2019 CISESS Science Meeting

Monitoring the Heatwave Events in 2019 Using NOAA VIIRS Land Surface Temperature Product

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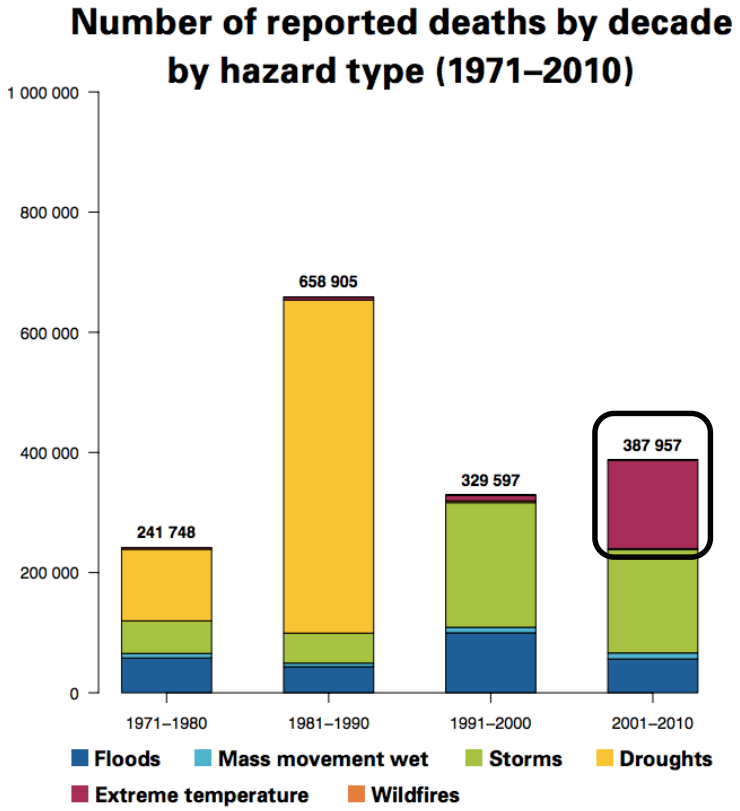
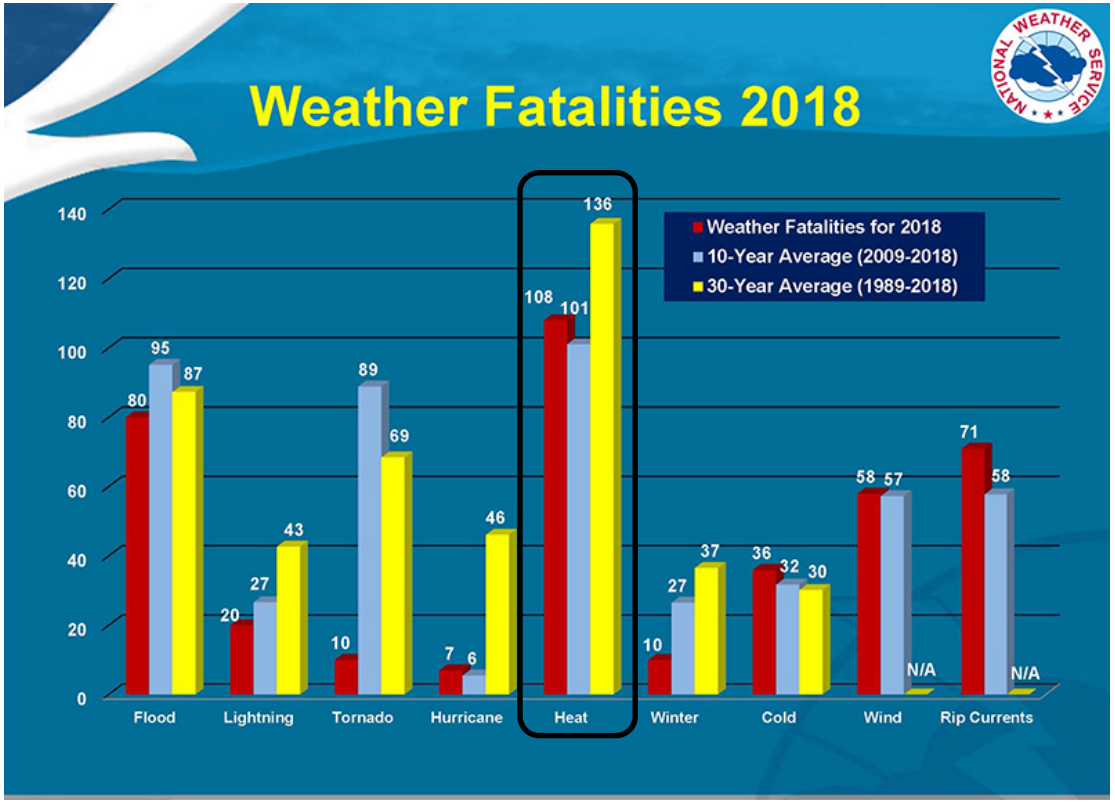
Heat Waves in Pictures

Credits: The Guardian.

Heatwave Impact in Numbers





From WMO, Global statistic. Europe in 2003, Russia in 2010 accounted for the majority

From NOAA NWS (https://www.weather.gov/hazstat/), Statistics in the 50 states, Puerto Rico, Guam and the Virgin Islands in 2018.

Heat Wave in Words

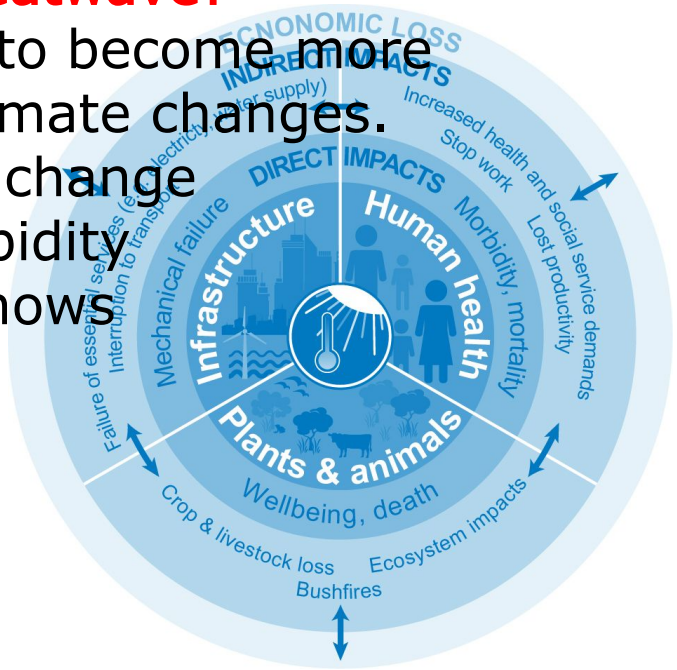
What is heatwave?

