



Overview ground-based validation of SGP 6.00 Diagnostic Data Set



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Acknowledgements

NDACC, SHADOZ and GAW PIs

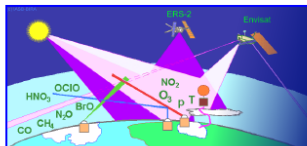
+ staff at stations

ESA, BELSPO

SGP V6 validation report

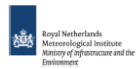
Multi-TASTE Phase F

Multi-Mission Technical Assistance to ESA Validation by Sounders, Spectrometers and Radiometers



Validation report

Delta-validation of SCIAMACHY SGP upgrade
from V5.02 to V6.00



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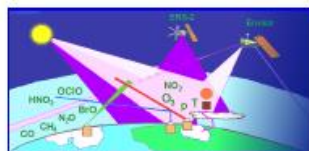
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Multi-TASTE final report

Multi-TASTE Phase F

Technical Assistance to ESA Multi-Mission Validation by Sounders, Spectrometers and Radiometers



Final report

October 2013 – December 2015



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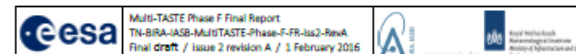
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Issue 2A under review by ESA (Feb 2016)

Data sets

SCIAMACHY

- SGP 3.01/R complete data set (Aug 2002 – Jan 2010)
- SGP 5.02/W complete data set (Aug 2002 – Apr 2012)
- SGP 6.00/Y diagnostic data set (Aug 2002 – Apr 2012)

Ground-based instruments

- O3 column 36 Dobsons, 32 Brewers, 17 UV-visible spectrometers (GAW, NDACC)
- NO2 column 19 UV-visible spectrometers (NDACC)
- BrO column 1 UV-visible spectrometers at Harestua (60°N)
- CO column 12 FTIRs (NDACC)
- H2O column 40 radiosondes (GAW, NDACC, SHADOZ)
- O3 profile 79 ozonesondes, 12 lidars, 3 MWRs (GAW, NDACC, SHADOZ)
- BrO profile 1 UV-visible spectrometer at Harestua (60°N)

Executive summary

	Nadir					Limb	
	O3 column	NO2 column	CO column	BrO column	H2O column	O3 profile	BrO profile
Observed issues	<p>Positive overall bias, but not significant.</p> <p>Negative drift of 1.5% / decade at mid N latitudes.</p>	No significant bias.	Very large bias and noise remains in monthly data.	<ul style="list-style-type: none"> Negative bias of -12%, spread of 18%, Use of total GB AMF improves agreement. 	Dry in most conditions.	<ul style="list-style-type: none"> AK induce vert. oscillations, Complicated bias patterns, Drift in MS, Quality worse in Arctic MS, Auxiliary data not adequate. 	<p>Quality inferior to IUP product</p> <ul style="list-style-type: none"> Larger bias, Larger spread, No annual cycle.

O3 nadir column

Ground-based bias is reduced, now at most $+(1-1.5)\%$

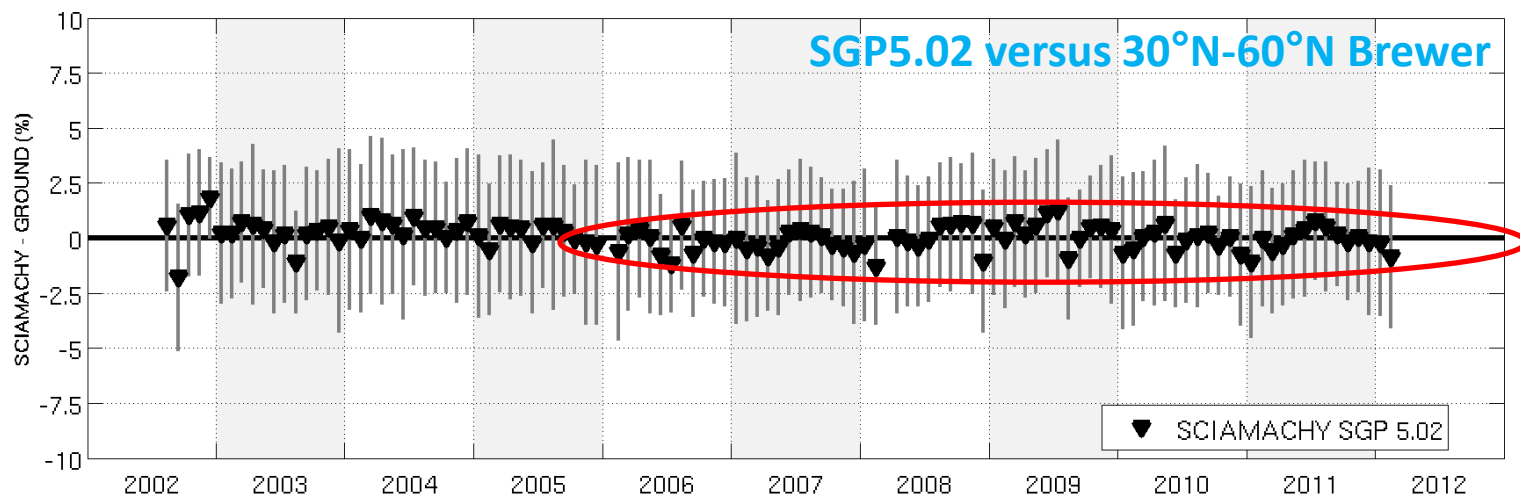
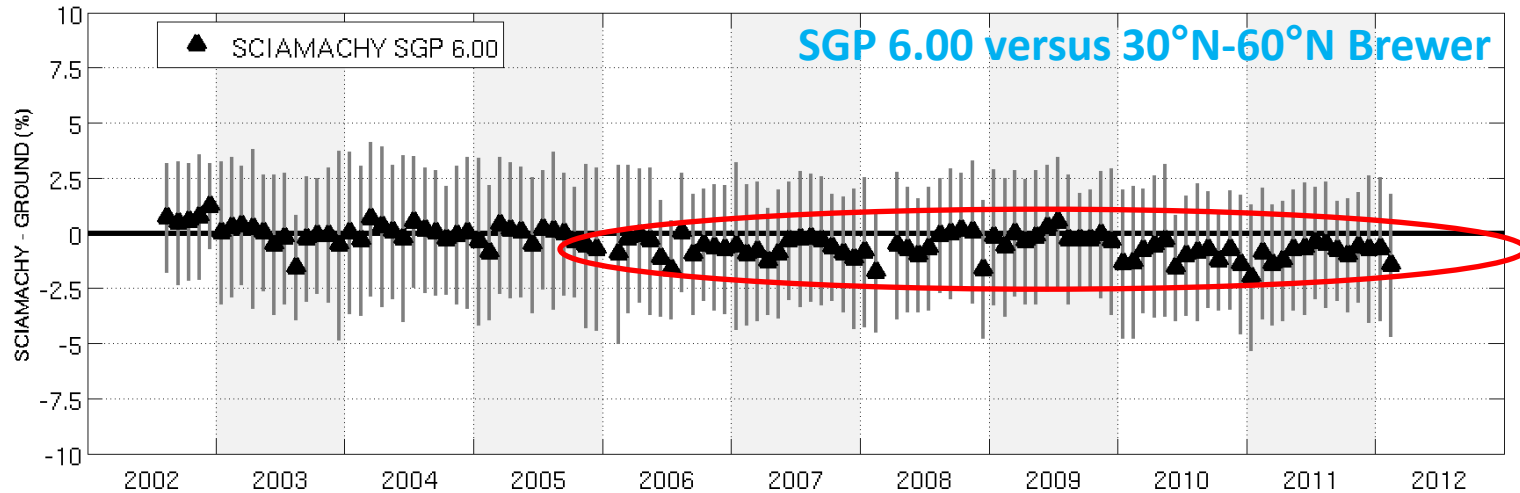
(close to GND measurement uncertainties)

- V6 columns on average 0.2-0.6% smaller than V5 at most stations
- No changes in SZA or cloud-dependence of bias
- No clear changes in spread

However V6 columns exhibit a long-term drift in NH!

- It is negative and about 1.5% over mission lifetime
- Consistent results for Dobson & Brewer
- Not seen for V5

