Land surface contribution to seasonal climate variability and predictability

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Background

Three conditions must be satisfied for the land surface to contribute to seasonal climate predictability:

Land surface anomalies must have a significant (Potential Predictability) and realistic (Effective Predictability) impact on seasonal atmospheric variability

Land surface anomalies must be predictable at the monthly to seasonal timescale (using statistical or dynamical tools)

Real-time global analyses must be available to initialize the relevant land surface variables (snow mass, deep soil moisture, vegetation density, others ?)

AGCM sensitivity experiments (prescribed observed and/or climatological SST)

Type of study	Role of land surface Boundary Conditions Free/Clim/Analyses	Role of land surface Initial Conditions Free/Clim/Analyses
Potential Predict. (perfect model)	Koster et al. 2000 (16x45) Reale and Dirmeyer 2002 (16x49) Douville 2003 (10x15)	Schlosser and Milly 2002 (10x8) Douville 2004 (10x15)
Effective Predict. (against obs.)	Dirmeyer 2000 (4x2) Douville 2000 & 2002 (6x2) Kanae et al. 2006 (5x48) Conil et al. 2007a (10x10)	Douville and Chauvin 2000 (6x2) Koster and Suarez 2003 (16x5) Kanamitsu et al. 2003 (10x18) Dirmeyer 2003 & 2005 (10x21) Conil et al. 2007b (10x10)

Experiment Design

ARPEGE-Climat AGCM at TL63 truncation (128x64) coupled with the ISBA land surface model

Ensembles of 10-member AMIP-type simulations over the 1986-1995 period

Use of the GSWP-2 reanalysis (ISBA driven by NCEP/DOE meteorological analyses hydridized with monthly observations) to relax ARPEGE-Climat (nudging) towards more realistic deep soil moisture or snow mass boundary conditions

5 ensembles:

- **FF**: Control experiment (interactive land surface hydrology)
- **GG**: Nudging towards GSWP-2 soil moisture
- **EE**: Same as GG, but with climatological SSTs
- **SS**: Nudging towards GSWP-2 snow mass
- **TT**: Same as SS, but with climatological SSTs

2 additional seasonal ensembles:

- **GF**: Same as GG, but no nudging after the end of May
- **SF**: Same as SS, but no nudging after the end of March

