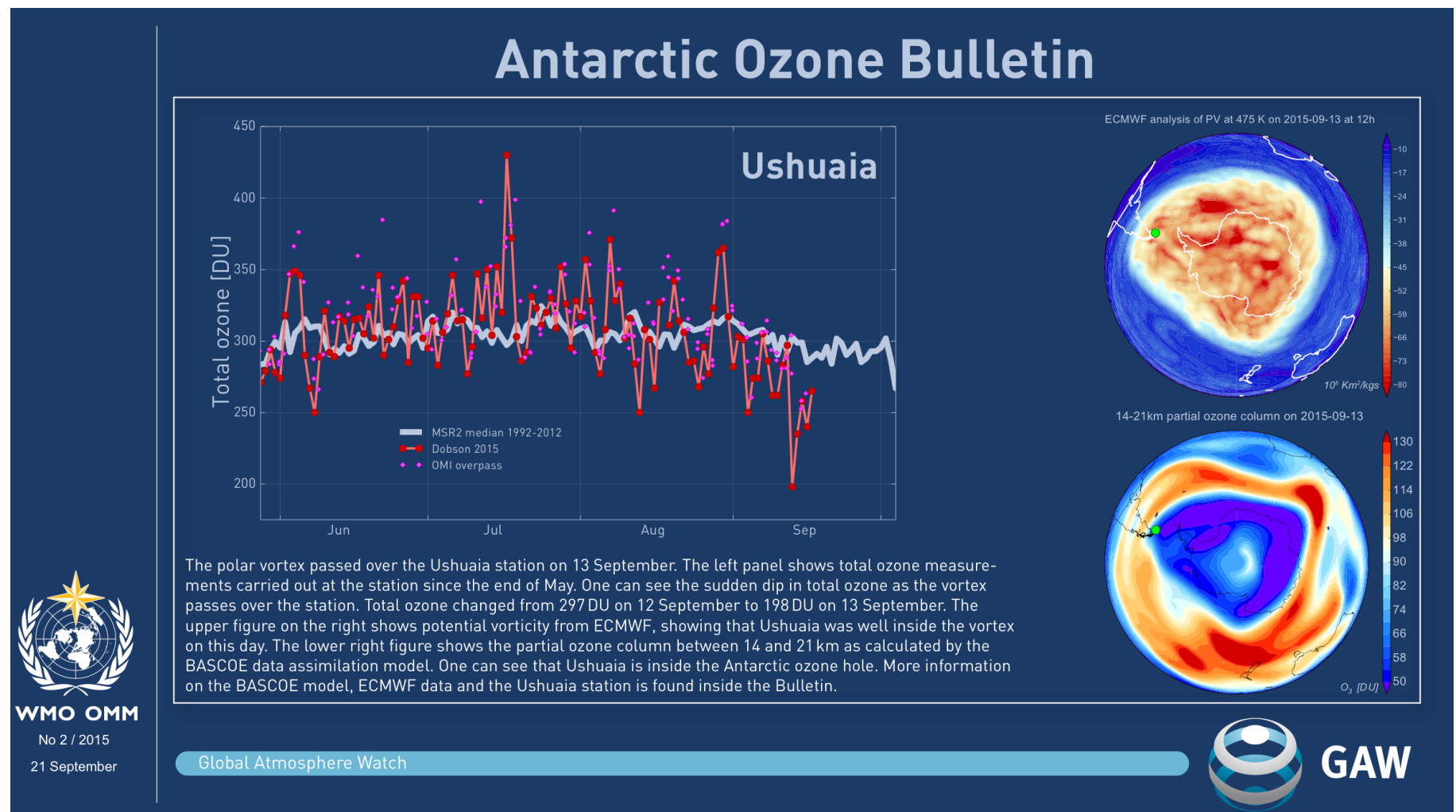


# BASCOE Reanalysis of Aura MLS (BRAM-1) with a focus on stratospheric polar winter conditions

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## 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](http://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 Antarctic Ozone Bulletin. Here the cover page of the 2<sup>nd</sup> 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 tuned using Desroziers' method (Desroziers et al., QJRM, 2005).

**Observations:**

- Aura MLS v4.2 profiles of O<sub>3</sub>, H<sub>2</sub>O, HNO<sub>3</sub>, N<sub>2</sub>O, HCl, ClO, CO and CH<sub>3</sub>Cl according to the recommendations of the MLS Data Quality Document.
- Period: **Aug 2004-Dec 2016**.

