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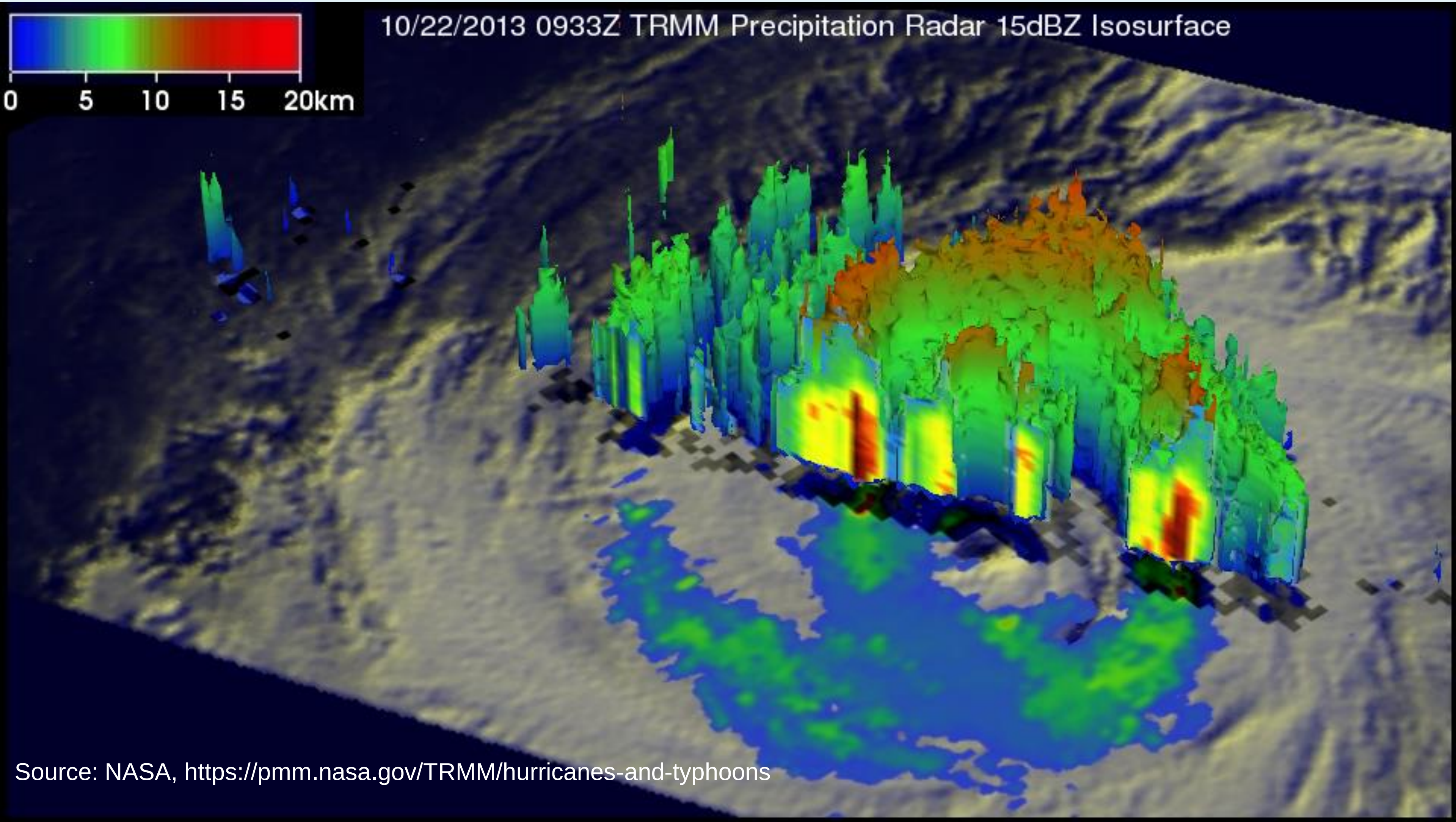
TC rainfall forecasting



Source: NASA, https://pmm.nasa.gov/TRMM/hurricanes-and-typhoons

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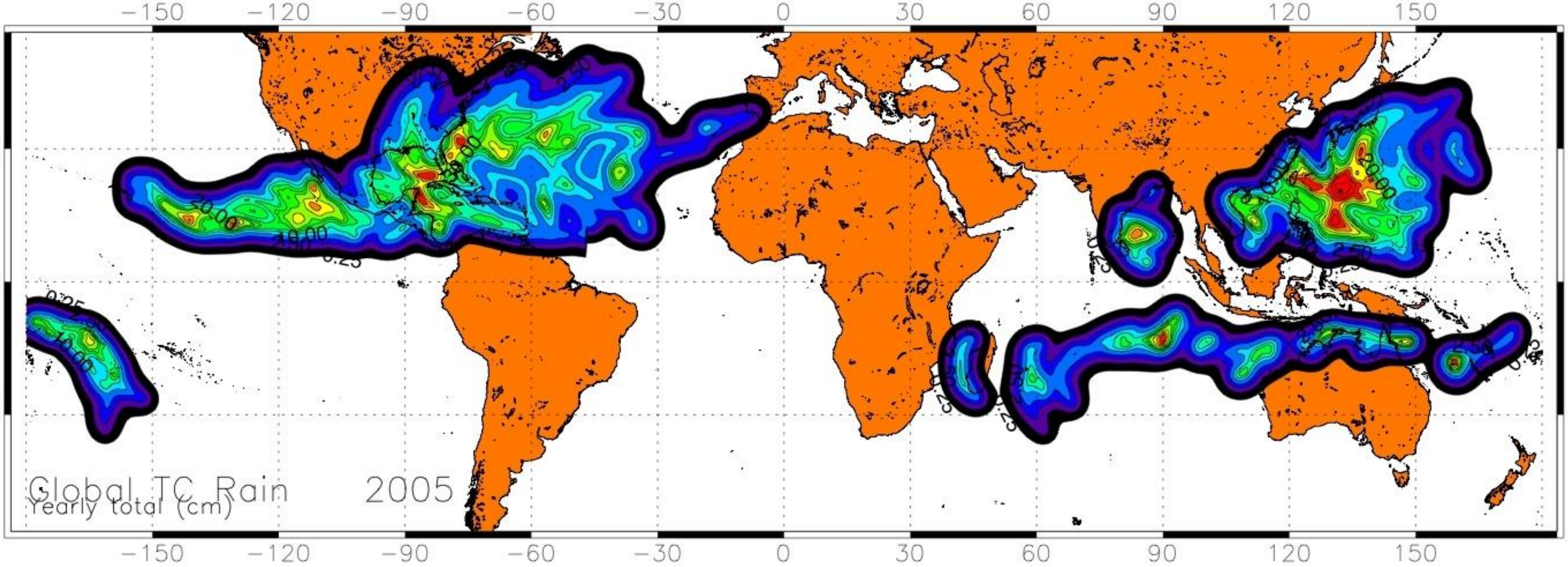
Global TC Rainfall



