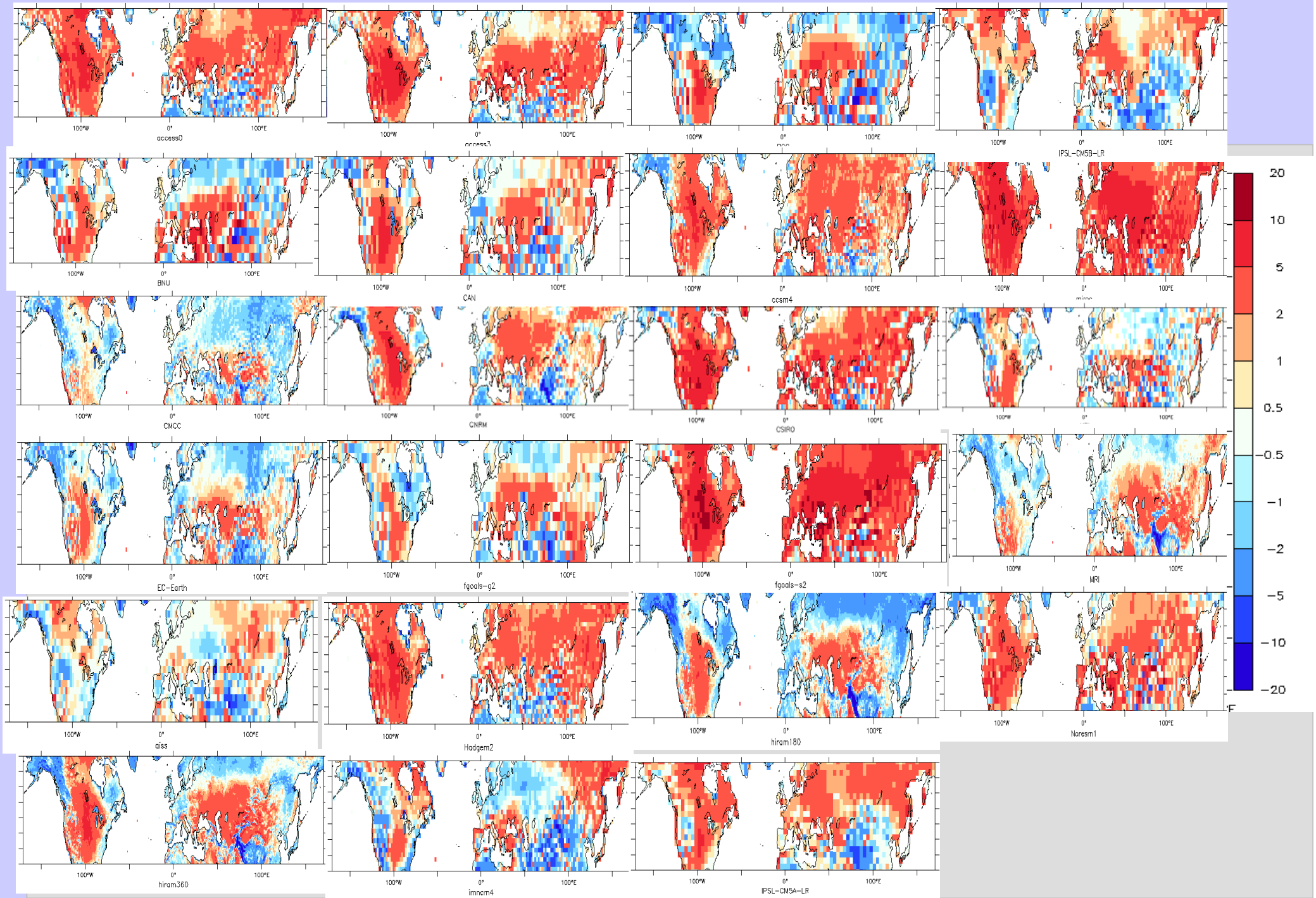
Analyse of the mid-latitude warm bias in AMIP simulations, consequences for climate projections

F.Cheruy
A. Campoy, A. Ducharne, F. Hourdin

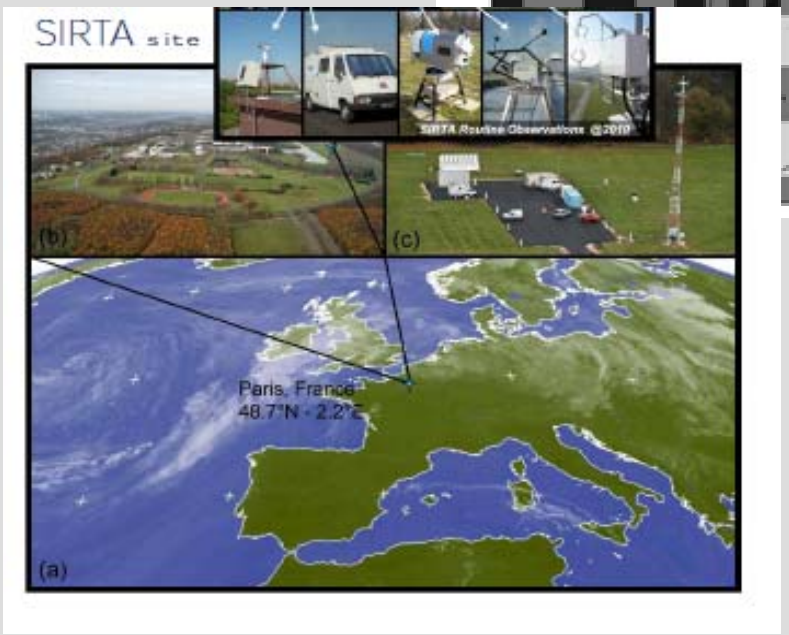
CMIP5 2m-T-2m CRU JJA (AMIP)

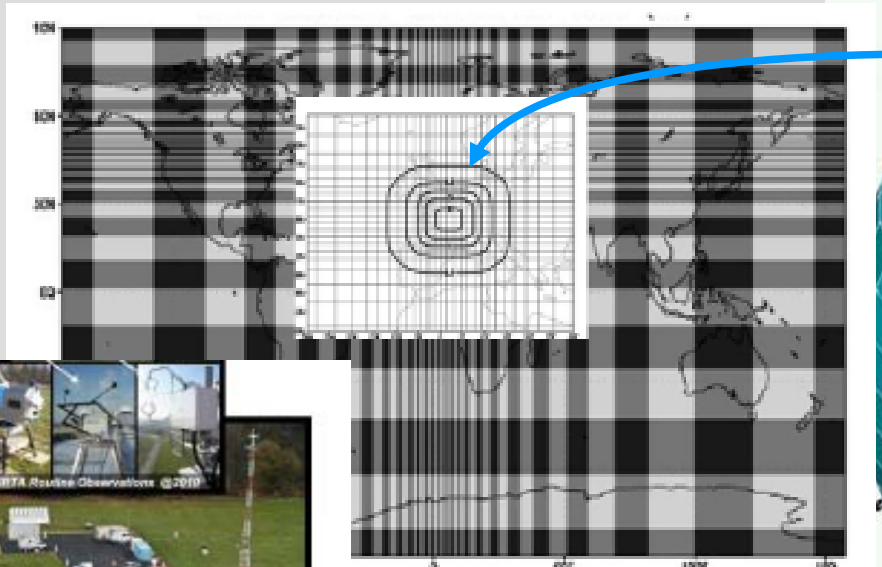


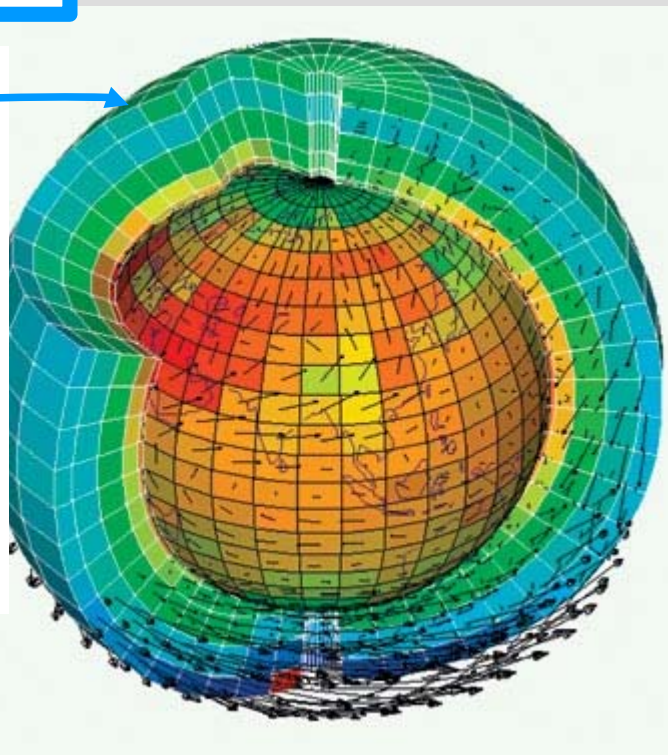
- Process analysis using instrumented site observations (SIRTA) and LMDZ/IPSL model
- The warm biais in the AMIP-CMIP5 simulations
- Consequences on the climate projections
- Summary

Process oriented evaluation of IPSL-CM at the SIRTA site with a zoomed and nudged configuration

$$\frac{\partial X}{\partial t} = F(X) + \frac{X^a - X}{\tau}$$







4 versions (2 atmosphere, 2 hydrology)

Table 2 LMDZ configurations used for the simulations

Name	Surface hydrology	Boundary layer	Cloud scheme	Convection scheme
SP-ORC2	Ducoudré et al. (1993) Choisnel et al. (1995)	Louis (1979) Laval et al. (1981)	Bony and Emanuel (2001)	Emanuel (1991)
SP-ORC11	De Rosnay et al. (2002) d'Orgeval et al. (2008)	Louis (1979) Laval et al. (1981)	Bony and Emanuel (2001)	Emanuel (1991)
NP-ORC2	Ducoudré et al. (1993) Choisnel et al. (1995)	Rio et al. (2012) Yamada (1983)	Jam et al. (2012)	Hourdin et al. (2012b) Grandpeix and Lafore (2010)
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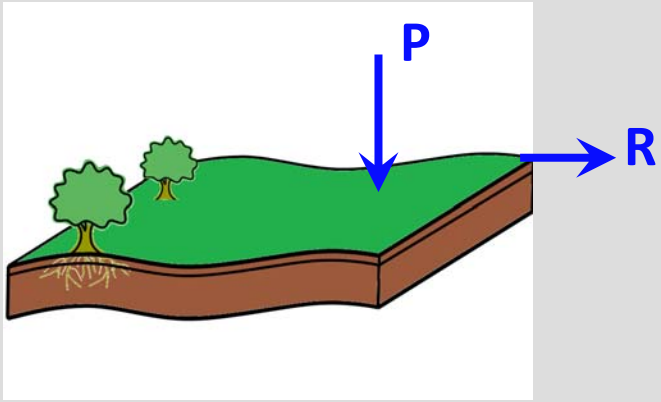
Cheruy et al. 2013, Clim Dyn

Two versions of soil hydrology

Old = ORC2

Ducoudré et al., 1993; de Rosnay et al. 1998



- **Conceptual description of soil moisture storage**
- **2-m soil and 2-layers**
- Top layer can vanish
- Constant available water holding capacity (between FC and WP)
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We just diagnose a drainage as 95% of runoff for the routing scheme

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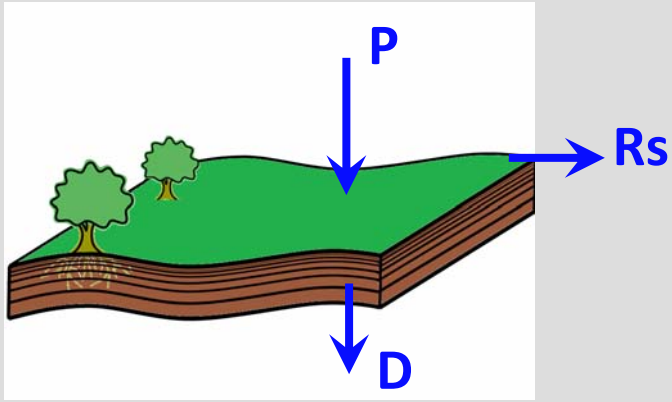

- **Physically-based description of soil water fluxes using Richards equation**
- **2-m soil and 11-layers**
- Formulation of Fokker-Planck
- Hydraulic properties based on van Genuchten-Mualem formulation
- Related parameter based on texture (fine, medium, coarse)
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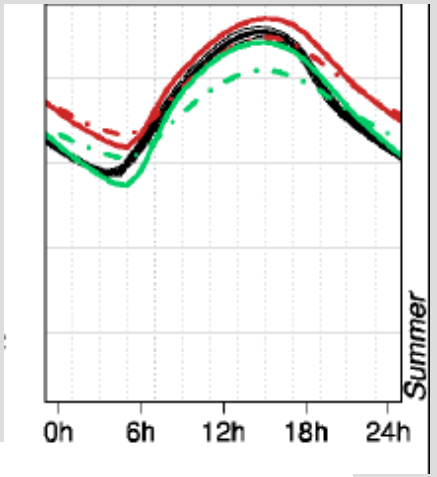
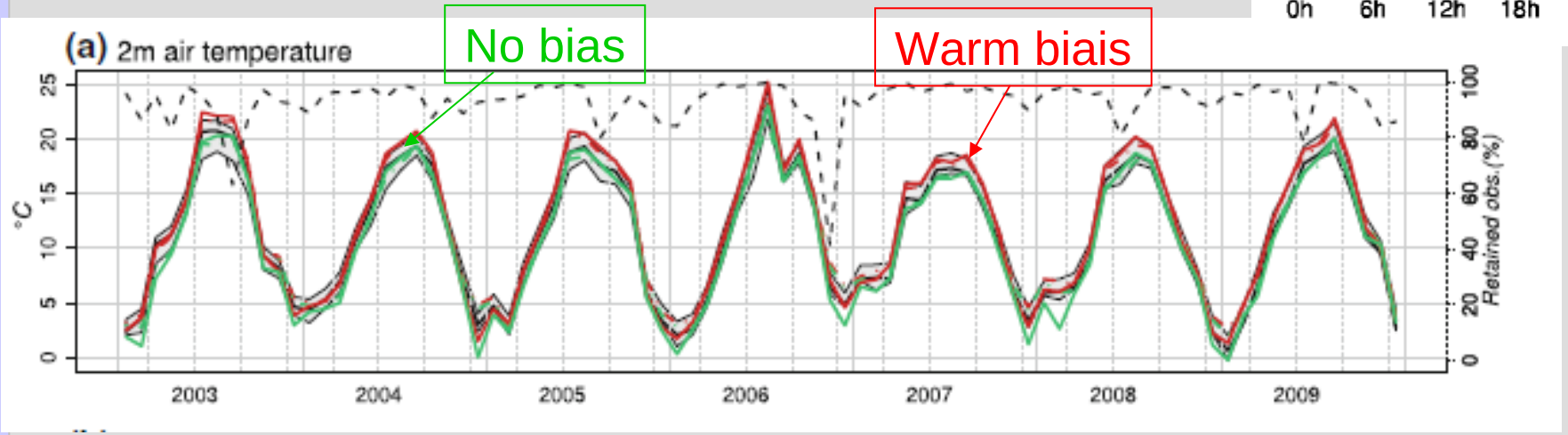
- Free drainage at the bottom

