# Improving forecasts of the record-breaking Guangzhou “57” rainstorm by assimilating every 10-min AHI radiances with WRF 4DVAR

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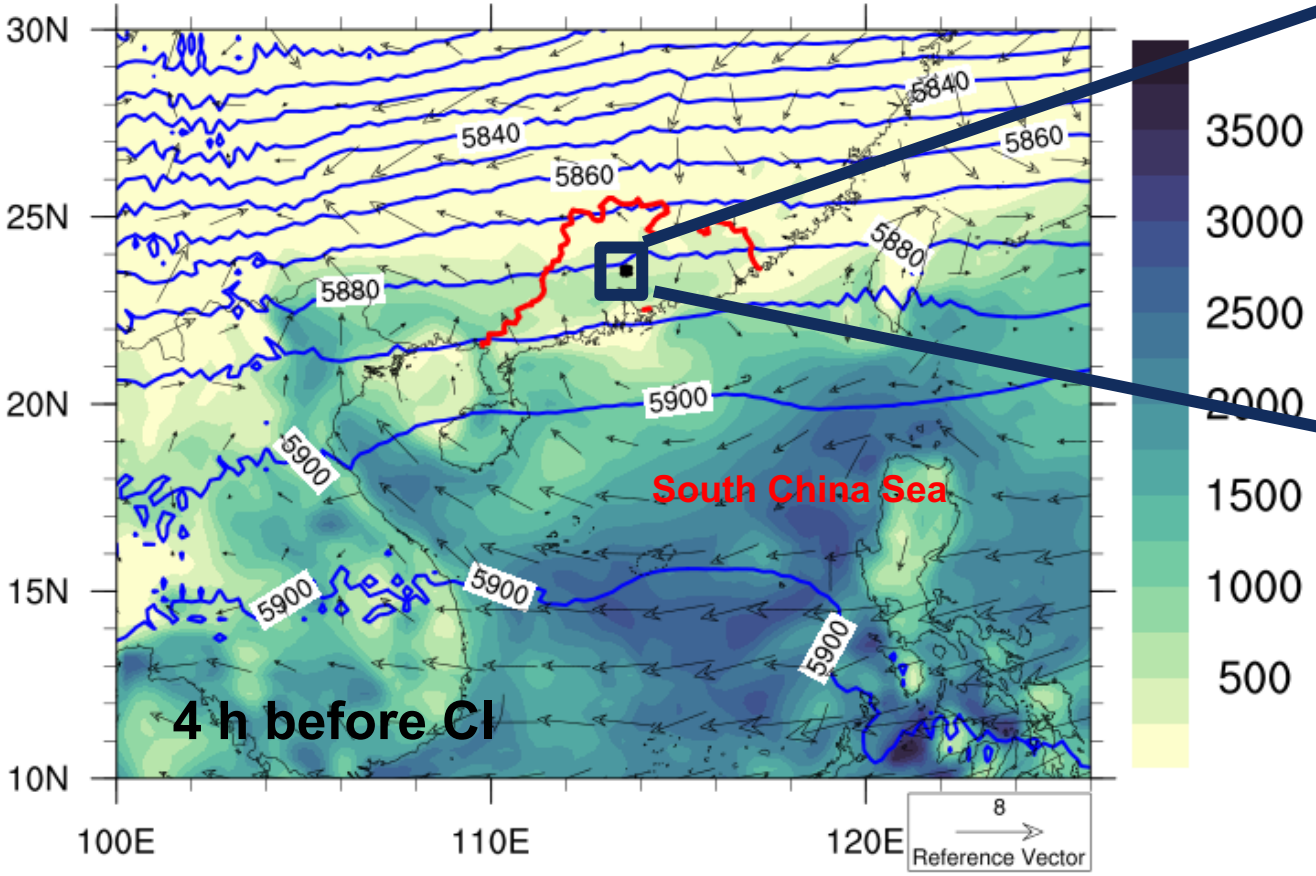
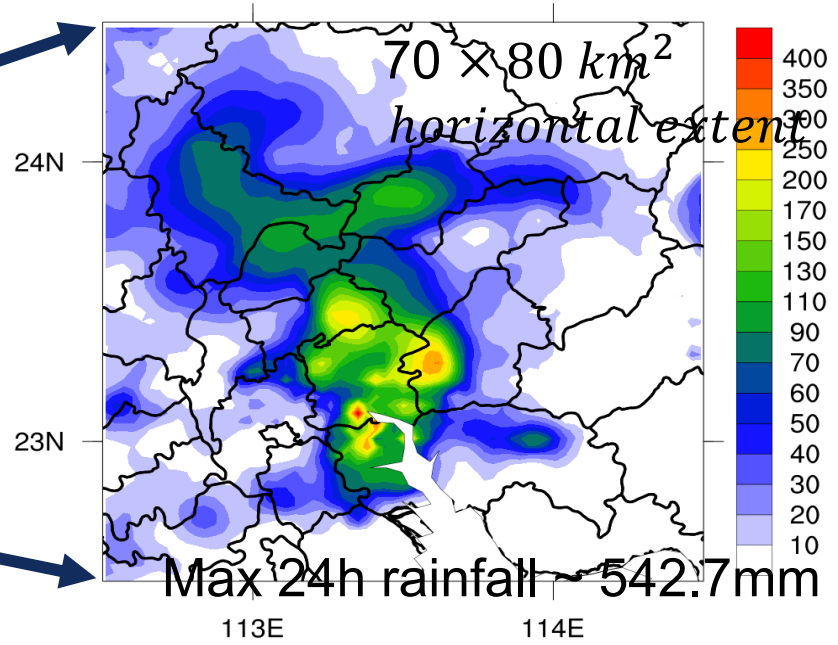
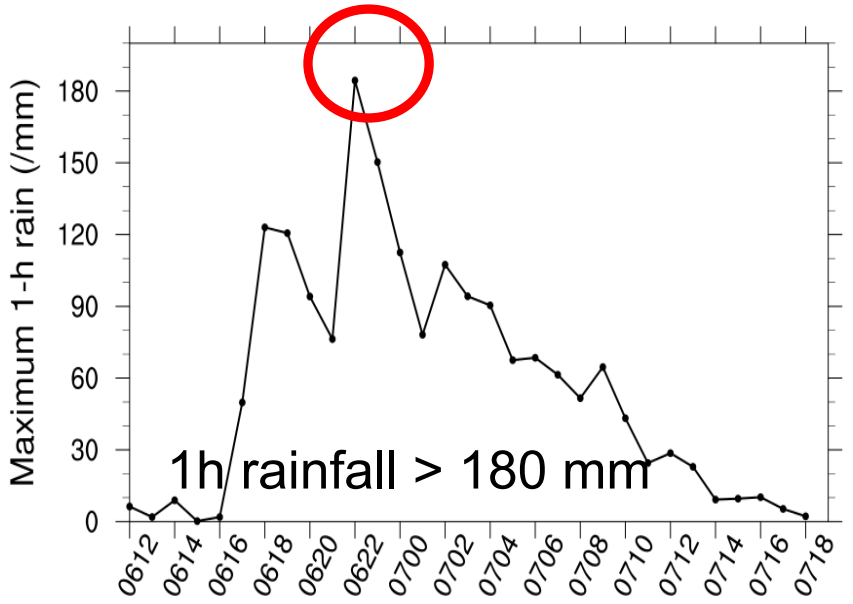
# Case review

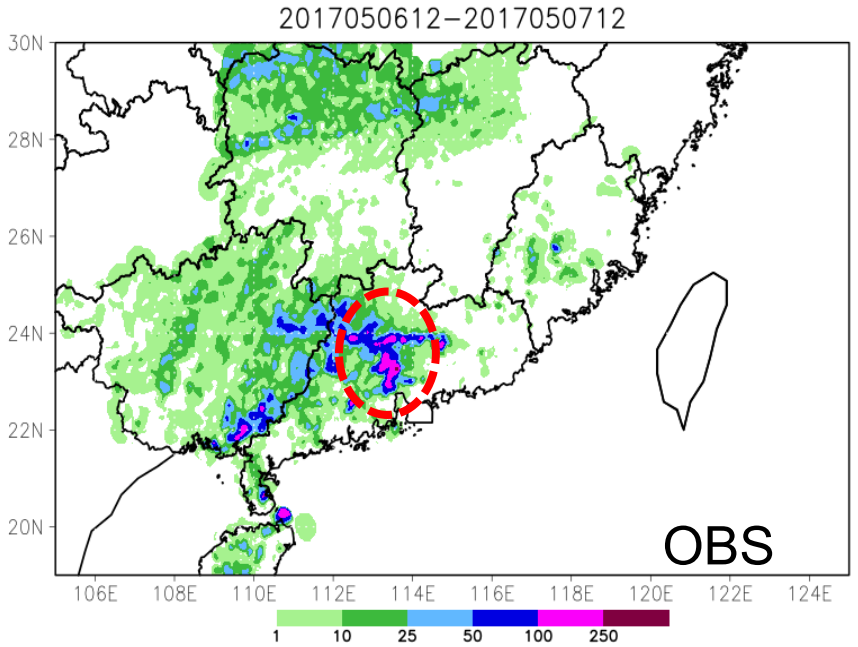
A record-breaking rainstorm, Guangzhou, 7 May 2017

