Annual Report 2021

cmcc
Centro Euro-Mediterraneo sui Cambiamenti Climatici

Annual Report 2021

CMCC Annual Report 2021

Edited by
Mauro Buonocore

Contributors
Francesco Bassetti, Francesco Bosello, Milena Cagnazzo, Ottavia Carlon, Giovanni Coppini, Italo Epicoco, Giulia Galluccio, Silvio Gualdi, Ivana Losa, Simona Masina, Serena Marras, Alessandra Mazzai, Paola Mercogliano, Jaroslav Mysiak, Manuela Santagata, Selvaggia Santin, Monia Santini, Massimo Tavoni, Silvia Torresan.

Graphic Design
Lorenzo Tarricone, Renato Dalla Venezia

Contents

Highlights of 2021

11
Research divisions

132
Projects

227
Refereed papers

214
People

2021: in Numbers

People

FTE (full-time equivalent)

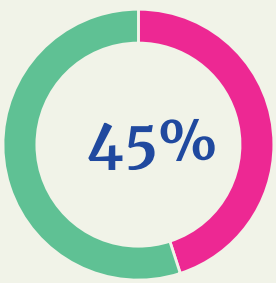
214 People at CMCC

72% Research Area

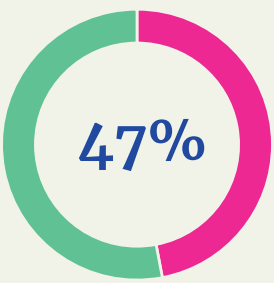
28% Services for Research

43% Senior Positions

Women at CMCC



of the people at CMCC



of senior positions

Staff numbers and roles

ROLE	TOT	M	W
Senior Scientist	17	12	5
Scientist	25	15	10
Junior Scientist	18	12	6
Senior Scientific Manager	20	2	18
Junior Scientific Manager	4	1	3
Senior Research Associate	20	15	5
Junior Research Associate	27	20	7
Post Doc	24	13	11
Post Degree	19	10	9
Senior Administrative Staff	11	5	6
Junior Administrative Staff	28	13	15

Find job opportunities at CMCC. Submit your CV, browse our open positions, check if your requisites fit with any of them: www.cmcc.it/work-with-us

Publications

View the full list of publications: www.cmcc.it/publications

227 Refereed papers published

157 of which in top 20% refereed journals

42 Datasets published

Applications

1 Reanalysis

12 Forecast Systems

4 Decision Support Systems

15 Risk Analysis Systems

2 Skill of Forecasts

4 Monitoring Systems

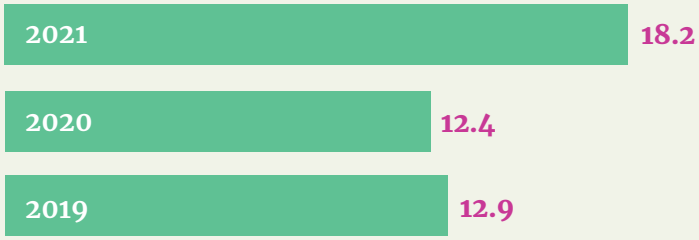
10 Other Applications

Research Projects

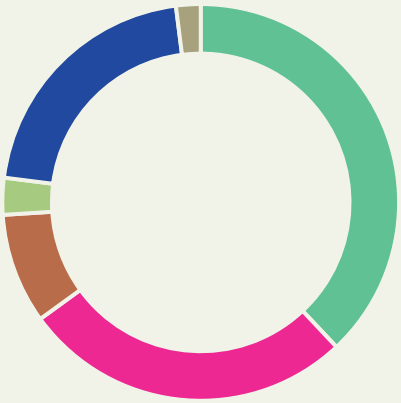
132 Running Projects in 2021

Fund Raising Capacity

The CMCC's capacity to attract new funds over the last three years.
These funds are over and above the annual operating grants (Million €).

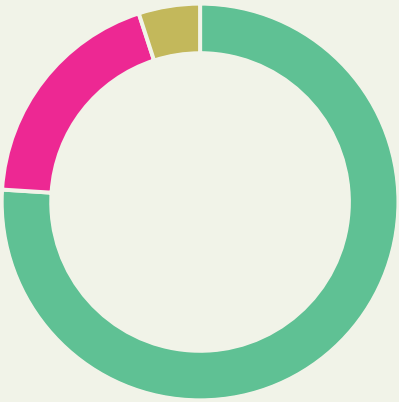


Source of Funding (per budget, per starting date) last 5 years (2016-2020)



EU H2020	38%
EU Copernicus	27%
EU Interreg	9%
Other EU Funds	3%
National Funds	21%
Other International Funds	2%

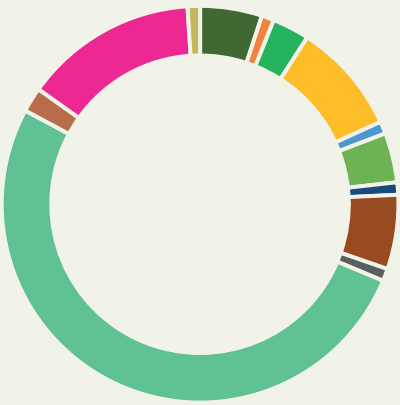
CMCC Participation in H2020 Pillars



Societal Challenges	76%
Excellent Science	19%
Industrial Leadership	5%

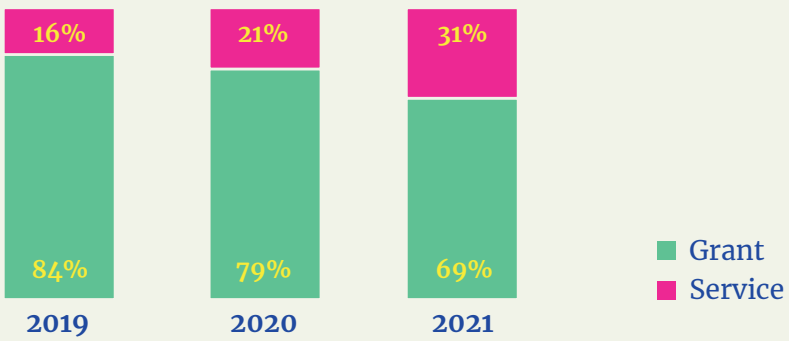
CMCC Participation in H2020 Work Programs

The last H2020 calls closed during 2021. Below, CMCC participation data for the entire program period (2014-2020) are provided



ERC	5%
Future and Emerging Technologies	1%
Marie Sklodowska-Curie Actions (MSCA)	3%
European Research Infrastructure	9%
ICT	1%
Space	4%
Health, Demographic Change and Wellbeing	1%
Food security	6%
Secure, Clean and Efficient Energy	1%
Climate Action, Environment, Resource Efficiency and Raw Materials	51%
Secure Societies	2%
Cross-cutting Activities 2018-2020	14%
EuroHPC Joint Undertaking	1%

Type of funding % per budget



Education and Training

View the complete list of Education and Training Programs:
www.cmcc.it/education-programs

PhD Programs in collaboration with Partner Universities

Science and Management of Climate Change
(Ca' Foscari University of Venice)

Agrometeorology and Ecophysiology of Agricultural and Forestry Eco-Systems
(University of Sassari)

Sciences, Technologies and Biotechnologies for Sustainability
(University of Tuscia)

Biological and Environmental Sciences and Technologies
(University of Salento)

Complex Systems Engineering
(University of Salento)

Future Earth, Climate Change and Societal Challenges
(Alma Mater University of Bologna)

Master of Research in Science and Management of Climate Change
(in collaboration with Ca' Foscari University of Venice)

Outreach

Online Analytics

125k Unique visitors

450k Page views

46 Webinars

Social Media Presence

Twitter
4,557 followers
(+ 20%)

Instagram
23,526 followers
(+205%)

Facebook
5,674 fans
(+10%)

Linkedin
6,551 followers
(+ 62%)

Financial Report

BALANCE SHEET: ASSETS	2021	2020
A) Receivables from shareholders for contributions due	0	0
B) Fixed assets	11,711,345	8,805,658
I, Intangible fixed assets	*279,895*	*246,900*
II, Tangible fixed assets	*10,329,160*	*7,747,408*
III, Financial assets	*1,102,290*	*811,350*
C) Current Assets	22,275,933	19,917,744
I, Inventories (Work in Progress - WIP)	*12,075,584*	*11,007,267*
II, Receivables	*872,350*	*1,197,408*
III, Current financial assets	*2,000,000*	*2,000,000*
IV, Cash at hand	*7,327,999*	*5,713,069*
D) Prepayments and accrued income	**27,400**	**28,307**
TOTAL ASSETS	**34,014,678**	**28,751,709**

BALANCE SHEET: LIABILITIES	2021	2020
A) Net Liabilities	7,756,475	6,369,857
Capital	*662,000*	*662,000*
Reserve Funds	*6,607,242*	*5,055,157*
Profit for the year	*487,233*	*652,700*
B) Provisions for risks and charges	406,057	301,103
C) Employee Severance Indemnities	1,457,356	1,183,269
D) Payments from Clients	17,134,946	14,251,949
E) Accruals and deferred charges	7,259,844	6,644,824
TOTAL LIABILITIES	**34,014,678**	**28,751,002**

PROFIT AND LOSS	2021	2020
A) Revenues	19,487,139	16,482,168
Revenues from sales and services	*3,634,539*	*4,410,694*
Variations in stocks (WIP)	*1,074,144*	*1,199,785*
Other revenues	*14,778,456*	*10,871,689*
B) Expenses	18,953,389	15,770,480
Consumable	*192,251*	*114,785*
Services	*7,903,586*	*6,570,475*
Leases	*340,073*	*345,706*
Personnel	*7,591,655*	*7,095,863*
Depreciation	*1,689,982*	*1,313,175*
Other Operating Expenses	*1,235,842*	*330,476*
Difference between revenues and expenses (A-B)	533,750	711,688
C) Financial income and charges	40,241	8,688
D) Impairment on financial assets	0	0
E) Extraordinary income and charges	-57,221	-46,572
Results before taxes (A-B±C±D±E)	**516,770**	**673,804**
Income tax expenses - current and deferred	29,537	21,104
a) Current taxes	*29,537*	*21,081*
b) Deferred taxes	*0*	*23*
Profit (loss) for the year	**487,233**	**652,700**

Supercomputing Center

Supercomputing Center

Since 2008, the CMCC Supercomputing Centre (SCC) is the most powerful computational facility in Italy and among the most advanced in Europe, fully dedicated to Climate Change research.
In 2022 the CMCC Supercomputing Center changed its location to the new CMCC headquarters in Lecce. This also includes the upgrading of the computing and storage facilities.
Zeus, the supercomputer currently in operation, is based on 348 Lenovo SD530 biprocessor nodes (for a total of 12.528 cores) all interconnected by means of an Infiniband EDR network. The HPC system has a computing power (theoretical peak performance) of 1.202 TFlops.

This new project also includes the upgrading of the computing and storage facilities. In particular, CMCC plans to have its new HPC facility (named Juno) in production starting from the third quarter of 2022. The new supercomputer Juno will have a computing power (theoretical peak performance) of about 1.134 TFlops and will be based on the new Intel processors generation (3rd Generation Intel Xeon Scalable codenamed "Ice Lake") and also on the latest generation of NVIDIA GPU (NVIDIA Ampere architecture).
The technical details of both the supercomputers Zeus and Juno are summarized in the following table.

	CMCC HPC facilities – Systems Overview	
	ZEUS supercomputer	**JUNO supercomputer***
Compute node type	Lenovo SD530	Lenovo SD630 v2
Processor type	Intel Xeon Gold 6154 (18 cores)	Intel Xeon Platinum 8360Y (36 cores)
Processor Speed	3,0 GHz	2,4 GHz
# of processor cores	12.528	12.240
GPU type	---	NVIDIA A100
# GPU	0	20
# of nodes	348 (dual processors nodes)	170 (dual processors nodes)
Memory per node	96 GB	512 GB
Interconnection	Infiniband EDR (100Gbps)	Infiniband HDR (200Gbps)
Peak Performance	1.202 TFlops	1.134 TFlops
Operating System	Linux CentOS 7.6 x86_64	Linux x86_64 (Red Hat or Suse)
Batch Queueing System	IBM Spectrum LSF v. 10.2.0.9 (HPC Suite)	IBM Spectrum LSF v. 10.x (HPC Suite)
Cluster Parallel File System	IBM Spectrum Scale v.5.0.3 (GPFS)	IBM Spectrum Scale v.5.x (GPFS)
File systems	/users_home 100TB /work 4 PB of usable capacity /data 4 PB of usable capacity	/users_home 100TB /work 11,3 PB of usable capacity /data 11,7 PB of usable capacity

*In production at the beginning of the third quarter of 2022.

The hardware components of this new system are:

- IBM TS4500 tape library with nr 6 LTO8 drives and 2 accessors, 5PBytes of capacity
- Nr 2 servers Lenovo ThinkSystem SR630
- Nr 1 IBM DS2200 FC storage system
- 16Gbps FC SAN implemented with nr 2 Lenovo FC switches B6505

IBM Spectrum Archive Enterprise Edition is the software that manages the tape library operations and stores the data on the tape tier in the Linear Tape File System (LTFS) format.