Towards the reduction of the summer temperature bias

Mean diurnal cycle

New hydrology model (11 layers)
Old hydrology model (2 layers)
New atmospheric model (LMDZ5B)
Old atmospheric model (LMDZ5A)
Observations at SIRTA
Available observations (in %)





Inter-annual

Towards the reduction of the summer temperature bias

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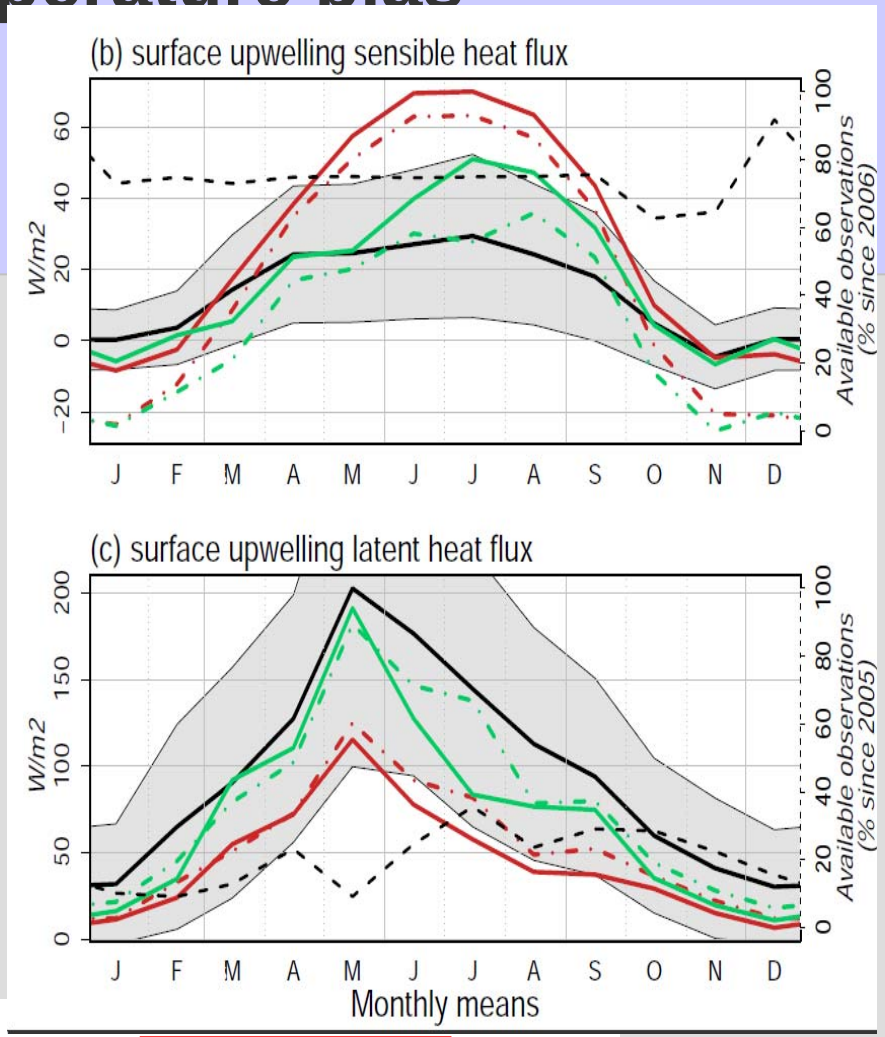

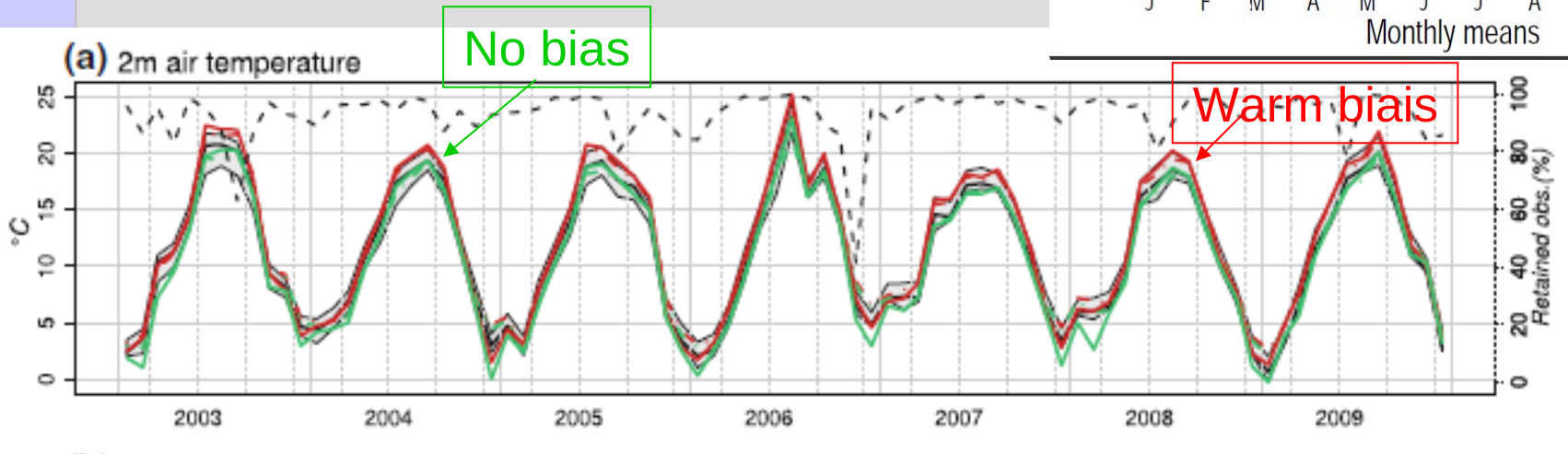

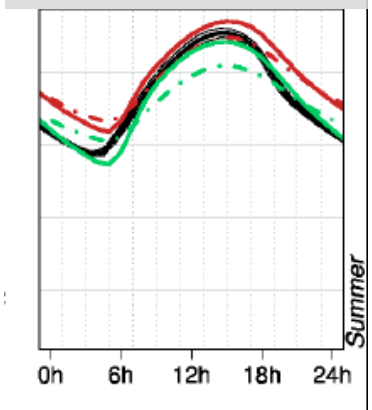

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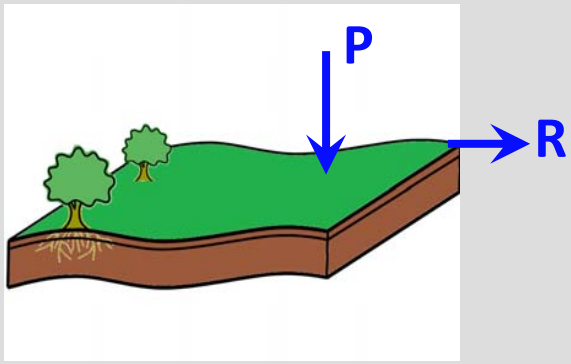
Evaporation limited by a resistance to soil evaporation



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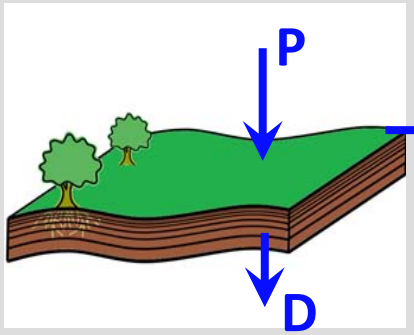
Evaporation limited by soil water diffusion to the top layer



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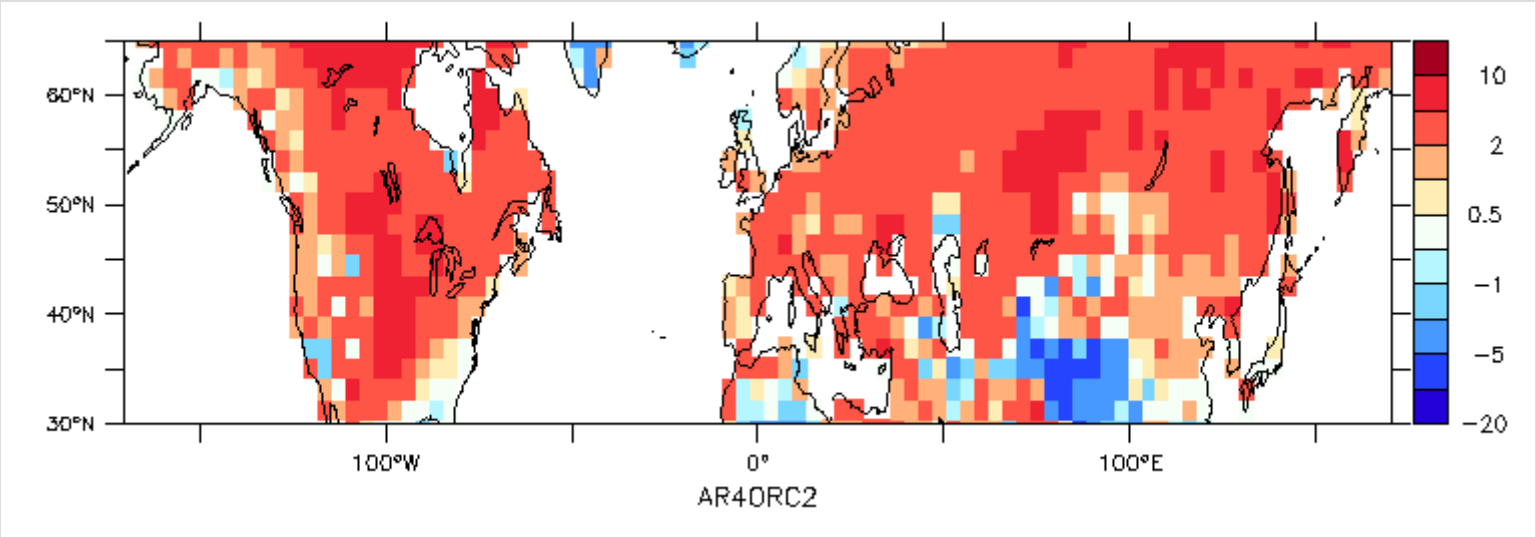
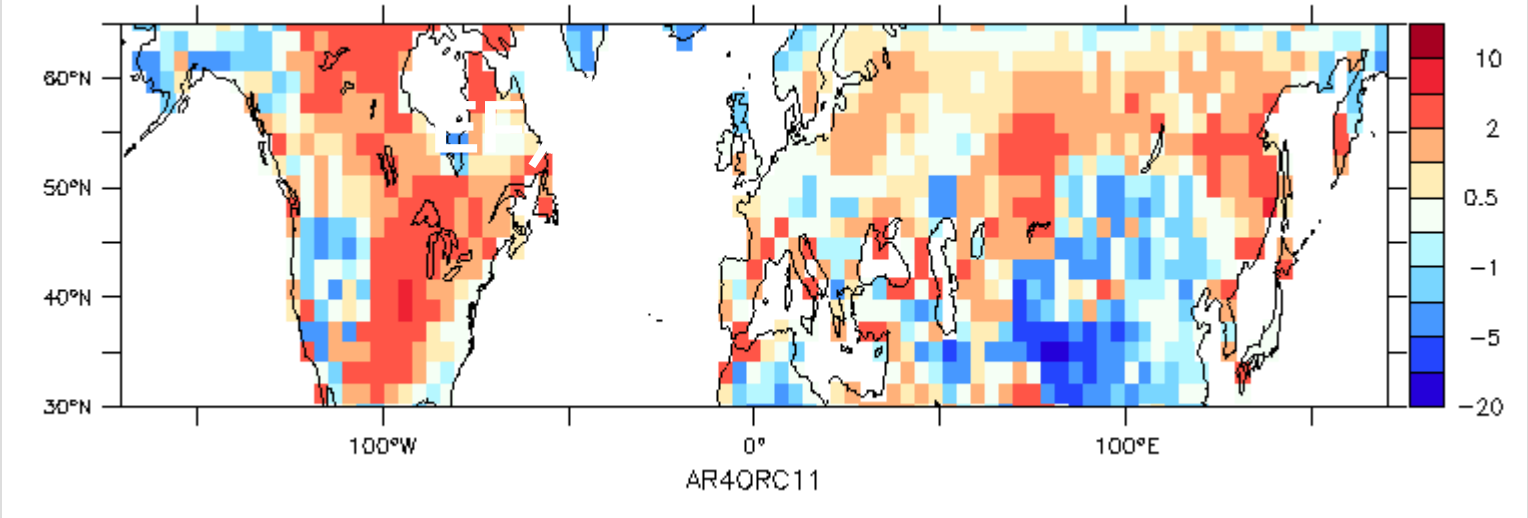
T_2m bias (vs CRU)

