
Radiance Assimilation over Northern High Latitude Regions

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(NCAR/MMM)

Acknowledgements:
Collaborators from Ohio State University

Outline

- Background: Arctic System Reanalysis (ASR) Project
- Preliminary Results from 2 test periods
- Summary and future work

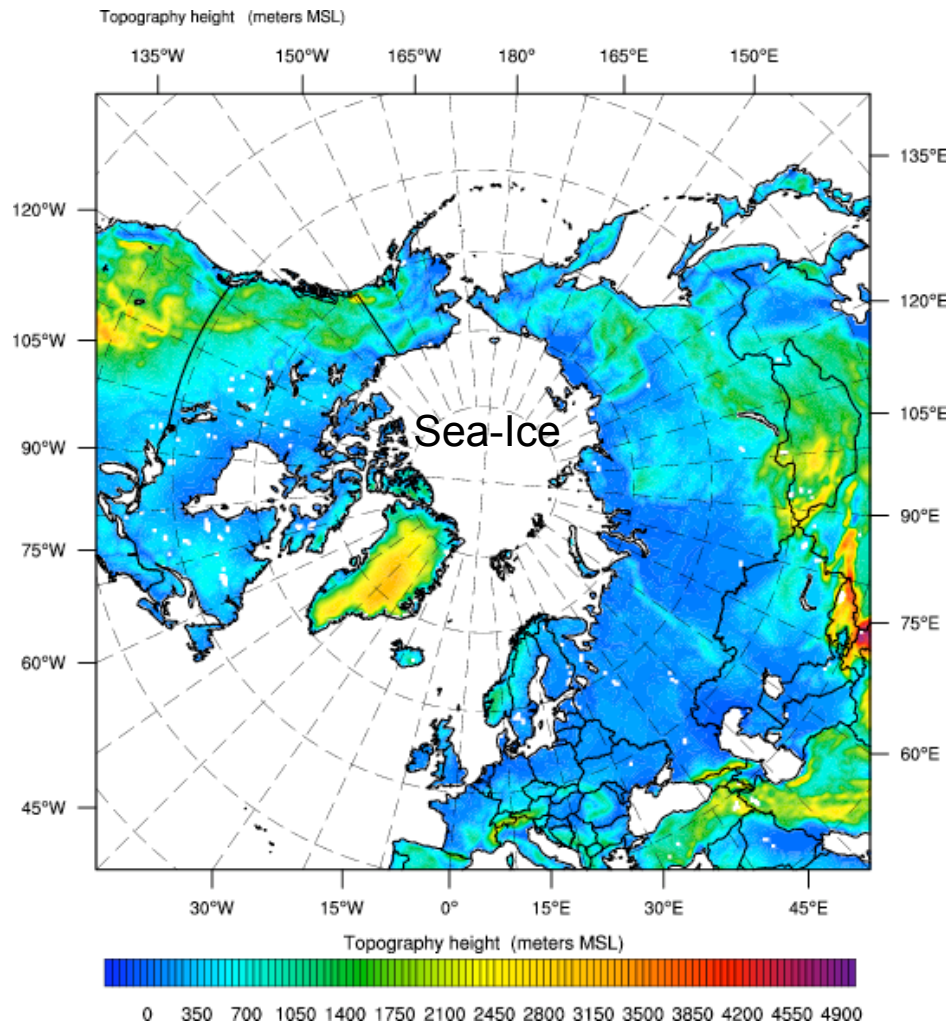
Background

- Arctic System Reanalysis (ASR) project
 - Funded by US NSF
 - University efforts: OSU, NCAR, UIUC, CU
 - 11 years reanalysis: 2000~2010
 - Currently testing for 30km, may go up to 10km?
 - NCEP provided conventional and radiance data.
- Testing/Tuning the system for 2 months
 - Dec. 2007: use NCEP FNL (1°X1°, P levels) as LBC
 - Aug. 2008: use ERA-Interim (80X80km, model level) as LBC

WRFDA-3DVAR

- WRFDA includes 3D/4DVAR and Hybrid VAR/Ensemble scheme
- 3DVAR is adopted for ASR for computational efficiency
 - 3-hr cycling regional DA, time window: ± 1.5 h
- Control variables: stream function, unbalanced velocity potential, unbalanced T, pseudo RH, unbalanced Ps.
- NMC method to generate background error covariance statistics.
 - Domain-averaged statistics.
- Recursive filter in horizontal, EOF in vertical for covariance modeling.

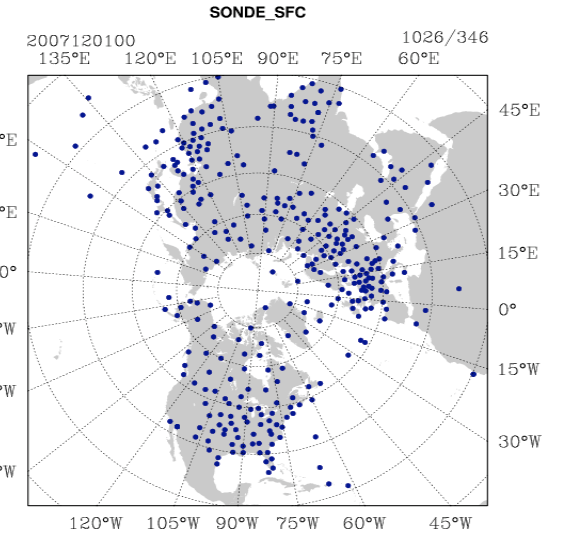
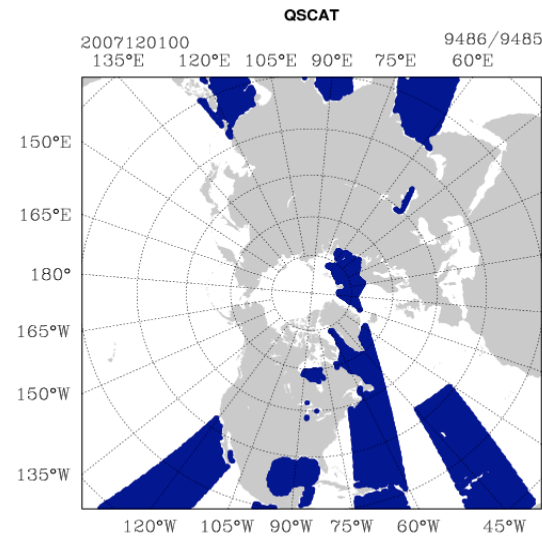
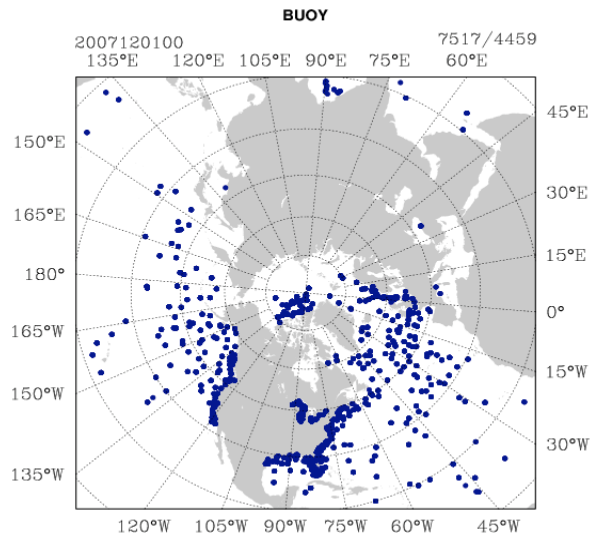
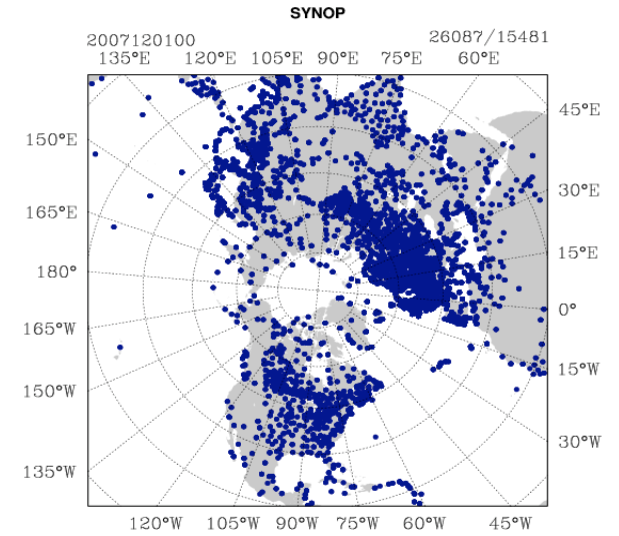
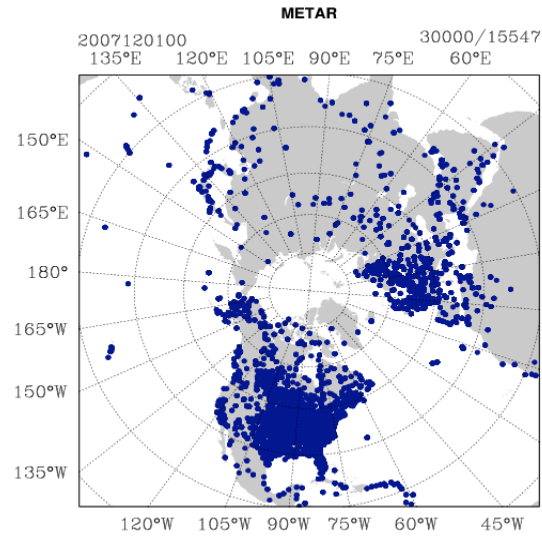
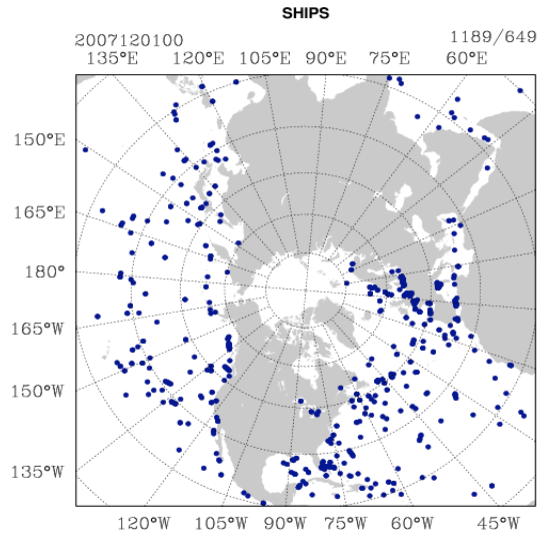
ASR domain

