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Spectral analysis of the Southern Hemisphere atmospheric variability to assess the role of baroclinic instability in seasonal forecasts

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Baroclinic instability in the mid-latitudes is a significant component of the climate system, as it is associated with the meridional transport of a large amount of energy and momentum. Hence, the ability of climate models to correctly predict the properties of atmospheric circulation in that latitudinal band is a very important requirement. This study aims to estimate the power content of the atmospheric phenomena typical of mid-latitudes, such as baroclinic perturbations, and to understand how seasonal forecasts can be practically used to assess energy transfer in the atmosphere. We compare the Southern Hemisphere mid-latitude winter variability of the long-range forecasting system SEAS5 with the ERA5 reanalysis. Both datasets are produced by the European Centre for Medium-Range Weather Forecasts (ECMWF). The analysis is carried out by computing the Hayashi spectra of the 500-hPa geopotential height field. Both the reanalysis and the seasonal forecast show a series of peaks in the spectral region of eastward-traveling waves, which corresponds to the high frequency-high wavenumber domain. We quantify the amount of energy released from the atmosphere by calculating the Baroclinic Amplitude Index. Results suggest that the seasonal forecasts correctly reflect the variability of the geopotential height power spectra in the Southern Hemisphere, with some minor discrepancies related to the sub-daily variability, which is not correctly discriminated. However, the energy associated with the baroclinic activity is well represented by the seasonal forecast in the Southern Hemisphere, where the orographic effect is negligible compared to the Northern Hemisphere. This work is carried out as part of the European FOCUS-Africa project, which develops innovative and sustainable climate services in the Southern African Development Community (SADC) region.