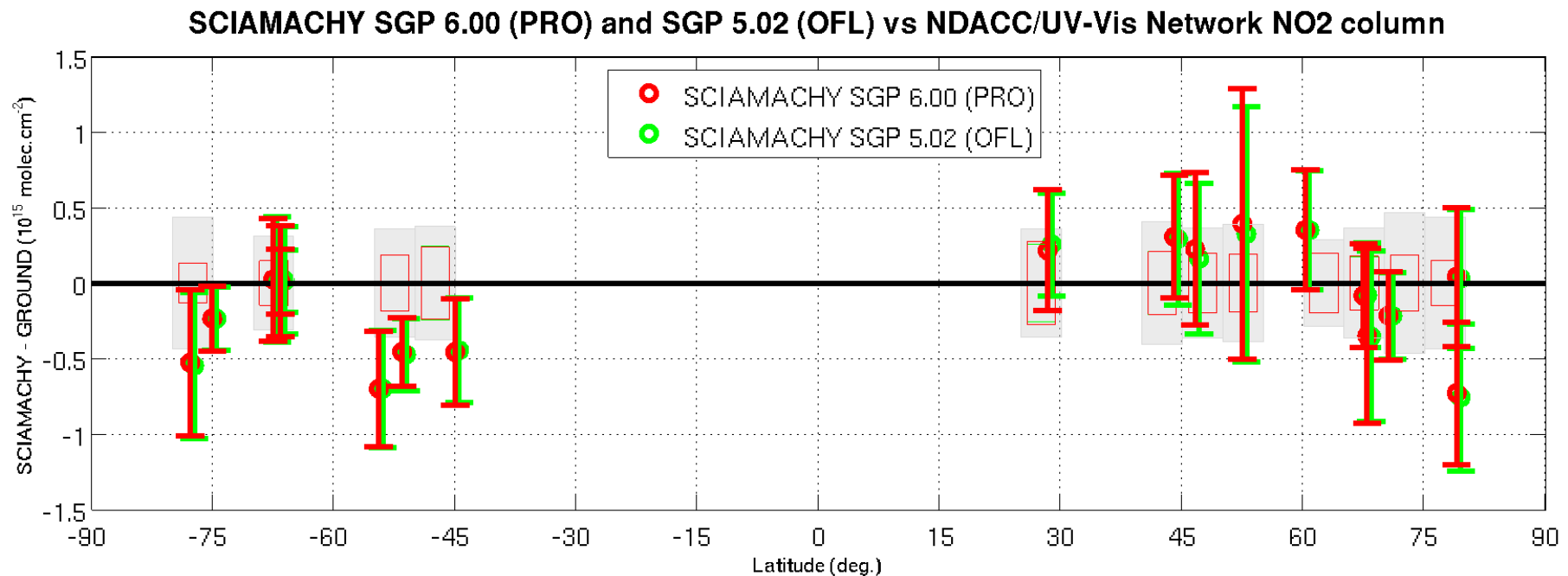
O3 nadir column



NO₂ nadir column

Differences between SGP V6 and V5 are hardly noticeable and well below the detection limit of the ground-based measurements

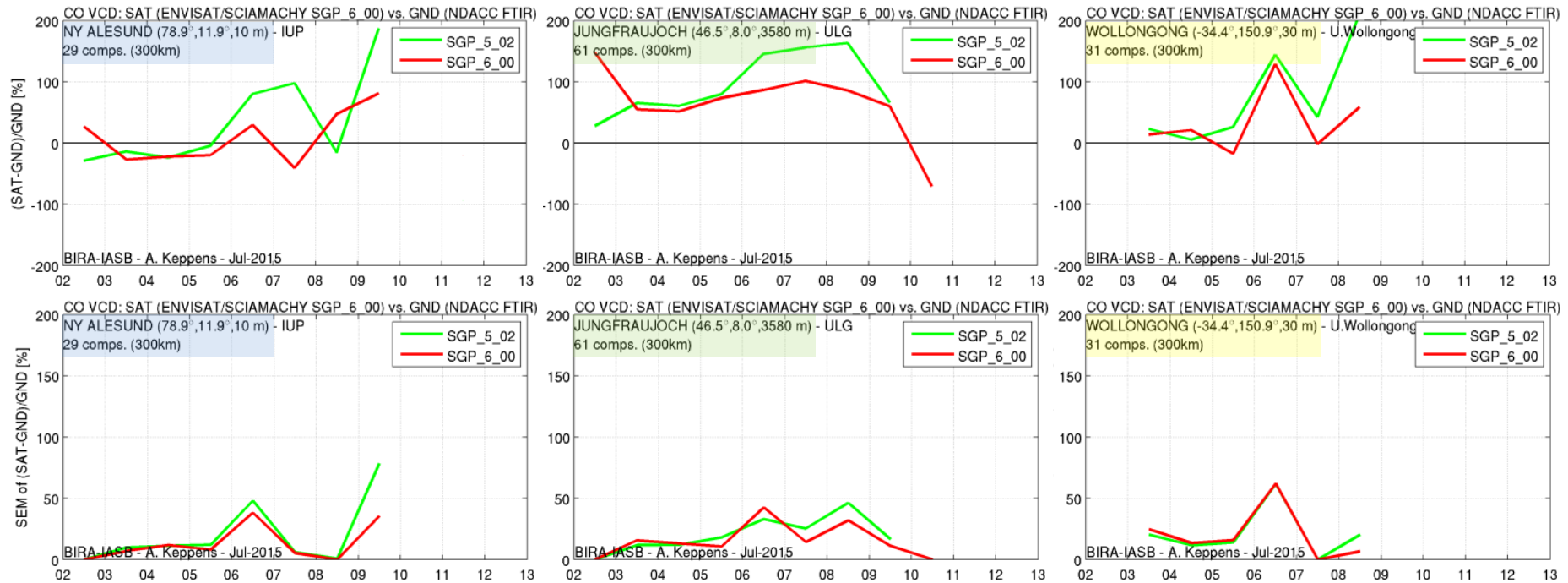
- Median bias is less than $\pm 4 \times 10^{14}$ molec. cm⁻² (~10-15%) at stations without tropospheric pollution and where the diurnal cycle can be accounted for accurately.
- Difference between mid N and mid S bias ($\sim 7 \times 10^{14}$ molec. cm⁻²) possibly due to tropospheric pollution and residual diurnal cycle effects.



CO nadir column

In general, the annual median bias of V6 is comparable to that of V5, but appears clearly reduced during 2006-2010 (TBC with more data)

- No clear differences in spread between V5 and V6
- Large amount of outliers and negatives (even for monthly means...)
- Due to large variability no seasonal cycle, decadal trend or meridian dependence can be observed
- Product remains inadequate in both precision and accuracy

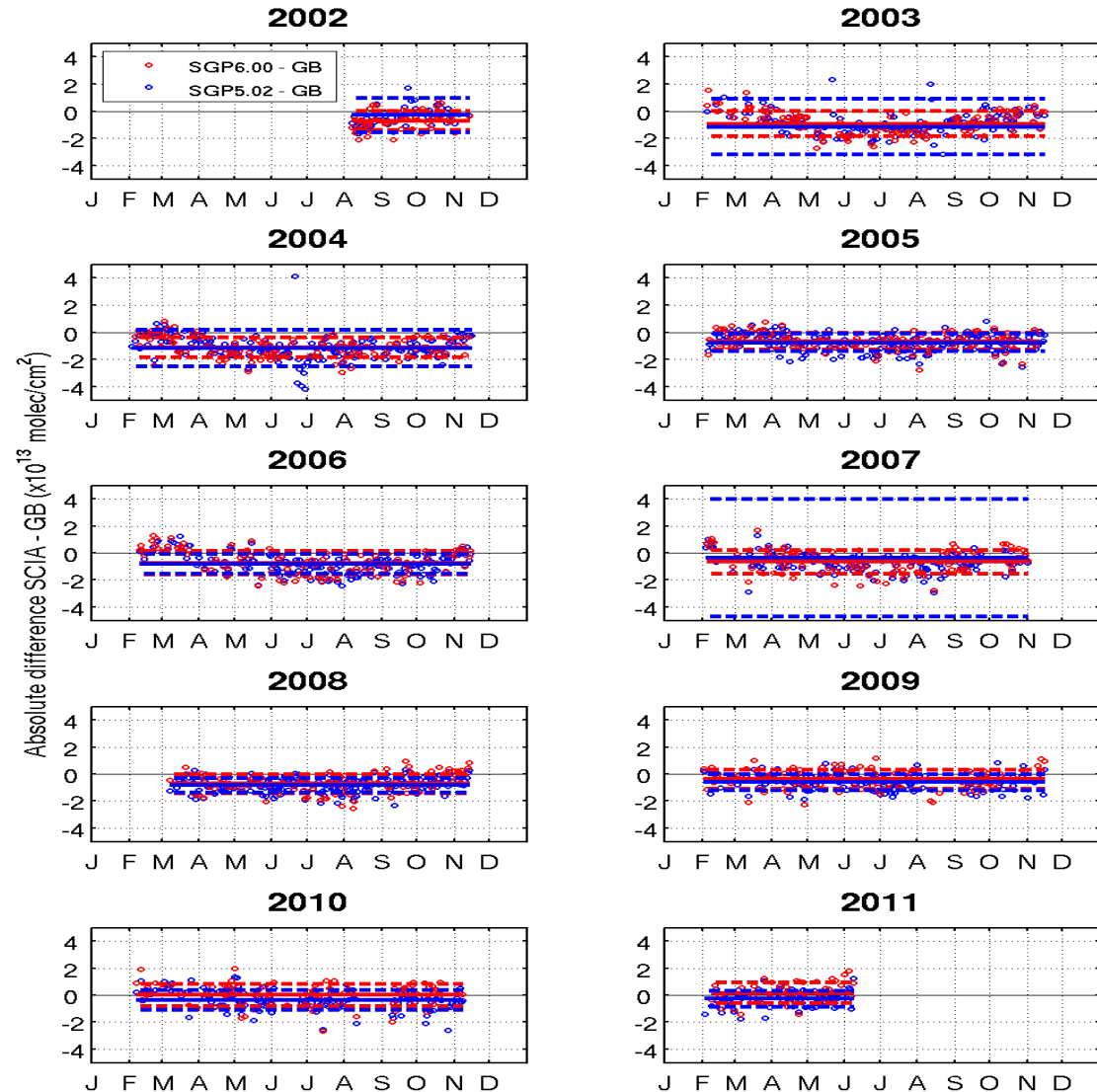


BrO nadir column

at Harestua (60°N)

Very similar data quality*

- Annual cycle well reproduced
- Negative bias reduced by ~0.5% (insignificant)
- More outliers in V5 data (2003, 2004, 2007) (?)



