Clear-sky and all-sky AHI radiance DA at convective-scale with WRFDA

Jake Liu, Yali Wu, Dongmei Xu

National Center for Atmospheric Research, Boulder CO, USA

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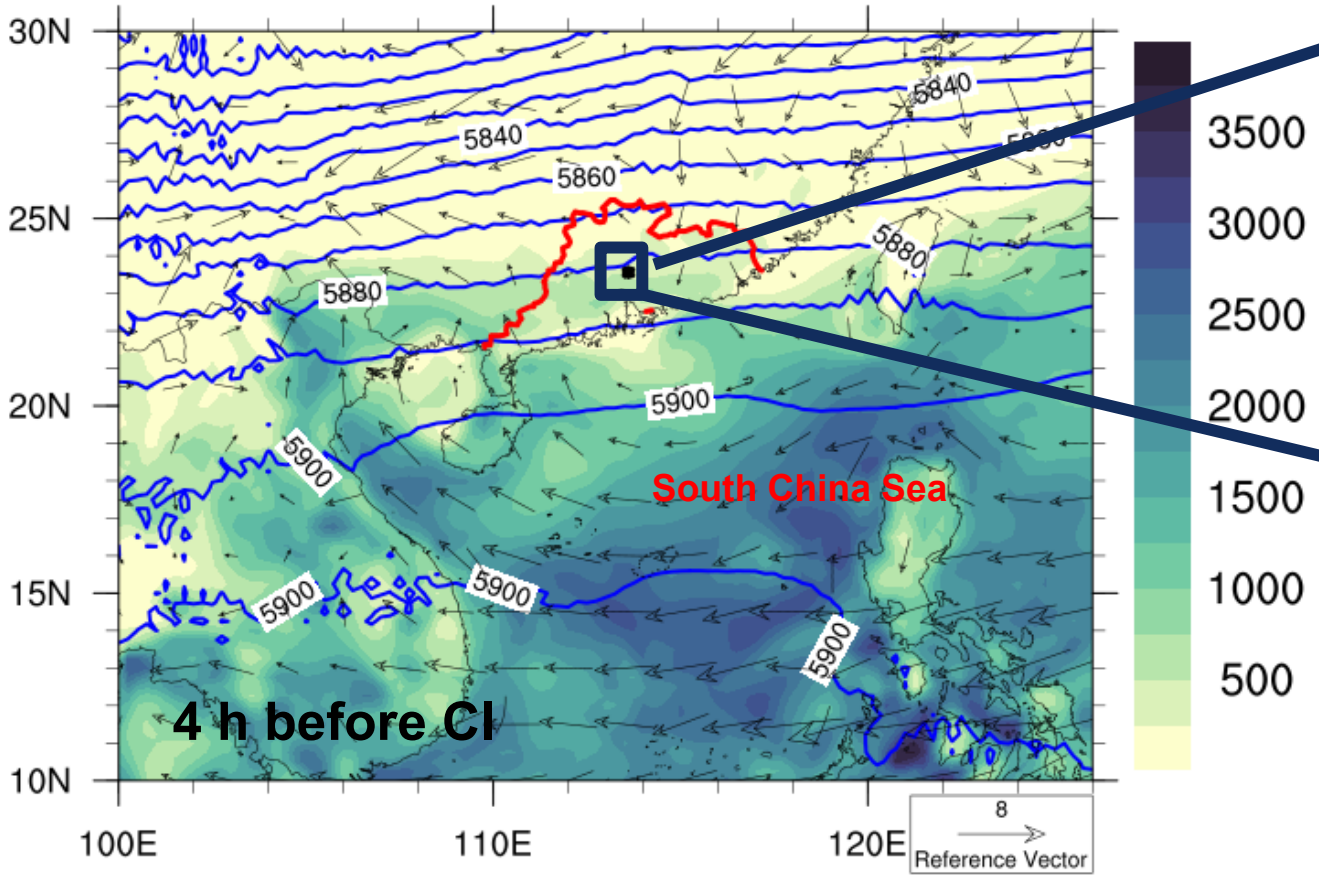
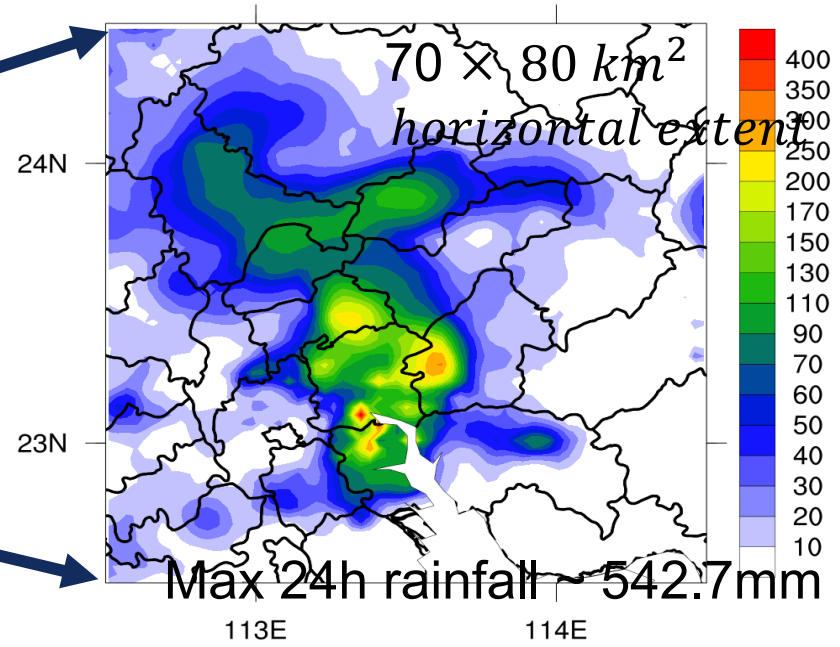
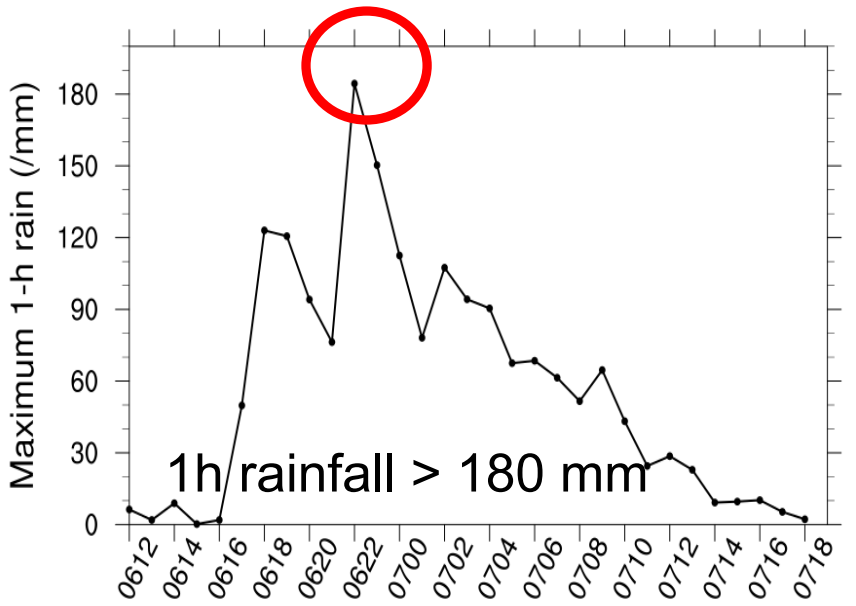
Outline

