



**METEOROLOGICAL
SERVICE
SINGAPORE**

Forecasting and Warnings of Heavy Rain in Singapore

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**Initial Planning Meeting for The Southeastern Asia-
Oceania Flash Flood Guidance (SAOFFG) System
Jakarta, Indonesia,
2 - 4 February 2016**

2 Feb 2016

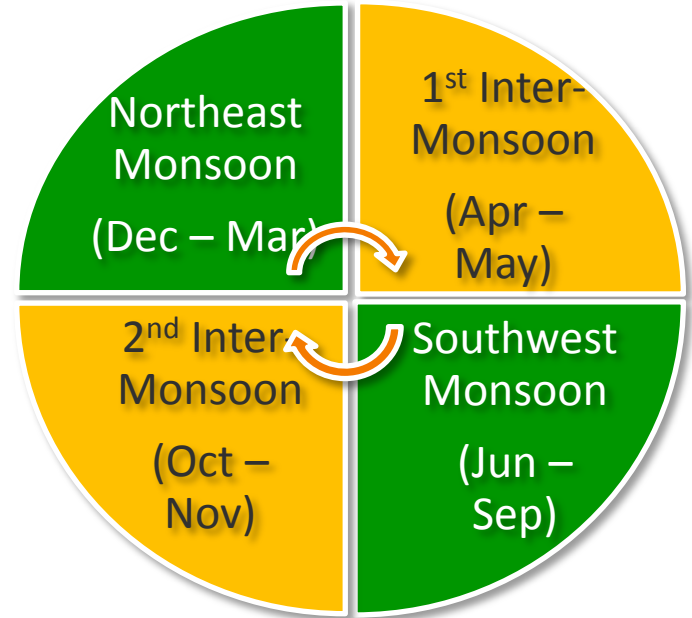
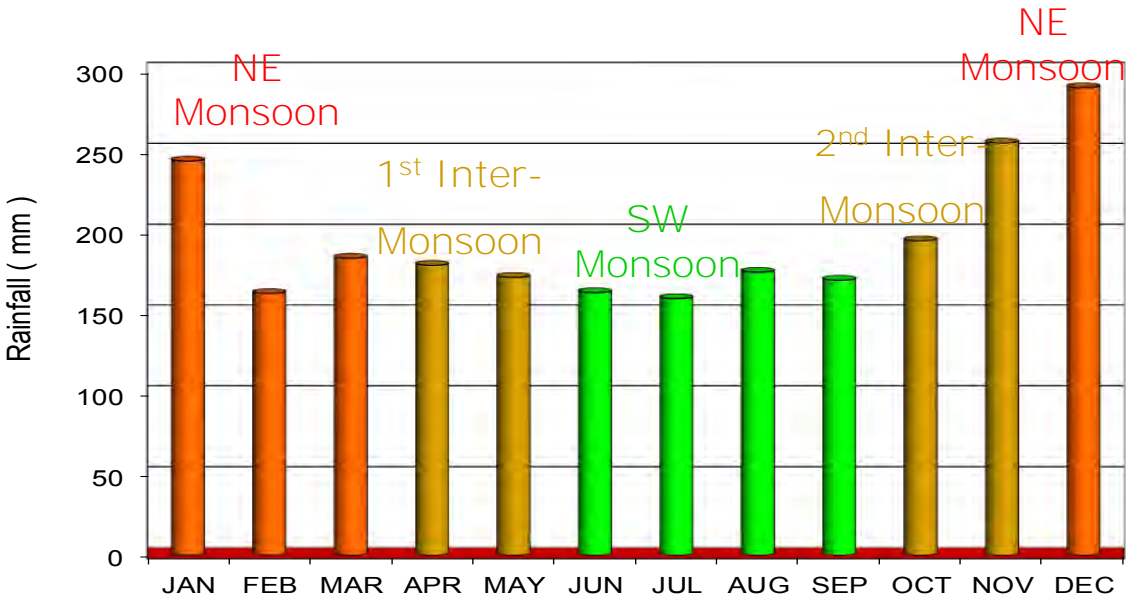
Outline

- Weather and Climate of Singapore
- Fundamental challenges in weather forecasting
- Role of Agencies in the event of heavy rainfall
- Provision of Heavy Rain Warnings
- Operational tools to forecast and warn of impending heavy rainfall

