Impact des évènements extrêmes sur la qualité de l’air

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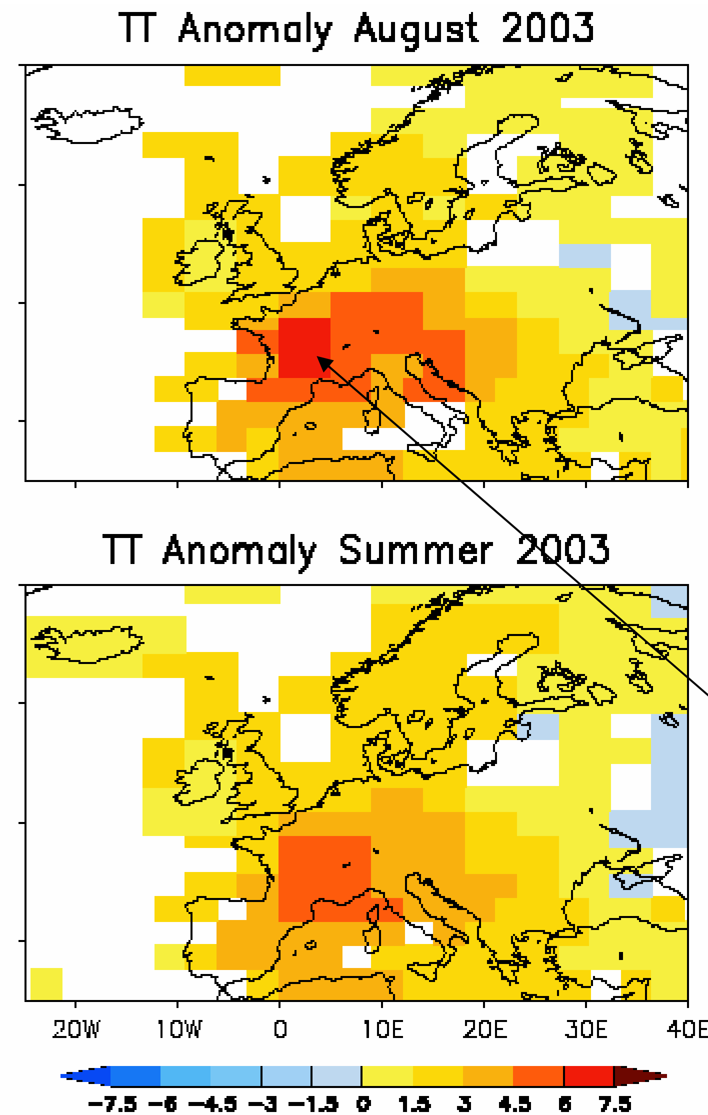
Sommaire

- Vague de chaleur 2003
- Focus sur la compréhension des hautes valeurs d'ozone en 2003
- Vagues de chaleur dans le futur
- Conclusions

Magnitude/location of the T anomalies

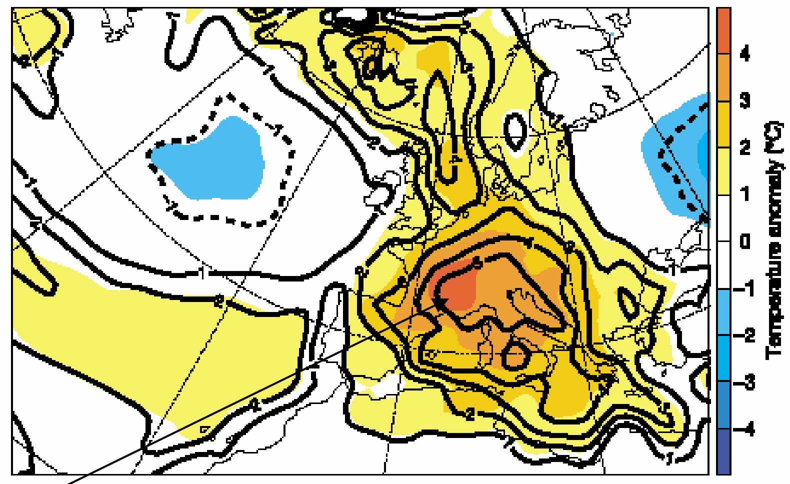
Surface T (relative to 1901-1995 average)



[Luterbacher et al., Science, 2005]

Also very strong anom. in June but not in July

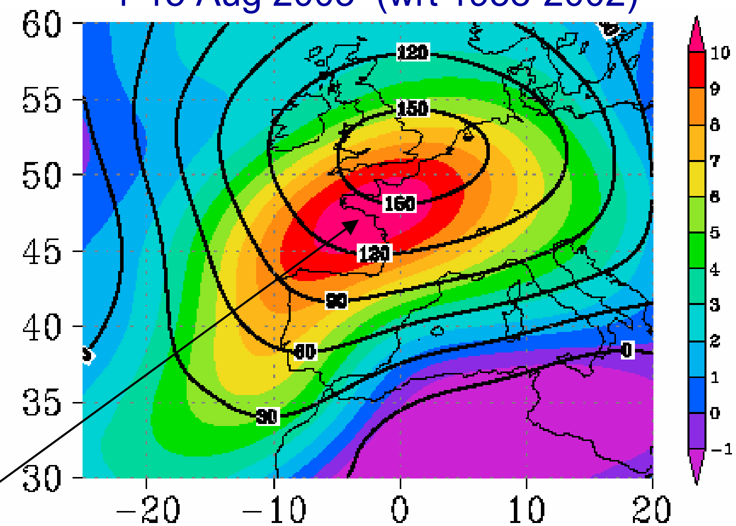
Surface T anom. in JJA 2003 (wrt.1961–90 mean)



Excess of ~3°C (up to 5 stdev)

[Schär et al., Nature, 2005]

850 hPa T (°C) anomalies 1-15 Aug 2003 (wrt 1958-2002)

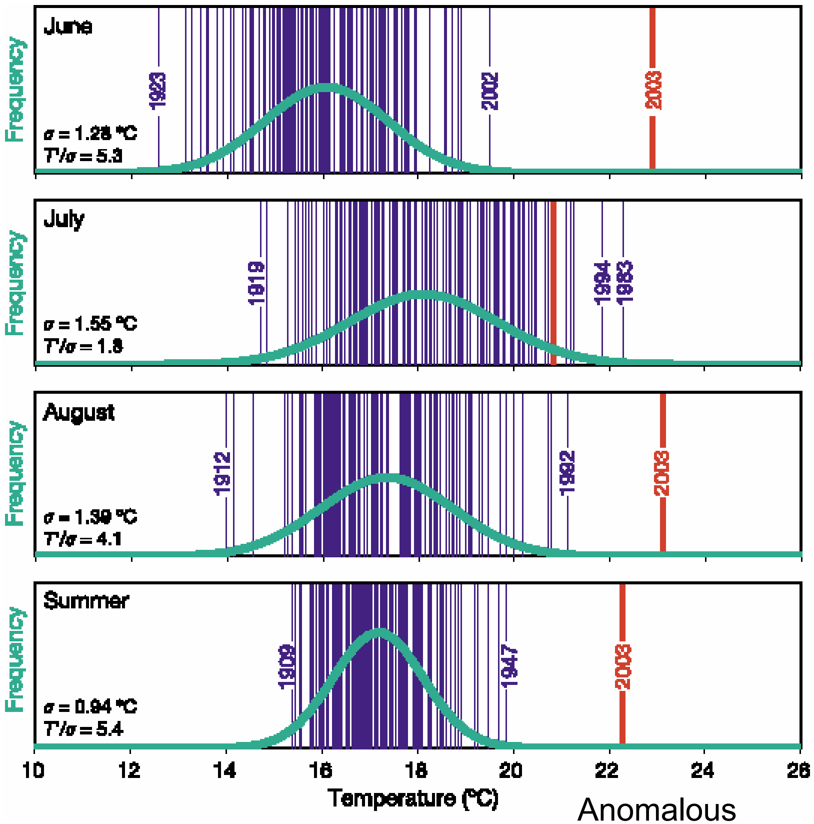


Anom of > 10°C (> 4°C over historical max.)

[Trigo et al., GRL, 2005]

Climatology/meteorology

Gaussian fit of mean T at Basel, Geneva, Bern & Zürich for 1864–2003 [Schär et al., Nature, 2004]

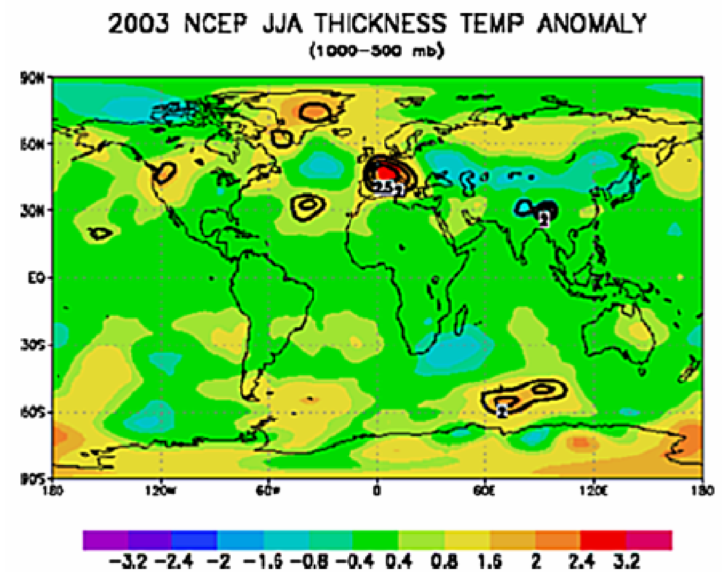


Anomalous
June and August

Return period (wrt. 1990- 2002): $\tau > 10^4$ yr

Luterbacher et al. [Science, 2004]: Summer 2003 was very likely warmer than any other summer during the last 500 years.

Global T anomalies within 1000-500 hPa



(Areas exceeding 2.0, 2.5,and 3.0 SD from the 1979–2003 mean are contoured in thick lines)

- European heatwave of summer 2003 was a deep tropospheric phenomenon
- However, the percentage of the area of 22°–80°N covered by JJA thickness T anomalies of 2.0 SD, 3.0 and 3.5 SD has been larger on other years.

[Chase et al., GRL, 2006]

In summer 2003, an unprecedented heat wave in Western Europe.

International Herald Tribune
Wednesday, September 10, 2003 | 5

Heat claimed 15,000 in France

Estimate by funeral director exceeds latest by government

From news reports

PARIS: The number of people who died in France because of the August heat wave is 15,000, the country's largest undertaker estimated Tuesday, placing the death toll about 3,500 higher than the official government figure.

Isabelle Dubois-Costes, a spokeswoman for General Funeral Services, said the revised total includes deaths from the second half of August, after record-breaking temperatures had abated.

