A Comparison Study of Mei-Yu Front Structure and Impacts on Extreme Precipitation over Taiwan

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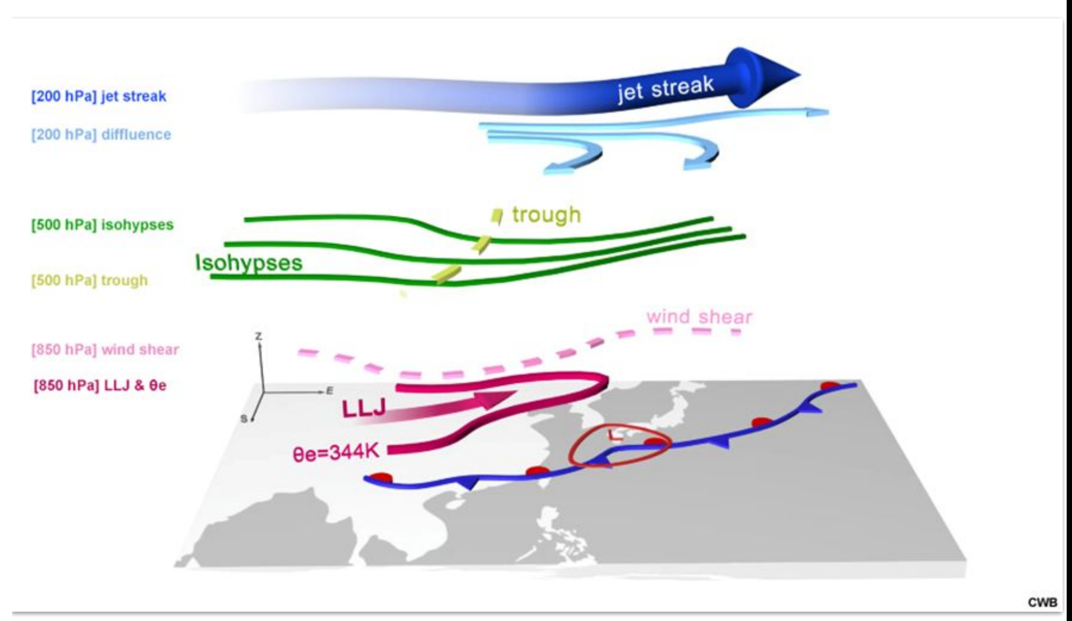
Introduction

The Mei-Yu Front is a stationary moisture boundary that annually produces heavy, sometimes torrential, rain. It forms when the southwest monsoon is strengthening and the northeast monsoon is weakening, neither is strong enough to displace the other, thus they create a stationary boundary. It is difficult for forecasters to predict the position of the front and the amount of rain it may produce. This also makes it hard to determine the type of threat this may have on citizens.

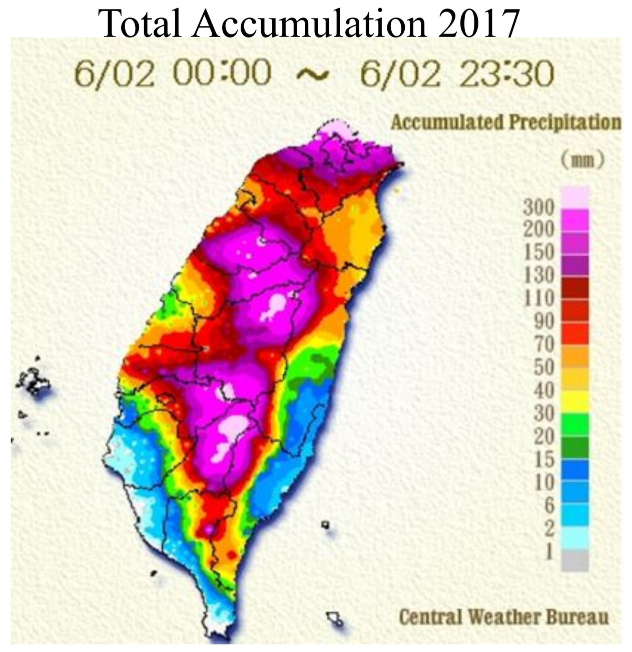


Methodology

We studied two cases where the front produced significant precipitation. The WRF model output I used has a 2 km domain. The times examined were 12Z 6/1/2017 - 12Z 6/3/2017 and 00Z 6/9/2019 - 00Z 6/12/17.

