高解析區域模式預報系統之發展

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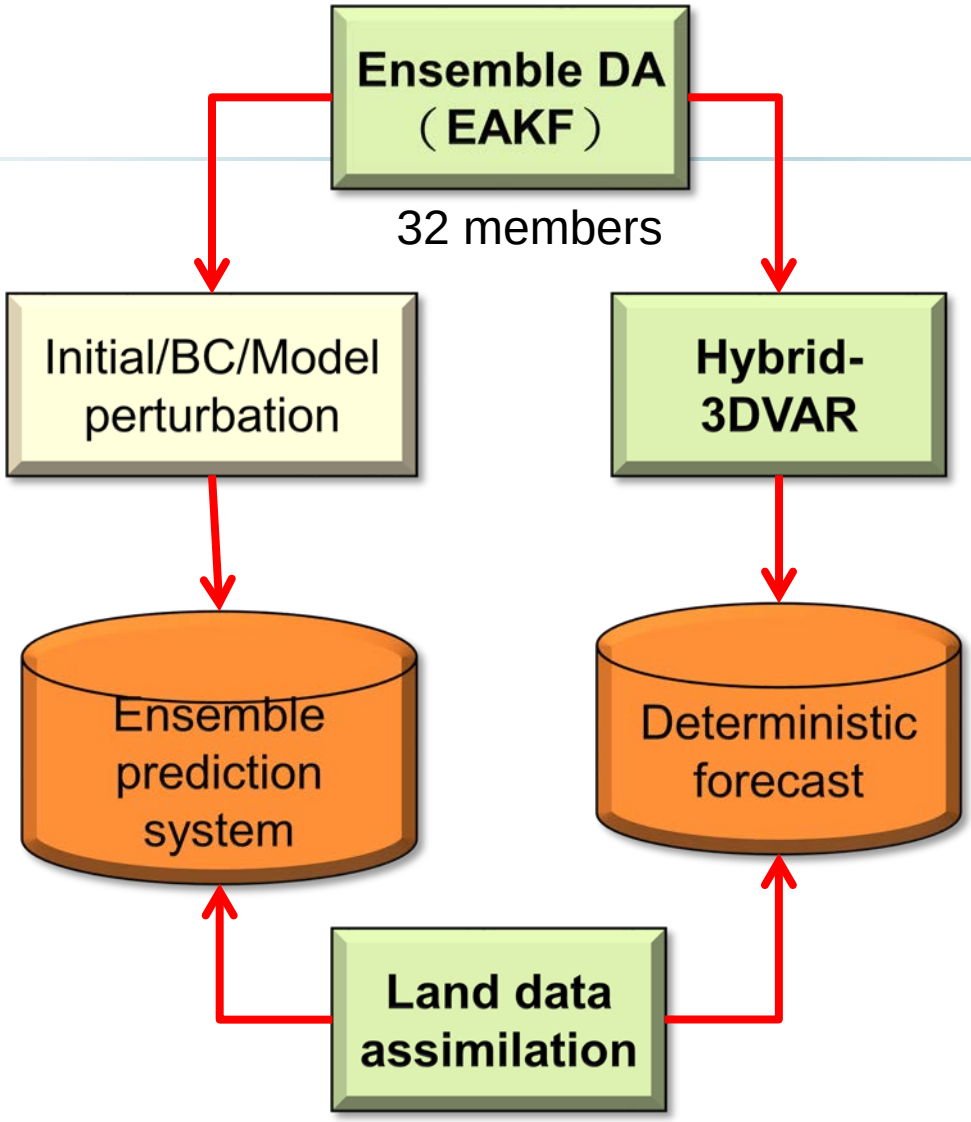
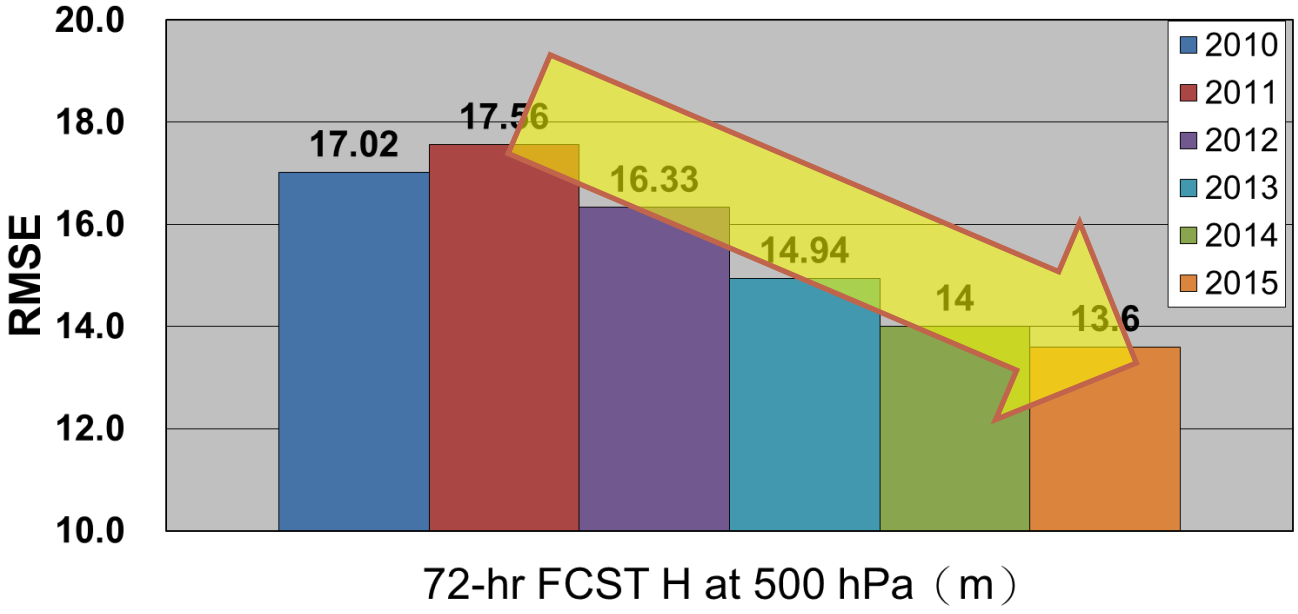
NCAR

WRF-Based Forecast System

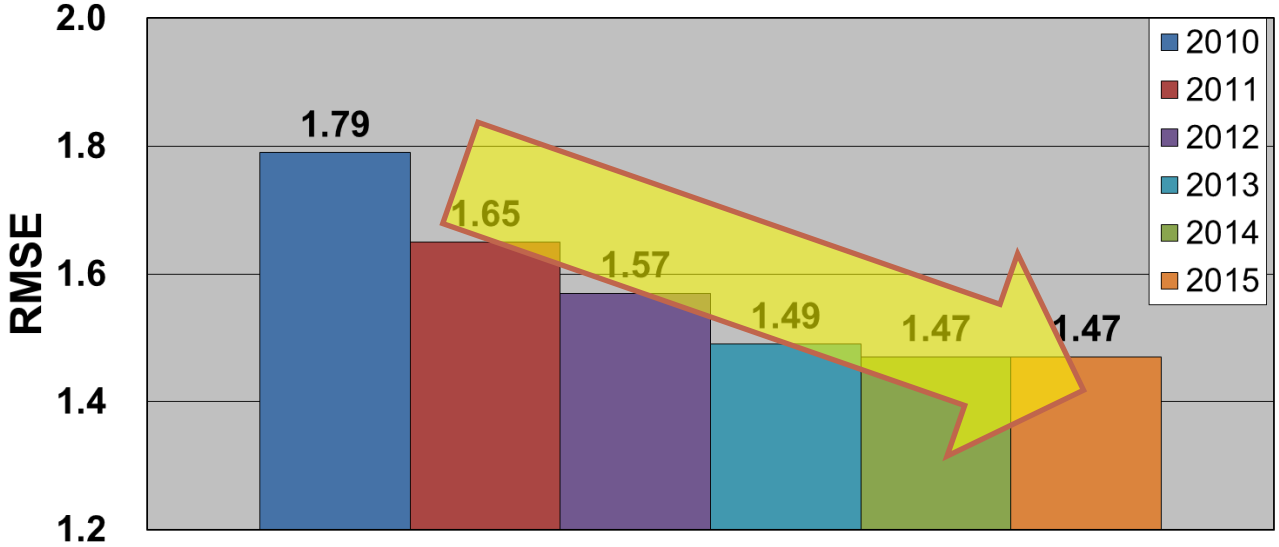
- An ARW-WRF based system, was implemented at CWB in **2004** and went through comprehensive evaluations.
- CWB-NCAR Collaborative Project was initiated in **2005**
- CWB WRF was operational as the 3rd generation regional forecast system since Nov **2007**

- **Deterministic forecast, 4 times per day**
  - **WRF M00** (45/15/5-km resolution)
  - **WRF M04** (**15/3-km resolution in 2016**)
- **Ensemble prediction system , 4 times per day**
  - 20 members (45/15/5-km resolution, **15/3-km resolution in 2017**)
- **Radar DA system (2-km resolution in 2016)**


Ensemble DA
（EAKF）
32 members
Initial/BC/Model perturbation
Hybrid-3DVAR
Ensemble prediction system
Deterministic forecast
Land data assimilation

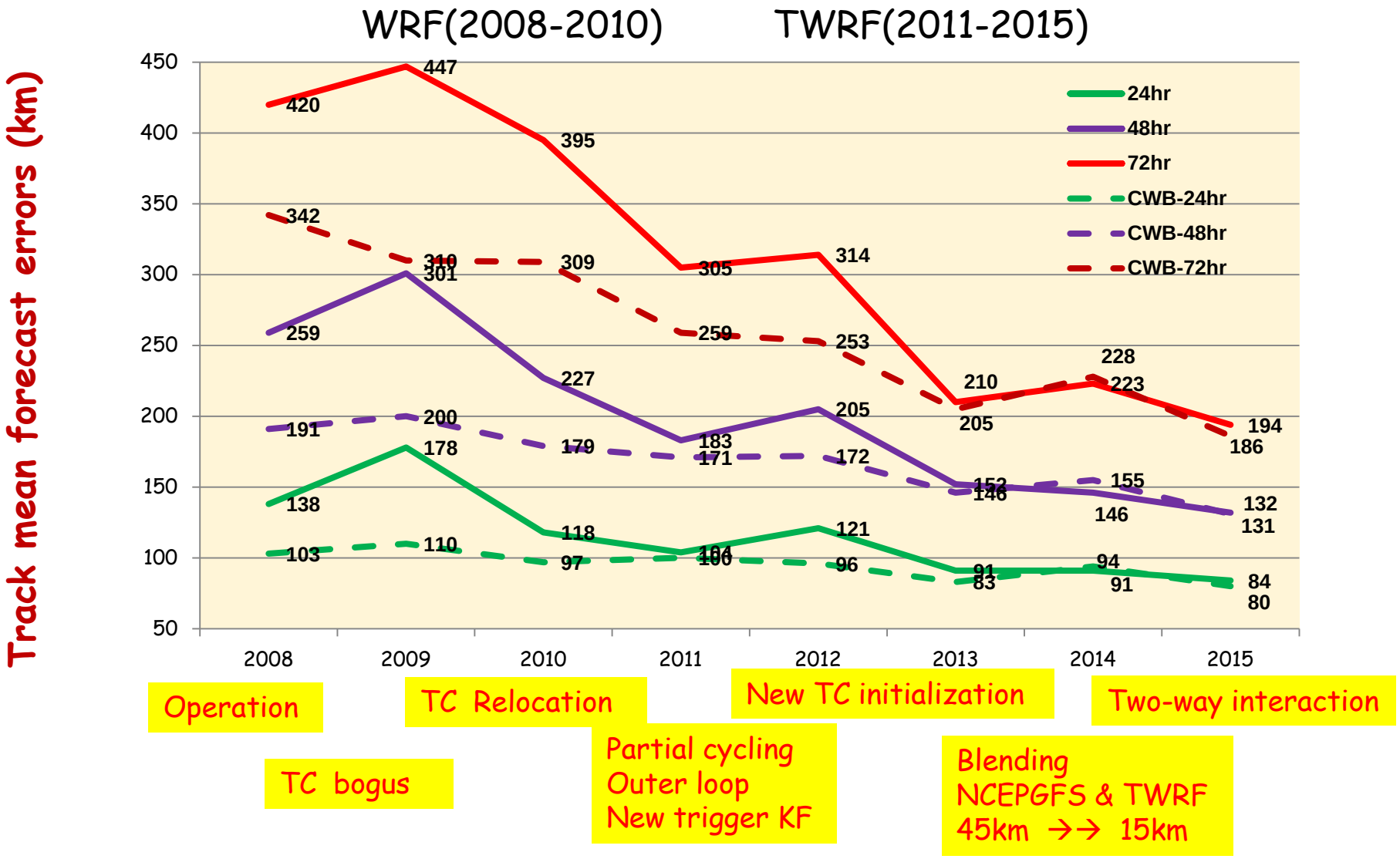


72-hr FCST H at 500 hPa（m）



72-hr FCST T at 850 hPa（˚C）

Comparison between TWRF & CWB for the TC Track Forecast Errors



Contributions to the forecast improvement

Model Physics improvement

- From GD to K-F CuP
- Migrate to RRTMG Rad scheme
- Tuning of the GWDO scheme
- Modify the trigger function in K-FCuP
- Modify the surface roughness
- Develop the MODIS based vegetation fraction
- Update the land-use table and the soil texture
- …