Generally, Heat wave (extreme heat) is a period of excessively hot weather, maybe accompanied by high humidity.

Specific agencies have their own definitions. (e.g. three or more days of maximum temperatures that are unusual)

Why do we concern about heatwave?

- Heat waves are expected to become more frequent and severe as climate changes.
- A classic signal of climate change
- Rise in mortality and morbidity
- Other impacts as figure shows



How to identify and monitor the heatwave?

Remote sensing is an useful approach, the land surface temperature (LST) could be used as an indicator to monitor the development of heatwave.

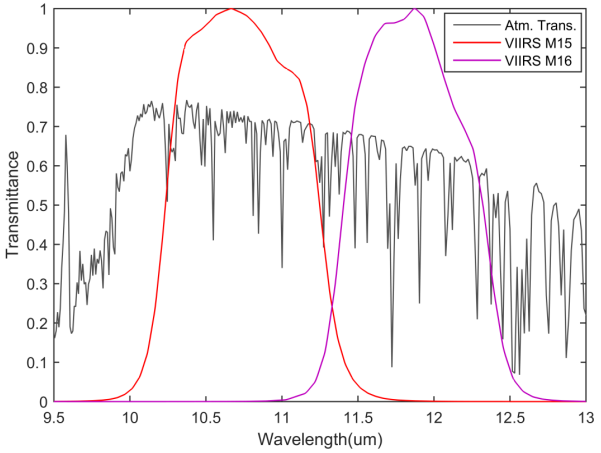
1850-2018 annual temperature from UK Met Office. By Ed Hawkins

https://app.longpaddock.qld.gov.au/heatwave/

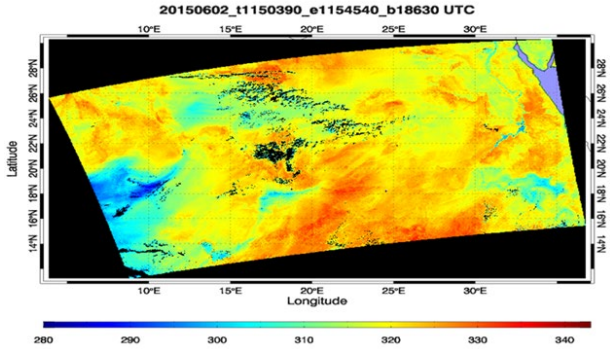
LST Retrieval from Space

- Land Surface Temperature (LST) derived from infrared remote sensing data is a measure of how hot or cold the skin surface of the Earth.

- From a climate perspective, LST is important for:
  - Evaluation of land surface and land-atmosphere exchange processes
  - Constraint of surface energy budgets and flux variations
  - Global and regional observations of surface temperature variations



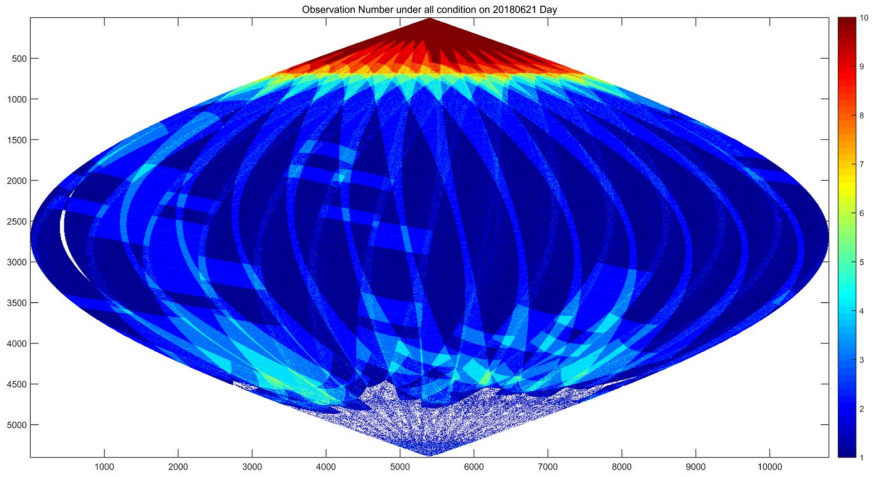
- Operational S-NPP & NOAA20 LST Products (L2):
  - Based on split window (VIIRS M15&16 band) technique to correct the atmospheric effect which is particularly significant for hot and humid condition.
  - Single 1.5 min granule data
  - Resolution: 750 m (nadir)
  - Accuracy: 1.4 K



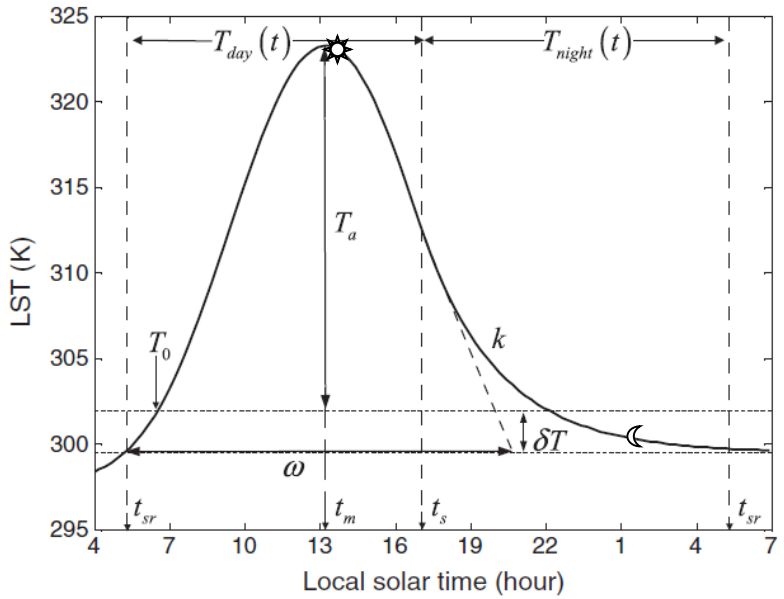
VIIRS L3 Daily LST

- Why L3 Gridded LST Product needed?
  - Making LST more friendly to the users.
  - Saving LST in regular grid could reduce the storage.
- The L3 LST Product features:
  - Directly from VIIRS L2 LST.
  - Global daily LST at 1km resolution
  - Include two layers: daytime LST (~ 1:30PM, local time) and night LST (~ 1:30 AM), could be used as the Max/Min LST in that day.
  - For grids with multi-observations, select the best quality data (criteria: cloud, view angle, LST value).
  - Expected to be in operational by the end of this year