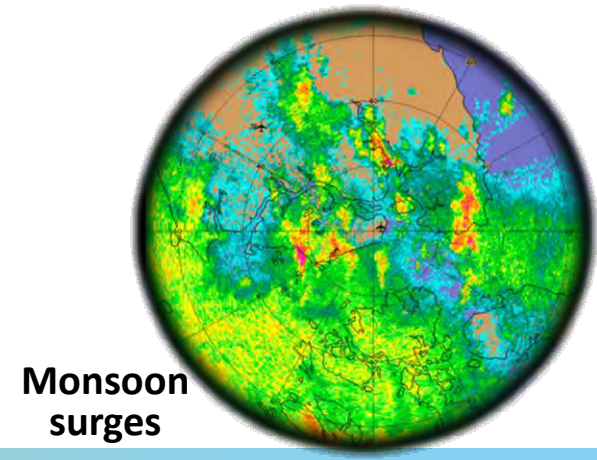
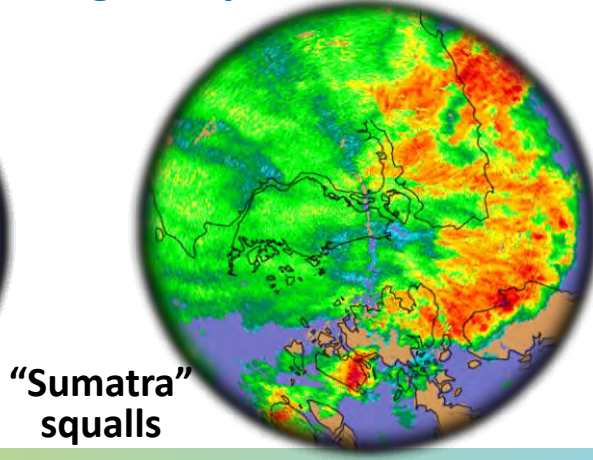
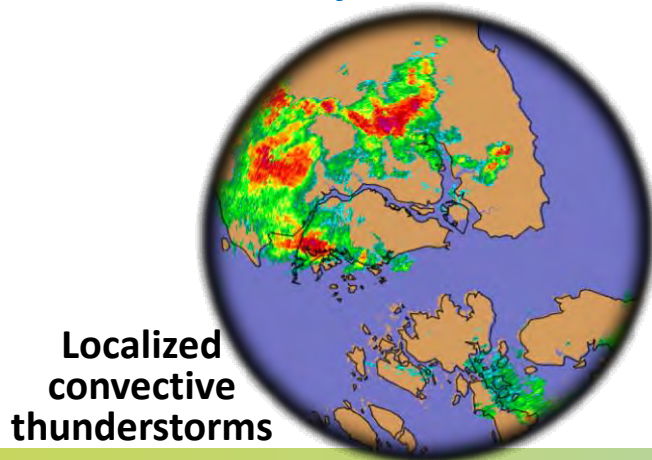


