Evaluation of WRF for pan-Arctic Simulations

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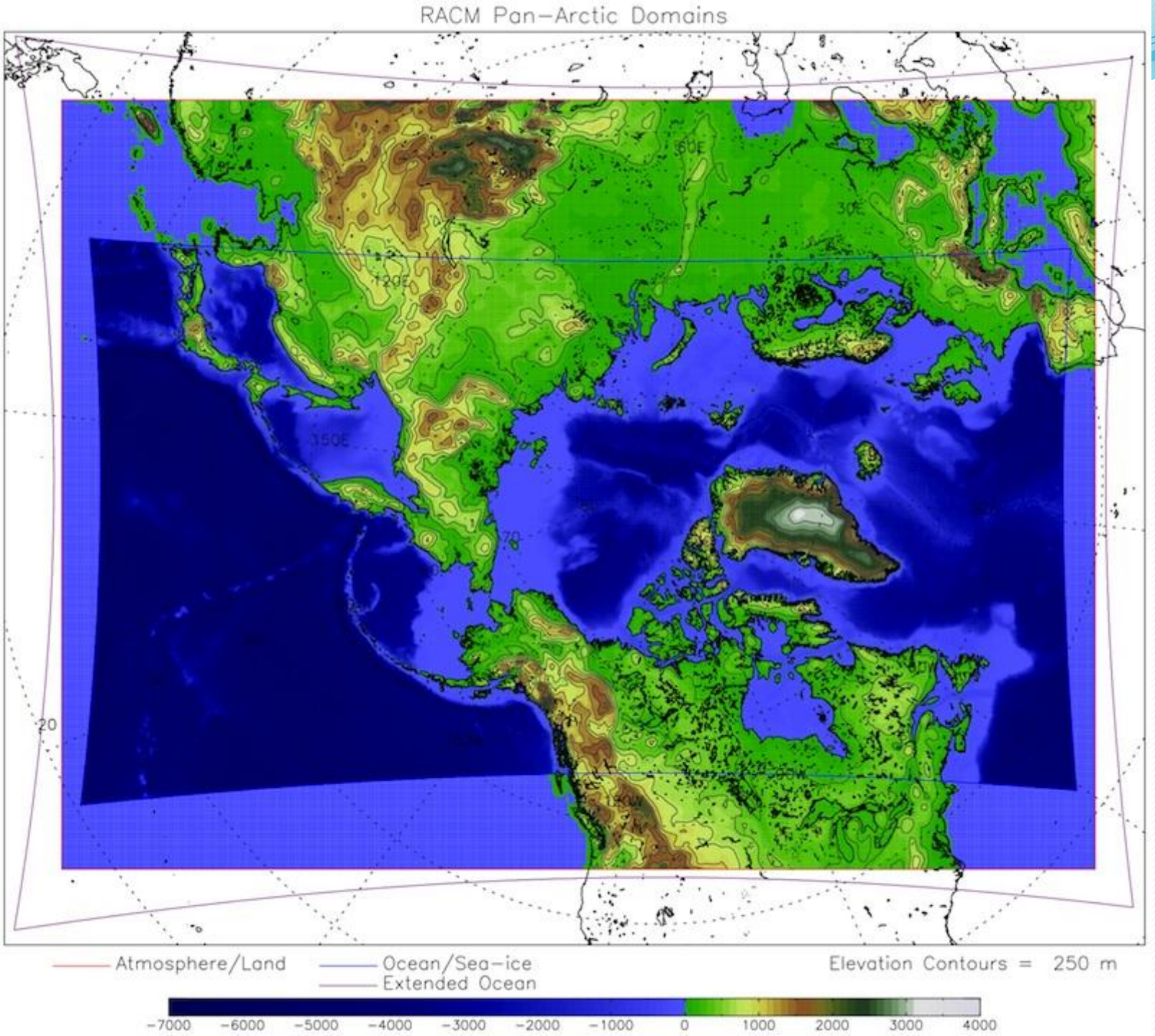
Outline

- Goal: Refine WRF model physics selection for RACM pan-Arctic simulations
  - WRF configuration and physics options
  - Statistical evaluation of WRF simulations
  - Spatial analysis of WRF simulations
    - WRF physics evaluation
    - Varied horizontal model domain
    - Use of spectral nudging

Simulation design

- Month-long simulations
  - January, April, July, and October 2007
- Perform 3 member ensemble simulations for each month
  - Model initialized 1, 15, and 29 days before start of month
- Use RACM wr50a model domain
- NCEP reanalysis data used for model ICs and LBCs
- Specify sea ice fraction from NSIDC data
- Model experiments used varied model physics
  - Radiation, clouds, boundary layer, sea ice treatment


RACM Pan-Arctic Domains
60E
30E
120E
150E
20
Atmosphere/Land
Ocean/Sea-ice
Extended Ocean
Elevation Contours = 250 m
-7000
-6000
-5000
-4000
-3000
-2000
-1000
0
1000
2000
3000
4000

