Poster-18

An Update on the SMILES NICT Level-2 Processing

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on behalf of **SMILES NICT team**

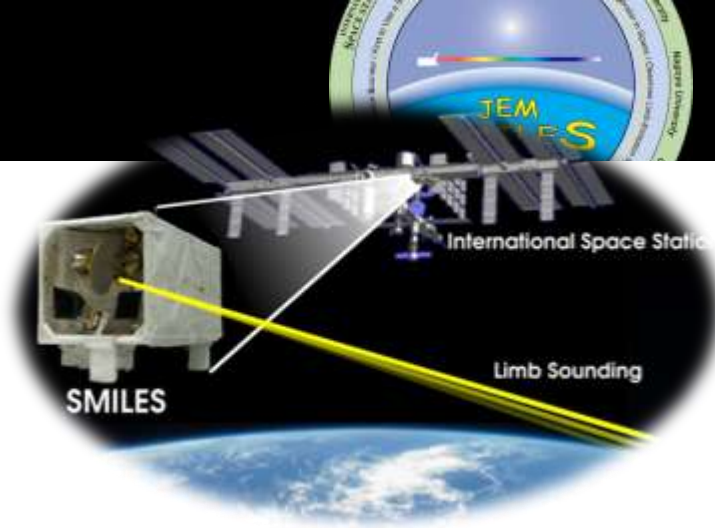
1. NICT/Japan

- Outline

- Overview of the JEM/SMILES
  - Instrumental specification
  - Observation characteristics
- Status of validation of the SMILES level-2 research product
  - Error analysis of L2r O3 product
  - Inter-instruments comparison of O3 profiles with MLS, SMR, MIPAS, OSIRIS, and Ozonesonde
- Ongoing updates with a new version of the calibrated data

- JEM/SMILES

Superconducting SubMillimeter-Wave Limb-Emission Sounder
onboard the Japanese Experiment Module of the International Space Station



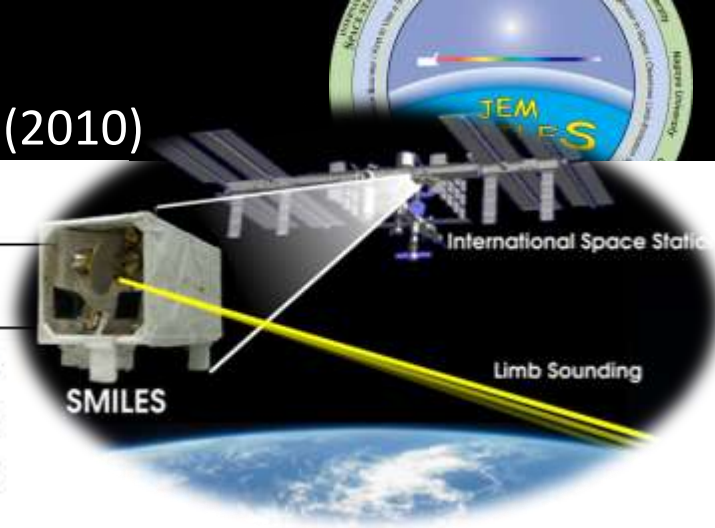
- Jointly developed by JAXA & NICT.
- Launched on 11 Sep. 2009.
- Installed on JEM/ISS: **Non sun-synchronous orbit** with an inclination angle of 51.6 deg.
- **4-Kelvin cooled SIS receivers** (625 & 650 GHz bands).
- Started the scientific operation from Oct. 2009, and finished 21 Apr. 2010 (due to a failure in the local oscillator).
- Operational level-2 product is processed in the ground segment in JAXA [e.g., Takahashi et al. 2010]; another **level-2 research product** (topic of this presentation) **is processed in NICT**.

- Inst. Specification

Kikuchi et al. (2010)

Table 1. Specifications of the SMILES Instrument

	Specified Value
Frequency coverage	Band A: 624.32–625.52 GHz Band B: 625.12–626.32 GHz Band C: 649.12–650.32 GHz
Frequency sampling	0.8 MHz
Frequency resolution	~1.1–1.2 MHz (full width at half maximum)
System noise temperature	~350 K
Integration time	0.5 s for each observation tangent point
Noise level in brightness temperature	<0.7 K (for 0.5 s integration time)
Calibration accuracy	<1.0 K (for 0.5 s integration time)
Observation cycle	53 s
Observation altitude range	10–60 km (nominal)
Vertical sampling	~2 km (nominal)
Instrumental height resolution (IFOV)	3.5–4.1 km (nominal)
Observation latitudes	38°S–65°N (nominal)
Observation azimuth angle	−10–95° (0 = north)
Power consumption	~320 W (at beginning of life)
Payload weight	476 kg
Payload size	0.8 m (W) × 1 m (H) × 1.85 m (L)

