Cloud radiative effect on biases and responses of mid-latitude summer temperatures in CMIP5 and COOKIE experiments

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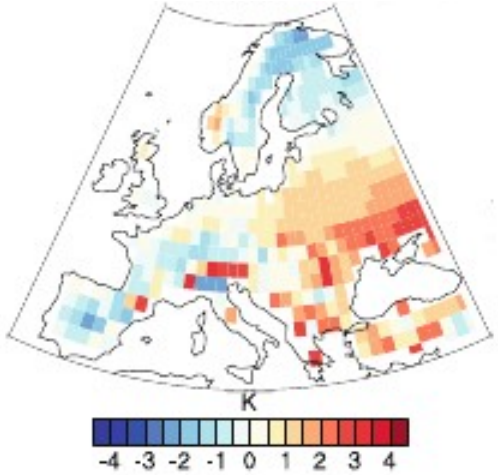
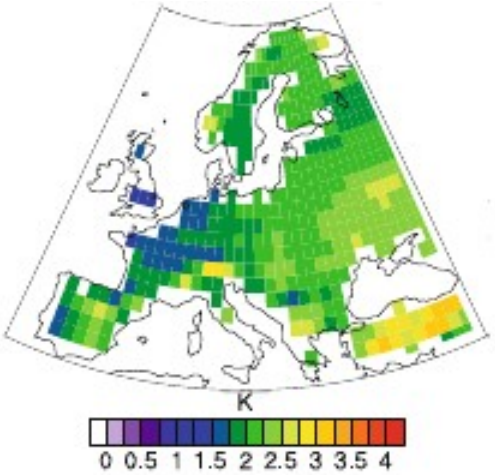
JJAS T2m *biases* (HIST, top) & *changes* (RCP8.5, bottom)

