

# On the use of zenith-sky, MAXDOAS and direct-sun network observations to validate GOME-2 total and tropospheric NO<sub>2</sub> columns

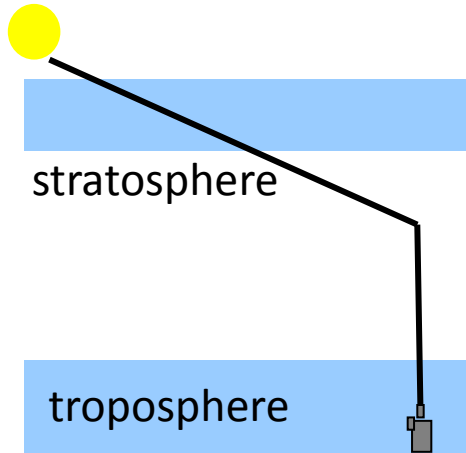
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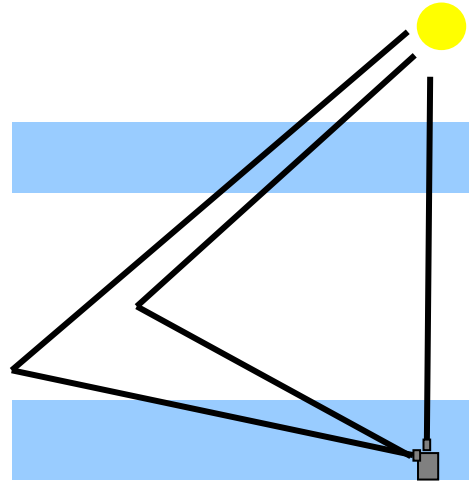
# Ground-based instruments

## ZenithSky



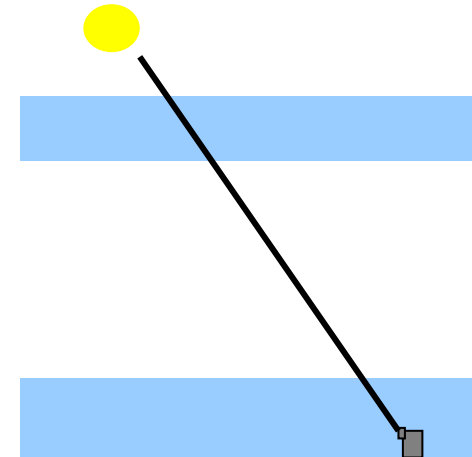
Stratospheric  
measurements at  
twilight

## MAXDOAS



Tropospheric  
measurements  
during the day

## DirectSun



Total column  
measurements  
during the day

Perfect ensemble of data to validate the satellite  
NO<sub>2</sub> product, that measures the 3 components:

$$V_{\text{tropo}} = (S - M_{\text{strato}} V_{\text{strato}}) / M_{\text{tropo}}$$



