The Centre for Australian Weather and Climate Research
A partnership between CSIRO and the Bureau of Meteorology

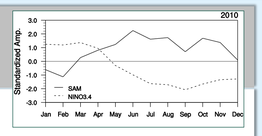
Understanding and predicting the extreme wet conditions over Australia in 2010 spring

Eun-Pa Lim, Harry H. Hendon, Guo Liu and Griffith Young

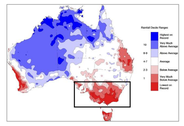
The Centre for Australian Weather and Climate Research – A partnership between the Bureau of Meteorology and CSIRO, Melbourne, Australia

e.lim@bom.gov.au

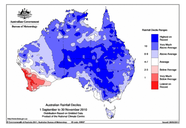
Why 2010 spring?



- A rapid development of strong La Nina from El Nino in 2009/2010
- Extreme wet conditions over most of the Australian continent



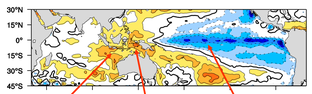
Map of the annual mean rainfall deciles for the 1997–2009 drought (Bertrand and Drosdowsky 2012 IJC)



2010 spring rainfall deciles

Extraordinary climate conditions in spring 2010 (Hendon et al. 2013 Clim. Dyn.)

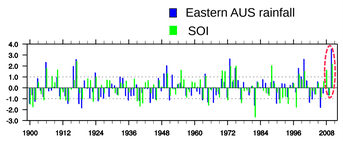
SST anomaly in 2010 austral spring – "perfect SSTs" for AUS flood



Negative IOD

Anomalously warm SSTs due to La Nina & trend

Strong La Nina whose cold SST extended to far west

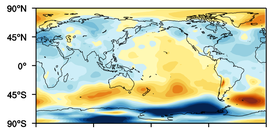


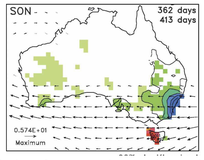
Strong La Nina was a major cause of the wet condition in the east in 2010 spring

→ A large portion of the rainfall anomaly was more or less predictable

Extraordinary strength of +ve phase of SAM in 2010 spring (Hendon et al. 2013 Clim. Dyn.)

MSLP anomaly in 2010 spring





(taken from Hendon et al. 2007)

~10-40% rainfall anomalies of 2010 spring in the eastern AUS regions explained by the strong positive SAM

SAM induced seasonal rainfall is unpredictable because the SAM is considered to be unpredictable in a seasonal time scale

Wet 2010 spring due to La Nina was predictable, but its extremity due to SAM was unlikely to be predictable, *provided that* the SAM of 2010 spring was unpredictable

However!

Seasonal SAM has some predictability stemming from its relationship with ENSO in austral spring to summer seasons (e.g. Zhou and Yu 2004, Lim et al. 2013)

→ **Was the record strength of +ve SAM in 2010 spring driven by the strong La Nina?**

→ **Did the positive SAM bring additional rainfall to eastern Australia beyond what was driven by the strong La Nina?**

To answer these research questions, we did

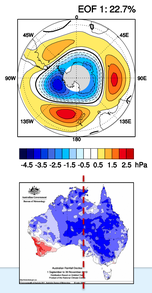
- **Examine POAMA forecasts for this extraordinary climate condition of 2010 spring**
- **Conduct two sensitivity experiments to forecast initial conditions**

POAMA2 (p24; Cottrill et al. 2013 Wea. Forecasting)

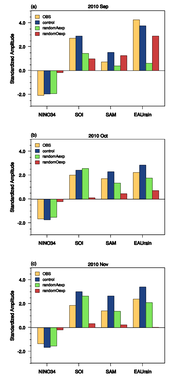
- **Initial conditions**
  - Realistic atmosphere & land initial conditions generated from a nudging scheme ALI
  - Realistic ocean initial conditions generated from the POAMA Ensemble Ocean Data Assimilation System (PEODAS)
- 30 forecasts initialised on the 1st of September 2010 were verified in Sep-Oct-Nov 2010

	CONTROL (POAMA2)	randomAexp	randomOexp
Atmosphere	1st Sep 2010	1st Sep 1980-2009	1st Sep 2010
Ocean	1st Sep 2010 (La Nina)	1st Sep 2010 (La Nina)	1st Sep 1980-2009 (no La Nina)

- **Verification data sets**
  - Hurrell et al. (2008)'s SST product (combination of HadISST & Reynolds SST)
  - ERA-Interim MSLP data
  - Australia Water Availability Project (AWAP) rainfall analysis (Jones et al. 200)
- **Climate Indices**
  - La Nina : NINO3.4 index and SOI
  - SAM : the time series of 1st EOF of monthly MSLP anomaly over the SH extratropics (20-70°S)
  - rainfall : eastern Australia area-averaged rainfall (135-156°E)



