LS4P Experimental Design and Challenge, and Lessons in Initialization of Land Surface Temperature and Tests of its Effects

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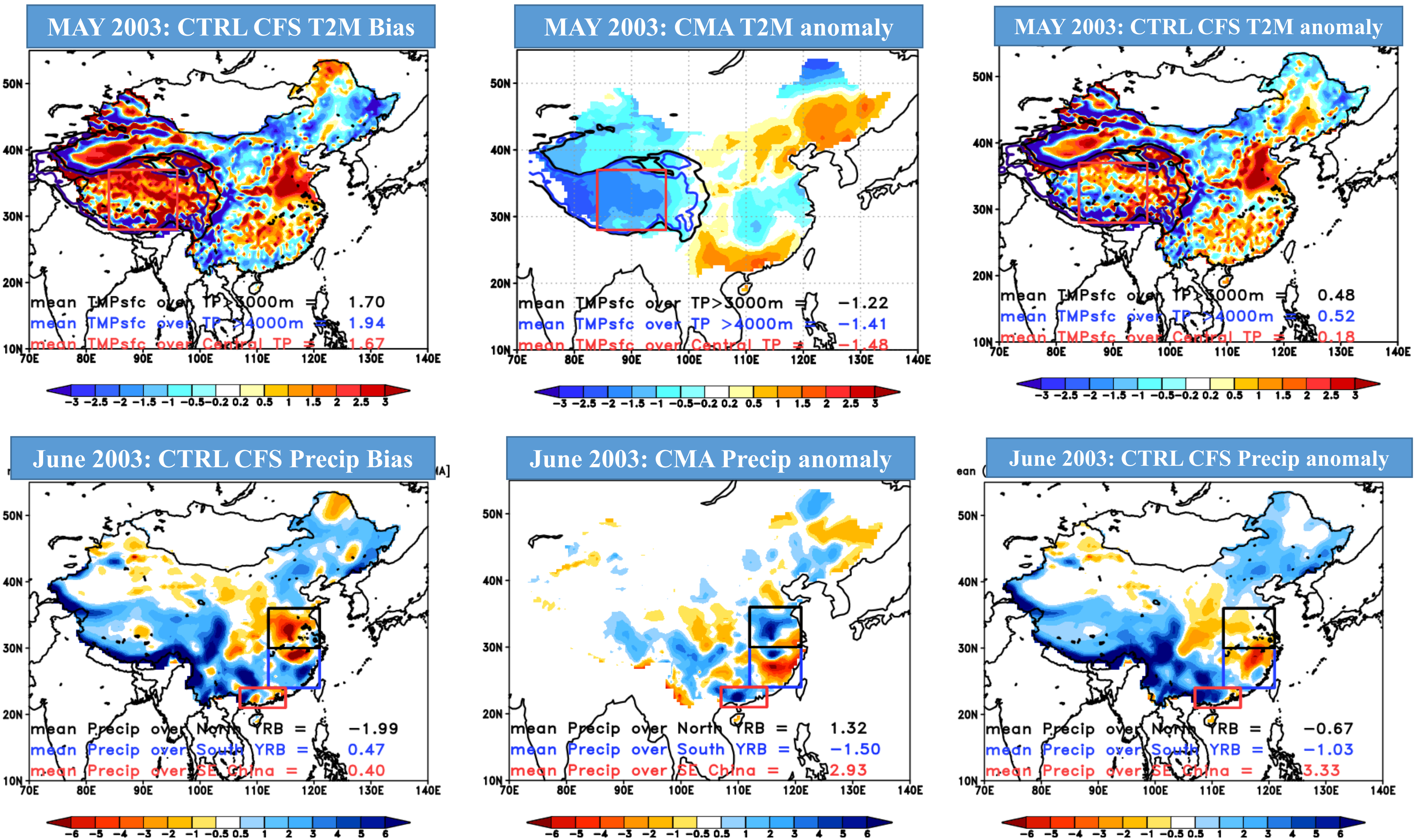
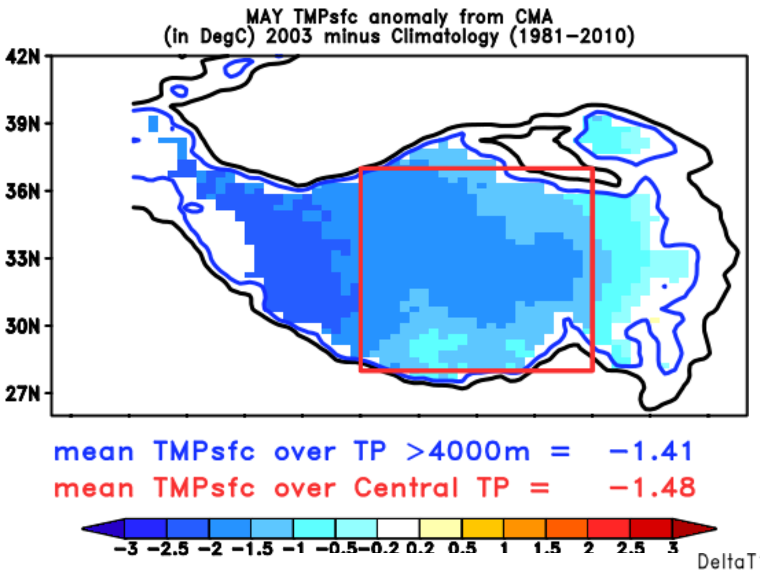
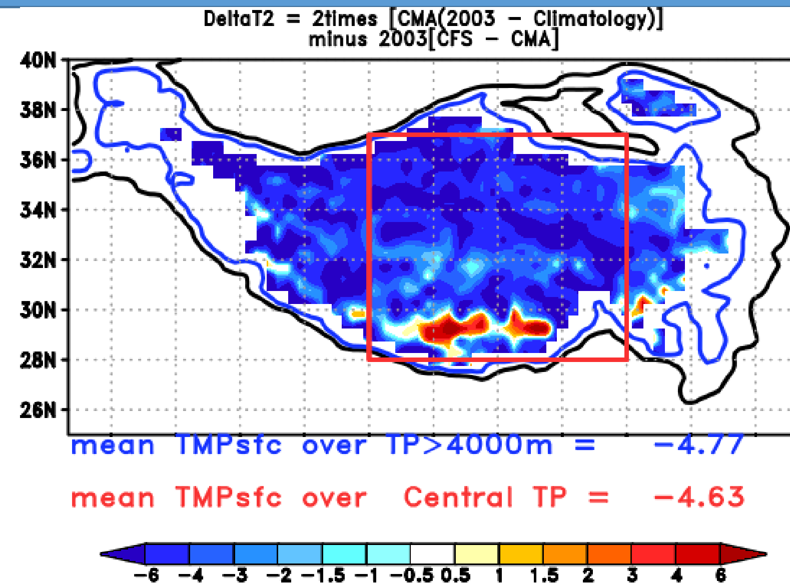
Each Model products need to produce the following figures for the model preliminary evaluation. No model in the world has no severe bias in the Tibetan Plateau area. A mask will be generated intending to correct this bias and to produce observed anomaly.

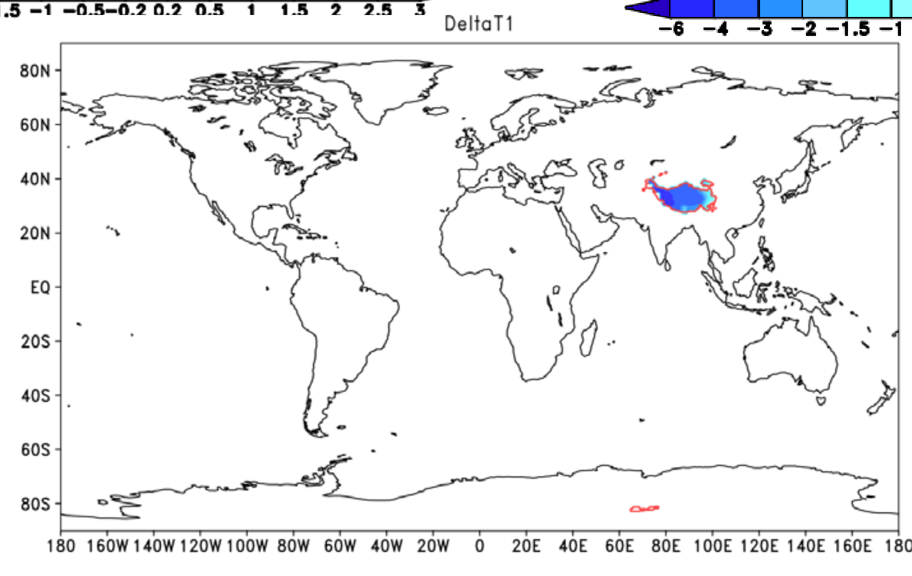

MAY 2003: CTRL CFS T2M Bias
mean TMPsfc over TP>3000m = 1.70
mean TMPsfc over TP >4000m = 1.94
mean TMPsfc over Central TP = 1.67
MAY 2003: CMA T2M anomaly
mean TMPsfc over TP>3000m = −1.22
mean TMPsfc over TP >4000m = −1.41
mean TMPsfc over Central TP = −1.48
MAY 2003: CTRL CFS T2M anomaly
mean TMPsfc over TP>3000m = 0.48
mean TMPsfc over TP >4000m = 0.52
mean TMPsfc over Central TP = 0.18
June 2003: CTRL CFS Precip Bias
mean Precip over North YRB = −1.99
mean Precip over South YRB = 0.47
mean Precip over SE China = 0.40
June 2003: CMA Precip anomaly
mean Precip over North YRB = 1.32
mean Precip over South YRB = −1.50
mean Precip over SE China = 2.93
June 2003: CTRL CFS Precip anomaly
mean Precip over North YRB = −0.67
mean Precip over South YRB = −1.03
mean Precip over SE China = 3.33

