

# Overview of SMILES Mission and Scientific Outcomes

**Masato Shiotani (Kyoto University, Japan) and SMILES mission team  
(Presented by Takuki SANO, ISAS/JAXA)**

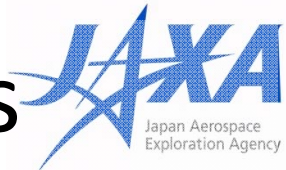
# Who am I ?

Takuki SANO:

- Belongs to Institute of Space and Astronautical Science (ISAS), Japan Aerospace Exploration Agency (JAXA)
- Was the secretariat of the 6<sup>th</sup> Limb Conference (@Kyoto, Japan)
- Will present on behalf of Prof. Masato SHIOTANI, who is the PI of SMILES science



# JEM/SMILES mission and status



(SMILES: Superconducting Submillimeter-Wave Limb-Emission Sounder)



## Mission objectives (\*cooperative project with NICT)

- Demonstration of superconducting mixer and 4-K mechanical cooler for the submillimeter limb-emission sounding in space
- High-sensitivity observations on atmospheric minor constituents in the middle atmosphere

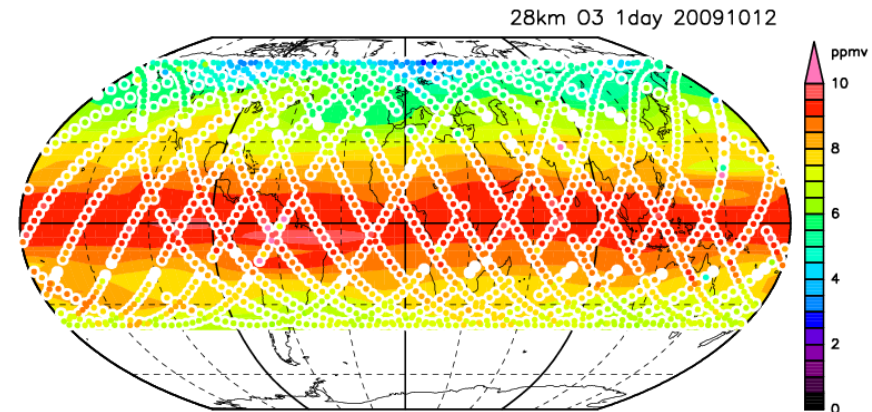
## Status

- Sep. 11, 2009: SMILES was carried by H-IIB with H-II Transfer Vehicle (HTV)
- Oct. 12: Continuous observations started
- Apr. 21, 2010: Observations was suspended due to the failure of a critical component
- June 5: The cooler stopped operation due to the failure of the JEM thermal control system
- Jan 19, 2011: JAXA officially announced termination of the normal operation

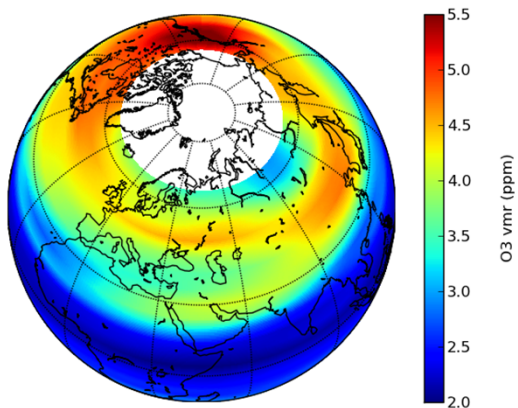


# SMILES Measurements

- High sensitivity in detecting atmospheric limb emission of the submillimeter wave range
- Vertical profiling (about 3km resolution) from ISS with latitudinal coverage of 65N to 38S
- One sequence for 53 sec, about 100 points per one orbit, and about 1600 points per day



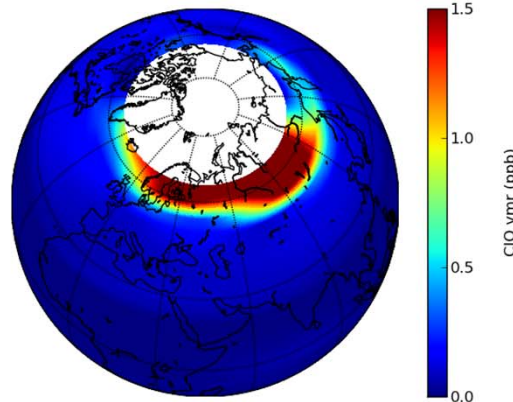
O3 (AB) 2010-01-23



SMILES: 007-08-0310\_new

Altitude: 22.00 km

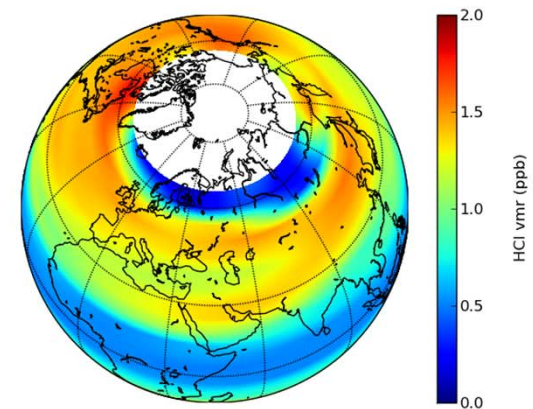
ClO (C) 2010-01-23



SMILES: 007-08-0310\_new

Altitude: 22.00 km

HCl (AB) 2010-01-23



SMILES: 007-08-0310\_new

Altitude: 22.00 km

SMILES can measure several radical species crucial to the ozone chemistry ( $O_3$ , ClO, HCl, HOCl, BrO,  $HO_2$  ...) at different local times because of the non-sun-synchronous ISS orbit.

# JAXA Level 2 products



- v1.0 (005-06-0024): for retrieval test (2010/01/23 released)
- v1.1 (005-06-0032): for mapping test (2010/04/19 released)
- v1.2 (005-06-0150): algorithm update I (2010/09/15 released)
- v1.3 (006-06-0200): algorithm update II (2011/03/02 released)
- v2.0 (007-08-0300): major update (2011/10/04 released)
- v2.1 (007-08-0310): improvement in HOCl (2012/01/16 released)
  - Public release (2012/03/05)
- v2.2 (007-09-0400): algorithm update (unofficial release: no documents)
- v2.3 (007-09-0402): minor update (unofficial release: no documents)
- v2.4 (008-11-0502): a priori profile update (Planned to release 2013/8)

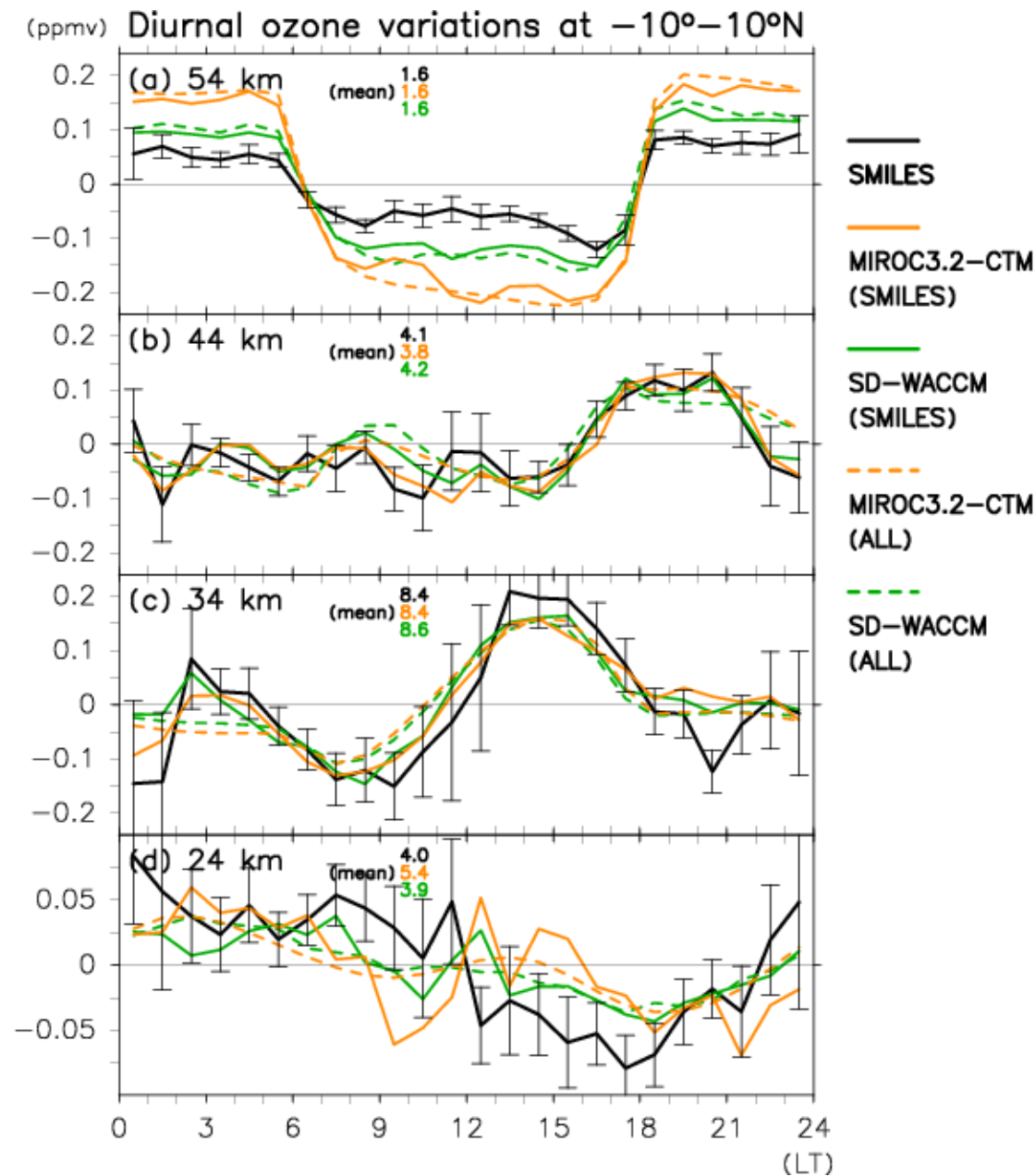
<http://smiles.isas.jaxa.jp/access/indexe.shtml>