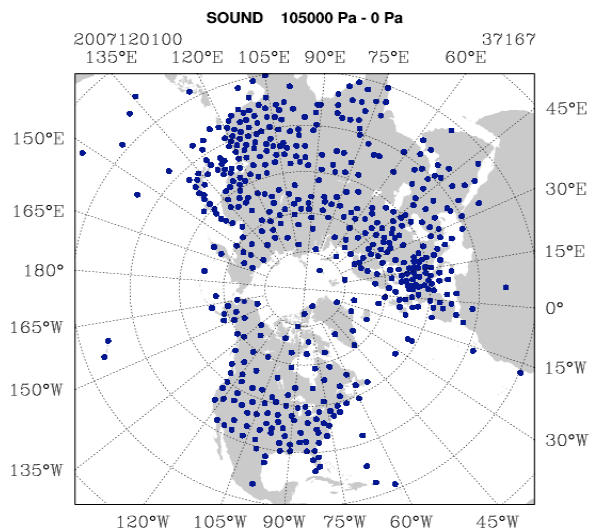
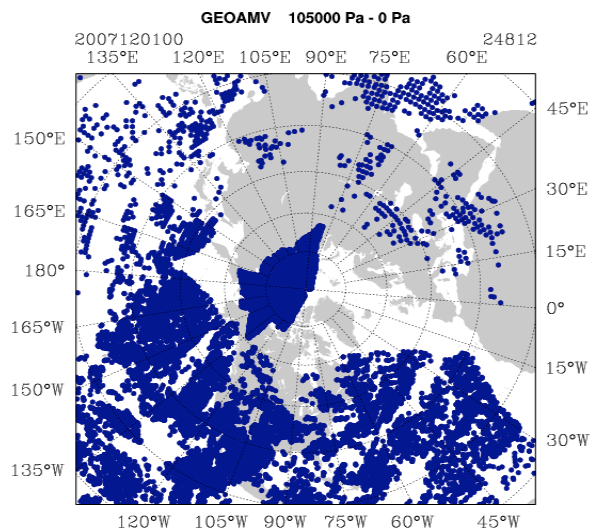
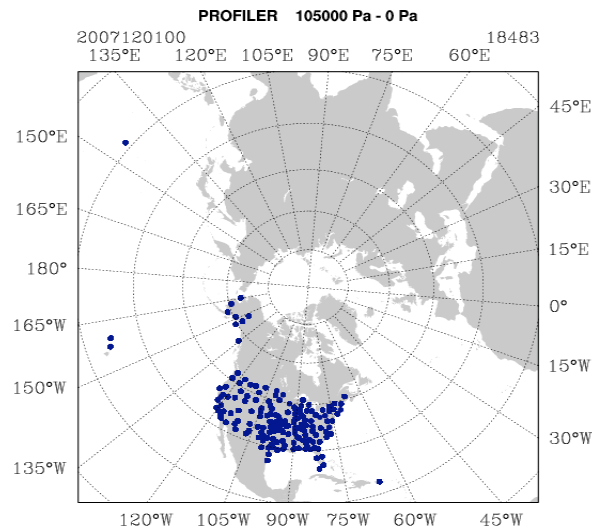
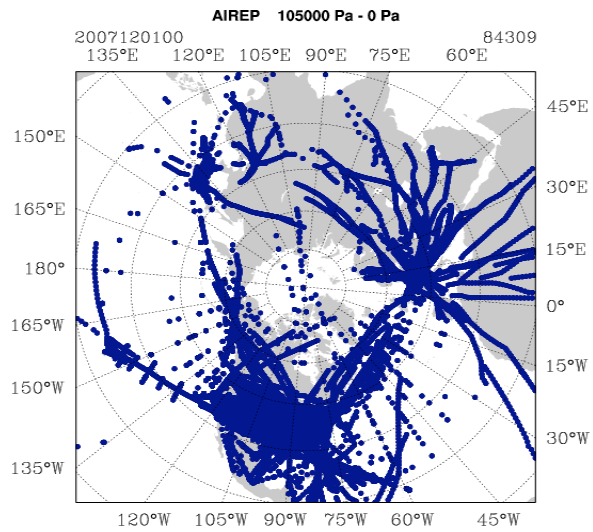


WRF model version 3.1:
30km*30km (360*360),
70 Levels (Top@10hPa)
40m-50m vertical spacing in PBL

DFI, GWD, fractional sea-ice
WSM5 MP, new Grell,
MYNN2.5 PBL, sw/lw RRTMG,
Noah LSM.

NCEP PREPBUFR data (2007120100, +/-3h time window)



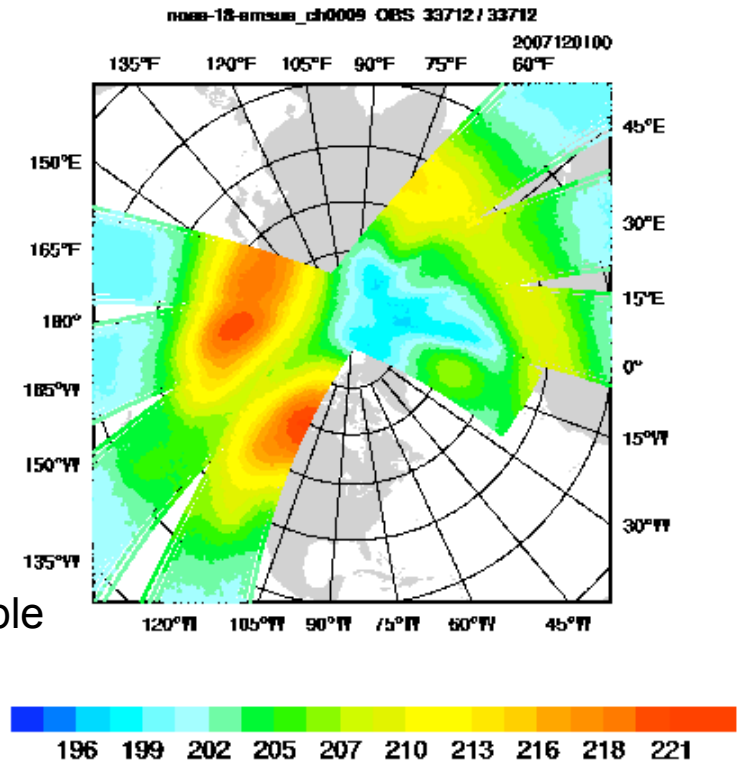


GPSRO data caused large cold biases near model top due to bad quality control (data above 30km not rejected).

