SCIENTIFIC REPORT

ACTION: ES1303 TOPROF
MEETING: SWG 3.6
TITLE: MWR O-B analysis in the radiance space
VENUE: Vienna, Austria
DATE: 20-21 April, 2016

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Introduction

During the TOPROF MC meeting in Toulouse (20 October 2015), a SWG on "RTTOV + O-B" (SWG15 on MC5 Minutes, Annex6) was approved for Grant Period 3 and originally scheduled for April-May 2016. Since a good number of WG3 members planned to attend the annual European Geophysical Union (EGU) general assembly in Vienna, SWG15 has been anticipated and hosted during the EGU general assembly for the interest of economy.

The objectives of SWG15 are:

- Review the results from recent microwave radiometer (MWR) observation-minus-background (O-B) analysis in retrieval space
- Introduce the activities for the O-B analysis in radiance space
- Discuss plans for O-B analysis in radiance space
- Discuss plans for future activities (STSM/SWG)

Thus, the following agenda was approved:

Slot 1: April 20 13:30-17:00

D. Cimini – Introduction

U. Lohnert/A. Haefele/F. Navas – Update of O-B analysis in profile space

O. Caumont – Background dataset

F. De Angelis/P. Martinet – MWR Tb datasets

All – Discussion

Slot 2: April 21 09:00-12:30

F. De Angelis – Status of RTTOVgb software tool

P. Martinet/F. De Angelis – Status of 1DVAR software tool

All – Discussion on O-B analysis in radiance space

D. Cimini – Next STSM/WG3 meetings

All – Discussion and Scientific Report drafting

D. Cimini – Summary and conclusions

Achievements

The status of the activities of TOPROF WG3 has been briefly reviewed. Concerning O-B analysis, the results of a recent experiment have been reviewed at first. These are presented in the paper by Caumont et al. (2016), showing the O-B analysis in the retrieval space (temperature and specific humidity from surface to 10 km height) for

twelve MWR falling in the Meteo France Arome West Mediterranean domain. The analysis spans over forty-one days (from 15/10/2011 to 25/11/2011). A summary of the O-B statistics reported in Caumont et al. (2016) is showed in Figure 1 for temperature and Figure 2 for specific humidity.

