

The ECMWF operational system

Depressing similar to the presentation which I gave at OPST-8

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Highlights for recent changes of ECMWF's operational system

- No changes yet for the ocean modelling and data assimilation system, but we are finalizing a major upgrade of the physics-based modelling system upgrading the NEMO model version from 3.4 to 4.0:
 - Just like we have been for many years
 - But this time we mean it 😊 with the new system expect to go live on May 12 2026 with CY50R1
- Machine learning for the atmospheric prediction is done operationally
 - We expect to introduce a 10 wave fields in the next AIFS upgrade (also on May 12 2026) with ocean fields to follow in later upgrades

Summary of 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 (reanalysis and real-time):
 - ocean5: NEMOVAR 3D-VAR FGAT
 - T/S/SLA/SIC observations, SST via relaxation
- All forecasting systems are coupled (atmospheric and wave resolution list below)
 - HRES CY49R1 (Nov-12, 2024) 9 km deterministic 10 days twice daily
 - ENS CY49R1 9 km 51 members 15 days twice (0z/12z) daily
 - Monthly CY49R1 36 km 101 member 46 days daily 0z starting from day 0 (not from day 15 ENS)
 - SEAS5 CY43R1 (November 2017) 36 km 7 months every month, 13 months every 3 months
- We use hindcasts to calibrate forecasts
 - A lot of product are calibrate based on model climate

Summary of the ECMWF ML operational models.

AIFS v1.1 is currently operational in two configurations:

- AIFS Single – deterministic model trained by minimising the MSE
- AIFS ENS – ensemble prediction model trained by minimising the CRPS (51 members)

Both models feature: 6h timestep, 31km resolution, 15-day lead time, 4 runs per day, initialisation from IFS initial conditions, training on ERA5 and finetuning on ECMWF's operational analysis.

AIFS v2 will be operationalised on May 12 2026 with IFS 50r1. It brings:

- Ocean waves (10 fields)
 - Snow cover and depth over land
 - Revised atmospheric vertical velocities and stratospheric representation
- ...and more!

AIFS is built with



AIFS S2S will start near-real-time production from summer 2026.

