Indian Ocean observations for operational S2S forecasts

Aneesh Subramanian
Scripps Institution of Oceanography, UCSD

with
Frederic Vitart (ECMWF)
Chidong Zhang (PMEL)
Arun Kumar (NCEP)
Magdalena Balmaseda (ECMWF)

Monsoon clouds over Bangladesh. Courtesy: NASA
Air-sea interaction and seasonal monsoon forecasts

Correlation maps of

(a) observed SSTs and monsoon rainfall simulated from uncoupled model,

(b) simulated SSTs and monsoon rainfall from the coupled model.

(c) observed SSTs and observed monsoon rainfall

PDFs of correlation skill of June – September Indian monsoon rainfall

(red) 'perfect model'

(blue) actual skill

Closed coloured circles - skill of two of AGCM coupled ML model.

Krishna Kumar et al., 2005
Madden-Julian Oscillation

Largest signal in tropical precipitation on timescales shorter than a year

source: Prof. A. Matthews, Univ. of E. Anglia
Impact of high-frequency air-sea interactions on MJO

Diurnal coupling in a regional model improves MJO due to rectification of shallow moistening

Seo et al. 2014
Ocean coupling improves MJO predictability

- Subseasonal forecasts of the MJO benefit significantly from coupling to the ocean (20 years of initialized forecasts)
- Ocean-atmosphere phase locking of anomalies and feedback act as a source of predictability on S2S timescales
- Understand coupled processes better to improve models and predictions on subseasonal timescales

Subramanian et al. 2017 (sub judice)
MJO phases: forecast skill

- Prediction skill for forecasts targeting strong MJOs as a function of MJO phase and forecast lag day
- Low skill in initial and Maritime Continent phases

Kim et al. (2014)
MJO and the Maritime Continent

Individual and joint number distributions of

(a) starting vs ending longitudes

(b) starting longitudes vs mean strength

(c) mean zonal scales vs mean strength

(d) mean zonal scales vs propagation ranges of tracked MJO events using the TRMM precipitation data.

Zhang and Ling (2017)
Monsoon Intraseasonal Oscillation

Based on an EEOF analysis of precipitation in the Tropics.
Neena et al., 2017
Air-sea interaction is key

PBL convergence maximum north of the convection maximum leads to feedbacks that propagate the system poleward.
Kemball-Cook and Wang (2001)
Air-sea interaction for MISO forecasts

During MISO propagation, the observed phase relation between latent heat flux, SST and SW radiation is better represented in coupled NCEP forecasts compared to uncoupled forecasts.

Wang et al. 2009
Ocean data assimilation impact: Precipitation in MISO predictions

ECMWF sub seasonal forecast system

All ocean observations assimilated prior to hindcast initialization ⇒ more coherent MISO propagation

Reanalysis

Only surface SST was assimilated prior to hindcast initialization

Subramanian et al. (2018, In Prep.)
Ocean data assimilation impact: LH Flux anomalies in MISO predictions

ECMWF sub seasonal forecast system

All ocean observations assimilated prior to hindcast initialization ⇒ more consistent surface flux anomalies

Reanalysis

Only surface SST was assimilated prior to hindcast initialization

Subramanian et al. (2018, In Prep.)
Process Studies

BoBBLE

ASIRI-OMM and MISO-BOB

NASCAr

Years of Maritime Continent
Recommendations

• Resolve diurnal cycle: increase the vertical resolution in the upper 10 m of RAMA buoy.

• Add new sites of surface buoys in the eastern Indian Ocean and MC for upper ocean and air-sea fluxes

• Increase the surface flux buoy sites in western Indian Ocean (equatorial and Arabian Sea) while also maintaining the existing surface mooring sites in the revised RAMA-2.0 design

• Enhance some of the existing RAMA buoy measurements by augmenting the existing upper ocean measurements with concurrent high frequency meteorological measurements for the atmospheric state

• Increase observations in coastal regions especially near the Maritime Continent region (either through moorings or other platforms (saildrones??)).
Summary

• Air-sea interaction plays a key role in MJO, MISO and monsoon dynamics

• Improved upper ocean representation in a coupled forecasting system can help improve model fidelity and predictions of MJO / MISO (data assimilation can help with coupled initialization)

• Improved process understanding required for better parameterizations in the upper ocean
Thank you

Monsoon clouds over Bangladesh. Courtesy: NASA
Monsoons

One of the largest seasonal reversals of winds and exchange of heat and freshwater between the ocean-land-atmosphere in one season

source: D. Randall (2012)
Impact of high-frequency air-sea interactions on MISO

Higher vertical resolution in the upper ocean and resolving the diurnal cycle in coupling helps improve the representation of MISO.

Klingaman et al., 2010