從社群模式到作業模式（R2O）之經驗歷程

以氣象局區域預報模式為例

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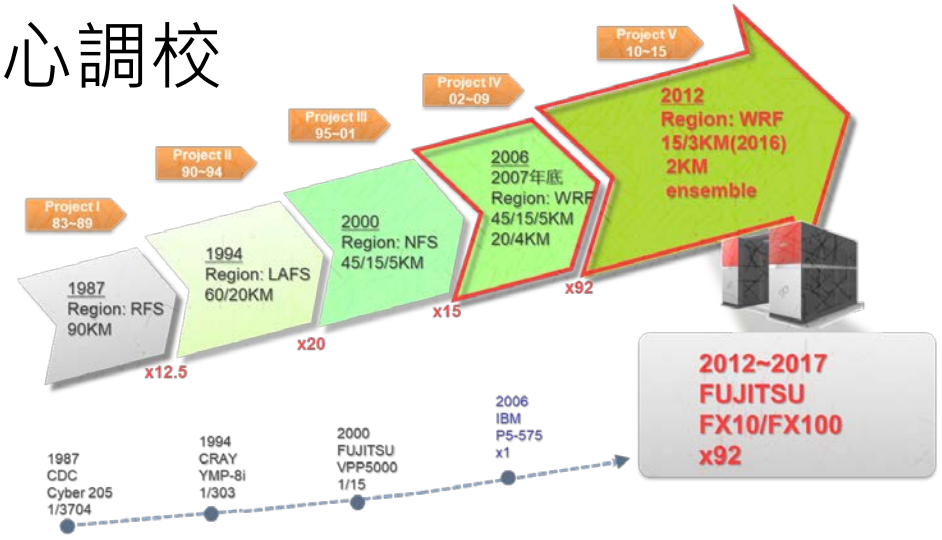
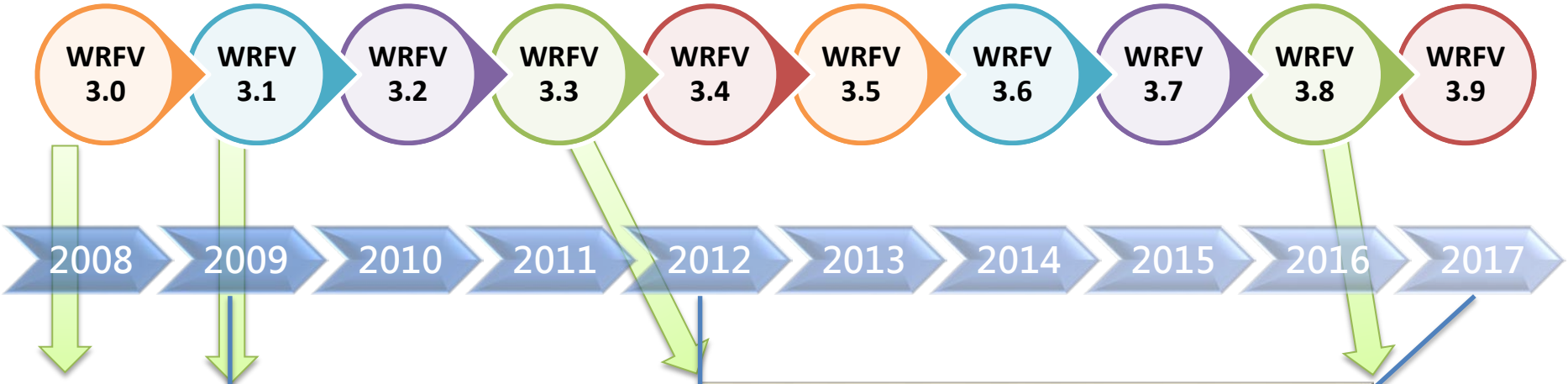
江琇瑛 洪景山 陳得松 馮欽賜 王薇 Jim Bresch

社群模式的優缺點

- **優點**
  - 容易取得
  - 有多元社群研究成果挹注
  - 有廣大社群使用者的經驗分享
- **缺點**
  - 模式預報效能仍須精心調校



CWBWRF的更新演進



2007~2009

- OP1.0
- OP2.0
  - WRF3.0
  - 使用NCEP全球資料
  - 循環更新

2009~2012

- OP2.1
  - 修正GPSRO同化資料處理方法、使用模式本身之背景誤差協方差
- OP2.2
  - 土地利用資料更新、颱風位置重置處理
- OP2.3
  - 積雲參數法更新
  - 部分循環更新同化策略

