極短期劇烈天氣預報系統之發展與現況

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Ying Zhang[2]、Juanzhen Sun[2]

20240905

Model configuration

10-km mesh:

- Downscale run from NCEP GFS.
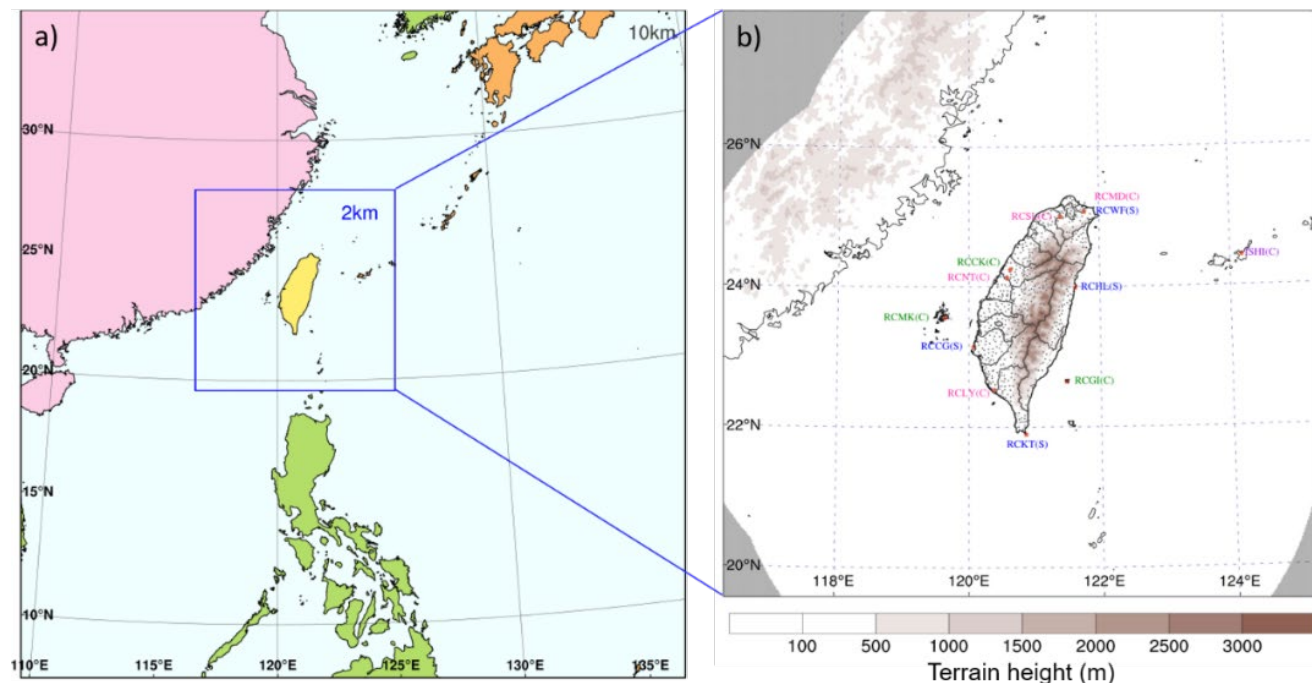- **Drive 2-km mesh by IC & BC**

2-km mesh:

- Provide next **13 hours** model forecast
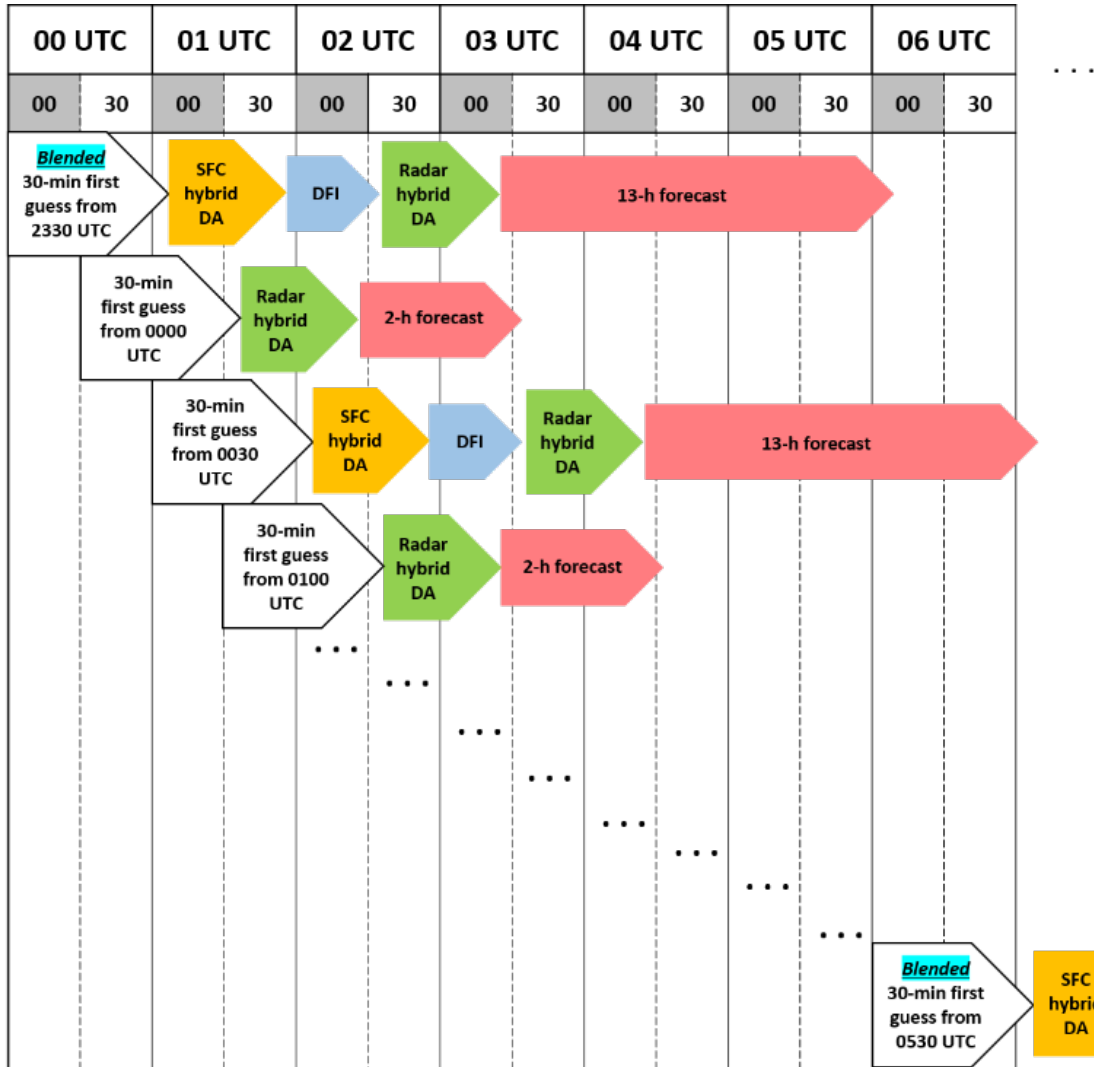

