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**BSc Meteorology and Climate Science**

**Project title: Characterisation of the sea breeze over Indonesia and its importance on severe weather**

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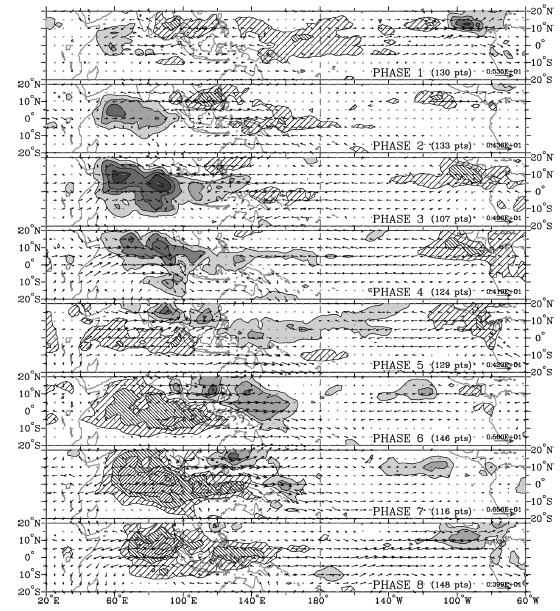
**UGRL Scholarship Report – Summer 2016**

# Project Outline

#### Overview and background

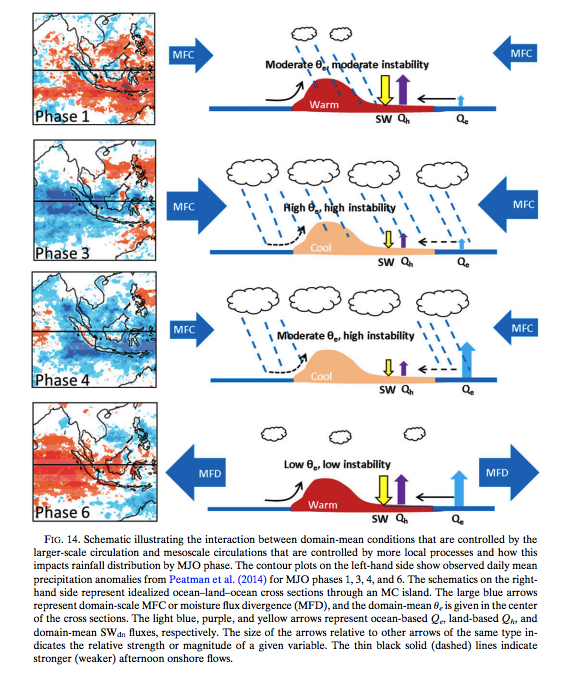
My UGRL research project explores the variation of sea-breeze strength with the larger-scale Madden Julian Oscillation (MJO) and its associated importance on the development of severe weather over the Maritime Continent (MC). The MJO is an important component of intraseasonal variability in the tropics, featuring large-scale eastward propagation of rainfall over a region of warm sea surface temperatures originating over the Indian Ocean and propagating over the MC into the Western Pacific within a 30-90 day period (Zhang, 2005 cited in Birch et al., 2016). Wheeler and Hendon (2004) have divided one MJO cycle into eight distinct phases based on the spatiotemporal distribution of enhanced and suppressed convection (Figure 1).

***Figure 1: Eastward propagation of enhanced convection (dark shading) based on MJO phase (Taken from Fig. 8, Wheeler and Hendon, 2004).***



