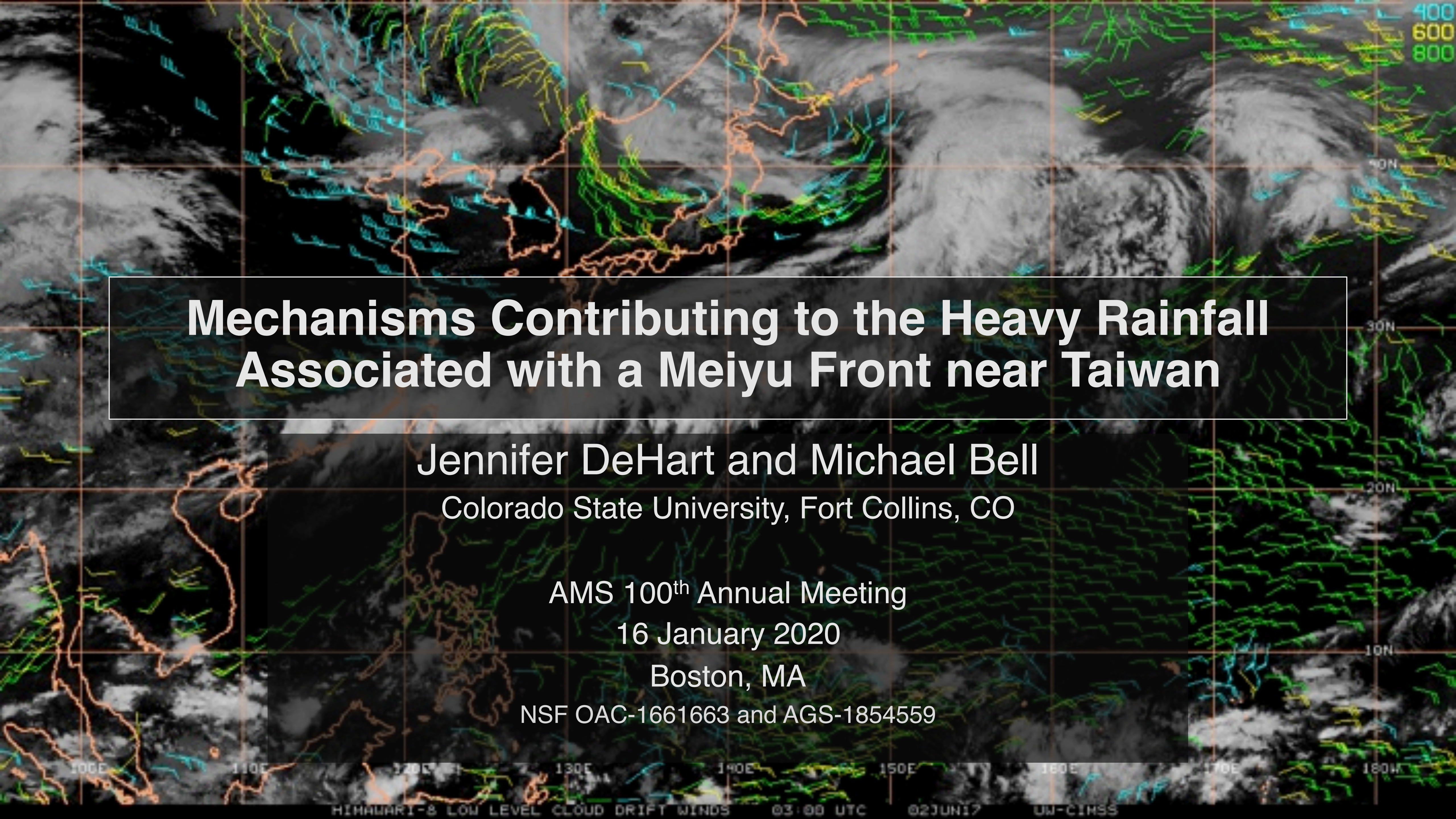


# Mechanisms Contributing to the Heavy Rainfall Associated with a Meiyu Front near Taiwan

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Colorado State University, Fort Collins, CO

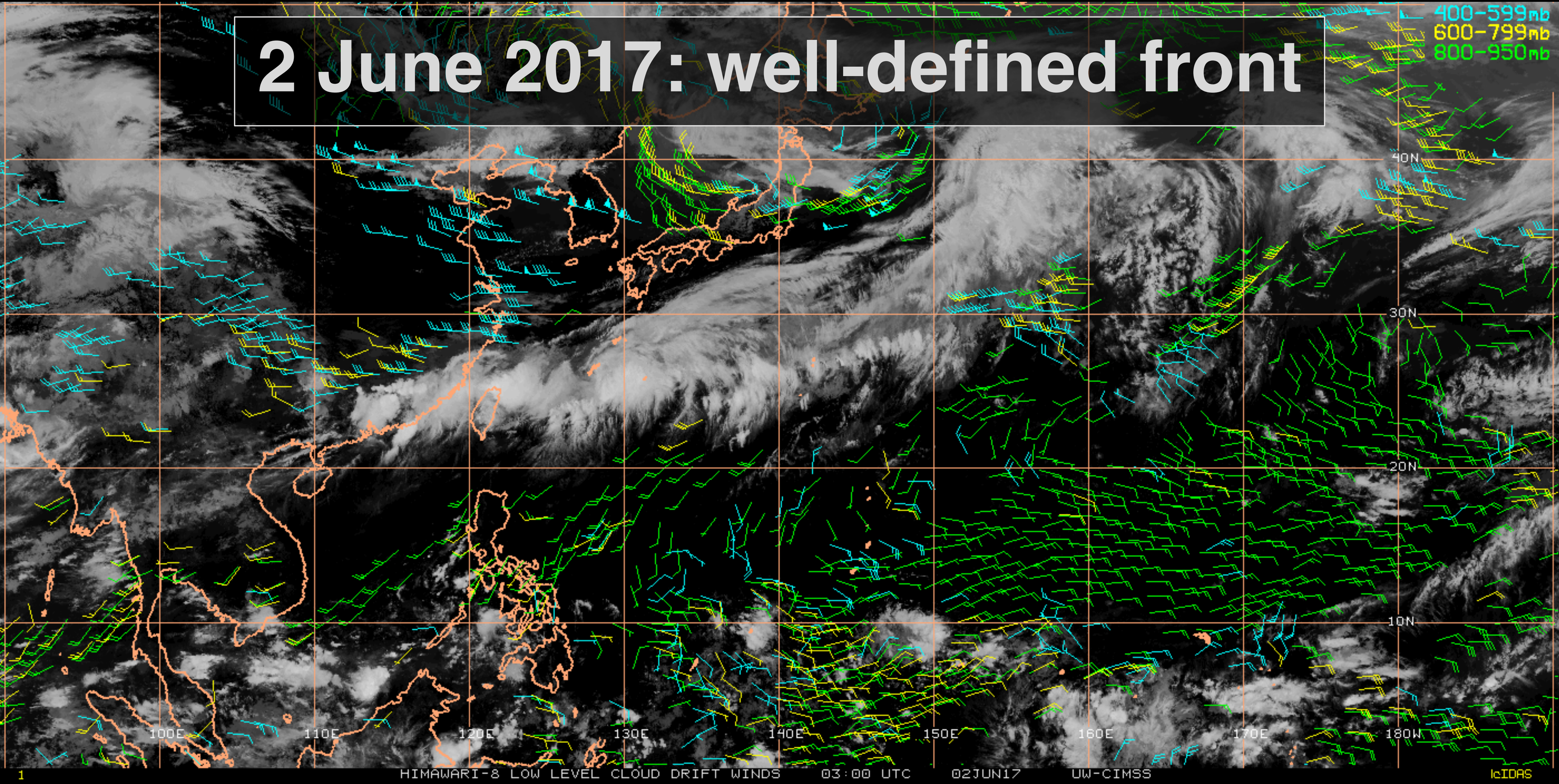
AMS 100th Annual Meeting

16 January 2020

Boston, MA

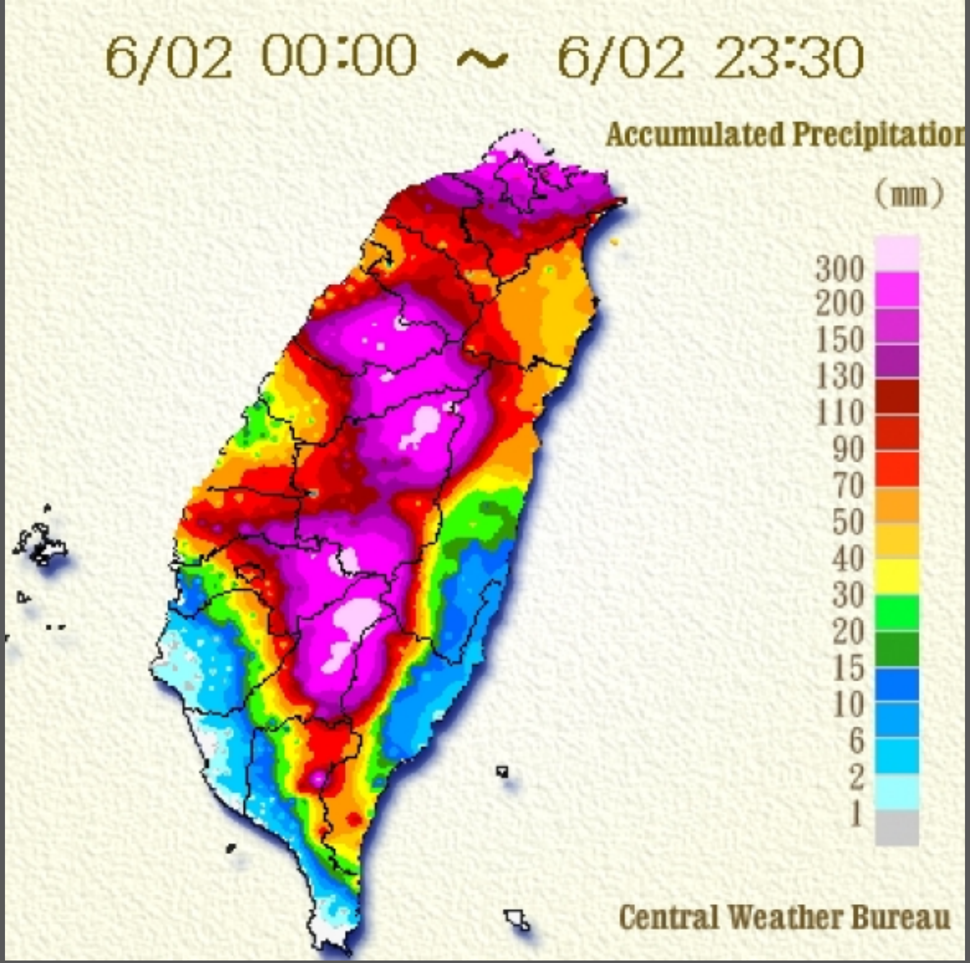
NSF OAC-1661663 and AGS-1854559

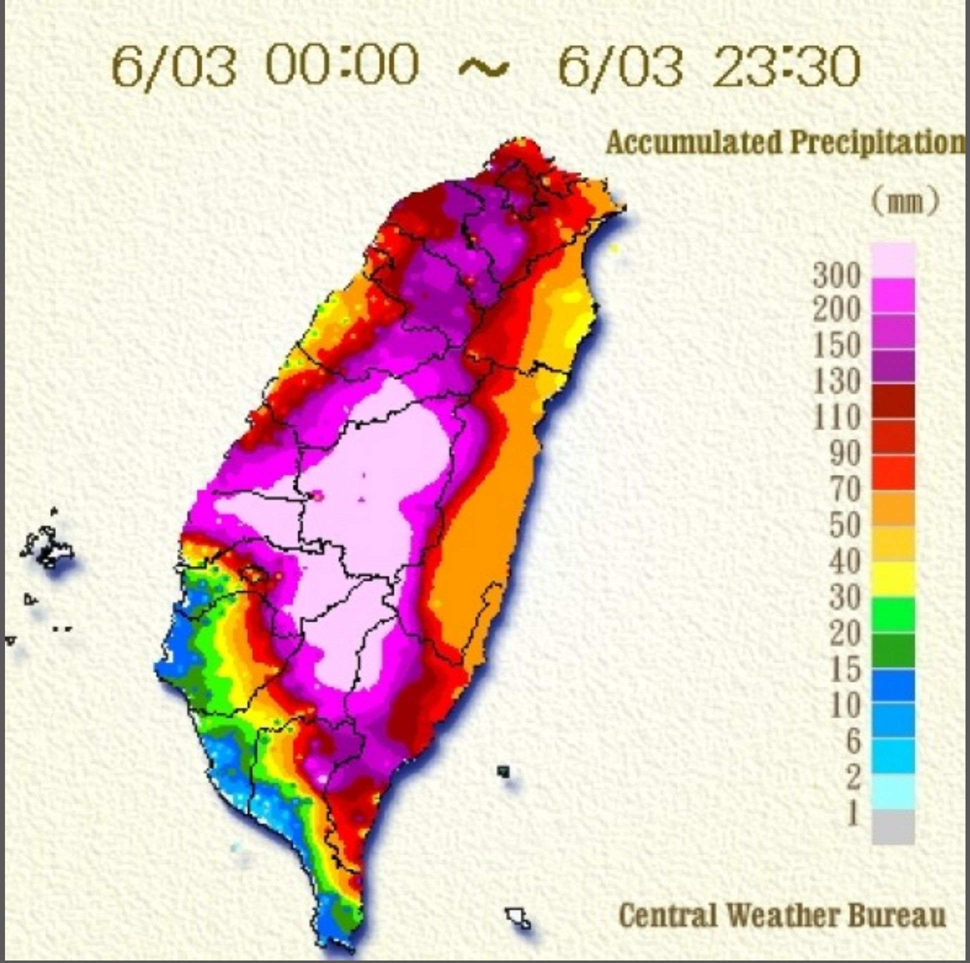
# 2 June 2017: well-defined front




03 UTC on 2 June: IR, low-level winds (c/o CIMSS)

# Widespread heavy rainfall across Taiwan on 2-3 June



# Motivates the PRECIP campaign

- PRECIP goal:
  - Identify the universal processes that produce heavy rainfall

# Overarching questions

- What mechanisms were responsible for heavy rainfall in the June 2017 case?
- What processes were important at different spatial and temporal scales?