10 years of AMIP run, JJA





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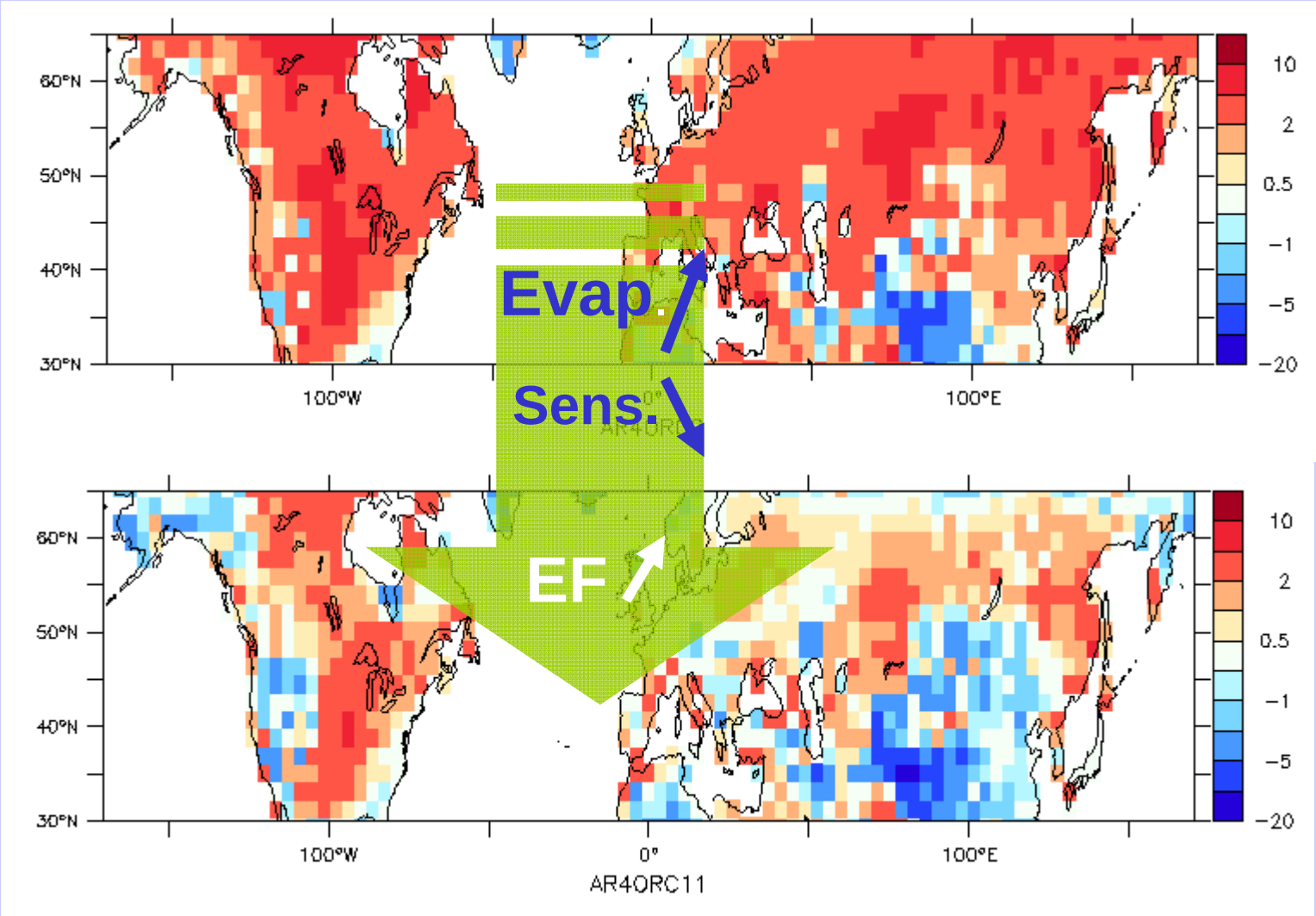

What about CMIP5 models?

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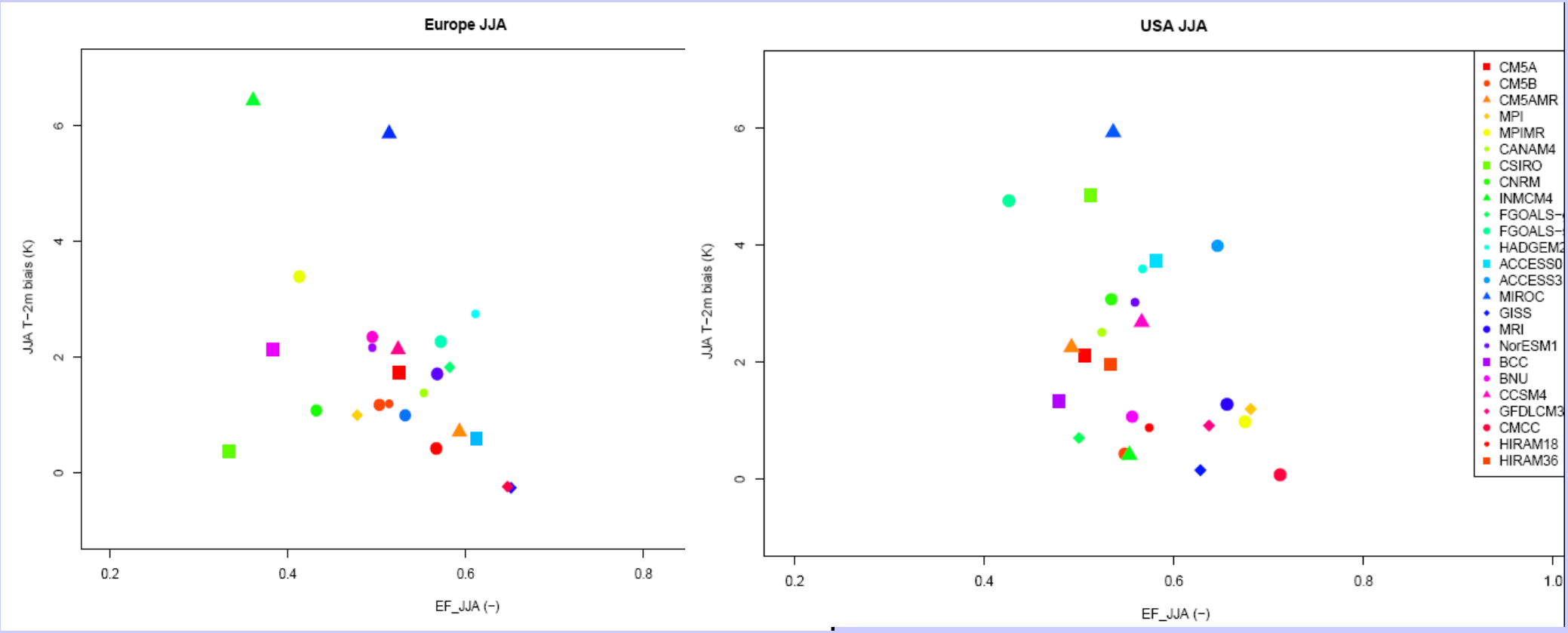
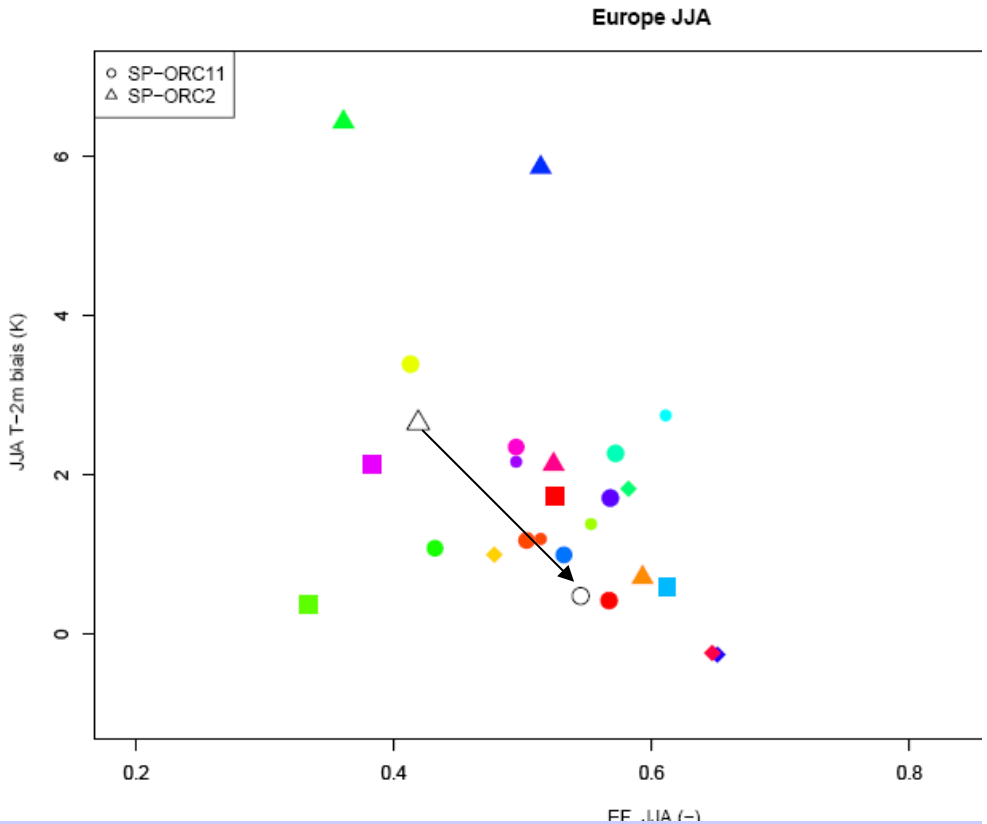
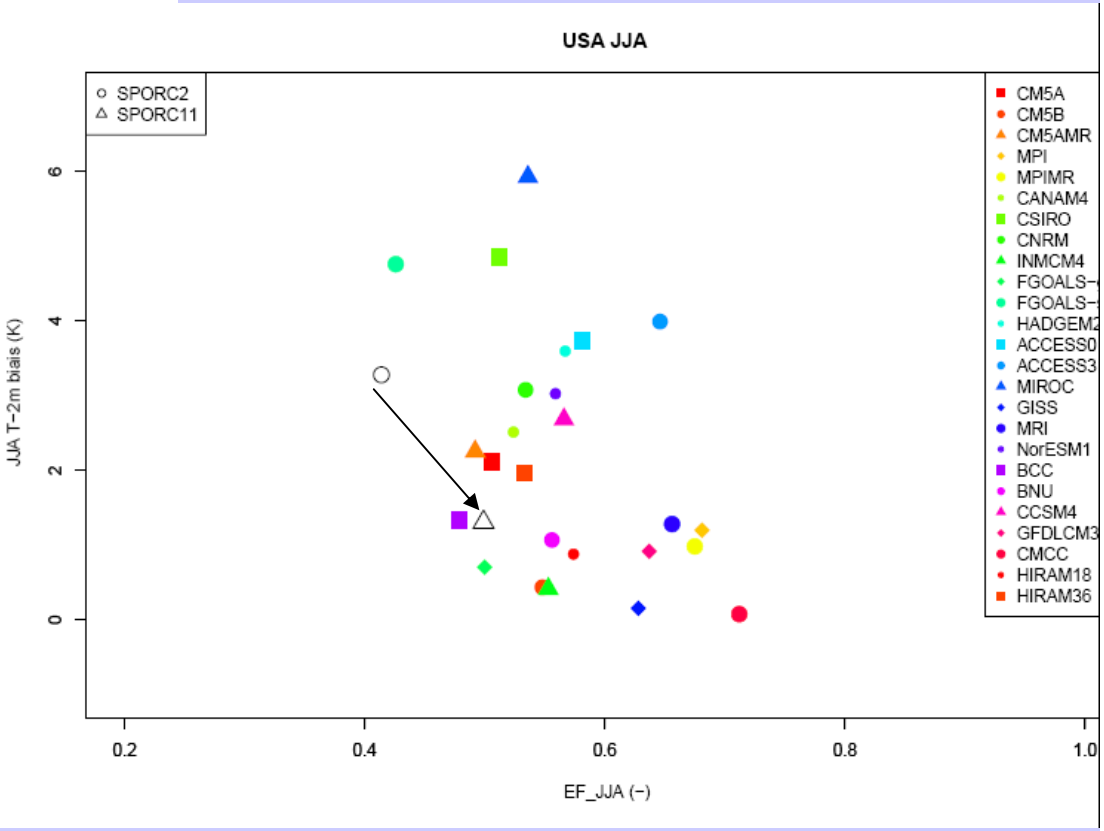
AMIP-CMIP5
MEAN BIAS versus EF



