Stratospheric wind observation with the passive submillimeter sensor JEM/SMILES.

P. Baron[1], H. Sagawa[1], S. Ochiai[1], K. Kikuchi[1], Y. Kasai[1], D. Murtagh[2], J. Urban[2]
and the SMILES team
[1]National Institute of information and Communications Technology (NICT), Koganei, Japan
[2]Chalmers Technical University, Goëteborg, Sweden
email: baron@nict.go.jp

1. SMILES observations

The Superconducting Submillimeter-Wave Limb-Emission Sounder (SMILES) is a highly sensitive radiometer used to study atmospheric chemistry with a focus on the stratosphere[1]. It was developed by the Japan Aerospace Exploration Agency (JAXA) and the National Institute of Information and Communications Technology (NICT, Japan). Observations have been performed from the Japanese Experiment Module (JEM) onboard the International Space Station (ISS) from October 2009 to April 2010. The nominal latitude coverage is 38°S – 65°N. The targets of JEM/SMILES is the measurement of the vertical distribution of ozone (O_3) and radicals involved in its chemistry (e.g. chlorine and bromine monoxydes).

In this study we present a first attempt to use the small Doppler shift induced by air-parcels motion at the line-of-sight tangent point (100 kHz for 50 ms^{-1}) to retrieve horizontal wind in the line-of-sight direction. We use three spectral lines from O_3 at 625.371 GHz, $H^{37}Cl$ at 624.964 GHz and $H^{35}Cl$ at 625.901 measured with a spectral resolution of ∼1.4 MHz. They are the most intense lines of the SMILES spectral bands. Three bands are measured named A, B and C. The O_3 line is measured both in bands A and B . The $H^{37}Cl$ and $H^{35}Cl$ lines are measured in the band A and B, respectively. An interesting feature of the SMILES measurement is that the line-of-sight is close to the meridional direction in the descending branch of the orbit and close to the zonal direction in the ascending branch.

2. Wind retrieval

In the very first step of the processing, the Doppler shift induced by the ISS motion is removed. The line-of-sight tangent heights and the vertical distribution of the temperature and chemical species are retrieved in the second step of the processing. These parameters are not sensitive to the small wind-induced frequency shift. They are used as input parameters in the wind retrieval process. The wind vertical profile is retrieved from a single vertical scan of the atmospheric limb. Wind are retrieved with a constant bias of 100 ms^{-1} due to errors on the spectroscopic line frequency, acousto-optic spectrometers frequency and radiance calibrations. In order to remove these bias a zero-wind profile is created each day using data in the meridional direction (±5°) and in latitudes between 10°S–10°N. Analysis are currently being conducted in order to characterize these errors and to avoid the use of the 0-wind correction.

3. Data quality assessment

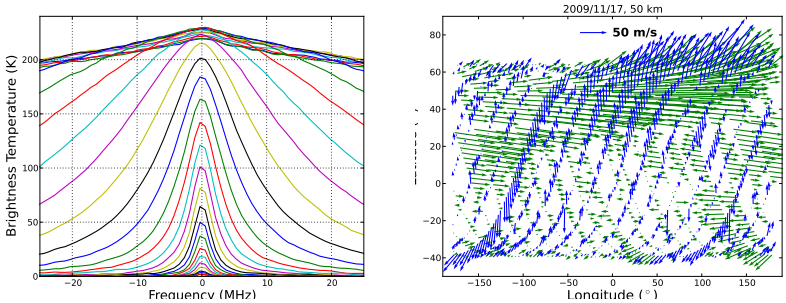

Figure 1: Left panel: Variation of the O_3 line at 625.371 GHz during a vertical scan of the atmospheric limb. The tangent heights range in the plot is 15–70 km with 2 km spacing. The line is broadened by atmospheric pressure. Right panel: Line-of-sight wind retrieved at 50 km from the O_3 line on 17 Nov 2009. The blue line indicates data obtained in descending branch of the orbits and the green lines are data obtained in the ascending branch.

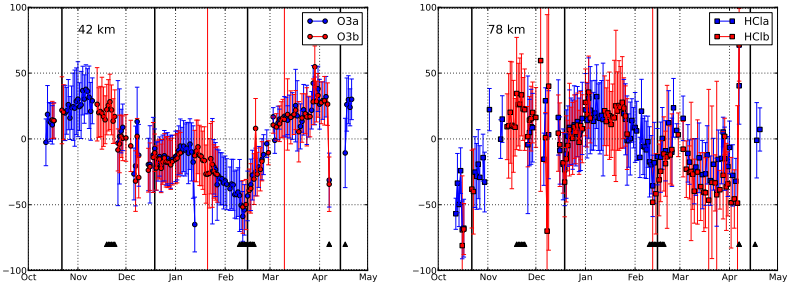

Figure 2: Semi-seaonal variation of Tropical (15°S–15°N) quasi-meridional wind (ms^{-1}) at 42 and 78 km. Vertical bars indicate the intra-day variability.

Three wind products are retrieved from the three lines, respectively. Sensitivity studies show that the precision for a single scan is better than:

- 20 ms^{-1} between 25–30 km (from the O_3 line),
- 15 ms^{-1} between 30–60 km and 5% between 40-55 km (from the O3 line)
- 30 ms^{-1} between 60–80 km (from the $H^{35}Cl$ line)

A statistical analysis of the full dataset (Fig 2) and a comparison with ECMWF and GEOS5 analysis give an upper-limit of the precision in the Tropical mid-stratosphere of about 8 ms^{-1} that is consistent with precision estimation. A RMS of 15–20 ms^{-1} is found in the mid-stratosphere Tropics for the difference between SMILES quasi-zonal wind and ECMWF analysis. A larger RMS of 15–30 ms^{-1} is found for the GEOS5 analysis.

Reference Kikuchi, K et al., Overview and Early Results of the Superconducting Submillimeter-Wave Limb-Emission Sounder (SMILES), J. Geophys. Res., 115, D23 306, doi: 10.1029/2010JD014379, 2010.