



North-Atlantic SST amplified recent European land temperature extremes and trends.

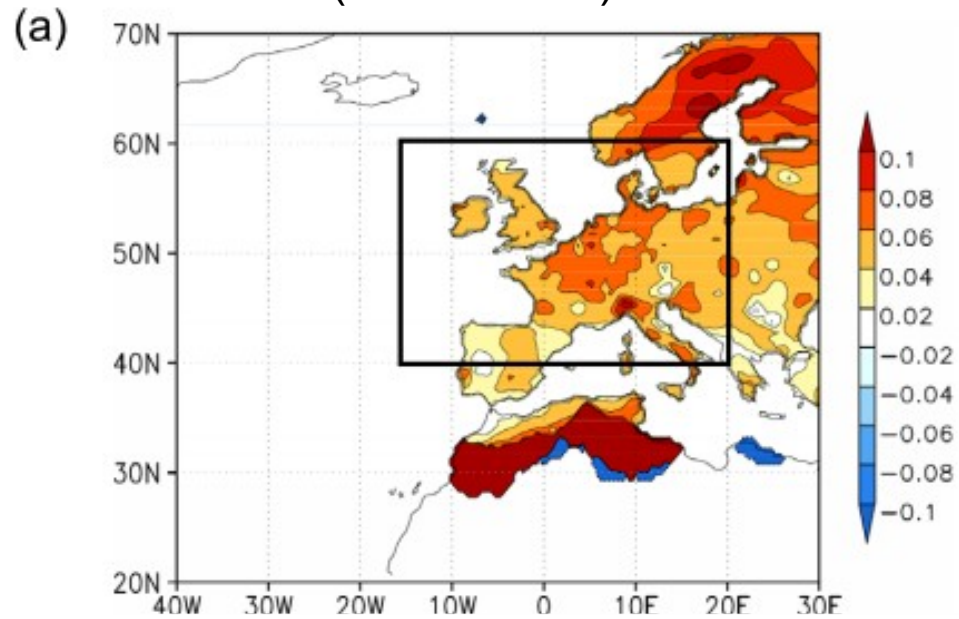
Julien Cattiaux
Robert Vautard & Pascal Yiou.

LSCE – IPSL
CEA / CNRS / UVSQ
Gif sur Yvette FRANCE



Introduction: European recent warming

Tobs anomalies (wrt 1961-90): 1978-2007 trend



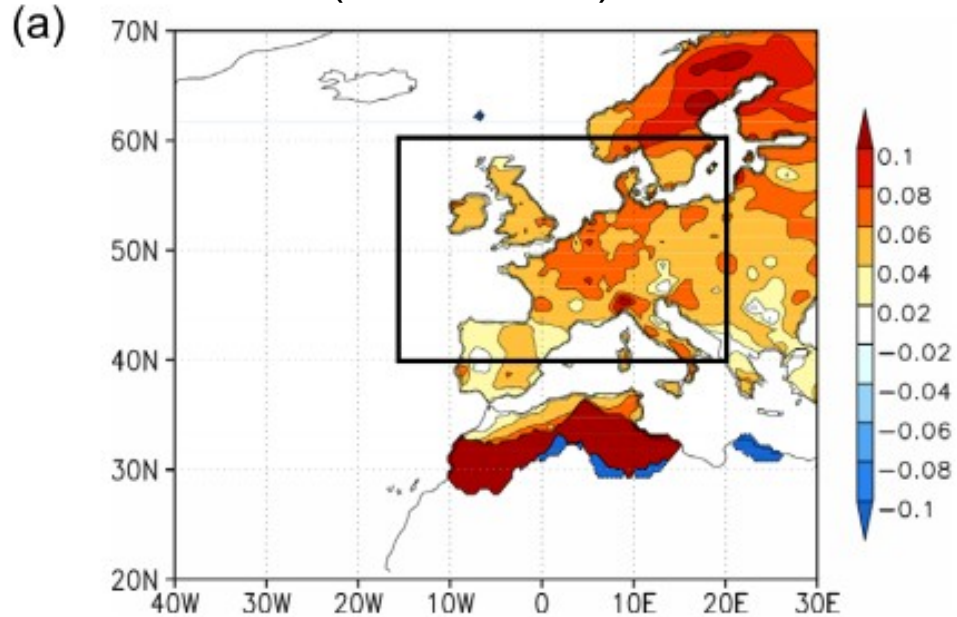
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Interpolated from ECA

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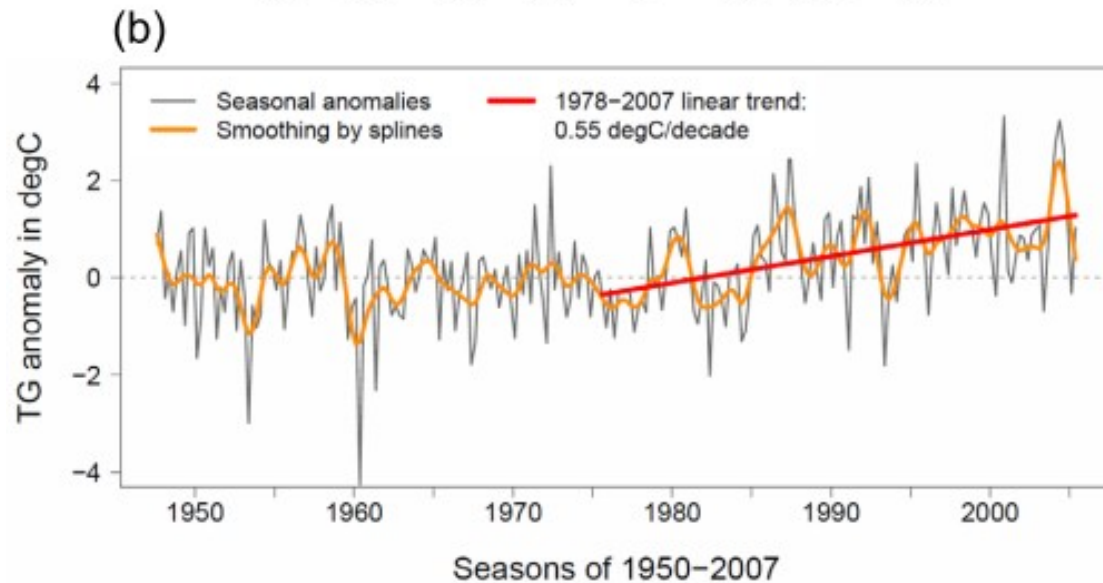
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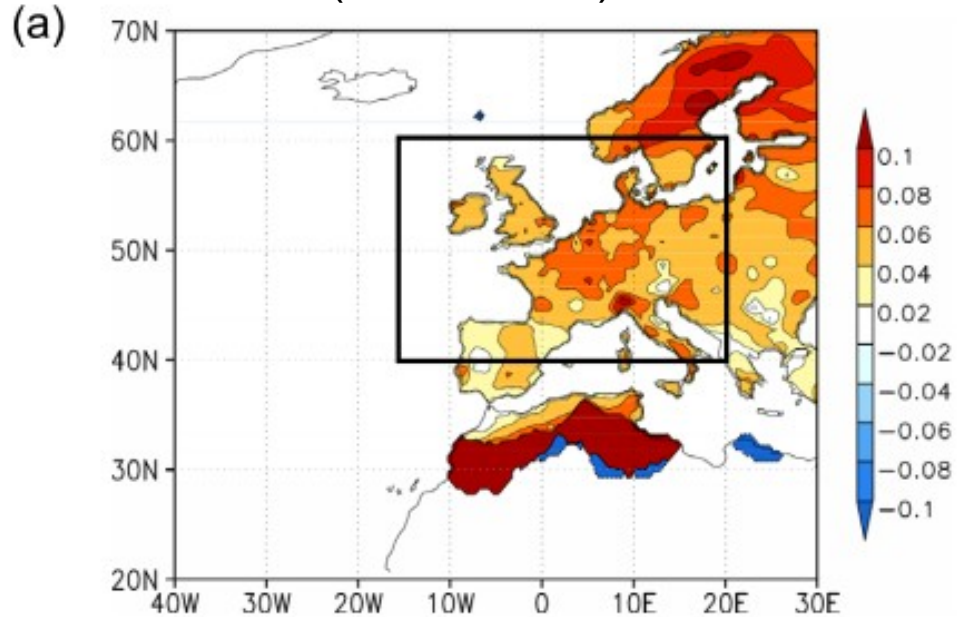
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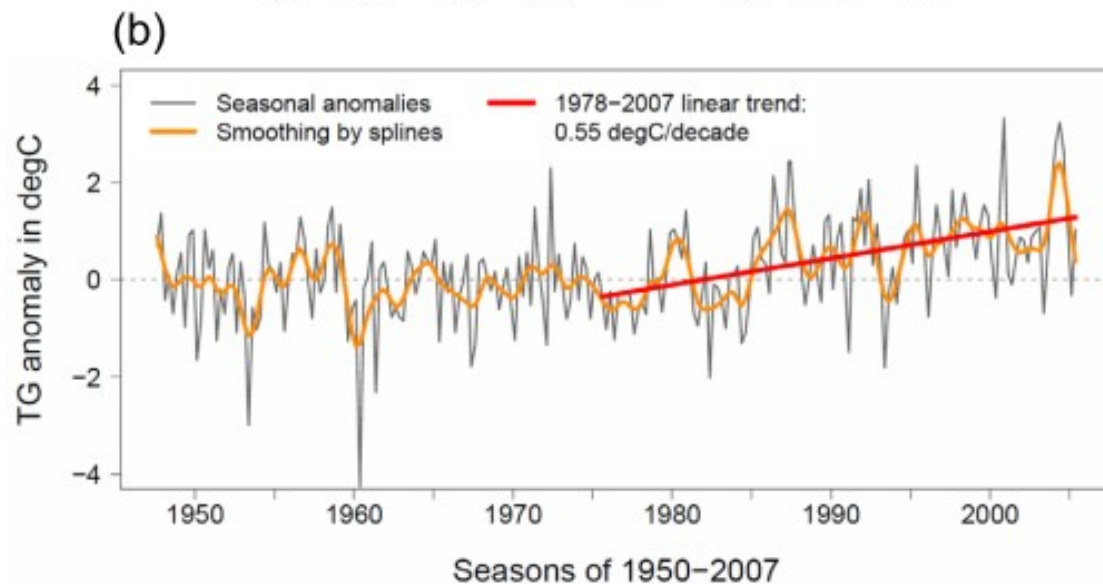
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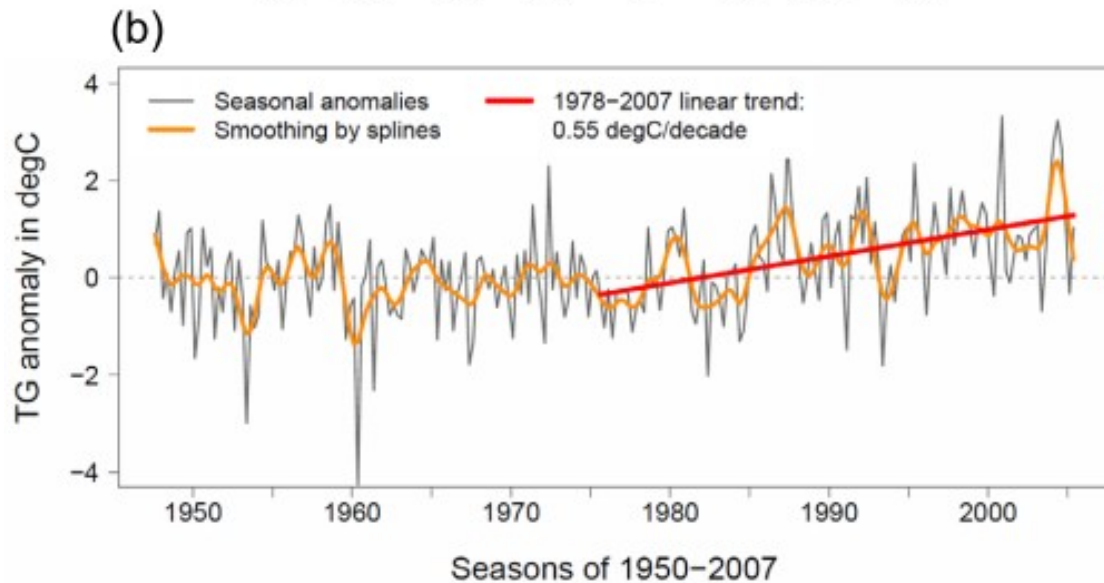
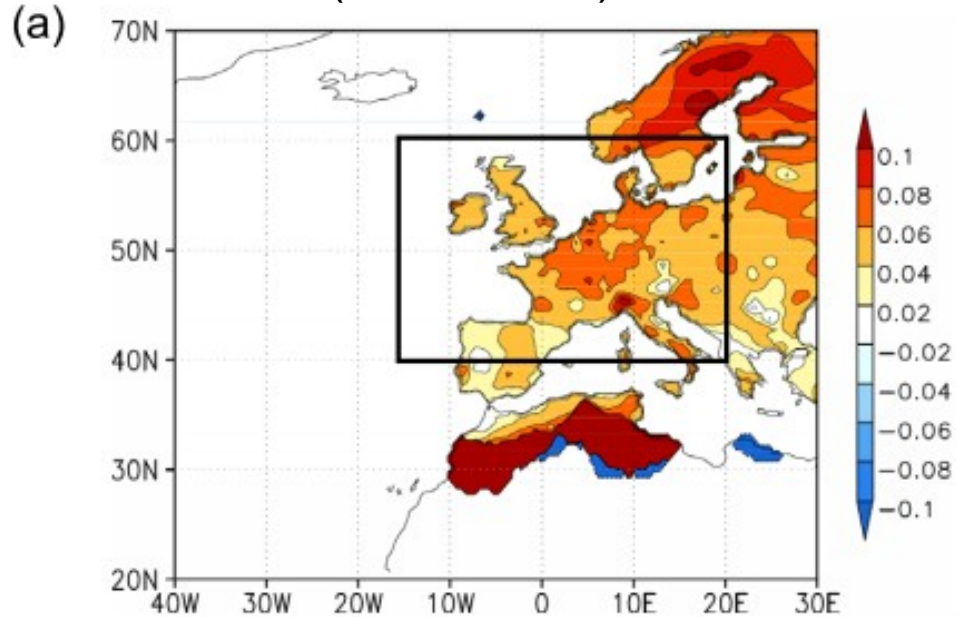
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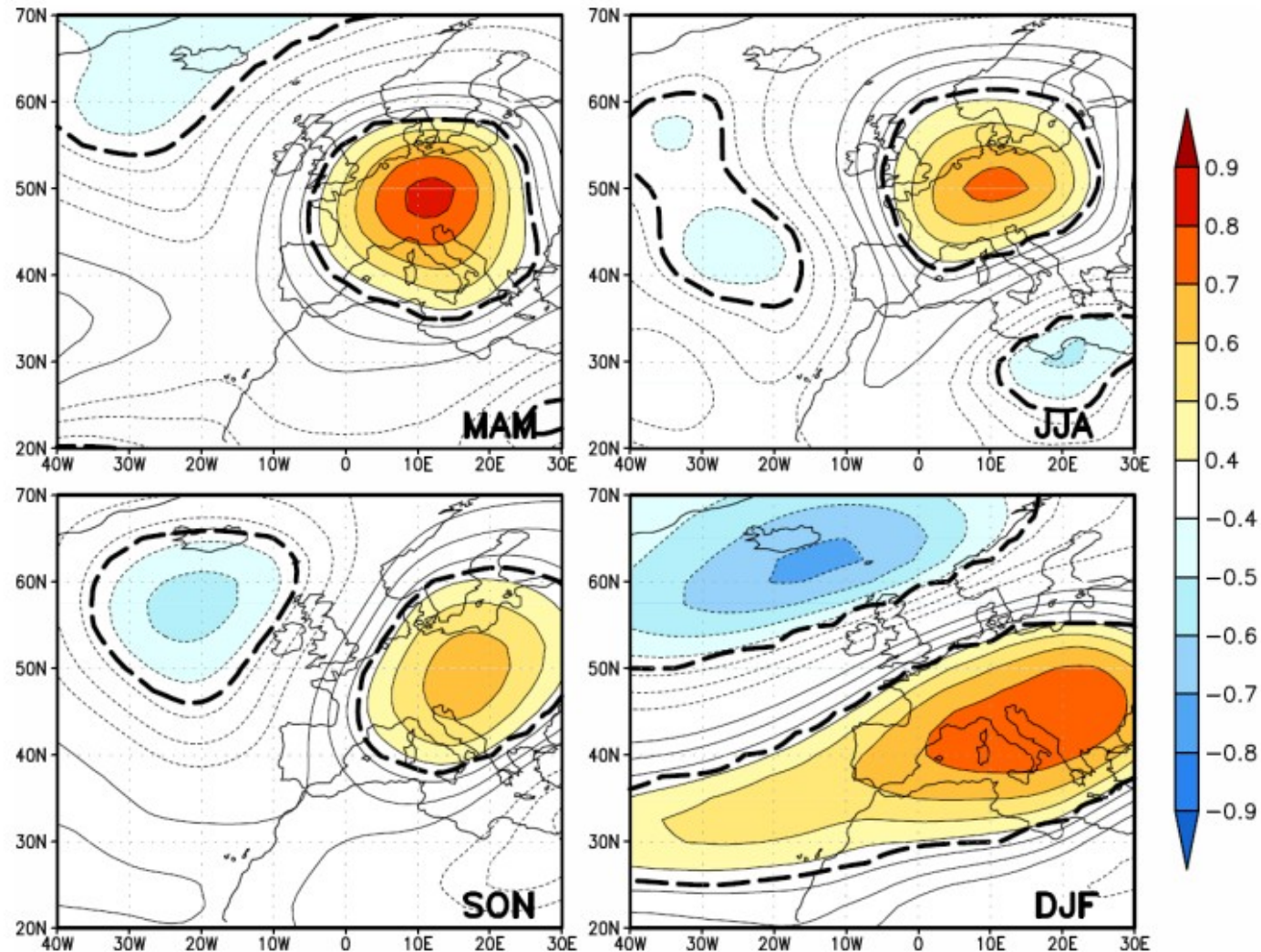
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Recent extreme seasons
(MAM 2007, JJA 2003, SON 2006, DJF 2006).

