香港天文台
HONG KONG OBSERVATORY

The Hong Kong Observatory's Operational Data Management Systems

YC CHENG
HKO

ECMWF Meteorological Operational Systems Workshop – November 2009

香港天文台
HONG KONG OBSERVATORY

Content

- Briefly introduce data management systems storing observational data in HKO
- Introduce key components of the Decision Support System (DSS) in HKO using observational data extensively
- Review database structure of two typical applications in HKO and introduce the use of Oracle Real Application Cluster (RAC) and Data Guard technologies on these databases

香港天文台
HONG KONG OBSERVATORY

Data Management Systems in HKO

- GTS data (SYNOP, radiosonde, SHIP, …)
  - Used since 2003
  - Oracle 9i on IBM HACMP cluster
  - Data exchange with RTH Tokyo, RTH Beijing, NMC Macau, met. centres of nearby cities like Guangzhou, Shenzhen, etc.
  - Upgrade planned for early 2010, 11g?
- AWS data
  - Used since 2007
  - Oracle 10g
  - Local (1 min frequency, ~100 stations)
  - Regional (10 min to hourly frequency, ~450 stations)
- Rainguage data
  - Use since 2007
  - Oracle 10g
  - ~140 stations of HKO, GEO (Geotechnical Engineering Office), DSD (Drainage Service Department)
- Reporting, forecast, warning bulletins data
  - Use since 2007
  - Oracle 10g on RAC with Data Guard
  - Support Public Weather Service

香港天文台
HONG KONG OBSERVATORY

Decision Support System in HKO

- SWIRLS – Short-range Warning of Intense Rainstorm in Localized System
- LAPS – Local Analysis and Prediction System
- NHM – Non-Hydrostatic Model
- RAPIDS – Rainstorm Analysis and Prediction Integrated Data-processing System
- TIPS – Tropical Cyclone Information Processing System
- MINDS – Meteorological Information Dissemination System

香港天文台
HONG KONG OBSERVATORY

HKO's Nowcasting system - SWIRLS

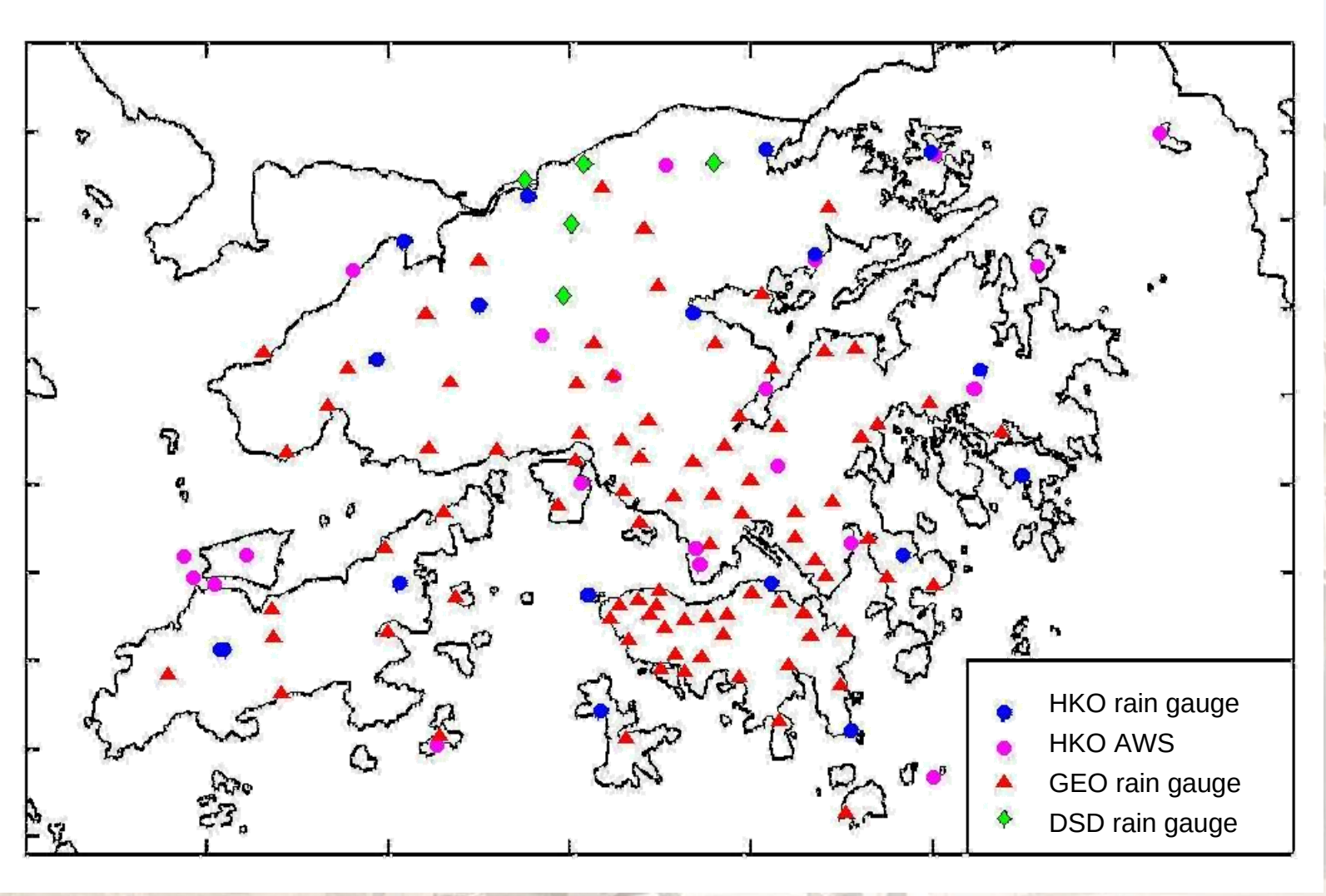
- SWIRLS
  - Short-range (1-6 hours)
  - Warning of
  - Intense (≥30 mm per hour)
  - Rainstorm in
  - Localized (10 – 100 km)
  - Systems
- in operation since April 1999
- originally designed for rainstorms
- evolving to handle other severe weathers
- 2nd generation in operational trial in 2009

香港天文台
HONG KONG OBSERVATORY

Observation Network

香港天文台
HONG KONG OBSERVATORY

Raingauge Networks



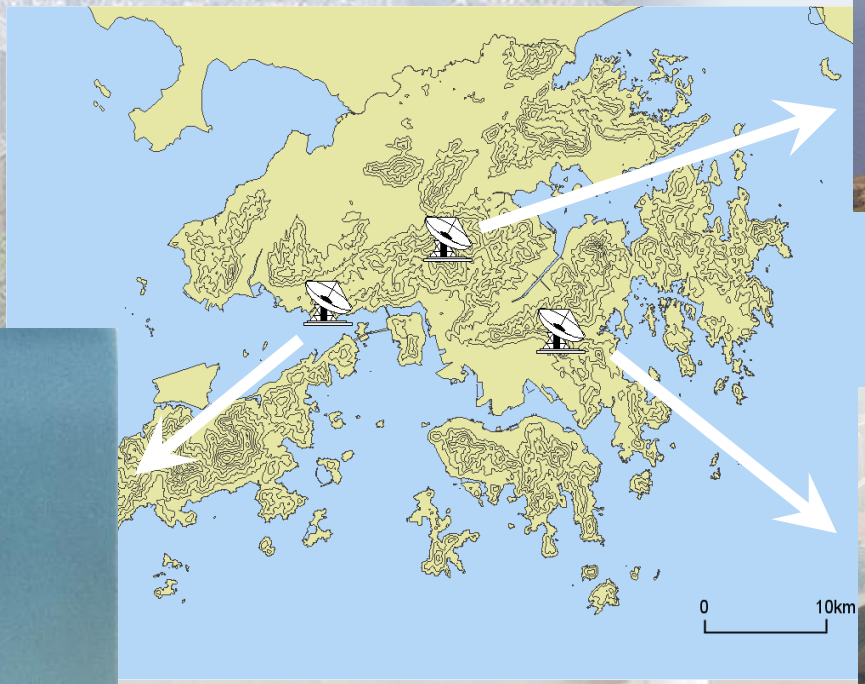
Total no. ~ 140, updated every 5 mins, mean separation ~ 1.5 km

香港天文台
HONG KONG OBSERVATORY

Doppler Weather Radar

S-band
10cm

Tai Mo Shan (since 1999)



C-band,
5cm
TDWR

TDWR (since 1996)

S-band,
10cm

Tates' Cairn (since 1994)

香港天文台
HONG KONG OBSERVATORY

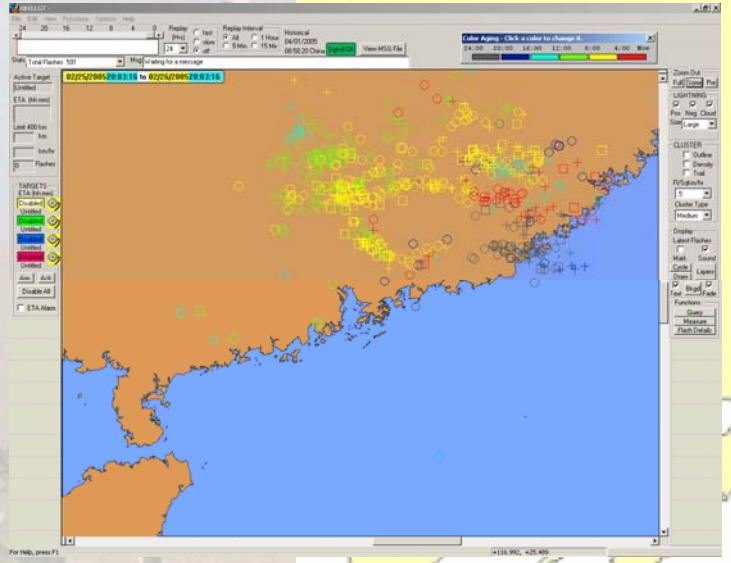
Lightning Location Detection Network

三水

Mainland China site

- Sites provides by HKO, SMG and GMB
- Equipment provided by HKO
- Lightning data shared by HKO, SMG and GMB

惠東



Mainland China site

沙頭角

尖鼻咀

Hong Kong sites

澳門

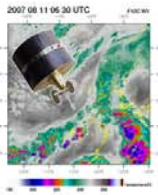
Macau site

春坎角

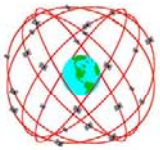
香港天文台『小渦旋』臨近預報系統 — SWIRLS

The Fully Automated Nowcasting System of the Hong Kong Observatory for Short-range Warning of Intense Rainstorms in Localized Systems

