LMU LUDWIG-MAXIMILIANS-UNIVERSITÄT MÜNCHEN | MIM | Hans-Ertel-Centre for Weather Research DATA ASSIMILATION BRANCH | Hans-Ertel-Zentrum für Wetterforschung Deutscher Wetterdienst DWD

POTENTIAL OF MSG SEVIRI SATELLITE OBSERVATIONS FOR CONVECTIVE-SCALE ENSEMBLE DATA ASSIMILATION

Florian Harnisch and Martin Weissmann

Hans-Ertel-Centre for Weather Research, Data Assimilation Branch, LMU München, Germany

BACKGROUND

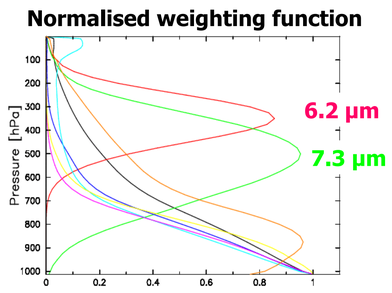
- Increase the usage of frequent high-resolution observations for data assimilation in convective-scale limited area models
- Geostationary satellite observations have a high spatial and temporal resolution and provide information on atmospheric humidity, temperature and clouds
- Improved understanding of observation errors and biases is needed to optimally use the complex satellite observations for data assimilation

⇨ Direct assimilation of MSG SEVIRI clear-sky / all-sky observations in the experimental kilometre-scale ensemble data assimilation (KENDA) system of DWD

MSG SEVIRI OBSERVATIONS

MSG Spinning-Enhanced Visible and Infrared Imager

- Twelve channels between 600 nm and 13.4 µm with 3 km nadir resolution (Germany ~3-5 km) and full disc every 15 minutes
- Infrared (IR) channels at 6.2 µm, 7.3 µm are sensitive to atmospheric water vapour and provide information on humidity and temperature in clear-sky conditions and on the cloud distribution

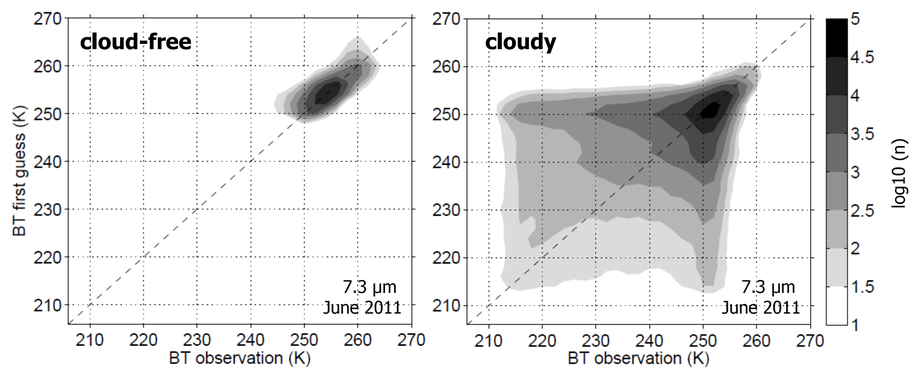


from EUMETRAIN, 2008

ERROR MODEL FOR THE ASSIMILATION OF CLOUD-AFFECTED IR SATELLITE OBSERVATIONS

Reference experiment with KENDA, a LETKF DA system for the COSMO-DE model, assimilating conventional observations with 1-hourly cycling using 40 members;
Monitoring of MSG SEVIRI brightness temperatures (BT) at 6.2 µm and **7.3 µm** over Germany during two 5-day periods in June 2011 and May 2014;

- Observation were thinned zonally and meridionally by a factor of three to reduce the data amount (7920 profiles)
- Model BTs were simulated from 1-h COSMO-DE model first guess (2.8 km) with RTTOV (v10.2) using Wyser (1998) parametrization, assuming aggregate ice crystal shape
- Simplified, constant bias correction: systematic difference between cloud-free BT observations and first guess (-2.2 K at 7.3 µm) is removed from the BT observations



- Cloud-free: BT observations and first guess match quite well
- Cloudy: large differences between BT observations and first guess → mis-location
- Model forecasts are not able to predict the exact cloud type at the correct location

