GAIA-CLIM deliverable D4.4

Gap Analysis for Integrated Atmospheric ECV CLImate Monitoring

WP4: Assessment of reference data in global assimilation systems and characterization of key satellite data

D4.4: “Publicly available web based monitoring pages showing a comparison of GRUAN observations with Met Office and ECMWF data assimilation systems as an input to Virtual Observatory”.

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Introduction

The characterisation of traceable uncertainties in Numerical Weather Prediction (NWP) models is one of the planned outcomes of the Horizon 2020 GAIA-CLIM project. To achieve this goal, observations from the Vaisala RS-92 radiosonde product of the GCOS reference upper-air network (GRUAN) are being used to assess uncertainties in Met Office and ECMWF models.

To achieve this, a *GRUAN Processor* is being designed as a stand-alone software module based on a core radiative transfer model built around the RTTOV fast radiative transfer model (Hocking et al., 2015) and a Radiance Simulator (Smith, 2014) which provides an efficient interface to process NWP model fields. These two products have been developed and made publicly available as part of EUMETSAT's NWP Satellite Application Facility. The GRUAN processor enables the comparison of geophysical fields and simulated brightness temperatures calculated from radiosondes (including their uncertainties) and NWP models. This report briefly outlines the functionality of the GRUAN processor, the preliminary outputs, and details of how to access the online data, in fulfillment of Deliverable 4.4 of GAIA-CLIM, due in February 2017.

Processing details

The GRUAN processor accepts as input both MetOffice and ECMWF operational model fields (UM Field Files and GRIB files, respectively) as well as the GRUAN version 2 observational data files. GRUAN spatio-temporal coordinate profiles (latitude, longitude, and time) are used to interpolate (linearly) the model fields in space and time along the path of the radiosonde. The model 3-hourly forecasts to T+9 (T+15 for ECMWF) from analysis (T=0) time are used for the temporal interpolation.

The radiative transfer model RTTOV version 11.3 is used to simulate Top of Atmosphere (TOA) brightness temperatures (BTs) for selected satellite instruments. Note that the lack of information in the upper atmosphere, and in some cases at the surface, in the GRUAN data requires a merging with the interpolated model fields in order to use RTTOV. Two sets of BTs simulated with GRUAN temperature, humidity, and pressure profiles which have been increased (and decreased) by their associated total uncertainties are used to estimate the total uncertainty in terms of brightness temperatures. In addition, a third set of BTs simulated with the model profiles forced to GRUAN measured surface pressure is used to estimate the uncertainty in surface sensitive channels due to the horizontal interpolation of the model grid.

The processor outputs consist of two sets of netcdf files (one for the model, one for GRUAN) containing, among other parameters, the profiles of temperature, specific humidity, pressure, the simulated BTs, and their respective uncertainties.

The preliminary analysis of processor outputs (processed for all available GRUAN profiles in 2013) revealed that in spite of a close agreement between GRUAN and NWP temperature (within ±0.2K), the simulated BTs for temperature sounding channels are biased by ~1K for microwave (MW) instruments and ~0.5K for infrared (IR) instruments. This discrepancy has been traced back to the radiative transfer equation being applied to several thousand vertical levels for the radiosonde and 70 (91 or 137) for the Met Office (ECMWF) model. Experiments show that when both input profiles are provided on the same vertical grid, (either interpolated to the sonde levels or to those of the model), the difference in BTs is reduced to a few tenths of a Kelvin. This issue will be addressed in the next version of the processor during the third year of the project.

The processor will also provide a better representation of GRUAN uncertainties (including systematic, random, and possibly structured random). The systematic uncertainty in BTs should be estimated with an ensemble of perturbed BTs generated with the GRUAN error covariance matrix. As Vaisala (the sonde supplier) and GRUAN do not currently provide such information, the covariance will be estimated via a statistical approach (described in Desroziers et al., 2005) at the Met Office.

Webpage

4210 sondes from 15 sites have been processed and compared to both the Met Office and ECMWF model fields. Eleven GRUAN sites are located in the Northern Hemisphere, namely, Barrow, AK, USA, (BAR), Beltsville, MD, USA, (BEL), Boulder, CO, USA, (BOU), Cabauw, Netherlands, (CAB), Lindenberg, Germany, (LIN), Ny-Ålesund, Norway, (NYA), Payerne, Switzerland, (PAY), Potenza, Italy, (POT), Lamont, OK, USA, (SGP), Sodankylä, Finland, (SOD), and Tateno, Japan, (TAT), three are in the tropics, namely, Manus, Papua New Guinea, (MAN), Nauru, Nauru, (NAU), La Réunion, France, (REU), and one in the Southern Hemisphere, namely, Lauder, New Zealand, (LAU).