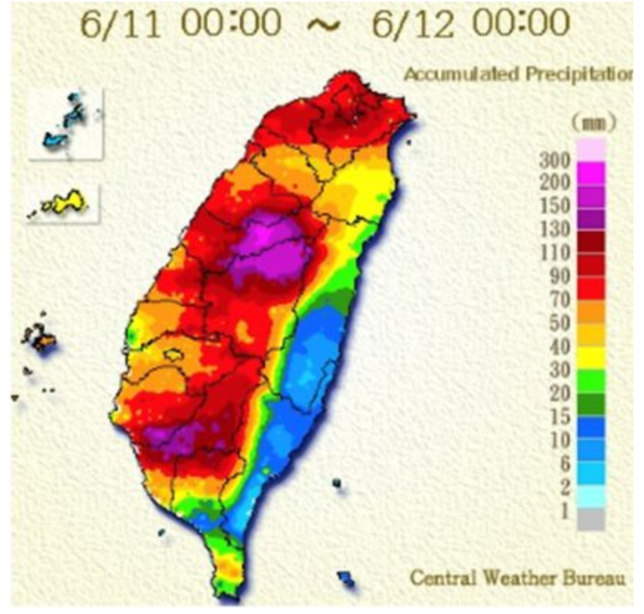
The Two Cases

Total Accumulation 2017



Rain accumulation ~600mm

Total Accumulation 2019

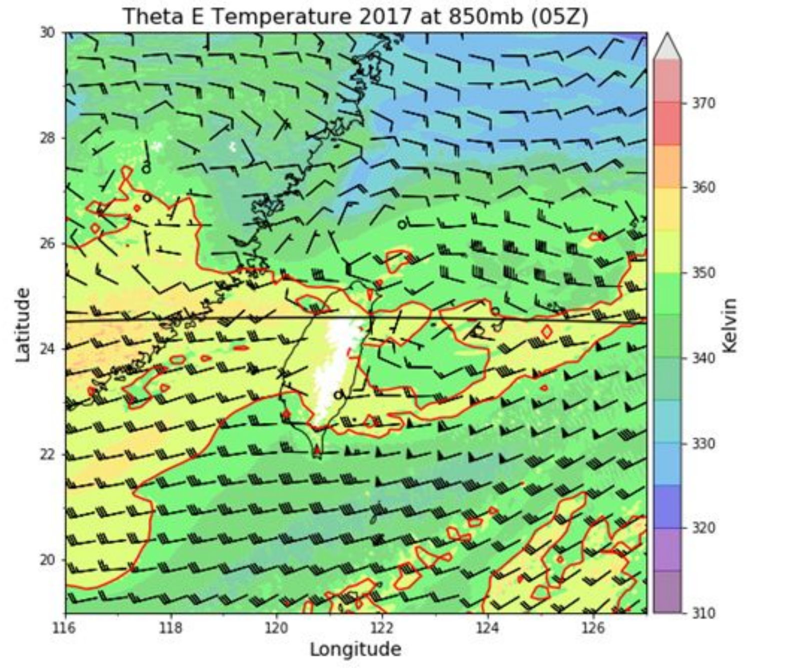


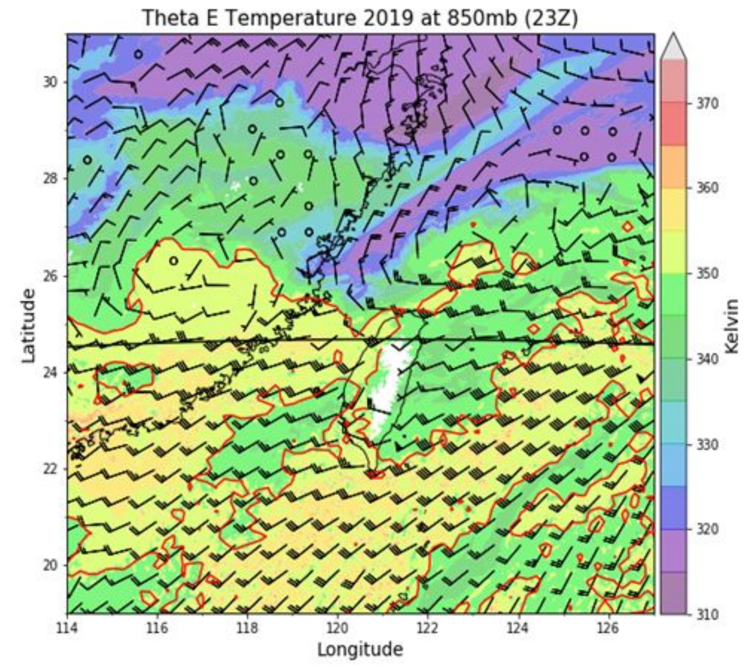
Rain accumulation ~300mm

Equivalent Potential Temperature and Wind Analysis

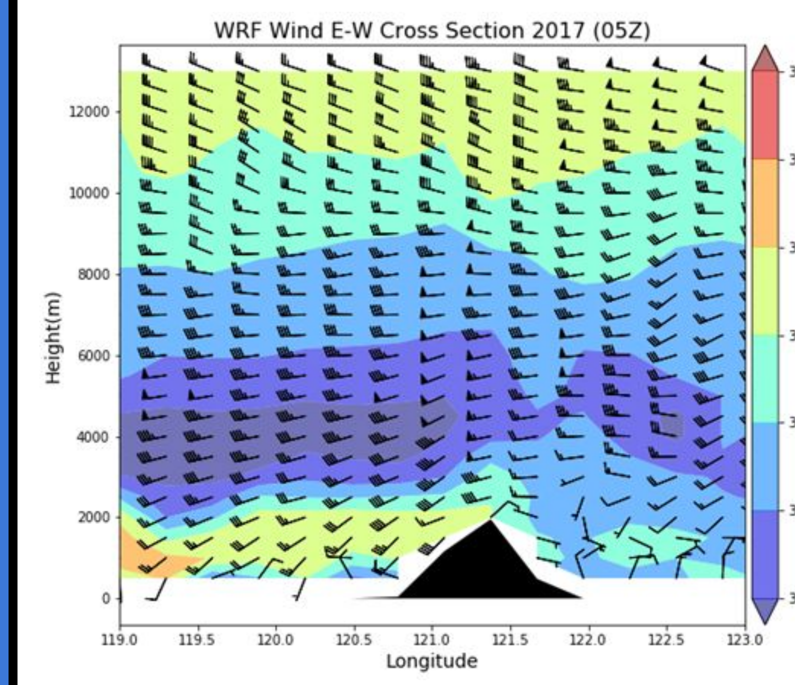
2017:
- Warm θ_e maximum is discrete and moderate winds direct the axis toward northern Taiwan.
- Strong winds advect moisture inland.

