

# Simulation and inversion of borehole temperature profiles in surrogate climates: last millennium LULC influence on temperature spatial distribution and surface coupling

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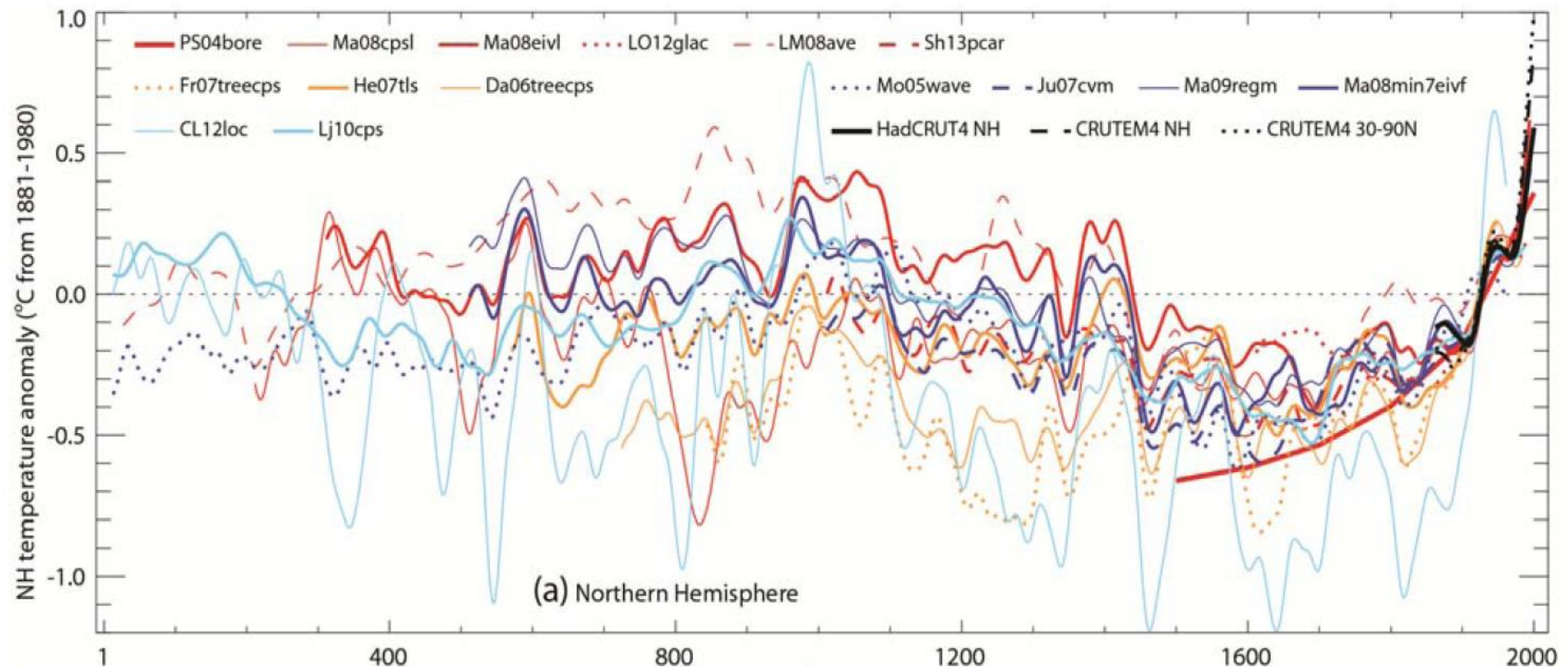
Paleoclimate Modeling & Analysis (PalMA)

Departamento de Física de la Tierra, Astronomía y Astrofísica II

Universidad Complutense de Madrid

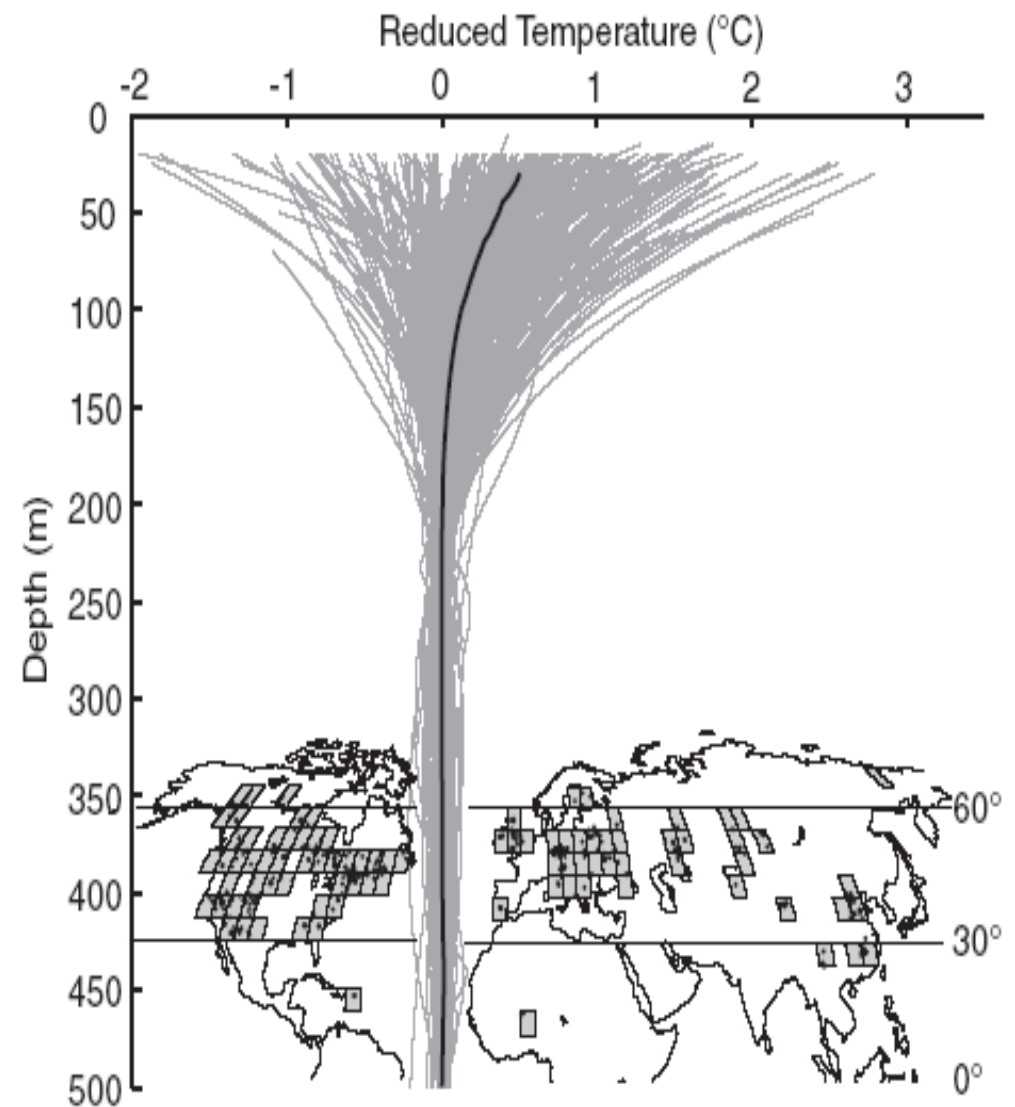
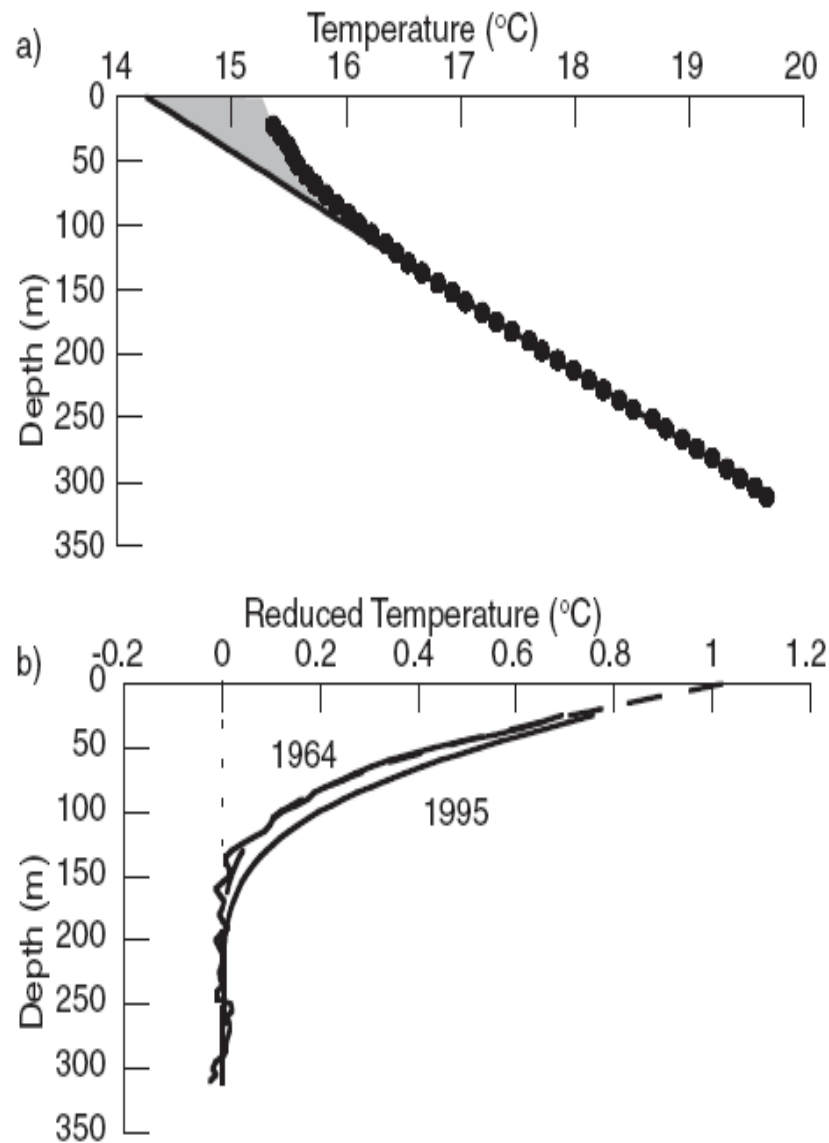


