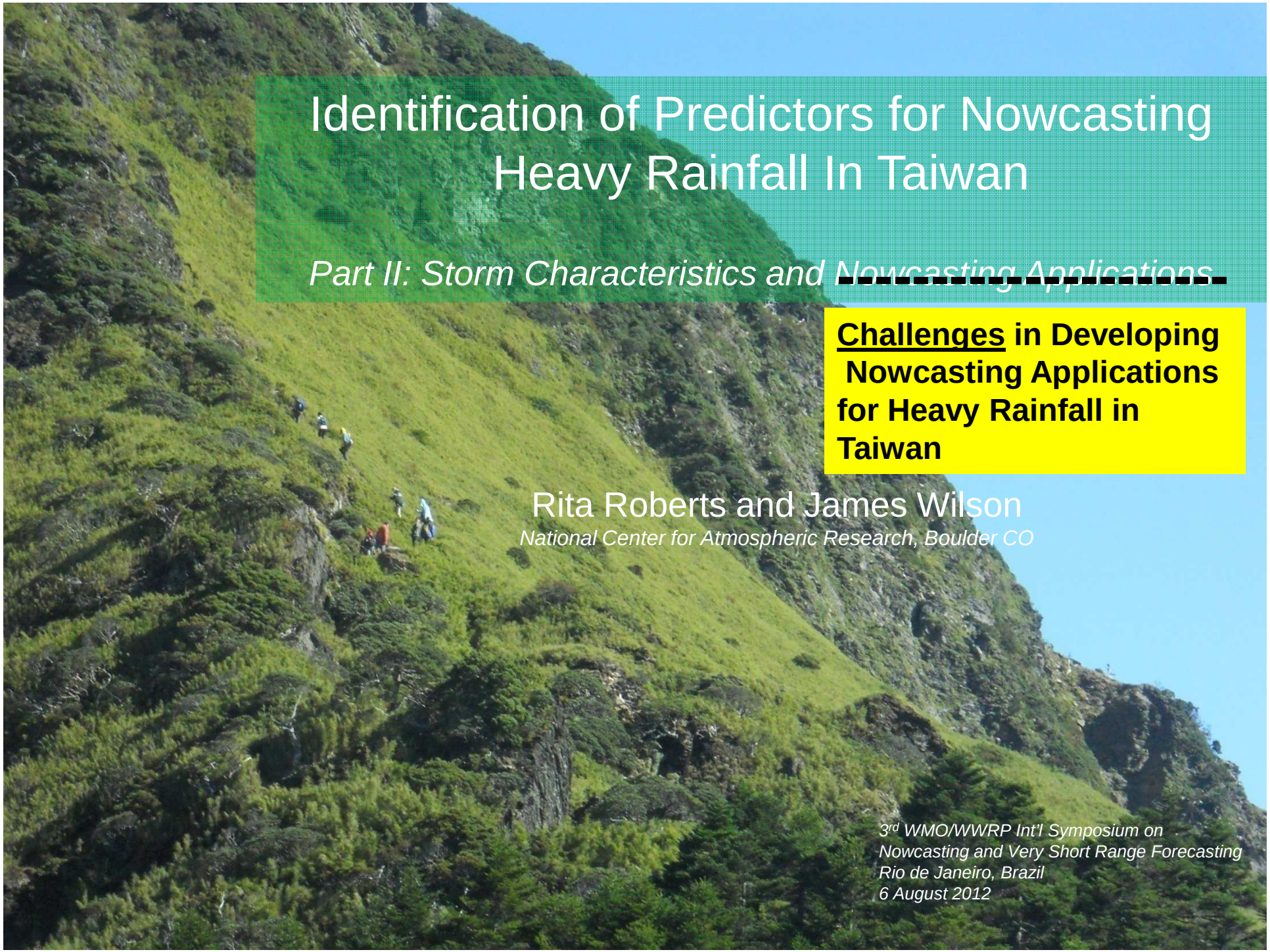


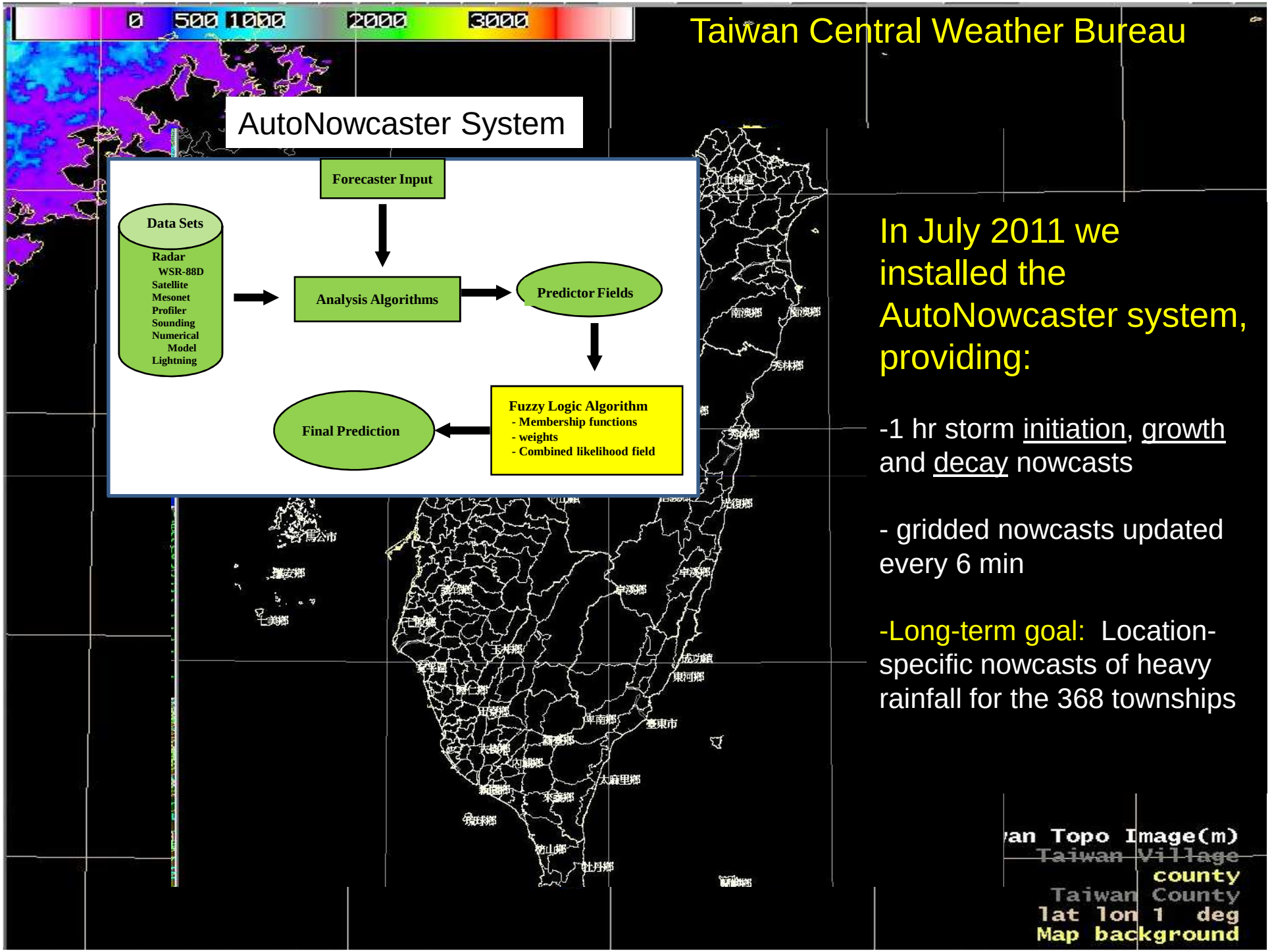
Identification of Predictors for Nowcasting Heavy Rainfall In Taiwan

Part II: Storm Characteristics and Nowcasting Applications

Challenges in Developing Nowcasting Applications for Heavy Rainfall in Taiwan

Rita Roberts and James Wilson
National Center for Atmospheric Research, Boulder CO

3rd WMO/WWRP Int'l Symposium on Nowcasting and Very Short Range Forecasting
Rio de Janeiro, Brazil
6 August 2012


0 500 1000 2000 3000
Taiwan Central Weather Bureau
AutoNowcaster System
Forecaster Input
Data Sets
Radar
WSR-88D
Satellite
Mesonet
Profiler
Sounding
Numerical
Model
Lightning
Analysis Algorithms
Predictor Fields
Fuzzy Logic Algorithm
- Membership functions
- weights
- Combined likelihood field
Final Prediction
In July 2011 we installed the AutoNowcaster system, providing:
-1 hr storm initiation, growth and decay nowcasts
- gridded nowcasts updated every 6 min
-Long-term goal: Location-specific nowcasts of heavy rainfall for the 368 townships
an Topo Image(m)
Taiwan Village
county
Taiwan County
lat lon 1 deg
Map background

