

# The Hong Kong Observatory's Operational Data Management Systems

YC CHENG  
HKO

ECMWF Meteorological Operational  
Systems Workshop – November 2009

# 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

# 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

# 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

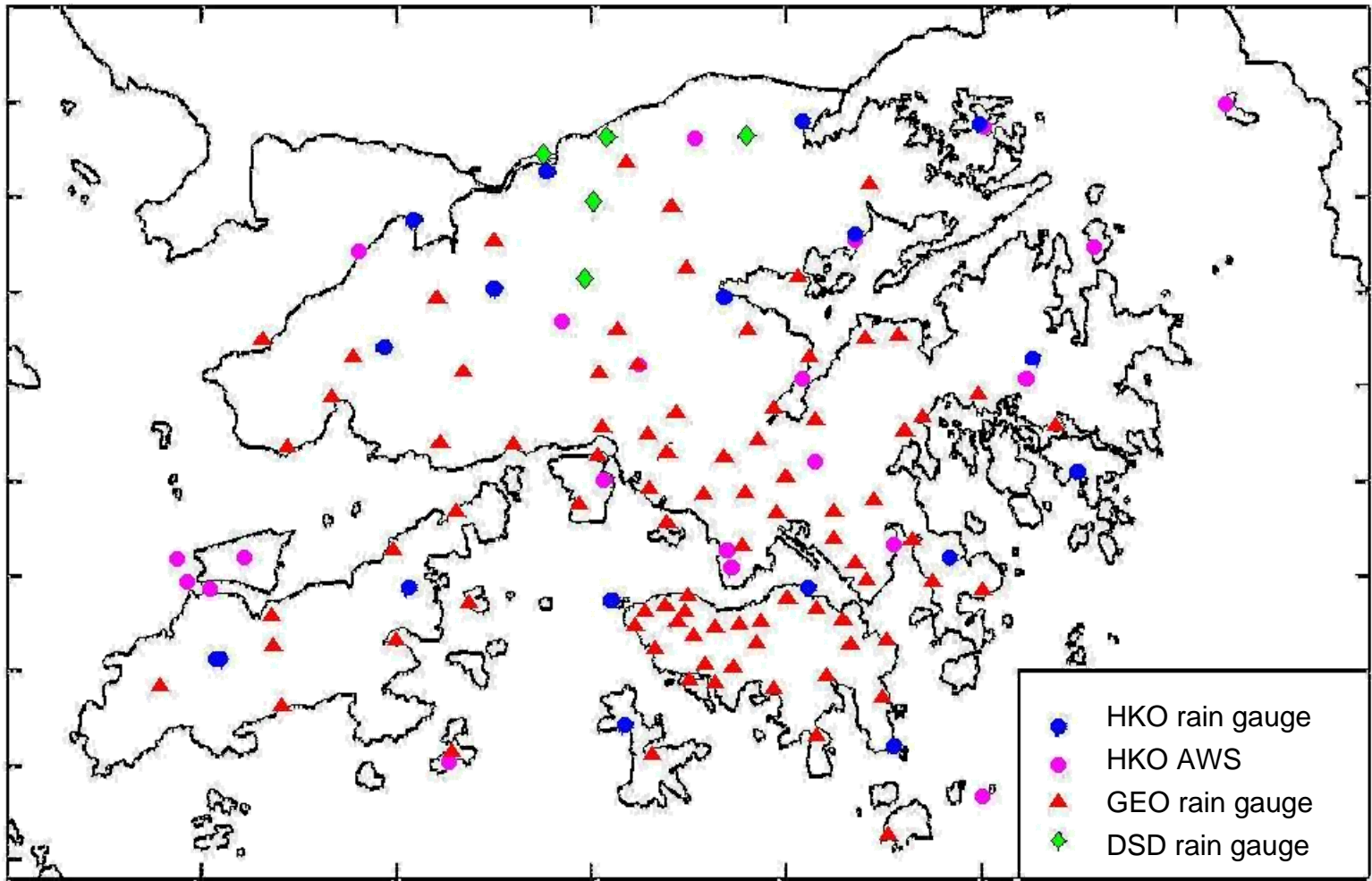
# HKO's Nowcasting system - SWIRLS

- SWIRLS
  - Short-range (1-6 hours)
  - Warning of
  - Intense ( $\geq 30$  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

# Observation Network

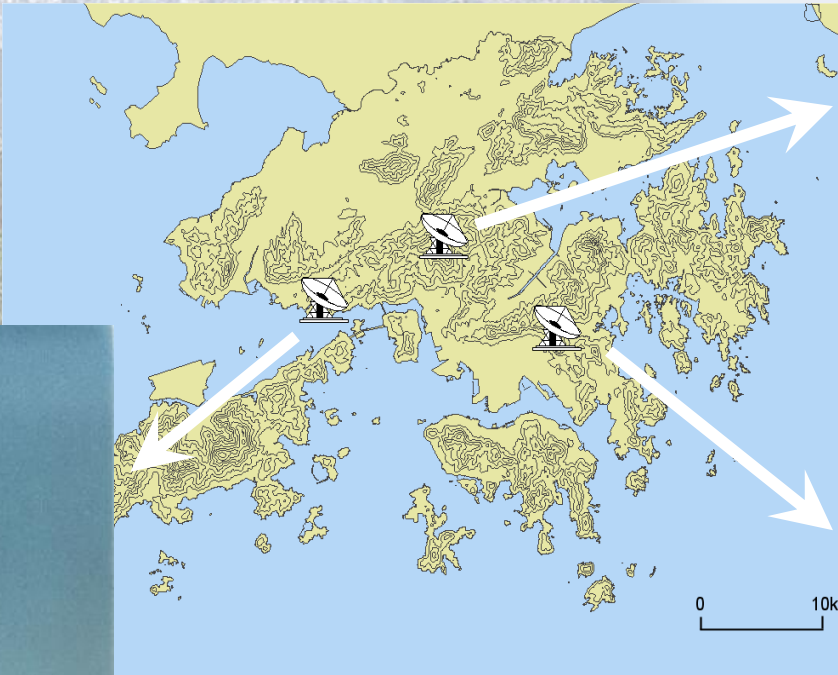


# Raingauge Networks



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

# Doppler Weather Radar



S-band  
10cm

Tai Mo Shan (since 1999)



S-band,  
10cm

Tates' Cairn (since 1994)

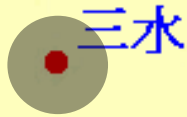


C-band,  
5cm  
TDWR

TDWR (since 1996)



# Lightning Location Detection Network



三水

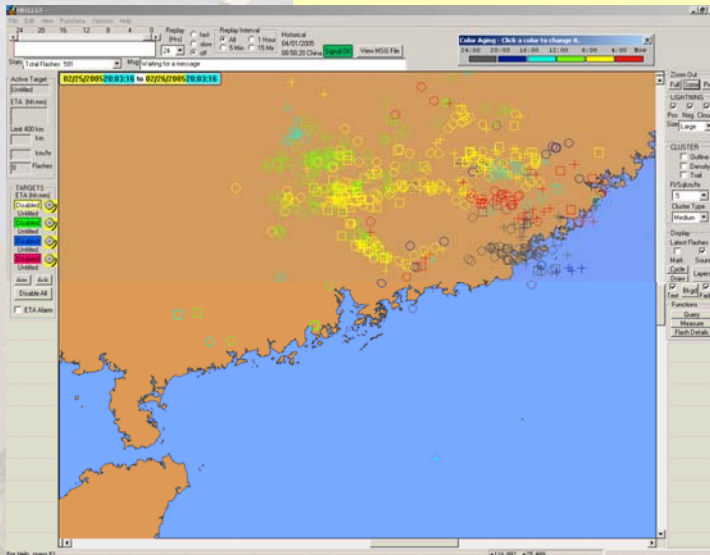
Mainland  
China site

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

惠東



Mainland  
China site



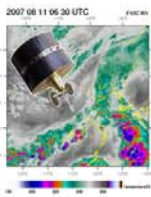


# 香港天文台「小渦旋」臨近預報系統 — SWIRLS

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



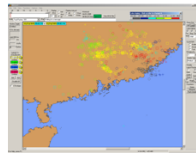
自動雨量計  
Automatic Raingauge



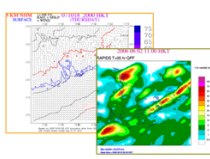
探空儀  
Radiosonde



氣流剖析儀  
Wind Profiler



閃電資訊  
Lightning Information



數值模式  
Numerical Model



「小渦旋」高速電腦系統  
SWIRLS Supercomputer Systems

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

雷達自動量雨筒分析  
Radar-Raingauge 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