Late last month, the government issued its official estimate of 11,435, but the Health Surveillance Institute, which calculated the death toll for the government, said Tuesday that the total only counted deaths through the first died. At the time, the government put the figure at a maximum of 3,000.

The heat wave brought suffocating temperatures of up to 40 degrees Celsius (104 degrees Fahrenheit) in the first two weeks of August in a country where air conditioning is rare. The heat baked many parts of Europe, but nowhere was

The revised total includes deaths from the second half of August.

the toll higher than in France.

While the bulk of the victims — many families were away on lengthy August vacations. Authorities reportedly had difficulty making contact with survivors who were away on vacation.

A team of medial experts named by the Health Ministry to conduct the first official inquiry into the crisis issued a scathing report Monday that found "an error in anticipation, organization and coordination," and said "the response was not suited" to the situation.

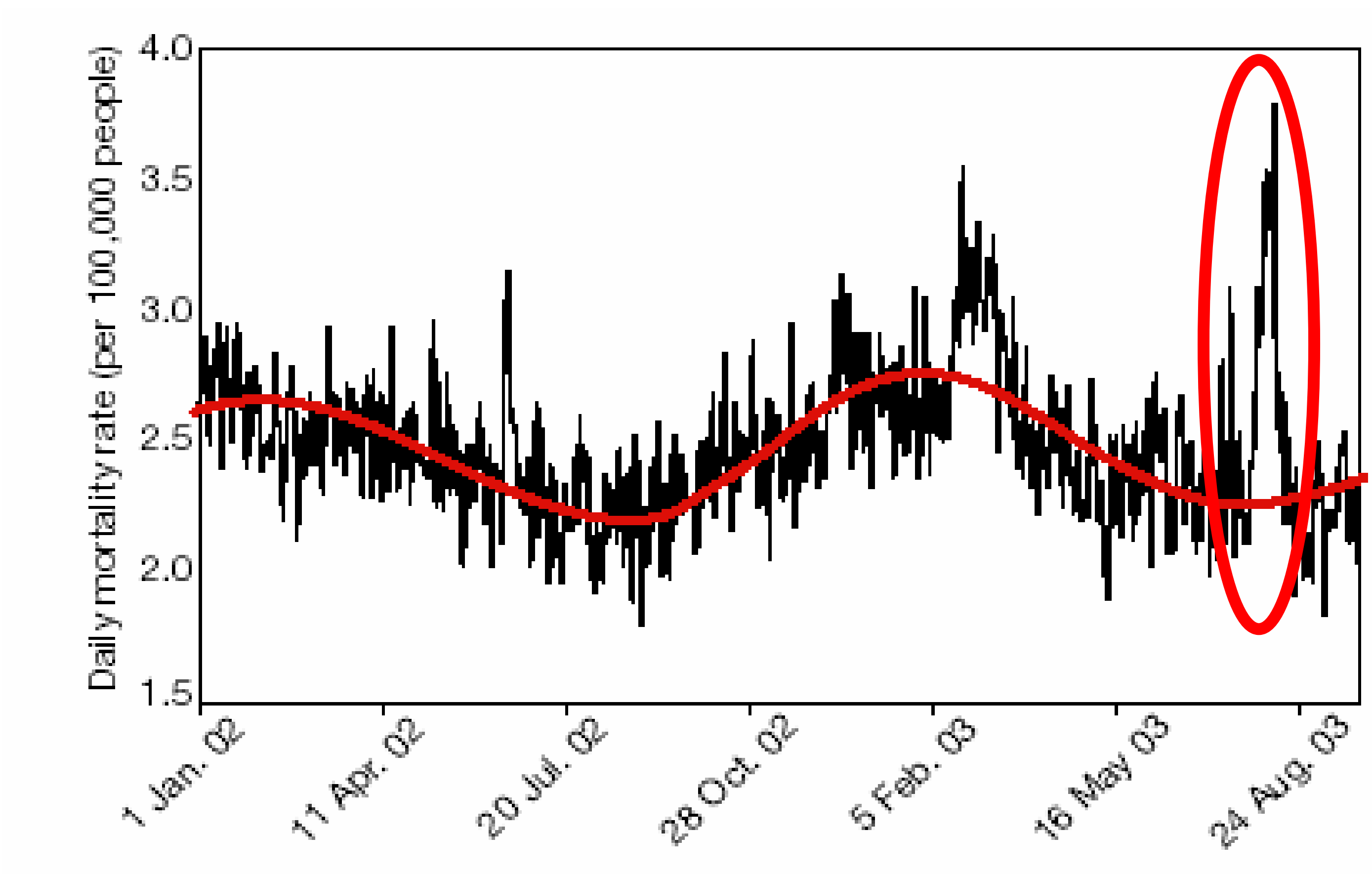
The experts said the "compartmentalization" of services between the health and other ministries and workers in the field prevented a pooling of available information about the scope of the crisis.

French doctors on Tuesday reacted angrily to the government report.

Gilles Brucker, director of the Health

European summer drought 2003:

Crop damage 12,3 billion USD, forest fires Portugal 1,6 billion USD, thawing of tundra caused slides; 22,000-35,000 heat wave related deaths in Europe 1-15.8.2003, in France death rate increased by 54%, significant in all age groups above 45 years. Figure from Baden-Württemberg (Schär and Jendritzky Nature 2.12.2004 p. 560). 1/3 of deaths ozone related.

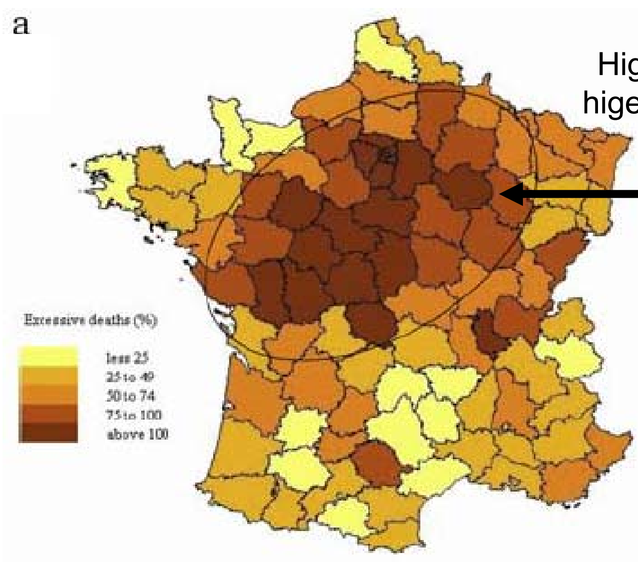


Air Quality and Mortality

More than 30,000 additional deaths associated to the heatwave in Europe

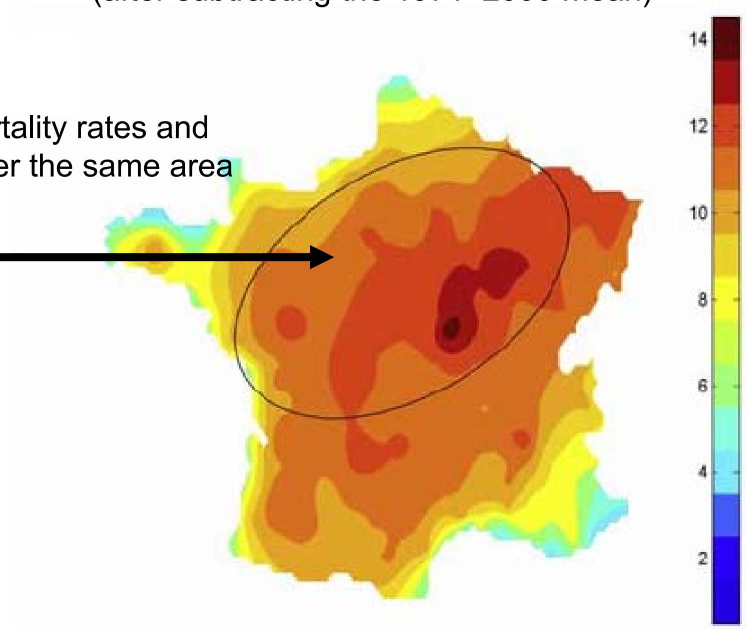
France (~15000), Germany (~ 5000), Italy (?), Spain (~6000), Holland (~1.500), Portugal (~2000) and the United Kingdom (~2000).

Excessive mortality rates (%) for 1–15 August 2003 (by comparison with the 2000–2002 mean)



Highest excessive mortality rates and higest T_{max} anomaly over the same area

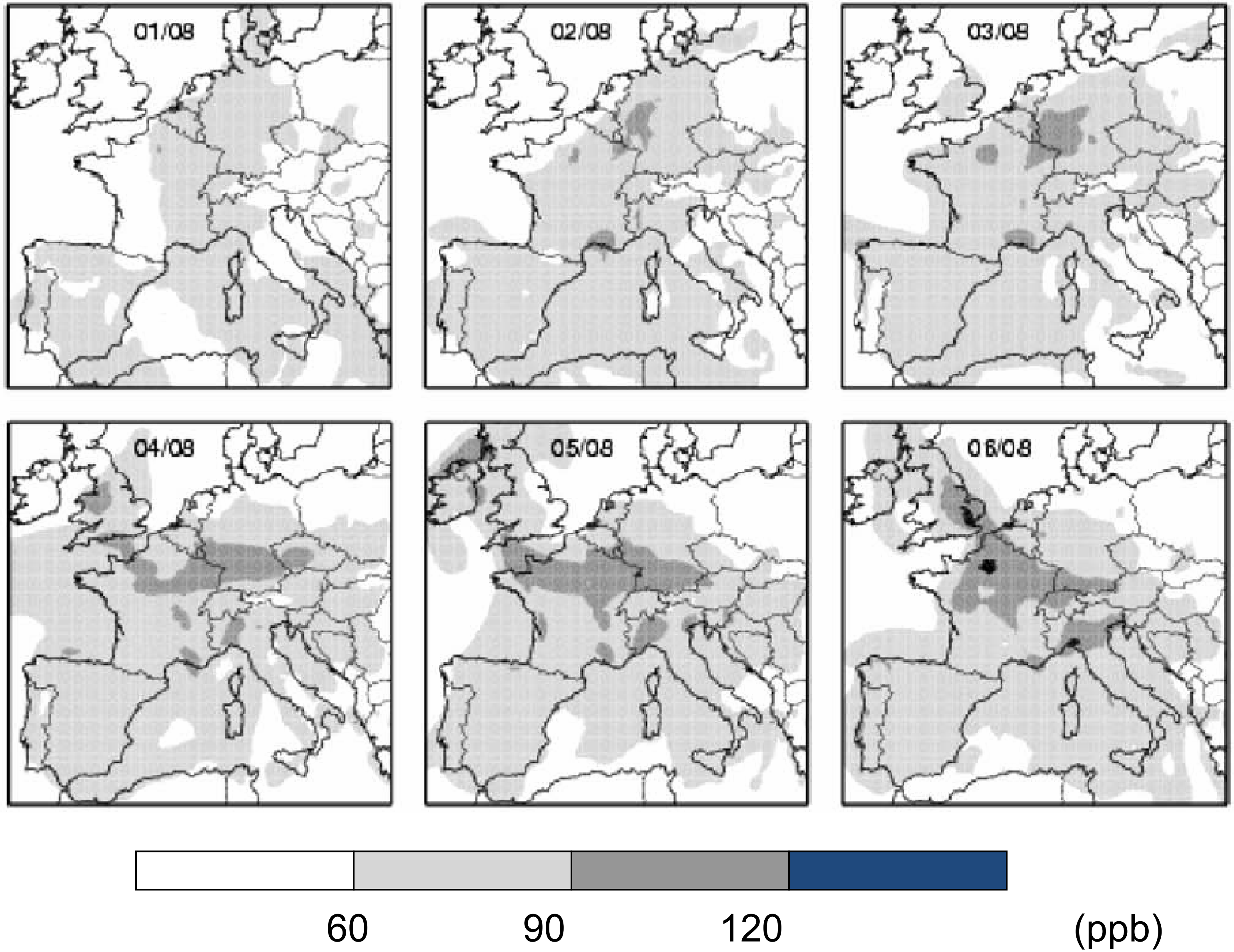
T_{max} anomaly (°C) for 1–15 August 2003 (after subtracting the 1971–2000 mean)



