Italian Society for Climate Sciences
SISC

ACCELERATING CLIMATE ACTION

A JUST TRANSITION IN A POST-COVID ERA

Book of Abstracts

9th SISC Annual Conference, online, 22-24 Set 2021

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More information on the Italian Society for the Climate Sciences - SISC is available at www.sisclima.it

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About SISC Conference

"Accelerating Climate Action: A just transition in a post-Covid era" is the title of the SISC 9th Annual Conference, held on September 22nd-24th, 2021.
Due to the COVID-19 virus, all sessions of "Accelerating Climate Action" Conference were held exclusively online.
The Conference aimed at connecting leading scientists, researchers, economists, practitioners, business leaders, and policy makers, whose activities are focused on different aspects of climate change, its impacts and related policies.
The Conference was an important interdisciplinary platform for the presentation of new advances and research results in the fields of science and management of climate change.

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About SISC

The Italian Society for Climate Sciences (Società Italiana per le Scienze del Clima - SISC) is a non-profit and non-advocacy association, which aims at contributing to scientific progress and the innovation of climatic sciences in Italy by promoting the convergence of disciplines and multidisciplinary research. SISC aims to be a reference point for all scholars dealing with climate-related sciences and their applications.

SISC was created to serve as a meeting point for scientists from different disciplines, who use climate information for their research: from climatologists to physicists and chemists, geographers to agronomists, economists to political scientists, and all scholars that deal with climate-related sciences and their applications.

The Italian Society for Climate Sciences aims at contributing to scientific progress and innovation of climatic sciences in Italy by promoting the convergence of disciplines and multidisciplinary research.

The institutional purposes of the SISC are:

a) to the world of research:

- to foster the exchange of ideas, the creativity and the development of new interdisciplinary research;

- to promote communication and cooperation between universities and research institutions in Italy, strengthening the presence of climatic sciences in both Italian universities as well as higher education systems;
- to attract young talents to build a new interdisciplinary scientific community and increase overall productivity;
- to stimulate and coordinate the Italian contributions to the International programs in the field of climate sciences;
- to become the reference point and the meeting place for Italian scientists living abroad.

b) to the society:

- to increase the impact of the studies and of the debate on climate issues, giving scientific rigour to the analysis of climate policies for mitigation and adaptation;
- to promote the dialogue among scientists, policy makers, businesses and citizens to support actions in the interests of the society and the environment;
- to provide research results to institutions, businesses and citizens

The SISC association is non-profit and non-advocacy, acts according to ethical principles and promotes policies for equal opportunities.

The aims of the Association are pursued in particular through the organization of conferences and debates addressed to the scientific and policy communities, the implementation of web-communications, the promotion of training courses for young graduates, and collaboration with multidisciplinary doctoral courses on climate science.

1 Plenary Lectures

ORAL

Transitioning Italy and the world to 100% clean, renewable energy and storage for everything

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Global warming, air pollution, and energy insecurity are three of the most significant problems facing the world today. This talk discusses technical and economic roadmaps designed to address these issues. If put in place, the roadmaps will substantially eliminate global warming and seven million air pollution deaths worldwide each year while creating millions of jobs and reducing energy costs, catastrophic risk, and international conflicts over energy. The plans call for converting the energy infrastructures of homes, cities, states, and countries of the world, including Italy, to those powered by 100% wind, water, and sunlight (WWS) and storage for all purposes (electricity, transportation, building heating/cooling, and industry). To date, roadmaps have been developed for 127 international cities, all 50 U.S. states, and 145 countries. Results indicates the electric power grid can remain stable at low cost worldwide with these roadmaps. The talk also discusses policies and laws in place to date resulting from these roadmaps, public opinion, and what is still needed to transition fully. Please see the following links to papers and a textbook

http://web.stanford.edu/group/efmh/jacobson/Articles/I/WWS-50-USState-plans.html

https://web.stanford.edu/group/efmh/jacobson/WWSBook/WWSBook.html

for more information.

ORAL

Assessing the economic impacts of environmental policies

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Over the years, governments have gradually adopted more rigorous environmental policies to tackle challenges associated with pressing environmental issues, such as climate change, air pollution, waste management or biodiversity loss. The ambition of these policies is, however, often tempered by their perceived negative effects on the economy. Do differences in the stringency of environmental policies across countries alter firms' competitiveness and cost jobs? Does taking the lead trigger a first-mover advantage? What are the differentiated impacts across firms, industries and regions? And are these policies effective in reducing emissions from industry? A recent OECD publication presents evidence from a decade of research and analysis on the relationship between environmental policies and economic outcomes such as employment, investment, trade and productivity

ORAL

Accelerating climate-change solutions: Designing for near-term and long-term benefits

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Past thinking about investments in climate-change solutions typically characterized them as pulling resources away from productive near-term uses. Investments in mitigation were viewed as required to meet long-term commitments, and investments in adaptation were viewed as valuable, but only under a narrow range of conditions associated with climate extremes. Increasingly, it is clear that a broad range of investments in both mitigation and adaptation can provide both near-term and long-term benefits. High levels of near-term benefits can come from four factors: (1) technology leadership and its influence on market dominance, (2) lower cost or higher performance, (3) increased efficiency, and (4) multi-hazard risk reduction. Developing all four in ways that balance environmental justice with economic opportunities remains a challenge. Still, a wide range of climate-change solutions can contribute simultaneously to mitigation, adaption, near-term economic growth, and a just transition.

2 Climate policies, transition pathways and mitigation technologies in the contest of sustainable development

ORAL

Impacts of and policy response to extreme weather and pandemics in the context of electricity demand and economic growth

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Keywords: COVID-19; extreme weather; water shortage; residential electricity consumption; economic growth

Severely COVID-19 hit the world in many aspects, including not only health risk, but electricity consumption, economic growth and human development (IMF 2020; United Nations, 2020; UNDP, 2020; Mathouraparsad et al., 2021; Kassouf, 2021). Despite that Taiwan did a good job in 2020 in terms of protection against the epidemic and, therefore, achieved a positive economic growth rate, the good luck, however, was overturned in 2021 since we encountered, in addition to the worsening epidemic situation, a severe island-wide shortage of water and electricity breakout, mainly due to extreme weather as well as the pandemic.

Interesting phenomena had been observed since the beginning of 2021. Firstly, electricity consumption in residential sector grows as usual and, for the first time in history, exceeds other sectors (next to industrial sector only), although generous subsidies were provided by the authority to the household for accelerating phaseout of the aged and energy inefficient appliances. Secondly, we experienced the most severe drought since 1970 caused mainly by extreme weather. Water supply capacity of all dams are deteriorating in 2021 to an unsustainable level and, as a result, disables

hydraulic power generation. Thirdly, to meet the national targets of carbon emission reduction, EPA attempts to revise the Act of 2015 to impose a carbon fee on major GHG emitters, while a cap-and-trade scheme is stipulated in the Act without full implementation. Lastly, despite such misfortunes come along all together with two consecutive electricity blackouts in one week, the economic growth rate is expected to reach an incredible level as high as 8% in 2021.

This paper presents an endogenous growth model that integrates several key factors such as industrial competitiveness, energy and environmental policy variables, and health risk owing to COVID-19. The peculiar phenomena illustrated above were then explained. A factor decomposition approach was also constructed to evaluate the contribution of all factors to residential electricity consumption. It is found that high temperature, prevalence of COVID-19, growth of electric vehicles, as well as industrial structure and competitiveness play significant role.

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ORAL

Towards a more structured dialogue between climate science and policy in Italian institutions

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Keywords: Climate science; policy; Italian institutions

As climate scientists, we are well used to a certain kind of communication to the policy makers, the so-called "one-way communication". Our results are transferred to them (and to other people) by means of press releases, reports, popularization books and summaries especially devoted to policy makers, such as the SPMs by IPCC.

Obviously, in this kind of communication, the final result concerning the reception of a message of scientific importance for society, which requires political actions, depends on the ability to explain the scientific analysis by scientists, but also, crucially, on the "interest" of policy makers. And this depends on political, economic and cultural views, which can lead to accept, or deny, or distort the scientific message.

At present, when the need for basing policy actions on the best science available is more and more evident (especially dealing with both the Covid-19 pandemic and the climate influences on our societies), unfortunately we realise that this one-way communication framework does not work.
It is quite clear that we need a more strict dialogue between science and policy, not only in emergency situations, but also for planning society development. This is usually carried out by policy makers through the figures of personal scientific advisors. But this way of acting shows some problems, too.

First of all, these advisors could be "biased" towards the view of the policy maker and could not be representatives of the best assessed science in a certain research field: for instance, this happened in the US when Trump chose advisors and heads for agencies such as EPA, who have just these characteristic features. Secondly, dealing with topics such as climate change, which require continual political and concrete actions to be planned for years or decades, opposite and "waving" policies lead almost surely to not achieve the final result of stopping global warming and its most dangerous climatic impacts.

In this framework, the many aspects of science-policy relationship have been discussed at length in literature, especially when dealing with environmental problems: see, for instance, E. Skolnikoff (1999), D.J. Roux et al. (2006), J. Lacey et al. (2018). Here I would like to discuss a possible framework for a more structured dialogue between (climate) science and policy in Italian institutions which could overcome the limits of previous paradigms.

Although a general lack or scarcity of scientific culture in Italian policy makers, recently the emergency due to the Covid-19 pandemic led to understand the crucial role of science in solving problems of vital importance for individuals and society. In particular, this example stressed the need

for a correct perception of a complex problem through specific and interdisciplinary expertise, in order to perform actions which must be prompt and effective. This concern led to the foundation of the Comitato Tecnico Scientifico (CTS) for contrasting the Covid pandemic.

Obviously, the foundation of the CTS has been due to this emergency situation, but we know that other upcoming problems (namely, climate change) reveal the same complex dynamics of the Covid pandemic (Pasini and Mazzocchi, 2020). Furthermore, although with different evolution times, climate change involves consequences on the entire society and its future development in many sectors. Thus, even if I do not want to discuss the specific efficacy of CTS and its composition on the management of the Covid-19 pandemic, this has to be considered probably as the first example of a concrete and continuous interaction between policy and science in Italy which can outline future ways of dialogue. Recently the Next Generation EU pushed Italy to perform an ecological transition and a specific Ministry has been established for this aim. In this situation, we need to think of a strict dialogue between policy and all the scientific disciplines involved in this transition. Could this be performed through the establishment of a "CTS for ecological transition"?

As a matter of fact, this can be obviously possible, but in doing so we could fall into the same problems about the biased choices by policy makers and the non-representativeness of the best science available that I cited above. Thus, referring to a recent open letter addressed to the Italian President of Council by a group of scientists (Bettinardi, Bonoli, Danovaro, Pasini et al., 2021), I propose a more structured relationship between science and policy inside the Italian institutions.

In particular, in my opinion there is the need for an interdisciplinary National Scientific Council (NSC) composed by the main representatives of high-level science in Italy, namely the President of the Accademia Nazionale dei Lincei, the President of CRUI, the President of the Consulta degli Enti Pubblici di Ricerca, but also representatives elected by the scientific community in many disciplines on the basis of their high-level scientific CVs.

This NSC could be inserted inside the Presidenza del Consiglio as a scientific advisory body for the Government on scientific strategic topics. The particular choice of its scientists (Presidents or elected) should guarantee a high scientific level and avoid political biases or "waving" political choices. Furthermore, this NSC could be a reference point for an Office for Scientific Studies (OSS) at the Italian Parliament (it exists in other nations), which can inform the elected people in the Parliament on the scientific problems which mainly affect our society. It could be an advisory body for the members of Italian Parliament. OSS should be composed by members chosen by NSC on the basis of their expertise in many disciplines as scientists and scientific popularisers.

Finally, inside the NSC, scientific committees for specific needs or emergencies, with members chosen by the NSC itself, could be established. At present, we have the Committee for Bioethics and the CTS, which could be considered the precursors of other committees which are necessary today. In my opinion, the first committee to be established should be a Committee for climate, environment and health, energy and ecological transition. In doing so, NSC should keep particular attention to the choice of members who can represent all the scientific expertise involved in this interdisciplinary effort. Today, for instance, even if we have a Ministry for ecological transition, inside the experts called for advisory there is a significant lack of ecologists, as stressed by several ecological associations.

I hope that this basic "project" for a more structured dialogue between science and policy can represent a basis of discussion inside our scientific community, for achieving an increased role of science – and climate science in particular – in the political choices of our country.

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ORAL

Emission trading in a high dimensional context: To what extent carbon markets are integrated with the broader system?

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Keywords: EU ETS; emission trading; hierarchical VAR; impulse-response

The following work will be providing further insights on the influence European Emission Allowance (EUA) prices exert on carbon dioxide trends and relevant variables of the economic-financial-climate-environmental system employing a large set of time series (i.e., industrial production, financial index, commodity prices, temperatures, rainfall patterns, wind speed). The methodological approach, developed in (W.B. Nicholson et al. 2020) (e.g., Hierarchical Vector Autoregressive Models), is conceived to deal with high dimensional time series as it includes lasso-based penalization on the choice of the lag order. Despite the scarce application to macroeconomic analysis, this technique appears to be more suitable to deal with the multiple dimensions (economic-environmental) of the research issue in account. Results of the two specifications highlighted how CO_2 appears to be more influenced by commodity prices (e.g., natural gas), climate variables (e.g., rainfall, temperatures) along with past industrial performances. Impulse-Response Function on the standardized first

differences of the series showed that a shock of carbon prices could potentially exert a significant turbulence on the carbon dioxide series fading in intensity as time goes by. Forecast Error Variance Decomposition (FEVD) analysis, identified how the influence of carbon prices appears to be rather weak for the variables considered. Furthermore, most of the variance is still explained by the own's variable lagged terms. Overall, despite some instances (e.g., CO_2) there appears to be a clear (negative) effect on the influence of carbon prices on the system. As the cornerstone of the EU climate policy, this work sheds light on the influence the EU ETS exerts on a system of multidimensional variables. These findings provide ulterior insights to policymakers as for better taking into account possible sources of carbon price shocks (e.g., overlapping policies) and tailoring existing adjustment mechanisms (e.g., Market Stability Reserve) for the stability of the European Emission Trading Scheme.

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ORAL

Buffered enhanced weathering of limestone as CO_2 storage technology: Material and energy balance and cost analysis

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Keywords: Mitigation; CCS; CO_2 storage; limestone; slaked lime; cost analysis

To limit global warming "well below 2°C", according to Art. 2 of the Paris Agreement, Carbon Capture and Storage (CCS) could play a role for decarbonizing "hard-to-abate" sectors. Furthermore, CCS could be combined with bioenergy and direct-air capture and storage could achieve negative CO_2. The storage of CO_2 is also needed for process such as ocean liming, that can lead to negative emissions if CO_2 emissions from limestone calcination are stored (Fuss et al., 2018; Renforth et al., 2013).

The most developed technology for storing CO_2 is the chemical-physical trapping of CO_2 in geological formations (Bui et al., 2018) whose main drawbacks are long times (5-10 years) for qualifying a suited geological formation and the uneven geographical distribution of the sites (Ajayi et al., 2019). A complementary approach, Buffered Enhanced Weathering of Limestone (BEWL), has been proposed, and consists in an innovation of Enhanced Weathering of Limestone (EWL) proposed by Rau and Caldeira (1999). The chemical fundamental of EWL is to store CO_2 in the form of bicarbonate in shallow seawater dissolving limestone (mainly composed of calcium carbonate, $CaCO_3$)

and CO_2 in seawater, i.e. it is an acceleration of the geological process of limestone weathering (Ciais et al., 2013).

With the aim to increase the CO_2 storage efficiency and reduce the water consumption with respect to EWL, BEWL proposes to discharge in the sea depth a buffered ionic solution composed of dissolved CO_2, $CaCO_3$ and seawater. BEWL configuration consists of an onshore mixer where CO_2 dissolves in seawater and a long tubular reactor where micron-sized $CaCO_3$ particles react with the seawater exiting from the mixer. The idea is that the length (up to 100 km) of the reactor pipeline allows the residence time needed for the dissolution of $CaCO_3$, and the increasing hydrostatic pressures (hundreds of bar in case of discharge at 2,000-3,000 m depth) enhances the solubility of the carbonate minerals. To complete the buffering process of CO_2, calcium hydroxide ($Ca(OH)_2$) is finally added to buffer the unreacted CO_2 before discharge in seawater. Thus, the buffered ionic solution at the discharge has a pH similar to the sea one. Other components of BEWL are the mill for grinding $CaCO_3$ in micron-sized particles and the electric calciner for producing $Ca(OH)_2$. Thus, the basic products needed for the storage with BEWL are limestone, seawater and renewable energy.
Here, the mass and energy balance of the whole process BEWL will be presented, together with a cost analysis of the whole process.

The first phase of the analysed process is the size reduction of limestone, a sedimentary carbonate rock composed mainly of the mineral calcite ($CaCO_3$), to obtain ground micron-size particles with a large specific surface. Rock comminution is a mature commercial technology. The costs and the energy necessary for mining and grinding of limestone was considered on the basis of the review carried out by De Marco et al. (2021). Then, an electric calciner that produces calcium oxide (CaO) using $CaCO_3$ is integrated with a slaker where Ca(OH)2 is produced adding water to CaO. The heat released by the cooling of CaO and the slaking process is used to evaporate the water that is fed in the calciner, lowering the calcination temperatures, and allowing an easier capture of the CO_2. In this way, the process produces decarbonised calcium hydroxide used for the buffering.

The CO_2 released by the calcination process and the external CO_2 from an industrial process is scrubbed by a proper quantity of seawater and the ground limestone is then added into the mixer before entering the dissolution reactor pipeline, where the carbonate mineral is completely dissolved into an ionic solution during its way towards the sea, prior to the end of the pipeline. The residual acidity of the ionic solution at the end of the pipeline due to the unreacted CO_2 is buffered in the buffering reactor, i.e. the final part of the pipeline, by a proper quantity of calcium hydroxide provided by a second pipeline. The main objective of the dissolution reactor pipeline is to maximise the amount of $CaCO_3$ dissolved per ton of CO_2 stored, so to minimise the use of $Ca(OH)_2$. The discharge of the solution at the same pH of the surrounding seawater allows permanent CO_2 storage in the form of bicarbonate ions.

According to the results of the chemical analysis of the dissolution kinetics in the reactor presented by Righi et al. (2020), the materials required for storing 1 ton CO_2 are approximately 2,820 m^3 of seawater and 2.5 ton of limestone of which 0.7 ton is used for $Ca(OH)_2$ production. For the energy demand of the whole process, the energy necessary for calcination, limestone milling, CO_2 and seawater pumping will be evaluated, while in the cost analysis, the operational expenditure (OPEX) and capital expenditure (CAPEX) will be assessed. The OPEX includes the cost of limestone, electricity, maintenance, personnel and other costs, while the CAPEX the costs of HDPE pipelines, pipelines

installation, mill, calciner, slaker, and the other components. A sensitivity analysis of the costs will also be shown.

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ORAL

Energy needs for adaptation significantly impact mitigation pathways

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Keywords: Energy; adaptation; mitigation policy; integrated assessment model;

MOTIVATION. Climate adaptation actions can be energy-intensive. If households and industries use more energy to cope with the ongoing and expected changes in climate conditions, the mitigation challenge can look inherently different. This adaptation-energy feedback is absent in most of the up-to-date energy scenarios. Here we provide new evidence on how climate change impacts and adaptation can alter mitigation pathways with a focus on the response of residential, commercial, and industrial activities. We quantify the impacts of climate-induced adaptive changes in final energy use on energy investments and costs, emissions, and on air pollution.

This article sheds light on a blind spot of the energy transition and of the implementation of climate policies, namely how adaptation needs might reduce the effectiveness of climate policy, making it necessary to revise those policies. In the context of a rapid transformation and simultaneous occurrence of climate change impacts, it is important to examine how responses to climate change affect energy systems, and therefore the achievement of mitigation goals, as well as their economic costs.

METHOD. By integrating what we call the adaptation-energy feedback loop into the World Induced Technical Change Hybrid model - WITCH, our study is one of the first to fully integrate the energy needs for adaptation endogenously into mitigation pathways, so that climate policy design is directly influenced by adaptation energy needs. Such integrated framework makes it possible to analyze how decarbonization and policy design changes when adaptation needs are taken into account. We show that ignoring the energy system costs and the environmental implications attributable to rising adaptation needs in IAMs results in an underestimation of the benefits of mitigation policies.

Our model development consists of three novel elements. First, we empirically estimate a reduced-form relationship (statistical emulator) between country-level annual average temperature and the annual occurrence of extreme cold and hot days using historical data. Second, we model the direct relationship between changes in the occurrence of extreme temperature days and the demand for electricity, gas and oil in the residential, commercial, and industrial sectors using empirical estimates from the recent empirical literature. Third, we implement the direct changes in energy demand through (inverse) changes in energy productivity in the production tree of the IAM. We then quantify the impacts of climate-induced changes in final energy use on the energy investments and costs, on

the costs of mitigation policies, and on the mitigation co-benefits on air pollution. The model is calibrated on the existing empirical evidence, but it relies on a modular and flexible structure that can be adapted to other models and updated with the availability of new empirical evidence on how climate change affects energy use and energy supply.

RESULTS. Our results indicate that, if done in a traditional way, adapting to climate change while reducing emissions, as indicated in the currently implemented climate policies, will raise the demand for electricity by 7\% (18\%) and for fuels by 1\% (2.5\%) by 2050 (2100). The increase in energy needs leads to more energy capital locked-in into fossil fuels, for an additional 200 Gigawatt (GW) of coal-fired capacity, 250 GW of oil-fired capacity and 520 GW of gas-fired capacity by 2050. Adaptation would imply also more economic resources for grid investments, power generation, and fuel consumption. The carbon price required to reach a certain carbon budget would need to increase, and the cost-effective allocation of emissions over time would also look different compared to a scenario without the adaptation-energy feedback loop. When the energy requirements for adaptation are accounted for, the level of the carbon price needed to achieve mitigation policy goals increases by up to 30%.

POSTER

Adaptation and sustainable development, climate policies and trajectories post Covid-19

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Keywords: Climate change; adaptation; (international) law and policies; biodiversity; Chile

Adaptation to climate change is an international obligation to be fulfilled: adverse effects of Climate Change on terrestrial biodiversity (AECCTB). Application of adaptation has included current information or practical solutions (based on case studies and court cases) to gain knowledge of facts and criteria required to confront this threat (closing legal and policy knowledge gap, allowing this international obligation to be honoured because treaties and policies are in force in Chilean legal system). My contribution focuses on the relationship between international and Chilean law and policies, specifically on the obligation of adaptation vis a vis AECCTB finding source(s) for juridical knowledge in order to fill the juridical gap.

