BASCOE Reanalysis of Aura MLS (BRAM-1) with a focus on water vapour

Q. Errera[1] (quentin@aeronomie.be), S. Chabrillat[1] , Y. Christophe[1], J. Debosscher[1], M. Santee[2] and S. Skachko[3]

Motivations

- The BASCOE system provides operational analysis of the stratospheric chemical composition since 2009 using MLS scientific retrievals with a latency of 3 to 5 days (www.copernicus-stratosphere.eu).
- These analyses are used, among other datasets, by WMO Global Atmosphere Watch (GAW) to produce the Arctic and Antarctic Ozone Bulletin.
- BASCOE analyses are provided as 6-hourly snapshots and make the interpretation of the global state of the stratosphere easier than with MLS profiles and are more accurate than a free model run.
- A reanalysis of MLS between 2004-2016 will allow GAW to evaluate more easily the evolution of the polar stratosphere since 2004.
- Here, we present BRAM – the BASCOE Reanalysis of Aura MLS – version 1.

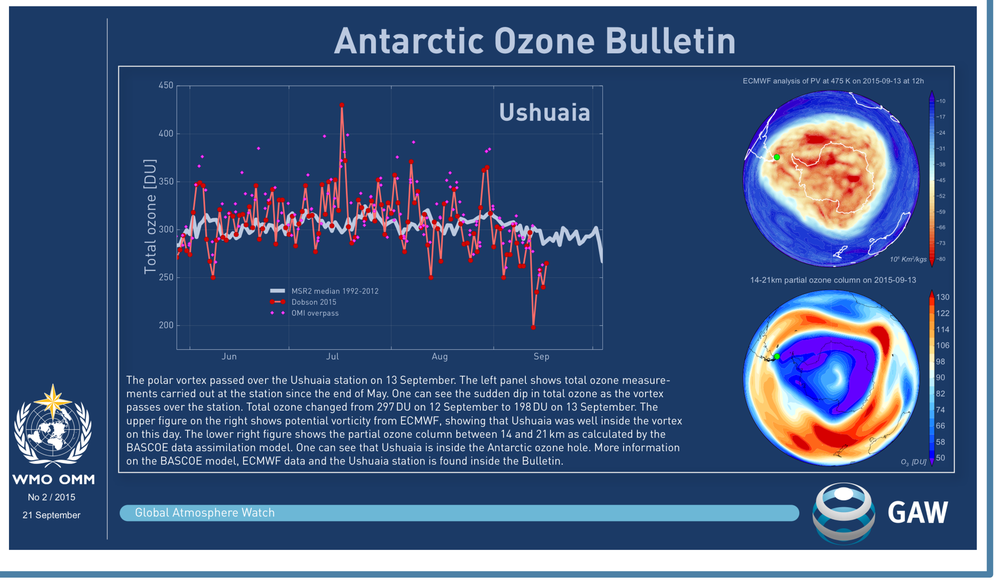


Figure 1: *Illustration of use of BASCOE analyses of MLS for the production of the WMO GAW Antarctic Ozone Bulletin. Here the cover page of the 2nd bulletin of 2015 is shown.*

Experimental Set Up

BRAM has been produced by the Belgian Assimilation System for Chemical Observations (BASCOE)

Chemistry Transport Model (Errera et al., ACP, 2008):

- 58 stratospheric species advected by the Flux Form Semi Lagrangian (Lin and Rood, MWR, 1996).
- Around 200 chemical reactions (gas phase, photolysis and heterogeneous).
- PSC parameterization of their formation/evaporation, sedimentation and heterogeneous reaction rates on their surface (Huijnen et al., GMD, 2016).
- Spatial resolution: 2.5°lat x 3.75°lon x 37 levels between 0.1 hPa – surface.
- Time step: 30 minutes.
- Dynamical fields: ERA-Interim.

Data Assimilation (Skachko et al., GMD, 2014, 2016) :

- EnKF.
- Observational error taken from MLS retrieval.

Observations:

- Aura MLS v4.2 profiles of O_3, H_2O, HNO_3, N_2O, HCl, ClO, CO and CH_3Cl according to the recommendations of the MLS Data Quality Document.
- Period: **Aug 2004-Dec 2016**.

How to obtain BRAM-1

- 6-hourly analyses of the 8 assimilated species plus Cl_2O_2 are freely available.
- Each species and ERA-I temperature are delivered in yearly NetCDF-CF files.
- Size per files: 1,5 Gb ; total size: 233 Gb.
- To download the dataset, ask login/password to quentin@aeronomie.be.
- See also information on BASCOE webpage: strato.aeronomie.be -> Datasets -> BRAM.

