UGRL Project Background Readings

# Why Precipitation is Mostly Concentrated over Islands in the Maritime Continent – Jian Hua Qian, 2007

## Summary (Abstract and conclusions)

* High-resolution observations and regional climate model simulations show precipitation over Maritime Continent is most concentrated over islands in afternoon and evening:
* Secondary concentration over seas between large islands during late night and morning hours
* Analysis of diurnal cycles of precipitation and winds:
* Major role in maintaining spatial and temporal distribution of precipitation. Results show:
* Day time – more solar heating on land than sea – sea breezes
* Sea-breeze fronts converge from coasts toward island centre in afternoon, lift moist air, and trigger convection
* Valley winds reinforce sea breezes – more mountainous island convection
* Cumulus merger processes further enhance precipitation
* Diurnal cycles amplified
* Land-breeze convergence = less heavy nocturnal and morning rainfall over seas.
* But underrepresentation of islands and terrain in MC weakens atmospheric disturbance associated with diurnal cycle (i.e. daily alternation of land-sea breezes and mountain-valley winds), and precipitation underestimated.
* Global circulation models than see large systematic errors – coarse resolution
* This is due to insufficient representation of land-sea breezes associated with complex topography of Maritime Continent.
* So eleven global model shows precipitation over MC is less than observed.
* Even simulated upper-atmospheric velocity potential, that represents large-scale tropospheric heating, was displaced 2000km eastward compared to observations.
* Solutions to enhancing spatial resolution over MC in numerical models:

1. Multi-scale unified models – but global model at high resolution very $$ for long-term climate simulations
2. Two-way nesting, stretched-grid regional model that concentrates high resolution over area of interest, or interactively nesting fine-grid regional model into coarse-grid global model.

## Introduction – paper will compare 30 years simulation by high-resolution regional climate model to satellite measurements

* Need to understand small scale processes – focus on diurnal cycles of precipitation
* Important to improve regional climate predictability
* Lots of warm water in eastern Indian/western Pacific Ocean – Warm Pool
* Lots of evaporation as a result – increased atmospheric moisture
* Largest rainy area on earth
* Condensational latent heating released in precipitation process drives large-scale atmospheric circulation as a “boiler box”.
* So reason for precipitation underestimation in global circulation models:
* Grid resolution over MC too coarse to represent complex topography over MC

Satellite measurements

* Cover both land and sea
* Spatial and temporal resolutions improved over recent years
* E.g. Climate Prediction Centre’s Morphing Technique (CMORPH)
* Combines best features of geostationary and polar-orbiting satellites:
* Geostationary – higher space and time coverage in IR
* Polar – passive microwave rainfall estimates more accurate

Importance of diurnal cycles of wind systems in tropics:

* Synoptic-scale pressure gradients weak
* Local pressure gradients by differential solar radiative heating between different surface types strong: high vs lowland, land vs sea.

Dirunal cycles:

* Land heats quickly in day under influence of short-wavelength solar radiation, while sea surfaces cooler as thermal inertia (specific heat capacity) of water relatively large (4900 J kg-1K-1) and because waves, turbulence, and penetration into deep water mix heat downward from surface water – sea breeze and convectional cells rise over land
* Land cools off rapidly at night – longwave radiation loss – pressure gradients reversed and land breeze.

Rainfall trends from TRMM measurements:

* Afternoon rainfall > morning rainfall over land but less than morning rainfall over oceans in tropics
* Convergence between winter monsoon and land breezes contributes to nocturnal offshore rainfall northwest of Borneo (NE monsoon)

**Paper aims:**

* Investigate physical mechanisms for spatial distribution of precipitation in MC
* Address local precipitation processes from land breezes, and discuss implications from global climatological perspective.
* Implications of regional model for global atmospheric modelling discussed.