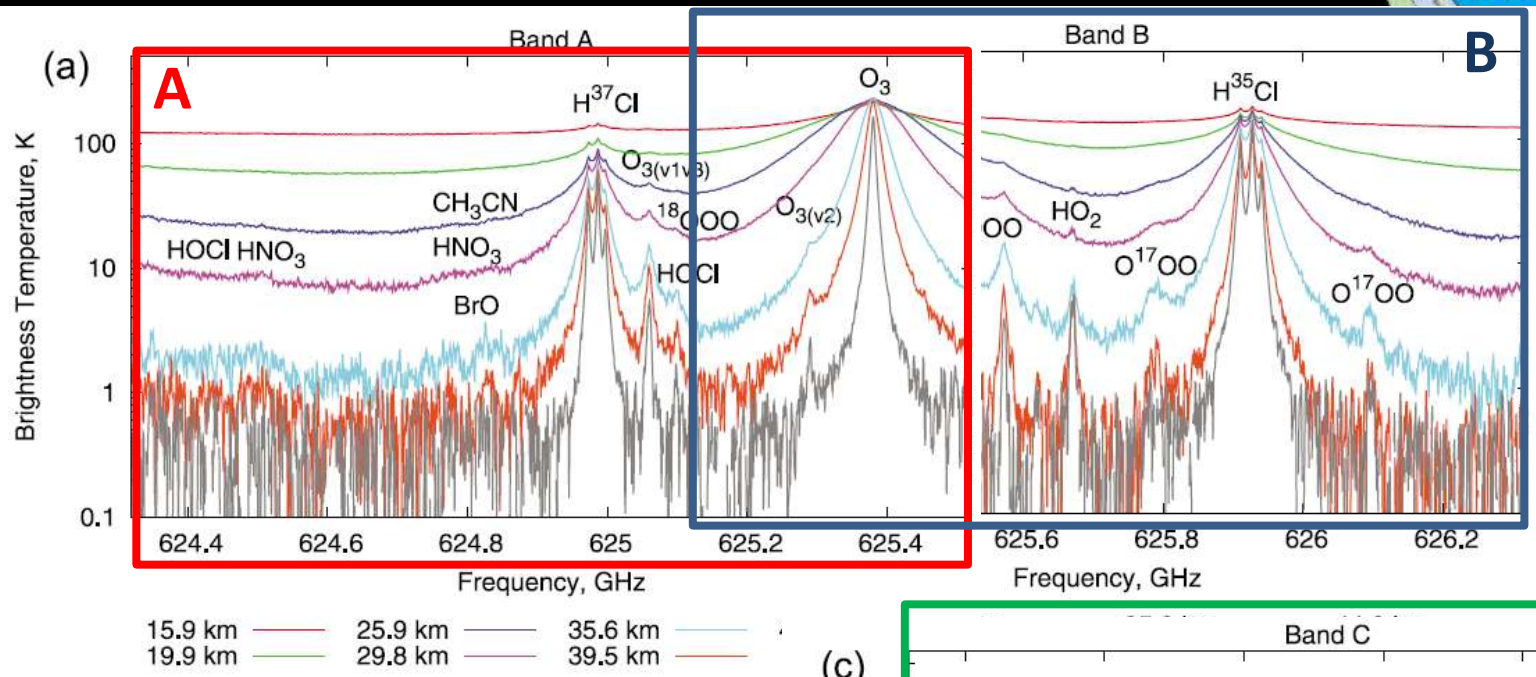


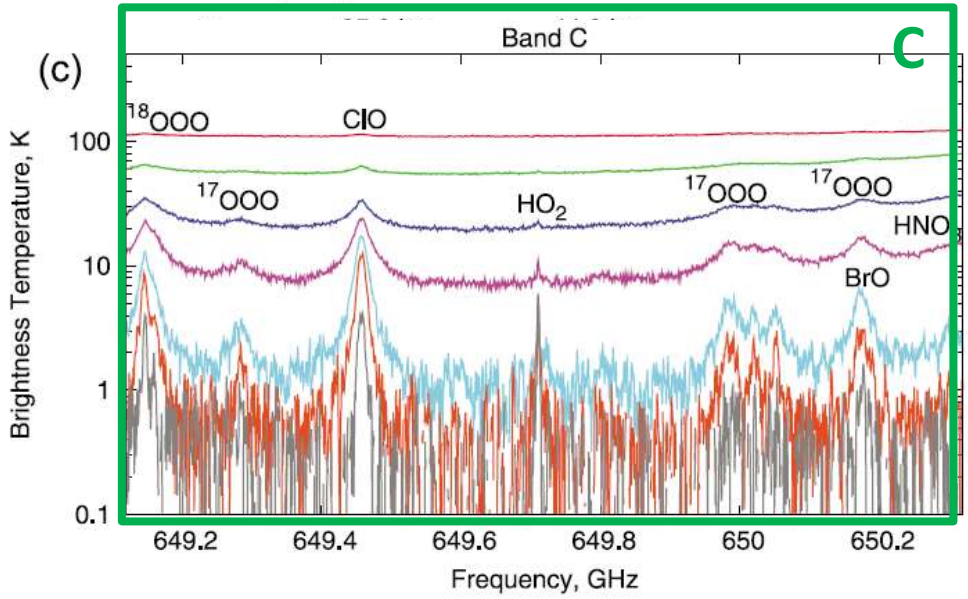
A factor of 10 – 20 better than the before-SMILES submm limb emission sounders.

Enables us to observe the trace gases in the mesosphere!

Shifted a bit northward from the original latitude range restricted by the ISS orbit inclination (51.6 deg.).

- Observation Spectra





3 Bands (A, B, C) in 600 GHz domain.

Bands A & B overlap on O_3 625 GHz line.

Thanks to having two spectrometers, **two of the three Bands were observed simultaneously, i.e., A+B, B+C, or C+A**.

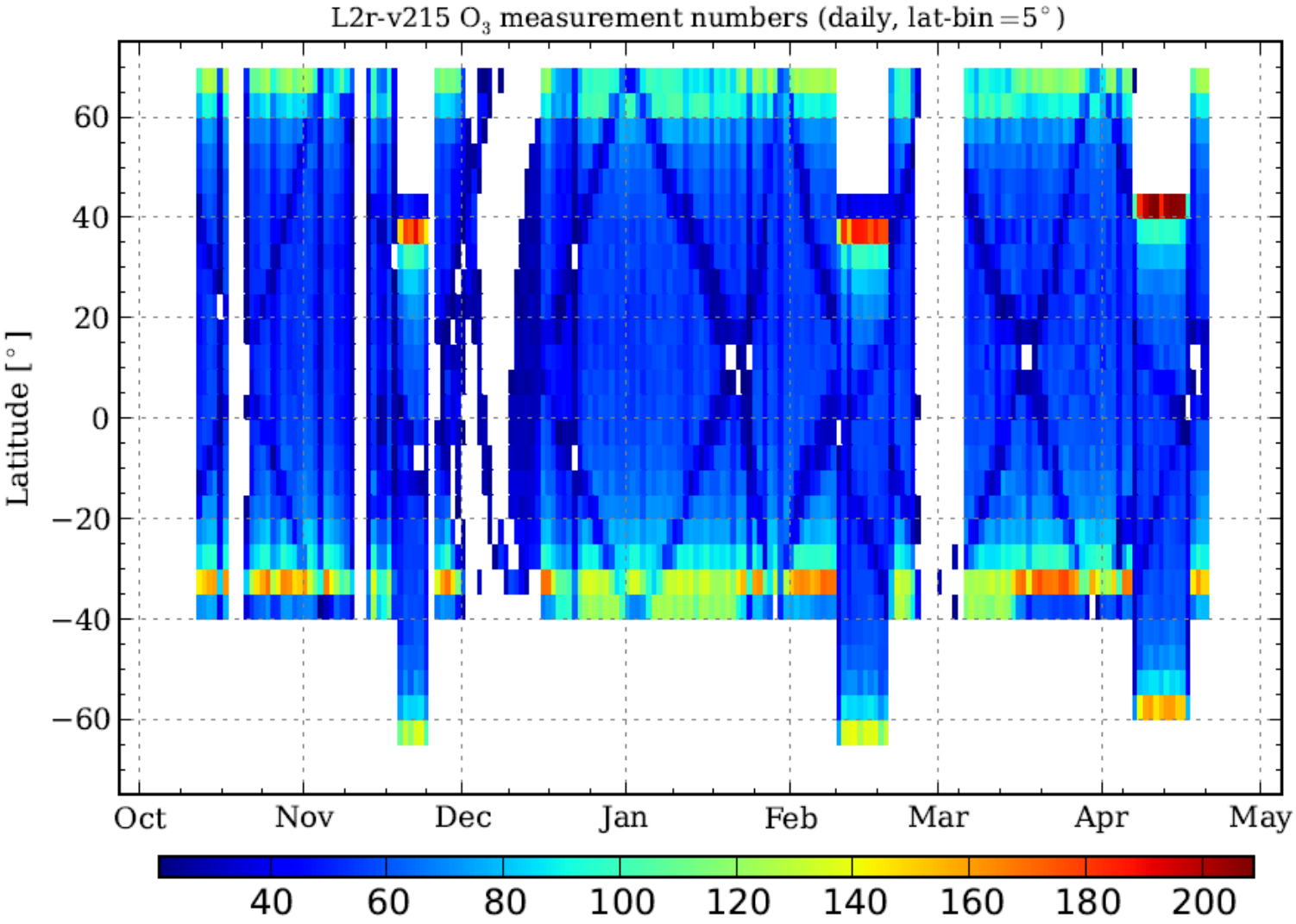
This means, some species were continuously observed over the full SMILES period (O_3, HCl, HO_2, BrO, etc).

Kikuchi et al. (2010)

- Obs. Sampling Density

approx. 1600 scans/day provides one global map per day

…with a quite inhomogeneous sampling density !



