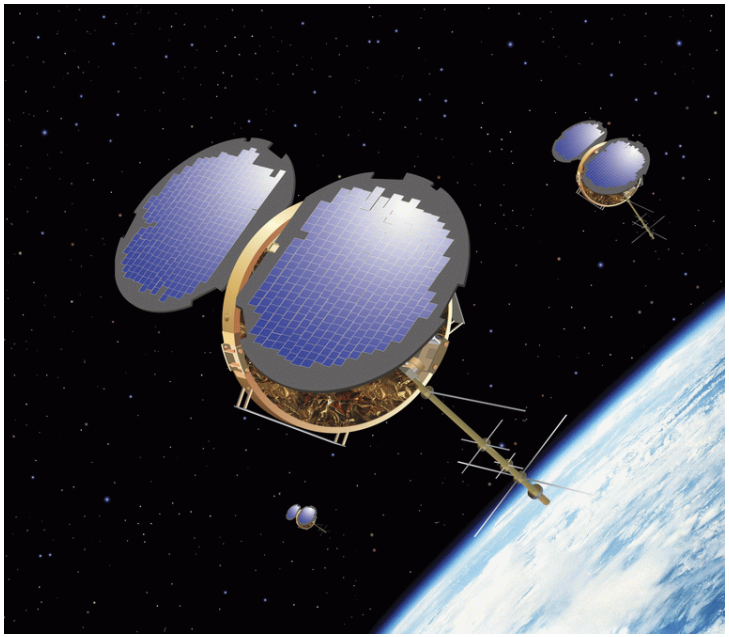
An Impact Study of FORMOSAT-3/ COSMIC GPS Radio Occultation and Dropsonde Data on WRF Simulations



2007 Mei-yu season

Chien and Kuo (2010)

--*GPS Solutions*, **14,** P. 51-63.

2009 Mei-yu season

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Major Findings of Chien and Kuo (2010)

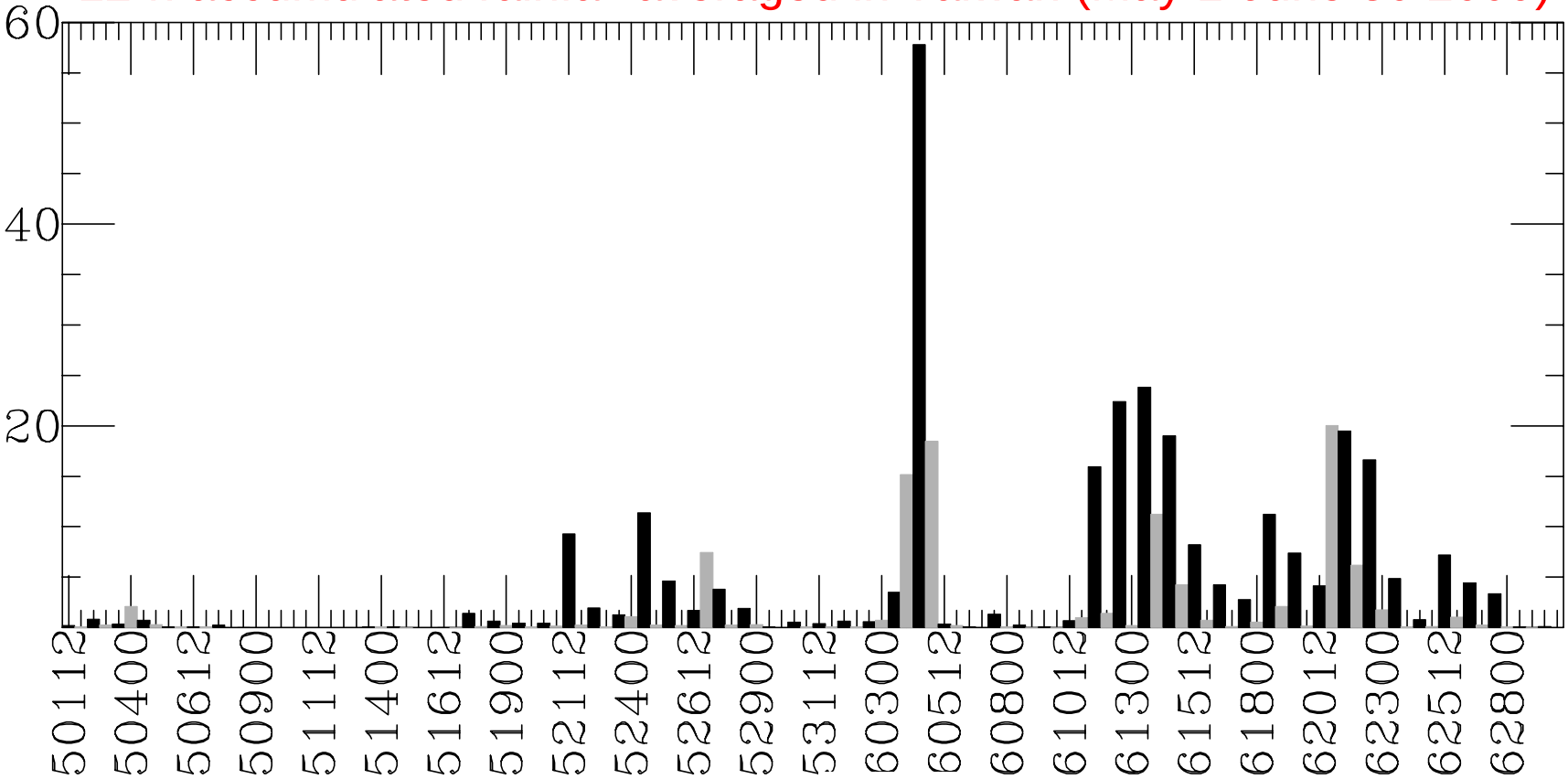
- The assimilation of the GPS data can help to improve the simulation for longer integration. The dropsonde data have smaller positive impact than the GPS data, and the impact slightly decreases over time.
- Geopotential height has the greatest benefit from GPS RO obs.
- With both the GPS and the dropsonde data assimilated together, the simulation shows even greater improvement.
- At early time, there is no impact of GPS and dropsonde data on rainfall forecasts. However, for longer integration, the GPS and dropsonde data start to help the rainfall simulation.

Motivations

- Will the WRF simulation of the 2009 Mei-yu season show the similar impact from the GPS RO and dropsonde data as in 2007?
- Besides the 15-km domain, what is the data impact on the 45-km and 5-km domain simulations?
- What is the regional distribution of the data impact?
- What will be the result if the simulation is verified by traditional soundings, instead of analysis data?

The 2009 Mei-yu season

12-h accumulated rainfall averaged in Taiwan (May 1-June 30 2009)



May

June

Impact of dropsondes on WRF

FORMOSAT-3/COSMIC GPS RO

Dropsonde obs

Simulation period

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WRF settings

- Model settings for the control experiment (CON)
  - WRF V2.2: WSM 5-class microphysics, Kain-Fritsch cumulus parameterization scheme, and YSU PBL scheme
  - WRF Var v2.2 (surface obs and soundings)
  - Contains 22 runs of 72-h simulation that are initialized twice daily from 1200 UTC 11 June to 0000 UTC 22 June 2009.
  - The initial data of the first run at 1200 UTC 11 June 2009 are obtained from the NCEP GFS + WRF Var.
  - The initial data of the other 21 runs are obtained from the 6-h update cycle of the previous WRF run + WRF Var.
- The GPS experiment (GPS)
  - CON + GPS RO data assimilation
- The DRP experiment (DRP)
  - CON + dropsonde data assimilation
- The ALL experiment (ALL)
  - CON + GPS RO + dropsonde data assimilation