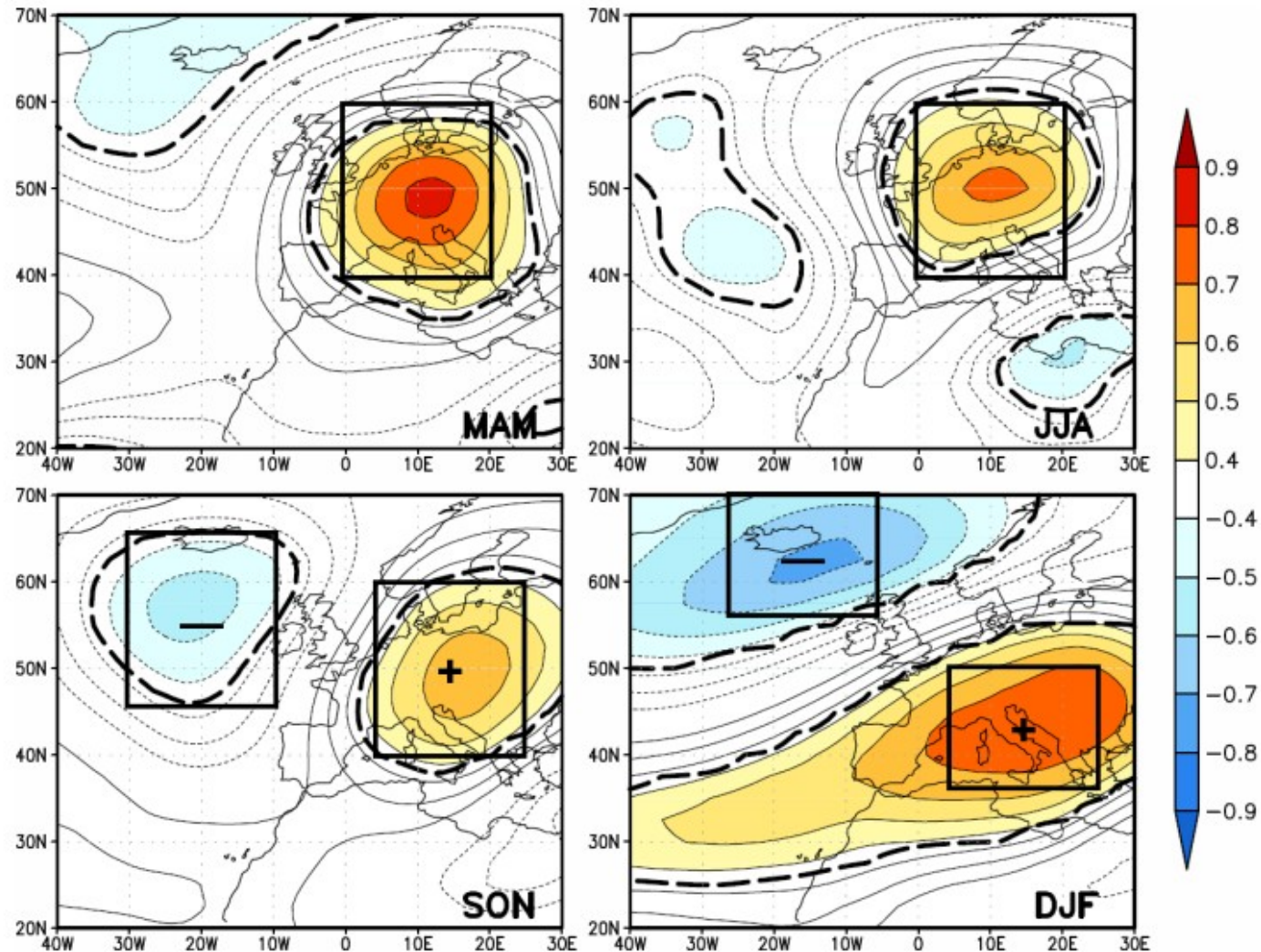
Atmospheric patterns associated with European temperatures

Spatial correlation of **Z500d** (NCEP) with Tobs time series



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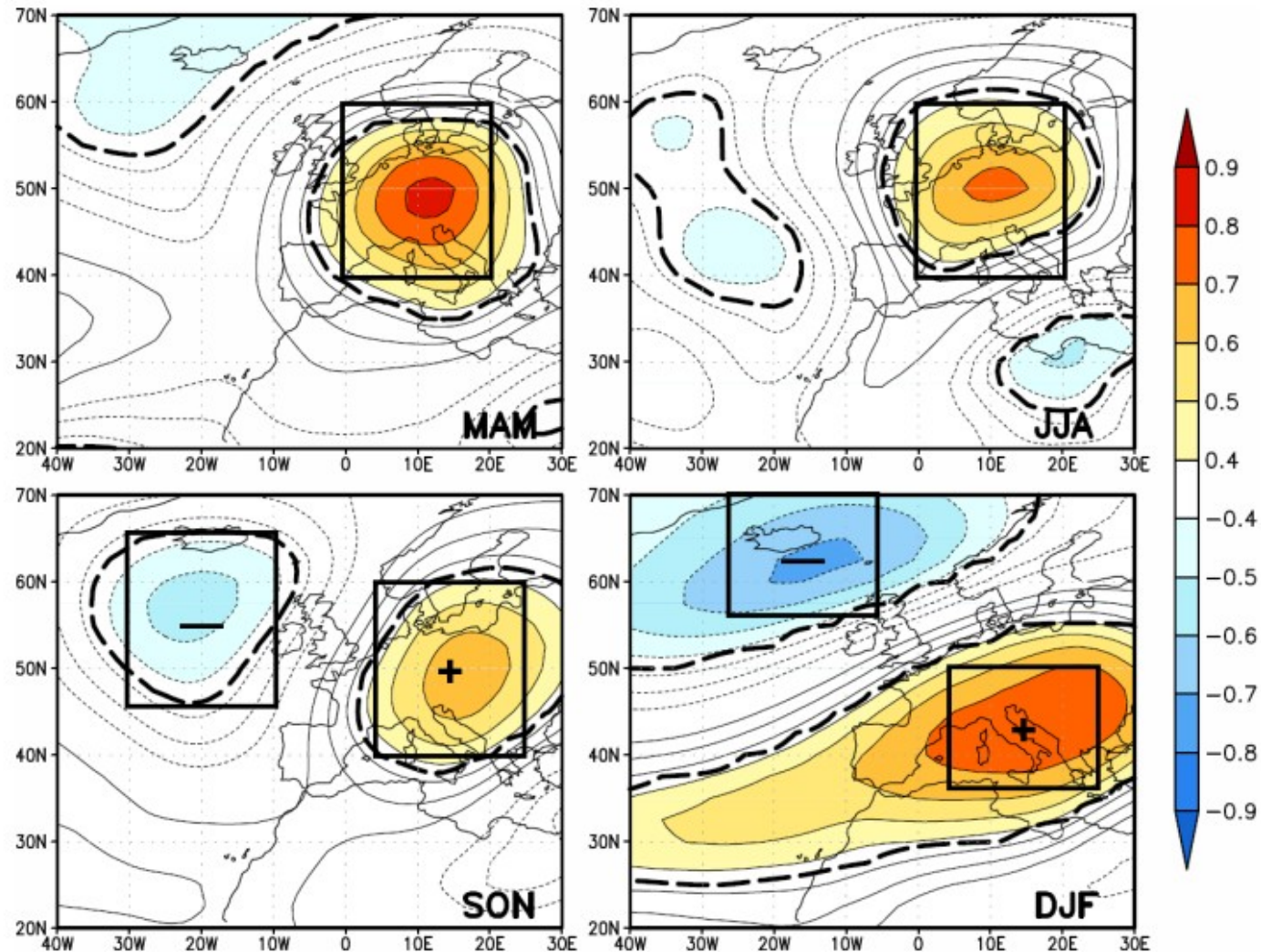
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Seasonal **D**ynamics **I**ndex (**SDI**): based on regional averages of **Z500d** anomalies.