暴雨  
Rainstorm



水浸  
Flooding



山泥傾瀉  
Landslip



閃電  
Lightning



狂風  
Squalls



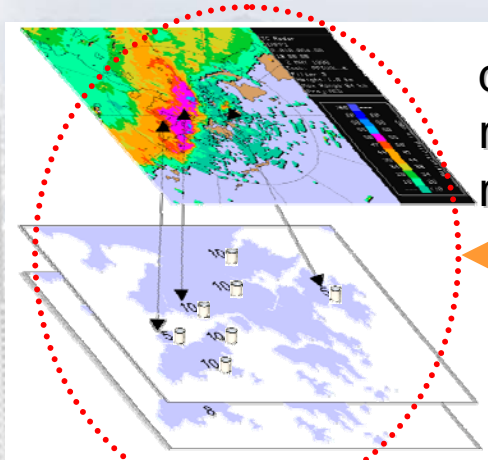
冰雹  
Hail



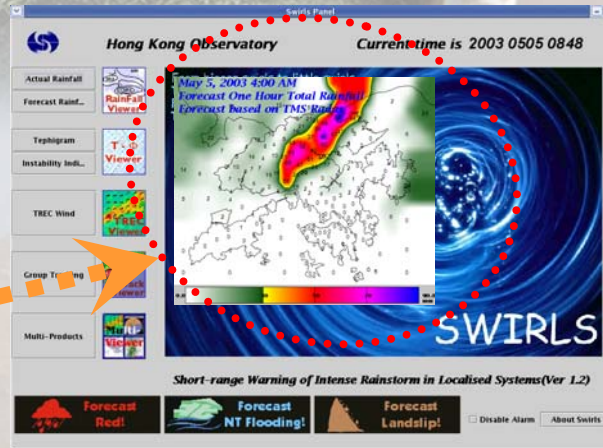
熱帶氣旋  
Tropical  
Cyclone

預報  
Forecast

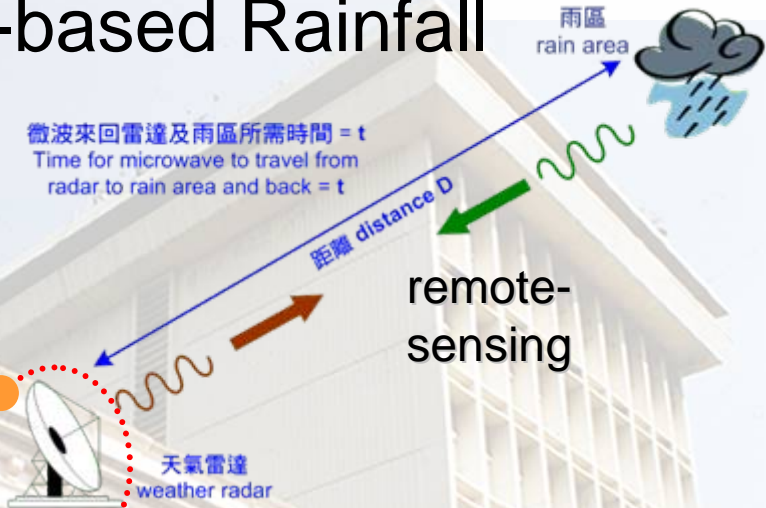
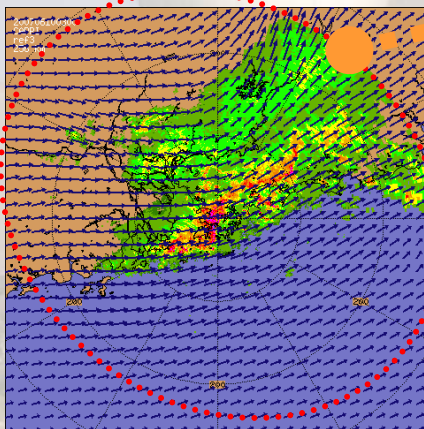
# Basic Principles of Radar-based Rainfall Nowcast



dynamic  
radar-rain gauge  
rainfall calibration

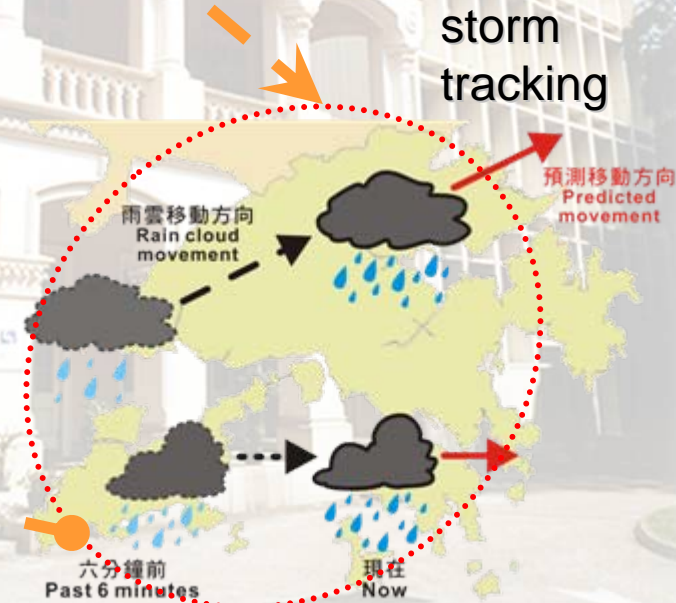


time integration  
(Semi-Lagrangian advection)



微波來回雷達及雨區所需時間 = t  
Time for microwave to travel from  
radar to rain area and back = t

