對流尺度系集預報系統研究：多模式物理參數法之測試評估

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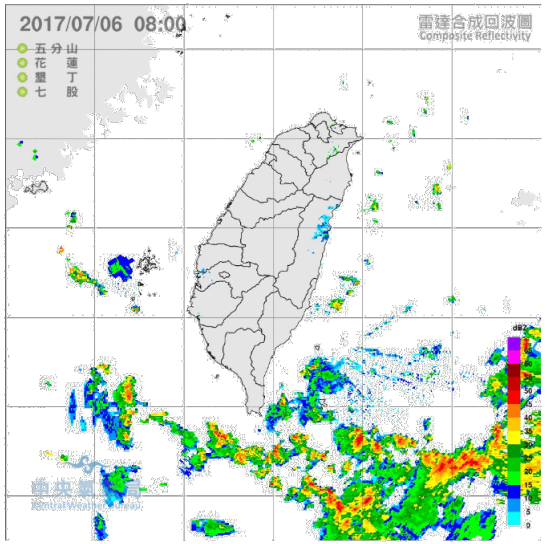
氣象資訊中心

中央氣象局

Convective-scale Ensemble Predict System

- Requirement for the prediction of the high-impact weather system ：
  - Provide the better QPF. (timing, location and quantity)
- Challenge ：
  - Low predictability
    - Diversity of the local circulation from the complex terrain.
    - Multiscale interaction of the weather system.
    - Rapid evolution.
    - …etc
- Solution
  - High resolution model
  - For deterministic : Rapid update cycle with radar/sfc DA
  - For ensemble : To well capture the model uncertainty based on the rapid update system

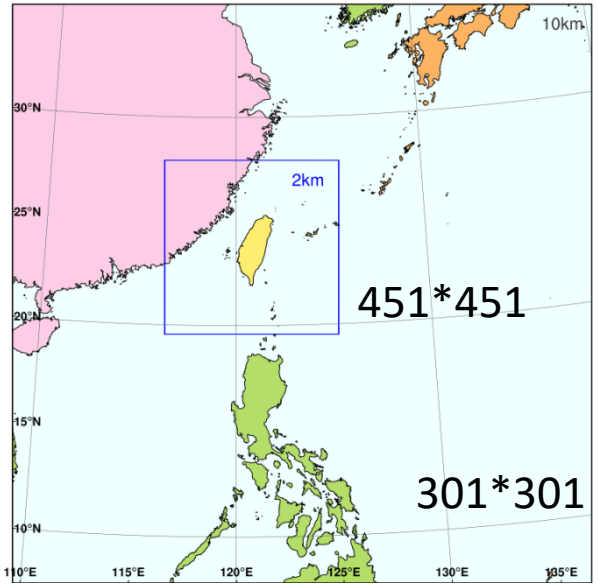


➔ CEPS

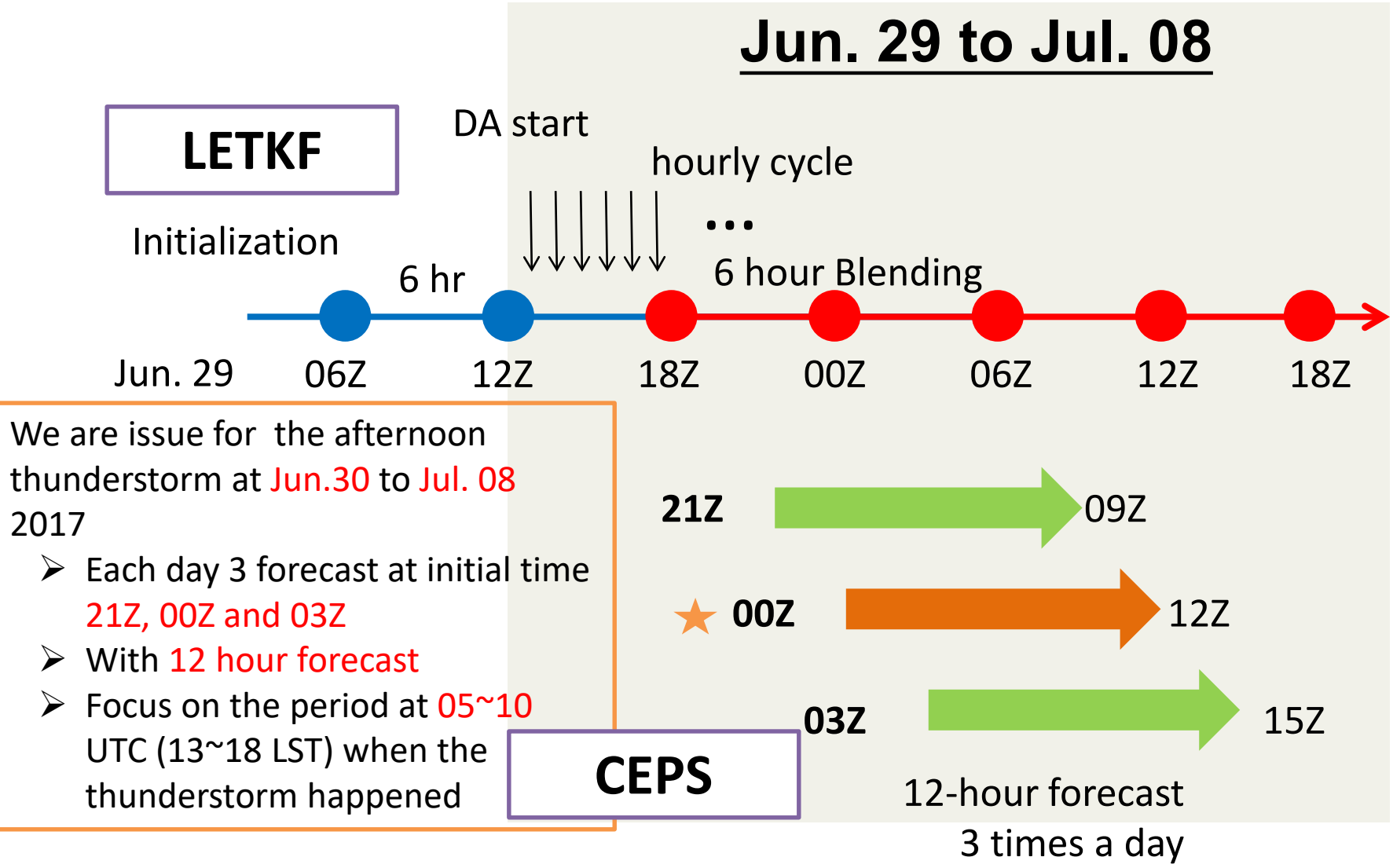
CEPS Configuration

- 16 Ensemble members
- 52 vertical levels
- Deterministic 10 km mesh :
  - Downscale WRF forecast from the NCEP GFS for provide the BC of 2km grid
- Ensemble 2 km mesh :
  - BC from the 10-km WRF deterministic forecast.
  - IC form LETKF analysis field ,

    Hourly update with Surface DA& Radar DA
  - **Model perturbation**
    - **Stochastic**
    - **…**