During 2022, the CMCC archiving system will be moved to the new CMCC data center and will also be upgraded in order to extend both its capacity (to 40 PetaBytes) and its I/O throughput by adding 8 more LTO8 drives.

Computational Resources

24,769 cores

2,400 TFlops

Theoretical peak performance
(1 TFlop = 1,000 billion operations per second)

32 PetaBytes

Over storage system capacity

40 PetaBytes

Tape Library (archiving system)

2021: Selected Topics

Photo by Boris Bobrov on Unsplash

Future Earth

What will the climate of the future look like? The CMCC Foundation has a long experience in the field of climate predictions making it one of its most important assets and becoming one of the few centers at the international level to produce climate forecasts at many different time scales. The latest-generation climate simulations allowed by the cutting-edge models developed by CMCC are among those that provided the data basis for the Working Group I volume of the IPCC 6th Assessment Report. Moreover, the great potential of artificial intelligence is being increasingly explored and exploited by our researchers to better understand the climate of the future and the risks of climate change.

CMCC among the top global producing centers of climate information.

Seasonal forecasts can be used in a wide range of economic sectors, ranging from energy production and distribution to agriculture, water management and health. The private sector can also benefit from them, for instance with companies involved in renewable energy production or insurance companies, who are asking for help in better defining their climate-related risk levels and managing their activities. CMCC has become an international benchmark in the field of climate predictions, and in 2021 was formally selected by the World Meteorological Organization (WMO) among the 14 world-class research centers for operational seasonal forecasts, namely the "Global Producing Centres of Long-Range Forecasts". The "Global Seasonal Climate Update" of the WMO uses Italian research to realize its quarterly bulletins: a very important achievement, which confirms the leading role of the CMCC among the most advanced research centers in the field of climate sciences.

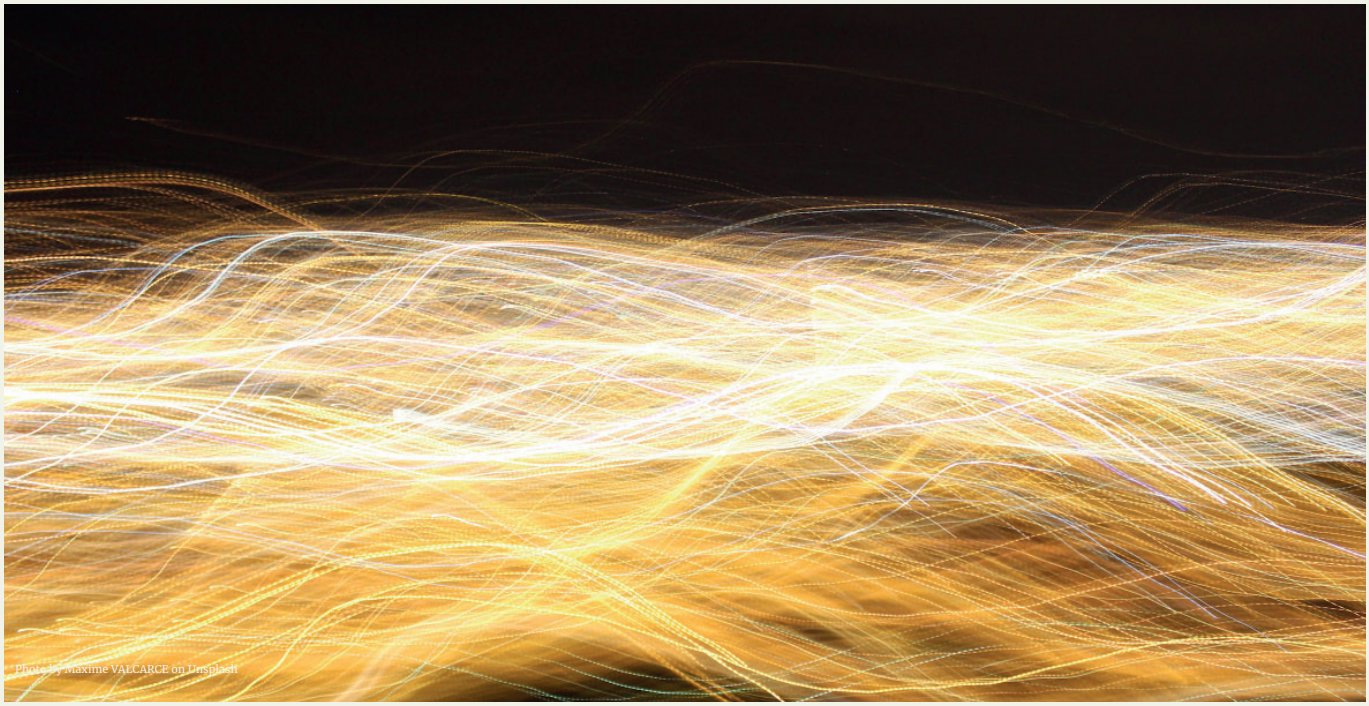
Photo by NASA on Unsplash

A leading center in decadal predictions in Europe.

In the framework of the EUCP (European Climate Prediction) project, CMCC further developed its decadal prediction system and capabilities, contributing also to the WMO Decadal Climate Prediction Project (decadal hindcasts 1960–2020). Moreover, CMCC participated in the C3S_34c Copernicus tender - ended in 2021 - that aimed at developing prototype climate services using decadal predictions, thus responding to an emerging scientific opportunity and societal need for climate services with a forecast horizon beyond one year. Through its participation in these projects, CMCC placed itself between the leading centers in decadal predictions in Europe.

New generation models to inform the IPCC Reports.

CMCC contributed to the IPCC Sixth Assessment Report Working Group I "Climate Change 2021: the Physical Science Basis" providing latest-generation climate simulations using its models CMCC-CM2 (CMCC - Climate Model 2, in its various configurations) and CMCC-ESM2 (CMCC - Earth System Model 2). Indeed, these models are included in the sixth Coupled Model Intercomparison Project Phase 6 (CMIP6) whose multi-model output - made publicly available in a standardised format - provided the data basis for the Report, as explained by the IPCC Focal Point for Italy, hosted by the CMCC Foundation. CMIP6 is the sixth phase of a global effort coordinated by the World Climate Research Programme (WCRP) and undertaken by the worldwide scientific community to better understand past, present and future climate changes arising from natural, unforced variability or in response to changes in radiative forcing in a multi-model context.



Earth System Models improvements.

Major new improvements that are being incorporated into upcoming Coupled Earth System Model infrastructure have been presented by Mariana Vertenstein from the National Center for Atmospheric Research and member of the CMCC scientific Advisory Board, in a webinar on February 3, 2021.

Artificial intelligence, the new frontier in climate change risks assessment.

Machine learning - a branch of artificial intelligence - represents the future of risk assessment, but its great potential is not yet widely exploited. In an in-depth review of more than 1,200 articles on the subject published in the last 20 years, a CMCC study highlights that machine learning can allow researchers to disentangle complex relationships underlying the functioning of socio-ecological systems, exploiting the big data collected from various sources, including sensors for environmental analysis at high temporal frequency, social media, satellite data and images, and drones. Moreover, they can combine different types of data, thus enabling an assessment of the risk extent whilst taking into account all its dimensions. These include not only the triggering hazard (for example, an increase in rainfall), but also the vulnerability and exposure of the socio-economic system at stake, which are crucial factors in an evaluation of overall impacts. Machine learning can therefore improve the understanding of these interactions and dynamics, in order to support decision makers in managing current and future climate change risks.

High-Performance Computing processes, data analytics, and artificial intelligence.

Nowadays, developers lack tools that enable the development of complex workflows involving High-Performance Computing (HPC) simulations and modelling with data analytics and machine learning. The new project eFlows4HPC – Enabling dynamic and intelligent workflows in the future EuroHPC Ecosystem - of which the CMCC Foundation is a partner - aims to deliver a workflow software stack and an additional set of services to enable the integration of HPC simulations and modelling with big data analytics and machine learning in scientific and industrial applications. The software stack will allow creating innovative adaptive workflows that efficiently use the computing resources considering novel storage solutions. CMCC leads the work package which develops innovative adaptive workflows for climate and for the study of Tropical Cyclones in the context of the CMIP6 experiment, including in-situ analytics.

Photo by NASA on Unsplash

Data Learning: Integrating Data Assimilation and Machine Learning.

Data Learning is a field that integrates Data Assimilation and Machine Learning. In a CMCC webinar held on February 25, 2021, Data Learning was introduced as a way to overcome limitations in data-driven models applying to real-world data in order to increase the reliability of predictions.

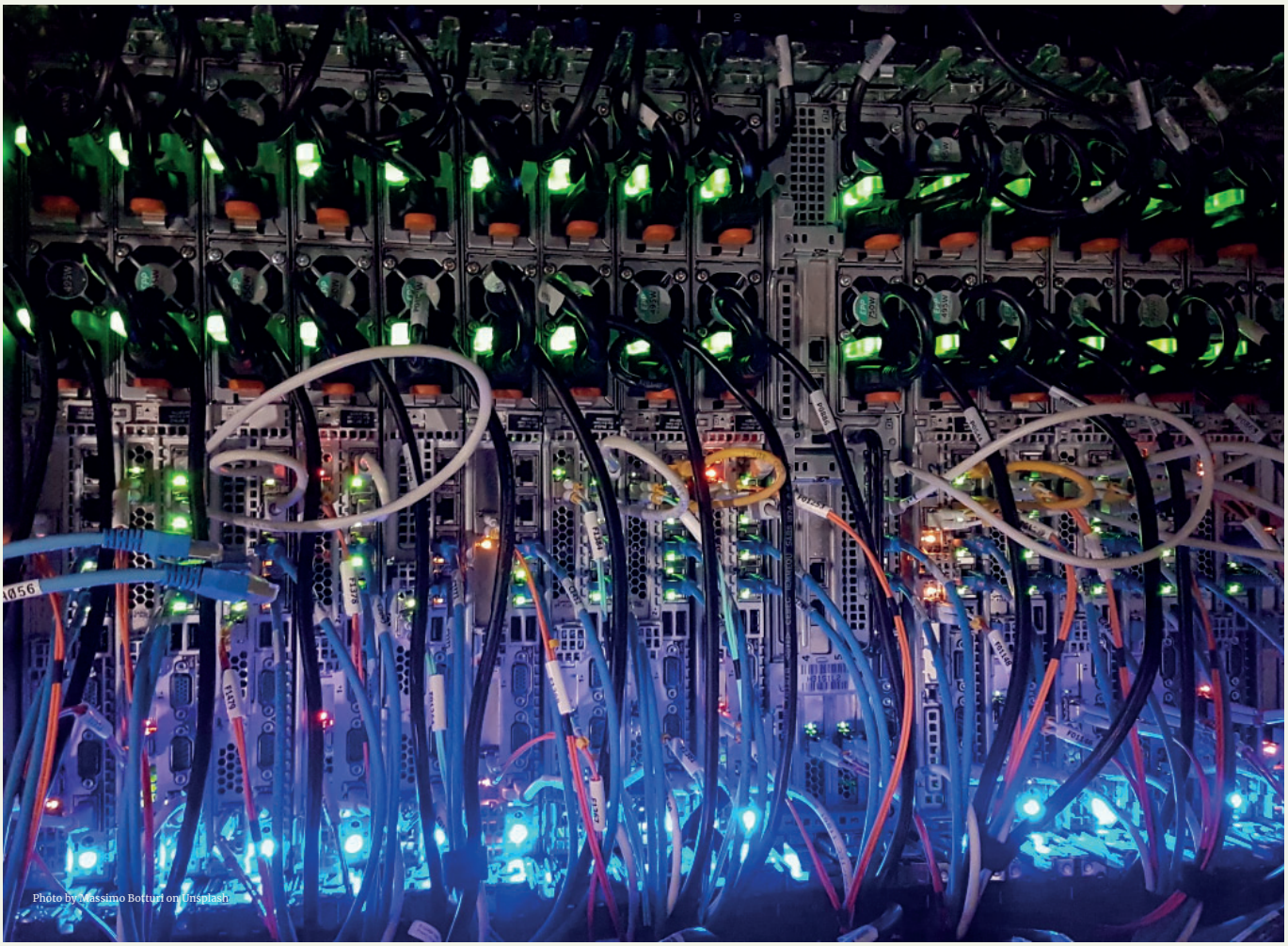


Photo by Massimo Botturi on Unsplash

Over the past few years, Data Assimilation (DA) have increased in sophistication to better fit application requirements and circumvent implementation issues. Nevertheless, these approaches are incapable of fully overcoming their unrealistic assumptions. Machine Learning (ML) shows great capability in approximating nonlinear systems, and extracting high–dimensional features. ML algorithms are capable of assisting or replacing traditional forecasting methods. However, the data used during training in any ML algorithm include numerical, approximation and round off errors, which are trained into the forecasting model. Integration of ML with DA increases the reliability of prediction by including information with a physical meaning. The webinar provided an introduction to Data Learning, a field that integrates Data Assimilation and Machine Learning to overcome limitations in applying these fields to real-world data. The fundamental equations of DA and ML were presented and developed to show how they can be combined into Data Learning. We present a number of Data Learning methods and results for some test cases, though the equations are general and can easily be applied elsewhere.