Will re-include in future exps. with refined QC.

Radiance data used

| | amsua | amsub | mhs |
|---------|-------------|-------|-------|
| Noaa-15 | 4,5,6,7,8,9 | 3,5 | |
| Noaa-16 | 4,5,6,7,8 | 3,4,5 | |
| Noaa-17 | | 3,4,5 | |
| Noaa-18 | 4,5,6,7,8 | | 3,4,5 |
| Metop-2 | 4,5,6,8,9 | | 3,4,5 |
| Aqua | 4,5,6,8,9 | | |



Follow NCEP provided instrument/Channel availability table
AMSU-A ch4 only over sea
Thinning to 90km.
CRTM, Variational Bias Correction

AIRS new cloud detection scheme was found instable.
May include it in future runs.

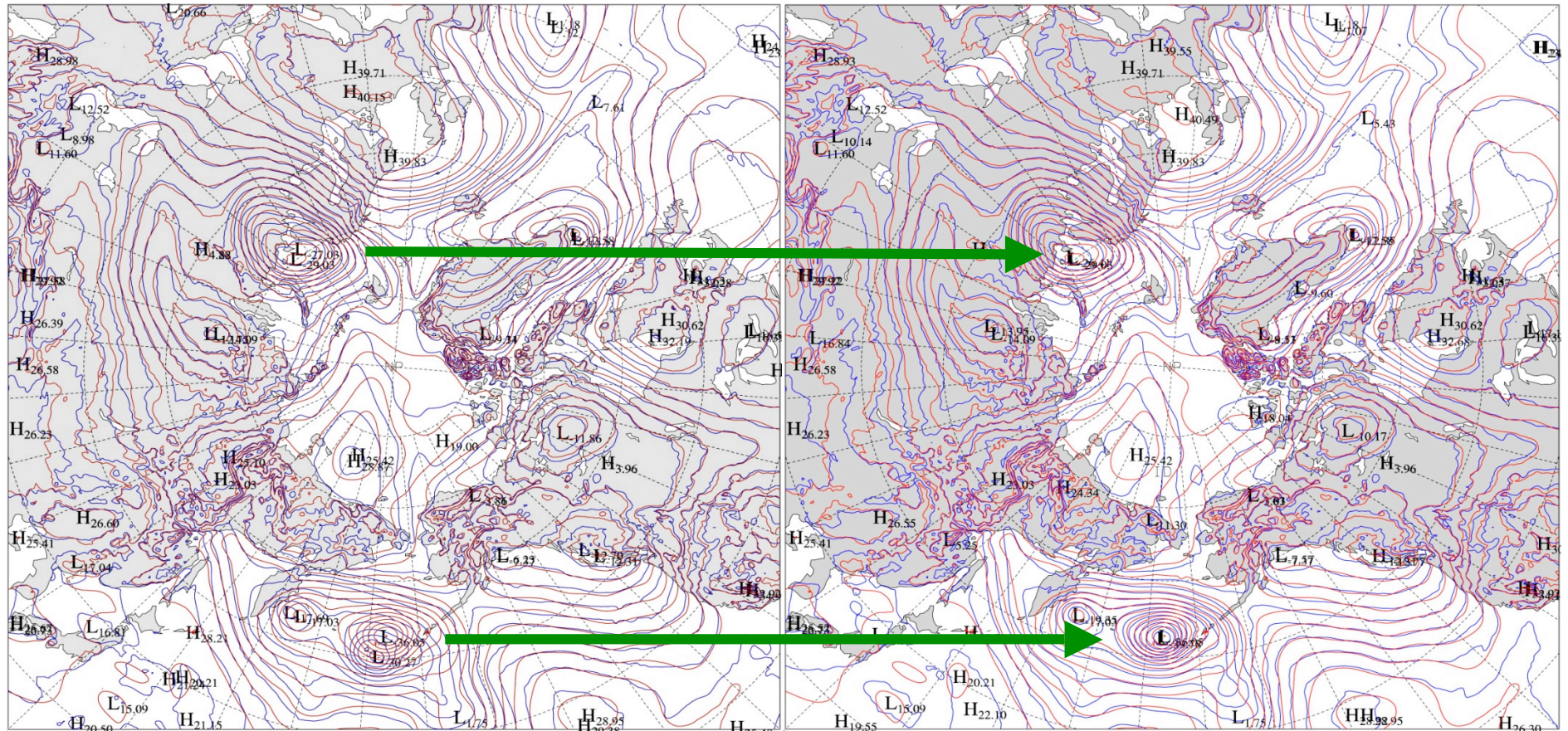
Results from Dec. 2007

NCEP FNL as LBC

Radiances better positioning Low Pressure centers

W/O Radiances

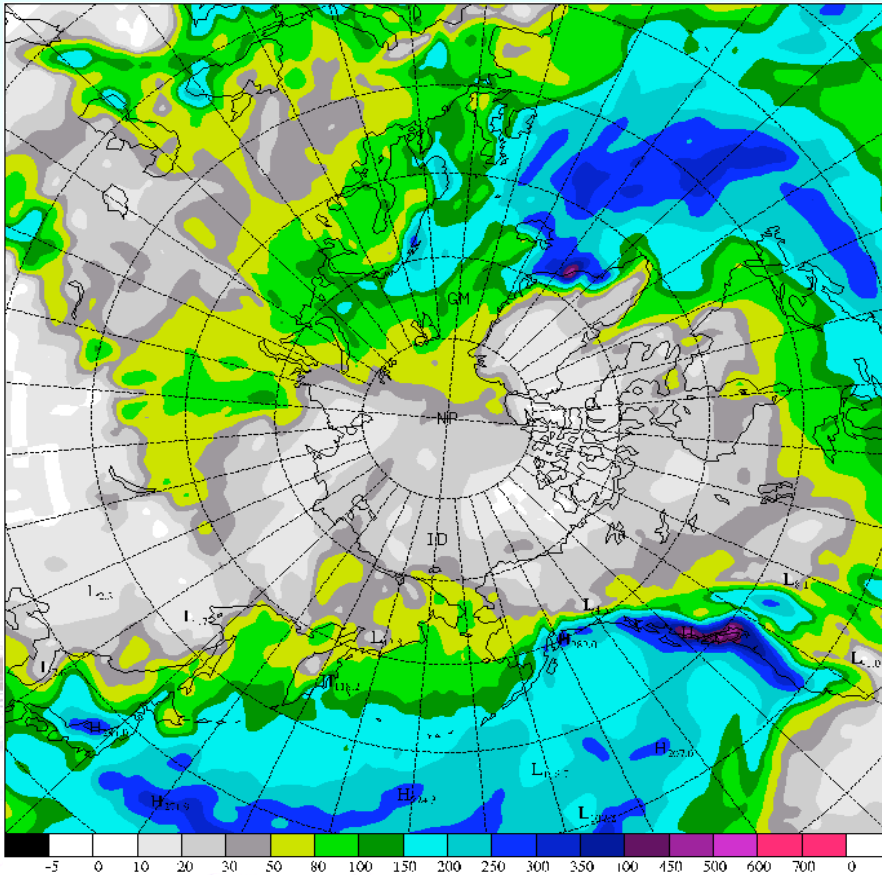
With Radiances



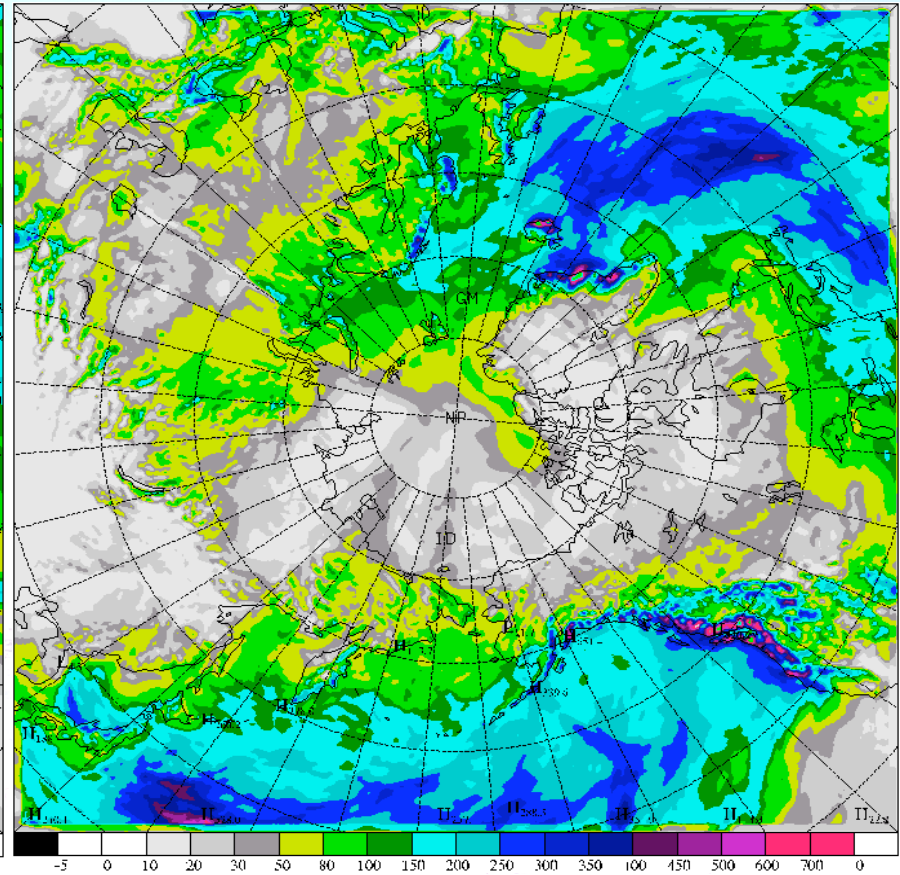
ASR(blue) v. FNL(red): P'@model level-1 @day-20 in Dec. 2007

