National University of Defense Technology

# Probability Forecast Model of Tropical Cyclone Heavy Rainfall Area Based on Multi-element Diagnosis

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# Motivation


## External influences

- Dynamics
  - Vertical wind shear
  - Upper-level divergence
  - Trough/ridge interactions
- Thermodynamics
  - Static stability
  - Atmospheric moisture content

## Internal influences

- Latent Heat Release (LHR) is the primary heat source within TCs
- Eyewall Dynamics
- Rainbands and Vortex Rossby Waves
- Mesoscale vortices

# Motivation

**Case: Tropical Cyclone, Soulik(2013)**

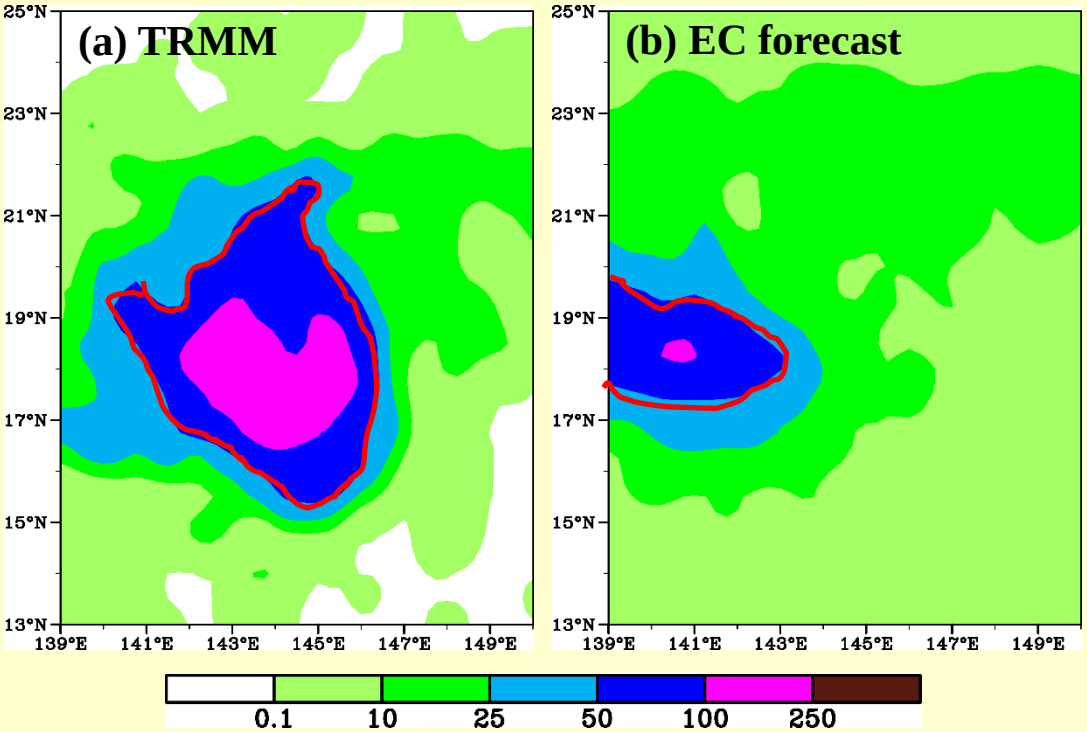



Fig.1 24_h rainfall accumulation from 20130708_00Z (unit: mm)

Model output

↓

Diagnostic precipitation

↓ calibration

Forecast precipitation

# Physical elements

- Specific Humidity
- Helicity (Lilly D.K. 1986)
- Pseudo-equivalent temperature
- Wet enthalpy $E_1$ (Ye, et al, 1960) $E_1 = c_p T + Lq$
- Wet enthalpy advection
- Pressure energy $E_p$ (Chen 2007) $E_p = gZ' + \frac{1}{2}V^2$
- Pressure energy vorticity

- ✓ Vorticity;
- ✓ Vertical wind shear;
- ✓ Moisture content,
- ✓ Energy

(Shou et al., 1981;Xu, 1996; Huang et al,2002)

