JEM/SMILES limb sounder: the Level 2 research products

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Outline

• Brief introduction about SMILES observations

• Description of the L2 research products

• Description of the processing chain for the L2-research

• Conclusions and future works
Superconducting submillimeter-Wave Limb Emission Sounder (SMILES) overview

- Limb-sounder to study the middle atmosphere chemistry and dynamics (~10-~80 km)
- 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).
- To be launched in Sept. 2009
Observation characteristics

- Atmosphere is repeatedly scanned from the below surface to ~100 km height (1600 scans/day).
- 3 spectral bands ($\lambda=0.1$ 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

band A

band B

band C

from SMILES Mission Plan
SMILES geophysical (Level 2) data

Level 1b
(calibrated spectra and attitude data)

ISAS/JAXA

JAXA (Tsukuba)

NICT

Level 2 operational products

Level 2 research products
Why a L2 research product?

• Support the operational chain:
  – cross-comparison of the products (retrieval algorithms validation)
  – investigate improvement for retrieval algorithms
  – correct instrument problems observed after launch

• Produce data that are not in the operational data
  – UT/LS H2O, ice water content ...
  – mesospheric data
  – molecules with extremely low SNR

• Research on atmospheric remote sensing
## The Level 2 research products

<table>
<thead>
<tr>
<th>Processing modes</th>
<th>Band A</th>
<th>Band B</th>
<th>Band C</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Stratospheric</strong></td>
<td><em>O$_3$, H$^{37}$Cl, H$_2$O, Temp, Pointing offset, wind</em></td>
<td><em>O$_3$, H$^{35}$Cl, H$_2$O, Temp, Pointing offset, wind</em></td>
<td><em>H$_2$O, ClO, O$_3$</em></td>
</tr>
<tr>
<td>high SNR 10-60 km</td>
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<tr>
<td><strong>Stratospheric</strong></td>
<td>HOCI, CH$_3$CN, 18OOO, HNO$_3$, BrO, H$_2$O$_2$, SO$_2$</td>
<td>N$_2$O, 18OOO, HO$_2$, HNO$_3$, SO$_2$, O$^{17}$OO</td>
<td>18OOO, 17OOO, HO$_2$, HNO$_3$, BrO, O$^{17}$OO</td>
</tr>
<tr>
<td>medium/low SNR 10-60 km</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Mesospheric</strong></td>
<td><em>O$_3$, H$^{37}$Cl, wind, 18OOO, H$_2$O$_2$</em></td>
<td><em>O$_3$, H$^{35}$Cl, wind, 18OOO, HO$_2$, SO$_2$</em></td>
<td><em>HO$_2$, 18OOO, 17OOO, ClO</em></td>
</tr>
<tr>
<td>medium/low SNR</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>UT/LS</strong></td>
<td>H$_2$O, Ice water content, O$_3$</td>
<td></td>
<td></td>
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<tr>
<td><strong>Extremely Low SNR</strong></td>
<td>H$_2$CO, HOBr, ClONO$_2$, OCIO, CIOOCI, H$_2$SO$_4$</td>
<td>CH$_3$Cl, H$_2$CO, HOBr, ClONO$_2$, OCIO, CIOOCI</td>
<td>COF$_2$, ClONO$_2$, NO$_2$, OCIO, CIOOCI</td>
</tr>
</tbody>
</table>

*blue: single scan, red: daily average, green: monthly average, black: very challenging*
Example of mesospheric products:

**HO2 (band B)**

- **Averaging kernel**
- **black-dots**: a priori error
- **full line**: single scan precision
- **dashed line**: daily average precision
- **dash-dot line**: monthly average

Altitude coverage: 50 - 96 km
Vertical resolution: 4.5 km
Single scan precision: 100 %
**Daily average**: 10-20%

**H2O2 (band C)**

- **Averaging kernel**
- **Averaging kernel**

Altitude coverage: 64 - 80 km
Vertical resolution: 8 - 12 km
Single scan precision: 500 %
**Monthly average**: 10%
The L2 research processing chain

**JAXA (Tsukuba)**

- level 1b (Level 0)

**NASA’s GODDARD Space flight center (USA)**

- Meteorological data

**JAXA/ISAS**

- Climatology and Level 2 operational

**NICT**

- L2 research Processing: AMATERASU

- System/job management, data access, quicklook services...

- Download services

- Database and files storage systems
  - L1
  - L2
  - L3
  - Other data...

- Algorithm team

- Researchers
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
Retrieval strategy:

For each scan retrieve bands configuration: A+B, A+C, B+C

- **High SNR retrieval**
  - O3, HCl, pointing, T/p, ...

- **Medium SNR retrieval**
  - HOCl, ...

- **Mesosphere retrieval**
  - O3, ...

- **Other modes**

- **Select data for band A or B**

- **Select data for band C**

- **No strong signal**

- **UT/LS retrieval**
  - H2O, IWC, O3

- **Medium SNR retrieval**
  - O3, ClO, ...

- **Mesosphere retrieval**
  - HO2, ...
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
Conclusions

• A **L2 research** chain for JEM/SMILES is under development at NICT:
  – Same molecules as the operational chain will be produced, plus extra-products (UT/LS, mesosphere, extremely low SNR)
  – A first version of the retrieval strategy has been defined and a data processing chain is being installed in NICT

• A full error analysis will be carried out to estimate the accuracy and the precision of the research products before launch.

• Improvements of the retrieval strategy are already being investigated: joint AOS bands and pointing jitter retrievals, ...
Collaborations

• SMILES L2 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

To use the SMILES data, please write a research announcement proposal (soon at http://smiles.tksc.jaxa.jp)