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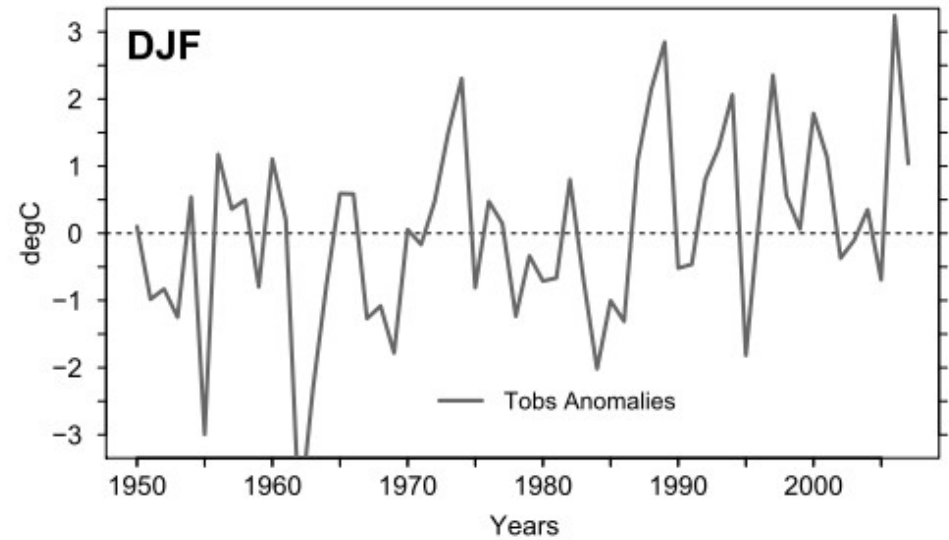
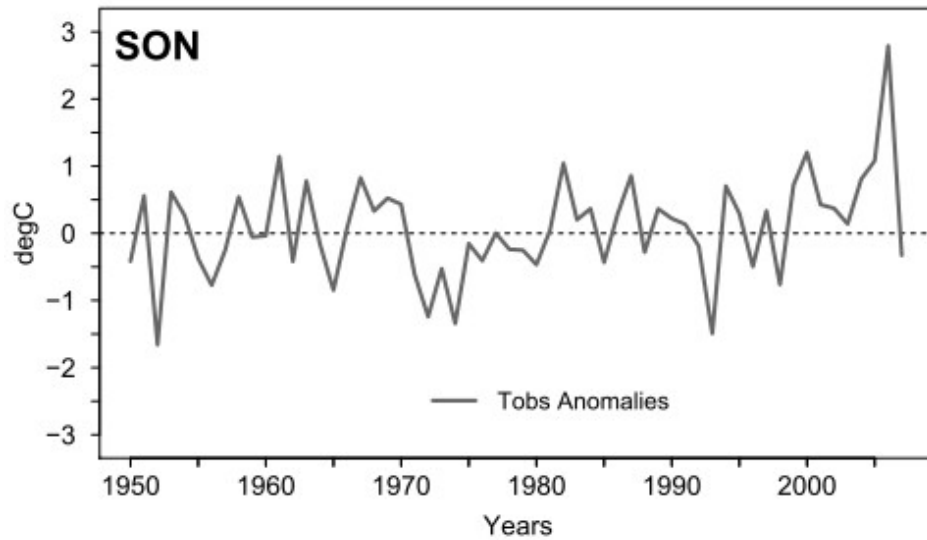
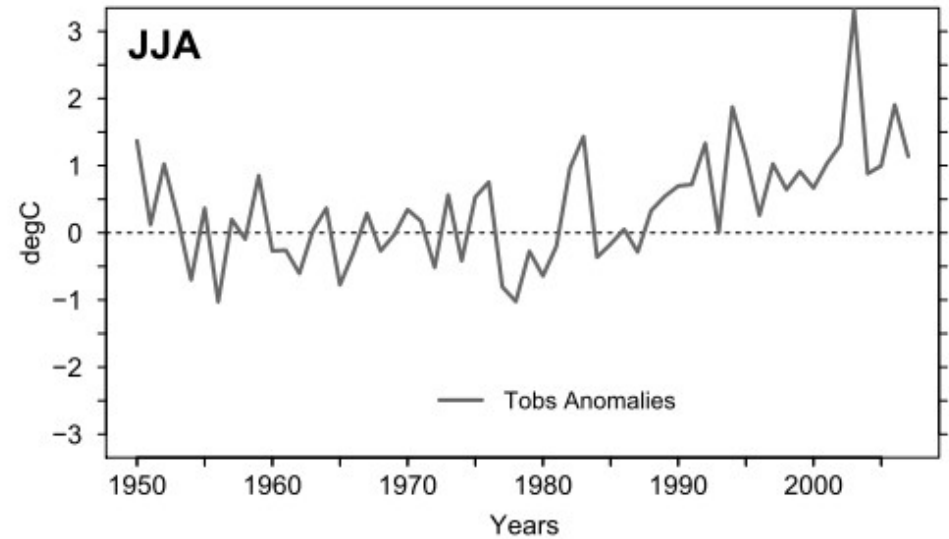
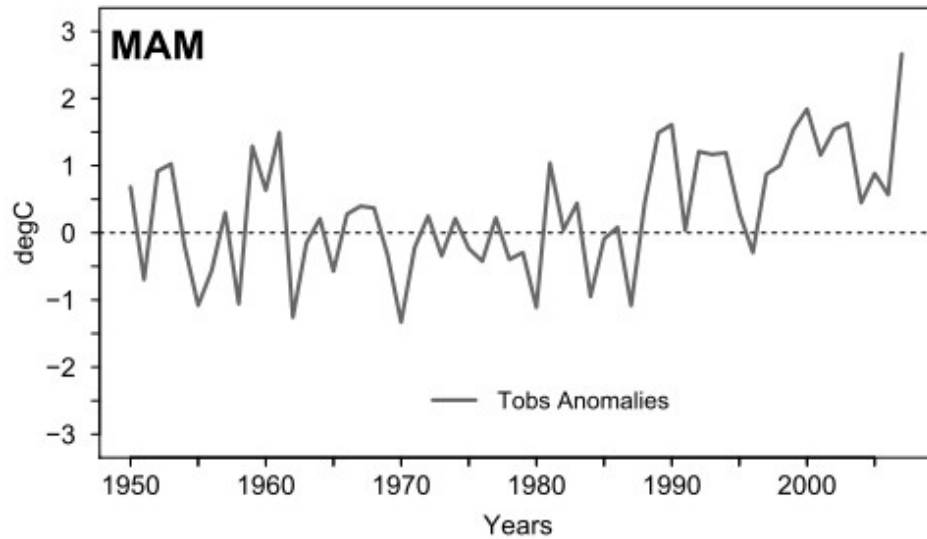
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Can European temperatures be described by this **Seasonal Dynamics Index (SDI)**?
Are European recent warming and extremes explained by **circulation changes**?

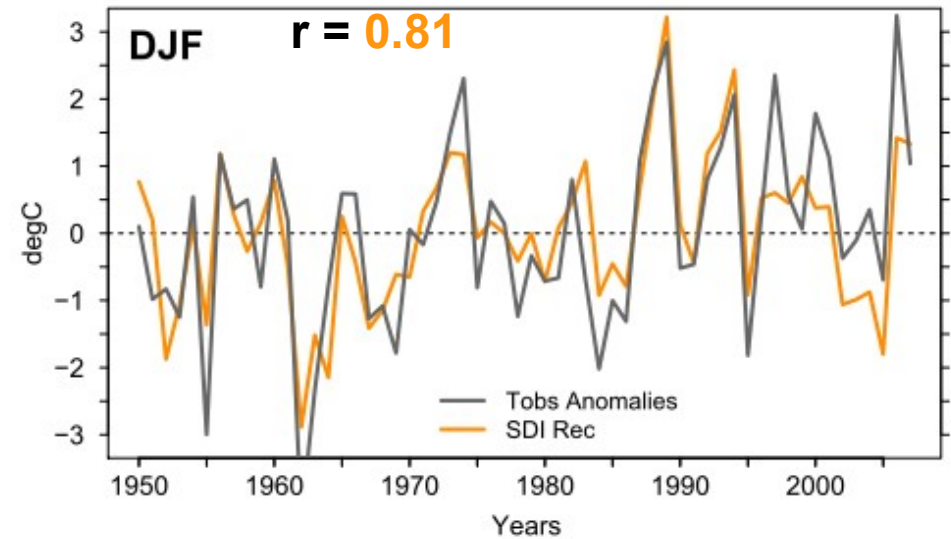
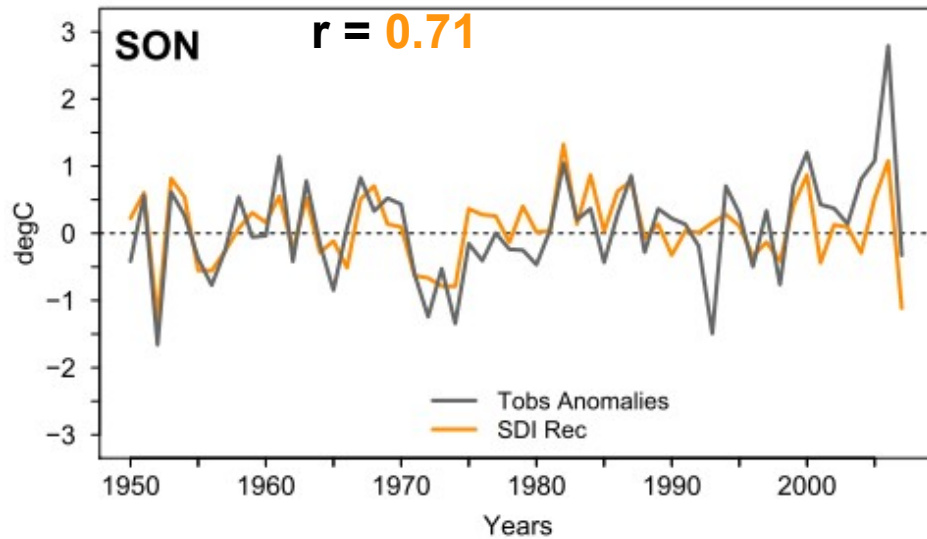
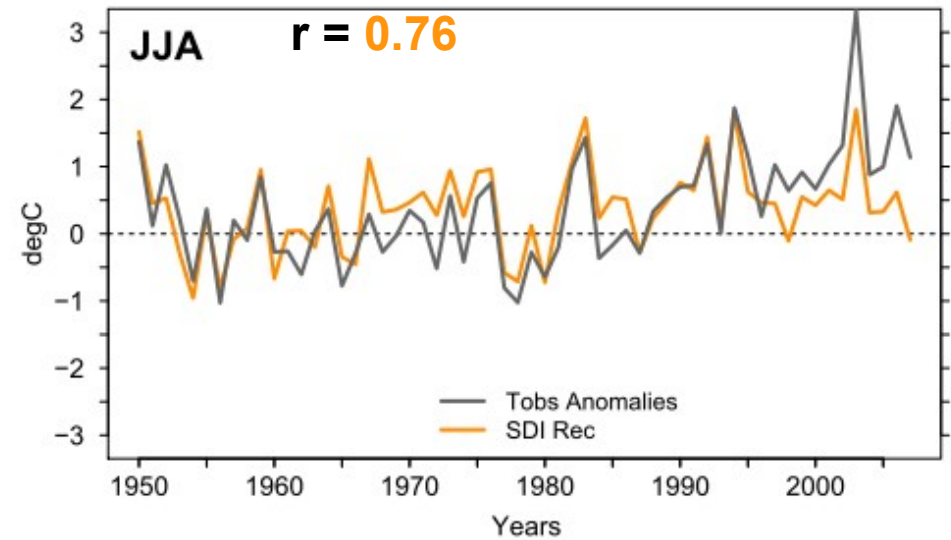
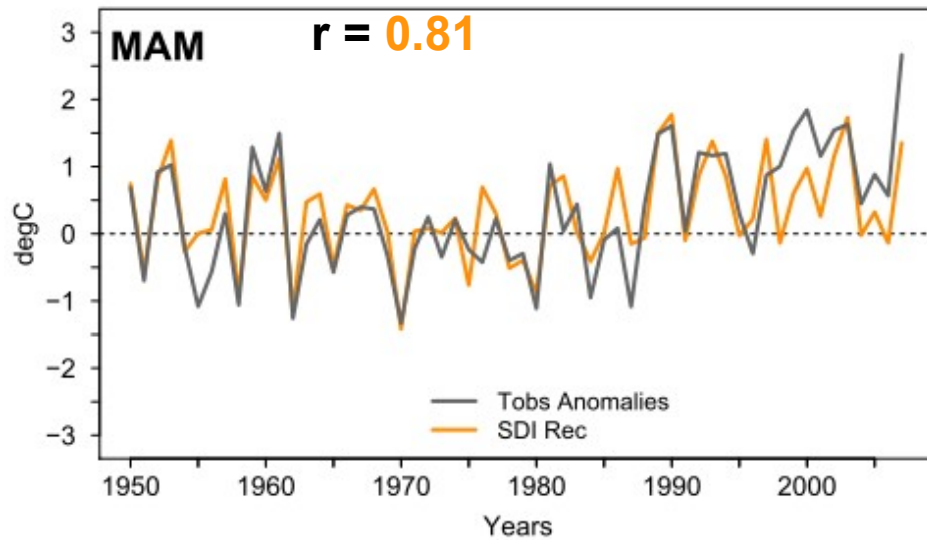
North-Atlantic dynamics and European temperatures

Fitting **SDI** on **Tobs** time series...



