*The European Climate Change Adaptation Conference (**ECCA**) is the leading European forum for sharing the latest science, policy, and practice on climate adaptation.*

*As a leading research center on climate science and impacts, **CMCC** plays a key role at the European level. The following press brief is designed to provide journalists and media with themes, research, data, and tools to explore crucial aspects of the climate challenge and tell impactful stories connecting science, policy, and society.*

Oceans and coasts: At the forefront of climate change impacts

Global mean sea level has risen by approximately 20 cm since 1900 - at a current rate of more than 3 millimeters per year - impacting not only marine ecosystems but also coastal communities, global economies and society. At the same time, projections for 2100 show that storm surges which were considered a once every 100-year event could now occur as frequently as every ten years, if not annually, in some parts of the world. CMCC research is not only at the forefront of identifying these risks, but also provides the tools and solutions to deal with the challenges they pose.

Key messages:

- **Sea level rise could cost EU and UK economies upwards of 870 billion euros by 2100**
- **Nature based solutions (NBS) for coastal protection have been shown to provide tangible benefits, such as reducing bottom current velocity by up to 40% and wave height by up to 20% along the Italian coastline**
- **Science provides crucial information on the interplay between coasts and oceans through the CoastPredict program - which through the GlobalCoast initiative is involving 130 pilot sites across 64 countries and 270 institutions, and new methods that allow researchers to identify at-risk infrastructure and inform users**

- **CMCC researchers are high level experts advancing technology and science in ocean and coastal studies; developing innovative tools such as machine learning, climate simulations and digital twins of the ocean**

The latest *Copernicus Ocean State Report*, involving CMCC, reveals alarming trends in ocean responses to climate change, including detailed analyses of sea temperature changes, rising sea levels, acidification, and extreme variability. The report underscores **the urgent need for actionable insights to manage the ocean's changing dynamics and mitigate the impacts of climate change on coastal communities and beyond**.

Coastal regions are the most impacted

Coastal regions are home to 40% of the world's population and 12 of the 15 largest megacities. These areas, whilst remaining vital for the global economy as 90% of global trade passes through ports and other critical infrastructure such as railways, are also under **immense pressure from climate impacts including sea-level rise (SLR) and extreme weather events**.

CMCC co-leads the Global Coast initiative, aimed at advancing "*knowledge, innovative products and services to support coastal community resilience*", within the framework of CoastPredict, a programme endorsed by the **United Nations Decade of Ocean Science for Sustainable Development (2021-2030)**.

The programme addresses challenges identified by over 130 stakeholders worldwide, from Africa to the Mediterranean, bridging local and international partnerships to develop **an innovative cloud computing infrastructure** that can **create globally replicable solutions and services**.

"Projections for 2100 show that what is currently considered a once every 100-year storm surge event could now occur as frequently as every ten years – if not annually," says **Nadia Pinardi**, Professor at the University of Bologna and Member of the Strategy Council of CMCC. *"**We must create a legacy of science** that can effectively tackle urgent issues like these and use*

*oceanography to **assess coastal risks**, which is central to advancing **community resilience**."*

Researchers, including CMCC experts, analyzed storm surges along the North Georgia coast during Hurricanes Matthew (2016) and Dorian (2019). Using advanced models and high-resolution data, they found that the timing of local and remote forces determines where surges peak. When these forces align, **storm surges can intensify by up to 50%**, emphasizing the need for accurate predictions to protect coastal communities.

Adapting coastal railways to rising seas: A case study on infrastructure resilience

As climate change intensifies, protecting vital infrastructure becomes essential for building long-term resilience. CMCC researchers, in collaboration with the Parthenope University of Naples and Rete Ferroviaria Italiana (RFI), developed an innovative methodology to **assess the vulnerability of Italy's coastal railway network to sea level rise**. Railways are not only a lifeline for people and goods but also a cornerstone of low-carbon mobility strategies. Damage from flooding or submersion could disrupt daily life and the economy – from delayed travel to soaring maintenance costs.

This study provides a practical tool for identifying the most at-risk sections of coastal railway lines under different climate scenarios. By combining high-resolution climate projections, detailed exposure data, and a participatory approach that includes infrastructure managers, the methodology delivers actionable insights for adaptation planning. It offers a replicable model that can be applied to other infrastructure types and hazards, supporting climate-resilient investment decisions. This case exemplifies approaches that turn climate science into concrete solutions for real-world challenges, showing the power of research-stakeholder collaboration in shaping smarter, future-proof infrastructure.