# LM climate reconstructions

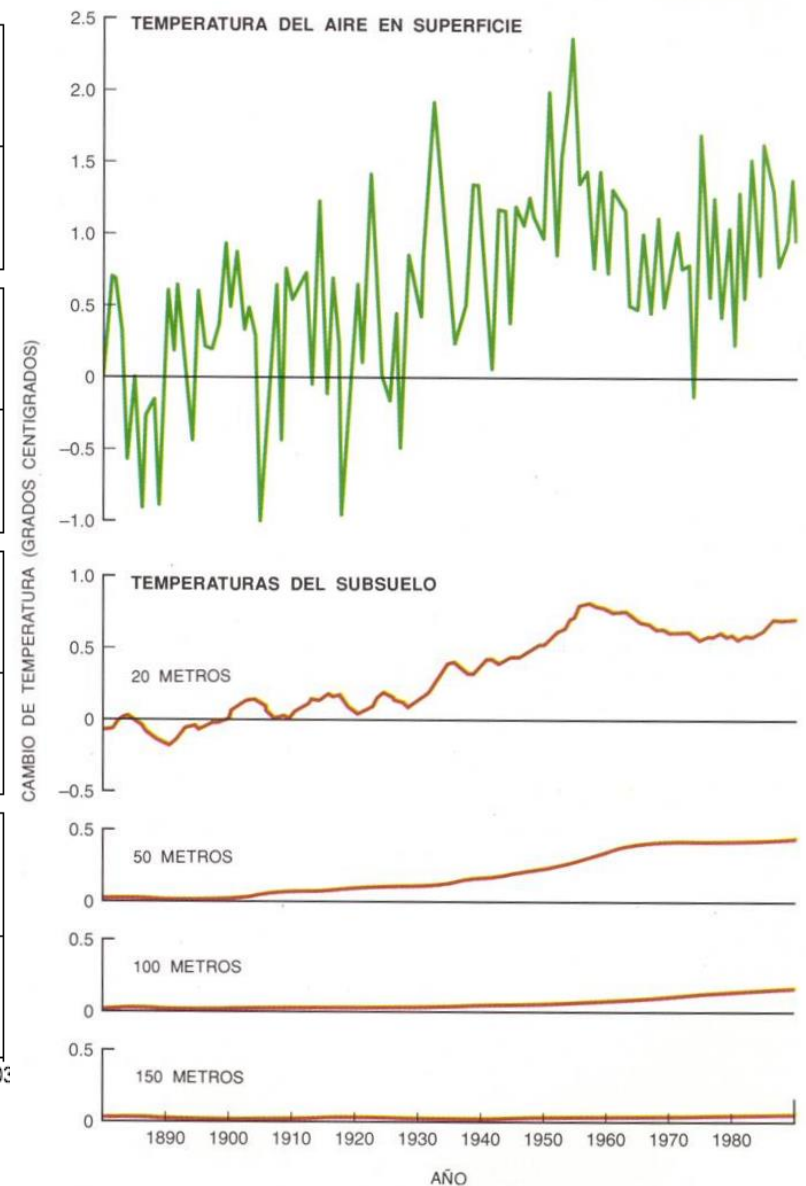
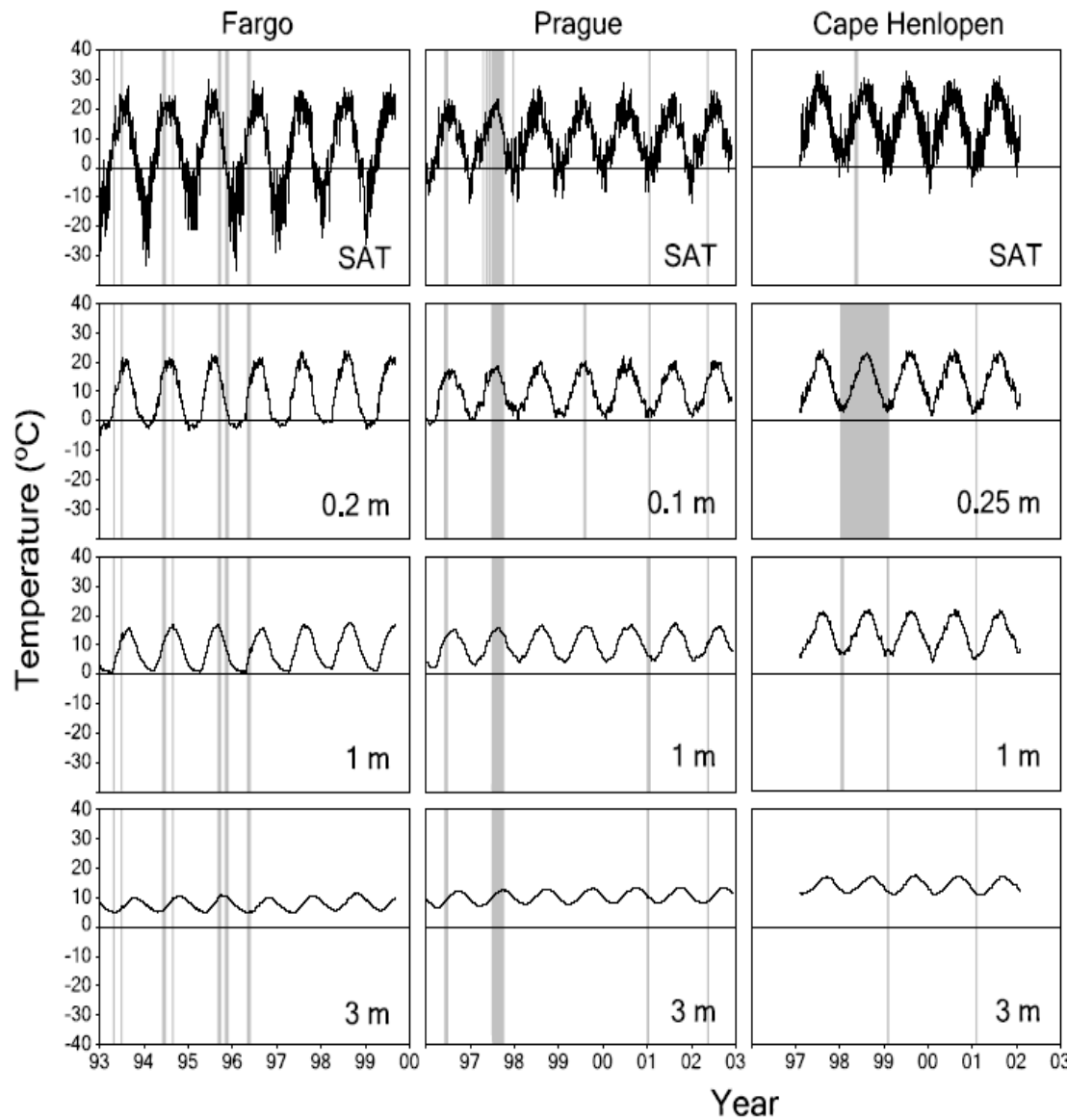


Borehole reconstruction, shows an overall warming of the ground surface of about 1.0 °C over the past five centuries while other traditional proxy-based reconstructions typically estimate a net warming of about 0.5° C.

# How is past temperature recovered from BH?



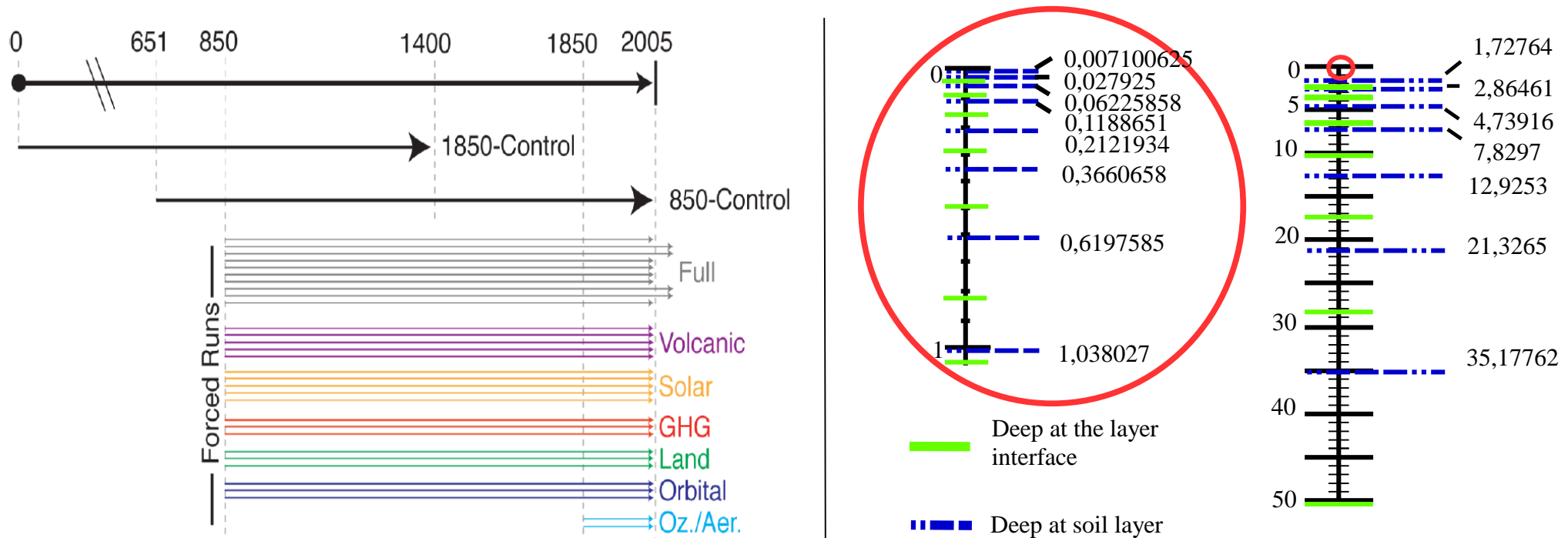
# How is the SAT and GST coupling?



**1. How well the climate models represent the air and soil temperature coupling?**

**2. Can we use model simulations as a surrogate reality for reconstructing past surface temperatures and testing the ability of borehole reconstruction technique ?**

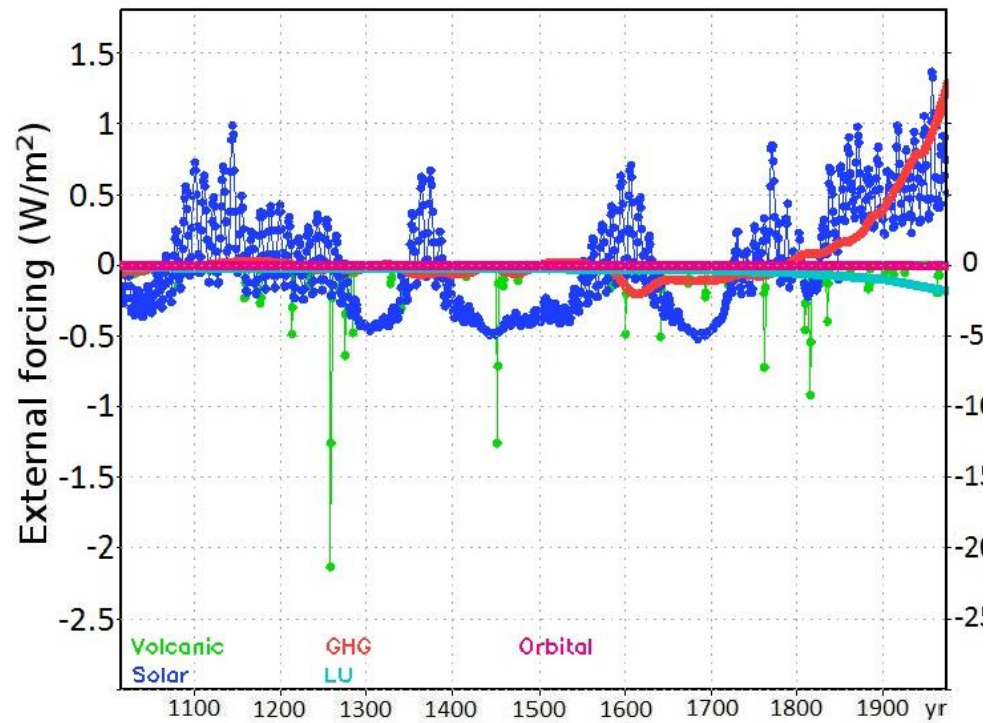
# CESM-LME



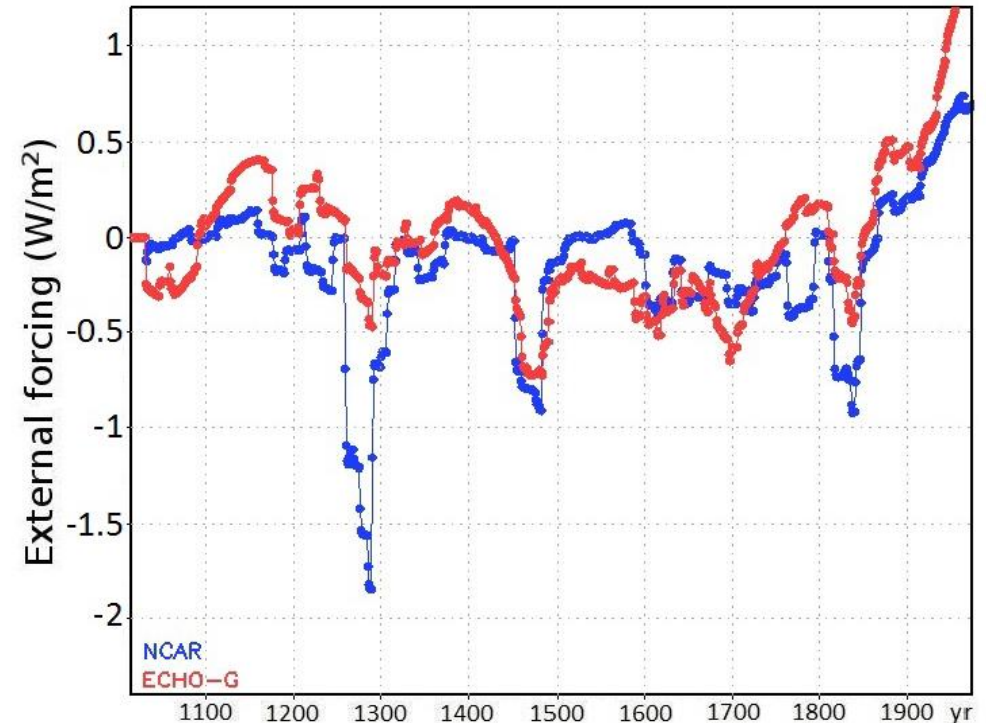
**CLM** has the deepest boundary condition among the current GCMs with a zero heat flux boundary condition placed at ~50 m depth