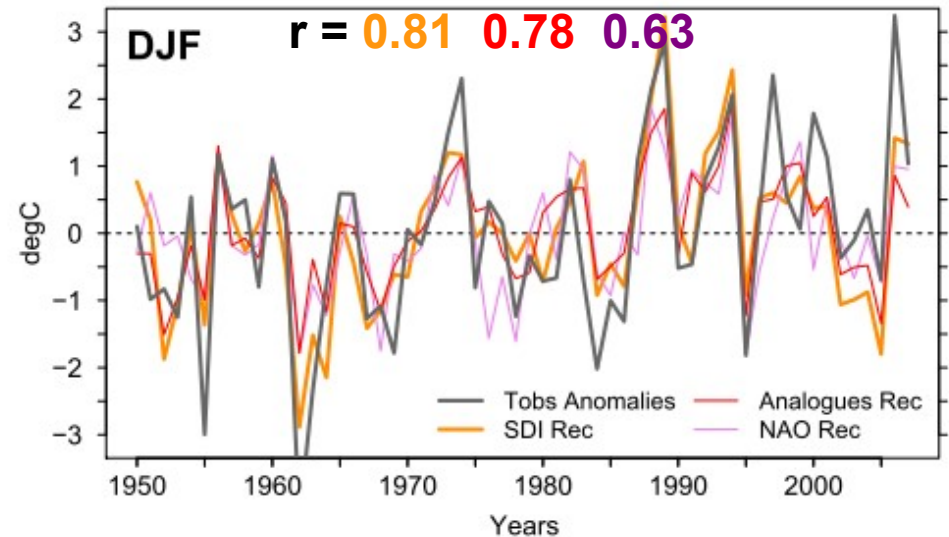
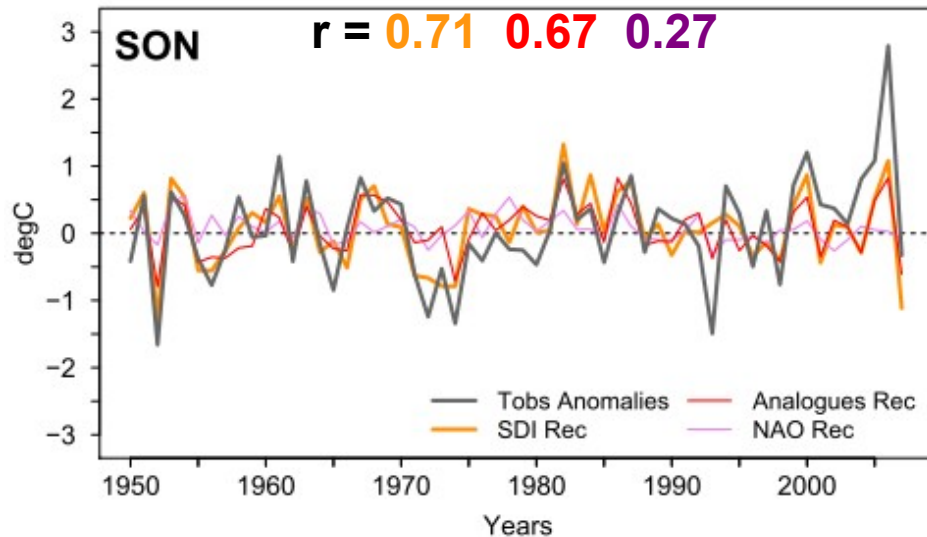
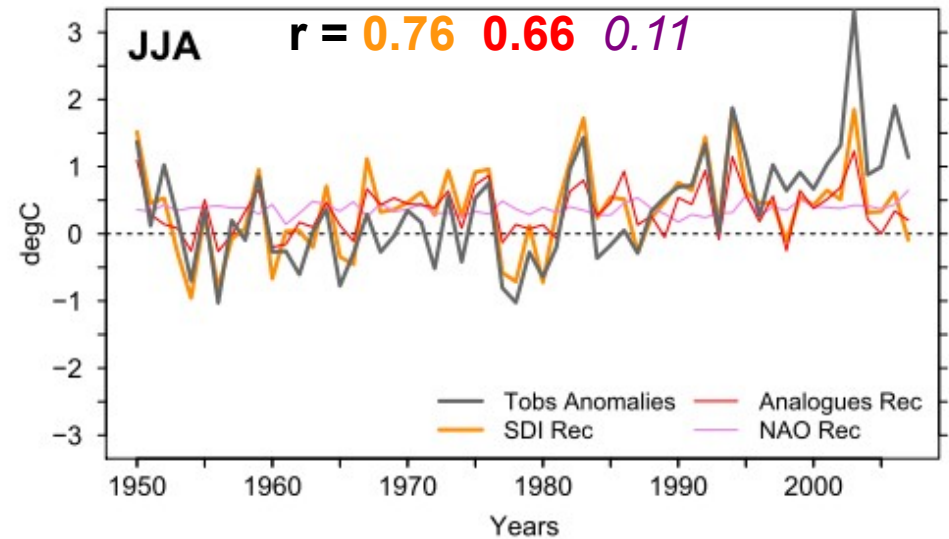
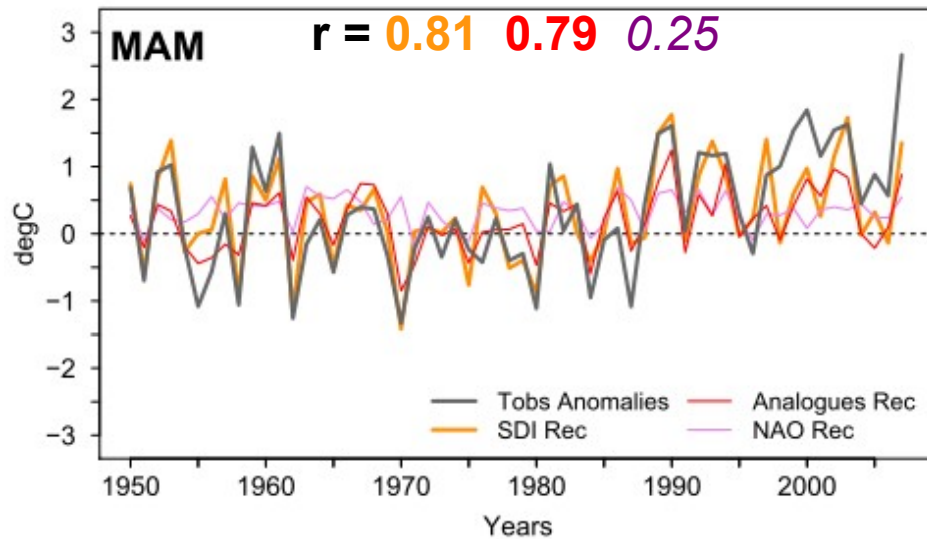
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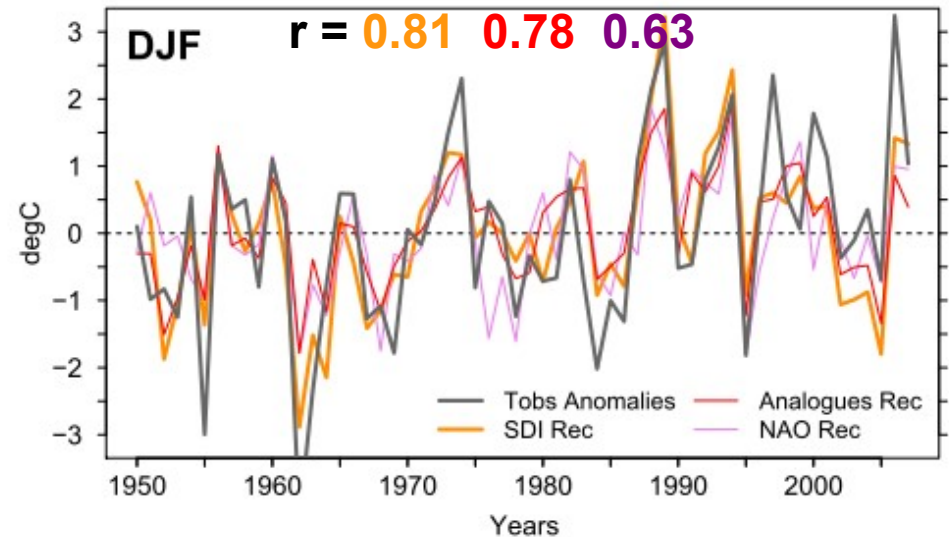
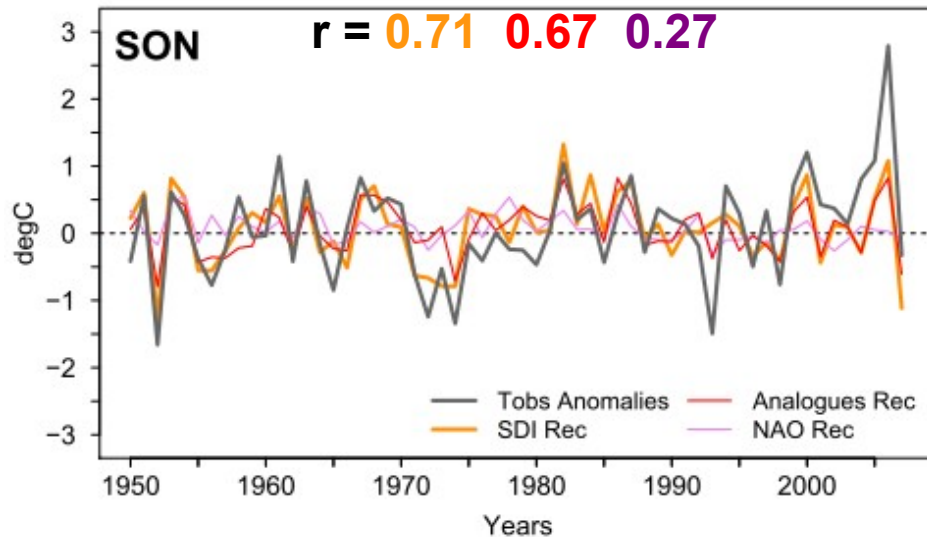
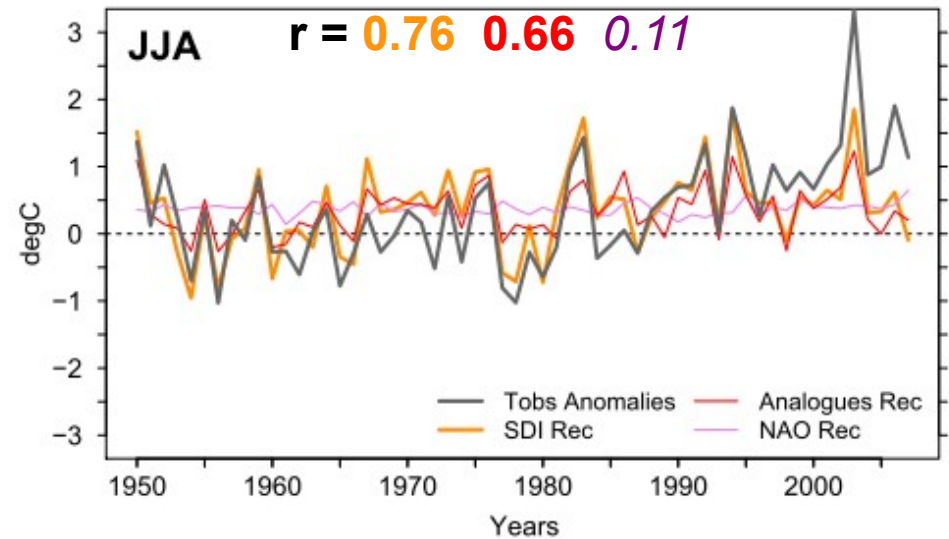
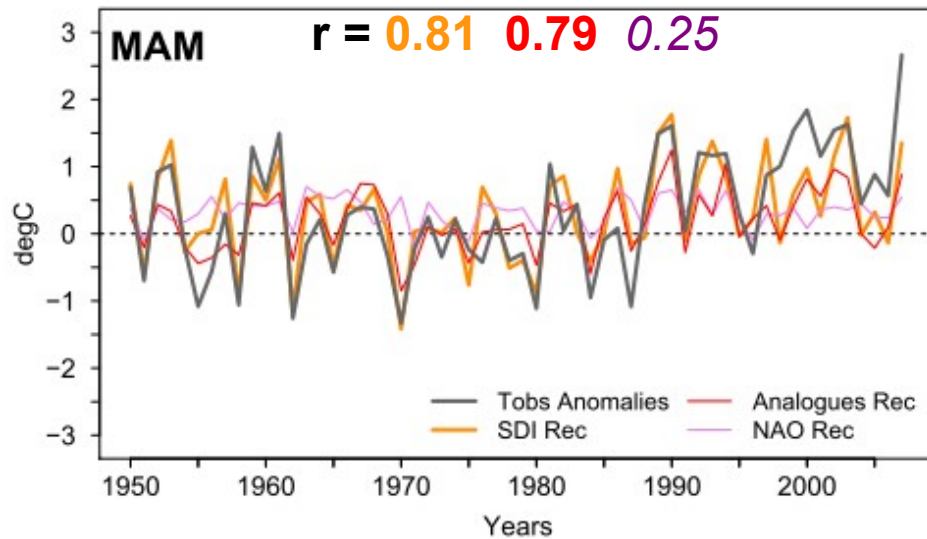
Fitting **SDI** on **Tobs** time series...



.. comparing to **analogues** [Vautard & Yiou, GRL 2009]
and **NAO** index [Jones, IJC 1997; Osborne, Weather 2006].

