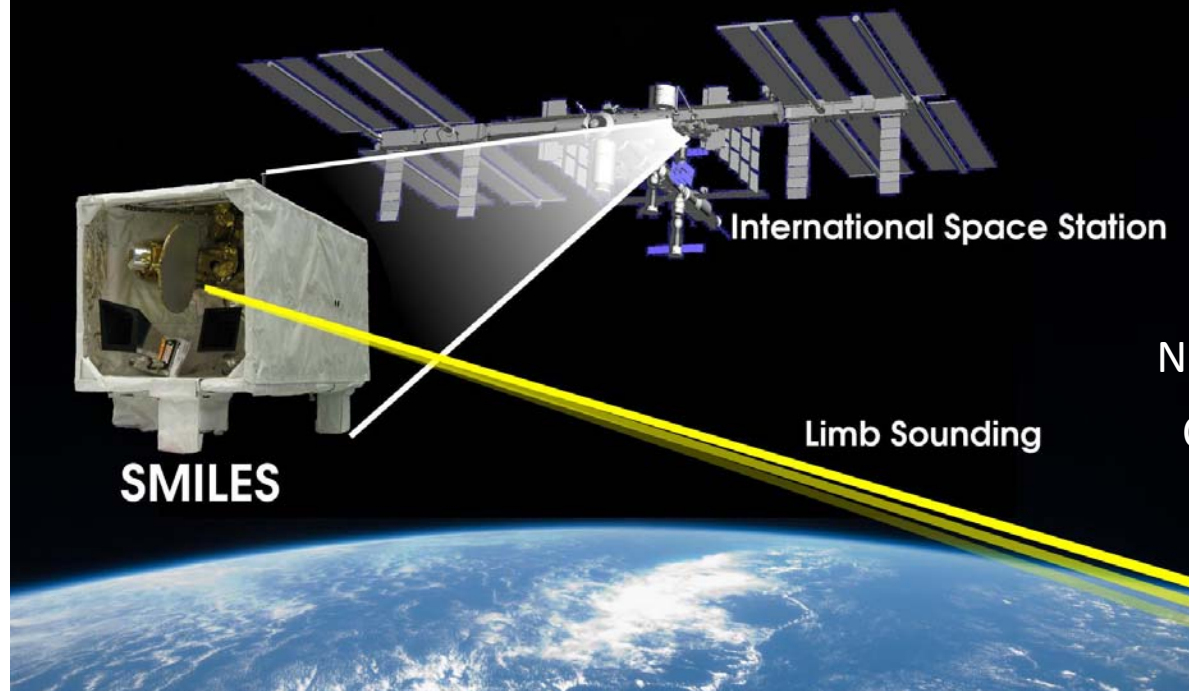


# Overview of SMILES project in NICT

and diurnal variation of HCl, ClO, HOCl, and BrO in upper atmosphere



Yasko KASAI

National Institute of Information and  
Communications Technology (NICT)

Tokyo Institute of Technology

# Thanks to SMILES Project Members

SMILES is a Collaboration project of NICT and JAXA



## NICT SMILES members

Leader: Yasko Kasai (NICT/ Tokyo Institute of Tech)

Instrument and L1b: Satoshi Ochiai, Ken Kikuchi,

L2 research: Hideo Sagawa, Tomohiro Sato, Jana Mendrok(Lulea U.),  
Joachim Urban, Patrick Eriksson, Donal Murtagh (Chalmers U.)

Validation and Science: Kengo Yokoyama, Kota Kuribayashi, Takayoshi  
Yamada, Nawo Suzuki, Mona Mahani, Bengt Rydberg

Climatology: Daniel Kreyling

Modeling: Ralph Lehmann, Miriam and B-M Sinnhubers

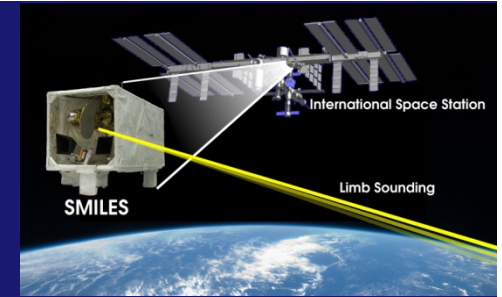
## JAXA SMILES members

Leader: Masato Takayanagi, Masato Shiotani (Kyoto U.)