Precipitation (Monthly total in Dec 2007)

(Unit: mm)



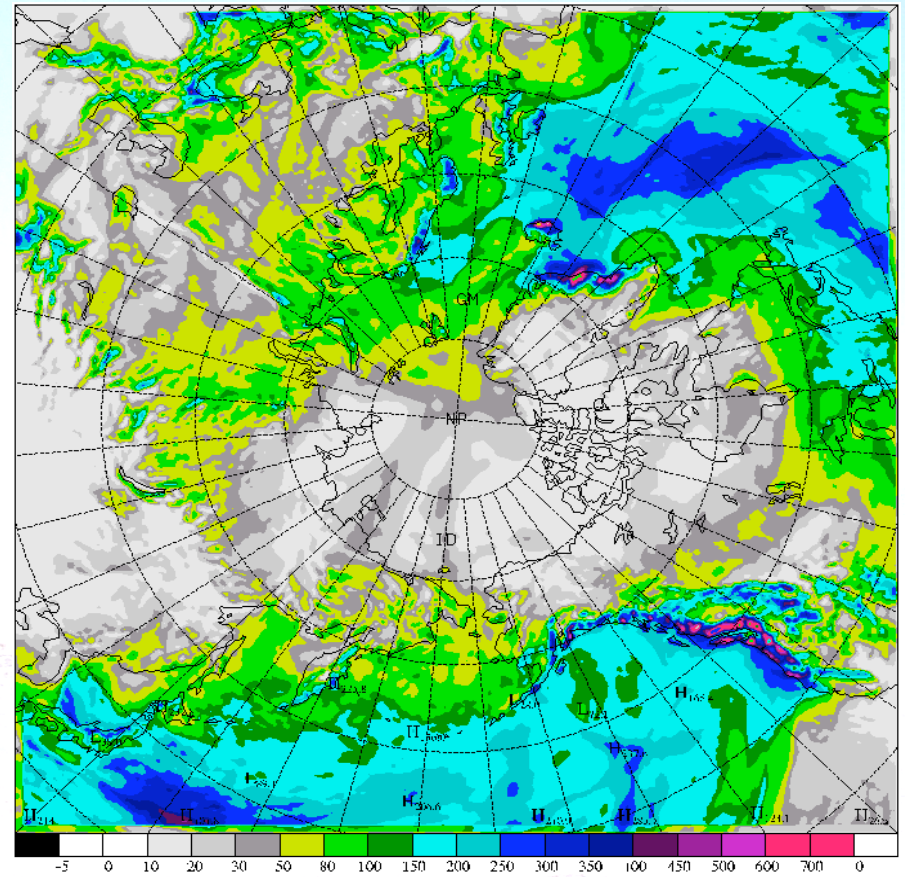
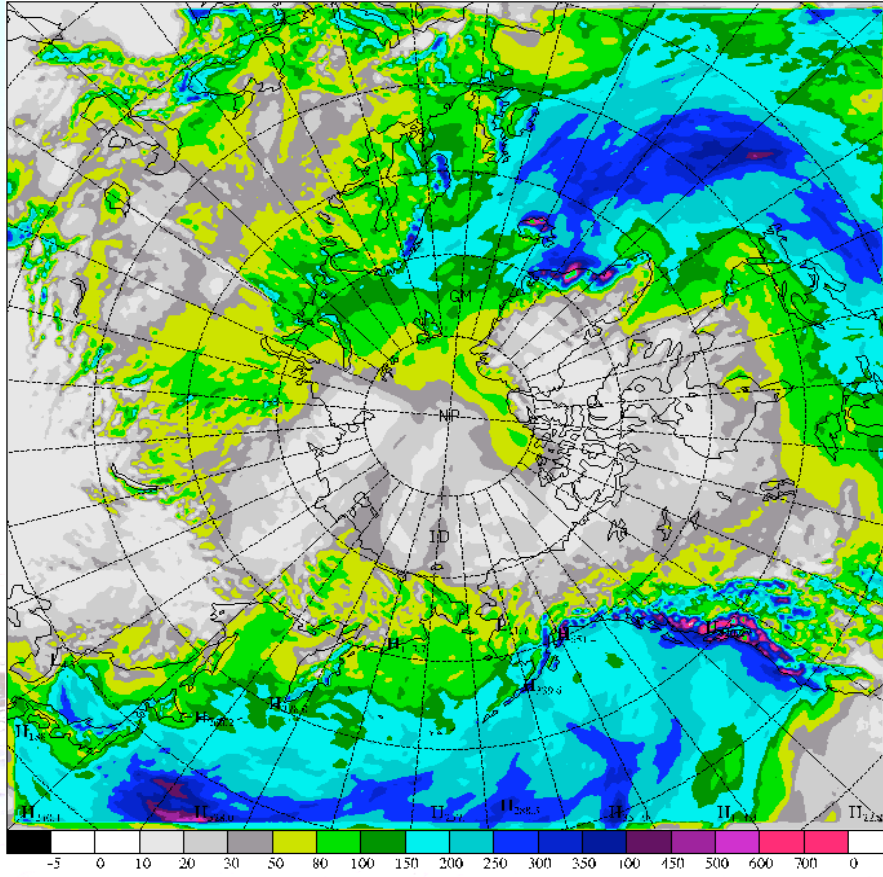
ERA-Interim



ASR with Radiances

Precipitation (Monthly total in Dec 2007)

(Unit: mm)



