Equatorial mountain torques, Equatorial Angular Momentum and cold surges in a GCM,

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Abstract :

The dynamical relations between the equatorial mountain torques and the cold surges are analysed in the LMDz-GCM. After verification that the Equatorial AAM budget is well closed in the model (not shown) we confirm that the equatorial torques due to the Tibetan plateau, the Rockies and the Andes are well related to the cold surges developing over South Eastern China, North America, and the Southern South America respectively. For all these mountains, a peak in the Equatorial mountain torque component that points locally toward the pole precedes by few days the development of the cold surges (as in observations).

The contributions to the torques of the parameterized forces is substantial. But in experiments without the parameterized stresses, the explicit terms partly compensate the parameterized contributions to the torque and the cold surges are not much affected. This shows that the cold surges can be well captured by models, providing that the synoptic conditions prior to their onset are well represented. The compensation between torques is nevertheless not complete and some weekening of the cold surges is found when the mountain forcings are reduced.

AAM Budget and Equatorial Mountain Torques

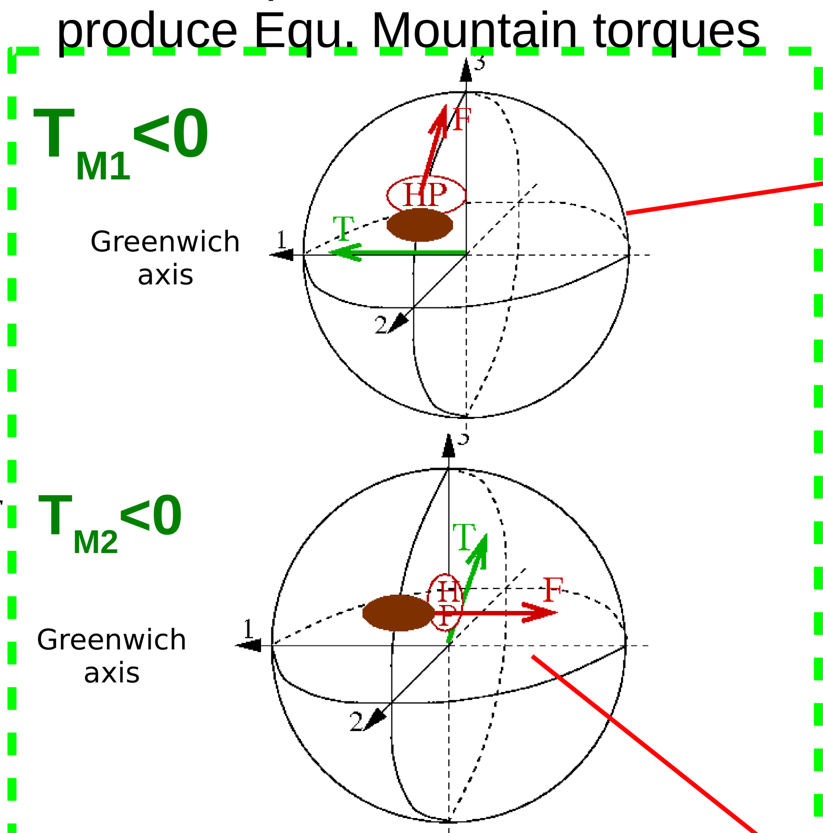
The mountain torques are the **dominant forcing** of the **equatorial** components of the Atmospheric Angular Momentum budget (compared to the frictional torques):

$$\frac{d\left(\vec{M}_\Omega+\vec{M}_r\right)}{dt} + \vec{\Omega}\times\vec{M}_r = \vec{T}_M + \vec{T}_f$$

$\vec{M}_r$ Wind AAM — $\vec{T}_f$ Parametrized torque

$\vec{M}_\Omega$ Mass AAM — $\vec{T}_M$ Mountain torque

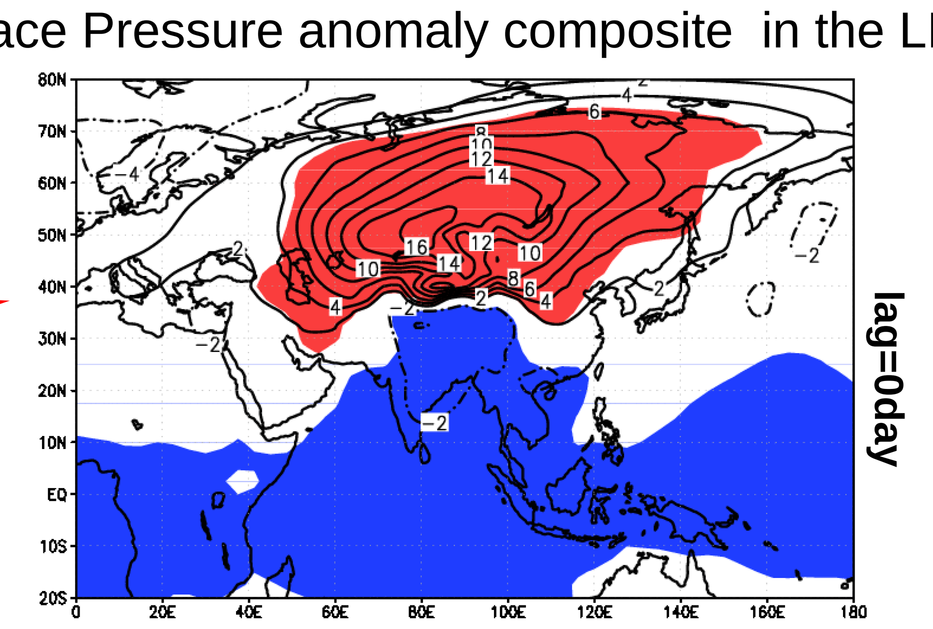
Heuristic description of how surface pressures anomalies produce Equ. Mountain torques

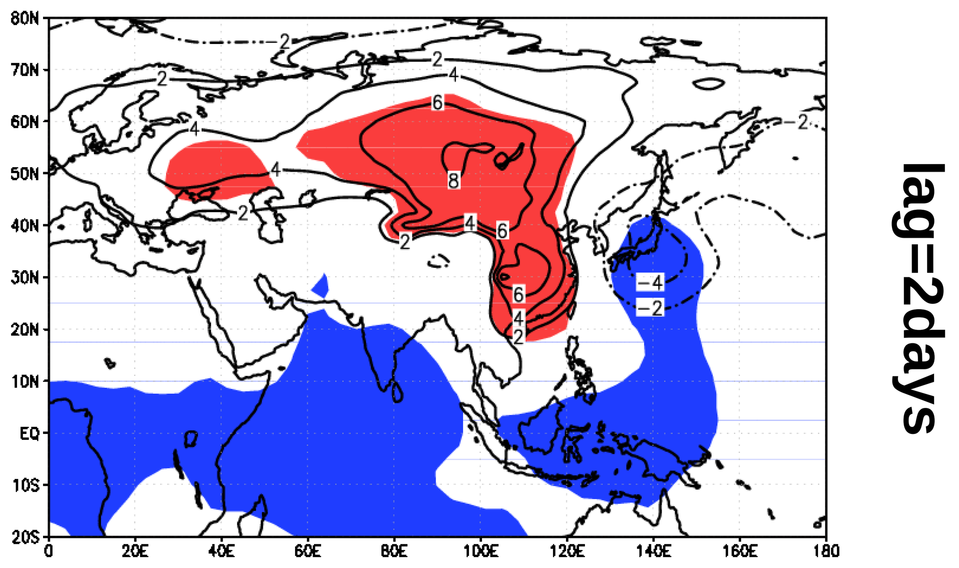


F: reactive force applied by the mountain on the atmosphere (almost perpendicular to the local wind)

T_M: Torques applied by the mountain on the atmosphere

Surface Pressure anomaly composite in the LMDz – GCM (almost identical Results from NCEP)

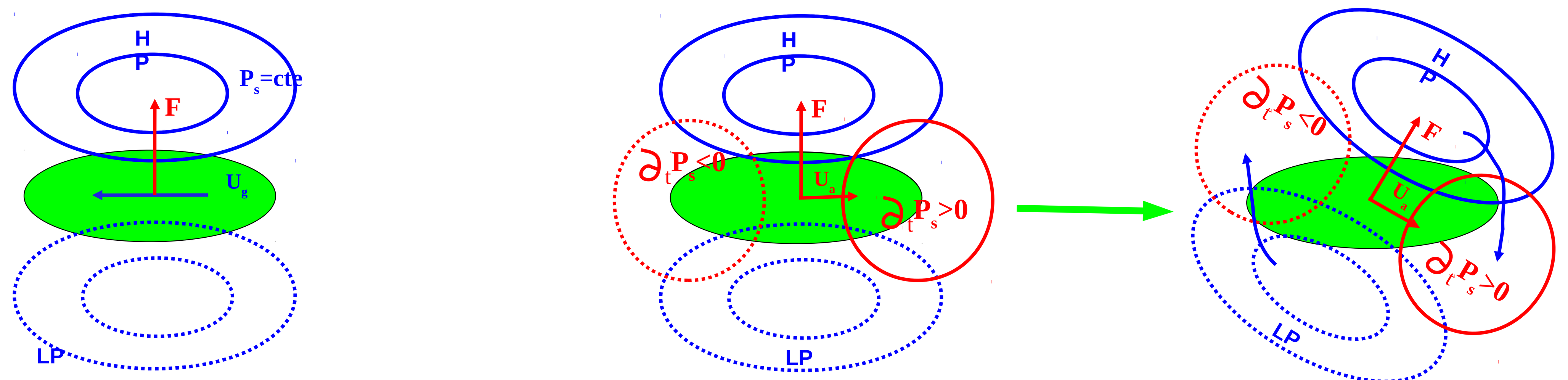




Composites keyed to the first component of the Eq. Mountain torque due to the Tibetan plateau

Dynamical origin

How a poleward « force » can result in a cold surge at a later stage (few days)



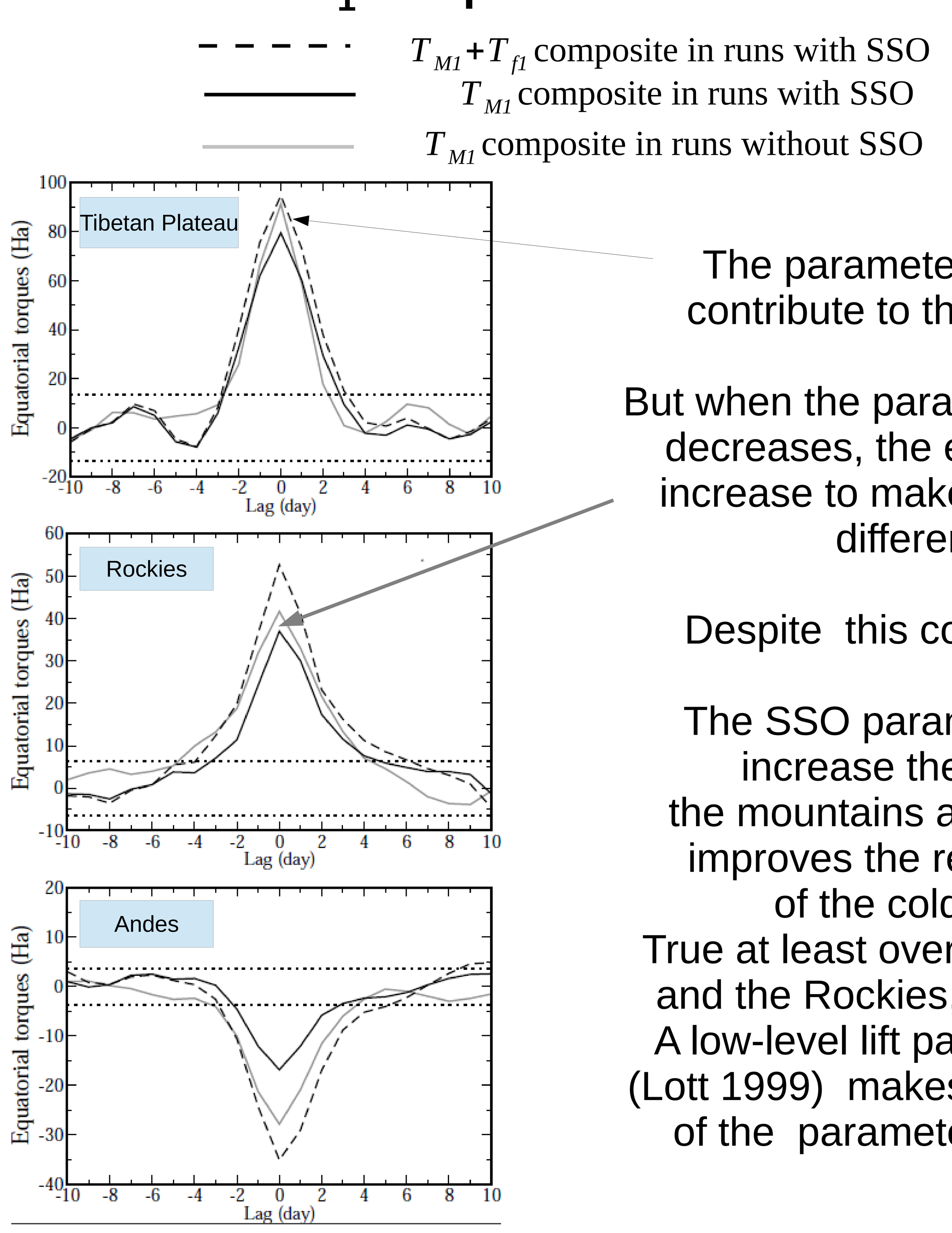
U_g: Geostrophic wind
F: Reactive force on the flow
P_s: Surface pressure

U_a ageostrophic wind:
Equilibrates F via Coriolis ($-f\,U_a$=F)
Transports mass from left to the right here

This transport of mass build up a high pressure pattern on the eastward slope of the mountain

Composites keyed on T_{M1} : Runs with and without SSO parameterizations

T_1 composites



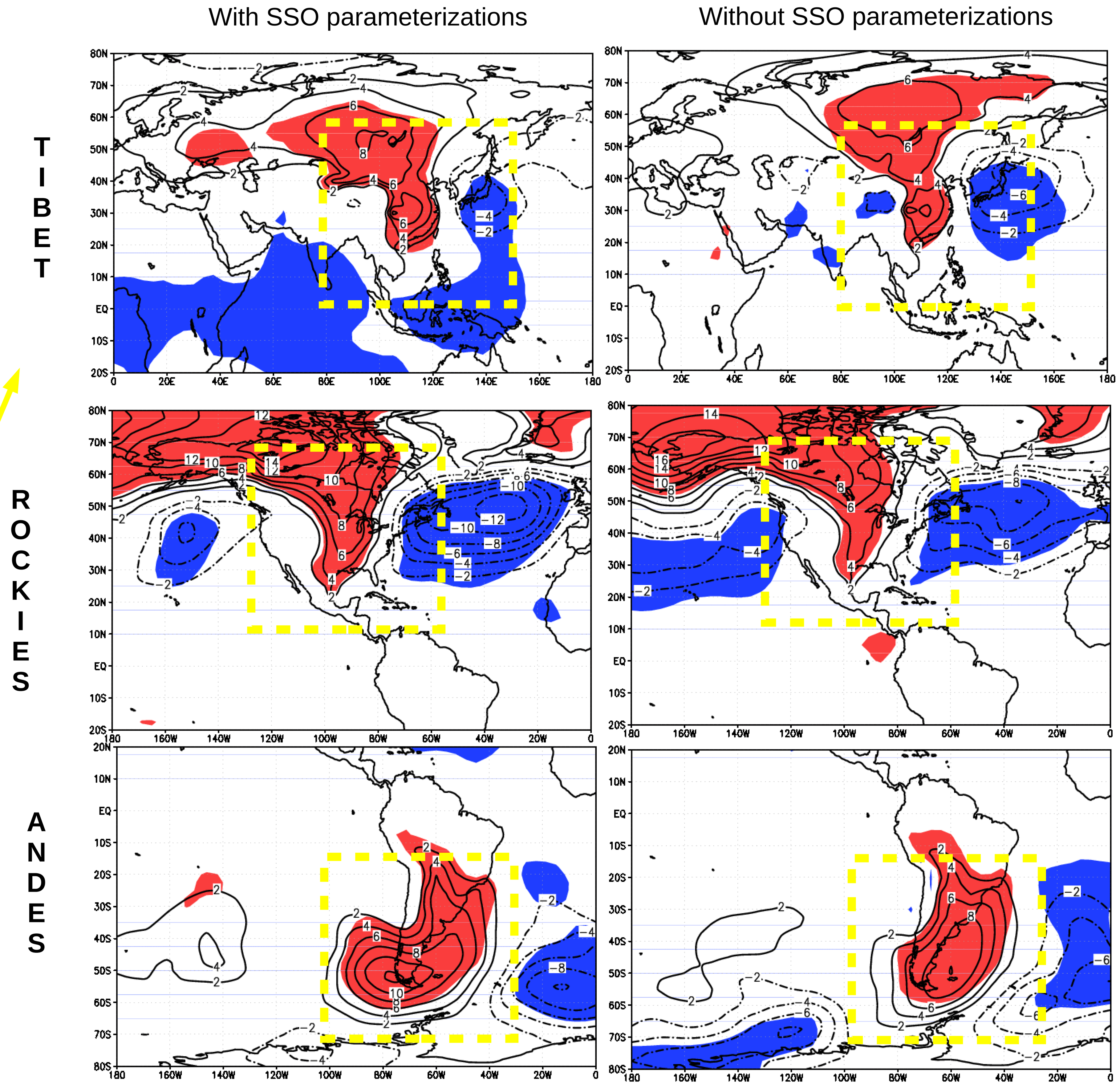
The parameterized forces contribute to the total torque

But when the parametrized torques decreases, the explicit torques increase to make up part of the differences

Despite this compensation:

The SSO parameterisations increase the impact of the mountains and marginally improves the representation of the cold surges:
True at least over the Himalayas and the Rockies, place where a A low-level lift parameterization (Lott 1999) makes up a good part of the parameterized torque

Surface pressure composite at day=2 lag



This is an attempt to validate mountain subgrid scale parametrizations by looking at their systematic impacts on synoptic scale systems.

Lott, F., Alleviation of stationary biases in a GCM through a mountain drag parametrization scheme and a simple representation of mountain lift forces, MWR, 127, 788--801, 1999

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S. Mailler and F. Lott, 2015: Impact of Subgrid-scale Orography on Equatorial Angular Momentum Budget and the Cold Surges in a General Circulation Model, MWR, In press.