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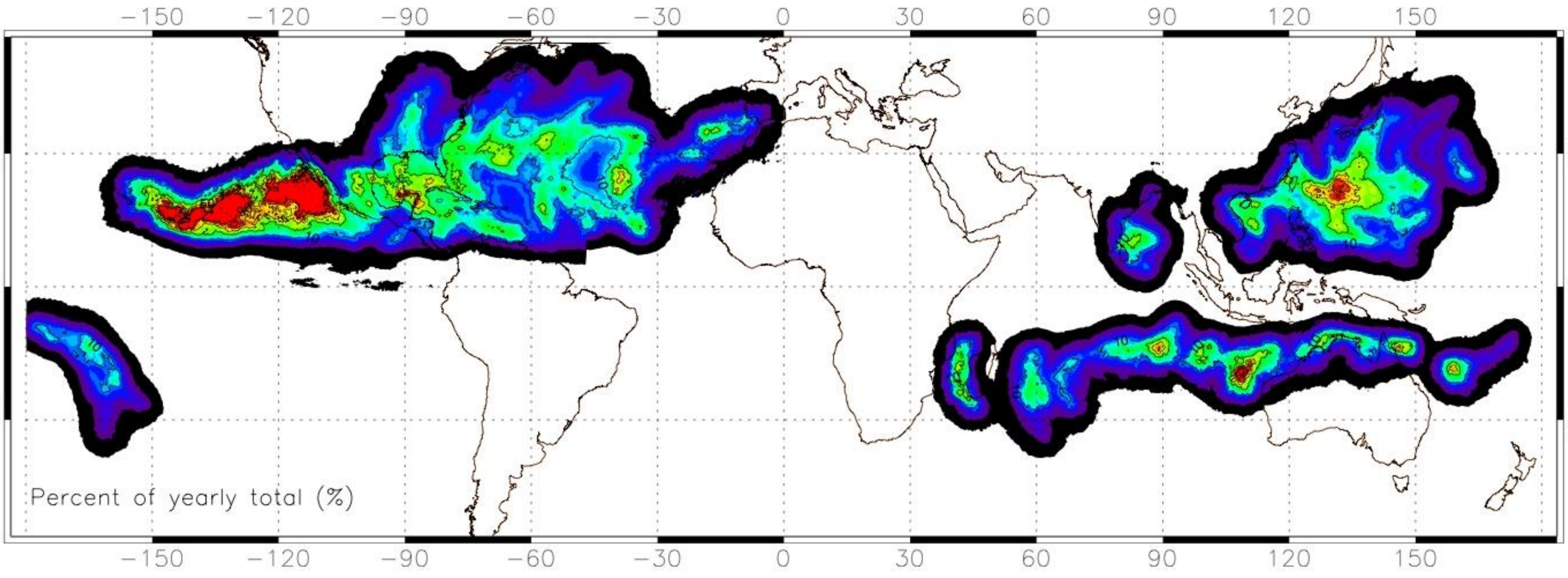
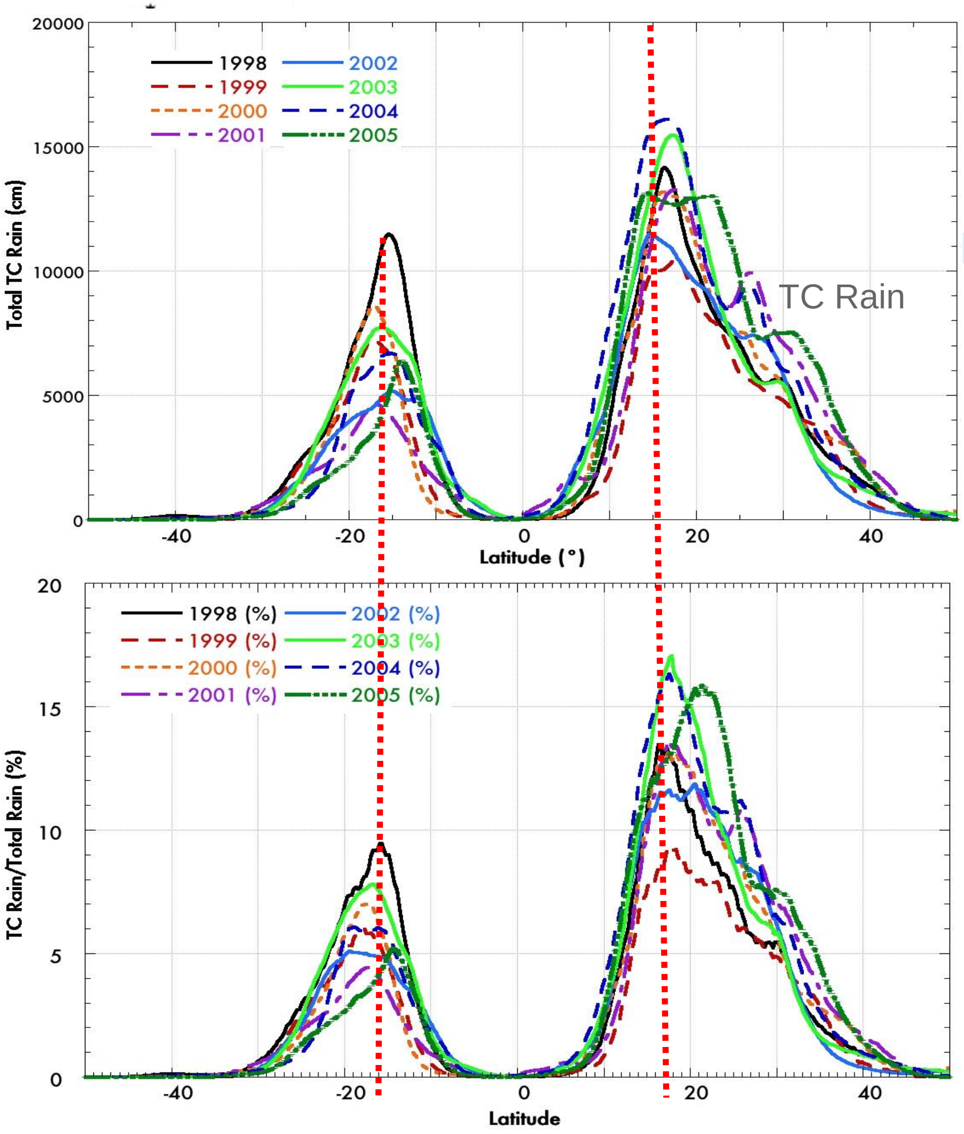
Global TC Rainfall