多普勒天氣雷達
Doppler Weather Radar



氣象衛星
Meteorological Satellite



全球衛星定位系統
Global Positioning System

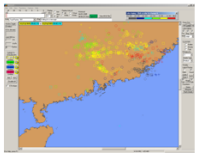
自動氣象站
Automatic Weather Station

自動雨量計
Automatic Raingauge

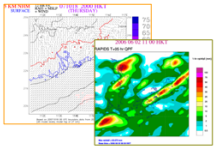
探空儀
Radiosonde

『小渦旋』高速電腦系統
SWIRLS Supercomputer Systems

氣流剖析儀
Wind Profiler



閃電資訊
Lightning Information



數值模式
Numerical Model

雷達回波追蹤和外推
Radar Echo Tracking & Extrapolation

雷達自動量雨筒分析
Radar-Rainguage Rainfall Analysis

定量、概率降雨預報
Quantitative & Probabilistic Precipitation Forecast

強風暴追蹤及預報 (閃電、狂風、冰雹)
Severe Storm Tracking & Forecast (lightning, squalls & hail)

大氣穩定度分析
Atmospheric Stability Analysis

中小尺度大氣分析
Local & Mesoscale Analysis

數值模式預報融合
Blending with Numerical Model

大氣水汽含量分析
Atmospheric Water Vapour Analysis

圖象用戶介面與網頁製作
Graphical User Interface & Web Page Production

氣候統計個案資料庫
Climatological Case Book

預報
Forecast

暴雨
Rainstorm

水浸
Flooding

山泥傾瀉
Landslip

閃電
Lightning

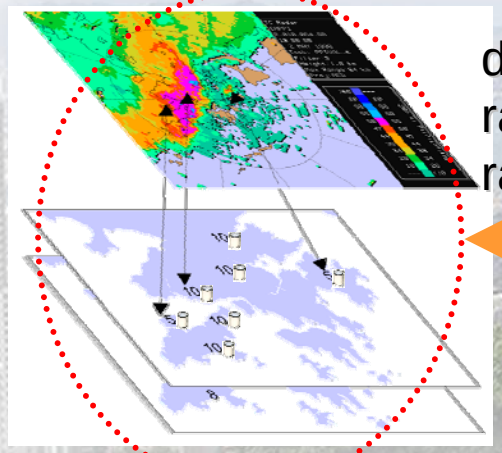
狂風
Squalls

冰雹
Hail

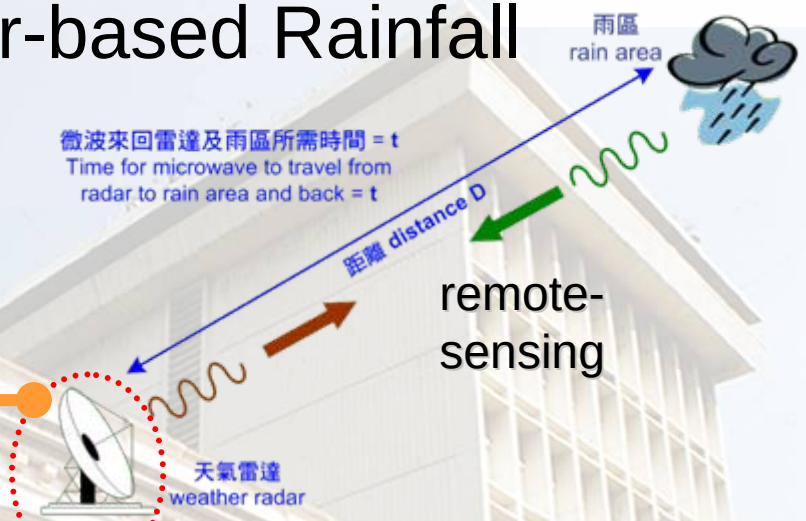
熱帶氣旋
Tropical Cyclone

香港天文台
HONG KONG OBSERVATORY

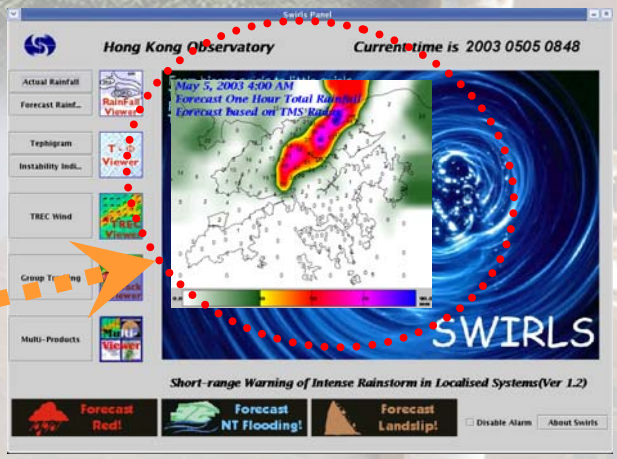
Basic Principles of Radar-based Rainfall Nowcast



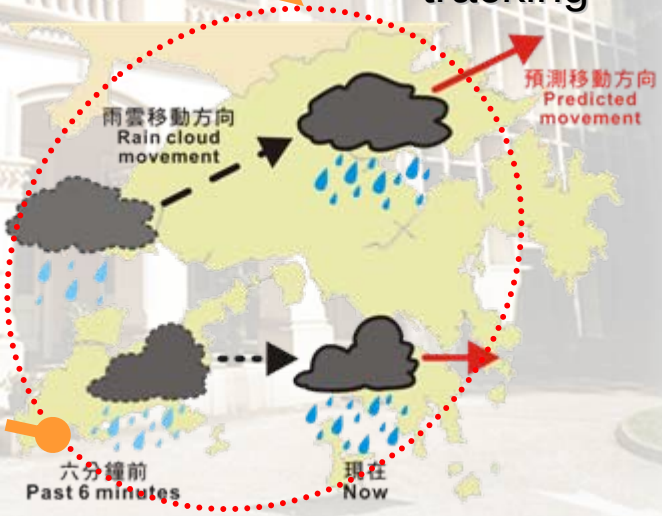
dynamic
radar-raingauge
rainfall calibration

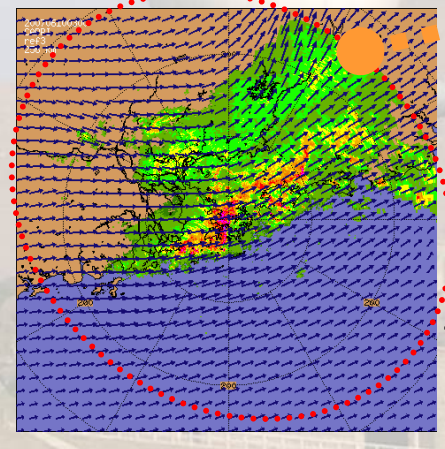


remote-
sensing



storm
tracking

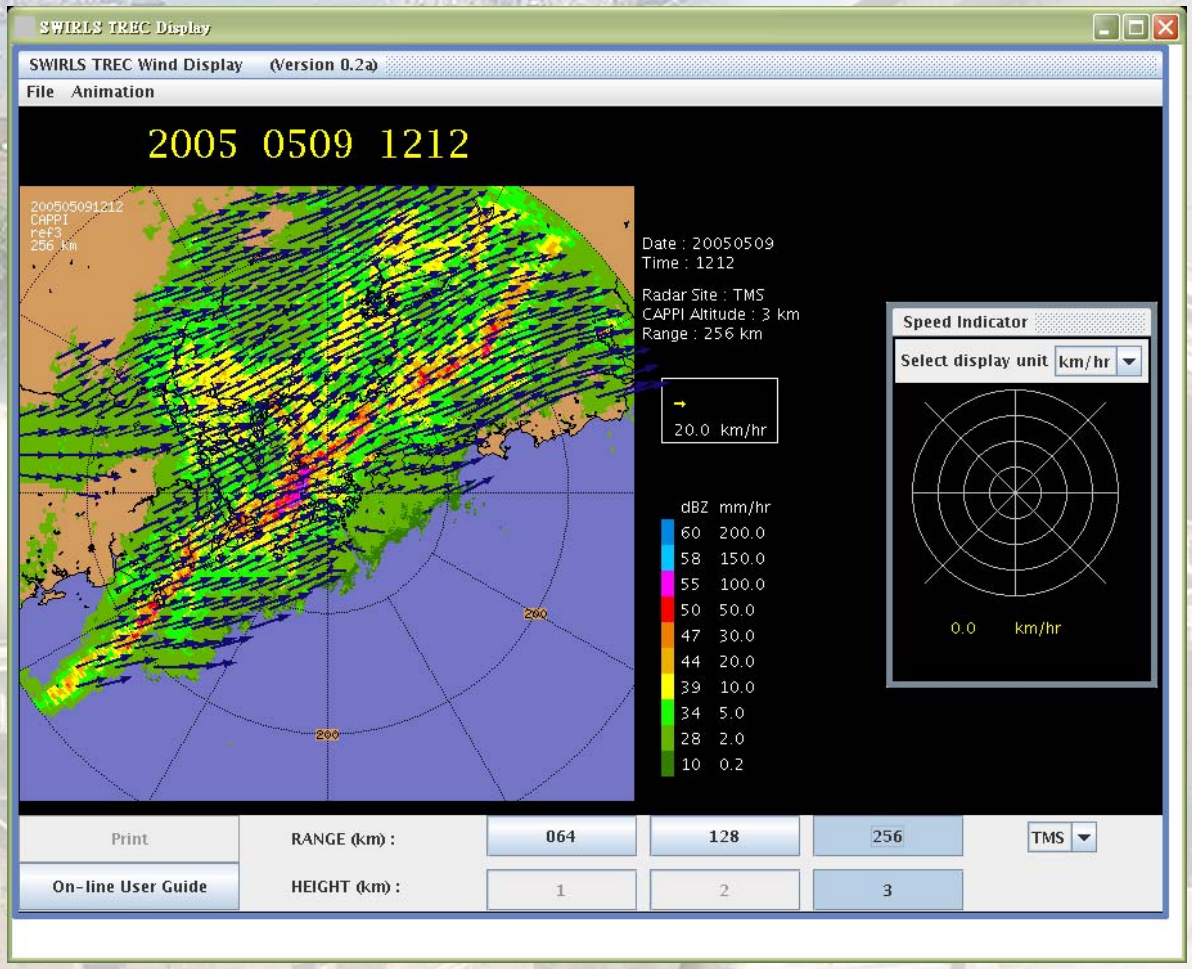




time integration
(Semi-Lagrangian advection)

