Disruption of the European climate seasonal clock in a warming world

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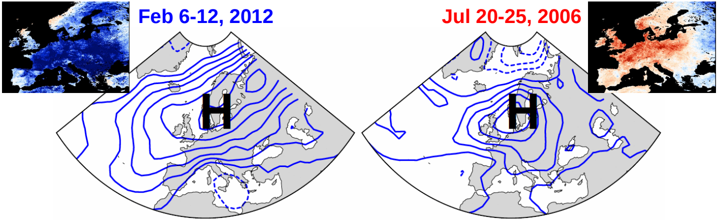
Canmore, June 6, 2016

Introduction

- W-European T extremes are associated with persistent H systems (*blockings*).
  Cassou et al. (2005); Schneidereit et al. (2012); Sillmann et al. (2012)...



SLP anomaly of cold spell Feb 2012 & heat wave July 2006

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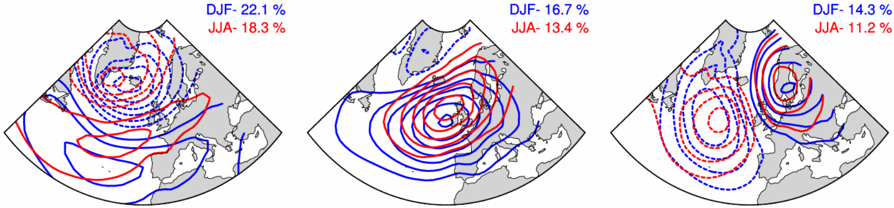

EOF 1, 2 & 3 of daily SLP anomalies | NCEP-NCAR reanalysis 1950–2012

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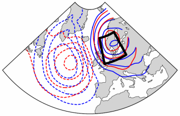

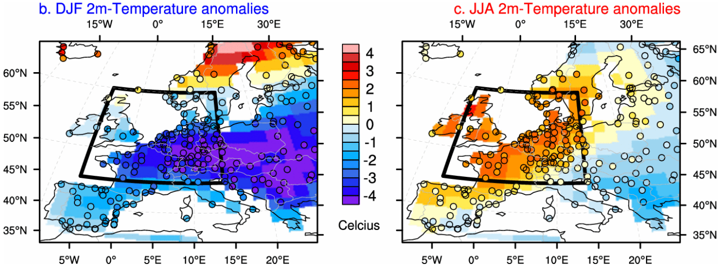

Composites of daily T anomalies over days with SLP index $> 1\sigma$
NCEP-NCAR reanalysis + ECA&D stations 1950–2012

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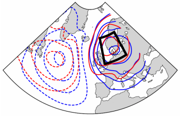
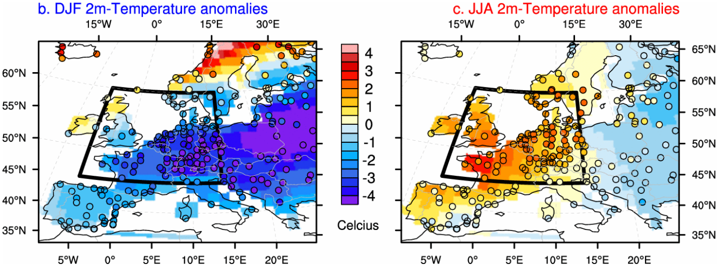
- This season-dependent SLP-T relationship is well captured by climate models.