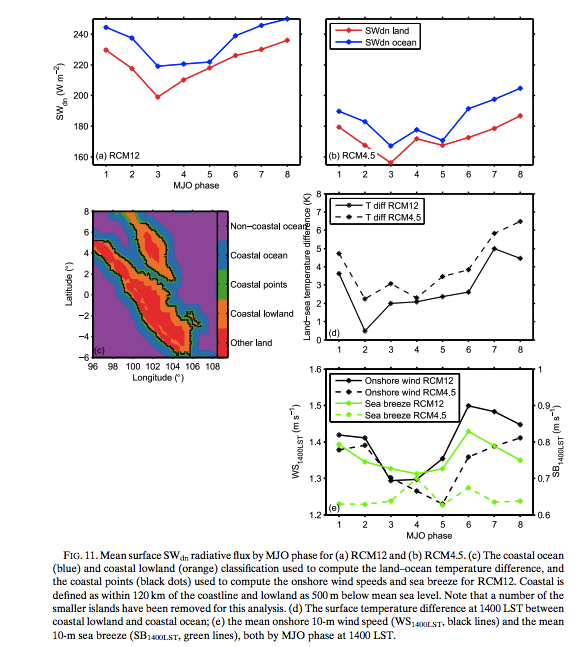
Over the MC, convection is generally enhanced during phases 3-4, and suppressed from phases 6-7 but there are differences between the anomalies over land and see in some phases (left-hand side of Figure 2). In phase 1 there is a wet anomaly over the land but a dry anomaly over the ocean. The reverse is true in phase 4, with a dry anomaly over land and a wet anomaly over the ocean. In the peak of the wet and dry phases (3 and 6 respectively) the anomalies are the same over land and sea. Birch et al. (2016) utilised high-resolution climate simulations to understand the differing behaviour by MJO phase in terms of synoptic-scale and mesoscale dynamical and thermodynamical processes.

***Figure 2: Convection anomalies over the MC in association with MJO phase (Taken from Fig. 14, Birch et al., 2016).***



According to Birch et al. (2016), there is moderate large-scale moisture convergence (MFC) and rainfall is concentrated over the land surface in phase 1. The reduced cloud cover in this phase means there is strong solar radiation (SWR) during the day that drives and sustains a strong land-sea breezeland-based convection in phase 1. This phase occurs before the arrival of the main large-scale MJO convective envelope in the Western MC in phase 3, where MFC is strongest, promoting wet conditions, high cloud cover and high instability over both land and sea due to enhanced convection despite weaker incoming SWR and a weaker sea breeze. Rainfall is mostly concentrated along the coasts and sea by phase 4 as MFC is reduced, large-scale conditions are insufficient to maintain wet anomalies over land and the high cloud cover weakens the sea breeze. By phase 6 the winds diverge (i.e. negative MFC), promoting stable and dry conditions over both land and sea. This is a main feature of the suppressed MJO phases. Such divergence during the negative MFC approaches 0 by phase 8, setting up the environment for the next MJO cycle. Hence, the MJO cycle is an important control of wet and dry anomalies in the large-scale environment and mesoscale circulations.

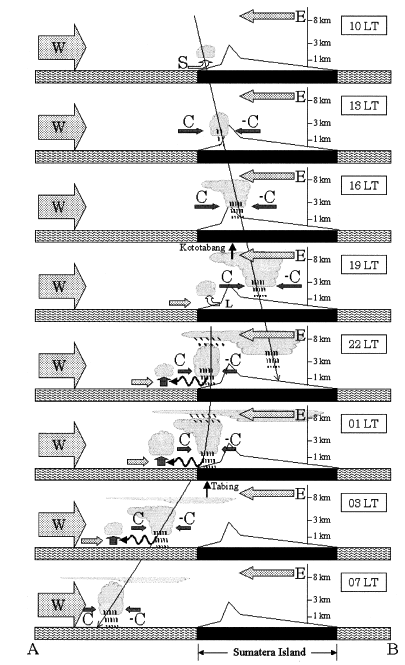
Models from Birch et al. (2016) then explore how sea breeze and onshore wind strength vary with MJO phase (Figure 3).



***Figure 3: The relationship between sea-breeze strength and MJO phase using coarse resolution (12km) models (RCM12) and high-resolution (4.5km) models (RCM 4.5) (Taken from Fig.11, Birch et al., 2016).***

The magnitude (WS) of onshore wind is similar in both the RCM12 and RCM4.5 in the sense that the wind strength is greatest during the suppressed phases of the MJO. However, there is significant disagreement with the sea breeze strength (i.e. the difference between the onshore wind at 1400LST and mean onshore wind) between the two models (Birch et al., 2016). This is a consequence of higher and more variable mean nocturnal wind speeds in RCM4.5 relative to RCM12, removing the clear signal of sea breeze by MJO phase, presenting limitations and difficulties in tropical weather forecasting.

Particularly over Sumatra Island in Indonesia, the sea breeze instigates the convergence of wind over inland areas (Figure 4), which triggers convection that could grow into squall lines that potentially result in severe weather (i.e. Sumatra Squalls).



