Numerical Simulation of Heavy Snowfall over the Ho-Nam Province of Korea in December 2005 Using WRF

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Acknowledgement :

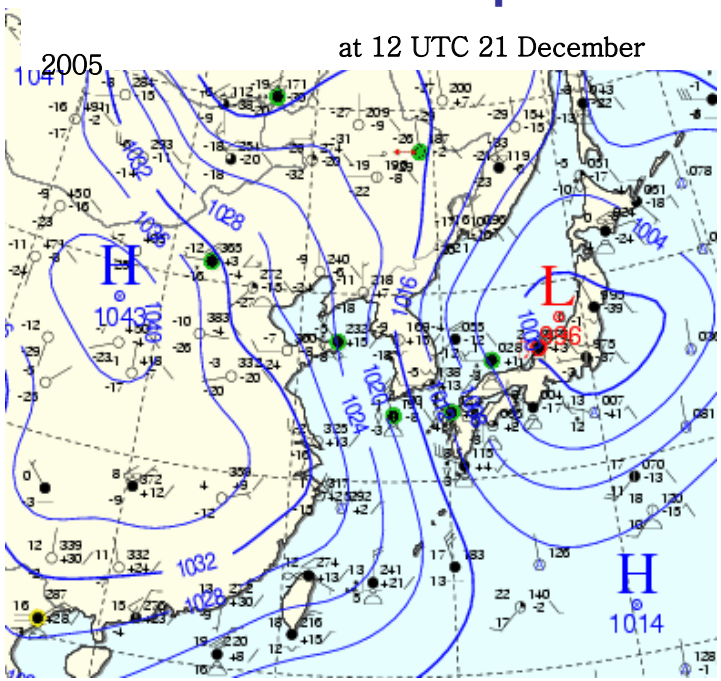
Jung Choi

Synoptic overview

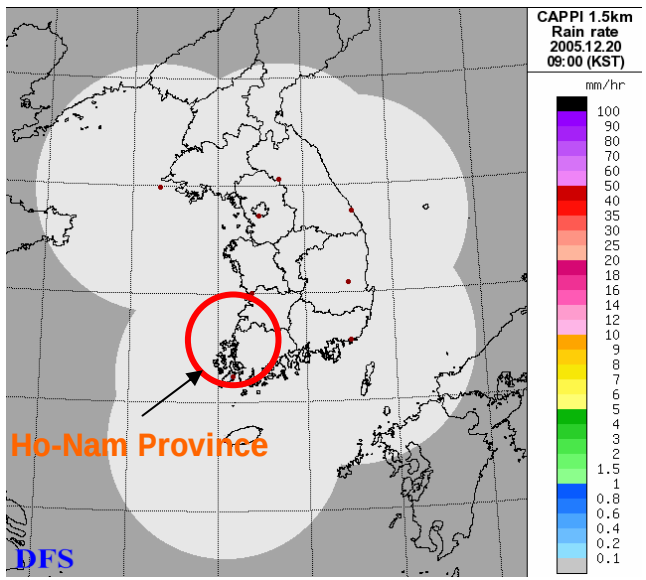
Snowfall over the Ho-Nam province is induced by strong continental high-pressure systems
-Air Mass Transformation Mechanism

-Intensity of precipitation is determined by differences of temperature between the sea surface temperature and cold air accompanied by continental high-pressure

Surface weather map



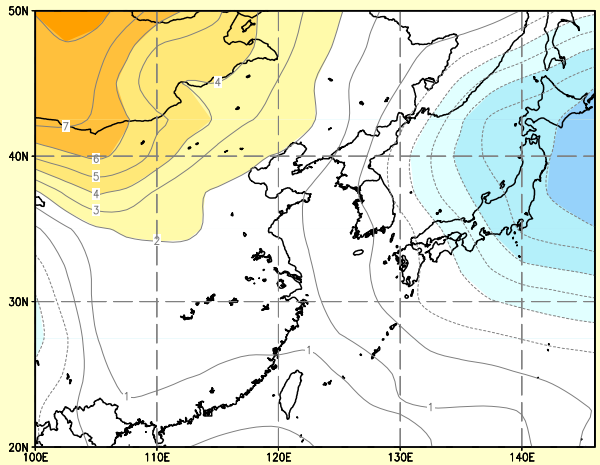
Radar Image



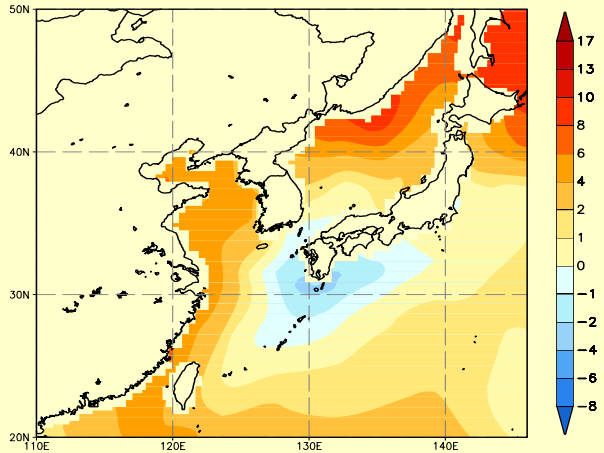
Climate extreme in December 2005

December 2005 Anomaly

Surface Pressure (mb) (OBS-CLM)

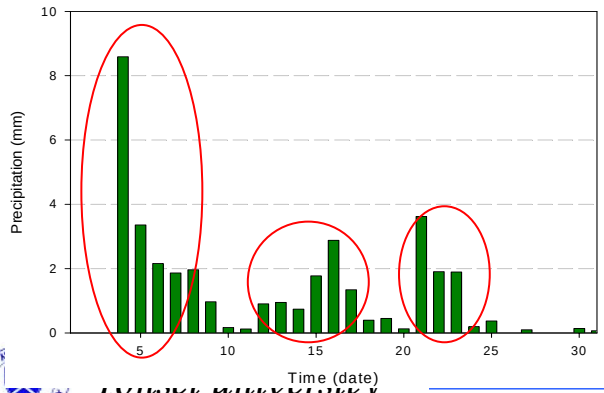


SST(K) (OBS-CLM)

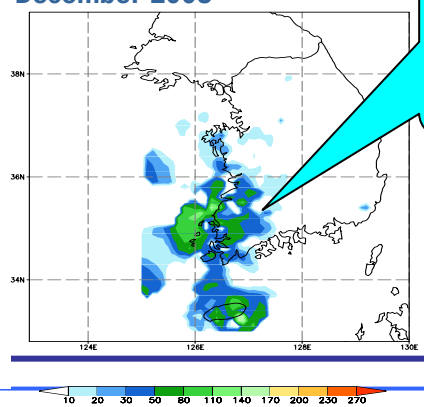


Abnormal snowfall over the Ho-Nam province

✓ Time series



✓ Accumulated snowfall during December 2005



Unusual heavy snowfall events induced by the warm sea surface temperature over the Yellow Sea

Objective

- To show the capability of the WRF model in simulating heavy-snowfall over the Ho-Nam province.
- To investigate the effects of abnormal sea surface temperature on the snowfall.
- To find out the room for reducing the model bias.
- To compare the capability of regional model (WRF,MM5 and RSM) in simulating regional climate over the East Asia during the winter time.

