# L2/L3 data processing in NICT for JEM/SMILES
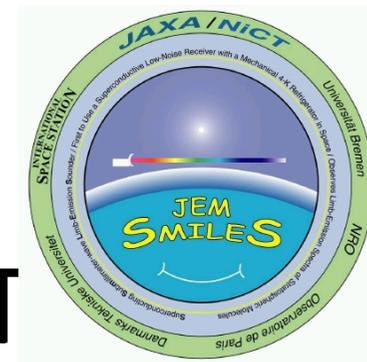
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and the SMILES instrument/mission teams

(1) National Institute of Information and Communications Technology (NICT), Tokyo, Japan.

(2) Chalmers University of Technology, Goteborg, Sweden

Outline

- Brief introduction of SMILES
- Description of the L2 research products
- Some examples
  - Mesospheric O3,ClO and HO2 profiles
  - Lower stratospheric O3 profile from band C
  - Impact of clouds on the Limb radiances
- Conclusions

Superconducting submillimeter-Wave Limb Emission Sounder (SMILES) overview

- Limb-sounder to study the chemistry and dynamics in middel atmosphere

- High sensitive sub-millimeter receiver (first use for atmospheric observation of a 4K cooled SIS mixer in space)

- Operate from the Japanese Experiment Module (JEM) on the International Space Station (ISS).

- Launched in Sept. 2009, commissioning phase ended the 6th Nov.

Observation characteristics

Limb scanning observation

from SMILES Mission Plan
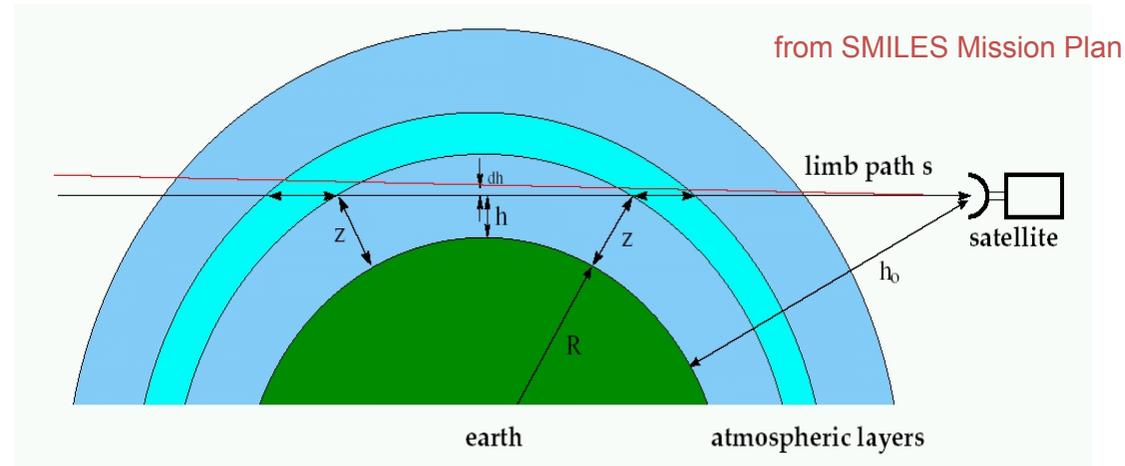
- Atmosphere is repeatedly scanned from the below surface to ~100 km height (1600 scans/day).

- Latitudes coverage from 40S to 60N

- 3 spectral bands (λ=0.1 mm) have been defined but **only 2** are simultaneously observed during one scan.

- Vertical distribution of molecular abundances and temperature/pressure (Level 2 data) are derived from each scan.

Frequency bands
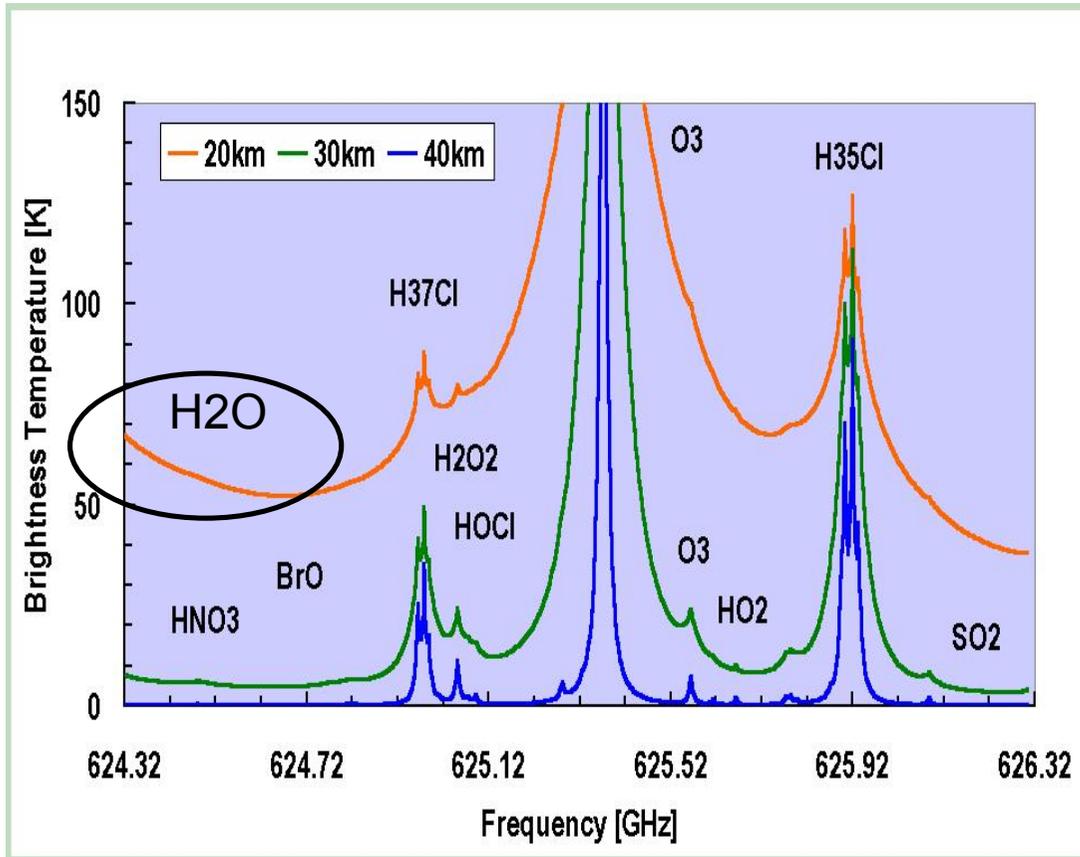
from SMILES Mission Plan
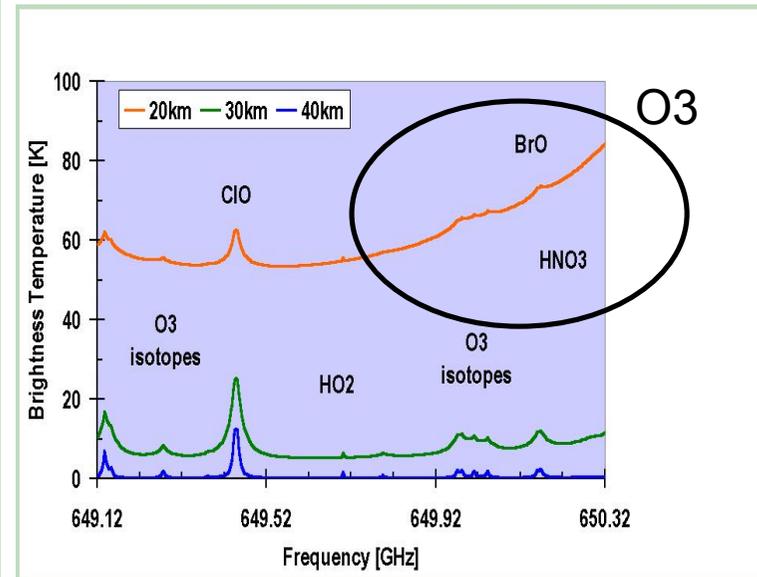
Use of a SIS mixer to reduce the noise level