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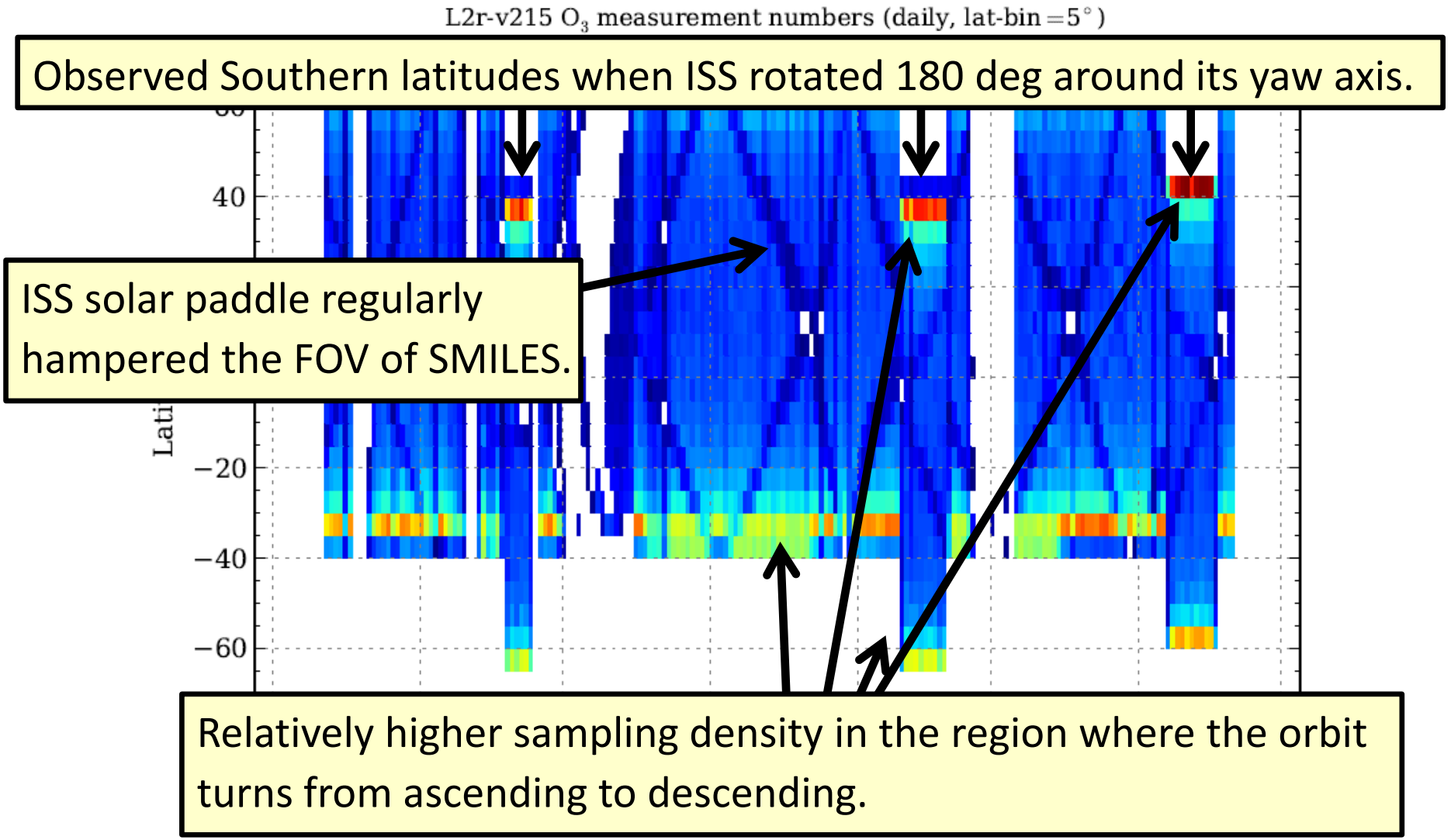
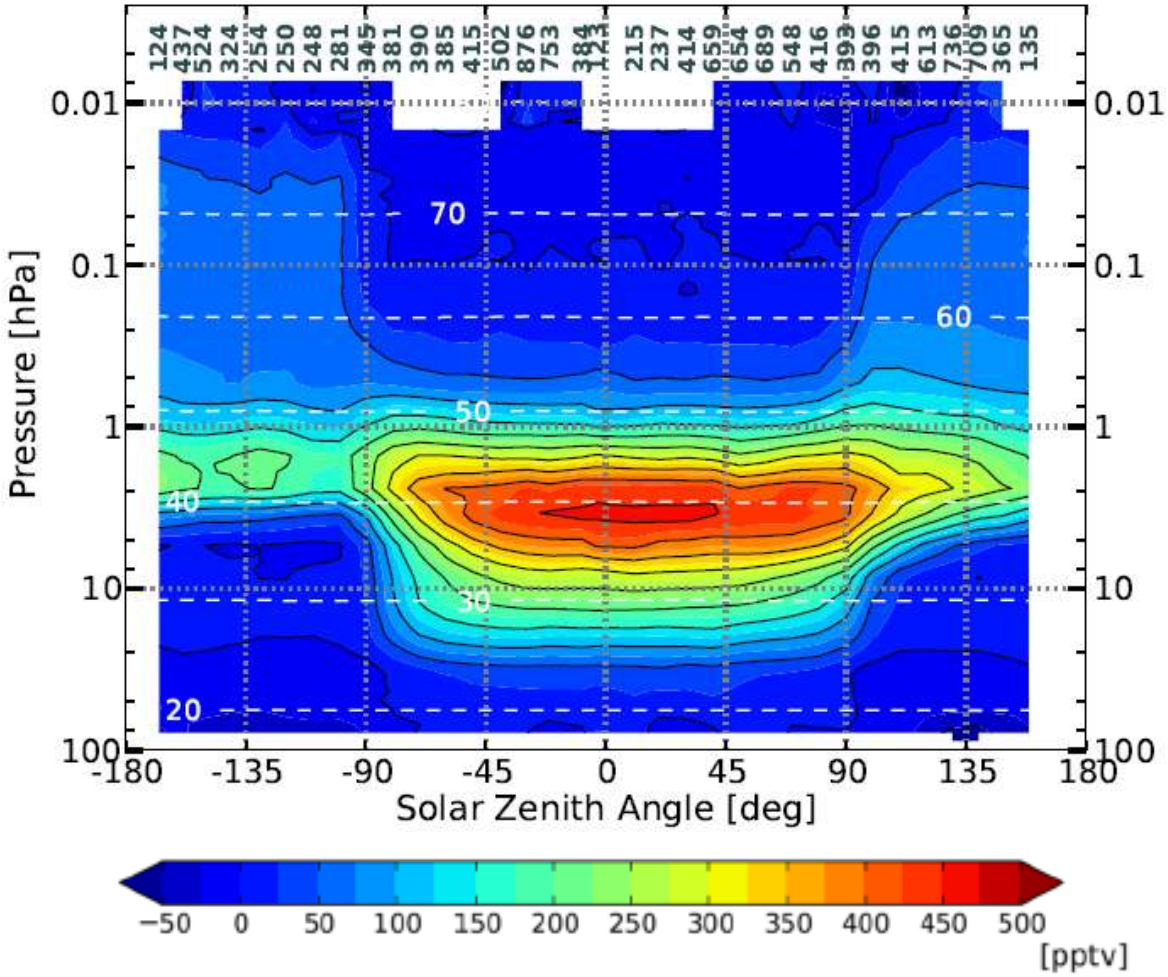


- ISS Non-Sun Synchronous Orbit

…provides the capability to study the diurnal variations!!



← **Diurnal variation** (as a function of the solar zenith angle) **of ClO** obtained from SMILES observations of Oct. + Nov. 2009 (20S – 20N).

Daytime enhancement of stratospheric ClO and the opposite behavior in the mesosphere: Drastic diurnal behavior of ClO is nicely observed ☺ !

