Spatial and temporal variations of thermal contrast in the planetary boundary layer

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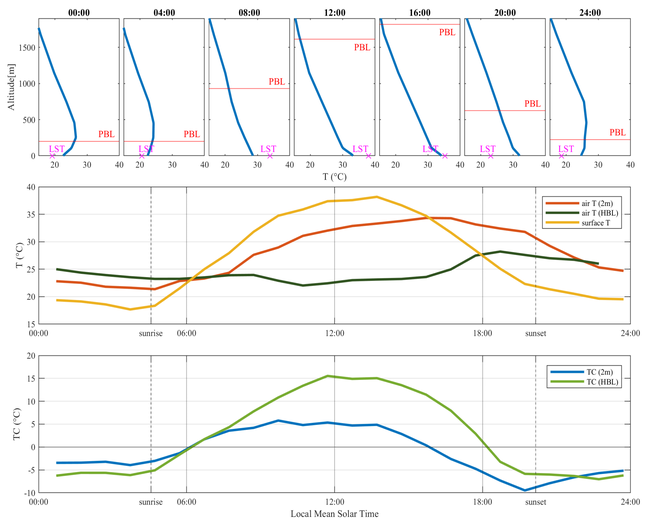
What is thermal contrast?

- The **thermal contrast** (TC) is the temperature difference between the Earth's skin temperature and the temperature of the atmosphere.
- It is mainly generated by the differential cooling/heating rates of the surface and atmosphere and varies as a function of time of the day, time of the year, latitude, surface type.

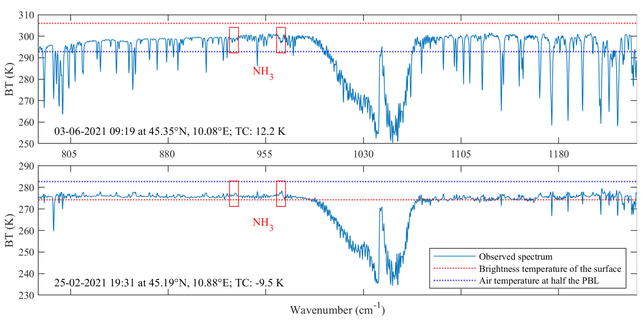
An example of the diel cycle of the TC in the Po Valley



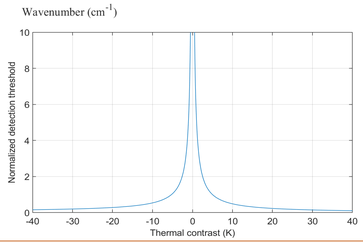
TC as a driver for IR satellite sensitivity

- Short-lived atmospheric pollutants mainly reside in the **planetary boundary layer** (PBL).
- The **sensitivity** of high-resolution infrared sounders to the PBL has been amply demonstrated in favourable TC conditions [1,2,4].
- The sensitivity of infrared sounders to the PBL varies strongly as a function of **TC.**

IASI spectra corresponding to a positive TC (top) and a negative TC (bottom)



