Assessment of the internal consistency of the NDACC ozonesonde network by comparison with the satellite system of ozone profilers

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Satellite Science and Processing Teams

SAGE-II, OSIRIS, GOMOS, MIPAS, SCIAMACHY, Aura-MLS

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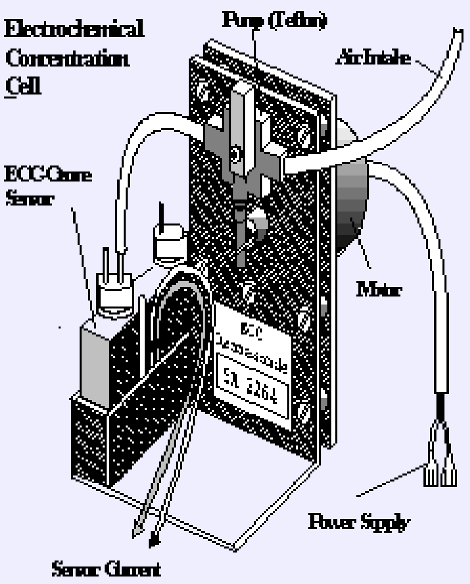
Ozonesondes = workhorse for ozone profile validation

E.g. contributions to ACVE…

- Limb profiles: GOMOS (Hauchecorne, Van Gijsel), MIPAS (Van Gijsel, Verhoelst), SCIAMACHY (Van Gijsel), OSIRIS (Adams), Envisat+TPM (Hubert)
- Nadir profiles: GOME (Keppens), GOME-2 (Delcloo), TES (Verstraeten)
- Ozonesonde data: Payerne/Nairobi (Stübi), Sodankyla/Marambio (Kivi), OHP (Pastel)

Why?

- In-situ measurement of p_{air}, T_{air} and p_{O3} from 0-33km with high vertical resolution (0.1-0.2km)
- Pseudo-global coverage with most stations offering weekly soundings (NDACC, GAW/WOUDC, SHADOZ)
- Data readily available and well-characterized [Smit and ASOPOS Panel (2011), WMO Report #201]
- But…



O3 profiles from ozonesondes…

$$P_{O3} = 0.04307 \cdot \eta_C \cdot \frac{T_P}{\Phi_P} \cdot (I_M - I_B)$$

- Ozone Pressure [mPa]
- Pump Temperature [K]
- Conversion Efficiency
- Pump Flow [cm3/s]
- Background Current [μA]
- Measured Current [μA]

[Smit / Oltmans, SI2N, Baltimore, 2012]

Simple measurement principle, but timeseries affected by

- Ozonesonde type & manufacturer (ECC Ensci, ECC SPC, Brewer-Mast, KC79, …)
- Sensing solution type and strength (SST1.0, SST0.5, SST2.0)
- Background current correction
- Pump flow rate / efficiency correction
- Pump temperature
- Radiosonde type (RS-80, RS-92, Modem, …)

→ Use satellite data records to evaluate possible inhomogeneities in timeseries of single stations or across the network

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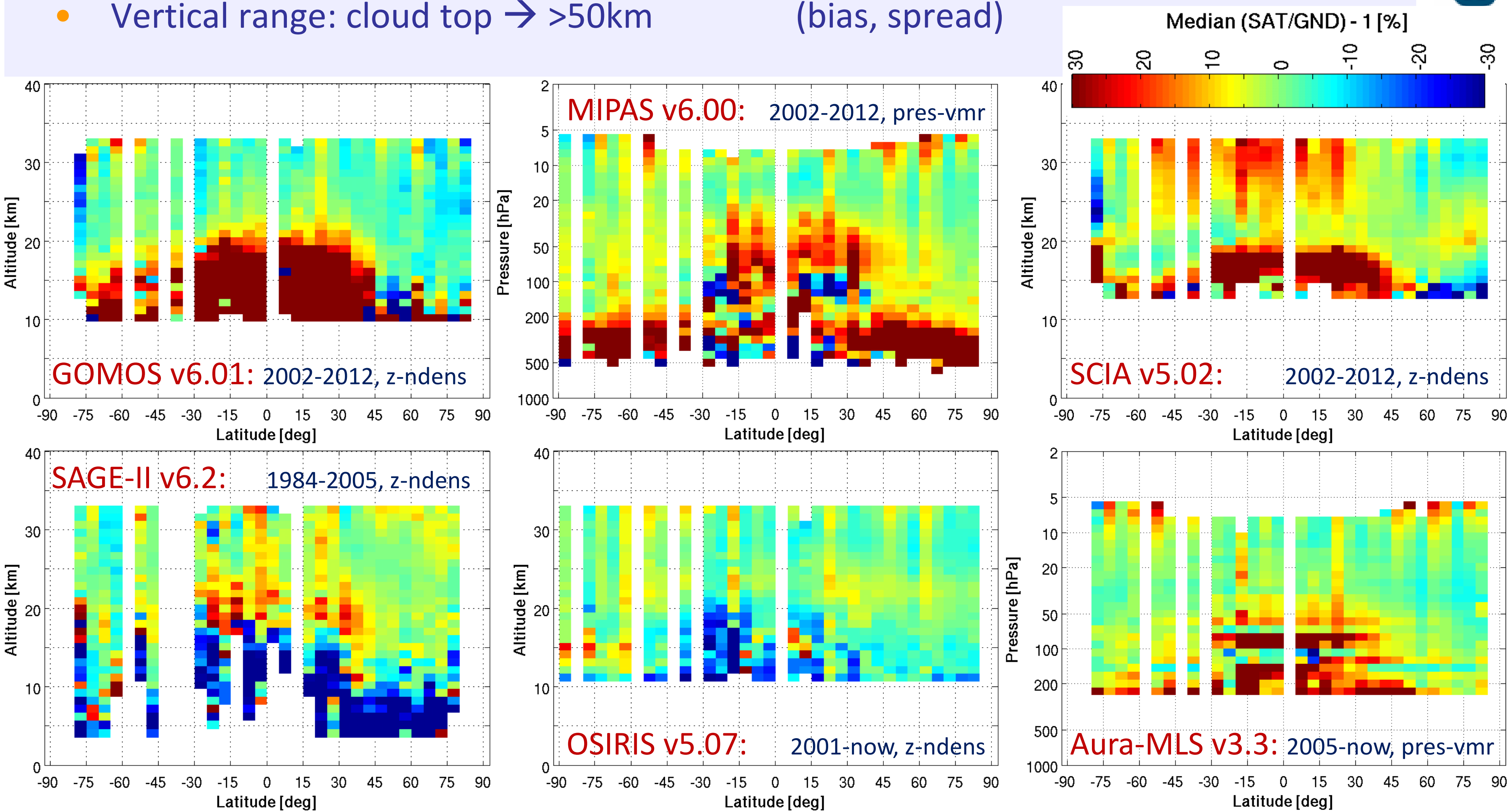
Satellite ozone profilers