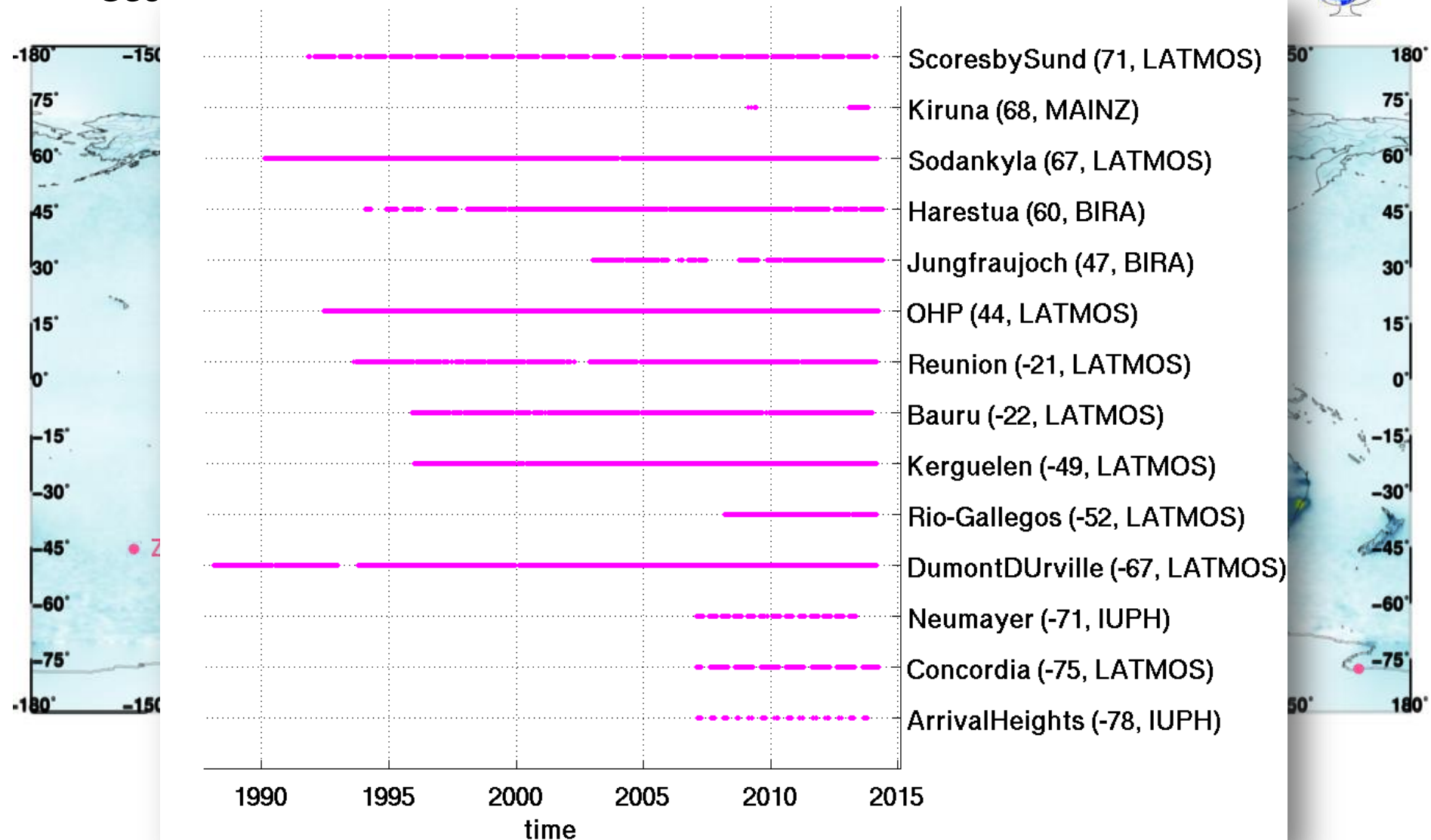
# ZenithSky instruments



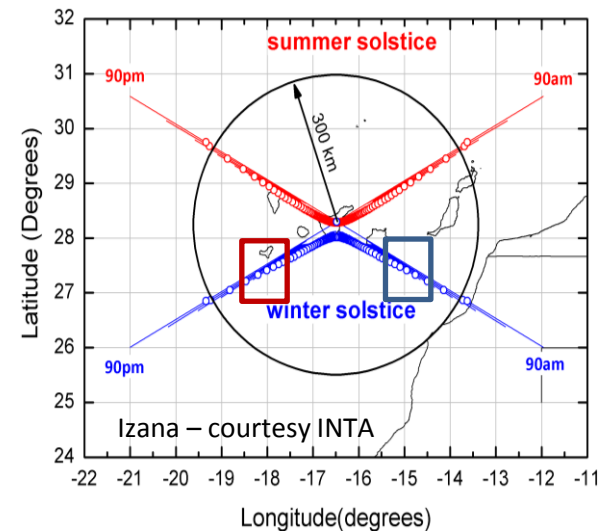
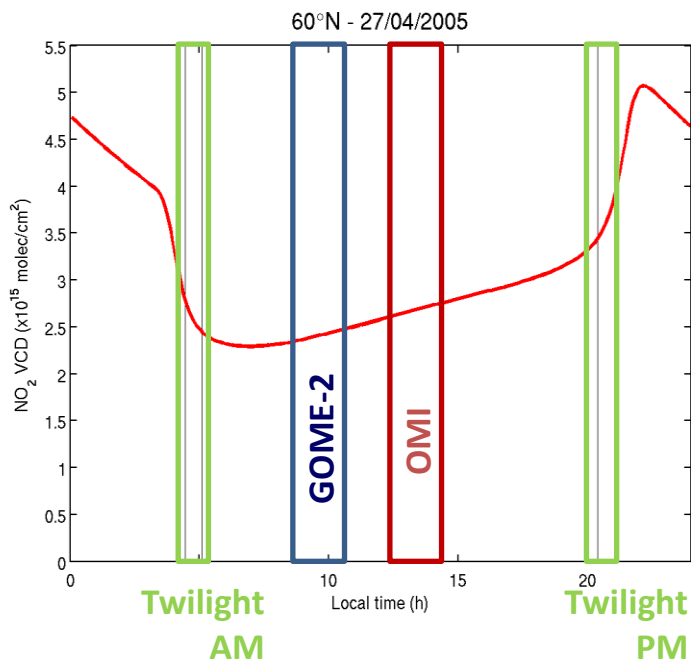
BIRA-IASB 1964-2014



## - Geographical and temporal distribution



- Stratospheric  $\text{NO}_2$  VCD retrieval from ZenithSky:
  - VCD retrieval at twilight: harmonized NDACC recommendations (SCD retrieval settings, AMF LUTs, twilight reporting period, ...)
  - Twilight VCD must be photochemically matched with satellite VCD measured during the day
  - Displacement of the effective air-mass location wrt to station coordinates  
→ spatial matching



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## → Use of tools developed within the NORS project:

