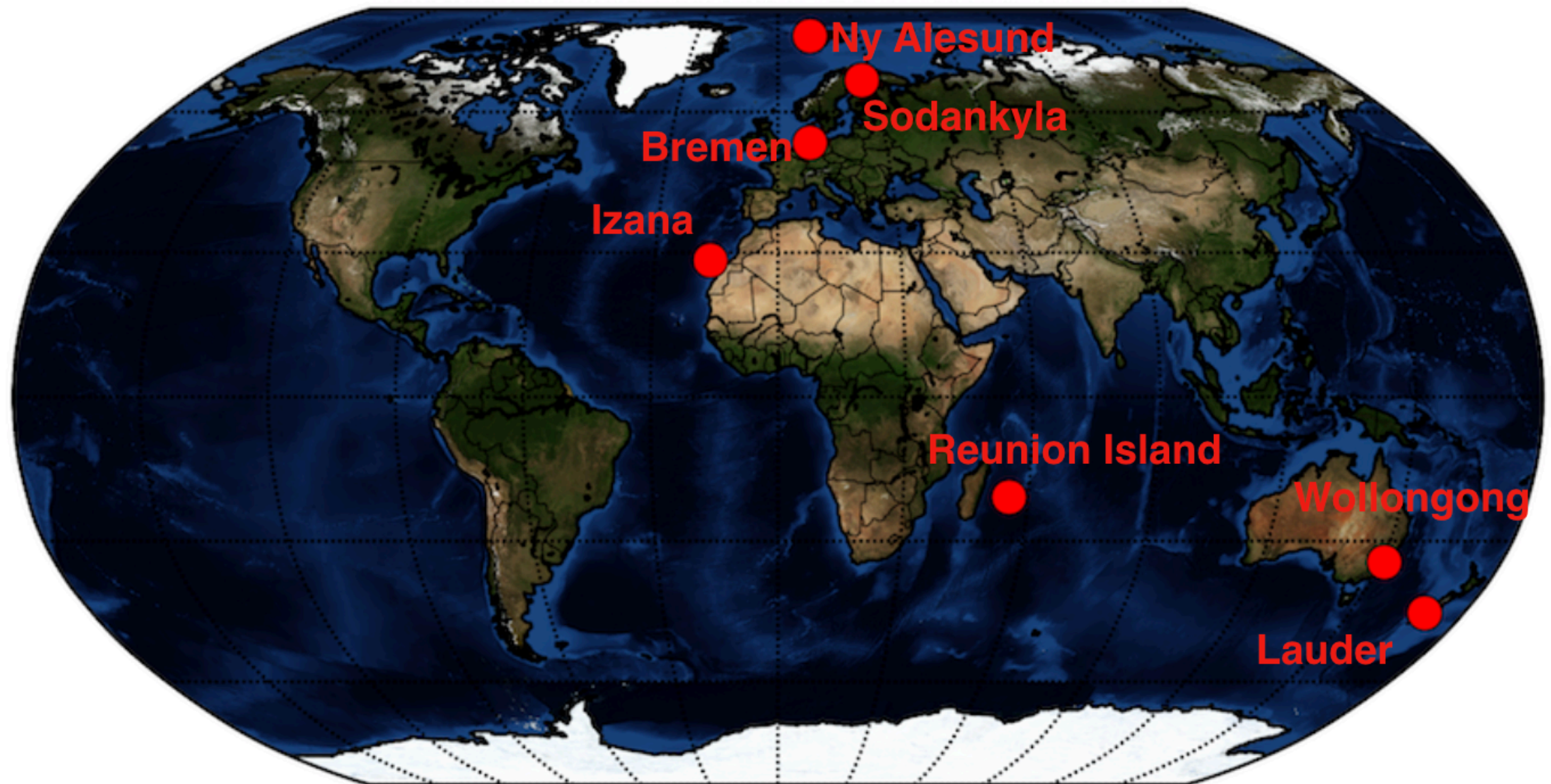


Inter-comparison between TCCON and NDACC XN₂O measurements

Minqiang Zhou and BIRA colleagues

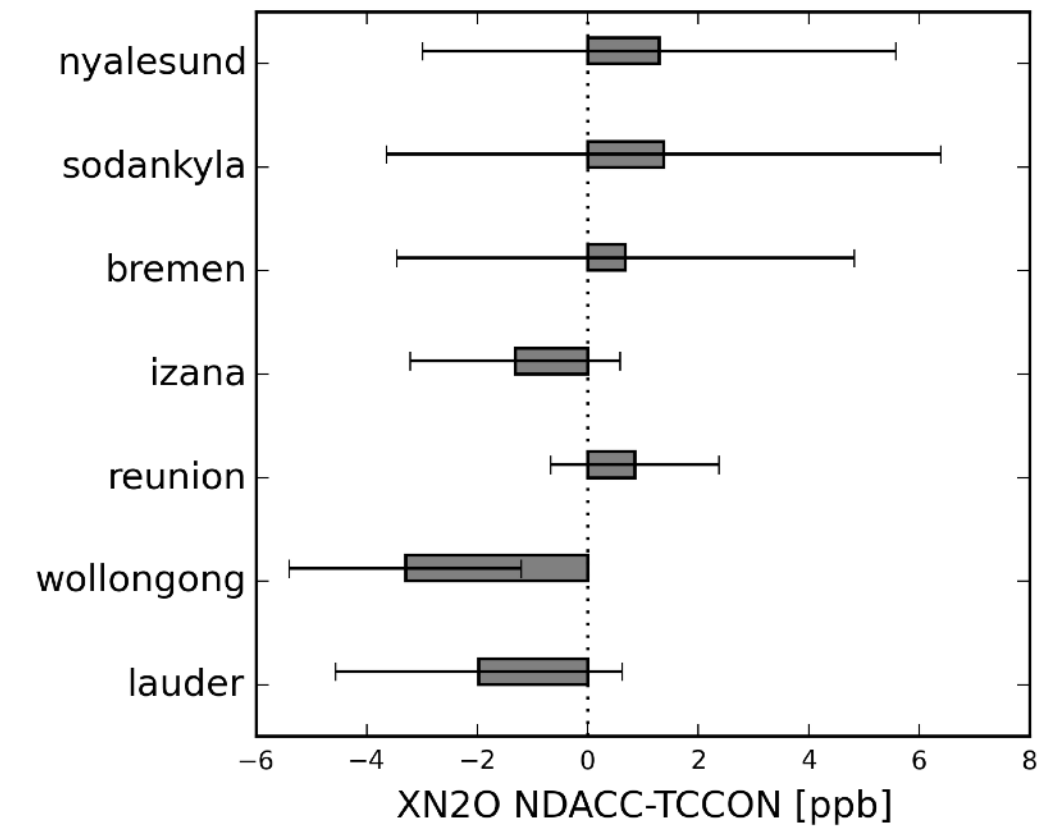
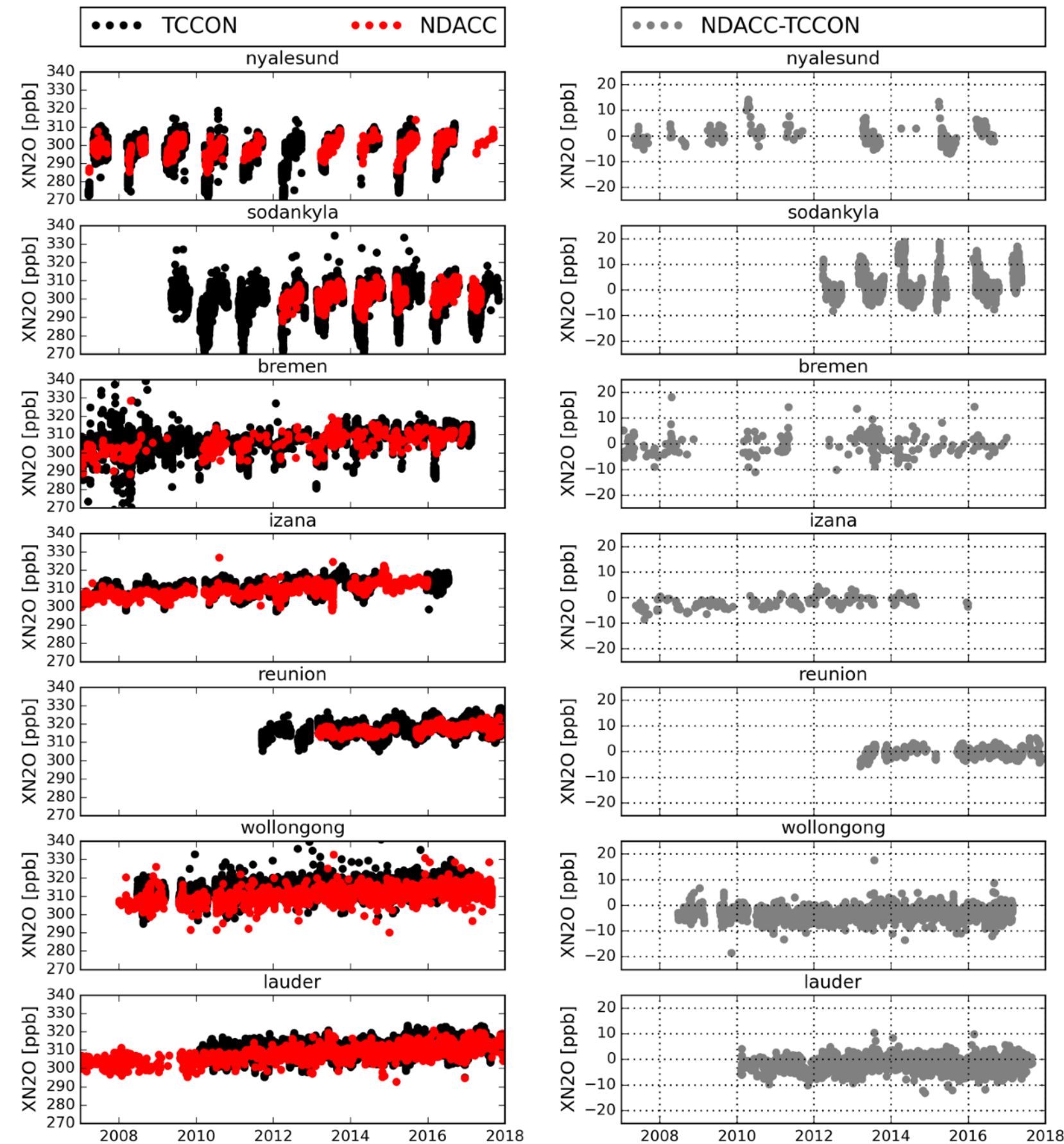
TCCON/NDACC FTIR: Martine De Mazière, Dan Smale, Nicholas Jones,
Thomas Blumenstock, Matthias Palm, Rigel Kivi, and more...
GEOS-Chem model: Kelley C. Wells and Dylan Millet



