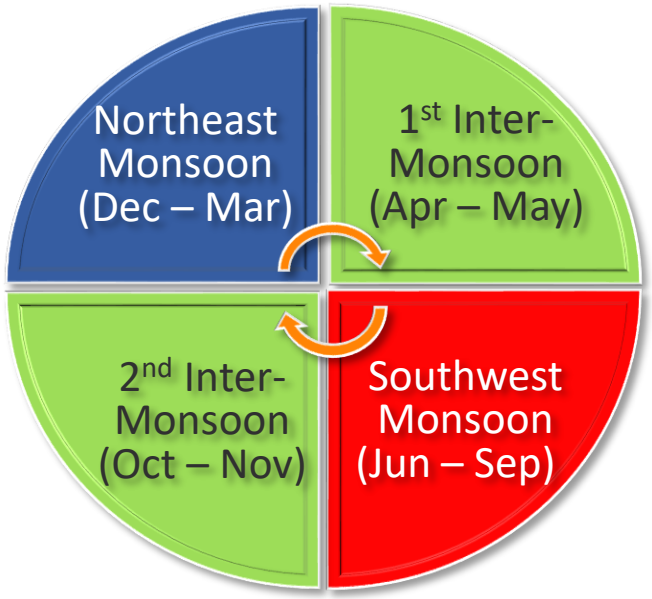
METEOROLOGICAL SERVICE SINGAPORE

MET-ATM Collaboration in Singapore

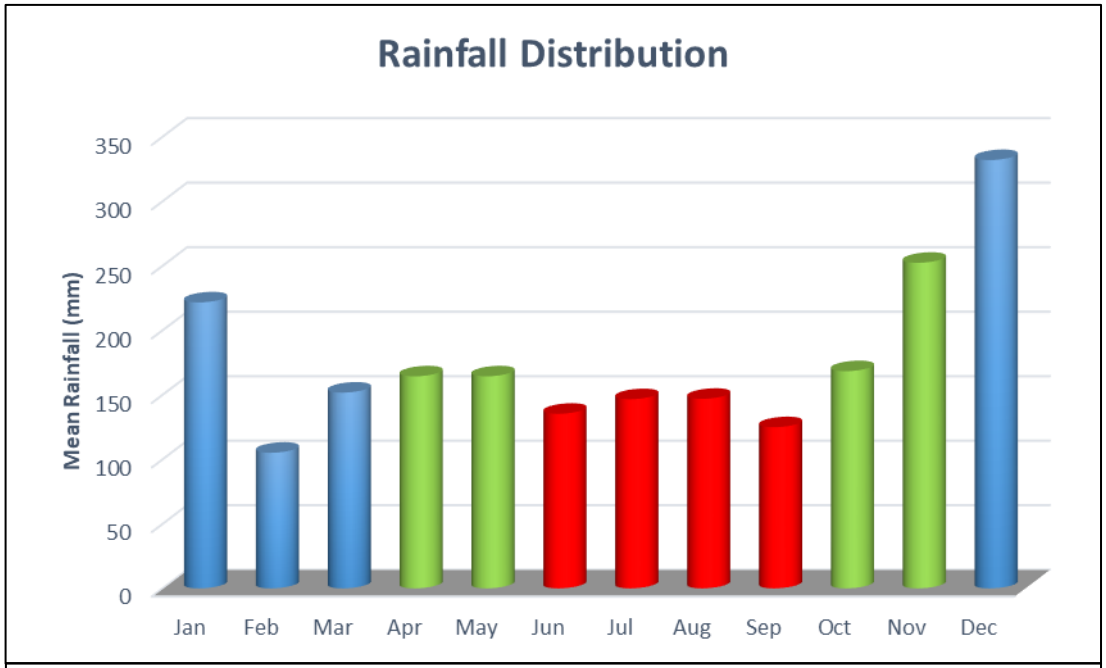
Yeo Cheng Xun

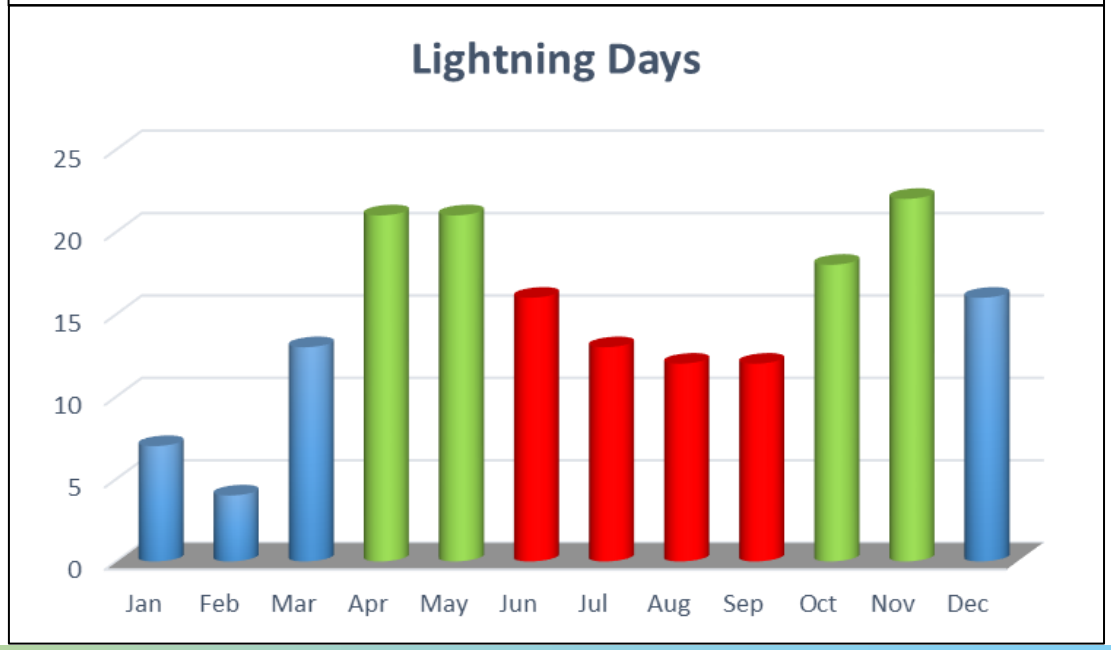
Executive Meteorologist

Climate of Singapore



Singapore has one of the highest rates of lightning in the world; There is an average of 176 lightning days per year

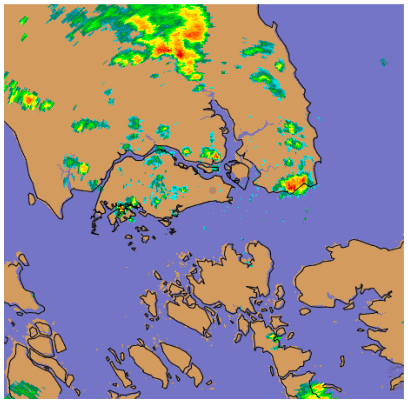




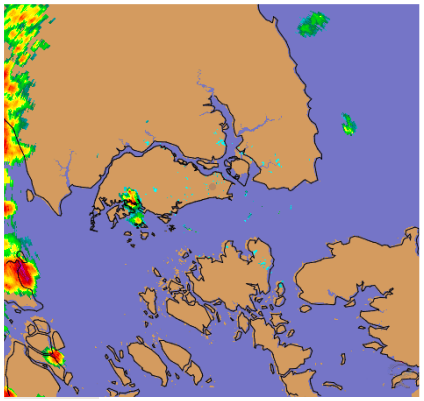
Challenges in Forecasting Thunderstorms

- Rapid development, short lifespan, small scale
- Tropical weather systems largely driven by winds, which tend to be weaker and more variable in direction
  - Difficulty in determining possibility of occurrence, onset, duration, location and intensity
  - Short lead time for warnings (often 15 mins or less)
- Off-the-shelf global numerical models have relatively low skill in predicting convective-scale weather systems, such as rain showers and localised thunderstorms

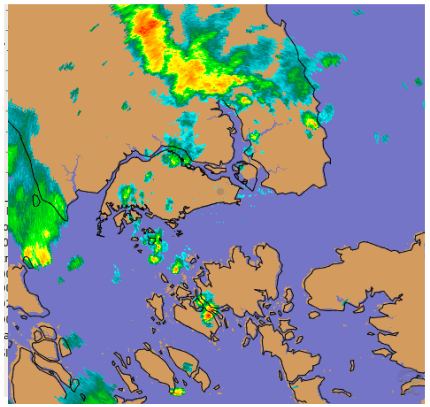
Main weather systems:



Localized convective thunderstorms



“Sumatra” squalls

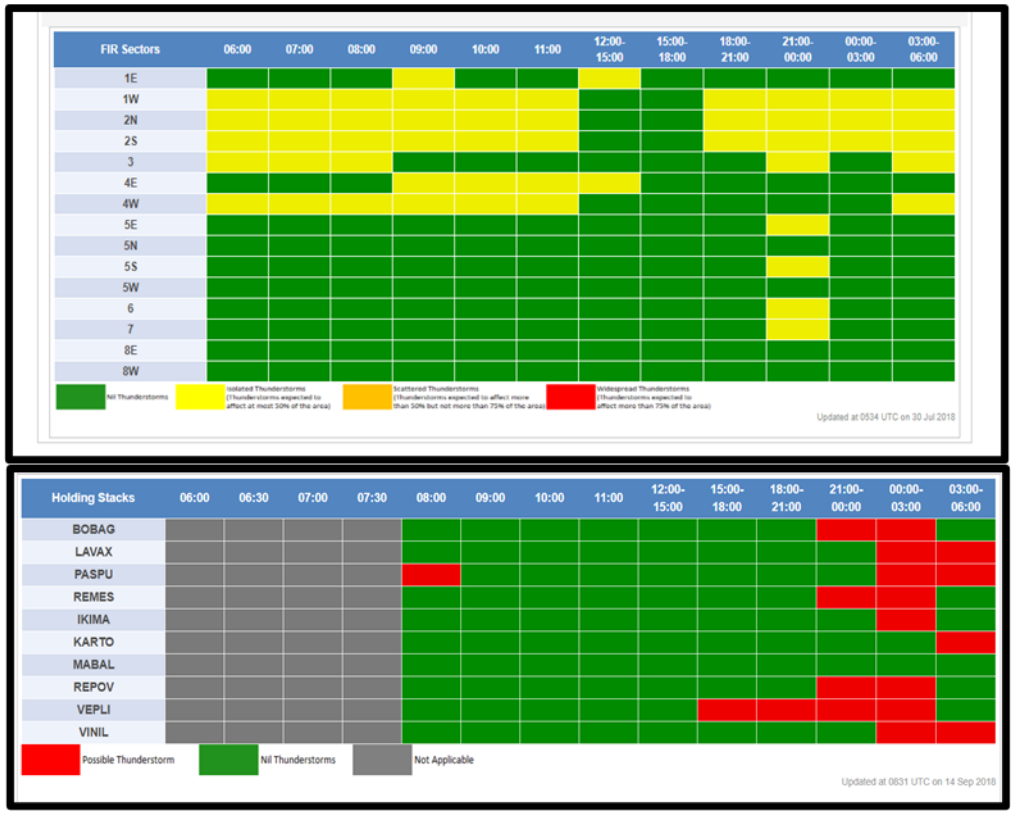


Monsoon surges

Tailored Services for ATM

Tailored Services for ATM

Weather Window

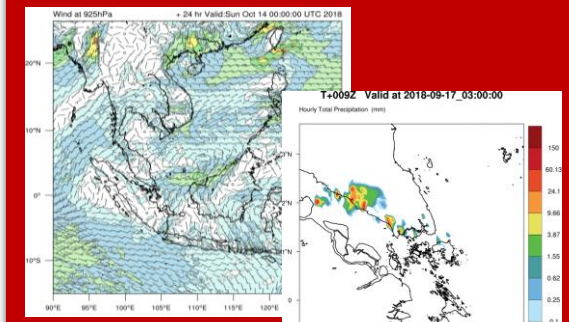


- Categorical forecasts over critical watch areas (En-route sectors, approach, waypoints and aerodromes)
- Two types: Areal extent and Binary Forecast
- Valid for 24 hours, with finer temporal resolution for near-term forecast.
- Updated every 3 hours and amended as required.

Forecasting tools for Weather Window

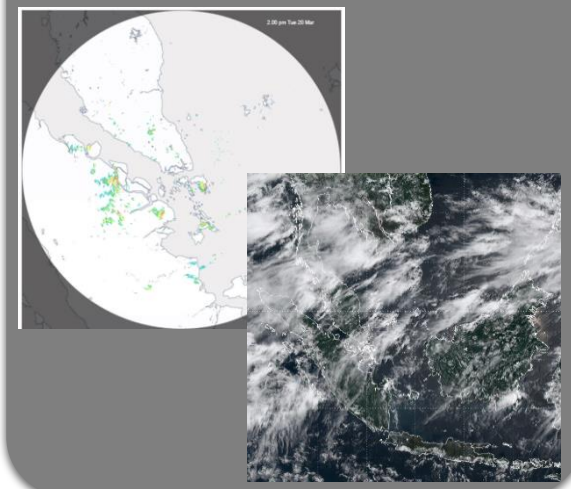
Models

- Global/Mesoscale NWP (see more)