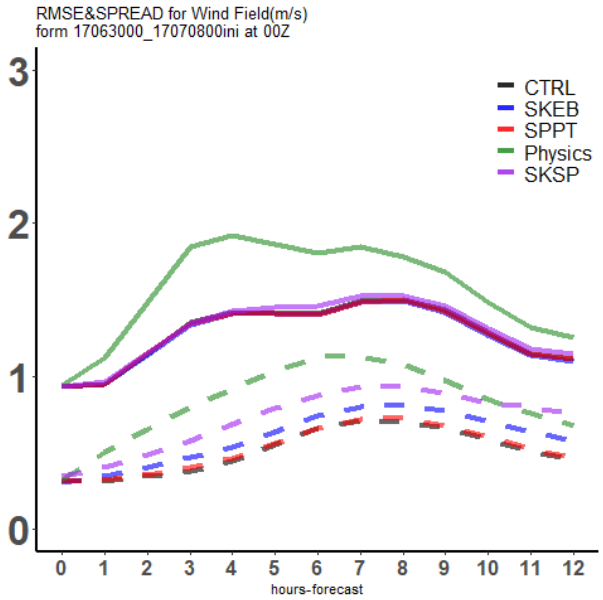
Case Study



- We are issue for the afternoon thunderstorm at Jun.30 to Jul. 08 2017
  - Each day 3 forecast at initial time 21Z, 00Z and 03Z
  - With 12 hour forecast
  - Focus on the period at 05~10 UTC (13~18 LST) when the thunderstorm happened

Stochastic perturbation

EXP	IC pert.	Model pert.	LBC pert.	Lower BDY pert.
Ctrl	LETKF 16/32	X	X	X
SPPT	Same as Ctrl	SPPT	X	X
SKEB	Same as Ctrl	SKEB	X	X
SKSP	Same as Ctrl	SKEB+SPPT	X	X
Multi-Physics	Same as Ctrl	3 PBL (YSU, MYJ, MYNN2) 2 MPS (Goddard, WSM5)	X	X



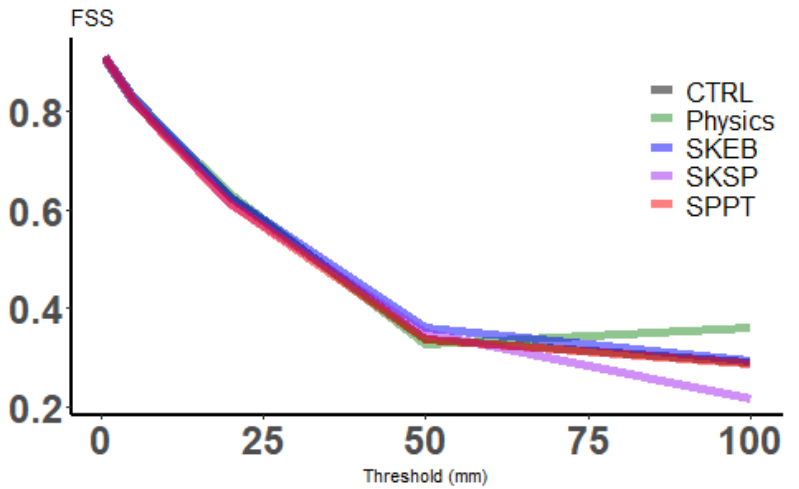
Stochastic perturbation can increase SPRD and no effect on RMSE.

SKEB is more effective than SPPT.

➔ SPRD ↑ RMSE –

Physics setting is ref to WEPS.

➔ SPRD ↑ RMSE ↑



More about multi-Physics…

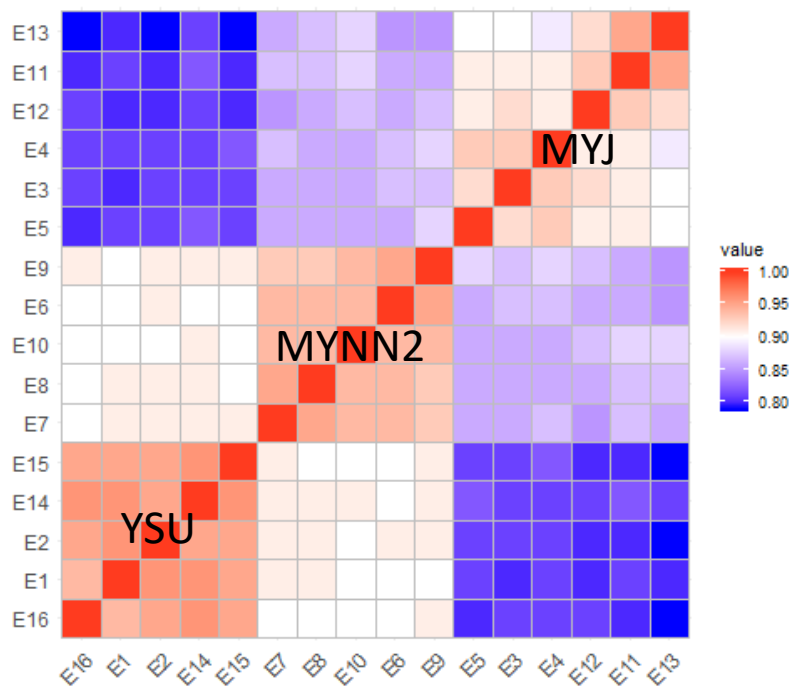
- To test the spread of multi-Physics setting, we build the **Correlation matrix.**
  - ➢ Correlation of each members on surface parameters

- Verify by Correlation matrix & hierarchical clustering(HC)

EN	PBL	Surface layer	Microphysics
1	YSU	MM5	Goddard
2	YSU	MM5	Goddard
3	MYJ	MM5	Goddard
4	MYJ	MM5	Goddard
5	MYJ	MM5	Goddard
6	MYNN	MYNN	Goddard
7	MYNN	MYNN	Goddard
8	MYNN	MYNN	Goddard
9	MYNN	MYNN	WSM6
10	MYNN	MYNN	WSM6
11	MYJ	MM5	WSM6
12	MYJ	MM5	WSM6
13	MYJ	MM5	WSM6
14	YSU	MM5	WSM6
15	YSU	MM5	WSM6
16	YSU	MM5	WSM6

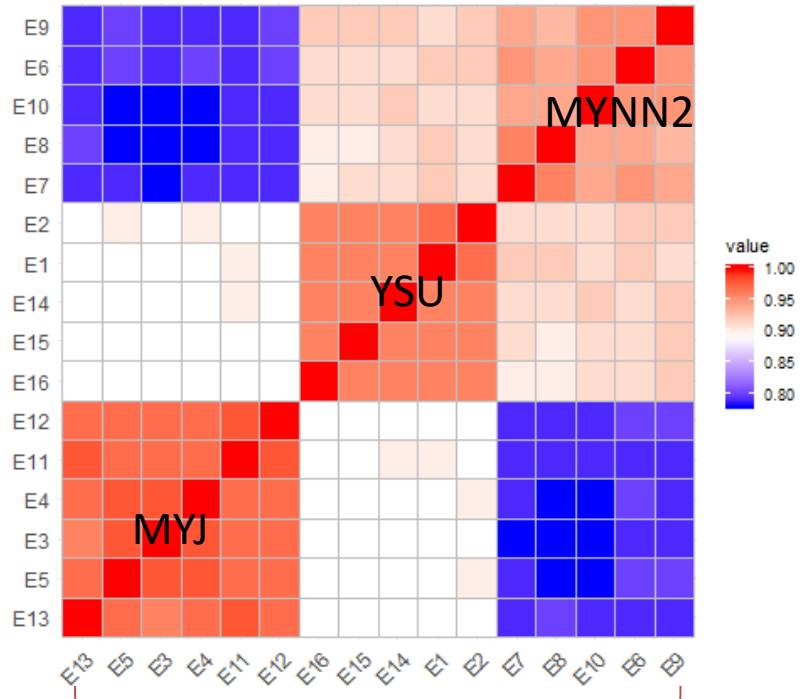
More about multi-Physics…

10m Wind speed



All the members in this box use YSU PBL scheme

Mixing Ratio



Order of Members sorting by HC

We need more spread at the multi-physics setting.

