Deutscher Wetterdienst
Wetter und Klima aus einer Hand

Assimilation of ATMS data at DWD

1. Introduction

There are several differences between ATMS and the predecessor AMSU-A (see table 1):

- The horizontal coverage of ATMS is better, due to the bigger maximum scan angle. For this reason it is important to use ***scan angle dependent obserrors*** for the assimilation of ATMS data (see boxes 2 + 3).
- The horizontal resolution of ATMS is better at the cost of a smaller measurement accuracy. In order to assimilate ATMS with a weight similar to AMSU-A *superobbed* ATMS data is assimilated. At DWD we use a simple 3x3 superobbing (see Fig.1). The use of superobbed data allows to introduce ***new QC criteria*** (see box 4).

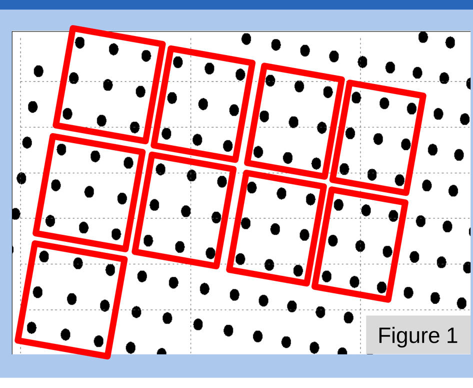

Figure 1

Table 1	ATMS	AMSUA
#FOVs per scanline	96	30
Size of FOV at nadir	Ch. 1-2: 78km Ch. 3-16: 33km Ch. 17-22: 17km	50 km
Maximum scan angle	52.25°	48.3°
Maximum sat. zenith angle	64°	58°

2. Scan angle dependent obserrors

Motivation:

ATMS swaths are much wider than AMSU-A swaths. The larger scan angles/sat. zenith angles at the edges of the swath cause several problems:

- Strongly nonlinear dependency of geolocation on on scan angle → ***geolocation error***
- Strongly nonlinear dependency of path through atmosphere on scan angle → ***forward model error***
- Probably larger ***instrument error***
- Larger FOVs/superobbing areas → ***QC problems*** (see 4. Superobbing QC criteria)

➡ **Scan angle dependent obserrors might be important for ATMS**

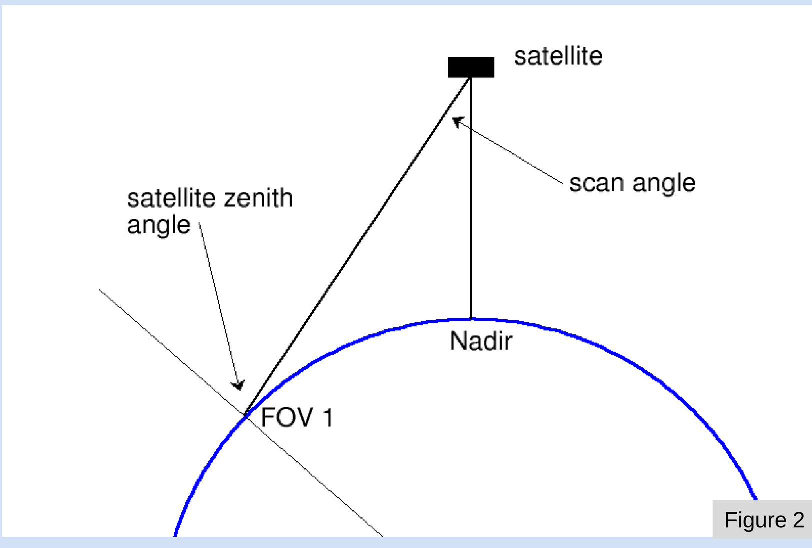

Figure 2

Method:

Desroziers, G., Berre, L., Chapnik, P., Poli, P., 2005: *Diagnosis of observation, background and analysis-error statistics in observation space*. Q. J. R. Meteorol. Soc., 131, 3385-3396.

