Impact of Targeted Dropsonde Data on Mid-latitude Numerical Weather Forecasts during the 2011 Winter Storms Reconnaissance Program

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presentation to THORPEX DAOS, September 2012, Madison, WI, USA

Motivation for this study

- THORPEX DAOS has been looking for a clear statement on the impact of targeting in the mid-latitudes since the inception of this committee.

- Members have been skeptical that optimistic prior results may not be replicable today with modern assimilation and forecast systems.

- Targeting concept with in-situ observations may be difficult, for suggested target areas are much broader than tracks that can be covered in a single plane sortie.

Agreed-upon project to test concept

- NOAA supplies a winter's worth of targeted dropsonde observations to ECMWF (Jan-Mar 2011; 98 flights, 776 dropsondes).
- ECMWF runs parallel forecast and assimilation cycles, with and without targeted observations added to the full data stream.
  - Data assimilation: 4D-Var, inner loops linearized T255, T159, T159. Outer loop, nonlinear T511. 10-member perturbed-obs 4D-Var at T159 to set background-error variances in 4D-Var.
  - Deterministic forecast to 120 h, T511.
  - IFS version 37r2

Targeting procedure

- Potential high-impact cases identified in advance by NCEP Hydrometeorological Prediction Center scientists. Downstream locations ("verification region") and times of expected maximum impact are selected
  - Anticipated high/medium/low impact also noted.
  - Target lead times defined by forecasters, 12 to 120 h.
  - ETKF summary map guidance of signal variance within the verification region, together with ETKF selections of optimal flight tracks, are computed.
- ~ Two days prior to flight, targeting request sent out. Flights deployed from Anchorage, Yokota, Honolulu, Gulf of Mexico (Biloxi MS).
- Assimilation:
  - "CONTROL" – includes dropsonde data
  - "NODROP" – excludes dropsonde data

Norm to evaluate impact

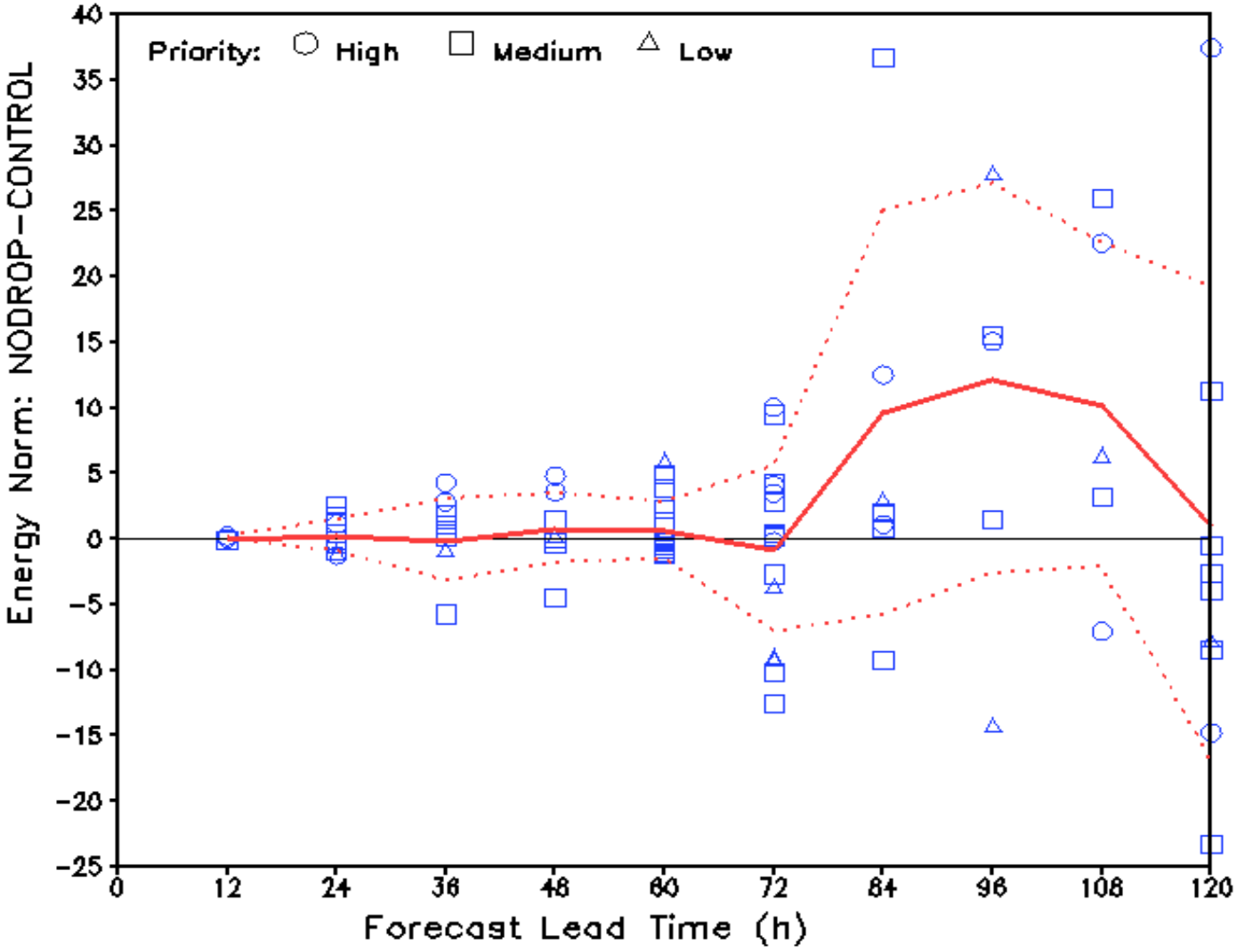
An approximation to the total energy norm

$$E = \left[\frac{1}{2} \int_A \left(\begin{array}{l} \frac{1}{4}\left(\mathbf{u}_{250}^2 + \mathbf{v}_{250}^2 + \frac{c_p}{T_r}\mathbf{t}_{250}^2 \right) + \\ \frac{1}{4}\left(\mathbf{u}_{500}^2 + \mathbf{v}_{500}^2 + \frac{c_p}{T_r}\mathbf{t}_{500}^2 \right) + \\ \frac{1}{4}\left(\mathbf{u}_{850}^2 + \mathbf{v}_{850}^2 + \frac{c_p}{T_r}\mathbf{t}_{850}^2 \right) + \\ \frac{1}{4}\left(\mathbf{u}_{10m}^2 + \mathbf{v}_{10m}^2 + \frac{c_p}{T_r}\mathbf{t}_{2m}^2 \right) + R_d T_r \left(\frac{\mathbf{p}}{P_r} \right)^2 \end{array} \right) \right]^{1/2},$$

Table 2. Number of flights associated with each forecast lead time, and the number of flights deployed from each of the different airbases.