EN	PBL	Surface layer	Microphysics
1	YSU	MM5	Goddard
2	YSU	MM5	Goddard
3	MYJ	MM5	Goddard
4	MYJ	MM5	Goddard
5	MYJ	MM5	Goddard
6	MYNN	MYNN	Goddard
7	MYNN	MYNN	Goddard
8	MYNN	MYNN	Goddard
9	MYNN	MYNN	WSM6
10	MYNN	MYNN	WSM6
11	MYJ	MM5	WSM6
12	MYJ	MM5	WSM6
13	MYJ	MM5	WSM6
14	YSU	MM5	WSM6
15	YSU	MM5	WSM6
16	YSU	MM5	WSM6

5PBL

4MP

EN	PBL	Surface layer	Microphysics
1	YSU	MM5	Goddard
2	MYNN	MYNN	WSM6
3	MYNN3	MYNN	Morrision
4	Shin-Hong	MM5	NSSL
5	BouLac	MM5	Goddard
6	YSU	MM5	WSM6
7	MYNN	MYNN	Morrision
8	MYNN3	MYNN	NSSL
9	Shin-Hong	MM5	Goddard
10	BouLac	MM5	WSM6
11	YSU	MM5	Morrision
12	MYNN	MYNN	NSSL
13	MYNN3	MYNN	Goddard
14	Shin-Hong	MM5	WSM6
15	BouLac	MM5	Morrision
16	MYNN3	MYNN	NSSL

Physics Parameter update

- PBL
  - YSU, ~~MYJ,~~ MYNN

  + MYNN3, Shin-Hong, BouLac

- MP
  - Goddard, WSM6

  + Morrision, NSSL

	5PBL		4MP
EN	PBL	Surface layer	Microphysics
1	YSU	MM5	Goddard
2	MYNN	MYNN	WSM6
3	MYNN3	MYNN	Morrision
4	Shin-Hong	MM5	NSSL
5	BouLac	MM5	Goddard
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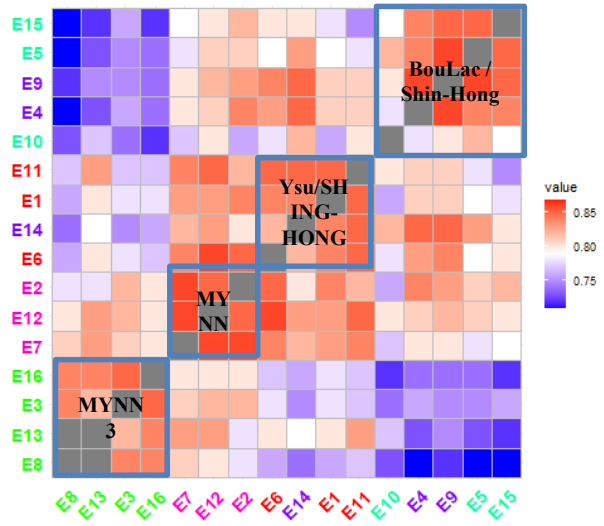
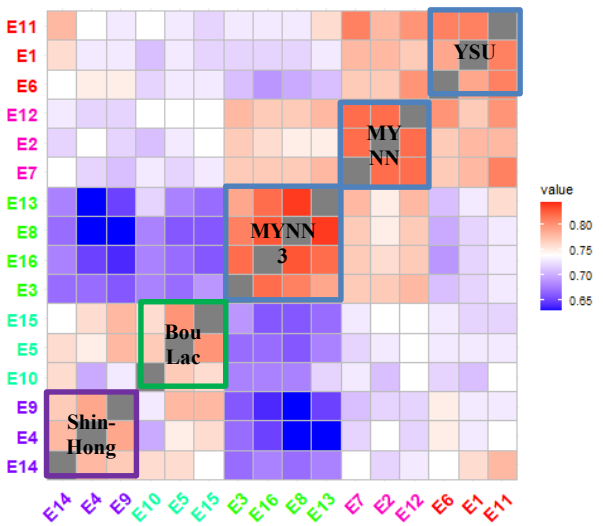
9	Shin-Hong	MM5	Goddard
10	BouLac	MM5	WSM6
11	YSU	MM5	Morrision
12	MYNN	MYNN	NSSL
13	MYNN3	MYNN	Goddard
14	Shin-Hong	MM5	WSM6
15	BouLac	MM5	Morrision
16	MYNN3	MYNN	NSSL