% of yearly total



Global TC Rainfall



Frank Marks (HRD)

- TC rainfall peaks when global rainfall is low
- Asymmetric-generally more rain in the Northern Hemisphere
- Global rainfall is decreasing with increasing latitude while TC rainfall is increasing
- TC contributes 10-17% of global rain 15-30° poleward from Equator (subtropics)

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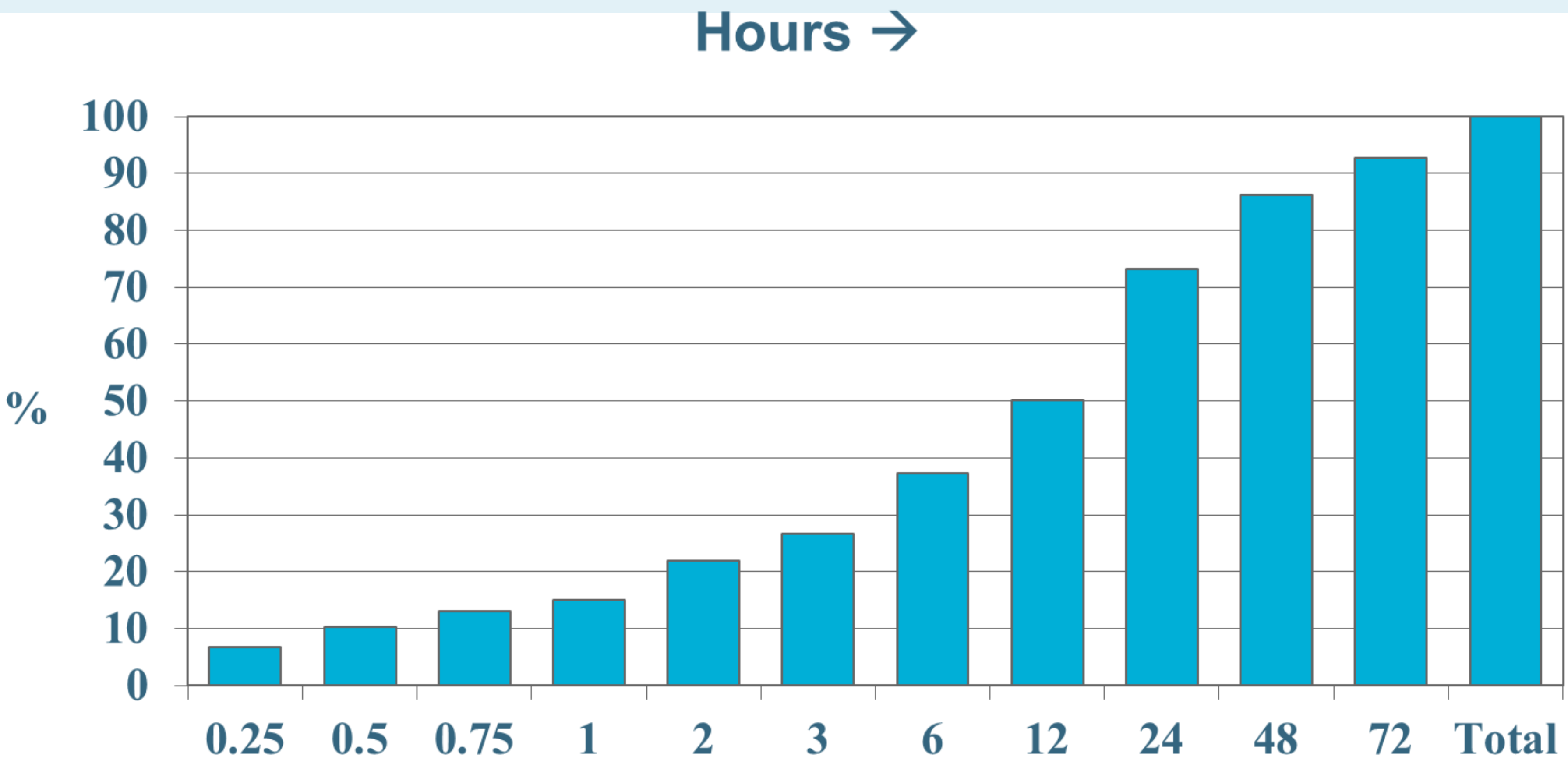
Percent of maximum storm total rainfall (h) 81 cases – 1991-2005

50% of total rain falls in 12h; 90% falls in 72h



Average (mm)	23	35	44	51	75	90	125	168	244	287	309	334
Maximum	48	76	114	152	251	337	557	708	813	882	908	1017

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Factors affecting rainfall?