Photo by Nathan Dumlao on Unsplash

Health

The links between health and climate change are undeniable. Climate change is already having an impact on people's health and health systems, directly and indirectly. Extreme weather events; growing heat stress; wildfires, floods and landslides; food and water safety and security threats; and the emergence and spread of infectious diseases, are expected to generate serious health risks and amplify existing health problems. The COVID-19 pandemic has only reinforced the urgency of action.

To understand, anticipate and minimize the health threats caused by climate change, the European Commission and the European Environment Agency, together with other key players in the field, launched in March 2021 the **European Climate and Health Observatory**. Valentina Giannini and Katie Johnson, CMCC scientists and ETC/CCA task managers coordinating the European Climate Adaptation Platform Climate-ADAPT, are task managers of the virtual Observatory, that will be a first concrete deliverable of the European Commission's new Adaptation Strategy.

European Climate and Health Observatory

"Code red for a healthy future".

Claims the 2021 report of the Lancet Countdown on health and climate change, the international collaboration that independently monitors the health consequences of a changing climate, edited by the outstanding journal on medical science. CMCC researcher Shouro Dasgupta is among the 90+ authors, world-leading experts from academic institutions and UN agencies spanning every continent, that have looked at more than 40 indicators to track the relationship between health and climate change. He presented the Report in the Bangladeshi Launch on December 4, 2021, contextualizing the findings of the Report in the context of Bangladesh, and providing a clear imperative for accelerated action that puts the health of people and planet above all else.

Sustainability, circular economy and one health.

People, ecosystems and animals are closely interconnected and health is a topical and crucial part of this complex link. For a better understanding of the interactions between climate change, health and sustainability in the context of livestock farming, a Framework Collaboration Agreement "Sustainability, Circular Economy and One Health" has been signed between CMCC Foundation and Istituto Zooprofilattico Sperimentale del Lazio e della Toscana 'M. Aleandri'. The Agreement formalizes the collaboration between the two institutes to carry out scientific activities, training courses, exchange of expertise and promotion and implementation of other initiatives linked to thematic areas of common interest.

Air pollution, health and agriculture.

Italy is the second EU country for premature deaths from air pollution. The COVID-19 pandemic has made air pollution more salient, by raising awareness of its devastating effects and amplification of concurrent diseases, including viral ones. However, it has also made clear the extent to which agriculture and livestock are part of the problem, and should likewise be part of the solution. CMCC-EIEE is a partner of the project INHALE – Impact on humaN Health of Agriculture and Livestock Emissions, that seeks to understand the health impact of agricultural industry and livestock farming on air pollution using data science methods. Moreover, the project will support the design and development of sustainable agricultural policies.

EIEE's studies on the effects of the COVID-19 lockdowns on pollution reduction in northern Italy have been reported by National Geographic.

The impact of climate change on child health, food security and inequalities.

Climate change affects human health in a number of complex ways. It is critical to quantify these impacts to identify hotspots and aid evidence-based policy making. CMCC studies on their impacts on child health and how heat stress has had an increasingly negative impact on food security, amplifying existing inequalities, have been presented in a CMCC Webinar on April 27, 2021 and in a Glasgow COP26 Health Pavilion Side Event on November 9, 2021, where an international panel of experts discussed the implications of these findings for policies that can reduce food insecurity and undernutrition; and build resilience in lower-income countries.

Economy, poverty and climate in the post-COVID-19 era.

A study led by the RFF-CMCC European Institute on Economics and the Environment (EIEE) and the International Monetary Fund predicts the economic impacts of COVID-19 will persist in the coming years, based on an analysis of the effects of five previous major epidemics in this century (SARS, H1N1, MERS, Ebola and Zika).

Scientists estimated how past pandemics affected our economies and societies and found that they led to significant and persistent reductions of GDP, along with increases in unemployment, income inequality and public debt-to-GDP ratios.

The research shows that energy demand and CO2 emissions drop significantly during a pandemic event, but mostly because of the persistent decline in the level of economic activity rather than structural changes in the energy sector. Only about one-third of CO2 emission reduction can be attributed to the decarbonization of energy, an insufficient share to contribute significantly to a greener economy, as without deliberate policy actions, initial environmental gains will not remain entrenched.

Applying historical estimates to project the impact of COVID-19, the study foresees significant scarring in economic performance and income distribution through 2025.

The combined impact on economic growth and inequality has led to an increase in poverty of approximately 75 million people in 2020, and also here policies are key to revert this process" says Emmerling, specifying that the study likely provides lower-bound estimates of the effects of COVID-19, since it is more widespread than the average health crisis in the considered sample and containment measures undertaken to limit the contagion are without precedents.

These projections, affirm the authors, point to the need for a strong policy response to counter the lingering adverse effects of COVID-19 and show how the recovery packages should align to sustainability targets.

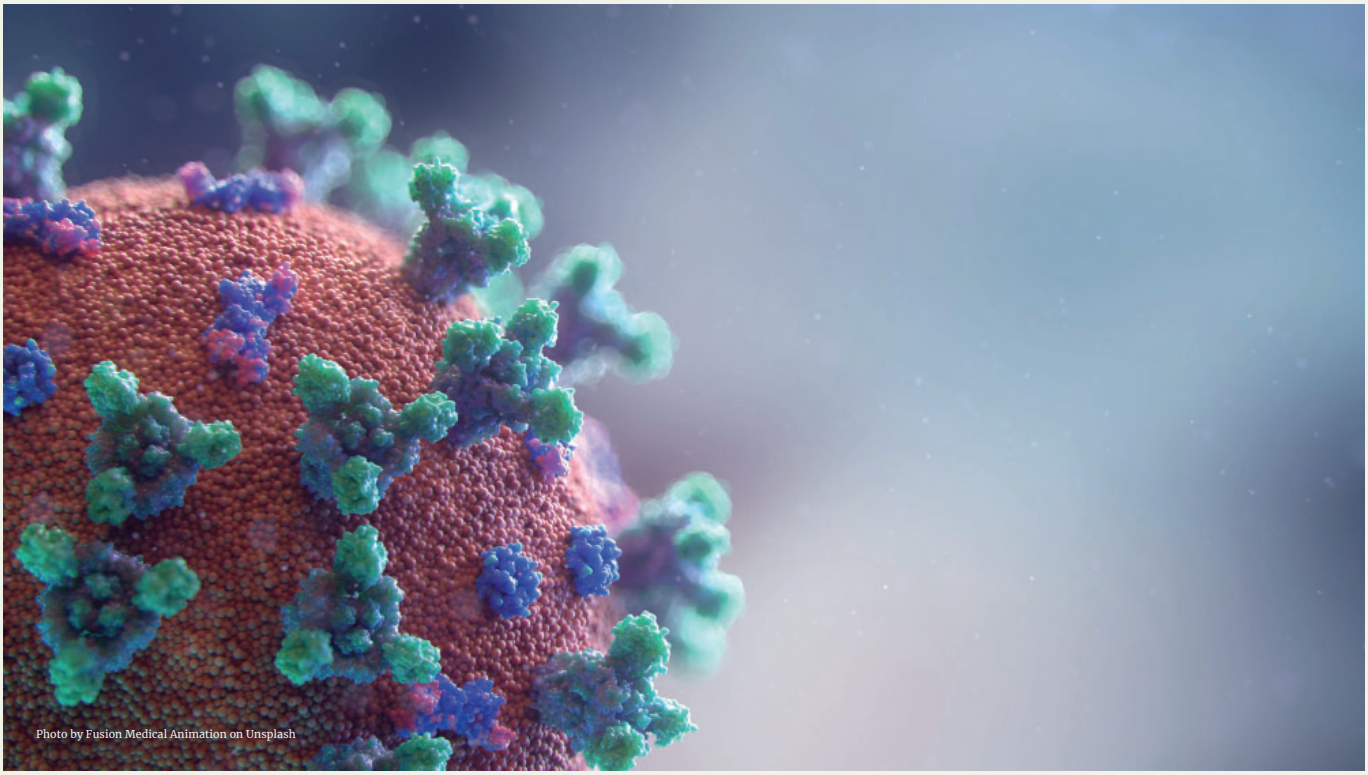


Photo by Fusion Medical Animation on Unsplash

Climate impacts on health and urban areas: heatwaves and death rate.

Over the last half-century, the probability of heat extreme events has changed by orders of magnitude in almost every region of the world, with occurrences that are now up to a hundred times more in respect to a century ago. Of all-natural disasters, extreme high temperature events are the main cause of weather-related mortality and they are also expected to be the main factor responsible for additional deaths due to climate change in the coming years.

In cities, the heat island effect creates higher temperatures than in vegetated areas. But conditions within urban areas are not equal in all their parts – either due to their physical form or to the specific needs or vulnerabilities of inhabitants – therefore not all districts of a city are equally vulnerable to heatwaves. Thus, identifying those areas which are particularly vulnerable to heat stress is particularly important to implement interventions at local level aimed at improving the capacity to cope with the impacts of heat waves on citizens' health.

The literature review "The heat-health nexus in the urban context: A systematic literature review exploring the socio-economic vulnerabilities and built environment characteristics", published on the Journal "Urban Climate", conducted by the CMCC Foundation in collaboration with Ca' Foscari University of Venice and disseminated on CMCC website, aimed at exploring which vulnerability factors determine the nexus between the heat and the health outcome in a urban context. The analysis selected forty articles from the vast literature on the subject, extracted from two well-known databases of peer-reviewed literature (Scopus e PubMed).

Photo by NASA on Unsplash

From Science to Society

Climate change and its impacts stand center stage among today's global issues. Now more than ever, making informed and efficient decisions that help build a better future requires a combination of reliable scientific data, as well as innovative and smart tools to analyze and make sense of it. These include climate services, knowledge-intensive business services that employ a range of advanced physically-based models and model simulations. This is how climate-related data can transform into customized products - such as projections, forecasts, trends, economic analysis - at the service of society and the policy sphere.

A Study on Adaptation Modelling

Was commissioned by the EU Commission's Directorate-General for Climate Action to a group of international scientists coordinated by the CMCC Foundation and hosts the experiences of the main EU experts on climate adaptation modelling. The research supported better-informed decision-making on adaptation, which is among the priority areas of the EU Strategy on adaptation to climate change. The project provided an up-to-date and forward-looking overview to inform the elaboration and assessment of investment and policy options. In 2021 this led to 6 open access publications on the Publication Office of the EU website and an important accompanying event to the launch of the new EU Adaptation Strategy.

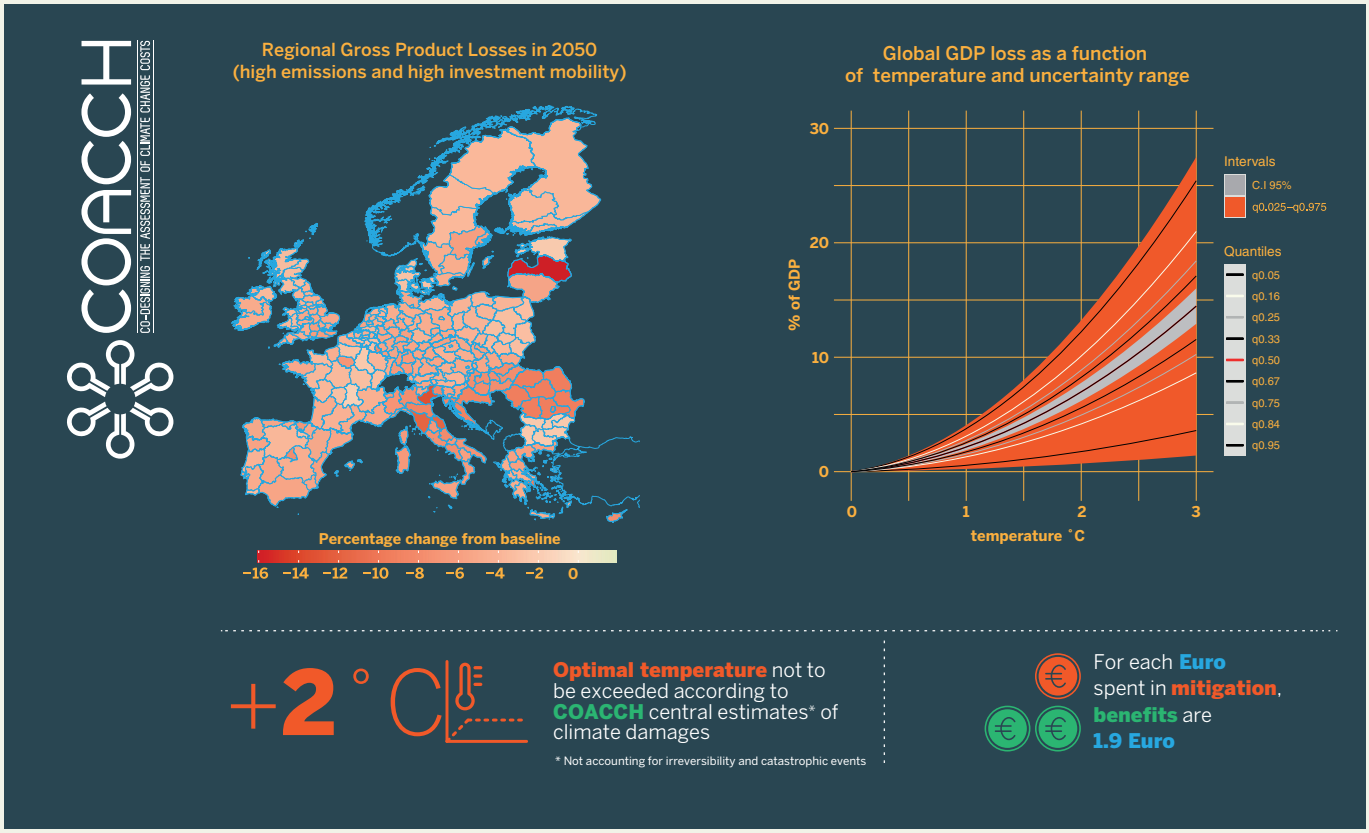
Event accompanying the adoption of the new EU Climate Adaptation Strategy

Science informs policy through climate services.