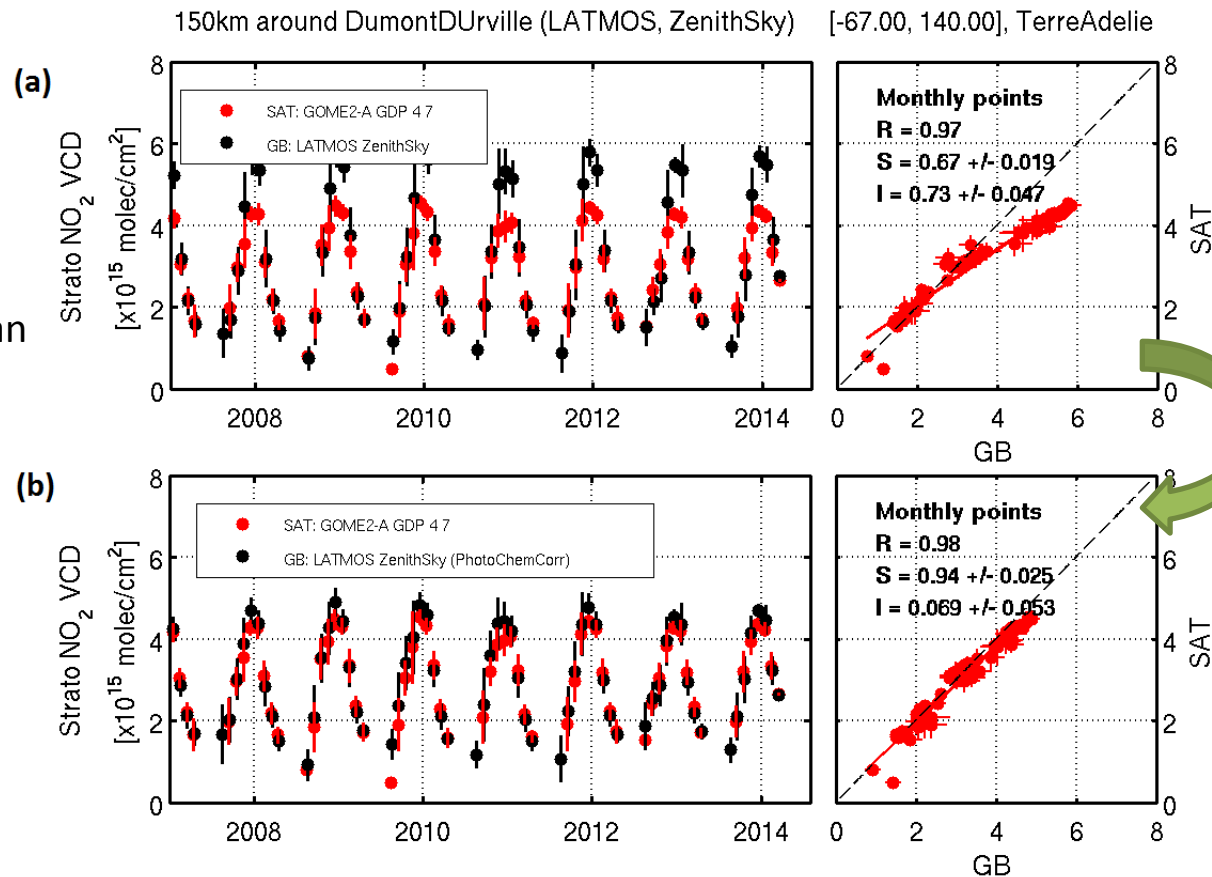
- **Effective SZA locations**
- **Photochemical NO<sub>2</sub> correction**
  - 'Off-line' look-up tables of NO<sub>2</sub> profile diurnal variation calculated using the photochemical box model PSCBOX initialized with SLIMCAT chemical and meteorological fields corresponding to the 2000-2009 period.
  - parameters: altitude (24 levels), latitude (18 values covering 85°N→85°S by 10° step), months 1-12.



**For each day, sunrise/sunset ZenithSky VCD are photochemically converted to the satellite overpass SZA of the day and these corrected NO<sub>2</sub> VCD are compared to the satellite measurement**

# stratospheric NO<sub>2</sub> comparison

- Comparisons with GOME-2 GDP 4.7:



Impact of the  
photochemical  
correction:  
reduce high  
columns in  
summer for high  
latitude stations

Method:

SAT extracted within **150km** and **mean values**

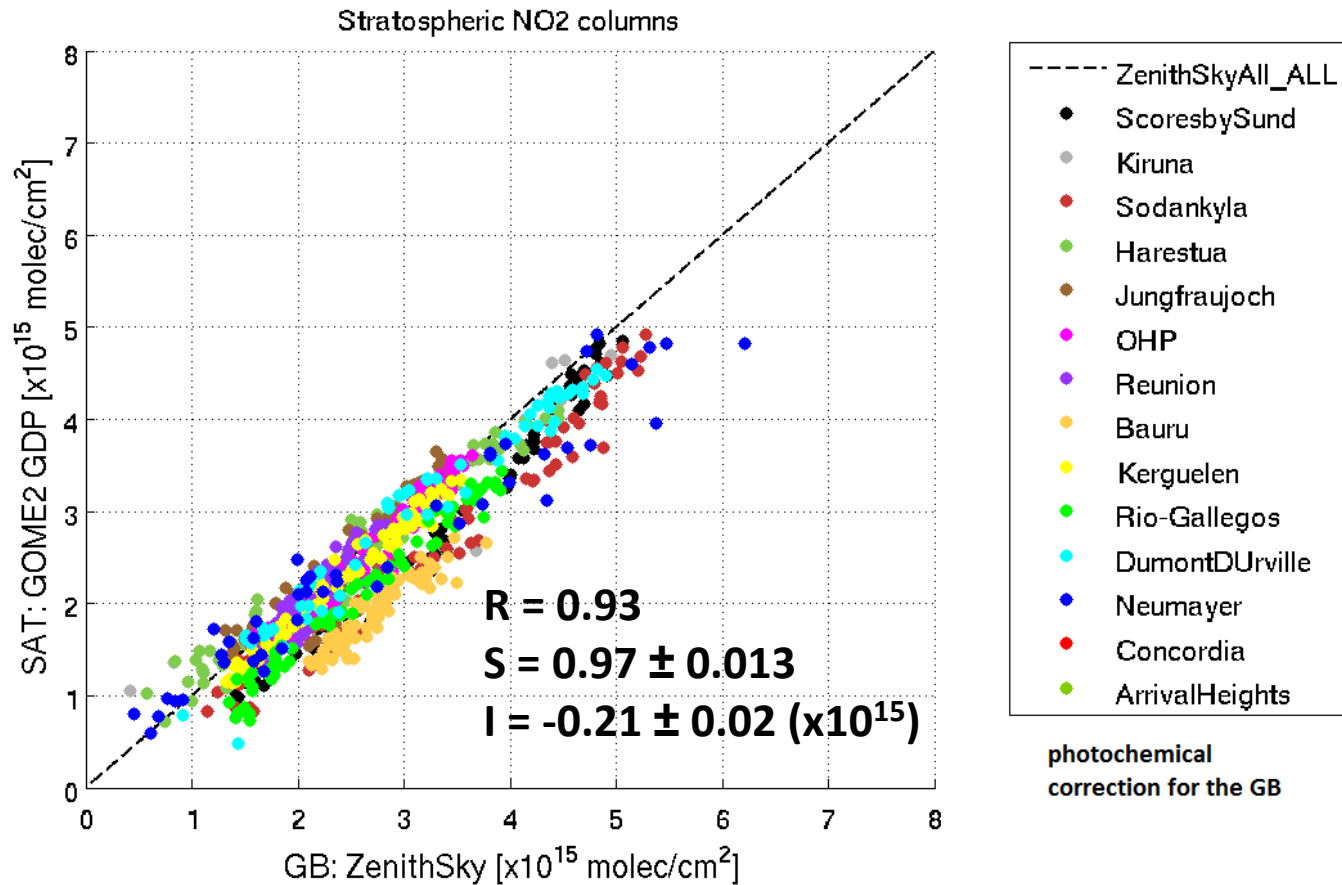
GB: AM VCD photochemically converted to SAT ovp time (considering the effective SZA of the air-masses) and corrected for the different T° of the NO<sub>2</sub> xs ( → VCDgb(@243K): 7% smaller than original at 220K)