Monsoon Seasons in Singapore

Singapore's weather is dominated by the Monsoons

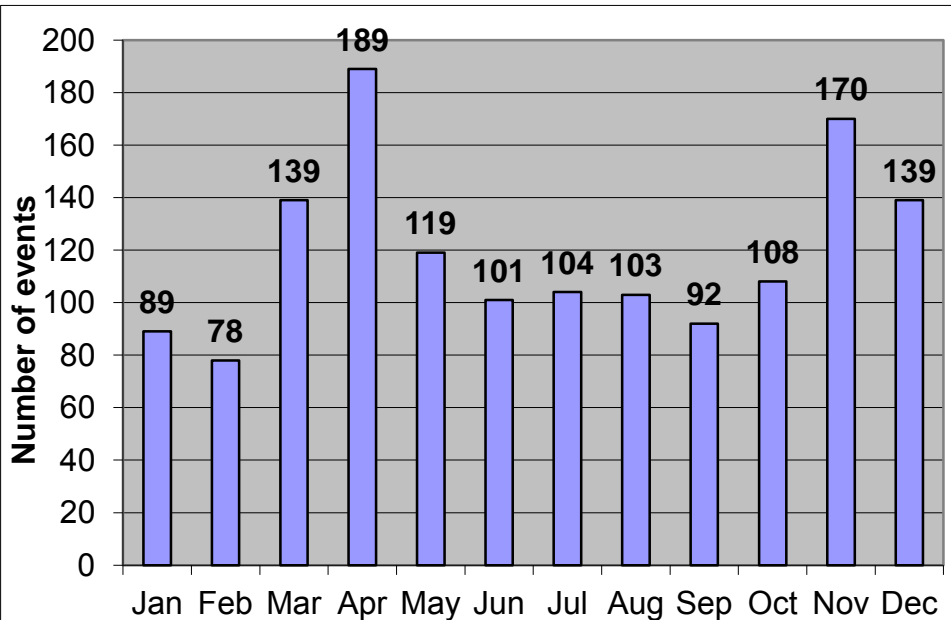


Main Weather Systems that can bring heavy rainfall

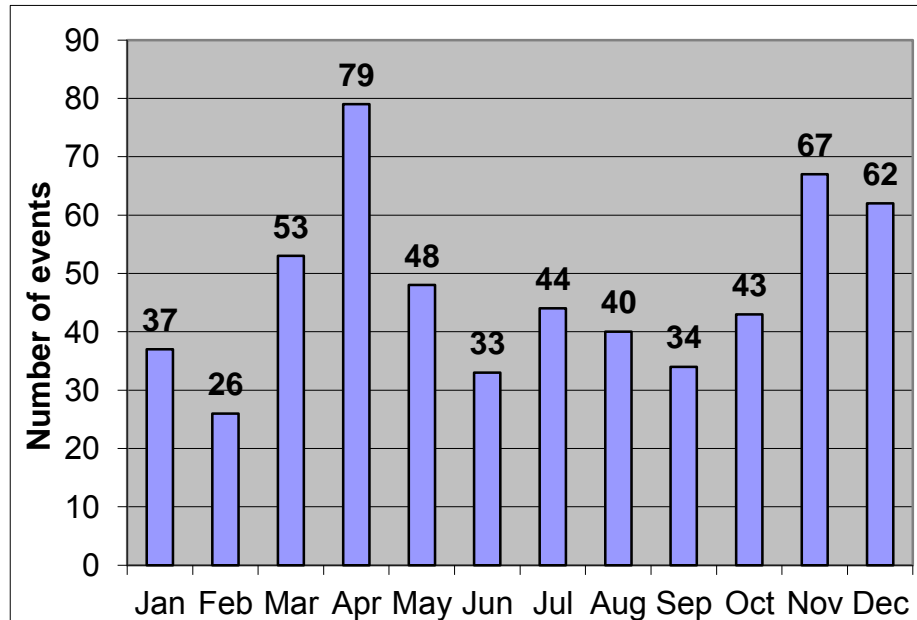


Definition of Heavy Rain

Defines heavy rain as “1H total moving 5min rainfall **greater than or equal to 50 mm** reported by one or more rain gauges **AND** with a duration **greater than or equal to 15 minutes**.”



Number of Events Hourly Rainfall >50mm (1991-2012)

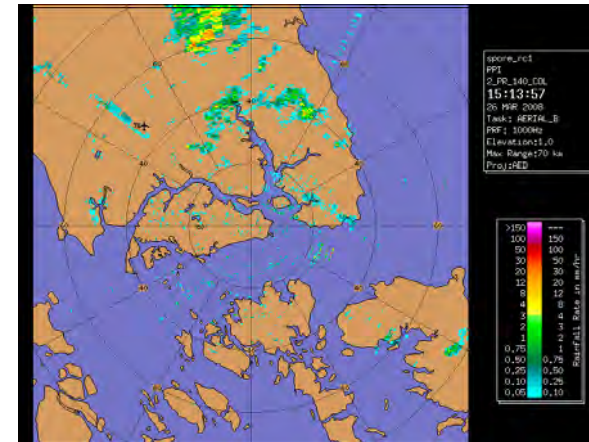
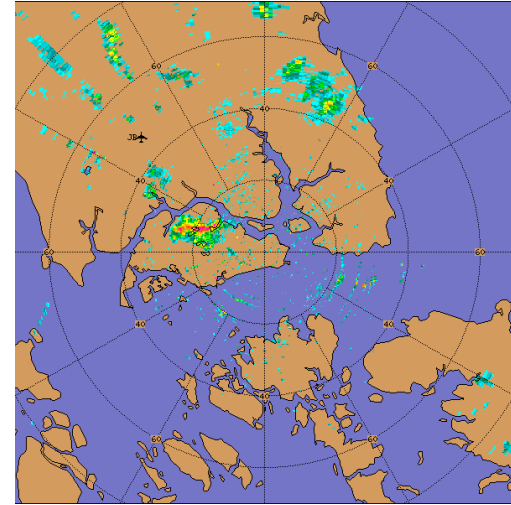


Number of Events Hourly Rainfall >70mm (1991-2012)

Fundamental Challenges in Forecasting

Tropical weather systems are complex:

- Convective rain clouds develop rapidly and have short-life span
- Development of tropical weather systems are largely driven by winds, which tend to be weaker and more variable in direction in the tropics
- Difficult to give precise forecasts of onset, location and intensity
- “Off-the-shelf” Numerical Weather Prediction (NWP) models
 - Low skill in predicting convective-scale systems (rain showers, localised thunderstorms)