***Figure 4: Diurnal cycle of convection and convective rainfall migration in Sumatra Island resulting from local convergence of sea breeze against mountains and land breeze against the background westerly (W) wind (Taken from Fig.12, Mori et al., 2004).***

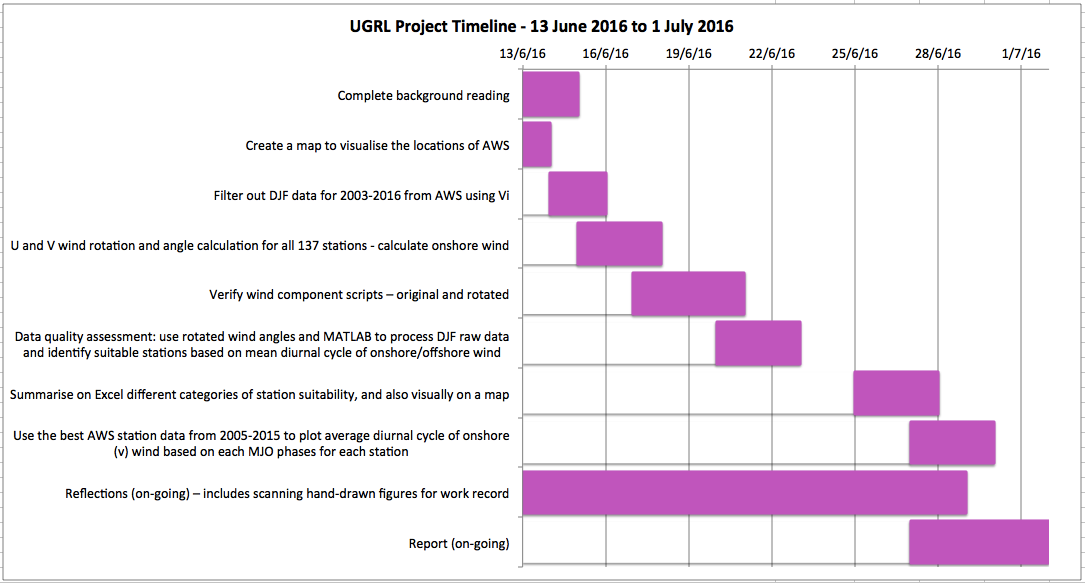
Findings from Mori et al. (2004) from satellite observations illustrate that around 70% of rainfall over the inland region of Sumatra Island during the evening is resultant of convection. Convection initiates in the late morning and late evening due to local convergence of sea breeze against mountains and land breeze against background westerly winds. Most convective clouds along the SW coastline of Sumatra Island typically develop within 1300-1600LT. Spatial rainfall variability is also caused by the migration of peak rainfall from the coastline to inland areas during the day, and towards offshore regions at night. These findings are crucial in regards to forecasting severe weather over the MC and tropical regions.

Project aims

In my project, analysis of AWS aims to verify model simulations that variation in onshore wind truly varies by MJO phase. This would illustrate how the sea breeze and its scale interaction with the MJO influences severe weather within the MC and aid in improvements of tropical weather forecasting of such phenomena.

# Project Highlights

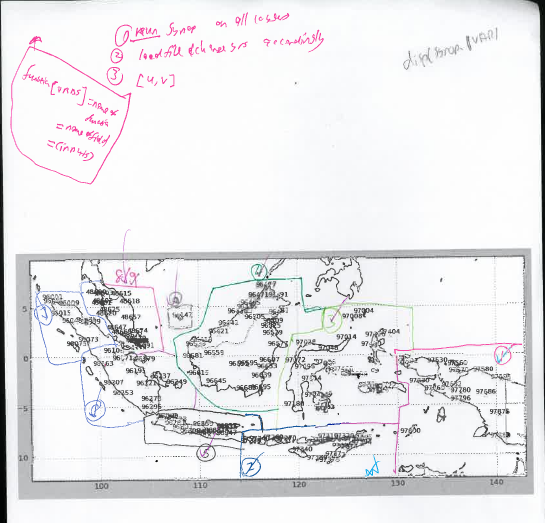
#### 13 June 2016 to 1 July 2016

**** During the first three weeks of the UGRL Scholarship project work, I have gained a basic understanding of the syntax and applications of Linux and MATLAB. These, along with knowledge of some simple Vi commands, were essential in processing the large quantities of AWS data within the MC. I have established a clear idea of the overall project goals, and that of this 3-week period (Figure 4).