- 10-min clear-sky AHI DA using 4DVar for a local storm event

- All-sky AHI DA using hybrid-3DEnVar for cloud analysis/forecast





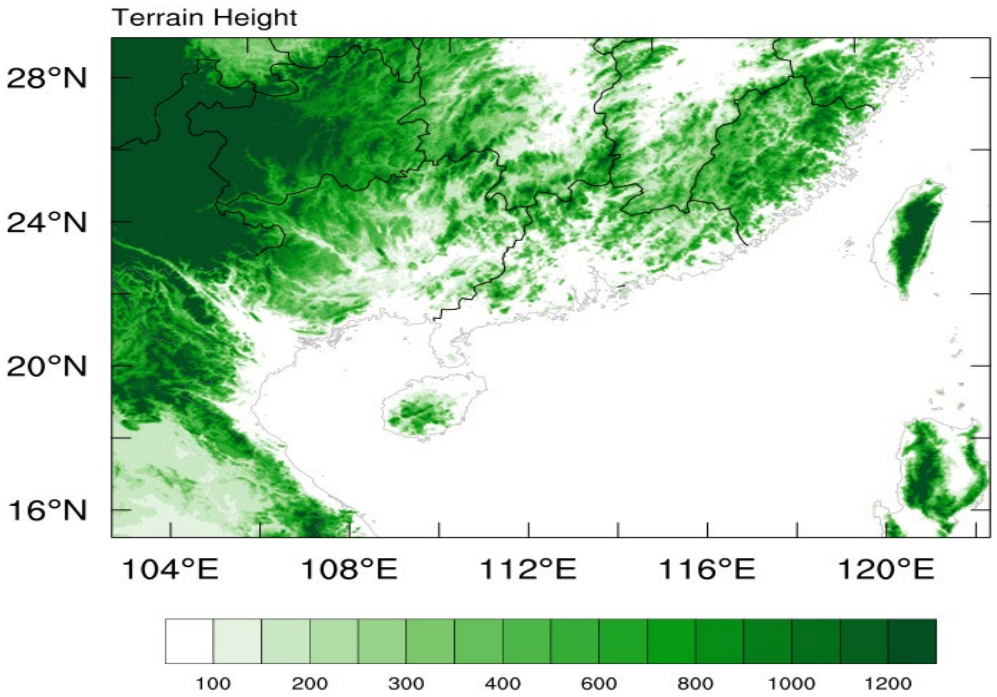


CAPE: 1000-1500 J/kg (shaded)
500 hPa gph: weak large-scale forcing (contours)
850 hPa wind: weak (vectors)

No global model able to predict it.
Regional radar DA useful after CI.

A record-breaking rainstorm, Guangzhou, 7 May 2017

Experimental design

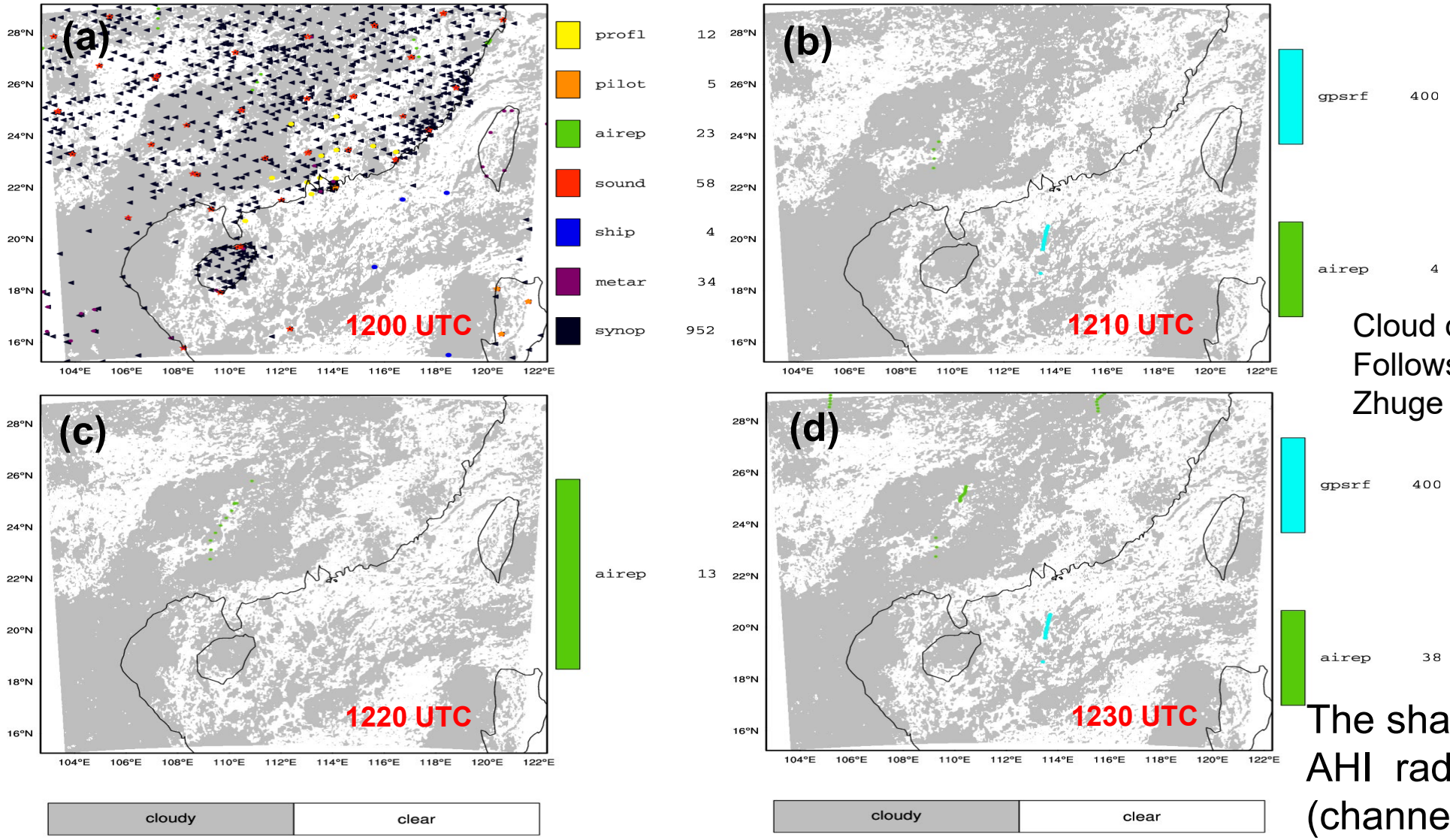


Exps	Observations	DA method	
CON_3D	Conventional	3DVar	
AHI_3D	Conventional + AHI (single time) 3 WV channels	3DVar	
CON_4D	Conventional	4DVar	[0, 30] min
AHI_4D	Conventional + AHI (every 10-min) 3 WV channels	4DVar	[0, 30] min
Exps were initialized at 12 UTC, 6 May, 4 hours before convection initiation For 4DVar, 27-km for the 1st outer loop; 9-km for the 2nd outer loop			

WRF model forecast resolution: 3 km

Can we improve forecast of convection-initiation and subsequent rainfall using 4DVar plus 10-min AHI 3 WV channels' radiances?