List of Presentation

Evaluation of WRF Model

Sensitivity Test

Vertical Resolution

Comparison with MM5, RSM

Conclusion!!

Part I

Evaluation of WRF model (Control Simulation)

Experimental Setup

Period

00Z01 December ~ 00Z31 December 2005

BDY

NCEP/DOE Reanalysis Ⅱ data

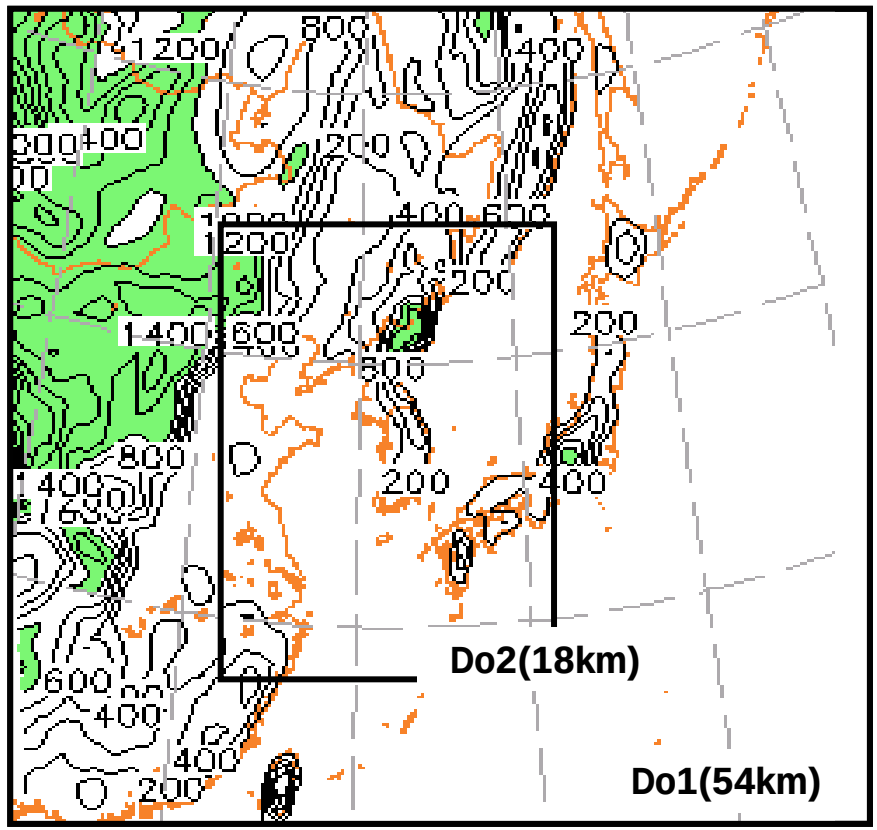
Physical option

MIC	WSM6
LWR	RRTM
SWR	Dudhia
LSM	Noah
PBL	YSU
Cumulus	Kain-Fritsch

Vertical resolution