Simulation of the SMILES ClO line as it would be seen by Odin/SMR
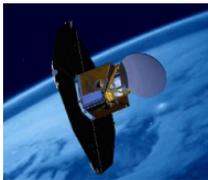
Odin/SMR (2001-)
Tsys: 3000K
(SSB@500GHz)
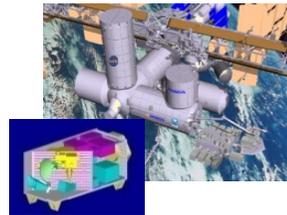
JEM/SMILES (2009-)
Tsys: 300K
(SSB@650GHz)
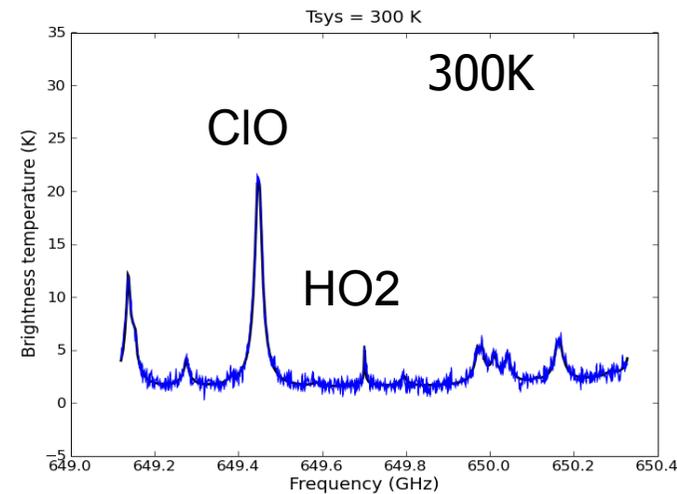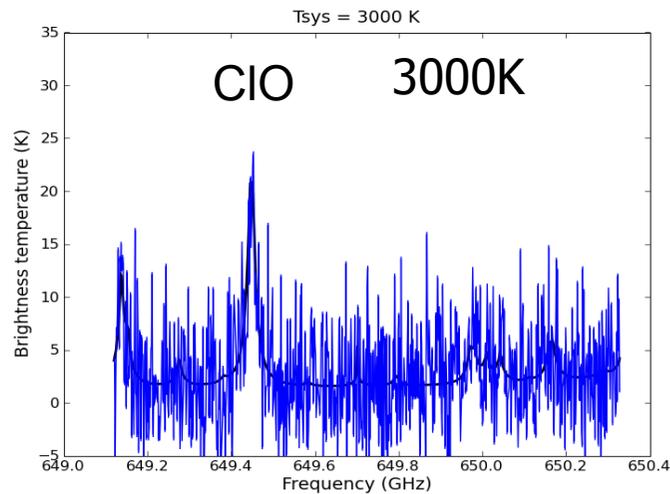
# SMILES limb observations on 2009/10/10

Band A
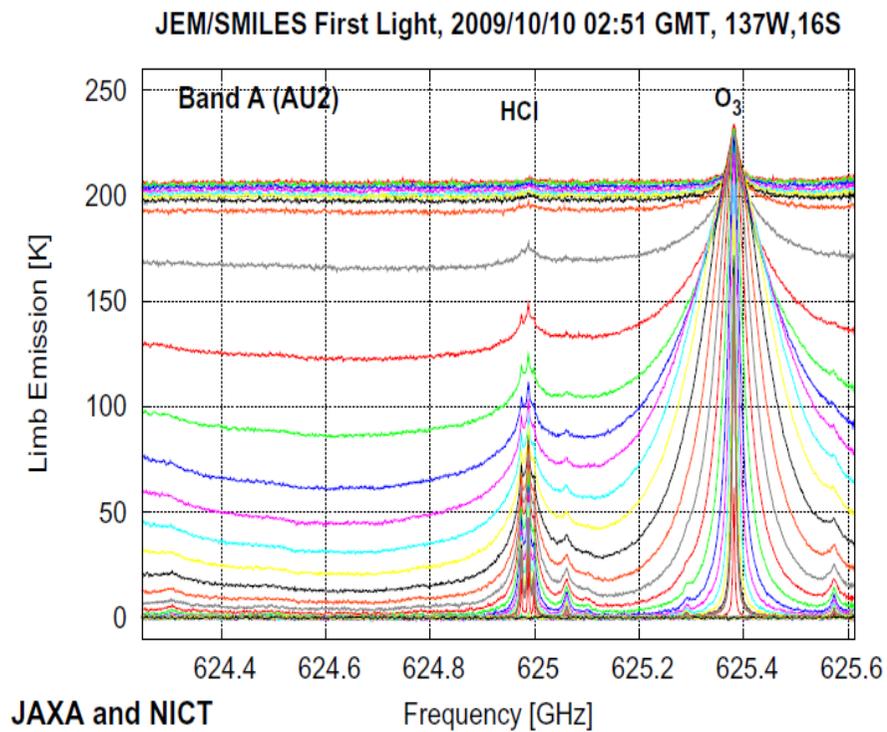
Band C
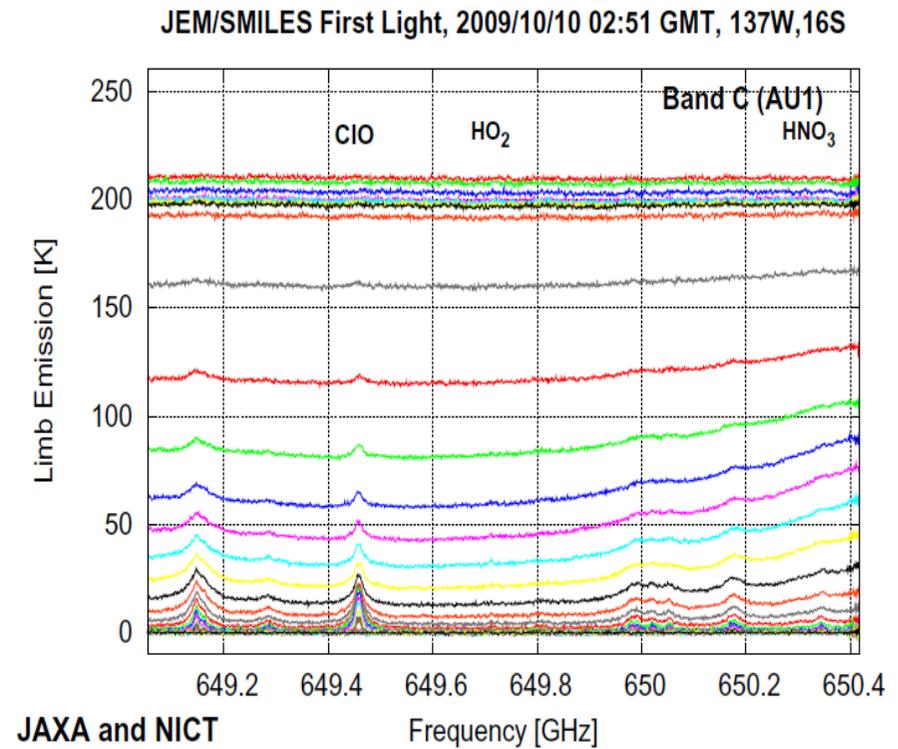
SMILES system temperature is 300 K (500 K expected)

# Diurnal cycle
(orbit drifts of 24 hours in 2 months)

2009-10-22

2009-11-03
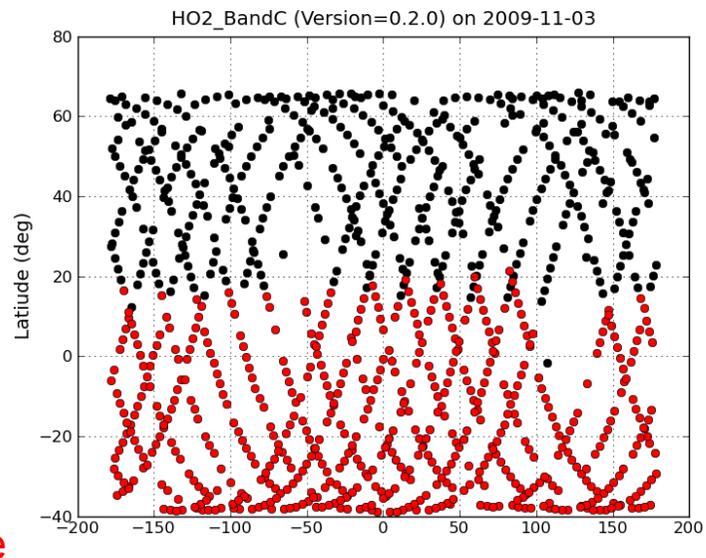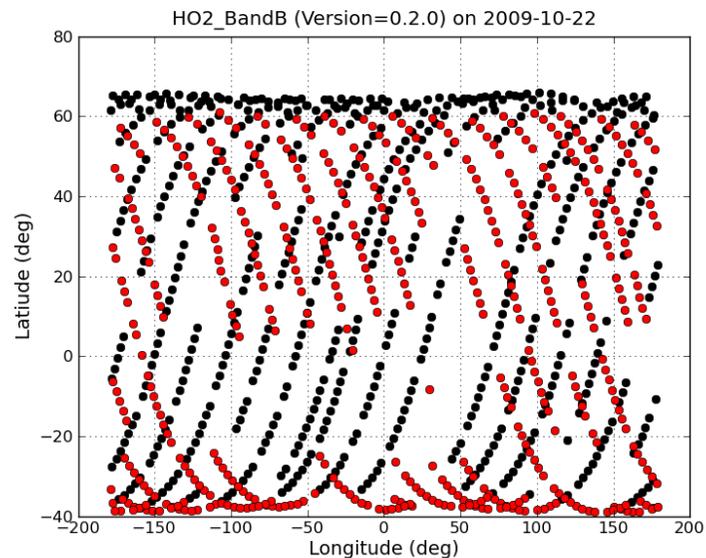
red=day time