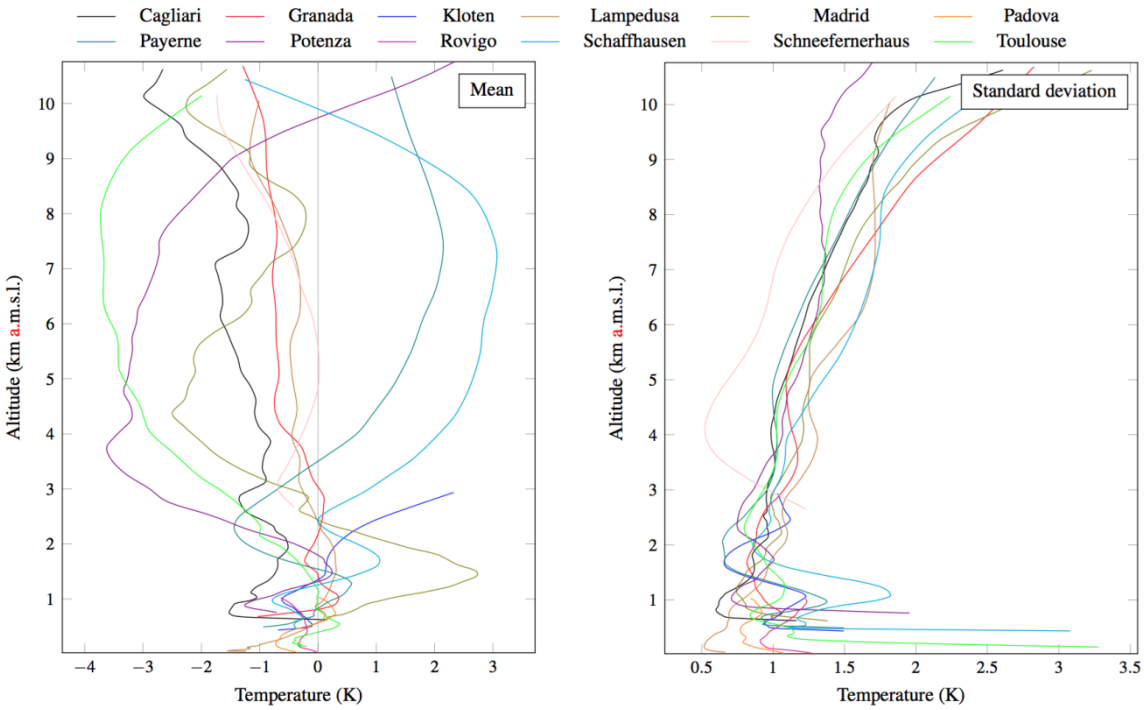

Figure 1: Vertical profiles of mean (left) and standard deviation (right) of observations-minus-background temperature [K] for each MWR station (after Caumont et al., 2016).

Then, preliminary results from the O-B analysis in the retrieval space carried on within TOPROF have been presented by the group in University of Köln. Currently a data set of one-month temperature retrievals (from surface to 10 km height above ground level), collected in April 2014 from six MWR stations, is considered. The six stations are: RAO (Lindenberg), JOYCE (Julich), CESAR (Cabauw), SIRTA (Paris), LACROS (Leipzig) and Payerne. For this analysis the background is the output of the Meteo France Arome model, with the configuration operational in 2014 (60 pressure levels).

Preliminary results for temperature O-B statistics (bias, std, rms) are shown in Figure 3 for the CESAR station in Cabauw (NL). Similar results have been produced for other three stations (JOYCE, LACROS, RAO), while there remain issues to be resolved for the data set from the other two stations (SIRTA and Payerne).

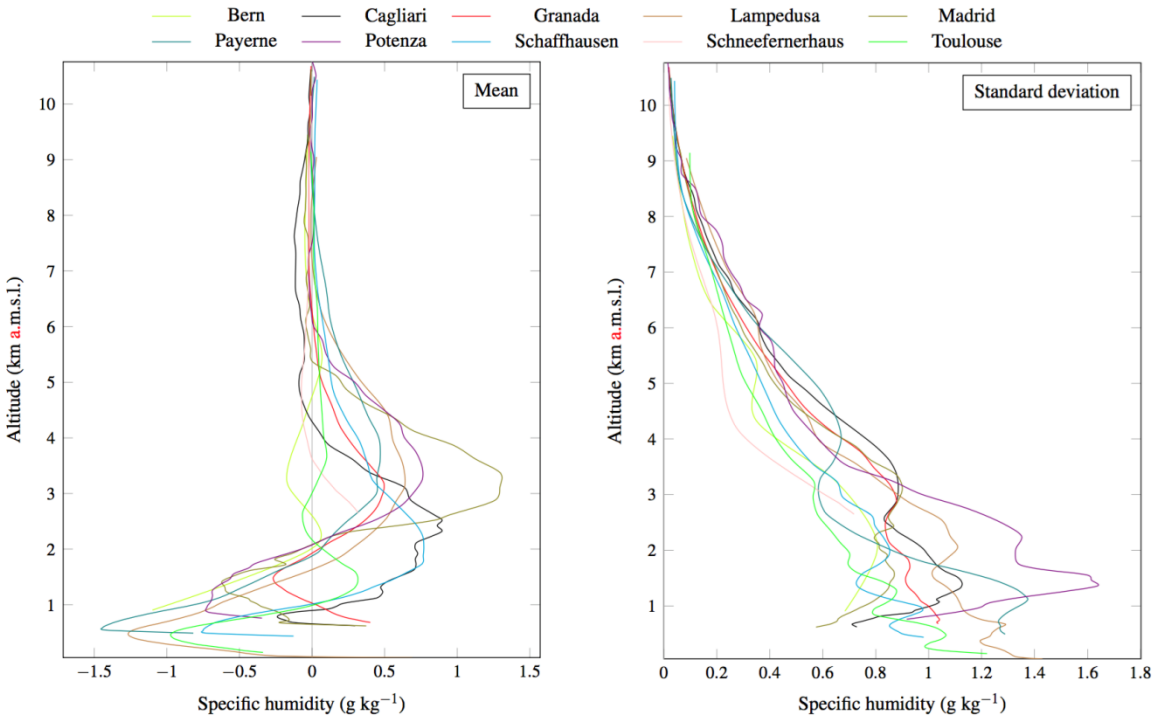

Figure 2: Vertical profiles of mean (left) and standard deviation (right) of observations-minus-background specific humidity [g kg^{-1}] for each MWR station (after Caumont et al., 2016).