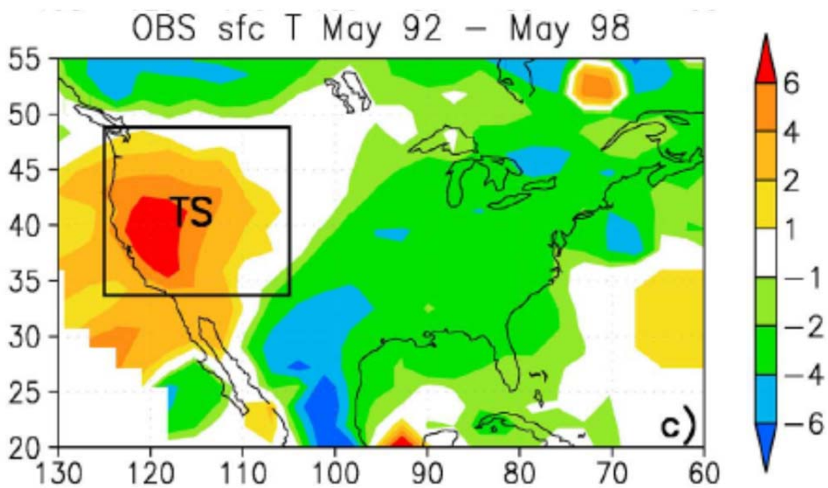
CMA OBS anomaly

A mask based on CMA OBS anomaly for the model

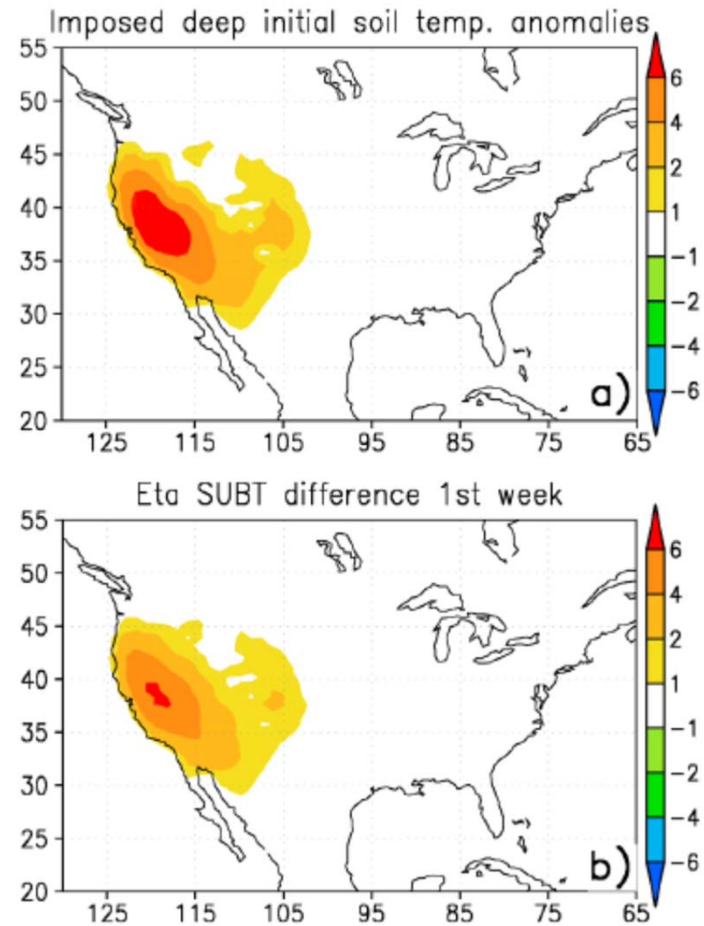


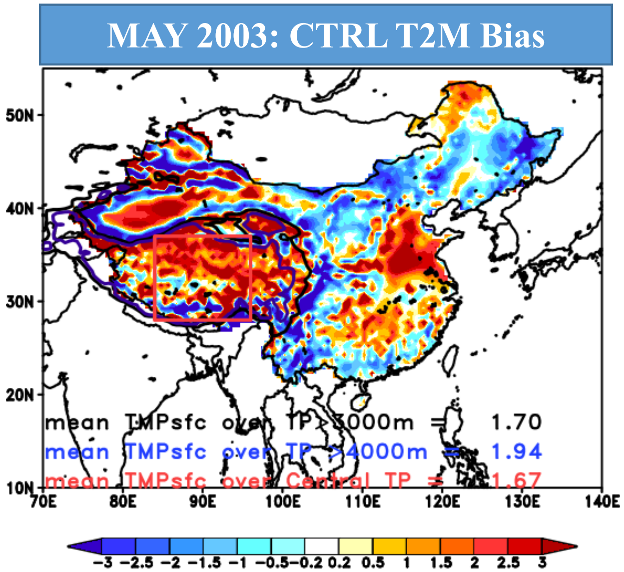


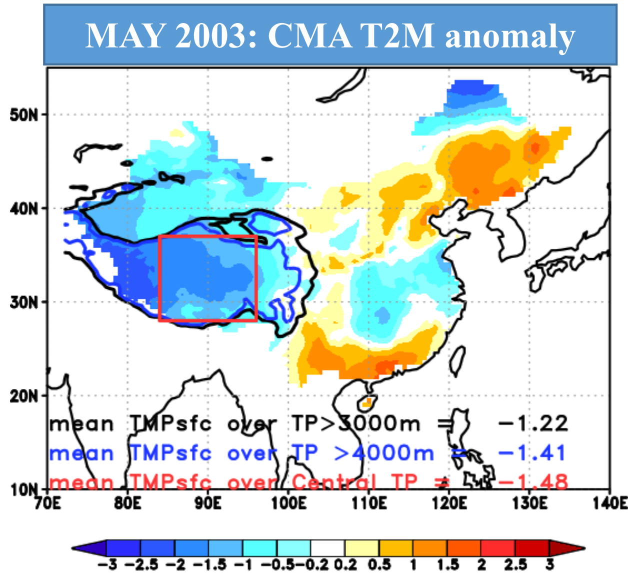




Current ESM land model has difficulty to keep land memory

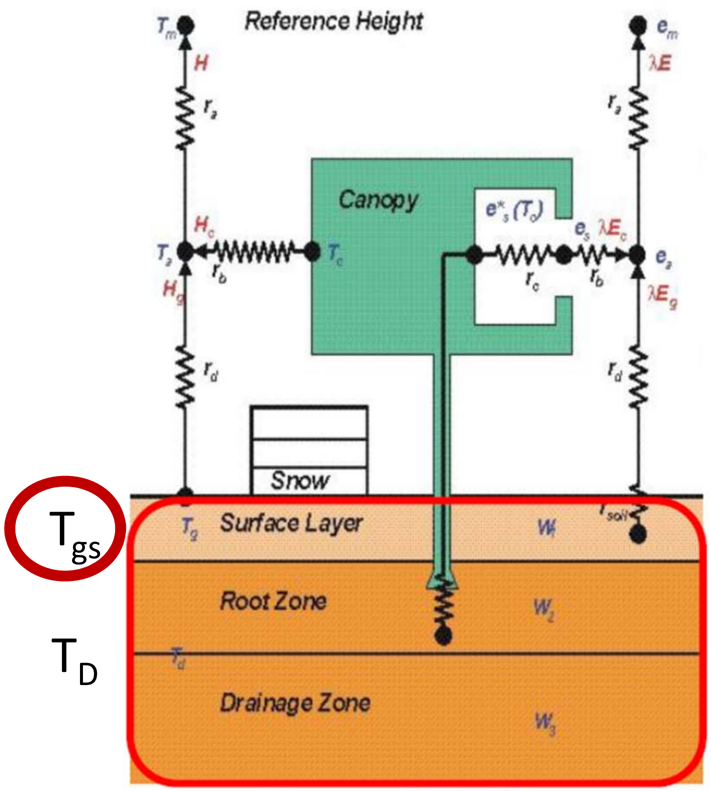






Lesson I

Impose ΔT to the soil layer temperature but produce not much difference, for instance bias reduces from 1.94 to 1.93.