North-Atlantic dynamics and European temperatures

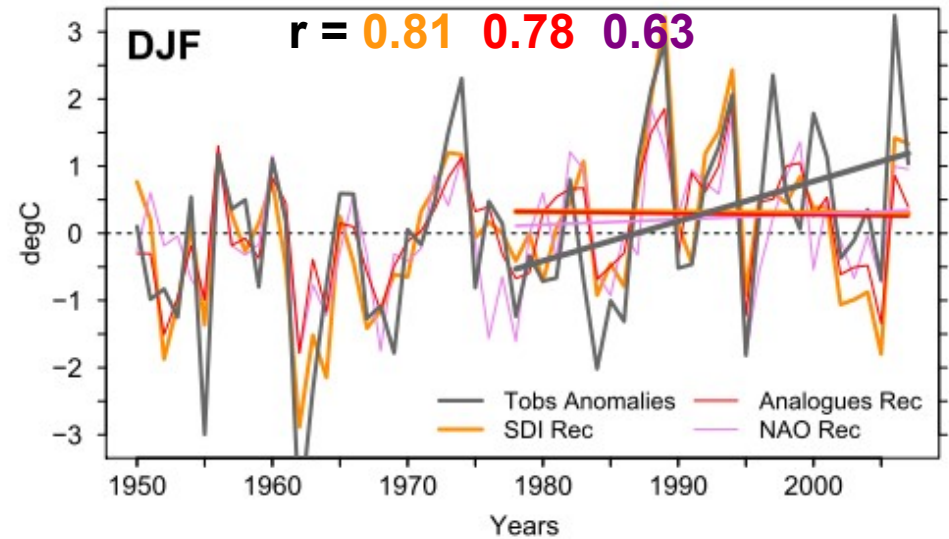
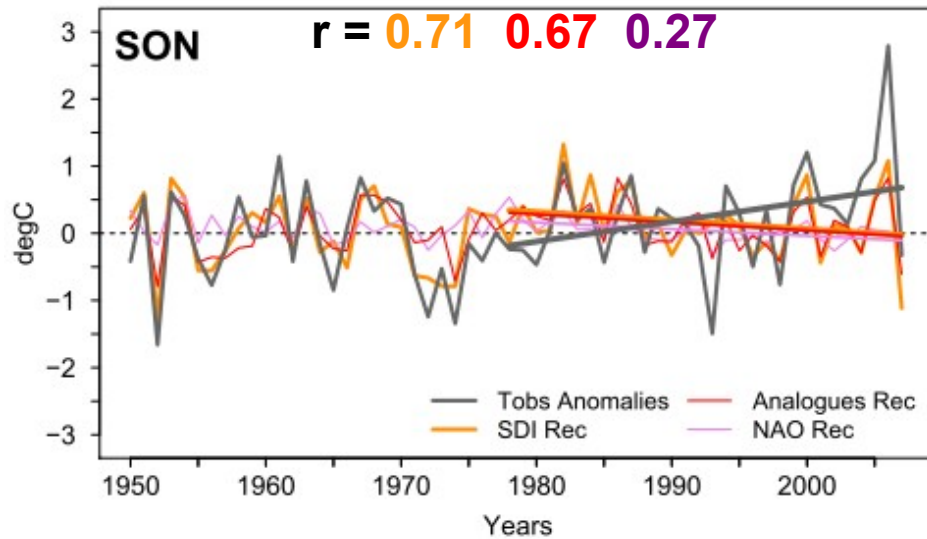
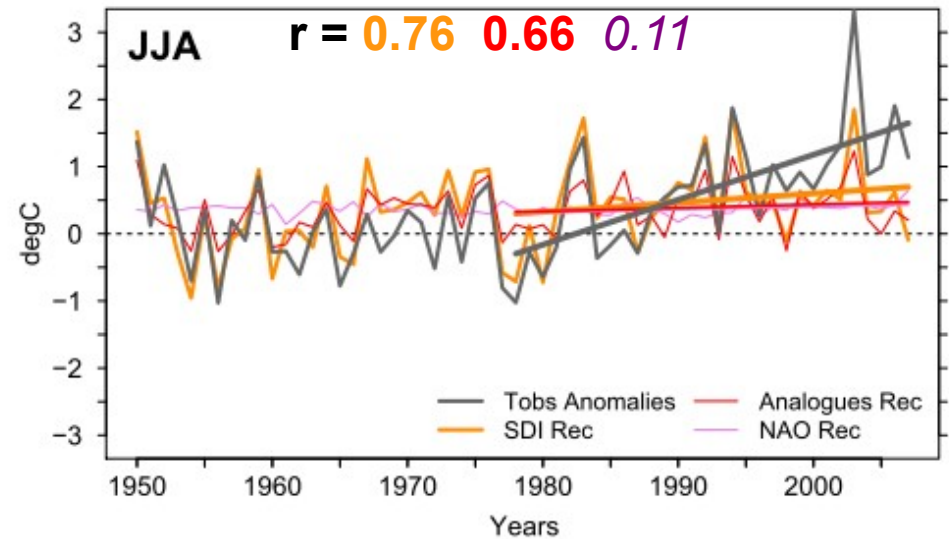
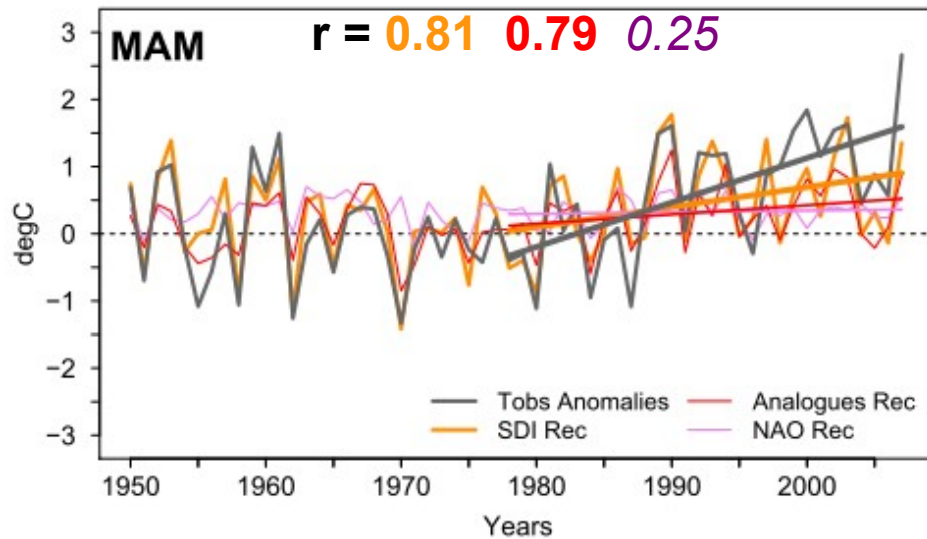
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... **dynamics** explains Tobs variability...

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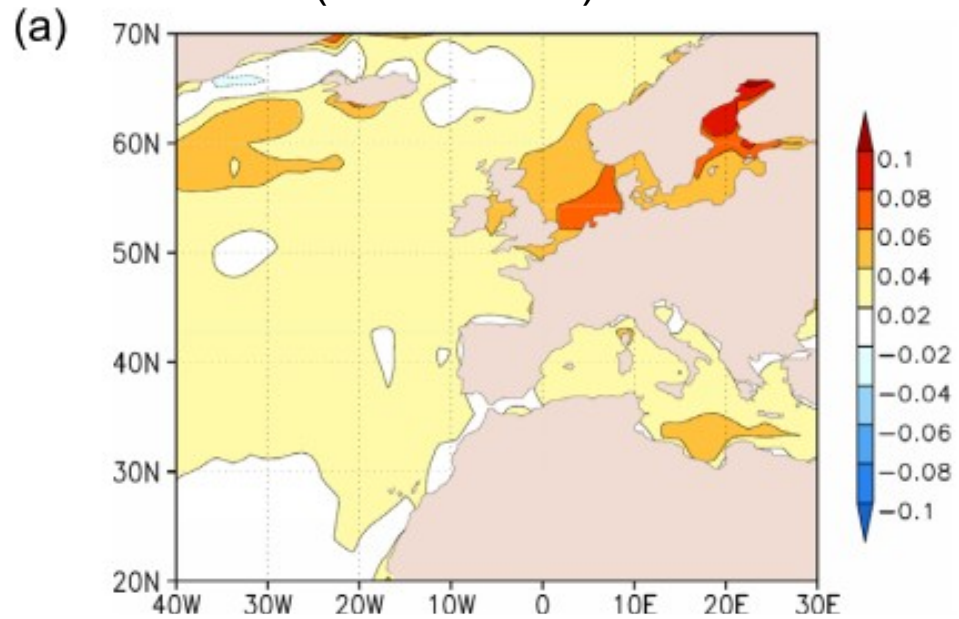
Fitting **SDI** on Tobs time series...



... **dynamics** explains Tobs **variability**, but not **trends**.

North-Atlantic recent surface warming

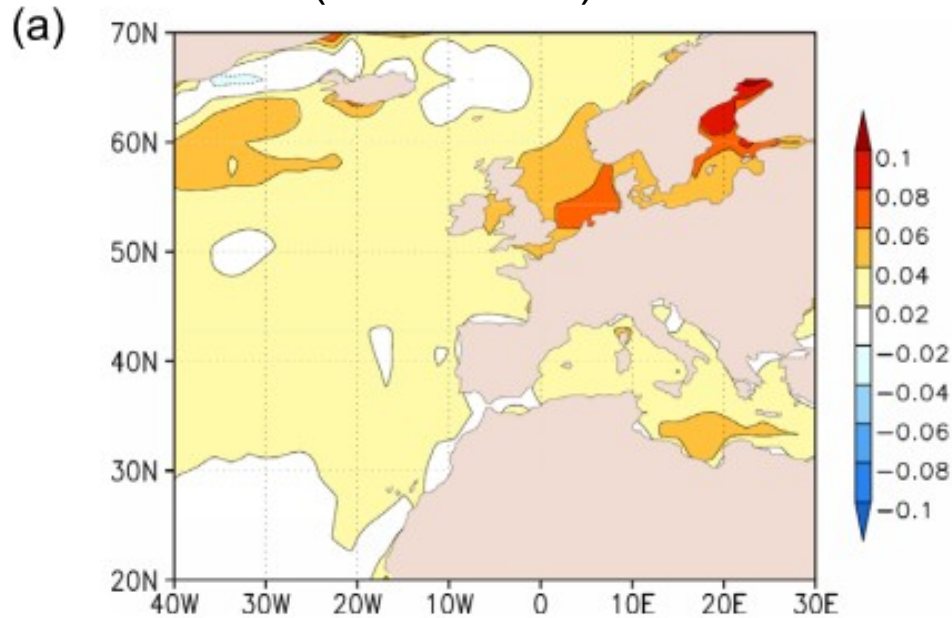
SST anomalies (wrt 1961-90): 1978-2007 trend



Dataset: **NCEP** re-analyses.