## Spatial distribution of observed precipitation in MC

**Observed trends – monsoonal from CMORPH seasonal averages**

* More precipitation in southern MC in boreal winter months (DJF)
* More rainfall in northern MC in boreal summer months (JJA)
* Intermediate values during boreal spring (MAM) and fall (SON)
* See figure 2 on page 1431

**Spatial distribution**

* Using high resolution (0.25 degree grid) satellite data
* Lots of inhomogeneity in distribution.
* Strong contrast between land and sea over MC in all seasons
* Heavy rain concentrated over islands with relatively dry ring surrounding each island.
* Even when dry season of SE MC (JJA), more rain over islands than surrounding seas.

**Diurnal cycles of temperature, rainfall, and wind in the tropics**

* Much more pronounced than in extra tropics
* Small heat capacity of land and large in oceans
* Thus, amplitude of diurnal cycle of surface and lower-atmospheric temperature over land much larger than ocean.

**Diurnal cycle magnitude**

* ***Largest in DJF wet season* (**e.g. Java very strong – 25mm/day rain rate)
* Followed by MAM and SON
* Smallest in JJA dry season
* So TRMM satellite rainfall measurements show that although rainfall from small to medium-sized clouds end earlier in afternoon, mesoscale convective systems (MCS) developed during afternoon and maintained strength until early morning over Borneo (Nesbitt and Zipser 2003).
* Over java sea, diurnal cycle strong in DJF months and weaker in others.

**Diurnal cycle fluctuations with time – see fig 3 p.1432**

* In all 3, diurnal cycle stronger over DJF than in JJA
* Only Borneo island has relatively stronger cycle in JJA months
* Borneo – rain rate peaks in early evening to midnight
* Java sea – rain rate peaks in morning (nocturnal to morning rain – explains why coastal areas like Jakarta experiences morning rain)
* Java island – peak in late afternoon and very strong diurnal cycle in DJF.

**Visual illustration in figure 4 page 1433**

* Precipitation over islands max in late afternoon/evening and minimum at night/early morning
* Precipitation over seas maximum at night/early morning and light in afternoon/early evening.

## Diurnal cycle over Java as simulated by a regional climate model

* Abdus Salam International Centre for Theoretical Physics (ICTP) Regional Climate Model version 3 (RegCM3) – over Java
* Radiation parametrization used.
* Over land – Biosphere Atmosphere Transfer Scheme (BATS)
* Computes surface radiative, sensible and latent heat, and momentum fluxes and surface temperatures based on ahe assigned vegetation and soil parameters.
* Over ocean, this model forced by SST spatially and temporally interpolated from monthly dataset – no diurnal variation in prescribed SST field.

**Figure 5 – diurnal cycle of CMORPH precipitation (mm/day) over Java in DJF.**

* Afternoon and evening more rain inland, less in coast and seas
* Morning and night more coastal rain and in surrounding seas, less inland

**Figure 6: Climatology of diurnal cycle that includes horizontal winds (vectors m/s) and divergence in DJF.**

* Land breeze and divergence over land = convergence at sea (morning/night)
* Sea breeze and convergence over land = divergence at sea (afternoon/evening)

Some detail

* Winds near mountains over Java converge toward mountain peaks in the form of valley winds – divergence and dry ring over coastal seas
* Sea breeze in early afternoon to late evening enhance precipitation over Java – and even around midnight (2200-0100 LT), winds over seas still in direction of sea breezes, but winds near mountains start to diverge away from mountain peaks. This leads to convergence and wet ring around the island.
* After midnight, land breezes – wind anomalies reversed.
* The large positive precipitation difference in afternoon over central mountain range indicates valley winds enhance diurnal cycle greatly and help concentrate more rainfall over mountains.
* So combined sea breezes and valley winds enlarge rainfall over Java, particularly over mountain rains – energised and can last longer into evening.
* **See figure 7 on page 1437**

**Considerable amount of precipitation over Java persists after sunset**

* Cumulus merger process
* Deep convection associated with cumulus merger
* Cumulus merger – indirectly important in amplifying precipitation initiated by sea-breeze convergence.