Adopt from the community
Collaboration with NCAR
In-house development

Initialization process

- Digital Filter initialization
- Two-way nested
- Modify the calculation of the geopotential height
- Develop the blending scheme
- Develop the typhoon bogus and re-location scheme
- Improve the vertical interpolation scheme
- …

Bug fix

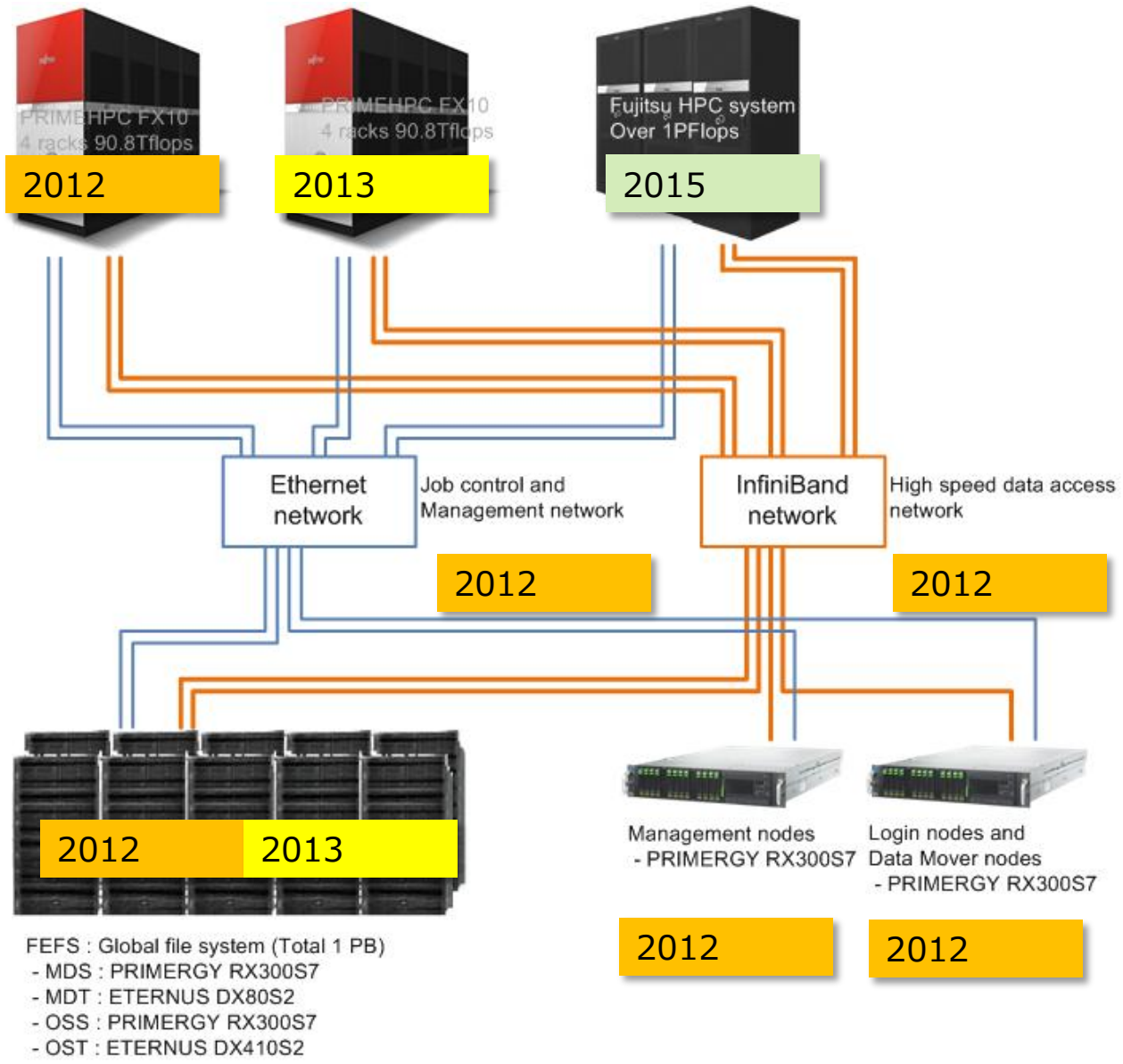
- Many bugs in WRFDA
- Mis-match of the global SST

Some of the improvement has been feedback to the community

Data assimilation

- The Hybrid ensemble-variational scheme
- Ensemble adjustment Kalman filter
- High Resolution Land Data Assimilation System
- Assimilation of the COSMIC and ground base ZTD observation
- Develop the outer loop process in 3DVAR
- Re-center the EAKF using the blending scheme
- Fine tune the background error covariance and the use of the observation
- Design the partial cycle strategy
- …

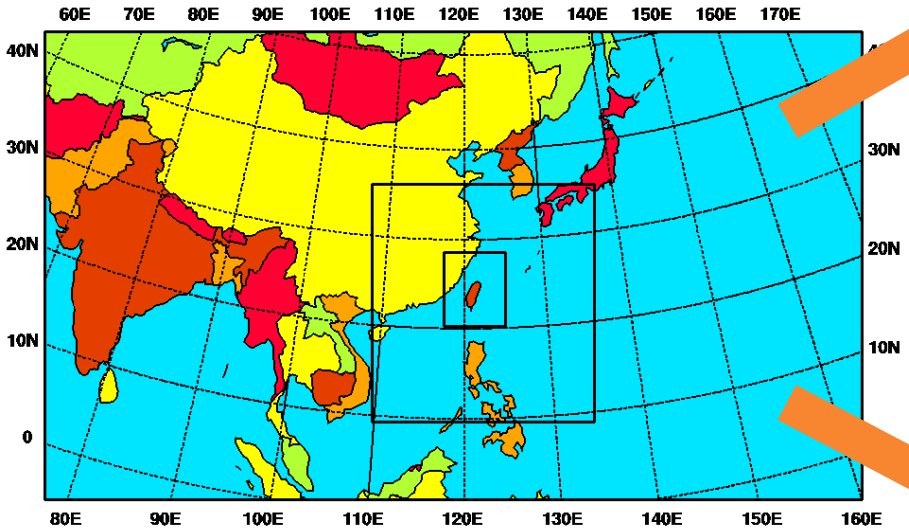
5th Generation HPC system for 2015



PEAK: 1.4 PFlops
Storage: 1.2 PByte

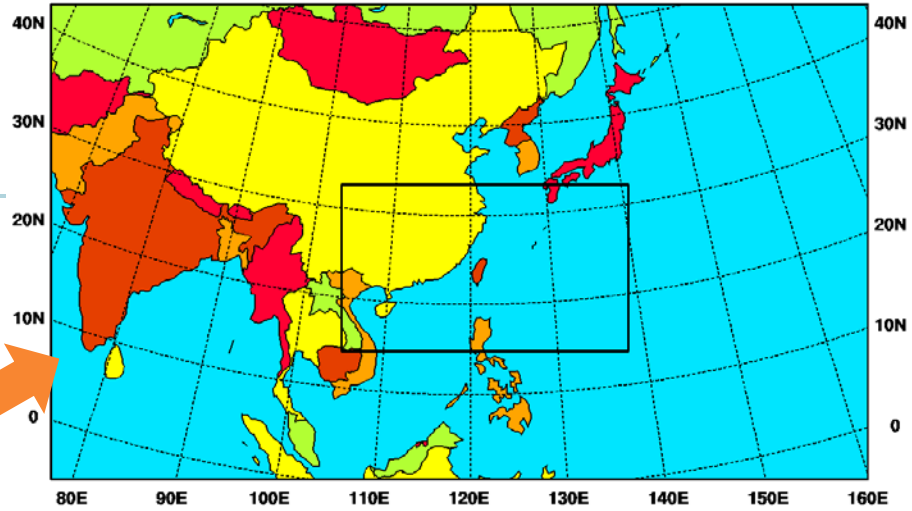
Machine Name	PRIMEHPC FX10 / FX100
Cores	>46,000
Peak Performance	1.4 PF
Rmax	1.2 PF
Storage size	1.221 PB

Migration of the model resolution



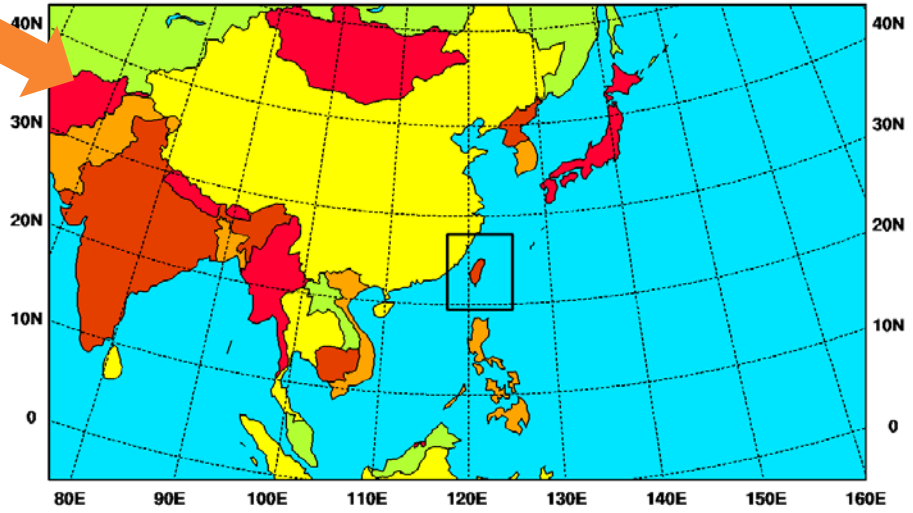
45-/15-/5-km grids system
45-levels to 30 hPa
For deterministic and ensemble run

