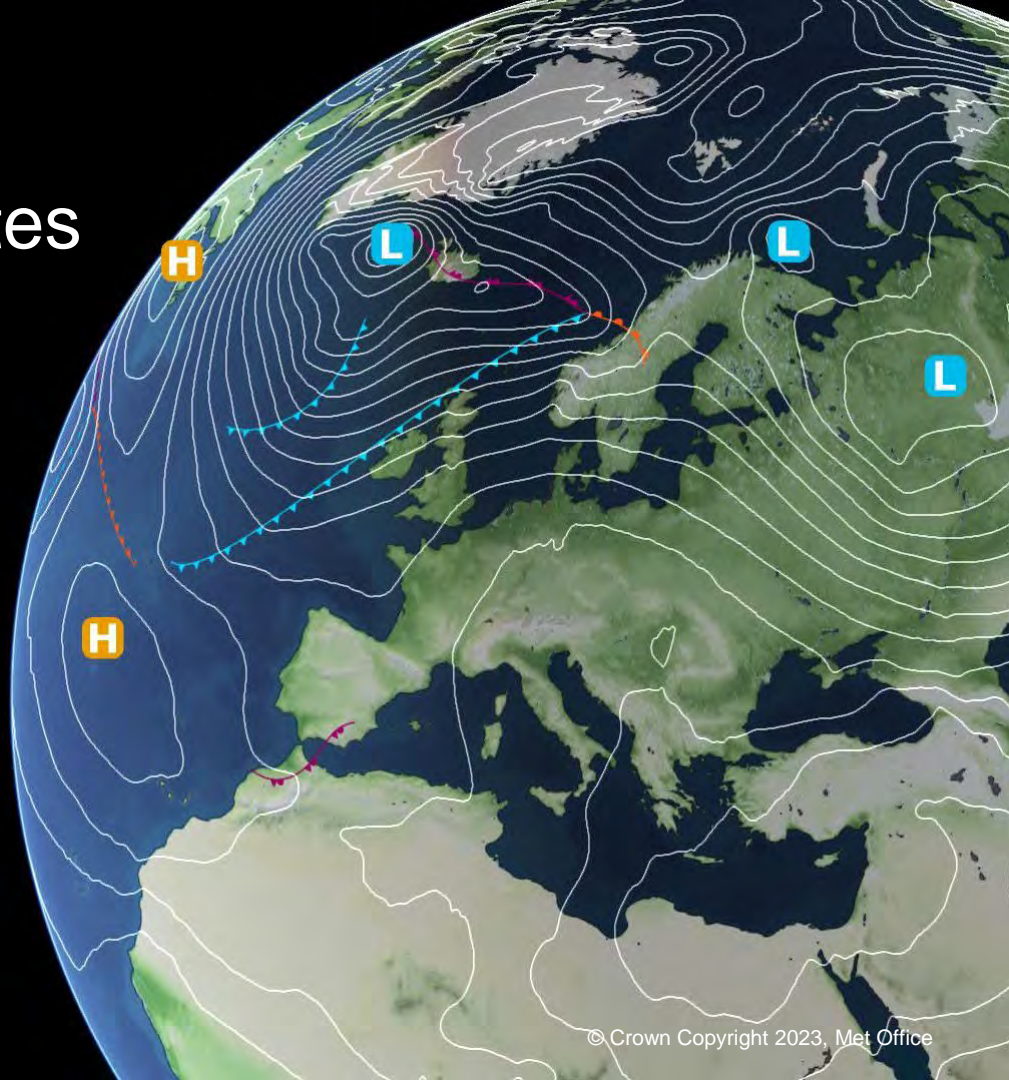


# Met Office systems updates

David Ford with thanks to colleagues in  
the Ocean Forecasting R&D team

Ocean Predict Science Team meeting,  
8<sup>th</sup> November 2023



- **Operational 3D ocean (FOAM)**
  - Global ocean – atmosphere – land – sea ice
  - Regional ocean – waves
  - Regional ocean – biogeochemistry
- **Operational 2D ocean**
  - Global and regional waves
  - Regional storm surge
  - Global SST and sea ice analysis (OSTIA)
- **R&D**
  - Regional ocean – atmosphere – land – waves – biogeochemistry
  - Global ocean – sea ice – biogeochemistry
  - High-res global ocean – sea ice