Results:

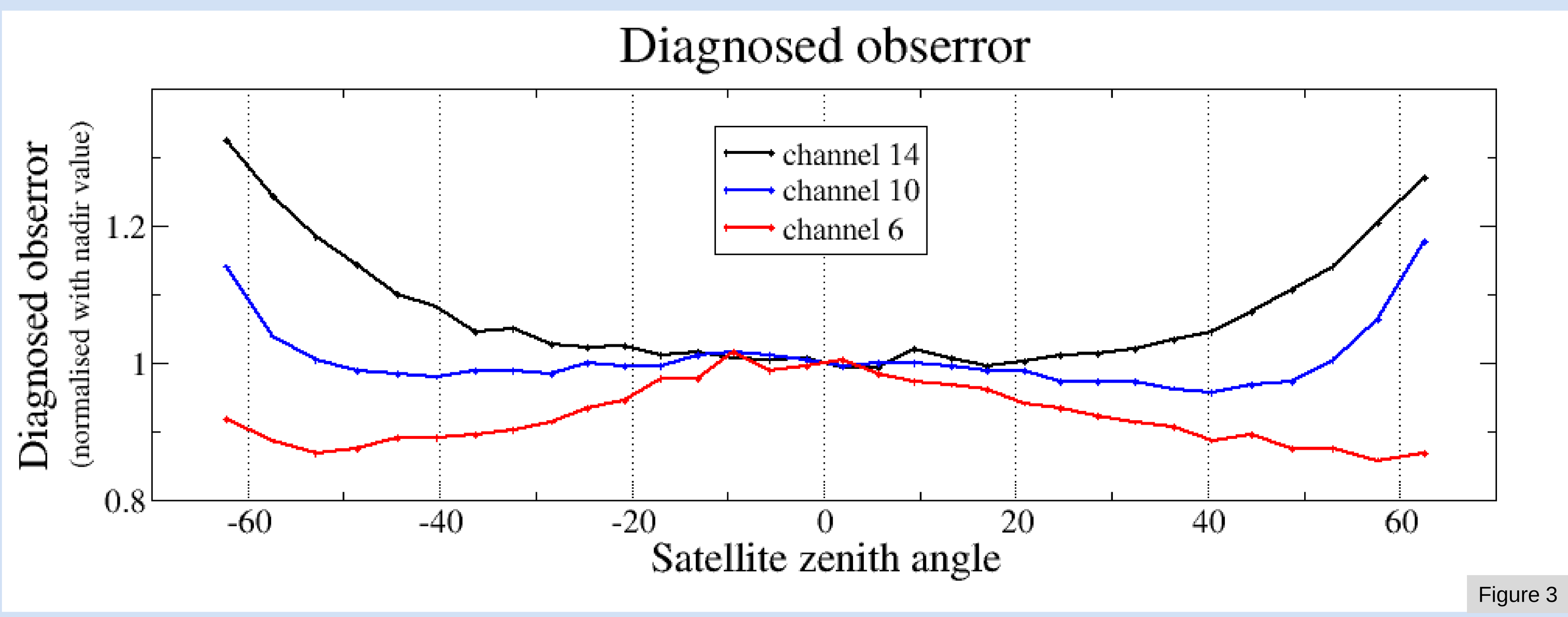

Figure 3

➡ **A significant scan-angle dependency of the ATMS obserror is diagnosed. The obserror can be parameterized with a 6th order polynomial in the satellite zenith angle** (see Fig. 4)**.**

3. ATMS impact experiments

In a first experiment, where the obserror was constant i.e. ***not scan angle dependent*** (see the dashed line in Fig. 4), ATMS had a slightly ***degrading impact*** (not shown).
In order to improve on that, several obserror specifications were tested in impact experiments that ran for two months (Jan. and Feb. 2013):