Instrument: Toshiyuki Nishibori,

L2: Takuki Sano, Makoto Suzuki,

# SMILES

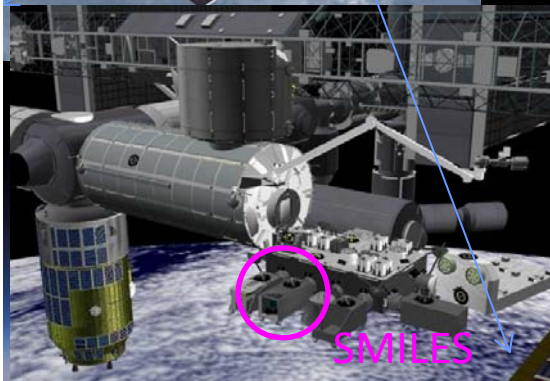
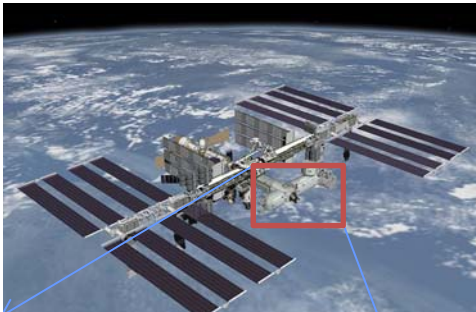


## Outline

1. Current status of SMILES
2. NICT activity and its scientific highlight
3. Feature mission after SMILES

# SMILES

Superconducting Submillimeter-Wave Limb-Emission Sounder



Frequency region: 600 GHz (624.32-626.32, 649.12-650.32GHz)

Receiver system: Super-conductive SIS receiver

**Tsys = about 350K**

Obs. height region: UT – lower ionosphere

Latitude coverage: 65N-38S (Nominal)

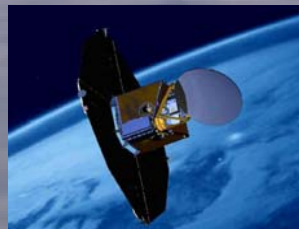
(38N-65 total 4 weeks)

ISS Orbit: Non sun-synchronized orbit

Obs. period: 12 Oct. 2009 – 21 Apr. 2010

**One order magnitude better sensitivity**

Odin/SMR



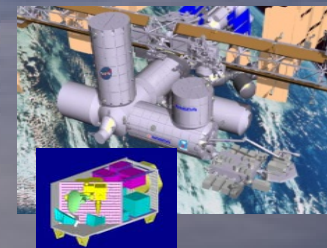
Tsys: 3000K  
(SSB@500GHz)

Aura/MLS



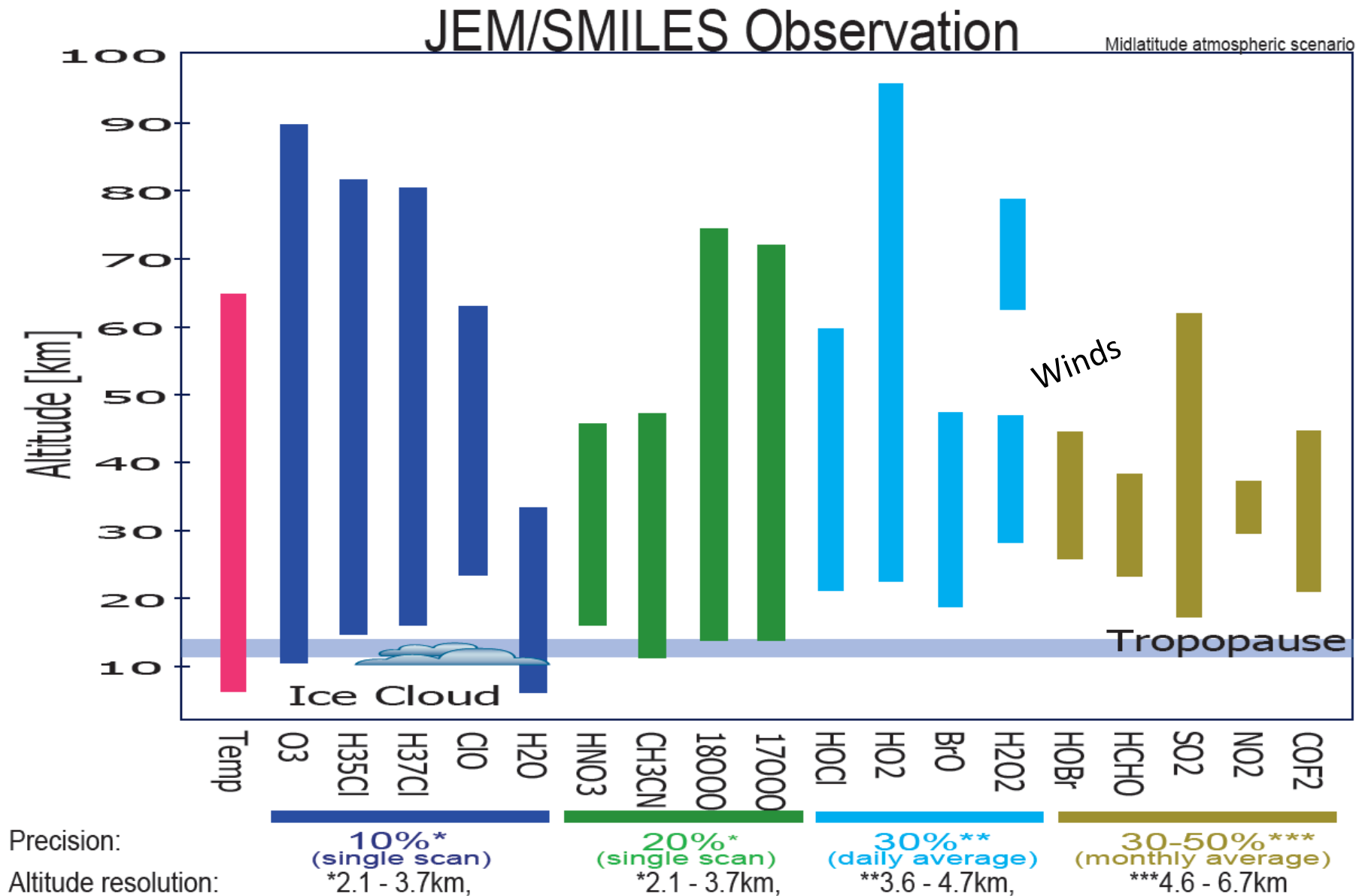
Tsys: 6000K  
(DSB@650GHz)

