

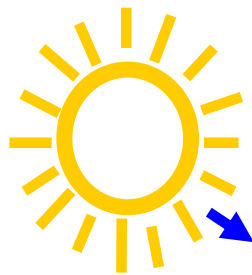
RRTMG輻射參數法 對WRF模式預報之效能評估

陳怡儒¹ 洪景山¹ 戴俐卉¹ 馮欽賜¹ Wei Wang²

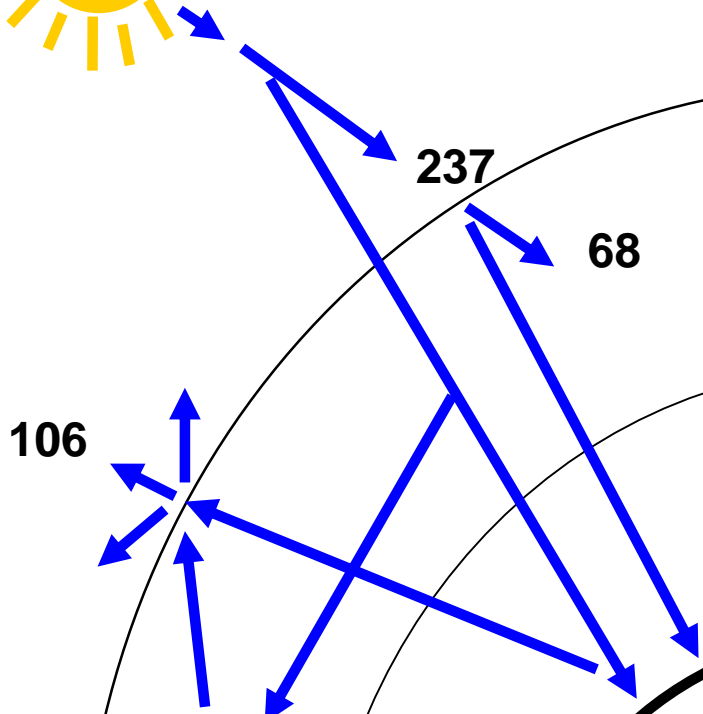
中央氣象局氣象資訊中心¹

National Center for Atmospheric Research²

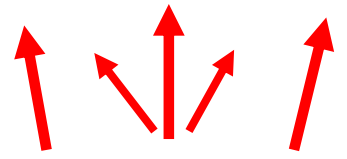
The global radiative balance



343



237



H_2O, CO_2, O_3, \dots

390



169

70 % of the absorbed SW radiation is deposited at the surface: 169 vs. 237 Wm⁻² at ToA

327

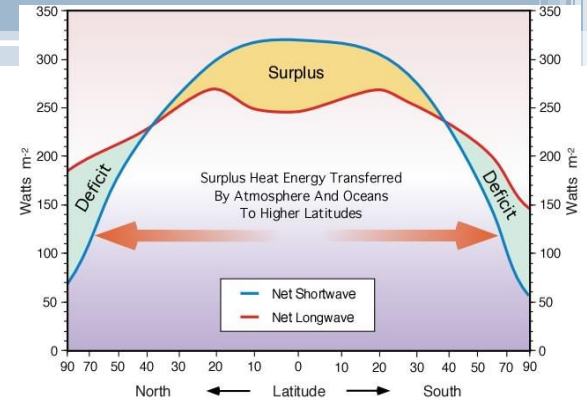


90



16

atmosphere



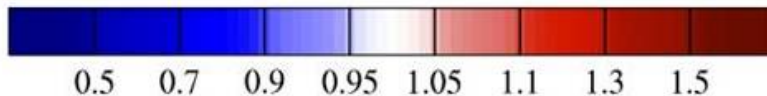
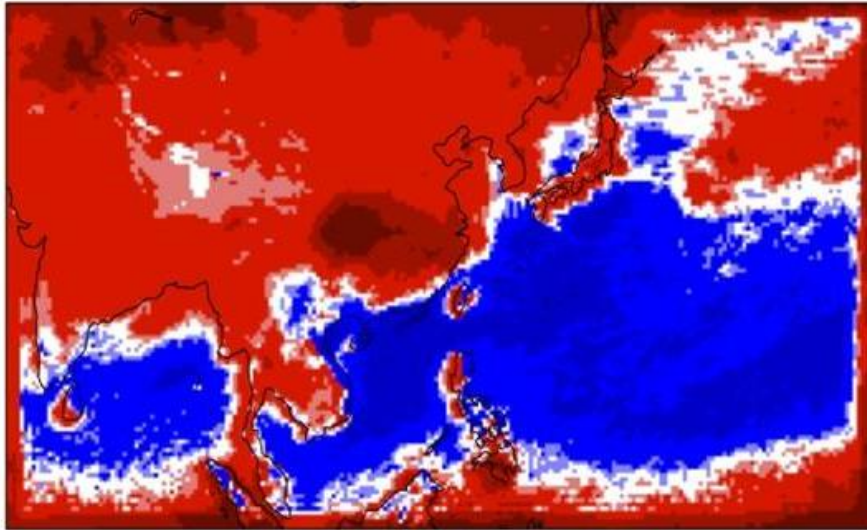
- Solar
- Terrestrial
- Latent heat
- Sensible heat

All fluxes in Wm⁻²

現行作業模式輻射參數法問題

- Radiation flux → 陸地太多(warm) , 海洋太少(cold)

WRF/ERA Solar Radiation Ratio: January



海洋輻射量太少推測是由於積雲參數法在海上產生低層雲，造成海洋上的冷偏差

進一步了解陸地短波輻射量過多的情形

Radiation Experiment - 1

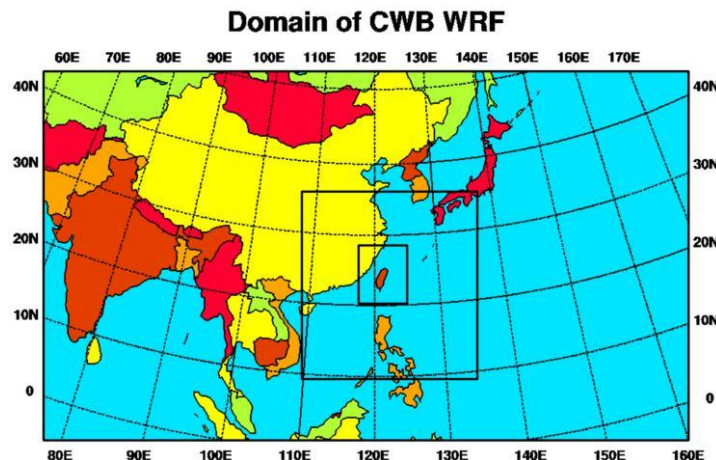
- **控制組 (OP24)**
rrtm scheme (long wave)
Goddard shortwave scheme (short wave)
- **對照組 (RRTMG)**
rrtmg scheme (long / short wave)
- **Aerosol**
rrtmg scheme + aerosol (long / short wave)

Experiment Design

- 夏 : 2012/06/01 00Z – 2012/06/30 12Z (45 km Domain 1)
2012/06/01 00Z – 2012/06/15 12Z (5 km Domain 3)
- 冬 : 2012/12/01 00Z – 2012/12/15 12Z
(45 、 15 、 5 km Domain 1 、 2 、 3)

Diagnosis

- 2012/06/01 12Z – 06/15 12Z
(15個 initial time)



Verification

- Against OBS
2012/06/01 00Z – 06/15 12Z
(30個 initial time)
- Against NCEP
2012/06/01 00Z – 06/30 12Z
(60個 initial time)
2012/12/01 00Z – 12/15 12Z
(30個 initial time)

2012 06/01 12Z ~ 06/15 12Z

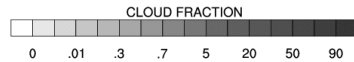
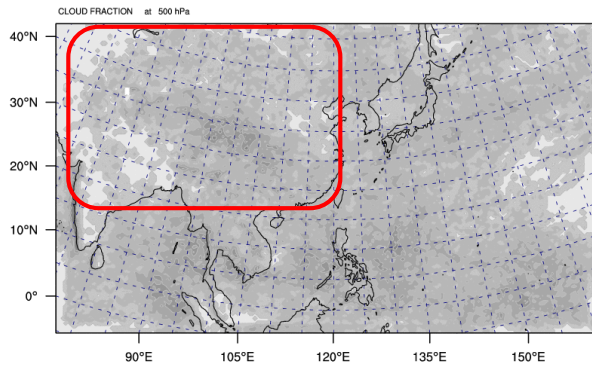
(15個initial time)