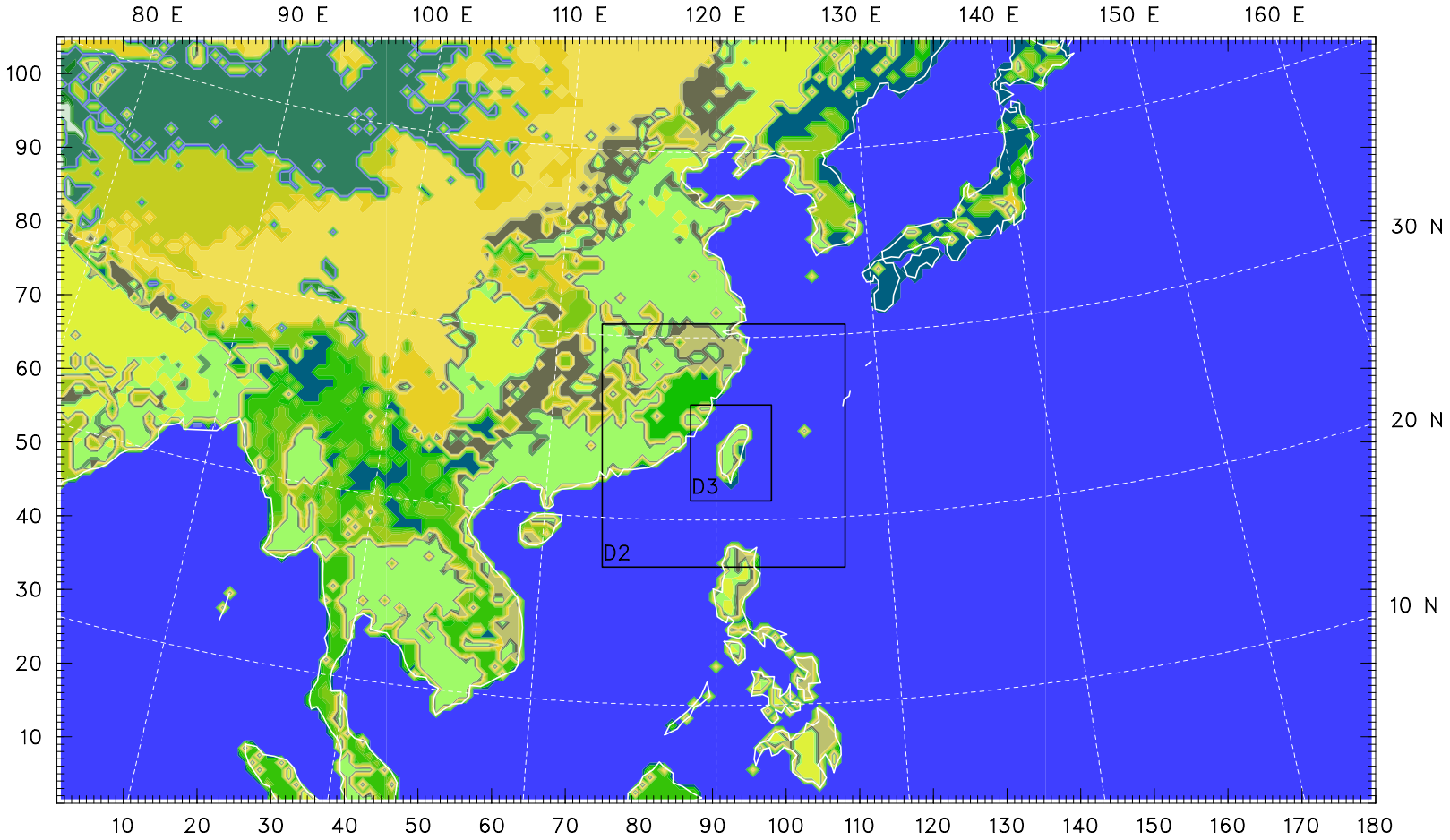
Verification on pressure levels

- Verification method:
  - Root-mean-square error (RMSE)
  - Mean error (ME)
  - Correlation coefficient (CC)
  - Skill score (SS)

$$SS = \frac{RMSE_{CON} - RMSE_{GPS}}{RMSE_{CON}} \times 100\%$$

  - Averaged on (1) grid points of each domain against ECWMF analyses + WRF Var with sounding and surface obs, (2) traditional sounding stations inside D1 and D2. Averaged for all the 22 runs (11 days) of each experiment.
- Variables:
  - H, T, RH, U, V
- Pressure levels:
  - 850 hPa, 500 hPa, 300 hPa
- Times:
  - 0, 12, 24, 36, 48, 60, 72 h

- D01, D02, D03
- Resolution : 45 km、15 km、5 km



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Amounts of obs used in WRF Var

Init time (dd/hh)	6/11 12	6/11 18	6/12 00	6/12 06	6/12 12	6/12 18	6/13 00	6/13 06	6/13 12	6/13 18	6/14 00	6/14 06
SYNOP	979	934	983	984	988	936	979	981	986	941	982	982
SOUND	132	5	153	5	132	6	159	6	133	6	157	6
GPS RO	3	2	1	17	3	16	7	8	6	9	9	7
Dropsonde	15	0	13	0	15	0	15	0	14	0	0	0
Init time (dd/hh)	**6/14 12**	**6/14 18**	**6/15 00**	**6/15 06**	**6/15 12**	**6/15 18**	**6/16 00**	**6/16 06**	**6/16 12**	**6/16 18**	**6/17 00**	**6/17 06**
SYNOP	986	929	964	979	981	915	961	986	958	918	961	973
SOUND	133	5	158	5	132	4	155	2	126	2	155	2
GPS RO	5	12	10	15	9	10	11	10	7	10	15	13
Dropsonde	0	0	0	0	14	0	0	0	0	0	0	0

