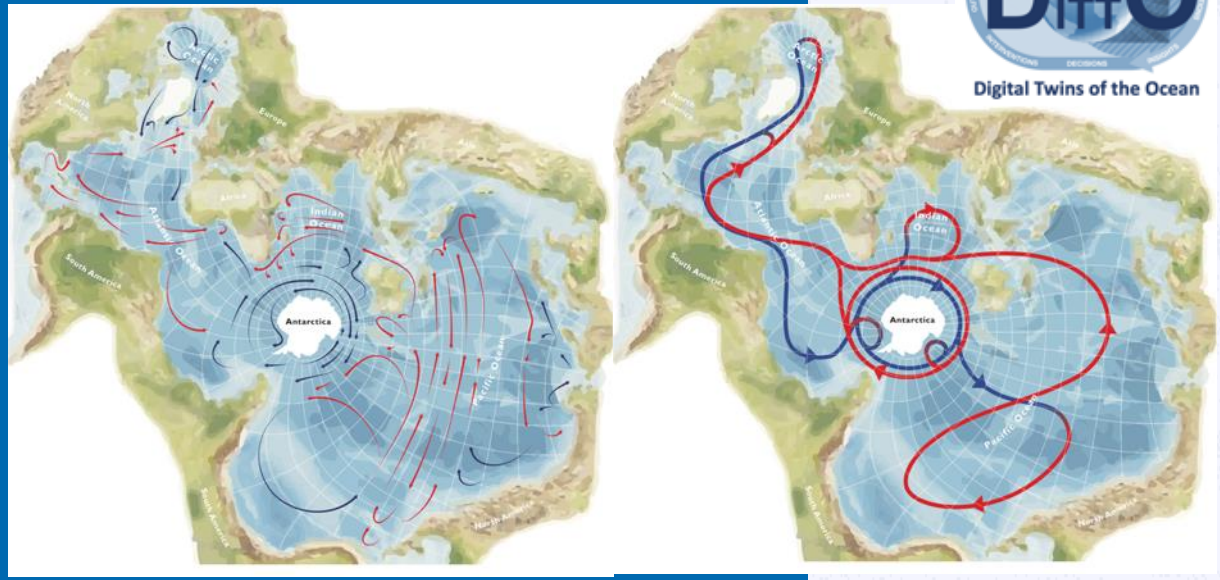
“Digital Twins of the Ocean” Opportunities to connect science to society



"Jamie Oliver, British Antarctic Survey"

DITTO
Digital Twins of the Ocean

2021 2030 United Nations Decade of Ocean Science for Sustainable Development

Martin Visbeck

GEOMAR Helmholtz Center for Ocean Research Kiel
Kiel University, Germany

GEOMAR

future ocean
KIEL MARINE SCIENCES

Digital Twins of the Ocean

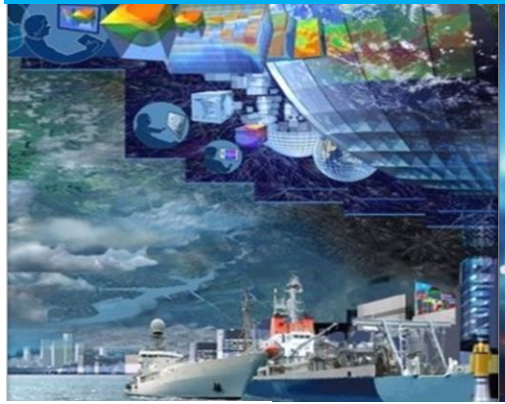
GEOMAR Helmholtz Centre for Ocean Research Kiel

