Eddy-driven jet sensitivity to diabatic heating in an idealized GCM

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NERC SCIENCE OF THE ENVIRONMENT

GFDL Flexible Modelling System

We perform idealized sensitivity experiments using the dry dynamical core of the GFDL FMS at T42 with 37 sigma levels.

The model is configured to create a basic state with hemispheres mimicking the North Atlantic ocean storm track in winter and summer.

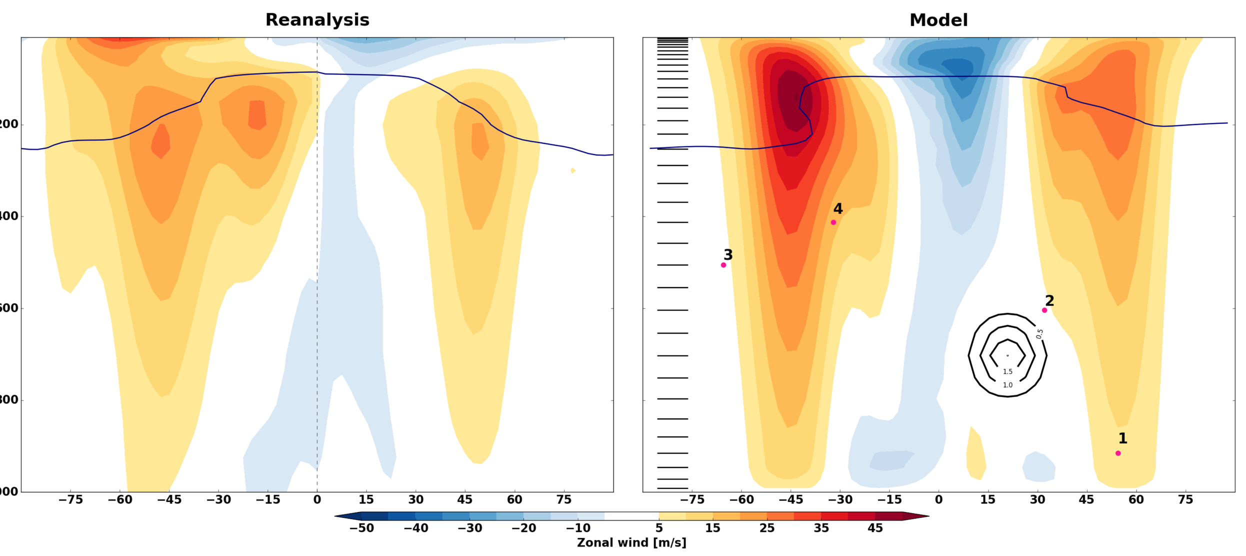

Fig. 1 Comparison of zonal wind. The dashed grey line shows where the winter and summer NCEP reanalysis data (1979-2015) over the North Atlantic (0-60W) have been stitched together, left (winter), right (summer). Shown in black are the model levels. A sample heating is plotted in the black contours. Pink dots indicate the locations of the case studies.

We apply localized Gaussian heatings with amplitude q0=2K/day in the latitude-sigma plane and measure the jet response with respect to a control simulation.

The eddy-driven jet is defined at sigma=0.85, taking the jet speed and latitude from the speed and position of the maximum zonal mean zonal wind in each hemisphere.

Mechanisms

Proposed mechanisms for the sensitivities arise from changes in the slopes of isentropic surfaces and hence in the location and strength of strongest horizontal low level temperature gradients.

Shifts are driven by changes in the position of maximum low level meridional gradients, which determine where the maximum meridional heat flux occurs.

Changes in strength arise from changes in the mean low level meridional temperature gradient across the storm track, which dictate the amount of meridional heat flux.