- Complementary geometry, spectral range, retrieval techniques
- Good spatial, temporal sampling
- Vertical range: cloud top → >50km
- Vertical resolution: 1-3km
- Stable: drifts < 3% / decade
- Good data quality in stratosphere (bias, spread)



Methodology

Pre-processing

- Screening according to recommendations data providers
- Comparison pairs: within 500km and up to 6h/12h from O3sonde profile
- Comparison grid: ~1km spacing
- Coordinate systems:
  - pressure – volume mixing ratio (closest to O3S)
  - altitude – number density (closest to most SAT)
- Vertical smoothing of O3sonde profiles:
  - none
  - boxcar in altitude domain (width = SAT resolution)

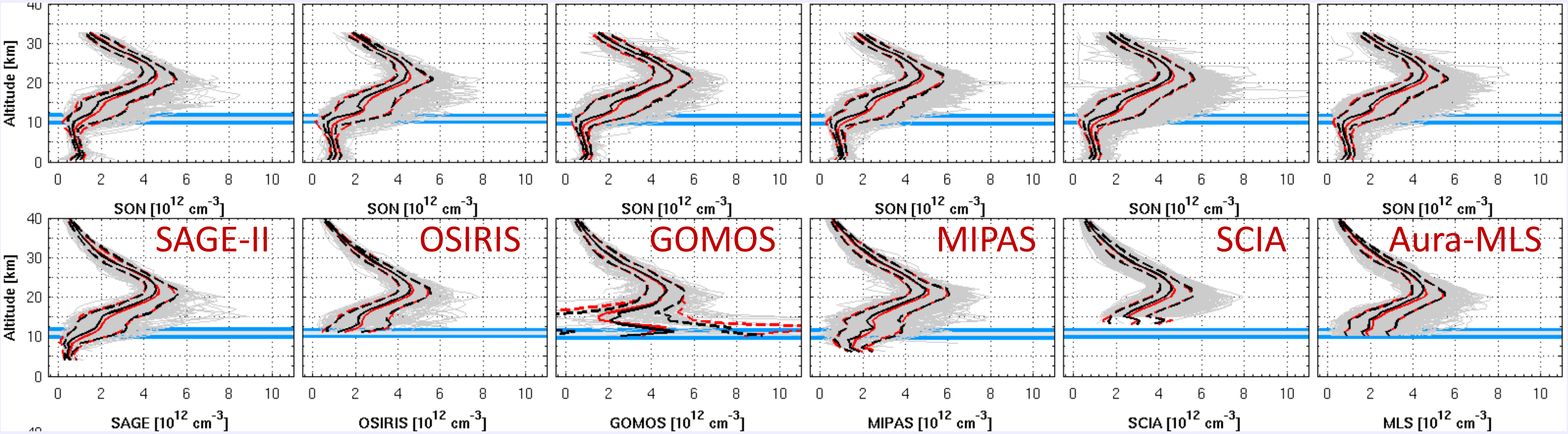
Analysis

- Single station
  - Determine bias w.r.t. each individual SAT data set
  - Compute weighted mean bias
- Across NDACC O3 sonde network
  - Compare multi-SAT bias at 30 NDACC stations