Framework of SSiB

Lesson II

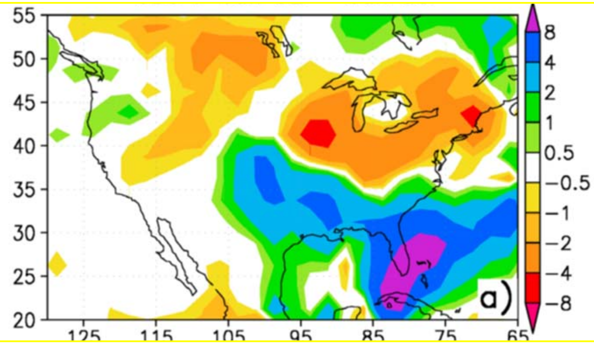
Impose the ΔT initial condition only on the 1st soil layer.

At this point, imposing ΔT initial condition to deep soil layers is the only way for an ESM to reproduce the observed T-2m temperature anomaly

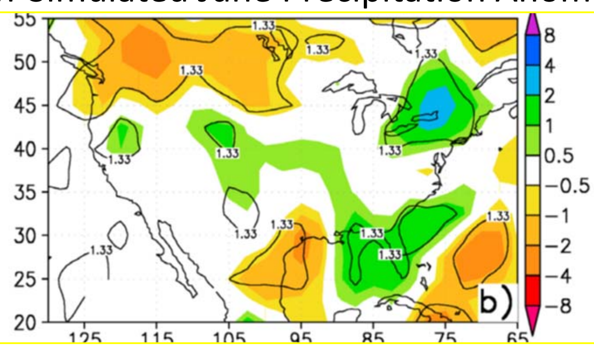
Lesson III

Impose reanalysis LBC for both control and sensitivity runs with improper domain size

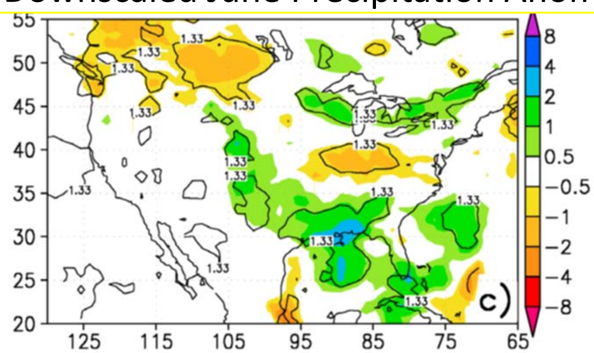
Observed June Precipitation Anomaly



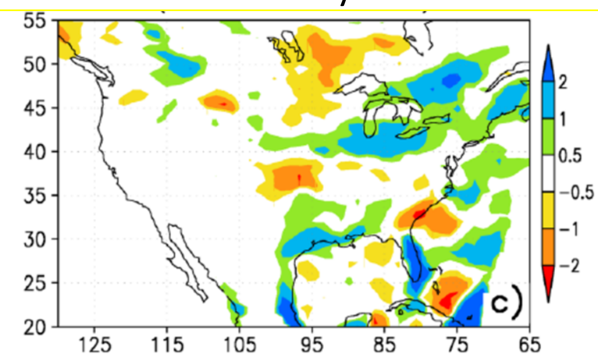
GCM-Simulated June Precipitation Anomaly



RCM-Downscaled June Precipitation Anomaly



RCM-Downscaled June Precipitation Anomaly With Reanalysis as LBC



Lesson IV

Using a RCM size conveniently obtained without carefully testing

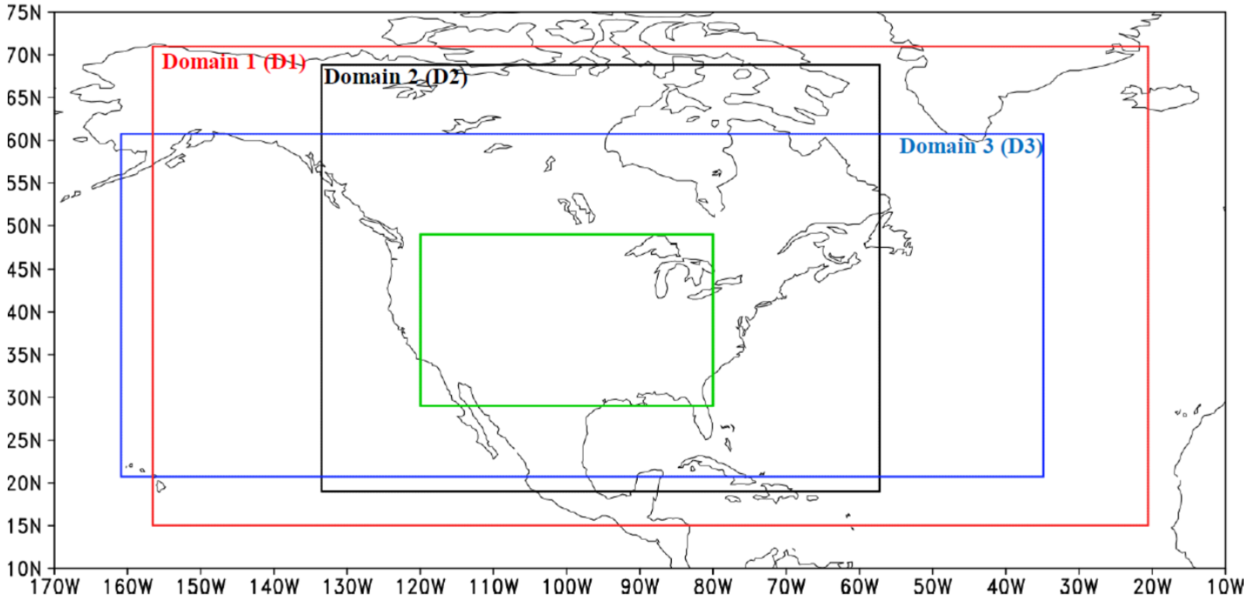


Figure 1: Domains used for the Weather Research and Forecasting (WRF) model simulations. Domains of configurations D1, D2, and D3 for WRF/SSiB3 are delimited by red box, black box and blue box, respectively. The innermost box represents the ''Test area'' (whole USA or CVA), for which statistic measures are computed.