Sensitivity to localized diabatic heatings

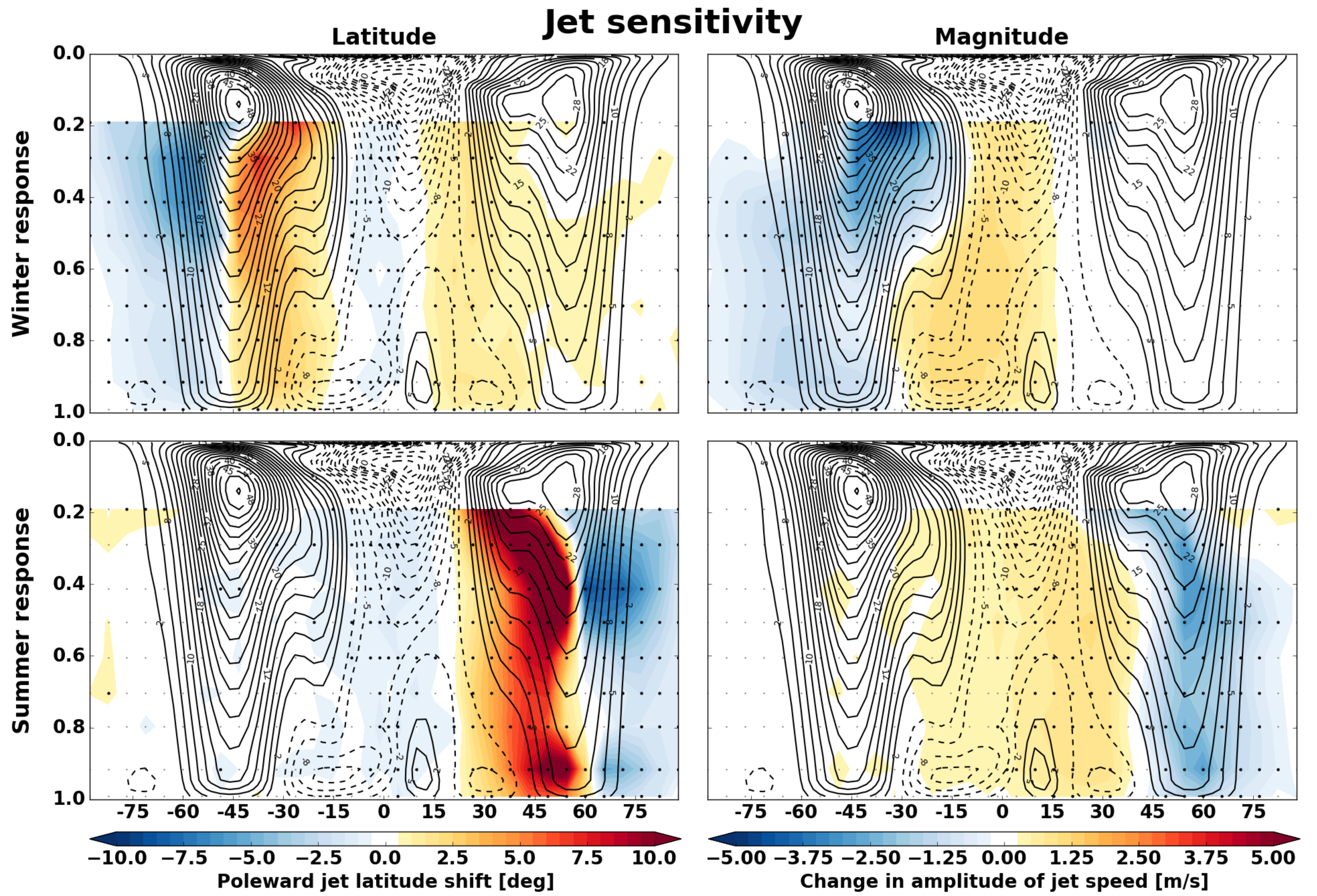

Fig. 2 Sensitivity of the jet indices to heating experiments (colours) in the latitude-sigma plane. Contours indicate the control zonal wind. The black dots mark where the difference between the control and perturbed simulations is statistically significantly different from the control, while the grey dots show where the difference is not statistically significant. Positive values correspond to poleward shift or strengthening of the jet in the target hemisphere (top: winter; bottom: summer).