23 layers

Domain

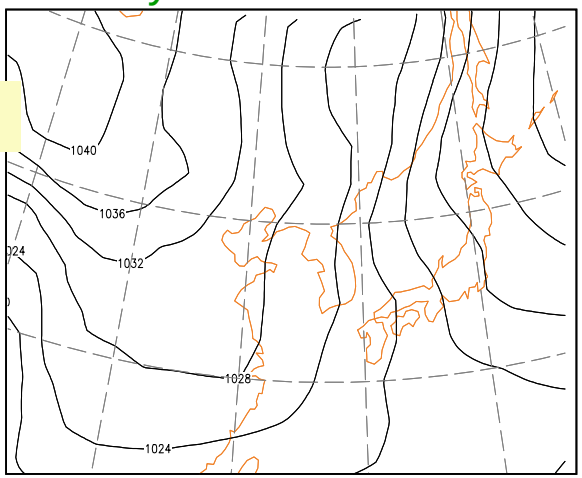


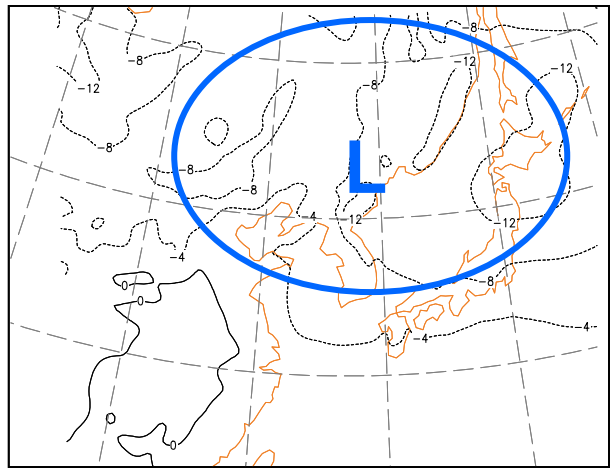
Evaluation of Large Scale Simulation

Reanalysis Ⅱ data

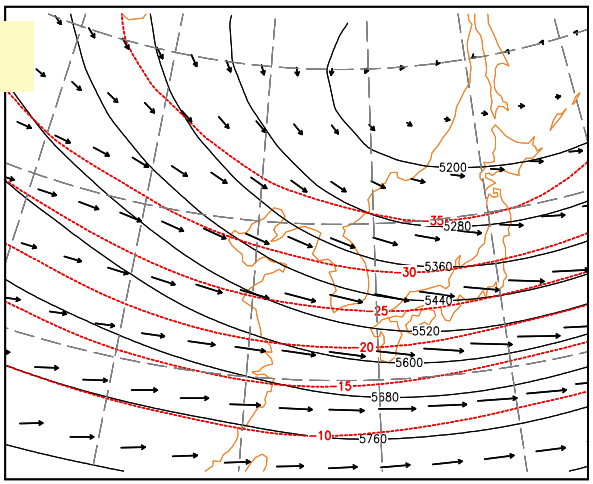
WRF - Reanalysis Ⅱ data

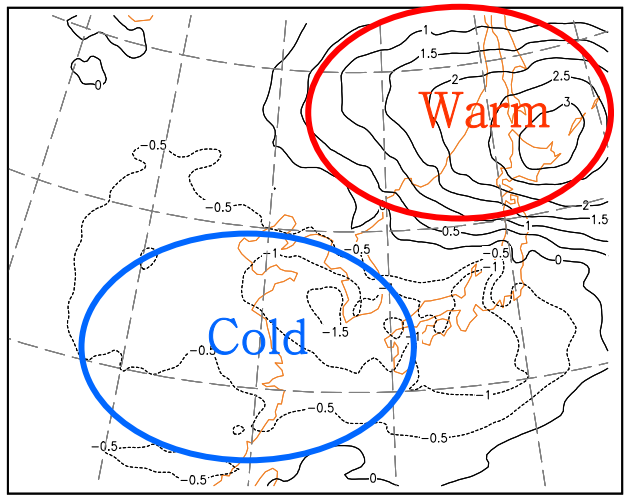
Sea level





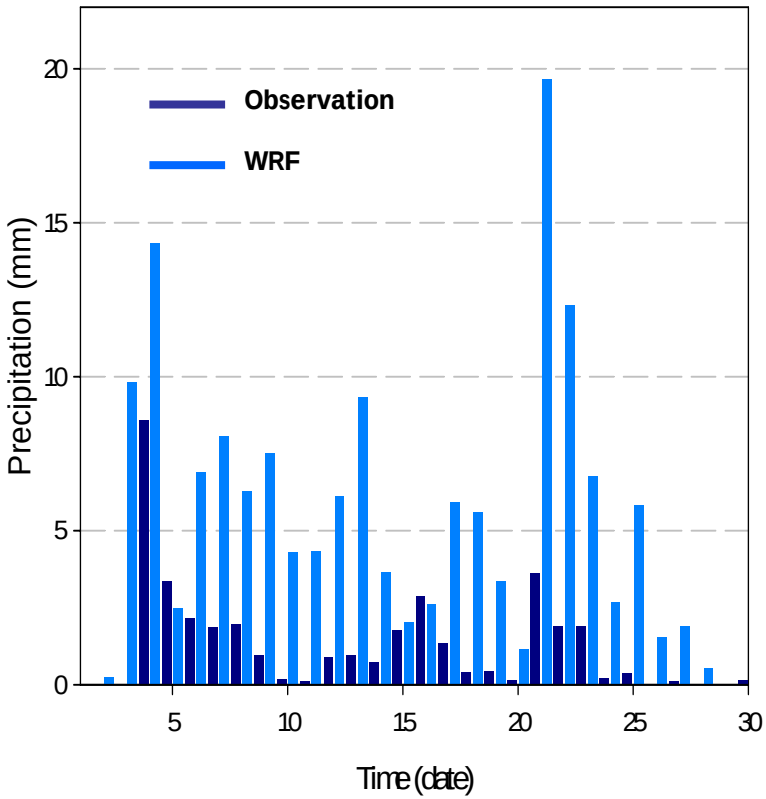
500mb



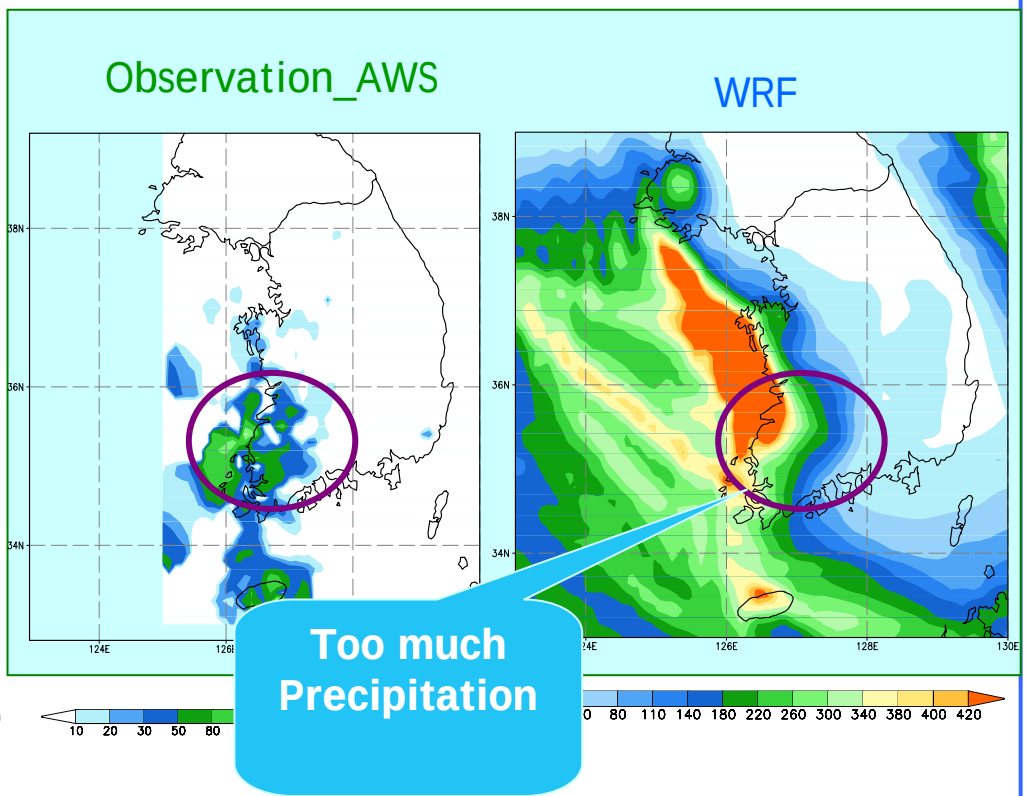


Precipitation (Control simulation)