Data coverage (For a 4DVar analysis)

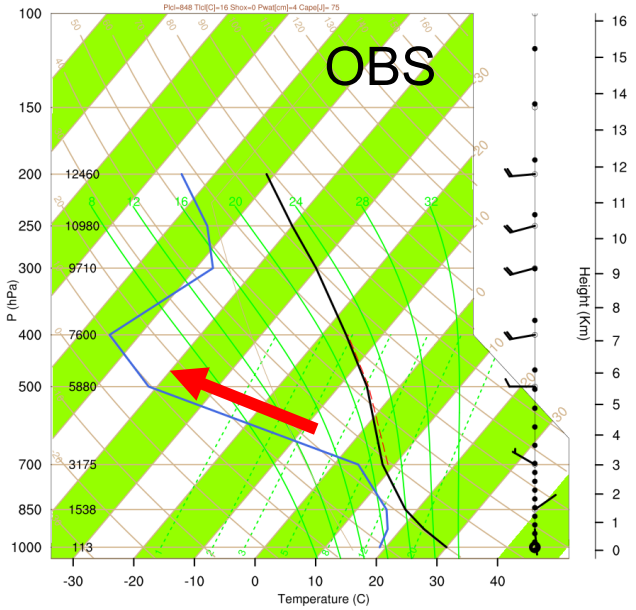


Cloud detection
Follows
Zhuge and Zou, 2016

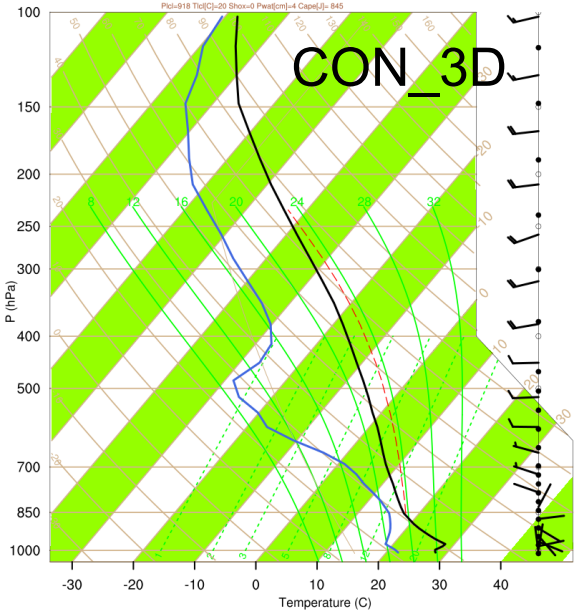
The shaded indicates
AHI radiances
(channel 8 for example)

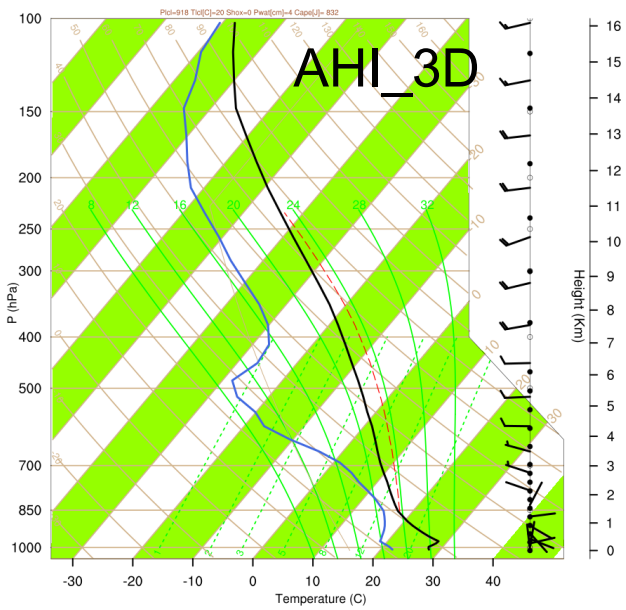
Skew-T verification

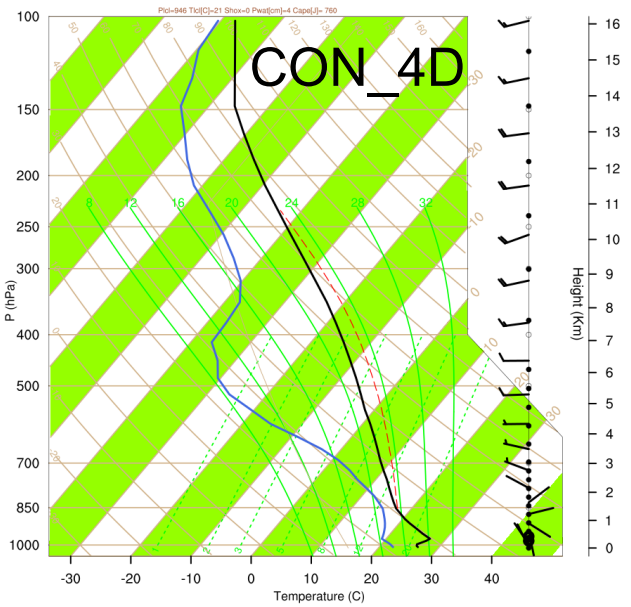
against soundings at QingYuan station

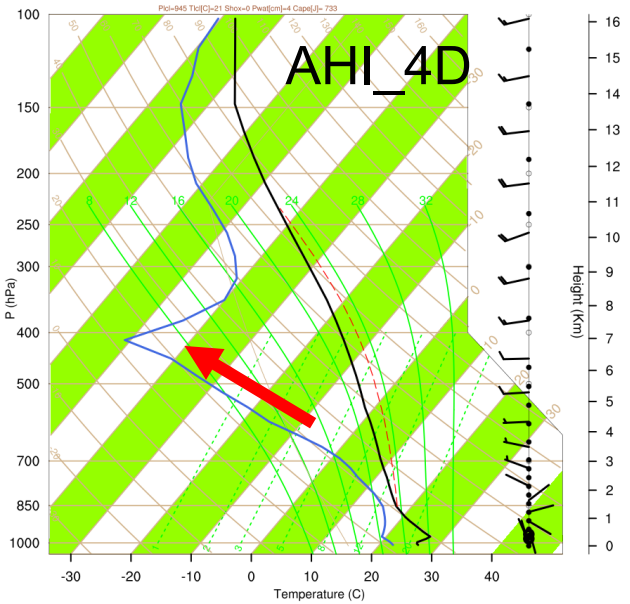


- OBS: dry layers at 700 – 400 hPa (favor for convergence)
- AHI_4D agreed best with OBS