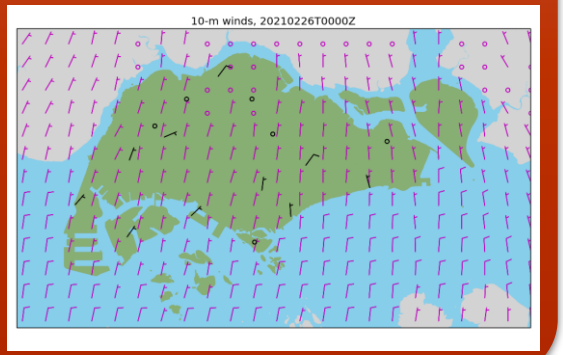
Observations

- Radar/Satellite/OPMET/etc



Local Knowledge

- Climatology
- Local Influences (e.g. seabreeze)



Weather Window

NWP models in use

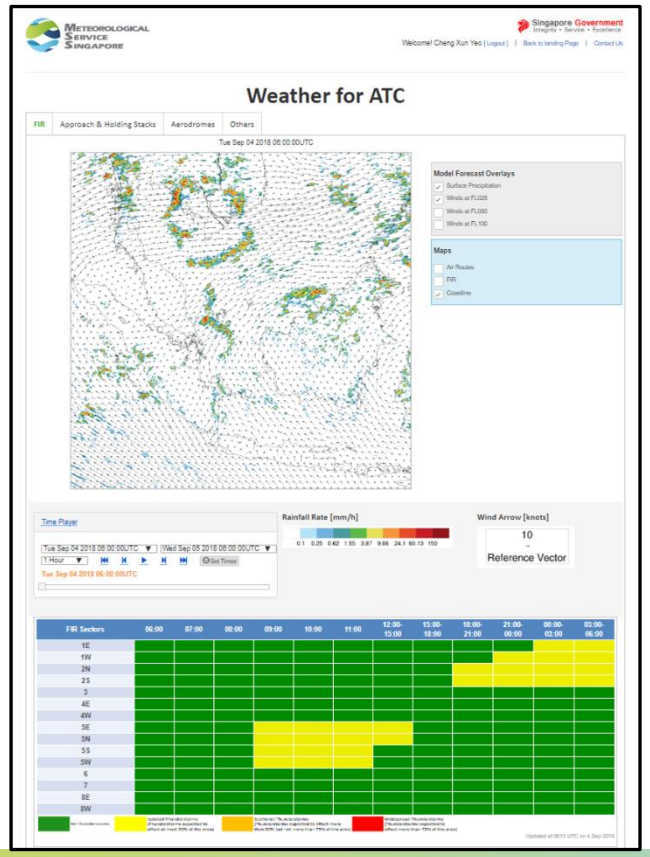
- Global
  - ECMWF Global (HRES) – High Resolution (~9km), Medium range (0 – 10 days forecast)

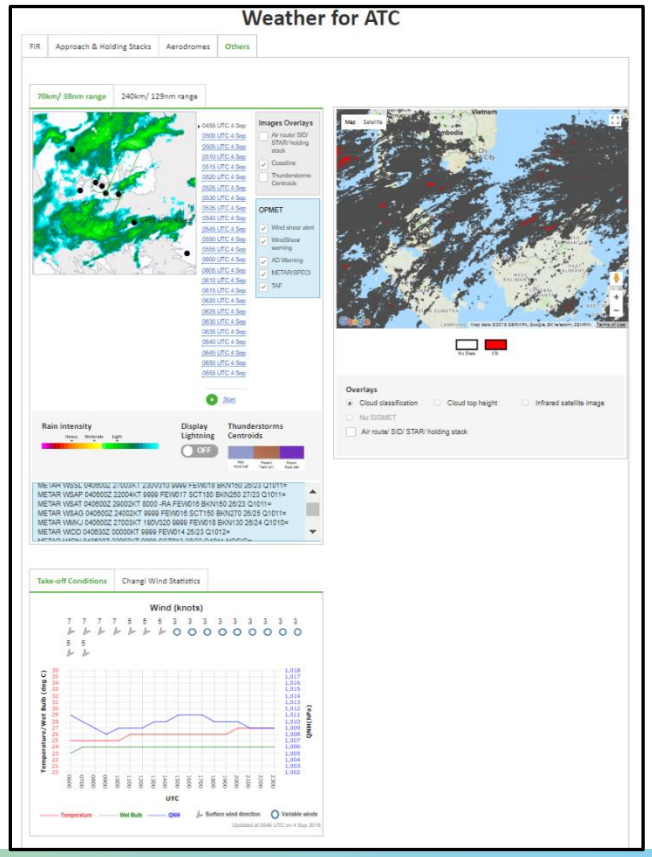
- Mesoscale
  - SINGV (Singapore Variable resolution model)
    - Multi-year collaboration project with UKMO to develop a tropical convective-scale NWP/Nowcasting capability for Southeast Asia region
    - Full non-hydrostatic equations and explicit convection treatment
      - SingV-DS: Downscaler with boundary conditions from ECMWF Global (HRES)
      - SingV-DA: SingV-DS + 3D VAR data assimilation