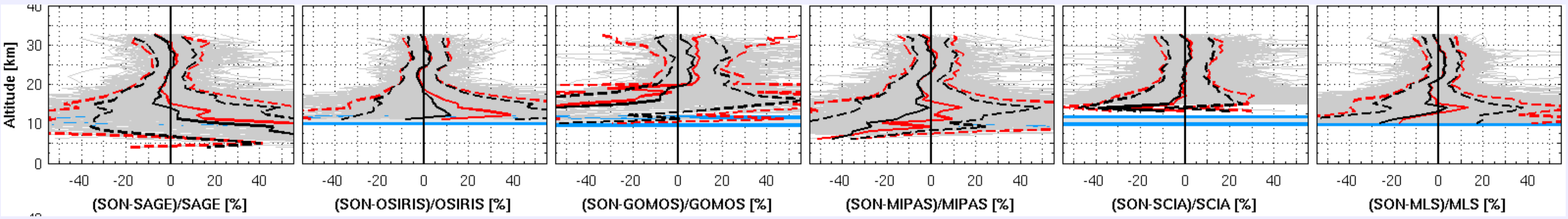
Comparisons at each station

Illustration for Uccle station

- O3S and SAT profile (median / mean statistics)



- Relative differences $\Delta X = X_{O3S}/X_{sat} - 1$



Multi-satellite weighted mean

Vertical structure similar for most satellites, at most stations

→ calculate weighted mean bias, for each O3sonde station

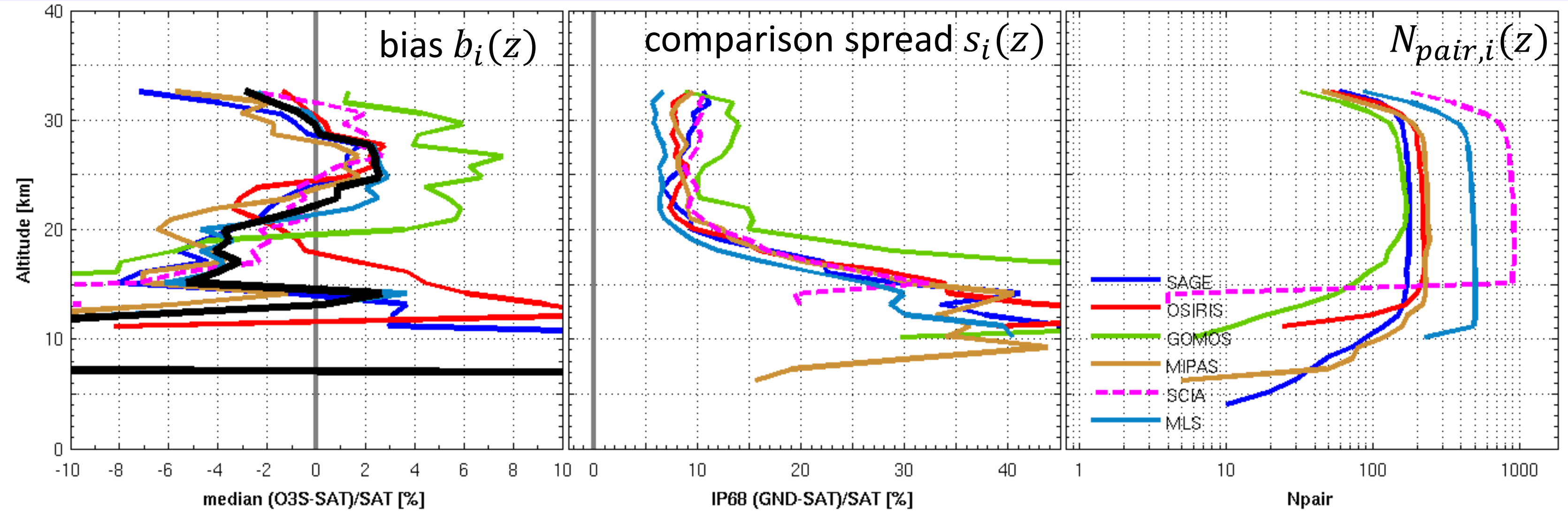
$$b(z) = \sum_{i=1\dots N_{sat}} w_i(z) b_i(z)$$

with $b_i(z)$ = bias O3S w.r.t. SAT i = median (O3S/SAT – 1)

$s_i(z)$ = comparison spread w.r.t. SAT i = 68% interpercentile (O3S/SAT – 1)