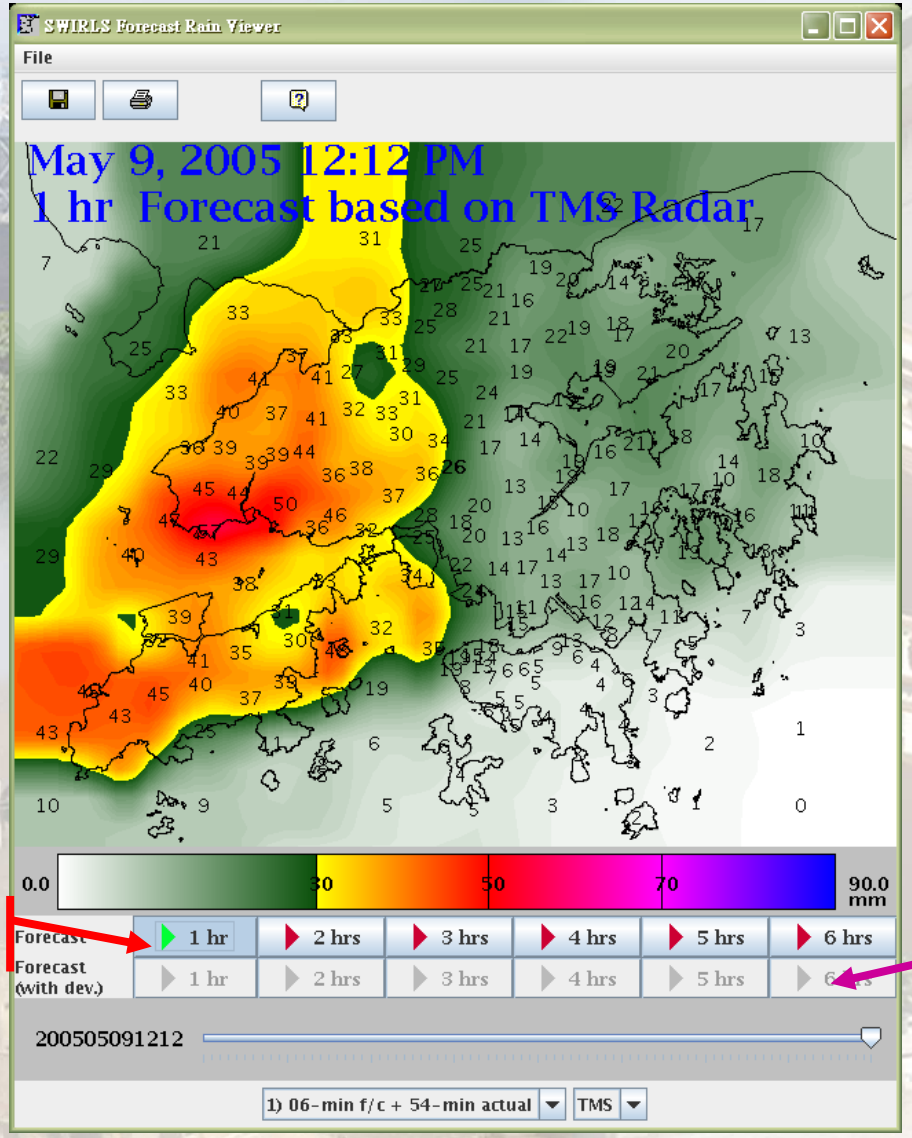
香港天文台
HONG KONG OBSERVATORY

SWIRLS Echo Motion Viewer



香港天文台
HONG KONG OBSERVATORY

SWIRLS F/C Rainfall Viewer



Radar nowcast

Nowcast and NWP blended

香港天文台
HONG KONG OBSERVATORY

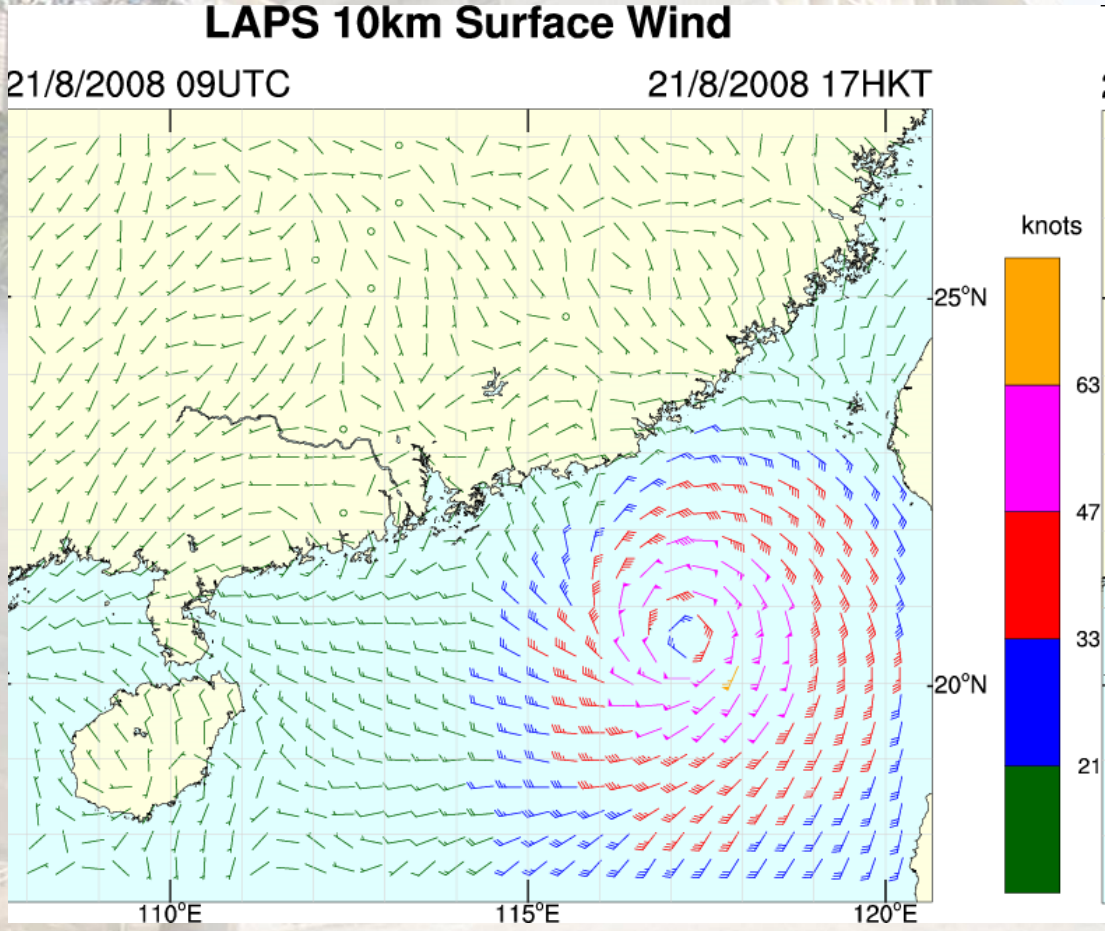
HKO's Mesoscale Data Analysis System - LAPS

	LAPS
Horizontal Resolution	10 km (TC applications) 5 km, 1.5 km and 500 m (Nowcast)
Update frequency	Hourly
Data ingested	SYNOP, SHIP, BUOY AWS data from Hong Kong and Guangdong; Radiosonde; Wind profiler; Aircraft (AMDAR); Satellites (FY-2C/MTSAT) Radar (reflectivity and Doppler velocity)
Model background	HKO-RSM (20 km resolution) NHM (5km resolution)
Computer platforms	IBM SP / Linux PC

香港天文台
HONG KONG OBSERVATORY

HKO-LAPS Domain (1)

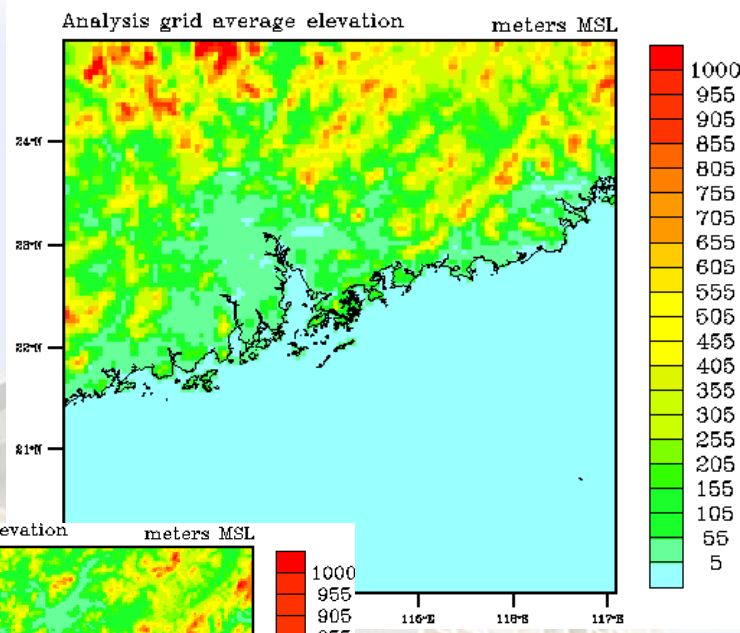
- TC-LAPS
  - 10 km resolution
  - Mesoscale analysis over southern China and South China Sea
  - Nowcast of wind/pressure at selected stations in HK during TC sitatuations

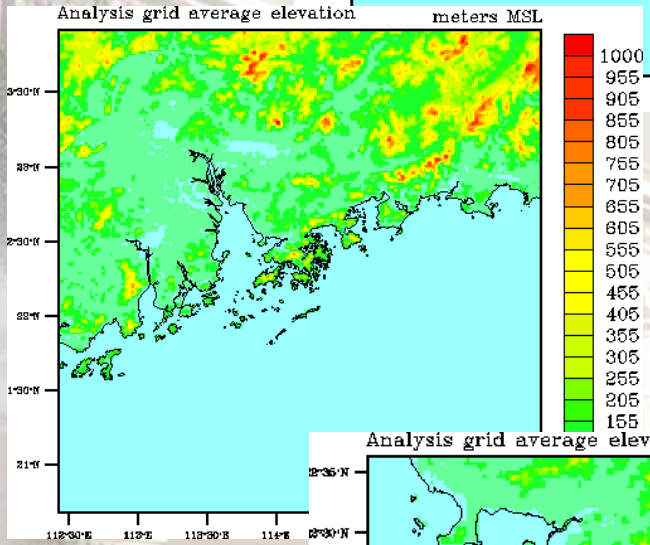


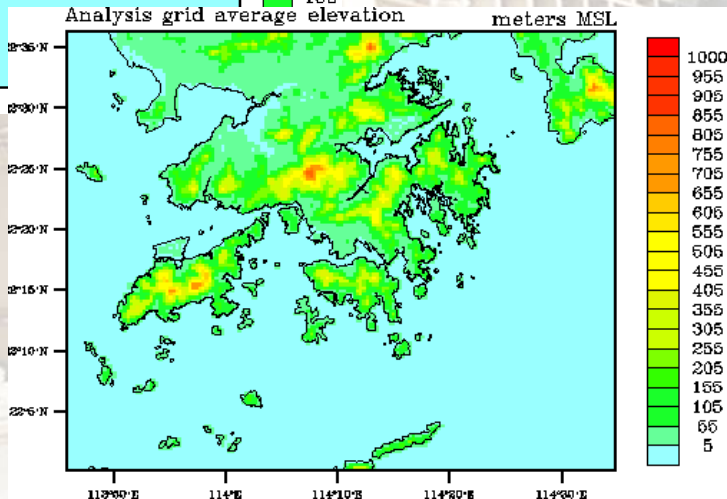
香港天文台
HONG KONG OBSERVATORY

LAPS Domains (2)