- **Operational 3D ocean (FOAM)**
  - Global ocean – atmosphere – land – sea ice
  - Regional ocean – waves
  - Regional ocean – biogeochemistry
- **Operational 2D ocean**
  - Regional storm surge
  - Global and regional waves
  - Global SST and sea ice analysis (OSTIA)
- **R&D**
  - Regional ocean – atmosphere – land – waves – biogeochemistry
  - Global ocean – sea ice – biogeochemistry
  - High-res global ocean – sea ice

# Global coupled ocean-atmosphere

- Deterministic (N1280 atmosphere)
- 18-member ensemble (N640 atmosphere)
- Both run 6-hourly with  $1/4^\circ$  ocean
- Up to 8-day forecasts

UM atmosphere



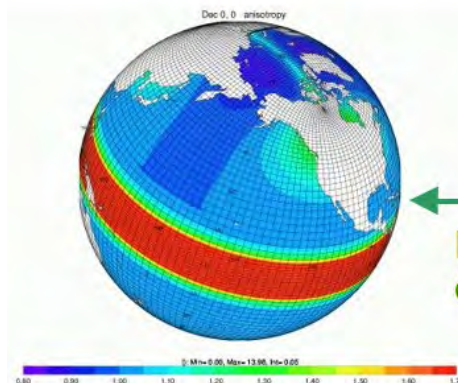
JULES land surface



Internal communication

OASIS3-MCT coupler (every hour)