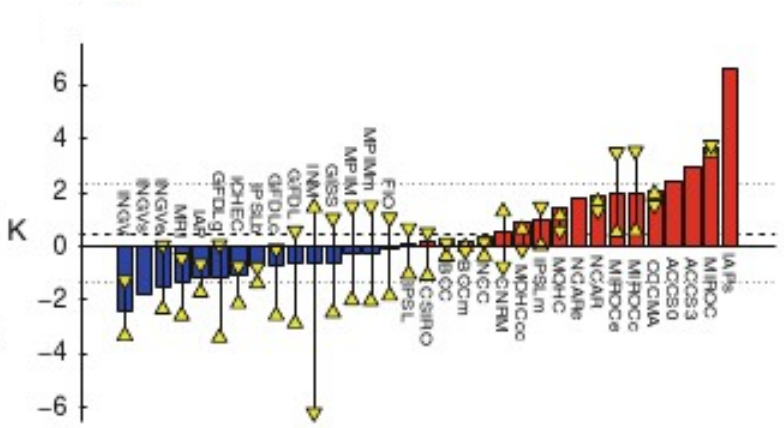
MME mean

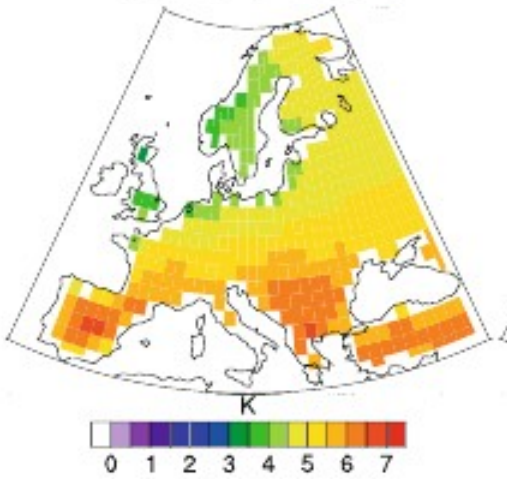


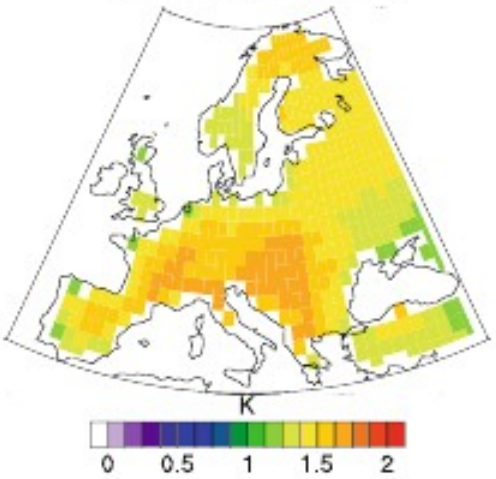
MME stdev

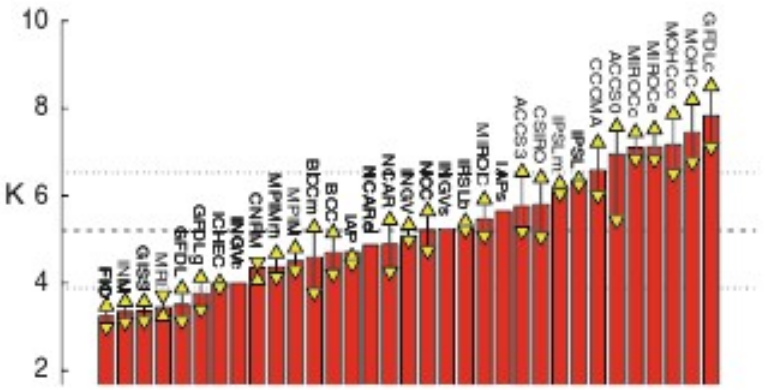


Spatial average for each model



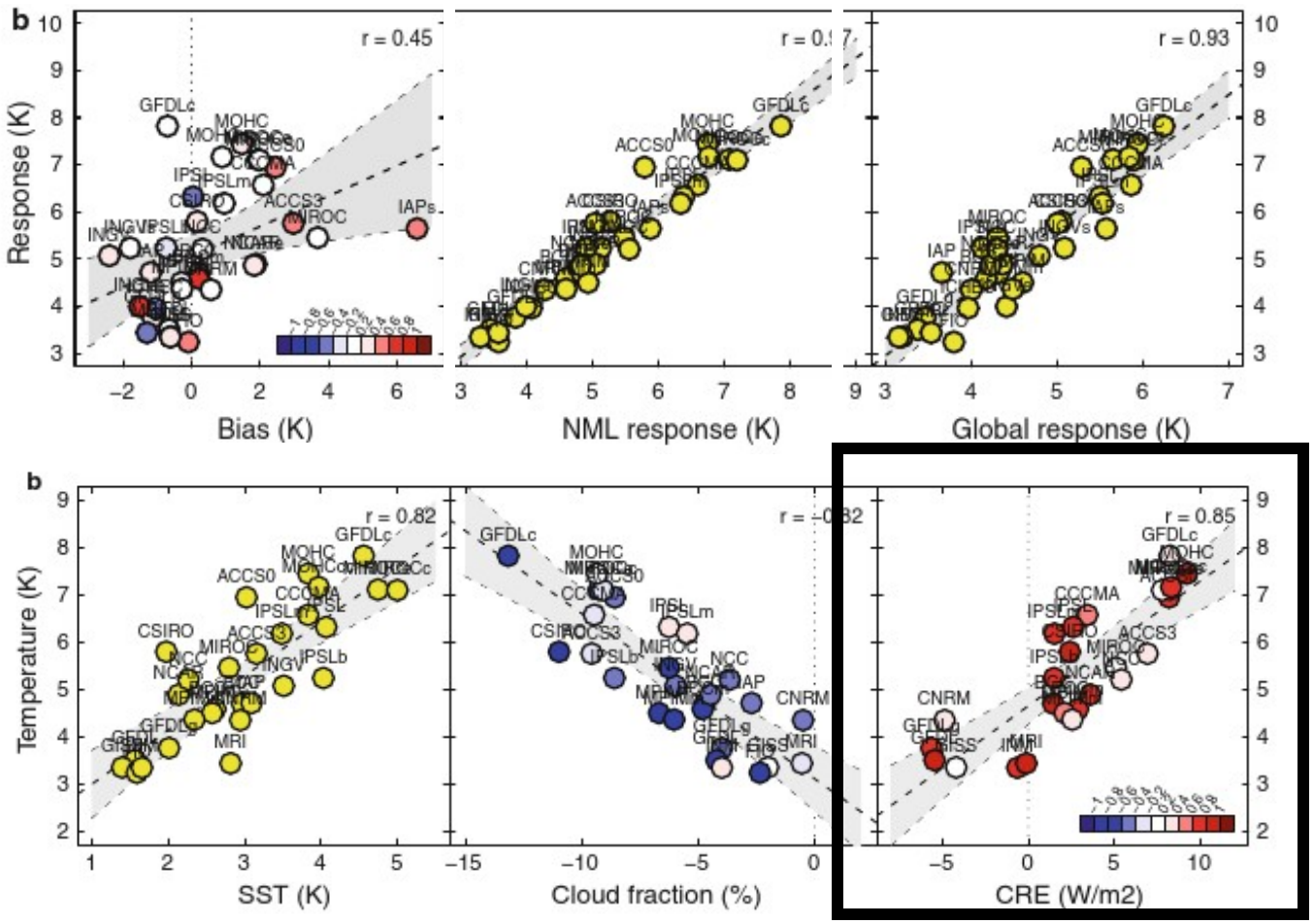






Cattiaux et al. 2013

European average JJAS T2m *changes* vs…



The projected JJAS warming over Europe

- ❑ shows a significant link with T2m biases
- ❑ scales with global warming
- ❑ shows a strong link with the projected CRF response

Cattiaux et al. 2013

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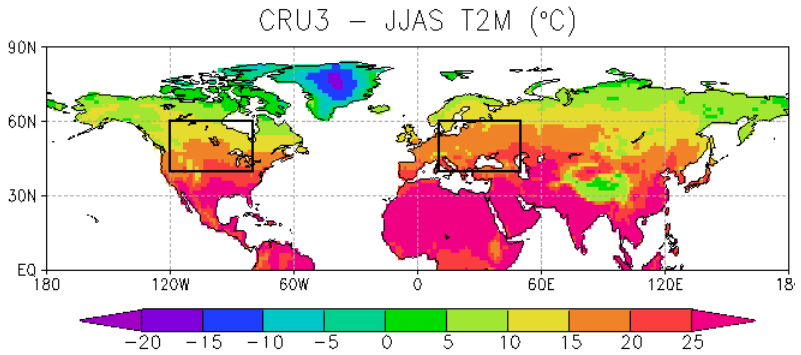
Motivations

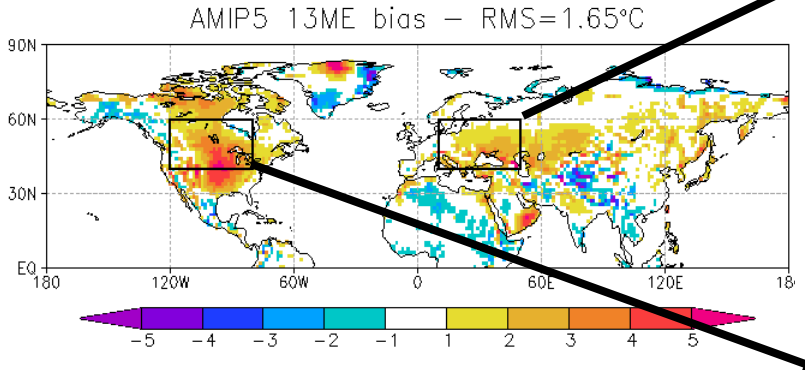
- What is the cloud contribution to (the inter-model spread in) the mid-latitude warm bias ?
- What is the cloud contribution to (the inter-model spread in) the mid-latitude projected surface warming ?
- Can we constrain the projections ?

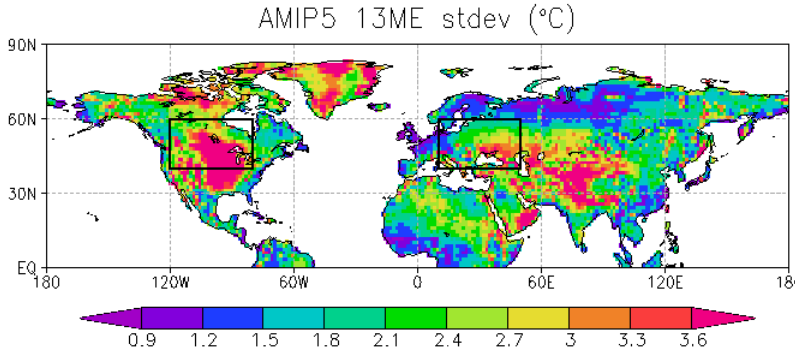
Data (30-yr JJAS averages)

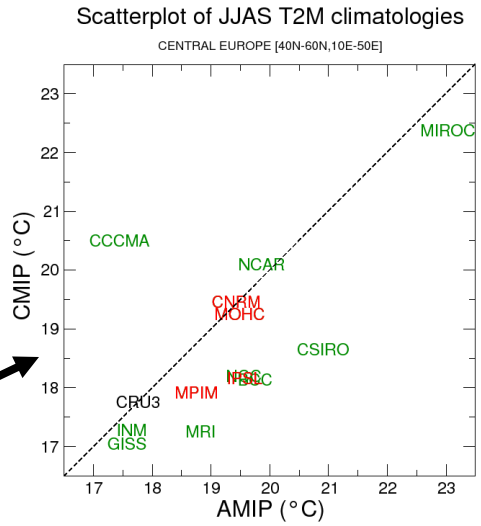
- 13 CMIP5 models also integrated in AMIP mode
- 1 simulation per model (no ensemble)
- Historical (1979-2008), RCP8.5 (2071-2100) and 1%CO2 (yrs 19-48 & 111-140)
- 4 « EUCLIPSE models » with CFMIP2 & COOKIE expts: CNRM, IPSL, MOHC, MPIM
- Gridded observations & reanalyses: **T2m** (CRU_TS3), **CRFSW** (SRB3, 1984-2007), **EF**=LE/(LE+H) (ERAI)