Author's Affiliations

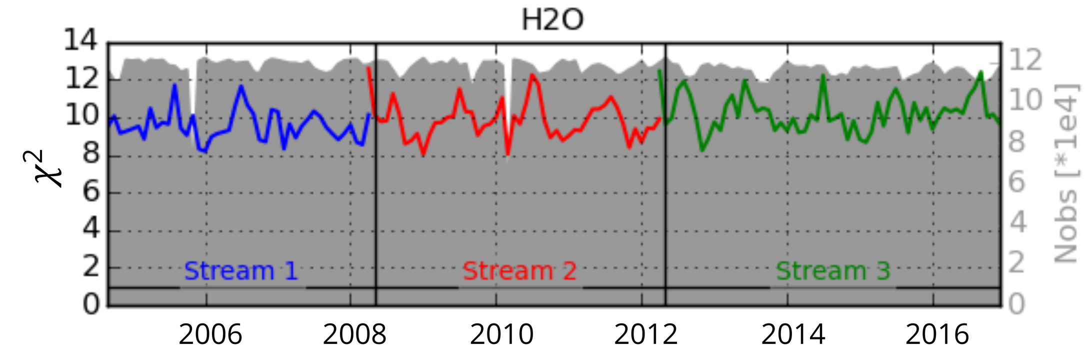
[1]Royal Belgian Institute for Space Aeronomy (BIRA-IASB), Brussels, Belgium
[2]Jet Propulsion Laboratory, California Institute of Technology, USA
[3]Meteorological Research Division, Environment and Climatic Change Canada

Poster presented at EGU 2018 with ID EGU2018-15176.
This poster can be download here: strato.aeronomie.be -> Presentations

χ^2-test

- BRAM is based on three streams with an overlap of 1 month between each stream and there is a good overlap between the streams (**Fig. 2**).
- Observational errors of H_2O are unchanged to get the system closer to MLS. This explains why $\chi^2 \neq 1$.
- All time series are stable over the years while showing seasonal variations for some species.

Figure 2: *Time series of χ^2–test for H_2O (colored lines, left y-axis) and the number of assimilated observations (gray area, right y-axis).*



Forecast-minus-Observations statistics

- BRAM is evaluated on the basis of the Forecast-minus-Observations (FmO) statistics where BRAM is the forecast and the observations are MLS or ACEFTS.
- FmO are calculated for different regions and seasons.
- The mean BRAM-MLS is within the MLS accuracy and is <1% between 2-100 hPa (**Fig. 3**). The Std. Dev. of the FmO are higher than the MLS precision but <5% between 1-50 hPa outside PSC conditions and <10% during PSC conditions. Thus, some averaging of BRAM is necessary to consider it as a proxy of MLS.
- BRAM agrees well with independent observations from ACEFTS (**Fig. 4**) and higlights the differences between both instruments (see box on drift between MLS and ACEFTS).