***Figure 5: UGRL Project Timeline for the first half of Summer 2016 illustrated in a Gantt chart***

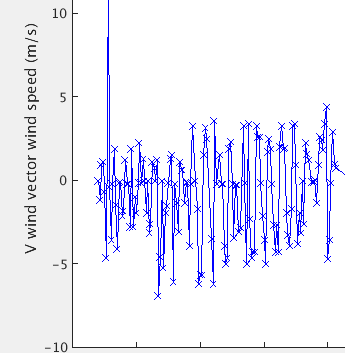
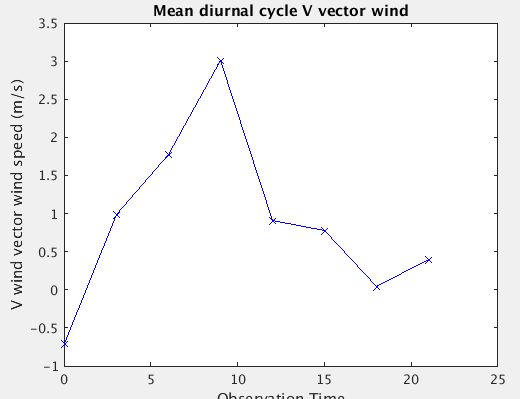
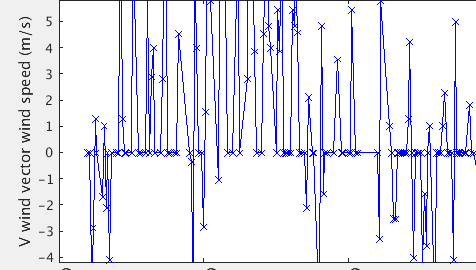
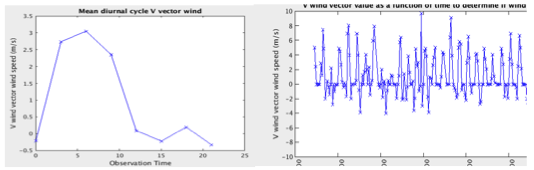
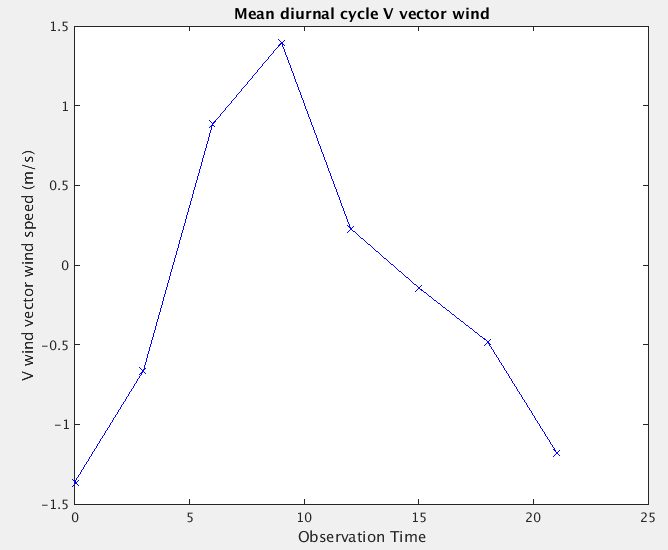
Based on my progress so far, some important figures, maps, and example datasets have been documented below. These include:

* Initial map of the MC produced in MATLAB to visualise the spatial locations of all AWS (Figure 6).
* Annotations on a zoomed in map to illustrate an example of determining the angle of rotation of the onshore (v) component of wind that is perpendicular to the coast (Figure 7).
* Example plots of the mean diurnal cycle of onshore wind in a given year using the rotated angles that was made for each station to assess AWS data quality (Figures 8-10). An example of one station with excellent data, decent data, and just acceptable data respectively was used to illustrate the qualitative criteria for determining AWS data quality.
* Another map of the MC to show the spatial distribution of stations of excellent quality, acceptable quality, and unacceptable quality (Figure 11).
* Mean diurnal cycle of onshore wind from good and excellent quality AWS data that is based on each of the eight MJO phases. An example plot for station 96315 was included in this report (Figure 12).