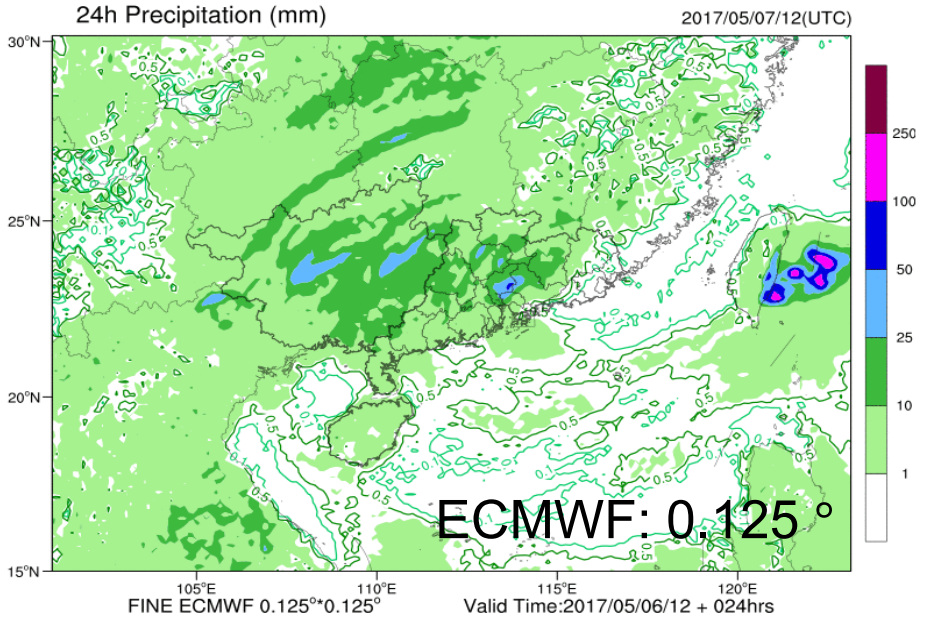


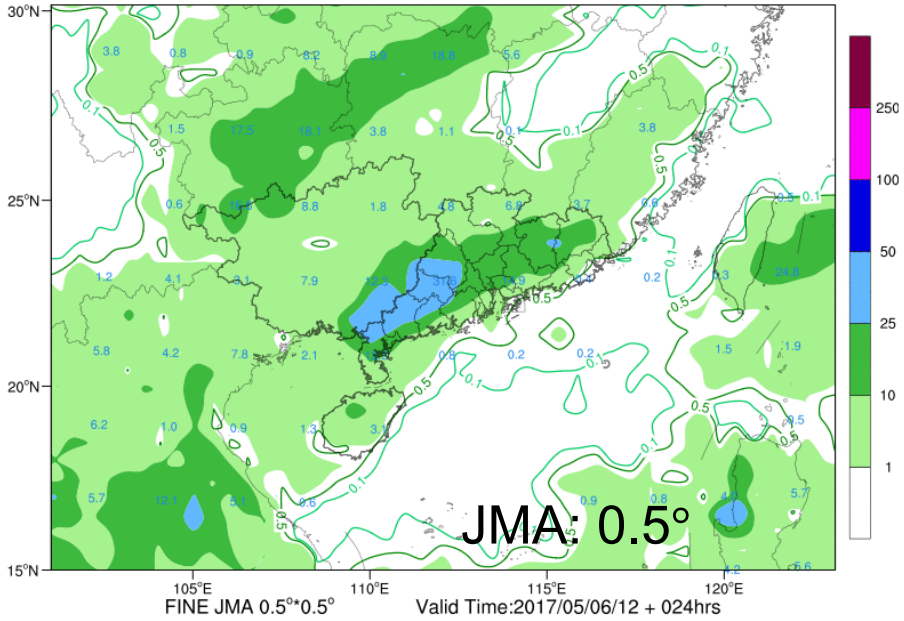



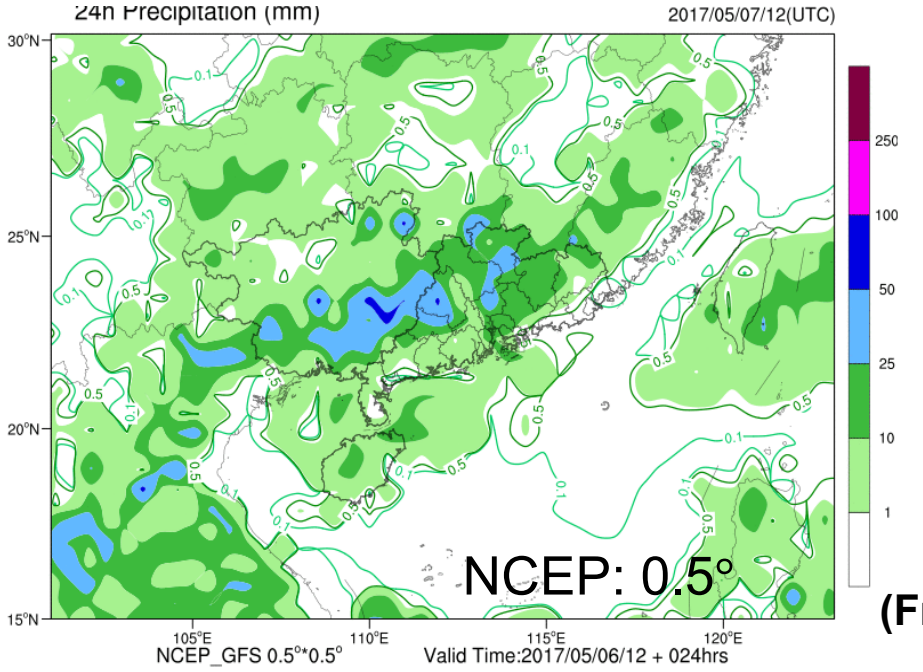




CAPE: 1000-1500 J/kg (shaded)
500 hPa gph: weak large-scale forcing (contours)
850 hPa wind: weak (vectors)




**(From GITMM/CMA)**

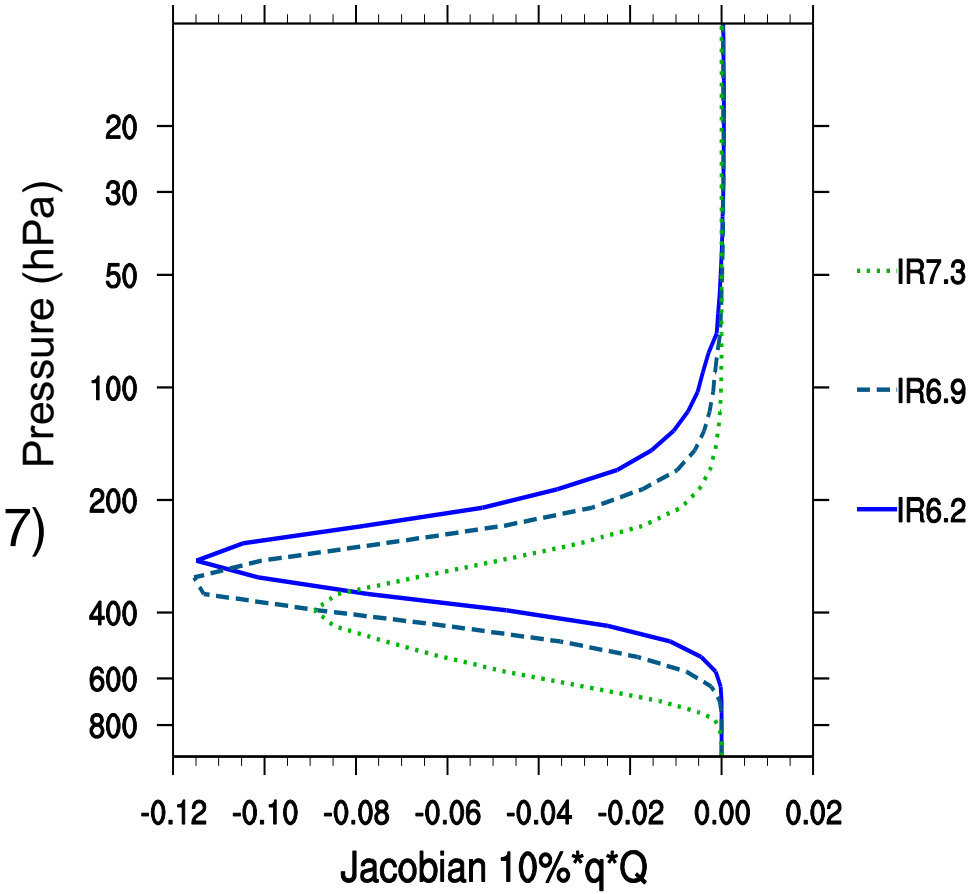
# Method and data

- Method : WRF MRI-4DVar (WRF model : 3 km)
- Data: GFS 0.25° + Conventional obs +