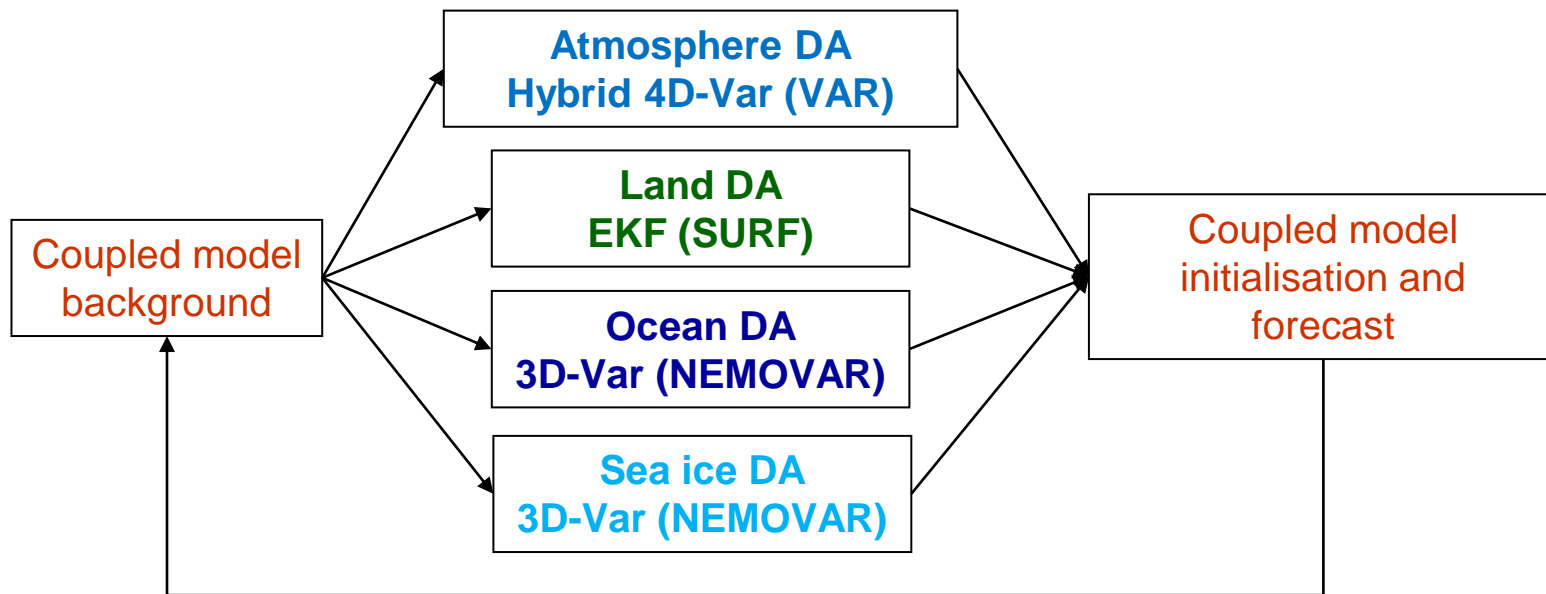
Internal communication



NEMO ocean

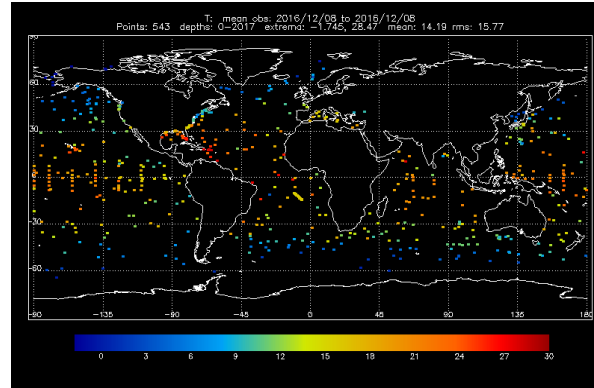
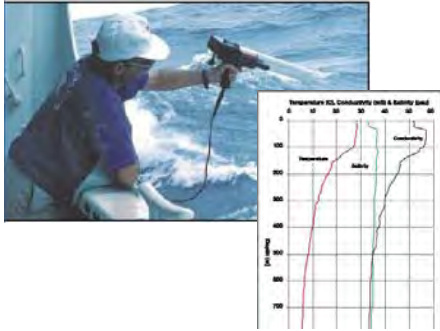
CICE sea ice

# Met Office Weakly coupled data assimilation

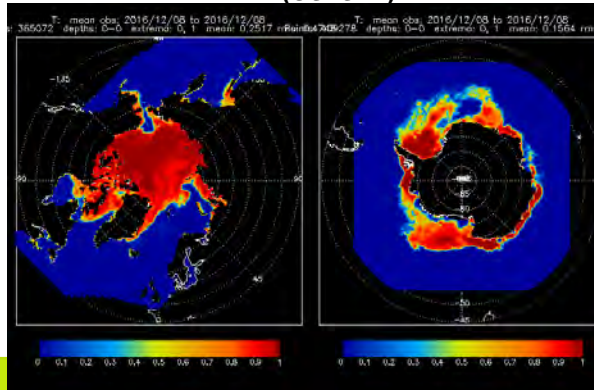
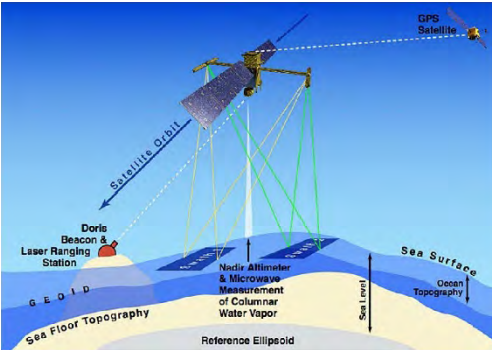


- Coupled model used in the forecast (and for DA background)
- Separate component DA with increments added to coupled model

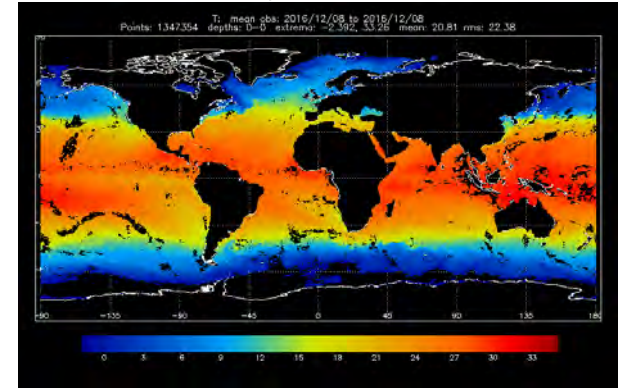
**Temperature and salinity profiles**  
(Argo floats, XBTs, CDTs, buoys, gliders, marine mammals...)