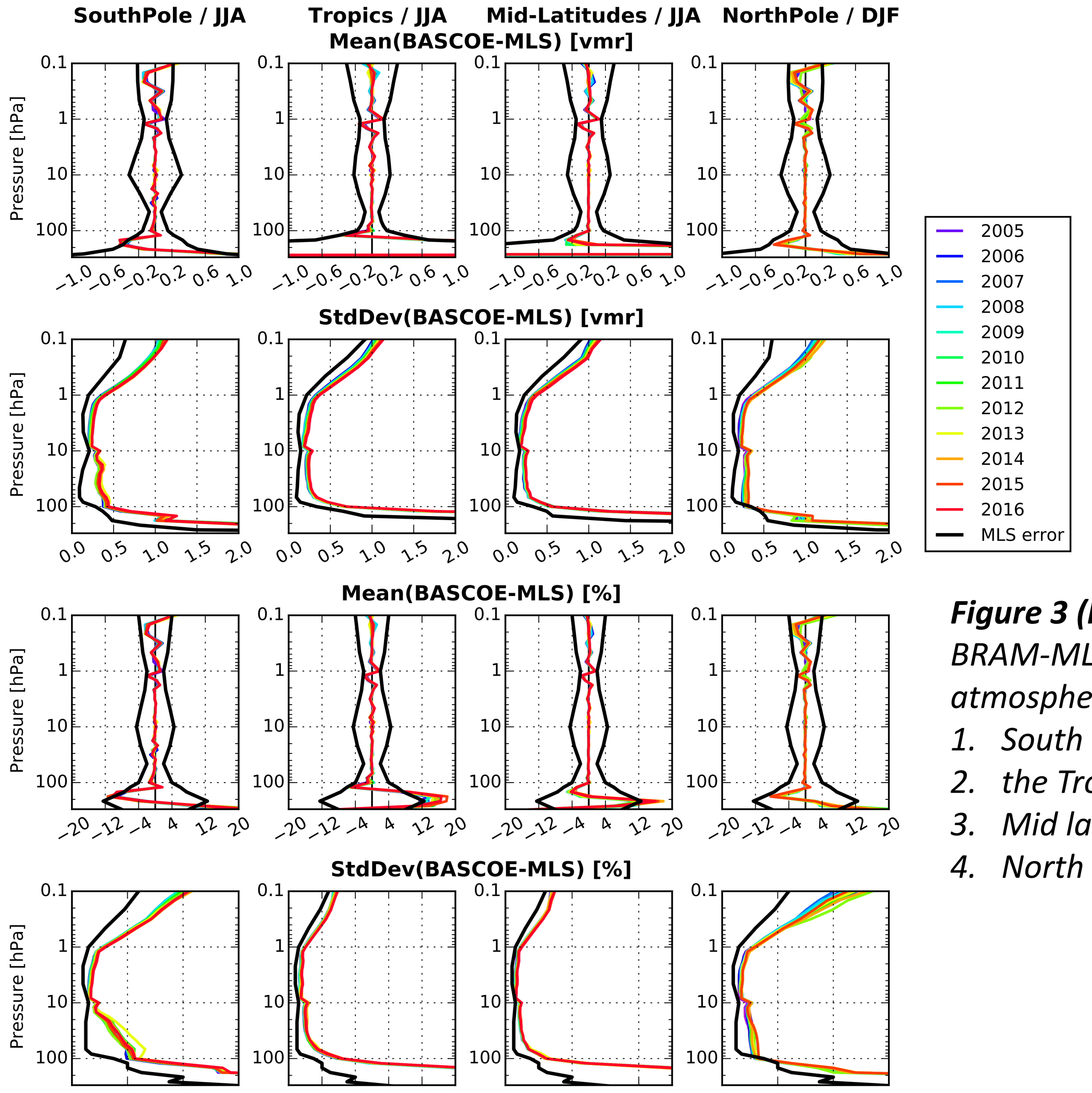
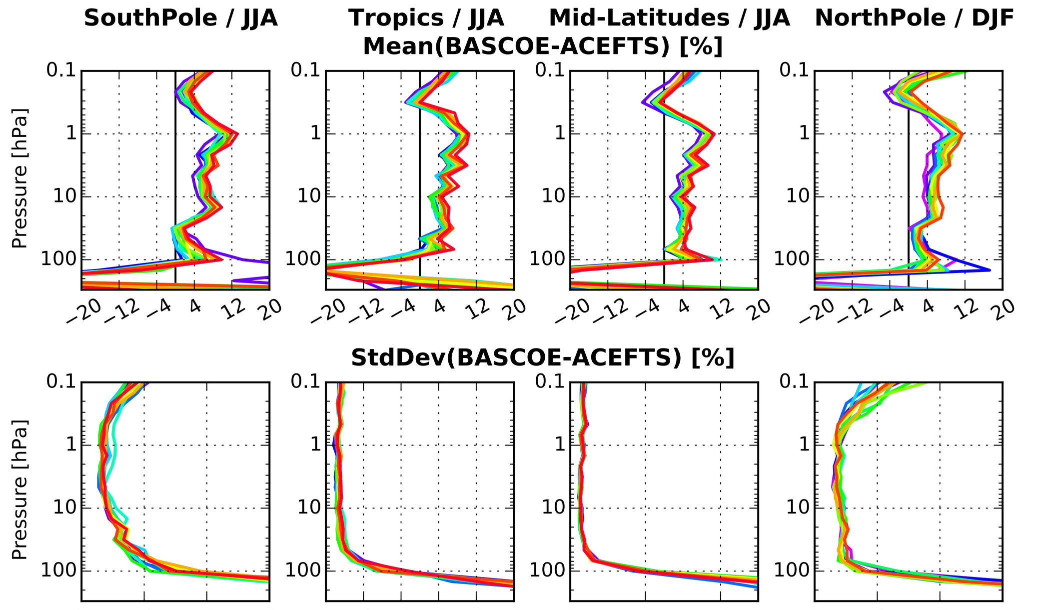


Figure 3 (left): *FmO statistics BRAM-MLS for H_2O and four atmospheric region/season:*

1. *South Pole (90°S-60°S)/JJA*
2. *the Tropics (30°S-30°N)/JJA*
3. *Mid latitude (30°N-60°N)/JJA*
4. *North Pole (60°N,90°N)/DJF*

Figure 4 (left): *as Fig. 4 but for BRAM-ACEFTS*



Descent of mesospheric air

- During each polar winter, dry air from the mesosphere descents in the stratosphere.
- Good agreement between BRAM and MLS while no mesospheric source of H_2O at model lid (**Fig. 5**).