The Paris Agreement (PA) (UNb, 2015) and current discussions on a draft law on Climate Change in Chile have not recognized problem or legal and policy solutions (Moraga, P. et al, 2020). AECCTB have been recognized by the Minister of the Environment of Chile (Schmidt, 2019). A definition of "adverse effects" has been enacted, but no general legal rule(s) on means to confront AECCTB have been drafted in Chilean law and policies are at the starting point and literature faces the same

oversight, focusing on dated forms of conservation, or ongoing discussions regarding the problem. Movements from plants and animals without help (from policy and law) could end in a possible disaster (people's rejection to movements, zoonosis, etc.) or success (shelters, constructions for animals, reintroduction of species, etc). Acceptance of the oversight to legally and policy address AECCTB ("types": animals, plants, microorganisms) condemns them to extinction as they cannot easily move, adapt, and create resilience (Bellard, 2012). In a country rich in (agro) biodiversity, which plays an important role in the life of the Chilean people, it is not necessary to accept catastrophic consequences of AECCTB, already established by world historians. The need for an analysis of sources with current solutions to "translate" their standards in legal and policy knowledge, will give insights on material sources for legal and policy knowledge (even, legal rules) (Bulygin, 2009). Ruling adaptation of biodiversity by law has been the focus of legal scholars, like Hollo (2012), when addressing the effects of Climate Change and the response of Law, including international law and international policy. The general goal of this contribution is to examine case studies as sources of knowledge to be used in designing legal solutions for adaptation against AECCTB. In order to achieve this goal, specific sub-goals have been established like a definition of "case studies" as being source for criteria on the adaptation against AECCTB, based on three different sources that face problems pertaining to AECCTB, and the use of these criterias for gathering data, creating knowledge for effective juridical solutions, standards to accomplish international obligations from adaptation as stated in the PA and UNFCCC into the Chilean legal system, saving biodiversity from AECCTB, small wine producers is one of the cases (Hafgaard, 2016, Hannah, 2013, Giraldo, 2017, Haddad, E. (2019)). My approach is qualitative, based on previously gathered data and publications by grounded theory research and phenomenological research. This research design considers that practical research is not common in international law, but previous research and publications have provided enough data to present this contribution. My hypothesis should be tested, the question answered, and the problem solved in an ongoing process due to inherent difficulties of negative effects of climate change and the diversity of answers to help terrestrial biodiversity in their peril for survival, simultaneously creating standards from these answers and generating juridical and policy knowledge to fill in the intellectual gap on sources for solutions. It is expected to further knowledge on ways to fill the gap on sources to accomplish international obligations in the Chilean legal system. Another conclusion relates to the distinction between effective sources versus non effective for the provision of practical experiences to provide information on the application of an international obligation. In addition, it will provide data regarding an international obligations application process on an international treaty when changes in subjects and adapting obligations object to the national legal system and local territories.

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POSTER

Quantification (evaluation and valuation) of the mitigation capacity by the whole natural compendium (sea and land) in Italy

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Keywords: Marine and terrestrial habitats; nature mitigation potential; CO_2 sequestration and storage - Italy

The IPCC reports that limiting global mean temperature increase to 1.5° C will require net CO_2 emissions to fall worldwide by about 45% by 2030 and to reach global net-zero emissions by 2050. To meet the former target, the European Union with the Green New Deal legally binded member states to reach the 55% net greenhouse gas reduction by 2030, including emissions and removals. In the present framework, two are the sides to consider: the positive emissions (those produced by the national economy) and the negative emissions (those absorbed by the natural compendium). Italy is planning to reduce emission in different productive sectors, as reported in the PNRR (Piano Nazionale di Ripresa e Resilienza), using part of the Next Generation EU (Recovery) funds. However, to date at the best of author's knowledge the contribution of nature in terms of quantification of sequestration and storage of CO_2 is almost unknown. Quantifying the capacity of nature to offset national emissions should be straightforward in a country that has around 80% of its land covered by pristine or semi-anthropized habitats and an even double-fold area of sea in its Exclusive Economic Zone (EZZ). The present study represents the first estimate of annual CO_2 removal provided by the whole Italian natural compendium (marine and terrestrial habitats). Besides this evaluation, a valuation in monetary terms (euro) has been performed using the metrics of social cost of carbon. This information aside from highlighting the value of nature and its potential in climate change mitigation has the underlying role to remind the consideration of nature in Italy to meet the net-zero target. To reach it by 2030, there is a need to quantify the removals by the natural

compendium in light of creating a baseline upon which all other efforts in mitigation (e.g., Carbon Capture and Storage (CCS)) can be added.

3 Climate trends: Changes in means and extreme events in observations, simulations and projections

ORAL

Radiative impact of biomass-burning aerosols at THAAO and over the western Arctic in August 2017

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Keywords: Wildfires; radiative budget; arctic; biomass-burning

Extended and intense biomass burning fires occurred in Northern Canada and on the Greenlandic West coast during summer 2017. The smoke plume emitted into the atmosphere was transported and spread in the Arctic, producing one of the most significant impacts ever observed in the region. Evidence of Canadian and Greenlandic wildfires was recorded at the Thule High Arctic Atmospheric Observatory (THAAO, 76.5°N, 68.8°W, www.thuleatmos-it.it) by a suite of instruments managed by ENEA, INGV, Univ. of Florence, and NCAR.

Chemical tracers such as CO, HCN, H2CO, C2H6, and NH3 were measured in the atmospheric column above Thule from 19 August to 23 August by an FTIR. The aerosol optical depth measured by the AERONET sunphotometer was dominated by the fine fraction, reaching a peak value of about 0.86

on 21 August. An air sampler monitored several wildfire compounds at a 48-hour resolution. Ground-based radiometers allowed the quantification of the surface radiation budget at THAAO.
Backward trajectories produced through HYSPLIT simulations (Stein et al., 2015) were also employed to understand the atmospheric dynamics indicating the origin of the transported smoke.

MODTRAN6.0 radiative transfer model (Berk et al., 2014) was used to estimate the aerosol radiative effect (ARE) and the heating rate profiles at 78° SZA. Measured temperature profiles, integrated water vapour, surface albedo, spectral AOD and aerosol extinction profiles from CALIOP onboard CALIPSO satellite were used as model input. The shortwave ARE at the surface was -43.7 W/m2 at 78° solar zenith angle (SZA) for AOD=0.626. The peak aerosol heating rate (+0.5 K/day) was reached within the aerosol layer between 8 and 12 km, while the maximum radiative effect (-45.4 W/m2) was found at 3 km, below the most extensive aerosol layer.

The regional impact of the event observed between 15 and 25 August was investigated using MODTRAN to model the aerosol radiative effect efficiency (AREE) with measurements of AOD and surface albedo over land retrieved from MODIS. Instead, albedo data over the ocean were obtained from Jin et al. (2004). The radiative transfer model was fed with the atmospheric properties used in the ARE simulation at THAAO.

The values of aerosol radiative effect efficiency (AREE) span from -3 W/m2 to -132 W/m2, depending on surface albedo and solar zenith angle. The fire plume covered a vast portion of the Arctic, with large values of the AOD reaching the eastern Greenlandic coast and with the shortwave ARE lasting for a few days. In particular, we calculated a cumulative ARE during the considered period and found a negative peak value of -120 TW on 21-22 August over the Arctic sector between 60°N - 80°N and 110°W - 0°E. Instead, the mean daily ARE shows values between -65 and -25 W/m2 between 15 and 25 August, being influenced by really large AOD values mainly during the first part of the period over northern Canada. This large amount of aerosol is also expected to influence cloud properties in the Arctic, producing significant indirect radiative effects.

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ORAL

Spectral analysis of a climatological period of simulations of soil temperature and moisture in northern Italy with UTOPIA model

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Keywords: Soil temperature; soil moisture; spectral analysis; UTOPIA; land surface modelling; Italy; climatology

In recent years, the scientific community has recognized the importance of the earth's surface as a key component of the climate system. The soil, vegetated or not, can be considered a lower boundary condition for the atmosphere since it is a source term for the hydrological and energy budgets of the atmospheric surface layer. Slightly different conditions of some crucial parameters, such as soil humidity and temperature, can affect the stability of the boundary layer and, in general, of the entire troposphere. Despite the importance of these variables in the climate system, there is a lack of complete observational data at a climatological level, so it is very difficult to adequately assess the energy balances of the earth's surface for large areas and for long periods. For this reason, the alternative method called CLImatology of Parameters at the Surface (CLIPS) can be used: the numerical outputs of a certain trusted LSM are used as a surrogate for the observational data; the chosen LSM is usually guided by observations from meteorological stations.

In this study, the variables of soil temperature and humidity (as well as other variables in the surface atmospheric layer and soil, not relevant for this presentation) were evaluated through simulations conducted with the UTOPIA model (University of Turin model of land Processes Interaction with Atmosphere; Cassardo, 2015) in northern Italy. The required data for the initialization of UTOPIA have been extracted from the worldwide climatological database GLDAS (Global Land Data Assimilation System; Rui and Beaudoing, 2018) over a region including Northern Italy. GLDAS data are available every three hours on grid points whose average distance is approximately 15 km. More precisely, the geographic domain chosen involves most of the Alpine region and the Po basin, delimited by the meridians 5° and 15° E and by the parallels 43° and 48° N, and the maximum temporal extension available on GLDAS was used, from January 1st, 1948 to December 31, 2014.
The outputs of soil temperature and moisture in the surface layer of the soil were arranged in a time series of 10 days values averaged over the whole geographic domain.

These variables were analysed with methods able to evaluate possible cyclicity or pseudo-cyclicity in their trends. This kind of spectral analysis was extensively used for atmospheric variables, while – at least for what is at our knowledge – it was quite unusual for soil related variables. The methods used were: autocovariance, autocorrelation, spectral analysis and CWT (Continuous Wavelet Transform), and the white and red noise signal were used to infer the meaningfulness of the results. The main results obtained with those methods will be presented in this conference. In particular, the

periods highlighted by almost all methods were 1.5 years for surface soil temperature and about 4-5 years for surface soil moisture. These results could be considered not generated by mathematical or numerical artifacts, since they were obtained using different methods. Further investigations are required to understand their nature and cause.

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ORAL

Chilling requirements of olive trees over the Euro-Mediterranean region under climate change

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Keywords: Chilling requirements; olive crop; the Euro-Mediterranean region; climate change and chilling methods

To minimize the effects of low temperatures, trees suspend their growth during the year`s cold months, which is called dormancy stage. To end the dormancy and regulate bud breaking end flowering, trees require accumulating specific thresholds of cooling, which is called chilling accumulation. Olive industry as one of the major Mediterranean tree crops would be barricaded by climate change impacts and consequently warmer winter months that would cause insufficient chilling disturbing dormancy breaking time in the olive tree. This investigation aims to evaluate the impact of climate change on the chilling accumulation required for the Olive trees on a large scale over the Euro-Mediterranean region.

To this end, we applied the chilling methods over a historical and future period (respectively, 1981-2020 and 2021-2060) using ERA5 (the fifth generation ECMWF reanalysis) and CORDEX (the Coordinated Regional Climate Downscaling Experiment) that consist of bias-adjusted results of 4 regional climate models (RCMs) under Representative Concentration Pathways (RCPs) of 4.5 and 8.5. All data sets including maximum and minimum temperatures, are downloaded with a spatial resolution of 0.11 degrees and in a daily temporal scale. Basic data processing has been done using CDO (Climate Data Operator) and then applying R package (chillR version 0.72.2) to compute chilling,

by developing a specific R script for a grid point-based data series over the study area. Three chilling methods are presented as follows; Weinberger model (1950) computes every hour between 0 and 7.2°C as a chilling hour (CH). The Utah model (1974) uses the temperature range of 1.4-12.4°C to calculate the chilling units (CU). In this model, temperatures are weighted, and then accumulated to have CU for a defined period of time. The dynamic model suggested by Erez and Fishman (1998) calculates chilling accumulation as chill portions (CP), using a range of temperatures at -2°C and 12.5°C with zero effect, and the highest efficiency at 6 to 8°C (some temperatures are more effective than others).

The obtained results, regardless of the applied chilling methods as well as the RCPs, project an increasing chilling accumulation over northern latitudes, whereas, over Mediterranean regions and the southern parts of the study area because of warmer winter temperatures, insufficient chilling, and for the middle regions relatively little change would be expected, during the future period. The findings are strongly applicable for the development planning of future olive tree plantations in a climate change context, supporting adaptation measurements of olive tree crops and their varieties in the Mediterranean region.

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ORAL

Interannual to decadal predictability of heatwaves over Europe in large-ensemble hindcasts

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Keywords: Heatwaves; Europe; AMV; CESM decadal prediction large ensemble; predictability

Climate-change studies suggest that summer heatwaves over the European continent will become more frequent and intense, leading to significant impacts on society, including a rise in heat-related health problems. The most severe impacts are associated to the combination of extremely high daily and night temperatures with an increase of heatwave intensity, duration and frequency of episodes. The projected increased severity of such events makes it very urgent to improve our capability to predict them on all time scales, from the shorter timescales to the sub-seasonal and decadal timescale. In this respect, recent studies suggest a relationship between the heatwave frequency over

Europe and the Atlantic Multidecadal Variability (AMV), with possible implications on the relative predictability. Skilful predictions of heatwaves could, therefore, provide useful information to policy makers and be beneficial for society at large. The study we present here aims at investigating the variability of heatwaves occurrence over Europe and at assessing the ability of the CESM Decadal Prediction Large Ensemble (CESM-DPLE, 40 members; provided by NCAR) to predict their frequency on annual to decadal timescales. The role of the AMV variability and intensity on the modulation of heatwaves duration over this region is also investigated and the possible relations between heatwaves statistics and broad-scale SST patterns is discussed. Since recent studies highlight the existence of skilful AMV predictability in the CESM-DPLE, and a relation between heatwaves statistics and the AMV has also been shown, we anticipate that skilful predictability of heatwaves on long timescales is to be expected.

ORAL

Towards local scale scenarios of coastal climate change in the Northern Adriatic area

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Keywords: Climate change; downscaling; sensitivity cases; high resolution simulations; Northern Adriatic sea

Awareness of global trends in climate evolution has reached almost the whole society and the demand of mitigation and adaptation actions is already part of the policies at all hierarchical levels, that is from international through national and down to the county one.

The huge amount of work done, during the last decades [1], to generate climate change scenarios, both for atmosphere and ocean, with spatial resolutions that are suitable to identify potential impacts, at global and continental scales, it is not enough to support policies at the county level. In fact, especially in environmental complex areas, the atmospheric and marine trends depicted at the global level are just the frame in which local features, of the future climate, have to be considered. For Italian coastal areas, the demand of sub regional details in the sea level rise, the water temperature and salinity, air temperature, humidity, breezes intensity and the other atmospheric boundary layer fields,

which are required to evaluate the impacts on the ecosystem and the human activities, are mandatory.

In this work, we describe our approach in matching the stakeholder request, of local scale marine and atmospheric climate change scenarios. Even if, it has to be considered a first order approximation of the problem, to be exploited meanwhile the fully coupled atmospheric and marine models will reach the needed spatial resolution, it is shown that the results are useful to downscale some classes of climate change related hazards, which are requested by stakeholders to feed the impact chains.
Since the problem we had to face is strongly characterized by the boundary conditions, because of the reduced size of the domains in comparison of the continental scale, we simulated a set of yearly periods, forcing the models with boundary conditions coming from future climate scenarios already available for the continental scale. In that way, the physical processes implemented in the models make the environmental system to evolve reaching the desired spatial resolution, according with the larger scale climatic frame. Of course these are not climate simulations and we prefer to name them sensitivity cases.

For example, we generated the future sea state, referring to a set of year across 2030 and 2050, by means of the shallow water numerical model SHYFEM [2], forcing it to the boundaries with thermohaline, currents and sea level fields extracted from continental and basin scale scenarios fields, EURO-CORDEX [3] and MED-CORDEX [4].

The method is applied to the Gulf of Trieste and the lagoon of Grado and Marano [5], which are modelled as a unique domain having a variable mesh, starting form a few kilometers of resolution off shore and reaching the tens of meters in the lagoon. Two Representative Concentration Pathway (RCP) [6] have been considered, namely the 4.5 and the 8.5. The quality of the shallow water model implementation has been verified by means of a series of hindcast simulations.

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ORAL

Modelling hail probability over Italy with a machine learning approach

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Keywords: Hail model; hail risk; extreme events; genetic algorithm; convection

Hail is a meteorological phenomenon with adverse impacts affecting multiple socio economic sectors such as agriculture, renewable energy and insurance (e.g. Púčik et al., 2019; Martius et al., 2018; Macdonald et al., 2016) . The mitigation of the hail-related risk in particularly sensitive regions such as Italy has fostered the hail research, including a deeper understanding of the favourable environmental conditions for hail formation and the improvement of hail forecasting skill (Mohr and Kunz, 2013). Nevertheless, one of the major limitations for the study of long-term hail variability is the inherent difficulty in measuring all the hail occurrences and the consequent scarce temporal and spatial coverage of hail observations (Mohr et al., 2015). Therefore, in this study the Probability Density Functions (PDFs) of several large-scale meteorological variables and convective indices from the ERA5 reanalysis are considered instead, with the aim of describing a conditioned hail probability, following the statistical method by Prein and Holland (2018). Then, the best set of variables to be used as predictors in the hail model has been selected with a machine learning approach, based on a genetic algorithm. The model output is an estimation of the hail probability over Italy in the 1979-2020 period, on a 30x30 km grid. The estimated hail probability has been used to characterize the seasonality, long-term variability and trends of the hail frequency and to investigate the potential large-scale drivers of hailstorms over Italy.

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ORAL

Future projections of ROSSBY wave packets and blocking events with particular attention to the northern hemisphere

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Keywords: Climate change; Rossby wave packets; blocking events; CMIP6; ssp585

Rossby Wave Packets (RWPs) and Atmospheric Blocking Events (ABEs) are of great interest in today's meteorology and climatology researches because at the mid-latitudes they may be precursors of extreme meteorological events, such as summer heat waves, winter spells, droughts, heavy rains and floods. As climate change might affect the trend and the variability of RWPs and ABEs, it is interesting to study their evolution over different geographical regions. This study aims to identify some areas more likely affected by these atmospheric structures' modifications related to climate changes in a pessimist global warming scenario.

Rossby waves are undulations of zonal winds and they are typically located at the altitudes of the jet streams. Generally, synoptic Rossby waves travel from west to east in coherent wave packets, showing large amplitude ripples, containing a finite number of ridges and troughs (meandering). RWP decay might generate deep troughs, often followed by precipitation and temperature anomalies. In the Northern Hemisphere they have prevailing paths with high frequency and activity (the so-called storm tracks), sited over Atlantic and Pacific basins.

ABEs are upper troposphere patterns characterized by persistent (from 4 days to several weeks) and stationary high pressure anomalies, that often are associated to the Rossby wave breaking. ABEs are able to "block", i.e. to interrupt and/or to invert the westerly wind, causing the modification in the jet stream meandering and the deviation of the transient synoptic disturbances. ABEs may be closely connected with temperature and precipitation extremes at continental and regional scales inducing different temperature anomalies upstream (warm) and downstream (cold) of the blocking high pressure.

ABEs and recurrent RWPs in phase at the same longitude often occur together, determining the persistence of meteorological conditions. In the Northern Hemisphere the prevailing regions of ABE occurrences are located at the exit zones of the main RWP storm tracks, on the eastern sides of the Atlantic and Pacific oceans.

The frequency variations of RWPs and ABEs in future climate projections at seasonal scale have been investigated by applying well-known literature methodologies to the ERA5 reanalysis dataset

and to an ensemble of 10 CMIP6 global climate models under the hypothesis of the most pessimistic "business as usual" scenario, i.e. in the absence of greenhouse gases mitigation actions (scenario MIP ssp585). The study has been focused on winter and summer seasons. In addition, RWP analysis has been extended to spring and autumn.

For the RWP and ABE analyses, the atmospheric variables considered are respectively:

- the meridional wind velocity at 250 hPa (va250) to estimate the envelope of the Wave Packet Amplitude (WPA) by applying the method of Zimin at al. (2003, 2006), known as the Hilbert transform technique (Karami, 2019), and to compute the frequency of WPA exceeding 20 m/s (WPA20);

- the geopotential height at 500 hPa (zg500) to estimate the frequency of the blocking events by referring to Davini et al. (2012) and Woollings et al. (2018). In this work the methods ExtraD12 (that computes the differences of absolute values), and S04 (that considers the anomalies respect to climatological thresholds) have been applied by means of R package MiLES (Mid-Latitude Evaluation System; Davini, 2018).

At first the performances of the multi-model mean (MMM) in reconstructing the frequency of WPA20 and Blocking Events has been investigated by comparing MMM results with the ERA5 climatology in the historical period 1986 – 2005 (bias analysis). Then the future variations expected at short- (2021- 2040) and long-term (2081 – 2100) have been analysed by considering the models' agreement in the sign of anomalies and by applying the Wilcoxon test to the different scenarios.

The results of RWP analysis have shown that in the reference period MMM reproduces correctly the annual cycle of the main storm tracks, whose deployments affect predominantly North Atlantic (NA), North Pacific (NP) and Southern Hemisphere (SH). Focusing on the Northern Hemisphere, the MMM generally underestimates the frequencies, in particular for the NP storm track (until –22%), respect to ERA5 whose average values range from about 20% to 40 % and maxima reach 65-70% locally for NA and NP. About future scenarios, moving from the short to the long-term, some significant changes in the WPA20 occurrences have been found respect to the reference period. Specifically, for the NA storm track, a frequency decrease over the Eastern American coasts is expected in winter and spring, and a frequency increase over the Europe and Western Asia (especially over the region between the Caspian and Black Seas) is likely in winter. A frequency reduction is projected for NA in the summer and autumn seasons and for NP in all seasons. Moreover, some results suggest a poleward shift of the storm tracks.

The ABE occurrences have been analysed for the Northern Hemisphere, for which MiLES has been developed. The two methods Extra12 and S04 agree in correctly identifying the frequency maxima areas (10 ÷ 20 %) in the reference period: the region covering the British Isles and Scandinavia (European Blocking - EB) and the region extending between North Pacific and Siberia (North Pacific Blocking – NPB). Two secondary maxima are identified over Greenland by using ExtraD12, and over Ural and Kara Sea region by applying S04. The aforementioned areas show lower frequency values in summer, shifting to North-East respect to winter. The MMM climatology differs from ERA5 within the range of -14% ÷ + 6%. Both methods underestimate the winter EB frequency, but they differ in the other regions/seasons. By applying ExtraD12, no significant climatic changes are projected at short-term, while at long-term a significant decrease of blocking occurrences is expected over Greenland, Pacific and North-Western Europe in winter. In this same season blocking frequencies are projected to intensify slightly over the South-Eastern Europe, defining a dipolar structure, even if such anomalies

are poor significant according to Wilcoxon test. Despite the difficulty to investigate future scenarios by using S04 due to the adaptative climatological threshold intrinsic in the method, some results may be inferred: in comparison with ExtraD12, S04 confirms significant variations at long term in winter and highlights a similar dipolar structure with a frequency decreasing (increasing) in the north-western (south-eastern) Atlantic/European area.

In conclusion, focusing on Europe, in spite of a generalized underestimation of the CMIP6 models in reconstructing the frequency of RWPs and ABEs, the work highlights at long term a significant frequency increase for WPA20 in winter and spring seasons, and a significant decrease of blocking events over the North-Western area in winter. A frequency reduction of RWPs is expected in the other seasons, whereas no climatic signal is found out for the blockings in summer season.

