P0038

Recent Warm Extremes in Europe: A Taste of Future Climate?

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Recent record-breaking seasons in Europe

Over the past few years, Europe witnessed a **spate of extremely warm seasons** (Fig 1):

- Devastating **Summer (JJA) 2003** heat wave [1].
- Warmest **Fall (SON) / Winter (DJF) / Spring (MAM)** on record in **2006/2007**.
- 5 of the 10 warmest seasons since 1948 belong to the 5 last years.

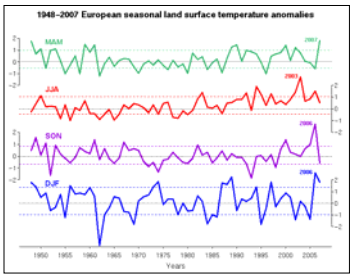
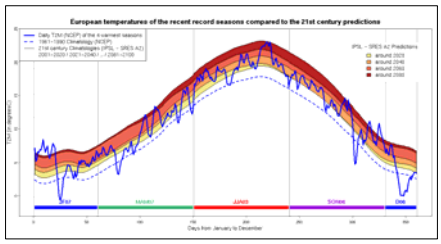


Table 1. Seasonal mean temperatures records

	Year	Anomaly	Std Deviation
MAM	2007	+1.8°C	2.1σ
JJA	2003	+2.7°C	3.3σ
SON	2006	+2.7°C	3.4σ
DJF	2006	+2.6°C	2.0σ

Figure 1. 1948-2007 time series of European seasonal 2m-temperature anomalies (NCEP) averaged over the Western Europe [5°W-20°E ; 40-60°N] land areas. Anomalies are computed relative to the 1961-1990 climatology. Record years are indicated.

Observed anomalies vs. 21st century predictions



IPSL Simulations :
1860-2000 : 2L36 (20C3M)
2000-2100 : 2L26 (SRES A2)

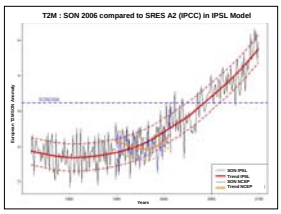
Figure 2. Comparison between the daily 2m-temperatures of the 4 recent record seasons (juxtaposed in solid blue) and the 2001-2020, 2021-2040, 2041-2060, 2061-2080 and 2081-2100 daily standards (5 black lines separated by orange colors) predicted by IPSL model under SRES A2 (IPCC). NCEP 1961-1990 daily climatology is added (dashed blue).

- The fictive year composed by the **4 recent record-seasons** presents daily temperatures comparable to the **2041-2060 standards** (under SRES A2 [2]) (Fig 2).

- Some **short events** largely exceed the 2081-2100 standards (above the 90th quantile [3]).

- Example of the **Fall 2006**:
With a 2.7°C 2m-temperature anomaly over Europe, SON 2006 will be **in the average** (+/- 1σ) **around 2045** (+/- 20 years) (Fig 3).

Figure 3. Evolution 1860-2100 of the Fall 2m-temperature anomaly over Europe from the IPSL Model in SRES A2 (IPCC) in black (smoothed in red). The NCEP data are added in blue (smoothed in orange).



In a more global context

- The global air temperature warming since the 1970s is associated with an **increase in the occurrence of extreme events**.
- Since the mid 1990's more and more (less and less) Northern Hemisphere regions have been affected by extremely warm (cold) seasonal temperatures (Fig 4).
- Maximum in **SON 2006**: 12% of the Northern Hemisphere surface was covered by temperatures above 2σ.

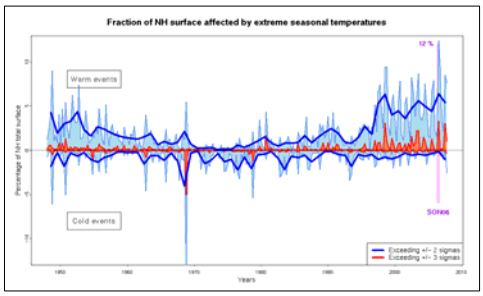


Figure 4. Percentage of the Northern Hemisphere surface above 20°N affected by seasonal 2m-temperature anomalies exceeding +/- 2σ (blue) or +/- 3σ (red) for each season of 1948-2007. Annual means are added in thick lines for the +/- 2σ levels. Warm (cold) extremes are positively (negatively) represented.

A **shift of the temperature** distribution due to global warming could explain an increasing observation of extreme events, but not as extreme as SON 2006 or JJA 2003 which might be signs of a **change in variability** [4].

References

Data & Models: *2m-temperature, meridional wind, and SST are taken from the National Center of Environmental Prediction (NCEP) 1948-2007 reanalyses [10], and 2m-temperature simulations over 1860-2100 are taken from the Institut Pierre Simon Laplace (IPSL) Model [11]. Regional Model MM5 is provided by the Penn State University / National Center for Atmospheric Research [8][9].*

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[11] Marti, O, et al. (2005) The new IPSL climate system model: IPSL-CM4. *Report No. 26*, Institut Pierre Simon Laplace, Paris

Origins of the extremely warm European Fall of 2006

From: ***Cattiaux, J., et al. (2008)***, Origins of the extremely warm European Fall of 2006, *Geophys. Res. Lett., submitted.*

European Fall climate and 2006 extreme anomaly (2.7°C) (Fig 5)

- Fall European climate strongly linked to the **North-Atlantic atmospheric circulation** [5][6].
- **Inconsistency** in this relation since the mid 1990s (max. in 2006) [7]: presence of **enhancing factors** making temperatures warmer than in the past for analogue atmospheric conditions.
- **SON2006**: Exceptional persistence of **northward flow** and extremely **warm coastal SST** anomaly.