remote-  
sensing



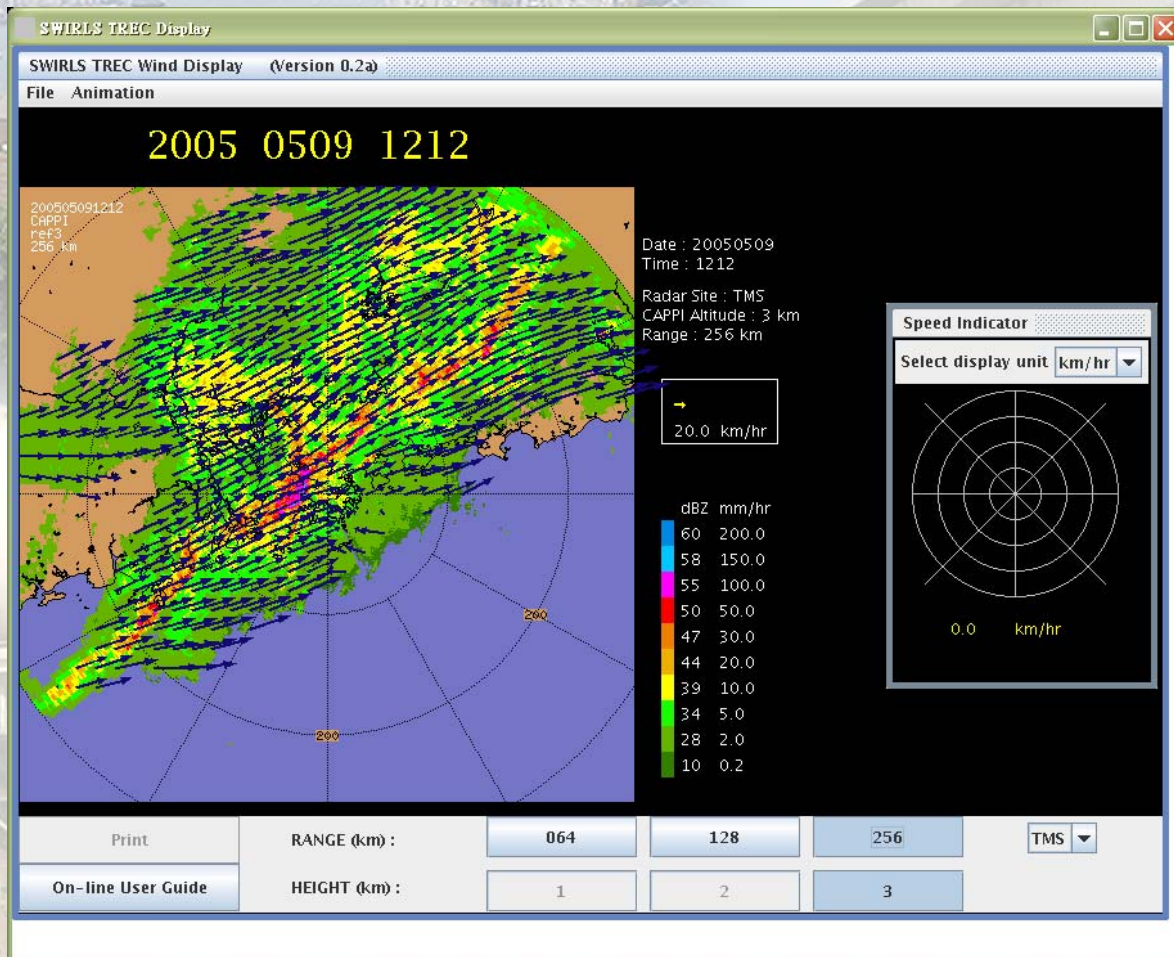
storm  
tracking

雨雲移動方向  
Rain cloud  
movement

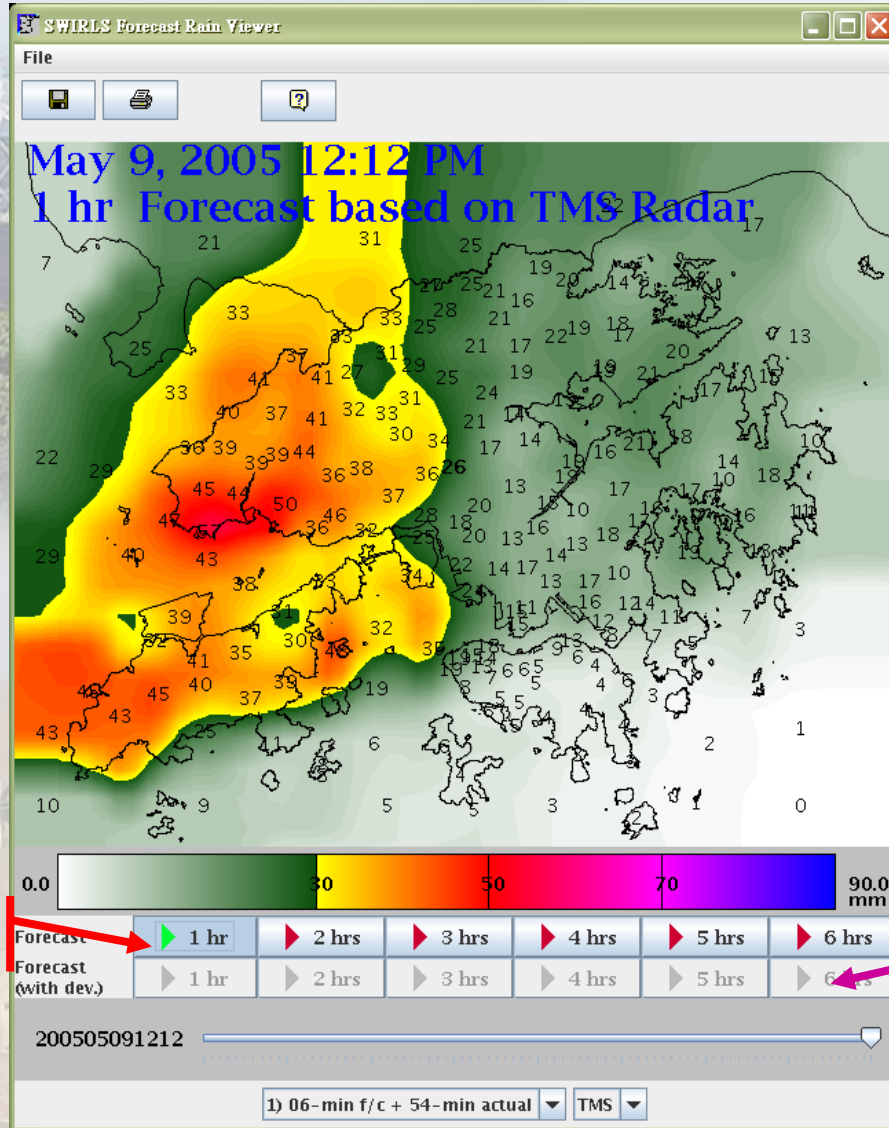
六分鐘前  
Past 6 minutes

現在  
Now

# SWIRLS Echo Motion Viewer



# SWIRLS F/C Rainfall Viewer



Radar nowcast

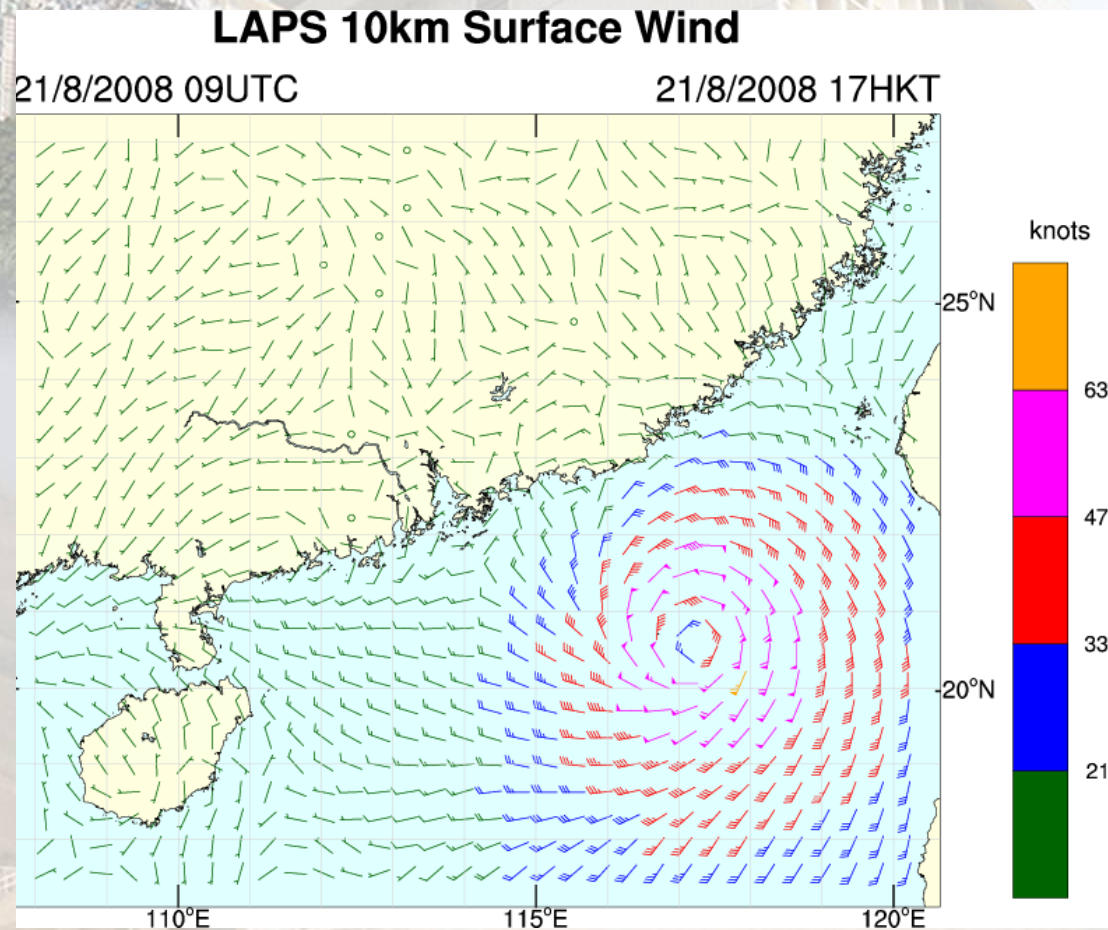
Nowcast and NWP blended

# 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

# 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 situations



# LAPS Domains (2)

- GD-LAPS

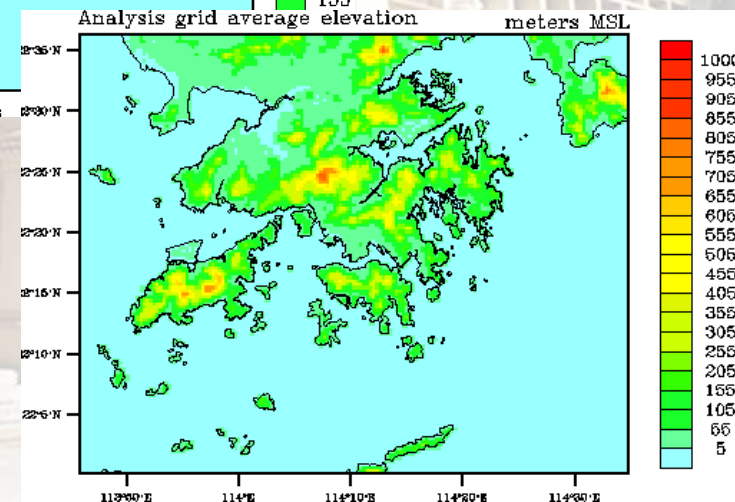
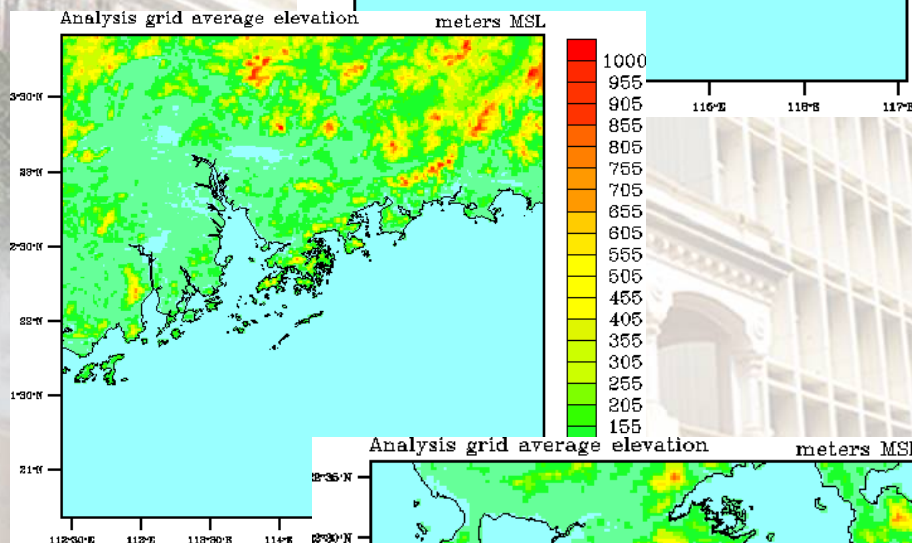
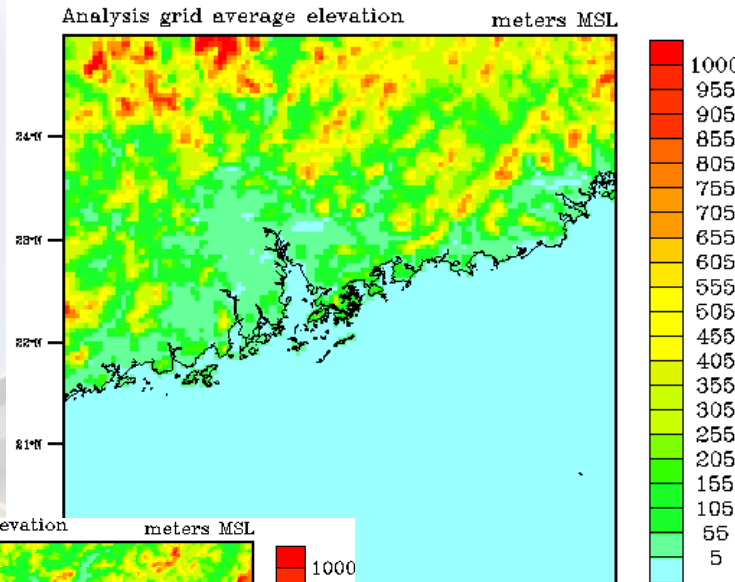
- 5 km resolution
- Mesoscale analysis over Guangdong
- initialize moisture variables in NHM
- input to SWIRLS lightning nowcast

- PRD-LAPS

- 1.5 km resolution
- 241x241; 45 pressure levels
- Mesoscale analysis over the Pearl River Delta

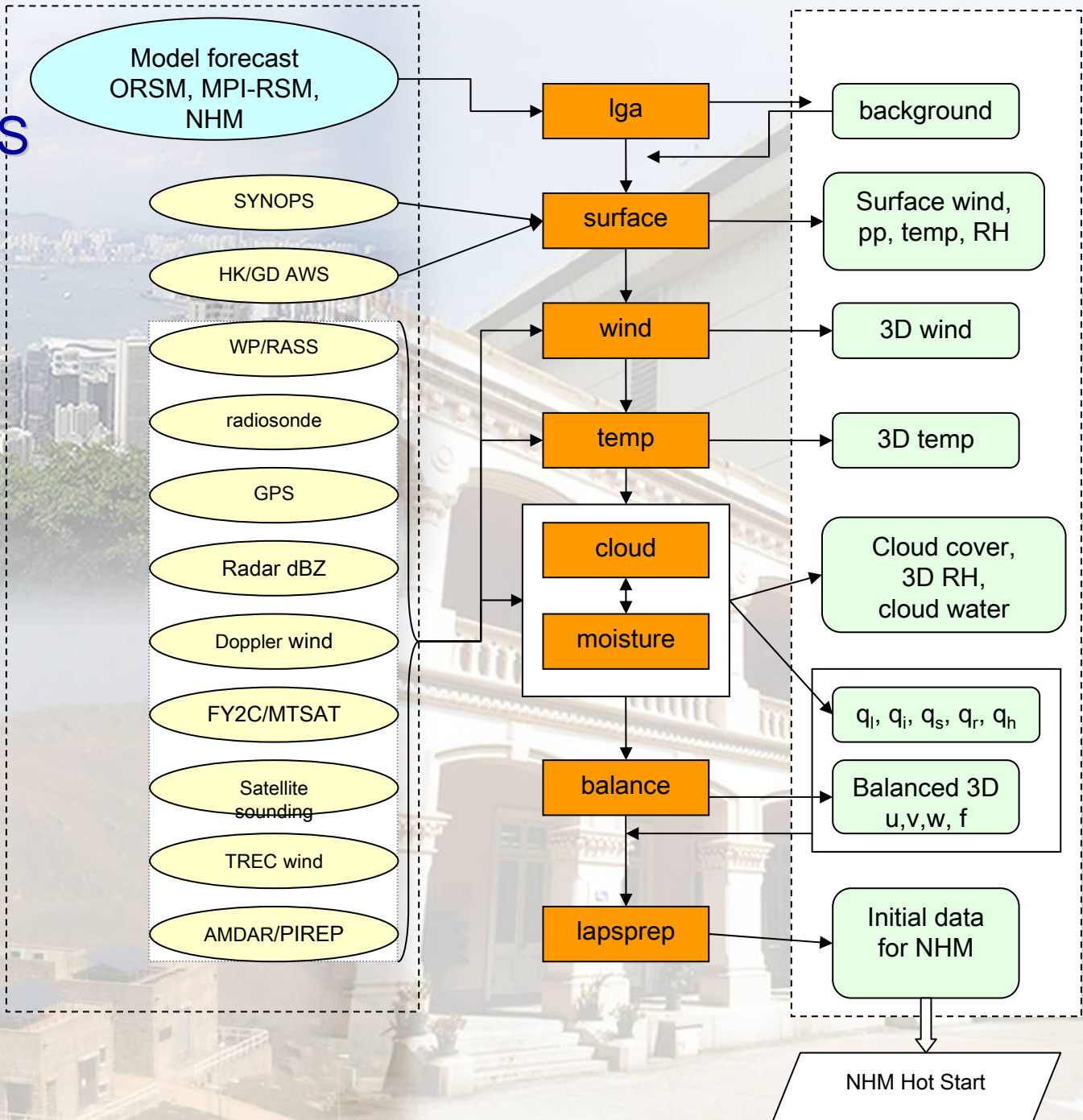
- HK-LAPS

- 500 m resolution
- 169x135; 45 pressure levels
- Local scale analysis





# Data flow in LAPS



# 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

Analysis time (UTC): 200806120900

Next update: Analysis time T+55 min.