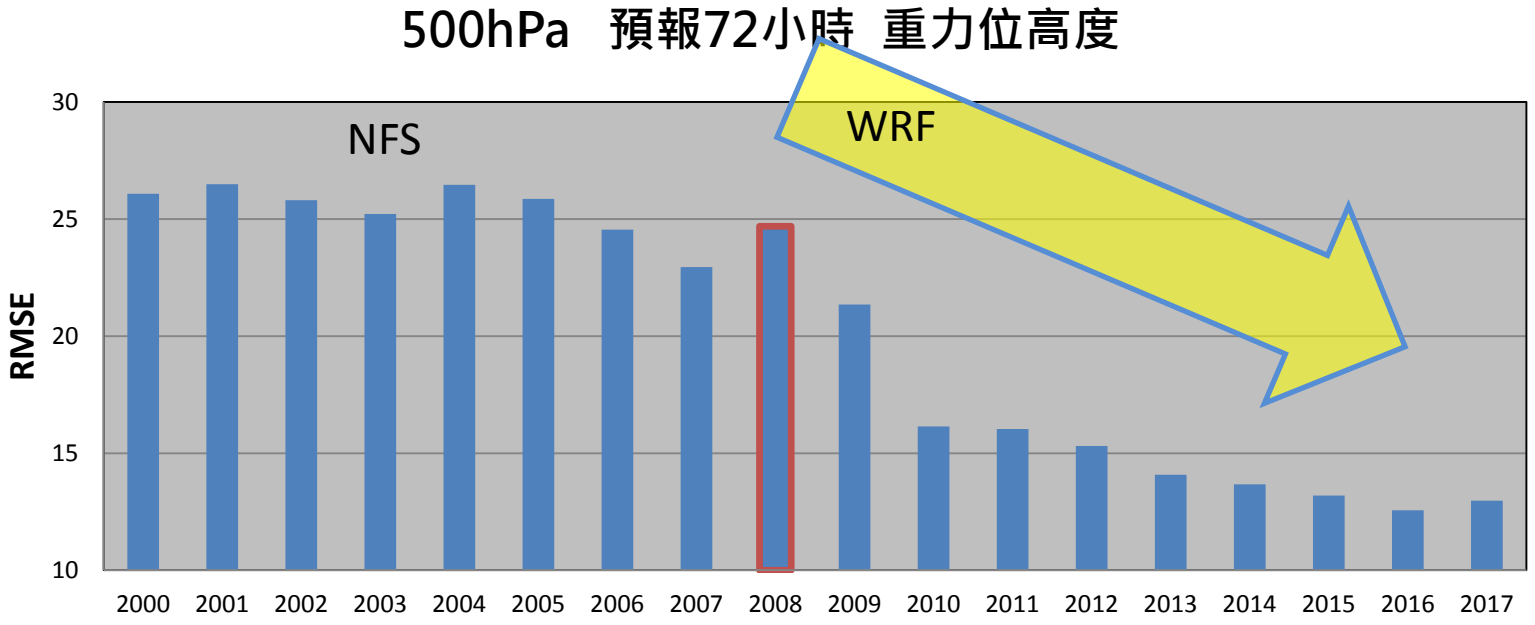
2012~2016

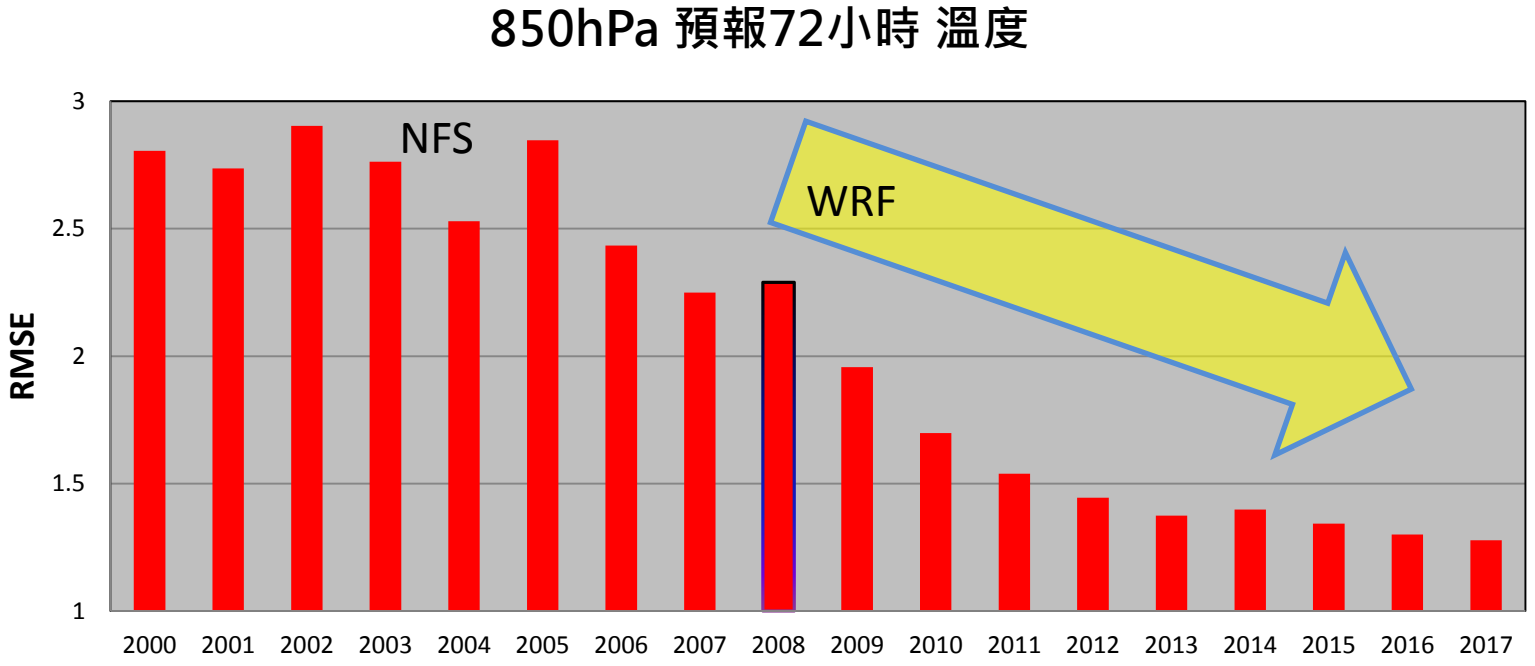
- OP2.4
  - 邊界層參數法(V3.1)、重力波拖曳
  - 同化ground GPS ZTD資料
- OP2.5
  - 植物分布率、地面風修正及輻射參數法
  - Blending
- OP2.6
  - Hybrid-3DVar、土壤同化
- OP4.0
  - 解析度(45-/15-/5-km/lev45 → 15-/3-km/lev52)
  - 重力位拖曳參數調整、3Dvar、CV3、no Hrldas、

2017~

- OP4.1
  - WRFV381
  - CV5、Hybrid、Hrldas、GWDO、PBL、.....

■ 模式的調校必須在穩定的版本上持續進行


500hPa 預報72小時 重力位高度
NFS
WRF
RMSE
30
25
20
15
10
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017


850hPa 預報72小時 溫度
NFS
WRF
RMSE
3
2.5
2
1.5
1
2000
2001
2002
2003
2004
2005
2006
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2008
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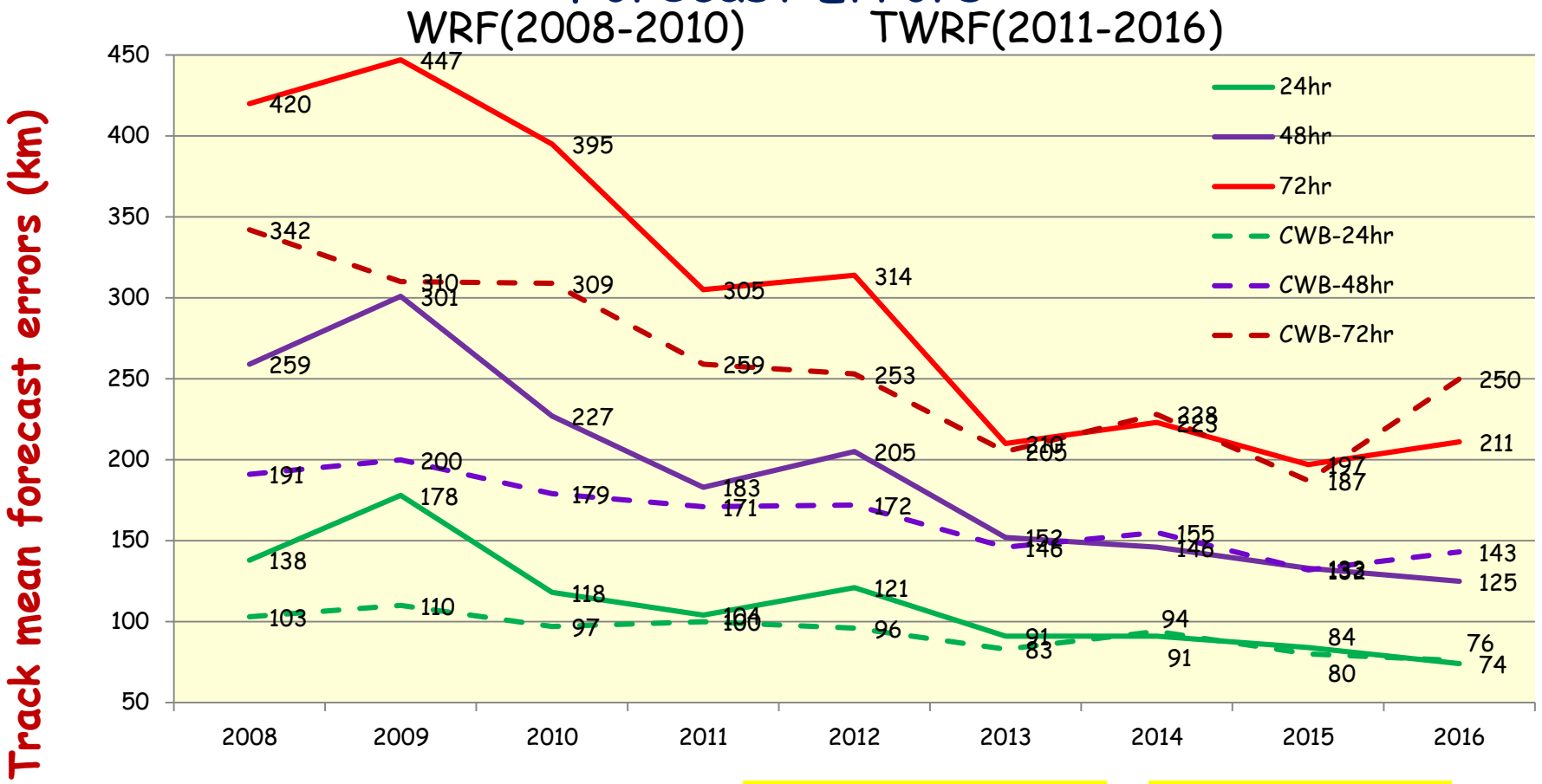
2014
2015
2016
2017

