Development of the ensemble QPF in Central Weather Bureau (CWB) of Taiwan

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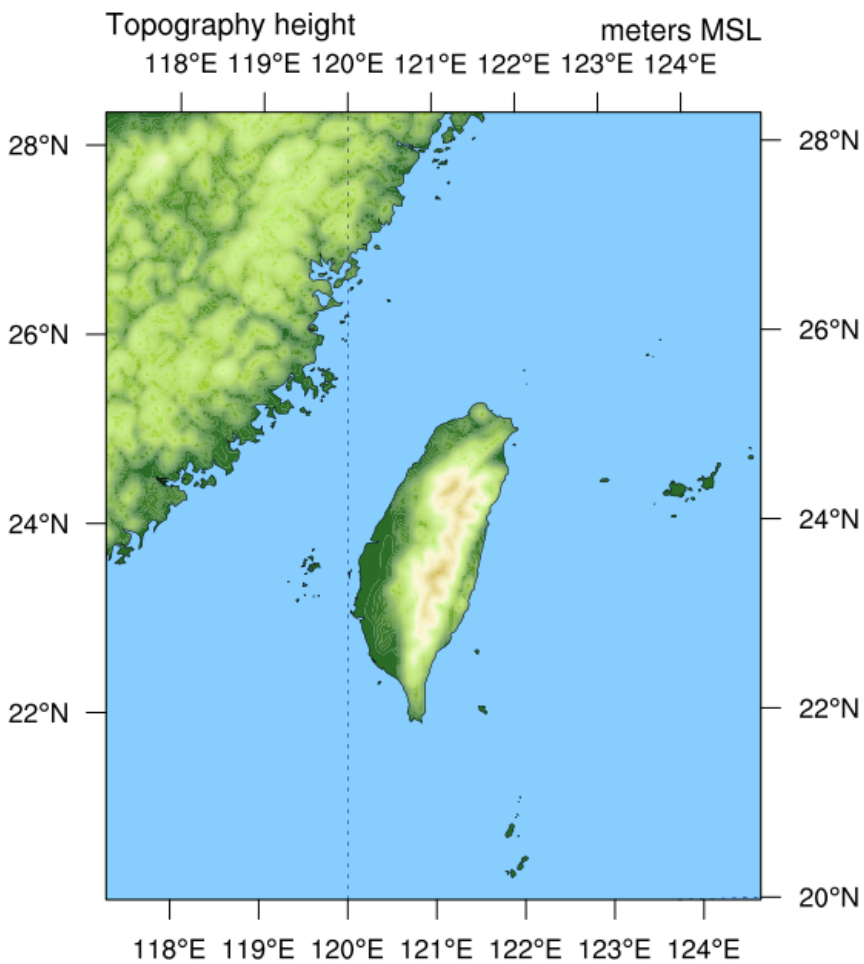
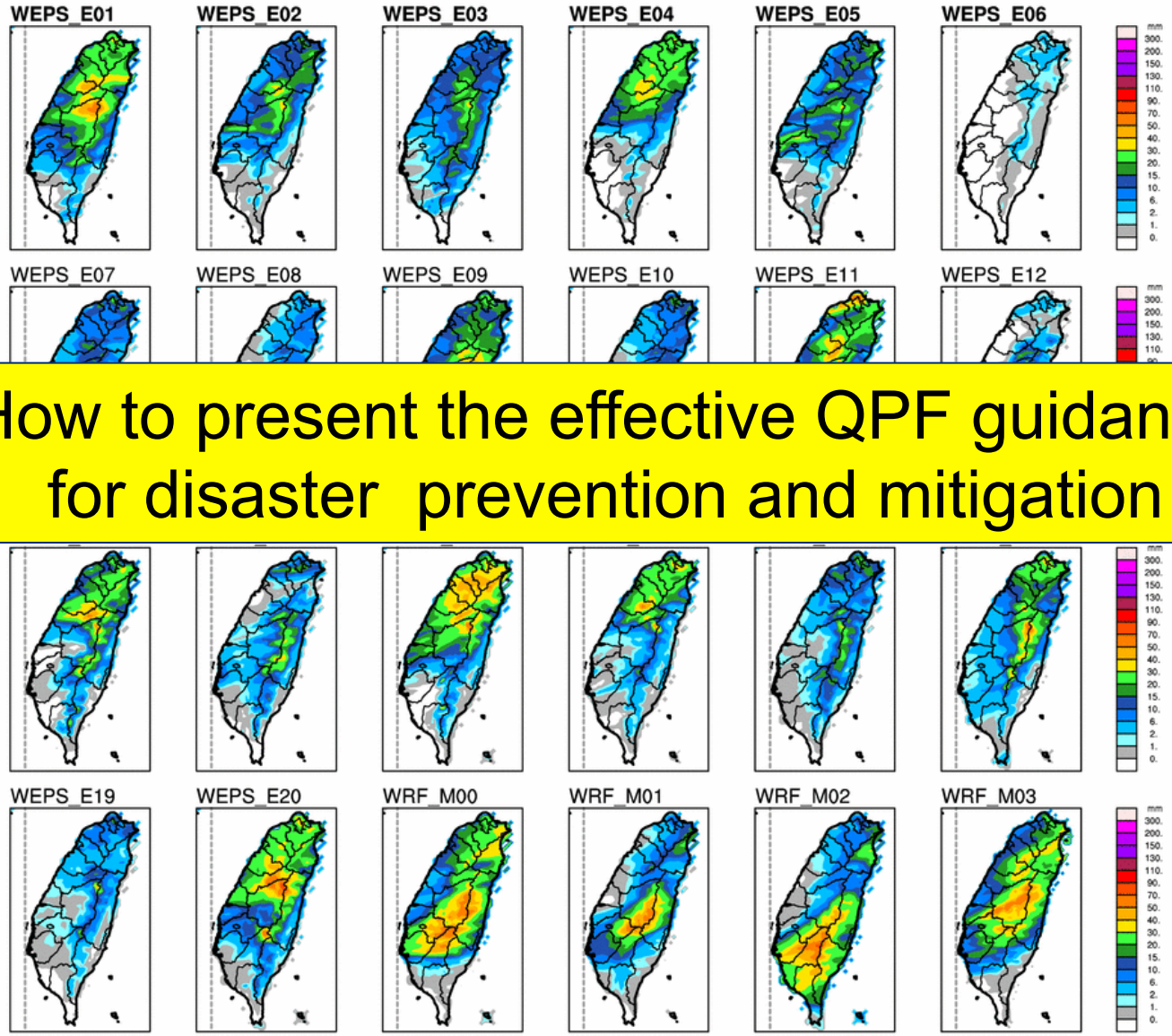
Configurations of the CWB EPS



- 4 times per day
- 20 members from
  - Control run from the deterministic analysis
  - Initial perturbation from EAKF 6-hr fcst perturbation
  - Boundary perturbation from the NCEP ensemble GFS
  - Model perturbation from 20-physics suite

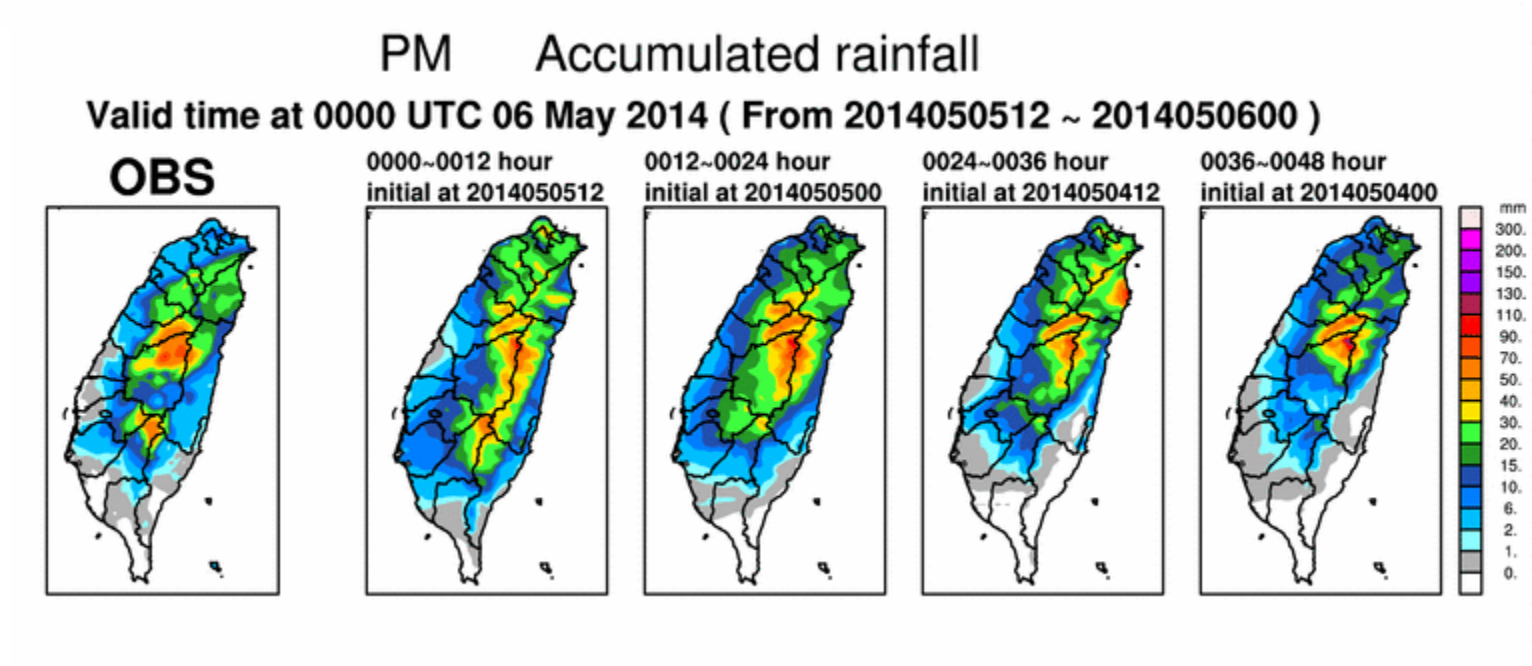
initail at 0000 UTC 06 May 2014
00~12hr fcst Accumulated rainfall from 2014050600 ~ 2014050612
Ensemble QPF

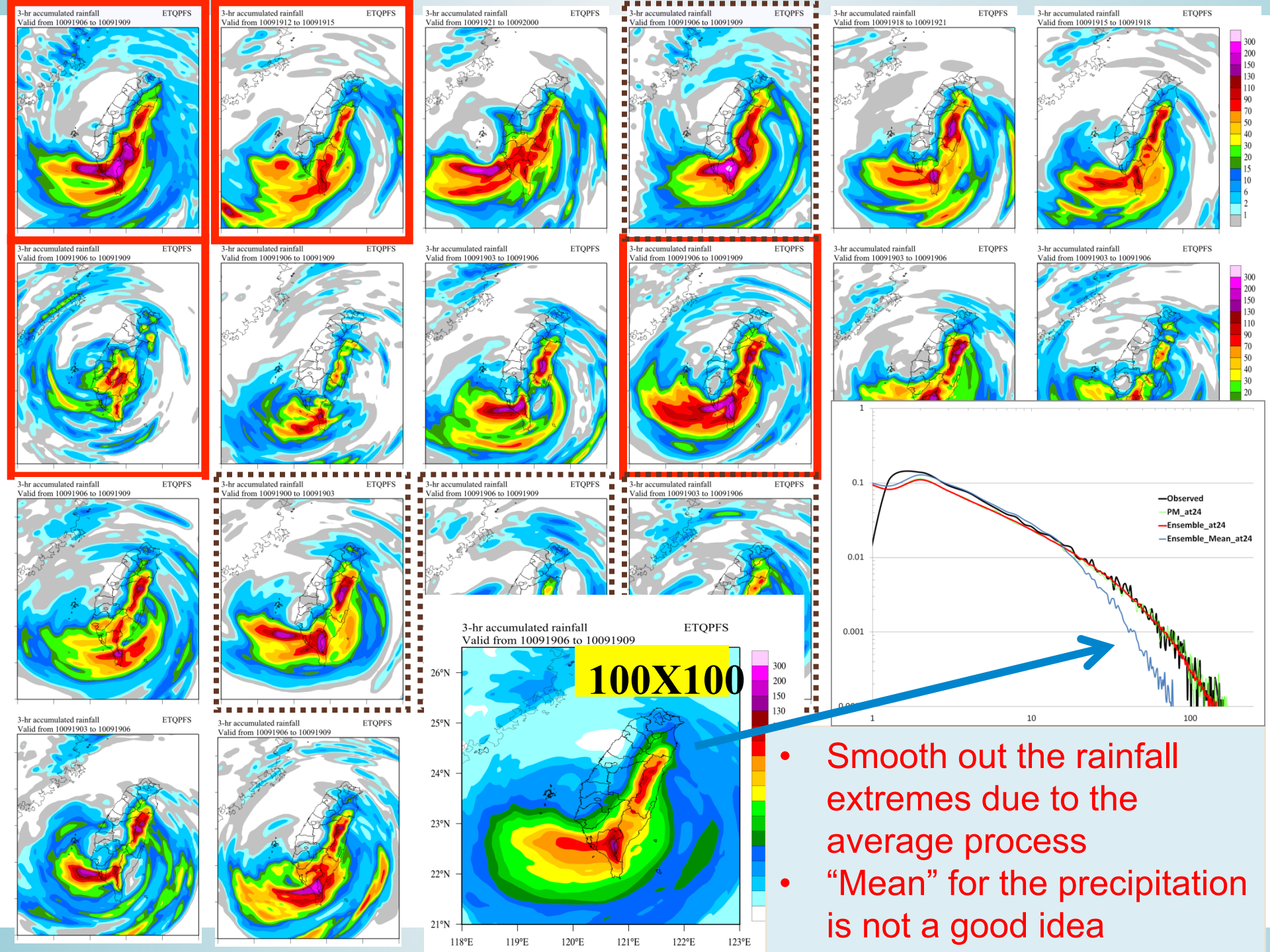


How to present the effective QPF guidance for disaster prevention and mitigation

Probability match rainfall

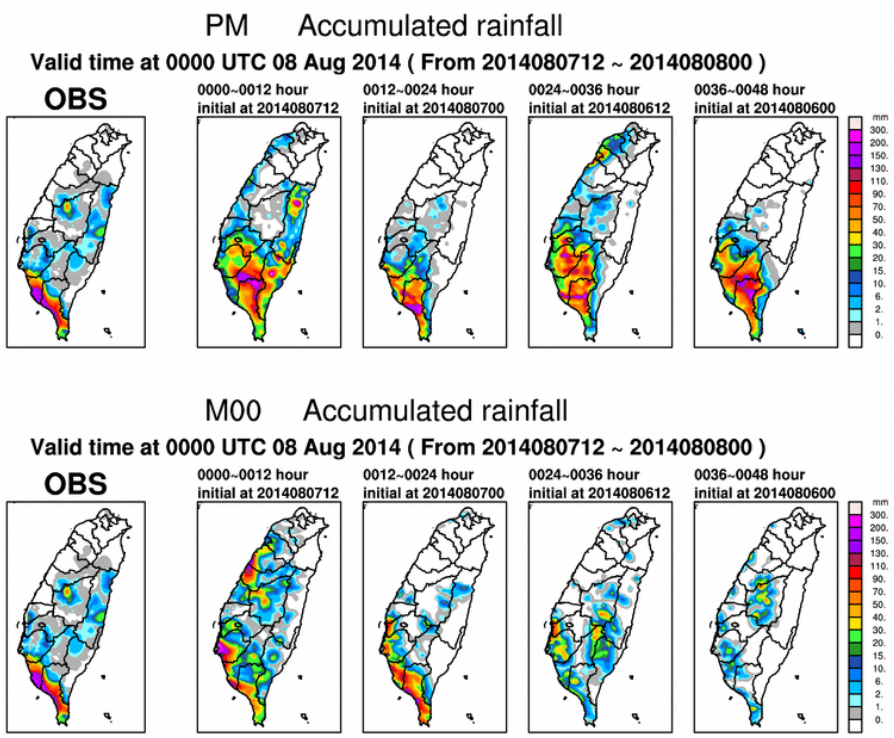
- Based on the ensemble mean
  - Out-performs the deterministic forecast with different lead-time
- Re-construct the PDF of the ensemble mean rainfall using the PDF of the whole ensemble QPF
  - Without under-estimate the rainfall amount