63小時預報 → 11:00 LST

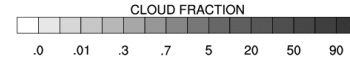
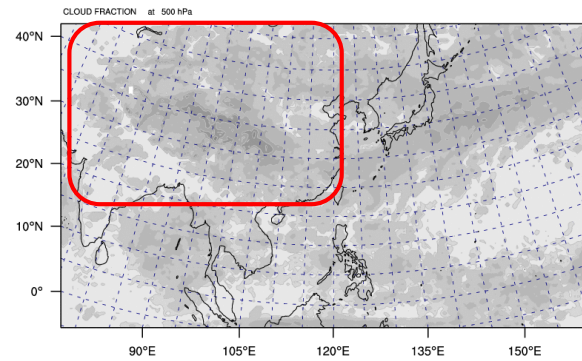
SWDOWN

63小時預報 (11:00 LST)

WRF **OP24**
Init: 2012-06-01_12:00:00
 Valid: 2012-06-04_03:00:00

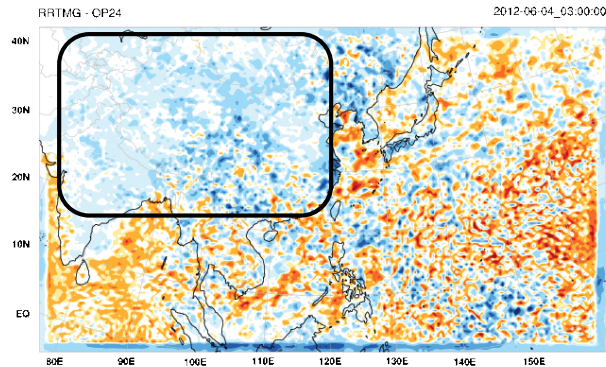


WRF **RRTMG**
Init: 2012-06-01_12:00:00
 Valid: 2012-06-04_03:00:00



RRTMG-OP24

SWDOWN diff



LAND AVG(RRTMG-OP24): -34.1582



max 363.626 min -303.413 avg -8.27831

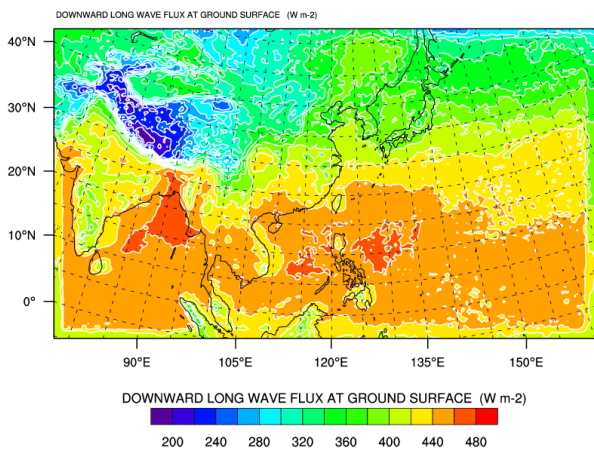
減少陸地上的短波輻射
 (-34.16 W / m^2)



GLW

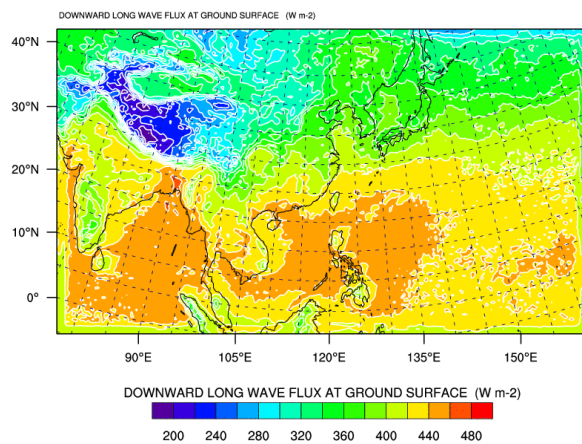
63小時預報 (11:00 LST)

WRF **OP24** In: 2012-06-01_12:00:00
Valid: 2012-06-04_03:00:00



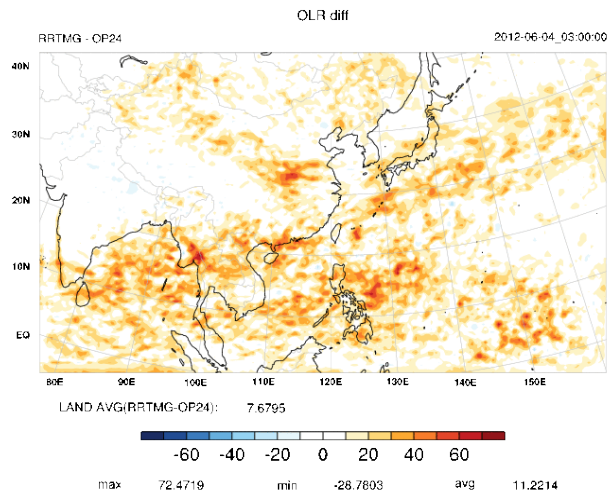
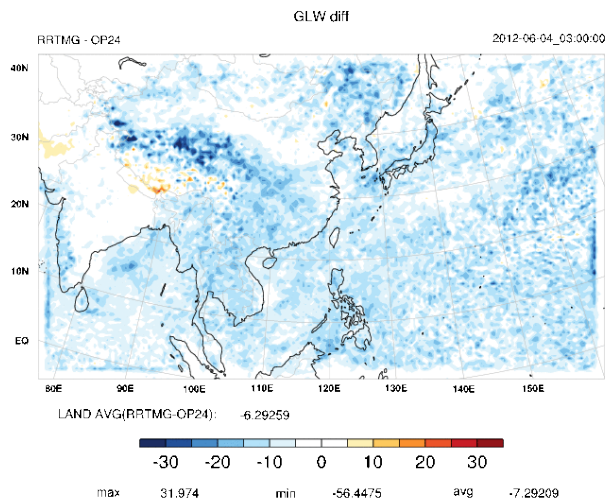
OUTPUT FROM WRF V3.3.1 MODEL
WE = 222 ; SN = 128 ; Levels = 45 ; Di = 45km ; Phys Opt = 7 ; PBL Opt = 1 ; Cu Opt = 1

WRF **RRTMG** In: 2012-06-01_12:00:00
Valid: 2012-06-04_03:00:00



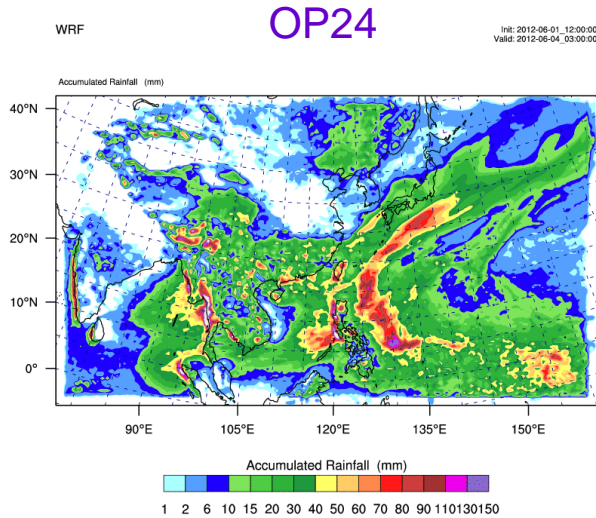
OUTPUT FROM WRF V3.3.1 MODEL
WE = 222 ; SN = 128 ; Levels = 45 ; Di = 45km ; Phys Opt = 7 ; PBL Opt = 1 ; Cu Opt = 1

RRTMG-OP24

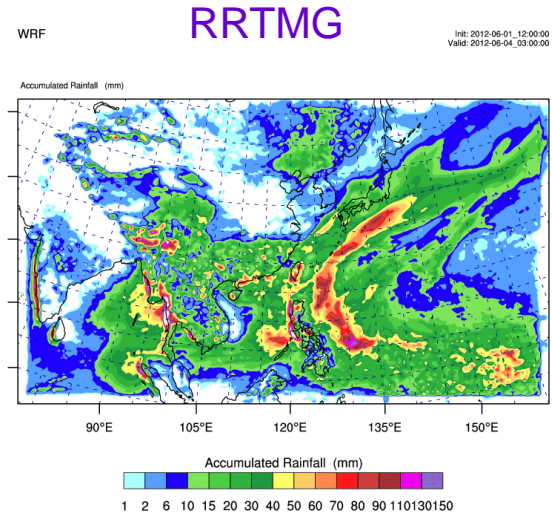


Rain

63小時預報 (11:00 LST)

