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Time evolution of temperature profiles retrieved from 13 years of IASI data using an artificial neural network

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The IASI remote sensor measures Earth's thermal infrared radiation over 8461 channels between 645 and 2760 cm^{-1}. Atmospheric temperatures at different altitudes can be retrieved from the radiances measured in the CO_2 absorption bands (645-800 cm^{-1} and 2250-2400 cm^{-1}) by selecting the channels that are the most sensitive to the temperature profile. The three IASI instruments on board of the Metop suite of satellites launched in 2006, 2012 and 2018, will provide a long time series for temperature, adequate for studying the long term evolution of atmospheric temperature. However, over the past 14 years, EUMETSAT, who processes radiances and computes atmospheric temperatures, has carried out several updates on the processing algorithms for both radiances and temperatures, leading to non-homogeneous time series and thus large difficulties in the computation of trends for temperature and atmospheric composition.

In 2018, EUMETSAT has reprocessed the radiances with the most recent version of the algorithm and there is now a homogeneous radiance dataset available. In this study, we retrieve a new temperature record from the homogeneous IASI radiances using an artificial neural network (ANN). We train the ANN with IASI radiances as input and the European Centre for Medium-Range Weather Forecasts reanalysis ERA5 temperatures as output. We validate the results using ERA5 and in situ radiosonde temperatures from the ARSA database. Between 750 and 7 hPa, where IASI has most of its sensitivity, a very good agreement is observed between the 3 datasets. This work suggests that ANN can be a simple yet powerful tool to retrieve IASI temperatures at different altitudes in the upper troposphere and in the stratosphere, allowing us to construct a homogeneous and consistent temperature data record.

We use this new dataset to study extreme events such as sudden stratospheric warmings, and to

compute trends over the IASI coverage period [2008-2020]. We find that in the past thirteen years, there is a general warming trend of the troposphere, that is more important at the poles and at mid latitudes (0.5 K/decade at mid latitudes, 1 K/decade at the North Pole). The stratosphere is globally cooling on average, except at the South Pole as a result of the ozone layer recovery and a sudden stratospheric warming in 2019. The cooling is most pronounced in the equatorial upper stratosphere (-1 K/decade).