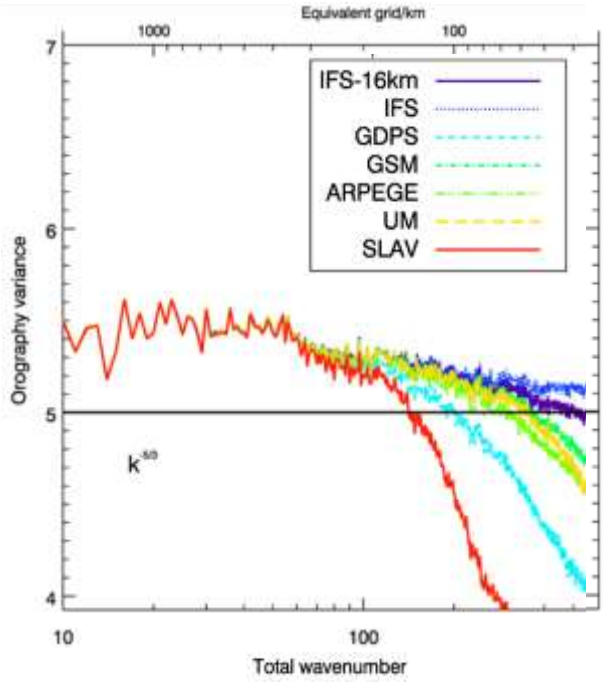
Constraining the source of significant variation in orographic drag representation in numerical weather prediction: a model orography intercomparison and implications for drag parameterization

Andy Elvidge[1], Irina Sandu[2], Nils Wedi[2], Ayrton Zadra[3], Simon Vosper[1], Masashi Ujiie[4], Mikhail Tolstykh[5], Francois Bouyssel[6], Anton Beljaars[2], Souhail Boussetta[2], Annelize Van Niekerk[1]

[1] Met Office, [2] ECMWF, [3] Canadian Meteorological Centre, [4] Japan Meteorological Agency, [5] Russian Academy of Sciences, [6] Météo France

Power spectra of mean (resolved) grid box orography:

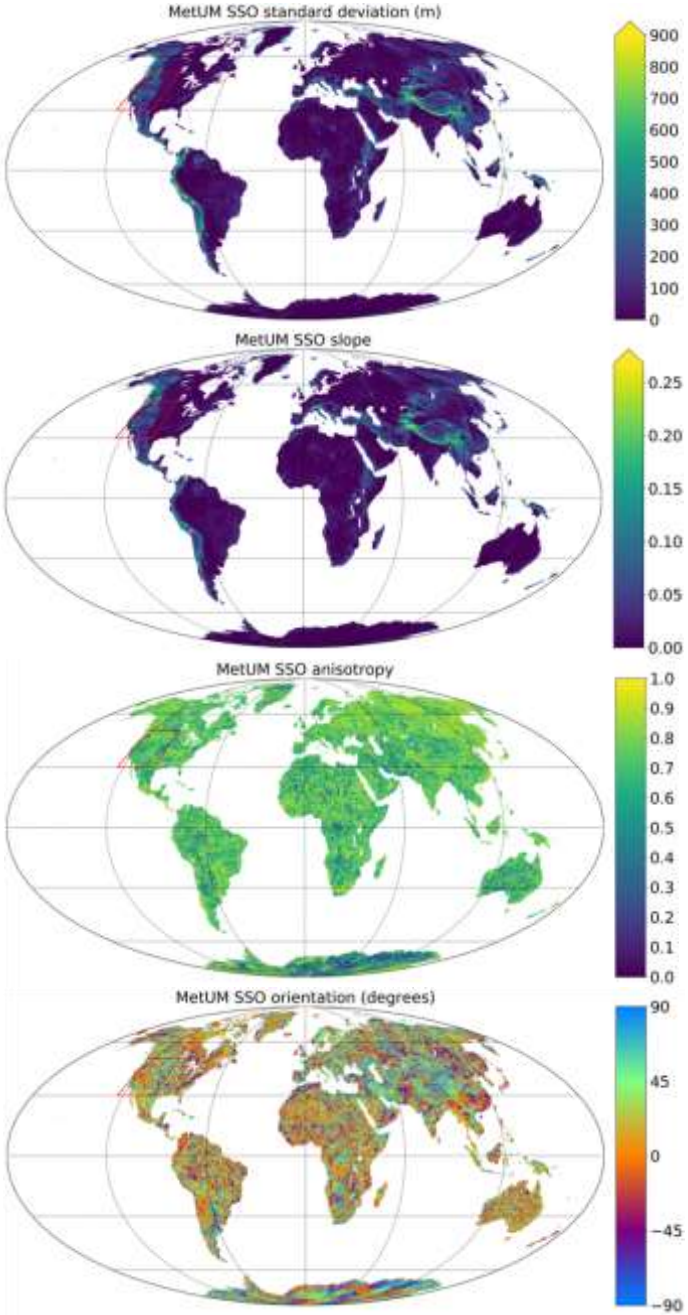


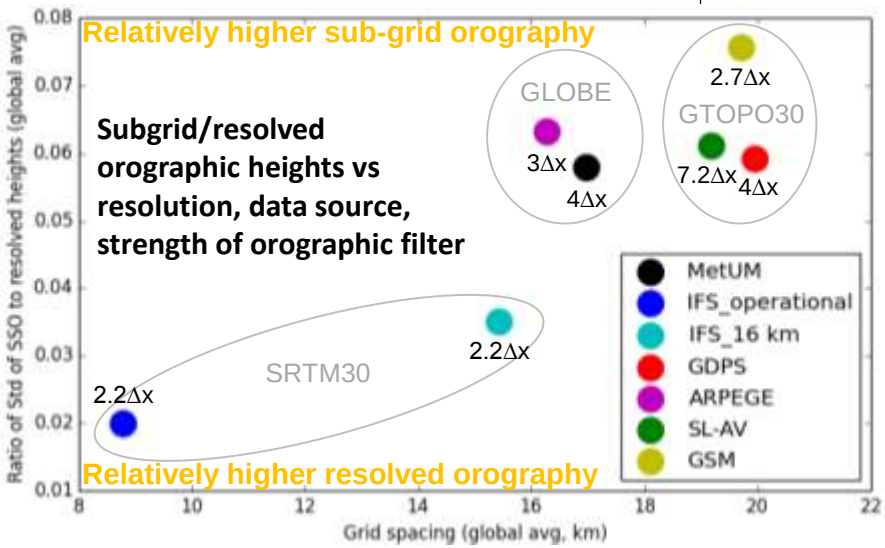
Height:
Height of subgrid-scale mountains, given by the grid-box standard deviation of subgrid-scale orography (SSO)

Slope:
Grid box SSO gradient

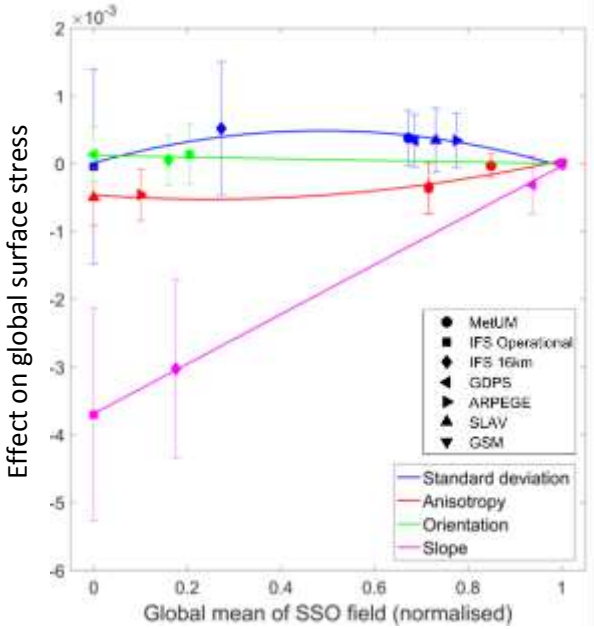
Anisotropy:
Ridge-like (0) to dome-like (1) SSO