Composites of daily T anomalies over days with SLP index $> 1\sigma$
CNRM-CM5 historical simulation + ECA&D stations 1950–2012

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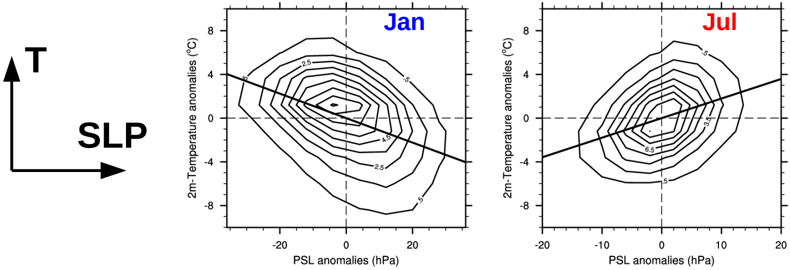
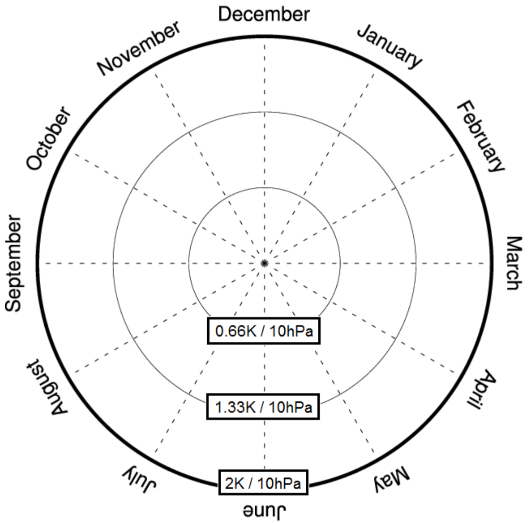
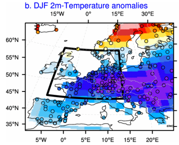
- The SLP-T regression is -1.4K/10hPa in January & 2.0K/10hPa in July.



Daily T index vs. daily SLP index (illustrations)

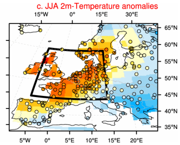
The European climate seasonal clock





January
SLP-T regression:
$-1.4K/10hPa$

July
SLP-T regression:
2.0K/10hPa



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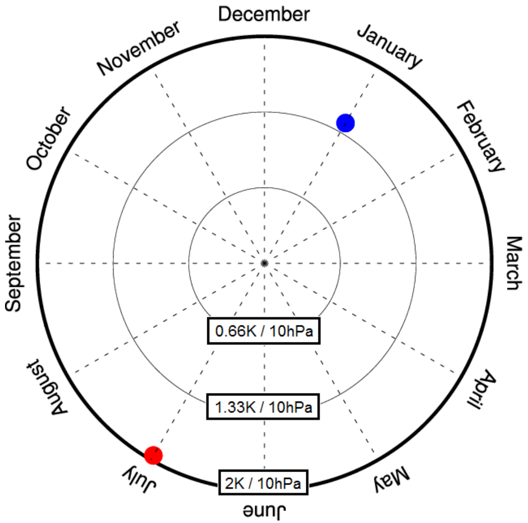

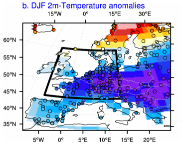

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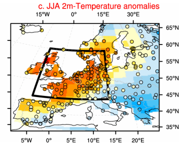

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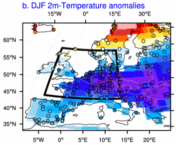

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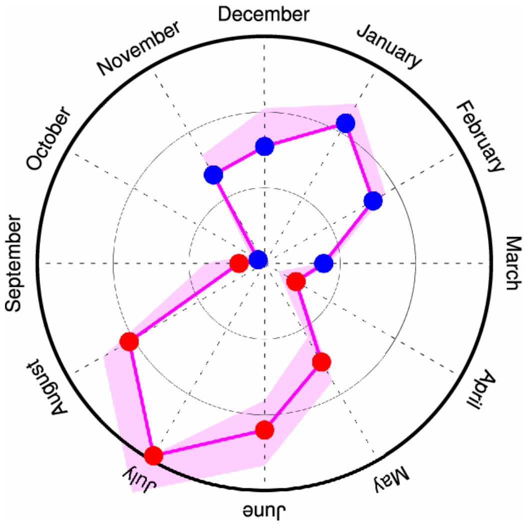