black=night time
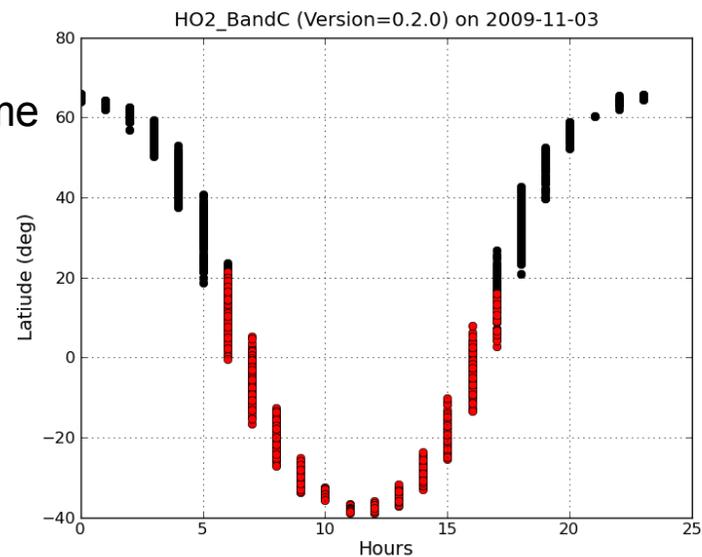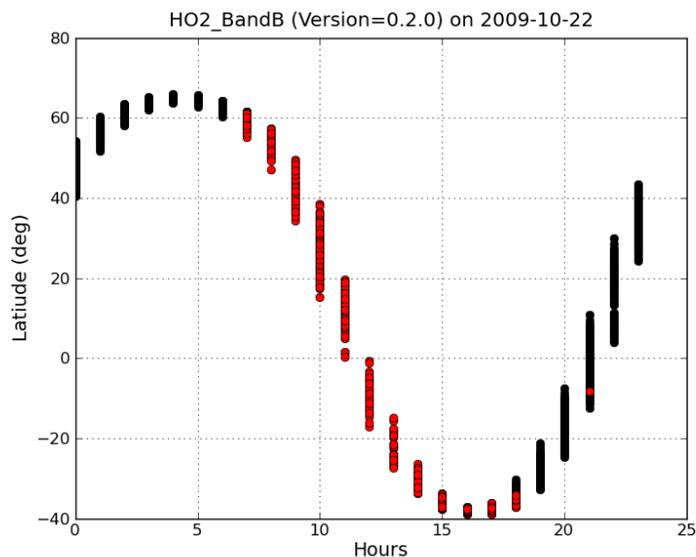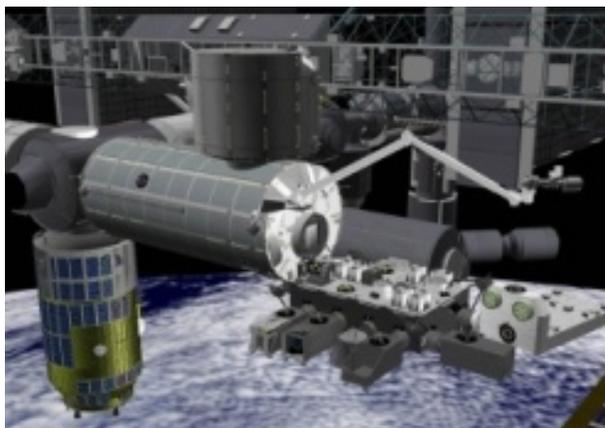
ISS

JAXA/TKSC

L0/L1b data

JAXA/ISAS

NICT

L2 Operational

Steady, Real time, and Complete
system for operational processing

L2 Research

Flexible, Fast, and Small system
for research processing
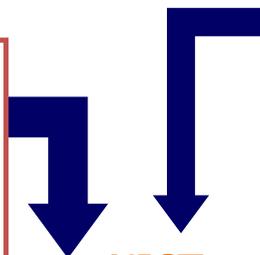
NICT

L3 data

Theoretical precision and altitude range of SMILES species

JEM/SMILES Observation

Midlatitude atmospheric scenario

Operational processing

Altitude [km]

Tropopause

Ice Cloud

Temp | O3 | H35Cl | H37Cl | ClO | H2O | HNO3 | CH3CN | 18000 | 17000 | HOCl | HO2 | BrO | H2O2 | HOBr | HCHO | SO2 | NO2 | COF2

Precision:
10%* (single scan)   20%* (single scan)   30%** (daily average)   30-50%*** (monthly average)

Altitude resolution:
*2.1 - 3.7km,   *2.1 - 3.7km,   **3.6 - 4.7km,   ***4.6 - 6.7km
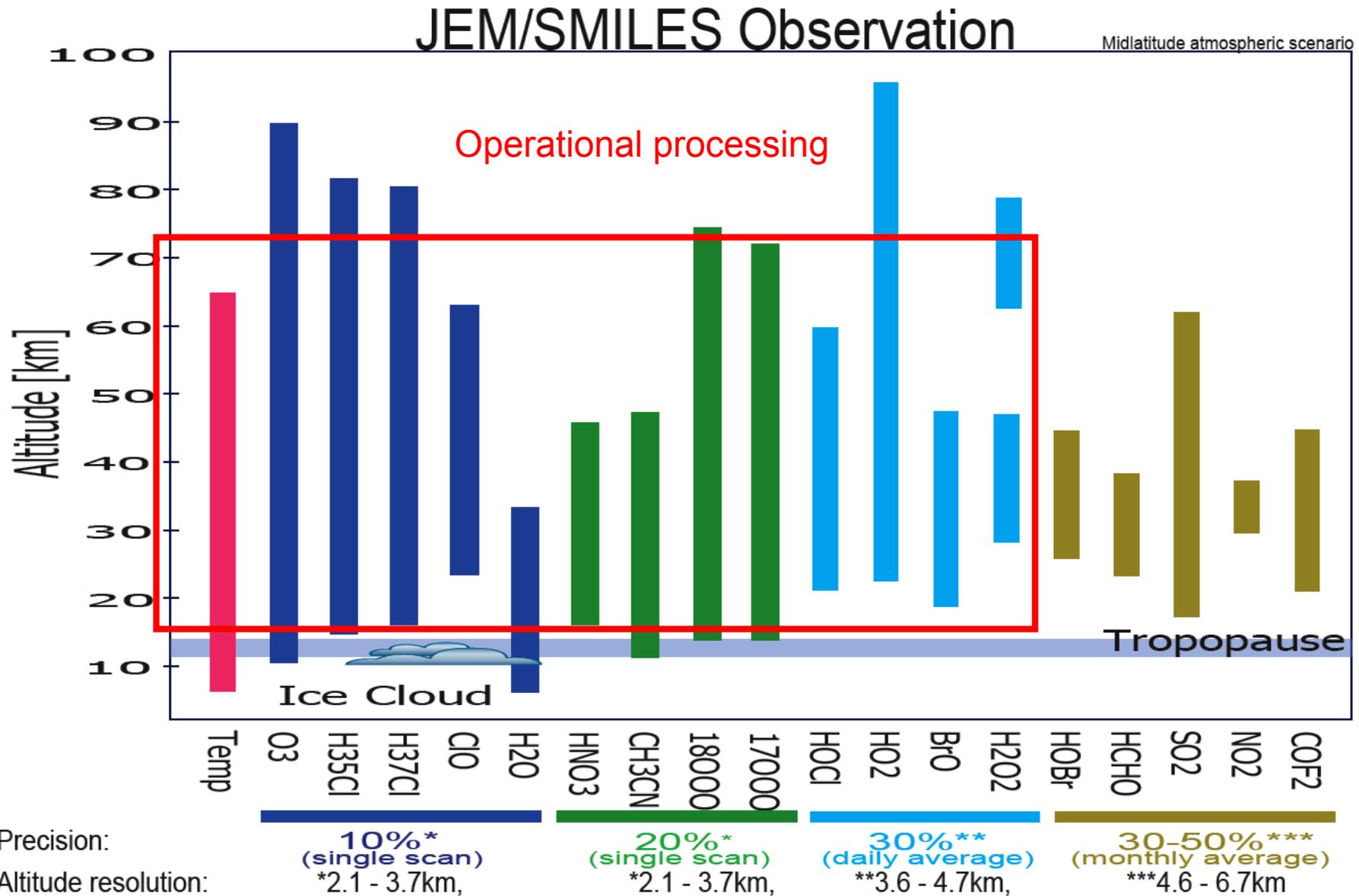
Why a L2 research chain ?