✓ Time series



✓ Accumulated precipitation during the December 2005



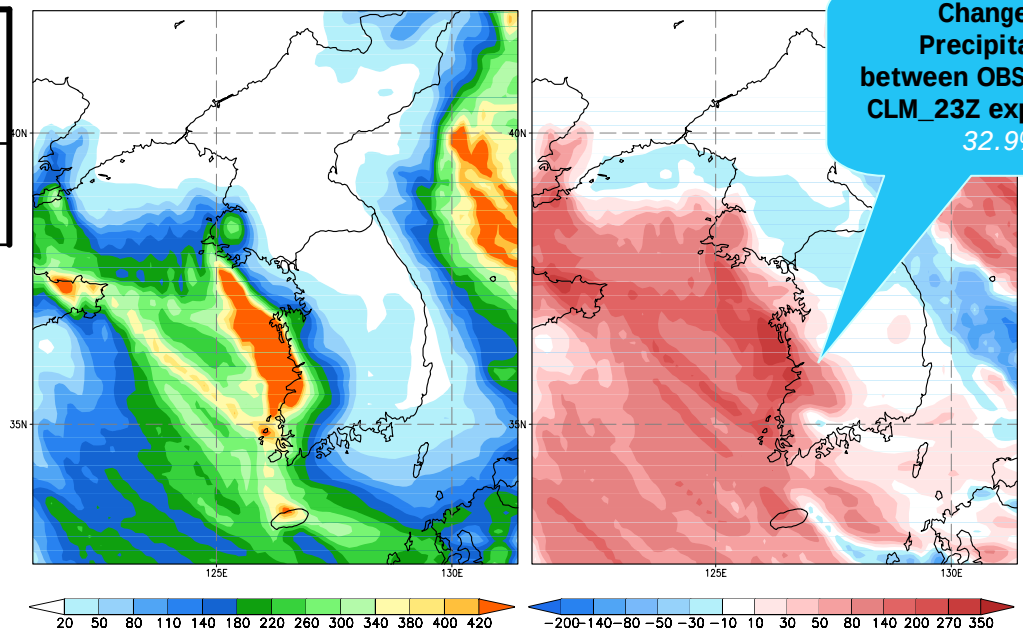
Effects of Sea Surface Temperature

✓ Experiments

CLM_23Z	Climatological SST during from 1979 to 2003
OBS_23Z	Observed SST during December 2005

✓ Accumulated snowfall

OBS_23Z　　OBS_23Z - CLM_23Z



Change of Precipitation between OBS_23Z and CLM_23Z experiment
32.9%

✓ Statistic scores

	Correlation	Bias Score	Average (mm)	Max Preci (mm)
OBS_23Z	0.58(0.63)	8.66(2.98)	248.52 (134.8)	543
CLM_23Z	0.55(0.76)	5.81(2.42)	166.81(109.43)	337

Part I Result

Control simulation reproduces the heavy snowfall in terms of timing and distribution, but its amount was overestimated

Abnormal sea surface temperature over the Yellow Sea

About 30 % Increase in the amount of snowfall!!!

Part Ⅱ

Sensitivity Test

- Vertical Resolution (OBS_23Z, OBS_43Z, and OBS_63Z)

✓ Back ground

- Kim and Lee (2002, J. Korean Meteor. Soc.)– Differences in cumulus parameterization, planetary boundary layer schemes and initial condition do not affect the snowfall over the Korean peninsula.

- Byun (2006, to be submitted to Mon. Wea. Rev.) -WRF and MM5 simulate more snowfall associated with mass transformation irrespective of the horizontal resolution and microphysics scheme

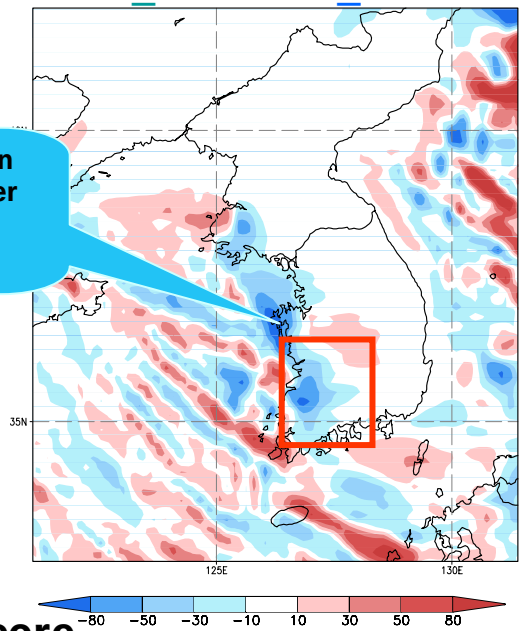
✓ Summary of Experiments

OBS_23Z	Experiment with observed SST during December 2005
OBS_43Z	Same as in the OBS_23Z except for the number of 43 vertical grid
OBS_63Z	Same as in the OBS_23Z except for the number of 63 vertical grid

For reducing the model bias, designing a vertical resolution will be important in the snowfall simulation associated with air mass transformation during cold air break occur!!!

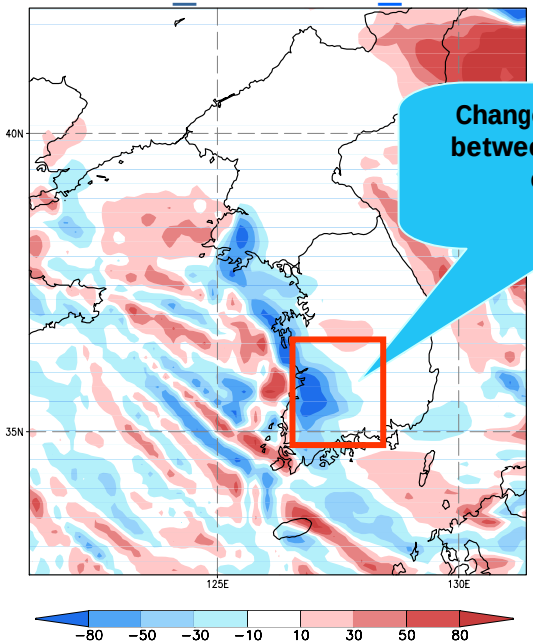
Vertical Resolution

OBS_43Z – OBS_23Z



Change of Precipitation between 43 and 23layer experiment
10.9%

OBS_63Z – OBS_23Z



Change of Precipitation between 63 and 23layer experiment
19.7%

✓ **Statistic score**

Precipitation	Correlation	Bias Score	Average (mm)	Max Preci (mm)
OBS_23Z	0.58 (0.63)	8.66 (2.98)	248.52 (134.8)	543
OBS_43Z	0.57 (0.65)	6.95 (2.99)	221.45 (135.44)	519
OBS_63Z	0.56 (0.65)	6.72 (2.92)	199.52 (132.39)	458

