

OPST-3 National Groups presentation (1 slide per system)

OPST-3, GoTo meeting – 7, 8 and 10 December 2020

Systems represented in Deck:



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| | | |

China Global Forecasting System: status and future



Future

NMEFC High Resolution Forecasting System based on NEMO

Status



- ✓ Code --NEMO3.6 + LIM3
- ✓ Horizontal resolution --1°/12
- ✓ Effectiveness--7~10 days
- ✓ Forcing-- NCEP GFS or ECMWF

| | 2019 | Bias | RMSE |
|---------|-----------------|---------|--------|
| SLA | SLA (cm) | -0.071 | 5.223 |
| Current | velocity (cm/s) | -21.369 | 32.461 |
| (TOGA) | direction (°) | 19.154 | 27.681 |
| T (°C) | SST | 0.178 | 0.409 |
| | T profile | 0.029 | 0.726 |
| S (PSU) | S profile | -0.024 | 0.239 |



Improvement of NEMO forecasting system

- > Assimilation of Sea Ice, Salinity and Current
- Two-way nest between Global and Regional systems
- Coupled with Ocean Wave and Atmospheric systems

MCOM: Mass Conservation Ocean Model



- A new press coordinate Ocean Model
- Multi-grid inclued tripole, cubic with global and regional
- High quality partition for parallel computing and load balancing
- GPU Acceleration

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CONCEPTS System Status and Plans

| Status | Plans | | | | |
|--|---|--|--|--|--|
| Global System - GIOPSv3 SEEK DA + 3DVar T/S Bias correction 2x daily coupled 10day fcst + 16day ensemble fcst Weekly: 32-day coupled ensemble forecasts (20 member) seasonal forecasts initialization | For next operational roll out (Sept 202,IC3) Incl. diurnal SST variability to analysis Ice parameterization (P*,C*,z0ai) to reduce ice drift error Monitoring package using NEMO XIOS and python <u>R&D:</u> Ensemble analyses | | | | |
| <u>Regional System - RIOPSv2</u> SEEK DA + online dynamic harmonic analysis for tides 4 x daily 48 hr uncoupled forecasts 2 x daily 48 hr coupled forecasts (for YOPP) ending spring 2021 | For next operational roll out (Sept 2021, IC3) 3Dvar T/S Bias correction k-ε vertical mixing + wave breaking upgrades as in GIOPS (above) <u>R&D:</u> OSEs in Arctic | | | | |
| <u>Coastal Port Systems:</u> R&D on Nested NEMO downscaling from RIOPSv2 to 6 ports with max resolution 20m – 100 m | Port Ocean Models for routine prediction 4 x day to support E-NAV Best effort Demos March 2021-March 2022 for 6 | | | | |

OceanPredict Advancing the science of ocean prediction

Innovations of SLA (2016-19)





[G,R,C]IOPS=[Global,Regional, Coastal] Ice Ocean Prediction System

ports

IC3: Innovation Cycle 3. Operational Sep. 2021

Smith et al., GMDD, 2020



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.

Met Office FOAM-UK overview of status and plans



New and upcoming operational system developments:

- Operational implementation of global 1/12° FOAM will go live in Dec 2020. Developed for UK Royal Navy.
- Coupled NWP development and implementation. Deterministic 10km resolution atmosphere/land, 1/4° ocean/sea-ice, with weakly coupled DA. Coupled ensemble (with 1/4° ocean). Planned for operational implementation in 2021.
- Development of a global ocean ensemble and hybrid ensemble/variational DA. Planned for operational implementation in 2023 to improve the ocean component of coupled NWP ensemble system. (Long time-scale partly due to new supercomputer system expected in 2021/22 and the associated porting work).

Assimilation of new data types:

- Assimilation of sea-ice thickness: daily along-track freeboard from Cryosat2 and thickness from SMOS.
- ESA A-TSCV project: testing impact of assimilating Total Surface Current Velocity (TSCV) from future missions like SKIM (in collaboration with Mercator-Ocean).
- SWOT preparation: work started in 1.5 km shelf-seas configuration, global next year.
- Operational ocean colour assimilation in shelf-seas physical/biogeochemical model.

India-INDian Ocean FOrecasting System (INDOFOS)



High-resolution Operational Ocean Forecast and reanalysis System (HOOFS) [Francis et. al 2020.]