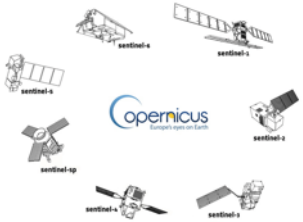
Digital Twin

DITTO Digital Twins of the Ocean

2021 2030 United Nations Decade of Ocean Science for Sustainable Development

Observations	Data	Knowledge





AtlantOS

Copernicus Marine Service

Blue-Cloud
Piloting innovative services for Marine Research & the Blue Economy

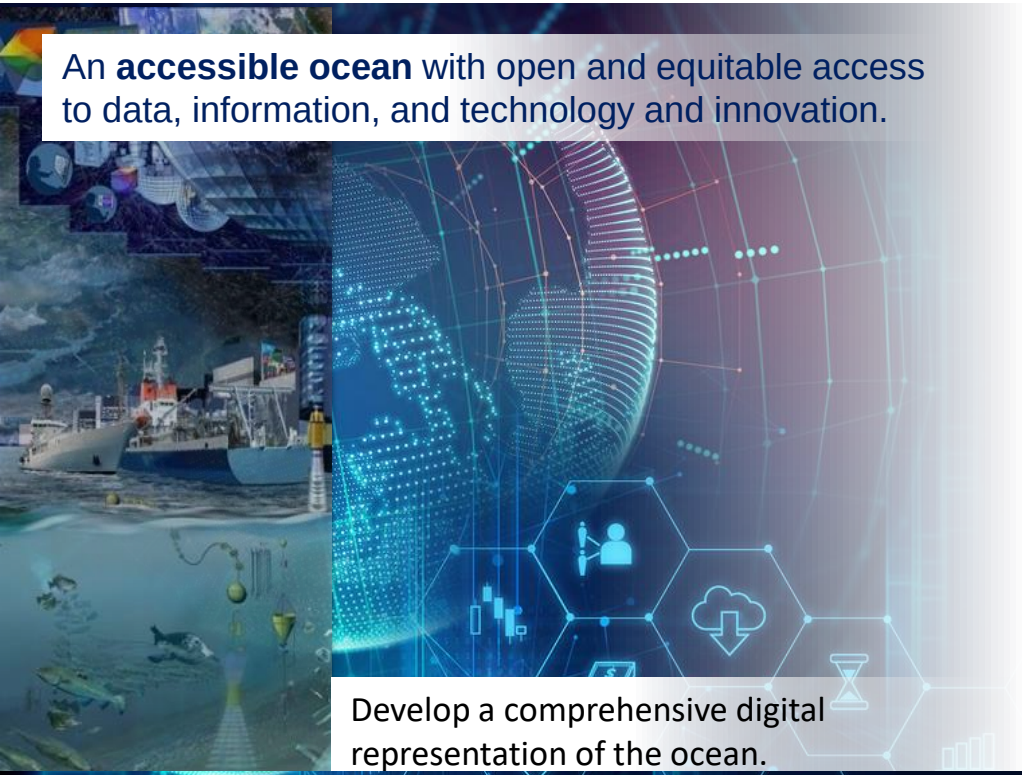
EOOS European Ocean Observing System

EMODnet European Marine Observation and Data Network

DITTO - Digital Twins of the Ocean

Digital Twins of the Ocean – DITTO

establising a common understanding of a DTO



An **accessible ocean** with open and equitable access to data, information, and technology and innovation.

Develop a comprehensive digital representation of the ocean.

Digital twins are fine-grained virtualizations of physical objects and systems which have been widely applied in the engineering realm for tasks such as engine optimization and port management.

As a concept, **digital twinning is gaining momentum in Earth and Ocean science**, particularly as a way to intuitively bundle and provide easy access to marine data, models, and simulations.

A well-constructed digital twin of the ocean will **enable a wider range of users to interact with digital assets to explore current and future scenarios,** especially related to human interactions with the ocean.

2021 2030 United Nations Decade of Ocean Science for Sustainable Development

Decade programme

- Global or regional in scale
- Fulfils one or more of the Decade objectives.
- Long-term (multi-year), interdisciplinary and typically multi-national.
- Includes component projects, and enabling activities.