Comparison between TWRF & CWB for the TC Track Forecast Errors



Operation

TC Relocation

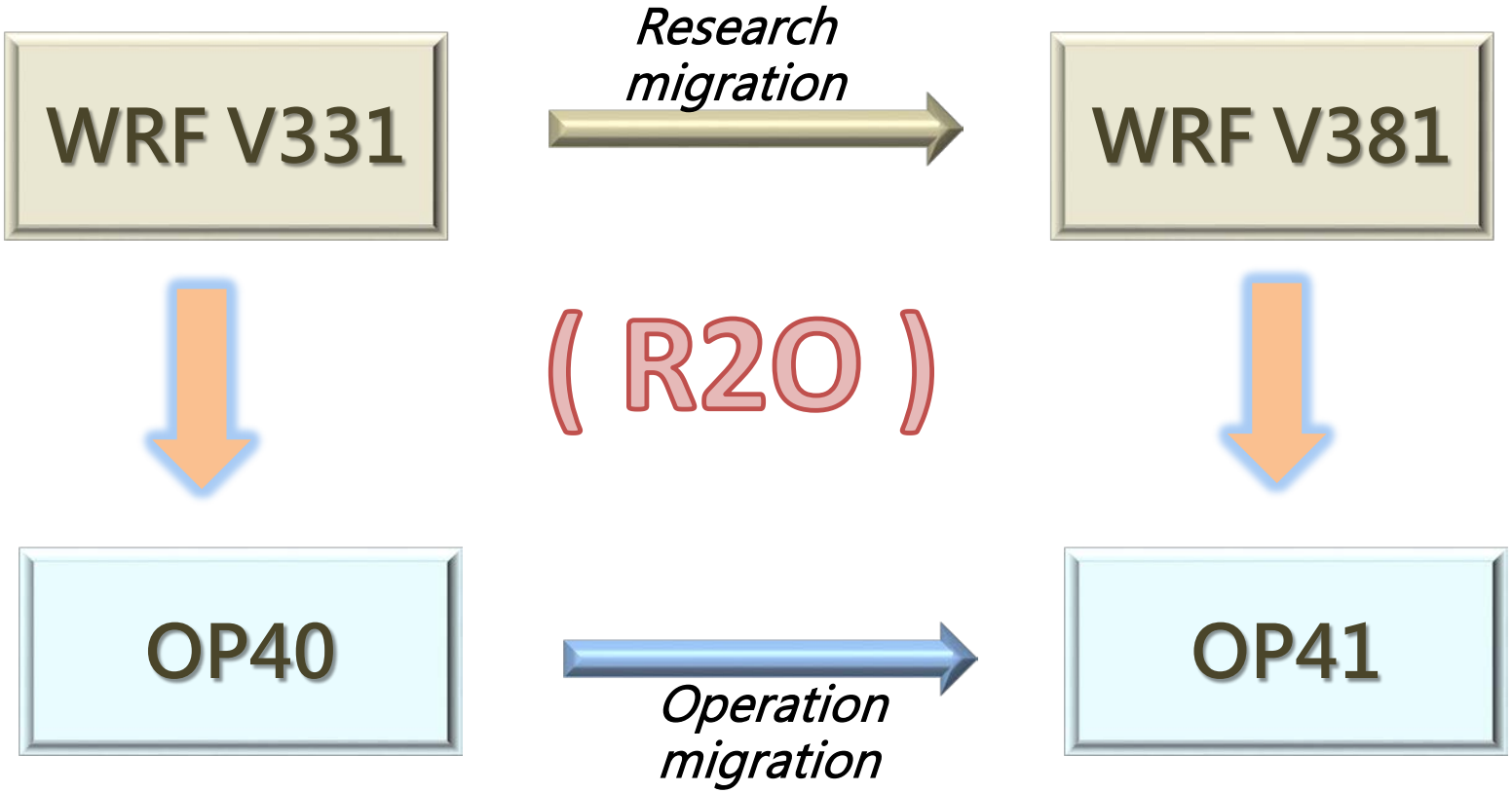
New TC initialization

Two-way interaction

TC bogus

Partial cycling
Outer loop
New trigger KF

Blending
NCEPGFS & TWRF
45km →→ 15km



當WRF從V331升級成V381時，會讓OP41變得比較好嗎?

版本更新 (V3.3.1➔ V3.8.1)所面對的差異(1/2)

輻射
- **RRTMG**: options to use CAM ozone data (**o3input=2)** (V35)
- **RRTMG**: time-varying green-house gases for CAM/RRTM/RRTMG longwave radiation options
- **RRTMG:** shortwave radiation: extinction coefficient updated from RRTM group(V361)

積雲
- **KF-type schems (cu_physics=1,11**): fix to correctly detrain frozen species to microphysics scheme that do not have QICE array, but QSNOW only

PBL
- **YSU**: improved Pr number computation and change to lower limits on diffusion(V34)
- **YSU**: fix for stable surface and consistency with thermal roughness length. The change may result in improvement in surface wind forecast at night.(V341)
- **YSU**: a bug fix for nest starting at later time due to introduction of 'topo_wind' option, even if the option isn't used.(V341)
- **YSU**: prevent large negative Ri in unstable regime (which could potentially cause model blowup over high terrain)(V351)
- **YSU and Shin-Hong PBLs**: background diffusion was reduced, which helps removing a large cold bias at the model top layer. (*Thanks to Songyou Hong of KIAPS, Korea*)(V38)
- **topo_wind=2**: a simpler terrain-variance-related correction, and it works for YSU PBL(V35)

地表
- **Surface layer physics option 1 and 11 (MM5 scheme)**: Recode Garratt formula. The formula gives nearly identical results *(Thanks to B. Green of PSU)*.(V351)
- **namelist option sf_sfclay_physics = 1 is now the revised MM5 surface layer scheme.** The old MM5 surface layer option is now 91. *(V36)*
- **Revised and original MM5 surface layer schemes (sf_sfclay_physics = 1, 91):** heat and moisture exchange coefficients over water is changed from Carlson-Boland to COARE 3. This helps to reduce fluxes over ocean. A term proportional to 1/u* is added to represent roughness of ocean at very low wind speed.(V37)
- **Revised MM5 surface layer schemes (sf_sfclay_physics = 1):** fix a out-of-bounds issue.