GPS RO: refractivity

Dropsonde: Φ, T, q, and wind

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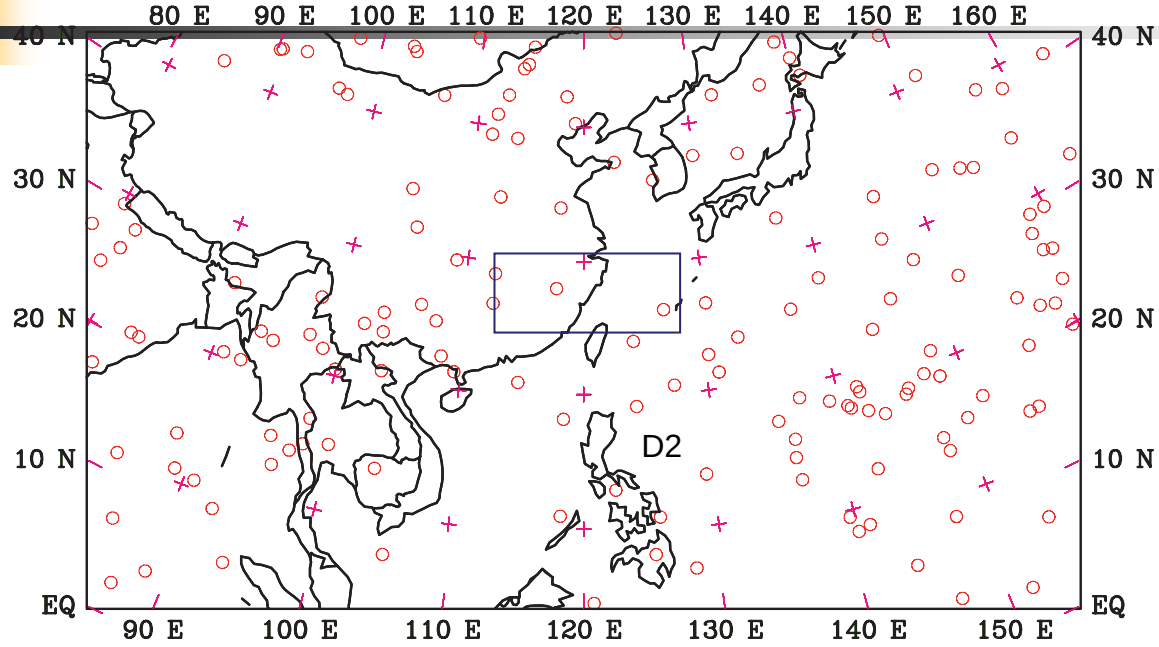
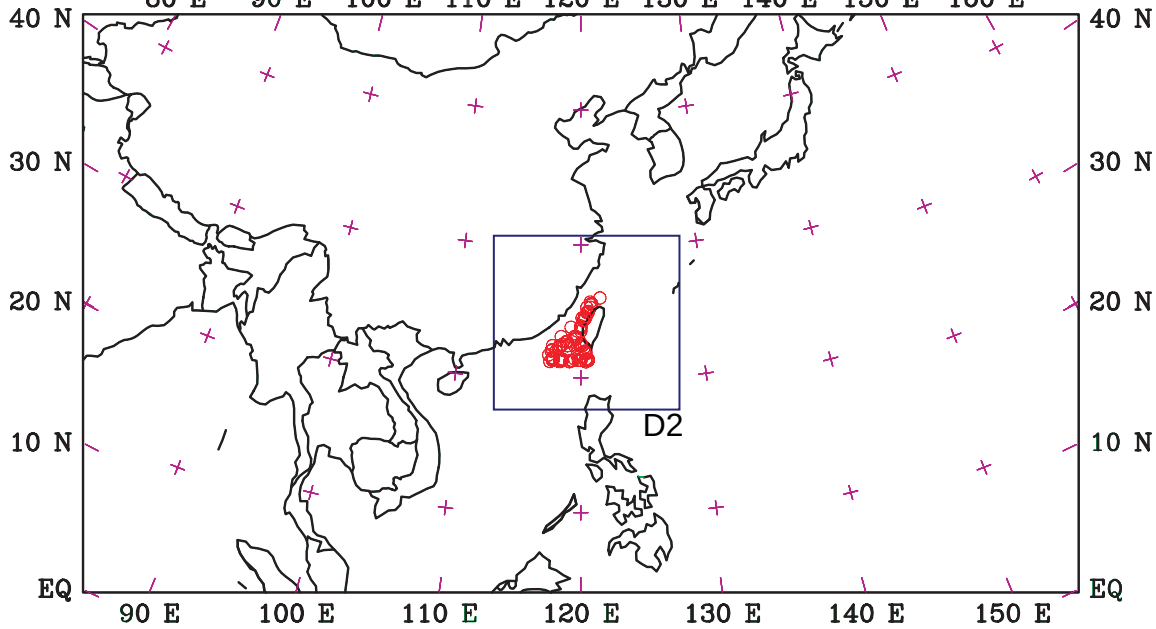
Locations of obs in 11 days



2009
0611/1200~
0622/0000 UTC

GPS RO



dropsonde

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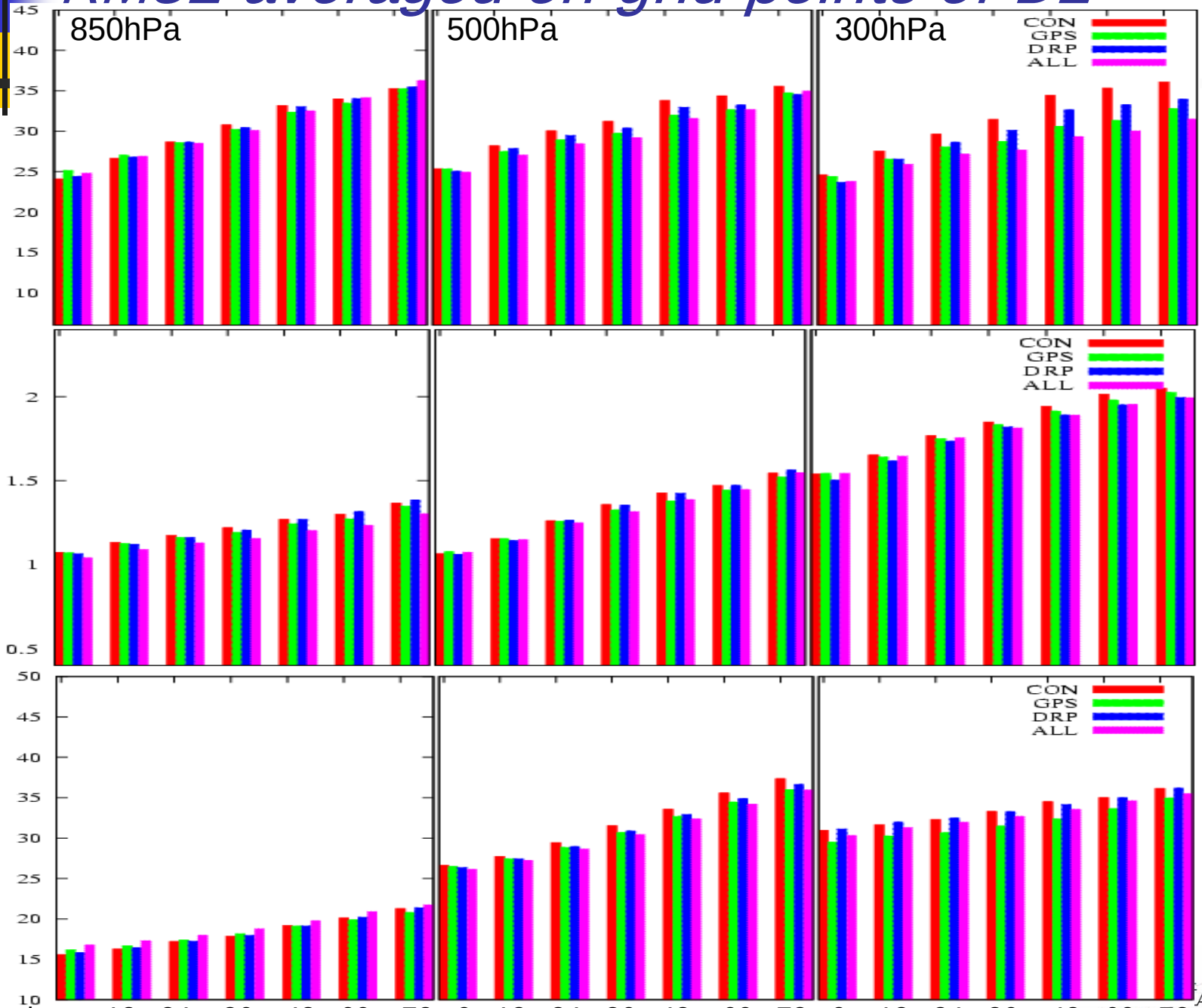
RMSE averaged on grid points of D2