Proposal for an OceanDecade Global Programme
January 2021

Digital Twins of the Ocean - DITTO

Lead-PI: Martin Visbeck, GEOMAR, Kiel, Germany

Digital Twins of the Ocean

Summary:

DITTO will establish and advance a **digital framework** on which all marine data, modelling and simulation along with HPC capacities, AI algorithms and specialized tools including relevant best practices will form a new globally shared capacity to access, manipulate, analyse and visualise marine information. It will enable users and partners to create ocean related development scenarios addressing issues such as green energy developments (renewable, non-renewable), mining impacts, fisheries and mariculture, marine protected area siteing, nature based solutions and ocean based tourism. Digital twins can quantify benefits and environmental change and provide powerful visualizations based on data and model derived knowledge. DITTO will
professionals including scientific users to create their own local
using standard workflows.

Digital Twins of the Ocean – DITTO

Value chain and frames of intervention

Digital Twins of the Ocean

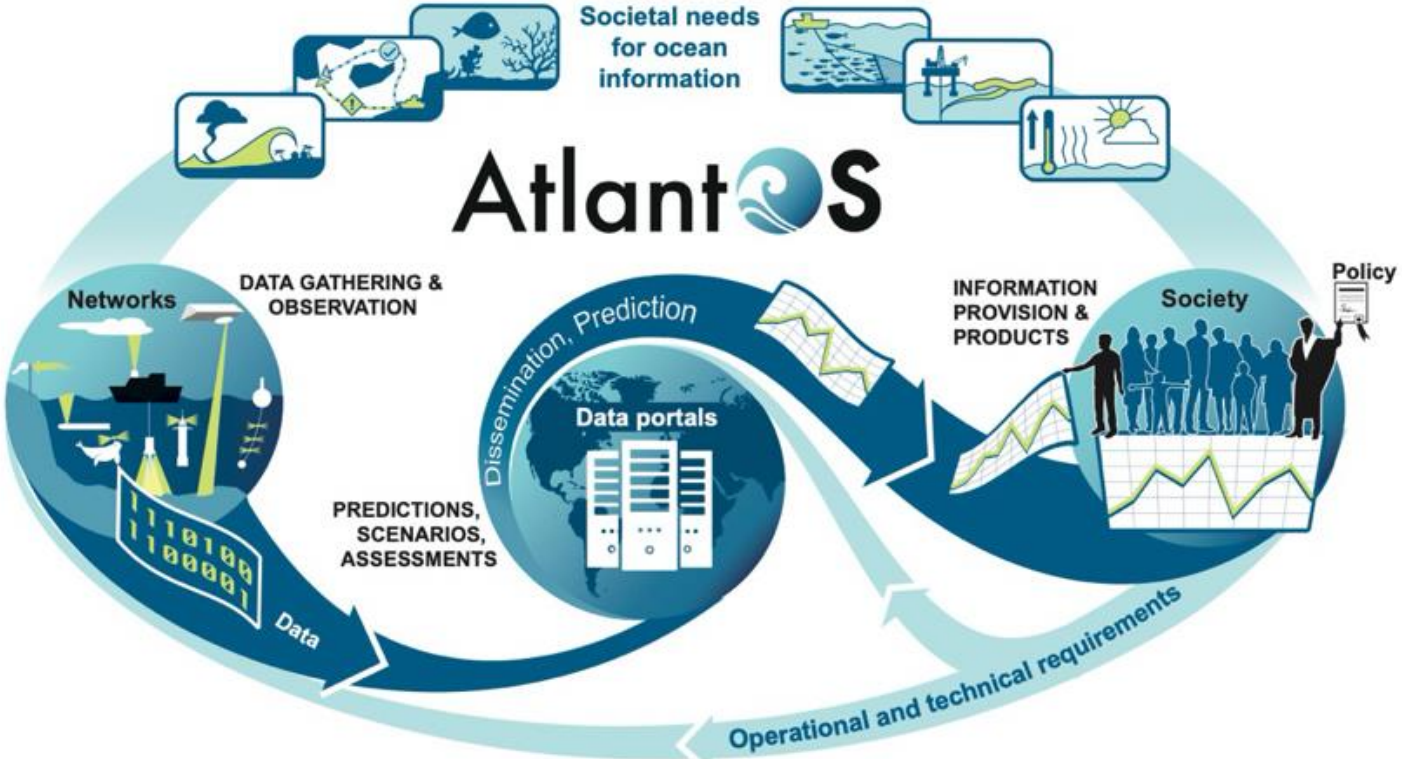
An **accessible ocean** with open and equitable access to data, information, and technology and innovation.