- Support for improving the operational chain:
  - cross-comparison of the products
  - development of new retrieval algorithms
  - Try to retrieve new products

- Current research focus on:
  - H_2O and O_3 profiles in UT/LS
  - ice water content in the upper troposphere
  - mesospheric profiles of O_3, HO_2, HCl, ClO, $HOCl$, H_2O_2,…
  - Stratospheric and mesospheric line of sight winds

Examples of Mesospheric retrievals

High sensitivity in the mesosphere: good quality of single profiles of O3, HO2, ClO, HCl
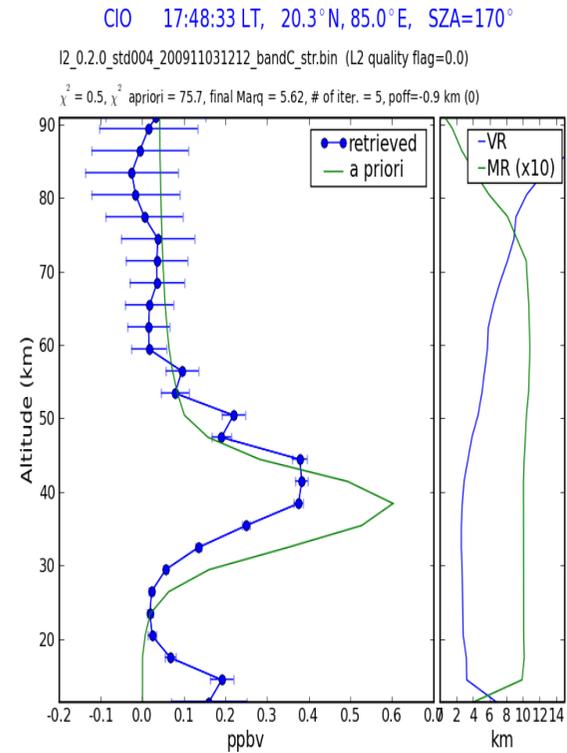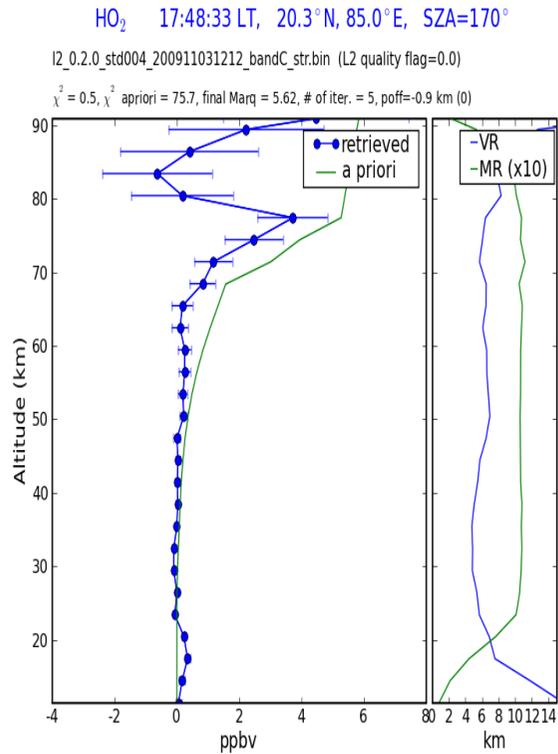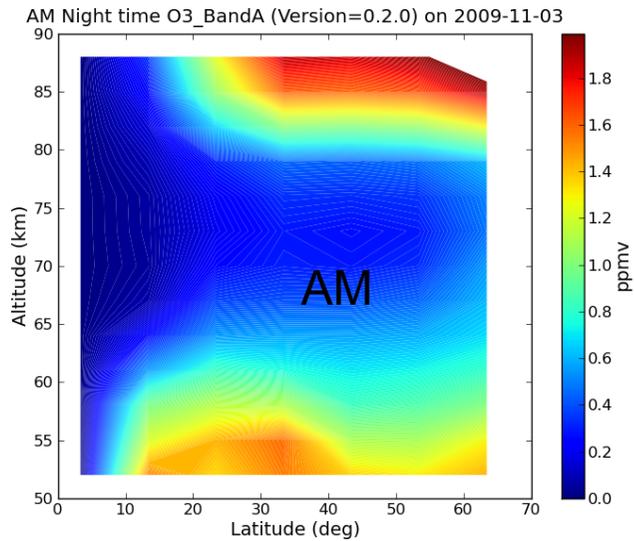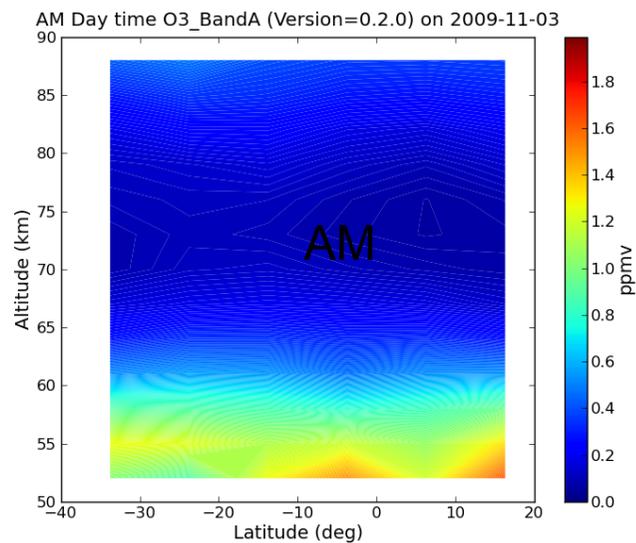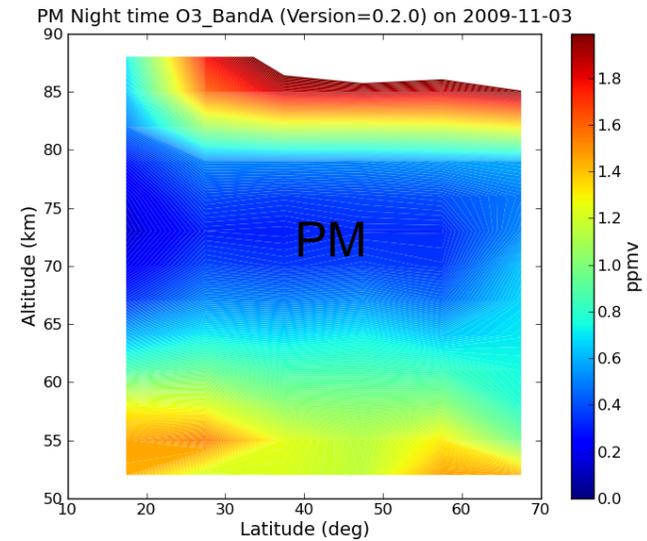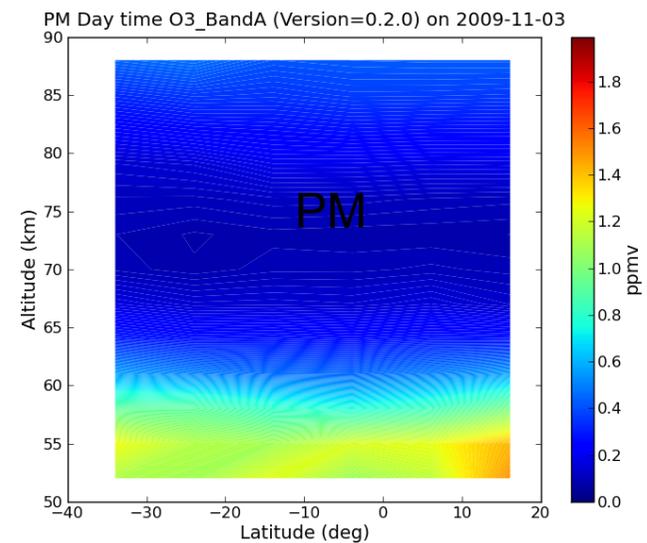

HO$_2$ 17:48:33 LT, 20.3°N, 85.0°E, SZA=170°

l2_0.2.0_std004_200911031212_bandC_str.bin (L2 quality flag=0.0)

χ^2 = 0.5, χ^2 apriori = 75.7, final Marq = 5.62, # of iter. = 5, poff=-0.9 km (0)

ClO   17:48:33 LT, 20.3°N, 85.0°E, SZA=170°

l2_0.2.0_std004_200911031212_bandC_str.bin (L2 quality flag=0.0)