5PBL - correlation matrix by HC

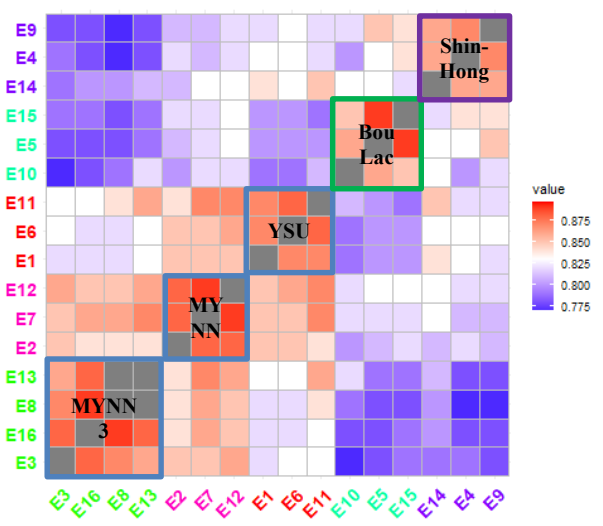
CAPE



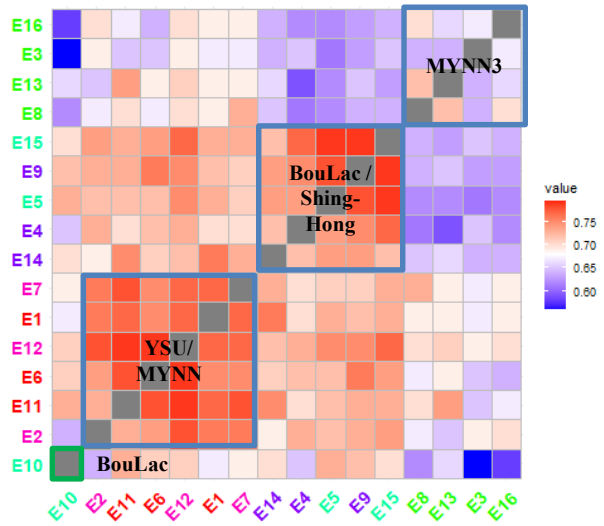
10m U



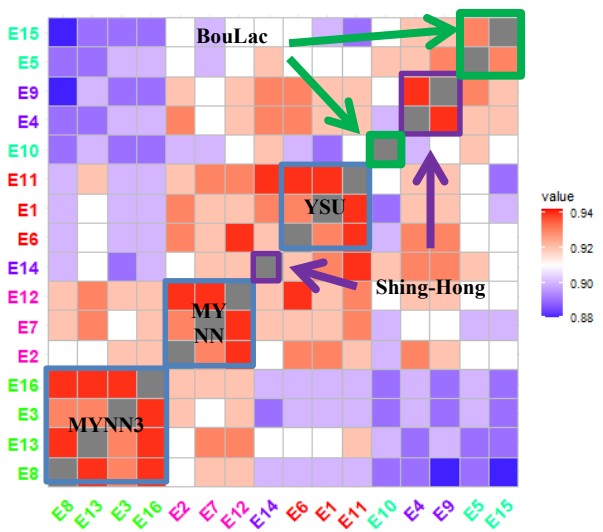
10m V



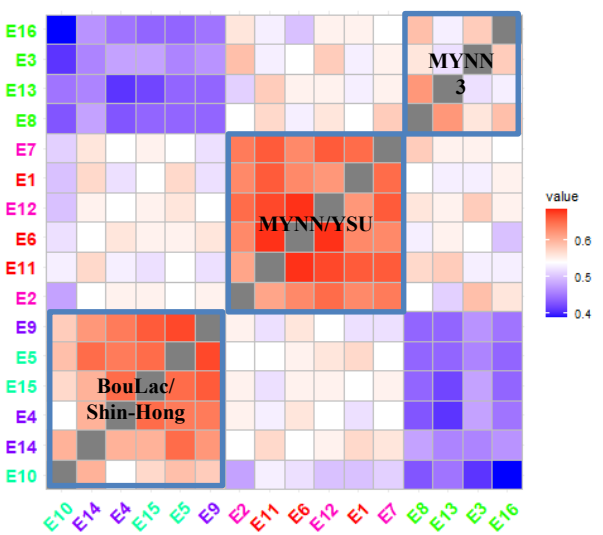
reflectivity



2m Mixing ratio

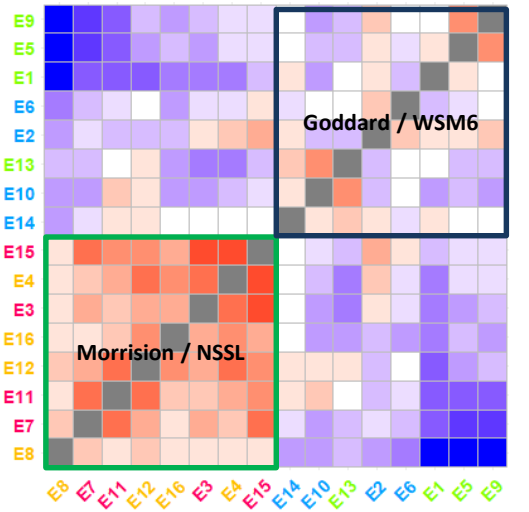


Totol rainfall

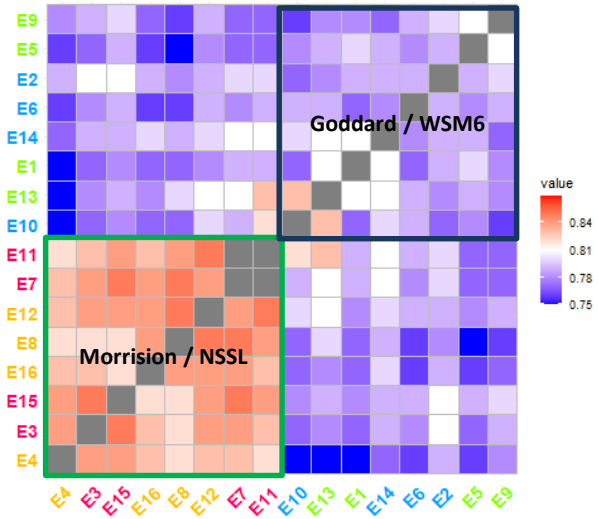


4MP - correlation matrix by HC

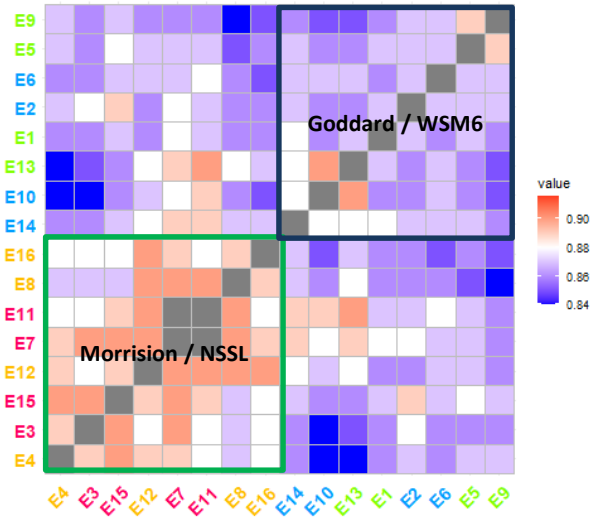
CAPE



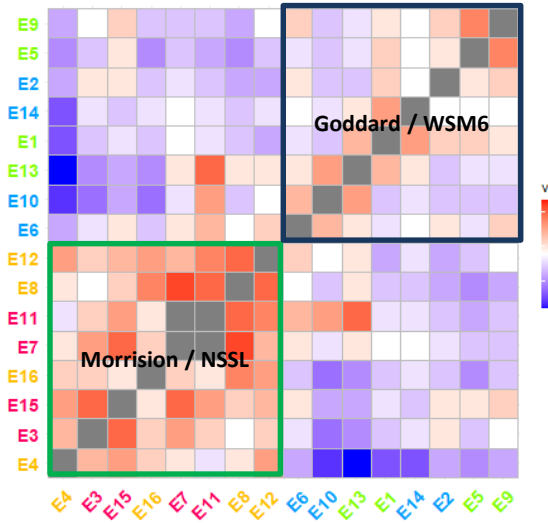
10m U



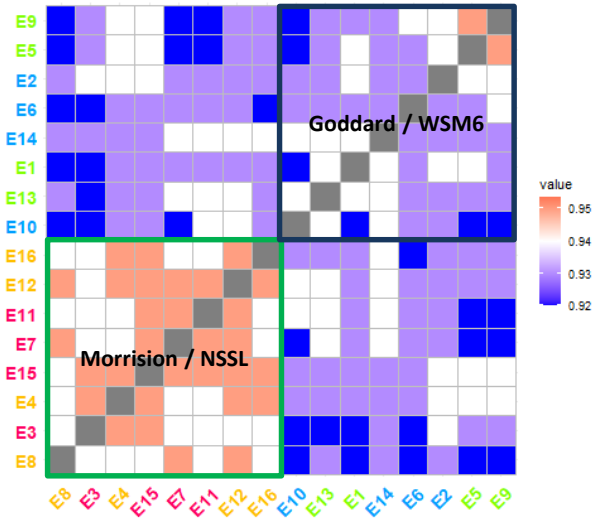
10m V



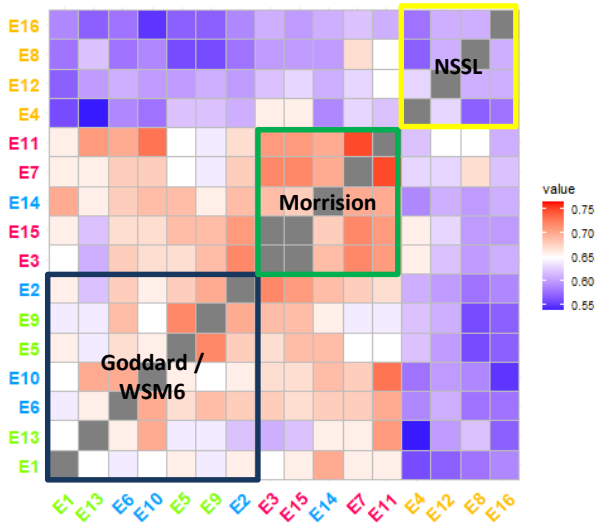
reflectivity



2m Mixing ratio



