The Role of Interactive Chemistry in Modelling Sudden Stratospheric Warming Events

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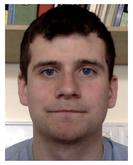

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Motivation

- SSW events are rapid disruptions of the NH winter stratospheric polar vortex caused by planetary wave breaking
- They can influence US and European winter climate
- Representing SSWs in GCMs is key to improving predictability
- Atmospheric Chemistry is an expensive challenge for climate models.
- Either chemistry is prescribed or a chemistry climate model is coupled to the dynamical core (expensive).

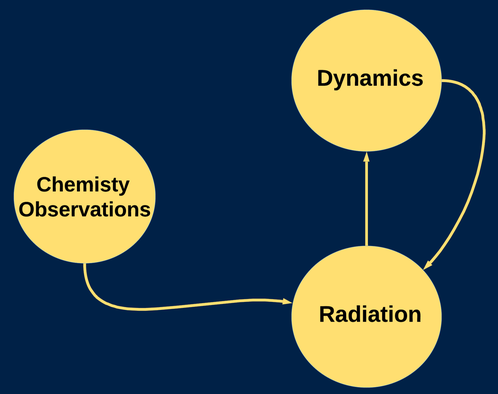
Science Question

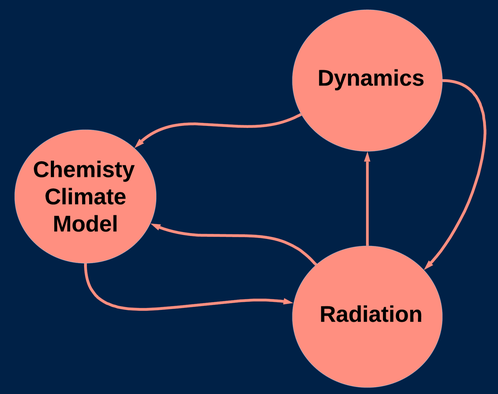
Are coupled (interactive) chemistry schemes necessary to represent SSWs well in GCMs?

Experiment

Compare representation of SSWs in 500 year PI control runs of the MetOffice's latest GCMs.

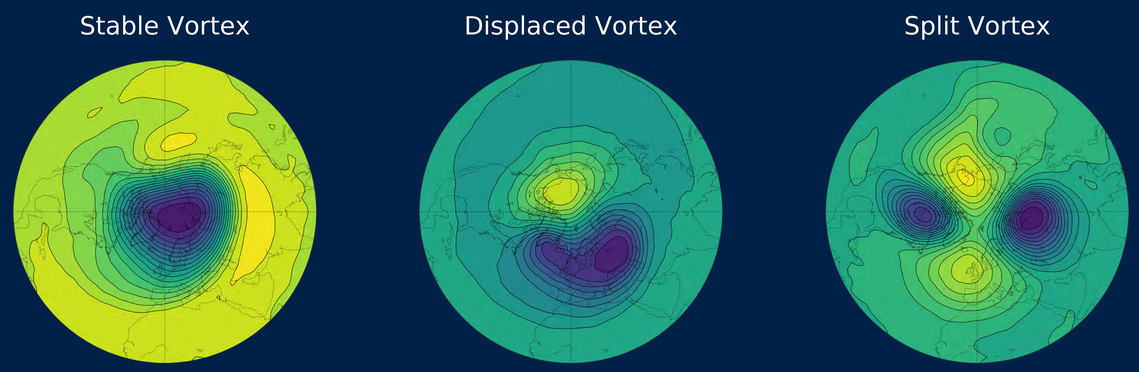
- HadgemGC3.1 (GC3) prescribes chemical fields at two horizontal resolutions (N96 and N216).
- UKESM represents chemistry interactively (only N96 resolution) coupling the same dynamical core as GC3 to the UK Chemistry and Aerosols Model (UKCA).





Climate models which **prescribe chemistry** constrain **Sudden Stratospheric Warming** events just as well as those with **interactive chemistry schemes.**

But both types of model under-represent elements of SSW driven Stratosphere-Troposphere coupling.



Supervised by Prof Lesley Gray and Dr Scott Osprey

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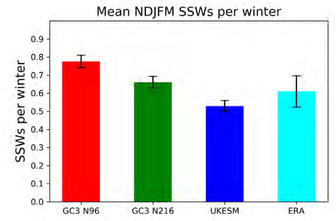
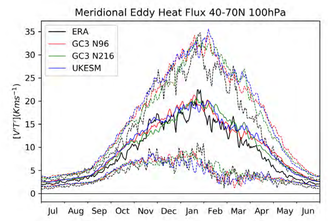
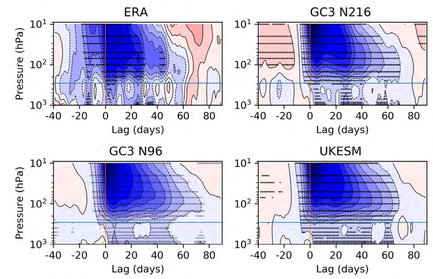
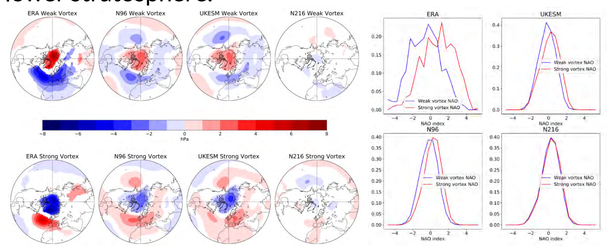




The inclusion of interactive chemistry in UKESM acts to suppress SSW occurrence compared to GC3. Physical mechanisms behind this suppression are yet to be explained. Vertically propagating planetary wave activity remains similar in both models (figure 2). However, both GC3 and UKESM give reasonable estimates of event abundance compared reanalysis (ECMWF interim reanalysis, denoted ERA).



The downward propagation of anomalies caused by SSWs (as measured above left by composites of the northern annular mode of geopotential height around events) is similar in each dataset. Each model slightly overestimates the persistence of anomalies in the lower stratosphere.



The mean response of NH sea level pressure (above left) and the North Atlantic Oscillation index (above right) to SSW events at a lag of 0-30 days is underrepresented in each model compared to reanalysis. The SLP response to events is spatially diffuse over the northern hemisphere as opposed to concentrated of the north Atlantic in reanalysis and the shift of the NAO index distribution between strong and weak (SSW) vortex events is underestimated by GC3 and UKESM.

Conclusion and future work

Coupled Chemsitry does not appear significantly to improve model representations of SSWs. Further work is required to identify and rectify biases in sea level pressure response to SSWs in both models as chemical scheme appears to have minimal influence.