Observation Number, 20180621 Daytime



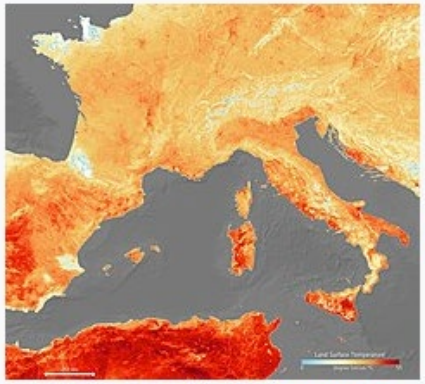
Sun-synchronous orbit, 1:30 PM 1:30 AM



The Hottest-Ever Europe

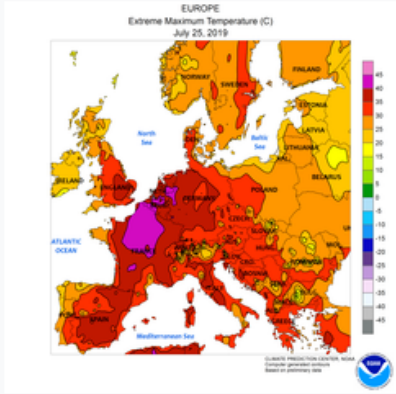
Two rounds heatwave

June 2019 European heat wave



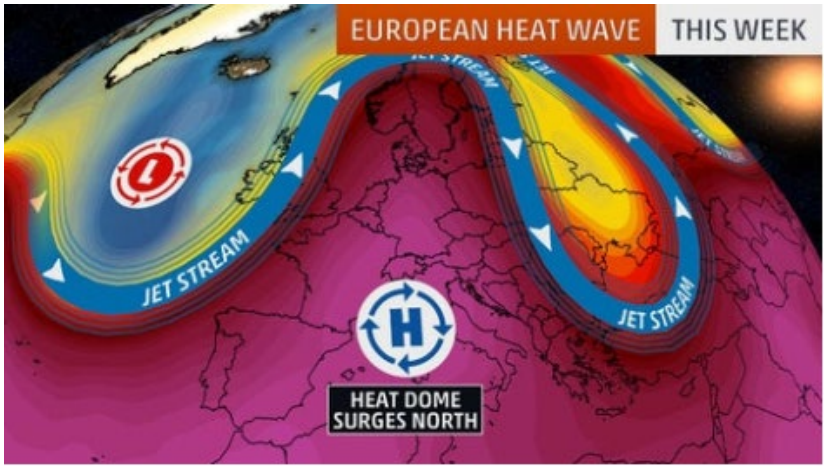
Temperature of the land on 26 June

Date	24 June 2019 – 2 July 2019
Location	Europe
Type	Heat wave



Maximum temperatures on 25 July

Date	21–28 July 2019
Location	Europe, Greenland
Type	Heat wave
Cause	Omega block
Deaths	**869**: 868 in France[1] 1 in Belgium[2]

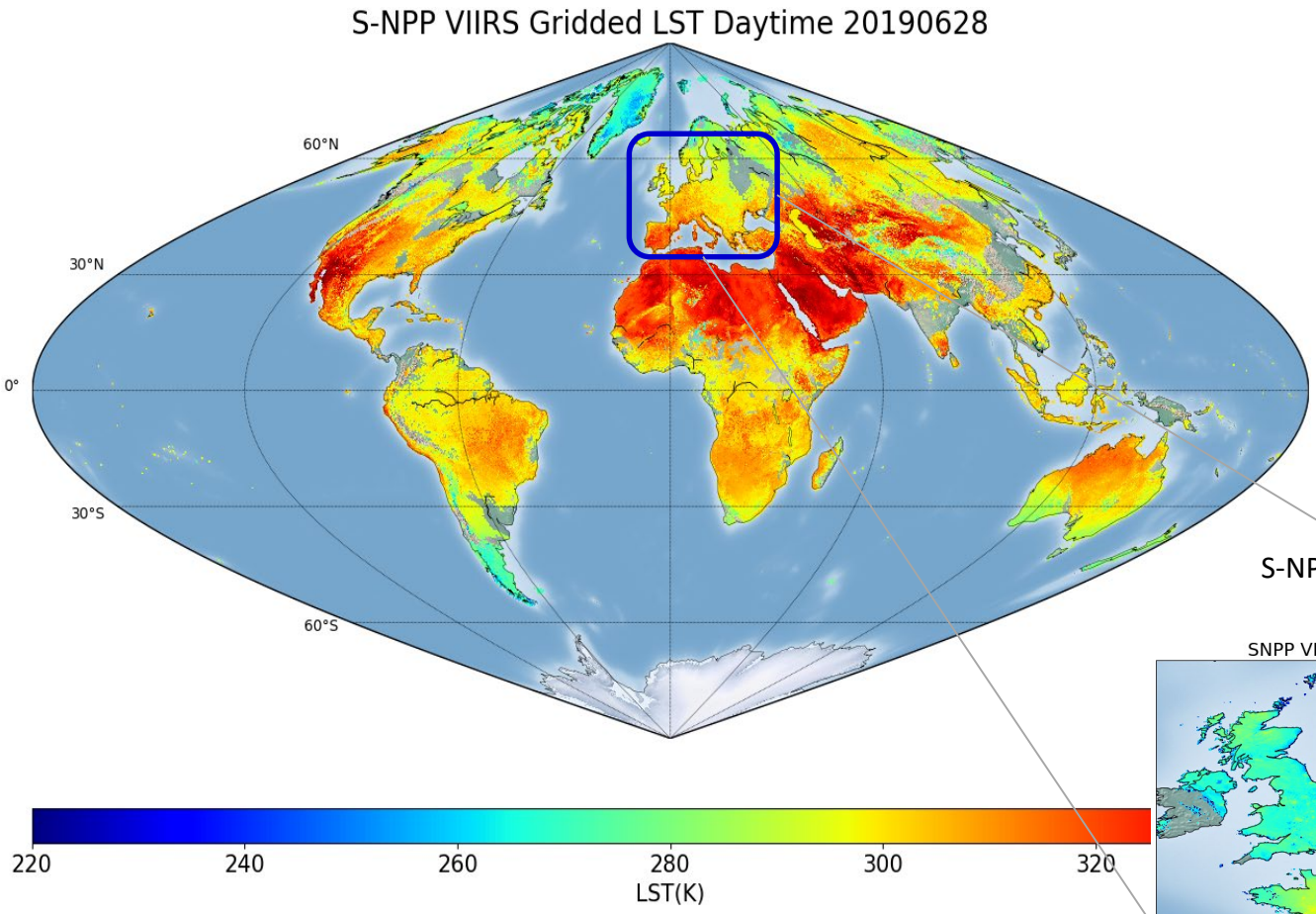


The European heat wave was caused by a strong omega block, consisting of hot, dry air from North Africa, trapped between cold storm systems.