[Trigo et al., GRL, 2005]

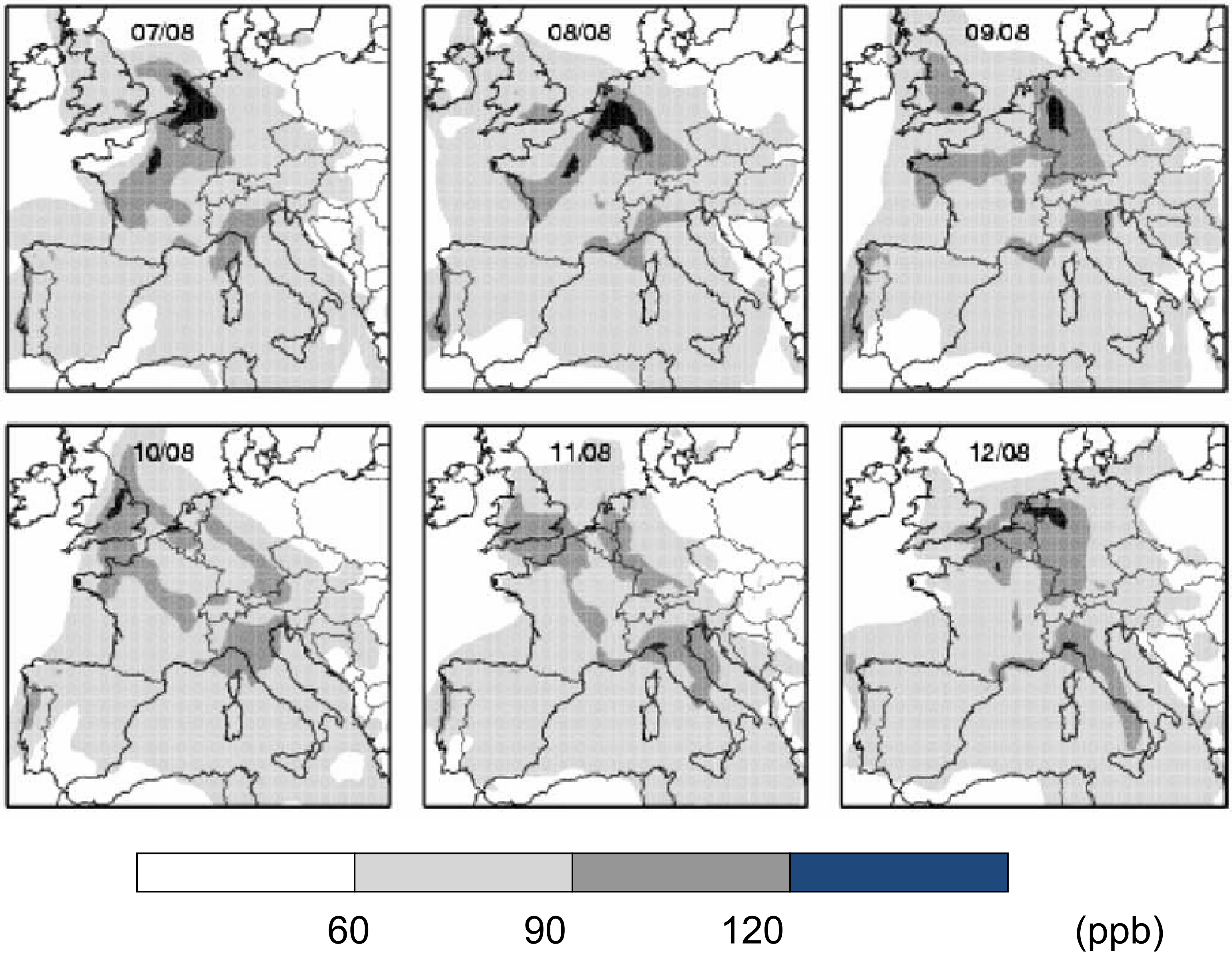
Evolution of 15 h UT ozone at ~900 m above ground (A)

before Aug
westerly flow



[Vautard et al., 2005]

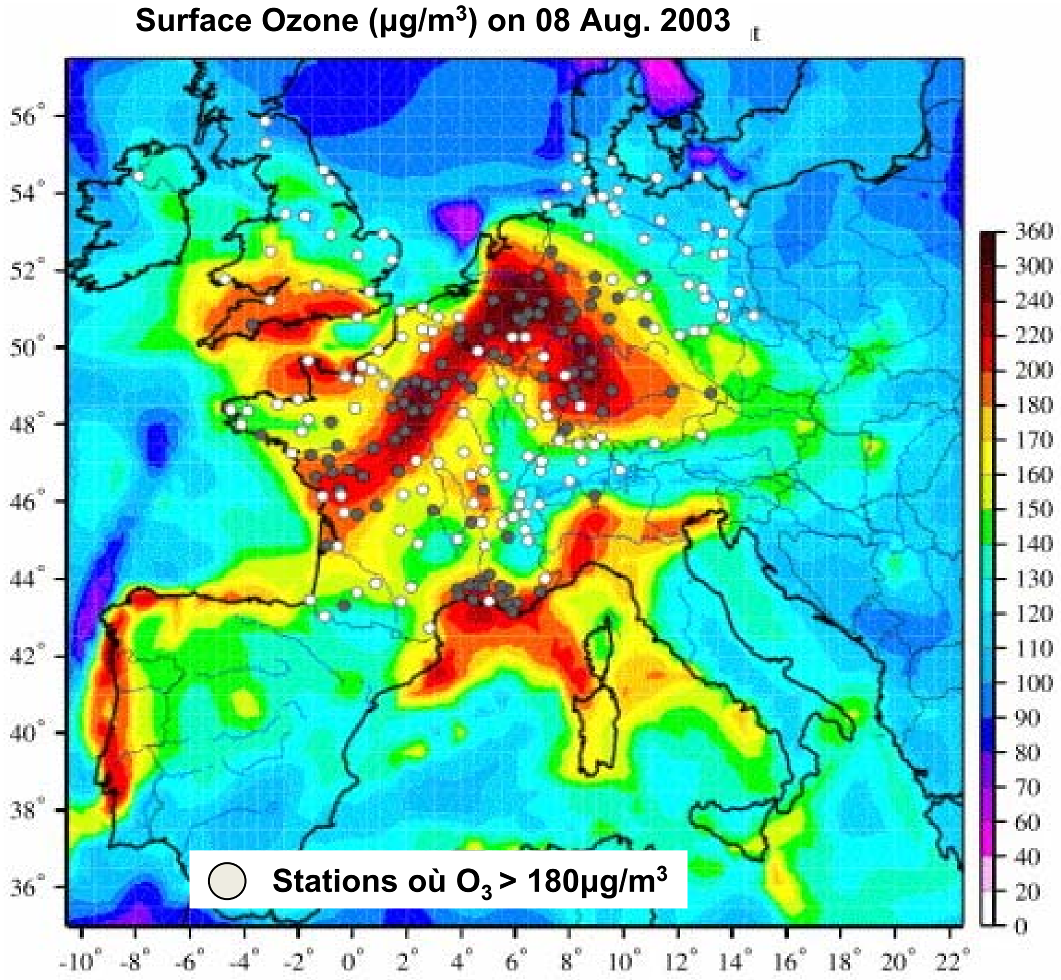
Evolution of 15 h UT ozone at ~900 m above ground (B)



