Using the enthalpy and physical limits to constrain initial conditions :

Rationale and first results

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Context

- LS4P experiment (Xue et al. 2021) : correct the LST bias over the Tibetan Plateau at initialization of subseasonal forecasts

- LST correction breaks the soil energy balance
  - spurious land-atmosphere interactions ?
  - questionable atmospheric response ?

- GLACE2 setup (Koster et al. 2011) on initial soil moisture : conserves neither energy nor water balance

- Can we adapt the LS4P setup to improve soil energy balance at initialization ?

Goal : conserve the soil enthalpy

- The soil **enthalpy** quantifies the **soil heat content** :
  It integrates temperature, ice and liquid water content as well as soil texture.
- Enthalpy (h) equation for a soil layer :

$$h = [\rho_s c_s (1 - w_{sat}) + \rho_l c_l w_l + \rho_i c_i w_i](T - T_f) - \rho_i L_f w_i$$

- We developped a strategy to conserve the soil enthalpy ’as well as possible’

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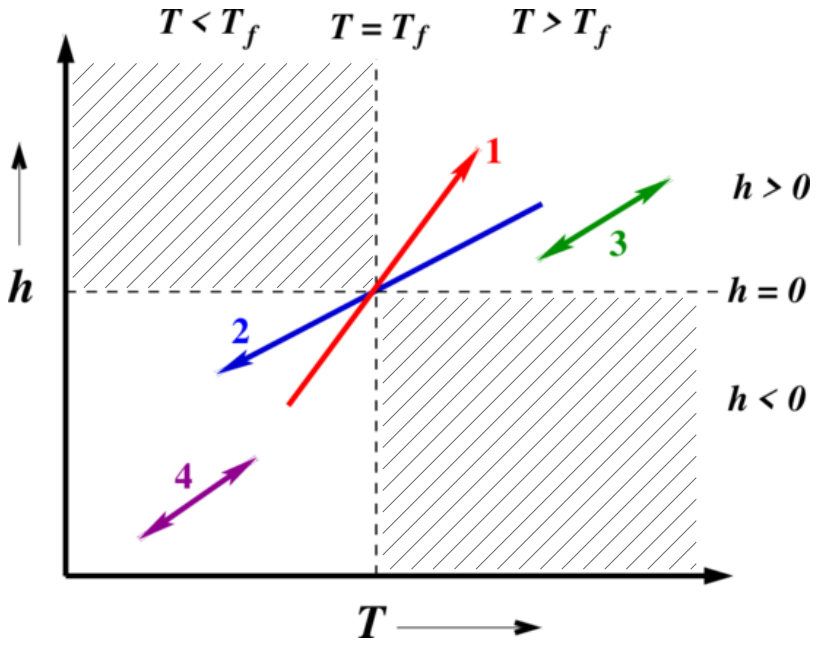

$h=a(T-T_f)-b$ with a > 0 and b ≥ 0

Case 1 :

- If $T < T_f$, then $h < 0$
- If soil is heated so that $T>T_f$, then ice disappears and $h>0$

In such case, h cannot be conserved

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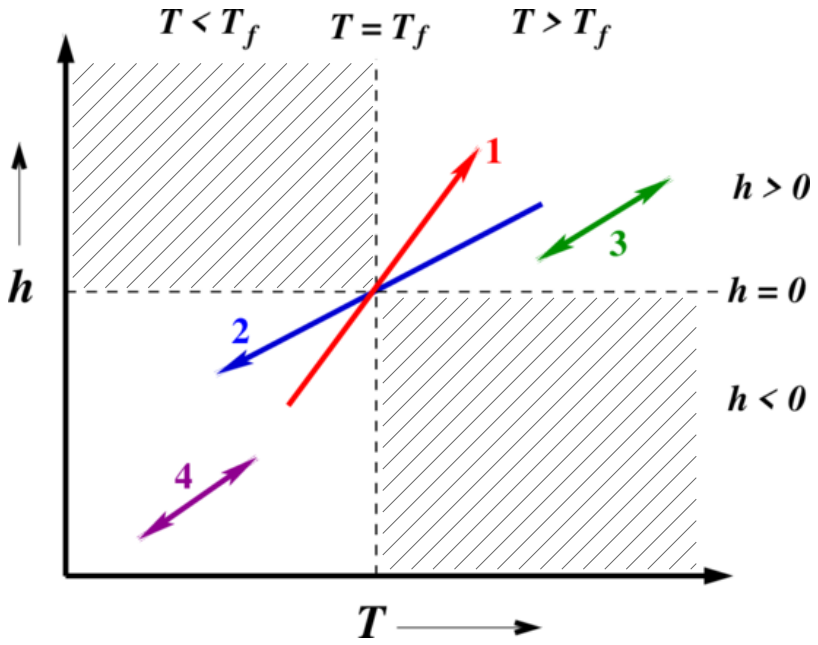
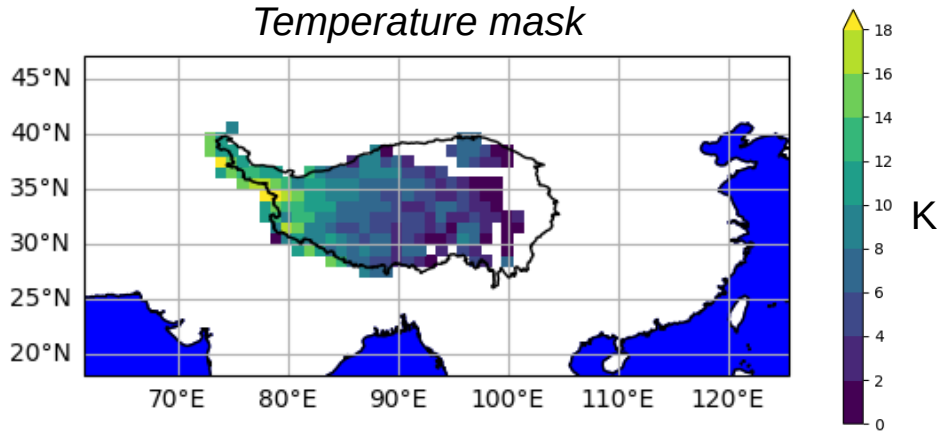


