Detection and retrieval of nitrous acid (HONO) in global fire plumes throughout the IASI time series

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ABSTRACT

Nitrous acid (HONO) is pivotal in atmospheric chemistry, serving as a significant source of hydroxyl radical (OH), the main oxidant in the Earth's atmosphere. Despite its importance, uncertainties about its spatial and temporal distribution, formation mechanisms, and the balance between primary emissions and secondary formation persist. Recently, UV-Vis measurements from the TROPOMI/S5P sounder have provided a global perspective on HONO in biomass burning plumes, underscoring the value of satellite data in understanding atmospheric HONO. The IASI/Metop instrument, with its twice-daily global thermal infrared (TIR) observations and extensive, consistent record since 2007, provides potential for complementary measurements and additional insights.

Using a sensitive detection method, we demonstrate that HONO enhancements can be reliably identified in IASI spectra from fire plumes worldwide, extending beyond the well-documented Australian bushfires. Analysing the 2007-2023 IASI time series, we present a 15-year record of fire events with detectable HONO. Our findings indicate that HONO is primarily detected by IASI at mid- and high latitudes in the Northern Hemisphere. Remarkably, evening IASI measurements yield significantly more HONO detections than daytime measurements, despite the generally lower sensitivity of night-time observations. We present the key factors contributing to these patterns, including HONO's diel variability, fire intensity, and IASI's vertical sensitivity.

To quantify HONO's vertical column densities (VCDs), we apply a neural-network-based retrieval approach to IASI measurements. For selected fire events, we track the temporal evolution of HONO VCDs and compare these with TROPOMI data. This study underscores the complementary strengths of TIR and UV-Vis satellite measurements in monitoring pyrogenic HONO, with IASI's morning and evening passes providing critical data on HONO's persistence and long-range transport in fire plumes, while TROPOMI's exceptional performance allows it to capture HONO in smaller fire plumes and in proximity to fire sources.

This work also helps establish a methodology for routinely monitoring pyrogenic HONO using future polar-orbiting and geostationary TIR satellite sounders.