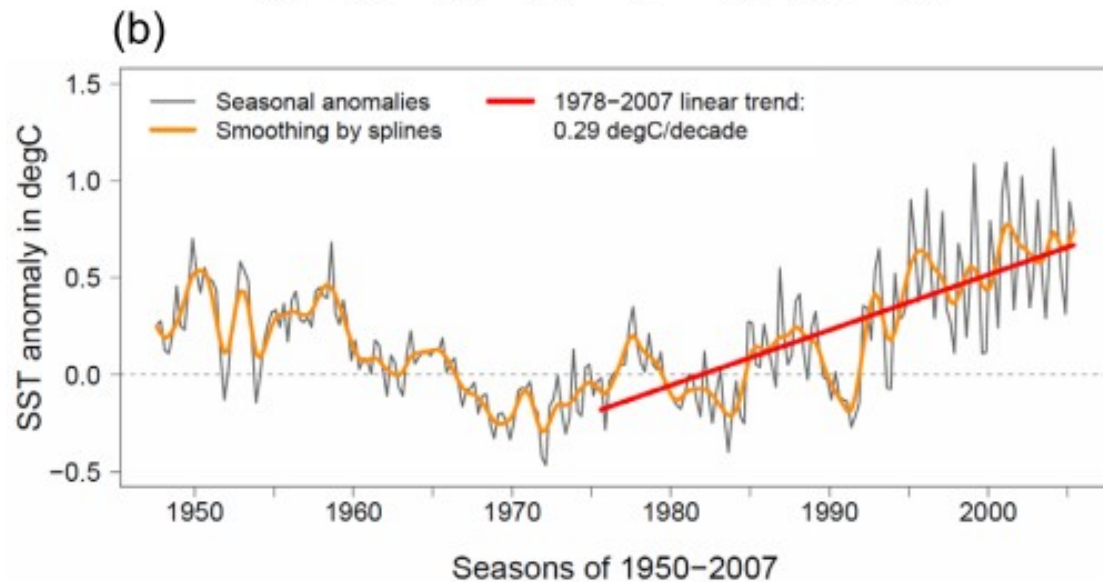
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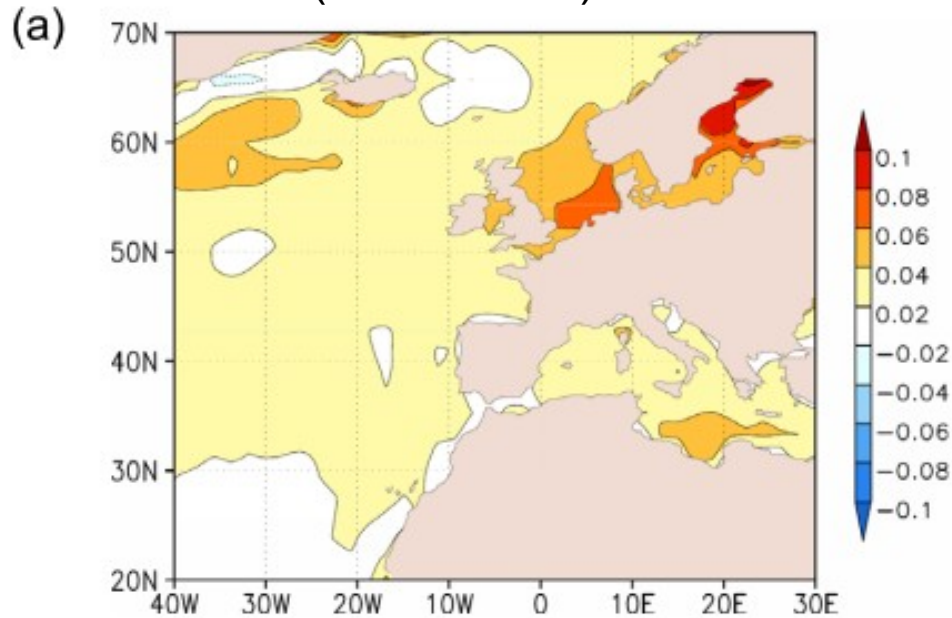
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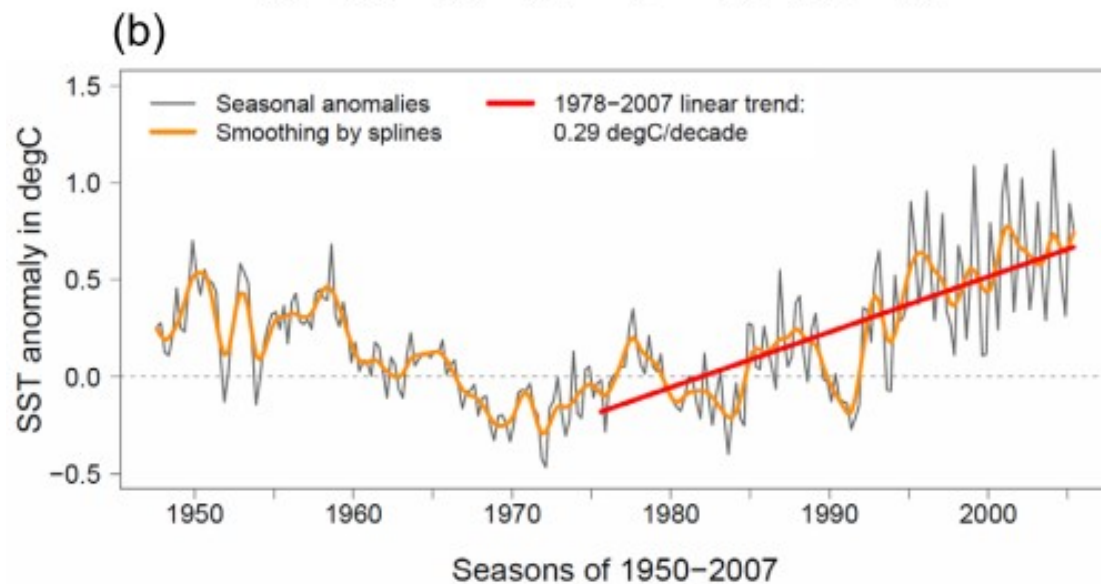
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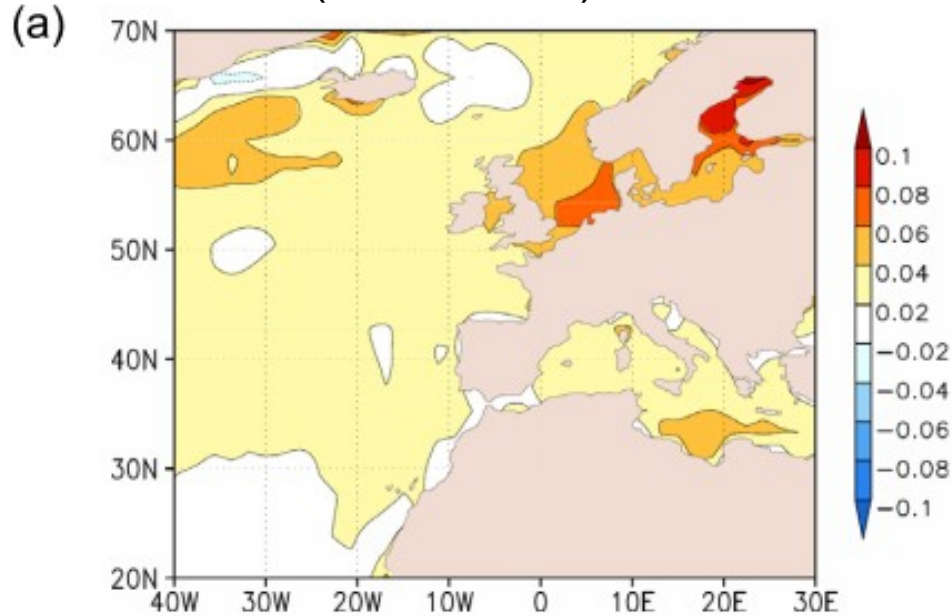
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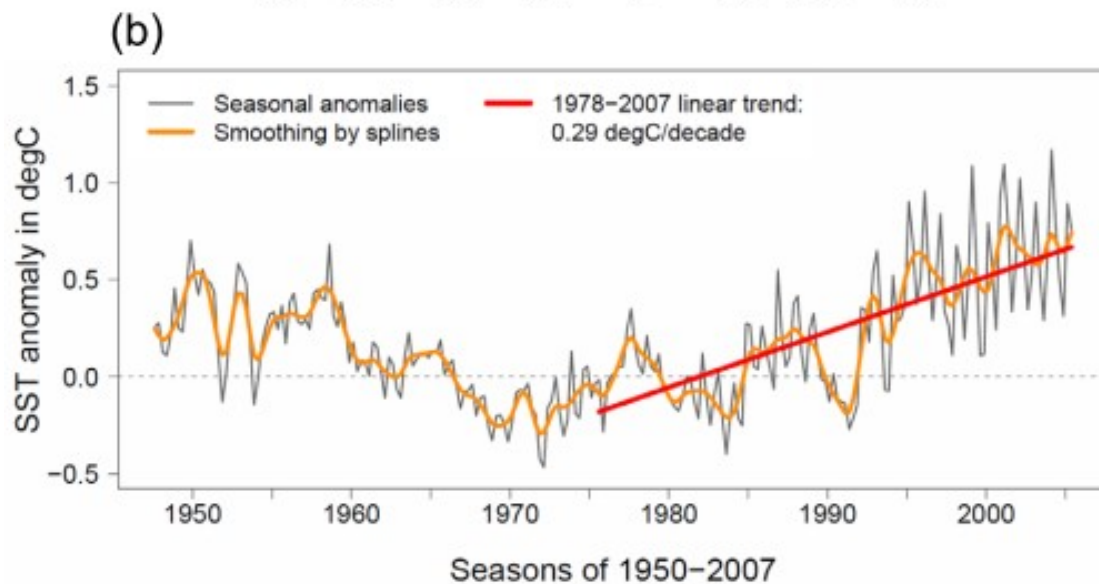
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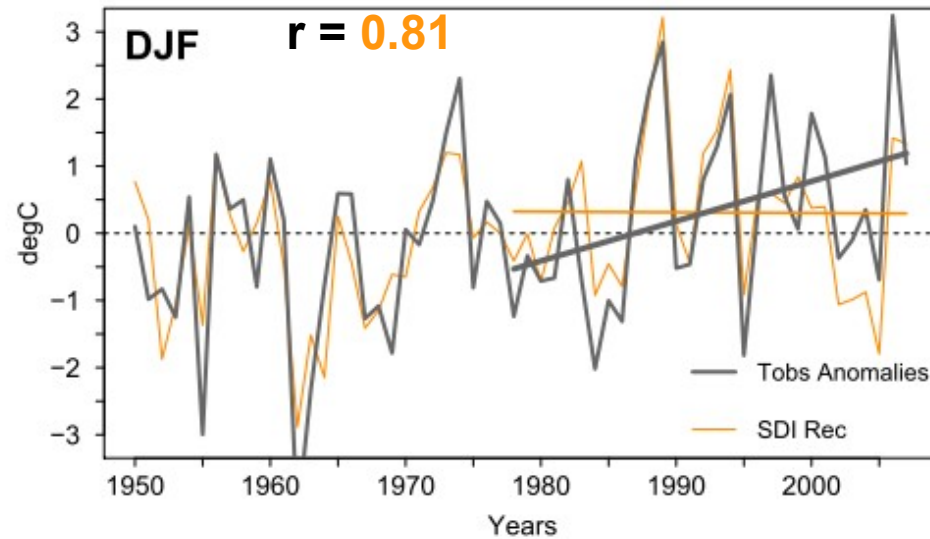
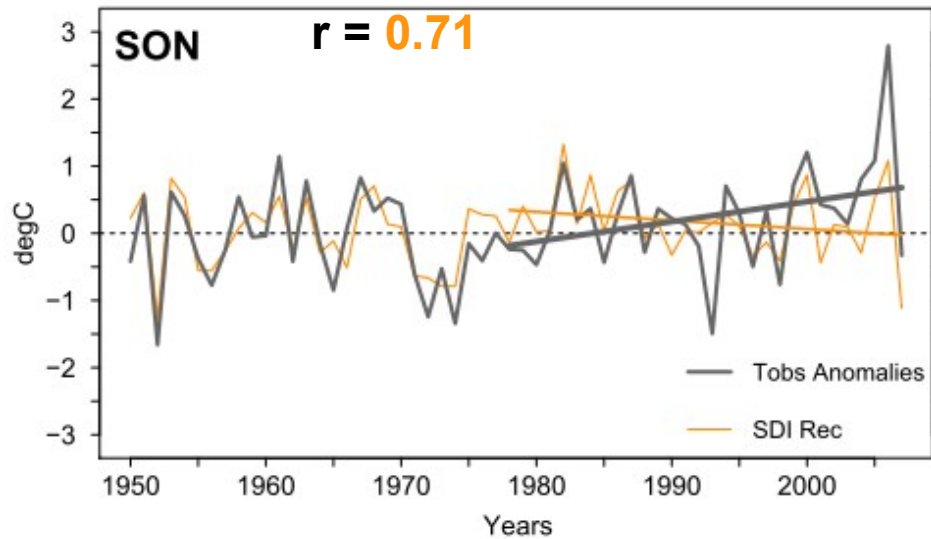
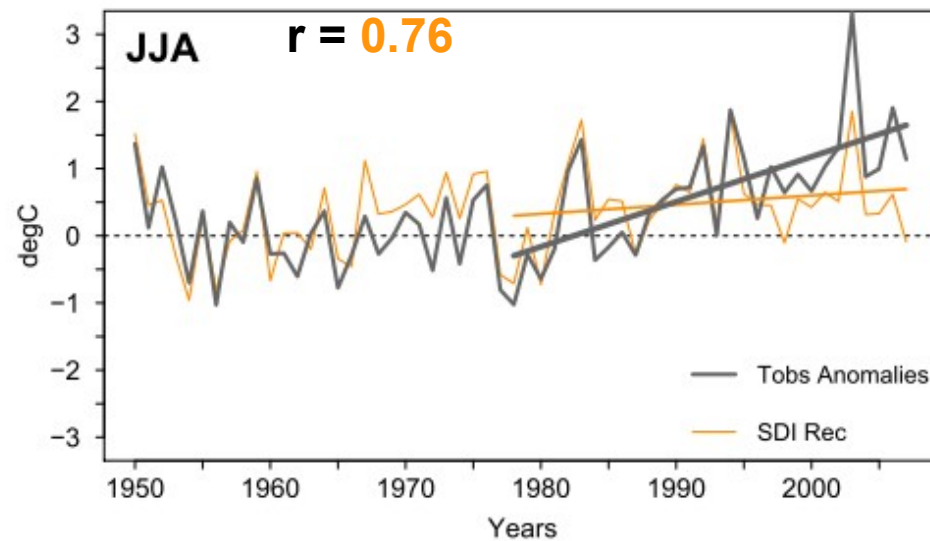
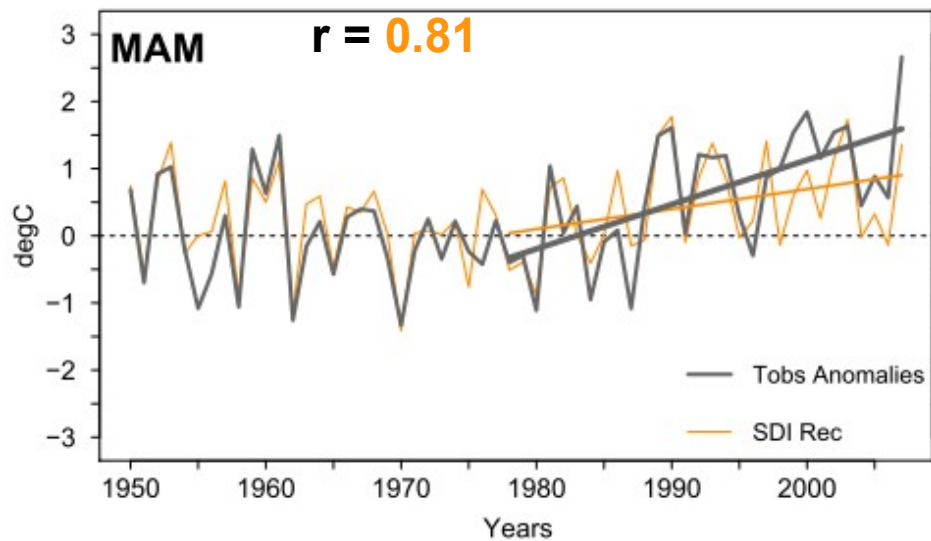
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Did SSTs contribute to recent European warming trend and extremes?

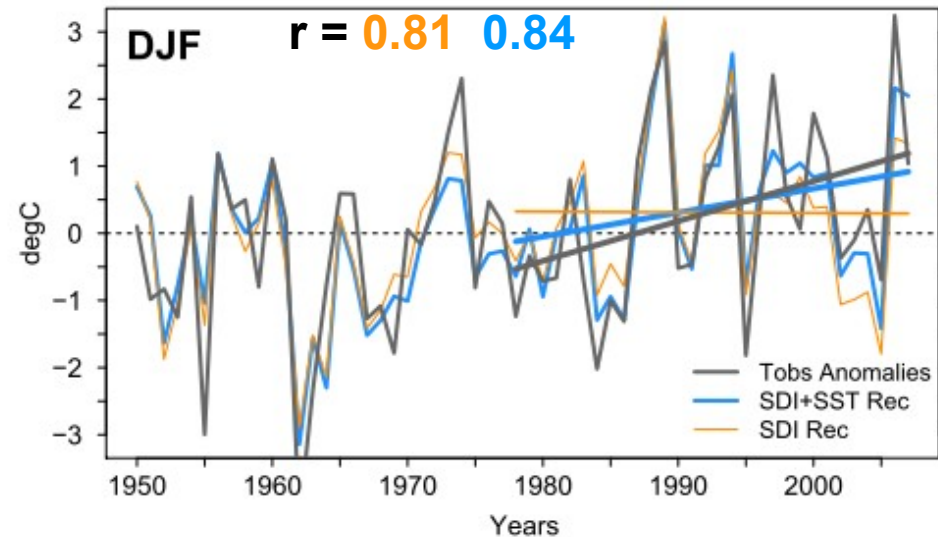
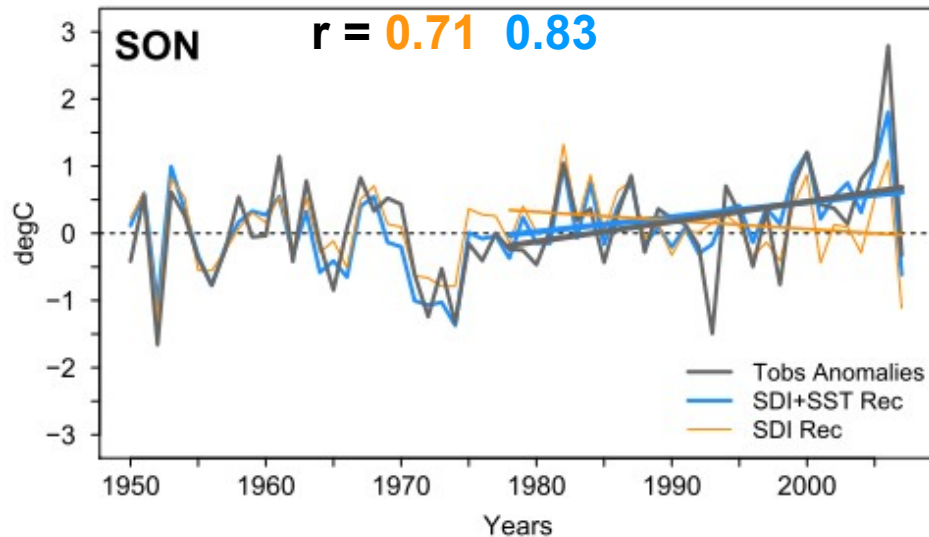
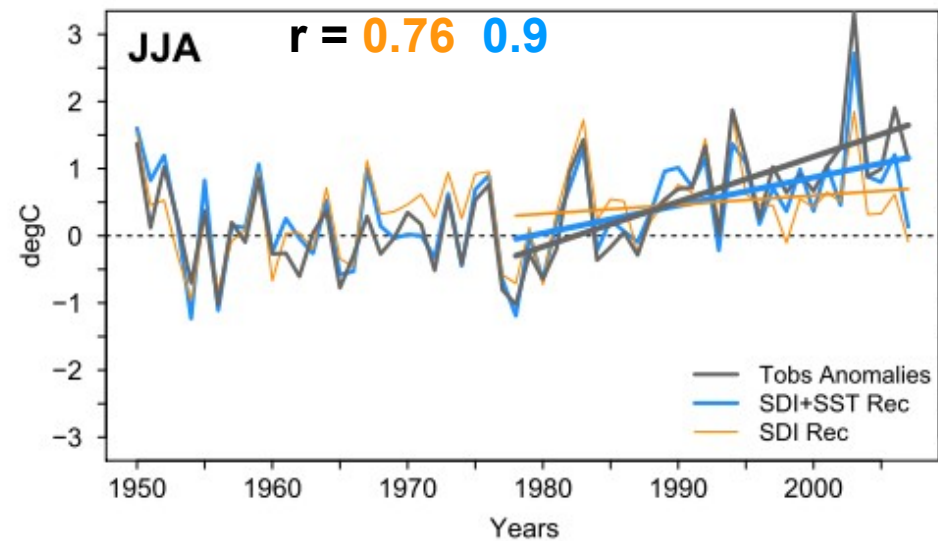
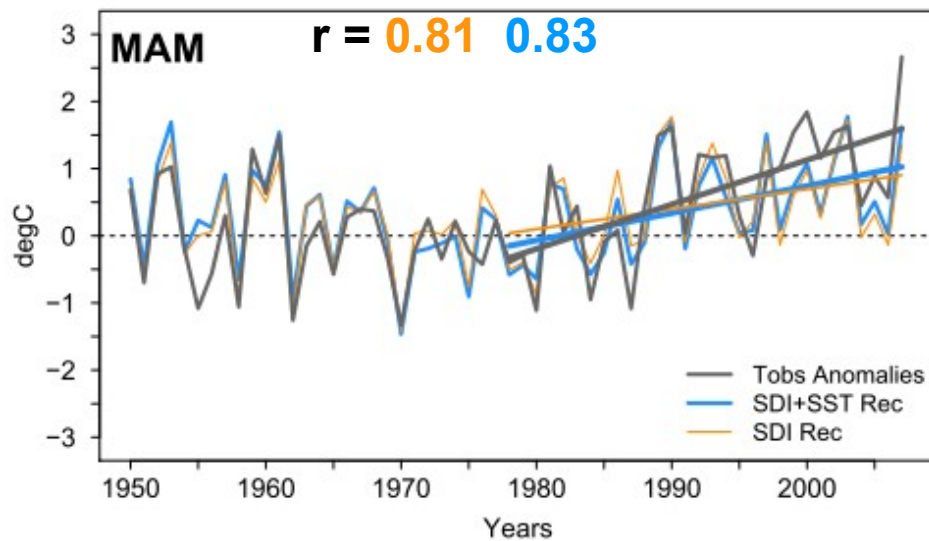
Atlantic SST contribution to land warming