**Figure 8 – timing and intensity of mean diurnal cycle of rain rate simulated by RegCM3 control run over Java in DJF**

* Near-surface air temperature daily maximum in early afternoon (not shown) – 1300LT
* Peak precipitation around sunset (1800 LT) – 20mm/day – deep convection and heavy rainfall
* The figure also models that no mountains = less intense and earlier peak (around 1430LT).
* Observed and modelled with mountains fairly close correlations

**Large islands vs. small islands**

* Large islands (e.g. Borneo)
* Rainfall initiated along sea breeze front along coastlands during 1300-1600
* Take long time to collide at centre of island – so late evening
* Small islands
* Short time fro sea breeze to collide
* So max rainfall in early afternoon

Explains why most rainfall over islands and over mountains than on flat coastlands.

**Major large-scale atmospheric moisture source (PHYSICS!)**

* Evaporation from subtropical oceans (Trenberth 1999)
* Moisture transported to remote places in tropics by winds (Hastenrath and Lamb 2004)
* ***Global perspective – combination of islands and seas in MC optically located to accumulate incoming moisture from oceans transported by trade winds, assisted by diurnal alternation of land-sea breezes and mountain-valley winds to produce huge amounts of precipitation and latent heating of atmosphere.***

## Implications of the role of the diurnal cycle for large-scale atmospheric modelling

* Talks about underestimation precipitation for several reasons:
* Flat island (TER) run modelled underestimated precipitation as compared to observed control run
* Mountain height must have been underestimated – coarse-resolution models
* Neglecting small islands worsens this.
* ***See figure 9 – all ocean and flat-island runs underestimate! Least error in dry season***
* Consequences of underestimating precipitation over MC – global!
* Condensational latent heating in atmosphere decreased
* Further affects general circulation of atmosphere

So large islands (e.g. Borneo) underrepresented, medium and small (e.g. Java and Timor) not represented.

***Because role of atmospheric heating over MC is important energy source for large-scale circulation, such systematic error in MC precipitation will inevitably contaminate simulations elsewhere, such as in the Asian-Australian monsoon, subtropical jets, and storm tracks!***

# Reading 2: Scale Interactions between the MJO and the western Maritime Continent (Birch et al., unpublished).

## Abstract

* Regional climate model simulations able to resolve key mesoscale circulations are used to understand interaction between convective MJO environment and processes governing strong diurnal cycle of MC islands
* Previously work showed:
* Land-based rainfall peaks before active convective envelop of MJO reaches MC
* Oceanic rainfall rates peak whilst active convective envelop resides over region
* Oceanic rainfall controlled by large-scale environment and atmospheric stability, followed by high oceanic latent heat flux forced by near-surface winds in the later active MJO phases.
* Land rainfall peaks before main convective envelop arrives – models agree with obs – even though large-scale convective environment is only moderately favourable for convection.
* Early rainfall peak are convective triggers from land-sea breeze circulations that are strong due to high surface insolation and heating.
* During peak MJO phases cloud cover increase, surface insolation decreases, weakening mesoscale circulations and reducing land-based rainfall, even though large-scale environment is favourable for convection.
* ***Key: Scale interactions essential part of MJO transition across MC.***

## Introduction

**MC:**

* Tropical warm pool – one of the wettest places on earth
* High latent heat release from organised convective activity in region influences global circulation and climate via downstream Rossby wave response.
* Diurnally – precip in afternoon due to sea-breeze convergence and propagates off-shore overnight due to reversal to land breeze and gravity waves

**MJO:**

* Dominant component of intraseasonal variability in tropics
* Consist of large-scale E-ward moving convective and circulation anomalies that originate over Indian Ocean and propagate over MC into western Pacific within 30-90 day period. (E-ward heat source)
* Need understanding of MJO and MC interaction for accurate medium-range forecast – but Global Circulation Models (GCM) cannot show this – coarse resolution?