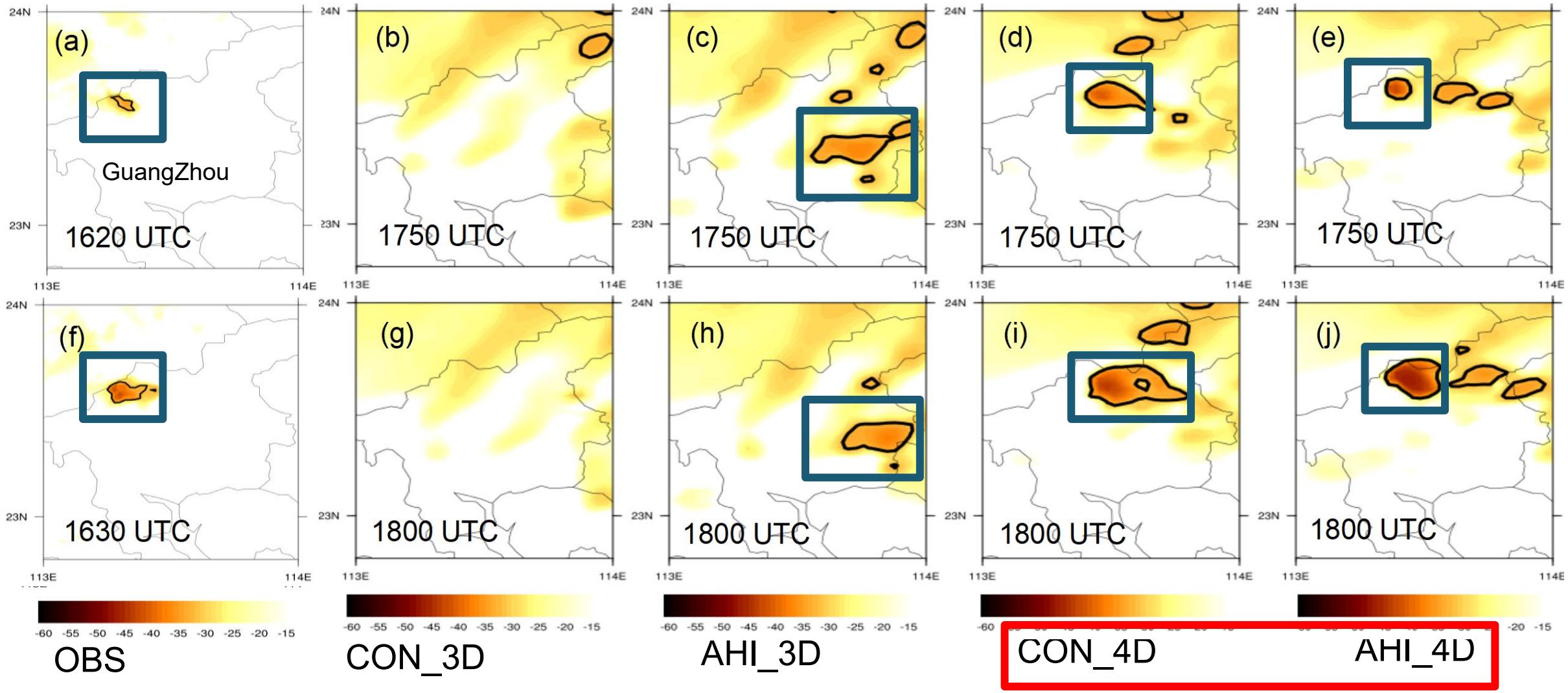








Convection initiation (CI, BT@10.4μm)

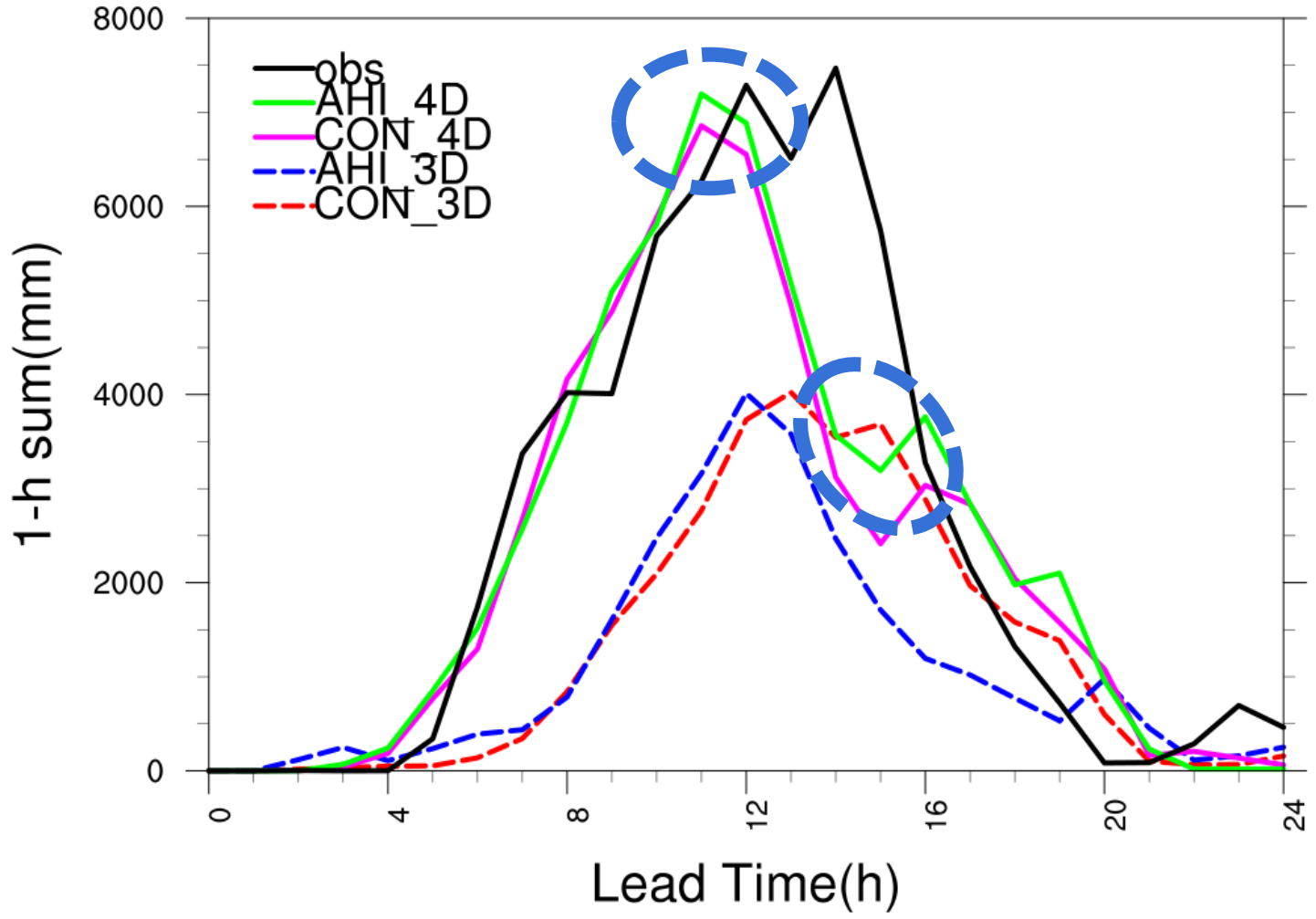


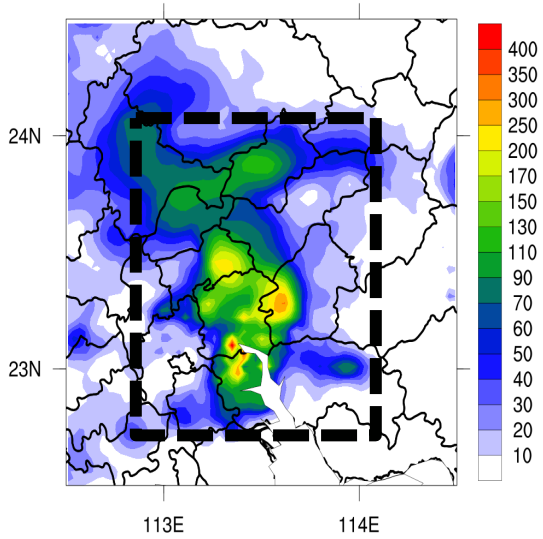
90-min timing error, 20-30 km location error

On May 6, 2017

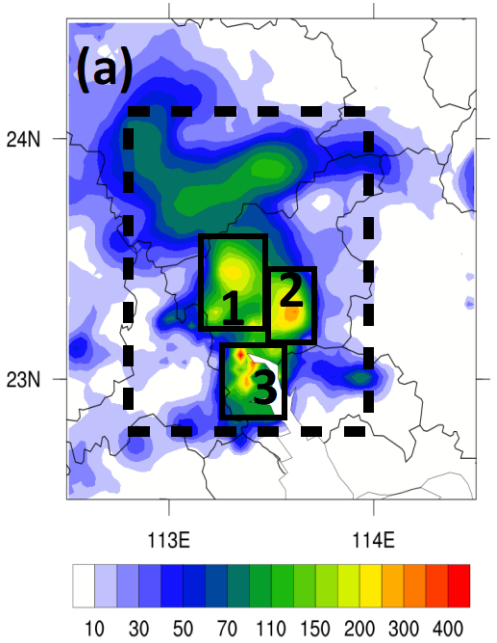
Contour: -32 degreeC

Hourly area -summed rainfall amount





20-h accumulated rainfall



(b)