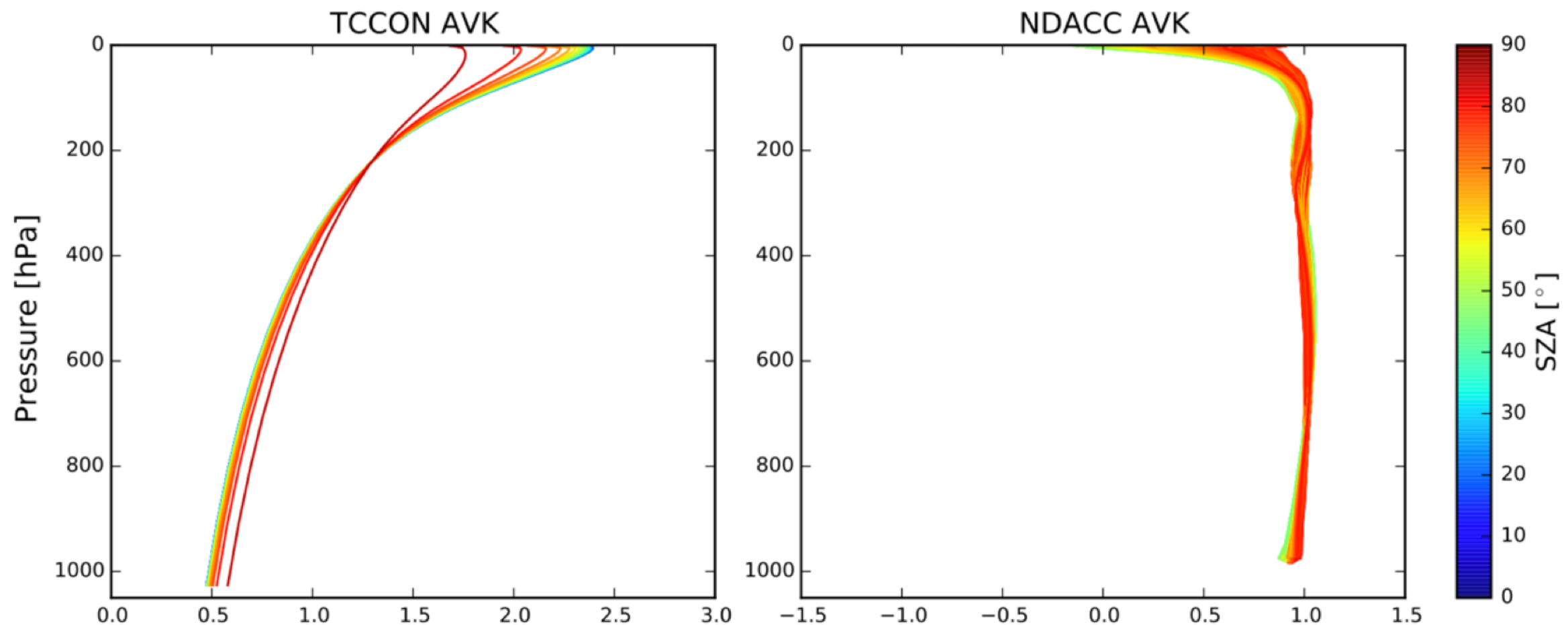


All data from the TCCON and NDACC database
(except Sodankyla MIR retrievals, which is not belong to NDACC yet)
The TCCON/NDACC data at Reunion Island is from Stdenis/Maido

XN2O time series



the averaged difference between the TCCON and NDACC (NDACC-TCCON) is **-3.32 - 1.37 ppb (-1.1 - 0.5 %)** with the standard deviation of **1.52 - 5.01 ppb (0.5 - 1.6 %)**.



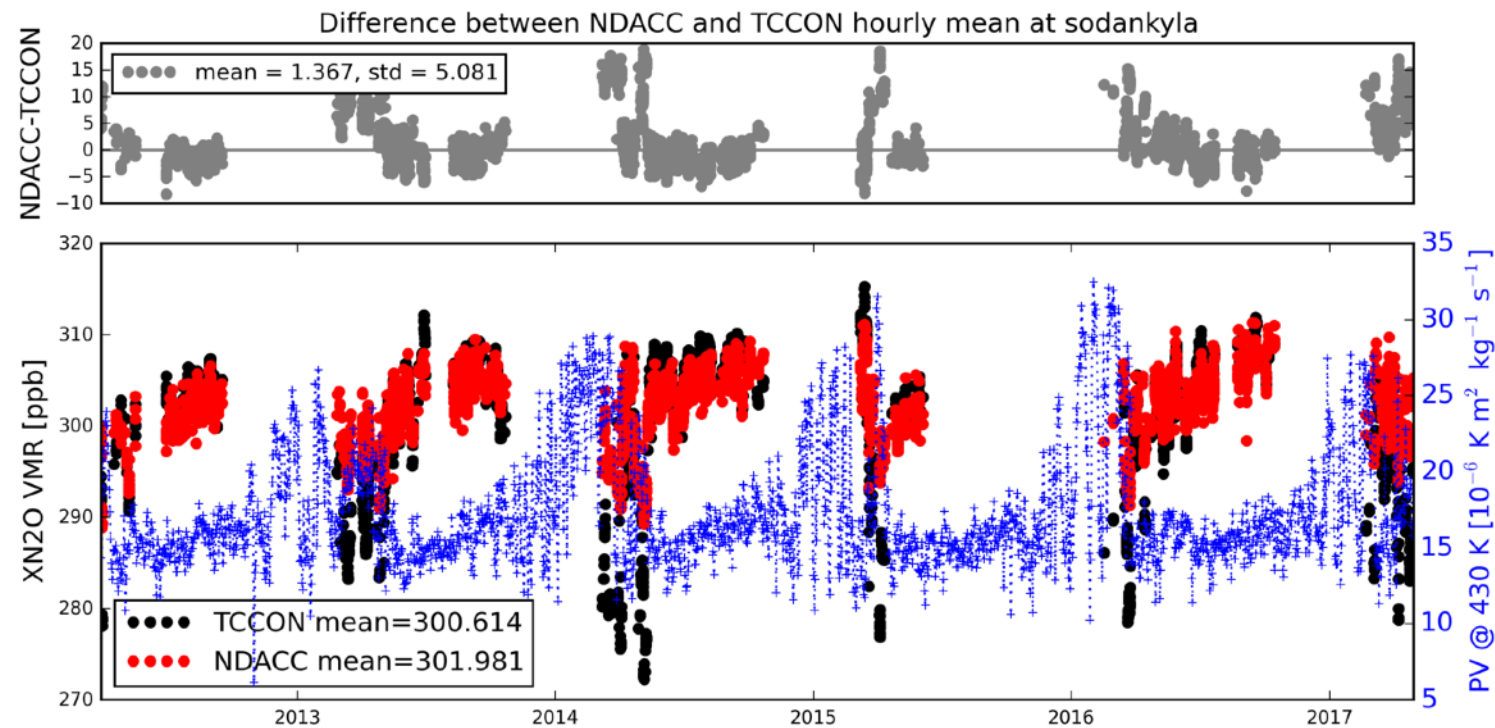
TCCON: **underestimating** the a deviation of the a priori in the lower troposphere and **overestimating** it in the stratosphere

NDACC: **good sensitivity** in the troposphere and stratosphere.

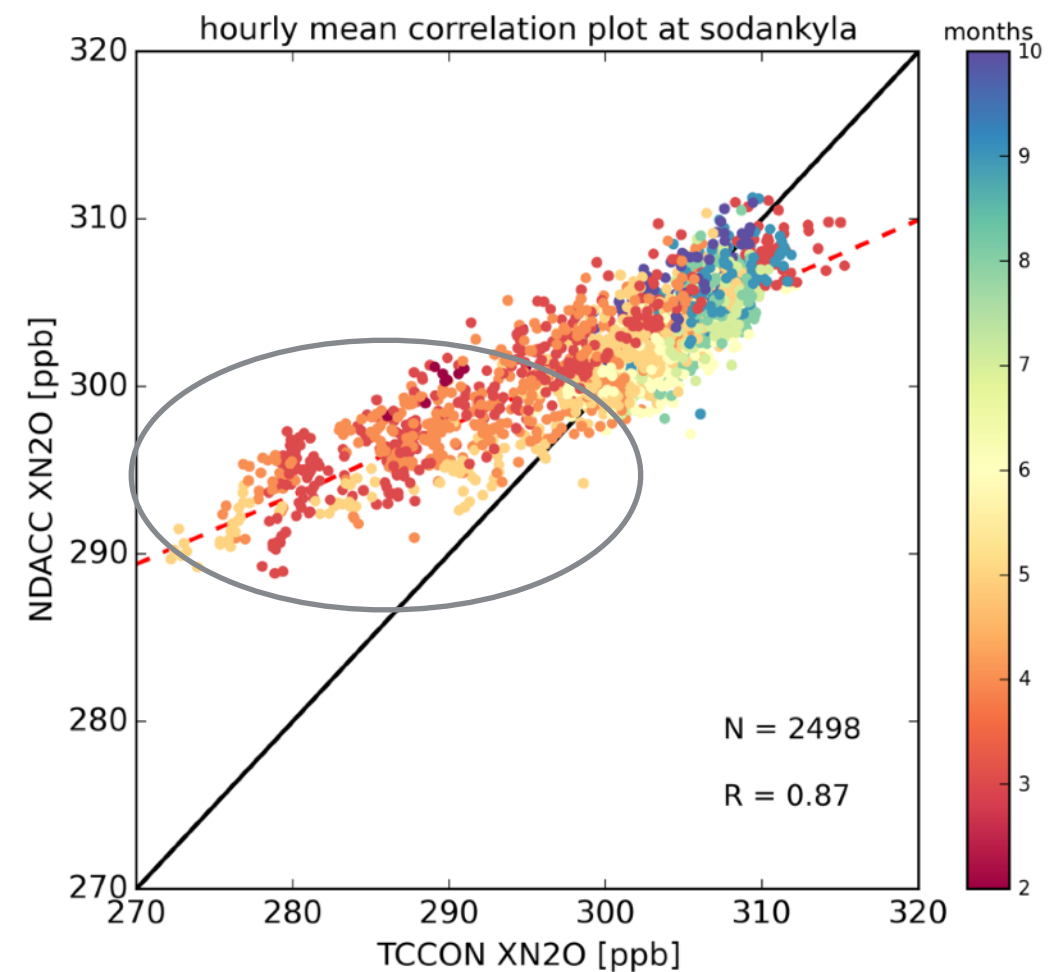
Since the NDACC AVK is very close to 1, **the smoothing error could be ignored**

Test@sodankyla and @Reunion: using the TCCON a priori profile as the a priori profile for NDACC retrieval, the results is almost same (within 0.02%).