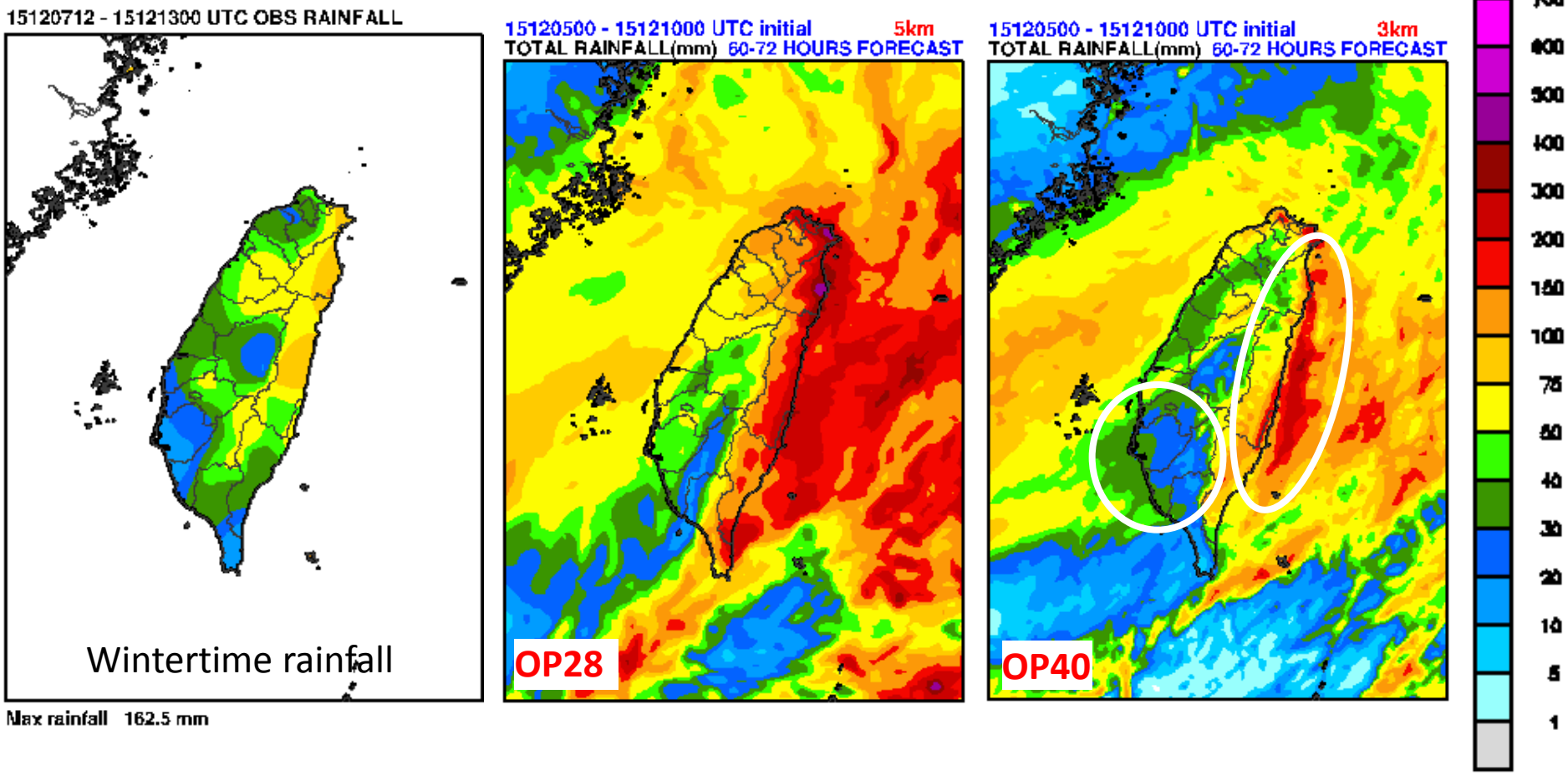
Deterministic system in 2016



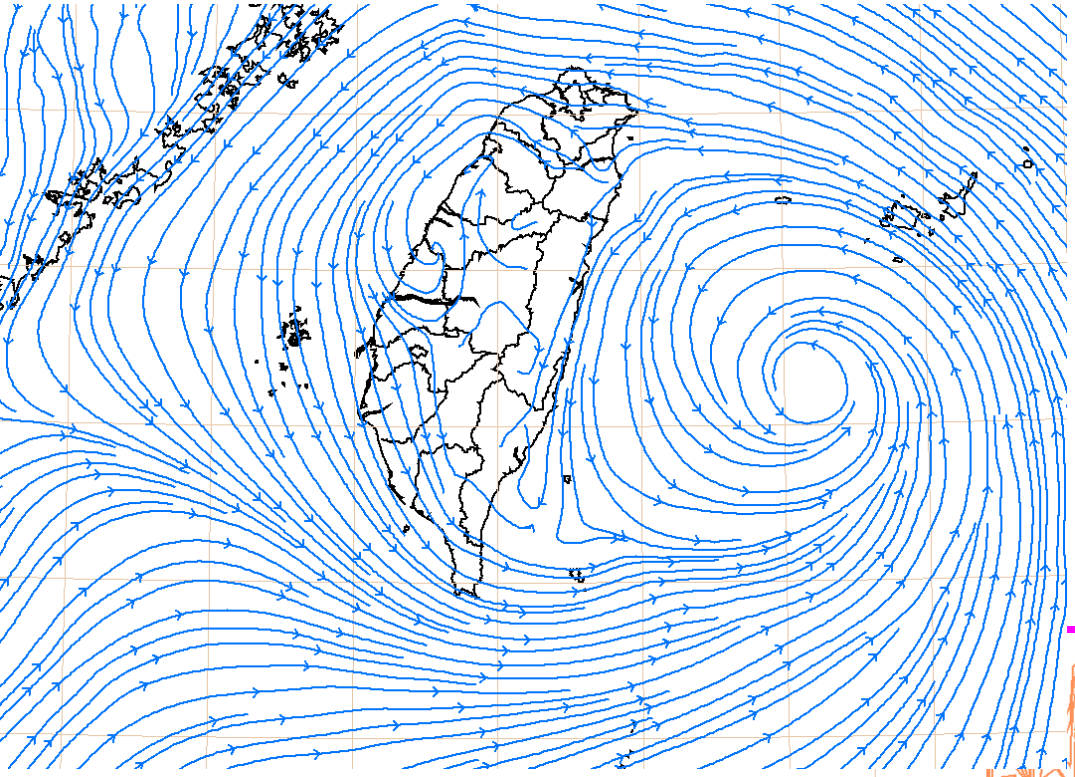
15-/3-km grids system
52-levels to 20 hPa

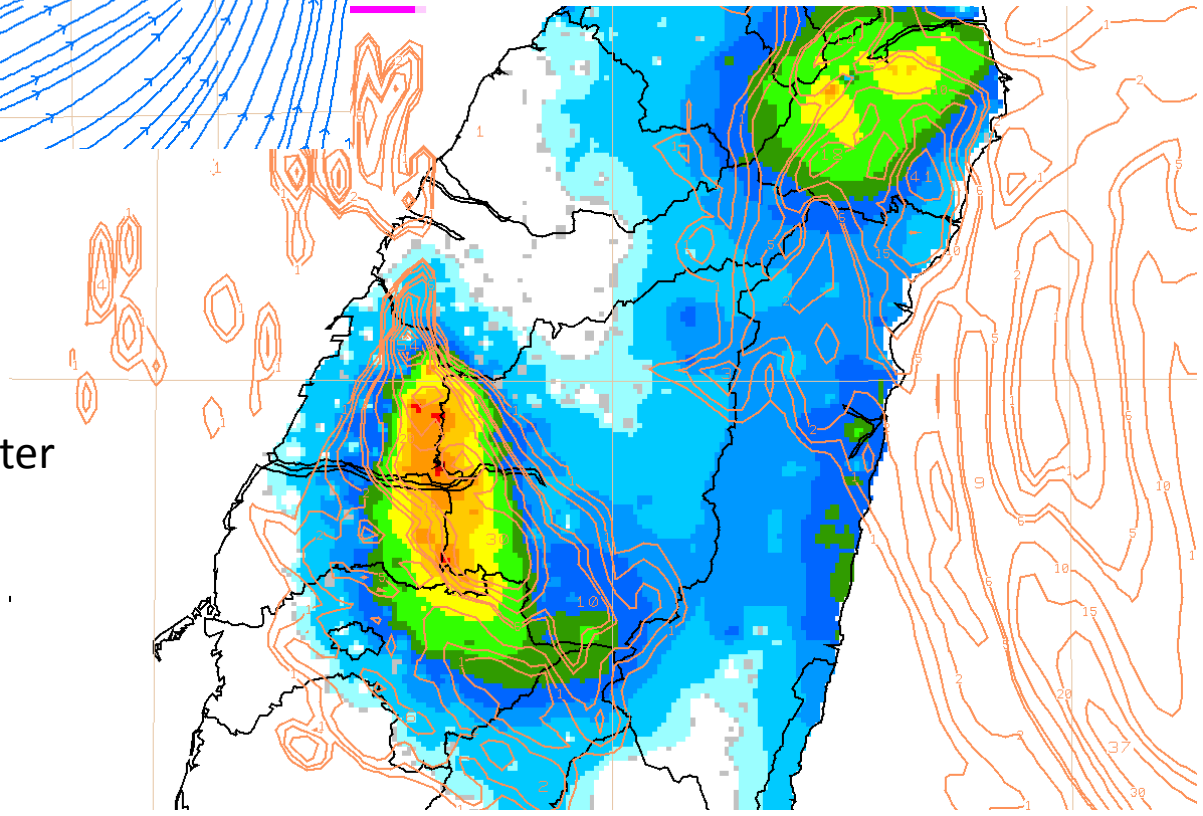
Ensemble system in 2017



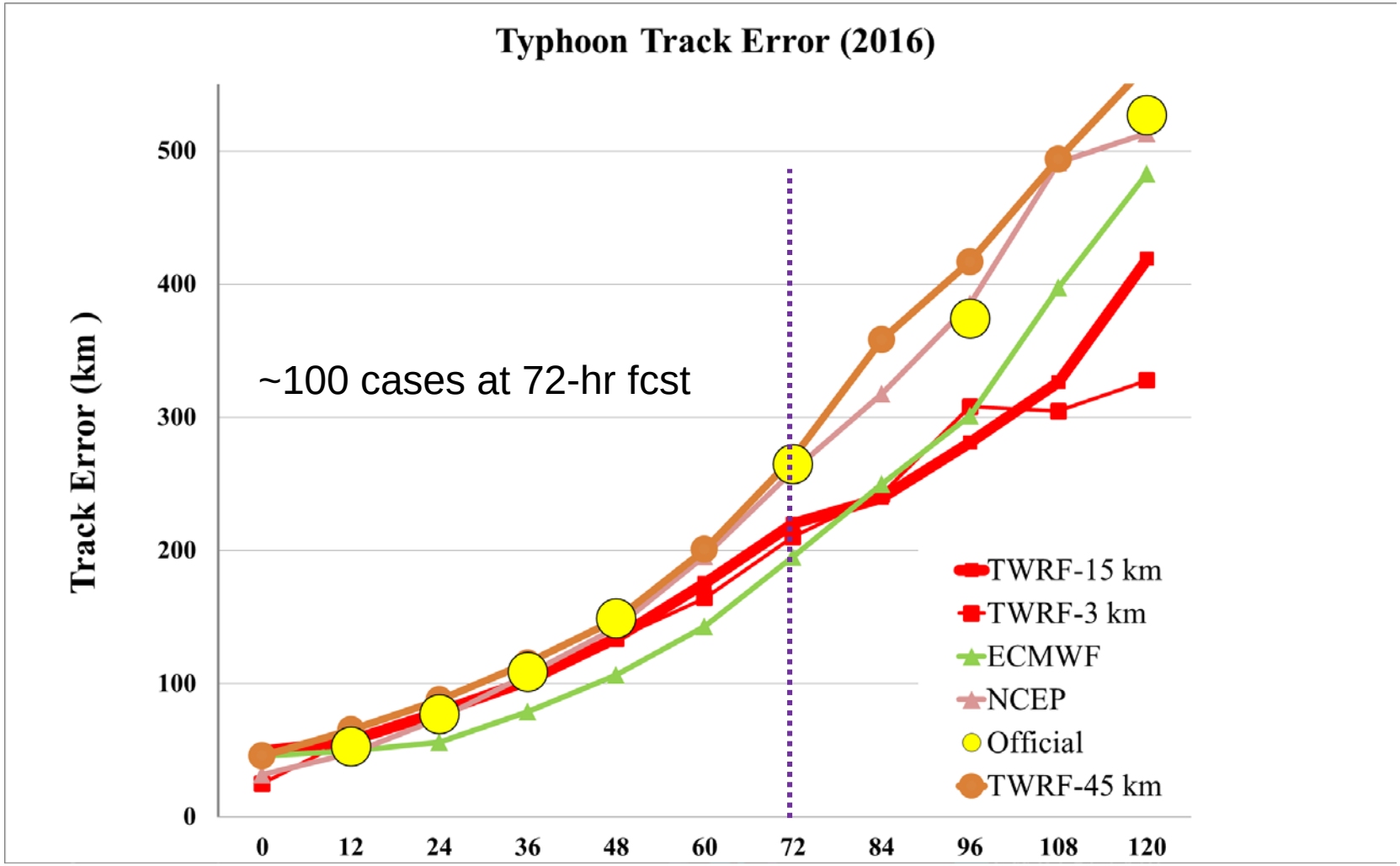


Higher resolution, higher better terrain rainfall prediction



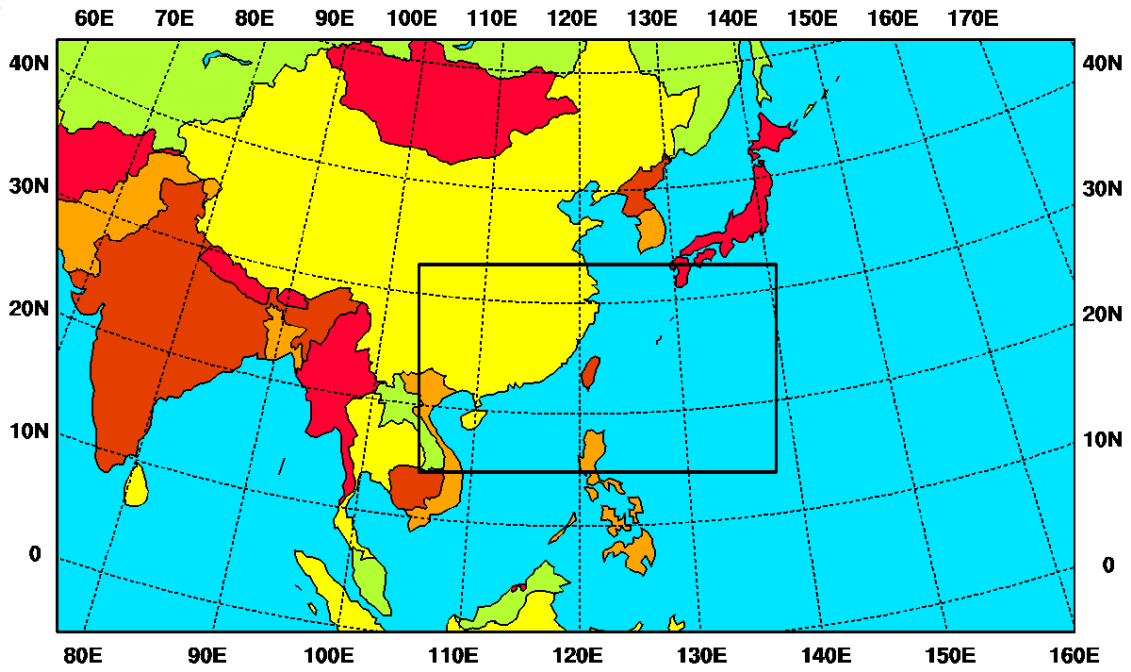


Impact of Taiwan terrain on the outer circulation of Ty Malakas (2016) produced the lee-vortex and the distant rainfall system



- Why is the 15-km TWRF prediction better than the NCEP GFS and 45-km TWRF?
- What will happen if WRF initialized from the ECMWF analysis?