- GD-LAPS
  - 5 km resolution
  - Mesoscale analysis over Guangdong
  - initialize moisture variables in NHM
  - input to SWIRLS lightning nowcast
- PRD-LAPS
  - 1.5 km resolution
  - 241x241; 45 pressure levels
  - Mesoscale analysis over the Pearl River Delta
- HK-LAPS
  - 500 m resolution
  - 169x135; 45 pressure levels
  - Local scale analysis

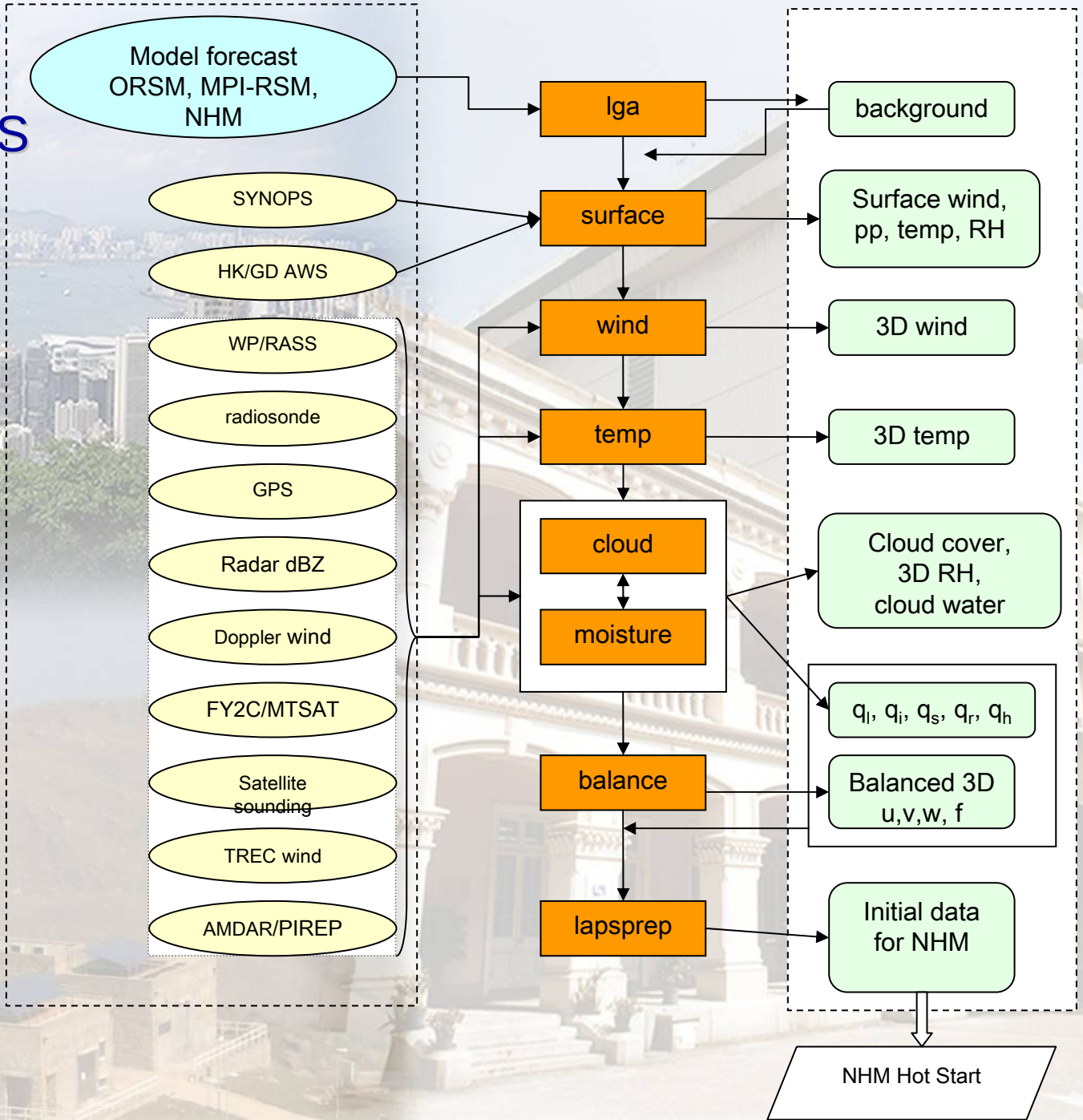






香港天文台
HONG KONG OBSERVATORY

Data flow in LAPS



香港天文台
HONG KONG OBSERVATORY

Application of LAPS in mesoscale analysis

- LAPS Hourly Analysis
  - an integrated platform to digest all available observation data (AWS, radar ..) to monitor mesoscale weather systems
  - analyse and diagnose mesoscale circulation in rapidly-update cycle
  - High resolution:
    - 5 km/1.5 km and 500 m horizontal resolution
    - Initialization of cloud hydrometeor fields in non-hydrostatic NWP model (HKO-NHM)

LAPS Hourly Analysis

Op. Trial ver.2008-04; based on laps-0-32-15

Date	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
12 Jun, 2008	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗
11 Jun, 2008	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Analysis time (UTC): 200806120900

Reset Back Next

Next update: Analysis time T+55 min.