WRF configuration and physics

Control experiment

WRF version	3.1.0
Longwave radiation	CAM (3)
Shortwave radiation	CAM (3)
Surface layer	Monin-Obukhov (Janic ETA) (2)
Boundary layer	MYJ TKE (2)
Cloud microphysics	Goddard GCE scheme (7)
Cumulus clouds	Grell-Devenyi (3)
Land surface	Noah LSM (2)
Fractional sea ice	Specified fractional sea ice extent for all ocean grid points

Model Experiments

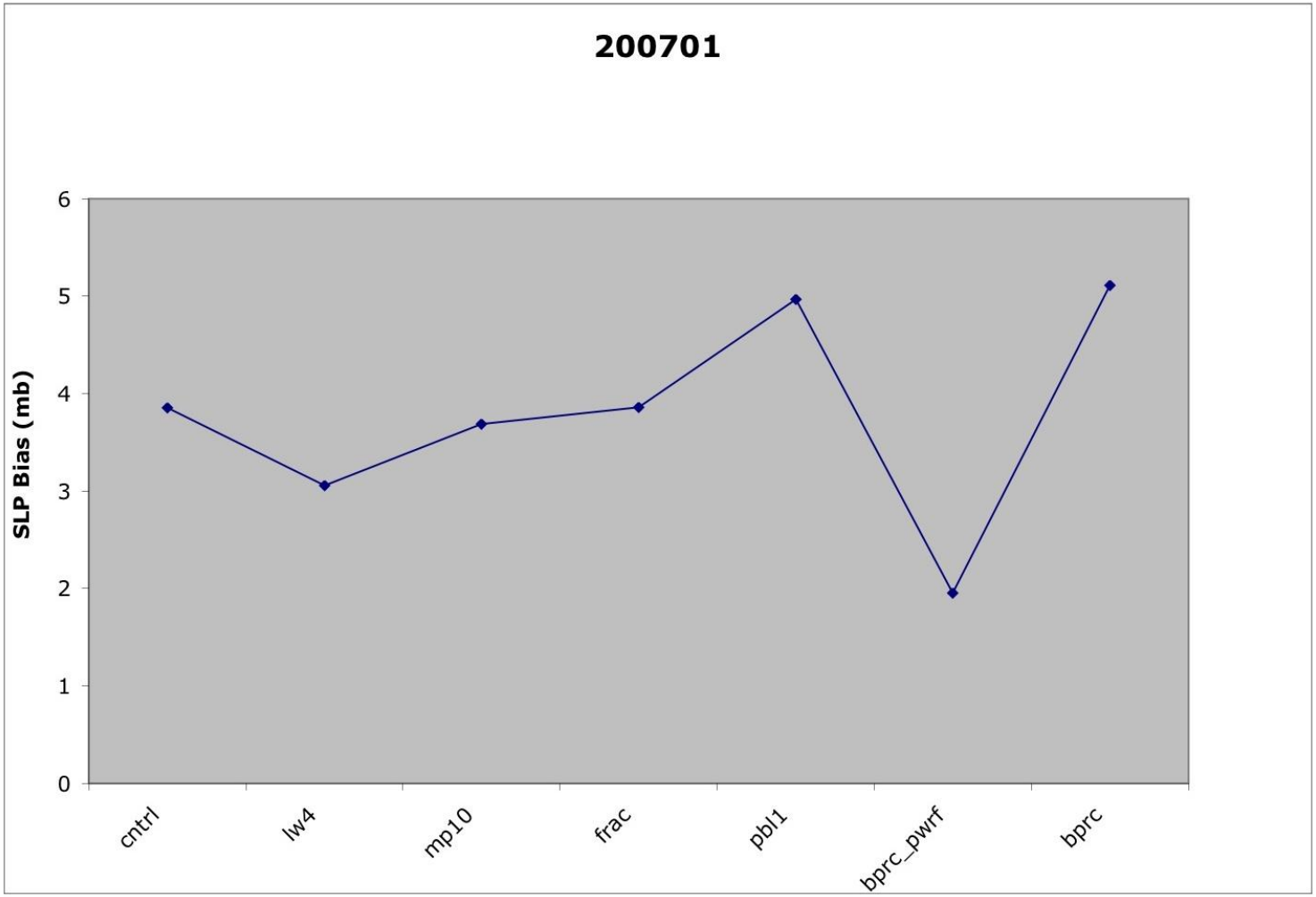
Experiment Name	WRF options (differences from cntrl)
cntrl	None
lw4	RRTM-G LW (4) and SW (4)
pbl1	Monin-Obukhov SL (1) and YSU PBL (1)
mp10	Morrison 2-moment microphysics (10)
frac	No fractional sea ice
bprc	RRTM LW, Goddard SW, and Morrison microphysics
bprc-pwrf	Same as BPRC, except use Polar WRF 3.1.1
sfdda_rmp_wv2	Same as lw4 except uses spectral nudging four-dimensional data assimilation for wave numbers 1 and 2 to nudge model simulation towards driving data for top 20 of 40 model levels.