Role of Agencies in event of Heavy Rainfall

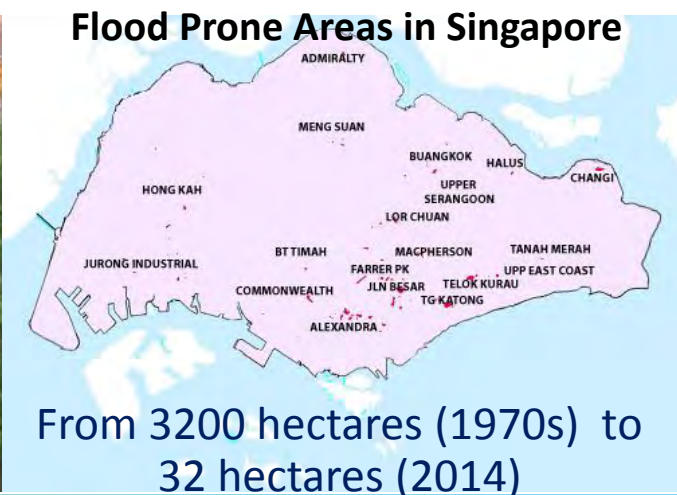
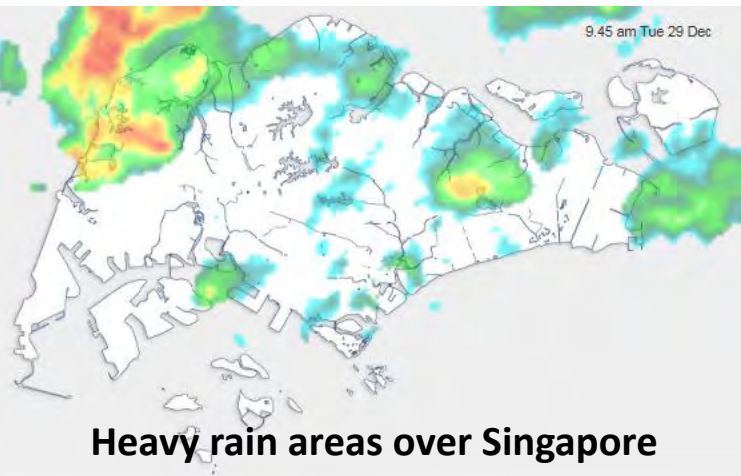


- Observation and Monitoring of weather
- Forecasting of weather , including impending heavy rain
- Issues warnings of heavy rain



Public Utilities Board
National Water Agency

- PUB will advise agencies on the possible impacts of flooding
- Warn the public on possible flood areas across Singapore e.g. flood prone areas/hotspots



Heavy Rain Warning

Heavy Rainfall

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graph TD; A[Heavy Rainfall] --> B[Short Duration Heavy Rain Warning]; A --> C[Prolonged Monsoon Heavy Rain Advisory/Warning];
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Short Duration Heavy Rain Warning

- Observed rain with intensity > 25 mm/hour,
- Observed radar-echo tops with height > 10 km;
- Observed/expected area affected > 20% of Singapore Island within next half-hour

Prolonged Monsoon Heavy Rain Advisory/Warning

- During NE Monsoon season
- Advisory issued to agencies 2-3 days when rain expected to be widespread due to monsoon surge
- Observed radar and/or satellite rainfall intensity exceeding 20 mm/hr upwind of Singapore and expected to affect Singapore within the next few hours;
- Expected duration of moderate to heavy rain exceeding 6 hours