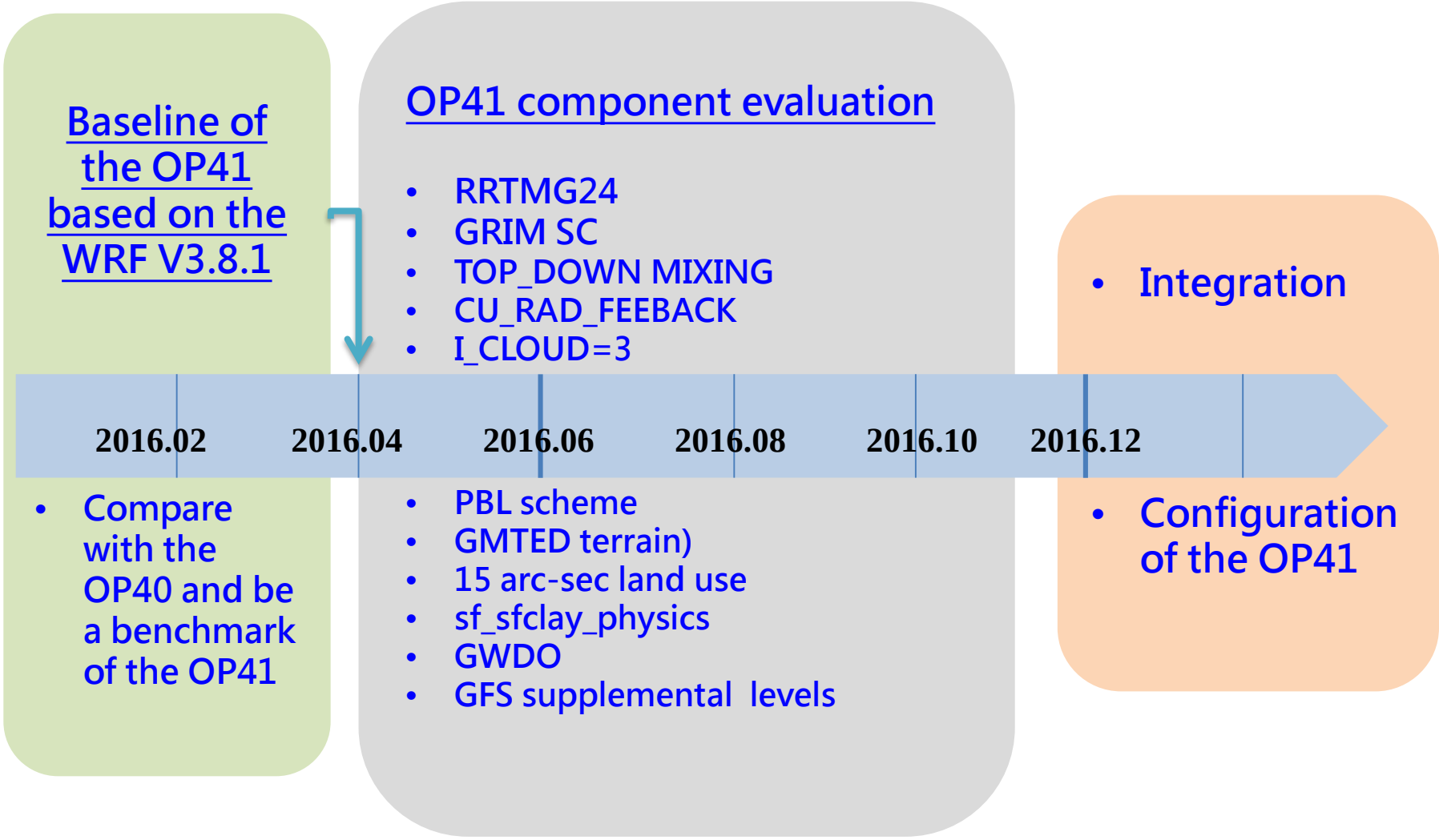
Migration of the WRF model
From OP40 (V3.3.1) to OP41 (V3.8.1)



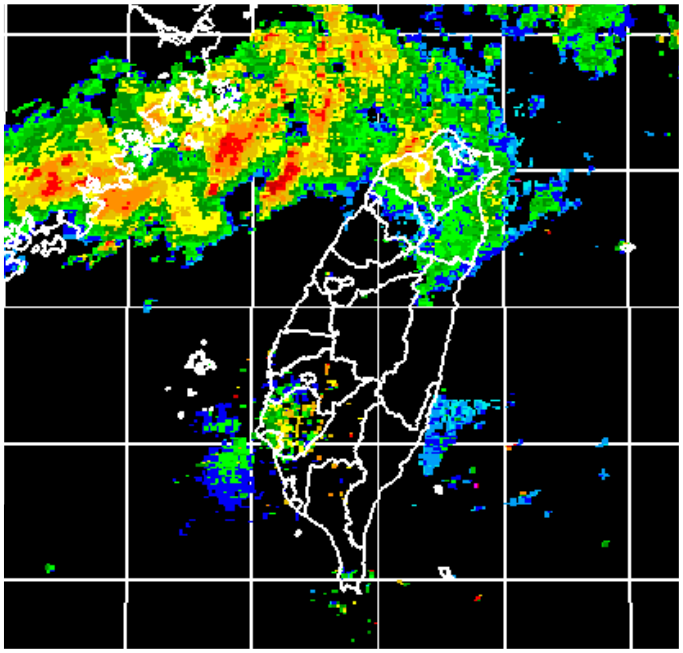
- 3DVAR → Hybrid 3DVAR
- 15-km EAKF
- 3-KM HRLDAS over Taiwan
- Update several model physics
- Update the model static database

- **15-3 km WEPS**

From OP4.0 (V3.3.1) to OP4.1 (V3.8.1)

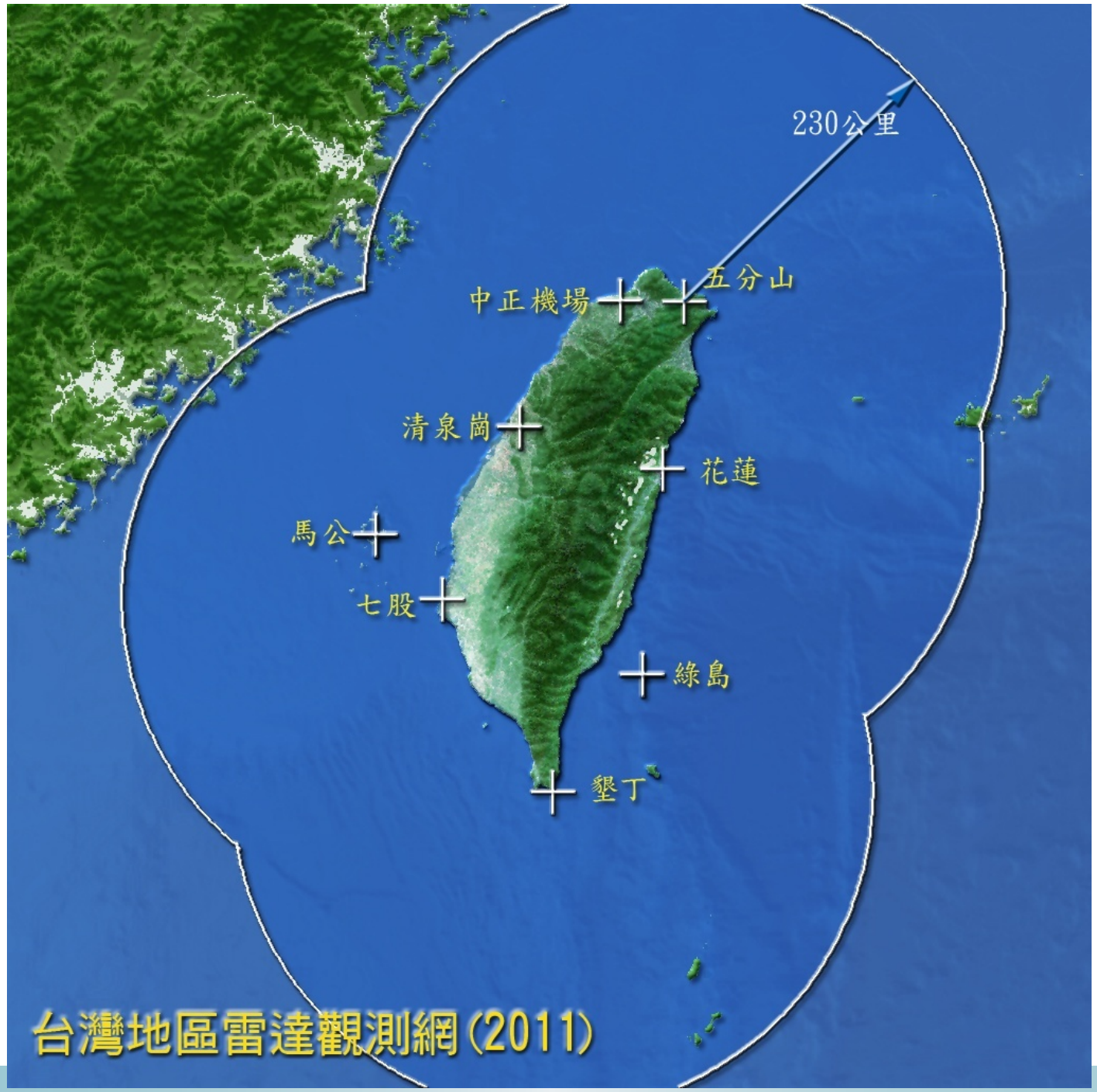


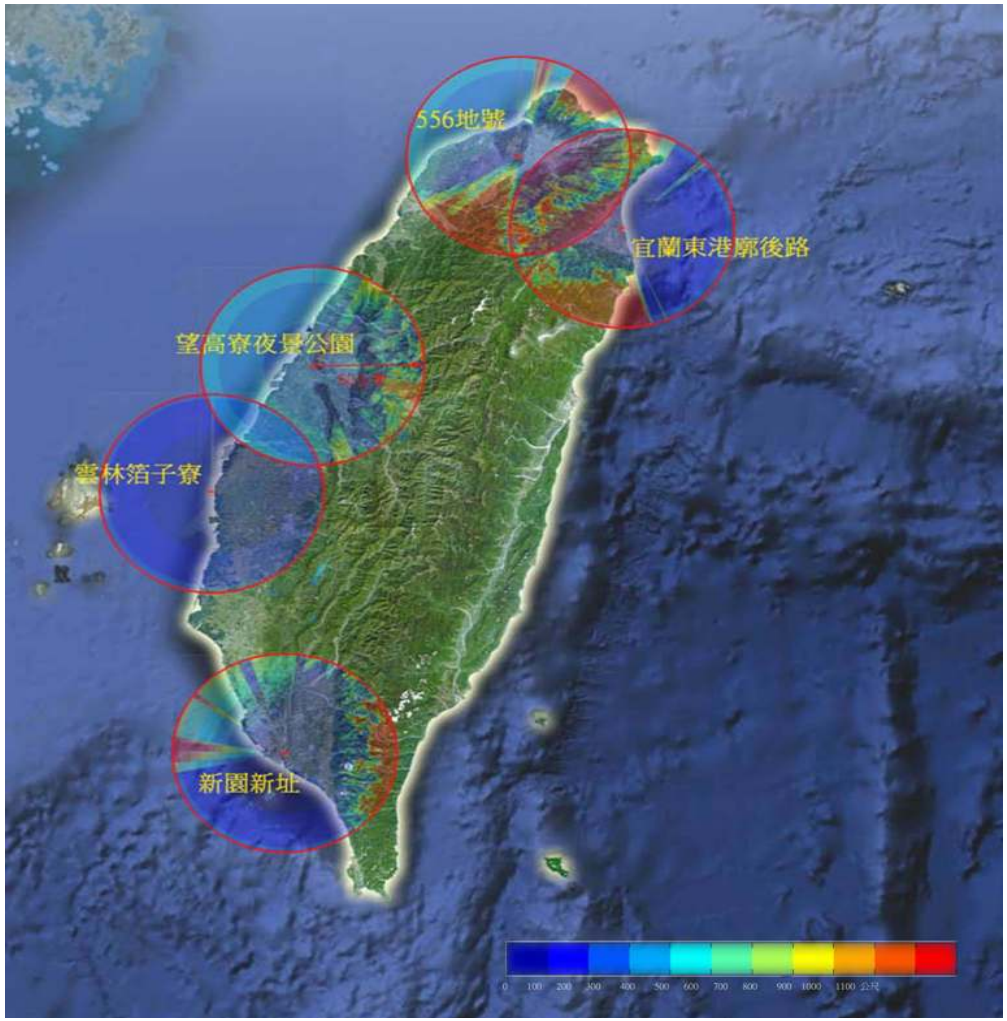
The next mile of the regional NWP



- To meet the strong requirements **for the short-duration (e.g., 1~3 hour) extreme rainfalls (>100 mm)**

