European heatwave in July 2006: how local processes amplify favorable large-scale conditions

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European heatwaves : what are the ingredients?

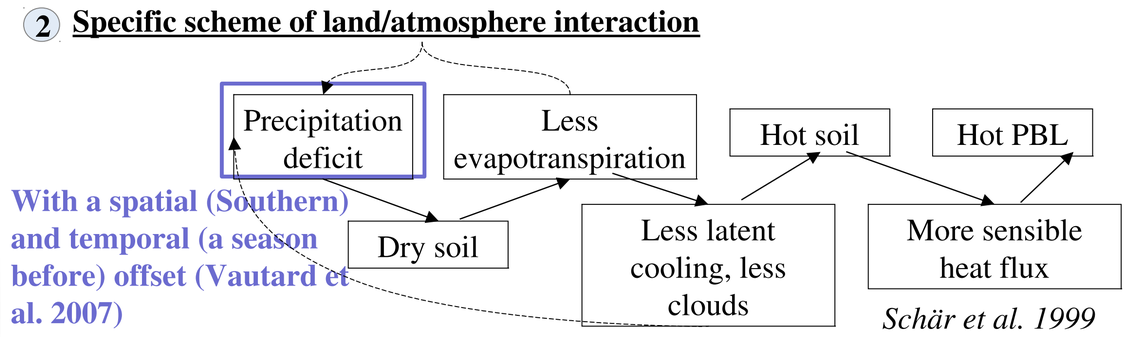
1 Particular large-scale conditions

-quasi-stationary **anticyclonic** circulation ➔ subsidence & warm-air advection (Fischer et al. (2007)

-It induces **high T** collocalized with **fair weather** & **high P** (Stefanon et al. 2012)

-**Warm** Atlantic **SSTs** (Sutton & Hodson 2005) and/or Mediterranean ones that favor **weather regime excitation** in summer (Fendale & Shukla 2007)

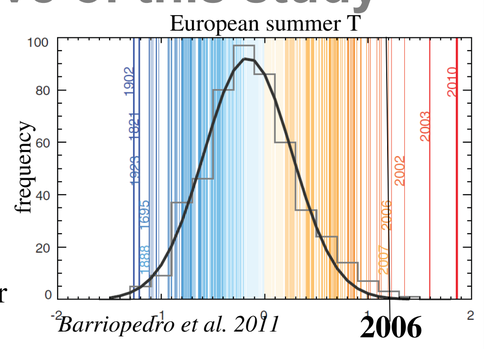
2 Specific scheme of land/atmosphere interaction



+ crucial role of the **partitioning between latent and sensible** heat fluxes, controlled by soil moisture (Fischer et al. 2012)

Objective of this study

- Which of the ingredients listed next for 2006 July heatwave?
- Does the Schär et al. 1999 scheme needs new adjustments?
- What is the particular role of clouds?



- Knowing that models are still not very performing to simulate heatwave (Vautard et al. 2013), what can we learn from observations?

Tools

Observations:

From **SIRTA** (http://sirta.ipsl.polytechnique.fr), a ground-based atmospheric observatory near Paris, collecting data (*in- situ*, active and passive remote-sensing…) since 2002: about 10 years of a completely resolved atmospheric column

!! We use **reanalysis of observations** : one single netCDF file, hourly averaged, homogeneous data, quality control ++ (http://climserv.ipsl.polytechnique.fr/cfmip-obs.html)

Simulations:

Using CORDEX simulations, WRF regional model: 28 vertical levels, ERA-Interim forcing, horizontal resolution 20 km, extraction of the SIRTA grid-point

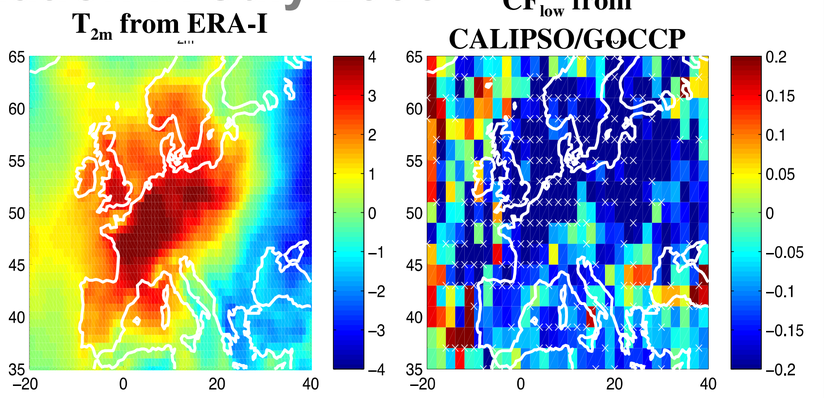
- Simu. 1 (1989 – 2011): RUC surface scheme, soil moisture can evolve freely
-Simu. 2 (1989 – 2008): DIF surface scheme, prescribed soil moisture (wintertime value)