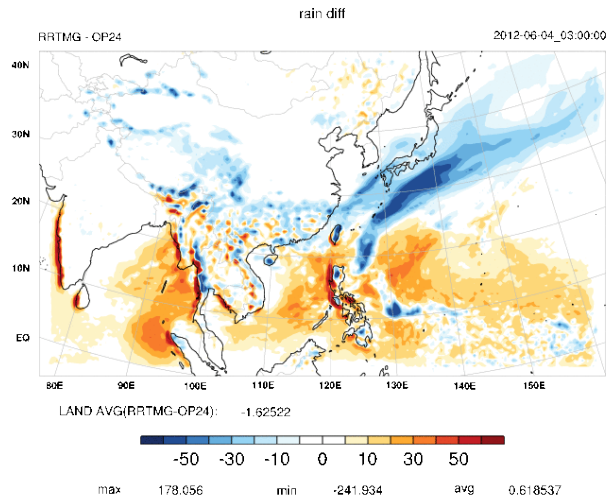


OUTPUT FROM WRF V3.3.1 MODEL
WE = 222 ; SN = 128 ; Levels = 45 ; Di = 45km ; Phys Opt = 7 ; PBL Opt = 1 ; Cu Opt = 1



OUTPUT FROM WRF V3.3.1 MODEL
WE = 222 ; SN = 128 ; Levels = 45 ; Di = 45km ; Phys Opt = 7 ; PBL Opt = 1 ; Cu Opt = 1

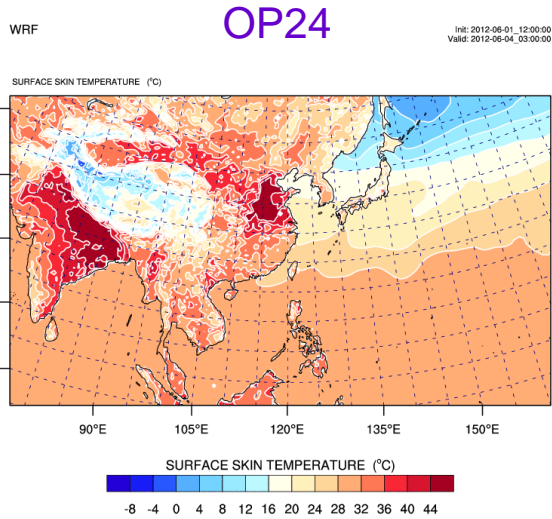
RRTMG-OP24



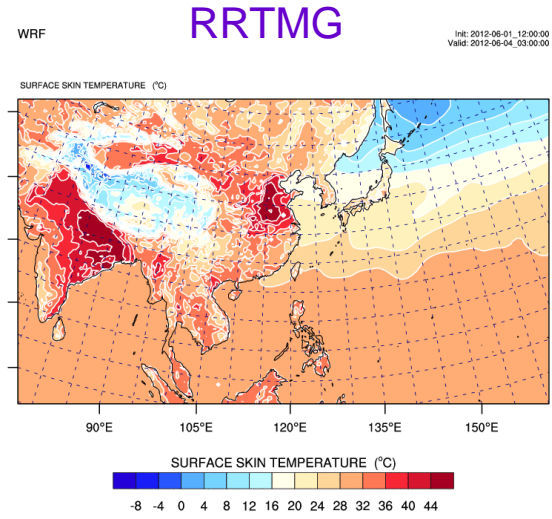
對雨量無系統性差異

TSK

63小時預報 (11:00 LST)

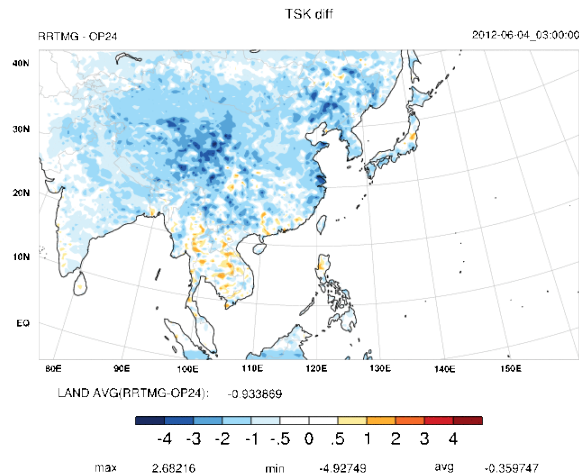


OUTPUT FROM WRF V3.3.1 MODEL
WE = 222 ; SN = 128 ; Levels = 45 ; Di = 45km ; Phys Opt = 7 ; PBL Opt = 1 ; Cu Opt = 1



OUTPUT FROM WRF V3.3.1 MODEL
WE = 222 ; SN = 128 ; Levels = 45 ; Di = 45km ; Phys Opt = 7 ; PBL Opt = 1 ; Cu Opt = 1

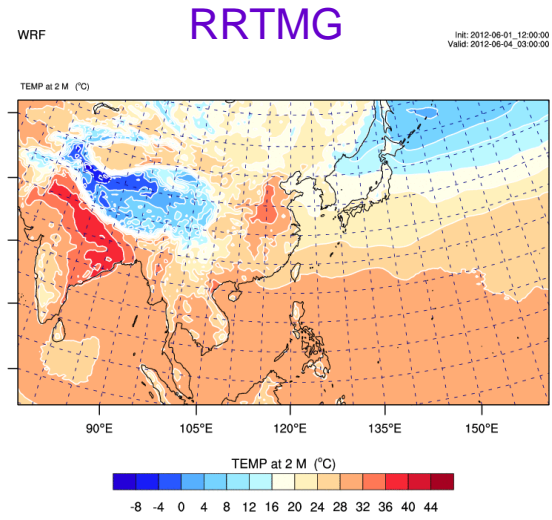
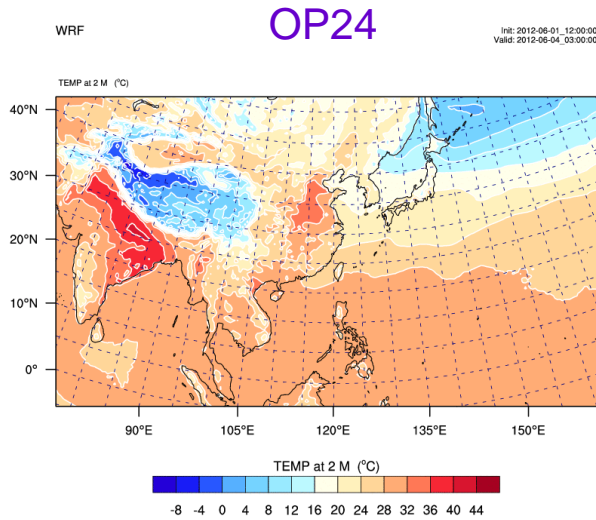
RRTMG-OP24



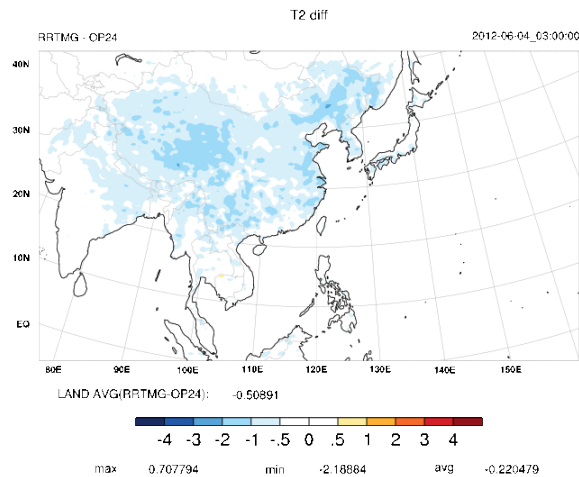
地表溫度下降
(-0.93°C)

T_{2m}

63小時預報 (11:00 LST)



RRTMG-OP24 (日)



陸地の兩米溫度下降
(-0.51 °C)

Radiation Experiment - 2

- **OP24**

rrtm scheme (long wave)

Goddard shortwave scheme (short wave)

- **RRTMG**

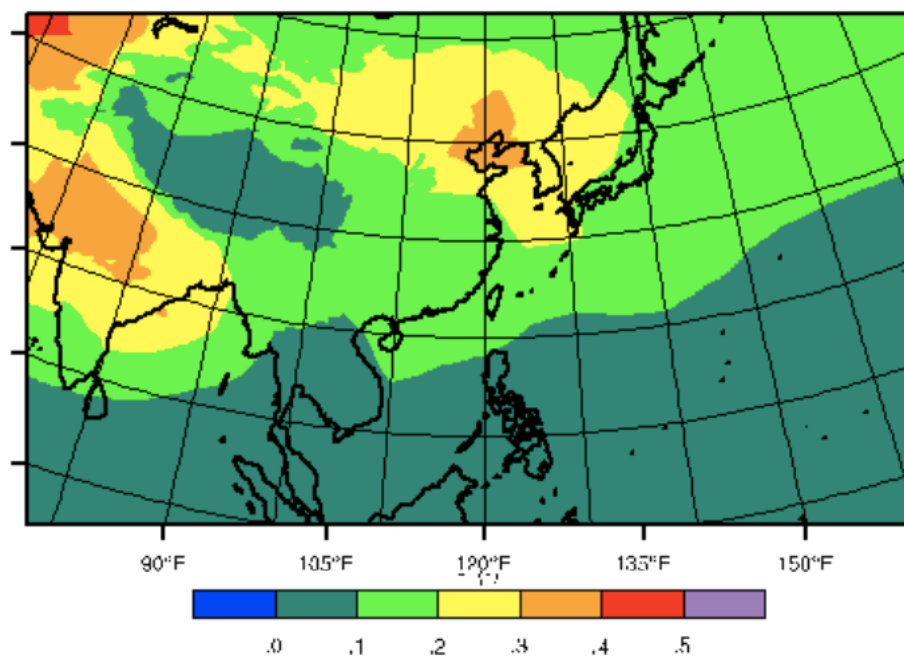
rrtmg scheme (long / short wave)