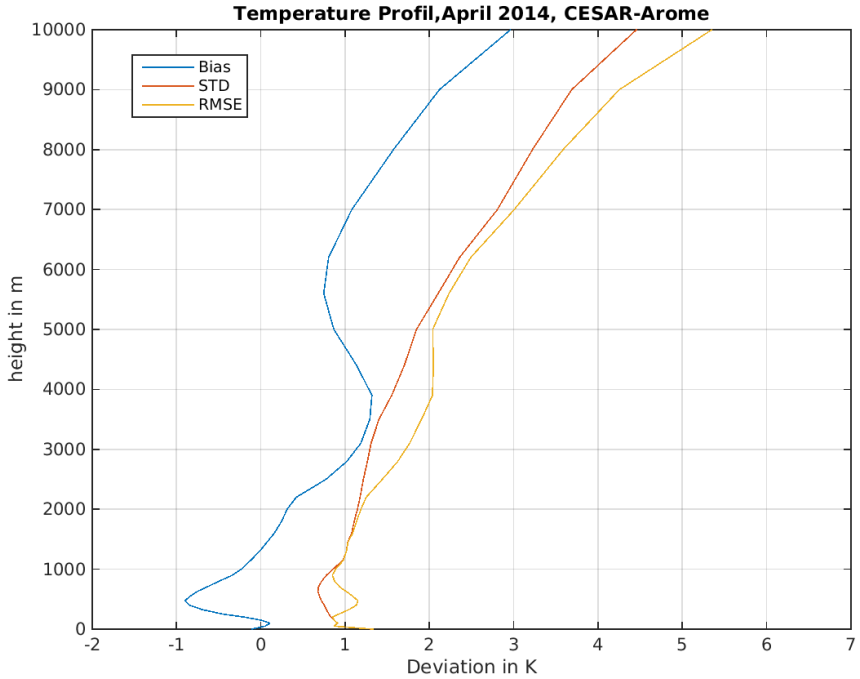

Figure 3: Vertical profiles of mean (blue), std (red), and rms (yellow) of O-B temperature [K] for CESAR station in Cabauw.

The O-B analysis in the retrieval space is also focusing on the daily cycle of the statistics. One example, again for the MWR at the CESAR station in Cabauw, is shown in Figure 4. Similar figures have been produced for JOYCE, LACROS, and RAO.