➢**RWRF- Hybrid**

- ✓ Hybrid 3DEnVar, with ensemble BE from 40-member 2-km LETKF forecast
- ✓ Radar (30 minutes update frequency) and Surface (Hourly update frequency) DA

➢**RWRF-LETKF**（江琇瑛 A2-40)

- ✓ Radar and surface DA
- ✓ Hourly update frequency
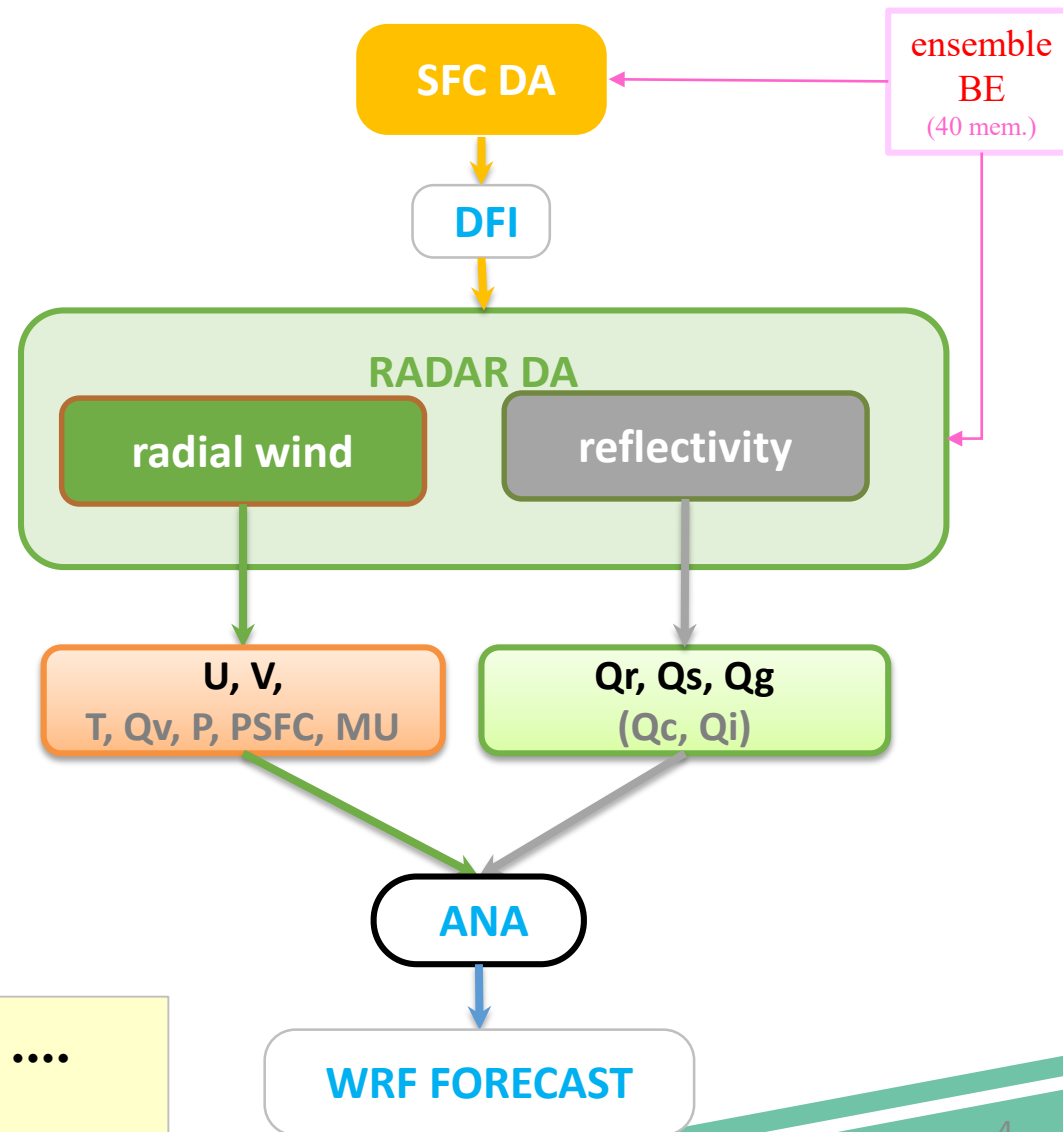
RWRF-hybrid Data assimilation strategy

00 UTC		01 UTC		02 UTC		03 UTC		04 UTC		05 UTC		06 UTC	
00	30	00	30	00	30	00	30	00	30	00	30	00	30

Blended 30-min first guess from 2330 UTC → SFC hybrid DA → DFI → Radar hybrid DA → 13-h forecast

30-min first guess from 0000 UTC → Radar hybrid DA → 2-h forecast

30-min first guess from 0030 UTC → SFC hybrid DA → DFI → Radar hybrid DA → 13-h forecast

30-min first guess from 0100 UTC → Radar hybrid DA → 2-h forecast

Blended 30-min first guess from 0530 UTC → SFC hybrid DA → DFI → Radar hybrid DA → 13-h forecast

hybrid DA = hybrid 3DEnVar with flow-dependent component from the 40 member RWRF-LETKF ensemble

- **Full cycling**
- **Blended at 00/06/12/18**
- **assimilated surface observations, radar radial velocity and reflectivity**
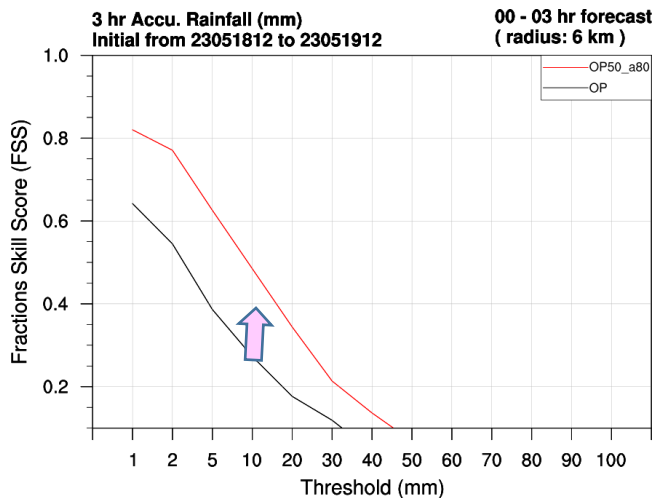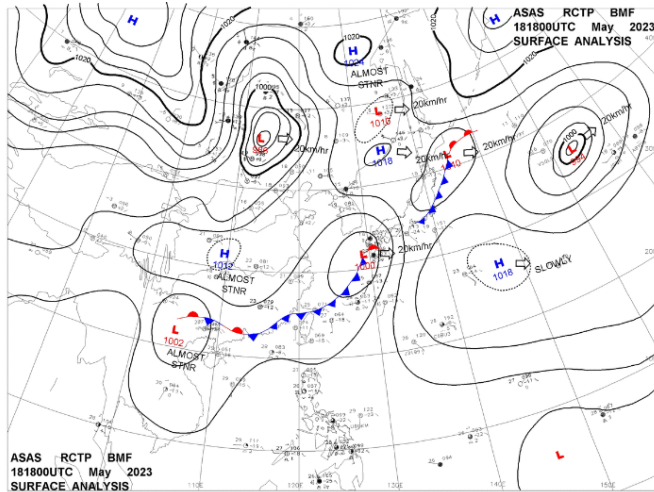
RWRF- Hybrid operational at 2024 Q2