Compare only common days and then do monthly means of the daily comparisons

# stratospheric NO<sub>2</sub> comparison

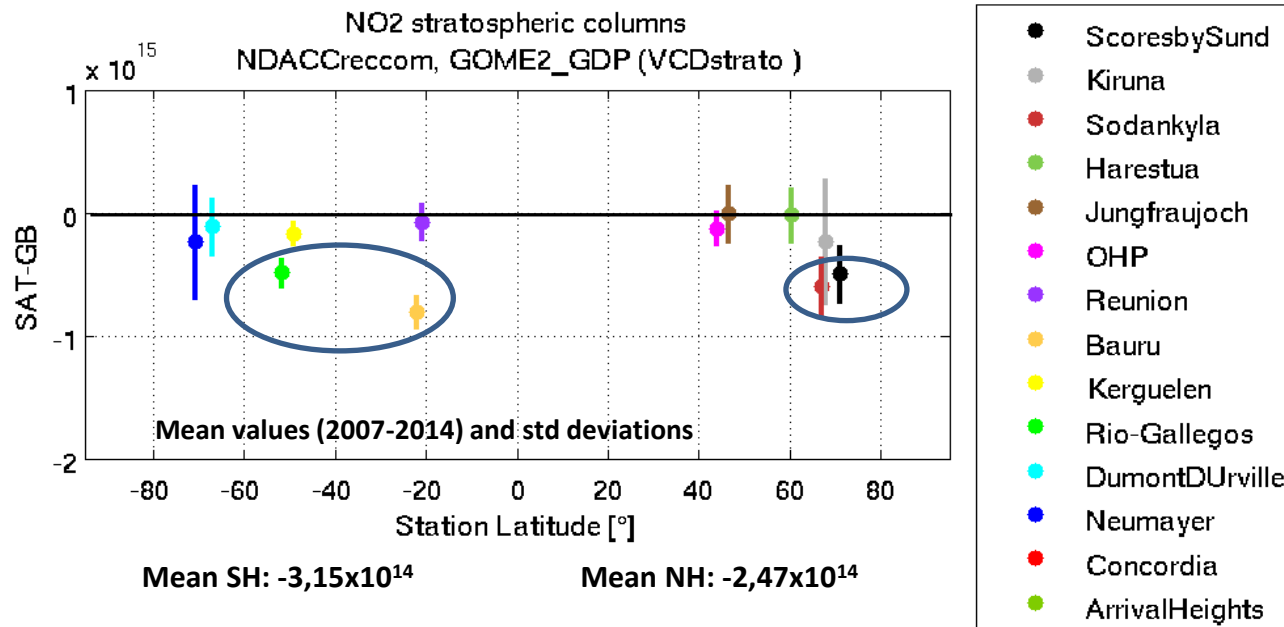
- Correlation plots and effect of the photochemical correction:

Monthly  
means  
VCD



# stratospheric NO<sub>2</sub> comparison

- Overview of the differences as a function of latitude:



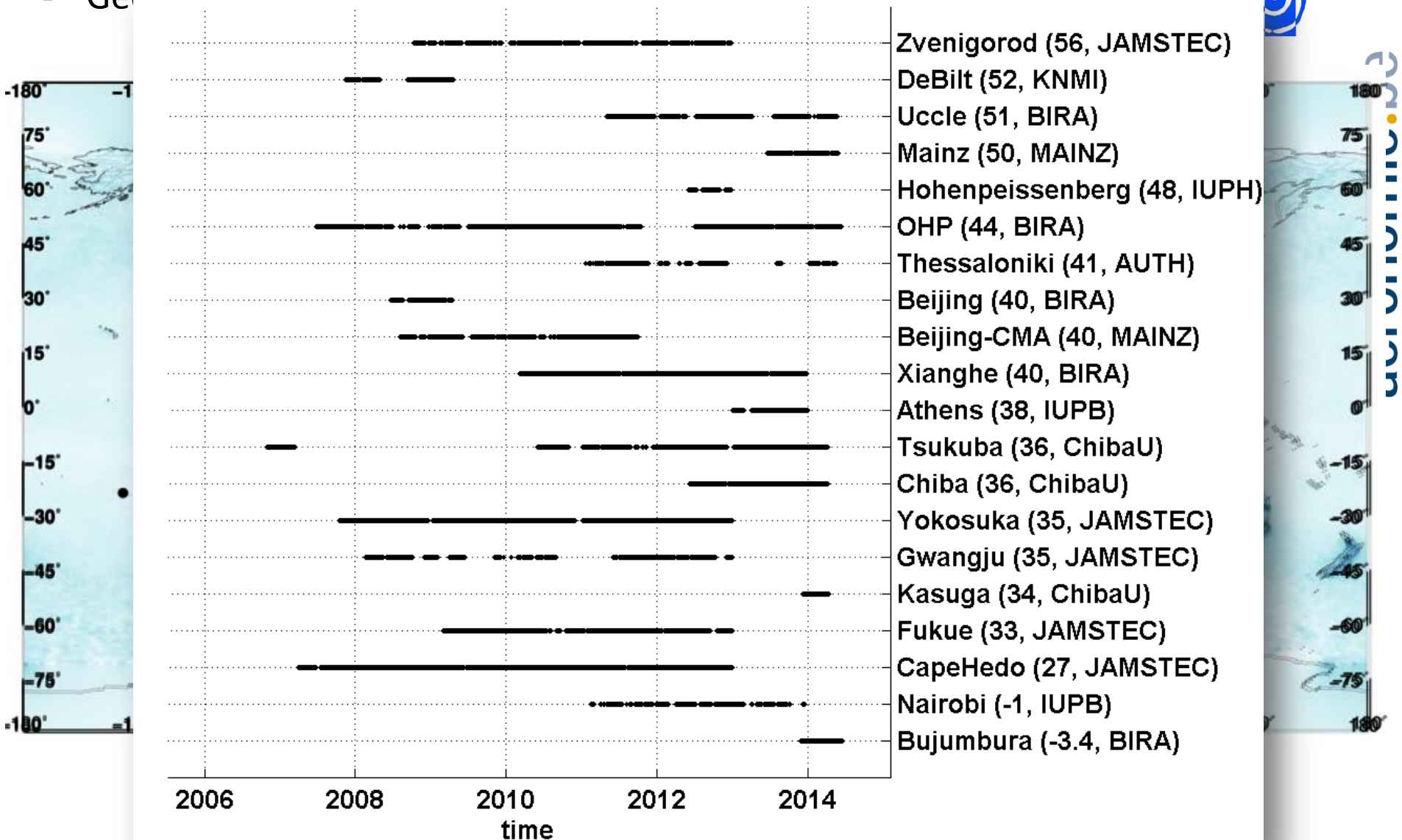
- Rio Gallegos, Bauru, Sodankyla and ScoresbySund: larger differences, to be further investigated with the partners
- + possibly add other stations → **let me know if you want to participate!**
- Tests with other satellite datasets are ongoing



# MAXDOAS instruments



## - Geographical and temporal distribution



Tropospheric NO<sub>2</sub> VCD retrieval from MAXDOAS:

- Effort to harmonise SCDs following Roscoe et al. (2010, CINDI campaign)
- Currently no harmonisation of VCDs and profiles. Different methods are being used:
  - **geometrical approach** (e.g. Honninger et al., 2004)
  - **Optimal estimation** → full vertical profile inversion (e.g. Friess et al., 2006)
  - **Parameterisation** → vertical profile using analytical functions constrained by a few parameters (e.g. Irie et al., 2008)

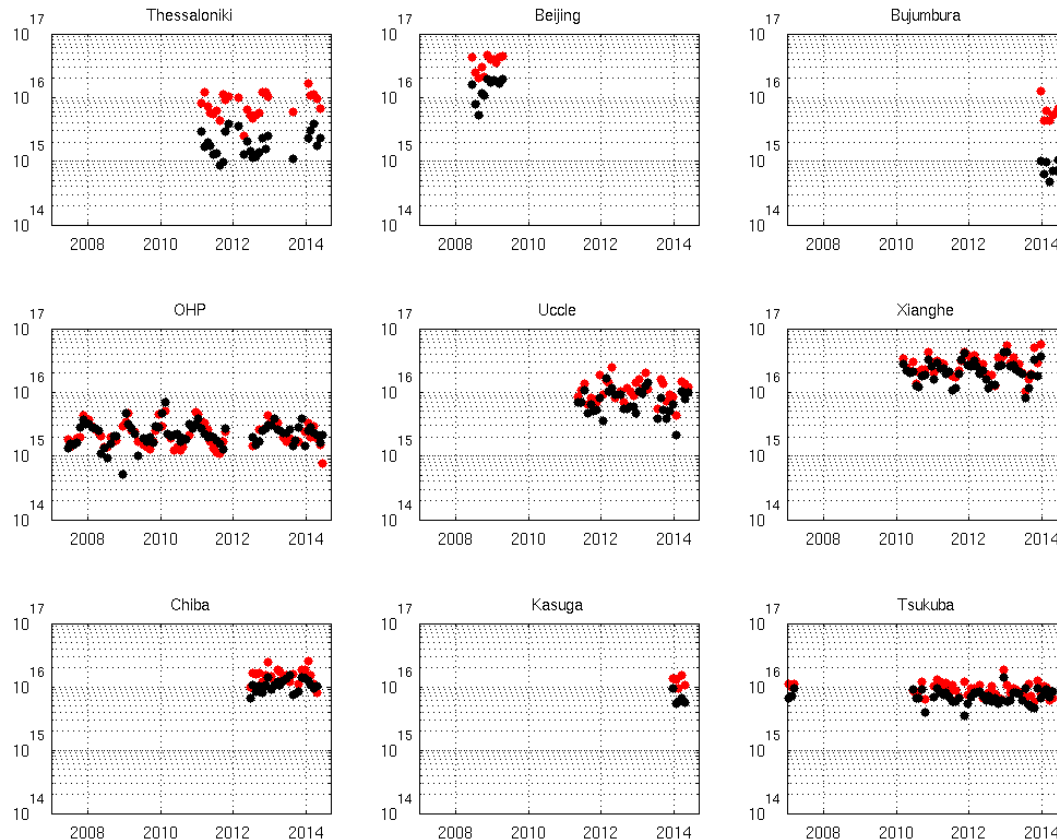
Inversion methods provide **profiles in the 0-4 km altitude range with a DOFS comprised between 1.5 and 3.**