after 12/08
air mass pushed
eastwards
by cold front

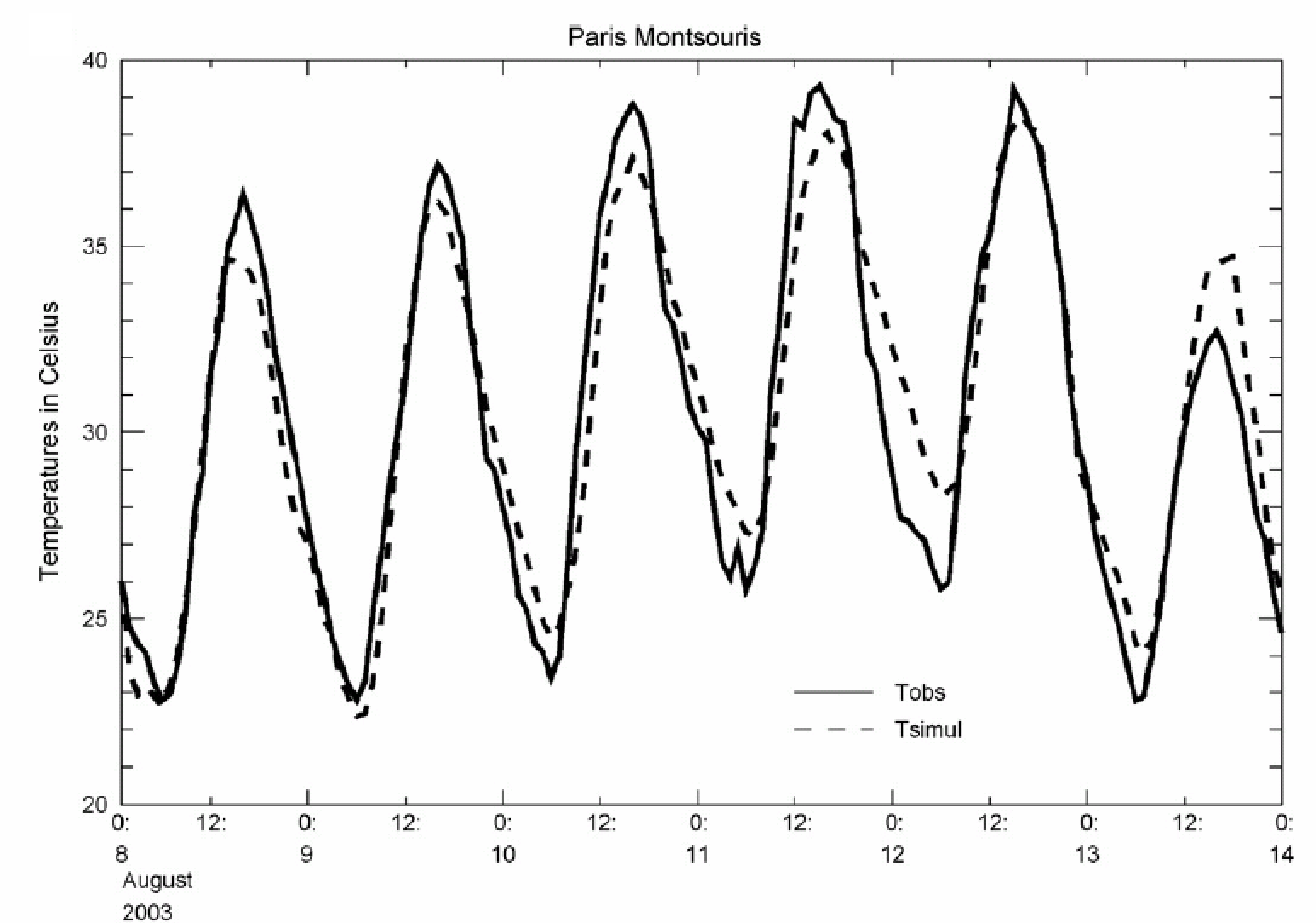
[Vautard et al., 2005]

Ozone en Août 2003



Vautard et coll., C..R. Ac. Sci, 2007

Température en Août 2003

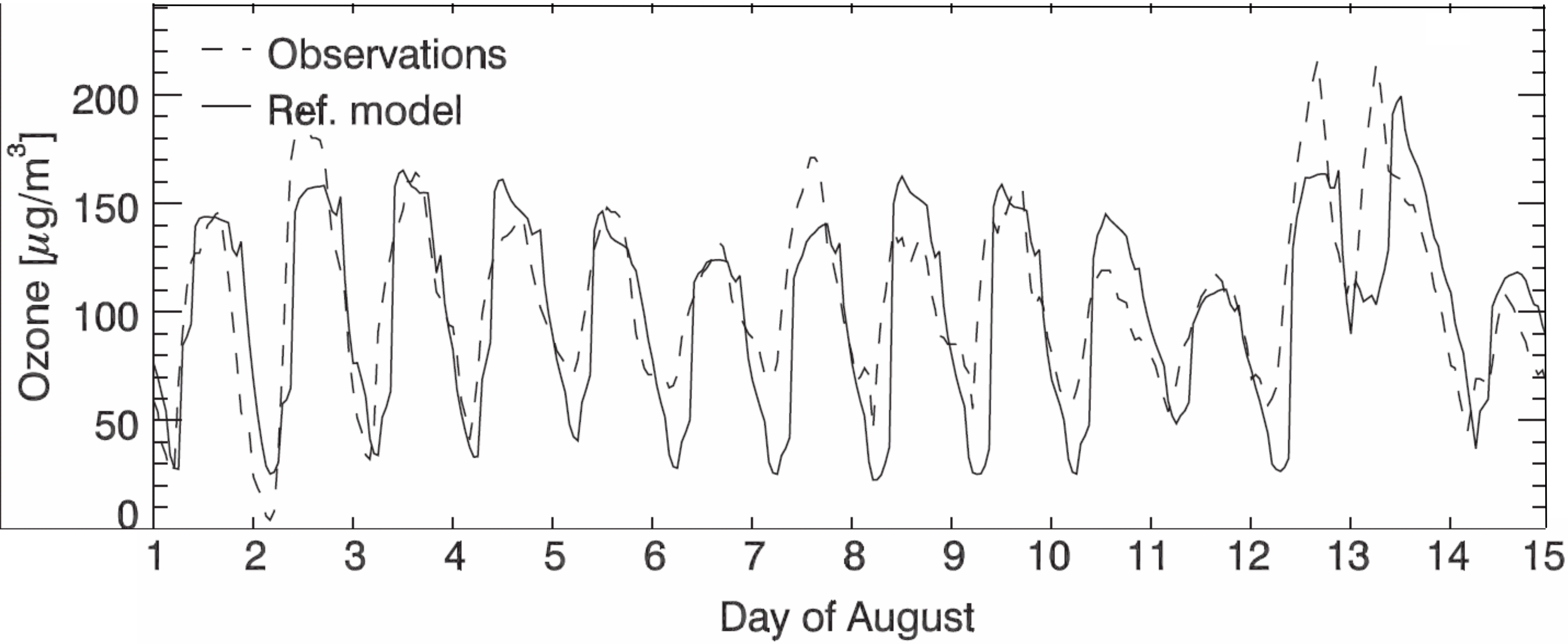


Vautard et coll., C..R. Ac. Sci, 2007

Autres facteurs contribuant à la formation d’ozone

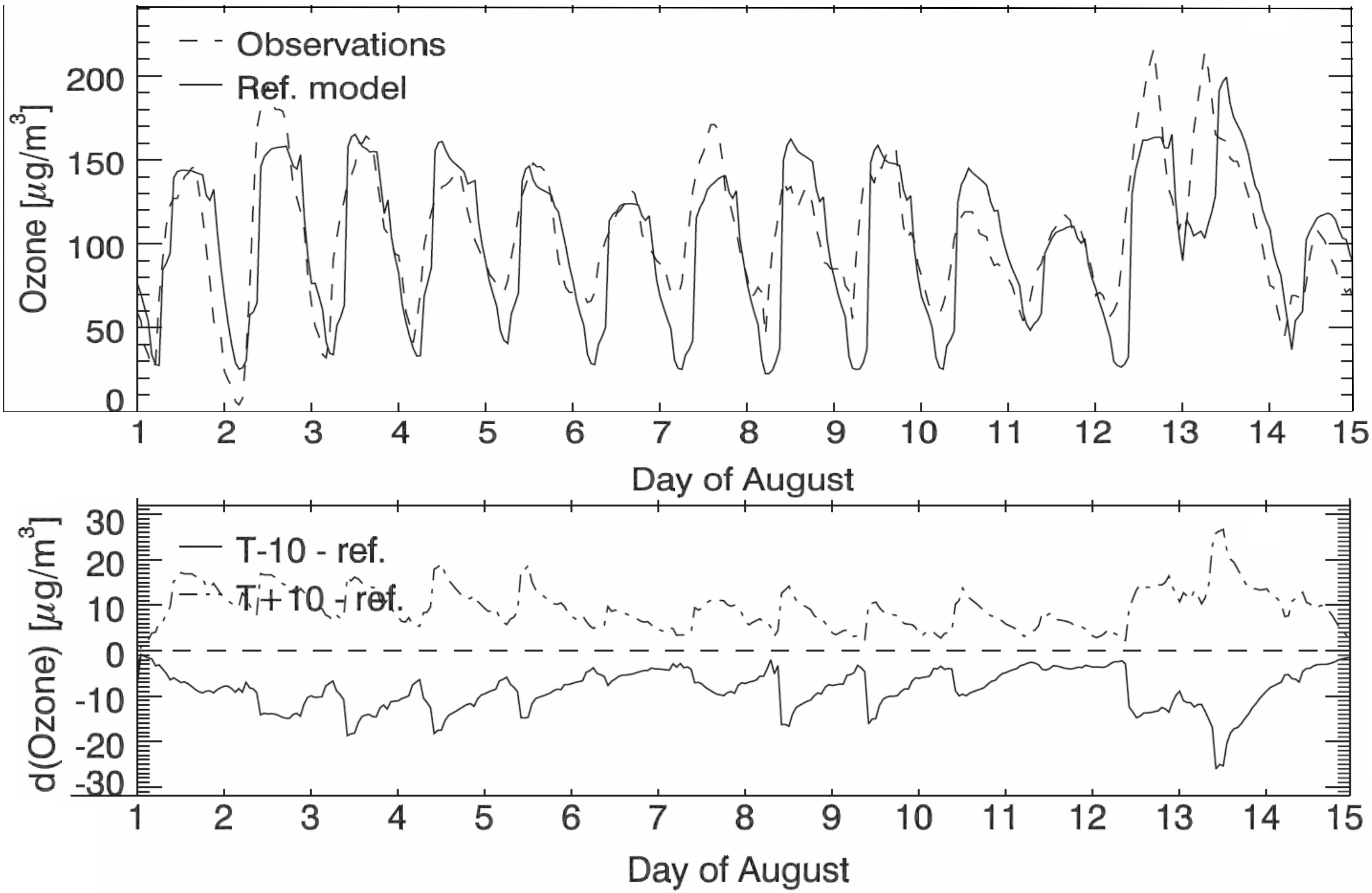
- Augmentation de température favorise la production d’ozone
- Conditions sèches limitent la destruction d’ozone (faible effet) et la formation d’OH
- Impact du dépôt sec
- Augmentation de température favorise la production d’isoprène