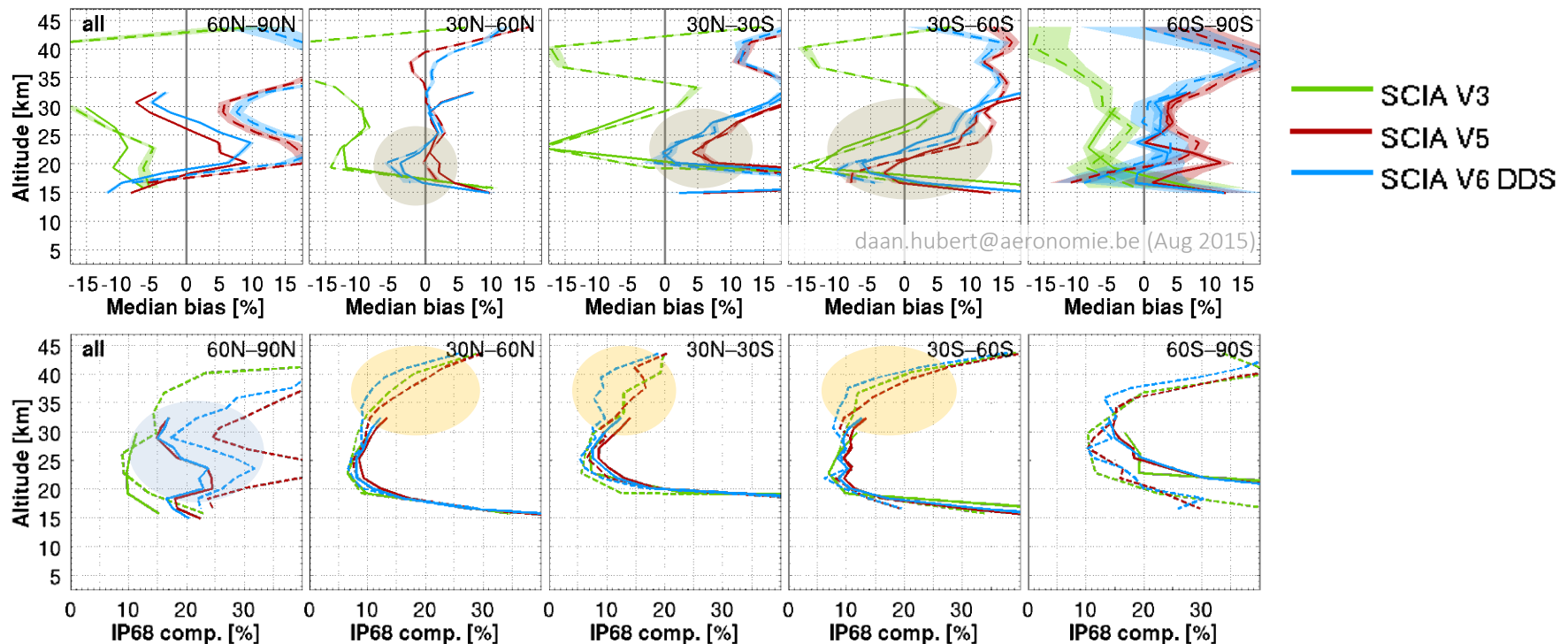
* Sampling differences may play a role in above results (V5 = full mission, V6 = DDS)

O3 limb profile

UTLS and stratosphere

Overall, V5&V6 are very similar, but in parts of the atmosphere clear changes are noted

- Upper stratosphere : reduction in short-term variability
- Arctic : clear improvement of variability
- 3-7% less ozone below 30-35km (bias reduction 30N-90S, bias increase 30N-90N)

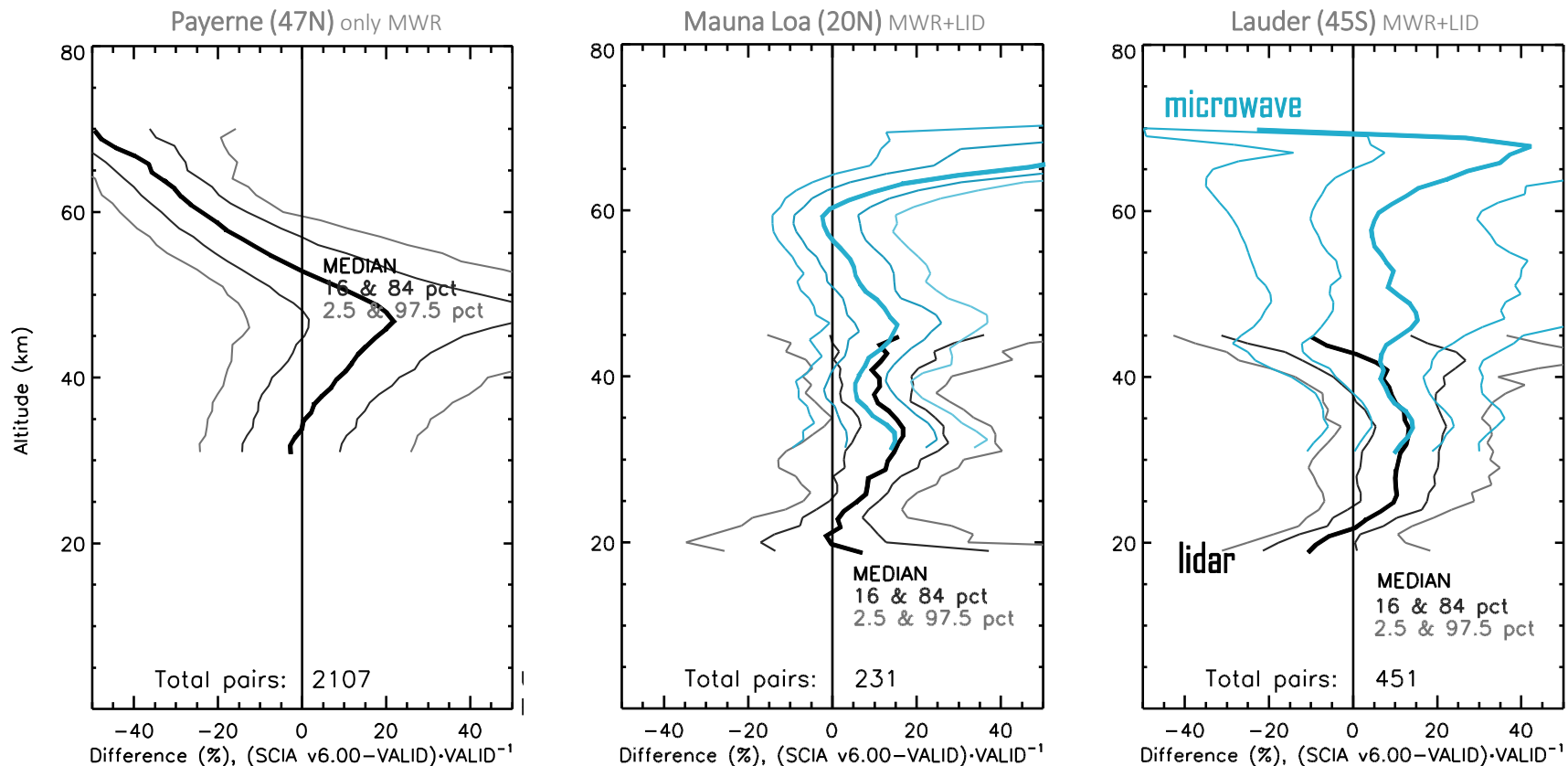


O3 limb profile

mesosphere (& stratosphere)

Positive bias in large part of the mesosphere, less clear above ~60km

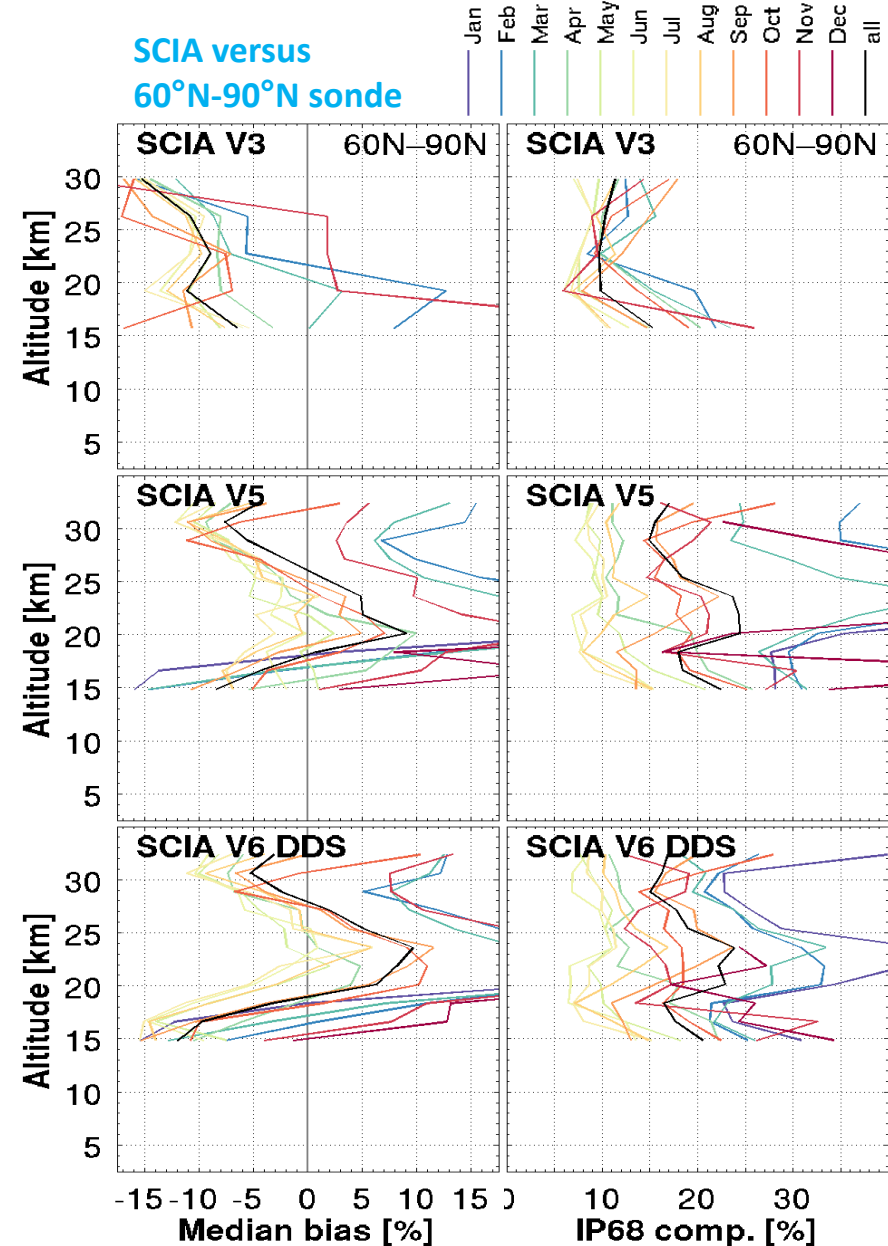
- Comparison to three microwave radiometer stations (47°N, 20°N and 45°S)
- Consistent results (within 5%) for microwave and lidar over 30-42 km