(c)

(d)

(e)

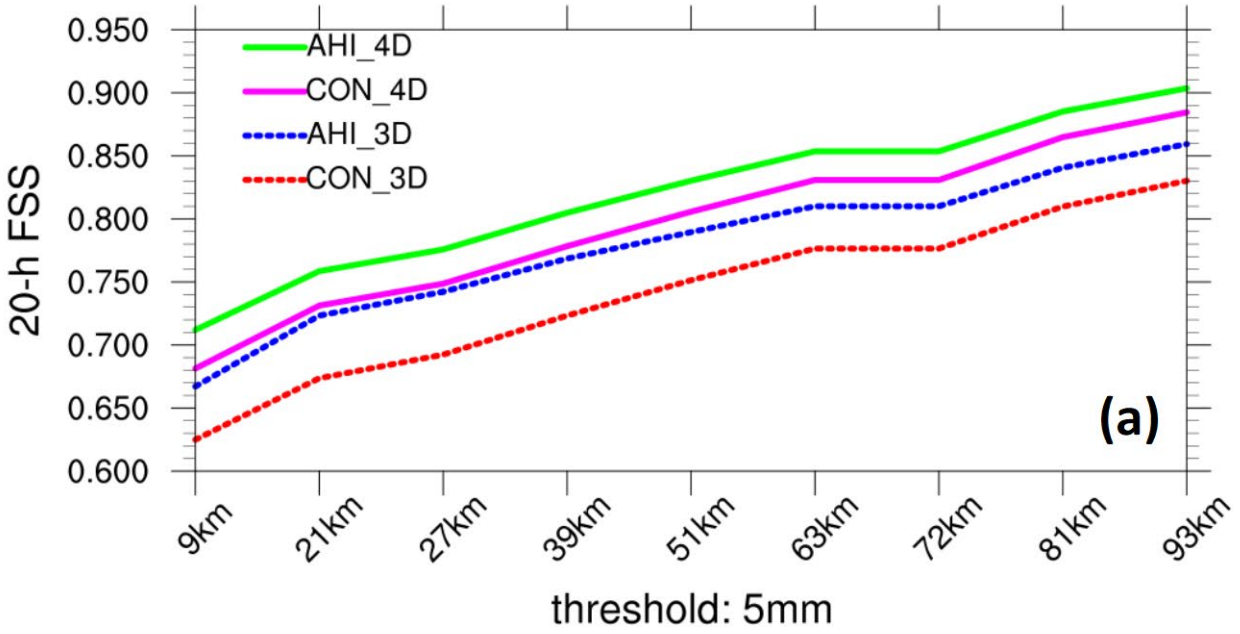
OBS

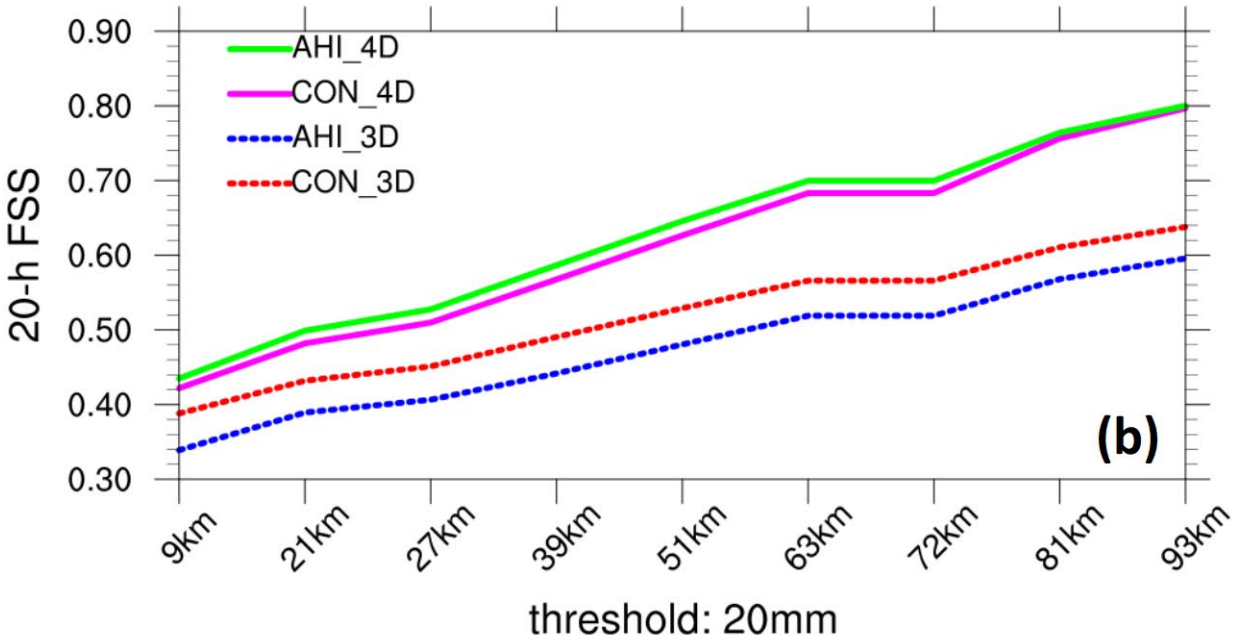
CON_3D

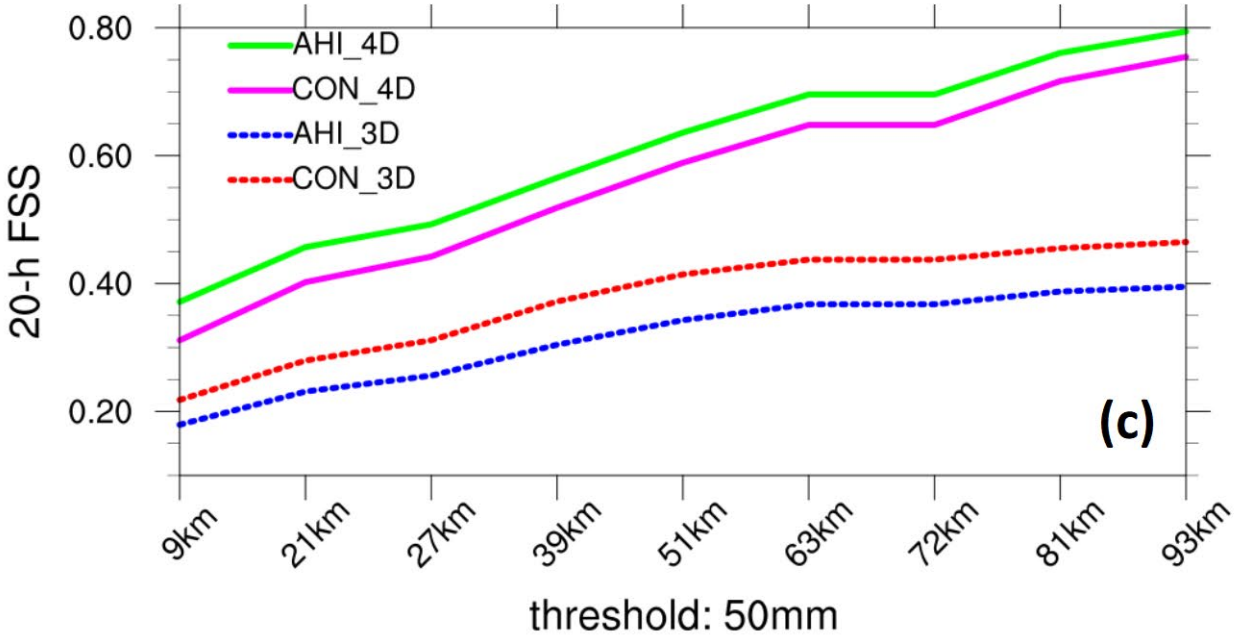
AHI_3D

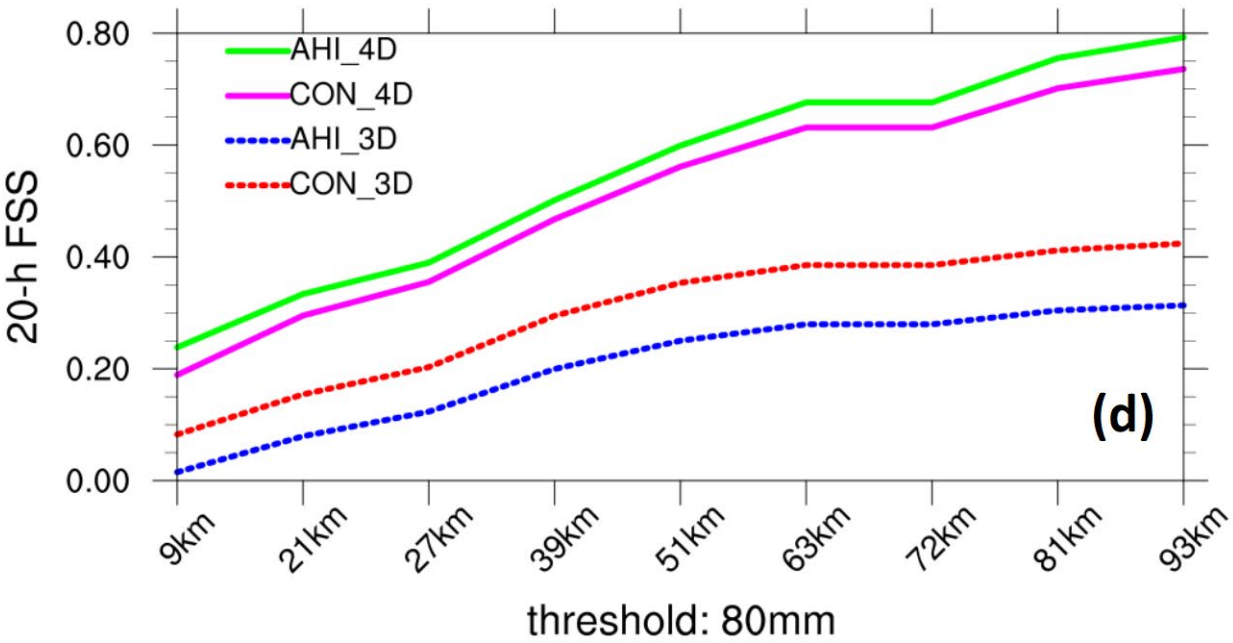
CON_4D

AHI_4D


0.950
0.900
0.850
0.800
0.750
0.700
0.650
0.600
20-h FSS
AHI_4D
CON_4D
AHI_3D
CON_3D
(a)
9km
21km
27km
39km
51km
63km
72km
81km
93km
threshold: 5mm


0.90
0.80
0.70
0.60
0.50
0.40
0.30
20-h FSS
AHI_4D
CON_4D
AHI_3D
CON_3D
(b)
9km
21km
27km
39km
51km
63km
72km
81km
93km
threshold: 20mm


0.80
0.60
0.40
0.20
20-h FSS
AHI_4D
CON_4D
AHI_3D
CON_3D
(c)
9km
21km
27km
39km
51km
63km
72km
81km
93km
threshold: 50mm


0.80
0.60
0.40
0.20
0.00
20-h FSS
AHI_4D
CON_4D
AHI_3D
CON_3D
(d)
9km
21km
27km
39km
51km
63km
72km
81km
93km
threshold: 80mm

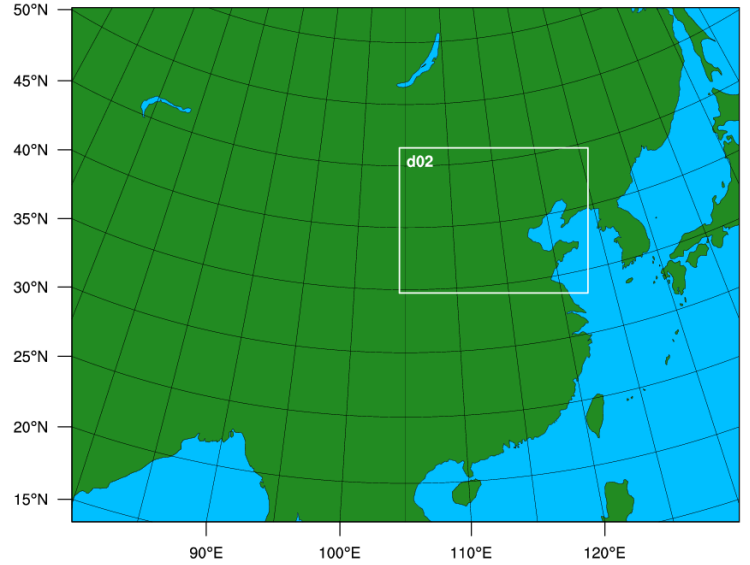
Outline

- 10-min clear-sky AHI DA using 4DVar for a local storm event

