Seventeen years surface temperature measurements from IASI

Consiglio Nazionale delle Ricerche | LATMOS | ULB

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Introduction

Developed by CNES in cooperation with EUMETSAT, the IASI instrument (Clerbaux et al., 2009)[1] flies onboard the European meteorological satellites, Metop. Aside from measuring the temperature and humidity of the atmosphere, IASI also measures more than 33 atmospheric components with high precision, and is also used to monitor the climate. The first IASI instrument (Infrared Atmospheric Sounding Interferometer) was launched onboard the Metop-A polar-orbiting satellite in 2006, followed by a second and third similar instruments on Metop-B and Metop-C at the end of 2012 and 2018, respectively.

The IASI – Flux and Temperature (IASI-FT) project aims to provide new benchmarks for top-of-atmosphere radiative flux and temperature observations using IASI's calibrated radiances. This project develops innovative algorithms and statistical tools to generate global climate data records of spectrally resolved outgoing radiances, land and sea surface temperatures, and temperatures at selected altitudes.

Methods

IASI consists of a Fourier transform spectrometer (FTS) associated with an imaging instrument. It is designed to measure the outgoing top-of-atmosphere radiation spectrum emitted by the Earth-atmosphere system in the thermal infrared spectral range, using nadir geometry. Measurements are performed from the Metop polar orbit, at an altitude of ~817 km. The satellite is sun-synchronous with a 98.7° inclination to the equator, and the satellite's ground track is at about 09:30 local time in the morning (and 21:30 in the evening). The IASI Level1 processing generates calibrated atmospheric spectra (L1C) from raw interferograms. (**Fig.1**).

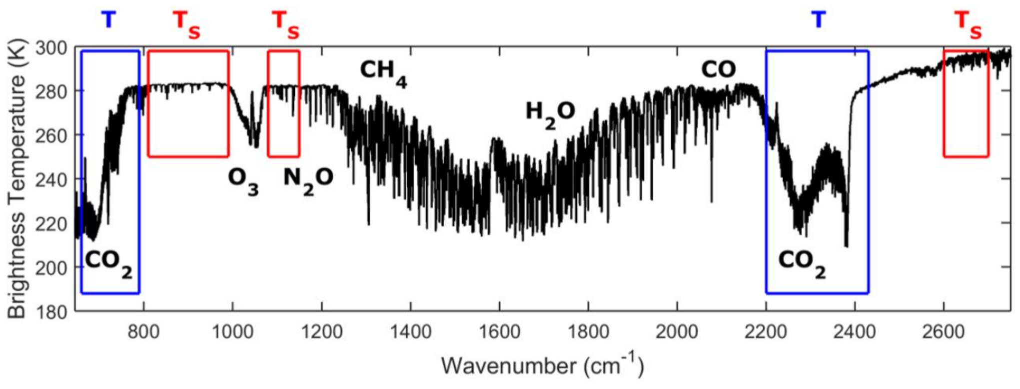

Fig.1 *One IASI atmospheric spectrum (in brightness temperature units, normalized with Plank's function). The spectral windows to retrieved skin temperature (Ts, red), and temperature profile (T, blue) and the main molecular absorption features are indicated.*

Products

Five products are developed within the IASI-FT project: IASI Outgoing Longwave Radiation, IASI Cloud Detection, IASI Skin Temperature, IASI Sea Surface Temperature and IASI Atmospheric Temperature Profiles.

- The IASI spectrally resolved Outgoing Longwave Radiation product (IASI OLR)[2] is a monthly (L3), 2°x2° global dataset of spectral OLR derived from the clear-sky IASI satellite radiance measurements in the range 645-2300cm^{-1} at the 0.25cm^{-1} native spectral sampling of the L1C spectra. The algorithm for the conversion of the spectra to the OLR is detailed in Whitburn et al. (2020)[3].

- The IASI Cloud Detection product (IASI CLD)[4] is a cloud mask available at the IASI pixel level (L2) that was developed for climate applications purposes. The algorithm is detailed in Whitburn et al. (2022)[5]. It combines an high sensitivity to cloud detection, a very good consistency over time and between the three IASI instruments and simplicity in its parametrization.

- IASI Skin Temperature product (SkT)[6] is a monthly (L3), 1°x1° global dataset of skin temperatures over land derived from the IASI satellite radiances data. The data was computed using artificial neural networks over a selected set of IASI radiance channels, trained with ERA5-skin temperature product. Emissivity is also used as input in the neural network (Safieddine et al., 2020)[7]. This method was applied to the whole IASI time series to produce a homogeneous skin temperature data record from Sept. 2007 to the present (**Fig.2**). Timeseries and quicklooks plots of Tskin anomalies (**Fig.3**) anomalies are also computed.