## How to obtain BRAM-1

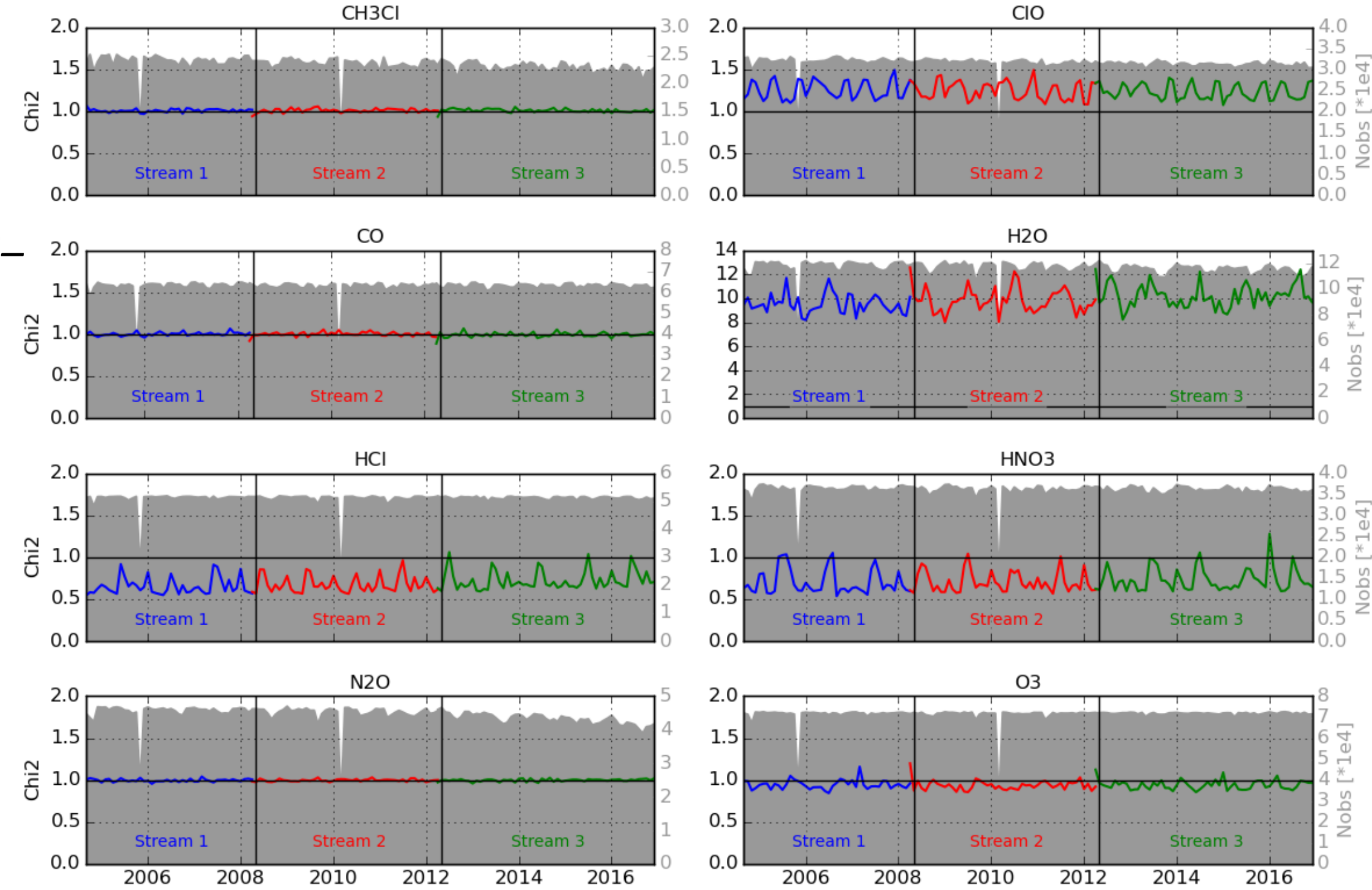
- 6-hourly analyses of the 8 assimilated species plus Cl<sub>2</sub>O<sub>2</sub> are freely available.
- Each species and ERA-I temperature are delivered in yearly NetCDF-CF files.
- Size per files: 1,5 Gb ; total size: 233 Gb.
- To download the dataset, ask login/password to [quentin@aeronomie.be](mailto:quentin@aeronomie.be).
- See also information on the BASCOE webpage: [strato.aeronomie.be](http://strato.aeronomie.be) -> Datasets -> BRAM