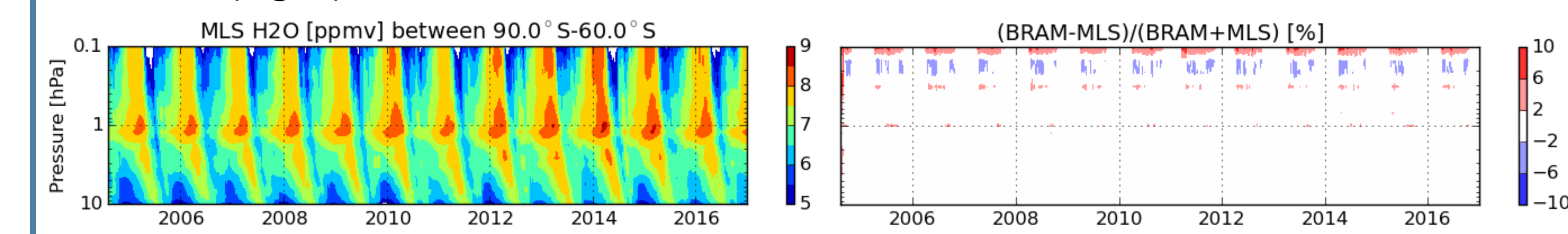


Figure 5: *Left: Time series of daily mean MLS H_2O between 90°S-60°S. Right: Time series of the differences with BRAM.*

H_2O tape recorder

- Very good agreement between BRAM and MLS (**Fig. 6**).
- Might be useful to evaluate vertical transport in CCMs.

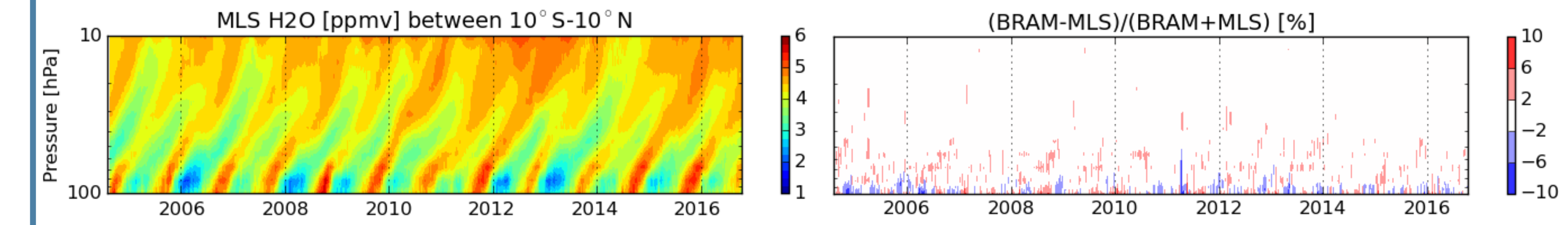


Figure 6: *Left: Time series of daily mean MLS H_2O between 10°S-10°N. Right: Time series of the differences with BRAM.*

Drift between MLS and ACEFTS

- Between 2-50 hPa, the difference BRAM-MLS is <1±5% (**Fig. 3**). Considering BRAM as a proxy of MLS, we have used it to evaluate the differences MLS-ACEFTS.
- Between 2-50 hPa, ACEFTS is drier than MLS by around [2,10]% ±[2,10]%, depending on the year (**Fig. 4**). This agrees with Sheese et al. (JQSRT, 2017) that compared ACEFTS and MLS with a colocation critrerium of 3h and 350 km.
- From Fig. 5, one can deduce a drift in the difference MLS-ACEFTS. This is confirmed in **Fig. 7** (top) which shows the time series of monthly mean BRAM-ACEFTS at 10 hPa and averaged between 60°S-60°N. The drift is 2.1%/decade. Similar drifts are found at other levels within 2-50 hPa.
- The drift of the difference MLS-ACEFTS is attributed to MLS which shows a trend of +0.25 ppmv/decade (**Fig. 7**, bottom)
- These values must be confirmed by more robust trend analysis taking into accound the signal of the QBO.
- This drift analysis is possible thanks to the use of all ACEFTS observation in contrast to the Sheese et al. study which is limited to pairs of colocated MLS and ACEFTS profiles.