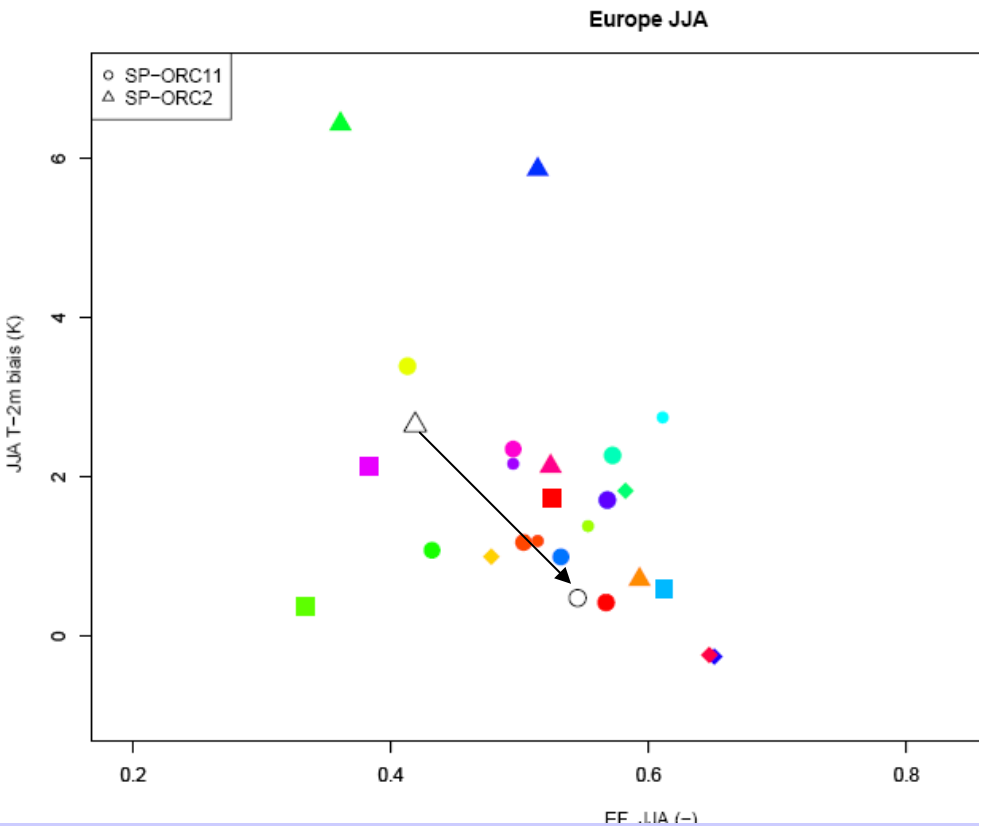
MEAN BIAS versus EF

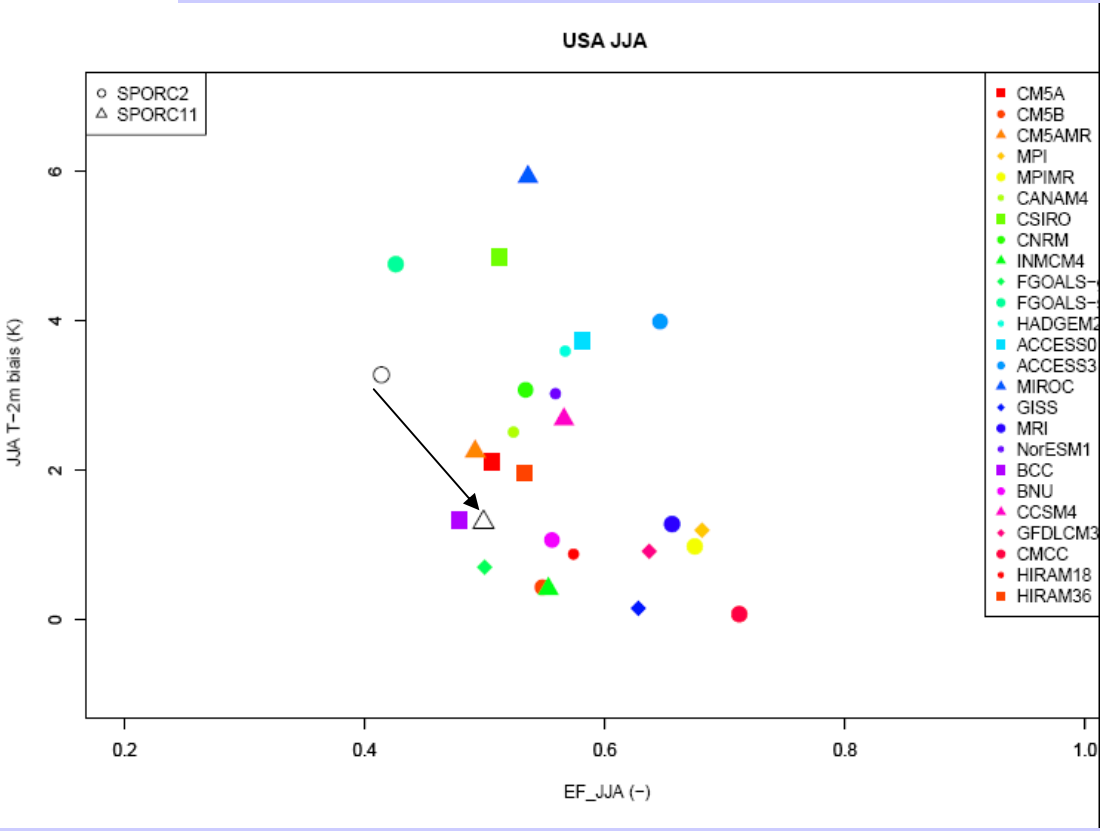


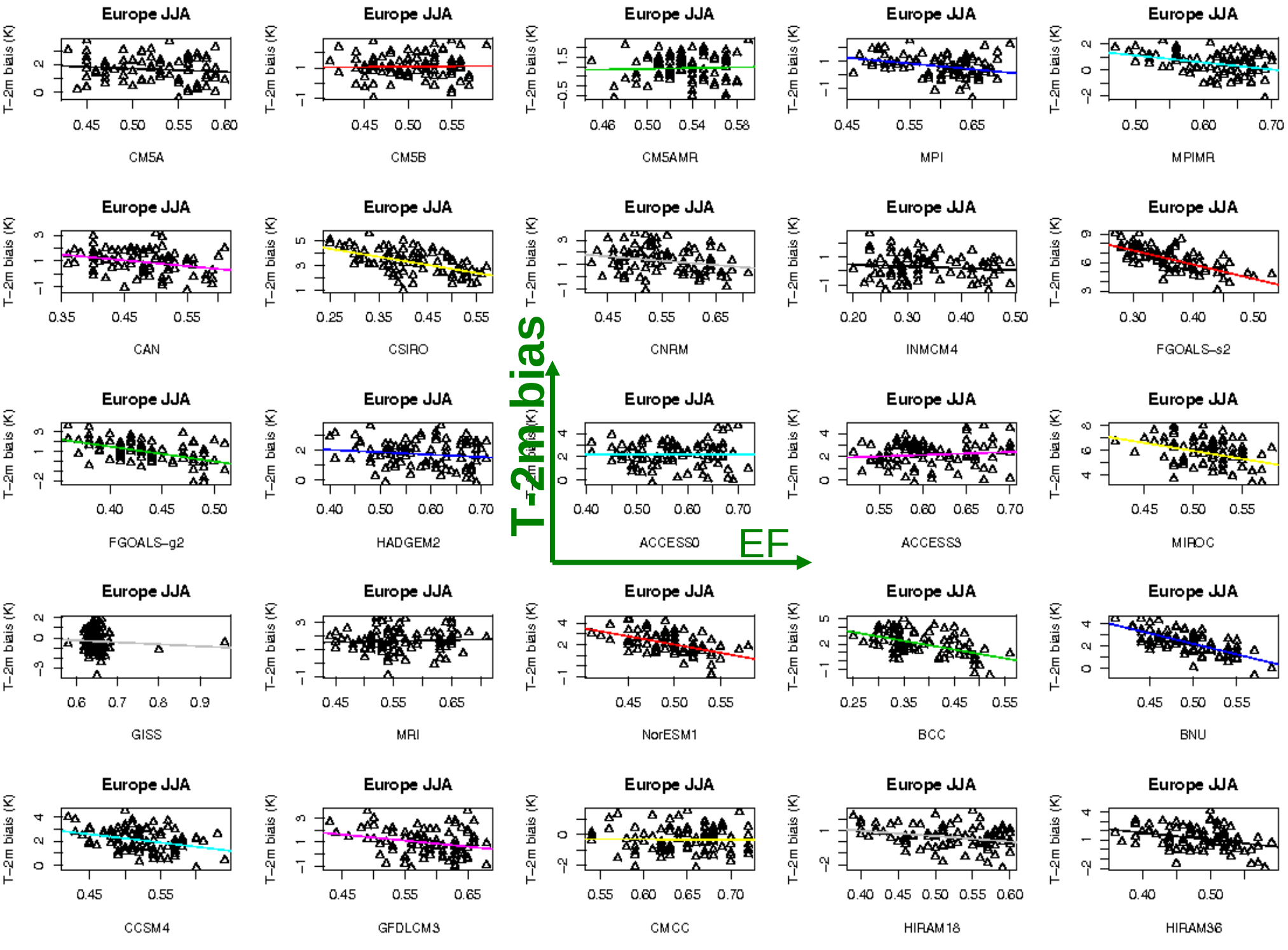


MEAN BIAS versus EF

OBS?
Fluxnet?, LandFlux Eval?

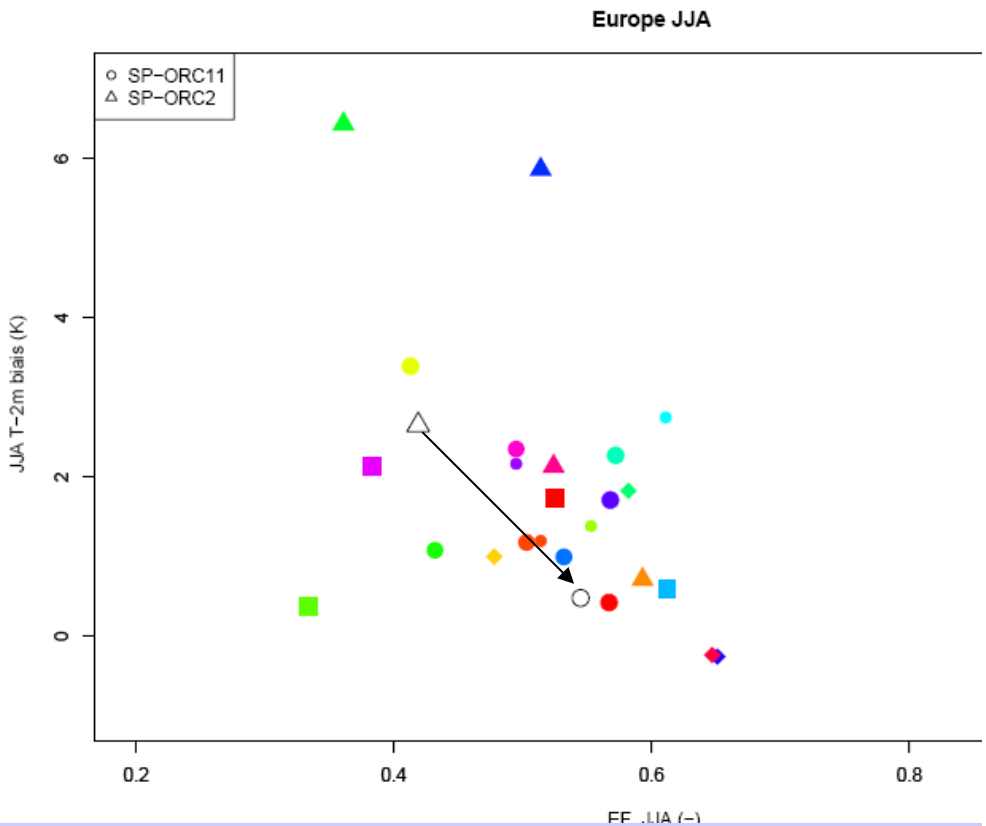


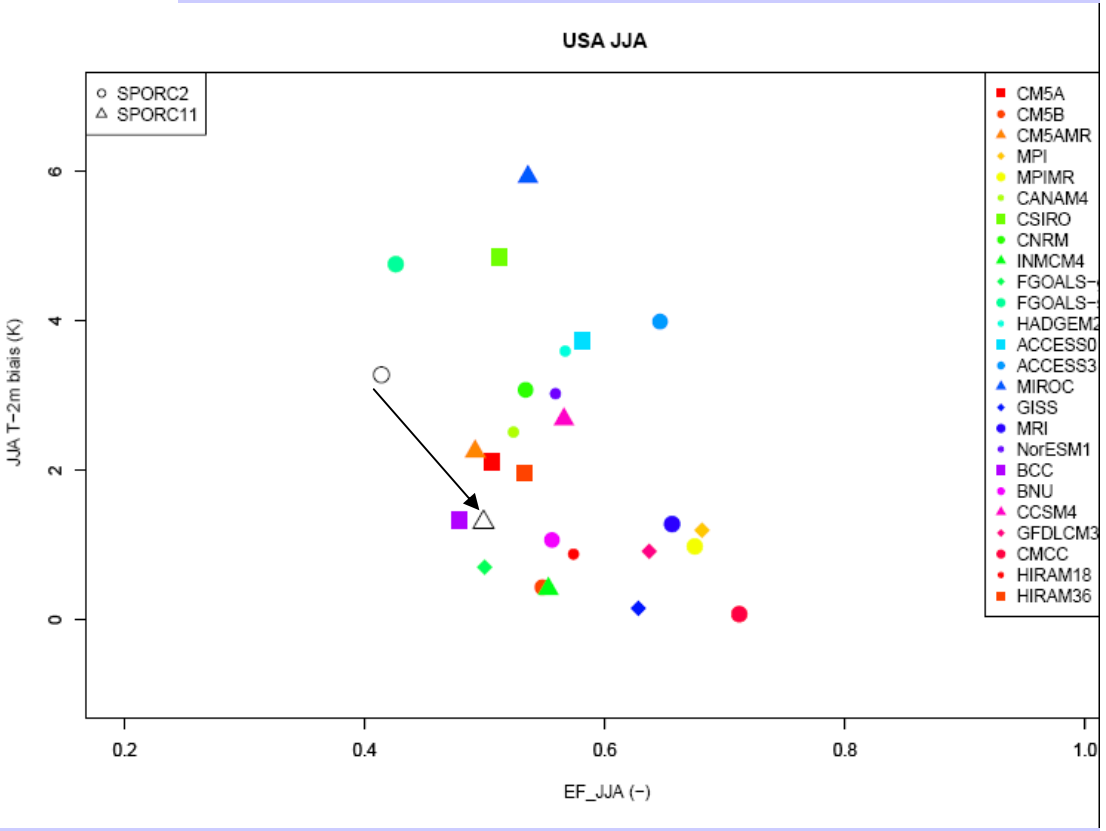



Europe JJA
T−2m biais (K)
CM5A
CM5B
CM5AMR
MPI
MPIMR
CAN
CSIRO
CNRM
INMCM4
FGOALS−s2
FGOALS−g2
HADGEM2
ACCESS0
ACCESS3
MIROC
GISS
MRI
NorESM1
BCC
BNU
CCSM4
GFDLCM3
CMCC
HIRAM18
HIRAM36
T-2m bias
EF