1

May 2015 TMPsfc Anomaly

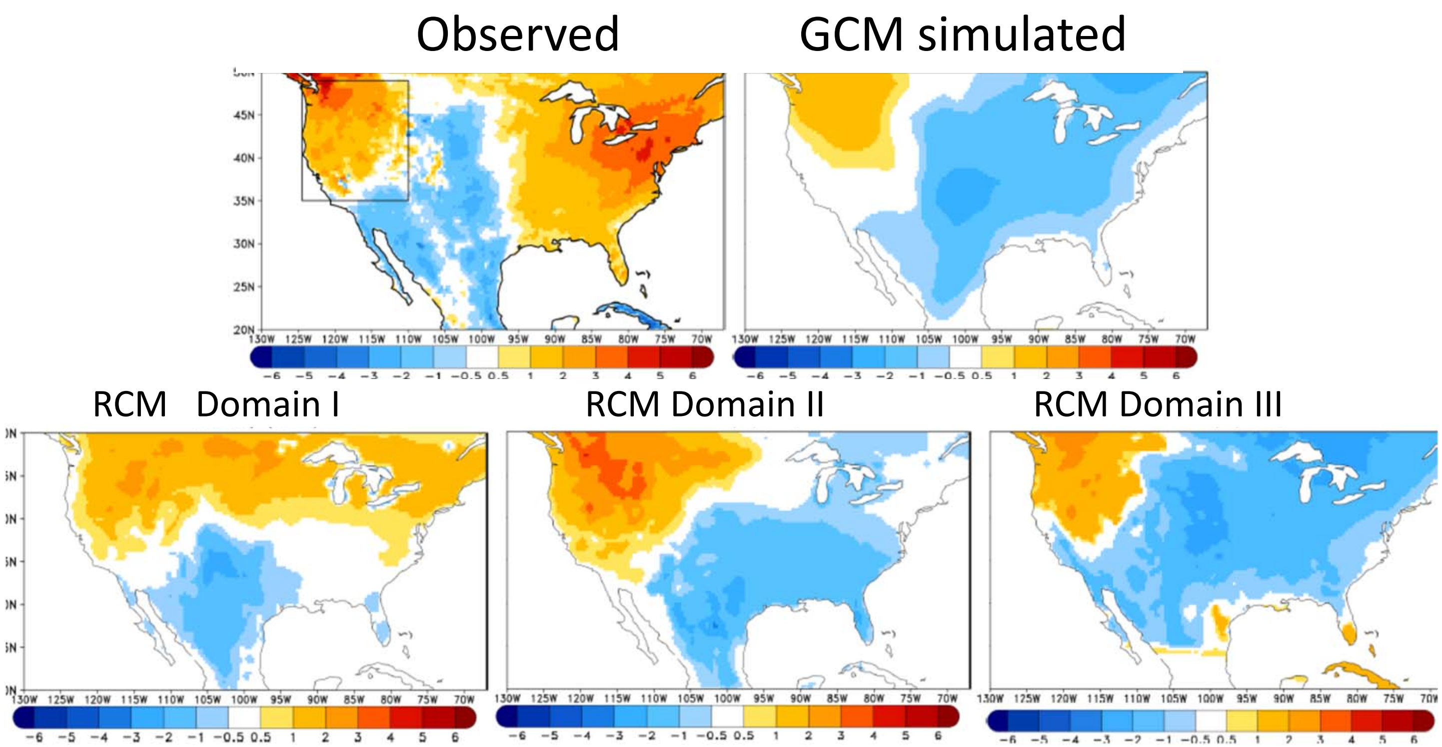


Figure 2: May 2015 Observed (NARR reanalysis) and simulated land surface temperature (LST; unit: °C) anomalies over United State: (a) NARR LST difference between May 2015 and the 1986-2015 climatology. (**b**)-(**e**) the corresponding simulated LST anomalies fro Case GCM, Case D1, Case D2 and Case D3, respectively. The black box in (a) indicates the Western United States (WUS) considered i his study.

May 2015 Precipitation Anomaly

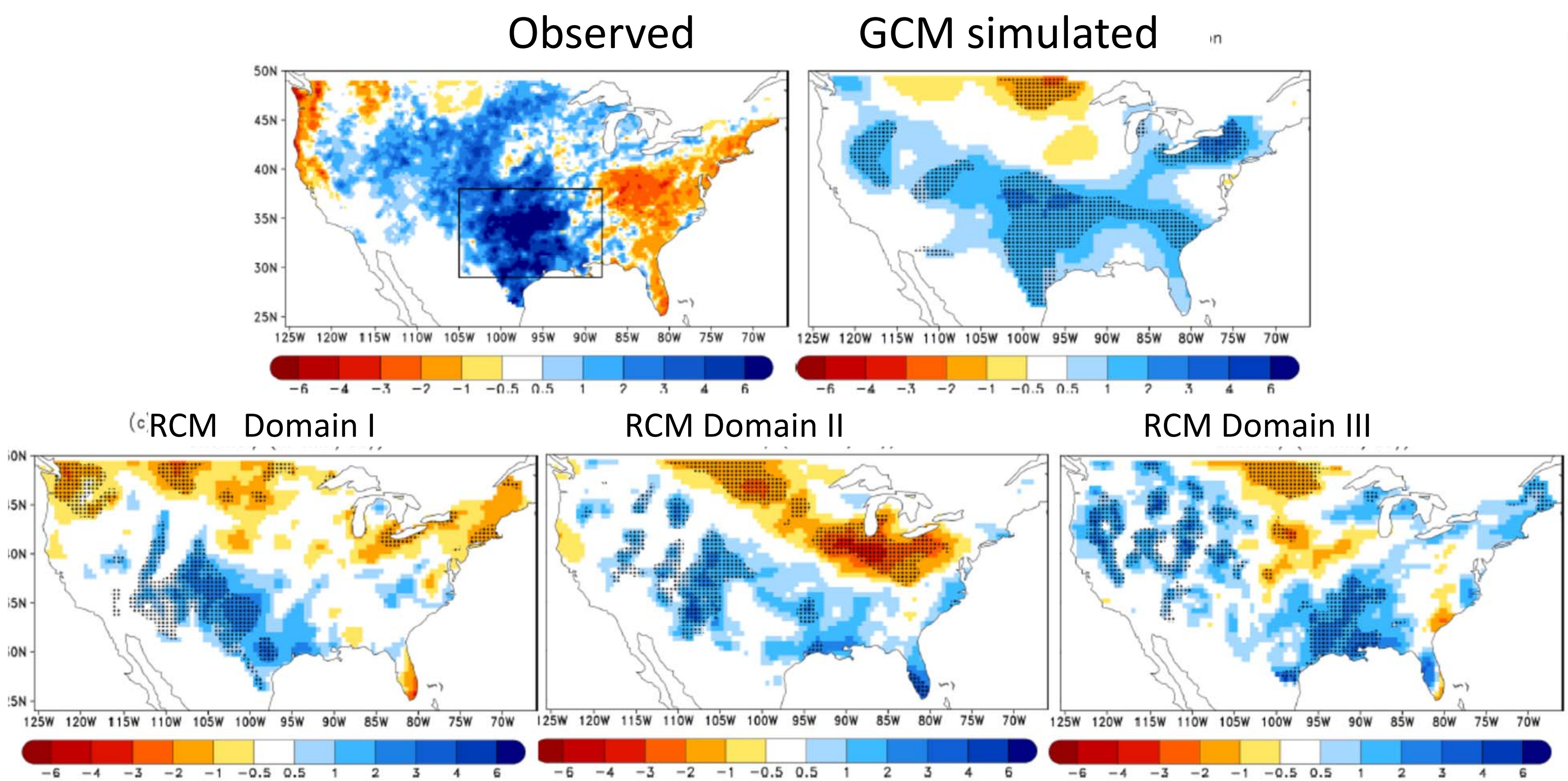


Figure 3: Same as Figure 2, except showing precipitation (Unit: mm/day) results, where observations are represented by GTS. Black boxed region in (**a**) indicates the Southern Great Plains and adjacent areas. The stippled (dotted) areas denote the areas statistically significant at a 90% confidence level.

Lesson V Model dynamics matters

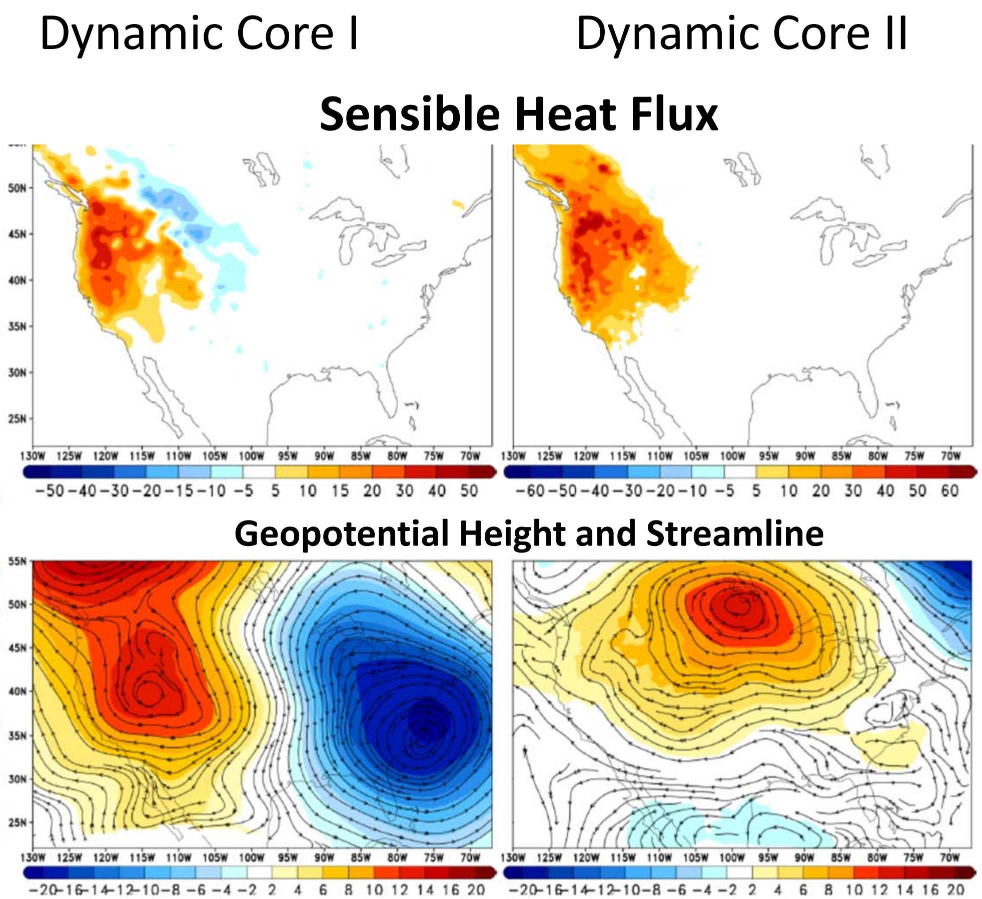
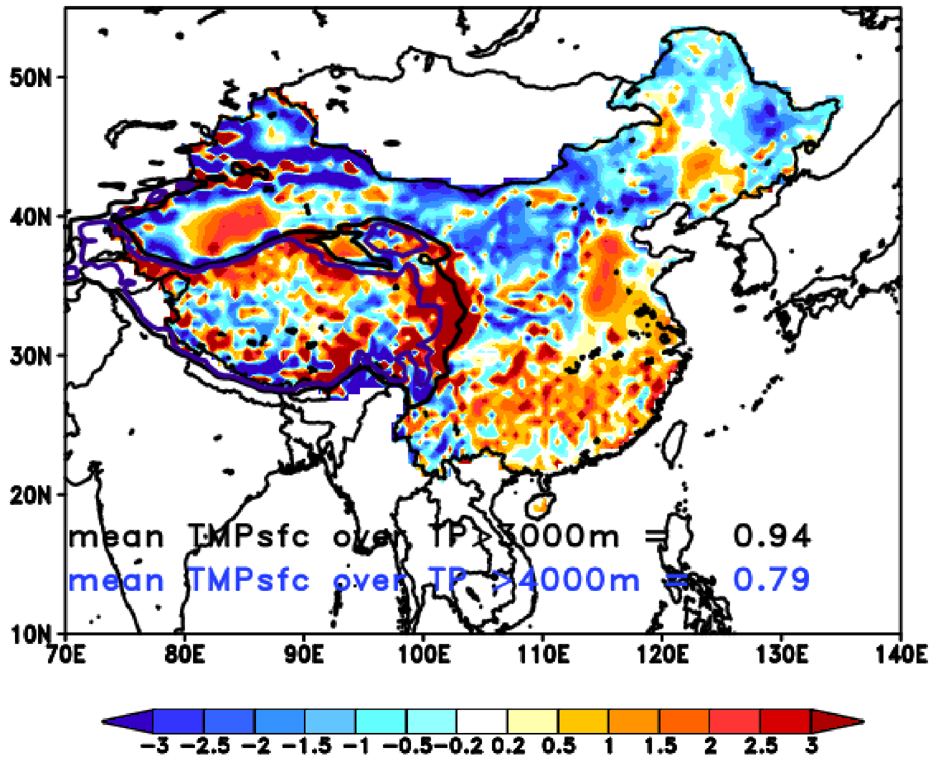