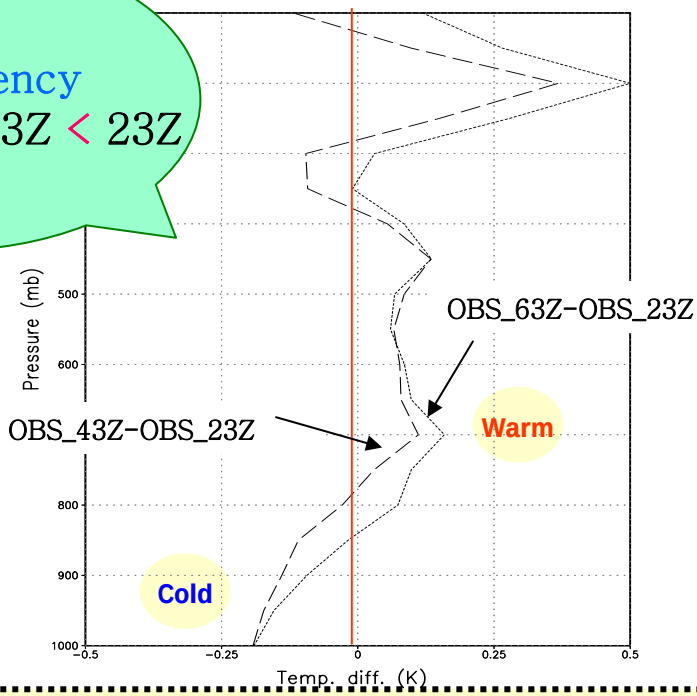
Hear Flux	LH	SH
OBS_23Z	965.70 (514.83)	682.07 (354.50)
OBS_43Z	965.27 (517.80)	694.85 (361.62)
OBS_63Z	960.91 (514.26)	699.46 (349.35)

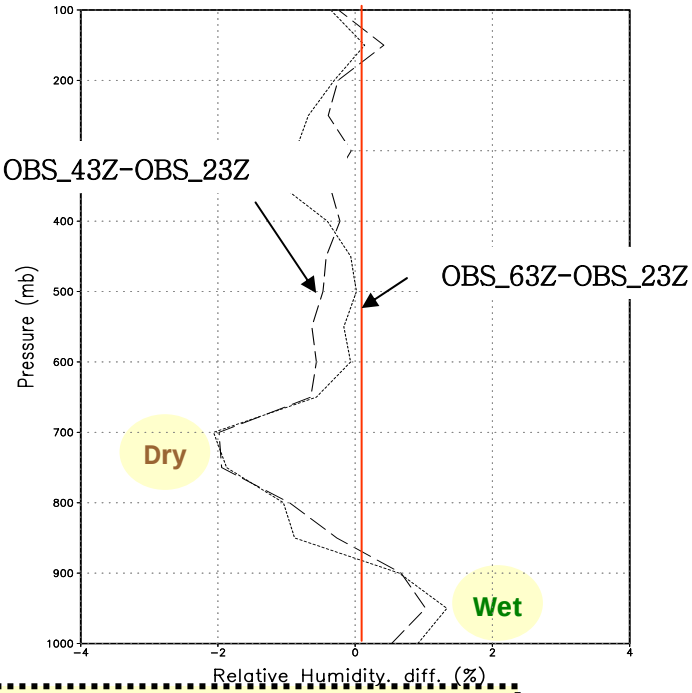
Part II Result

temperature

Relative humidity

Mixing efficiency
OBS_63Z < 43Z < 23Z





Increased number of layers

Reducing the simulated precipitation amount!!

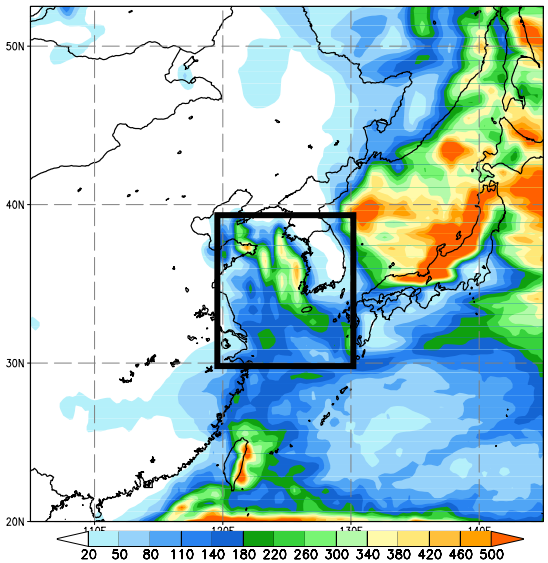
Improving the precipitation by reducing positive bias!!!

Part Ⅲ

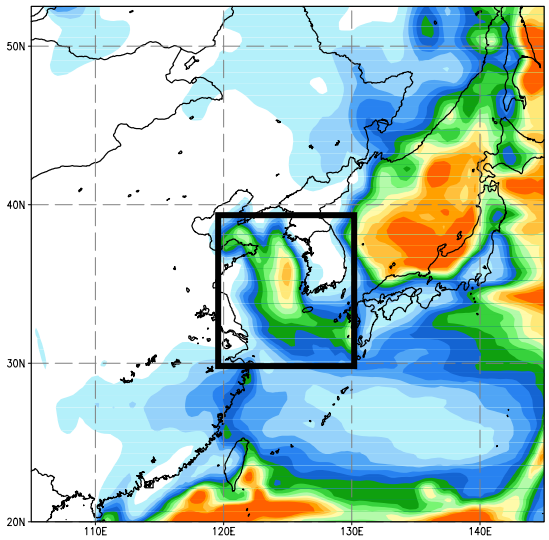
Comparison with the results using the MM5 and RSM in the Regional Climate Simulation During the Winter time