Totol rainfall



Physics Parameter update

- PBL
  - YSU, ~~MYJ,~~ MYNN

  + MYNN3, Shin-Hong, BouLac

- MP
  - Goddard, WSM6

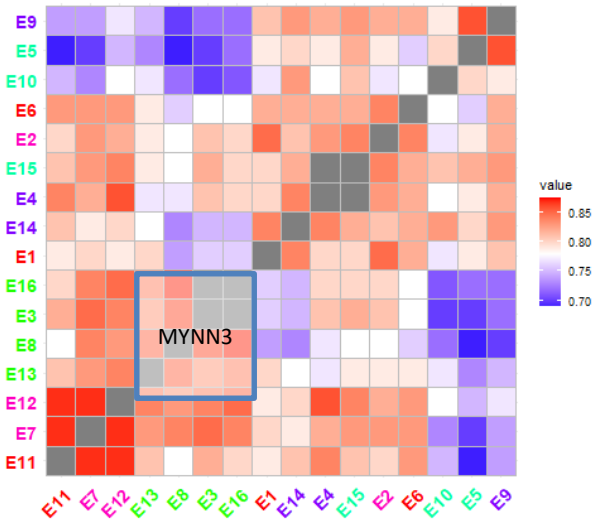
  + Morrision, NSSL

- **5PBL+4MP → P5M4**

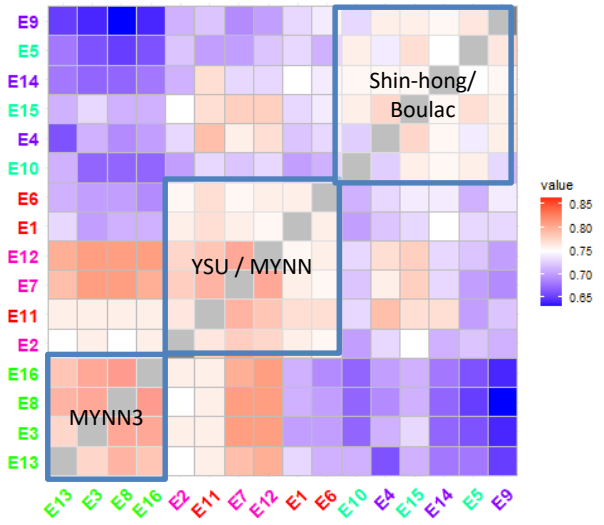
	5PBL		4MP
EN	PBL	Surface layer	Microphysics
1	YSU	MM5	Goddard
2	MYNN	MYNN	WSM6
3	MYNN3	MYNN	Morrision
4	Shin-Hong	MM5	NSSL
5	BouLac	MM5	Goddard
6	YSU	MM5	WSM6
7	MYNN	MYNN	Morrision
8	MYNN3	MYNN	NSSL
9	Shin-Hong	MM5	Goddard
10	BouLac	MM5	WSM6
11	YSU	MM5	Morrision
12	MYNN	MYNN	NSSL
13	MYNN3	MYNN	Goddard
14	Shin-Hong	MM5	WSM6
15	BouLac	MM5	Morrision
16	MYNN3	MYNN	NSSL

