Satellite estimates of momentum fluxes from high-impact gravity wave events in the stratosphere and their effects on circulation

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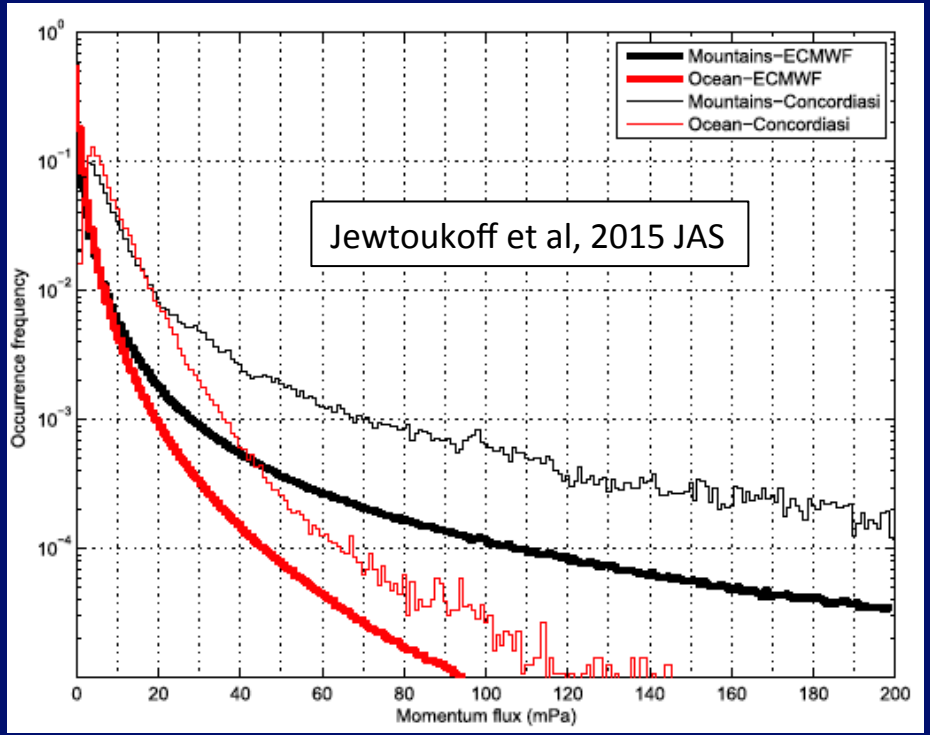
Motivation



Large-amplitude GWs are important drivers of circulation and transport in the stratosphere, yet they are not treated correctly in most climate models

GW parameterizations remain poorly constrained by observations in part because the uncertainties in observed momentum fluxes are very large

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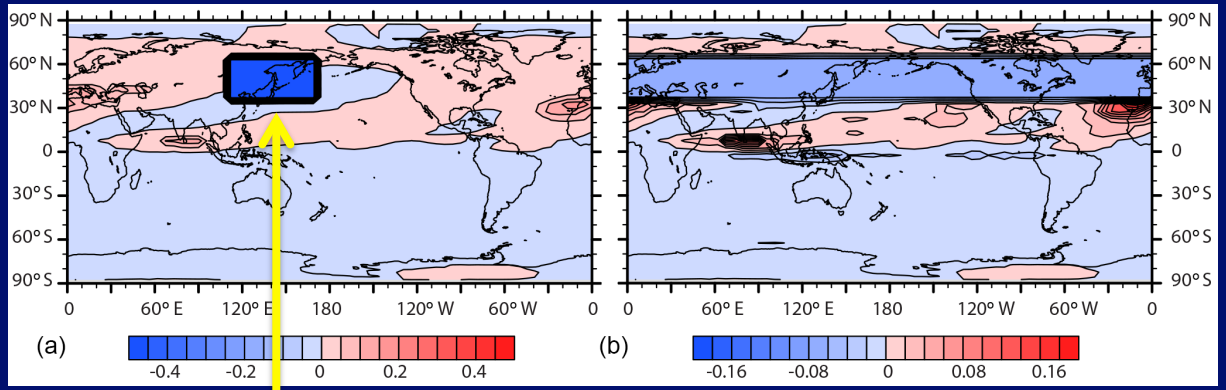
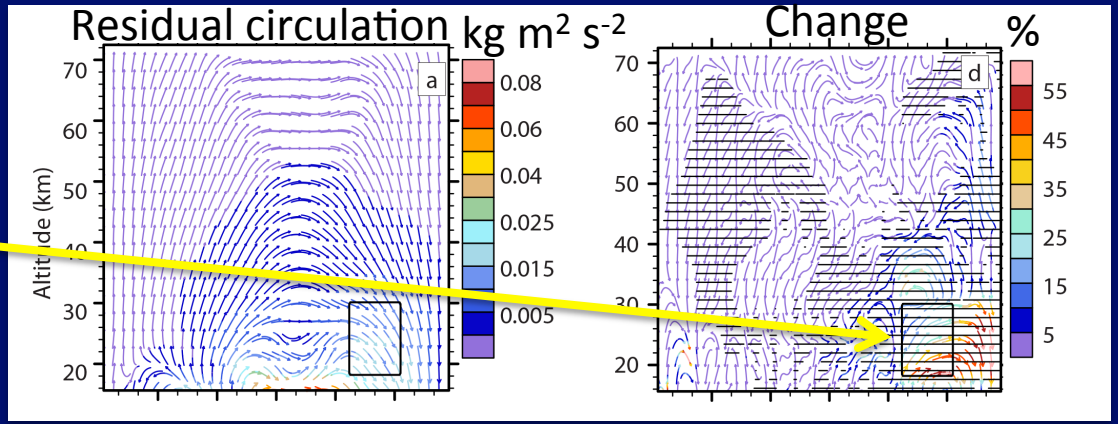