<http://darts.isas.jaxa.jp/iss/smiles/>

Diurnal ozone variations in the  
stratosphere revealed in observations from  
the Superconducting Submillimeter-Wave  
Limb-Emission Sounder (SMILES) onboard  
the International Space Station (ISS)

by Sakazaki et al.  
(JGR, 2013)

# Diurnal variations (10S-10N)

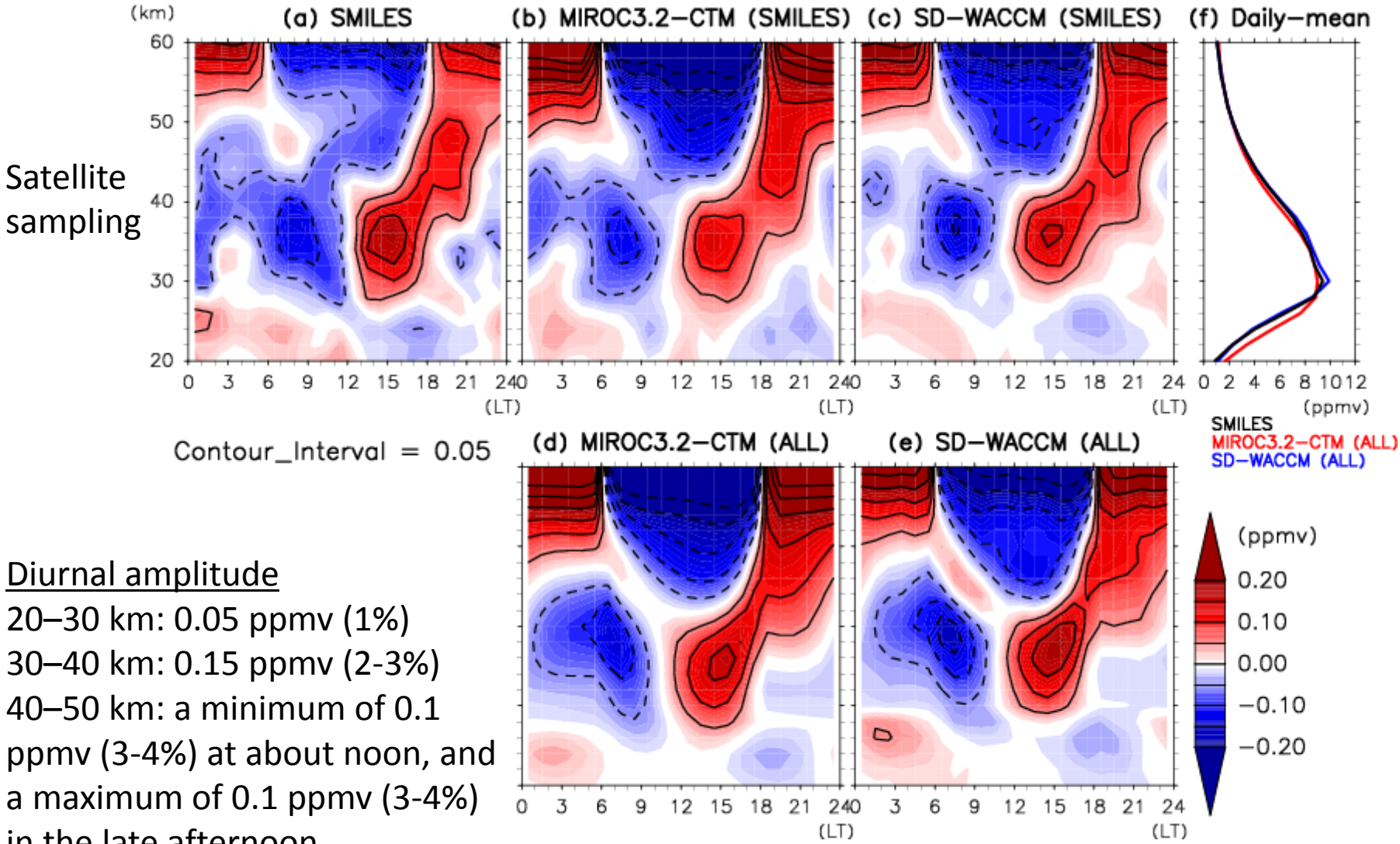


## SD-WACCM (by NCAR)

- Specified Dynamics (SD) version of WACCM
- Whole Atmosphere Community Climate Model
- Temperature and wind fields from NASA GEOS5.1 are nudged
- horizontal:  $1.9^{\circ} \times 2.5^{\circ}$ , vertical: 88 levels (up to 140km)
- 57 species (Ox, NOx, HOx, ClOx, BrOx etc.)
- 230 chemical reactions