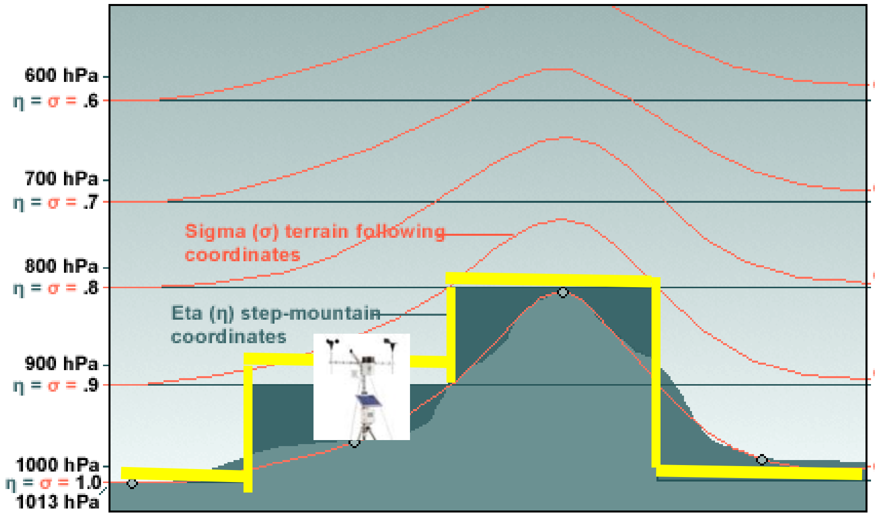
Figure 7: Simulated sensible heat flux (unit: W/m differences for the 1st 10 days from: (**a**) Case D3 and (**b**) Case C3. (**c**) Same as (**a**) but for the 500-hPa geopotential height (shaded, unit: gpm) superimposed with the 500-hPa wind direction (streamlines, unit: m/s). (**d**) Same as (**c**) but for Case C3.

Lesson VI 2-m air temperature height correction

Simulated Temperature Bias (Simulation minus Observation)



2). 2-m air temperature height correction



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Weather Station

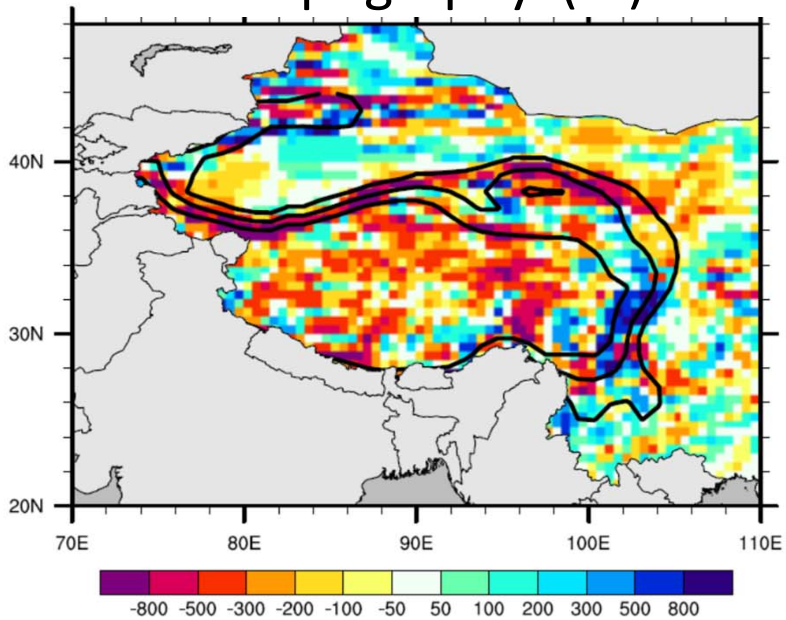
2-m air temperature height correction

The environmental lapse rate (ELR), is the rate of decrease of temperature with altitude in the stationary atmosphere at a given time and location. As an average, an international standard atmosphere with **a temperature lapse rate of 6.49 K/km**

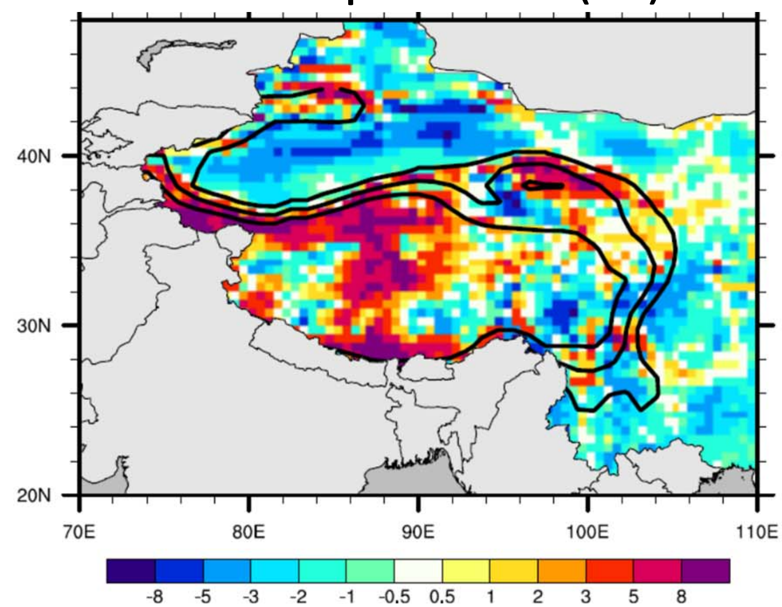
Xue et al., 1996

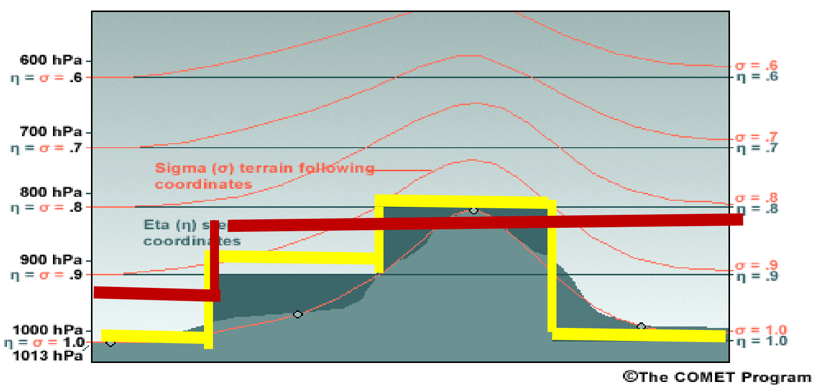
Differences between CMA and CAMS data

Topography (m)