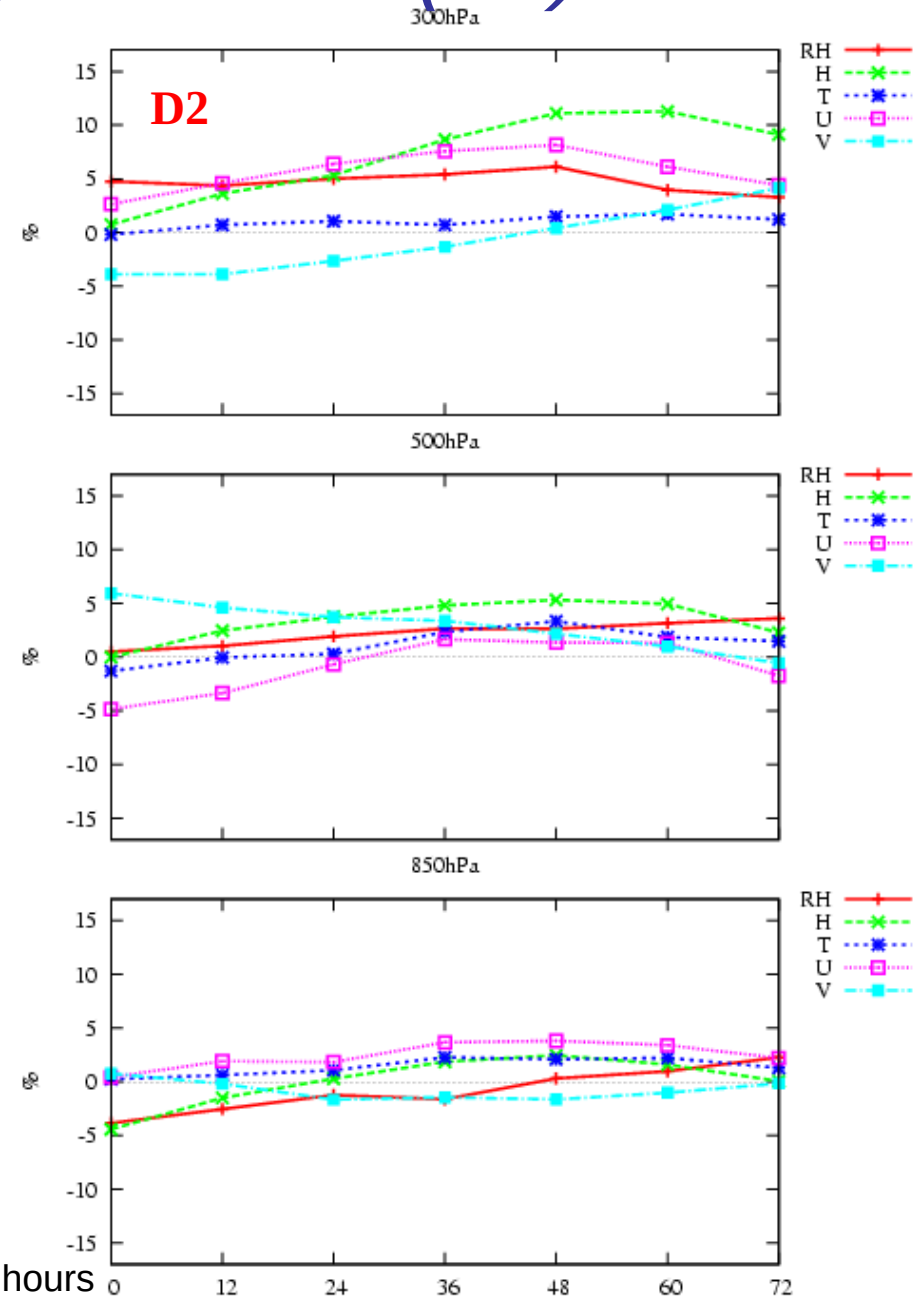


Skill Score of GPS against CON (D2)

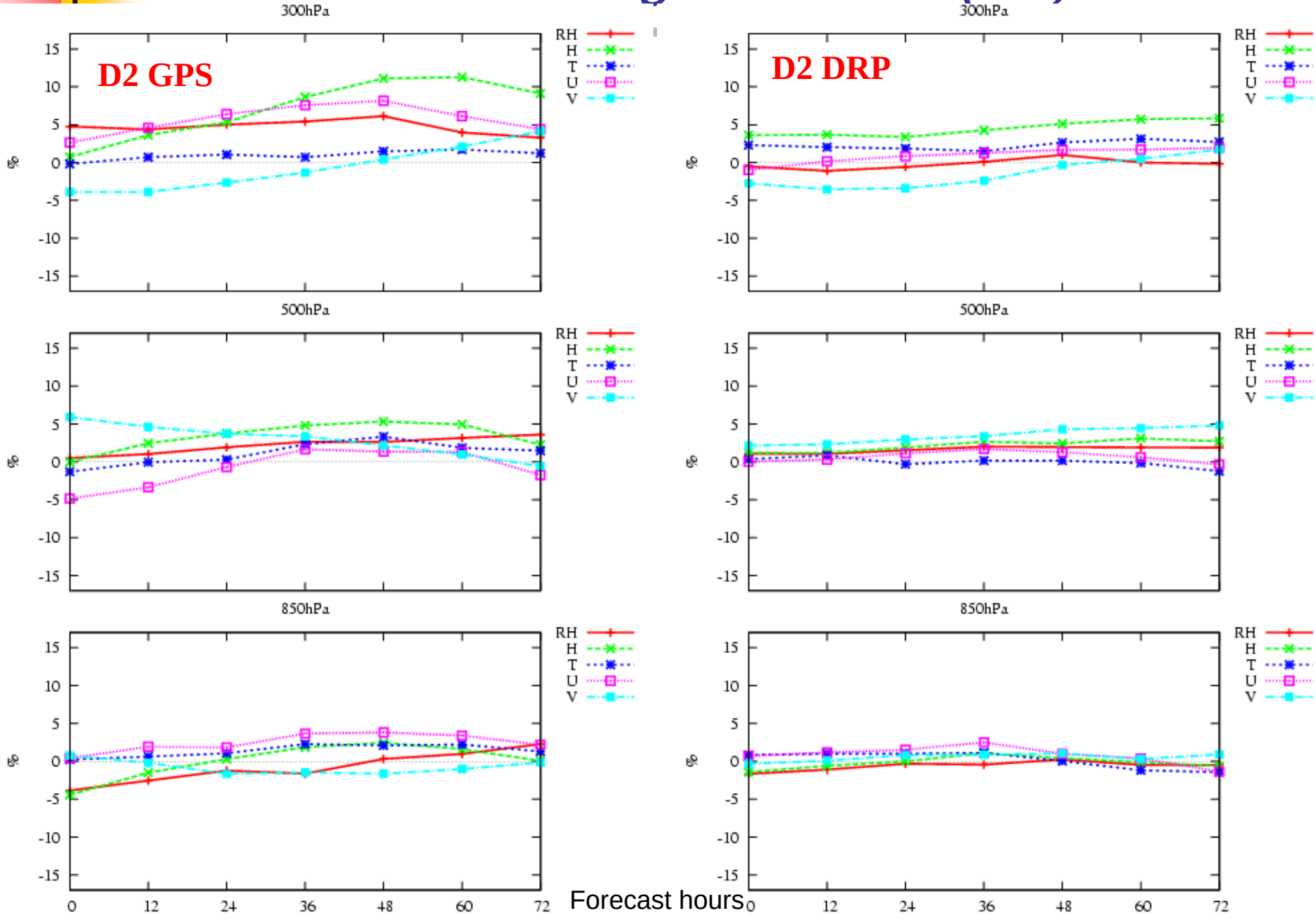
$$SS = \frac{RMSE_{CON} - RMSE_{GPS}}{RMSE_{CON}} \times 100\%$$