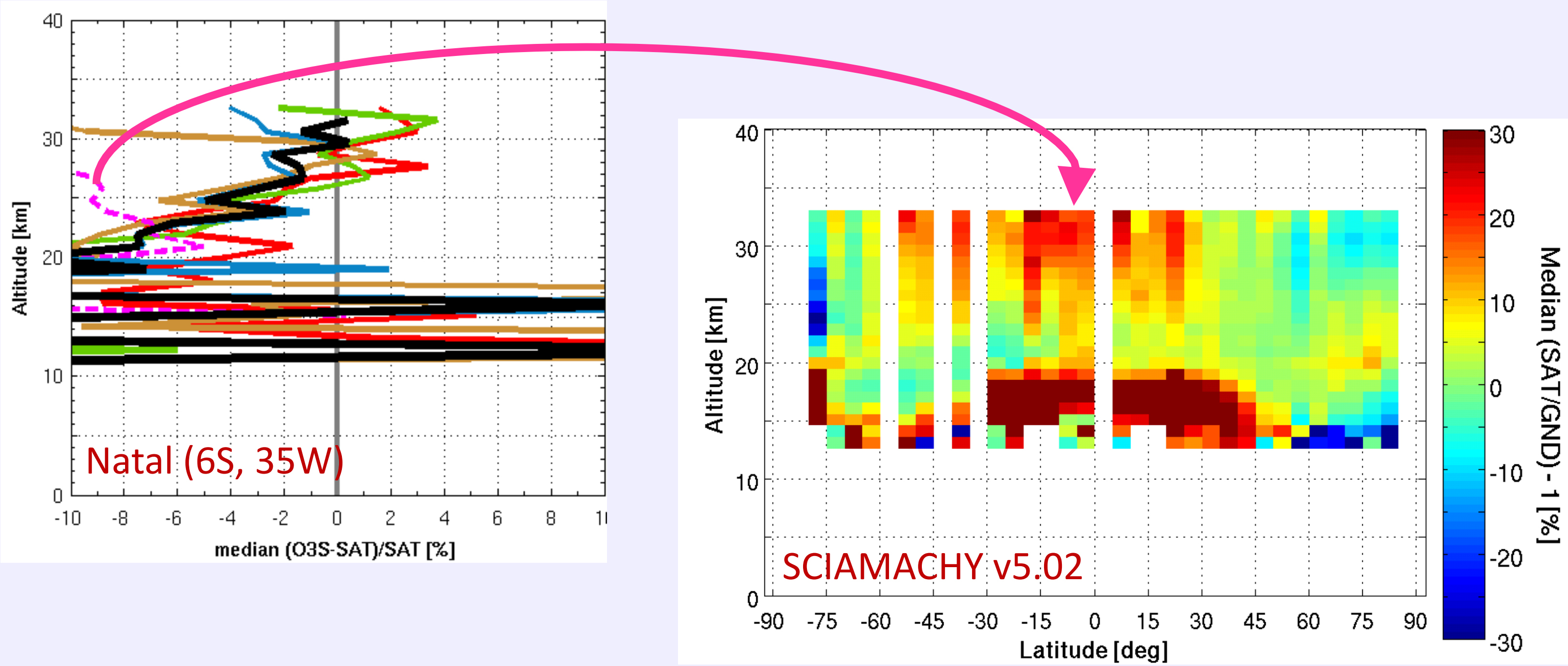
$$w_i(z) = \frac{1}{\left[s_i(z) / \sqrt{N_{pair,i}(z)} \right]^2}$$

Uccle (51N, 4E)



About the satellite sample

SCIAMACHY v5.02 bias inconsistent with other SAT instruments (especially in Tropics)
large contribution to $b(z)$ → excluded from weighted mean