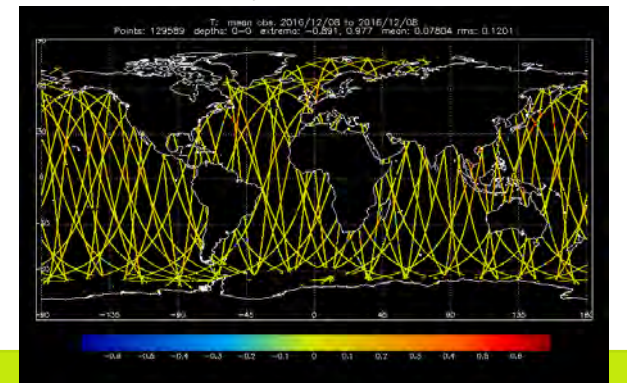
**Sea-ice concentration**  
(OSI-SAF)



**Satellite and in-situ SST**  
(METOP, AMSR2, VIIRS, SEVIRI, SLSTR, buoys, ships,...)



**Satellite Altimeter SSH**  
(Jason 3, AltiKa, CryoSat2, Sentinel-3, Sentinel-6)



# Met Office Ocean updates since Nov 2020 report

- Coupled ocean-atmosphere
  - Transition from low-res R&D to full operational system
  - NWP and ocean forecasts all from coupled system
- Updated mean dynamic topography
- Improved observation processing
- Major improvements to postprocessing

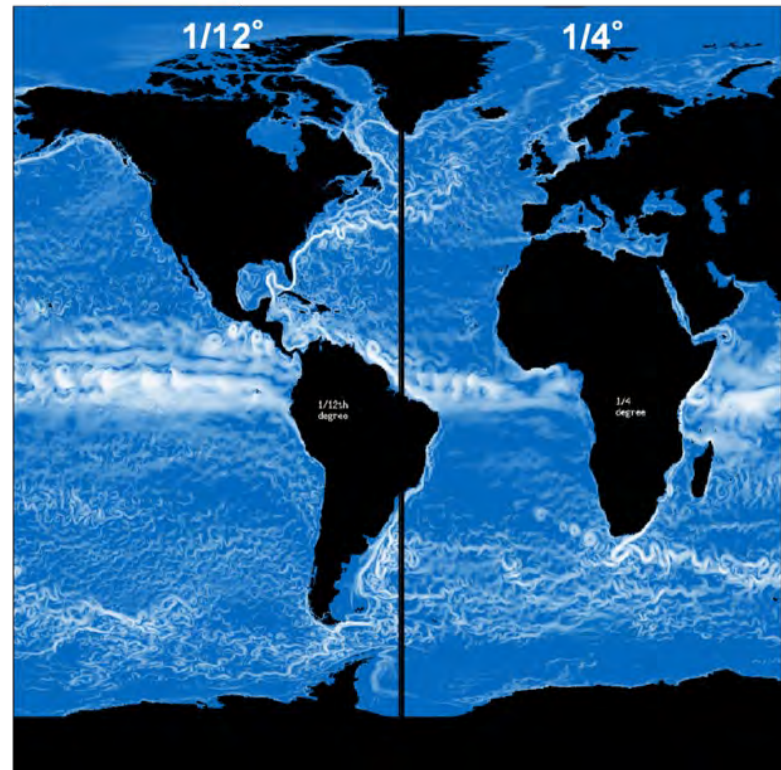


# Met Office Planned ocean upgrades (short-term)

- New HPC
- NEMO v3.6 -> v4.0.4 including TEOS10 equation of state
- SI3 instead of CICE for sea ice modelling
- JEDI-based (JOPA) observation processing
- Updated error covariances
- 14-day ensemble forecasts