Dissemination of Heavy Rain Warning

Met Service Singapore
issues
Heavy Rain Warning



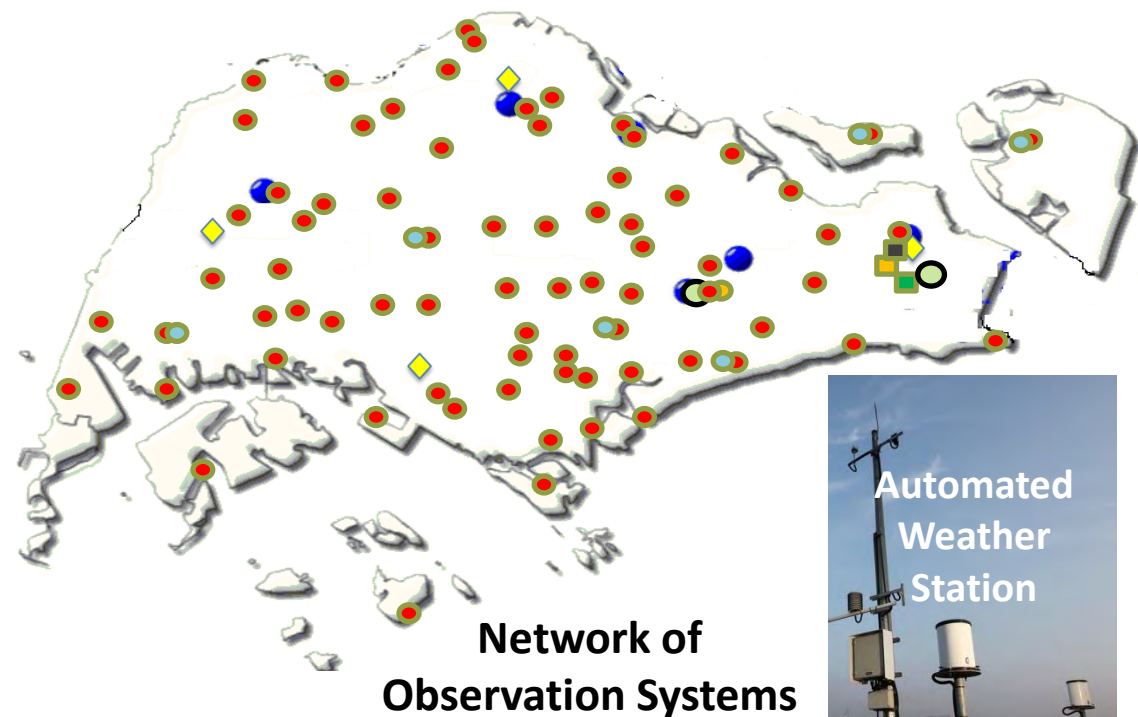
Mode of
Dissemination



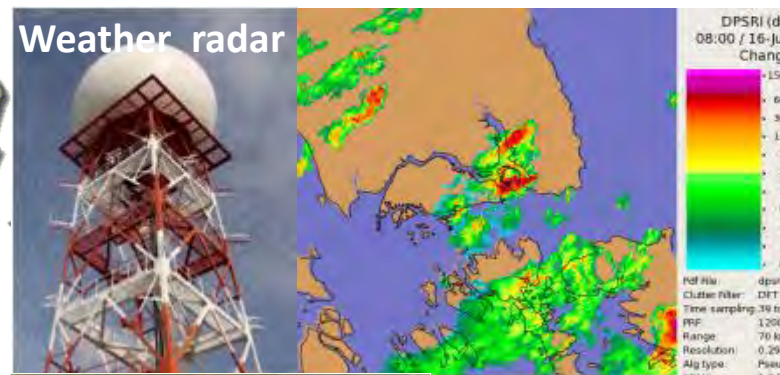
Users of the
heavy rain
warnings



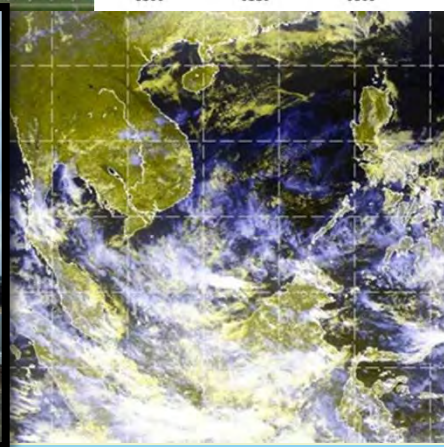
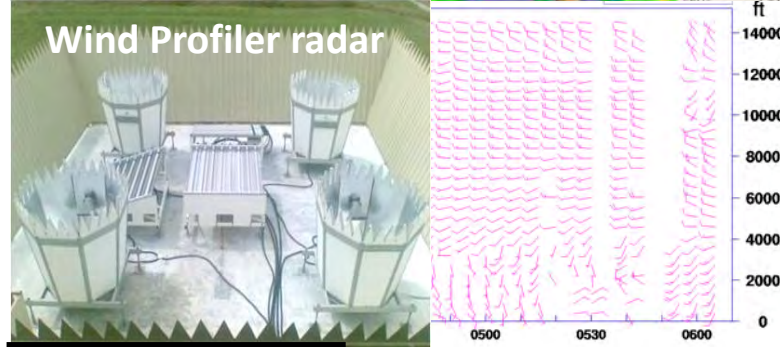
Operational Tools to Forecast Heavy Rainfall