Polar WRF v.3.1.1 includes modification of land surface properties, assumes constant snow depth of 5 cm on sea ice, and sea ice thickness of 3 m

Statistical evaluation

- All results presented are for average of 3 members of each model experiment ensemble
- Calculate domain wide statistics (excluding 5 grid points adjacent to lateral boundaries) between WRF and NCEP reanalysis
- Statistics: Bias, MAE, RMSE, and correlation
- Variables: SLP, Z500, Z300, T2m, and precipitation
- Subjectively rank each model experiment for each variable, statistic, and month (group rank)

Subjective Ranking Procedure

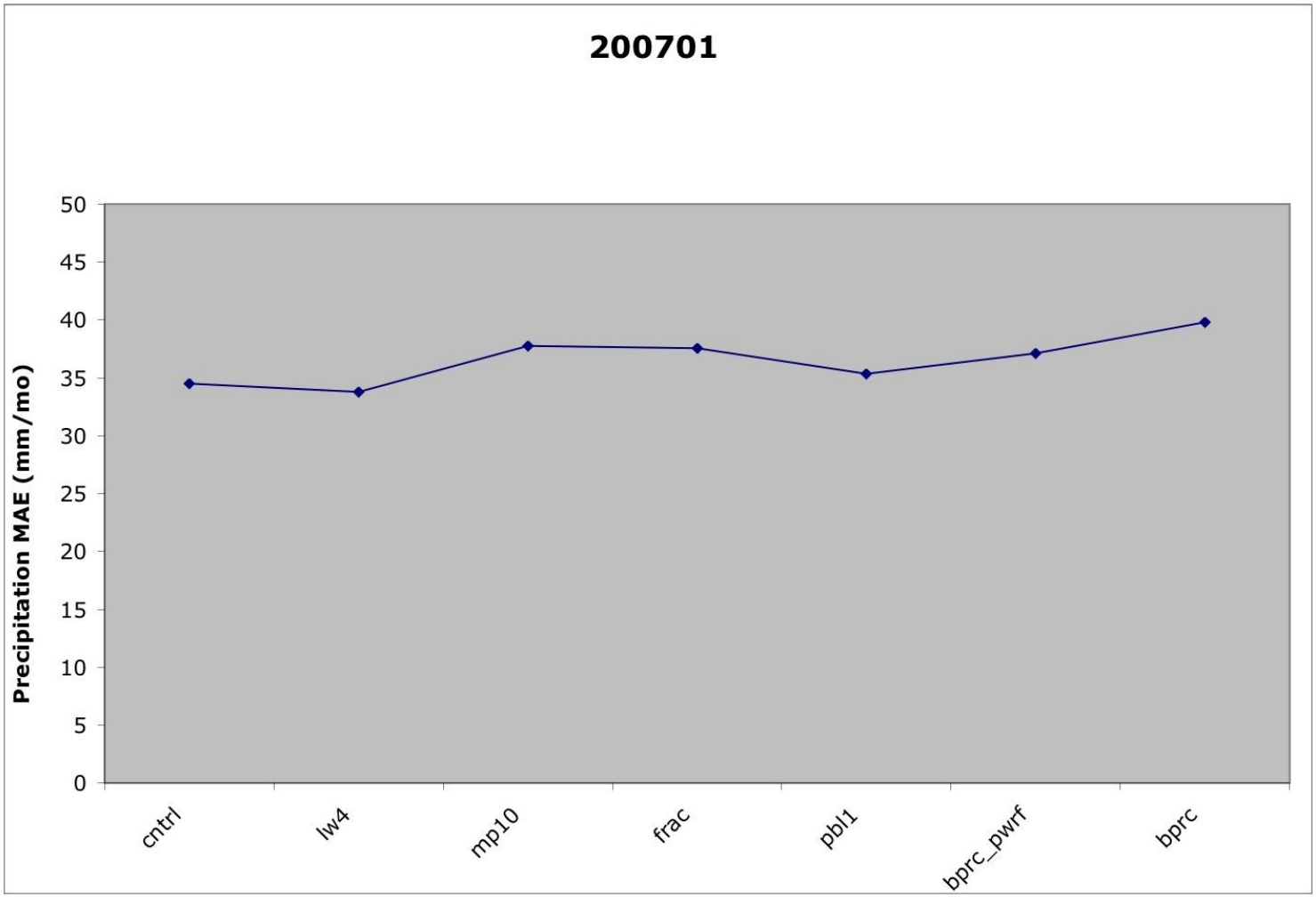


1: bprc-pwrf

2: lw4, mp10, frac, and cntrl

3: pbl, bprc

Subjective Ranking Procedure



All simulations are ranked equally in this case

Statistical Evaluation

- Average group ranks of all statistics (bias, MAE, RMSE, and correlation) for each variable and month
- Calculate average circulation group rank from SLP, Z500, and Z300 group ranks
- Calculate average group rank for all variables (Circulation, T2m, and precipitation)