- Storm track (location and translation speed)
- Storm size (positive) – the bigger the storm, the more it rains at any given spot
- Wind shear (negative) – leads to a quicker dropoff in rainfall for inland TCs
- Topography – Positive in the upslope areas, but negative past the spine of the mountains
- Nearby synoptic-scale features/Extratropical Transition
- Time of day – core rainfall overnight/ outer band rainfall during day

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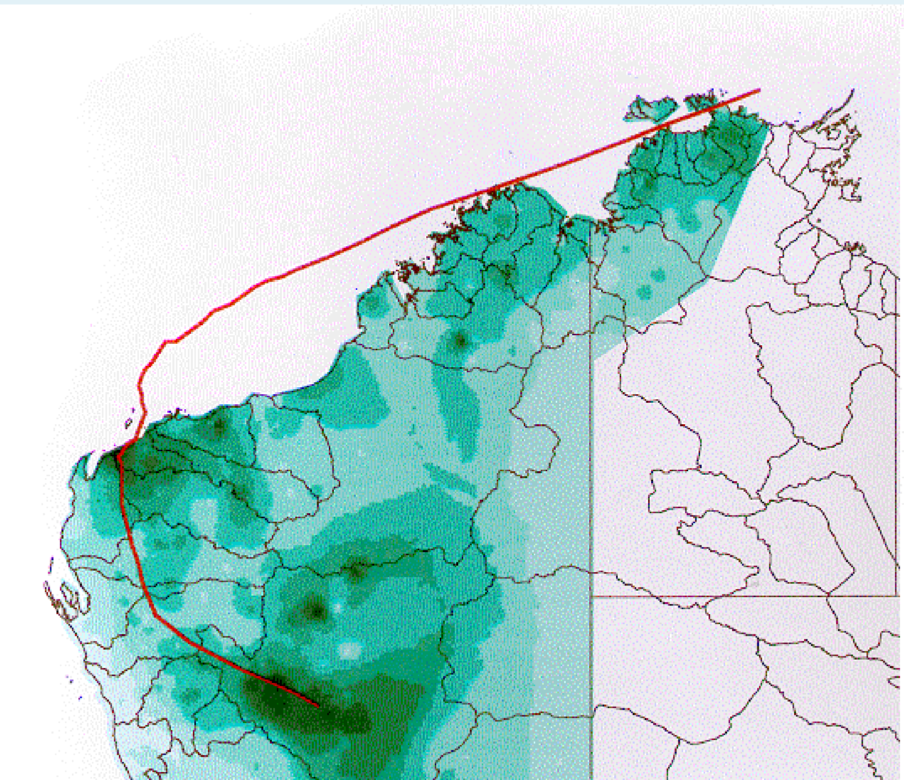
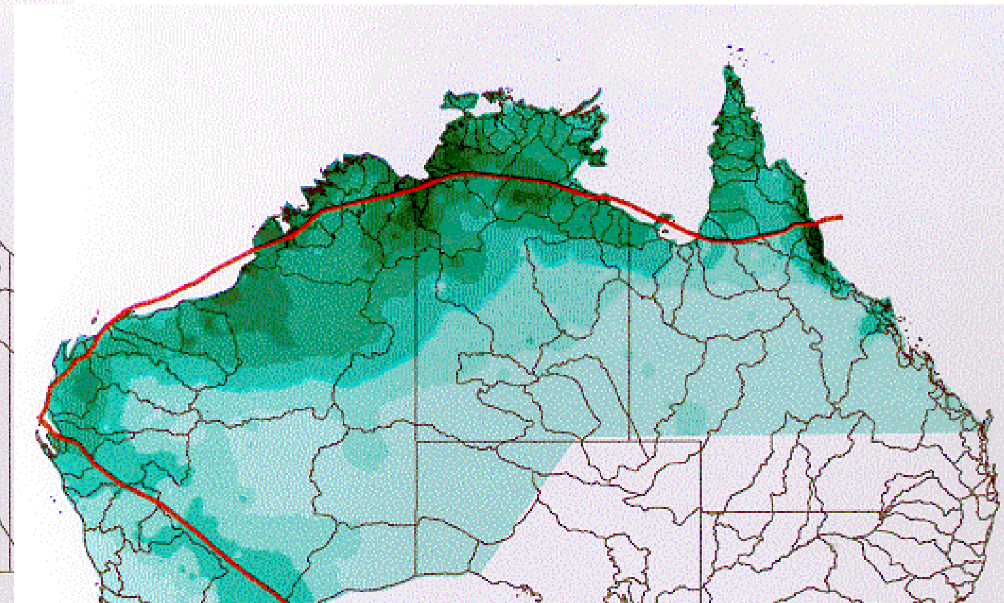
Rainfall – does intensity matter?



CYCLONE BOBBY

Category 4

(measured on 24/02/1995)



CYCLONE STEVE

Cyclone Category 2 (27/02/2000)

Rain (24h) in 291mm (29/02/2000)

Flood Average Recurrence Interval in about 80years

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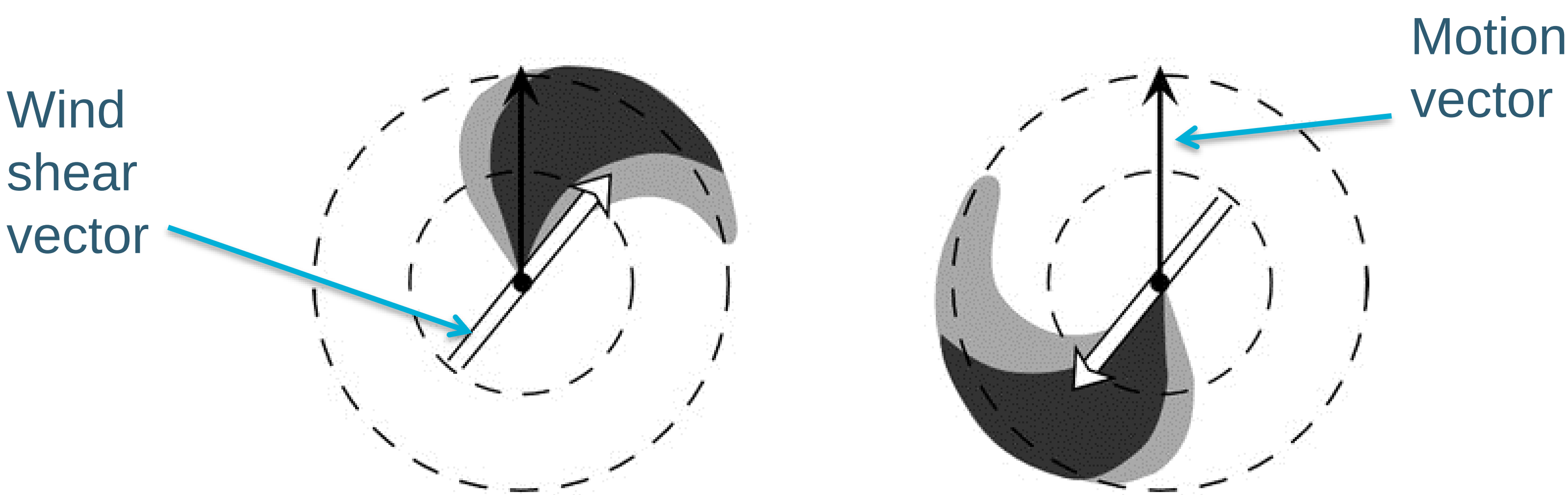
Vertical Wind Shear