TiMREX : Terrain-influenced Monsoon Rainfall Experiment

May-June 2008

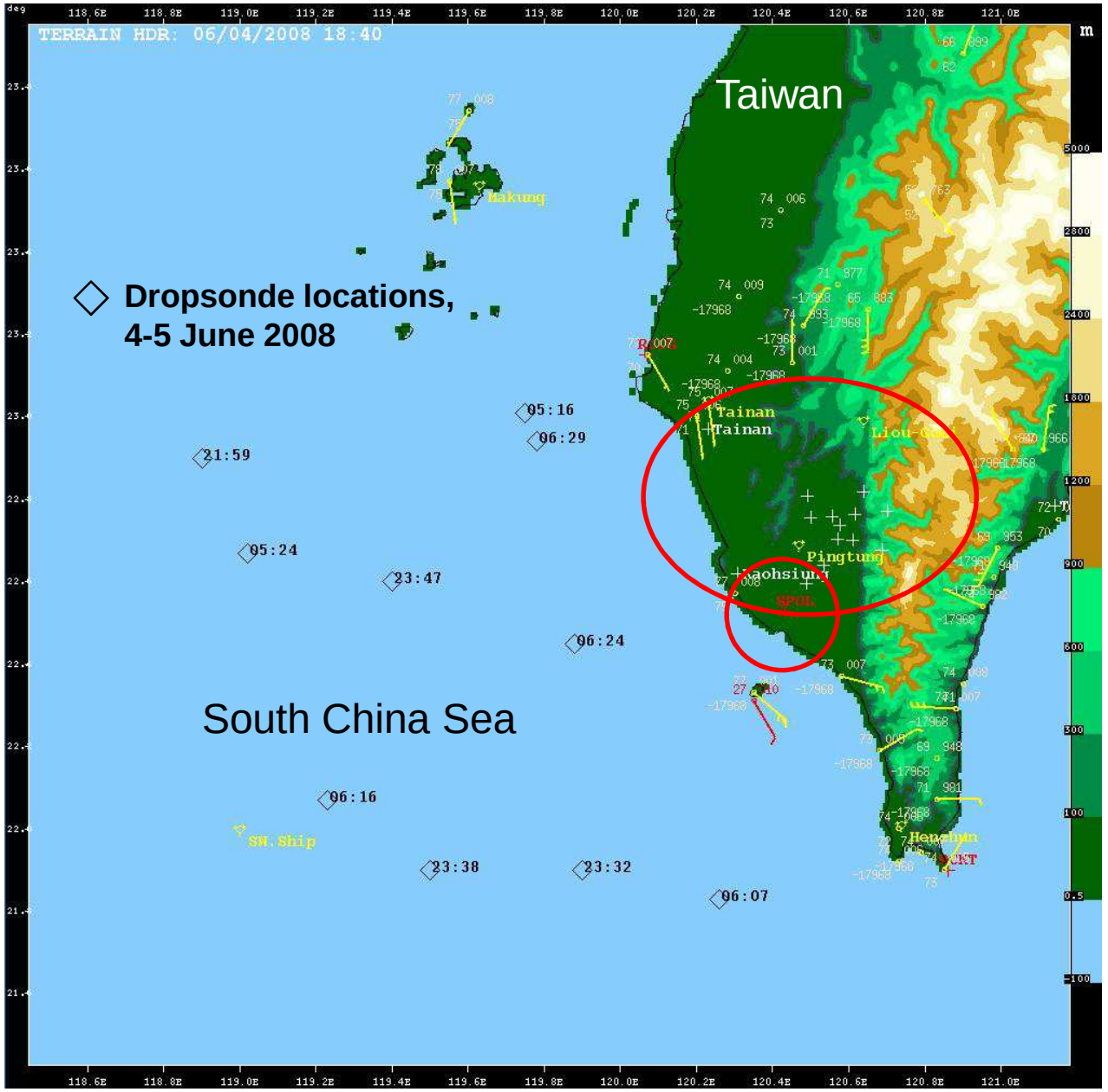
NCAR S-Pol (dual-polarization) Doppler radar

Vertical profiling instruments at “Super Site”

3-hourly sounding launches

400+ raingauge & surface stations

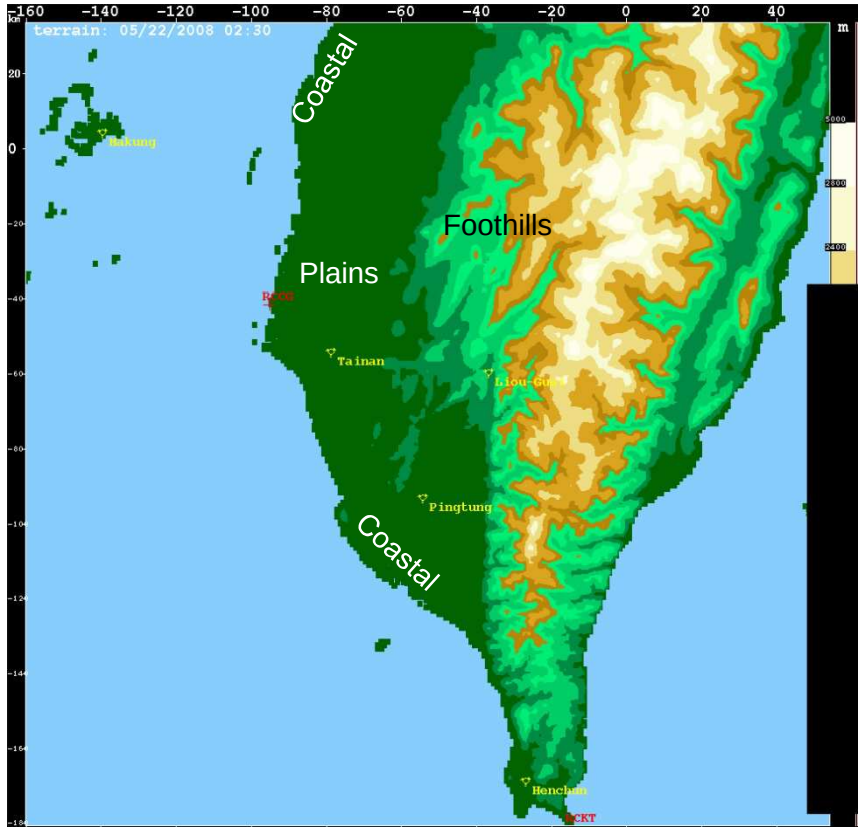
15-20 dropsondes per misson



Scenarios Leading to Heavy Rainfall

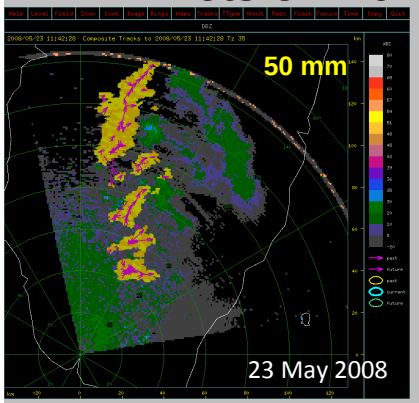
Locally-Driven Weather

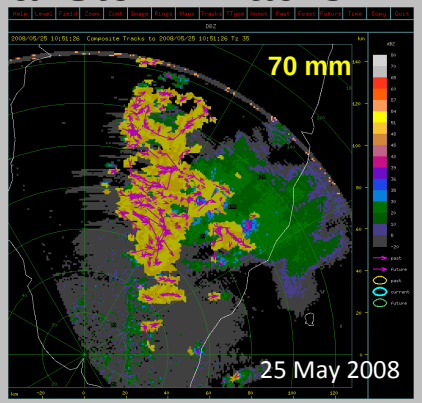
- **Foothills**: Recurring storm initiations and storm mergers over same regions of elevated terrain.
- **Coastal**: Continual storm initiation above sea breeze
- **Plains**: Storm initiation and storm mergers above convergence boundaries

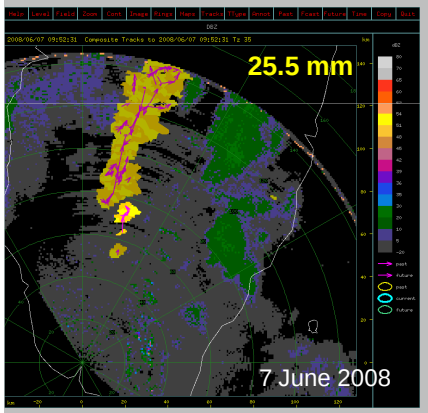


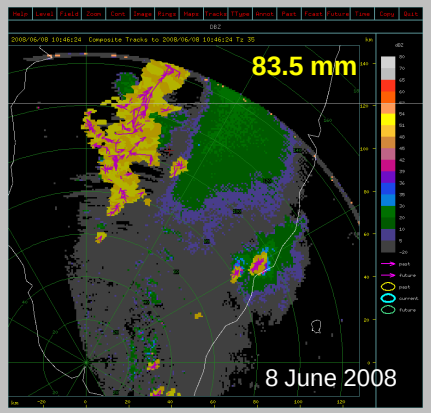
Foothills: Recurring Storm Initiation/Storm Mergers Over Elevated Terrain