The response of the residual circulation and transport to forcing depends strongly on the latitude of the applied force and its spatial and temporal scales

Change in residual circulation from a strong local imposed GWD ~20-30 km

Šácha et al., 2016



Objectives

Combine observations from AIRS and HIRDLS to estimate momentum flux from high-impact gravity wave events

Use a high-resolution global model constrained by observed large-scale (>600 km) winds and validated by observations from AIRS and HIRDLS to calculate “drag” from high-impact gravity wave events and impact on circulation and transport

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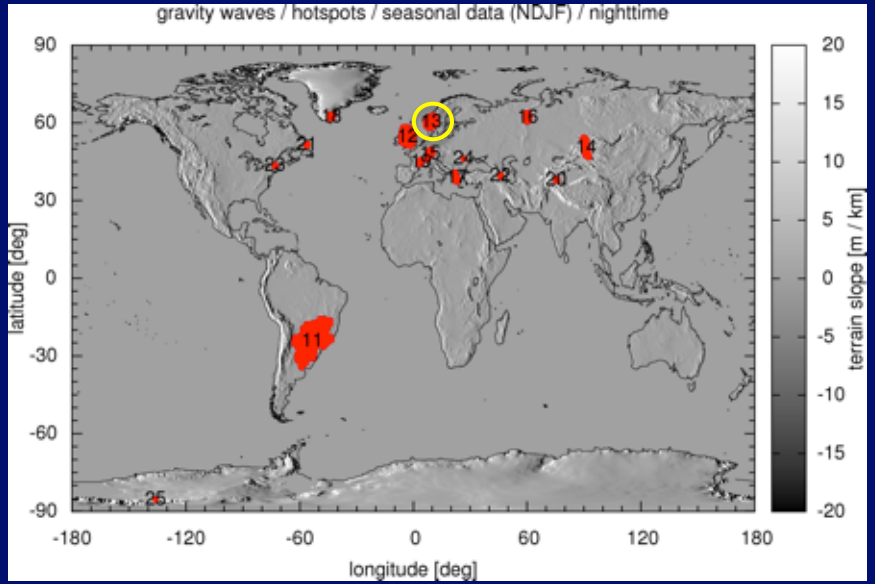
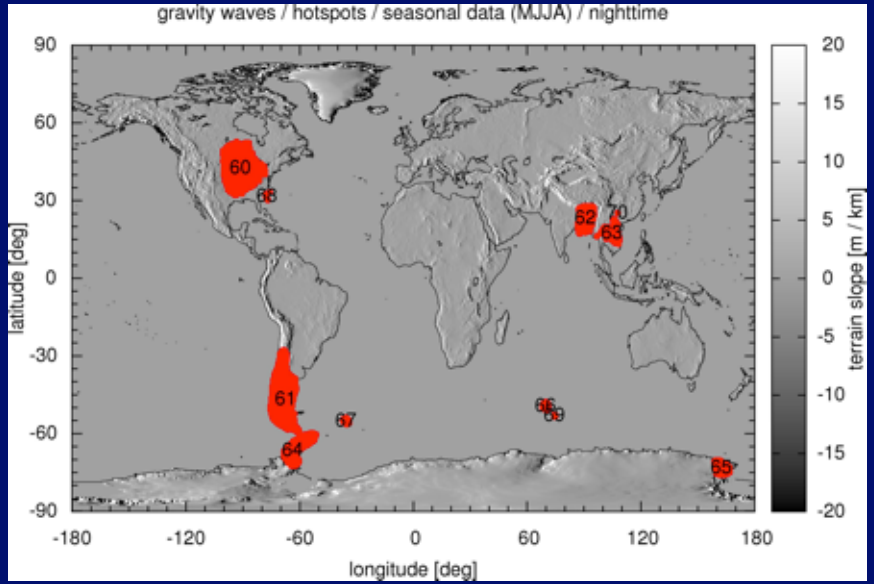
Gravity wave hot spots in AIRS

