Integrated Forecasting System - IFS

The ECMWF Integrated Forecasting System (IFS) consists of several components coupled together in various different ways:

- an atmospheric model run at various resolutions appropriate to the forecast length (high resolution (HRES), ensemble (ENS), extended-range, and seasonal forecast).
- an ocean wave model (ECWAM) run with various configurations (HRES-WAM, HREW-SAW, ...)
- an ocean model (NEMO) including a sea ice model, the Louvain-la-Neuve Sea Ice Model (LIM2).
- a land surface model (HTESSEL) including a lake model (FLake).
- a data analysis system (4D-VAR).
- perturbation techniques for generation of the ensembles.

These are outlined in Fig2.1, Fig 2.2 and Fig2.3. The models and programs run co-operatively to produce forecasts from analysis time out to days, weeks or months ahead.

Fig2.1: ECMWF Integrated Forecasting System (IFS) Illustrates interactions between components of the IFS (observation assimilation and post-processing not shown).
Fig 2.2: Exchange of physical quantities between the atmospheric, ocean wave and ocean models (currently operational). All the Atmospheric models give to the Wave model information on air density, ice cover, and surface wind and gusts whilst the Wave model gives to Atmospheric models information on surface roughness (associated with the forecast waves). Additionally, for the ENS forecast only:

- the ENS exchanges information with the Ocean model on currents and sea-surface temperature and surface energy fluxes,
- the ENS gains information from the Ice model on ice cover,
- the Ocean model gains information from the Wave model on stress, drift, turbulent energy.

Fig 2.2A: Exchange of physical quantities between the atmospheric, ocean wave and ocean models (proposed for introduction in 2018). All the models (not just the ENS) exchange information and additionally the Wave model gains from the Ice model information on ice cover.
The Atmospheric Model is coupled with the Wave Model (ECWAM) and the Ocean Model (NEMO) because:

- the ocean is the lower boundary for the atmosphere for a large part of the earth.
- the lower boundary gives important feedback to the atmosphere if accurately modelled (especially important for long-range predictions like monthly or seasonal forecasting and for features such as ENSO).
- the ocean state (including seaice) can change on a daily timescale and these variations can be important in certain situations during the forecast evolution. Important impacts of the modelled state of the ocean upon the evolution include:
  - drag from the waves on the atmosphere (can help prevent over-deepening of lows as bigger waves impart more drag),
  - ice variations and extent (gives more information on boundary temperatures, and can hinder the propagation of ocean waves),
  - storm or hurricane feed back to or from the ocean (potential for upwelling of colder water induced by passage of a major storm or depression over a temperature-stratified ocean).

The Atmospheric Model is coupled with HTESSEL and FLake because:

- the land is the lower boundary for the atmosphere for a less extensive area than the sea but it has a complex orography and exhibits far more temporal and spatial variability in the characteristics of energy storage and exchange.
- the lower boundary gives important feedback to the atmosphere if accurately modelled (important for short and long-range forecasting).
- the state of the landmasses (including soil moisture and cover and depth of snow and lake ice) can change on a daily timescale and these variations can be important in certain situations during the forecast evolution. Important aspects of the modelled state of the land that can affect the atmospheric evolution include:
  - rainfall absorption and soil moisture (give more information on boundary moisture flux),
  - ice variations on lakes (gives more information on albedo and boundary heat and moisture fluxes),
  - land/lake temperature variations for evaluation of heat fluxes,
  - snow variations and extent (gives more information on albedo and boundary heat and moisture fluxes).

The coupled model configuration is used with:

- the HRES (but without ocean and ice coupling - not currently coupled with NEMO, though this will be introduced in 2018)
- the ENS from Day0 to Day15.
- the monthly extension forecast from Day16 to Day46, twice per week.
- the seasonal forecast.

More information is given within the Users Guide on the structures of the **Global Atmospheric Model**, the **Ocean Wave Model**, and the **Dynamic Ocean Model** and regarding the resolution of the models currently used within the IFS.

Real-time forecasts are initialized from the operational analysis using 4D-Var. Re-forecasts are initialized from ERA-Interim, except for soil initial conditions (soil temperature, soil moisture, snow initial conditions) which are provided by an offline soil reanalysis. Oceanic models are initialized from the real-time suite, NEMOVAR.