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ORAL

Recent trends and future perspectives of upwelling events in the Gulf of Trieste

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Keywords: Air sea interaction; Bora wind; coastal upwelling; climate change; downscaling EURO-CORDEX simulations

In the Gulf of Trieste, northern Adriatic Sea, the interaction between atmosphere and sea is responsible for the formation of dense and cold water during winter season. Next to the formation, such water mass moves southward contributing to the Eastern Mediterranean flow. The formation events are consequence of water upwelling along the eastern coast of the gulf, due to the strong and

long lasting Bora wind events, that characterize the Balkans and the Adriatic region winters. Furthermore, the shallow and continuously mixed water is cooled, loosing heat in the very cold atmospheric boundary layer. In the warm season, the strong Bora episodes are shorter than winter ones and they are related to cold fronts impinging on the Alps. Also in these cases the upwelling of sea water occurs and the mixing involves the whole water column, as in winter. In the stratified summer waters, the Bora events break the thermocline and allow the oxygenation also in the oxygen poor bottom water. In that way, the hypoxic conditions, which are stressing the benthic ecosystem for long periods in summer, are suddenly removed and normal environmental conditions are restored.

Awareness of this important consequences, of the air sea interactions in the Gulf of Trieste, stimulates the investigation of the evolution of the upwelling events in the frame of the climate change scenarios. To this end, both for winter and summer analyses, the atmospheric features worth to be considered are the wind stress at the sea surface, the duration of the Bora episodes, the air temperature and moisture, while for the sea the water stratification summarizes all the physical variables needed to evaluate the mixing occurrence and the restoring times of the water column stability.

In this work we describe the measurements and the methods used to study the evolution of upwelling episodes in the Gulf of Trieste, across the past twenty years, and how the atmospheric mean sea level horizontal pressure gradients can be used as a proxy to downscale the regional climate change scenarios for the while XXI century. The downscaling method is applied to the EURO-CORDEX fields, of a selected set of model outputs, for the three Representative Concentration Pathway (RCP) climate change scenarios, namely the RCP 2.6, RCP 4.5 and RCP 8.5. For both winter and summer upwelling Bora related events, the resulting trends are presented as local air sea interaction impacts of global climate change scenarios.

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ORAL

Observed and simulated meridional moisture transport associated with Tropical Cyclones

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Keywords: Moisture transport; Tropical Cyclone; highResMIP; CMIP6

Tropical cyclones (TCs) transport energy and moisture along their pathways interacting with the climate system and TCs activities are expected to extend further poleward during the 21st century. Moreover, the transport of moisture associated with TCs may influence the atmospheric water distribution impacting regional mean state and extreme events also at middle latitudes.
For this reason, it is essential to assess the distribution of moisture transport associated with TCs. Besides, it is fundamental to evaluate the ability of state-of-the-art climate models in representing the observed distribution of moisture transport.

In particular, the present work focuses on the meridional transport of moisture associated with TCs. This meridional transport is evaluated using the vertically integrated meridional water vapour transport associated with TCs over the North Atlantic, analyzed as a sample region, while the same approach can be applied on a multi-basin basis.

The observed present-day moisture transport associated with TCs is estimated using the International Best Track Archive for Climate Stewardship (IBTrACS) and the Japanese 55-year Reanalysis (JRA-55) data. The model data are taken from the simulations performed as part of the High-Resolution Model Intercomparison Project (HighResMIP) in the framework of the community Coupled Model Intercomparison Project phase 6 (CMIP6) effort. HighResMIP provides simulations at both standard and high horizontal resolution, which are required to accurately reconstruct TCs activity. These simulations give the possibility to assess the impact of the model resolution on the reconstruction of the moisture associated with TCs. Moreover, the impact of boundary conditions, i.e. observed ocean surface state, is examined by considering both coupled and atmosphere-only HighResMIP model configurations.

In the North Atlantic basin, the observed largest impact of TCs on meridional moisture transport at basin scale is detected in the tropical region, where the TCs tend to reside the most. Climate models correctly reproduce the TCs latitudinal distribution in their high-resolution configuration, with a general underestimation at lower latitudes and a slight overestimation at high-latitudes compared to observed TCs tracks (i.e. IBTrACS). The simulated moisture transport associated with TCs displays reasonably good performance in atmosphere-only high-resolution models configuration. In general, high-resolution climate models are able to seize the observed moisture meridional transport

associated with TCs, and they will be the principal tools in investigating the future evolution of TCs activity.

Further analysis is required to evaluate the change in moisture transport associated with TCs at the local and regional scale.

POSTER

Precipitation trends in Abruzzo 1980-2019: Rainfall erosivity and comparison with gridded dataset

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Keywords: Precipitation trend; rainfall erosivity factor; E-OBS; climate change; Abruzzo

We used monthly and hourly observations of precipitation over a complex terrain region in Central Italy, Abruzzo, to analyse the trends of rainfall erosivity and indices of extreme precipitation in the period 1980-2019. The data base was produced through the development of a readily portable procedure for building an upgradable long-term homogeneous climate dataset using monthly and daily observations of temperature and precipitation (Curci et al., 2021). We show that precipitation extremes are increasing in the region, especially along the coast, with rain accumulated in the rainiest days increasing at a rate of 1-2%/year over the period 1980-2019.

We also evaluated the trends of the erosive capacity of precipitation, which depends on its intensity, volume, and duration. The rainfall erosivity factor (R) of the Universal Soil Loss Equation (USLE) requires high frequency (sub-hourly) data. When these are not available, R can be estimated from simplified indices such as the Modified Fournier Index (MFI), the Precipitation Concentration Index (PCI), and the Seasonality Index (SI), which are computed from monthly precipitation. We calculated these indices based on both gauge (point) and grid datasets (E-OBS) (Di Lena et al., 2021). For MFI, grid data do not capture the peaks in high-altitude stations and the low values in some inland areas, de-tected by the point dataset. Grid data show significant MFI positive trends in 74% of the stations, while the point data display significant positive trends in only 26% of stations and significant negative trends in four stations in the inland areas. The use of grid data in complex orography requires preliminary validation work.

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4 Urban areas: Assessing, predicting and managing the current and future risk

ORAL

Assessment tools for the thermal impact of multi-scale urban modifications

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Keywords: Urban climate; climate change; assessment

The well-known relevance of urban environments for resilience plans to climate change is a strong motivation for a growing number of scientific research and applications. Remote sensing and numerical modelling are the main branches of recent development in urban meteorology, while direct observations and climatological studies are sometimes less considered: nevertheless, they remain fundamental.

On the other hand, cities evolve rapidly morphologically as well as in their metabolism: their climate is a combined consequence of the regional one (subject to global climate change and impacting at smaller local scales) and of anthropogenic urban variations. Furthermore, both effects have a comparable (short) time scale and can hardly be evaluated separately, even if the former is acting at a larger spatial scale while the latter covers a spectrum going from a single building to the whole metropolitan area: direct measurements are a primary tool to monitor changes in the urban environment as they are at larger scales.

In studying cities, land cover and land use are fundamental data and are nowadays generally available with fine details also thanks to air- and space-borne remote sensing. Urban meteorological (and consequently climatological) information is on the contrary often inadequate to describe all spatial and temporal scales of interest because of the complexity of the urban atmosphere and the difficulties in operating a sufficiently dense observational network (Muller et al., 2013). On the other

side, adaptation and mitigation plans at urban level cover all spatial scales and often require high resolution information, and this can hardly be achieved with in situ observations alone. Fortunately, also in this case remote sensing is much helping in spatial resolution, but at least for space-borne sensors temporal resolution remains until now largely unsatisfying due to space platform availability and orbital characteristics.

Meteorological modelling is a viable method to overcome the scarcity of measurements in space and time: nevertheless, urban models are still in a development phase or at best in a pre-operational state because of physical complexity and site dependence and are mainly used for research or exploratory work.

Therefore, a suitable combination of sparse but high-quality in situ observations with highly resolved remote-sensed data is at the moment the only way to efficiently monitor at high resolution the thermal behavior of the urban environment. This can be done in different ways: for instance, by some interpolation technique or performing multivariate analysis. A difficulty that must be underlined here is the meaning of the temperature obtained: in other words, at which layer of the urban atmosphere the resulting temperature should be assigned. It is clear that a careful consideration must be paid to this question in designing the methodology as well as using the outputs: land surface and air temperature, even if in some way correlated, are quite different variables and it is the latter that is the most required for a large number of applications.

The result is anyway a spatial description of the thermal characteristics and behavior of a city at given times and at a resolution compatible with resolution and uncertainty of the input data. Time series of so obtained spatial fields, if long enough, provide a thermal urban climatology and eventually the possibility to investigate in details its variations with time: in particular, the effects on the local thermal field, at various day times and in different seasons, of specific modifications in land cover or land use (as new green installations or other nature based solutions) or of modifications in energy production/consumption (as new energy saving technologies, especially in air conditioning).

Consequently, those methodologies could represent an effective assessment tool for urban modifications of any type and in particular for past, present and future projects intended to decrease the thermal risk in the urban environment in consideration of actual global warming and climate forecasts in the next decades. Nevertheless, ex post assessment is poorly considered in most urban resilience plans and there is a need to produce clear evidence of possible tools for an observation-based evaluation of recent and future realizations.

In this work some preliminary results are presented and discussed for the thermal assessment of urban modifications at different scales in the city of Milan. The methodology adopted, developed in the framework of Project ClimaMi (Lavecchia et al., 2019; project web site in References) and easily exportable, is based on a cokriging technique. The cokriging interpolation (Montoli et al., 2021: submitted) is applied to:

- in situ air temperature measurements by a dedicated urban climatological network operated under metrological criteria and used as the primary variable, and by some other accurately selected stations,

- and to remote sensed land surface temperatures obtained by space-borne platforms with different spatial resolutions as the secondary one.

The result, depending on original remote sensed data, is a medium- to high-resolution (100 to 30 m) air temperature field for the metropolitan area and neighborhoods at satellite pass times for

(almost) cloud free weather situations. Furthermore, to each field an objective uncertainty estimation is also provided: figures obtained are not much larger than other uncertainty sources for field measurements and often quite low especially nearby surface stations, generally under 1°C. Covering by now almost a decade, the database set up by ClimaMi already represent a statistically relevant description of the recent urban climatology at an unprecedented resolution for air temperature and the related uncertainty.

Applications to some specific and well documented urban modification allowed to gain experience in assessment methodology: in particular for a new industrial site in SW outskirt of Milan, for greenery intervention in small scale Milan squares, as well as for assistance and guidance in new projects and development plans in smaller towns in Lombardy region. Interactions with urban planners and designers are mandatory for necessary and useful feedbacks: ClimaMi, as a typical interdisciplinary project, has been a suitable and fruitful framework.

Assessment results are discussed in terms of spatial resolution achievable, observational limitations, methodological aspect and user's requirements. Finally, conclusions are drawn for a progressive implementation of an effective climate service, helping public institutions and private enterprises to assess realizations and to correctly planning future projects and developments.

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Project ClimaMI, https://www.progettoclimami.it/home-eng

ORAL

A new reanalysis dataset to support pluvial flood analysis assessment in urban areas

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Keywords: Dynamical downscaling; climate reanalysis; ERA5 reanalysis; IDF curves; sub-daily extreme rainfall; disaster risk reduction; urban flooding

Urban areas are one of the most challenging environments to analyse in the general context of weather-induced risks (Vacondio et al., 2016). Significant challenges are represented on one hand by the typically high exposures in terms of people, buildings and infrastructures, which increase risk levels; on the other hand, by the modelling complexity provided by the built environment, deeply influencing both rainfall generation and the rainfall-runoff transformation. Such difficulties are even worsened when dealing with extreme meteorological events, and especially with extreme rainfall, due to the usual lack of past observations covering time windows large enough to provide statistically significant estimations, and with horizontal and temporal resolutions suitable for urban flood analysis. In this perspective, widespread gridded observational datasets, such as E-OBS, or reanalysis products, such as ERA5, cannot be used despite their large temporal and spatial coverage, since they can only be used to infer about extreme rainfall events with daily durations at minimum. Moreover, such datasets are characterized by horizontal resolutions of about 11 and 31 km respectively, too coarse to be suitable for local analyses such as those focusing on urban or sub-urban scales.

In order to bridge this gap (that is, to obtain reliable datasets representing current climate conditions, and also suitable for local extreme climate analyses) novel convection-permitting regional climate models (CP-RCMs, with horizontal resolutions finer than 4 km) are currently being developed within a number of European initiatives and research (Adinolfi et al., 2021; Raffa et al., 2021). CP-RCMs are characterized by an enhanced representation of features such as local/regional circulations, seasonal average precipitation, and especially hourly precipitation intensities, particularly useful to investigate short-duration precipitation extremes. As such, they represent a step change in the capability for understanding past climate and future climate change at local scales and for extreme weather events that most impact society (Kendon et al., 2021).

In this framework, ERA5@2km dynamically downscales ERA5 at the convection permitting scale of about 2.2 km to derive a high-resolution hourly precipitation dataset. The downscaling is performed with the Regional Climate Model (RCM) COSMO-CLM (CCLM) (Rockel et al., 2008), also activating the TERRA-URB module (Wouters et al., 2016) to account for the urban parameterizations. ERA5@2km is developed by the CMCC Foundation within the Copernicus Climate Change Service Contract C3S_430

(Sectoral Information System to Support Disaster Risk Reduction) and it is exploited to provide datasets and indicators for pluvial flood risk assessment over a pool of 20 European cities for the 30-years period 1989-2018 (https://climate.copernicus.eu/pluvial-flood-risk-assessment-urban-areas). As particularly concerns short-duration precipitation extremes, ERA5@2km is exploited in the Contract to provide Intensity-Duration-Frequency (IDF) curves, which is the standard tool used by managers, designers, practitioners and scientists to perform probabilistic assessments.

In the Contract, IDF curves are obtained by means of the storm index method (Viglione et al., 2007; Padulano et al., 2019). According to the storm index method, the rainfall depth of an extreme precipitation event x with return period T and rainfall duration d can be estimated (Eq. 1) as the product of a scale parameter (μ) only depending on duration d (i.e., deterministic part of Eq. 1), and a frequency parameter or "growth factor" (k_T) only depending on the return period T (i.e., probabilistic part of Eq. 1):

$$x(d,T) = \mu[x(d)] \cdot k_T(T) \qquad (1)$$

Eq. 1 is known to ensure rainfall consistency, as it preserves the increasing dependence of precipitation depth on both duration and return period. In practical applications, Eq. 1 is usually subject to a regionalization process whose aim is to identify homogeneous areas (usually related to significant hydrographic units such as watersheds) where the statistical behaviour of extreme rainfall can be considered the same, and relations are calibrated basing on pooled samples (Wallis et al., 2007). In this perspective, within a homogeneous region only one probability model is calibrated, whereas mean rainfall is considered spatially distributed (implying a dependence on elevation z as well as on duration d). The use of a pooled sample is the cornerstone of regional frequency analysis of extreme rainfall events, since including a larger number of extreme rainfall events increases the statistical significance and reliability of the assessments (Caporali et al., 2008; Madsen et al., 2017).

For each of the 20 considered urban areas, annual maxima for different durations in the range 1 – 24 hours can be extracted for all the ERA5@2km grid points of the simulated domain, and data can be pooled after ensuring their homogeneous behaviour by means of suitable statistical tests. Then, the deterministic dependence of the mean of annual maxima on duration and elevation can be quantified by means of the well-known Sherman formula (Chow et al., 1988), whereas the Generalized Extreme Value probability distribution can be applied to growth factors. Finally, for each urban area, quantiles for different durations corresponding to relevant return periods (i.e. 5, 10, 25, 50 and 100 years) are provided.

For each domain, results can be compared to existing observational and reanalysis datasets (in the Contract, E-OBS, ERA5, ERA5-Land and UERRA gridded datasets are used), and also validated with local official design IDF curves, which are directly provided by official extreme rainfall regionalization projects (such as the VAPI project for the Italian country) or derived by high-resolution gridded precipitation datasets (such as the CEH-GEAR dataset for UK, the RADKLIM-RW dataset for Germany, the GRIPHO dataset for Italy), as long as such additional data cover similar temporal windows, to ensure statistical consistency. Comparison with the above-mentioned datasets confirm the added value of the Very High-Resolution (VHR) dynamical downscaling reanalysis ERA5@2km in terms of localization and magnitude of precipitation events for urban areas, especially concerning extreme

atmospheric events. The significant enhancement in the representation of short-duration rainfall events justifies the considerable investment in time and computational resources required by such downscaling. In this perspective, ERA5@2km provides a reliable suite of extreme precipitation values for city analyses, overcoming the usual constraints of existing observational and reanalysis products in terms of temporal and spatial resolutions.

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ORAL

Connected urban green spaces for disaster risk reduction in the Metropolitan area of Milan

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Keywords: Nature-based solutions; green infrastructure network; connectivity; ecosystem services; flood risk

Urban environment is facing increasing challenges and risks related to extreme climate events, such as floods and heat waves. Green Infrastructures (GI) are considered viable options to face the increasing threats represented by drivers of environmental and climatic changes. They are strategically planned networks of natural and semi-natural areas designed and managed to deliver a wide range of ecosystem services. They act shaping living organisms and material flow across the landscape and way they are designed is crucial as it influences the potential benefits they provide. This is particularly true in the complex urban environment. Rethinking GI in following a network approach has shown to be effective in supporting ecological functions and increasing the connectivity between green features needed for the circulation of services across ecosystems and mitigate. Therefore, this study aims to identify the key green elements that can constitute the GI network in cities and to analyse existing and potential GI network configuration that can both improve ecosystem services provision and be more effective to address climate-related risks. Investigating the case study of the Metropolitan area of Milan (Italy), the assessment of the available green options is compared with the most exposed areas of the city to flood risks and to green spaces access availability. On this basis, the study proposes the development of potential configuration of a new GI network to improve green spaces connectivity while mitigating flood risk, and the assessing the potential effects. The results would support greener landscape management policy and practice to face climate and environmental challenges through a more integrated management and planning of green infrastructure. This would also help to develop a better understanding on the link between the alteration of ecosystem services provision to the changing landscape in order to support climate change adaptation and disaster risk reduction strategies, by providing simultaneous multiple benefits to the society.

ORAL

Updating the current field of ISA in TERRA_URB scheme within the COSMO(-CLM) model. Survey of the existing land cover datasets

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Keywords: Land cover; urban parameterization; regional climate modelling

Observation of land cover is essential for understanding and monitoring changes related to human activity both at the global and local scale. Governments and scientific communities use such information for a variety of purposes, such as coordinate action to mitigate and adapt to climate change, enhance forest management and monitor agricultural land availability (Tsendbazar et al., 2015). Land cover change impacts a variety of ecosystem services with significant consequences related, as for example, at the regional and global scales to loss of biodiversity, distresses in hydrological cycles, increase in soil erosion and, at the local level, to increased microclimate discomfort and water runoff. Several studies have recognized the interactions between land cover and environmental processes: many applications and models developed to analyse, vegetation changes and climate or hydrological dynamics are based on land cover dataset as one of the model inputs (Hibbard et al., 2010; Verburg et al., 2011).

A number of global land cover mapping activities exist: given the wide diversity of datasets characteristics (e.g. source of information, inventory techniques, classification scheme, sampling design, accuracy, etc.) is necessary to consider and assess the suitability of the data for the specific application (Verburg et al., 2011). In the context of regional climate modelling, one of the key challenges is to find the better representation of urban features, capturing the heterogeneity of the city's morphology. Recent research has shown that the urban canopy parameters values have a substantial effect on urban climate modelling, such as the building height, impervious/pervious fraction area, aspect ratio of street canyon and thermo-physical parameters (e.g. albedo, emissivity and heat capacity of urban materials), and their quantification is of great interest for climate community.

One of the aim of the COSMO-CLM Community (Climate Limited-area Modelling Community) is to improve urban climate simulations and weather forecasting for cities by implementing an urban surface parameterization in the COSMO model (COSMO, 2021). The gradual transition of the COSMO model system to the ICON modelling framework planned in the period 2020-2022 requires the transfer of the achievements of the COSMO Priority Task AEVUS and AEVUS2 (COSMO, 2017) with respect to the urban surface parameterisation TERRA_URB (urban-canopy land-surface scheme) and its external parameters (Wouters et al., 2017) from the COSMO atmospheric model to the ICON(-LAM) model (limited-area version of the global ICON model for numerical weather prediction applications). Further

advancements and applications are planned regarding the update of the external parameters (EXTPAR fields) and in particular of the impervious fraction (or impervious surface area - ISA).

ISA is defined as the impervious surface of urban areas including all the sealed areas (covered by materials such as asphalt, concrete, brick and stone) which water cannot infiltrate and are primarily associated with transportation (streets, highways, parking lots and sidewalks) and building rooftops, excluding the vegetation cover (e.g. gardens, parks). Several studies are involved in mapping and monitoring ISA at global and regional level.

The main goal of this study is to replace the ISA global field by investigating the availability of impervious cover classes within more recent land cover datasets. The study is part of a wider research aimed at updating the current EXTPAR fields in TERRA_URB scheme within the COSMO(-CLM) model. The workflow is structured around the following items: 1) survey of the existing datasets; 2) development of a complete dataset for climate modelling at urban scale; 3) implementation of dataset in EXTPAR.

The present study focuses on the first item: information from various existing land cover datasets at global and pan-European scale are analysed and their potential use in the context of climate modelling at local scale is assessed. Several global and pan-European datasets are considered in the study (such as GlobCover, ECOCLIMAP-SD, GLC2000, CORINE Land Cover, etc.). A desk review is conducted to compare the main characteristics of land cover datasets (e.g. spatial and temporal coverage, spatial and temporal resolution, sensors, classification schemes) and to identify the land cover classes that could better represent the ISA field. A comparison between 5 European cities is conducted to assess the ability of datasets in representing heterogeneous urban contexts.

For various reasons (e.g. production year, spatial and temporal resolution) it emerges that some datasets are better to represent the impervious coverage at local scale, which are selected to update the current ISA field. The selected datasets could be adopted as input data in numerical simulations carried out with COSMO(-CLM) model and TERRA-URB scheme and a further advancement of this study could be related to their implementation in simulations for the 5 European cities.