PBL
- Gravity Wave Drag: clean-up, minor fix, add diagnostic output(V34)
- Gravity wave Drag: updated and includes flow blocking (*Thanks to Hyun-Joo Choi of KIAPS, S. Korea*)(V37)

版本更新 (V3.3.1➔ V3.8.1)所面對的差異(2/2)

- **Noah:** fixes bugs to prevent discontinuous behavior for soil ice melting, and add a dew term to QFX over snow cover. Sets minimum LAI. For mosaic option, fields are now interpolated to the nest and allowed to fed back to parent domain.(V37)
- **Noah (sf_surface_physics=2):** fix to the calculation of skin temperature over seaice when snow melting is occurring. (V371)
- **Noah:** fix for a sudden jump in 2m Qv due to abrupt change in exchange coefficient(V371)
- **Noah: (V38)**

  (a) added option (*opt_thcnd*) for calculation of soil thermal conductivity for soil type 3 (sandy loam) and 4 (silt loam) based on results in Massey, et al (2014; JAMC)
  (b) fixes high-frequency oscillations in LH flux seen in time series output over snow.
  (c) Fixed Noah glacial and sea-ice to allow negative moisture flux

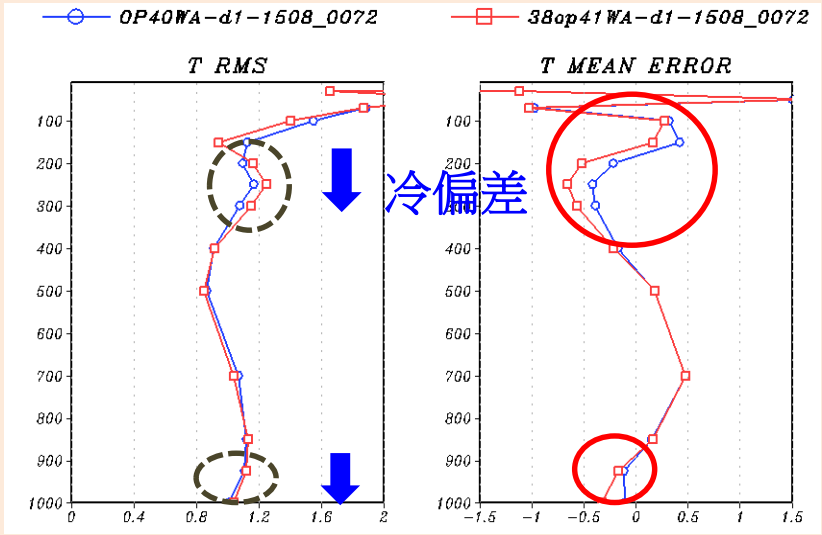
土壤

- Add feedback to surface diagnostic fields: T2, TH2, Q2, U10, V10 and PSFC(V341)
- corrected parameters in SOILPARM.TBL (V35)
- VEGPARM.TBL in run/ is updated *(V37、V38)*
- the default value for iso_temp has been changed from 0 to 200 K in V3.5(V35)
- A new vertical interpolation option using cubic spline is added (*Thanks to CWB of Taiwan)(V36)*
- DFI: turn off other advection except for Qv(V37)
- Lateral boundary conditions: fix a problem with specified and nested boundary conditions off by one time step (V371)