模式更新項目 (M00/M01/30MN)
• WRF模式版本更新，由WRF v3.8.1更新至WRF v4.4.2
• 提升WRF前處理系統 (WPS 4.4)版本
• 更新植被覆蓋率資料、土地利用型態資料及地形資料
• CWBGCE雲微物理參數法 **TCWA1**
• 優化NOAH土壤模式設定
• 採用新版次網格地形重力波拖曳力參數法(GWD3)
DA更新項目 (M01/30MN)
• 雷達資料同化由3DVAR提升為**Hybrid 3DEnVar**
• 雷達資料前處理模式更新
• 雷達資料同化模組更新
other更新項目 (M01)
• 更新blend模組，調整尺度長度設定
• 逐10分鐘輸出延長至 10小時

3D: U V P T QVAPOR QRAIN QSNOW QGRAUP ....
2D: T2 U10 V10 PSFC SST ....

ensemble BE (40 mem.)

SFC DA

DFI

RADAR DA

radial wind — **reflectivity**

U, V, T, Qv, P, PSFC, MU — **Qr, Qs, Qg (Qc, Qi)**

ANA

WRF FORECAST

Case: 2023051812~2023051912

Wind

Mean Error of Wind Field (m/s)   CWB RWRF (2km)
Initial from 12UTC 18 May 2023 to 12UTC 19 May 2023
OP (0.520)
OP50 (0.490)

OP   OP50   OBS

3-hr Accu. Rainfall (mm) @ 00 - 03 hr forecast
Initial at 0300 UTC 19 May 2023 / Valid at 2023051903 - 2023051906 UTC
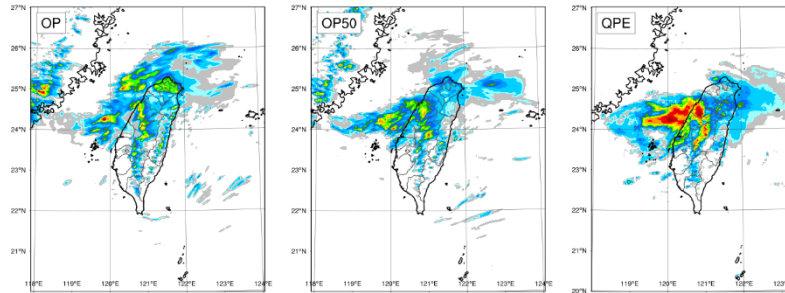
3-hr Accu. Rainfall (mm) @ 00 - 03 hr forecast
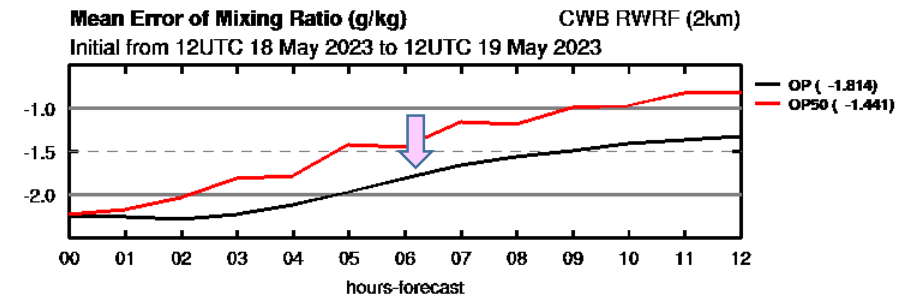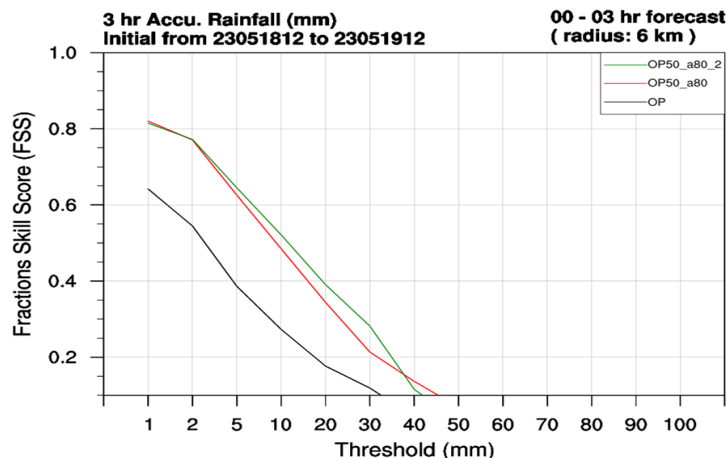Initial at 0600 UTC 19 May 2023 / Valid at 2023051906 - 2023051909 UTC

Q

Mean Error of Mixing Ratio (g/kg)   CWB RWRF (2km)
Initial from 12UTC 18 May 2023 to 12UTC 19 May 2023
OP (-1.814)
OP50 (-1.441)

0.1 1 2 6 10 15 20 30 40 50 70 90 110 130 150 200 300

T

3 hr Accu. Rainfall (mm)
Initial from 23051812 to 23051912

00 - 03 hr forecast
(radius: 6 km)

OP50_a80
OP
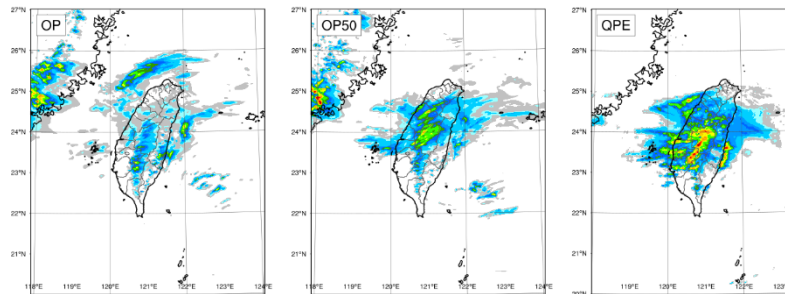
OP50 enhances rainfall forecasting
accuracy and improves the reliability
of surface weather predictions.
=> Increase the computing resources.