NH winter

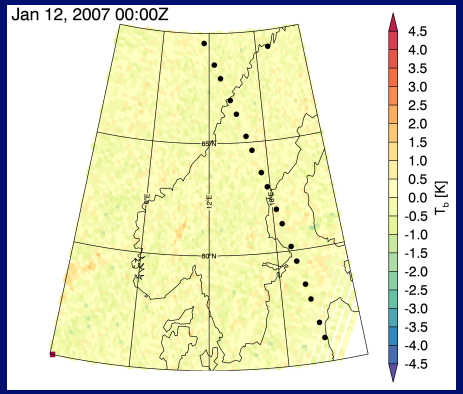


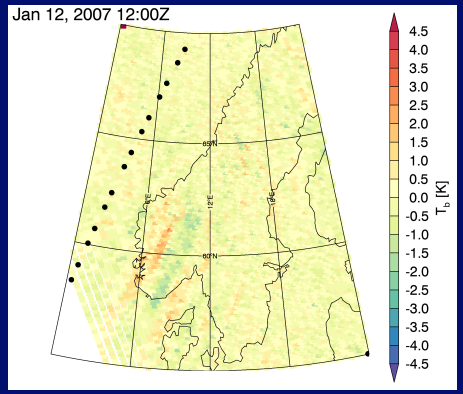
SH winter

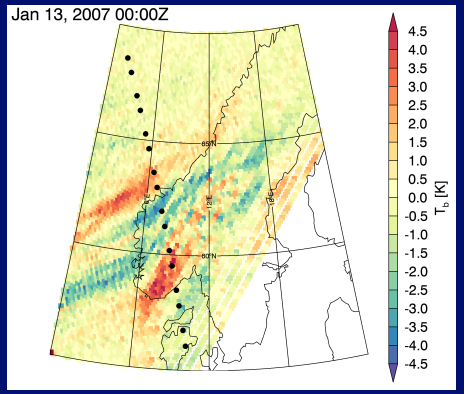


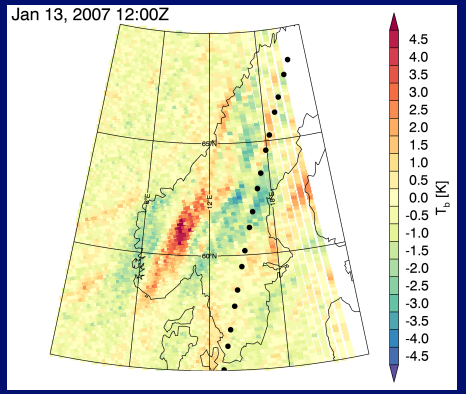
Hoffmann et al., 2013

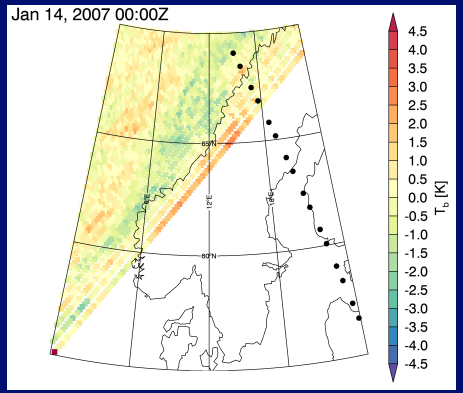
AIRS brightness T anomalies

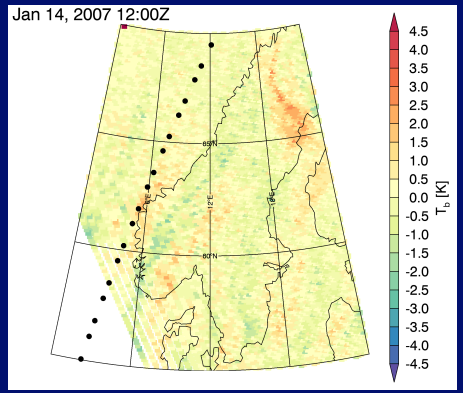


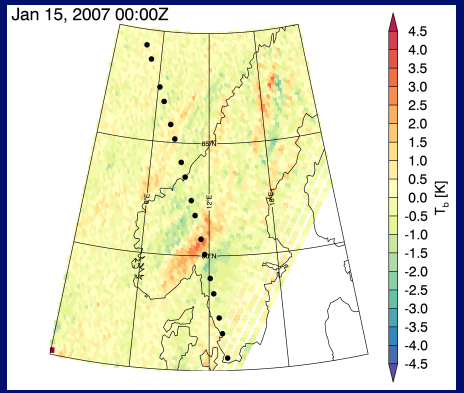