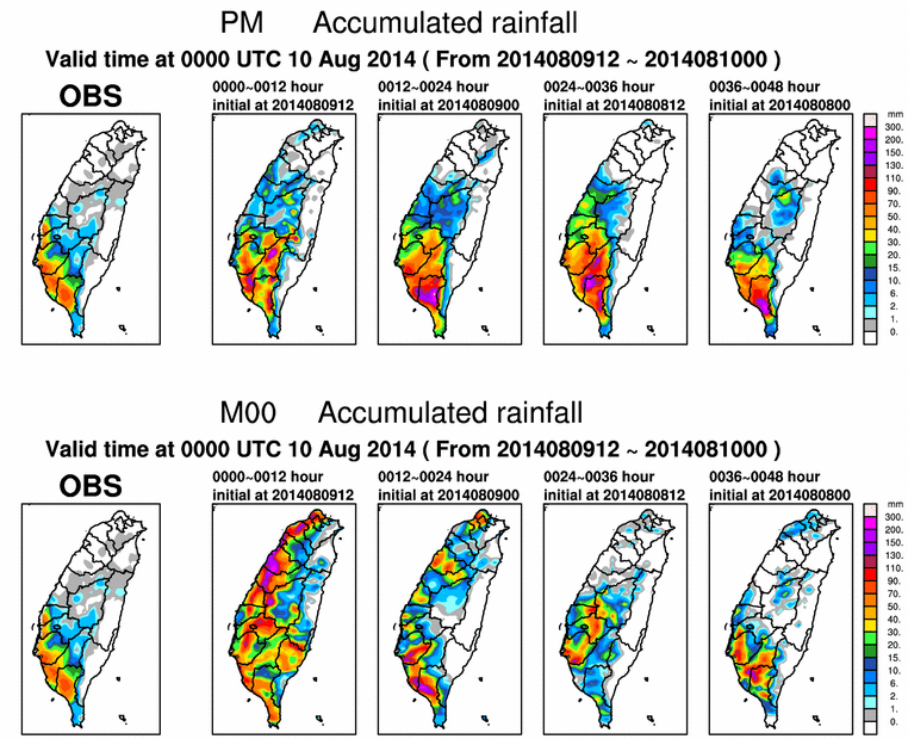


- Smooth out the rainfall extremes due to the average process
- “Mean” for the precipitation is not a good idea

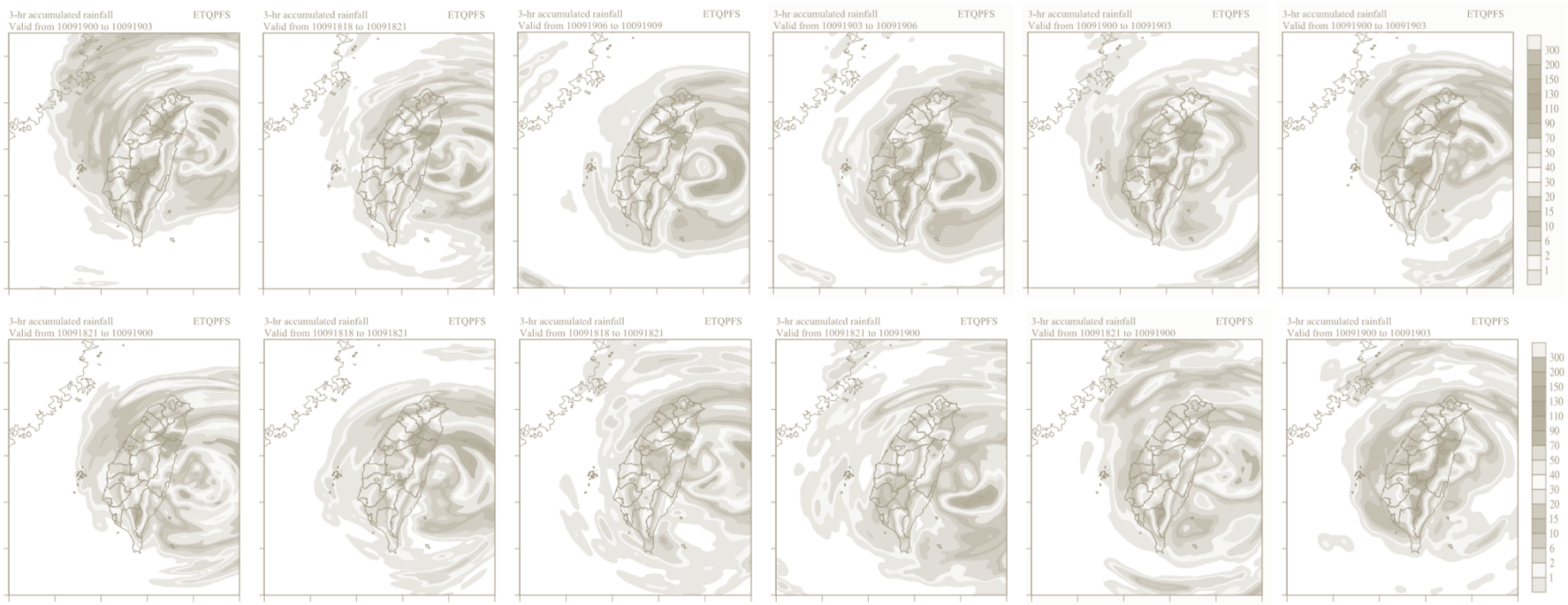
Valid time at 2014080712 ~ 2014080800

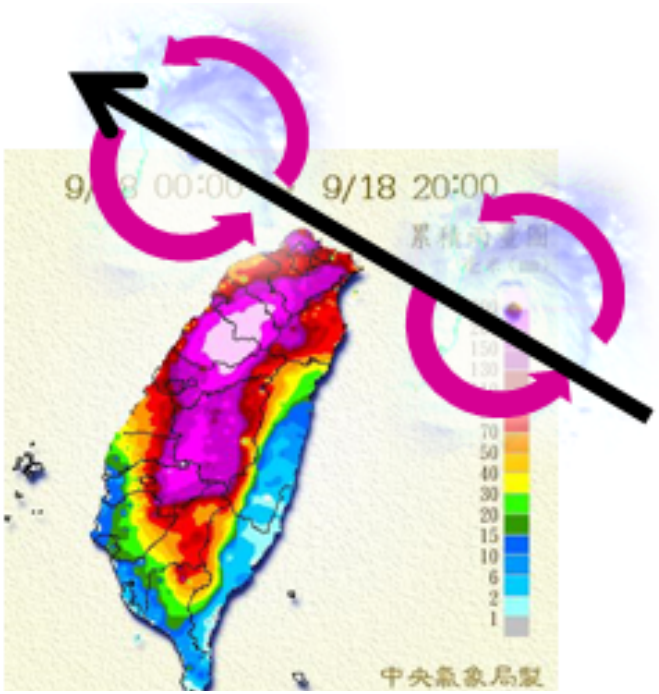


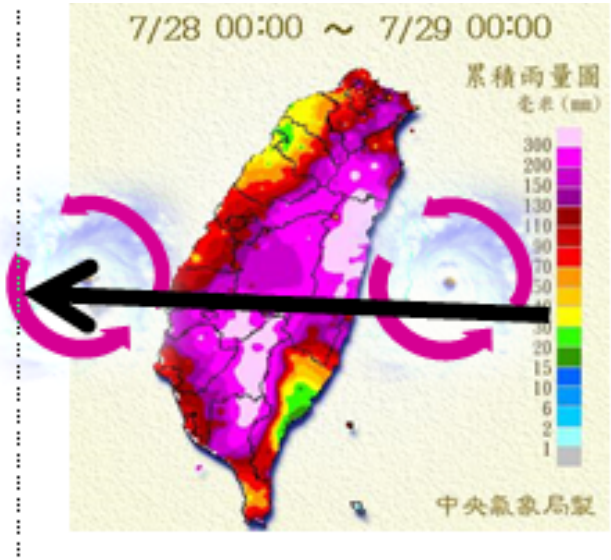
Valid time at 2014080912 ~ 2014081000



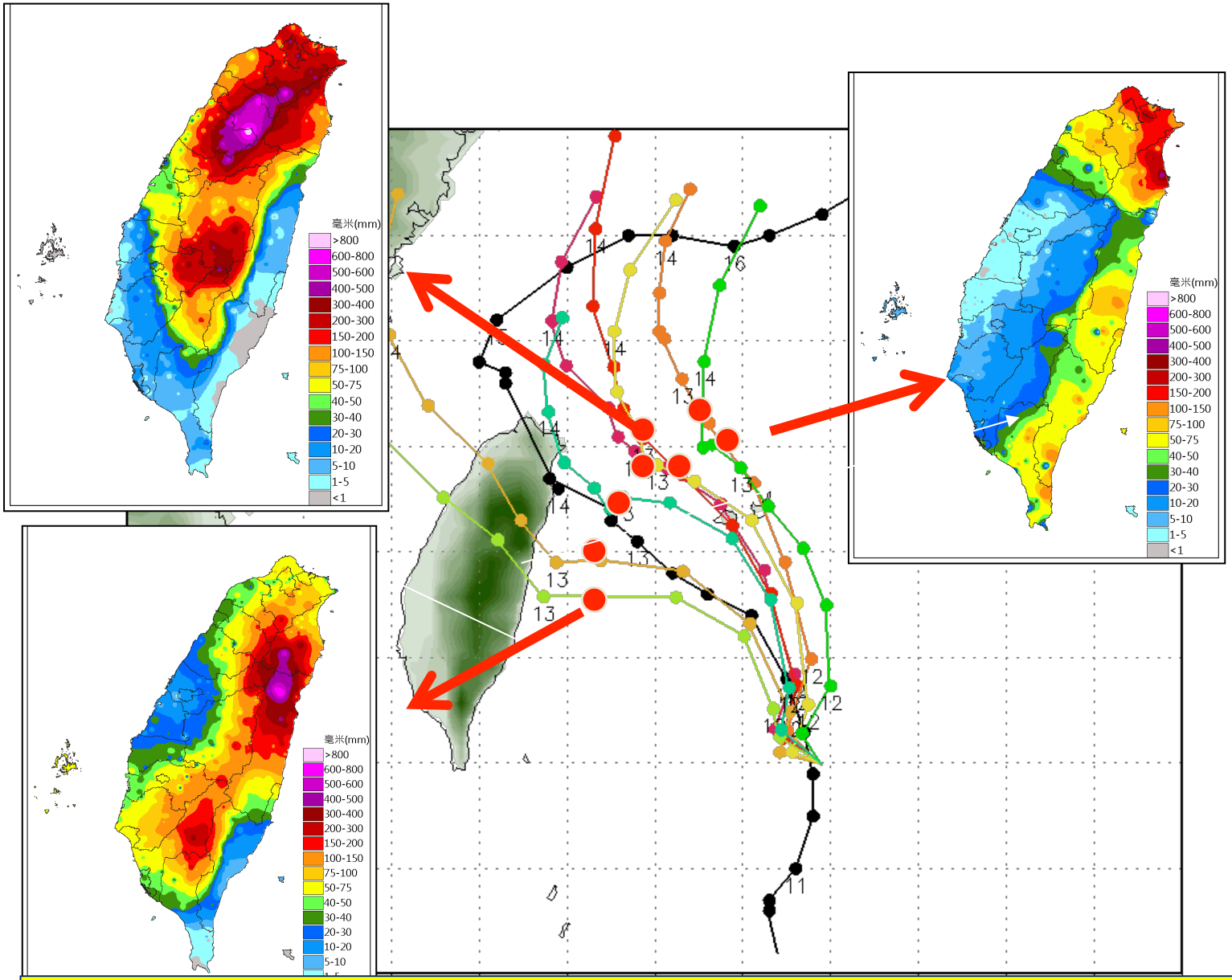
For Typhoon, the Probability Match rainfall can not function well







Due to the high mountain range, the distribution and amount of the typhoon rainfall over Taiwan is highly related to the typhoon position, it is so called **topographic locking**.