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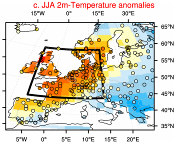

Obs. estimates (20CR/NCEP/ECA&D | 1950–2010)

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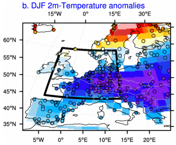

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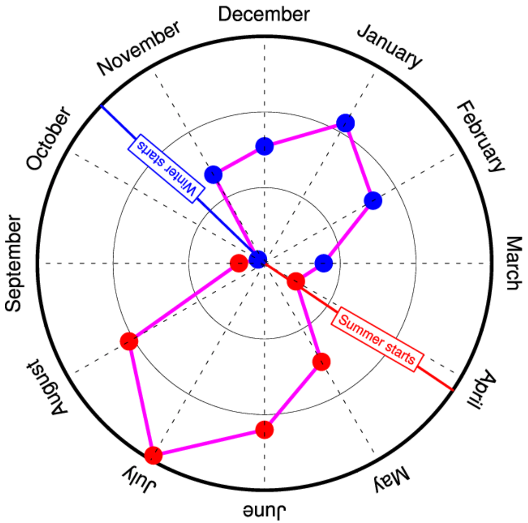

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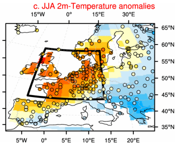

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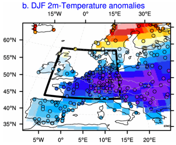

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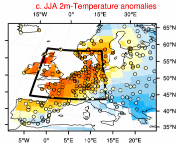
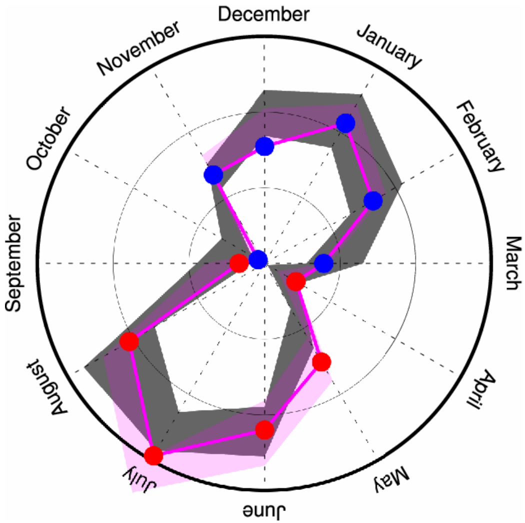
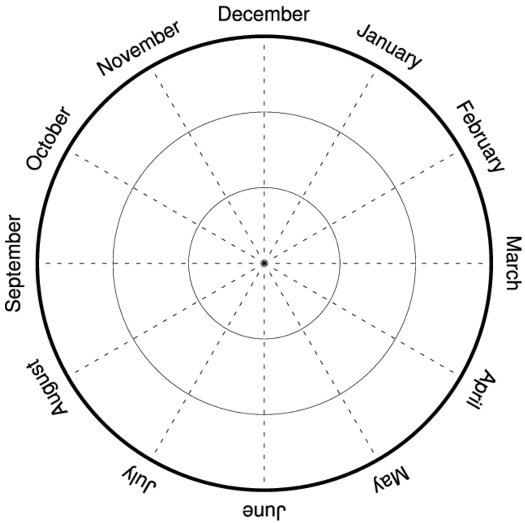
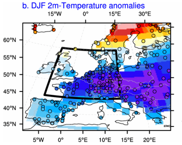


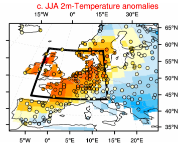


Obs. estimates (20CR/NCEP/ECA&D | 1950–2010)
CNRM-CM5 historical (10 members | 1950–2010)