# CESM forcings

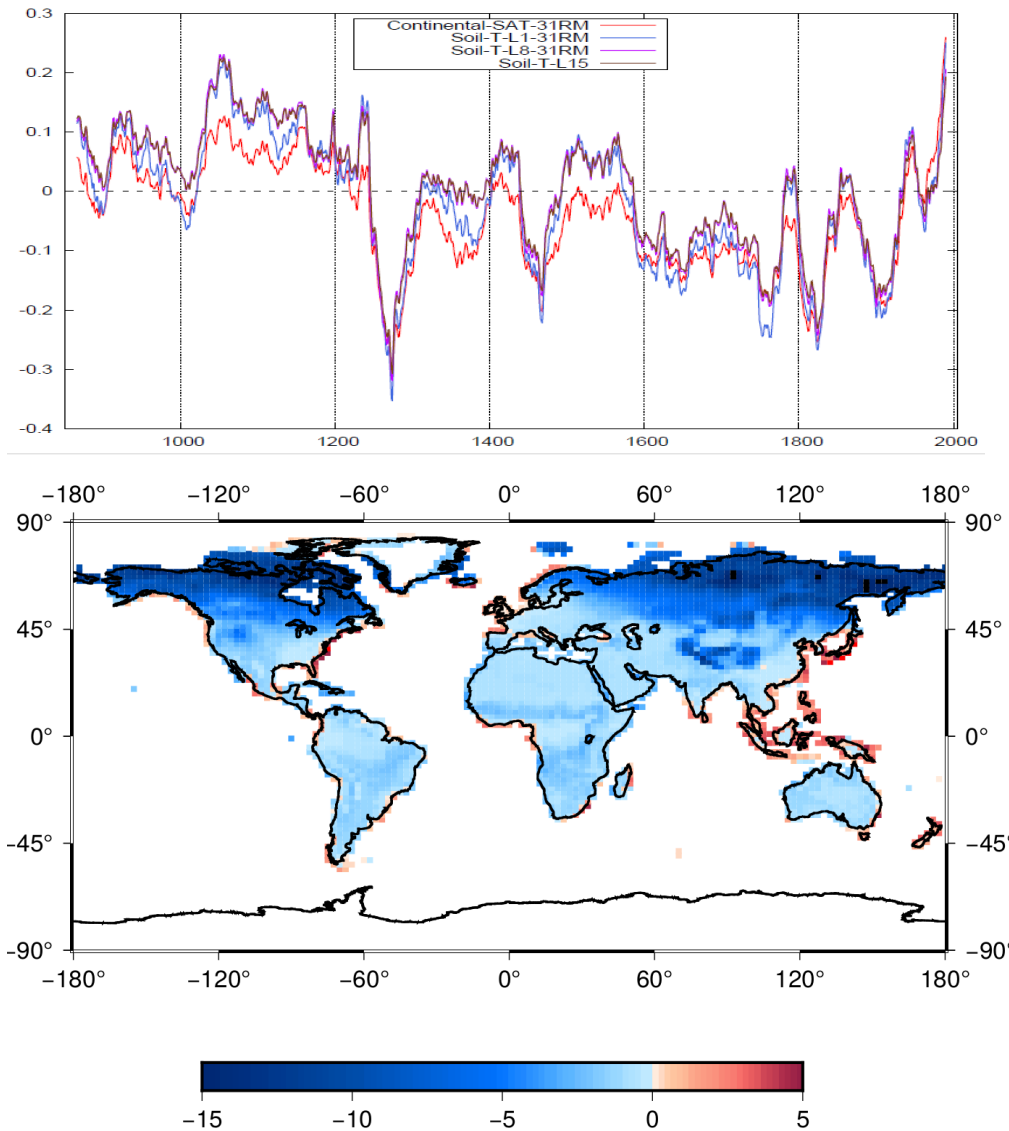


**Individual forcings**



**TEF**

# Simulated SAT-ST anomalies 850-2005



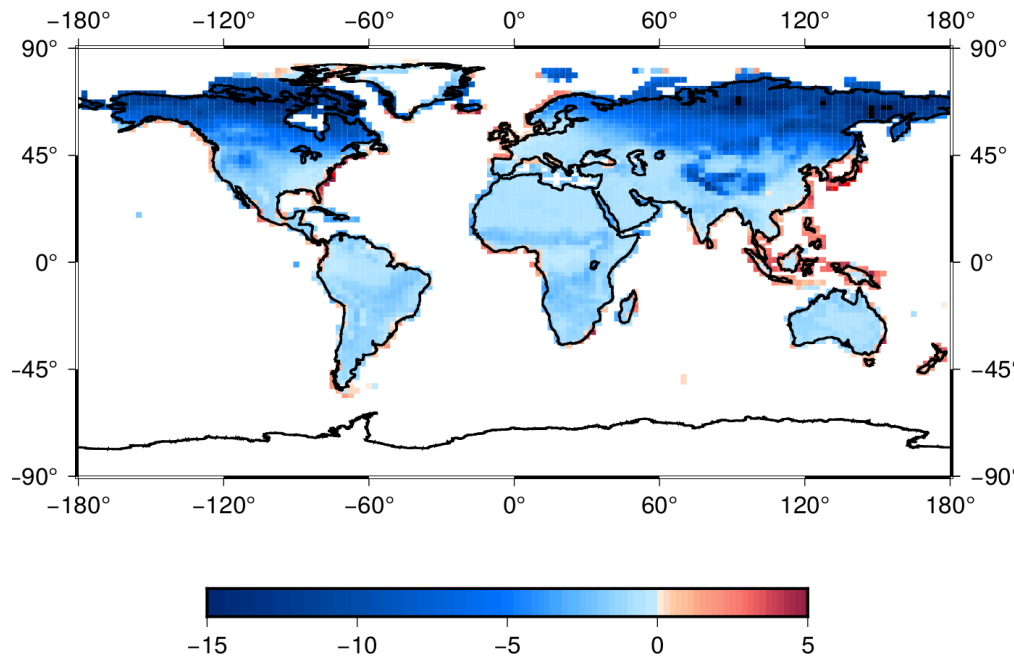
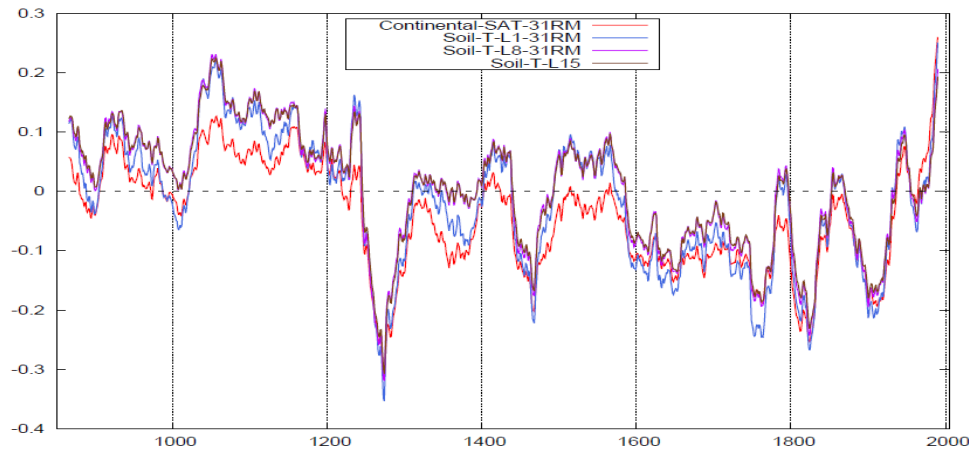
Air and ground temperature tracking at decadal and centennial time-scales

The spatial differences are higher in those areas where snow cover is characteristic in winter months