Develop a comprehensive digital representation of the ocean.

Ocean Information **supporting Services**

Ocean Information **assessing Interventions**

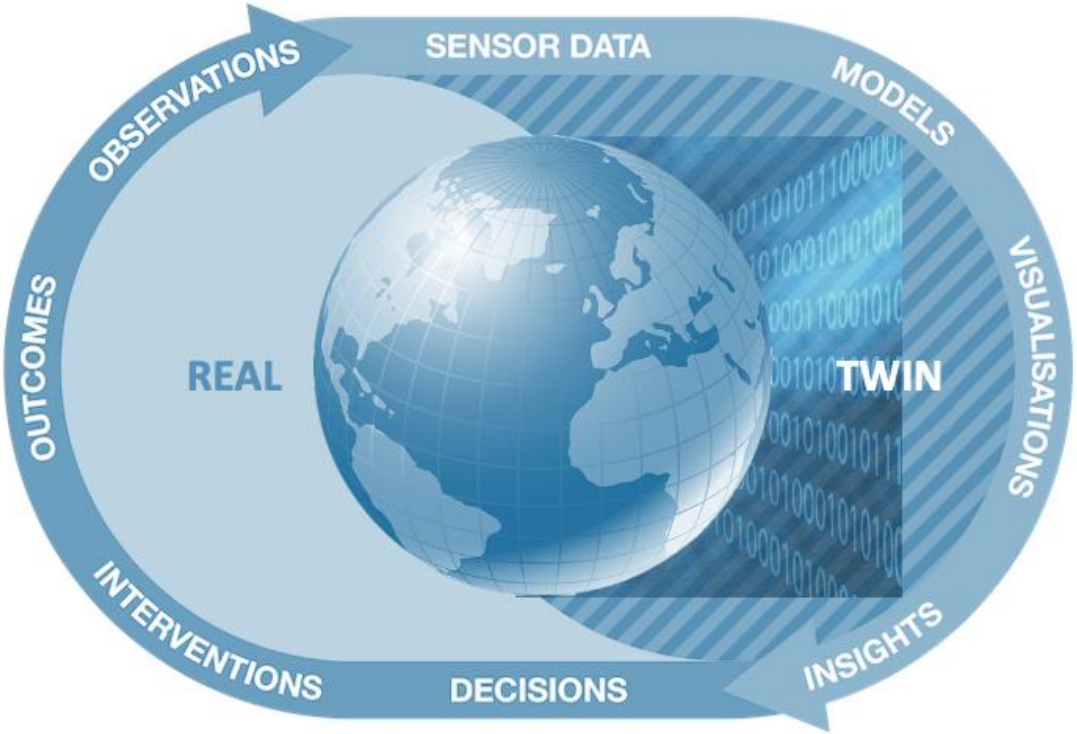
Ocean Observation and Information Value Chain



Ocean Information **supporting Services**

What is the state of the ocean today? And how will it change tomorrow?
Initial Value Probelm