The seasonal clock in a warmer world







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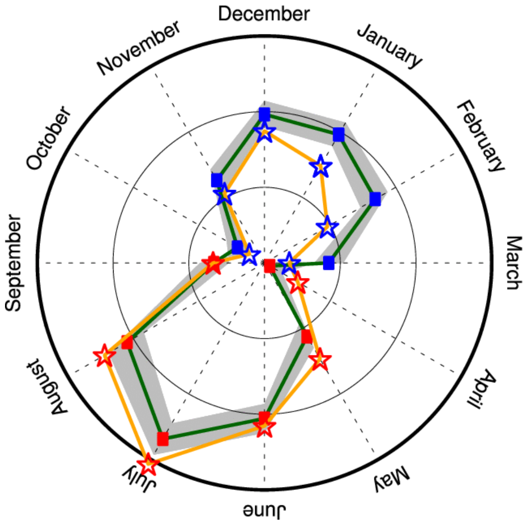
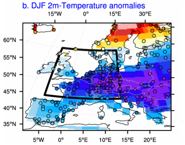
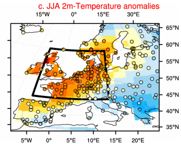




The regression decreases in winter.

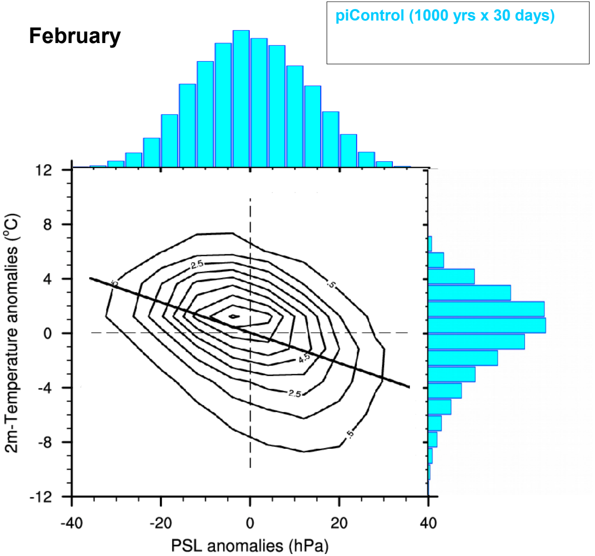
The regression increases in summer.



CNRM-CM5 piControl (1000 yrs) + 90%-level C.I

CNRM-CM5 rcp85 (5-member ens. mean | 2070–2100)

Weaker winter SLP-T regression



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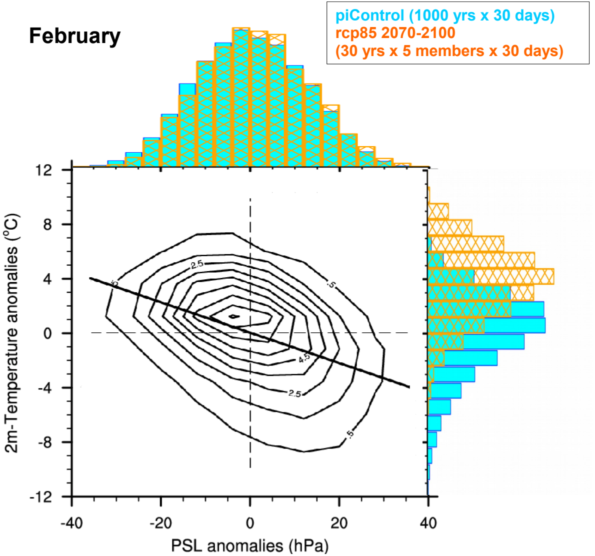

- No major SLP change, warm shift of T pdf.