Mean Error of Surface Temperature (°C)   CWB RWRF (2km)
Initial from 12UTC 18 May 2023 to 12UTC 19 May 2023
OP (0.538)
OP50 (0.331)
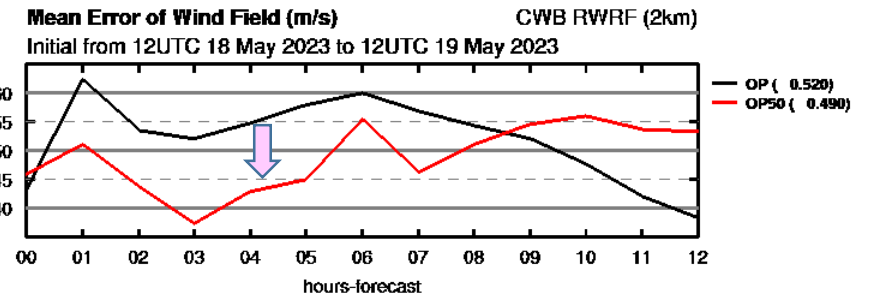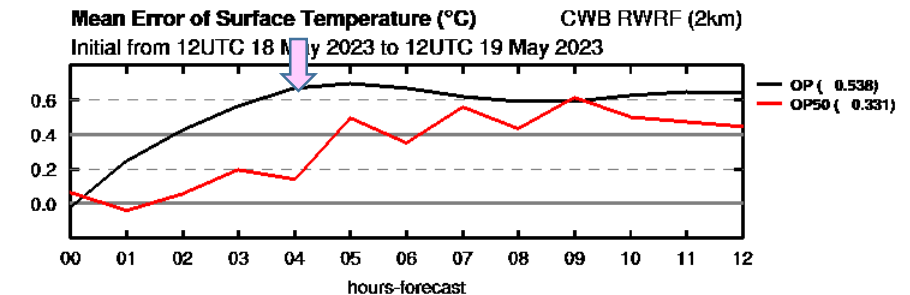
OP50 : epssm=0.1 time_step=6

OP50_em5 : epssm=0.5 time_step=10

- epssm => control slope-generated instabilities due to vertically propagating sound waves

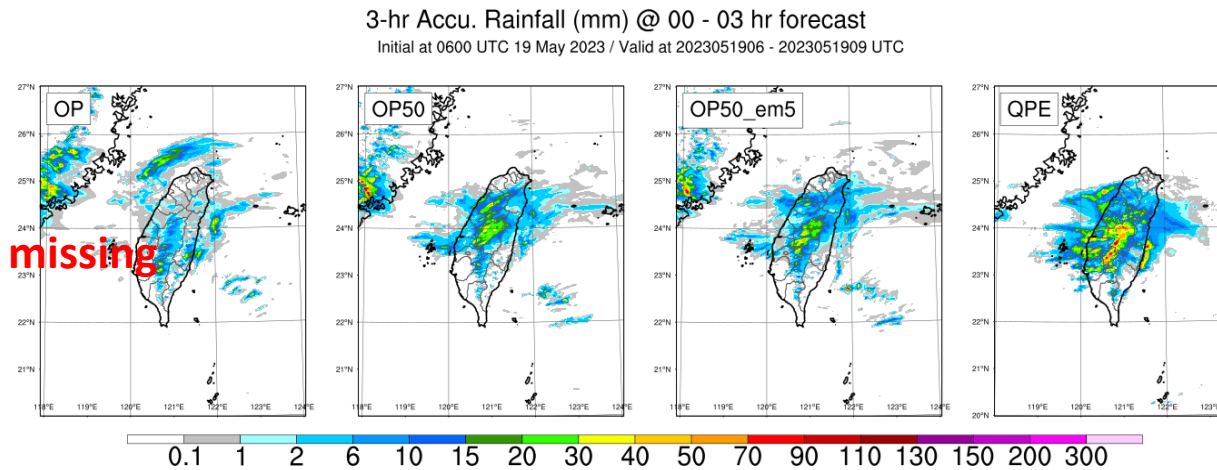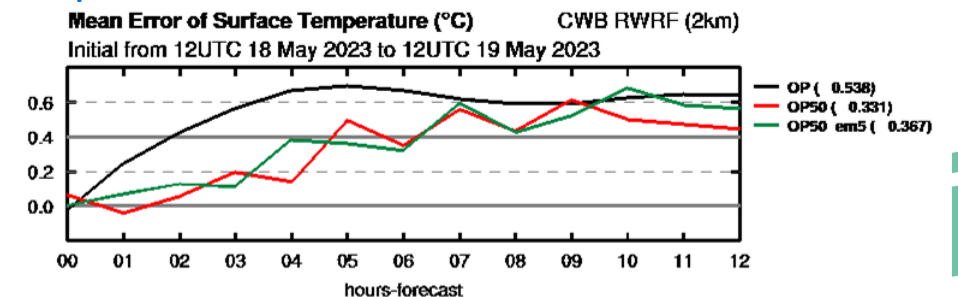- Reduced the computational time for a 13-hour RWRF forecast from approximately 35 minutes to 30 minutes.
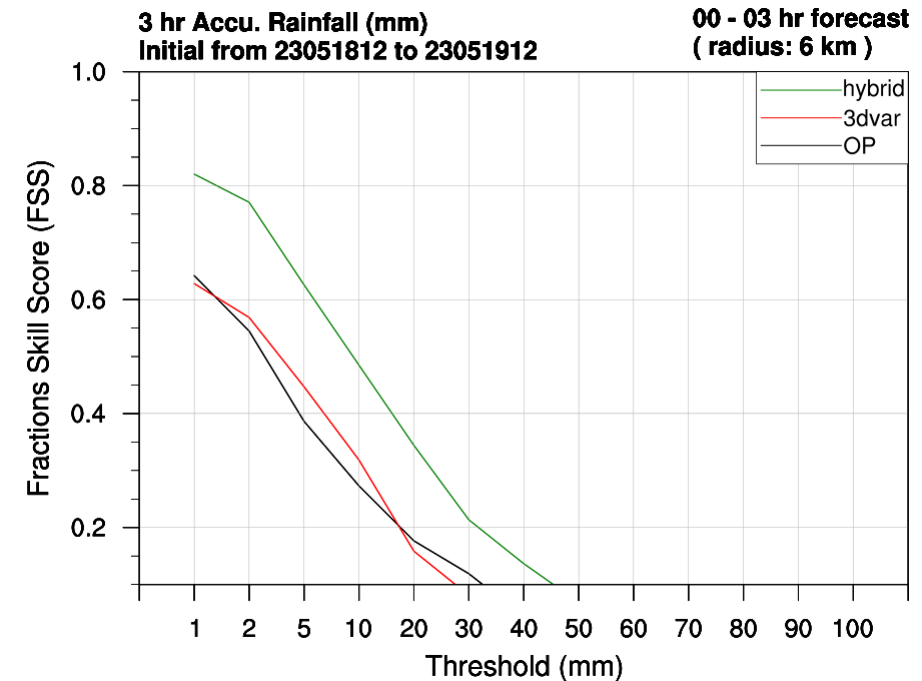
Wind

3-hr Accu. Rainfall (mm) @ 00 - 03 hr forecast
Initial at 0600 UTC 19 May 2023 / Valid at 2023051906 - 2023051909 UTC

OP   OP50   OP50_em5   QPE

missing

0.1 1 2 6 10 15 20 30 40 50 70 90 110 130 150 200 300

Q

T

3 hr Accu. Rainfall (mm)
Initial from 23051812 to 23051912

00 - 03 hr forecast
(radius: 6 km)

113天氣分析與預報研討會

RWRF- Hybrid operational at 2024 Q2

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- OP to OP50(radar DA with 3Dvar)

- 3Dvar to Hybrid 3Denvar

3 hr Accu. Rainfall (mm)
Initial from 23051812 to 23051912
00 - 03 hr forecast (radius: 6 km)