Domain (Resolution)	normal	zoom
GD 5km	◉	○
PRD 1.5km	○	○
Hong Kong 500m	○	

Surface

Wind	●	Wind+MSLP	●
Wind+Temp.	●	Wind+RH	●
Wind+EPT	●		

Upper levels

	Wind+RH	
925hPa	●	
850hPa	●	
700hPa	●	
500hPa	●	

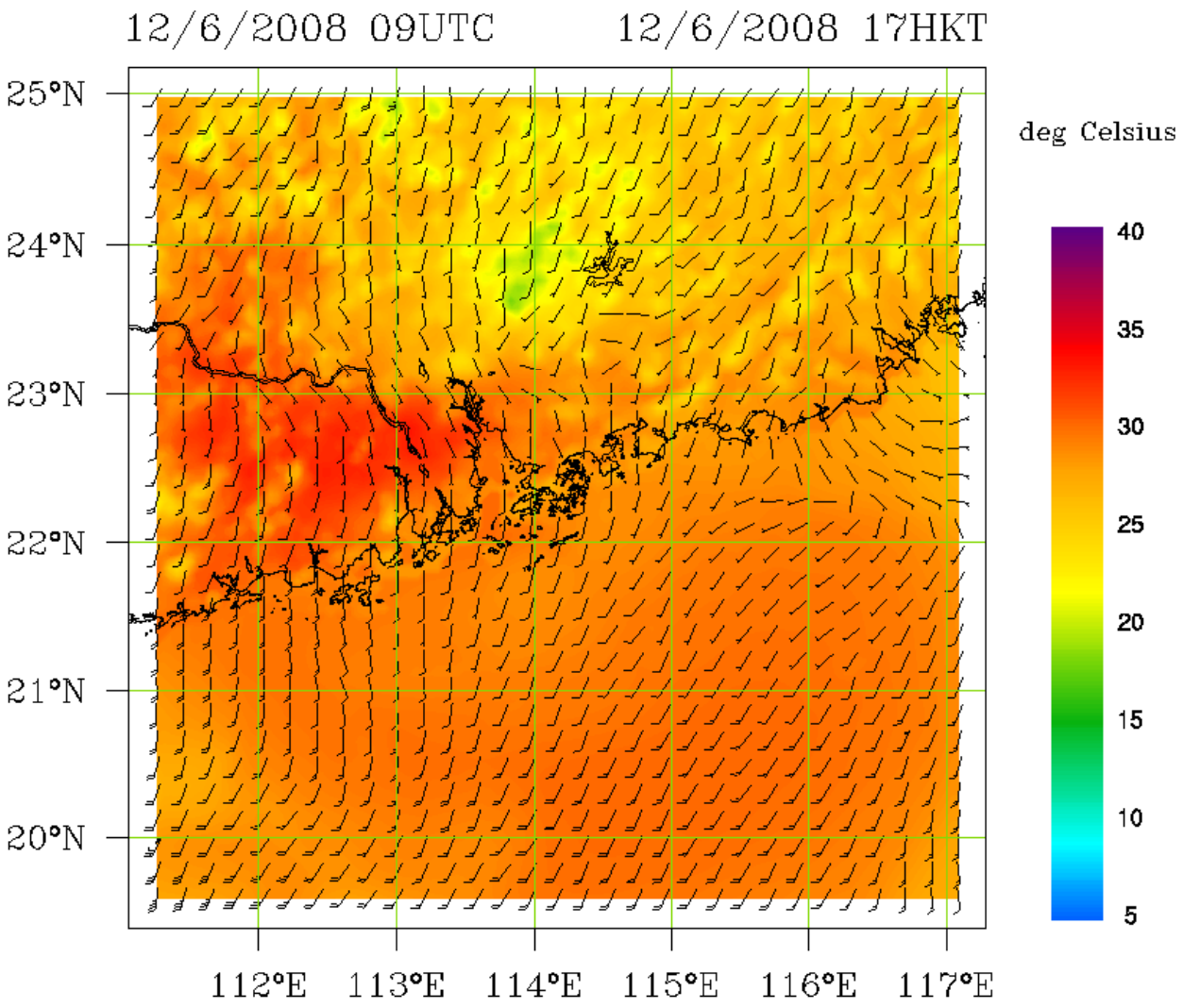
Instability and moisture analyses

K index	●	Lifted Index	●
Total Totals index	●	Total Precip. Water	●

Descriptions of Stability Indices

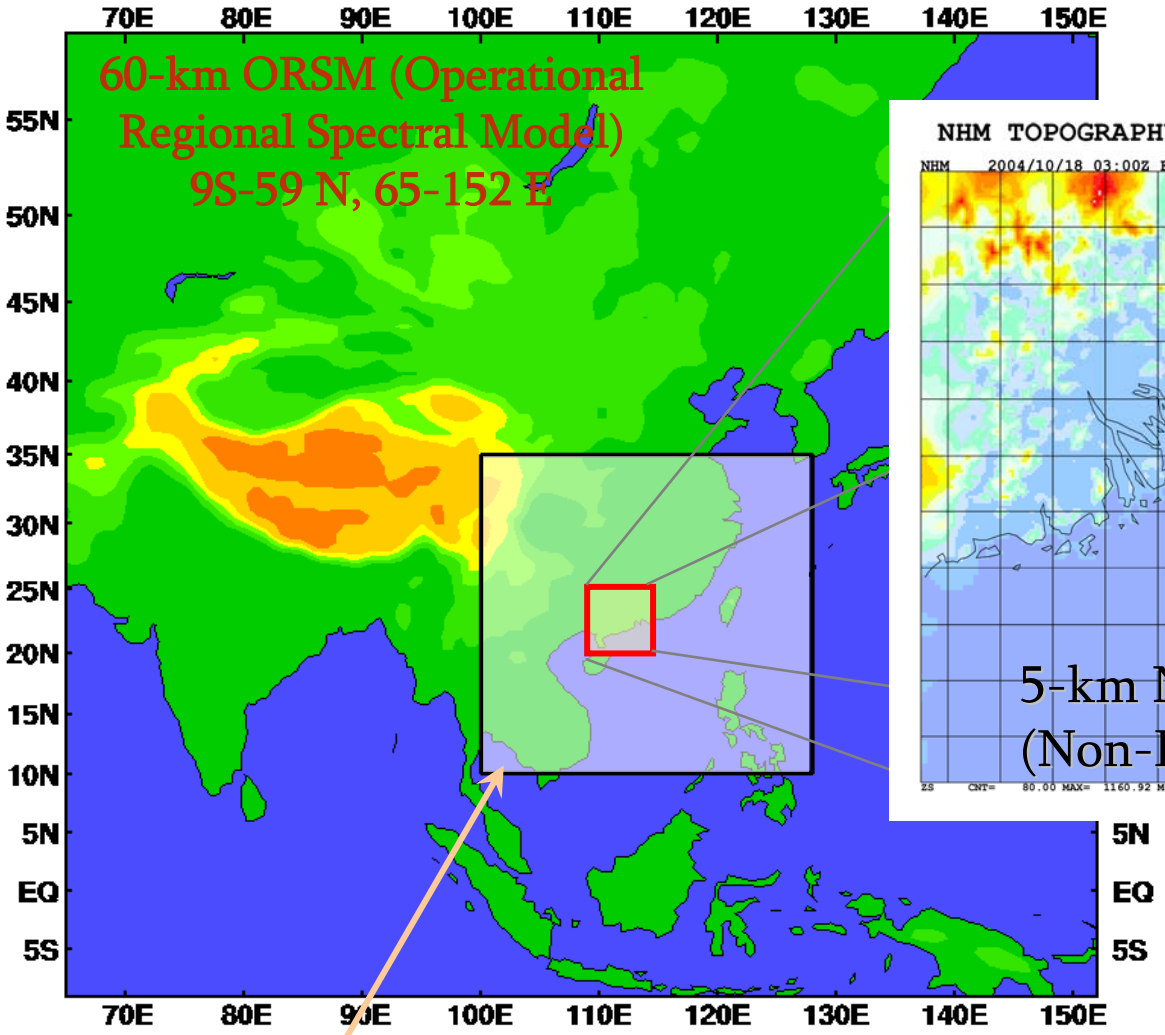
Link to LAPS TC Nowcast

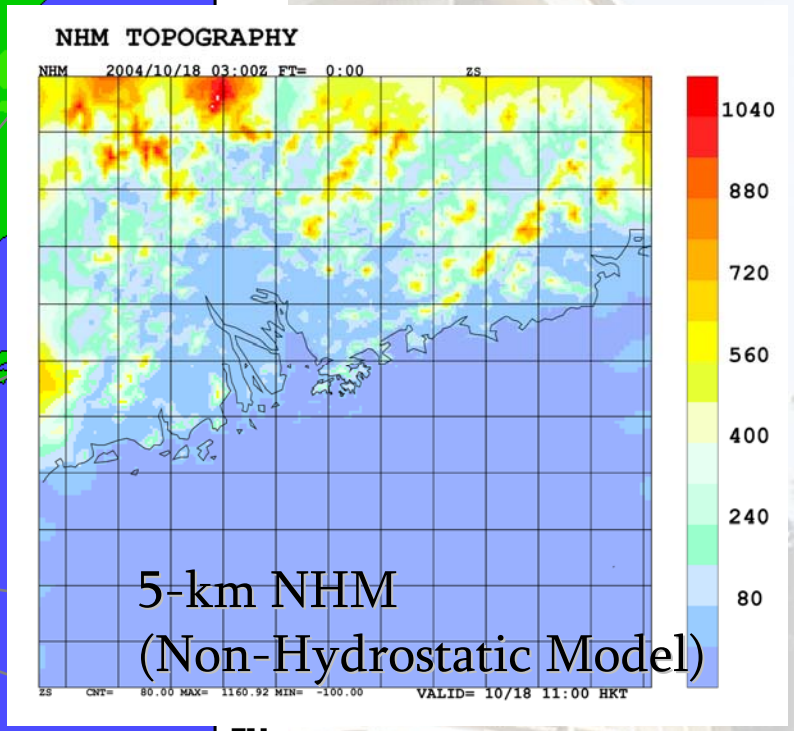
LAPS 5km surface wind and temp.



香港天文台
HONG KONG OBSERVATORY

Current NWP Systems in HKO





香港天文台
HONG KONG OBSERVATORY

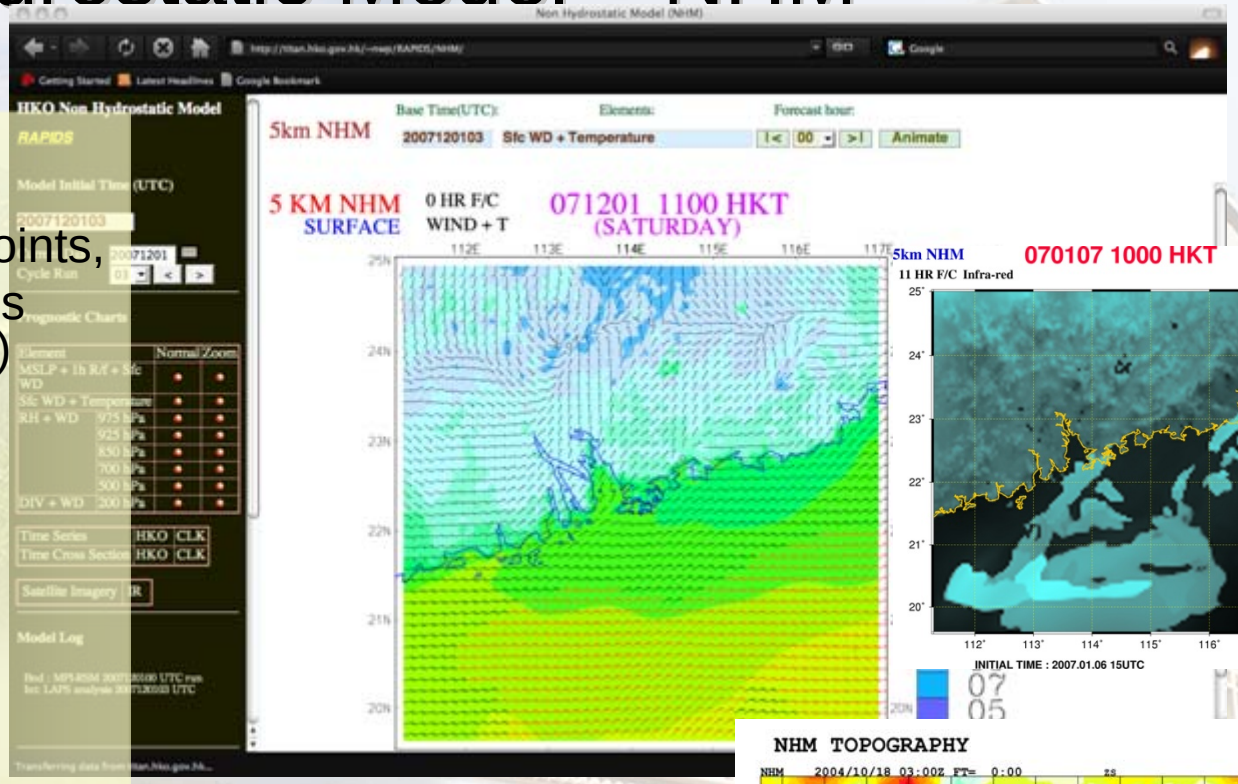
Main Applications

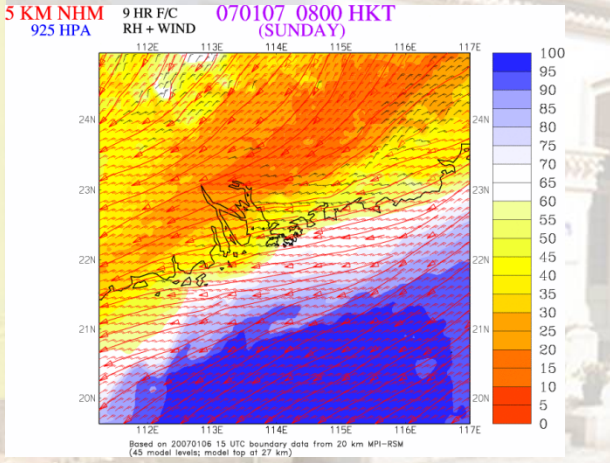
	ORSM	NHM	WRF
Regional temperature forecast	√		
Tropical Cyclones	√	√	
Rainstorms	√	√	
Land-sea breeze		√	
Others			Research and specialized meteorological support

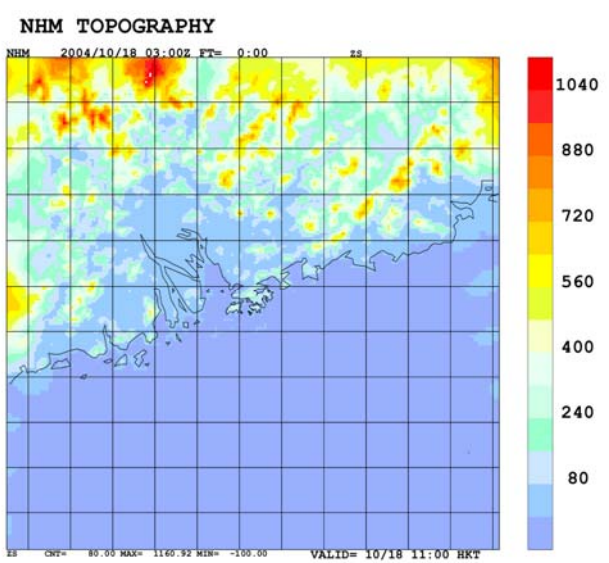
香港天文台
HONG KONG OBSERVATORY

Non-hydrostatic Model – NHM

- 5-km horizontal resolution
  - 121x121 grid-points,
  - 45 vertical levels (lowest at 10m)
- Initial condition:
  - 20-km ORSM + LAPS moisture analysis
- Boundary : 20-km ORSM
- KF + cloud microphysics
- Hourly update
- Provides 12-hour forecast







香港天文台
HONG KONG OBSERVATORY

Operation of 5km NHM

- IBM p690
- 2 nodes,32 Power 4 processors @1.1 GHz
- 48 GB memory
- Peak performance 141 GFLOPS

香港天文台
HONG KONG OBSERVATORY

RAPIDS – Rainstorm Analysis and Prediction Integrated Data-processing System

- Application of NHM in very short-range precipitation prediction ⇒ NWP-Nowcast Blending
- Nowcasting component – SWIRLS
  - 1 - 6 hr QPF by extending the linear extrapolation of radar echoes
- NWP component – Non-hydrostatic Model (NHM)
  - 1 – 6 hr QPF by non-hydrostatic numerical model