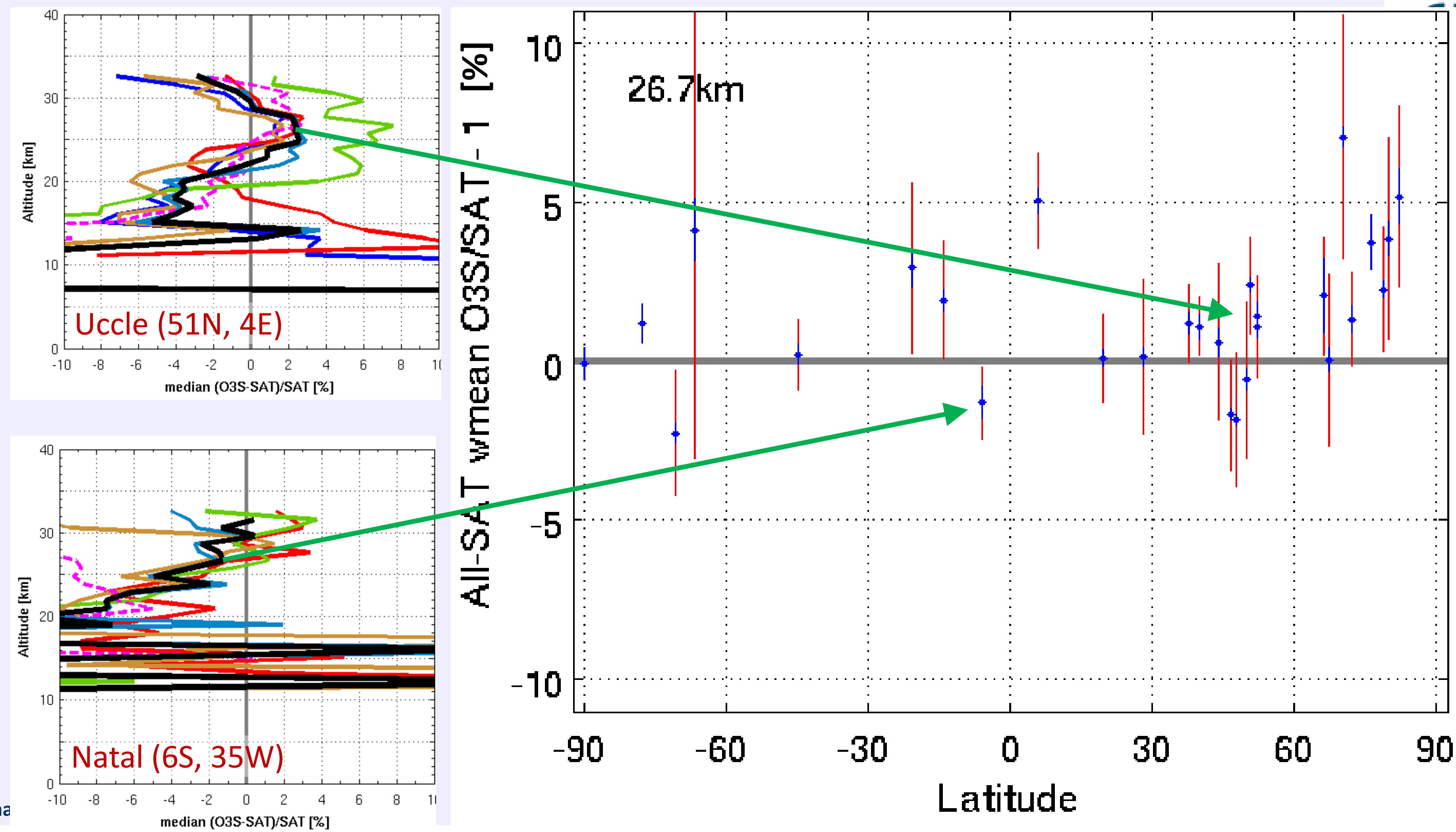
Weighted bias dominated by largest sample (spreads are similar)

1. Aura-MLS v3.3
2. OSIRIS v5.07, MIPAS v6.00
3. SAGE-II v6.2, GOMOS v6.01

Internal consistency NDACC O3S network

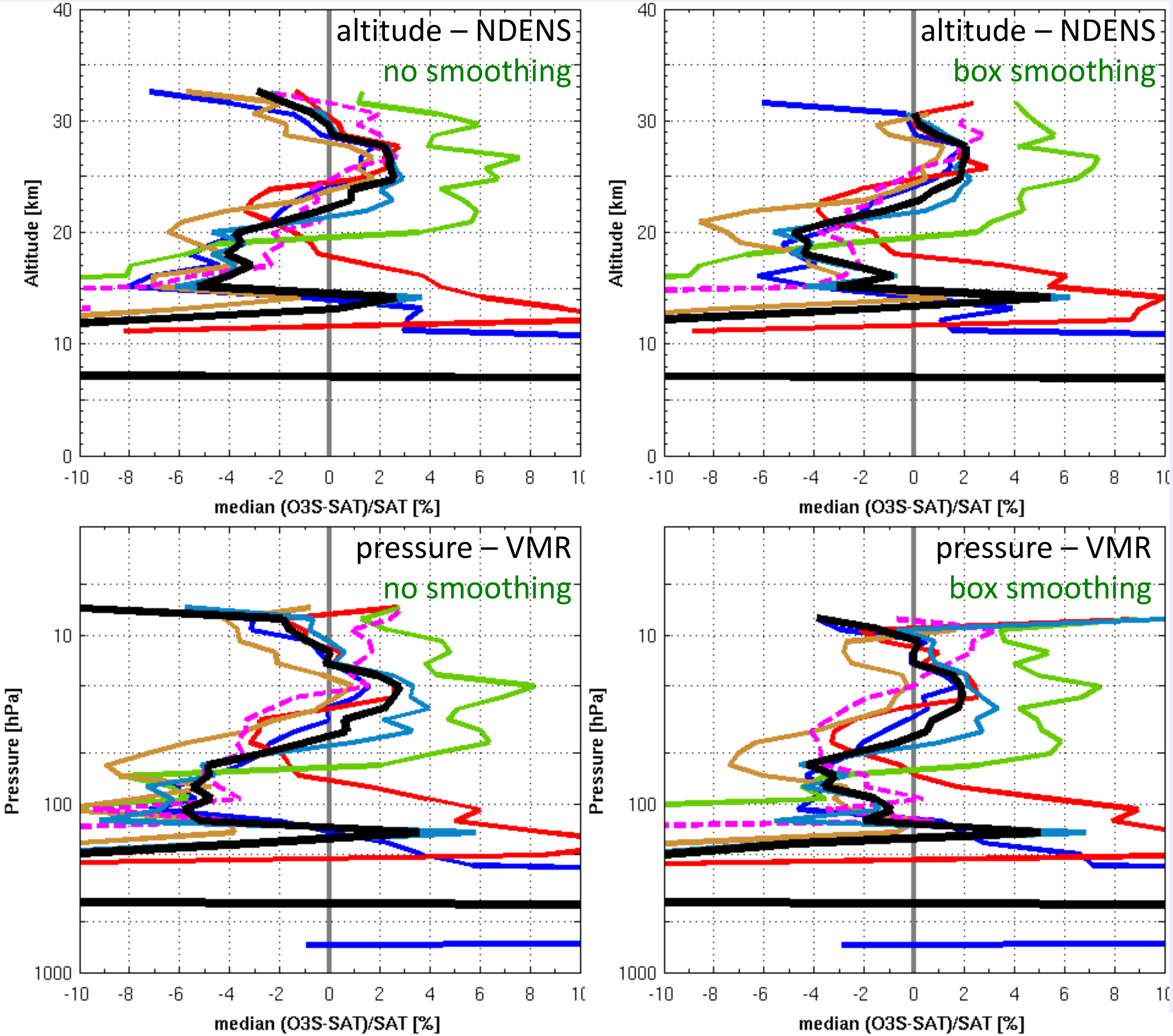
Meridian structure O3S bias at ozone peak