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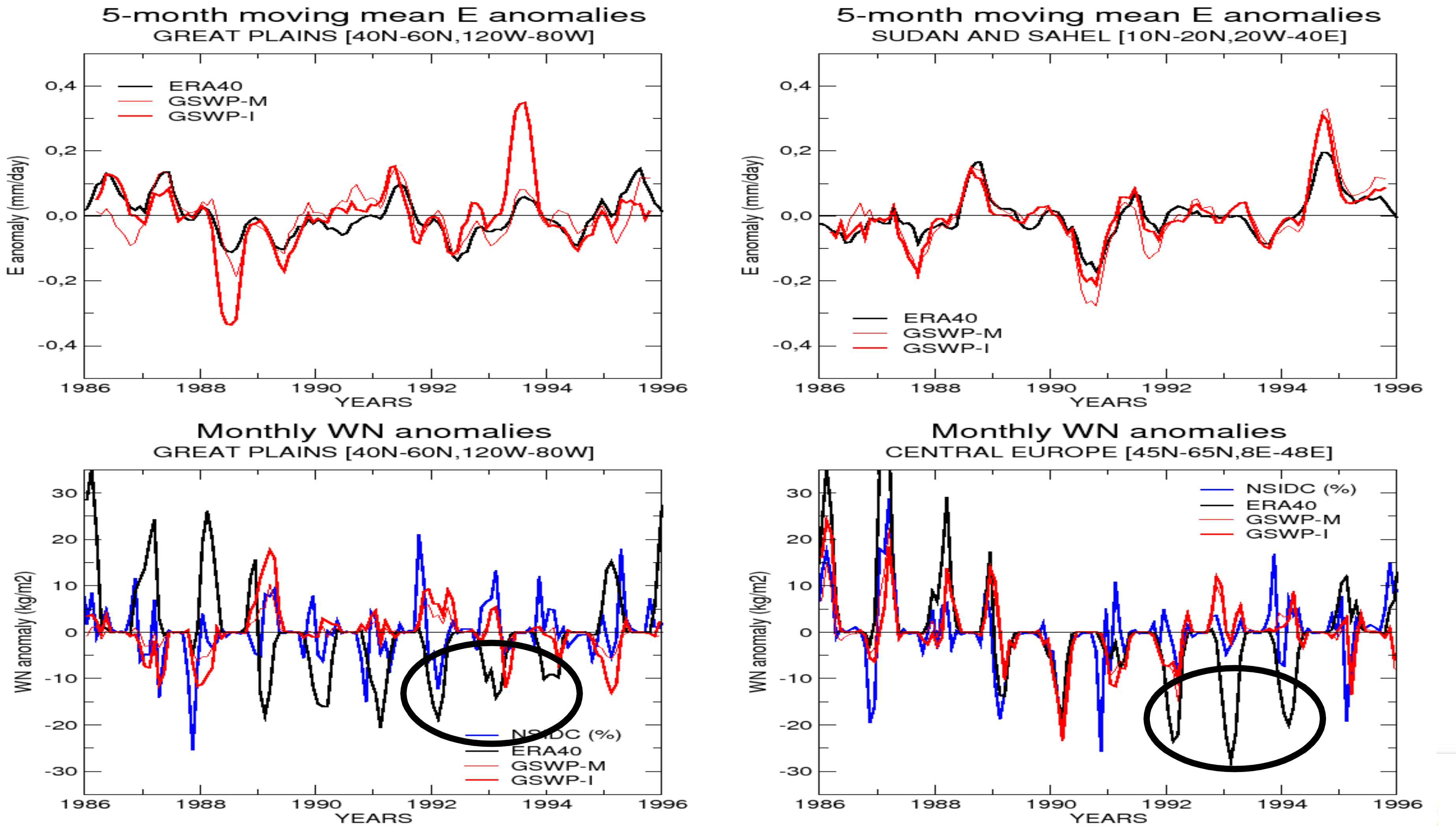
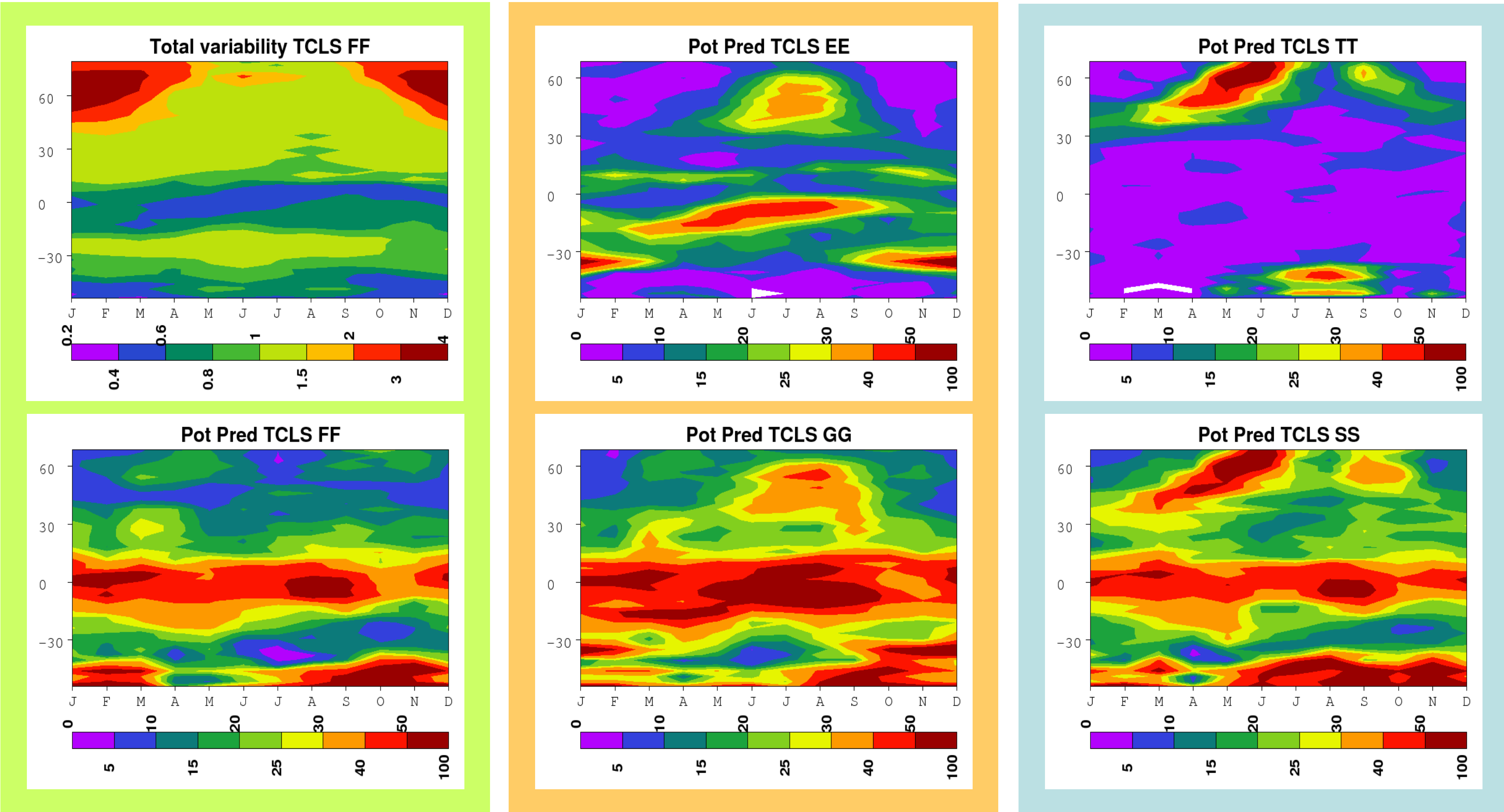
Comparison between GSWP and ERA40 Root Zone Soil Moisture and Snow Mass



FRANCE

Seasonal cycle of zonal mean PP (ANOVA)
Screen-Level Temperature (Land only)