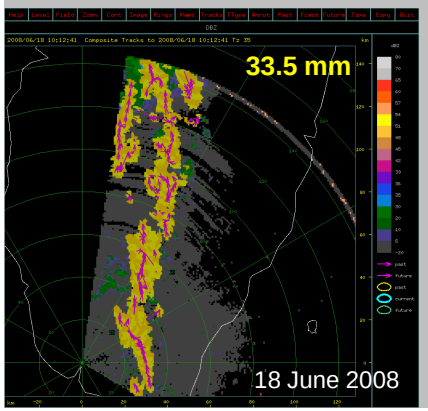
Plots of Diurnal Storm Tracks

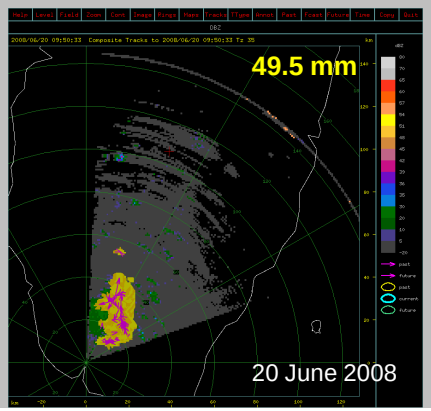










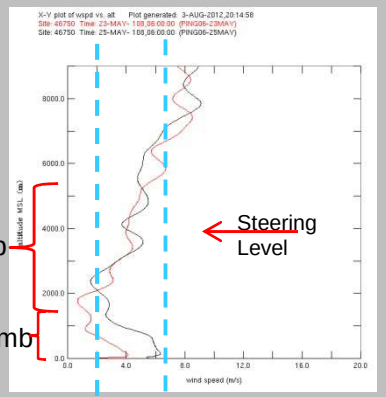


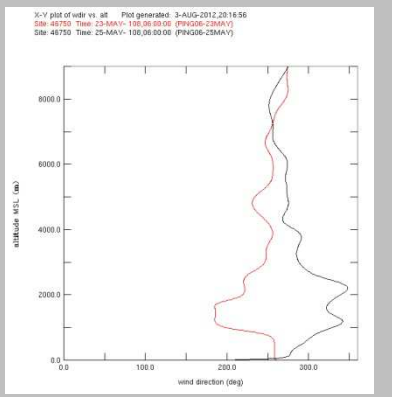
Wind Speed

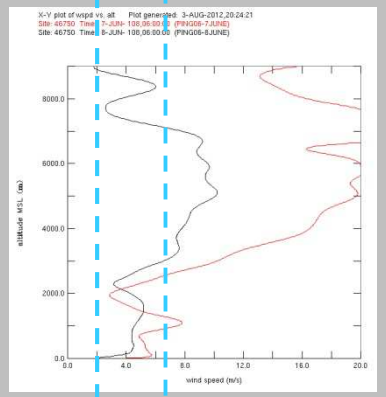
Wind Direction

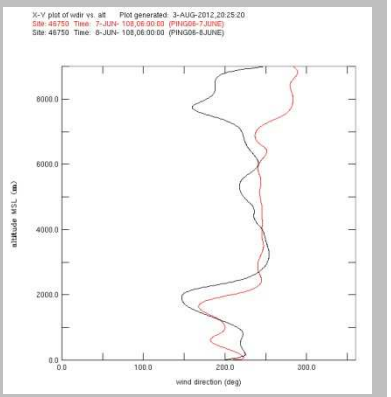
ML: 800-400mb

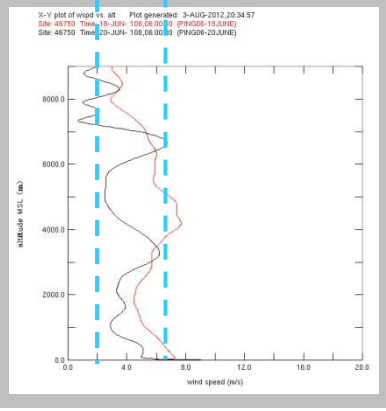
BL: 1000-800mb

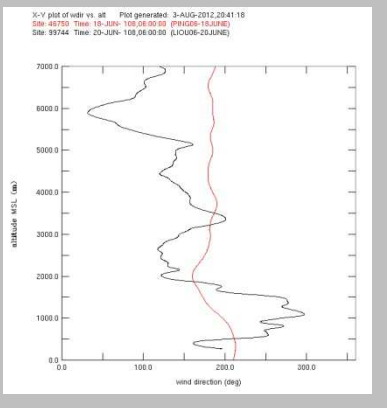






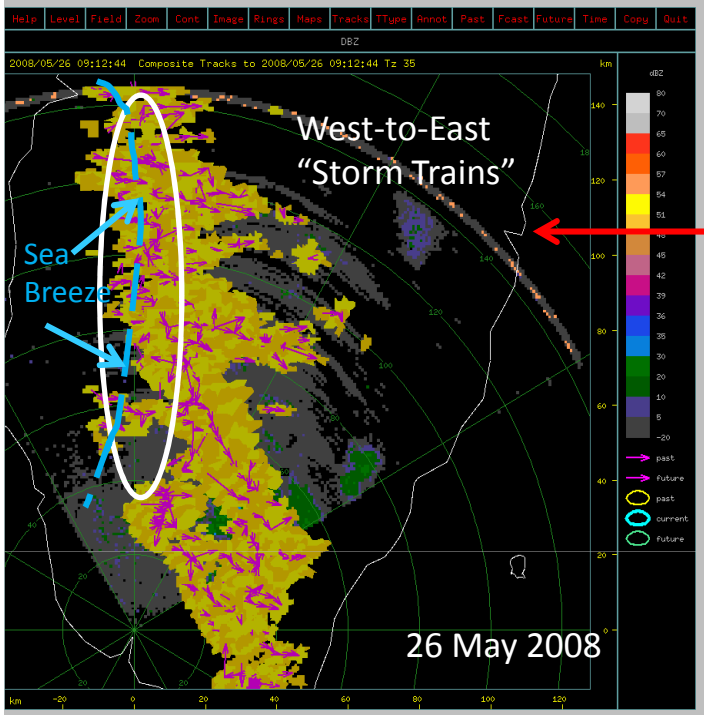






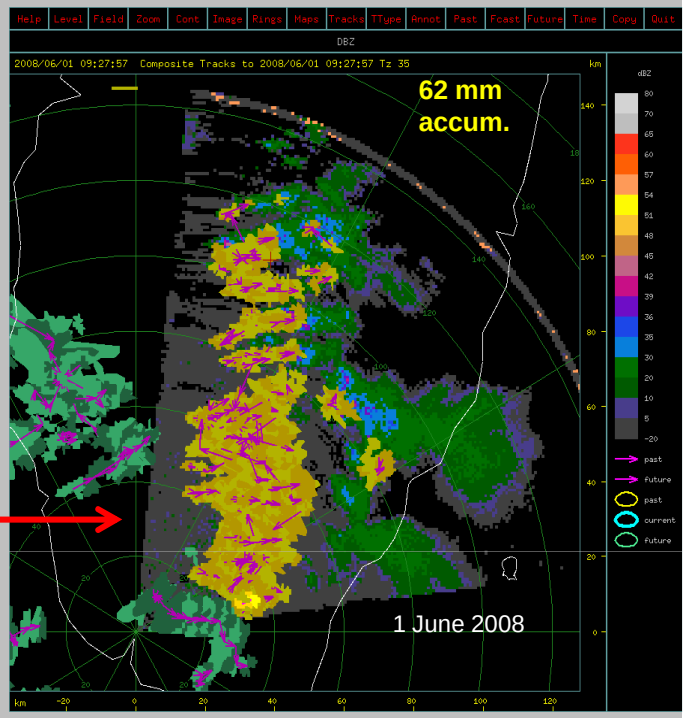
Coastal: Continual storm initiation above sea breeze

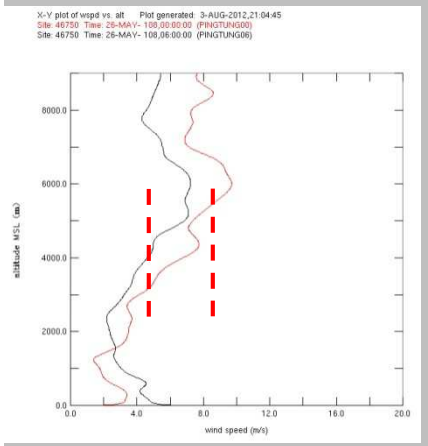
Plains: Storm initiation and mergers above convergence boundaries

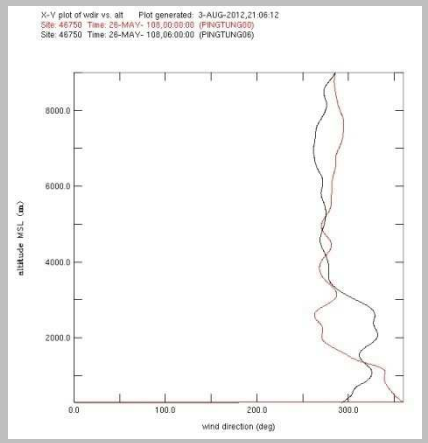


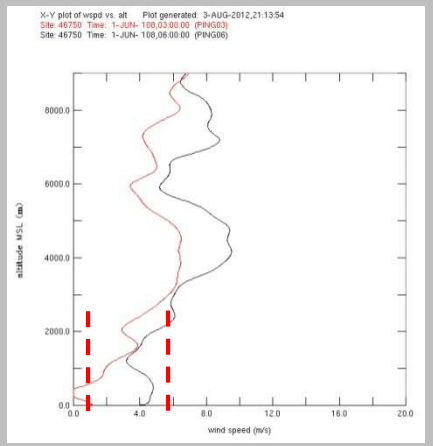
Under modest steering winds, recurring initiation above the sea breeze led to propagation of "storm trains" to foothills, and localized heavy rain.

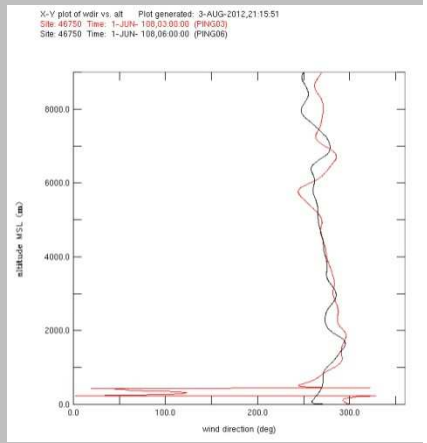
Localized heavy rainfall occurred when gust-front triggered storms merged together or backbuilt under weak-modest steering level winds.