ASR with Radiances

ASR w/o Radiances

Results from Aug. 2008

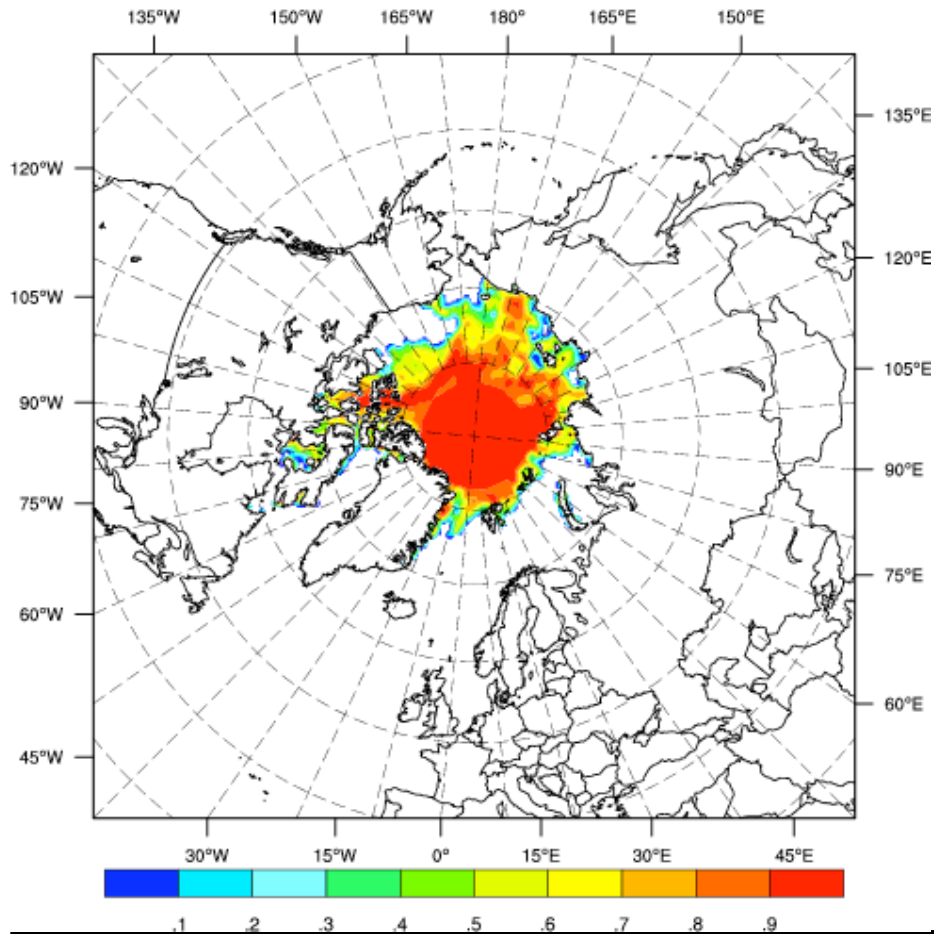
ERA-Interim as LBC

ERA-Interim Fractional Sea-Ice

Beginning of August

SEAICE at 2008-08-01_12:00:00

ASR min: 0.0202278 max: 1

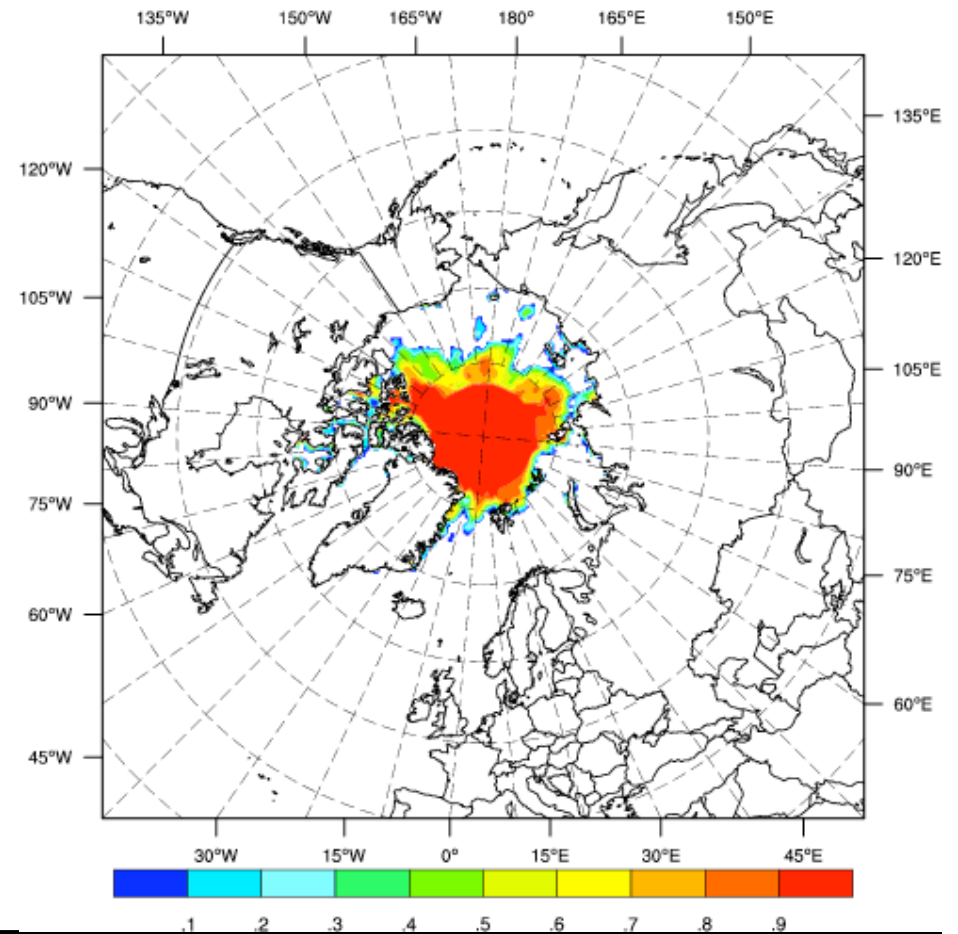


4/19/2010

End of August

SEAICE at 2008-08-31_12:00:00

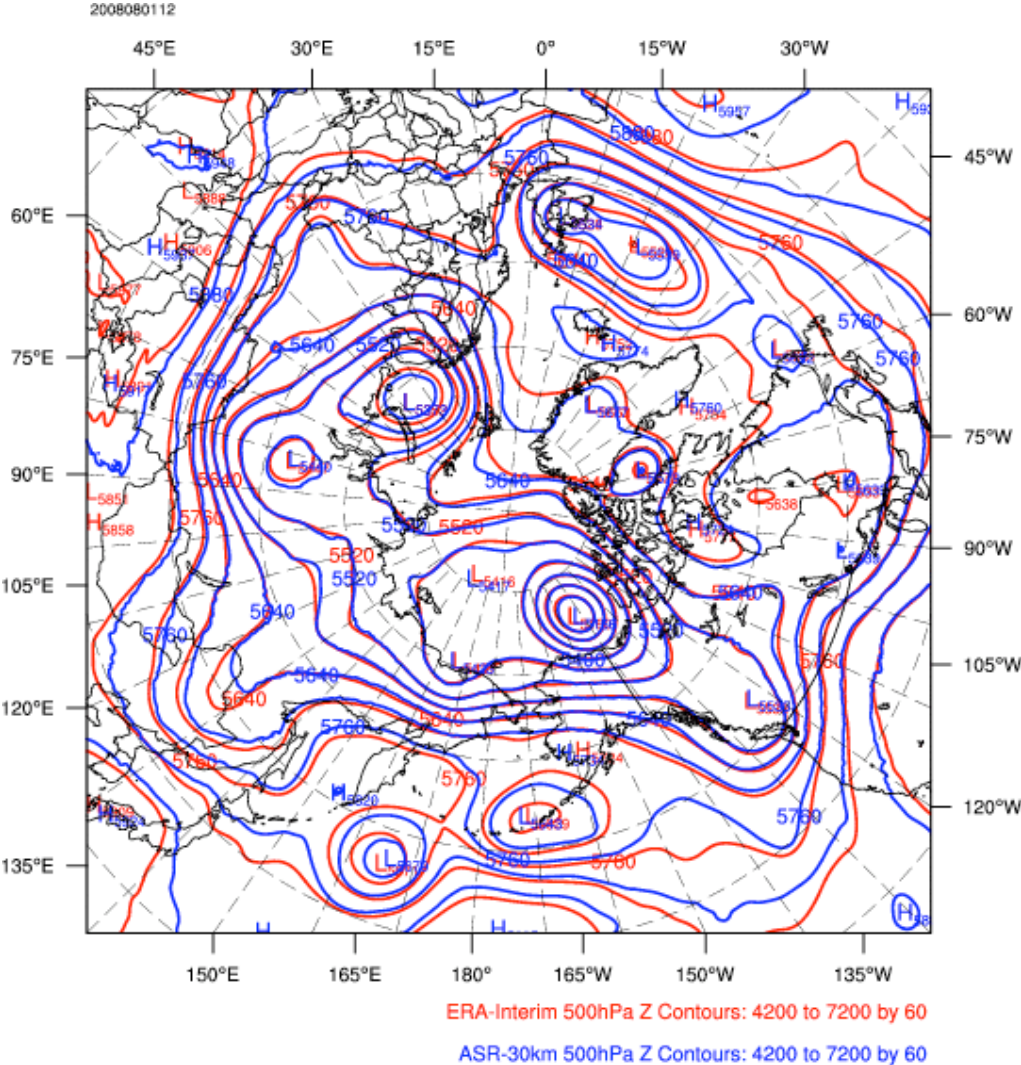
ERA min: 0.020004 max: 1