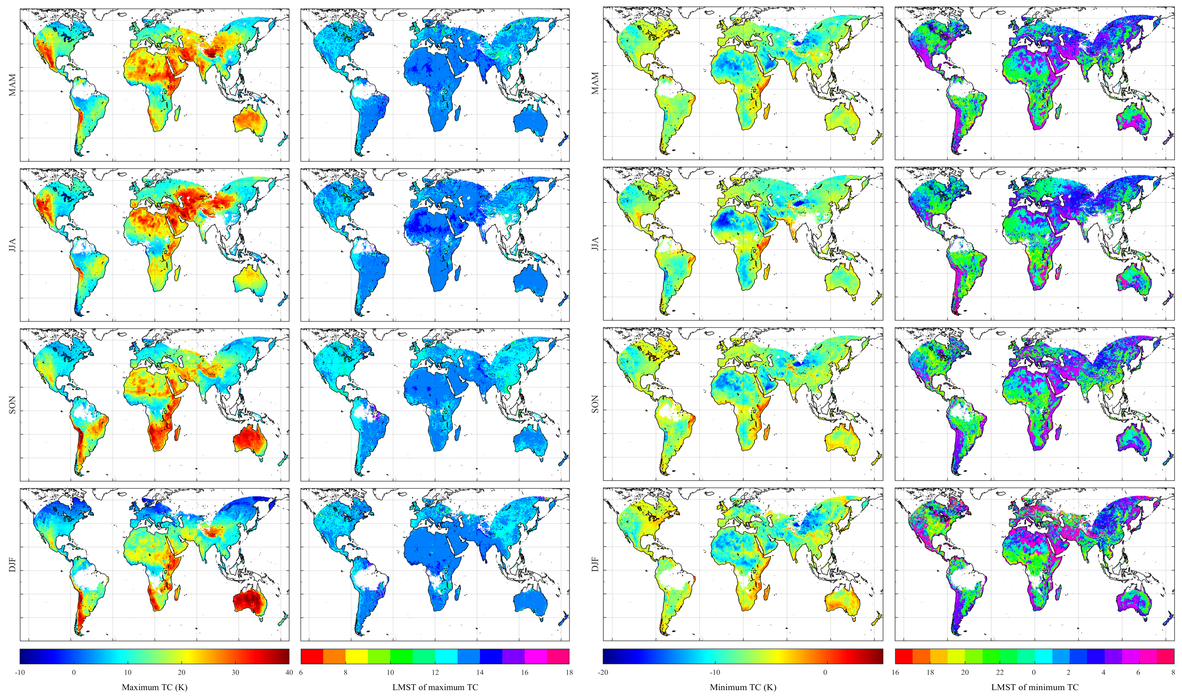
Relation between TC and the sensor-dependent detection threshold



Analysis – seasonal distribution

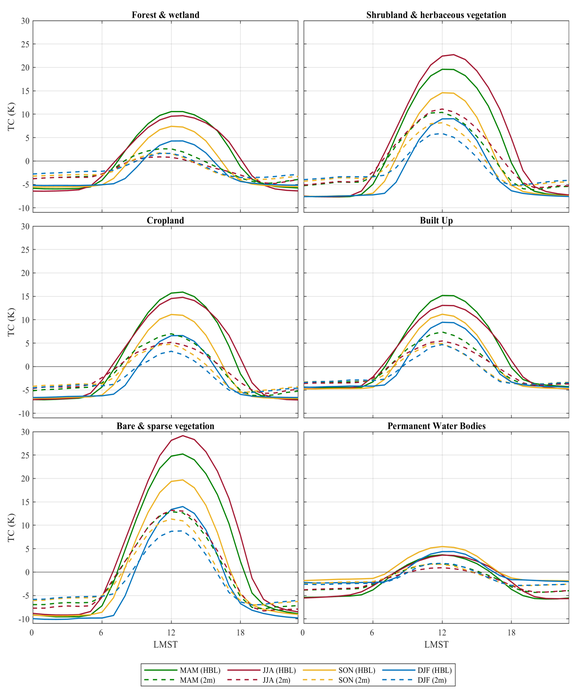
Seasonal maximum TC (at half the PBL) and corresponding LMST hour