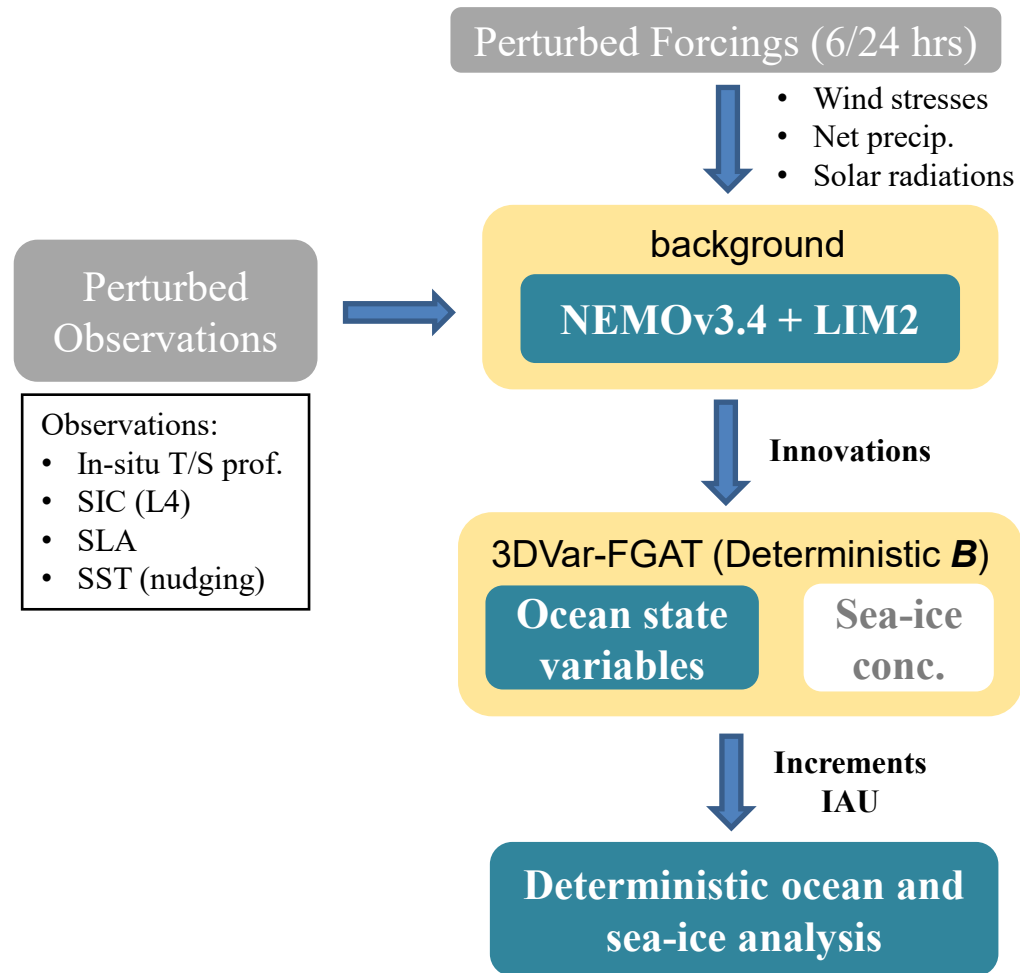
Next major ocean modelling upgrade 1

- Upgrade the ocean model from NEMO V3.4 to NEMO V4.0
 - New sea ice model SI³
 - Multi-category sea ice is a first for us
- Upgrade use of forcing fields from ERA-Interim to ERA5 for the reanalysis
 - Higher atmospheric resolution
 - Hourly forcings
 - Diurnal cycle in the ocean initial conditions
 - Real time system will also use hourly forcing from NWP
- Upgrade the data assimilation to a later version of NEMOVAR
 - More details on this later

Next major ocean modelling upgrade 2

- Change in ocean diagnostics output from netCDF4 to GRIB2
 - Similar to the atmospheric model
- The output of the ocean reanalysis will be used as input to the next atmospheric reanalysis ERA6 (CY49R2)
 - Coupled trajectories will add more coupling to ERA6
 - Ocean fields will be available from ERA6
- The operational 4D-VAR will update the ocean and sea-ice variables (coupled DA)
 - But it will start from the uncoupled ORAS6 system every day
- Expected to be implemented shortly (May 2026)