Forecast lead time (hours)	**Total Flights**	**Gulf Flights**	**Anchorage Flights**	**Honolulu Flights**	**Yokota Flights**
12	3	3	0	0	0
24	11	5	4	2	0
36	10	2	4	3	1
48	8	1	3	2	2
60	17	0	10	1	6
72	17	0	10	4	3
84	9	0	5	0	4
96	6	6	2	1	3
108	5	0	4	0	1
120	12	0	6	0	6

Impact as a function of target lead time

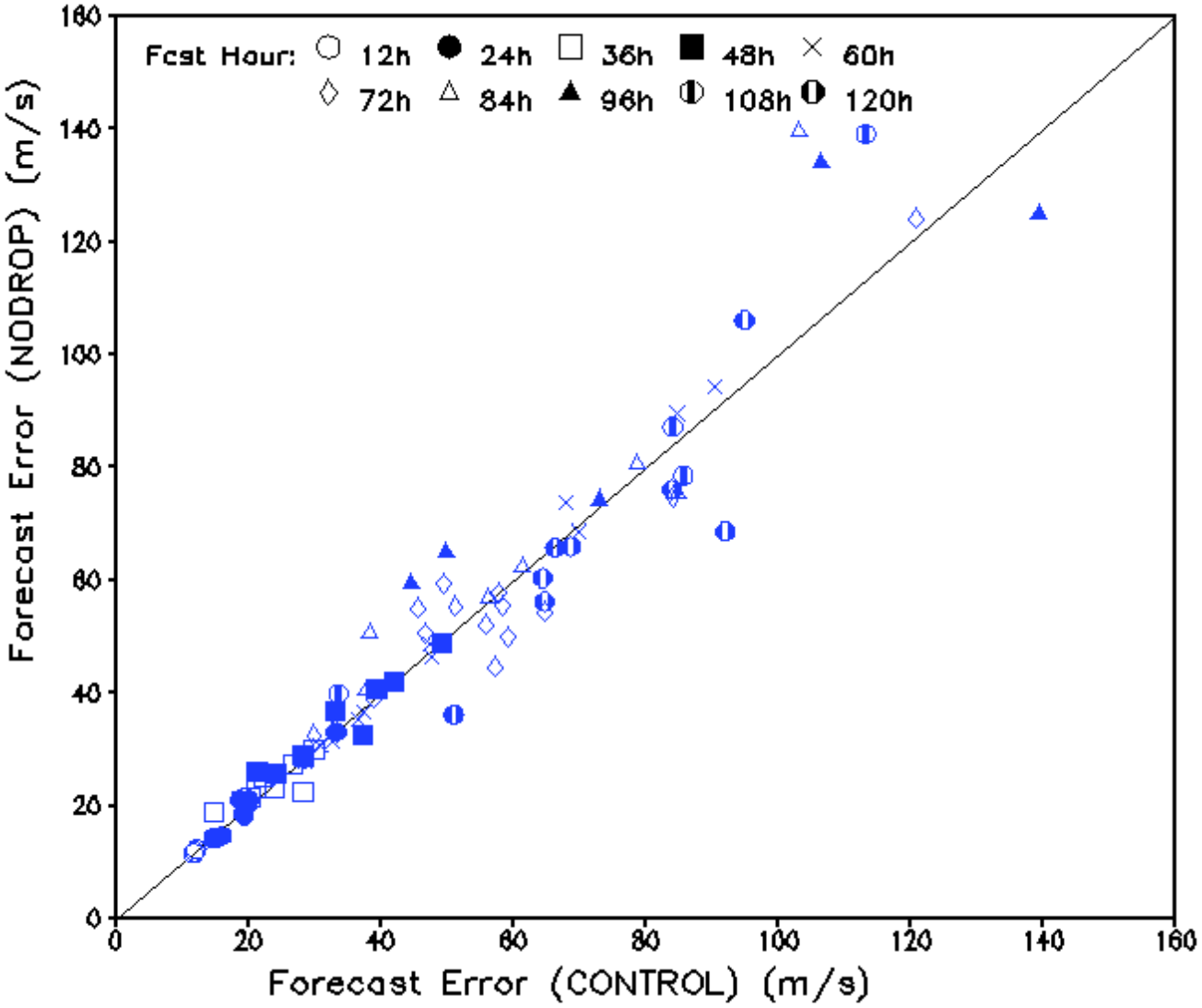


Verification area here is a +/- 10 degree box centered on target

Solid line: mean

Dashed line: +/- 1 standard deviation.