Take the ensemble mean? It is definitely not a good idea

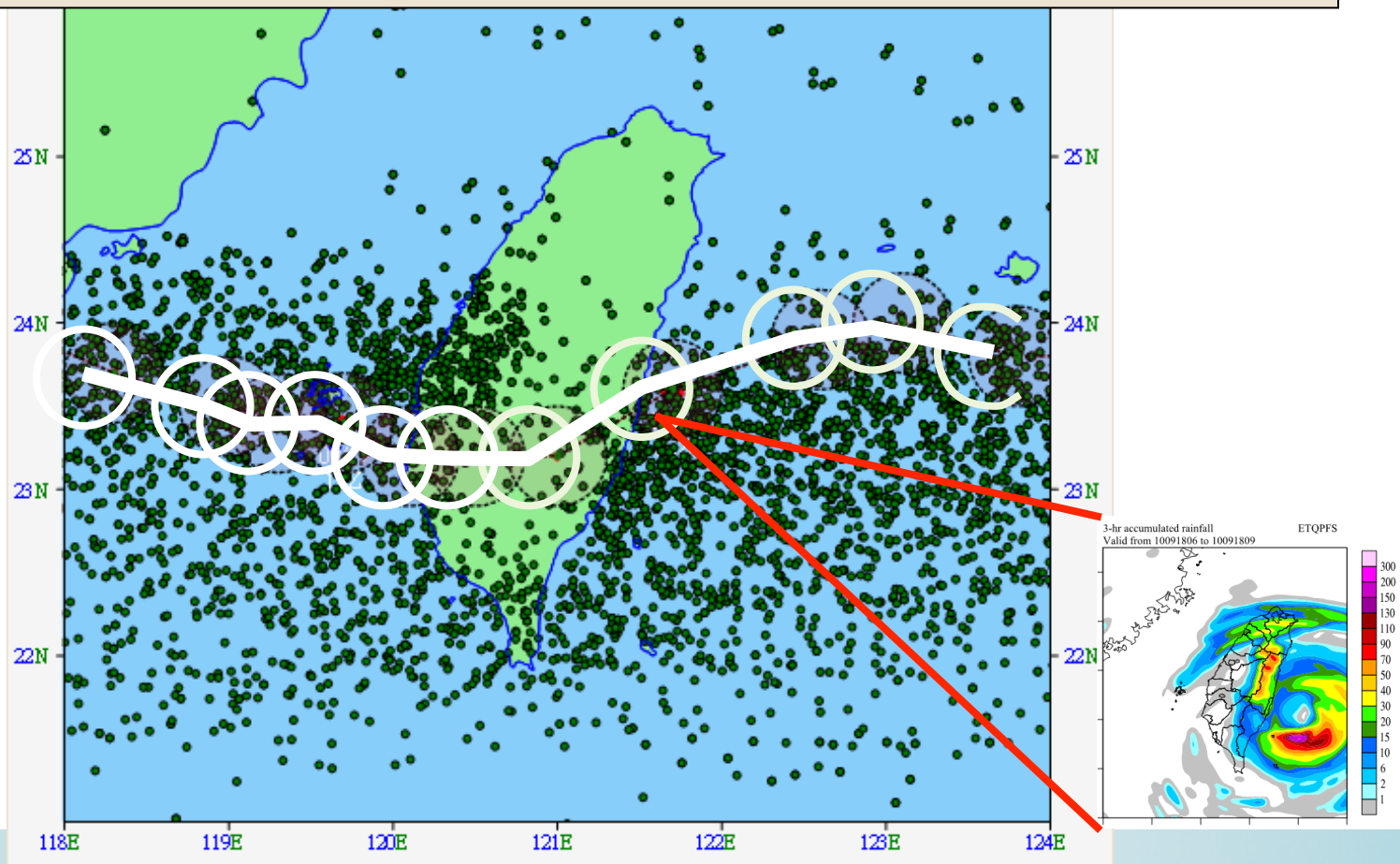
Toward the Ensemble Typhoon QPF (ETQPF)

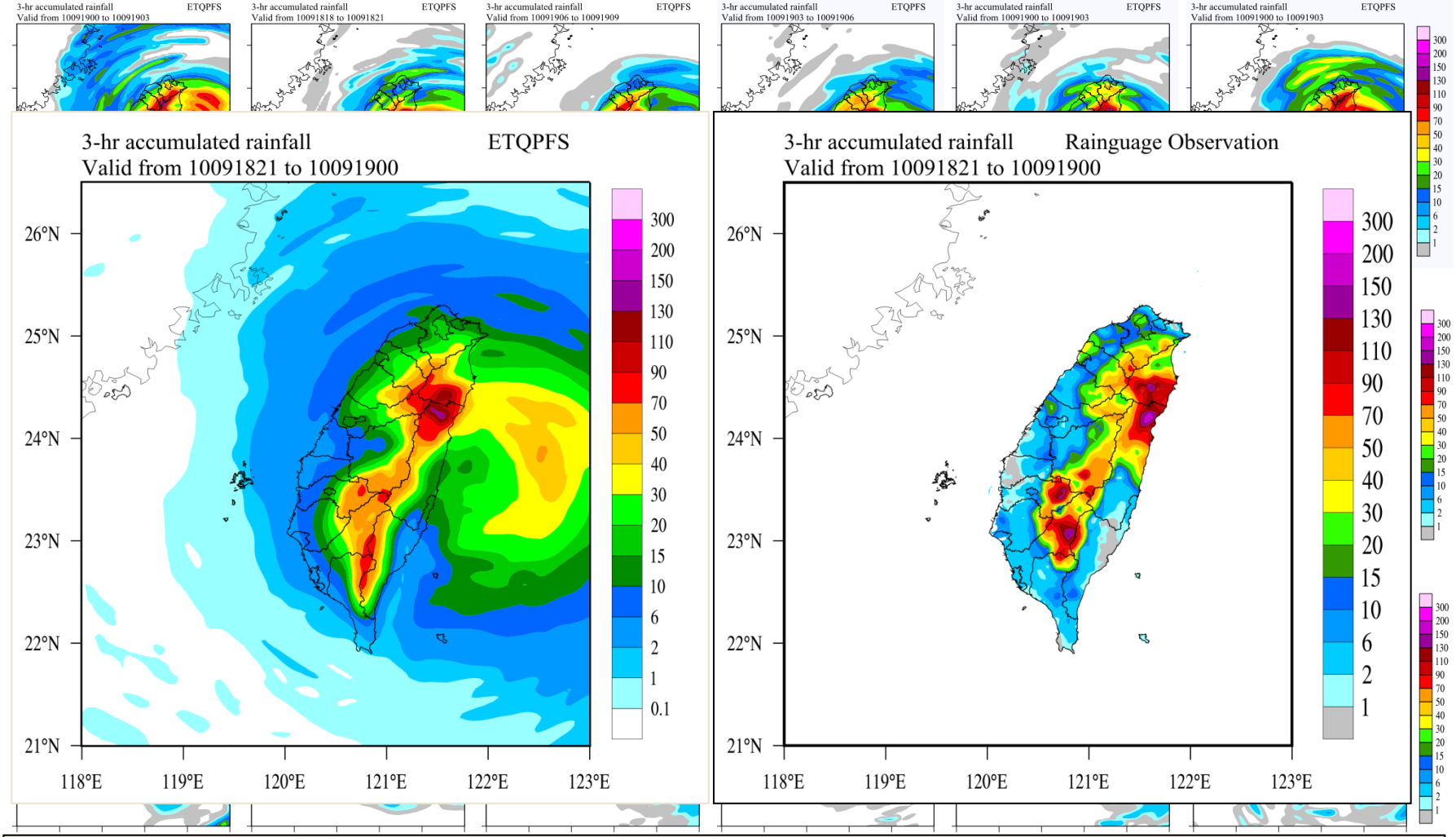
- Typhoon locations with 3-hr intervals (ensemble cases) were given by the ensemble prediction systems.
  It is the **total uncertainties** from the EPS

- Each ensemble case is associated with a 3-hr accumulated rainfall map.

3 days
4 runs per day
30 members per run
24 dots per mem (72/3 hr)
Total: 3x4x30x24=8640 dots

- We are trying to **reduce the uncertainties** according to the prior estimate of the track



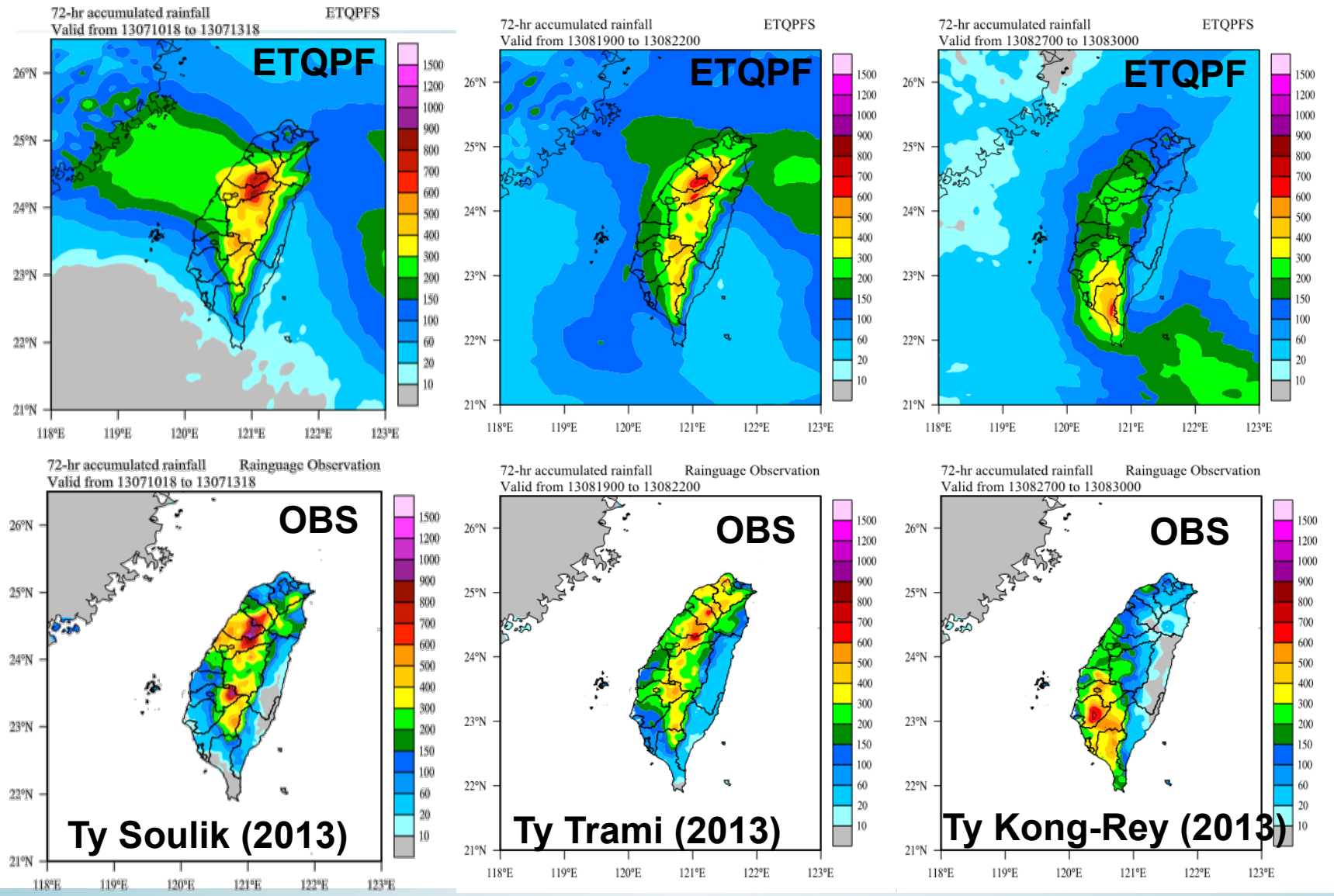


- A "**QPF scenario**" was provided by the given typhoon track.
  →ensemble typhoon QPF (ETQPF)
- A kind of "data mining" from the huge ensemble dataset.
  - Typhoon track is as a probe to mining the ensemble dataset

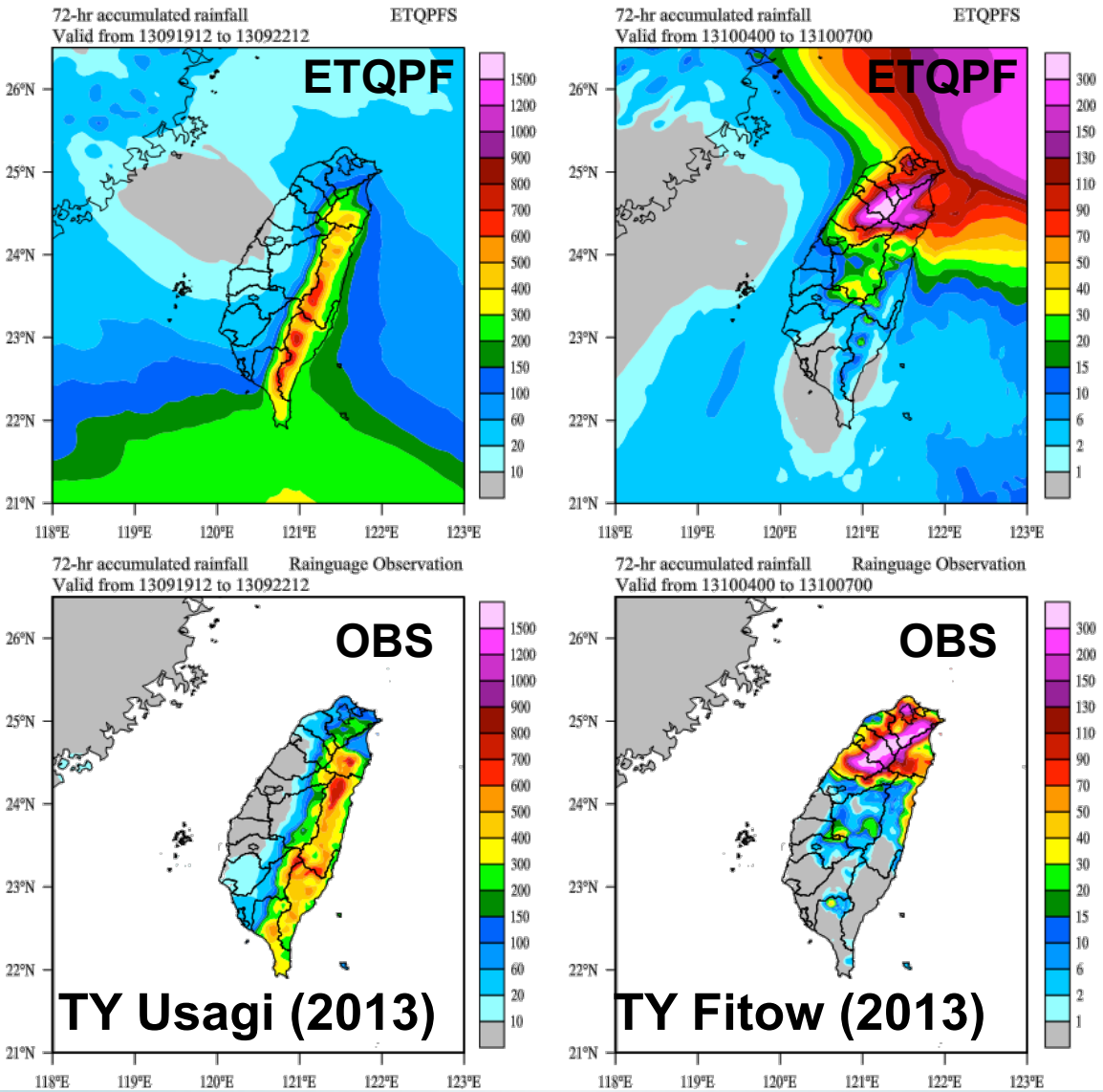
Performance of the ETQPF

With best track (no tract error)