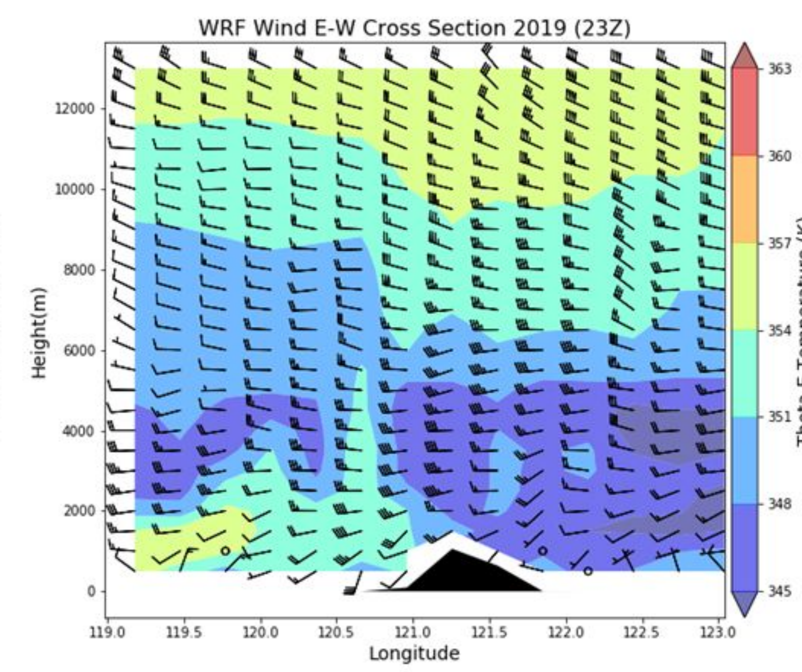
2019:
- There are sporadic areas of θ_e maximums
- The cold tongue extending southward may be inhibiting moisture production.





*The area outlined in red is equivalent potential temperature greater than 350 Kelvin
*Lines indicate vertical cross section