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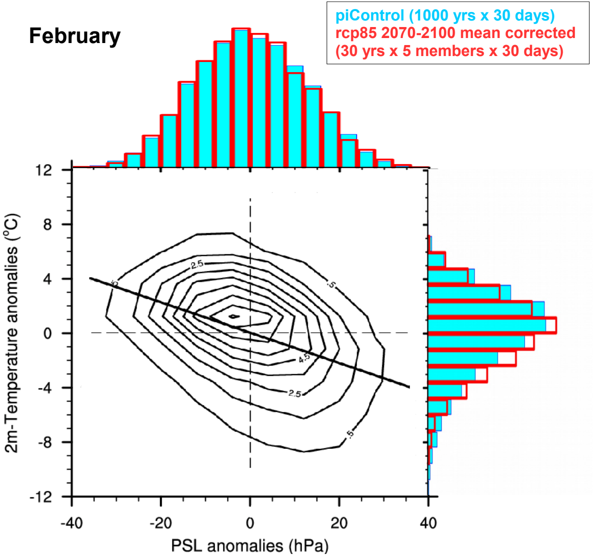

- No major SLP change, warm shift of T pdf.
- Beyond the shift, the T variance decreases.

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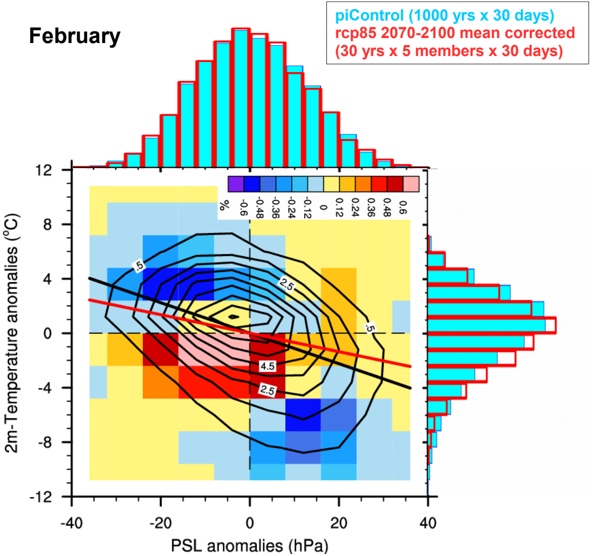
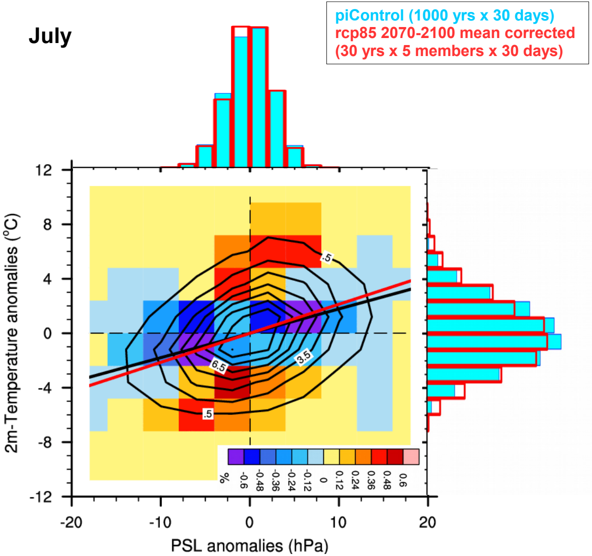


- No major SLP change, warm shift of T pdf.
- Beyond the shift, the T variance decreases.
- T changes are dependent on SLP.
  → Both warm+west & cold+east days become less frequent.

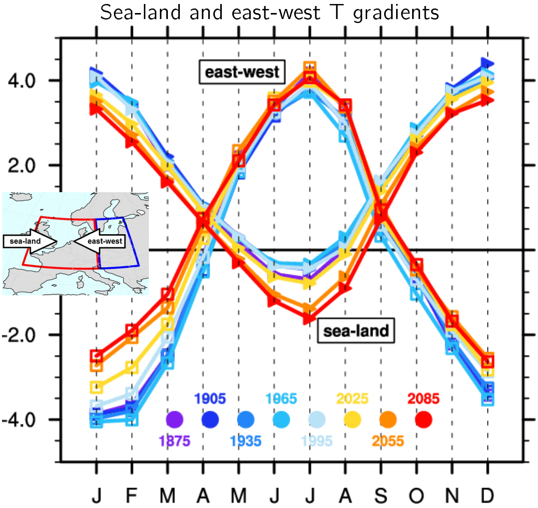
Stronger summer SLP-T regression



- No major SLP change, warm shift of T pdf.
- Beyond the shift, the T variance increases.
- T changes are less dependent on SLP.