O3 limb profile

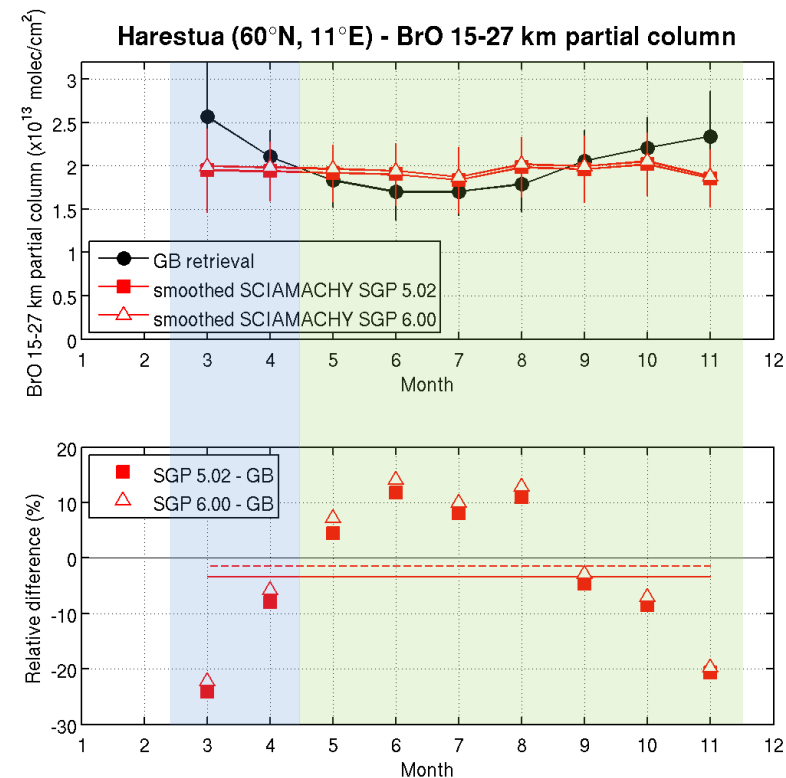
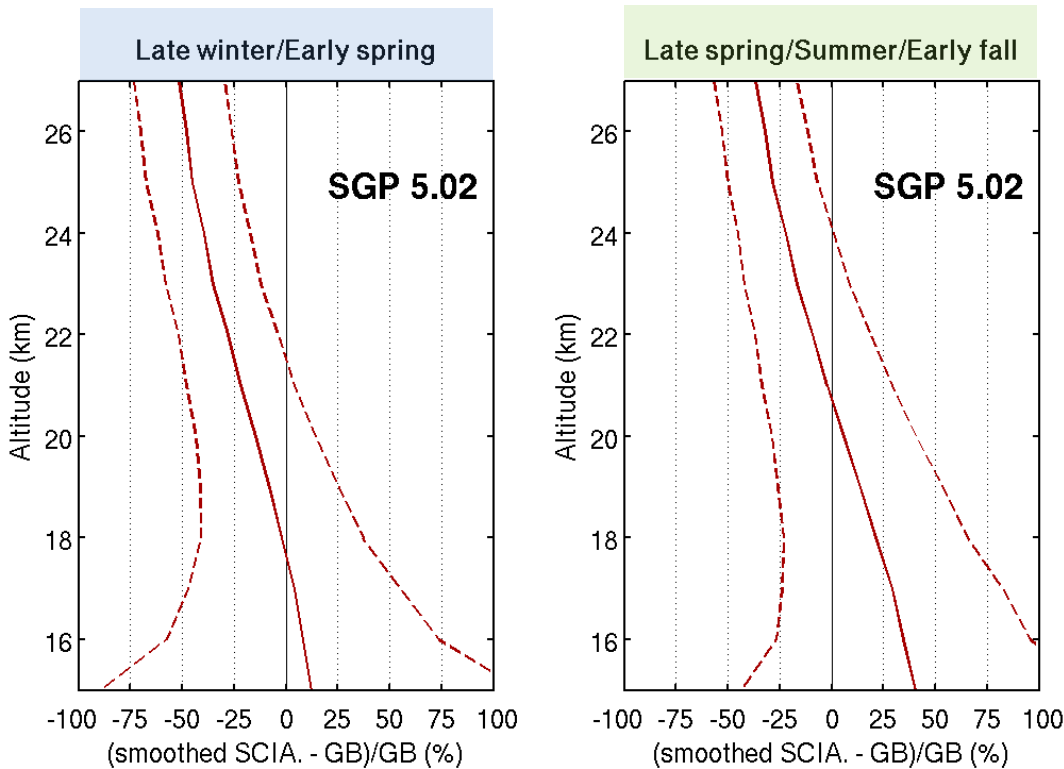
All major issues remain

1. vertical AK introduces large oscillations
→ not suitable for smoothing
2. bias is large and has complex structure
3. significant degradation of data quality in Arctic middle stratosphere (not for V3)
→ what happens during DJF?
4. clear negative decadal drift in middle stratosphere
→ trends are off by 5% / decade
5. clear impact of auxiliary pT on bias
→ not useful for conversions



BrO limb profile

at Harestua (60°N)



- V6 BrO concentrations up to 3% larger than V5
- Bias is season- and altitude-dependent
- Spread is similar for V5 and V6
- **Biases are significantly larger than those obtained for the IUP-Bremen scientific product at the same station (+10/-20%), see Hendrick et al. (2009)**

- Similar results for 15-27km partial column
- **V5 and V6 do not capture the seasonality** seen in the ground-based partial columns
- This seasonality is well captured by the IUP-Bremen scientific product (Hendrick et al., 2009)

H₂O nadir column

Methodology

Pre-processing of radiosonde data

- 40 stations (attached to ozonesonde, many RS92, but also other models)
- Convert relative humidity to VMR
- Integrate profile between surface and 10 km

Co-location

- Closest SCIA pixel to sonde launch, must be within <100km and <3h
- Land pixel pairs (63%) : 1239 cloudy + 134 cloud-free
- Ocean pixel pairs (37%) : 768 cloudy + 29 cloud-free

Compute median statistics of $\Delta X = X_{\text{SCIA}} - X_{\text{GND}}$ (g cm⁻²)

H2O nadir column

Results

Confirms most findings of du Piesanie et al. (2013) ...

- SCIAMACHY data is in general dry by 0.06 g cm^{-2} , except for cloud-free land pixels
- Bias changes sign around $\text{CF}=0.15$ and around $\text{SZA}=30^\circ$
- Seasonal cycle in comparison spread
- Data quality best for AMF correction factor > 1.1