ITSC-17, Monterey

14

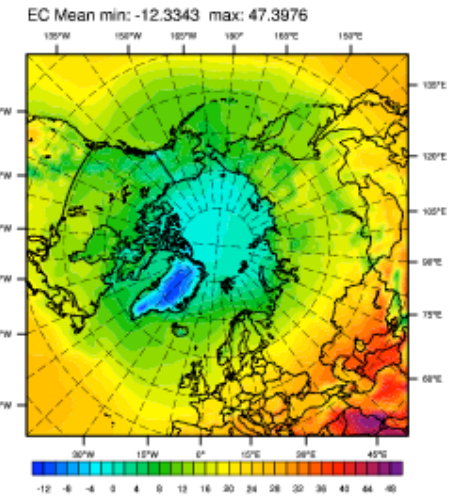
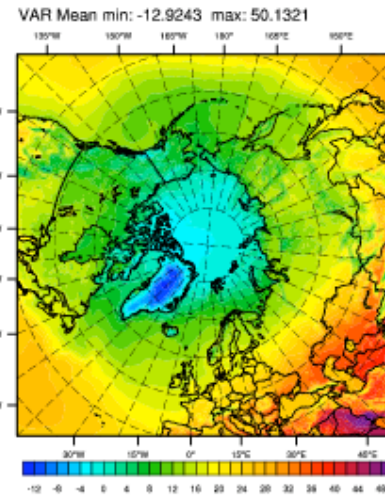
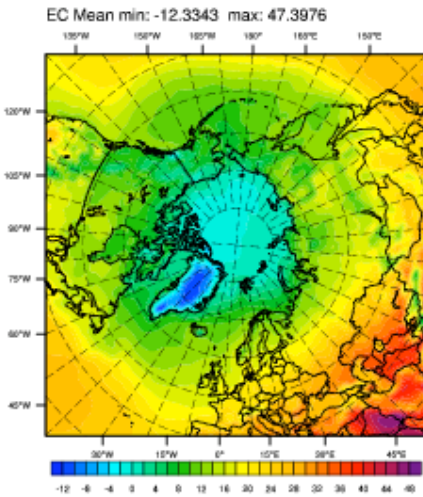
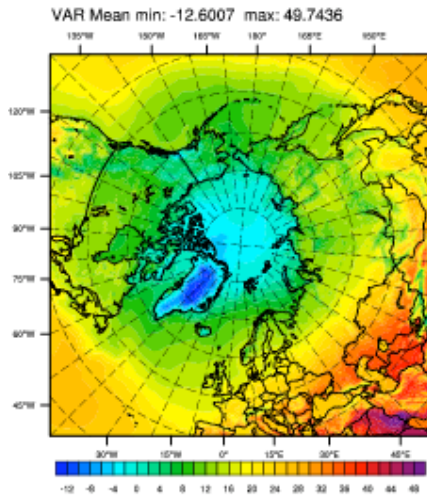
500hPa Height Analyses



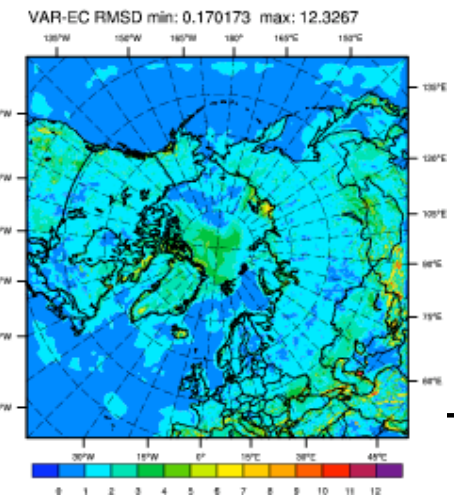
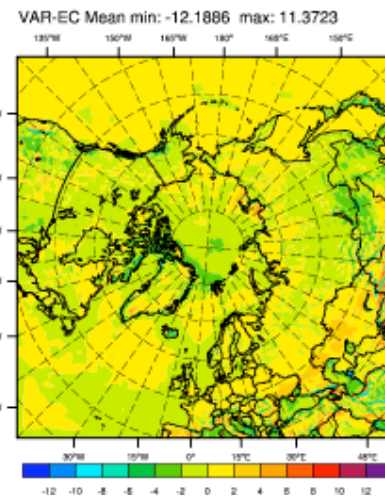
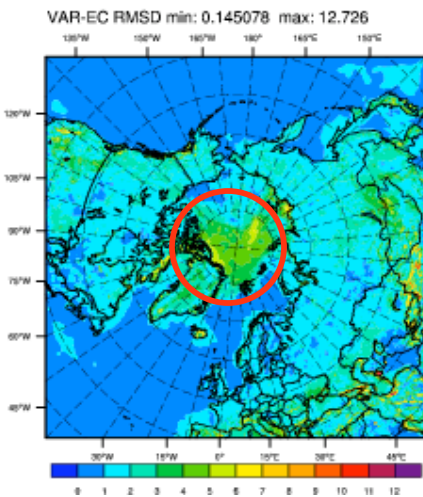
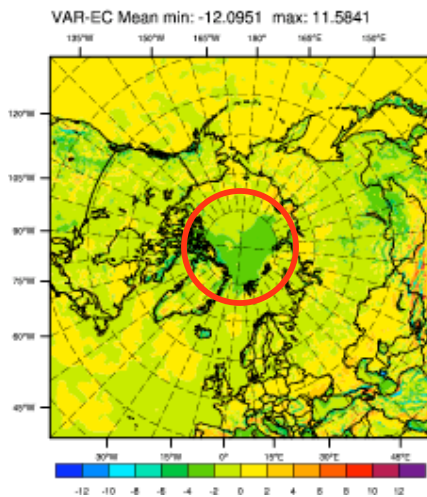
Monthly Mean T2m