Case study @ sodankyla



high potential vorticity (pv) value
indicates sodankyla is inside the polar
vortex region



Comparison with ACE-FTS measurements

all the days, we have FTIR and
ACE-FTS measurements

3 days inside the polar vortex

2015-03-25

2016-02-16

2016-03-24

40 days outside the polar vortex

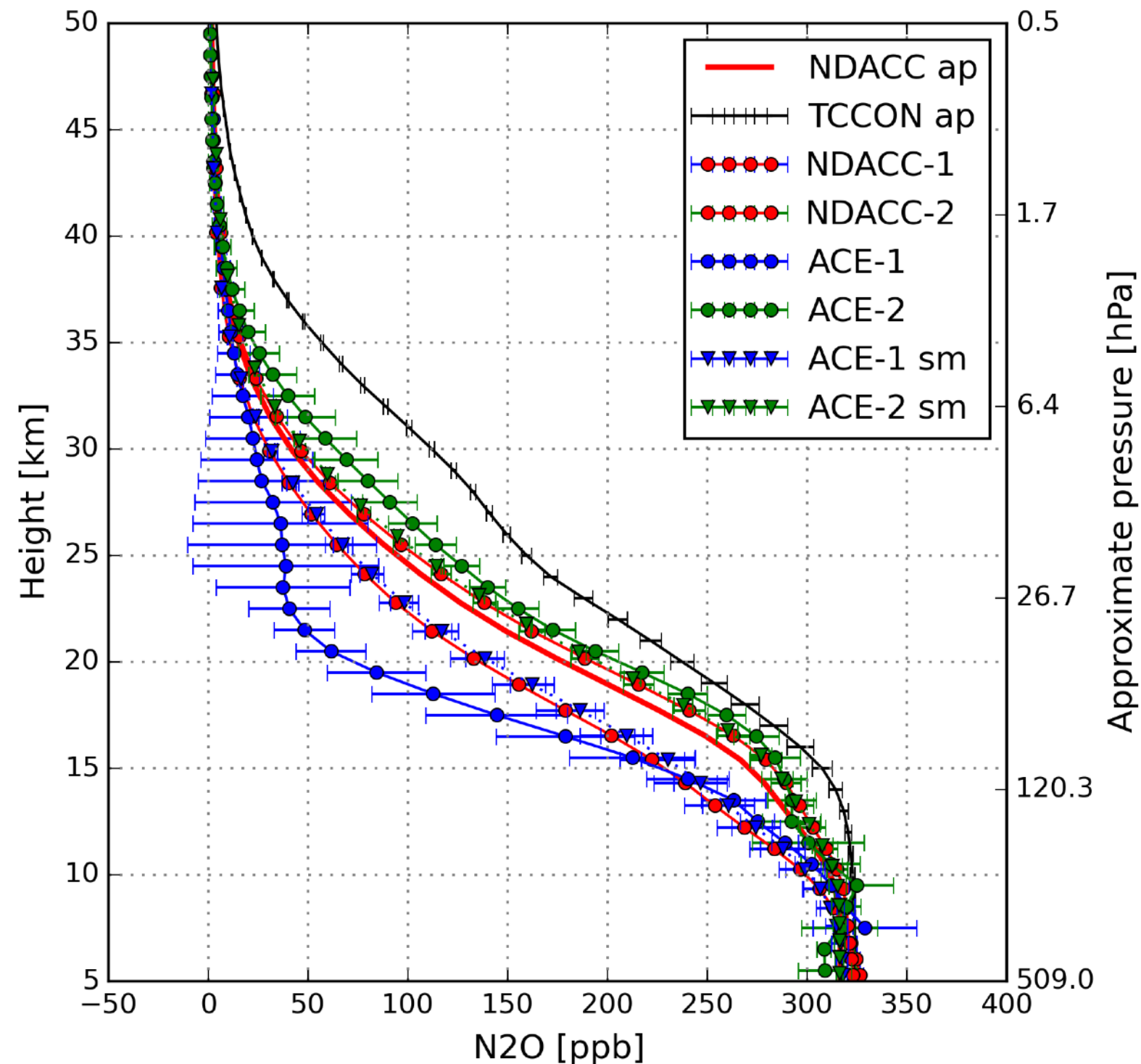
2012 ...

2013...

2014...