High wind shear – shear dominates over motion asymmetry

If the shear is strong enough all rainfall may move away from the centre

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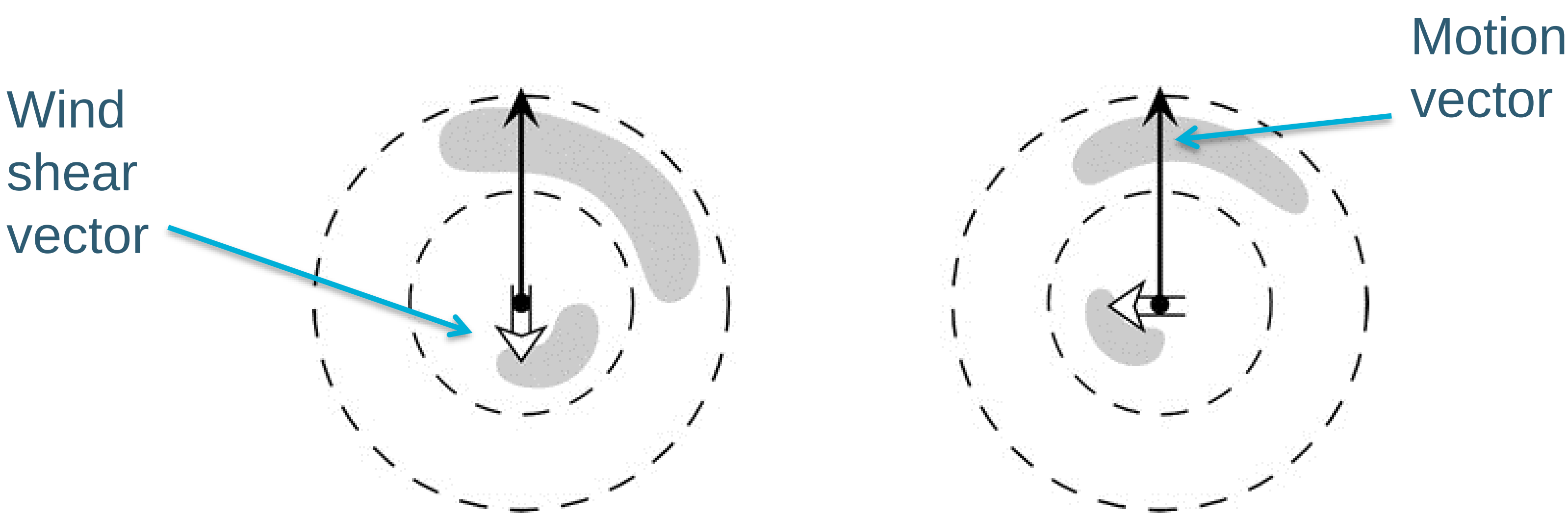
Vertical Wind Shear



Low wind shear – motion dominates over shear asymmetry in outer bands

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Rainfall: forecasting tools

- Climatology : general 100-200mm/day + topography
- Kraft rule of thumb:
  - **Rainfall accumulation (mm) = 2500/(translation speed in knots)**
- TPC
  - **Rain Accumulation = (Diameter * Rain Rate) / (translation speed)**
- eTrap http://www.ssd.noaa.gov/PS/TROP/etrap.html
- NWP and ensembles of NWP

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TPC method

$$\text{RAIN ACCUMULATION} = \frac{\text{DIAMETER * RAIN RATE}}{\text{VELOCITY}}$$

Convective Rainfall Rates

Average Climatological Rain Rate = 2 mm / hour

Core Rain Rate = 5 times this Average

or

Core Rain Rate = 10 mm /hour

Reinforced by radial amounts computed within Jiang, Halverson, Simpson AMS Hurricane Conference preprint (2006)