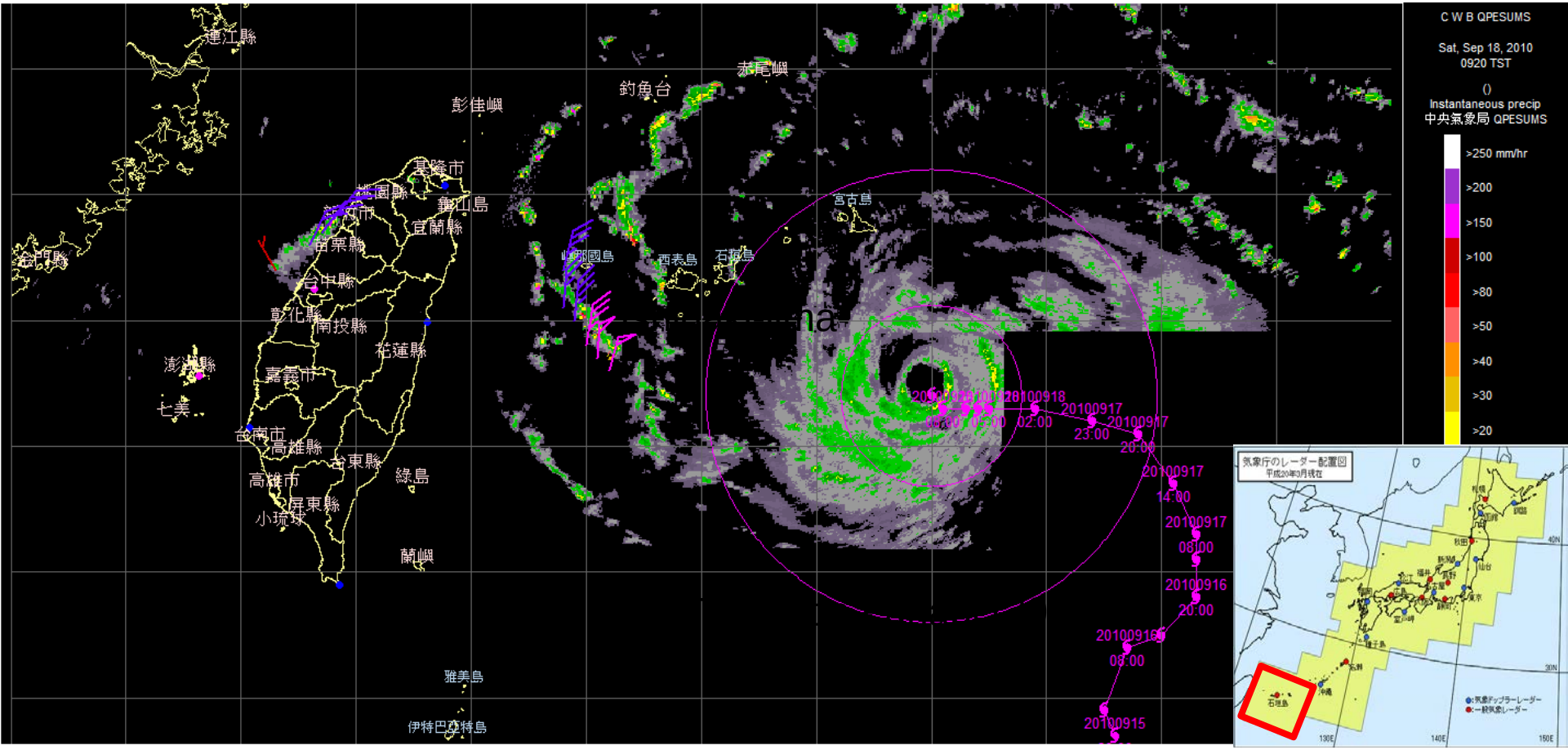
Opportunities of the meso-scale observation systems over Taiwan Island


230公里
中正機場
五分山
清泉崗
花蓮
馬公
七股
綠島
墾丁
台灣地區雷達觀測網(2011)

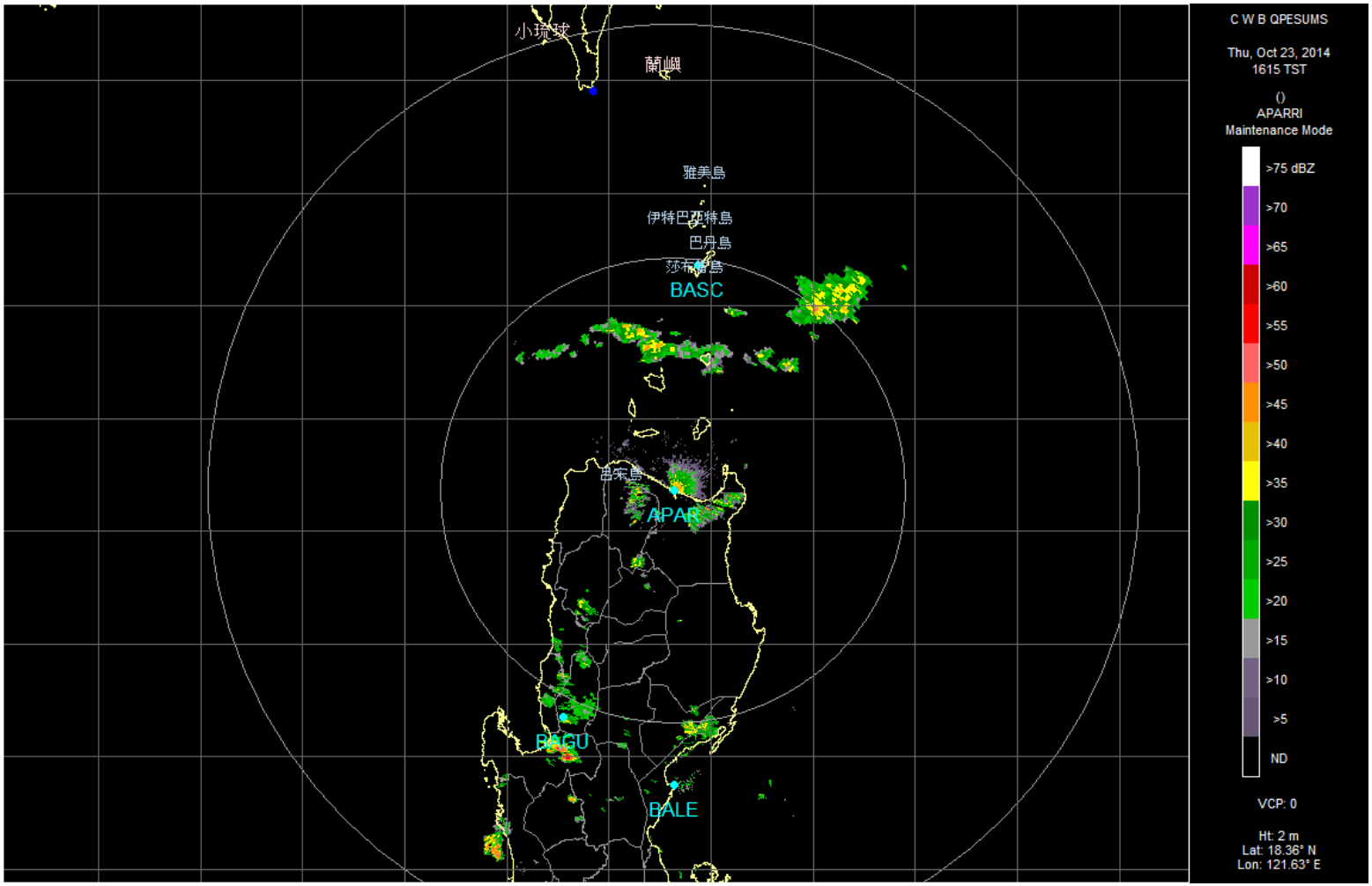


C-band precipitation radar

(Integrate Ishigaki Island Radar)



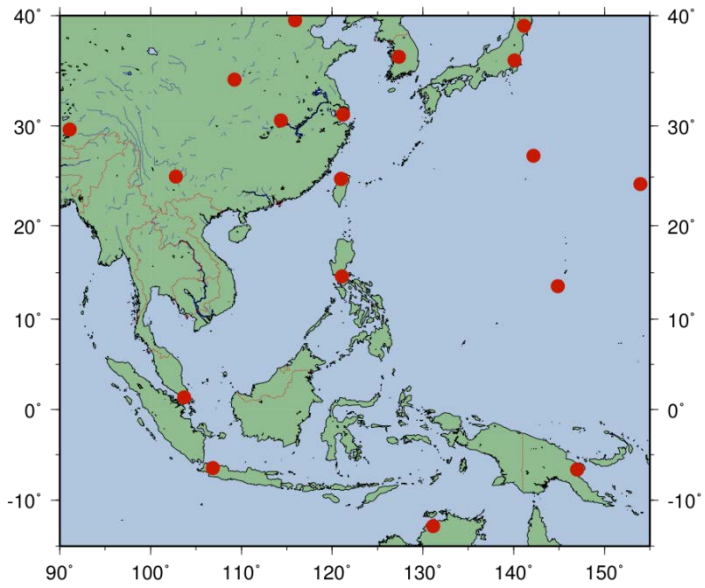
(Meteorological data service agreement between CWB and JWA)