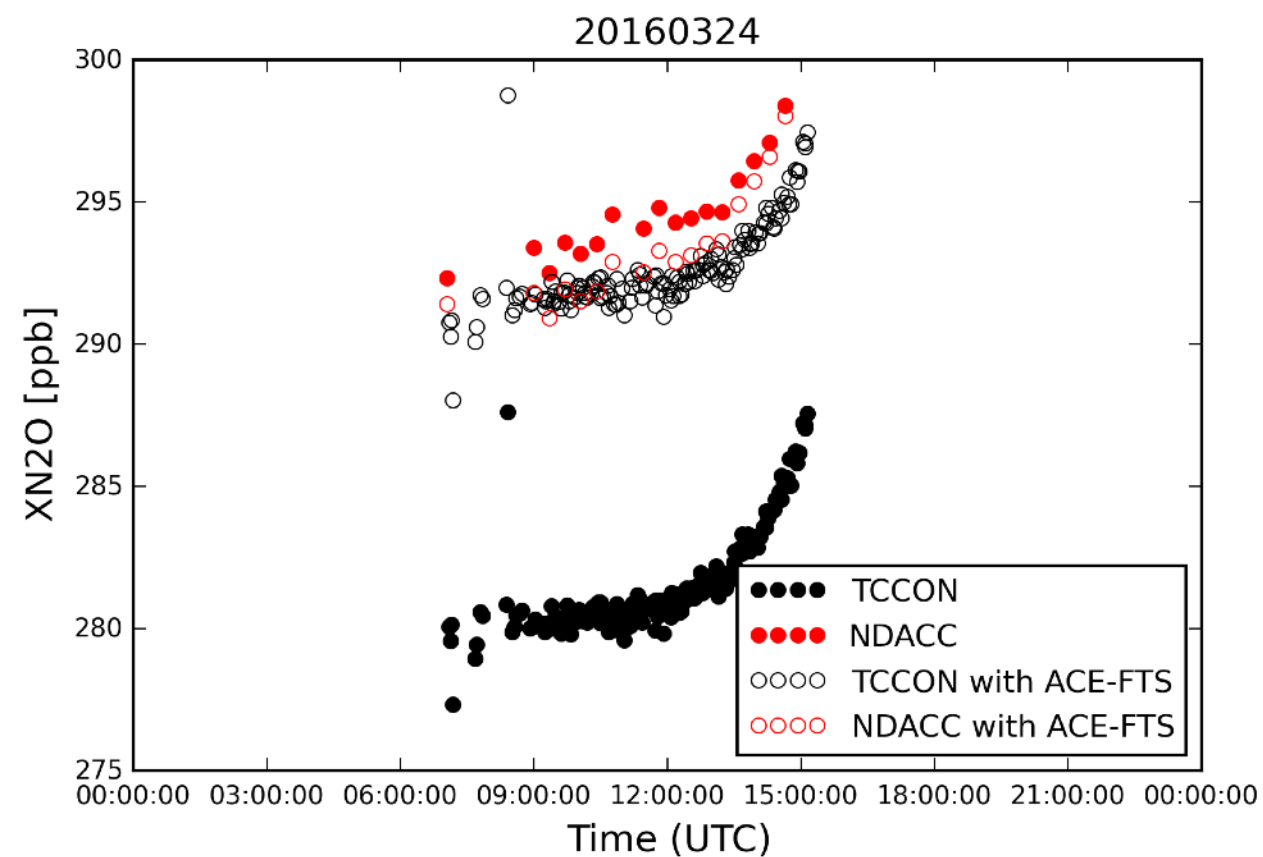
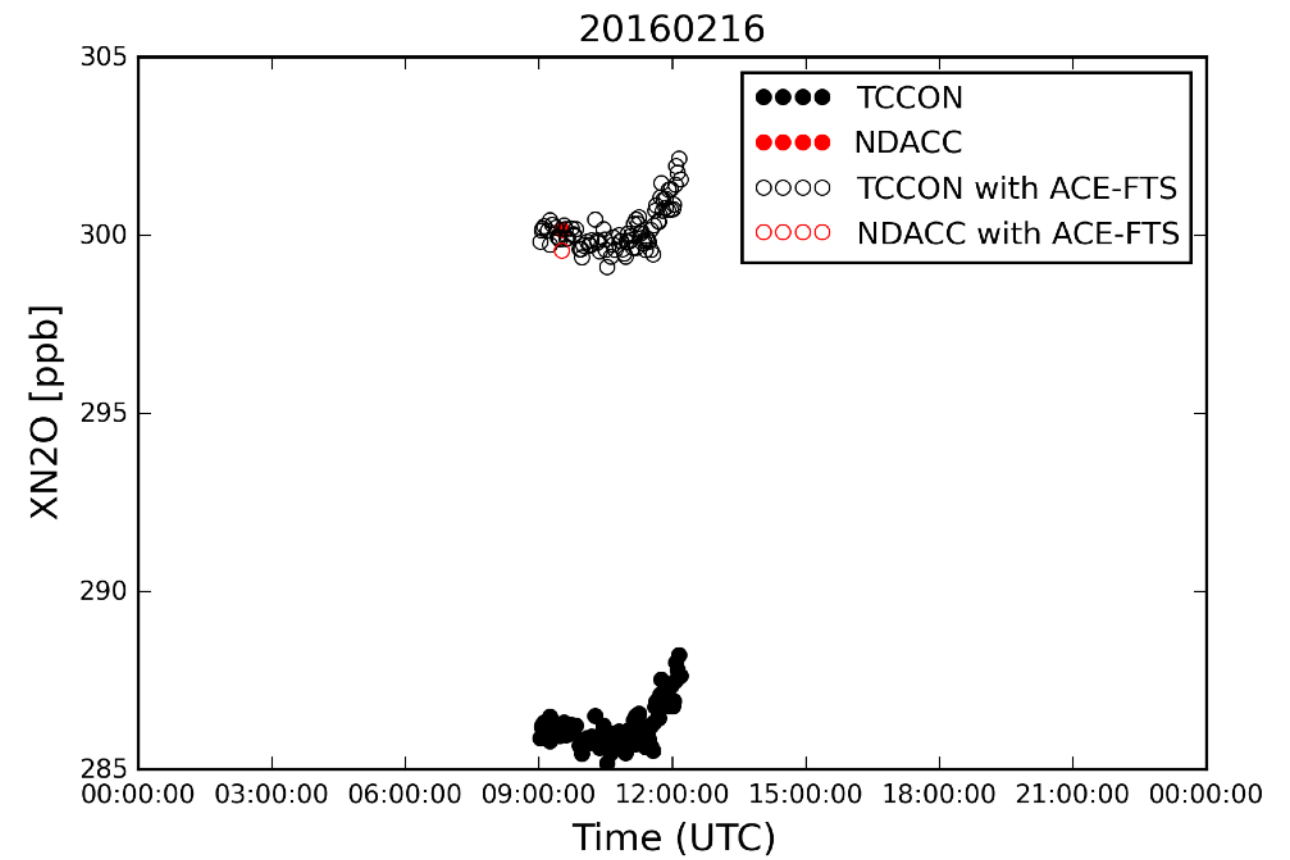
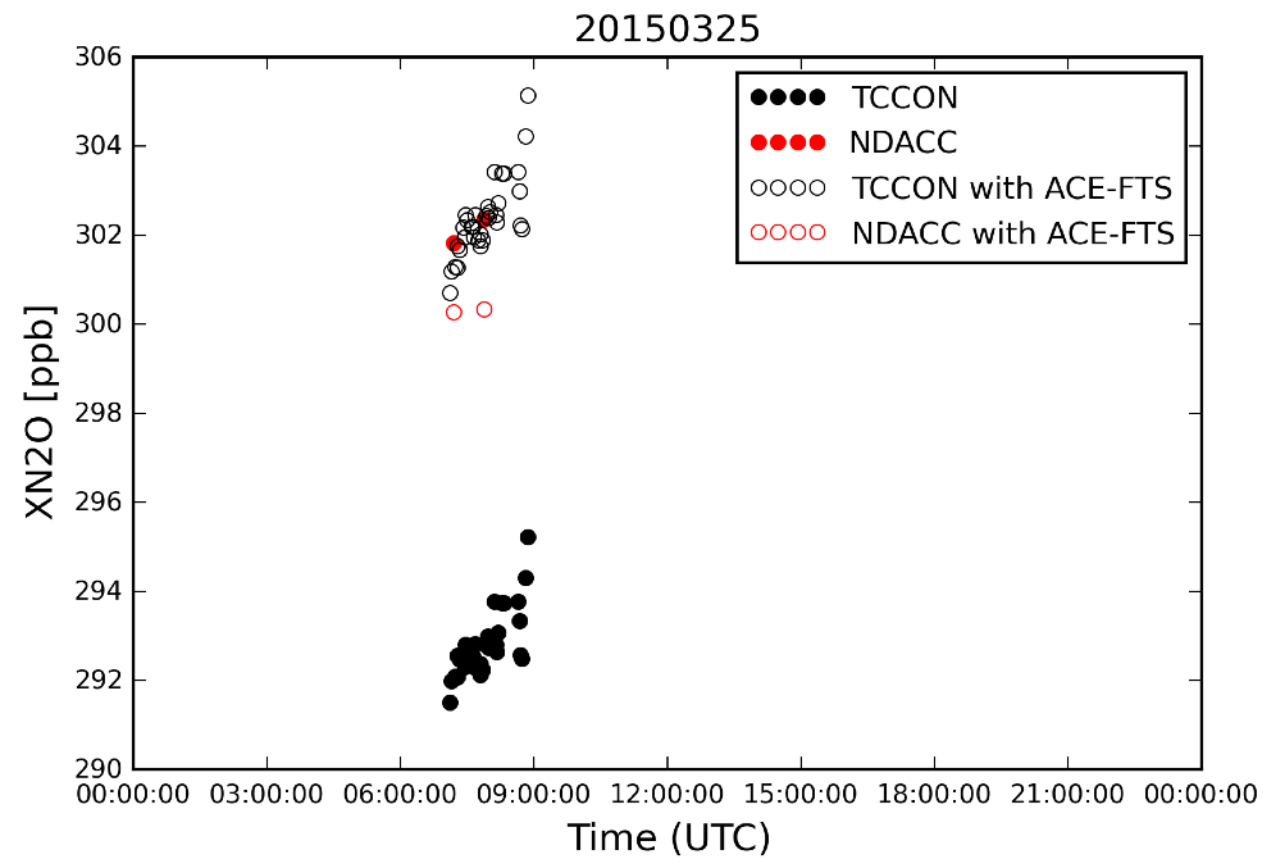
2015...

2016...



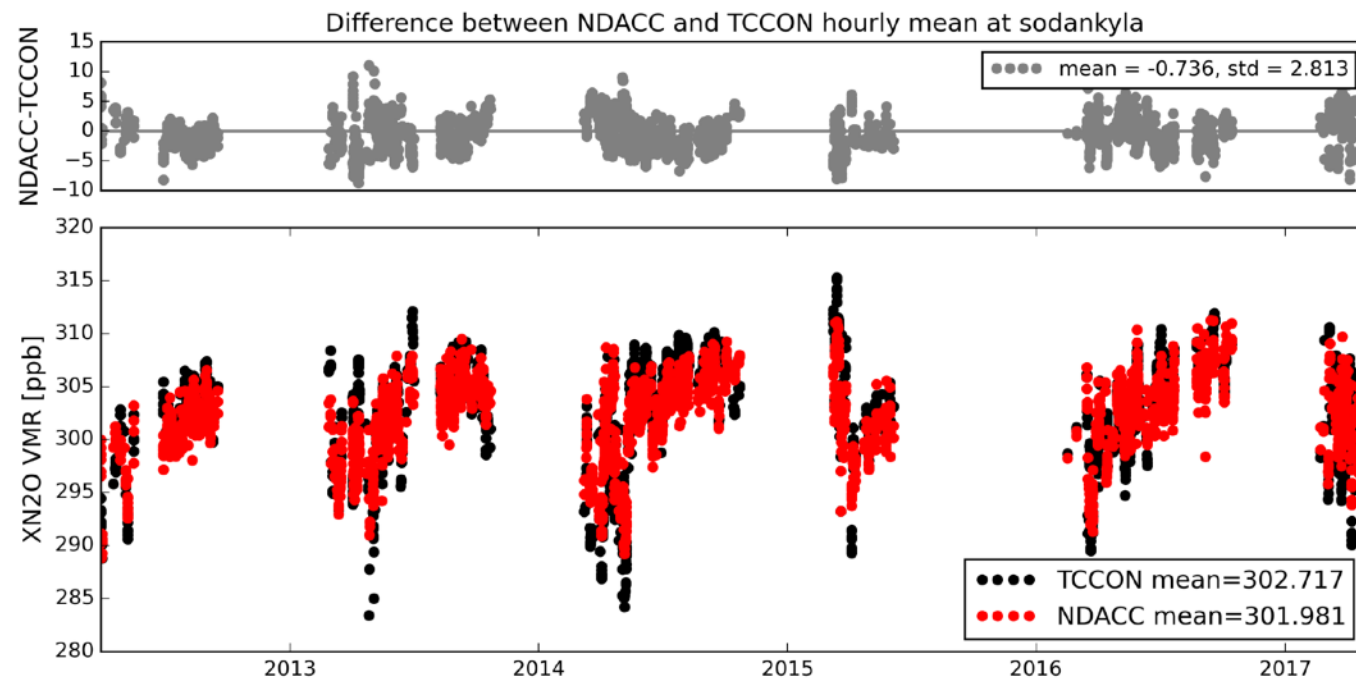
The N₂O profiles of the TCCON a priori profile (TCCON ap), NDACC a priori profile (NDACC ap), NDACC retrievals inside/outside the polar vortex region (NDACC-1/NDACC-2), collocated ACE-FTS measurements inside/outside the polar vortex region (ACE-1/ACE-2) and the ACE-FTS measurements smoothed with the NDACC AVK inside/outside the polar vortex region (ACE-1 sm/ACE-2 sm).