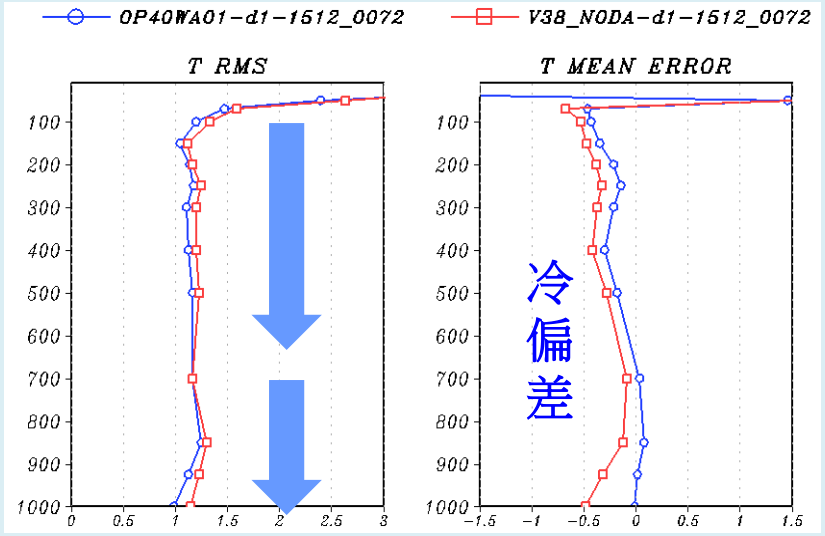
其他

OP40 vs. V381

- 2015年8月

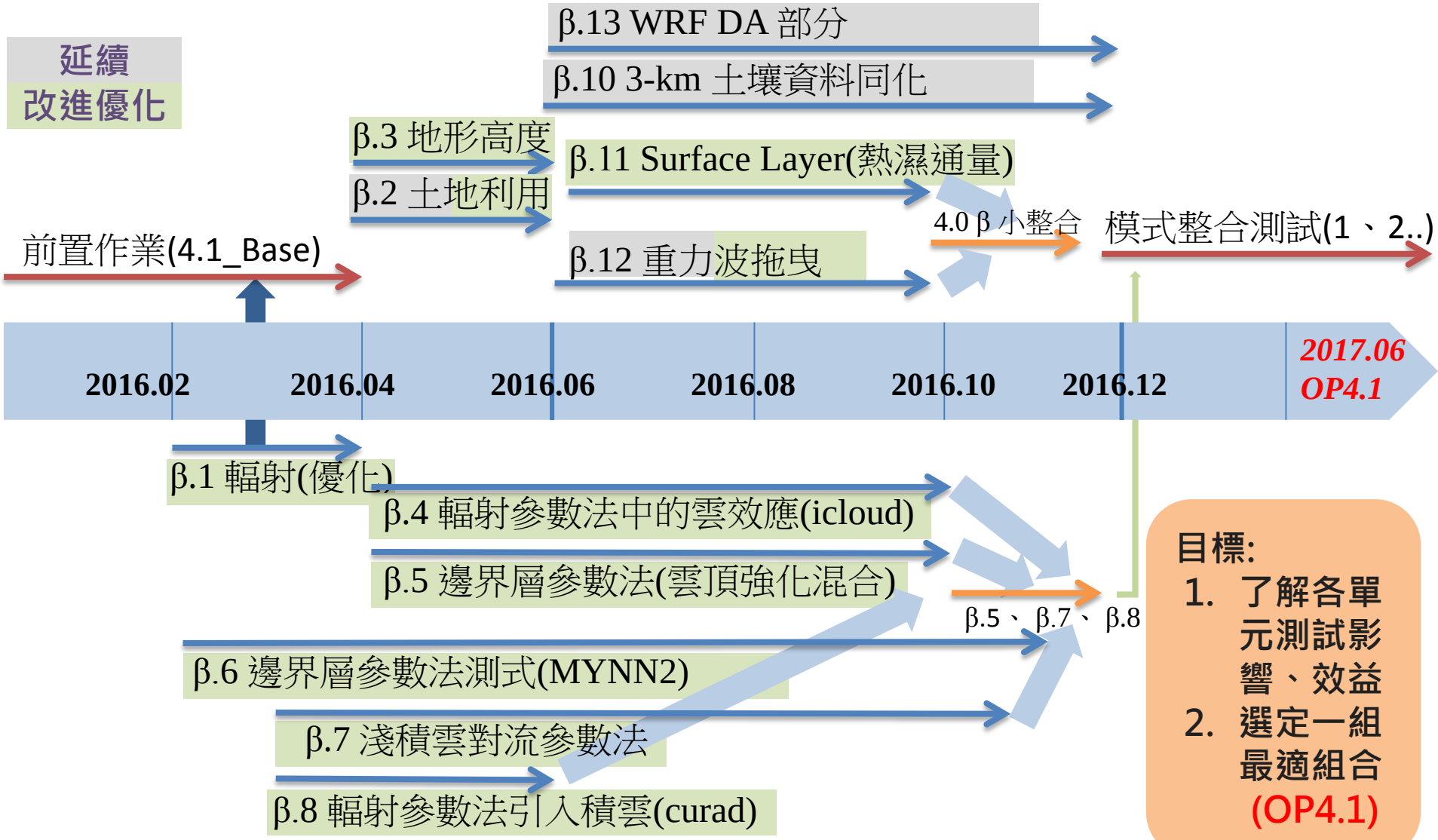


- 2015年12月

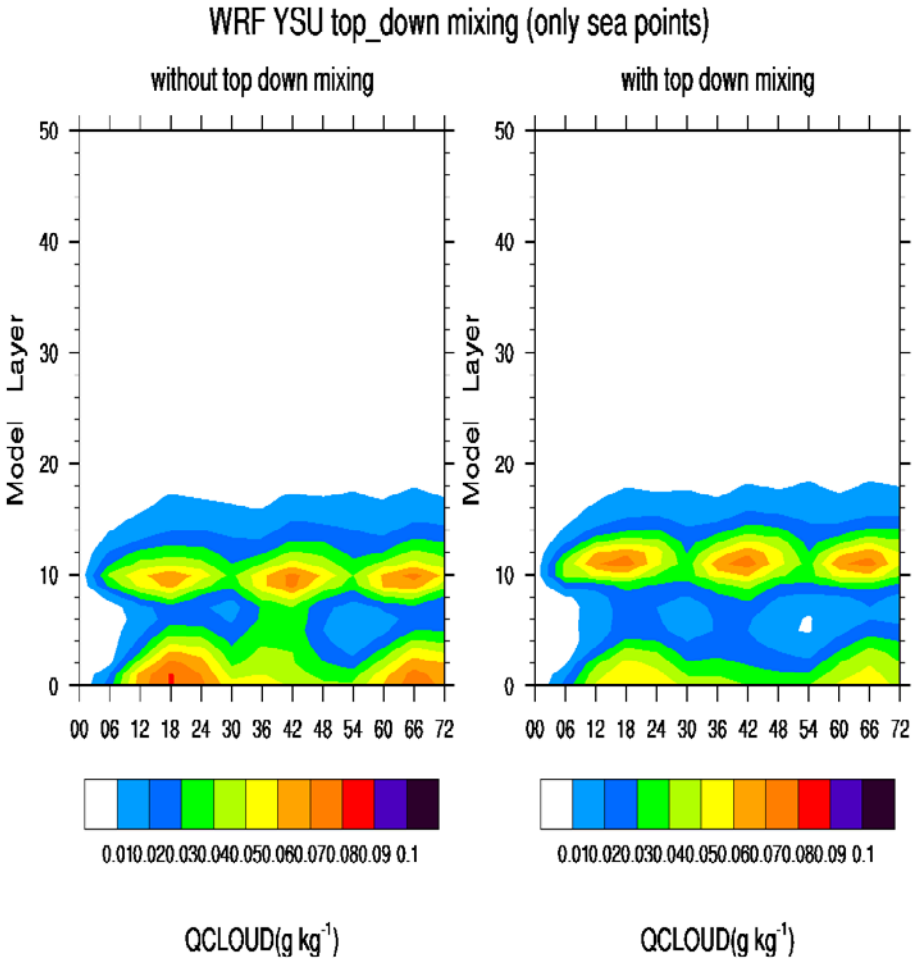


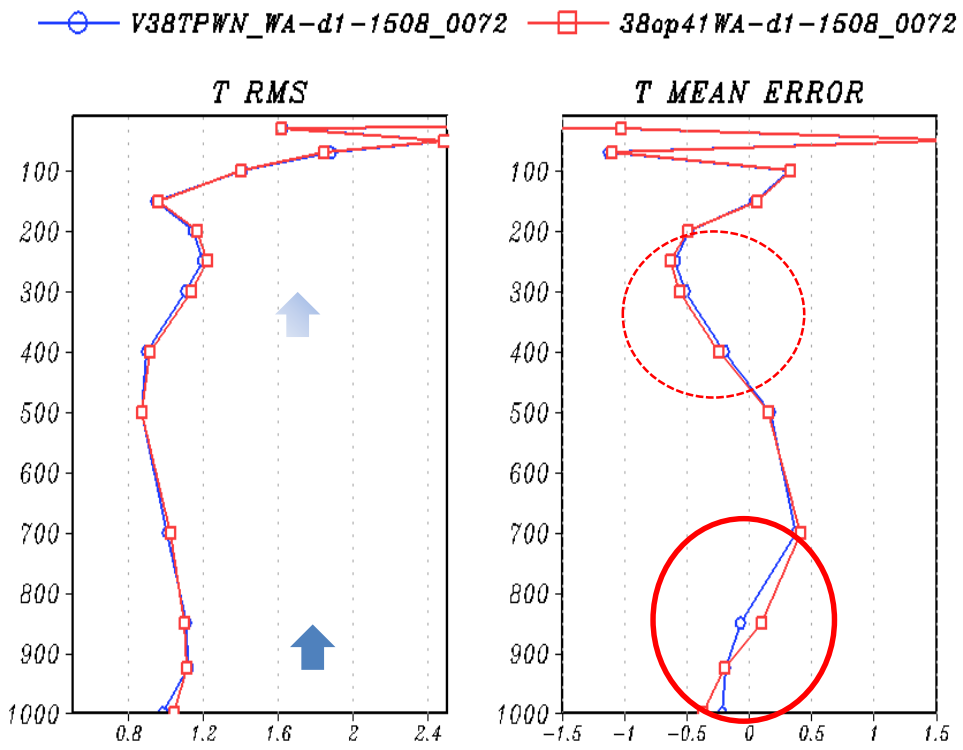
(⊙０⊙)！