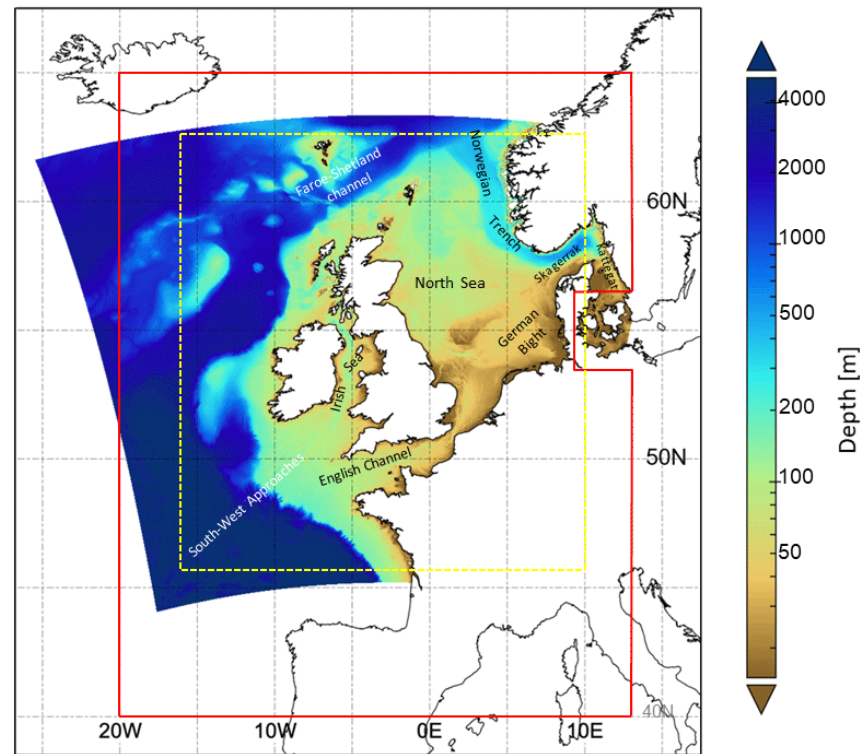
# Met Office Planned ocean upgrades (medium-term)

- $1/12^\circ$  ocean
- Sea ice thickness assimilation
- SWOT wide-swath altimeter assimilation
- Ocean ensemble perturbations
- Hybrid-3DEnVar (see Lea et al., 2022)



# Northwest European Shelf ocean-wave

- NEMO coupled with WaveWatch III
- 1.5 km resolution
- 3D-Var (NEMOVAR)
  - T, S, SST, SLA
- Ocean-only, but used as lower boundary condition for UK NWP
- Run daily, 6-day forecasts