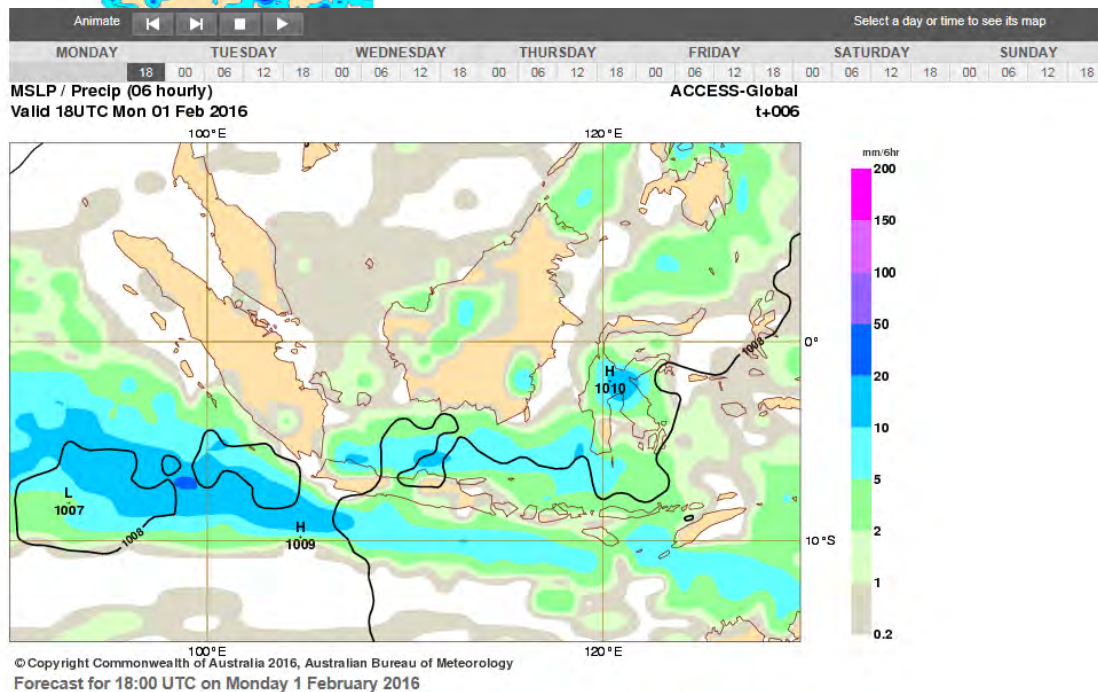
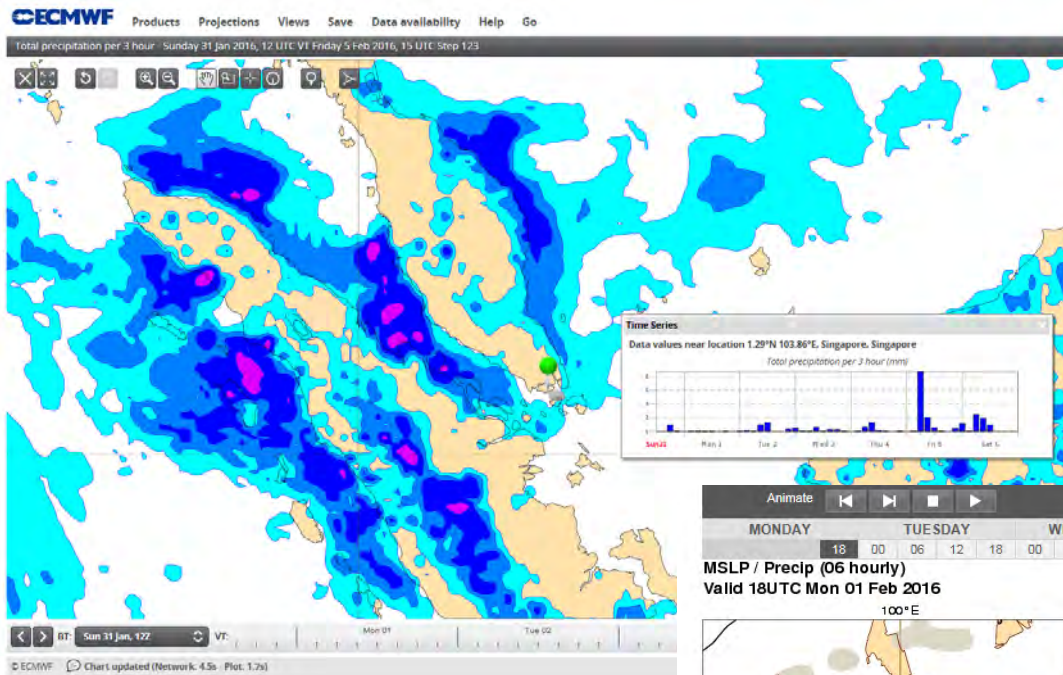
Weather radar



Wind Profiler radar



Operational Tools to Forecast Heavy Rainfall



Operational Tools to Forecast Heavy Rainfall

Total Threat Score (TTS) interface

Forecast Soundings' Model Run @ 19-Jul-2015 12Z

EC High Resolution Model

Select other Seasons

For SW Season (1 day trend)