Sato et al. (2012)

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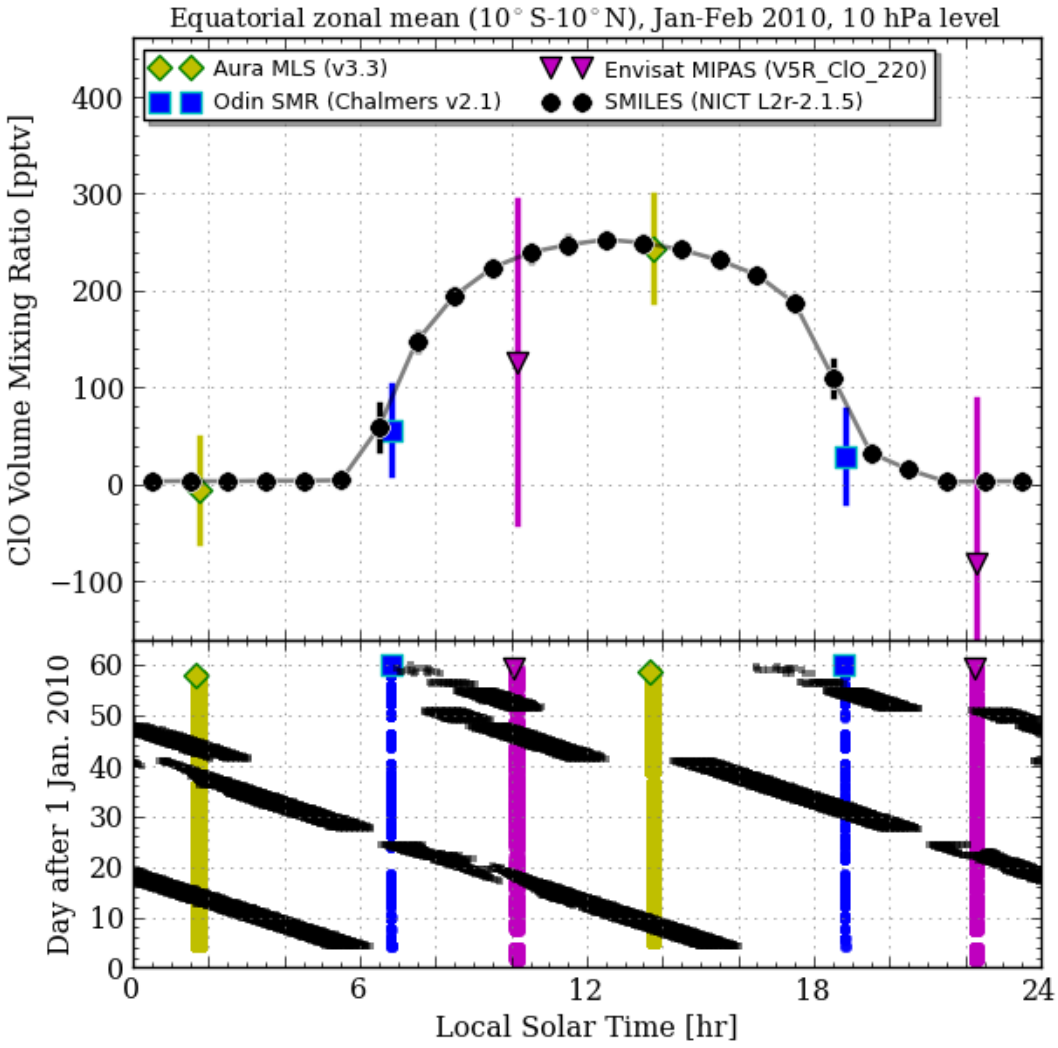


For the short-lived species such as ClO, **SMILES dataset can be a good reference for validating other satellites' measurements** which have fixed local time data samplings.

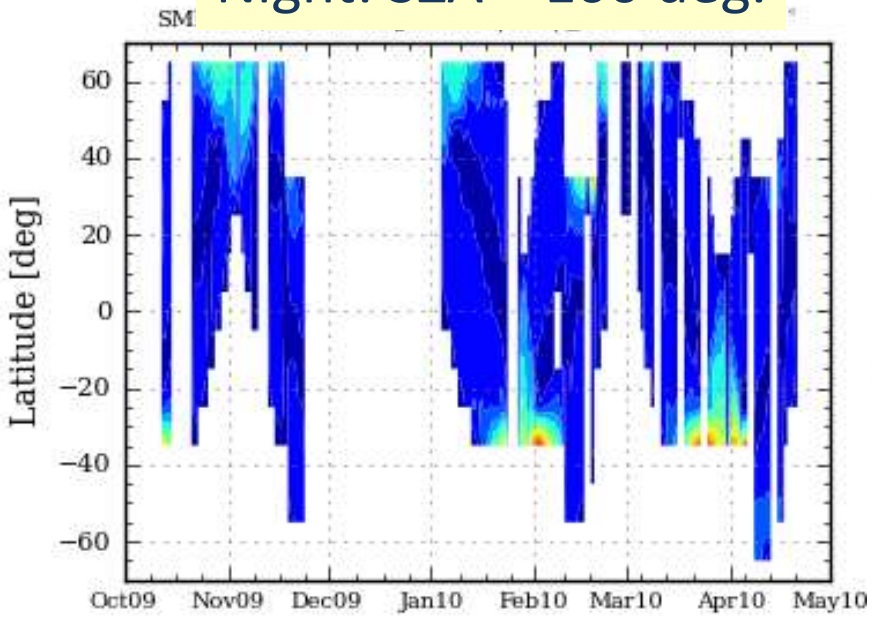
Sagawa et al. (2013)

- ISS Non-Sun Synchronous Orbit

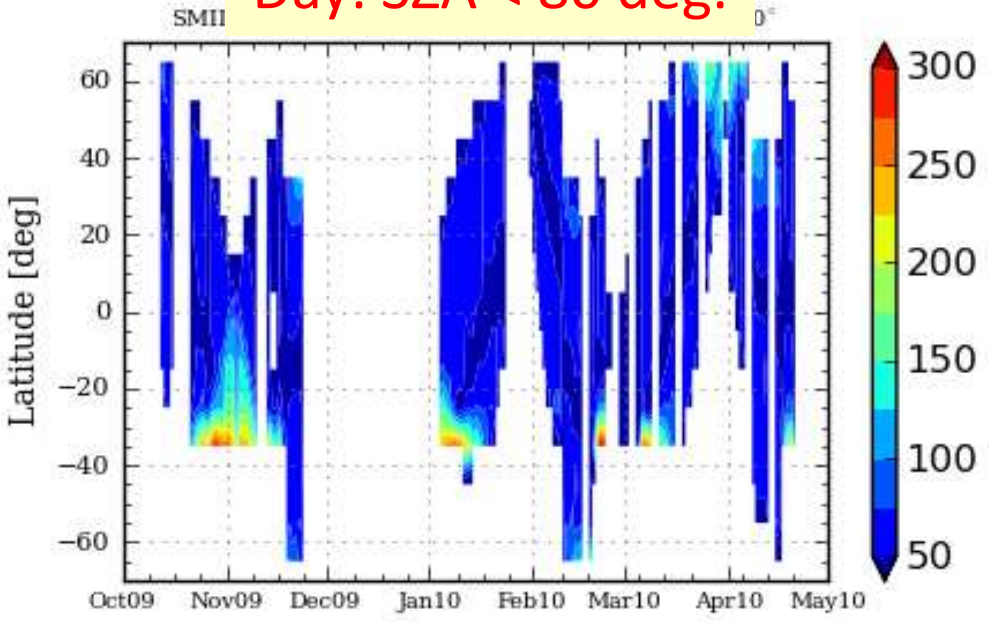
…provides the capability to study the diurnal variations!!

… but don't forget about its non-uniform sampling issue!

Night: SZA > 100 deg.



Day: SZA < 80 deg.



For example, there are no night time measurements in Southern latitudes at late-Feb/early-Mar 2010.

A "simple" data averaging over latitudes or dates can introduce a significant bias into the output mean.