Group ranks: January 2007

Experiment	Circulation rank	Experiment	All rank
lw4	1.30	lw4	1.52
mp10	1.39	mp10	1.64
cntrl	1.47	bprc-pwrf	1.67
bprc-pwrf	2.00	cntrl	1.68
frac	2.55	pbl	1.91
pbl	2.72	bprc	2.04
bprc	3.11	frac	2.43

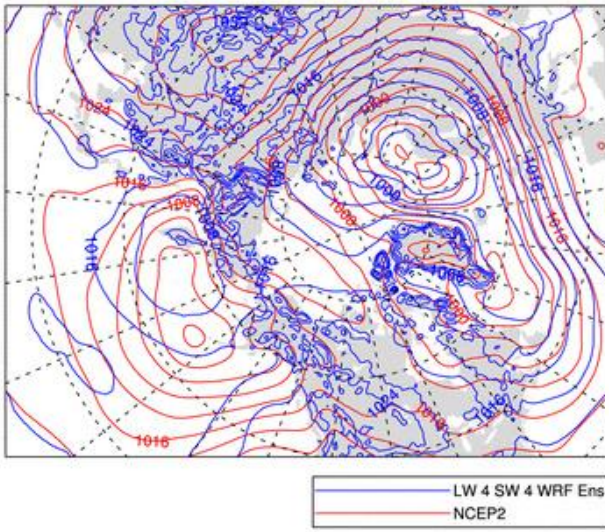
Group ranks: July 2007

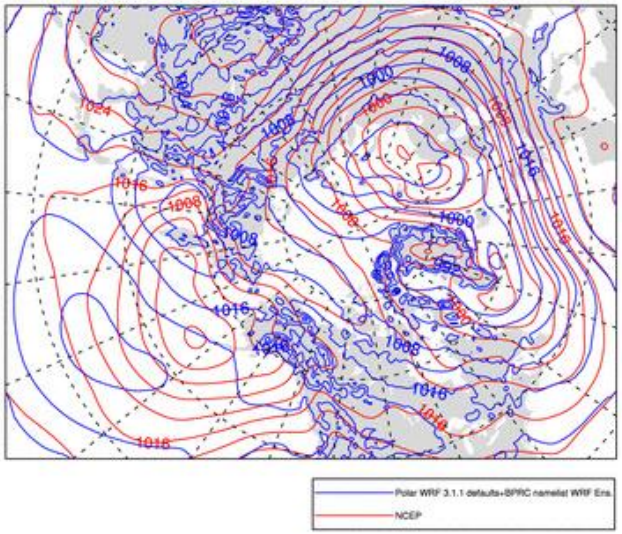
Experiment	Circulation rank	Experiment	All rank
lw4	1.33	bprc-pwrf	1.23
bprc-pwrf	1.44	lw4	1.47
pbl	2.22	bprc	1.92
frac	2.22	pbl	2.10
bprc	2.50	frac	2.16
cntrl	2.81	cntrl	2.52
mp10	3.14	mp10	2.80

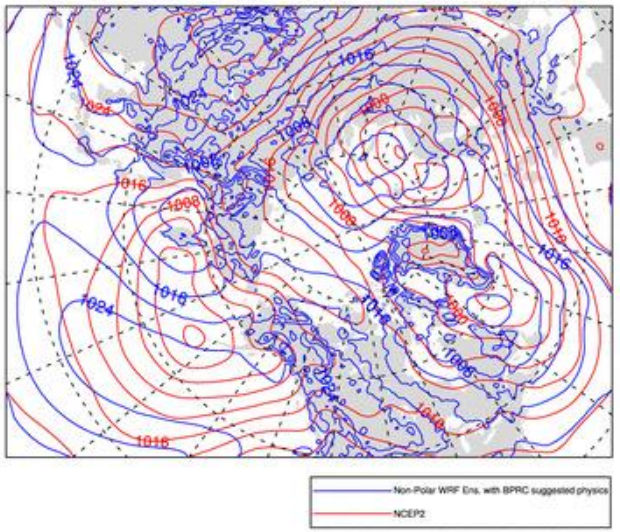
Statistical Evaluation: Summary

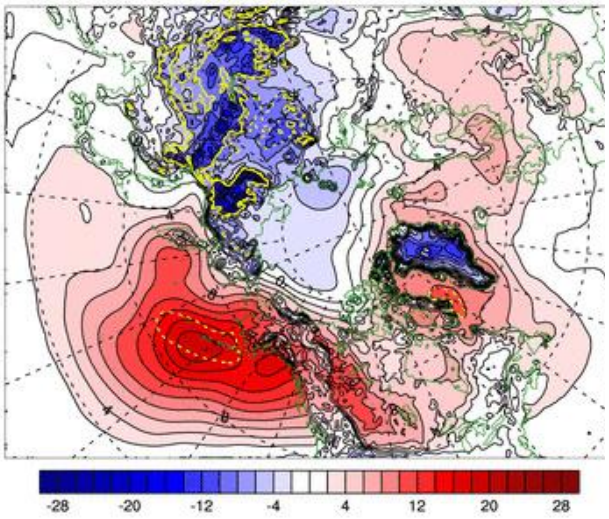
- The lw4 and bprc-pwrf simulations consistently ranked highest
- The mp10, frac, and cntrl experiments consistently ranked lowest