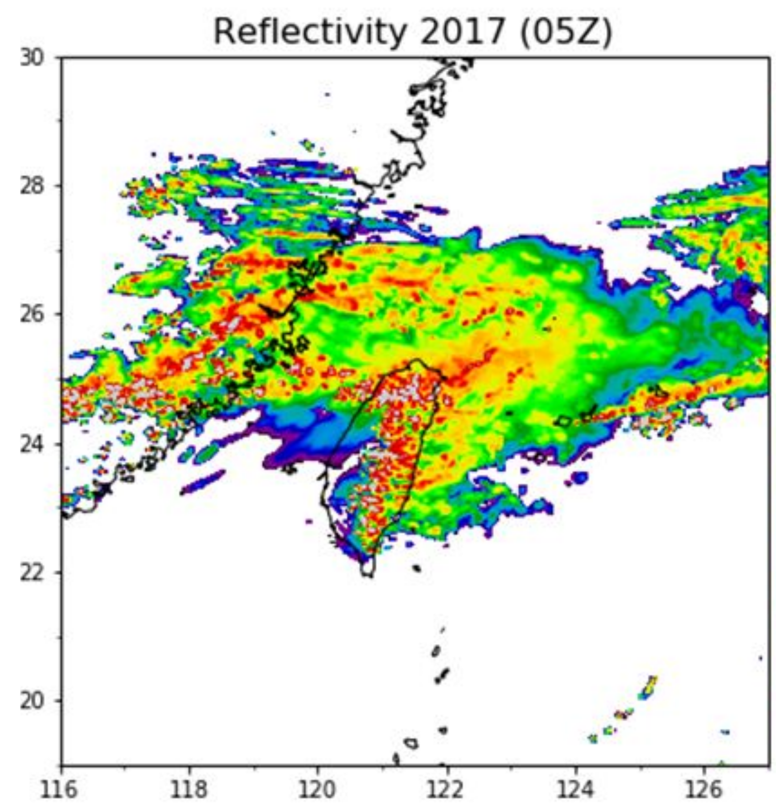


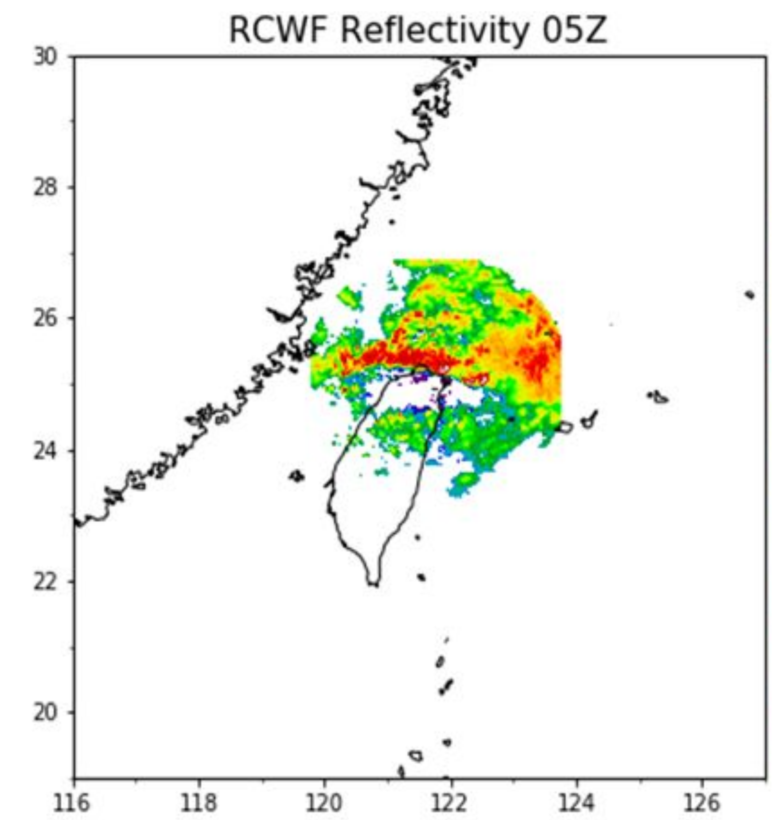
2017:
- Deep, warm wedge of low-level θ_e provides more moisture during frontal passage.