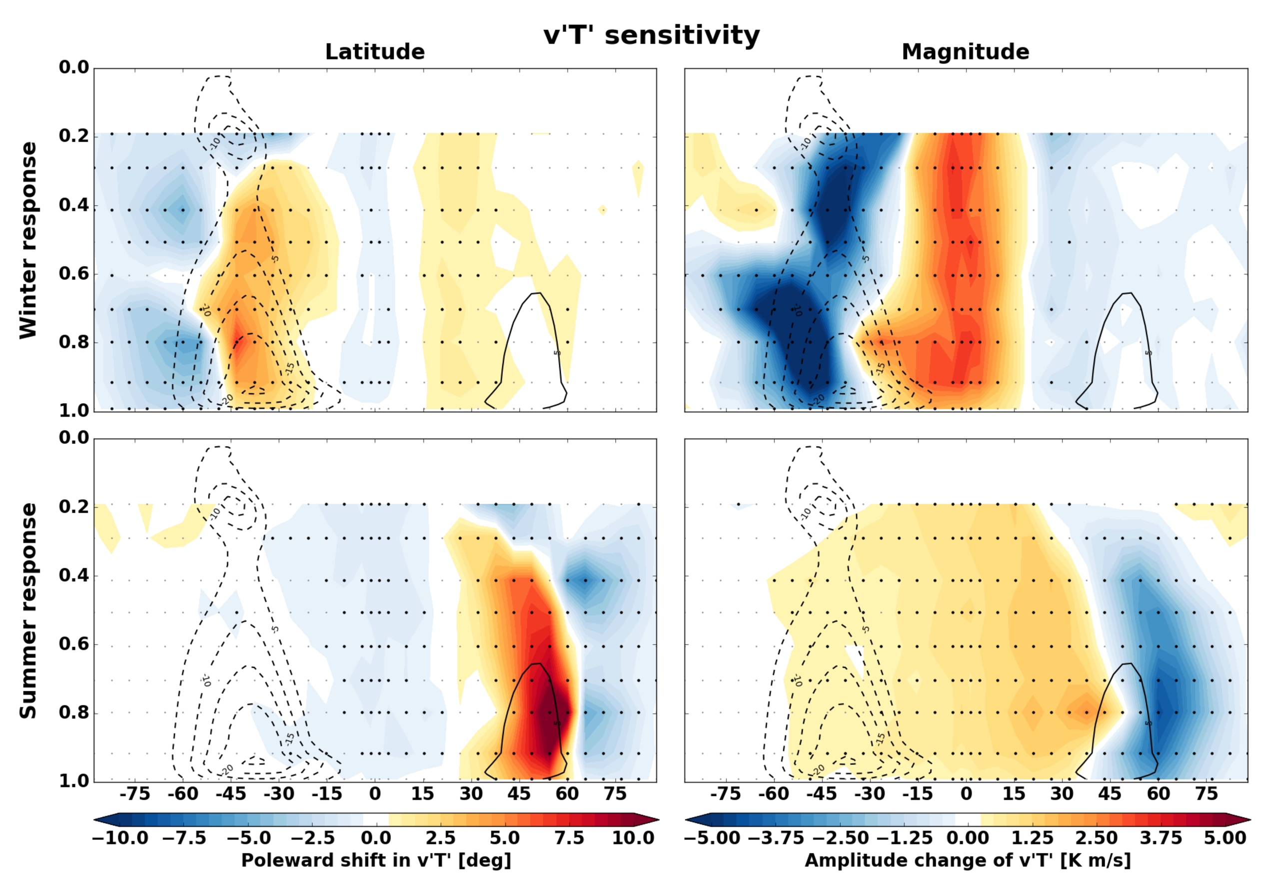

Fig. 3 Sensitivity of the v'T' (control in contours). Positive values correspond to poleward shift or increasing of the amplitude of v'T' in the target hemisphere.