Types of data	Main Variables Assimilated	Sources
Satellite	Radiance, Satellite-derived winds	Himawari-8, MODIS, ASCAT
Aircraft	Air Temperature, Wind Speed, Wind Direction	AMDAR, AIREPS
Radiosondes		Mainly TEMP (weather balloon)
Ground Observations		SYNOPS, METARS, Buoys

Tailored Services for ATM

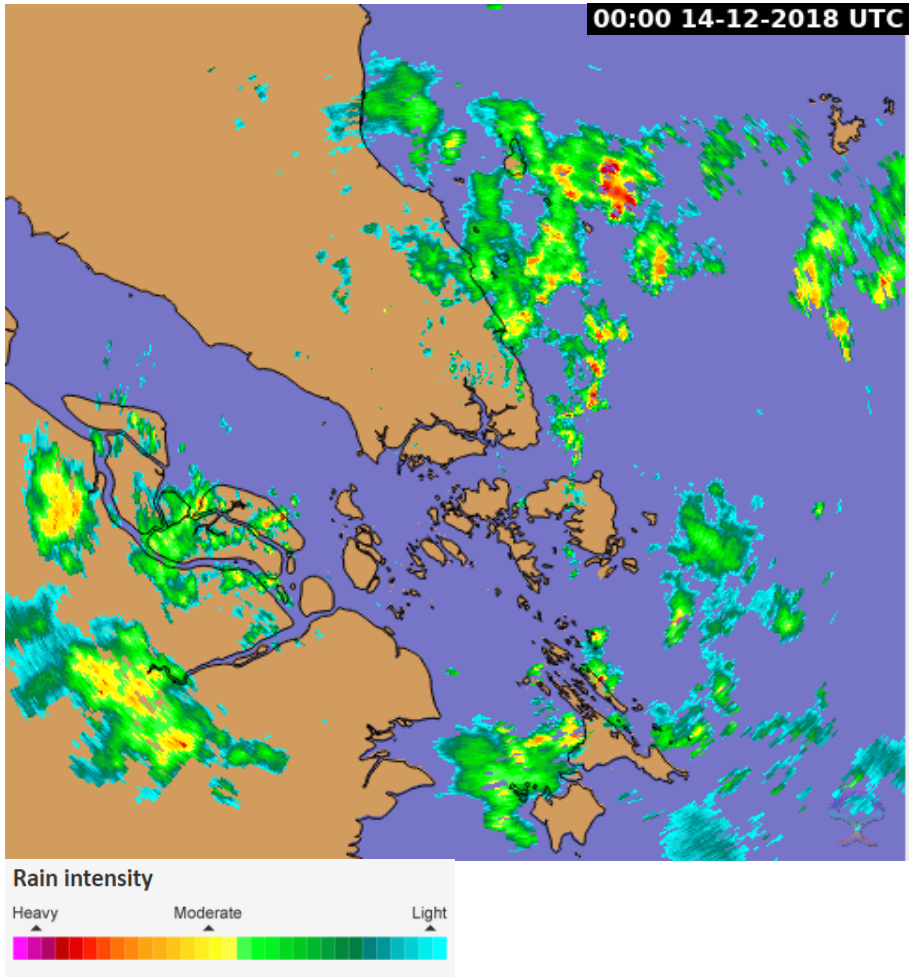
- Weather window supplemented with
  - Daily Weather Briefs (Morning and Afternoon); via web conference
  - Direct Communication Line
- Products delivered via a dedicated web portal for Air Traffic Controllers