"Climate services born out of the recognition that climate information and knowledge is not or not sufficiently used for and relied on in tactic and operative decision making" explained Jaroslav Mysiak, director of the CMCC division on Risk Assessment and Adaptation Strategies division at the 2nd biennial EU Conference on modelling for policy support, organised by the European Commission Competence Centre on Modelling in November 2021. At the international event, lessons learnt were presented from two Horizon 2020 funded projects coordinated by the CMCC Foundation, COACCH (CO-designing the Assessment of Climate CHange costs) and CLARA (Climate forecast enabled knowledge services), in a discussion on the role of climate change adaptation modelling as a key support tool for evidence-based policies in a time of planetary crisis.

Exploring climate change impact scenarios.

Interactive, user-friendly, and based on open-access data: the Climate Change Impact Scenario Explorer is a web-based tool that allows expert and non-expert users to assess the projected economic impacts of climate change in all EU countries in a variety of different sectors: from forestry to fishery, agriculture, transport and energy – just to name a few. From a co-design process to the delivery of solutions, decision-makers can now visualize and use up-to-date climate data by navigating through sectors, timelines, scenarios, and regions with the new tool provided by COACCH (CO-designing the Assessment of Climate CHange costs), a Horizon 2020 project coordinated by CMCC and concluded in 2021. COACCH produced an improved regionalized physical and economic assessment of the risks and costs of climate change in Europe, including climatic and socioeconomic tipping points. All the outputs are accessible by different users from the business, investment, and the policy making community.



Cities in the Adriatic region at the forefront of climate change impacts.

Coastal and river floods, coastal erosion, subsidence, salinization of aquifers, droughts, heat waves: the Adriatic coast is getting ready for the impacts of climate change with new and updated adaptation plans based on scientific evidence. The Italian-Croatian Adriadapt project coordinated by the CMCC Foundation launched in 2021 a multilingual adaptation platform that offers solutions for dealing with the predicted impacts of climate change on the area, and presents the adaptation plans adopted by Italian and Croatian cities.

Improving water management and resilience to extreme weather events.

An integrated Toolbox for a climate-proof management of water resources through sustainable land-use management was designed and developed in the framework of the Interreg Central Europe TEACHER-CE project (joinT Efforts to increase water management Adaptation to climate CHanges in central EuRope), of which the CMCC Foundation is a partner. The toolbox includes a web map service that provides a spatial orientation on all identified issues in water management, provides information on climate change scenarios with key indicators, navigation through EU and national data portals, links to the tools developed in past EU projects and an integrated comprehensive catalogue of measures.

Photo by Anders Jildén on Unsplash

Science-based evidence to reach climate neutrality in Europe.

CMCC is a partner of the European Climate and Energy Modelling Forum, a Horizon 2020 funded project whose aim is to establish a European forum for energy and climate researchers and policy makers to achieve climate neutrality. The Forum will inform future energy and climate policies at national and European level and present a more coherent, unified evidence base that will, in turn, form a concrete basis for action by policy makers.

Tailored coastal restoration.

Healthy and climate-resilient European coastal regions achieved through innovative large-scale systemic restoration, enhance the delivery of ecosystem services and improve coastal biodiversity. To overcome present hurdles to upscale coastal restoration interventions through new technical, financial, management and transfer tools, aligned with the needs of coastal vulnerable regions and society, an international consortium of 37 institutions launched the new project REST-COAST (Large scale RESToration of COASTal ecosystems through rivers to sea connectivity). CMCC leads the Venice pilot.

Science-based evidence to reach climate neutrality in Europe.

CMCC is a partner of the European Climate and Energy Modelling Forum - ECEMF , a Horizon 2020 funded project whose aim is to establish a European forum for energy and climate researchers and policy makers to achieve climate neutrality. The Forum will inform future energy and climate policies at national and European level and present a more coherent, unified evidence base that will, in turn, form a concrete basis for action by policy makers. ECEMF will provide content arising from the first inclusive and open full-scale model comparison exercise on achieving climate neutrality in Europe, including from the outset over 20 models and 15 top research groups, to produce a coherent and relevant evidence-base for energy and climate policy impact assessment.ECEMF's evidence-base will support the development of policy-relevant insights which will be communicated to and discussed with the key decision makers via a range of novel methods, including interactive embeddable visualisation blocks, policy briefs, workshops and high-profile events.

Photo by Melanija Tacconi on Unsplash

Zero Carbon World

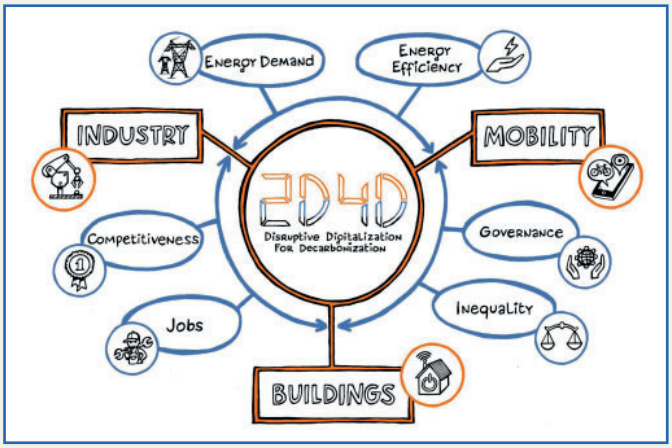
As our planet increasingly faces the unpredictable consequences of climate change and resource depletion, urgent action is needed to switch to a more sustainable development model. In order to meet the 1.5°C temperature increase goal set out in the Paris Agreement, global carbon emissions must reach net zero around mid-century. The solutions on the table are many: renewable energy, advances in technology, a more active financial sector, carbon pricing. CMCC contributes to advance the international dialogue on zero carbon by taking part in several innovative research projects and authoring cutting-edge scientific publications.

Sustainable finance for a smooth low-carbon transition.

The threat of climate change calls for a rapid transition to a low-carbon society. Aligning the financial system with climate stability is a crucial prerequisite for achieving decarbonization while preserving economic prosperity and societal welfare. CMCC is exploring this topic through SMOOTH, a H2020 project which will lay the foundations of an innovative macro-financial analytical framework to provide essential insights on the links between financial systems and decarbonization dynamics. SMOOTH plans to create a new interdisciplinary field of research integrating elements from macroeconomic modeling, climate economics, political economy, behavioural finance, transition theory and political science, with the aim of developing a solid understanding of the links between finance and the low-carbon transition.

Digitalization to reach net-zero.

Digitalization will fundamentally change all sectors of the European economy in the next decades. At the same time, the EU is committed to reaching net-zero carbon emissions by 2050. These two transformations will undoubtedly affect each other, but the extent to which they will be mutually supporting is currently unknown. Most importantly, there is a danger that the digital transformation will delay the progress towards a net-zero carbon economy. The 2D4D project, funded by the EU through an ERC Grant and participated by CMCC within the SEME – Sustainable Earth Modelling Economics Division, aims at ensuring that the digital transformation is not a barrier to decarbonisation, rather an enabler. The project will identify and measure the decarbonisation consequences of three disruptive digitalisation technologies in hard-to-decarbonise sectors: additive manufacturing in industry, mobility-as-a-service in transportation, and AI in buildings. The project will produce a distinctive data collection to examine the technical and socioeconomic potential of these technologies, enhance decarbonisation narratives and ensure that digital technology supports energy transition.



A method to ensure accurate estimates of the collective climate progress.

To limit global warming and achieve the goal of the Paris Agreement, we must change the way we use land while reducing emissions from deforestation, as well as enhancing the current capacity of CO2 sinks. Changes in land use and land management contribute around 14% of the total global anthropogenic CO2 emissions, mainly through deforestation. The study, led by the European Commission's Joint Research Centre and realized with the collaboration of the CMCC Foundation (among the authors, CMCC scientist Lucia Perugini), reconciles the different land-use GHG estimates by "translating" the results of global models into figures comparable to countries' GHG inventories. The findings of the study are relevant for the global carbon modelling community (including the Intergovernmental Panel on Climate Change) and for the Global Stocktake (the periodic assessment of collective climate progress starting in 2022 under the Paris Agreement).

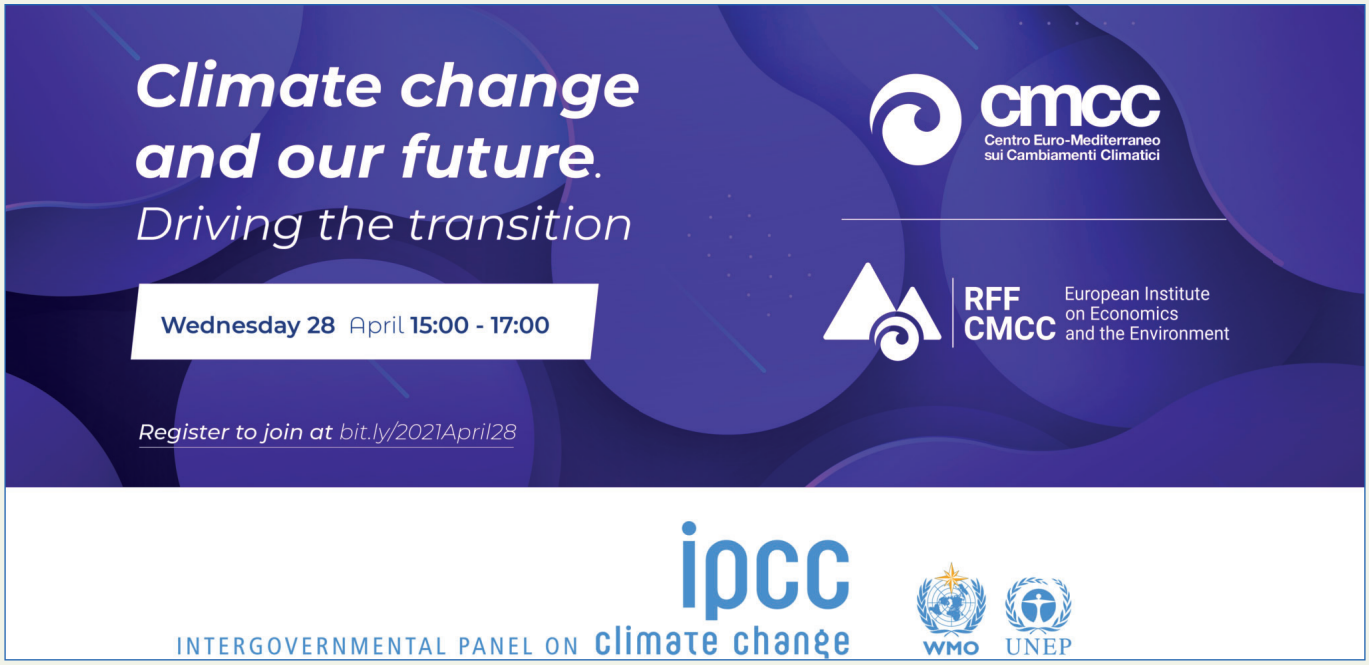
Photo by Casey Horner on Unsplash

IPCC WGIII eLAM4 Outreach Event – Climate change and our future: driving the transition.

Right before the release of the IPCC Sixth Assessment Report cycle (AR6), an eagerly awaited report of the last six years and in the most important year for renewing climate ambition, Working Group III (WGIII) of the Intergovernmental Panel on Climate Change (IPCC), CMCC, and the RFF-CMCC European Institute on Economics and the Environment (EIEE) organized the interactive online event Climate change and our future – driving the transition. Held on 28 April 2021, it provided expert insights on how to drive the future of the climate transition, in a dialogue between science, institutions, novel writing and the young generations.