χ^2 = 0.5, χ^2 apriori = 75.7, final Marq = 5.62, # of iter. = 5, poff=-0.9 km (0)
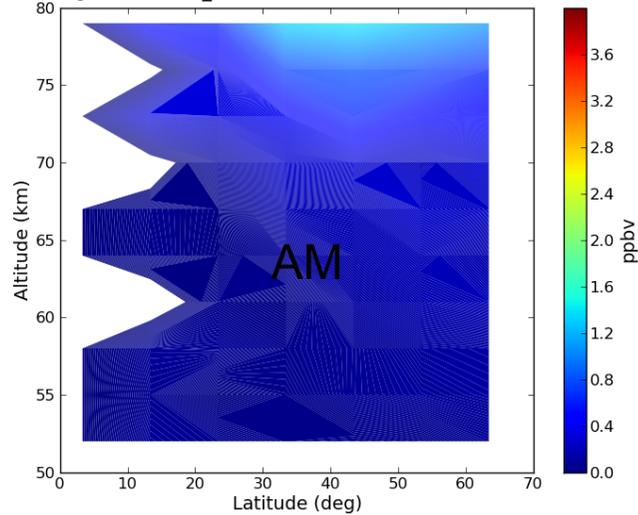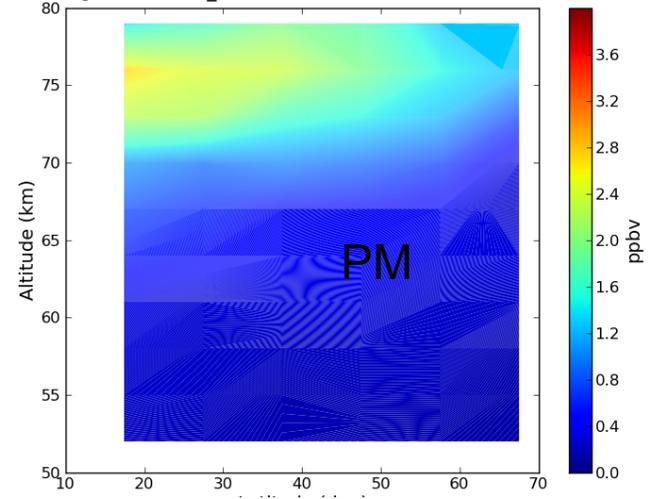
O3 in the mesosphere: 20091103 (preliminary results)
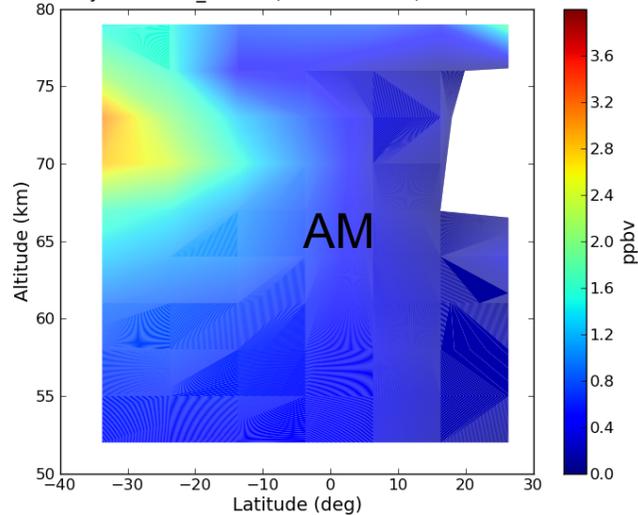
HO2 in the mesosphere: 20091103 (preliminary results)
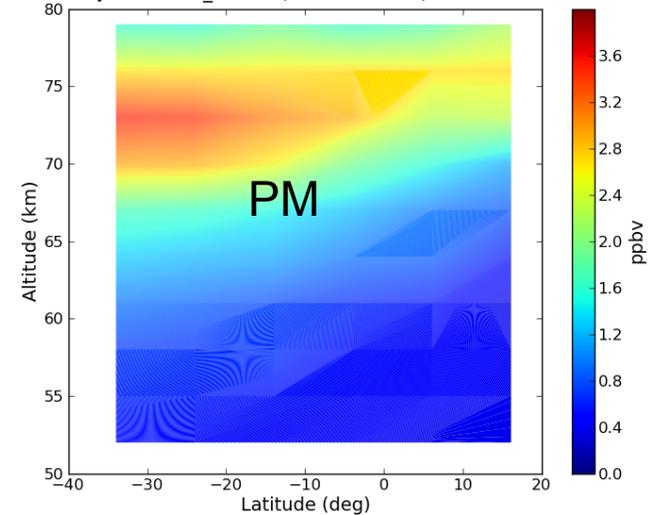
ClO in the mesosphere: 20091103 (preliminary results)
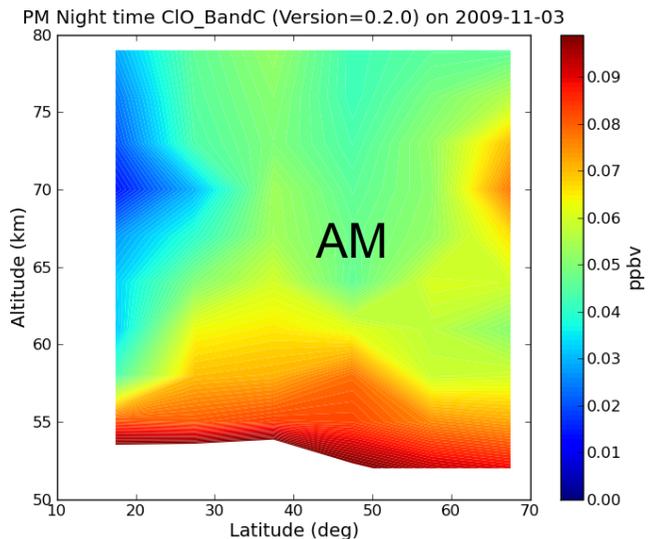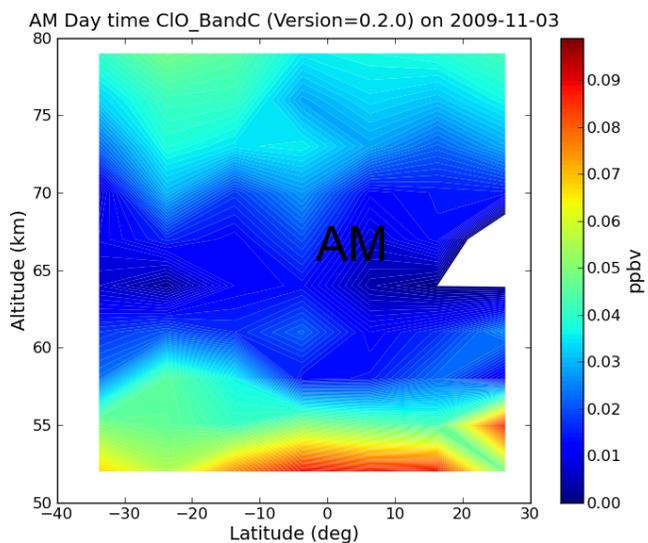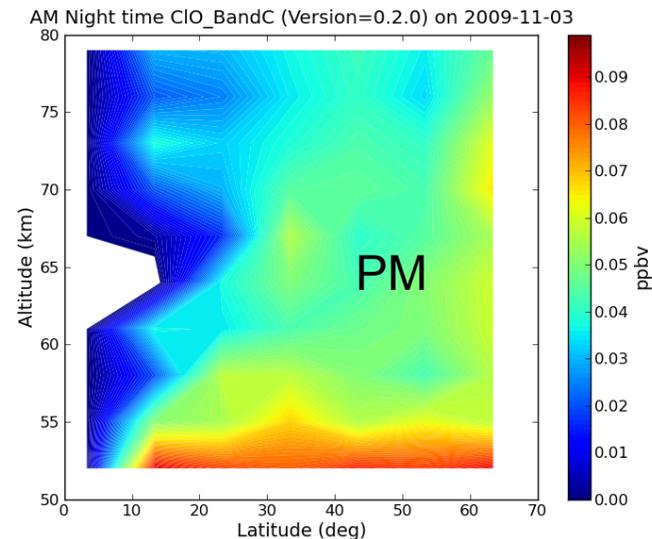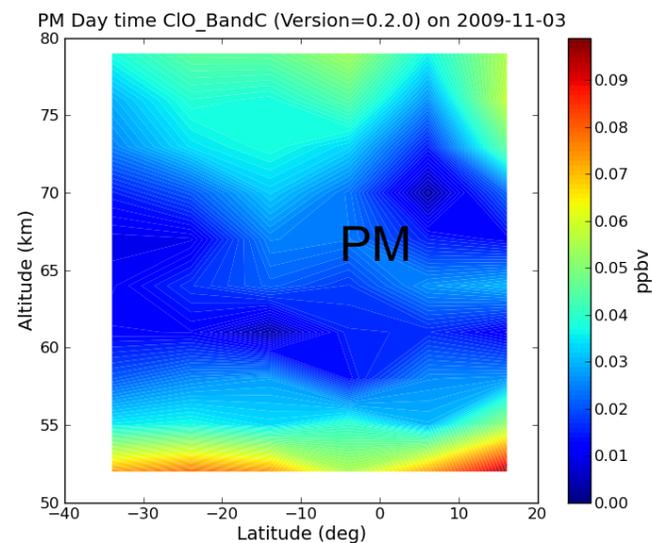
Mesosphere (20091022)
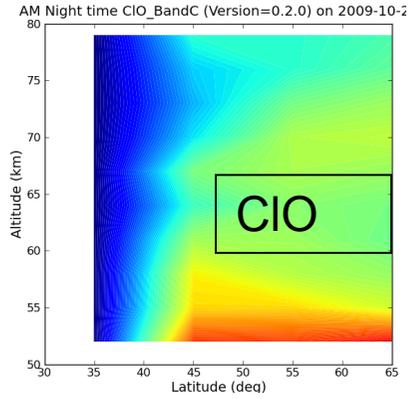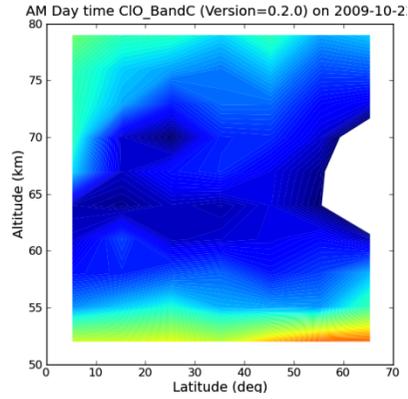
AM-night	AM-day	PM-day	PM-night
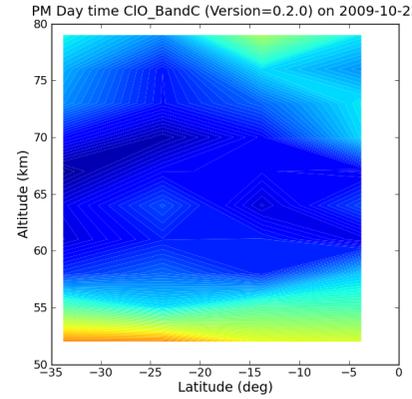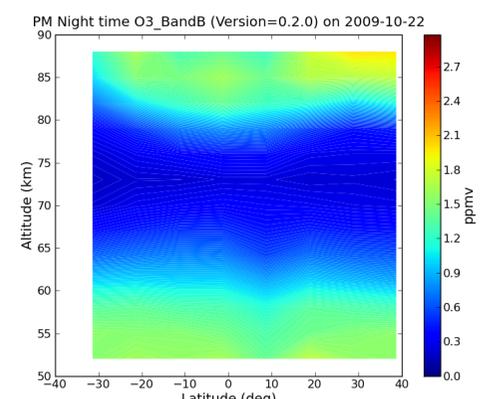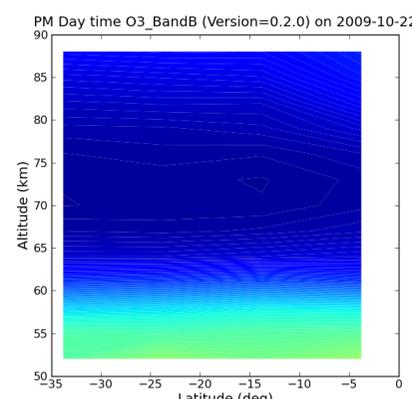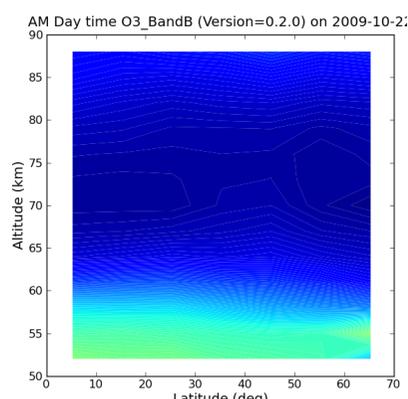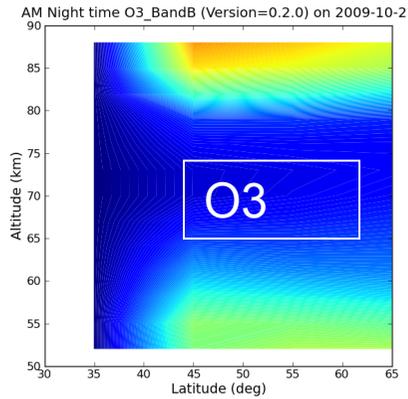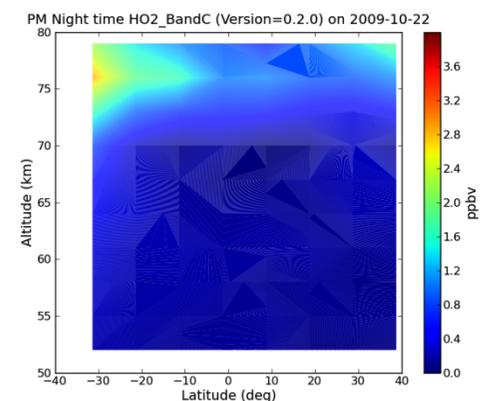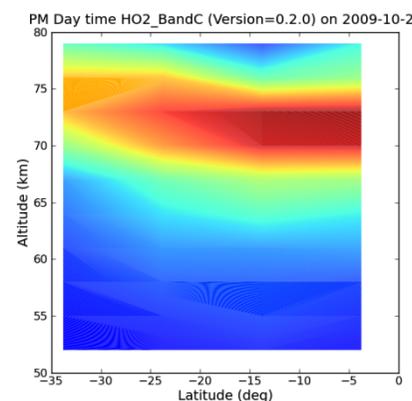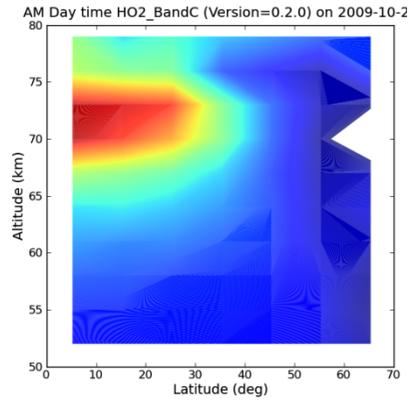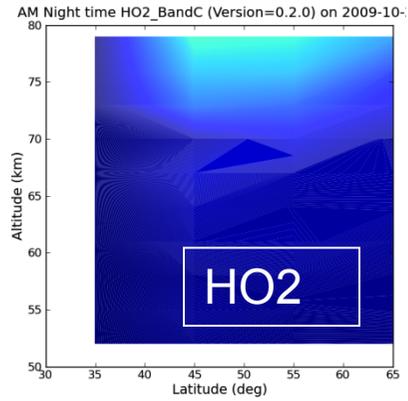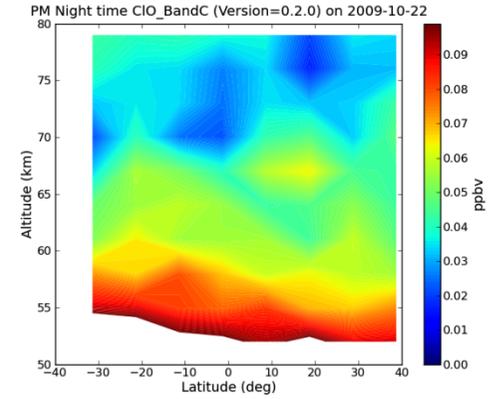
Examples of UT/LS analysis