- 2 km resolution
- T+1 to T + 6 hour forecast

香港天文台
HONG KONG OBSERVATORY

RAPIDS

Radar-based nowcasting system; extrapolation effective in advective cases

Guidance on dynamic evolution of precipitation systems in rapidly changing cases

SWIRLS

NHM

RAPIDS

high resolution, rapidly updated very-short-range QPF

Browning(1998),
Lin et al (2004)

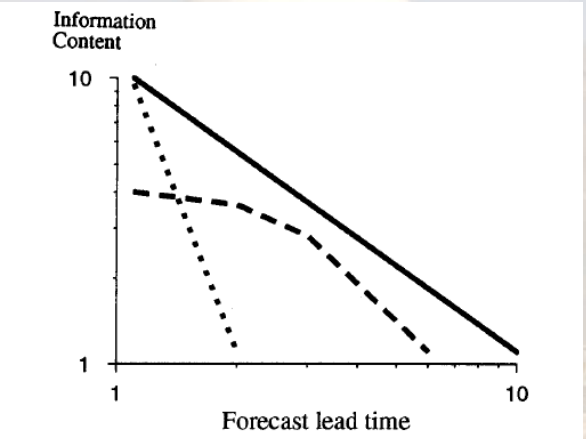
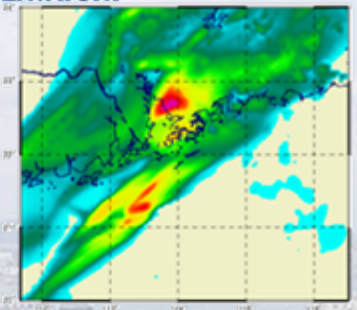


Figure 1. *Schematic representation of the loss of information content in forecasts as a function of lead time. The solid line represents the theoretical limit of predictability. The dashed line represents NWP models and the dotted line nowcasting methods.*

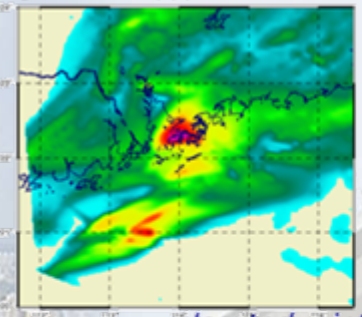
香港天文台
HONG KONG OBSERVATORY

Data flow of QPF blending in RAPIDS

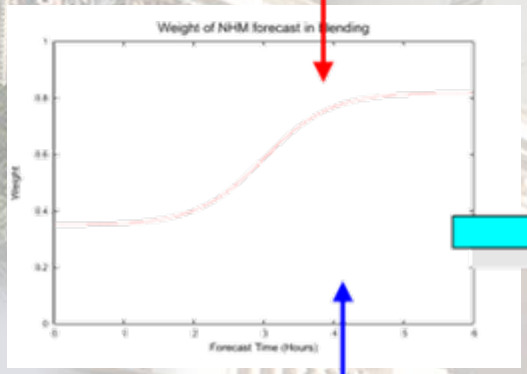
Rainfall forecast using 5 km NHM



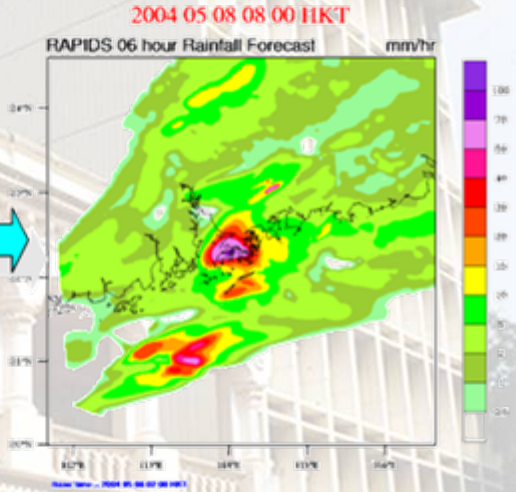
Downscaled to 2-km grid using interpolation



re-located rainfall distribution



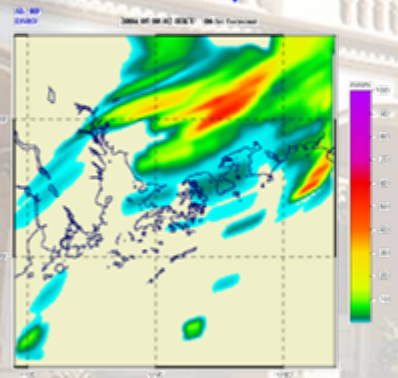
Weight of NHM forecast in blending



6 hr RAPIDS rainfall forecast

6 hr forecast of rainfall using SWIRLS semi-Lagrangian advection scheme based on TREC analysis