- Global : INCOIS-GODAS (MOM4.0+3DVAR)
- Regional: ROMS v3.6 + LETKF
- Coastal : ROMS v3.6

INCOIS Tentral Ocean Prediction System for Indian Ocean (ITOPSI)

- Global : HYCOM (HYCOM+TSIS)
- Regional: HYCOM

(HYCOM+TSIS)

Wave Forecasts

- Global : WAVEWATCH III
- Regional: WAVEWATCH III
- Coastal : SWAN

Storm Surge

Regional: ADCIRC+ SWAN

High-Resolution Operational Ocean Forecast and Reanalysis System for the Indian Ocean

P. A. Francis, A. K. Jithin, J. B. Effy, A. Chatterjee, K. Chakraborty, A. Paul, B. Balaji, S. S. C. Shenoi, P. Biswarnoy, A. Mukherjee, P. Singh, B. Deepsankar, S. Siva Reddy, P. N. Vinayachandran, M. S. Girish Kumar, T. V. S. Udaya Bhaskar, M. Ravichandran, A. S. Unnikrishnan, D. Shankar, A. Prakash, S. G. Aparna, R. Harikumar, K. Kaviyazhahu, K. Suprit, R. V. Shesu, N. Kiran Kumar, N. Srinivasa Rao, K. Annapurnaiah, R. Venkatesan, A. S. Rao, E. N. Rajagopal, V. S. Prasad, M. D. Gupta, T. M. Balakrishnan Nair, E. P. R. Rao, and B. V. Satyanarayana



Future Plans: An unified ocean modeling and forecasting system

Existing ocean modeling system will be replaced by the following systems in phased manner

- MOM6 for global to regional level applications.
- LETKF based DA system in MOM6
- **FVCOM** for coastal/shelf sea/estuary applications.
- WAVEWATCH III for global to coastal wave forecast
- ADCIRC+SWAN for tsunami and storm surge prediction
- MOM6+WRF coupled system



OceanPredict

☆ JMA Ocean Prediction System Updated in Oct. 2020





KHOA's KOOFS



STATUS

KOOFS (2015~2020)

KOOFS (2021 ~ 2025)

PLAN

| FOCUS | PREDICTIVE TIME SCALE | APPLICATION | FOCUS | PREDICTIVE TIME SCALE | APPLICATION |
|----------|--------------------------|---|----------|--------------------------|--|
| Local | day | Coastal Modeling System Atmosphere (WRF: ~4 km) Circulation (ROMS: 0.1 ~ 1 km, MOHID: ~300 m) | Local | day | Coastal Modeling System Circulation (ROMS) - Ulleungdo • Dokdo (~300 m) - East Korea Coastal (1 km) |
| Regional | day | Regional Modeling Systems Atmosphere (WRF: ~20 km) Circulation (ROMS) - Yellow and East China Seas (3 km) - East Sea (3 km) - North Pacific Ocean (1/4°) | Regional | week | Regional Modeling System Circulation (MOM5: ~4 km) - East Sea & Yellow and East China Seas (1 km) - Northwest Pacific Ocean (~4 km) |

KIOST's KOOS



STATUS

R&D (2018~2022)

National Program (2022 ~ 2029)

PLAN

| FOCUS | PREDICTIVE TIME SCALE | APPLICATION | FOCUS | PREDICTIVE TIME SCALE | APPLICATION |
|----------|--------------------------|--|----------|--------------------------|---|
| Local | dav | Coastal Modeling System Atmosphere (WRF: ~4 km) | Local | hour | AI (Deep Learning) |
| Loodi | ddy | Circulation (MOHID: ~300 m , TELEMAC: ~10 m) Wave (SWAN: 300 m) | Looui | day | Coastal Modeling System Atmosphere (MPAS-A) |
| Regional | week | Circulation (MOM5: ~4 km) | Regional | week | Circulation (MOM6, MOHID, TELEMAC) Wave (SWAN, TOMAWAC) |
| Global | | Global Modeling System (under developing) Atmosphere (MPAS-A: ~15 km) Circulation (MOM6: ~9 km) | Global | month year | Global Modeling System - Coupled Model Atmosphere – Ocean –Ice – Land – Ecosystem |



The Oceanographic Modeling and Observation Network (REMO)



is a research group formed by Federal Univ. of Bahia (UFBA), Federal Univ. of Rio de Janeiro (UFRJ), Petrobras Research Center (CENPES) and the Brazilian Navy Hydrography Center (CHM), that holds the REMO-CHM ocean operational forecasting system (OOFS) for the Atlantic.

- The OOFS uses HYCOM and the REMO Ocean Data Assimilation System (RODAS) based on EnOI. HYCOM+RODAS assimilates Argo T/S data, UK MetOffice OSTIA SST and along-track AVISO SLA data.
- Assimilation is performed twice a week, but 5-day forecasts are performed daily forced by a combination of CHM-COSMOS atmospheric forecasts (3-d window) and NOAA/NCEP/GFS forecasts (4 to 5-d window).
- A system with 3 nested grids is employed today
- A **new OOFS** operational since March 2020 will replace the current system in the first semester of 2021.
- UFBA and UFRJ produced 4 10-yr reanalysis in 2019-2020 from 2008 to 2017.
- UFBA develped a preliminar version of an **EnKF** with 11 members only, and will improve it to 30-members in 2021.
- Efforts on OSSEs with SWOT and on OSEs with SSS are underway.