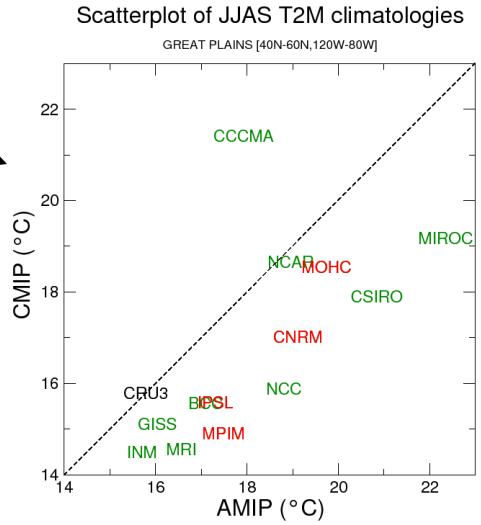
Present-day JJAS T2m











- ❑ Warm bias over Central Europe (CE)
- ❑ Worse over the US Great Plains (GP)
- ❑ Worse in AMIP than in CMIP expts
- ❑ Also true for « EUCLIPSE models »

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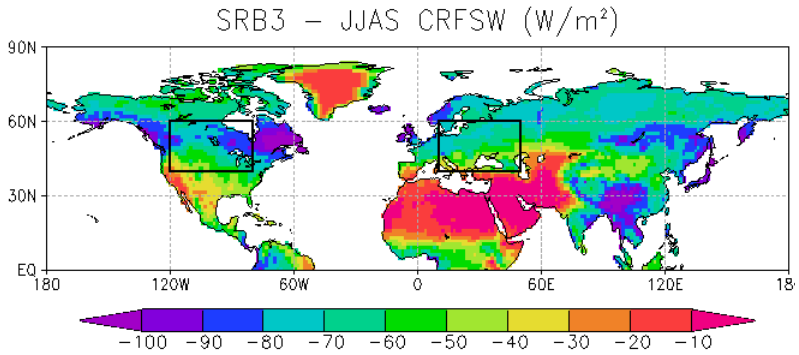
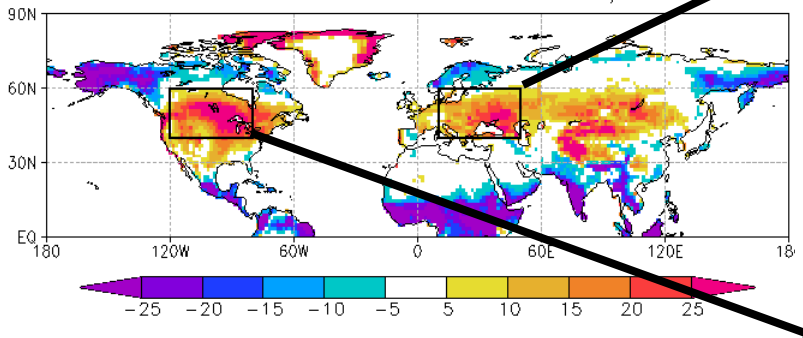
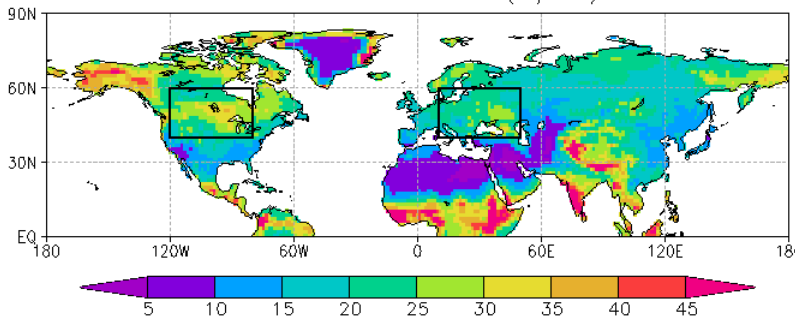
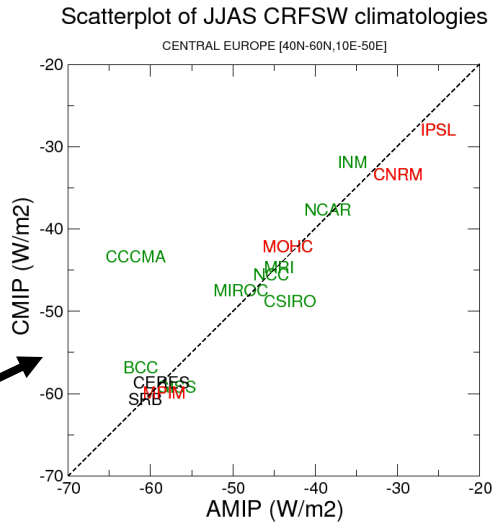
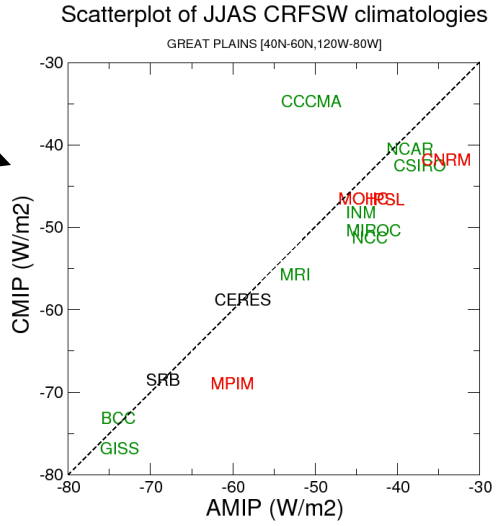
Present-day JJAS CRFSW











- Lack of **negative** CRFSW over both CE & GP
- Biases are often beyond observation uncertainties
- Biases are similar in AMIP & CMIP expts