- Error bars: std.dev. of weighted mean or std.dev. of weighted sample



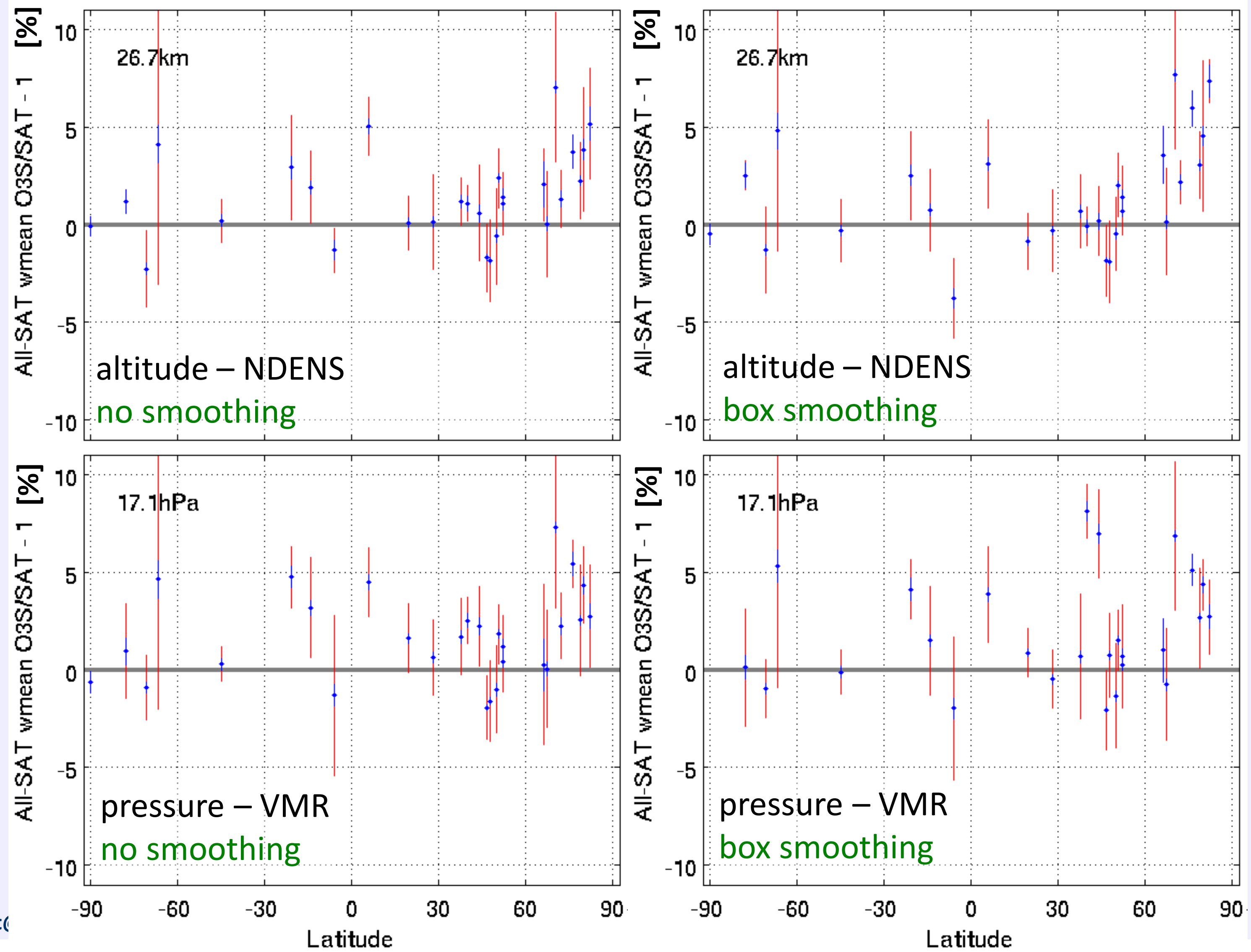
Sensitivity checks: coordinate & vertical smoothing

