# Orographic gravity wave drag in CMIP6 and its influence on the polar vortex

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## Introduction and motivation

**Orographic gravity waves (OGWs)** are important in the **energy and momentum transport** in our atmosphere. GWs also influence different components of the atmosphere dynamics such as **propagation of planetary waves,** QBO**,** BDC etc.

Effects of OGWs must be included in general circulation models but as they exist on quite **small scales**, going from few to thousands of kilometres in horizontal, they **cannot be fully resolved by the current models**. For this, **parameterisations** are used to artificially add their influence on the mean flow to the model.

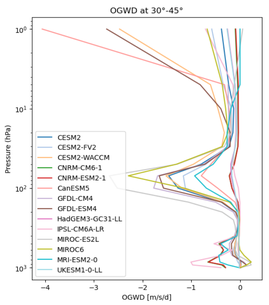


**Figure 1:** *OGWD from 14 CMIP6 model, latitude 30°-45°N,1979-2014*

Differences in the tuning and parameterisation schemes can result in very **different values of OGW drag** – the main output of these schemes (Figure 1**)** – and consequently differently influence the mean flow and other parts of the dynamics. It has been already shown before that this effect is important in CMIP6 models (e.g. Hájková and Šácha, 2024).

## Data and Methodology

We are using data from 14 CMIP6 amip experiment models, to compare OGWD and indices that describe strength and stability of stratospheric polar vortex.

- NAM index is calculated using monthly geopotential data as the standardized principal component time series of the leading EOF at 10 hPa 20°-90°N. We then calculated frequency of month with stronger negative indices <-1
- Polar vortex moments, aspect ratio and centroid latitude, were calculated as in Seviour et al. 2013 and frequency of days with critical values, >2.4 and <66° respectively

## Results

- **Stratospheric polar vortex** and its **stability** is one of the **large uncertainties in models** together with SSWs, Figure 2.
- Stability of the vortex is strongly tied to the **planetary wave activity**, represented here with Eliassen-Palm flux divergence (EPFD), Figure 3.
- **larger OGWD** values lead to **weaker propagation of planetary waves upwards**, but stronger propagation towards higher latitudes in the lower stratosphere. This leads to changes in the zonal winds, Figure 4.
- **significant correlations with frequencies of negative NAM index as well as polar vortex moments,** where larger OGWD values are connected to lower frequencies of weaker, misshaped or displaced polar vortex, Figure 5.

**Climatological values of OGWD in CMIP6 influence the stability of polar vortex via the influence on planetary wave propagation and dissipation.**

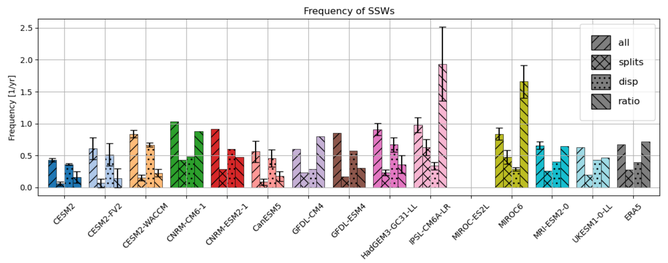


**Figure 2:** *Frequencies of SSWs and their types in CMIP6 model, 1979-1984*

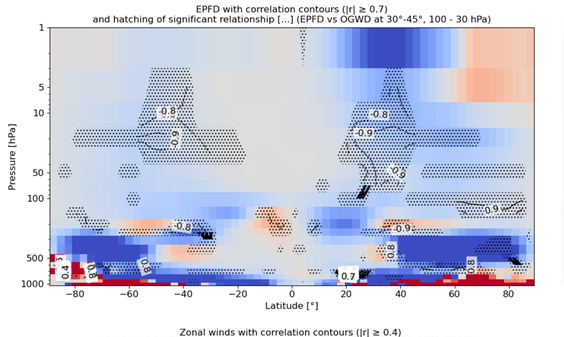


**Figure 3:** *Mean of EPFD taken over 9 CMIP6 model (colours) and corelation with OGWD taken at 100 hPa-30 hPa and 30°-45° (contours) with hatching over statistically significant regions.*

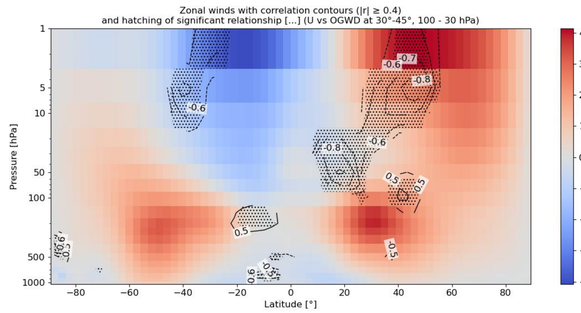


**Figure 4:** *Mean of zonal wind taken over 14 CMIP6 model (colours) and corelation with OGWD taken at 100 hPa-30 hPa and 30°-45° (contours) with hatching over statistically significant regions.*

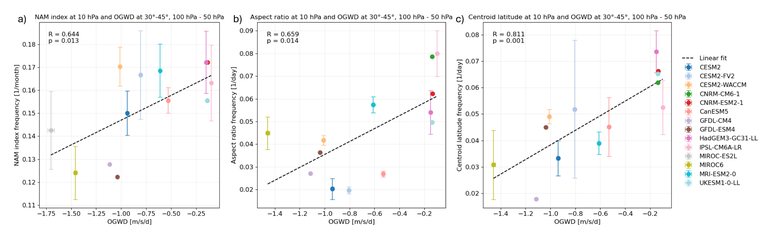


**Figure 5:** *OGWD taken at 100 hPa-30 hPa and 30°-45°)and a) frequency of NAM index < -1, b) frequency of aspect ratio > 2.4 and c) frequency of centroid latitude < 66°, all at 10 hPa.*

## KEY RESULTS

- OGWD differs significantly between CMIP6 models
- There is significant climatological relationship between OGWD and propagation and dissipation of resolved planetary waves
- More OGWD in the model leads to less events with unstable polar vortex

### Acknowledgement

This work is funded by JUNIOR STAR GAČR grant 23-04921M

### Bibliography

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