- IASI Sea Surface Temperature product (SST)[8] is a monthly (L3), 1°x1° global dataset of skin temperatures over the sea derived from the IASI satellite radiances data (**Fig.4**). The data was computed using Planck's law and simple atmospheric corrections (Parracho et al., 2021)[9]. Timeseries and quicklooks plots of SST anomalies are also computed.

- IASI Atmospheric Temperature Profiles product (ATP)[10] is a daily 1°x1° global dataset of atmospheric temperatures derived from all IASI radiance observations. The temperatures profiles are given on 11 static pressure levels from 750 to 2 hPa. The method used to retrieve atmospheric temperatures from IASI radiances is detailed in Bouillon et al., 2021[11]. An Artificial Neural Network (ANN) was applied to reprocessed IASI L1C data, in order to produce a homogeneous atmospheric temperature record from 2008 to present.

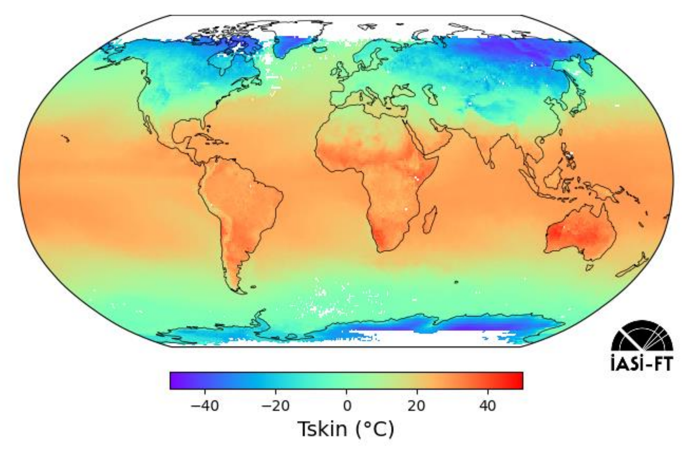

Fig.2 *Example of IASI Tskin map*

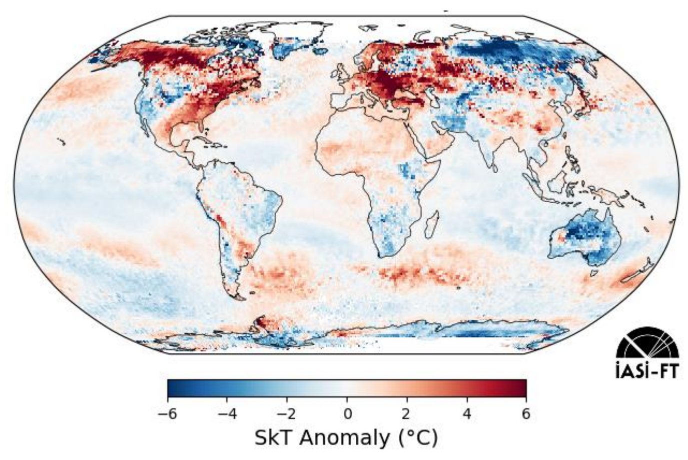

Fig.3 *Example of IASI Tskin Anomaly map*

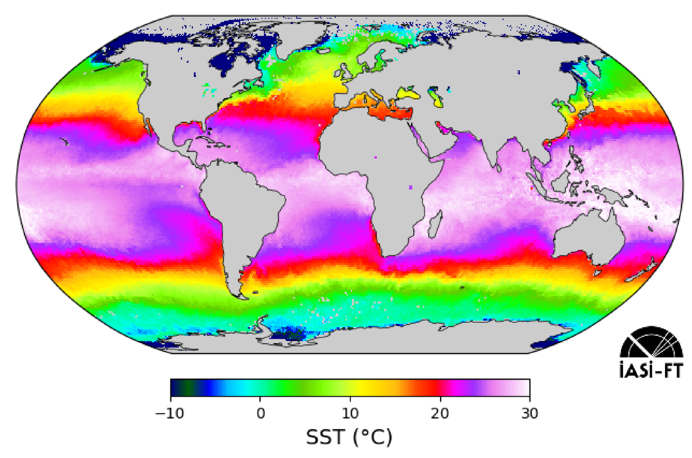

Fig.4 *Example of IASI SST map*

Available data and plots, via www.iasi-ft.eu

IASI-FT Flux and temperature

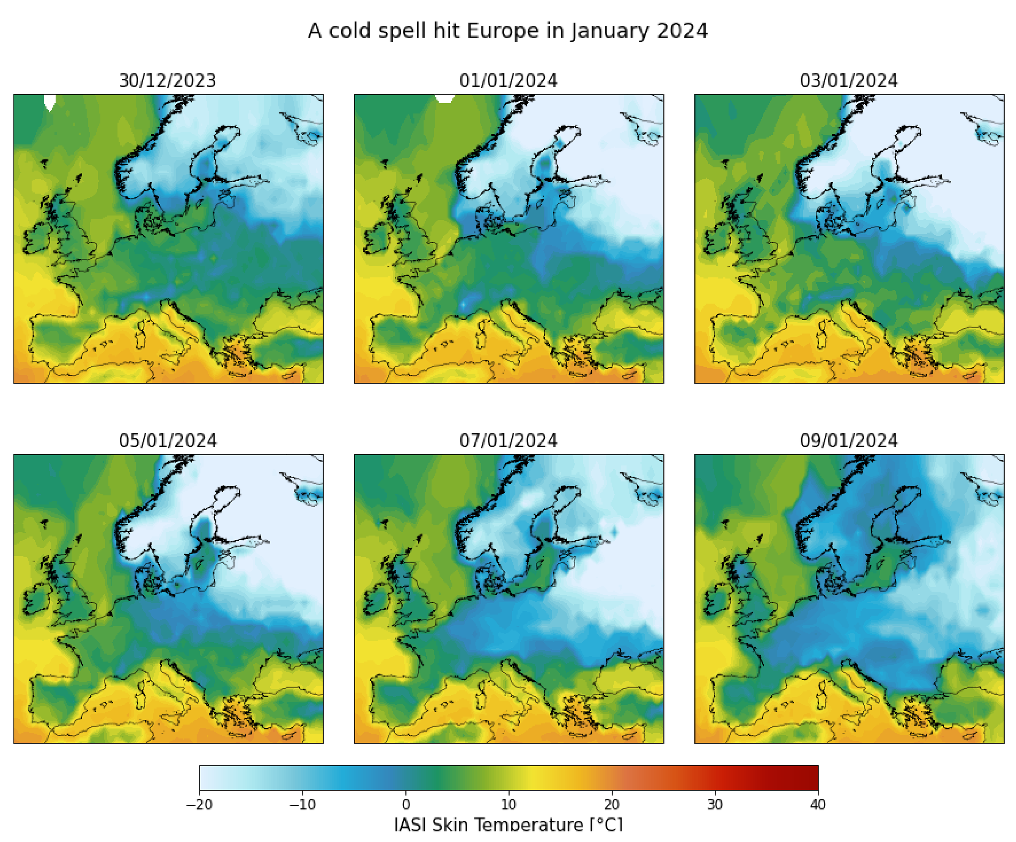

Fig.5 *A cold episode hit Europe in January 2023, originating from northern countries and resulting in negative skin temperatures (in blue to white).*