P5M4 - correlation matrix by HC

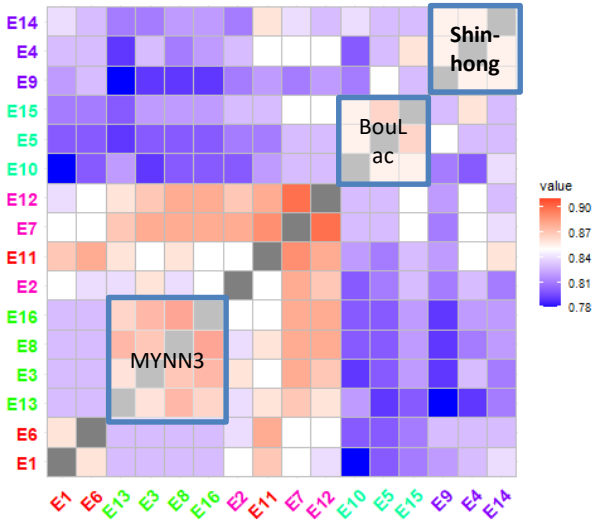
CAPE



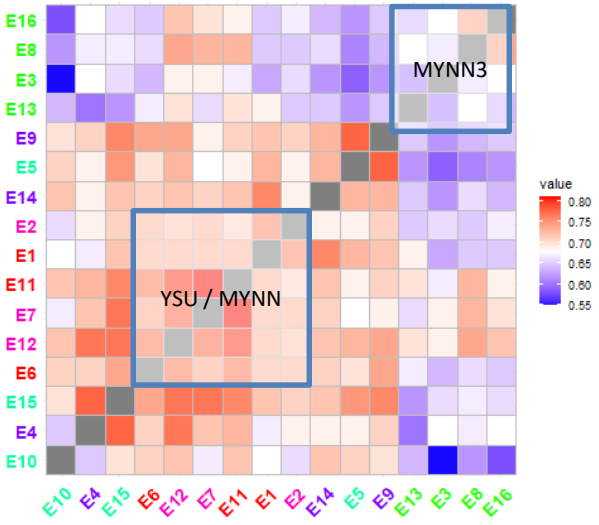
10m U



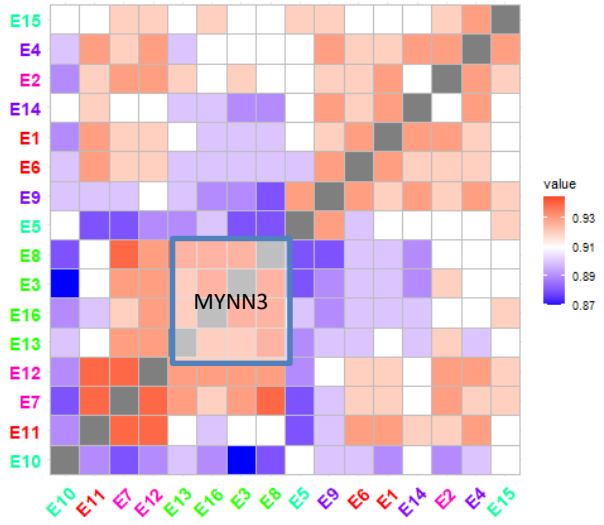
10m V



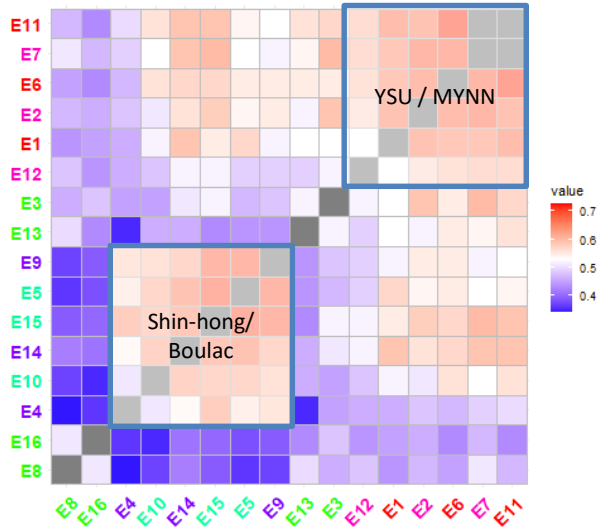
reflectivity

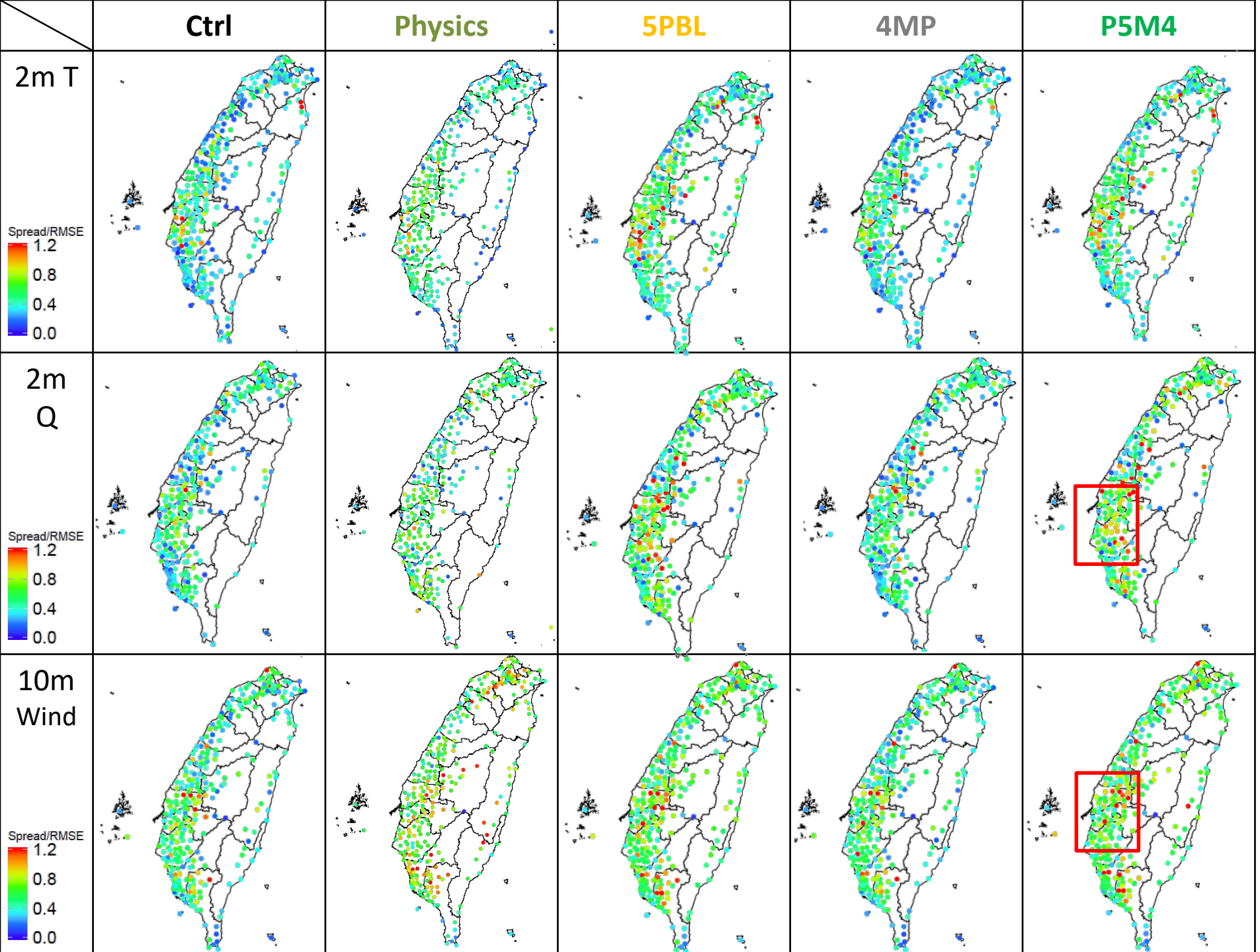


2m Mixing ratio

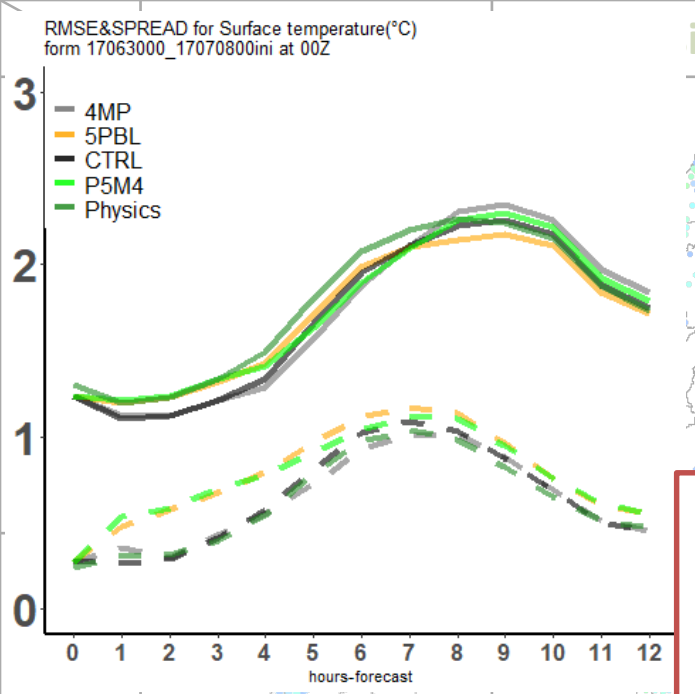


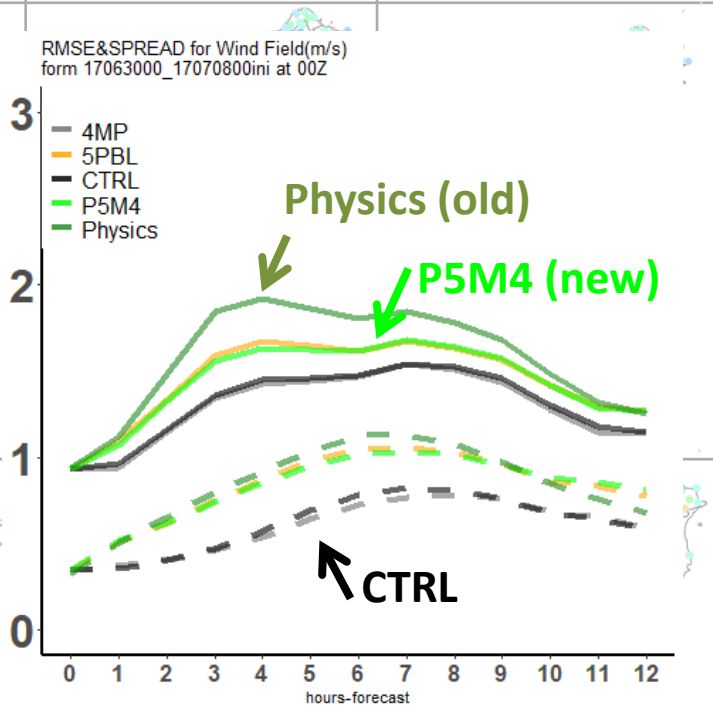
