UGRL Presentation script

# 1. Introduce

1. Hi everyone, I’m Isaac Tan and I am here to present some findings from my research this summer on the characterisation of the sea breeze over Indonesia and its importance for severe weather – supervised by Dr. Cathryn Birch and Ms Beth Woodhams.

# 2. Outline

I’ll firstly give you a background of what this project involves and the motivation for it. This leads on to the project aims. I will then describe some of the methods used briefly to obtain my results and findings on MATLAB, and there I aim to present some of the key findings from the project. Finally, I will give a brief summary based on my findings.

# 3. Background

## 4. Project Outline

* My project explores the variation (and perhaps interaction) of sea-breeze strength with the larger-scale Madden Julian Oscillation (MJO) and its associated importance on the development of severe weather over the Maritime Continent (MC).
* According to Mori et al (2004) it is already proposed that 70% of rainfall over Sumatra island in Indonesia results from convection, which initiates in the late morning and late evening due to local convergence of sea breeze against mountains and land breeze against background Westerly winds. (Go to 5)

1. These convective clouds normally develop within 1-4pm local time. Mori et al illustrate that within each diurnal cycle, spatial rainfall variability is caused by migration of peak rainfall from the coastline to inland areas during the day and then towards offshore regions at night. (Animate and point to illustrate analysis of the figure)

* (CLICK) Such findings are crucial when it comes to forecasting severe weather in the MC.

## 6. MJO

* The MJO features a large-scale eastward propagation of rainfall over a region of warm SST in the tropics and is an important component of intraseasonal variability in the region, and that of the regional-scale environment and Mesoscale circulations.
* Over a 30-90 day cycle, this enhanced convection zone moves from the Indian Ocean all the way to Western Pacific. We split one MJO cycle into 8 distinct phases based on the spatiotemporal distribution of enhanced and suppressed convection. (CLICK - Describe animation)

1. The figure here from Birch et al just shows also what I described in the animation – I will use this figure again in later slides.

## 8. Sea breeze

8. The sea breeze relates to wind blowing from sea to land due to the temperature gradient where land areas receive more solar heating in the day due to the high heat capacity of water. (CLICK) At night, this reduces to a land breeze as the land cools more rapidly than the sea.

1. Birch et al. showed a relationship between sea breeze strength and onshore wind in relation to MJO phase using coarse resolution (12km models and high-resolution (4.5km) models.

* Here, there is a clear relationship between onshore wind and MJO phase– greatest magnitude in suppressed phase and lowest in enhanced agreed in both models.
* But there is significant disagreement in the relationship between sea breeze strength and MJO phase between the two models – in other words, there is no clear signal of sea breeze by MJO phase, presenting limitations and difficulties in tropical weather forecasting
* (CLICK) Yet the sea breeze is what instigates convergence of wind over the land area, triggering convection that could grow into squall lines and result in severe weather. (This air diverges aloft – conservation of energy)

# 10. Project aims

1. (Hence), the aim of my project is to use Automatic Weather Station (AWS) data to verify model simulations that variation in onshore wind does indeed vary by MJO phase.

* This would clarify the relationship between sea breeze and MJO and how these influence severe weather within the MC to aid in improvements of forecasting such phenomena in the tropics.

# 12. Methods

Brief overview of methods I used to obtain results and findings of this project

1. Firstly, I created a map to visualise the locations of all 137 AWS stations using MATLAB. I split the map into 9 sectors to conveniently determine the angle of onshore wind relative to the North vector by rotating the U and V components of wind such that the V vector is perpendicular to the coast.
2. An example of this rotation can be seen below – (Must explain briefly).
3. To assess the data quality of each station, I looked at a plot of the mean diurnal cycle of onshore wind on MATLAB for a given year – 2005 using the rotated angles determined for each station. Initially, I defined the quality based on the number of “zeros” present (i.e. if there are many means it’s likely that observations were not taken at specific times”. (SHOW EXCELLENT, DECENT, AND ACCEPTABLE) – ***STATION MAP!***
4. Even then, only 61 stations were considered acceptable – meaning that over half the stations were not used due to lots of missing data (or the station didn’t exist in the climatological records!)
5. Later on, my supervisors pointed out that I actually had to redefine the threshold for “acceptable data” as there were many values of ZERO causing issues in the overall diurnal cycle of onshore wind and sea breeze plots. So we came up with 2 conditions that were incorporated into the MATLAB script:
6. Wind speeds must be within -20 and 20 knots – anything above or below generally stick out occasionally and may disrupt the overall plots
7. The proportion of 0s in each plot must <12.5% - since there are 8 observations each day, if there are 12.5% zeros it means that measurements may not have been taken at a specific time of the day and should have been recorded as missing values
8. Hence here is a new station map showing which stations can be used
9. I then split this map into 3 sectors to account for the longitudinal time difference and onset of MJO as the onset starts off in the West.
   1. Western Domain – Birch et al 2016 paper fig 1
   2. Central Domain – Java Borneo
   3. Eastern Domain – Sulawesi

The same process from steps 3-5 was used for the temperature component of this project – this is to explain why the sea breeze strength might vary with MJO phase.