JEM/SMILES



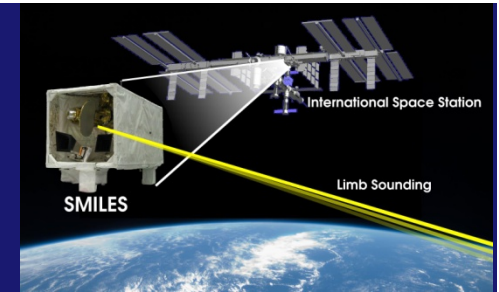
Tsys: 350K  
(SSB@650GHz)

# SMILES observed **wide height region** between upper troposphere and lower ionosphere





# Status of SMILES



- Launch: 11 September 2009
- Observation period: 12 October 2009 – 21 April 2010
- SMILES Project (JAXA-NICT) plan to finish FY 2013,

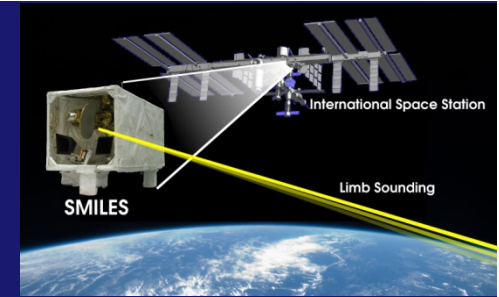
BUT!

**NICT continue the current SMILES research on**

- ✓ L1b calibration algorithm and data processing
- ✓ L2 retrieval algorithm and data processing
- ✓ L3 = Climatology development
- ✓ Future mission study (Anu/APOLLO, JUICE/SWI)

**as a center research institute for sub-mm/THz technology in Japan**

# SMILES



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# SMILES NICT project activity

## L1b, L2, validation, and Climatology

L1b	L2/Molecules, T,	L2/Ice cloud	Validation/ Comparison Error analysis	L3/Climatology
S. Ochiai, K. Kikuchi, S. Mizobuchi	H. Sagawa T. Sato (O3 isotopes) Y. Kasai K. Yokoyama(HCl)	H. Sagawa R. Bengt P. Eriksson	Y. Kasai, H. Sagawa, T. Sato, K. Yokoyama, R. Bengt	D. Kreyling
v700 (Aug 2011-)	v215 (Oct 2011-) O3, HCl, ClO, HO2, HOCl, BrO, CH3CN, HNO3, T, wind 24 -100km	---	O3, HCl, ClO, HOCl, HO2, BrO, T	O3, HCl, ClO, HO2, HOCl, BrO, T
v800 (Dec 2012-) Current version Tangent height, calibration for non- linearity problem, AOS parameters improve a lot.	v300 (Aug 2013) + O3 isotope 12 -100km	V300 (Aug 2013)	+ O3 isotopes	
V900 (2013)	v310		+ CH3CN, HNO3	
Freq. collection required.				