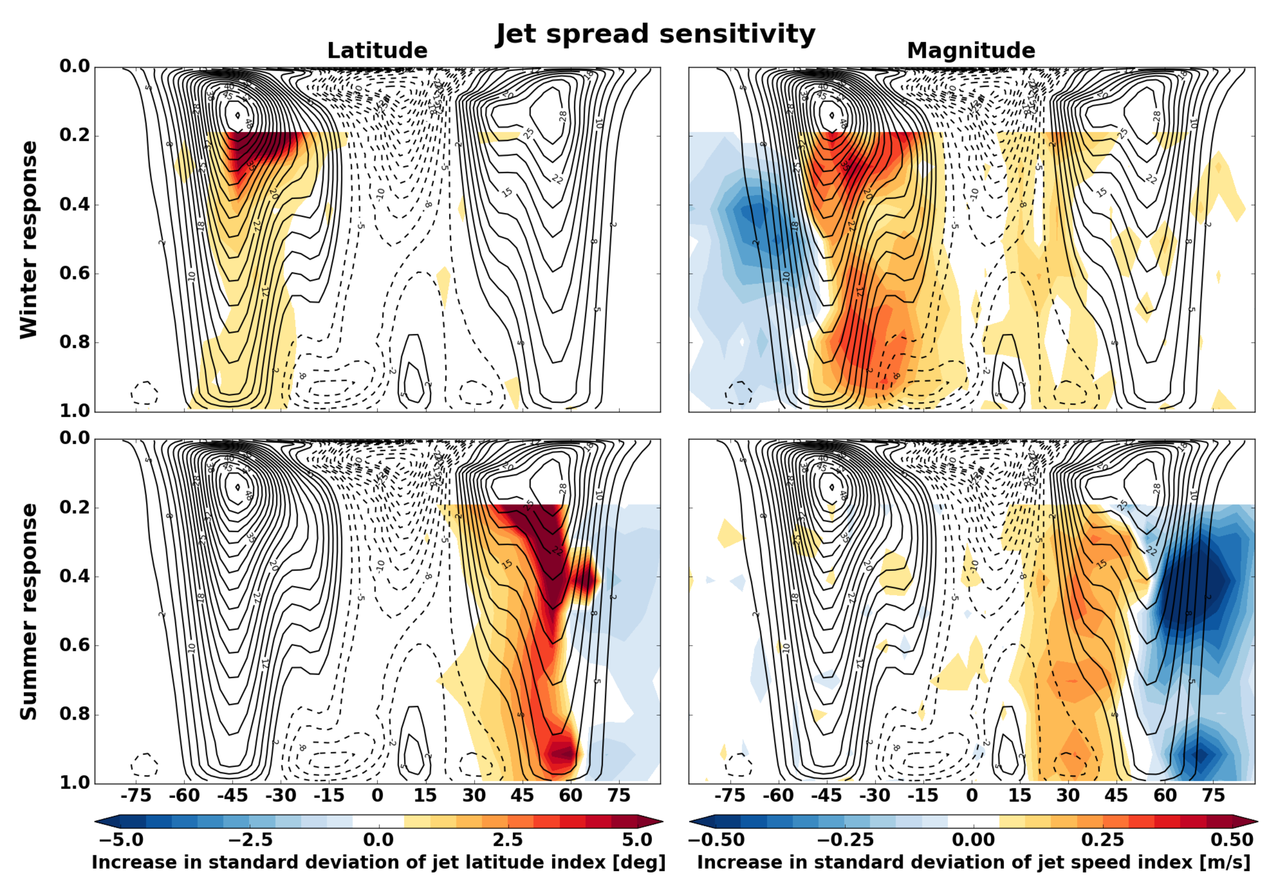

Fig. 4 Sensitivity of the jet spread (defined as the difference in s.d. of daily jet indices between forced and control runs). Positive values correspond to an increase in spread of jet position or strength in the target hemisphere.