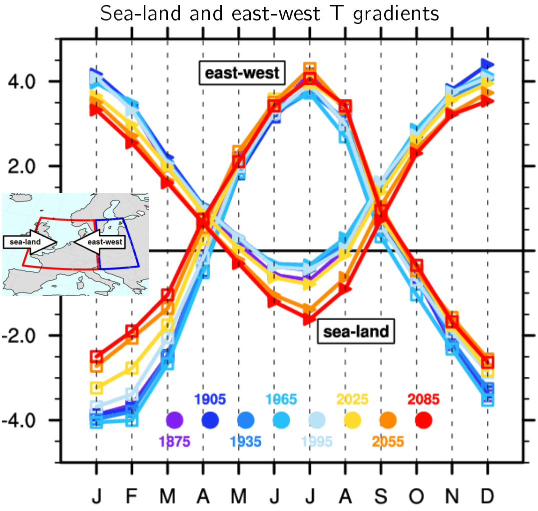
→ Warm or cold days more frequent regardless of circulation.

Changes in zonal T gradients



CNRM-CM5 historical+rcp85 (5-member 30-yr climatologies)

Changes in zonal T gradients



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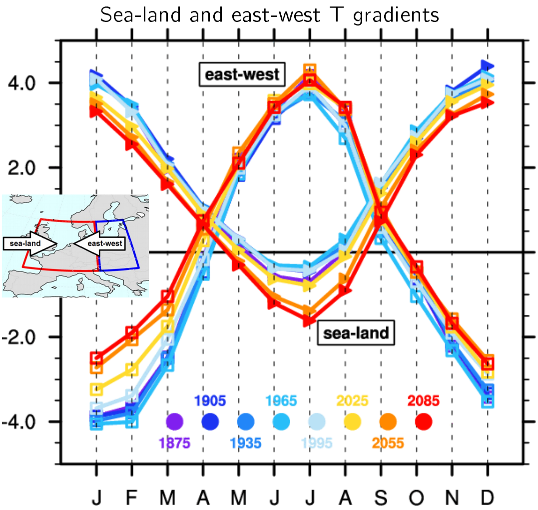
- Winter T variance decrease linked to decreases in both gradients.

→ Westerlies less efficient to warm, easterlies less efficient to cool.

Cattiaux et al. (2011); De Vries et al. (2012).

Changes in zonal T gradients



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- **Winter T variance decrease** linked to decreases in both gradients.

→ Westerlies less efficient to warm, easterlies less efficient to cool.

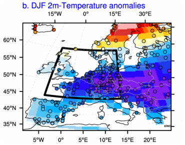
Cattiaux et al. (2011); De Vries et al. (2012).

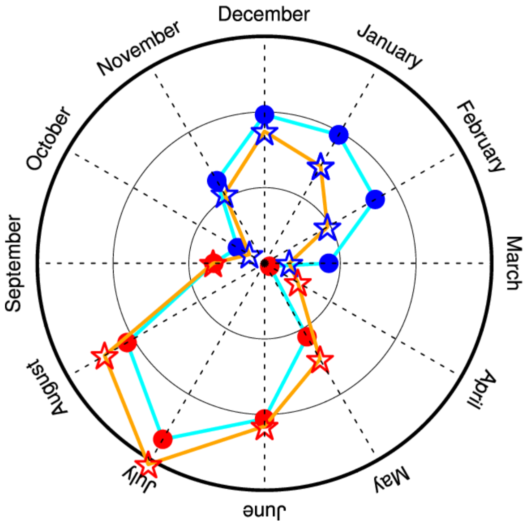
- **Summer T variance increase** partially linked to the increase in sea-land gradient.