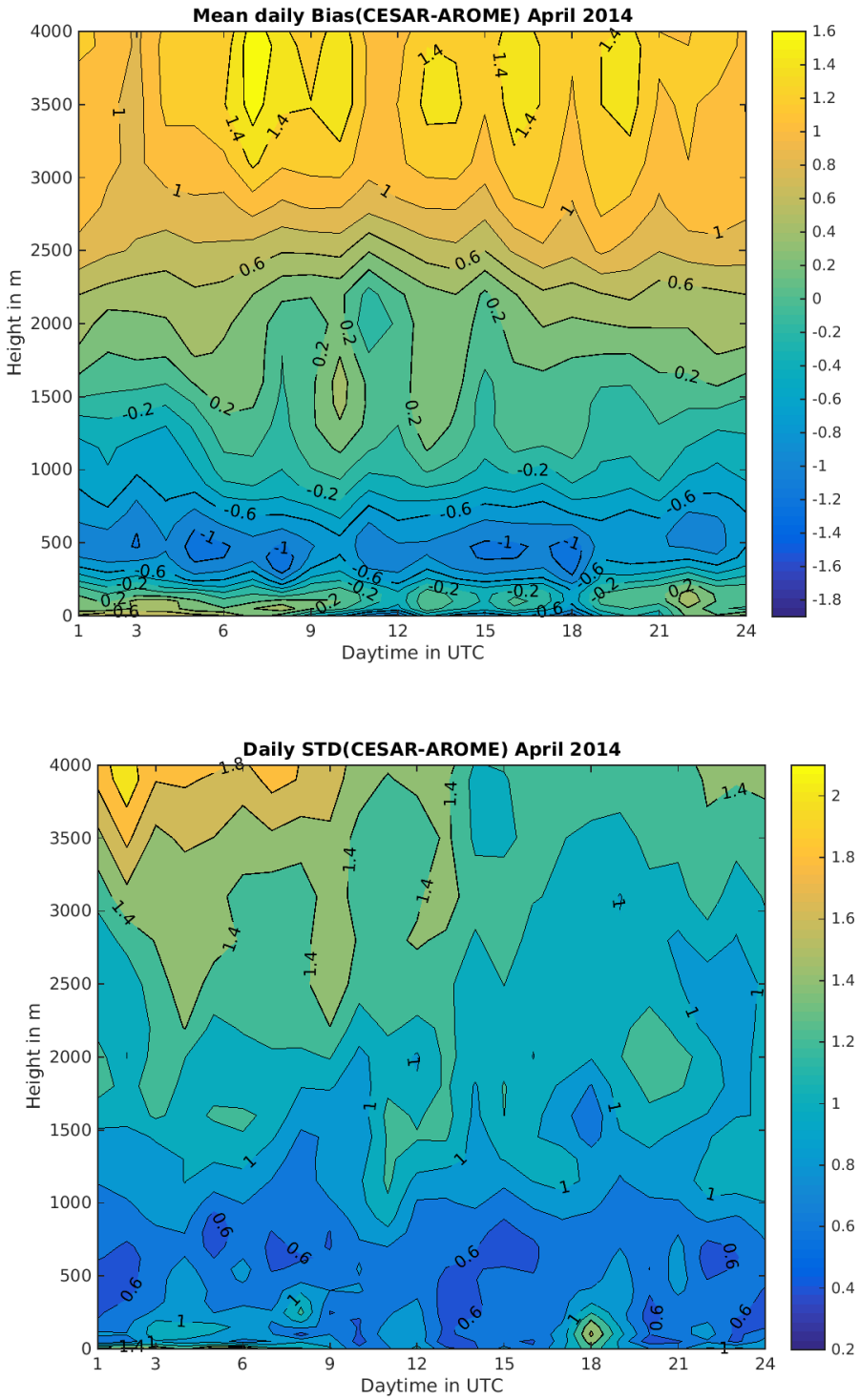

Figure 3: Average daily cycle of temperature [K] bias (top) and std (bottom) for April 2014 at CESAR station in Cabauw.

In order to complete the preliminary O-B analysis on the one-month data set, the remaining issues with the data sets from SIRTA and Payerne need to be addressed. The instrument representatives at these two sites have been contacted and are currently working on reprocessing the data in the required format. Once the reprocessed data are available, the O-B analysis shall be extended to the remaining sites and results shall be discussed in the view of extending the analysis over an entire year.

The discussion then moved to the plans for O-B in the radiance (or brightness temperature, TB) space. This analysis requires the availability of level 1 MWR data, that is the calibrated TB. These data files have not been collected for all sites yet but two, i.e. RAO and Payerne. Thus, the O-B analysis in the TB space will initially be performed on these two sites only. The MWR data files in the native level 1 format at each site have been collected for the same period of the O-B in the retrieval space (April 2014). Once available, the level 1 data files in the format agreed within TOPROF WG3 shall be collected and used (compliant to the HD(CP)2 standard). Ceilometer data at the two sites have also been collected to have an independent estimate of cloud presence. Cloud base detection from ceilometers will be used to screen cloudy sky from clear sky conditions at the two sites. If a ceilometer is not available at the other sites, other criteria should be adopted for cloud screening, e.g. thresholds on standard deviation of TB at 31 GHz.

