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 from TRMM)

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. To go into a little more detail:

* Phase 1 – wet and warm over land, dry sea
* Phase 3 – wet over both land and sea – cool land
* Phase 4 – cool land, wet over sea, dry land
* Phase 6 – warm land, dry everywhere
* Shows balance between large scale MFC and MFD, cloud cover, and mesoscale circulations (black arrows)
* (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)

# 8. 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.

# 10. 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) – hence, only data of excellent quality was used.
4. Here is a new station map showing which stations can be used (elaborate blue and green)
5. 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.

## 16. 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 all stations. 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. There are differences between the means and medians though as 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.***
2. These are the charts for the mean and median sea breeze by MJO phase firstly over 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. 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!***

1. In addition to the Birch et al paper, 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). 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 clear in the mean although they should be negatively correlated since MJO onset is 1st in west then later in east)
2. I also kept a record of the mean and median diurnal cycle of temperature by MJO phase – here showing all stations. 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! Data quality here is also much better than that of temperature with only the odd spurious or missing value.
3. Now here are 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. I also analysed the x correlation for sea breeze against temperature by corresponding sector. And for all, it can be seen that the lag is 0 – no lag means these two components are in phase, which shows a clear relationship between SB and temperature.

# Summary

1. Based on my findings, we can see that onshore wind is strongest in the dry phases and weakest in the wet. Such trends are also evident in temperature data. Model simulations were generally verified by obs for SB strength. Although the lag between west central and east should be –ve correlated, they are not clearly defined possibly due to some noisy data, but it is already surprising that there is a weak MJO phase signal altogether. Finally, x-correlations confirm that SB and temperature are in phase – clear relationship.
2. So in terms of any future work, these findings are potential for a GRL paper titled: “Signal of MJO is apparent in mesoscale circulation observations from AWS”.

* Also, possibilities for next summer include:
* Severe weather case studies using model data
* Relationship between MJO and severe weather cases
* Or cases of severe storms in the UK – radar analysis

These are all not set in stone yet but are just some ideas from CB for my second year of research in the UGRL programme.

1. Thank you – end of presentation
2. References

Model divergence (extra)

1. 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
2. And here are 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.
3. 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)