Domain (Resolution) normal zoom

GD 5km    
 PRD 1.5km    
 Hong Kong 500m

## Surface

Wind	<input checked="" type="checkbox"/>	Wind+MSLP	<input checked="" type="checkbox"/>
Wind+Temp.	<input checked="" type="checkbox"/>	Wind+RH	<input checked="" type="checkbox"/>
Wind+EPT	<input checked="" type="checkbox"/>		

## Upper levels

	Wind+RH
925hPa	<input checked="" type="checkbox"/>
850hPa	<input checked="" type="checkbox"/>
700hPa	<input checked="" type="checkbox"/>
500hPa	<input checked="" type="checkbox"/>

## Instability and moisture analyses

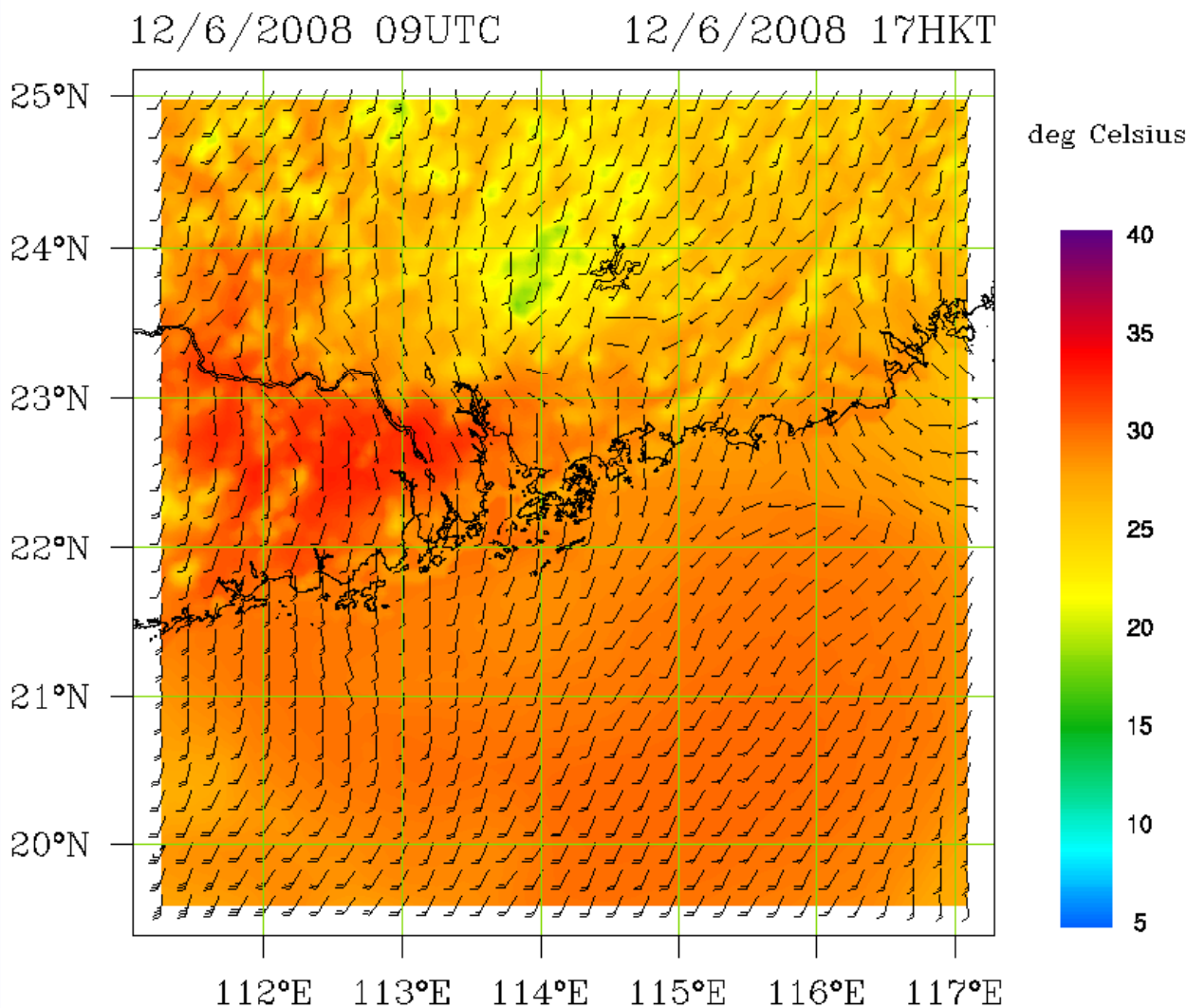
K index	<input checked="" type="checkbox"/>	Lifted Index	<input checked="" type="checkbox"/>
Total Totals index	<input checked="" type="checkbox"/>	Total Precip. Water	<input checked="" type="checkbox"/>

[Descriptions of Stability Indices](#)

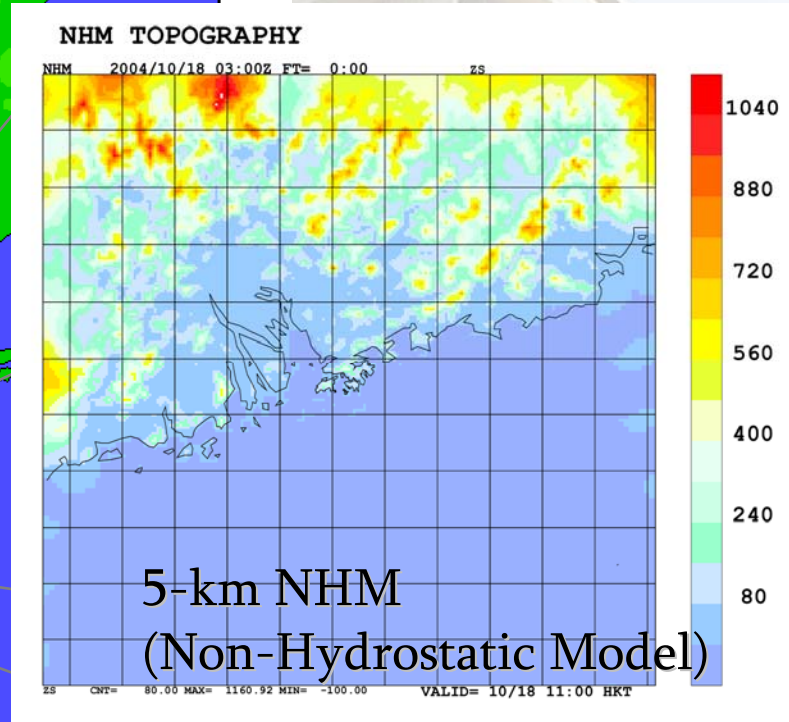
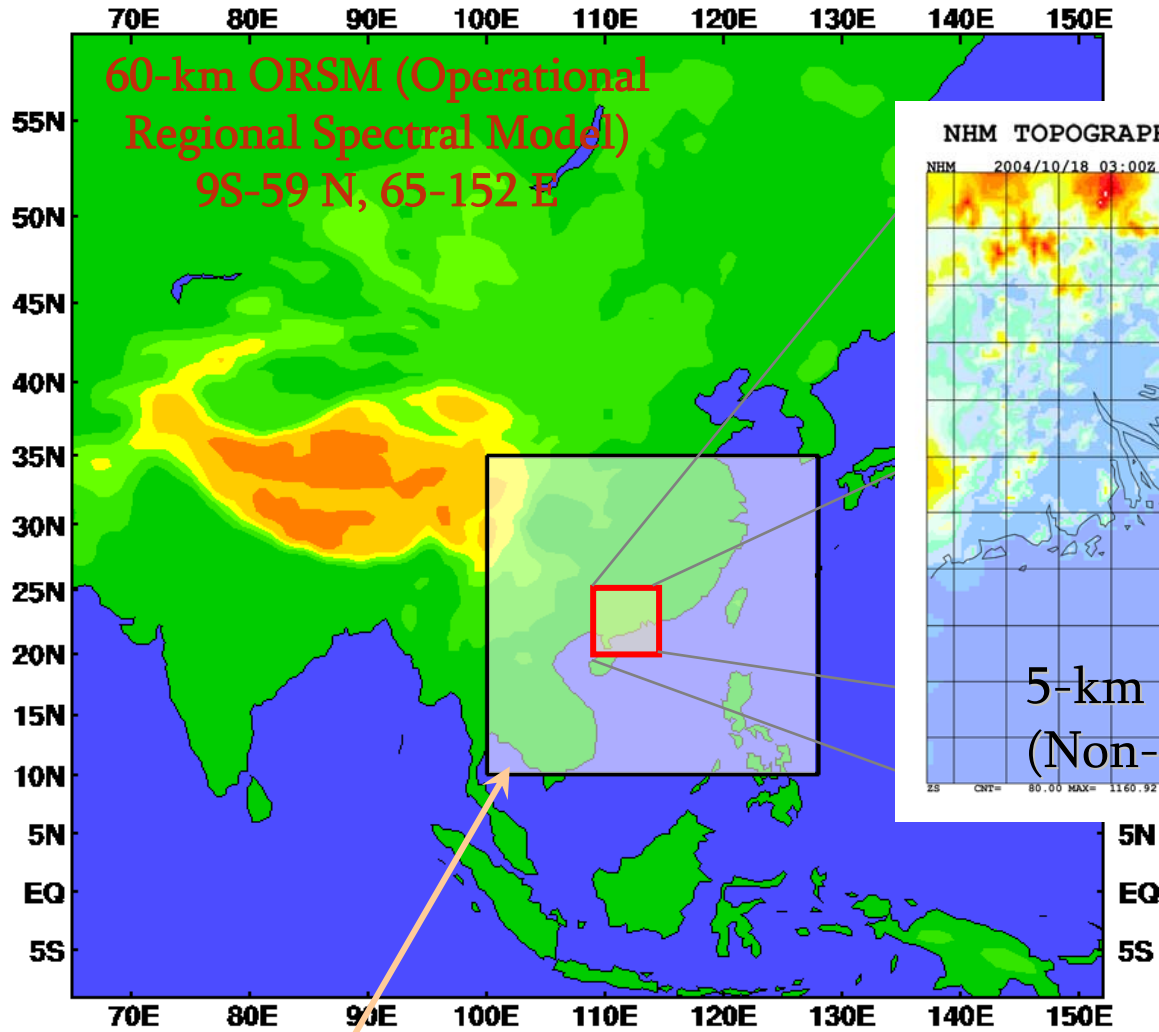
[Link to LAPS TC Nowcast](#)