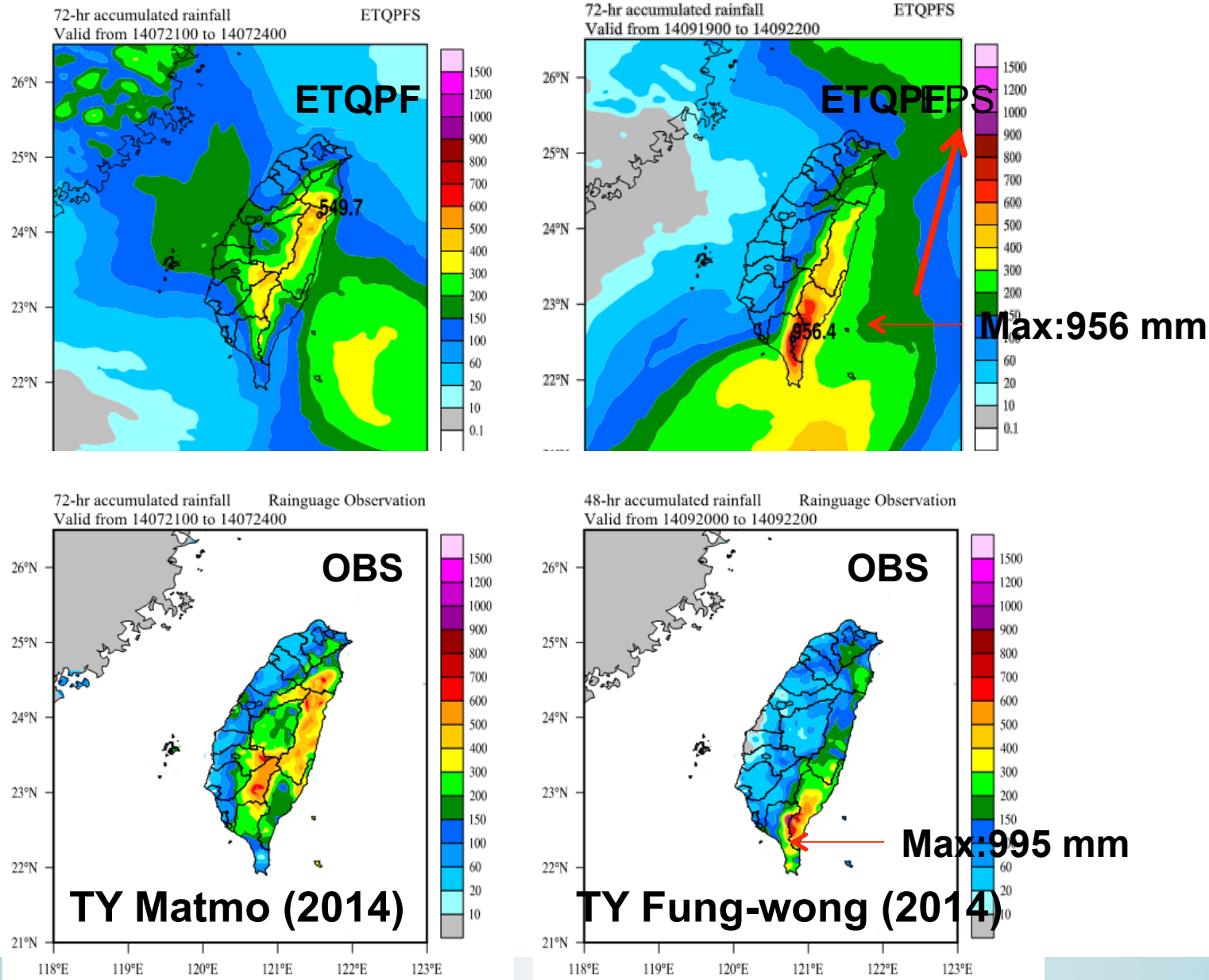
The Ensemble Typhoon QPF (ETQPF) for the typhoons affecting Taiwan in 2013



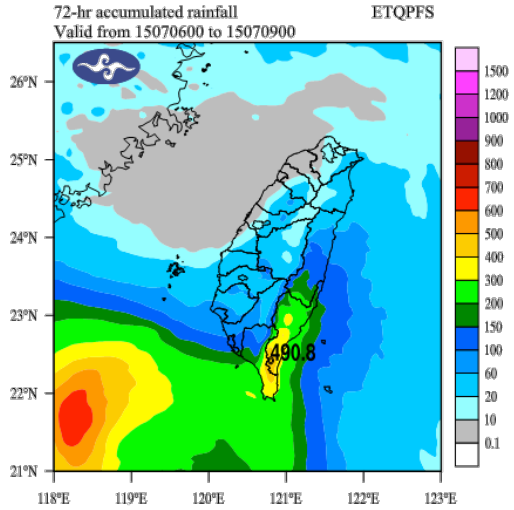
The Ensemble Typhoon QPF (ETQPF) for the typhoons affecting Taiwan in 2013

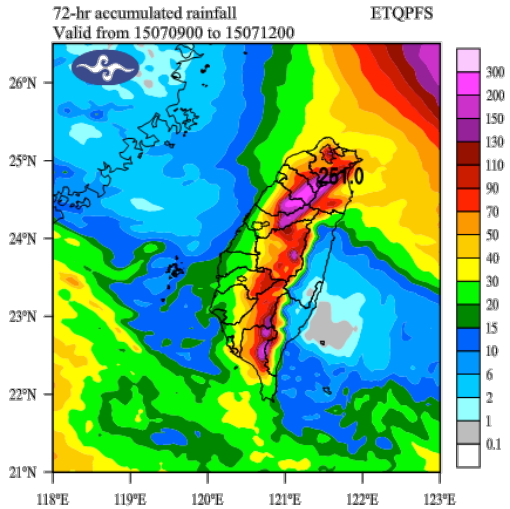


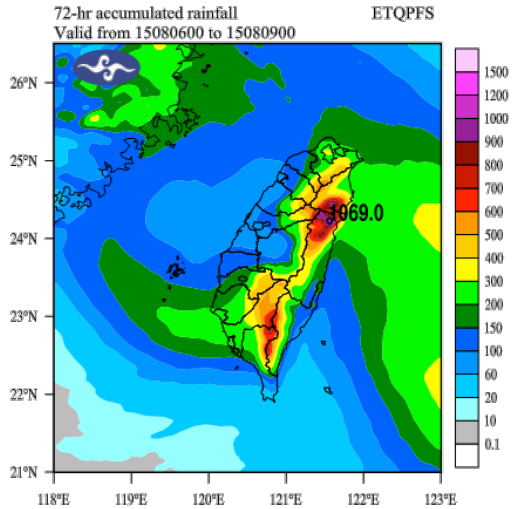
The Ensemble Typhoon QPF (ETQPF) for the typhoons affecting Taiwan in 2014

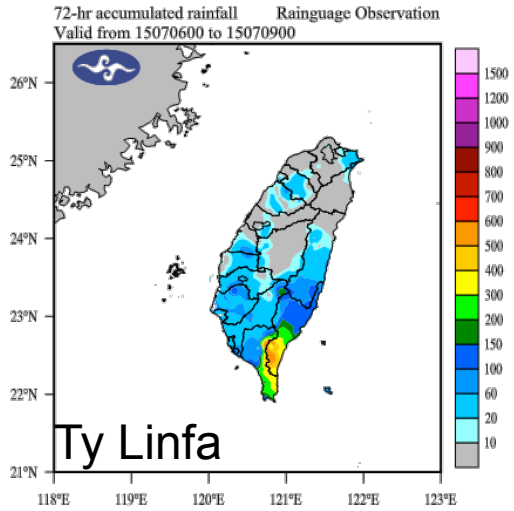


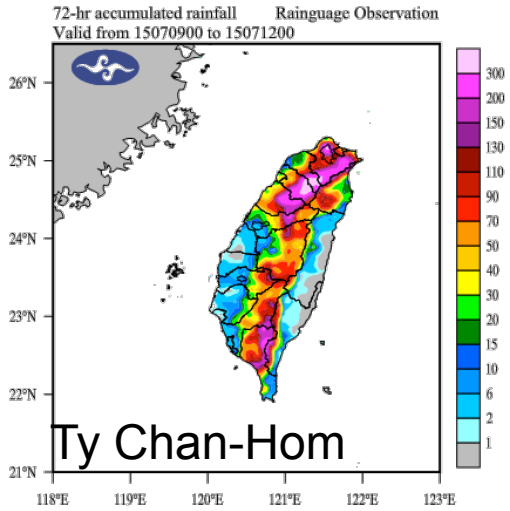
The Ensemble Typhoon QPF (ETQPF) for the typhoons affecting Taiwan in 2015

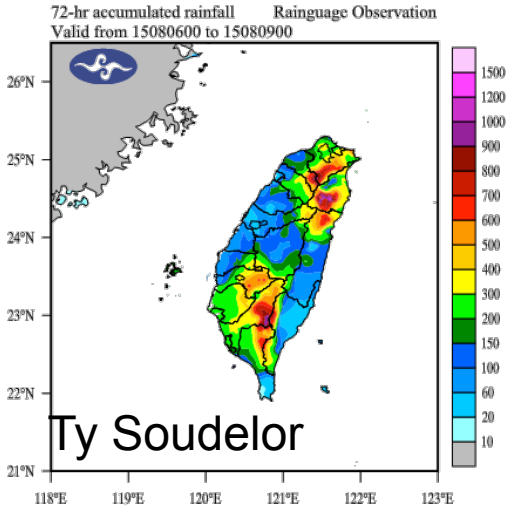




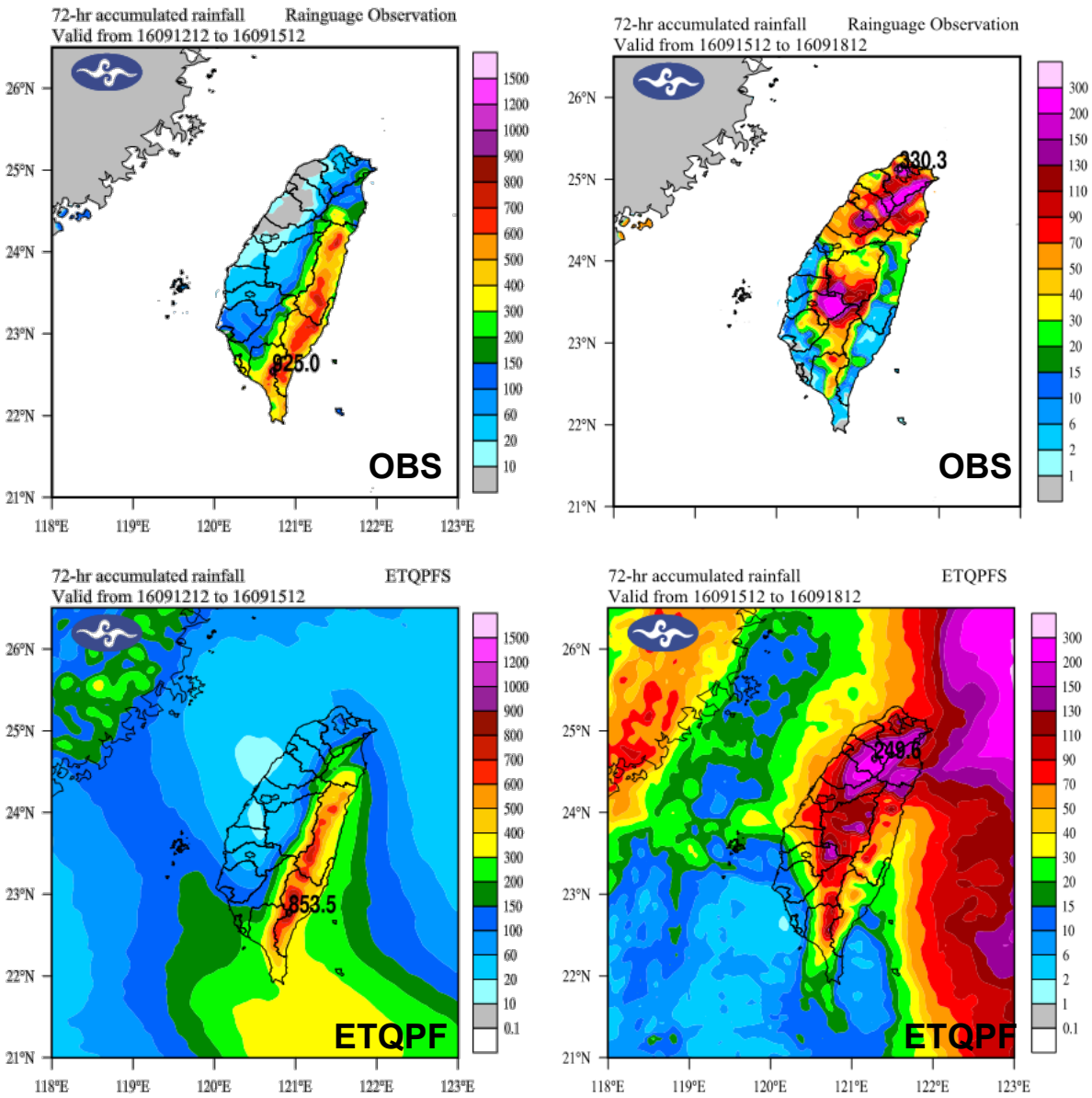








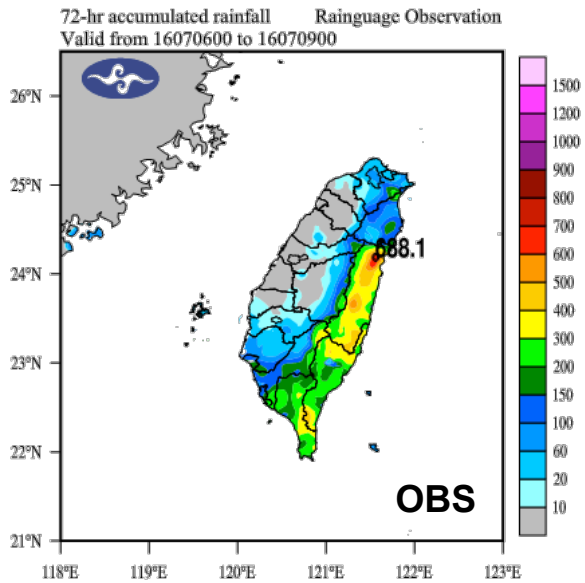
2016 3-day accumulated ETQPF for best track