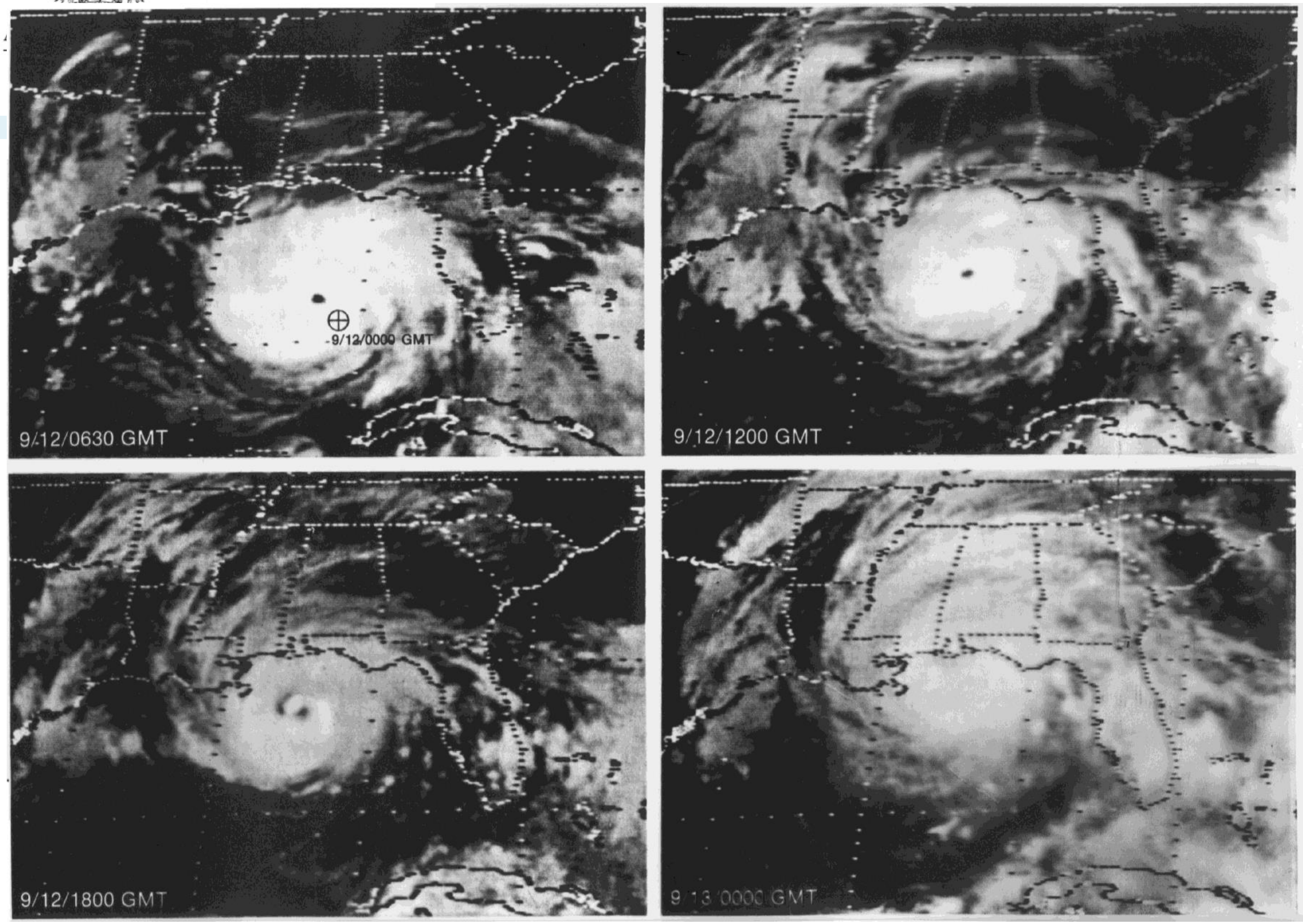
RAINFALL CALCULATION USING UNENHANCED INFRARED IMAGERY

Storm Name: FREDERIC **Date:** 12 SEPT 1979

Image Date/Time		Diameter of Storm in Direction of Motion			
12 / 0630	UTC	5.5	deg * 110 km/deg =	605	km
12 / 1200	UTC	5.5	deg * 110 km/deg =	605	km
12 / 1800	UTC	4.0	deg * 110 km/deg =	440	km
12 / 0000	UTC	4.5	deg * 110 km/deg =	495	km

Mean Diameter: D = 540 km

Frederic


9/12/0000 GMT
9/12/0630 GMT
9/12/1200 GMT
9/12/1800 GMT
9/13/0000 GMT

Forecast translation speed: V = 4.0 deg * 110 km/deg / 18 hrs = 24 km/hr

Mean rainfall rate: R = 0.2 cm/hr

Rainfall Potential: $P = \dfrac{D * R}{V}$

$$P = \frac{540 \text{ km} * 0.2 \text{ cm/hr}}{24 \text{ km/hr}} = 4.5 \text{ cm}$$

Core Rainfall: C = 5 * P = 22.5 cm (8.9”)

Rule of Thumb: $T = \dfrac{450}{V \text{ km/hr}} = \dfrac{450}{24 \text{ km/hr}} = 18.8$ cm (7.4”)

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Mean diameter in direction of motion D = 540 km

