Predictability and prediction skill of the Southern Annular Mode based on its relationship with ENSO

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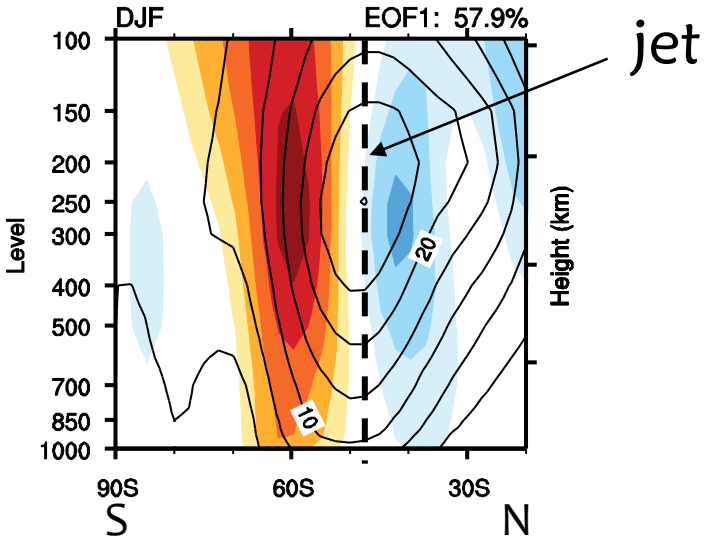
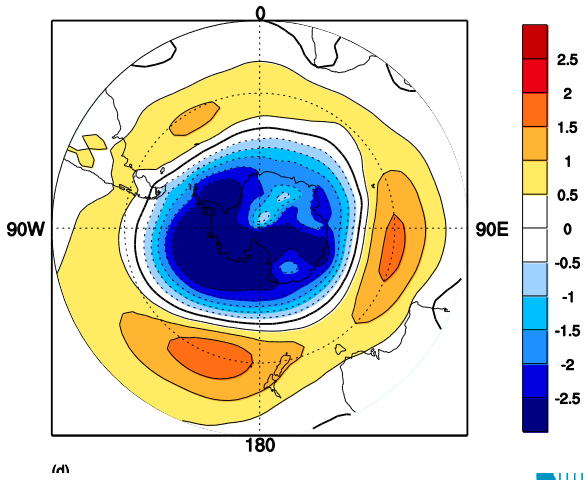
Southern Annular Mode (SAM; also known as Antarctic Oscillation)

- The most dominant mode of variability of the extratropical circulation in the SH in various time scales – from weeks to centuries
- Characterized by zonally symmetric north-south swing of the strength of the westerly jet in the extratropics
- Results in zonally symmetric north-south shifts of storm tracks that grow with the energy available from the vertical wind shear
- Projected onto an annular pattern of pressure/geopotential height anomalies with the opposite signs between the mid and high latitudes

+ve SAM





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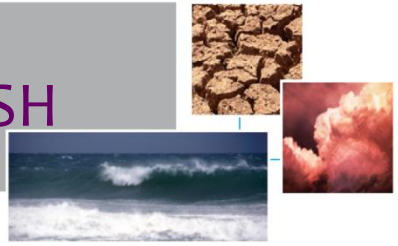
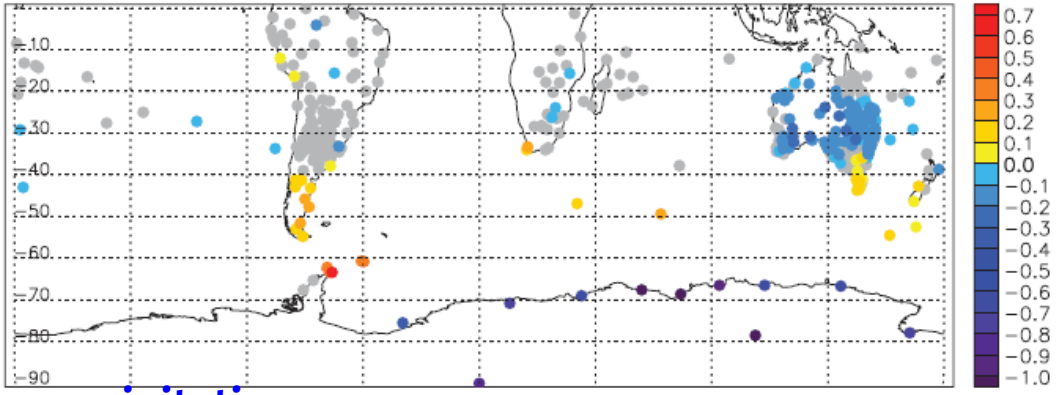
SAM's impact on regional climate is significant in the SH