W/O Radiances

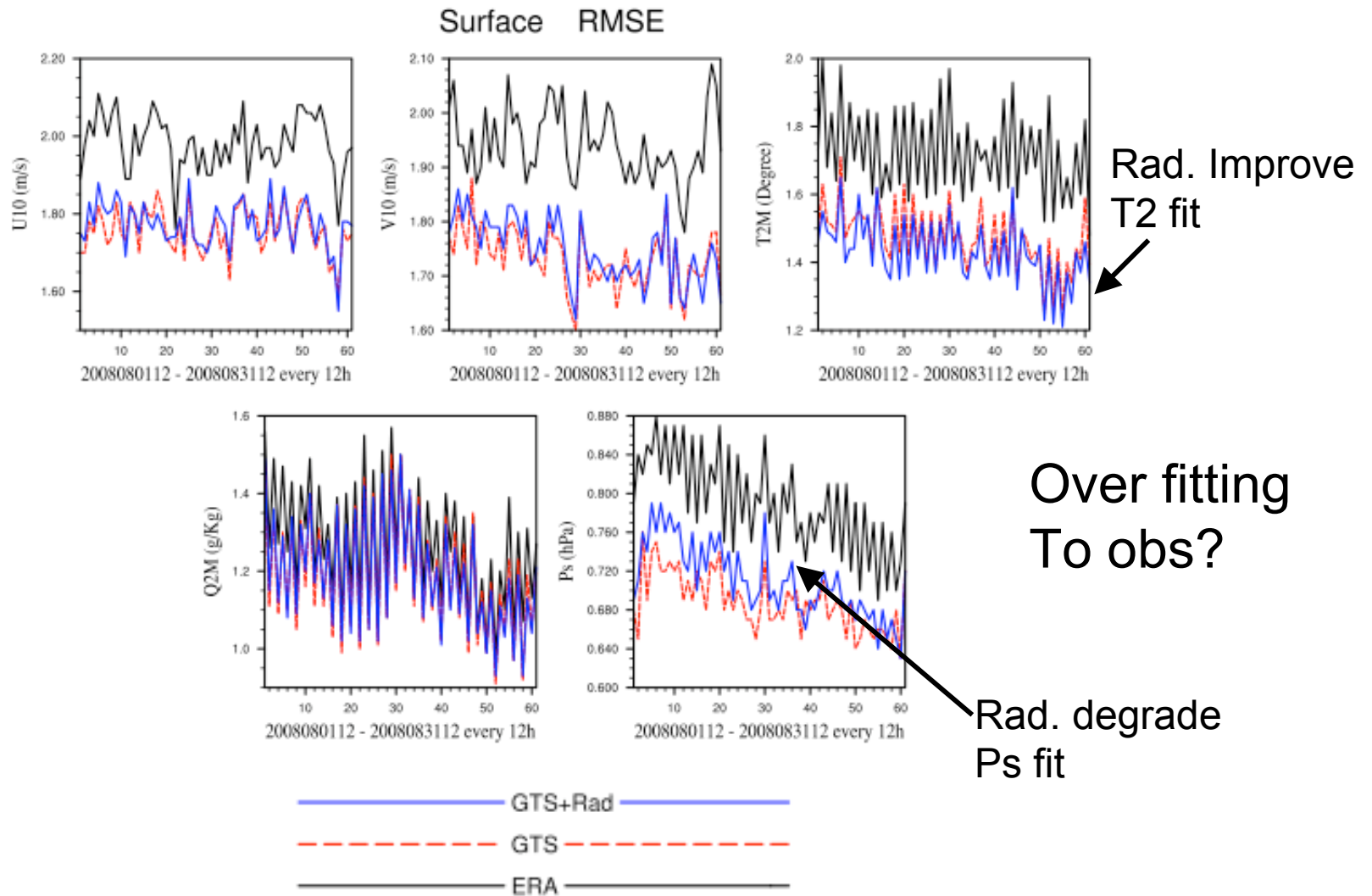
Monthly Map: T2 (C) at 12Z 08/2008



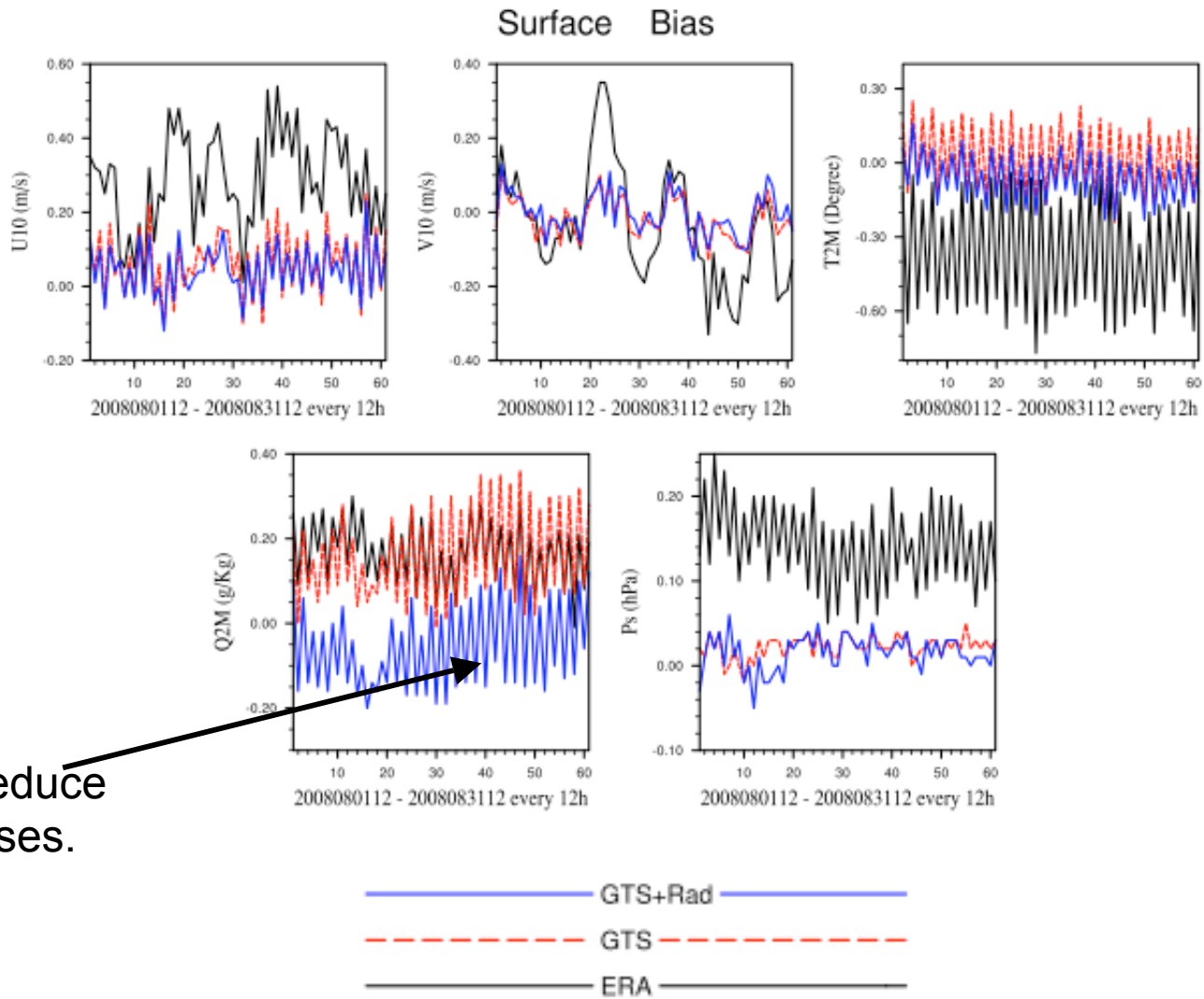
4K colder than ERA



Analyses vs. SYNOP (RMSE)



Analyses vs. SYNOP (Biases)



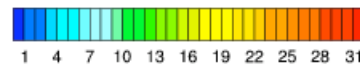
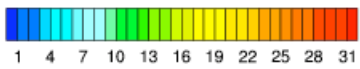
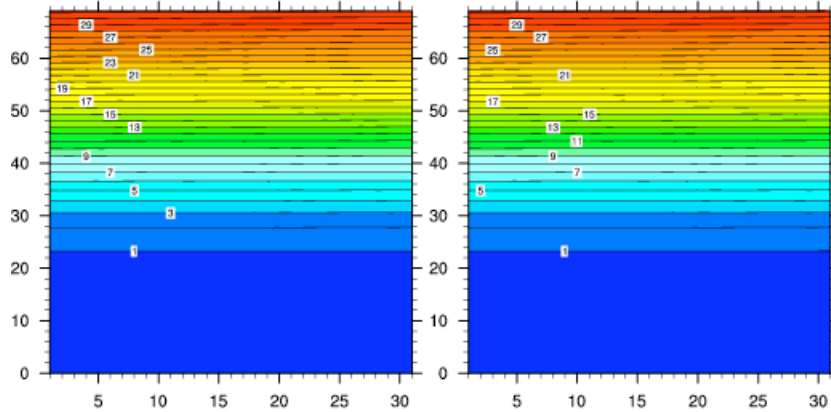
Z: ASR vs. ERA-Interim

W/O Radiances

z(m) 1200UTC 08/2008

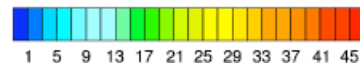
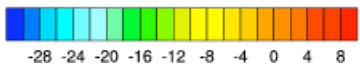
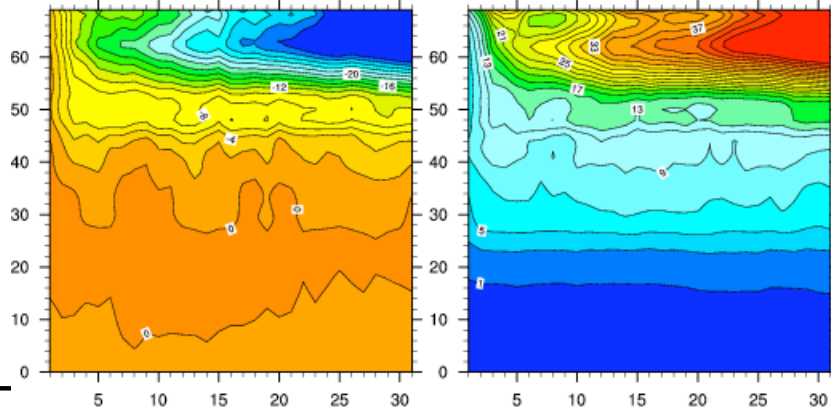
ASR: 0.311846 31.2622

ERA: 0.311854 31.2653



mean(ASR-ERA): -38.8281 1.09644

RMS(ASR-ERA): 0.0225297 55.5013

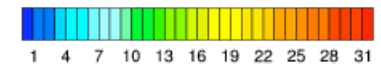
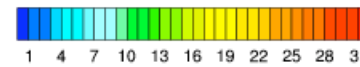
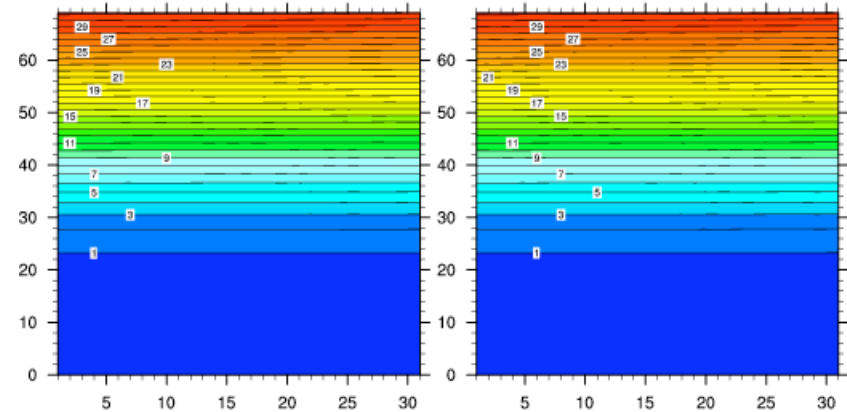