Adding **SST** time series to **Tobs**–**SDI** linear regressions...



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Adding **SST** time series to **Tobs**–**SDI** linear regressions...



... improves the fit, especially in **fall** and **winter**.

SST sensitivity experiments: set-up

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MM5 = Penn State University / NCAR 5th generation of Mesoscale Model.
Non-hydrostatic equations of motion over a predefined domain.
32 vertical levels and 4 active soil layers.
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For each season of 2003-2007:

AS: Actual SST (as from 4xdaily NCEP re-analyses).

CS: Climatological SST (as from 1961-1990 4xdaily NCEP climatology).

Nudging on wind 3D field, not on temperature and humidity 3D fields.

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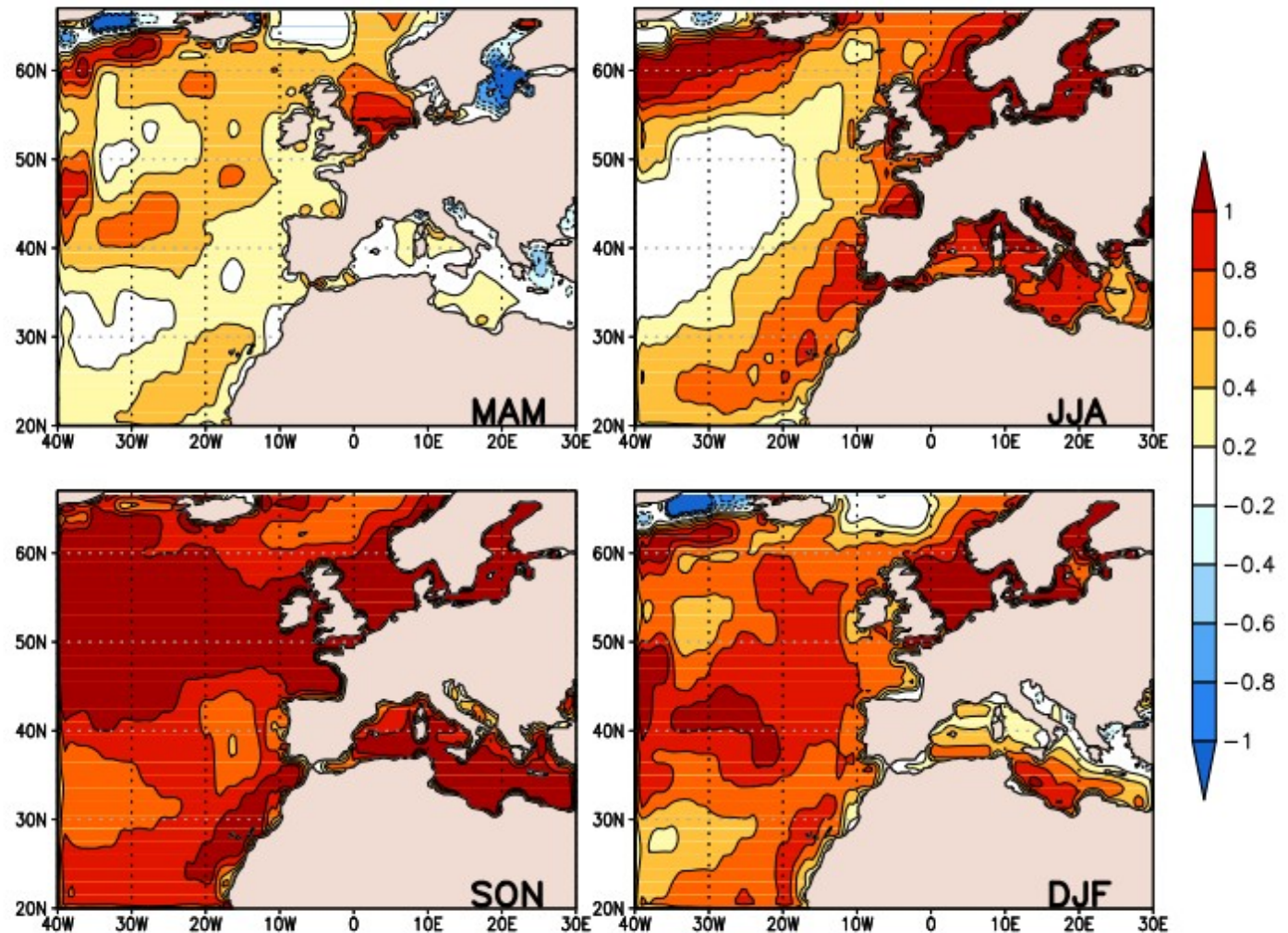
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>> AS – CS: SST anomaly influence.

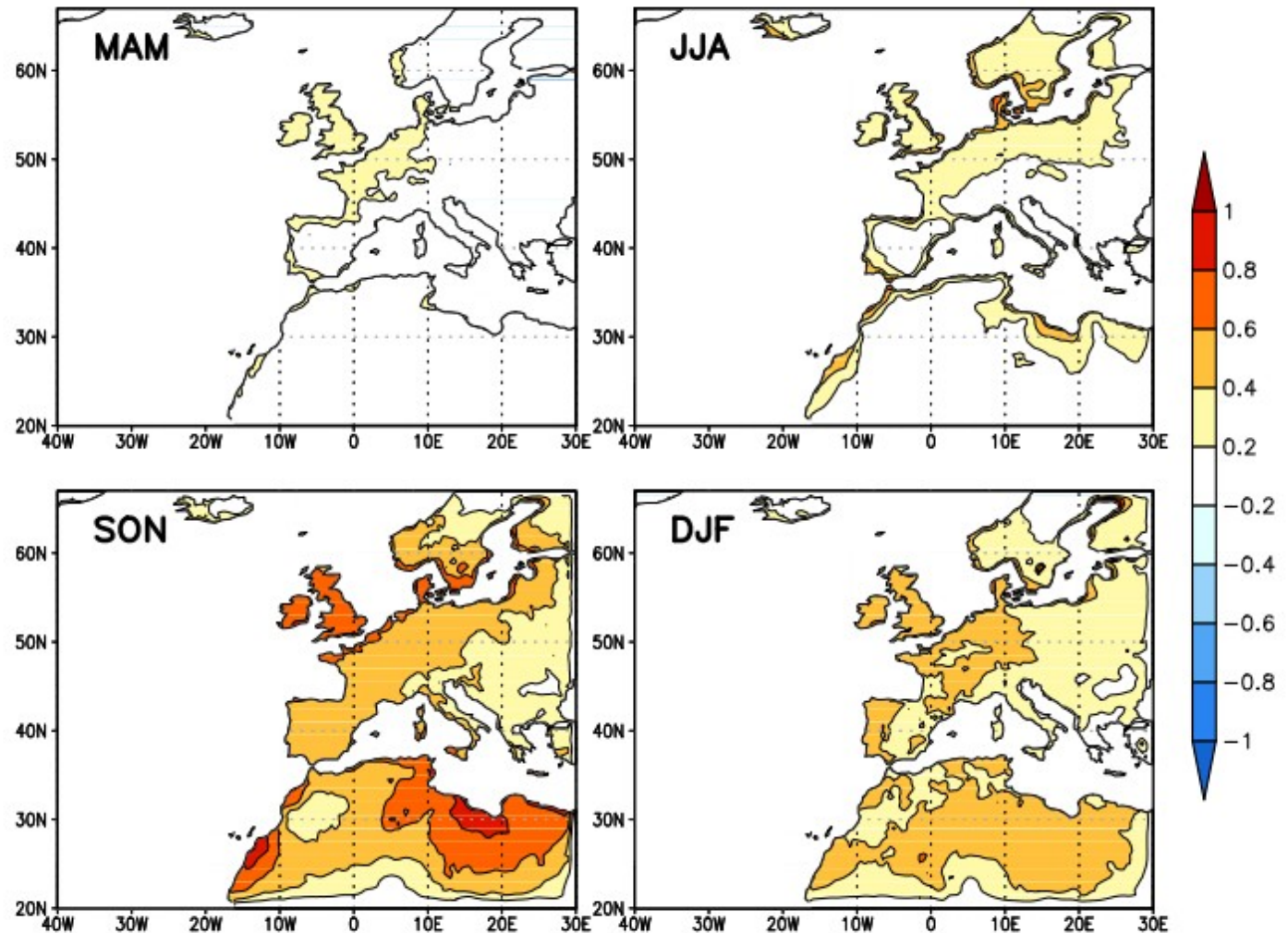
SST sensitivity experiments: AS – CS SST forcings

= SST anomalies averaged over 2003-2007.

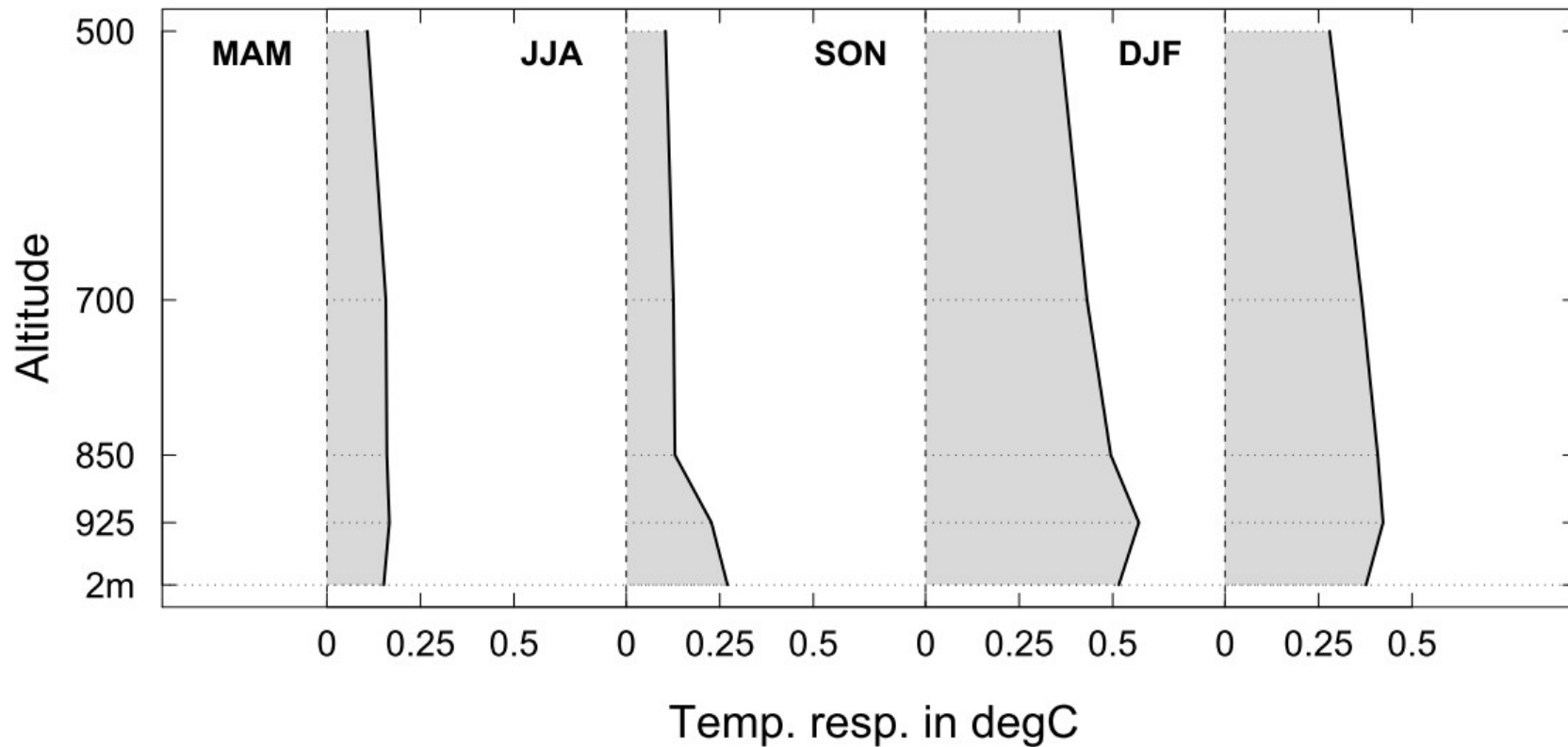


SST sensitivity experiments: AS – CS T2m responses

= SST anomalies contribution to 2003-2007 land warming.