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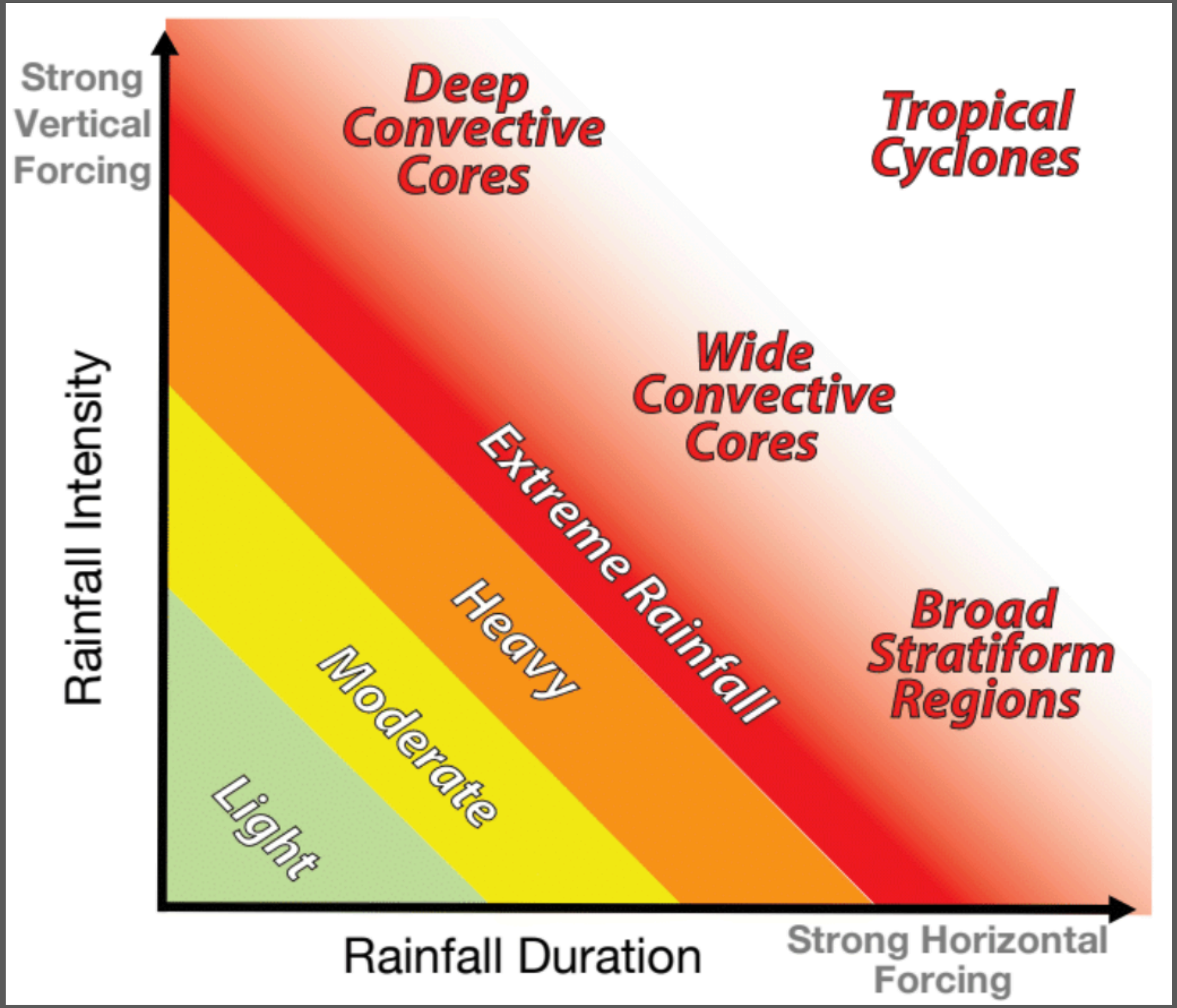
- What mechanisms were responsible for heavy rainfall in the June 2017 case?
- What processes were important at different spatial and temporal scales?

- Prior studies have examined large-scale forcing, cloud morphology, effect of cold pools, orographic influences
  - Sampe and Xie 2010, Xu and Zipser 2015, Chen et al. 2018

# Mechanisms behind heavy rainfall

- PRECIP hypotheses
  - Rainfall duration is related to horizontal moisture transport
  - Rainfall intensity is related to vertical forcing



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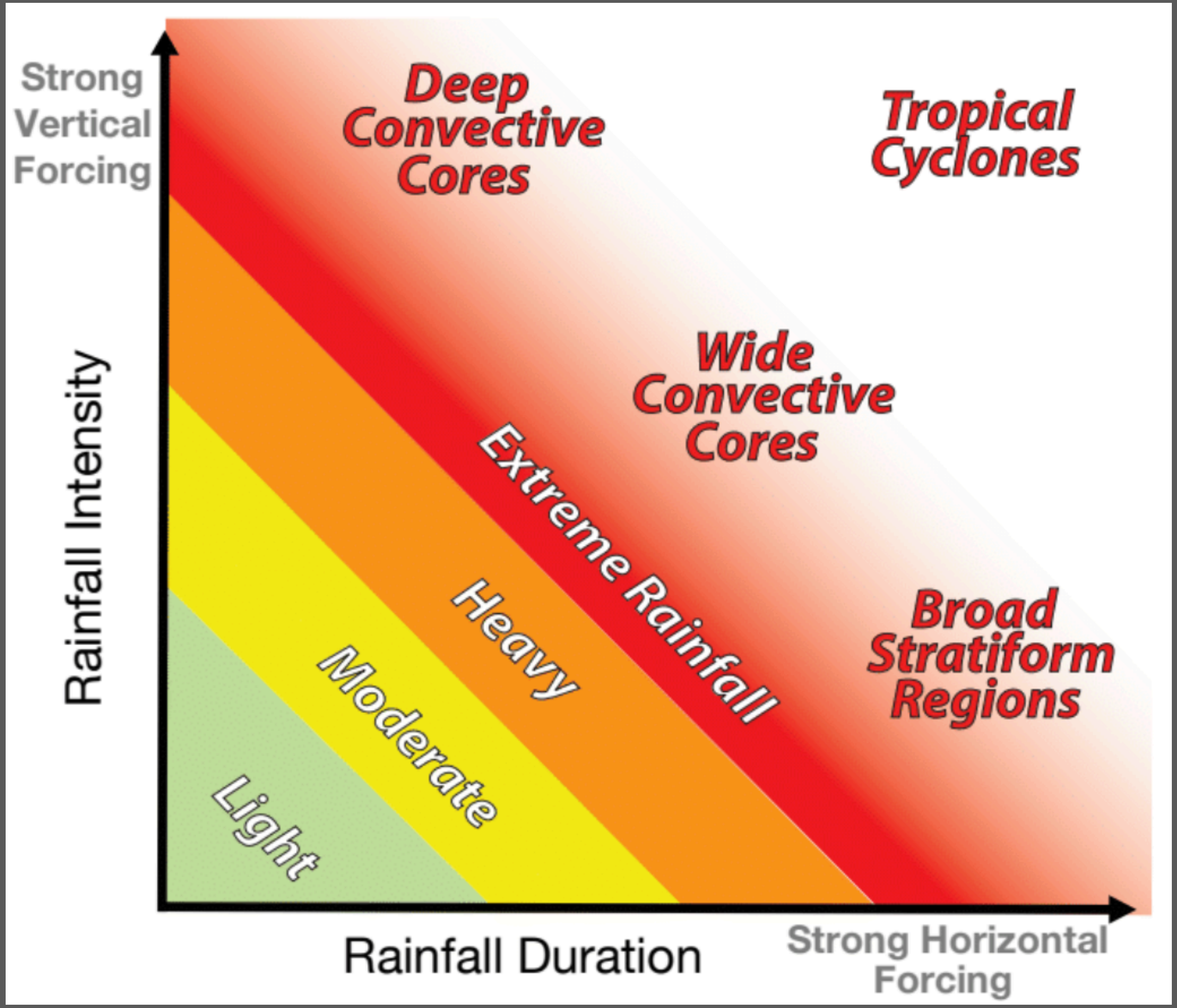


# Possible intense rainfall forcings

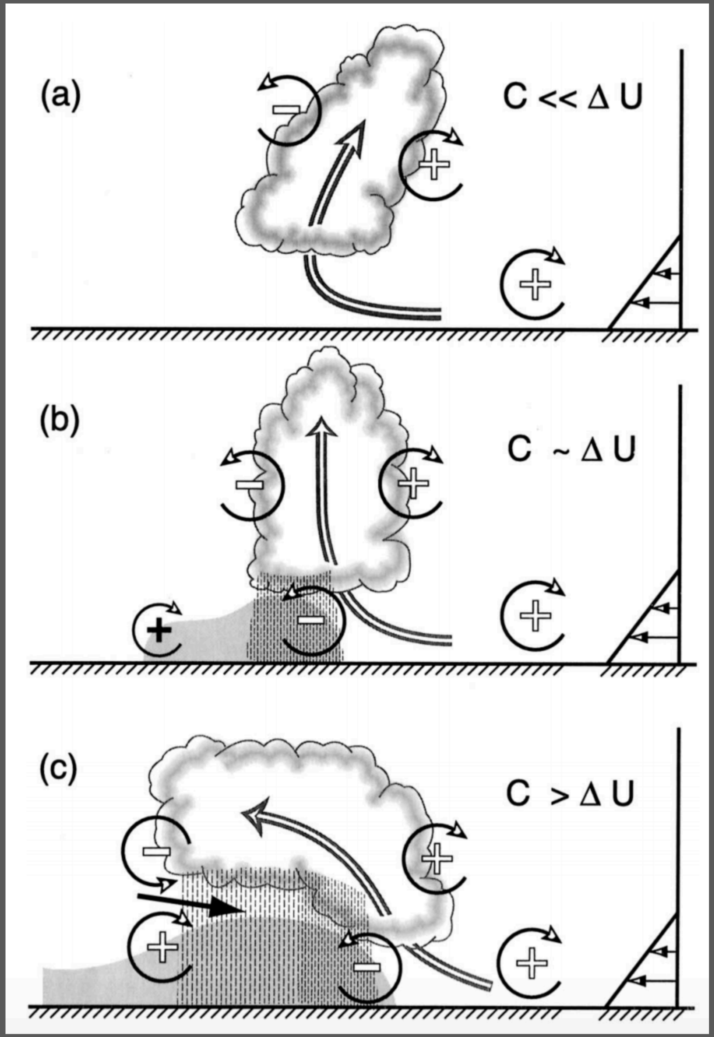
- RKW theory
- Vertical moisture flux
- Instability, efficient microphysical processes

$$R = Ewq\,.$$

**Doswell 1996**

# Possible intense rainfall forcings

- **RKW theory**: convection maximizes when cold pool and environmental shear balance
- Vertical moisture flux