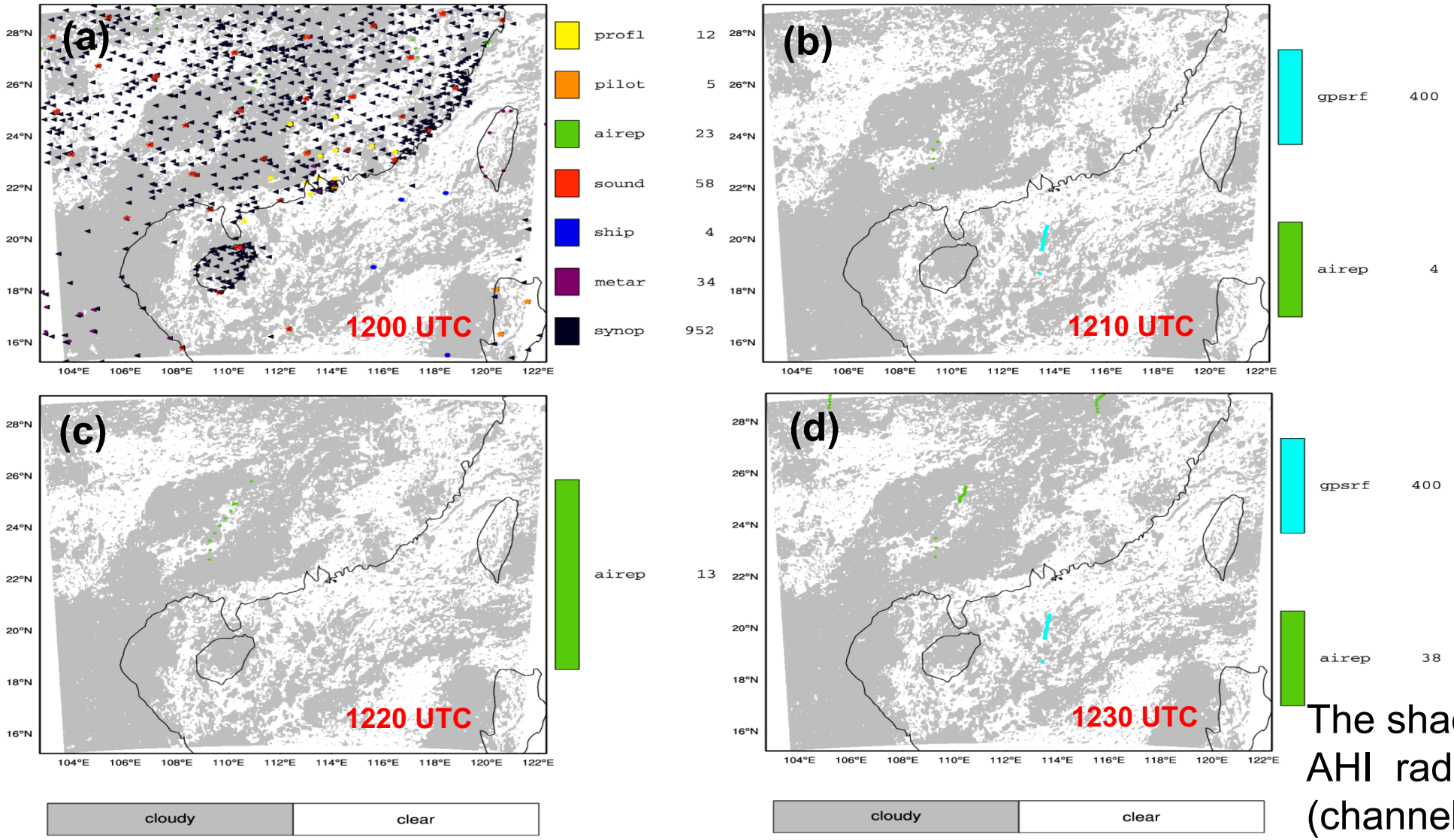
***Himawari-8 AHI three water vapor channels***

***in clear-sky conditions:***

  - 2-km, every 10-min
  - Quality control (Honda et al, 2018a, b; Okamoto，2017)
  - Cloud detection (Zhuge and Zou, 2016.)
  - Obs error statistics
  - WRFDA offline VARBC statistics

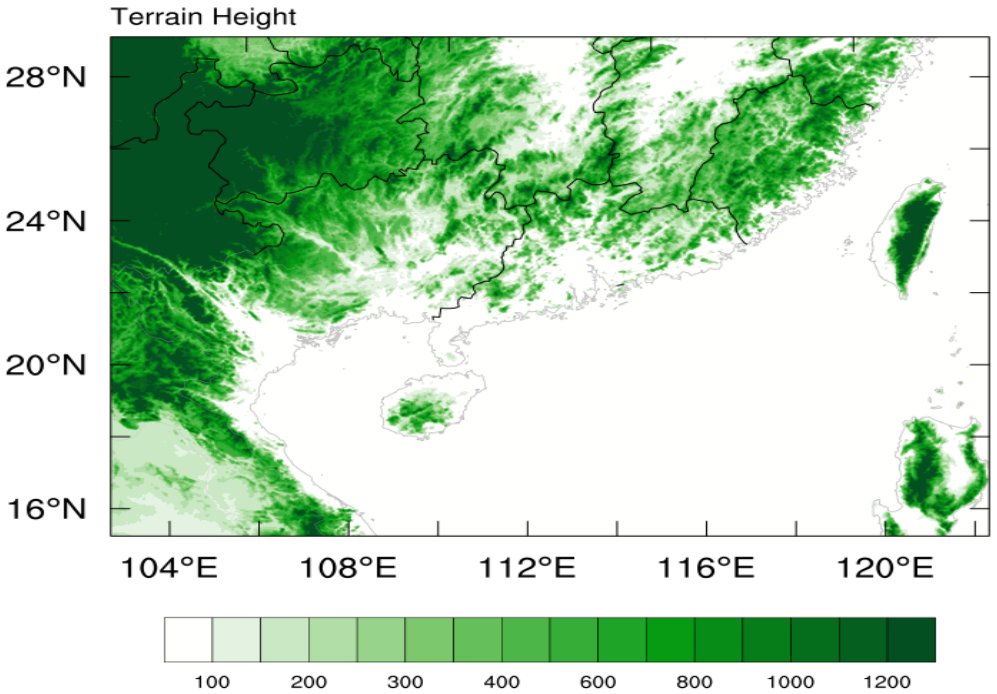


# Data coverage (For a 4DVar analysis)




The shaded indicates AHI radiances (channel 8 for example)

