Pathways to extratropical skill

Climate Analysis Forecast Ensemble system

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Introduction

The extratropical continents are subject to considerable climate variability and impacts. That variability is a consequence of internal modes of variability and external forcing. Deriving forecast skill (on seasonal to multiyear timescales) for the internal modes relies on capturing the longlived sources of skill in the tropics, teleconnecting that signal through tropical–extratropical pathways, and modulating extratropical internal modes. Some results along this skill pathway are highlighted here for the CAFE system, which uses the coupled GFDL MOM5 AM2 configuration.

Tropical source & expression

The main source of memory in the climate system on seasonal to multiyear scales is the tropical ocean. That region is captured here by the maximum zone of inband temperature variance in the CAFE ocean in figure 1a. CAFE forecasts are bred in this region. The dominant expression of seasonal to multiyear variability is through ENSO, which is reflected in figure 1b for the CAFE forecasts.

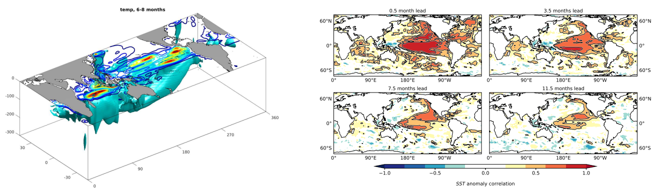

Figure 1: a) Inband T variance and b) ACC skill

The RPSS skill signal for tropical temperatures is a function of ENSO state (figure 2), showing skill in El Niño and La Niña, but not neutral states.

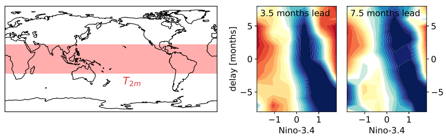

Figure 2: RPSS for tropical T_{2m}.

Teleconnections

A range of teleconnection processes may carry the tropical signal to the extratropical jets and storm tracks. While stationary Rossby waves provide a pathway in some cases, we find stronger relationships for a thermal wind pathway in the Southern Hemisphere (O'Kane et al. 2017). The skill score for thermal wind in CAFE (figure 3) is also a function of ENSO state, and reflects the role of thermal wind as 'carrier' of the tropical ENSO signal.

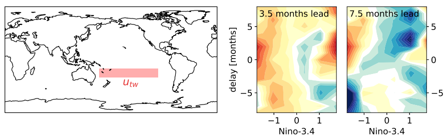

Figure 3: RPSS for thermal wind V_T at 500hPa

Extratropical modes

The ENSO signal modulates the jets via the thermal wind. The jets provide a primary source of extratropical variability manifest through jetstream waveguide modes such as the PSA. The model needs a realistic simulation of waveguide modes to provide an extratropical translation of the ENSO signal. The CAFE control run provides realistic waveguide modes such as the PSA (figure 4) (Tozer et al. 2018), which is a necessary condition for extratropical skill.

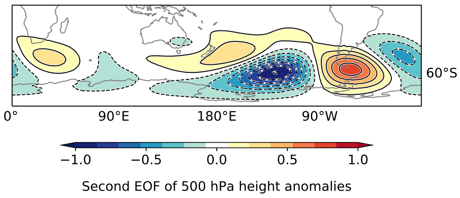

Figure 4: CAFE coupled control run PSA mode

Extratropical skill

The teleconnected signal is transmitted to the extratropical storm track modes, which in turn influence variability of rainfall and temperature in the extratropical regions (Risbey et al. 2018). The skill for a selected region of the extratropics is shown in figure 5. The RPSS skill score is relatively low, but still reflects some skill in either ENSO extreme. ENSO skill tends to be masked by the absence of skill in the neutral state when averaging over all ENSO states.

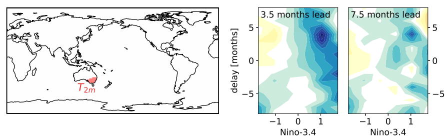

Figure 5: RPSS for T_{2m} over southeast Australia

Conclusions

The Southern Hemisphere extratropical continental regions seem reliant on the tropical oceans for a source of skill on seasonal to multiyear scales (excepting responses to external forcing). The signal that emerges in the tropics is a source of extratropical skill largely only when ENSO is in either of its extreme states (El Niño or La Niña). There seems little extratropical skill when ENSO is neutral. Extratropical skill is currently weak. To the extent that such skill is related to ENSO, it can potentially be improved when ENSO skill improves, but there are clear limits, as much of the extratropical variability is non-ENSO related. The role of poor simulation of teleconnection processes in weak extratropical skill is still unclear and will be the topic of future work.

Ranked probability skill score

$RPS = \frac{1}{M-1}\sum_{m=1}^{M}[(\sum_{k=1}^{m} f_k) - (\sum_{k=1}^{m} o_k)]^2$ — M forecast categories

$RPSS = 1 - RPS_f/RPS_{clim}$ — relative improvement over climatology

FOR FURTHER INFORMATION
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