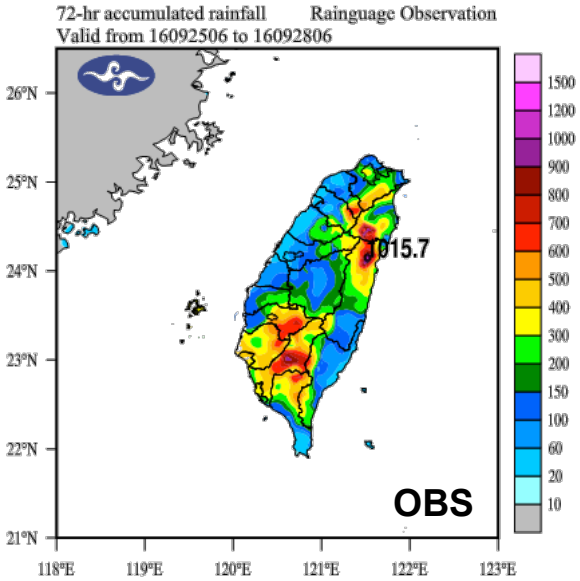


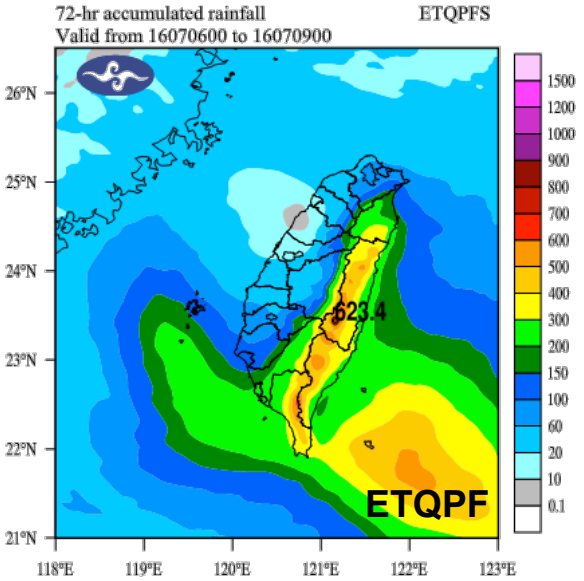
TY Meranti

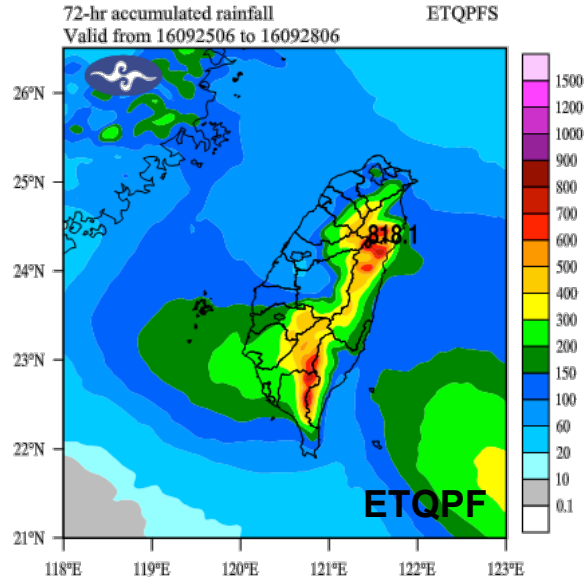
TY Malakas

2016 3-day accumulated ETQPF for best track





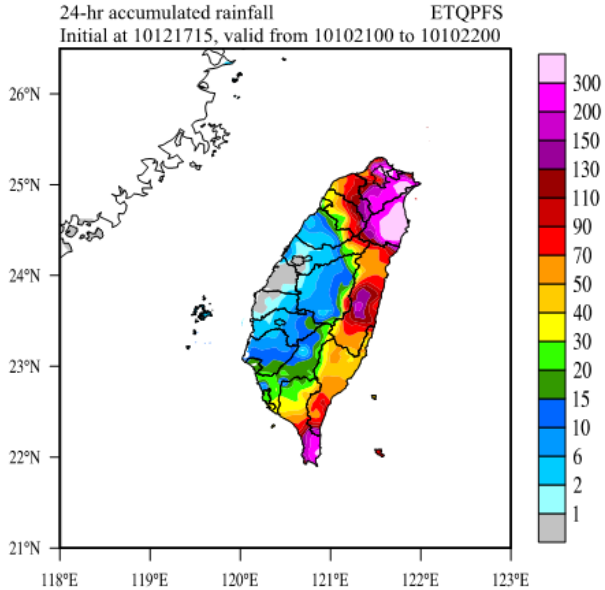




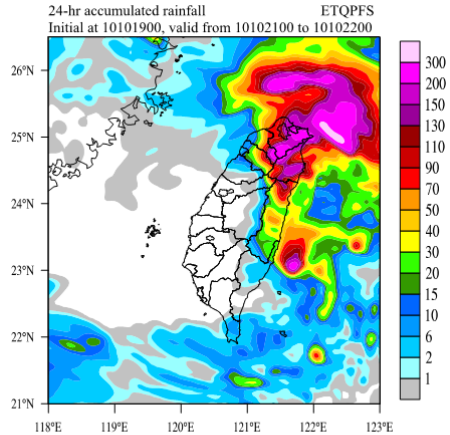
TY Nepartak

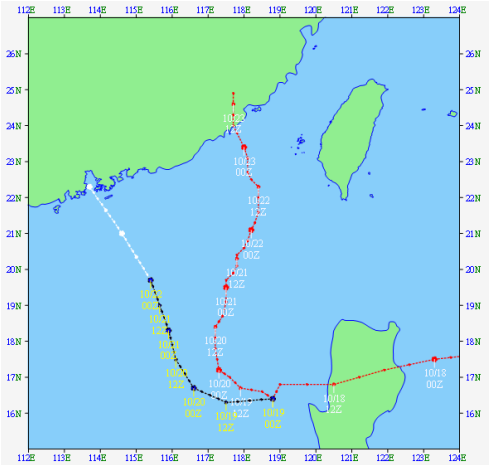
TY Megi

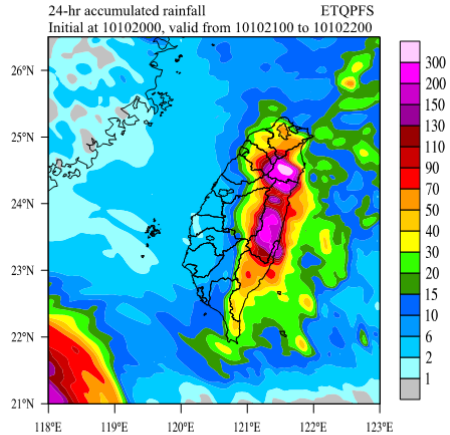
Performance of the ETQPF
With forecast track
(with tract error)

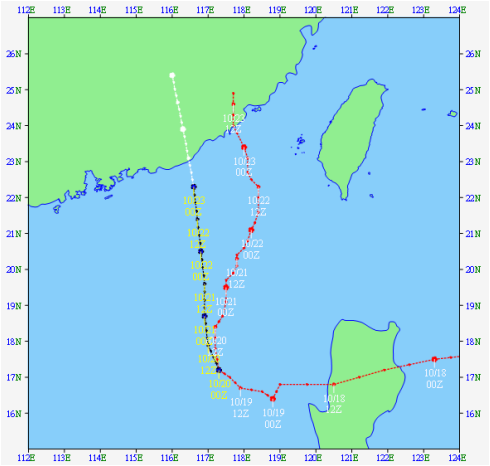


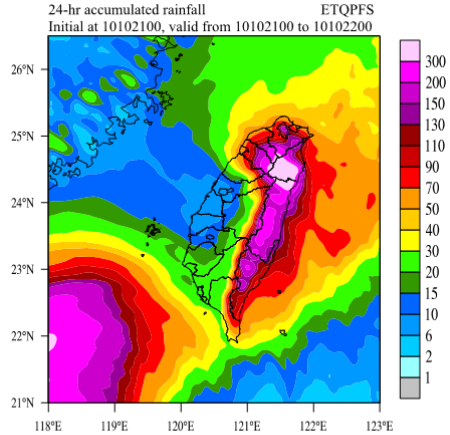
Observation

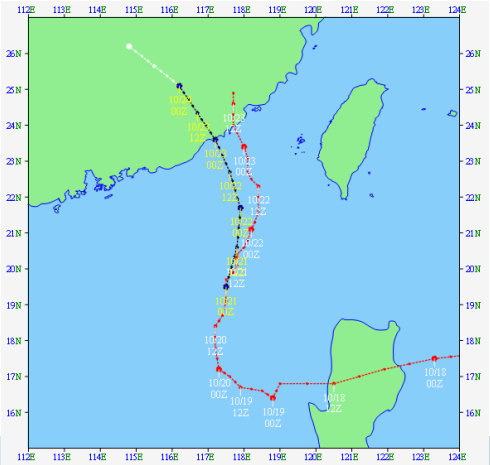




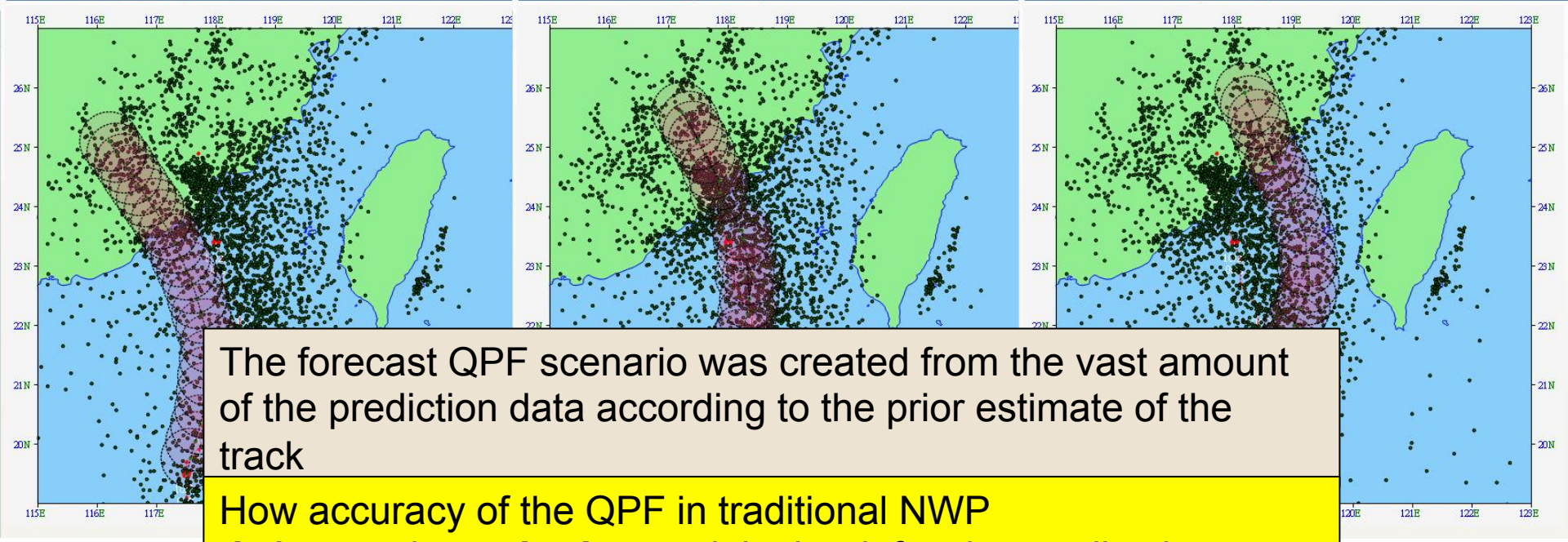








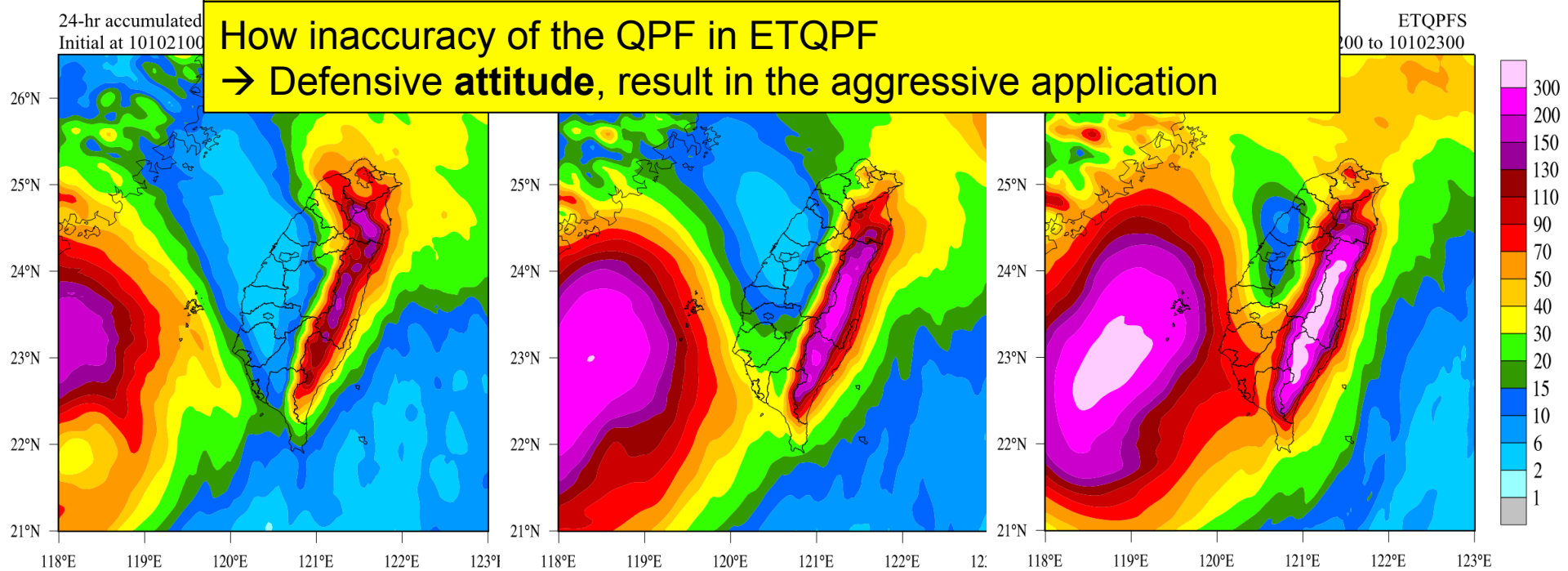
Better estimate of the typhoon track
→Better QPF



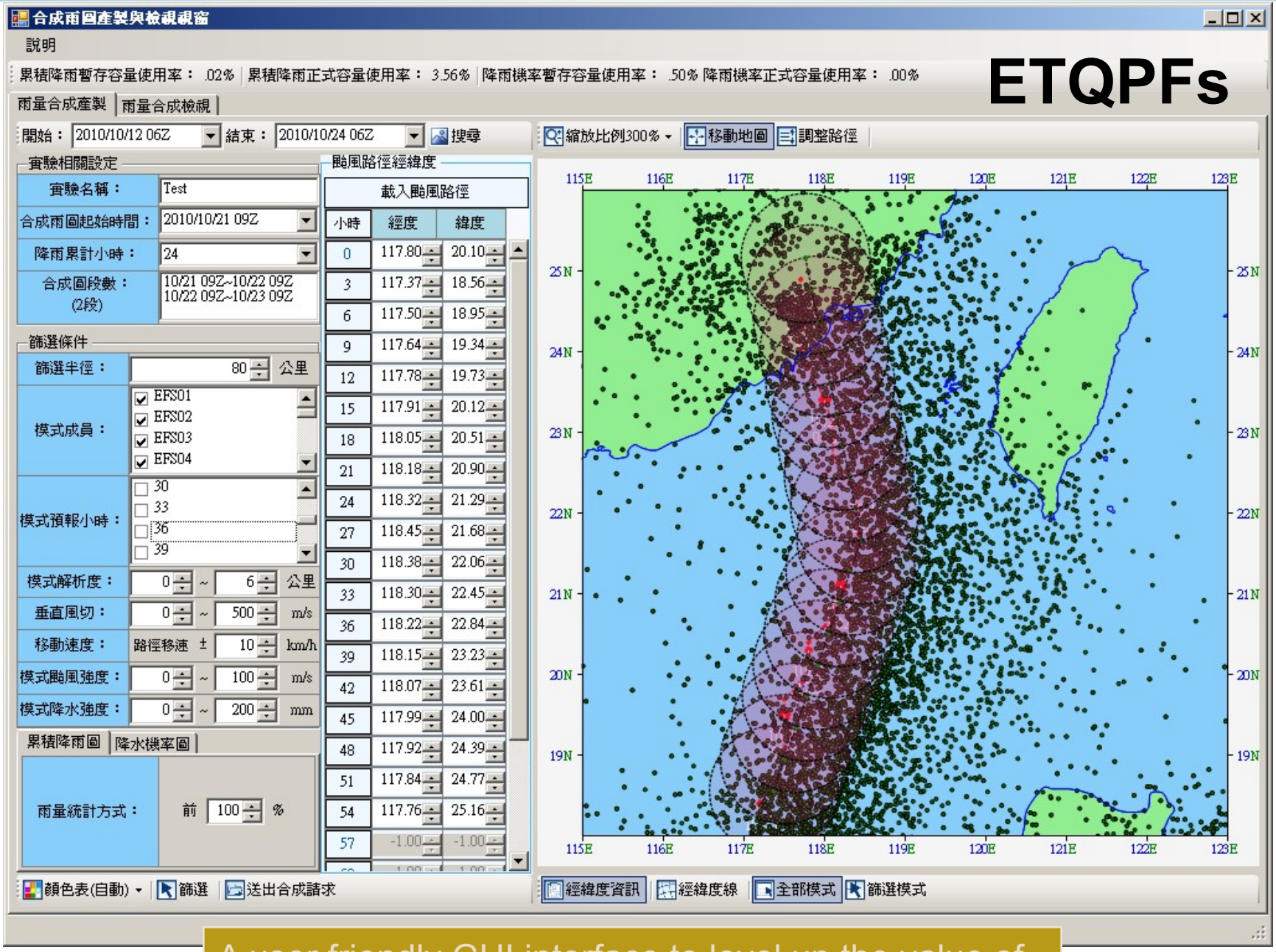
The forecast QPF scenario was created from the vast amount of the prediction data according to the prior estimate of the track