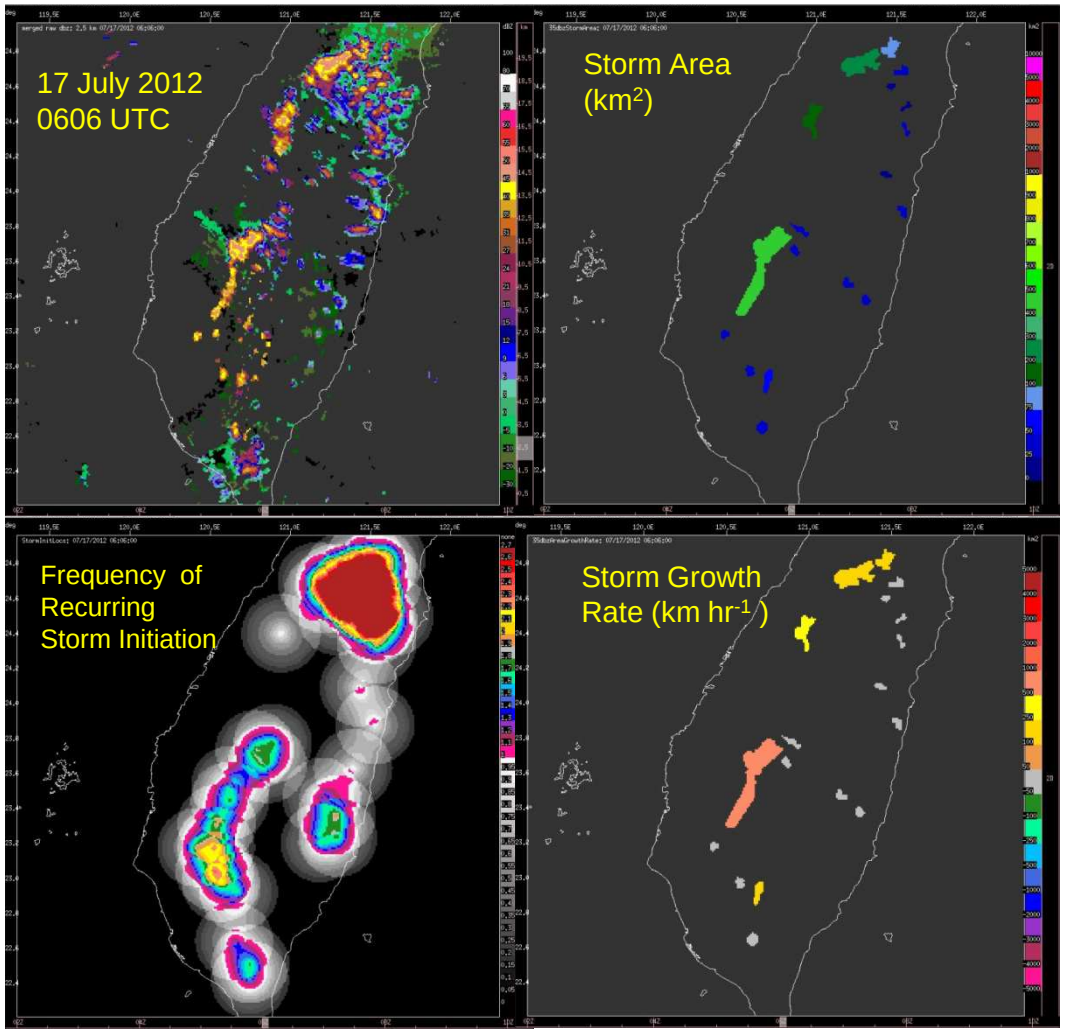






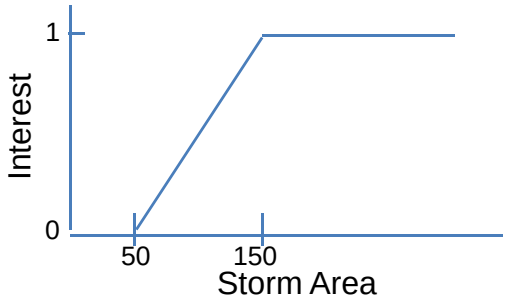


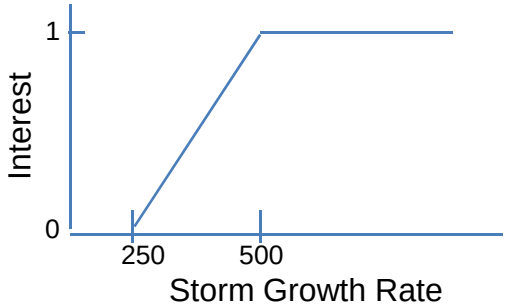
Membership functions modified within the Taiwan Autonowcaster

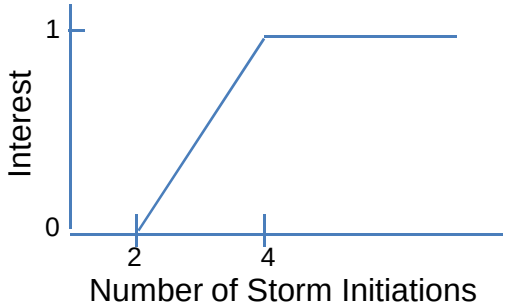


Output fields from the TITAN storm tracking algorithm

New thresholds set for storms more likely to produce heavy rainfall.





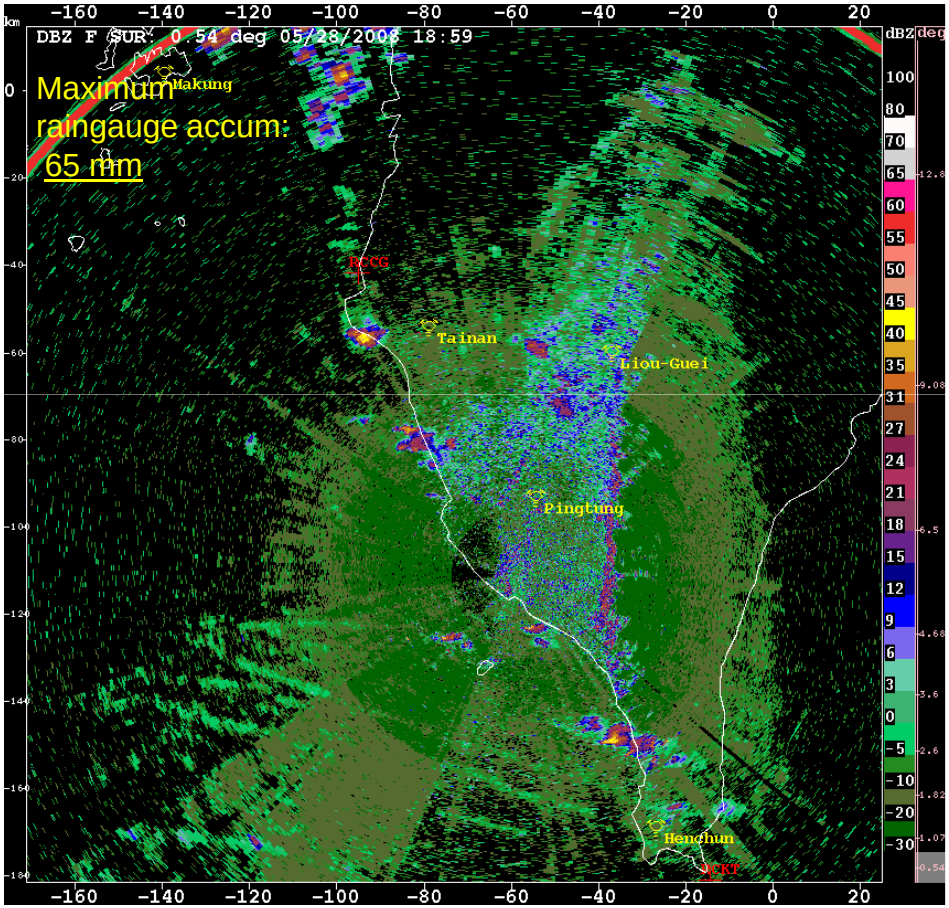


Scenarios Leading to Heavy Rainfall

Synoptically-Driven Weather

- Front (cold season)
- Mei-Yu Front (spring)
- Southwesterly (southern) monsoon
- Mesoscale Convective System (MCS)/ Mesoscale Convective Vortex (MCV)
- Short-wave Trough
- Typhoons
- Easterly Wave

Waves of Convective Storms



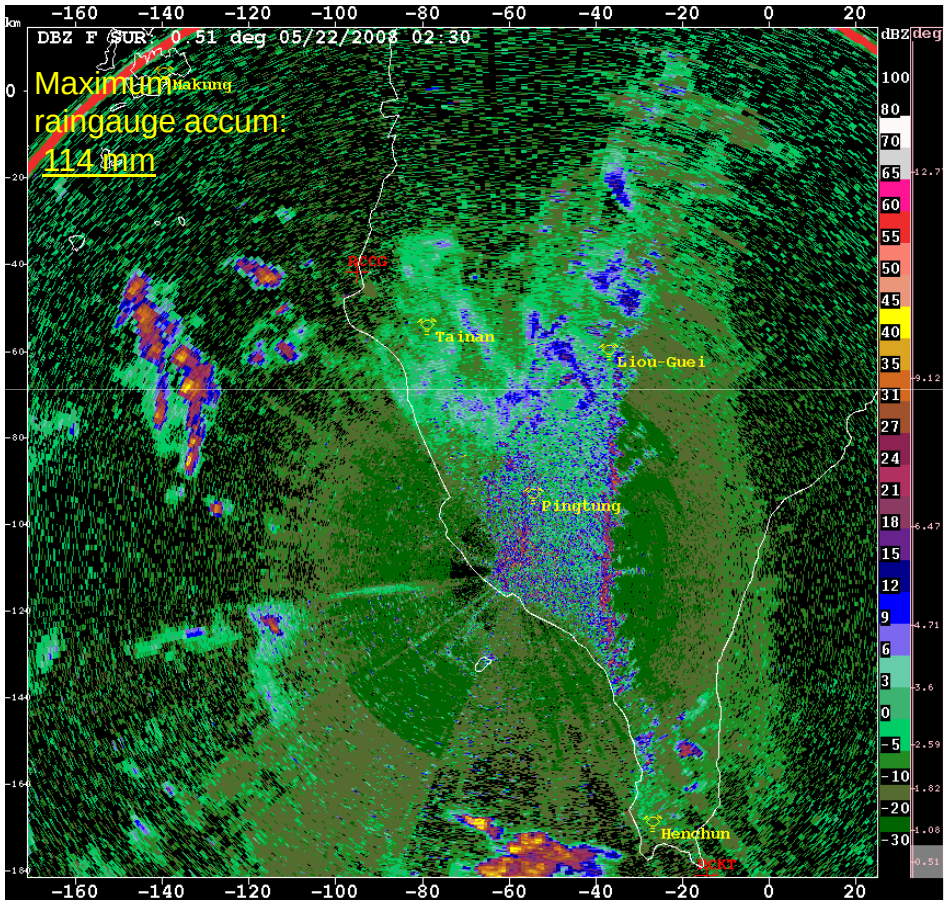
28-29 May 2008

Scenarios Leading to Heavy Rainfall

Synoptically-Driven Weather

- Front (cold season)
- Mei-Yu Front (spring)
- Southwesterly (southern) monsoon
- Mesoscale Convective System (MCS)/ Mesoscale Convective Vortex (MCV)
- Short-wave Trough
- Typhoons
- Easterly Wave

Convective Bands & Foothills Initiation



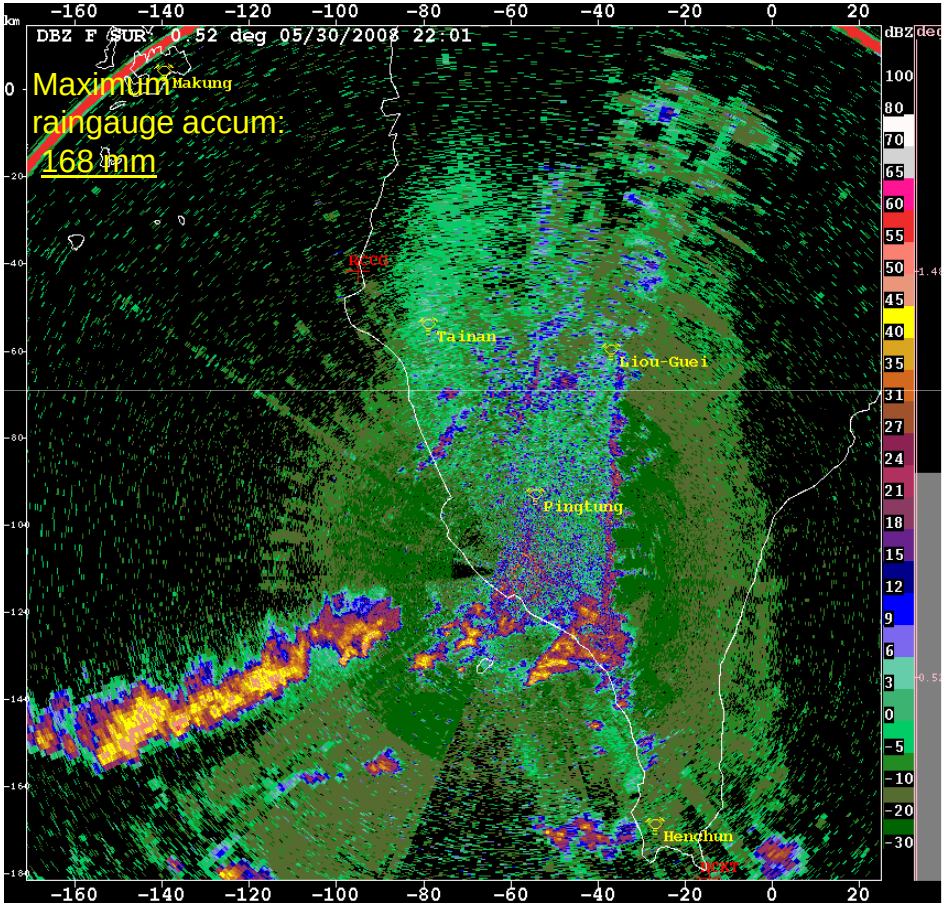
Short-WaveTrough: 22 May 2008

Scenarios Leading to Heavy Rainfall

Synoptically-Driven Weather

- Front (cold season)
- Mei-Yu Front (spring)
- Southwesterly (southern) monsoon
- Mesoscale Convective System (MCS)/ Mesoscale Convective Vortex (MCV)
- Short-wave Trough
- Typhoons
- Easterly Wave