# Diurnal variations in ozone

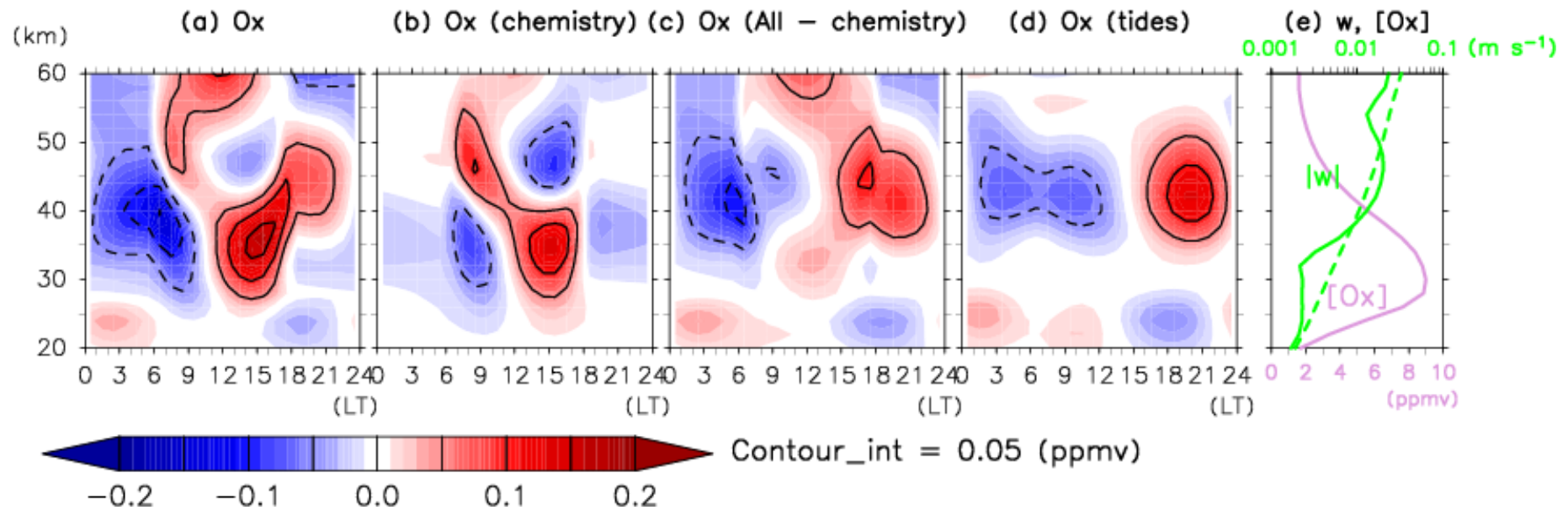


Diurnal amplitude

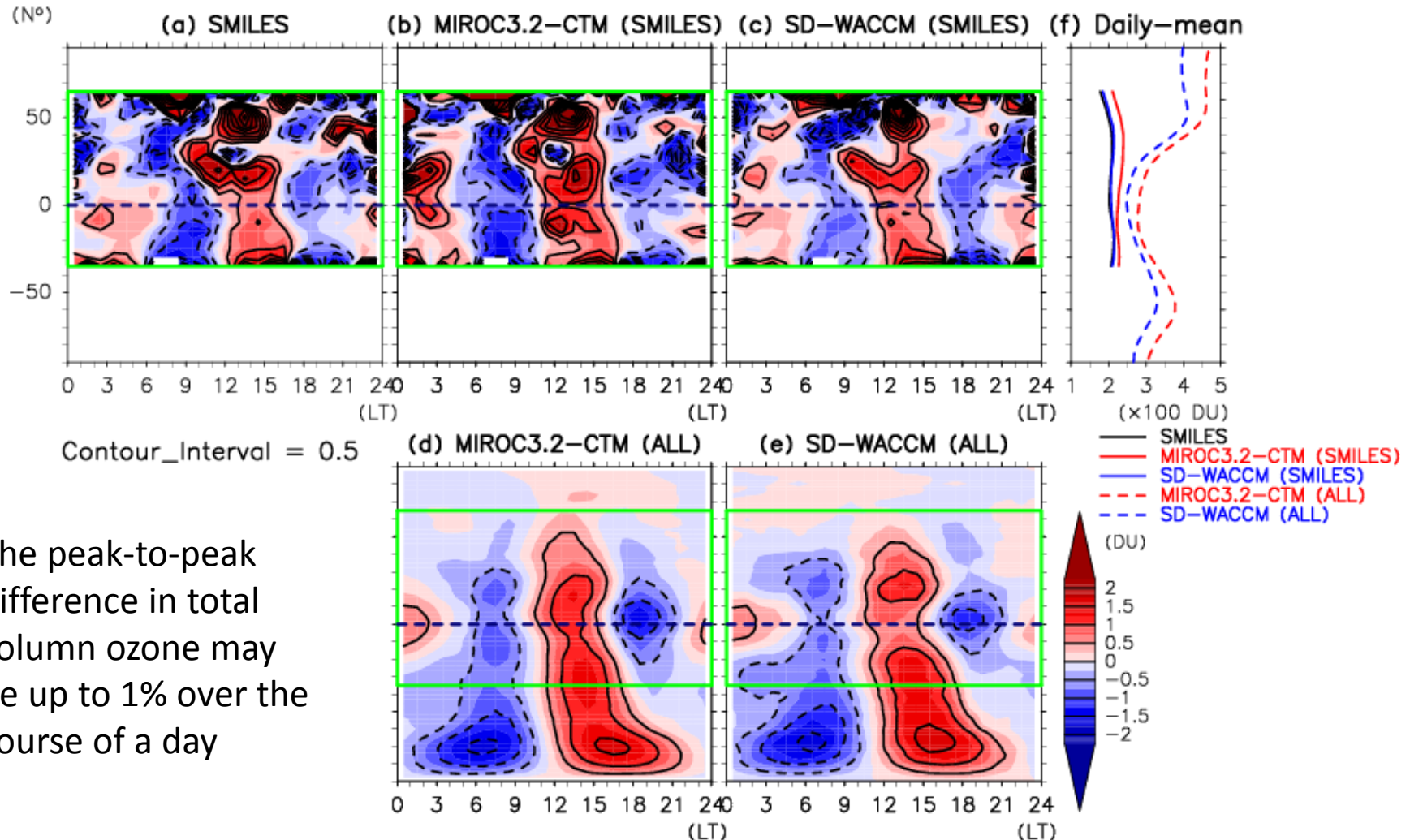
20–30 km: 0.05 ppmv (1%)  
 30–40 km: 0.15 ppmv (2-3%)  
 40–50 km: a minimum of 0.1 ppmv (3-4%) at about noon, and a maximum of 0.1 ppmv (3-4%) in the late afternoon



# Mechanism of the diurnal variations



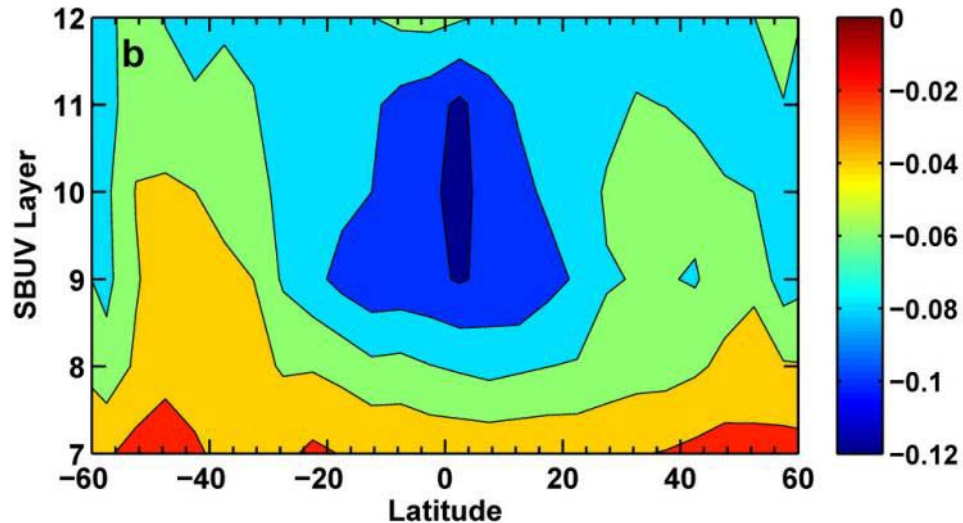
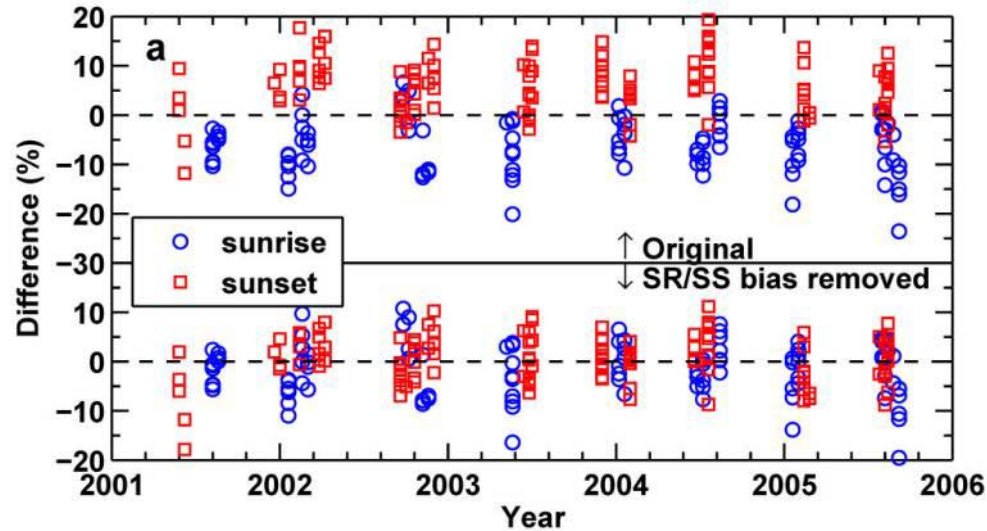
# Diurnal variations in total ozone



The peak-to-peak difference in total column ozone may be up to 1% over the course of a day

- A bias in the SAGE sunrise and sunset profiles [McLinden et al., 2009]
- Orbital drift of SBUV onboard NOAA satellites [Wang et al., 2012]
- TOMS and OMI measurement local times are 1130 LT and 1330 LT