Key points

- **Jet speed and jet latitude display different sensitivities to thermal forcing; both display seasonal variation too.**
- **Storm track sensitivities closely match those of the jet.**
- **Changes in spread are consistent with changes in baroclinic zone width and low level meridional temperature gradients.**
- **Responses scale approximately linearly with the strength and combination of forcings applied.**

Linearity

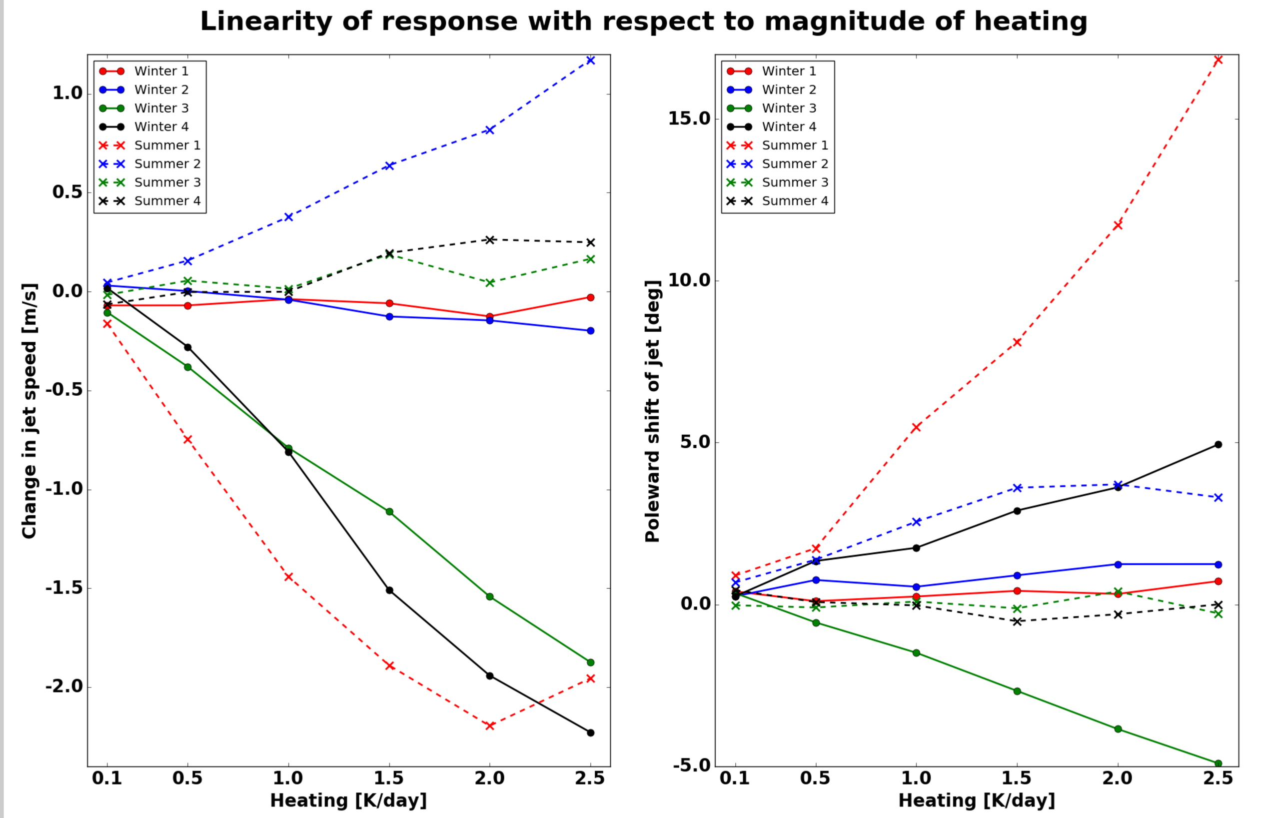

Fig. 5 Change in jet speed (left) and jet latitude (right) for each of the four case studies in winter and summer as q0 varies.