Ocean Simulation Digital Twin Framework



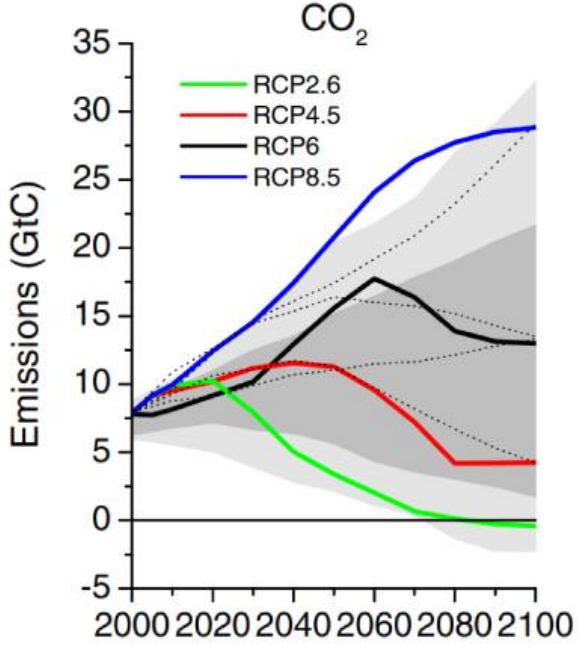
Digital Twins of the Ocean

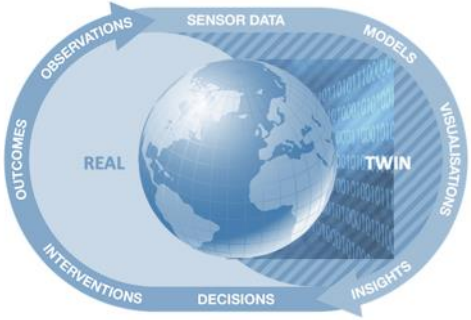
Ocean Information **assessing Interventions**

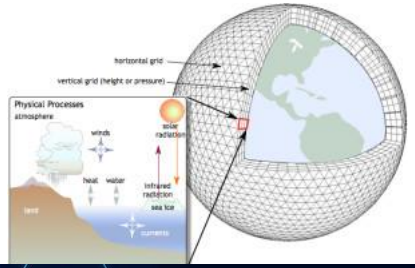
What – If Scenarios
How will the ocean change if humans act?
Boundary Value Probelm

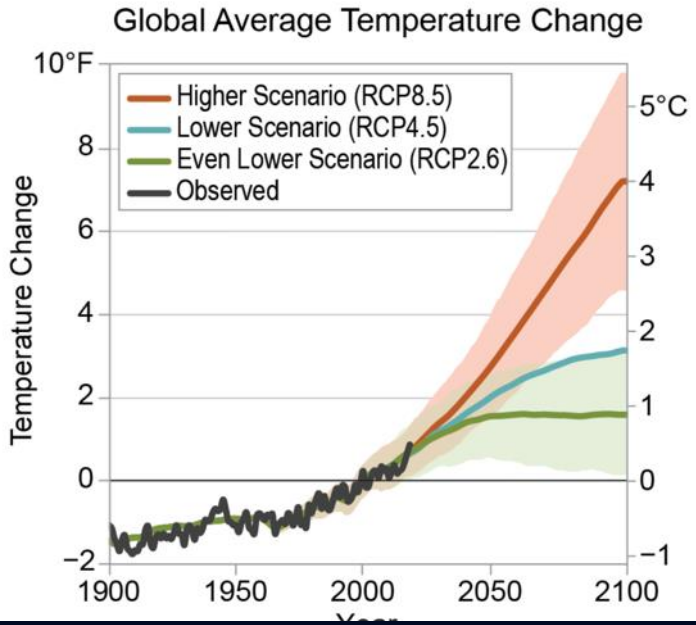
Digital Twin ‚Prototype‘

What would the global temperature look like if we put CO2 in the atmosphere?









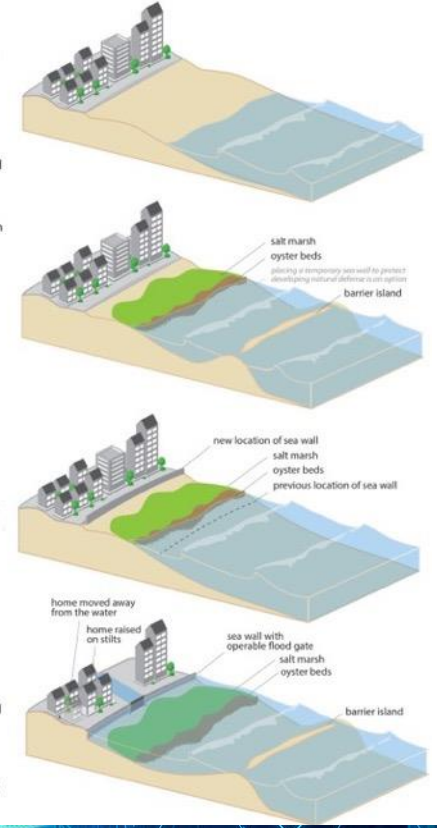
Digital Twin ‚Prototype‘

Minimal Defense
Many communities have developed right along the ocean with only minimal natural defenses from a small strip of beach between them and the ocean.