Acknowledgements

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ORAL

A smart monitoring to manage and safeguard the vegetation component of historic gardens from climate change: The EFFORT approach

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Keywords: Climate change; historic garden; plant monitoring; precision agriculture; monumental tree

An historic garden, identified by artistic and predominant plant components, provides, as any other green urban area, important services (e.g. recreational, water regulation, biodiversity, pollution removal) with additional values (e.g. monumental, aesthetic, historical, economic). However, the current state of conservation of the plant component of some historic gardens is often precarious, because historic gardens were created in a climate that is now historic itself. Specifically, in the recent decades, the natural senescence processes of the plant component have been accentuated by various types of biotic and abiotic stressors, often related to climatic extreme events associated with global warming (e.g. prolonged periods of drought, waterlogging and intense wind storms) mainly affecting old specimens. Such process is becoming a critical issue for those entities involved in the management and conservation of these heritages, often causing safety problems for humans and architectural artefacts. To support the conservation, restoration, and management of those places, ad hoc guidelines for managers to face environmental changes are thus needed. On this basis, a smart monitoring approach, developed within EFFORT project (co-funded by Tuscany Region and Cassa di Risparmio di Firenze, Italy), is hereby presented so as to combine innovative technologies to support the multidisciplinary segments of two historical gardens, namely: the Medicean gardens of Villa di Castello and Villa la Petraia, in Florence, Italy. The monitoring, started in March 2020, is applied both at garden and single plant level by using remote sensing (high resolution cameras, Sentinel2 images and LIDAR), image analysis techniques and ecophysiological sensors. Preliminary results, demonstrating to be effective in monitoring the vegetation and architectural segments of the garden at high spatial and temporal scale, will be used to establish guidelines and measures to drive gardens in a process of adaptation to the new climatic conditions. Finally, the

assessment of effectiveness of the smart monitoring approach will leverage the possibility of its replicability in any historic garden as well as the development of guidelines for garden managers to face environmental changes.

ORAL

Innovative methodologies to review and conduct climate risk assessments in urban contexts. Results and opportunities from the Milan case study

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Keywords: Resilience ; climate risk assessment; urban risks; climate change; floods; heatwaves; disaster risk; Copernicus

"The Battle for sustainability will be won or lost in cities", this is the main remark by Amina J. Mohammed, UN Deputy Secretary-General at the high-level General Assembly meeting on the New Urban Agenda and UN-Habitat (New York, September 2017). Now more relevant than ever, this simple statement highlights the need of clear, immediate action towards a more sustainable and resilient future designed and driven by local actors.

Cities are the hotspots where the effects of climate change are the most amplified and evident. The increase in population and the recent rapid urbanisation, often not adequately regulated and not informed by present and future risk scenarios, have inexorably exacerbated cities' intrinsic vulnerabilities. Urban disaster risk is constantly rising, costing a growing number of lives, and causing long-lasting economic impacts and social inequalities. On the other hand, cities demonstrate the ability to become excellent hubs to experiment policies that are more dynamic and innovative compared to the ones at national and regional levels . Innovative districts attract different and multi-sectorial actors with expertise in the urban-specific socioeconomic context, and who have the potential of triggering systemic, innovative and just resilience, by reducing disasters and fostering climate adaptation plans.

In this context, a preliminary requirement for the definition of effective disaster risk reduction and climate adaptation strategies is the implementation at local level of a comprehensive risk assessment in a climate perspective.

This work presents two new methodologies to review and conduct risk assessments and their application to the Municipality of Milan, which was chosen as a pilot case study.

The first methodology aims to carry out a comprehensive review of the risk assessment documents at municipality level, conducting the analysis across six key aspects: legislative and procedural

framework, risk identification, risk analysis, risk evaluation, communication of risk and risk assessment capacities. The approach is based on a broader analytical assessment framework, designed in the context of the EU-funded programme Peer Review Programme of disaster risk management and civil protection system 2020-2022 . This framework was developed as an operational method to conduct a review of the whole disaster risk management system at national level. A specific section of this framework concerning risk assessment was adapted to shift from a traditional to a more climate-centred approach, which considers the evaluation of future risk scenarios defined on the basis of recent climate projections. The framework was also tailored on the needs of the local scale. The scope is to investigate the local cross-sectoral processes of identifying, analysing and evaluating the risk of the most relevant climate-related hazards insisting on the municipal territory, as well as to identify if and how this process is mainstreamed in existing disaster risk reduction and climate adaptation strategies and plans. Inspired by the UNDRR Making Cities Resilient approach, and specifically by the Disaster resilience scorecard for cities tool, a specific scoring methodology was developed. This common metric ensures comparability of reviews across cities and allows to easily identify trends of improvements over time within the same urban context.

The second methodology deals with a new approach to conduct risk assessments at local level that improves understanding of the financial and economic risks posed by flood hazard in urban contexts. The cutting-edge assessment framework exploits the fragmented records of past floods' losses, complementing these with high resolution exposure and impact data and state-of-the art hazard, loss and recovery modelling. The results are then used to generate a shock to the local, regional or national economy. This new approach includes the macro-economic point of view in the risk assessment, using the Computational general equilibrium model (CGE) at sub-national scale. Beside this, the application of flood hazard modelling and Copernicus Earth Observation data for vulnerability and risk assessment represents an advancement in climate risk assessments, propelled by high performance computing, new generation of climate and disaster loss models, and high-resolution exposure datasets.

The Municipality of Milan was considered a pilot trial for both methodologies, providing positive and useful results on their applicability and effectiveness. The success of both approaches suggests the possibility of their application and expansion to other urban contexts to improve the assessment of current and future climate risk.

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ORAL

Italian city efficiency under climate variability: An empirical analysis

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Keywords: Smart and resilient city; climate variability; Italian cities efficiency

In the next future, climate change (CC) effects will represent a challenge for Europe and especially for European cities. Making cities more livable, resilient, and more efficient has become the most important and no-longer postpoable objective for policymakers. Cities are the world's engines for economic growth, generating more than 80 percent of global GDP and representing centers of economic development, technological innovation, and culture and creativity (Un-Habitat, 2016). This new century is becoming the century of cities as rapid urbanization occurred. The United Nations (2018) describes like 55% of the world's population is currently residing in urban areas with an expectation of rising to around 68% in 2050. Europe presents urbanization rates relatively high, as around 72% of the European population lives in medium-sized cities, closer to each other, and creating a dense network of urban areas (European Commission, 2016). In Italy, about 56% of the population lives in functional urban areas, representing an integrated urban territory where the city is the fulcrum of the economic activities of the area (Istat, 2020).

Urbanization, however, brings some ambivalent and contradictory effects such as traffic congestion, overcrowding, unemployment, corruption, lack of infrastructure, institutional weakness, and environmental negative effects. These environmental pressures caused by cities may be due to the exploitation of natural resources such as water, food, and energy supplies that are relevant necessities to increase the wellbeing of the citizens. CC and its negative effects may only intensify the city's environmental pressures. Thus, the increasing vulnerability to CC events may raise the risk for a city to maintain itself along a sustainable development path. The transformation of cities into smart, resilient, and sustainable cities has emerged as the main urban strategy to pursue (Auci and Mundula, 2017). As Hunt and Watkiss (2010) underlined, CC has several direct impacts on energy usage, health system, sea-level, and water and resource availability in cities. Moreover, extreme weather events may affect built infrastructures as well as transport and sewage systems. Cultural heritage and tourism are also directly impacted at the city level. According to Auci and Mundula (2017), a smart city may be compared to a firm production system. The idea comes from considering a city as a living organism that needs and uses several resources such as natural resources, physical and human capital, labour, energy, and soil to reach a desirable level of urban well-being for its own citizens. A city should promote goods and services production for increasing citizens' wellbeing, attract good business projects and endorsing social and relational capital within an urban area. Human capital and

technology represent the main resources of a smart city, aiming to stimulate collaborations among individuals and favor creation, hybridization, and the spread of knowledge and technology from the world of scientific research. A smart city is not only related to the ability of a city of saving energy but also includes the efficient use of all the available resources. This assumption is closer to the efficiency of a firm when has to maximize its profit based on a specific production function. Similar to a firm, a city may be defined as smart when it uses in an efficient way its own resources. In a firm, resources or inputs are combined through a production function for obtaining that level of output that allows gaining the maximum level of profit. This analysis, based on profit-maximizing assumption, implies that a firm's behavior is always efficient. City resources are combined by the public governance to improve citizens' urban well-being. According to the well-being-maximizing assumption, a city may reach an efficient behaviour for obtaining a fair and sustainable output for all citizens.

In the literature, urban efficiency is closely related to the so-called "optimal city size" (Alonso, 1971 and Richardson, 1979). However, some criticisms arose against this theory, because cities may be heterogeneous and thus may perform different functions, be characterized by different specializations, and use different resources. As for firms, which cannot obtain the same output or income even if they can be identical in terms of inputs used, two cities cannot reach the same level of efficiency even if they present an identical level of resources. Similar to firms, cities are born for satisfying human needs. These necessities and objects are strictly associated with three main groups of individuals who live in a city and represent the main city resources: families, firms, and public institutions. Needs and objects of these three typologies of individuals can be considered as inputs of a city production function. The governance of institutions allows inputs to be combined efficiently to obtain an optimal level of well-being for all the citizens. Considering a city like a unique entity that maximizes its final object, i.e. citizens' well-being, allows a city production function to be described as land, physical, natural and human capital beyond labour inputs.

Using the stochastic frontier approach (SFA), this work aims to analyze the impacts of climate variability on the Italian cities' performance in a period spanning from 2010-2019. Considering some meteo-climatic variables as proxies for climate variability pressure, we estimate simultaneously the city's optimal production function and the cities' technical efficiency after having controlled for different factors determining cities' wellbeing.

A balanced panel dataset drawn by Istat Surveys Databases is used. For socio-economic variables, the National Accounts, System of European Accounts - SEC 2010 revised in 2019 and Istat Survey on Labour Force is used. The meteo-climatic variables are drawn from the Istat Survey on Meteo-climatic and Hydrological Data started in 2017. This annual survey collects daily data on temperature and precipitation by meteorological stations managed by Public Institutions and Research bodies for 109 cities. Finally, as regards the environmental variables, we collect data from Istat Survey on Environmental Data in the Cities, started in 2000. This annual survey collects data on 8 thematic areas of which we consider water, urban green and urban mobility for 109 Italian provincial capital municipalities.

By assuming that the production function takes the log-linear homogeneous Cobb-Douglas, the Battese and Coelli (1995) specification of the stochastic frontier production model (SFA) is applied.
As dependent variable, we consider the city value added at current prices, while as independent variables, we include labour, physical (circulating vehicle density within a city), and human capital

beyond to natural capital such as green area density and water dummy of the supply rationing measures for domestic uses. The inefficieny function includes as determinants the deviation of annual mean temperature (°C) from the Clino 1971-2000 value and the deviation of annual total precipitation (mm) from the Clino 1971-2000 value.
Results indicate that the production function performs relatively well even if not all the input factors coefficients of the production function show a positive sign. Labour force and circulating vehicle density have a positive and significant coefficient as expected. Human capital, urban green, water show negative coefficients. Human capital with only the secondary level of education, green area density, and water restrictions seems not being enhancing inputs for cities' value added. An explanation of this result may be relateted to the exclusion of green aspects from the GDP calculation. Concerning education level and green aspects, a deeper analysis is needed. As regards the inefficiency model, the climatic determinants show a different relevance. While rainfall deviation is not signficant temperature deviation is significant with a positive sign as expected, suggesting that higher temperature increases inefficiency with negative effect on city value added and perfomance.
Our findings, thus, confirm that temperature have a direct and significant effect on technical efficiency and an indirect effect on the city's performance. Moreover, our results indicate that cities sited in the North-east and Centre macro-areas of Italy seem the best performance cities in terms of technical efficiency, suggesting that these cities are more resilient to climate variability.

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ORAL

Temperature and energy price's impact on mortality in European cities

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Keywords: Temperature; energy price; mortality; climate policy

The objective of this study is to analyze the role of residential energy prices in the temperature-mortality relationship in European cities. The detrimental effect of extreme temperatures on excess mortality is well recognized in the literature (Analitis et al., 2008; Deschênes, 2012; Gasparrini et al., 2015). Studies focusing both on United States and Europe show that, although mortality risk associated to extreme temperature exposure has been declining in the last decades, it remains significant as temperatures continue to increase because of climate change (Davis et al., 2003; De Donato et al., 2015; Barreca et al., 2016). Strong mitigation actions as well as the ability to adapt to temperature extremes represent crucial aspects in the climate change-human health relationship. However, tradeoffs may emerge as emission reduction policies, aimed at slowing down long-term temperature rise, may lead to an increase in energy prices and, consequently, in the marginal costs of adaptation. Households that spend higher portion of their income on energy bills, both for keeping their home warm in winter or cool it during the summer, may, indeed, have a reduced capacity to adapt to temperature variations due to climate changes (De Cian et al., 2019). Despite being connected, the two drivers (temperature and prices) have mainly been analyzed separately. Novel studies started to investigate empirically the direct impact of energy prices on temperature-related mortality and they find that changes in gas or electricity prices play a role in exacerbating or mediating excess mortality especially for vulnerable households (Chirakijja et al. 2019, Neidell et al. 2019).We aim at contributing to understand the extent of the issue in the European area. For this purpose, we match climate data, natural gas and electricity prices and mortality information for 280 European urban areas between 1990 and 2017. Our sample covers about 308 million citizens representing 60% of total European population. We use a panel regression model with year and city fixed effect. We build on previous literature (Deschênes and Greenstone 2011, Barreca et al. 2016) to construct annual bins to approximate the distribution of daily temperatures and model the estimate mortality response. We extend this approach adding the interaction between extreme temperature bins and energy prices. We then use the results of the empirical analysis to simulate the future combined impacts of temperatures and energy prices on mortality rate under different climate policy scenarios. Our results show a significant effect on mortality for every additional day with temperatures below -4°C (24°F) in winter and above 26°C (78°F) in summer. Moreover, the energy prices played a role in the temperature-mortality relation. The interaction between extreme cold temperatures and both natural gas and electricity prices have positive sign and statistically significant effect. Simulations at 2040

show that the benefits in terms of reduced mortality of emission mitigation policy may be reversed by the energy price effect. Considering the interaction of temperature and energy prices, the aggregate annual mortality rate of European cities under a RCP4.5 scenario would be 1% higher compared to a scenario with limited mitigation policy. Greater potential tradeoffs emerge for more ambitious climate policies, such as those in line with 2°C. Our study offers important insights on the potential interaction between climate change impacts, mitigation policies and autonomous adaptation strategies. Our findings stress the importance of climate and social policy design aimed at addressing public health impacts arising from both changes in temperature and energy prices.

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POSTER

Global perceptions and priorities in urban stormwater adaptation management

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Keywords: Urban adaptation; rainfall management; stormwater; multi-criteria decision analysis

Cities must adapt to increasing heavy rainfall events caused by climate change. As increasing precipitation intensities overwhelm urban infrastructure, localized flooding results in economic, social and political losses. Currently, there are no global standards, frameworks or best practice management guidance when approaching urban rainfall adaptation policy. Such standards would allow those cities with limited time, financial resources and research capacities to make more confident adaptation policy decisions based in a determined and globally agreed theoretical basis. Using stakeholder perceptions in six global and developed cities, we explore to what extent a standardized hierarchy of urban-rainfall adaptation techniques can be established through a Multi-Criteria Decision Analysis combination of the AHP and TOPSIS methodologies. While regional and stakeholder differences emerge, our study demonstrates that some international consensus exists on best practice management techniques for urban stormwater adaptation.

POSTER

Spatio-temporal machine learning models to enhance pluvial flood risk assessment and community resilience to climate change

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Keywords: Pluvial flood risk; machine learning; spatio-temporal cross-validation; spatial overfitting; triggering factors; forward feature selection; Metropolitan city of Venice.

Extreme weather events (e.g., heavy rainfall) are natural hazards that pose increasing threats to many sectors and across sub-regions worldwide (IPCC, 2014). Heavy rainfall phenomena can overwhelm drainage systems causing flooding events, hence exposing people and assets to damaging effects. Developing climate and adaptation services is therefore essential to transfer and communicate scientific knowledge about climate related risks to local decision- makers. In order to predict pluvial flood risks under different spatio-temporal conditions, three generalized Machine Learning (ML) models are developed and applied to the Metropolitan City of Venice: Logistic Regression (LR), Neural Networks (NN) and Random Forest (RF). The models consider 60 historical pluvial flood events, occurred in the timeframe 1995-2020. The historical events helped to identify and prioritize sub-areas that are more likely to be affected by pluvial flood risk due to heavy precipitation. In addition, while developing the model, 13 triggering factors have been selected and assessed: aspect, curvature, distance to river, distance to road, distance to sea, elevation, land use, NDVI, permeability, precipitation, slope, soil and texture. The models are validated with two different approaches: Random Cross-Validation (R-CV) and Leave Location and Time Out cross-validation (LLTO-CV), that splits data considering both time and location. In addition, a forward features selection method was applied to understand which features better face spatio-temporal overfitting in pluvial flood prediction based on AUC score. Results of the analysis showed that the most accurate models were obtained with the LLTO-CV approach (AUCLR = 0.8596, AUCNN = 0.8426, AUCRF = 0.8436), while R-CV overfitted data in the validation set, bringing about lower performances in the test set (AUCLR = 0.8545, AUCNN = 0.8370, AUCRF = 0.7216). Therefore, Logistic Regression resulted the lesser overfitted model to predict a new spatio-temporal pluvial flood event. In conclusion, the most important triggering factors affecting pluvial flood were the daily precipitation, the distance to river and the distance to road.

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5 Climate related impacts, risks and adaptation options

ORAL

Pre-processing and analysis of treetalker's data: An example from Chestnut Forest

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Keywords: Chestnut; internet of things; treetalker; data quality assurance

Increasingly, severe and frequent extreme events are expected to become a major risk for forest ecosystems under predicted climate change which will result in changes in the forest structure. As a consequence, forest management has to adapt to novel climate conditions to allow both mitigation and adaptation to climate change and to ensure the supply of ecosystem services, including the provision of wood and food products as in the case of chestnut forests.

To ensure the continuous supply of services from forest ecosystems, real time monitoring of forest health is of utmost importance and it is also mandatory to develop early warning system so that under different climate change scenarios we can predict the future of forest ecosystem. Recently Internet of Things technologies (IoT) have grown rapidly and represent today a unique opportunity for improving our environmental monitoring capabilities at extremely low cost. For this purpose, a single device (TreeTalker) is developed which can monitor: the water transport inside the tree; the diameter growth; the quantity and quality of tree foliage and climatic parameters (temperature, humidity). Each equipped tree with TreeTalker can transmit high frequency data on the web cloud with a unique IoT identifier allowing to follow the individual tree life along its development from hours to season and inter-annual time scale.

First step of handling 'Big Data' coming from all TreeTalkers is its quality assurance, transformation and basic analysis to produce some meaningful results. Pre-processing and analysis of a one-year series of TreeTalker's data placed on 48 chestnut trees in 4 plots in an Apennine forest in northern Italy (Val Reno, Bologna) show preliminary results on the effects of different pruning treatments on the water transport, potential productivity (net primary production – NPP) and quality of tree foliage.

ORAL

Cumulative Impacts Assessment (CIA) on marine and coastal ecosystems: Key outputs from the scientometric and systematic reviews

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Keywords: Cumulative impact assessment; marine and coastal ecosystems; machine learning; complex inter-relations; ecosystem services

Cumulative impacts increasingly threaten marine and coastal ecosystems. The growing interplay between climate change hazards and human-induced pressures from land-based and maritime activities are exacerbating environmental risks, resulting in severe water quality degradation, biodiversity loss and decline in the provisioning of ecosystem services for human well-being. To address these issues, the research community has started designing and testing different methodological approaches and tools that apply cumulative impact appraisal schemes for a sound evaluation of the complex interactions and dynamics among multiple pressures affecting marine and coastal ecosystems.

Through an iterative scientometric and systematic review, this study provides a state of the art of these methods, giving a specific emphasis to the identification of cutting-edge approaches exploring

and modelling inter-relations among climatic and anthropogenic pressures, vulnerability and resilience of marine coastal ecosystems to these pressures, and the resulting changes in the ecosystem services flow. Despite recent advances in computer sciences and the rising availability of big data for environmental monitoring and management, this review revealed a limited implementation of advanced complex system methods for cumulative risk assessment. Moreover, only recently experts have started integrating ecosystem services flow into cumulative impact appraisal frameworks, as generally assessments endpoint within the overall evaluation process (changes in the bundle of ES against cumulative impacts).

The present two-tiered review also highlighted a lack of integrated approaches and complex tools able to frame, explain, and model spatio-temporal dynamics of marine coastal ecosystems' response to multiple pressures, as required under relevant EU legislation (e.g., Water Framework and Marine Strategy Framework Directives). Progress in understanding cumulative impacts, exploiting the functionalities of more sophisticated machine learning-based approaches (e.g., big data integration), will support decision-makers in the achievement of environmental and sustainability targets.

ORAL

Classifying banks from an environmental perspective

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Keywords: Banks; climate risk; internal controls; financial climate adaptation

Climate risks refer to the set of potential risks that can derive from climate change and that could have a potential impact on the safety and soundness of individual financial institutions and have wider implications on the financial stability of the entire banking system (Basel Committee on Banking Supervision, 2020). Climate change poses a threat to the security and soundness of financial companies mainly through two ways: physical risks and transition risks. Physical risks concern extreme weather events, with an increasing frequency of occurrence and severity, and long-term climate changes, which cause physical damage to the value of financial assets and guarantees held by banks. The transition risks, on the other hand, concern the process of adapting to an economy with a low-carbon regime. They can also lead to significant changes in asset value and increased operating costs. These risks are increasingly being considered throughout the financial system (Kamdem-Fotso, Ngouadje and Ermeneux, 2020). While it is not accurate to attribute individual extreme weather events to climate change, it is fair to say that climate change leads to an increased frequency of such events. Therefore, it is important to focus the efforts of both policy makers and academic research on understanding how financial institutions are exposed to climate risks and how they can respond to

them. Therefore, ensuring that financial institutions regularly assess their exposure to climate-related risks is an increasingly important part of the process in general (Bassetti, 2019). The Financial Stability Board (FSB) has carried out a study on how physical and transitional risks from climate change can not only affect financial stability, but also the potential for interaction between the latter. It examined how climate-related risks could be transmitted and amplified by the financial system, including through its interaction with the real economy and the degree of cross-border transmission including through financial institution exposures. It also studied how the action of market operators and regulatory authorities could contribute to the mitigation of these risks to ensure financial stability (FCB, 2020).) Among the main steps taken in this direction, the following should be noted in particular: the establishment of the Task Force on Climate-related Financial Disclosure (TCFD) by the FSB in 2015, the establishment of the Green Finance Study Group (GFSG) within the framework of the G20 and the establishment of the High Level Expert Group (HLEG) on sustainable finance by the European Commission in 2016. The HLEG report formed the basis for the plan action of the European Commission on Sustainable Financial Growth and the consequent package of measures for the implementation of several key actions announced in the aforementioned action plan, including, of particular importance, the definition of a common taxonomy of sustainable investments.

The European Central Bank (ECB) have now inaugurated a new phase under the banner of the growing centrality of issues related to climate change and its risks on the financial business (ECB, 2020). The ECB has published its latest updated guide on environmental and climate risks. The guide explains how the ECB expects banks to manage and transparently manage these risks under current prudential rules. In fact, banks must begin to understand how to take climate risk into account already in the credit granting phase.