How accuracy of the QPF in traditional NWP
→ Aggressive **attitude**, result in the defensive application

How inaccuracy of the QPF in ETQPF
→ Defensive **attitude**, result in the aggressive application

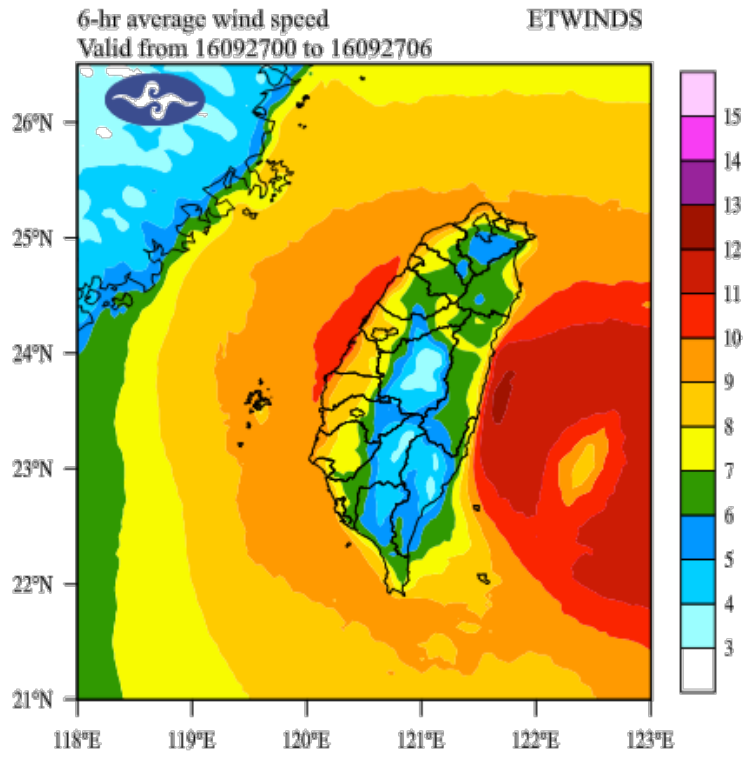


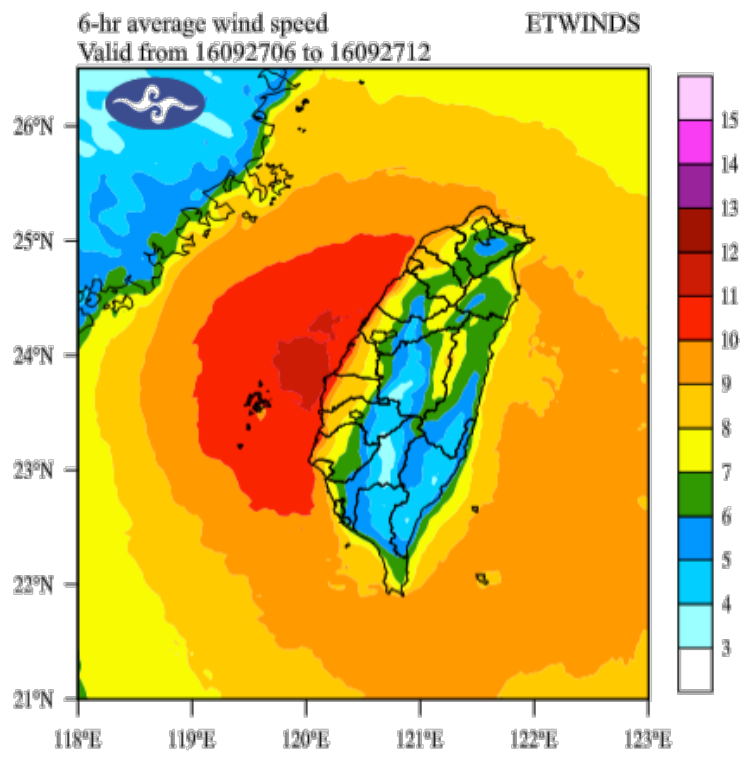
ETQPFs



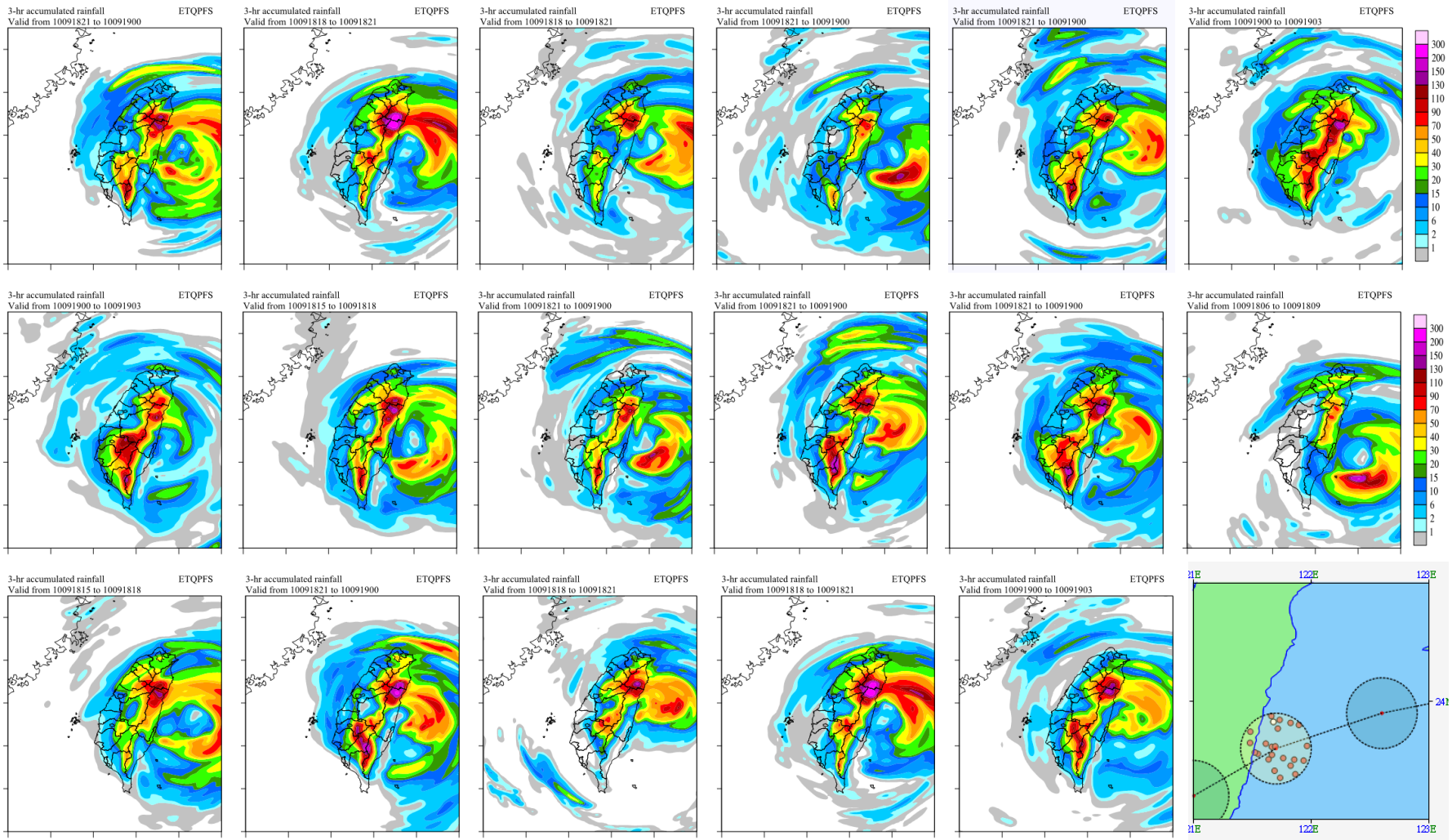
A user friendly GUI interface to level up the value of the ETQPF algorithm

Extend to ETWIND





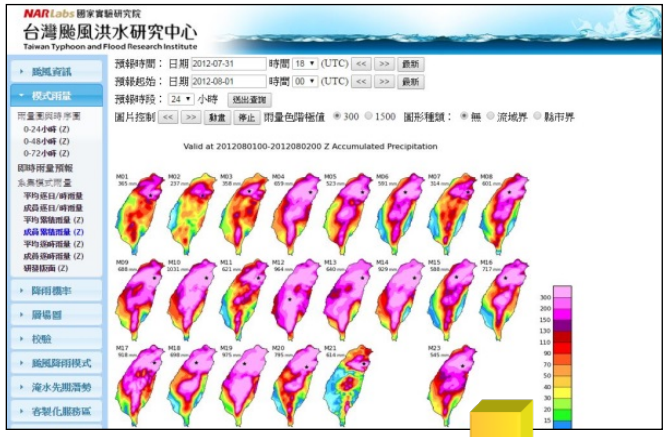
6-hr ETWIND (Maximum wind speed within 6-hr interval) for TY Megi

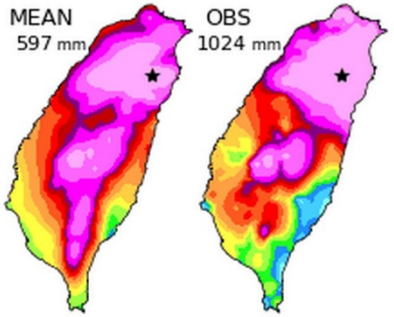


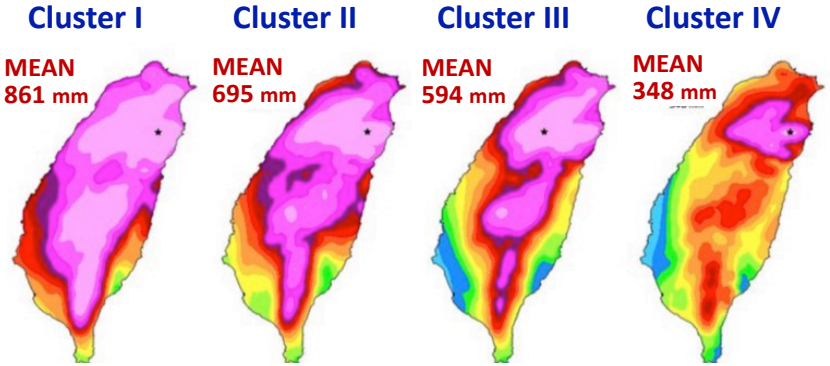
In stead of the uncertainty of the track forecast, something important looks behind the ensemble members……

