Investigating variability in the Australian monsoon and rainfall with cluster analysis

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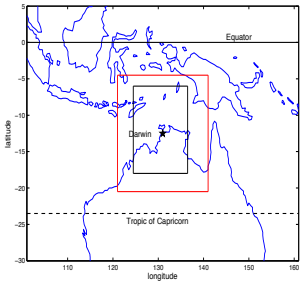
Motivation

- The Australian monsoon is a major component of global climate and the primary source of rainfall for northern Australia.
- Previous studies have shown that the monsoon has substantial interannual variability (onset, intensity) and intraseasonal variability (active and break periods).
- The Madden-Julian Oscillation (MJO) is the major contributor to intraseasonal variability in the tropical Indo-Pacific.

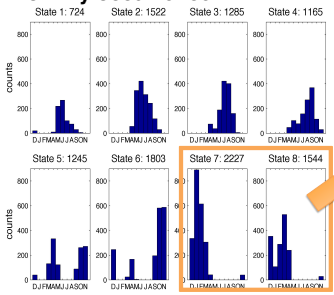
Methods

- We use a clustering algorithm acting on ERA-Interim reanalysis data to define a set of 8 atmospheric states for the region surrounding Darwin (red box at right).
- States are defined in terms of surface pressure and 3D temperature, winds, and humidity in the region.
- We classify all ERA-Interim observation times into one of the 8 states, creating a 33 year, 4x daily record of atmospheric state at Darwin.
- We find 8 states, two (States 7 & 8) of which we identify as the active and break periods of the monsoon.

Region of study

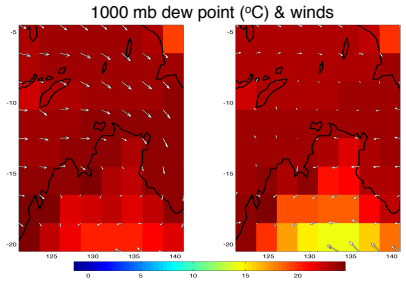


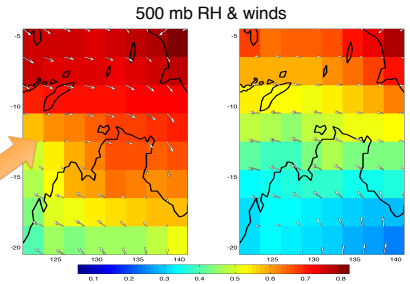
Monthly occurrence



Meteorology of the monsoon states

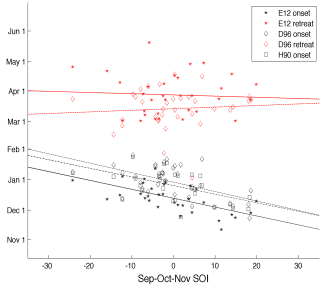
State 7 - active monsoon State 8 - break monsoon



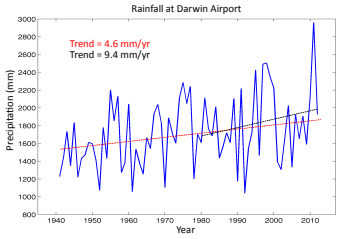


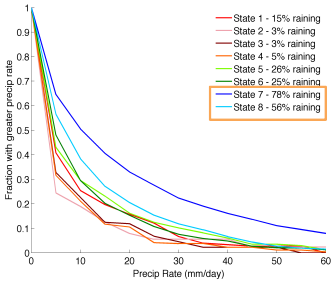
Role of ENSO

- Our study (E12) defines monsoon **onset** / **retreat** each season as the first / last 24 hour periods classified as active monsoon.
- The variability in onset date is strongly correlated with ENSO, while the variability in retreat is uncorrelated. These findings are in agreement with other studies, e.g. Drosdowsky 1996 (D96) and Holland 1990 (H90).
- No such relationship exists for retreat date.



Precipitation



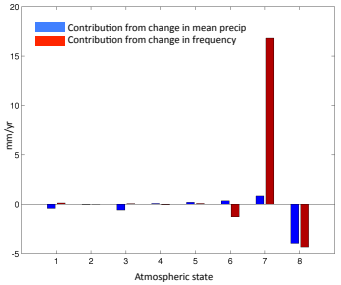


- Monsoon states rain much more frequently than other states.
- The active monsoon rains much harder than other states.

Contributions to precipitation trend at Darwin

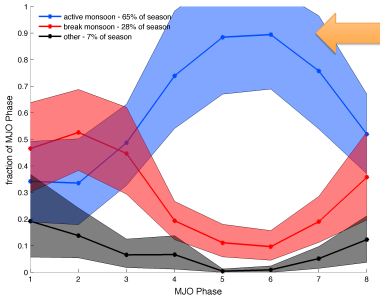
- Divide trend in rainfall (ΔR) into contributions from the trends in state mean rainfall (ΔP) and trends in state frequency of occurrence (ΔN).

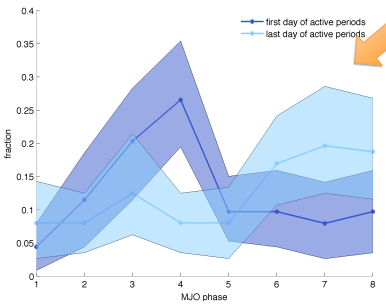
$$\Delta R = \sum_i N_i \Delta P_i + \sum_i \Delta N_i P_i$$



- Trend in rainfall driven by increase in frequency of active monsoon (State 7).
- Contribution from break monsoon equally divided between frequency and mean precip.
- Dry and shoulder seasons contribute little.

Role of the MJO





Likelihood of the monsoon being active

- When the MJO is present at Darwin (phases 4-7) the monsoon is much more likely to be in the active state.
- When the MJO is away from Darwin (phases 1-2) the monsoon is more likely to be in the break state.

Active period initiation / termination

- Active periods begin when the MJO arrives at Darwin (phases 3-4).
- Active periods end when the MJO moves away from Darwin (phases 7-8).

Conclusions

- Our atmospheric state classification successfully captures established relationships between the monsoon and ENSO.
- The precipitation trend at Darwin is attributable to an increase in the occurrence of the active monsoon.
- The presence of the MJO at Darwin strongly favors an active period of the monsoon.
- Initiation and termination of active monsoon periods coincides with the arrival and departure of the MJO at Darwin.

Thoughts? Questions? Email *sevans@atmos.uw.edu*