Forecast translation speed V = 24 km/h

Mean rainfall rate R = 2 mm/h

Rainfall potential   P = (D x R) / V

= (540 x 2) / 24 = 45 mm

Core rainfall C = 5 x P = **225 mm**

Kraft “rule of thumb” K = 2500 / 13.5 = **185 mm**

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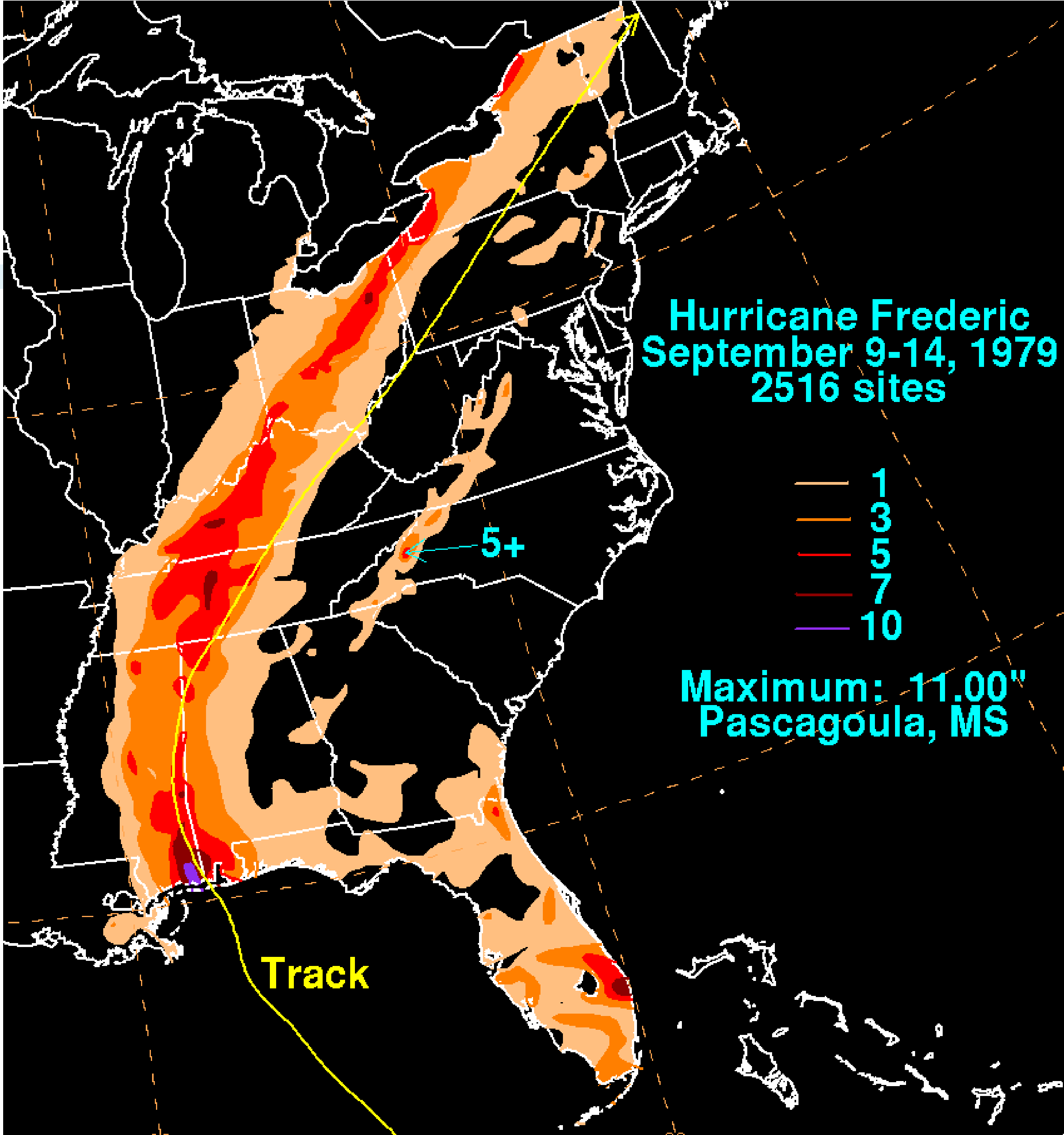
1” = 25 mm

10” = 250 mm

11” = 225 mm



Picking an analog for a TC event

- Size is important…look at the current rain shield and compare it to storm totals/storms from the past
- Is/was there vertical wind shear in current and past events?
- Look for storms with similar/parallel tracks
- Is topography/prism data a consideration?
- Look for nearby fronts/depth of nearby upper troughs for current and possible analogs
- Not all TC events will have a useful analog

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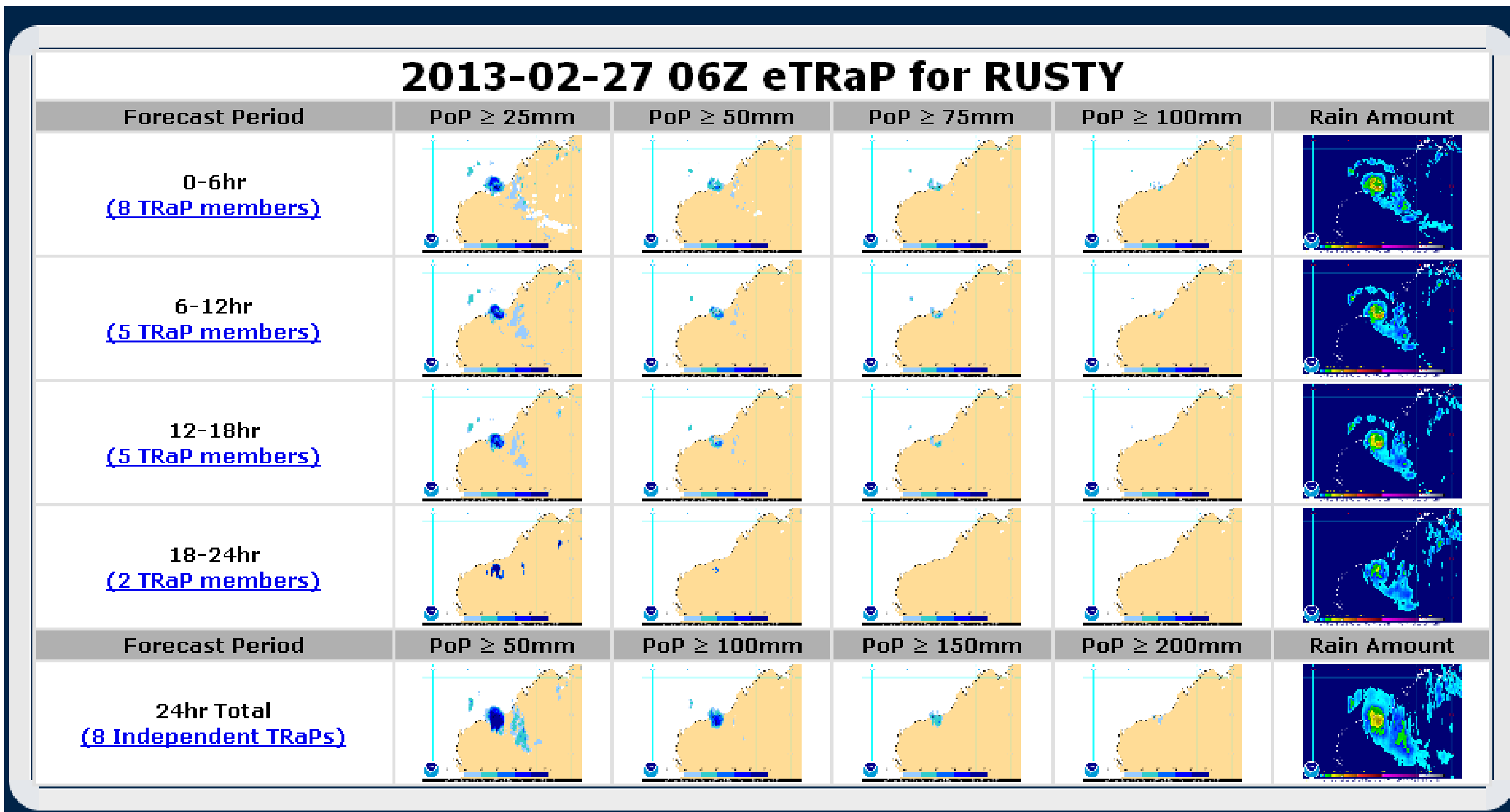
Tropical Cyclone- eTRaP