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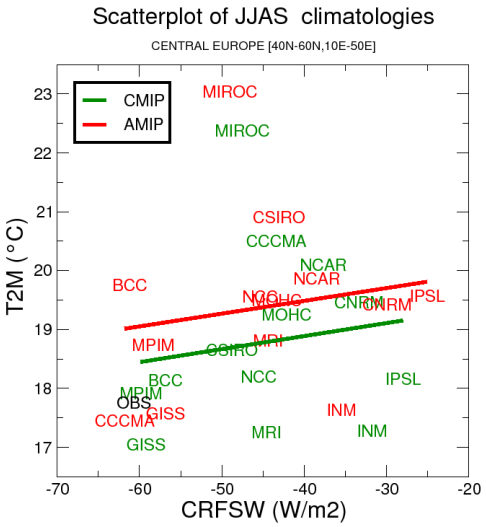
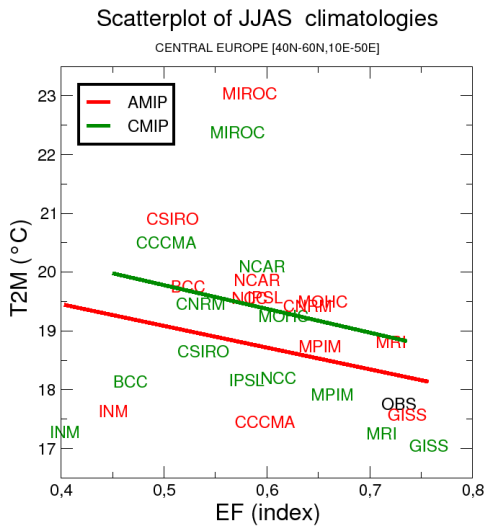
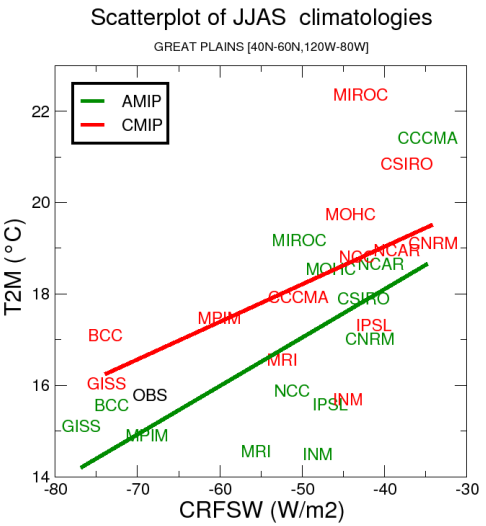
Present-day JJAS T2m vs … (AMIP & CMIP)

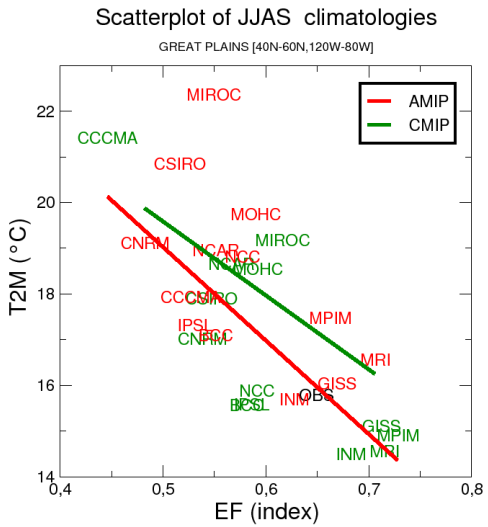
Central Europe

Great Plains









CRFSW

EF

- CRFSW does not explain the whole spread in CMIP5 models
- Stronger link over GP (less aerosols?) than over CE
- Similar links between biases in T2m and **EF=LE/(LE+H)**

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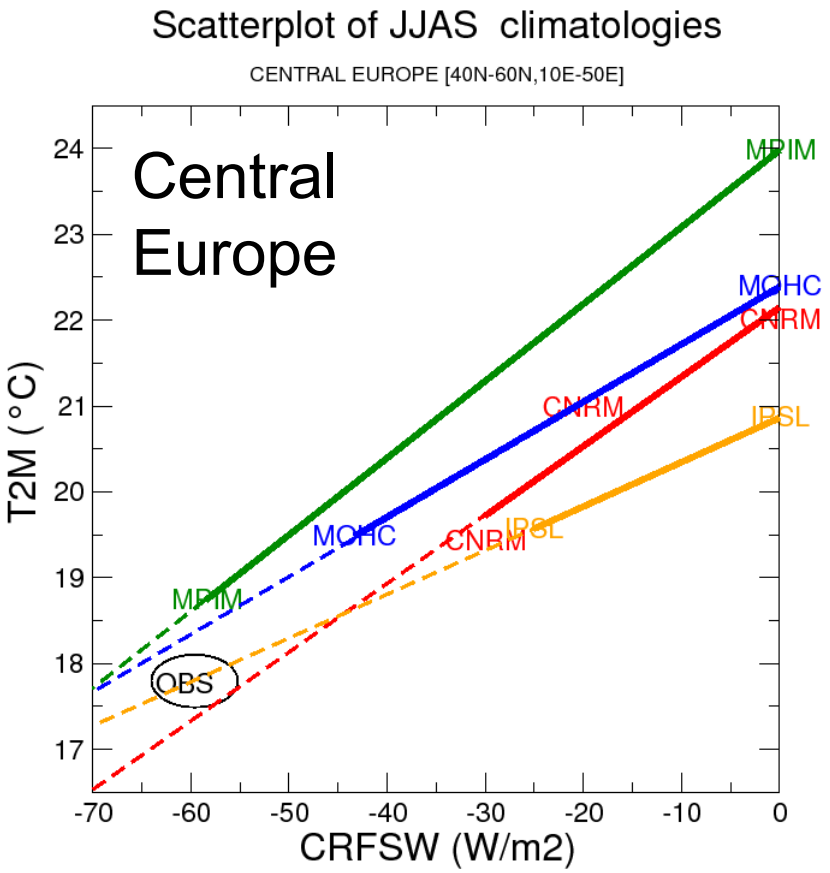
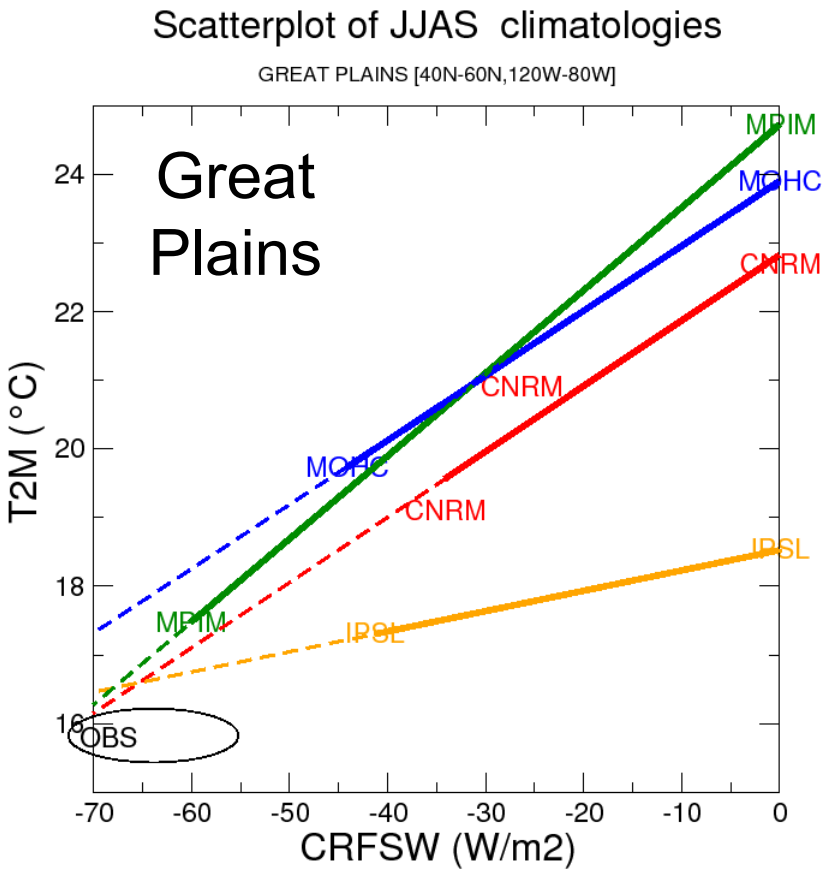
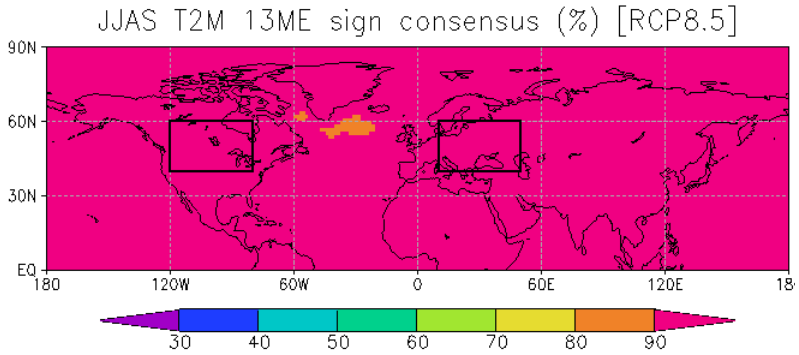
JJAS T2M vs CRFSW (AMIP vs OffAMIP)