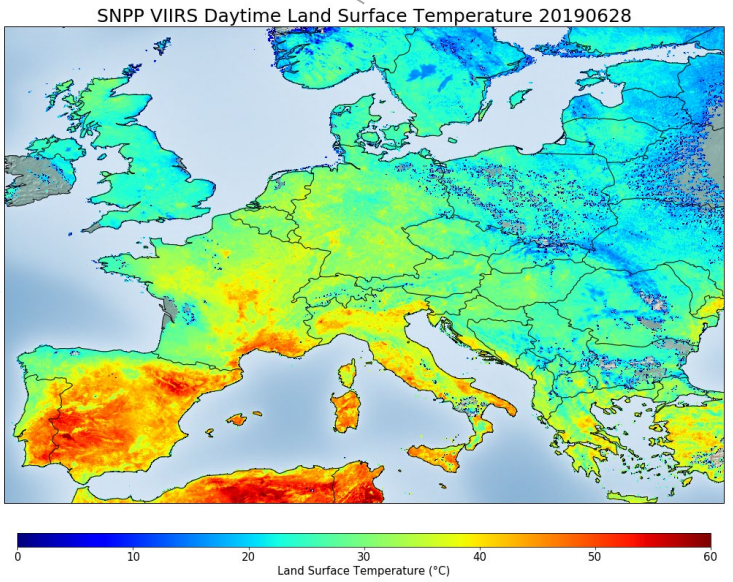
The countries reached temperature record in 2019 (from Wikipedia)

Country/Region	Temperature	Town/Location	Date
Belgium	41.8 °C (107.2 °F)	Begijnendijk, Flemish Brabant[notes 4]	25 July 2019[76]
Germany	42.6 °C (108.7 °F)	Lingen, Lower Saxony[notes 4]	25 July 2019[85]
Luxembourg	40.8 °C (105.4 °F)	Steinsel, Luxembourg[notes 4]	25 July 2019[96]
Netherlands	40.7 °C (105.3 °F)	Gilze en Rijen[notes 4]	25 July 2019[101]
United Kingdom	38.7 °C (101.7 °F)	Cambridge, Cambridgeshire[notes 4]	25 July 2019[116][117]
France	46.0 °C (114.8 °F)	Vérargues, Hérault	28 June 2019[78]

VIIRS L3 LST Product



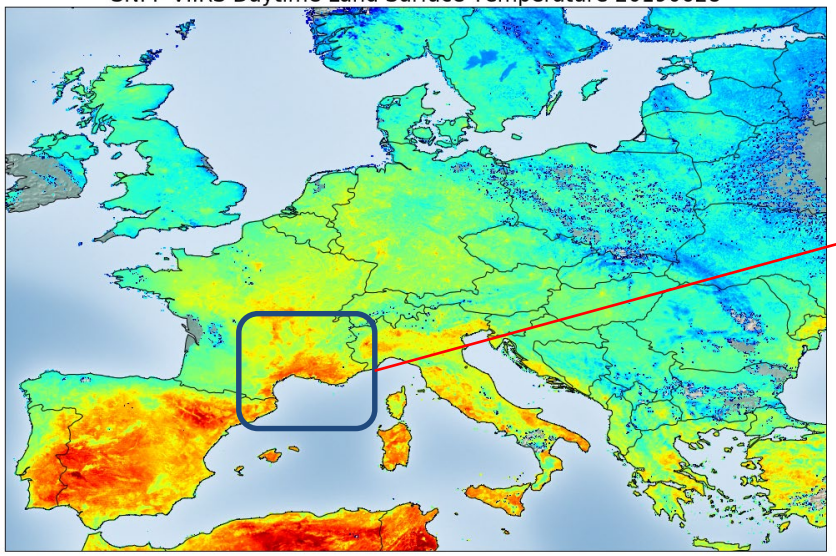
S-NPP VIIRS daily LST of June 28, 2019
(around 13:30 local time)

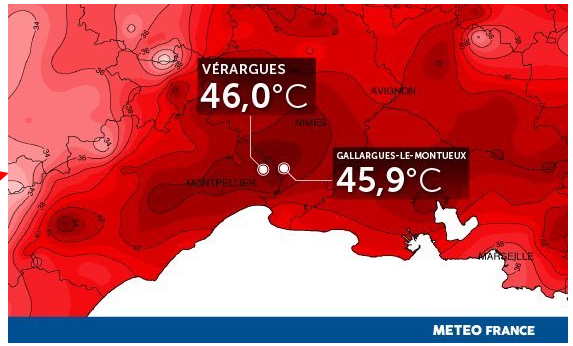


Routinely generated at local machine with one day latency, will in operational in NOAA soon.

VIIRS LST During Heat Waves

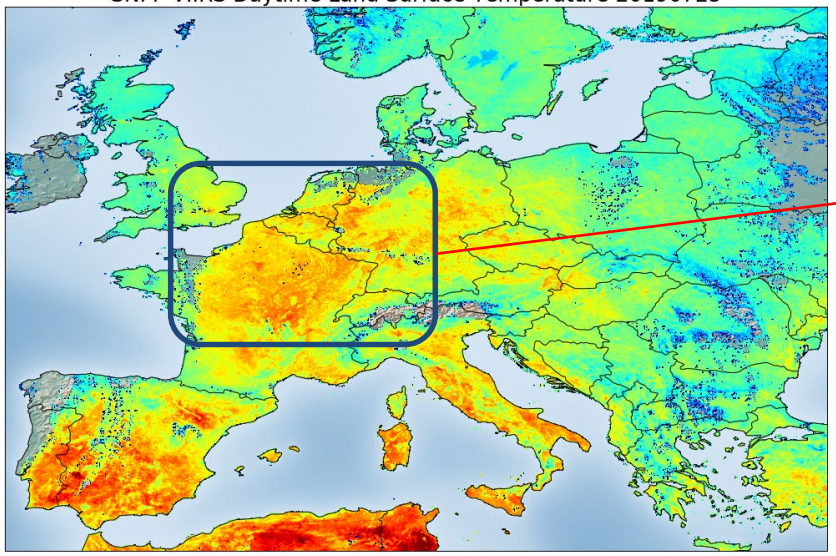
SNPP VIIRS Daytime Land Surface Temperature 20190628