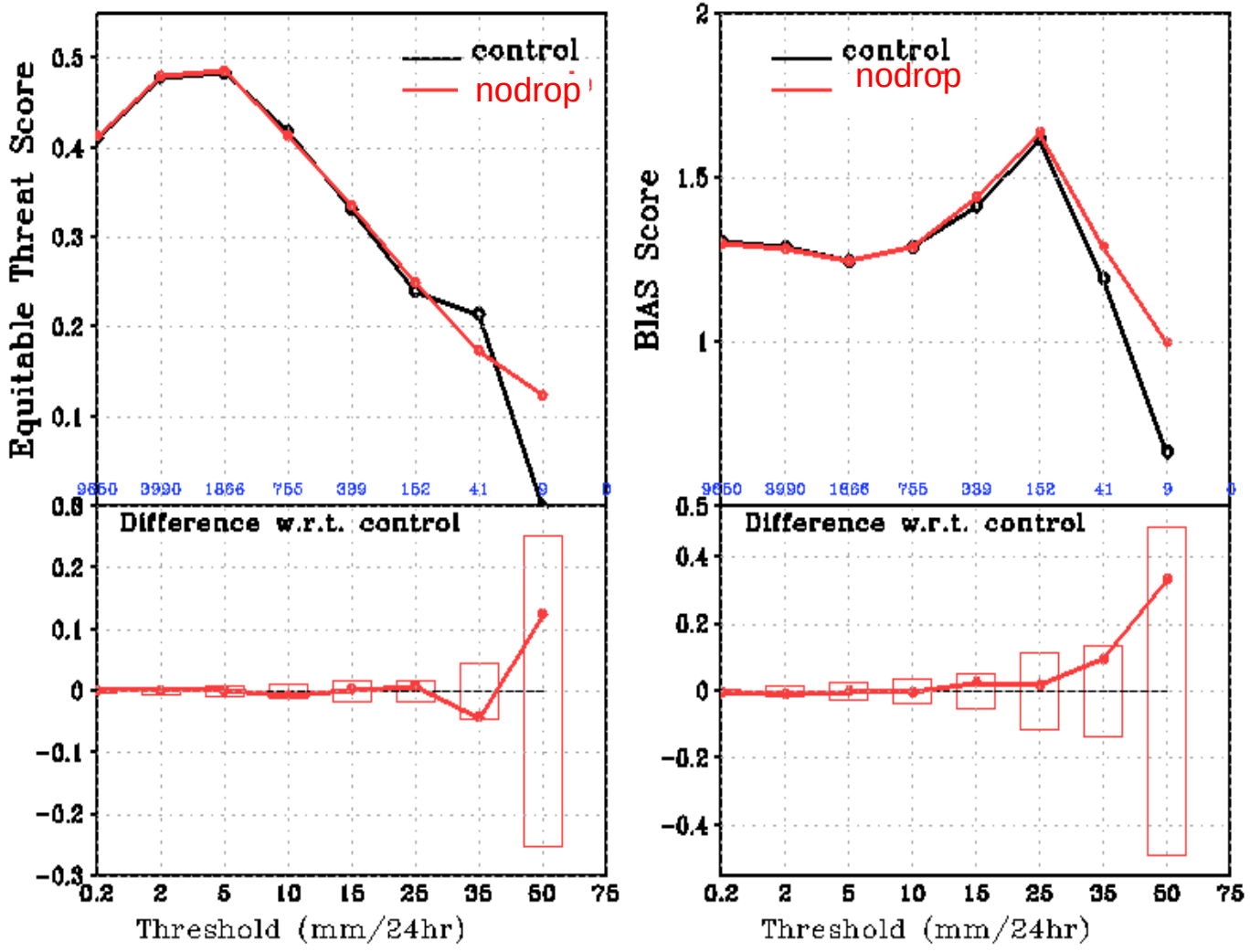
Scatterplot of impacts



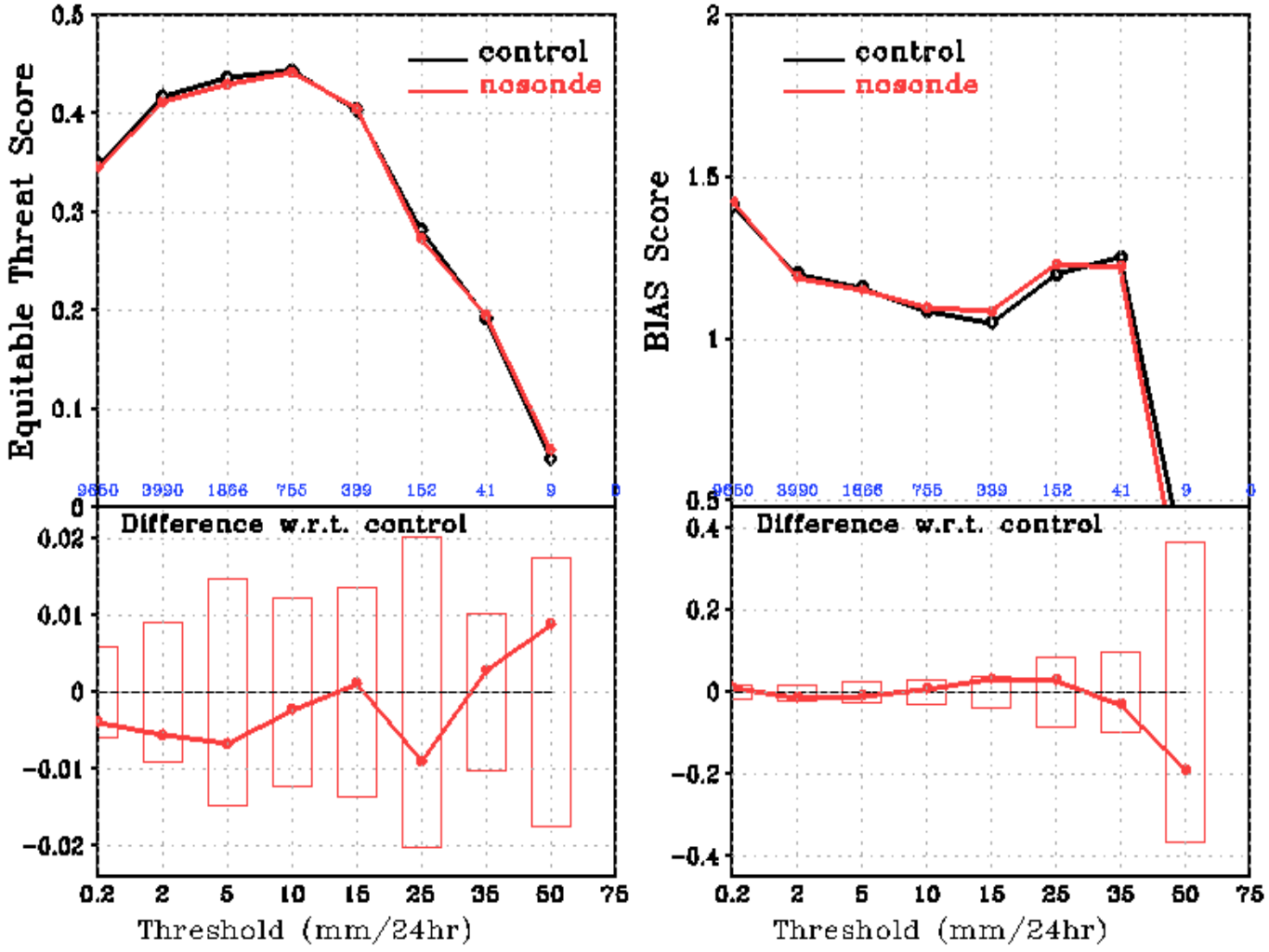
Verification area here is a +/- 10 degree box centered on target