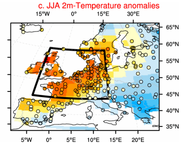
→ Other factors, e.g. local soil drying for hot extremes.

Boé & Terray (2014); Cattiaux et al. (2011,2015); Fischer et al. (2009,2012); Seneviratne et al. (2006)...

Winter/summer onsets in a warmer world



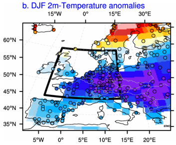


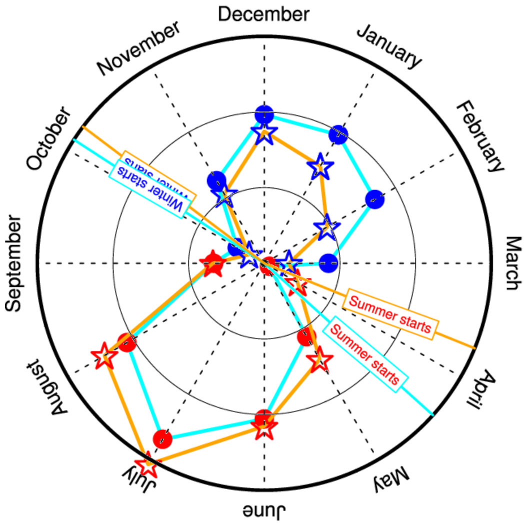


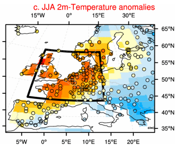
CNRM-CM5 piControl (1000 yrs)
CNRM-CM5 rcp85 (5-member ens. mean | 2070–2100)

Winter/summer onsets in a warmer world

The winter onset is slightly delayed.







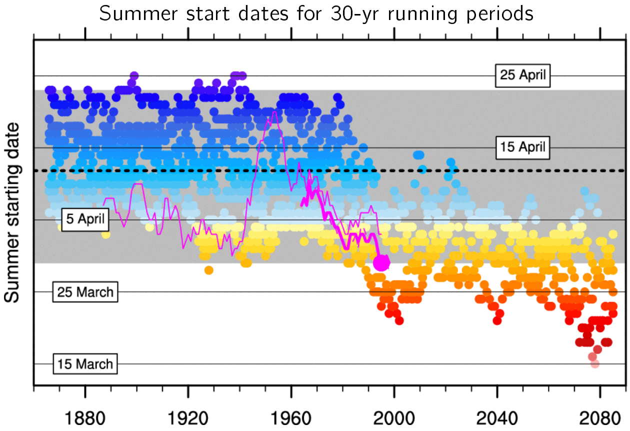
The summer starts ∼25 days earlier.

CNRM-CM5 piControl (1000 yrs)

CNRM-CM5 rcp85 (5-member ens. mean | 2070–2100)

An earlier summer onset

- Observed trend of ~ -2.5 days/decade since the 1960s.

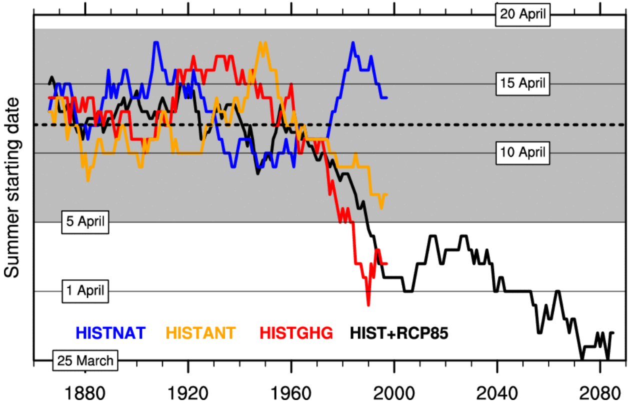


Obs. estimates (NCEP 1948–2014 | 20CR 1870–2012)
CNRM-CM5 piControl 90%-level C.I from 1000 random 30-yr periods
CNRM-CM5 historical+rcp85 (10 members 1850–2005 | 5 members 2006–2100)