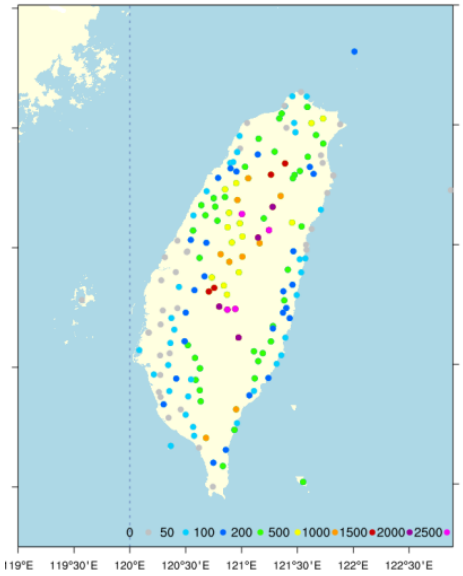
PAGASA radar network

Assimilate the GPS ZTD around Taiwan to improve the model QPF

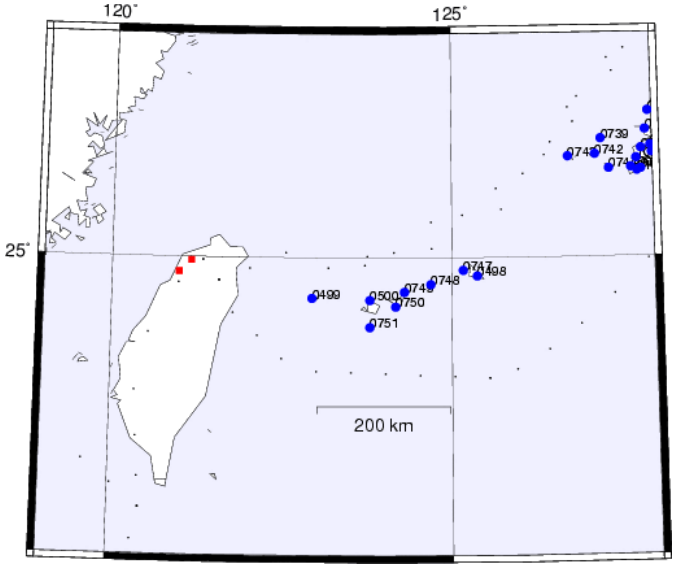
IGS stations

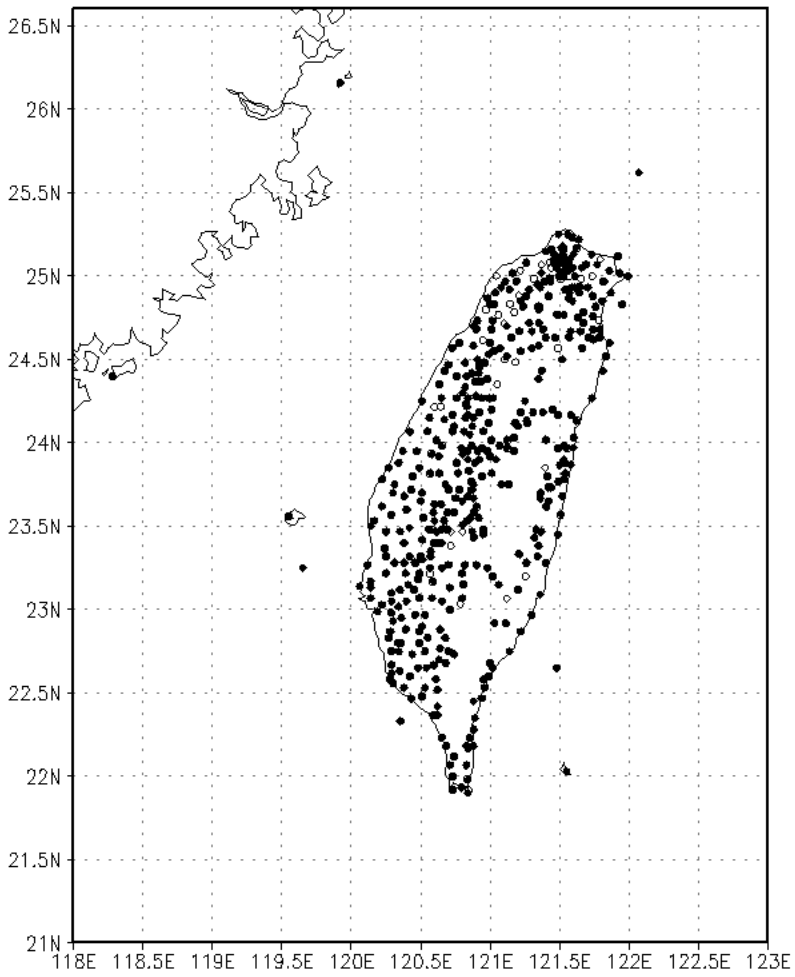


GPS stations over Taiwan

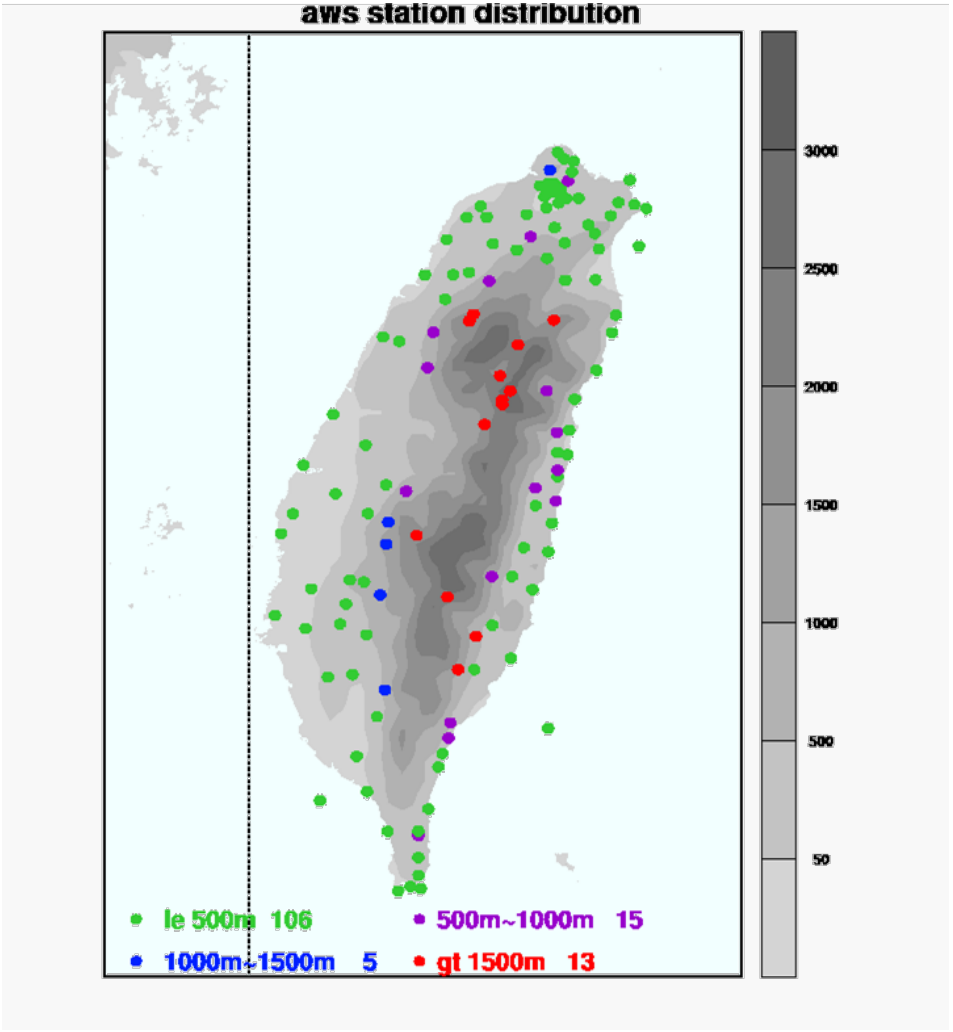


GPS stations from Japan





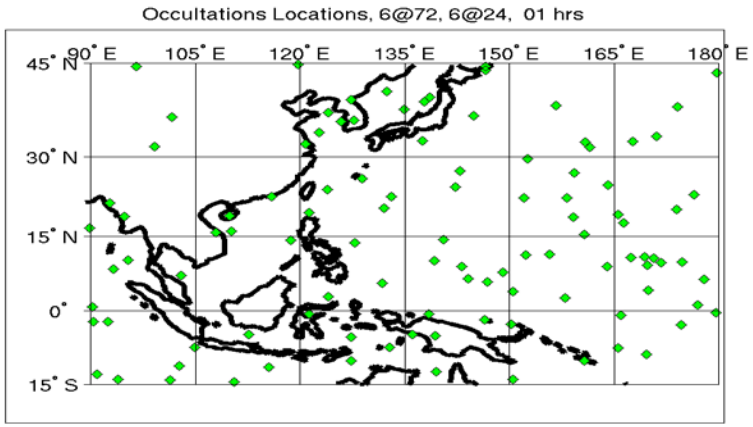
Rain gauge station



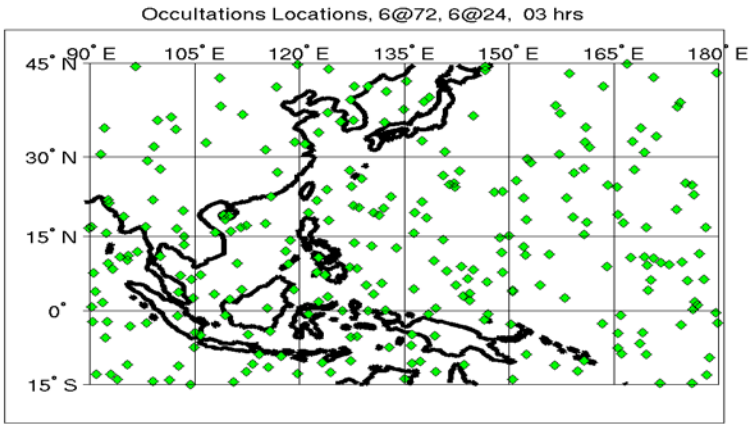
Surface observation

FORMOSAT-7/COSMIC-2 Soundings

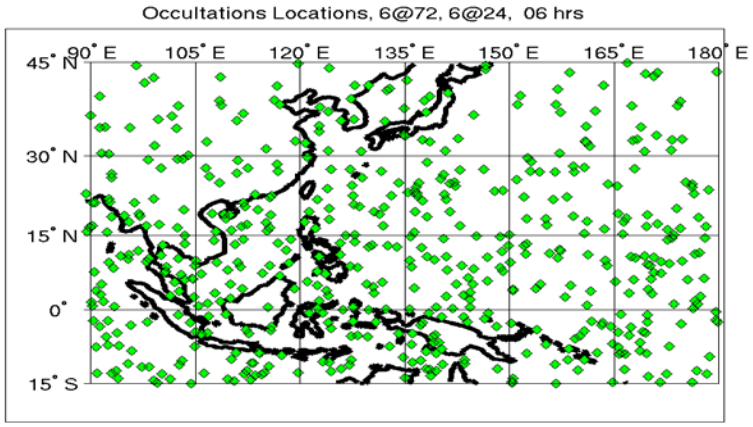
1 hour



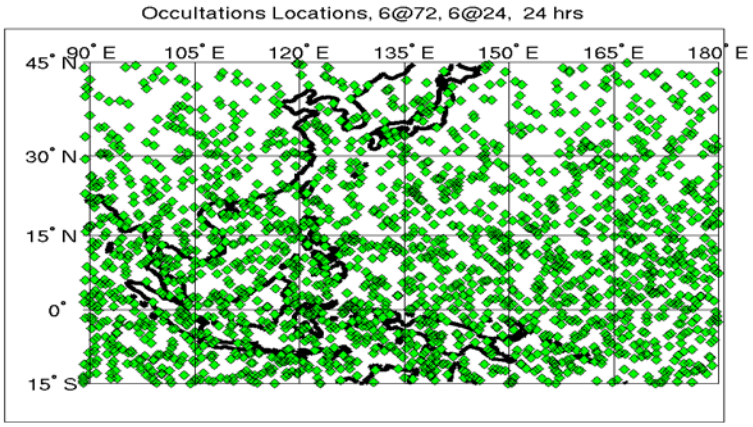
3 hour



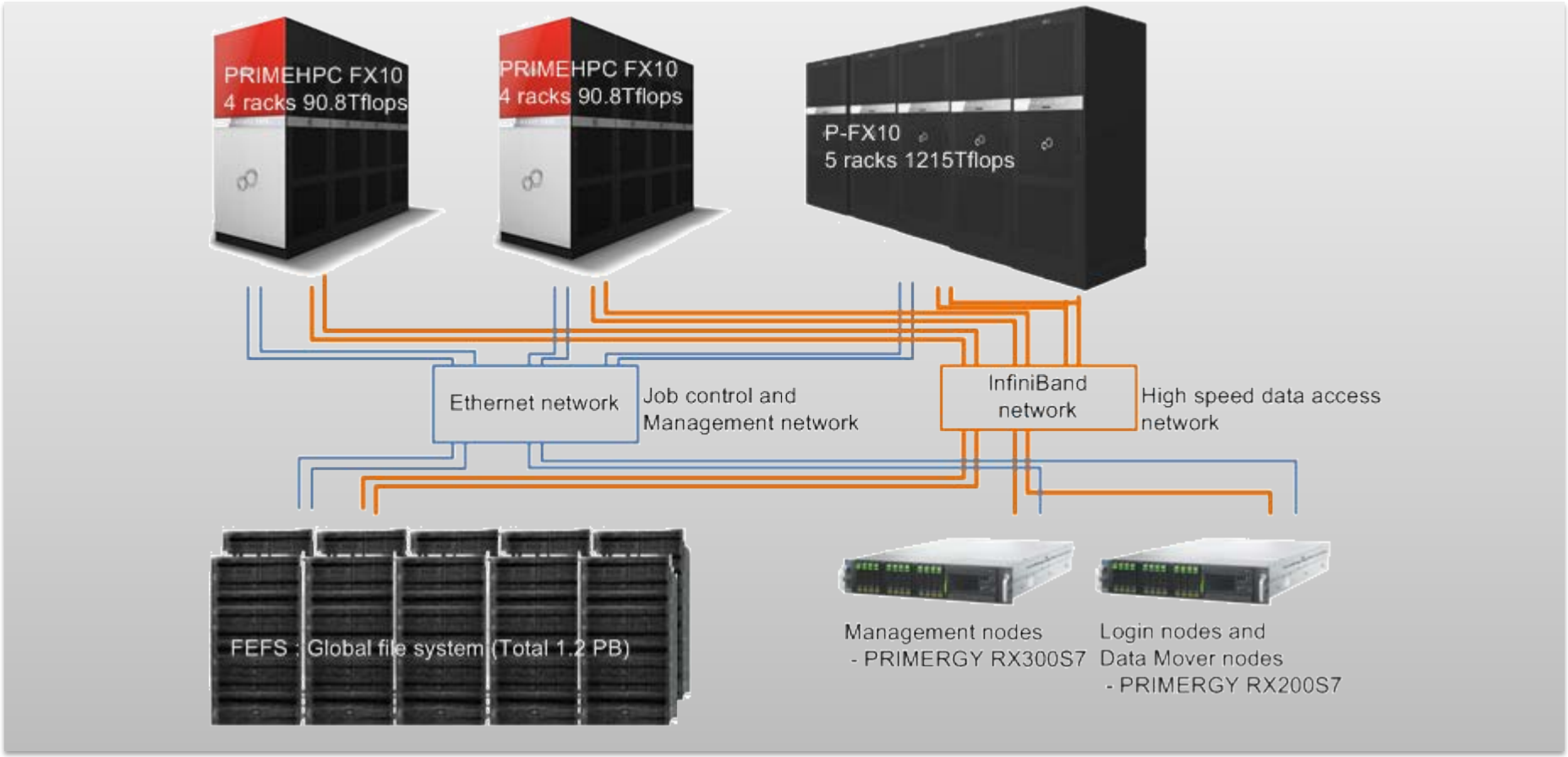
6 hour



24 hour



A petascale HPC system