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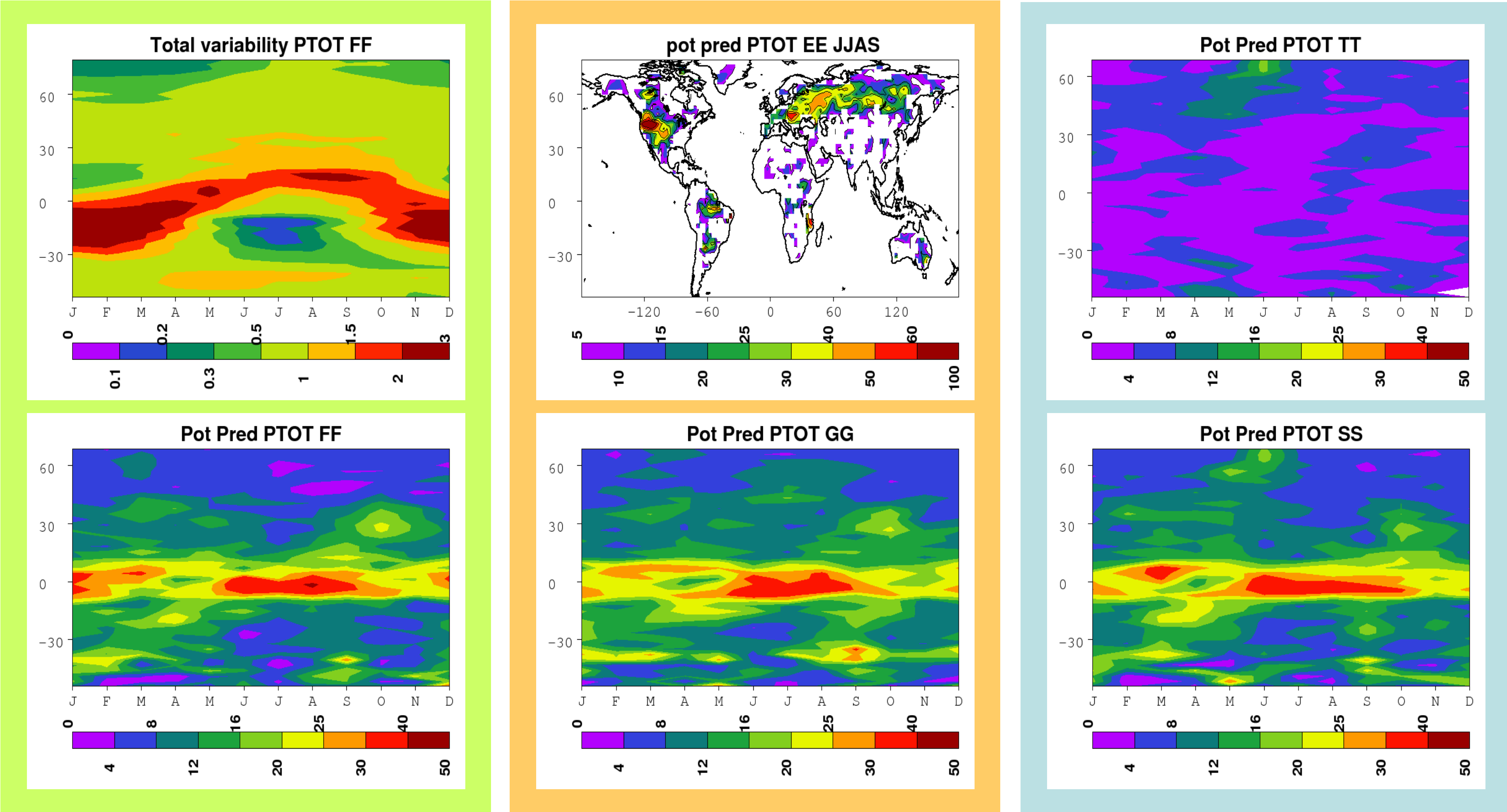
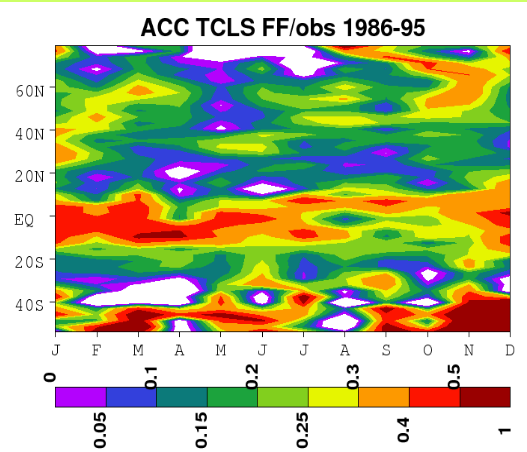
Seasonal cycle of zonal mean PP (ANOVA)

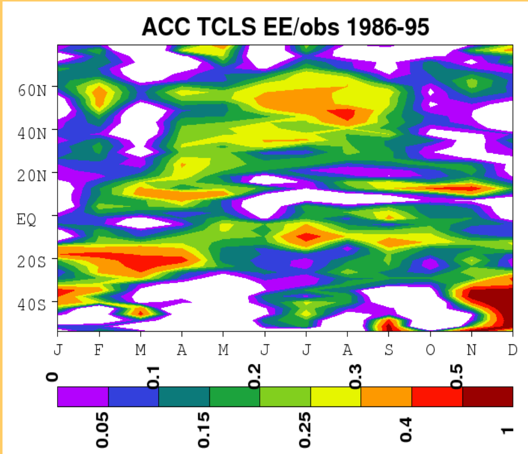
Total Precipitation (Land only)

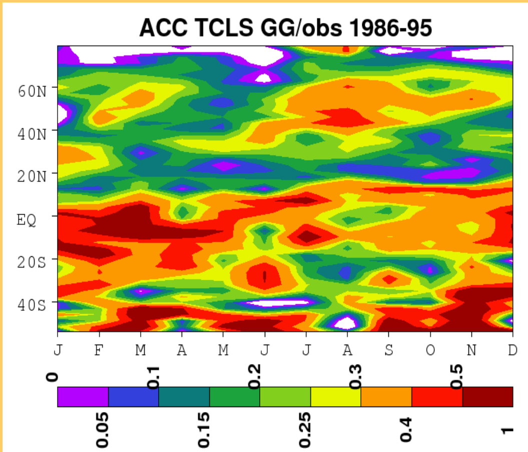


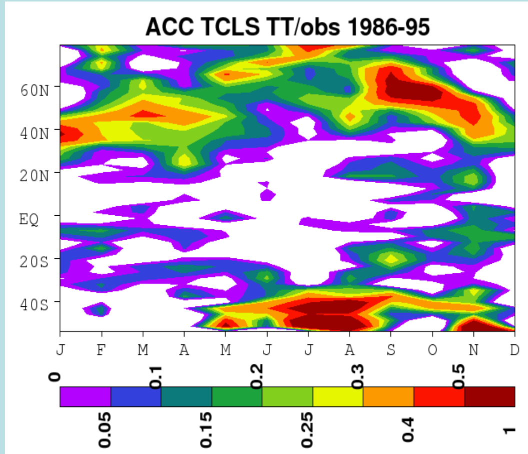
Seasonal cycle of zonal mean ACC (skill)
Screen-level temperature (Land only)