An earlier summer onset – Attribution runs

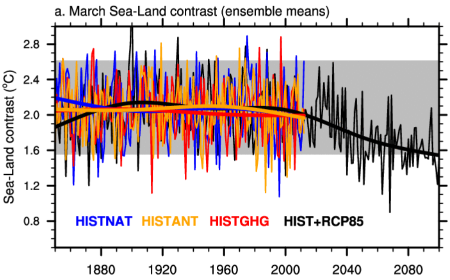
- ~ -2.5 days/decade is consistent with the expected response to GHG.

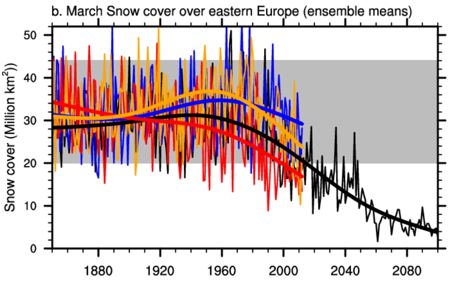
Summer start dates for 30-yr running periods (ensemble means)



CNRM-CM5 historical+rcp85 (5 members 1850–2100)
CNRM-CM5 piControl 90%-level C.I from 1000 averages of 5 random 30-yr periods
CNRM-CM5 historicalNat, **historicalAnt** & **historicalGHG** (5 members 1860–2005 each)

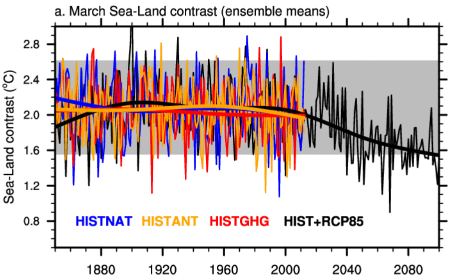
The role of snow cover decline





- Summer advance explained by the reduced March east-west T gradient linked to snow cover decline.

The role of snow cover decline



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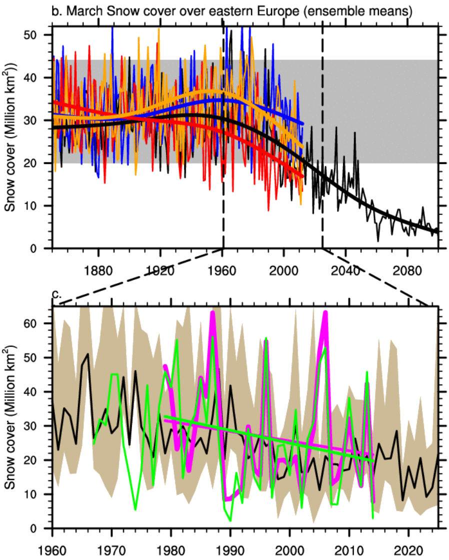
- CNRM-CM5 snow trend consistent with obs. estimates (1960–2015).



Trend-HIST= [-6/-1] Mkm^2/10yr
Trend-MERRA= -2.8 Mkm^2/10yr
Trend-NSIDC= -3.7 Mkm^2/10yr

Summary

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Based on a intrinsic feature of the circulation-temperature relationship.

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This work:

Cassou, C. and J. Cattiaux (2016), Disruption of the European climate seasonal clock in a warming world, *Nature Climate Change*, 6, 589–594.

+ 2 recent papers on the increase in European summer temperature variability:

Cattiaux, J., H. Douville, R. Schoetter, S. Parey and P. Yiou (2015), Projected increase in diurnal and inter-diurnal variations of European summer temperatures, *Geophysical Research Letters*, 42(3), 899-907.

Douville, H., J. Colin, E. Krug, J. Cattiaux and S. Thao (2016), Mid-latitude daily summer temperatures reshaped by soil moisture under climate change, *Geophysical Research Letters*, 43(2), 812–818.