# Possible intense rainfall forcings

- RKW theory
- **Vertical moisture flux:** the more moisture fluxed upward, the greater the chance of condensation and precipitation

$$R = Ewq\,.$$

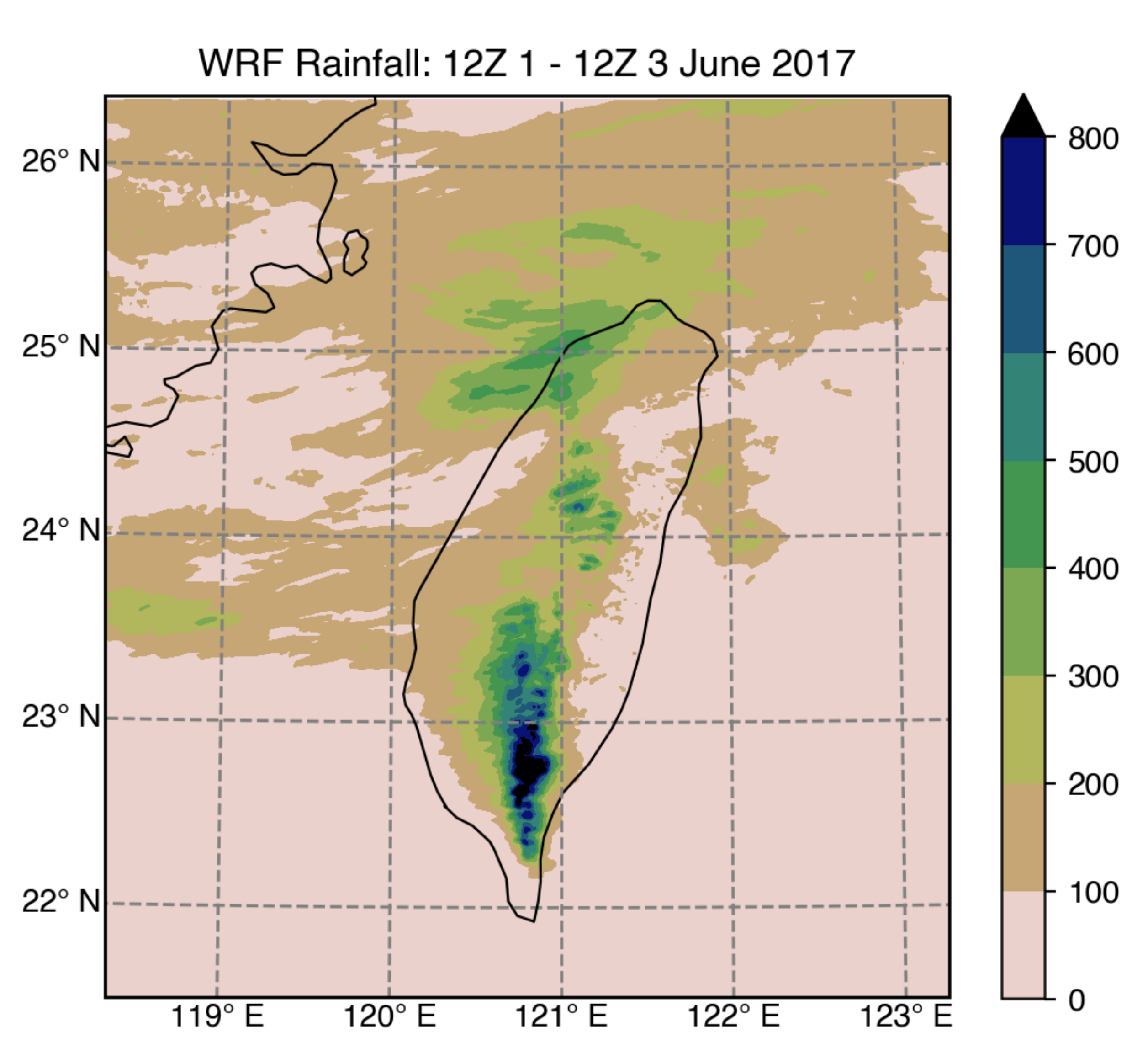
**Doswell 1996**

# WRF Simulations

- Domains: 6, 2, 2/3 km
- MP: Thompson aerosol aware

- 12Z 6/1 – 12Z 6/3
- 20 TST 6/1 – 20 TST 6/3

- **Total rain is similar spatially, but the maximum rainfall is further south and lower in magnitude**

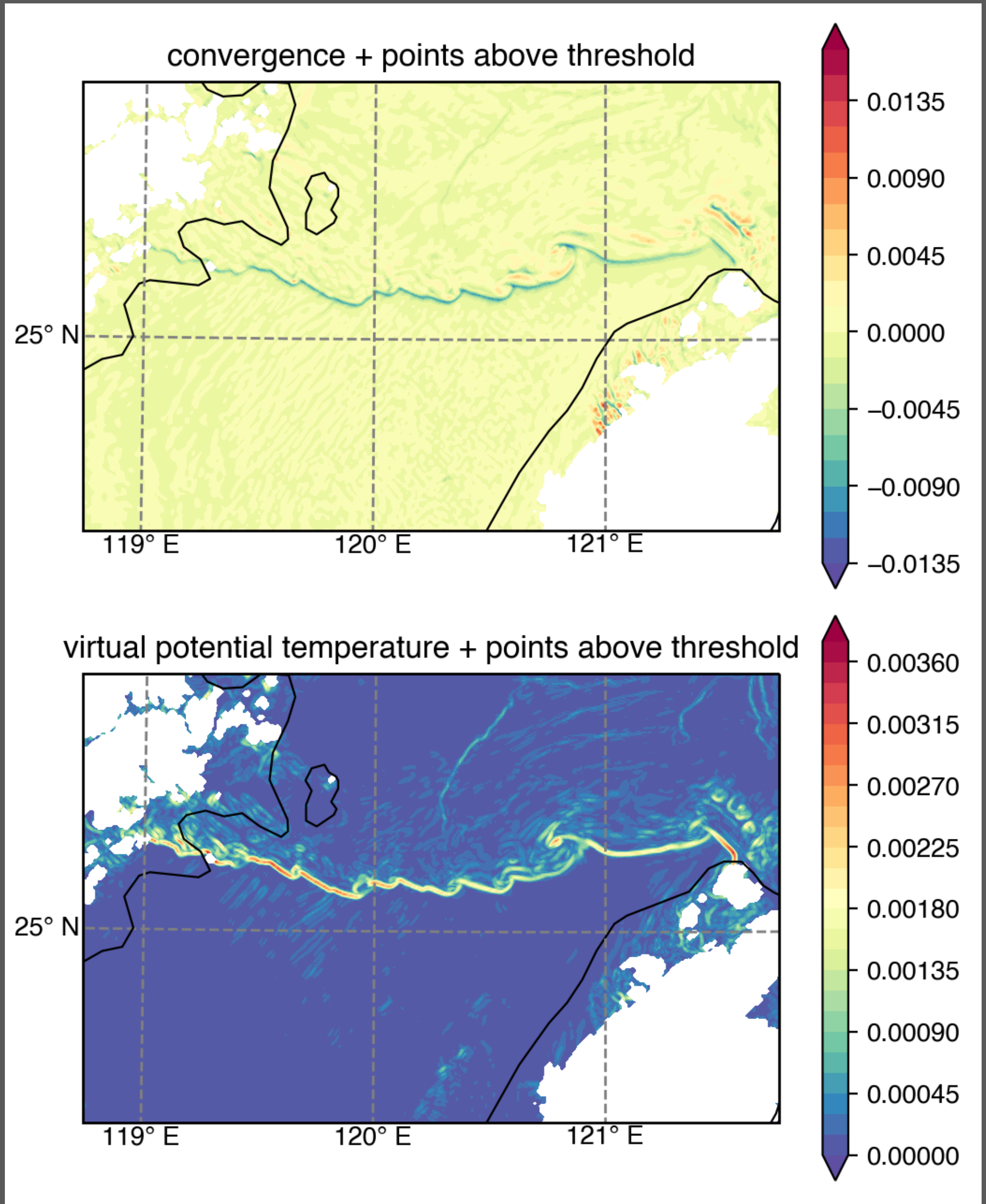


# Identify the front

1. Use convergence + gradient in virtual potential temperature at 975 hPa

$$\theta_p = \theta(1 + 0.608 q_v - q_{cloud} - q_{rain})$$

2. Thresholds
   1. convergence: < -0.0025
   2. $\theta_V$ gradient: > 0.00075



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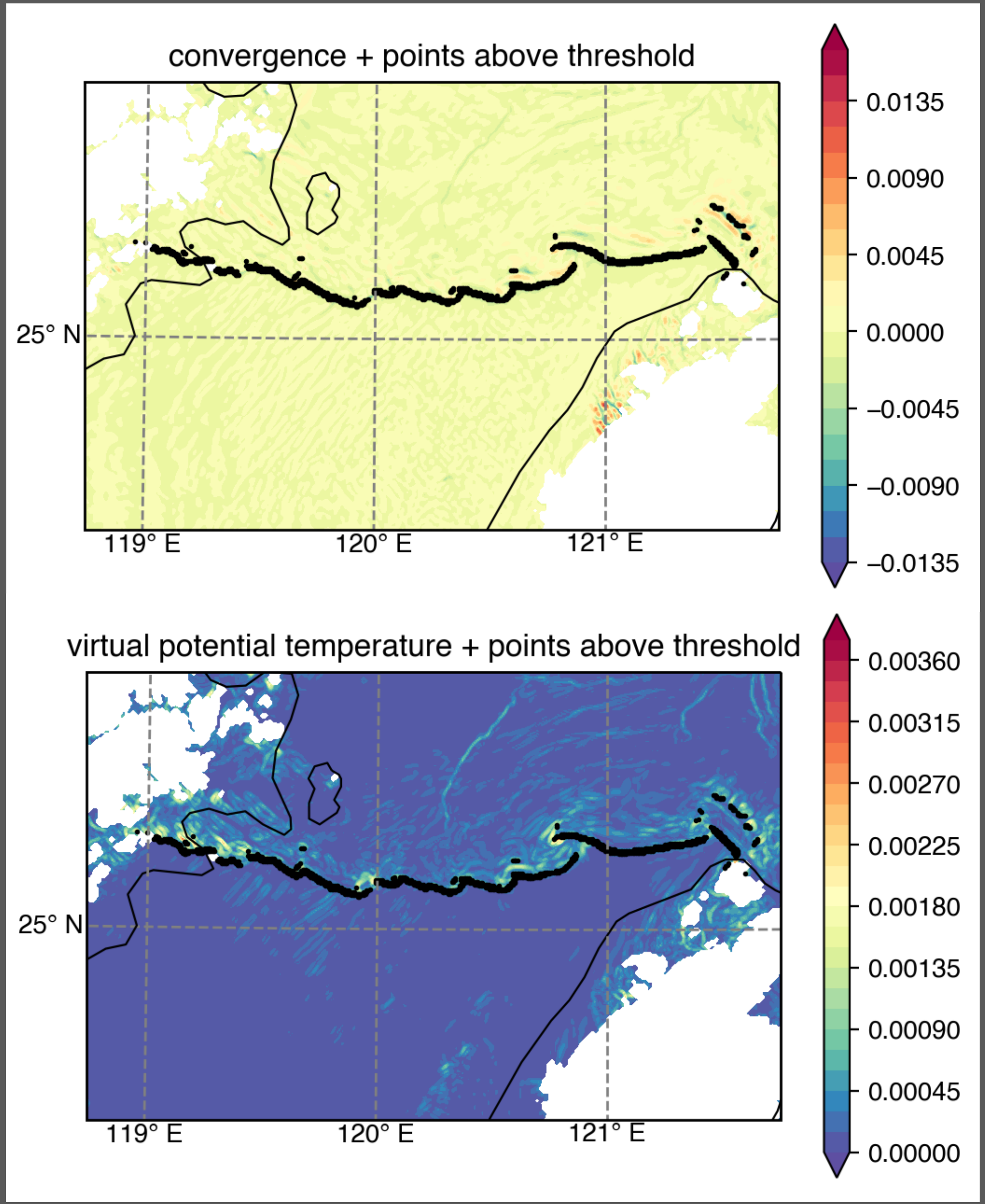
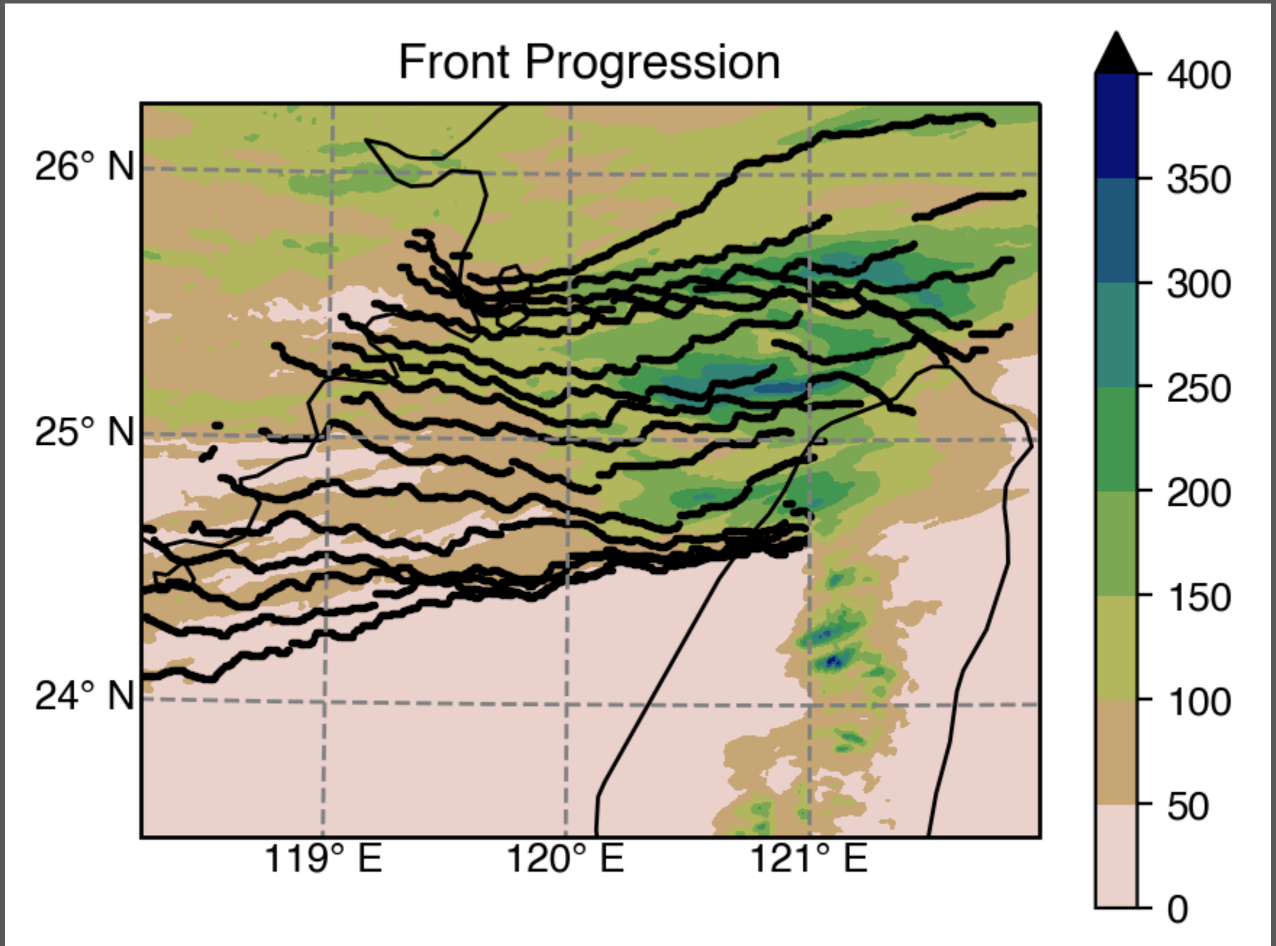