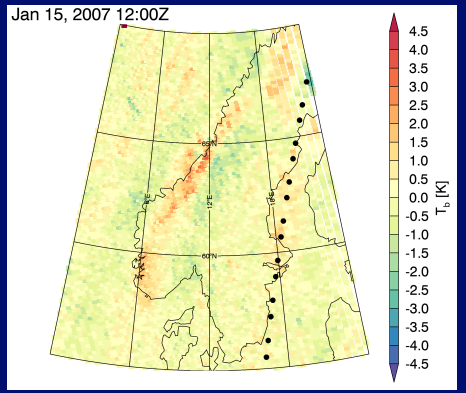




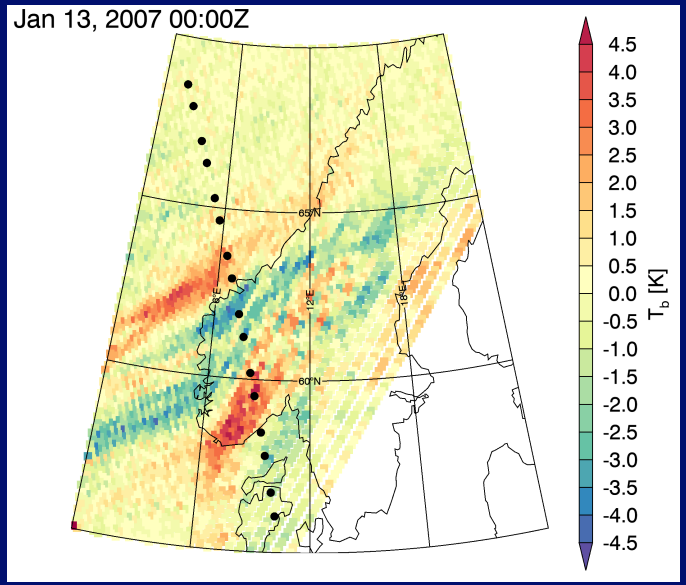


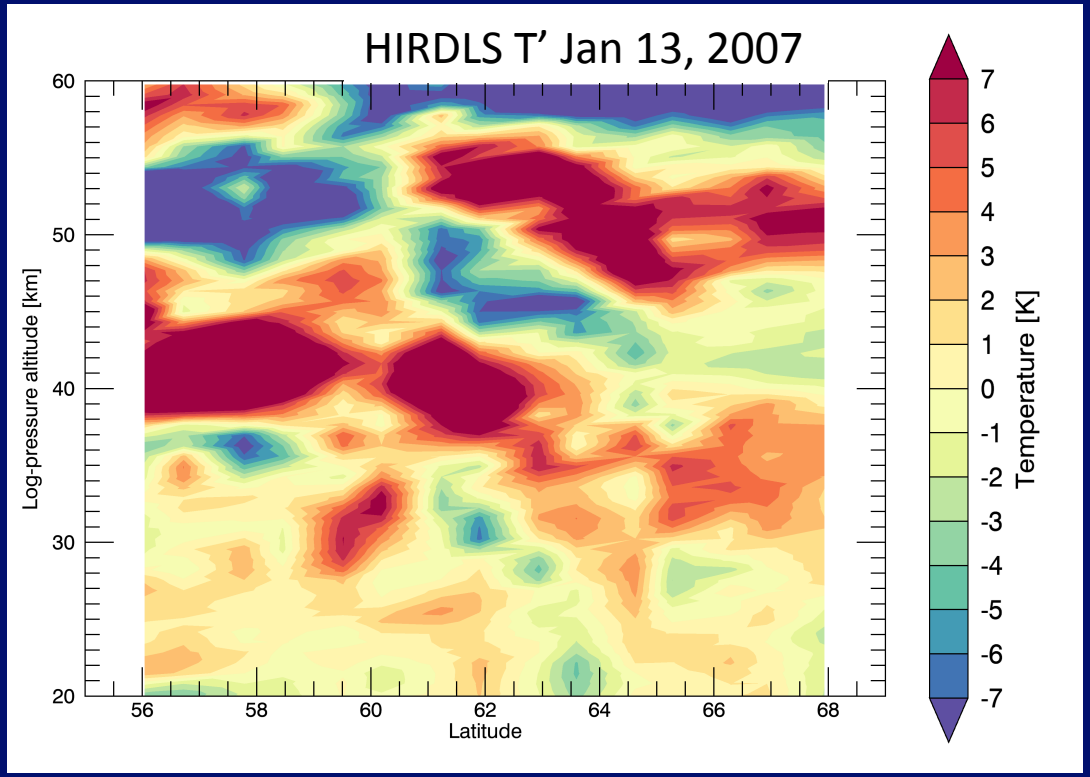




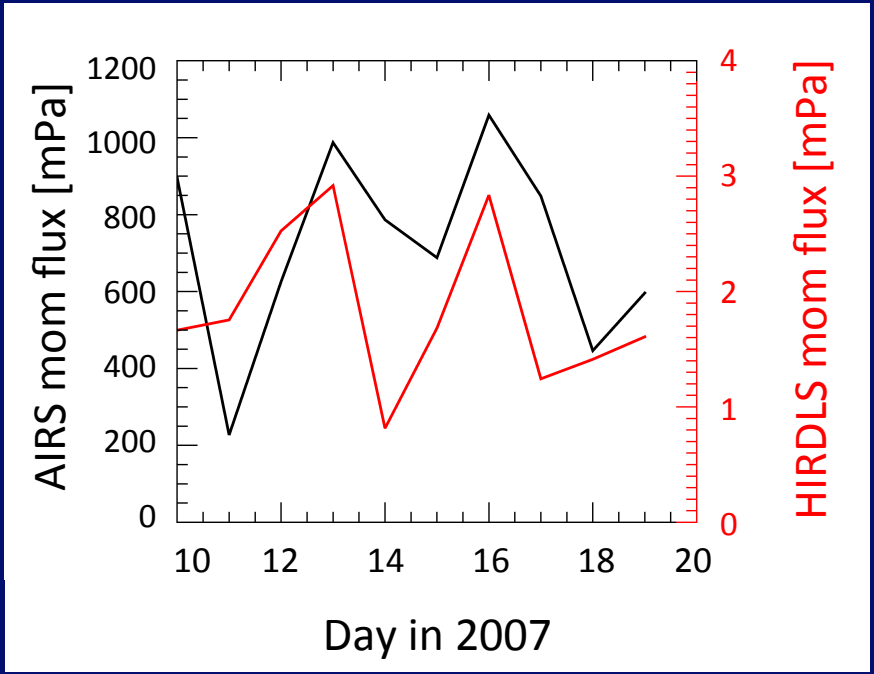


AIRS T_b and HIRDLS T anomalies





Uncertainty in momentum flux derived from observations is very large



More than 2 orders of magnitude between AIRS and HIRDLS estimates for the same orographic area over Norway