Work on comparing the different methods is ongoing (e.g. Vlemmix et al., 2014; Wittrock et al. in preparation)

# tropospheric NO<sub>2</sub> comparison

- Comparisons with GOME-2 GDP 4.7 :

Monthly mean  
time-series:  
**MAXDOAS**  
**GOME-2**



Depending on  
the location,  
good agreement  
or larger  
differences

Method:

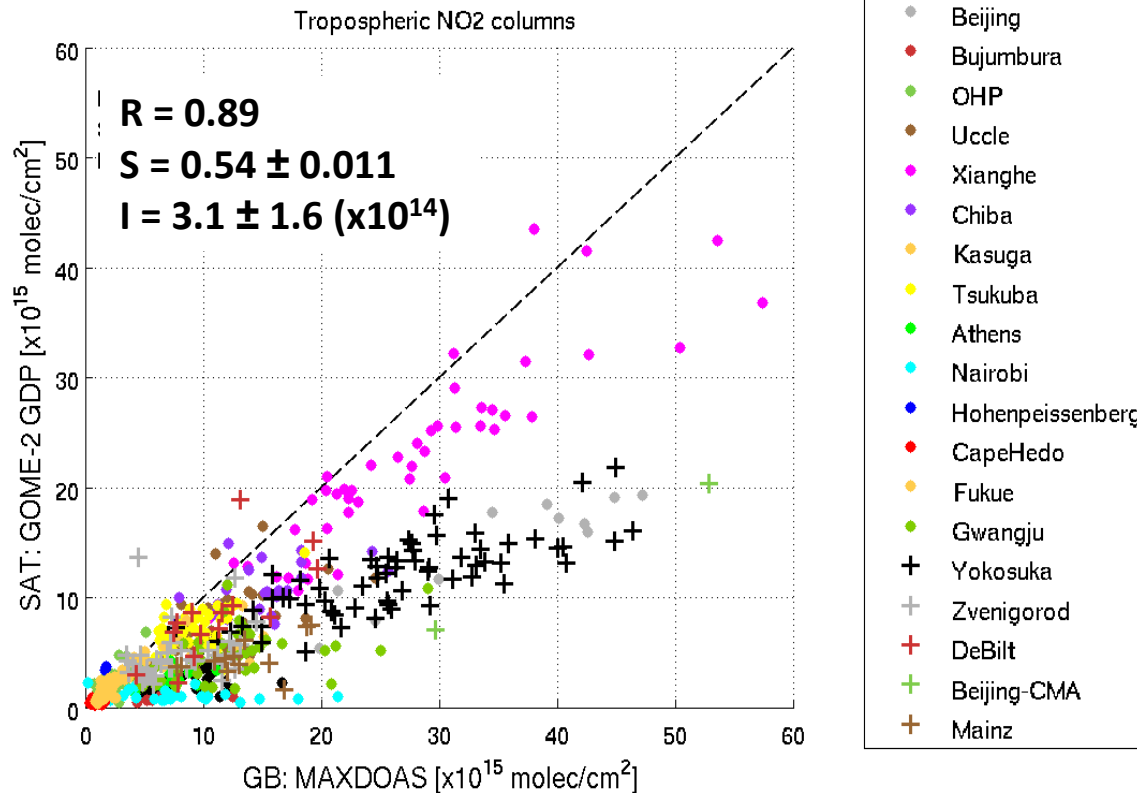
SAT extracted within **50km** and **mean values of cloud free pixels (CF<20%)**

GB: filtering of the data following partners recommendation and then interpolate around the satellite overpass time

Compare only common days and then do monthly means of the daily comparisons

- Overview of the different stations: (20)