Parameters	20-Jul-2015 00Z/8AM (ACTUAL)	20-Jul-2015 03Z/11AM	20-Jul-2015 06Z/2PM	20-Jul-2015 09Z/5PM	20-Jul-2015 12Z/8PM
Total Threat Score	46 (49)	33	43	36	42
Mean RH (%)	69 (77)	65	70	68	67
Water (cm)	4.41 (4.89)	4.33	4.53	4.52	4.66
Storm Speed (knots)	4 (4)	6	7	6	6
Vorticity Generation Potential (VGP)	0.25 (0.944)	0.228	0.16	0.163	0.213
K-Index	28 (28.1)	24.6	26.4	25	24.9
Jefferson Index	27 (27)	24	27	25	25
700-500 Lapse Rate (degC/km)	-5.8 (-5.3)	-5.9	-5.9	-6	-6.2
WBZ Height (feet)	11911 (11765)	11661	11848	11767	12290
MMR (g/kg)	19.2 (19.6)	18.5	17.4	18.1	19
Shear Speed (knots)	3.1 (5.6)	7.2	6.5	5.1	2.6
CAPE (J/kg)	2533 (3509)	2119	1664	1909	2177
Mid-level DS*Wind(7000ft- 20000ft)	1724 (1445.7)	1313	1489	1157	1046
Low-level Dry Slot(<7000ft)	0 (0)	3	0	9	10
Number of 'miss' parameters	0 (0)	0	0	0	0
'Miss' parameters	nil	nil	nil	nil	nil