NH estimates are more challenging than SH because winds are more variable

Uncertainty in momentum flux derived from observations is very large

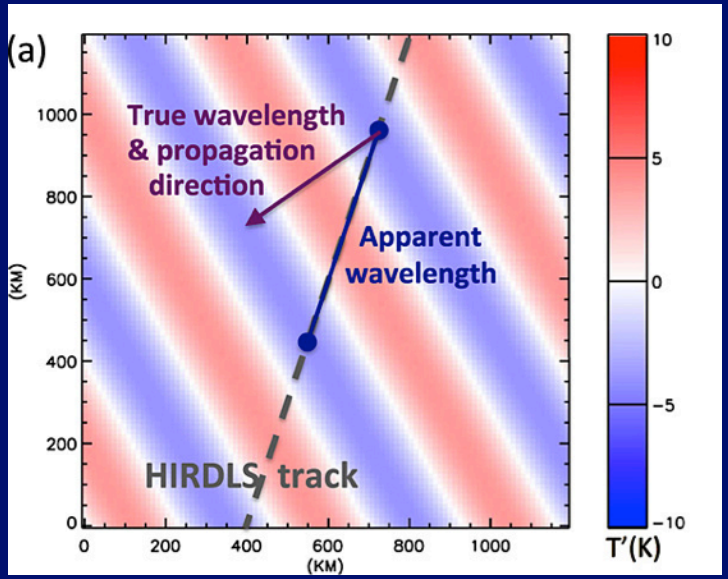
Momentum flux from observations:

$$M = \frac{\bar{\rho}}{2}\frac{k}{m}\left(\frac{g}{N}\right)^2\left(\frac{\hat{T}}{\bar{T}}\right)^2$$