Totol rainfall



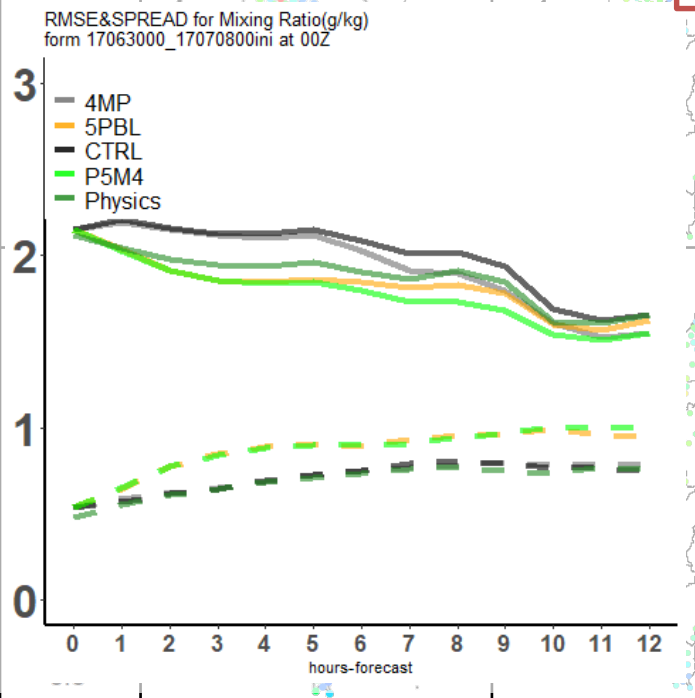

Ctrl
Physics
5PBL
4MP
P5M4
2m T
2m Q
10m Wind
Spread/RMSE
1.2
0.8
0.4
0.0

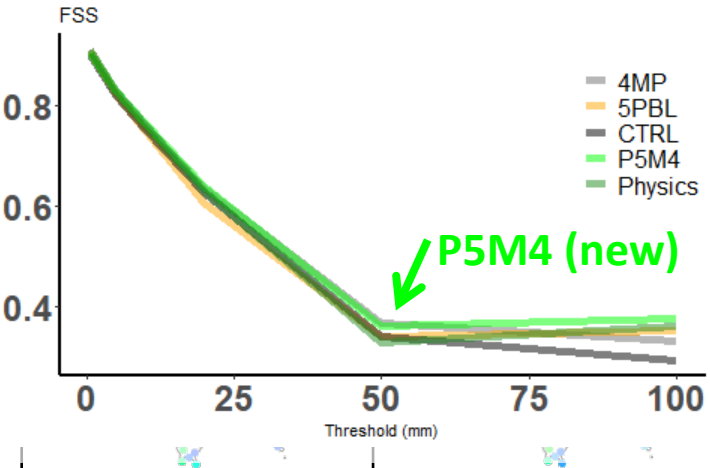
ics | 5PBL | 4MP | P5M4

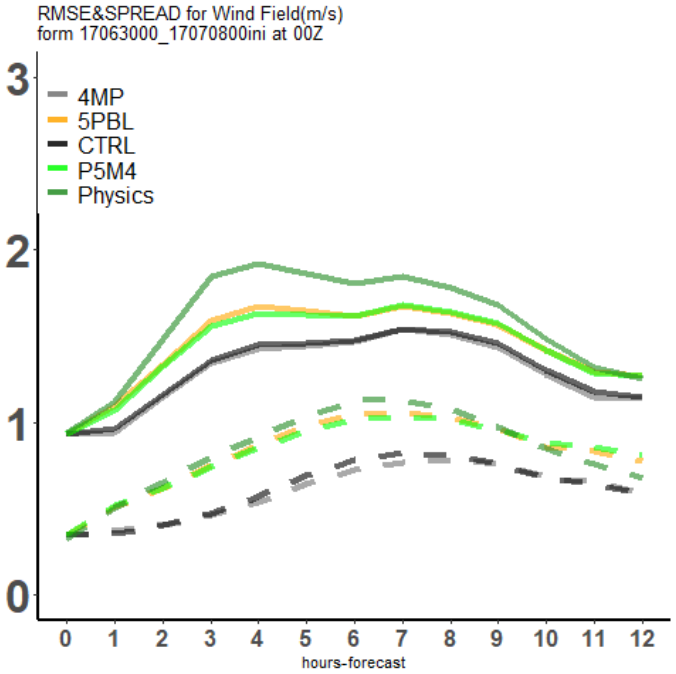


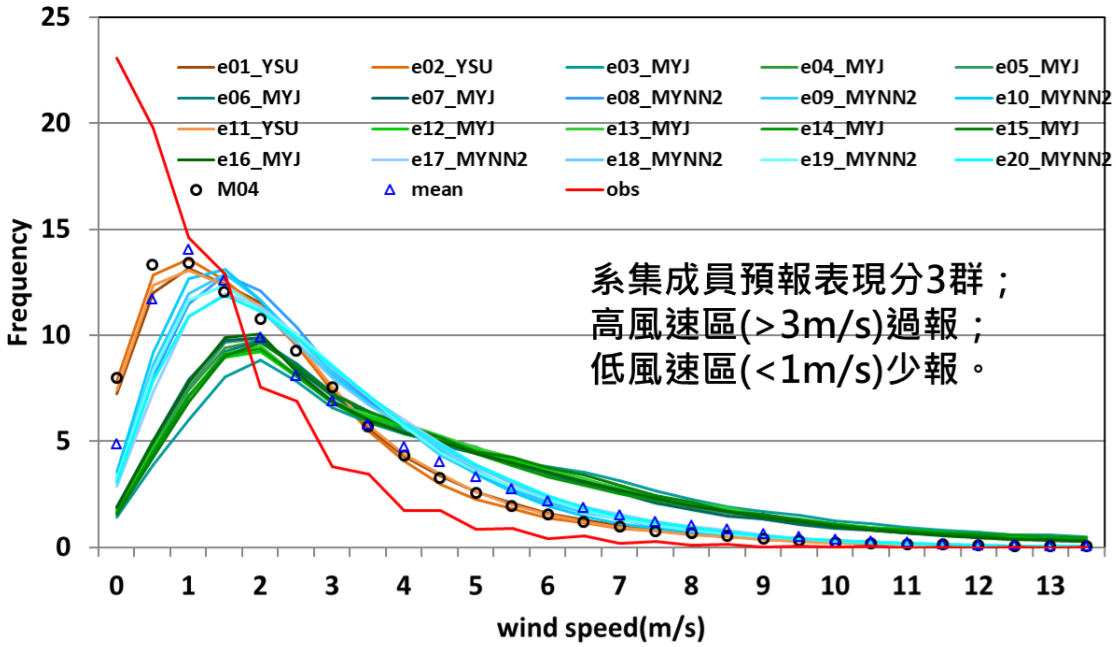


PBL schemes has the greatest influence on near-surface parameters.