Precipitation

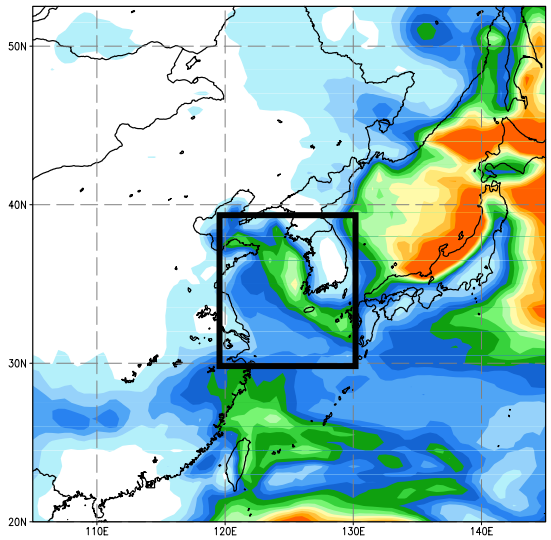
WRF



MM5



RSM



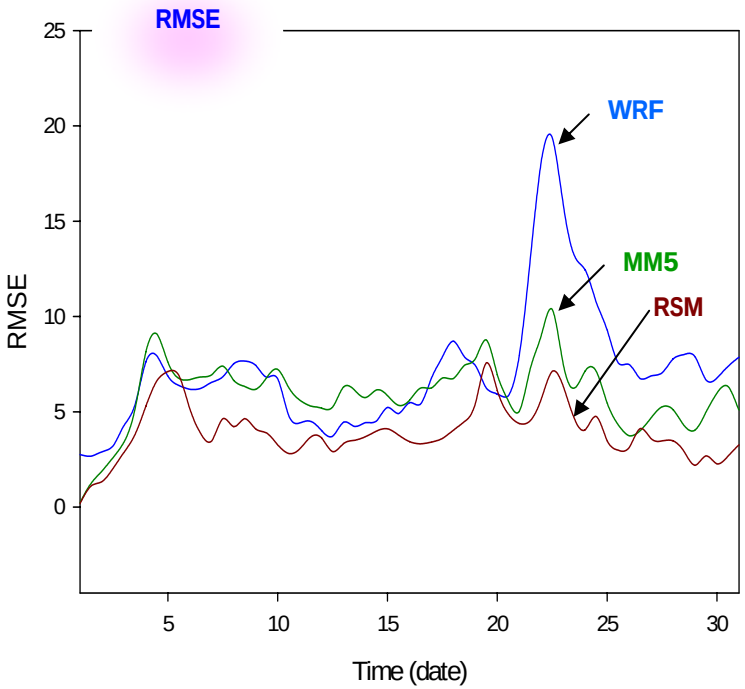
✓ **Statistic scores**

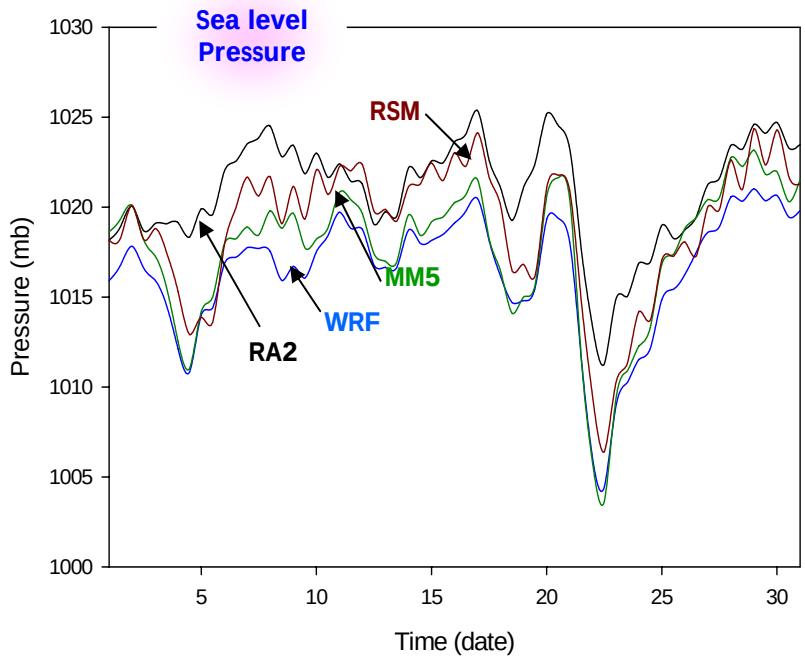
	Bias Score	Averaged Rain (mm)
WRF	3.95	130.72
MM5	4.02	133.15
RSM	3.46	118.05

Sea Level Pressure

Domain averaged over 103E-155E/20N-52.5N

✓ Time Series





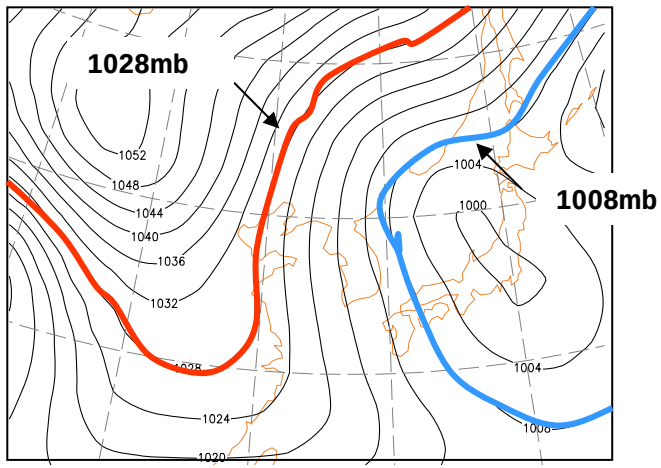
RMSE of SLP increases as forecast time increases in WRF!!

Magnitude of RMSE : WRF > MM5 > RSM

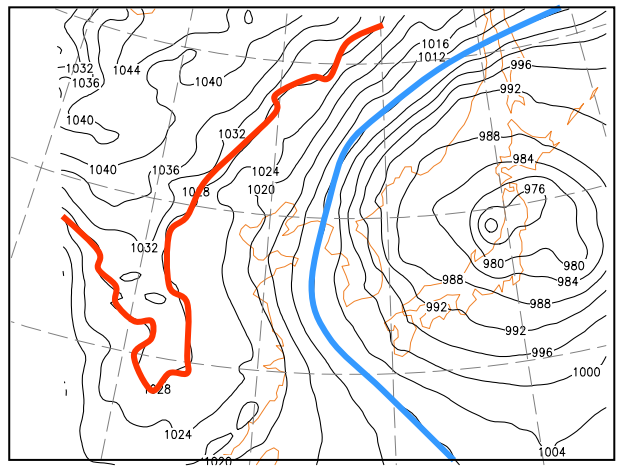
Snap Shots of Large Scale (SLP)