HIRDLS

AIRS

$$\lambda_Z = 2\pi\left(\frac{N^2}{U^2} - |\mathbf{k}|^2\right)^{-1/2}$$



Alexander 2015

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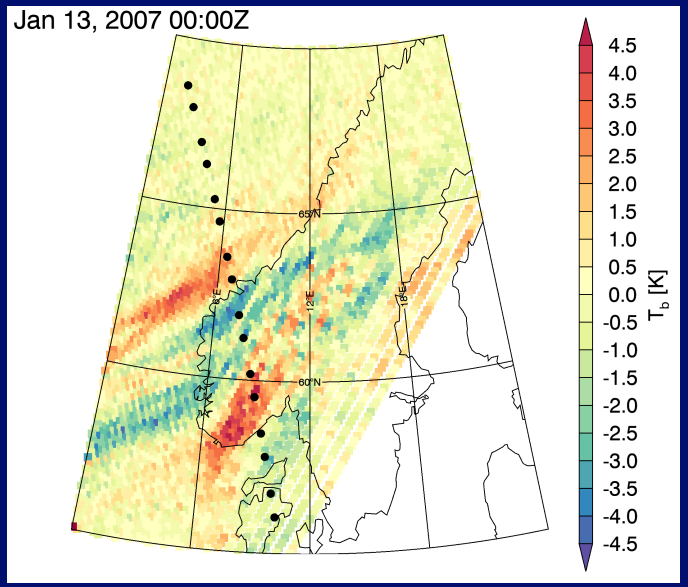
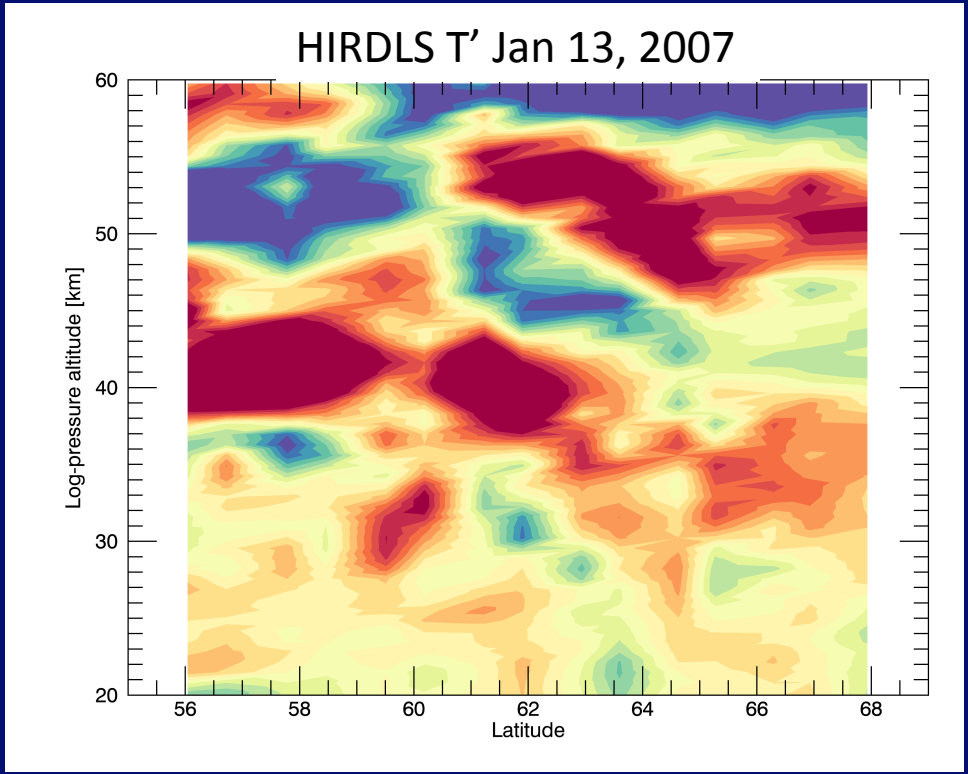
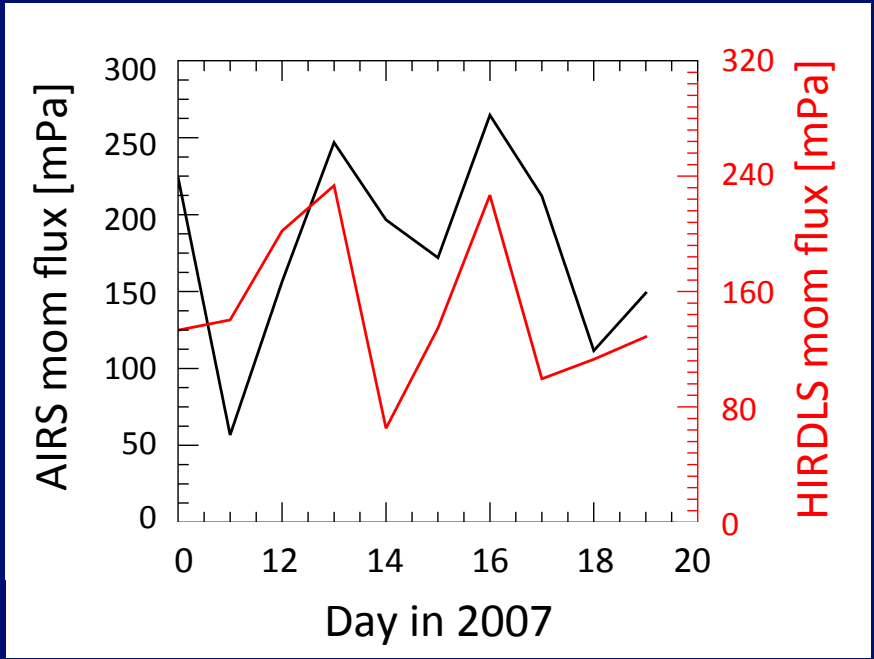
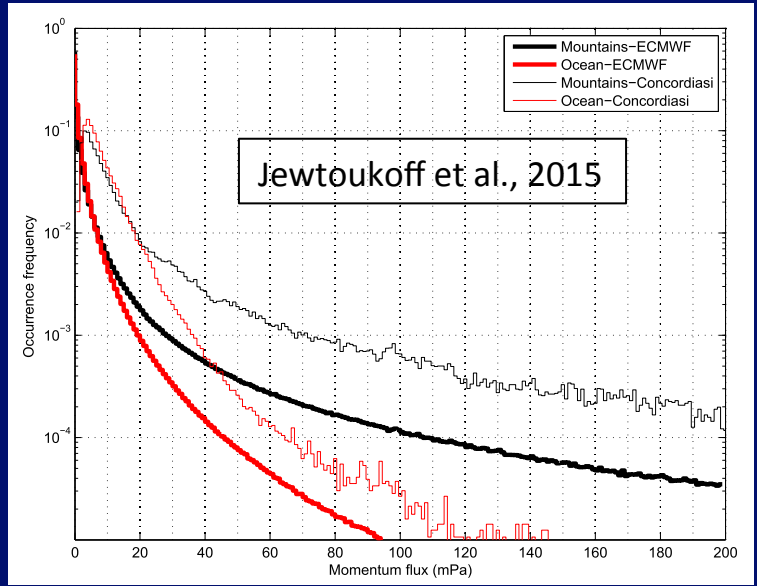