- **Aerosol**

rrtmg scheme + aerosol (long / short wave)

Aerosol

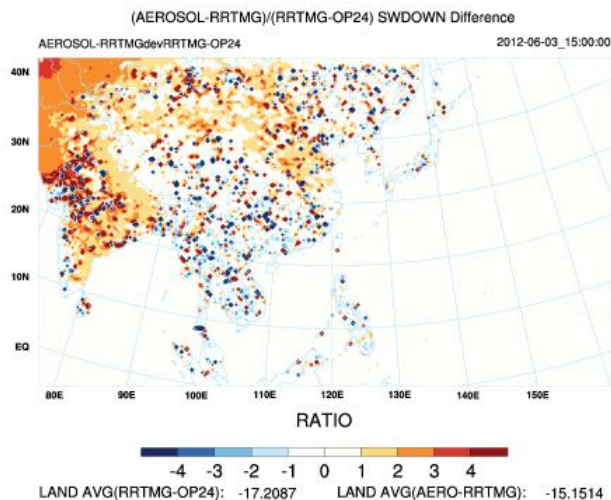
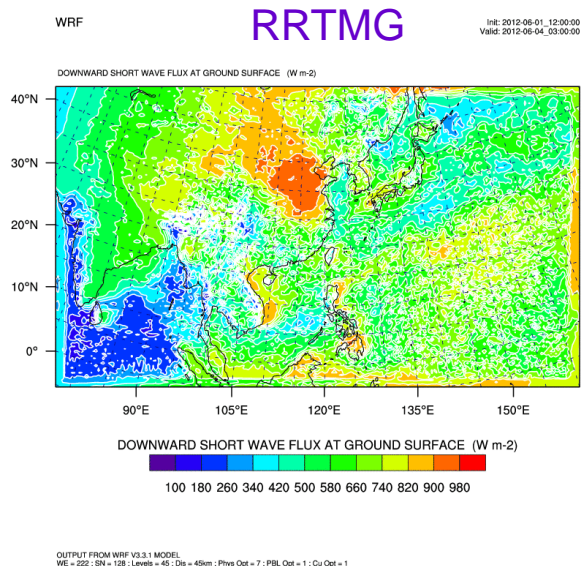
- 影響全球輻射收支
- 氣溶膠分布受人類活動及大氣環流影響，具有區域性



(Wei 2012)

SWDOWN

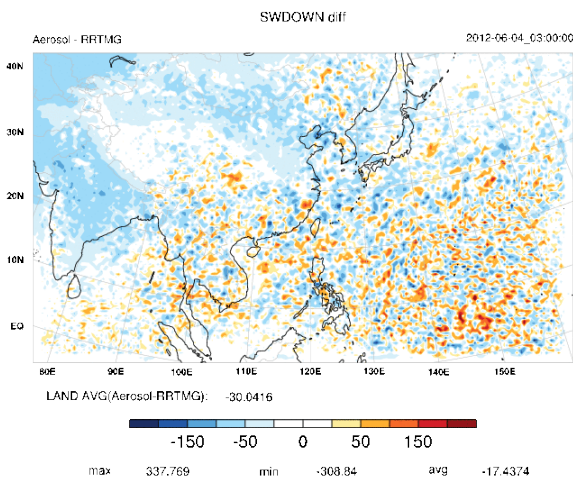
63小時預報 (11:00 LST)



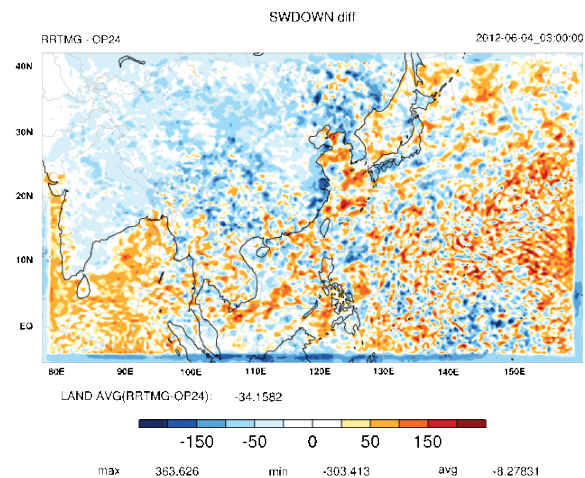
Aerosol-RRTMG

RRTMG-OP24

陸地:
-30.04 W/m²



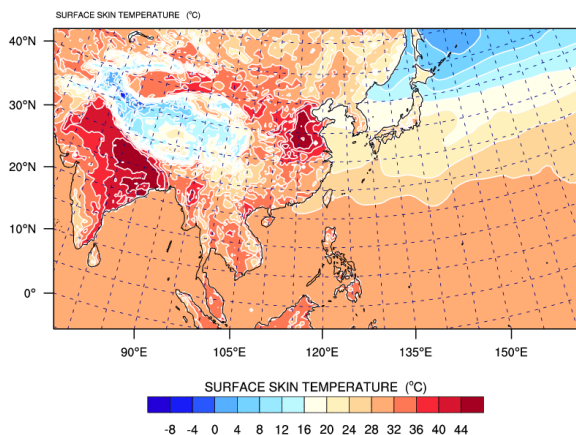
陸地:
-34.16 W/m²



TSK

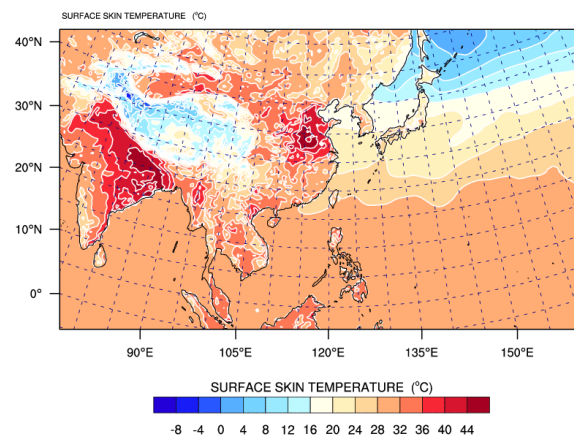
63小時預報 (11:00 LST)

WRF **RRTMG** InH: 2012-06-01 12:00:00
Valid: 2012-06-04 03:00:00



OUTPUT FROM WRF V3.3.1 MODEL
WE = 222 ; SN = 128 ; Levels = 45 ; Dis = 45km ; Phys Opt = 7 ; PBL Opt = 1 ; Cu Opt = 1

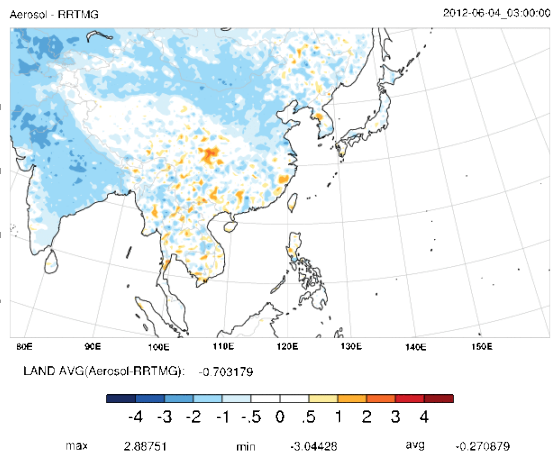
WRF **Aerosol** InH: 2012-06-01 12:00:00
Valid: 2012-06-04 03:00:00



OUTPUT FROM WRF V3.3.1 MODEL
WE = 222 ; SN = 128 ; Levels = 45 ; Dis = 45km ; Phys Opt = 7 ; PBL Opt = 1 ; Cu Opt = 1