Consistent results at Uccle (51N, 4E)



Sensitivity checks: coordinate & vertical smoothing

Consistent results at most stations

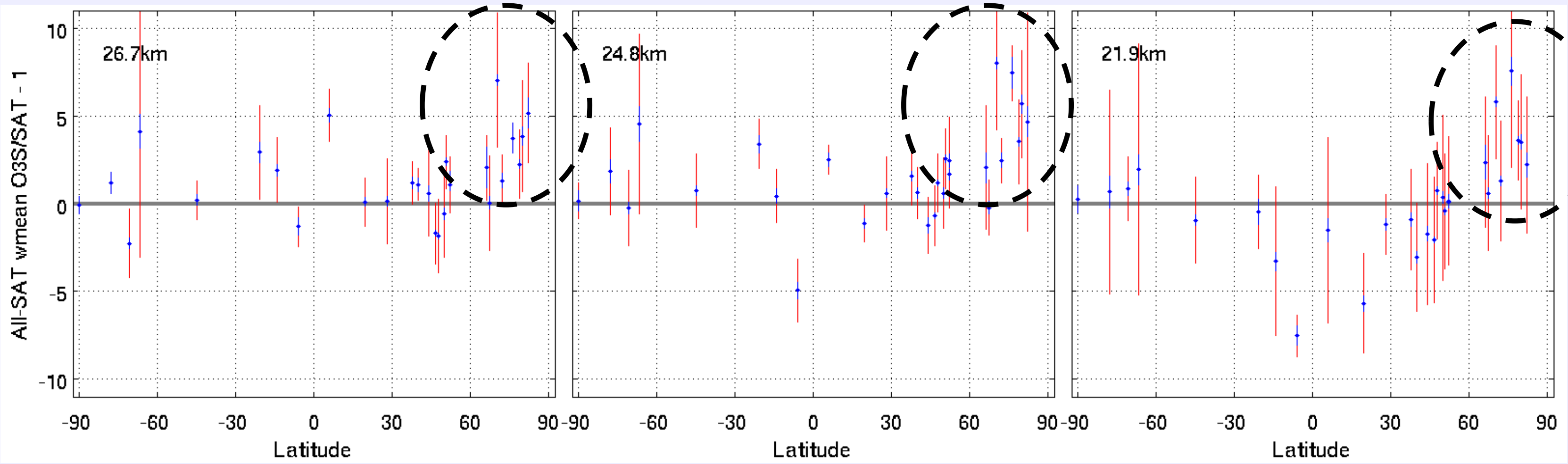


Internal consistency NDACC network

PRELIMINARY

Middle stratosphere : 22-27km

- Very good sonde and satellite data quality
- Most O3 sonde stations within 1-2% from multi-SAT sample
- Station-to-station variability smaller than ~3%



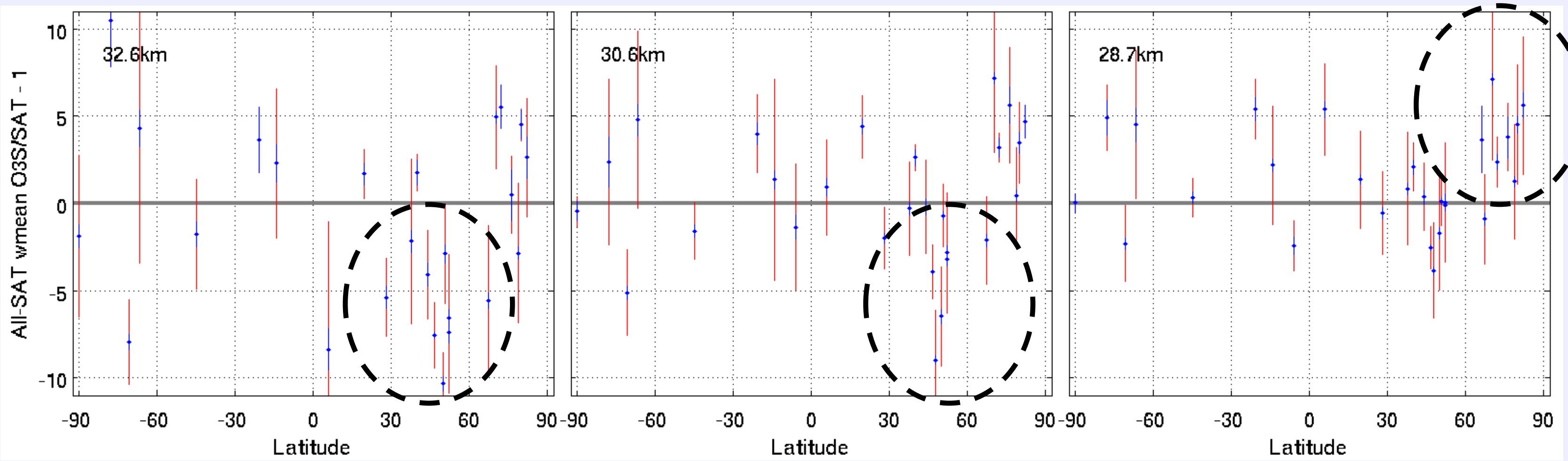
- Positive bias of about +4% at high Northern latitudes
  - Needs further investigation