Averaged for 11 days and for the entire domain

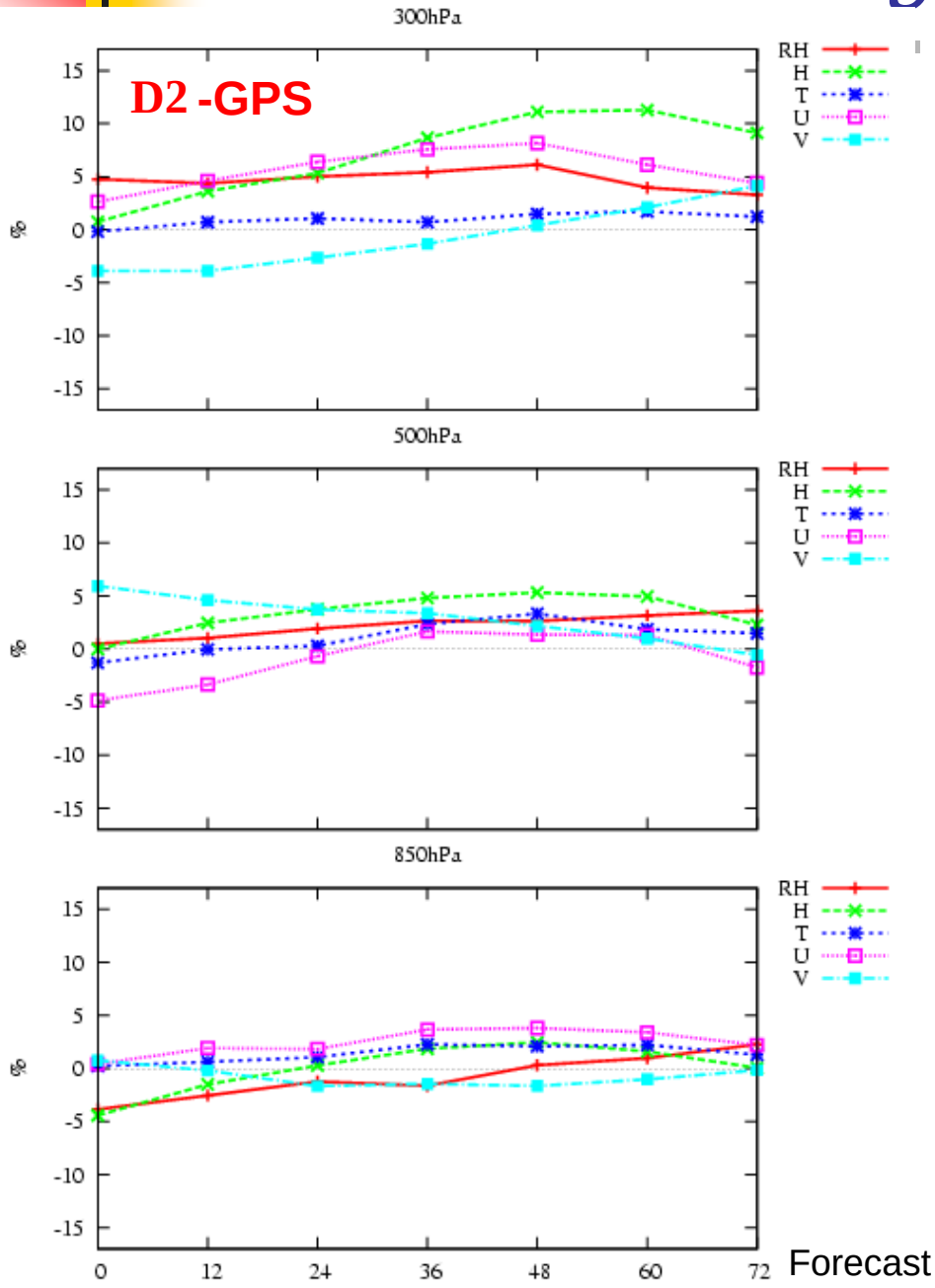
- Why does the assimilation of GPS data have greater impact for longer integration? Because the large-scale simulation (D1) is first improved using the GPS RO observations, and the resulting changes can have a positive impact on the mesoscale (D2) at the later time.

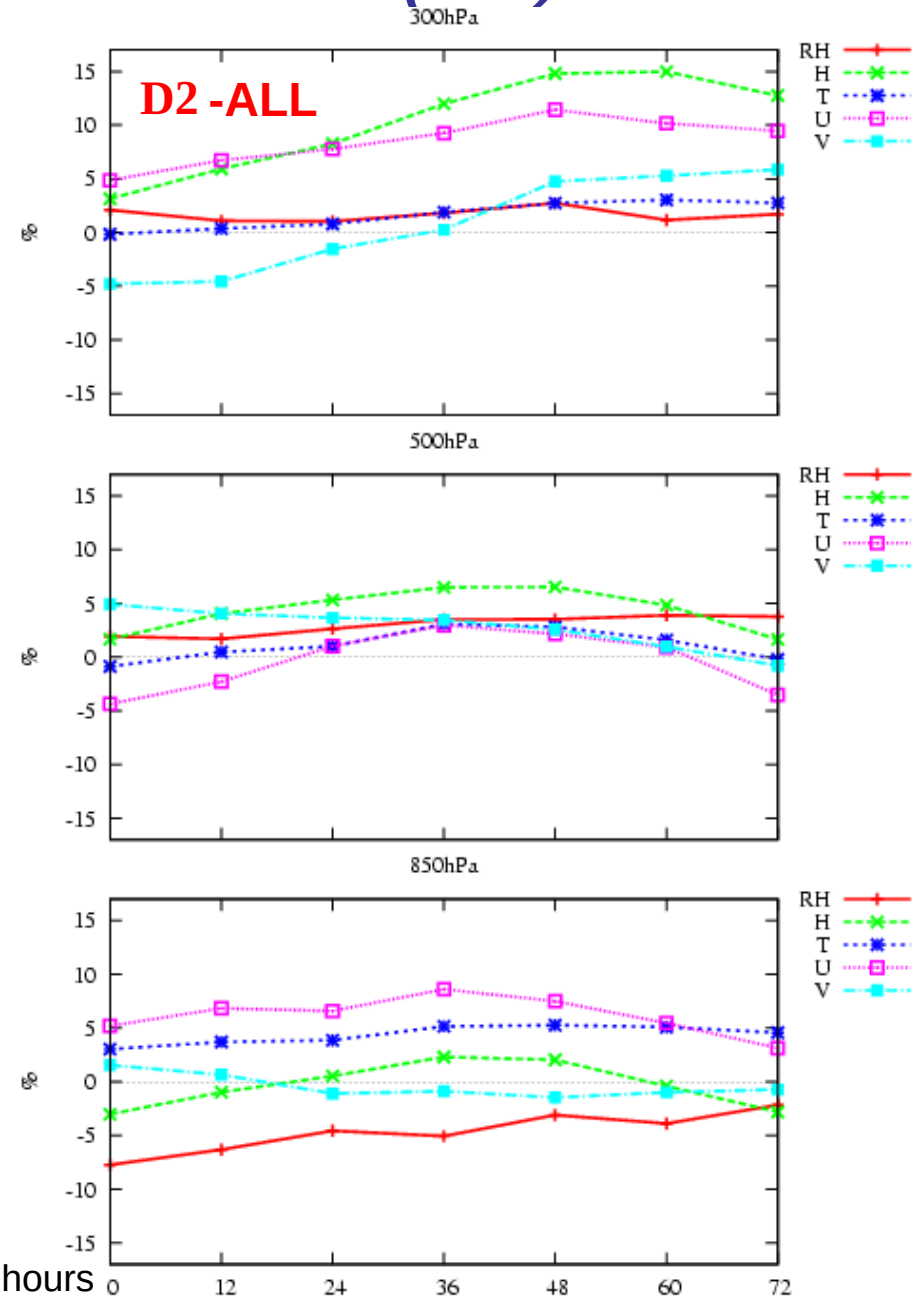


Skill Score of DRP against CON (D2)