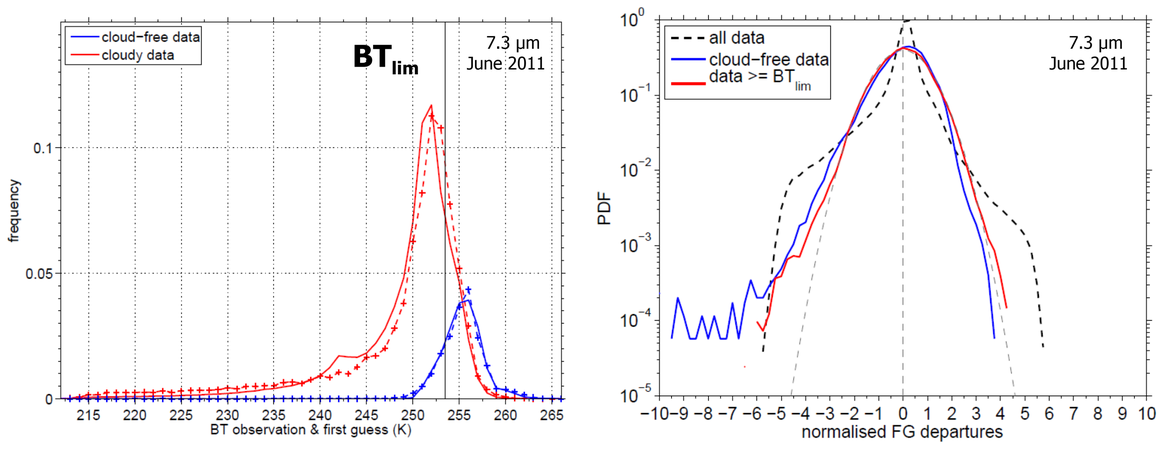
- Average cloud impact (C^a) combines the cloud impact on the BT first guess (C^F) and the BT observations (C^O):

$$C^a = \frac{C^F + C^O}{2} \qquad \begin{cases} C^F = \max\left(0, \mathrm{BT}_{lim} - \mathrm{BT}_f\right) \\ C^O = \max\left(0, \mathrm{BT}_{lim} + \mathrm{BT}_{bc} - \mathrm{BT}_o\right) \end{cases}$$

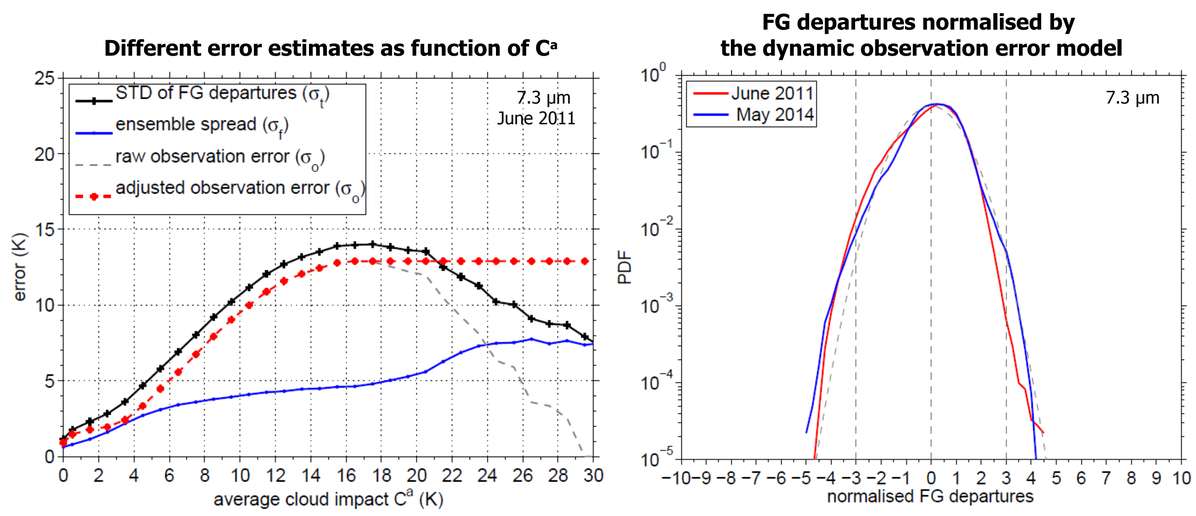
- STD of binned FG departures represent a total error estimate σ_t, which can be split into the observation (σ_o^2) and the first guess (σ_f^2) error variance:

$$\sigma_t = \sqrt{\sigma_o^2 + \sigma_f^2}$$

- Using a EnKF DA system: FG departures using the ensemble mean ($y - H(x^f)$) and first guess error (σ_f) is computed from the binned ensemble spread
- Model of observation error σ_o as function of the average cloud impact