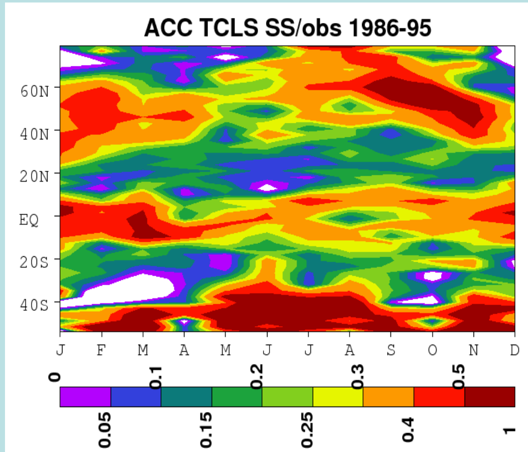
No
nudging
Ref=ERA40





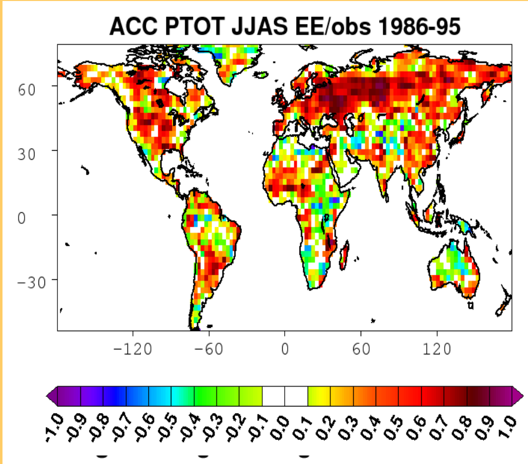


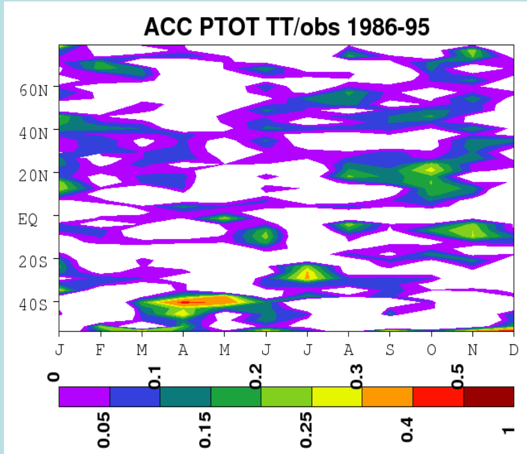


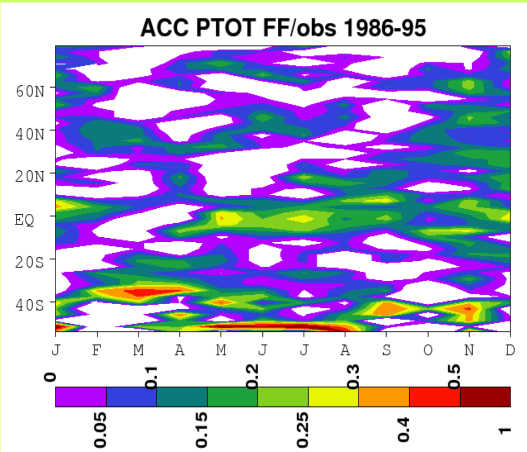


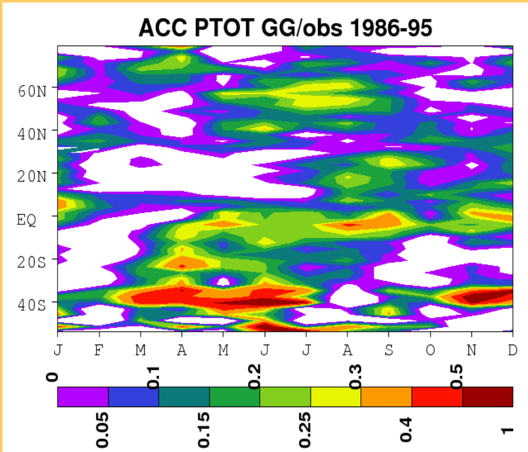
Seasonal cycle of zonal mean ACC (skill)
Total Precipitation (Land only)

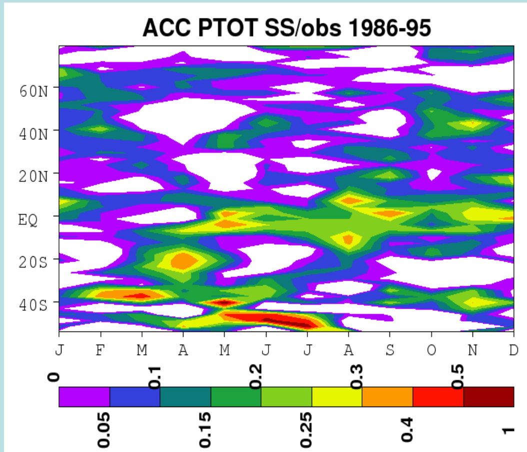
No nudging
Ref=GPCC











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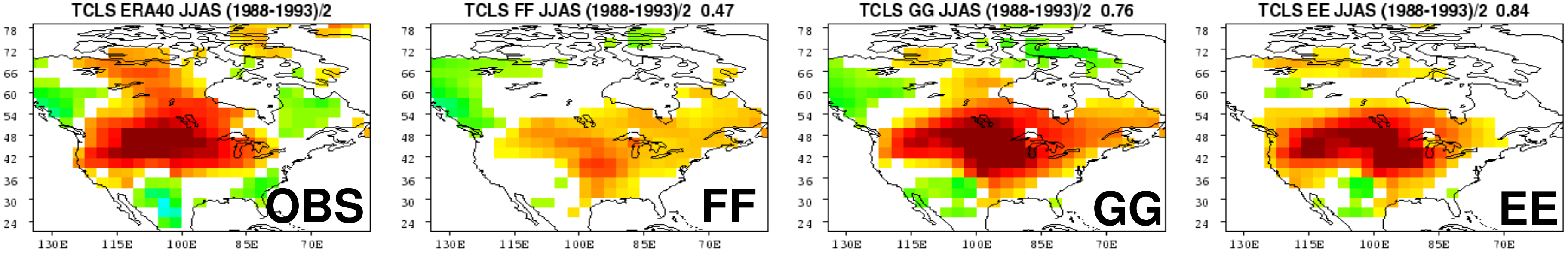
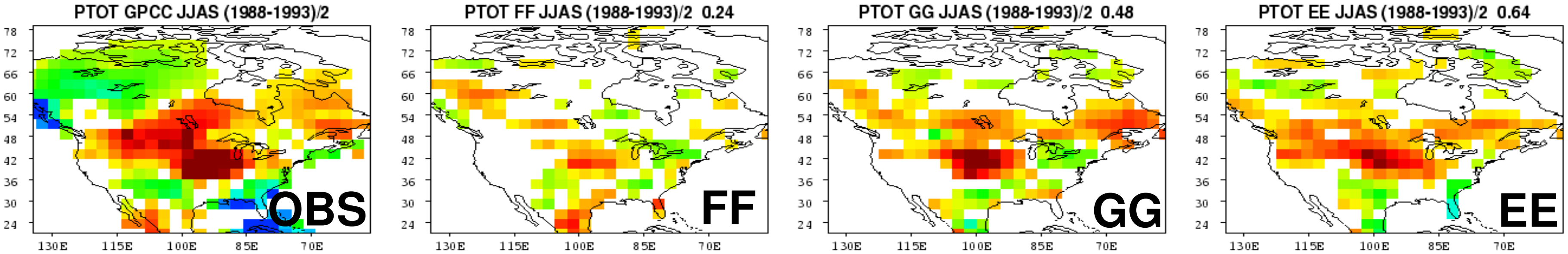
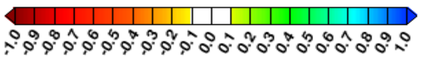
Seasonal Contrast (Dry minus Wet Summer)
JJAS (1988-1993)/2