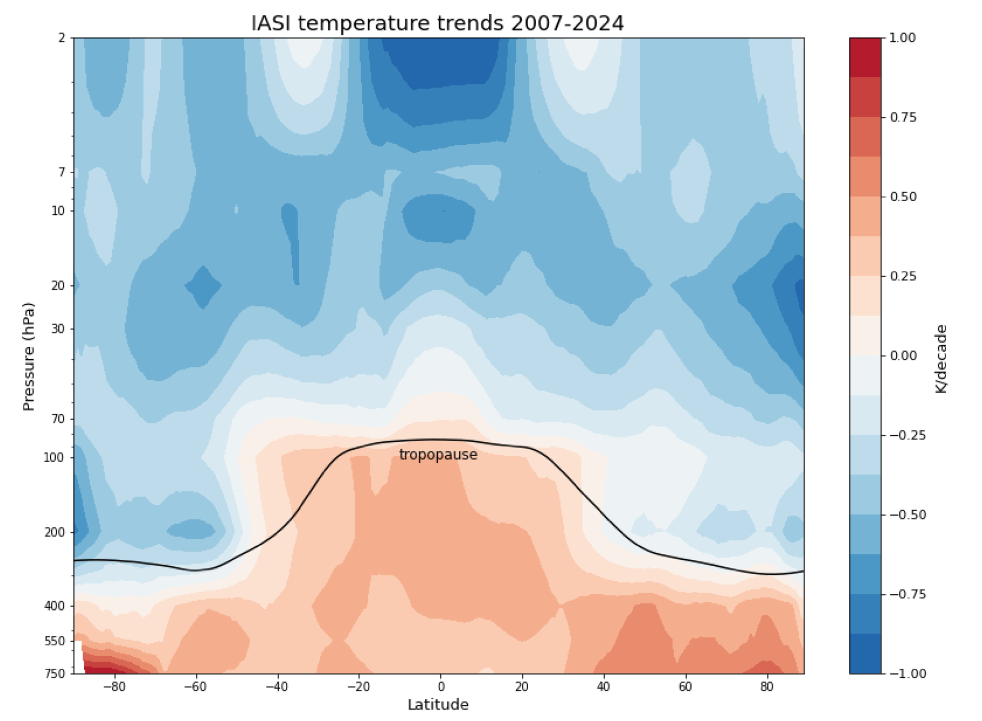

Fig.6 *Zonal temperature trends for the period July 2007– may 2024 computed with the outputs of an artificial neural network (ANN). A general warming of the troposphere, more important at the poles and mid-latitudes, is visible, whereas the stratosphere is globally cooling.*

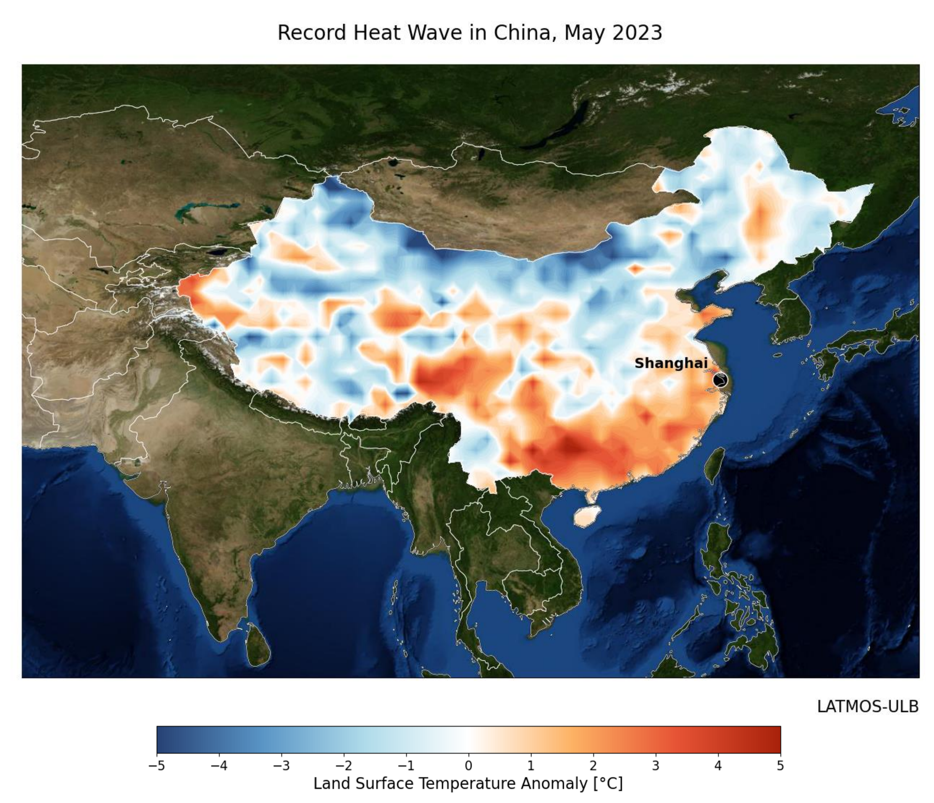

Fig.7 *A significant heat wave affected several regions in China during May 2023, with temperature records observed in towns like Shanghai. The red areas indicate skin temperatures exceeding the reference skin temperature for May (wrt 2008-2022).*