cases above line indicate benefit from targeted data

ETS and BIA, eastern US, 24-48 h forecasts



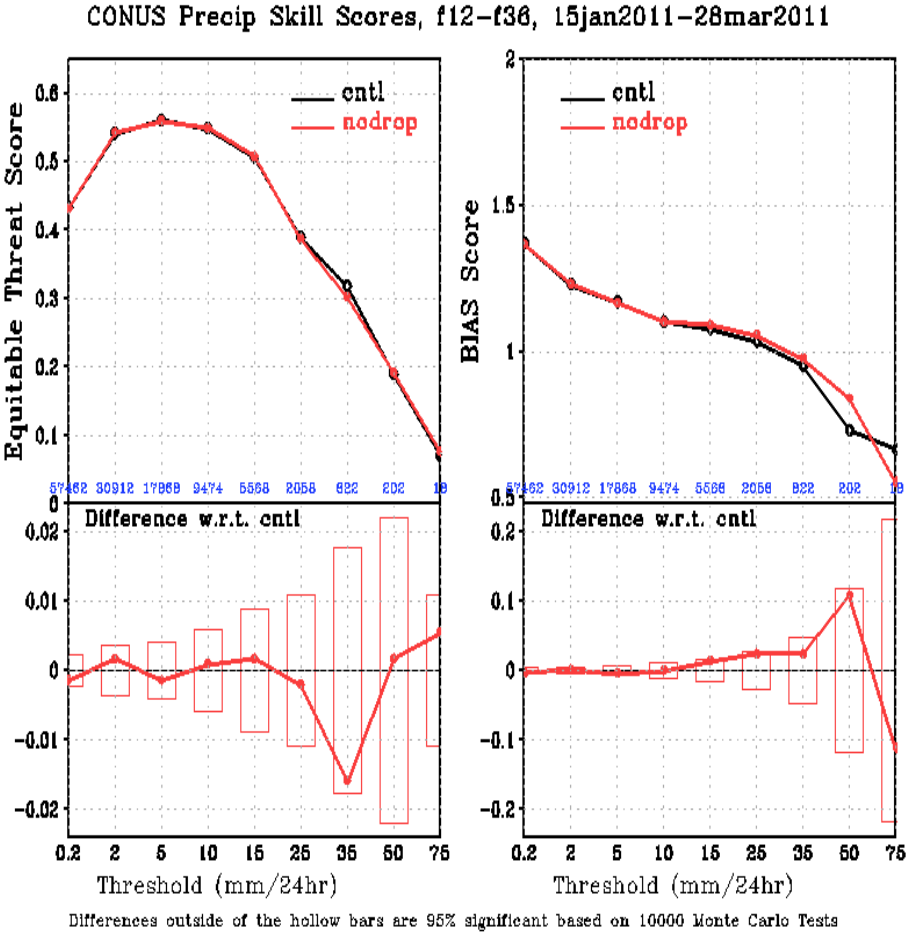
ETS and BIA, eastern US, 48-72-h forecasts



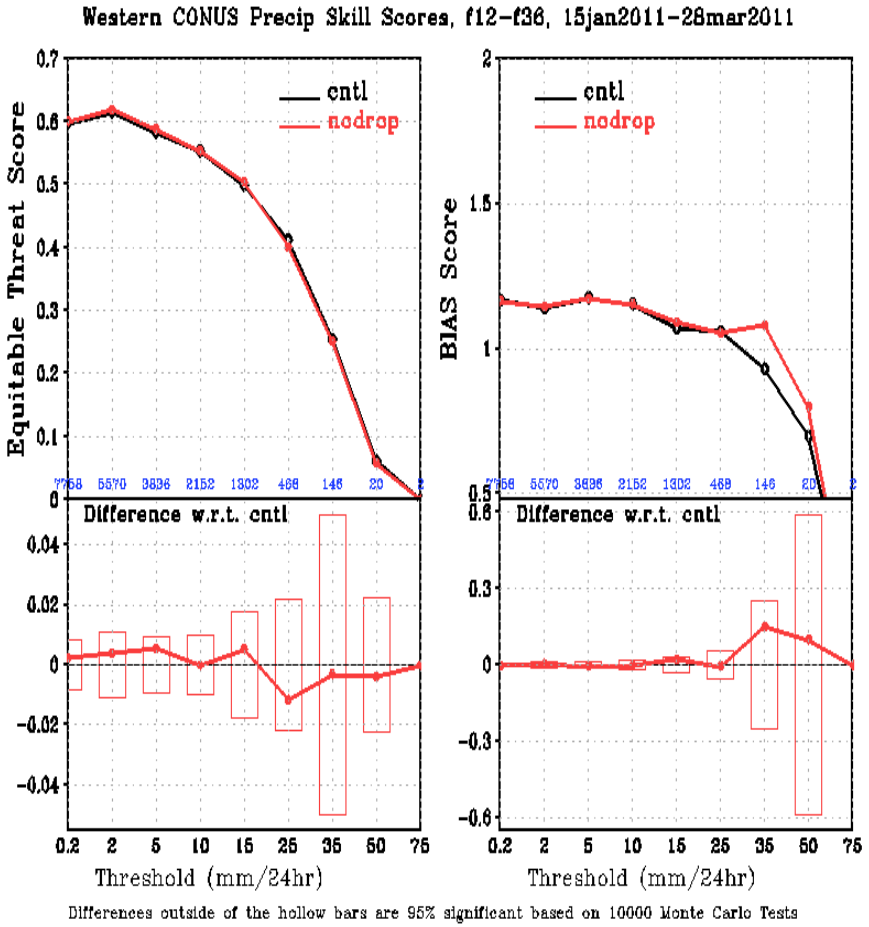
Differences outside of the hollow bars are 95% significant based on 10000 Monte Carlo Tests

