We report the first global observations of winds from the mid-stratosphere to lower mesosphere using the SMILES sub-mm radiometer (JAXA/NICT) that was launched in September 2009. SMILES operated on the Japanese Experiment Module on the International Space Station until April 2010. We have exploited its high frequency resolution and signal-to-noise ratio to derive the small Doppler shifts in the atmospheric spectra and thereby line-of-sight wind velocities. Wind information is derived from 35–80 km and from 40–65 N with uncertainties ~10 m s⁻¹ between 35 and 50 km. Both zonal and meridional components are measured (not simultaneously). Measurements are compared with the ECMWF analysis. A larger bias is found in the Tropics where the thermal wind hypothesis used in ECMWF analysis is not valid. Dynamical phenomena such as the Equatorial semi-annual oscillation and the sudden stratospheric warming at high-latitudes are shown. Although the instrument was not designed for this purpose, these observations demonstrate that sub-mm wave radiometers have the potential to fill the altitude gap in middle-atmospheric wind measurements.

In this analysis, three winds profiles are retrieved, two from a strong O₃ line measured with two different instrumental settings (bands A and B) and the third one from a strong H⁺Cl line measured in band B. The retrieval algorithm is the same as the one developed in NICT for retrieving species profiles. A wind composite profile is obtained by combining winds retrieved from the O₃ line between 7 and 0.1 hPa and from the HCl line between 0.1 and 0.007 hPa. Errors on the spectroscopic line frequency and on the spectrometer frequency calibration are mitigated by subtracted a daily ‘zero-wind’ profile consisting of the average of observations in the meridional direction (+/- 10°) in tropical region where the flow is predominantly zonal.

The theoretical precision in the upper stratosphere and lower mesosphere (40-60 km) is 5 m/s and the accuracy is <5 m/s. The vertical resolution is 5-7 km up to 0.02 hPa.

Because of the rotation of the ISS during an orbit, the line-of-sight is close to the meridional direction between 30–55 N in the ascending branch of the orbits while it is close to the zonal direction in the descending branch in the same latitudes range. The lower panel shows large differences (>15 m/s) with ECMWF analysis during period of fast dynamical changes. The major SSW is characterized by a large increase of the daily and zonally averaged Arctic temperature measured by AURA/MLS (blue line) - fast and temporary reversal of zonal-winds direction.

Equatorial semi-annual oscillation.

- HRDI and WINDII were on the UARS satellite and operated from Sept 1991-January 2000.
- TSDI operates on the TIMED satellite from 2002-present
- AURA-MLS operates on the Aura satellite from July 2004 - present
- SMILES operated on the ISS from Sept 2009 - April 2010,
- Acopol is a lidar instrument operated by NASA in Canada but has been abandoned

References


Upper limit of the retrieval errors derived from the comparison with ECMWF analysis

<table>
<thead>
<tr>
<th>Bias / accuracy</th>
<th>&lt; 5 m/s</th>
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<tr>
<td>STD / precision</td>
<td>&lt;10 m/s between 5-0.4 hPa</td>
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<tr>
<td></td>
<td>&lt;15 m/s between 0.4-0.08 hPa</td>
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Monthly and zonally averaged zonal-winds

<table>
<thead>
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<th>Month</th>
<th>Value</th>
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<tbody>
<tr>
<td>Dec 2009</td>
<td>15-20 m/s</td>
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<tr>
<td>Mar 2010</td>
<td>10-20 m/s</td>
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</tbody>
</table>

Measurement of horizontal wind in the middle atmosphere (30-80 km) by the submillimeter limb sounder SMILES.

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