O3 in the UT/LS from band C (preliminary results)

JEM/SMILES First Light, 2009/10/10 02:51 GMT, 137W,16S

JAXA and NICT

O3_BandC (Version=0.2.0) on 2009-11-03
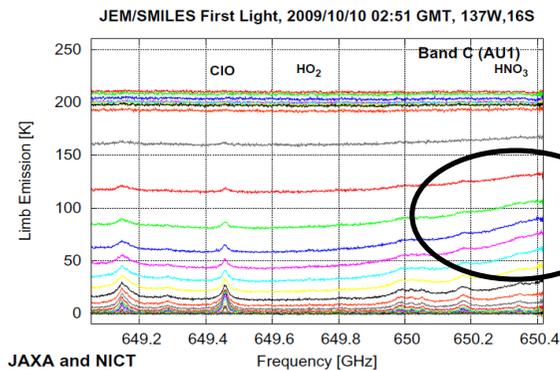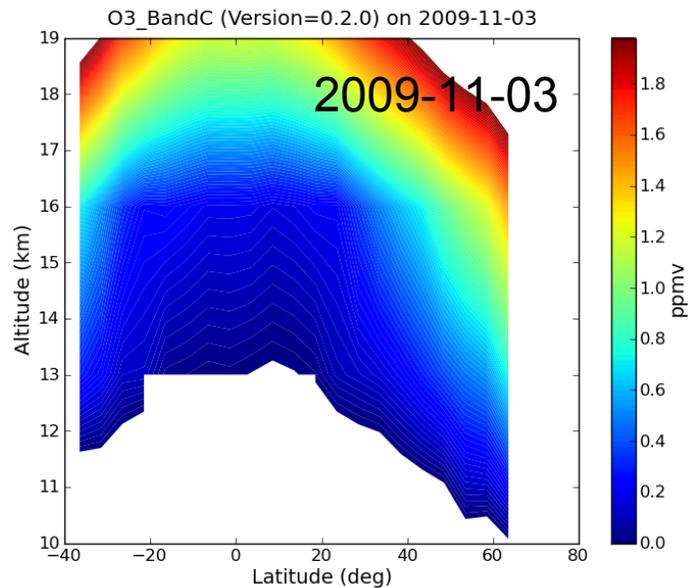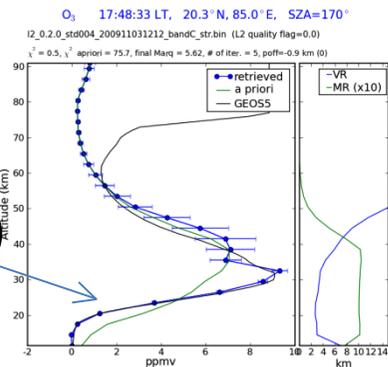
2009-11-03