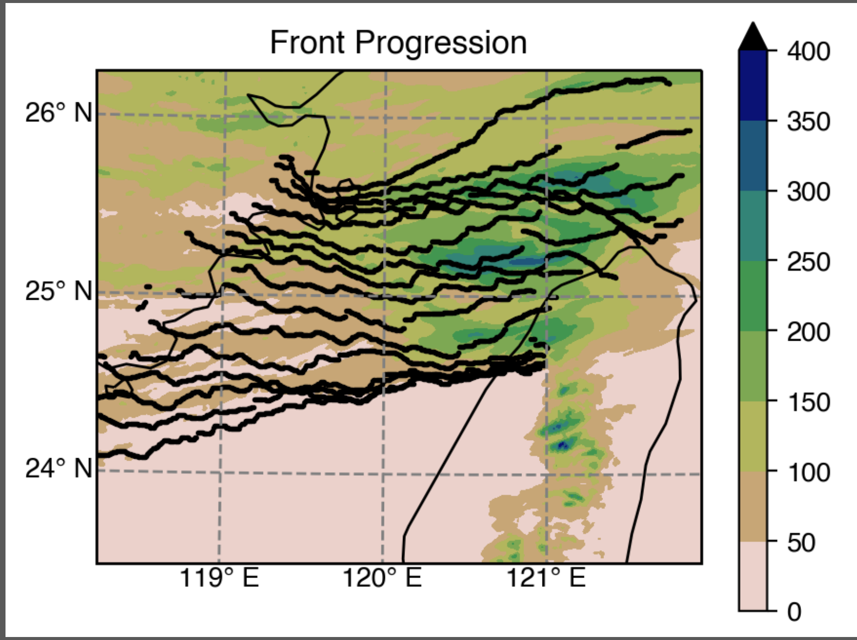
# Identify the front

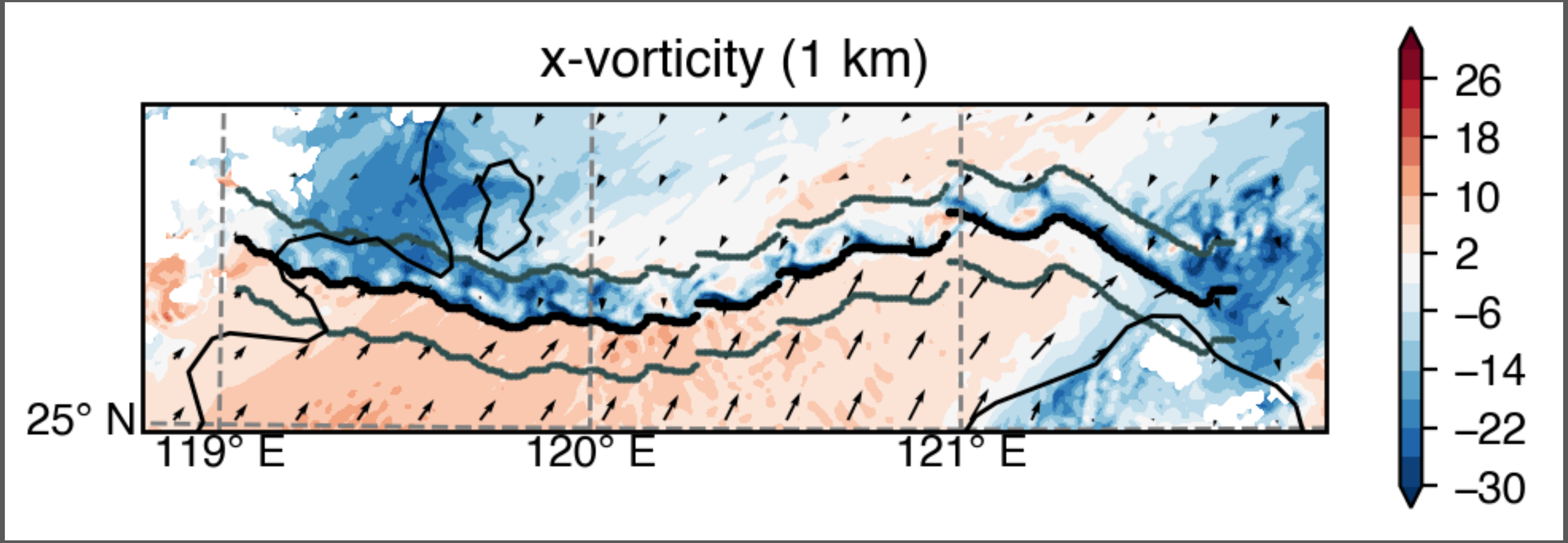
After additional processing and filtering, we can reasonably track the front through time.