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## $\chi^2$ -test

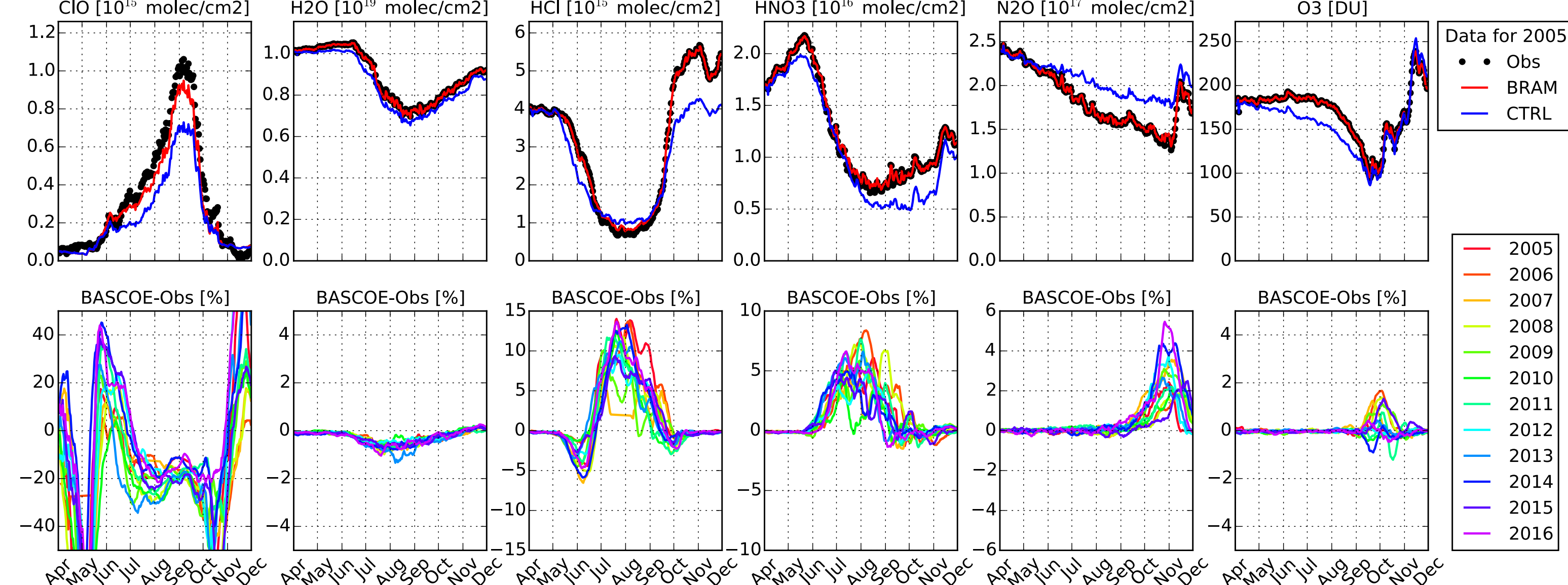
- BRAM is based on three streams with an overlap of 1 month between each stream and there is a good overlap between the streams (**Fig. 2**).
- Observational errors of O<sub>3</sub>, N<sub>2</sub>O, CO and CH<sub>3</sub>Cl are tuned using Desroziers' method which ensures  $\chi^2 \approx 1$ .
- Observational error of HNO<sub>3</sub>, HCl, H<sub>2</sub>O and ClO 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  $\chi^2$ -test for each assimilated species (colored lines, left y-axis) and the number of assimilated observations (gray area, right y-axis).