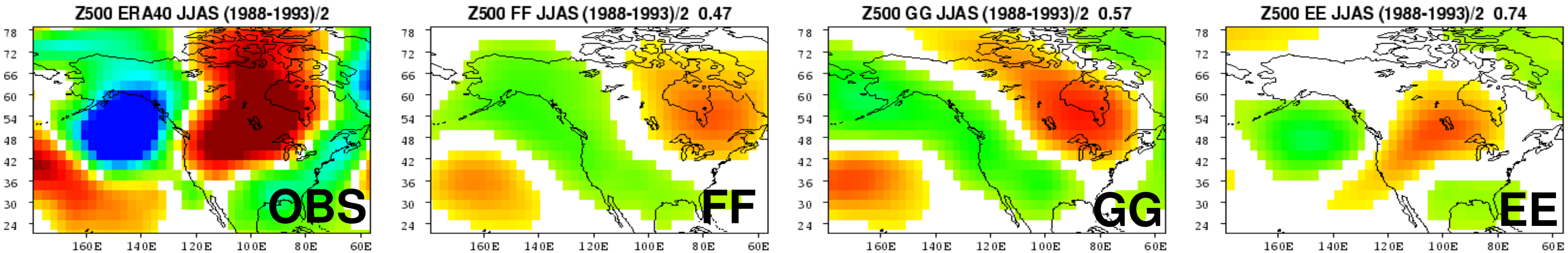


JJAS 2-m temperature differences (K)





JJAS precipitation differences (mm/day)

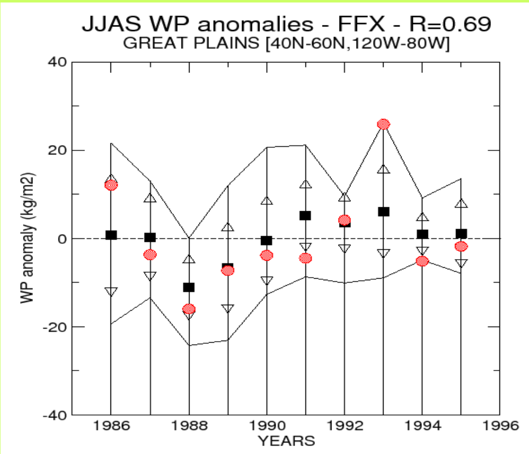


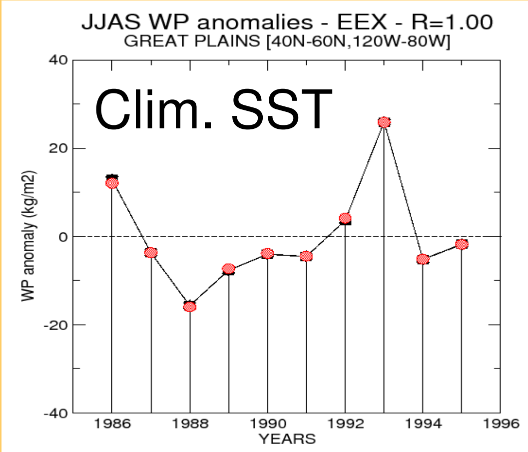
JJAS Z500 differences (m)

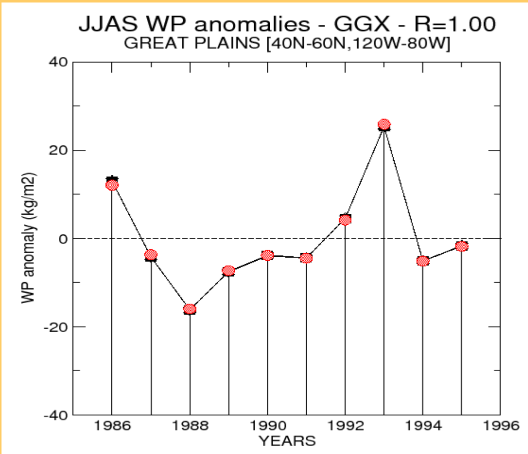
Conil et al. (Climate Dyn., 2007a)

Seasonal Anomalies (Great Plains, JJAS)
Soil Moisture (vs GSWP)

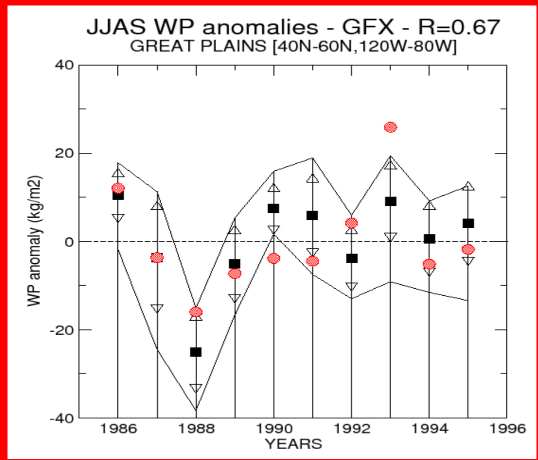
No nudging (control)