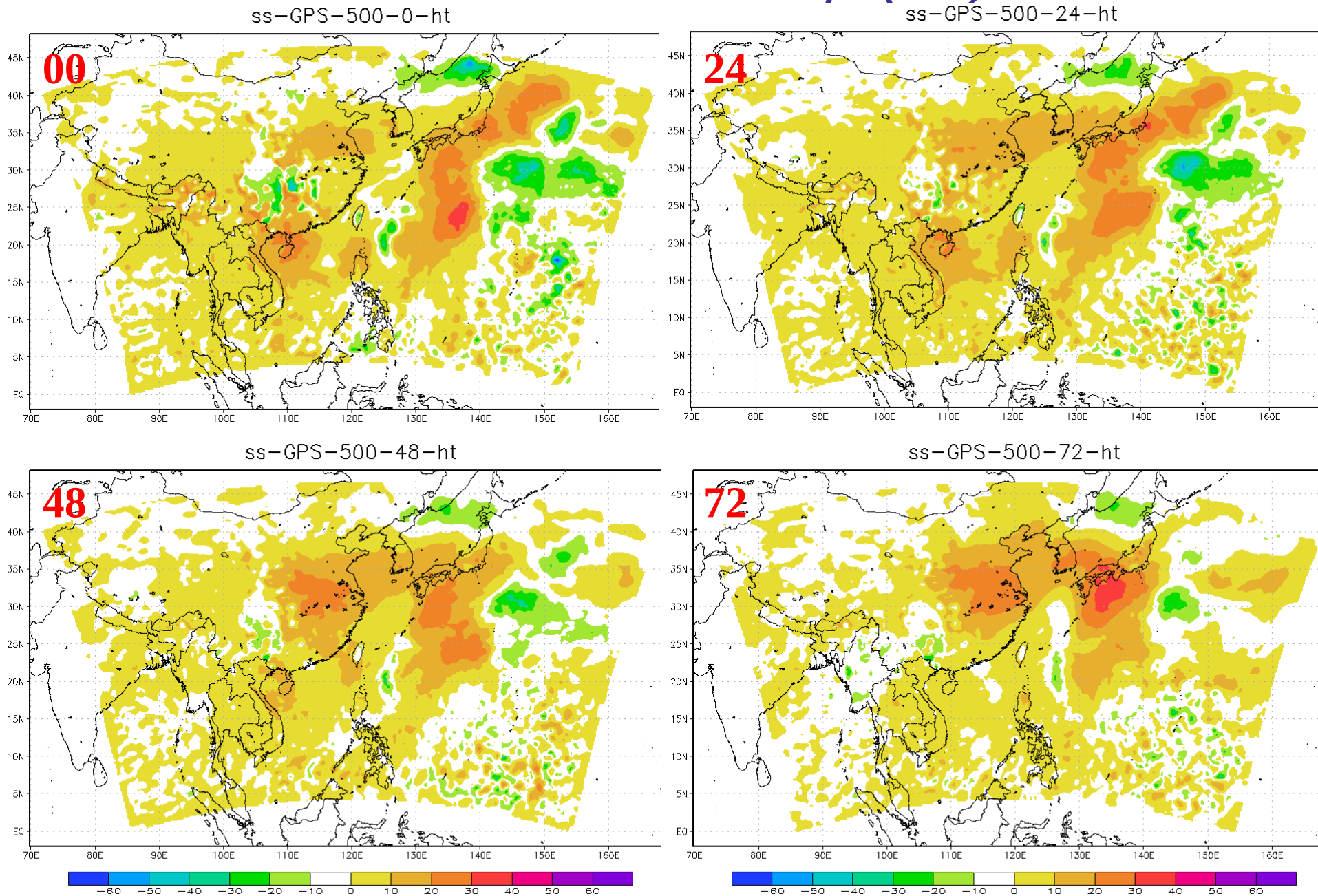


Skill Score of ALL against CON (D2)





Skill Score of H for GPS exp.(D1) *11-day average*

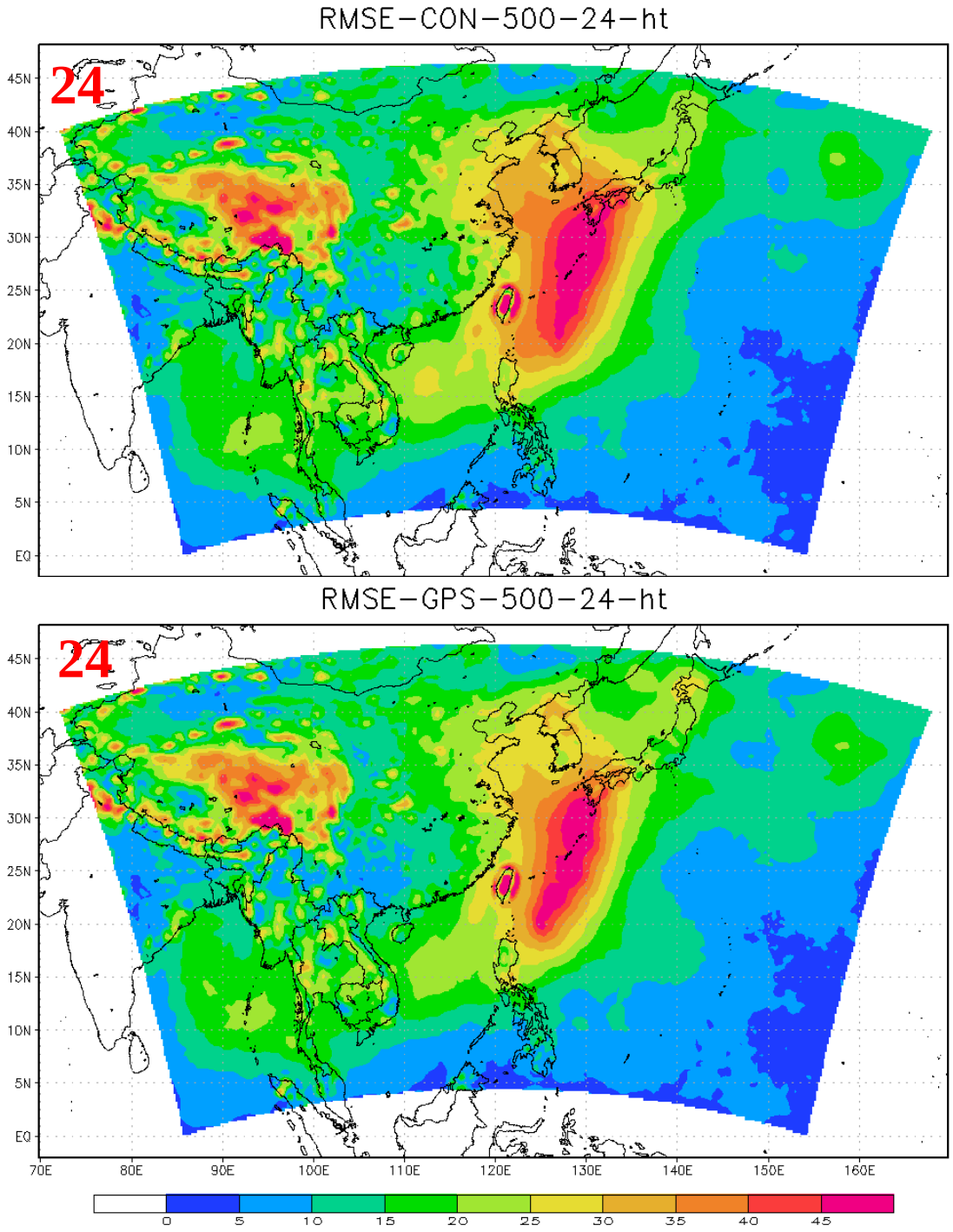


RMSE of 500mb H (D1)