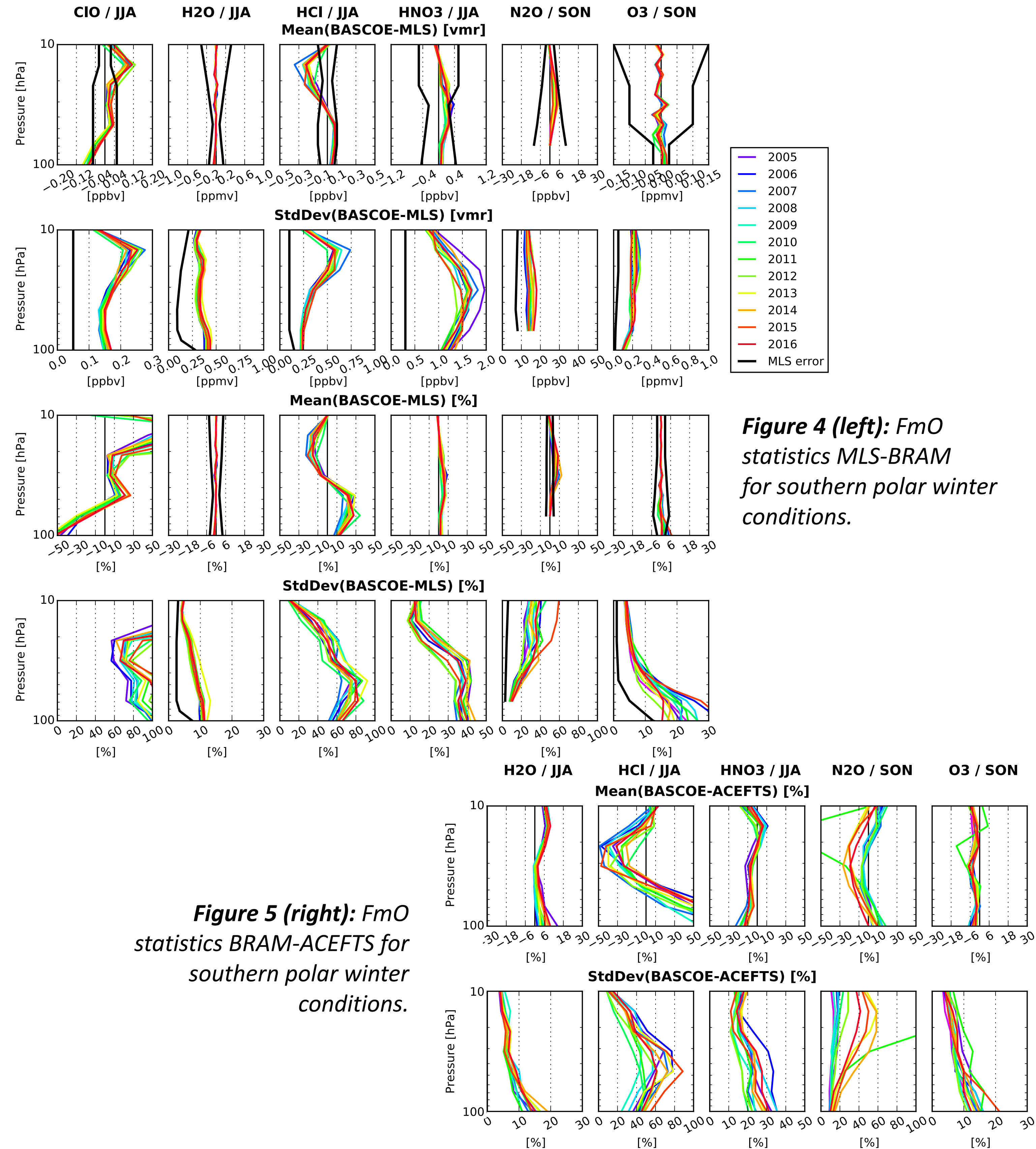
## Southern Polar Winters

- PSC schemes implemented in atmospheric models are generally subject to large uncertainties (much larger than in normal conditions). Chemical assimilation in PSC conditions is thus challenging.
- Qualitatively, BRAM is able to reproduce the evolution of the chemical state of the southern polar stratosphere as measured by MLS (**Fig. 3**). Compared to a control run (no assimilation, CTRL), BRAM corrects most of the model deficiencies.
- Forecast-minus-Observations (FmO) statistics of BRAM-MLS (**Fig. 3**) show that:
  - The mean of the FmO is usually within the MLS accuracy (i.e. the bias is not significant) except for HCl and ClO above 20 hPa.
  - The standard deviations of the FmO are higher than the MLS precision and some averaging of BRAM is necessary to reach the MLS uncertainty. This may be due to the relatively low horizontal resolution of BRAM.
- Comparisons of BRAM vs MLS are very stable over the years (**Fig. 3 and 4**) thanks to the stability of MLS and the tuning of the observational error in BRAM.
- BRAM agrees well with ACEFTS (**Fig. 5**) while the differences are less stable from year to year due to variability in the sampling of ACEFTS. For H<sub>2</sub>O, since BRAM agree very well with MLS, most of the differences are due to the difference between the two sensors.