Precipitation Threat Skill Scores over CONUS
12-36 hour Forecast

Entire CONUS



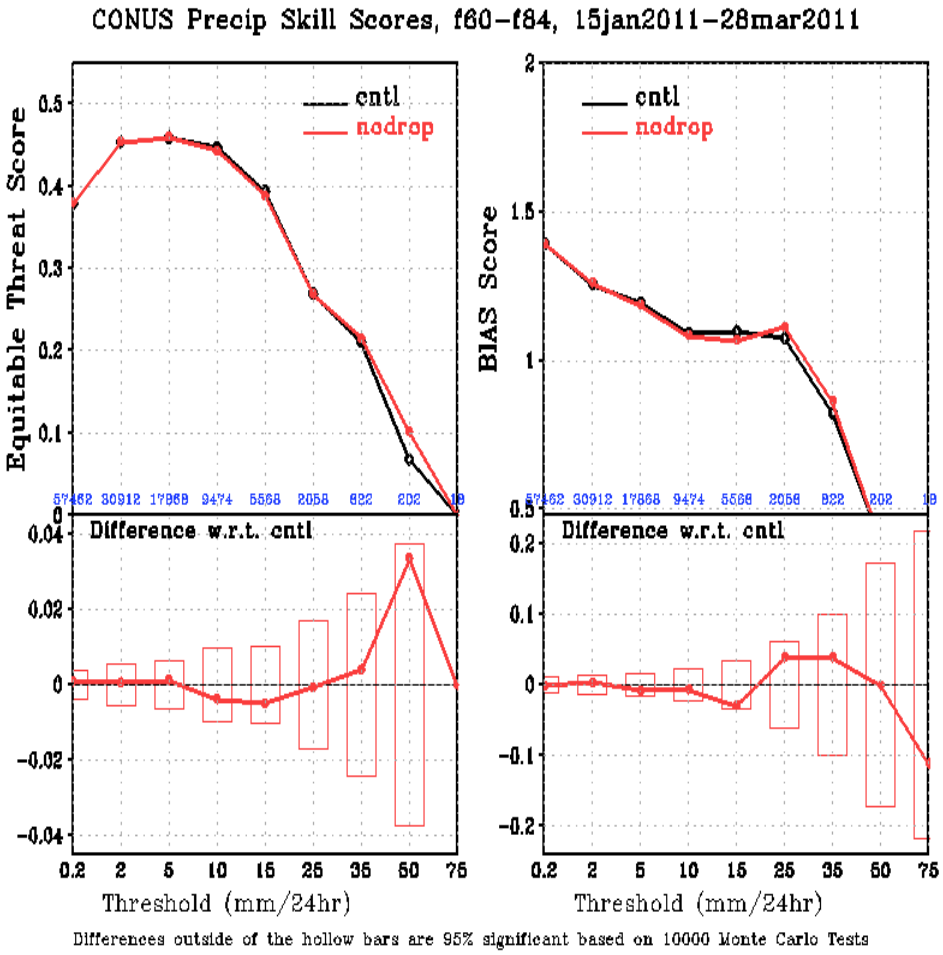
Western CONUS



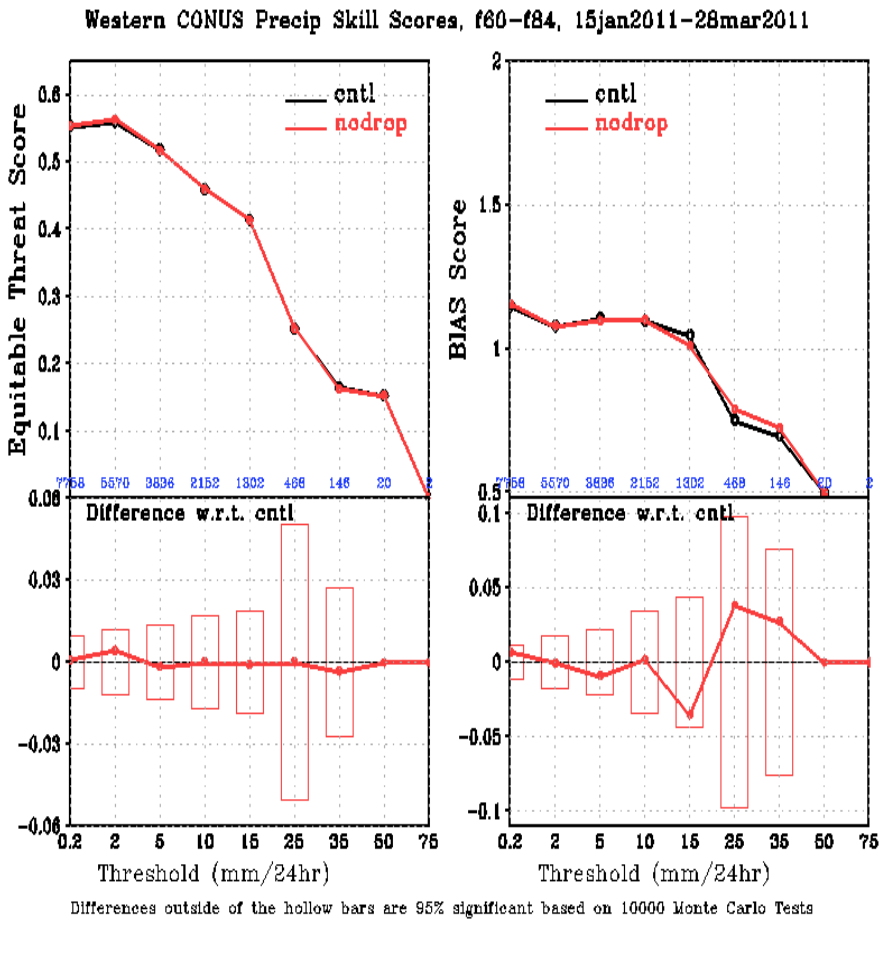
No statistically significant differences