Ocean and sea-ice reanalysis at ECMWF: ORAS5

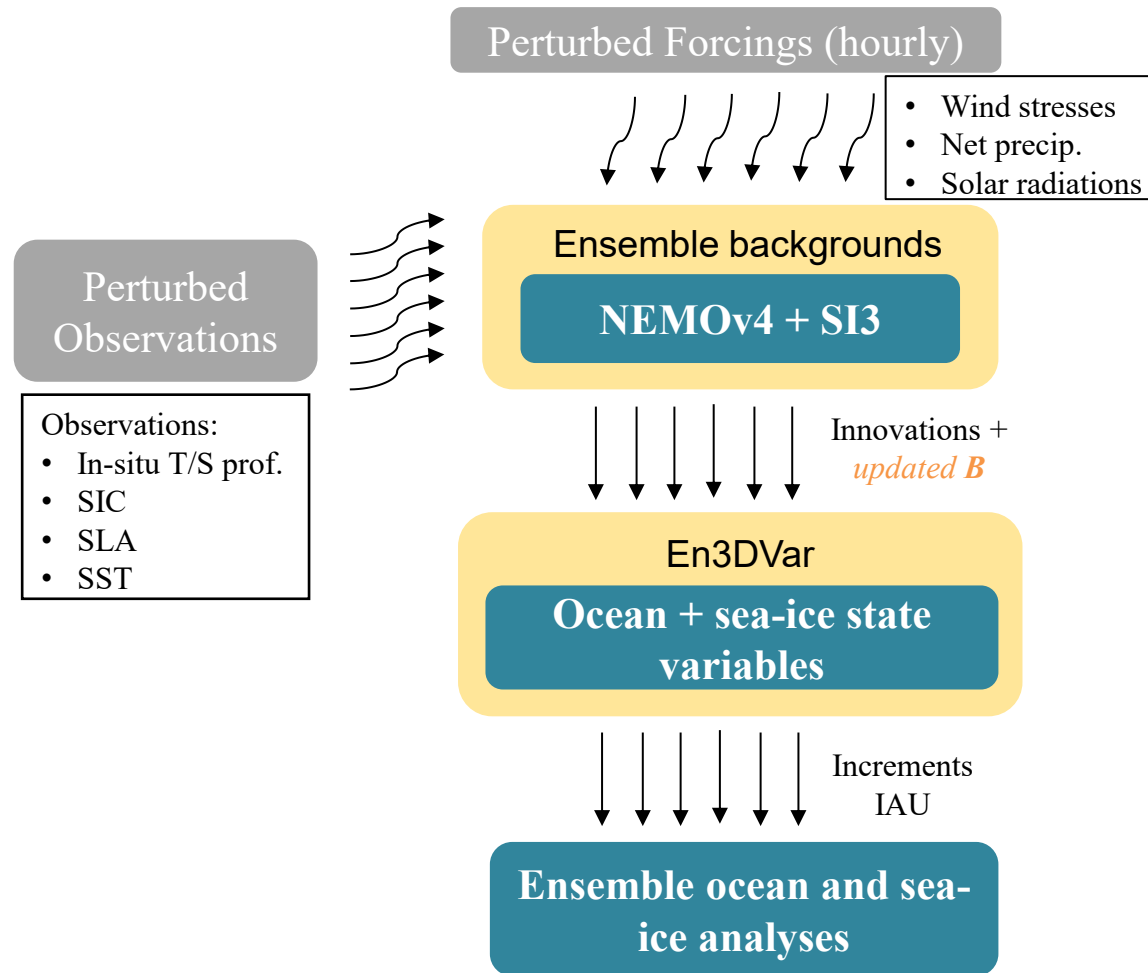


ORAS5 is deterministic ocean and sea-ice reanalysis

- *5 member generated with perturbed forcing and observation inputs.*
- *Each member is a deterministic analysis produced with 3DVar-FGAT approach.*
- *No feedback between ensemble backgrounds and Covariance **B***

Overview of the ORAS5/OCEAN5 system

Ocean and sea-ice reanalysis at ECMWF: ORAS6



ORAS6 is the new ECMWF ensemble ocean and sea-ice reanalyses. ORAS6 will replace ORAS5 to provide ocean and sea-ice initial conditions for all ECMWF coupled forecasts in 2024 (including ERA6).

- *NEMOv4 + SI3 (1/4 deg +75 level)*
- *Assimilates ocean in-situ and surface observations*
- *Use En3DVar FGAT scheme, 11 members*
- *Covariance **B** is updated every cycle with ensemble backgrounds, generated by perturbed forcings and observations*