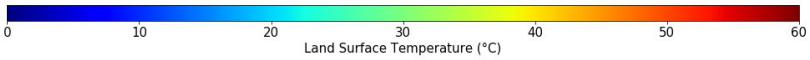


On June 28, 2019, Verargues (France) reached all-time temperature record of 46 °C, with LST over 50 °C

SNPP VIIRS Daytime Land Surface Temperature 20190725



On July 25, 2019, Central Europe countries Germany, Belgium, Netherland, Luxemburg all reached all-time temperature record of over 40 °C, meanwhile, UK reach a record of 38.7 °C.

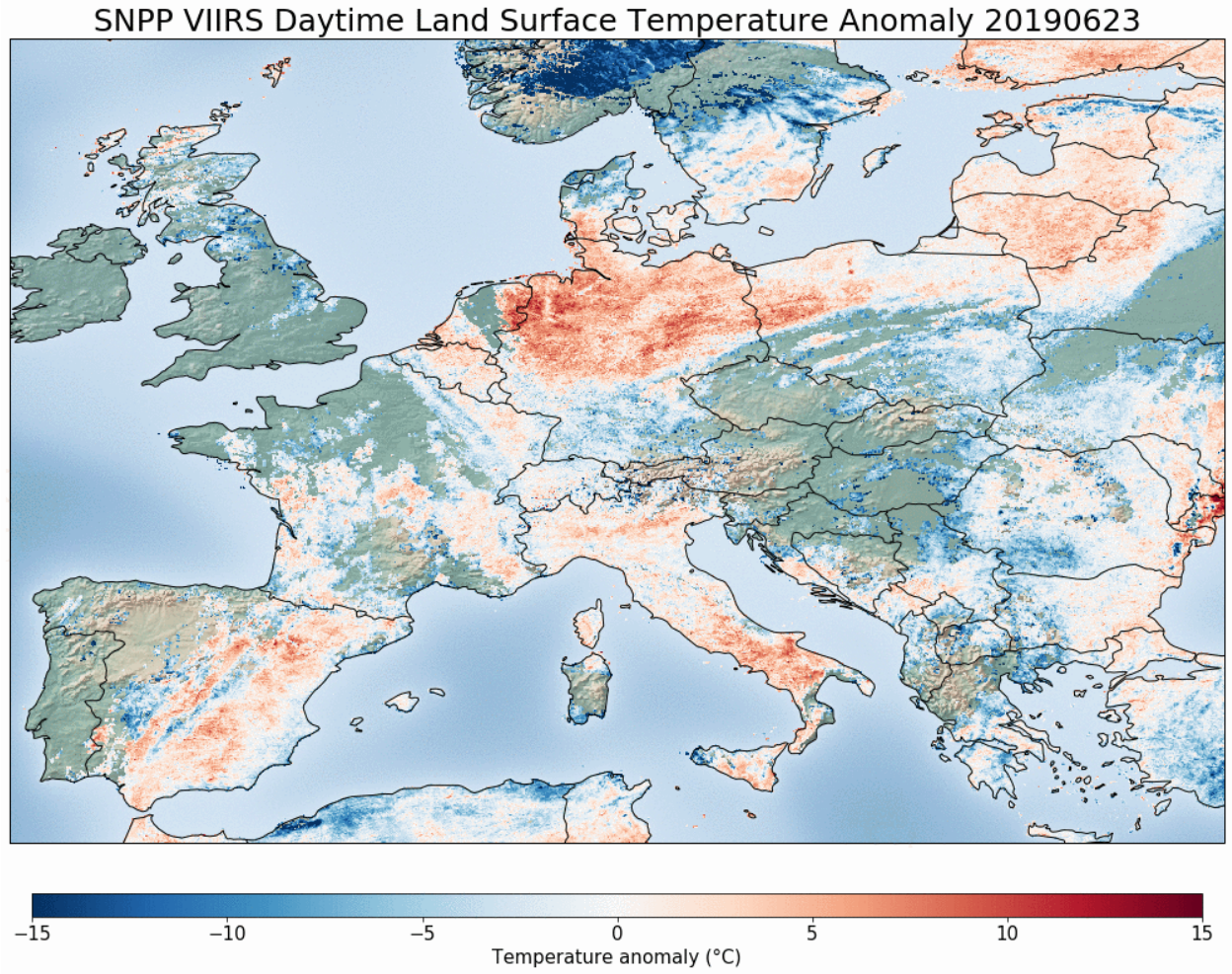


Temperature Anomaly

- Reference LST
  - 8-Day composite of LST during the same period. (e.g. 07/21-07/28)
  - Mean S-NPP VIIRS LST of previous 3 years (2016-2018)

- Temperature Anomaly
  - Daily LST with one day latency (24 + 3 hours)
  - Only for clear-sky condition
  - LST difference between VIIRS daily LST and reference LST