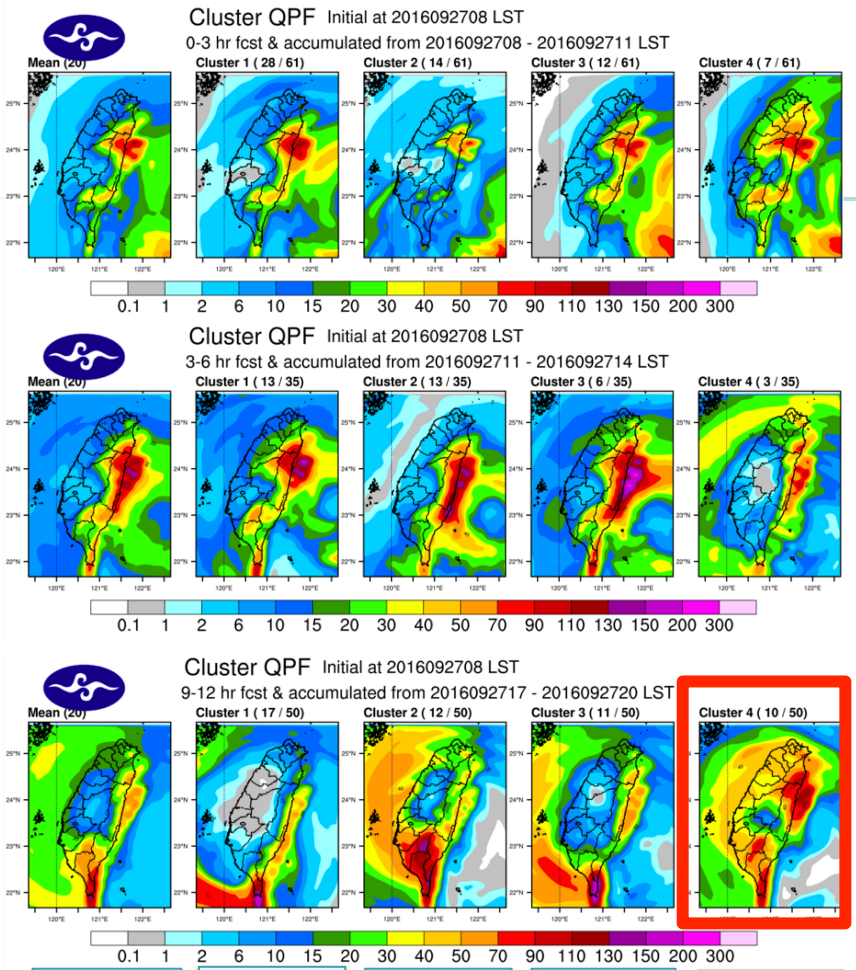
Clustering the ensemble QPF

- To explore the rainfall scenario

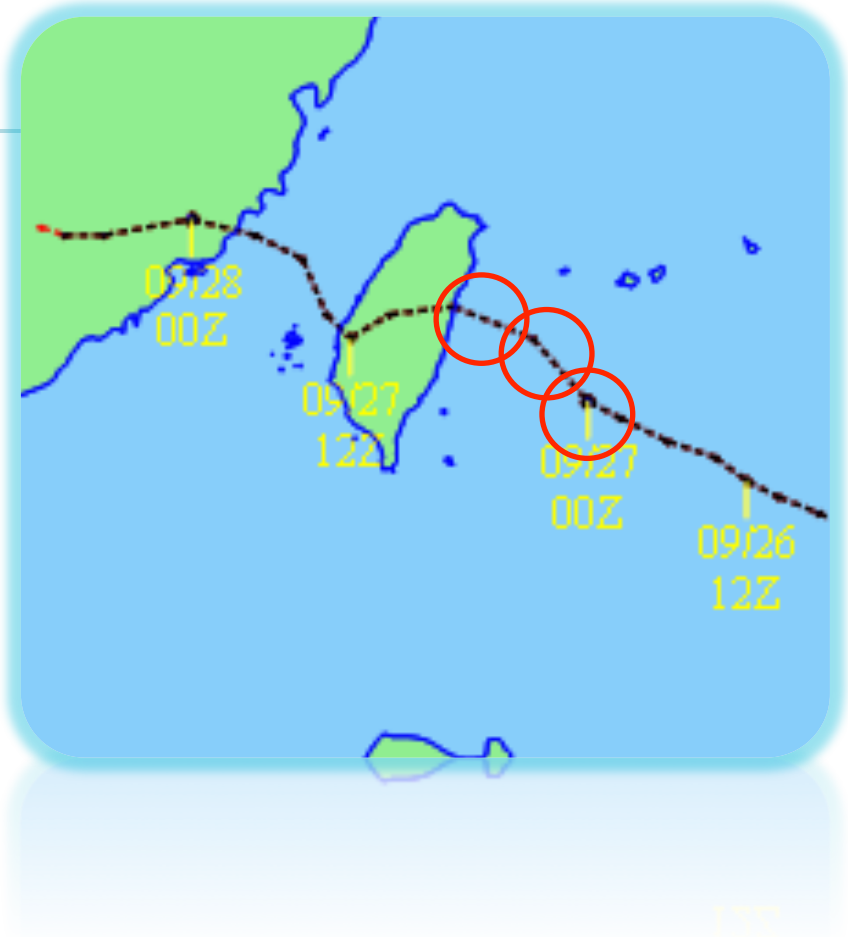




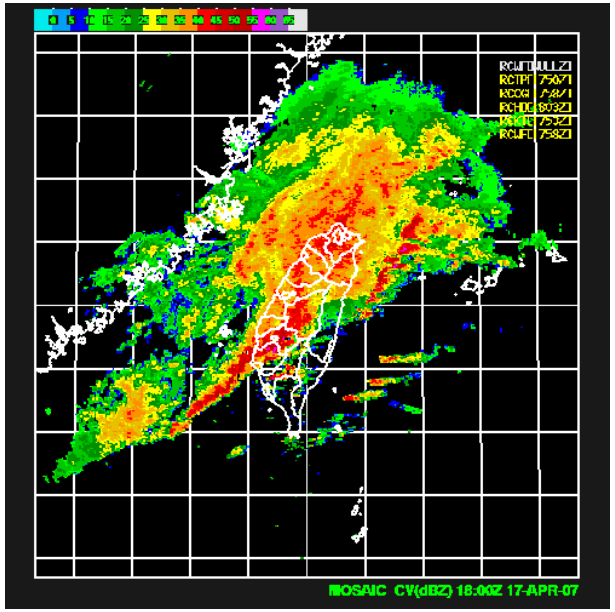


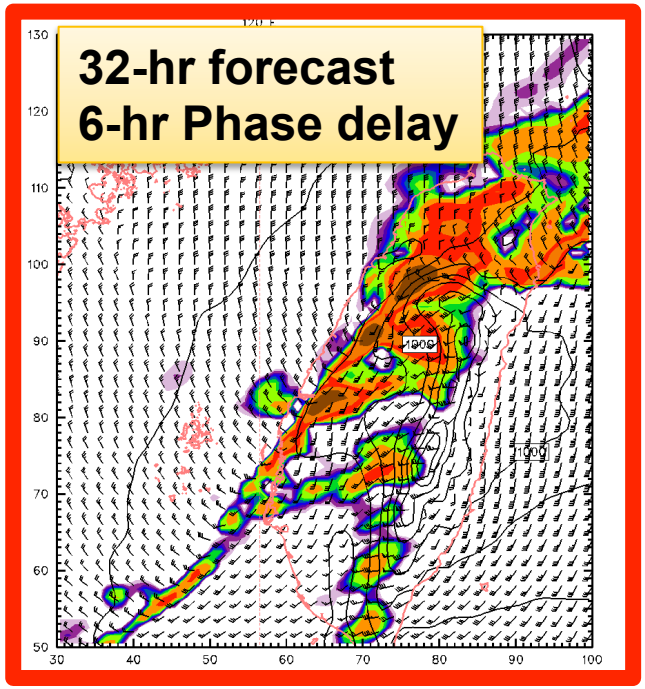


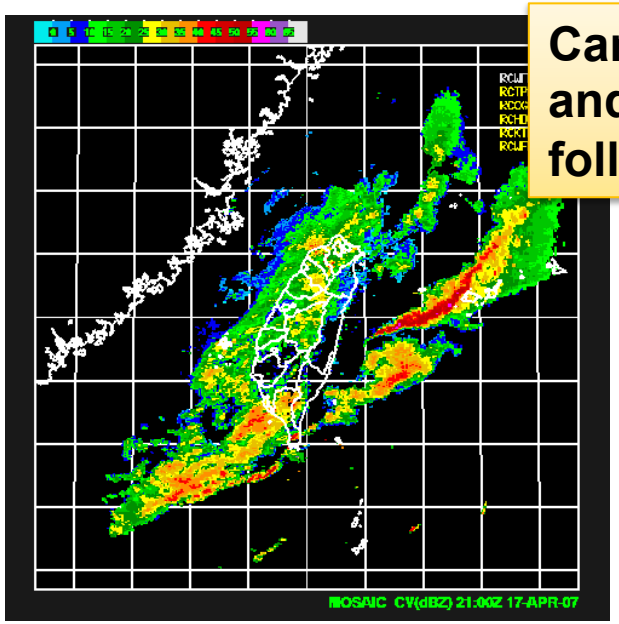
Mean | **17/50** | **12/50** | **11/50** | **10/50**



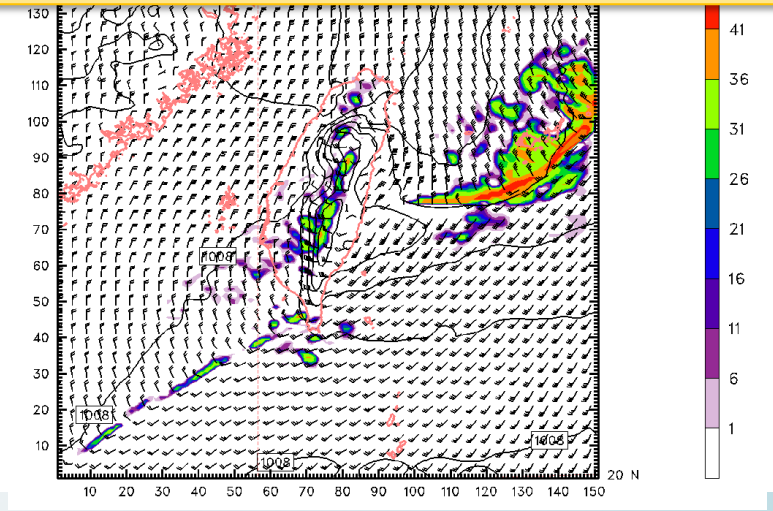
Clustering QPF is workable for **non-typhoon rainfall event**

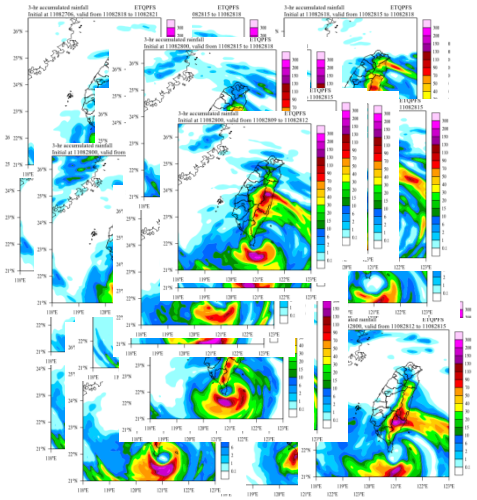




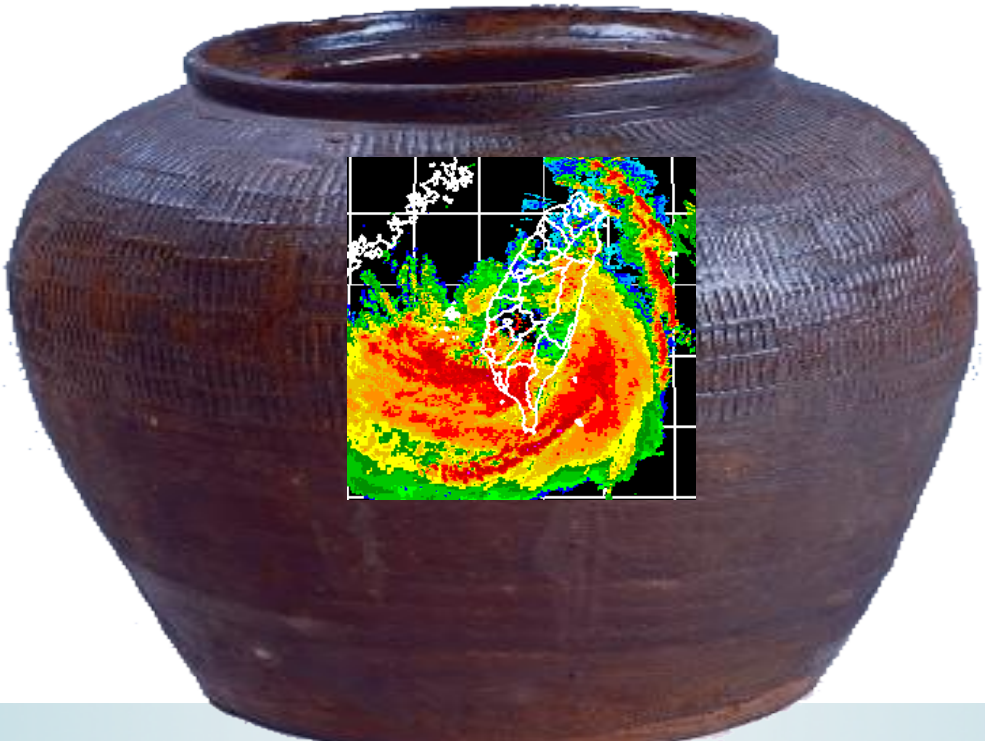


Can we find this member (if exist) in EPS, and assess the performance of the following 6-hr QPF



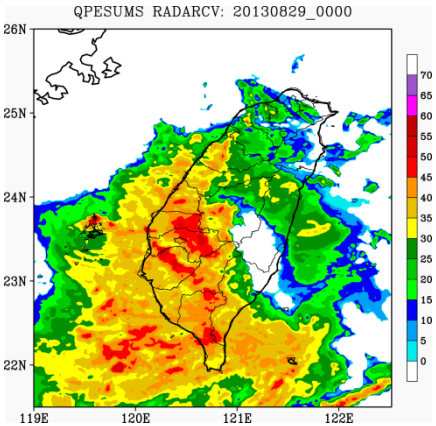


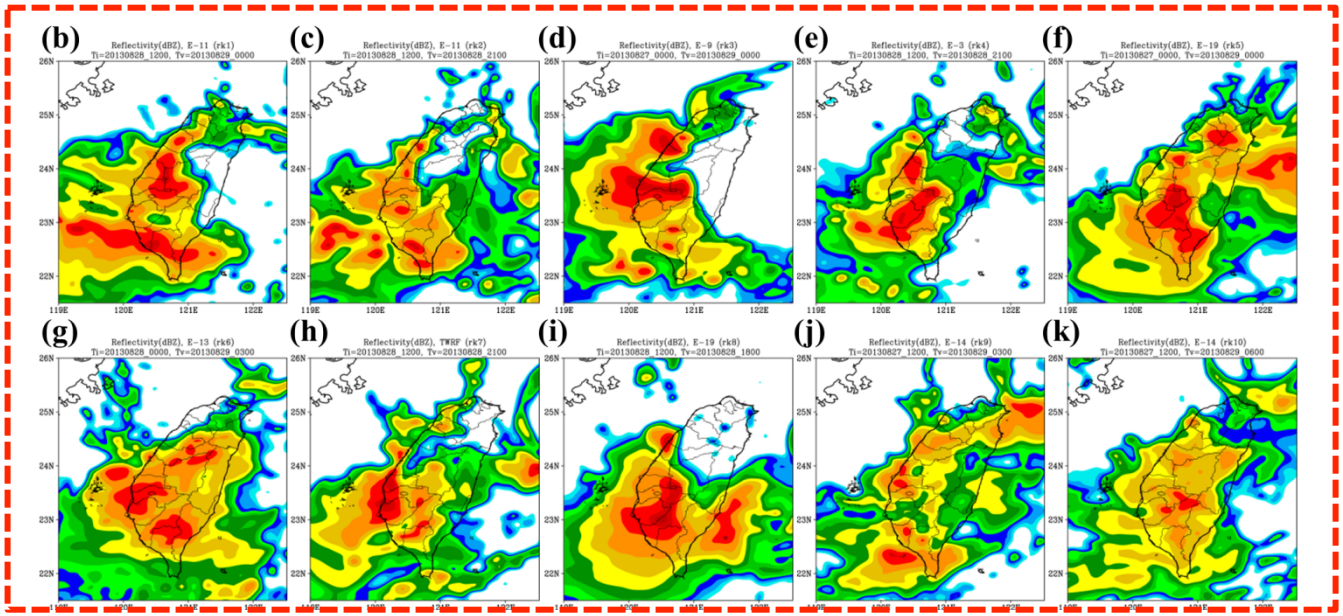
- Construct database to contain the hourly (6-72 hr fcst) predict radar CV from **the recent 10 EPS runs**, e.g.
  - A total of 10 IC*66 fcst*30 members =19800 ensemble cases
- Referring the **realtime** radar CV, using the pattern recognition technique to mining the 19800 ensemble cases and rank the results
- Calculate the 0-3, 0-6 hr QPF according to the selected members



Rank Top 10 of radar CV in Ty Kong-Rey (2013)