Monthly  
means  
VCD



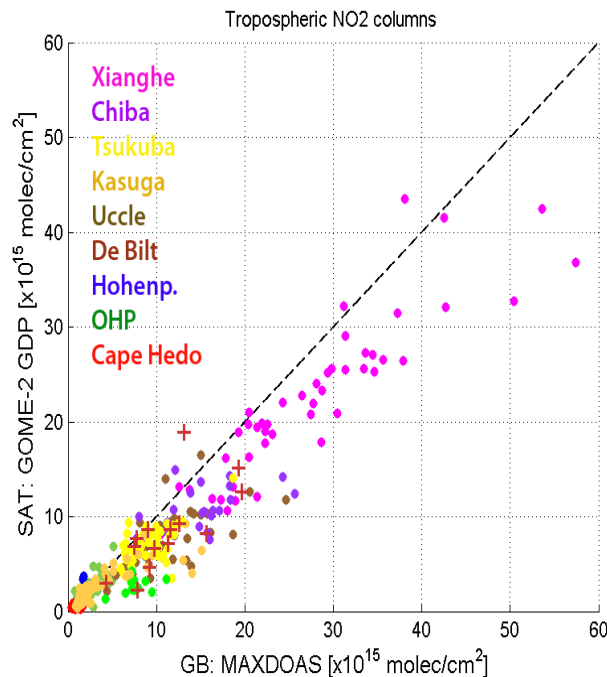
Validation results strongly depend on the location of the station:

- GOME-2 in good agreement (Xianghe, OHP, Uccle, Kasuga)
- GOME-2 with smaller columns than the ground-based MAXDOASes (Beijing, Yokosuka, Gwangju, Thessaloniki).

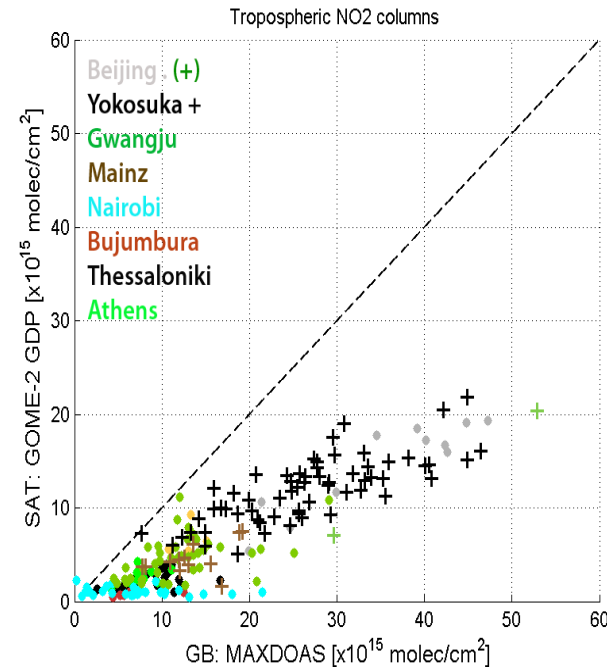
# tropospheric NO<sub>2</sub> comparison