$h = a(T - T_f) - b$ with a > 0 and b ≥ 0

	Case	Mass conservation	Enthalpy conservation
Physically-based limits imposed (for a given *dT*)	1	✓	✗
	2	✓	✗
h conserved (unless physical limits passed → then adjustment)	3	✗	✓
	4	✓	✓

Experimental setup

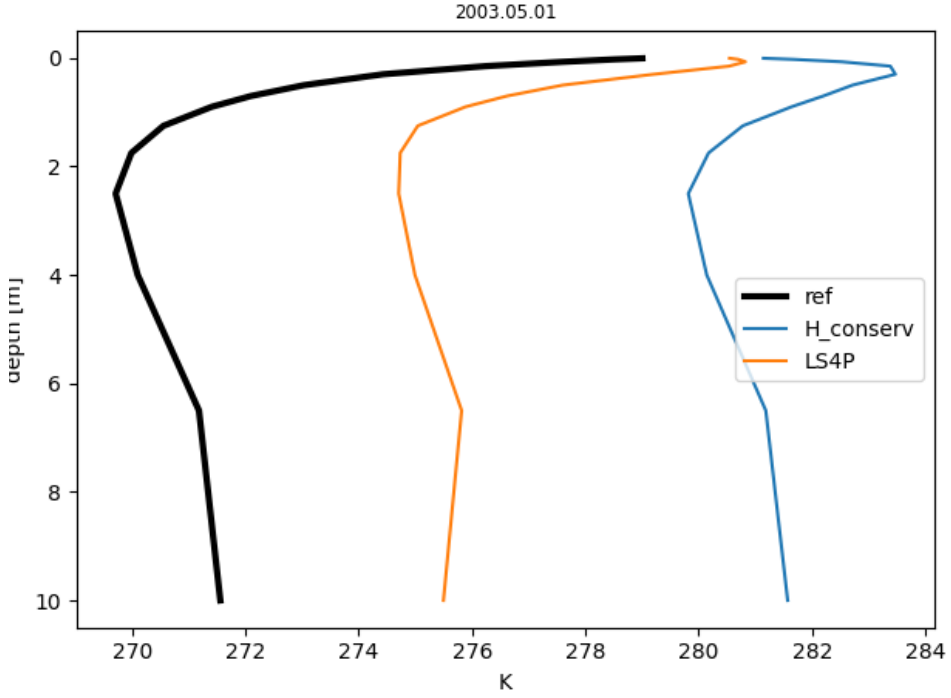
- Earth system model : CNRM-CM6.1 (Voldoire et al. 2019)
- 2-month ensemble reforecasts initialized on May 1st 2003



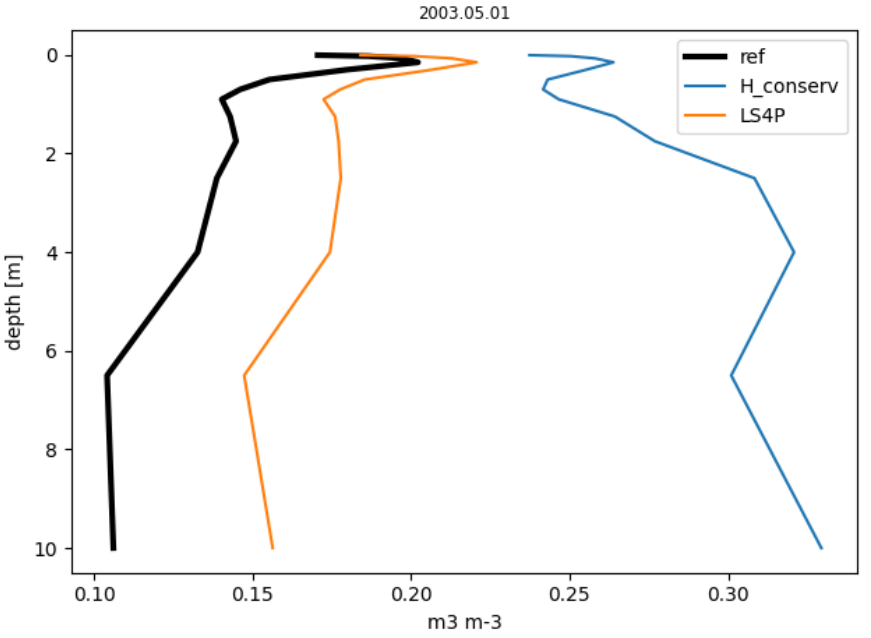
Name	**REF**	**LS4P**	**H_conserv**
Temperature mask	No mask	Yes	Yes
Enthalpy & physical adjustment	No	No	Yes