Timeline of OP4.1 Project



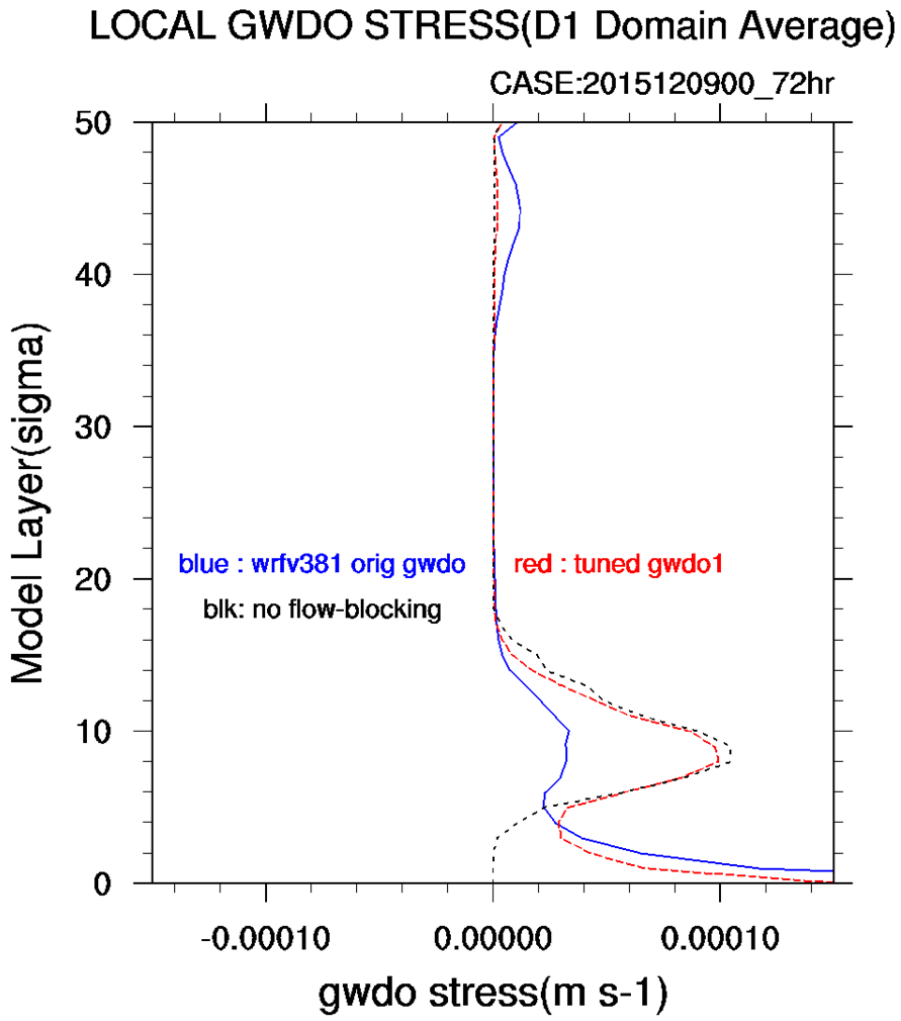
1. YSU邊界層參數法之雲頂輻射所致強化混和作用 (Top_Down mixing)影響

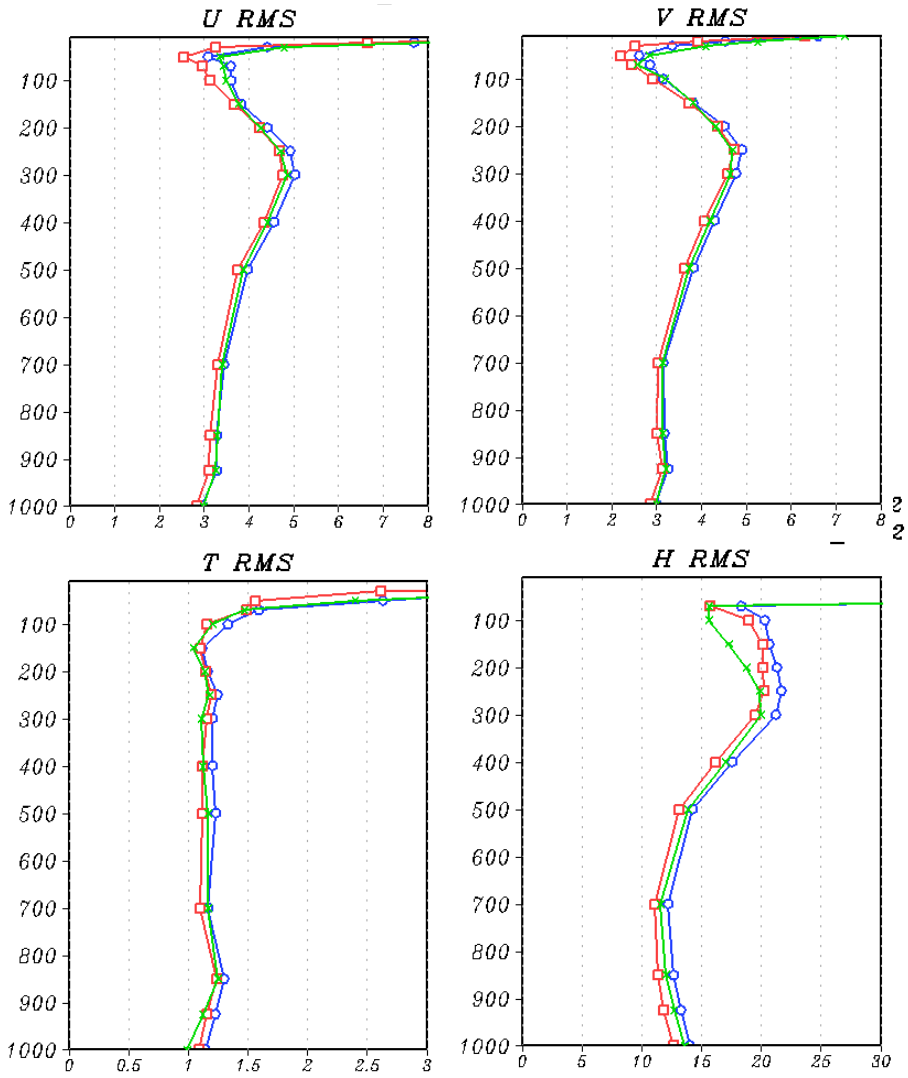




2. 地形重力波拖曳調整

OP40, V38 and V38_GWD1 (2015 Dec, 72h forecast error)