## 20. Results and findings – I used MATLAB for all of them

1. Firstly, here are the plots for mean and median diurnal cycle of onshore wind (i.e. rotated wind vector at 1400 LST) for each sector. The idea is to compare means and medians such that if they are similar, a small number of very large or small values will not impact the overall mean. I also included overall plots for all stations (22)
2. There are differences between the means and medians though! For the Onshore wind charts (pick any two) the peak onshore wind differs in MJO phase for means and medians (state which phase peaks in mean and which in median). This peak generally at 6 UTC, which is roughly 1400 LST in the MC! (CLICK) ***Here, observations agree (with the Birch et al figure) that in phases 6-8 and 1 (dry phases), it is strongest from the birch et al figure with all the phases, and that 3-5 (wet phases) is weakest – for diurnal cycle.***
3. Here are the charts for the mean and median sea breeze by MJO phase firstly in all stations. The sea breeze for each MJO phase (SB1400LST) is the diurnal anomaly of mean onshore wind at 1400 local standard time (LST) (WS1400LST - WSdailymean).

**(1)**

1. I also plotted on single axes, the mean and median sea breeze for each sector to account for the longitudinal time difference – this makes it easier to make comparisons amongst individual sectors (all tend to be lower during phases 3-6) – (wet phases and transition to dry phase).
2. Here is my plot of mean sea breeze (blue) in the Birch et al western domain based on obs vs the Birch et al 2016 Fig 11 model data (explain colours). Below we can compare quantitatively the difference between observation and model data. I believe that this difference is because the model is not reducing the sea breeze enough in phases 3-6. However there is better agreement between models and obs in other phases.

***(CLICK) In summary, model data tends to underestimate both the magnitude of troughs and peaks of the sea breeze (i.e. too low for peaks and too high for troughs) as in the first place, would struggle to reproduce the MJO. Hence, it is already good they even show a weak signal!***

## Temperature data

1. Regarding temperature, data quality was generally much better. There was only the odd spurious value and very few missing data points. Hence, I only allowed MATLAB to exclude data where temperature readings fall below 16C and rise above 37C. These thresholds are based on theoretical extremes for the region.
2. So this is just visualising what a typical temperature plot would look like, and also one with an extremely spurious value – -47C! Because it would never be so cold in the MC, that point must be excluded so that the overall trend is not affected.
3. Once again, I have kept a record of the mean and median diurnal cycle of temperature by MJO phase in each sector. Generally, day time temperature is highest (i.e. warmest) in phase 8, 1-2 (dry phases) and lower in the wet phases which is what we would expect since cloud cover is highest in the wet phases, meaning that less strong solar radiation heats up the land. The plots also agree that overnight temperatures are highest in the wet phases since cloud cover traps heat in the night, limiting cooling – diurnal cycle temperature contrast in wet phases is generally less in the dry phases as would be expected – results look very promising as such!
4. And also that of all stations (can do blue explanation here instead but keep it flexible)
5. Here is the mean and median temperatures at 1400LST by MJO phase for all 41 stations. The temperature by MJO phase (TEMP1400LST) is the mean diurnal anomaly of the temperature at 1400 LST (T1400LST - Tdailymean). Again, means and medians are compared such that a small number of spurious values will not affect the overall mean.

**Notice the temperature values are not the actual temperature as we are taking the temperature at 1400 LST (peak temperature) minus the daily mean – so this value is that difference just like the sea breeze by MJO phase.**

1. I also plotted on single axes, the mean and median temperature for each sector for the longitudinal time difference again – as expected, all tend to be lower during phases 3-6) – (wet phases and transition to dry phase).
2. Next are the findings from model data of divergence averaged over 42 days at 1400 LST – which is the peak sea breeze and a couple of hours before storms typically fire up. Using this time makes it easier to see the difference in the magnitude of convergence/divergence by MJO phase. So here is phases 1-4
3. And here is phases 5-8. Even by this, it is still fairly challenging to contrast the differences by eye. In theory, the convergence should be strongest in the dry phases and weakest in the wet phases according to the Birch et al paper. But generally, wind converges for the most part.
4. So I took the difference between the phases 3 and 6 (wettest and driest). The areas in red highlight that convergence in phase 6 is stronger since the difference is a positive value. E.g. if phase 3 had a convergence of -2, and phase 6 had -3, the difference between 3 and 6 will be +1. So the red portion over the Sumatra and Malaysian coastlines for example represents this correctly (point)

***MORE STUFF***

1. ***Additional findings***
2. Cross correlation of sea breeze lag (both mean and median) due to different timings of MJO onset – compare 3 combinations of 2 sectors (describe – also that differences not really seen in the median but more so in the mean)
3. Mean and median onshore wind for all sectors by MJO phase. It was worth plotting this since I was also going to analyse the lag through x-correlation.
4. Which is shown here
5. Similarly for temperature – same fact that median doesn’t show much difference by sector but for the mean this time trends are as expected as there is most lag between west and east, but hardly between west and central, and central and east since they are adjacent.
6. Finally, I analysed the x correlation for sea breeze vs. temperature by corresponding sector. And for all, it can be seen that the lag is 0 – no lag means these two components are perfectly correlated.

# Summary

1. Based on my findings, it is clear that model simulations are generally verified by the observations – satisfying the aim. It is already really good that the model can reproduce even a weak MJO signal as they struggle to do so.

* Onshore wind trends description
* Model divergence data confirms the trends
* Cross correlations – describe trends

1. Thank you – end of presentation
2. References