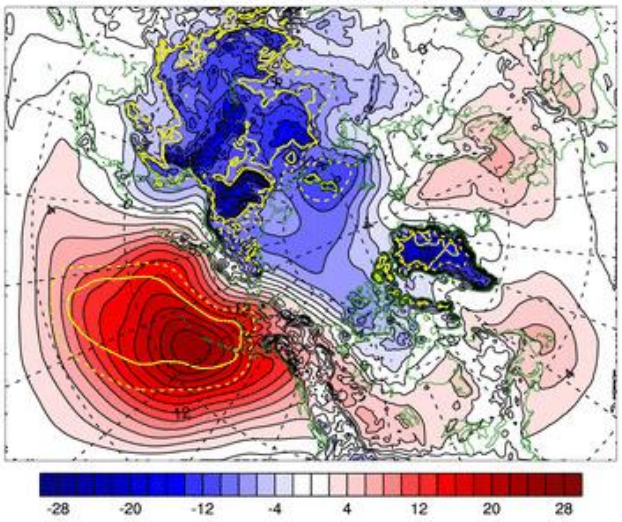
Spatial analysis: SLP Jan 2007

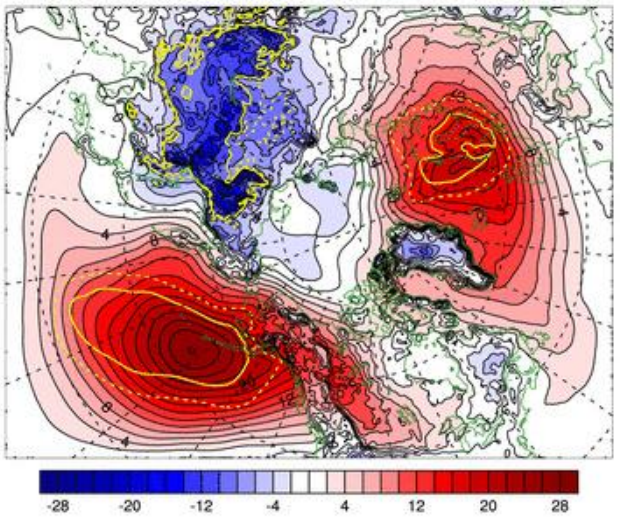


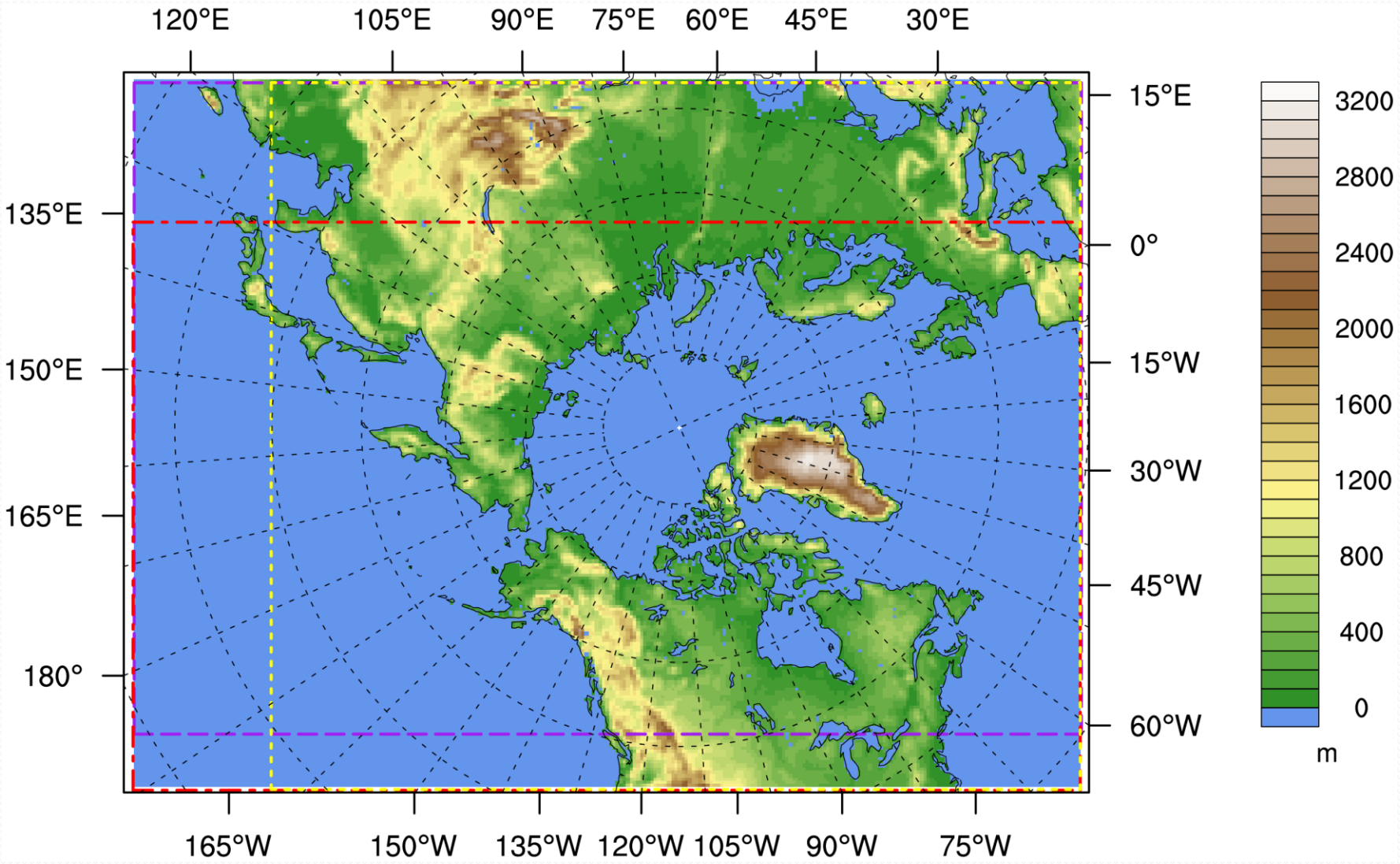




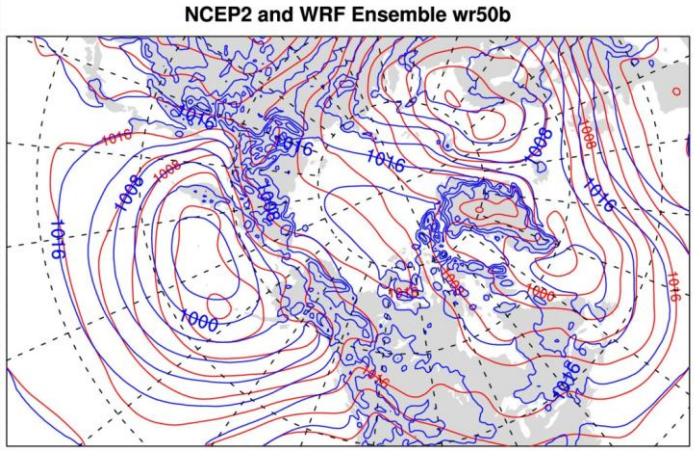


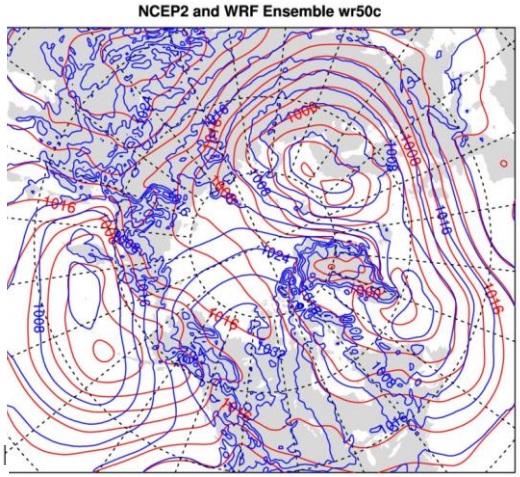