# SAGE sunrise & sunset bias



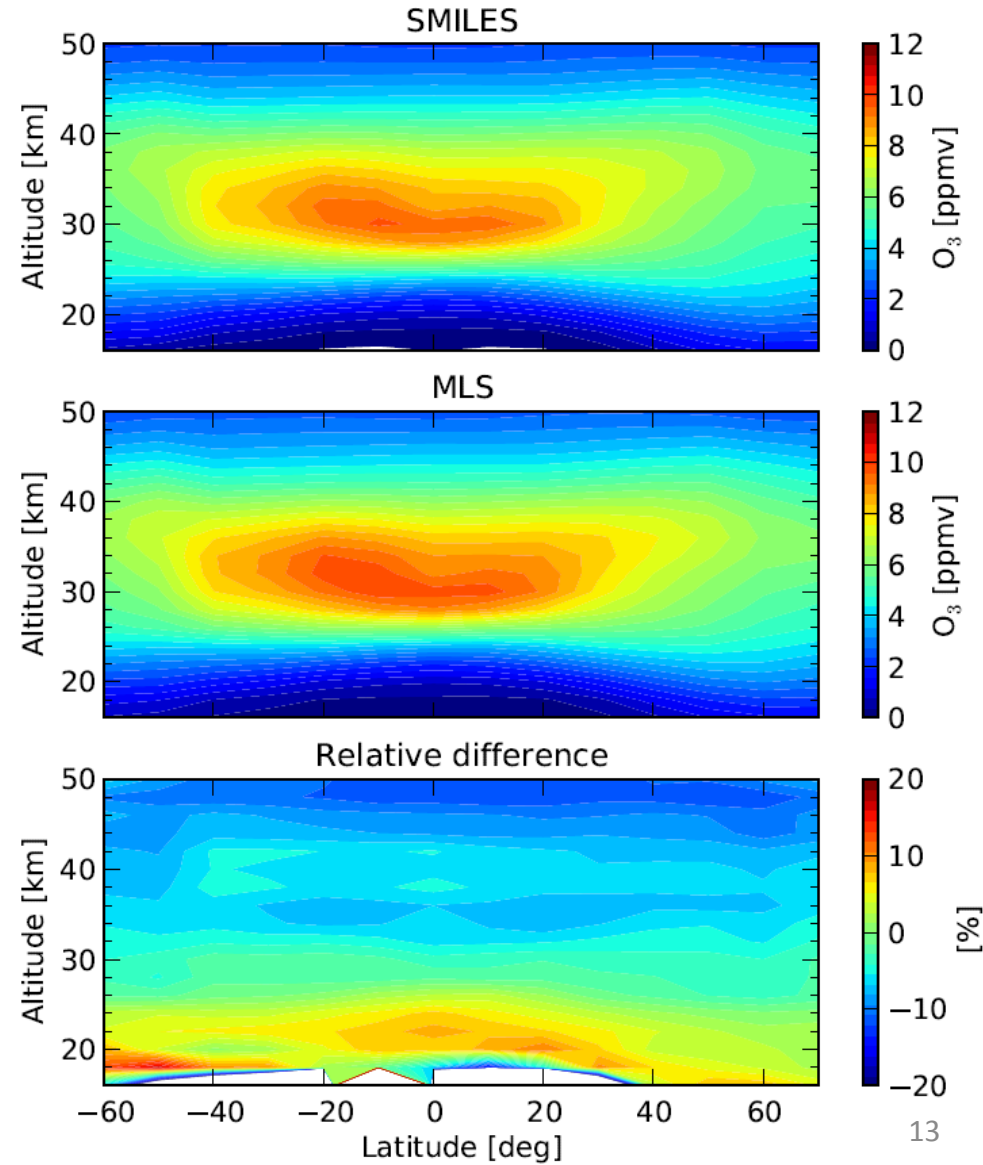
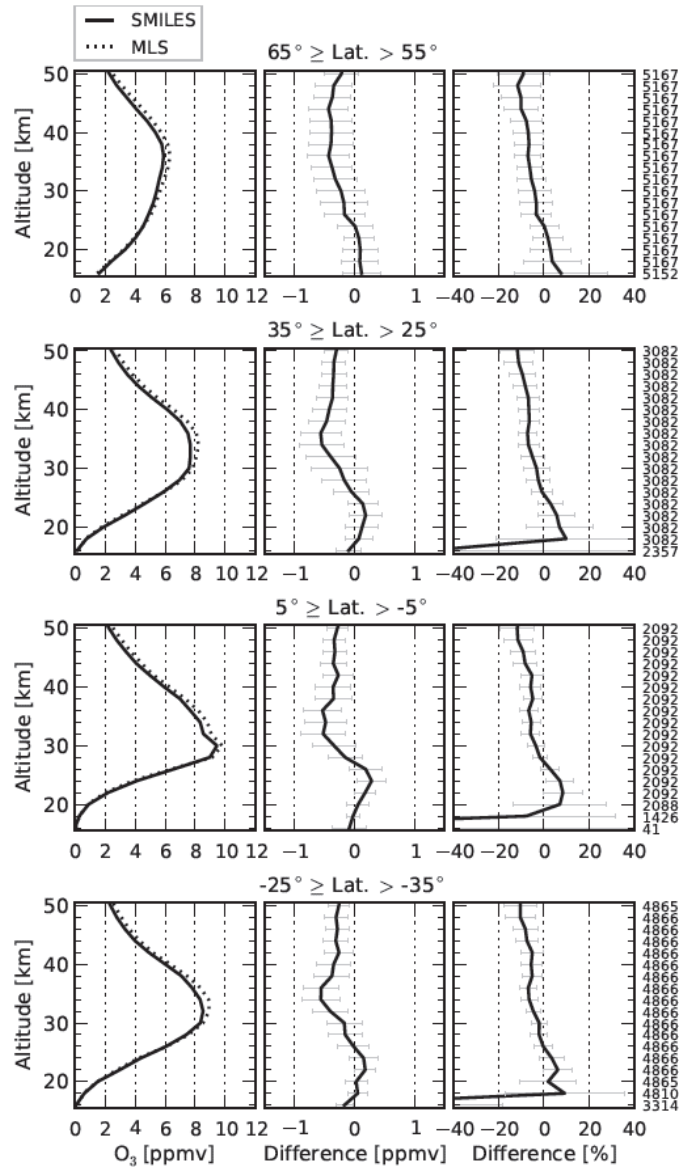
(upper) Relative difference between SAGEII and NOAA16/SBUV2 ozone partial columns in layer 10 at 0-5N before and after the sunrise/sunset (SR/SS) bias was removed.  
(lower) SR/SS bias  
(McLinden et al., 2009, ACP)

# Validation of ozone data from the Superconducting Submillimeter-Wave Limb-Emission Sounder (SMILES)

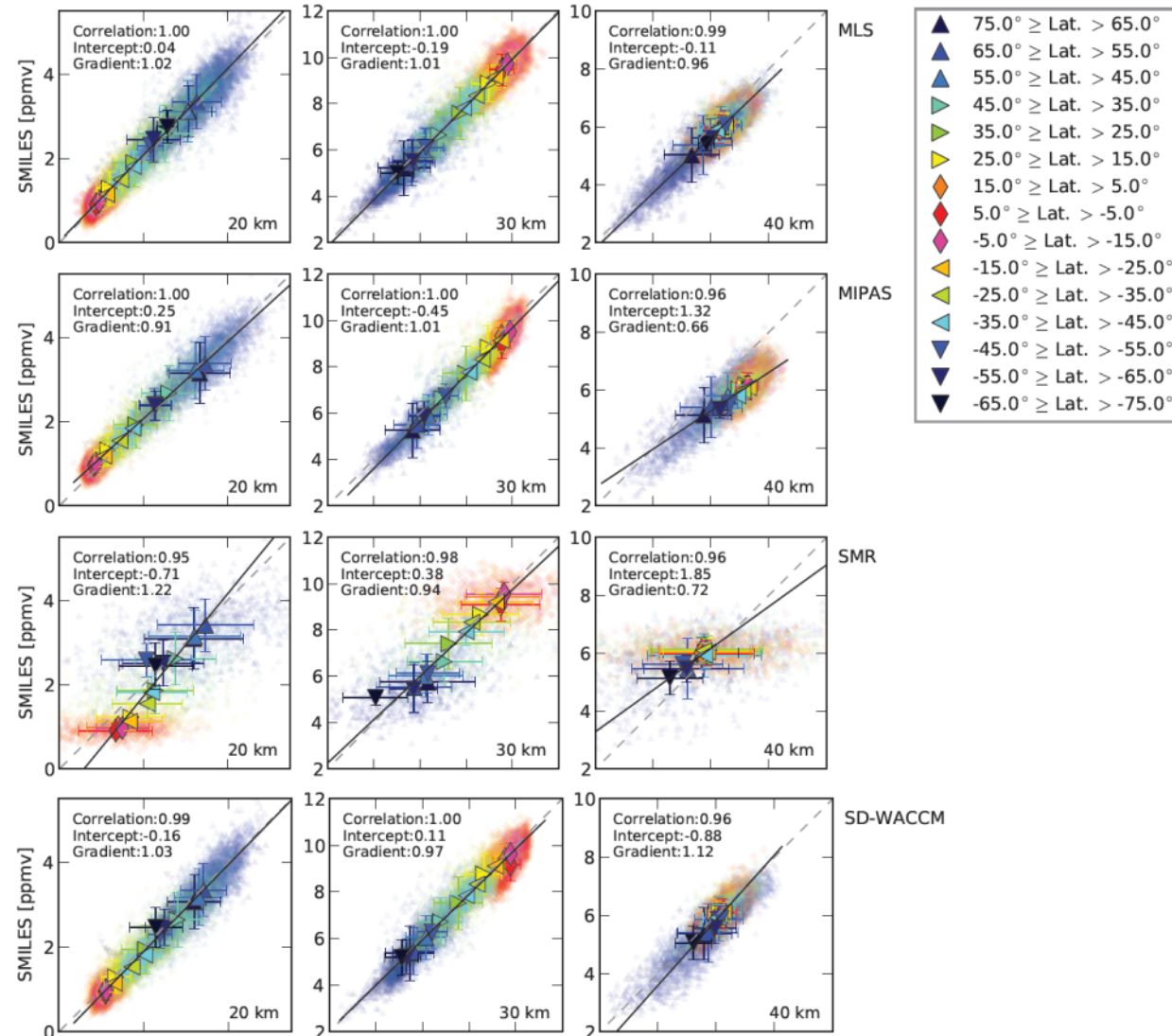
by Imai et al.  
(JGR, 2013)