Ensemble Tropical Rainfall Potential (eTRaP)

The eTRaP is a simple ensemble whose members are the 6-hourly totals from the single-orbit TRaPs.
More information may be found at these links: eTRaP product information and Digital eTRaP Formats.
(Last Run for active storms: 2013-07-12-04Z)



2013-02-27 06Z eTRaP for RUSTY

Forecast Period	PoP ≥ 25mm	PoP ≥ 50mm	PoP ≥ 75mm	PoP ≥ 100mm	Rain Amount
0-6hr (8 TRaP members)					
6-12hr (5 TRaP members)					
12-18hr (5 TRaP members)					
18-24hr (2 TRaP members)					
Forecast Period	**PoP ≥ 50mm**	**PoP ≥ 100mm**	**PoP ≥ 150mm**	**PoP ≥ 200mm**	**Rain Amount**
24hr Total (8 Independent TRaPs)					

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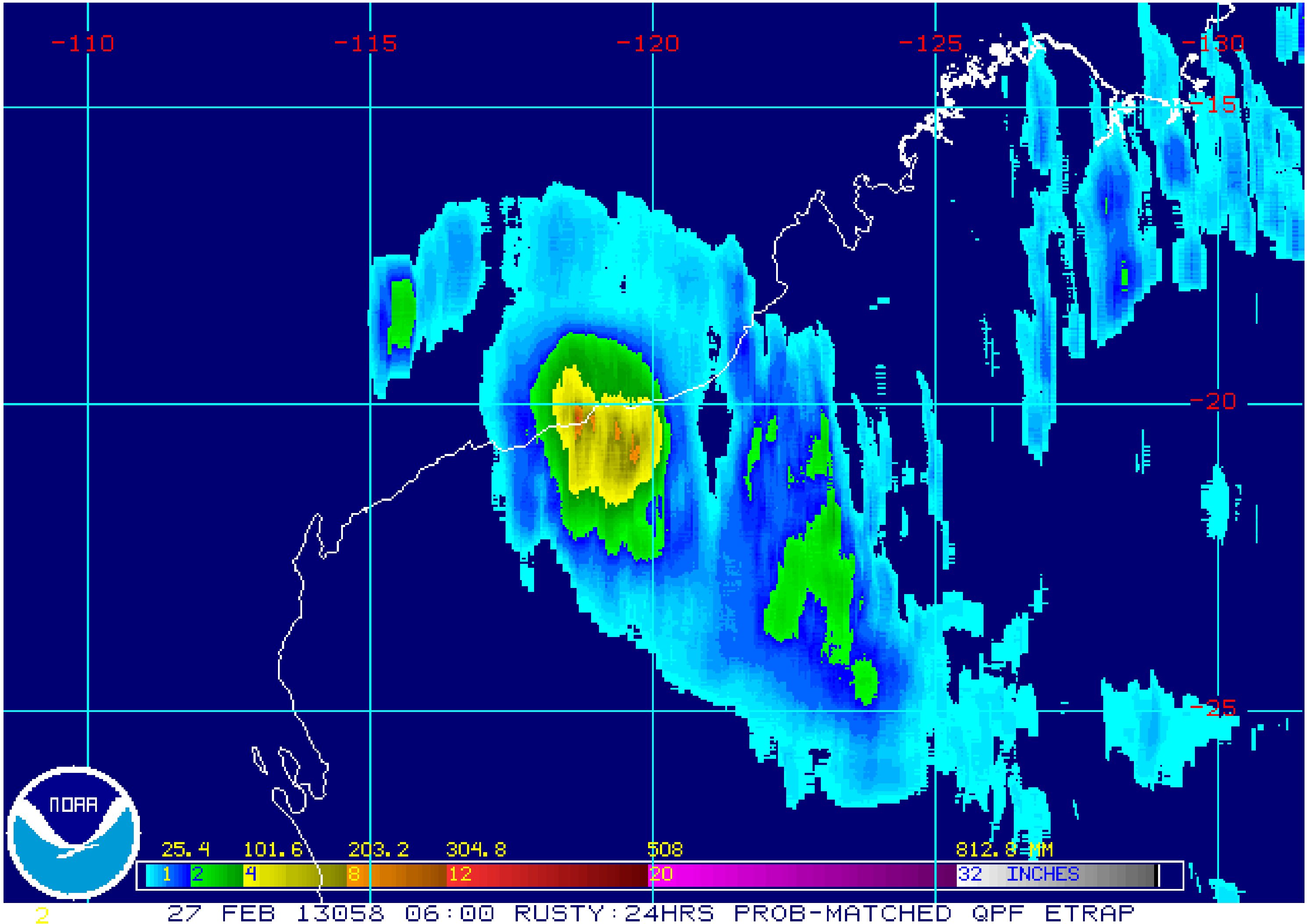
Tropical Cyclone:

Rusty eTRaP rainfall +24h total



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Production of TC Rainfall Forecasts

- Start with model closest to consensus forecast
- Locate relevant synoptic scale boundaries/coastal front
- Use conceptual models/current structure to modify/shift QPF (quantitative precipitation forecasts)
  (TRaP and recent satellite/radar imagery for current structure)
- Look at storm-relative shear/H2 winds to further shift/limit QPF
- Use climatology (r-CLIPER, TC Rainfall Climatology) to:
  - Temper down forecast bias/act as a reality check
  - Depict areas of terrain that could be significantly affected

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TC rainfall forecasting - exercise

- Choose real-time case:
- Determine motion and size
- eTRaP
- NWP
- Topography/modifications (shear?)