Convective Bands



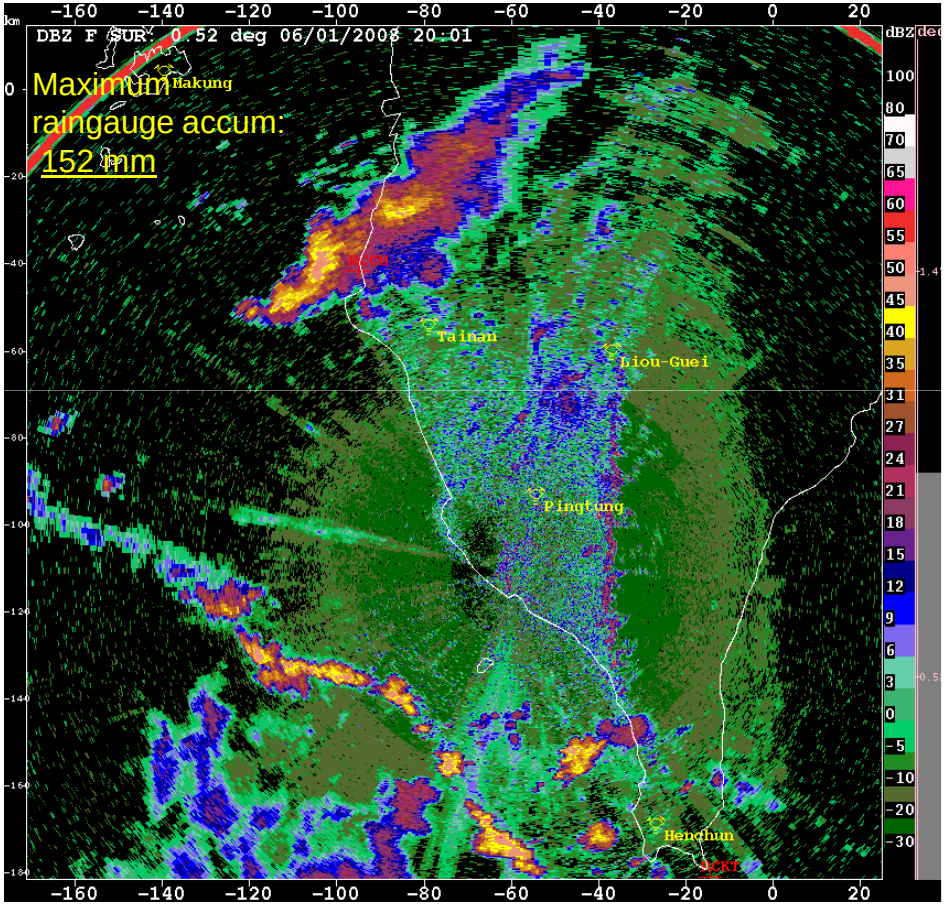
Mei-Yu Front: 31 May 2008

Scenarios Leading to Heavy Rainfall

Synoptically-Driven Weather

- Front (cold season)
- Mei-Yu Front (spring)
- Southwesterly (southern) monsoon
- Mesoscale Convective System (MCS)/ Mesoscale Convective Vortex (MCV)
- Short-wave Trough
- Typhoons
- Easterly Wave

Convective Bands



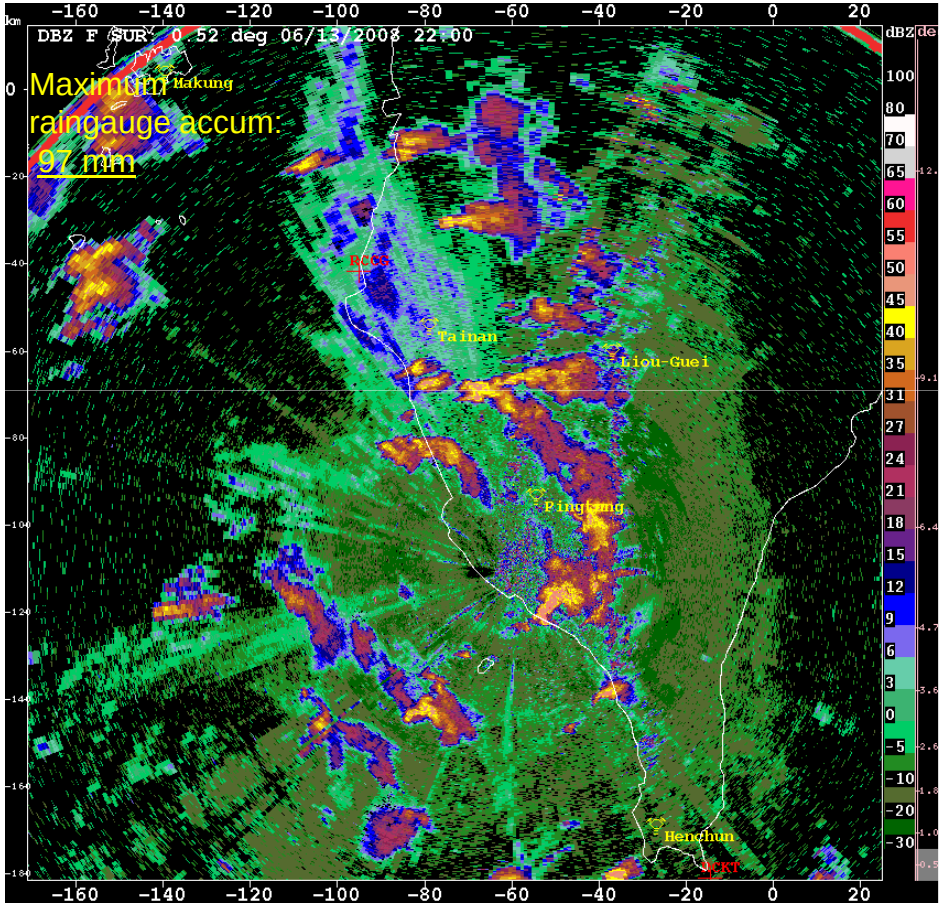
SW Monsoon/MCS: 2 June 2008

Scenarios Leading to Heavy Rainfall

Synoptically-Driven Weather

- Front (cold season)
- Mei-Yu Front (spring)
- Southwesterly (southern) monsoon
- Mesoscale Convective System (MCS)/ Mesoscale Convective Vortex (MCV)
- Short-wave Trough
- Typhoons
- Easterly Wave

Convective Bands & Local Initiation

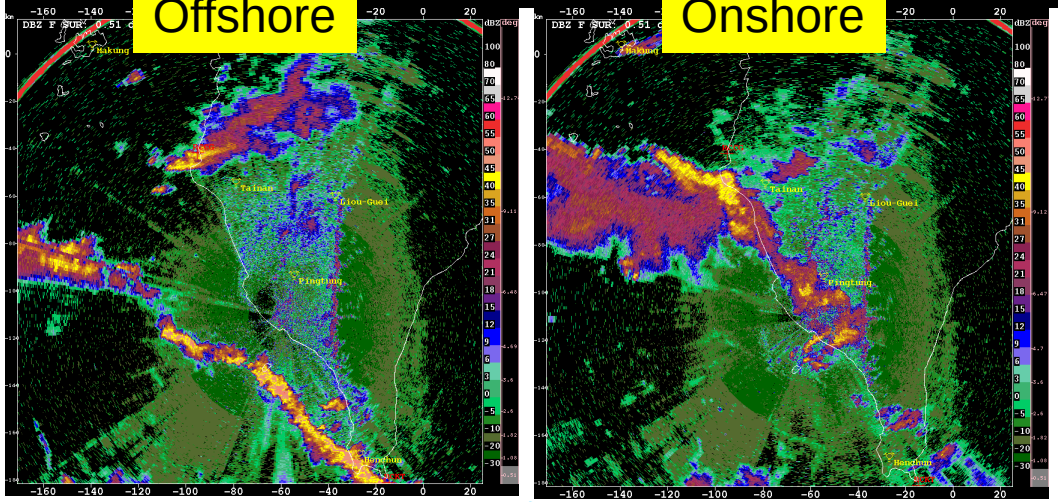


Mei-Yu Front/MCS: 14 June 2008

Challenges in Nowcasting Heavy Rainfall

- **Need to be able to nowcast those convective bands that will intensify as they move onshore**

Challenges in Nowcasting Heavy Rainfall

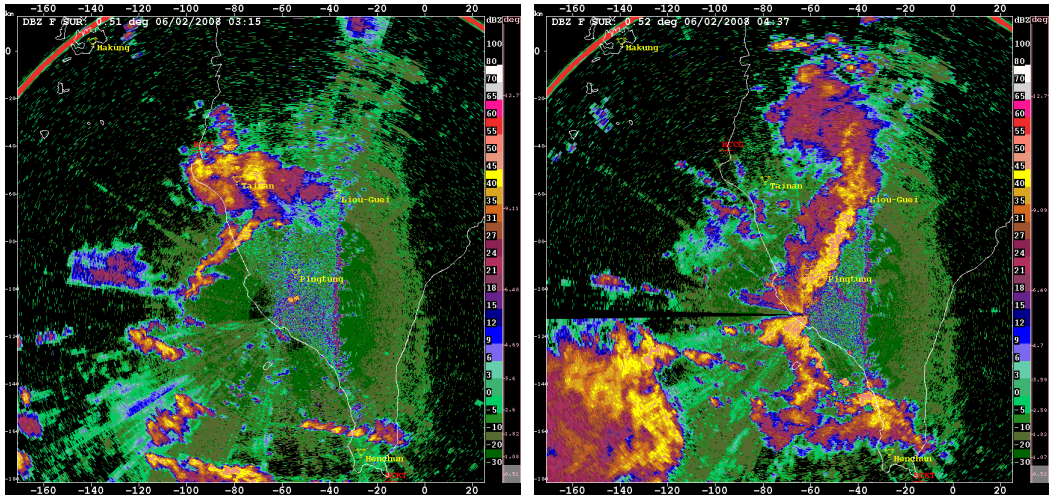


Convective Bands → Widespread Stratiform

1-2 June
20 UTC – 00 UTC

What causes these differences??