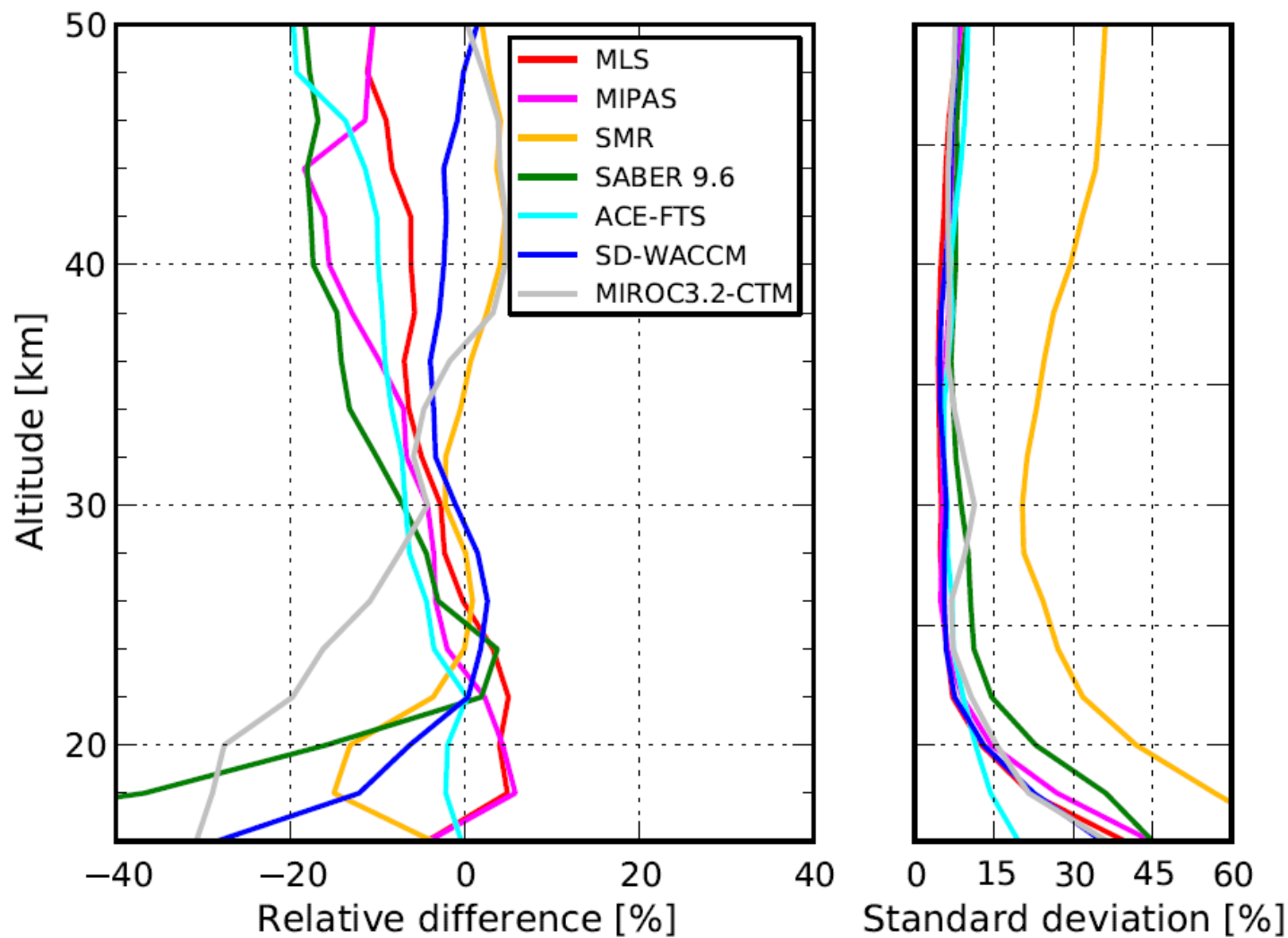
# SMILES and MLS comparisons



# Variability of SMILES ozone data



# Comparisons of ozone with other data

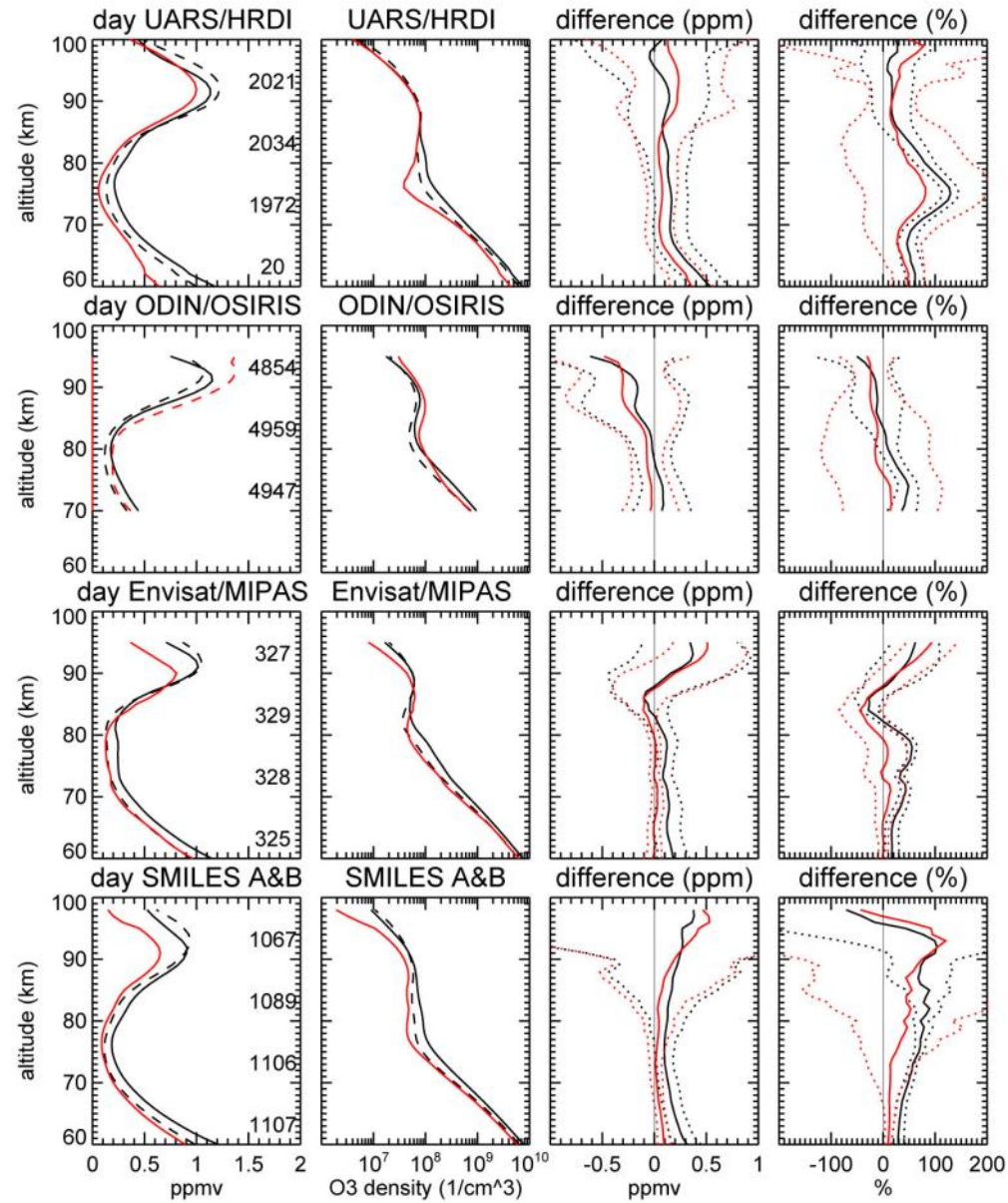


# Satellite Observations of Ozone in the Upper Mesosphere

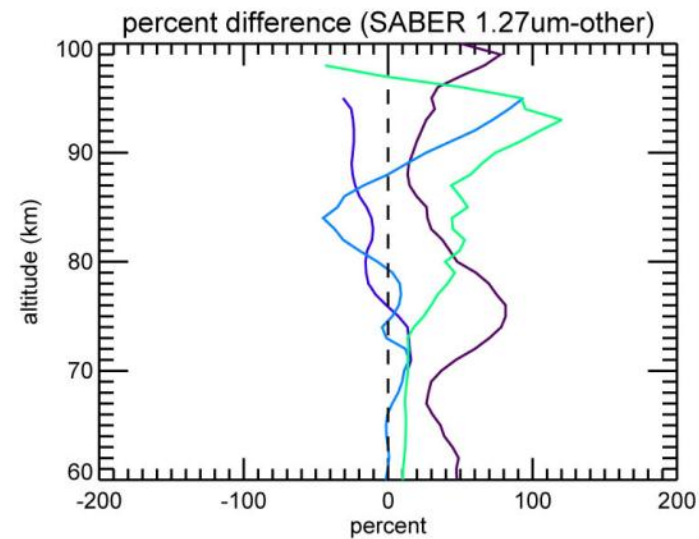