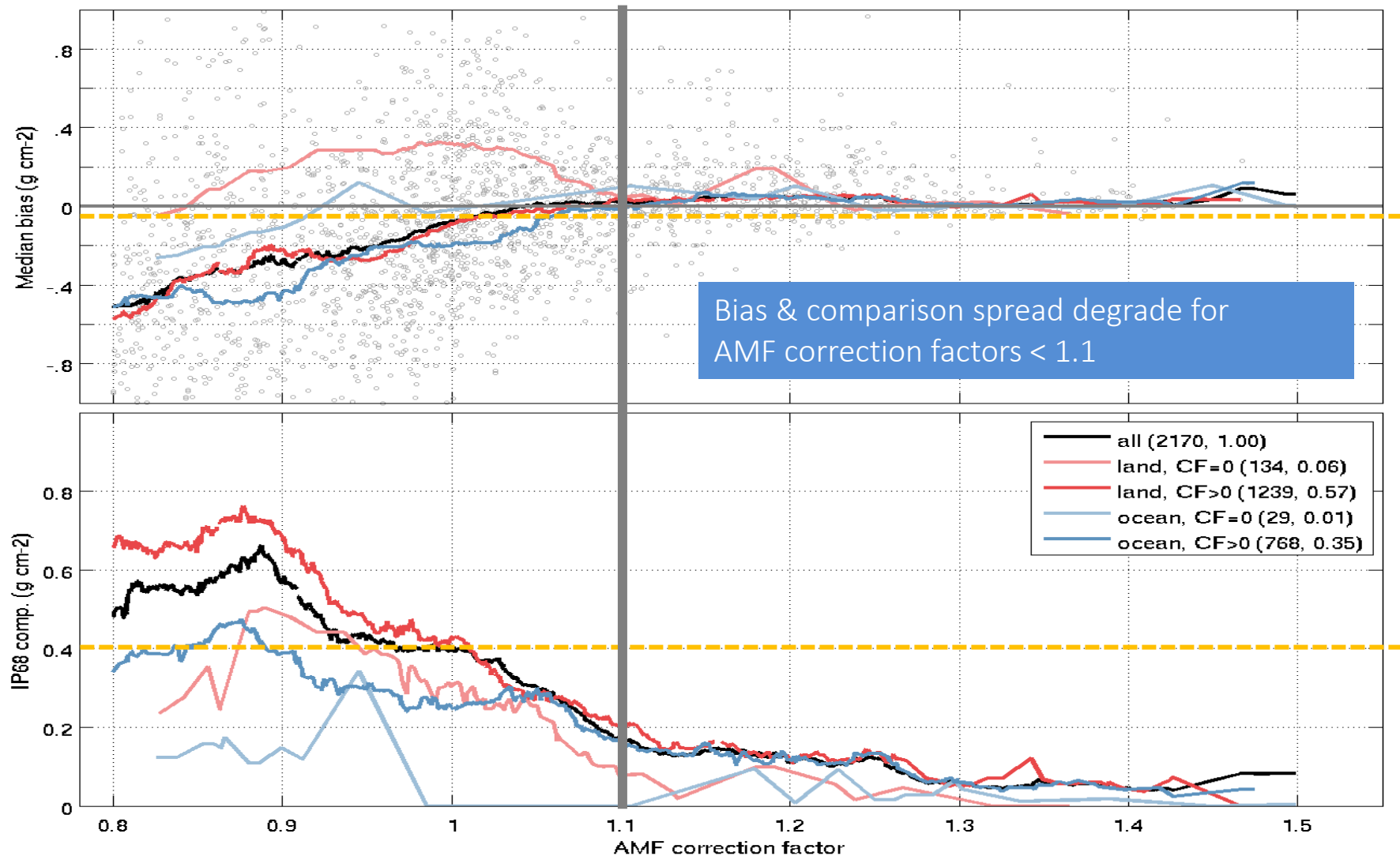
No clear differences between SGP 6.00 and 5.02

(Redo analyses with sonde integrated from CT to 10km)

SGP V6.00 DDS versus sonde		Co-located pairs	Median bias		Comparison spread	
			(g cm^{-2})	(%)	(g cm^{-2})	(%)
Land	CF=0	134	+0.22	+17	0.30	20
	CF>0	1239	-0.07	-7	0.46	31
Ocean	CF=0	(29)	(-0.02)	(-4)	(0.14)	(20)
	CF>0	768	-0.05	-9	0.30	29
All	All	2170	-0.04	-6	0.39	30