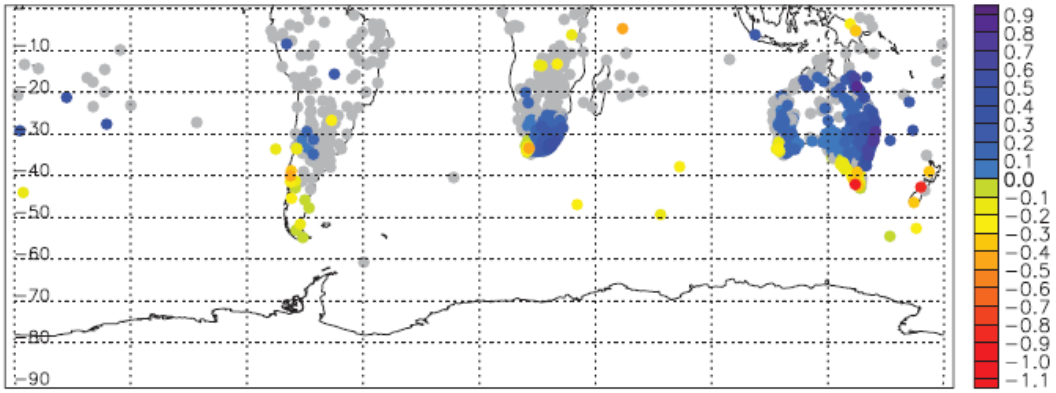


Regression of monthly station data onto Marshall's **SAM index**

(b) **temperature**



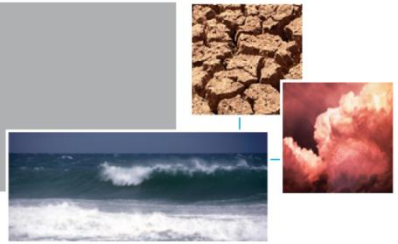
(c) **precipitation**



Taken from Gillett et al. (2006) their Fig1 in GRL,.

Any predictability of the SAM in a seasonal time scale, which enables us to make seasonal prediction of the SAM with useful skill??

Predictability of SAM



- SAM is driven by internal atmospheric dynamics

  i) decorrelation time of < 2 weeks

  ii) reproducibility in GCMs without SST forcing

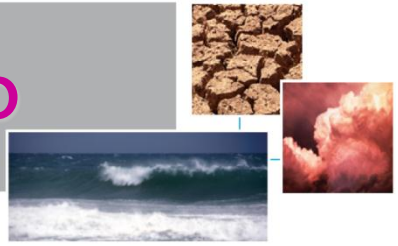
  → Thought to be unpredictable beyond a week

- Nevertheless,

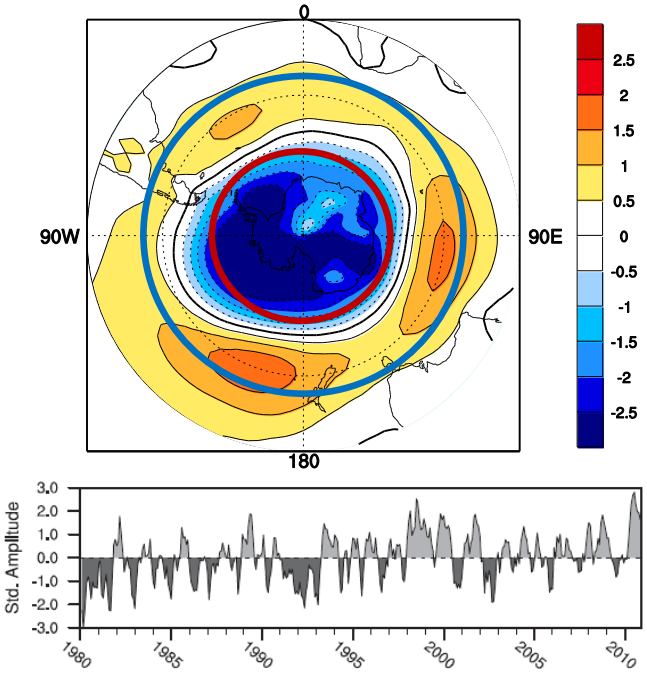
  statistically moderate but dynamically meaningful relationship exists between SAM and ENSO in austral spring to summer
  (e.g. Karoly 1989, Seager et al. 2003, Zhou and Yu 2004, L'Heureux & Thompson 2006, Chen et al. 2007, Lu et al. 2007)