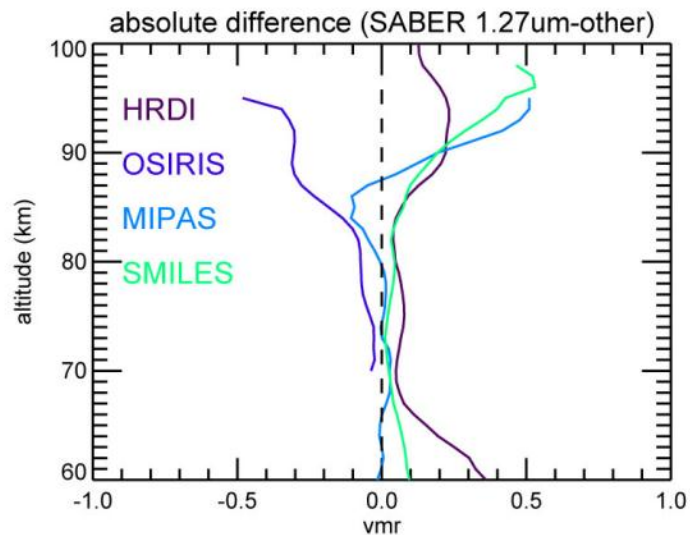
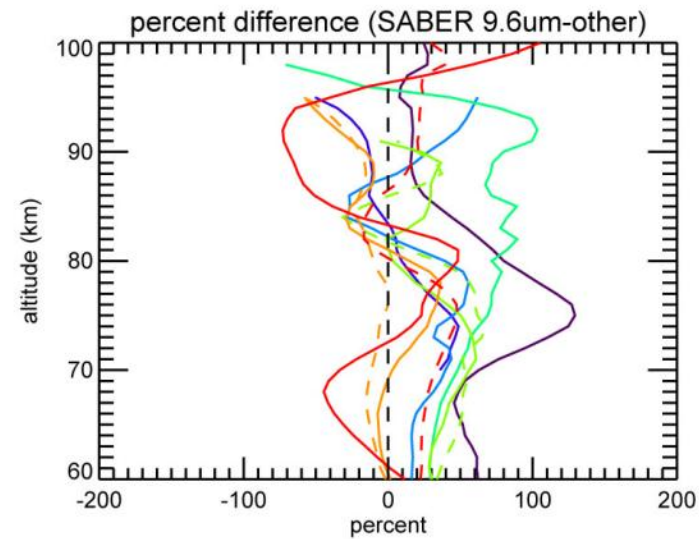
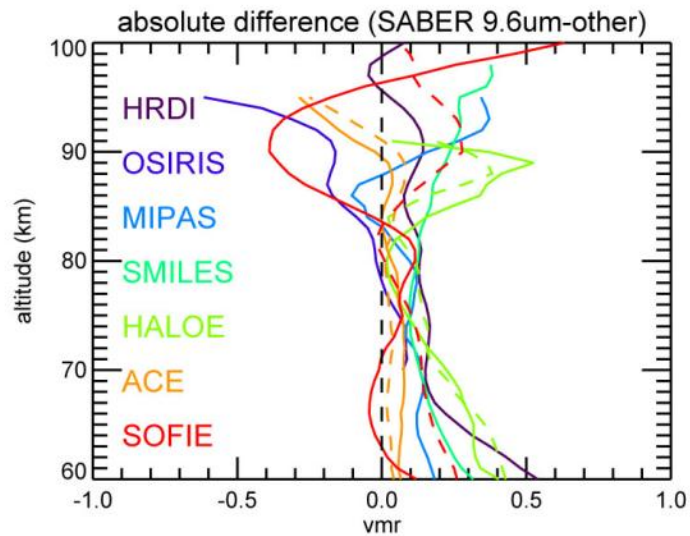
by Smith et al.  
(JGR, 2013)



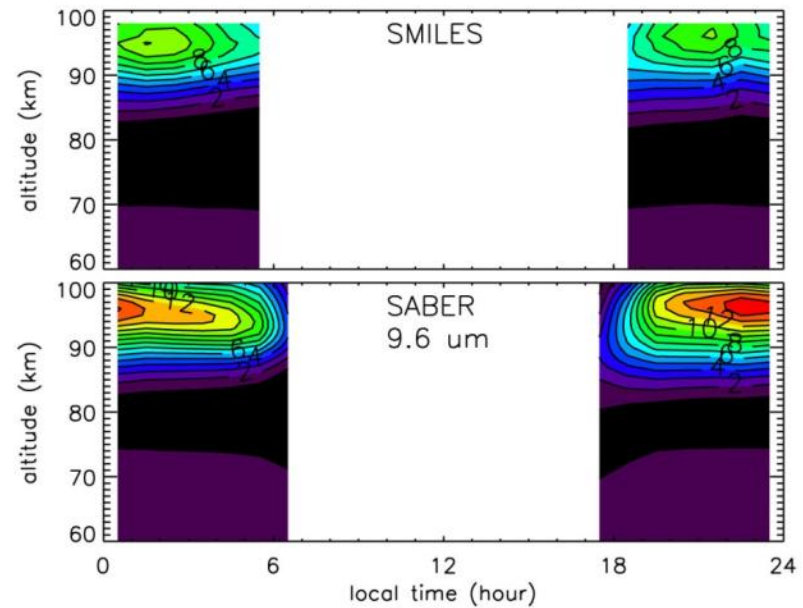
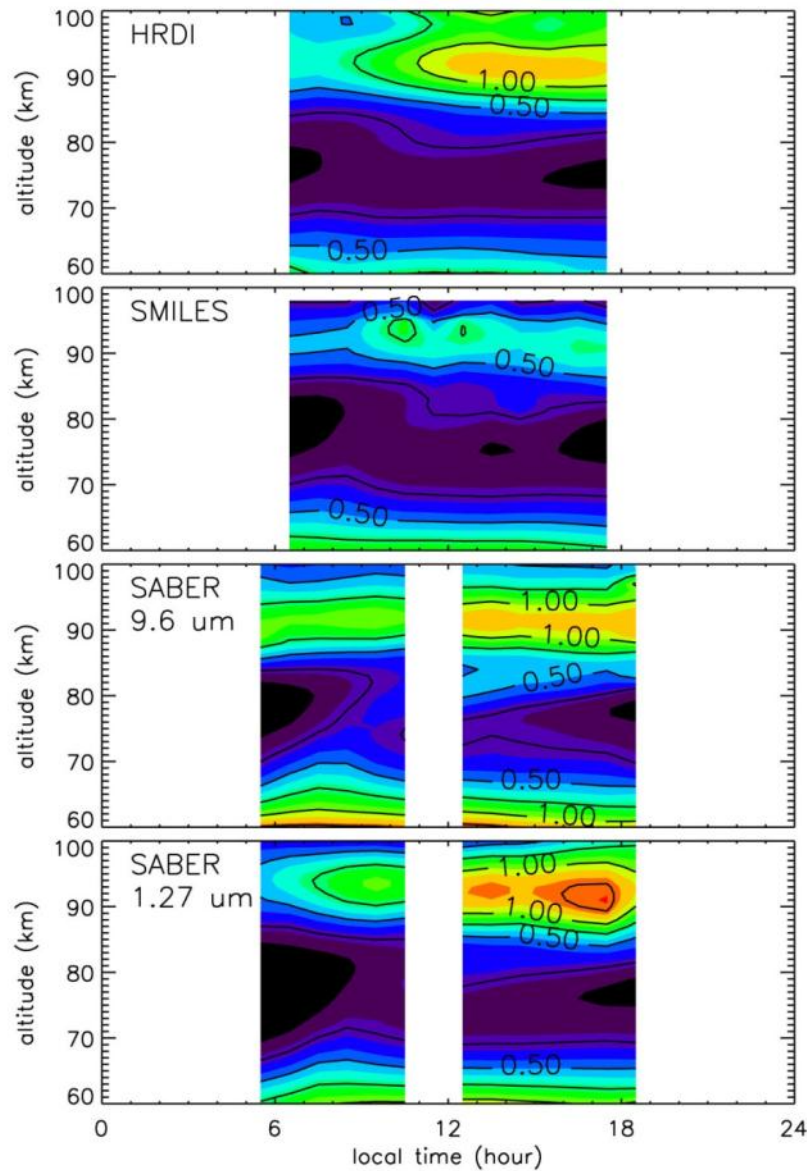
# Profiles of daytime ozone