3 model options

EC high resolution

WRF-EC

WRF-GFS

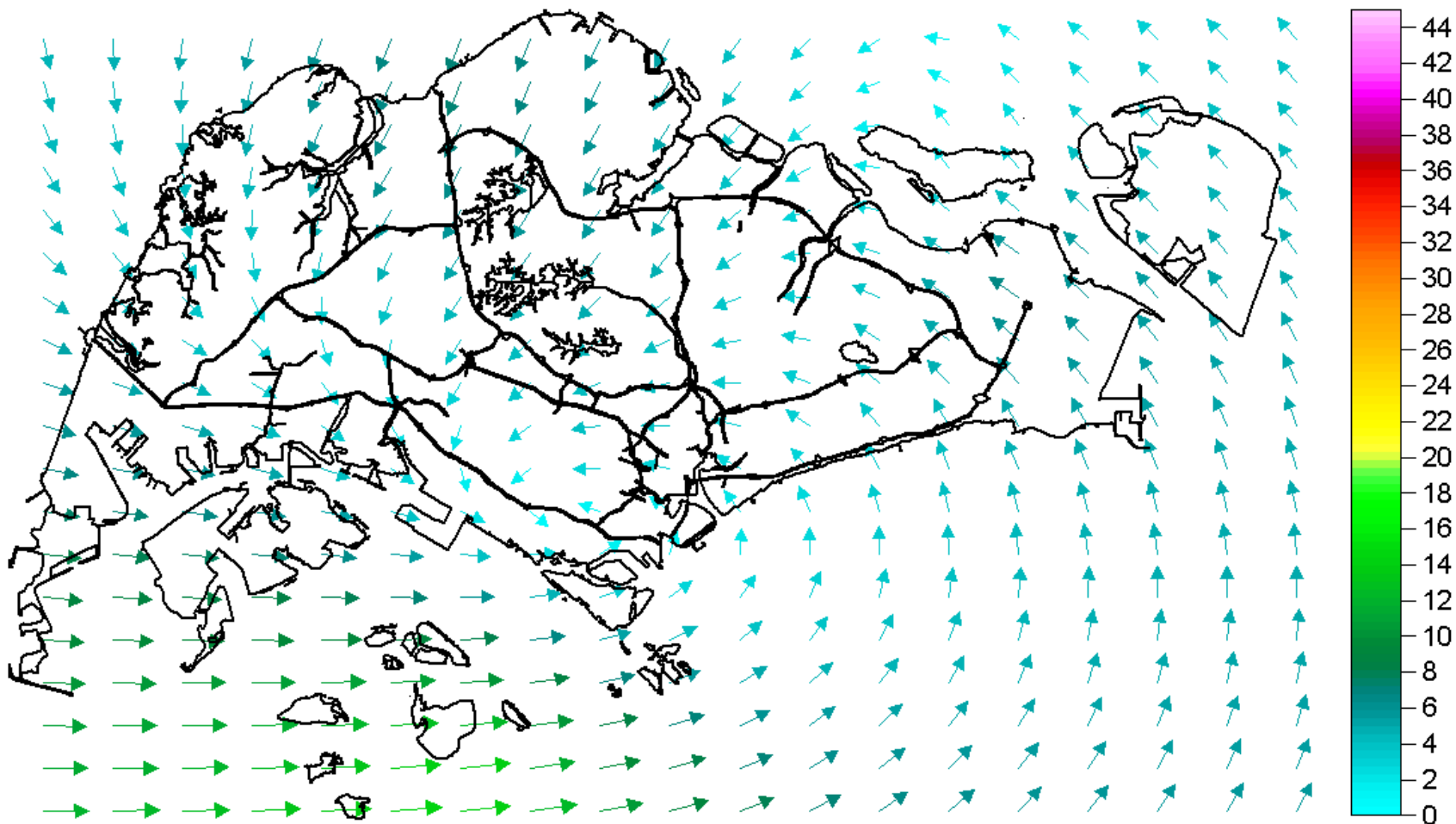
3-Hour Total Threat Score

Low TTS indicates low
chance of heavy rain
from 8am to 8pm

() actual day sounding's
parameters

Operational Tools to Forecast Heavy Rainfall

Real time observation of Wind Convergence Field



Thank You

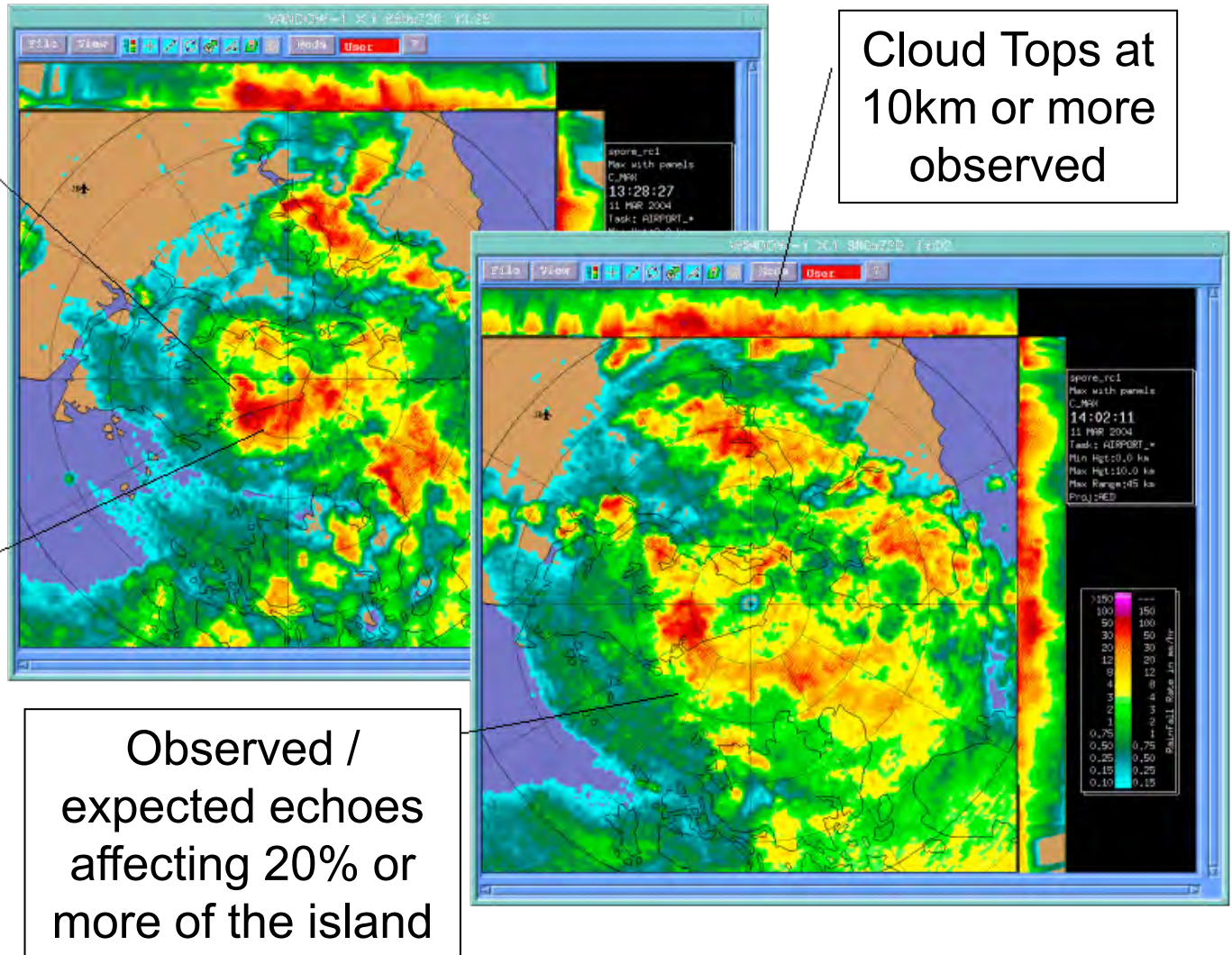
Criteria for issuing Heavy Rain Warning

Rain rate at 25 mm/h or more observed (color red on radar MAX display)

Movement at 15 km/h or less observed

Observed / expected echoes affecting 20% or more of the island

Cloud Tops at 10km or more observed



What is Heavy Rain event?

The World Meteorological Organization (WMO) defines heavy rain as "rainfall **greater than or equal to 50 mm** in past **24 hours**" in their web site of the Severe Weather Information Centre (SWIC).

Our definition?