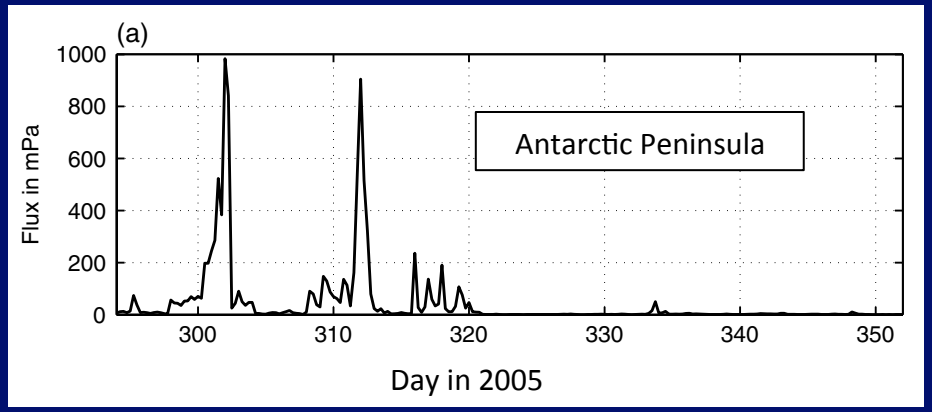
Corrected momentum fluxes

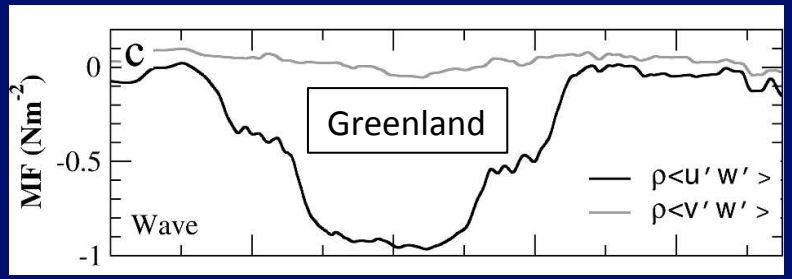




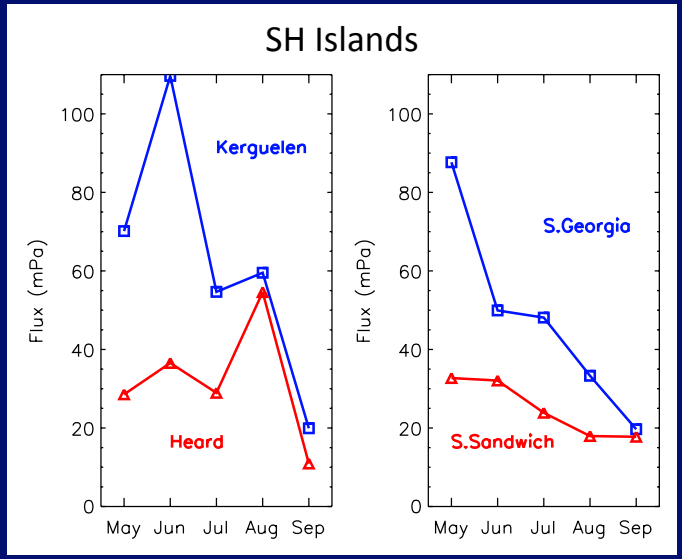
Other estimates of orographic MF

Plougonven et al., 2013





Doyle et al., 2005



Alexander and Grimsdell, 2013

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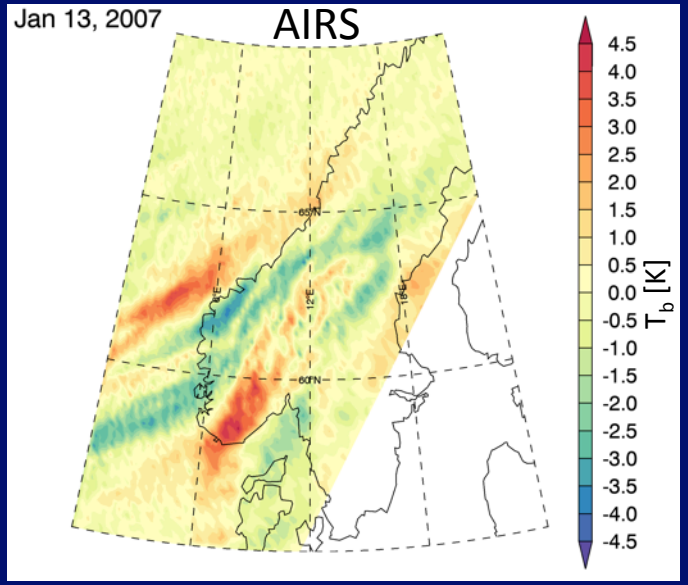

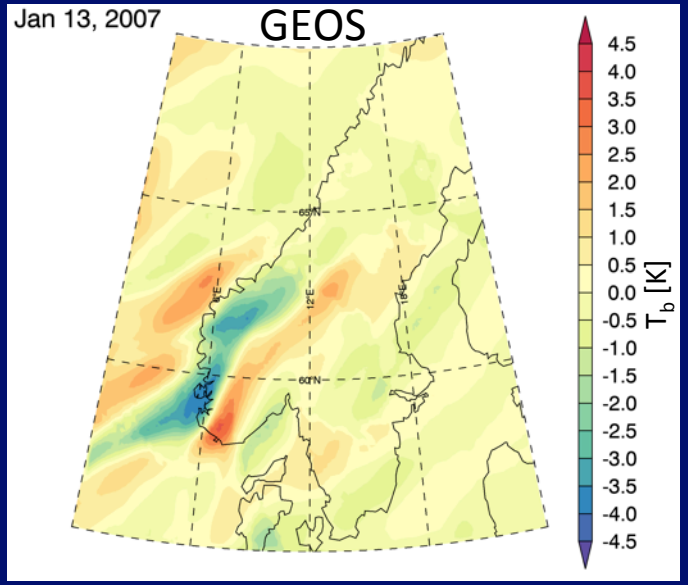

- GEOS T_b wavelength and amplitude are remarkably similar to AIRS
- GEOS is smoother, probably because of smoothed topography

Summary and Conclusions

- High-impact GW events are important for circulation in the lower stratosphere
- GW mom flux and especially drag are difficult to calculate from observations
- Combining HIRDLS and AIRS can improve estimates of GW drag
- "Drag" and circulation effects can be estimated with global high-res model

Ongoing work:

- Extending methods to other orographic hotspots to get a global picture of effects on circulation and transport
- Extending methods to nonorographic hotspots
- New global, high-resolution runs with 12-, 6-, 3-, and 1.5-km horizontal resolution

Thank you!