Story ideas:

- The hidden cost of rising seas: Which infrastructure is most at risk?
- 100-year storms every 10 years: How science is rethinking coastal risk
- Building a worldwide coastal resilience network from the ground up

Nature-based solutions for adaptation

CMCC research is developing from a focus on describing risks to finding **ways to manage economic growth and societal objectives** in a world where material conditions are changing.

Today, only 15% of the world's coastlines remain in their natural state and yet there is growing evidence that nature itself could provide crucial adaptation solutions. CMCC research helps identify initiatives that are built upon and combine disaster risk financing and investments with NBS.

One of CMCC's key goals is to enhance the efficiency of restoration projects for marine and coastal ecosystems. By utilizing advanced tools, such as Digital Twins of the Coastal Ocean, the center aims to reduce planning costs and quantify the benefits of NBS, such as restoring seagrass meadows (which have been shown to reduce bottom current velocity by up to 50%, and wave height by up to 20%), for **coastal protection, biodiversity enhancement, and CO_2 absorption**.

CMCC is advancing **large-scale coastal restoration efforts by addressing technical, economic, and governance challenges**. At the pilot site in Venice, CMCC applies hydrodynamic models to predict coastal hazards with and without restoration interventions and uses machine learning tools to assess multi-hazard risks under climate change. These efforts demonstrate how adaptation efforts, such as the **restoration of habitats like wetlands and seagrass meadows, can reduce risks to infrastructure whilst enhancing biodiversity and improving community resilience**.

A concrete step towards climate-smart coastal planning is being developed through the **DT3-Coastal** project, led by the CMCC Foundation in partnership with Capgemini. The Coastal Digital Twin (DT#3) is funded by the European Space Agency (ESA) within the framework of the IRIDE satellite constellation program, under the Italian National Recovery and Resilience Plan (PNRR – Piano Nazionale di Ripresa e Resilienza).

The initiative is working towards the creation of a **Coastal Digital Twin** tailored to support local adaptation and protection needs in the Italian municipalities of Pilot Sites such as **Rimini, Manfredonia and Zaponeta**.
The prototype integrates **high-resolution hydrodynamic waves and flooding models,** augmented with **AI,** on an interactive cloud-based platform. Within this digital environment, the potential of **nature-based solutions** - such as dune and coastal marine restoration - can be tested under different extreme weather scenarios to assess their effectiveness in reducing risks such as storm surge.

The DT3-Coastal approach exemplifies how Digital Twins can make complex environmental information accessible and actionable for local stakeholders, enabling more informed, participatory, and resilient adaptation strategies.

Promoting coastal resilience: Two case studies in Italy

Marine ecosystems are impacted by the expansion of human-made **infrastructure**, such as in the case-study of the Civitavecchia Port Hub in Italy. By testing **innovative restoration and mitigation techniques**, the project aims to recover critical habitats and species, whilst **ensuring that critical infrastructure continues to operate and therefore advancing societal objectives**.

The integration of NBS with advanced water management strategies is at the basis of targeted adaptation actions tackling climate adaptation in the Po River Basin. CMCC leads the technical and methodological framework of pilot projects to **enhance ecosystem services, and develop a coastal alert system for extreme water events**. The project strengthens climate resilience, improves water security, and provides **scalable solutions for climate-smart governance across the basin**.

Story ideas:

- From seagrass to AI: How scientists are protecting Venice from rising seas
- Port vs. planet? Inside the restoration project balancing infrastructure and ecosystems
- Climate-smart solutions for coastal adaptation

A scientific and technological approach

CMCC addresses the complexities inherent in global coasts through an integrated, multidisciplinary, and innovative approach. By leveraging **advanced models and high-resolution climate data**, researchers identify coastal challenges and develop cutting-edge tools to test effective solutions. Among these is the **Digital Twin of the Coastal Ocean (DTCO)**, a platform that combines modeling, observations, and **"*what-if*" scenarios** in a realistic environment, empowering both local and global decision-makers.

"Scientific research needs to bring together different aspects such as technological innovation, large computing capacity, the possibility of creating and using ocean Digital Twins and of interacting concretely and operationally with many different stakeholders," says Giovanni Coppini, Director of Global Coastal Ocean at CMCC.
This positions CMCC researchers as **high level experts** in how to respond to storm surges or sea-level rise, as well as **optimizing adaptation strategies for ports, coastal cities, and vulnerable areas**. Tools like DTC identify unsolved problems and propose integrated solutions that protect not only coastal infrastructure but also the natural and social capital of communities.