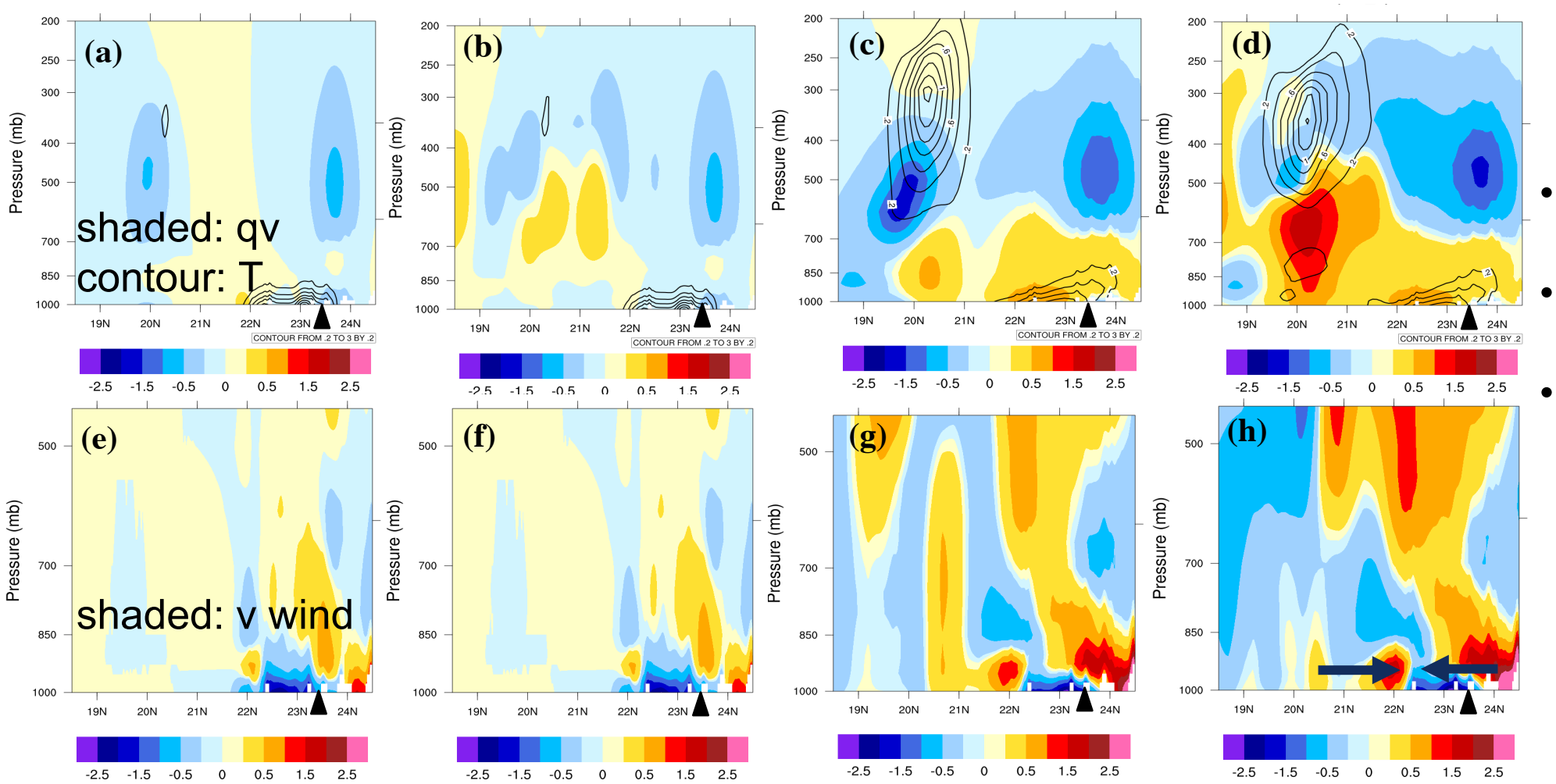
# Experiment design




| Exps | Observations | DA method | |
|---|---|---|---|
| CON_3D | Con | 3DVar | |
| AHI_3D | Con + AHI (single time) | 3DVar | |
| CON_4D | Con | 4DVar | [0, 30] min |
| AHI_4D | Con + AHI (every 10-min) | 4DVar | [0, 30] min |
| Exprs were initialized 4 hours before CI<br>For 4DVar, 27-km for the 1st outer loop; 9-km for the 2nd outer loop | | | |

- MP: Thompson for model, warm-rain for 4dvar
- No Cu for model, KF Cu for innovation, cudu for minimization
- Short-wave radiation:  RRTMG
- Long-wave radiation: RRTMG
- PBL: YSU; A simple vertical diffusion with surface friction scheme for 4DVAR
- Surface layer: Revised MM5 Monin-Obukhov scheme
- Land surface: unified Noah land-surface model

# Analysis increment

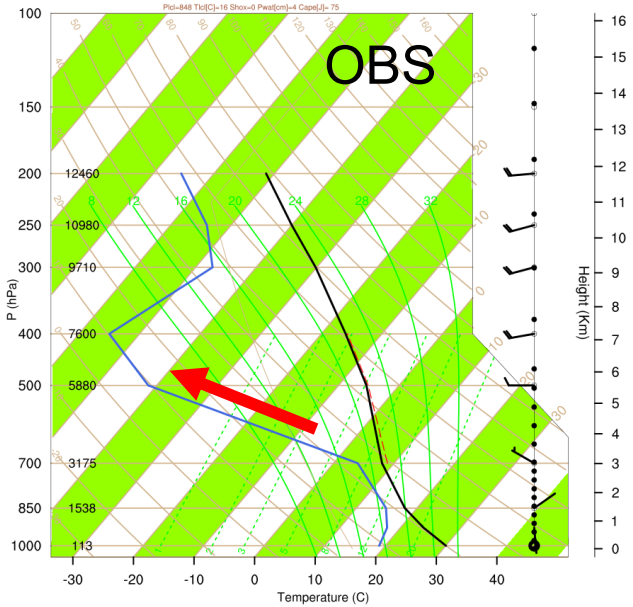



CON_3D AHI_3D CON_4D AHI_4D ***(4-h before CI)***

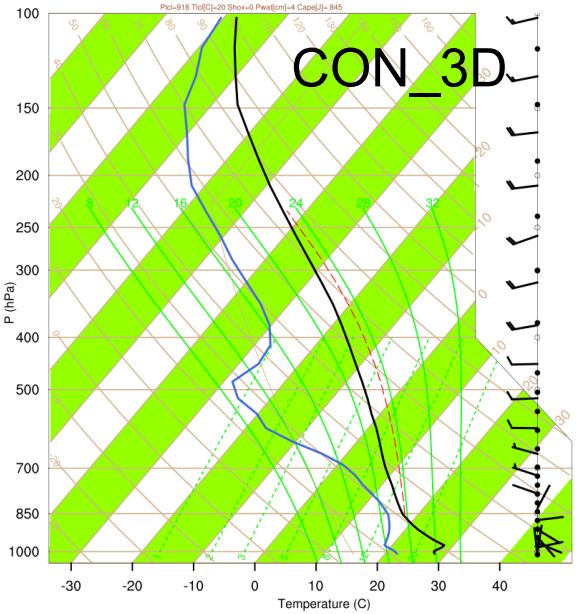
- Upstream: AHI -> wetter low-levels
- Target area: AHI -> drier mid-levels
- 4DVar produced larger increments, especially for v wind, than 3DVar

