Towards Development of Multyear Climate Prediction Framework for Australia

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Motivation

Australia experiences droughts & pluvials at multiyear timescales that have pronounced impacts on climate-sensitive sectors including agriculture.

NACP aims to improve understanding of multiyear variations and to assess of the feasibility and potential predictability for multiyear climate forecasts – with a focus on Northern Australia

Multiyear Climate Prediction Framework for Australia
Motivation

• ENSO has significant impacts on regional Australia via atmospheric teleconnections - ENSO events lasting for 2 or more years can cause more severe socio-economic distress.

• There is a growing demand for long-range ENSO prediction and multiyear climate information in Australia.

• Skilful prediction of ENSO and its related climate impacts beyond a year is crucial for effective risk management in Australia.

• Previous studies indicate predictive skill of ENSO well beyond the typical 6-9 months lead time used by operational centres.
  e.g. ENSO/climate outlooks from BoM limited to 6-month lead time only.

• Efforts on quantifying ENSO prediction skill beyond a year remain limited, partly due to inadequate long records of seasonal reforecasts.

Skilful long-range prediction of ENSO and related impacts beyond a year will be valuable.
What drives multiyear wet/dry conditions over northern Australia?

- Regional asymmetry in multiyear rainfall variation.

Sharmila S. | USCLIVAR Multiyear Workshop | March 2022

Sharmila and Hendon 2020
What drives multiyear wet/dry conditions over northern Australia?

Regional asymmetry in multiyear rainfall variation.

Multiyear NW rainfall modulated by local rainfall-wind evaporation feedback & rainfall-soil moisture feedback.
What drives multiyear wet/dry conditions over northern Australia?

• **Regional asymmetry** in multiyear rainfall variation.

• Role of **local vs remote** drivers on observed multiyear rainfall variability over northern Australia.

**Multiyear NW rainfall modulated by local rainfall-wind evaporation feedback & rainfall-soil moisture feedback.**

**Multiyear NE rainfall modulated by remote low-frequency ENSO induced tropical Pacific SST.**

Sharmila and Hendon 2020
Assessment of ENSO predictability beyond a year from experimental multiyear hindcasts

Complete set of multiyear hindcasts (1981-) using ACCESS-S2 in currently underway

Assessment of ENSO predictability beyond a year from experimental multiyear hindcasts

Based on 25 start dates only

Limited ensemble

Short hindcast period

Running multiyear hindcasts - computationally very expensive!

Weisheimer et al. 2022

Initial Conditions: CERA-20C

• To address various aspects of ENSO predictability.

• To assess prospects for 2-year climate prediction.

Multiyear Climate Prediction for Northern Australia

Skillful long-lead ENSO prediction will provide a new foundation for predicting multiyear climate over Australia!
ECMWF model (SEAS5-20C)

1901-2010, 10-member, 24-month hindcasts

a state-of-the-art coupled model and data assimilation system

• ECMWF's Integrated Forecasting System (IFS) coupled model – similar to SEAS5
• SEAS5 low-resolution configuration
• Initial conditions: ECMWF Reanalyses of the 20th Century (CERA-20C)
• Coupled data assimilation
• Start date: 1 November and 1 May
• 24-month hindcasts with 10 ensemble members
• Hindcast period: 1901-2010, 110 years

Data for verification: ERSST.v5 (SST), AWAP (rainfall) etc.

This assessment aims to provide crucial insights on some fundamental questions related to ENSO predictability & prospects for 2-year climate prediction!
Long-lead ENSO prediction skill

ENSO Predictability beyond a year

How far ahead can we predict ENSO?

- ENSO can be skillfully predicted up to 18 months in advance (1 Nov start).
- Skill largely depends on the hindcast period – best forecasts achieved in the recent period.

- ENSO may be predictable 1 year in advance when initialized on 1st May.
- Strong decadal variation in ENSO prediction skill is also noted (Weisheimer et al. 2022).
Which ENSO phase is more predictable?

- El Nino to La Nina transition is more predictable.
- Development of La Nina in year 2 is more predictable.
Prediction of multiyear ENSO events

- Model forecasts can predict if a current El Niño will terminate in the following year or continue – but underestimate the magnitude.
Prediction of multiyear ENSO events

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Recommends to extend ENSO outlooks at least 2 years into the future – currently BoM provides up to 6 months only.

Model can predict distinct evolution of SST and surface wind for 2-yr El Nino events though underestimates the magnitude.

Based on Composite analysis
2-year prediction of wet-season global SST anomalies is skilful over most of the oceans especially in the equatorial Pacific region.

Sharmila et al. (part 3, in prep)
2-year climate prediction: Global SST (NDJFMA)

- 2-year prediction of wet-season global SST anomalies is skilful over most of the oceans especially in the equatorial Pacific region.

- The warming trends in the tropical Indian Ocean and north Atlantic also contributed to the overall skill, signifying the role of forecasted trends on multiyear climate prediction.
• Skilful prediction of wet-season rainfall for year 1 & year 1–2 avg, especially in the eastern Australia.

• Many challenges remain, e.g., limited skill in predicting year 2 rainfall.

• More investigation required on model biases and process-oriented understanding of climate predictability to achieve greater confidence in future real-time operational forecasts.
• **Improved basic science of multiyear droughts**: Improved industry and community knowledge on the drivers of multiyear climate variability and droughts over northern Australia.

• **Advanced knowledge on ENSO predictability**: Skilful long-lead ENSO prediction in ECMWF SEAS5-20C & predictability of multiyear ENSO events signify the prospects for extending seasonal operational forecasts beyond a year.
  - Key driver of BoM's future strategy for extending operational ENSO outlooks up to 2 years into the future.
  - 2-year experimental hindcasts from ACCESS-S2 are currently underway for further assessment.

• **Development of a multiyear climate prediction framework for Australia**: Skilful 2-year prediction of global and regional climate - will be highly useful for managing droughts, climate risk and decision making across Australia.

  Skilful prediction of ENSO beyond a year provides a new foundation for forecasting prolonged droughts & widespread flooding at multiyear timescales.

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**Summary**


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Data & Method

• We explored observational and reanalysis datasets (1901-2017) to identify key drivers of multiyear rainfall variation across northern Australia. More details on various methods used are available in Sharmila and Hendon (2020).

• To explore multiyear ENSO predictability and to develop a more general framework for multiyear climate prediction, we assessed large ensembles of multiyear coupled model experimental hindcasts from DePreSys3 (UKMO; 1960-2014, limited Nov start dates) and ACCESS-S2 (BoM; 1981-2014, May start) with forecast lead time over 60 months and 110 years of hindcasts from SEAS5-20C (ECMWF, 1901-2010, Weisheimer et al. 2021, Nov & May start) with forecast lead time of 24 months.

• We used standard metrics and statistical methods to evaluate the model biases, and prediction skill.

• We removed the model drift by subtracting the model's climatology from each ensemble forecast at each lead time before assessing the prediction skill.

• More details on the model, hindcasts and verification methods are available in the submitted papers (e.g., Sharmila et al. 2022a; Weisheimer et al. 2022).