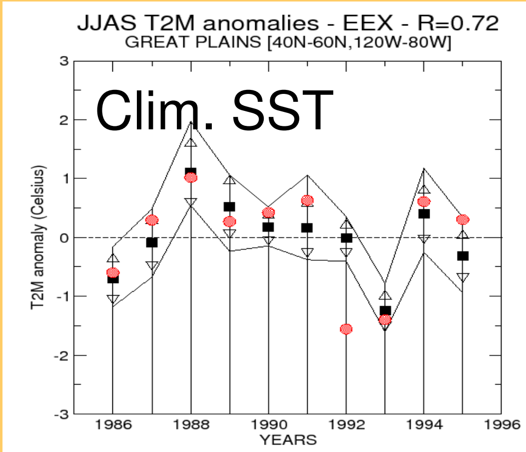


Nudging until end of May

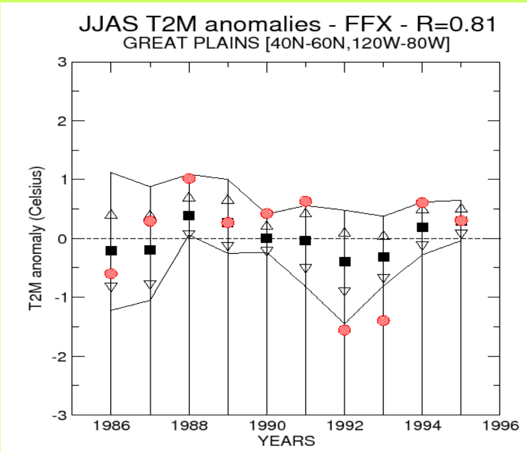


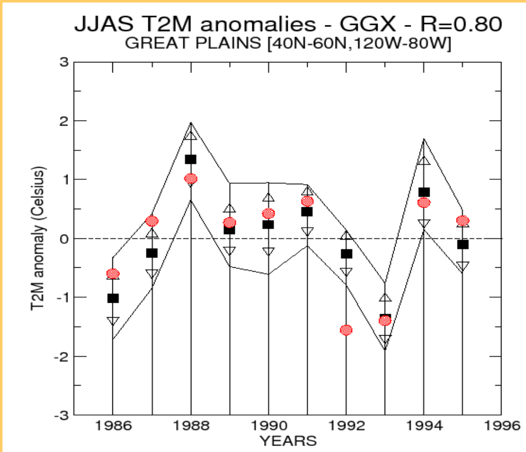
Seasonal Anomalies (Great Plains, JJAS)
Screen-Level Temperature (vs CRU2)

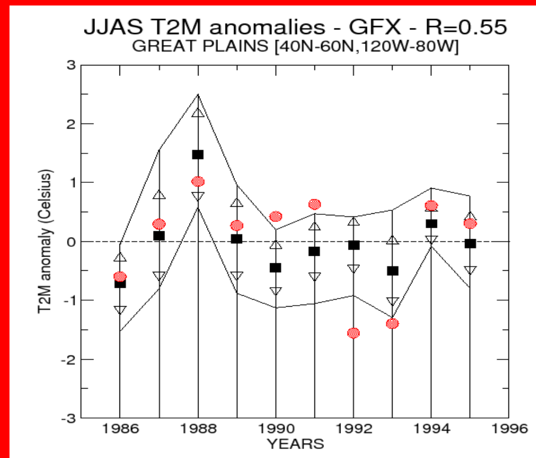
No nudging (control)



Nudging until end of May







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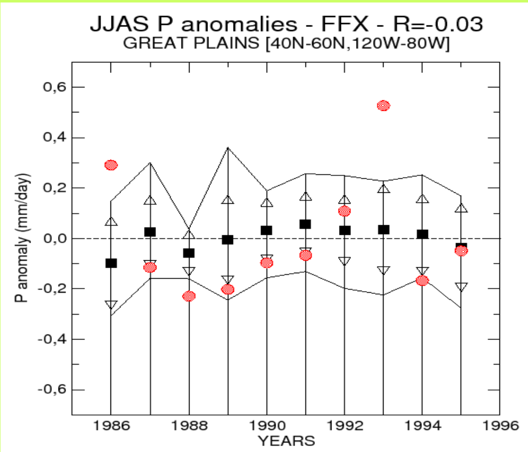
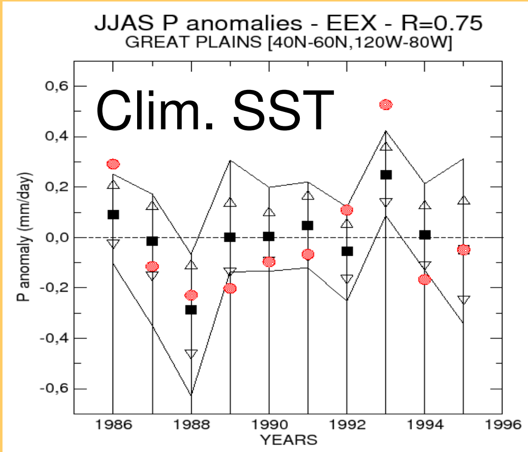
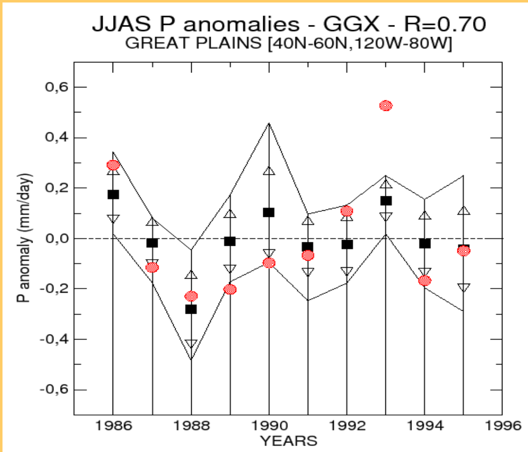
Seasonal Anomalies (Great Plains, JJAS)

Total Precipitation (vs CRU2)

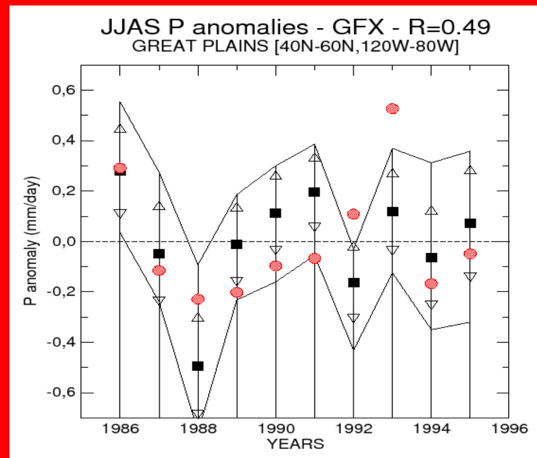
No nudging (control)