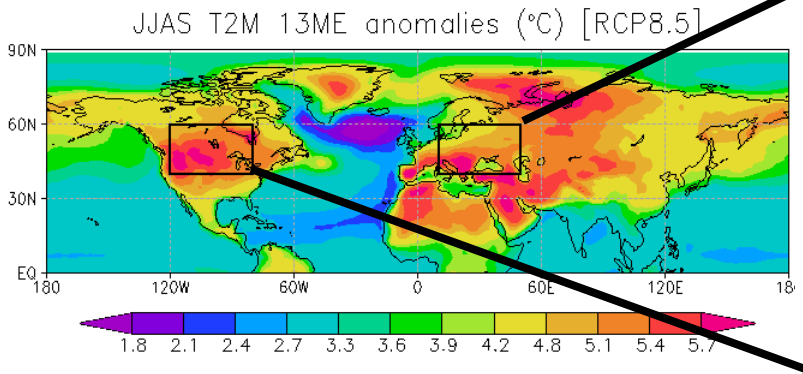


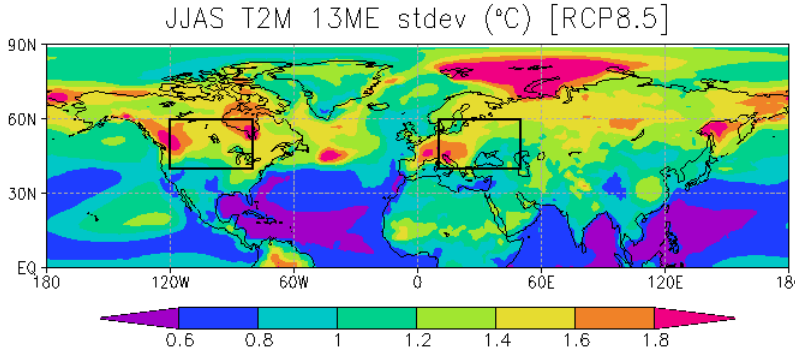


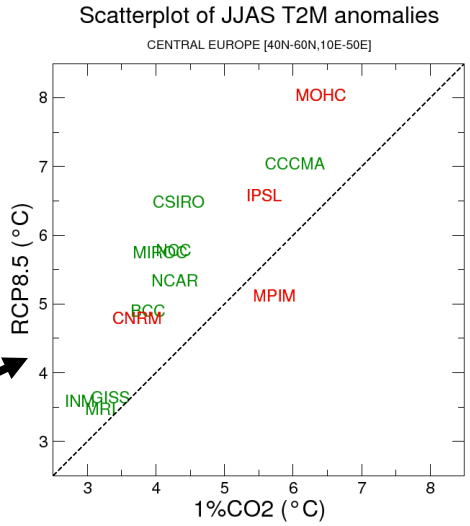
❑ Assuming a linear relationship between CRFSW and T2m, CFMIP2 & COOKIE expts suggest that T2m biases are largely explained by cloud biases over both CE (left) and GP (right)

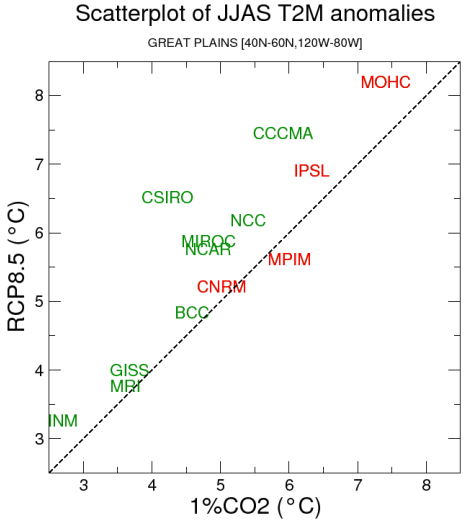
JJAS T2m *anomalies* (RCP8.5 & 1%CO2)











- Projected warming is not uniform
- Spread is not uniform and has <u>not</u> the same pattern as for model biases
- Spread is dominated by « sensitivity »