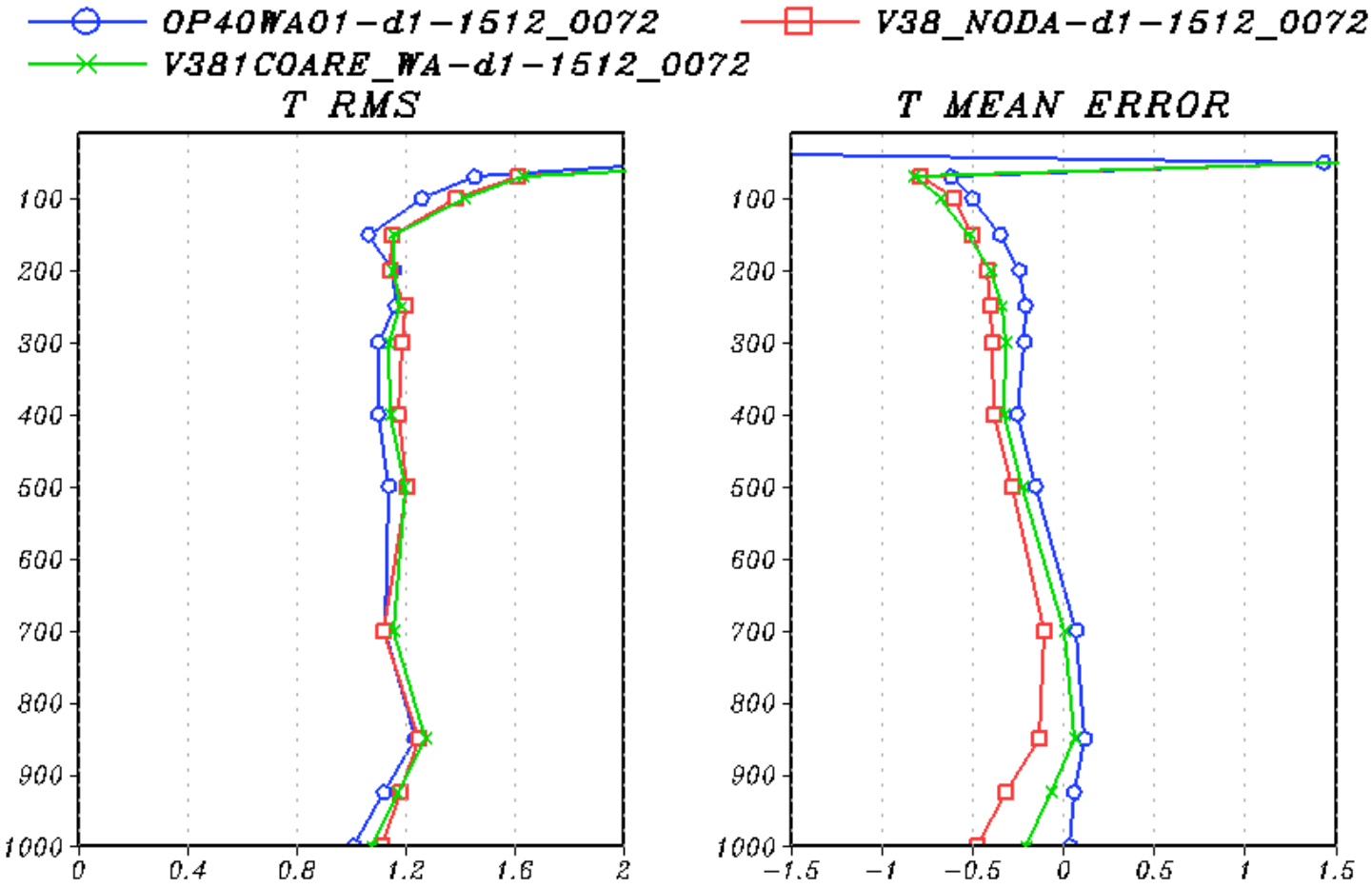




GWDO1 improved a lot

3. 地表層參數法中海上熱濕通量計算的修改

- 概念: 在更新版本中使用新方法重新修正計算海氣的溫度(與濕度)交換係數(COARE)，使得海氣通量變小，但其結果會使模式在冬季海面上空有明顯過冷的情形。因此對其方法進行調整。



WRF OP41更新優化項目

模式 | **資料同化** | **作業流程**

1. 在YSU邊界層參數法中增強雲頂混和效應
2. 新版重力波拖曳力的再調整
3. 地面層參數法中新版海上roughness length計算方法的再調整
4. 更新地形背景檔：高解析度土地利用(Land Use)、 更新之地形高度(GMTED2010)、 去除小島地形

WRF OP41更新優化項目

模式 | **資料同化** | 作業流程

1. D01：使用Hybrid-3DVar，D02：3DVAR

2. Static BE：CV5 (data：2015.08.01 - 2015.08.31)

3. 地面觀測資料同化: 改為在模式最低層計算觀測增量，調整水氣場的觀測誤差

4. 颱風Relocation程式修正

5. 耦合3公里之土壤資料同化系統(Hrldas)

Summary

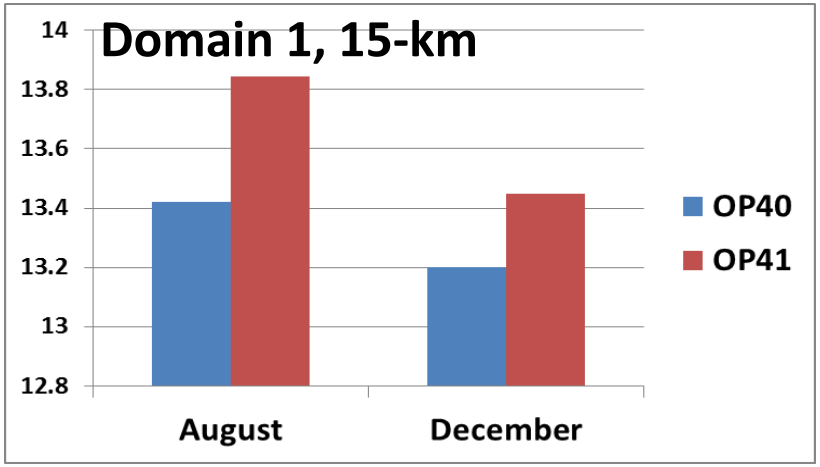
2015 .08 OP41 vs. OP40 (D1)