2024/07/24 04:00

RWRF-3DVAR to RWRF-hybrid

Model Domain @ 2-km Grid Spacing

assimilated
SFC data

radar data
with Hybrid
3DEnVar
LETKF
with 40 member

2019

2020

2024

2018

assimilated
radar data
with cold start

2017

full cycle

SFC data
with Hybrid
3DEnVAR

2016

LETKF
with 32
member

Developing
1-km model
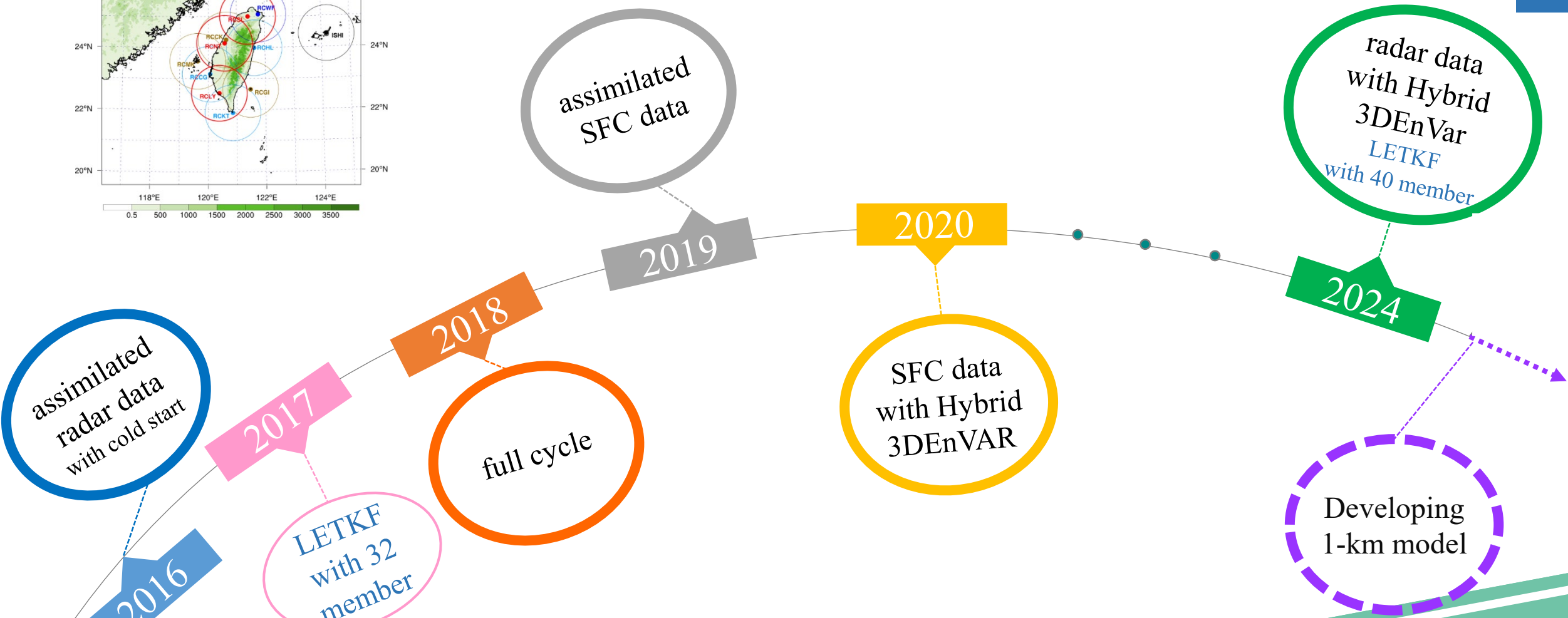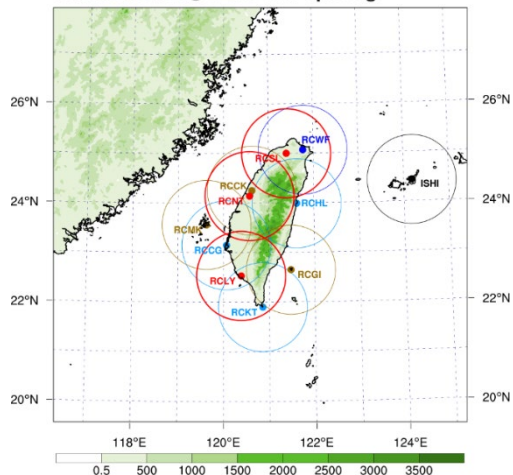
Evaluate the impact of 1-km DA on RWRF

WPS Domain Configuration

451 x 451
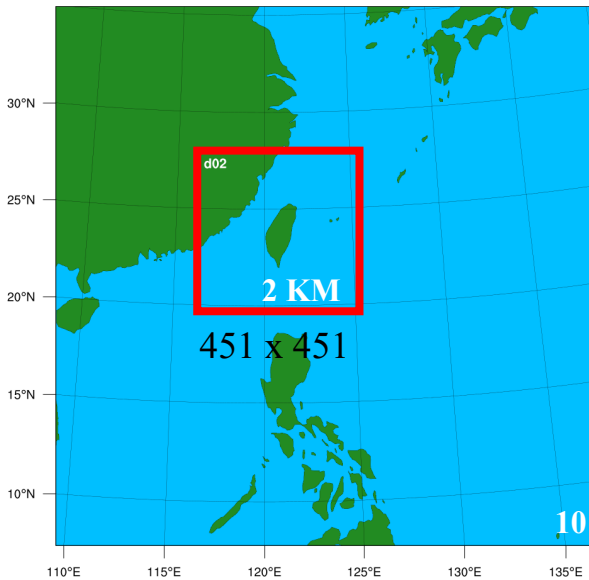
10 KM NODA

Downscaling to 2 km
(bdy)