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	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
11 Jun, 2008	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>

## LAPS 5km surface wind and temp.



# Current NWP Systems in HKO



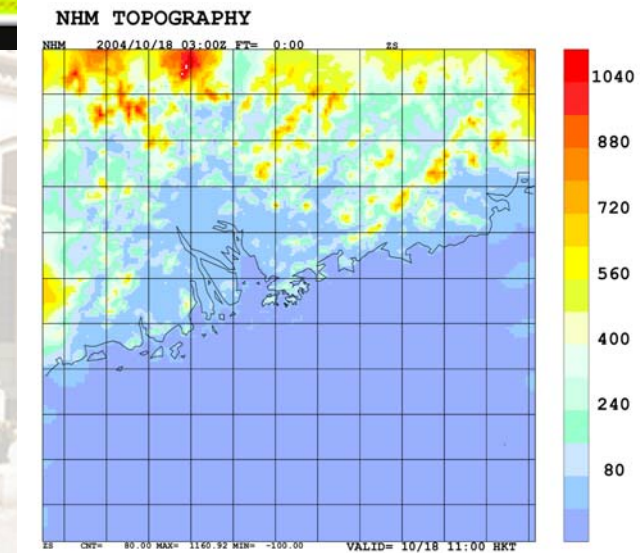
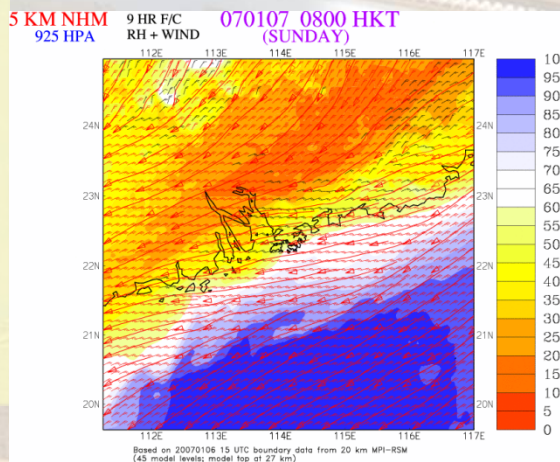
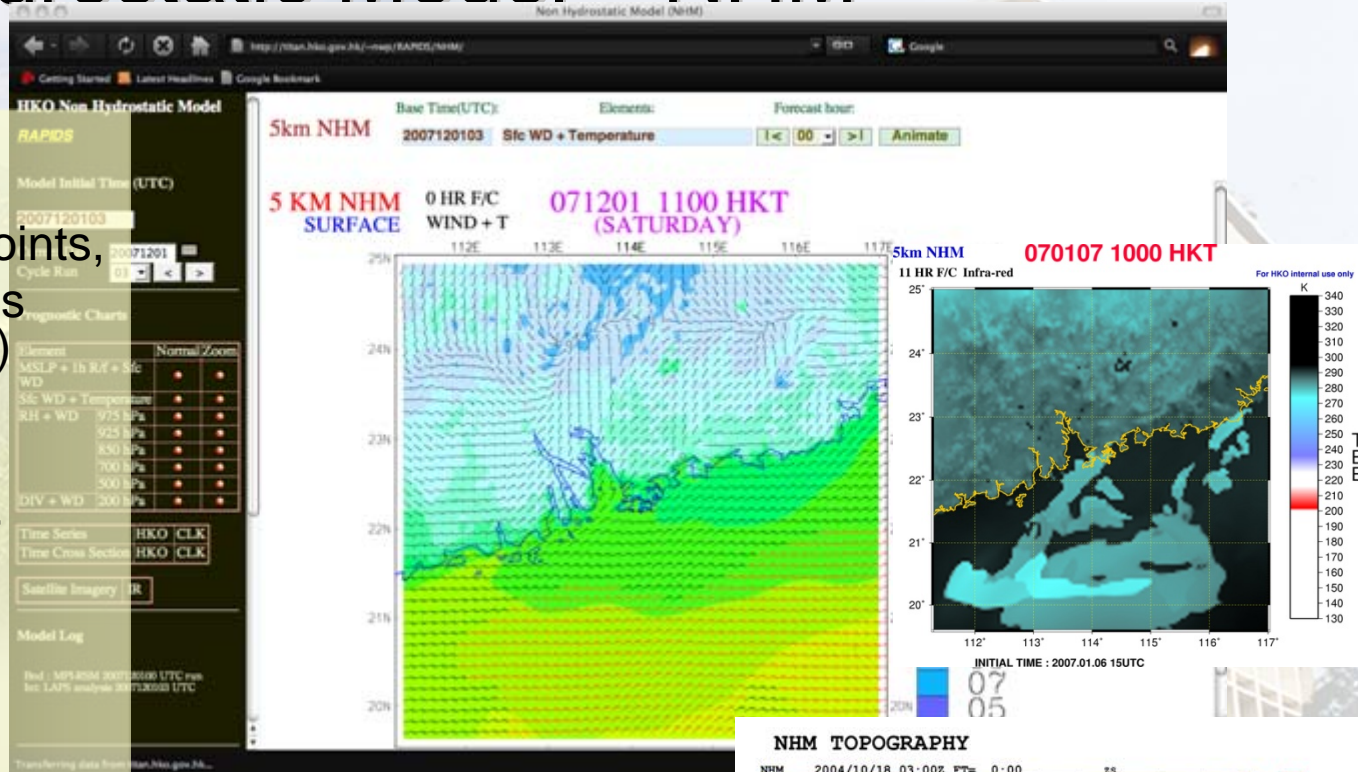
20-km ORSM  
10-35 N, 100-128 E

# Main Applications

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

# 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



# Operation of 5km NHM

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



# RAPIDS – Rainstorm Analysis and Prediction Integrated Data-processing System

- Application of NHM in very short-range precipitation prediction  $\Rightarrow$  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



# RAPIDS

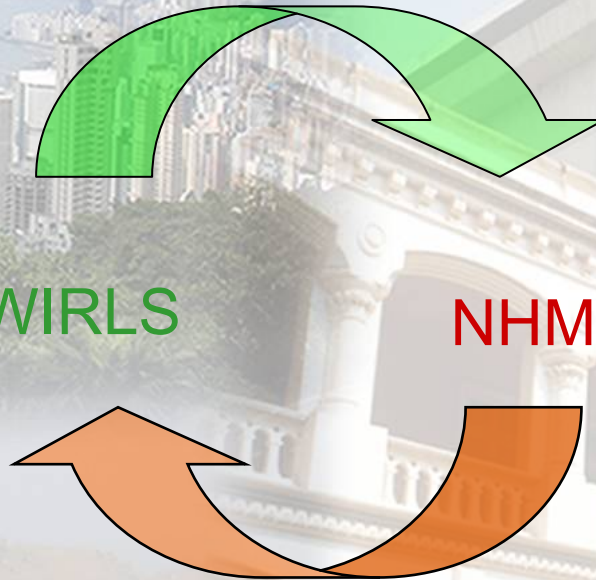
Radar-based nowcasting system; extrapolation effective in advective cases

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)

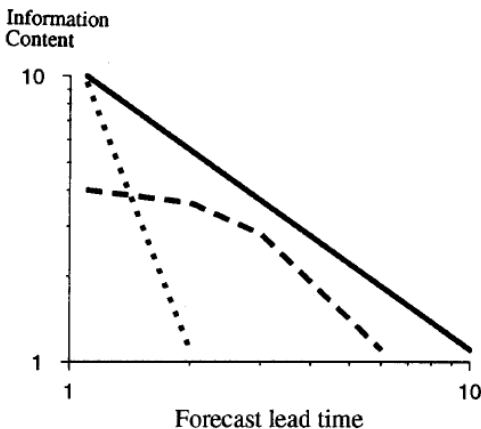
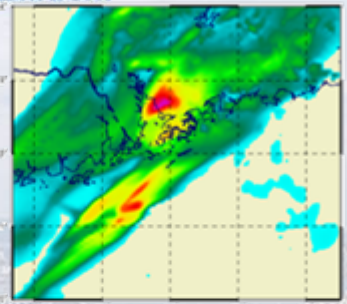
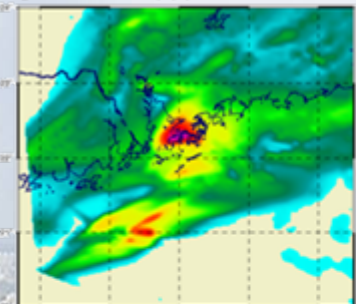


Figure 1. Schematic representation of the loss of information content in forecasts as a function of lead time. The solid line represents the theoretical limit of predictability. The dashed line represents NWP models and the dotted line nowcasting methods.