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***Figure 6: Initial map of the MC to visualise AWS locations. The map was split into 9 main sectors for the calculations of onshore (v) wind rotation angles.***

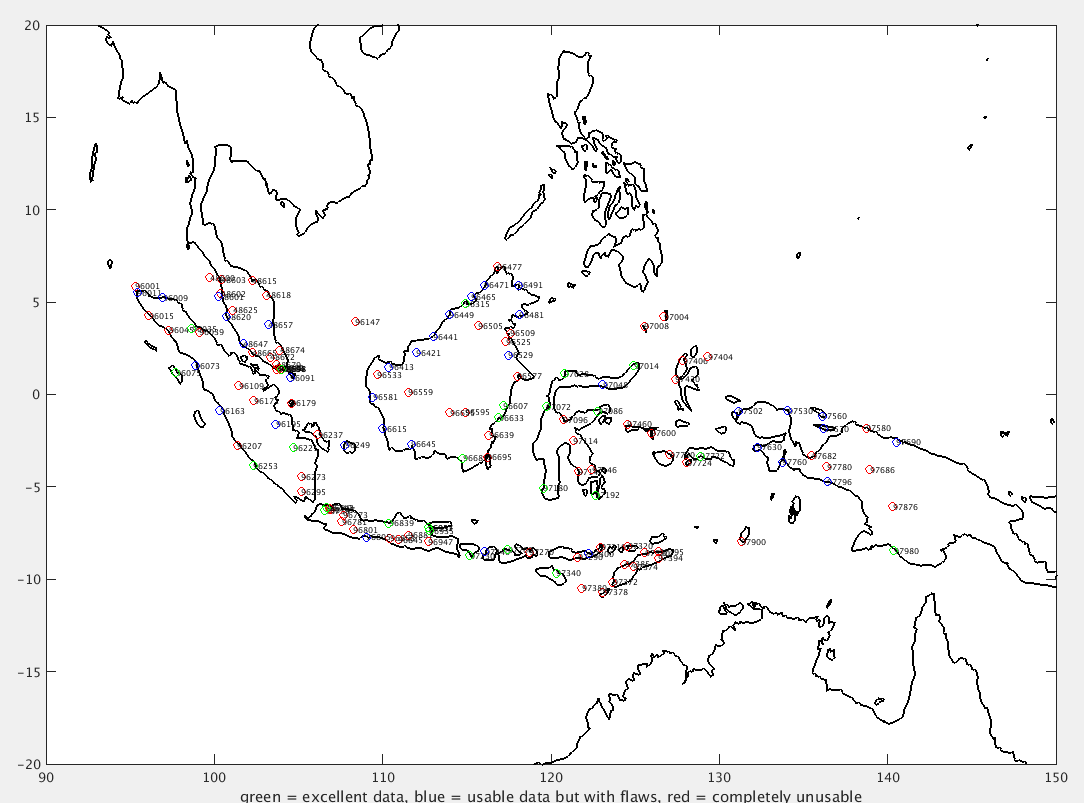
***Figure 7: Example map sector (Map 7) that was used to determine onshore wind rotation angles.***



***Figure 9: Data quality assessment – example of a station with good data (station 97014 in Map 3). Here, there is some missing information, but the diurnal cycle of onshore wind generally aligns with that of model simulations.***

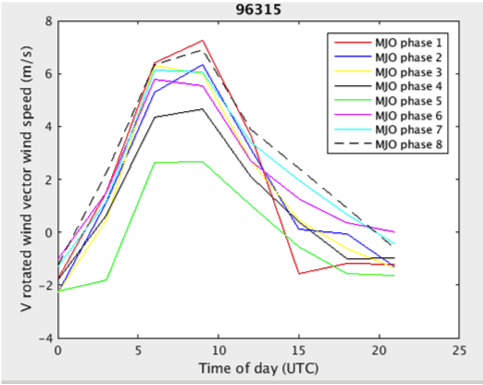
***Figure 10: Data quality assessment – example of a station with only just acceptable data (station 96685 in Map 4). Here, there are substantial quantities of missing information, but the diurnal cycle of onshore wind generally aligns with that of model simulations. Any data of poorer quality was disregarded***