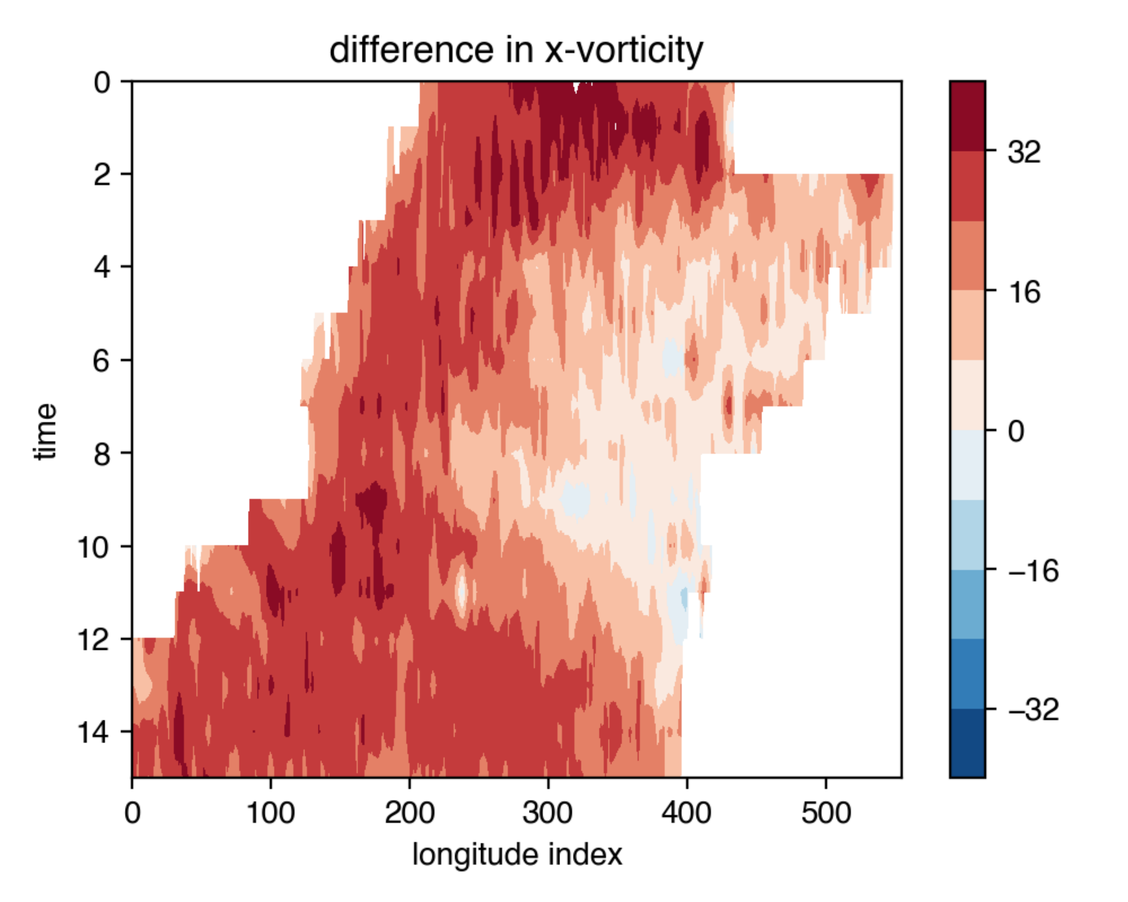
# RKW Theory

# Compare the difference in x-vorticity across the front to evaluate RKW theory



# Vorticity difference is stronger *before* and *after* the heaviest rainfall



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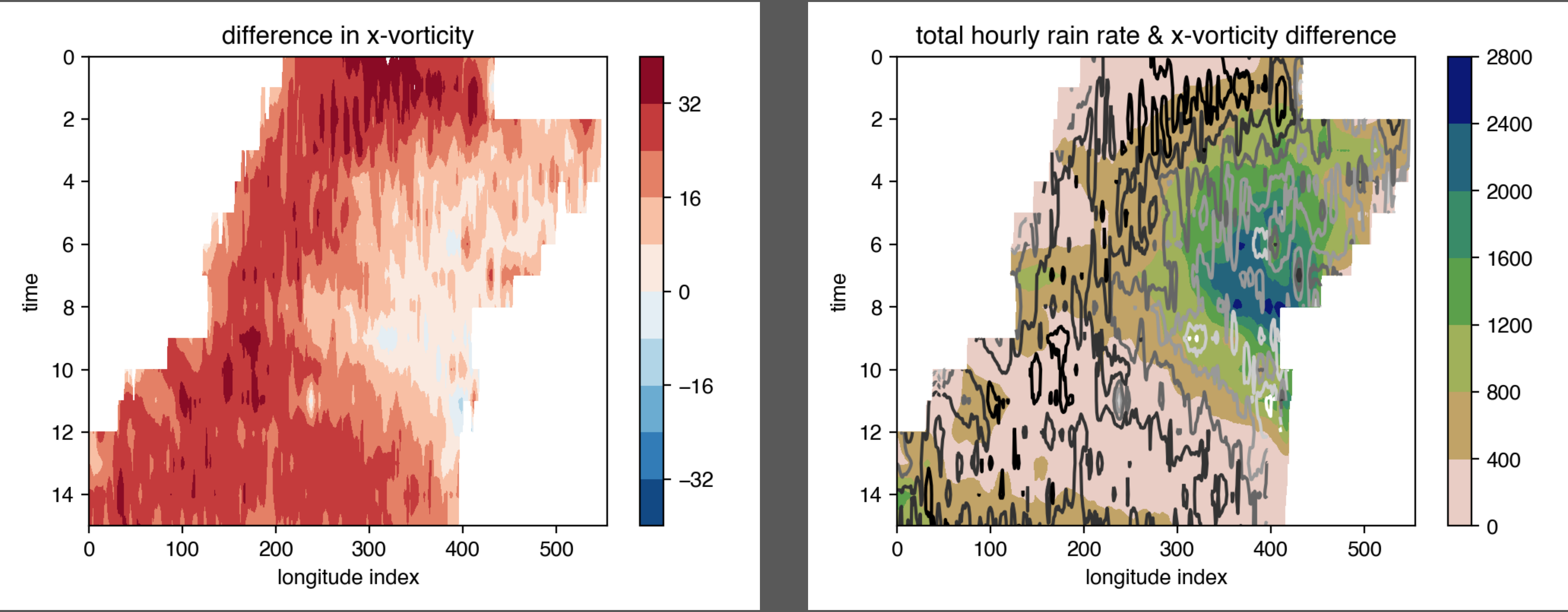
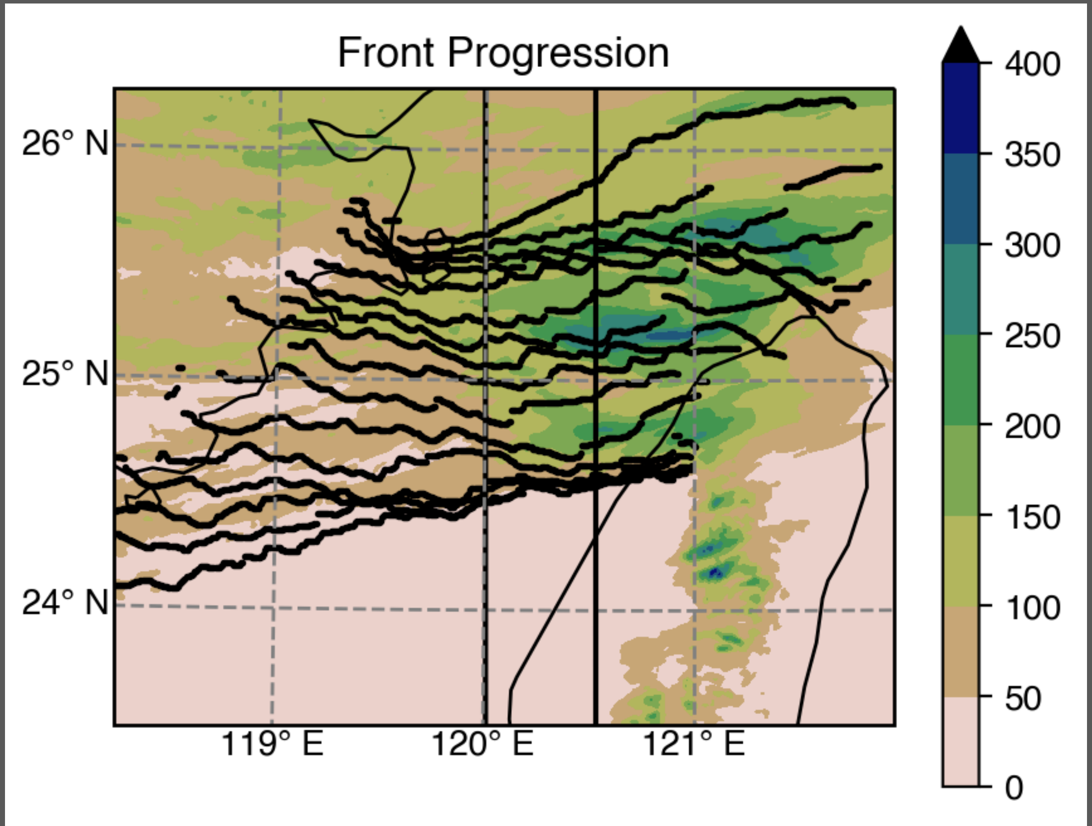
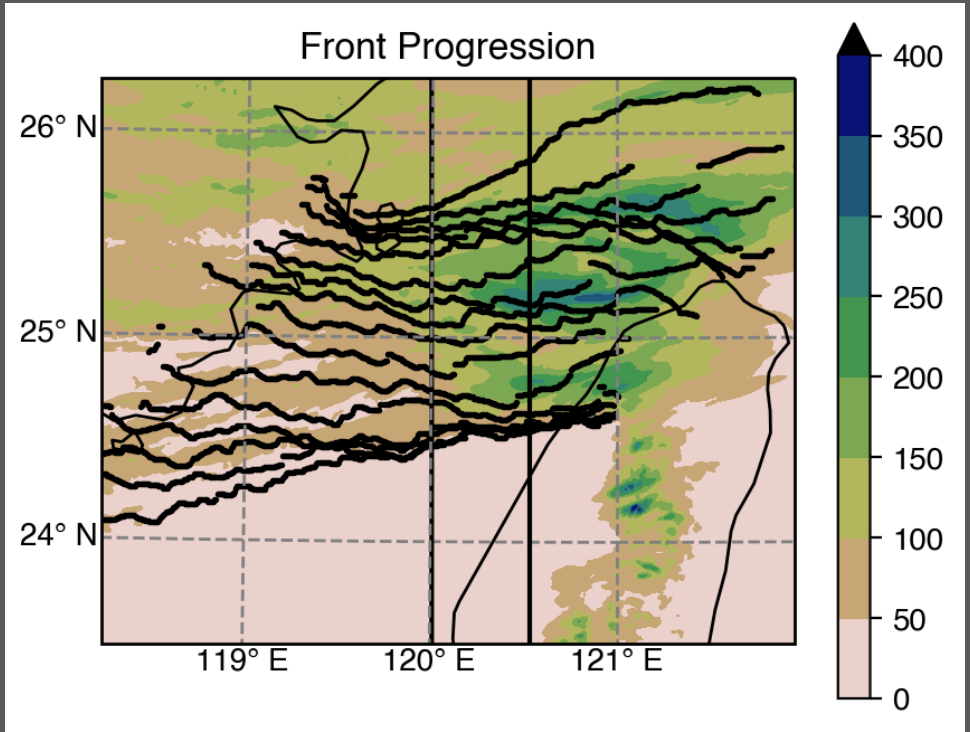


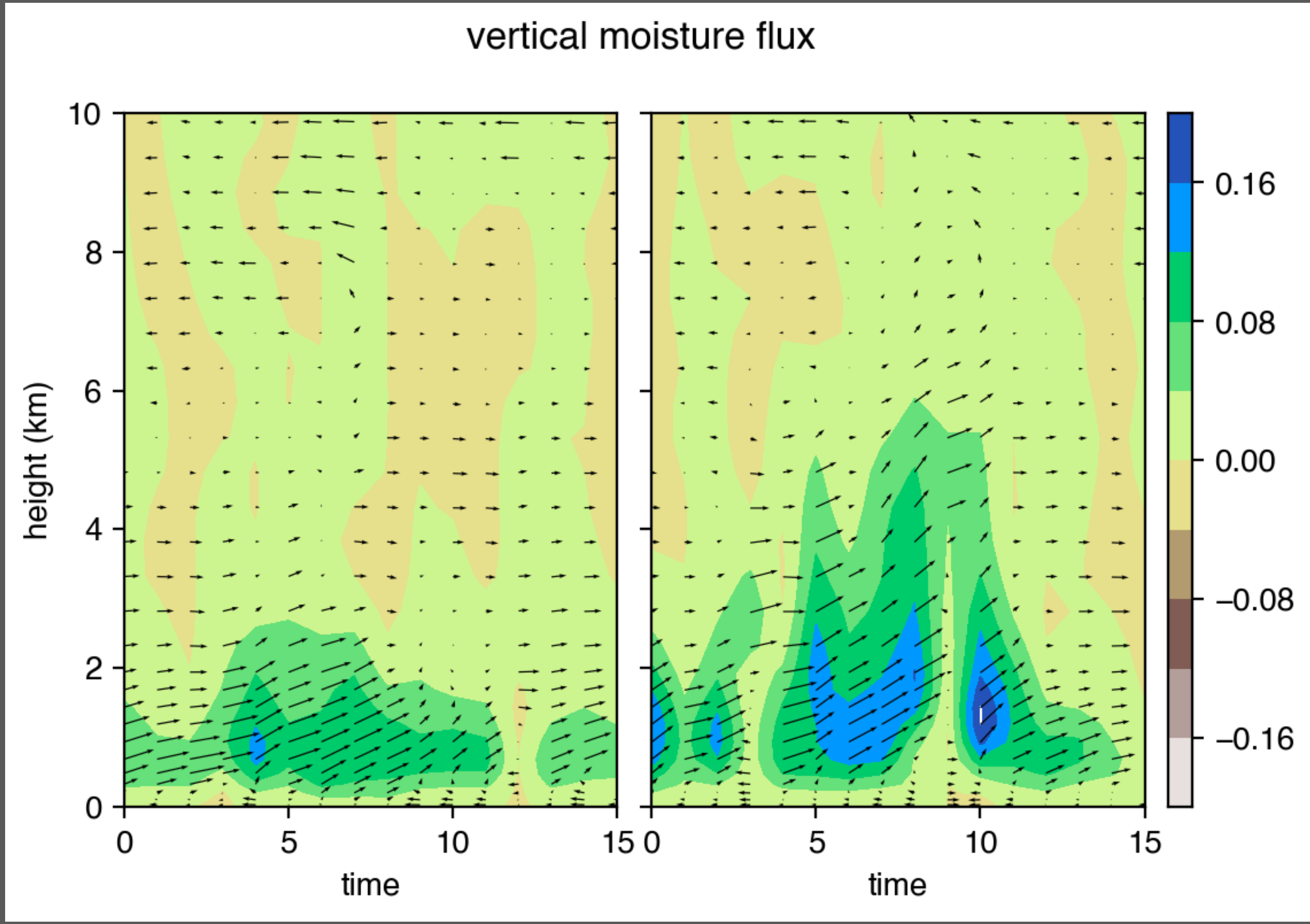
# Vertical Moisture Flux

# Comparing vertical profiles of vertical moisture flux *at* the front at 2 locations



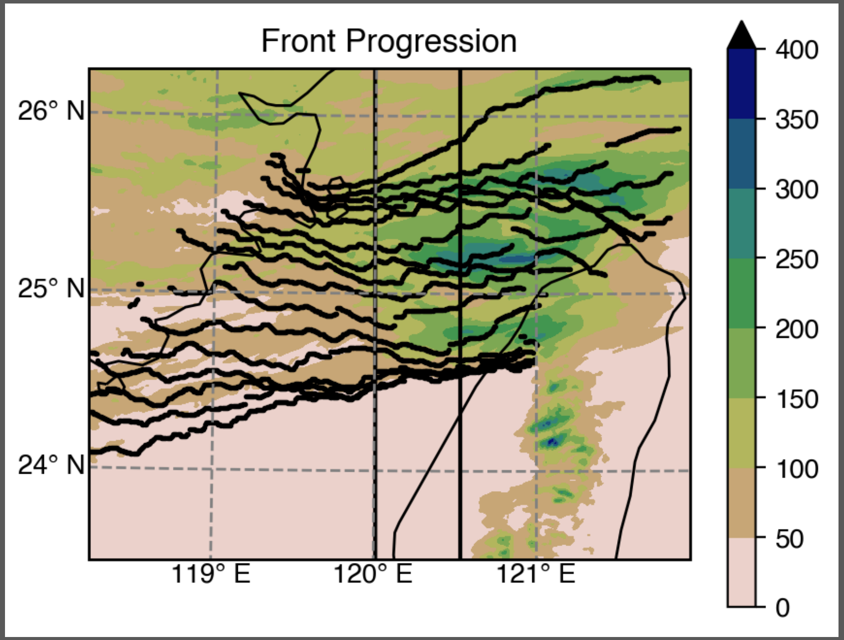
# Vertical moisture flux correlates with greater rainfall