# Comparisons of SABER vs. others (including SMILES)



# Diurnal variations of mesospheric ozone



# Validation of ClO data from the Superconducting Submillimeter-Wave Limb-Emission Sounder (SMILES)

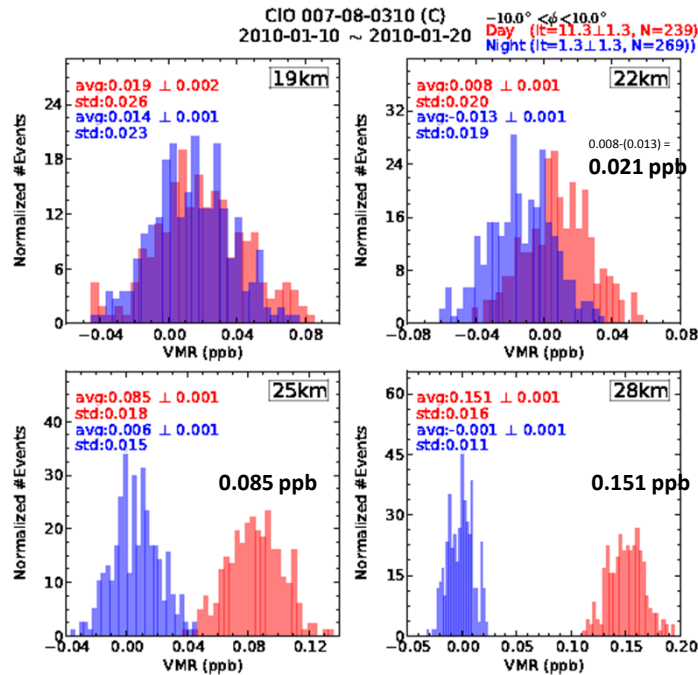
by Suzuki et al.

(See the poster No.21 in detail)

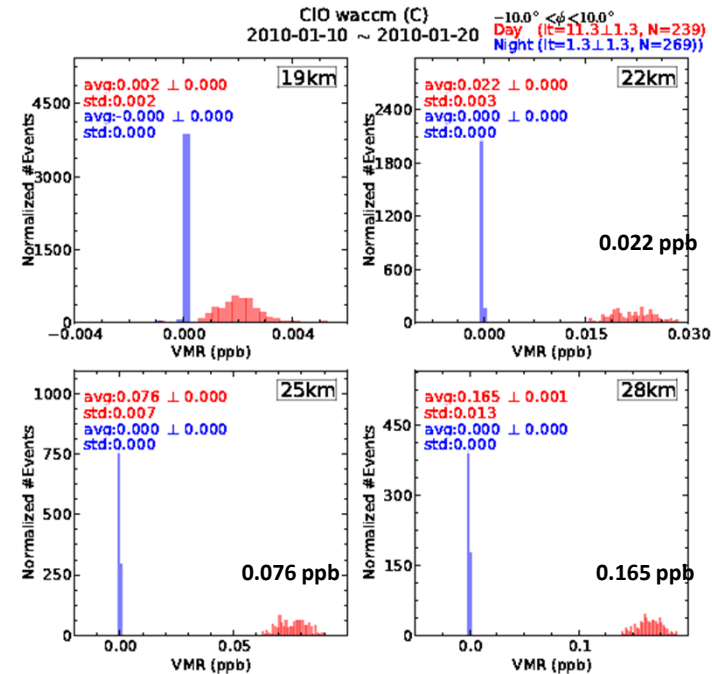


# CIO in the Equatorial lower stratosphere

## SMILES



## SD-WACCM

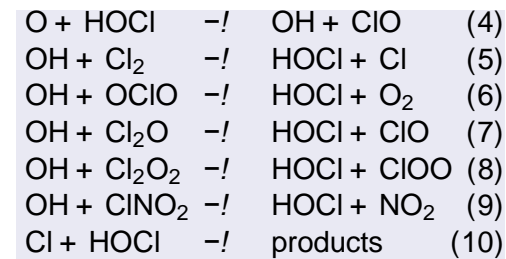
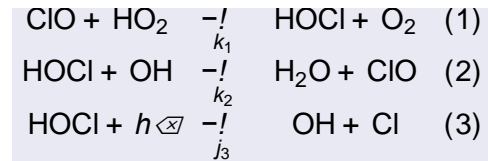
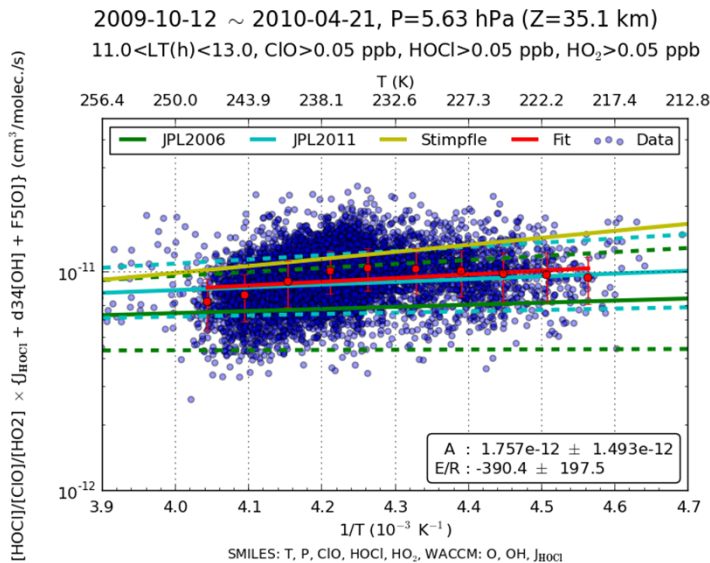
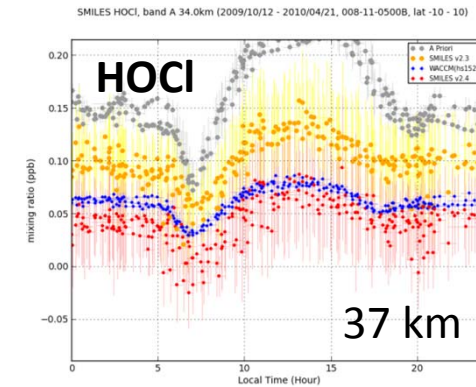
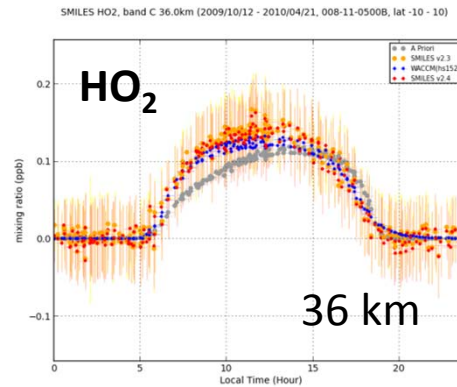
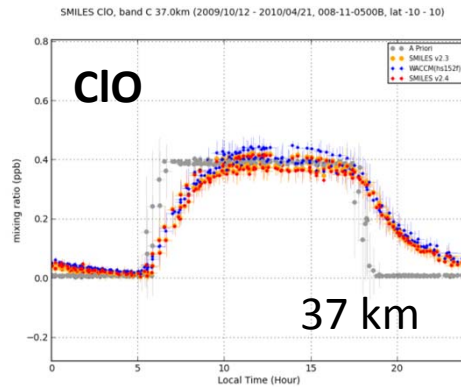