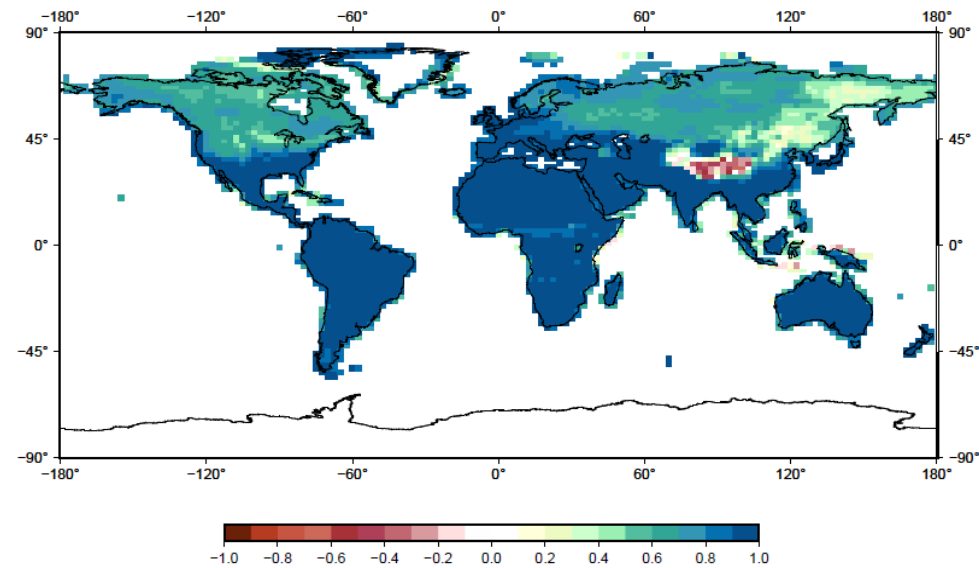
**Spatial differences**



# Simulated SAT-ST anomalies 850-2005

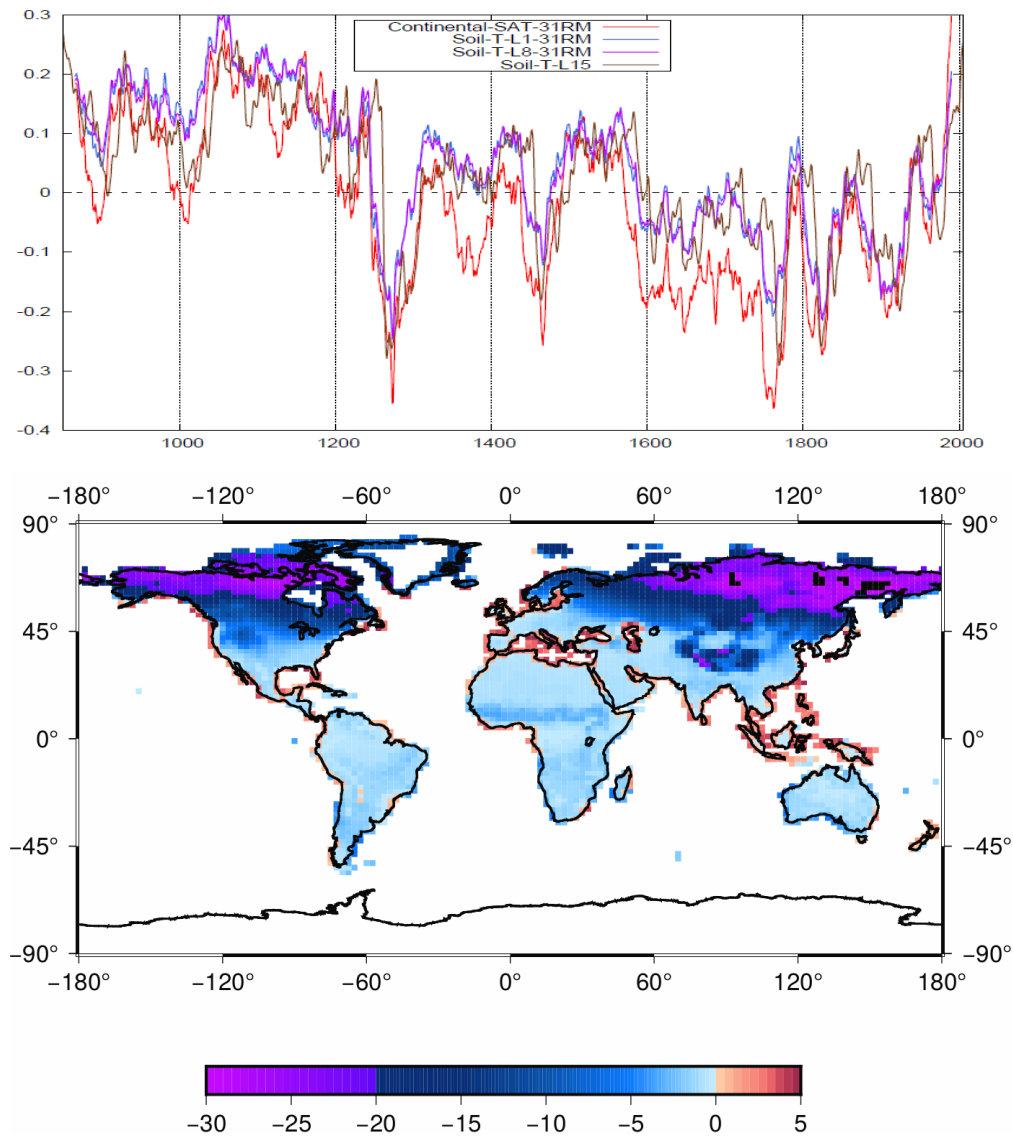


**Spatial differences**



**Correlations**

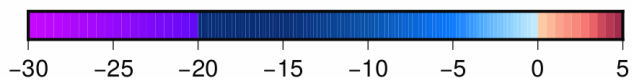
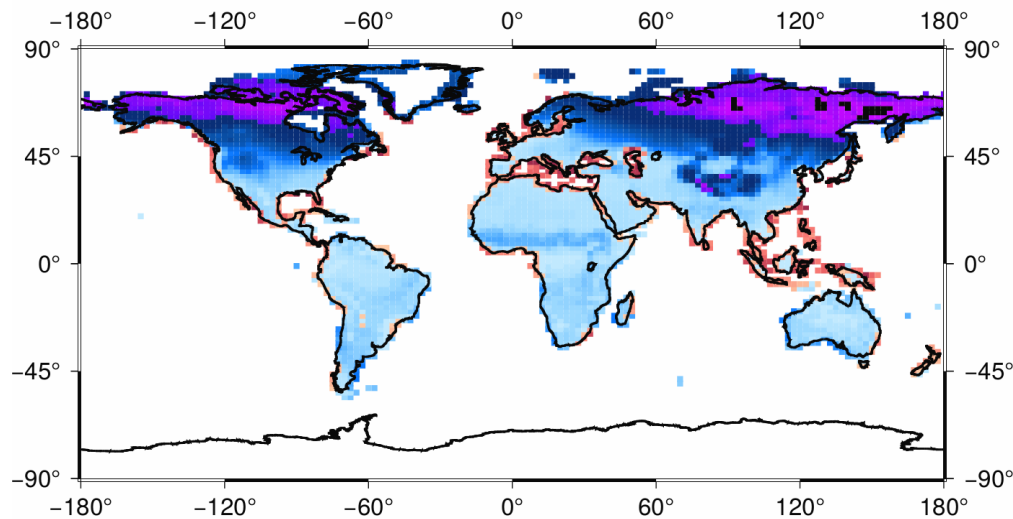
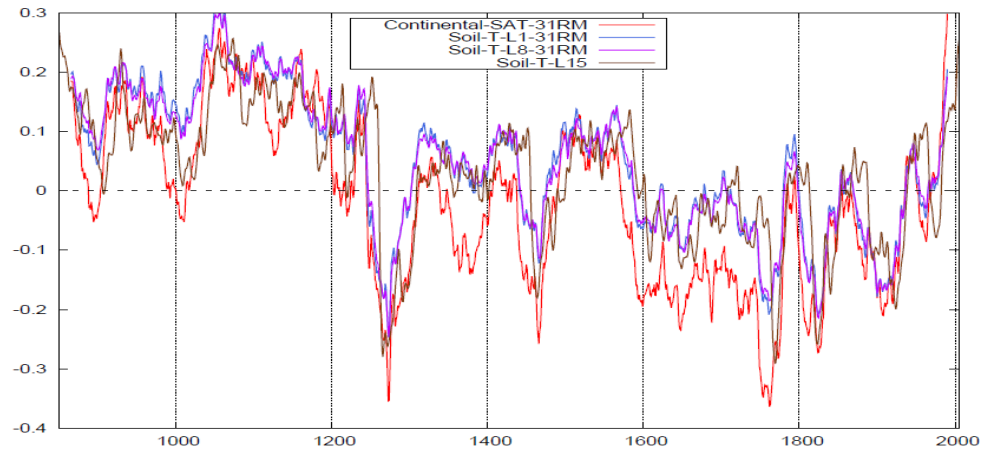
# Simulated SAT-ST anomalies 850-2005



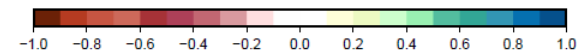
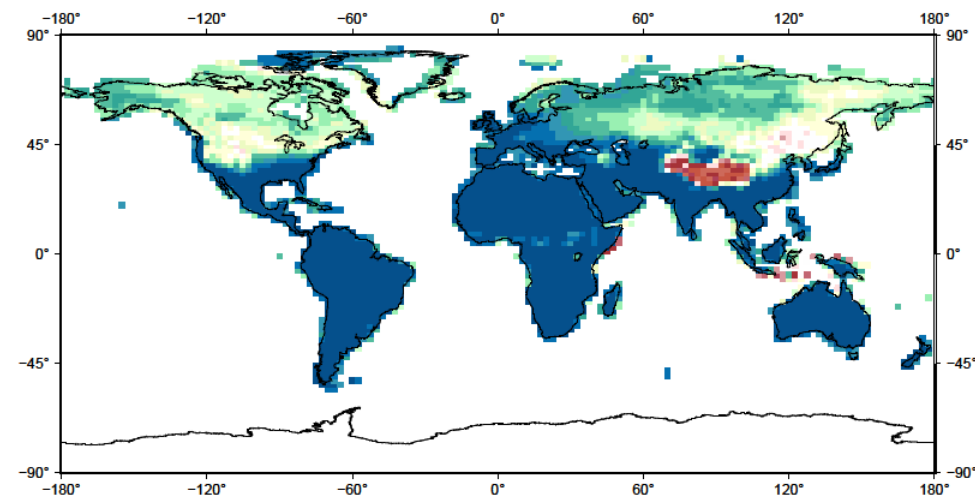
Air and ground temperature signal are decoupled during winter. Soil temperature is always warmer than surface temperature.

The spatial differences are even higher in those areas with snow cover and permafrost

# Simulated SAT-ST anomalies 850-2005

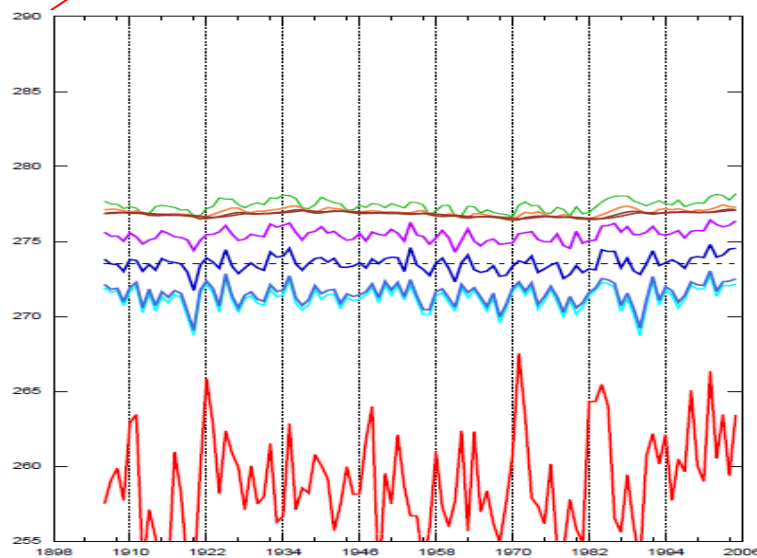
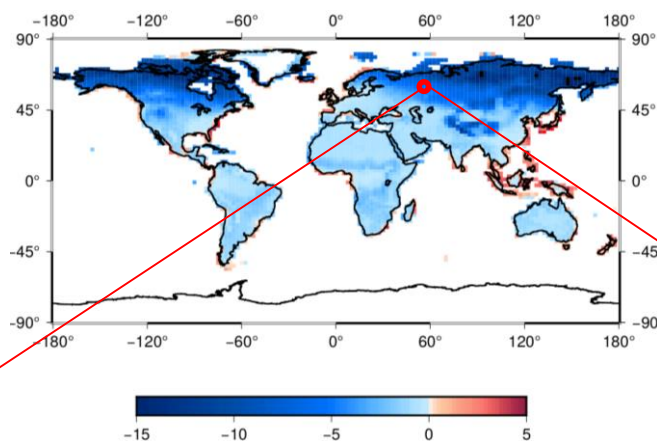