**MC + MJO**

* 2-way interaction
* Strong forcing provided by MC islands cause MJO variations as it passes
* MJO influences local climate through modulation of both cloud and precip characteristics.
* MJO enhances precipitation over MC islands and suppresses over surrounding seas
* Hypothesis
* MJO and MC behaviour is a consequence of interplay between large-scale circulation and mesoscale circulations forced by MC islands.
* Large-scale circulation and moisture convergence changes preceding arrival of MJO, forced by large-scale equatorial wave dynamics, increase moisture availability before the active phase of MJO sets in over MC.
* So rainfall over land enhanced as solar insolation remains high ahead of active MJO – maintains high land-sea temperature gradient driving rain-bearing mechanisms.
* But this understanding cannot be reproduced by GCM simulations due to coarse resolution.

**Observations**

* Now we have more computational power and high-resolution models to allow convective parameterisation to be switched off and convection to develop explicitly.
* High horizontal resolution for land-sea breeze
* 12km – parameterised convection
* 4.5km – convection-permitting
* These used for the study to:
* Understand reasons for the land-ocean contrasts in MC rainfall by MJO phase
* Understand impact of high horizontal grid resolution and representation of convection on the MJO in regional climate models
* New aspect of the study is the length of high-resolution regional climate model simulations, which allow an investigation of interplay between large-scale convective environment and mesoscale circulations within a mode of intraseasonal variability.

## Methods

**Regional Climate Modelling (RCM)**

* RCM 4.5 a little coarse to represent convection without parameterisation
* But RCM 4.5 (4.5km resolution) used instead of RCM 1.5 as it was said the differences are much smaller than between RCM 4.5 and RCM 12.
* Initial conditions:
* SST
* Soil moisture

**Observations – TRMM (Tropical Rainfall Measuring Mission)**

* TRMM combined with satellite and rain gauge observations
* TRMM always underestimates station rainfall by factor of 2 – over steep and high topography – bias.
* Radiosondes also used to compare with RCM simulations

## Results

* Most rain in high topography in W Sumatra, least in west coast of Sumatra
* 2-3 hour difference in diurnal timing over land heating – could be due to coarse grid-spacing
* Precipitations appears too early over land in RCM 12.
* MJO Phase:
* 1 – precipitation suppressed over oceans but wetter than average along W coast of islands
* 2-3 – large-scale active envelop of MJO convection moves over west MC and rainfall higher in both land and ocean
* 4-5 – large-scale envelop of convection remains over west MC and strong negative rainfall anomalies over ocean, but dry anomalies over land
* 6-8 – suppressed phases of MJO over west MC and rainfall lower than average over both land and ocean
* Both RCM 12 and RCM 4.5 show that high-rainfall MJO phases over land occur before high-rainfall MJO phases over ocean

**MJO Phases and moisture fluxes**

* Phase 1 – Active envelop of MJO convection to west of MC, moisture flux convergence small but +ve.
* Phase 2 – moisture flux convergence peaks – convection favourable
* Phase 3-4 – unstable profile with warm and humid air in lower atmosphere and cool air above – favour convection!
* Phase 5-7 – moisture flux convergence negative and becomes divergence – drier environment unfavourable for convection
* Phase 8 – next active MJO phase sign – moisture flux still divergence but builds to near-zero anomaly.
* Heat, moisture, and instability build between phases 6-8 and 1-3, and decrease more rapidly between 3-6.

## Conclusions

* Using RCM simulations and observations to test for the differences in mean rainfall anomaly over land and sea by MJO phase over MC, it is suggested that this difference is a combination of variability by MJO phase of:
* Large scale environment forced by equatorial wave dynamics
* Land-sea temperature gradient through surface insolation, resulting in varying strength of mesoscale convective triggers.
* Hypothesis – by Peatman et al., 2014 is supported
* Solar insolation reduced during active phases of MJO when cloud cover is maximum, reducing daytime onshore flow controlled by combination of sea-breeze circulation, upslope mountain winds, and synoptic-scale circulation, which are thought to be major convective triggers over MC region.
* Equatorial wave dynamics control larger-scale convective environment, by controlling amount of moisture transported into MC region, atmospheric stability, and oceanic latent heat flux through moderation of near-surface wind speed.
* So this is why land-based rainfall peaks in earlier MJO phase compared to ocean.
* Second aim was to evaluate ability of RCM to represent key processes relating to MJO – rainfall and large-scale convective environment
* Model obs differences up to 10mm/day
* Both RCMs drier than TRMM elsewhere
* RCM 4.5 wetter than TRMM over high orography – issue in Met Office CP model!
* Oceanic rainfall not as well represented as compared to over land
* But overall performance enough to be confident of conclusions in study

# Madden Julian Oscillation – MJO reading – the concepts (Zhang, 2005)

## Abstract – what is the MJO?

\* Dominant component of intraseasonal (30-90 days) variability in tropical atmosphere.