Soil profile on May 1st (after 1 day of integration) averaged over the TP

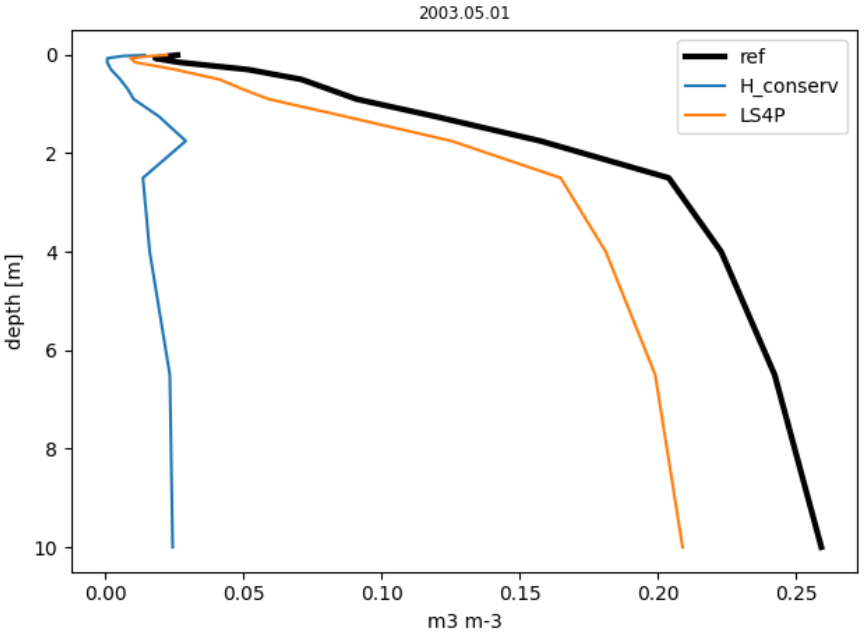
Temperature



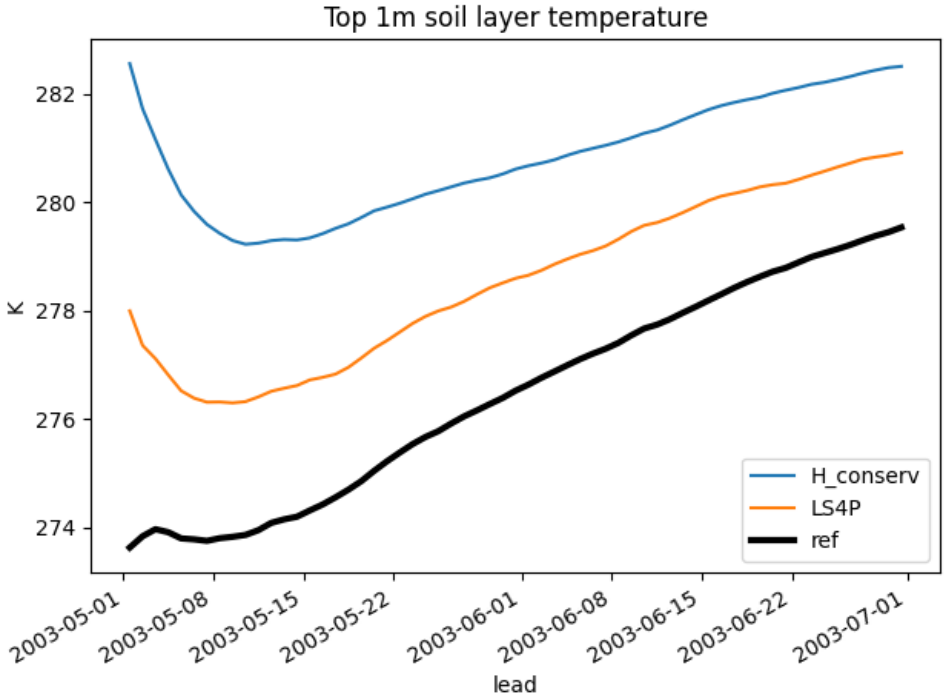
Liquid water

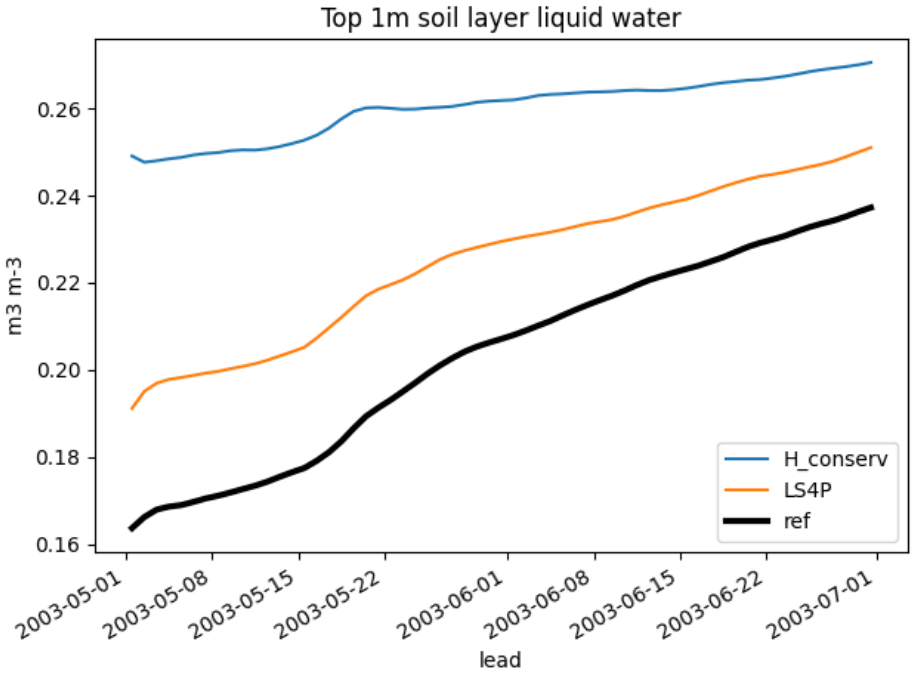


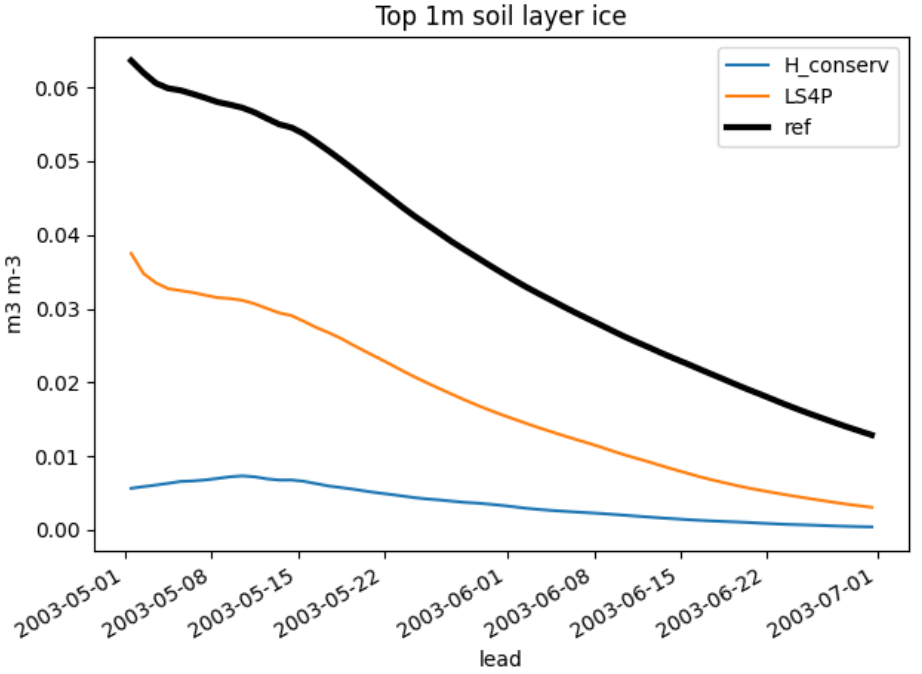
Ice



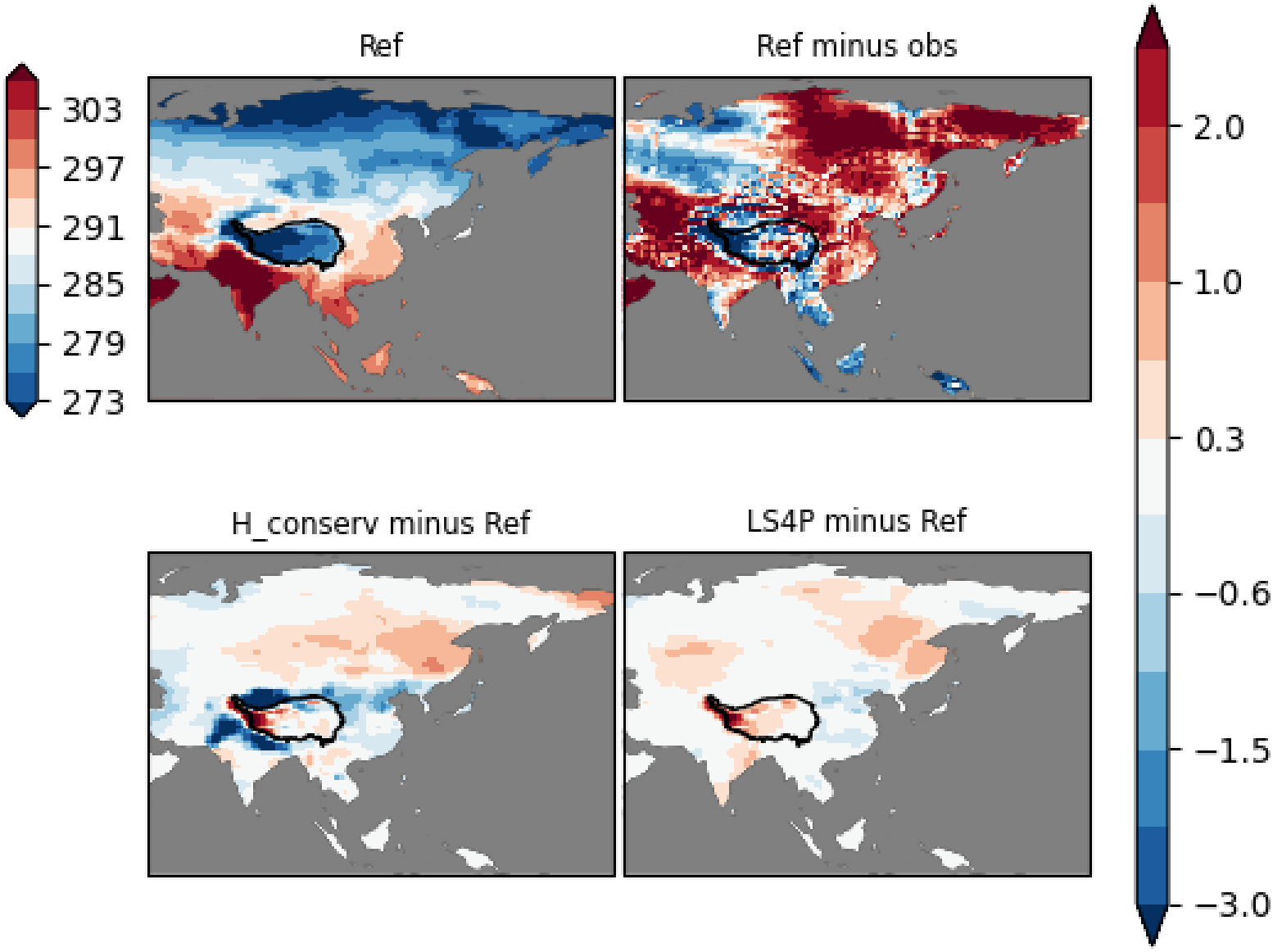
Top 1m soil layer evolution (Tibetan Plateau)





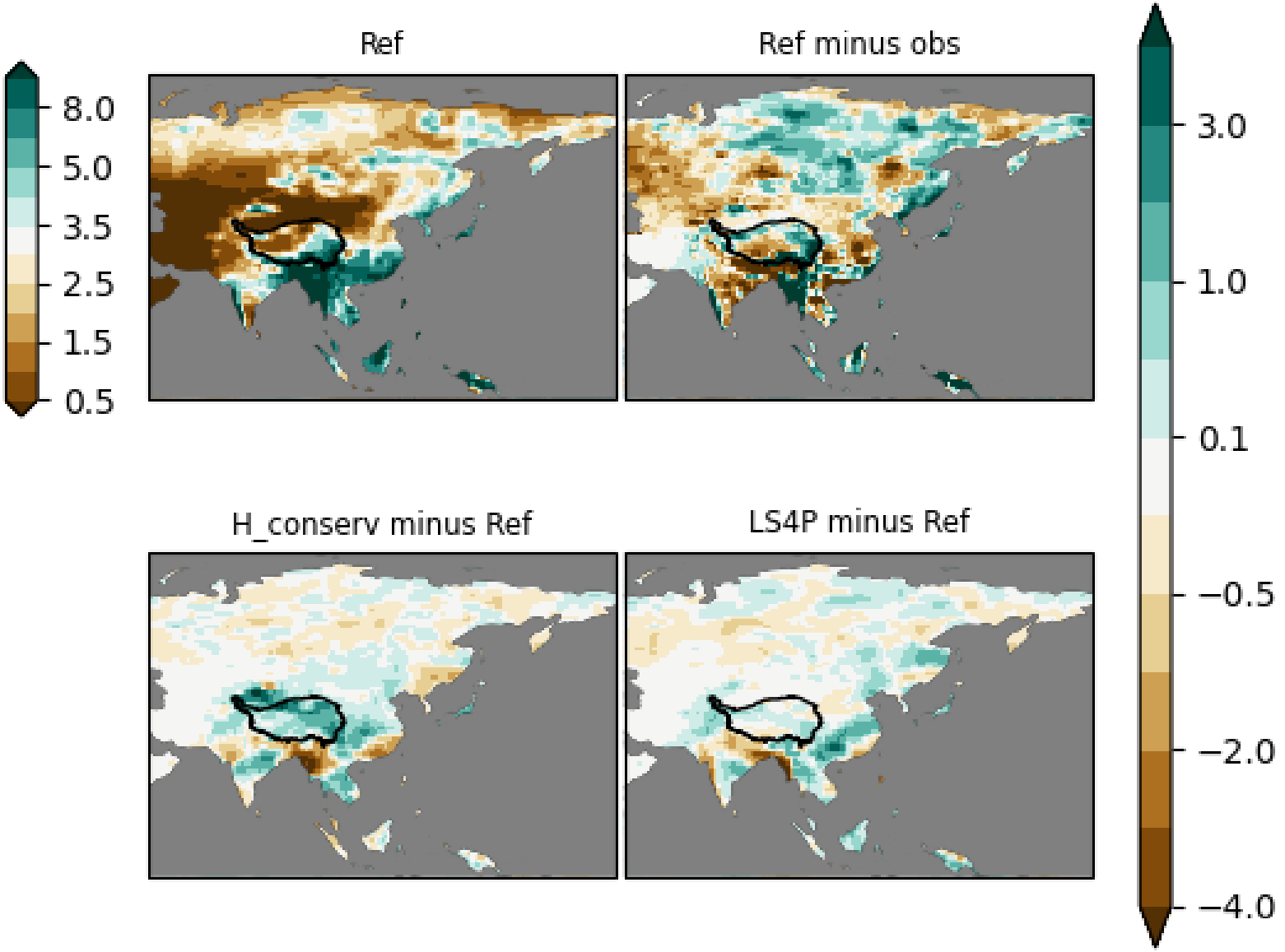


May 2003 2-m temperature anomaly



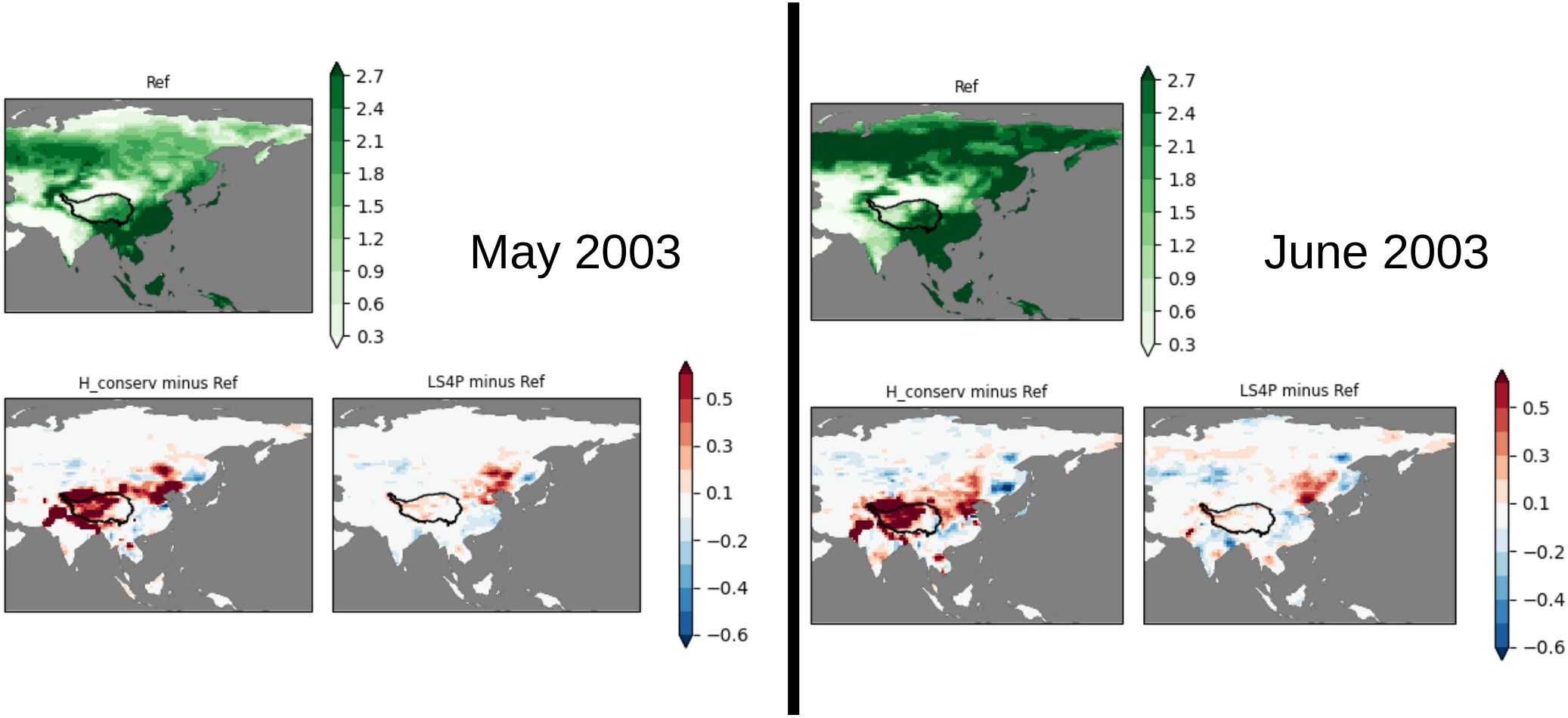
*Obs = CRU TS4.05 (Harris et al. 2020)

June 2003 precip anomaly (mm/day)



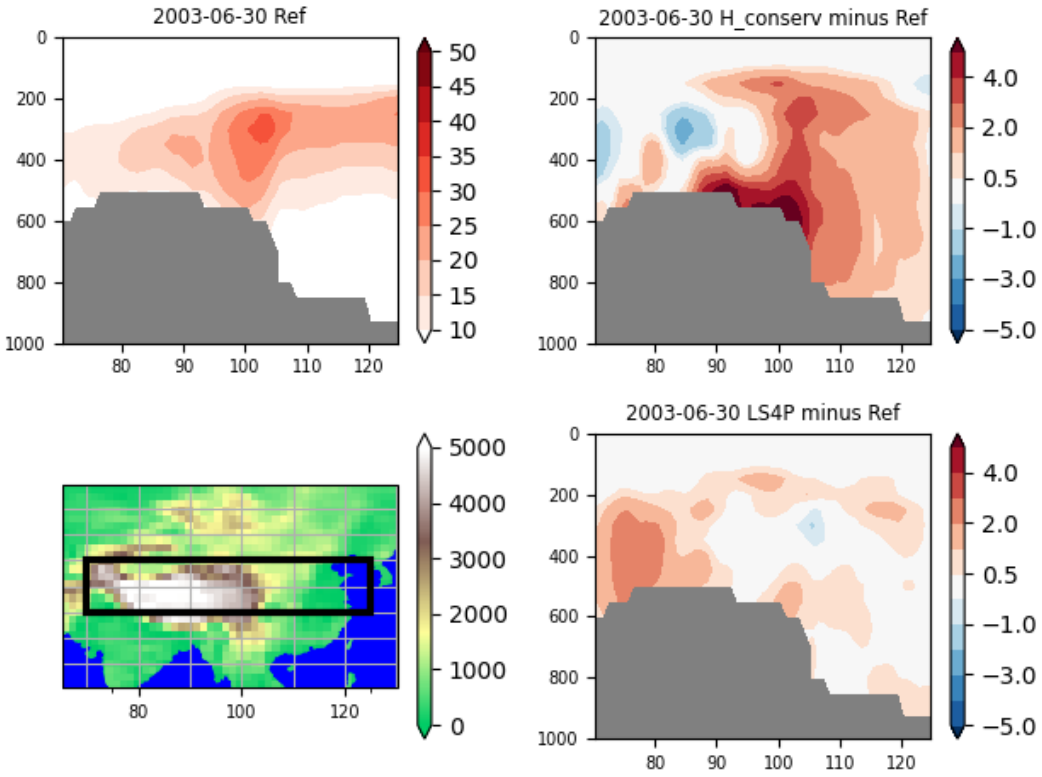
*Obs = MSWEP (Beck et al. 2017)

Evapotranspiration (mm/day)



June 2003 atmospheric meridional cross-section

Cloud fraction in %



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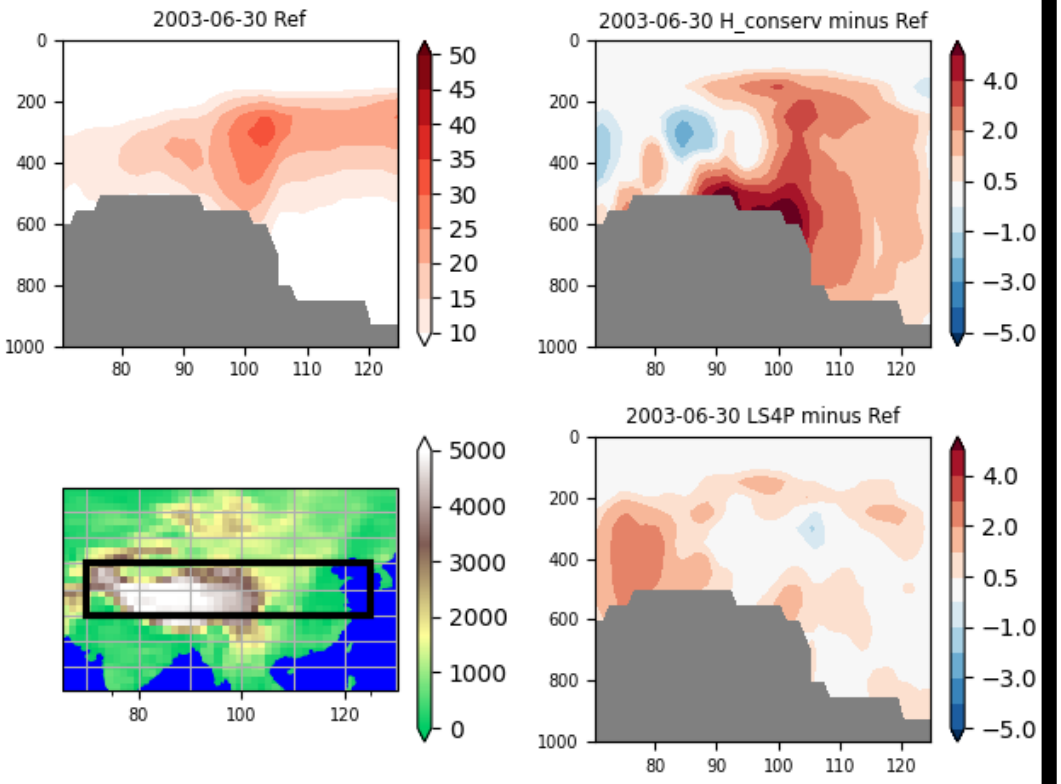
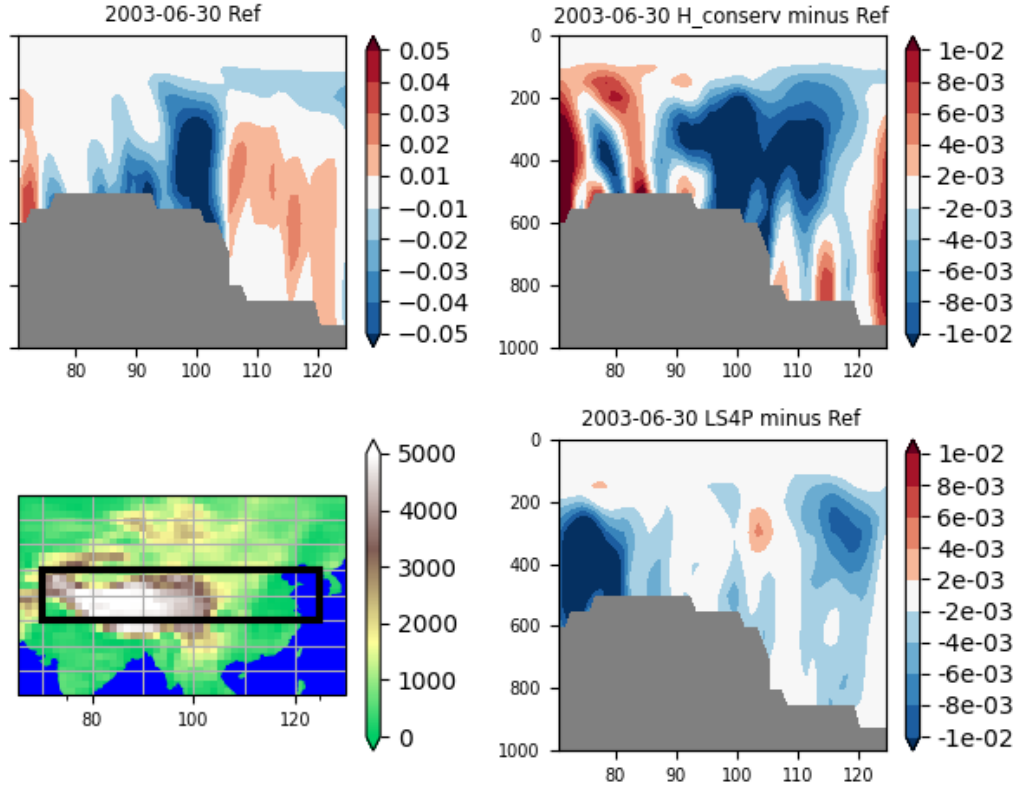


Vertical velocity in Pa/s



Conclusion and prospects

- In the LS4P setup, the temperature correction signal applied to the TP is partly lost while the model adjusts equilibrium between temperature, liquid water and ice
- Impacts on the atmospheric circulation and east-Asia monsoonal flow
- Significance tests yet to be performed
- Impact on ensemble spread

Questions ?