- Effect of location: urban VS suburban/remote conditions

Suburban  
and  
background

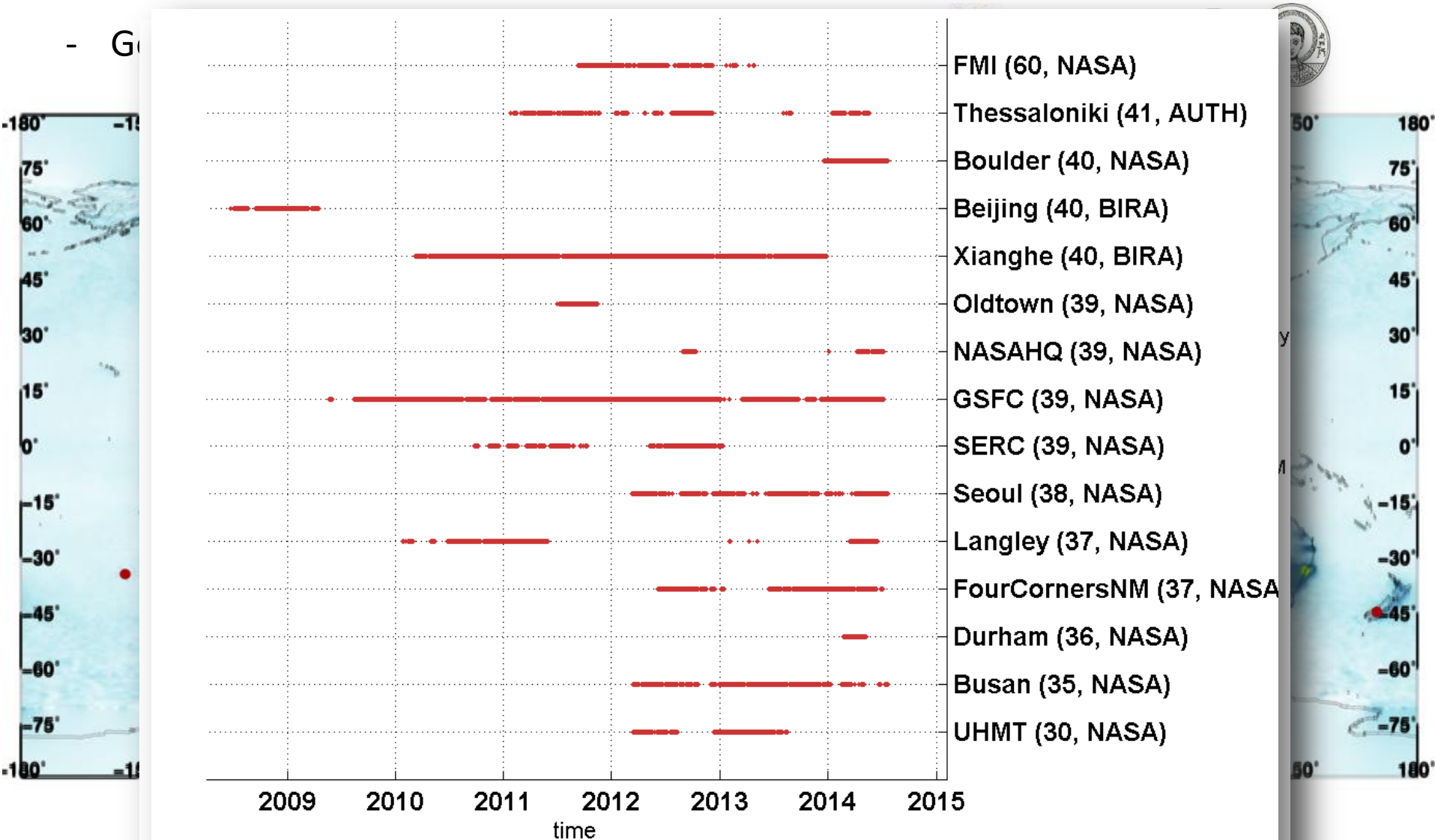


Urban  
sites



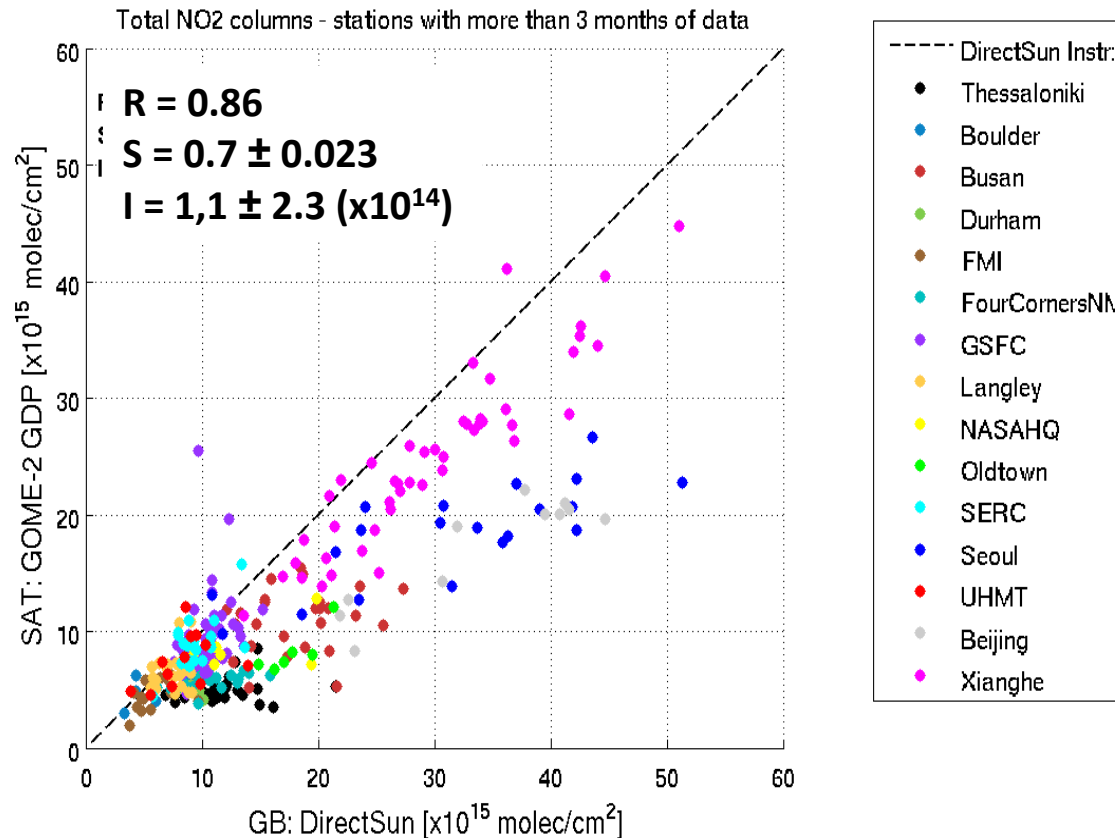
- Good agreement for suburban and background sites
- Urban conditions: MAXDOAS is generally higher than GOME-2 (→ impact of local pollution sources, not adequately sampled at the coarse resolution of GOME-2?)
- Very large discrepancies for Greek and African sites → to be further investigated

# DirectSun instruments



# total NO<sub>2</sub> comparison

- Overview of the different stations:



15  
stations  
with more  
than 3  
month of  
data

As for MAXDOAS, the comparison results strongly depend on the location of the station:

- GOME-2 generally in good agreement in suburban conditions (Xianghe)
- GOME-2 smaller columns than the DirectSun in urban conditions (Beijing, Seoul, Thessaloniki, OldTown).

- Gathering of more than 40 ground-based UV-VIS DOAS instruments measuring  $\text{NO}_2$ , to validate GOME-2 GDP  $\text{NO}_2$  columns (2007 to now)
- This study confirm previous validation results (at few stations):
  - Stratospheric  $\text{NO}_2$ : good comparisons when using the photochemical correction – few stations need to be looked more carefully
  - Tropospheric and Total  $\text{NO}_2$ : good agreement in remote and suburban locations while GOME-2 is much smaller in urban conditions (+ Greece and Africa)
- The harmonization/homogeneity of the network(s) is an essential point to use the data as a reference dataset
  - Tests with different versions (LATMOS v2 and v3) and different satellite products are ongoing
- Extension of the study:
  - MAXDOAS: profile measurements can be compared to satellite data using AK
  - Further exploit the complementarity of the observations
  - Improve the classification of urban/suburban/remote type of sites