  → **Predictability of SAM in a seasonal time scale!**

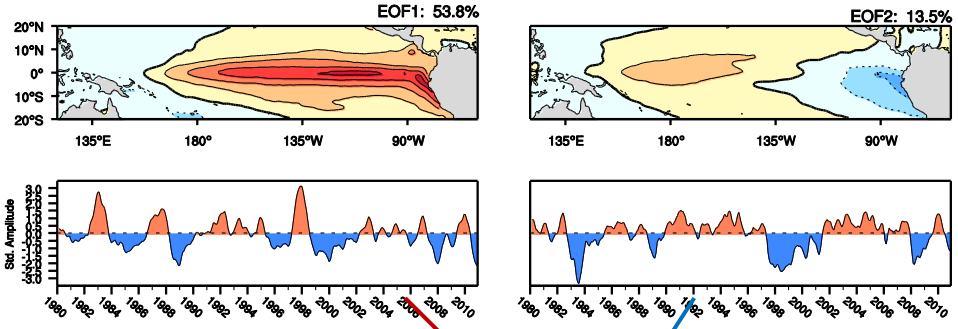
Predictability of seasonal SAM stemming from ENSO

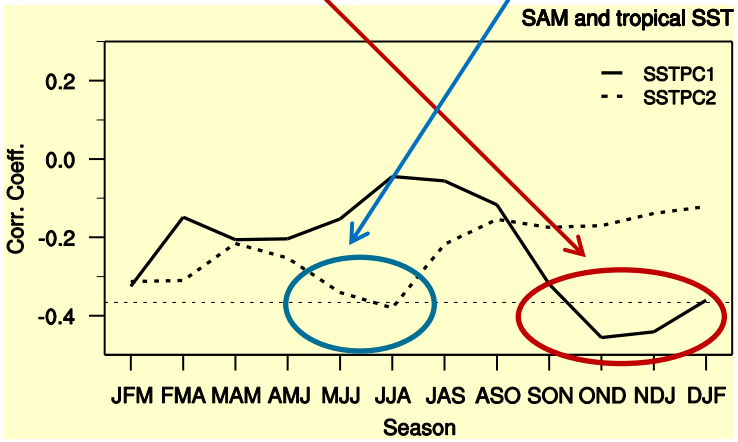


SAM index (Gong & Wang 1999):
Difference of Normalised [MSLPa] at 40°S and 65°S
(ERA-Interim reanalysis for the period 1980-2010)

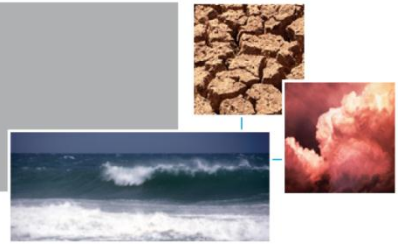


ENSO time series:
EOF analysis on the tropical Pacific SSTs
(Hurrell et al (2008)'s SST data for 1980-2010)





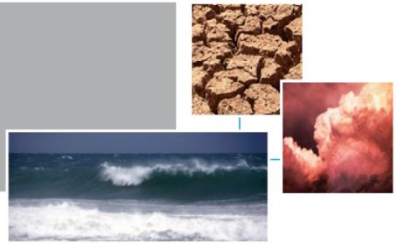
If we can predict the development of the two types of ENSO, we can predict the component of the SAM driven by ENSO in the SH cold & warm seasons



Can the SAM-ENSO relationship be exploited in seasonal forecasts for SAM?

→ Answer was sought by assessing the skill of retrospective seasonal forecasts from the Australian Bureau of Met. dynamical seasonal forecast system, **POAMA**

Predictive Ocean & Atmosphere Model for Australia



POAMA is an atmosphere-ocean coupled system:

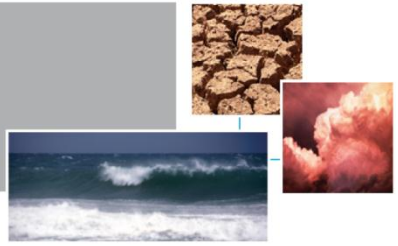
- Atmospheric model: **B**ureau's **A**tmospheric **M**odel v3
  (~250km x 250km x 17 vertical levels)
- Ocean model: **A**ustralian **C**ommunity **O**cean **M**odel **2**
  (200km x 50-150 km x 25 vertical levels)

coupled by **O**cean **A**tmosphere **S**ea **I**ce **S**oil (Valcke et al. 2000)

POAMA v2:

- Realistic atmosphere and land initial conditions generated from **ALI** (Hudson et al. 2010 Clim. Dyn.)
- Realistic ocean initial conditions generated from the POAMA Ensemble Ocean Data Assimilation System (**PEODAS**, Yin et al. 2011 Mon. Wea. Rev.)
- 30 member ensemble forecasts initialised on the 1st of each month for 1980-2010
- Monthly anomalies of forecasts computed by removing the forecast climatology as a function of lead time → model's mean bias removed from the forecasts
- Forecast skill computed with ensemble mean forecasts

POAMA

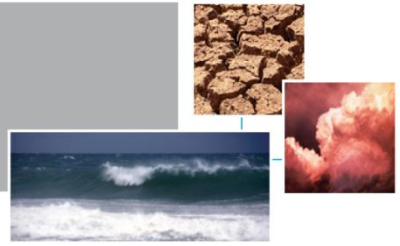


Limitations of the current POAMA system for SAM prediction

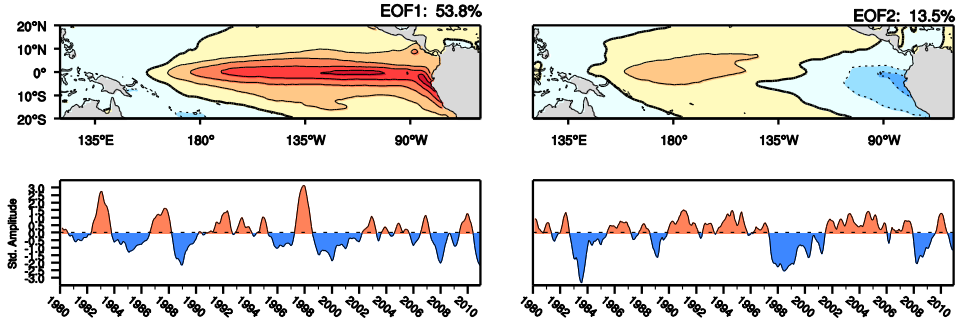
- Model's stratosphere resolution is too coarse (only 4 levels above tropopause) to fully resolve stratosphere-troposphere interactions
- Monthly climatologies of ozone and sea-ice extent are prescribed

these issues are being addressed in the development of POAMA3-ACCESS

Condition for good seasonal prediction of the SAM based on its relationship with ENSO



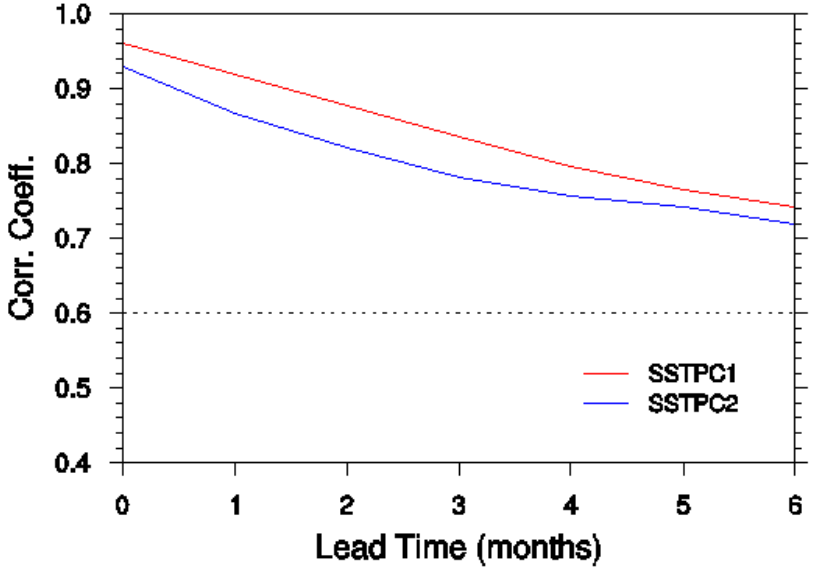
POAMA must skilfully predict two types of ENSO



