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Advancing the science of ocean prediction

OPST-4

Collection of National Group presentations

UN Decade plans and/or critical updates

Systems represented:

Australia (BoM)
Brazil (REMO)
Canada (CONCEPTS)
France (MOi)
Italy (CMCC and OGS)
Japan (MRI-JMA)
Norway (TOPAZ)
South Korea (KIOST)
UK/Europe (ECMWF)
UK (FOAM)
USA (NCEP)
USA (OceanPredict.US)

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Australia (BoM)

Gary Brassington

Australian Government
Bureau of Meteorology

National report - Australia

Plans your operational centre has/is considering for the UN Decade - ForeSea

- Maximise the benefits of ocean observations
  - Advanced prediction systems (modelling, data assimilation, data science)
  - Support collation/sharing of existing platforms (IMOS, commercial)
  - Support the rapid/efficient uptake of new platforms (SWOT, SKIM)
  - Support building capacity/strategy in adaptive/autonomous platforms (IMOS)
- Support development and maturation of the full-length op. ocean value chain
  - Support the development of KPI for ocean forecast applications (2 year)
  - Support rigorous forecast verification/evaluation/intercomaprison (IV-TT, ongoing)
  - Support the development and uptake of probabilistic forecasts (2 years)
- Advance the science behind ocean prediction and its connection to atmosphere
  - Advanced data assimilation (1 year)
  - Ensemble forecasting (2 year)
  - Coupled Numerical Weather-Ocean prediction system (3 years)
    - Deterministic/Ensemble – seamless prediction
- Quantify the impact and utility of ocean prediction
  - Support the development of ocean service KPI (existing, Sea-ice, probabilistic)

Gary B. Brassington, gary.brassington@bom.gov.au

Australian Government
Bureau of Meteorology

National report - Australia

Any critical updates related to your operational system/activities of relevance to the Decade

Specific updates

- Multi-scale data assimilation (BRAN2020 and OceanMAPSv3.4)
- Ocean current verification
- Blue Maps

Other activities

- ForeSea – Bureau/CSIRO
- CoastPredict – CSIRO/Bureau/Universities
- SynObs – CSIRO/Bureau
- DITTO – IMOS, UWA
- Ocean Decade Australia (https://oceandecadeaustralia.org)

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Brazil (REMO)

Clemente Tanajura -UFBA

REMO-CHM Plans Considering the UN Decade

1. The activities related to the UN Decade of Ocean Science for Sustainable Development in Brazil are organized under the **Ministry of Science, Technology and Innovations** (MCTI)

2. The Navy will continue its support to
   - research in Antarctica
   - PIRATA
   - NOAA XBT line AX97
   - All-Atlantic Research Alliance
   - improve the observational system with gliders off S-SE Brazil
   - improve the operational forecasting system in the Atlantic

3. The Navy Hydrographic Center (CHM) in collaboration with universities will develop and implement a regional operational system for detection and forescasting the trajectory of oil spills

4. CHM operational system based on HYCOM+RODAS (EnOI) was upgraded last year to a higher-resoultion nested grid system and it will work to produce an operational EnKF to improve the forecasts.

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Canada (CONCEPTS)

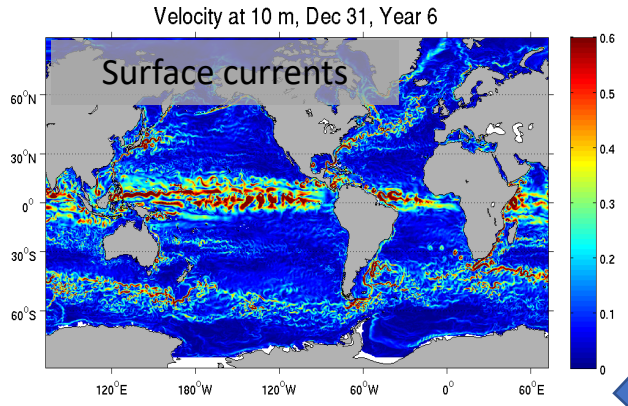
Greg Smith (ECCC)

Canadian National Report

Status of Operational Oceanographic Systems

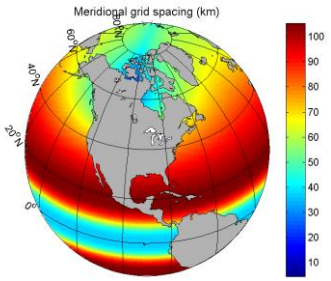
NEMO + CICE

Operational
Experimental

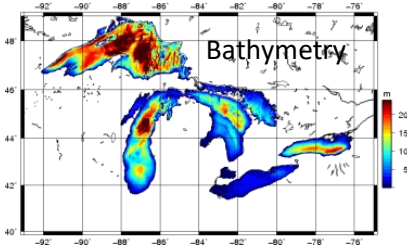


GIOPS: 1/4° Global, Coupled to GDPS (10day) and GEPS (16day and monthly)