at 1200UTC 4 December

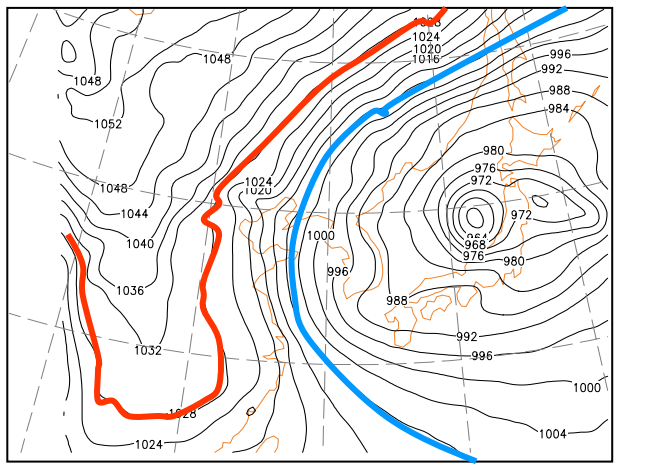
RA2



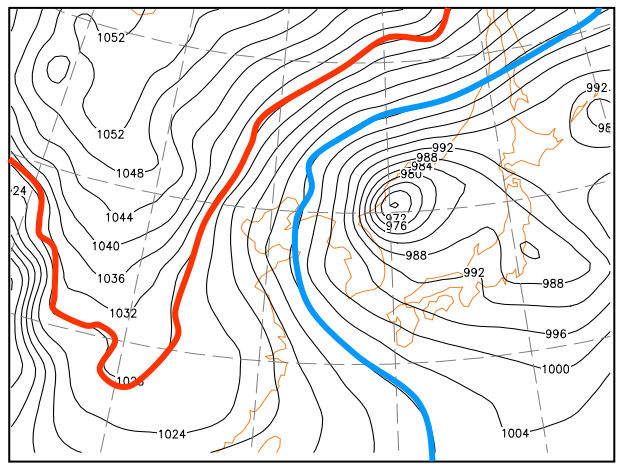
WRF



MM5



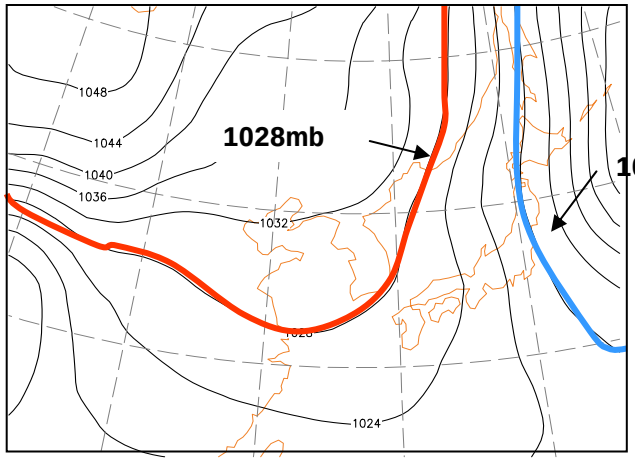
RSM



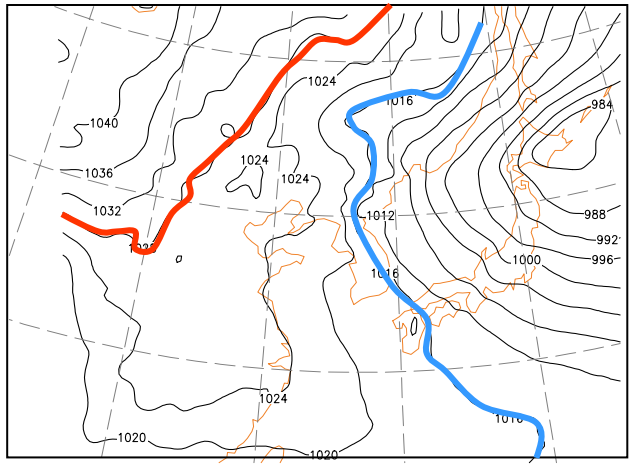
Snap Shots of Large Scale (SLP)

at 1200UTC 19 December

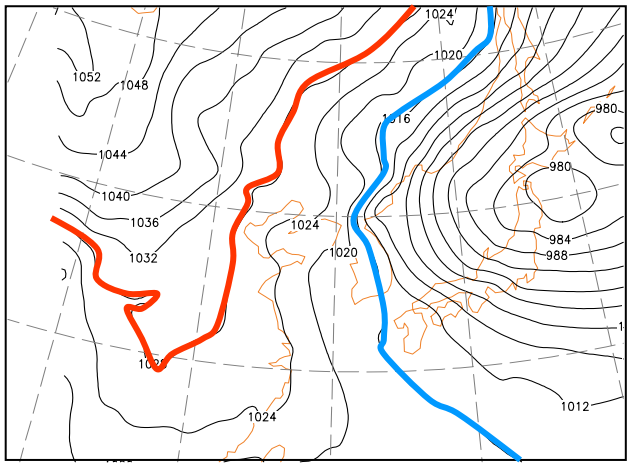
RA2



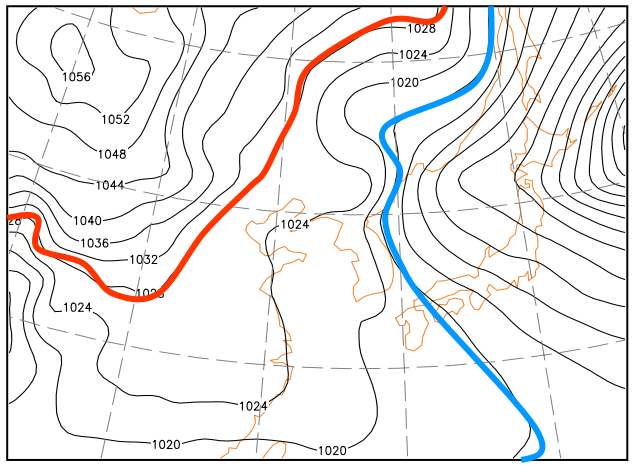
WRF



MM5



RSM



Conclusion

Regional Climate modeling study during the winter season is conducted using the WRF model.

✓ The WRF model captures the formation of the observed heavy snowfall; however, its amount was overestimated.