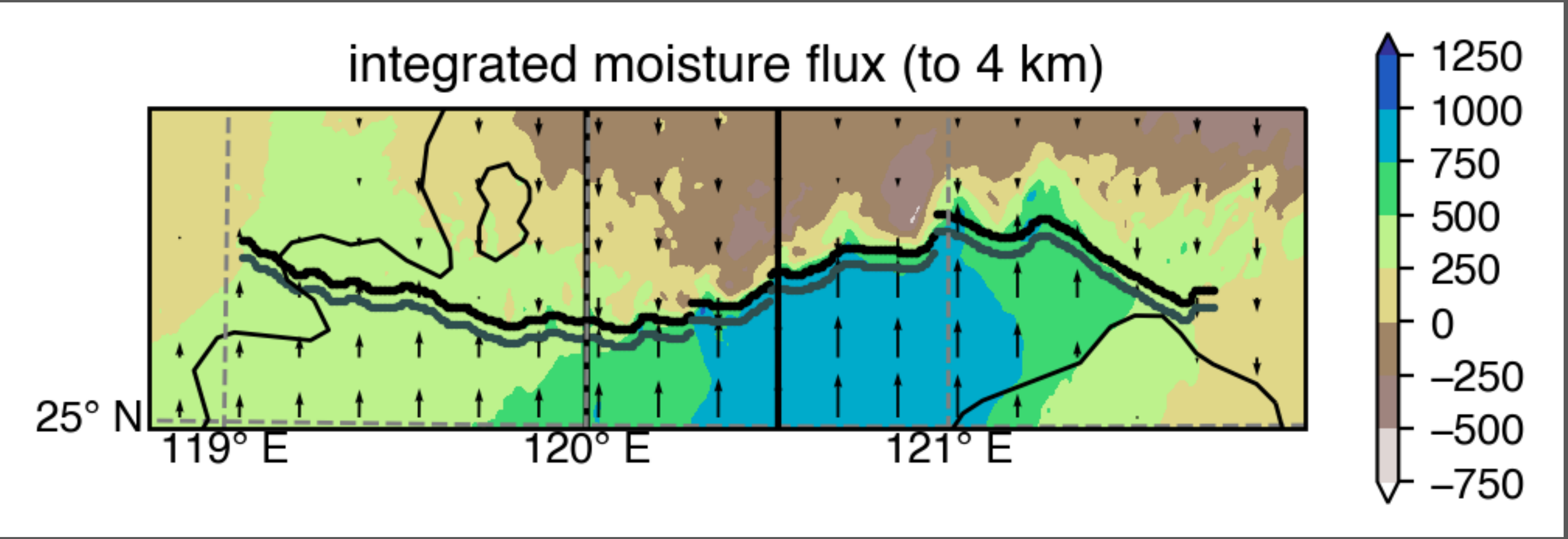


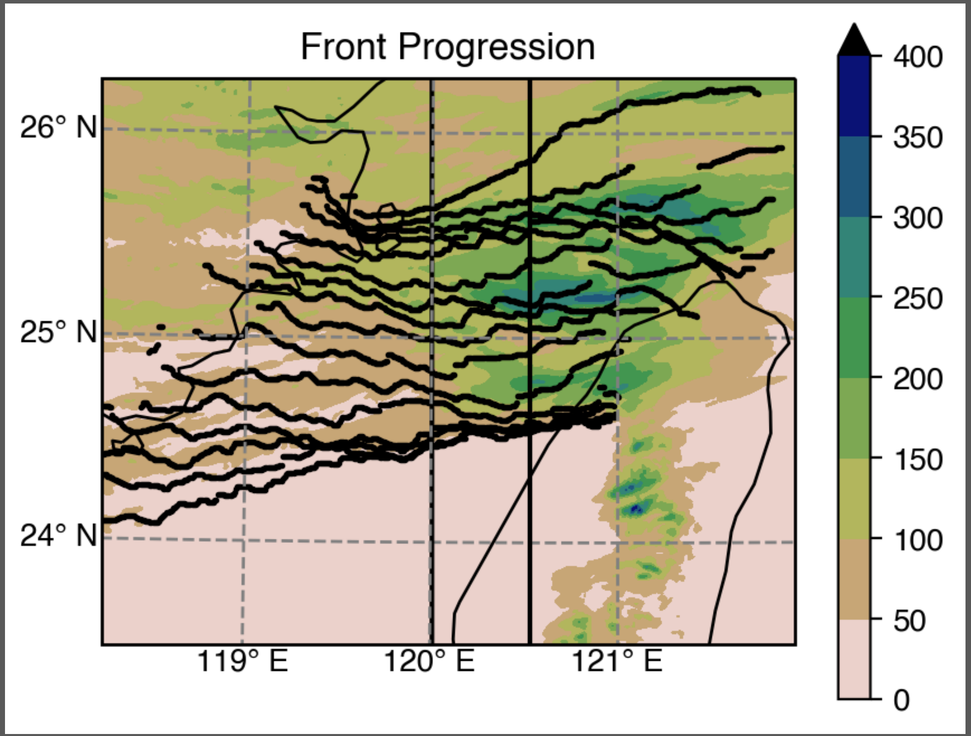
# Horizontal Moisture Flux

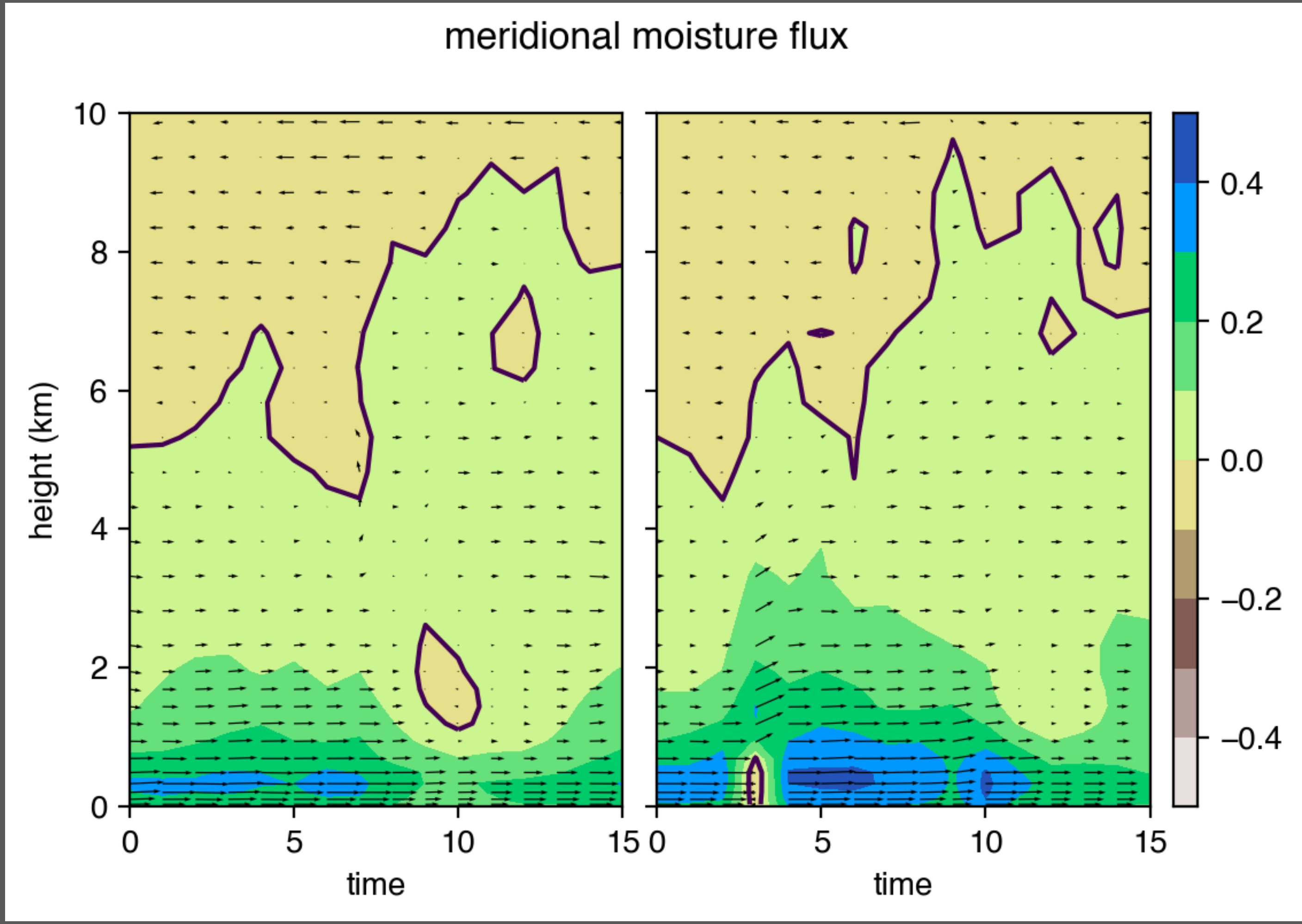
# Compare the vertical profiles of horizontal moisture flux ahead of the front



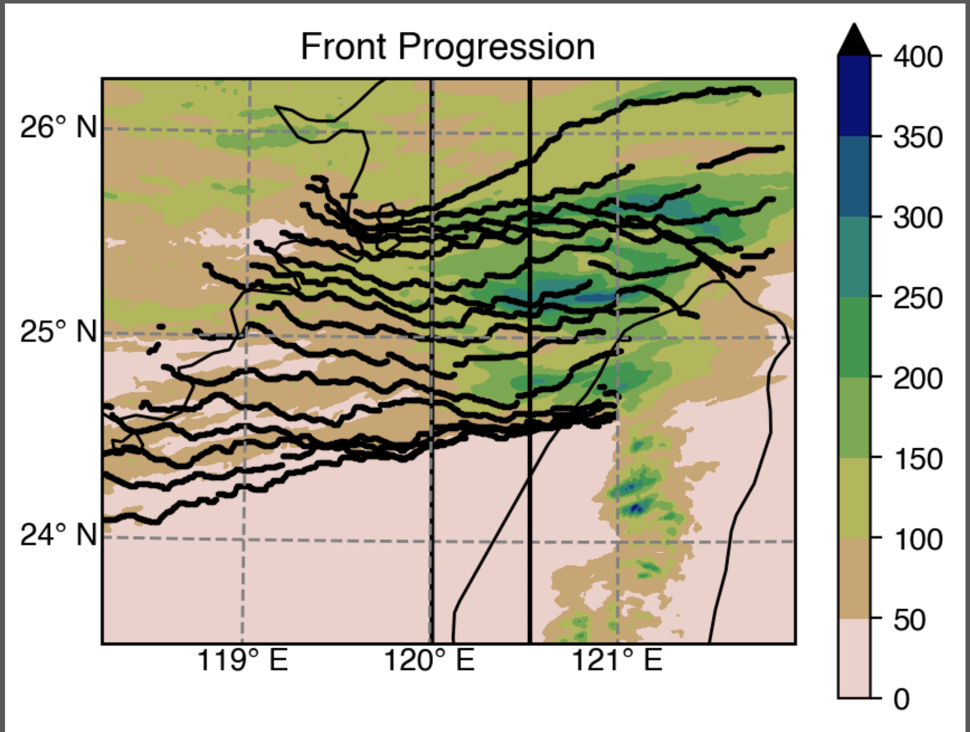



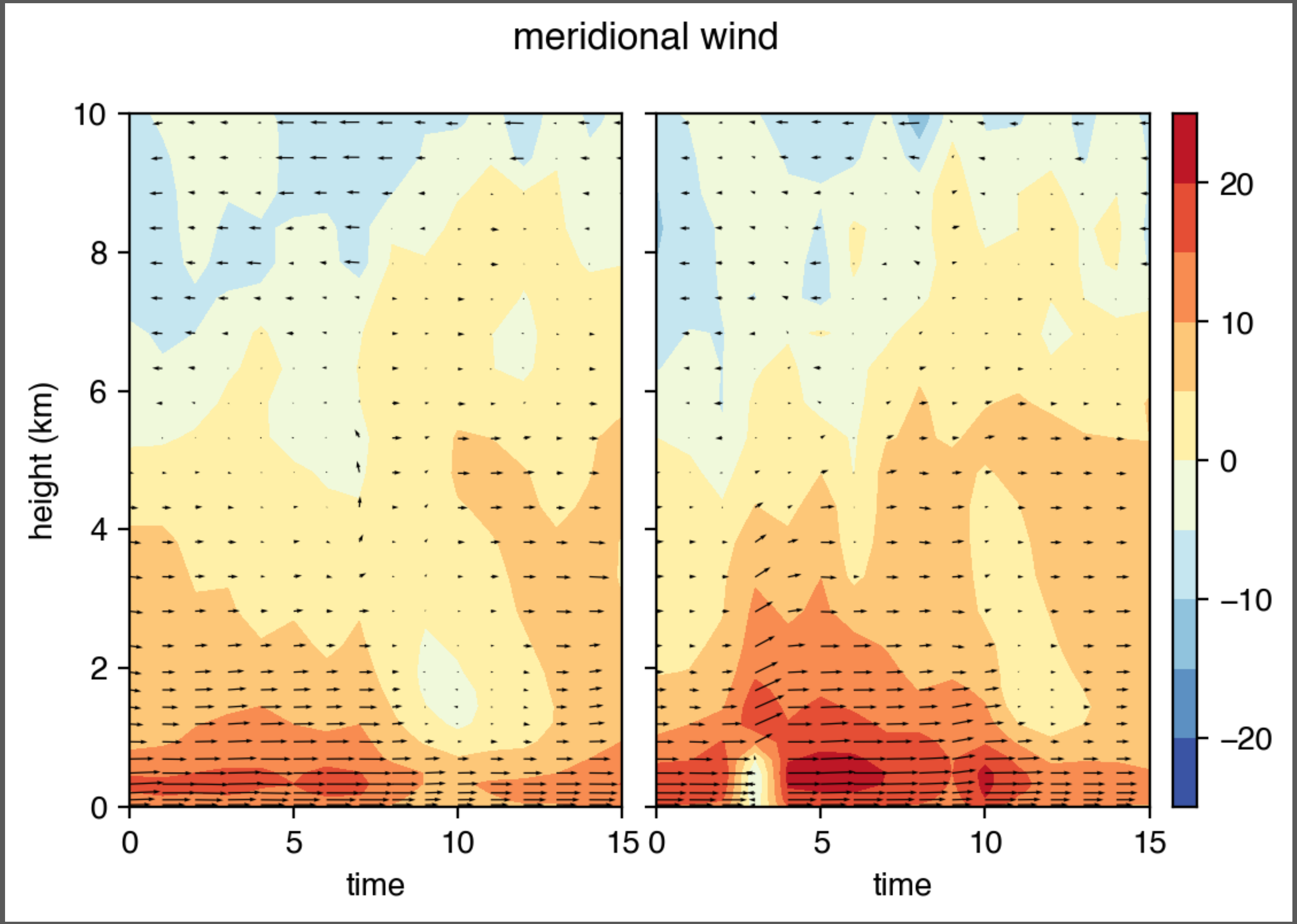
# Horizontal moisture flux ahead of front correlates with greater rainfall