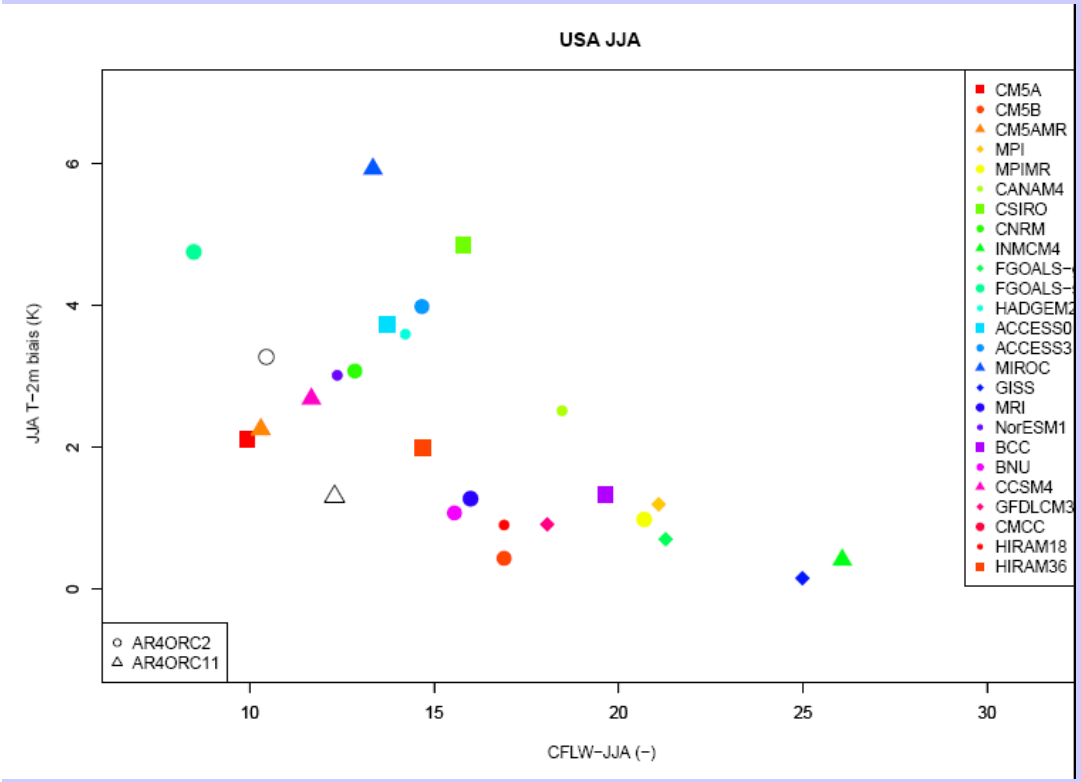
MEAN BIAS versus EF

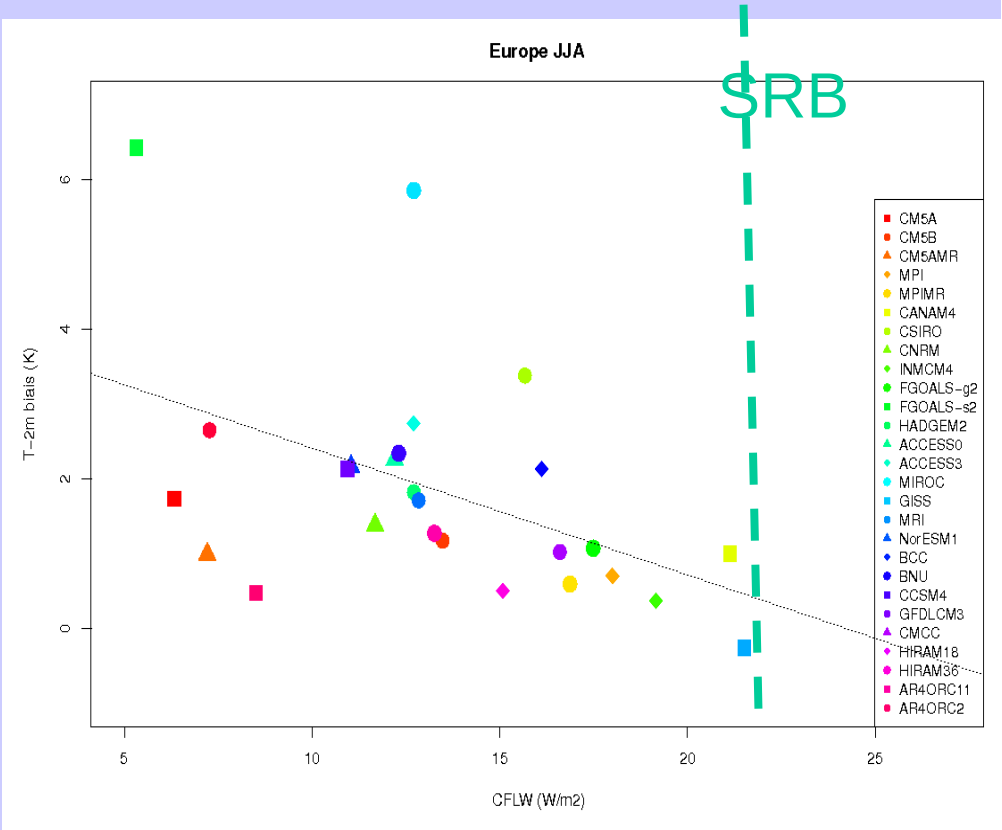
LINKED with PBL GROWTH, LCL, LFC clouds?





MEAN BIAS versus LW CRE

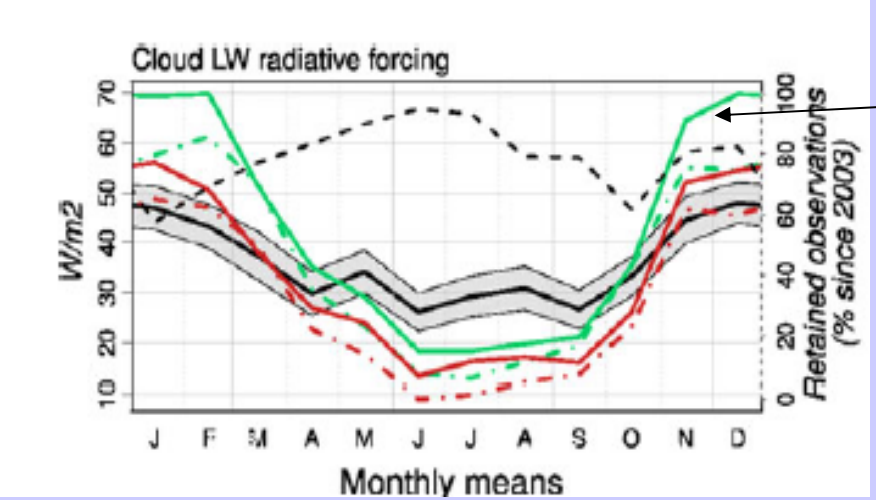




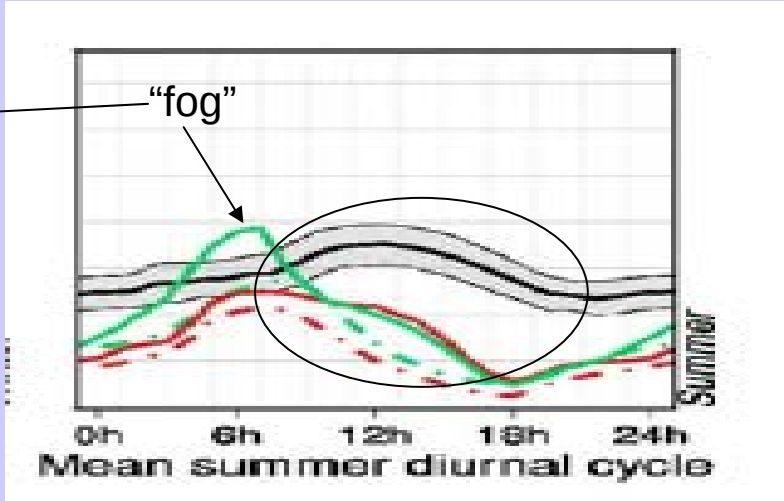
Missing clouds in summer over mid-latitudes

SIRTA

Annual cycle



Diurnal cycle (summer)



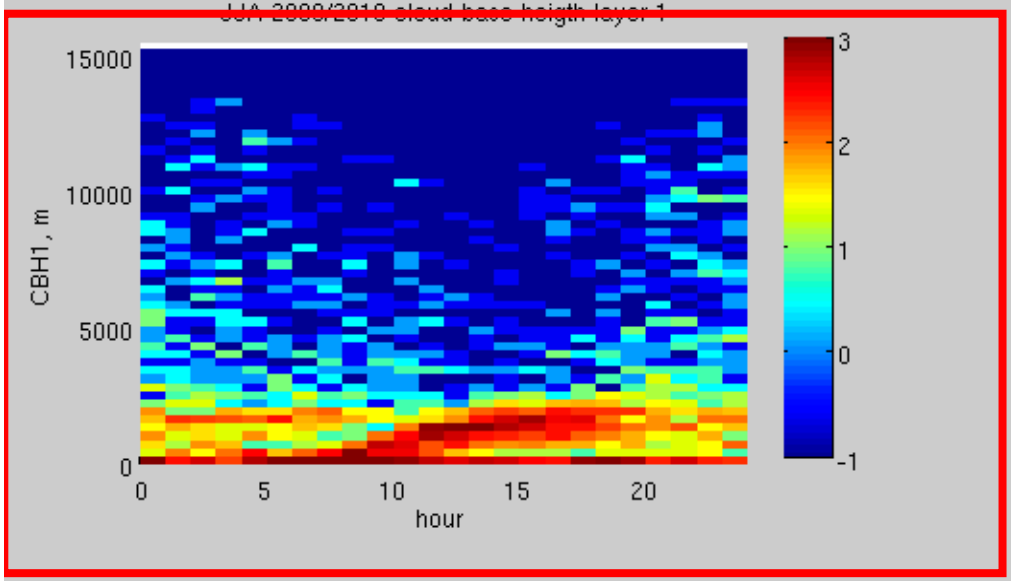
New hydrology model (11 layers)

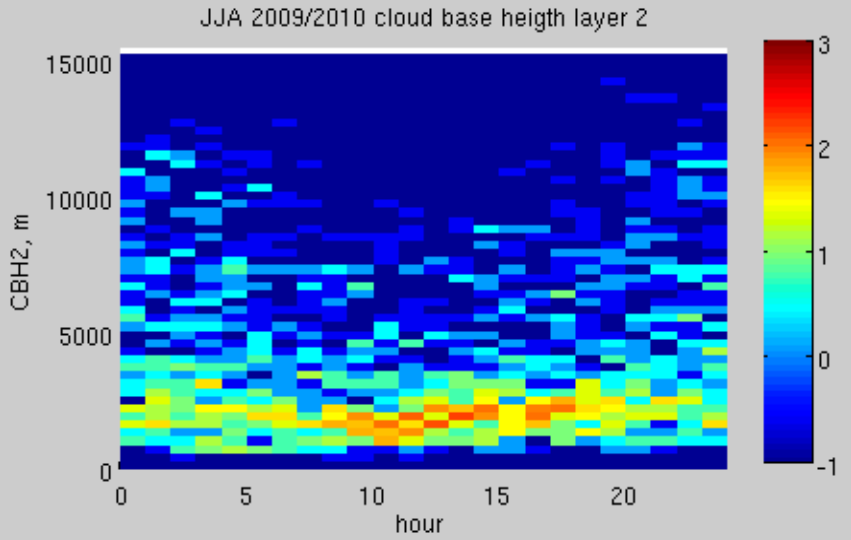
Old hydrology model (2 layers)

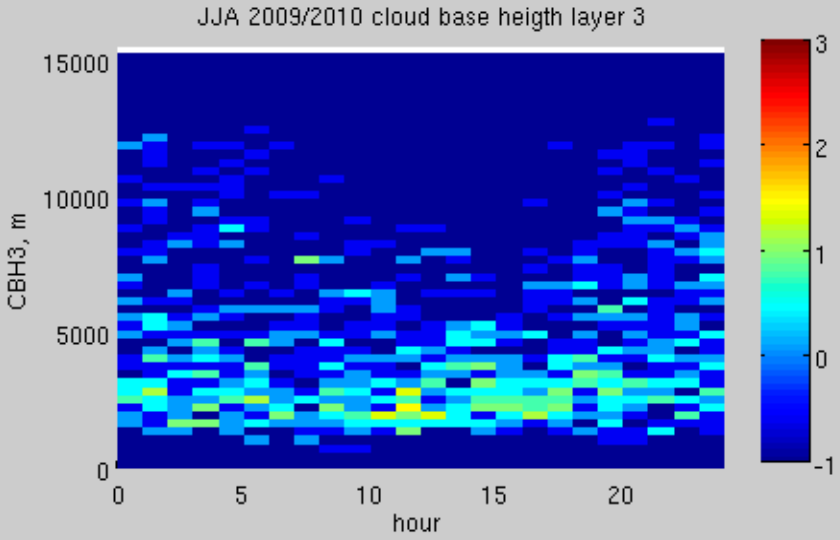
New atmospheric model (LMDZ5B)

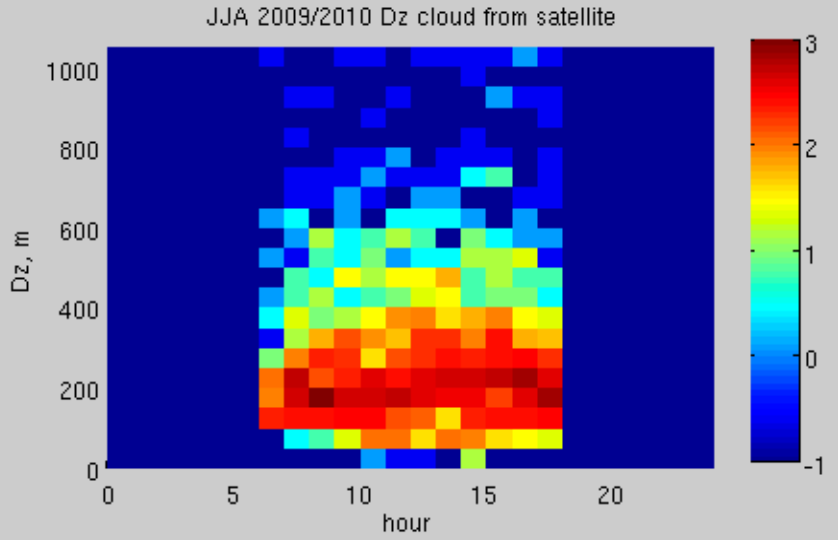
Old atmospheric model (LMDZ5A)

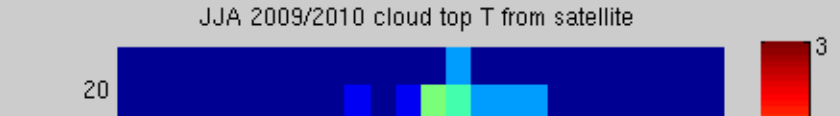
Courtesy of M. Chiriaco, LATMOS/IPSL
From lidar obs. at SIRTA