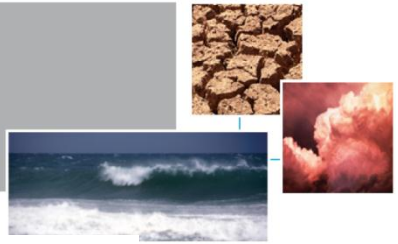
SSTPC1

SSTPC2

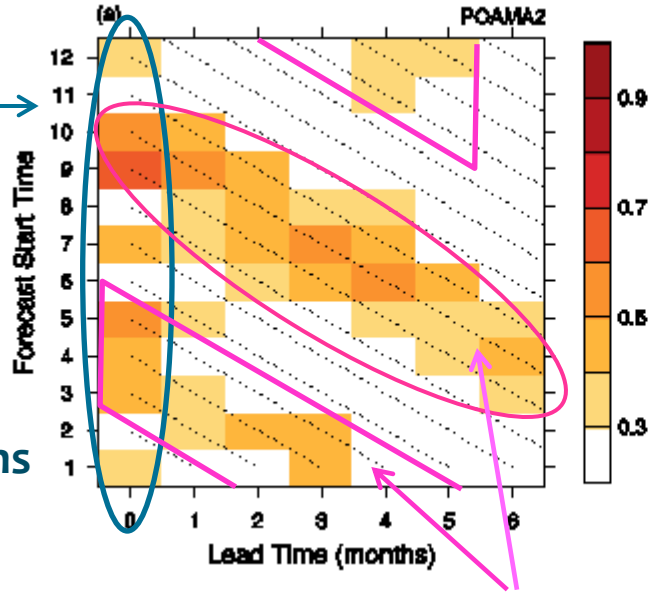
POAMA skill to predict two types of ENSO

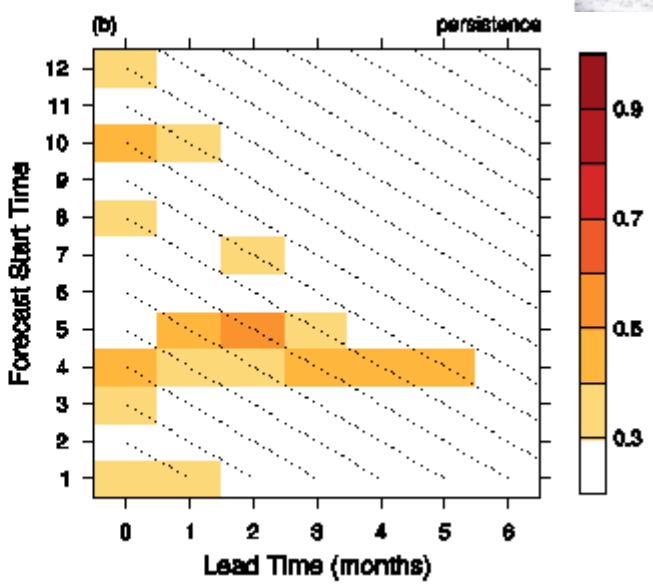


POAMA skill to predict seasonal SAM



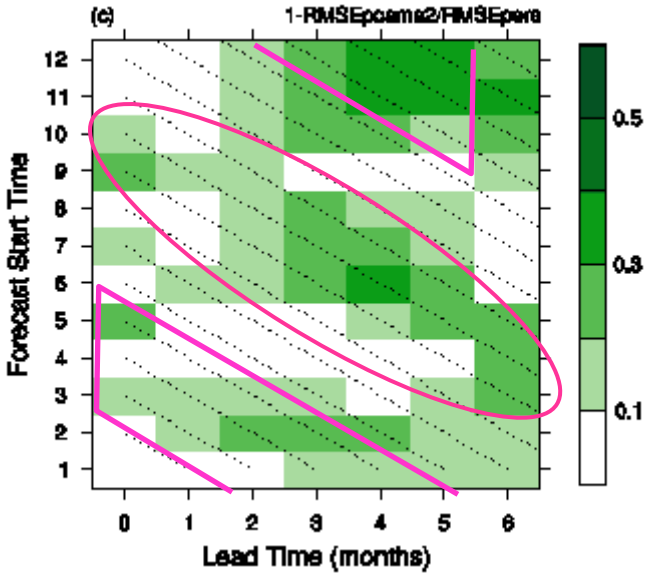
Skill coming from **realistic atmos. initial conditions**





Persistence forecasts using previous month obs SAM as a predictor

Skill coming from **SAM-ENSO teleconnection**



Seasonal mean behaviour of the SAM can be predicted in certain times of year at long lead time of 1-2 seasons!

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Summary

- There are significant relationships between **SAM and two types of ENSO** in a seasonal time scale during the SH cold and warm seasons → provides **predictability to seasonal SAM**

- POAMAv2 demonstrates **good skill to predict seasonal SAM**

  - **at the shortest lead time** for most time of the year **due to realistic atmospheric initial conditions**

  - **at longer lead times** beyond a season for the SH late autumn and spring-early summer seasons **due to the SAM-ENSO teleconnection**

- There is **a large scope to improve the skill of predicting the seasonal SAM** by increasing the model resolution and having interactive ozone or sea-ice extents → will benefit the seasonal prediction of regional climate associated with SAM

(Details of this study can be found in Lim et al. 2013 J. Climate, ***26****, 8037-8054)*