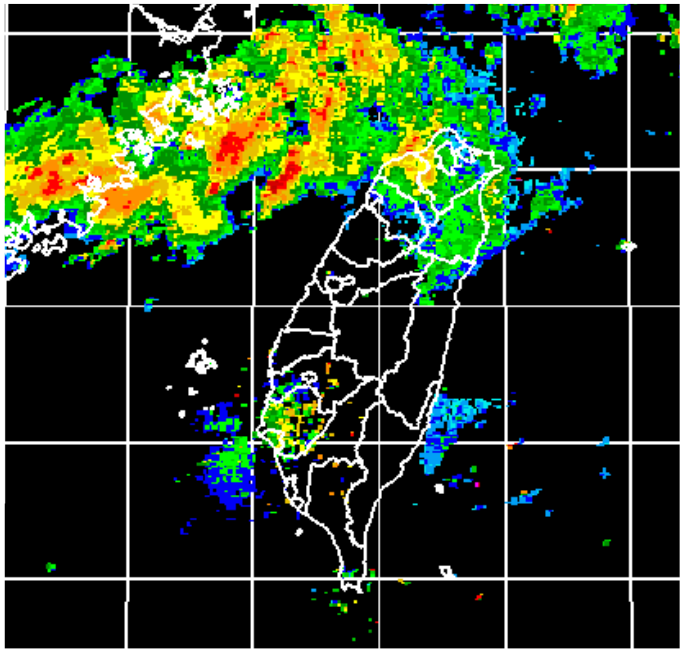


The next mile of the regional NWP

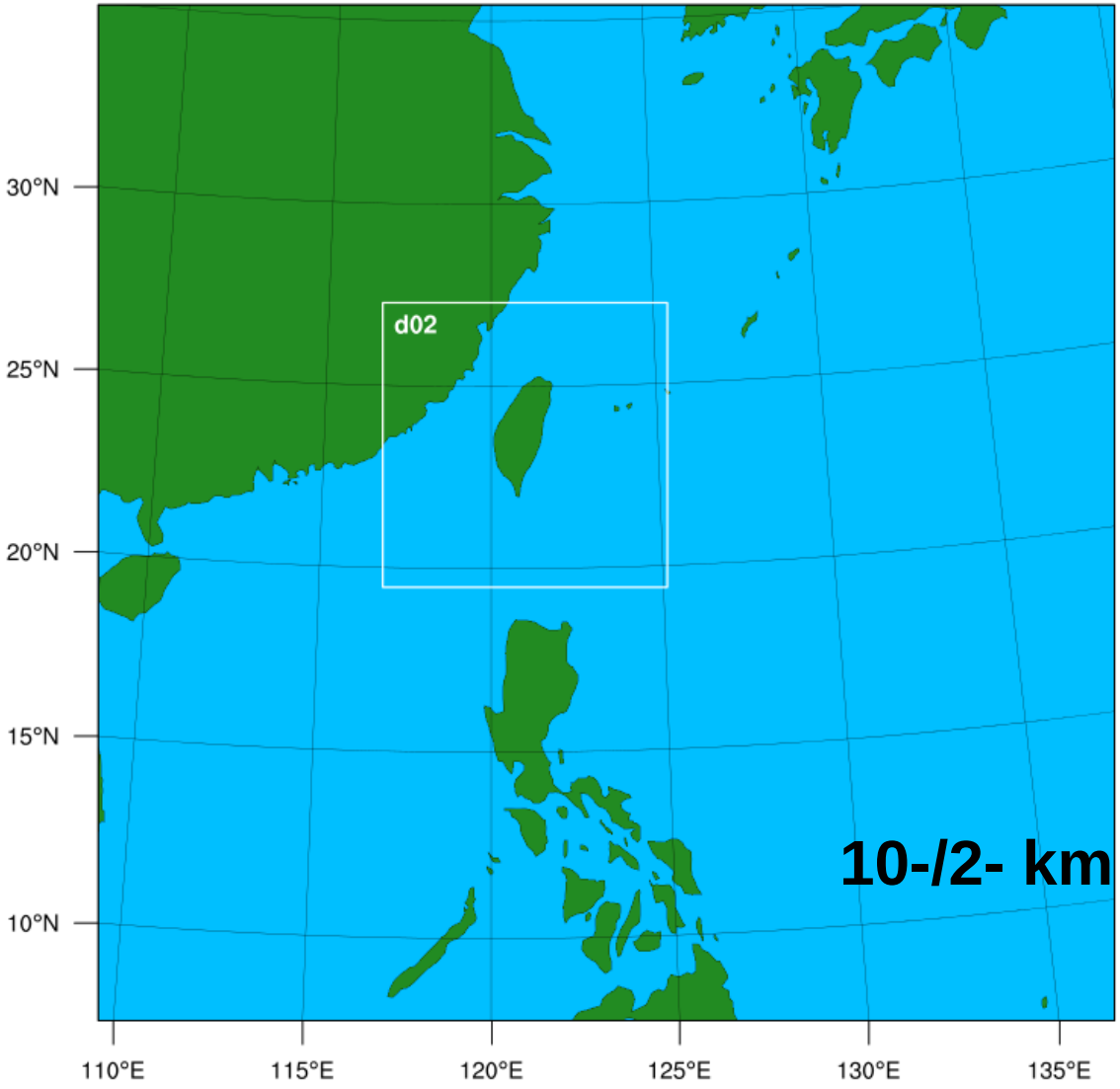
- To meet the strong requirements

  Provide the forecast guidance for the short-duration (e.g., 1~3 hour) extreme rainfalls

- The solutions
  - To develop the rapid updated convective-scale data assimilation system, from **3DVAR, hybrid, to 4DVAR**
  - To develop the convective scale ensemble prediction system

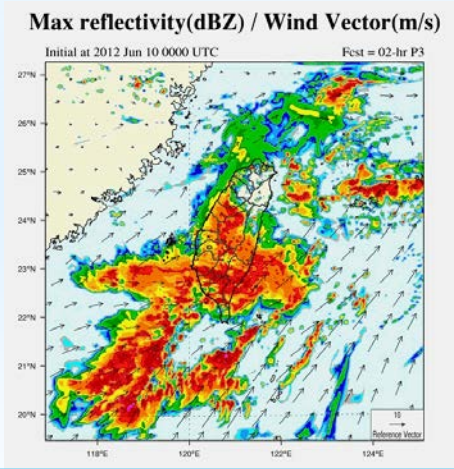


Radar DA



- Radar DA and convective scale prediction is run on 2-km grid
- 10-km grid initialized by the GFS every 6-hr and provide the IC/BC for hourly updated radar DA.