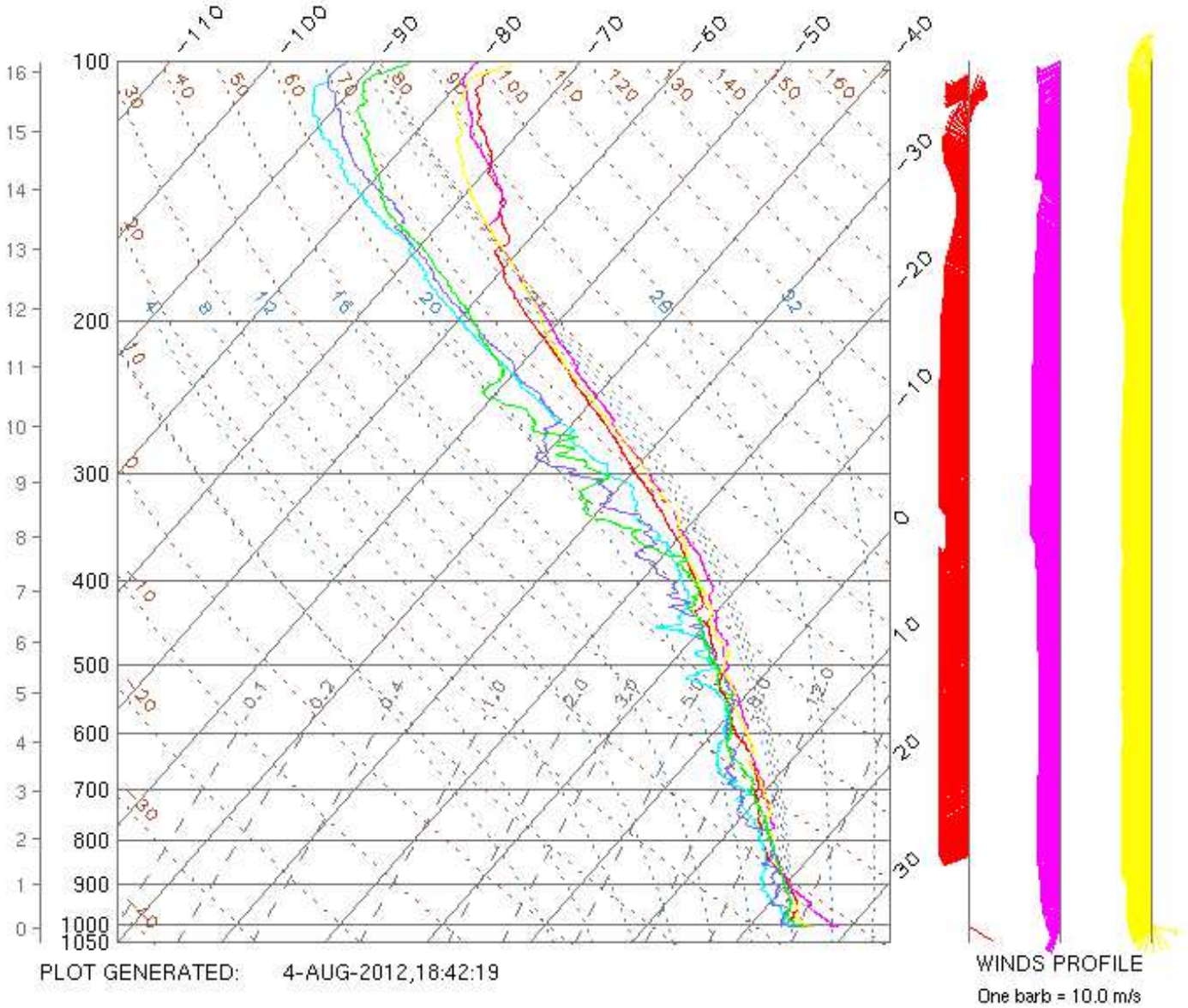
Can we predict these changes in precipitation intensity?



Convective Bands → Intensification

2 June
00 UTC – 04 UTC

SITE: 46750 TIME: 2-JUN- 108,00:00:00 (PINGTUNG00) TEMP/WINDS DEWPOINT
SITE: 46750 TIME: 2-JUN- 108,03:00:00 (PINGTUNG03) TEMP/WINDS DEWPOINT
SITE: 46750 TIME: 2-JUN- 108,06:00:00 (PINGTUNG06) TEMP/WINDS DEWPOINT



PLOT GENERATED: 4-AUG-2012,18:42:19

Challenges in Nowcasting Heavy Rainfall

- **Need to be able to nowcast those convective bands that will intensify as they move onshore**
  - **Do we have sufficient observations to detect and predict these subtle changes in atmospheric stability?**

    No!!
  - **Are there other important factors that we are not routinely observing/measuring?**

Mei-Yu Front and MCV
Kaohsiung, Taiwan
5 June 2008

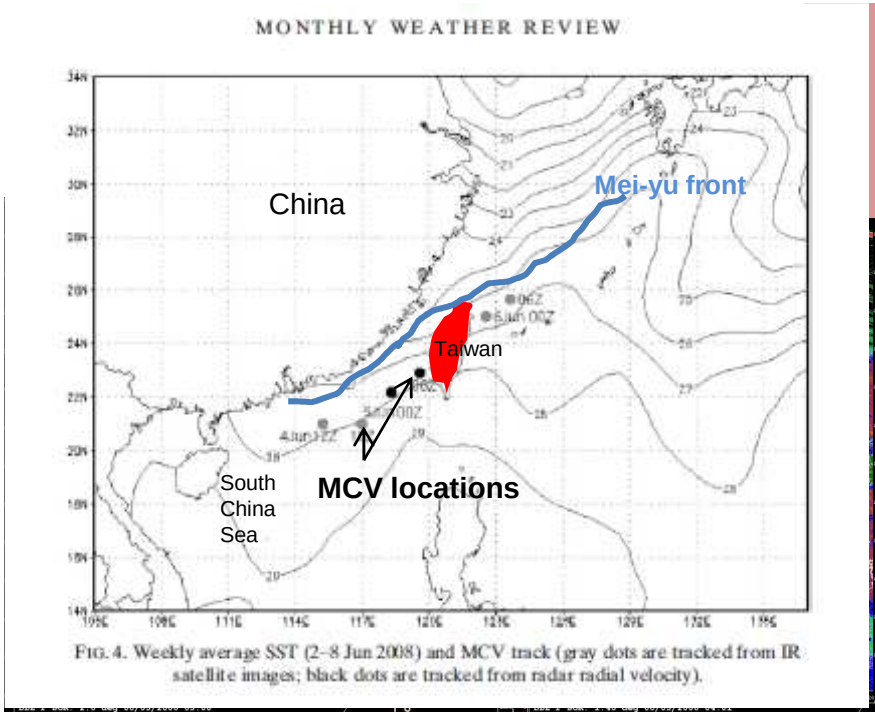
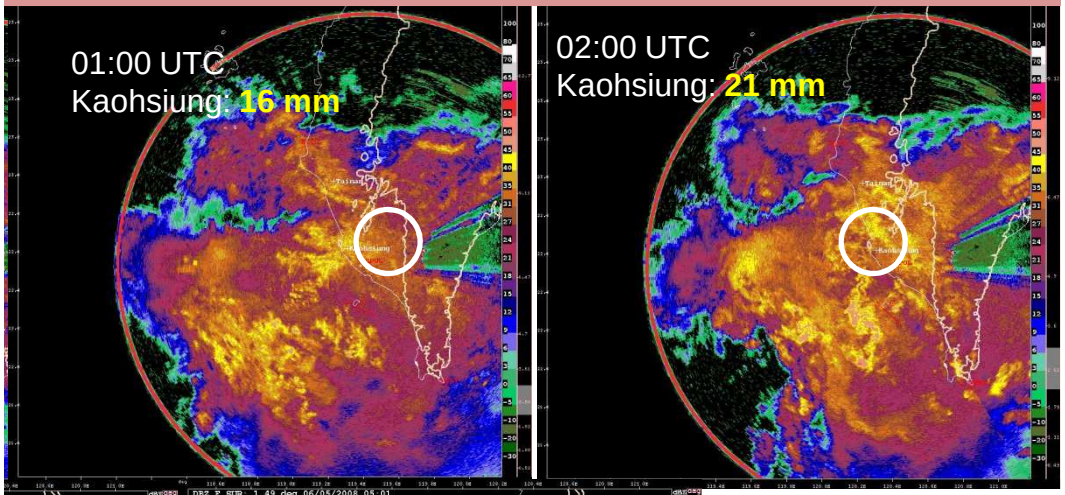
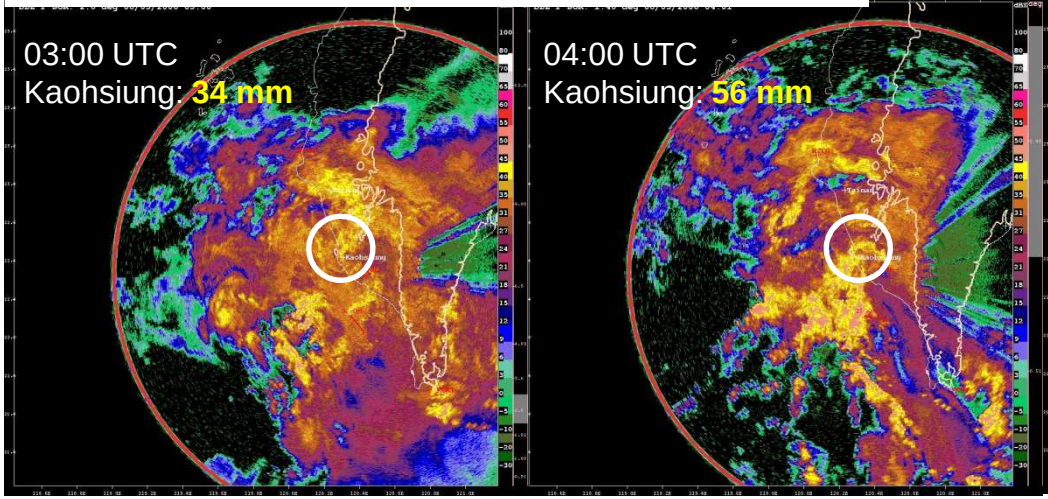
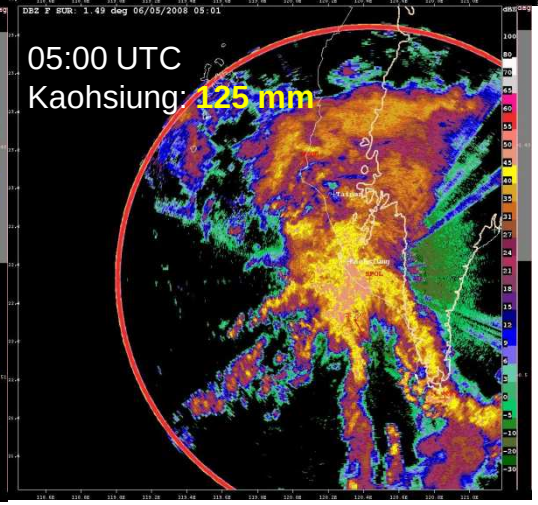