Method:

In order to determine if the different variables anomalies are explained or not by large-scale circulation variability, the method of analogs (Yiou et al. 2007) is applied to both simulations and observations

Large-scale situation in July 2006

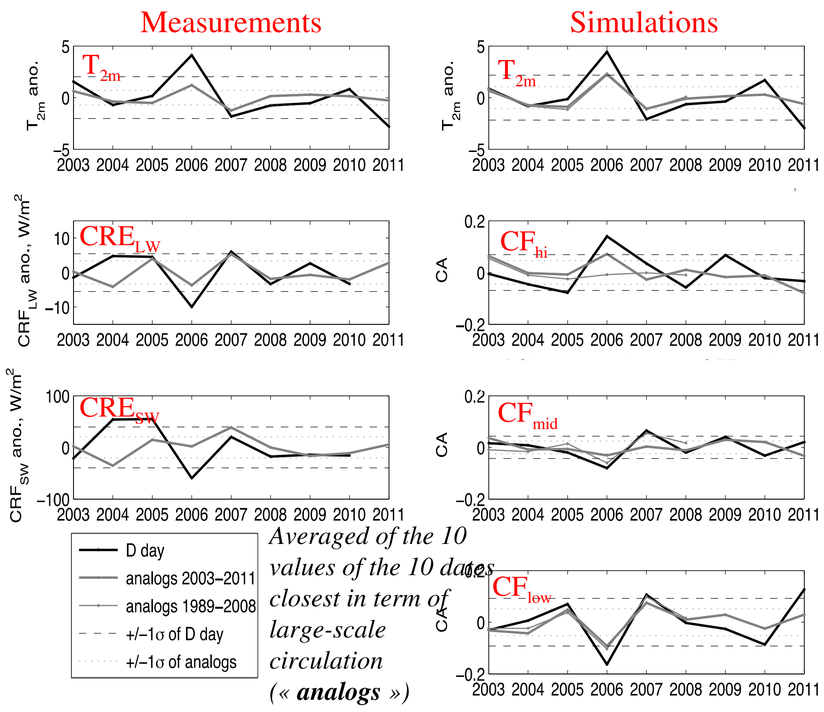
2006 July monthly anomaly comparing to 2006 – 2012 July mean values; x = above 1σ



- ✓ Heatwave occurs over Western Europe, with some variability of amplitude: the **excess of T2 is about 4 to 5°C warmer than the mean, in France.**
- ✓ **Low cloud deficit** with a very similar pattern as T_{2m} anomaly, but with no distinction between land and ocean.
- ✓ Circulation: SLP above normal; air advected over France comes **from North-East** of Europe (i.e. dry air)

➔ **heatwave correlated to low cloud deficit, consistently with the direction of air circulation**

Monthly anomaly at SIRTA



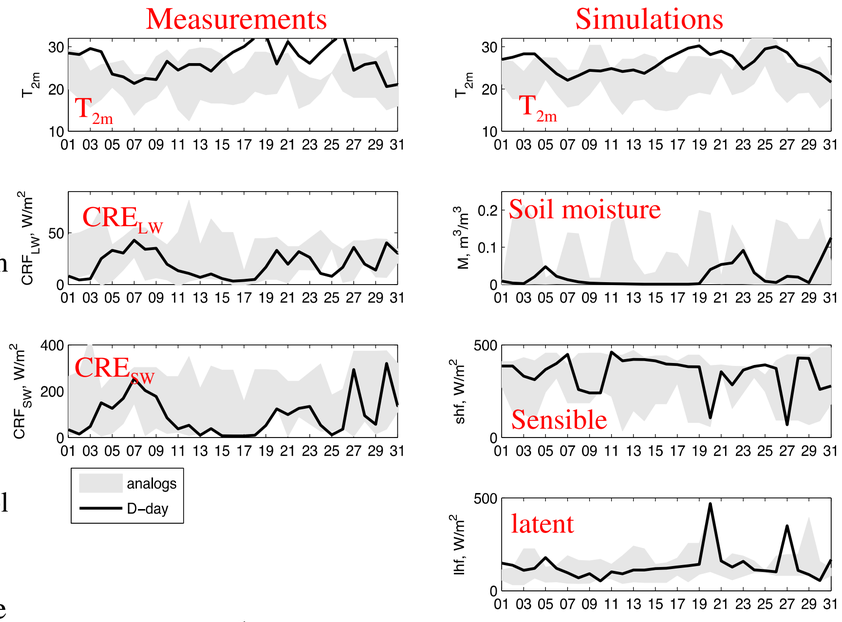
*Averaged of the 10 values of the 10 days closest in term of large-scale circulation (« **analogs** »)*