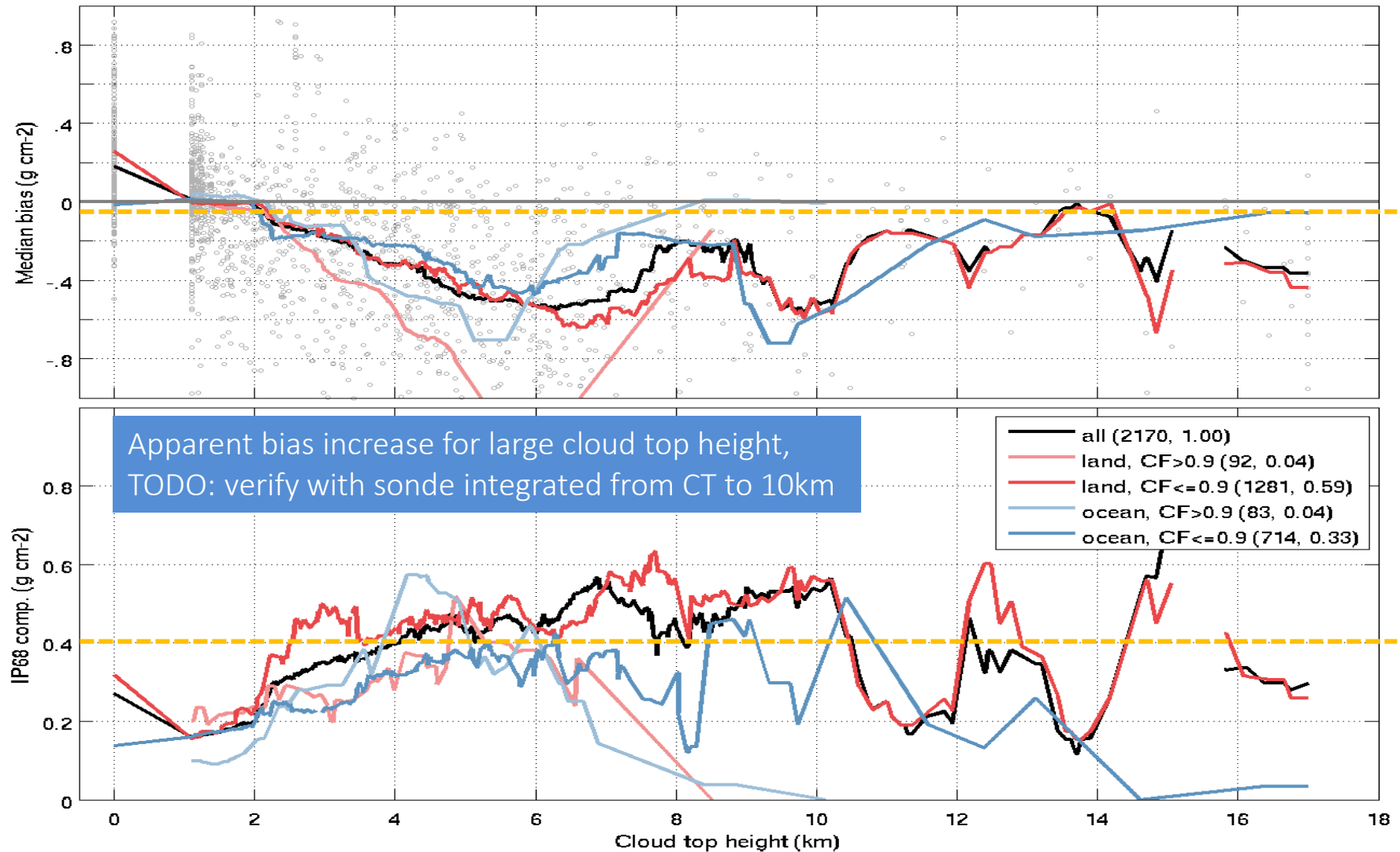
H₂O nadir column

AMF correction factor



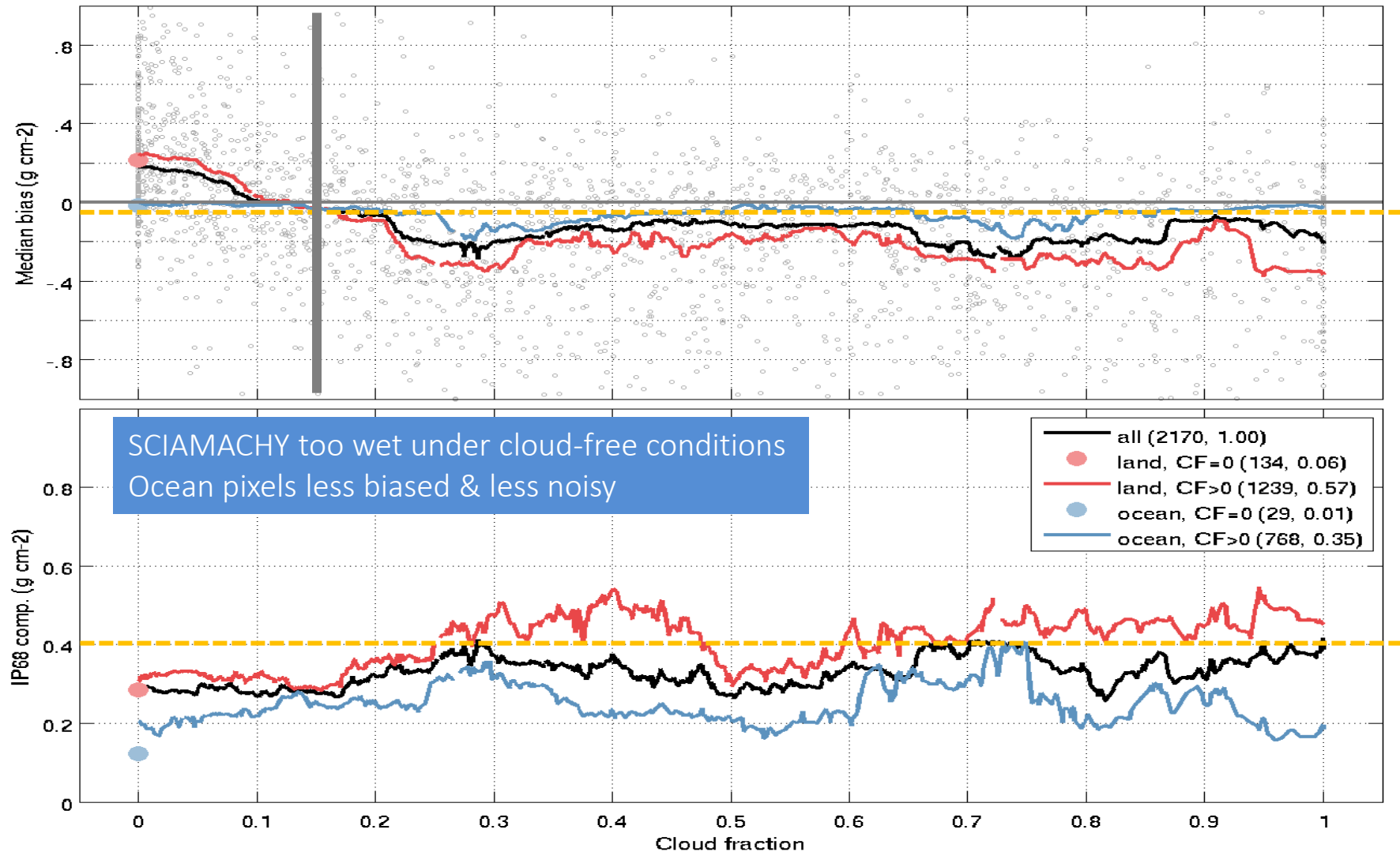
H₂O nadir column

Cloud Top Height



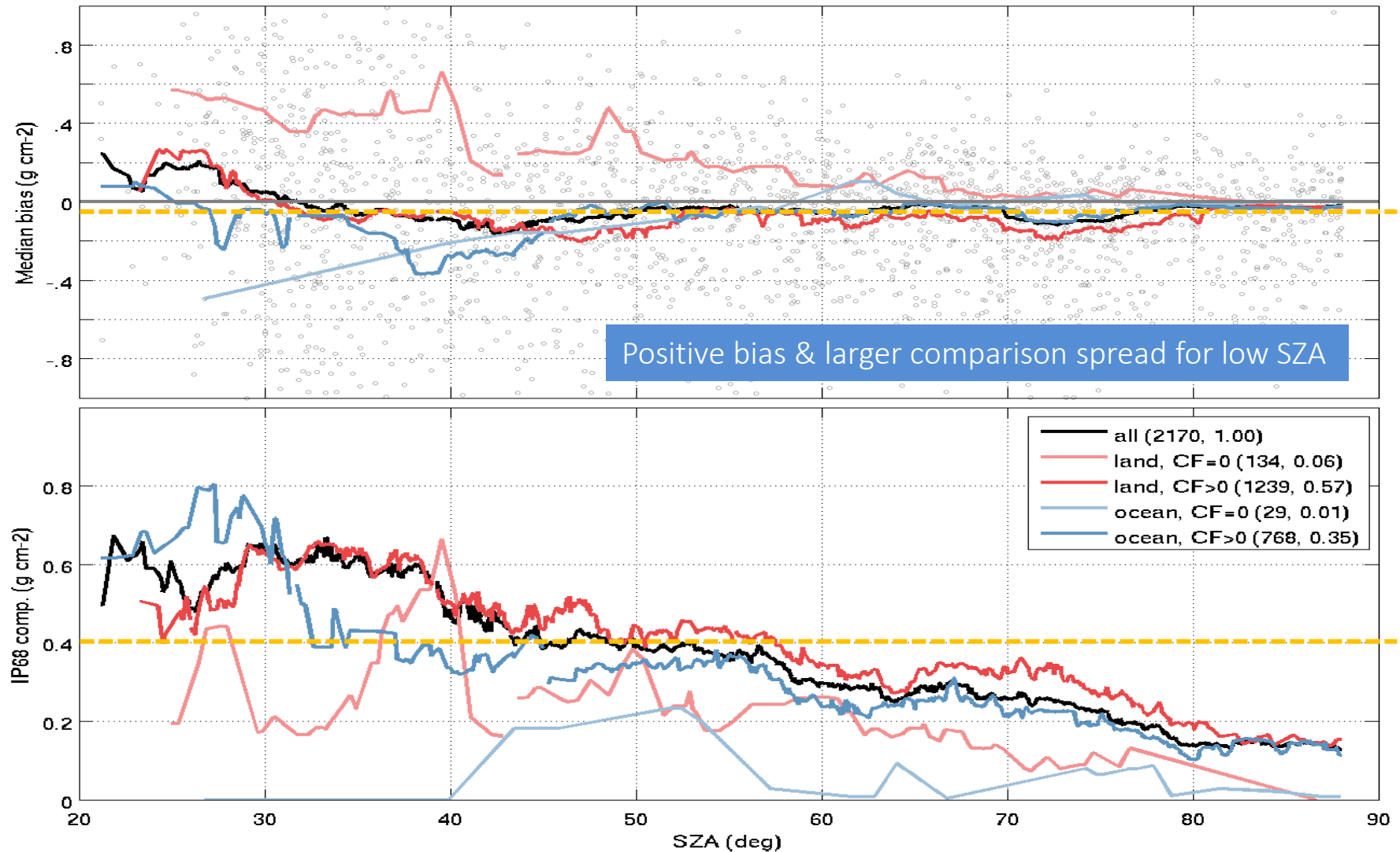
H₂O nadir column

Cloud fraction



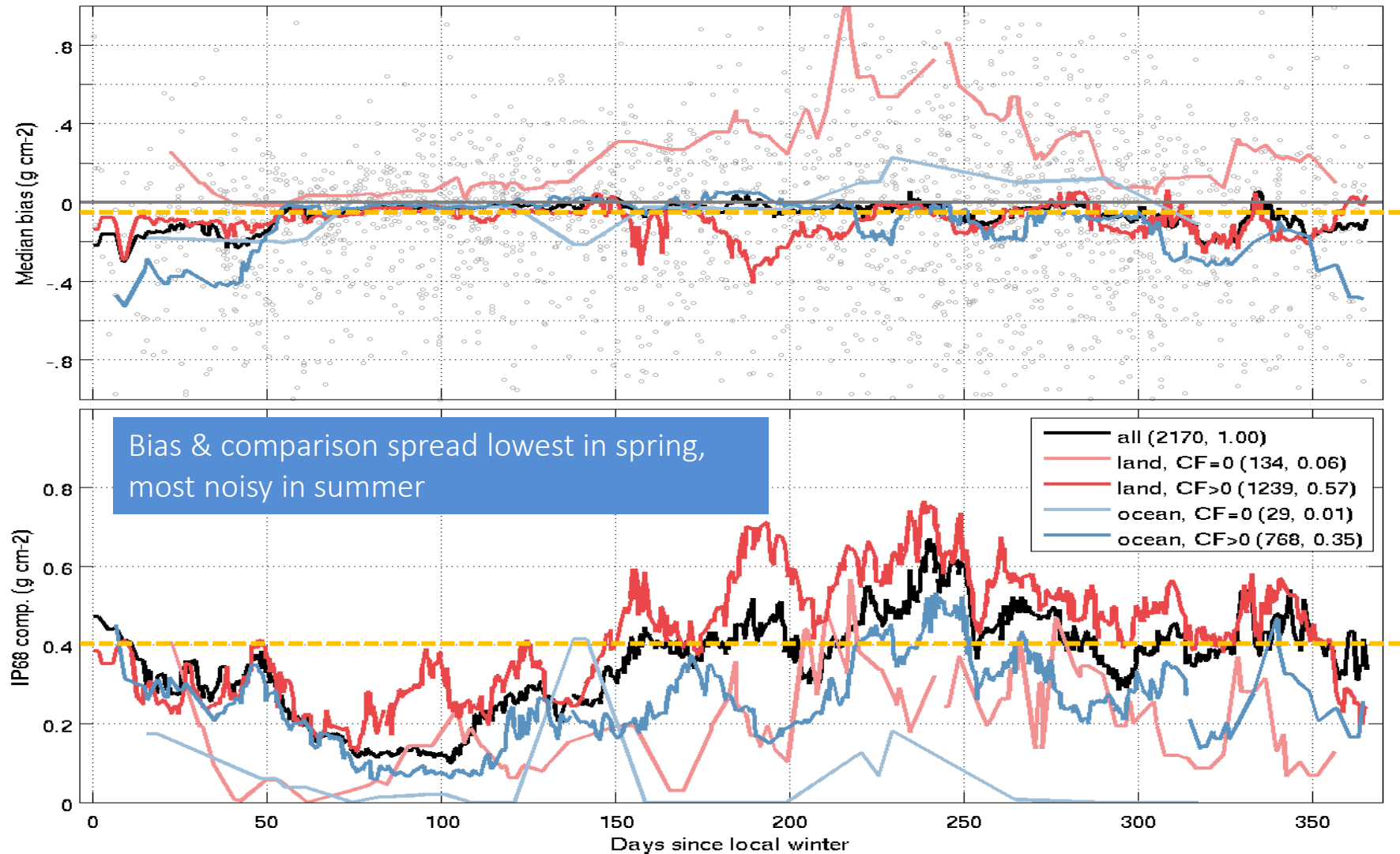
H₂O nadir column

Solar zenith angle



H₂O nadir column

Days since local winter



Executive summary

	Nadir					Limb	
	O3 column	NO2 column	CO column	BrO column	H2O column	O3 profile	BrO profile
Change V6 vs V5	<ul style="list-style-type: none"> Reduced positive bias, Spread is similar, Negative drift of 1.5% / dec. at NH middle latitudes. 	Differences between the two SGP data versions are hardly noticeable and below the detection limit of the ground-based measurements.	<ul style="list-style-type: none"> Bias clearly reduced during 2006-2010, Spread is similar. 	Perhaps slightly better <ul style="list-style-type: none"> negative bias slightly reduced, possibly less outliers. 	No clear changes in data quality	As expected, V6 is very similar in quality to V5. It has slightly improved bias, short-term variability and estimates of random uncertainty in some regions of the atmosphere.	Very similar: <ul style="list-style-type: none"> BrO conc. increase by 0-3%, spread is quasi unchanged, again, no annual cycle.
Maturity evaluation	Representative global	Representative global, except in Tropics	Possible sampling issues, better precision expected for full mission	1 Arctic station	Representative land, perhaps ocean	Representative global, except in mesosphere	1 Arctic station
Observed issues	Positive overall bias, but not significant. Negative drift of 1.5% / decade at mid N latitudes.	No significant bias.	Very large bias and noise remains in monthly data.	<ul style="list-style-type: none"> Negative bias of -12%, spread of 18%, Use of total GB AMF improves agreement. 	Dry in most conditions.	<ul style="list-style-type: none"> AK induce vert. oscillations, Complicated bias patterns, Drift in MS, Quality worse in Arctic MS, Auxiliary data not adequate. 	Quality inferior to IUP product <ul style="list-style-type: none"> Larger bias, Larger spread, No annual cycle.