\* Consists of large-scale coupled patterns in atmospheric circulation and deep convection, with coherent signals in many other variables, all propagating Eastward at 5m/s through warm Indian and Pacific ocean sector (warm = convection)

\* Constantly interacts with underlying ocean and influences many weather and climate systems

\* Large-scale structure – broad influences on tropical and extratropical weather and climate – PLANETARY SCALE

\* Hard to understand MJO in relation to tropical atmosphere

## Introduction

\* The MJO is intriguing because it influences variability of rainfall over:

1. Pacific Islands
2. Asian and Australian monsoon regions
3. West coast of North America
4. South America
5. Africa

\* Modulates genesis of tropical cyclones in Pacific Ocean and Caribbean Sea and affects equatorial surface winds in Atlantic ocean.

\* Thus, MJO affects global medium and extended range weather forecasts.

\* MJO involves atmospheric planetary-scale circulations and interaction with mesoscale convective activities (smaller scale).

\* MJO interacts with ocean and can influence El Nino.

\* Very hard to use state of the art GCM to simulate MJO!

***\* Aim of study is to synthesize current MJO knowledge and summarise unknowns that urgently need to be addressed.***

\* MJO is dominant but not only component of intraseasonal variations in tropics.

## **The Basics**

\* In equatorial Indian and western Pacific oceans MJO features large-scale, eastward moving centre of strong deep convection and precipitation – active phase

\* This is flanked to both east and west by regions of weak deep convection and precipitation – inactive/suppressed phase

\* Both phases connected by overturning zonal circulations that extend vertically through troposphere

* Lower troposphere (1.5km or 850hPa level) and near surface feature strong W winds to the west of the large-scale convective centre and E winds to the east.
* Zonal winds reverse in upper troposphere

**Planetary Zonal scale**

\* MJO is an isolated or discrete pulse-like event rather than sinusoidal wave

**Eastward Propagation**

\* 5m/s – fundamental features that is unique to MJO – slow!

**Convection-Wind coupling**

\* Large-scale wind structure described in terms of equatorial waves coupled to deep convection. This compares to 15-17m/s Kelvin wave

\* East of convective centre has low-level easterlies and upper level westerlies to resemble equatorial Kelvin wave. To the west, low-level westerlies ad upper easterlies and associated pair of cyclonic circulation steaddling equator are the characteristics of the equatorial Rossby wave.

\* Both Kelvin and Rossby wave structures considered dynamically essential to MJO.

## Other key points

\* Numerical simulations of MJO by GCMs have evolved with slow but steady progress.

\* Models improving – some – but others inept

\* GCMs give unrealistic simulations – so hard to study dynamics of MJO

\* Need to improve numerical simulations with advancing theories as highest priority of study of MJO

\* Topics of study now include:

> Scale interactions  
> Air-sea interactions

> Prediction

> Interaction with ENSO

> Modulation of TC

> Interaction with monsoon

> Influences on higher latitude weather

\* MJO special to tropical global circulation because of broad impact on various aspects of weather and climate – e.g. rainfall variability and convection!

\* MJO should be key to research in tropical weather, circulation, and climate.

# Rmet reading – Propagation of the MJO through the MC and scale interaction with the diurnal cycle of precipitation (Peatman, 2014)

## Abstract

\* Talks about convectively active part of MJO propagating Eastward through warm pool, from Indian Ocean to MC to W Pacific.

\* Complex topography in MC means exact nature of MJO propagation unclear

\* Local errors in latent heat (LH) release and global errors in medium-range weather prediction and climate simulation as a result.