Seasonal minimum TC (at half the PBL) and corresponding LMST hour

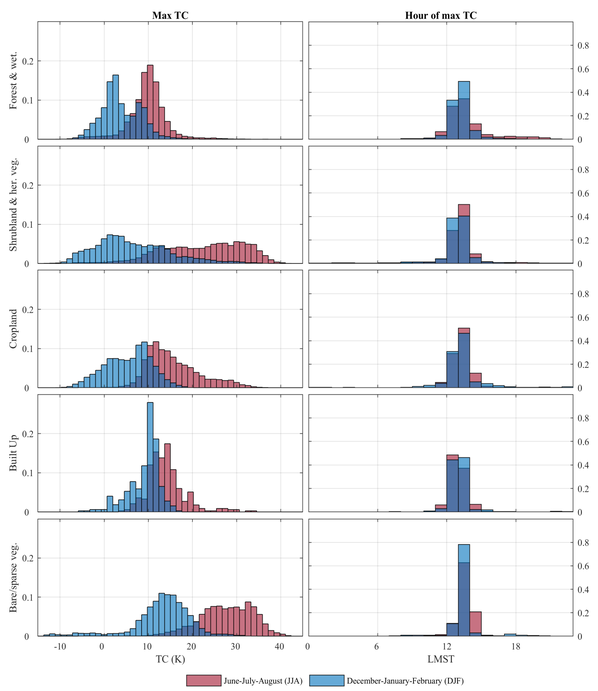


Analysis – land cover type

Diel cycles of TC for different land cover types and seasons between 30° and 60°N



Maximum TC distribution (at half the PBL), for different land cover types and seasons between 30° and 60°N

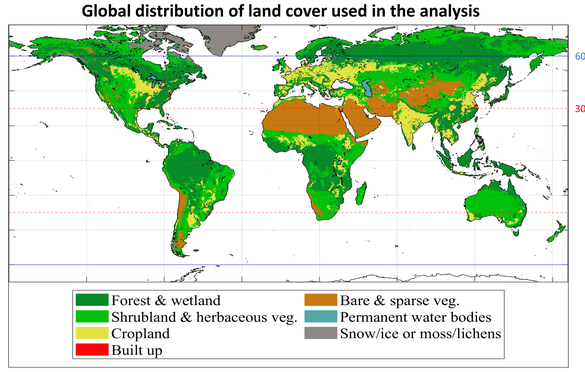


Data and methods

Source datasets

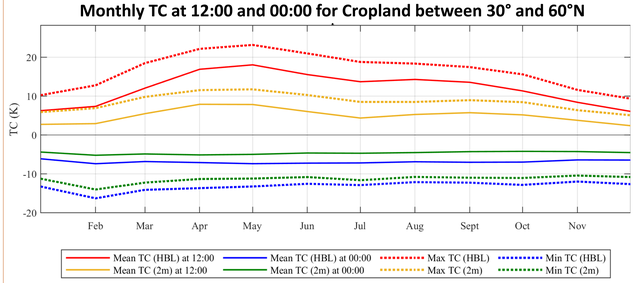
- **Air temperatures** are derived from the ECMWF ERA5 dataset at two different altitudes, the standard meteorological height of 2 meters (2m), and half the PBL height (HBL) .
- Direct satellite measurements of **surface temperatures** are obtained from the Land Surface Temperature dataset of the Copernicus Global Land Service.
- A **land cover map** produced by Copernicus Land Service and derived from satellite observations is used to perform a quantitative analysis.

Global distribution of land cover used in the analysis



TC is calculated on hourly maps and then averaged monthly, giving a 4D matrix: latitude, longitude, month and hour.

Monthly TC at 12:00 and 00:00 for Cropland between 30° and 60°N



We also interpolate and remap the UTC maps for different **local mean solar time** (LMST) with: *LMST= UTC + longitude/15.*

A publicly available dataset

The TC datasets built in this work, developed at high temporal (1 h) and high spatial (31 km) resolution, will be made publicly available soon.

- It can be used to provide constraints on the **time windows** and **boundary conditions** for which the sensitivity of the IR instruments is best.
- It also allows determining the most favourable **overpass time** for polar orbiting infrared sounders or for aerial measurement campaigns for near-surface pollutants.
- It can be used to statistically assess the measurement **sensitivity** of current and future infrared sounders.

References

[1] S. Bauduin et al. (2016). Retrieval of near-surface sulfur dioxide SO_2 concentrations at a global scale using IASI satellite observations, Atmospheric Measurement Techniques, 9, 721–740.
[2] L. Clarisse et al. (2010). Satellite monitoring of ammonia: A case study of the San Joaquin Valley, Journal of Geophysical Research: Atmospheres, 115.
[3] T. Di Gioacchino et al. (2023). Spatial and temporal variations of thermal contrast in the planetary boundary layer (in preparation).
[4] B. Franco et al. (2022). Ethylene industrial emitters seen from space, Nature Communications, 13, 6452.