Precipitation Threat Skill Scores over CONUS
60-84 hour Forecast

Entire CONUS



Western CONUS



No statistically significant differences

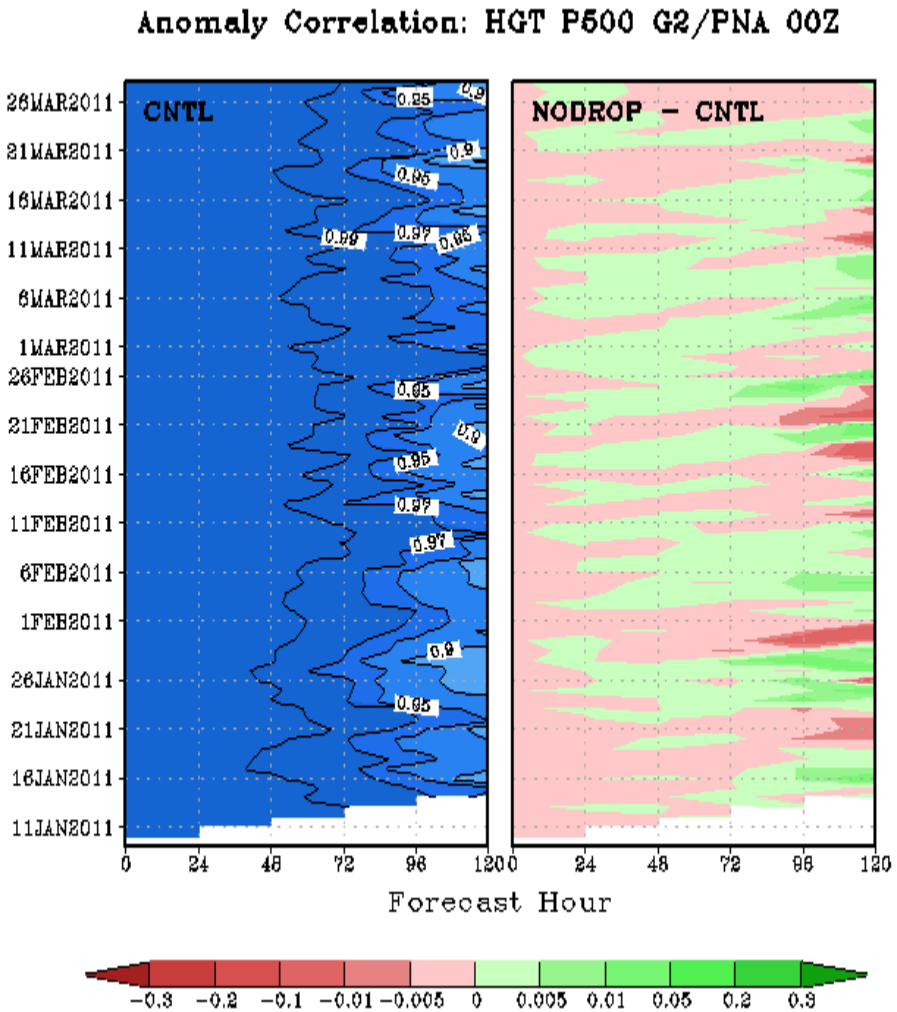
Time Mean Statistics

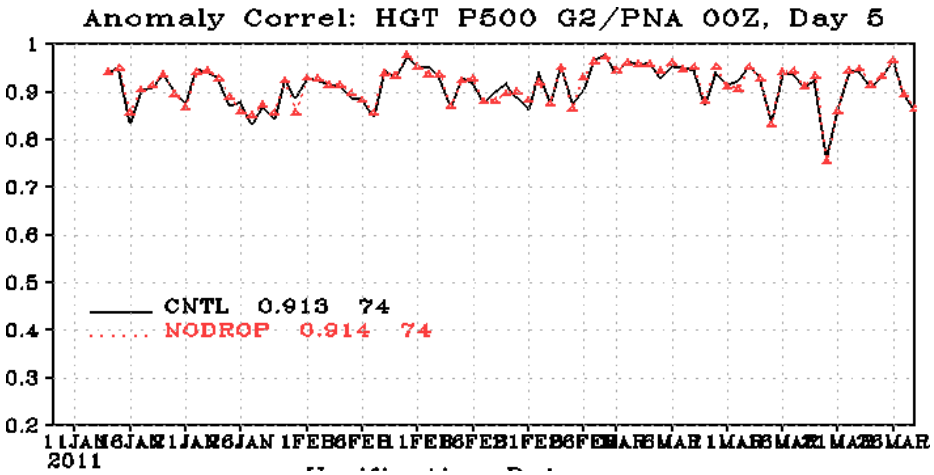
10Jan2011 ~ 28Mar2011

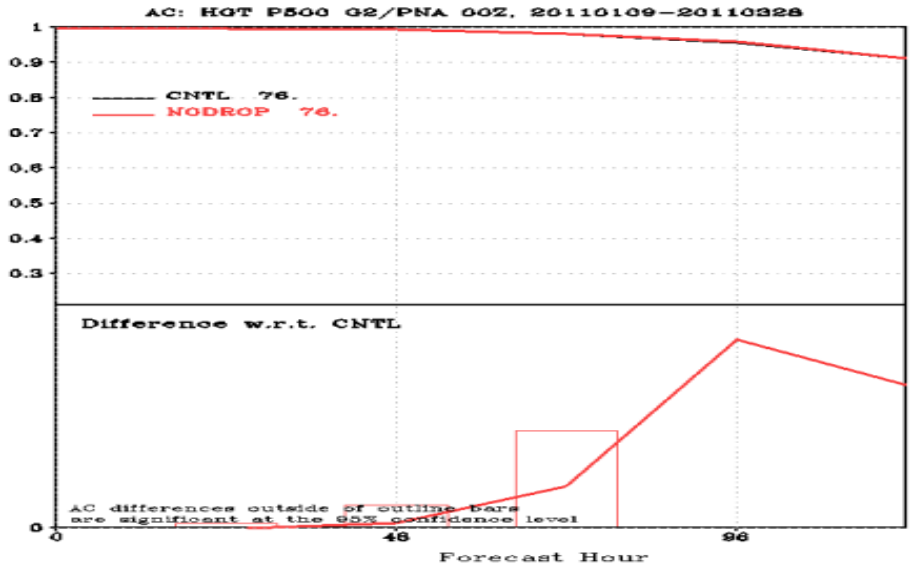
500hPa HGT Anomaly Correlation over Pacific North American Region (20N-75N, 180E-320E)