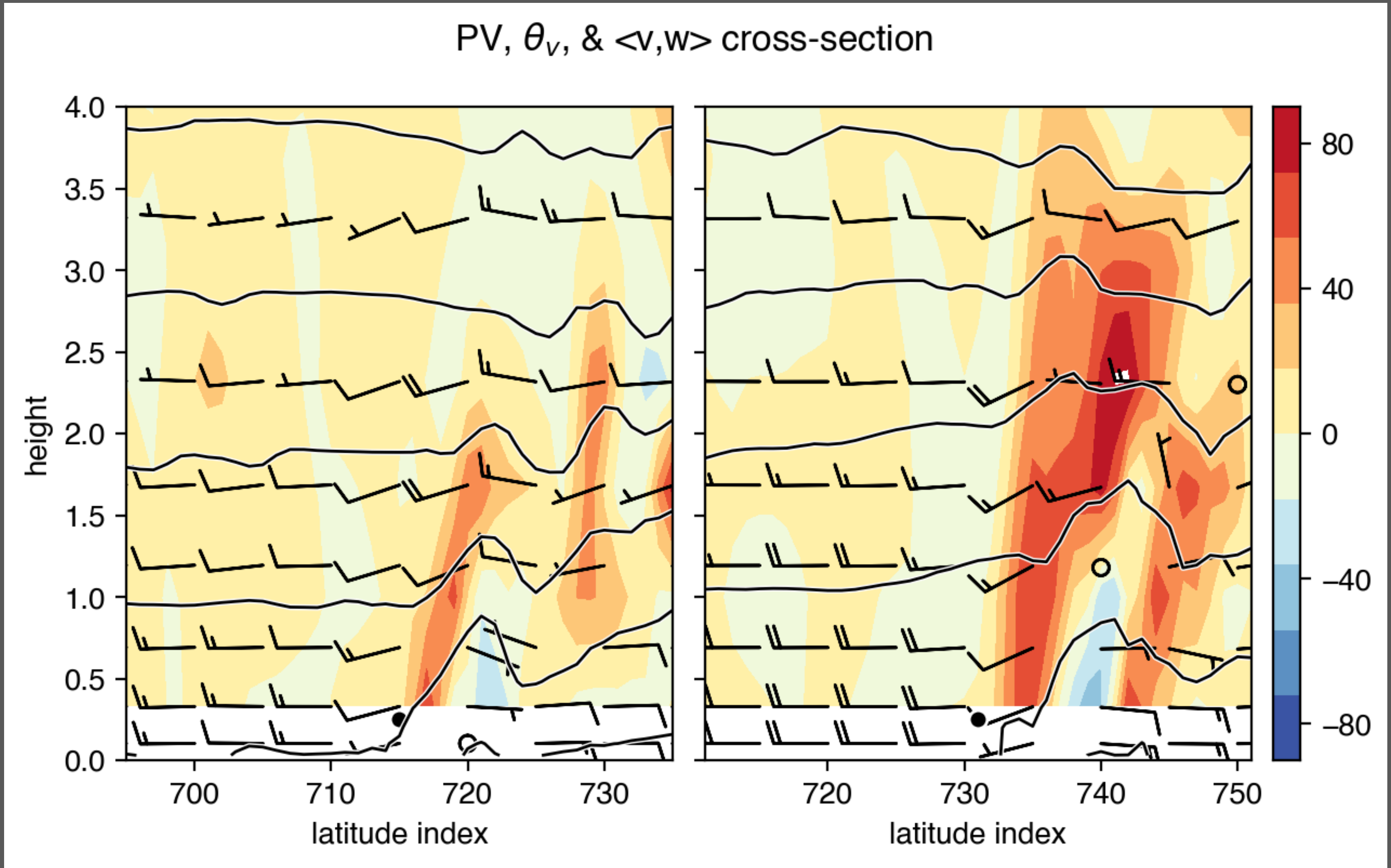



# Moisture flux dominated by wind



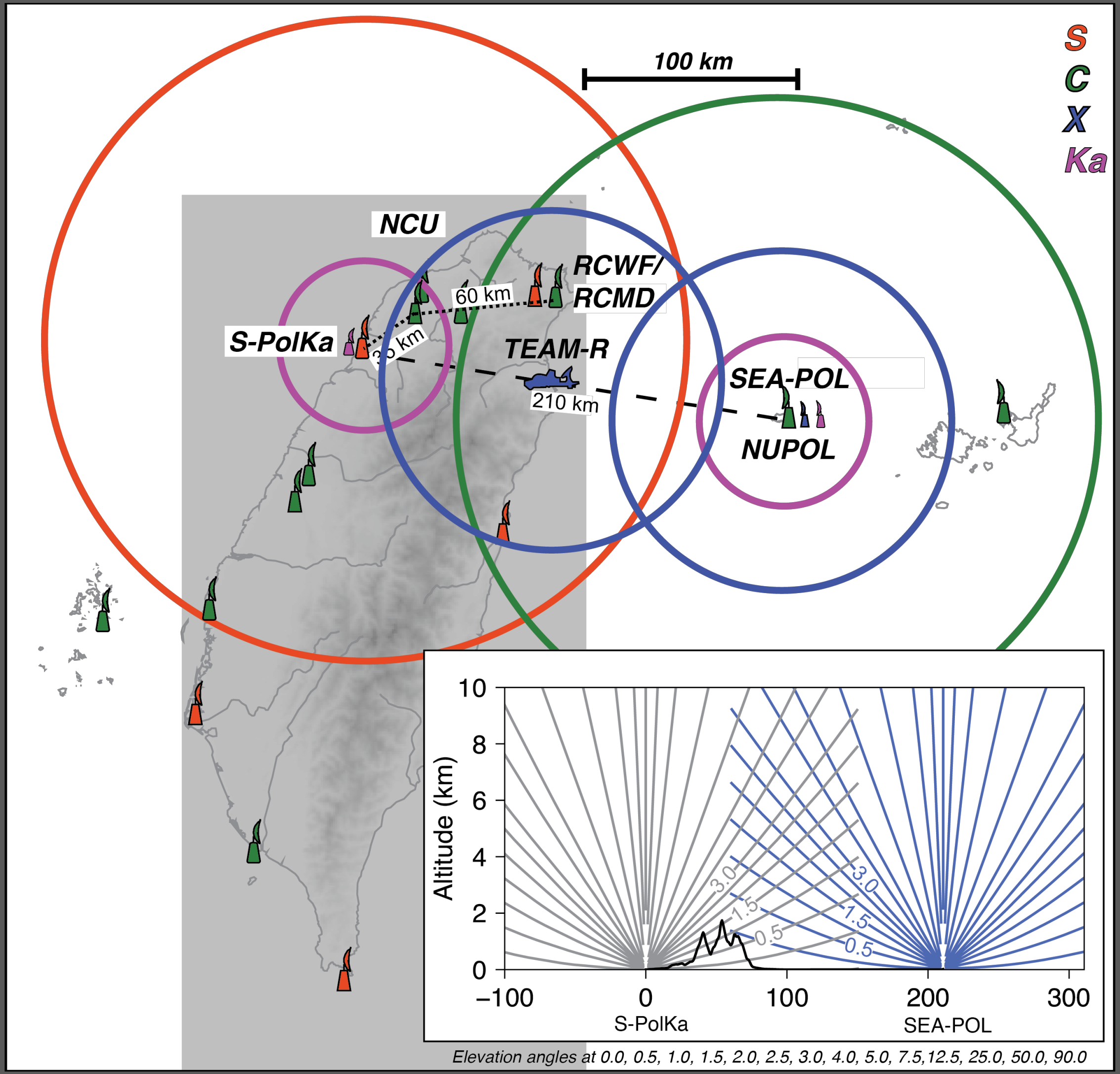
# Suggests isentropic ascent / PV framework might be applicable

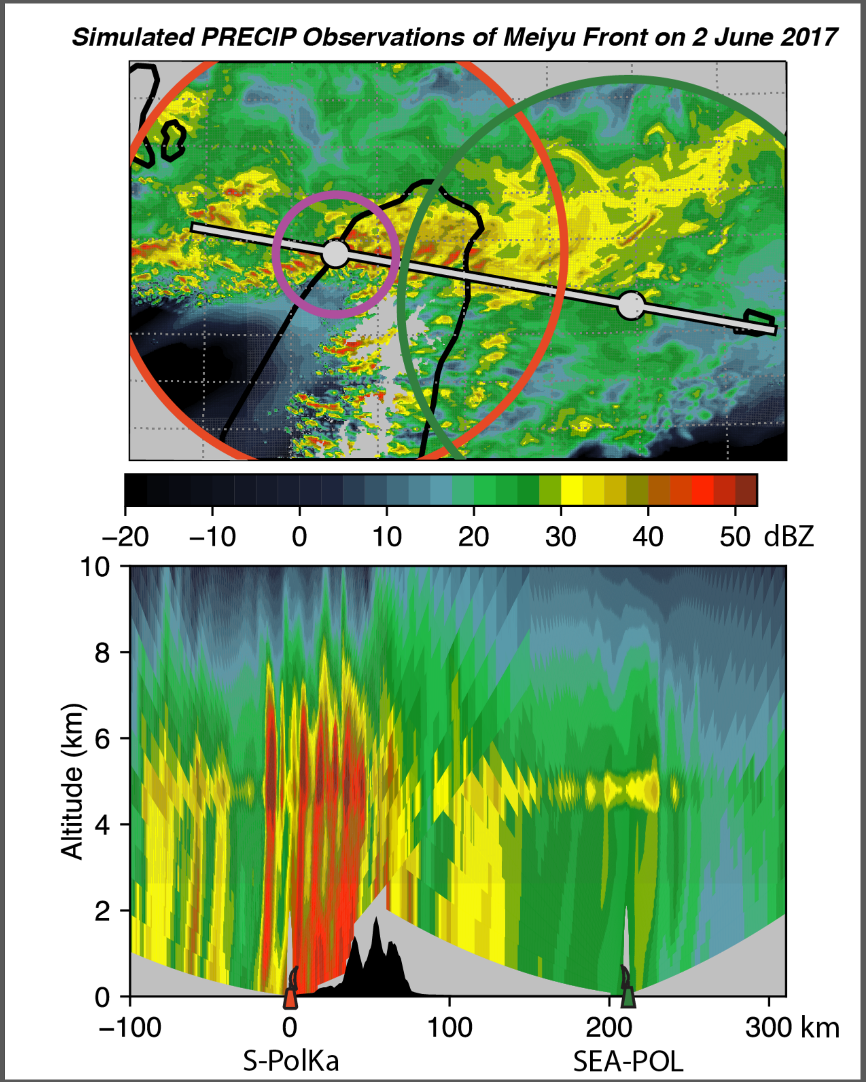


# Aforementioned analysis is from a numerical simulation

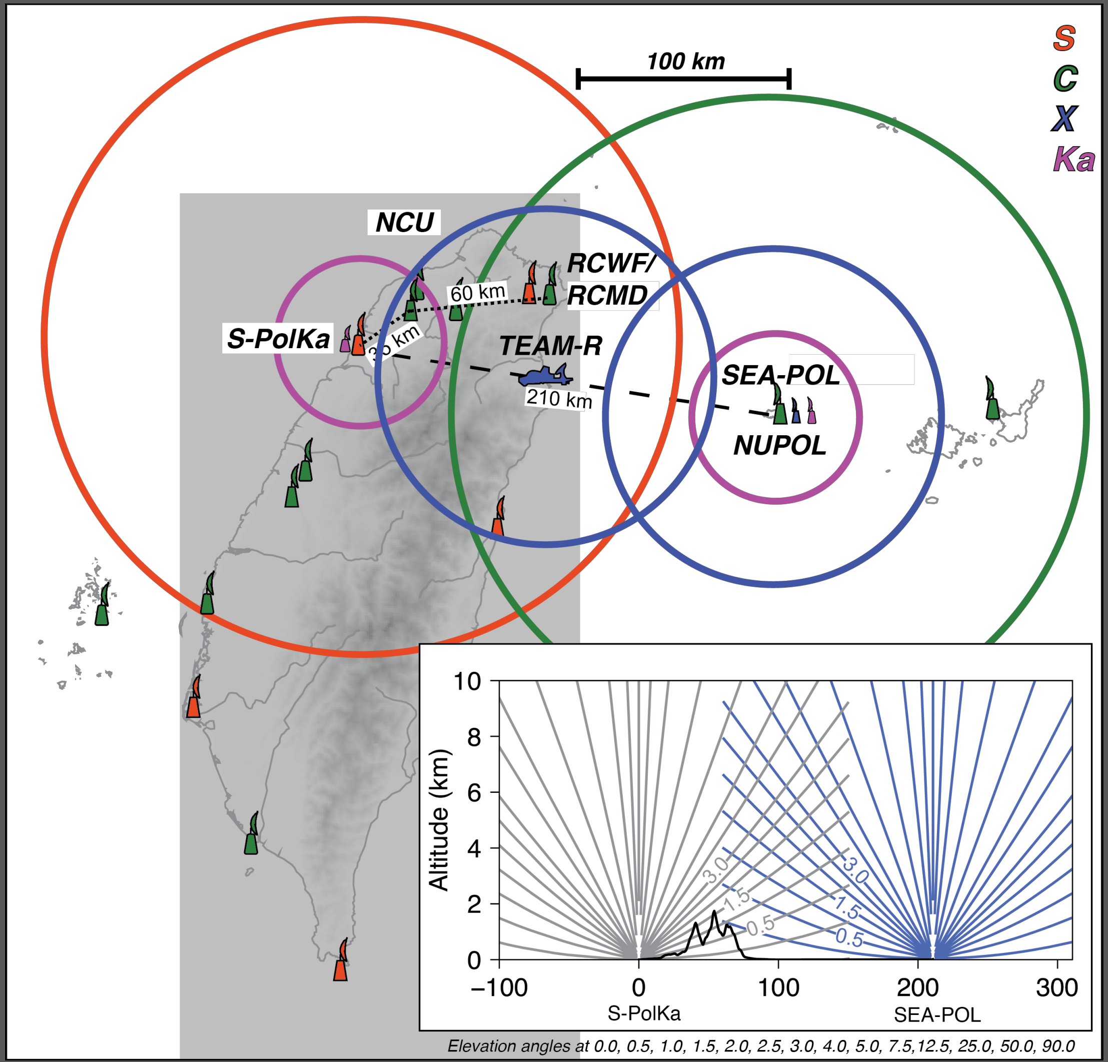
- PRECIP will assess whether the relative importance of these mechanisms is similar in the real world
  - *And* observe bulk microphysical processes