# Pattern-matching criterion

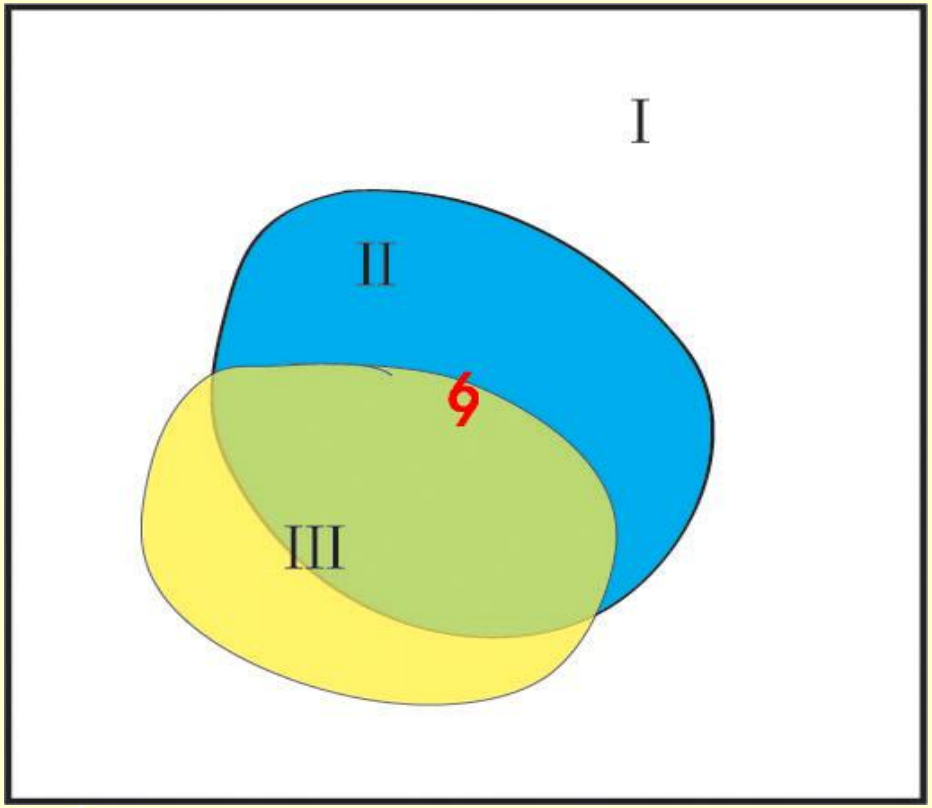



**Diagram of rainfall and physical element entity**

(Lee, et al 2010; Ebert, E.E, et al ,1998)

## Criterion 1: Relative centroid

$$A_p(x_i, y_i) = R_p(x_i, y_i) - H_p(x_i, y_i)$$

## Criterion 2: Accuracy rate

$$CS1 = \frac{n1}{\delta 1} \times 100\%;$$

$$CS2 = \frac{n2 - n1}{\delta 2 - \delta 1} \times 100\%;$$

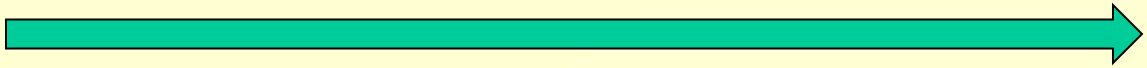
$$SS1 = CS1 \times C1 + (100 - CS2) \times C2$$