11-day average

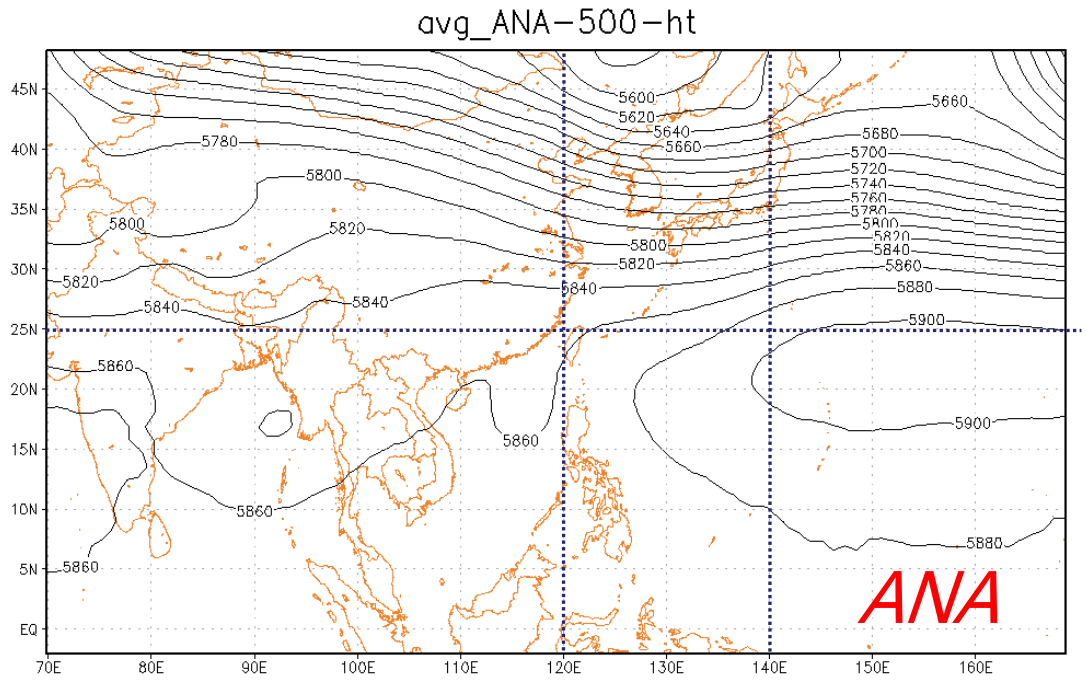
CON

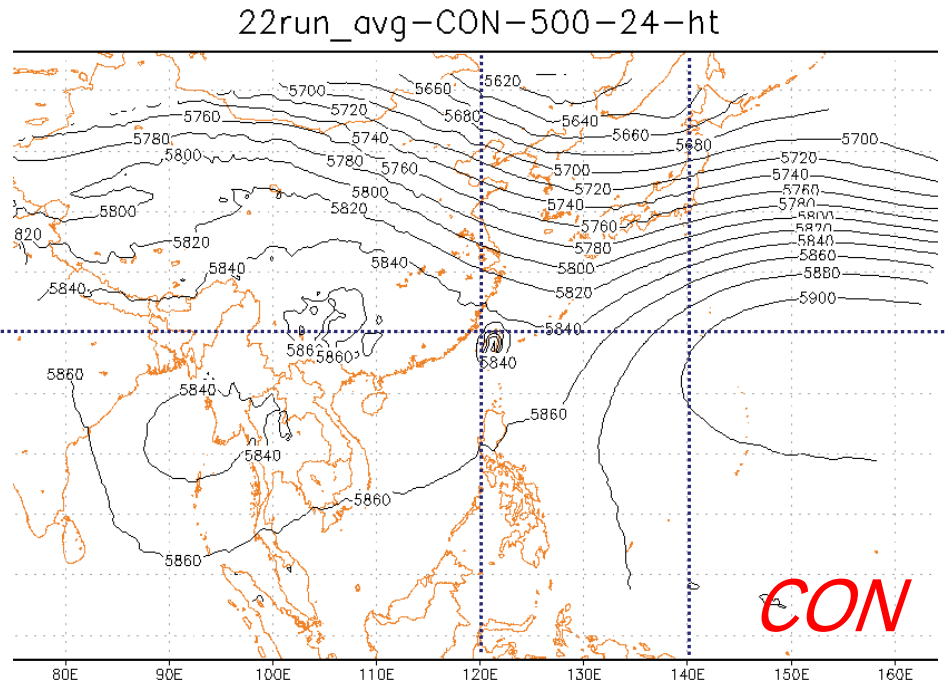
GPS

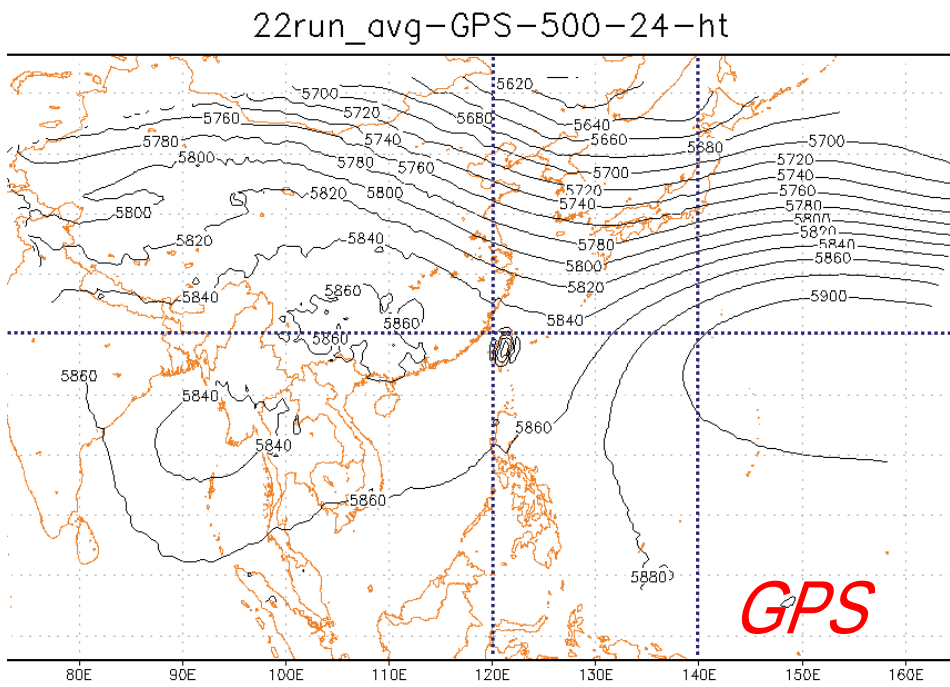


Ave 500mb H (D1)

11-day average



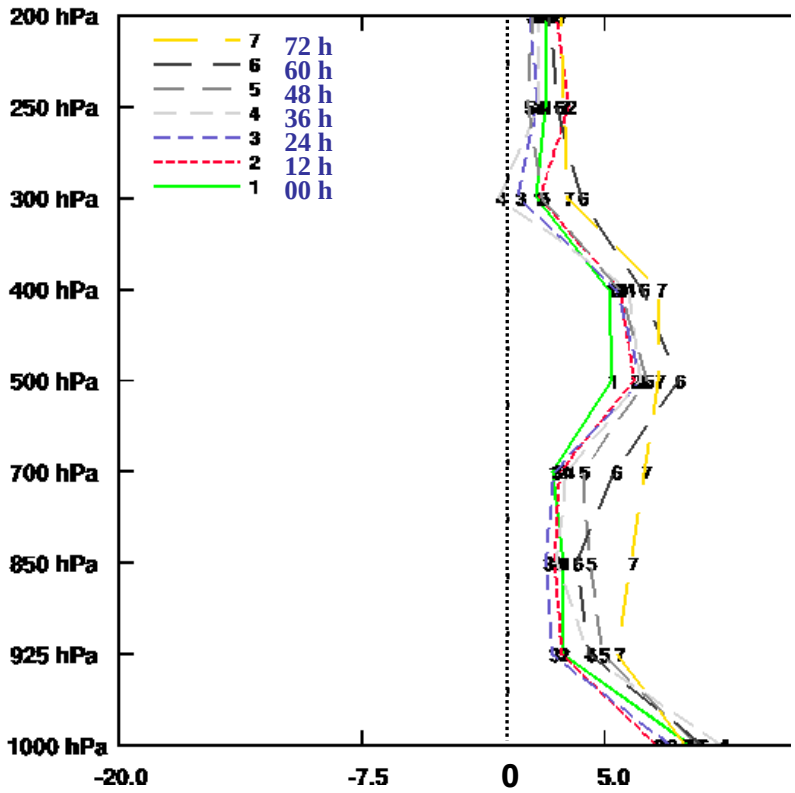




SS of H for GPS exp. (verified by soundings)