**Spatial differences**

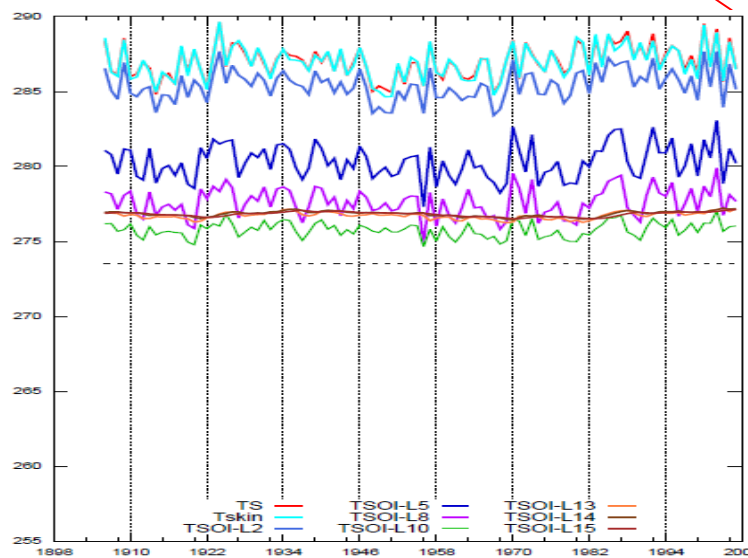


**Correlations**

# Snow cover effect

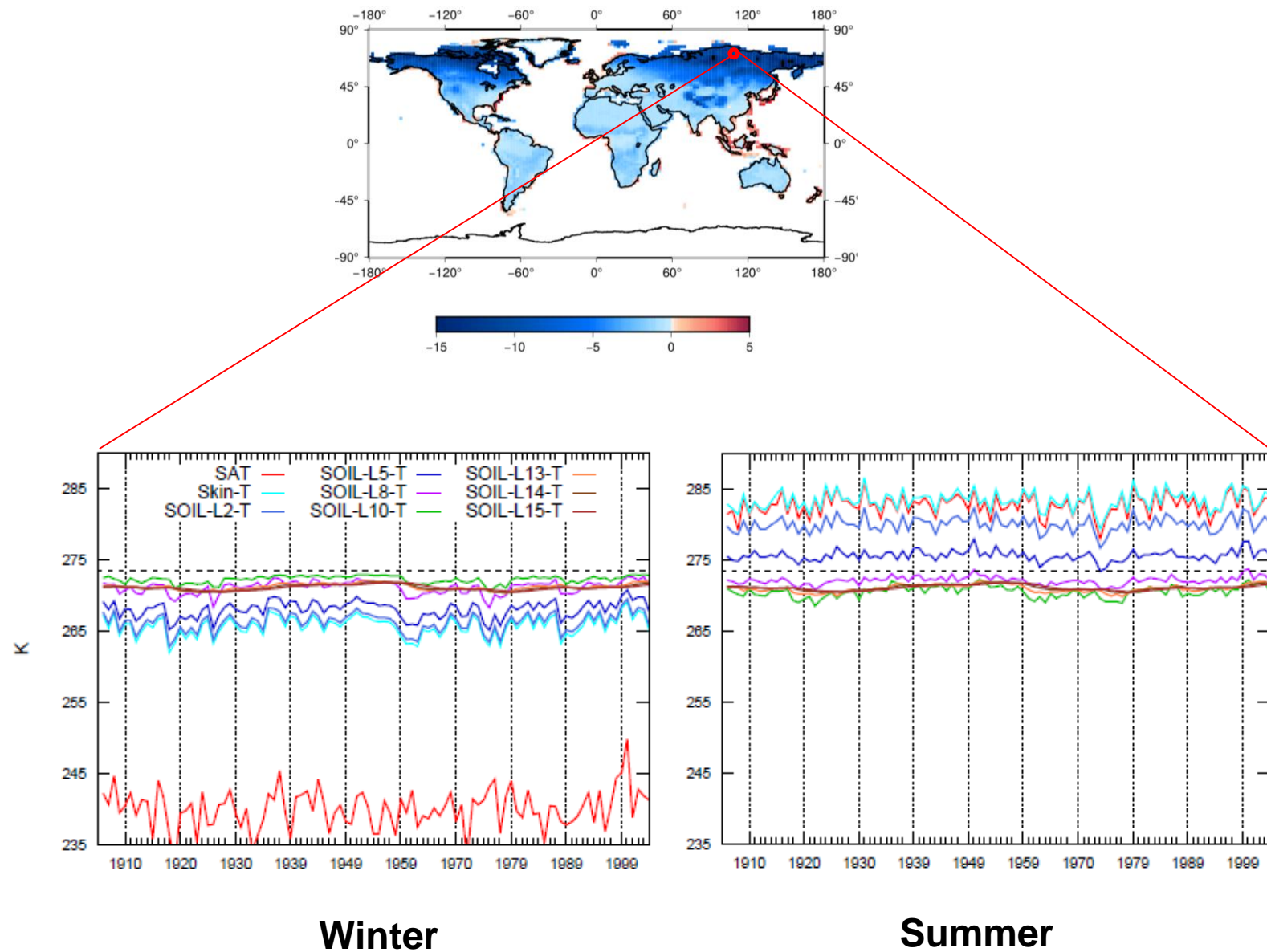


**Winter**

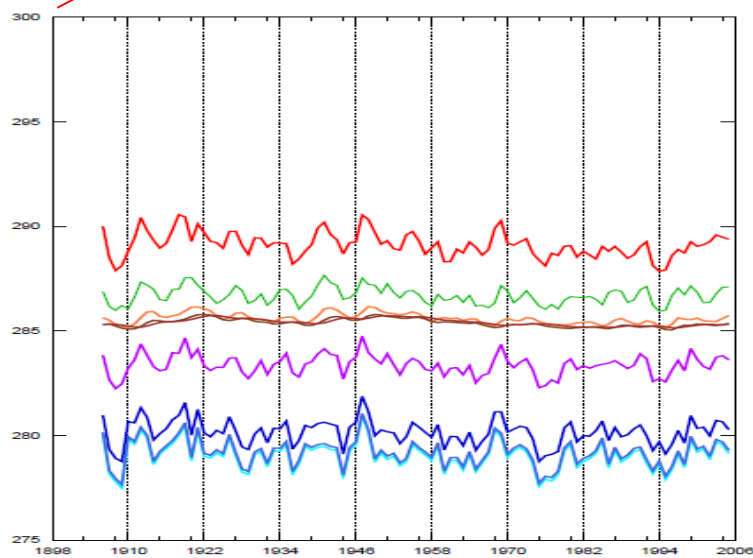
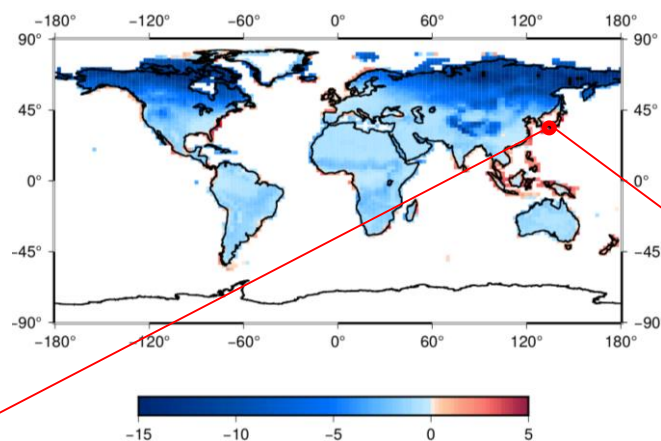