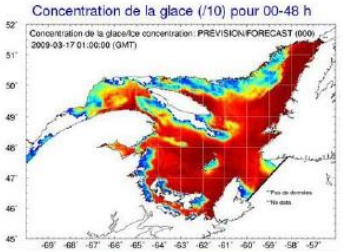
Seasonal 1°

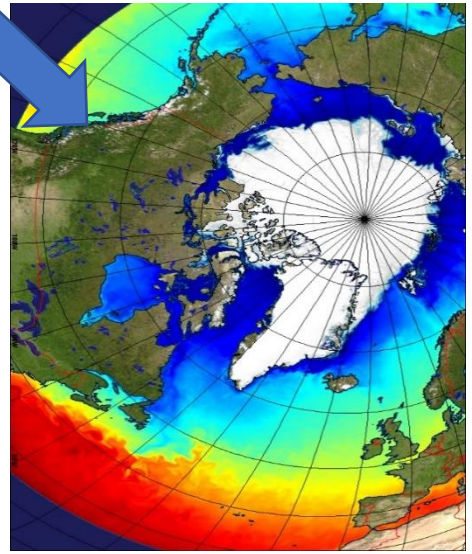


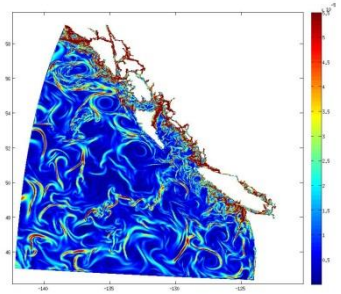
Great Lakes 2km



Gulf of St. Lawrence, 5km

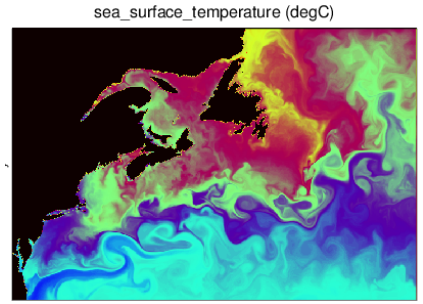






CIOPS-W: Northeast Pacific 1/36°

RIOPS: Regional 1/12° Coupled for YOPP (3km atm)



CIOPS-E: Coastal East Coast 1/36°

CONCEPTS
CANADIAN OPERATIONAL NETWORK OF COUPLED ENVIRONMENTAL PREDICTION SYSTEMS

CONCEPTS
Users and Applications

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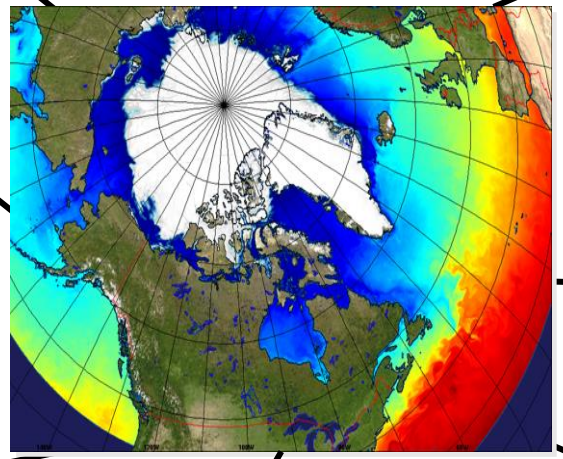
DFO Applications
- Fisheries and Aquaculture management
- Ocean climate monitoring

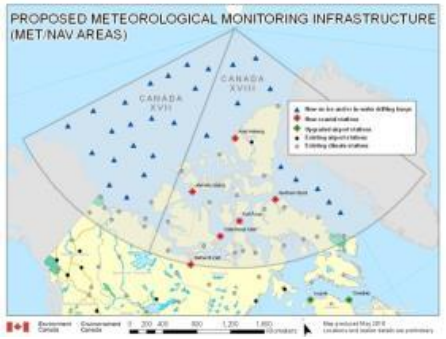
DND Applications
- Situational awareness
- Anti-submarine warfare
- Operational support

Canadian Coast Guard
- Search and Rescue
- Environmental Emergency Response

National Environmental Emergency response Centre (NEEC)
- Oil spill

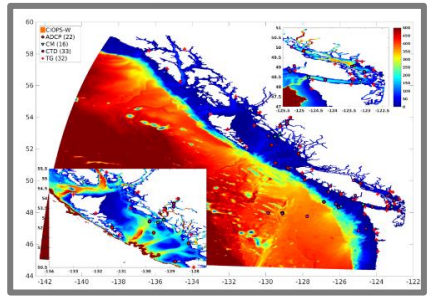


METAREAS 17&18

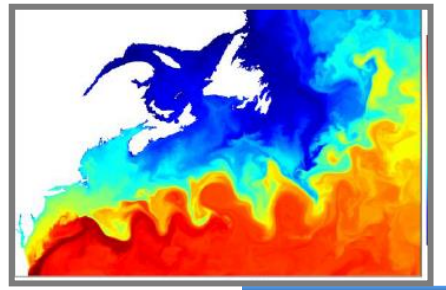


CIS Operations
- High-pressure ridges
- Automated analyses
- Iceberg drift

Downstream systems
CIOPS, e-Nav, Waves, storm surge



CIOPS-West



CIOPS-East

CONCEPTS
CANADIAN OPERATIONAL NETWORK OF COUPLED ENVIRONMENTAL PREDICTION SYSTEMS

Potential UN Decade Plans

- Installation of Port-scale models
- Expand products to external Government of Canada users
- BGC model development based on NEMO and other models
- Developing hindcasts, S2S prediction and climate projections
- Enhance data assimilation and developing reanalysis products
- Promoting more applications of model products to support the Blue Economy strategy

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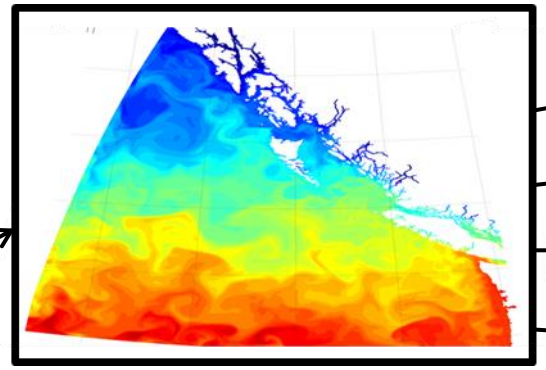
CONCEPTS
CANADIAN OPERATIONAL NETWORK OF COUPLED ENVIRONMENTAL PREDICTION SYSTEMS