# SMILES

## NICT v215 Validation/Evaluation Status

Molecule	Precision and Accuracy	Papers
Ozone	5%, 20% (100-0.01 hPa)	<b>Y. Kasai et al.</b> , "Validation of stratospheric and mesospheric ozone observed from SMILES onboard International Space Station" Atmos. Meas. Tech. Discuss., 6, 2643-2720, 2013
ClO	10%, 20% (60–0.1hPa)	<b>T. O. Sato et al.</b> , "Strato-Mesospheric ClO Observations by SMILES: Error Analysis and Diurnal Variation"(2012) Atmos. Meas. Tech. Discuss., 5, 4667-4710, 2012 <b>H. Sagawa et al.</b> , "Validation ClO observed from SMILES onboard International Space Station" Atmos. Meas. Tech. Discuss., 6, 613-663, 2013
HCl	5%, 20% (100-0.01 hPa)	<b>K. Yokoyama et al.</b> , "Validation of HCl observed from SMILES onboard International Space Station"2013 to be submitted to JGR
HOCl, HO <sub>2</sub> , BrO, winds, ice cloud/humidity	30%, 30% (100 – 0.1 hPa)	<b>P. Baron et al.</b> , "Observation of horizontal winds in the middle-atmosphere between 30S and 55N during the northern winter 2009/2010." (2012) Accepted to ACP <b>K. Kuribayashi et al.</b> , "Evaluation of ClO + HO <sub>2</sub> →HOCl+O <sub>2</sub> reaction in the atmosphere by SMILES observation", Atmos. Chem. Phys. Discuss., 13, 12797-12823, 2013 <b>R.A. Stachnik et al.</b> , "Stratospheric BrO abundance measured by a balloon-borne submillimeterwave radiometer" (2012) Accepted ACP <b>E Millan et al.</b> , "SMILES Ice Cloud Products", (2012), Accepted JGR

This discussion paper is/has been under review for the journal Atmospheric Measurement Techniques (AMT). Please refer to the corresponding final paper in AMT if available.

# Validation of stratospheric and mesospheric ozone observed by SMILES from International Space Station

Y. Kasai<sup>1,2</sup>, H. Sagawa<sup>1</sup>, D. Kreyling<sup>1</sup>, K. Suzuki<sup>1,3</sup>, E. Dupuy<sup>1,4</sup>, T. O. Sato<sup>2,1</sup>, J. Mendrok<sup>5,1</sup>, P. Baron<sup>1</sup>, T. Nishibori<sup>6,1</sup>, S. Mizobuchi<sup>6</sup>, K. Kikuchi<sup>1</sup>, T. Manabe<sup>7</sup>, H. Ozeki<sup>8</sup>, T. Sugita<sup>4</sup>, M. Fujiwara<sup>9</sup>, Y. Irimajiri<sup>1</sup>, K. A. Walker<sup>10,11</sup>, P. F. Bernath<sup>12</sup>, C. Boone<sup>11</sup>, G. Stiller<sup>13</sup>, T. von Clarmann<sup>13</sup>, J. Orphal<sup>13</sup>, J. Urban<sup>14</sup>, D. Murtagh<sup>14</sup>, E. J. Llewellyn<sup>15</sup>, D. Degenstein<sup>15</sup>, A. E. Bourassa<sup>15</sup>, N. D. Lloyd<sup>15</sup>, L. Froidevaux<sup>16</sup>, M. Birk<sup>17</sup>, G. Wagner<sup>17</sup>, F. Schreier<sup>17</sup>, J. Xu<sup>17</sup>, P. Vogt<sup>17</sup>, T. Trautmann<sup>17</sup>, and M. Yasui<sup>1</sup>

<sup>1</sup>National Institute of Information and Communications Technology (NICT), Koganei, Tokyo, Japan

<sup>2</sup>Tokyo Institute of Technology, Yokohama, Kanagawa, Japan

<sup>3</sup>The University of Tokyo, Graduate School of Arts and Sciences, Meguro, Tokyo, Japan

<sup>4</sup>National Institute for Environmental Studies, Tsukuba, Ibaraki, Japan