Overview of the ECMWF ORAS6 system

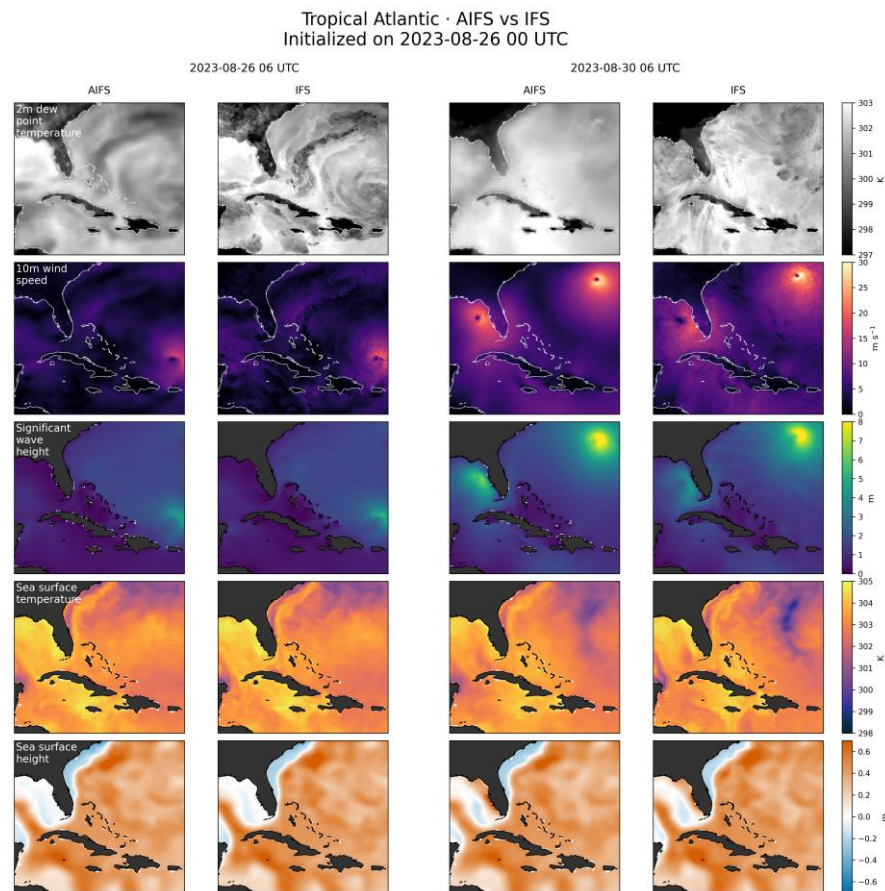
Short term plans for the next 6 months

1. Finalize the upgrade to NEMO V4 and AIFS v2 next month
2. Upgrade the seasonal forecasting system (SEAS6) to use NEMO V4 and produce hindcasts for calibration (SEAS6)
 - Produce hindcasts from the ORAS6 BRT system
3. Implement the forecasting capability for SEAS6 (CY49R2)
 - Will use the RT ocean DA system

ECMWF perspective on data-driven ocean modelling

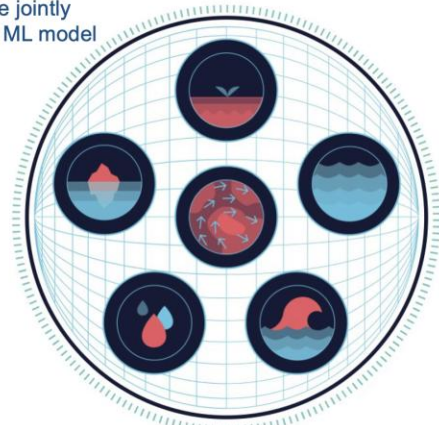
ECMWF is experimenting with several ML model setups featuring ocean and sea ice, with both surface and 3D representations.

Here is a TC case study from an AIFS prototype, including atmosphere, surface ocean, sea ice, and waves.



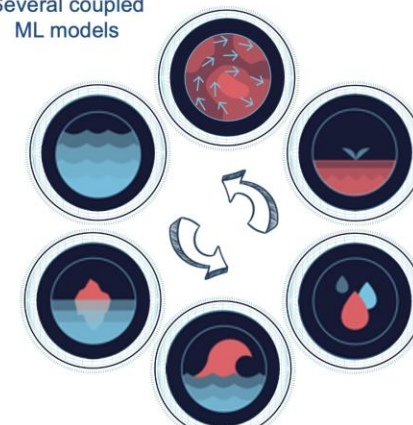
How do we combine the Ocean and Atmosphere?
Joint vs Coupled approach

One jointly
learnt ML model



“joint model”

Several coupled
ML models



“coupled model”

Outlook for the mid term (beyond the next ocean upgrade)

- Explore the 1/12 degree NEMO eORCA12 configuration
 - At the moment. it seems unlikely that we will be able to afford this in operations even after the planned HPC upgrade in 2027
 - But we might still use it to produce training data for ML applications
- Add more ocean components to the AIFS systems (surface ocean likely in AIFS v3)
- Start using NEMO rather than FLAKE over large inland water bodies
 - Caspian Sea, Sea of Azov and Great lakes.