Implemented Aug. 2019



Near-shore NEMO
on-demand config for select regions

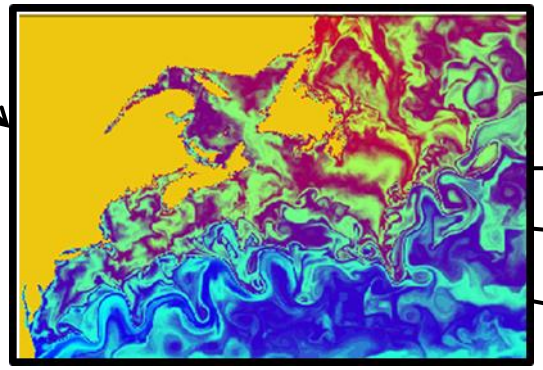
E-Nav Kitimat

E-Nav Fraser

E-Nav Vancouver

RIOPS

CIOPS



Near-shore NEMO
on demand configs for select regions

H2D2 St. Lawrence

E-Nav Canso

E-Nav Saint John

Implemented Jun. 2020

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France (Moi)

Yann Drillet

Mercator Ocean International

- Plans for the UN decade :

1. Continuity of **operational production** of ocean short term forecast and ocean reanalysis for the global ocean and for Irish Biscay and Irish sea area.
2. Strong focus on **biogeochemistry** and **biodiversity**
3. Develop **Digital Twin Ocean** concept based on model & data assimilation technics and more flexible and interactive engine including big data, cloud platform, machine learning and **on demand model** and **whatif scenario**.

- Main critical updates for the next decade

1. **Resolution**, move to 1/36° global forecasting system
2. **Uncertainty**, move to ensemble analysis and forecast systems
3. **Coupling**, improve coupling between main components of the ocean system (physics, biogeochemistry, sea ice, atmosphere, waves, rivers, low, mid and high trophic level models …)

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Italy (CMCC and OGS)

Simona Masina

Italian operational centers (CMCC and OGS) plans considering for the UN Decade

Euro-Mediterranean Center on Climate Change

CMCC Contributing to ForeSea:

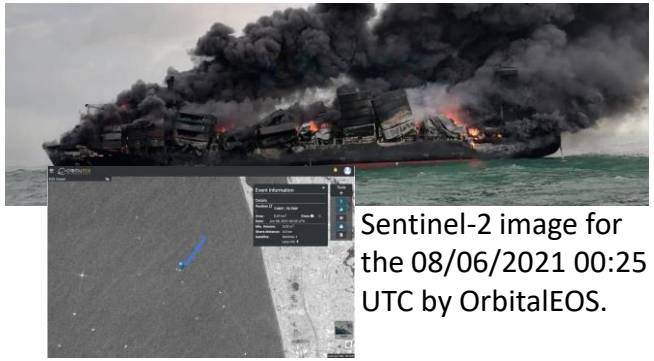
- Global and Regional forecasting, ocean visualization,
- added value products at Global scale (e.g. Oil spill forecasting in collaboration with MOI)

CMCC Contribution to CoastPredict:

- Part of the Steering committee of CoastPredict
- Global to coastal applications (WITOIL multimodel oil spill forecasting global, regional (CMEMS) and coastal service)
- Two projects proposal proposed in the framework of CoastPredict:
  1) “NAVIgating in the COASTal ocean“ (NAVICOAST)
  2) Support for marine pollution in coastal zones

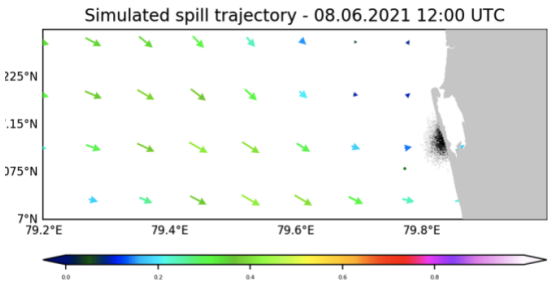
CMCC Contributing to the Italian National Committee for the Ocean Decade

Global ocean oil spill forecasting: CMCC, MOI and OrbitalERO Bulletin for MV X-Press Pearl chemical and oil leaks in support of response and clean-up, June 2021



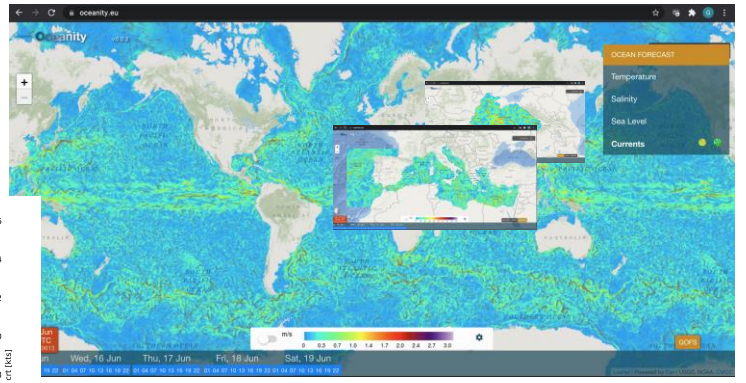
Sentinel-2 image for the 08/06/2021 00:25 UTC by OrbitalEOS.

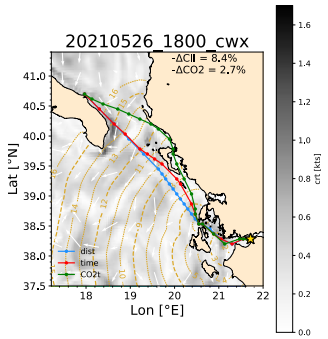
Simulated oil spill trajectory by CMCC and MOI.