Backup

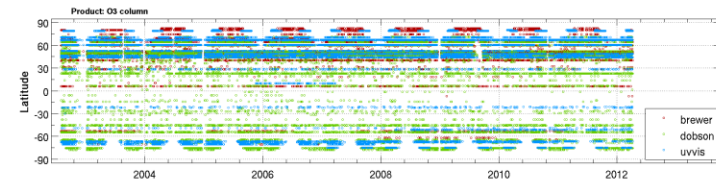
Diagnostic Data Set

Shown: difference in (latitude, time) sampling of
SCIAMACHY-ground co-locations for entire mission
and Diagnostic Data Set (5011 orbits)

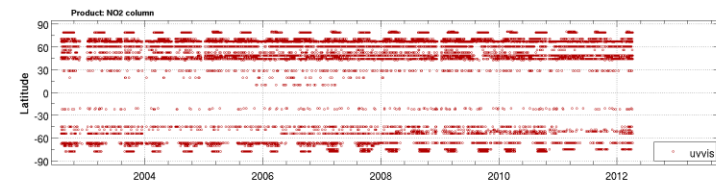
DDS-derived results are generally
representative in space and time, except

- space: BrO (only one station in Arctic)
and CO (1 station in Tropics + Antarctic)
- time : less CO data to compare
differences in monthly mean
→ full mission should increase
precision of bias estimates

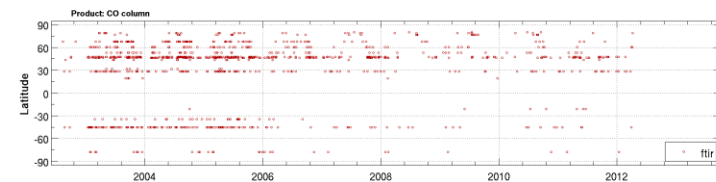
SCIAMACHY SGP V6 Diagnostic Data Set: co-locations with NDACC/WOUDC/CalVal data



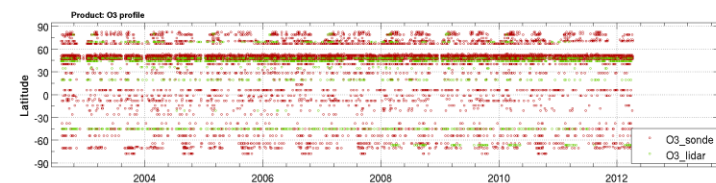
O3 column



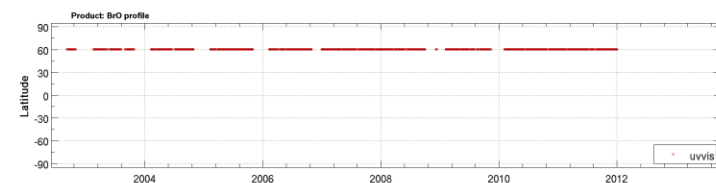
NO2 column



CO column



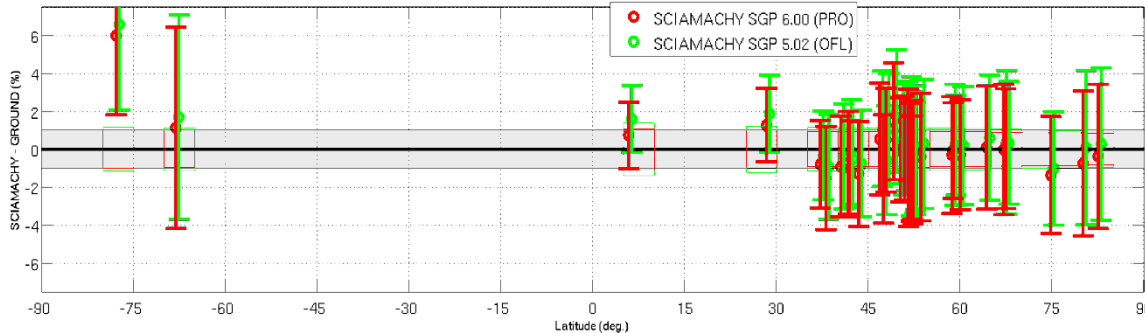
O3 profile



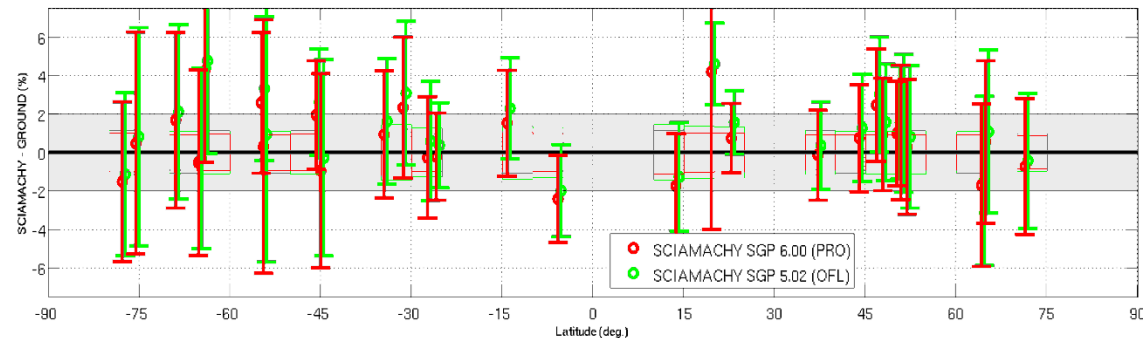
BrO column
/ profile

O₃ nadir column

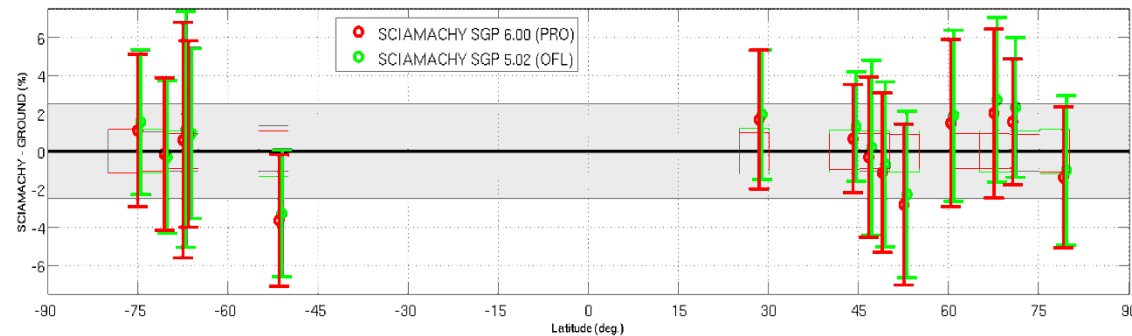
SCIAMACHY SGP 6.00 (PRO) and SGP 5.02 (OFL) vs NDACC/Brewer Network O₃ column



SCIAMACHY SGP 6.00 (PRO) and SGP 5.02 (OFL) vs NDACC/Dobson Network O₃ column



SCIAMACHY SGP 6.00 (PRO) and SGP 5.02 (OFL) vs NDACC/UV-Vis Network O₃ column

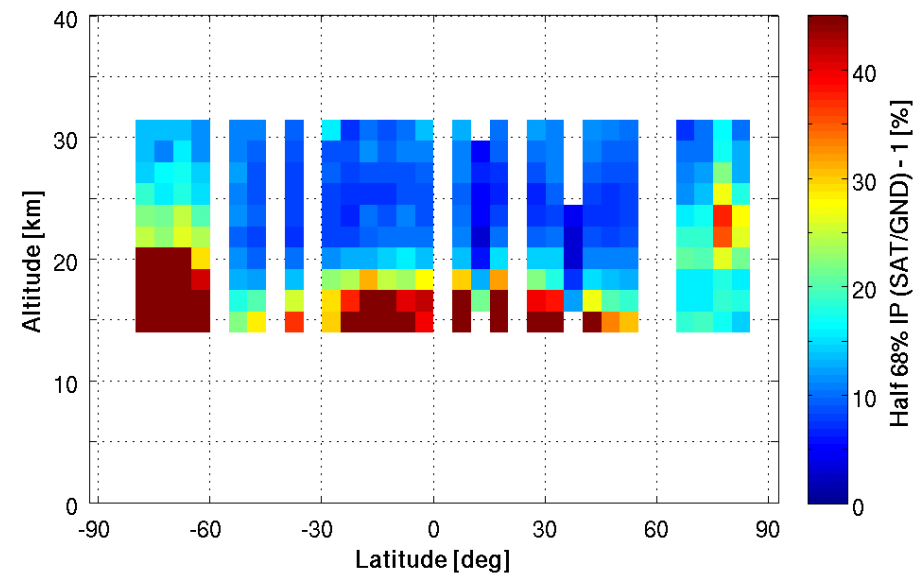
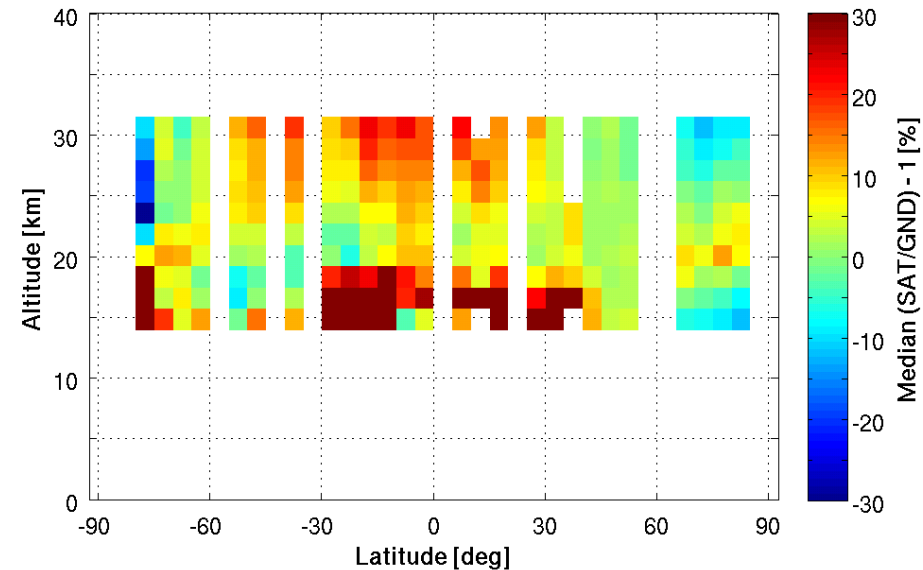