Financing a sustainable Europe.

Global investments hold the key to fighting climate change, with trillions already invested in solutions such as renewables and energy efficiency. The Paris Agreement could represent a massive investment opportunity. How to unlock it? Re-orienting private capital to more sustainable investments, which requires a comprehensive rethinking of how our financial system works. This is necessary if the EU is to develop more sustainable economic growth, ensure the stability of the financial system, and foster more transparency and long-termism in the economy. CMCC has explored the opportunities and challenges of sustainable finance in the EU in an article on its digital magazine Foresight (www.climateforesight.eu), with a contribution by Jaroslav Mysiak, Director of the CMCC Risk Assessment and Adaptation Strategies - RAAS Division.



The Climate Neutrality Forum.

Bringing together leading researchers, policymakers and practitioners, the Climate Neutrality Forum aimed to explore the challenges and opportunities in the achievement of climate neutrality in Europe and globally in the context of the goals of the Paris Agreement, the statements of policy ambition to 2030 and 2050, and the implications of the latest findings provided by the IPCC Working Group I report. The event, jointly organized by Mercator Research Institute on Global Commons and Climate Change, the RFF-CMCC European Institute on Economics and the Environment and Oxford Net Zero at the University of Oxford, took place simultaneously in four hubs: Milan, Berlin, Brussels and Oxford.

After COP26. Challenges and opportunities for GHG monitoring.

Right after COP26 in Glasgow, CMCC and ICOS Italy organized a webinar to discuss the perspectives, challenges and needs emerged from the international dialogue involving governments from all over the globe. The meeting created an opportunity for debate among representatives from the world of institutions, experts, and scientists. The first part of the event was devoted to speeches by institutional representatives and environmental experts, and was followed by a roundtable to discuss opportunities for collaboration and exchange between ICOS Italy and the numerous institutional partners at national level.

CMCC is a partner institution of ICOS Italy and within the ICOS Research Infrastructure (RI) is also commissioned to coordinate the ICOS ETC for Italy.

Watch ZERO CARBON | The era of climate opportunity - with Michael E. Mann & Marina Lalovic

A live streaming event for the CMCC Climate Change Communication Award "Rebecca Ballestra", as part of the series Seeds. Words that feed the future

Risk Analysis

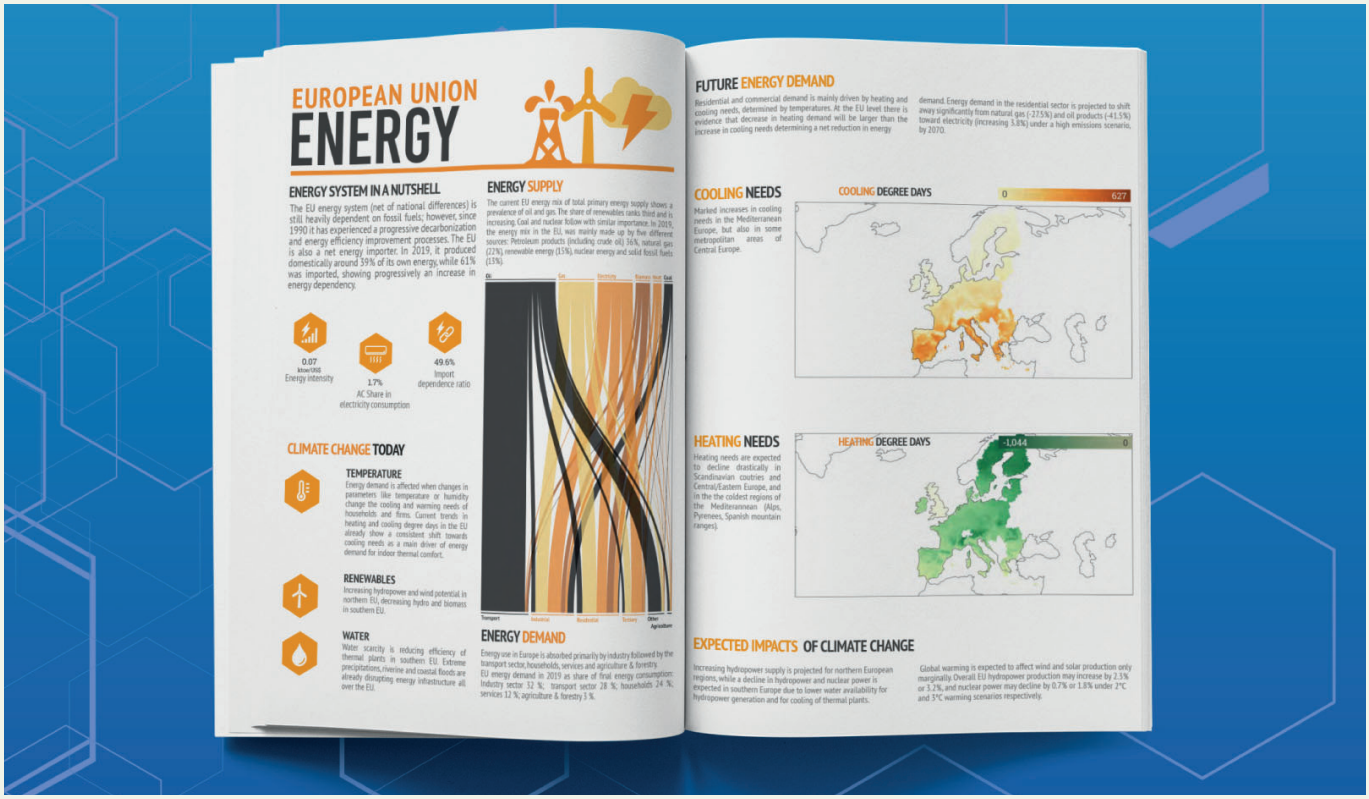
Photo by Saikiran Kesari on Unsplash

From coastal erosion to the spread of tropical diseases, every country in the world is at risk from the impacts of climate change. Among other impacts, research shows that rising temperatures and intense heatwaves could cause severe droughts, threatening essential water supplies for agriculture, causing huge loss of human life and increasing the chance of fires. It is therefore crucial to be able to predict, as precisely as possible, the risks deriving from climate change impacts all over the world.

The G20 Climate Risks Atlas.

On the eve of the G20 meeting in Italy, CMCC released the G20 Climate Risks Atlas. Impacts, Policy, Economics, a series of Country Factsheets which summarises scientific projections of how climate impacts will play out in the world's most industrialized countries over the coming decades.

Based on the most advanced scientific knowledge available on the topic, the study is the first of its kind, and the Atlas is easy to be consulted, designed with a mix of infographics, maps and short narrative descriptions using a simple language. Impacts, risks, and interactions with climate change that are expected by the middle and end of the century are assessed at the national level, under different degrees of warming and development models, with an in-depth analysis of key sectors of the G20 economies.



Risk analysis: climate change in six Italian cities.

If we think about the Italian urban system, where more than 56% of the population resides, its physical and structural characteristics in terms of quantity and quality of the built environment - with a high presence of impermeable surfaces and limited green areas - it is clear that our urban centers are real hot-spots for the consequences of climate change. This means that extreme phenomena such as heatwaves and intense rainfall can produce impacts with a higher intensity, putting the health and safety of populations at serious risk. In order to limit these negative consequences, studies and analyses are needed to identify the risks of each individual urban reality and to implement the most appropriate response tools that take into account the peculiarities of the different territories.

In this context, the report "Risk analysis. Climate Change in Six Italian Cities" produced by CMCC provides an integrated risk analysis aimed at providing information on the expected scenarios for six of Italy's largest cities and how they are preparing to cope with the expected risks. This in-depth analysis uses for the first time the results of high-resolution data to propose an overview of the climate, impacts, risks and tools that Bologna, Milan, Naples, Rome, Turin and Venice will provide themselves with. The interactive report also includes numerous dedicated infographics to be consulted online or downloaded.

Assessing climate risks through new macroeconomic models.

The development of new models to assess climate-related risks for the financial system and to define the role of central banks in their management is the core pillar of a novel project funded by the **International Network for Sustainable Financial Policy Insights, Research and Exchange (Inspire)**. A team involving researchers from **RFF-CMCC European Institute on Economics (Milan)**, **Bocconi University**, the **Institute of Economics of the Sant'Anna School of Advanced Studies in Pisa**, **Polytechnic University of Milan** has been awarded a research grant to support central banks and governments' coordination in managing climate risks.

The project aims to develop a new macroeconomic model, capable of analyzing both physical and transition risks for the global financial system, so far analysed separately by the scientific literature. Over the next years, a new approach to modeling climate risk for macroeconomic dynamics will be developed, focusing in particular on understanding how fiscal policy, monetary policy and macroprudential policy can interact in a synergistic way to ensure a rapid and orderly transition towards a zero-emission economy by 2050.

Enhancing risk-informed management and decision-making in the EU.

In order to predict and tackle climate change risks, policymakers, decision-makers and practitioners must develop forward-looking disaster risk management pathways that assess trade-offs and synergies across sectors, hazards, and scales. To help them succeed in this task is the aim of the H2020 MYRIAD-EU project, in which CMCC participates through the RAAS - Risk Assessment and Adaptation Strategies Division.

The project aims to co-develop the first harmonised framework for multi-hazard, multi-sector, systemic risk management. It provides a set of practical guidelines for carrying out a multi-risk assessment, formalised in guidance protocols. It also developed a web-based dashboard for navigating the framework, which gives access to state-of-the-art products and services of MYRIAD-EU and links to key resources from external projects.

Central to MYRIAD-EU is a laboratory of systemic multi-hazard risk assessment and management. Within this laboratory, the project co-develops the framework, and products and services to operationalise the framework, with stakeholders in five multiscale Pilots: North Sea, Canary Islands, Scandinavia, Danube, Veneto. Each Pilot focuses on (interlinkages between) three of the following six sectors: infrastructure & transport, food & agriculture, ecosystems & forestry, energy, finance, tourism. For each Pilot, the project examines multi-hazard risk within the region, as well as indirect, cross-sectoral, and interregional risks throughout the EU.

Sectoral Information System to Support Disaster Risk Reduction.

Copernicus is the European Union's flagship earth observation programme. The European Centre for Medium-range Weather Forecasts (ECMWF) has been appointed by the EU to operate the Copernicus Atmosphere Monitoring Service and the Copernicus Climate Change Service on its behalf, and CMCC has been contracted by ECMWF to develop a climate change service to support Disaster Risk Reduction (DRR) in Europe. The service exploits Copernicus C3S data and generates knowledge required for assessing risks from extreme weather and climate related events. The features of the artifacts developed within Sectoral Information System to Support Disaster Risk Reduction have been described in a dedicated webinar: two different datasets and two applications hosted by Copernicus Climate Change Service (C3S) with the goal to generate information required for assessing risks associated to extreme rainfall events in Europe, starting from data already available in the platform but also defining new ones (such as the downscaled re-analysis of ERA5 at 2 km over selected 20 cities). The artifacts have been developed according to the consultation of the representative organisations, business entities and policy networks brought on board during the first phase of the project to identify data gaps and user needs.

More specifically, during the workshop the features of the dataset and applications developed covering different aspects were presented, such as: evaluation of precipitation indicators over historical periods related to extreme precipitation over all the European areas by using different dataset (E-OBS and ERA5); catalogue of extreme precipitation events: Ranking of past extreme precipitation events in terms of affected area, magnitude and severity (impact/losses) at pan-European scale (daily data) and city scale for 20 case studies in Europe (by using sub daily data); pluvial flooding hazard: inundation probability maps and water depth for expected precipitation under fixed return period over 20 case studies; pluvial flooding risk: assessed damages for expected precipitation under fixed return periods for 20 case studies.