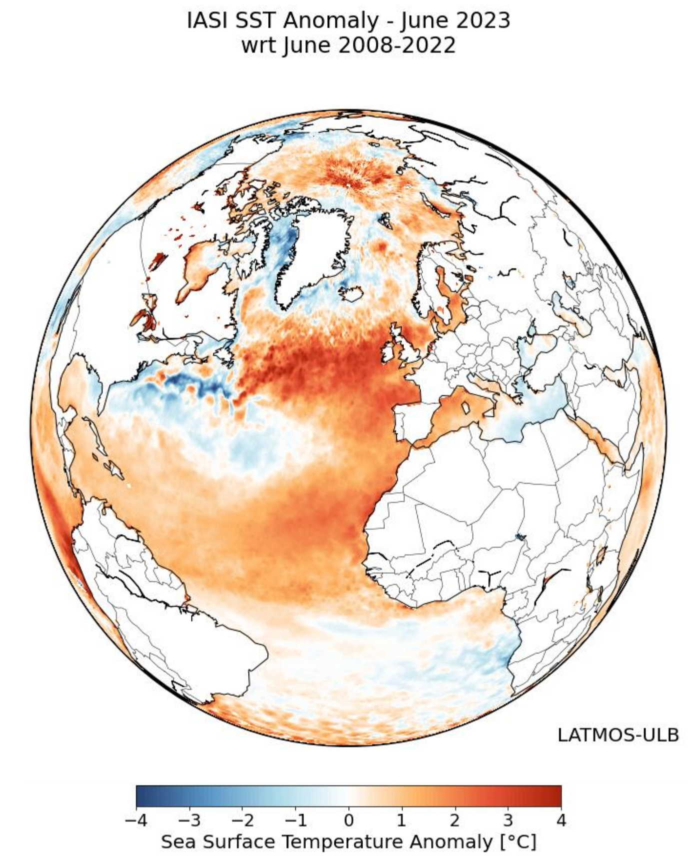

Fig.8 *The entire year of 2023 has been exceptional in terms of sea surface temperature. June 2023 in the North Atlantic Ocean recorded the highest temperatures ever for the month of June.*

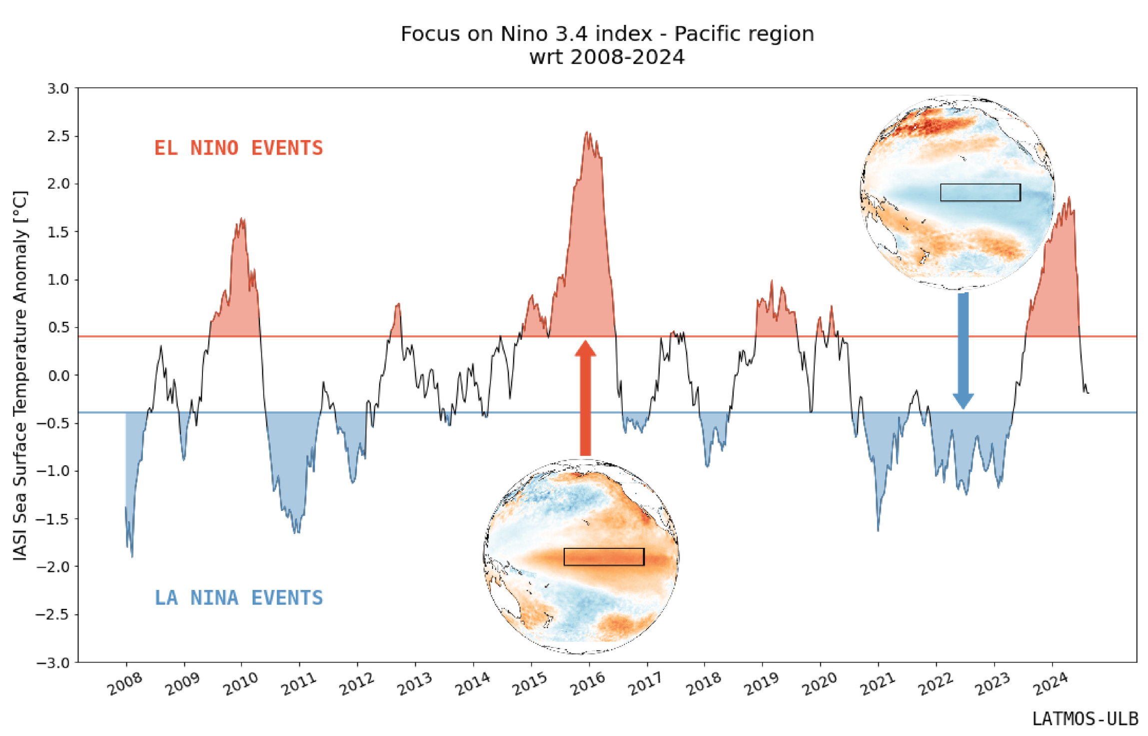

Fig.9 *SST anomalies are used to calculate the Niño 3.4 index, in Equatorial Pacific region [5°S-5°N,170°W-120°W]. El Niño or La Niña events are defined as the Niño 3.4 SSTs exceeding ± 0.4°C for a period of six months or more. Starting in May 2023 and definitively ending in April 2024, the last El Niño event was one of the biggest episodes observed since the one of 2015-2016.*

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[4] Whitburn, S. (2022). A CO2-free cloud mask from IASI radiances for climate applications (from IASI/Metop-A, B and C) [Data set]. ULB/LATMOS.

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