Why adding multi-physics setting will increase the RMSE?

Different physics setting make the ensemble Mean PDF strange.

BY 蔡金成 2020

Model Perturbation Integration

EXP	IC pert.	Model pert.	LBC pert.	Lower BDY pert.
Ctrl	LETKF 16/32	X	X	X
SPPT	LETKF 16/32	SPPT	X	X
SKEB	LETKF 16/32	SKEB	X	X
SKSP			X	X
Multi-Physics	LETKF 16/32	3 PBL (YSU, MYJ, MYNN2) 2 MPS (Goddard, WSM5)	X	X
5PBL	LETKF 16/32	5PBL	X	X
4MP	LETKF 16/32	4MP	X	X
P5M4	LETKF 16/32	5PBL+4MP	X	X

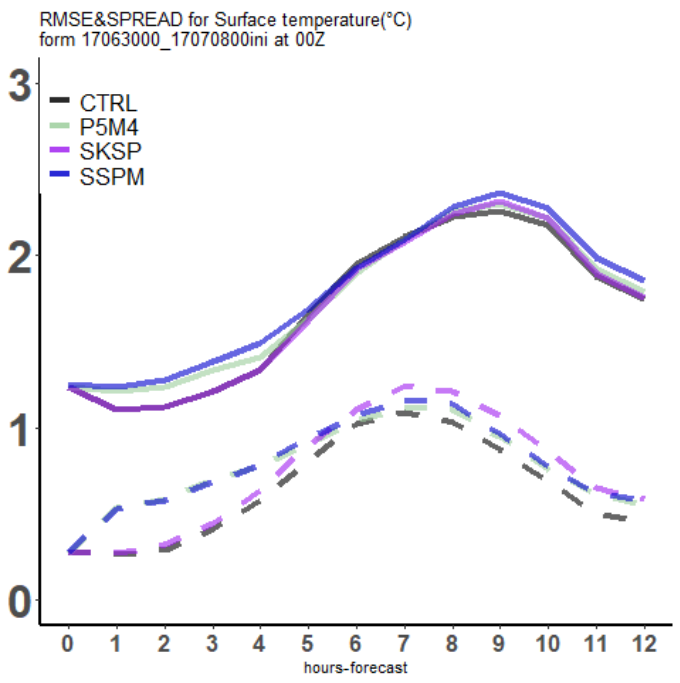
Exp1

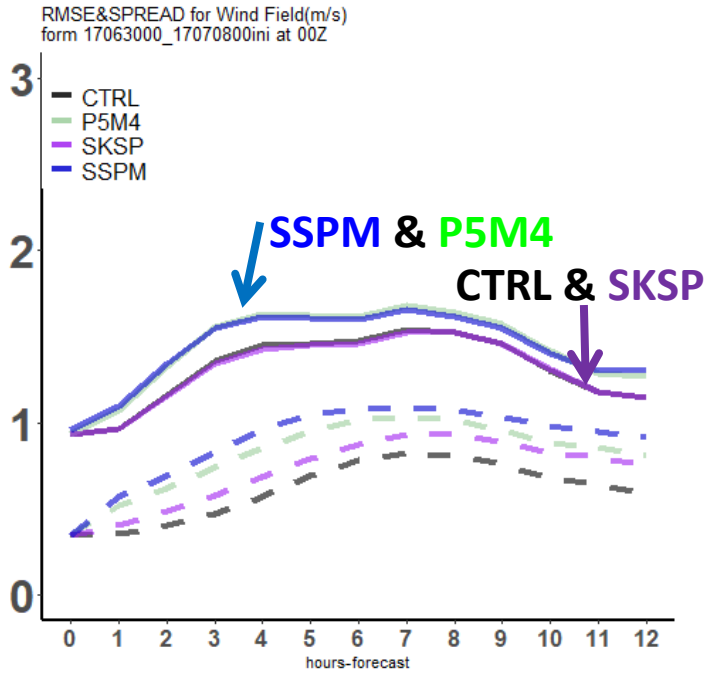
Exp2

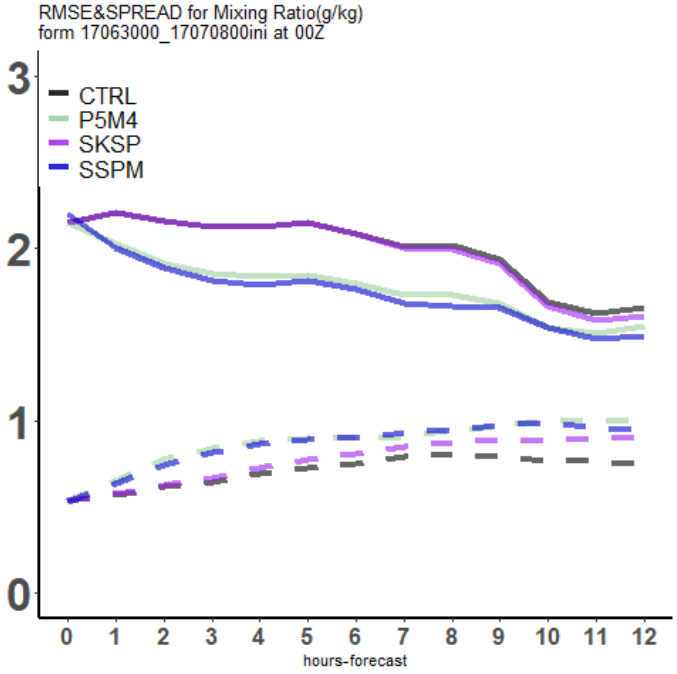
SKSP

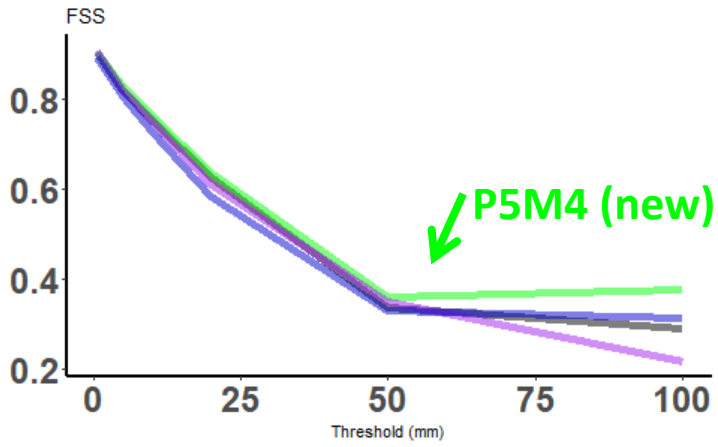
P5M4

SSPM









In general, the dispersion-relationship and QPF ability of SSPM is slightly improved.

結論

- 經相關性的分析後，本文選出5種PBL參數法與4種微物理參數法來當作CEPS之多模式物理參數方法之設定。
  - 結合PBL參數跟MP參數的的擾動設定能減少濕度場誤差並增加離散度。
  - PBL參數法的更新對於風速場預報的準確度跟離散度有顯著的提升。
  - PBL參數的擾動在風速仍有準確度下降的問題，仍是系集預報系統需要精進的目標。

- 整合SKEB、SPPT與多模式物理參數擾動的結果（SSPM）能顯著改善系集預報離散度，但對降水預報的預報效能仍有改善空間。

Reference

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