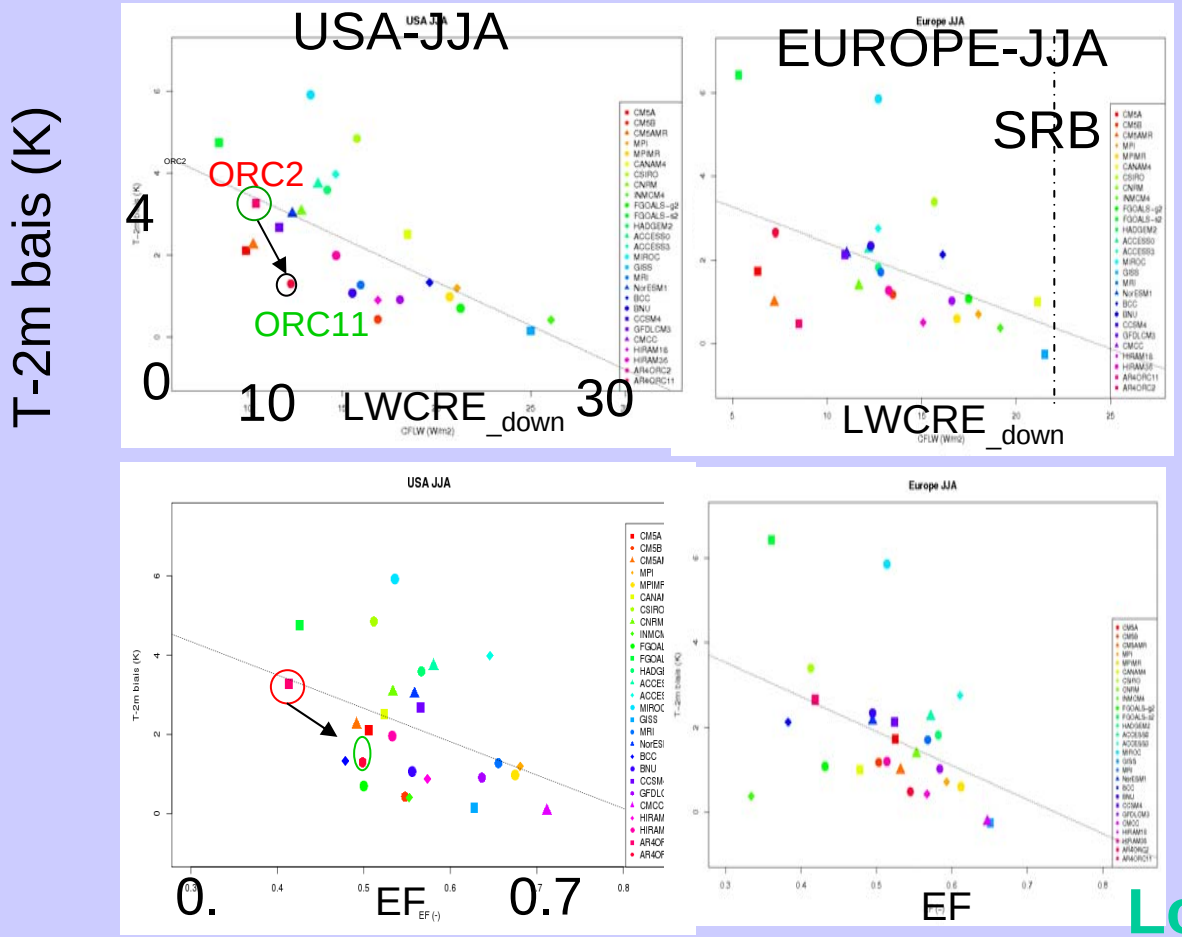




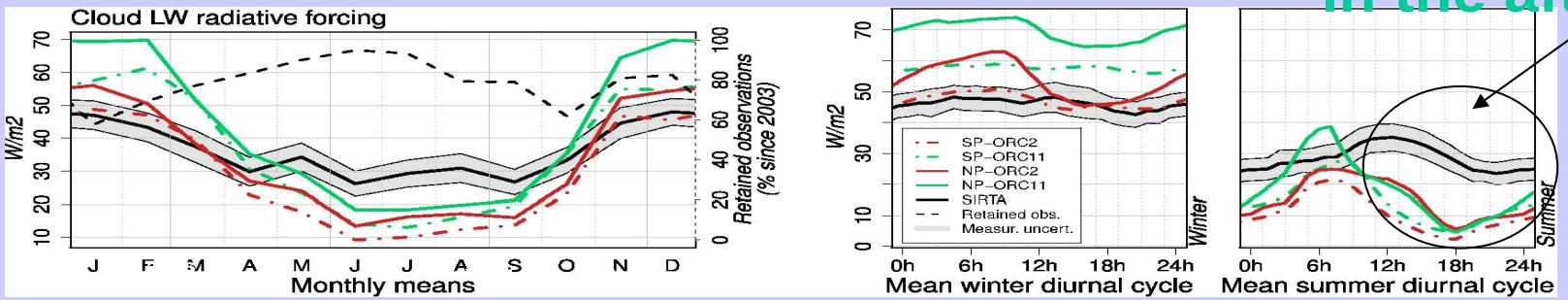




A common problem in CMIP5 AMIP



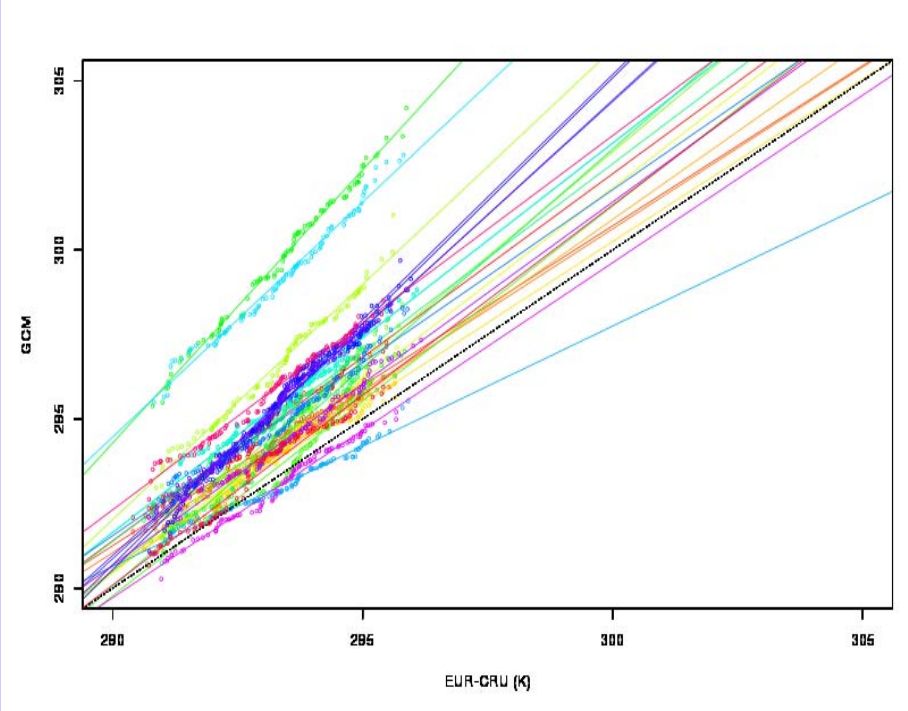
Low level cloud deficit in the afternoon



IPSL-CM

LINK WITH THE PROJECTION?

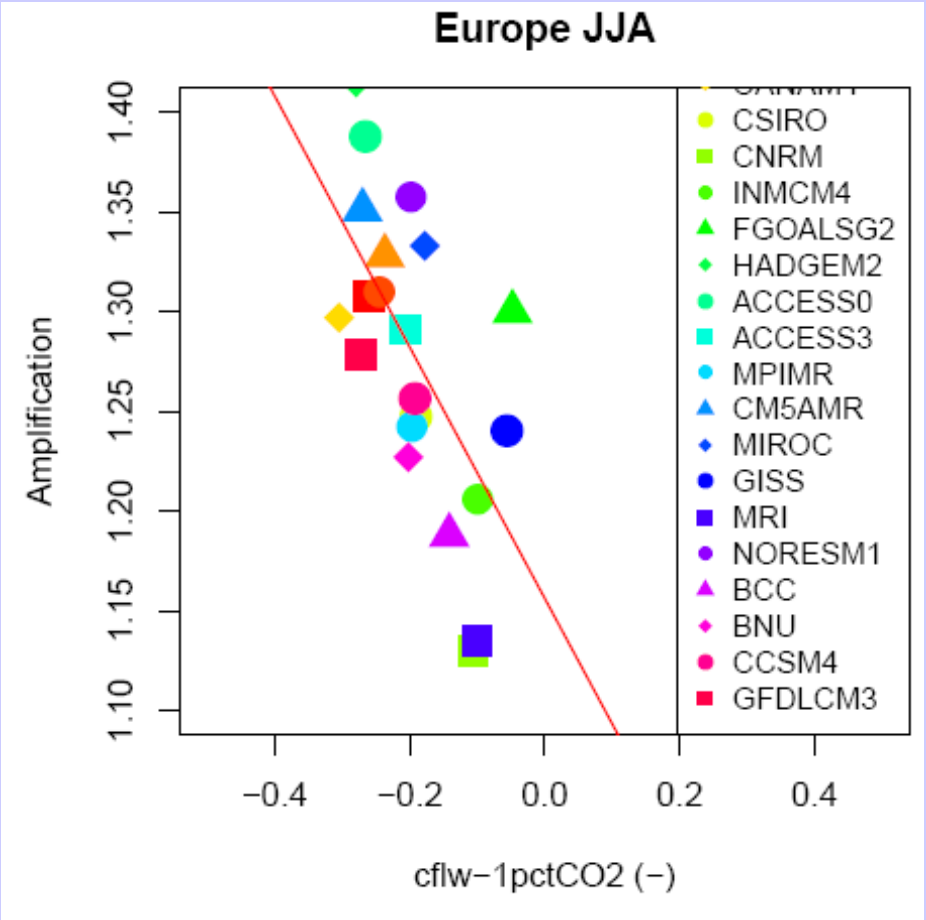
- Christensen and Boberg (2012): amplification of the warming linked with the slope of qqplot (GCM/CRU) (did not considered the mean bias)

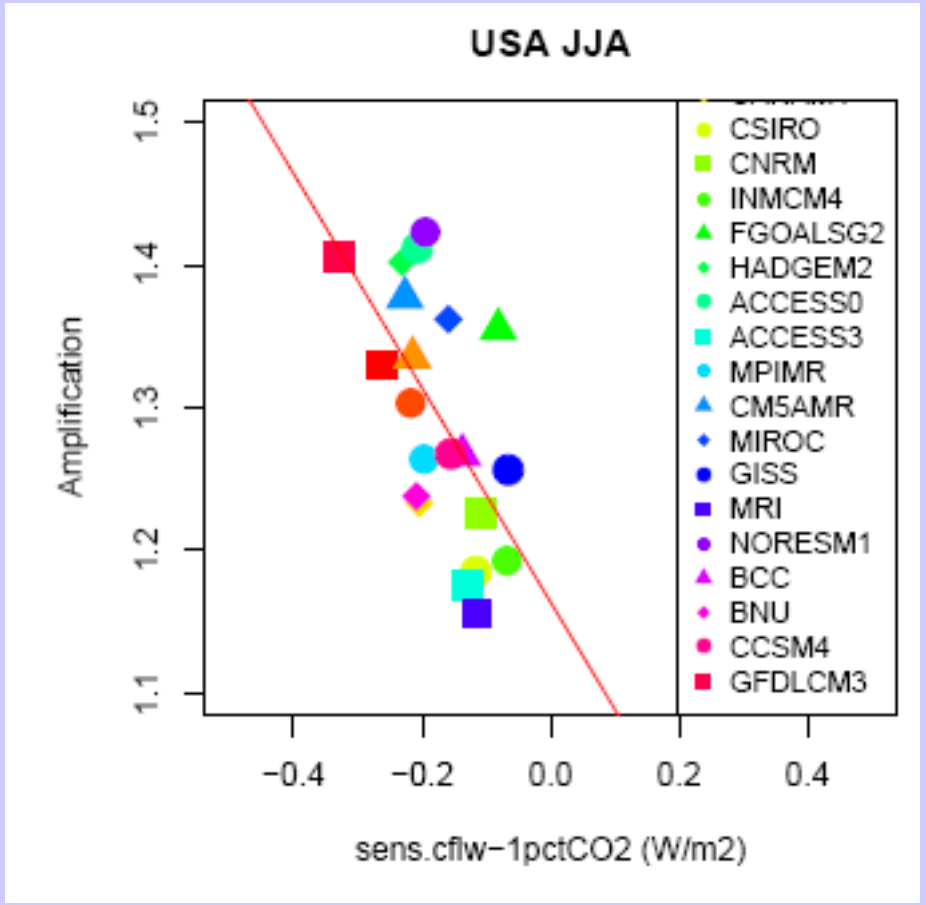


- The mean EF, or mean CRE are not signicantly correlated with the amplification of the warming

Mean regional amplification, versus relative variation of CRE for the 1pctCO2 period: $(CRE_{end} - CRE_{beg})/ (CRE_{end} + CRE_{beg})$

$\Delta T_{region}/\Delta T_{global}$



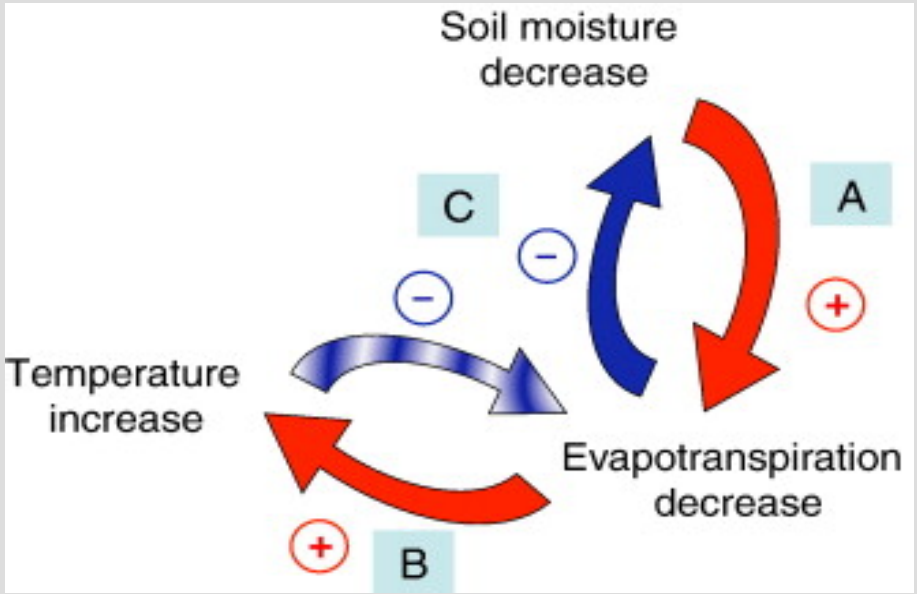


correlation when considering the Latent flux as well (less significative)