- High-θ_e air extends inland

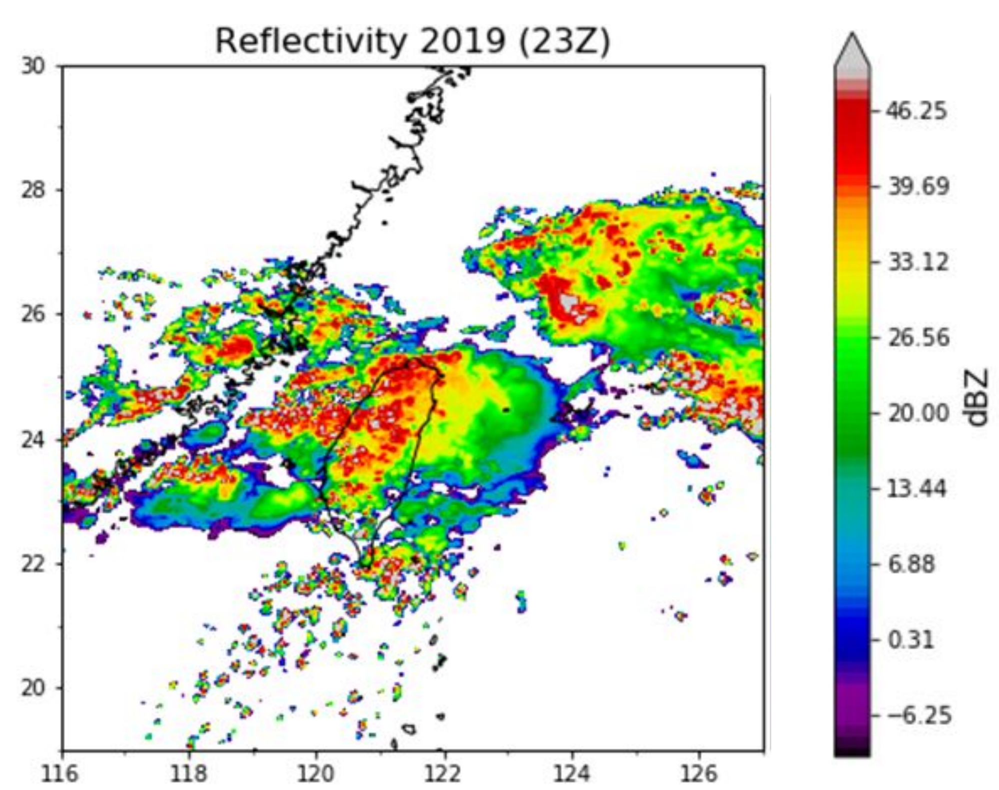
2019:
- There is a smaller wedge of θ_e present at lower levels
- Weaker winds provide less advection of warmer θ_e inland.