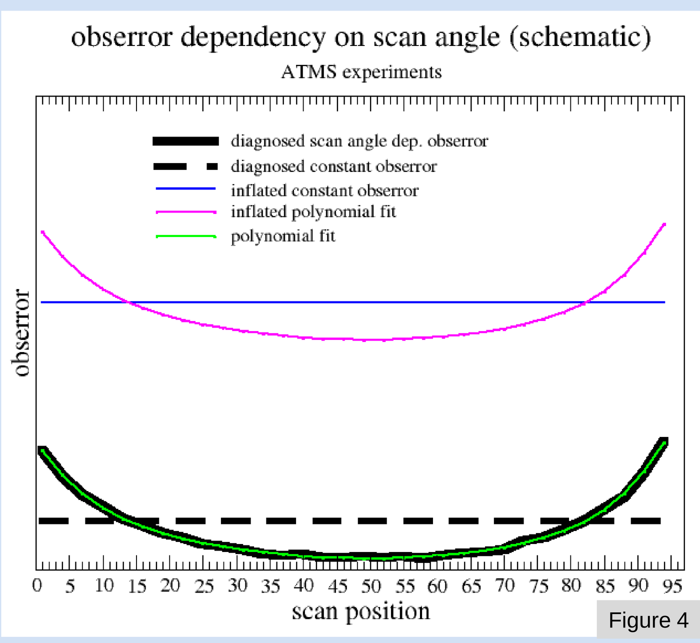

Figure 4

- In a first experiment the ATMS obserrors were inflated. This was motivated by the positive impact of a previous experiment with raw (not superobbed) ATMS data (not shown). This experiment (blue in Figs. 4 and 5) results in improved hemispheric scores. However, the scores for Europe, which is the most important region for the DWD, are still bad (see Fig. 5).
- A second experiment with scan angle dependent obserrors (still inflated) resulted in strongly improved scores over Europe (see magenta in Figs. 4 and 5).
- A third experiment with obserrors, that are in agreement with the ***diagnosed scan angle dependent obserrors*** (green color) ***performs best***. In particular the anomaly correlation for 7 days forecasts for Europe is increased by nearly 2%.

We suggest, that the degraded scores of the experiment with constant obserrors (dashed line in Fig. 4) are due to noise that is introduced into the system by observations at the edges of the scans, which have too small obserrors and too large weights in the assimilation.

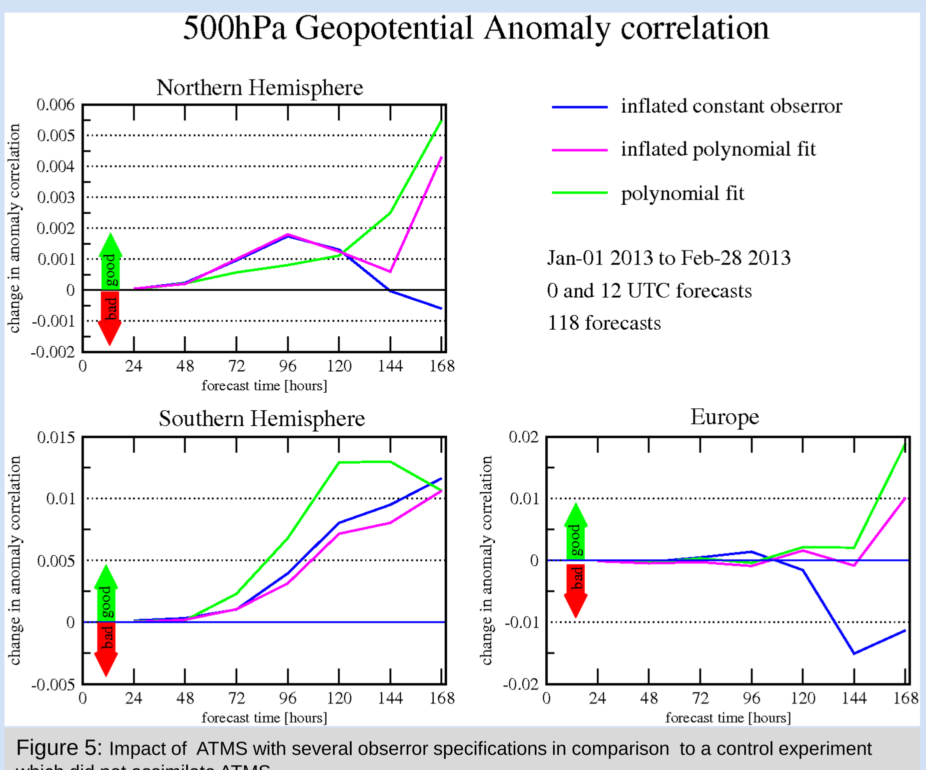

Figure 5: Impact of ATMS with several obserror specifications in comparison to a control experiment which did not assimilate ATMS.

➡ **Scan angle dependent obserrors are important for ATMS assimilation at DWD. In particular scores over Europe are sensitive to this.**

4. Superobbing QC criteria

Motivation/Idea:

- As a byproduct of superobbing it is possible to derive information about the horizontal homogeneity of the observed scene. Inhomogeneities within the superobbed observations might be caused by observations that are disturbed by clouds or surface influences. Thus, it might be recommended not to use the superobbed observations that were calculated from inhomogeneous observations.
- For technical reasons in the DWD system the superobbing is performed on observations before undergoing a cloud check. The subsequent cloud check using the superobbed data might fail at the edges of clouds, where clear and cloudy observations are mixed. Particularly, for such systems it might be important to flag strongly inhomogeneous scenes as they may be caused by cloud affected observations.