Internal consistency NDACC network

PRELIMINARY

At the top of the ozonesonde profile : 29-33km

- Increased station-to-station variability, but mostly consistent within error bars
  - Possibly caused by differences/uncertainties in pump flow correction, radiosonde, sensing solution type, …



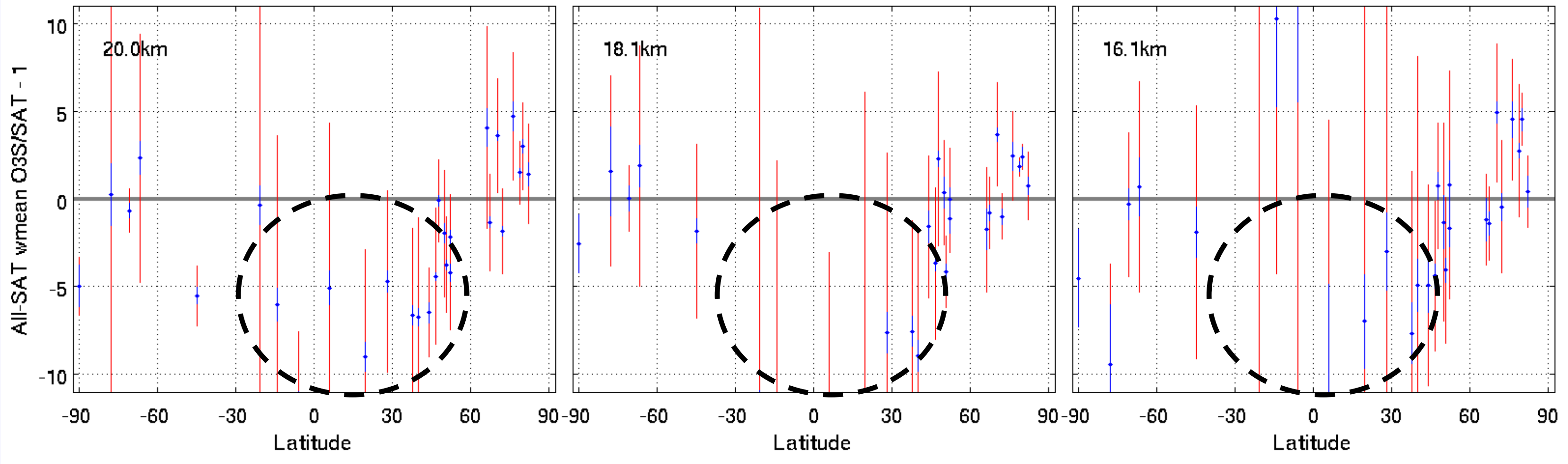
- Northern mid latitudes stations possibly have ~5% low ozone w.r.t. satellites above ~30km

Internal consistency NDACC network

PRELIMINARY

Lower stratosphere : 16-20km

- Increased uncertainties due to
  - Lower S/N for satellite records
  - Increased natural variability



- Apparent negative sonde bias in Tropics
  - Very likely caused by positive bias of most satellite instruments, rather than sonde issue (TBC)

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Conclusions

Study of internal consistency O3sonde data

- Satellites offer possibility to evaluate O3sonde data quality
- Vertical structure sonde bias w.r.t. different SAT instruments very similar
  → weighted multi-SAT mean bias makes sense
- Is not very sensitive to coordinate / vertical smoothing changes at bulk of tested stations

Preliminary results for NDACC data

- Variability between sonde stations below 3 percent over 22-27 km
- Above 28km, larger station-to-station variability
- Below 20km, more challenging to evaluate sonde record due to decreased SAT data quality and increased natural variability

Future work

- Consolidate analysis
- Extend to WOUDC, SHADOZ data
- Evaluate newly homogenized O3S data from O3S-DQA initiative

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The O3S-DQA

O3 Sonde **D**ata **Q**uality **A**ssessment

- Two major objectives
    1. Homogenization of selected ozone sonde data sets to be used for this ozone assessment: Goal reduce uncertainty from 10-20% down to 5-10% (focus on transfer functions)
    2. Documentation of the homogenization process and the quality of ozonesonde measurements generally to allow the recent record to be linked to the older records

- Proposed guidelines to homogenize O3 sonde records at 50 participating stations should result in
    - Reduced temporal inhomogeneity at single stations (reduce jumps in time series) → important for SAT drift analyses
    - Reduced spatial inhomogeneity between stations → important for SAT bias validation
    - Introduction of uncertainty values for each measurement level in the profile
    - Extensive documentation of homogenization process

- Ready in 2013…

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