Reflectivity Analysis

- The WRF model reasonably represented the precipitation.
- A continuous rainband is produced along the front.
- Although not shown, the precipitation aligns with the shearline at the 975mb rather than the thermal boundary.





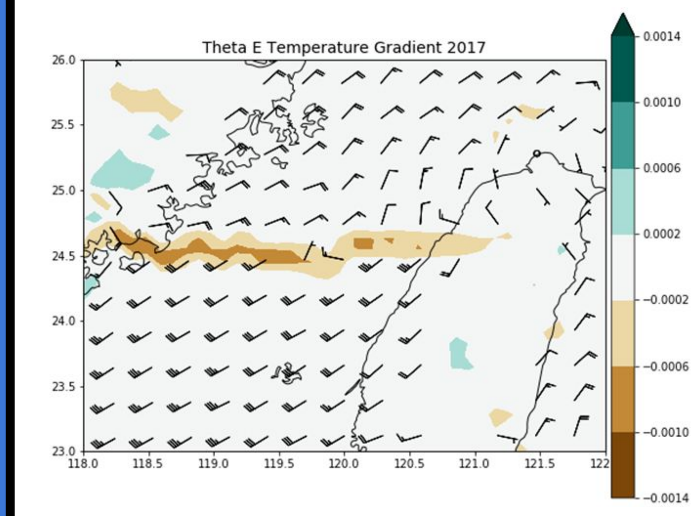


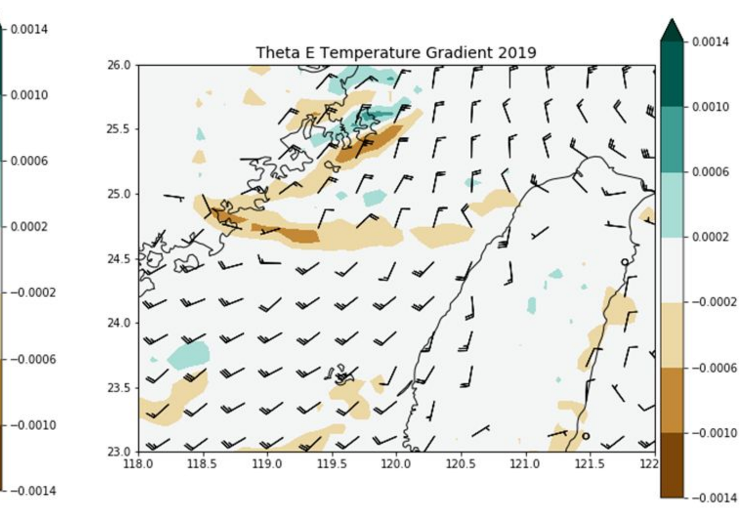
- I was unable to receive raw radar data for 2019.
- The rainband is discontinuous.
- Most of the more intense rain is located offshore