With Radiances

z(m) 1200UTC 08/2008

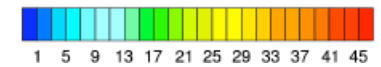
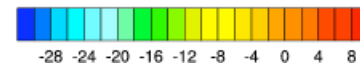
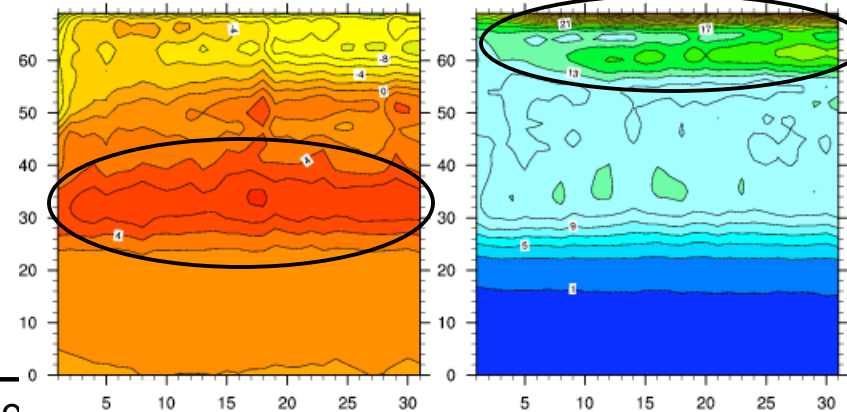
ASR: 0.311851 31.2503

ERA: 0.311854 31.2653



mean(ASR-ERA): -14.9766 8.37793

RMS(ASR-ERA): 0.0219929 42.1279



17, Mo

Summary

- Several issues in WRFDA were found during testing
 - GPSRO QC, AIRS cloud detection scheme.
 - Errors near the model top increasing with the time.
 - Other issues not listed/mentioned in this talk
- Radiance impact is mixed
 - Adding radiances tends to produce more precip. over ocean.
 - Better positioning Low pressure centers over ocean
 - Radiances apparently improve T2m/Q2m.
 - But larger Ps error.
 - Mixed impact for upper air. Model top biases make things complicate.
- Difficulties to do reanalysis for university.
 - Computational resource limitation, limited man power
 - Data collection/processing
 - Lack detailed obs monitoring information (usually available in operational NWP centers. e.g., blacklist of various obs types)

Future work

- More testing/tuning needed before production run
 - Diagnose HBH^T and compare to R
 - Use observation sensitivity tools to identify impact from different obs types (& individual radiance channel)
 - Model top issue: nudging global fields at top levels? increase model top? Add O3?
- Need run forecasts to judge analysis performance.

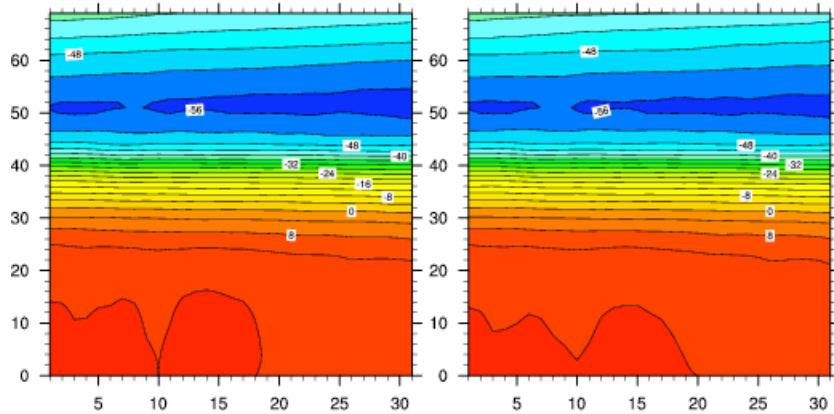
T: ASR vs. ERA-Interim

W/O Radiances

tc(C) 1200UTC 08/2008

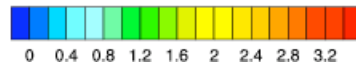
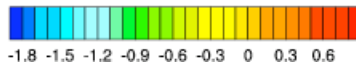
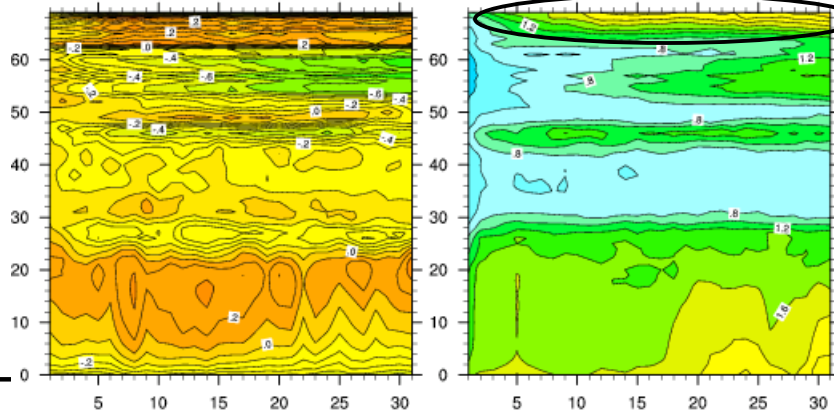
ASR: -57.1355 16.547

ERA: -56.8657 16.7969



mean(ASR-ERA): -0.898949 0.512405

RMS(ASR-ERA): 0.325467 2.36211



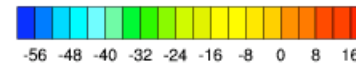
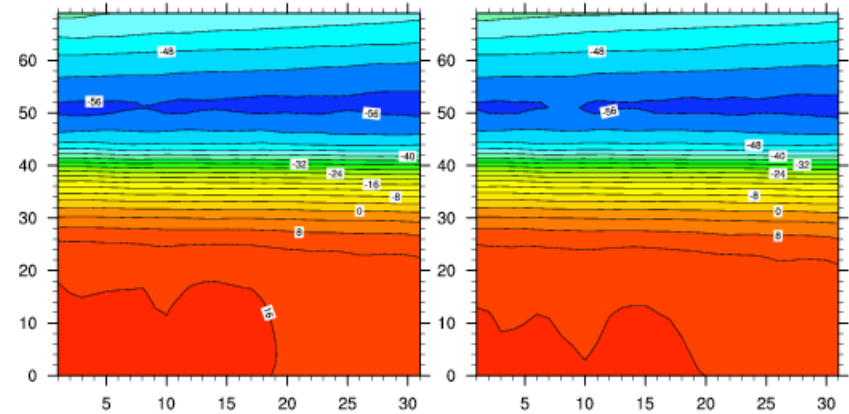
C-17, M

With Radiances

tc(C) 1200UTC 08/2008

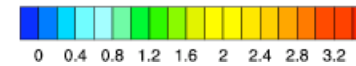
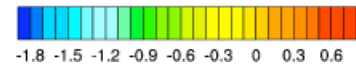
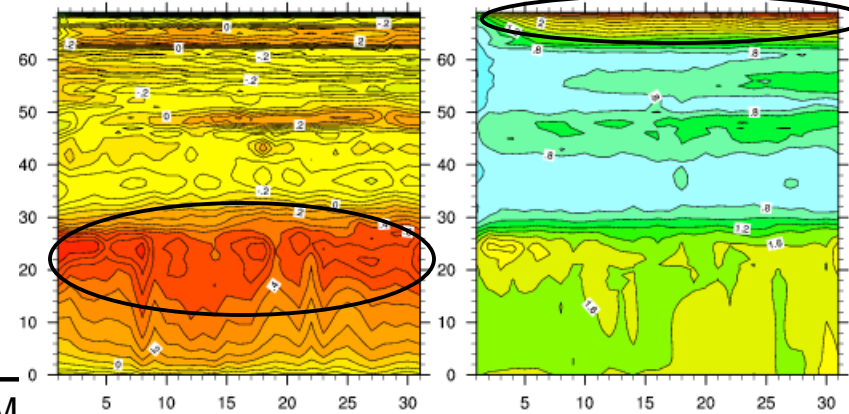
ASR: -56.9734 16.7604

ERA: -56.8657 16.7969



mean(ASR-ERA): -1.94632 0.895719

RMS(ASR-ERA): 0.384408 3.64282



International TOVS Study Conference, 17th, ITSC-17, Monterey, CA, 14-20 April 2010.
Madison, WI, University of Wisconsin-Madison, Space Science and Engineering Center,
Cooperative Institute for Meteorological Satellite Studies, 2011.