	SMILES			SD-WACCM		
	Day	Night	Day-Night	Day	Night	Day-Night
22 km	8 ± 1	-13 ± 1	21 ± 2	22	0	22
25 km	85 ± 1	6 ± 1	79 ± 2	76	0	76
28 km	151 ± 1	-1 ± 1	152 ± 2	165 ± 1	0	165 ± 1 <sub>21</sub>

# Diurnal variation of ClO, HO<sub>2</sub>, and HOCl



Trial to verify the reaction rate of ClO + HO<sub>2</sub> using SMILES data



$$k_1 = \frac{[\text{HOCl}]}{[\text{HO}_2][\text{ClO}]} (j_3 + k_2[\text{OH}] + k_4[\text{O}])$$

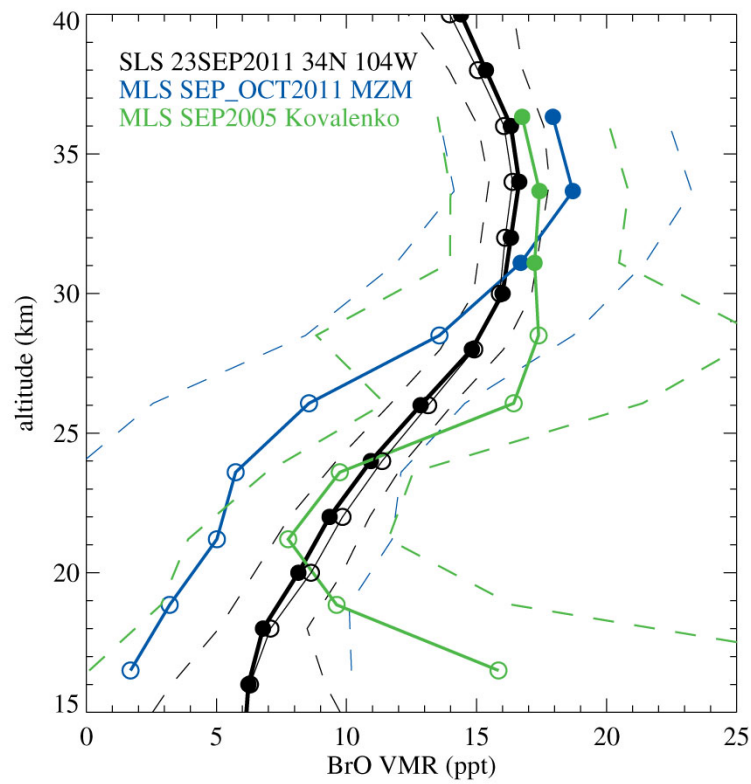
# Stratospheric BrO abundance measured by a balloon-borne submillimeterwave radiometer

by Stachnik et al.  
(ACP, 2013)

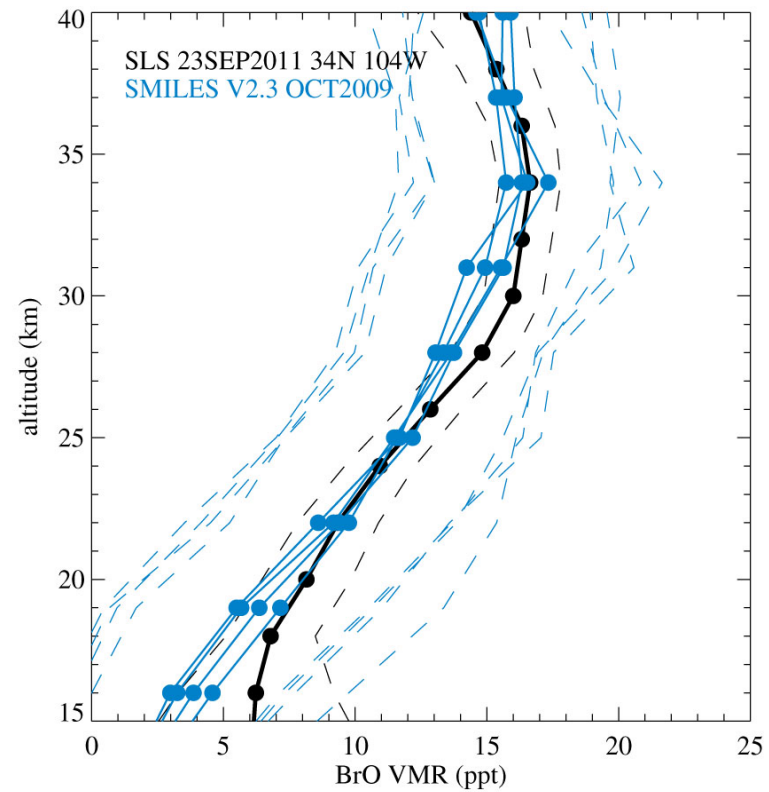
# BrO observations



## MLS

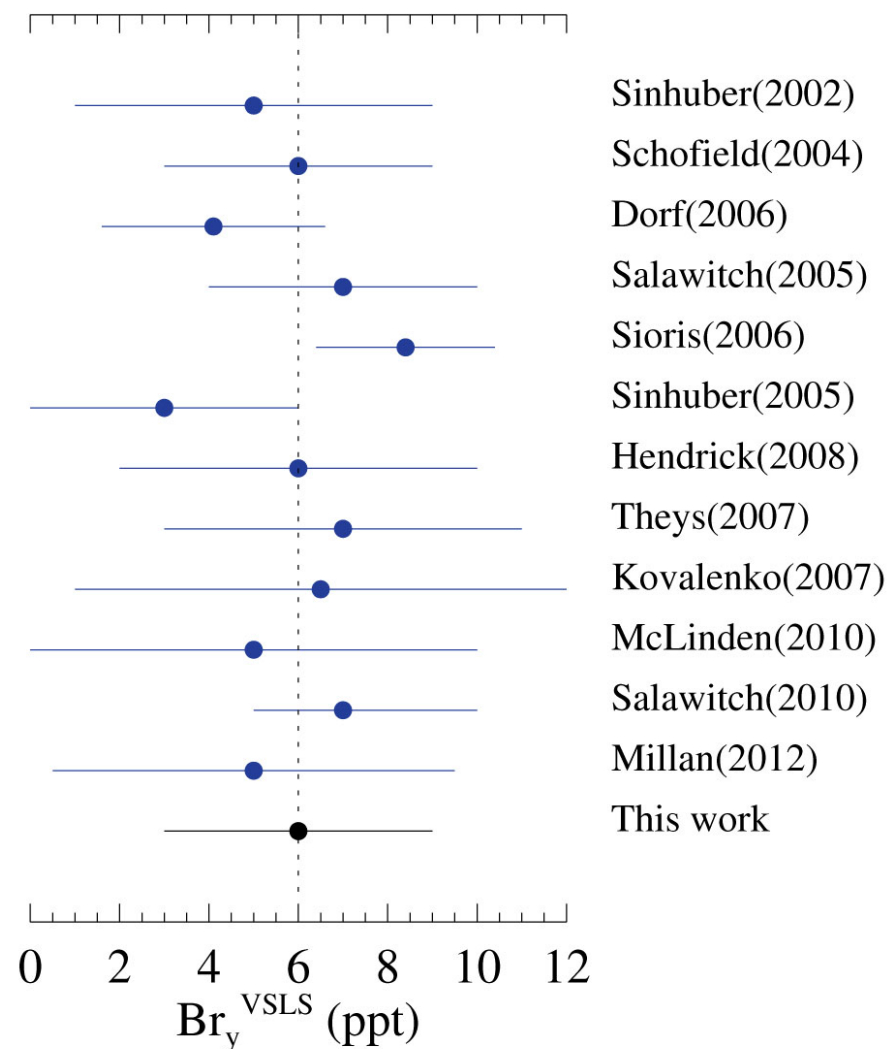


## SMILES





# Estimations of the VSLs contribution to stratospheric inorganic bromine



# SUMMARY

- SMILES made high sensitivity measurements with lower noise than other instruments, and reasonable retrieval results are coming out.
- Diurnal variation of such as  $O_3$ , ClO and so on is one of the unique outcomes contributing to scientific issues in the middle atmosphere.
- We released the SMILES level 2 data to the science community in March 2012. (Latest version will be released in summer of 2013)