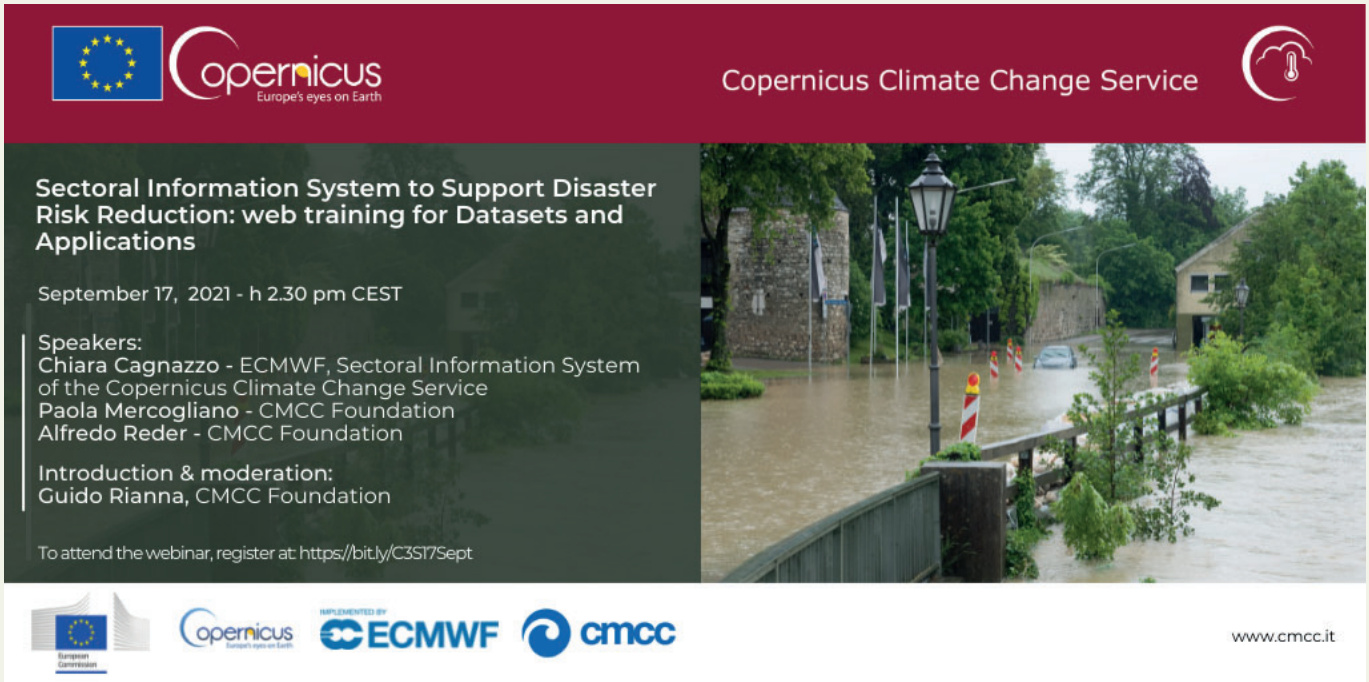


Photo by Arno Senoner on Unsplash

Land

Land is the main source of food, freshwater and energy for the planet. However, increasing exploitation due to human activities, along with the numerous and vast impacts of climate change are making it increasingly vulnerable and threatening its wellbeing. In this situation, sustainable land management is crucial as it can contribute to reducing the negative impacts of multiple stressors, including climate change, on ecosystems and societies. The CMCC developed international projects and collaborations that focus on forests, biodiversity, land use and management, and food.

Climate and agriculture in the Mediterranean.

Worsening climate conditions are expected to threaten water supplies in the Mediterranean region and its agricultural systems, which rely extensively on irrigation. A profound understanding of the effect of climate change on crop water consumption and irrigation requirements is crucial to better manage water resources, particularly in regions largely affected by water scarcity with aggravating conflicts between water-demanding sectors.

In the study "A modelling platform for climate change impact on local and regional crop water requirements", an international team of scientists led by CMCC in collaboration with the IHE Delft Institute for Water Education, UC Davis, and the University of Sassari elaborated assessments of crop consumption and irrigation requirements under future climatic conditions. The results provide guidelines for precision agriculture at a local scale and help evaluate requirements at a larger scale. This couples big data with climate projections to support climate change adaptation policy planning.

Photo by Markus Spiske on Unsplash

The link between biodiversity and resilience of the agricultural sector in European Mediterranean countries.

Estimating the impact of climate change on the agricultural sector by assessing the importance of preserving biodiversity to increase the resilience of agroecosystems in Mediterranean Europe: this is the subject of the study of CMCC researcher Lea Nicita, who has been awarded the International Sustainability and Food Award on World Food Day 2021, at the 6th edition of the Bologna Award. From Nicita's studies, focused on the Mediterranean basin – referred to as a hotspot for climate change due to the increased risk of drought – it appears clear that biodiversity contributes significantly to the value of land and to the profitability of farms. These data provide policymakers with a measure of the potential benefits to farms and allow the distribution of these benefits to be mapped over the territory.

Preventing and fighting extreme wildfires: Ofidia2 and SILVANUS projects.

Rising temperatures are progressively increasing the threat of wildfires in forests and rural areas, with many severe consequences on biodiversity and socio-economic systems.

The recently concluded Interreg Italy-Greece project Ofidia2, coordinated by CMCC, provided a network of technologies, infrastructures and scientific knowledge to support environmental protection measures in the region of Puglia (Italy) and in Epirus (Greece) by setting up an operational big data infrastructure. Its main goal was to prevent wildfires and protect biodiversity by means of fire hazard forecasting and real-time monitoring, along with a dedicated wildfire control room and specific equipment. The project also focused on environmental lifelong learning through activities that aim to raise awareness of forest and biodiversity protection.

Human, environment and economy resilience to wildfires is also being addressed by CMCC within SILVANUS: this H2020 project, currently ongoing with a consortium of more than 40 partners from all over Europe and beyond, envisages to deliver an innovative, environmentally sustainable technological platform for forest management providing decision-making support in preparedness, response and recovery phase of the wildfire management cycle.

A global transition towards sustainable food production and consumption.

Informing and engaging citizens to adopt sustainable diets is a key strategy for reducing global environmental impacts of the agricultural and food sectors.

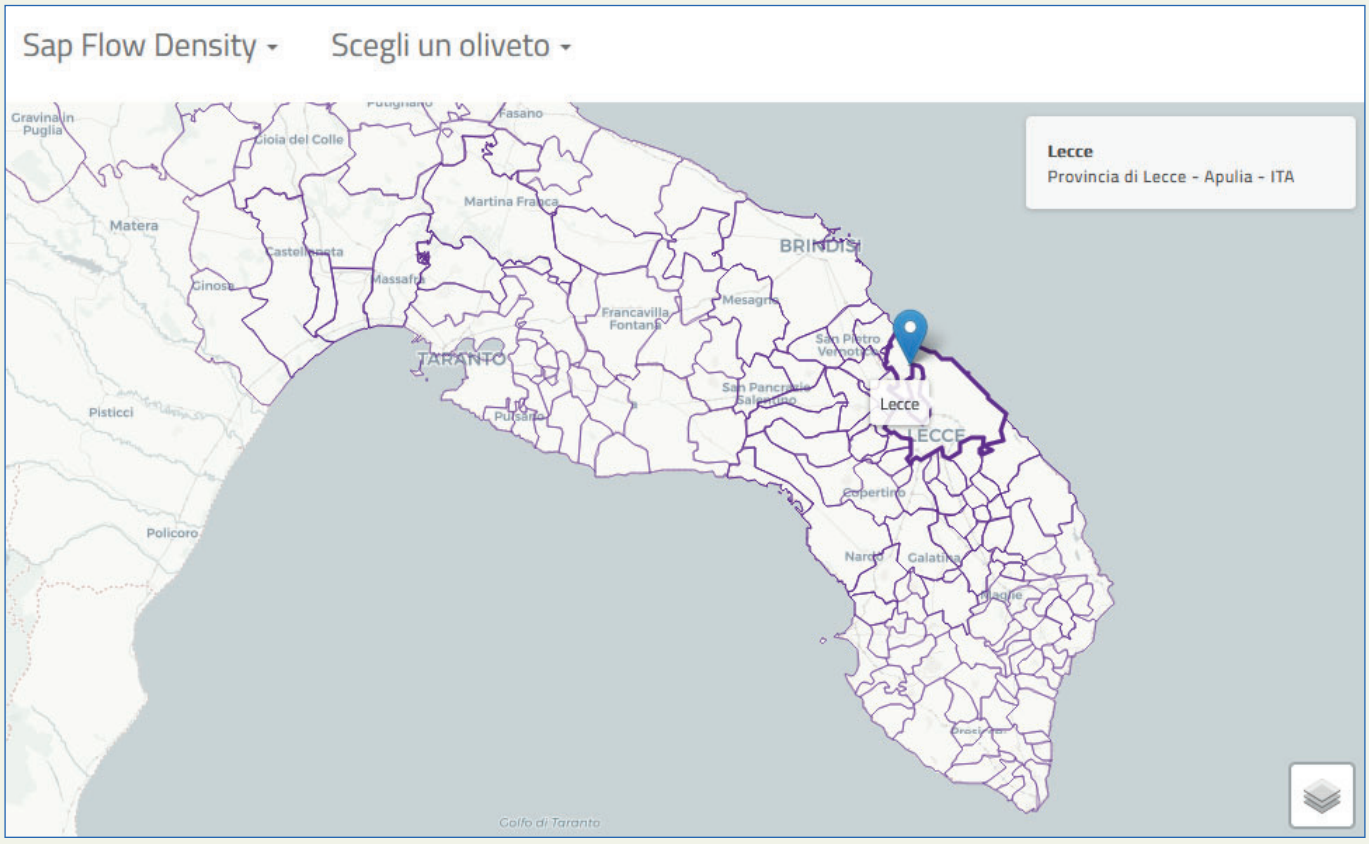
The first requisite to support citizens and actors of the food sector is to provide them a publicly available, reliable and ready to use synthesis of environmental pressures associated with food commodities. Researchers from CMCC along with University of Tuscia and other institutions released the **SU-EATABLE LIFE** database, a multilevel database of carbon (CF) and water (WF) footprint values of food commodities, based on a standardized methodology to extract information and assign optimal footprint values and uncertainties to food items. Developed in the framework of the EU SU-EATABLE LIFE project, the database provides a solid basis for evaluating the impact of dietary shifts on global environmental policies, including climate mitigation through greenhouse gas emission reductions. Moreover, it ensures repeatability and further expansion, providing a reliable science-based tool for managers and researchers in the food sector.


Photo by Megan Thomas on Unsplash

Listening to the plants. The ANTIDOTE project.

Climate change is altering many natural ecosystems, causing new or existing bacteria to spread and attack different species of plants and trees, sometimes causing real pandemics. With these increasing levels of stress to the agricultural system, understanding and predicting the environment surrounding us becomes crucial. CMCC was involved in the recently concluded ANTIDOTE project (frAmework for moNiToring Detection and fOrecasTing for xylElla), which created a system for the diagnosis and monitoring of the Xylella Fastidiosa (Xf) bacterial disease. Relying on interdisciplinary expertise, the system allows to identify the state of some plant parameters (xylem) and geographical conditions (climatic - environmental, territorial - management - related) that, in isolation or combined, can characterise, trigger, favour or accelerate Xf infections and the subsequent symptoms of desiccation. The ultimate objective of the system is to support the mapping and prediction of the risk of desiccation in one or more plants in a monitored field.

The ANTIDOTE project also aims to foster the development of know-how on monitoring techniques, techniques for diagnosing the bacterium, as well as environmental and agronomic factors predisposing the spread of infections and proper vegetative-productive growth of plants.



Greenhouse gases and climate change, the contribution of JRU ICOS Italy.

High-quality data, monitoring and measurement stations, cutting-edge technology and innovation, and integration into a first-class European network: ICOS Italy, the Italian network for the measurement of greenhouse gas emissions, has a strategic role in facing the challenges launched by the Glasgow Climate Pact at the recent COP26., while providing scientific support to decision-making processes towards a zero carbon society.

With its 17 stations (10 for terrestrial ecosystems, 4 for the ocean, 3 for the atmosphere) and with the coordination and direction of the Ecosystem Thematic Centre, ICOS Italy aims to be the point of reference for making available data on emissions and carbon balance in our country, with increasingly advanced information.

A public event entitled "After COP26. Science, Challenges and Perspectives for Greenhouse Gas Monitoring" was the occasion for a wide-ranging and participatory debate on the topic, with the participation of representatives from the Ministry of Education, University and Research, the Ministry of Ecological Transition, and the Ministry of Agriculture, Food and Forestry, along with representatives of the research world aggregated around Icos Italia.

In the presence of a large and participatory audience, speakers addressed numerous themes that emerged from the COP26 by providing a multidisciplinary insight into how the highest quality data that are collected by the ICOS network can contribute to strategies to combat climate change, especially with regard to greenhouse gas emission and GHG sink. It was also clear from the dialogue among the participants that the Italian scientific community, together with the network of Institutions and Local Authorities, is ready to lead at the international level the ambitious actions envisaged by the Paris agreements and COP26, also by taking advantage of some of the substantial funds that the PNRR will make available in the coming years.

Photo by Daniele Colucci on Unsplash

Ocean

The ocean and the cryosphere play a fundamental role for life on Earth, and they are an indicator of the health of our planet. The constant increase in the global temperature due to past and current GHG emissions is causing severe consequences for this system: the ocean is becoming warmer, more acid and less hospitable for biodiversity. The melting of the ice is causing sea level rise with consequent extreme events on the coastal areas becoming more intense.
CMCC is providing a scientific contribution to this topic with its observing and forecasting activities, while also taking an active role in international networks and organizing events dedicated to the ocean and its protection.

The key role of sea ice and snow in the polar and global climate system.