*wherin*, $C1 = 0.6, C2 = 0.4.$

# Pattern-matching statistics (2001-2012)

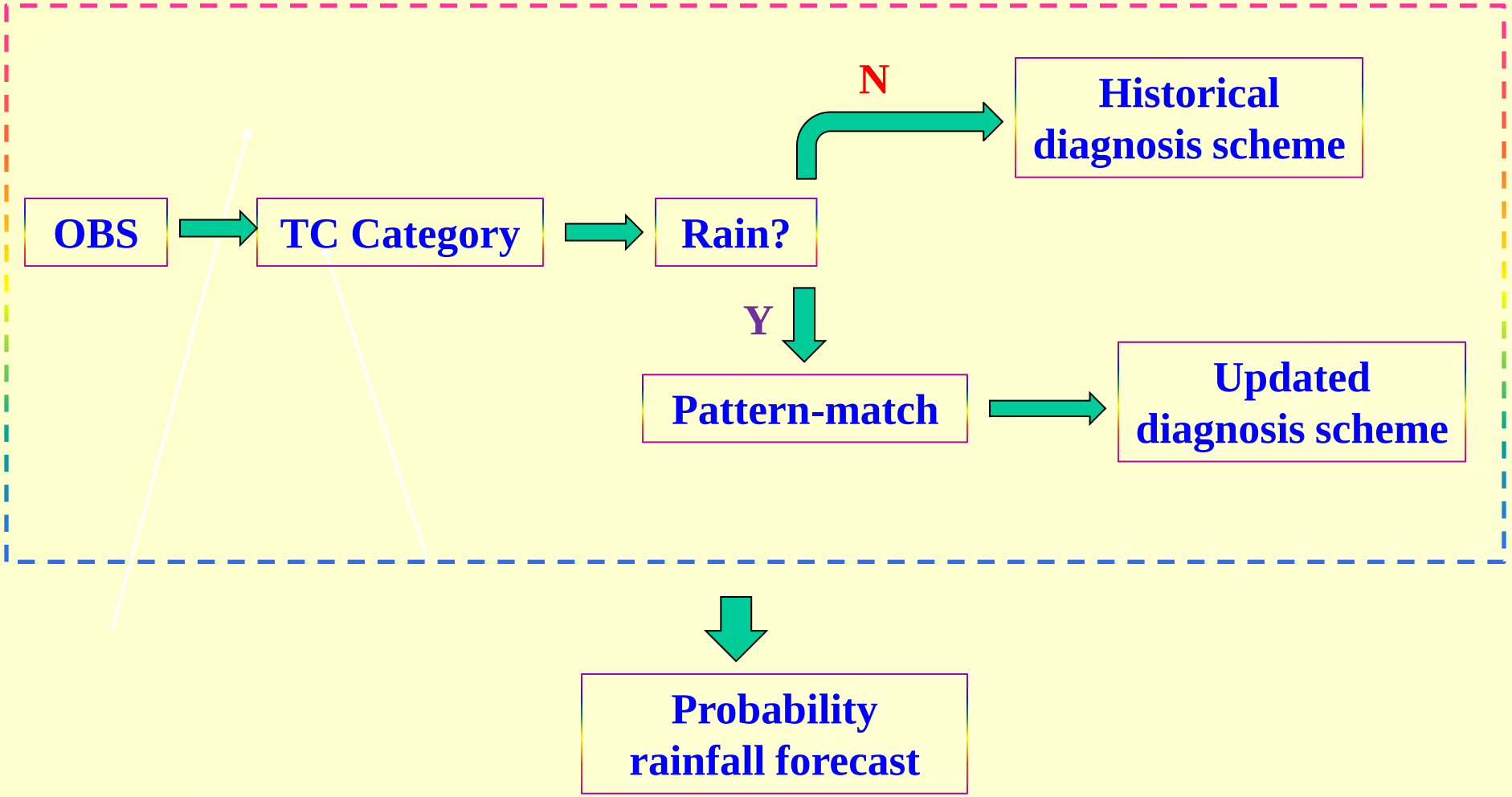
Table 1 Diagnostic Scheme for different TC Category

| | Specific Humidity | Helicity | Wet Enthalpy | Pressure Energy Vorticity | Pseudo-Equivalent temperature | Wet enthalpy advection | Pressure energy |
|---|---|---|---|---|---|---|---|
| Tropical Depression | 750hPa | 850hPa | 750hPa | 600hPa | 500hPa | 850hPa | 850hPa |
| Tropical Storm | 800hPa | 700hPa | 750hPa | 550hPa | 500hPa | 850hPa | 850hPa |
| Severe Tropical Storm | 600hPa | 600hPa | 600hPa | 500hPa | 500hPa | 850hPa | 850hPa |
| Typhoon | 750hPa | 700hPa | 650hPa | 500hPa | 500hPa | 850hPa | 850hPa |



Sorted in a descending order to characterize the heavy rainfall area!