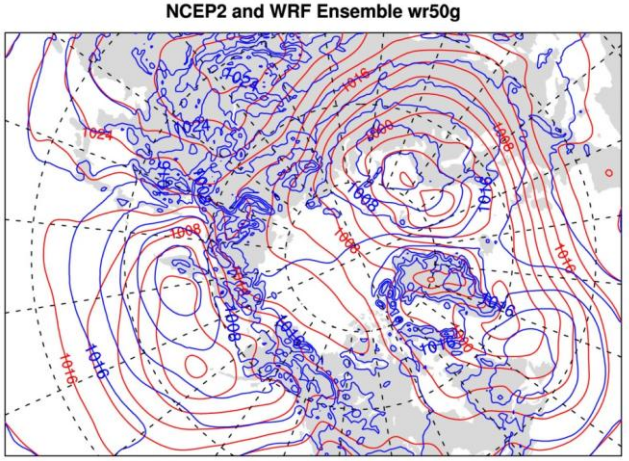


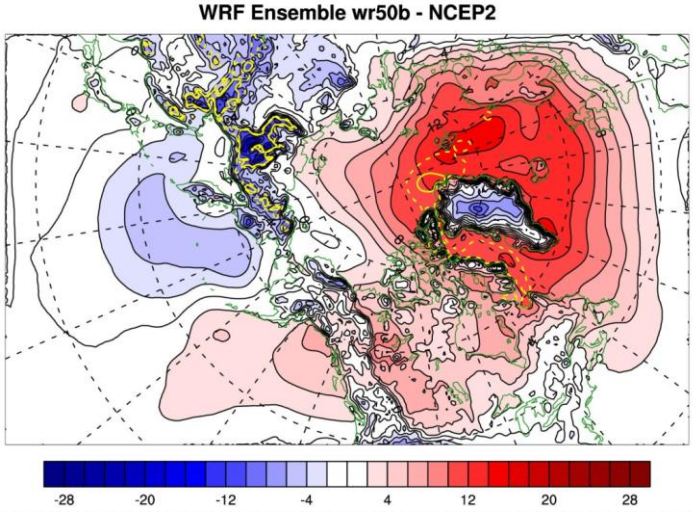

120°E
105°E
90°E
75°E
60°E
45°E
30°E
15°E
0°
15°W
30°W
45°W
60°W
135°E
150°E
165°E
180°
165°W
150°W
135°W
120°W
105°W
90°W
75°W
3200
2800
2400
2000
1600
1200
800
400
0
m