The Arctic and Antarctic regions are experiencing rapid and unprecedented changes due to polar and global climate change, clearly caused by anthropogenic activities. 21st century projections show substantial decrease of sea ice in both Arctic and Antarctic, which are expected to impact people in the Arctic and societies beyond polar regions. The study of sea ice and snow in the polar and global climate system is crucial to gain a more precise understanding of the ocean-ice-snow-atmosphere system and deliver improved models that describe polar and global climate. CMCC is partner of the H2020 CRiceS project, which brings together 21 international research teams from Europe, Canada, South Africa, India and Russia, at the forefront of polar and global climate research. The project focuses on improving model predictions of the role of polar processes in the climate system that consists of the oceans, ice and snow cover, and the atmosphere.

Improving and integrating the European Ocean Observing and Forecasting System: the EuroSea project.

Ocean is an essential part of the Earth's system. However, there are still fundamental gaps in our ocean observing and forecasting capabilities. These gaps limit our capacity to sustainably manage our activities and sustain ocean resources. CMCC is involved in the EuroSea project with several research divisions: Ocean Predictions and Applications - OPA, Ocean modeling and Data Assimilation - ODA, and Climate Simulations and Predictions - CSP. The project aims to deliver ocean observations and forecasts to advance scientific knowledge about ocean climate, marine ecosystems and their vulnerability to human impacts. The project also aims to demonstrate how the ocean is an essential part of an economically viable and healthy society not only today but also in the decades to come.

Mysea: CMCC research for marine turtle protection.

Loggerheads (*Caretta caretta* marine turtles), are the most common turtle in the Mediterranean, nesting on beaches from Italy, Greece and Turkey to Israel and Libya, but areconsidered a vulnerable species: the increasing impacts of fishing and in particular the impact and mortality of fisheries bycatch, that is the accidental capture of marine animals in fishing gear, loss of habitats, microplastics pollution in oceans and other human unsustainable activities, are potential deadly threats for sea turtles. CMCC is partner of MYSEA, a project coordinated and funded by Consorzio di Gestione Torre Guaceto that aims to create a "Puglia Marine Observatory" for the protection of *Caretta caretta* turtles. More in detail, the researchers of the CMCC Ocean Predictions and Applications - OPA Division provide the operational forecasts for the Mediterranean Sea needed to understand and identify the environmental parameters that influence the movements of sea turtles; CMCC is also responsible for the collection and analysis of the data sent by sensors on tortoise shells and is in charge of the development and management of the portal mysea.it.

Photo by Rita Lecci, CMCC Foundation

CMCC Webinar Series on the Arctic system.

Between September and October 2021, CMCC designed and organized a series of webinars dedicated to the Arctic system and its predictability. The events saw the participation of distinguished invited speakers from different institutions, and topics covered included regional predictions, short-term forecasts of the Arctic ocean-sea ice-atmosphere coupled system, and seasonal to multi-decadal timescales. All the webinars have been recorded and are available on the CMCC website and Youtube Channel.

Zero-emission waterborne transport.

On 15 June 2021, the European Commission took an important step towards the realisation of zero-emission waterborne transport. A Memorandum of Understanding (MoU) for a Co-Programmed Partnership between the European Commission and the Waterborne Technology Platform under the framework of Horizon Europe was adopted, and signed during the European Research and Innovation Days on 23 June 2021. CMCC is a member of the Waterborne Technology Platform.

The Partnership will provide and demonstrate zero-emission solutions for all main ship types and services before 2030, which will enable zero-emission waterborne transport before 2050. The Partnership will be essential to deliver solutions for pressing environmental and societal challenges. By doing so, the Partnership will strengthen the competitiveness of European industries in growing green ship technology markets and provide the capability to re-enter markets presently dominated by Europe's competitors.

Fisheries and ecosystem services.

Ocean net primary production, the fixation of CO_2 by marine phytoplankton, is the primary source of organic compounds and energy transfer to marine ecosystems. It is at the origin of marine life and provides livelihood to its ecosystems, supports the marine food webs and, consequently, fisheries production.

Climate change, by affecting various elements of the Earth system – from atmospheric circulation to marine physics, including sea water temperature – is expected to have impacts on ocean primary production. And alterations to primary production will have consequences and costs for all the marine ecosystem services that it supports.

The study "*Persistent uncertainties in ocean net primary production*", released with the participation of CMCC, highlights an uncertainty that represents a warning signal for climate change adaptation strategies, since it makes it hard for the world of research to provide clear information on ocean primary production to be used by decision makers to build policies to adapt to climate change.

An uncertainty that does not characterize other indicators related to climate change, such as global warming or ocean acidification. So far, the scientific literature suggested that there would be a global reduction in ocean net primary production for the next few decades, although considerable uncertainty was observed, as highlighted by the differences in the results of different models used. Previous literature on the topic, including that on which the IPCC Special Report "Ocean and Cryosphere in a Changing Climate" (2019) relies, uses outputs from the Coupled Model Intercomparison Project (CMIP5 – Phase 5). Instead, this study uses its evolution (CMIP6), which uses higher resolution models and allows for better representation of small-scale processes. CMIP6 also includes some processes that previously were not present or not explored in depth, such as biological nitrogen fixation or remineralization of nutrients by planktonic bacteria.

The implications of such significant uncertainty in the future of marine primary production are diverse and considerable, and have economic implications as well.

Photo by Paul Einerhand on Unsplash

Ocean. Stories of humans and climate change.

The ocean tells stories of climate change. Journalism brings them to the world. Kenneth R. Weiss is a Pulitzer Prize winner for Explanatory Reporting with his work on Altered Oceans, a five-part series – published in the Los Angeles Times – about the unfolding crisis in the world's oceans. As a writer and journalist, he focuses on science, the environment and public health. On World Ocean Day 2021, he joined a live-streaming and interactive dialogue session moderated by the renowned journalist Veronica Fernandes. The event "immersed" the audience in the deep intricacies of the ocean, revealing how climate change and pollution affect it and people's lives, and showing how stories grounded in scientific evidence can be made accessible to the public through journalism and writing. "My job as a storyteller is to show the human faces associated with what's coming", Weis explained. "I start with the science: I learn what I need to learn about a specific slice of the issue, and then I go and look for examples. How can I "show" a problem and not just "tell" the science? I think showing and telling stories is a much more powerful way to connect with people than just sum up science in clear language."

The webinar was part of "Seeds. Words that feed the future", a series of live streaming dialogues among experts and journalists on ideas and innovations to communicate and face the climate transition. Seeds is an initiative for the CMCC Climate Change Communication Award "Rebecca Ballestra."

Watch OCEAN | Stories of humans and climate change - with Kenneth R. Weiss

A live streaming event for the CMCC Climate Change Communication Award "Rebecca Ballestra", as part of the series Seeds. Words that feed the future.

Outreach

Photo by Ismael Paramo on Unsplash

Climate change is considered to be one of the most prominent challenges of our times. A pervasive topic that actively involves countless actors around the world, conditioning every sector of society. The scientific community is providing increasingly detailed and shared knowledge on the causes of climate change, the options to limit its impacts, and the solutions to build climate-resilient communities. Decision makers, both from the public and the private spheres, are strongly engaged as climate change is a cross-cutting challenge that can no longer be ignored. Civil society is putting pressure on leaders to transform knowledge into action. In this context, the communication realm has the important role to find languages and solutions best suited to describe the complexity of climate change and foster the transition.

The world's best initiatives raising awareness on climate change.

The first call for proposal of the CMCC Climate Change Communication Award "Rebecca Ballestra" gathered 108 projects from very different countries and contexts, drawing an inspiring landscape of initiatives innovating climate change communication. The CMCC Award focuses on innovative projects and initiatives that deliver engaging messages and communicate climate change in education, advocacy, media production and social engagement activities. It honours the memory of the artist Rebecca Ballestra, who was committed to shaping a sustainable future and promoting positive transformation processes in the fields of science, humanities, economy, ecology and art and collaborated with the CMCC Foundation in various cultural initiatives. The outcomes of the Award - determined by an outstanding international jury - together with the special mentions jointly assigned by CMCC Foundation and Radio3 Scienza, the Italian public radio's daily science show, were announced in Milan on September 30, 2021 at the event "Voices of the transition. Climate change communication for a sustainable future". The event brought together a collection of voices offering different points of view on how to address the same challenge: finding the words and means to raise awareness on climate change.

"Seeds. Words that feed the future" digital events.

Experts with ideas and innovations to communicate and face the climate transition joined in dialogue with journalists in the series of live streaming events "Seeds. Words that feed the future", which took place in May and June, 2021, featuring:

PHOTOGRAPHY | The power of images to communicate climate change - with Ed Kashi, award-winning photojournalist, filmmaker, public speaker, and educator, and Elisabetta Tola, science and data journalist, Radio3Scienza and Il Bo Live

SUSTAINABLE ARCHITECTURE | Nature is the best technology - with Eric Corey Freed, Award-winning architect, Founding Principal of organicARCHITECT, and Elisabetta Tola, Science and data journalist

OCEAN | Stories of humans and climate change - with Kenneth R. Weiss, Writer and Pulitzer Prize-winning journalist, and Veronica Fernandes, journalist, Rainews24

ZERO CARBON | The era of climate opportunity - with Michael E. Mann, Climatologist and geophysicist, director of the Earth System Science Center at Pennsylvania State University and Marina Lalovic, journalist at Rai – Radiotelevisione Italiana – Rainews24.

The most influential climate academics worldwide.

The 'Reuters Hot List' is the Reuters list of the world's top climate scientists, ranking 1,000 climate academics according to how influential they are. Eight out of twenty Italian scientists included in the ranking are part of the CMCC Foundation, with Massimo Tavoni, Director of RFF-CMCC European Institute on Economics and the Environment, leading the Italian ranking, followed by Valentina Bosetti, Enrica De Cian, Carlo Carraro, Silvio Gualdi, Antonio Navarra, Francesco Bosello, Simona Masina.

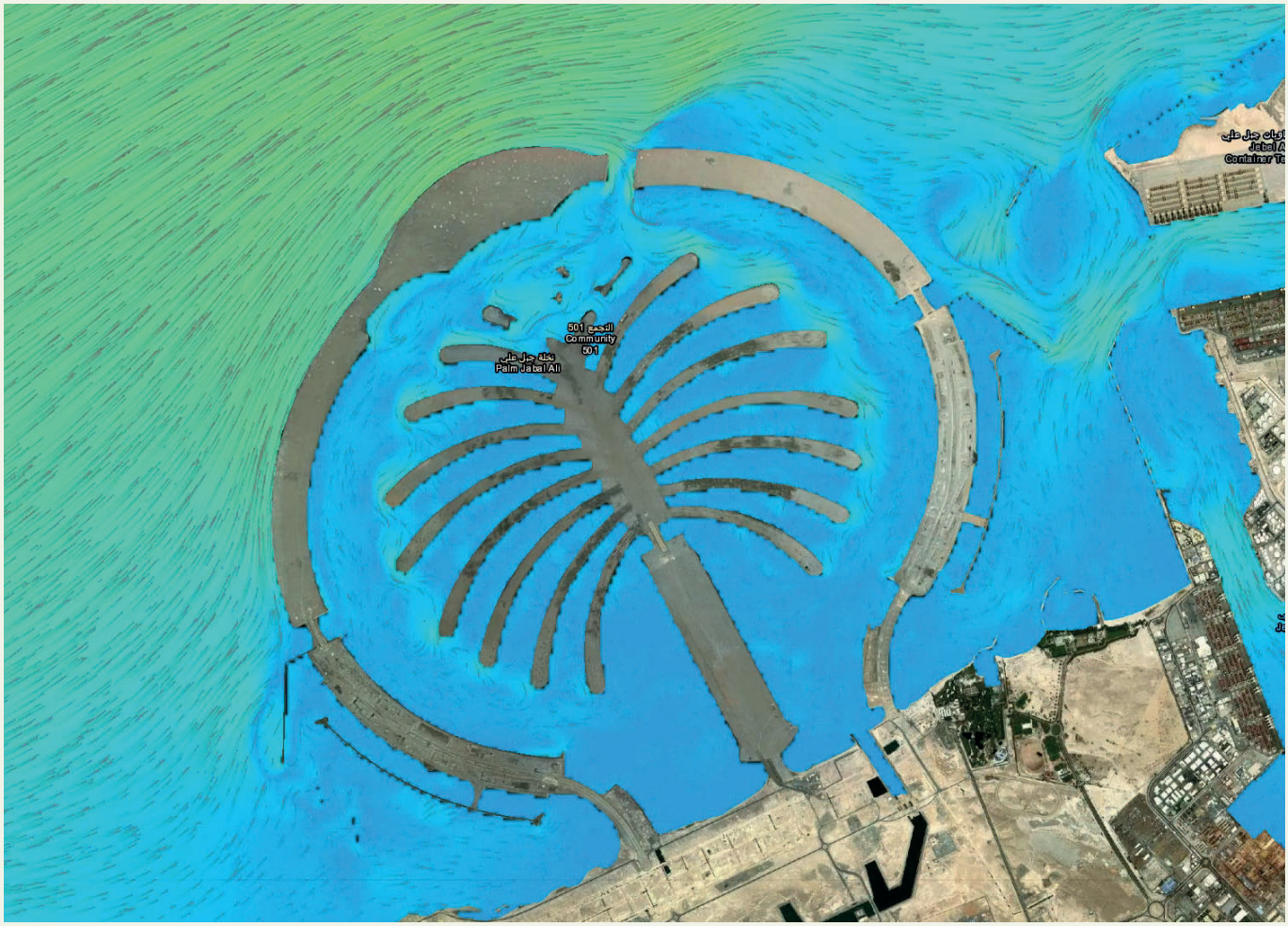
The CMCC at the Science Festival in Rome.