Etude de sensibilité: simulation de base



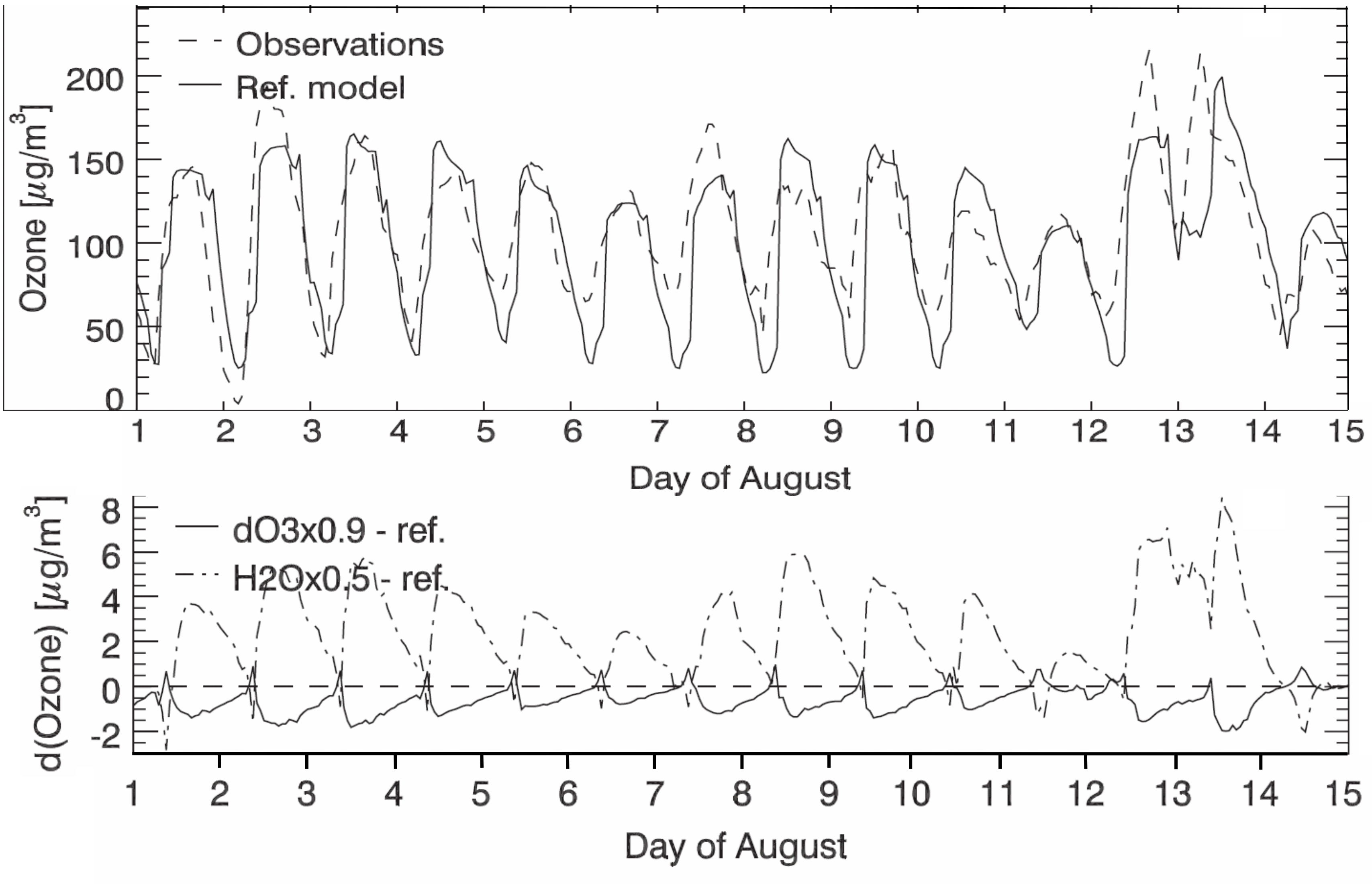
Simulation d'ozone de surface, Waldhof, Allemagne (Solberg et coll., JGR, 2008)

Changement dû à la temperature



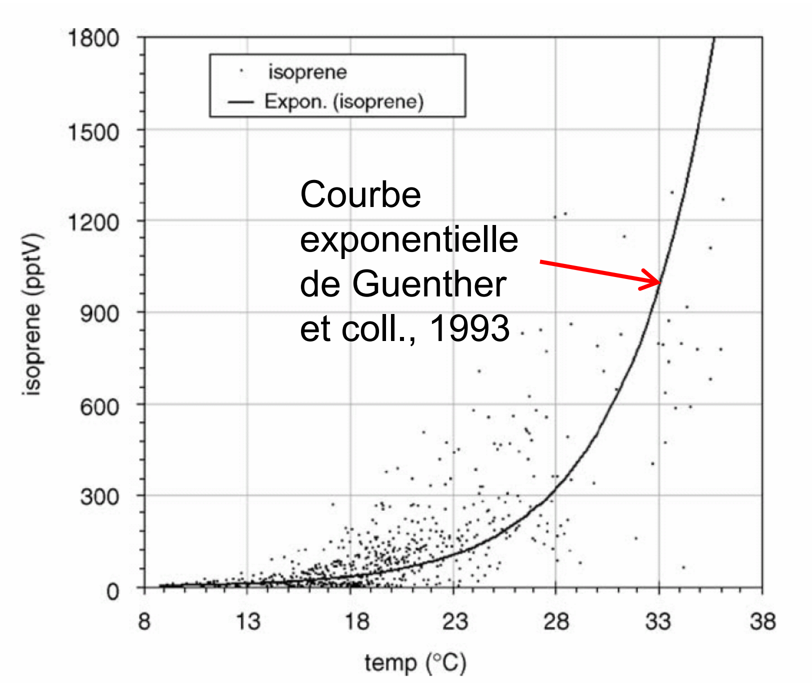
(Solberg et coll., JGR, 2008)

Changement dû à l'humidité

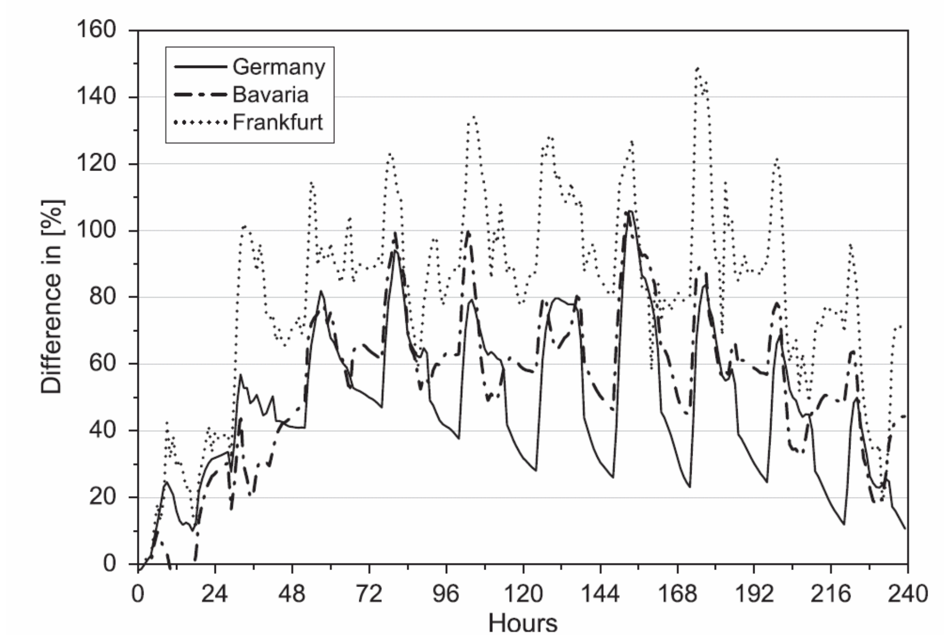


(Solberg et coll., JGR, 2008)

Emissions d'isoprène

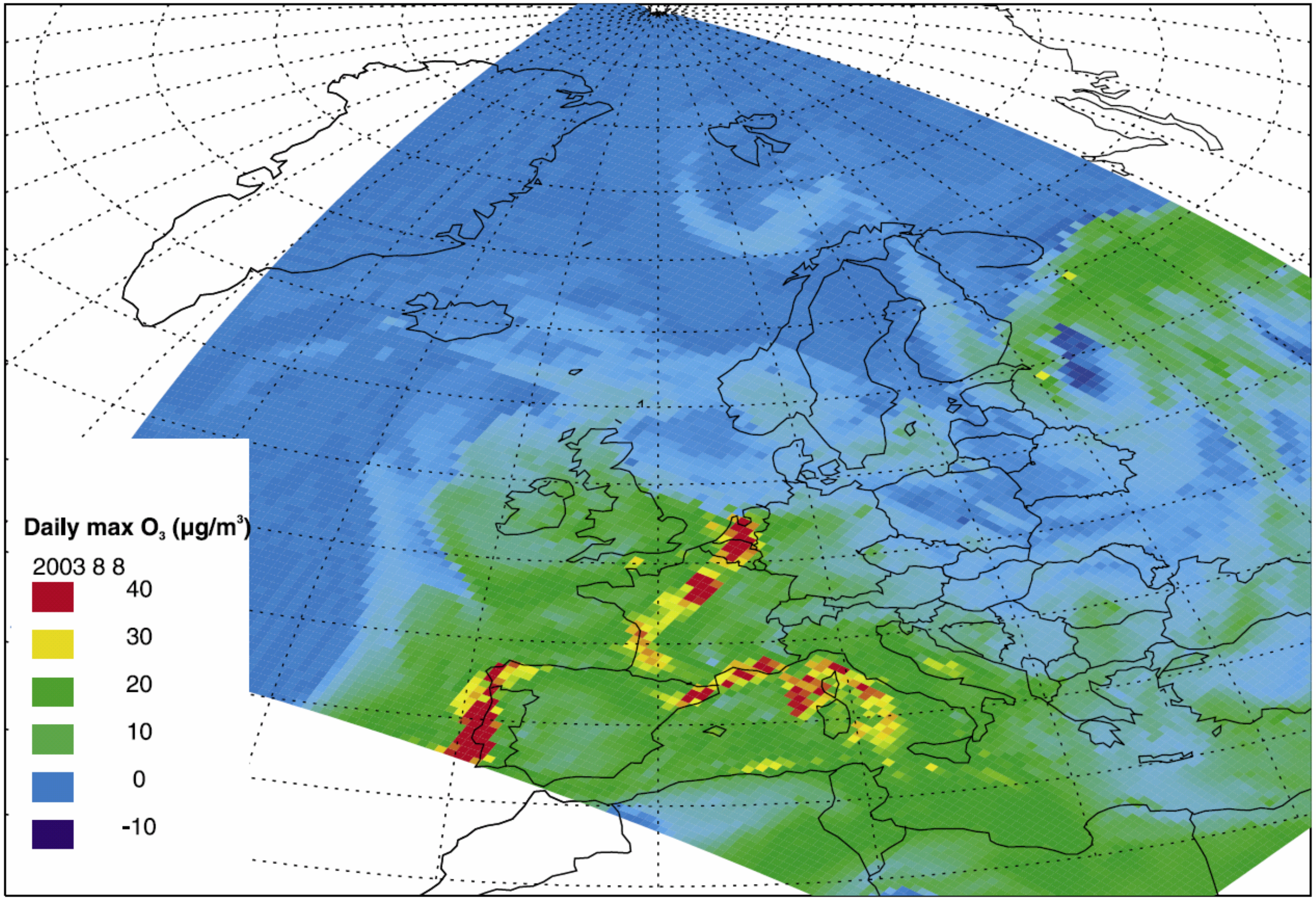


Concentration d'isoprène en UK, Août 2003. Lee et coll., Tellus, 2006.