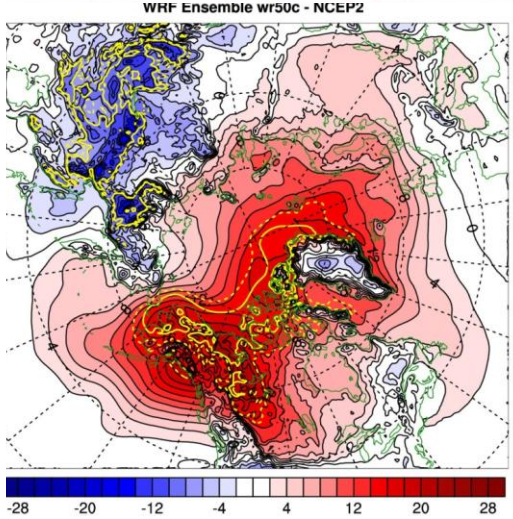
Spatial analysis: SLP Jan 2007

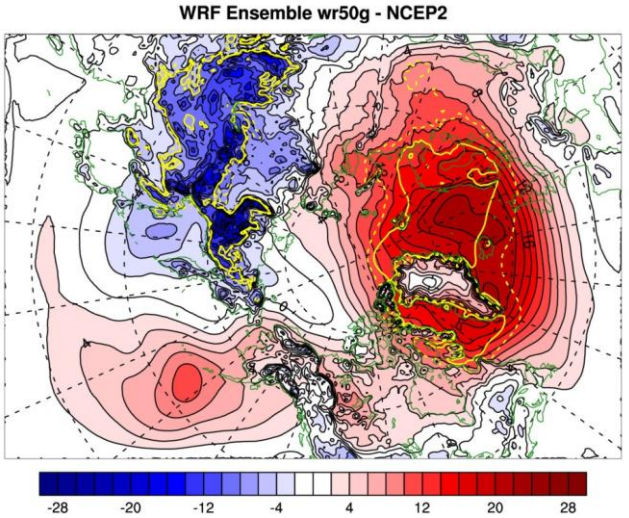




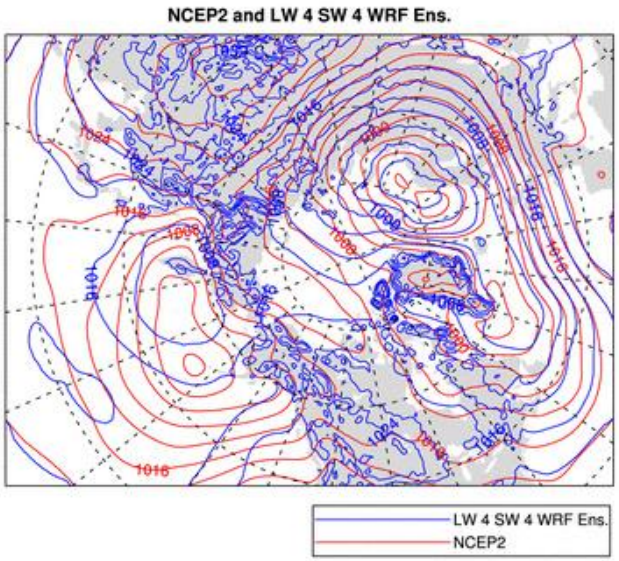


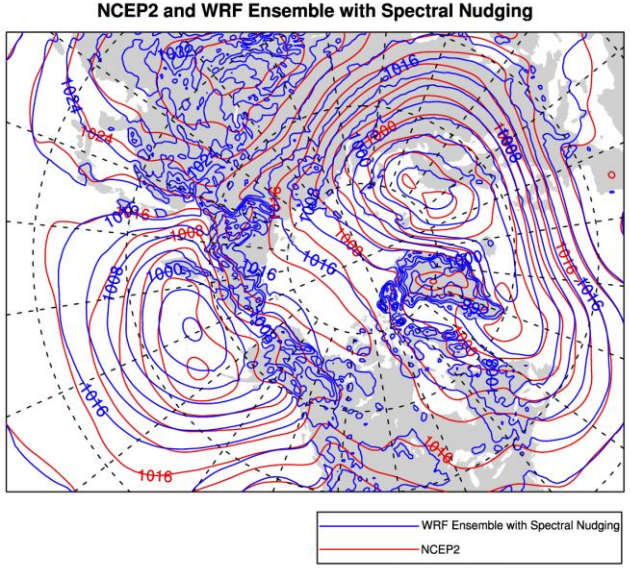


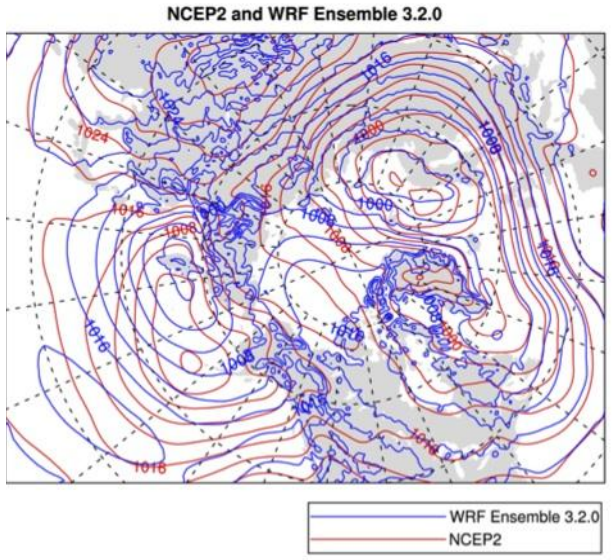


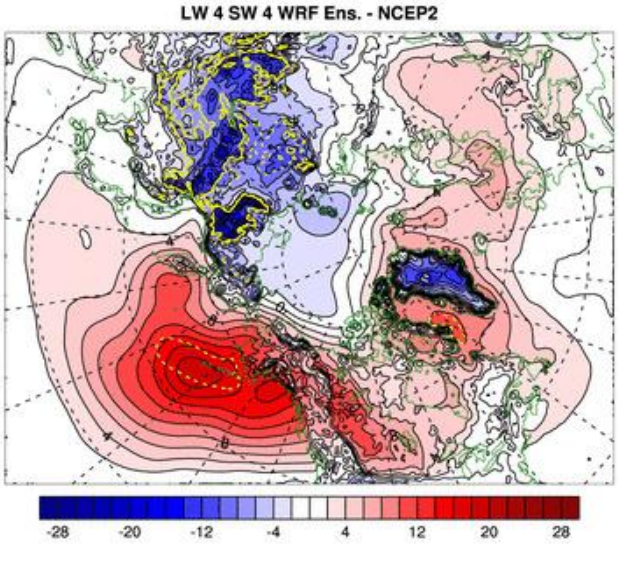


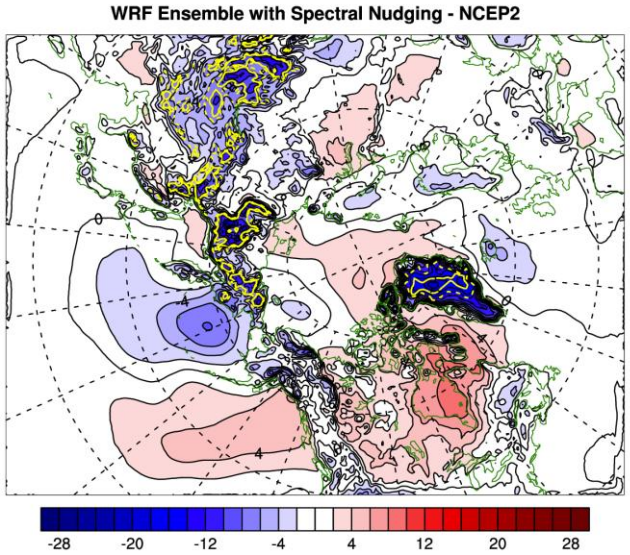
Spatial analysis: SLP Jan 2007