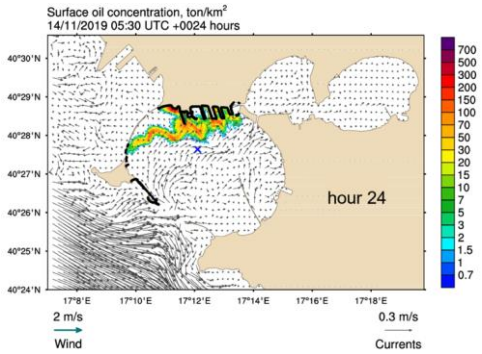


http://oceanity.eu

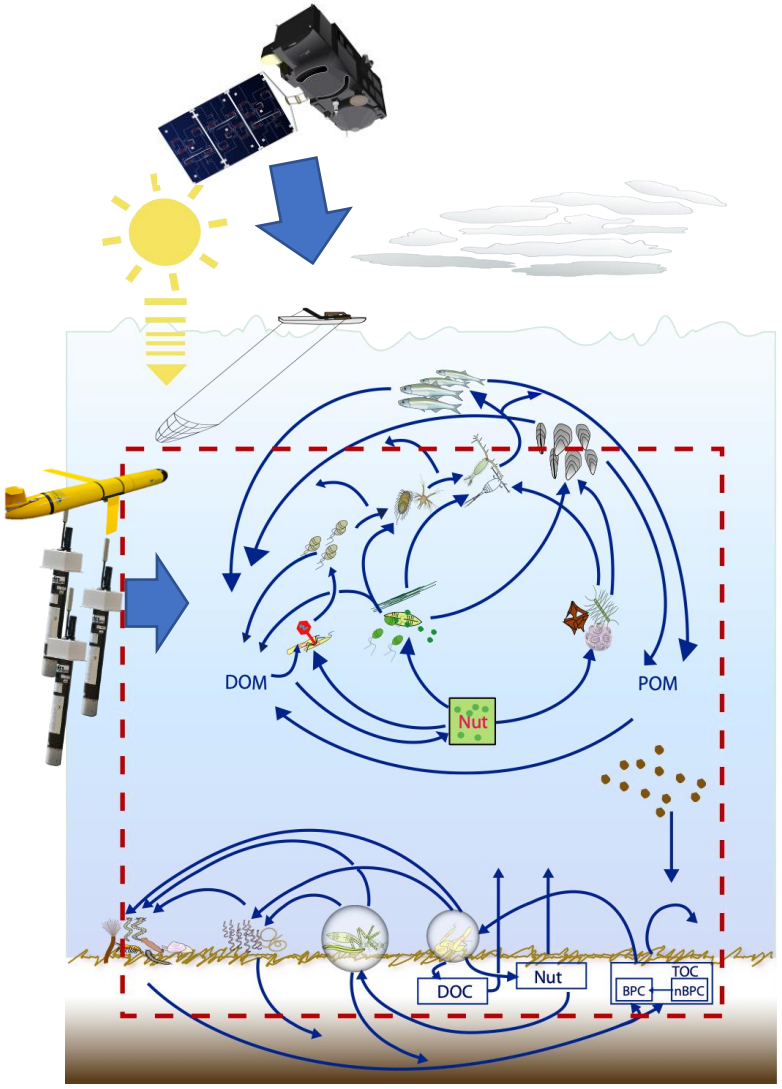
multimodel multi scale ocean visualization







Italian operational centers (CMCC and OGS) plans considering for the UN Decade



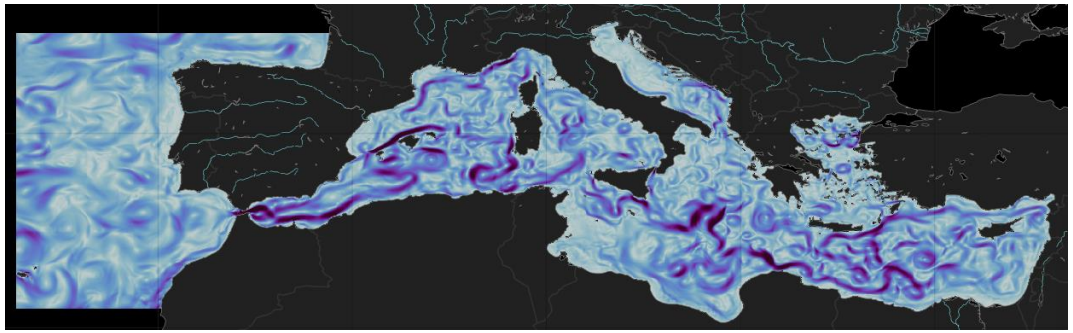
Considering objectives of the UN decades, the OGS plan for model developments includes several major system upgrades toward an ecosystem approach:

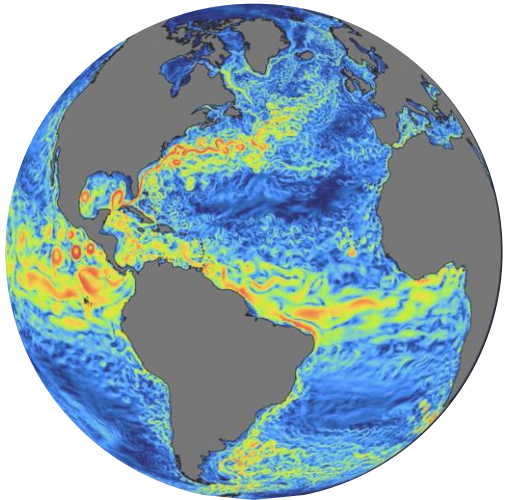
- Including pollutants in ecosystem modelling to support a *clean ocean*
- improving *predictability* by model developments: novel optics, diversity of plankton components (e.g., PFTs, mixoplankton), better resolved carbon cycle (microbial food web *vs* classical food chain; POC and DOC dynamics), benthic-pelagic coupling, land-ocean coupling)
- Improving *predictability* using new generation of biogeochemical data assimilation (new datastreams – new satellite products, bgc-float and glider -, and ensemble data assimilation scheme)
- Coupling low and high trophic level modelling (e.g., suitability model for sensible species and fisheries and E2E modelling) to support a *healthy and resilient* and a *sustainable harvested ocean*