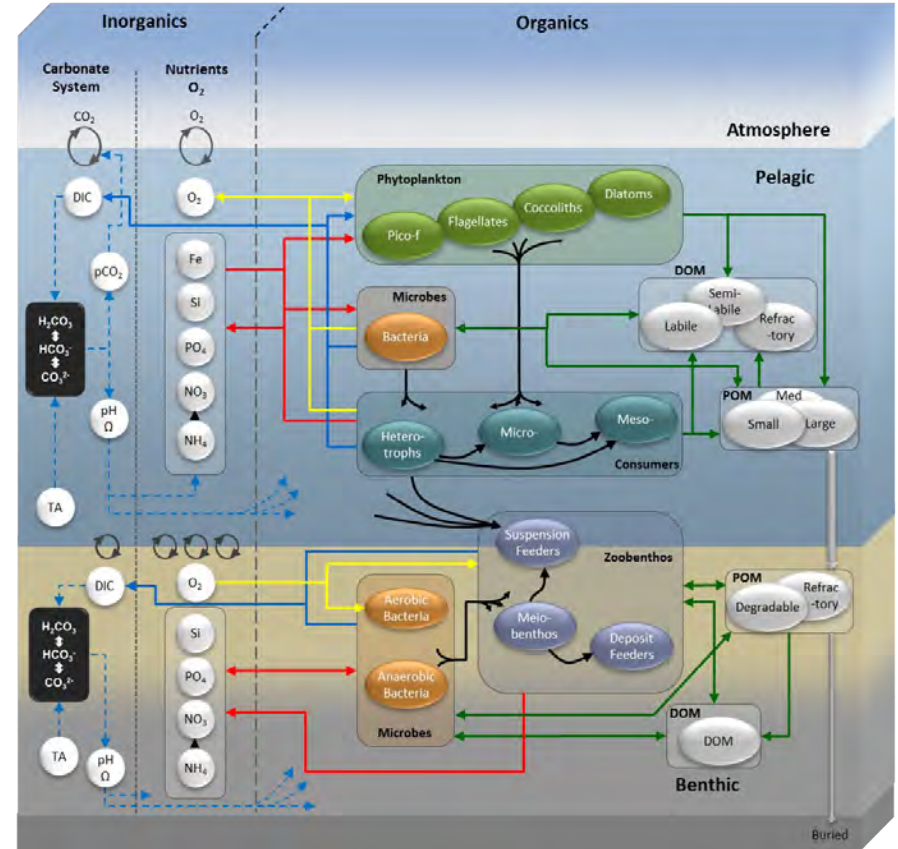


Tonani et al., 2019, GMD

- **Short-term**
  - New HPC
  - Updated forcing and boundaries
  - On-shelf SLA assimilation
- **Medium-term**
  - Upgrade NEMO version
  - Wetting and drying
  - Updated error covariances
  - Ensembles

# Northwest European Shelf ocean-biogeochemistry

- NEMO coupled with ERSEM
- 7 km resolution
- 3D-Var (NEMOVAR)
  - Physics as per 1.5 km system
  - Ocean colour chlorophyll-a
- Run daily, 6-day forecasts



Butenschön et al., 2016, GMD

- **Short-term**

- New HPC
- Updated forcing and boundaries
- On-shelf SLA assimilation
- Upgrade ERSEM version
- Updated ocean colour error covariances

- **Medium-term**

- 1.5 km resolution
- Assimilate in situ biogeochemistry if sufficient data
- Improved multivariate biogeochemistry assimilation



# Outputs and users

- UK Marine and Climate Advisory Service (UKMCAS) to be launched in late 2023, with the following freely publicly available via FTP:
  - Global ocean forecasts from coupled system
  - Regional ocean-wave and ocean-biogeochemistry forecasts
  - OSTIA SST and sea ice analysis
- These are products in the process of being retired from the Copernicus Marine Service catalogue. The UK is very pleased that it can re-associate with Horizon and Copernicus. We are reviewing how best we might re-integrate with Copernicus services, including the marine service, in future – although we are very aware that in some services there has been significant work on replacement products for UK based ones that shouldn't be ignored.
- Regional ocean, wave, and biogeochemistry reanalysis products will remain available from the Copernicus Marine Service until at least Dec 2024.

# Met Office Users (not comprehensive)

- Boundary conditions for NWP and regional/coastal models
- Initial conditions for seasonal forecasting
- Search and rescue
- Coastal flooding
- Beach safety
- Marine pollution response
- Defence
- Environmental monitoring
- Offshore energy
- Shipping

# Observation design and impacts

# Met Office Current and recent projects

- Leading the ESA A-TSCV project to improve impact understanding of surface currents assimilation and define requirements
- OSSEs contributing to design of Sentinel-3 NG altimeter constellation
- Contributing to SynObs by running OSEs with 1/12° global system
- ESA CCI: impact of assimilating satellite SSS data, and physics-BGC assimilation for reanalysis and seasonal prediction
- Operational forecasts used to autonomously navigate a glider towards algal blooms in real time

DCC, ML/AI, DT, etc

- **Plans for digital twins and AI/ML?**
  - Investigating use of machine learning in data assimilation and postprocessing
  - Keeping an eye on the landscape
- **Relationship and communalities with NWP groups?**
  - NWP and ocean forecasting collocated in same organisation
- **Awareness of OP-DCC interactions (e.g. Atlas), best practice approaches, etc?**
  - Aware and contributing where we can

# Questions?