Existing studies on climate risk has brought various results in terms of studies and research carried out in this regard. Roncoroni et al. (2020) proposed a new methodology, based on the creation of an operational framework, to analytically understand the interaction between climate policy shocks and market conditions. This methodology was applied to a real case, namely the Mexican financial system, to get an idea, from a numerical point of view, of the impact on the country's economy and to understand any political implications more generally. Capasso et al. (2020) instead assessed how much the exposure of companies to climate risks, measured in terms of level and intensity of CO_2 emissions, can be associated with Merton's distance to default, a measure for creditworthiness widely used by agencies and investors. Monasterolo (2020) addresses the topic of climate-related financial risks by discussing the progress achieved in research: conceptual and methodological innovations for the assessment of risks relating to the investor portfolio; then introduces a science-based approach (CLIMAFIN tool) for the quantitative assessment of investors' exposure to future climate risks, giving a value to this risk, in terms of price, to be included in the financial portfolio. Instead, through the study and analysis of the regulations and supervisory practices currently present in governance, regarding the management of risk associated with climate change in the financial sector, Feridun & Güngör (2020) try to provide, with their work, information and any guidelines for banks, banking regulatory authorities and jurisdictions, to support the identification of actions and activities necessary for the management of climate change in their sector. Park & Kim (2020) carried out an analysis of the differences between the approaches and tools adopted, to manage climate risk, by developed countries and those of still developing countries, in particular the actions of " green banking

"both collective and individual carried out by international commercial banks, which were analysed in terms of performance achieved and areas for improvement to be explored.
None of the existing studies detects, directly from the operators, the management choices in terms of climate risks in the Italian sector.

The present work intends to fill this gap in existing studies. To this end, our survey develops an analysis of the current behaviour of Italian banks aimed at managing climate risk through internal strategic and organizational processes.

The methodology used for the analysis is based on a mixed approach. A first level of analysis considers the responses to the survey carried out within the Italian Association of Financial Industry Risk Managers (AIFIRM) and addressed to the Italian banking system with the aim of assessing the positioning of intermediaries in terms of climate change, highlighting their challenges and expectations. . The second level of analysis is based on the construction of clusters of distinct banks on the basis of the best behaviours adopted in managing climate risk.

In particular, we consider a set of $N \in \mathbb{N}$ banks and a set of $Q \in \mathbb{N}$ questions. We aim at analyzing the similarities between these banks from two standpoints:

1. *given any two banks i,j = 1, . . . , N, we wish to measure some kind of distance dij between bank i and bank j according to how different their answers are;*
2. *we wish to cluster these banks according to their answers.*

The results of the analysis offer an interesting picture on how to manage climate risk in the financial sector, identifying any gaps or organizational delays together with possible best practices. The implications of the analysis have relevance for regulators, financial intermediaries and their stakeholders.

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ORAL

Non-linear interactions between climate change and host processes drive the future of a helminth-herbivore system

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Keywords: Climate change; gastrointestinal helminths; long-term projections; host-parasite interactions

Climate change is one of the greatest challenges that humanity has to face, from impacting ecosystem functioning to affecting the survival and health of different forms of life on the planet. As we are learning from the SARS-CoV-2 pandemic, the relevance of infectious diseases as a global issue urges for a deeper understanding of their complex dynamics. The role of climate as driver of infectious diseases, and the climate change impacts on the emergence, distribution and severity of disease outbreaks are well known. Therefore, the understanding of how climate change alters the spatial and temporal dynamics of infections is fundamental to properly plan adaptation policies and mitigation strategies to reduce the climatic threat.

Soil-transmitted parasites infect 1/3 of the world human population and climate is expected to alter the abundance and viability of free-living stages in the environment and, consequently, the intensity of infection in the host. Within-host processes, such as a strong immune response, can mitigate these climatic effects by controlling the intensity of infection; however, if the host carries more than one parasite species, the immune response might not be as effective as the response of hosts with a single parasite infection. Here, we use a modeling approach based on parasite abundance observations and climatic scenarios to investigate how climate changes affect the dynamics of soil-transmitted helminths in hosts with single and dual infections.

As study case, we select two common gastrointestinal helminths of the European rabbits (Oryctolagus cuniculus), with contrasting immune responses: Graphidium strigosum, which shows no clear evidence of immune control, and Trichostrongylus retortaeformis, which is more clearly controlled.

We develop an immune-epidemiological model that explicitly considers the effect of climate and immune variables on the dynamics of infection in rabbits with one or both helminths; the model is calibrated and validated against time series of parasite infection from populations of rabbits in the UK. Across the UK, we find a contrasting seasonal infection and spatial distribution between the two helminths: G. strigosum intensity is higher in the humid west-central Scotland in winter, while T. retortaeformis intensity is higher in the warmer south-east England in late spring. Moreover, our

findings also indicate that by carrying a higher parasite burden and by shedding a greater number of eggs on the pasture, dual infected hosts contribute more heavily to the dynamics of infection of both helminths than single infected rabbits.

Future projections of temperature and humidity indicate a faster egg hatching and larval developmental rate, together with a lower mortality of the free living stages for both helminths due to more favorable future climatic conditions. These changes are predicted to impact the intensity of infection of the two helminths in a different way. Model simulations indicate that G. strigosum intensity will increase in rabbit populations as this helminth is not clearly controlled in the host, while the immune response will control T. retortaeformis intensity and no significant long-term changes in the burden of infection are expected in the future. Between single and co-infected hosts, changes are predicted for G. strigosum intensity of infection but not T. retortaeformis.

A further evaluation on whether these general trends are representative for the rest of Europe indicate that both helminths will experience an increase in larval mortality in the southern Europe.
Our study disentangles the combined effects of parasite-climatic responses and within-host regulation mechanisms in single and co-infection with gastrointestinal helminths in an herbivore system. This work provides novel insights to foresee climate change impacts on the dynamics of infection of two parasites, with contrasting reactions to the host immune response. We stress the importance to address the role of climate change on co-infections and the consequences for infection outbreaks and disease spread. Our study offers fundamental knowledge that can be used to advise intervention and control strategies in areas where helminthiases are endemic and commonly co-infect host populations.

ORAL

Impacts of climate change on pheno-physiological variables simulated with IVINE crop model in northern Italy vineyards

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Keywords: crop modelling; IVINE; northern Italy; GLDAS; vineyards; phenology; physiology; climatology

Grapevine productivity and quality strongly depend on meteorological and climatic factors. Thus, there are several studies in which the effects of different environmental conditions on vineyard's yield and organoleptic features were studied. Usually, temperature, solar radiation and precipitation are considered the fundamental meteorological variables that influence the grapevine phenological development and ripening. Several studies highlighted the impact of long-term warming over Europe for the 21st century: the predicted effects is a shortening of the growth season, with maturation already occurring during the hottest period of season. It is possible that new varieties, currently growing under certain climatic conditions, could be cultivated over new regions. Moreover winemakers may be induced to replace traditional varieties with later ripenig varieties in the attempt of adapting to the warmer conditions. In this context, crop models become an essential tools for investigating the effects of climate change on crop development and growth. In fact, such models could evaluate the interactions between plant, environment and management strategies, thus providing an instrument to understand the complex plant processes as influenced by pedo-climatic and management conditions. Usually meteorological conditions are the typical input data driving the crop models. Among the models, the IVINE (Italian Vineyard Integrated Numerical model for Estimating physiological values) was developed to simulate grapevine phenological and physiological processes and it was originally calibrated only for the cv. Nebbiolo in Piedmont Italian region (Andreoli et al. 2019). The IVINE requires in input a set of meteorological data (air temperature, air relative humidity, solar global radiation, photosynthetically active radiation, soil temperature, soil water content, wind speed and direction, rainfall) as boundary conditions, as well as information about the vineyard and the cultivar (geographic coordinates, soil hydrology, variety characteristics and vineyard management) as initial conditions. IVINE operates on a daily time step and simulates the evolution of main agronomic variables through their respective daily accumulation. The main model outputs are: the timing of the most relevant phenological stages, and the following physiological quantities: leaf development, yield, berry sugar concentration, and predawn leaf water potential.

In this work, we tried to simulate a long period, starting from 1948 and ending to 2014, using a set of data extracted from the worldwide climatological database GLDAS (Global Land Data Assimilation System; Rui and Beaudoing, 2018) over a region including Northern Italy. GLDAS data are available every three hours on grid points whose average distance is approximately 15 km. In a previous study

(Andreoli et al. 2019), we have considered three of such grid points in the Piedmontese wine region and we have concluded that the data were sufficiently representative of the mean landscape, when we remain far from the mountains, even if – of course – it is impossible to reconstruct the local variations over a single hill. The other data not available from GLDAS were derived from the simulation of the Land Surface model UTOPIA (University of Torino Model of Land Process Interaction with Atmosphere; Cassardo, 2015), initialized with GLDAS. In this conference we will present here the main results of the simulations carried out with IVINE on the grid points suitable for the cultivation of wine, reconstructing the climatology of the above mentioned pheno-physiological variables.

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ORAL

Subjective or objective climate change risk assessment for local adaptation plans: towards a materiality approach. A case study

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Keywords: Adaptation; perception; risk assessment; local; sustainable development; SDG

Risk assessment is a dominant task for adaptation planning at different spatial levels. Different interpretations historically survive for the concepts of risk and vulnerability assessment in the climate change and disaster risk reduction research communities. However, both vulnerability and risk assessments refer to a formal approach based on objective measures through the use of indicators and data-based metrics. Nevertheless, there are some non-negligible subjective elements in risk assessment (Slovic, 2016). In fact, another key element in risk assessment is the perception of risk, which also allows estimating the levels of propensity to act of the population (Brewer et al., 2004). For example, the inhabitants of a city affected by climate hazards (high temperatures, extreme rainfall, etc.) and related impacts (heat waves, landslides, flooding, etc.) are likely to show a higher perception

of the risk, and therefore to be more sensitive and willing to implement pro-environmental and resilient actions.

Vulnerability *and risk assessment find a special emphasis in the Guidelines for PAESC in Europe (Bertoldi, 2018), suitable to be applied to the municipal level, which also suggest setting up indicator-based monitoring systems on the effectiveness of the responses envisaged in the resulting action plans. Based on the recognition of municipalities as human and social systems where participatory procedures regularly take place to involve citizens and stakeholders in local decision-making, and on the studies concerning climate change risk perception and propensity to pro-environmental and resilient behaviors (Maiella et al., 2020), we developed a subjective assessment of both risk and propensity to adaptation behaviors, based on a questionnaire administered to experts and the general public in a medium-sized Italian city. In particular, two surveys were used. A questionnaire for citizens consisting of three main measures coherent with the factors adopted for objective risk and vulnerability assessment: the perception and assessment of the hazards observed; perception and identification of the exposed areas of the territory; perception and self-assessment to carry out pro-environmental and adaptive behaviors (in line with the theory of Planned Behavior; Masud et al., 2016). A questionnaire for experts aimed at evaluating a more technical perception on the impacts of climate change and vulnerable sectors of the territory and used as an adjustment measure for the reliability of the perceptions of the population.*

Materiality is the outcome of a relational analysis between a scientifically measured impact and the perception of the same impact by stakeholder groups considered relevant for the purpose of the analysis where the materiality assessment is made. We used the concept of "materiality" (AICPA, 2012; Eilifsen & Messier, 2015) to identify a more comprehensive measure for risk assessment, based on the combination of objective and subjective risk indicators that can be adopted for ranking, prioritizing and improving the efficacy of policy actions framed to address the risks under investigation.

Additionally, in line with the notion of climate compatible development (Wood et al., 2017), we propose a composite DSS to assess the suitability of proposed policy measures against an indicator-based function for local wellbeing constructed on the dimensions of risk, sustainable development, and governance, and including decision-makers preferences on possible trade-offs among the considered dimensions.

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ORAL

Exploring socio-natural factors of farmers' adaptation: A review on risk awareness and perception towards climate change

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Keywords: Risk; climate change; farmers; impacts; awareness; perception, behaviour

Risk awareness and perception have been linked to different types of behavioural models based on beliefs and concerns about the environment that influence how individuals respond to impacts of climate change (Schlüter et al. 2017). Some authors understand awareness as of the first step before developing any resilience-building process but also as a requirement that must be met during the resilience development process because it drives transformation (Abegaz & Wims 2015, Iturriza et al. 2020). Likewise, risk perception is how individuals receive information or stimuli from their environment, transform it into psychological awareness, and (re)act accordingly (Azocar et al. 2021). Perception varies with the individual's past experiences and the present sets or attitudes act through values, needs, memories, moods, social circumstances, and expectations (Hasan & Kumar 2020). Knowledge, interest, culture, and many other social processes shape the behaviour of an individual or social group who use the information and tries to influence that particular situation or phenomenon (Akhtar et al. 2019).

Farmers' awareness and perception towards climate change reflect their judgments and may affect their adaptation and mitigation behaviour (Hou et al. 2015). Sulewski & Kłoczko-Gajewska (2014) argued that if farmers are not aware of climate change risks, they will not respond to them. Li et al. (2017) applied path analysis to deepen on causality and inter-relationships between climate variability and farmers' beliefs, awareness, and adaptation capacity. The obtained results highlighted two main issues. Firstly, the belief in individual vulnerability was found not to directly influence adaptation

behaviour. Secondly, belief in climate change risks was heightened by the awareness of more observable climate change phenomena (e.g. extreme weather events and water shortage) but it was not a direct cause of adaptation behaviour. However, as some authors suggested, 'seeing is not believing', and even after acknowledging their experience with climatic extremes, many farmers continue to be resistant to the idea of the need to mitigate agricultural contributions to climate change (Houser et al. 2019).

In this work, a review of the literature examining farmer awareness and perception towards climate change is reported to identify the main statements and driving factors affecting farmers' awareness and perception. For example, asking about the statement 'climate change is occurring or had occurred', between 50-90% of farmers agreement was obtained, including experiences in which awareness is significant or total (75-100%) (Hundera et al. 2019, Mutandwa et al. 2019, Zhang et al. 2020). Most of the studies also reveal how climate change awareness is mainly based on some observed changes in weather patterns, such as the change in temperature and rainfall patterns with about an 80-98% of agreement (Ado et al. 2019, Voss 2021). Likewise, more than 90% of the farmers thought climate change impacts crop production, with 59% of the respondents asserting that the impact is quite obvious (Guo et al. 2021). Moreover, close to 60-76% of the farmers were aware of climate change because the weather is becoming unpredictable (Chhogyel et al. 2020). According to Le Dang et al. (2014), when farmers believe that higher risks of climate change are threatening their physical health, finance, production, social relationships and psychology, they are more likely to have an intention to adapt to climate change. Furthermore, adaptation intention also increases when farmers perceive greater effectiveness of adaptive measures in general and more agency to conduct adaptive measures in particular. On the contrary, some studies, such as Azadi et al. (2019), concluded how farmers' beliefs and awareness of climate change had no effects on their adaptation behaviours and risk perception. These authors argued that farmers' adaptation behaviours might occur without engaging their belief systems about climate causality. Otherwise, the results obtained by De Matos Carlos et al. (2020) demonstrated that there is no direct relation between awareness and perception about the harmful effects of climate change and adaptation; perception only affects adaptation when mediated by belief in the adverse effects of climate change (this result is called by the literature of 'indirect effect'). In other words, awareness and perception will influence adaptation practices when farmers believe in climate change. This type of results could contribute to reformulate policy interventions by considering farmers' recommendations and preferences to better respond to climate change from local experience.

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ORAL

Did with endogenous spillovers: Model and application to drought-shocks on the trade and production of wheat

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Keywords: Climate change impact; econometrics; trade; wheat

The most recent report of the IPCC predicts a continued increase in the frequency and intensity of extreme weather events. Agriculture, the economic sector most sensitive to changes in weather conditions, will be greatly affected by such changes regardless of a country's geographical location. Because of concerns about food security, a growing literature has investigated the capacity of international trade to act as a major adaptation mechanism to climate change. In this paper, we rely on a difference-in-difference setting with endogenous trade interactions to assess how the trade of wheat, a crop grown across 89 countries, and its production respond to drought. Based on fine spatial and temporal resolution drought data, our estimation results indicate that a drought promotes export when it takes place in the importing country, but it discourages export when it occurs in the exporting country. As a result, the true marginal effect of a drought on wheat production is based on a combination of its local impact and its impact abroad.

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ORAL

Evaluation of drought economic impacts on agriculture in the Po river basin (Northern Italy) through models and surveys

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Keywords: Drought; economic impacts on agriculture; suveys

Climate has a huge influence on both natural and human systems. Climate extremes poses significant challenges to many economic sectors. Agriculture, which necessarily relies on favourable climate conditions, is particularly affected by the consequences of extreme climatological events, such as floods, droughts, and hail. (Lesk et al., 2016) showed that droughts and heat waves are the weather extremes that significantly reduce cereal production at global level, while there is no evidence on the influence of floods and extreme cold on cereal yields. In a climate change context, frequency and severity of extreme events is expected to increase according to many influential studies (IPCC, 2014, 2019) and thus, the economic impacts these events have on agriculture is going to increase.

The way regulators manages water resources during droughts has effects on agricultural resilience and, as remarked in (Rey et al., 2017), the increased frequency of drought and water scarcity will require in future more collaborative partnership-based approaches to water resources and drought management. The importance of an integrated approach that sees water managers involved in drought management is fundamental, as well as better forecasting information to guide farm-level decision. Regarding the latter, as stated by (Bozzola & Swanson, 2014) the first level of adaptation to climate change in agriculture happens at local farm level. Farmers have different possible instruments for dealing with climate variability, including investments in irrigations systems and private storage reservoirs. Local farmers themselves can adapt to long term climate variability, based on their perception of it that sees linear changes in the mean level of precipitation and temperatures, but they face many issues in dealing with the great uncertainty related to climate change, with important yield reductions as consequence (Bozzola & Swanson, 2014; Commission of the European Communities, 2009; Mendelsohn et al., 1994; Mendelsohn, 2000).

This study aims at estimating the economic impacts of past droughts on the agricultural sector in the Po river basin (Northern Italy). Both rainfed and irrigated crops will be considered, to evaluate differences in yield losses between the two categories. Particular attention will be paid to irrigation expenses sustained by farmers and water management strategies adopted to deal with droughts. Water management strategies will be of crucial importance under climate change scenarios. Previous studies (Pedro-Monzonís et al., 2016) showed how in future specific measures will be necessary to mitigate the effects of climate change in water resources availability and allocation.

The Po river basin is the largest agricultural area in Italy and accounts for 35% of the country's agricultural production (Musolino et al., 2018). The basin covers an area of 71,000 km² involving seven Italian regions (Piedmont, Aosta Valley, Lombardy, Veneto, Liguria, Emilia-Romagna, Tuscany, and the Trento Autonomous Province) and small areas in Switzerland and France. The basin is characterized by the presence of big cities, such as Milan and Turin, and wide rural zones. Over the past years the Po basin, also known as Po Valley, was hit by multiple droughts (Crespi et al., 2020). The 2003-2008 events was reported to have huge economic impacts on the agricultural sector, with the 2005-2007 period causing around 1.857B€ of losses (Musolino et al., 2017).

In the Po basin, as stated by (Bozzola & Swanson, 2014) abundance of water resources and easy access to them, have a direct impact on water governance and management practices and on farmers decisions. The latter have often been characterized by an inefficient water use because farmers have adopted less expensive but less efficient irrigation methods, and the consequences of this are exacerbated during drought events when irrigation is the main source of water for crops. Under climate change scenarios, in the Po river basin droughts will happen more frequently and will be characterized by a contemporary decrease in precipitation during spring and summer and increase in temperature (Palatella et al., 2010). Thus, the assessment of drought economic impacts and water management strategies is essential to provide information on how to mitigate drought effects in the future.

The direct estimation of farmers economic losses due to droughts and heat waves is not so frequent. Until now, it has been carried on by just a few studies. (Rey et al., 2017) for example investigated how agricultural drought management in humid climates has adapted in response to increasing water scarcity conditions. Their work evaluated through surveys and interviews with farmers how drought management has evolved over time in the eastern England area, finding that an improving in planning irrigation strategies during droughts and investments in alternative water sources has led to an increased resilience in irrigated agriculture.

The present study at first shows the results of a survey on drought-related losses realized among cereal farmers of the Po river basin. An online survey was created and submitted to farmers in the Po river basin area, in particular in the provinces of Brescia, Pavia and Asti. In this study only surveys filled by farmers growing maize and winter wheat were analysed. Maize is considered as a good representative of irrigated crop, while winter wheat is usually a rainfed crop in the Po Valley.

The surveys' structure consists in different sections with closed-ended and semi-open-ended questions in which farmers were asked to identify the most severe drought and/or heatwave event that hit their farm over the past 20 years. Four main drought events (in 2003, 2015, 2017, 2019) were identified through the replies. In reference to those events, farmers provided information on yield reduction, mitigation criteria, irrigation expenses and irrigation strategies they adopted to mitigate the impacts of the events. Different types of drought management strategies at farm-scale and in a short-term time window (during the drought event and in relation to the ongoing cropping season) can be distinguished from surveys responses. Consequences of those strategies in terms of yield reduction, irrigation expenses and overall economic losses were assessed.

Secondly, drought vulnerability curves for the selected crops (winter wheat and maize) specific for the Po river basin were implemented. The curves were developed using the APSIM crop model (Agricultural Production System Simulator, described in (Keating et al., 2003)). The model was

calibrated on winter wheat and maize yields computed from production and harvested area data from the Italian National Institute of Statistic (ISTAT). The model was calibrated for each province. Meteorological data (daily rainfall, maximum, minimum and average temperature, and net solar radiation) from the EOBS dataset (cite the dataset) were used. Vulnerability curves, expressed in terms of percentage of available water versus yield reduction, were computed for the different crop growth stages.

Farmers economic losses during the four drought events identified through the surveys were estimated using the vulnerability curves. The losses estimated from the vulnerability curves and the losses retrieved from the questionnaires were compared. Results showed that the vulnerability curves tend to underestimate farmers losses, even if differences were found between rainfed crops (winter wheat) and irrigated crops (maize).

This study, with the comparison between empirical information gained by survey and predictable economic losses derived from model simulations, highlights the importance of farmers awareness on the effectiveness of irrigation infrastructures and the planning of a proper water resources management strategy.

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ORAL

A tool for assessing climate change impacts on the local energy sector

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Keywords: RCM; climate impacts; climate service; municipalities; energy sector

Lombardy Administration is engaged with drafting PREAC, that to say the Regional Plan for Energy, Environment and Climate. In this framework, a collaboration with the Environmental Protection Regional Agency (ARPA) has been set up to provide a tool for assessing climate change impacts on the local energy system.

The project aims to define well-suited climate indicators, collect referable data from available archives and/or monitoring networks, use them to fit climate Euro-Cordex climate projections to 2050 and 2070, according to differente IPCC scenarios.

The Environmental Protection Regional Agency (ARPA) is in charge for these tasks. The project has two main focuses: firstly, trying to find the best way to integrate data from our network of meteorological stations with climate historical regional climate model outputs, in order to find biases for our territories; secondly, deeply investigating the uncertainty of model ensembles over our region with the best spatial resolution.

The final step is to provide reliable forecasts targeted to our 1500 municipalities, that can be used as affordable benchmarks for city and environmental planning. Moreover, these dedicated information products could be usefully applied by ARPA's officers in their support activities on behalf of municipalities themselves.

This project is thought to to speed up the uptake of climate adaptation and mitigation issues in other institutional actions about environmental protection, required by law.