Using ACE-FTS measurements as the a priori for that 3 days



TCCON updated retrieved data
become close to NDACC retrievals

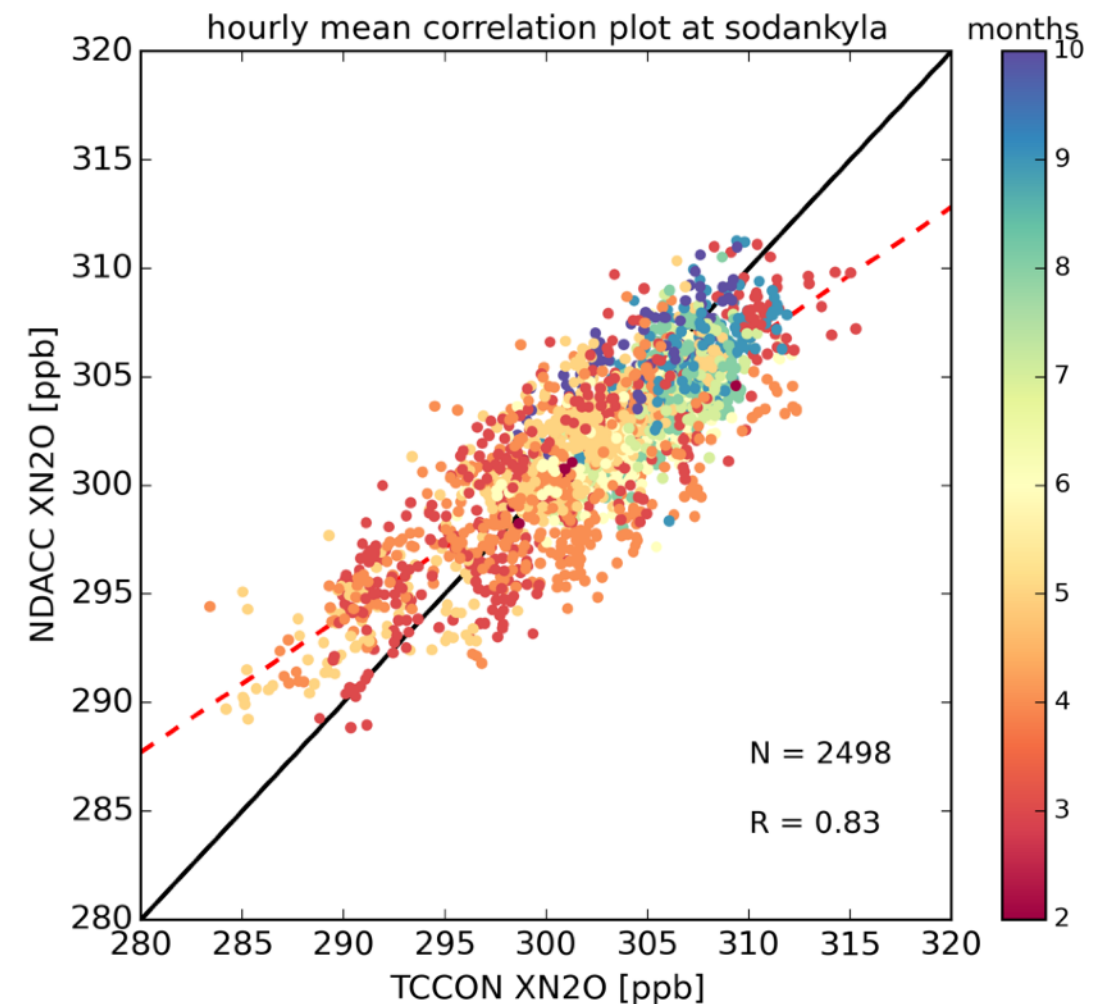
using the ACE-FTS measurements (above 10 km) as the a priori profile for all the TCCON retrievals inside the polar vortex region



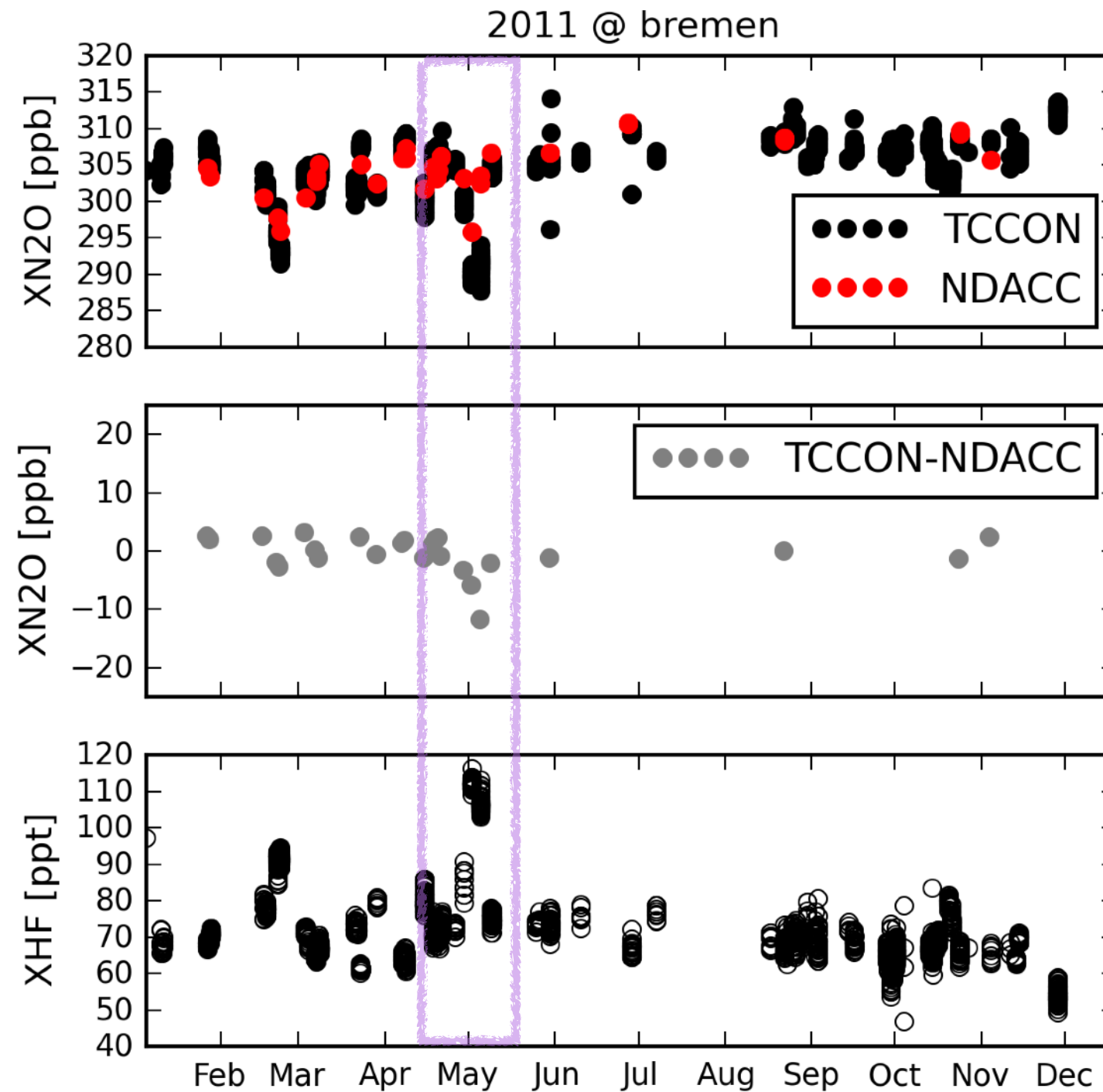
Select all the days, when

1) the NDACC daily mean is 6 ppb larger than the TCCON daily mean

2) PV value is larger than $20 \times 10^{-6} \text{ km}^2 \text{ kg}^{-1} \text{ s}^{-1}$



Large variability due to the STE (stratosphere-troposphere-exchange) activities

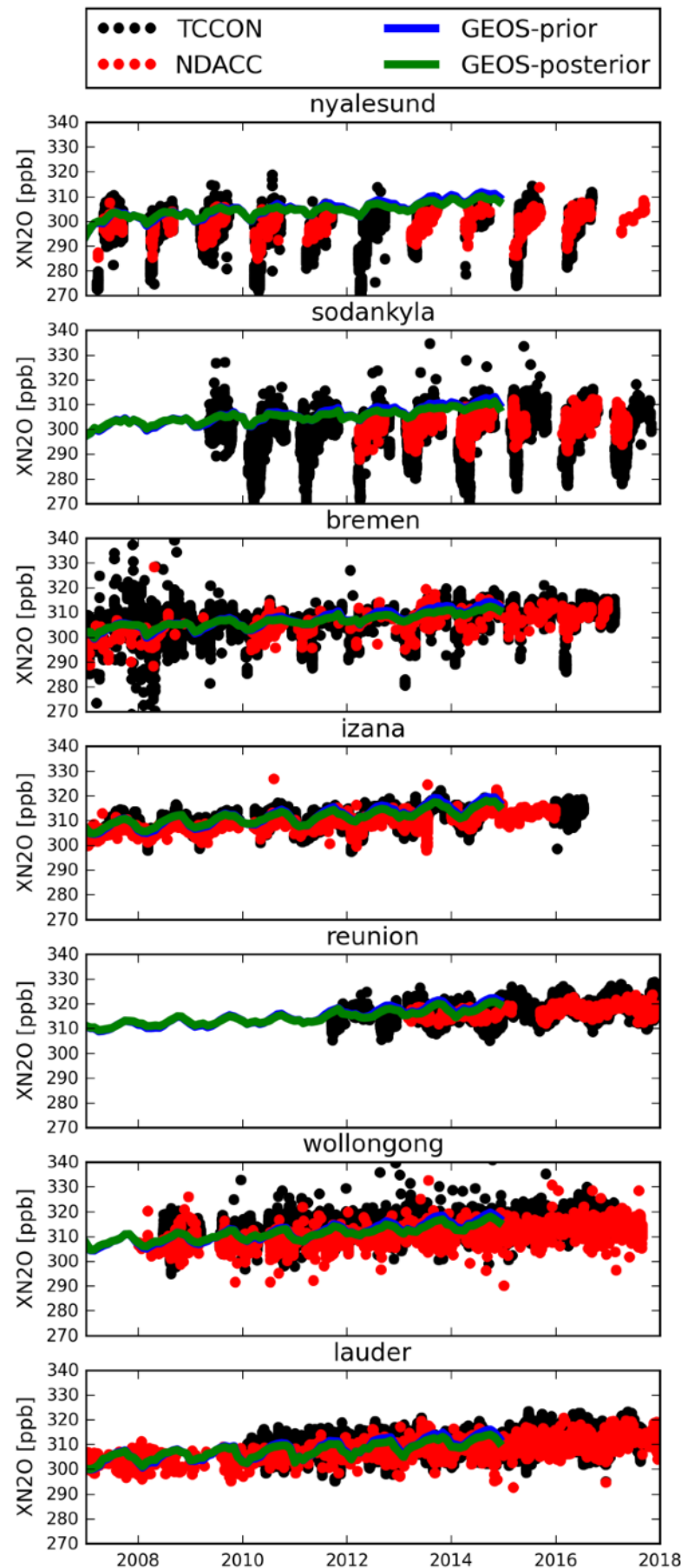


The GEOS-Chem model

- **Priori emissions :** **1) Non-soil anthropogenic** are from the **EDGARv4.2FT2010**; Monthly N₂O emissions from **2) soils** are from **OCNv1.1** (Zaehle and Friend, 2010) ; **3) Biomass burning** emissions are computed monthly based on the **GFEDv4.1s** (van der Werf et al., 2017); monthly **4) oceanic** N₂O emissions are from **PlankTOM5** (Le Quere et al., 2005);
- **Stratospheric loss** of N₂O reaction with O(1D) included, the lifetime of N₂O is ~ 127 years
- **Posterior emission:** adjoint inversions based on surface N₂O measurements with a 4-D vars method (Wells et al., 2018)
- **Meteorology data:** **MERRA-2** assimilated meteorological data from the NASA Goddard Earth Observing System
- **Output resolution:** 4x5 degrees with 47 vertical levels from the surface to 0.01 hPa , and a monthly time resolution from 2007-2014

*The priori inventories correspond to a global flux of a little over 18 Tg N/yr, whereas the posterior flux is typically between 16 and 17 Tg N/yr.