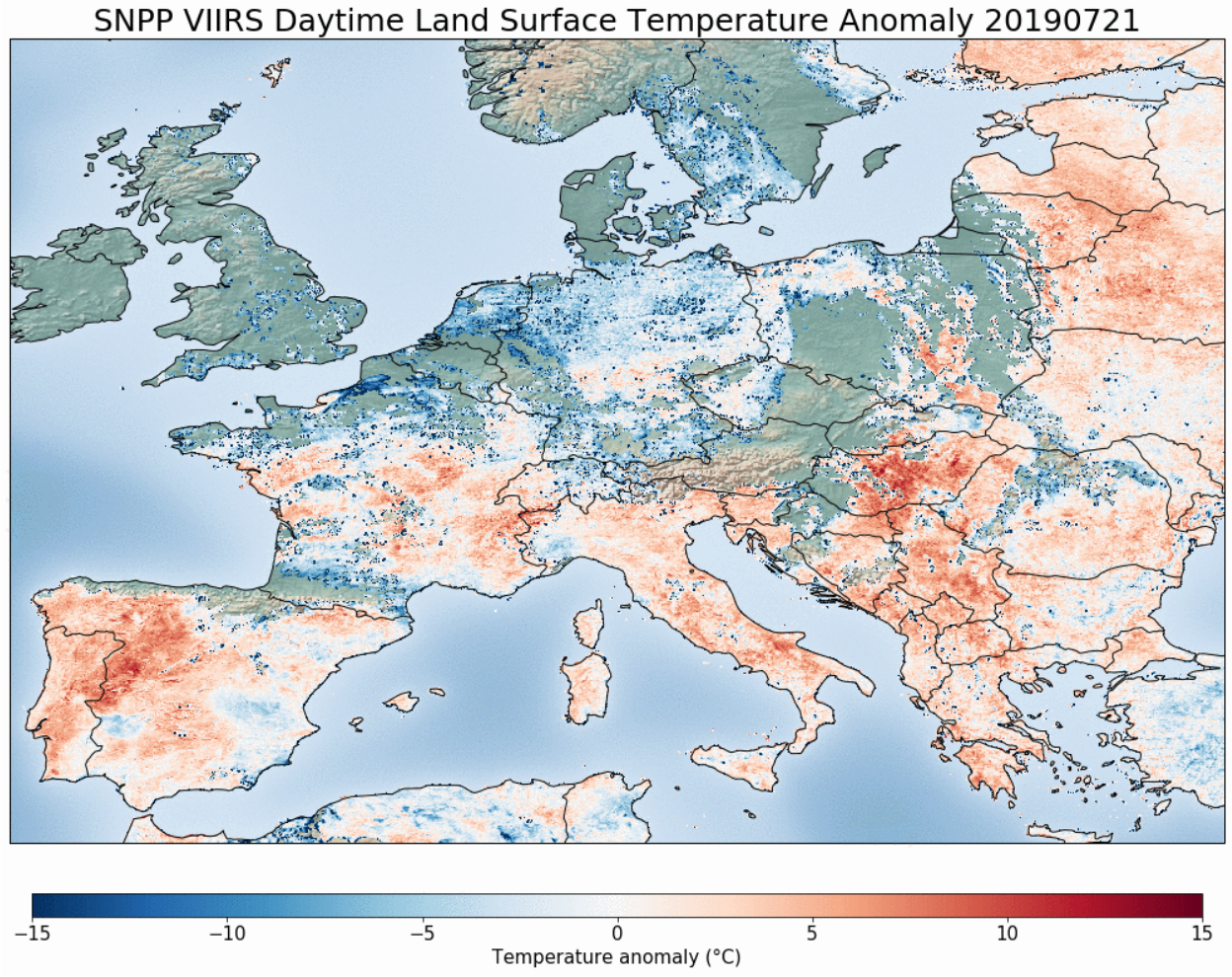
LST Anomaly 20190623 - 20190701



- **June heatwave development**
  - Started from June 24 in Germany, Poland.
  - Spread to the South Europe in the following days.
  - France, Italy and Spain reached the highest LST in June 28
  - End in July 2.
  - Temperature anomaly could reach over 15 ℃ during daytime.

June 2019 was found to be the hottest June on record

LST Anomaly 20190721 - 20190728



- **July heatwave development**
  - Started from July 22 in France.
  - In three consecutive day (23, 24, 25) temperature anomaly in central Europe.
  - Belgium, Germany, the Netherlands and the UK all reached record-breaking LST in July 25
  - Temperature anomaly could reach over 15 °C during daytime.

July 2019 was found to be the hottest July on record

Nighttime LST

Nighttime temperature and climate change

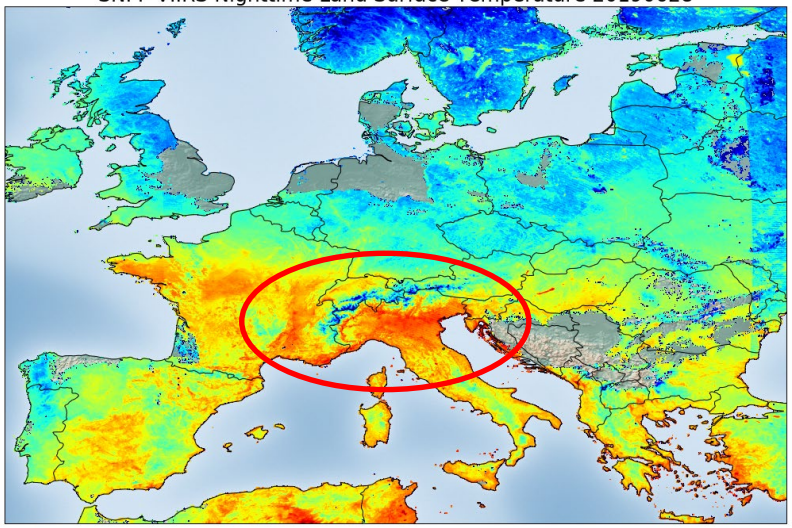
- Hot nights are particularly characteristic of climate change on a warming planet.
- Urban heat island effect is larger during night than daytime.
- Increase of humidity makes thing worse.
- Night is more deadlier than day for lack of cooler air. (e.g. 2003 France lack AC)
- Hot nighttime temperatures reduce the number of critically important relief windows during heat waves.

VIIRS Nighttime LST

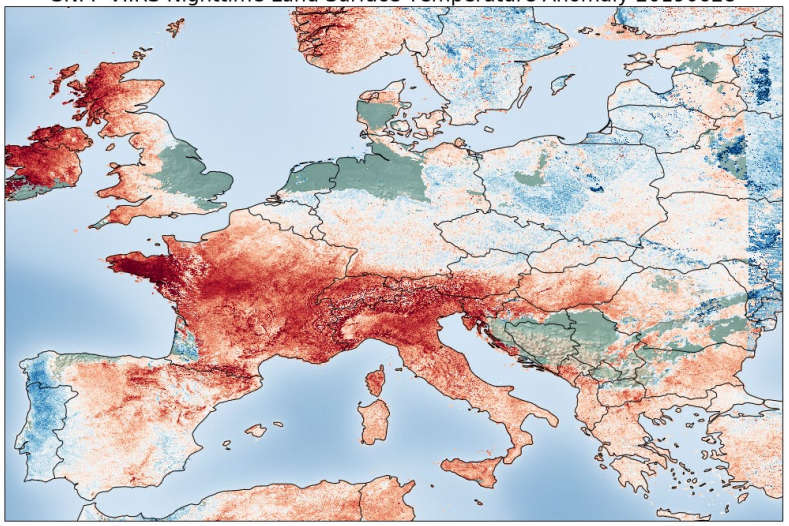
- Local solar time ~ 1:30AM, close to the daily minimum LST.
- LST is more homogeneous and close to the air temperature due to the energy exchange between atmosphere and land.