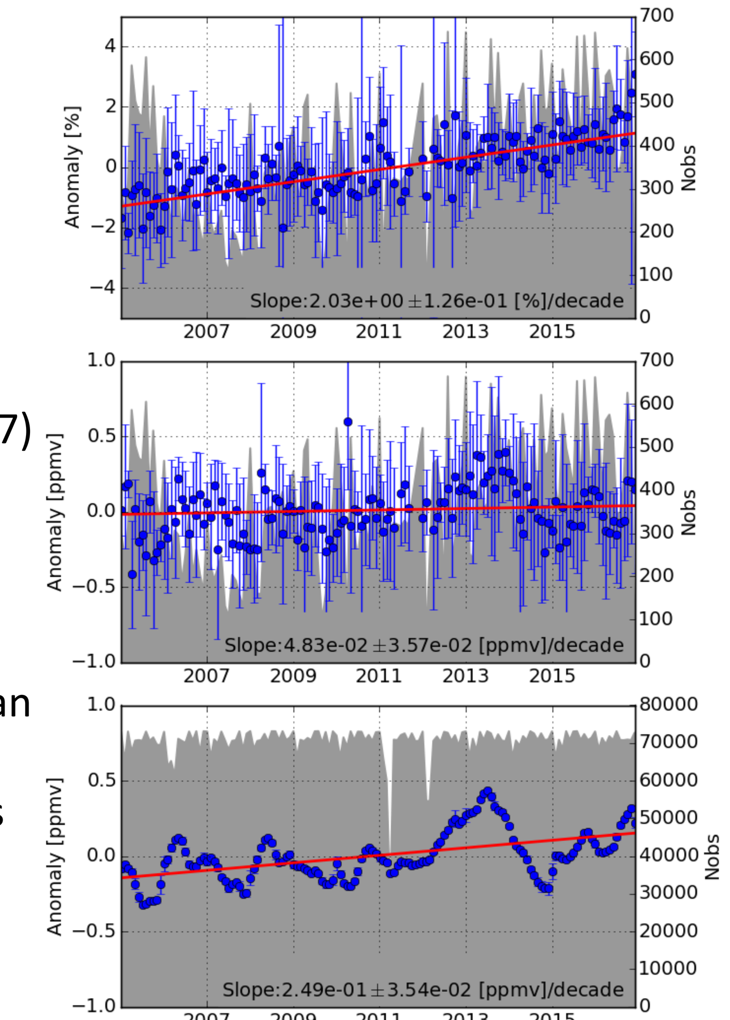


Figure 7: *Time series of monthly mean anomalies at 10 hPa and between 60°S-60°N (left y-axis) and corresponding number of observations (right y-axis)*
Top: Anomaly of BRAM-ACEFTS [%]
Middle: Anomaly of ACEFTS [ppmv]
Bottom: Anomaly of MLS [ppmv]

Dehydration by PSC sedimentation

- Dehydration by PSC sedimentation is well captured by BRAM which corrects most of the model deficiencies (CTRL run, **Fig. 8**).
- The stability of BRAM is also very good over the years of the reanalysis.

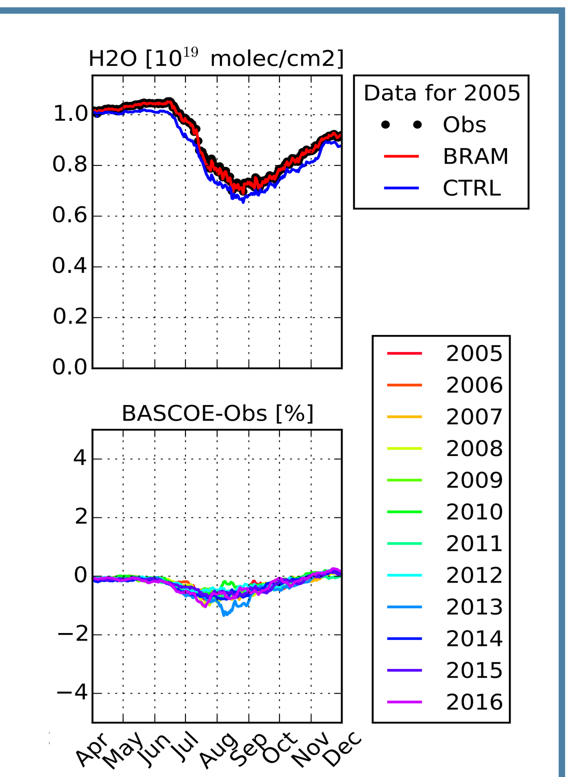


Figure 8: *Top: Time series of MLS H_2O partial column between 10-100 hPa and the corresponding BRAM and CTRL run in 2005. Bottom: Differences BRAM-MLS for all years.*