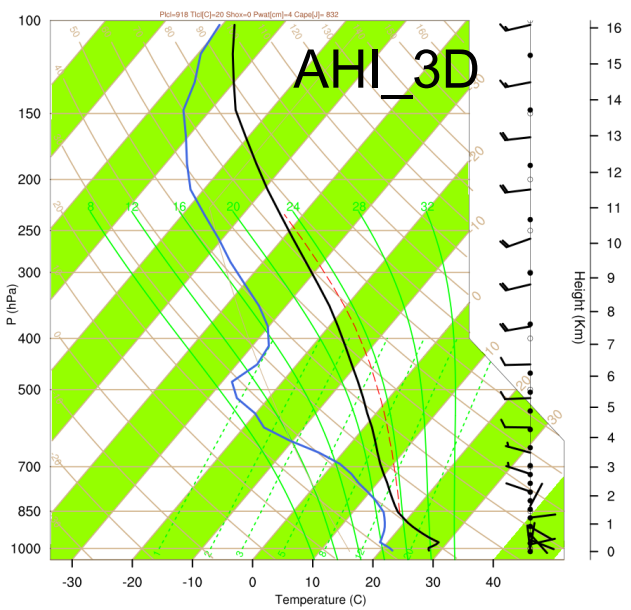
# Skew-T verification

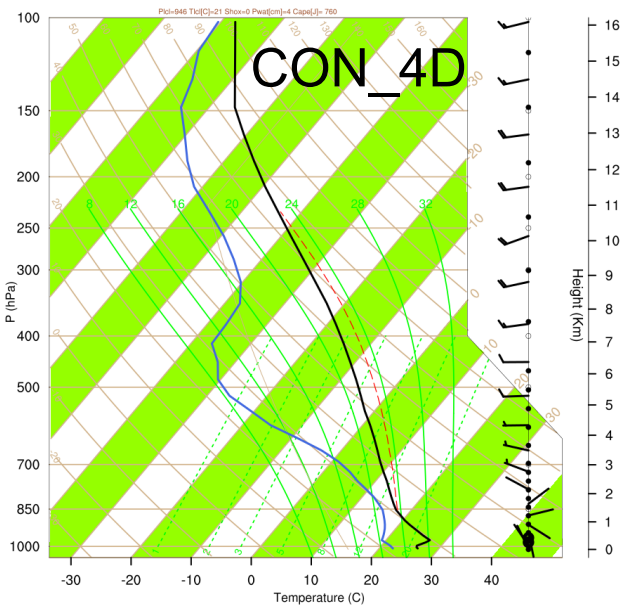
against soundings at QY station

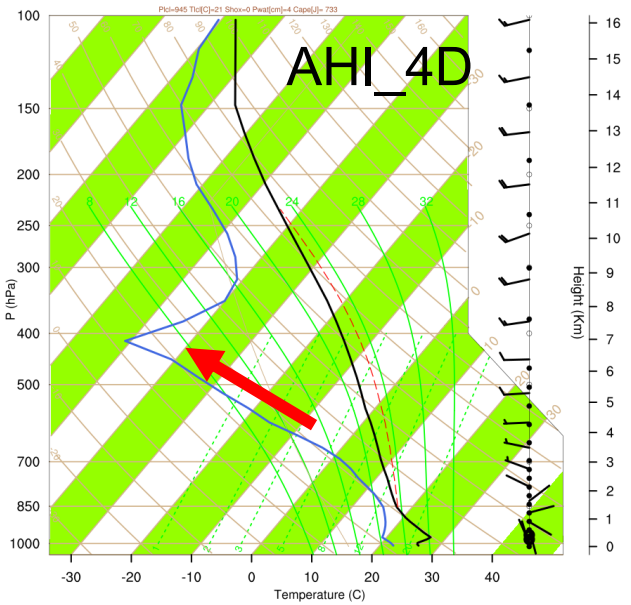



- OBS: dry layers during 700 – 400 hPa
- AHI_4D agreed best with OBS

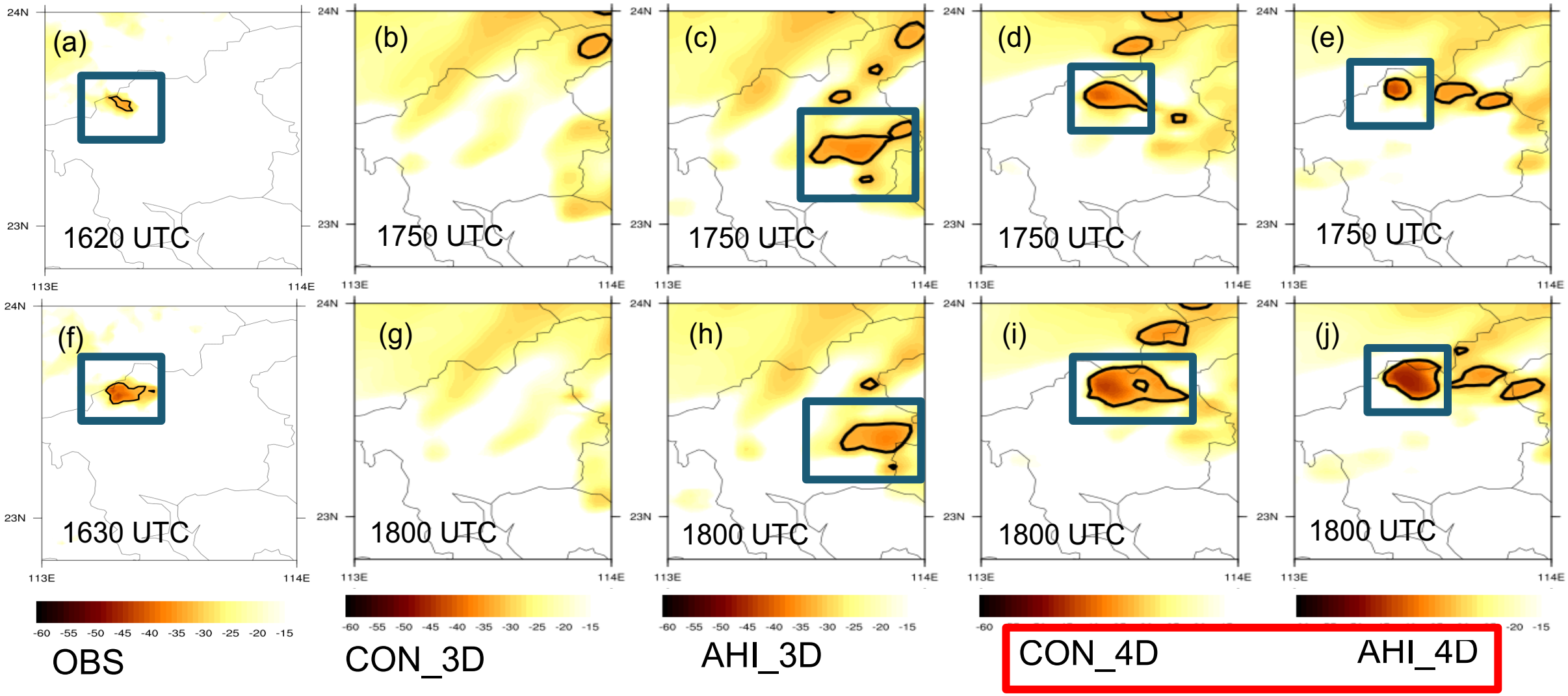


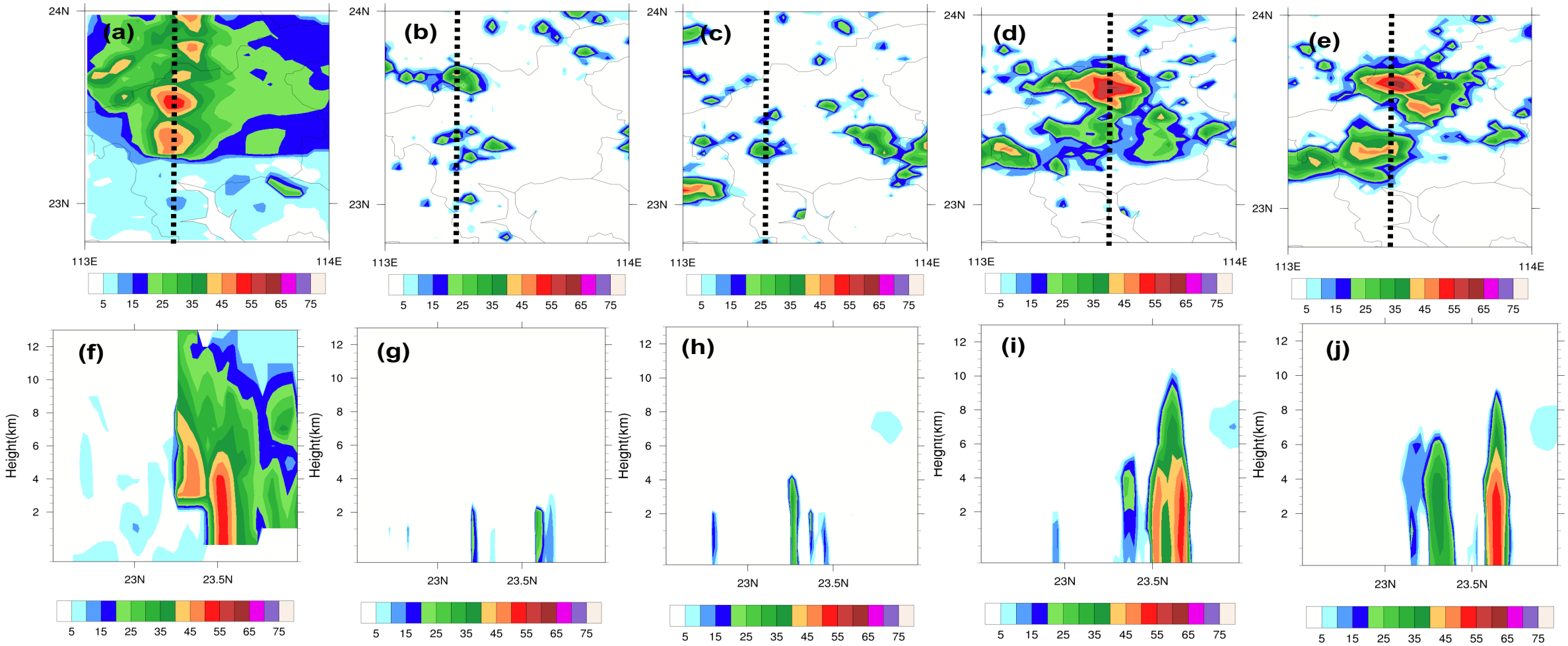
# Convection initiation (CI, BT@10.4 $\mu m$)