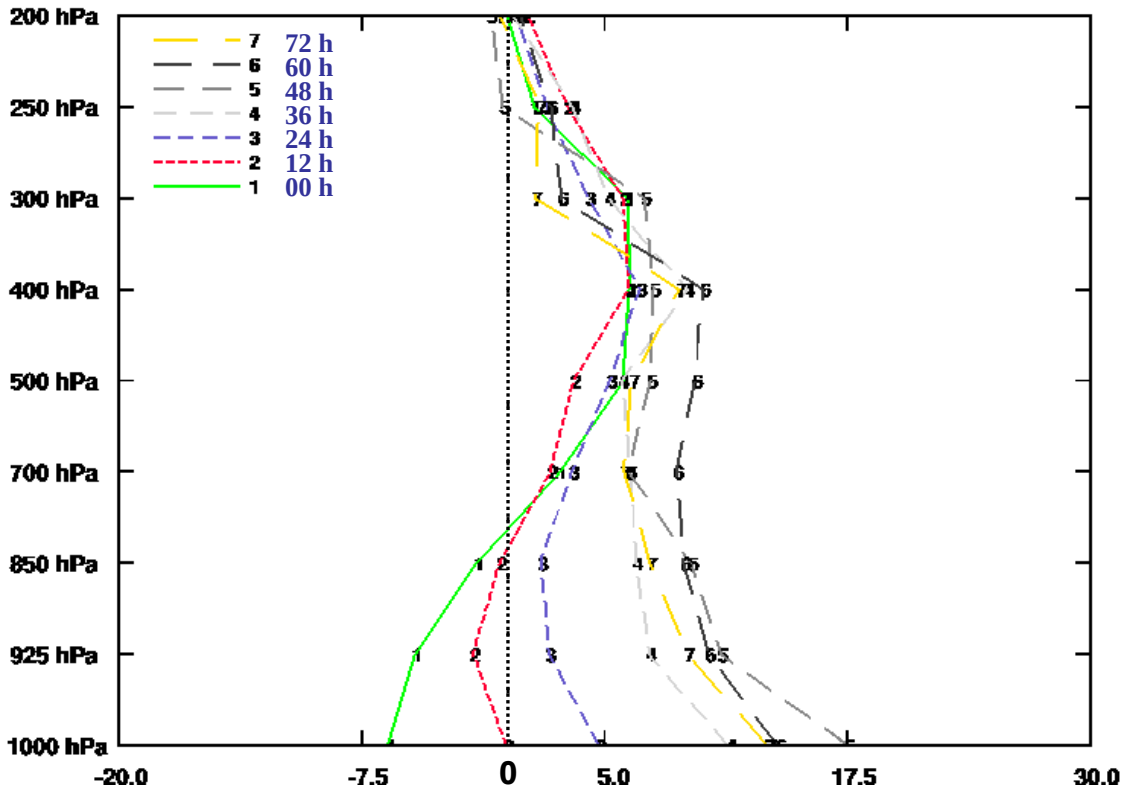
11-day average

D1 H Skill Score (%)



Avg of 175 soundings

D2 H Skill Score (%)



Avg of 28 soundings

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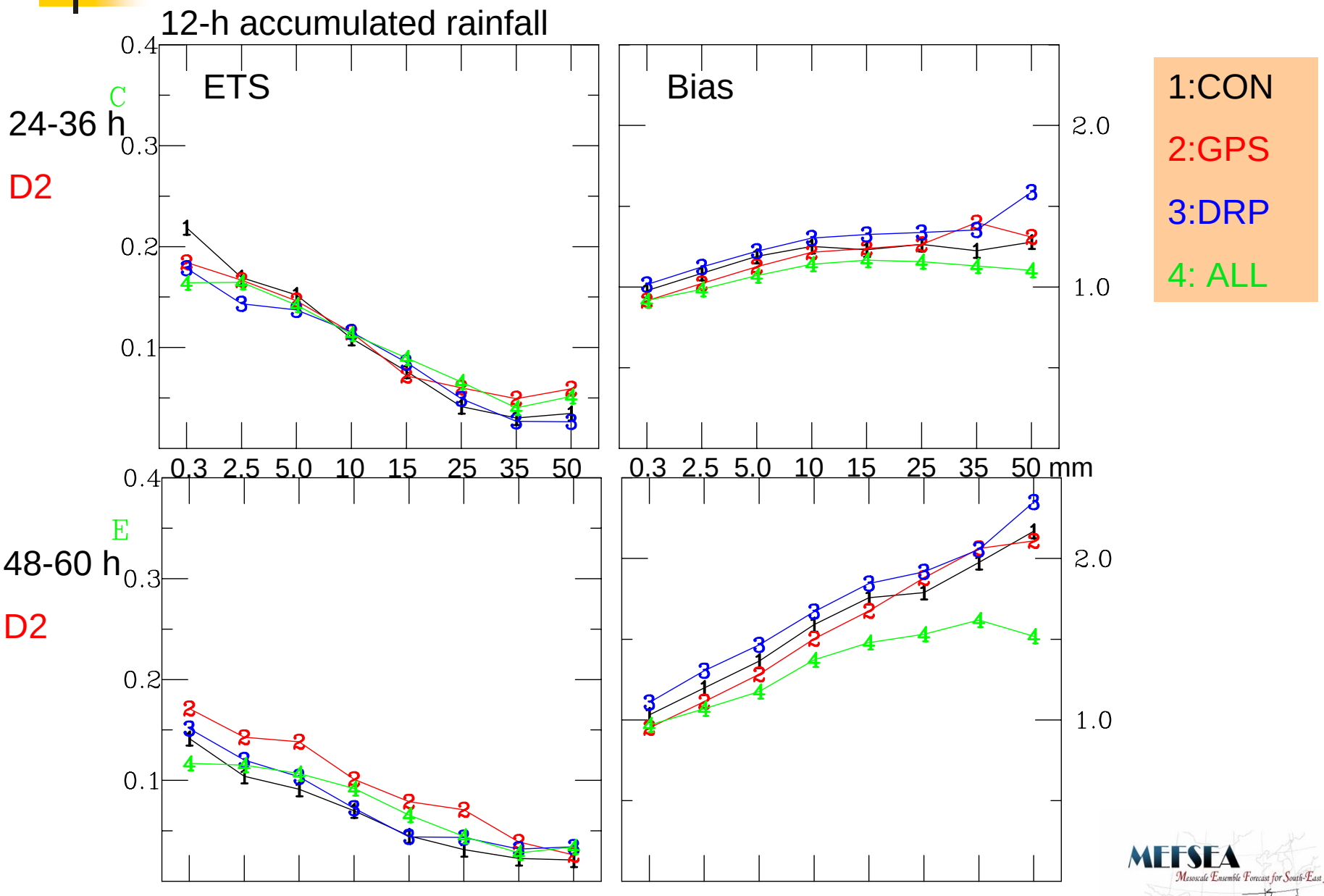
ETS and bias, verified against rain gauges



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Conclusions

- The assimilation of the GPS data can help to improve the simulation for longer integration, because the large-scale simulation is first improved using the GPS RO observations, and the resulting changes can have a positive impact on the mesoscale at the later time.
- The dropsonde data has smaller positive impact than the GPS data, and the impact slightly decreases over time, because the dropsonde observations were taken inside the fine domain such that their impact can be detected early in the simulation.
- Geopotential height has the greatest benefit from GPS RO obs, while the relative humidity has the least.
- The positive impact of GPS data mostly occurs over the western Pacific, because the GPS data assimilation can help to predict better trough in east Asia and the Pacific high.
- For D3, the dropsonde data that are collected near Taiwan can have greater impact than the GPS data on rainfall simulation in Taiwan. But, for D2, the GPS data can have greater impact on rainfall simulation, especially at longer integration time.