**Summer**

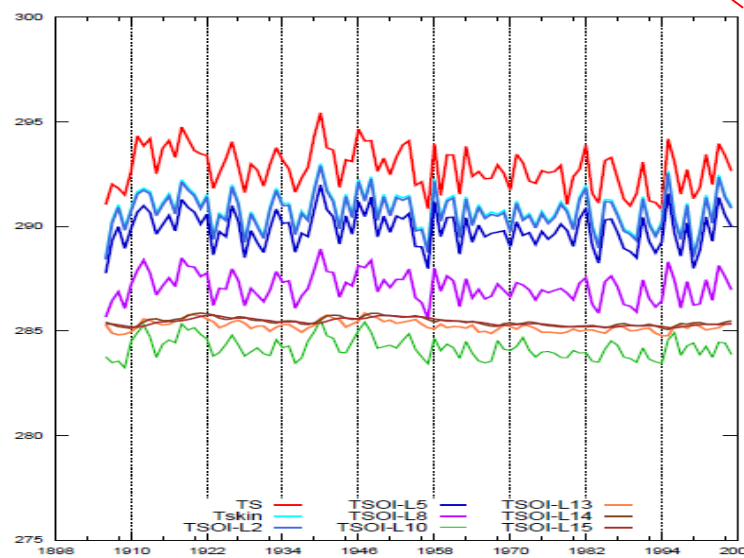
# Snow cover + permafrost



# Coastal areas



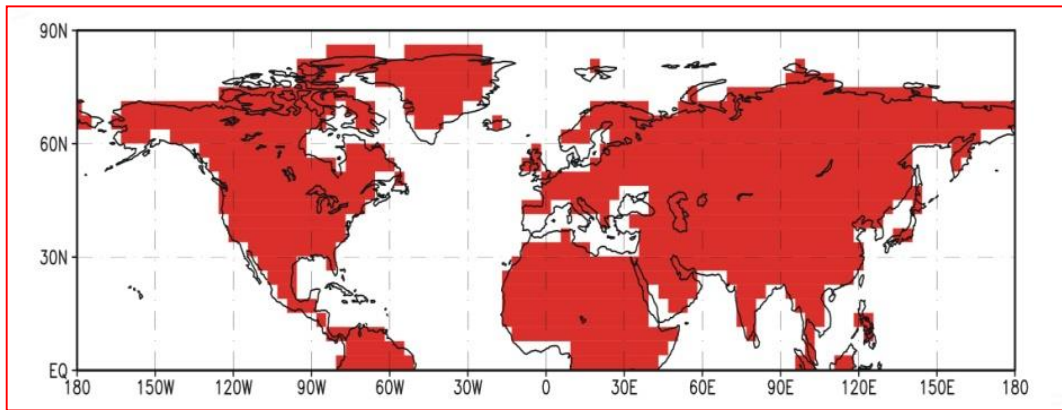
**Winter**



**Summer**

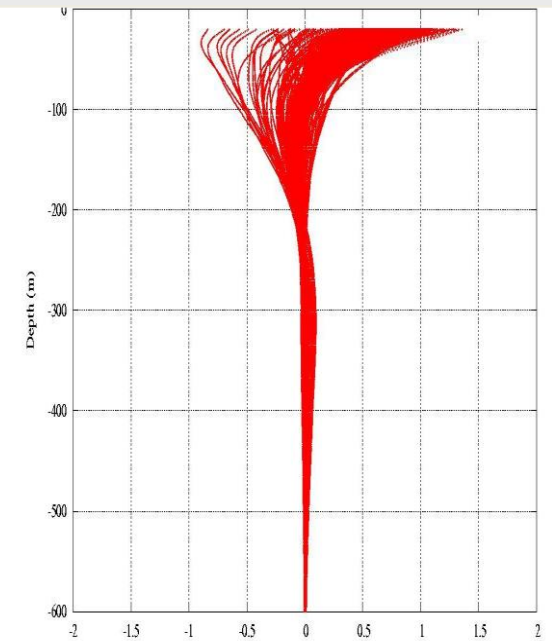


# AOGCMs as a surrogate reality



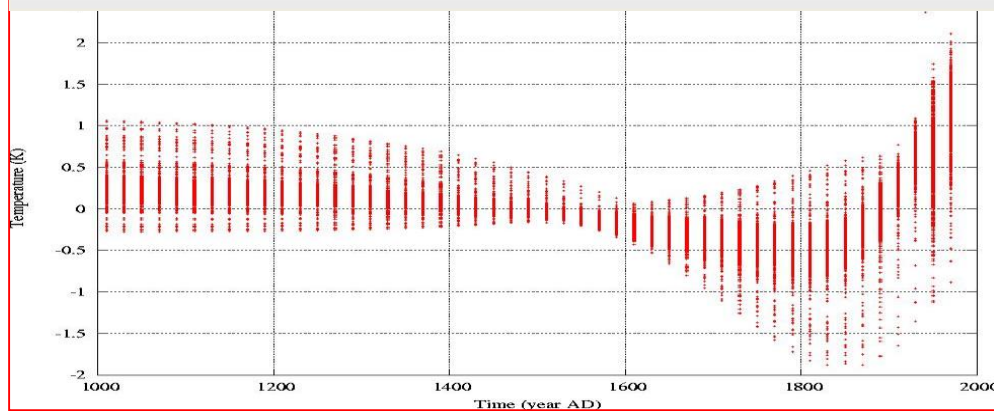
**Forward  
model**

Beltrami & Bourlon, EPSL,  
227, 169-177, 2004

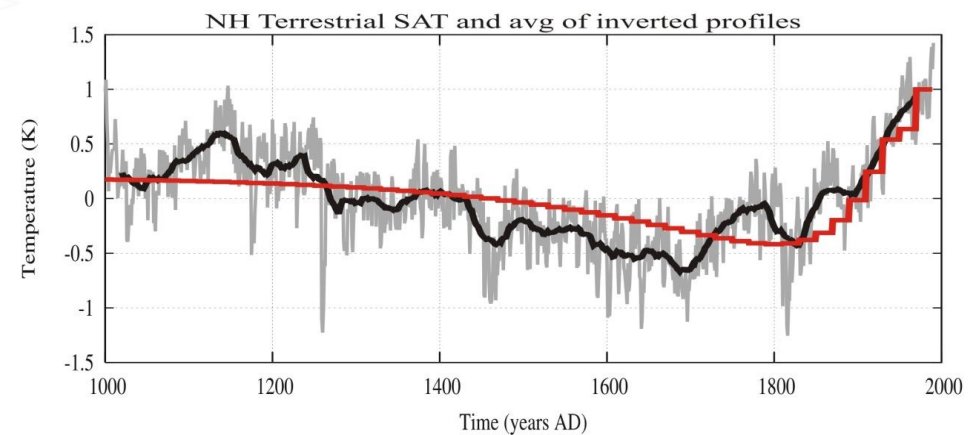


**Inversion**

**SVD:** Mareschal & Beltrami, Clim. Dyn., 6,  
605-608, 1992

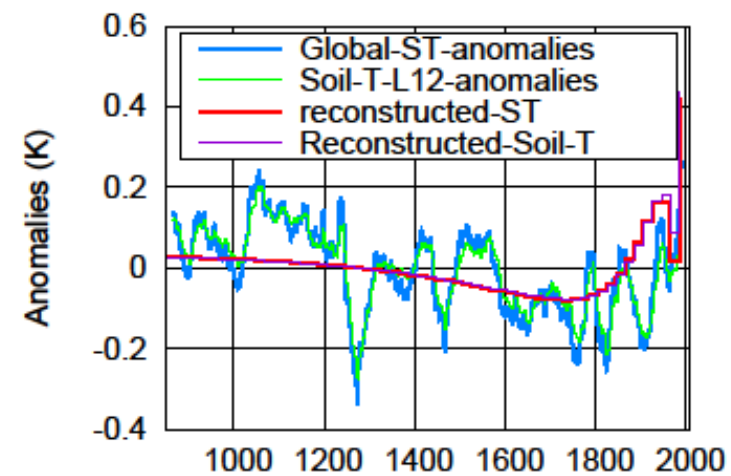
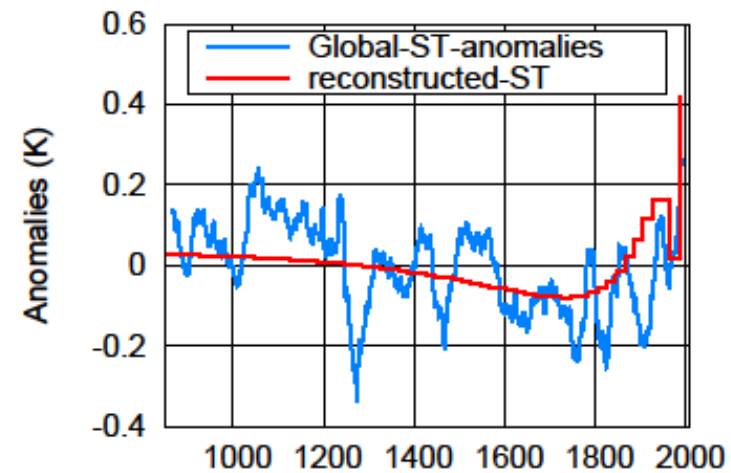
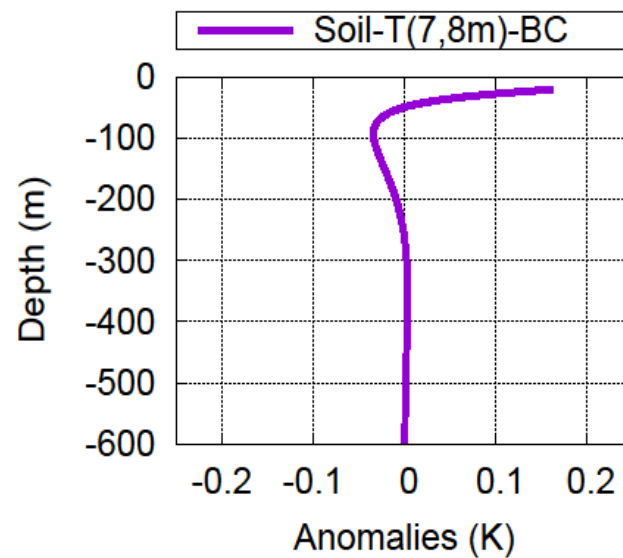
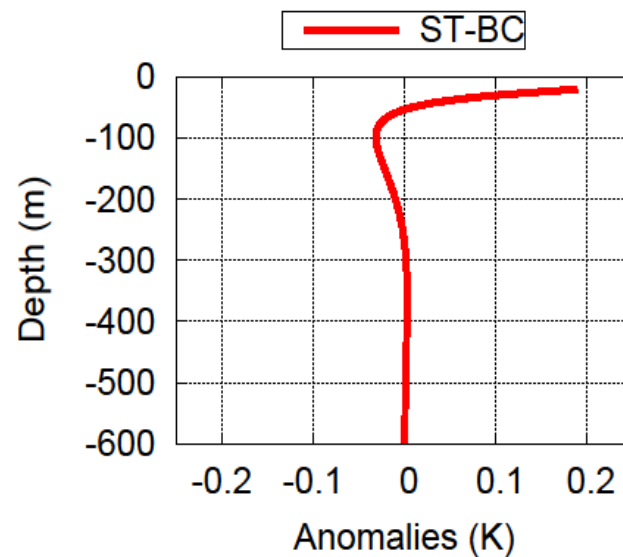


**Lat weighted avg.**





# Reconstruction approach



# SUMMARY

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Strong coupling between air and ground temperatures at decadal and centennial time-scales and the model is able to reproduce it.

Some local and regional factors produce a decoupling between the two temperatures both in summer and winter. This factors include the insulating effect of snow in the northern high latitudes, latent heat exchanges in other parts of the world.

CESM-LME is able to represent the main characteristic of the surface and soil temperatures coupling.

The use of GCMs as a test bed for climate reconstruction methods has provided evidence for the robustness of the borehole.

LULC may play a major role in decoupling?

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# Thank you for the attention!

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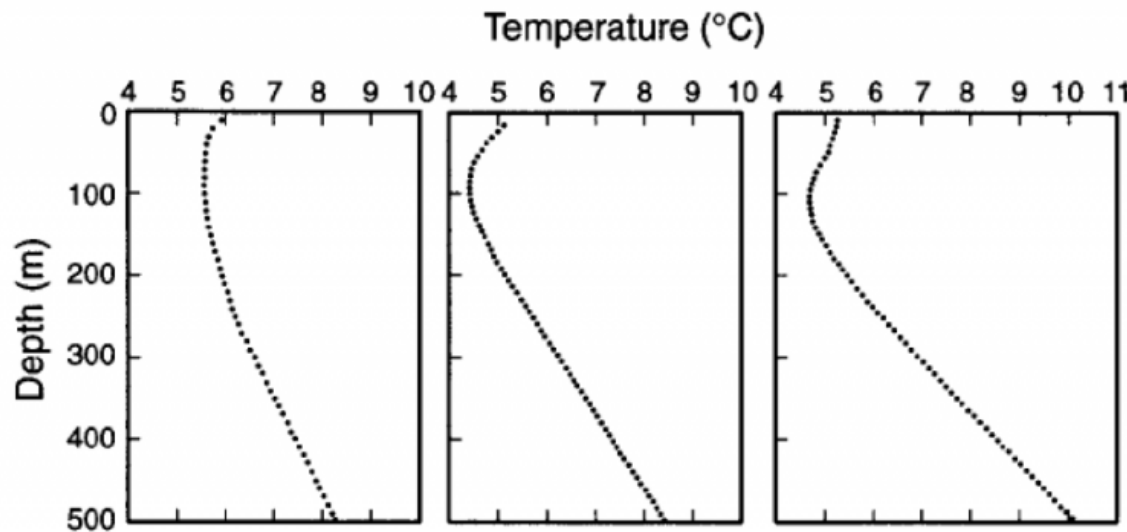
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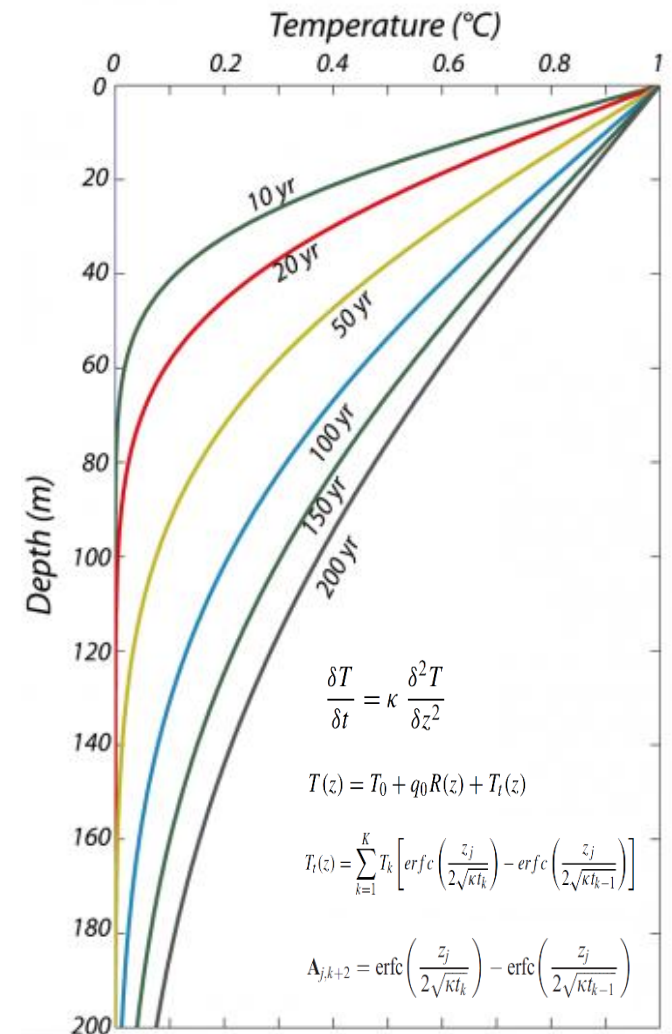
# How is past temperature recovered from BH?



Temperature changes at the Earth's surface propagate into the subsurface and impart a thermal signature to the rocks.