Nighttime LST & Anomaly

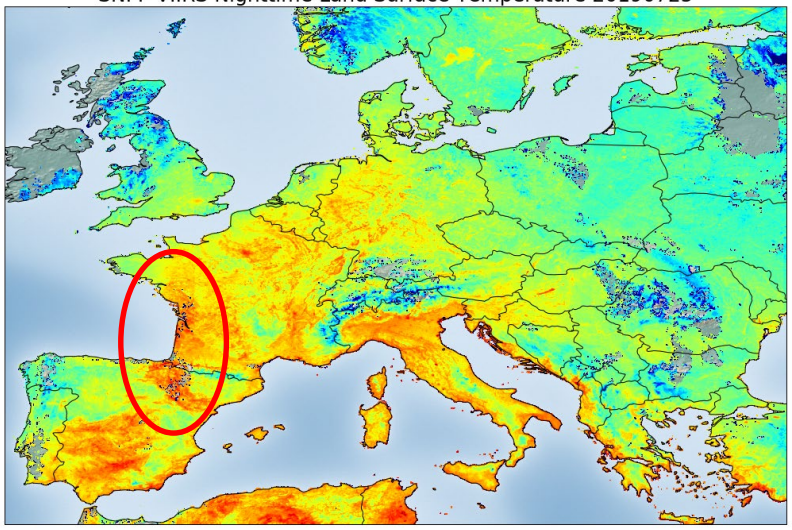
SNPP VIIRS Nighttime Land Surface Temperature 20190628



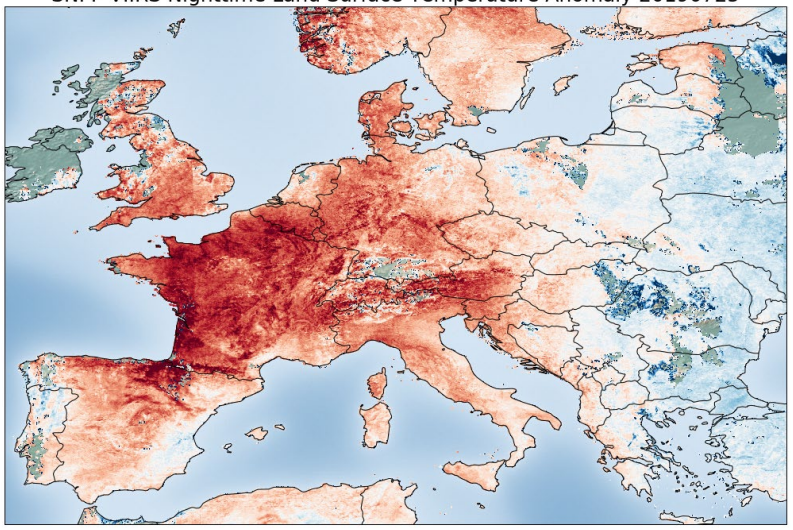
SNPP VIIRS Nighttime Land Surface Temperature Anomaly 20190628

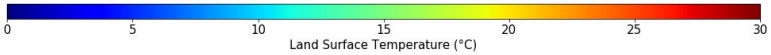


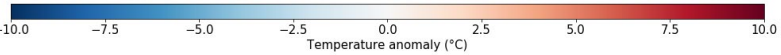
SNPP VIIRS Nighttime Land Surface Temperature 20190725



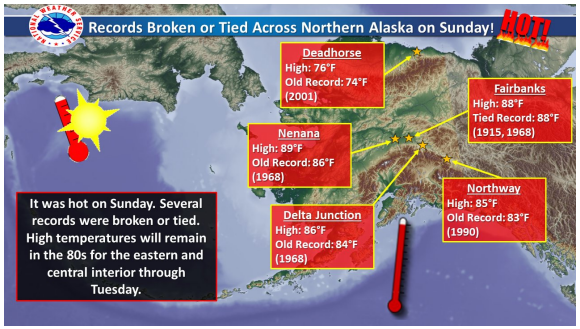
SNPP VIIRS Nighttime Land Surface Temperature Anomaly 20190725