Critical updates related to Italian CMCC operational system of relevance to the Decade

Italy will continue to improve the Mediterranean operational systems for the physical and biogeochemical components in the framework of the Copernicus Marine Service (CMEMS) within the Med-MFC consortium to support users, services and applications for societal activities in a sustainable way
The perspectives for the UN decade developments include several major system upgrades:

- a fully coupled physics-wave system
- improved representation of the vertical dynamics
- better representation of river inputs in the coastal areas
- ensemble forecasting achieved by perturbing the atmospheric forcing and the initial conditions
- development of an atmo-ocean-wave coupled system





Italy will also continue to improve the Global Ocean Forecast System at 1/16° GOFS16 http://gofs.cmcc.it/ including:

- a new atmospheric forcing
- tidal components
- assimilation of sea ice concentration and sea ice thickness
- improved validation tool

cmcc
Euro-Mediterranean Center on Climate Change

Japan (MRI-JMA)

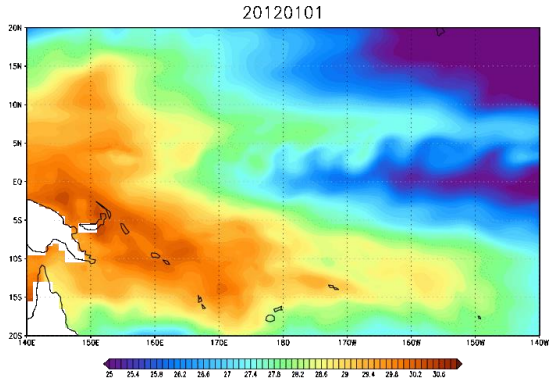
Goro Yamanaka

Summary for current JMA operational systems

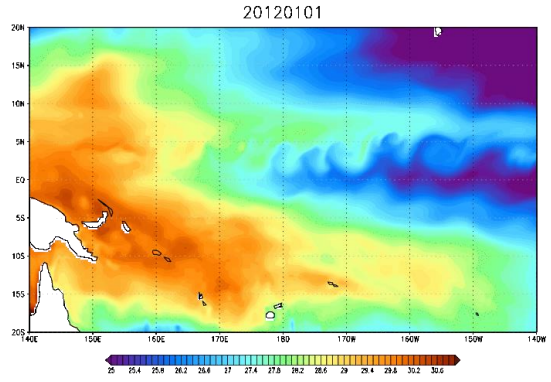
Global system - MOVE/MRI.COM-G3 *Planned for operational implementation in 2021*

- Analysis model (**G3A**)
  - Resolution: 1ºx0.3-0.5º
  - 4DVAR for T/S
  - 3DVAR for sea-ice
- Forecast model (**G3F**)
  - Resolution: 0.25º x 0.25º
  - Initialized with G3A through IAU downscaling

G3A-4DVAR SST (1º × 0.3-0.5º)



G3F-IAU SST (0.25º × 0.25º)

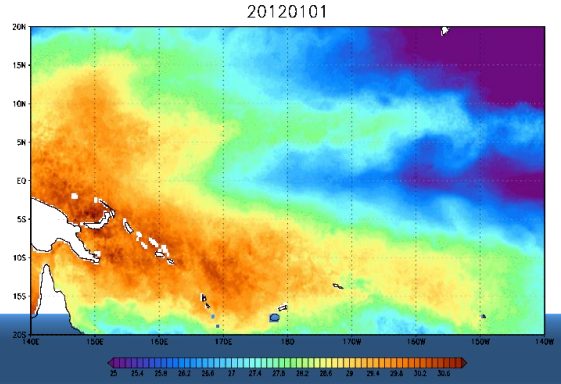


Regional system

- Analysis model - **MOVE/MRI.COM-NP**
  - Domain: North Pacific (15ºS-65ºN, 100ºE-75ºW)
  - Resolution: 10km (1/9º x 1/11º)
  - 4DVAR for T/S
  - 3DVAR for sea-ice
- Forecast model - **MOVE/MRI.COM-JPN**
  - Domain: Japan Area (20-52ºN, 117-160ºE)
  - Resolution: 2km (1/50º x 1/33º)
  - Initialized with MOVE-NP through IAU downscaling

- TIWs slowly move westward realistically in the data assimilation systems.

MGD-SST (0.25º × 0.25º)



JMA activities to engage with the UN Decade

aquaculture

marine debris

- plans of operational system in the Decade

providing information for societal benefit using operational system

- prediction of coastal currents and temperatures for aquaculture
- prediction of marine debris drift
- environmental assessment of offshore wind power generation

wind power generation

A predicted ocean

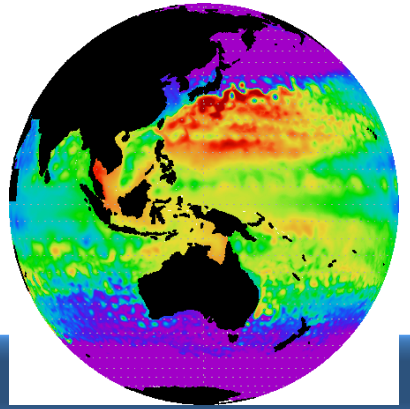
A clean ocean

A healthy and resilient ocean

- critical updates related to the operational system of relevant to the Decade

providing new high-resolution global SST products by directly assimilating satellite data

- application to weather forecasting
- application to marine resource management



A safe ocean

A productive ocean

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Norway (TOPAZ)

Laurent Bertino (NERSC)