ORAL

Intense Mediterranean cyclones: Impacts and predictability

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Keywords: Extreme events; impacts; intense Mediterranean cyclones; predictability

In order to reduce the risk of casualties and overall negative impacts in the environment and society, a better characterization and estimation of the frequency of future Intense Mediterranean Cyclones (IMC) would be necessary and of great interest for Meteorological/Climate services, insurance companies, governments, and population of the Mediterranean region. A robust detection method is required to better assess the future risks associated with IMC, for a better understanding of their features, variability, frequency and intensity. Thus, detection algorithms provides results that are remarkably similar in some aspects but may vary using the same data. The selection of a particular method can significantly affect the results. For these reasons it is necessary to use different approaches and datasets to study the detection approach, sensitivity and robustness. We use a combination of different methods based on previous studies found in the literature, within the framework of the EFIMERA project and to detect and track IMC. This new list of detected IMC events, together with the observed and well documented ones, are used here to create a new IMC database. This is meant to be used for the study of IMC impacts, risk associated and for the study of their predictability.

POSTER

Adaptive normative constraints to mitigate climate change induced conflicts in a snowmelt dominated water system

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Keywords: Climate change impacts; adaptation

The sustainability of many water systems worldwide is challenged by the profound alterations in the hydrologic regime due to changes in climate and growing demands. This is particularly true for snowmelt-dominated catchments, where even marginal temperature variations might dramatically shape the snowpack and glaciers dynamics, with impacts on the inflow's spatial and temporal distribution. Building new infrastructures to upgrade the storage capacity is nowadays considered the predominant option to cope with the new hydroclimatic regime. However, this hard solution often requires considerable financial outlays. In addition, when designed without fully considering the uncertainties in future inflow patterns, it might fail in producing the adaptation response which triggered the investment for its construction.

In this context, tailoring the normative constraints which define the reservoir discretionary operational capacity upon the hydrological regime, might represent a soft and cost-effective alternative to upgrading system infrastructures. In this study, we propose an integrated approach where the reservoir control policy and discretionary operating space are jointly designed to mitigate the ongoing and future climate change impact on a multi-stakeholder water system. We employ Evolutionary Multi-Objective Direct Policy Search, possibly informed by forecast information, to the recursive planning of the discretionary operating space boundaries, internalizing the operation design problem. The approach is tested using the Lake Como system in Northern Italy, a highly regulated water system where climate change-induced hydroclimatic uncertainties are already shaping the tradeoffs between downstream irrigation, hydropower production, flood protection and the tourism sector. We show that the operating policies found via joint optimization fully dominate those obtained considering the actual normative settings. In addition, they are also more robust against the long-term perturbation in the hydrological regime induced by climate change, even though adaptation in the irrigation demand patterns appears necessary to ensure the sustainability of the water system.

POSTER

Assessing future wildfire impacts across G20 countries

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Keywords: Climate; change; wildfires; fire emissions; burnt area

Fire is a main factor in biomes development, it has been crucial in the evolution of human societies and provide several types of ecosystem services such as sustaining biodiversity and forest health. At the same time, wildfires might generate significant impacts on anthropic and natural capital, affecting ecosystem services such as carbon storage, biodiversity conservation, water resources protection, soil erosion reduction and land degradation, and climate regulation. Furthermore, because of climate change, it is expected that future climate variability would enhance wildfire risk and severity also in those biomes not naturally prone to burn. Thus, assessing how the impacts of forest fires will change in the future is critical to developing adaptation and management policies at a large scale.

Addressing the climate change crisis is one of the challenges of the 2021 G20 Countries Summit. In this framework, this work aims to provide an overview of how climate change will affect wildfires-related impacts in the G20 countries, with the final goal to promote climate action and guide the policy-making process in G20 countries.

To achieve this goal, burnt area and carbon emission anomalies for the period 2036- 2099 under both socio-economic scenarios RCP2.6 and RCP6.0 were analyzed. Thanks to the Inter-Sectoral Impact Model Intercomparison Project (ISIMIP), the two fire metrics data was downloaded from https://esg.pik-potsdam.de/. The data are the output of two impacts models, i.e. LPJmL and ORCHIDEE-DGVM, from the Biomes sector, using different climate forcing. The ORCHIDEE-DGVM model dynamically simulates natural vegetation through 10 plant-functional types (PFT), agricultural land cover through four crop-functional types (CFT), two grazing land types and one bare soil type (https://www.isimip.org/impactmodels/details/261/). The LPJmL model simulates potential natural vegetation through 9 PFT and agricultural land-uses through 12 CFT (https://www.isimip.org/impactmodels/details/81/). Four climate models are available for LPJmL model (i.e., GFDL-ESM2M, HadGEM2-ES, IPSL-CM5A-LR and MIROC5), whereas only two climate models are available for ORCHIDEE-DGVM model (i.e., GFDL-ESM2M and IPSL-CM5A -LR). The study provides maps for each country representing the burnt area and carbon flux variations for each RCP scenario. Furthermore, the agreement across impact models and climate forcing on future projections was evaluated and integrated on the maps.

In addition, a review of the scientific literature on the most critical impacts of climate change on forest fire metrics and compound risks was carried out. While for some G20 countries, numerous papers estimate the effects that climate change will have on forest fires, there are still few studies that have addressed this problem for other countries.

6 Ocean climate variability and mitigation option

ORAL

Accelerating green transitions in the maritime ecosystem

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Keywords: Green transition; maritime ecosystem

Although Denmark is one of the green frontrunners and many green initiatives are launched, we are not going to reach the overarching goal of a 70% CO_2 emission reduction by 2030 – unless research and development efforts and results are accelerated dramatically.

The overall objective of this project is to study the transferability of the concepts behind accelerated innovation (Williamson & Yin, 2014) to promote a green transition of the Danish maritime industry which is traditionally seen as less open to innovation than other industries (Perunović & Vidić-Perunović, 2012) and to develop a general and global accelerated green transition model that can be exported across sectors around the world.

This project builds on the premise that accelerated innovation methods that have been scientifically validated exist and can be adapted to combat climate change. For instance there is a wealth of literature on how companies can accelerate innovation speed (Kessler & Bierly, 2002, p. 1144; Kessler & Chakrabarti, 1996). We will also assess the lessons learned from companies' current response to the major and rapid disruption caused by the recent pandemic sharing similarities with the pervasive and immediate challenges of climate change. For instance, early research shows that the pandemic accelerated global problem solving reducing lead time in product development and time to market of vaccines by maximizing the speed and decision-making required to deliver scientific advances in a

timely fashion thereby accelerating product development and evaluation (Corey, Mascola, Fauci, & Collins, 2020). Following these lines, this project will take us beyond the current state-of-the-art by targeting governance structures and introducing accelerated innovation management as a method for managing green transition projects in the Danish maritime ecosystem.

The project takes point of departure in three interrelated models developed for the purpose of this project: (1) Climate Risk and Opportunity Model, (2) Accelerated Climate Innovation Model, and (3) Climate Project Evaluation Model. These three models will be integrated into a coherent accelerated green transition model that can be generalized across contexts.

Climate Risk and Opportunity Model#1: Companies need a structured approach to analyze climate risk and opportunities and to identify and prioritize climate initiatives. The lack of practical context specific risk and opportunity assessment methods for companies have previously been documented with a proposal for a model (Sanderson et al., 2019). The first step is to consider the impacts of the Paris Agreement and the 70% reduction target (Sanderson et al., 2019) and relate this to risks in areas such as policies and the legal system, technology, market and reputation, as well as opportunities like resource efficiency, energy source, products and services, markets and resilience (TCFD, 2020). The model determines CO_2 emissions based on the Greenhouse Gas Protocol in the maritime ecosystem to ensure a sound baseline. The next step is to evaluate the potential effects of different emission reduction targets and efforts, and the starting point for this is the Science Based Targets. The final step is to co-create strategic scenarios in order to identify risk and opportunity hotspots which will feed into project portfolio management to assess which specific climate initiatives to start to increase companies' climate resilience (Gianoli, Grafakos, Olivotto & Haque, 2012).

Accelerated Climate Innovation Model#2: Accelerated innovation methods is crucial if project and portfolio managers want to succeed with their climate initiatives which need to transform business as usual - fast. This creates two important demands on companies' project management execution: a) establish comprehensive business impact cases focusing on a double bottom line of economic and environmental impacts (Ngacho & Das, 2014) and b) accelerate time to impact (Griffin, Langerak, & Eling, 2018; Svejvig, Geraldi, & Grex, 2019) by addressing the urgency of these initiatives and reducing the lead time from project initiation to launch (Kessler & Bierly, 2002; Kessler & Chakrabarti, 1996). These demands are addressed in an accelerated climate innovation model developed to increase climate project management efficiency and effectiveness.

Climate Project Evaluation Model#3: The final model focuses on constructive and conclusive process and outcome evaluation (Chen, 2015) of the green transition initiatives manifested in maritime ecosystem projects and programs. The maritime companies need to carefully map how climate initiatives are progressing and whether the desired climate goals are achieved. Learnings from other settings must be incorporated (Gianoli et al., 2012; Rode & Svejvig, 2021), and used for constructive evaluation to improve climate initiatives in the maritime ecosystem. Moreover, the evaluation is important input to the CO_2 accounting and disclosure that the financial actors demand (Sanderson et al., 2019; TCFD, 2020).

A multifaceted accelerated green transition model: By integrating research on climate action and accelerated innovation from the three models above and inserting it in the maritime industry, the project will develop a coherent accelerated green transition model that can enable companies to identify 1) which potential climate initiatives to undertake (Sanderson et al., 2019), 2) how to reduce

time to impact and speed up problem solving (Svejvig et al., 2019; Williamson & Yin, 2014), and 3) what to evaluate to ensure high success rates in green transition projects (Pinto, Kate, Ika, Judgev, & Zwikael, 2021; Rode & Svejvig, 2021). Thereby the project addresses the lack of applicable climate risk and opportunity analysis methods, the insufficient knowledge on transfer of validated accelerated innovation management methods to green climate contexts, and the gap of empirical research on green projects' effectiveness and efficiency.

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ORAL

Sub-seasonal to seasonal (S2S) drivers of Arctic sea ice variability clusters

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Keywords: Sea ice; sub-seasonal prediction; machine learning

The available multi-decadal record of passive microwave observations of the Arctic Ocean reveals unequivocal downward trends in sea ice extent, thickness and age, as well as a rapid transition towards seasonally ice-free conditions in most of the Arctic marginal seas [1-2]. On shorter timescales, however, frequent departures from the linear trend indicate a marked variability in the sea ice record. The origin of this variability is to be found in the circulation of the atmosphere and the oceans, which exert both a thermodynamic forcing on the sea ice, regulating its seasonal cycle through heat transport and exchange, and a dynamic forcing, driving sea ice motion within the Arctic basin and outflow via its main gateways [3]. However, the sea ice response to such forcing is neither temporally nor spatially uniform, as sea ice anomalies and their interactions with the other components of the climate system vary substantially from season to season and between different regions of the Arctic Ocean. The growing need for accurate sea ice predictions on monthly to seasonal timescales, especially in the context of increasingly frequent episodes of abrupt ice loss [4-5], requires a better understanding of the leading circulation patterns and their relative contribution to Arctic variability.

This work aims to assess Arctic sea ice predictability on sub-seasonal to seasonal timescales (S2S) by identifying the key drivers of sea ice variability that can act as predictors. We use ECMWF ERA5 reanalysis data at daily frequency from January 1979 to December 2018, with a focus on the seasons of maxima and minima in northern hemispheric sea ice concentration (SIC). In the first part of the study, we identify the key regional and temporal patterns of sea ice variability by fitting a clustering algorithm to detrended SIC anomalies. This analysis allows to go beyond the limitations of Empirical Orthogonal Function (EOF) while reducing the dimensionality of the dataset to a set of physically robust and recurrent clusters of variability. Subsequently, we analyze the dominant modes of atmospheric and oceanic circulation in the preceding weeks that could act as drivers of the clustered sea ice patterns. Using daily reanalysis data from ERA-5 and the CMCC Global Ocean Physical Reanalysis System (C-GLORS), we investigate the role of the following potential predictors: surface air temperature, mean sea level pressure, wind speed both at the surface and in the stratosphere, sea surface temperature and ocean heat content. The same analysis is then extended to key northern hemispheric land drivers to provide an insight into the processes by which an intensification of the

hydrological cycle can influence Arctic variability, namely through enhanced feedbacks between freshwater input, ocean circulation and sea ice melt.
Short-term sea ice prediction is crucial for reliable operational forecast systems, yet still at early stages for the Arctic [6]. This opens new prospects for exploiting the long-term reanalysis record to better understand the underlying processes that maximize predictability. This study highlights the potential of applying machine learning-based methods to disentangle the complex interactions between Arctic sea ice and its drivers of variability, drawing linkages between the key components of the northern hemispheric climate system.

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ORAL

Is Arctic climate change the missing component in Scotland's tsunami hazard assessments?

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Keywords: Tsunami; Scotland; Arctic climate change; hazard assessment

Climate change impacts on ice sheets, glaciers and sea-ice have been described in multiple contexts but rarely have they been studied from a Scottish perspective and with a focus on whether the pronounced climatic changes in the Arctic and their amplification and forcing through feedback loops would need to be considered in probabilistic tsunami hazard assessments (PTHA) as forcing factors of drivers of tsunamigenic submarine slides and glacial isostatic adjustment (GIA) induced seismicity.

Such focused investigation was undertaken in the author's recent undergraduate dissertation where a range of relevant literature across multiple disciplines was reviewed to pool evidence of factors which could – individually or in combination - potentially contribute towards an increased likelihood of tsunamigenic processes by reaching 'poorly understood climate thresholds' (IPCC 2012), the latter a stage which the Greenland ice sheet may already have reached (Bevis et al. 2019).

Subsequently, published documents which assessed or described the likelihood of a tsunami occurrence with effects on Scotland, were analysed to find out whether the evidence from the reviewed literature was reflected in hazard assessments for Scotland.

It was found that climate change does not feature prominently in Scottish tsunami hazard assessments despite a climatic influence on submarine slides and GIA-induced seismicity (i.e. Tappin 2012; McGuire 2013), accelerated deglaciation of the Greenland ice sheet which already exceeds its previous natural variability of mass balance (Mouginot et al. 2019) with associated land uplift rates (Khan et al. 2016), and despite at least one known pre-historic tsunami event in the wider region - the Storegga slide - with a possible climatic link (Talling et al. 2014). Evidently, climate change appears to be a missing component in Scotland's tsunami hazard assessments.

The presentation provides an overview of elements derived from scientific literature across many disciplines which should form part of future, more holistic PTHA concepts and sophisticated models which include climate change as a forcing factor of tsunami hazards and their drivers.

As an undergraduate dissertation, the full study has not (yet) been published but is available on request.

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ORAL

Review of costs and energy consumptions of limestone extraction, processing and transportation for a large-scale development of ocean liming

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Keywords: Ocean liming; limestone; quarrying; comminution; calcination; transportation; life cycle assessment

Achieving the net-zero emission target over the 21st century will require massive reductions of anthropogenic CO_2 release from point sources coupled with its removal from the atmosphere (Butenschön et al., 2021).

According to the Intergovernmental Panel on Climate Change, the total carbon to be removed from the atmosphere by 2100 to limit global warming to "well below 2°C", should fall in the range of 100-1000 Gtons, depending on the efficiency with which a net decarbonisation will take place in the near future and the measures employed to lower energy and land demand (IPPC, 2018)

Human-made carbon removal from the atmosphere could contribute to increasing the potential of natural carbon sinks. Among these, the world oceans are recognised as the largest active carbon pool on Earth (WOR, 2010). Ocean Liming (OL) is one of the options proposed to exploit this potential, thereby acting as an improved way to soak up carbon emissions and counteract ocean acidification at the same time.

A direct method to perform OL consists of spreading finely ground alkaline substances over the ocean surface. Such materials can be derived from either limestone in the form of calcium-bearing carbonate mineral, calcite, CaCO3, or other by-products such as quicklime, CaO, or slaked/hydrated lime, Ca(OH)2. There are at least two advantages in the use of limestone as a raw material. Firstly, its worldwide availability is unlikely to be a limiting factor for future OL implementations (Renforth et al., 2013; Storni et al., 2021). Secondly, its processing can rely on a well-mature industrial process chain. Among all the exploitable alkaline materials, slaked lime is one of the most appealing because of its good carbon dioxide removal rate (gCO_2/g-mineral) and its better solubility compared to that of limestone (Renforth and Henderson, 2017; Kruger, 2010). On the other hand, its manufacturing requires significant costs, energy consumptions, as well as CO_2 emissions. These factors are the main limits for the widespread deployment of OL.

The hydrated lime process chain includes five main stages: quarrying, comminution, calcination, hydration and dispersion. Transportation acts as a recurrent link activity over the whole chain. It is first required to move the ore and waste from the quarry to the mill or the disposal area (short haulage) and then to deliver the end product to the application site (long haulage).

The quarrying process consists of five sub-stages to make the extraction of the rock from the ground easier (IQ, 2021). These are called blasting, drilling, digging and loading, material handling, hauling and dewatering. Crushing and grinding, also collectively called comminution, serve to bring the coarsely fragmented rock to a finer designed size. The goal is to create new surface area in order to increase the material's reactivity in the dissolution reactions. Calcination is needed to transform limestone into quicklime. This is a highly endothermic process and it is carried out by processing the limestone at high temperature inside a kiln. In the subsequent hydration phase, quicklime reacts with water to yield slaked lime. The reaction, in this case, is exothermic. Finally, the dispersion of the end product into seawater can be performed through ships.

A literature review will be presented to show the state of the art of cost and energy requirements for each limestone quarrying and processing operation.

The results show that some of the most energy-intensive activities in the excavation phase are material handling and hauling (OEERE, 2002). Diesel is the most used resource to power the equipment as it supplies 80% of the energy required for the excavation of 1 ton of limestone (OEERE, 2007).

Grinding is the further crucial stage due to the large amounts of electric energy required. Crushing accounts for a small share of the total energy consumptions. The energy requirements are widely dependent on the particle size reduction to be achieved. Energy consumptions may increase by 8-10% for every 1 m2/g of new surface area created (Renforth et al., 2013).

Calcination and transportation (long hauling) are the last two significant energy and costs contributors. The former is attributable to the exploitation of natural gas. Transportation largely depends on both the distance travelled and the type of means of transport used.

Lastly, in order to upscale OL to the commercial stage, the identification of best practices and strategies to decrease the cost and the energy requirements will be highlighted.

Upscaling the newly developed technologies over the whole chain is the first key aspect. More accurate investigations on the relationships between mineral reactivity and comminution would bring advances in the raw material extraction life cycle (Renforth and Kruger, 2013). The recovery of waste in quarrying operations could both increase the availability of alkaline materials and reduce their environmental impacts (Renforth, 2019). Improvements upon blasting would lead to better rock fragmentations and thus to lower crushing and grinding energy consumptions (Workman and Eloranta, 2003).

Better controls of the fuel and limestone supply to the kiln, reductions in the size distribution of the particles fed to the kiln, updates in the kiln burners and the preheating of the combustion air could optimise the thermal efficiency of calcination (Gutiérrez et al., 2012).

The shift to renewable energies (solar and wind) and the use of low-carbon fuels (hydrogen, methane with carbon capture storage technologies) to power the equipment are further key steps to decrease the overall climate impact of the process. Similarly, the role played by policies and regulatory frameworks in relieving pressure on capital expenditures is equally essential for decisive advances in the launch of breakthrough methods and technologies.

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ORAL

The availability of limestone and other raw materials for ocean-based negative emission technologies

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Keywords: Ocean alkalinization; ocean liming

The increasing emission of greenhouse gases in the atmosphere is a serious threat to the real future of humankind. Especially the concentration of CO_2, the most important greenhouse gas by volume, is continuously rising since humankind has already released around 300 Gton C from the industrial revolution age, and at the moment about 9 Gton C/year from fossil fuels consumption and deforestation are being released. To counter this danger, different approaches to reduce CO_2 emissions and to reduce its atmospheric concentration with negative emission technologies (NETs) have been proposed, such as bioenergy with carbon capture and storage (BECCS), afforestation and reforestation, land management to increase carbon in soils, enhanced weathering, direct carbon storage, ocean fertilization, and ocean alkalinization (IPCC, 2018).

Ocean alkalinity enhancement and other ocean-based NETs are now gaining more importance (OceanNets, 2021). The ocean, containing 50 times more dissolved carbon dioxide than the atmosphere, plays an essential role in the carbon cycle and thus in the climate system, acting as a significant buffer of atmospheric CO_2. A variety of different mechanisms act to remove anthropogenic CO_2 added to the atmosphere, but these processes operate on a timescale ranging from years to hundreds of thousands of years (Archer et al., 2008). Ocean alkalinization points to speed up this natural process to a more human-time scale.

Given the importance of $CaCO_3$ dissolution in the carbon cycle, ocean liming has attracted attention due to its capability of contemporarily addressing the issues of global warming, via increased uptake of CO_2, and of ocean acidification, thanks to its alcalinity. However, limestone dissolves and precipitates at a slow rate and in order to avoid this problem, soluble calcium can be extracted from limestone in the form of lime, through calcination; obviously, this would require the capture of the CO_2 released during the calcination process.

Methods to optimize the emission during calcination by combining industrial technologies with CO_2 storage have been proposed (Caserini et al., 2019), overcoming the limiting factors of NETs, such as cost and energy requirements, logistics of spreading materials over large areas, and potential competition for land and freshwater. Moreover, ocean alkalinization can be attained by means of other technologies or processes utilizing different raw materials, like those containing magnesium instead of calcium, as forsterite, brucite and magnesite, which have slower dissolution than lime but still consistent, and do not require calcination (Renforth P. and Henderson G., 2017).

The aim of this work is to assess the available quantities and localizations of different raw materials suitable for ocean alkalization, such as limestone, forsterite, magnesite and brucite; in fact, to achieve meaningful results for carbon sequestration and to contrast the actual high quantity of CO_2 release in the atmosphere, hundreds of million tons of material would be needed yearly, and such quantities cannot be mined for every mineral. For this purpose, data about mineral production of selected raw materials as limestone, dolomite, forsterite, magnesite and brucite were collected from the literature. Given the fact that limestone is mined mostly for its use in the construction sector, a correlation between limestone production and cement production at the country level can be made, giving a current annual extraction of limestone of about 5 billion tons. Limestone reserves are estimated to be virtually infinite (several trillion tons) and with hundreds of thousand square kilometres of carbonate rocks outcrops area within 20km from the coast, where the logistics for transports can be optimal.

Production data for dolomite, forsterite, magnesite and brucite are less available, usually concerning the annual total extraction: a forsterite current extraction of 10 million tons yearly is assessed, similarly to the extraction rate of magnesite (20 million tons) and brucite. Their total reserves are estimated in a few billion tons, with mines scattered all around the world.

Whereas the availability of limestone is not a constraint for the large-scale development of ocean alkalinization, the potential of the other raw material is limited and could provide only a minor contribution to ocean-based carbon removal strategies.