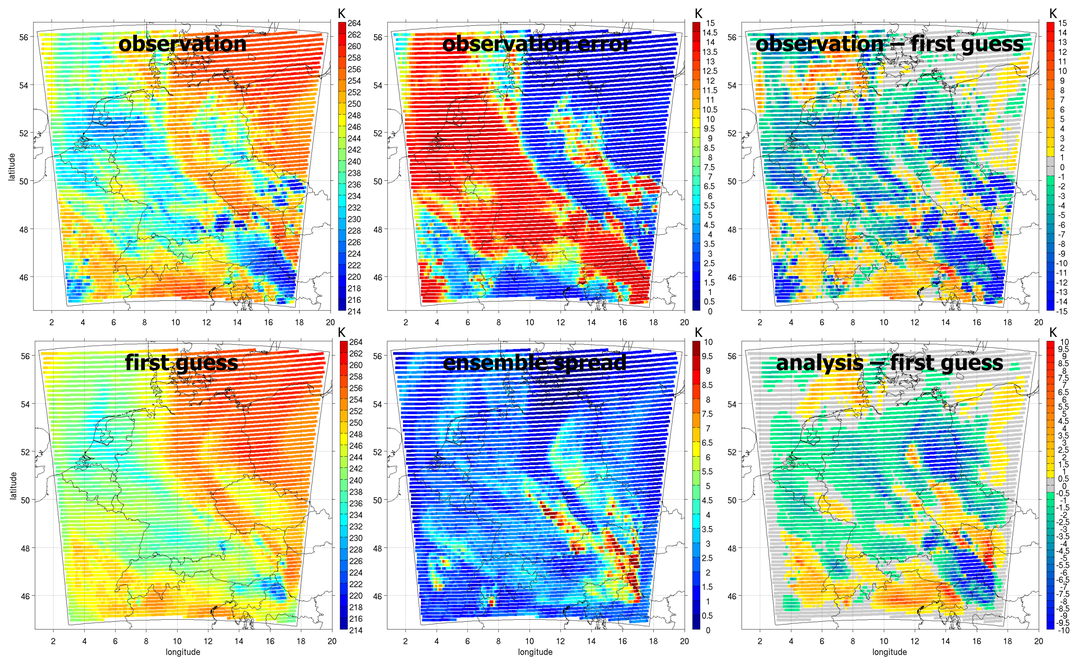
- Subjectively define a threshold **BT_{lim}** which separates the majority of cloud-free from cloudy data and further allows to quantify the cloud impact
- Observation minus first guess (FG) departures, normalised by a constant estimate of the observation error, show a strong non-Gaussian behaviour for all data, but subsets of cloud-free and BT_{lim} data exhibit more Gaussian FG departures

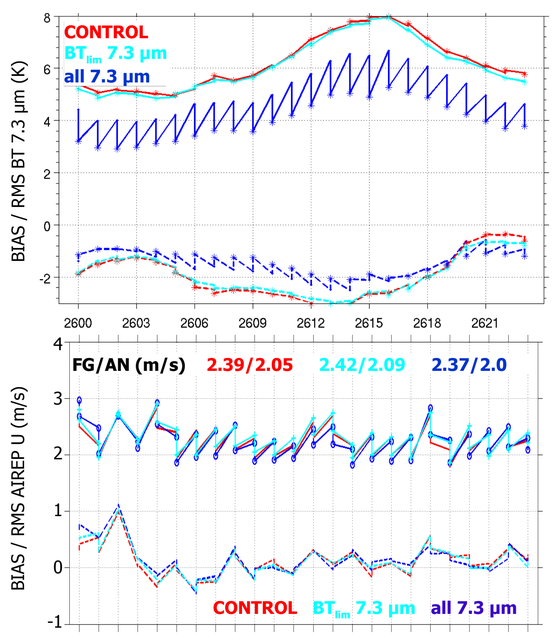


- First guess errors are much smaller than observation error for larger C^a, likely due to too small ensemble spread of cloud variables
- Using the dynamic observation error model as function of the average cloud impact leads to more Gaussian FG departures for the 6.2 µm and 7.3 µm channels
- The observation error model can be applied successfully to a different period

FIRST EXPERIMENTS ASSIMILATING IR SATELLITE OBSERVATIONS

- Assimilate clear-sky / all-sky MSG SEVIRI brightness temperatures (BT) at 6.2 µm and 7.3 µm over Germany using the 40-member KENDA system
- Observations are bias-corrected by a constant value derived from cloud-free data, and observation errors are adjusted according to the observation error model





Single-cycle experiments:

- Error model inflates the observation error strongly
- Ensemble spread in cloudy regions is much smaller than observation error
- Large systematic differences for cloudy data

Continuous cycling experiments:

- Model state is pulled towards the observations
- BT observations do not degrade the fit to conventional observations

Next steps / future work:

- Vertical localization of BT observations
- Super-obbing instead of thinning
- More adaptive bias correction, also correct systematic differences in cloudy regions (use C^a)
- Extend error model to VIS / NIR channels
- DA experiments with multiple channels