Advanced innovations for modelling and monitoring coasts

To help coastal regions adapt to rising climate risks, CMCC researchers developed a prototype tool that uses Artificial Intelligence and Machine Learning to assess the impacts of extreme weather. Applied to Italy's Veneto region, the model identifies key hazard drivers—such as **heavy rainfall, wind, and sea level rise**—and how their effects vary across municipalities. This innovative tool supports early warning systems and adaptation planning by combining environmental and vulnerability data, offering decision-makers a clearer picture of local risks. It marks a promising step toward smarter, data-driven climate resilience strategies for coastal areas.

As climate change and urban pressure squeeze coastal ecosystems, CMCC is advancing adaptation with cutting-edge monitoring tools. In collaboration with Politecnico di Torino, CMCC researchers developed an innovative algorithm that uses **ultra-high-resolution drone imagery and machine learning to map coastal dune vegetation with 76% accuracy**. This new method enables

precise identification of plant species at the individual level, offering a powerful tool for ecosystem monitoring and conservation planning. This approach sets a global benchmark for protecting these vital, biodiverse ecosystems – natural barriers that shield inland communities from storm surges and erosion.

By turning high-tech data into actionable insight, CMCC is helping build the foundation for smarter, more targeted adaptation strategies in fragile coastal zones. CMCC's mission is clear: **turn science into action for designing the future of our coasts**.

Story ideas:

- How Digital Twins and AI are reinventing coastal resilience and adaptation
- Mapping dunes from the sky: Helping protect coastal ecosystems
- Can Machine Learning predict the next flood?

Protecting mountain ecosystems and communities

According to the IPCC Special Report on the Ocean and Cryosphere in a Changing Climate, around **670 million people live in high mountain regions**, 680 million in low-lying coastal zones, 4 million in the Arctic, and 65 million in small island developing states. These numbers highlight how deeply climate change affects not only the people living in direct contact with these areas, but also the equilibrium of oceans and coastal ecosystems, the availability of water resources, the frequency of extreme events, food security and several productive and cultural sectors.

By 2100, **glaciers** – especially those outside polar regions – **could lose over 80% of their ice mass, while snow cover may shrink by 90%**. If global warming exceeds 2°C, the impacts will go far beyond the environment, threatening freshwater supply, ecosystems, tourism, and local economies that depend on snow and ice.

A CMCC-led study showcases how **agroforestry can become a powerful climate adaptation strategy in mountain regions**, delivering benefits for both people and the planet. By increasing tree cover on agricultural land – even by just 1% per year – farmers can significantly boost carbon sequestration, strengthen resilience to climate change, and support biodiversity. With over **29% of the world's irrecoverable carbon stored in mountain ecosystems**, protecting and enhancing these landscapes is critical. The research, developed with international partners, quantifies the climate

mitigation potential of agroforestry and highlights its effectiveness in preserving vital ecosystem services while improving food security and livelihoods.

Another CMCC study reveals **how climate change is reshaping Italy's mountain landscapes**, threatening native forest species, and pushing ecosystems toward dramatic transformations. By combining high-resolution climate modeling with detailed forest data, CMCC scientists mapped future scenarios for five vulnerable mountain regions across the Alps and Apennines. Their findings show that **rising temperatures are forcing species such as silver fir and European beech to retreat to higher, cooler altitudes –** some by several hundred meters – while others face the risk of local extinction.

The study highlights the northern and north-eastern Apennines as hotspots of vulnerability, where suitable habitats for many tree species could shrink significantly. This comprehensive analysis underscores the urgent need for adaptive conservation strategies and sustainable forest management to safeguard biodiversity.
CMCC research not only reveals the complex, region-specific impacts of climate change but also provides critical data to guide policymakers in protecting Italy's mountain ecosystems from irreversible loss, showing how integrating climate science and ecological forecasting can empower effective adaptation efforts in the face of environmental change.

Story ideas:

- Retreating forests: How climate change is rewriting the future of Italy's mountain ecosystems
- Agroforestry in the Alps: A nature-based strategy to boost resilience and carbon storage
- Mountains under threat: The race to protect snow, water, and livelihoods in a warming world

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CMCC experts are available to share their insights with interested parties, including journalists.

Contacts

Mauro Buonocore, *Press Officer, CMCC*
mauro.buonocore@cmcc.it
tel. +39 0832 1902411 - mob. +39 3453033512

Marina Menga, *Press Office, CMCC*
marina.menga@cmcc.it
tel: +39 0832 1902411, ext. 303

www.cmcc.it