OP41_GAMMA		
850H SCORE	0.654	▲
700H SCORE	0.679	▲
500H SCORE	0.706	▲
300H SCORE	0.709	▲
850T SCORE	0.724	▲
700T SCORE	0.744	▲
500T SCORE	0.701	▲
300T SCORE	0.623	▼
850U SCORE	0.444	▲
700U SCORE	0.457	▲
500U SCORE	0.492	▲
300U SCORE	0.44	▲
850V SCORE	0.43	▲
700V SCORE	0.463	▲
500V SCORE	0.508	▲
300V SCORE	0.473	▲
SLP SCORE	0.691	▲
Summary Index Score		13.845

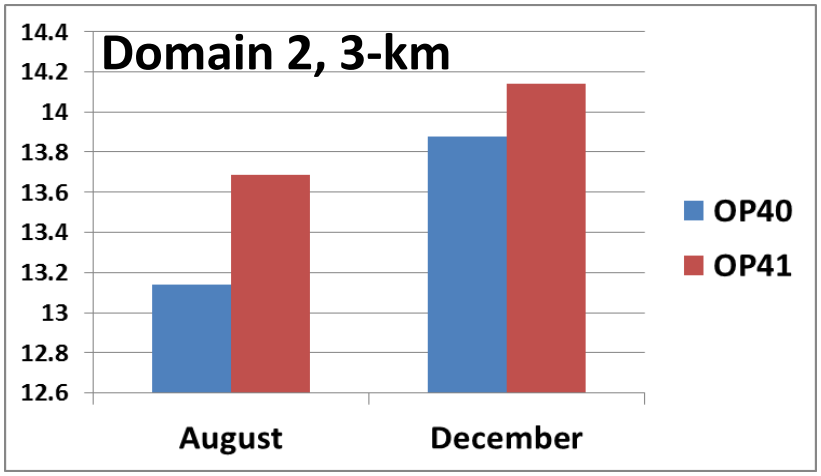
OP40 3DVAR	
850H SCORE	0.611
700H SCORE	0.647
500H SCORE	0.695
300H SCORE	0.702
850T SCORE	0.723
700T SCORE	0.737
500T SCORE	0.7
300T SCORE	0.637
850U SCORE	0.413
700U SCORE	0.438
500U SCORE	0.482
300U SCORE	0.428
850V SCORE	0.4
700V SCORE	0.445
500V SCORE	0.493
300V SCORE	0.455
SLP SCORE	0.651
Summary Index Score	13.42

OP41特性描述

- Score index OP41> OP40
- Aug > Dec



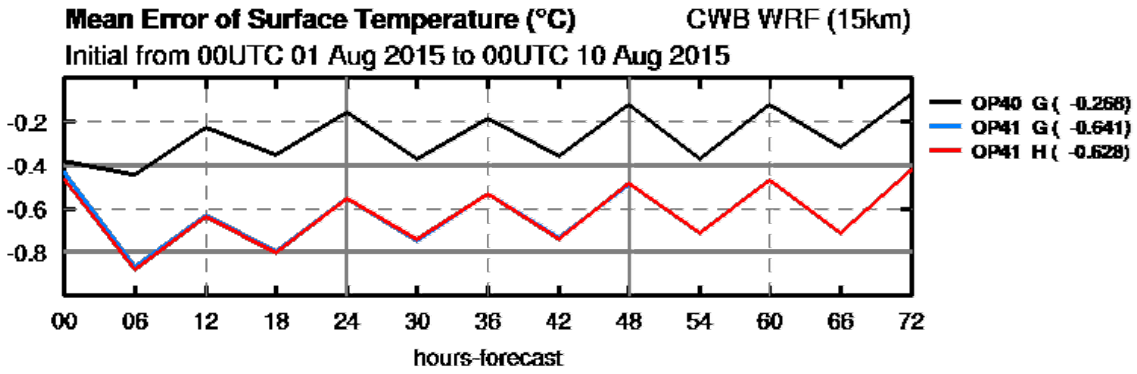
- Score index OP41> OP40
- Aug < Dec

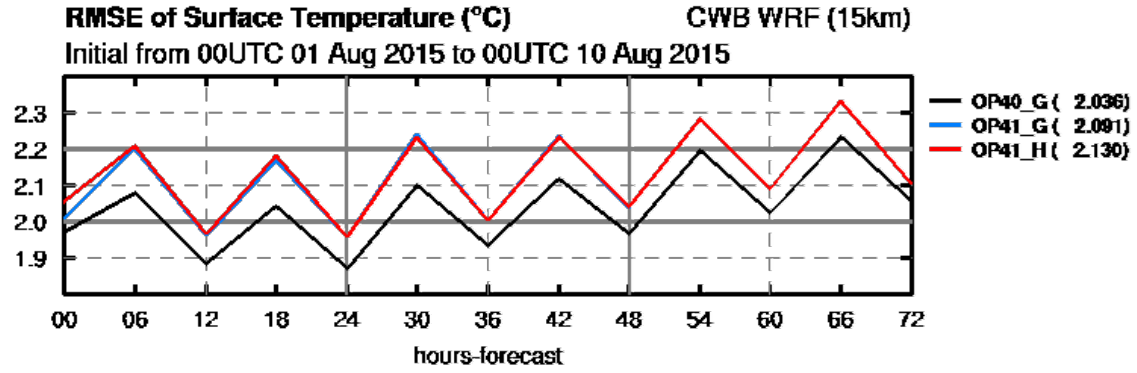


By 洪簡正

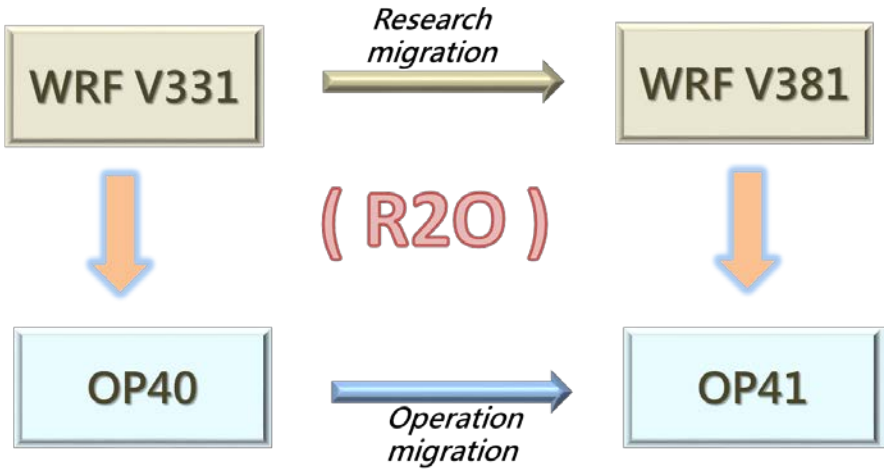
OP41特性描述

- 兩米溫度預報過低





CWB WRF (OP41)的價值與展望



- 以CWB為例，經過龐大的研發，取得R2O的成功，讓331→381時，使得OP41比OP40好
- 建立在更新的模式架構上，展望應用新的模式技術，改善模式預報
  - Hybrid vertical coordinate
  - Up-to-date physics, e.g. Scale aware physics
  - Couple ocean model
  - Apply delicate land surface process

報告完畢

感謝您的聆聽!