- ✓ T2 about 4.5°C higher than 2003-2012 mean, 2°C above 1σ, and more than for the analogs: the **excess of T2 is not explained by large-scale condition alone**;
- ✓ This heat-wave is detected in **simulations**
- ✓ Concerning **clouds**, important **deficit** of:
  - LW & SW cloud radiative effect (obs.)
  - Low clouds (simu.)

➔ **deficits more important than what is expected for similar large-scale circulation conditions** (« analogs »)

Day after day during July 2006

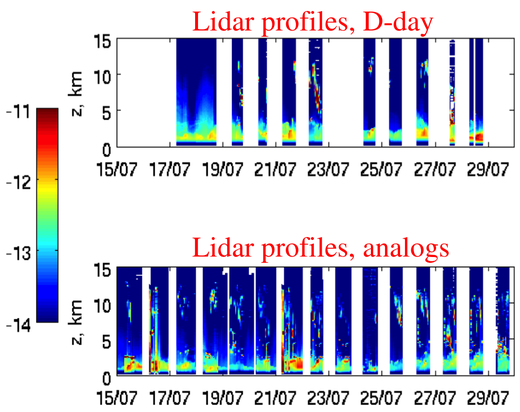
- ✓ The monthly positive anomaly of T2 is mainly due to a few days: **from July 15th to 27th** (obs. & simu.), above all analogs
- ✓ During the first days of th heatwave, **CRF are almost zero**
- ✓ The soil is **very dry**, & drier than analogs, & **6 days before the heat-wave** ➔ excess of sensibl

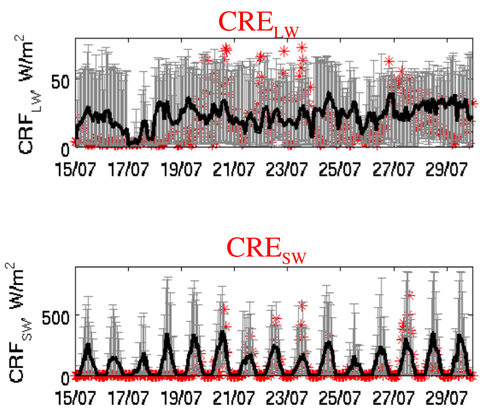


➔ In the first days of the deficit, T2 increases, becoming higher than excepted; From July 19th to 23rd clouds appear and the first soil is wetter (precip.), and T2 decreases a little, and it increases

Elements of discussion

- ✓ Persistent clear-sky conditions; July 17th, sky completely clear. These clouds also missing around SIRTA (see CF from MSG sat.)
- ✓ Cloud that are missing have an important daily cycle (see analogs): clouds missing until July 20th could be low-level clouds, mainly driven by the boundary layer.
- ✓ High clouds from July 20th to 23rd, and also some low-clouds; after: clear sky again





DIF: difference between D-day and analogs explains the part of T_{2m} anomaly due to large-scale circulation conditions ➔ **part of T_{2m} anomaly due to soil dryness can reach several degrees**.

✓Dry soil contributes to amplify T_{2m} anomaly in the first 5 days of heatwave only, during a "blocking regime" event

✓Dry soil not responsible of cloud deficit

Conclusions

- ✓ July 2006 heatwave not only explained by large-scale circulation conditions, even if the weather regimes are *Blocking* and then *Atlantic-low*, two regimes that promote heatwaves (Cassou et al. 2005).
- ✓ This heatwave explained by two concomitant
  - Particularly high SLP over Southern Scandinavia that favors clear sky
  - A dry soil which amplifies the surface temperature, making it higher than usual especially during the third week of July.

➔**Using advanced observations combined with meso-scale model may help in the understanding of extreme events**

➔**An anomaly which is important enough to be detected at a seasonal scale is actually explained by a few days and partially by local processes**