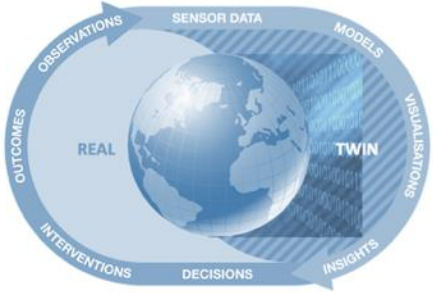
Natural
Natural habitats that can provide storm protection include salt marsh, oyster and coral reefs, mangroves, seagrasses, dunes, and barrier islands. A combination of natural habitats can be used to provide more protection, as seen in this figure. Communities could restore or create a barrier island, followed by oyster reefs and salt marsh. Temporary infrastructure (such as a removable sea wall) can protect natural infrastructure as it gets established.

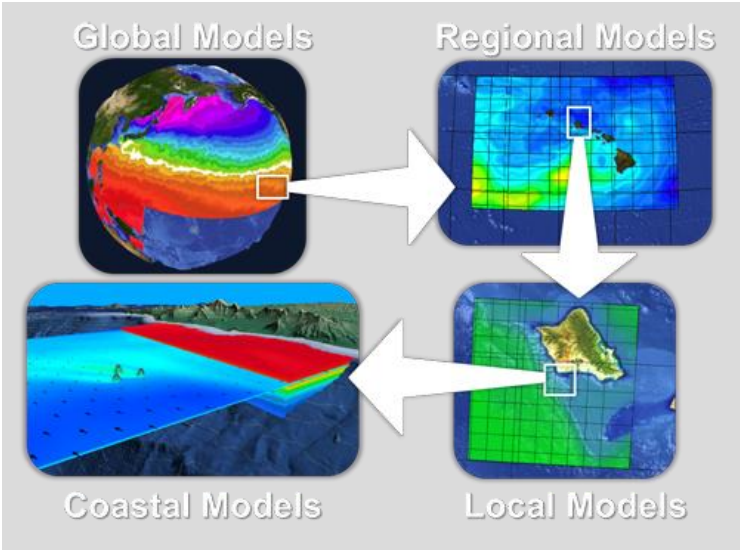
Managed Realignment
Natural infrastructure can be used to protect built infrastructure in order to help the built infrastructure have a longer lifetime and to provide more storm protection benefits. In managed realignment, communities are moving sea walls farther away from the ocean edge, closer to the community and allowing natural infrastructure to recruit between the ocean edge and the sea wall.

Hybrid
In the hybrid approach, specific built infrastructure, such as removable sea walls or openable flood gates (as shown here) are installed simultaneously with restored or created natural infrastructure, such as salt marsh and oyster reefs. Other options include moving houses away from the water and raising them on stilts. The natural infrastructure provides key storm protection benefits for small to medium storms and then when a large storm is expected, the built infrastructure is used for additional protection.