- All-sky AHI DA using hybrid-3DEnVar for clouds prediction

Experimental design

2018070700-2018071000, 9km-3km two-way nested domain, 3-km domain is centered around Beijing.
Partial cycling DA is conducted from 0000UTC to 2100UTC at an interval of 3h.
Each partial cycle starts at 0000 UTC from ECMWF global data



1) **CONT-3dvar:** assimilate conventional data on d01/d02, 3DVar

2) **CLRAHI-3dvar:** add clear-sky AHI 3 WV channels on d02

3) **ALLAHI-3dvar:** add all-sky AHI 3 WV channels on d02

4) **CLRAHI-hybrid:** similar to CLRAHI-3dvar, but using hybrid-3DEnVar

5) **ALLAHI-hybrid:** similar to ALLAHI-3dvar, but using hybrid-3DEnVar

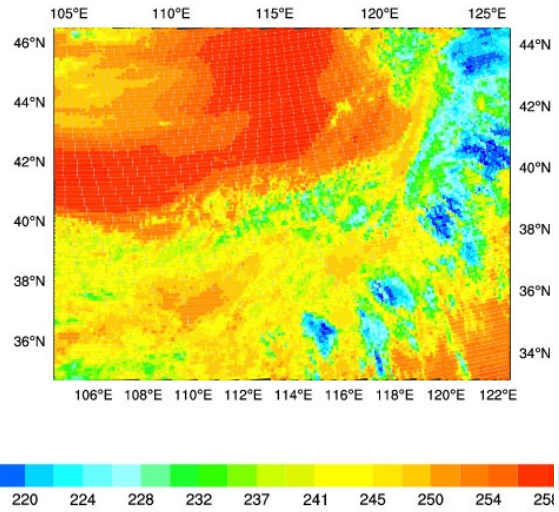
Note:

1. Ensemble input for 3-km hybrid-EnVar comes from 28-member 9-km EDA using perturbed observations

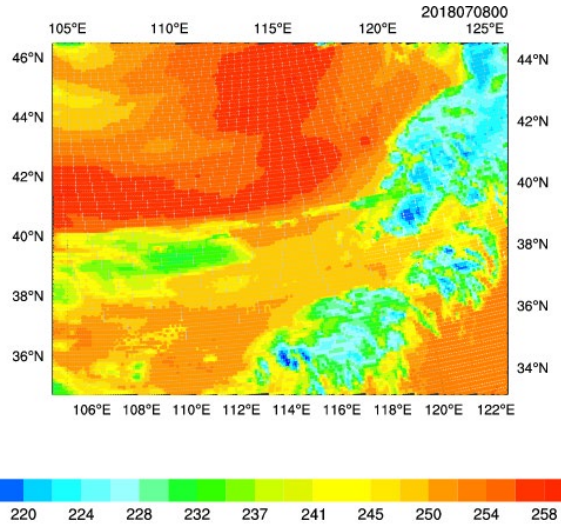
2. All-sky AHI radiance Symmetric Error Model follows Harnisch et al. (2016)