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

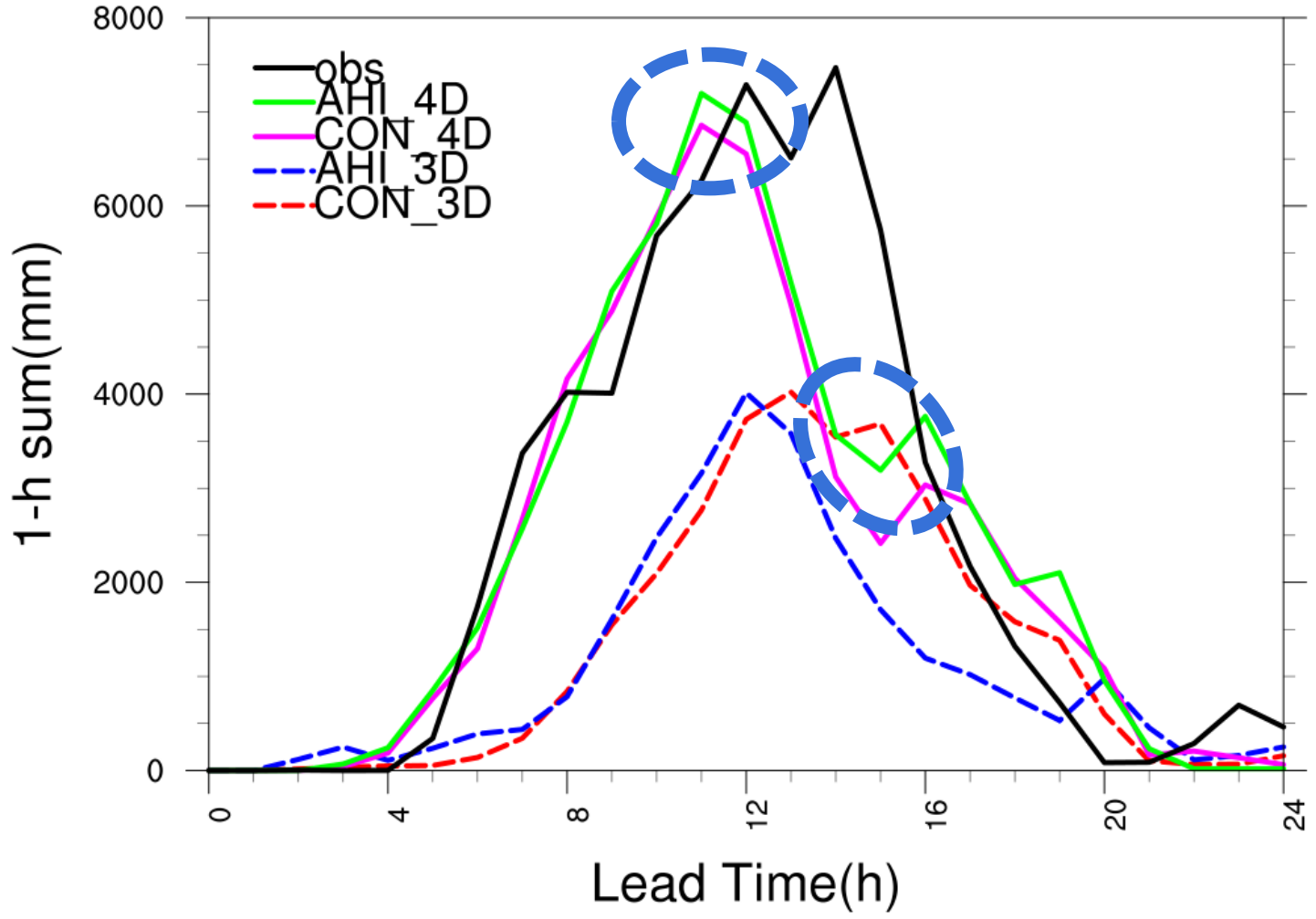
# Radar reflectivity

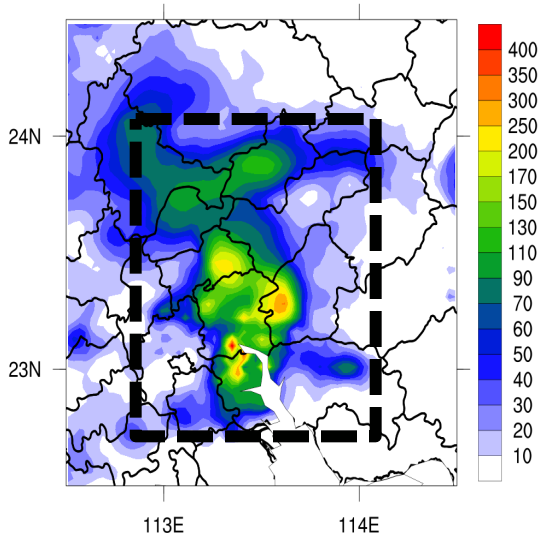
@1800 UTC



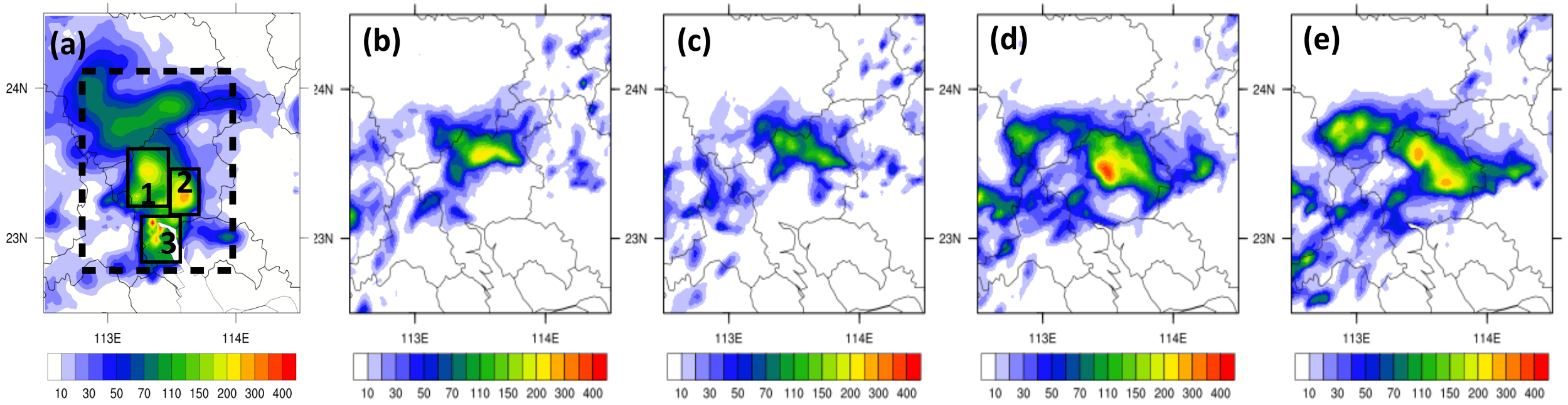

OBS CON_3D AHI_3D CON_4D AHI_4D

# Hourly area-summed rainfall amount

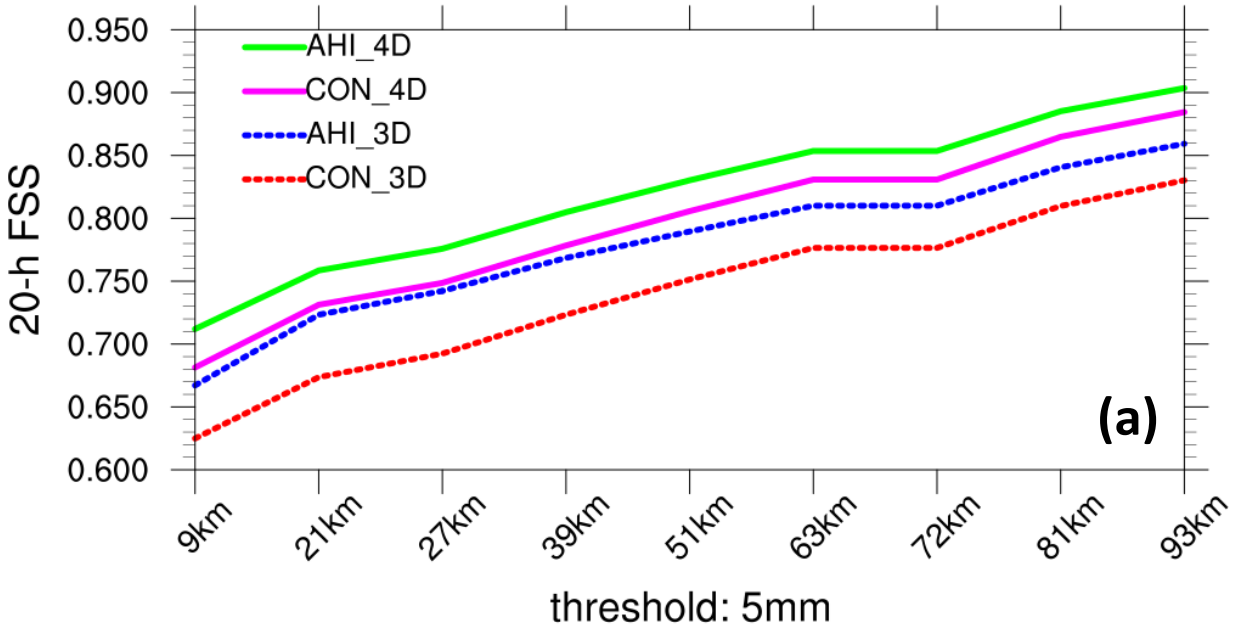


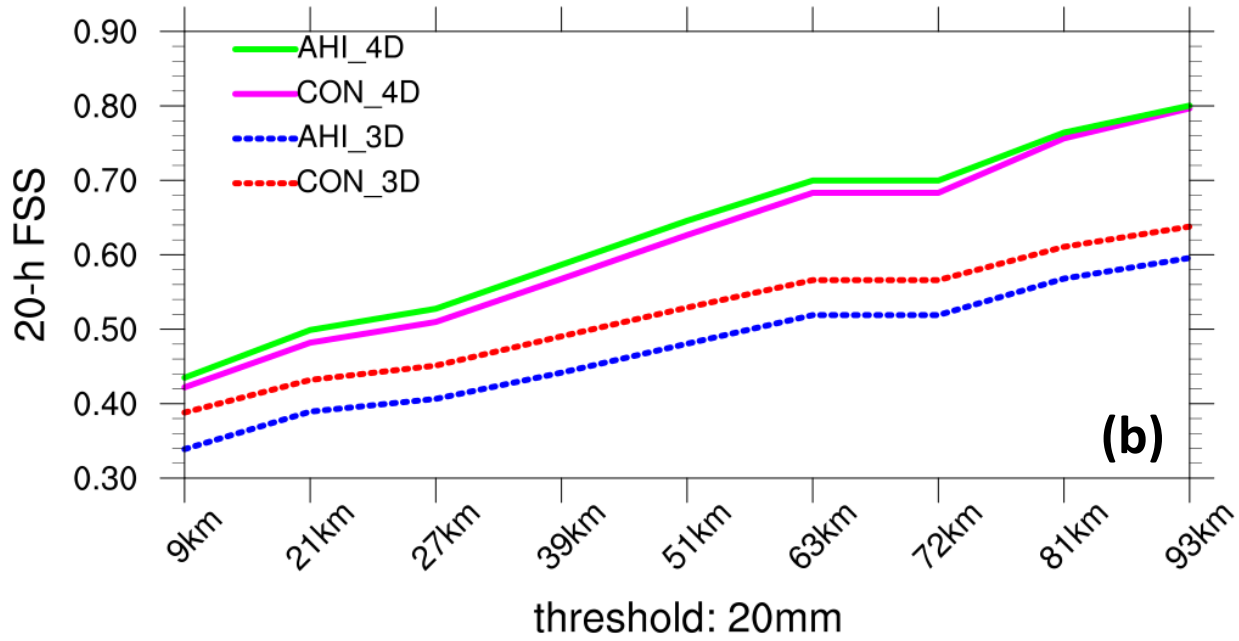



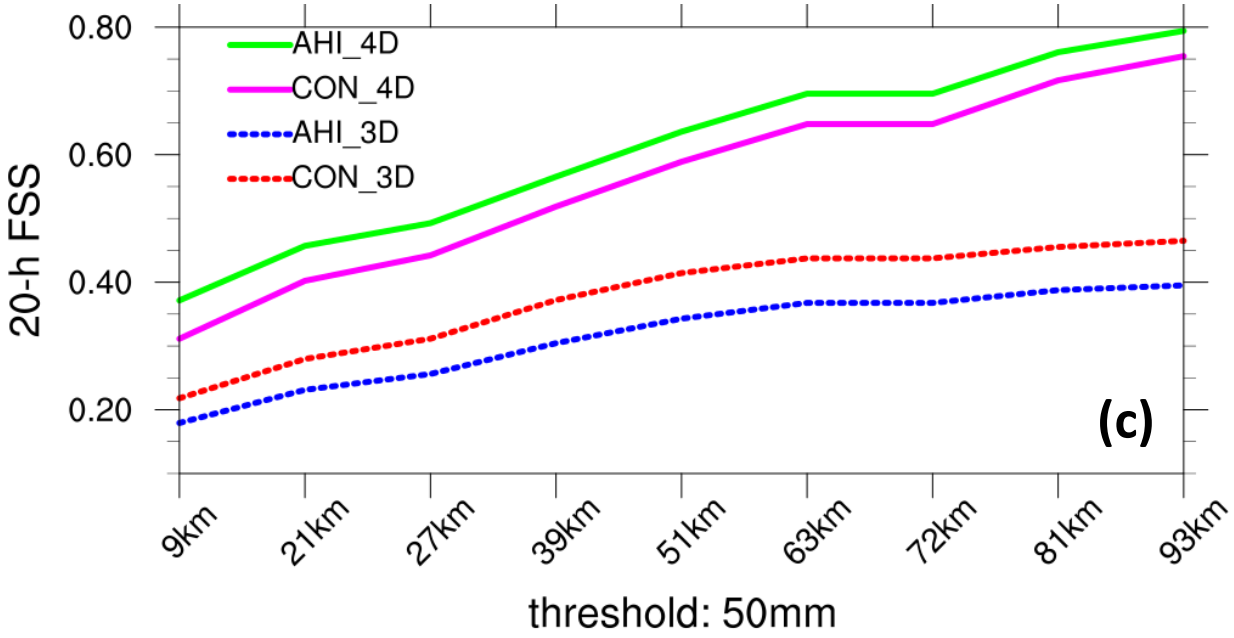
# 20-h accumulated rainfall

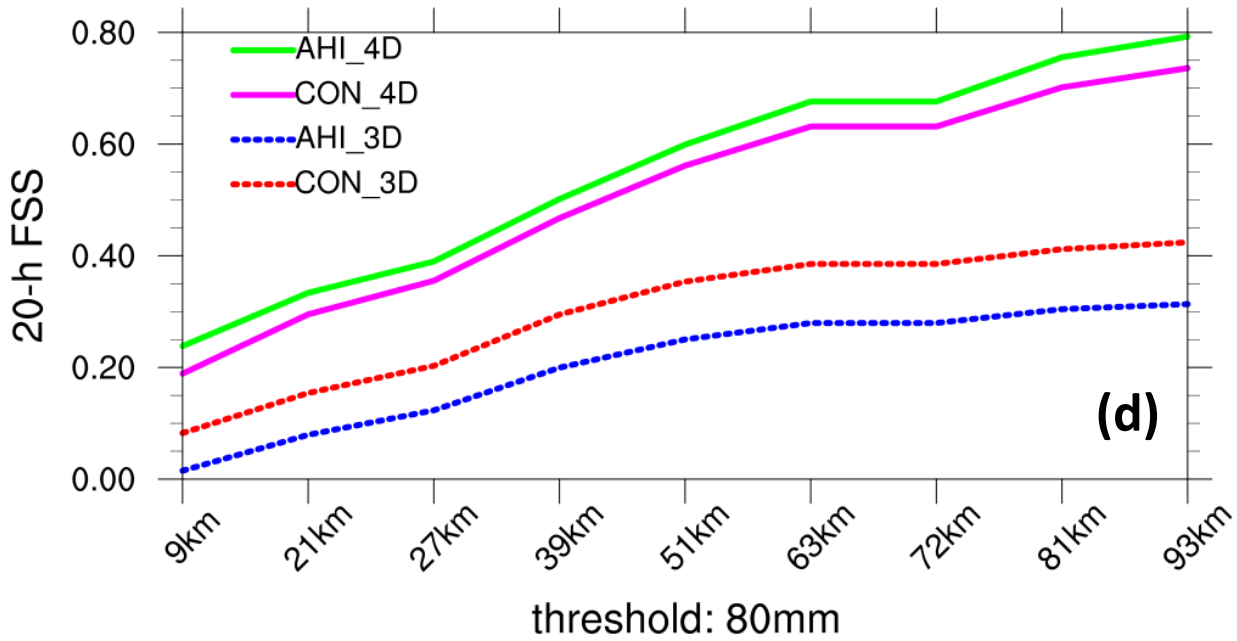


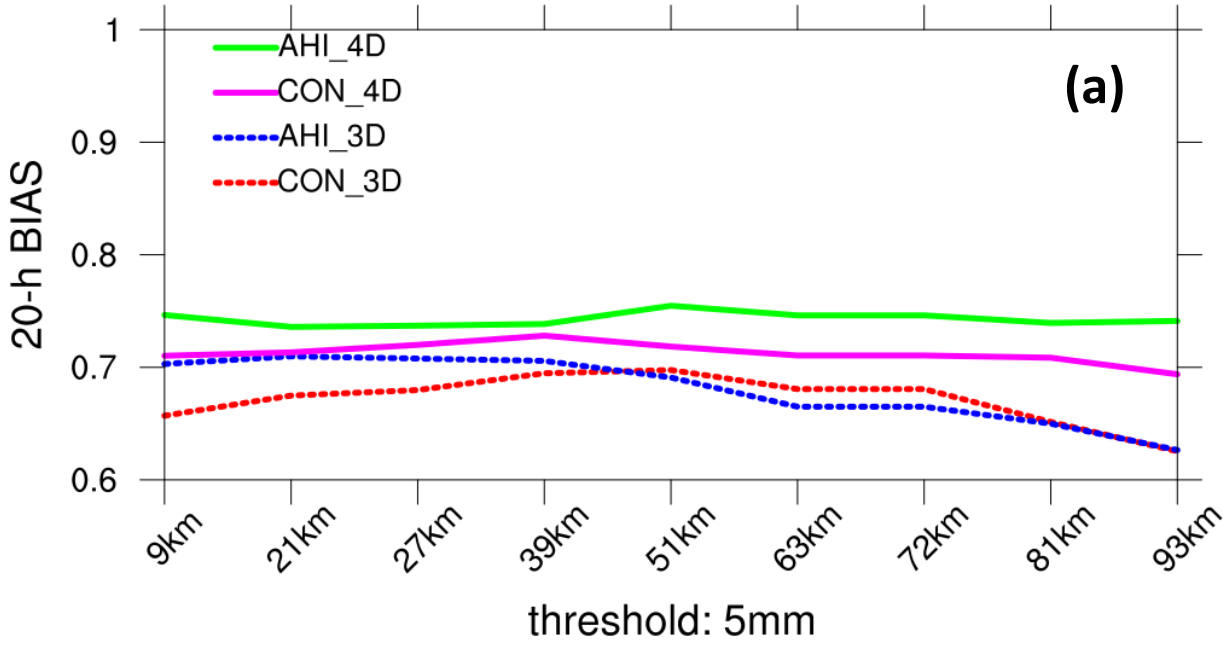

OBS CON_3D AHI_3D CON_4D AHI_4D

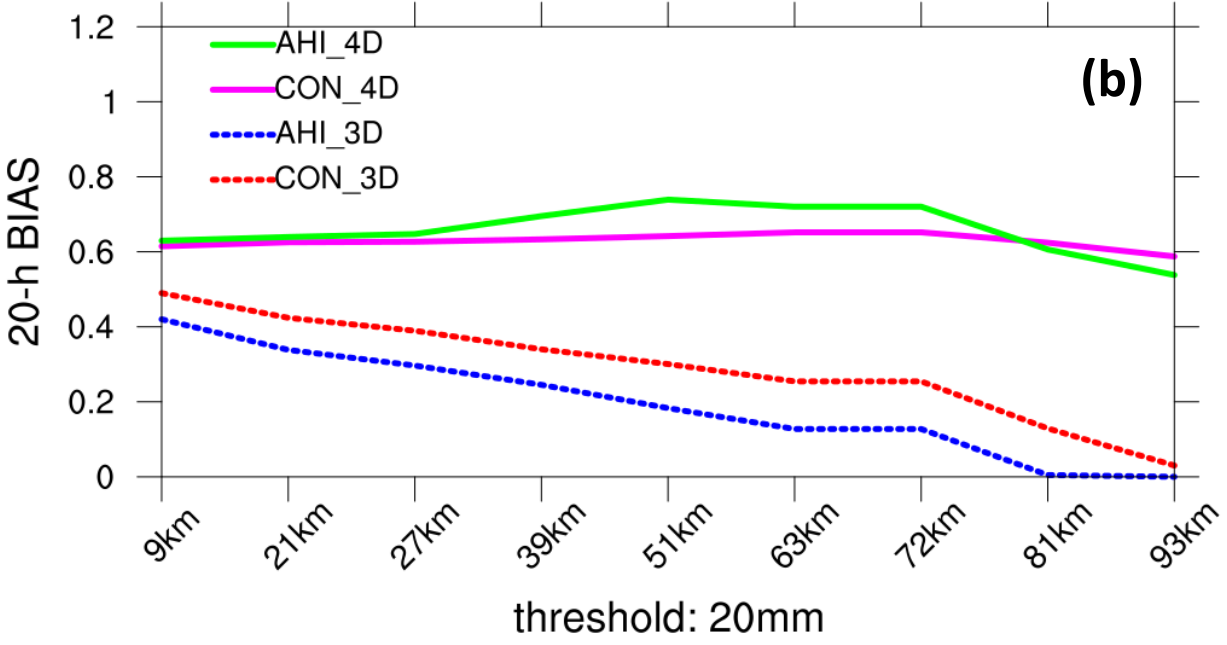

AHI_4D
CON_4D
AHI_3D
CON_3D
20-h FSS
0.950
0.900
0.850