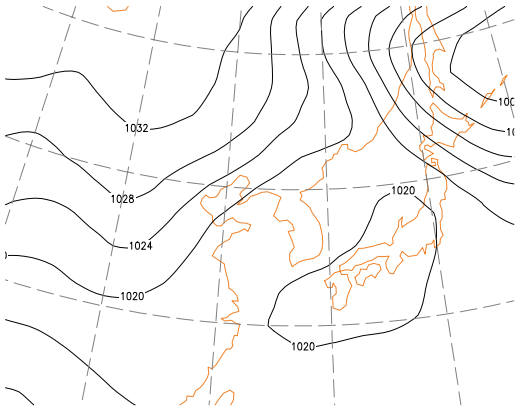
✓The abnormal warm SST over the Yellow Sea in December 2005 is responsible for the formation of extreme snowfall over Korea by about 30 %

✓The configuration of vertical layer is very important in the simulation of heavy snowfall induced by air-mass transformation

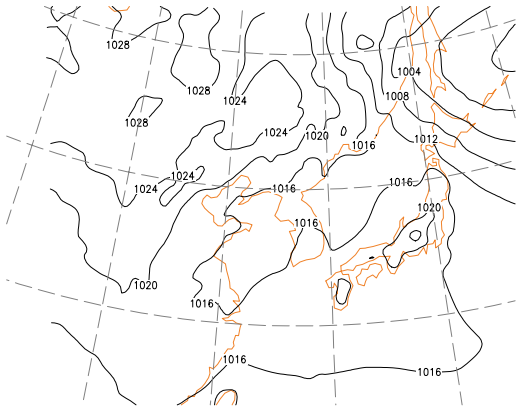
✓ The WRF may have a sort of systematic bias in the simulation of regional climate over East Asia in wintertime


Thank you

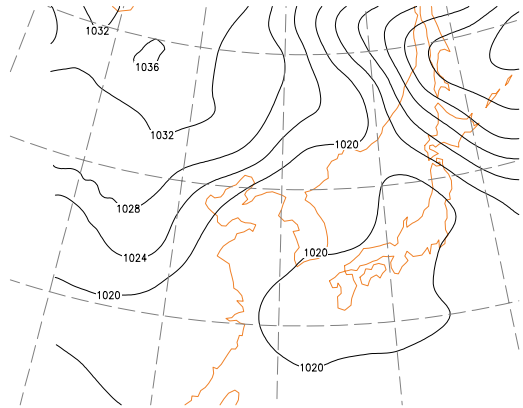
RA2



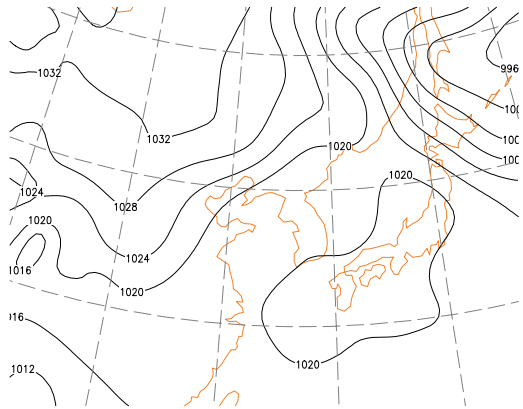
WRF



MM5

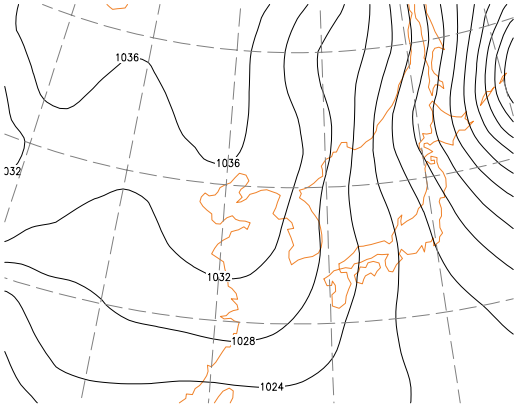


RSM

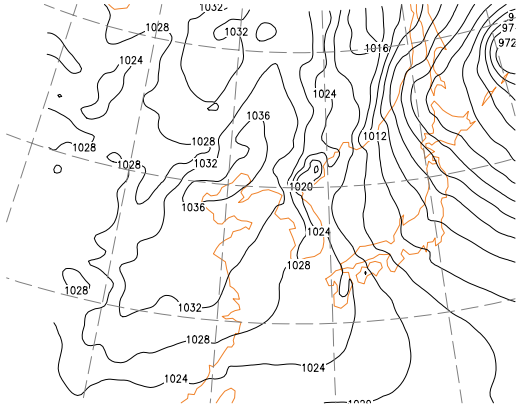


0000Z01 DEC

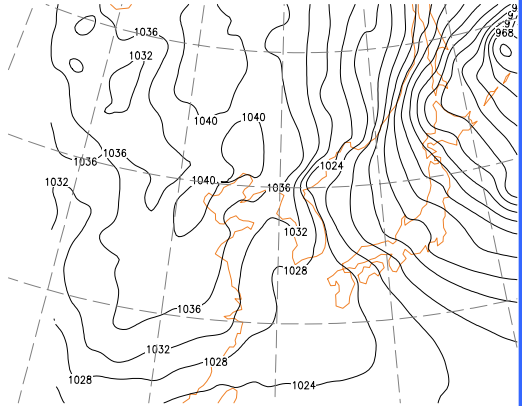
RA2



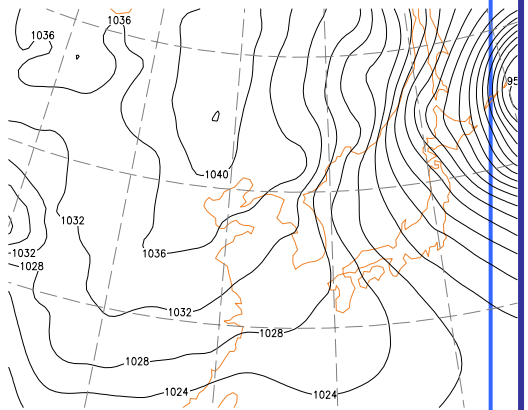
WRF



MM5



RSM



0000Z27 DEC

Korea (whole domain)

	Correlation	Bias Score	Average (mm)
OBS_23Z	0.58(0.63)	14.25(2.98)	88.16(134.8)
CLM_23Z	0.55(0.76)	11.83(2.42)	73.21(109.43)

	Correlation	Bias Score	Average (mm)	Max Preci (mm)
OBS_23Z	0.58 (0.63)	14.25 (2.98)	88.16 (134.8)	543
OBS_43Z	0.57 (0.65)	13.55 (2.99)	83.86 (135.44)	519
OBS_63Z	0.56 (0.65)	13.16 (2.92)	81.43 (132.39)	458