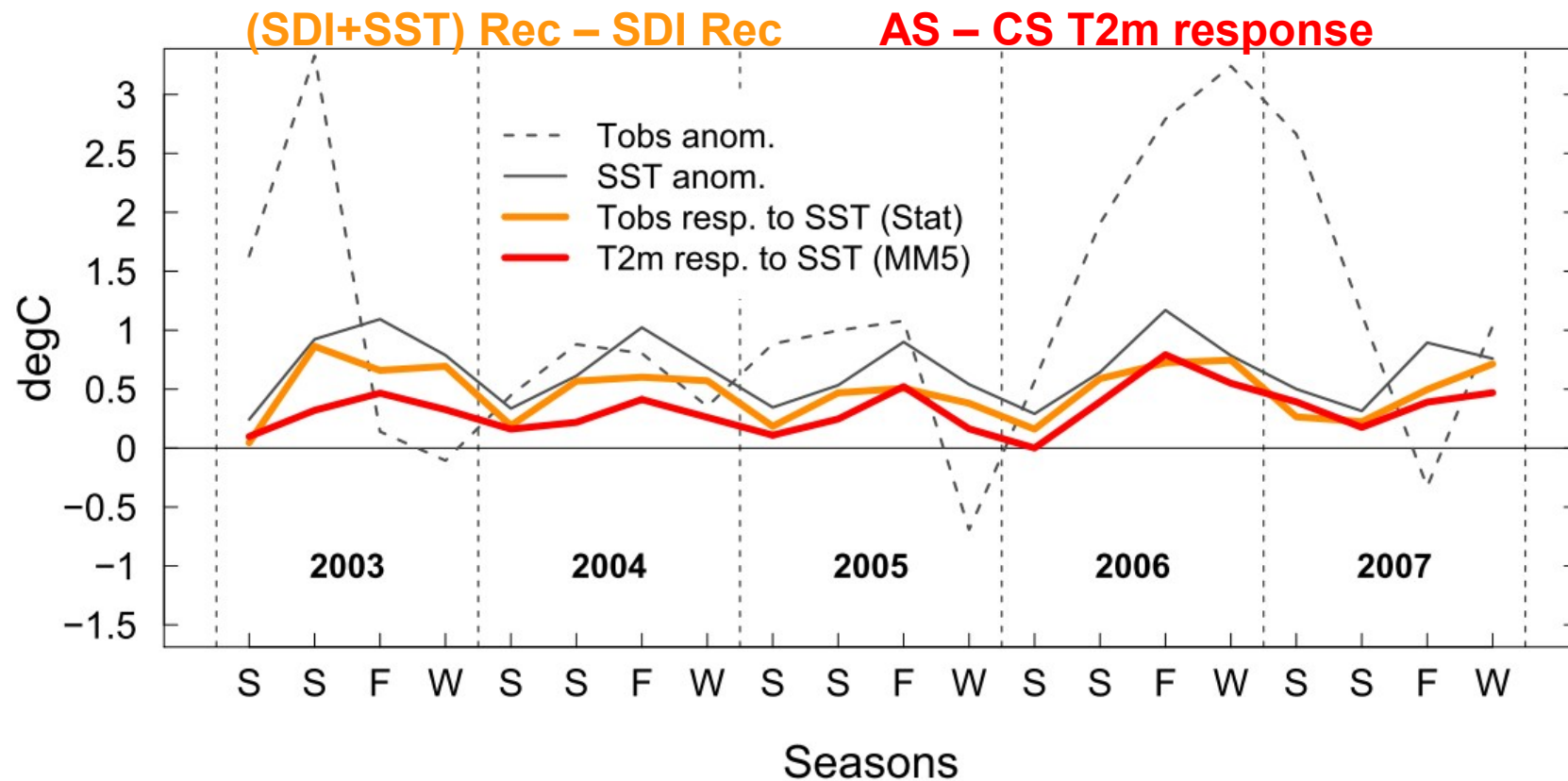


SST sensitivity experiments: AS – CS T(altitude) responses



SST anomalies seem **advected** from the Atlantic during **seasons of strong westerlies**.
Near-surface amplifying feedbacks appear in **summer**.

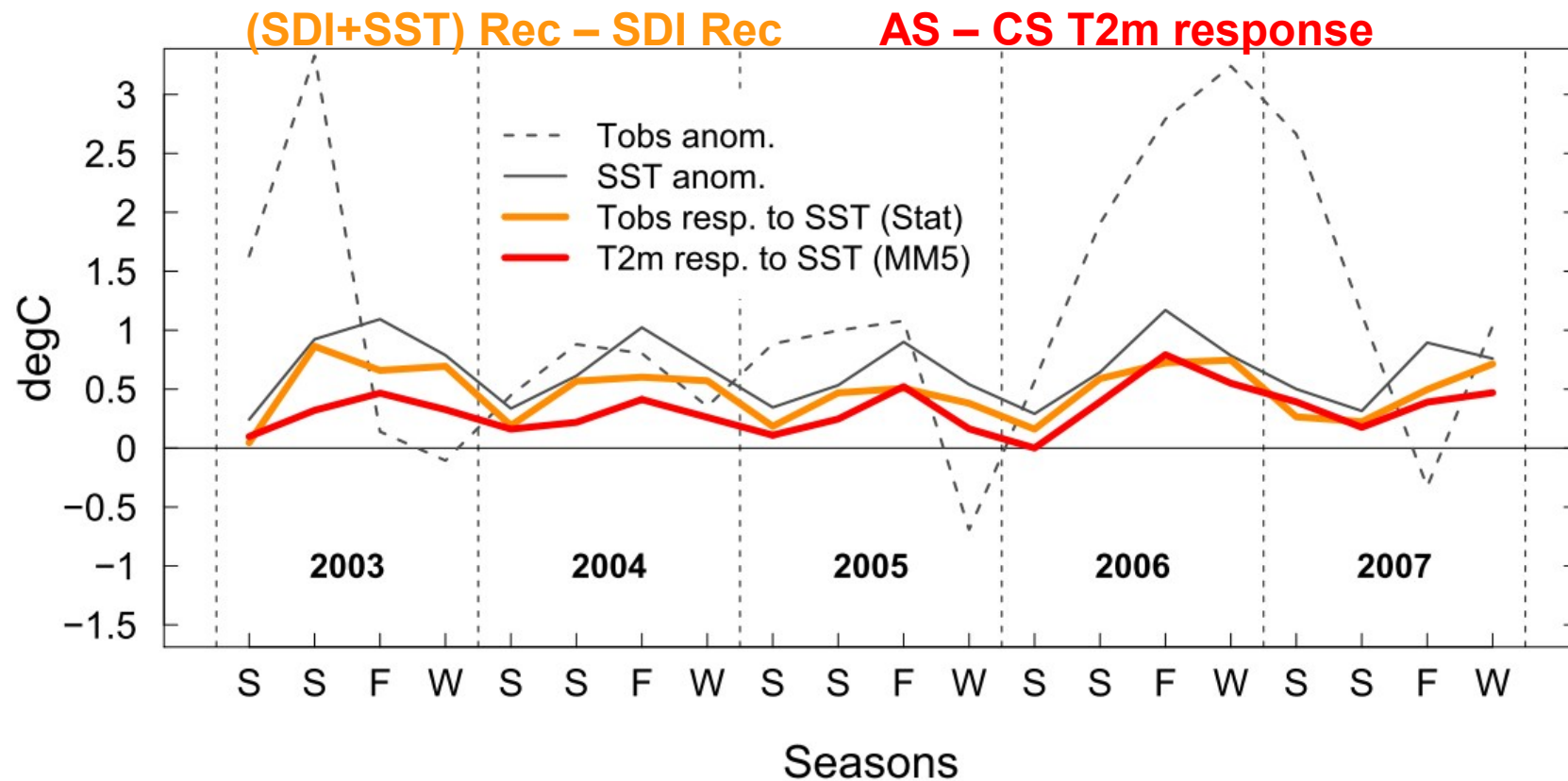
Statistical vs. Dynamical estimations of SST contribution



Agreement

Positive contributions for all seasons of 2003-2007 + **strong seasonality**.

Statistical vs. Dynamical estimations of SST contribution



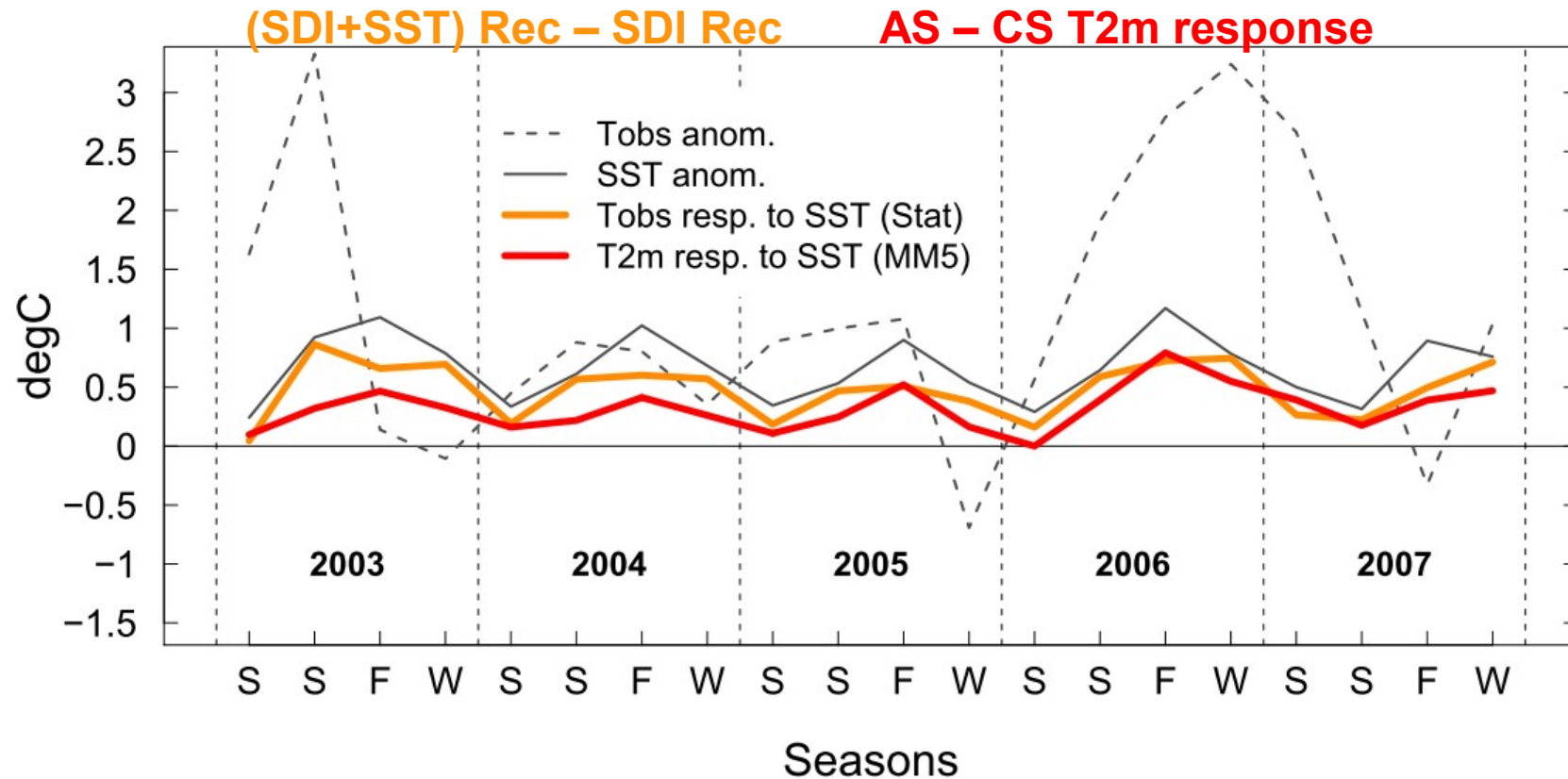
Agreement

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Limits

Statistics: SST-Tobs causal link is not identified. Over-estimation (esp. in MAM-JJA).
MM5: Unrealistic prescribing of both dynamics and SST.

Statistical vs. Dynamical estimations of SST contribution



Agreement

Positive contributions for all seasons of 2003-2007 + strong seasonality.

Extreme seasons

Autumn 2006: SST contributed to ~30%

[Cattiaux et al. GRL 2009; Shongwe et al. Clim Dyn 2009].

Summer 2003: Minor contribution (land-atmosphere feedback more important)

[Fischer et al. GRL 2007; Seneviratne et al. Nature 2006].

Conclusions

European temperatures variability remains driven by North-Atlantic dynamics, with season-dependent patterns.

Recent land warming is incompatible with circulation changes only.

Annual cycle of North-Atlantic SSTs has been both warming and delaying, which recently causes high SST anomalies in fall and winter.

The warming of SSTs enhances European land temperatures, since warmer air masses are advected from North-Atlantic.

Since both westerlies and anomalous SST are higher in autumn and winter, the land temperature response is more important during these two seasons, and SST significantly contributed to recent trends and extremes.

Land temperature responses to SST are less pronounced in spring or summer, where local feedbacks (soil-atmosphere, clouds, aerosols) are the main amplifiers of recent extremes.

... submitted in Climate Dynamics, in revision.