2 KM DA

Next-generation regional NWP system

WPS Domain Configuration

1741 x 1016

993 x 579

WPS Domain Configuration

481 x 481

1 KM

961x961
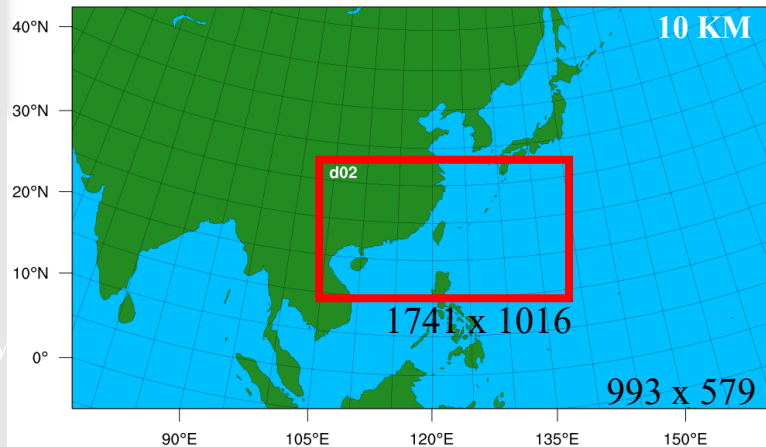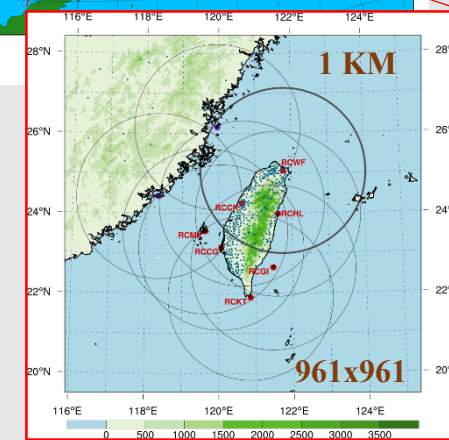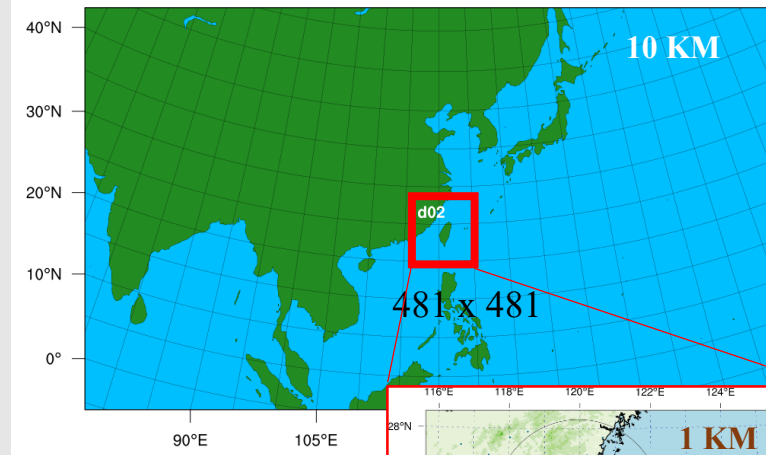
RWRF co
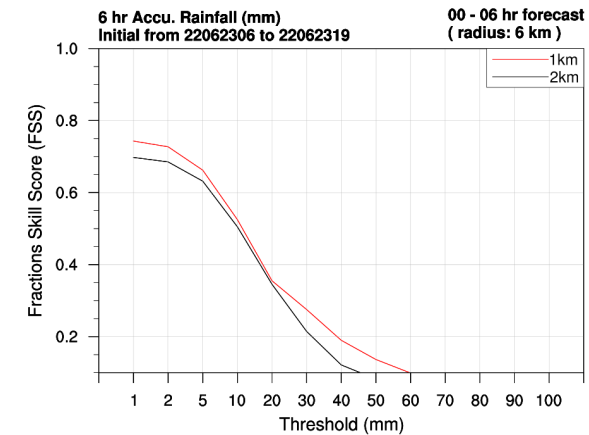
- **1-km** r
- Provide
- Radar a
  membe
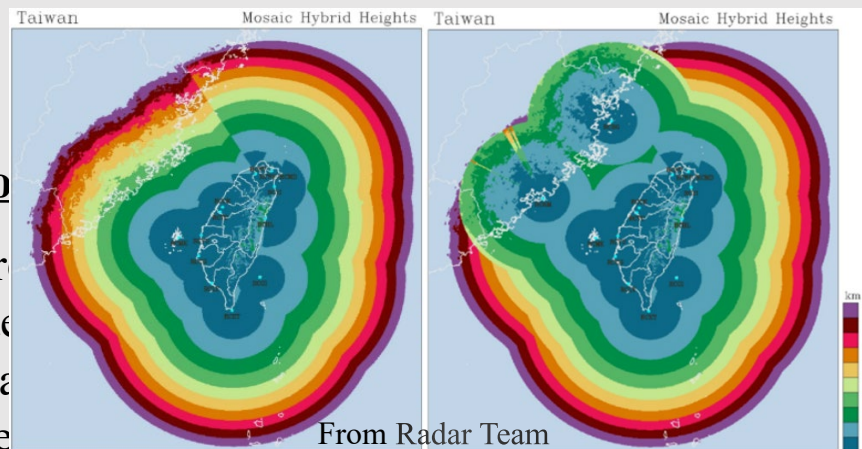
...ith ensemble BE from 40-

From Radar Team

Evaluate the impact of 1-km DA on RWRF

SOP2 ~ SOP3 : After thunderstorm
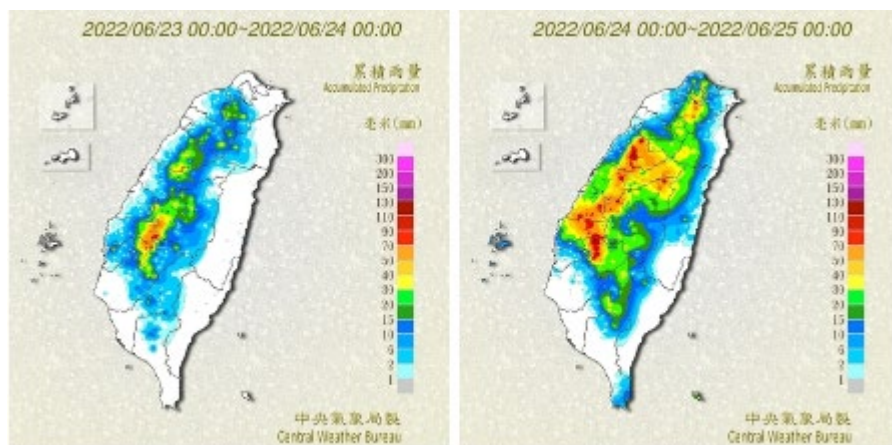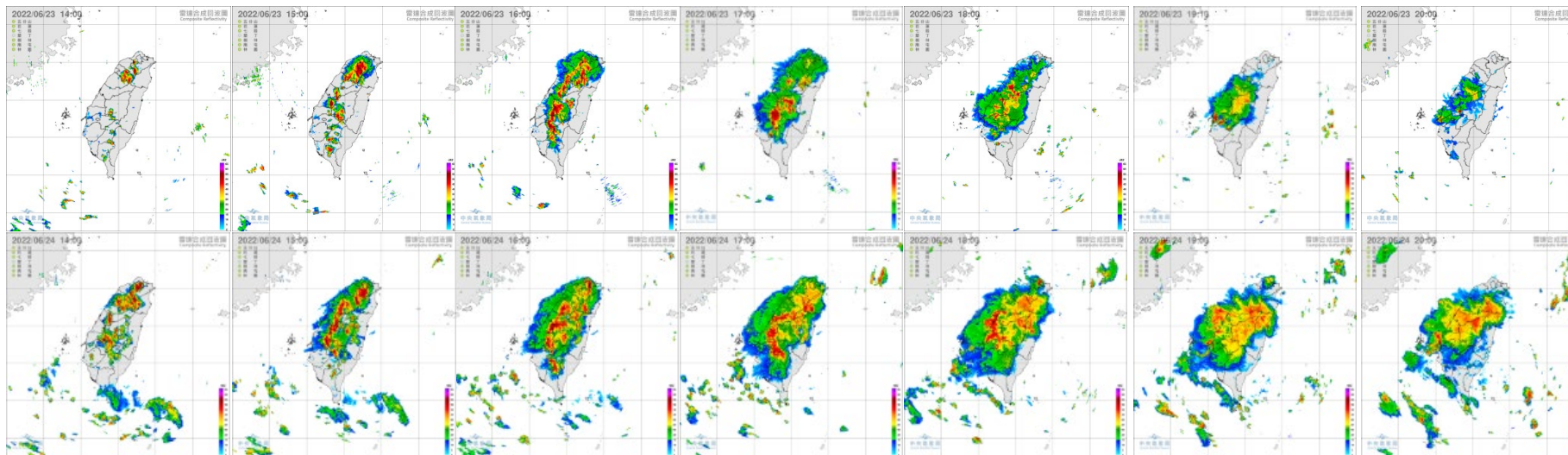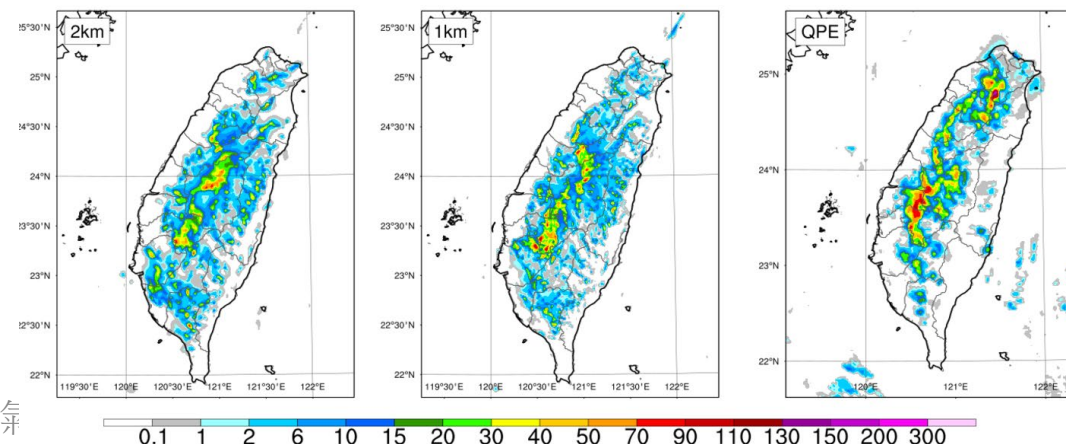
Evaluate the impact of Incremental Analysis Update (IAU) on RWRF