O3-**band C** *vs* GEOS-5

20091022

13 km

16 km

19 km
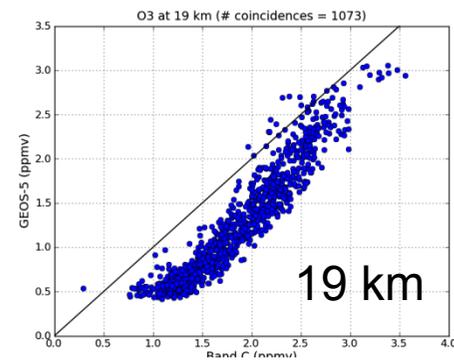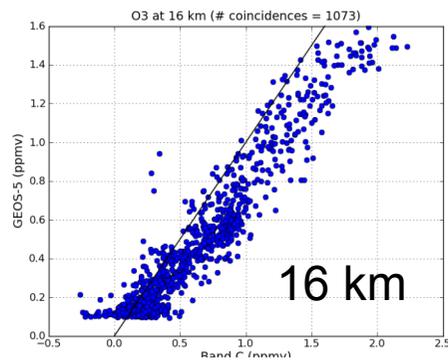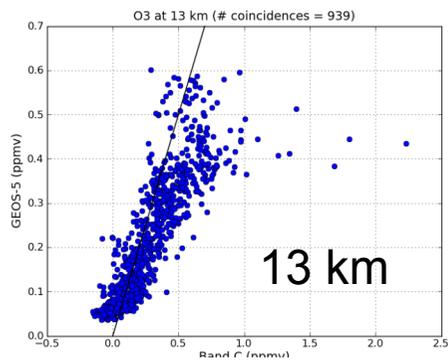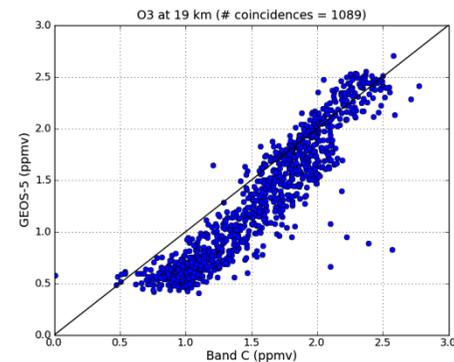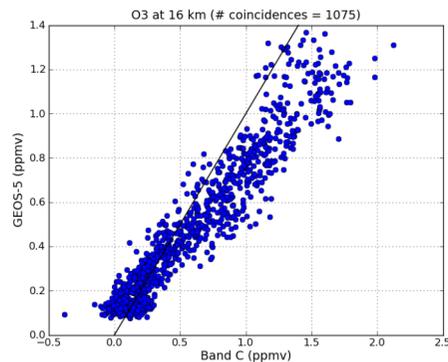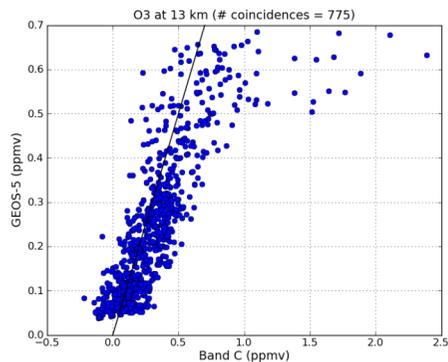
20091103

O3 in UT/LS:
comparison between bands A,B and C

O3_BandB (Version=0.2.0) on 2009-10-22

O3_Banda (Version=0.2.0) on 2009-11-03
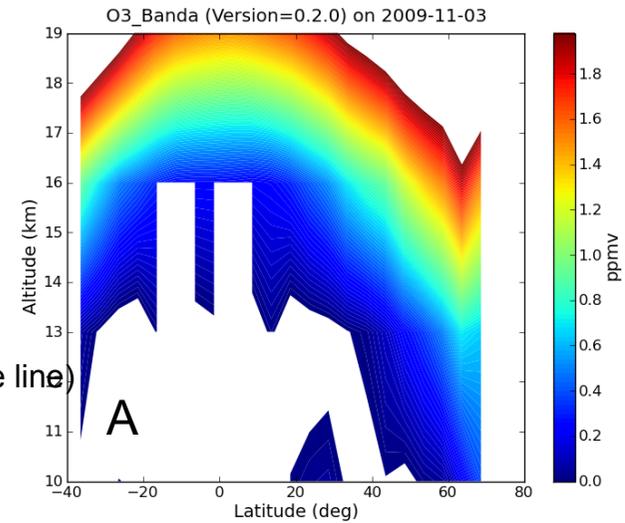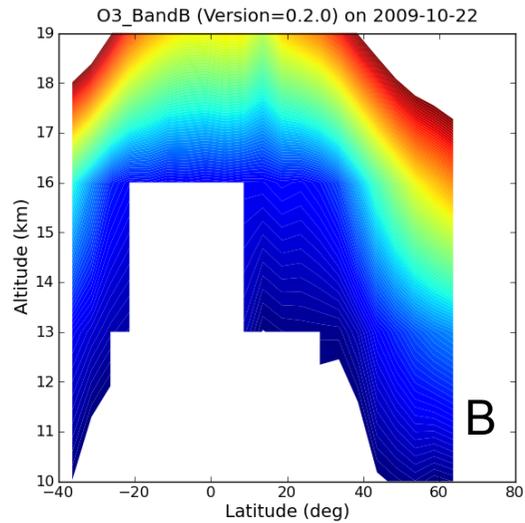
(contain same strong ozone line)

B

A

2009-10-22

2009-11-03

O3_BandC (Version=0.2.0) on 2009-10-22

O3_BandC (Version=0.2.0) on 2009-11-03

C

C
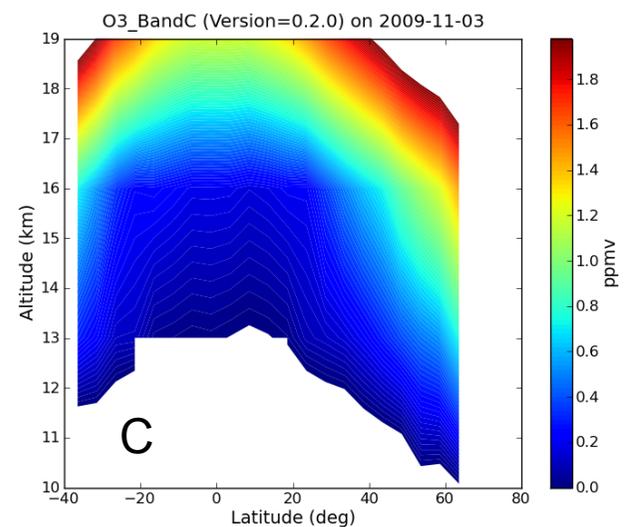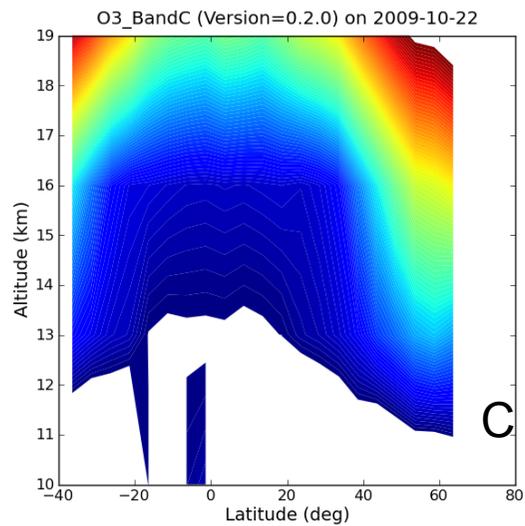
Sensitivity to ice particules in the upper troposphere :
illustration with observations in the Tropics

dashed line: clear sky

IWC Retrieval algorithms under development
(responsible **Jana Mendrok**, NICT/Luleå University)