10 Jan 2011 – 28 Mar 2011 mean
All verified against "CONTROL" analyses

negative numbers = + impact from dropsondes

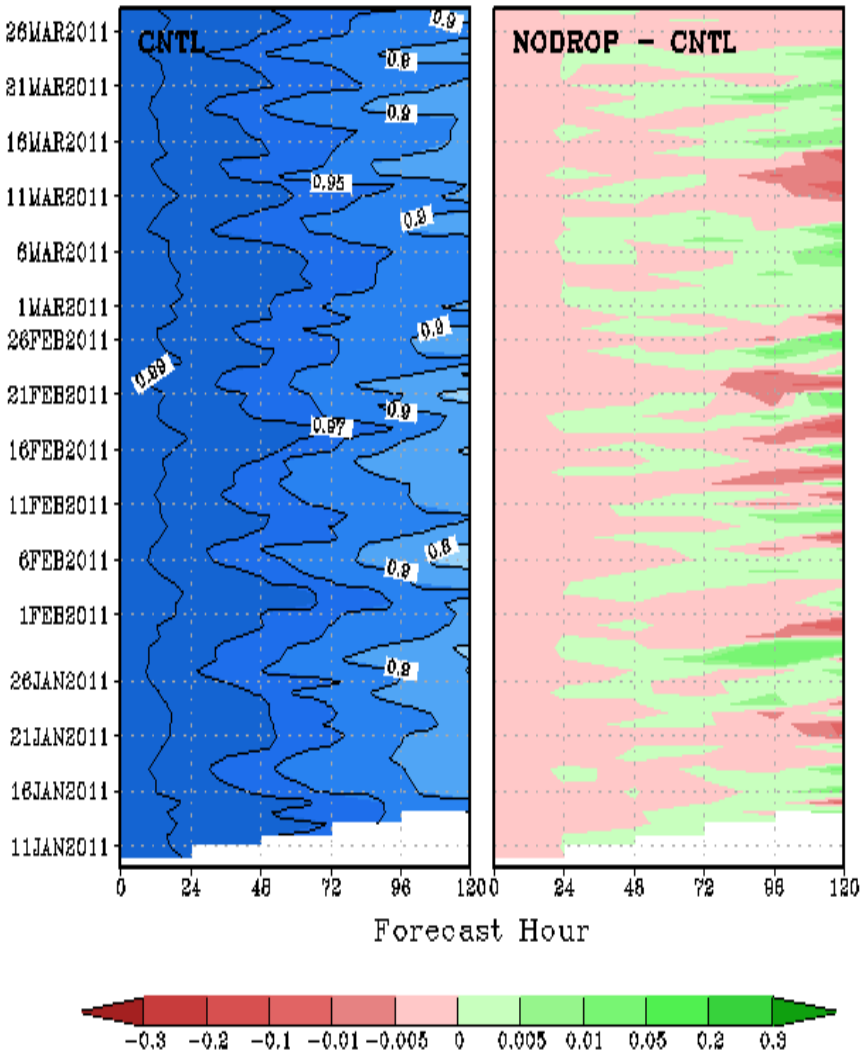


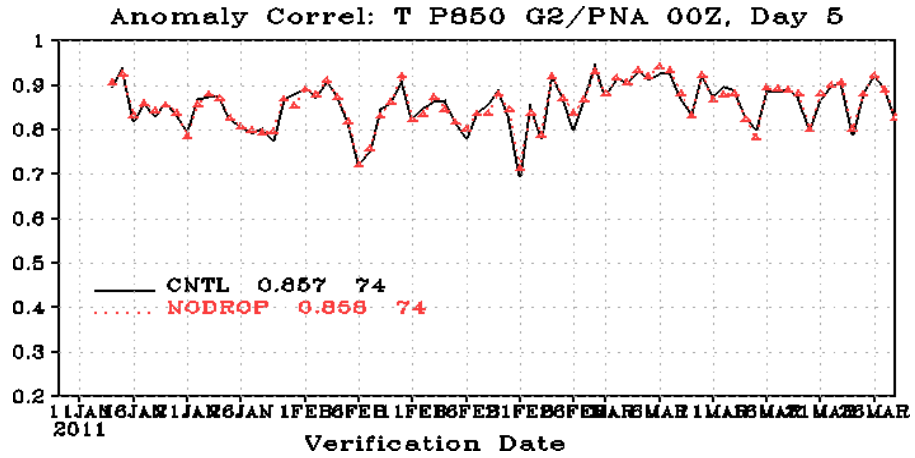


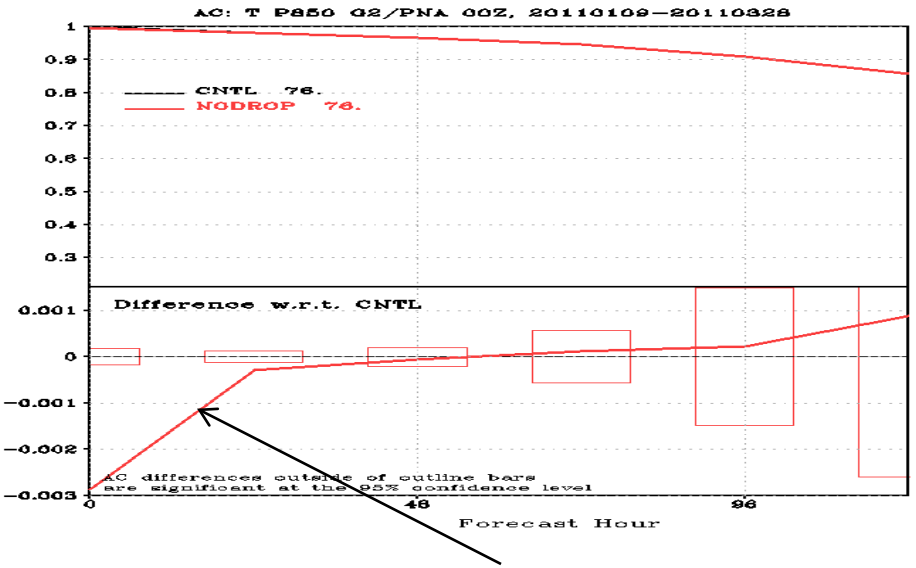


No statistically significant impact

850hPa Temperature Anomaly Correlation over Pacific North American Region (20N-75N, 180E-320E)