***Figure 8: Data quality assessment – example of a station with excellent data (station 97230 in Map 2). Here, there are little to no missing information, and the diurnal cycle of onshore wind aligns with that of model simulations.***



***Figure 11: Map of the MC showing the spatial distribution of stations with good/excellent data (green dots), acceptable data (blue dots), and unacceptable data (red dots).***

***Figure 12: Mean diurnal cycle of onshore wind (rotated v) for each MJO phase – example station 96315.***



#### Project highlights 2 September 2016 to 23 September 2016

Target: Present project work in a group meeting over next 3-week period.

# (WRITE THIS AFTER THE SECOND PERIOD OF SUMMER) – FIG 5 here too with 2nd Gantt Chart

# Skills and knowledge obtained

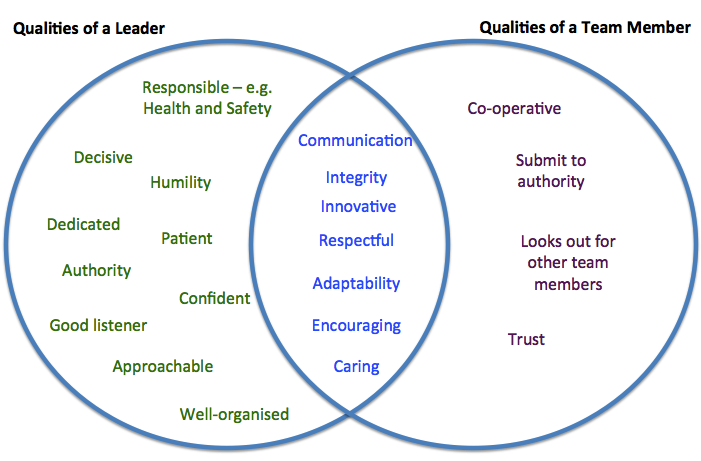
#### Project Work

Regarding my research project, I had the opportunity to extend my knowledge on the meteorological concepts learnt in Semester 2 2016. These relate to atmospheric processes and the basic principles of land/sea-breeze and diurnal cycles (e.g. SOEE 1400 lectures 10-11). Beyond first year meteorology, I gained a sound understanding of the MJO. The overall aim would be to analyse how the larger-scale MJO interacts with the smaller-scale sea breeze to enhance or suppress rainfall in the MC. This would apply the fundamental knowledge to the latest on-going research relating to such meteorological phenomena on a regional, and potentially global scale.

Skills obtained were generally technical and revolved around learning how to use Linux and MATLAB. I learnt and realised that these are essential tools for data analysis and modelling in current and future research.

#### Leadership Training Events

Beyond research skills, leadership training events with the other UGRL scholars at Weetwood hotel (8-9 June) and the Selside Outward Bound (23-24 June) equipped me with knowledge the essential qualities of teamwork and leadership skills (Figure 6) that I was also able to put into practice through practical team-building activities (i.e. wake-up shake-up). Both events enabled me to reflect on which qualities I possess, and those that need improvement.

Soft skills involving communication and project management were also emphasised, particularly during the talks at Weetwood hotel. Beyond team-building activities, I realised the importance of possessing competent presentation skills in terms of communicating my project and research to other stakeholders and audiences. The key messages to take away include:

***Figure 6: Some of the essential qualities in leaders and team members that were discussed during both the Weetwood event and the Selside Outward Bound illustrated in a Venn diagram.***

* Knowledge about my audience I am presenting to.
* Exhibiting authority and enthusiasm on stage – demonstrates confidence.
* Telling a story – beyond just the technical aspects of the research.

Prior to commencing my research project, I was also reminded of some of the skills required in project management. These broadly focused on exploring how project work differs from university coursework in terms of:

* Independence
* Relationship with supervisor
* Discovery of the unknown
* Flexibility to differ from original plan
* Time management – i.e. project stages, project specifications (e.g. technical requirements) and Gantt charts
* Critical thinking – not taking information at face value or analysing benefits and limitations of methods used for the project.