Aerosol-RRTMG

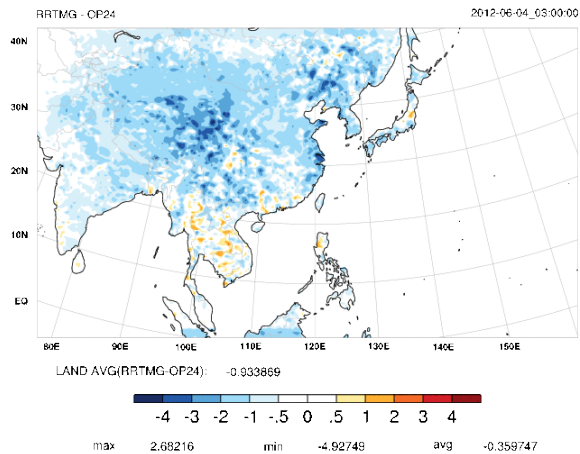
TSK diff



陸地: -0.7°C

RRTMG-OP24

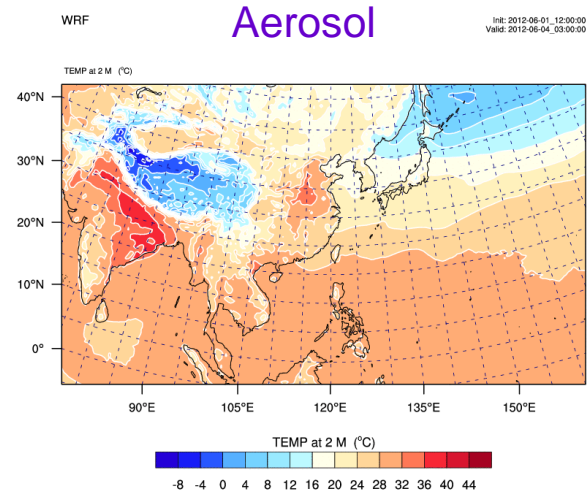
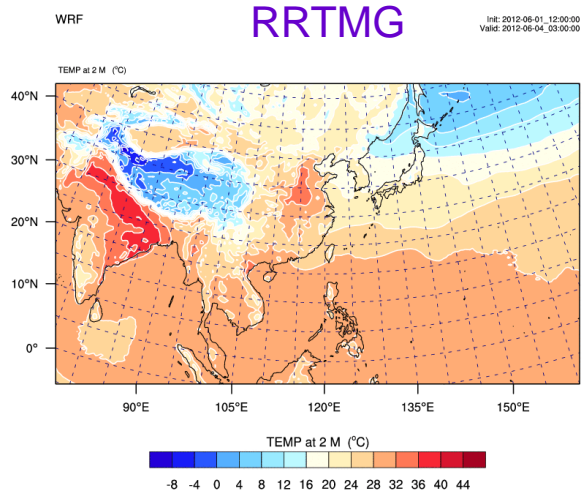
TSK diff



陸地: -0.93°C

T_{2m}

63小時預報 (11:00 LST)



OUTPUT FROM WRF V3.3.1 MODEL
WE = 222 ; SN = 128 ; Levels = 45 ; Dis = 45km ; Phys Opt = 7 ; PBL Opt = 1 ; Cu Opt = 1

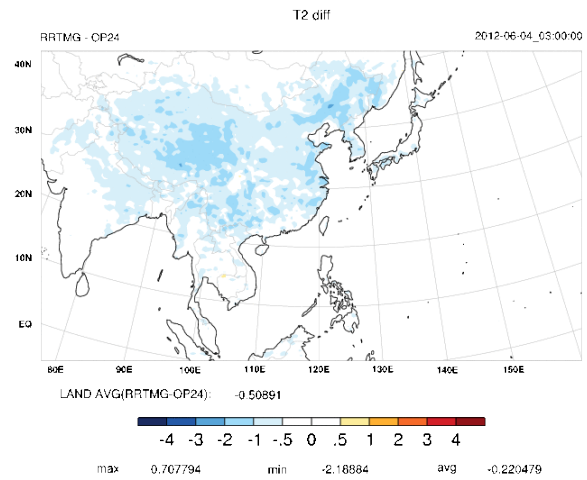
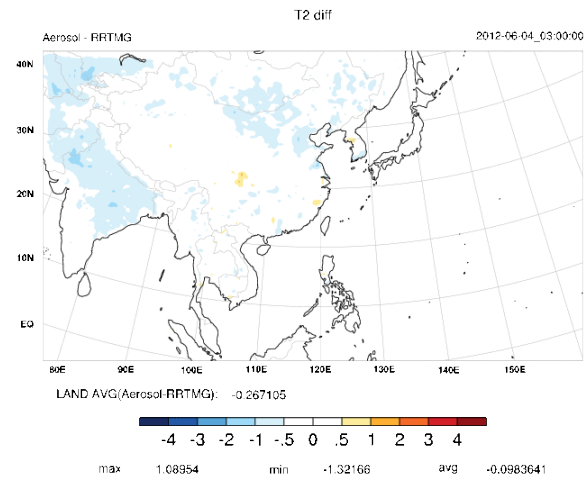
OUTPUT FROM WRF V3.3.1 MODEL
WE = 222 ; SN = 128 ; Levels = 45 ; Dis = 45km ; Phys Opt = 7 ; PBL Opt = 1 ; Cu Opt = 1

Aerosol-RRTMG

RRTMG-OP24

陸地: -0.27 °C

陸地: -0.51 °C



Verification Against Observation

□ 2012 June 1~15

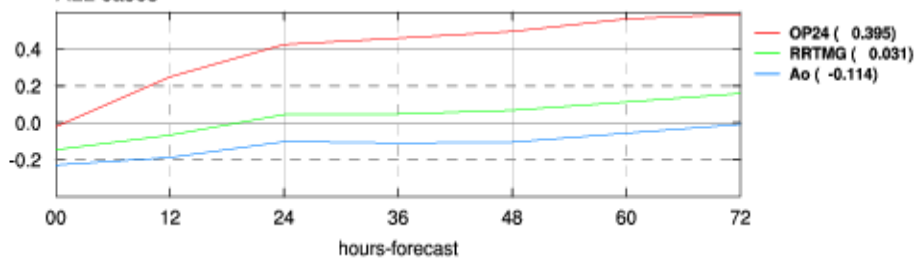
→ 30個 initial time

地面校驗

Domain 1 (45 km)

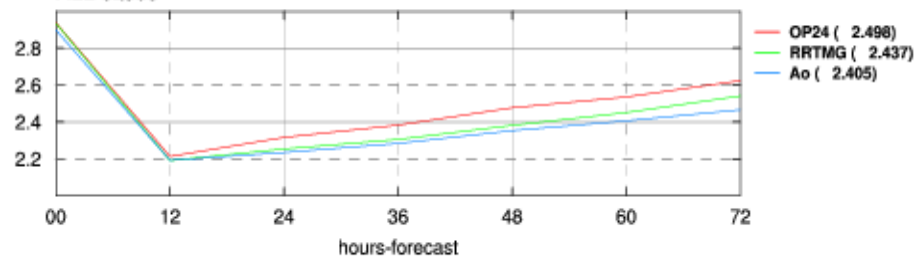
Mean Error of Surface Temperature (°C) CWB WRF (45km)

ALL cases



RMSE of Surface Temperature (°C) CWB WRF (45km)

ALL cases



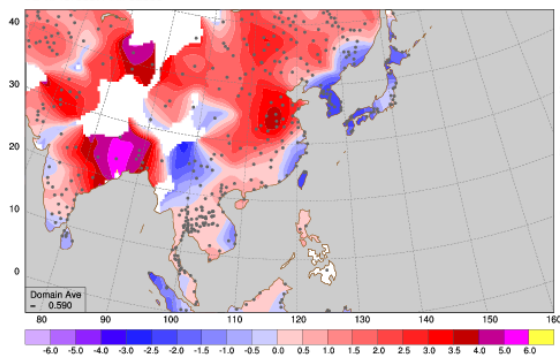
OP24

RRTMG

Aerosol

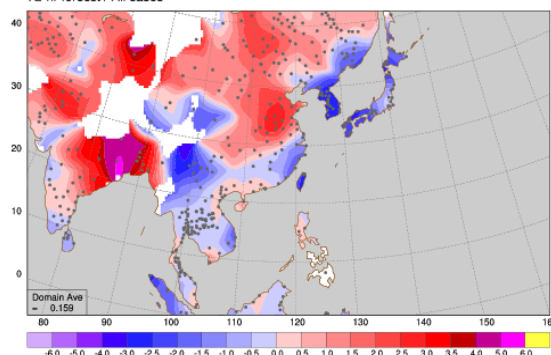
Mean Error of Surface Temperature (°C)
72-hr forecast / All cases

CWB WRF (45km)



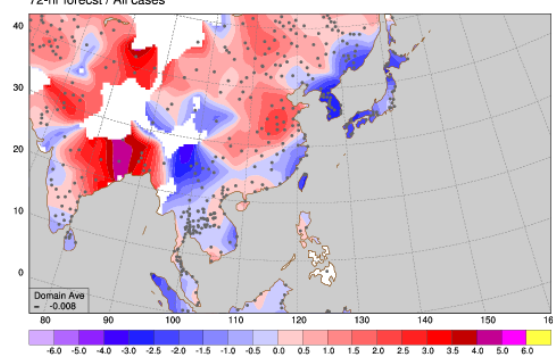
Mean Error of Surface Temperature (°C)
72-hr forecast / All cases