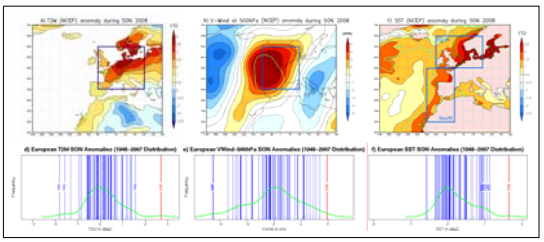


Figure 5. (a-c) SON2006 anomalies (NCEP) of (a) 2m-temperature (b) meridional wind at 500hPa (c) SST. **(d-f)** 1948-2007 distribution of the Fall anomalies of (d) 2m-temperature (e) meridional wind at 500hPa (f) SST, averaged over the respective violet areas of (a-c).

Statistical Model

Linear regressions between 2m-temperature, meridional wind and SST seasonal (Fall) time series.

- **SSTs have an influence** on land surface temperatures (particularly on the warming trend).
- **Contributions of dynamics** (meridional wind) **and SST** on the **SON2006** 2m-temperature warm anomaly are respectively estimated at **+1.3°C and +0.8°C** (Fig 6).

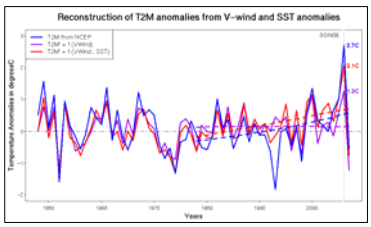


Figure 6. Reconstruction of the Fall air temperature anomaly (blue) from the Fall meridional wind anomaly only (violet) and from the Fall meridional wind anomaly + the Fall SST anomaly (red) over the 1948-2007 period. The 1978-2007 trends are added in dashed lines.

Table 2. Statistics of the reconstructions of T2M Fall anomalies from V-wind + SST

Reconstruction from:	Correlation actual/reconstructed T2M (SON1948-2007 time series)	1978-2007 trend reconstructed ?	SON2006 reconstructed T2M anomaly
V-wind	r = 0.7 ; p.value < 10^{-2}	No	+1.3°C
V-wind + SST	r = 0.8 ; p.value < 10^{-2}	Yes	+2.1°C

Dynamical Model

Sensitivity experiments with MM5 (PSU / NCAR mesoscale model) [8][9]
3 different simulations performed along SON2006

Simulations:
- CTL: Wind Nudged (*ECMWF*) and actual SON2006 SSTs.
- WNC: Wind Nudged (*ECMWF*) and SSTs from 1961-1990 Climatology.
- WFC: Wind Free and SSTs from 1961-1990 Climatology.

WNC-WFC: **Contribution of the atmospheric circulation**, estimated at +0.8°C for a 2.8m/s difference of meridional wind (Fig 7a). Extrapolated to SON2006 wind anomaly, the contribution is **+1.2°C**.

CTL-WNC: **Contribution of SST** anomaly, estimated at **+0.9°C** (Fig 7b). +0.5°C are attributed to the long-term trend of the SSTs, and +0.4°C to the exceptionalness of 2006 (not shown).

The remaining +0.6°C are unexplained, but consistent with the +0.54°C of global air warming since the 1970s (IPCC 2007 [2]).

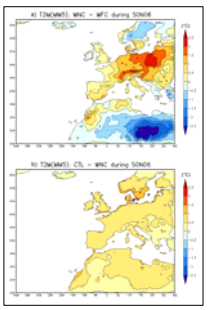


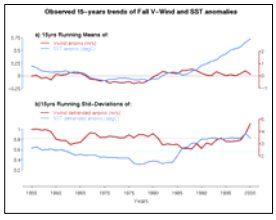
Figure 7. Mean SON06 MM5 output 2m-temperature differences between (a) WNC and WFC (b) CTL and WNC.

Both models attribute 50% of the SON2006 temperature anomaly to the exceptional atmospheric flow and 30% to the extreme SST anomaly. The missing 20% remain unexplained, but consistent with the global air temperature increase since the 1970s.

The anthropogenic (long-term trends) contribution is estimated at 1°C of the anomaly (35%).

Fall 2006: Taste of the Future Autumns?

- **Meridional wind: no mean trend**, but **its variability may start to increase** (Fig 8)
The occurrence of weather regimes may start to change: examples of the 2 last Falls (SON2006 – record of northward flow / SON2007 – record of southward flow).
- **Strong warming trend** for **SST** over Europe since the 1980s **(~0.5°C/decade)**.



The probability to have strong southly flow + highly warm SSTs during Fall is increasing.

Events like SON 2006 could occur more frequently in the future.

Figure 8. 15-years running (a) means and (b) standard deviations of the 1948-2007 time series of meridional wind (red) and SST (blue) Fall anomalies.

Conclusions

Europe has been affected by a spate of anomalously warm seasons that have broken temperature records in a very recent past.

These recent warm temperatures are comparable to the predicted 2050 standards (in a greenhouse climate), and some recent short events present anomalies warmer than the 2100 predictions.

Understanding the origins and the mechanisms of these recent extremes could enable to develop adaptation strategies to the impact of climate change.

Example of Fall 2006: 50% of the extremely warm continental anomaly can be attributed to the regional dynamics, 30% to the exceptional SSTs and 20% remain unexplained. The anthropogenic contribution is estimated at 35%, a proportion that should increase in the future.