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Recent and planned NWP developments at ECMWF

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2021 was a standout year for ECMWF in that not one, but two major upgrades were made to the operational NWP system.

Cycle 47r2 (introduced on 11 May) increased the ensemble forecast (ENS) vertical resolution from 91 to 137 levels, bringing it into line with the high-resolution forecast (HRES). The cost of this, which is significant, was offset by running the forecast model in single precision which saved equivalent cost and is meteorologically neutral. Overall validation showed statistically significant skill improvements by the ENS forecasts, for many fields, mostly in the range 0.5-2% RMS error reduction. It also showed improvements for specific meteorological phenomena (e.g. Tropical Cyclones, Madden-Julien Oscillation).

Cycle 47r3 (introduced on 12 October) contained model, assimilation and observation usage changes. A major change, and the result of many years of research, was a complete new moist physics package. This brings significant meteorological benefit, and it this aspect users of ECMWF forecasts will see, but it also simplifies and modernizes the physics code in the IFS, and this will facilitate future improvements. This physics package includes too many changes to list here, but includes a more consistent formulation of boundary layer turbulence, shallow convection and sub-grid cloud and a new parametrized deep convection closure with an additional dependence on total advective moisture convergence. On the observation and data assimilation side the new weak constraint 4D-Var approach was applied in the Ensemble of Data Assimilations, and the all-sky observation assimilation approach was extended to a temperature sounder for the first time (AMSU-A), as well as a major update in the radiative transfer model for observation assimilation.

Cycle 47r3 validation showed significant improvements. For example, extratropical upper-air geopotential and wind in the first few days of the forecast improved by 1-2% and tropical upper-air winds throughout the medium-range improved by 1-4%. Also, tropical cyclone track errors have been reduced by 10%.

Cycle 47r3 is now being ported to the new ATOS HPC in the new ECMWF data centre in Bologna. Following the migration, the first science upgrade will be Cycle 48r1 and will contain some very important changes. The most important from a user perspective will be the ENS resolution change to TCo1279 (~9 km), hence matching the current HRES (which will remain unchanged). There will also be a large number of other changes, including the first use of the OOPS system for 4D-Var. OOPS is a modern code system that encapsulates tasks as objects, enabling both separation of

concerns and more flexible interaction between components. The cycle will also see the introduction of a new multi-layer snow scheme (improving predictions of snow and of near-surface temperatures over snow), and enhancements to the use of satellite data over land. This last change represents a step on ECMWF's strategic direction to get yet more value out of satellite data by moving from an 'all-sky' to an 'all-sky, all-surface' approach.