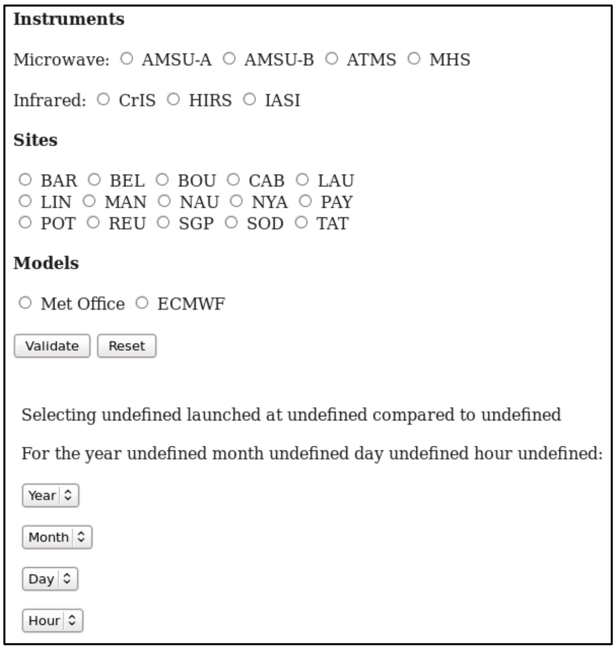
BTs have been generated for four microwave instruments, namely, the Advanced Microwave Sounding Unit – A and – B (AMSU-A, AMSU-B), the Advanced Technology Microwave Sounder (ATMS), and the Microwave Humidity Sounding (MHS), and three infrared instruments, namely, the Cross-track Infrared Sounder (CrIS), the High-resolution Infra-Red Sounder (HIRS), and the Infrared Atmospheric Sounding Interferometer (IASI). BTs seen by those instruments were simulated for clear sky conditions at nadir viewing angles.

Comparisons are available on the NWPSAF webpage:

https://nwpsaf.eu/GProc_test/fab/ins.shtml.

Note however that data shown on that web page are linearly interpolated on a fixed pressure grid (0 to 999 hPa) to facilitate the comparison. This is carried out in a post processing step aimed to ease visualization and is independent from the GRUAN-Processor itself. The GRUAN-Processor raw outputs are available through the GAIA-CLIM Virtual Observatory.

Users entering the GRUAN-Processor webpage will be able to select one of the instruments for which BTs have been simulated, the GRUAN launch site, and the model to be used for the comparison as shown in Fig.1. Upon clicking on “Validate”, users will be prompted to select the year, month, day, and hour corresponding of the launch dates available for their configuration. Once the date has been selected, a graphic file, similar to that shown on Fig.2, and a text file (Fig.3) containing the values plotted on the figures, becomes available to open or download. Note that the users are also offered to download the annual mean of the selected site (both in graphic and text format).



Instruments

Microwave: ○ AMSU-A ○ AMSU-B ○ ATMS ○ MHS

Infrared: ○ CrIS ○ HIRS ○ IASI

Sites

○ BAR ○ BEL ○ BOU ○ CAB ○ LAU
○ LIN ○ MAN ○ NAU ○ NYA ○ PAY
○ POT ○ REU ○ SGP ○ SOD ○ TAT

Models

○ Met Office ○ ECMWF

Selecting undefined launched at undefined compared to undefined

For the year undefined month undefined day undefined hour undefined:

Figure 1: Home page of the GRUAN Processor NWP SAF-hosted web access to post-process comparisons NWP-GRUAN.