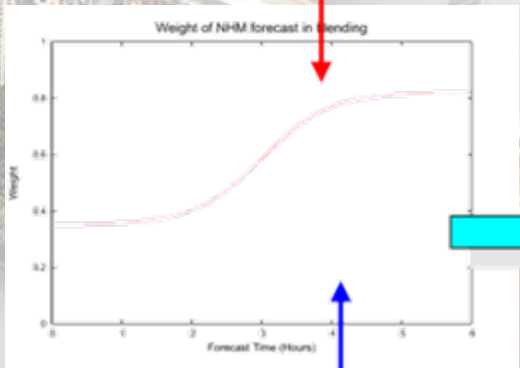
Rainfall forecast using 5 km NHM



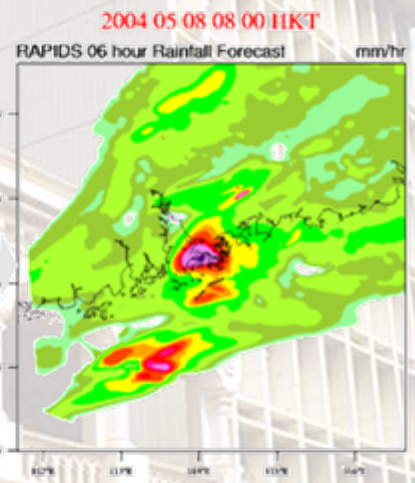
Downscaled to 2-km grid using interpolation



re-located rainfall distribution



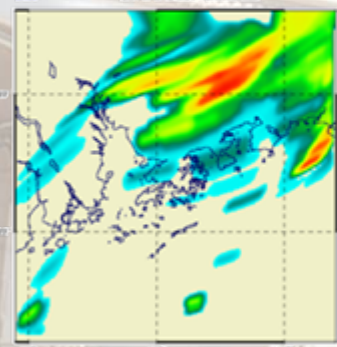
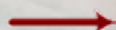
Weight of NHM forecast in blending



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

Data flow of QPF blending in RAPIDS

# SPIDASS - SWIRLS Integrated Warning Panel

SPIDASS - SWIRLS Panel for Integrated Display of Alerts on Severe Storms - Mozilla Firefox 3.5 Beta 4

http://3web01/spidass/swirls2/

## SWIRLS Panel for Integrated Display of Alerts on Severe Storms

Based on SWIRLS-2 for CFO

Real-time alert status auto-updated at: **01:30 AM 20090604**

Your clock: **01:47:14 AM**

Archives (offline)

Usage Note | SWIRLS | RAPIDS | NHM | ALOFT

Forecast System	Valid Date/time	(HKT)	20090604 00	20090604 01	20090604 02
SWIRLS (TREC)	Actual + F/C	200906040130		RRRA GGNNNN	
SWIRLS-2	Actual + F/C	200906040130		AAAA GNNNNN	
RAPIDS	Rainstorm in 1 h	200906040130			N
NHM	Rainstorm in 1 h	2009060322		N	
ORSM (UTC)		2009060312	⚡	⚡	⚡
blue -20km F/C		2009060312	HEAVY ⚡	HEAVY ⚡	HEAVY ⚡
cyan -60km F/C					

Forecast Product	Base Time (HKT)	00	01	02	03
Rainstorm in 1 h	SWIRLS (TREC)	RRRRRAAAGG	NNNNNN		
Rainstorm in 1 h	SWIRLS-2	BBBRAARRAA	GGNNNN		
Actual (accm 1 h)	SWIRLS-2 QPE	AAAAAA			
Rainstorm in 3 h	SWIRLS-2	RRRAGGAAGN	NNNNNN		
Actual (accm 3 h)	SWIRLS-2 QPE				
Rainstorm in 6 h	RAPIDS (hourly QPF)	1111111111	1N333N		
Rainstorm in 6 h	RAPIDS (3 hourly QPF)	333333333N	NNNNNN		
PoP (Green)	RAPIDS (0-i hour QPF)	1111111111	1N		
PoP (Amber)	RAPIDS (0-i hour QPF)	1111111111	NN		
PoP (Red)	RAPIDS (0-i hour QPF)	111113	NN		
PoP (Black)	RAPIDS (0-i hour QPF)	333	NN		
Rainstorm in 12h	NHM	N	N	R	G
Landslip (issue)	SWIRLS-2	NNNNNN	NNNNNN		
NT Flooding	SWIRLS-2	FFNNNN	NNNNNN		
Storm Track	G-Track	⚡⚡⚡⚡	⚡⚡⚡⚡		
Squalls	BLAAST	NNNNNN	NNNNNN		
Lightning	DELITE	3333233333	222222		
Hail	BRINGO	NNNNNN	NNNNNN		

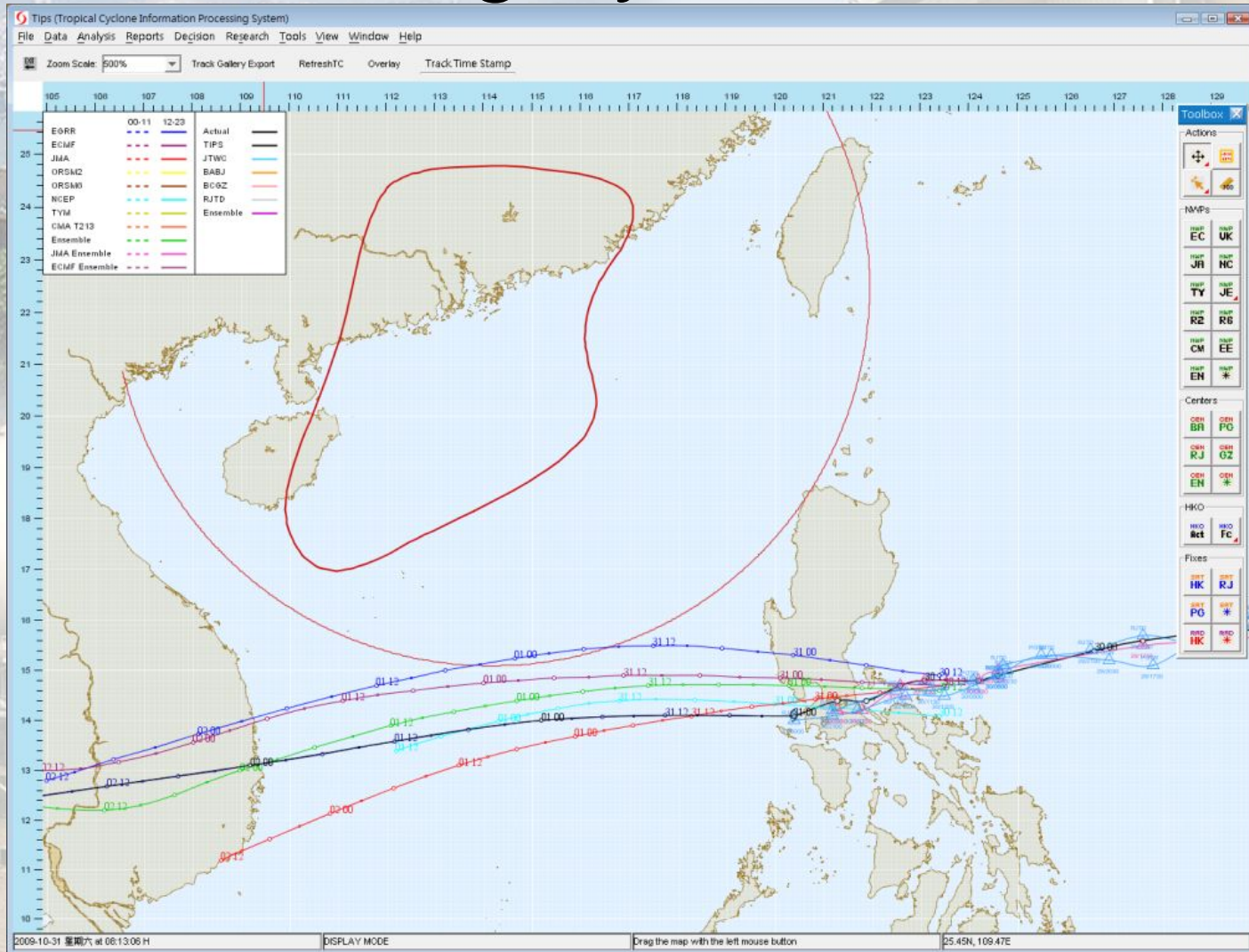
Forecast Product	Base Time (HKT)	System
Rainstorm in 1 h		SWIRLS (TREC)
Rainstorm in 1 h		SWIRLS-2
Actual (accm 1 h)		SWIRLS-2 QPE
Rainstorm in 3 h		SWIRLS-2
Actual (accm 3 h)		SWIRLS-2 QPE
Rainstorm in 6 h		RAPIDS (hourly QPF)
Rainstorm in 6 h		RAPIDS (3 hourly QPF)
PoP (Green)		RAPIDS (0-i hour QPF)
PoP (Amber)		RAPIDS (0-i hour QPF)
PoP (Red)		RAPIDS (0-i hour QPF)
PoP (Black)		RAPIDS (0-i hour QPF)
Rainstorm in 12h		NHM
Landslip (issue)		SWIRLS-2
NT Flooding		SWIRLS-2
Storm Track		G-Track
Squalls		BLAAST
Lightning		DELITE
Hail		BRINGO

**Legend** (Note: The following alerts apply to the Hong Kong domain only. Click on the status icons above to see the affected locations.)

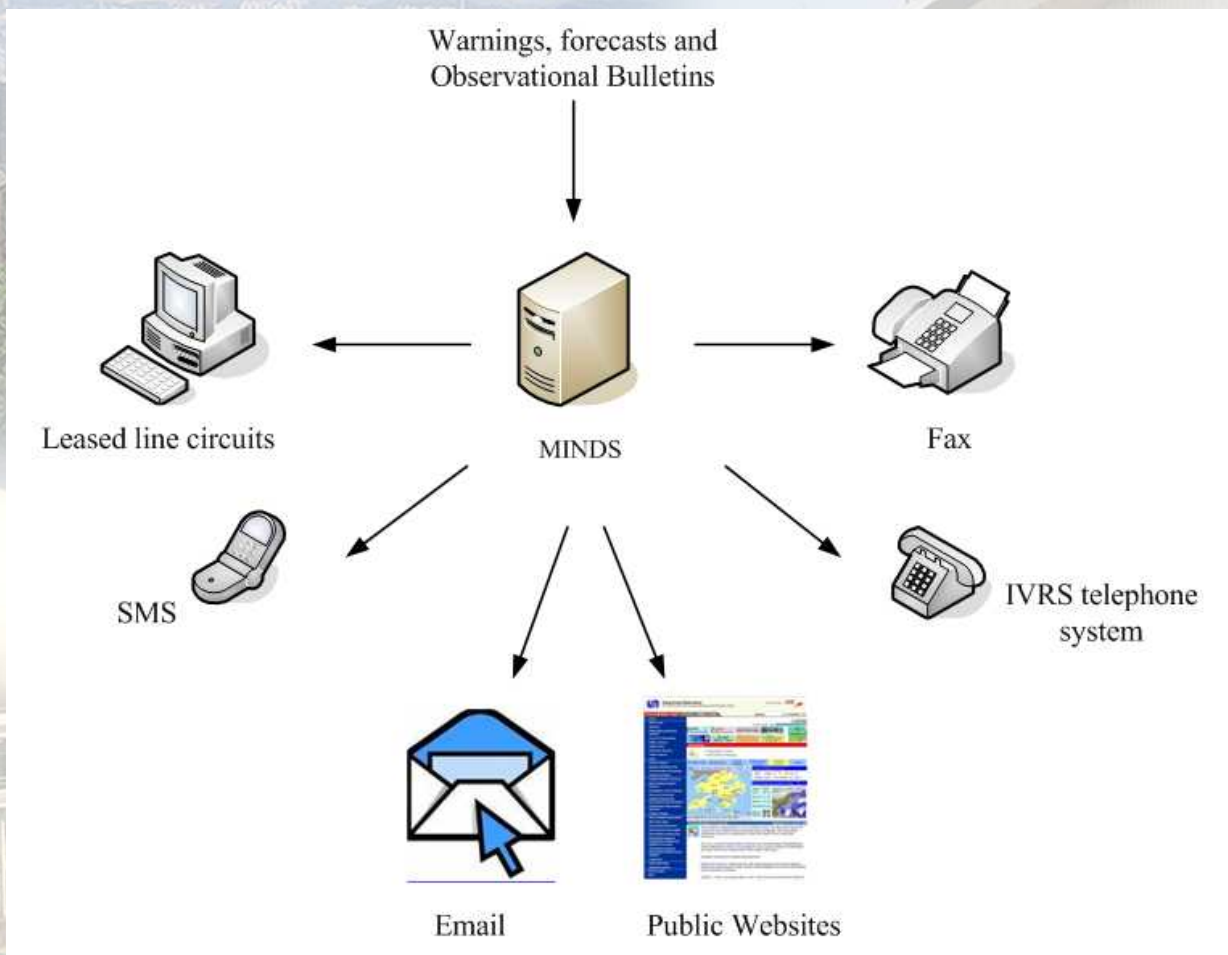
- G** rainfall ≥ 20 mm in 1 hour or 40 mm in 3 hours
- A** rainfall ≥ 30 mm in 1 hour or 60 mm in 3 hours
- R** rainfall ≥ 50 mm in 1 hour or 85 mm in 3 hours
- B** rainfall ≥ 70 mm in 1 hour or 120 mm in 3 hours
- N** No severe weather
- X** not available due to system/data problem
- F** Flooding threat in northern NT
- L** Landslip threat
- j** medium chance (≥ 40%) of severe weather in *j* hours
- h** high chance (≥ 70%) of severe weather in *j* hours
- where i = 1, 2, 3, 4, 5, 6**
- where j = 1, 3, 6**
- G** Severe squalls threat (gale force)
- S** Severe squalls threat (storm force)
- h** Severe squalls threat (hurricane force)
- ⚡** Lightning initiation threat (severity I, i.e. CG strikes less than 10 in 6 min)
- ⚡** Lightning initiation threat severity II, i.e. CG strikes between 10 and 100 in 6 min)
- ⚡** Lightning initiation threat (severity III, i.e. CG strikes more than 100 in 6 min)
- ⚡** Thunderstorm threat (reflectivity ≥ 34 dBZ)