CWB WRF (45km)



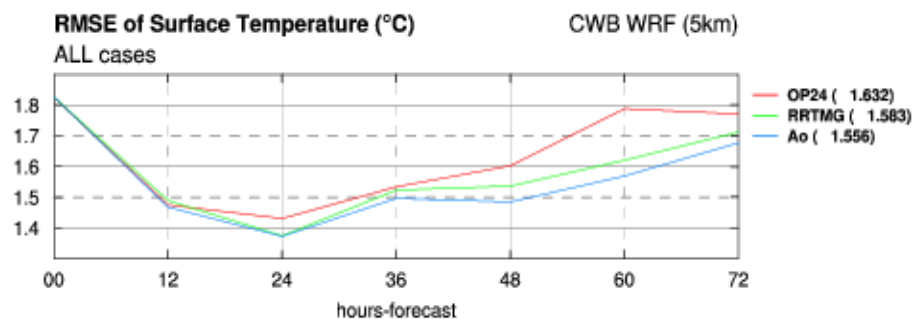
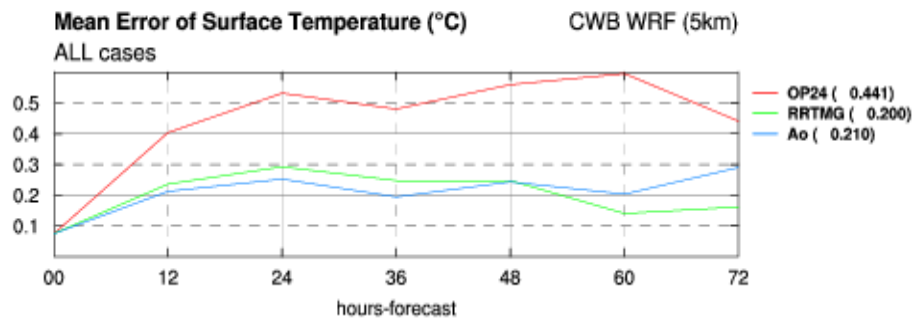
Mean Error of Surface Temperature (°C)
72-hr forecast / All cases

CWB WRF (45km)



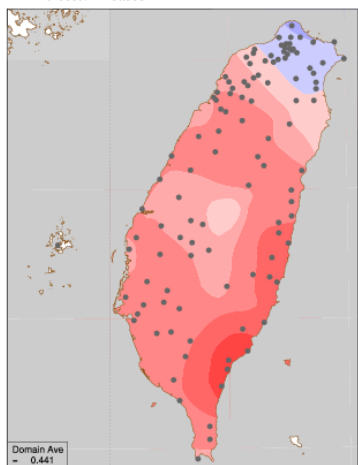
地面校驗

Domain 3 (5 km)



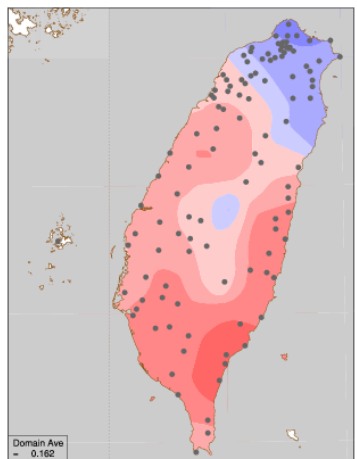
OP24

Mean Error of Surface Temperature (°C) CWB WRF (5km)
72-hr forecast / All cases



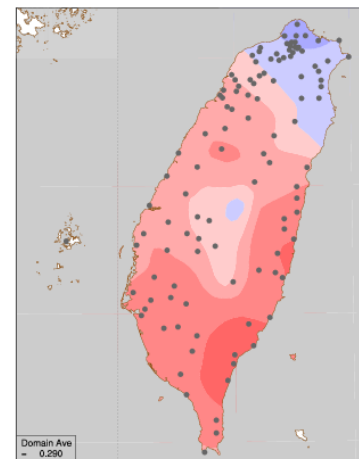
RRTMG

Mean Error of Surface Temperature (°C) CWB WRF (5km)
72-hr forecast / All cases



Aerosol

Mean Error of Surface Temperature (°C) CWB WRF (5km)
72-hr forecast / All cases



Verification Against NCEP

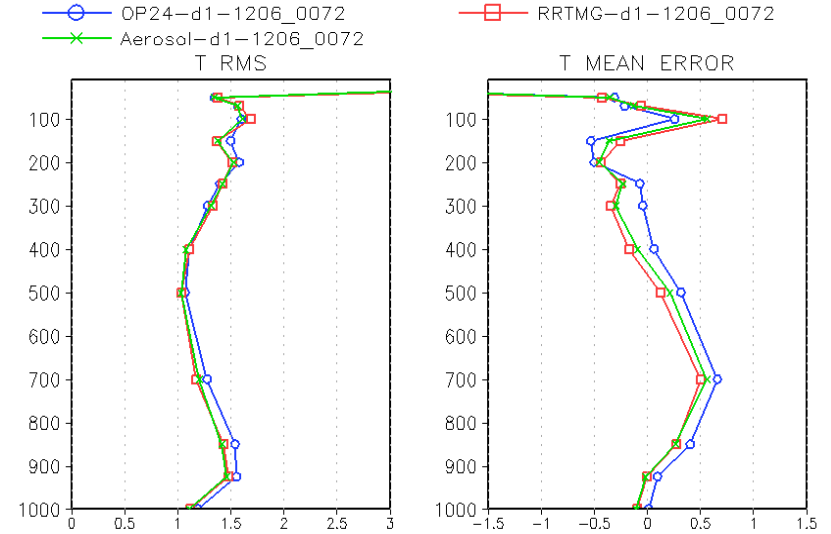
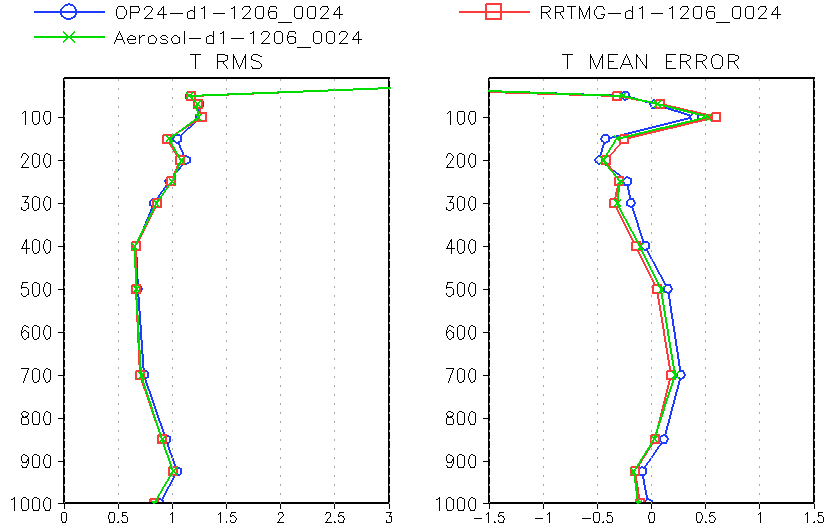
- **2012 June 1~30**
→ 60個 initial time
- **2012 December 1~15**
→ 30個 initial time