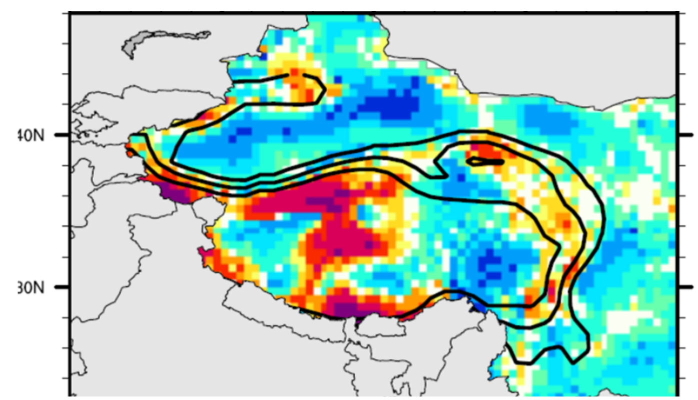


Temperature (°C)





Temperature difference after elevation correction



Current Approach to produce ΔT

1). Based on the model T bias to produce a ΔT mask.

$$\Delta T \text{ mask} = \text{Model T Bias} + N \times \text{observed T anomaly}$$

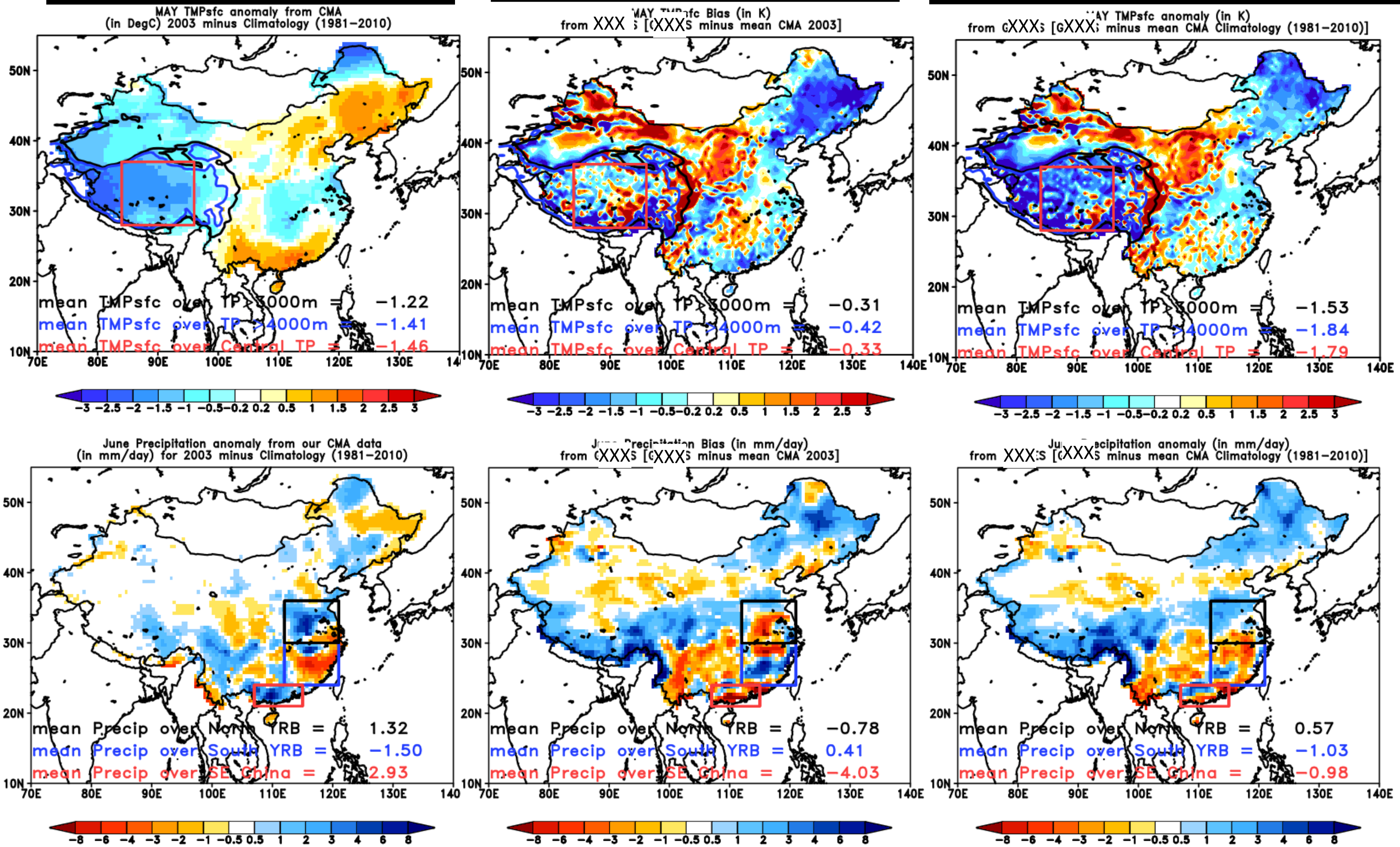
CMA observation anomaly

Simulated bias with respect to xxx

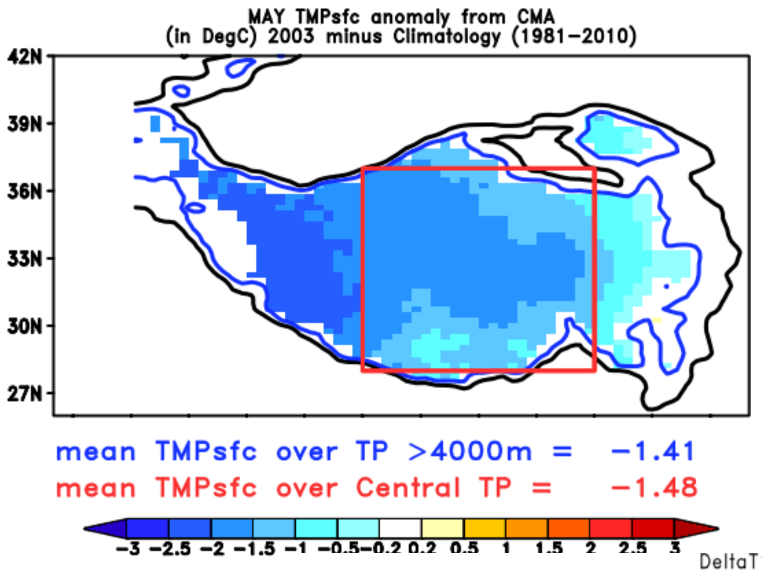
Simulated anomaly with respect to xxx Clim

MAY TMPsfc (in K)

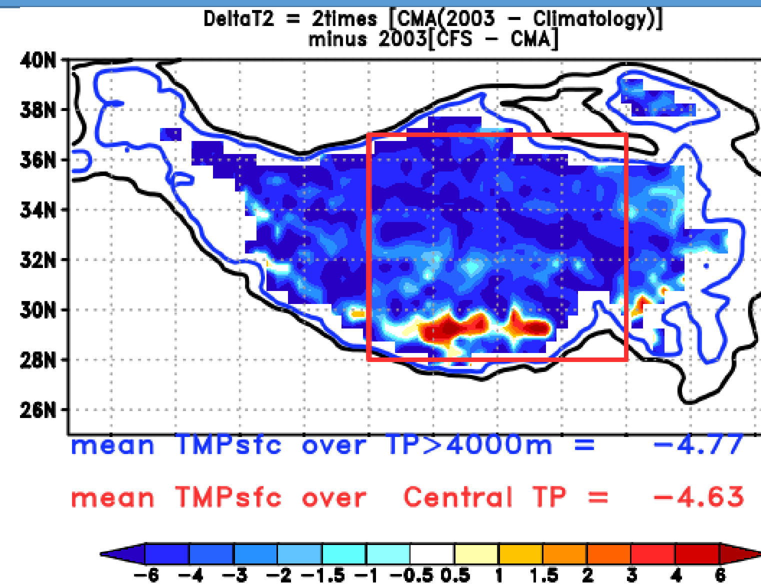
June Precipitation (in mm/day)