<sup>5</sup>Luleå University of Technology, Kiruna, Sweden

<sup>6</sup>Japan Aerospace Exploration Agency (JAXA), Tsukuba, Japan

<sup>7</sup>Osaka Prefecture University, Naka, Sakai, Osaka, Japan

## SMILES O<sub>3</sub> validation (NICT L2-v215)

Y. Kasai et al.

Title Page

Abstract

Introduction

Conclusions

References

Tables

Figures

◀

▶

◀

▶

Back

Close

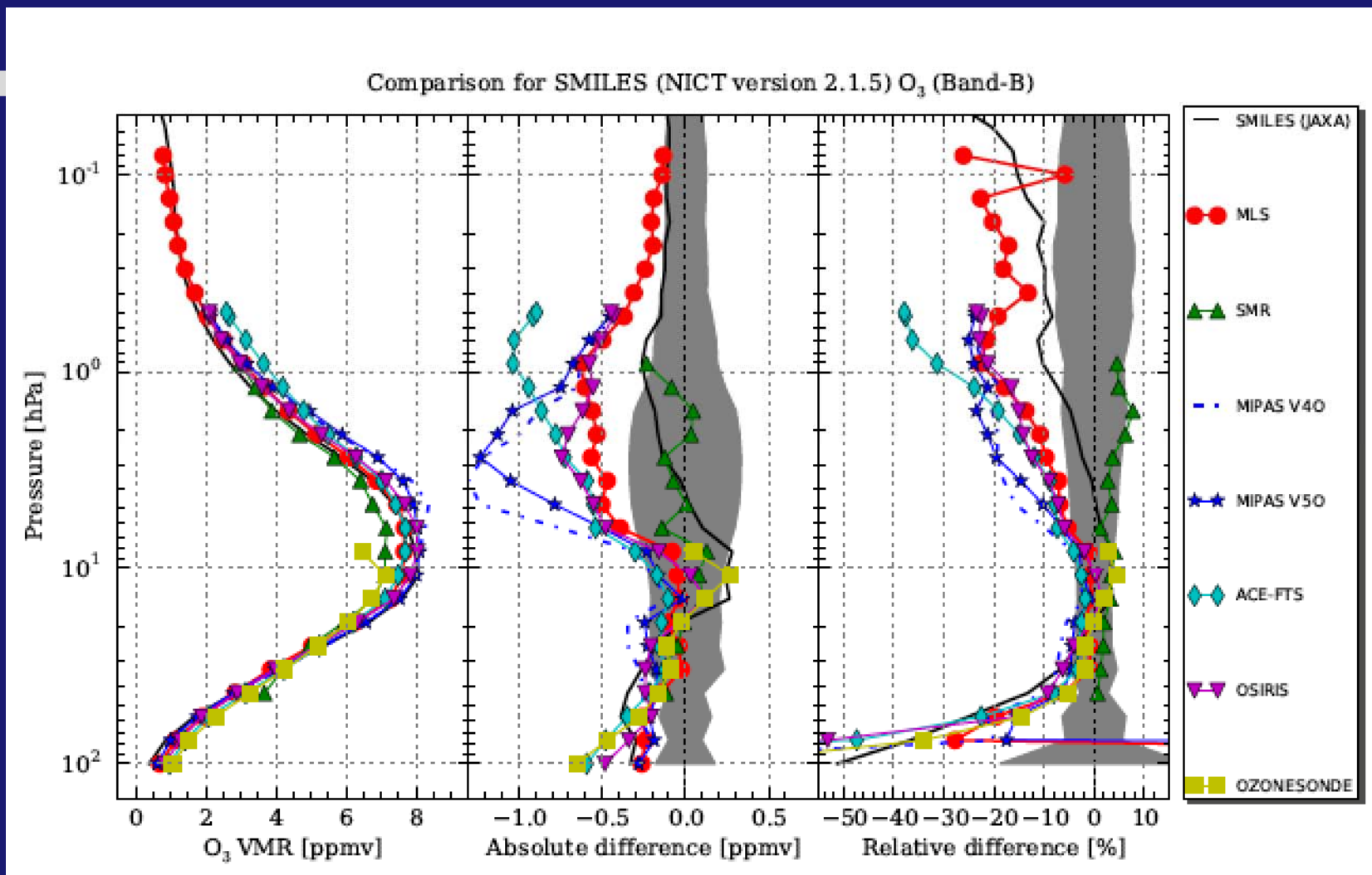