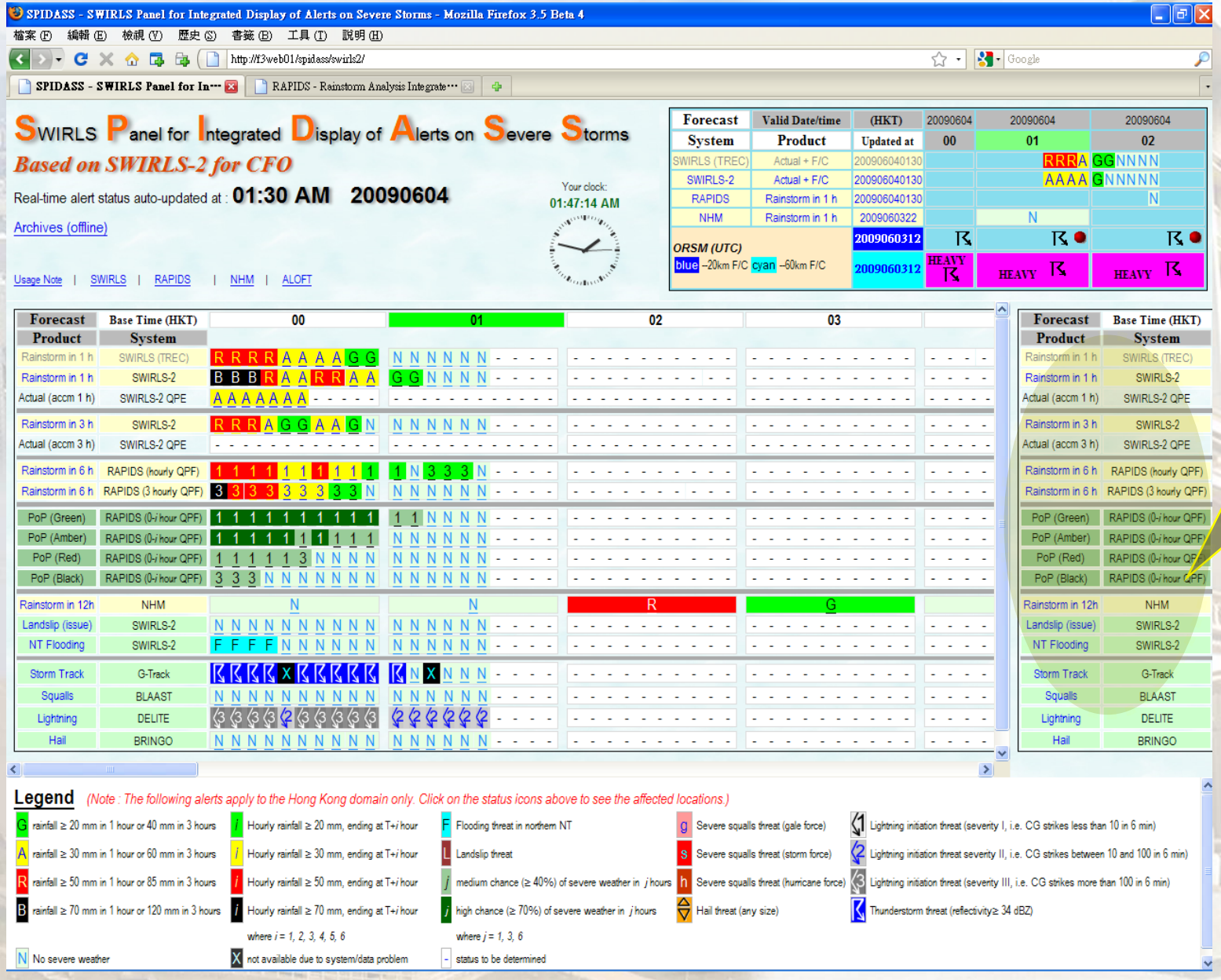
Radar 128 km range
~0.5 km resolution



Up-scaled to 2-km grid using grid-averaging

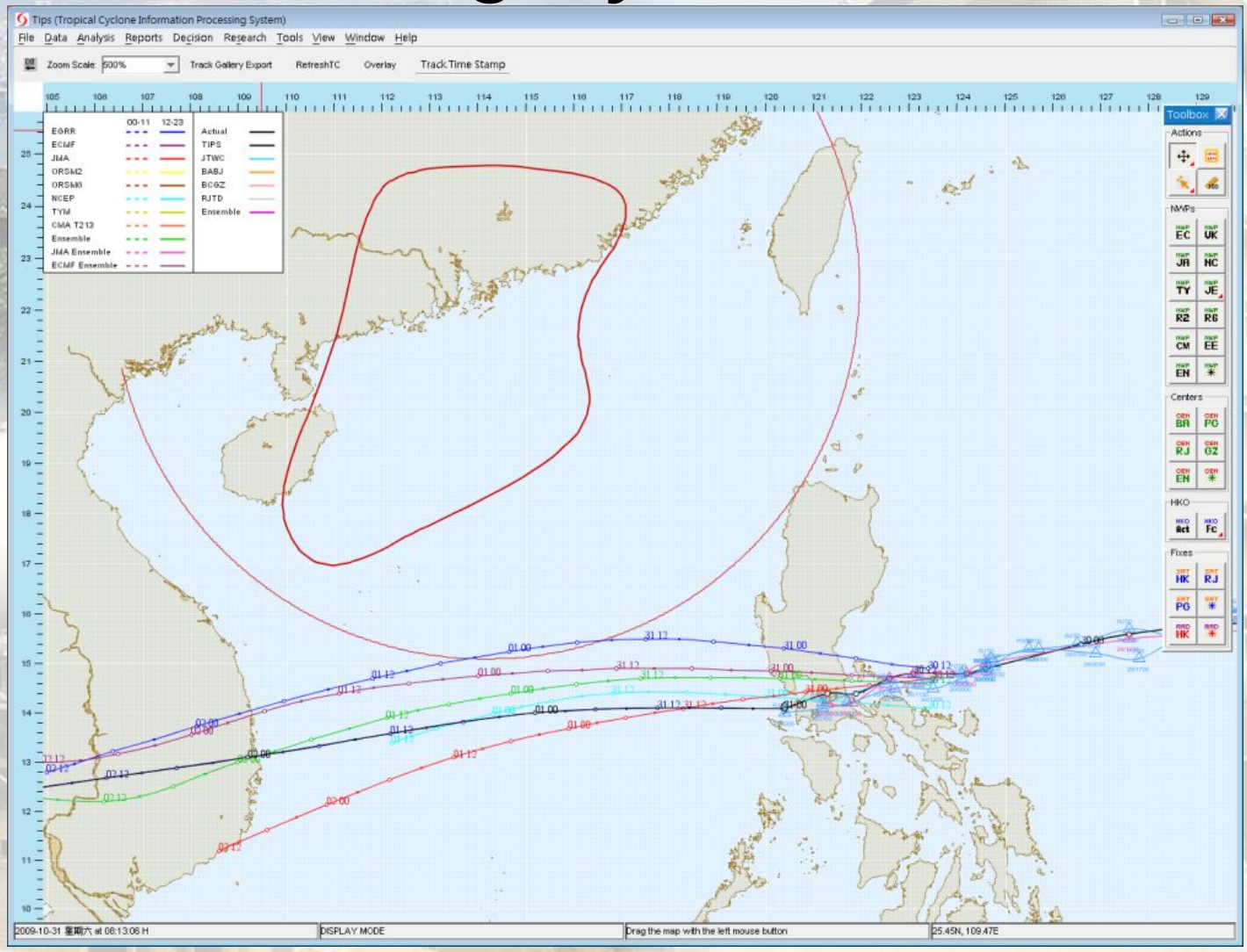
香港天文台
HONG KONG OBSERVATORY

SPIDASS - SWIRLS Integrated Warning Panel



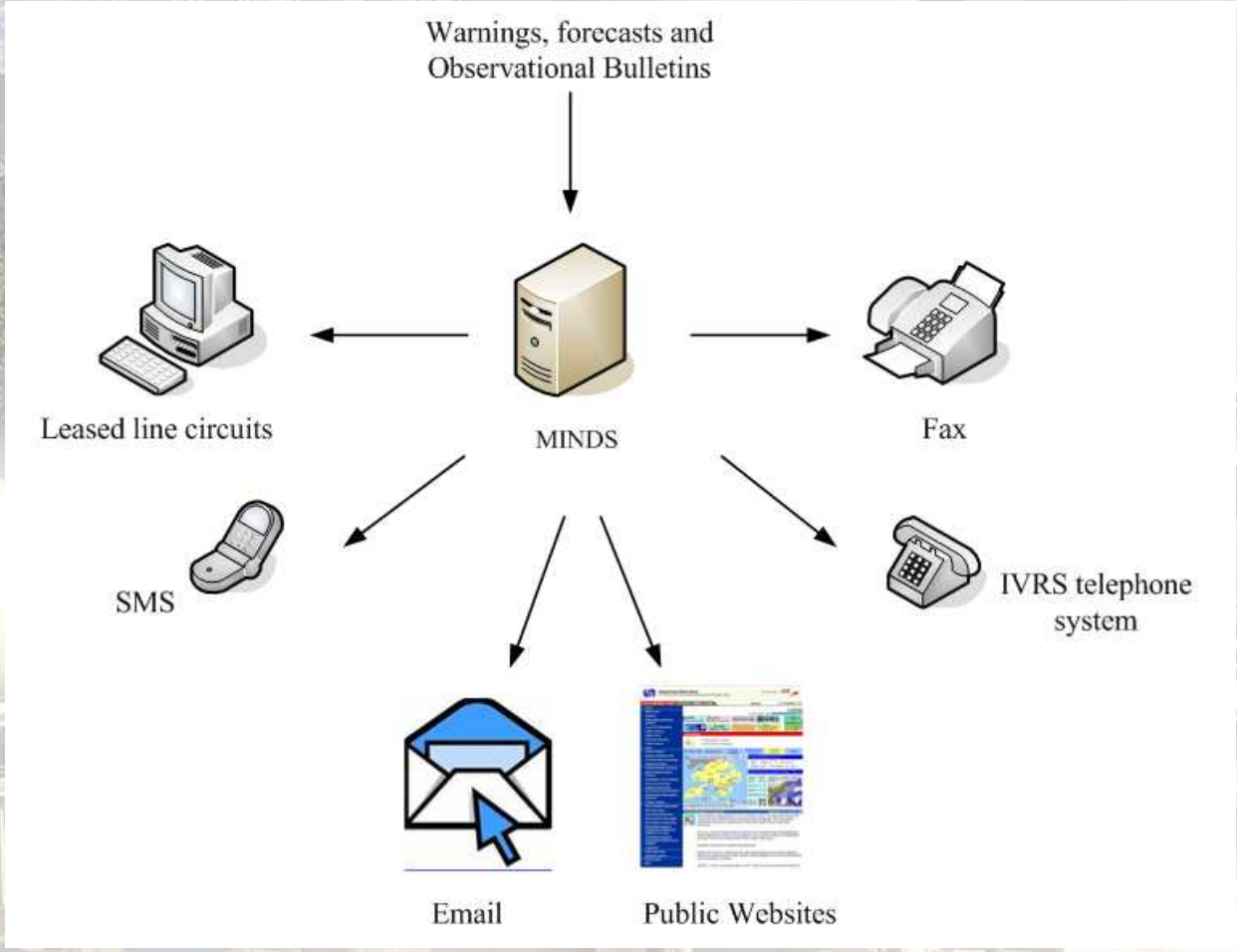
香港天文台
HONG KONG OBSERVATORY

Tropical Cyclone Information Processing System - TIPS



香港天文台
HONG KONG OBSERVATORY

Meteorological Information Dissemination System - MINDS



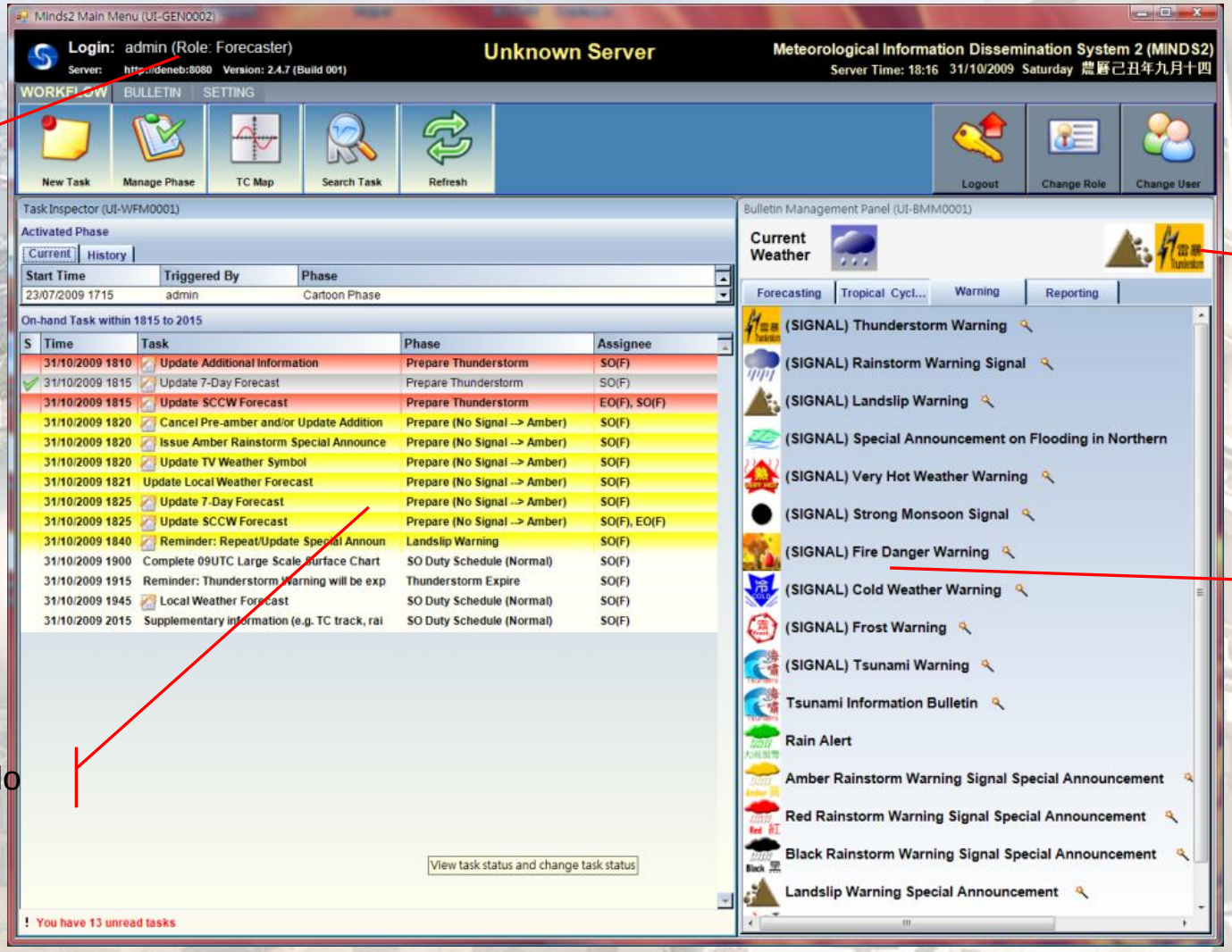
香港天文台
HONG KONG OBSERVATORY

Main Features of MINDS

- 2nd Generation – fully operational since Jan 2009
- 3-Tier Design: Client + Application Server + Database
- Data stored in XML format
- Support Work Flow
- Support Role
- Automatically bring up “tasks-to-do” to users when:
  - warnings criteria/thresholds reached/departed;
  - Tropical Cyclones entering/leaving Area of Responsibility;
  - issuance/cancellation of warnings.