\* From 14 northern winters of TRMM satellite data it is shown that, where mean diurnal cycle of precipitation is strong, 80% of MJO precipitation signal in MC is accounted for by changes in amplitude of diurnal cycle.

\* Relationship between outgoing LWR and precipitation weakened – LWR not proxy. The canonical view of MJO as smooth eastward propagation of large-scale precipitation envelop also breaks down over MC islands. But rather so a vanguard of precipitation jumps ahead of main body by around 6 days or 2000 km. This means more precipitation over Sumatra, Borneo or New Guinea when large-scale MJO envelop over surrounding ocean is one of suppressed precip.

## Introduction

\* MC has high SST and heavy precipitation accompanied by LH release

\* LH release makes MC a main driver of global atmospheric circulation – so it's known a 'boiler box'

\* But GCM coarse resolution means that land which precipitation is focused is poorly resolved. GCM also cannot resolve convective weather systems, so convection must be parameterised. But significant errors exist! So limited skill in forecasting MJO.

\* Land-sea temperature gradient exist in daytime due to heat capacity of water

\* Hence, convective precipitation is mostly over lands due to sea breeze and ascent of moist air over islands (convergence of wind)

\* Strong diurnal cycle exists – land mostly rains in afternoon and evening, moving inwards from coast (e.g. Borneo) or forming on flanks of mountains (e.g. sumatra)

\* Overnight, land precipitation decays and propagates offshore – land breeze as land cooler than sea (LWR escape)

\* So ocean diurnal cycle peaks in morning and decays in afternoon and evening – much weaker than land.

\* The study ***uses 14 Boreal winters (Nov-April) of high-resolution data to investigate:***

* How diurnal cycle of precipitation changes with MJO cycle
* How synchronous certain variations are during MJO evolution
* How these indicate scale interactions between two cycles
* Consideration of changes which occur as atmospheric state evolves through each successive MJO phase, as opposed to simply comparing the two separate regimes - active MJO and suppressed MJO.

## Data

\* TRMM – 0.25 grid every 3 hr for surface precipitation rate.

\* Full dataset created by assimilation of microwave and IR satellite observations

## Interaction between diurnal cycle and MJO

**Diurnal cycle in TRMM 3B42HQ precipitation**

**\*** Diurnal cycle of precip rate estimates over ocean consistently weaker than over most land-based

\* But over oceans between and around MC islands is much stronger diurnal cycle than that of open eastern Indian and western Pacific Oceans.

**Modulation of the diurnal cycle by** MJO

\* Daily mean greater during wetter and more active phase (3) than the drier suppressed phase (7).

\* Interaction between small scale diurnal cycle modulated by the state of large-scale MJO envelop is clear.

## Relative MJO phases – review the phase 1-8 as of the 2nd reading!

## Discussion

**Why does the diurnal cycle lead the main MJO envelope?**

\* Diurnal cycle strongest over land about 1/8 of an MJO cycle (6 days or 2000km) ahead of arrival of active MJO envelope.

\* Land diurnal cycle set up by land-sea temperatures gradient as insolation heats land faster

\* During active MJO sky is more cloudy – so SWR flux at surface minimum!

\* It is possible that the observed MJO phase lag is caused by diurnal cycle suppression due to low level of insolation during active phase of MJO, and that diurnal cycle precedes most active part of MJO.

**MJO propagation and diurnal cycle excitation by equatorial wave dynamics**

**\*** Wave dynamics with Kelvin wave act to suppress diurnal cycle when active convection has passed???

## Conclusions

\* Amplitude of diurnal cycle changes by as much as 10mm/day over land in opposite phases of MJO cycle.

\* LWR escape is not a good proxy for precipitation over land as of the computing of MJO harmonics

\* When diurnal amplitude peaks, over land it is so strong that diurnal cycle almost entirely accounts for daily mean precipitation

**\* Two-way scale interaction between MJO and diurnal cycle exist – large-scale environment by MJO modulates diurnal cycle and strength of diurnal cycle modifies MJO structure. This two-way scale interaction between diurnal cycle and MJO has consequences for forecasting precipitation in region and for simulation of MJO by GCMs.**

\* Model studies can hopefully test physical mechanism in this paper for MJO phase lag between diurnal cycle and large-scale MJO envelope.