Implementation:

Let $\bar{y} = \frac{1}{N}\sum_{i=1}^{N} y_i$, where the y_i are the individual observations. Implementing a threshold criterion requires a measure for the inhomogeneity. Possible candidates are:

$$\mathrm{stddev}(y) = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(y_i - \bar{y})^2} \;>\; C_1 \quad \text{or} \quad \max(y_i) - \min(y_i) \;>\; C_2$$

However, since the inhomogeneity varies strongly with the size of the area covered by the superobbed FOVs, and since the size of this area strongly depends on the scan angle (see Fig. 6), the threshold values C_1 and C_2 should also be functions of the scan angle. We propose the following expression:

$$C_{1,2} = a\,[\tan(\alpha + \beta + 0.5\,\gamma) - \tan(\alpha - \beta - 0.5\,\gamma)] \quad (1)$$

where α is the scan angle, β is the step angle and γ is the cone angle. The expression in square brackets is approximately proportional to the superobbed area.

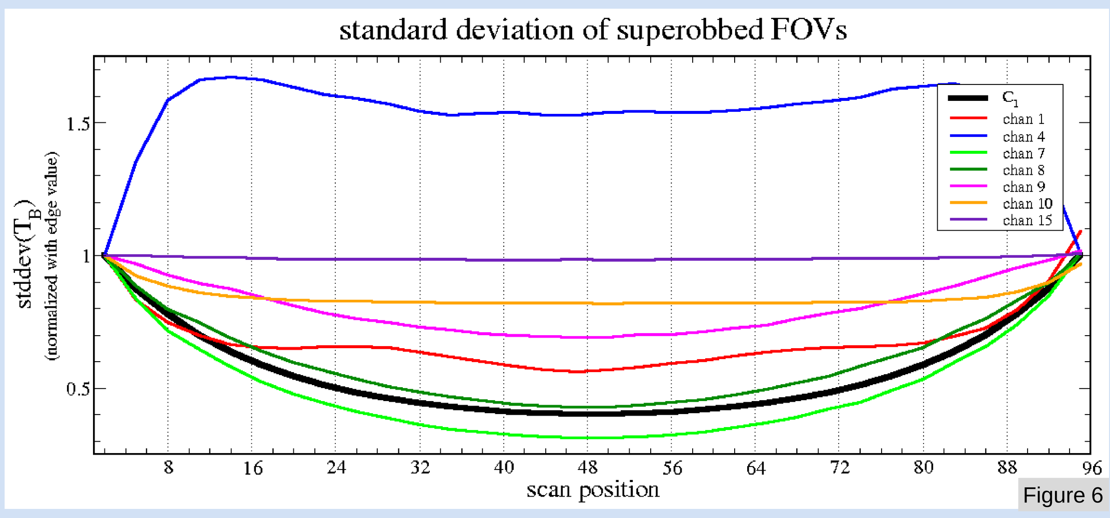

Figure 6

Figure 6 compares $\mathrm{stddev}(y)$ with (1). The agreement is good for the tropospheric channels (e.g. 7 and 8). For the surface sensitive channels the inhomogeneity close to nadir is larger than the value given by C_1, since the surface influence is increasing close to nadir. In the stratosphere most spatial variability is on scales larger than the superobbed areas. Therefore, the curve is much flatter for stratospheric channels.

For stratospheric channels and surface sensitive channels a more sophisticated approach for $C_{1,2}$ might be required. However, as explained above (see Motivation/Idea) the idea is to screen out cloud-affected areas and/or areas with inhomogeneous surface. Thus, it is sufficient to apply the criterion to a selected strongly cloud sensitive channel, e.g. a window channel.

Results:

Figure 7a shows $\mathrm{stddev}(y)$ for channel 1 and in Figure 7b the FOVs, which fulfill

$$\mathrm{stddev}(y) > 1.3\,[\tan(\alpha + \beta + 0.5\,\gamma) - \tan(\alpha - \beta - 0.5\,\gamma)]$$

are marked. This should be compared with the results of the operational cloud-check shown in Figure 7c. The criterion flags edges of cloudy areas where some residual cloud contamination is likely. This criterion had a small positive impact in a 4 month impact experiment (not shown). Other channels and objective methods to select thresholds will be investigated.

