I) Operational NWP system & satellite usage

Global:
- ICON @ 13 km global / 6.5 km Europe (two-way nest within global runs)
- EnVar ensemble DA, 40 members @ 40/20 km (global/Europe)
- ICON – EPS global ensemble forecasts @ 40/20 km (operational Dec 2017)

High-resolution:
- COSMO-DE: 2.8 km, 50 levels (non-hydrostatic)
- KENDA: 2.8 km, 80 levels with latent heat nudging (LH) for radar precipitation
- COSMO-DE-EPS ensemble forecasts @ 2.8 km, 40 members

Satellite data/ global IONC:
- AMSU-A (channel 1-4 everywhere, 5.8 only over ATMS, similar to 3/5 Exped) for stratospheric winds
- GPS-RO bending angles
- AMSR, IASI: cloud detection/irradiance, sea ice, sea surface temperature, land surface temperature

Technical aspects:
- RTTOV-10 (update to RTTOV-12 for G18/2018)
- Online bias correction
- Flexible satellite pre-processing & monitoring auto-alert packages

Current developments:
- Extended IASI usage, introduction of CrIS
- Operational introduction of VenBC
- MW and IR surface sensitive radiances (see IV)
- Use of IASI PC compressed data (see V)
- SEVIRI cloudy radiances (infrared water vapour and visible, see VI)
- Observation impact diagnostics in ensemble DA (see Poster 12p.09)

II) Operational Introduction of Ensemble DA

A fundamental upgrade of DWD’s operational NWP system has taken place over the last three years, consisting of:

1) Global model ICON model (ICosahedral Non-hydrostatic modelling framework, developed in cooperation between DWD and the MPI Hamburg for climate research), operational since January 2015. The non-hydrostatic model is formulated on an icosahedral grid, runs currently at 13 km resolution with 90 vertical z-levels (model top at 70km->2.6 Pa). Higher resolution forecasts are provided at 6.5 km for a European domain using two-way nesting (ICON EU, see Fig. 1).

2) Global EnVar data assimilation, operational since January 2016: a global LETKF ensemble data assimilation (following Hunt et al. 2007) at lower resolution, providing flow dependent background errors, is coupled to a full resolution deterministic 3DVar. The current ensemble size is 40 members (to be increased in 2018). See Fig. 1 for a schematic illustration of the setup.

3) Global ensemble forecasts, the ICON-EPS, with 40 members based on the members of the ensemble setup will become operational in December 2017 and produce forecasts up to 120 h (0, 12 UTC) and additionally 3 hourly 24 forecasts used as boundaries for the regional ensemble.

For the data usage over land to lower peaking channels, the use of the afloats provided with RTTOV-12 has been implemented (TSELMEM, CRMF for MW and UWRemis for IR) and tested resulting in consistently improved OBS FG fits for surface sensitive channels. Additionally, retrievals of surface emissivity $s$ are being studied. In the IR (IASI, CrIS), $s$ has been added to the state vector (containing also the skin temperature $T_s$) in the form of coefficient of a principal component (PC) representation of $s$. Current work focuses on the estimation of the FG errors for $s$ and PC coefficients and on improved (low) cloud detection. For the MW, a direct retrieval using window channels is being tested following Prigent et al. (2005). Fig. 8 illustrates the changes in $s$ from a direct retrieval (using AMSU-A channel 3) and Fig. 9 the resulting improved OBS-FG fit (compared to CRMN Atlas use) for the adjacent lowest sounding channel 4 using this $s$.

IV) MW & IR radiances over land

For the water vapour information with the model, it is necessary to make use of additional remote sensing. The water vapour in the atmosphere is a very strong absorbing species and cloud occurrence to detect and classify cloud types is necessary to determine clear sky conditions. In the past, the ozone channels (e.g., 11:183 GHz band, ch5: 23.8 GHz) were used to detect alerts of ozone, which is a reason why the sounding channels have been implemented (ATMS, AMSU-A, SAPHIR, GMI, AMSR) as well as humidity sounders and imagers to improve forecasts of convective events as well as cloud cover and water vapour content. The additional humidity sounders and imagers have also been technically implemented (ATMS, SAPHIR, GMI, AMSR-2) in a clear-sky context and are currently used for monitoring. The screening of the cloud/precipitation affected radiances and also the bias correction are currently tuned further before moving on to assimilation tests with these data.

IASI principal component (PC) compressed data have been technically implemented. Initial experiments have been run assimilating PC data in the form of reconstructed radiances (RecRad) treating the recovered MV/IR radiances in a first approach. A reduction in OBS-FG std can be seen for the temperature sensitive channels, attributed to reduced bias in the RecRad, which is not visible in the WV band having a much larger std of OBS-FG (Fig. 10). Differences are also observed in cloud screening results with less clear data for both channels and marginally more for very high backscattering (Fig. 11). Forecast scores in assimilation are neutral to slightly positive.

VI) Towards the assimilation of SEVIRI visible reflectances in the high-resolution LETKF

For the convective-resolving KENDA system, projects are ongoing to assimilate cloudy IR radiances as well as visible radiances to improve forecasts of convective events as well as very weak cloud events (e.g. for temperature applications, energy applications). The implementation of the fast forward operator MFASIS Schnell et al. (2016) simulating SEVIRI visible channels has been validated and tuned using OBS-FG ensemble statistics (Fig. 12, 13). The fit to observed reflectances at high solar zenith angles improves when some 3D effects are accounted for. The water content of subgrid-scale clouds has to be taken into account, but including snow/graupel gives no further improvement. First assimilation studies with the KENDA LETKF (in cooperation with Heiz at LMI/Munich) are very promising, resulting in improved cloud cover and also better fit of humidity fields to independent observations (radar/satellite).

References: