How turbulent mountain stress influences SSW occurrence in WACCM

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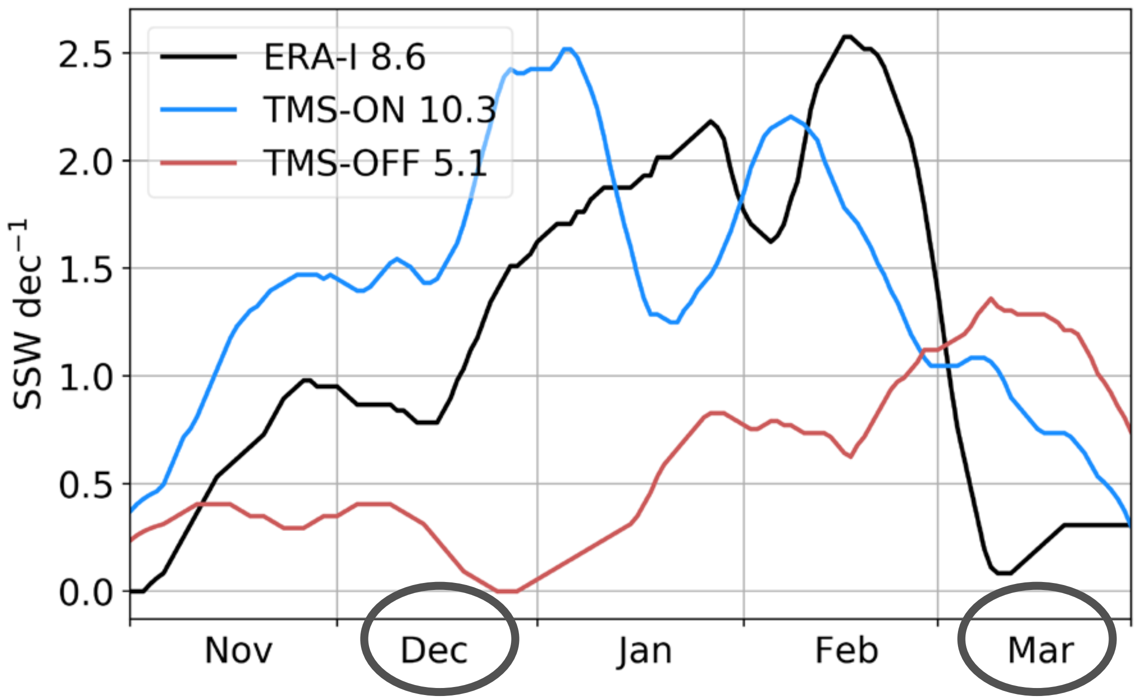
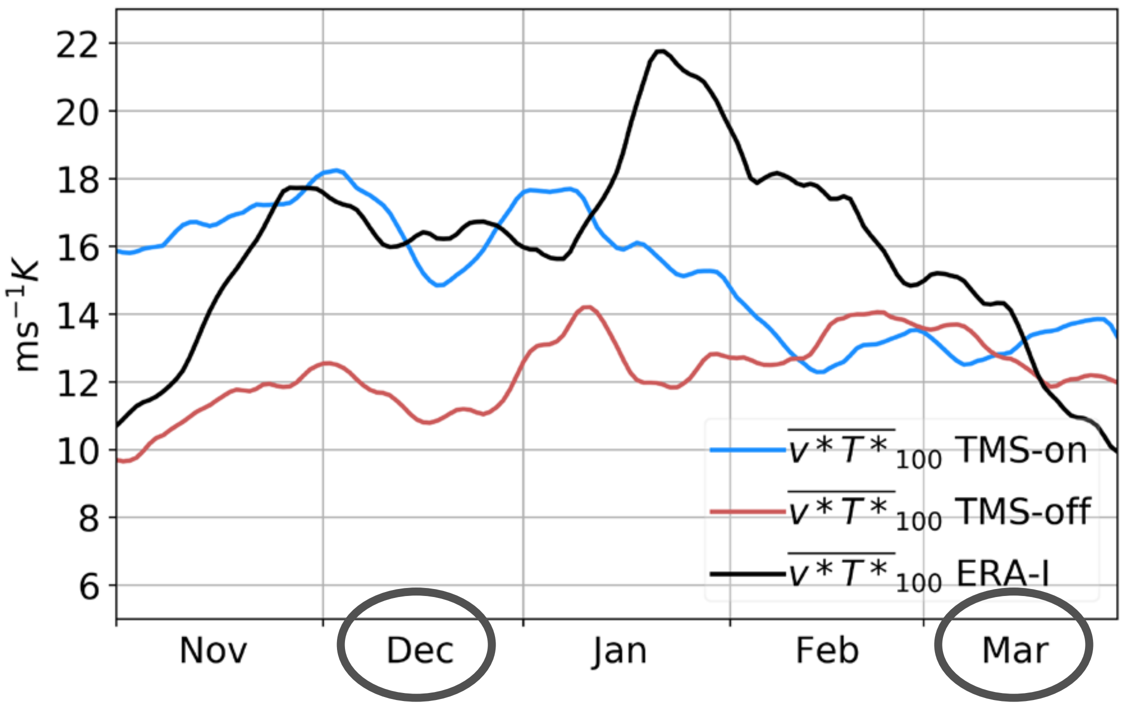
SSWs



100hPa-Eddy Heat flux



TMS-on shows a realistic SSW frequency and distribution through winter

TMS-off shows half SSW frequency compared to TMS-on; SSWs become realistic in late winter

The TMS effect is evident in early winter MORE HEAT-FLUX & MORE SSWs-> We'll compare TMS-on and TMS-off in December and March separately expecting larger differences in December.

Data and Methods

#**WACCM** version 4
2 x 50 years coupled runs: TMS-on and TMS-off (TMS is the only difference!!)

#**ERA-Interim** (1979-2010) for validation

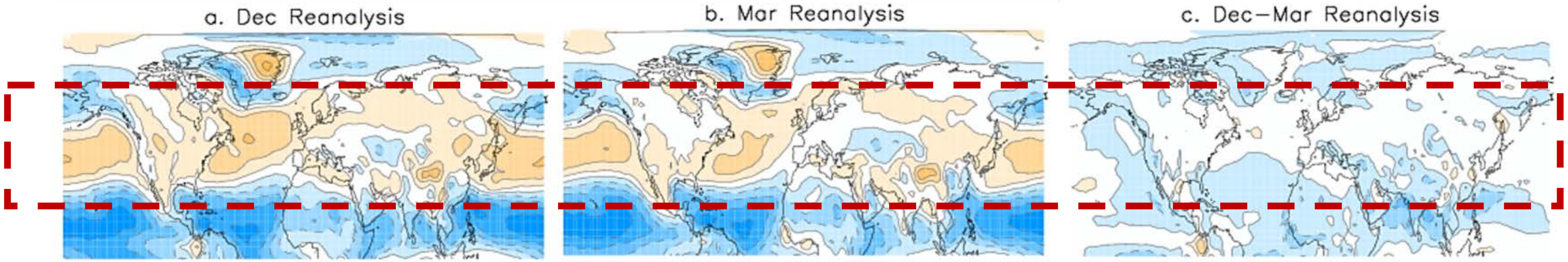
#SSWs are wind reversals (U<0) at 10 hPa at any latitude from 55 to 70 N
Final Warmings are discarded

#The turbulent mountain stress (TMS) is implemented at the surface, accounting for orographic details that the model does not resolve

Surface wind

December | March | Dec-minus-Mar

ERA



No intraseasonal differences in the westerly band

TMS-on

TMS-off

on-minus-off

Surface wind

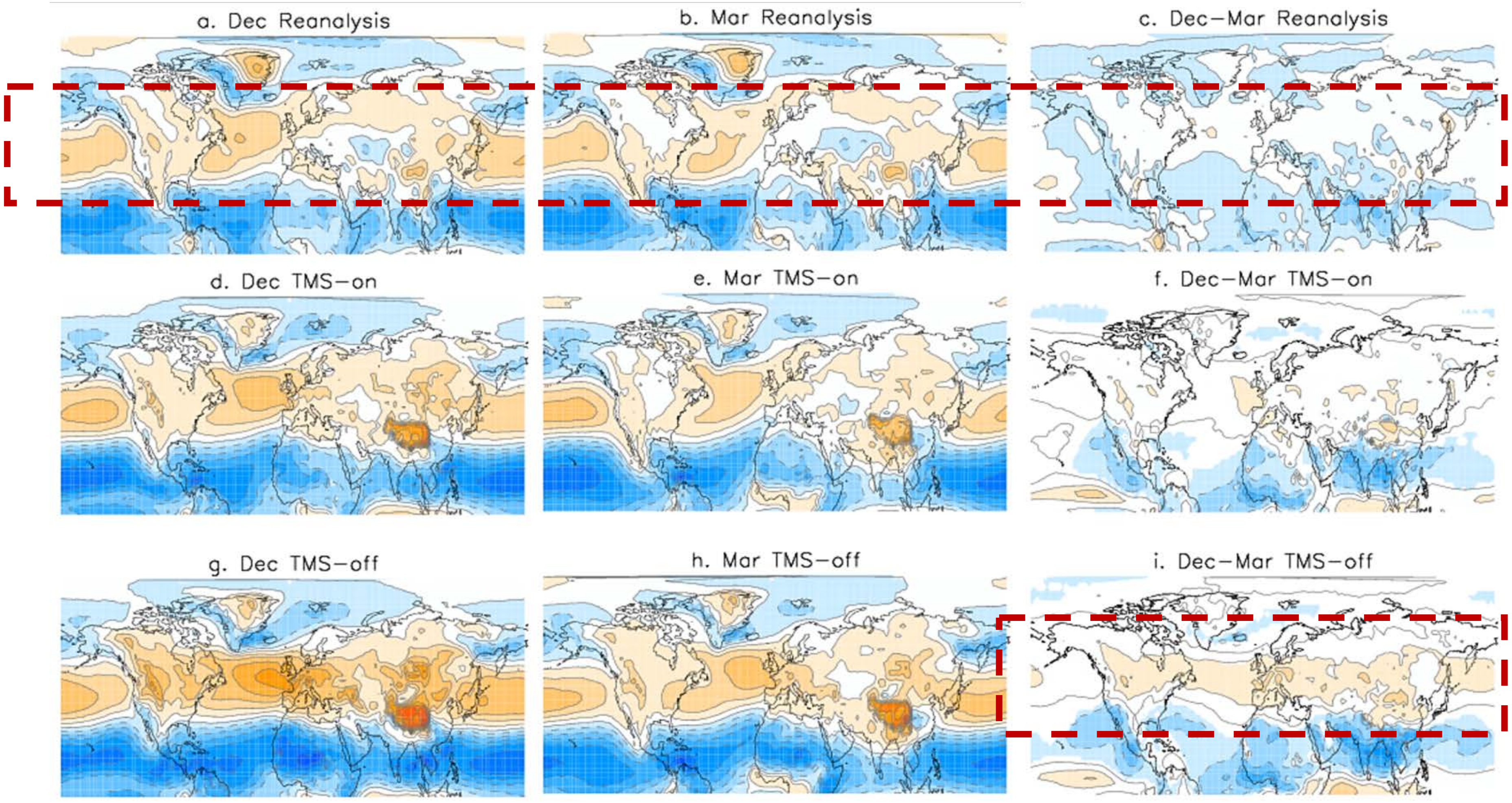
December | March | Dec-minus-Mar

ERA

TMS-on

TMS-off

on-minus-off



No intraseasonal differences in the westerly band

TMS-on ☺

TMS-off ☹

Surface wind

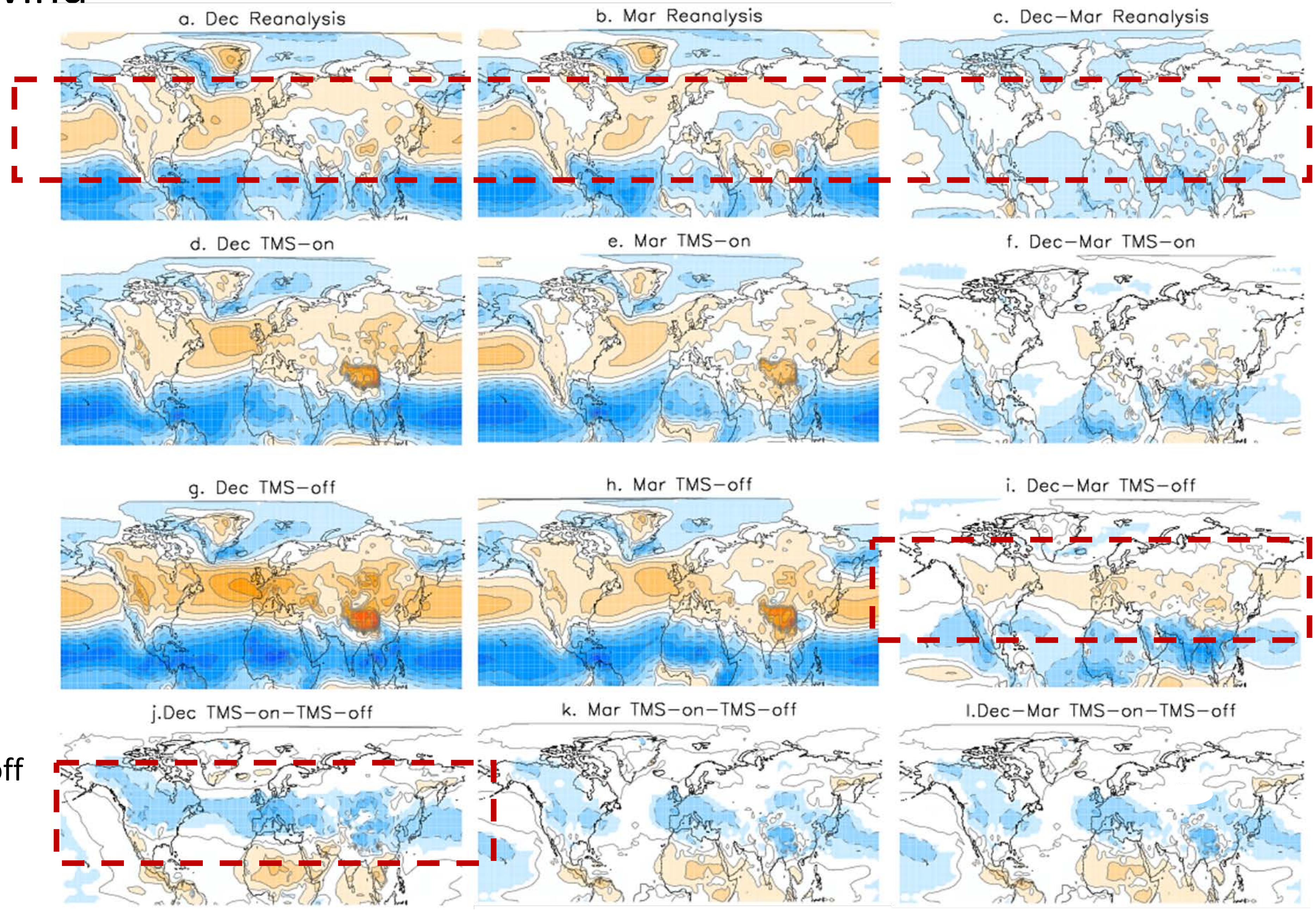
December | March | Dec-minus-Mar

ERA

TMS-on

TMS-off

on-minus-off



No intraseasonal differences in the westerly band

TMS-on ☺

TMS-off ☹

Larger differences in December

Changes in surface wind imply changes in the orographic gravity wave drag->

larger surface winds increase orographic gravity wave generation.

Let’s compare the **orographic gravity wave drag in the stratosphere** for TMS-on and TMS-off

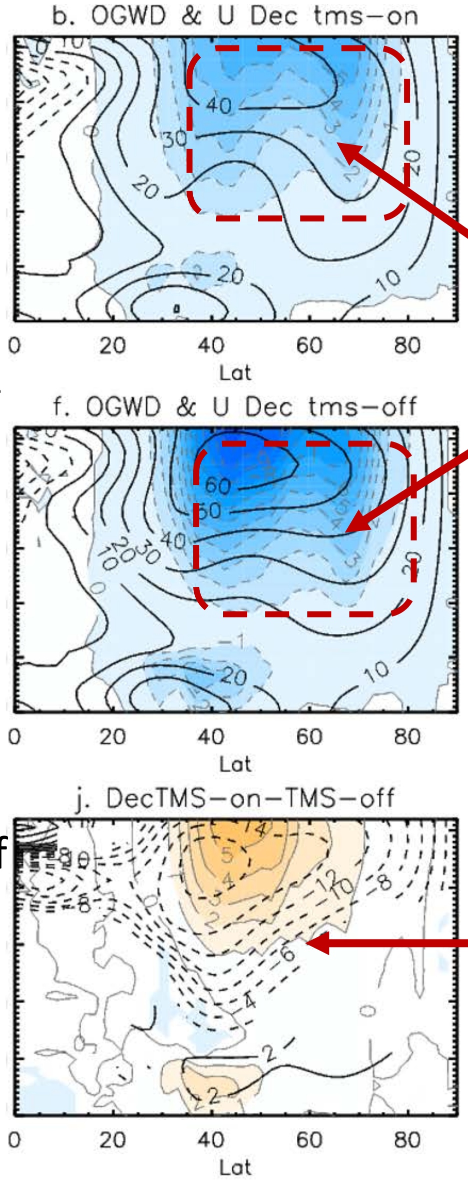
Orographic GW drag (Shading) & U (Contours)

December

TMS-on

TMS-off

Differences on-minus-off



Stronger surface winds during early winter in TMS-off result in stronger orographic gravity wave drag. This modifies the background flow and wave propagation into the selected region

The U deceleration in the stratosphere (dashed contours) is related to larger OGW drag but SSWs are associated to Planetary waves… The Eliassen Palm flux divergence can give us a picture of how much planetary wave forcing reaches the stratosphere, this weakens the vortex, and eventually results in an SSW.

Let’s see how planetary wave forcing looks in TMS-on and TMS-off

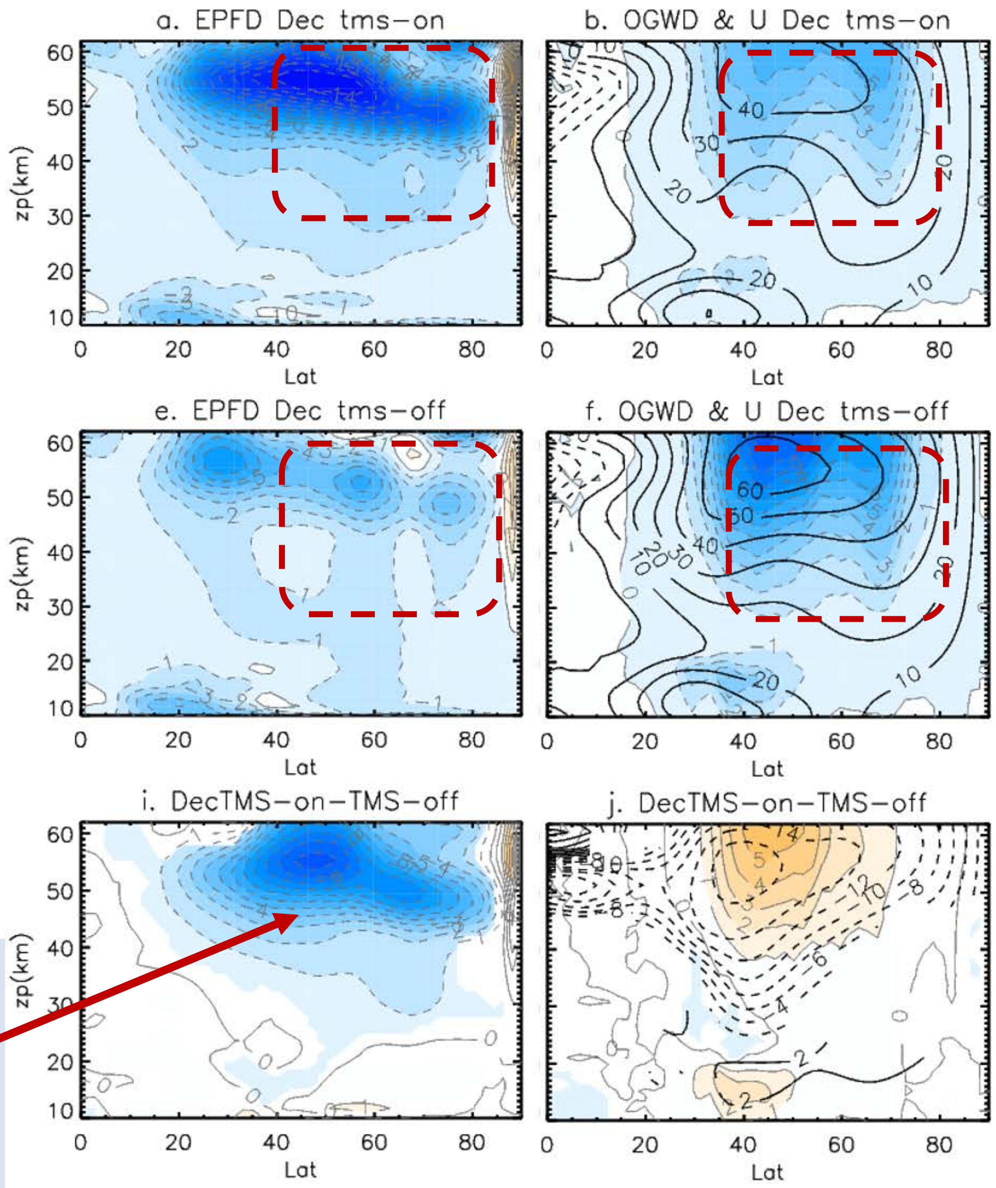
EP flux divergence Orographic GW drag & U

December

TMS-on

TMS-off

Differences on-minus-off



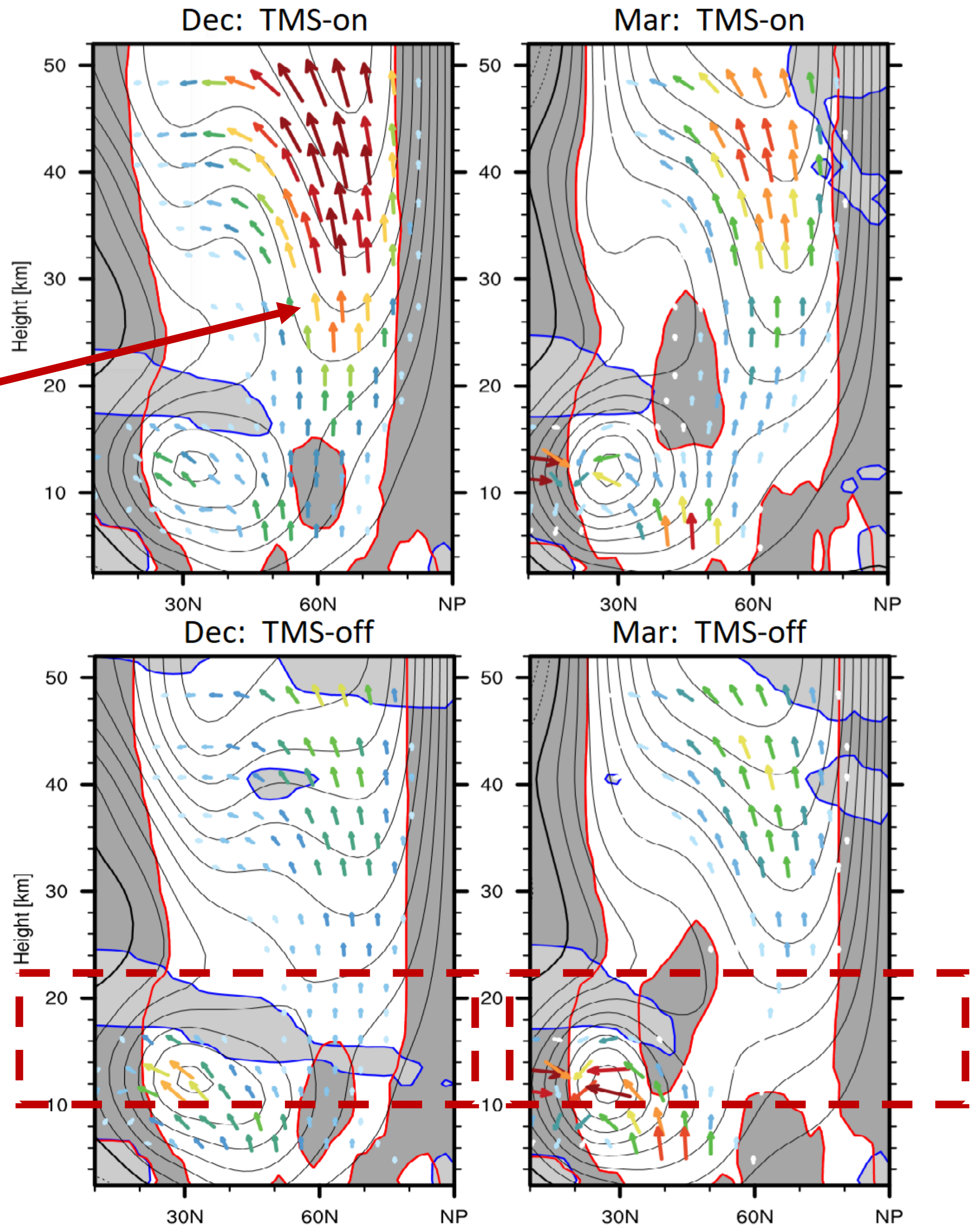
On the contrary, more planetary wave drag exists in TMS-on; consistent with more SSW occurrence.

To identify **changes in wave propagation**, we can compute reflecting surfaces and the vectors of the Eliassen Palm flux.

This will show **where planetary waves can propagate**

Reflecting Surfaces

TMS-on shows increased upward wave propagation in early winter as a result of a wave guide formation around [50-70]N and favoring SSWs



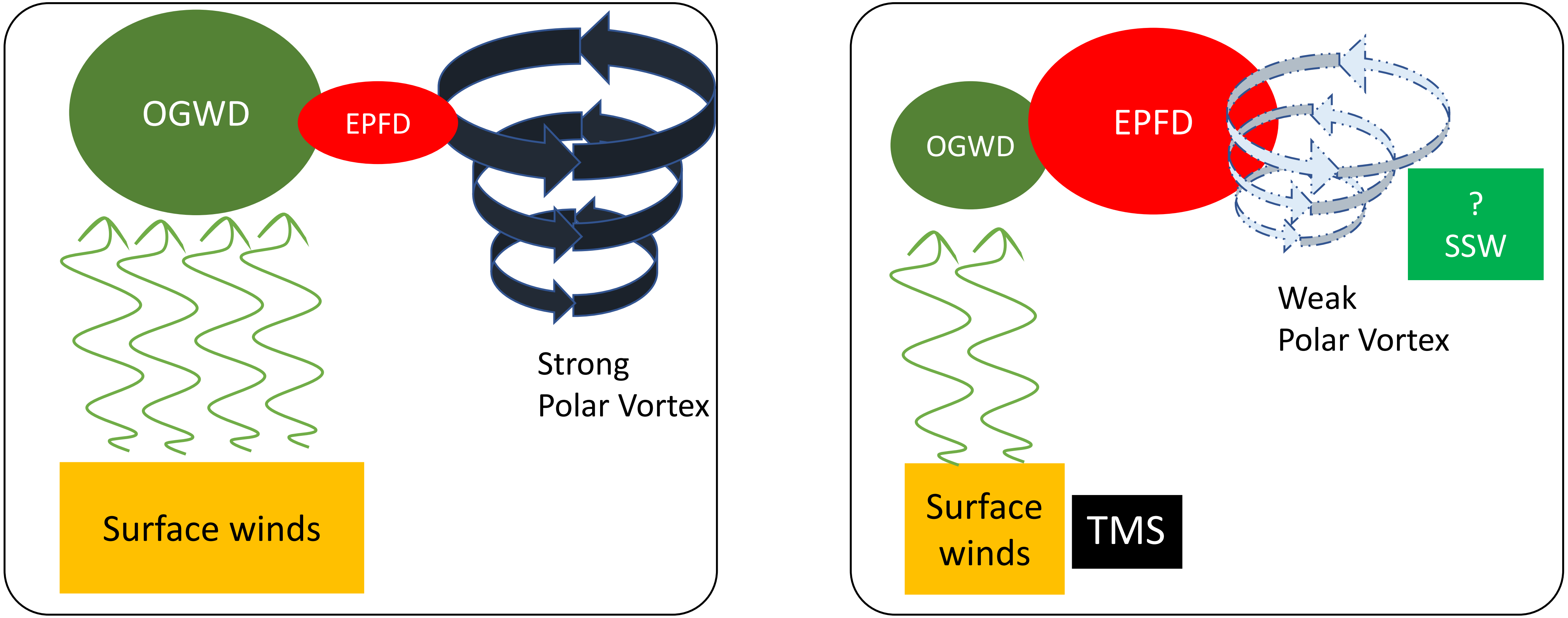
Contours: Zonal-mean U
Shading: Reflecting surfaces
Vectors: EP Flux (wave propagation)

During early winter, in TMS-off a horizontal reflecting surface appears ~20 km inhibiting upward wave propagation poleward of 50N

The reflecting surface disappears in late winter so upward wave propagation increases

Proposed Mechanism: The turbulent mountain stress (TMS) reduces **surface winds** which reduces **orographic gravity wave drag** in the stratosphere; this modifies the stratospheric jet enhancing upward **planetary wave propagation** that weakens the vortex and favors SSW occurrence.

TMS-off TMS-on



Palmeiro F.M., Garcia R.R., Calvo N., Barriopedro D. and Jiménez-Esteve B.
The influence of turbulent mountain stress on the frequency of sudden stratospheric warmings in WACCM.