# Probability forecast model



# Case study

**Case: Tropical Cyclone, Soulik(2013)**

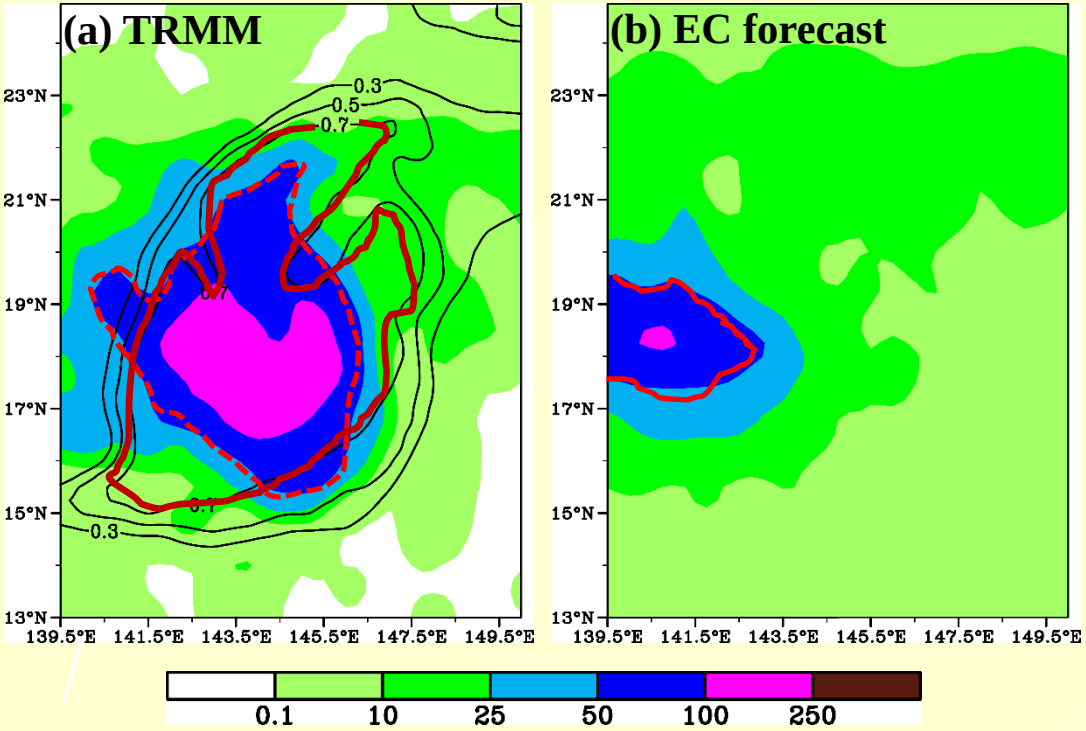
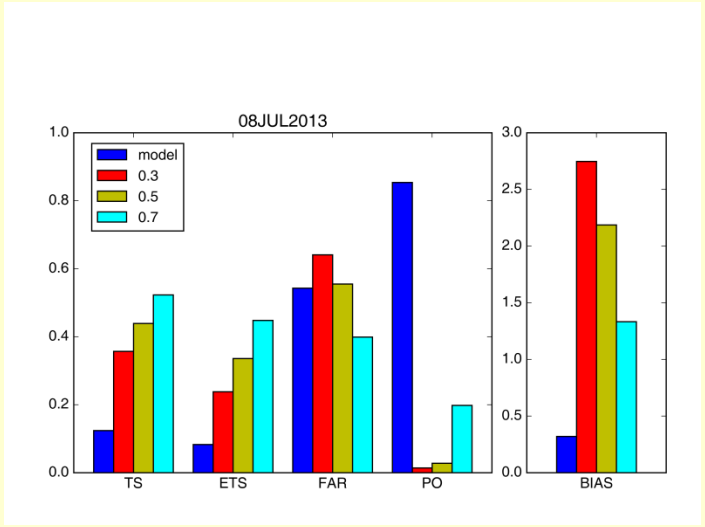
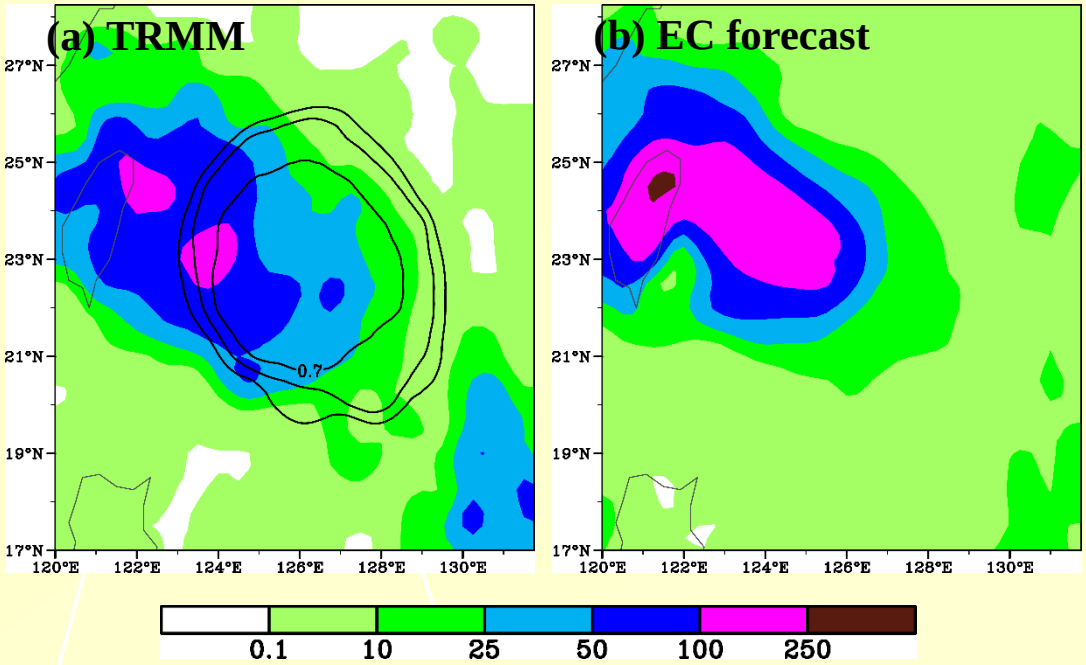