# Essential Reading – Modulation of Station Rainfall over the western Pacific by the MJO – Adrian Matthews, 2005

## Abstract

\* Rainfall difference between wet and dry MJO phases in Northern Winter is about 6mm/day. Climatological mean is 12mm/day.

\* Anomalies have strong spatial coherence, with over 80% of individual point station anomalies having the same sign as large-scale rainfall anomaly

## Intro – MJO basics

\* Large scale deep convective rainfall anomalies propagating slowly eastward from Indian Ocean – 30-60 days and passes Indo and W. Pacific.

\* Although station data are point measurements and gridded satellite products are area averages, we need to analyse station data to get extra info on small-scale spatial variability and coherence of rainfall patterns.

## Data and methods

\* Individual stations grouped into 10 x 10 degree boxes to better capture MJO variability

\* MJO most coherent during northern winter – so analysis only during Nov-Apr seasons from 1979-80 to 1996-97/

\* Agreement between station data and CMAP satellite data good

## Results

\* Out of 117 stations, 99 show dry anomaly in dry phase of MJO while 17 show wet anomaly.

\* Thus, 86% point rainfall measurements at individual stations agree with MJO

\* In wet phase, 77% of individual stations record wet conditions – strong relationship between sign of individual station rainfall anomalies and sign of the large-scale pattern.

## Conclusions

\* Raw station data very effective at identifying MJO signal over W Pacific.

\* Difference between wet and dry anomalies normally 2-6mm/day but in climatological is 4-12mm/day

\* Station data show spatial coherence of MJO rainfall signal, as approximately 80% of individual point stations have same sign rainfall anomaly as the large-scale signal from satellite data. Hence, station data GOOD!

# The Effect of the MJO on station rainfall and river level in the Fly River system, Papua New Guinea

## Abstract

\* Same basics on MJO and that MJO is felt most directly at local level – looking at the Fly River system at Papua New Guinea – at the heart of MJO envelope

\* 16-year time series of daily rainfall at 15 stations along river system exhibits strong MJO modulation in rainfall. Spread of rainfall between individual MJO events small enough such that rainfall distributions between wet and dry phases of MJO were clearly separated at catchment level.

\* So successful prediction of large-scale MJO envelope is practical for forecasting local rainfall.

## Introduction

\* MJO basics

\* Societal effects of precipitation felt at small local scales

\* MJO effects at local scales!

\* Same idea of large-scale LH release over warm tropical waters along with highest rainfall on planet – these trigger planetary Rossby waves and thereby a strong controlling influence on global circulation and climate.

## Findings

\* Rainfall data at each station on Fly River System show strong and coherent MJO signal.

\* MJO passage felt best at local scale – more relevant for societal impacts

\* Known biases between TRMM and station rainfall

\* Using microwave remote sensing as in TRMM has problems over orography

\* TRMM underestimates precipitation from deep convection in South America – and deep convection is a major component of precipitation over tropical mountainous regions such as New Guinea. TRMM has a dry bias of estimated 10mm/day and for a high station 20mm/day (e.g. Andes)

\* But TRMM also can overestimate in circumstances in the dry season (May-August). It underestimates in the wet season!

\* So cannot rely on just TRMM – need ground truthing!

\* Peak rainfall within MJO cycle in Phase 4 normally at all stations – exact timing between phase 3 and 4 of peak not robust though

\* The peak is so early – based on the outgoing LWR (OLR) – but OLR is not always a valid proxy! - agreed with other article

\* At catchment scale, the Fly River system shows a clear MJO signal in river level

\* Large-scale features of MJO skilfully forecast out to around 20 days lead time. So downscaling to local level important – using local station data to translate large-scale MJO forecasts into locally relevant quantities along Fly River.

\* This is very useful for local farming purposes.