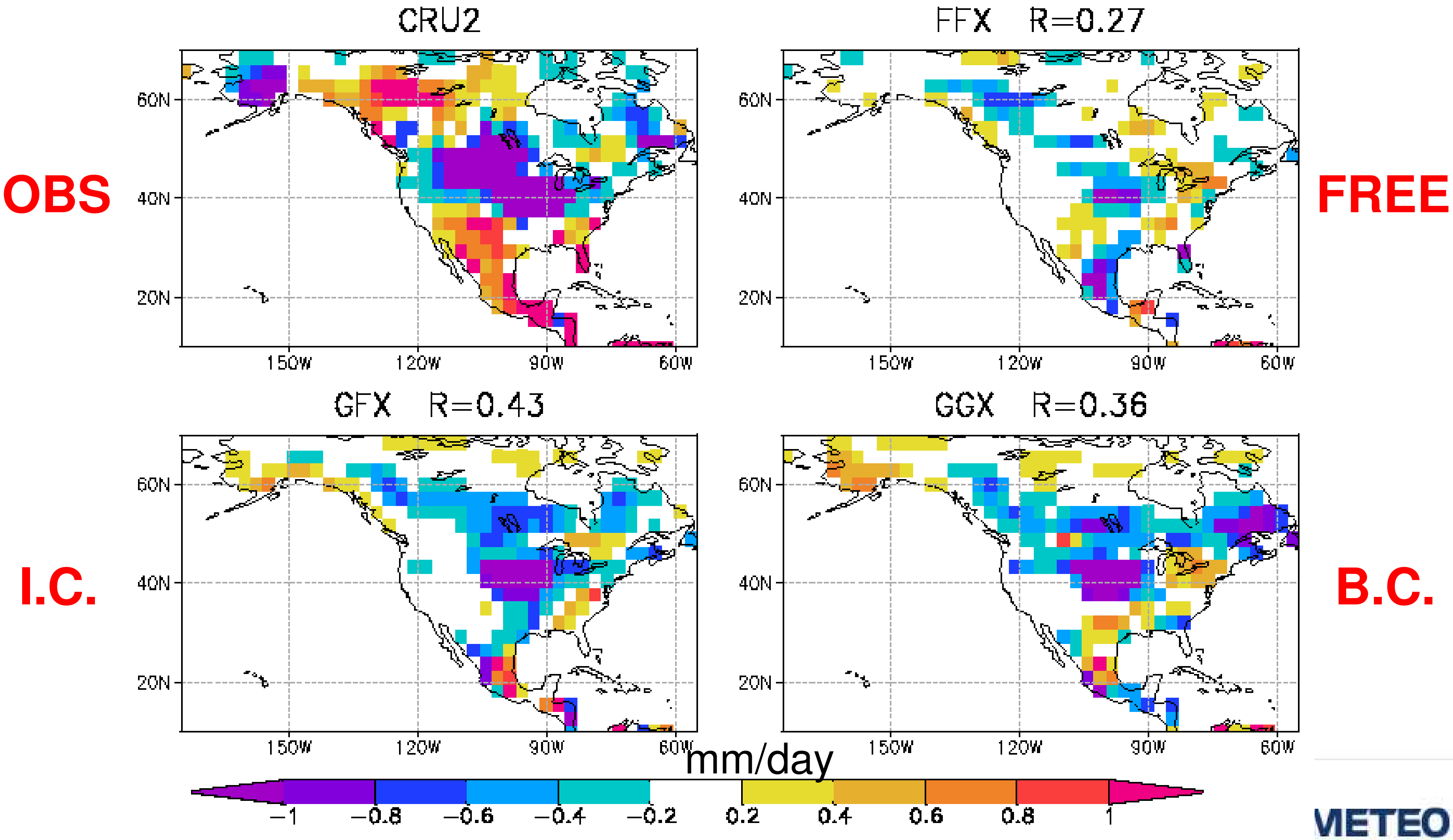




Nudging until end of May



Seasonal Contrast (Dry minus Wet)
1988-1993 JJAS Soil Moisture & Precipitation



Seasonal Contrast (Dry minus Wet)