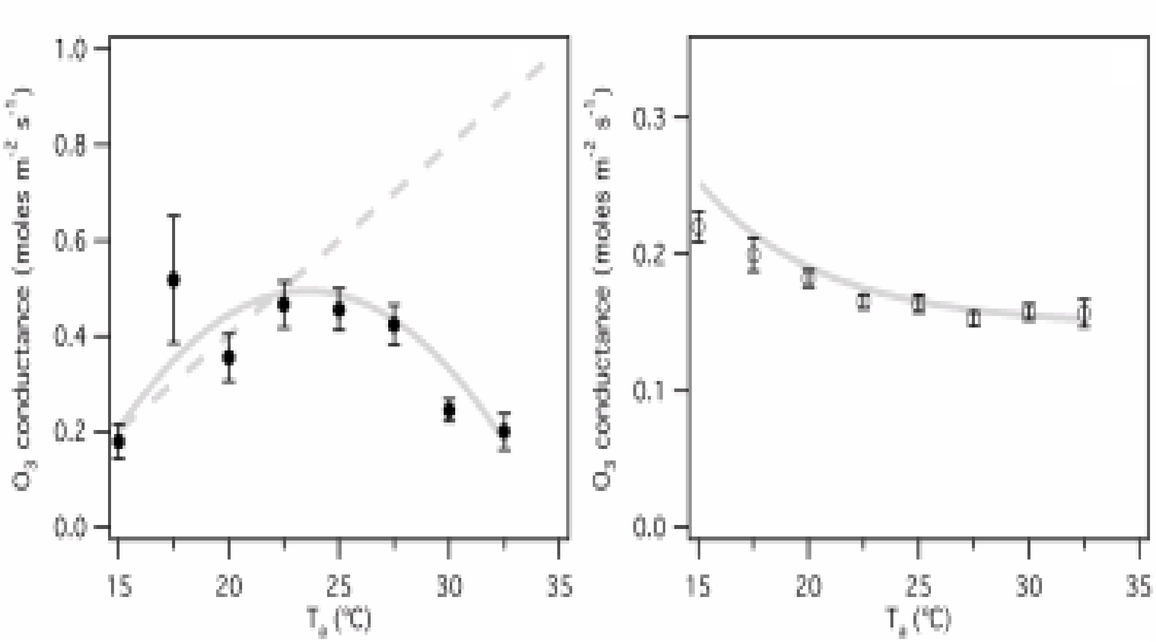
Difference (en %) des émissions d'isoprène 1-10 Août 2003 par rapport à la moyenne Août 1993-2003

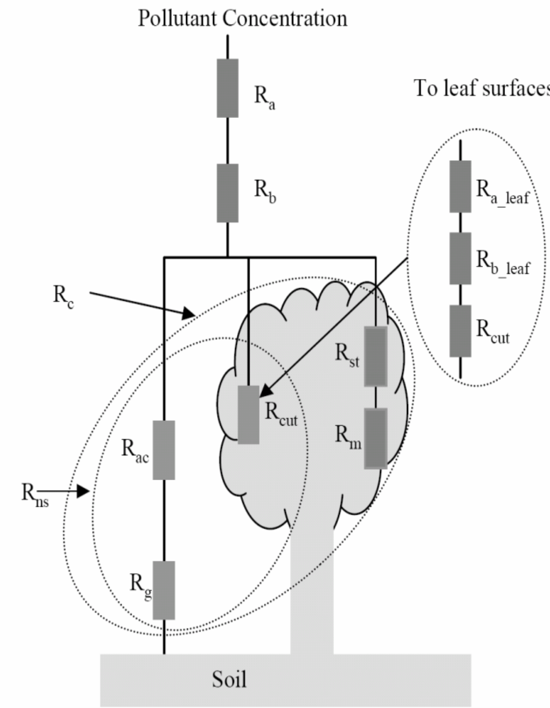
Changement dû aux émissions d'isoprène



(Solberg et coll., JGR, 2008)

Dépôt sec d'ozone



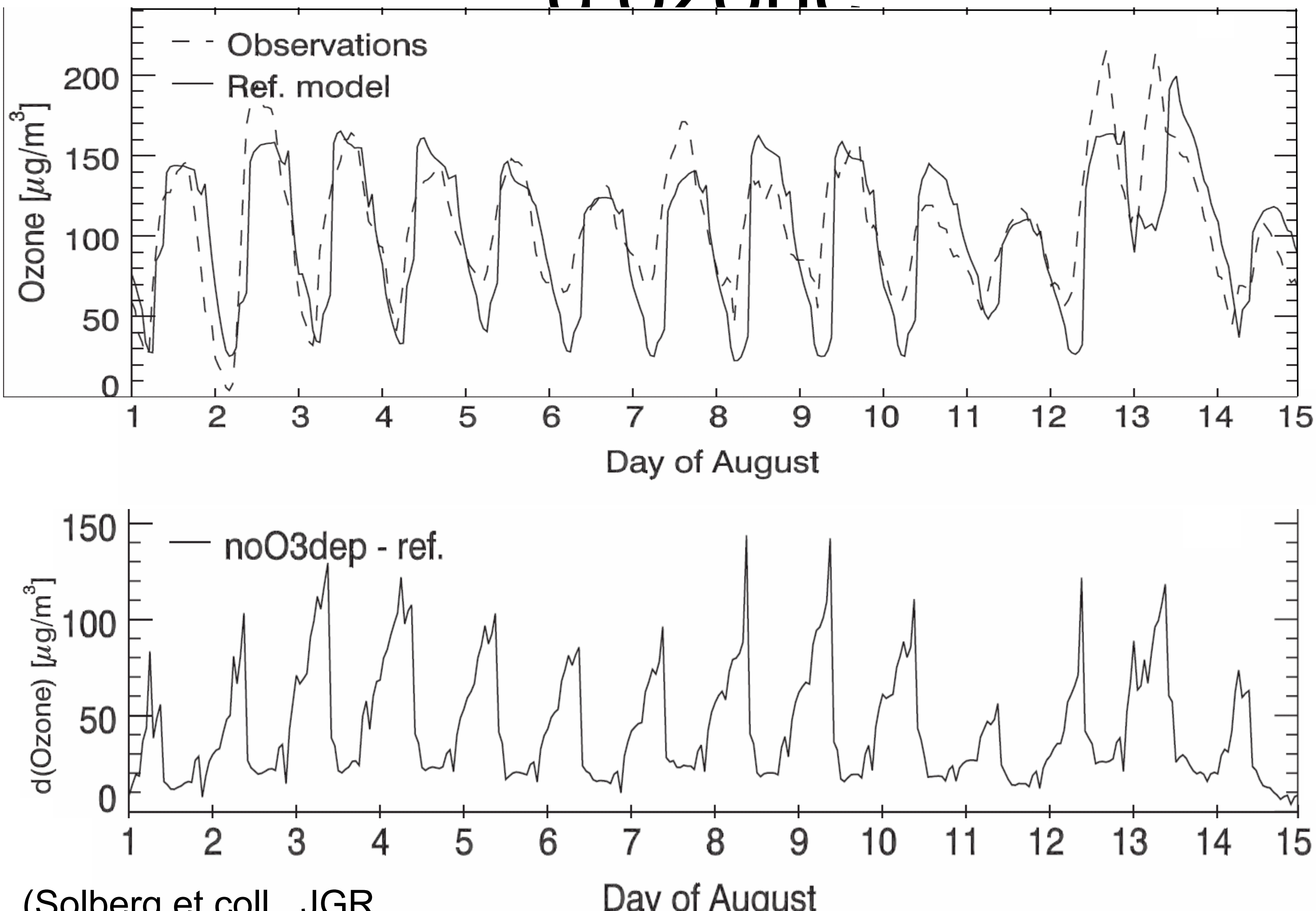


Diminution de la conductance non-stomatale (gauche) et saturation de la conductance stomatale (droite) avec l'augmentation de la température

Hogg et coll., Tellus, 2007

Zhang et coll., ACP, 2007

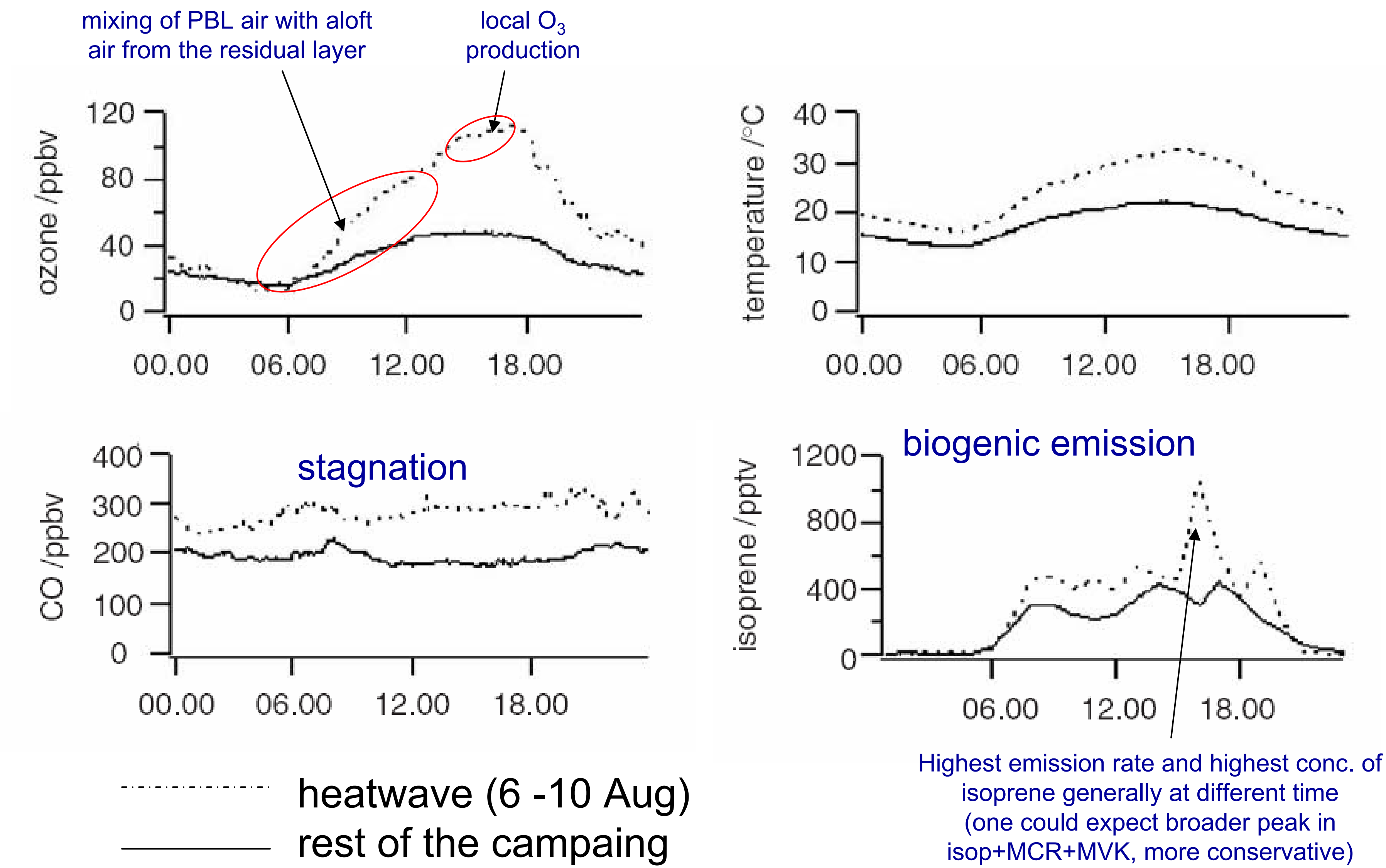
Changement dû au dépôt sec d'ozone



(Solberg et coll., JGR, 2008)