Norway – Pan-Arctic forecasts and reanalysis systems

- Latest news 2020 – 2021, part of CMEMS
  - TOPAZ6:
    - 3km HYCOM Arctic tidal and storm surge model, nested in Global MOi NEMO. Daily 10-days forecast. Used for Norwegian preparedness response.
  - neXtSIM-F:
    - Lagrangian adaptive-mesh sea ice forecast. Brittle-Bingham-Maxwell (BBM) rheology. Improved ice drift forecast.
  - ECOSMO2:
    - 6km NRT biogeochemical model. 50 layers. Carbon Cycle. Simple Assimilation of Ocean Colour.
  - WAM:
    - 3km Arctic wave forecast and hindcast
  - TOPAZ4b reanalysis:
    - 50 hybrid layers.
  - ECOSMO reanalysis: one-lag EnKS

- Plans 2022-2028
  - 6km EnKF (TOPAZ5) and 3km deterministic (TOPAZ6).
  - Prepare for new Copernicus Polar missions: CIMR, CRISTAL.
  - Wave terms in ocean
  - Improved river runoff (Arctic-HYPE)

- (Potential) Contributions for The Decade, depending on funding.
  - Safe ocean:
    - Forecasting targeted sea ice navigation (with large leads)
    - “Iceberg risk zone” forecasting
  - Predictable ocean:
    - Interpretable ensemble forecast
    - BGC-augmented fish habitat

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South Korea (KIOST)

Do-Seung Byun

Proposed Decade Contributions by KIOST

The "ROSE" Center (The Center for Recovering the Ocean towards a Sustainable Earth)

Oceanic effects on climate variability of the Northwest Pacific ✚ Mesopelagic ecosystem in the Pacific Ocean

- Understanding and predicting climate variability in the Northwest Pacific and its consequences in order to mitigate climate crisis
- Understanding the structure and function of the mesopelagic ecosystem in the Pacific Ocean

UN SDG : GOAL 13, 14, 17

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UK/Europe (ECMWF)

Kristian Mogensen

Summary and plans for current ECMWF operational systems

- Ocean model configurations
  - Current ocean model is based on NEMO V3.4.1 with local ECMWF modifications
  - Same ocean grid with about 0.25 degree resolution used for all operational systems
- Ocean analysis systems (BRT and RT):
  - ocean5: NEMOVAR 3D-VAR FGAT
    - T/S/SLA/SIC observations, SST via relaxation
- All forecasting systems are coupled (atmospheric resolution list below)
  - HRES CY47R1 (30/6-2020) 9 km deterministic 10 days twice daily
  - ENS CY47R1 18 km 51 members 15 days twice daily
  - Monthly CY47R1 36 km 51 member 46 days Monday and Thursday 0z
  - SEAS5 CY43R1 (November 2017) 36 km 7 months every month, 13 months every 3 months
- Plans for the next ocean model upgrade (2022 target)
  - Upgrade to NEMO V4. Biggest change is the LIM2 (mono-cat) to SI3 (multi-cat) sea ice model
  - Resolution will likely stay the around 0.25 degree for the ocean.

UK (FOAM)

David Ford (Met Office)

UK Met Office

- Engage with ForeSea, SynObs, and related projects
- Further international collaborations such as CMEMS, NEMO, NEMOVAR, etc
- High resolution coupled ocean-wave-atmosphere forecasts including ensembles with increased forecast frequency and longer lead times
- Implement hybrid ensemble-variational data assimilation
- Investigate strongly coupled data assimilation
- Increased focus on high coastal resolution and biogeochemical applications
- Improved modelling and reanalysis for recent/future changes in sea level and the regional marine environment around the UK
- Exploit new data types for assimilation, and contribute to observing system design
- Improved verification techniques and provision of uncertainties and probabilities

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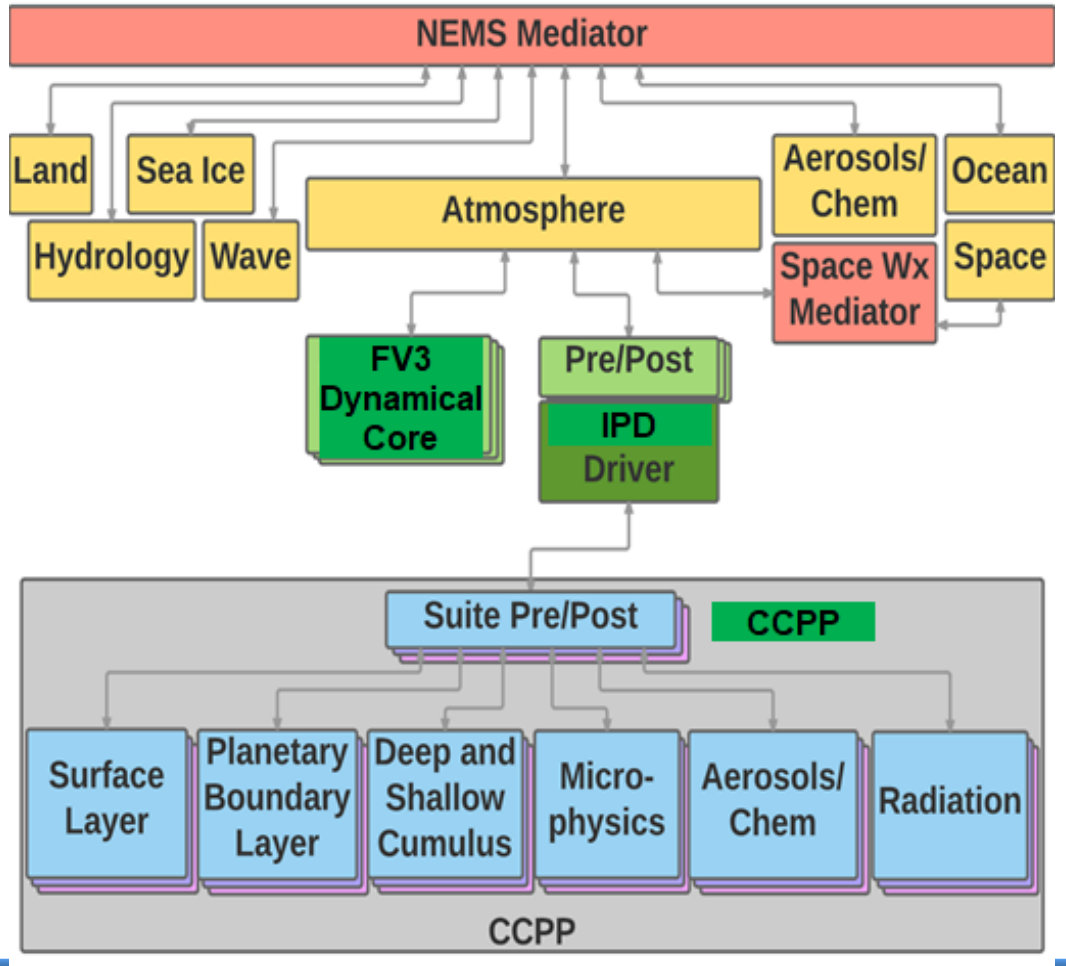
USA (NOAA-NCEP)