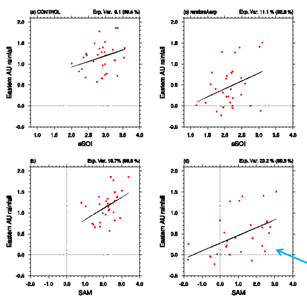
Results *Q1. Was the record strength of +ve SAM in 2010 spring driven by the strong La Nina?*



- **POAMA** forecasts were **skilful** in predicting the **strong La Nina, SAM and EAU rainfall**
- Forecasts from **RandomAexp** were **skilful** in predicting **La Nina**
- Forecasts were **not so good** in predicting the **SAM and EAU rainfall** in **Sep**.
- Forecasts captured **realistic amplitudes of SOI, SAM and EAU rainfall for Oct. & Nov.** → **high SAM with La Nina**
- Forecasts from **RandomOexp** were **skilful** in predicting the **SAM and EAU rainfall** in **Sep.**
- Forecasts **didn't simulate the high SAM and wet EAU in Oct and Nov → No high SAM without La Nina**

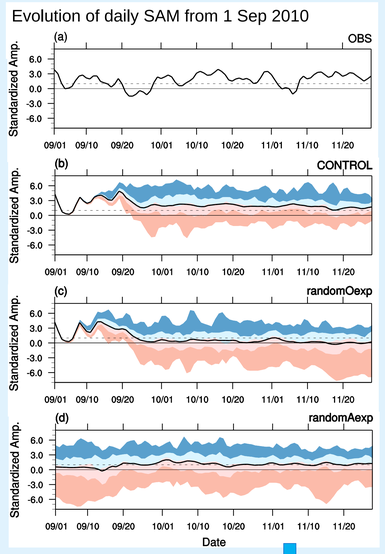
Q2. Did the +ve SAM bring additional rainfall to eastern Australia beyond what was driven by the strong La Nina?

Scatters of 30 member forecasts for SON 2010



- The stronger SOI was predicted, the more rainfall over eastern Australia was predicted → But the strength of the relationship was moderate
- **Tighter relationship between the EAU rainfall and +ve SAM forecasts → The SAM played an important role in determining the amount of rainfall over EAU in 2010 SON**

BUT, large internal variability of SAM limits the predictability of EAU rainfall associated with the SAM



Atmospheric processes were important for +ve SAM and heavy EAU rainfall in Sep 2010

La Nina was the necessary condition for strong +ve SAM and high EAU rainfall in Oct and Nov 2010

Summary

- Australia experienced an extreme climate condition in 2010 spring - strong La Nina, strong positive SAM and unprecedented amount of spring rainfall
- POAMA skilfully predicted this extreme condition (even at a lead time of up to a season)
- POAMA forecasts & the forecasts from two sensitivity experiments to atmosphere and ocean initial conditions suggest:
  - **atmospheric processes were important in 2010 September for the +ve SAM and the extreme amount of rainfall over eastern Australia**
  - **La Nina was an essential forcing for the +ve SAM and high rainfall over eastern Australia in the later part of the spring**
  - **strong positive SAM was an important driver for the extraordinary wet condition over eastern Australia in 2010 spring**

References:

Bertrand and Drosdowsky 2012: The relationship between the decline of Southeastern Australian rainfall and the strengthening of the subtropical ridge. *Int. J. Climatol.* 33:1021-1034

Cottrill et al. 2013: Seasonal forecasting in the Pacific using the coupled model POAMA-2. *Wea. Forecasting*, 28: 668-680

Hendon et al. 2007: Australian rainfall and surface temperature variations associated with the Southern Hemisphere annular mode. *J. Clim.* 20: 2452–2467.

Hendon et al. 2013: Causes and predictability of the record wet eastern Australian spring 2010. *Clim. Dyn.* DOI 10.1007/s00382-013-1700-5

Jones et al. 2009: High-quality spatial climate data-sets for Australia. *Aust Meteorol Oceanogr J.* 58:233–248

Lim et al. 2013: Seasonal predictability of the Southern Annular Mode due to its association with ENSO. *J. Clim.* 26:8037-8054

Lim and Hendon 2014: Understanding and predicting the strong Southern Annular Mode and its impact on the record wet east Australian spring 2010. submitted to *Clim. Dyn. Manuscript Available at* http://cawcr.gov.au/staff/elim/index.php

Zhou and Yu 2004: Sea-surface temperature induced variability of the Southern Annular Mode in an atmospheric general circulation model. *Geophy. Res. Lett.* 31:L24206