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POSTER

Antarctic sea ice area in ocean reanalyses

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Keywords: Sea ice; marginal ice zone; Antarctic sea ice

The knowledge of the changes of the pack and marginal ice area over seasons and years is important in the context of climate change in the Antarctic region. This study analyzes the temporal variability of Antarctic sea ice area during 1993-2019 based on global ocean reanalyses data provided by The Copernicus Marine Environment Monitoring Service (CMEMS). We focus on changes in the area of the marginal ice zone (MIZ) and pack ice that are not always in phase or anti-phase. The correlation between the time series of MIZ and pack ice area in different sub-regions is in general positive in summer and negative in spring. A significant trend of the MIZ/pack ice area ratio for the full domain is found only in summer. The main sea ice area trends occur in summer and are driven by the Weddell, the Ross, and Amundsen Seas. However, trends for the total ice area mask the signals in the MIZ and pack ice area which also have significant trends in spring and autumn. The results of this study can enhance the knowledge about the changes in Antarctic sea ice area and help to clarify understanding of possible reasons of observed variability. We also for the first time examine the performance of the four-member ensemble mean product named GREPv2 in the Southern hemisphere. GREPv2 and ocean reanalyses reproduce sea ice area on different time scales well but there is still a need for improvement of data assimilation schemes.

7 Predicting climate change in the context of risk and adaptation options

ORAL

Predicting climate change over the multi-annual range: A perspective from CMCC decadal prediction system

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Keywords: Climate predictions; decadal variability; numerical modeling

After the early pioneering studies during the 2000s, and the first coordinated multi-model effort within the framework of the 5th Coupled Model Inter-comparison Project (CMIP5) in early 2010s, decadal climate predictions are now entering a more mature phase of their historical development. Near-term climate prediction activities have been recently endorsed by the World Climate Research Programme (WCRP) as one of the Grand Challenges in climate science research, and the Lead Centre for Annual-to-Decadal Climate Prediction, collecting hindcasts and forecasts from several contributing centres worldwide has been established by the WMO.

Here we present results from the CMIP6 DCPP-A decadal hindcasts produced with the CMCC decadal prediction system (CMCC DPS), based on the fully-coupled CMCC-CM2-SR5 dynamical model. A 10-member suite of 10-year retrospective forecasts, initialized every year from 1960 to 2019, is performed using a full-field initialization strategy.

The predictive skill for key quantities is assessed and compared with a non-initialized historical simulation, so as to verify the added value of initialization. In particular, the CMCC DPS is capable to skilfully reproduce past-climate surface temperature over the North Atlantic ocean, the Indian ocean

and the Western Pacific ocean, as well as over most part of the continents. Beyond the contribution of the climate change, predictive skill emerges, among other regions, for the subpolar North Atlantic sea-surface temperatures, resembling the imprint of the extra-tropical part of the Atlantic Multidecadal Variability. Statistically significant predictive skill is also found for atmospheric circulation anomalies, such as the NAO.

In terms of precipitation, CMCC DPS is able to capture most of the decadal variability over the Northern part of the Eurasian continent. Indeed, a set of regional diagnostics is aimed to investigate the process at stake behind this high predictive skill.

ORAL

An idealised study of the tropospheric and stratospheric response to reduced winter land sea contrast

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Keywords: Land-sea contrast; mid latitudes; atmospheric variability

Long term projections of the Northern Hemisphere (NH) winter climate predict a zonally asymmetric surface warming with stronger trends on land than on sea, leading to a reduced winter land-sea contrast (LSC) in the mid latitudes. In addition to this, sea surface temperatures are expected to increase less in the North Atlantic than in the North Pacific in response to the predicted slowdown of the Atlantic Meridional Overturning Circulation. This second factor would produce a weaker LSC over the Atlantic sector than over the Pacific one.

In this work we devise a set of idealised simulations with reduced LSC to understand how it affects the stationary planetary waves and the variability in the extratropical atmosphere. We find a clear reduction in baroclinicity at the eastern boundaries of the NH continents which drives a weakening of the eddy-driven jets. Individual-sector forcing shows that the climate is most sensitive to Pacific LSC. However, both Atlantic and Pacific LSC exert large-scale changes in the tropospheric planetary-wave pattern that extend into the stratosphere.

ORAL

Helping the agriculture business make better choices: The value of seasonal climate forecasts

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Keywords: Agribusiness; maize; climate services; decision-making; seasonal prediction

Agriculture is expected to be strongly impacted by climate change in Southern Europe, where increasingly frequent droughts will likely affect highly water-demand crops like maize, whose yield is deeply influenced by water deficits during the flowering stage. A prior knowledge about the possible occurrence of a dry summer would allow farmers, buyers and insurers to protect their business. In this study, we compute the potential expense reduction that these stakeholders in the maize sector may achieve, by trusting a seasonal climate forecast of drought delivered in March that enables to adopt precautionary measures before summer. Using a decision-theory approach, we illustrate the payoff for each user that chooses to trust the outcome of the Copernicus C3S multi-model. It emerges that, depending on their cost-loss ratio, users benefit from a maximum expense reduction of approximately 30%, with respect to a decision process based on standard approaches. These results suggest that economic analysis can boost the uptake of climate information, thus promoting the development of more advanced techniques for the elaboration of long-term forecasts and contributing to the adaptation capacity of the region.

ORAL

Climate suitability predictions for the cultivation of macadamia (Macadamia integrifolia) in Malawi using climate change scenarios

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Keywords: Malawi; macadamia; suitability; climate change; ensemble model

Climate change is altering suitable areas of crop species worldwide, with cascading effects on people reliant upon those crop species as food sources and for income generation. Macadamia is one of Malawi's most important and profitable crop species; however, climate change threatens its production. Here, we used an ensemble model approach to determine the current and future distribution of macadamia-producing areas across Malawi in relation to climate. Thus, this study's objective is to quantitatively examine the potential impacts of climate change on the climate suitability for macadamia in Malawi. We achieved a good model fit in determining suitability classes for macadamia (AUC = 0.9). We found that precipitation of the driest month (29.1%) and isothermality (17.3%) were the climatic variables that strongly influenced macadamia's suitability in Malawi. Under current climatic conditions, 57% (53,925 km^2) of Malawi is climatically suitable for macadamia. Future projections suggest that climate change will decrease the suitable areas for macadamia by -18% (17,015 km^2) and -21.6% (20,414 km^2) based on RCP 4.5 and RCP 8.5, respectively, with the distribution of suitability shifting northwards in the 2050s. The southern and central regions of the country will suffer the greatest losses (≥ 7%), while the northern region will be the least impacted (4%). We conclude that our study provides critical evidence that climate change will reduce the suitable areas for macadamia production in Malawi, depending on climate drivers. Therefore area-specific adaptation strategies are required to build resilience among producers.

ORAL

An integrated and automatic approach to evaluate coastal erosion risk and its nexus with oceanographic drivers and water quality parameters: The Venice littoral case study

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Keywords: Coastal risk study; shoreline erosion; satellite images; Earth Observation Analysis; integrated coastal zone management

With increasing storminess and continuing sea-level rise, coastal erosion is becoming a primary issue along a significant percentage of littorals in the world. To assess coastal erosion risk against reference and future scenarios, it is important to study the shoreline position over years. This objective, however, becomes challenging when considering gentle-sloping sandy coasts which are commonly subjected to slow, but continuous changes.

Here we present a multidisciplinary research combining satellite image with machine learning and GIS spatial analysis tools to analyze coastal erosion risk in the Venice shoreline over the period 2015-2019. Firstly, an advanced image preprocessing (e.g. co-registration, colors normalization), that is not frequently adopted in coastal erosion studies, was performed on satellite images downloaded within the same tidal range. Secondly, different supervised and unsupervised machine learning classification methods were tested to accurately define shoreline position by recognizing land-sea areas in each image. Finally, the application of Digital Shoreline Analysis System (DSAS) tool in ArcGis was performed to evaluate the net shoreline movement overtime. The assessment was accompanied by correlation analysis with Copernicus Marine Service observations data to recognize key oceanographic drivers of coastal erosion (e.g. wave height/direction) and potential cascading effects on water quality parameters (e.g. suspended matter).

Results showed general shoreline stability in the considered timeframe. However, the high presence of anthropogenic structures (e.g. jetties, breakwaters) induces the formation of well-delimited hotspots of erosion/accretion. The correlation analysis instead showed a nexus between oceanographic drivers, shoreline evolution and water quality variations (i.e. changes in suspended matter). Despite limits posed by spatial and temporal resolutions of the data, the results obtained offer a basis to assess coastal erosion risk in coastal areas and to select the best suitable erosion defense, ensuring sustainable management of coastal communities, assets, and ecosystems, in the context of Integrated Coastal Zone Management.

ORAL

A novel approach in supporting the local authorities to define adaptation actions to climate change

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Keywords: Adaptation actions; impacts; stakeholder; participatory process

Climate change and its effects are both evident in Friuli Venezia Giulia, proved by data that show trends. In the region, several EU funded projects are tackling these issues, both from a mitigation and from an adaptation perspective. Most of the projects involve comparable activities, such as context analysis, improvement of climate monitoring and modelling systems, existing plans survey, stakeholders mapping and participatory processes.

Overlapping of initiatives occur inevitably and this is not a shortcoming, since the complexity of the problem requires a manifold approach. On the other hand, the risk to fall into discrepancies and inconsistencies among methodologies and results in not negligible. Furthermore, currently there are multiple participatory processes underway in the same area, often engaging the same stakeholders' categories and individuals.

Sharing this awareness, two INTERREG Italy-Croatia projects, namely AdriaClim [1] and RESPONSe [2], are joining their efforts to support local Public Authorities in Friuli Venezia Giulia coastal and lagoon area to find the way towards harmonized climate actions, focusing especially on planning climate change adaptation at a local scale.

A new perspective in the participation of the stakeholders in the climate change adaptation process is applied. According with this approach, the flow of information, form stakeholders to the analysts, is a continuous process as climate change is, so the resources available from the two projects are focused in maintaining open the communication channel, in spite of the typical life time of each project, which is very short in comparison of characteristic adaptation times.

To this end, AdriaClim and RESPONSe project partners which are permanently operating on the area, that is ARPA FVG [3], APE FVG [4] and INFORMEST [5], are experimenting a top down and bottom up approach in collecting and analyzing the data on the very local climate change related risks. The continuous flow of information is bidirectional; meanwhile the stakeholders rise the attentions on their

current problems and the perception they have of the future evolution, the experts of climate change hazards and related impacts bring technical information to the end users level, removing beliefs not supported by facts and bringing up to date findings to the stakeholders. It is a mutual learning process.

At the projects level, the set of collected data are obviously shared, thanks to the collaboration in organizing and programming the participation events, and there is a peer to peer comparison of specific supporting adaptation methodologies, which have been defined in each project. The methodology comparison involves also experts working in other EU funded project that are dealing with climate change adaptation.

In this work we preset the new perspective and its application, in the specific case of the participatory processes that is involving the stakeholders who are already facing, or are going to, the climate change effects in the Gulf of Trieste, the lagoon of Grado and Marano and the related cost.

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INFORMEST, http://www.informest.it/

ORAL

Knowledge for a warmer world: A patent analysis of climate change adaptation technologies

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Keywords: Climate change adaptation; innovation; technological change; patent data; incentives; double externality

The Earth's climate is undergoing a shift: concentrations of CO_2 are now at 418 parts per million, a level greater than anything witnessed in the last 800,000 years. Global mean temperature has risen by 1˚C since pre-industrial times and extreme weather events are becoming more common. As the world increases ambition to contain the rise of global greenhouse gas emissions, efforts are needed,

in equal measure, to adapt to the impacts of climate change. Innovation will play an important role in achieving this goal.

We study incentives to increase innovation in climate change adaptation technologies (CCATs). Many CCATs, such as sea walls, exhibit public good characteristics, since they are non-rival and non-excludable. Innovation in public goods suffers from twin market failures: imperfect appropriability which is common to all innovation, and more specifically, free-riding, which dampens private incentives to undertake public goods projects (Mandel 2015). Till date, there is no systematic evidence on the extent to this "twin externality" has impacted the development of CCATs.

Using global patent data, we examine who develops different types of CCATs. Our hypothesis is that for CCATs with strong public good characteristics, technological development is mainly undertaken by public entities such as universities or publicly funded research labs; while for CCATs that resemble private goods (e.g. irrigation systems), there is more private sector participation. Thereafter, using patent citation data, we map the technological knowledge base of CCATs. We assess what scientific disciplines underpin CCATs and whether these fields are relatively "under-funded". Our analysis elucidates the extent to which markets for CCATs are incomplete due to the twin externalities, and whether more government support is required.

The literature on innovation for CCATs is scarce (Popp 2019), in part because till recently, there was no ready classification of what counted as a CCAT. The "Y02A" classification which we use in our analysis was developed in April 2018 by the European Patent Office, which manages the World Patent Statistical Database (PATSTAT). While not all innovation for adaptation is patented, important subsets are, such as technologies relevant for agriculture, advanced weather forecasting, disease control and hazard defence.

The first global analysis of CCATs was done by Dechezlepretre et al. (2020) who leverage the Y02A classification and focus on the "geography" of CCATs. They find that two-thirds of innovation in adaptation - as measured by high-value patents filed between 2010-2015 - is concentrated in China, Germany, Japan, the Republic of Korea and the United States, and that international diffusion is limited. Conway et al. (2015) study the invention and diffusion water-related adaptation patents and, Hongxiu (2017), Miao and Popp (2014) and Hu et al. (2018) find that extreme weather events increase innovation in CCATs.

We build on these seminal contributions by asking who the inventors of CCATs are and whether the scientific fields that underpin CCATs receive enough funding, linking empirics to the theory of public goods. This work makes an important contribution to our understanding of the current state of innovation and incentives in CCATs.

An updated version of this reseach is available as open access at:
https://arxiv.org/abs/2108.03722

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ORAL

Seasonal forecast skill of upper-ocean heat content in coupled high-resolution systems

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Keywords: Seasonal forecasting; ocean reanalysis; essential ocean variables; ocean predictability; extreme seasons

The memory provided by ocean heat content (OHC) is a vital component of seasonal predictability in both the ocean and the atmosphere. However, the ability of forecasting systems to predict OHC remains largely untested. Here, we present a global assessment of OHC predictability in two state-of-the-art and fully-coupled seasonal forecasting systems. Throughout most of the global ocean, and for all seasons, predictions of OHC (in the upper 300 m) are typically more skilful than predictions of sea surface temperature (SST). While skill decay across the forecast period is expected, the decay of OHC skill is typically slower than for SST. Systems therefore have the potential to make seasonal predictions of subsurface temperature anomalies. We also identify regions where forecasting systems are out-performed by a simple anomaly persistence model. These regions, which are typically sub-polar or

dominated by sharp fronts, should be the focus of future improvements of climate forecasting systems.

POSTER

Evaluation of temperature and precipitation seasonal forecasts over the Mediterranean region

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Keywords: Seasonal forecasts; skill scores; probabilistic forecasts; Mediterranean; temperature; precipitation

Interest in seasonal forecasts has been increasing due to their potential applications in different economic and socially relevant sectors, including water management, agriculture and energy production. This study provides an overall assessment of the skills of the main seasonal forecast systems available in the Copernicus Climate Data Store (C3S) in representing temperature and precipitation anomalies at the monthly and seasonal time scale. The focus area is the Mediterranean, a densely populated region where seasonal forecasts could be helpful in a variety of economic sectors, including water management, hydropower production and agriculture.

In this analysis, seasonal forecast systems issued by 5 European institutions (ECMWF, Météo-France, UKMO, DWD, CMCC), together with two different Multi-Model Ensembles (MME) derived from them and a persistence (PERS) forecast, have been analysed. The added value of these forecast systems with respect to the simpler forecast approach based on climatology has been investigated.

Interest in seasonal forecasts has been increasing due to their potential applications in different economic and socially relevant sectors, including water management, agriculture and energy production. This study provides an overall assessment of the skills of the main seasonal forecast systems available in the Copernicus Climate Data Store (C3S) in representing temperature and precipitation anomalies at the monthly and seasonal time scale. The focus area is the Mediterranean, a densely populated region and a climatic hotspot.

In this analysis, seasonal forecast systems issued by 5 European institutions (ECMWF, Météo-France, UKMO, DWD, CMCC), together with two different Multi-Model Ensembles (MME) derived from them and a persistence (PERS) forecast, have been analysed. The added value of these forecast systems with respect to the simpler forecast approach based on climatology has been investigated. Different deterministic (Anomaly Correlation Coefficient) and probabilistic scores (Brier Score, Fair Continuous Ranked Probability Score and Receiver Operating Characteristic Curve) have been

employed to obtain an overall assessment of the "quality" of the forecasts (Wilks, 2011; Murphy, 1993; WMO, 2018), using ERA5 dataset as a reference. The ensemble quality is assessed through the discussion of rank histograms. We performed the analysis using 6-month forecasts starting on May 1st and November 1st to reproduce the following summer and the winter seasons, respectively, considering the forecasts at both monthly and seasonal time scales. To this purpose, a thorough analysis has been performed to quantify the effect of the data aggregation.

In general, temperature anomalies are better reproduced than precipitation anomalies. As shown in rank histograms, the overall ensemble quality is better for temperature, especially during the winter months. After the first month (lead time 0), decreasing skills are evident for almost any skill score, variable, starting date and model. The persistence forecast shows low accuracy and sharpness. Since forecast skills vary in space and time across different models, forecast skills for specific domains should be considered before developing particular applications. Moreover, we recommend using an ensemble of models, such as the MME forecast.

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POSTER

Multi-hazard assessment exploiting machine learning capabilities for eutrophication modeling: The Venice Lagoon case study

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Keywords: Machine learning; multi-hazard risk assessment; eutrophication; Venice lagoon; water quality; climate change

Eutrophication is a worldwide environmental problem affecting the health of close and semi-close water bodies as lagoons, lakes, and estuaries. The ecological and environmental state of water ecosystems is increasingly threatened by cultural eutrophication, i.e the excessive plant growth resulting from nutrient enrichment due to human activities (e.g. urban and agricultural waste and runoff), a process further exacerbated by simultaneous changes in water temperature, and turbidity.

A multi-hazard approach is then required to understand and model spatio-temporal changes in water quality, accounting for the complex interactions among natural and human-made pressures.

To this aim, a multivariate machine learning-based Long short-term memory (LSTM) algorithm integrating ecological, chemical, and physical data, was applied in this study to model Chl-a concentration, used as a proxy indicator of eutrophication processes in the Venice Lagoon case study. Specifically, half-hourly water quality (e.g. OD, salinity, and turbidity) and hydro-meteorological data (e.g. precipitation and river flow) for the 2008-2019 timeframe were used to train, validate and test the LSTM models developed for each of the 7 monitored lagoon water bodies.

Results from the case study showed as the LSTM model successfully captured Chl-a trends under a multi-hazard perspective accounting for changes in multiple concurrent parameters. In particular, models developed for water bodies with few missing data showed very good performances (best RMSE=0.774) with also high capability to capture Chl-a extreme low and high values.

The proposed Machine Learning-based multi-hazard model represents a valuable approach to strengthen eutrophication modelling and management, which could be a significant advantage for the design of effective strategies aimed at preventing transitional ecosystems' deterioration. Moreover, the designed model is a promising tool, ready for 'what-if' scenario analysis accounting for changes in climate conditions and urban development.

8 Climate services and their potential to support adaptation and risk management

ORAL

Synergizing earth observations and seasonal forecasts within an innovative climate index: The case of forage production in Italy

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Keywords: Climate service; climate index; earth observation; seasonal forecasts

In the agriculture sector, climate-related economic losses have reached an average of €73 bn a year worldwide. It is, hence, of utmost importance to act now to build a climate-resilient agricultural system by forecasting the future climate risk and implementing adaptation actions. Agriculture insurance plays a crucial role in promoting the resilience of the agricultural sector to external shocks, as it covers the production and financial risks of farmers, and related shortfall risks of interconnected stakeholders throughout the food chain. For a climate-proof agriculture, the insurance industry needs to evolve. Offering traditional coverage is becoming insufficient, with climate change unfolding its impact on the severity and frequency of extreme events.

We present a climate service for monitoring and forecasting the climate risk on crop and livestock production tailored to the needs of insurers providing agricultural coverage. The climate service have been developed and validated within the ESA funded project TERRA - climaTe sERvices for a Resilient Agriculture, thanks to the engagement of key stakeholders in the whole value chain. The service is a risk assessment and monitoring tool based on a climate-enhanced vulnerability index. Such an index seamlessly integrates satellite data, reanalysis products and seasonal forecasts. In particular, it combines the level-2 variables from sentinel 1, 2 and 3, available through the Copernicus Global Land Service, in a unified vulnerability index, that is integrated with the reanalysis products and seasonal

forecasts available through the Climate Data Store of the Copernicus Climate Change Service. The climate-enhanced vulnerability index is applied to the specific case of forage production in Italy.

ORAL

The Copernicus Climate Change Service (C3S) Sectoral Information System (SIS) pluvial flood risk assessment in urban areas

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Keywords: Disaster risk reduction; extreme precipitation; urban flood analysis; C3S

The "Pluvial Flood Risk Assessment in Urban Areas" is one of the Sectoral Information System activities developed by the Copernicus Climate Change Service (C3S) that is part of the Copernicus Earth Observation Programme and implemented by the European Centre for Medium-Range Weather Forecasts (ECMWF) on behalf of the European Commission. Such a Service is developed in the last two years by the Fondazione Centro Euro-Mediterraneo sui Cambiamenti Climatici (CMCC), acting as main Contractor, with the support as Sub-Contractors of the Wageningen Environmental Research (WENR), GECOsistema srl, and Royal Netherlands Meteorological Institute (KNMI). Its main aim is to support Disaster Risk Reduction (DRR) for the assessment of risks associated to extreme rainfall events in Europe.

This Service is based on data provided by Climate Data Store (CDS) infrastructure, and it is expected to inform the implementation of the Sendai Framework for DRR 2015-2030, the multi-hazard risk assessments compelled by the EU Civil Protection Mechanism, and climate change adaptation strategies and plans.

The Service is developed in a process of co-creation with users having interest in Disaster Risk Reduction issues: representative organisations, business entities and policy networks. Specifically, an analysis of Users' requirements is performed exploiting jointed ways, i.e., the identification of key users and mobilization of the network of DRR practitioners and experts, a desk review of surveys of users' requirements in the context of C3S and other projects relevant for the purpose of the Sectoral Information System, the participation in relevant DRR events to inform people about the project and to initiate discussions, and a huge activity of consultations via interviews, webinars, and a workshop,

engaging DRR experts and policy networks. To be effective for disaster risk reduction, information about climate risks has to be easily accessible and based on harmonized and standardized datasets. Based on insights collected through such initiatives, four main gaps are identified: (1) a clearer identification of the European areas more affected and impacted by heavy precipitation events in recent decades; (2) detailed information about the severity and the probability of occurrence of heavy precipitation events inducing impacts over Europe in recent decades; (3) frameworks and support permitting reliable but expeditious assessments about the urban areas potentially interested by pluvial flooding; (4) a clearer understanding about the added value of very high-resolution dynamical downscaling from ERA5 reanalysis (localization and magnitude of precipitation events at urban scale).