Avichal Mehra

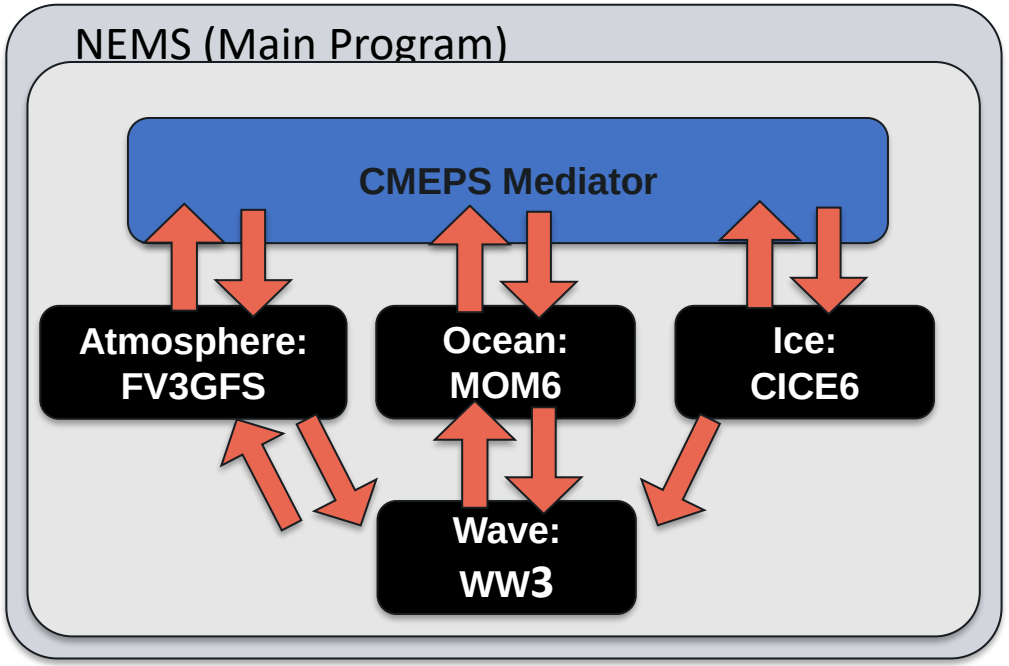
NWS-Unified Forecast System

- NWS UFS system consists of the following community components
  - NEMS for infrastructure
  - CMEPS mediator
  - FV3 dycore with CCPP Physics driver
  - **MOM6 ocean model** (S2S scales)
  - **HYCOM ocean model** (weather scales)
  - **WW3 wave model**
  - **CICE6 ice model**
  - NOAH-MP LSM
  - GOCART Aerosol model
- Each component has its own authoritative repository. NEMS infrastructure allows flexibility to connect instantiations of the repositories together to create a coupled model.
- *https://ufscommunity.org*



NWS-Unified Forecast System

- Infrastructure for coupling models together:
  - NOAA's Environmental Modeling System **(NEMS)** drivers and caps
  - Community Mediator for Earth Prediction Systems **(CMEPS)**
  - National Unified Operational Prediction Capability **(NUOPC)** conventions
- Infrastructure for interoperable physics:
  - Common Community Physics Package **(CCPP)** framework
- Infrastructure for data assimilation: Joint Effort for Data assimilation Integration **(JEDI)**