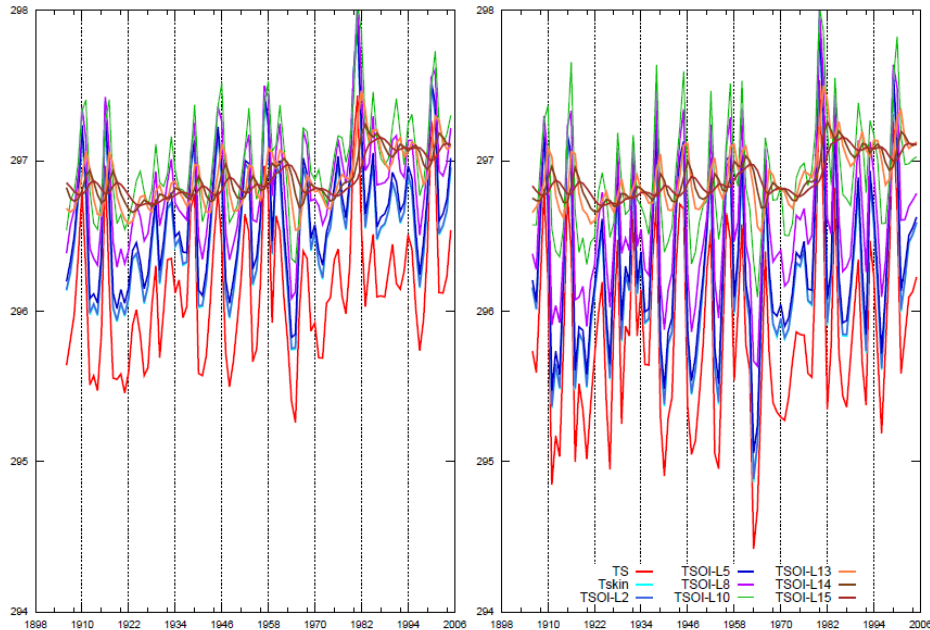
Conductive heat transport dominates below the surface.

## Downward Propagation of a Step Increase in Surface Temperature

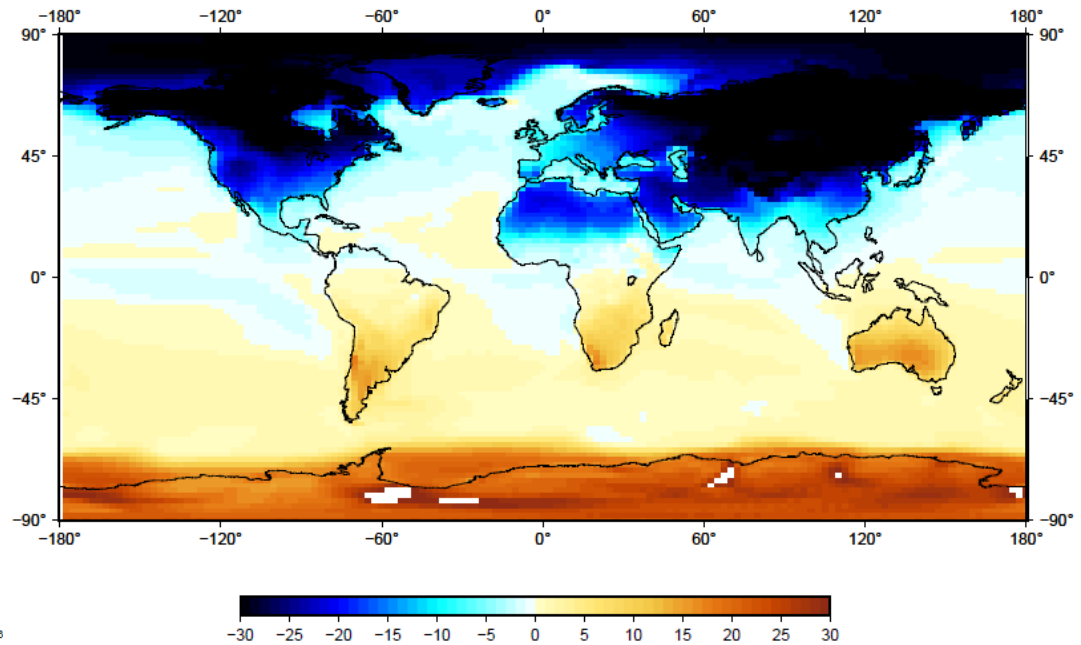


# Grid-points (Tropical low differences)

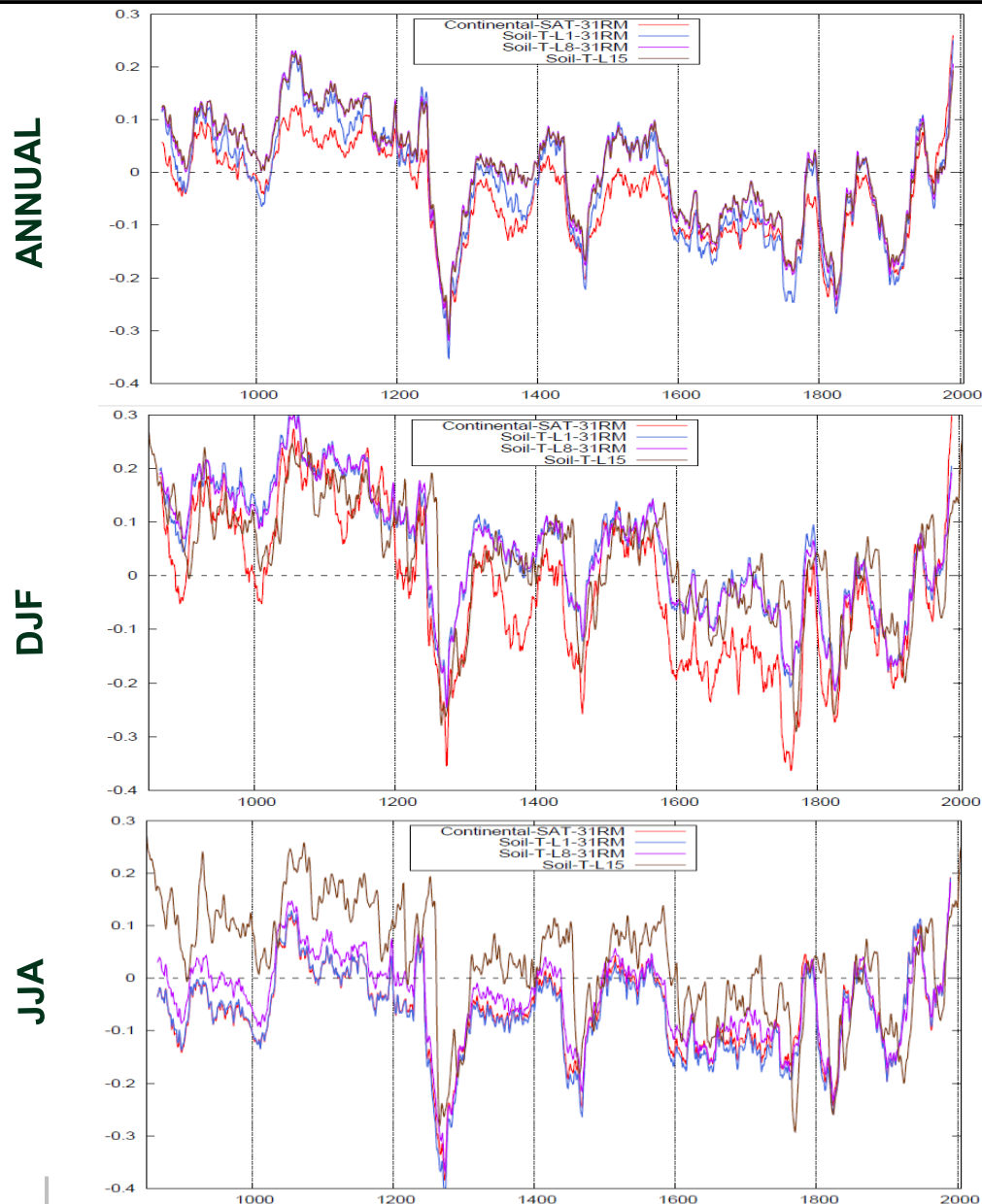
## Grid-point at Amazon forest



## Global SAT Winter - summer



# Simulated SAT-ST anomalies 850-2005



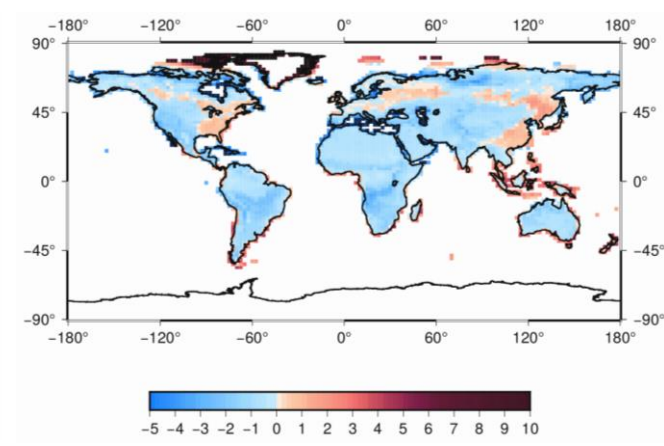
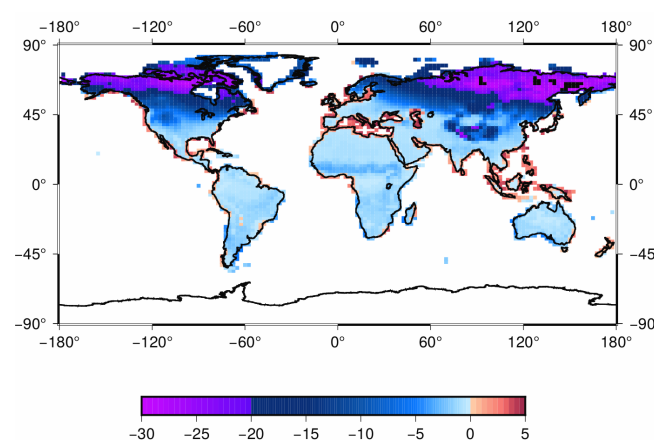
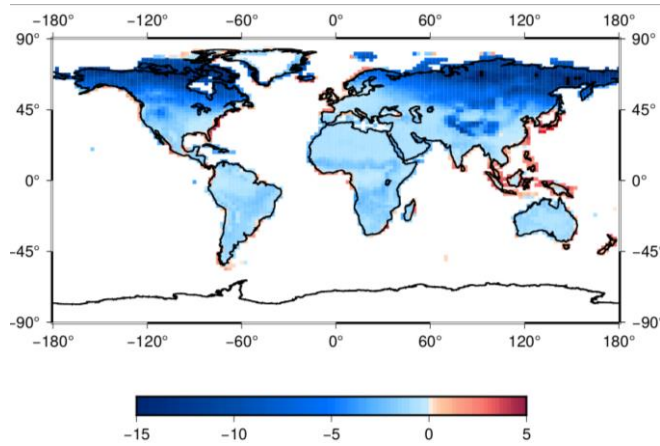
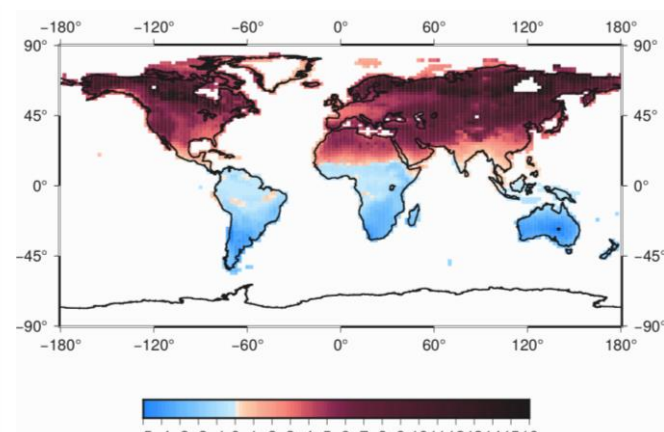
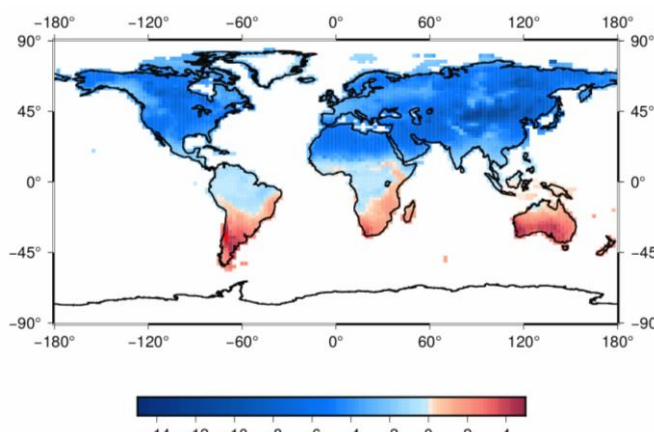
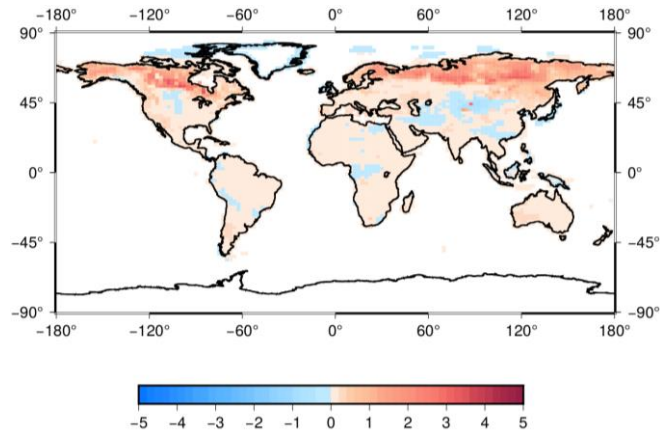
Air and ground temperature tracking at decadal and centennial time-scales