**Figure 3:** Top: Time series of MLS partial column between 10-100 hPa and the corresponding BRAM and CTRL in 2005. Bottom: Differences BRAM-MLS for all years.

## Southern Polar Winters (cont)

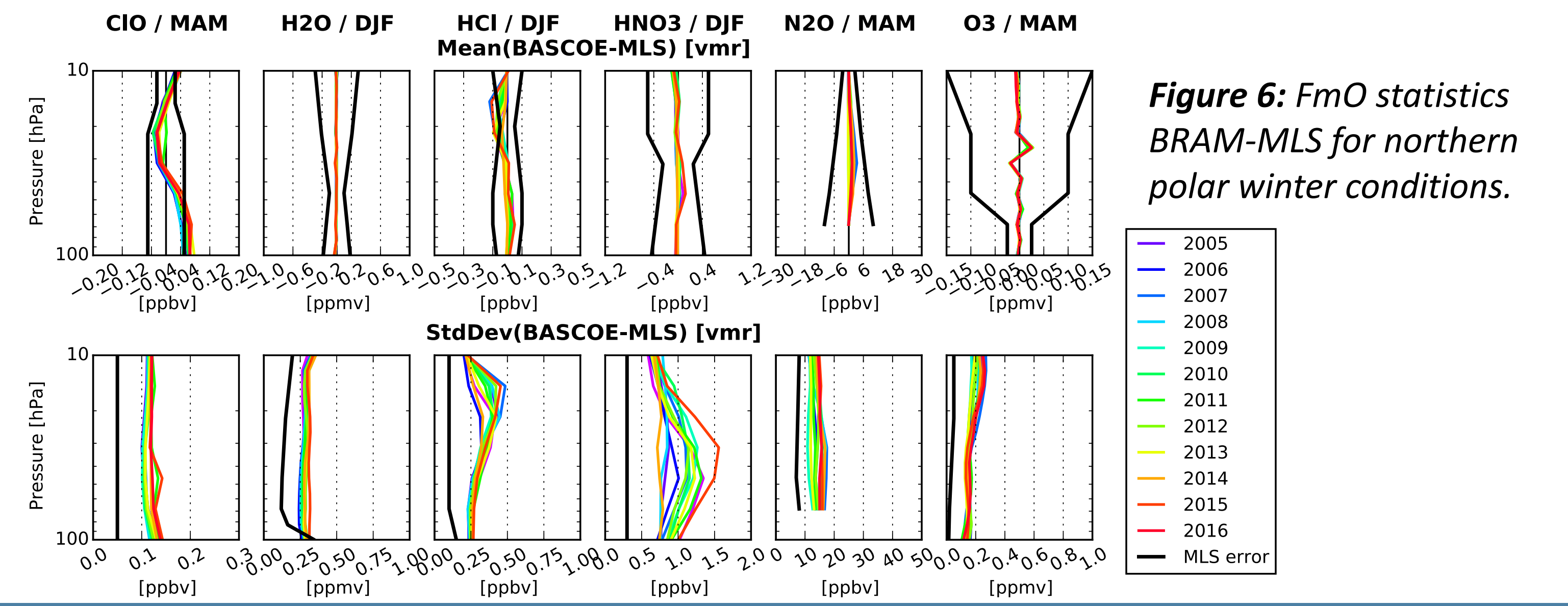


**Figure 4 (left):** FmO statistics BRAM-MLS for southern polar winter conditions.

**Figure 5 (right):** FmO statistics BRAM-ACEFTS for southern polar winter conditions.

## Northern Polar Winters

- PSC conditions are less challenging during northern polar winters, leading to a better agreement between BRAM and MLS (**Fig. 6**). Mean differences BRAM-MLS are within MLS accuracy. Std Dev of the differences are higher than MLS precision, as during southern polar winter condition.



**Figure 6:** FmO statistics BRAM-MLS for northern polar winter conditions.

## Conclusions and Perspectives

- Although chemical conditions are challenging, BRAM-1 and MLS usually agree within MLS accuracy during polar winter conditions.
- Recent updates in PSC scheme will allow us to improve HCl and ClO above 30 hPa (**Fig. 7**).
- Recent updates in EnKF allow BASCOE to reduce the standard deviation of the FmO for all species.

**Figure 7:** FmO statistics BRAM-MLS (blue) and the e0514a-MLS (red) during JJA 2008. Experiment e0514a includes updates in PSC schemes and in EnKF.