Case Study

Weather Window – 14 Dec 2018



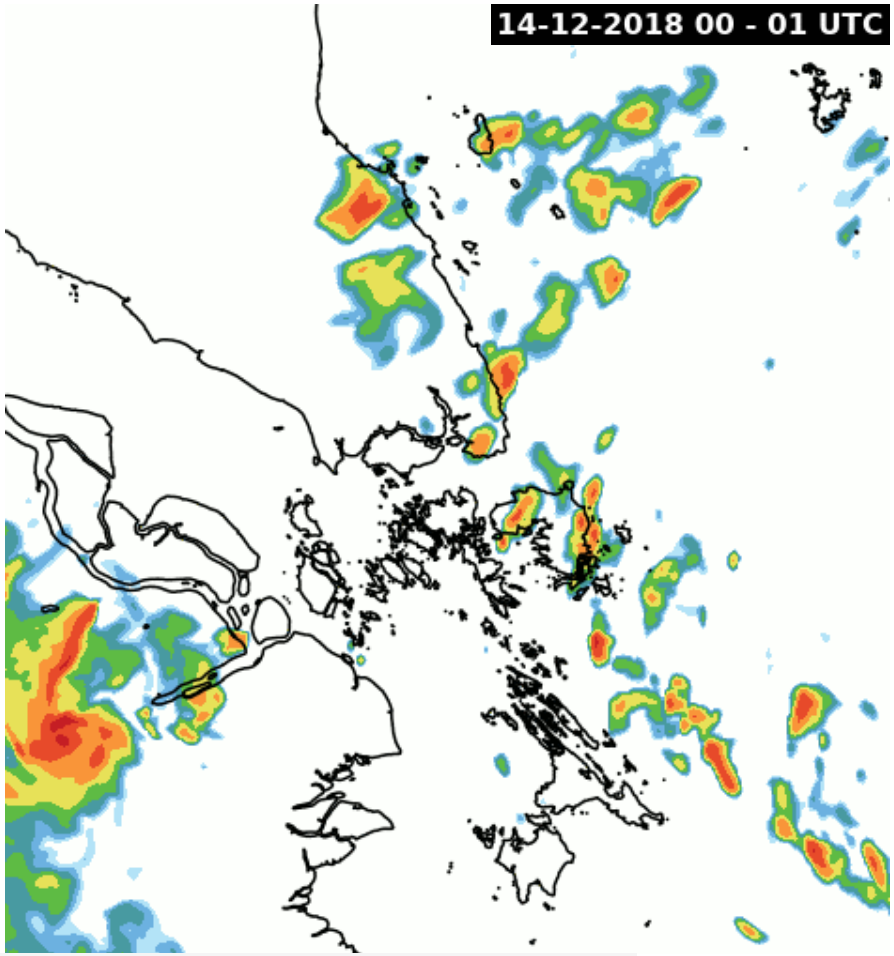
Weather conditions

- Northeast monsoon conditions
  - Winds blowing mainly from the northeast
- A monsoon surge event occurred on 14 December 2018
  - Convergence of winds at 925hPa (2500ft) over the South China Sea
  - Significant convective activities over Singapore and the surrounding region

Impact on air traffic

- Approach region most significantly affected between 05-06UTC
  - Embedded thunderstorms over routes to the northeast and south of the aerodrome
- Inclement weather did not affect airport significantly
- Resulted in reduced capacity and delays

Weather Window – 14 Dec 2018



- Review of the performance of the Numerical Weather Prediction (NWP) model :
  - Model correctly forecast the development of significant convective activities in areas surrounding Singapore
  - However, the model had over-forecast the extent of the thunderstorms

Weather Window – 14 Dec 2018

- Intervention by the Operational Meteorologist is necessary
  - Manual assimilation of latest observations and local-scale effects
  - Value add in knowledge and experience of climatology
- Corrected the extent of thunderstorms over the approach region
  - Moderated the expected impact => More efficient use of air space

Forecast by Operational Meteorologist

14 Dec 2018 00 - 24UTC

Approach Sectors	00:00	00:30	01:00	01:30	02:00	03:00	04:00	05:00	06:00-09:00	09:00-12:00	12:00-15:00	15:00-18:00	18:00-21:00	21:00-00:00
NW Sector														
NE Sector														
S Sector														

