EGU22-12010
https://doi.org/10.5194/egusphere-egu22-12010
EGU General Assembly 2022

Predictability of inter-annual variability in the Southern Hemisphere subtropics

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Seasonal prediction is generally skillful over the subtropical landmasses of the Southern Hemisphere during summer seasons with strong ENSO (El Niño Southern Oscillation) forcing. Skill is substantially reduced, however, during summer seasons that are ENSO neutral. Over southern Africa, forecast skill is also comparatively less for the spring and autumn seasons, and only marginally exists for winter. This seasonal cycle in predictive skill and the strong dependence of skill on ENSO forcing raise questions about the limits of predictability in the Southern Hemisphere subtropics. Here we explore these potential limits using Atmospheric Model Intercomparison Project (AMIP) simulations. These simulations are part of the larger Coupled Model Intercomparison Project Phase Six (CMIP6), and are constructed using global atmospheric models forced at their lower boundaries with historical sea-surface temperature and sea-ice reconstructions. Radiative forcing is in the form of historical greenhouse gas and ozone concentrations, as well as aerosol emissions, for the period 1979-2014 (the same historical forcings are used in ScenarioMIP of CMIP6). AMIP simulations may be regarded as providing an upper boundary of seasonal predictive skill, at least to the extent that atmospheric inter-annual variability is a response to inter-annual variations in lower-boundary and radiative forcing. AMIP simulations are initialized only once however, and don't make use of updated initial conditions as in the case of operational seasonal forecasts. Also, although the lower boundary forcing in AMIP simulations may be regarded as 'perfect', important coupled processes that influence inter-annual variability may not be represented. Our focus here is on analyzing the skill of AMIP simulations in representing inter-annual atmospheric variability over the subtropical landmasses of the Southern Hemisphere, focusing on rainfall and low-level circulation. NOAA-CIRES-DOE reanalysis v3 and Climatic Research Unit (CRU) data are used for verification. The first stage of analysis consist of constructing a multi-model ensemble of AMIP simulations, with each model contributing a single ensemble member. Such an ensemble isolates to some extent the predictability that may be derived purely from boundary forcing. In the second stage of the analysis, we evaluate skill for those AMIP models for which initial-condition based ensembles have been derived, thereby incorporating the effects of model internal-variability on predictive skill. The resulting evaluations of skill confirm the results from operational seasonal forecasting, namely that a pronounced seasonal cycle in predictive skill exists over the Southern Hemisphere continents in the subtropics, with peak skill in summer in association with ENSO forcing. However, in spring and autumn and particularly in winter, circulation patterns of lower predictability originating from the Southern Ocean impact on atmospheric variability over the subtropical landmasses. Since these circulation

patterns seem to be relatively unconstrained by lower boundary and atmospheric radiative forcing, it implies that predictability in the subtropics may be constrained in winter and the transition seasons by the relatively less predictable higher-latitude circulation regimes of the Southern Hemisphere.