75°S

-1.4

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Status and (immediate) plans, pan-Arctic products, Norway

NRT forecasts

- TOPAZ4, EnKF 100 mems @12 km
 - Addition of CS2SMOS ice thickness since Nov 20
- TOPAZ5, EnKF 100 mems @ 6km
 - ECOSMO BGC forecasts @6km scheduled for May 2021,
 - Coupling to CICE 5.1 ongoing
 - Release of physical variables planned Dec 2021
- TOPAZ6, including s. surge & tides @ 3km
- neXtSIM stand-alone @3km
 - Forced by TOPAZ4 ocean
 - Nudged daily to ice concentrations
 - New BBM rheology 15th Dec. 2020
- WAM @3 km forecast

Reanalyses

- TOPAZ4b, EnKF 100mems @12km
 - From 28 to 50 vertical layers
 - Partial release 15th Dec 2020
- ECOSMO, EnKS 80 mems @ 25 km
 - Assimilation of surface chl and nutrients profiles
 - Parameter estimation
 - Partial release 15th Dec 2020
- WAM @3km wave hindcast
 - Partial release 15th Dec 2020

Operational Real Time Ocean Forecast System (RTOFS) at NOAA/NWS/NCEP



- Operational Eddy Resolving Ocean Modeling and Initialization
- Coupled Modeling for Hurricanes (Air- Sea- Wave flux interactions, mixing)
- Inputs to operational Global (GFS v16) and Coastal (NWPS) wave models to admit wave-current interactions
- Coupled Ecosystem Forecasting (Biogeochemical, NPZD, tracers)
- RTOFS v2 upgrade scheduled for FY21 with a new data assimilation system
- Strong collaboration with US Navy, leveraging core HYCOM and ocean data assimilation developments at NRL.





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international :



Global Analysis & Forecast:

PHY (GLO12)

New products available: 3D 6h-instantaneous fields New global 1/12° under development.

BGC (BIO4)

OC assimilation

WAV (MF system at 1/12°)

Updated system assimilating new satellite observations (S3, CFOSAT) Daily 10 days forecasts

Global Reanalyses:



Available on Copernicus

- PHY (GLORYS12 + GREPv1/v2)
 GREPv1/v2 multi system ensemble reanalysis
 Switch to ERA5 in GLORYS for all reanalysis extension
- BGC (BIORYS & MICRORYS) BIORYS & MICRORYS at 1/4° MICRORYS at 1/12° in 2021 Assimilation of OC in BGC reanalysis postponed
- WAV (WAVERYS) 1/4° New RAN planned for Copernicus 2
- Interim RAN production under development (monthly update)

Overview of ITALIAN NATIONAL SYSTEMS (CMCC Contribution)

Global Ocean

AN FCST: GOFS16 @ 1/16° + 98 vert levs (NEMO) REA (CMEMS): 1/4° + 75 vert levels (NEMO) ERA-Interim – 1993-2019

Future Plan:

Z*, Include tides in AN FCST system

New Global Reanalysis using ERA5

Mediterranean Sea (CMEMS System)

AN FCST: MedFS @ 1/24° hor res. + 141 vert lev (NEMO+WW3)

REA: 1/16° hor res. + 72 vert lev (**NEMO**) ERA-Interim – 1987-2018



Include tides in the AN FCST system + improved river forcing

New Med Sea Reanalysis 1/24° hor res. + 141 vert lev (NEMO) ERA5 – 1987-2019

Data Provision within IV-TT:

Global and Mediterranean Sea Inter-comparison & Validation metrics (Global will enter in 2021, Med Sea should be re-included....)

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- Modeling MOM5 (current), MOM5+CICE5 (developed; Kiss et al., 2020), ROMS 1/50x1/50
- Data assimilation EnKF-C/EnOI (current), FGAT/Low-mode multiscale (developed), EnKF (developed)
- Observations VIIRS Metop-B and NOAA-20
- Systems OceanMAPSv3.3 (current) Bulk fluxes, ACCESS-G3
 - v3.4 (op-testing) FGAT+Low-mode assim,
 - v4.0i (final hindcast) EnKF (target 2021)
 - v4.0 (prelim) EnkF+MOM5/CICE5 (target 2022)
- Verification CLASS4 ocean current (detailed analysis with Mercator)
- Reanalysis BRAN2020 completed (JRA-do and Multiscale assimilation)
- Viewer New viewer on AWS (<u>https://www.seedragon.org</u>)
- Other
 - Bureau committed to coupled NWP (initial system ORCA025, next gen ORCA12) with UM partnership
 - Regional ocean models scheduled for operational 2021
 - Development project for coupled BGC