Fig.2 24_h rainfall accumulation from 20130708_00Z (unit: mm)




Improved!

# Case study



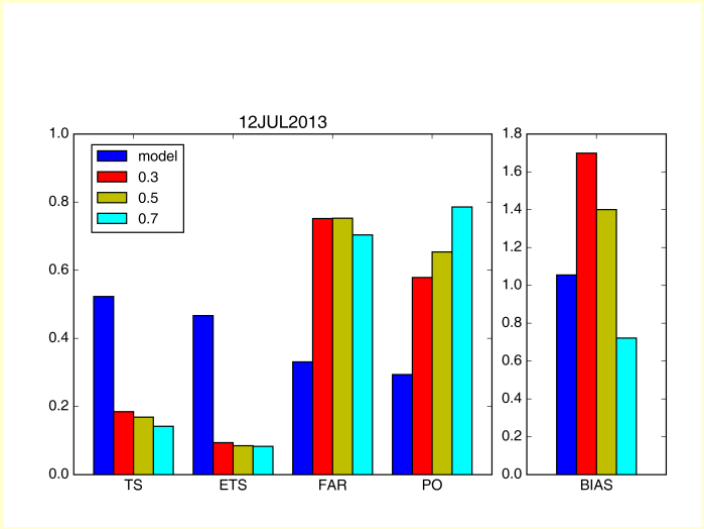




Fig.3 24_h rainfall accumulation from 20130712_00Z (unit: mm)

Failure!

# Summary

- Specific humidity, helicity, wet enthalpy, pressure energy vorticity, pseudo-equivalent temperature, enthalpy advection and pressure energy, can be sorted in a descending order to characterize the heavy rainfall area.
- The multi-element diagnosis schemes will change with TC intensity.
- The probability forecast can decrease the displacement error of the heavy rainfall area of TC.


# Thank You!