FIG. 4. Weekly average SST (2–8 Jun 2008) and MCV track (gray dots are tracked from IR satellite images; black dots are tracked from radar radial velocity).







Rainrate:

5:00-5:30 UTC

10 → 40 mm h^{-1}

Subsequent Accumulations:

06:00 UTC **202** mm
07:00 UTC **217** mm
08:00 UTC **226** mm

TiMREX : Terrain-influenced Monsoon Rainfall Experiment

May-June 2008

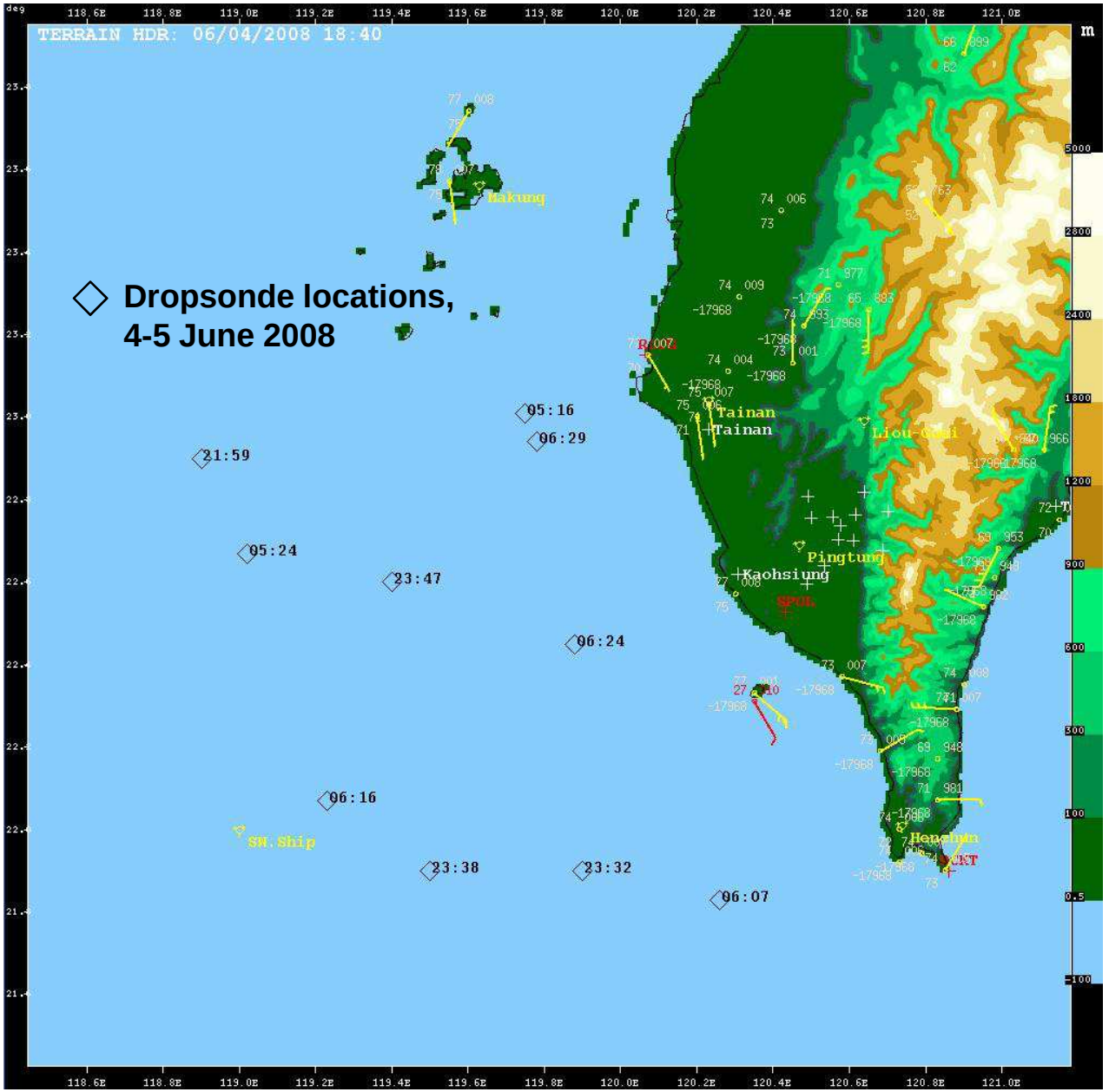
NCAR S-Pol (dual-polarization) Doppler radar

Vertical profiling instruments at “Super Site”

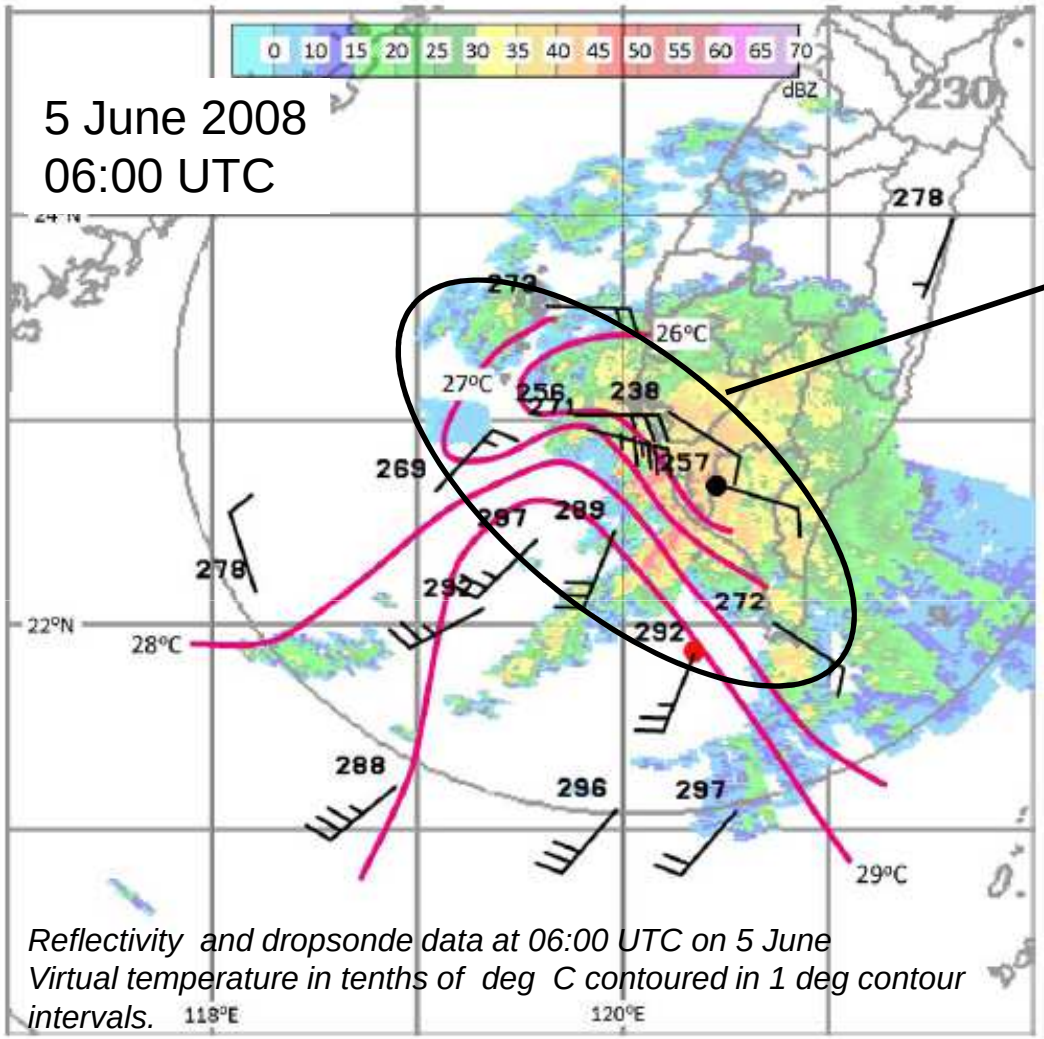
3-hourly sounding launches

400+ raingauge & surface stations

15-20 dropsondes per misson



Offshore Convergence Boundaries Important



Reflectivity and dropsonde data at 06:00 UTC on 5 June
Virtual temperature in tenths of deg C contoured in 1 deg contour intervals.

Heavy rainfall associated with well-defined, shallow (1 km deep) boundary located near the coast.

Due to extremely moist upstream, unstable air, boundaries appear to have strong influence on convection initiation or intensification near the coast.

Can be long-lived due to presence of cool downdrafts and absence of diurnal heating over land under cloudy conditions.