The O-B analysis in the TB space also requires a forward model operator to produce synthetic TB from the background profiles. In our analysis, the forward model operator is RTTOVgb, developed within TOPROF adapting the code RTTOV to ground-based simulations (De Angelis et al., 2016). The status of RTTOVgb has been briefly reviewed. RTTOVgb has been validated against accurate and less time-efficient line-by-line radiative transfer models. In the frequency range commonly used for temperature and humidity profiling (22-60 GHz), rms TB differences are smaller than typical MWR uncertainties (~0.5 K). TB simulated with RTTOVgb from radiosonde profiles have been compared with nearly simultaneous and colocated ground-based MWR observations. Differences between simulated and measured TB are below 0.5 K for all channels except for the water vapor band, where most of the uncertainty comes from instrumental errors. The Jacobians calculated with the K-module of RTTOVgb have been compared with those calculated with the brute force technique and those from the reference line-by-line model ARTS. Jacobians are found to be almost identical, except for liquid water content Jacobians for which a 10% difference between ARTS and RTTOVgb at transparent channels around 450hPa is attributed to differences in liquid water absorption models. It must be stressed that the current

version of RTTOVgb allows for monochromatic, pencil-beam synthetic observations. Thus, with respect to zenith, higher O-B differences are expected at low elevation angles.

The O-B analysis in the TB space is functional to the MWR data assimilation (DA) with variational schemes, such as 1-DVAR to 4-DVAR. A 1-DVAR software tool has been developed within TOPROF WG3 adapting the 1-DVAR software package developed by the NWPSAF. The status of 1-DVAR has been briefly reviewed. RTTOVgb has been applied as the forward model operator within the new version of the NWPSAF 1-DVAR software tool in an Observing-System Simulation Experiment (OSSE). For both temperature and humidity profiles, the 1-DVAR with RTTOVgb improves the retrievals with respect to NWP model in the first few kilometers from the ground, where the MWR provides the maximum information content.

Conclusions

In conclusion, the following actions have been agreed upon:

A1) Address the issues with MWR temperature retrieval data files for the two remaining sites (Payerne and SIRTA). Extend the O-B analysis to these two sites.

A2) Extend the data set for O-B in retrieval space to one full year (2014). The model background will be again Arome; data will be provided by O. Caumont (CNRM, Meteo France). The MWR retrievals (temperature and absolute humidity [kg/m^3]) will be provided by the site representatives in the agreed level 2 HD(CP)2 format.

A3) Perform O-B in TB space in clear sky and at all elevation angles observed by the considered MWR units. The analysis will initially consider two sites only (RAO and Payerne) but will be later extended to all sites considered in the O-B analysis in the retrieval space. All site representatives shall provide the elevation angles observed by their MWR.

A4) Perform 1-DVAR trials with RTTOVgb on real observations. These trials will follow the O-B TB analysis and thus will start from the two sites mentioned above (RAO and Payerne). This analysis will be eventually extended to other sites. A short-term scientific mission (STSM) is planned on this task on the second half of May at Meteo France.

A5) Organize a pan-WG3 meeting on “Preparing the assimilation of MWR observations from an optimized network configuration”. This meeting shall touch all the topics the WG3 is facing: calibration best practices, uncertainty estimate, harmonized data processing, common retrieval, data assimilation into NWP. The meeting should be hosted by a National Weather Service to maximize the chance to engage the DA community. MeteoSwiss (Zurich) and Meteo France (Toulouse) were proposed; the final decision will be made later this year.

A6) Two STSM are proposed to build the capacity for interfacing RTTOVgb with NWP systems currently operational in Europe (e.g. Arome, COSMO). These will be hosted either in L’Aquila or in Toulouse.

Advances on A1 to A4 are expected to be reported at next MC+WG meeting (1-3 June, Varna, BG).

This scientific report will be posted on the TOPROF website: www.toprof.eu.

References

Caumont O., B. Vincendon, D. Cimini, U. Löhnert, L. Alados-Arboledas, R. Bleisch, F. Buffa, M. E. Ferrario, A. Haefele, T. Huet, F. Madonna, G. Pace, Assimilation of humidity and temperature observations retrieved from ground-based microwave radiometers into a convective-scale model, *Quart. J. Royal Met. Soc.*, under review, 2016.

De Angelis F., D. Cimini, J. Hocking, P. Martinet, S. Kneifel, RTTOV-gb - Adapting the fast radiative transfer model RTTOV for the assimilation of ground-based microwave radiometer observations, *Geoscientific Model Development Discussion*, 2016.