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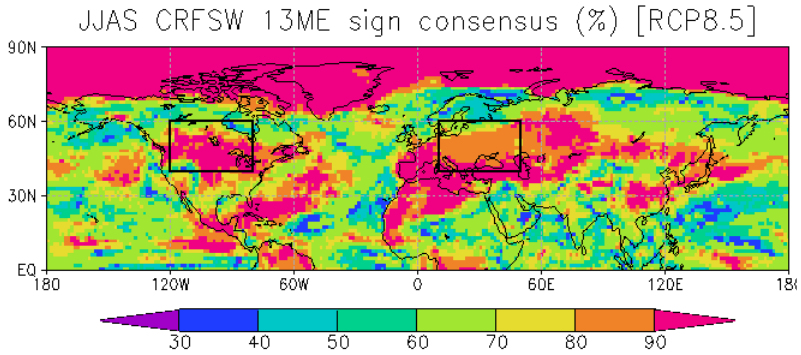
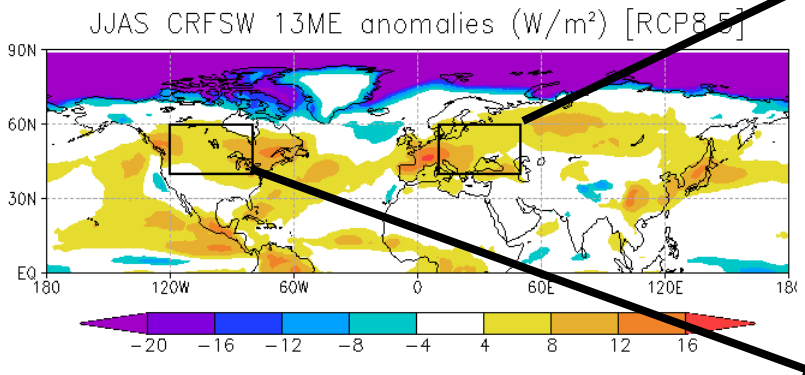
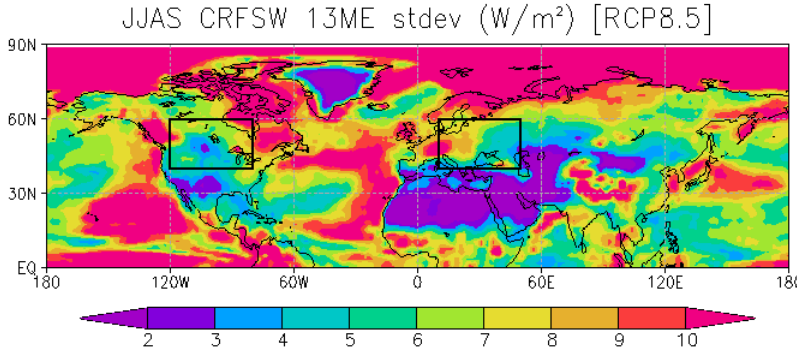
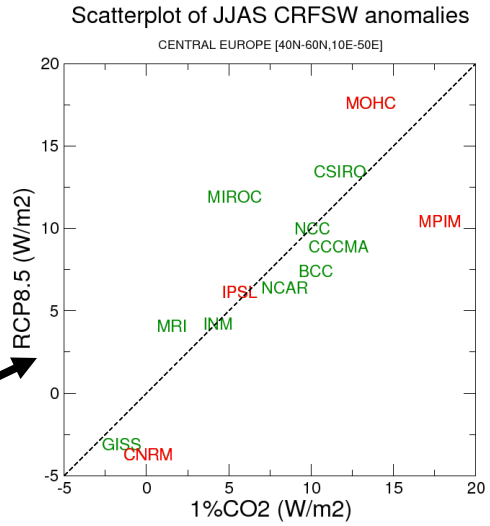
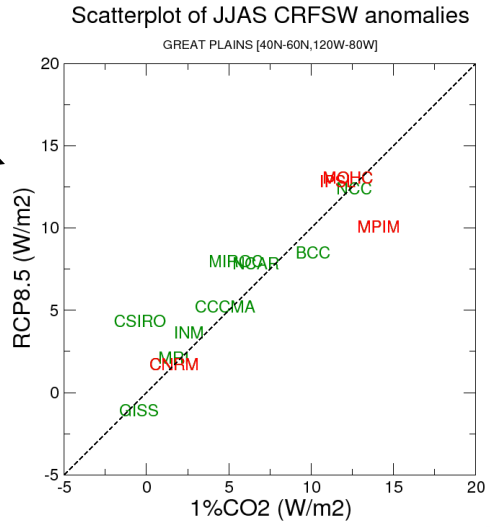
JJAS CRFSW *anomalies* (RCP8.5 & 1%CO2)











- Widespread increase in CRFSW in the mid-latitudes
- Spread is not uniform
- Spread is dominated by « sensitivity »

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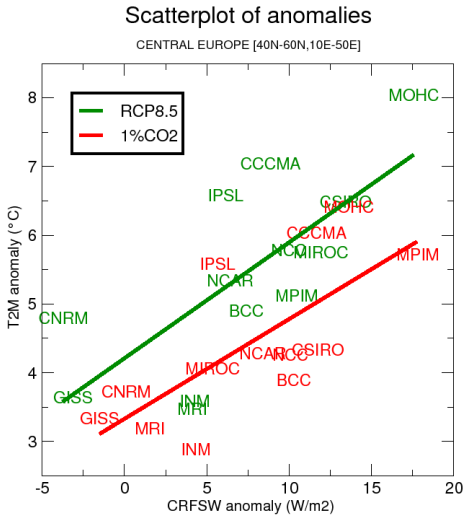
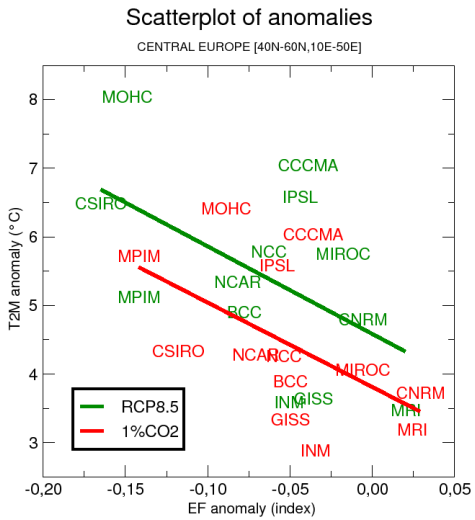
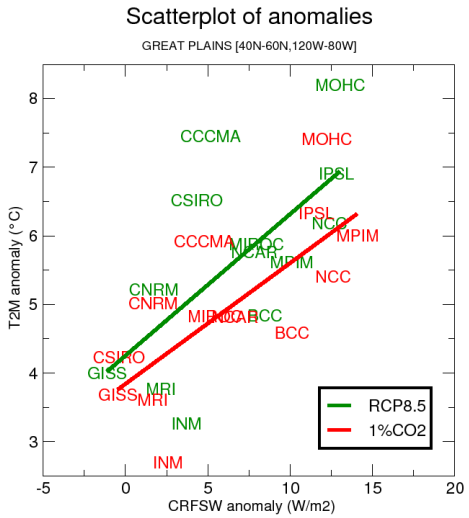
JJAS T2m *anomalies* vs… (RCP8.5 & 1%CO2)

