New model changes

Since ITSC-20, ECMWF implemented three substantial upgrades of its Integrated Forecasting System (IFS).

The three upgrades (41R2, 43R1 and 43R3) had a significant positive impact on forecast skill in the medium range and monthly forecasts.

Resolution increase:
• New cubed-octahedral grid
• The High resolution system upgraded to higher resolution T255-9km (41R2)
• The Ensembles upgraded to a higher resolution T255-9km (days 1-15) and T319-32km (days 16-46) (41R2)
• Increased horizontal resolutions for the HRES 4DVAR andEDA (41R2)
• The Ocean model (NEMO) resolution increased to 0.25° and 75 levels (43R1)

Observations:
• Activation of E-7.5 humidity sounding channels over ocean and extend all-sky assimilation to arctic land surfaces (41R2)
• Situation dependent observation errors for AMSU-A (41R2)
• Improved IASI aerosol screening (41R2)
• 25% increase of GSPRO observation errors (41R2)
• Update of RTTOV coefficient file for microwave instruments (41R2)
• AIRS-S1, AIRS-S2 assimilation (41R2)
• Asimilation of aircraft humidity (41R2)
• Viewing geometry (staircase path) fully taken into account when simulating radiances from clear-sky sounding (41R2) – See presentation 2.03 by N. Bormann
• Update observation error covariance for IASI and QDR (43R1)
• New channel selection for CRIS (115 channels instead of 78) (43R1). See poster 3p.01 by R. Eremeeva
• Update of aerosol detection scheme for IASI, AIRS and CRIS to improve the aerosol backscatter correction (43R1)
• Assimilation of snowfall from the NEXTRAD RADAR network over the USA (43R1)
• Activation of new humidity sounding saphir and GMI (43R1)
• Activation of 118 GHz channels over land from MWHS-2 instrument on-board FY-3C (43R1) – See poster 3p.04 by H. Lawrence
• Harmonised data usage over land and sea for microwave sounders (43R3) – See poster 10p.04 by N. Bormann
• Improved quality control for radiocloud occurrences and radiosonde data (43R3)
• Improved screening of infrared observations for anomalously high atmospheric concentrations of hydrogen cyanide (HCN) from wildfires (43R3)

Data assimilation changes:
• EDA cycling its own background errors (41R2)
• Compute scale-dependent hybrid background error covariance (48) by adding samples from latest EDA forecast to static climatological B with increasing weight of today’s EDA for smaller wavelengths (41R2)
• Improved calculation of humidity saturation for very cold temperatures (41R2)
• Update of SST perturbations used in the EDA (43R1)
• Re-activation of the stratosphere domain significant background constraint in the 4DVAR (43R1)
• New Ocean analysis/analysis (48S5) (43R1)
• Improved assimilation of screen level TROPOs observations in the land surface analysis (43R1)
• Improved EDA derived background estimates used in the 4DVAR (43R1)
• Improved humidity background error variance directly from the EDA (43R1)
• Revised waveform filtering of background error variances and revised quality control of dropsonde wind observations in 4DVAR to improve tropical cyclone structures (43R3)

Model changes:
• Improved representation of radiation-surface interaction (41R2)
• Improved free air physics (41R2)
• Improved parcel perturbation for deep convection (41R2)
• Inclusion of surface-lying for long-wave radiation interactions (41R2)
• Improved solar zenith angle calculation (41R2)
• Improvements of linear physics used in the data assimilation for gravity wave drag (41R2)
• Usage of new CAMS ozone climatology (43R1)
• Changes to boundary layer cloud for marine strato-cumulus at high latitudes (43R1)
• Modelling of surface coupling for 2 m temperature (43R1)
• New, more efficient and improved radiation scheme (43R2)
• New aerosol climatology based on ‘true’ CAMS aerosol re-analysis including dependence on relative humidity (43R3)
• Increased super-cooled liquid water at colder temperatures (down to -38C) from the convection scheme (43R3)

Microwave sounders/imager usage

Table 1: Assimilated microwave soundings/imaging channels

<table>
<thead>
<tr>
<th>Microwave sounders</th>
<th>AMSU-A</th>
<th>AMSU-B</th>
<th>NOAA-15</th>
<th>NOAA-18</th>
<th>NOAA-19</th>
<th>Himawari-8 CSR</th>
<th>Himawari-8 MHS</th>
<th>Himawari-8 CSR</th>
<th>Himawari-8 MHS</th>
<th>Himawari-8 CSR</th>
<th>Himawari-8 MHS</th>
<th>Himawari-8 CSR</th>
<th>Himawari-8 MHS</th>
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<td>Metop-A</td>
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<td>Himawari-8 MHS</td>
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<td>Himawari-8 CSR</td>
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Hyper-spectral infrared sounders usage

Table 2: Number of channels used

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<th>Hyper-spectral sounders</th>
<th>GPM</th>
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<td>FY-3D</td>
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<td>FY-3E (from FY-3D)</td>
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</table>

Geostationary radiances usage

Table 3: Assimilated geostationary radiances

<table>
<thead>
<tr>
<th>Geostationary radiances</th>
<th>SEVIRI</th>
<th>GOES Imager</th>
<th>AIRS</th>
</tr>
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<tbody>
<tr>
<td>Meteosat-10/11 (SEVIRI)</td>
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<td>Meteosat-8 (SEVIRI)</td>
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<td>GOES-13</td>
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<tr>
<td>Himawari-8 MHS</td>
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<tr>
<td>Severe</td>
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<tr>
<td>3.9 and 7.3 micron (7W)</td>
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<tr>
<td>6.2 and 7.3 micron (7W)</td>
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</table>

Slant-path radiative transfer for sounder radiances

- Shunted satellite geometry fully taken into account in the simulation and assimilation of clear sky radiances from sounders.
- Significant improvements in the simulation of brightness temperatures from model fields. This is most noticeable for large zenith angles for upper tropospheric and stratospheric channels.
- Slant-path RT leads to better agreement with observations.
- Overall positive impact especially in the on the stratospheric and at short ranges.
- Normalised differences in standard deviation of vector wind analysis increments (7±4°) when compared with experiment and the control

Main upcoming satellite changes (cycle 45R1)

The upcoming ECMWF model cycle 45R1 is expected to be implemented in Q1 2018 and will include a number of significant data assimilation changes:

- Improved radiator transfer model RTTOV-12 (see poster 1p.05 by C. Lupu)
- Improved treatment of biases (Constrained VarBC) for AMSUA channel 14 and AMT channel 15 (see presentation 12.02 by W. Han)
- Improved radiance over land (see presentation 10.01 by R. Eremeeva)
- Improved usage of all sky radiances in coastal areas
- Use of OIBG-MHWS5

Acknowledgments

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