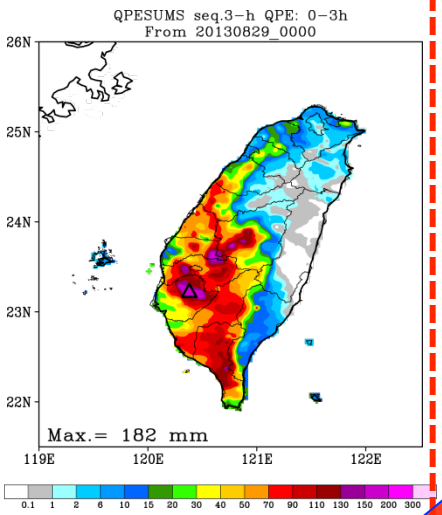
Observed radar CV

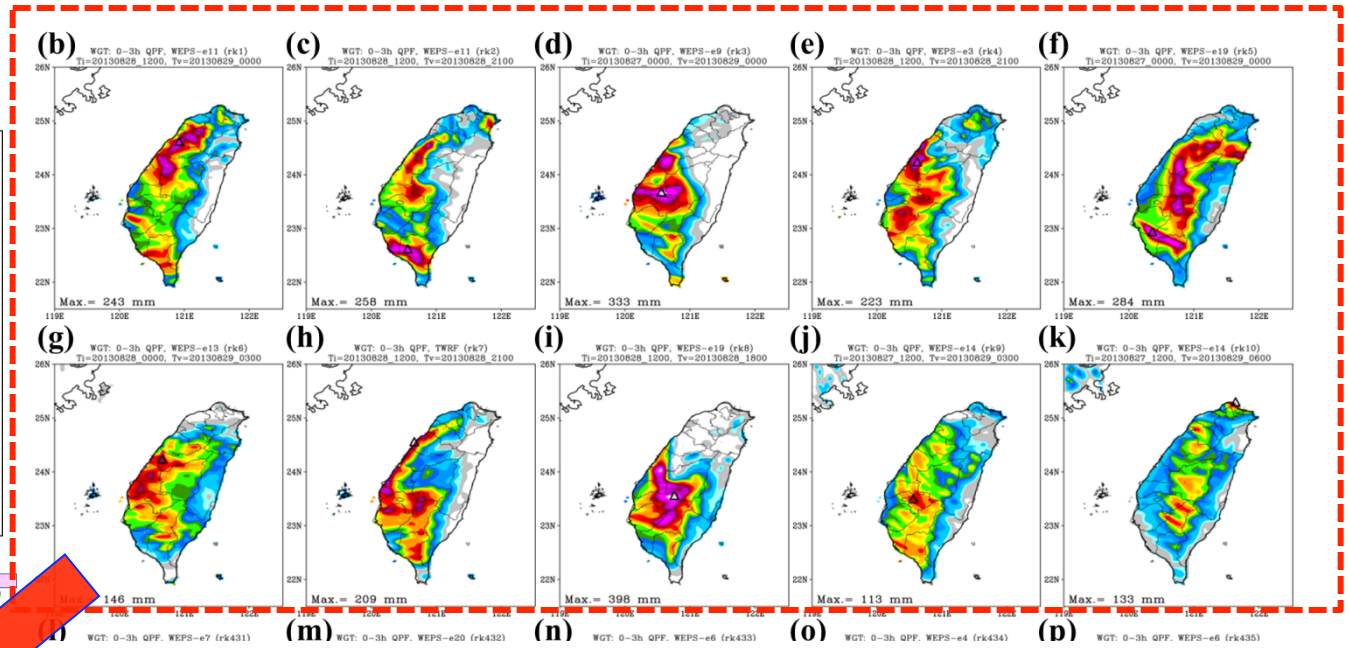




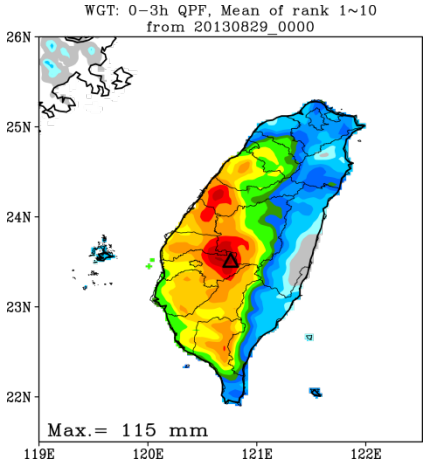
Rank Top 10 of the 3-hr QPE in Ty Kong-Rey (2013)

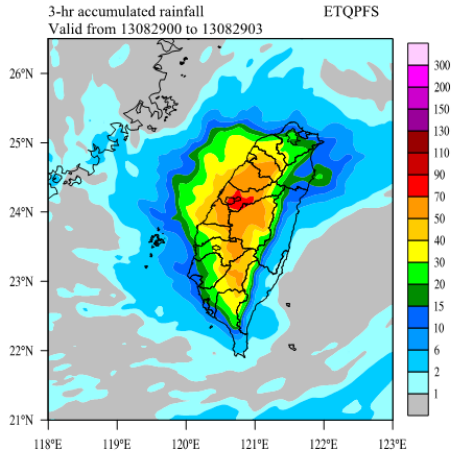
Observed 3-h QPE



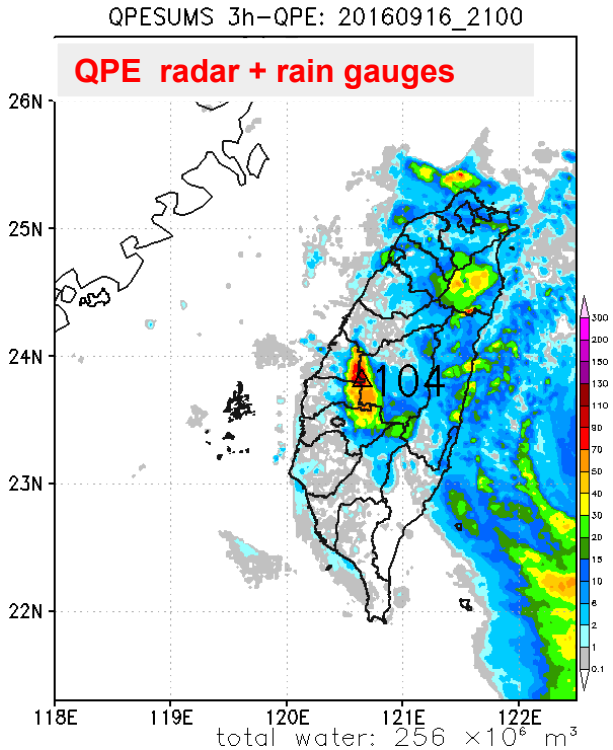


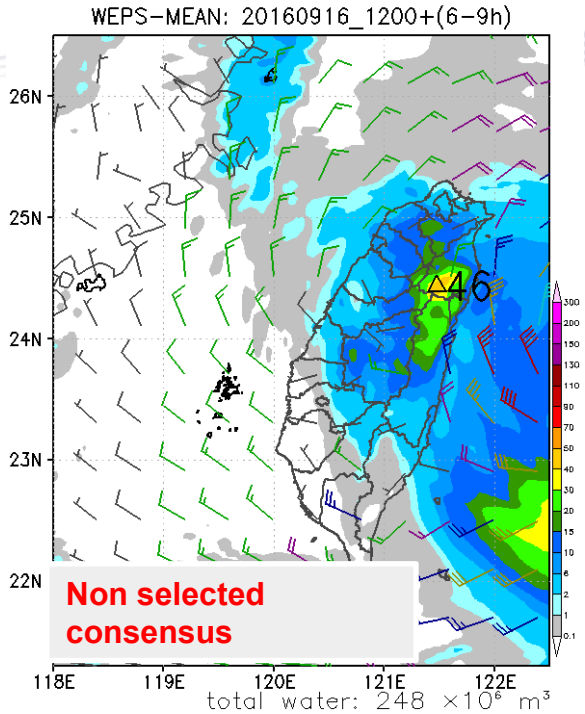
Ensemble mean

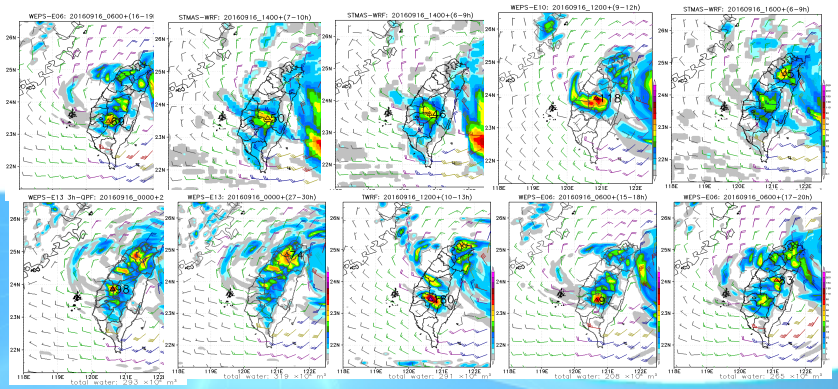




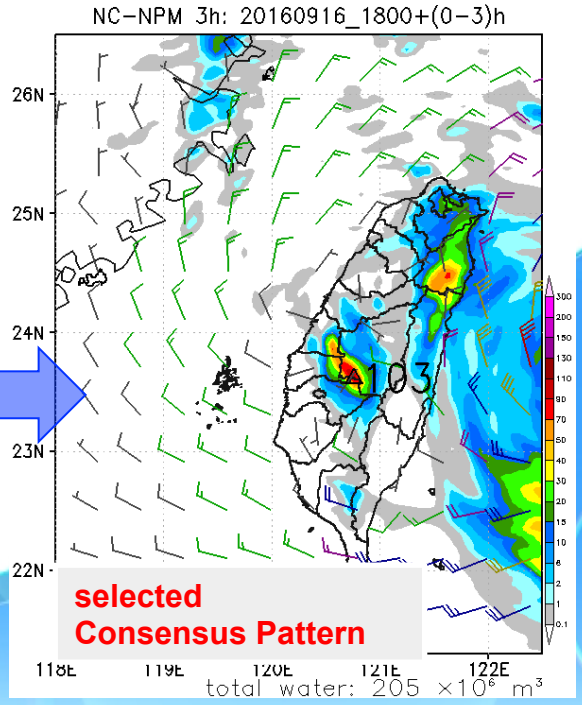
- It takes 1-min to process the pattern matching procedure after the radar MOSAIC arrived
- Using the near-realtime EPS to conduct the QPN (Nowcasting)



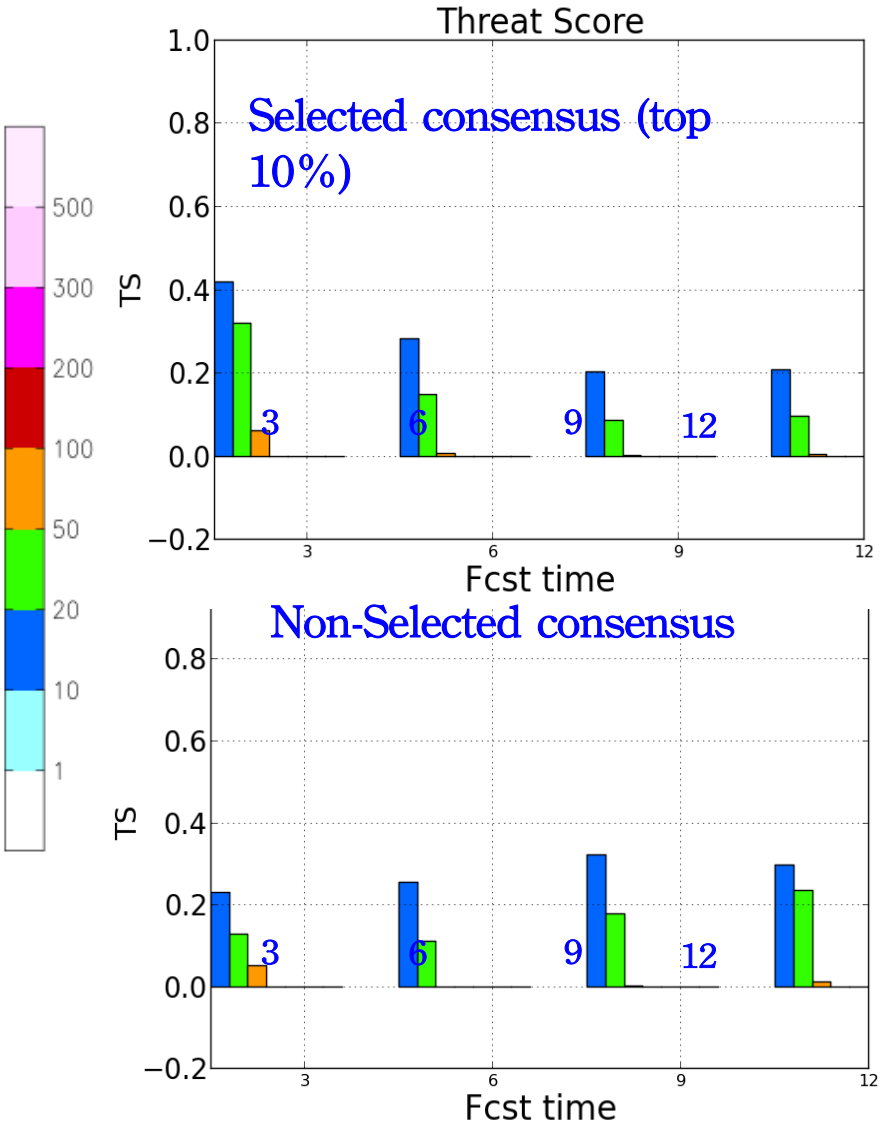


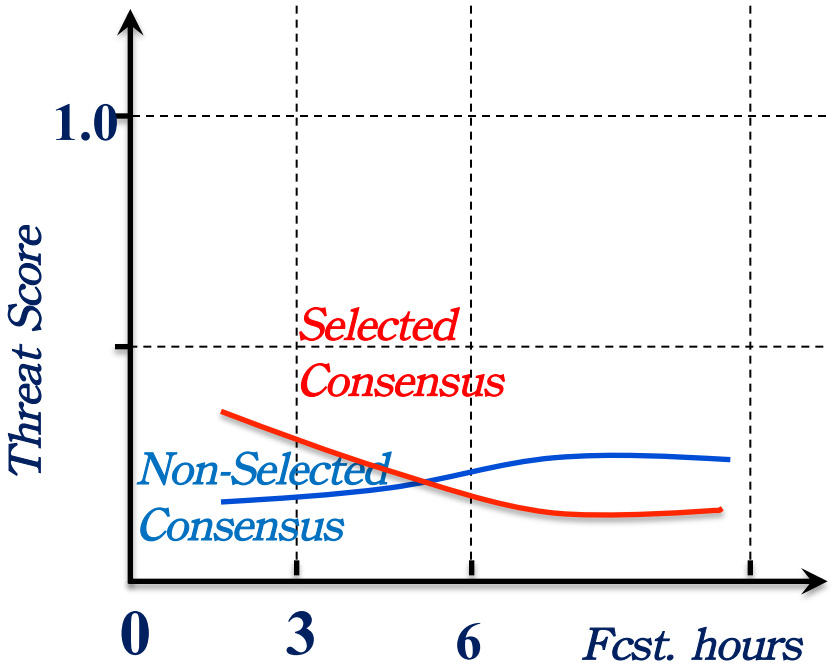


Rank Top 10 members



3-hourly QPF Verification for consensus During a Mei-Yu Front period in May 2015





from 19th12UTC to 25th12UTC May 2015

Threshold : 10 mm/3-h

Summary

- Many ensemble QPF products based on the data mining concept was developed in Central Weather Bureau of Taiwan
- The data mining was strongly driven according to the meteorological domain knowledge
- Applying the AI technique with less domain knowledge is possible to create the new view-point beyond the existed domain knowledge