Take away points

- Under-estimation of the evaporative fraction in AMIP CMIP5 models which have a warm bias at mid-latitude in summer
- The warmest models under-estimates the radiative impact of clouds at the surface.
- In the IPSL-CM, the ORC11 LSM helps to reduce the temperature biais, but the CRF is always underestimated
- By how much the too weak EF contribute to this bias?
  - The cause of the bias is also elsewhere but the EF allows for correction
  - Need to improve the parametrizations of cloudiness in summer
  - Revisit the SM-Boundary layer coupling
  - Other obs. (flux net?), CF-mip sites
- Impact on the climate projections trough the clouds affected by the way the soil hydrology, the ABL and their coupling are accounted for (highly model dependent)

Take away points



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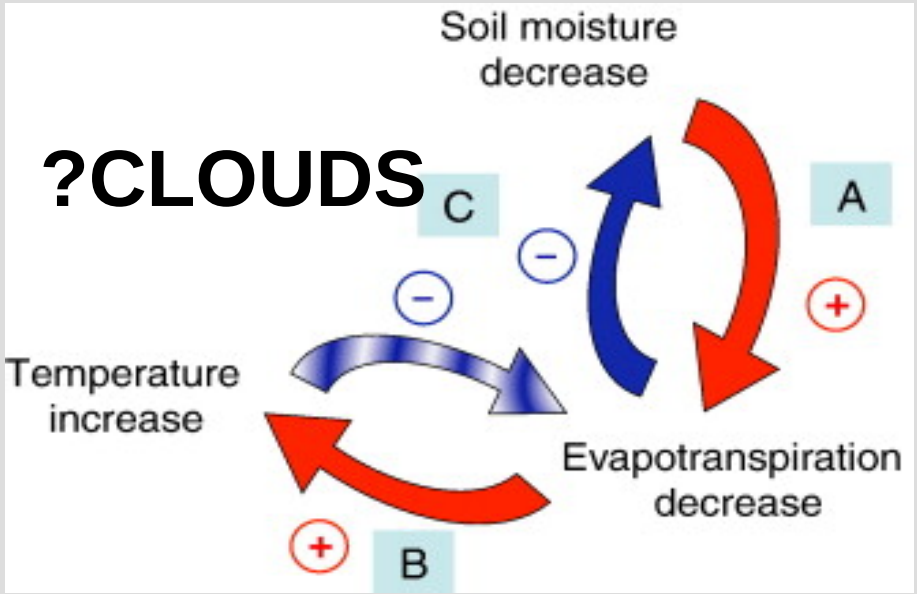

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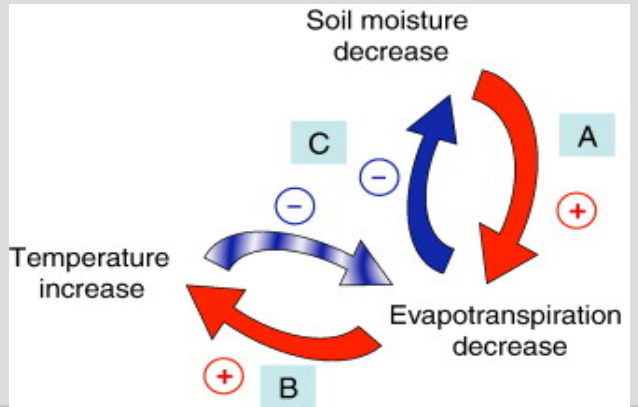
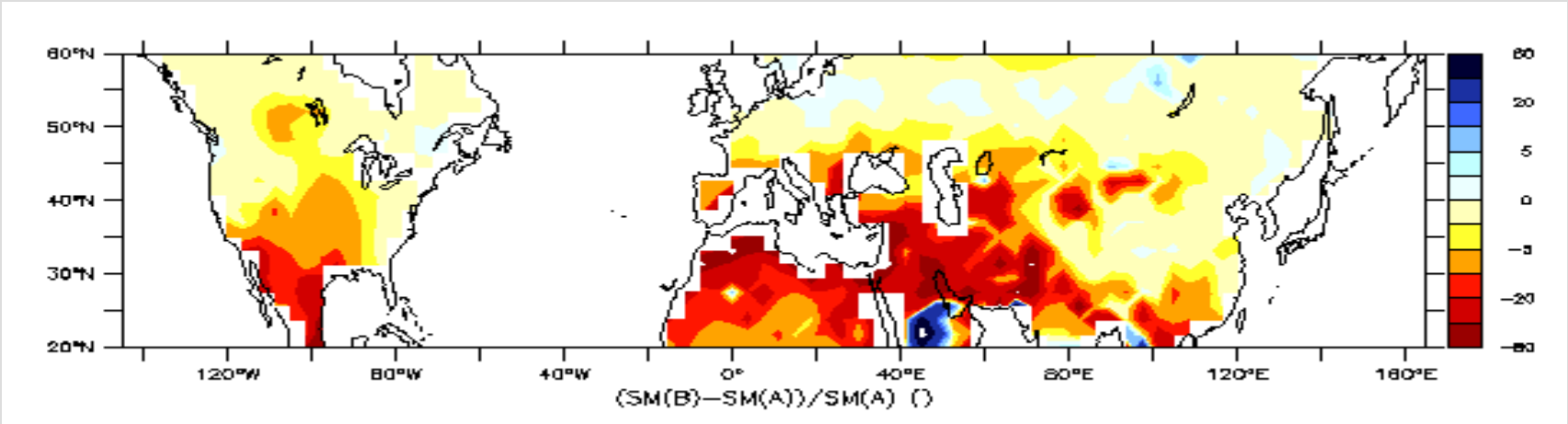


GLACE-CMIP5: quantifier l'impact du couplage humidité des sols/climat dans les projections CMIP5

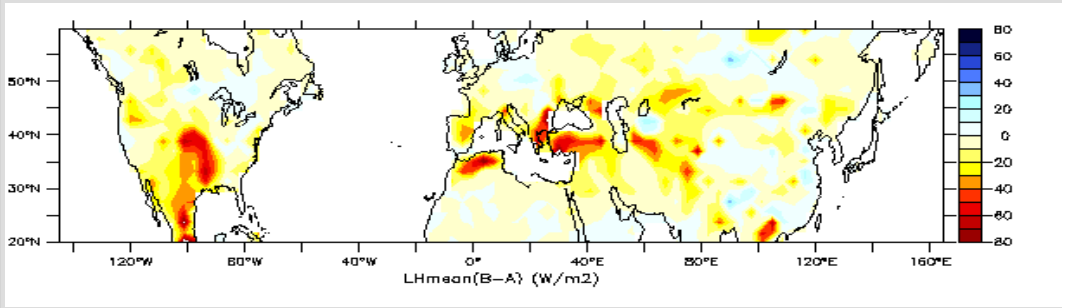
- CMIP5 historique + RCP85 (1950-2100), SST, Sea Ice et land cover de la simulation originale
- Modèles participants : GFDL, ECHAM6, CSM, IPSL-CM5A, Ec-Earth
- G1A85: cycle saisonnier de l'humidité des sols rappelé vers la climatologie des années 1971-2000 (issue du modèle)
- G1B85: Le cycle saisonnier est rappelé vers une climatologie transitoire sur 30ans [moyennes glissantes de 30 ans sur la période 1950-2100 du RCP8.5]

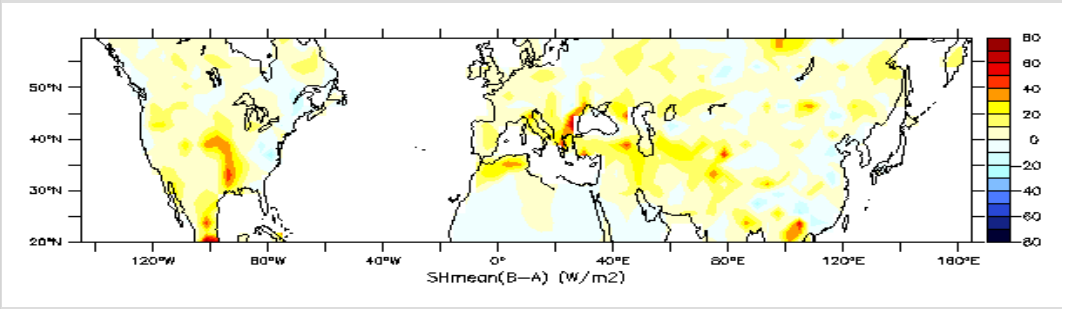
Soil Moisture (%) (G1B85-G1A85/G1A85)

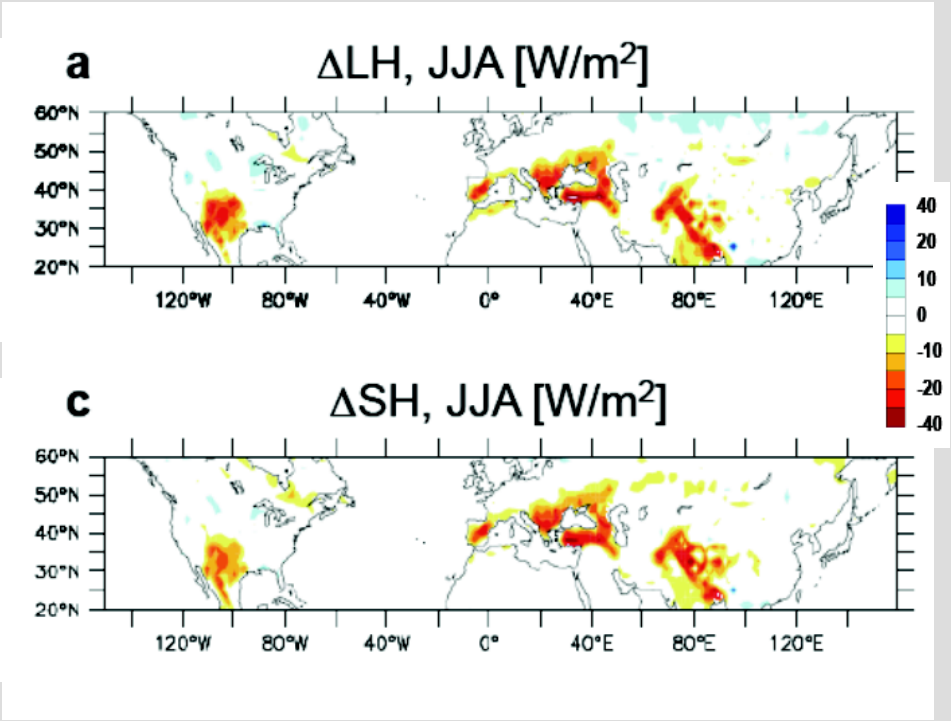


IPSL

Différences G1B85-G1A85 2071-2100: Flux







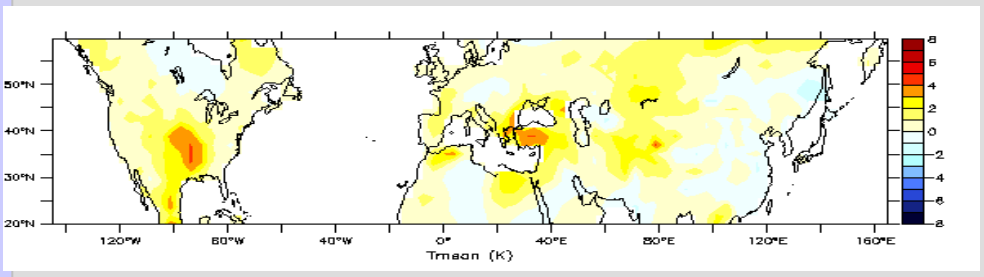
IPSL-CM5A **ECHAM6**

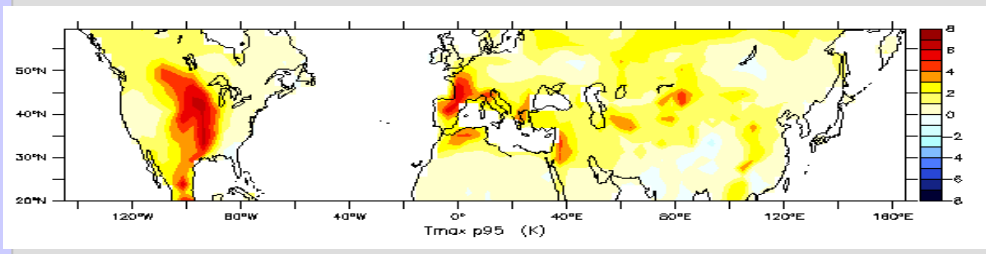
Impact of soil moisture-climate feedbacks on CMIP5 projections: First results from the GLACE-CMIP5 experiment

Seneviratne S., M. Wilhelm, T. Stanelle, B. van den Hurk , S.Hagemann, A. Berg, F. Cheruy, M. E. Higgins,