Time series



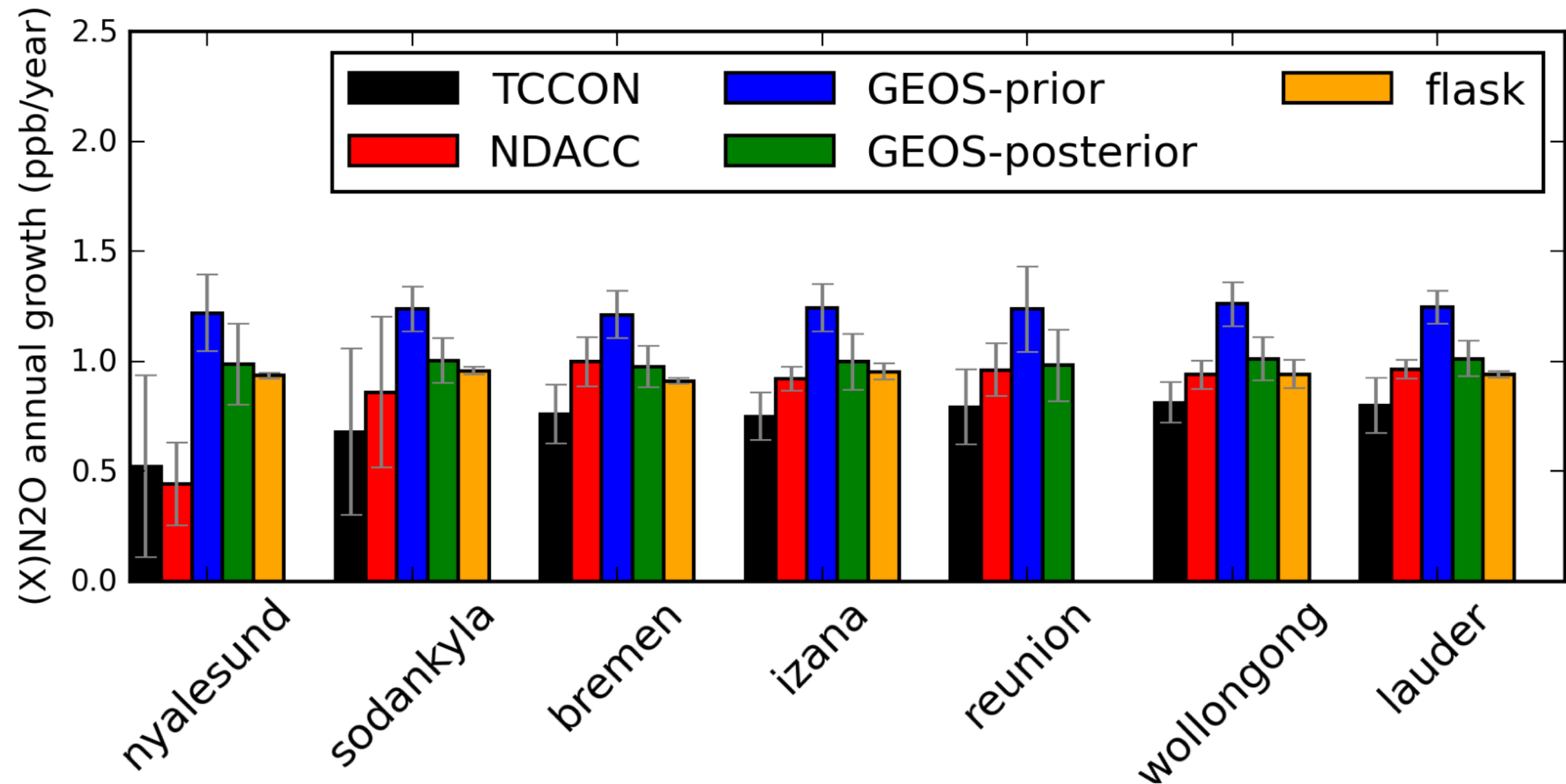
using the XN₂O to compare the FTIR measurements with GEOS-CHEM model simulations

$$X_{gas} = TC_{gas} / TC_{air}^{dry}$$

$$TC_{air}^{dry} = \frac{P_s}{gm_{air}^{dry}} - TC_{H_2O}(m_{H_2O}/m_{air}^{dry})$$

There TCCON and NDACC are the individual measurements
GEOS-CHEM model products are monthly means

Bias between TCCON and GEOS-posterior **is within 1%**



Note that:

- 1) all the available measurement data during 2007-2017 are used here
- 2) model data is from 2007-2014; without smoothing

- **The GEOS-Chem priori N₂O slightly overestimate the N₂O trend**
- **TCCON measurements seems underestimate the trend of XN₂O (TCCON only have 50-60% information from measurement and TCCON priori N₂O annual growth is 0.1%/yr, which is less than the observed one (~0.3%/yr))**

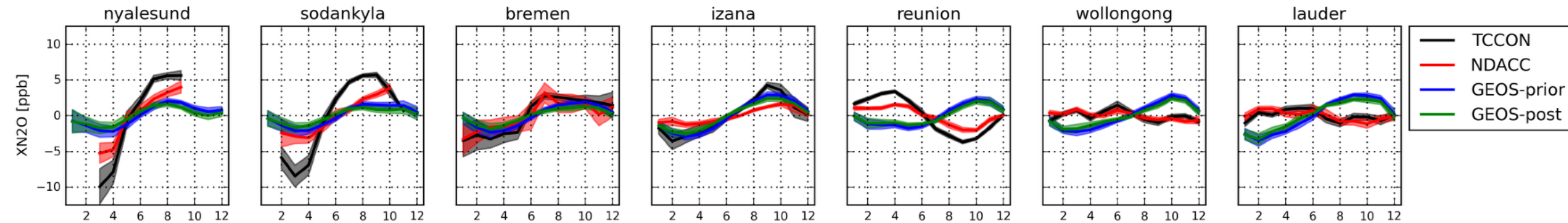
Test TCCON with updated a priori profile

If TCCON uses the a priori N₂O with the annual growth of 0.3%/year, the annual growths of XN₂O **increase by 0.5-1.0 ppb/year**

$$X_{r2} = X_{r1} + \int (I - A)(x_{a2} - x_{a1})d(dryair) / \int d(dryair)$$

Site	Nyalesund	Sodankyla	Bremen	Izana	Reunion	Wollongong	Lauder
TCCON	0.52/0.41	0.67/0.38	0.76/0.13	0.75/0.11	0.79/0.17	0.81/0.09	0.80/0.12
Using ap 0.3% /year	0.62/0.41	0.77/0.37	0.84/0.13	0.80/0.11	0.84/0.16	0.87/0.09	0.87/0.12

Seasonal cycles



1) Nyalesund and Sodankyla (Northern Hemisphere: high latitude):

- All seasonal cycles show high in Aug-Oct and low in Feb-Apr
- The amplitude of the seasonal cycle from NDACC measurements is slightly larger than that from the model

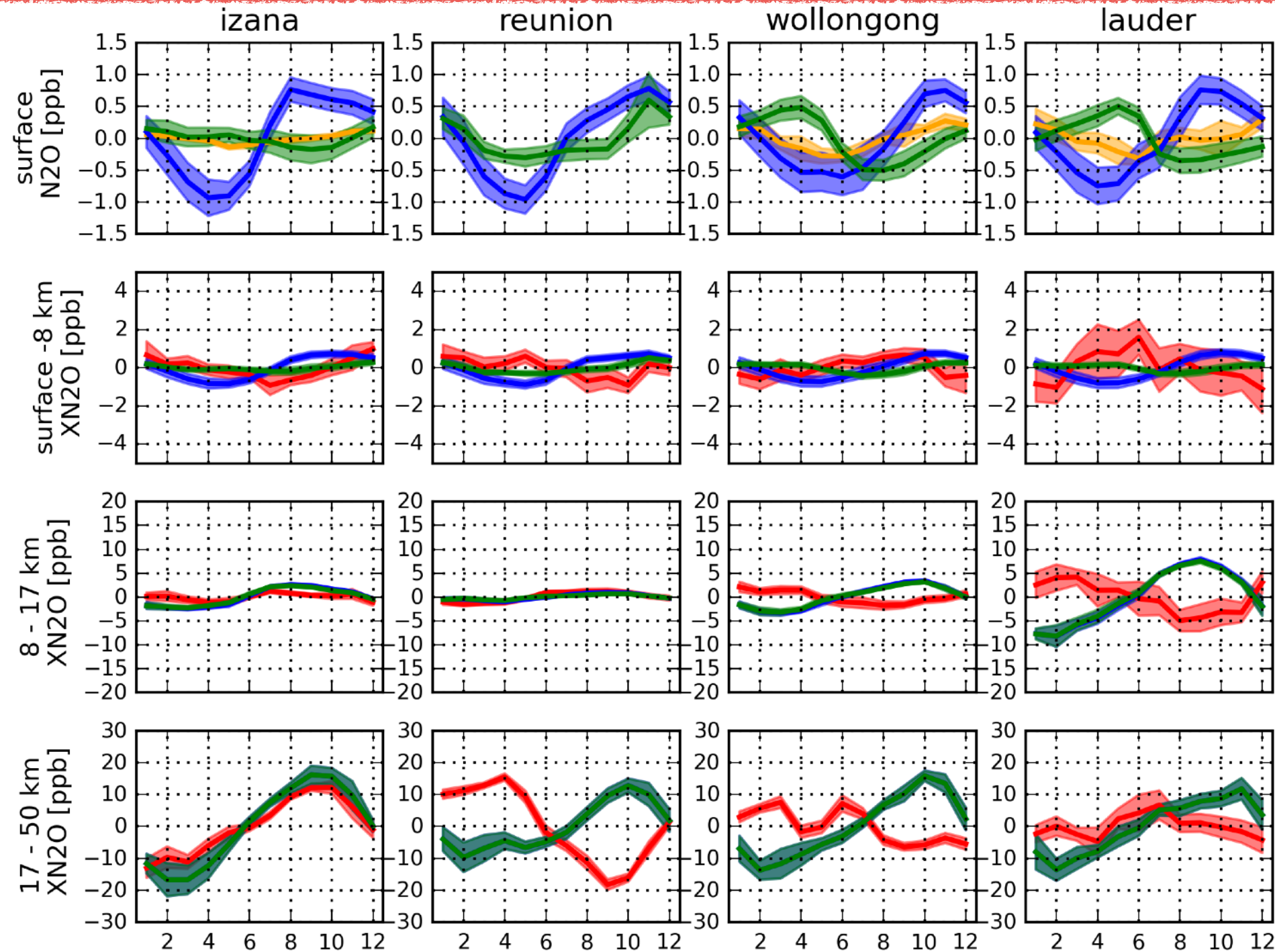
2) Bremen and Izana (Northern Hemisphere: mid latitude):