JUNE

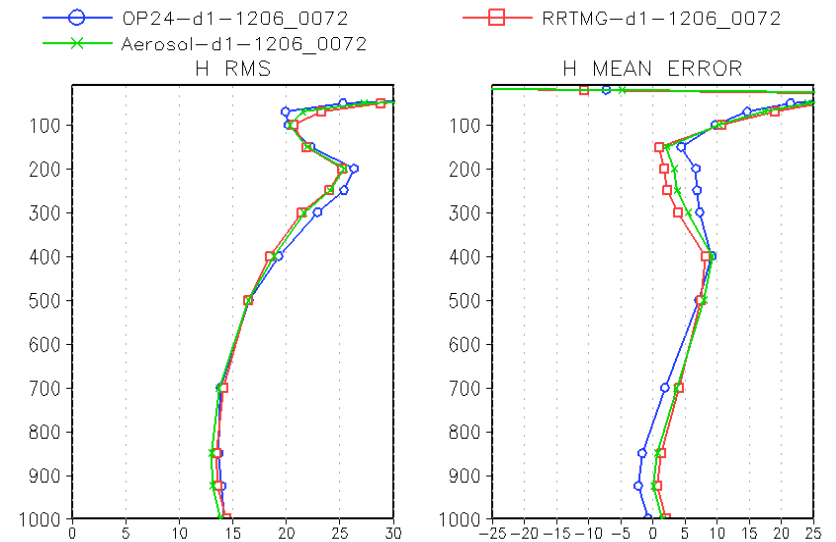
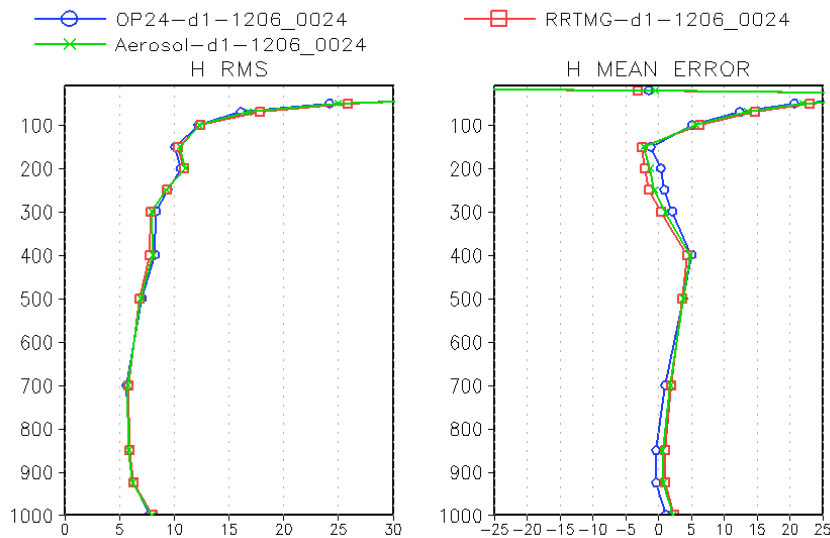
24

72

T



H

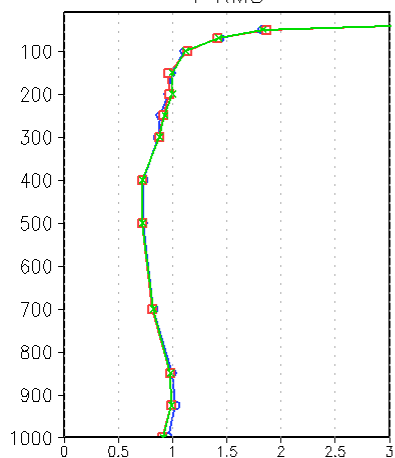


December

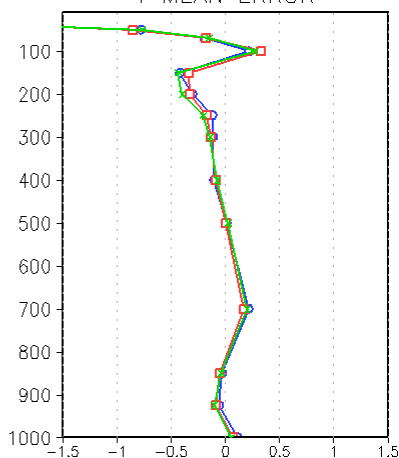
24

T

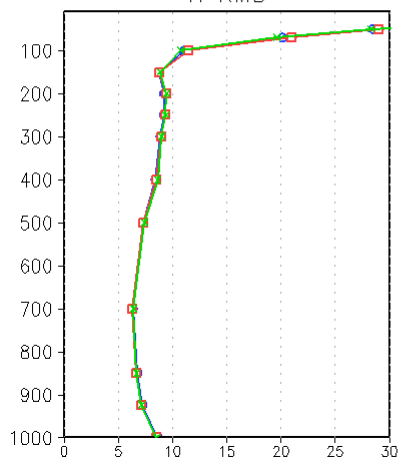
OP24-d1-1212_0024
Aerosol-d1-1212_0024
T RMS



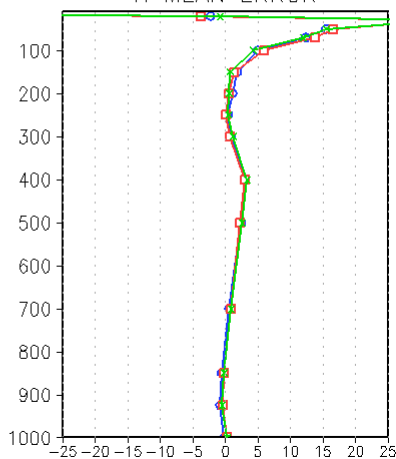
RRTMG-d1-1212_0024
T MEAN ERROR



OP24-d1-1212_0024
Aerosol-d1-1212_0024
H RMS



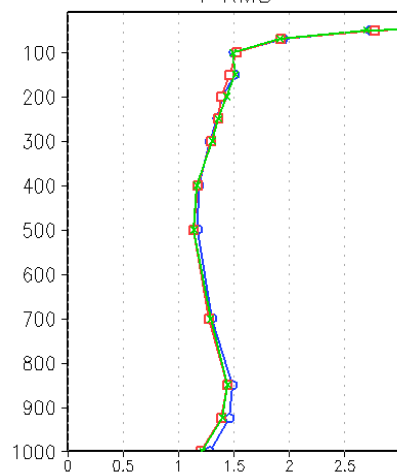
RRTMG-d1-1212_0024
H MEAN ERROR



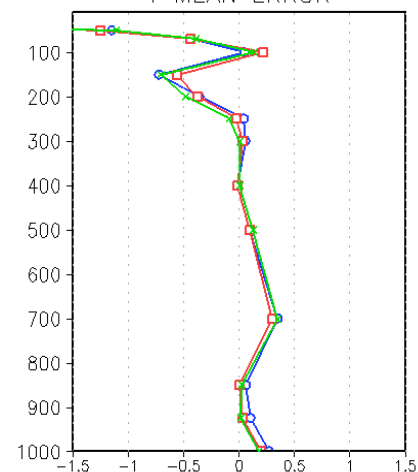
H

72

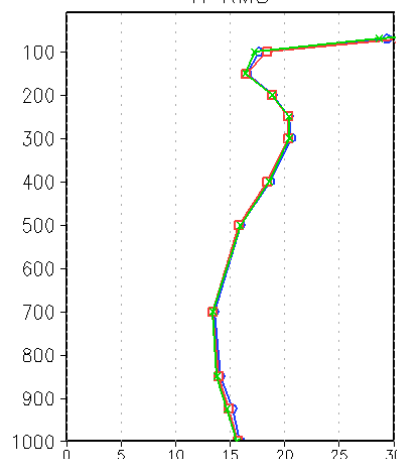
OP24-d1-1212_0072
Aerosol-d1-1212_0072
T RMS



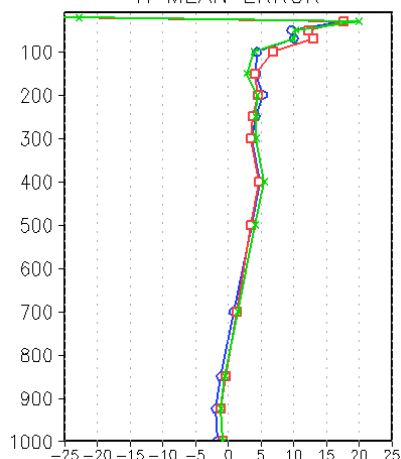
RRTMG-d1-1212_0072
T MEAN ERROR



OP24-d1-1212_0072
Aerosol-d1-1212_0072
H RMS



RRTMG-d1-1212_0072
H MEAN ERROR



CPU time

- 72小時預報
- NoDA
- 3 domain

	time	add
OP24	1h 29m	
RRTMG	1h 54m	+25m
Aerosol	2h13m	+44m
RRTMG_30min	1h 35m	+6m