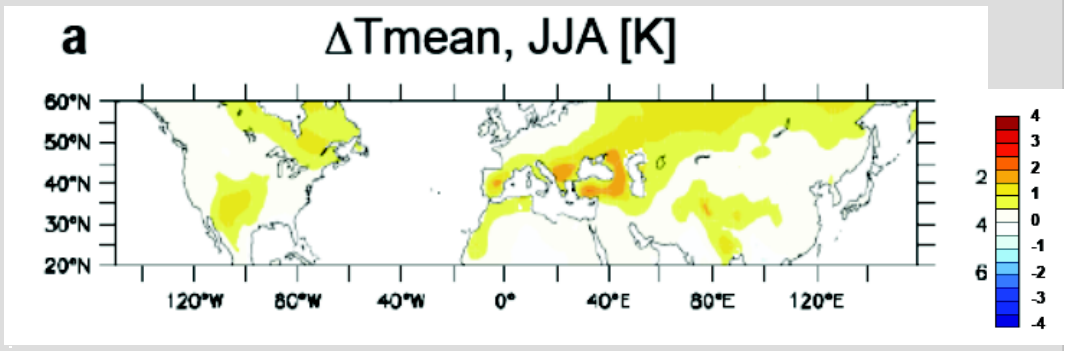
A. Meier ,V. Brovkin, M. Claussen, J.-L. Dufresne, K. Findell , D. M. Lawrence, S. Malyshev, B. Smith, In rev. GRL

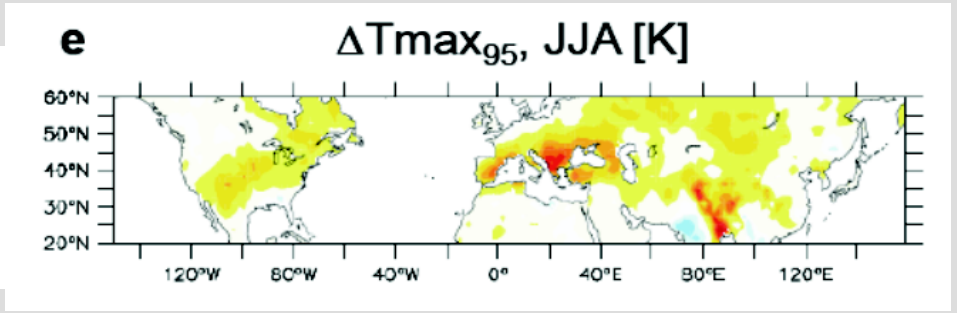
Différences G1B85/G1A85 2071-2100 : 2m-T



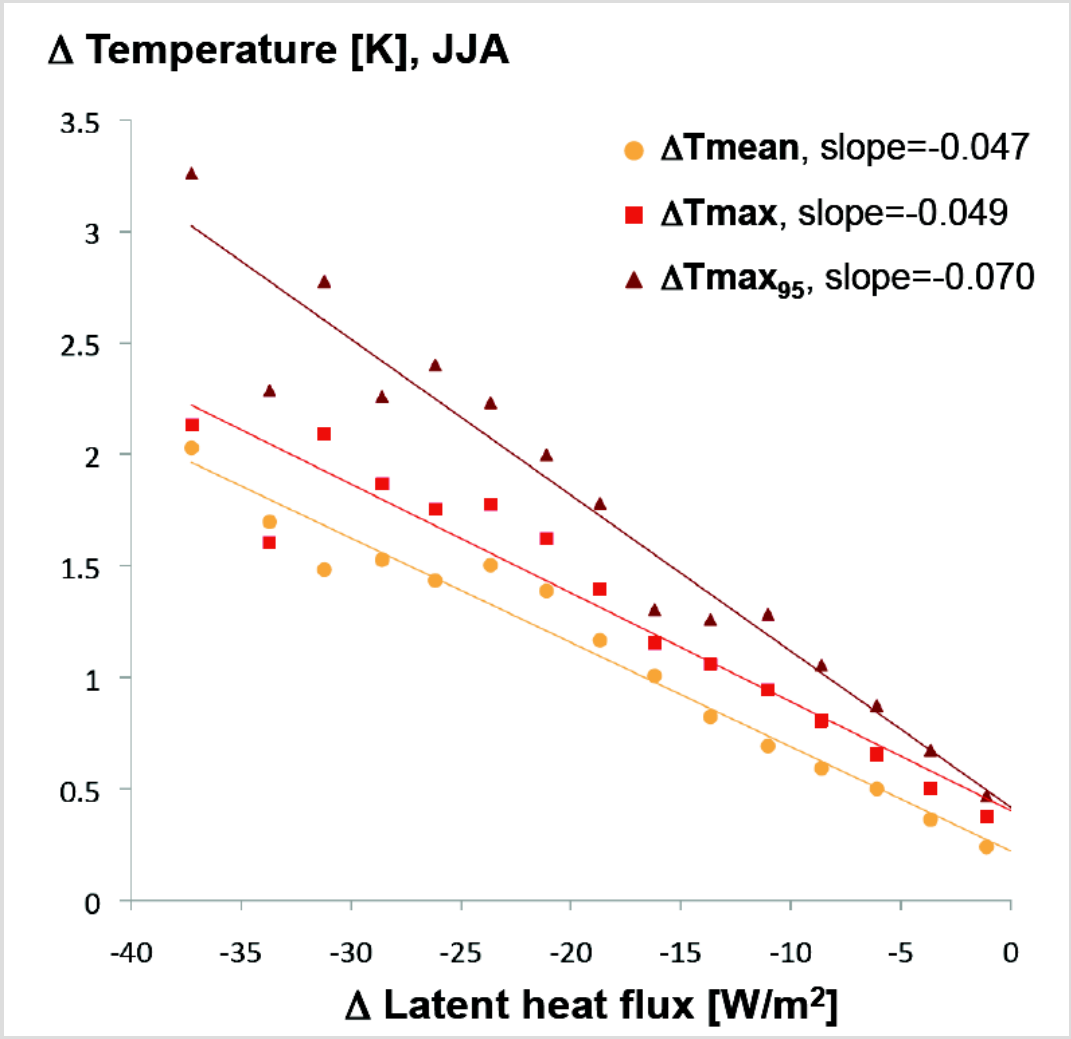


IPSL-CM5A

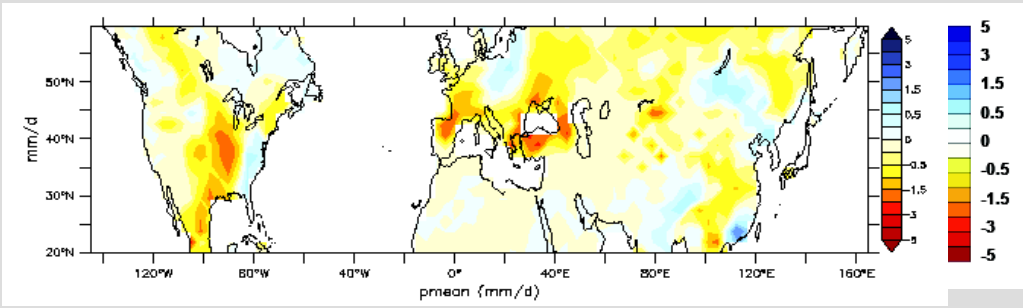


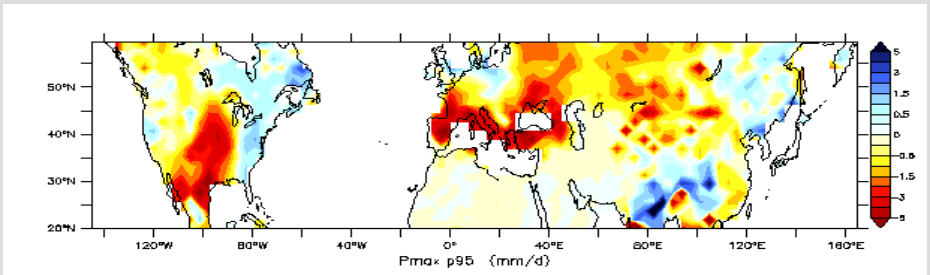


ECHAM-6

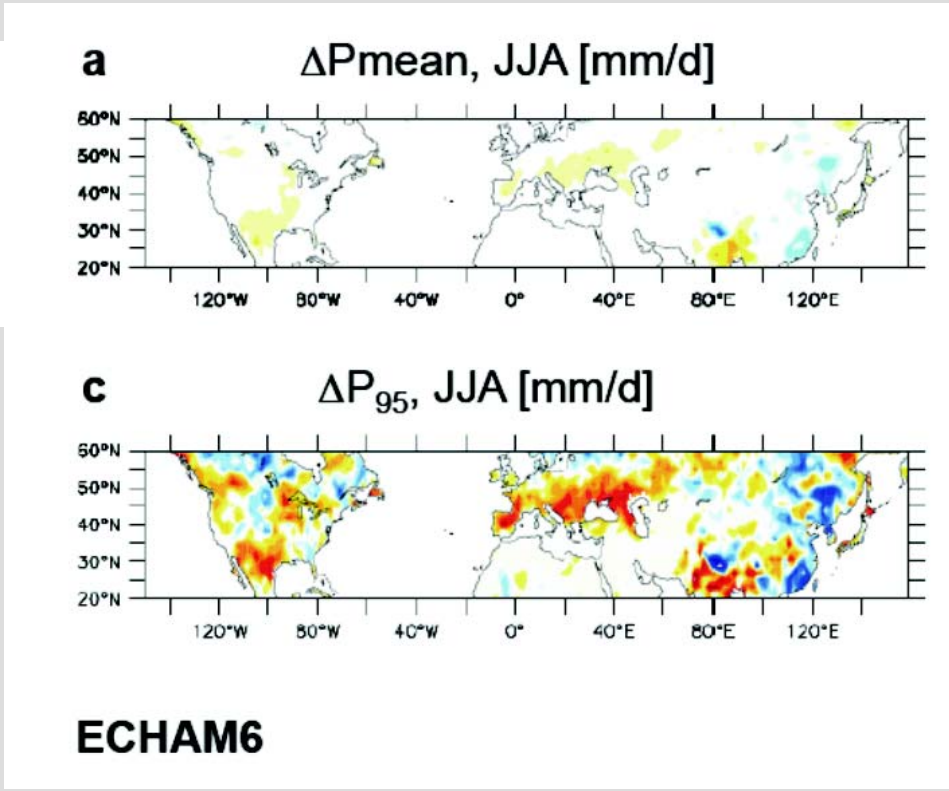

Δ Temperature [K], JJA
ΔTmean, slope=-0.047
ΔTmax, slope=-0.049
ΔTmax95, slope=-0.070
3.5
3
2.5
2
1.5
1
0.5
0
-40
-35
-30
-25
-20
-15
-10
-5
0
Δ Latent heat flux [W/m²]

Différences G1A85/G1B85 2071-2100: Précipitations





IPSL-CM5A

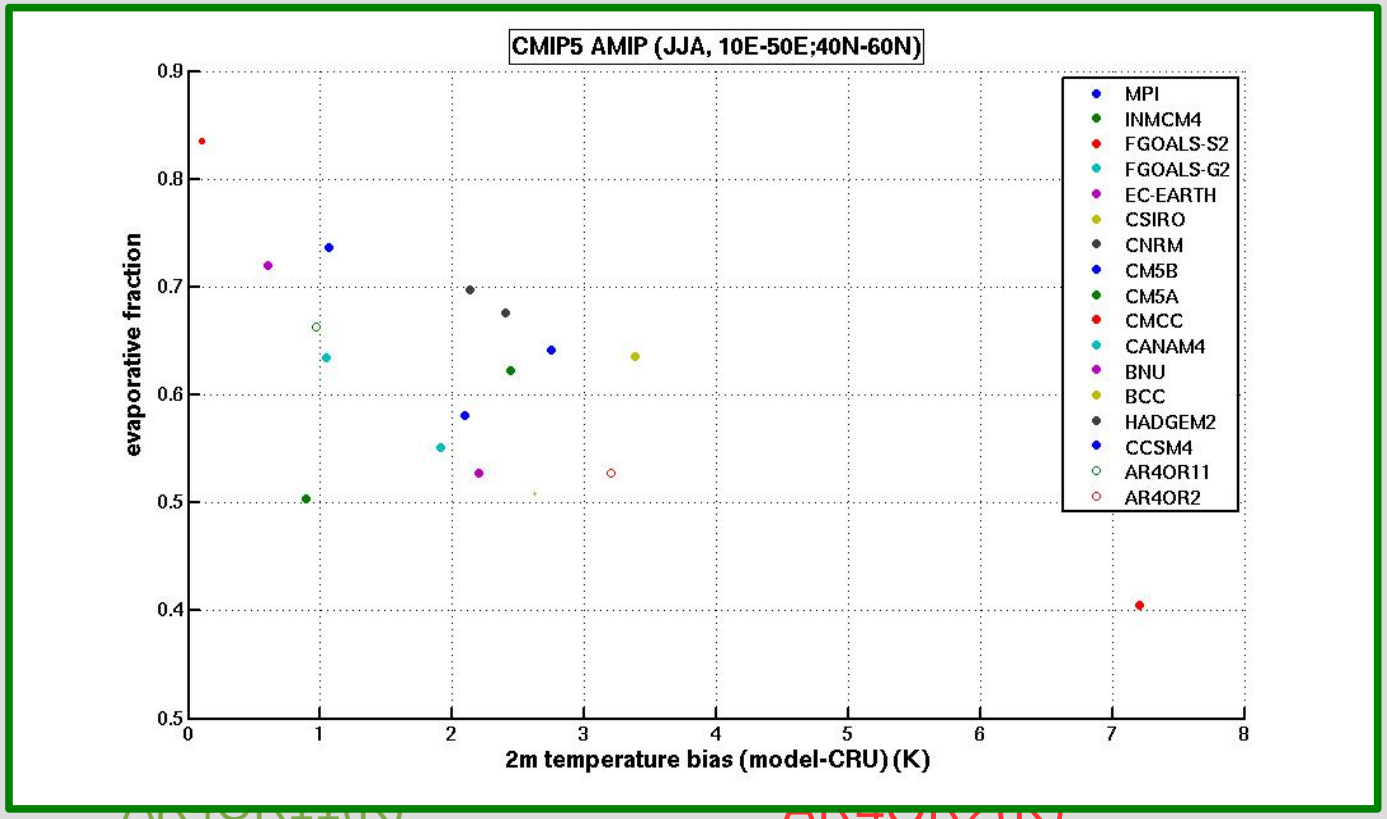


ECHAM6

Conclusions

- La diminution d'humidité du sol affecte le climat régional (T2m et pluie) en modifiant le refroidissement évaporatif (rôle des biais?)
- Impacts sur les moyennes et sur les extrêmes en T et précipitation
- Pas d'accord parfait sur les régions affectées et amplitude du signal

Near surfaceTemperature biais in CMIP5 AMIP Summer, Europe



Biais en température à 2m, JJA ,réf. CRU

SW cld forcing down