- goal to reduce the imbalance introduced by the high-frequency intermittent data assimilation, especially when radar data are included.
- With the application of IAU, the analysis increment is smoothly introduced into the model integration over a time window centered at the analysis time.
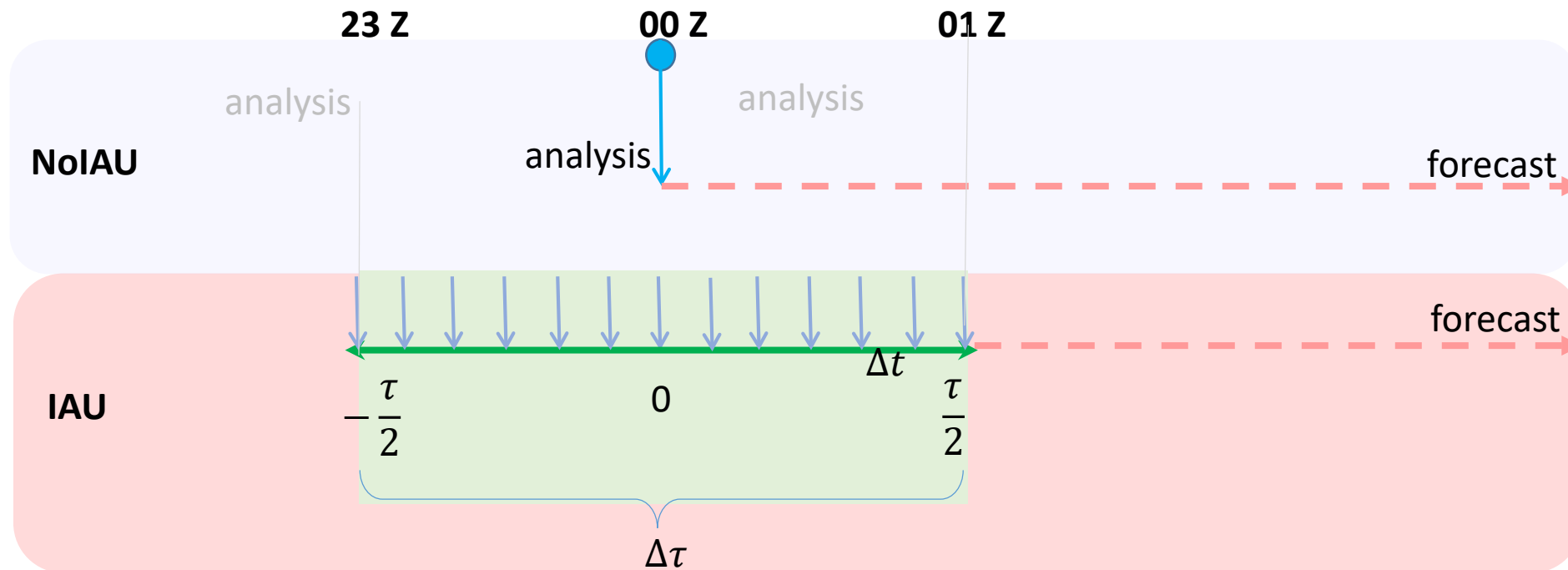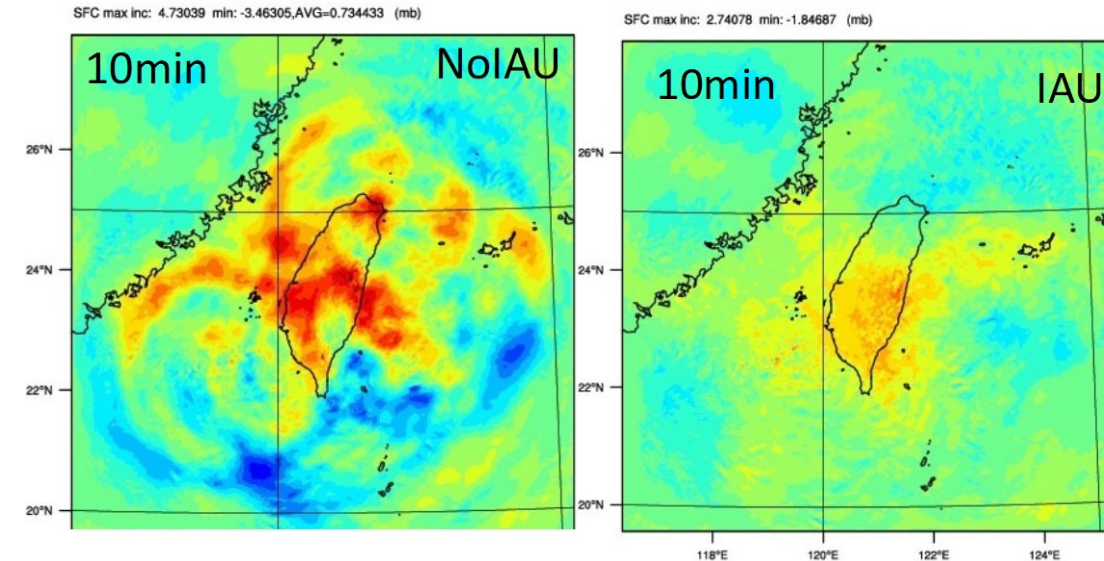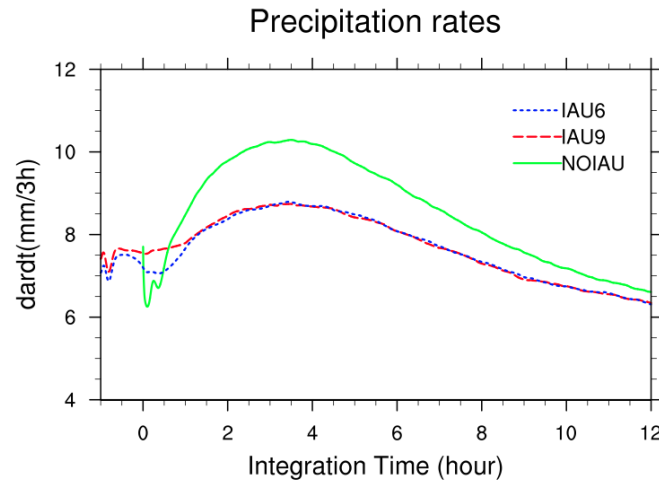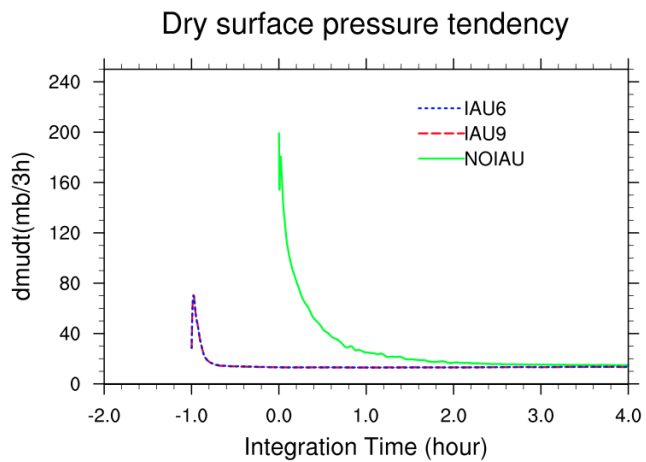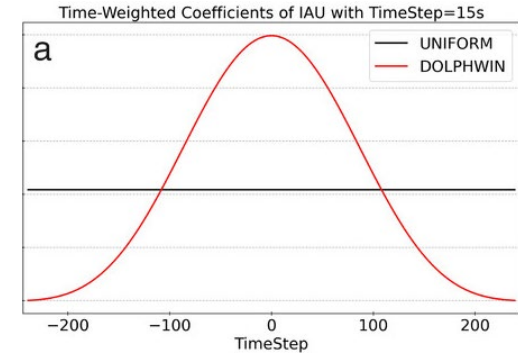