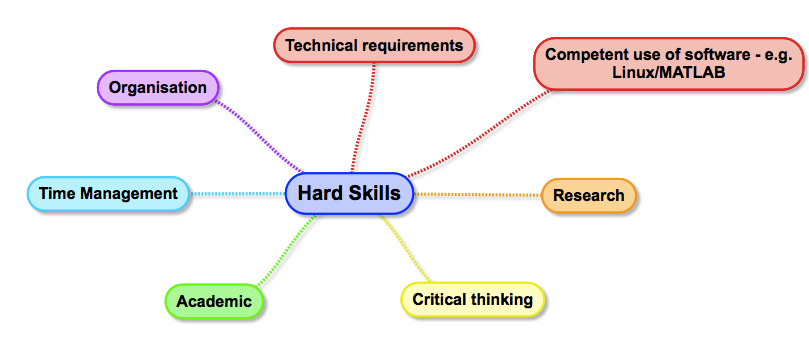
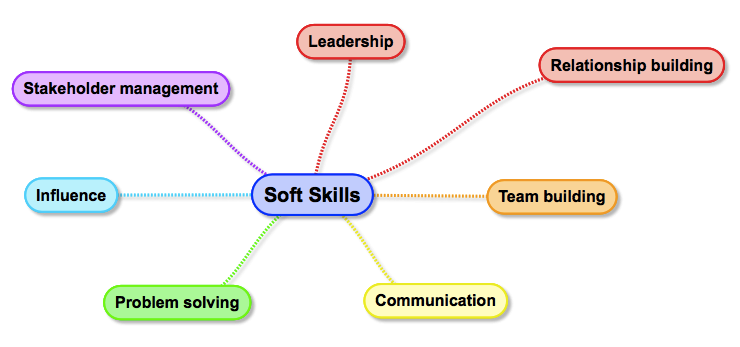
I believe that these skills are important leading up to my final year dissertation.

#### Other Opportunities

**Ambassadorial Duties as a UGRL Scholar**

Other opportunities that fostered my development of the essential soft skills in leadership involved volunteering to help out with events such as the Priestly International Centre for Climate (PICC), and the Centre of Excellence for Modelling Atmosphere and Climate (CEMAC) launch events. Both events involved ushering those attending to the right place, handing out brochures, and taking charge of registration. These events were a means to network with my fellow scholars, other students studying at Leeds over the summer, and my past and prospective lecturers. Getting involved in such activities inspired me to continue making full use of the opportunities available in regards to the scholarship.

#### Summary of hard and soft skills discussed/developed



***Figure 8: Soft skills developed during the UGRL Scholarship leadership training events and ambassadorial duties***

***Figure 7: Hard skills developed during the UGRL Scholarship research period***

# How the UGRL Scholarship has contributed to my career plans

Having been equipped with the relevant research and leadership skills, and engaging in opportunities that involve volunteering and networking, I believe that I have a clearer idea of my future career plans while the skills acquired would increase my employability. After working in an office for 6 weeks, and attending meetings and talks designed for lecturers and post-graduate students, I have embraced the notion of contributing to current research in a professional environment. This also helped me to realise that I would like a career that balances both technical office work, and practical outdoor fieldwork. (COMPLETE AFTER THE LAST 3 WEEKS)

(By the end of the 6 weeks, I’d probably not finished the whole project – so I can’t really say I know whether this is the field for me yet until next year’s report)

**Manchester RMET Conference 4-6 July 2016 – IN DC!**

# References

Birch, C.E., Webster, S., Peatman, S.C., Parker, D.J., Matthews, A.J., Li, Y., and Hassim, M.E.E. 2016. Scale Interactions between the MJO and the Western Maritime Continent. *Journal of Climate*. **29**(7), pp. 2471-2492.

Mori, S., Jun-Ichi, H., Tauhid, Y.I., and Yamanaka, M.D. 2004. Diurnal Land–Sea Rainfall Peak Migration over Sumatera Island, Indonesian Maritime Continent, Observed by TRMM Satellite and Intensive Rawinsonde Soundings. *Monthly Weather Review.* **132**(8), pp. 2021-2039.

Wheeler, M.C. and Hendon, H.H. 2004. An All-Season Real-Time Multivariate MJO Index: Development of an Index for Monitoring and Prediction. *Monthly Weather Review*. **132**(8), pp. 1917-1932.