The existence of a strong ground surface temperature (GST) and surface air temperature (SAT) coupling during summer

During winter, the insulating effect of snow and latent heat exchanges produce a decoupling



# SAT-ST spatial differences

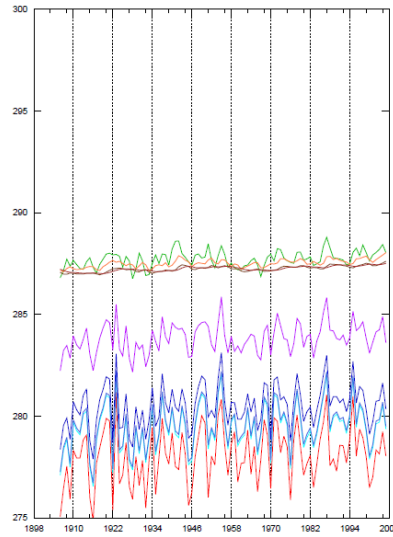
**ANNUAL****DJF****JJA****T2m-Tskin****Tskin-L8**



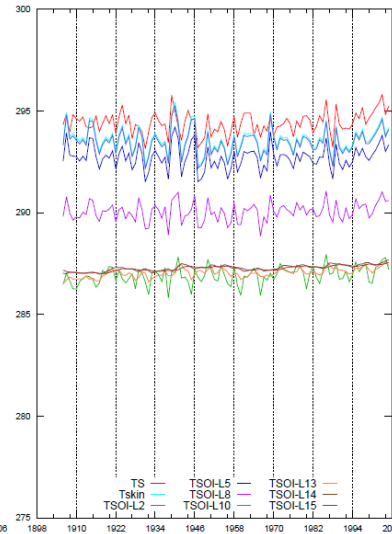
# Grid-points (differences summer)

South-East  
US

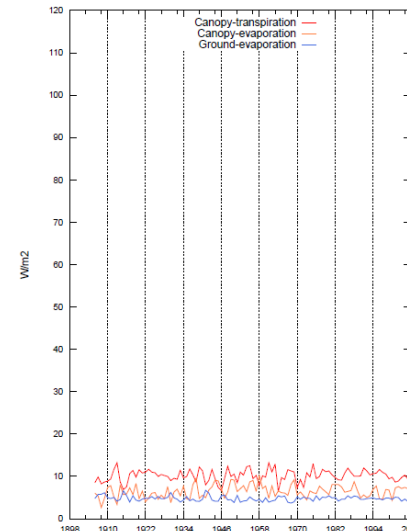
T-DJF



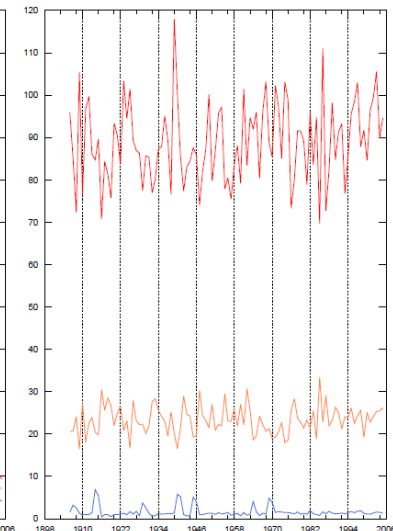
T-JJA



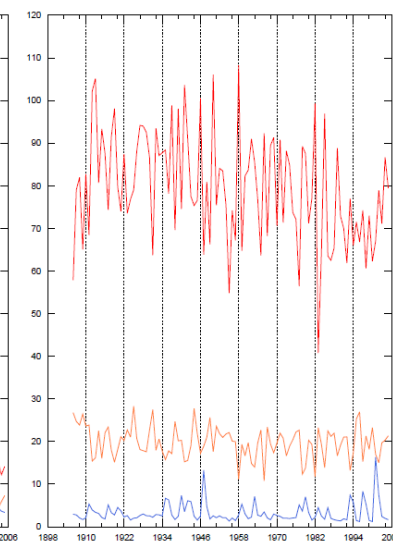
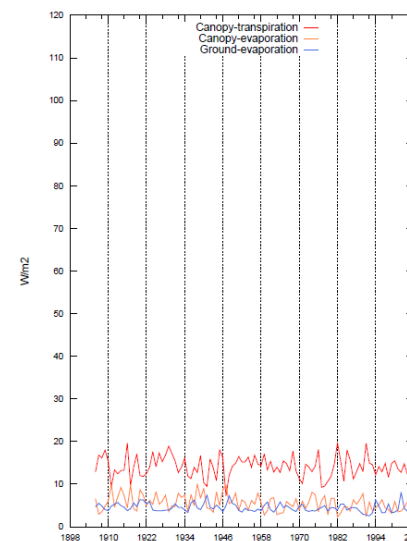
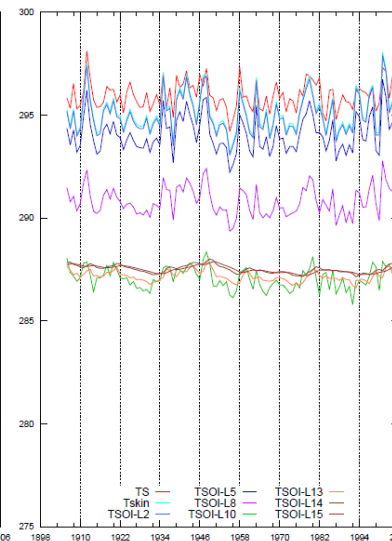
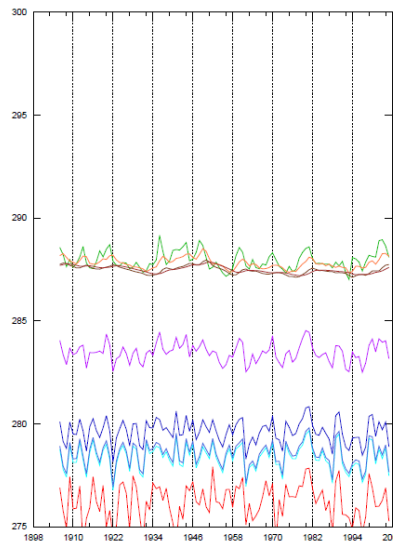
LHFLX-DJF



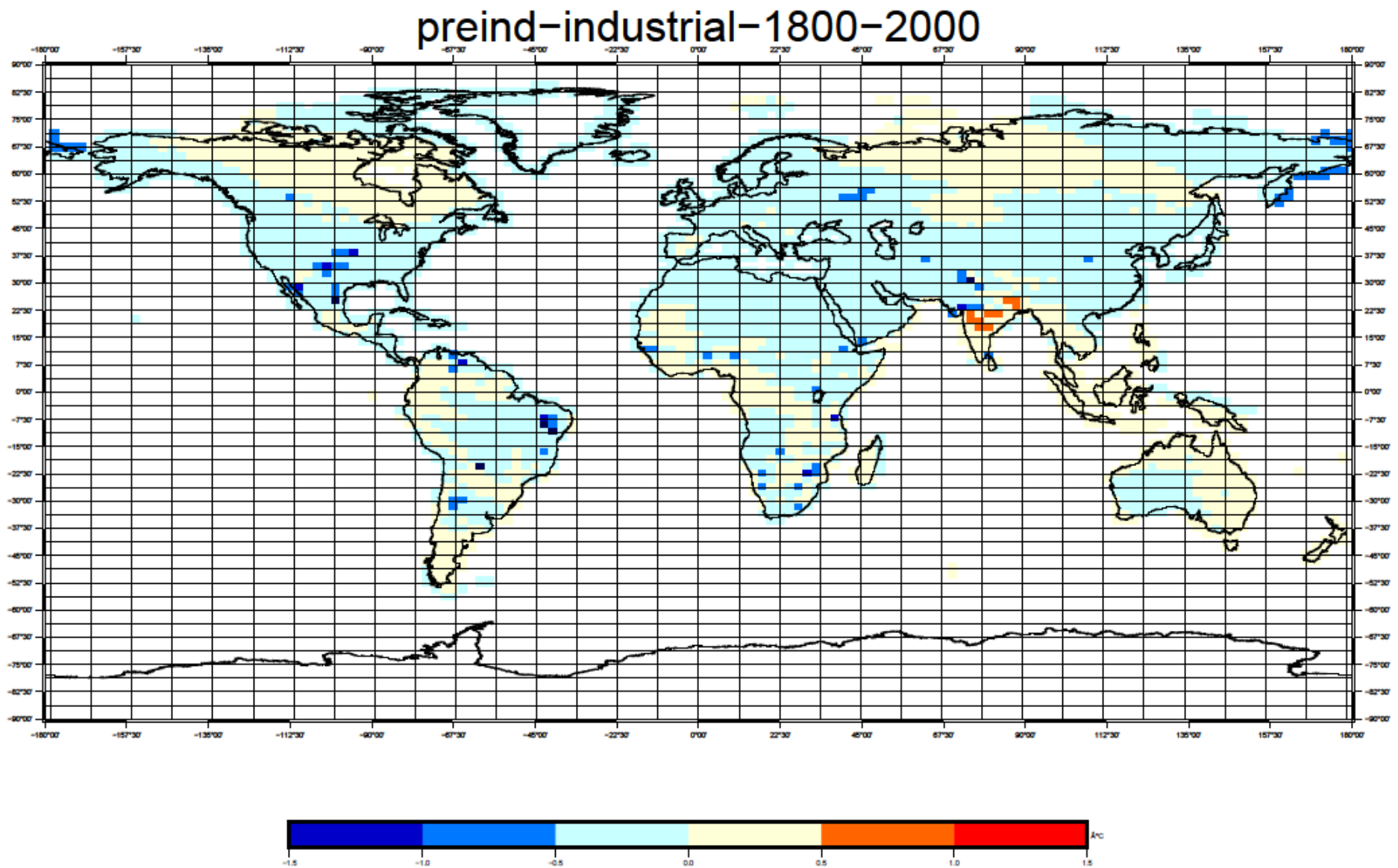
LHFLX-JJA



South-East  
China



# Other interesting issues



# Other interesting issues