TORCH campaign in the UK [Lee et al., Atm. Env., 2006]

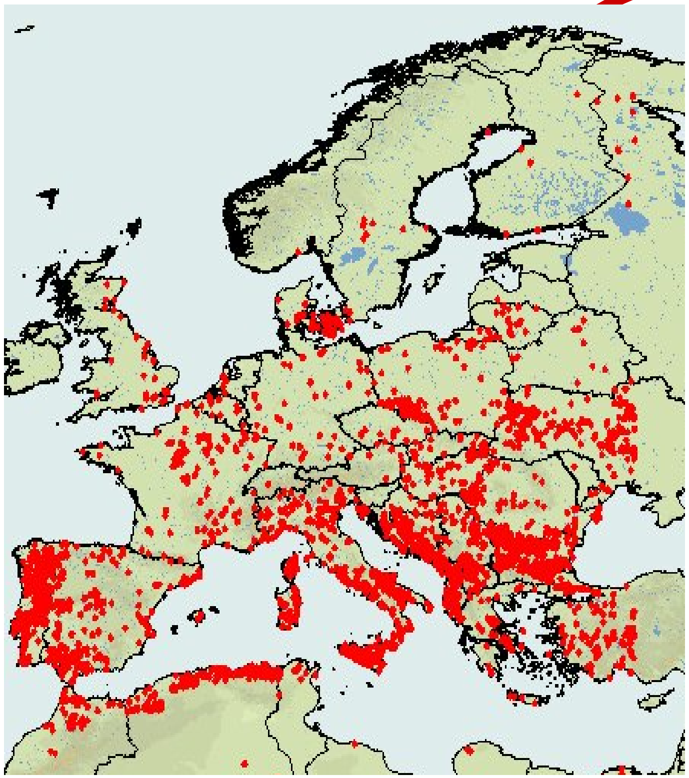
Daily cycles during TORCH



Emissions response to extreme weather conditions

Increased wildfire activity in Southern Europe (drought, T)

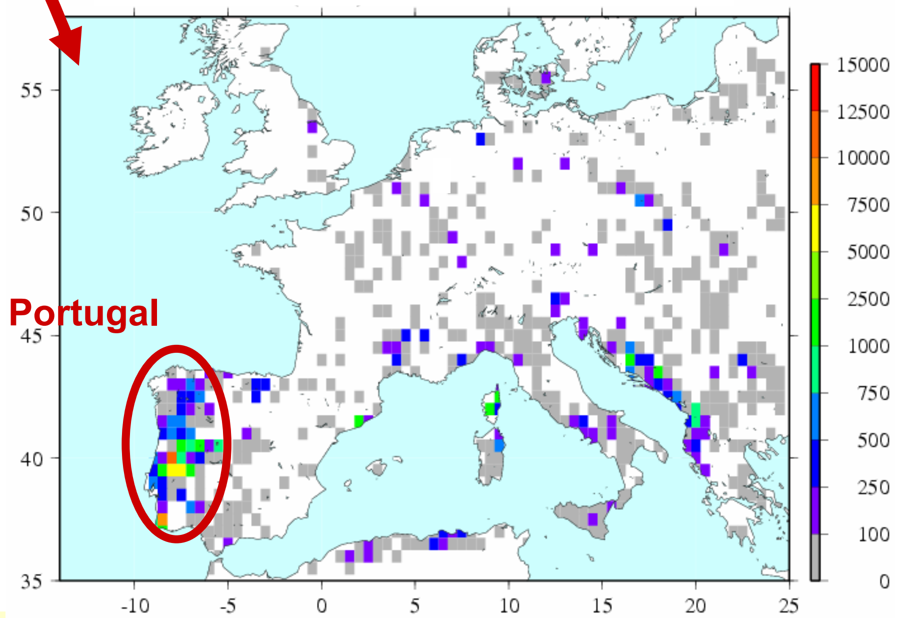
1-15 August 2003



MODIS fire counts

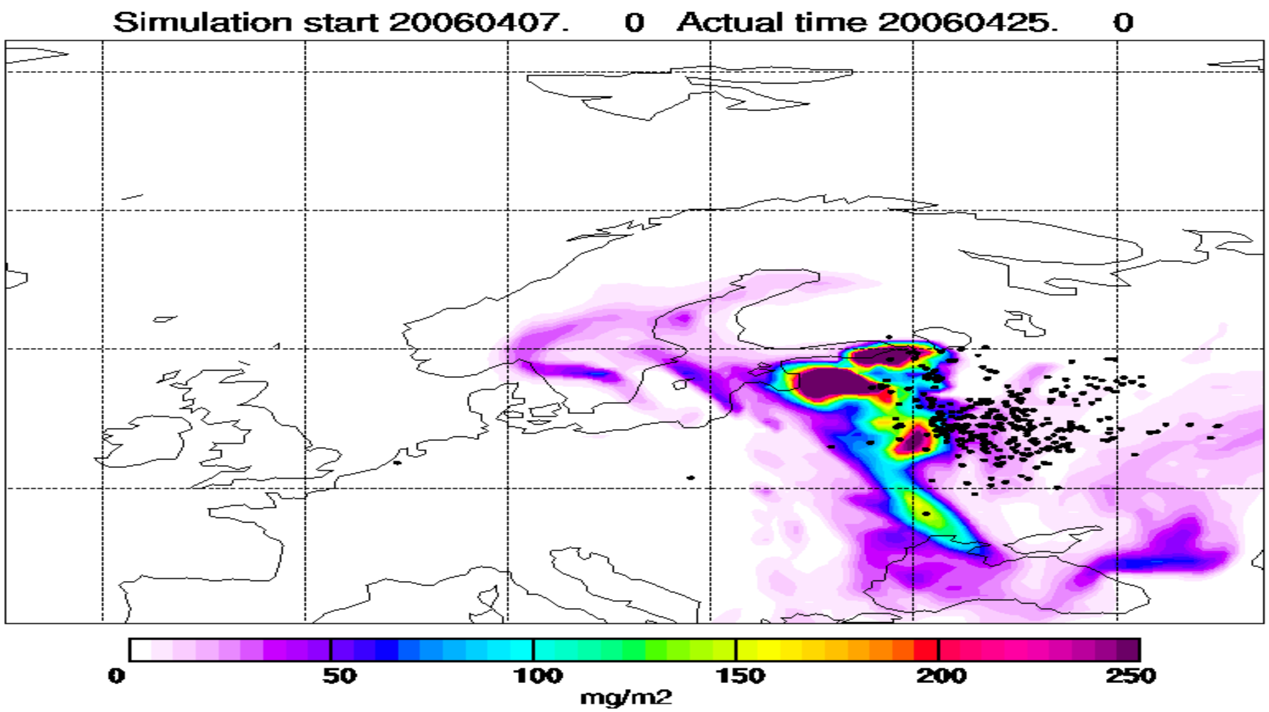
Fire emission cadastre for Europe / summer 2003
following Wiedinmyer et al. 2006

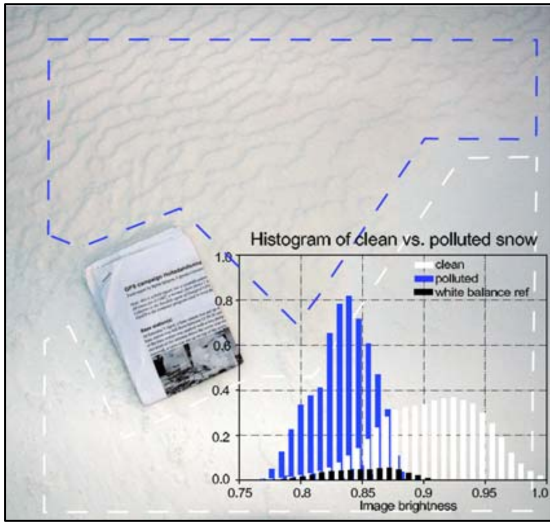
1-15 August 2003, $PM_{2.5}$ (Tons)

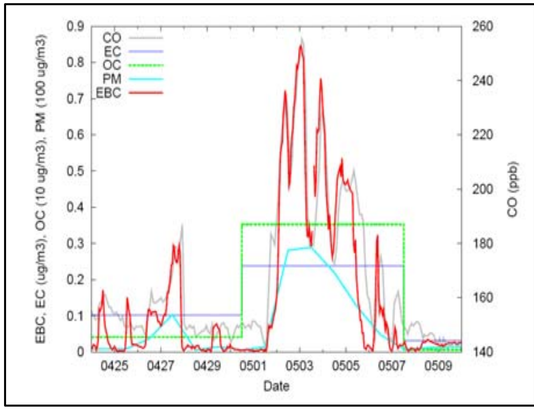


- $PM_{2.5}$ wildfire emissions = 130 kTons
- 84% of anthro. emissions in W.Europe