product names & underlying algorithms

# Tropical Cyclone Information Processing System - TIPS



# Meteorological Information Dissemination System - MINDS

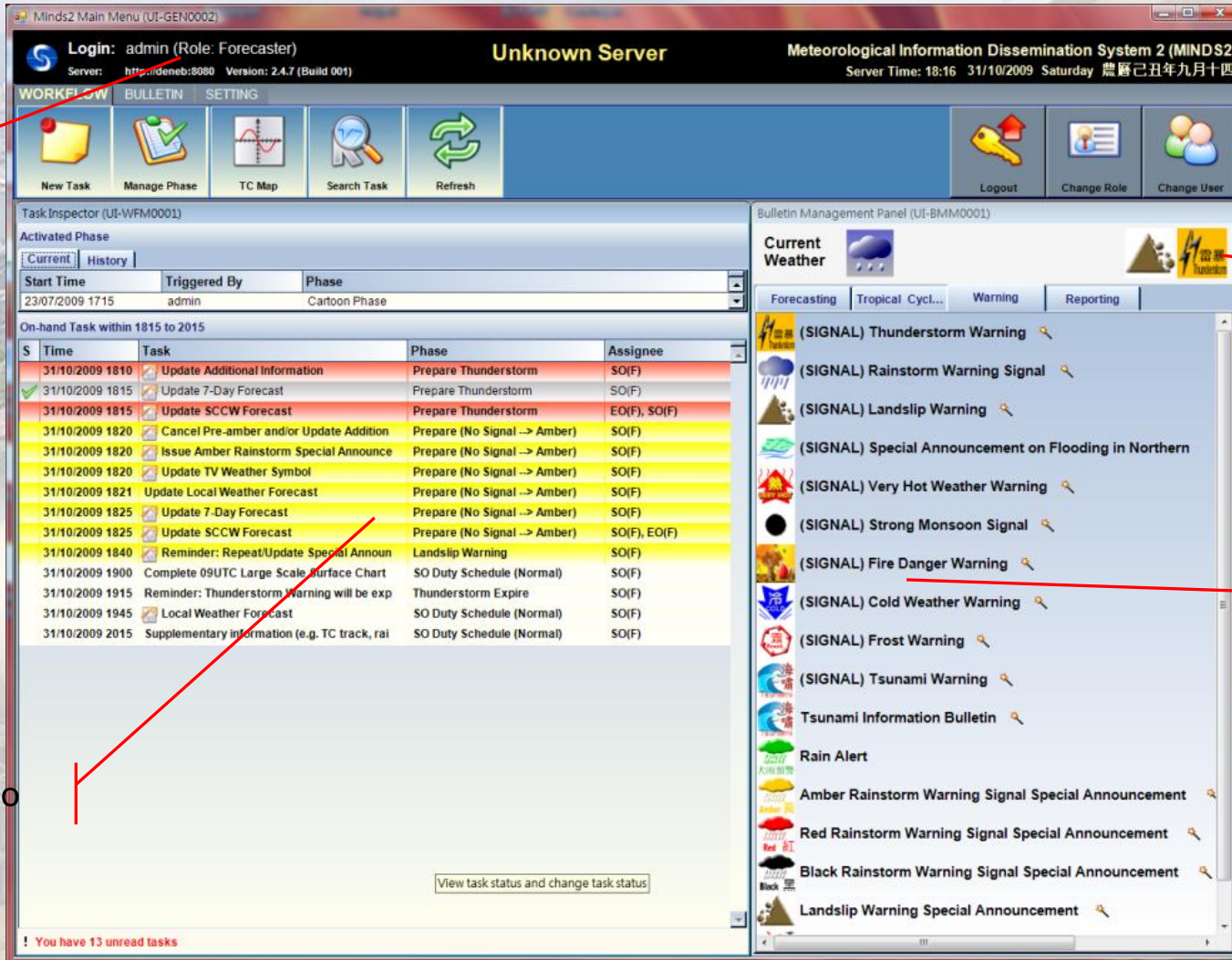


# Main Features of MINDS

- 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.

# MINDS User Interface

Roles



Login: admin (Role: Forecaster)      Unknown Server      Meteorological Information Dissemination System 2 (MINDS2)  
 Server: https://deneb:8080      Version: 2.4.7 (Build 001)      Server Time: 18:16 31/10/2009 Saturday 農曆己丑年九月十四

**WORKFLOW**    **BULLETIN**    **SETTING**

New Task    Manage Phase    TC Map    Search Task    Refresh    Logout    Change Role    Change User

**Task Inspector (UI-WFM0001)**  
 Activated Phase: [Current] | [History]  
 Start Time: 23/07/2009 17:15    Triggered By: admin    Phase: Cartoon Phase

**On-hand Task within 1815 to 2015**

S	Time	Task	Phase	Assignee
	31/10/2009 1810	Update Additional Information	Prepare Thunderstorm	SO(F)
✓	31/10/2009 1815	Update 7-Day Forecast	Prepare Thunderstorm	SO(F)
	31/10/2009 1815	Update SCCW Forecast	Prepare Thunderstorm	EO(F), SO(F)
	31/10/2009 1820	Cancel Pre-amber and/or Update Addition	Prepare (No Signal -> Amber)	SO(F)
	31/10/2009 1820	Issue Amber Rainstorm Special Announcement	Prepare (No Signal -> Amber)	SO(F)
	31/10/2009 1820	Update TV Weather Symbol	Prepare (No Signal -> Amber)	SO(F)
	31/10/2009 1821	Update Local Weather Forecast	Prepare (No Signal -> Amber)	SO(F)
	31/10/2009 1825	Update 7-Day Forecast	Prepare (No Signal -> Amber)	SO(F)
	31/10/2009 1825	Update SCCW Forecast	Prepare (No Signal -> Amber)	SO(F), EO(F)
	31/10/2009 1840	Reminder: Repeat/Update Special Announ	Landslip Warning	SO(F)
	31/10/2009 1900	Complete 09UTC Large Scale Surface Chart	SO Duty Schedule (Normal)	SO(F)
	31/10/2009 1915	Reminder: Thunderstorm Warning will be exp	Thunderstorm Expire	SO(F)
	31/10/2009 1945	Local Weather Forecast	SO Duty Schedule (Normal)	SO(F)
	31/10/2009 2015	Supplementary information (e.g. TC track, rai	SO Duty Schedule (Normal)	SO(F)