Statistical Analysis

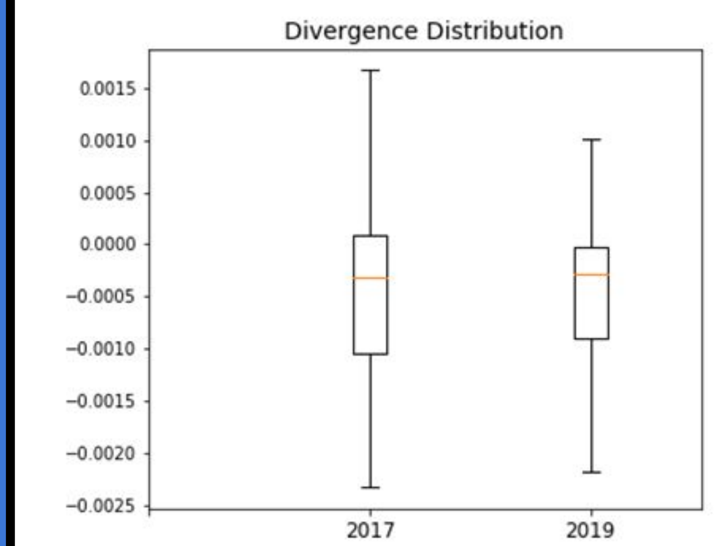
2017:
- Moderate winds advect strong θ_e gradient along the front inland.
- Gradient extends to the western shore.

2019:
- Weak θ_e gradient along the front provides less moisture
- Gradient does not extend onshore





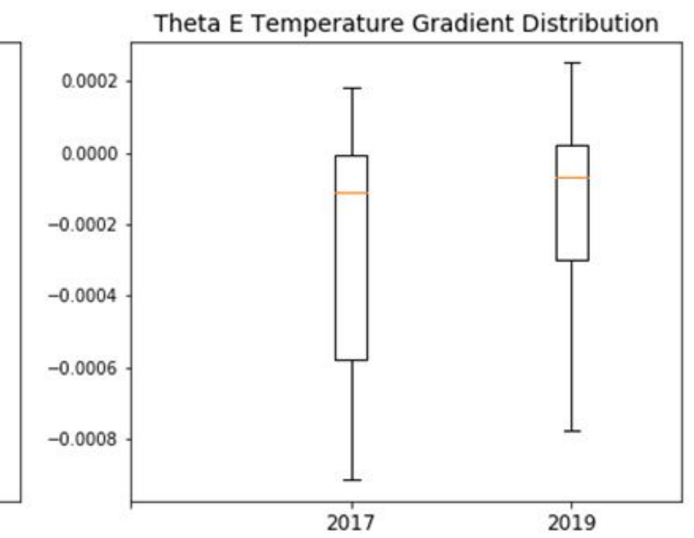
- Convergence along the front is not statistically different.
- It can be inferred these cases provided roughly the same amount of lift.
- The θ_e gradient distributions are statistically different at a 99% confidence level.



Wilcoxon-Mann-Whitney Rank Sum Test
Group 1: Div17
Group 2: Div19

	Group 1	Group 2
Count	150	150
Median	-0.000316949	-0.000285899

Median Difference	-3.10503e-05
Sum of Group 1 ranks	22499
Sum of Group 2 ranks	22651
Group1 U	11174
Group2 U	11326
P Value	0.9199
P Value method?	normal approximation



Wilcoxon-Mann-Whitney Rank Sum Test
Group 1: Eth17
Group 2: Eth19

	Group 1	Group 2
Count	150	150
Median	-0.000111718	-6.87202e-05

Median Difference	-4.29977e-05
Sum of Group 1 ranks	20440
Sum of Group 2 ranks	24710.5
Group1 U	9114.5
Group2 U	13386
P Value	0.004484
P Value method?	normal approximation

Conclusions

Both events produced generally the same amount of frontal convergence, however the differences in moisture set these two events apart. The 2017 case had more moisture availability and stronger winds. The 2019 case had weaker winds which were unable to advect much of the moisture over Taiwan. In 2020, there will be the PRECIP field campaign in Taiwan to better observe and study the Mei-Yu Front. The main goal is to help forecasters better predict the position of the front and how much rain it is possible of producing.

Acknowledgements

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