- All seasonal cycles show high in Aug-Oct and low in Feb-Apr
- The amplitudes of the seasonal cycles from TCCON and NDACC measurements are close to that from the model

3) Reunion, Wollongong and Lauder (Southern Hemisphere: low-mid latitude):

- Model seasonal cycles show high in Aug-Oct and low in Feb-Apr; while FTIR measurements show high in Feb-Apr and low in Aug-Oct

N₂O seasonal cycle in different vertical ranges



Orange: flask measurements
 Red: NDACC measurements
 Blue : geos-chem prior
 Green: geos-chem posterior

The XN₂O seasonal cycle discrepancy between model and FTIR measurements in SH is mainly from the difference in the stratosphere

- Overall, the TCCON and NDACC XN₂O measurements are close to each other.
- TCCON XN₂O retrievals are strongly affected by the a priori profile.
- The comparison between the FTIR measurements and GEOS-Chem simulation confirms that the a priori inventory for N₂O is overestimated.
- The seasonal cycles of N₂O from the GEOS-Chem simulation and FTIR measurements in the SH are different.

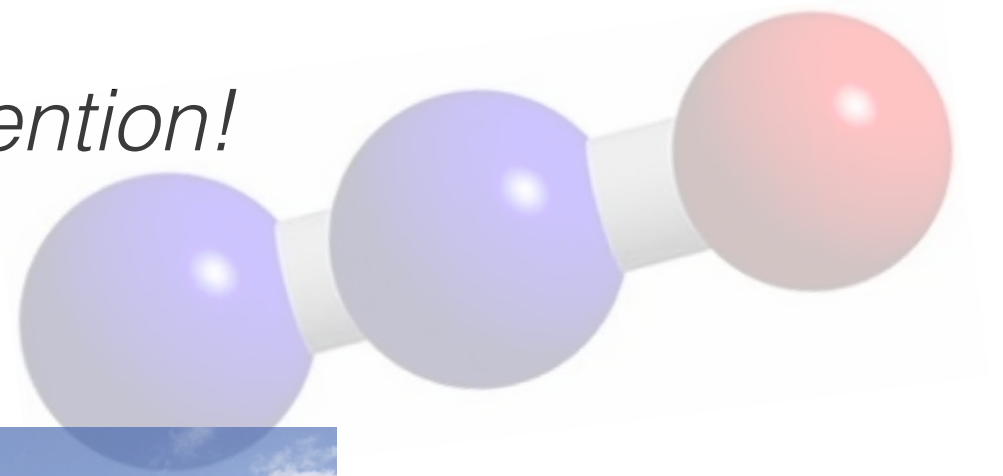
Next step

- More NDACC N₂O data will be investigated and applied to compare with the model simulation

A paper is preparing based on this ...

Thanks for your attention!