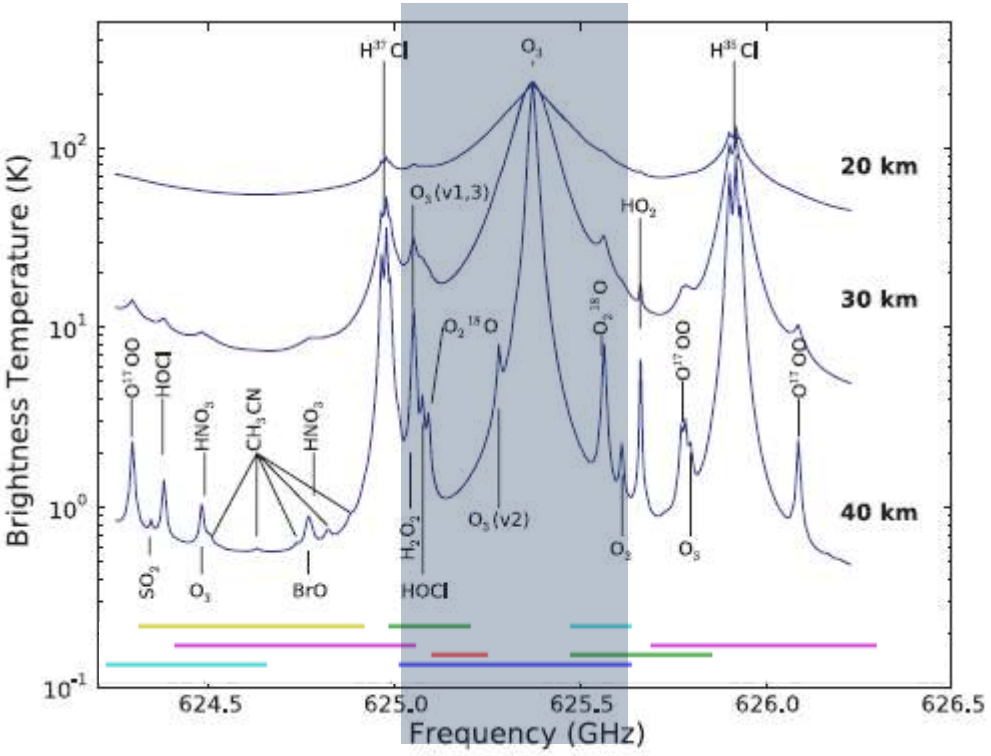
- NICT Level-2 Research Processing

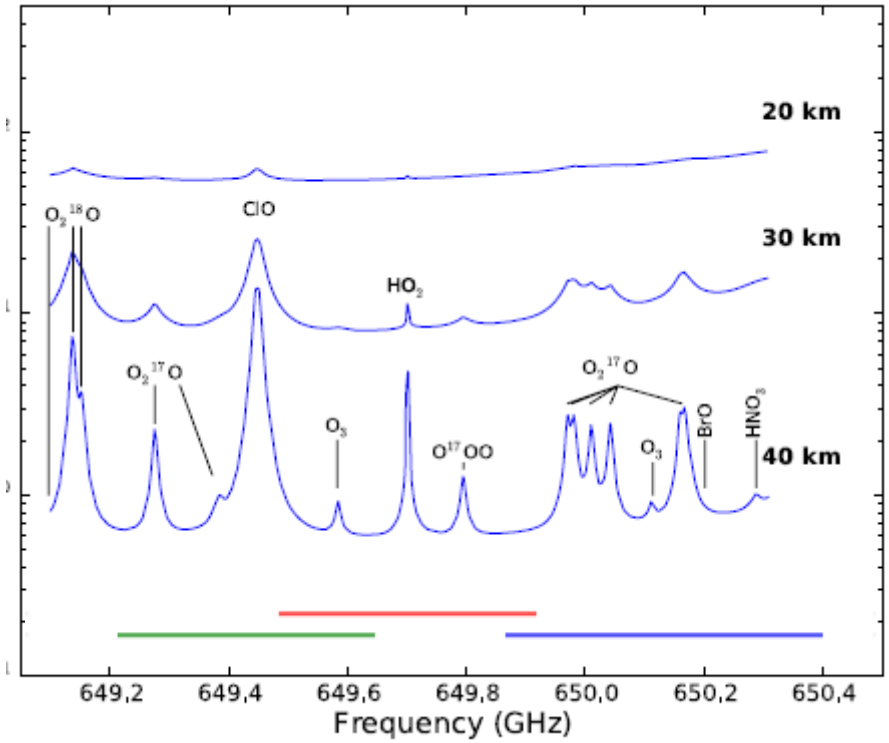
Detail description of its algorithm is published in Baron et al. (2011).

Major characteristics are:

- Use limited frequency range for each species and process sequentially starting from the more strong lines, instead retrieving all the species at once from the full band width.

→ Brings an improvement in the baseline fit of weak opacity lines at the expense of depressing sensitivity to the lower altitudes.





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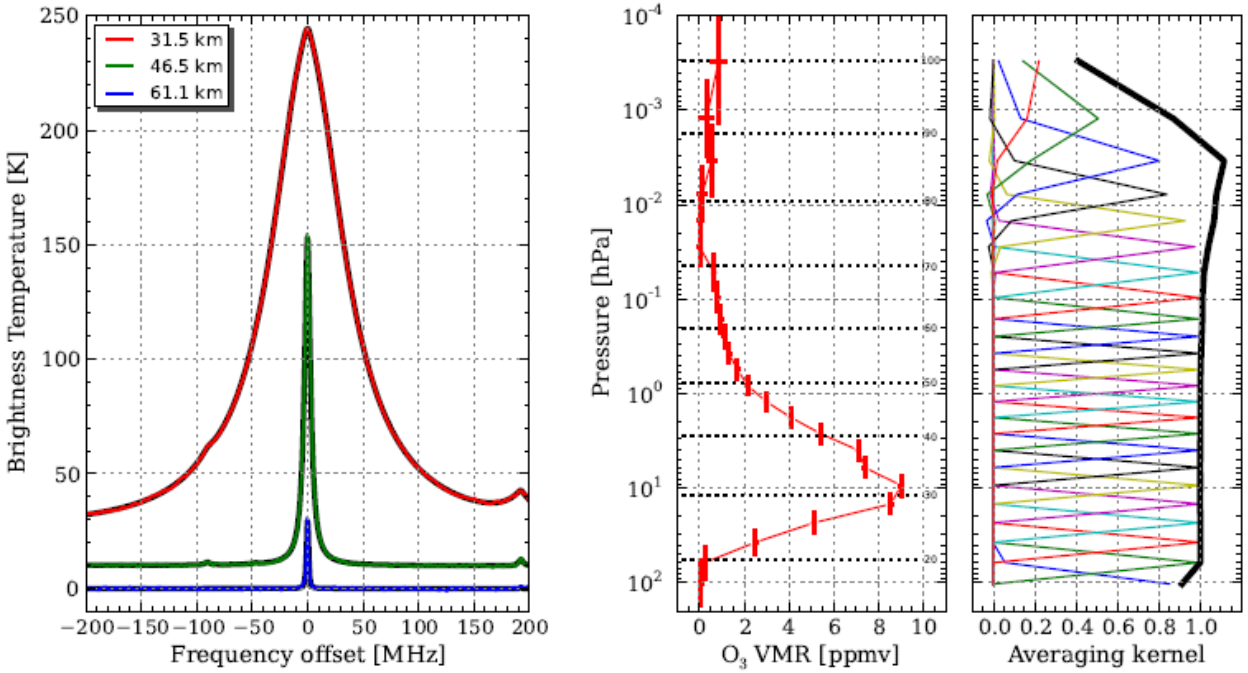


← Example of O3 retrieval in the L2r processing.

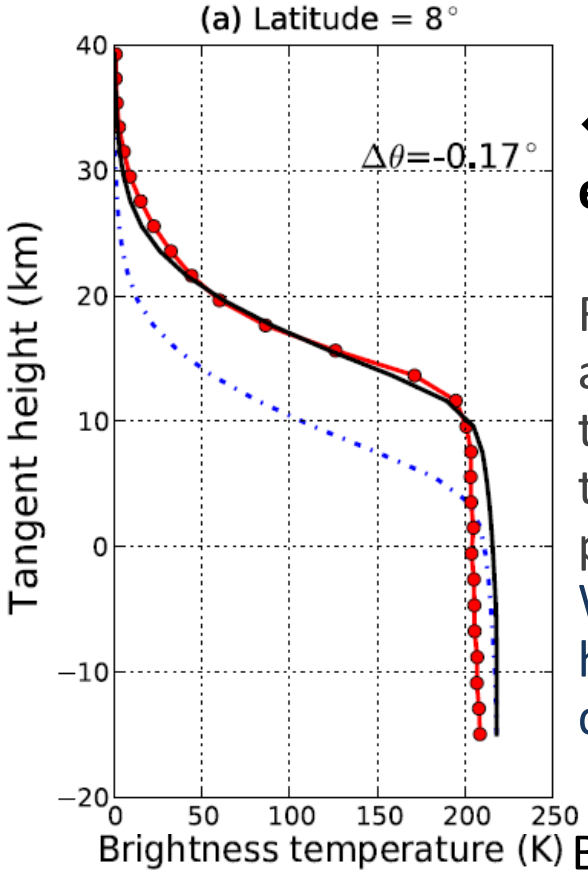
Vertical resolution of ~3 km is achieved in the stratosphere.

