S2S Monsoon Subseasonal Prediction
Overview of sub-project and Research Report on Prediction of Active/Break Episodes of Australian Summer Monsoon

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Harry Hendon
Andrew Marshall
Monsoons exhibit strong intraseasonal variation but relatively weak interannual variation (order 10% of mean).

Active/break have large-scale and are multiweek timescale, often associated with MJO/BISO > potential for long lead prediction.
Active/break cycles can have profound impacts on water resources, agriculture, infrastructure, and health and water.

**Northern Australian Sugar Cane Industry**
Challenge to manage fertilizer to minimize runoff to Great Barrier Reef

- avoid fertilizing prior to active burst

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**Great Barrier Reef**
Impacts on Transportation
Australia uniquely depends on "road trains" for transport of goods, food, fuel across tropical /rural Australia

forecasting bursts 1-3 weeks in advance has commercial and societal value
Multiweek prediction of monsoons poses a number of challenges:

• Models often deficient in depiction of MJO/BISO, especially poleward propagation during boreal summer (will hear more at this meeting)

• Dry biases over land masses

• Processes at land-ocean boundary (diurnal cycle) often not well treated
Area-mean rainfall limited to ~ 2 pentad (10 days) but prediction of large-scale MISO extends to 3-4 pentads – potential for improved predictions.

Fig. 1 Correlation coefficients between pentad mean observed and predicted area-averaged rainfall anomalies over Central India for the control and ensembles from CFSv2 perturbation experiments and lagged ensembles from NCEP CFSv2 reforecast. The correlation has been calculated for 24 pentads during summer monsoon (JJAS) for 9 years (2001–2009).

Fig. 6 Correlation coefficients between predicted and verifying analysis of MISO1 (top panel) and MISO2 (bottom panel) as a function of forecast lead in days.
Ongoing biases in coupled forecast models are acting to limit predictive skill

Dry bias persists
S2S offers opportunity to:

• Assess current multiweek predictive capability across all monsoons
• Reveal mechanisms of variability and role for predictability
• Highlight common model errors so to guide model improvement
• Determine utility of forecasts for practical application
Monsoon Subproject has two rather limited initial foci:

1) Assess current prediction capability of active/break episodes
   Gather (develop) indices of regional monsoon variation
   Serve historical/real time indices online (S2S page)
   to be used to assess forecast performance and to
   identify mechanisms of predictability

2) Specific focus on monsoon onset
   Gather historical records of onset (develop our own)
   Serve these records to promote assessment of predictive skill
   and causal mechanisms
   Assess onset prediction with S2S data base
S2S Monsoon Subproject

Not limited to Asian-Australian monsoon

Project is a loosely organized group trying to promote this activity

activities will evolve based on participation (eg expand to heat waves; extreme events, …)

Ultimately will lead to:

• Improved understanding of mechanisms and predictability of MISV

• Improved forecasts through improved models

• Increased uptake of multiweek prediction of monsoon variation
Assess Australian monsoon subseasonal predictions with POAMA M24 BoM coupled forecast model

Contributed to S2S data base
  Low res coupled model (T47 atmos, 0.5x2 deg ocean)
  Initialized with obs atmos/ocean states
  Coupled breeding ensemble perturbations (33 members, 3 model versions)
  Hindcasts 6 starts per month 1981-2014

Good depiction/prediction of the MJO but model has significant biases:
  Global cold drift
  Dry land bias
Predicting Active-Break Episodes Australian Summer Monsoon

Australian Summer Monsoon Rainfall index:

Area mean land points north of 20S
Define active/break days when exceed +/- 1 sigma using daily data
Westerly Wind Index: U850 0-10S 105E-135E
Expect predictability due to strong MJO impact
Good depiction of MJO in POAMA

Dry bias
Good skill for MJO from POAMA

RMSE for predicting RMM 1 and 2

solid lines - Ensemble spread
dashed lines - Ensemble mean RMSE

Courtesy D. Waliser
Composite for active monsoon days 1981-2014

Rainfall (shaded), vector surface winds, slp (contoured)
Figure 3: (upper) Correlation skill for predicting weekly-mean monsoon rainfall (left) and monsoon u850 (right) anomalies for lead times out to six weeks, using the ensemble mean from all forecasts (black bars), forecasts initialised only on monsoon active days (blue), and forecasts initialised only on monsoon break days (orange). (lower) Correlation skill for predicting weekly-mean monsoon rainfall anomalies using the “perfect” MJO forecast (black), the predicted MJO component of the total rainfall (grey), and the model's bias corrected local depiction of the MJO (white); see Section 3.3 for details. Circles represent correlation skill for rainfall using the ensemble mean from all POAMA forecasts (reproduced from the upper left panel). All forecasts verify during December through February 1981-2010.
Break down rainfall forecast by contribution from MJO

1) Perfect MJO forecast
   predicted rainfall (t) = $A_{obs}\, RMM_{1\, obs}(t) + B_{obs}\, RMM_{2\, obs}(t)$

   A and B regressions coefficients developed using obs 1981-2014 MJO onto obs rainfall

2) Model's MJO forecast
   predicted rainfall (t) = $A_{fcst}\, RMM_{1\, fcst}(t) + B_{fcst}\, RMM_{2\, fcst}(t)$
   regressions developed using fcst RMM and models rainfall

3) Calibrated MJO forecast:
   use models predicted RMM but use observed regression coefs onto rainfall
   predicted rainfall (t) = $A_{obs}\, RMM_{1\, fcst}(t) + B_{obs}\, RMM_{2\, fcst}(t)$

1) Reveals role of MJO (explained variance of rainfall by MJO)

Comparing 2) and 3) with 1) reveals improvement to be gained by improving prediction of MJO
• MJO accounts for ~15% variance but main source of predictability for week 3 and longer
• More skill to be gained from improved prediction of large-scale MJO rather than improved depiction of MJO in monsoon
• Source of high skill at short lead beyond what you get from MJO needs investigating
Summary

• Active/break Australian monsoon rainfall is predictable to a lead of 2 (maybe 3) weeks with BoM POAMA model
  Circulation is predictable 4-5 weeks so potential to improve
  Looking forward to comparing with other models in S2S database

• MJO is a primary source of predictability long lead (beyond week 2)
  Source of high skill at short lead needs to be assessed
  Possibility that improved predictions in medium range could be achieved if deficiencies in representation of this source can be identified

• Utility of forecasts is being explored for a number of industries
  Multi-model forecasts from S2S could provide critical improvements in accuracy and reliability that will further promote uptake
Indian Summer Monsoon

Composite daily rainfall anomaly for active Indian monsoon using Rajeevan's core monsoon region (all days greater than 1 sigma)