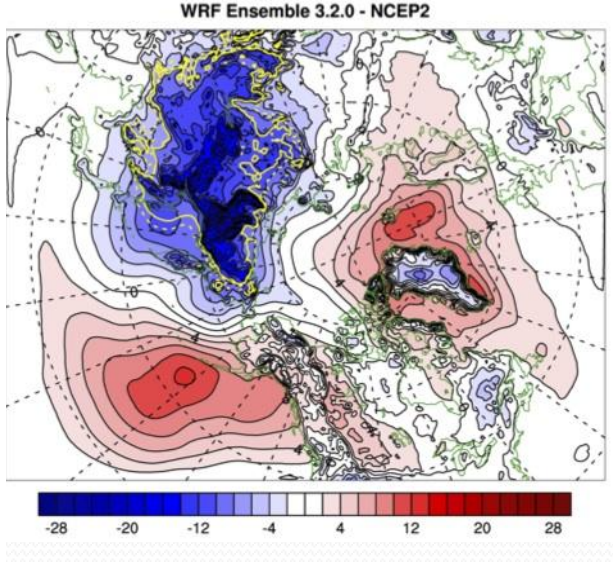












Conclusions

- Large error in circulation in N. Pacific is most striking feature of the simulations
- Changes in model domain size did not reduce this error
- Use of spectral nudging (wave numbers 1 and 2) at the top of the model domain significantly reduced all model errors
- Circulation error was also found to be reduced in WRF v3.2