Full Screen / Esc

Printer-friendly Version

Interactive Discussion



## Summary of comparison between SMILES and other measurements



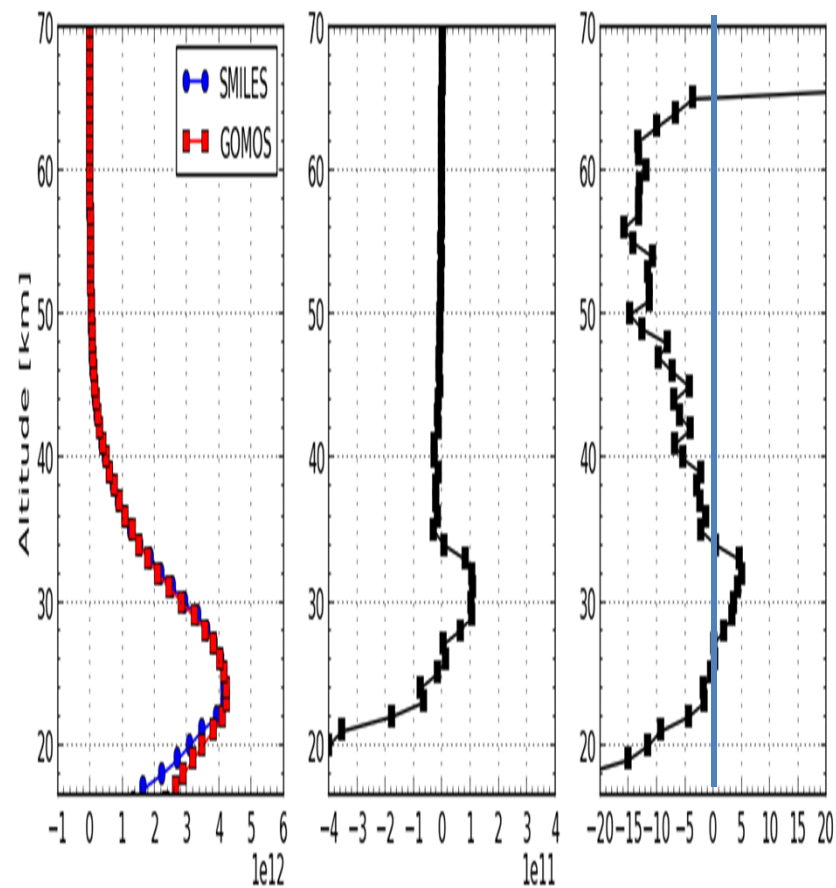
SMILES agree well in the stratosphere, had negative trend above 1hPa due to the problems of non-linearity and tangent height problem.



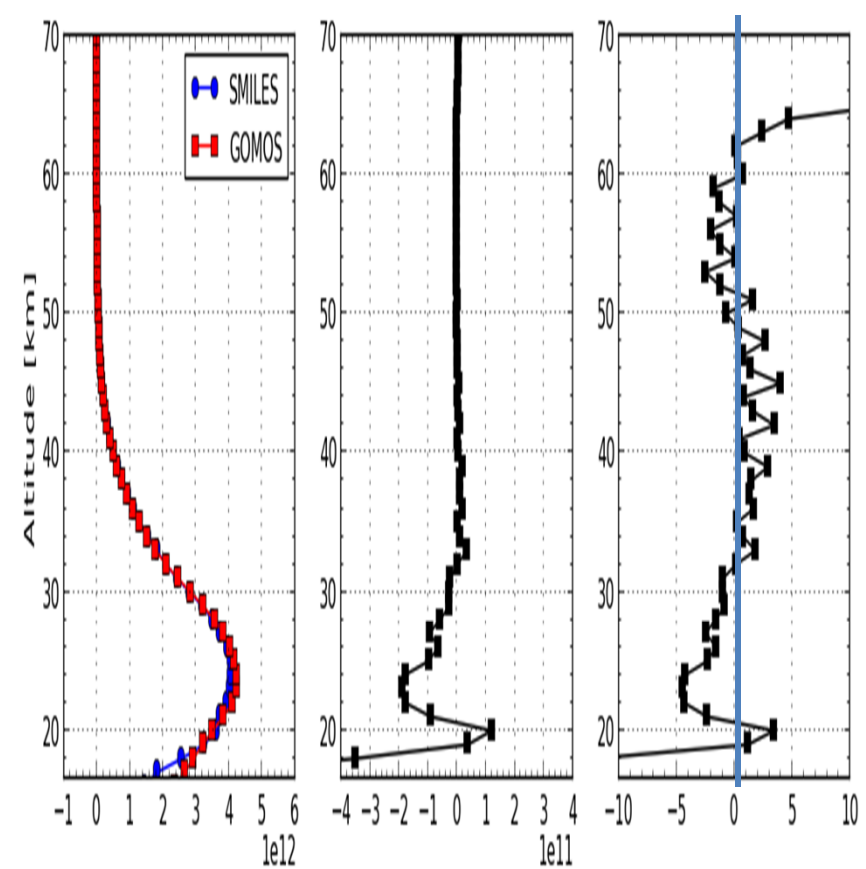
Thanks to Johanna Tamminen and Kyrölä Erkki

