Detection of Polar Stratospheric Clouds with IASI

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ABSTRACT

Polar Stratospheric Clouds (PSCs) play a key role in the formation of the Antarctic ozone hole. They contribute to the formation of reactive chlorine species and lead to the denitrification of the stratosphere, which prevents neutralization of these active chlorine species. PSCs, composed of nitric acid, sulfuric acid, and water, form when temperatures are sufficiently low, i.e., during the winter inside the polar vortex at altitudes between 15 and 25 km. Space-based observations of PSCs are critical for better characterizing their abundance, formation and spatiotemporal variations, as demonstrated by the recent observations from the limb sounders MIPAS and ACE, and the lidar sounder CALIOP. While their measurements offer excellent vertical characterization, they suffer from poor spatial coverage.

Here, we report the first IASI observations of the most important and abundant PSCs, the β-NAT, which are composed of nitric acid trihydrate particles. We analyse in detail a selection of IASI spectra and show the unambiguous presence of the characteristic spectral signature of β-NATs near 820 cm^{-1}. Using a hyperspectral range index (HRI) specifically developed for the South Pole (below 50°S), we demonstrate further that PSCs can be observed systematically in the polar winter and obtain detailed daily detection maps. With respect to the physicochemical mechanism at play in the Antarctic stratosphere, we show a remarkable consistency between the 2008-2023 timeseries of detected PSCs and the timeseries of temperature and nitric acid. In addition, during the winter months, we manage to show a clear anticorrelation at short time scales between the detection of PSCs and the abundance of nitric acid (or temperature). Interannual variability is also briefly investigated and discussed. Finally, we present the first steps towards the development of a quantitative product.

Overall, our results emphasize the remarkable capabilities of nadir hyperspectral sounders to monitor stratospheric polar processes. Further insights on the chemistry at play during the polar night will undoubtedly come with IASI-NG, owing especially to its to improved radiometric performances.