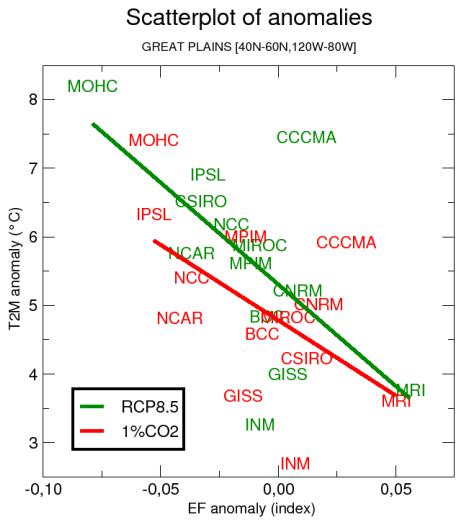
Central Europe

Great Plains









CRFSW

EF

- CRFSW contributes to the inter-model spread of T2m anomalies over both CE & GP
- Also true for **EF=LE/(LE+H)**
- Similar links in RCP8.5 and 1%CO2 expts

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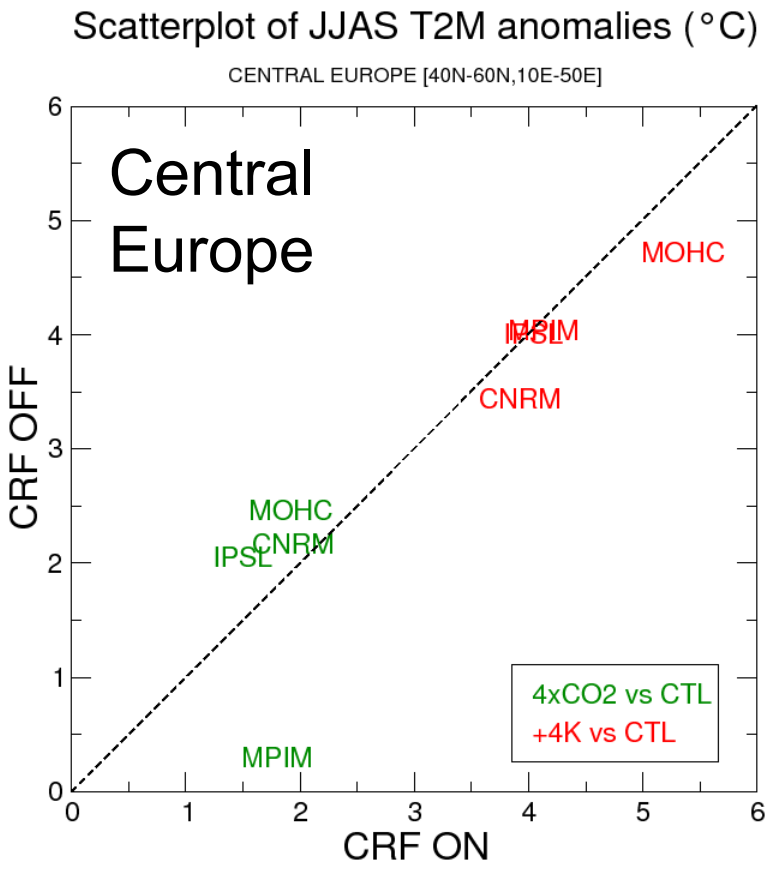
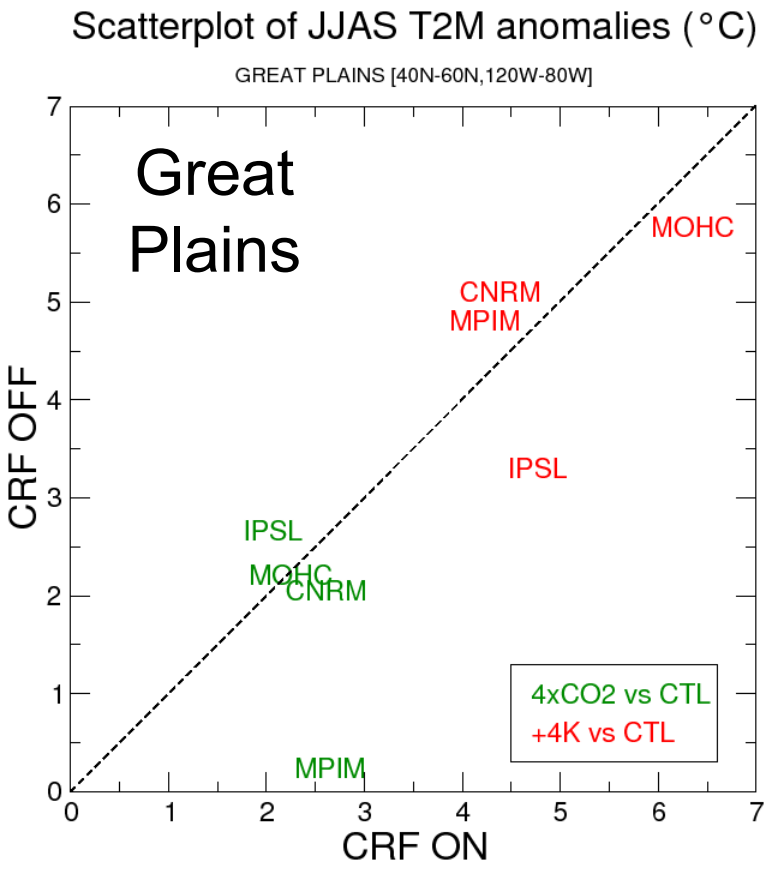
JJAS T2m *anomalies* in CFMIP2 & COOKIE expts





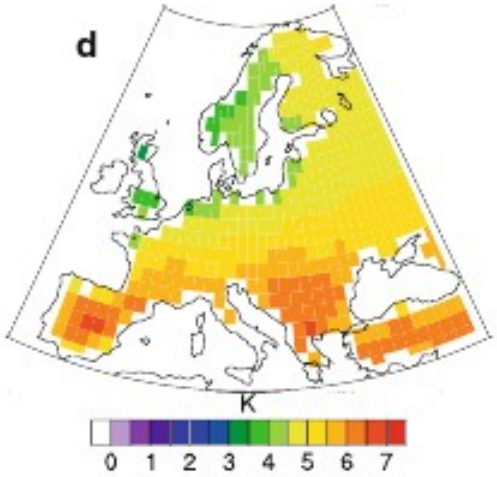
- ❑ No clear reduction of inter-model spread in COOKIE expts
- ❑ Weak response of MPIM to 4xCO2 in COOKIE expts ?

