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Comparing cyclone core pressure and vorticity changes in a transient Greenhouse Gas Scenario

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Winter cyclone activity over the Northern Hemisphere is investigated in an ECHAM4/OPYC3 transient GHG simulation. The goal of this investigation is to identify changes in cyclone intensity. Two 50-year time periods are analysed, one representing present day climate conditions and the other a perturbed climate when CO2 concentrations exceed twice the present day concentrations.

Cyclone activity is assessed using an automatic algorithm, which identifies and tracks cyclones based on sea level pressure fields. The algorithm detects both large and long living cyclones over the main ocean basins and their smaller counterparts in secondary storm track regions like the Mediterranean Basin. Cyclone intensity is quantified in terms of the laplacian of sea level pressure (proportional to vorticity), determined within a certain radius of the cyclone core, and alternatively in terms of core pressure. For the present climate, model results show a good agreement with NCEP-reanalysis, provided that the spectral and time resolutions of the reanalysis are reduced to those available for the model.

Several prominent changes in cyclone activity are observed for the scenario period in comparison to the present day climate, especially over the main ocean basins. When all cyclones are included in the analysis (irrespective of their intensity), a significant decrease of cyclone track density is found between 35 and 55 degrees North, together with a small increase polewards. These changes result from two different signals when distinguishing cyclones from vorticity: an increased number of intense cyclones (laplacian > 1.5 hPa/(deg.lat)^2) is found at higher latitudes, particularly over the North Atlantic (+8.5% for the northern North Atlantic), while for weaker systems

(laplacian < 1.5 hPa/(deg.lat)^2) a general decrease is found, especially at lower latitudes (e.g. -24% for the central North Atlantic and -43,5% for the Mediterranean region). The simulated changes for the intense cyclones are consistent with increases in upstream upper-tropospheric baroclinicity (more favourable conditions at higher latitudes, and less favourable conditions southwards).

The same kind of changes (a northward shift for deeper cyclones and an overall decrease for the shallower ones) are detected when considering cyclone core pressures. The signals in core pressure are, however, larger than those obtained using vorticity as the decreasing/increasing mean sea level pressure in higher/lower latitudes contribute to the changes in cyclone characteristics.