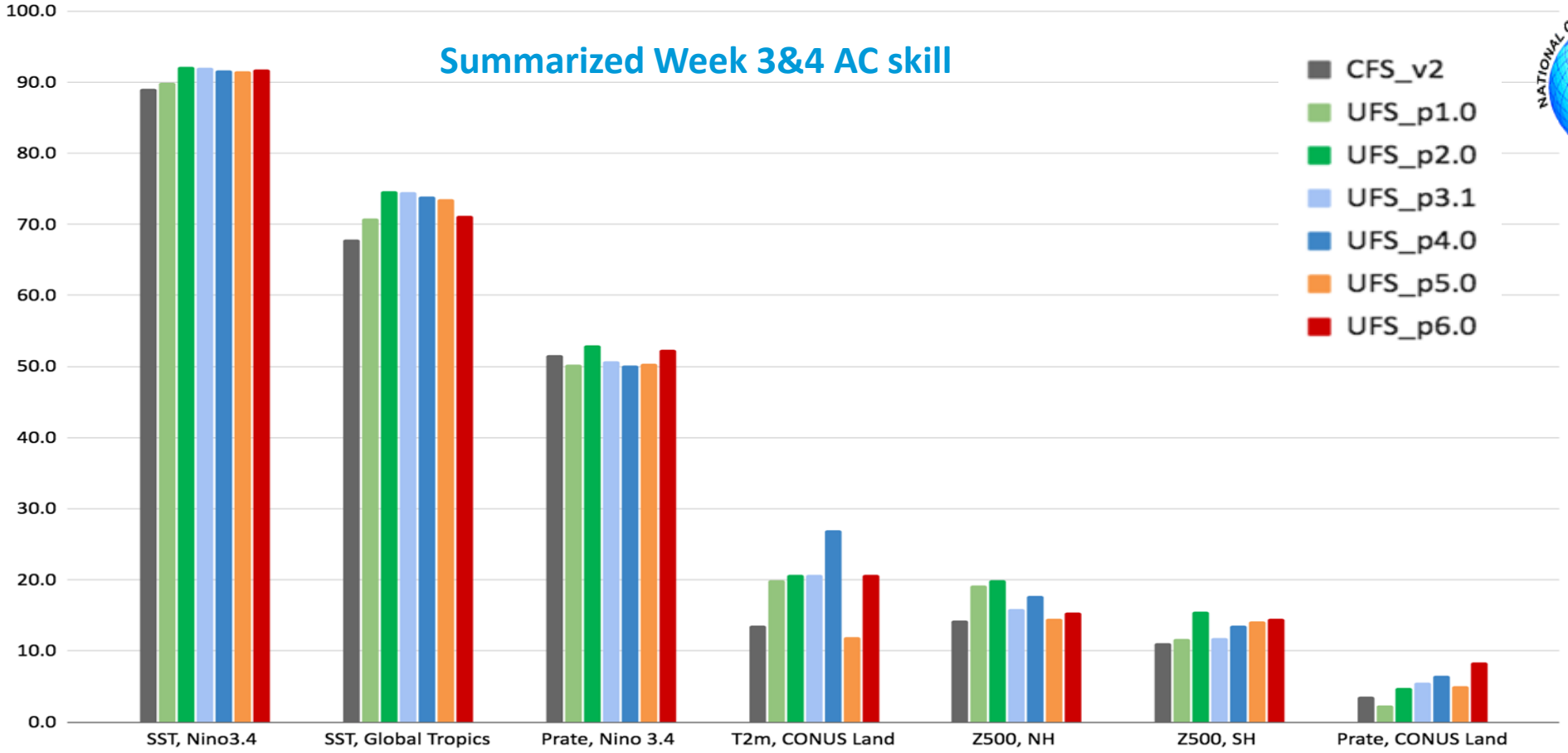


Common Goals with UN Decade of the Ocean:

Enhance Operational Earth Prediction Enterprise for all temporal scales (weather-to-subseasonal-to-seasonal) and include Global, Regional and Coastal UFS applications.

Leverage developments with UN endorsed Ocean Decade activities including **ForeSea, OASIS and CoastPredict**.

Development of Fully Coupled Unified Forecast System for Weather-to-Seasonal-to-Subseasonal Applications



Multiple prototypes of a fully coupled system (FV3-MOM6-CICE6-WW3-NOAH_MP-GOCART-CMEPS) have been completed. These prototypes target the next operational versions of GFS (medium-range), GEFS (sub-seasonal) and SFS (seasonal) forecast systems at NOAA/NCEP.

OceanPredict
Advancing the science of ocean prediction

USA (OceanPredict US)

Eric Chassignet

OceanPredict
Advancing the science of ocean prediction

OceanPredict.US

Coalescing the Nation's Operational Oceanography Enterprise

Vision:

Establish a framework for the U.S. operational oceanography enterprise, enabling the earth system science value chain from observation to decision-making and societal benefit.

Objective

OceanPredict
Advancing the science of ocean prediction

- **OceanPredict.US aims to:**
- **Coalesce** existing U.S. operational oceanography components into a coherent national enterprise, transformatively establishing a framework for sustained operations, comparable to the Nation's weather enterprise, spanning the blue (physical), white (sea ice), and green (ecological) ocean components.
- **Enable** informed decision-making for societal benefit, greater return on ocean-related investments, and integration of activities contributing to the ocean observation value chain, spanning observations, analyses, predictions, products, and services.
- **Evolve** the Nation's operational oceanography enterprise beyond the existing collection of ocean-related research activities and operational endeavors to a sufficient network of infrastructure and sustained operations at national, regional, and local levels.
- This **transboundary effort** seamlessly transitions from the open ocean to the coast and tropics to the poles for short-term "weather" to anthropogenic-forcing time scales.
- This **strongly interdisciplinary** effort connects the physical, biogeochemistry, and social sciences for societal benefit uses through integration and exploitation of ocean observations.
- **Provide a locus for transitioning governmental, non-governmental, and private sector research to operations for value-added products and services supporting informed decision-making**.

Status

- Proposed “Ocean-Shot”, ***OceanPredict.US***, submitted to the U.S. National Committee for the UN Ocean Decade

- **Initial engagement:**
  - Cross-NOAA discussion
    - National Ocean Service (NOS)
    - National Weather Service (NWS)
    - National Marine Fisheries Service (NMFS)
    - Office of Oceanic and Atmospheric Research (OAR)
    - National Environmental Satellite, Data, and Information Service (NESDIS)
  - IOOS Association (non-profit) – Working with the 11 U.S. IOOS Regional Associations and Federal partners
  - Industry group – Consortium for Ocean Leadership
  - Nominated NOAA Administrator
    - Under Secretary of Commerce for Oceans and Atmosphere
  - Recent past Acting NOAA Administrator
    - Under Secretary of Commerce for Oceans and Atmosphere

- Website established – pending initial content