Arctic Haze & Boreal Forest Fires: Impacts on Arctic/global climate





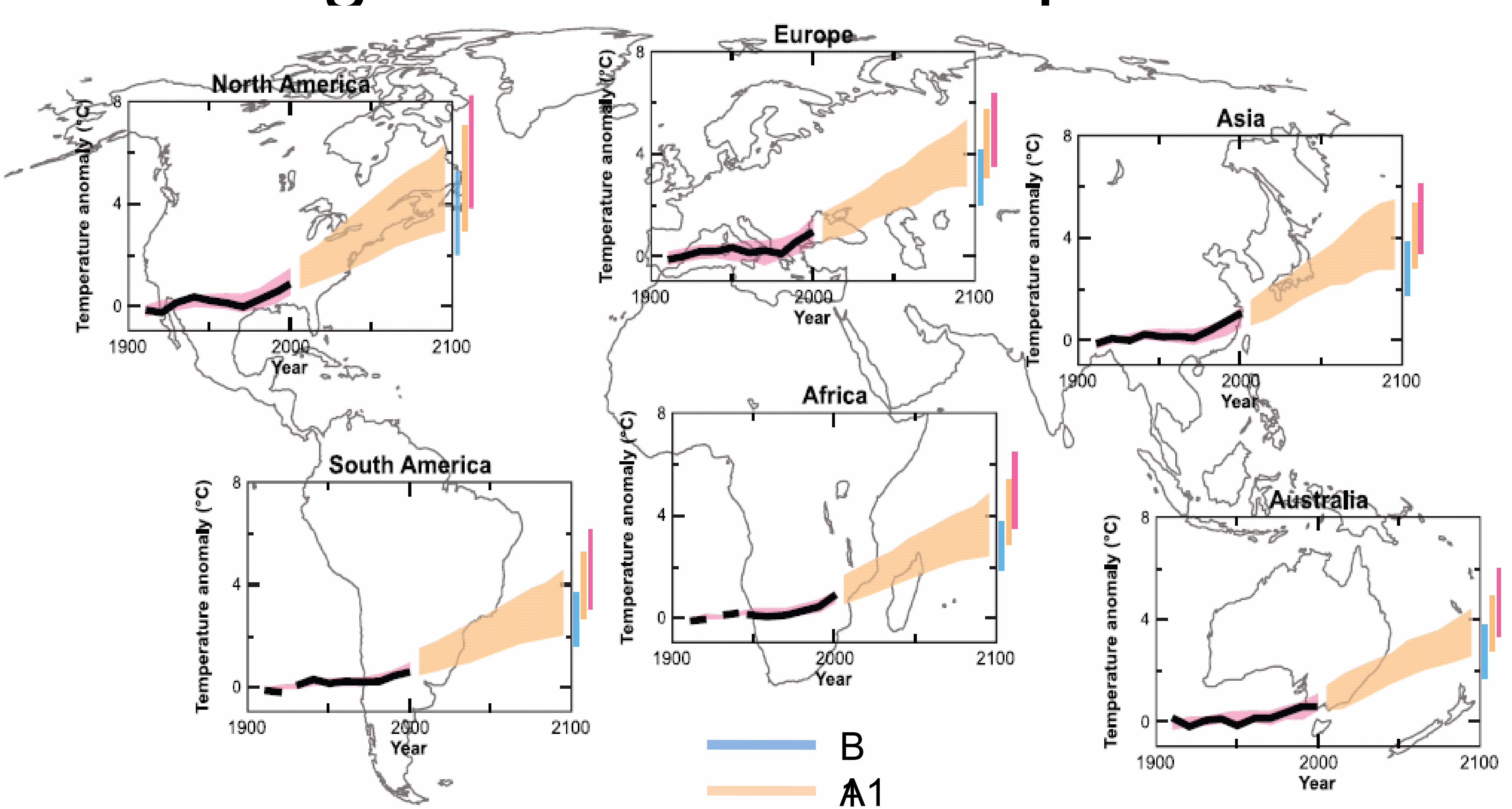


Example: eastern European agricultural fires transported pollutants (O3, aerosols) to Spitzbergen

- observed deposition of soot on snow

Refs: Stohl et al. 2007, ACPD; **Law & Stohl, Science, 2007**

Distribution régionale des projections d’augmentation de température

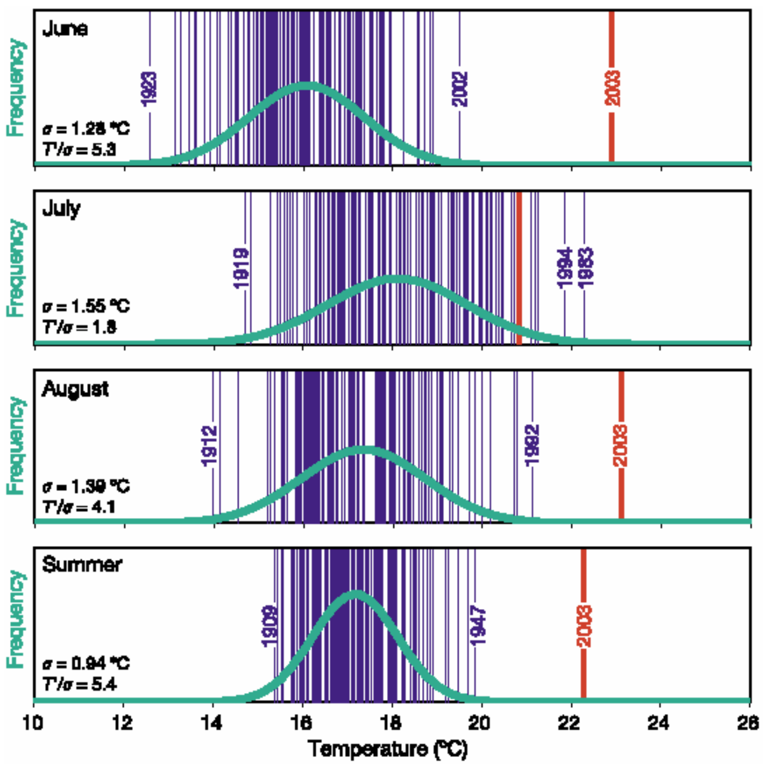


B1
A1B
A2

Chapitre 11, Box 11.1;
Christensen and Hewitson

Can we expect future episodes like that of 2003?

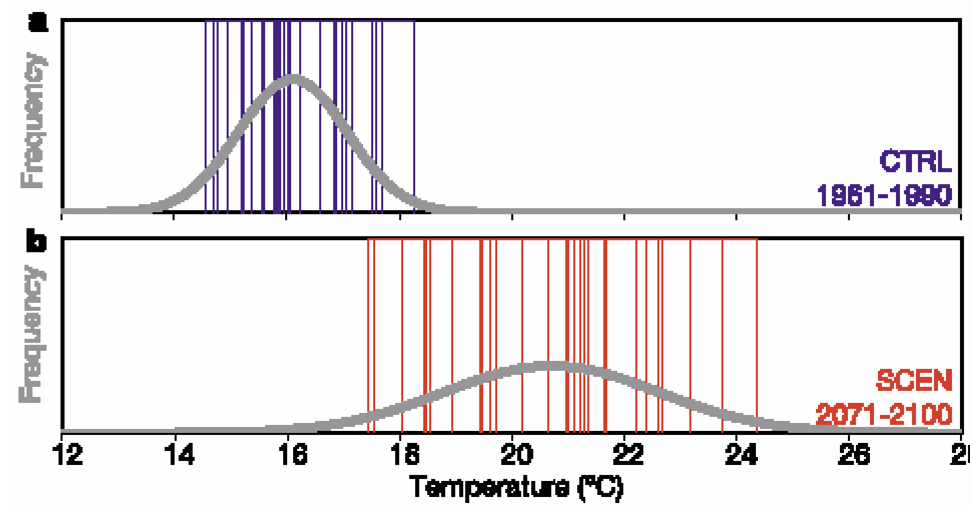
From the climatological point of view: YES



Return period (wrt. 1990- 2002): $\tau > 10^4$ yr

[Schär et al., Nature, 2004]

RCM simulations for Northern CH



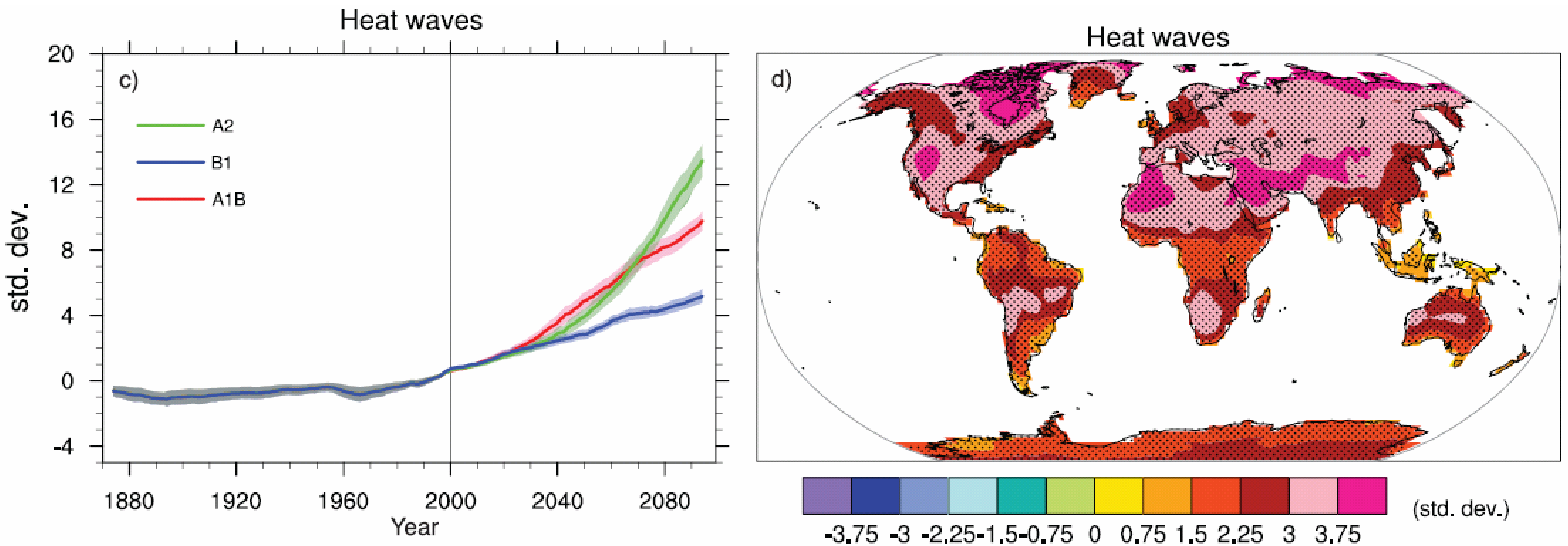
Future (under the SRES A2 transient greenhouse gas scenario specified by IPCC, 2000):

- 4.6 °C warmer
- σ increases by 102%.

(remember [Katz & Brown, Clim. Change, 1992])

Every second summer as dry and warm as 2003!!

Augmentation des vagues de chaleur (IPCC-AR5)



Moyenne multi-modèles de l'indice de vague de chaleur; chaque résultat est centre par rapport à la moyenne 1980-1999 et normalisé par sa déviation standard pour 1960-2099

Chapitre 10, Figure 10.19; Meehl and Stocker

Conclusions

- Les hautes concentrations d’ozone en 2003 sont dûes a une combinaison de facteurs météorologiques, biologiques et chimiques
- Il y a claire indication d’une augmentation probable des vagues de chaleur dans les 100 prochaines années
- L’impact du climat est du même ordre de grandeur que celui dû aux émissions anthropiques
- Le lien entre le changement du climat et la végétation est encore très peu compris, mais reste un des éléments les plus importants dans ce couplage