Assessment and Projected Changes of ENSO-related Interannual Variability of Southern Hemisphere Atmospheric Circulation in CMIP5 Models

Simon Grainger[1], Carsten S. Frederiksen[1], Xiaogu Zheng[2] and Janice M. Sisson[1]

[1]*Centre for Australian Weather and Climate Research, Bureau of Meteorology, PO Box 1289, Melbourne, VIC 3001, Australia.*

[2]*College of Global Change and Earth System Science, Beijing Normal University, Beijing, PR China.*

ENSO variability is an important driver of the Southern Hemisphere (SH) atmospheric circulation. Understanding the observed and projected changes in ENSO variability is therefore important to understanding changes in Australian surface climate. Using a recently developed methodology (Zheng et al., 2009), the coherent patterns, or modes, of ENSO-related variability in the SH atmospheric circulation can be separated from modes that are related to intraseasonal variability or to changes in radiative forcings. Under this methodology, the seasonal mean SH 500 hPa geopotential height is considered to consist of three components. These are: (1) an intraseasonal component related to internal dynamics on intraseasonal time scales; (2) a slow-internal component related to internal dynamics on slowly varying (interannual or longer) time scales, including ENSO; and (3) a slow-external component related to external (i.e. radiative) forcings. Empirical Orthogonal Functions (EOFs) are used to represent the modes of variability of the interannual covariance of the three components.

An assessment is first made of the modes in models from the Coupled Model Intercomparison Project Phase 5 (CMIP5) dataset for the SH summer and winter seasons in the 20th century. In reanalysis data, two EOFs of the slow component (which includes the slow-internal and slow-external components) have been found to be related to ENSO variability (Frederiksen and Zheng, 2007). In SH summer, the CMIP5 models reproduce the leading ENSO mode very well when the structures of the EOF and the associated SST, and associated variance are considered. There is substantial improvement in this mode when compared with the CMIP3 models shown in Grainger et al. (2012). However, the second ENSO mode in SH summer has a poorly reproduced EOF structure in the CMIP5 models, and the associated variance is generally underestimated. In SH winter, the performance of the CMIP5 models in reproducing the structure and variance is similar for both ENSO modes, with the associated variance being generally underestimated.

Projected changes in the modes in the 21st century are then investigated using ensembles of CMIP5 models that reproduce well the 20th century slow modes. The slow-internal and slow-external components are examined separately, allowing the projected changes in the response to ENSO variability to be separated from the response to changes in greenhouse gas concentrations. By using several ensembles, the model-dependency of the projected changes in the ENSO-related slow-internal modes is examined.

Frederiksen, C. S., and X. Zheng, 2007: Variability of seasonal-mean fields arising from intraseasonal variability. Part 3: Application to SH winter and summer circulations. *Climate Dyn.*, **28,** 849-866.

Grainger, S., C. S. Frederiksen, and X. Zheng, 2012: Modes of interannual variability of Southern Hemisphere atmospheric circulation in CMIP3 models: Assessment and Projections. Submitted to *Climate Dyn.*.

Zheng, X., D. M. Straus, C. S. Frederiksen, and S. Grainger, 2009: Potentially predictable patterns of extratropical tropospheric circulation in an ensemble of climate simulations with the COLA AGCM. *Quart. J. Roy. Meteor. Soc.*, **135,** 1816-1829.