- NICT Level-2 Research Processing

Detail description of its algorithm is published in Baron et al. (2011).

Major characteristics (for the NICT L2 version 2.1.5) are:

- Correct the information of tangent points of the measurements by using the line width of O3 (note: SMILES's tangent height information contains a large uncertainty (**at least until L1b-007**), and no O2 lines were observed).



Baron et al. (2011)

← More than 5 km offset in the tangent heights exists in those computed from the ISS attitude data!

Red-dot shows the measured brightness temperature (BT) at one frequency channel with respect to the "corrected" tangent heights information, which the correction is made to fit with the model BT curve (black) synthesized with a priori atmospheric state.

Without the correction, i.e. with the original tangent heights info from ISS, the BT curve appears as the blue-dotted one.

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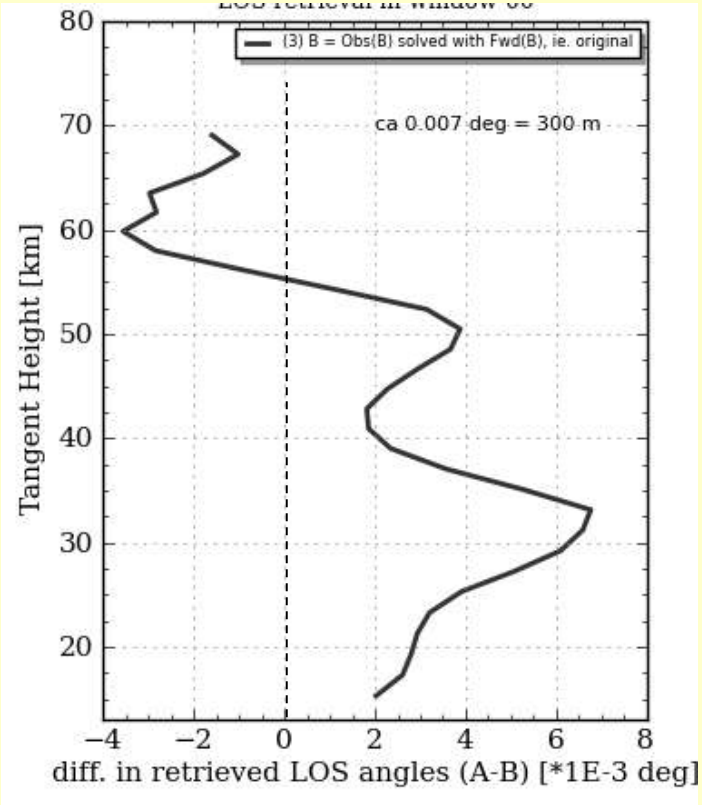
In practice, retrieving the tangent height from the O3 line is very sensitive to the accuracy of the radiance gain calibration of L1b data. We found that the version 2.1.5 of the NICT L2 processing was affected by this error i.e. mis-correction on the tangent height was introduced during the retrieval processing.



← Difference of the retrieved tangent heights from O3 lines observed in Band-A and Band-B of the same scan.
Ideally, the difference should be zero (dashed line) since they are from the same scan. But the actual data yield a certain difference, which is due to the imperfectness of the radiance gain calibration.

- Validation of NICT-L2 product

NICT-L2 O3 validation paper (Kasai et al. 2013) is now in revision to AMT.
Contents are:

- Error analysis
- Internal consistency check between L2r-O3 obtained from different observing Band.
- Comparison to the SMILES JAXA L2 operational product
- Comparison to Ozonsonde, Aura/MLS, Odin/SMR, OSIRIS, and Envisat/MIPAS.

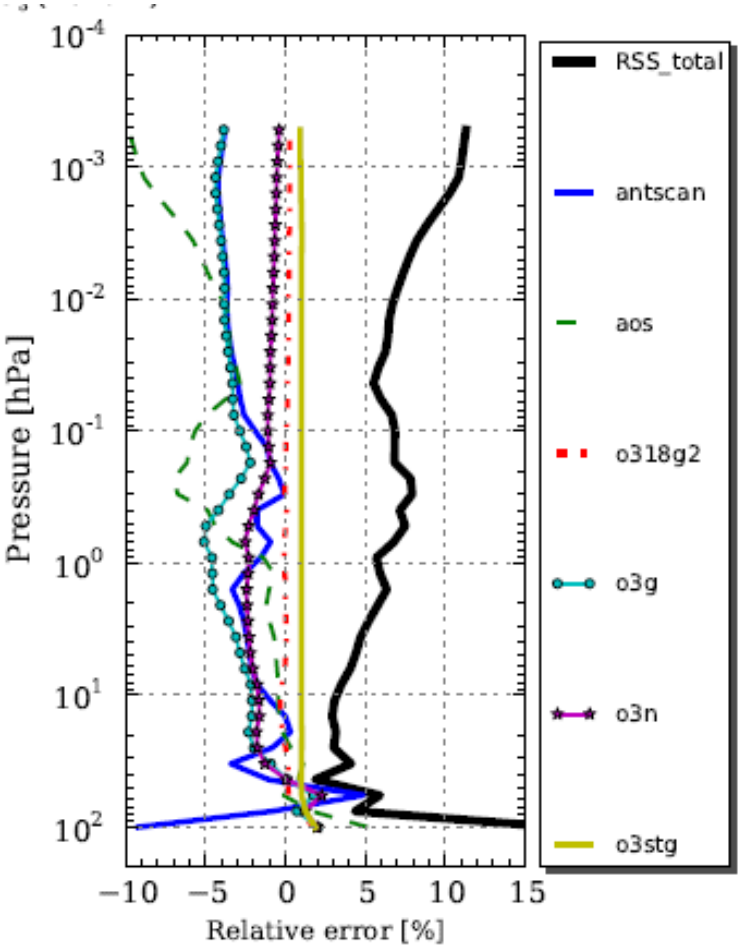
NICT-L2 ClO : A dedicated error analysis paper, **Sato et al. (2012)**, has been published in AMT. Comparison study with other instruments, **Sagawa et al. (2013)**, is now under revision to AMT .