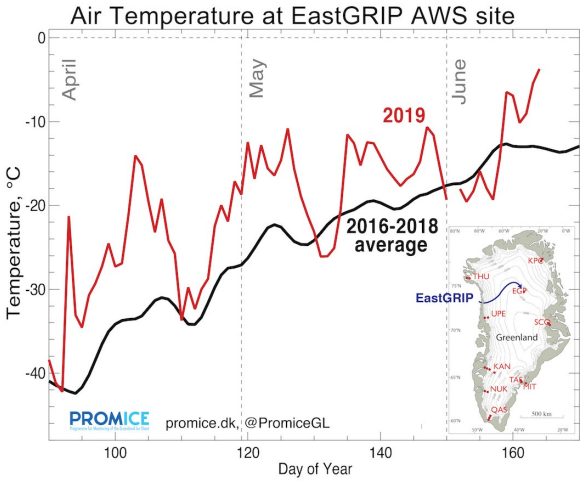


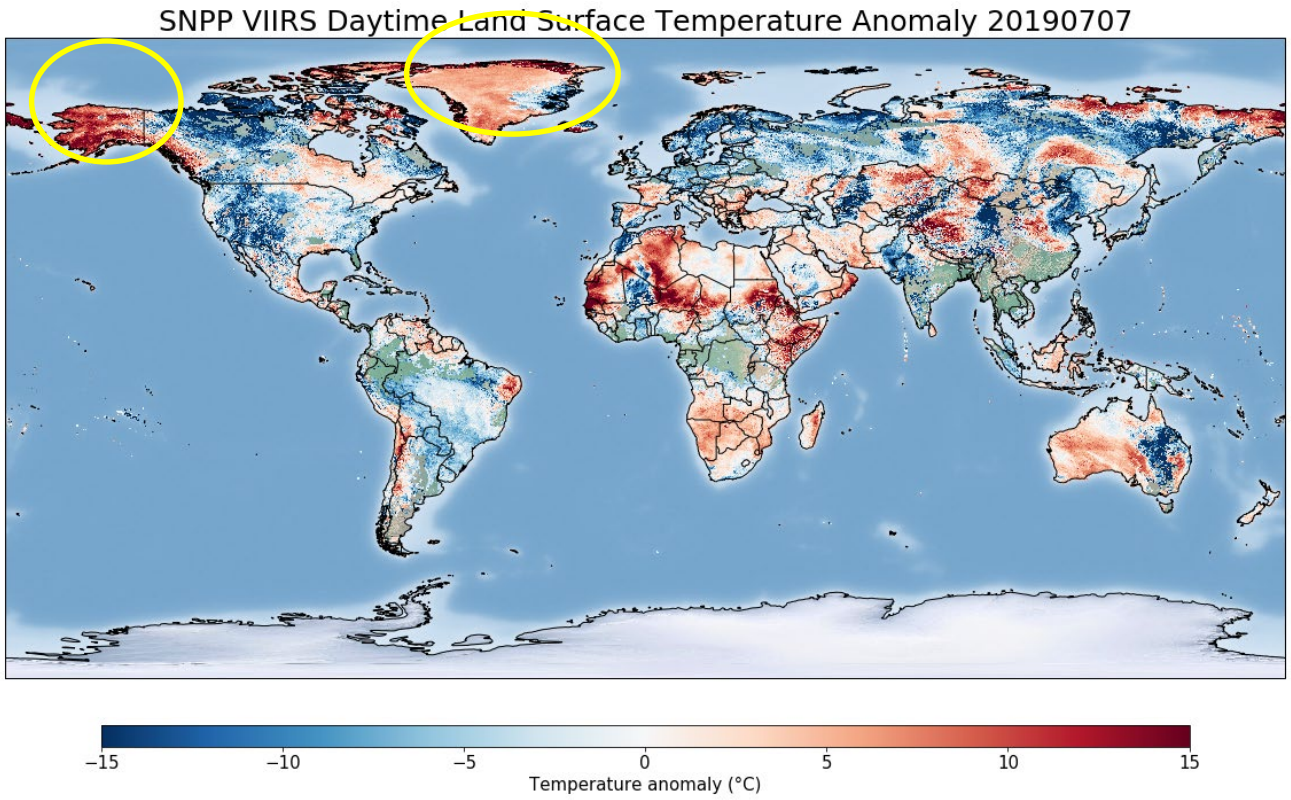




High Latitude LST Anomaly







High latitude LST anomaly: Early July of 2019

- Many cities in Alaska reached all-time record of 90 degrees Fahrenheit.
- Greenland got a positive temperature anomaly during this period. Consistent with the reported air temperature (Figure from PROMICE).

LST Potential Applications in Heatwave

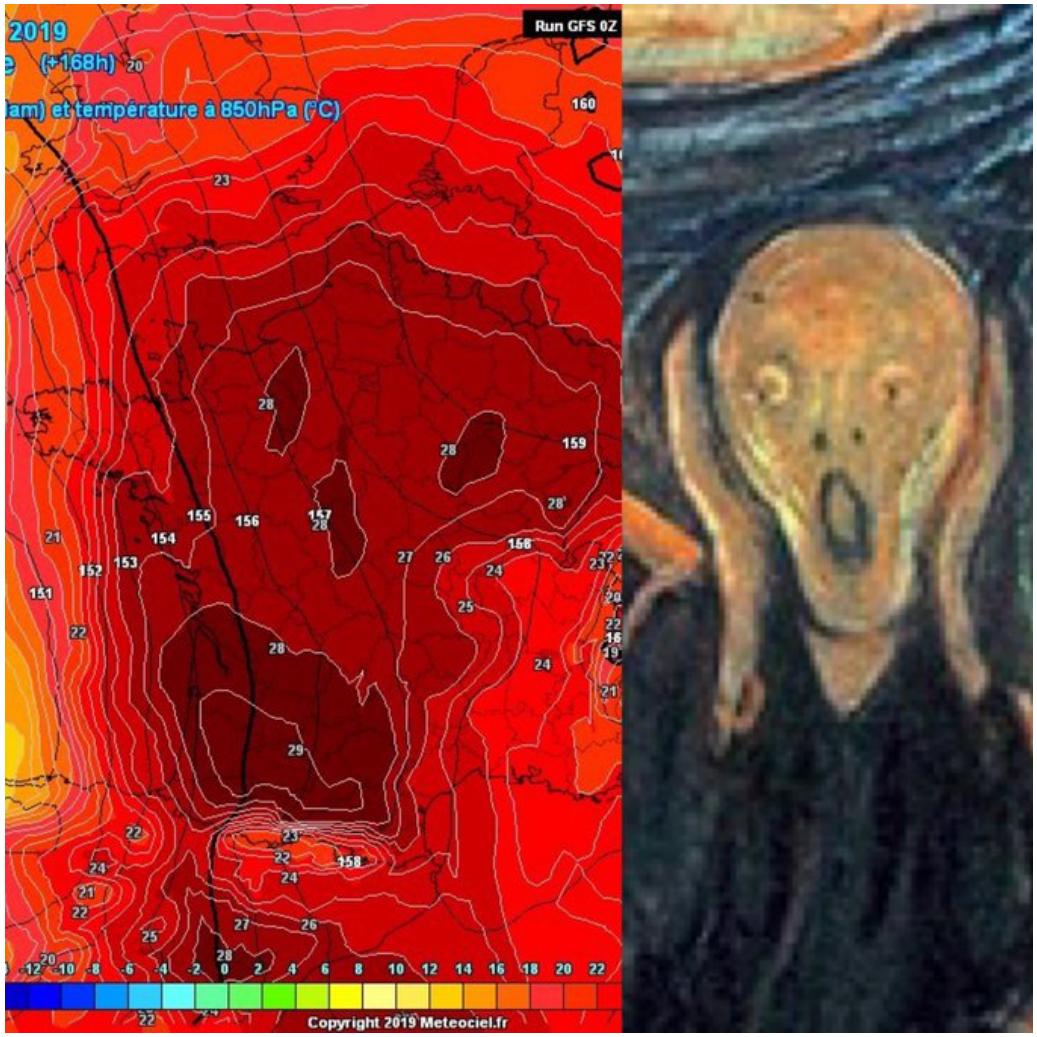
- **Urban heat island**
  - LST Downscaling might be required because of NOAA medium resolution LST products: VIIRS (1km) and GOES-16/17 ABI (2km).

- **Support the extreme heat vulnerability analysis**
  - Provide the exposure drive data (E) in the Vulnerability Index (HVI) Model (Wilhelmi & Hayden 2010), along with the Sensitivity (S) and Resilience (R)

$$HVI = E_i(x) + S_i(y) - R_i(z)$$

- **Derivation of air temperature for metrological, climate applications**
  - Air temperature is more close to climate change, human life.
  - Air temperature has strong correlation with LST

Thank You!



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