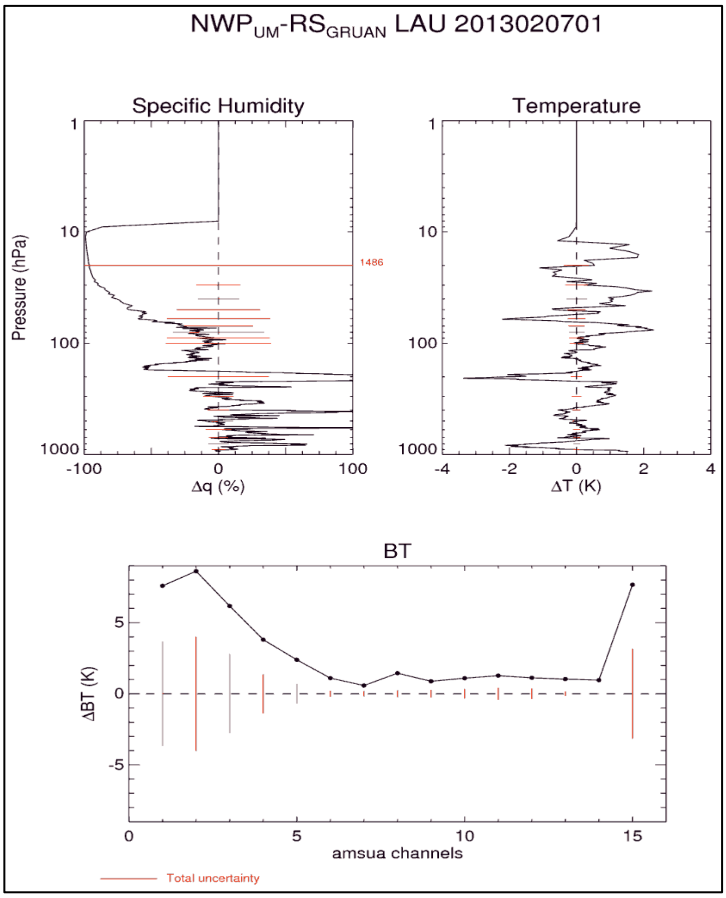
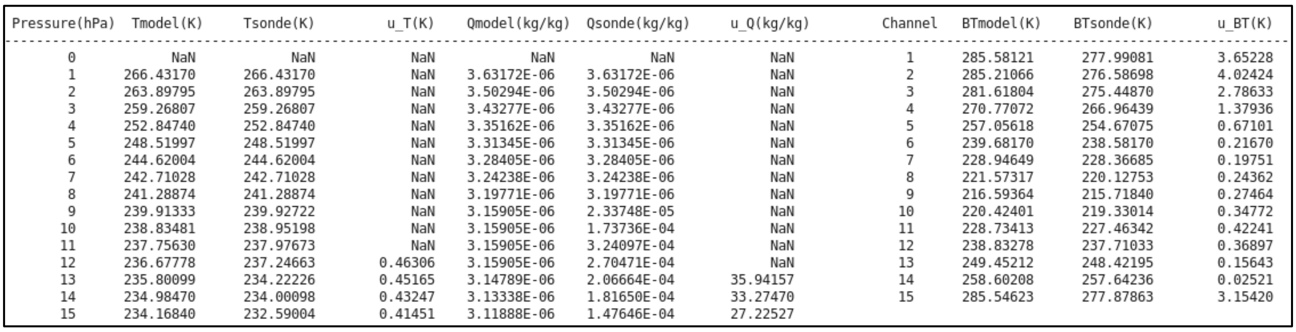


Figure 2: (Top left) Specific humidity difference UM minus GRUAN, for Lauder Feb 02, 2013, 0100UTC, and expressed in relative terms with respect to the GRUAN profile, as a function logarithmic pressure scale. (Top right) Same as *top left* but for temperature expressed in absolute value (K). (Bottom) Difference UM minus GRUAN expressed in simulated BT for AMSU-A channels. Red bars represent the total uncertainty in the GRUAN measurements.



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Pressure(hPa)  Tmodel(K)      Tsonde(K)         u_T(K)    Qmodel(kg/kg)  Qsonde(kg/kg)     u_Q(kg/kg)        Channel   BTmodel(K)     BTsonde(K)          u_BT(K)
-------------------------------------------------------------------------------------------------------------------------------------------------------------------
        0            NaN            NaN            NaN            NaN            NaN            NaN              1    285.58121      277.99081          3.65228
        1      266.43170      266.43170            NaN    3.63172E-06    3.63172E-06            NaN              2    285.21066      276.58698          4.02424
        2      263.89795      263.89795            NaN    3.50294E-06    3.50294E-06            NaN              3    281.61804      275.44870          2.78633
        3      259.26807      259.26807            NaN    3.43277E-06    3.43277E-06            NaN              4    270.77072      266.96439          1.37936
        4      252.84740      252.84740            NaN    3.35162E-06    3.35162E-06            NaN              5    257.05618      254.67075          0.67101
        5      248.51997      248.51997            NaN    3.31345E-06    3.31345E-06            NaN              6    239.68170      238.58170          0.21670
        6      244.62004      244.62004            NaN    3.28405E-06    3.28405E-06            NaN              7    228.94649      228.36685          0.19751
        7      242.71028      242.71028            NaN    3.24238E-06    3.24238E-06            NaN              8    221.57317      220.12753          0.24362
        8      241.28874      241.28874            NaN    3.19771E-06    3.19771E-06            NaN              9    216.59364      215.71840          0.27464
        9      239.91333      239.92722            NaN    3.15905E-06    2.33748E-05            NaN             10    220.42401      219.33014          0.34772
       10      238.83481      238.95198            NaN    3.15905E-06    1.73736E-04            NaN             11    228.73413      227.46342          0.42241
       11      237.75630      237.97673            NaN    3.15905E-06    3.24097E-04            NaN             12    238.83278      237.71033          0.36897
       12      236.67778      237.24663        0.46306    3.15905E-06    2.70471E-04            NaN             13    249.45212      248.42195          0.15643
       13      235.80099      234.22226        0.45165    3.14789E-06    2.06664E-04       35.94157             14    258.60208      257.64236          0.02521
       14      234.98470      234.00098        0.43247    3.13338E-06    1.81650E-04       33.27470             15    285.54623      277.87863          3.15420
       15      234.16840      232.59004        0.41451    3.11888E-06    1.47646E-04       27.22527
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Figure 3: Subset of the text-based value of temperature, specific humidity, and BTs, with their respective uncertainty available from the webpage.

References

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