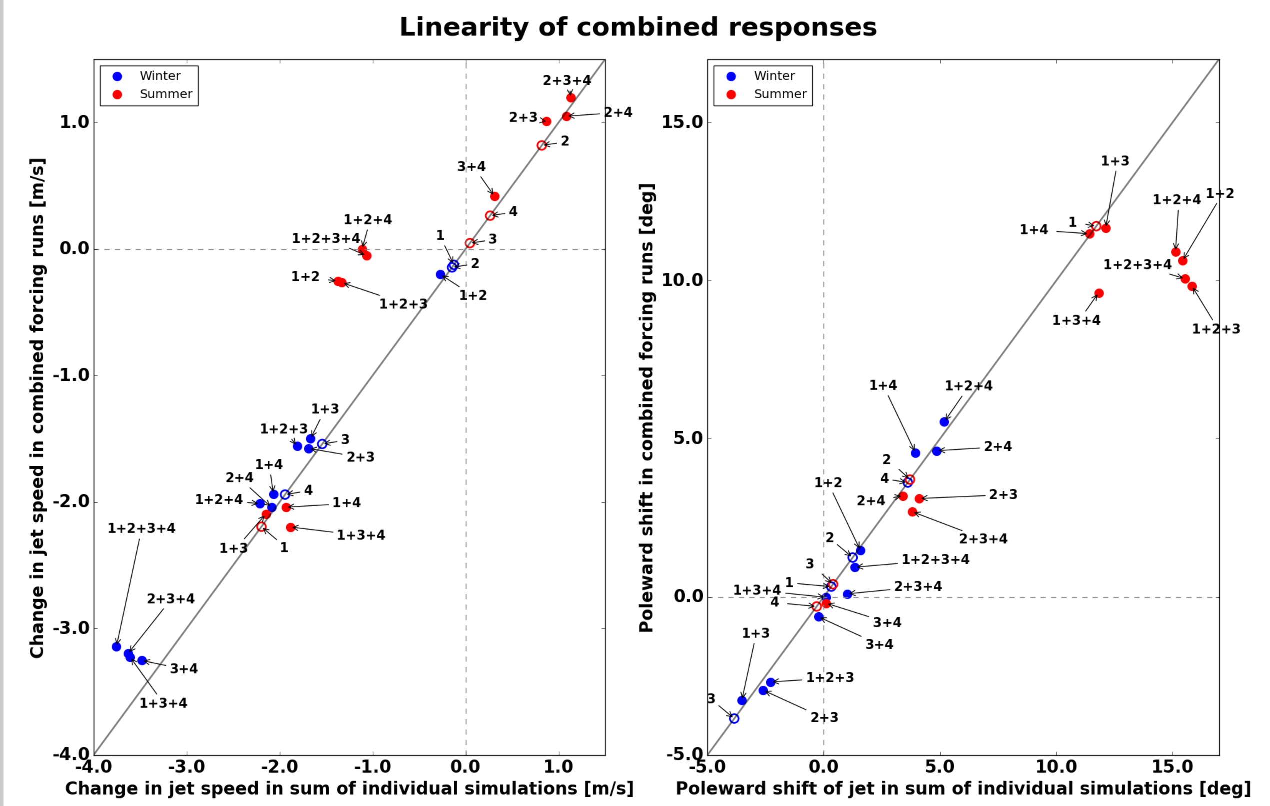

Fig. 6 Scatter graph showing the change in jet speed (left) and jet latitude (right) in simulations where the forcings used in the case studies are combined against linear combinations of the results from each individual case study. Open circles represent the changes in the sole forcing cases. The labels indicate which case study forcings have been combined at that particular point. In all simulations, q0=2.0K/day.