Davis, C. A., and W.-C. Lee, 2011: Mesoscale analysis of heavy rainfall episodes from SoWMEX/TiMREX. *J. Atmos. Sci*.

Challenges in Nowcasting Heavy Rainfall

- **Need** sufficient observations to detect subtle changes in temperature and shallow, long-lived convergence.

- How can we do this with no observations over the water?

VDRAS

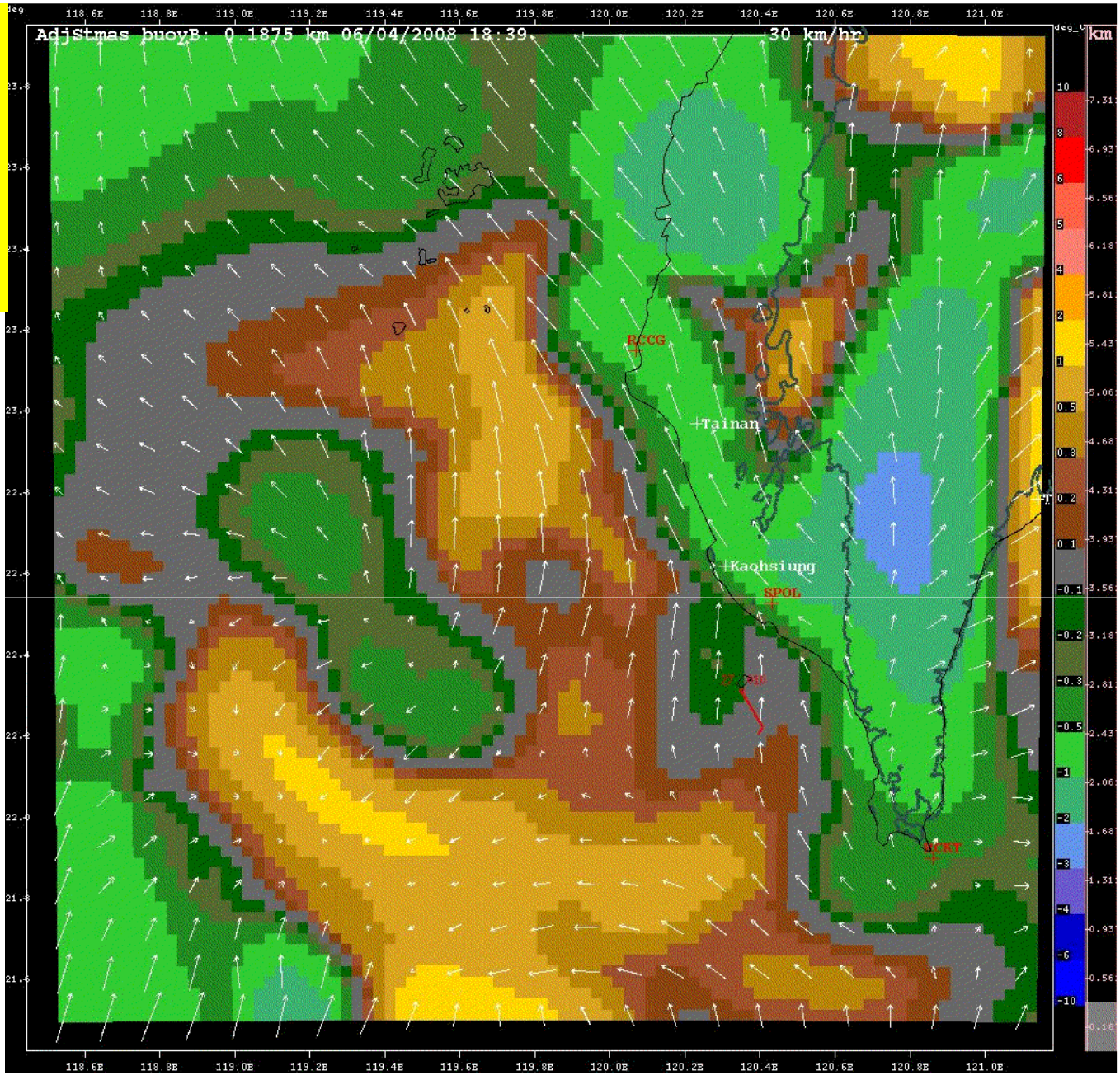
Temperature perturbation Field (shaded) and horizontal winds

0.187 km AGL

10 hr loop:
18:30 – 04:41 UTC

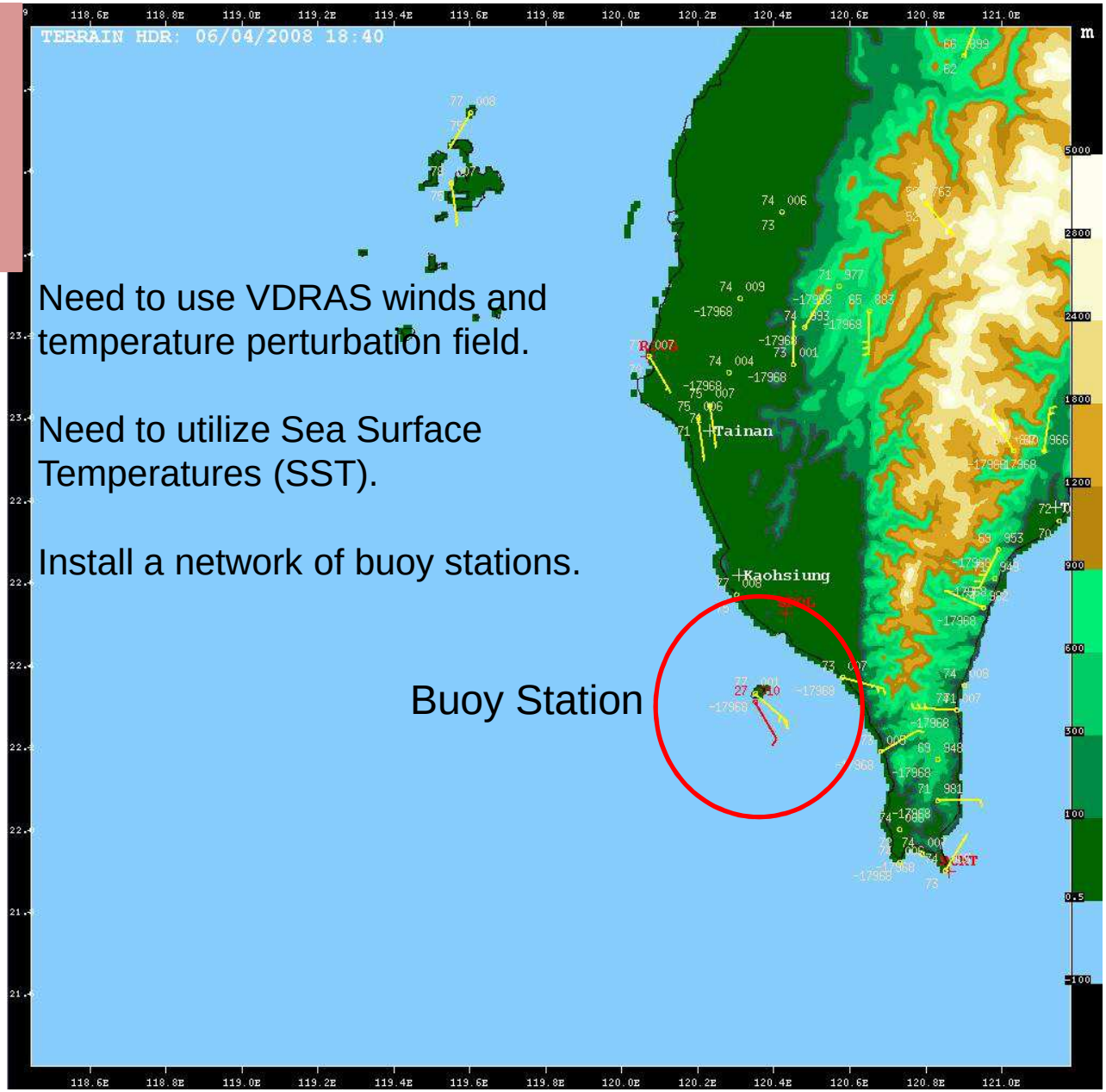
Green/blue shades:
Cooling trend

Browns/gold shades:
Warming trend



Jenny Sun and Zhuming Ying

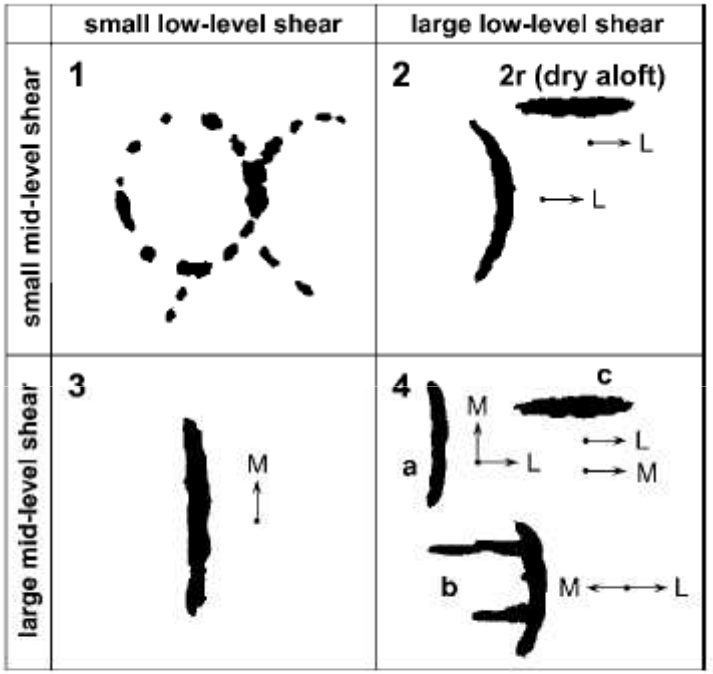
How to identify shallow convergence boundaries and temperature gradients offshore?



Challenges in Nowcasting Heavy Rainfall

- **Need to document the attributes of the different weather regimes**
  - Collaborating with Luca Panziera of MeteoSwiss to test **NORA** (Nowcasting Orographic Rainfall using Analogs) on 7 years of Taiwan data.
- **Need to monitor areal extent of storms and storm growth and dissipation rates**
- **Need to be able to predict regions storm mergers**
- **Need to document important environmental thresholds**

Tropical Convective Structures



(LeMone et al 1998; Johnson and Bresch, 2005)