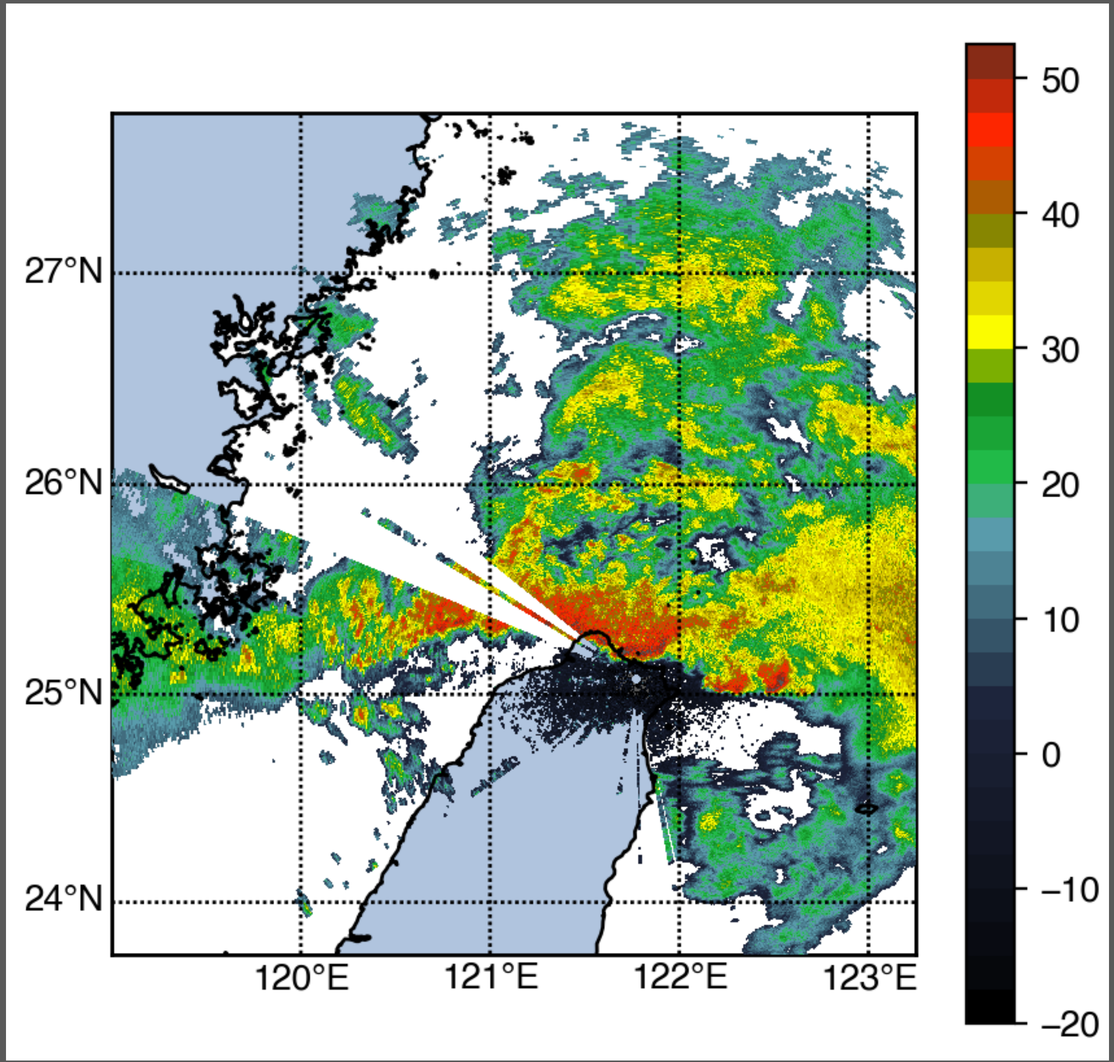
# PRECIP radar plan



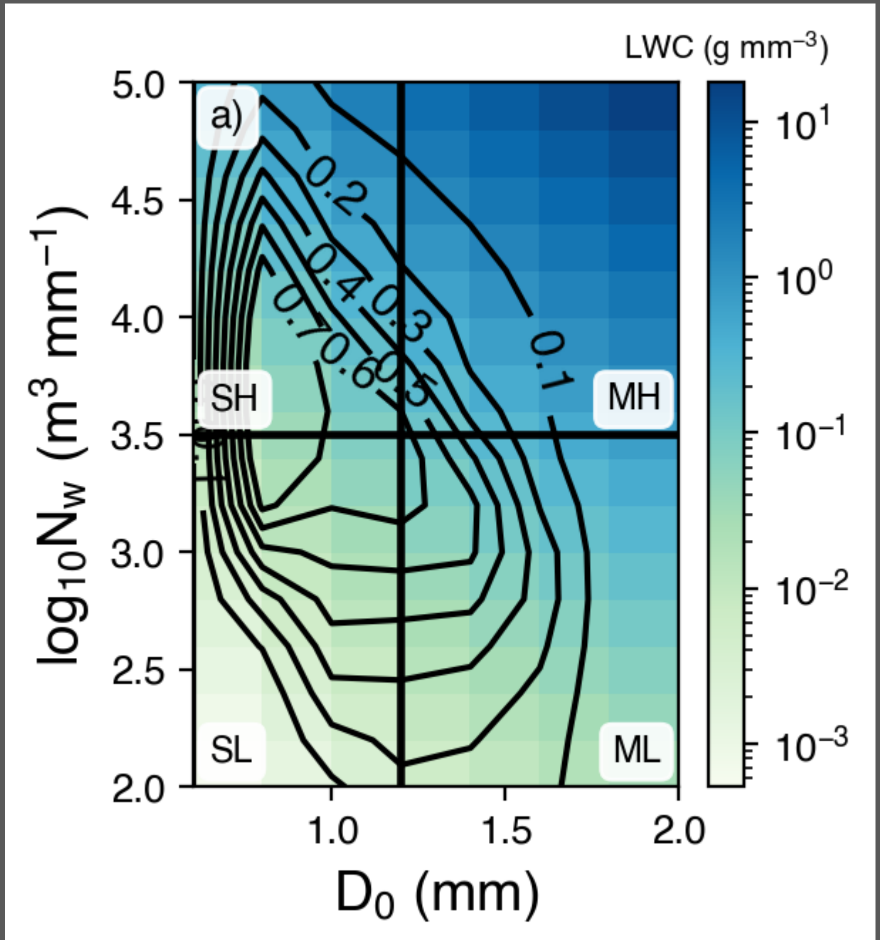



# We've begun preliminary analysis of radar data from 2 June case

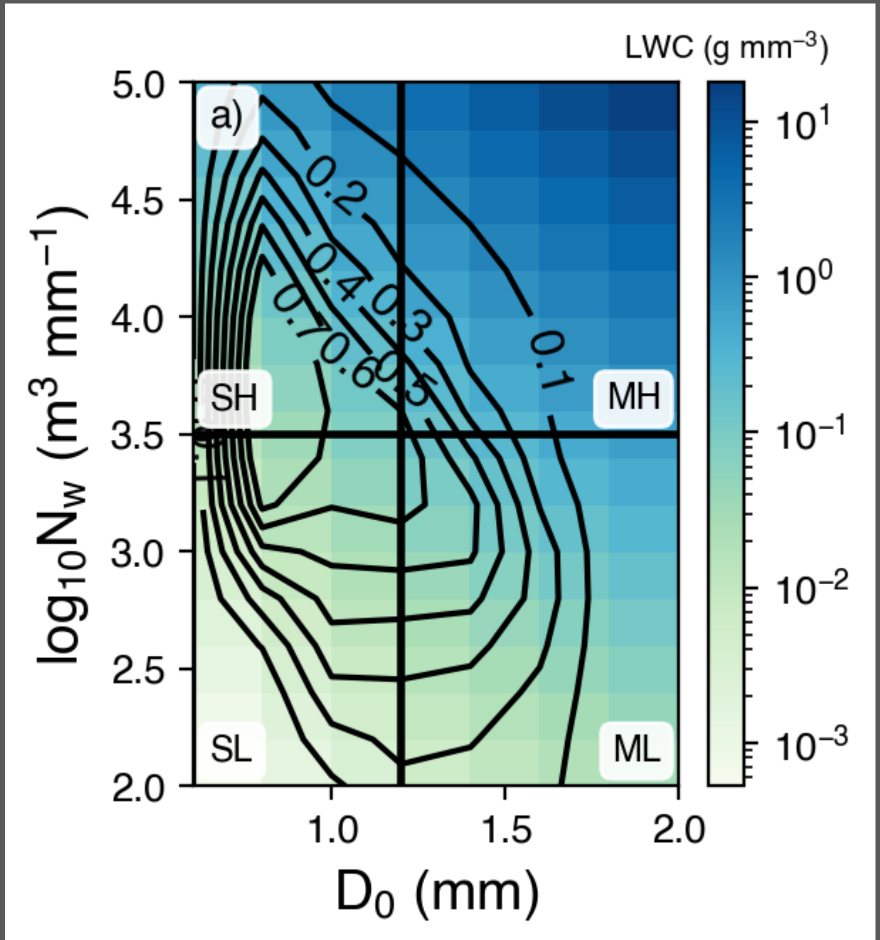


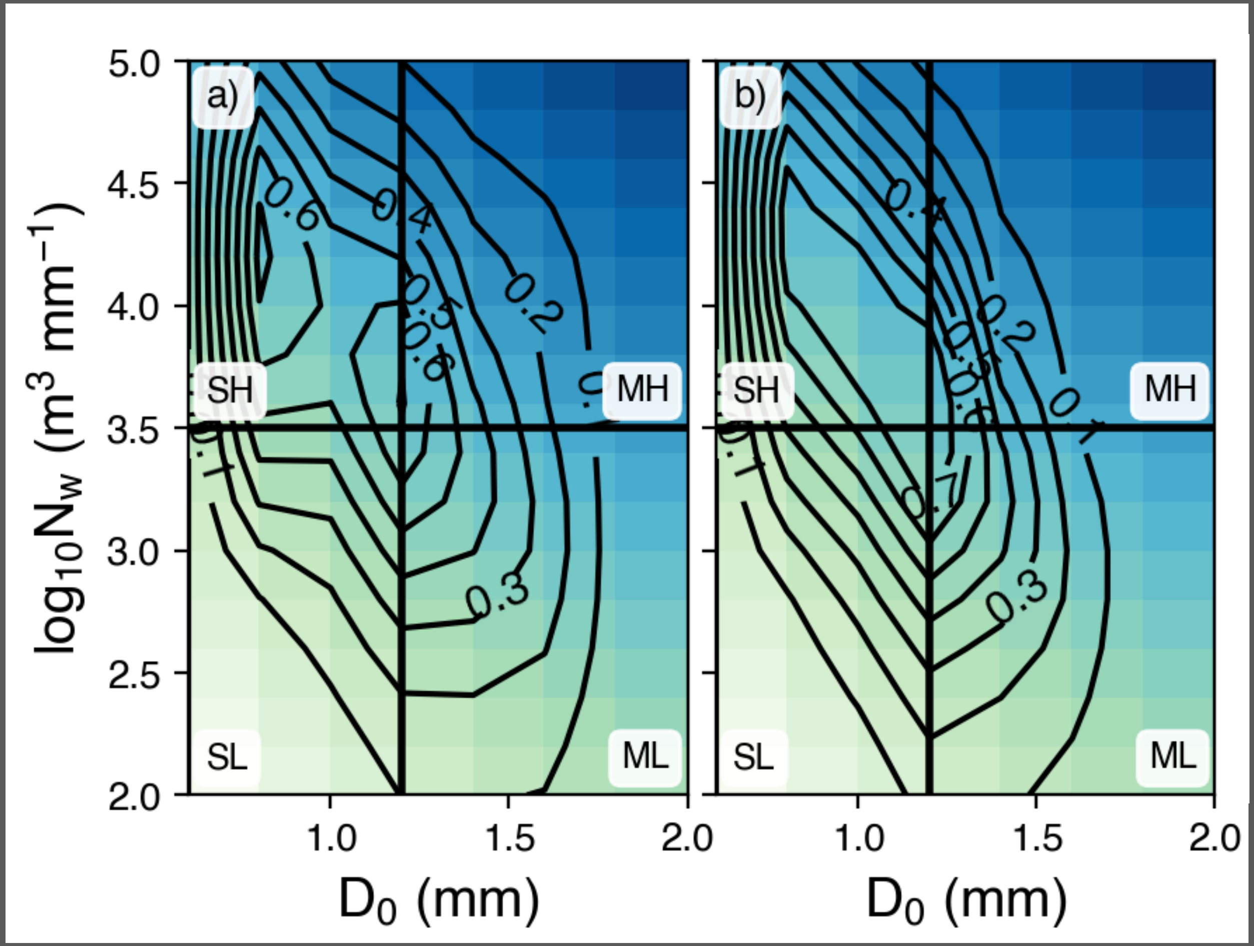



# Estimate DSD parameters with CSU RadarTools package



# Similar distribution as Hurricanes Harvey (2017) and Florence (2018)




DeHart and Bell 2020, in review

# Summary

- What mechanisms were responsible for heavy rainfall in the June 2017 case?
  - RKW theory does not appear important
  - Vertical and horizontal moisture flux correlate with hourly rainfall
- What processes were important at different spatial and temporal scales?
  - Horizontal moisture flux appears important at both