NICT-L2 HCl : On going. **See presentation by Yokoyama et al. on 19 June.**

- Systematic error of L2r O3 (2.1.5)

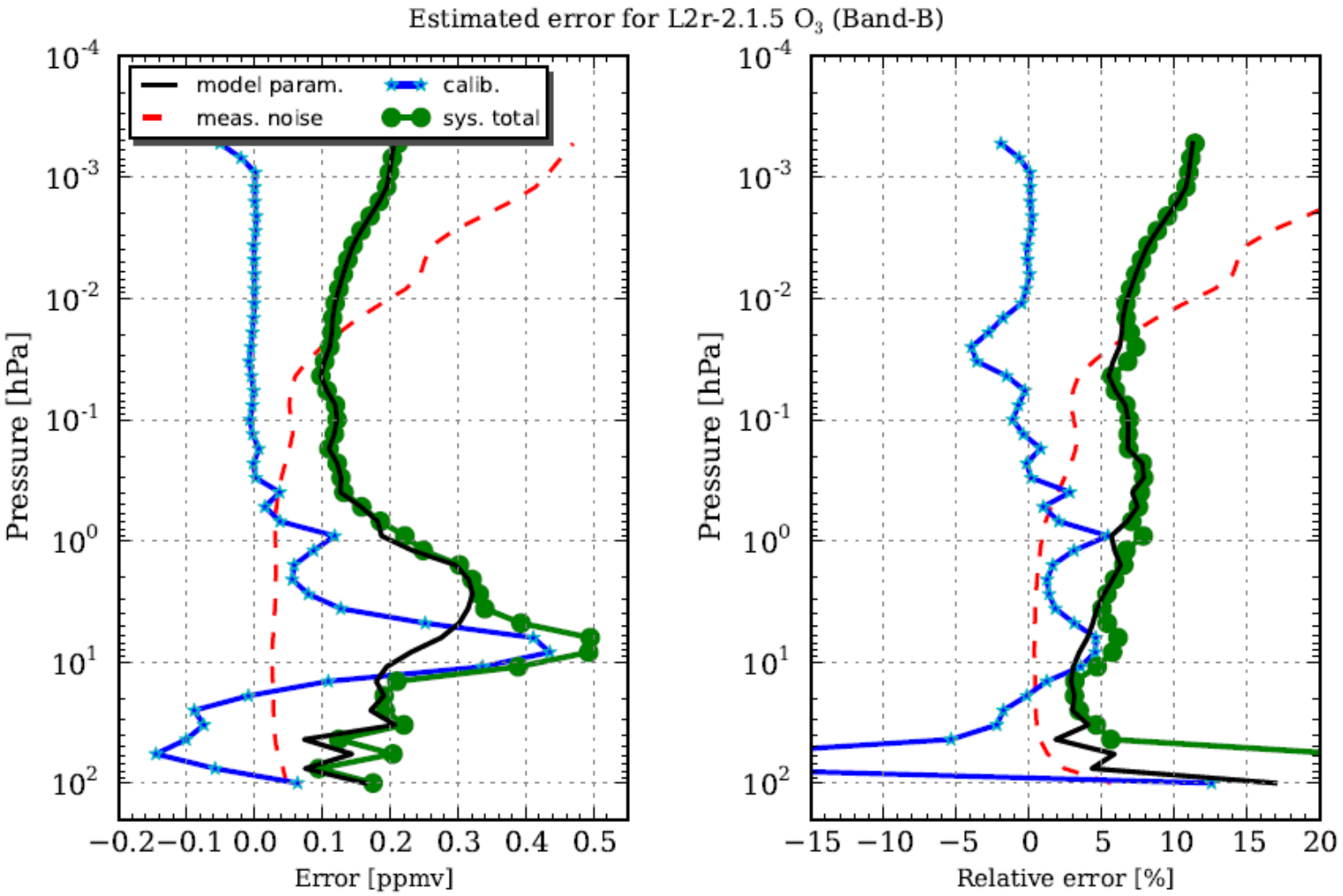
Errors coming from the forward model

source	perturbation	error on O_3 at 8.3 hPa
Spectroscopic parameters of O_3 625.371 GHz		
Line intensity (O3stg)	1%	1.0%
Air pressure broadening, γ (O3g)	3%	−2.2%
Temperature dependence, n of O3g (O3n)	10%	−1.8%
$H^{35}Cl$-625.901 GHz γ (HCl35g)	3%	0.01%
$H^{35}Cl$-625.901 GHz n (HCl35n)	10%	0.01%
$H^{37}Cl$-624.964 GHz γ (HCl37g)	3%	0.02%
$H^{37}Cl$-624.964 GHz n (HCl37n)	10%	0.01%
$O_3v_{1,3}$-625.051 GHz γ (O3v13g)	3%	0.01%
$OO^{18}O$-625.091 GHz γ (O318g)	3%	0.01%
$OO^{18}O$-625.563 GHz γ (O318g2)	3%	−0.2%
Image band (SSB)	ON↔OFF	−0.08%
AOS response function width (AOS)	10%	−0.4%
Dry air continuum (DRY)	20%	−0.05%
Antenna FOV drift (ANTSCAN)	ON↔OFF	−1.8%
Sum of model parameter error		3.5%



Spectroscopic parameters are the major error source in the forward model with respect to the stratospheric O3 retrieval. In the mesosphere, the error from **AOS response function** becomes more significant.

- Total Systematic Error for L2r O3

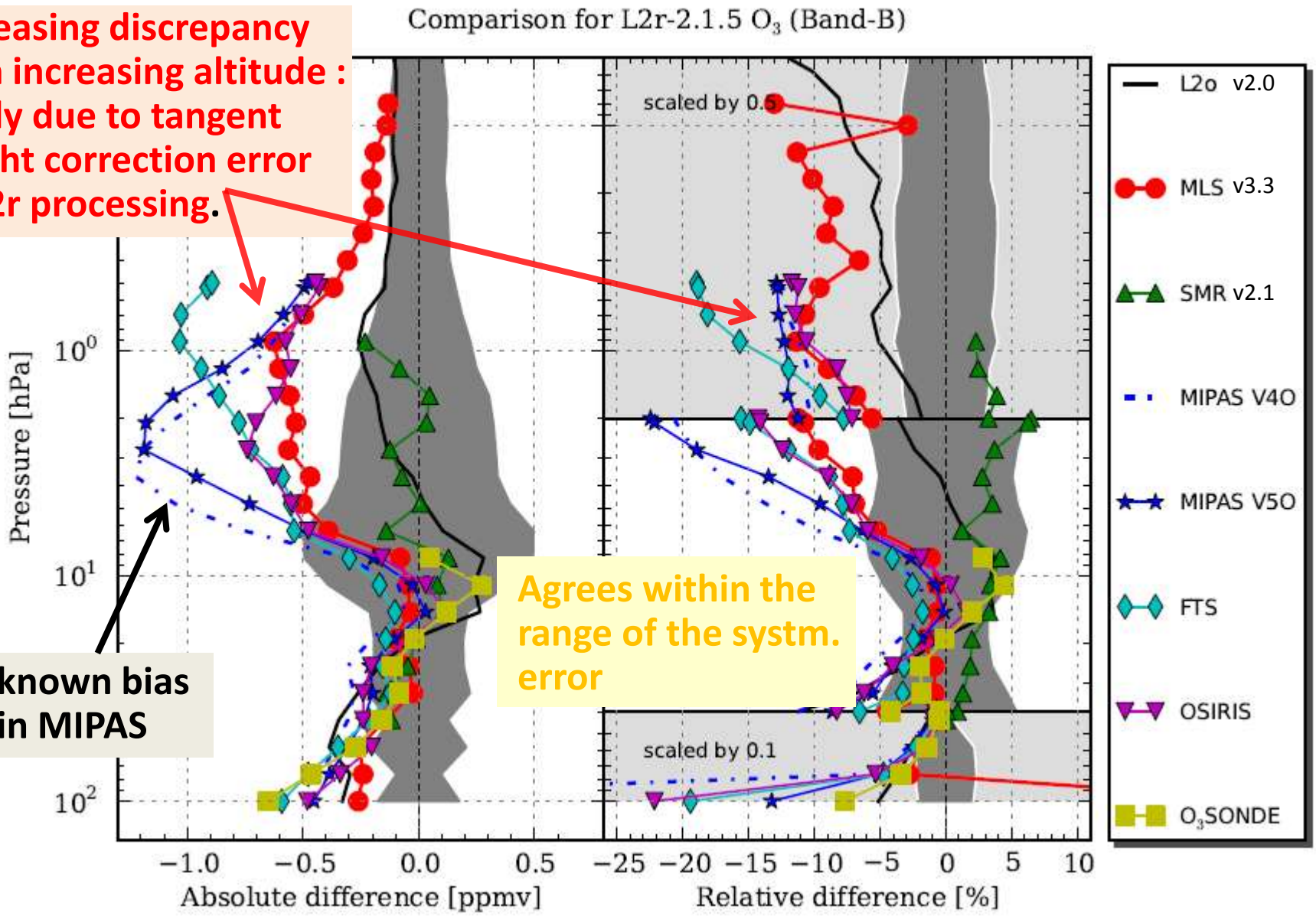


Green-dotted = Total systematic error for L2r-O3.