3. 5 hydrometeors are part of analysis variables for all-sky radiance DA. Used CRTM-2.3.0

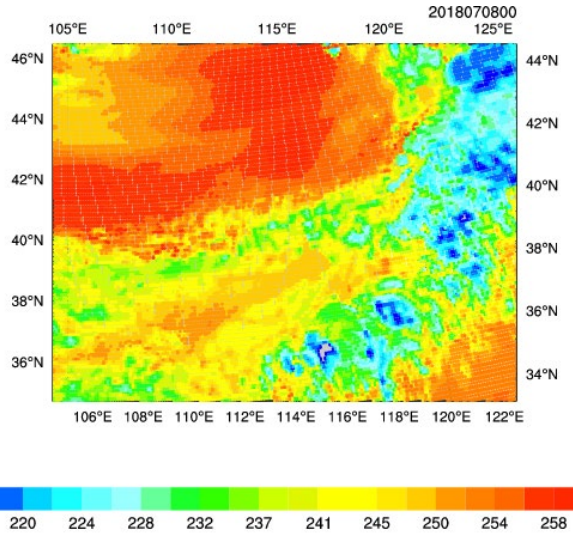
obs @Ch10, 7.3 um



Background Tb
6-h WRF FC from ECMWF



Analyzed Tb after 2 outer loops

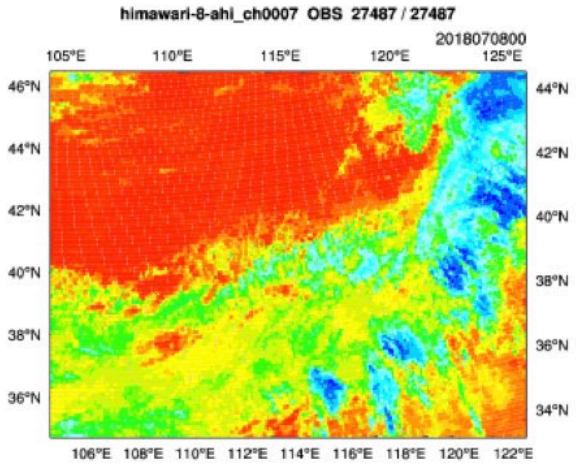


2018070800

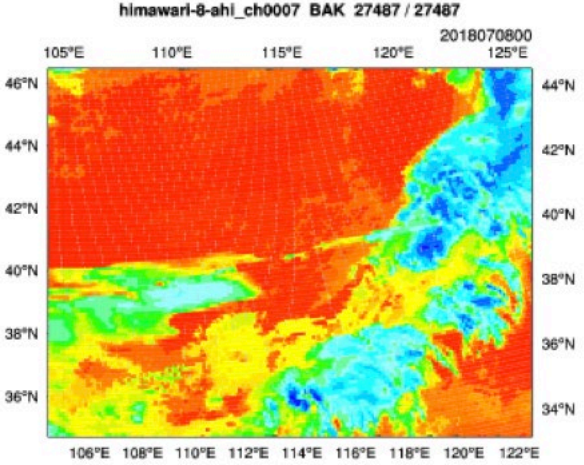
Assimilated AHI All-sky 3 WV channels radiances Using 3DVAR