- Relative to V5, O₃ column reduced on average by 0.2-0.6% at most stations
- **Bias is hereby reduced, now at most +(1-1.5)%** (close to GND measurement uncertainties)
- No changes in SZA or cloud-dependence of bias
- No clear changes in spread

O3 limb profile

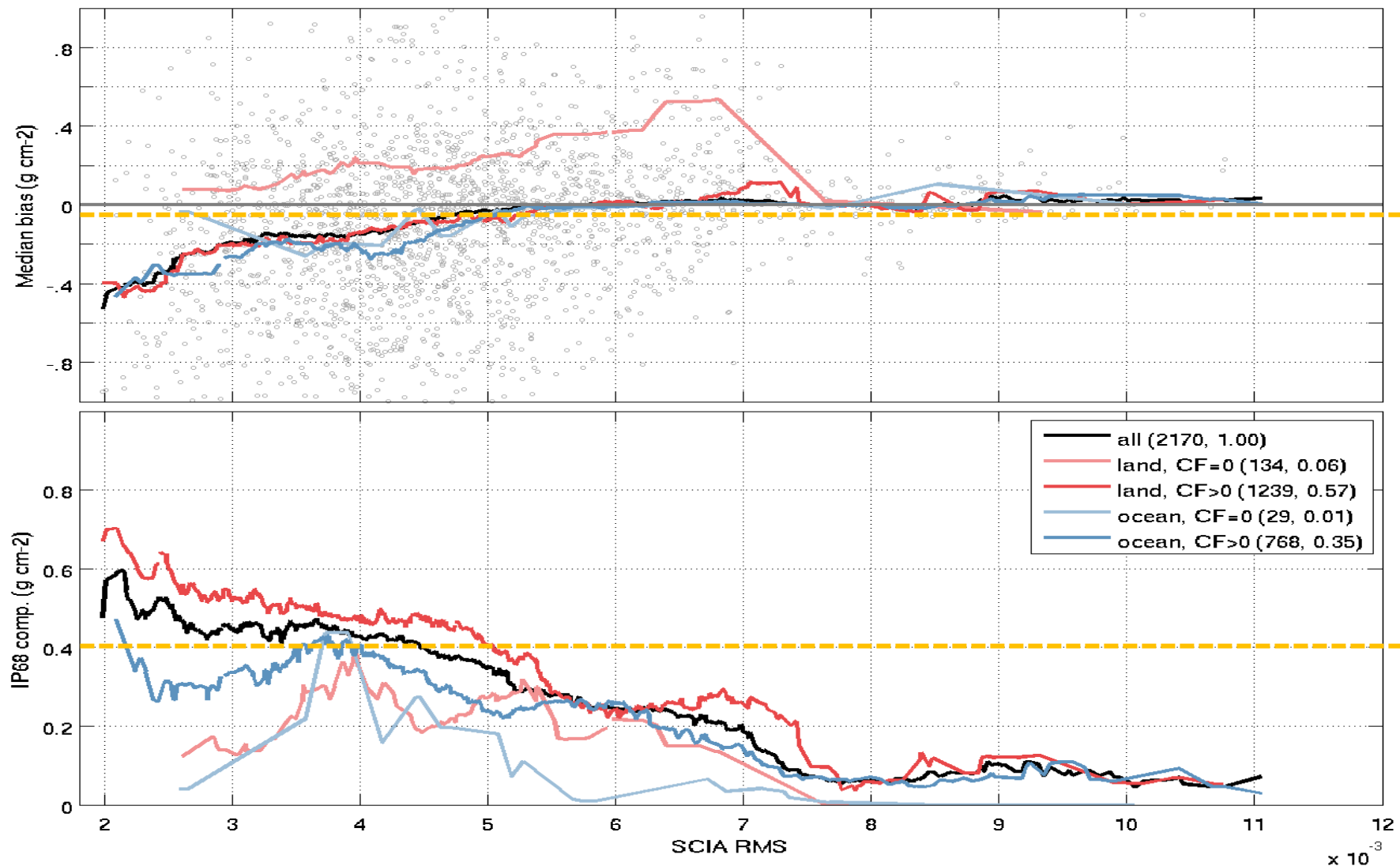
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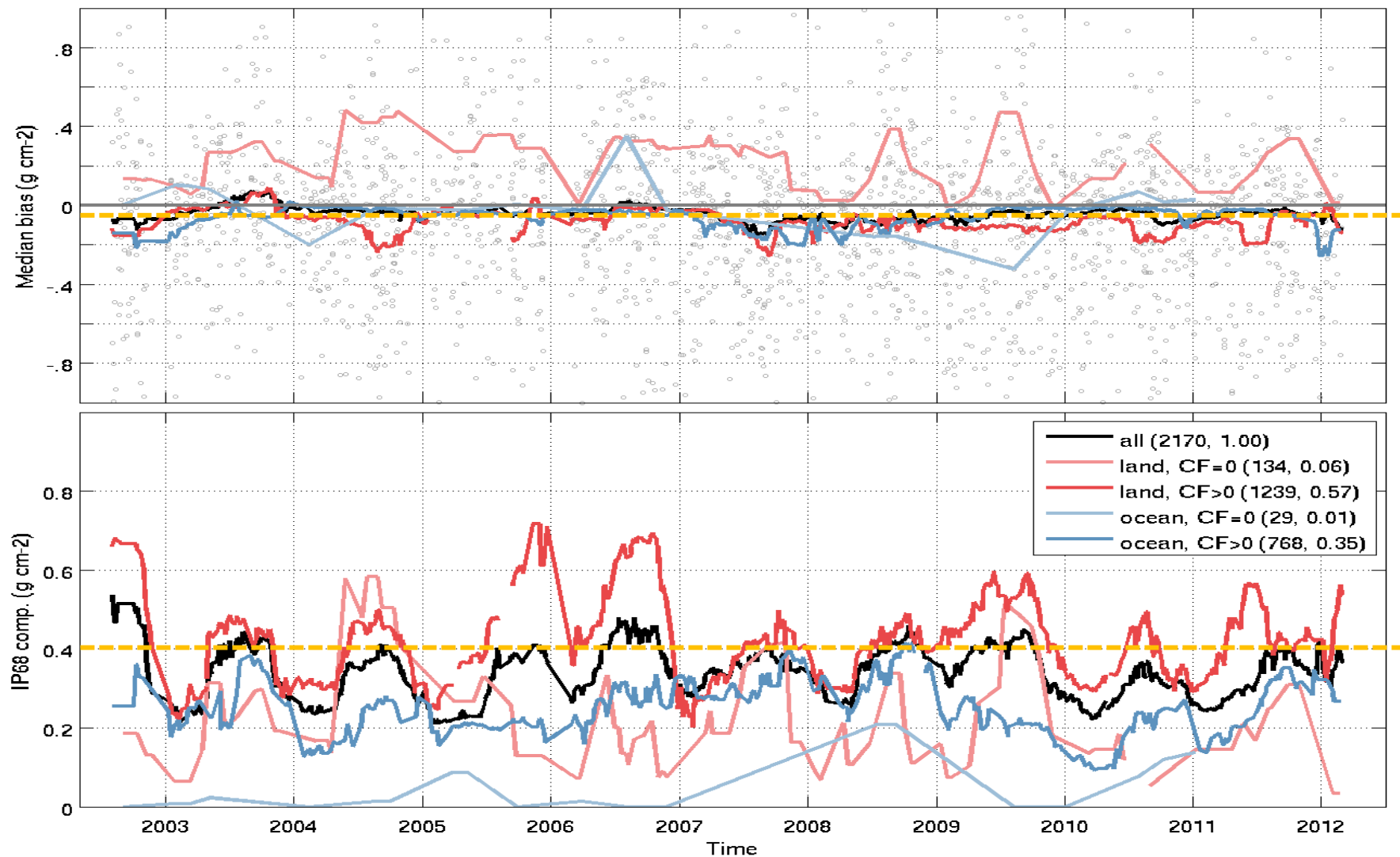
H2O nadir column

RMS



H2O nadir column

Time



H₂O nadir column

Cloud Optical Thickness