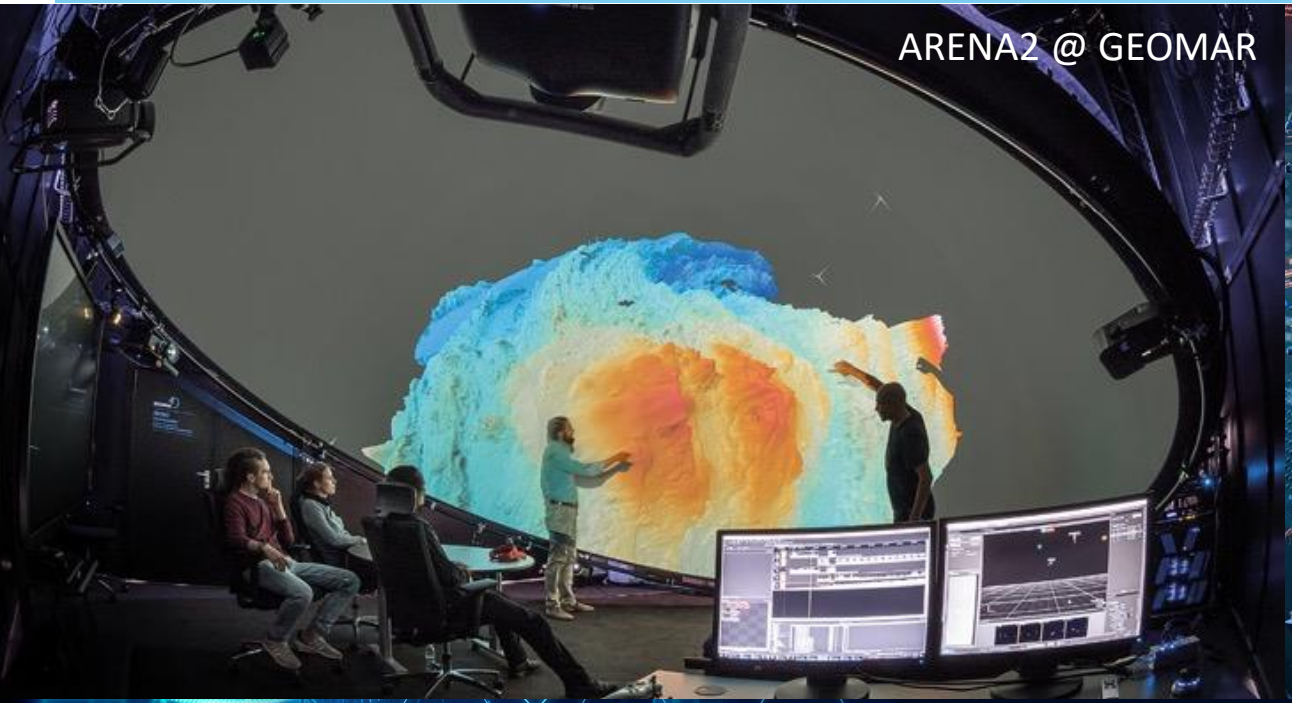
What is the most cost effective option to mitigate the coastal impact of sea level rise?





Delivering Digital Twin Information

Decision making theaters – Browser based systems – Jupiter Notebooks – 3D immersive environments



Digital Twins of the Ocean – DITTO

Program Proposal to the Ocean Decade

2021 2030 United Nations Decade of Ocean Science for Sustainable Development

An **accessible ocean** with open and equitable access to data, information, and technology and innovation.

DITTO will establish and advance a digital framework to explore ocean related development scenarios

40 Partners from around the world

Develop a comprehensive digital representation of the ocean.

Digital Twins of the Ocean

GEOMAR

esri

CONICET

EMODnet

IMOS Integrated Marine Observing System

Copernicus Marine Service

Ocean Networks Canada

Alma Mater Studiorum A.D. 1088

UN environment

The University of Western Australia

FURG Universidade Federal do Rio Grande

CIOOS

GRID Arendal — A Centre collaborating with UNEP

Fraunhofer IGD

Ocean Visions

University of South Florida 1956

NASA

GOOS The Global Ocean Observing System

ICES CIEM

1924 Ocean University of China

National Oceanography Centre

Digital Twins of the Ocean – DITTO

Program of the Ocean Decade

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Opportunities for DITTO – FourSea&OceanPredict

- Fully embrace the opportunities of the ‘digital revolution’ and shape the future of the digital knowledge ecosystem to be collaborative, shared and equitable.
- Establish an Digital Ocean community building on the momentum of the Ocean Decade, the Ocean Mission, The Digital Twin Earth actions, the G7 agreement and global, regional and national initiatives.
- Work together in a ***Community Of Practice*** around ocean prediction (Decade Outcome).