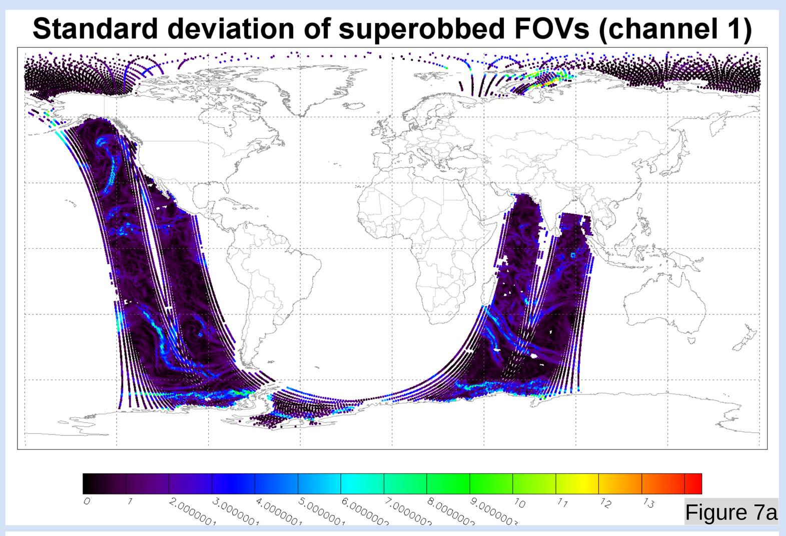

Figure 7a

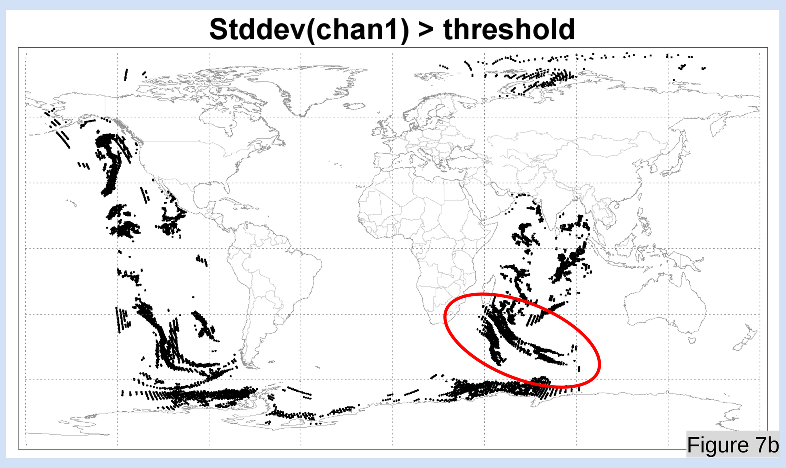

Figure 7b

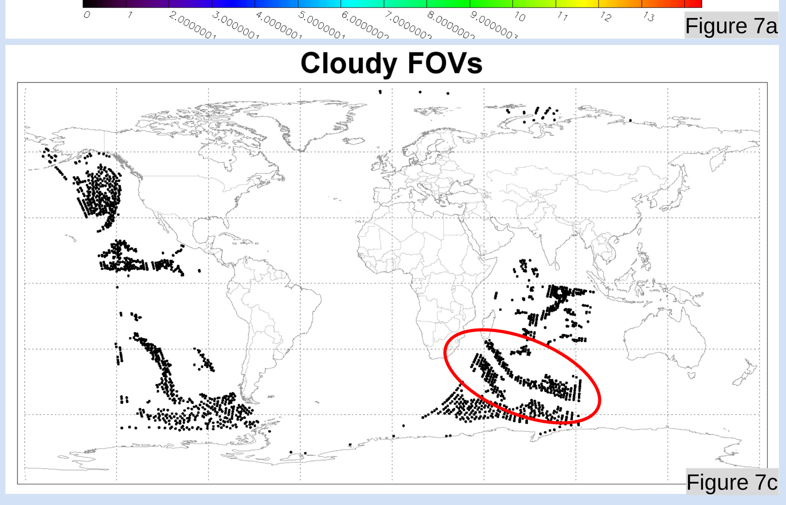

Figure 7c

5. Conclusions/Outlook

- For the assimilation of ATMS it is important to take into account the scan angle dependency of the obserrors.
- A QC criterion is proposed, that is based on superobbing. Inhomogeneous areas (affected by clouds or inhomogeneous surfaces) are screened out by this criterion.
- Instead of using the inhomogeneity within the superobbed FOVs as a QC criterion, it might be used alternatively as part of the obserror model.

DWD, German Meteorological Service, Data assimilation section
Presenter: Ana Fernandez del Rio, Ana.Fernandez-del-Rio@dwd.de
Author: Robin Faulwetter, Robin.Faulwetter@dwd.de