The CMCC Foundation contributed to the 16th edition of the Science Festival held in Rome from November 22 to 28, 2021 with four online events designed to bring climate science closer to society. One was dedicated to high school teachers to make the point on the current knowledge available on climate change. The second dealt with the energy transition, with a focus on solutions for low carbon societies, climate change mitigation strategies and the frontiers of energy research. The third focused on food, in light of some recent CMCC research on this issue, exploring the idea of a sustainable and healthy diet as a new approach to nutrition worldwide. The last one was about the UN Ocean Decade explained by some of its main protagonists.

The beauty of climate science at Expo 2020 Dubai.

Climate science, sustainable development and ocean exploration animated the Italy Pavilion at EXPO 2020 Dubai in virtue of the collaboration between the CMCC Foundation and the General Commission for the Italian participation at Expo 2020 Dubai, which opened its doors on the first of October.

The CMCC brought its techno-scientific contribution to Expo Dubai through the provision and visualization of weather-marine data, oceanographic modeling and marine applications, talks and events with international experts on critical issues such as the Global Coastal Ocean, and CoastPredict – endorsed by UNESCO as a programme under the United Nations Decade of Ocean Science for Sustainable Development.



The CMCC at the UN Climate Conference COP26.

At COP26, the UN Climate Change Conference hosted in Glasgow by the UK in partnership with Italy from 31 October to 12 November 2021, CMCC co-organized three side events, connecting the dots between research and policy action. A side event co-organized within the COP26 Health Pavilion addressed the negative health impacts on child health and food security that can be attributed to climate change. Our contribution to COP26 EU side events focused on coastal adaptation and on the role of climate change research on climate action.

Bridging science and policy by looking to the future.

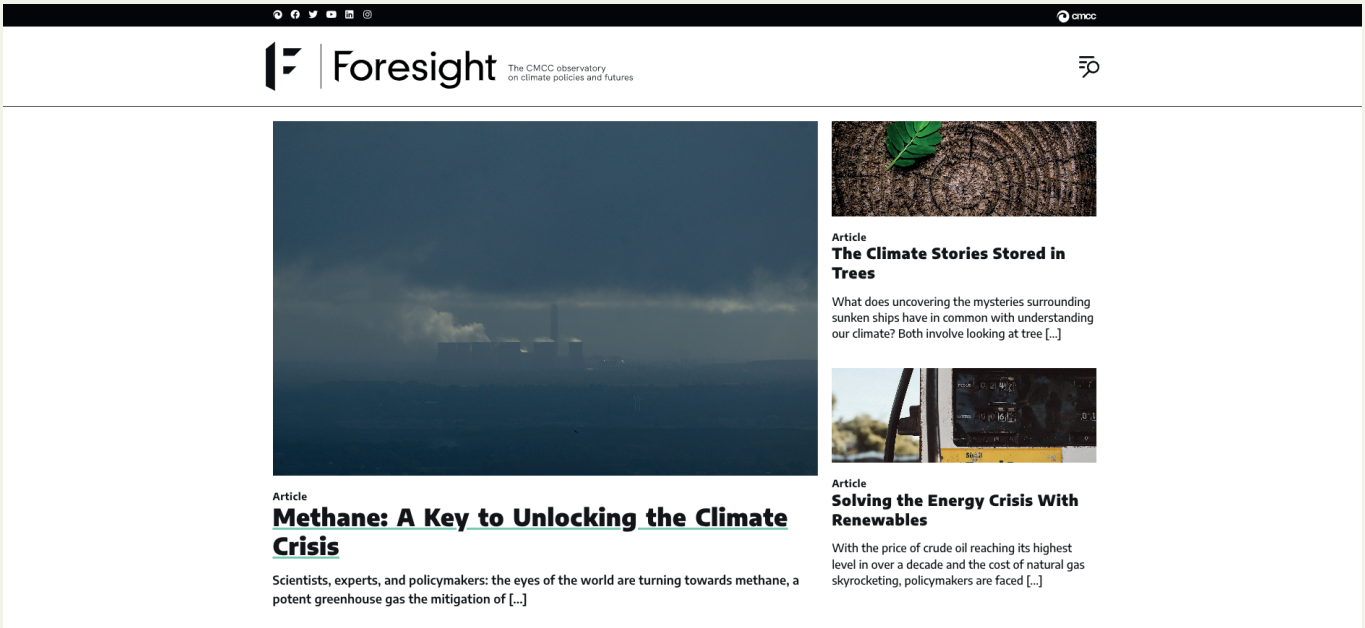
Shadows and lights from COP26, an in-depth summary of all the key outcomes in Glasgow and their implications were analyzed in the CMCC digital magazine Foresight: a collection of ideas, interviews, articles, videos, art performances, and multimedia to tell the stories of the future and connect science and policy.

CMCC took part in the Green&Blue Open Summit

on November 16 with Paola Mercogliano, Director of the CMCC Division on REgional Models and geo-Hydrological Impacts, who gave a speech on how climate change will affect life in Italy. The event hosted special guests including Giorgio Parisi, Amitav Gosh, Enrico Giovannini and Steve McCurry to take stock of sustainability, climate change and the achievements of Cop26.

Best Applied Game 2021: Special Mention to Change Game.

Change Game, the video game designed by the CMCC Foundation that confronts the complexity of climate change, received a Special Mention at the Rome VideoGame Lab, an event dedicated to recognizing excellence in the world of video games.

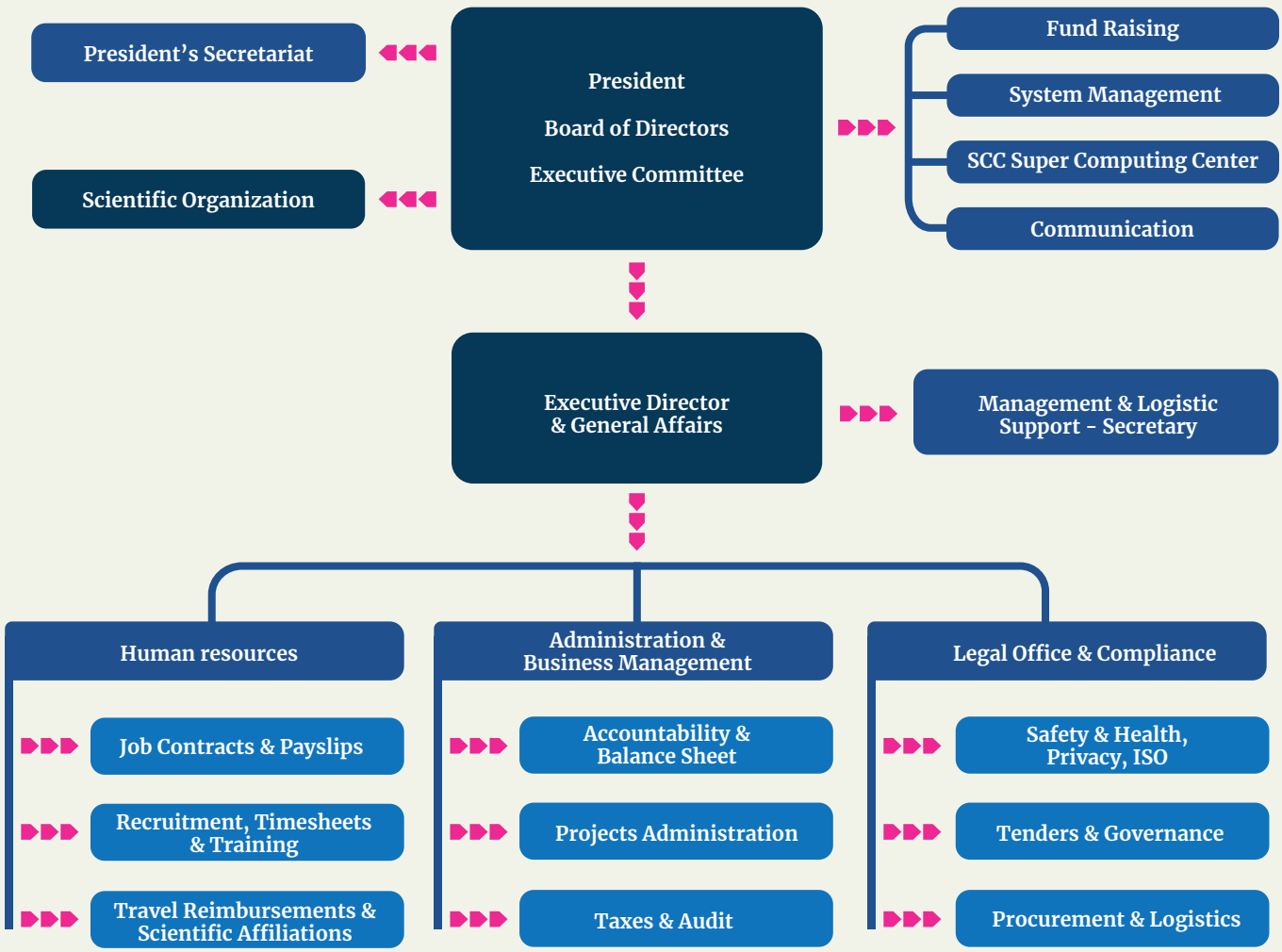


The CMCC Foundation

Mission

To investigate and model our climate system and its interactions with society to provide reliable, rigorous, and timely scientific results to stimulate sustainable growth, protect the environment and develop science driven adaptation and mitigation policies in a changing climate. To develop foresights and quantitative analysis of our future planet and society.

Administration and Management



COFOUNDERS

Istituto Nazionale di Geofisica e Vulcanologia
Università degli Studi del Salento
Centro Italiano di Ricerche Aerospaziali
Università Ca' Foscari Venezia
Università di Sassari
Università della Tuscia
Politecnico di Milano
Resources for the Future
Università di Bologna

STRATEGIC BOARD

Prof. **Giovanni Aloisio**
Prof. **Carlo Carraro**
Prof. **Stefano Consonni**
Prof. **Ray Copp**
Prof. **Antonio Marcomini**
Prof. **Antonio Navarra**
Prof. **Nadia Pinardi**
Dr. **Pasquale Schiano**
Prof. **Donatella Spano**
Prof. **Riccardo Valentini**

BOARD OF DIRECTORS

Antonio Navarra – CMCC President, Full Professor University of Bologna
Maria Siclari – ISPRA
Antonio Marcomini – Università Ca' Foscari Venezia
Fabio Pollice – Università degli Studi del Salento
Donatella Spano – Università di Sassari

SCIENTIFIC ADVISORY PANEL

Peter Bauer - European Centre for Medium-Range Weather Forecasts
Bart Muys - Leuven University – Forest, Nature and Landscape
Carolyn Fisher - Resources for the Future
Walter Oechel - University of California
Joe Tribbia - National Center for Atmospheric Research
Yueh-Lin Loo - Andlinger Center for Energy and the Environment
Mariana Vertenstein - National Center for Atmospheric Research
Hans Von Storch- Helmholtz Research Centre
Sabrina Speich - École Normale Supérieure
Nadim Farrokh - International Center for Geohazards
Daniela Jacob - Climate Service Center Germany

EXECUTIVE COMMITTEE

Antonio Navarra – CMCC, University of Bologna
Donatella Spano – Università di Sassari
Antonio Marcomini – Università Ca' Foscari Venezia

RESEARCH DIVISIONS DIRECTORS

Italo Epicoco – Advanced Scientific Computing
Silvio Gualdi – Climate Simulations and Predictions
Francesco Bosello – Economic analysis of Climate Impacts and Policy
Monia Santini – Impacts on Agriculture, Forests and Ecosystem Services
Serena Marras – Impacts on Agriculture, Forests and Ecosystem Services
Mauro Buonocore – Innovative Platforms for Science Outreach
Giulia Galluccio – Information Systems for Climate Science and Decision-making
Simona Masina – Ocean Modeling and Data Assimilation
Giovanni Coppini – Ocean Predictions and Applications
Paola Mercogliano – Regional Models and geo-Hydrological Impacts
Jaroslav Mysiak – Risk Assessment and Adaptation Strategies
Silvia Torresan – Risk Assessment and Adaptation Strategies
Massimo Tavoni – Sustainable Earth Modelling Economics

EXECUTIVE DIRECTOR

Laura Panzera

CMCC Foundation

Centro Euro-Mediterraneo sui Cambiamenti Climatici

Via Marco Biagi 5
73100 Lecce, Italy
Phone: +39.0832.1902411
info@cmcc.it

www.cmcc.it