# GOMOS-SMILES comparisons

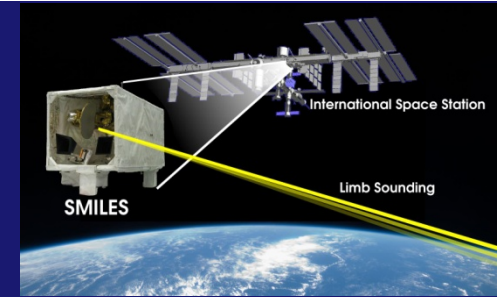
## L1b 007



## L1b 008



# SMILES



## Outline

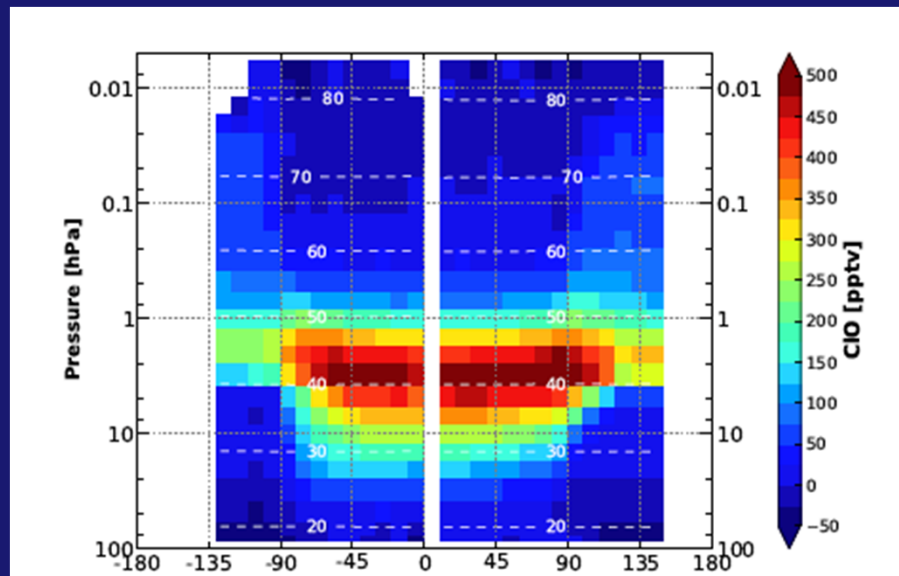
1. Current status of SMILES
2. NICT activity and its scientific highlight
3. Feature mission after SMILES



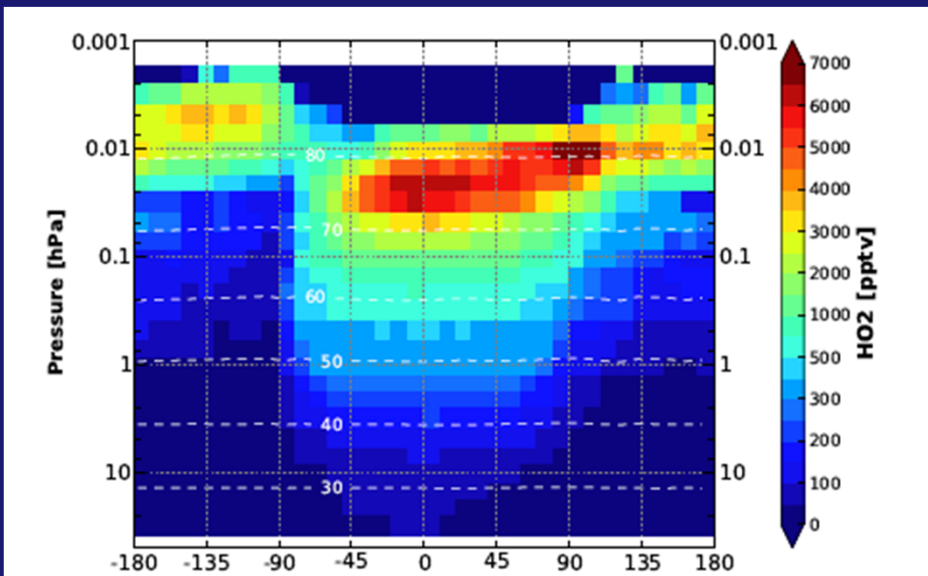
# SMILES Climatology for Diurnal cycles in short lived trace gas species

SMILES diurnal variation climatology of strato- and mesospheric trace gases: O<sub>3</sub>, HCl, HNO<sub>3</sub>, ClO, BrO, HOCl, HO<sub>2</sub>, and temperature, Daniel Kreyling, Hideo Sagawa, Ingo Wohltmann, Ralph Lehmann, and Yasuko Kasai, Submitted to JGR, SPARC DI special session

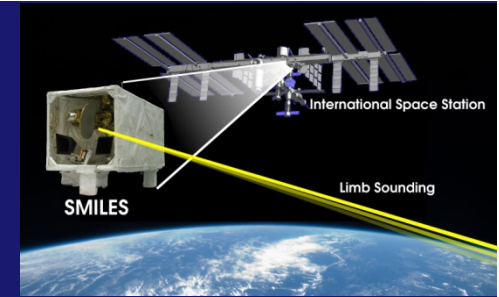
**ClO** October-November 2009 climatology as function of solar zenith angle (20S-20N).



