GOFS16:
A GLOBAL OCEAN FORECAST SYSTEM AT EDDYING RESOLUTION

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Motivation: Mesoscale Features

- A new global eddying forecasting system (GOFS16) is operating on a daily basis. Each forecast represents the ability of GOFS16 to address two key problems:

  how to model the natural processes at the “meso-scale”? (GLOB16, Iovino et al. 2016)

  what is the most probable state of the ocean, based on the observations?
“Eddy-resolving” at 1/10° (Smith et al. 2000) is not enough to resolve ocean “weather”

The horizontal resolution needed to resolve the first baroclinic deformation radius with two grid points

At all (present-day) resolution, OGCMs resolve the mesoscale in some regions but not others
Global eddy-resolving configuration: GLOB16

**Ocean/Sea Ice code**

NEMO / LIM: OPA is a finite difference, hydrostatic, primitive equation ocean general circulation model coupled to Louvain-la-Neuve sea Ice Model

**Mesh**

Global tri-polar grid: horizontal resolution spacing from 6.9 km at the equator to ~2 km at high latitudes with 98 vertical levels (5762 x 3963 x 98 points)

**Bathymetry**

Etopo2 (deep ocean) + GEBCO (continental shelves) + Bedmap2 (Antarctic region) - hand editing

**Initialization**

Temperature and Salinity from WOA 2013
Sea ice properties from 1/4° ocean reanalysis

**Atmospheric forcing**

Bulk CORE-II formulation
Era-Interim atmospheric forcing (1/4°)

River run-off from Dai et al. (2009) - global annual discharge of ~1.32 Sv

(Iovino et al. 2016)
implied transport estimates

in situ measurements

(Iovino et al. 2016)
The OceanVar assimilation scheme works with daily updates from multiple data sources

**In-situ data:** Argo floats, moorings, XBTs, CTDs and bathy-thermographs, assembled by the Ifremer/Coriolis real-time data center and disseminated from CMEMS

**Altimetric data** from Jason-2 (now Jason-3), AltiKa and CryoSat2, Sentinel 3a collected by CLS/AVISO and distributed by CMEMS.

**SST data:** Advanced Very High Resolution Radiometer (AVHRR) from NOAA and Advanced Microwave Scanning Radiometer2 (AMSR2) from NASA

**On-line nudging schemes:**

- Gridded SST (AVHRR) daily analyses by NOAA
- Gridded SSS from UK MetOffice EN4 (v4.1.1) objective analyses
- Nudging of sea-ice concentration satellite data processed by NCEP
Assimilation of satellite variables

Set up of a twin experiment for understanding and testing the impact of using different resolution at assimilation level

Increasing the resolution, the RE reduces and small-scale corrections emerge, leading the ocean state closer to observation.

**Time series of RMSE SST**

- Error improves about 15% for SST

**Time series of RMSE SLA**

- Error improves about 8% for SLA
**GLOBAL OCEAN FORECAST SYSTEM GOFS16**

GOFS16 represents CMCC efforts in pushing global forecasting systems to compete with regional operational systems in term of resolution and accuracy of mesoscale predictions.

GOFS16 = GLOB16 combined with a **OceanVar** data assimilation system.

GOFS16 runs operationally since July 2017 every day, and produces 7-day ocean forecast of 3D currents at 1/16° resolution at hourly frequency and 3D T and S at daily frequency.
GOFS16 Validation: SST

Forecast RMSE and Bias

Analysis RMSE

Day 2-4-6
GOFS16 VALIDATION: SLA

FORECAST RMSE AND BIAS

DAY 2-4-6

RMSE SLA ANALYSIS
Model currents are also compared to a gridded product named OSCAR that provides maps of the top 30m ocean currents with 5-day-mean frequency (https://www.esr.org/research/oscar/oscar-surface-currents/). Analysis consider the full 2018
An example of validation with independent data: The Global Drifter Program (GDP), a global 5x5 degree array of 1250 satellite-tracked surface drifting buoys

The model speed RMSE along drifter tracks is shown for each drifter and ordered for clarity. Most of drifters show errors between 0.1-0.2 m/sec
Drifter trajectories in the first 6 months of 2018

Simulated ones in the first 6 months of 2018
(daily-mean currents and nearest grid point approximation)
GOFS16 VALIDATION AT REGIONAL SCALE

Time-series of observations vs model speed (first day of forecast). Daily number of observations in gray.

Polar plot indicating direction and module of ocean currents (at 15 m) at 6h frequency along the drifter’s track for the observations and the model.

RMSE of surface currents at 15 m computed along drifter’s track.
Structured and Unstructured grid
Relocatable ocean platform for Forecast

- SURF provides a numerical platform for short-time forecast at higher spatial and temporal resolution
- It is based on two HD code: NEMO (Finite Difference model) and SHYFEM (Finite Element Model).
- It can be easily and quickly deployed in any region of a large-scale Ocean Forecasting System via one-way nesting procedure
- The platform includes multiple nesting capability - for each nesting, the coarse-grid (parent) model provides initial and lateral boundary condition to the fine-grid (child) model.
- increasing model resolution in sub-domains to resolve a wide range of scale, from mesoscale (10-100km) to submesoscale processes (100m-10km)
NESTED-GRID OCEAN MODELLING SYSTEM

CARIBEAN SEA

GOFS(1/16)  SURF(1/32)

Experiment Thesis Elise Bouden

GOFS(1/16)  SURF(1/64)

CENTRAL MED
• The Global Ocean Forecast System GOFS16 is an operational eddying ocean analysis and forecast system that runs daily at the Euro-Mediterranean Center on Climate Change since mid 2017

• GOFS16 produces 7-day ocean forecast of 3D currents at 1/16° resolution at hourly frequency and 3D T and S at daily frequency

• The forecast skill of the model is routinely monitored

• A preliminary assessment of GOFS16 predictive skills with respect to other global operational forecast systems is encouraging

• GOFS16 can be downscaled with a new tool, the Structured and Unstructured Relocatable ocean model for Forecasting (SURF) based on NEMO, reaching resolutions of 1/64° in any region of interest
Thanks