Not only the forward model parameters but also the calibration error does impact the stratospheric O3 retrieval.

- Comparison to Other Instruments

Increasing discrepancy with increasing altitude : Likely due to tangent height correction error in L2r processing.



known bias in MIPAS

Agrees within the range of the systm. error

- Updates for the Next Version

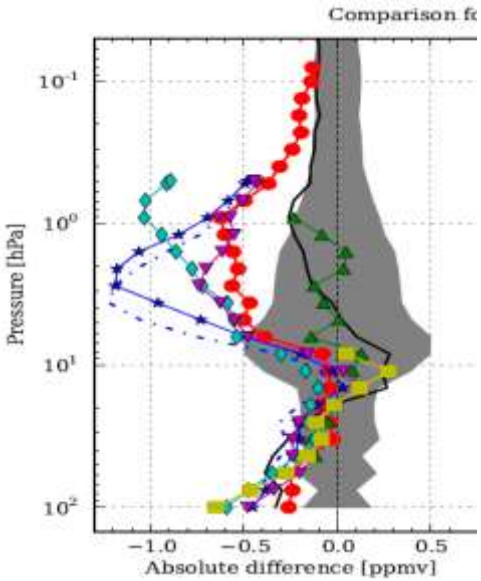
Updated calibrated radiance data (L1b-008) is now available.
This includes several important changes:

- New tangent height information [Ochiai et al. 2012].
  The SMILES star tracker data are “cleaned (smoothed)” based on the attitude information of the neighbor instrument MAXI.
- Improvements on the frequency calibration and AOS response function modeling, based on the on-orbit comb measurements [Mizobuchi et al. 2012].

→ The new NICT L2 processing (version 2.9.1, still under the investigation) uses the L1b-registered tangent heights instead of retrieving them from the O3 line.

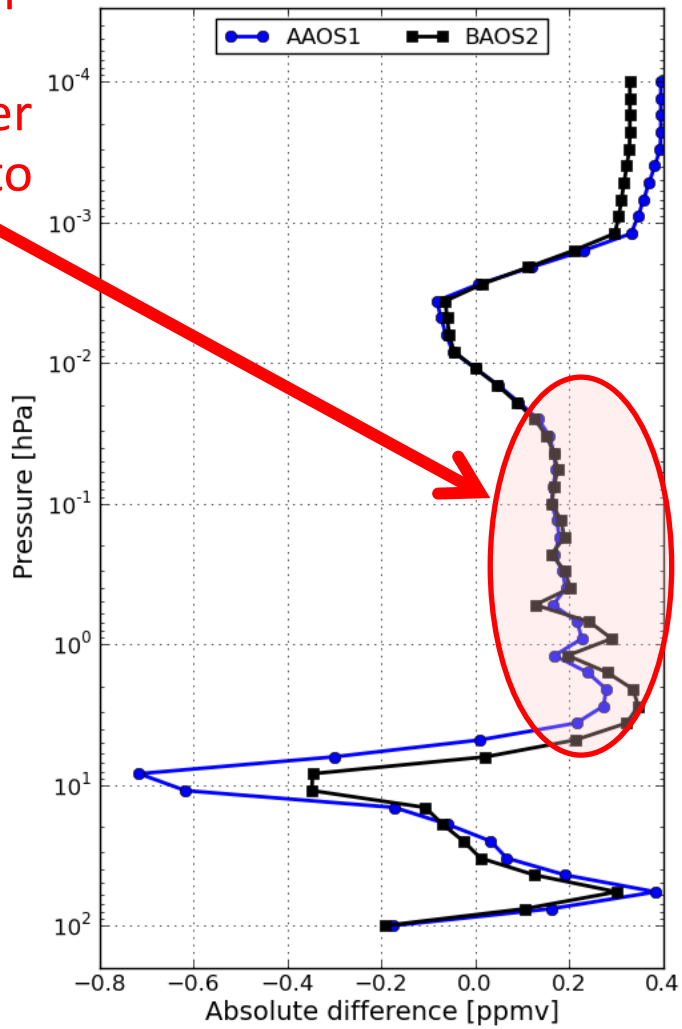
- Updates for the Next Version

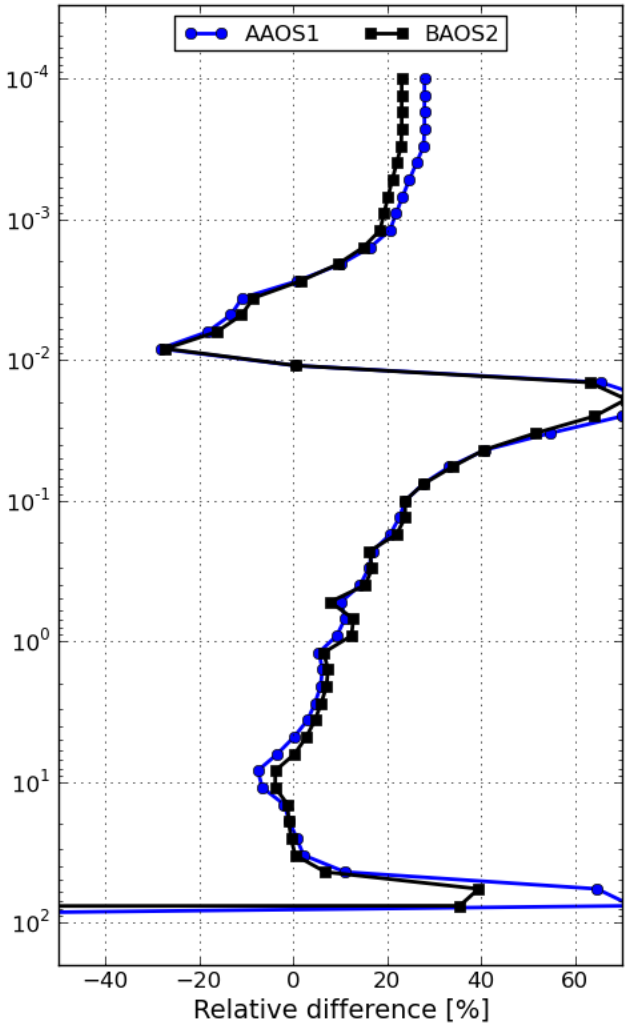
Large negative bias of SMILES NICT-2.1.5 observed at the upper stratosphere seems to be improved in the new version.



Difference of O3 between 2.9.1 with 2.1.5. (2.9.1 – 2.1.5)

Band–B, Average of Dec-2010 data





- Acknowledgements to…

- **SMILES NICT Level-2 research product development team (incl. former members)** :
  Y. Kasai [1], H. Sagawa [1], P. Baron [1], T.O. Sato [1], D. Kreyling [1], K. Yokoyama [2], J. Müller [3], J. Mendrok [4], J. Urban [5], D. Murtagh [5], B. Rydberg [3], E. Dupuy [1], K. Suzuki [1], S. Ochiai [1], K. Kikuchi [1], K. Muranaga [6], T. Haru [6], S. Mizobuchi [6], M. Yasui [1]

  1: NICT, 2: Osaka Pref. Univ., 3: Molflow Co. Ltd., 4: Lulea Univ., 5: Chalmers Univ., 6: SEC Co.

- **JEM/SMILES Mission team;** including the SMILES JAXA Level-2 operational team and the Level-1 calibration processing team.

- Looking forward to hearing any collaboration researches on the SMILES Level-2 data!
  Access: http://smiles.isas.jaxa.jp/access/indexe.shtml
  http://smiles.nict.go.jp/pub/data/access.html