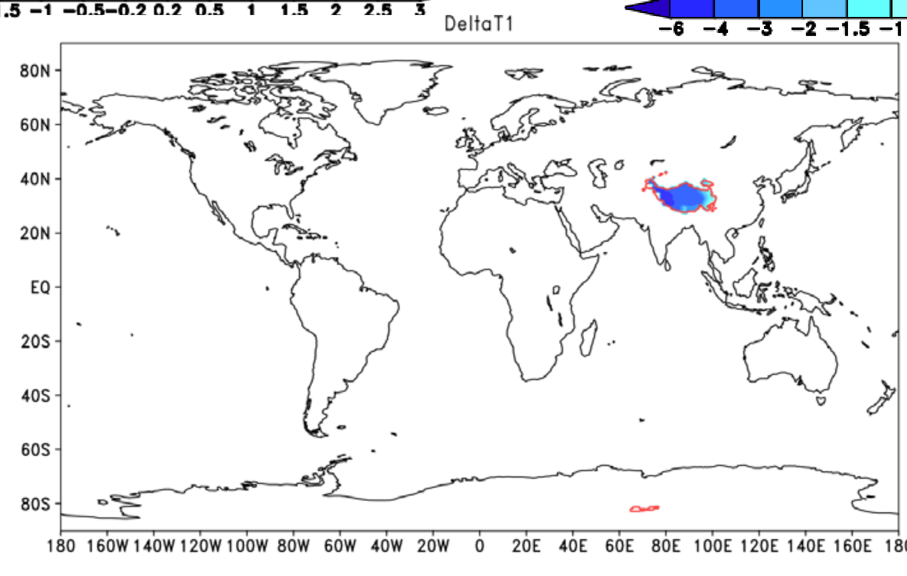


CMA OBS anomaly

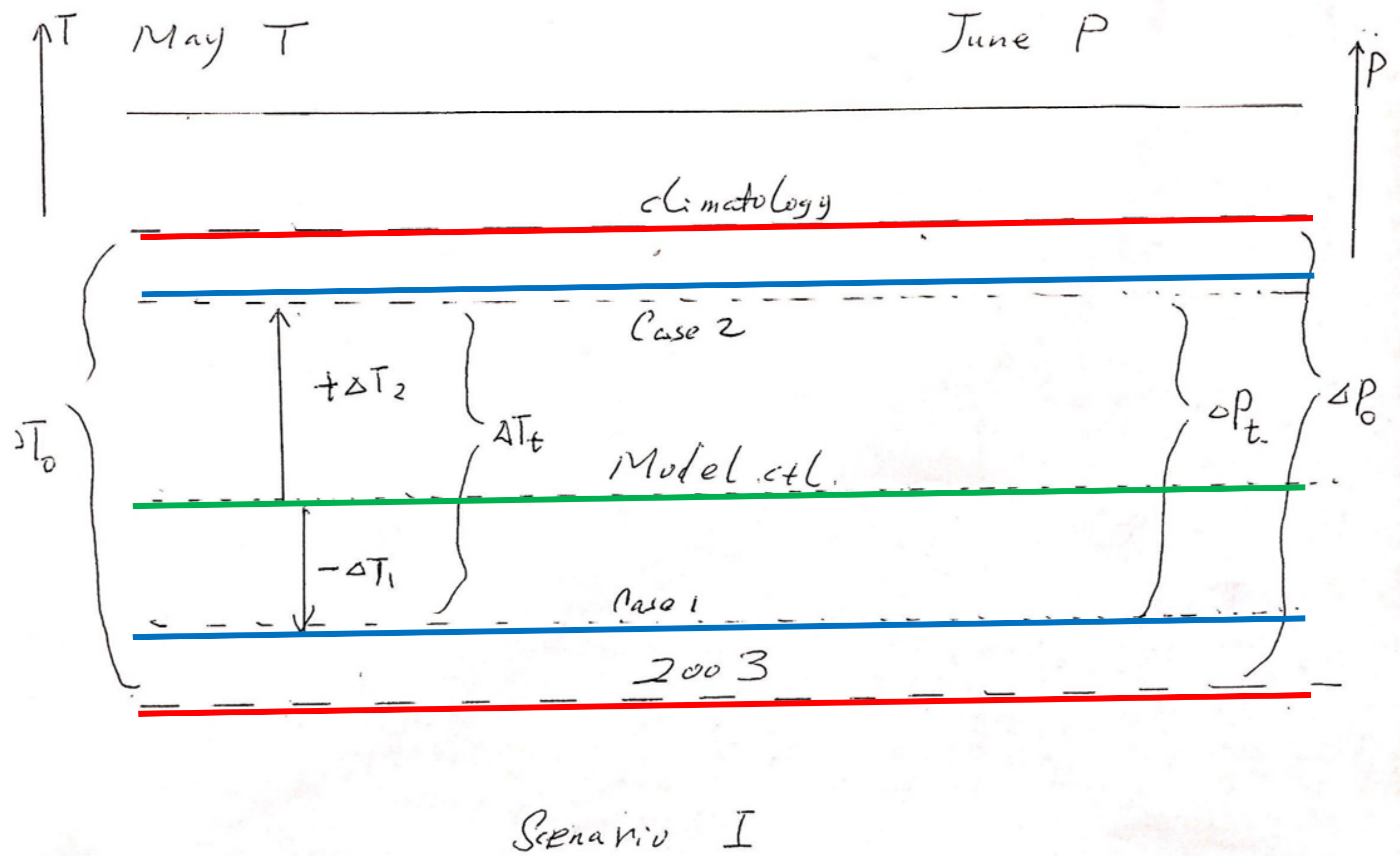


A mask based on CMA OBS anomaly for the model

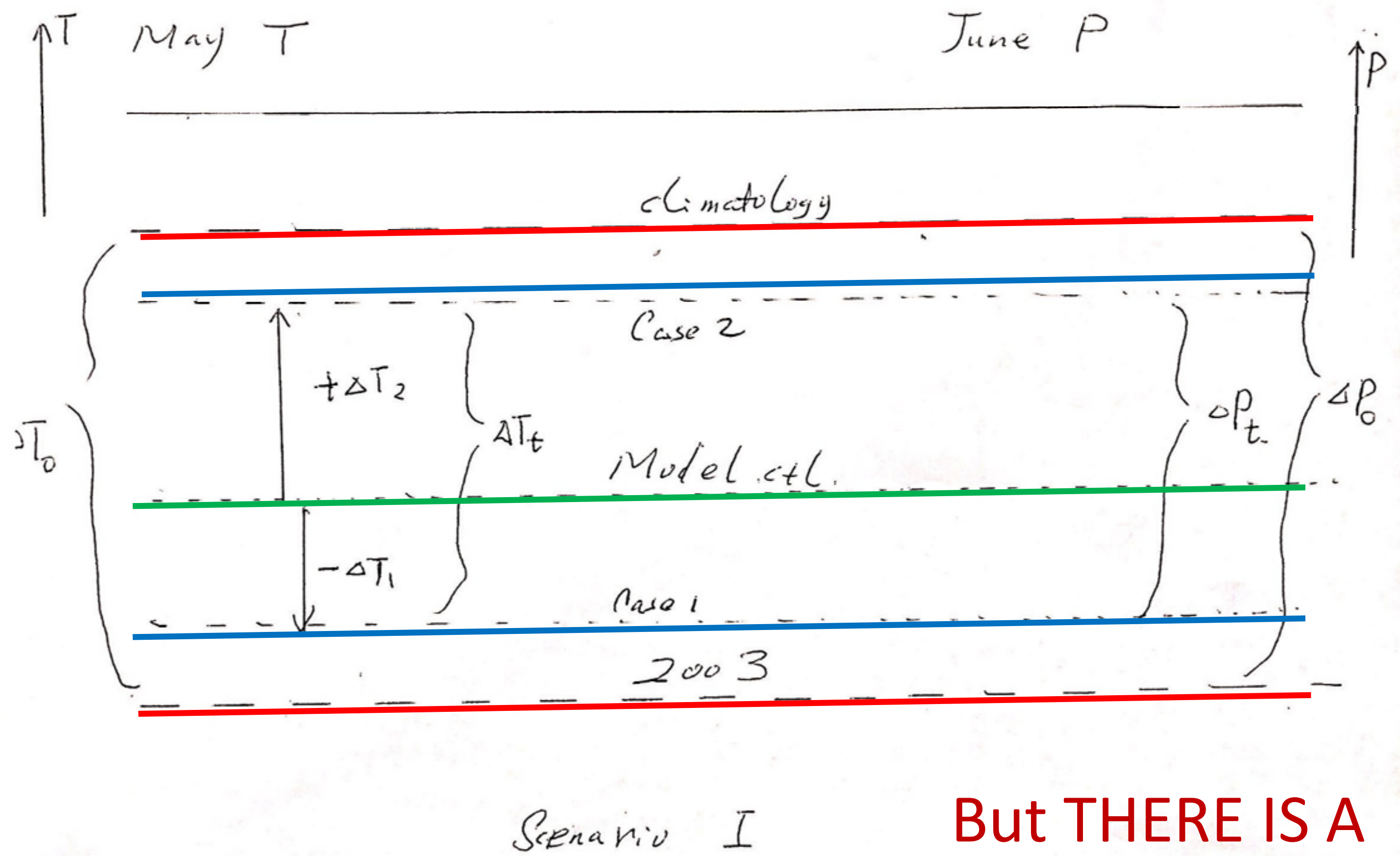




LS4P Sensitivity Study Scenario I



LS4P Sensitivity Study Scenario I

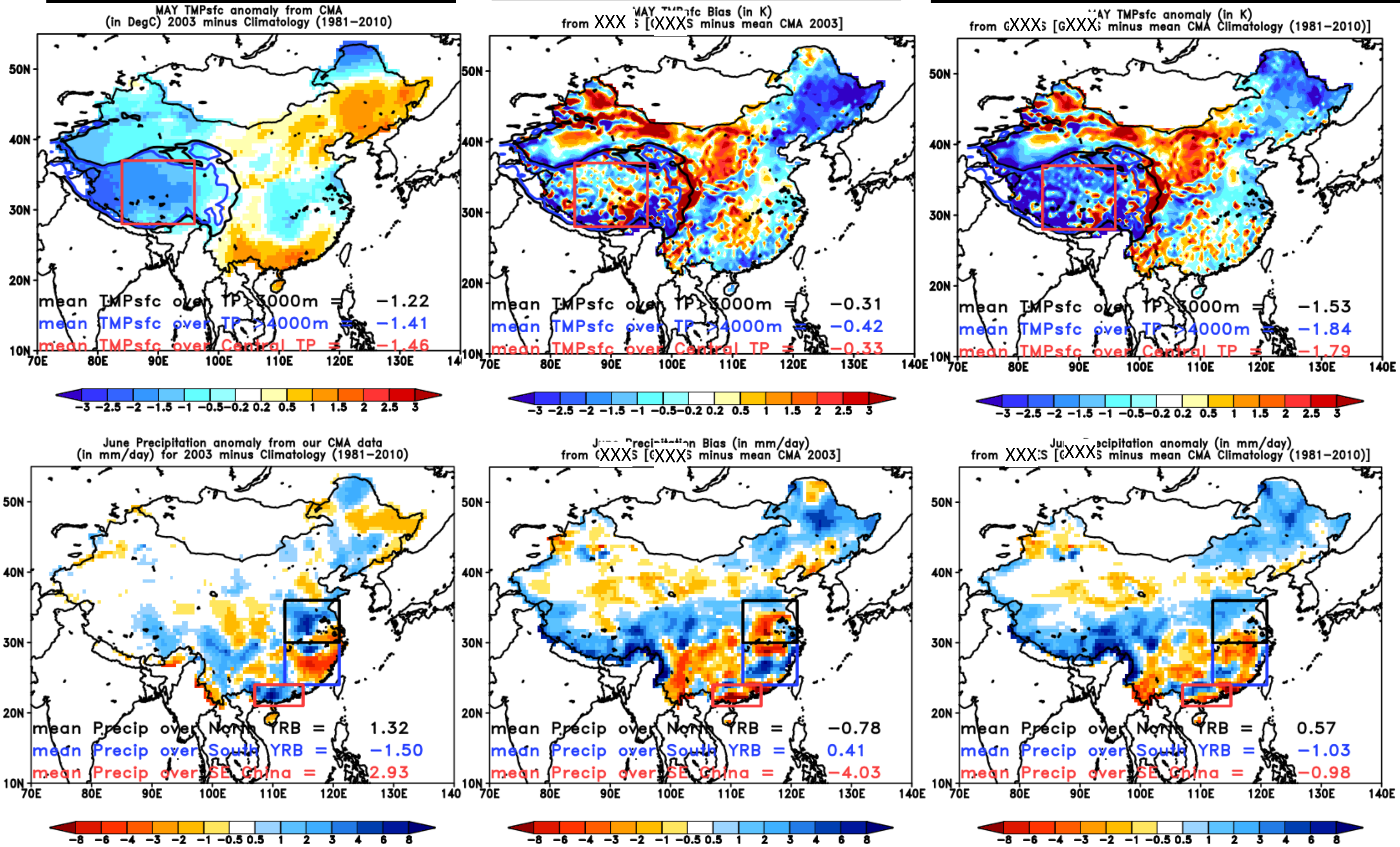


But THERE IS A LIMITATION !!!

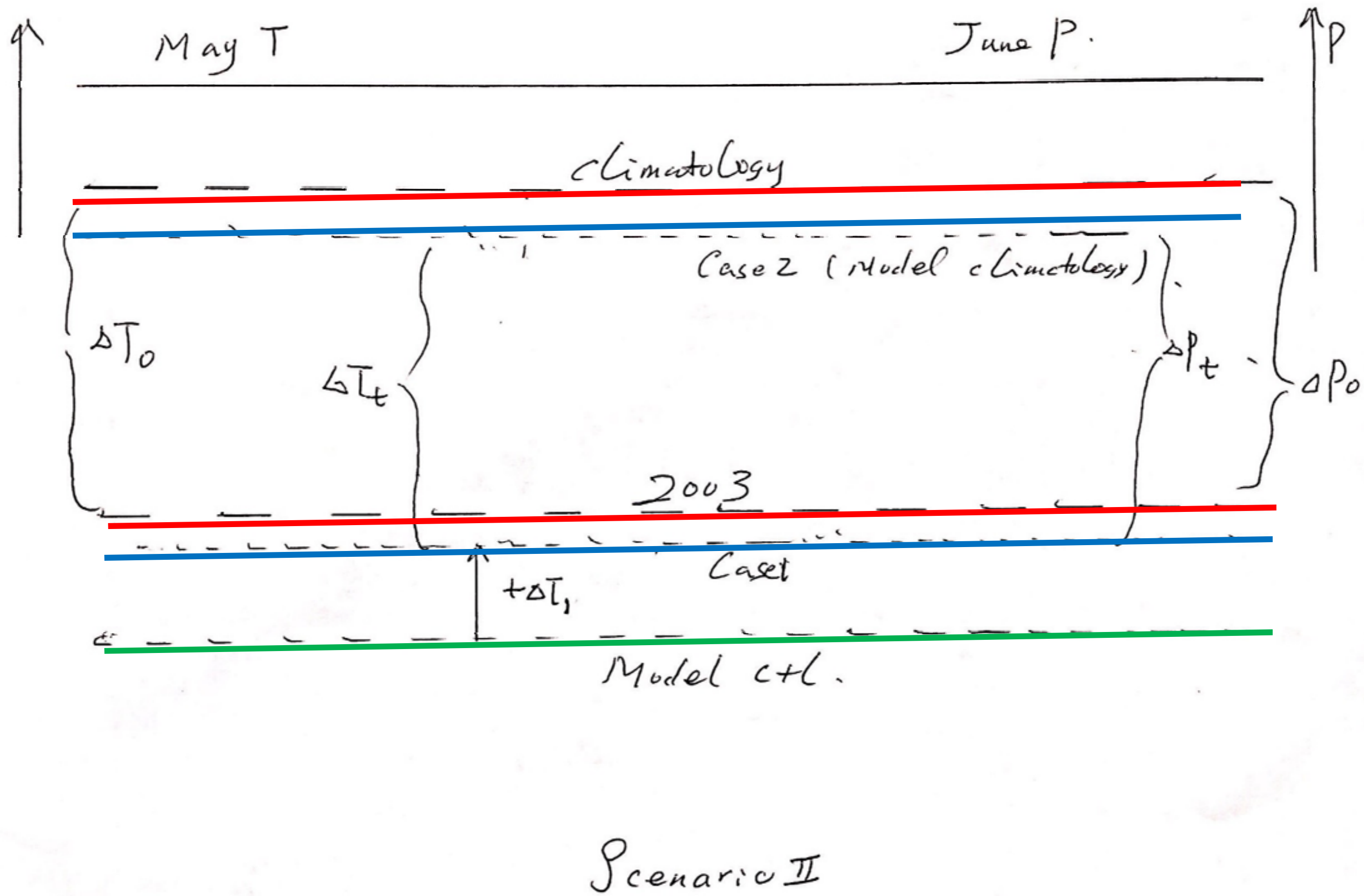
CMA observation anomaly | **Simulated bias with respect to xxx** | **Simulated anomaly with respect to xxx Clim**

MAY TMPsfc (in K)

June Precipitation (in mm/day)



LS4P Sensitivity Study Scenario II



There may be more different scenarios but bottom line is the model May T-2m bias and June P bias must be consistent with the MCA relationship based on observed May T-2m and June P.

Possible other approaches for consideration

2). Start earlier
3). Impose not only the 1st step
4). Prescribe deep layers