香港天文台
HONG KONG OBSERVATORY

MINDS User Interface



Roles

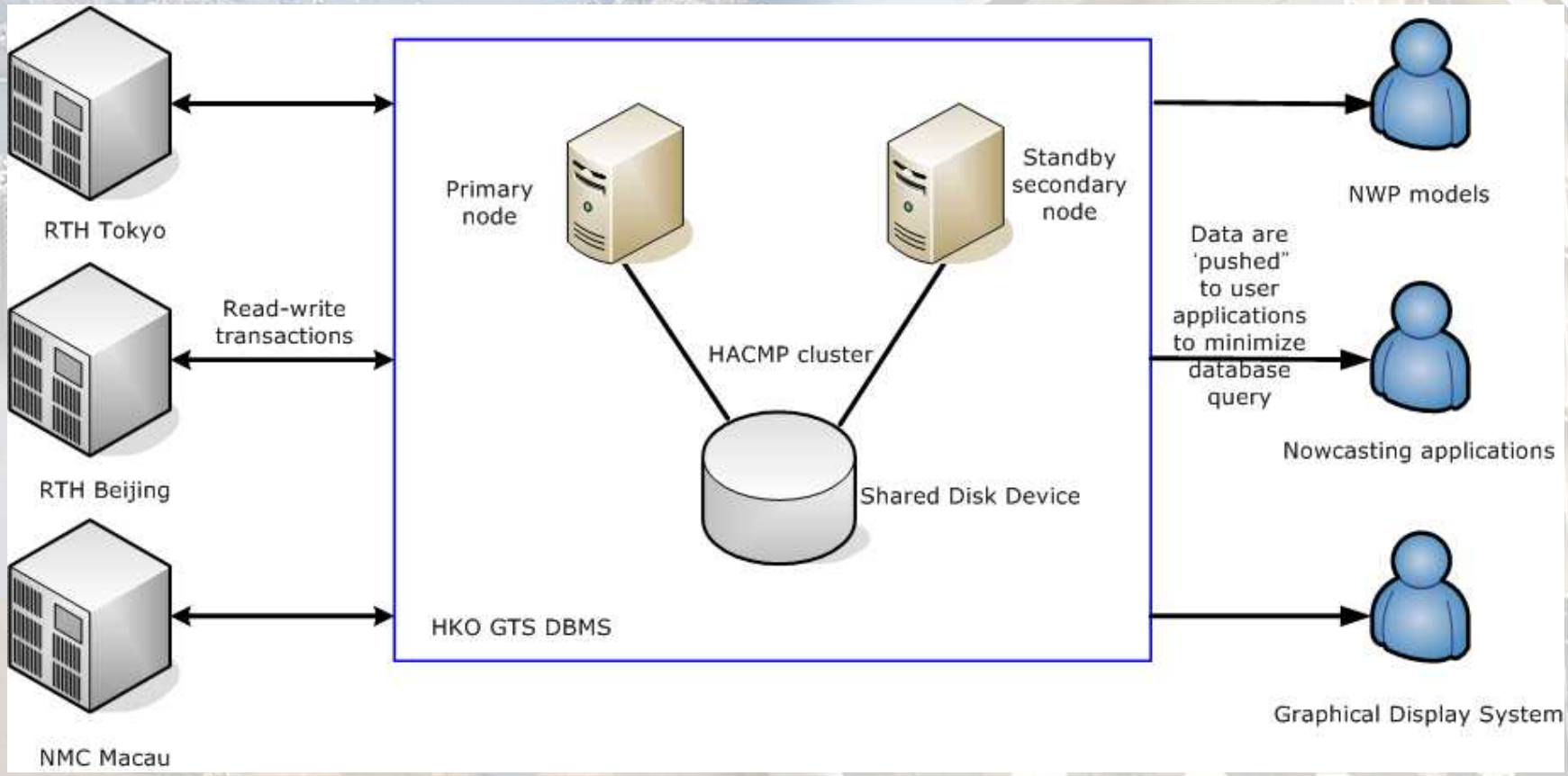
Tasks-to-do

Warnings in force

Warning bulletin preparation wizards

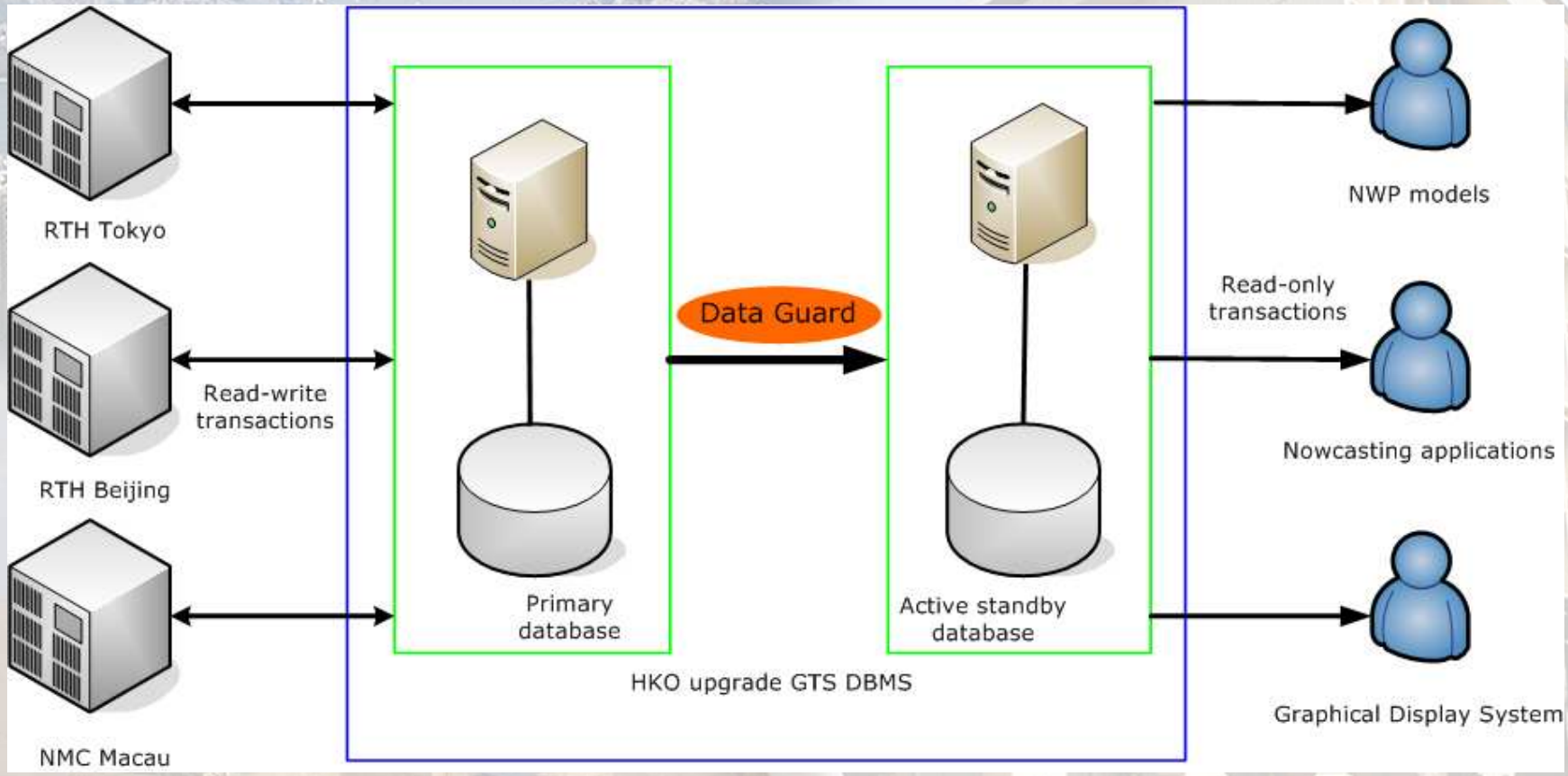
香港天文台
HONG KONG OBSERVATORY

HKO GTS DBMS



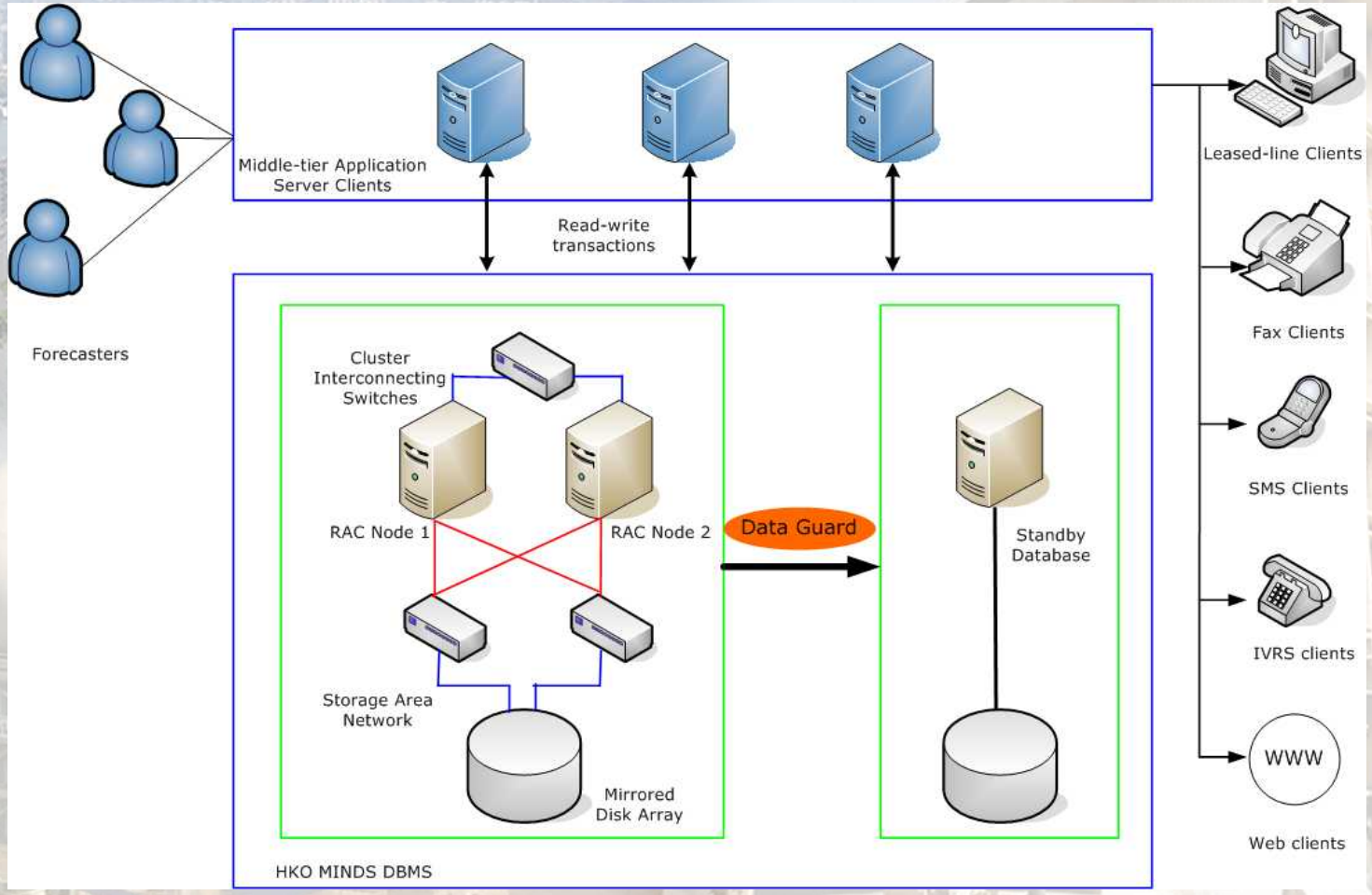
香港天文台
HONG KONG OBSERVATORY

Upgrade GTS DBMS



香港天文台
HONG KONG OBSERVATORY

HKO MINDS DBMS



香港天文台
HONG KONG OBSERVATORY

Conclusions

- MINDS database
  - Use RAC for high availability (a mission-critical system for public weather service operating round the clock with little tolerance in down time)
  - Use RAC for high scalability (choose a scalable storage system)
- GTS, AWS, Rainguage databases
  - Use Data Guard to improve availability (no shared disk device needed)
  - Deploy active standby database for read-only access to offload primary database

香港天文台
HONG KONG OBSERVATORY

Thank you