View task status and change task status

! You have 13 unread tasks

**Bulletin Management Panel (UI-BMM0001)**  
 Current Weather: [Thunderstorm]

Forecasting    Tropical Cycl...    Warning    Reporting

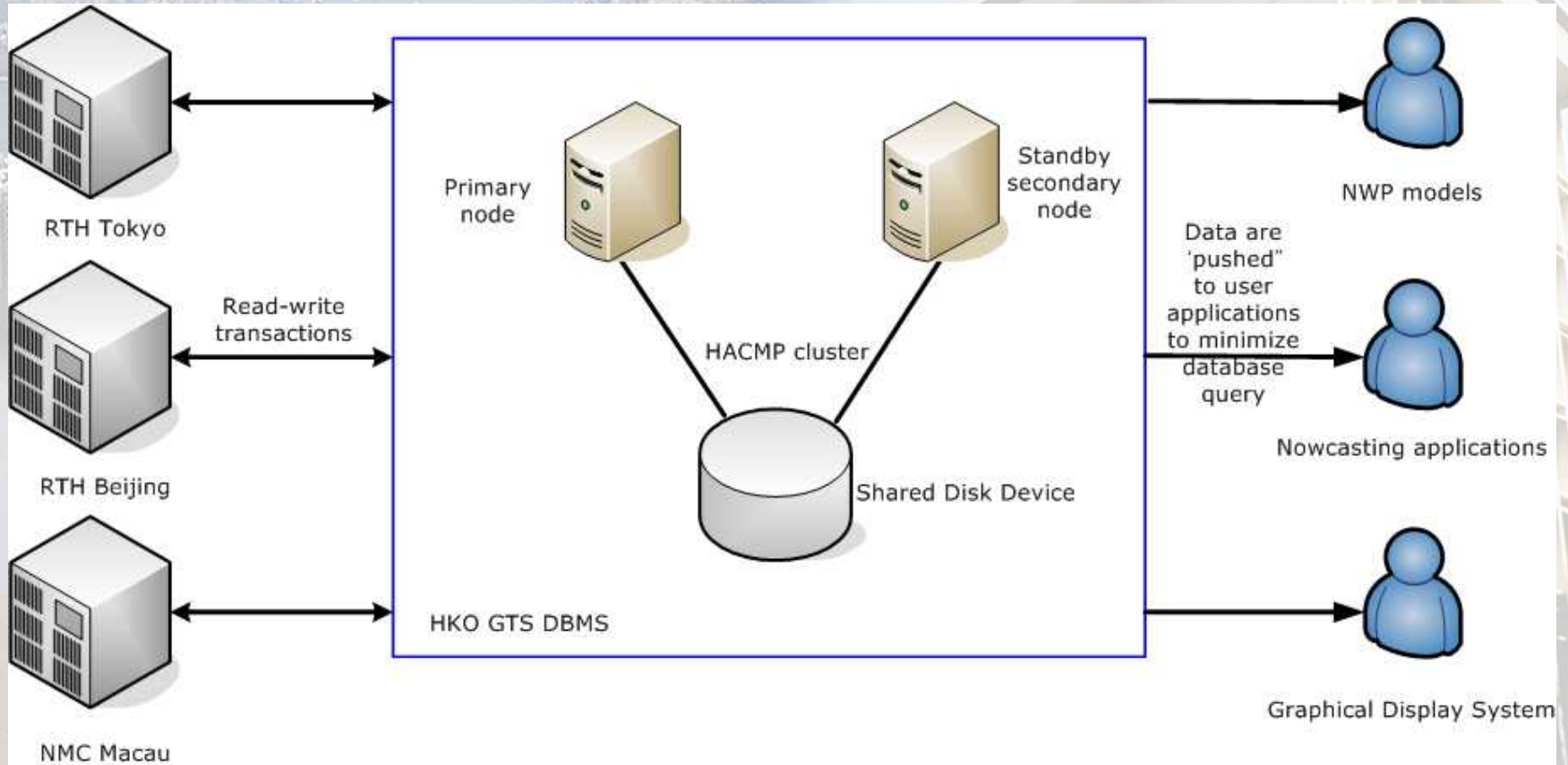
- (SIGNAL) Thunderstorm Warning
- (SIGNAL) Rainstorm Warning Signal
- (SIGNAL) Landslip Warning
- (SIGNAL) Special Announcement on Flooding in Northern
- (SIGNAL) Very Hot Weather Warning
- (SIGNAL) Strong Monsoon Signal
- (SIGNAL) Fire Danger Warning
- (SIGNAL) Cold Weather Warning
- (SIGNAL) Frost Warning
- (SIGNAL) Tsunami Warning
- Tsunami Information Bulletin
- Rain Alert
- Amber Rainstorm Warning Signal Special Announcement
- Red Rainstorm Warning Signal Special Announcement
- Black Rainstorm Warning Signal Special Announcement
- Landslip Warning Special Announcement

Warnings in force

Warning bulletin preparation wizards

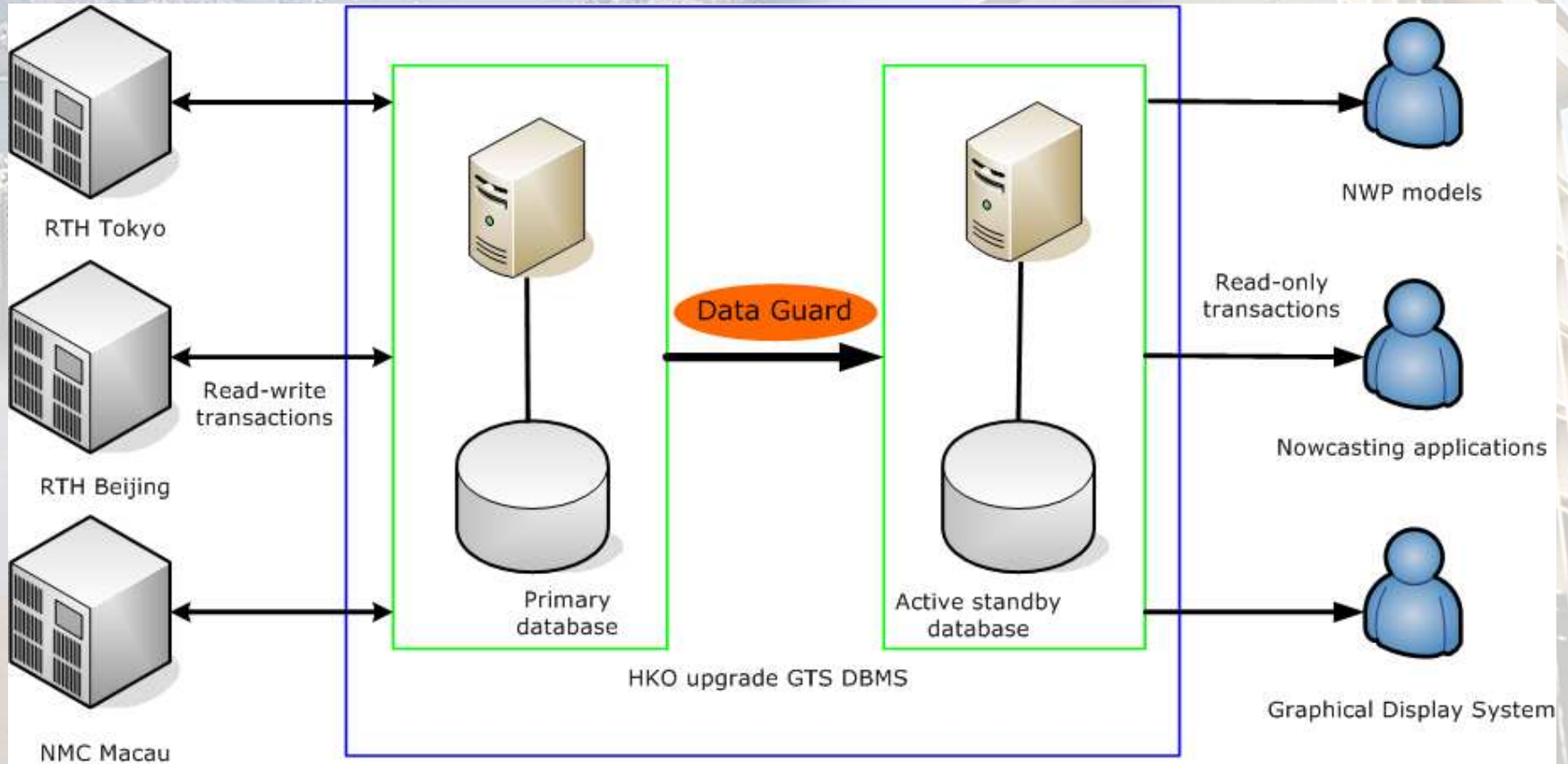
Tasks-to-do

# HKO GTS DBMS

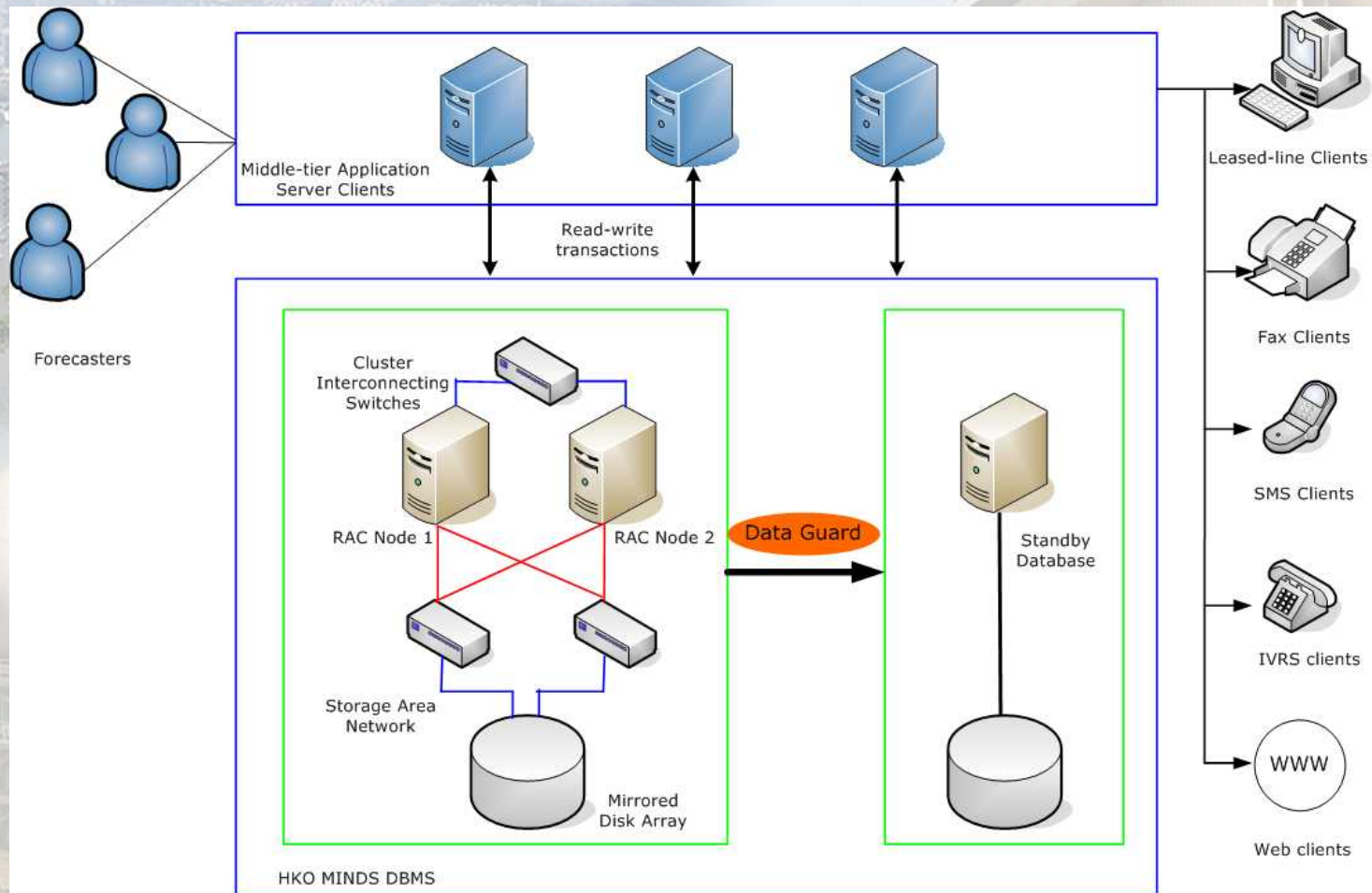




# Upgrade GTS DBMS



# HKO MINDS DBMS



# 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

Thank you