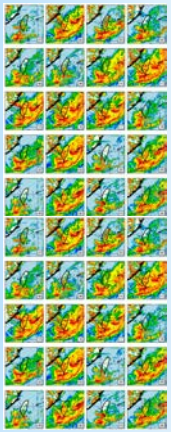
Radar DA



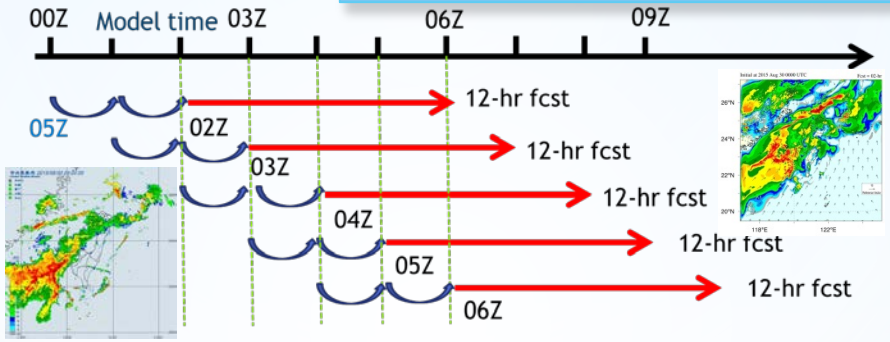
Hybrid 3DVAR

Hybrid 4DVAR

To be operational in 2016

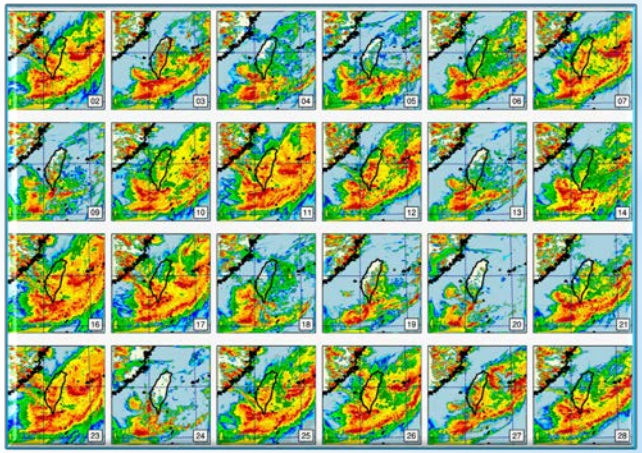


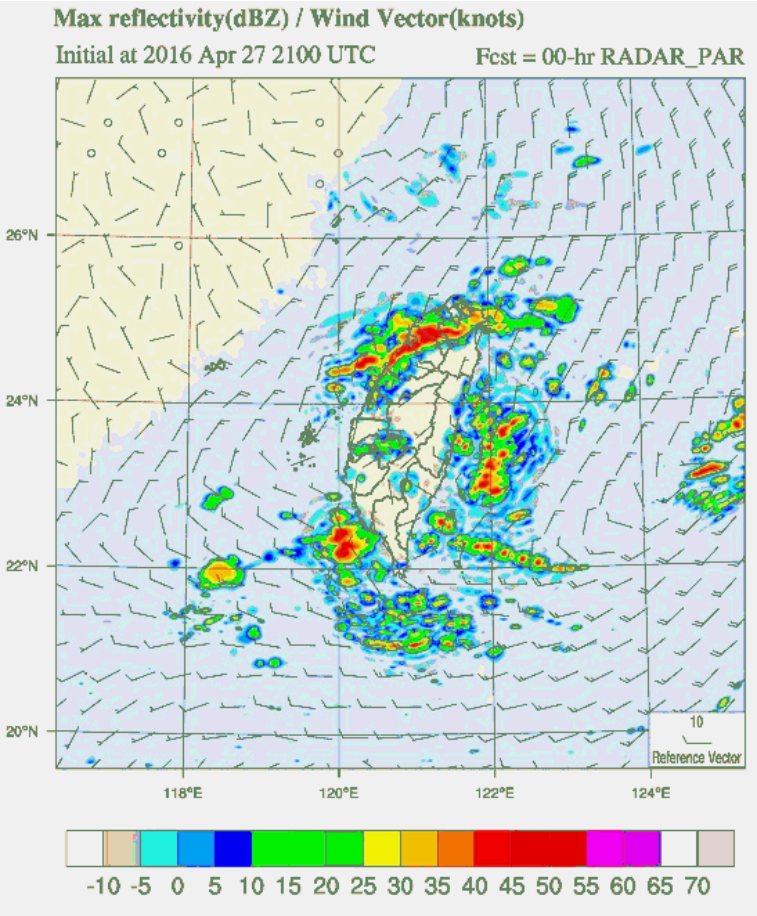
LETKF

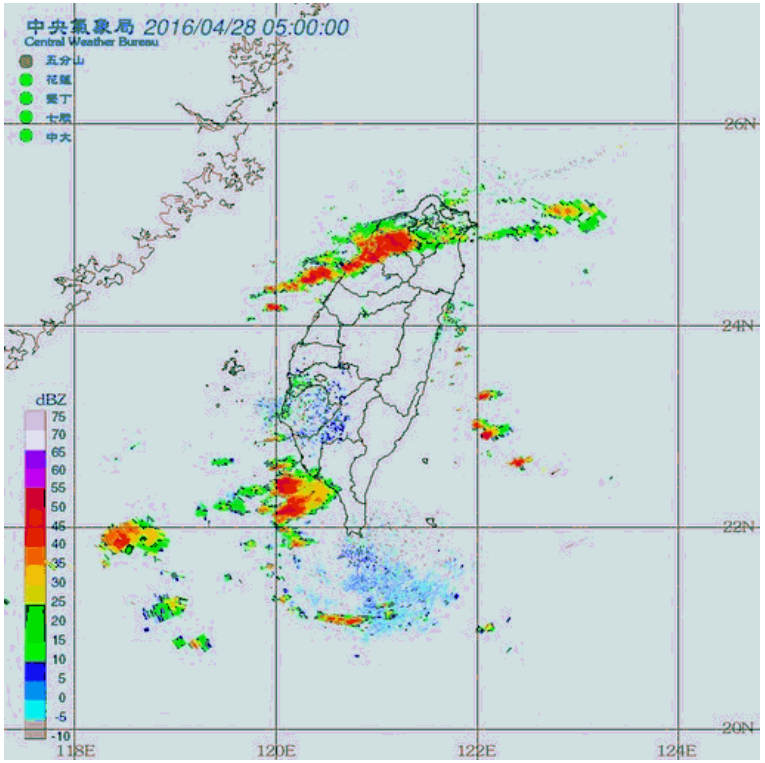


Realtime, hourly updated system extended to 24-r forecast

Convective scale EPS

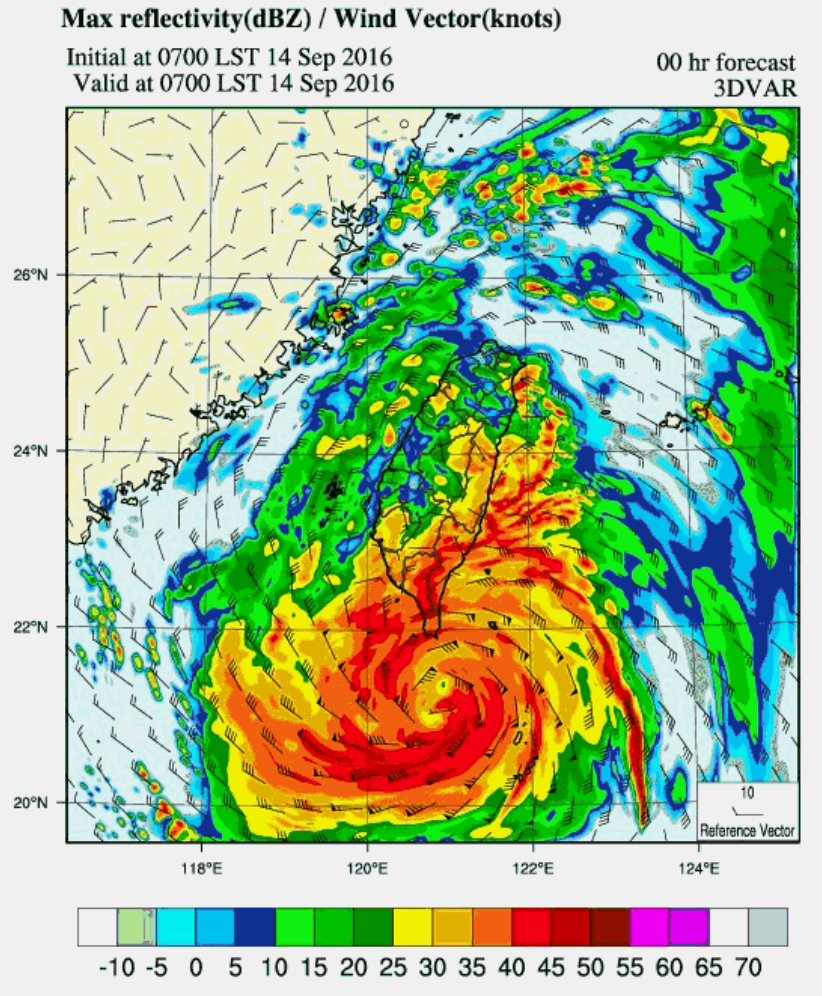


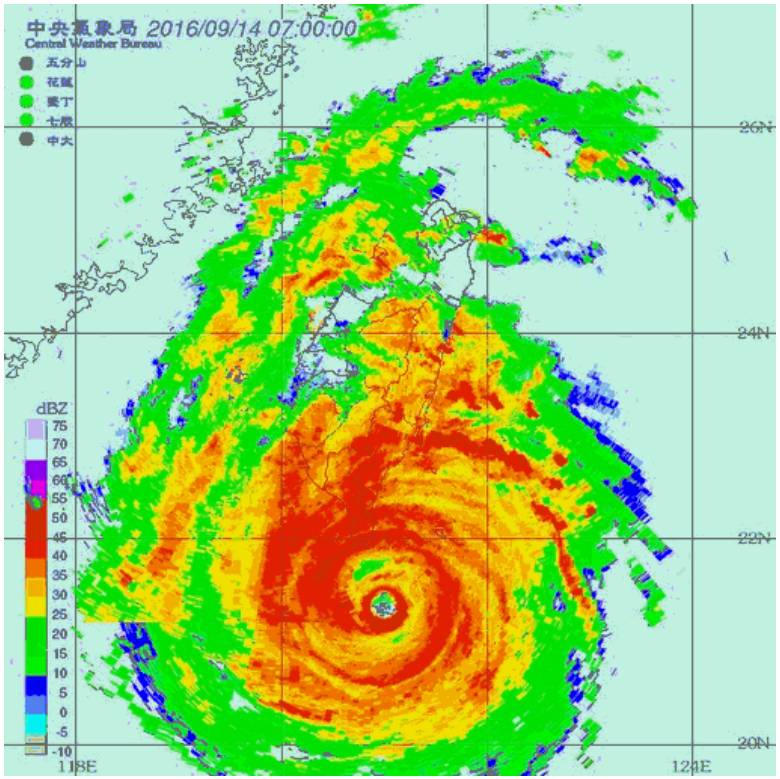




Initial：0428 **0500** LST

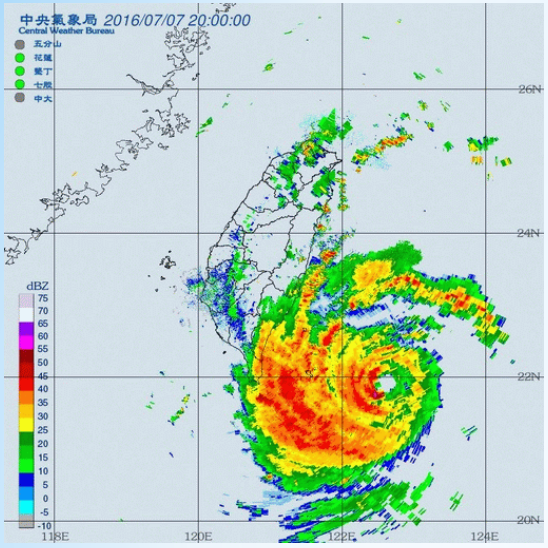
Cases from 3DVAR

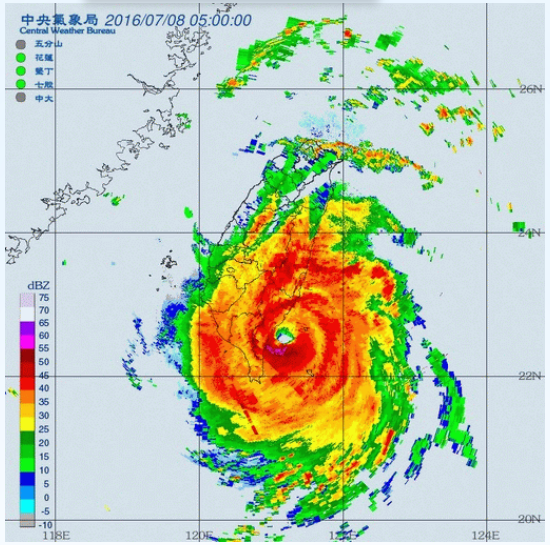


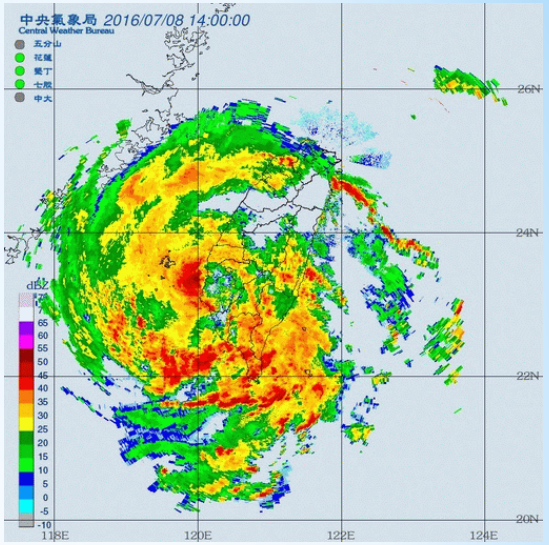


Typhoon Meranti – 3DVAR

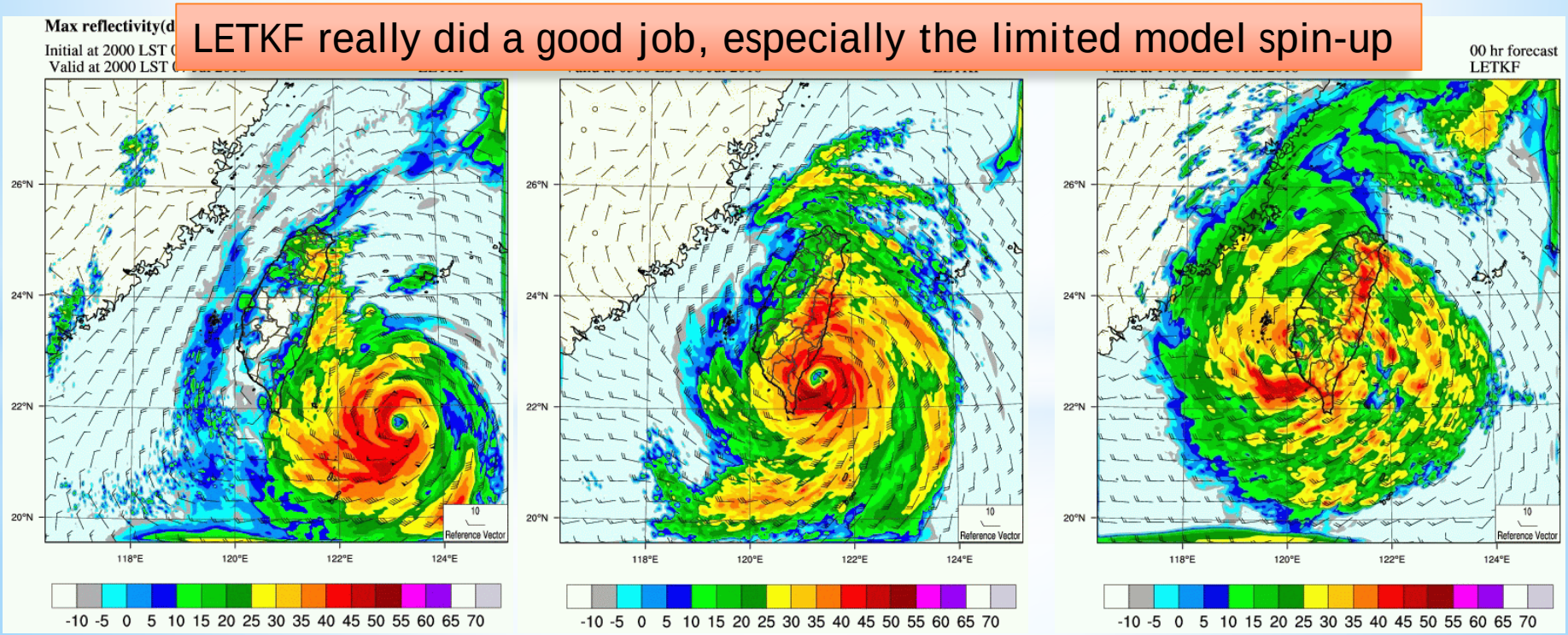
Ty Nepartak

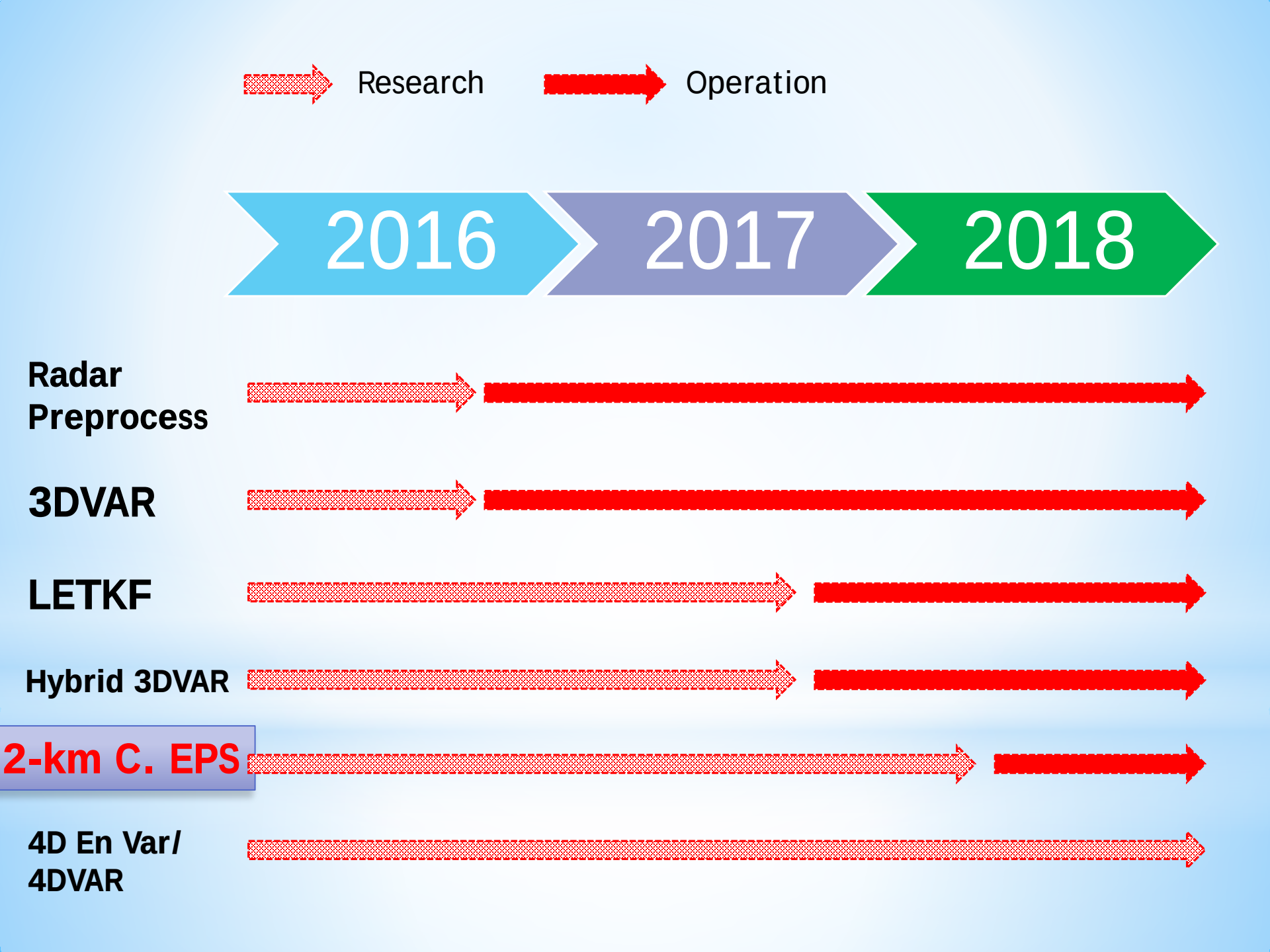






LETKF really did a good job, especially the limited model spin-up




Research
Operation
2016
2017
2018
Radar Preprocess
3DVAR
LETKF
Hybrid 3DVAR
2-km C. EPS
4D En Var/ 4DVAR