Orientation:
SSO ridge angle



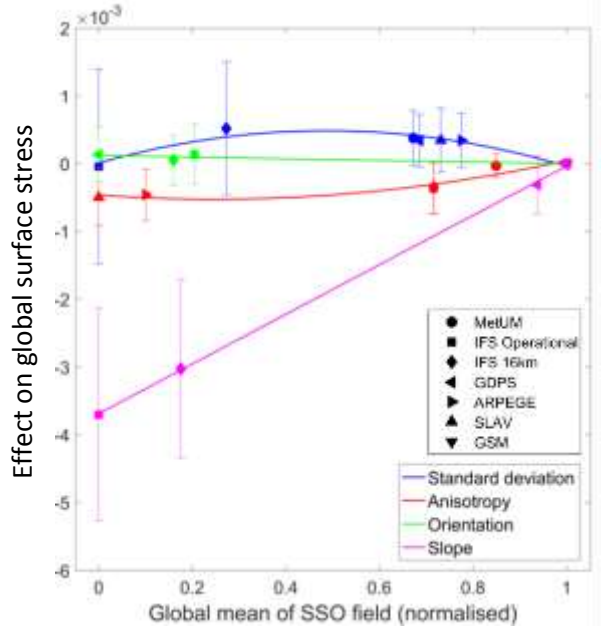


All SSO fields vary significantly across models



Offline SSO field sensitivity experiments (using Lott and Miller scheme) show:

- Global-average stress most sensitive to inter-model variability in *slope*, but both *slope* and *height* influential locally
- Local Froude number controls polarity and strength of drag response to variability in *height*
- Influence of *anisotropy* and *orientation* fields relatively small

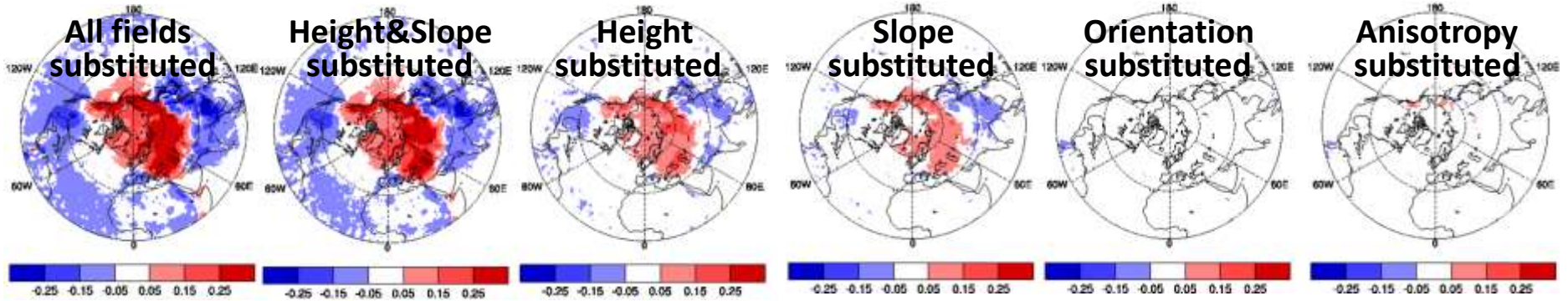


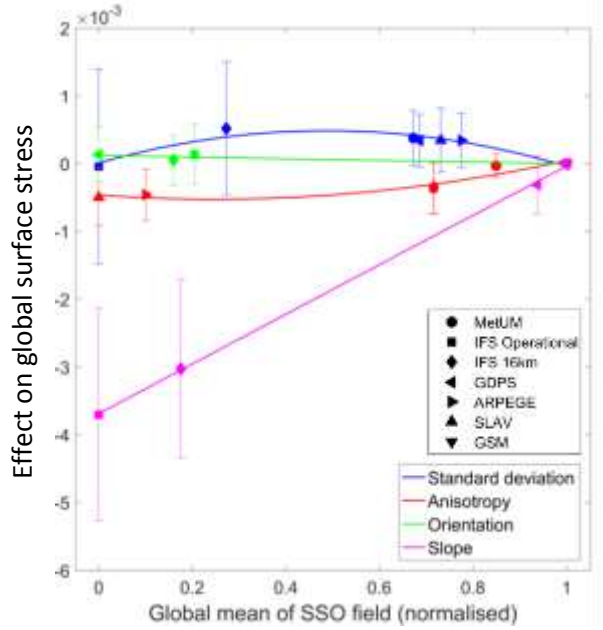
Offline SSO field sensitivity experiments (using Lott and Miller scheme) show:

- Global-average stress most sensitive to inter-model variability in *slope*, but both *slope* and *height* influential locally
- Local Froude number controls polarity and strength of drag response to variability in *height*
- Influence of *anisotropy* and *orientation* fields relatively small

IFS experiments where SSO fields are substituted for MetUM SSO fields:

- Combined effect of *height* & *slope* required to explain response in P_{sfc}
- Positive polar pressure signature resembles known MetUM model bias



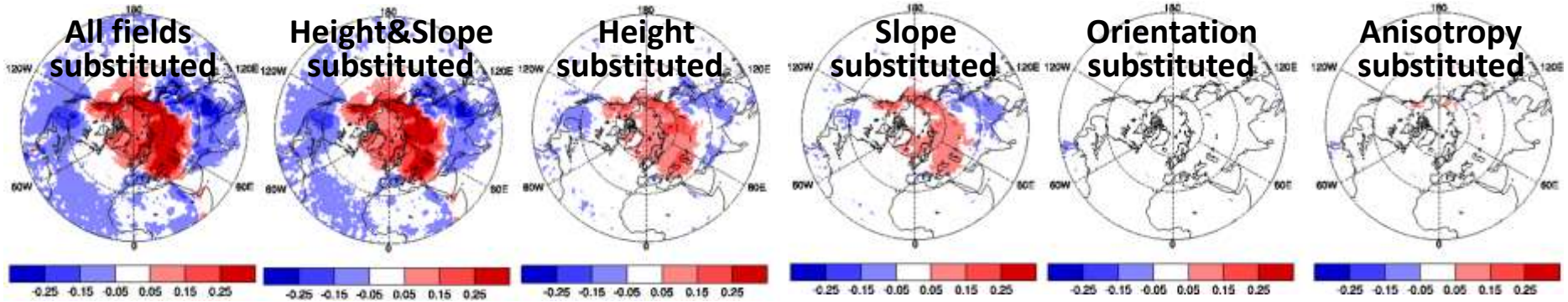


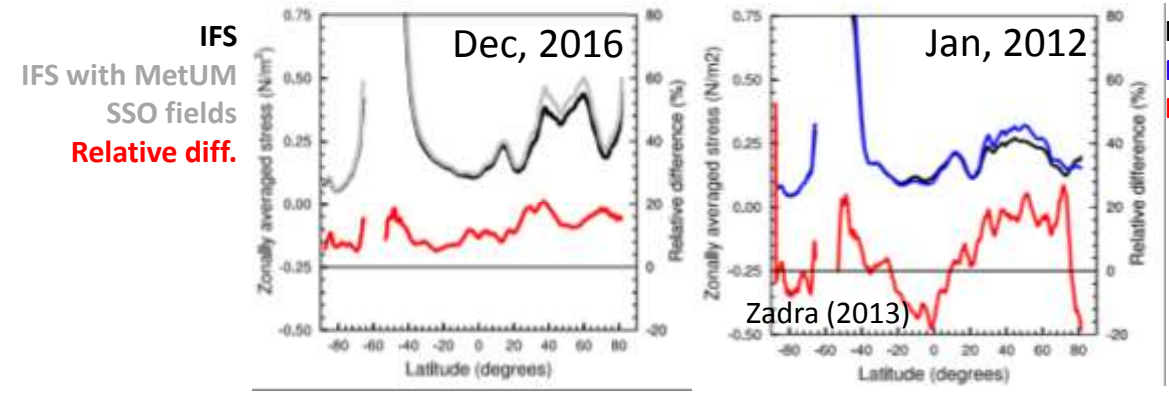
Offline SSO field sensitivity experiments (using Lott and Miller scheme) show:

- Global-average stress most sensitive to inter-model variability in *slope*, but both *slope* and *height* influential locally
- Local Froude number controls polarity and strength of drag response to variability in *height*
- Influence of *anisotropy* and *orientation* fields relatively small

IFS experiments where SSO fields are substituted for MetUM SSO fields:

- Combined effect of *height* & *slope* required to explain response in P_{sfc}
- Positive polar pressure signature resembles known MetUM model bias





Inter-model variability in SSO fields can be of first-order importance to the variability in drag seen across models