Observations

14 Dec 2018 00 - 24UTC

Approach Sectors	00:00	00:30	01:00	01:30	02:00	03:00	04:00	05:00	06:00-09:00	09:00-12:00	12:00-15:00	15:00-18:00	18:00-21:00	21:00-00:00
NW Sector														
NE Sector														
S Sector														

Nil Thunderstorms

Isolated Thunderstorms (Thunderstorms expected to affect at most 50% of the area)

Scattered Thunderstorms (Thunderstorms expected to affect more than 50% but not more than 75% of the area)

Widespread Thunderstorms (Thunderstorms expected to affect more than 75% of the area)

Not Applicable

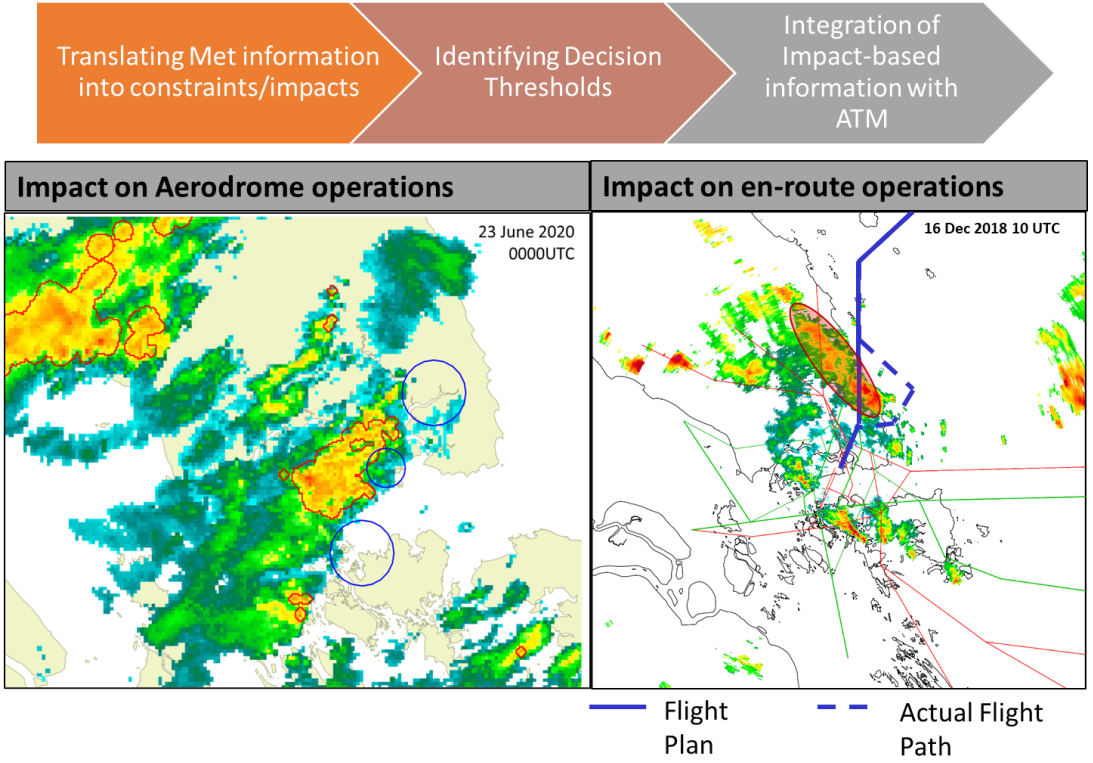
Lessons Learnt

- For convective-scale thunderstorms**, challenge lies on forecasting with precision,** the occurrence, onset, duration, location and intensity
- Need for High Resolution Numerical Weather Prediction (NWP) models though computationally expensive to resolve
  - Convective-scale thunderstorms
  - Land-sea contrasts and orography
- Model performance has made significant improvements but **manual intervention by Operational Meteorologist is still required**
- **Close coordination** between MET and ATC necessary to support tactical operations
  - Sharing of data for conducting case studies of disruptions to operations that are attributable to adverse weather
  - Analysis of MET information for strategic planning and management

Ongoing / Future Work

- Continuous engagement with stakeholders

- Collaborative analytical study (impact translation) with CAAS
  - Although weather window provides critical information for decision-making, objective categorisation of impacts of adverse weather can enhance decision support tools



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