->collaboration with Odin/SMR and EOS/MLS teams.
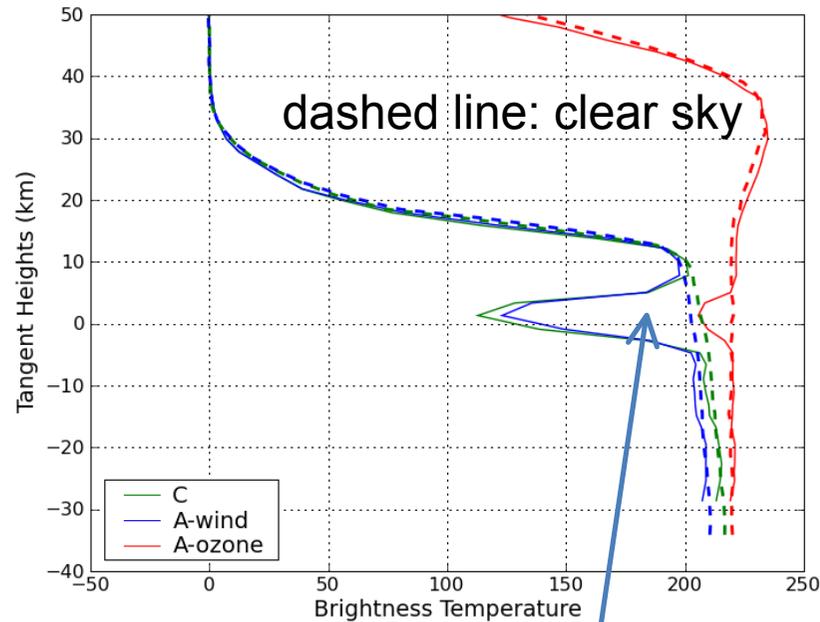
Decrease of intensity due to scattering from ice particules
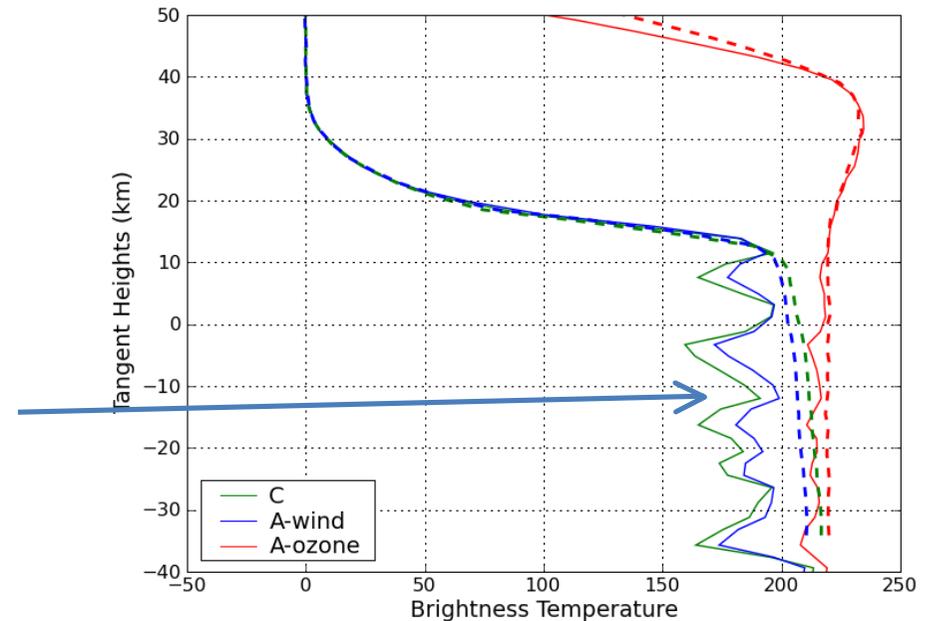
Conclusions

- SMILES has been launched on 11th September.
- Test observations was performed until 6th November (end of the commissioning phase)

- SMILES observations
    - O3 chemistry, chlorine and bromine budget related species
    - from 40S to 60N
    - high signal to noise ratio
    - follow the diurnal cycle.

- A **L2 research** chain is under development at NICT:
    - Analysis tool to improve the **operational products**
    - Current research on:
        1) mesospheric profiles of O3, HO2, ClO, …
        2) upper-tropospheric Ice Water Content
        3) upper-tropospheric/lower statrospheric water vapor and ozone profiles
        4) upper stratospheric winds

- L2 research chain status:
- Preliminary version (0.x) is currently running (some results have been presented)
- Version 1. (for distribution) is planned to start in January 2010.

Collaborations

- SMILES mission team (JAXA/ISAS)
- SMILES instrument team (JAXA, NICT + Osaka prefecture university + Toho university)
- Chalmers University of Technology
- Luleå Technical University (Sweden)
- Jet Propulsion Laboratory (US)

- *System Engineering Consultants (SEC), Tokyo*

Informations

http://smiles.tksc.jaxa.jp/indexj.shtml

http://smiles.nict.go.jp

The L2 research processing chain
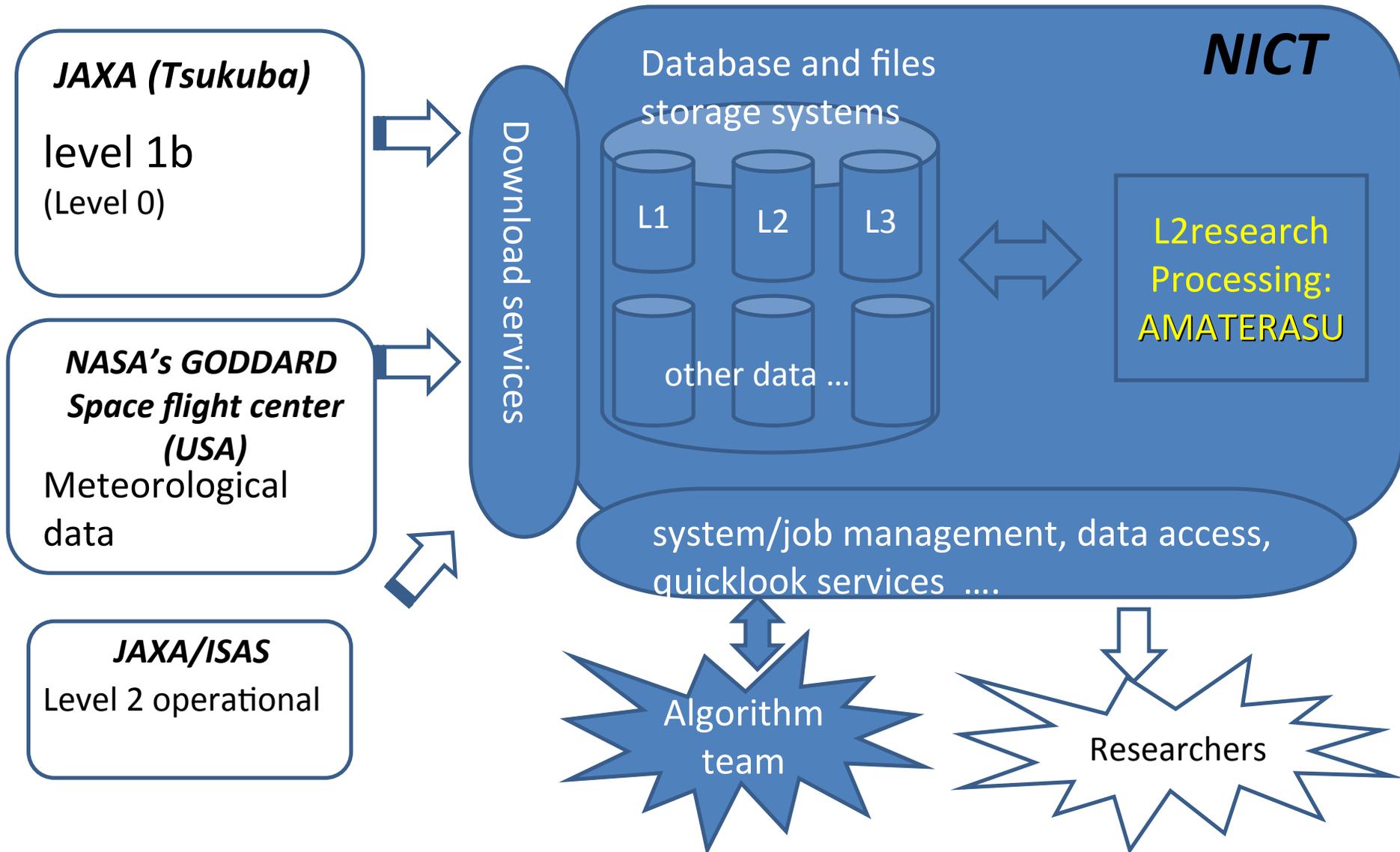
AMATERASU:

Advanced Model for Atmospheric TeraHertz Radiation Analysis and Simulation

- Model that is being developed in NICT for simulating SMILES radiances and retrieve atmospheric parameters (level 2)

- General model (not only used for SMILES):
  - Applicable from micro-wave to IR spectral domains
  - Applicable for different observation geometries and atmospheres
  - Able to take into account clouds on the line of sight
  - Horizontal inhomogeneities along the line of sight

Some details about the chain

- 4 computers:
  - 1 management computer
  - 1 file server with high storage capability (Raid 5 system)
  - 2 processing computers with high CPU capabilities
- Un-interruptible power supply (battery pack)
- Software:
  - Ubuntu Linux
  - Torques/MAUI for batch processing
  - MySQL database
  - Python + additional libraries (calculation/visualization/database connection)
  - AMATERASU code for L2 retrieval calculations