According to such requirements, it has been possible to identify goals and targets of the Service, whose scope is to make available a set of tools supporting disaster risk reduction associated to extreme precipitation events for several communities (e.g., insurance companies, actuarial experts, civil protection) by producing datasets to be included in the Copernicus Climate Data Store (CDS) and applications permitting user-friendly query, visualization and download of information. Specifically, the development of the Service relies on two datasets (D), labelled as "Extreme precipitation indicators for Europe and European cities from 1950 to 2019" and "Flood indicators for European cities from 1989 to 2018" which feed three applications (A), acknowledged as "Extreme Precipitation Statistics for Europe explorer", "Catalogue of Past Extreme Precipitation Events for Europe" and "Urban Pluvial Flood Risk Analysis". A short description of each product is reported in the following:

D1) Extreme precipitation indicators for Europe and European cities from 1950 to 2019. This dataset presents a set of Climate Impact Indicators allowing users to evaluate magnitude and frequency of extreme precipitation for recent decades. It includes historic records, computed recurrence intervals, and numerous statistical measures. To do this, the dataset makes use of data available on the CDS combined with data produced to improve spatial and temporal resolution over 20 European cities.

D2) Flood indicators for European cities from 1989 to 2018. This dataset presents indicators to evaluate spatial distribution of flood risk in terms of hazard and direct damages. These are provided as a focused, high-resolution, product for 20 cities situated across Europe. The dataset combines high-resolution, probabilistic description of extreme precipitation, exposure datasets and damage/vulnerability models into a comprehensive pluvial flood risk assessment for cities across Europe for the current climate. It allows city stakeholders to exploit flood risk analysis over the city, where the potential impact of expected 1-hour precipitation with different return period (5,10,25,50,100 years) is assessed in physical (e.g., water depth) and economic (e.g., damages on buildings) terms.

A1) Extreme Precipitation Statistics for Europe explorer. This application enables the user to easily access, analyse and/or compare information extracted from the Extreme precipitation indicators for Europe and European cities from 1950 to 2019 dataset available in the CDS. The Application allows to explore the dataset across Europe by adopting as visualization unit the different NUTS level (0-2). Through an interactive map, the User can pick one territorial unit and visualize maps and spatially-aggregated statistics for a user-selected indicator over a specific time period.

A2) Catalogue of Past Extreme Precipitation Events for Europe. This application is based on the information extracted from the Extreme precipitation indicators for Europe and European cities from

1950 to 2019 dataset. It enables the user to easily query an interactive catalogue about past extreme precipitation events occurred across Europe, providing information about their magnitudes, the percentage of area potentially affected within the selected area and, when available, information related to historical damages recorded from external repositories (e.g., HANZE, EM-DAT).

A3) Urban Pluvial Flood Risk Analysis. This application provides a scenario-based assessment of hazard and potential damage related to urban pluvial flooding for the current climate covering several expected return periods computed over the 30-yr period 1989-2018. The application is based on Flood indicators for European cities from 1989 to 2018 dataset.

For each product, relative Product User Guides and supporting materials are produced to ease their use. In this sense, a pivotal part of the Service is represented by the Support and help development activities aimed at documenting all data and ICT solutions employed for the scope of this Service, to facilitate data access, analysis and visualization; developing and making available supporting documentation and training material that allows the C3S user support function or another entity to take over the operational service at the end of the contract; developing activities for promoting and disseminating the achievements of the contract, also with the support of ECMWF and GOPA.COM. More details about the Service are available at https://climate.copernicus.eu/pluvial-flood-risk-assessment-urban-areas.

ORAL

Determination of seasonal forecast skill in identifying extreme events of temperature, wind speed, and SPI

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Keywords: Climate services; seasonal forecast; extreme events; Standard Precipitation Index (SPI)

In recent decades, changes in climate have caused impacts on natural and human systems on all continents and across the oceans (IPCC, 2014). Impacts from recent climate-related extremes, such as heatwaves, droughts, and floods, reveal significant vulnerability and exposure of some ecosystems and many human systems to current climate variability. Impacts of such climate-related extremes include alteration of ecosystems, disruption of food production and water supply, damage to infrastructure and settlements. Knowing a few months in advance the productivity of plants and the impact of extreme events on productivity and infrastructure can help operators and policymakers make the energy sector more resilient to climate variability, promoting the deployment of renewable energy while maintaining energy security.

The energy sector already uses weather forecasts up to 15 days for plant management; beyond this time horizon, climatologies are routinely used. This approach has inherent weaknesses, including the inability to predict extreme events, the prediction of which is extremely useful to decision-makers. Information on seasonal climate variability obtained through climate forecasts can be of considerable benefit in decision-making processes.

The Climate Data Store of the Copernicus Climate Change Service (C3S) provides seasonal forecasts and a common period of retrospective simulations (hindcasts) with equal spatial temporal resolution for simulations from 5 European forecast centres (European Centre for Medium-Range Weather Forecasts (ECMWF), Deutscher Wetterdienst (DWD), Meteo France (MF), UK Met Office (UKMO) and Euro-Mediterranean Centre on Climate Change (CMCC)), one US forecasting centre (NCEP) plus the Japan Meteorological Agency (JMA) model.

In this work, we analyse the skill and the accuracy of a subset of the operational seasonal forecasts provided by Copernicus C3S, focusing on three relevant essential climate variables for the energy sector: temperature (t2m), wind speed (sfcWind, relevant to the wind energy production), and precipitation. The latter has been analysed by taking the Standard Precipitation Index (SPI) into account.

First, the methodologies for bias correction have been defined. Subsequently, the reliability of the forecasts has been assessed using appropriate reliability indicators based on comparison with ERA5 reanalysis dataset

The hindcasts cover the period 1993-2017. For each of the variables considered, we evaluated the seasonal averages based on monthly means for two seasons: winter (DJF) and summer (JJA). Data have been bias corrected following two methodologies, one based on the application of a variance inflation technique to ensure the correction of the bias and the correspondence of variance between forecast and observation; the other based on the correction of the bias, the overall forecast variance and the ensemble spread.

Predictive ability has been assessed by calculating binary (Brier Skill Score, BSS hereafter, and Ranked Probability Skill Score, RPSS hereafter) and continuous (Continuous Ranked Probability Skill Score, CRPSS hereafter) scores.

Forecast performance has been assessed using ERA 5 reanalysis as pseudo-observations

In this work we discuss the results obtained with different bias correction techniques highlighting the outcomes obtained analyzing the BSS for the first and the last terciles and the first and the last percentiles (10th and 90th). This analysis has the goal to identify the regions in which the seasonal forecast can be used to identify potential extreme events.

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ORAL

Seasonal forecasting of mountain snow depth: Evaluation of a climate service prototype

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Keywords: Seasonal forecasts; snow; mountain; Alps; downscaling; climate services

Warming trends in the past decades in mountain regions have resulted in glacier shrinking, seasonal snow cover reduction, changes in the amount and seasonality of meltwater runoff (IPCC, 2019), and we expect droughts to become more severe in the future (Haslinger et al., 2014) with consequences for both mountain and downstream economies. Effective adaptation strategies to address and reduce negative climate change impacts involve multiple time scales, from the long-term support of mountain water resource management and the diversification of mountain tourism activities, to the seasonal scale, for the optimization of the available snow resources.

In the frame of the MEDSCOPE project we developed a prototype to generate seasonal forecasts of mountain snow resources, in order to estimate the temporal evolution of the depth and the water content of the snowpack with lead times of several months. The prototype has been tailored on the needs of water and hydropower plant managers and of mountain ski resorts managers. We present the modeling chain, based on the seasonal forecasts of ECMWF and Météo-France seasonal prediction systems, made available through the Copernicus Climate Change Service (C3S). Seasonal forecasts of precipitation, near-surface air temperature, radiative fluxes, wind and humidity are bias-corrected and downscaled to the sites of Bocchetta delle Pisse, 2410 m a.s.l., and Lago Agnel, 2304 m a.s.l., in the North-Western Italian Alps, and finally used as input for a physically-based multi-layer snow model (SNOWPACK, Bartelt and Lehning, 2002). The RainFARM stochastic downscaling procedure (Terzago et al., 2018) is used for precipitation data in order to allow an estimate of uncertainties linked to small-scale variability in the forcing.

The skills of the prototype in predicting the snow depth evolution from November 1st to May 31st in each season of the hindcast period 1995-2015 are demonstrated using station measurements as a reference. We show the correlation between forecast and observed snow depth anomalies and we quantify the forecast quality in terms of reliability, resolution, discrimination and sharpness using a set of probabilistic measures including Brier Skill Score, the Area Under the ROC Curve Skill Score and the Continuous Ranked Probability Skill Score (Wilks, 2011). Implications of the forecast quality at different lead times on climate services are discussed.

Real-time snow forecasts for the current season (2020-2021) are available at this link: http://wilma.to.isac.cnr.it/diss/snowpack/snowseas-eng.html

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ORAL

A prototype decadal prediction climate service

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Keywords: Decadal predictions; prototype climate service; hydropower

Decadal predictions have rapidly evolved in the last decade. A number of institutes have developed and implemented operational decadal prediction systems in order to bridge the gap between seasonal predictions and climate projections. Since climate variability on interannual to decadal timescales is important for planning and decision-making by governments, businesses and other socio-economic sectors, skillful decadal predictions present an emerging opportunity for the development and delivery of valuable climate services. On these grounds, the EU Copernicus Climate Change Service (C3S) project aims at revealing the potential benefits of decadal predictions for different industries and at developing real-time, sector-specific decadal prediction products.

CMCC, participating in the C3S_34c tender, developed a prototype decadal climate service for a specific end-user from the energy sector (ENEL Green Power). For the hydropower investments and operations of the end-user in three European drainage basins, forecasting interannual to decadal precipitation changes is most important. To meet the needs of the end-user, tailored decadal predictions were provided using a multi-model ensemble of four decadal prediction systems (DePreSys4, EC-Earth3, CMCC-CM2-SR5, MPI-ESM-HR). Assessing the direct multi-model output, statistically significant skill was found dependent on the calendar season and the geographical area (basin) considered. To further enhance the predictive skill, a hybrid approach was adopted based on

the higher skill for the North Atlantic Oscillation (NAO) and the observed linear relationship between precipitation and this teleconnection. Furthermore, we found promising evidence that large-scale teleconnection patterns can be also used for skillful decadal predictions of indices related to daily precipitation extremes.

POSTER

Project of network adjustment to WMO standards to provide FAIR dataset as a tool to supply weather and climate information to support climate adaptation and risk management in the Umbria Region

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Keywords: Weather and climate networks; risk management; fair data

Among the greatest challenges of this century climate change is considered both a European and a global challenge since it is accelerating (IPCC, 2018) and the frequency and the intensity of weather-related natural hazards and extreme events are increasing (IPCC, 2018, Alcantara-Ayala et al., 2015, World Economic Forum, 2019), requiring urgent adaptations (The World Bank, 2010).
A good tactical and strategic plan for facing varying weather and changing climate relies on adequate measurement methods and strategic planning for establishing application-oriented data sets to mitigate risk management and to build suitable weather and climate modeling environment.
In the recent past, during the pandemic period, the Climate Research Center of the University of Perugia (CIRIAF CRC-UNIPG) has undertaken a project in collaboration with the Center of Excellence Tele sensing of Environment and Model Prediction of Severe events (CETEMPS-University of L'Aquila) commissioned by the Umbria Regional Authority, designed to adjust to WMO standards the regional network and to supplement observations with weather and climate information better tailored to agricultural production.

The need of this project derived by the survey of the regional network aimed to the adaptation and inclusion of the regional dataset within the European network (E-OBS, COPERNICUS) following WMO standards and the fairness of the dataset. The term "fairness" describes how data meet FAIR principles (Findability, Accessibility, Interoperability, and Reusability) of data, a requirement that allows defining a minimal set of related but independent and separable guiding principles and practices, which enable both machines and humans to find, access, interoperate and re-use research data and metadata.

In fact, the regional information provided by the networks located in central Italy, and especially the ones in the Umbria region, characterized by a complex orography where only one station belongs to the GOS (Global Observing System) among other local stations, do not comply to a general standard of quality control (QC). Quality procedures are usually applied on daily or monthly processed data by local institutions, but since measurements taken from automatic weather stations (AWS), usually contain different types of errors and missing data, it is necessary to perform an extended QC together with a gap-filling technique to make the raw data suitable for any application given the formatting of data and metadata, as suggested by the WMO (2010a).

The novelty of this first application to the network (Cerlini et al., 2020), was the use of the ERA5 data set (Hersbach et al., 2020, ECMWF, 2018) either to fill missing data or to replace wrong data detected through the validation step. Data were transformed from raw and unformatted (text files) meteorological data into a formatted (NetCDF standard format) data set spatially and temporally coherent with the observed reality represented by the ERA5, the last generation of the reanalysis.
After the initial step where a QC procedure was established and applied to the whole dataset of the surface regional network, the adaptation project was focused on different scenarios each one to reach specific objectives focused to provide information critical for decision-makers to prevent risks including short-term meteorological events (floods, etc.) and long-term trends associated with climate change (e.g., persistent drought). Moreover, the involvement of the regional authorities as research and public stakeholders has been one crucial point during the building of the project.

In this presentation, we list the scenarios suggested, with a brief description of the specific goals starting from the base scenario that is focused on the development and maintenance of the Integrated Umbria Network (RIMU) following the international standards suitable to various purposes (weather and climate modeling, agricultural applications as crop modeling and decision systems, hydrological, tourist and aviation weather applications). Within this scenario, it is planned to acquire the radar data available inside the region (Monte Serano) to develop nowcasting products, and other products deriving from statistical application to meteors derived from radar data. The base scenario includes the development of the Integrated Sounding System (ISS) starting from an intermediate regional database whose purpose, among others, is to integrate the whole dataset within the data exploited by the COPERNICUS platform. Acquisition of upper air measurement tools, atmospheric modeling at high resolution, aimed to forecasts and subsequent elaboration of data into risk maps, climate indices, spatial interpolation, and downscaling of seasonal forecasts on the Umbria region, are some of the applications envisioned by the proposed project.

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POSTER

Can we use flood control infrastructures in forecast-based drought management in a drying climate?

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Keywords: Seasonal forecast; drought management; climate teleconnections

In Southern Europe, the occurrence of increasingly frequent and severe droughts is challenging existing water resources management. This trend calls for a proactive approach to drought management through the development of efficient monitoring, warning and forecasting systems. In this study we demonstrate the potential of using drought seasonal forecasts for promptly activating a drought management strategy aimed at mitigating the conflict between competing water users in the Lake Como system (Italy). Historically, in this region, water abundance was often the primary concern rather than water scarcity; however, the system has recently experienced a number of severe droughts with a consequent progressive lowering of the average lake level that have exacerbated conflicts between agriculture and other sectors, including navigation, tourism, and ecosystems.

In this context, we propose a drought management strategy based on the use of a mobile dikes system, originally designed to protect the shoreline of Como city from floods, as a means of reducing the impacts of drought. The intent is to lift the dikes in view of dry seasons to increase the storage capacity of the lake, with potential benefits both for irrigation supply and for low levels control. To operate the dikes only in the event of an actual drought, a seasonal drought forecast is generated with a statistical approach that relies on the teleconnection of El Niño Southern Oscillation (ENSO)

with local hydro-climatic conditions. When drought emergency conditions are detected, the lake operations switch from the historical policy to a new strategy specifically designed to manage the system and address the tradeoffs between the competing users in drought conditions. Our results show that many of the resulting solutions successfully improve the historical operation of the system both in terms of irrigation supply and low levels control, without increasing the risk of flooding.

POSTER

Creating neural network-based ensemble weather forecasts

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Keywords: Machine learning; neural networks; ensemble forecasts

Weather forecasts are intrinsically uncertain. To address this issue, many modern weather forecasts rely on so-called ensembles. These enable a measure of uncertainty to be attached to each forecast, for example by computing the ensemble's spread. Here, we focus on using a class of machine-learning algorithms, termed neural networks, for weather forecasting [1]. The neural networks are trained and tested on coarse-grained data from ECMWF's ERA5 reanalysis. We specifically test four different approaches to obtain an ensemble neural network forecasting system: random initial perturbations, retraining of the neural network, use of random dropout in the network, and the creation of initial perturbations with singular vector decomposition. The ensemble mean forecasts obtained from these four approaches all beat the unperturbed, deterministic neural network forecasts, with the retraining method yielding the highest improvement. We nonetheless note that, by most measures, the skill of the neural network forecasts is still systematically lower than that of state-of-the-art numerical weather prediction models.

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POSTER

Overcoming conflicting notions of climate forecasts reliability and skill in the agricultural sector: Lessons learnt from the MED-GOLD project

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Keywords: Climate service; agro-food systems; pasta; wine; olive oil

During the project MED-GOLD, whose aim is to co-develop pilot climate services for three staple Mediterranean agri-food systems: grape, olive and durum wheat, key challenges emerged in the process of identifying useful climate indicators and actionable definitions of the reliability of climate information. To address such conflicting notion of the reliability of climate information, a participatory workshop was organised with providers (mainly climate scientists) and users of climate data and information (representatives from agri-food companies but also providers of agromet services for farmers) to facilitate an open discussion and find ways of moving forward methodologically and practically towards the development of prototype services. We found that the scientists and users had very different conceptions and interpretations of terms such as skill and reliability of climate information. Furthermore, such disparate understandings created a level of friction between what the scientists understood as scientifically robust and credible climate information and what the users required in terms of saliency of the climate information developed in order to effectively support their decisions. Through an iterative and open discussion, scientists and users agreed the decision making landscape and on a notion of reliability of climate predictions connected to the type of decisions that climate information would support. We will describes the process of developing a common understanding on working definitions of the reliability of climate predictions in the MED-GOLD project and, provide a practical example of the application of this definition to a real case study focused on durum wheat cultivation in Italy.

9 One health and climate change: Multidisciplinary approaches and solutions

POSTER

Heat events in the Indian subcontinent under a warming climate scenario: Detection and implications on human health

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Keywords: Climate; heatwaves; India; climate change; health; heat indices

Global temperatures have shown a warming trend over the last century, mainly as a result of anthropogenic activities. Rising temperatures are a potential cause for increase of extreme climate events, such as heat waves, both in severity and frequency. Under an increasing extreme event scenario, the world population of mid- and low-latitude countries is more vulnerable to heat related mortality and morbidity. In India, the events occurred in recent years have made this vulnerability clear, since the numbers of heat related deaths are on a rise.

Over India, the heat waves occur during the months of April to June and can impact various sectors including health, agriculture, ecosystems and the national economy. In May 2015, a severe heat wave due to the delayed onset of southwest monsoon affected parts of south-eastern India, which claimed more than 2500 lives.

Preliminary results show the prevalence of Heat events in six different regions of India during the pre-monsoon (March, April, May) and transitional (May, June, July) months. We consider daily maximum temperatures and NOAA's Heat Index (HI), a combination of temperature and relative

humidity (also known as apparent temperature) which gives an insight into the discomfort because of increment in humidity. It is important to take HI along with temperature anomalies, since humidity also plays a role in transitional period.

Heatwaves over India are known to be linked with mortality and have indirect impacts on human health. To evaluate the heat related risk of mortality on Indian population, indicators and clusters of heat events were computed by taking into account population weighted temperature exposure.

POSTER

A Matrix for interdisciplinary research on health as a complex integrated system

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Keywords: Interdisciplinarity; health; system; circularity; theory; practice

Our investigation develops from a reflection of the UN Secretary General Guterres, who observed how "COVID-19 has x-rayed the world, exposing deep fissures and fragilities" (Geneva, 2020). The unprecedented impacts of the disease, whose origin is still unclear, but whose consequences have exposed the fragility of the human and planetary health, and of their connection, spur our reflections on the challenges and opportunities offered by the current global health crisis to look into health in an integrated manner, from the perspective of its circularity. Adopting an integrated approach to health, one that looks into the mutual relationships between planetary, cultural, human and non-human health, the contribution discusses on the feasibility to adopt a circular approach in research, one which encompasses the adoption of a holistic approach (the One Health approach) that has the potential to connect methods of analysis adopted in each discipline. The contribution creates awareness on the tension between division and union observed in different research fields, and provides readers and researchers with an overview of how the connection with planet Earth can be found in different research fields. Multidisciplinary and holistic approaches to health, food, and environment help to identify breaking points and achieve reconnection. Potential implications of further studies in this direction will lead to an increased discernment of solutions that could heal our broken system.

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POSTER

Community resilience evolutions during inter-twinned one health crises

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The idea of "One Health" has been introduced in the 2000s to summarize the idea that all the well being of living creatures are inter-depend and bounded to the health of the ecosystems[2].
The Rockfeller Foundation and The Lancet[2] has reprise this concept in 2015 through the definition of Planetary health as "the health of human civilization and the state of the natural systems on which it depends"
The COVID-19 pandemic outbreak in the climate crisis has strongly evidenced this vision in several points.

Particularly COVID-19 health crisis showed several similarities with climate crisis both in the causes and effects that it has run into human communities.
First of all COVID-19 has proven how the loss of biodiversity can enhance zoonisis phenomena.
Secondly COVID-19 has shocked so much the current state of anthroposphere that for one of the rare times, a biological component has shocked so much some human activities to reduce the emissions in atmosphere related to them.
More than over COVID-19 and climate crisis both are triggering community resilience in human settlements toward transformational changes[3].

Several authors defined community resilience in literature, in relationship to two concepts:
the system disruptor and the responses[4].
How a system activates as a whole in response to a system disruptor, developing synergies among its parts, more or less boosts it[5]

Community resilience goes beyond community stability, that is often addressed by the majority of health and social policies.It is dynamic, changing with internal conditions, external forces, and a community's ability to respond and develop.

In the responses rely on community resilience communities do not control all the conditions that affect them, rather they foster the ability to respond to change.

And more the changes are pushed by the system disruption over certain stability thresholds in which minor adaptations are no longer enough, more systemic transformations become necessary and healthy for the system itself to survive

This has been the case of COVID-19 on this short term scenario, as well this will be the case of crises at the medium or long term.

In such extreme cases the critical events create also opportunities to assess the effectiveness of structural mutation of system itself that finally can lead to improvements.

Such processes are exploiting in other term the transformational potential of the crises [4].

Community resilience is one of these potential and we had the chance to observe it in the first phases of the pandemic, when there were not other ways to manage the contagious by acting through collective restrictions, and efforts[2].

To do not waste such potentials learned and triggered from the crises its important to provide a framework to rationalize community resilience and transformational changes.

This work is addressed to conceptualize a framework to better understand community resilience triggered by critical system disruptors. As useful can be for this and future pandemic, it can be applied also to climate change adaptation and mitigation.

The framework should help not just to understand past processes but to help to go beyond the crises.

The step up from community resilience is indeed regenerativity: as derived from a positive application of the One-health concept, regenerativity stands into grant the health of human communities by fostering the health of living environment around.

It the such propositional implementation of One-health concept the health of ecosystems would not be granted "per se", but as a functional service to preserve in favour of human society.

On a regenerative vision, community resilience can be easily seen as not just a response but a inner transformation of the social, economical and physical relationships inside a community that could led to a collective empowerment toward a new state of dynamic internal and external equilibrium.

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