0.800
0.750
0.700
0.650
0.600
9km
21km
27km
39km
51km
63km
72km
81km
93km
(a)
threshold: 5mm

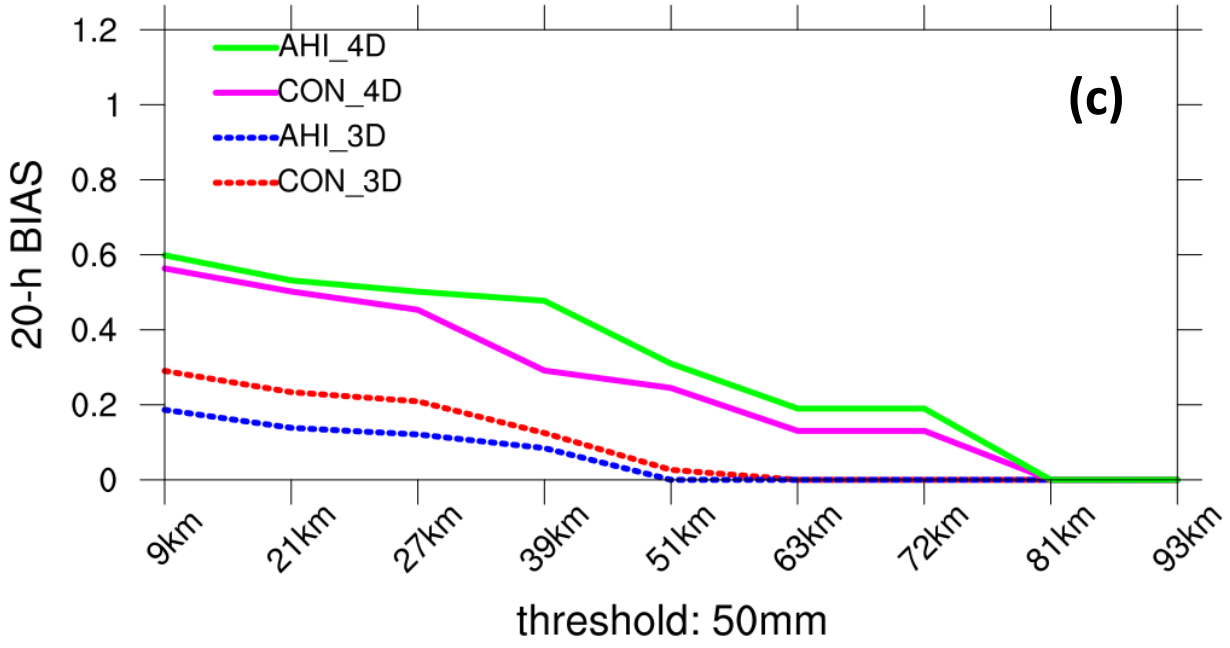

AHI_4D
CON_4D
AHI_3D
CON_3D
20-h FSS
0.90
0.80
0.70
0.60
0.50
0.40
0.30
9km
21km
27km
39km
51km
63km
72km
81km
93km
(b)
threshold: 20mm

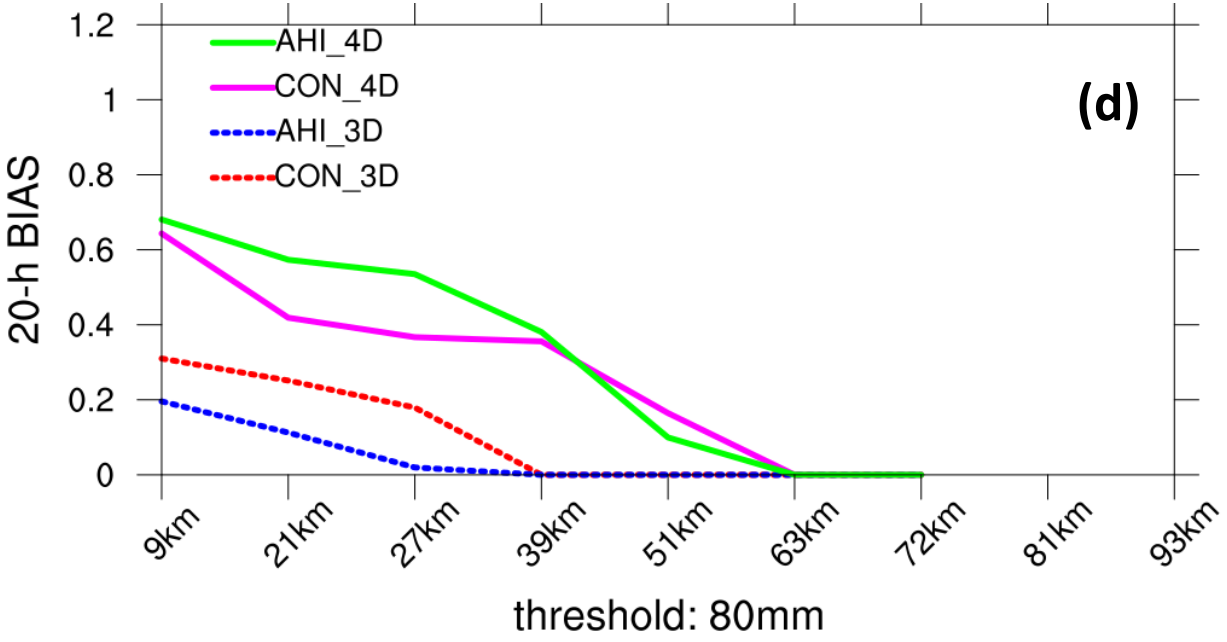

AHI_4D
CON_4D
AHI_3D
CON_3D
20-h FSS
0.80
0.60
0.40
0.20
9km
21km
27km
39km
51km
63km
72km
81km
93km
(c)
threshold: 50mm


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


AHI_4D
CON_4D
AHI_3D
CON_3D
(a)
20-h BIAS
1
0.9
0.8
0.7
0.6
9km
21km
27km
39km
51km
63km
72km
81km
93km
threshold: 5mm


AHI_4D
CON_4D
AHI_3D
CON_3D
(b)
20-h BIAS
1.2
1
0.8
0.6
0.4
0.2
0
9km
21km
27km
39km
51km
63km
72km
81km
93km
threshold: 20mm


AHI_4D
CON_4D
AHI_3D
CON_3D
(c)
20-h BIAS
1.2
1
0.8
0.6
0.4
0.2
0
9km
21km
27km
39km
51km
63km
72km
81km
93km
threshold: 50mm


AHI_4D
CON_4D
AHI_3D
CON_3D
(d)
20-h BIAS
1.2
1
0.8
0.6
0.4
0.2
0
9km
21km
27km
39km
51km
63km
72km
81km
93km
threshold: 80mm

# Conclusions & Future plan

- 4DVAR exps largely reduced timing and location errors in convection initiation forecasts, while every 10-min AHI radiance DA further improved location forecasts.
- The combination of 4DVAR and AHI radiances improved precipitation forecasts and FSS scores
- Future: All-sky radiance DA