Over North China with a 3-km resolution

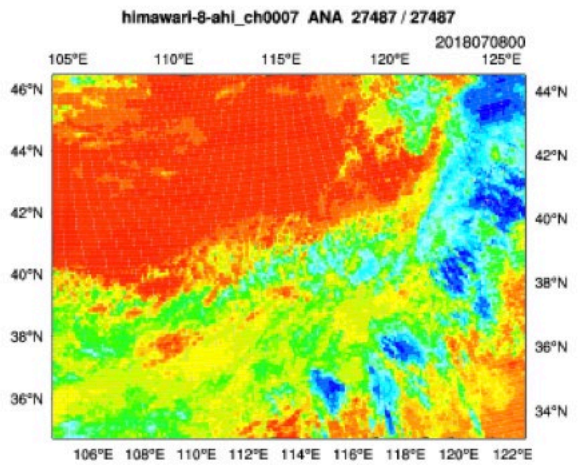
obs @Ch13, 10.4um
not assimilated



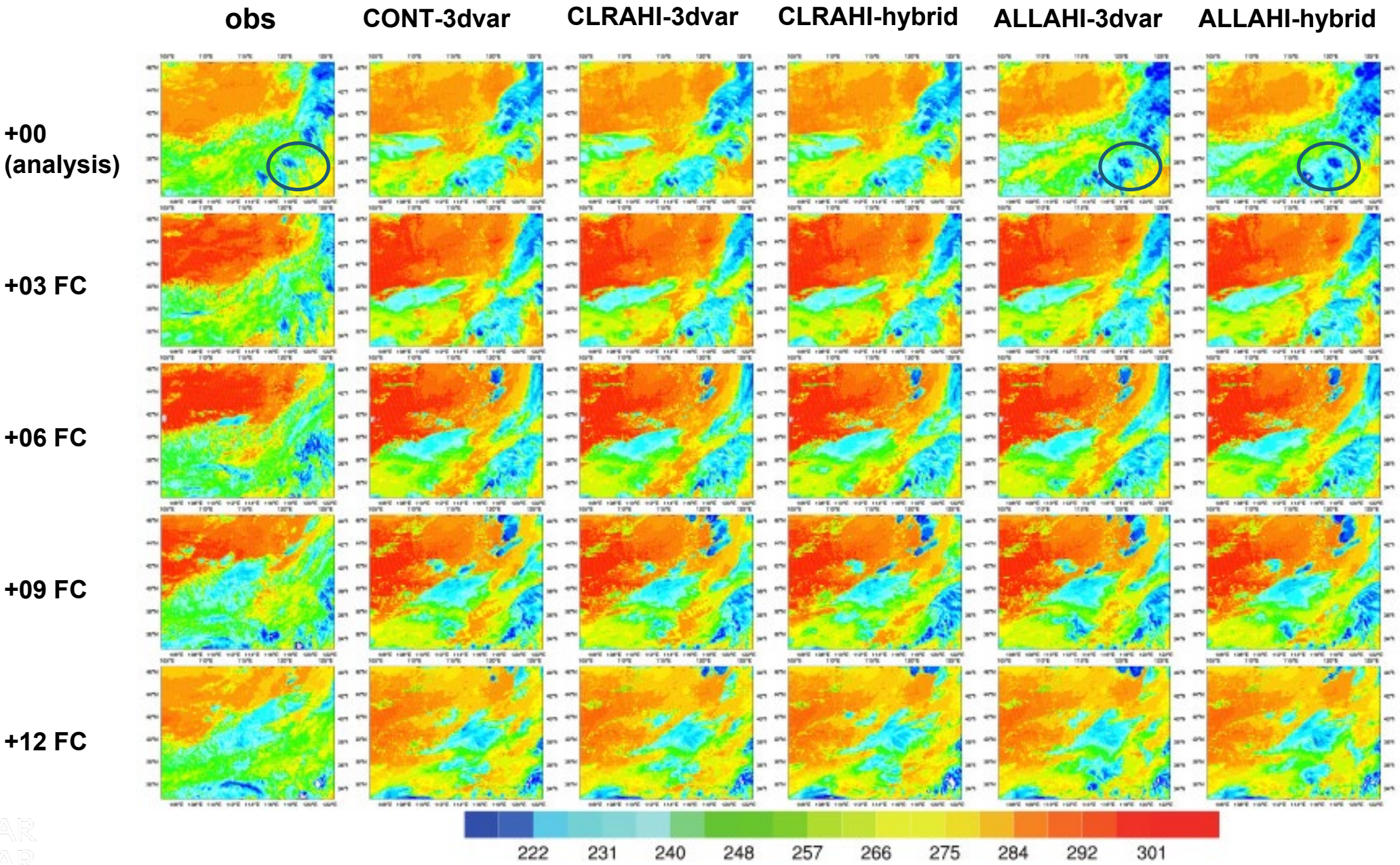
Background Tb
6-h WRF FC from WCMWF



Analyzed Tb after 2 outer loops



2018070800 ch13



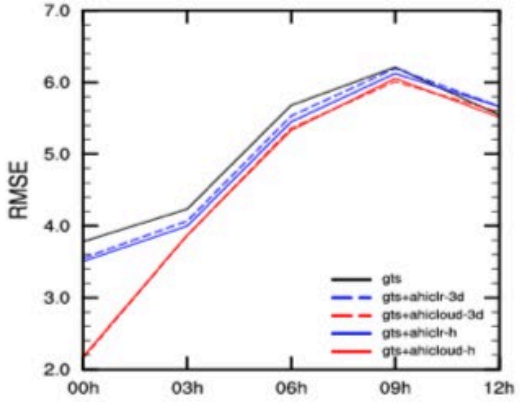
0-12h FC RMSE in Tb space

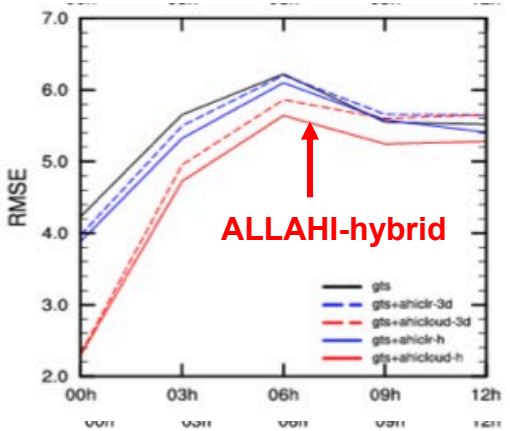
Init: 2018070800

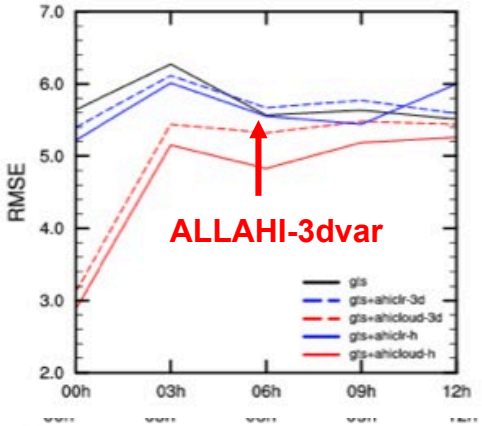
Init: 2018070803

Init: 2018070806

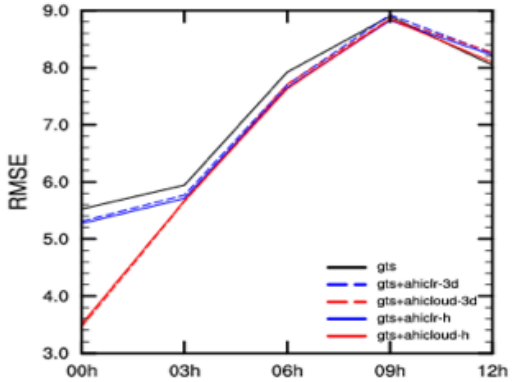
Channel 8

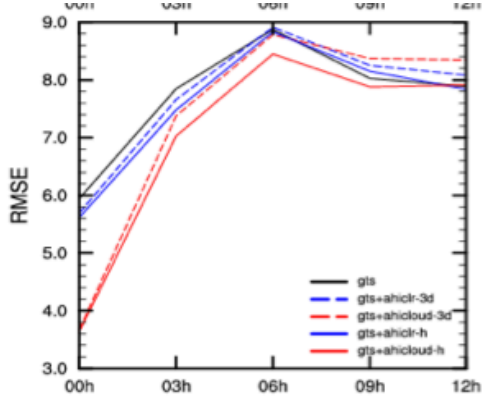


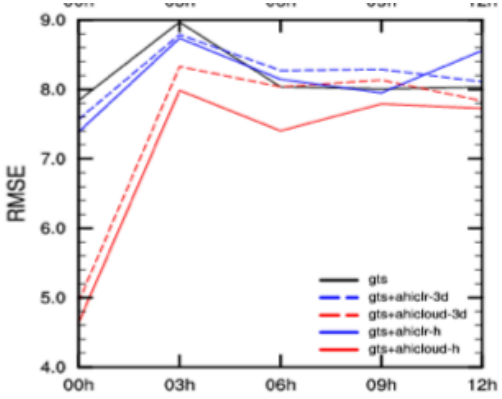




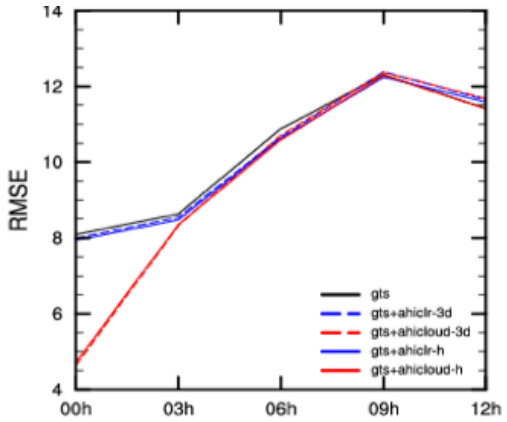
Channel 9

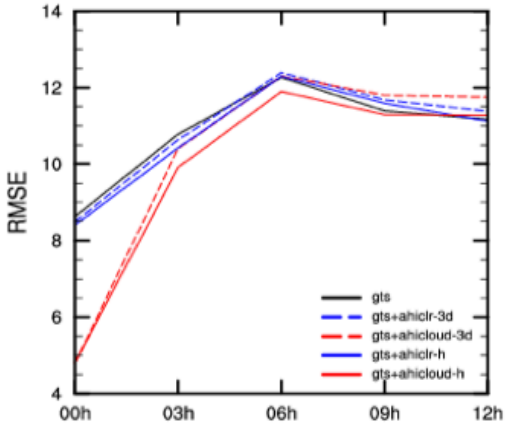


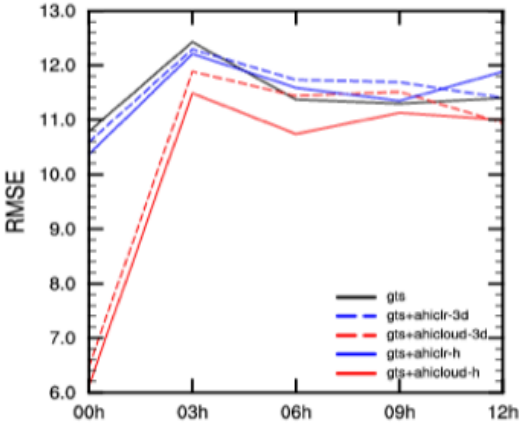




Channel 10







Future work for all -sky geostationary IR

- Take into account cross-channel correlation
- Better design of cloud analysis variables
- Use frequent data with Hybrid-4DEnVar
- Validate clouds with retrieval products
- Move to global MPAS-DA with multiple geostationary IR sensors