Summary

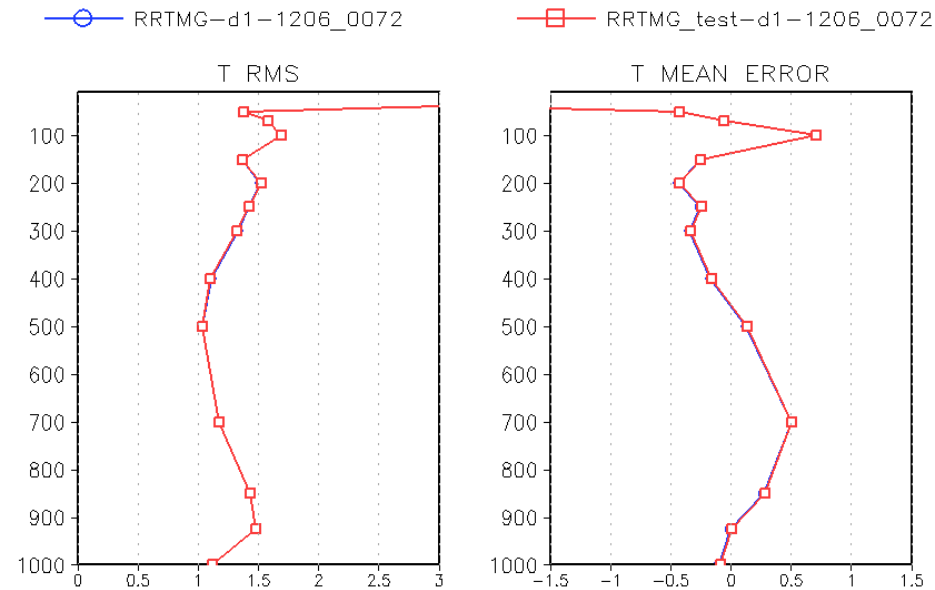
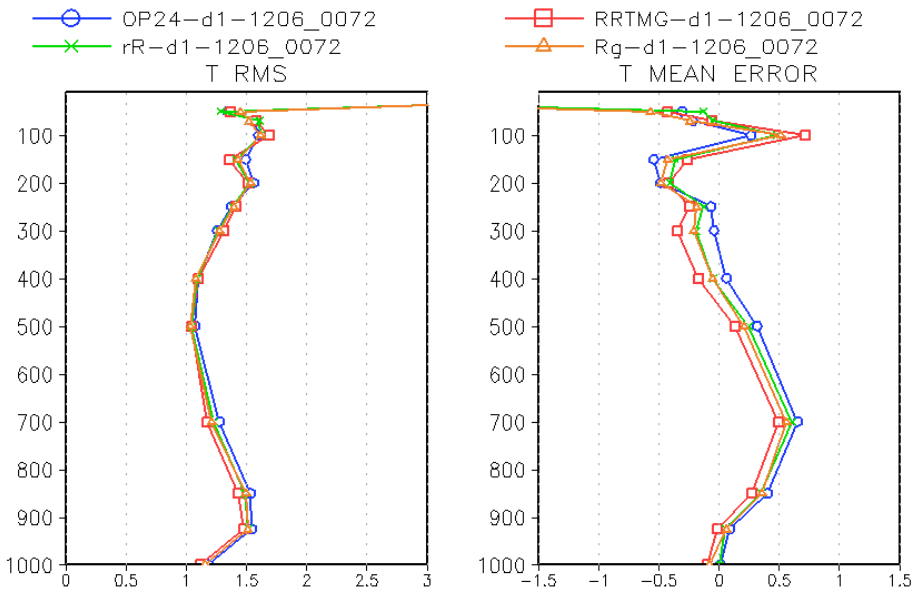
- 將RRTM / Goddard scheme皆改為RRTMG scheme
 - 夏季影響效果比冬天明顯
 - 減少陸地上的短波輻射通量約5%
 - 減少到達地面的長波輻射通量約2%
 - 地表溫度下降達0.9°C
 - 改善暖偏差情形以及降低模式預報的RMSE
- RRTMG scheme加入Aerosol後
 - 陸地上的短波輻射通量再減少，使地表溫度變得更低，但耗費更多的CPU time！

THE END

THANS FOR TOUR ATTENEION

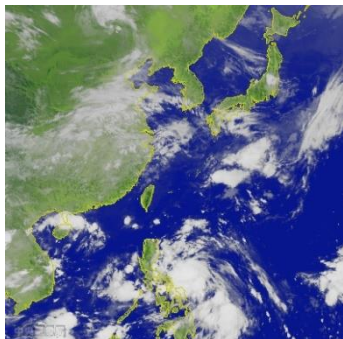
更換長/短波實驗

RRTMG改為30分鐘call一次

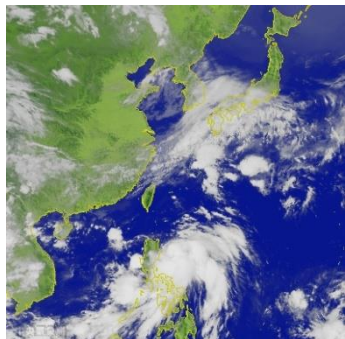


藍:OP24 紅:RRTMG
 綠:短波Goddard→RRTMG
 橘:長波rrtm→RRTMG

藍:RRTMG (15min)
 紅:RRTMG (30min)



METSAT2 IR Image 6/01 08:00(TST)



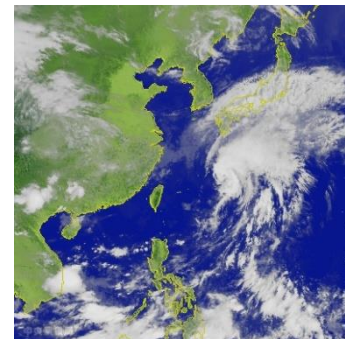
METSAT2 IR Image 6/02 08:00(TST)



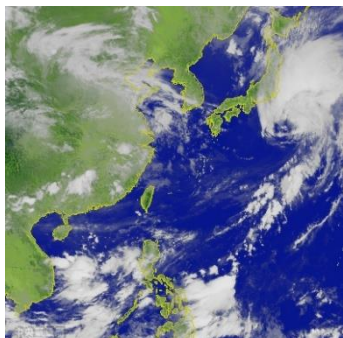
METSAT2 IR Image 6/03 08:00(TST)



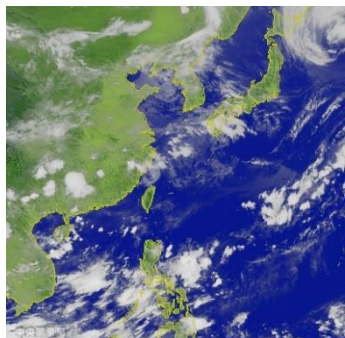
METSAT2 IR Image 6/04 08:00(TST)



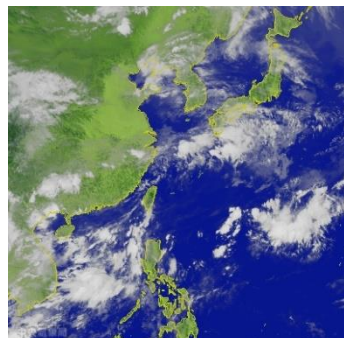
METSAT2 IR Image 6/05 08:00(TST)



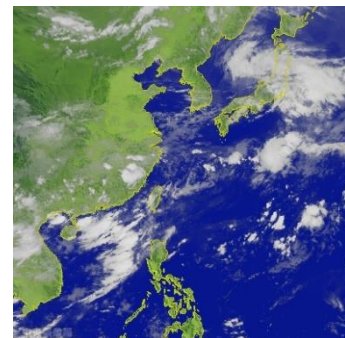
METSAT2 IR Image 6/06 08:00(TST)



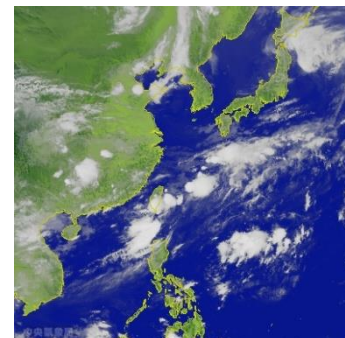
METSAT2 IR Image 6/07 08:00(TST)



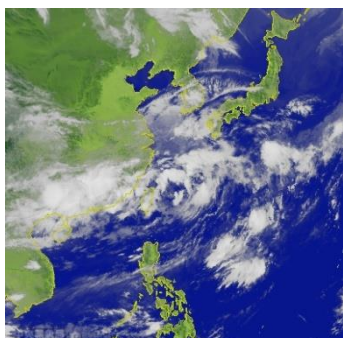
METSAT2 IR Image 6/08 08:00(TST)



METSAT2 IR Image 6/09 08:00(TST)



METSAT2 IR Image 6/10 08:00(TST)



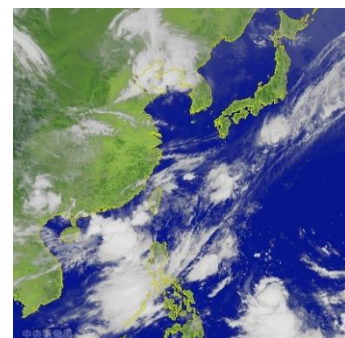
METSAT2 IR Image 6/11 08:00(TST)



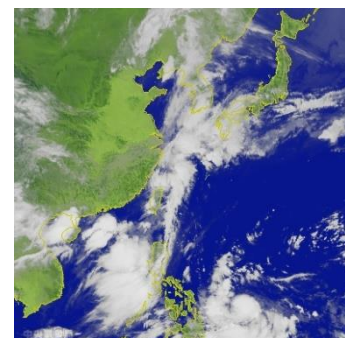
METSAT2 IR Image 6/12 08:00(TST)



METSAT2 IR Image 6/13 08:00(TST)



METSAT2 IR Image 6/14 08:00(TST)



METSAT2 IR Image 6/15 08:00(TST)