(J. Sun, Y. Zhang)

Experiment Design

NoIAU: 1-h continuous radar DA cycles without IAU

IAU9: 1-h continuous radar DA cycles with IAU,
and iau_nfilt = 9 (weighted by the constant of reciprocal of total forecast steps)

IAU6: 1-h continuous radar DA cycles with IAU,
and iau_nfilt = 6 (weighted by the Dolph-Chebyshev window filter)
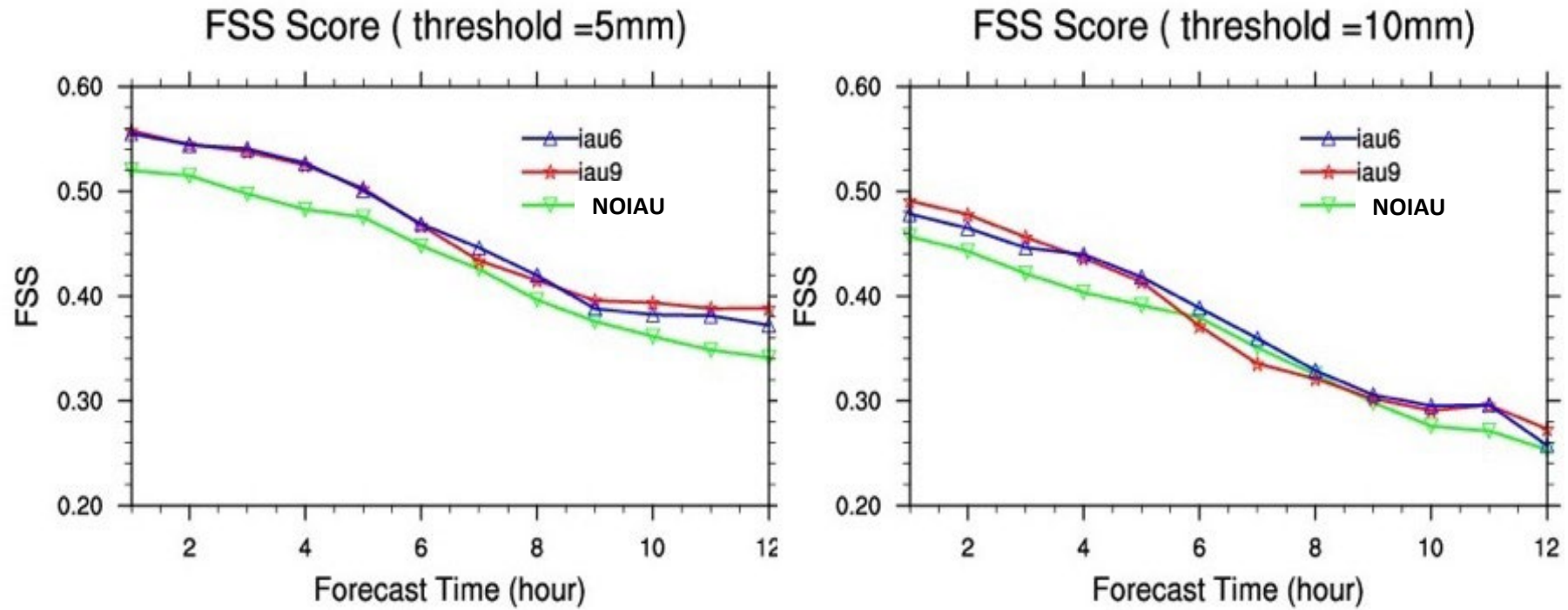

Impact of IAU on reduced model shock (19 cycle average)

Impact of IAU on RWRF precipitation forecast

Comparison of FSSs for the experiments NoIAU, IAU6, and IAU9
averaged over 19 forecast cycles

Future work

- **RWRF-Hybrid**

  Improve of the Radar Hybrid 3DEnVar

  - Increase the model *temporal* and *spatial* resolution

  - Improve the model initialization

  - Developing a data assimilation strategy that combines GDGPS data with radar data

Thanks for your listening.