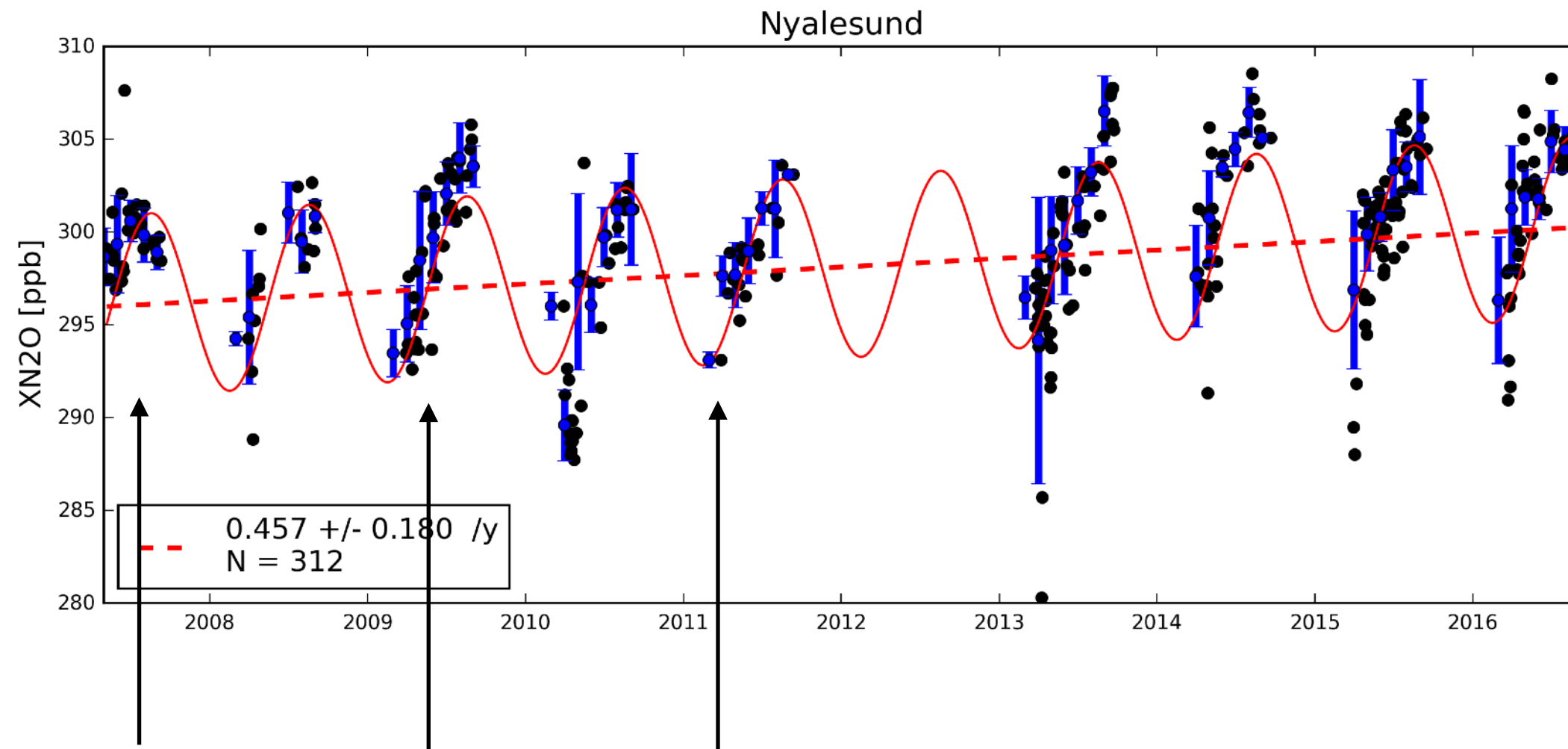
Gracias



The N₂O trend at Nyalesund and Sodankyla

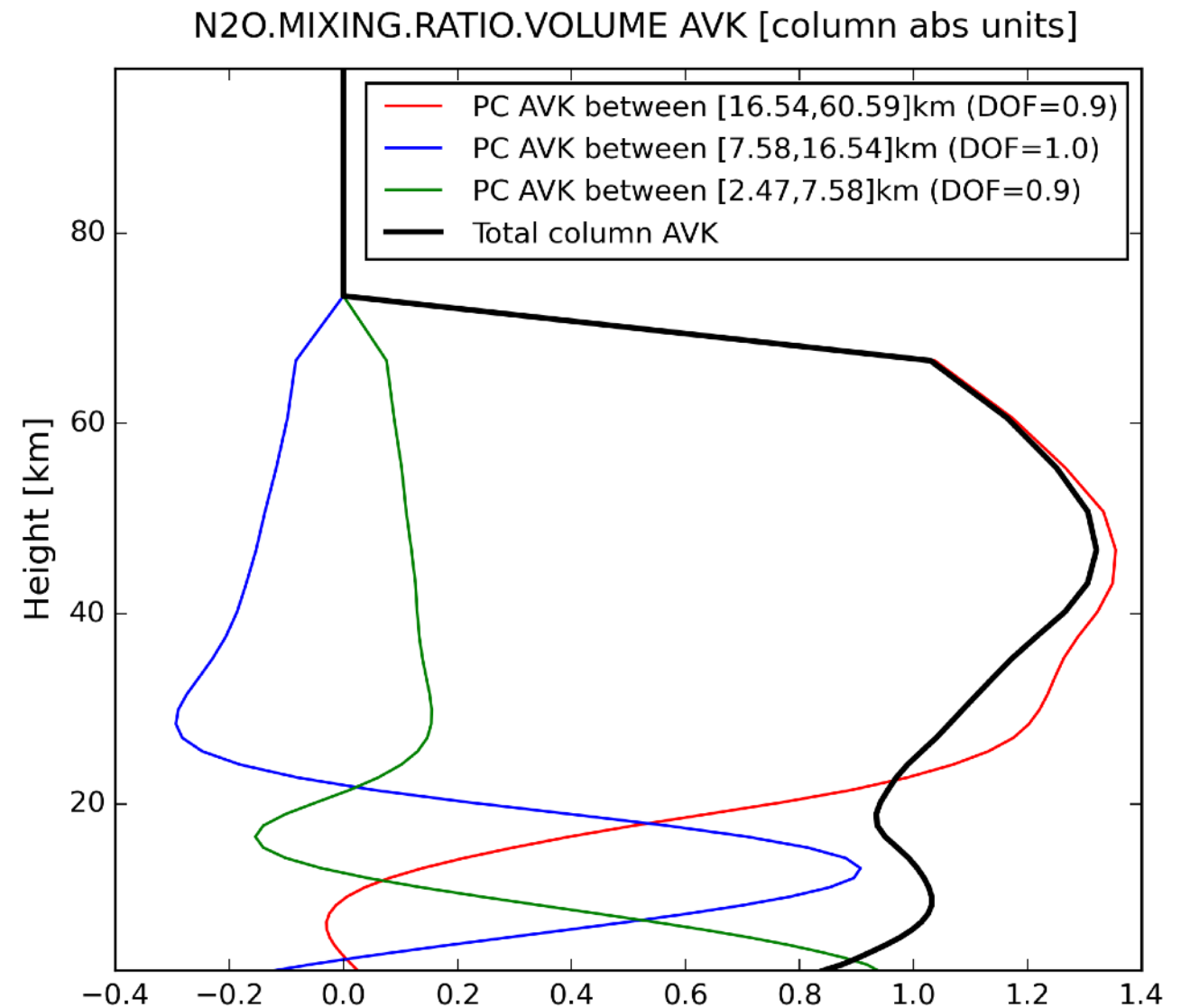
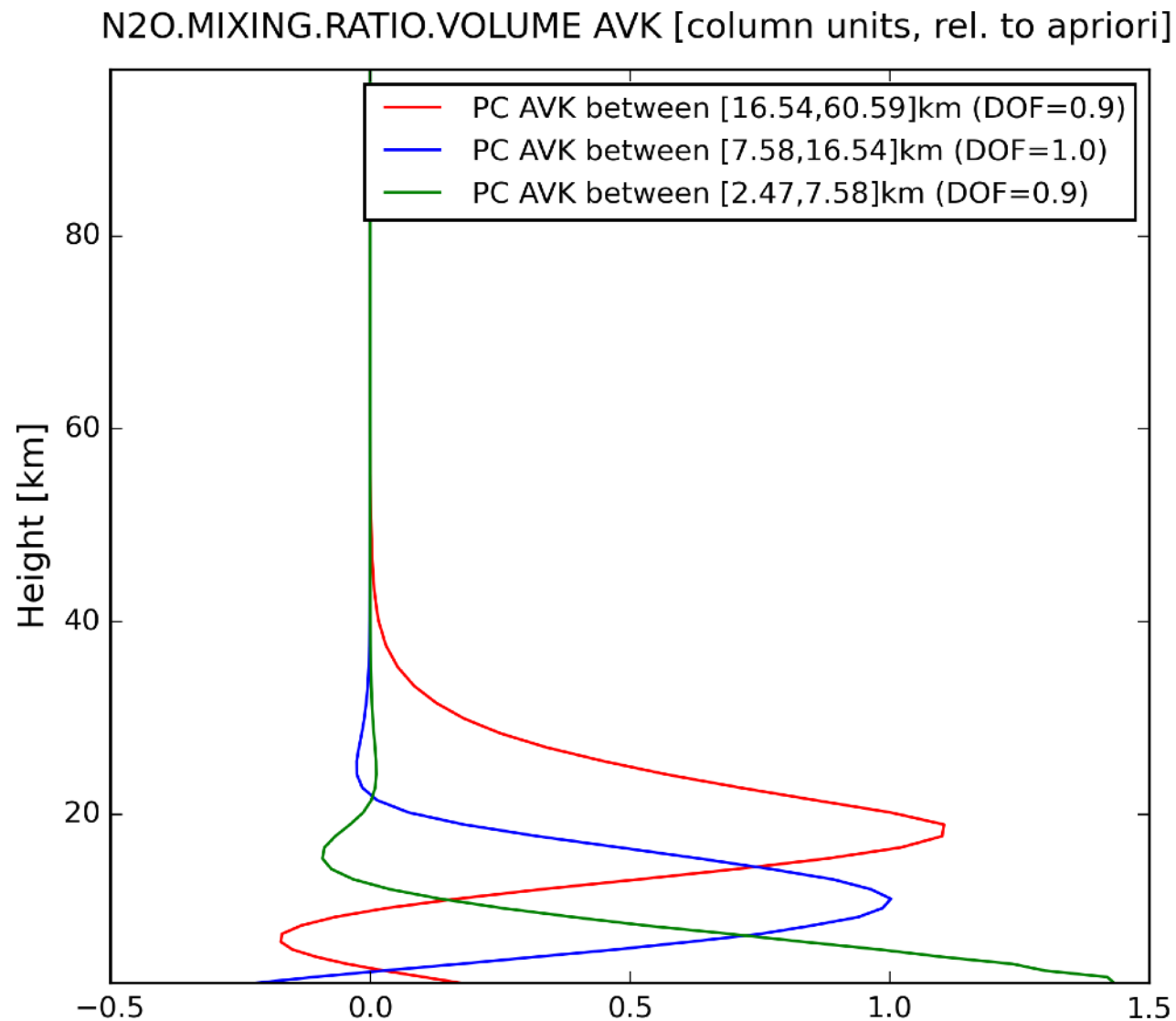
Large uncertainty of the trend from FTIR measurements

- There is a strong seasonal cycle for the XN₂O at polar region
- The intense of the polar vortex changes from year to year
- Limited measurement number at Ny Alesund and the polar vortex activity observed from year to year



No low XN₂O observed in these years

NDACC N2O vertical information



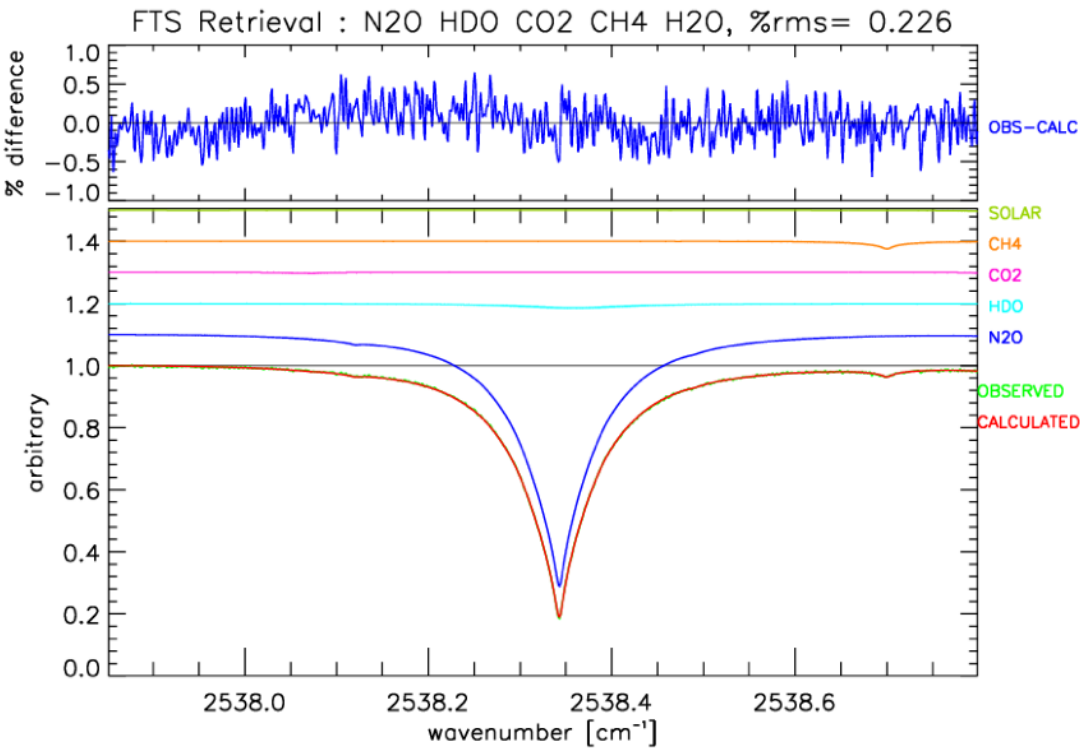
Typical partial column AVK @ reunion

~3 DOFs (0-8; 8-17; 17-50 km) for Izana, Reunion, Wollongong, Lauder

Update the NDACC N2O ctl? (no interfering species)

Gas	Required μ -w(s) [cm ⁻¹]	Optional μ w	OPD [cm]	Interfering species to be fit (pre- or simul-)	a Priori Linelist	Column or Profile	Note
O3	1000.0-1005.0	782.56-782.86 788.85-789.37 993.30-993.80	250	H2O, CO2, CH4, O668, O686	WACCMV5 HIT08	P	a,e
HCl	2727.73-2727.83 2775.70-2775.80 2925.80-2926.00		>180	O3, HDO N2O, O3 O3, CH4, NO2	WACCMV5 HIT08	P	
HF	4038.81 4039.07	4000.86-4001.10 4109.77-4110.07	>180	H2O, HDO, CH4 H2O, O3 H2O, HDO, CH4	WACCMV6 HIT08	P	c
ClONO2	780.10-780.35	780.0-781.3 779.0-780.0	>50	H2O CO2, O3 H2O	WACCMV5 HIT-XC/PL	C	d,g
HNO3	867.05-870.00	872.25-874.00			WACCMV5 HIT08	P	
N2O	2481.30-2482.60 2526.40-2528.20 2537.85-2538.80 2540.10-2540.70		250	CO2 CH4 H2O CO2 CH4 H2O HDO HDO CH4 CO2 H2O	WACCMV5 HIT08	P	
CH4	2613.70-2615.40		250	HDO CO2	WACCMV5	P	

IRWG_Uniform_RP_summary



The difference between the TCCON and NDACC retrieved N₂O columns

as the a priori is relatively small (0.19 ppb about 0.06%), because the AVK of NDACC is very close to 1.0. It is assumed that the NDACC retrieved N₂O total column is independent with the a priori profile

$$TC_{N_2O,ndacc} = TC_{wacm} + A_{ndacc}(PC_t - PC_{wacm}) = TC_{tcconap} + A_{ndacc}(PC_t - PC_{tcconap}). \quad (4)$$

Therefore, the difference between retrieved N₂O total column from TCCON and NDACC is mainly due to the difference of the AVK between TCCON and NDACC, and the difference of the N₂O partial column profile between the TCCON a priori and the true one

$$TC_{N_2O,ndacc} - TC_{N_2O,tcccon} = (A_{ndacc} - A_{tccon})(PC_t - PC_{tcconap}). \quad (5)$$