Conclusion
about the boreal summer mid-latitudes in CMIP5 models

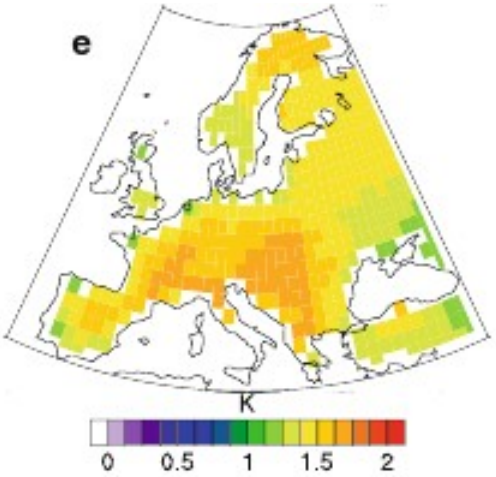
- CRF shows little improvements in CMIP5 vs CMIP3 (e.g Lauer and Hamilton 2013) and is partly responsible for the warm bias found in the ensemble mean climatology;
- Projected surface warming is strongly model dependent and is sensitive (though less than in winter) to model biases in T2m (e.g. Boberg & Christensen 2012, Cattiaux et al. 2013);
- Uncertainties are not dominated by cloud feedbacks and other processes (e.g. land surface and aerosols) are also important;
- Despite suppressed cloud feedbacks, COOKIE expts do not show more consensus than CFMIP2 on the simulated surface warming;
- CFMIP and COOKIE expts are highly idealized due to the lack of SST feedbacks.

Can we constrain regional JJAS T2m changes?

MME mean



MME stdev



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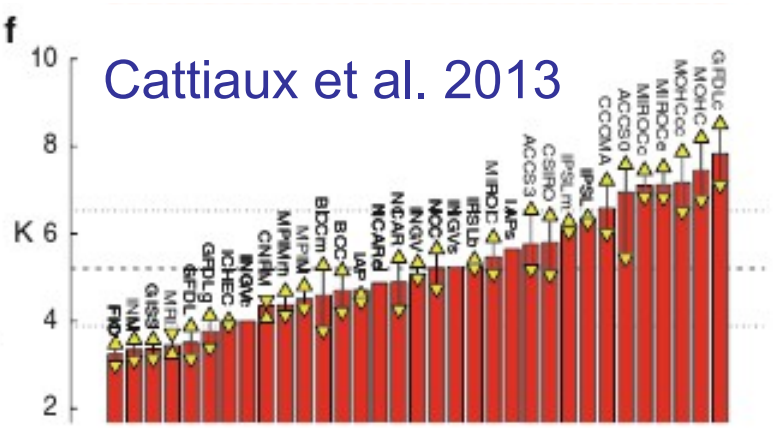

Yes, using a combination of observations and metrics:

- Temperature (Boberg and Christensen 2012, Stott et al. 2013), radiation, sensible heat flux (Stegehuis et al. 2013), latent heat flux…

- Mean or conditional bias (Boberg and Christensen 2012), annual cycle (Hall and Qu 2006), interannual variability (Douville et al. 2006, O'Gorman 2012), trends (Stott et al. 2013)…

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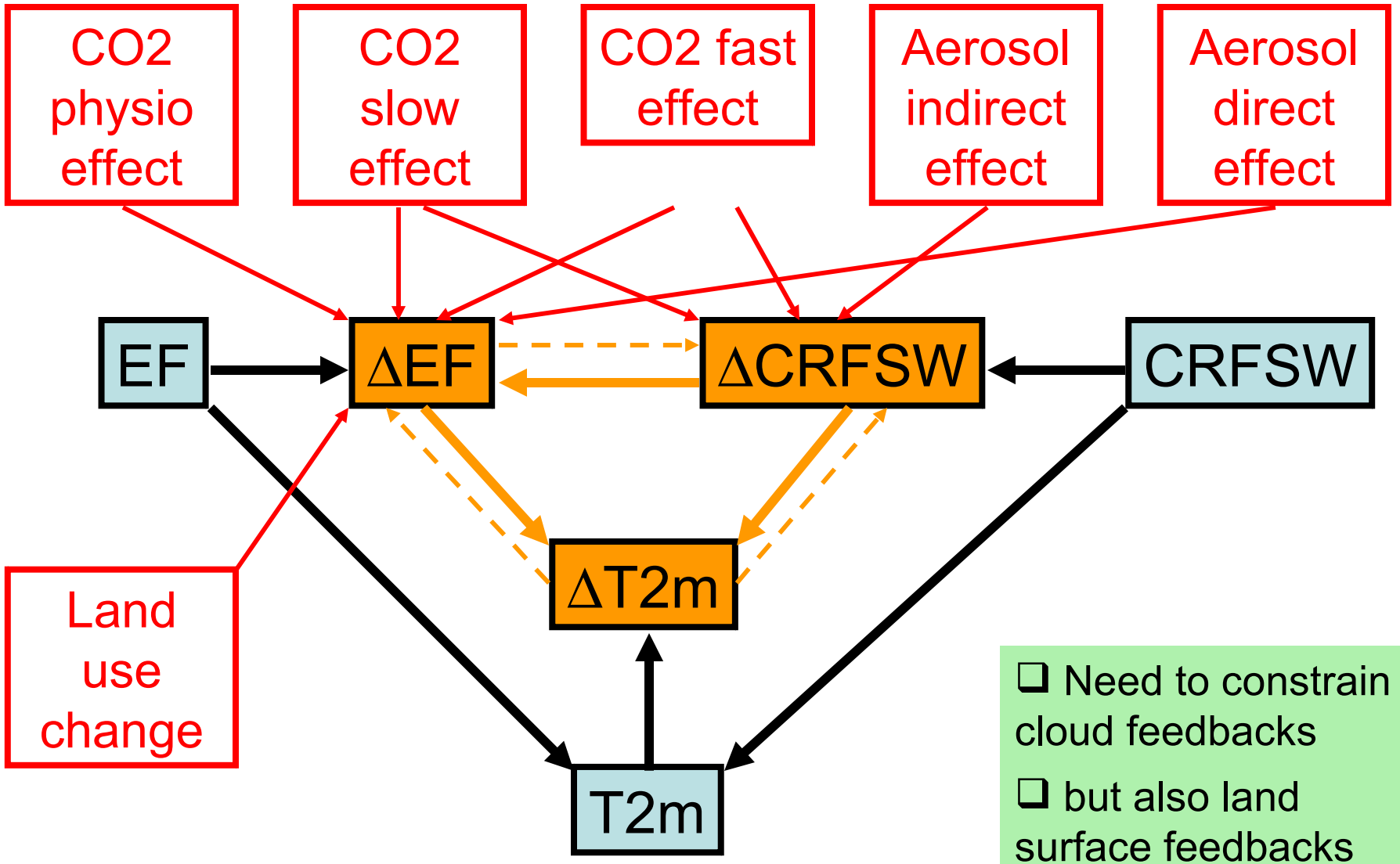

- Need to constrain cloud feedbacks
- but also land surface feedbacks