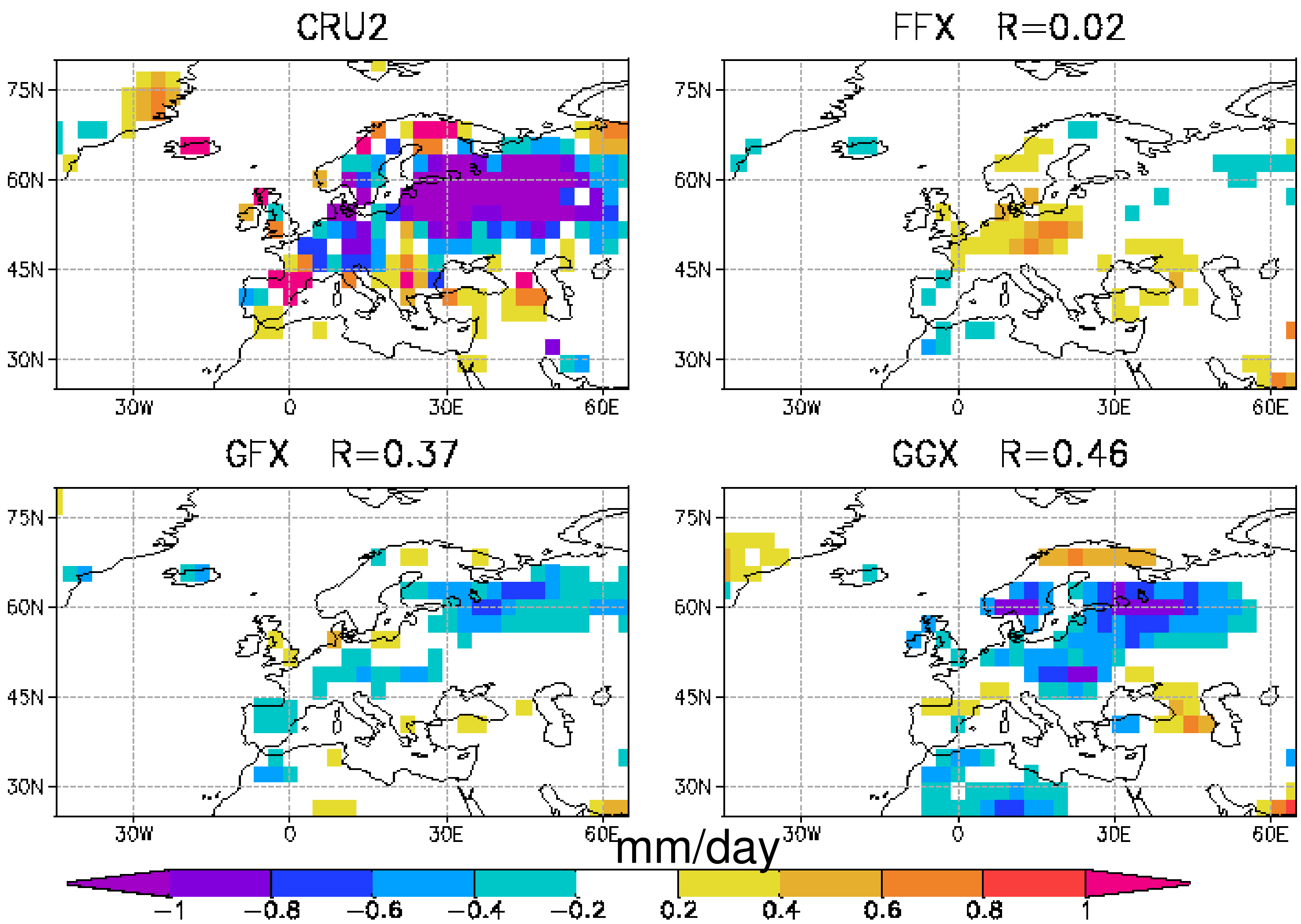
1992-1987 JJAS Soil Moisture & Precipitation

OBS

FREE

I.C.

B.C.



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Global Predictability of Soil Moisture
Statistical vs Dynamical Forecasts

Global number of grid points where each model is the best at predicting soil moisture (*Conil et al. 2007b*)

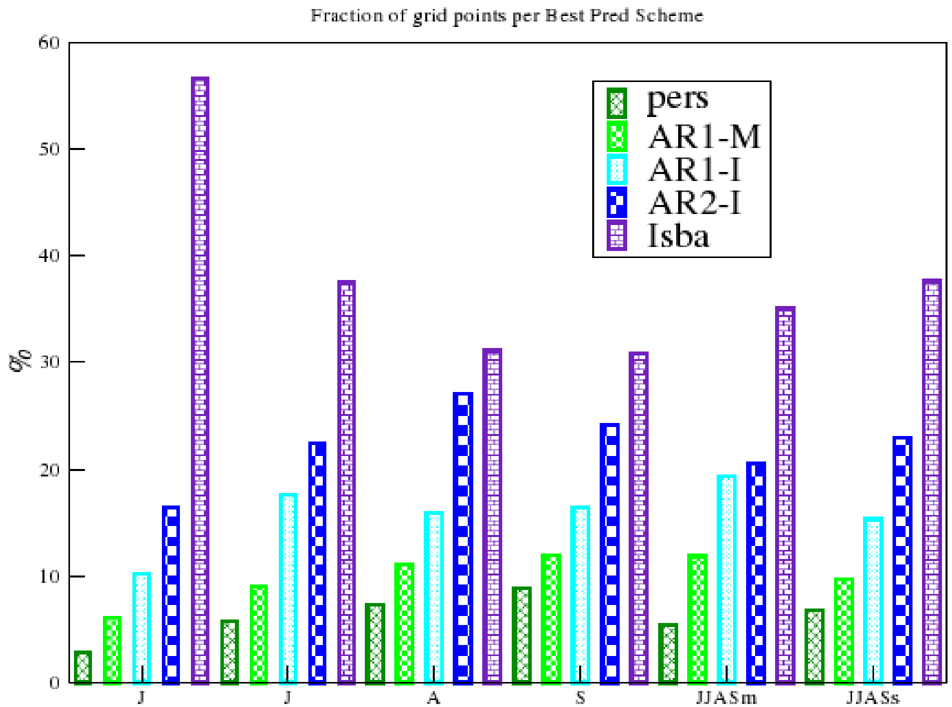

FIGURE 3: Number of grid points where each SM prediction model appears to be the best predicting scheme (Fraction of the total land grid points). The fraction of points where each model is the best is evaluated for each month June, July, August and September, showing the evolution with the lead-time but also for the overall season using monthly means (JJASm) and seasonal means (JJASs).

No horizontal dynamics => easy to combine dynamical and statistical methods

Conclusions

Land surface B.C. have a strong impact on climate variability and potential predictability at the seasonal timescale

They also have significant impacts on seasonal hindcast scores (including through the amplification and/or triggering of stationary waves), but such impacts are highly dependent on the region, season, (and model) one looks at

Long-range predictability of land surface hydrology is limited (mainly by the low predictability of precipitation) but is sufficient to sustain a land surface memory and can be improved by statistical techniques when and where the model drift is strong

Initialization of spring soil moisture has a weak but positive impact on seasonal hindcast scores in the summer mid-latitudes (North America, but also Europe), especially in years with large (extent and magnitude) initial anomalies

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Issues and prospects

What would be the impact in a more realistic DSP framework (predicted SST, initialized ocean & atmosphere, use of real-time analyses to initialize soil moisture or snow mass) ?

What would be the combined impact of soil moisture and snow mass (+ vegetation) ?

What would be the impact in other models (GLACE-2, role of land-atmosphere coupling + role of SST teleconnections) ?

What would be the impact on the seasonal predictability of severe and/or extreme climate events ?

What would be the impact through a statistical adaptation of the dynamical forecasts ?

References

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