**HO<sub>2</sub>** January-February 2010 climatology as function of solar zenith angle (20S-20N).



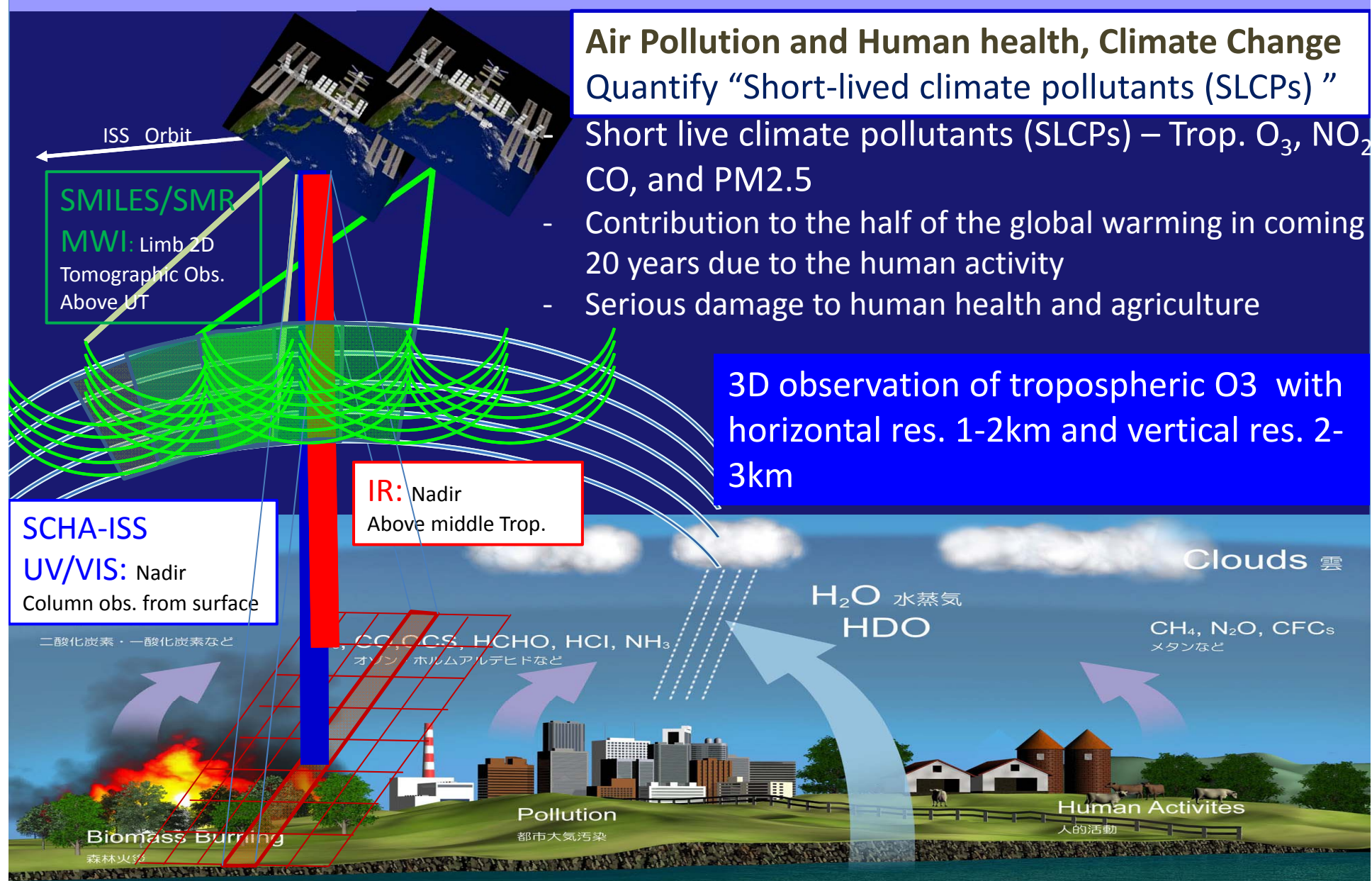
# SMILES



## Outline

1. Current status of SMILES
2. NICT activity and its scientific highlight
3. Feature mission after SMILES

# Future Mission: Anu/APOLLO



# Related presentation in limb workshop

- Kota Kuribayashi et al., Direct estimation of the reaction rate  $\text{ClO} + \text{HO}_2 \rightarrow \text{HOCl} + \text{O}_2$  from SMILES observation  
Atmos. Chem. Phys. Discuss., 13, 1–27, 2013
- Kengo Yokoyama et al., Strato-mesospheric HCl observed by Superconducting Submillimeter- Wave Limb-Emission Sounder (SMILES)
- Hideo Sagawa et al., An update on the SMILES NICT Level-2 Processing
- Naoko Saito et al., Analysis of Arctic stratospheric minor gases by combined use of JEM/SMILES and ACE-FTS

# ISS International Earth Observatory

for „Quantify SLCPs as pollutant and climate forcer”