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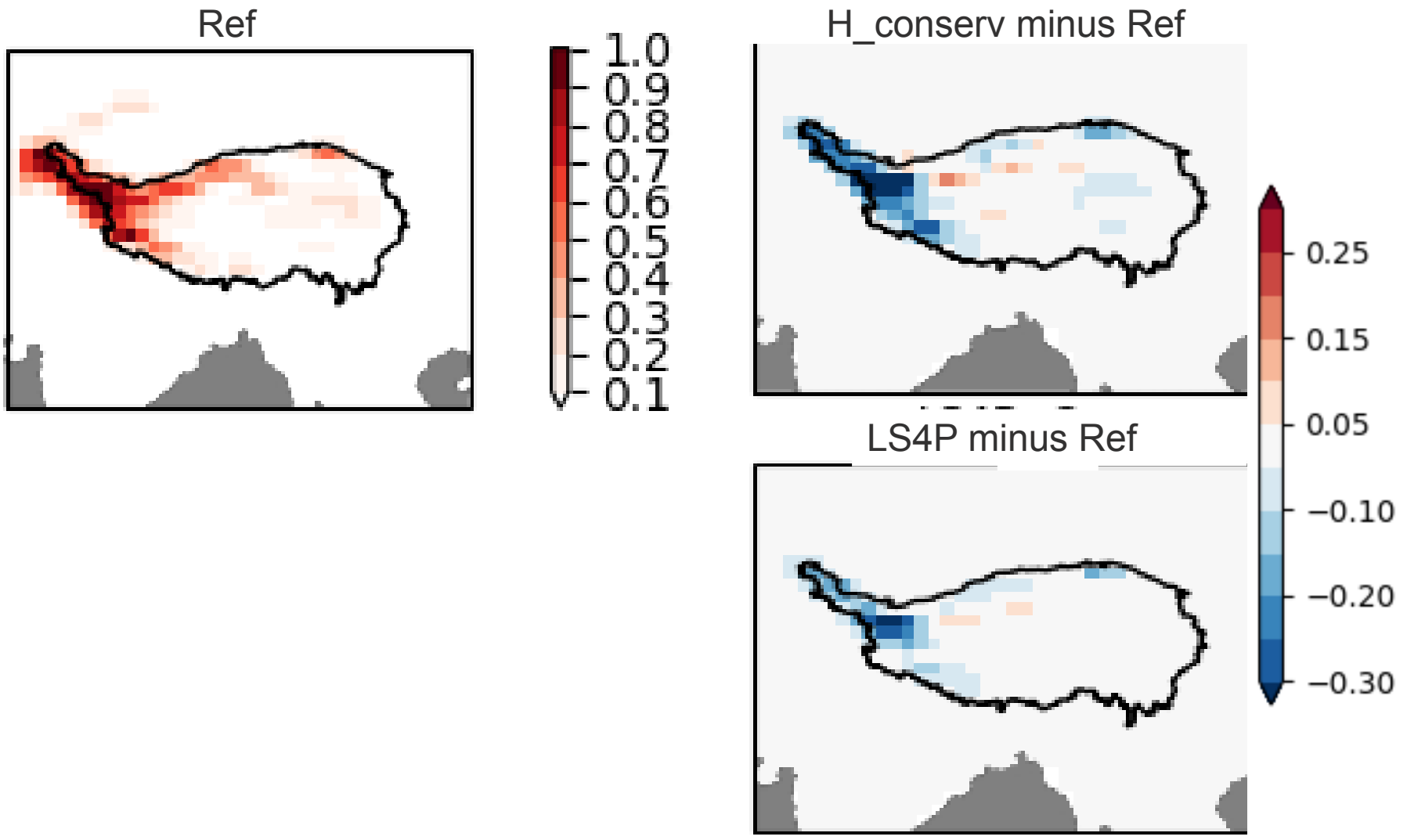
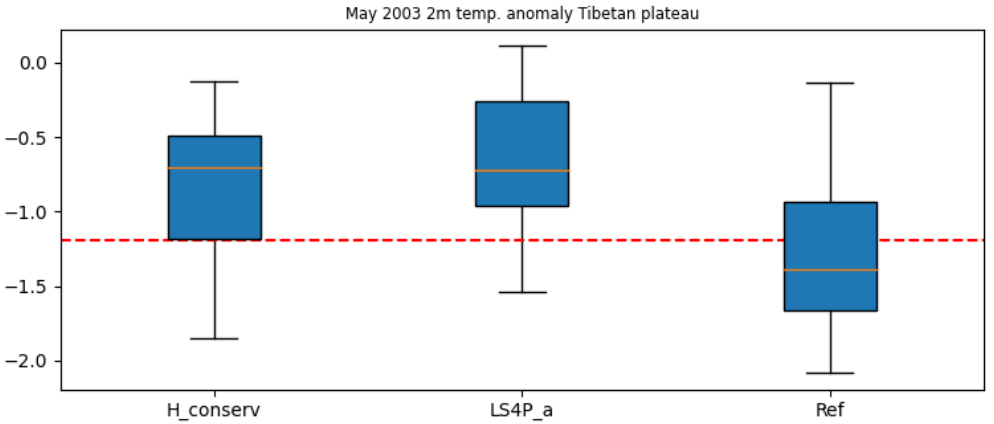
Snow cover fraction

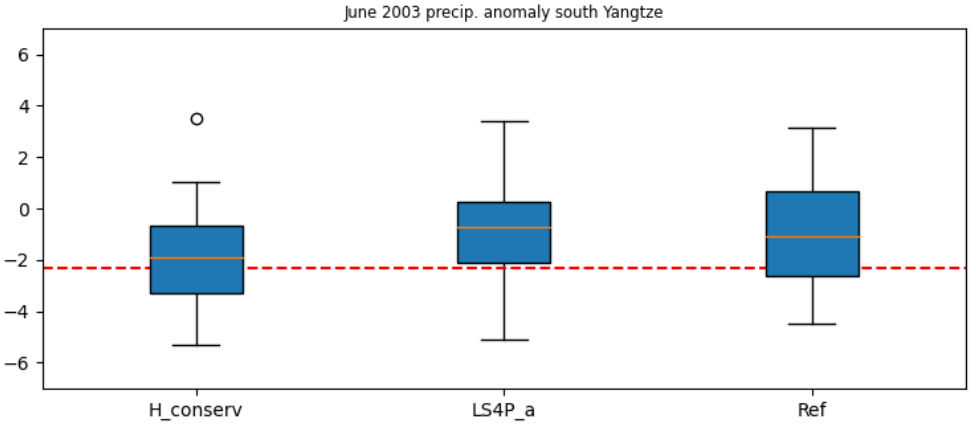


Ensemble spread

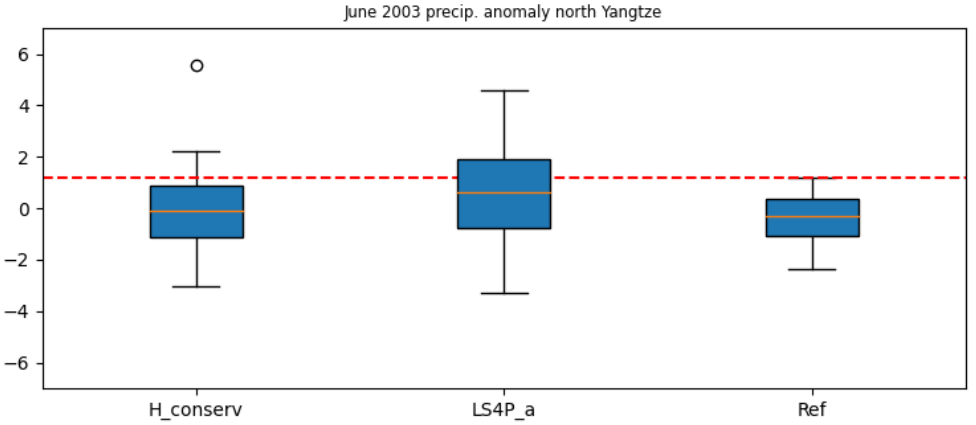
May 2003 TP 2-m temperature anomaly



June 2003 precip anomaly (South Yangtze)



June 2003 precip anomaly (North Yangtze)



Red-dotted line : observation

Boxplot : ensemble spread

CAPE monthly anomalies (left : May, right : June 2003)