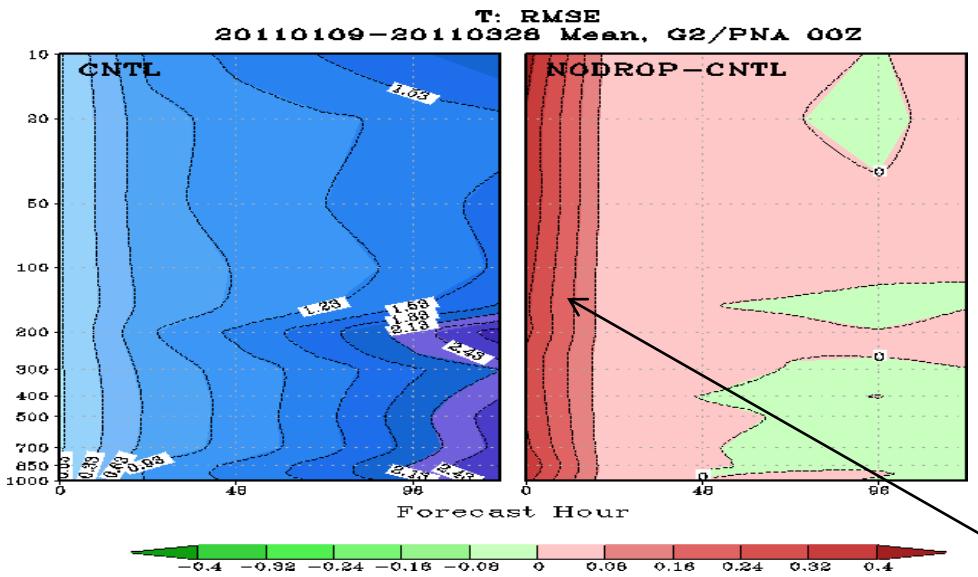


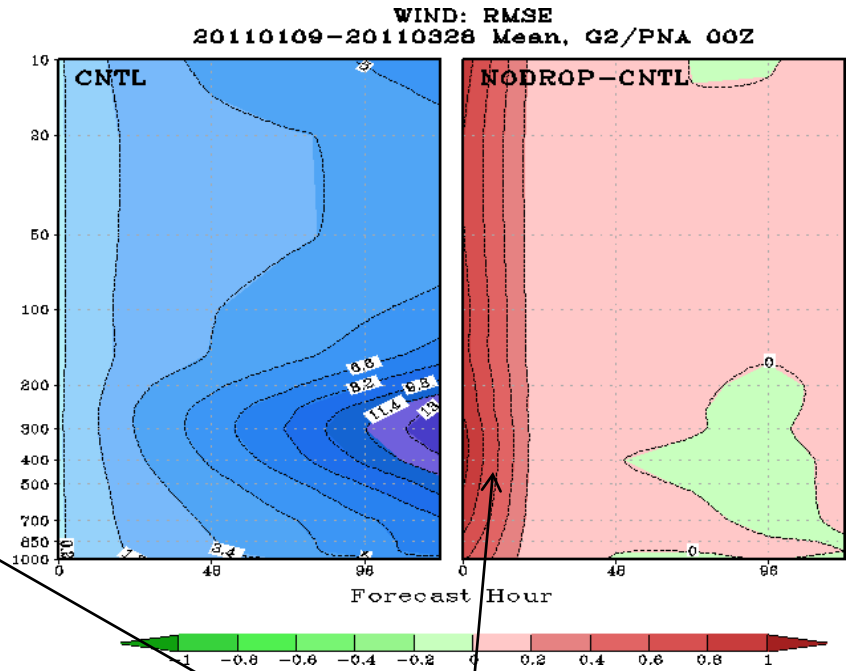


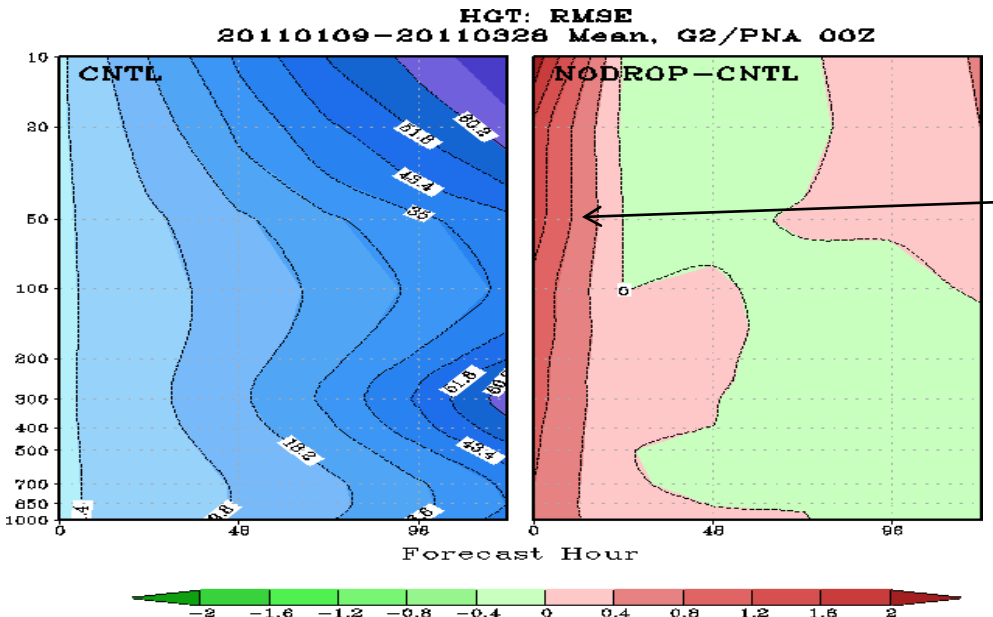


"nodrop" is significantly worse than "cntl" at initial forecast hours but may be due to incestuous relation w. analysis.

RMSE for Height, Temperature and Wind over Pacific North American Region (20N-75N, 180E-320E)

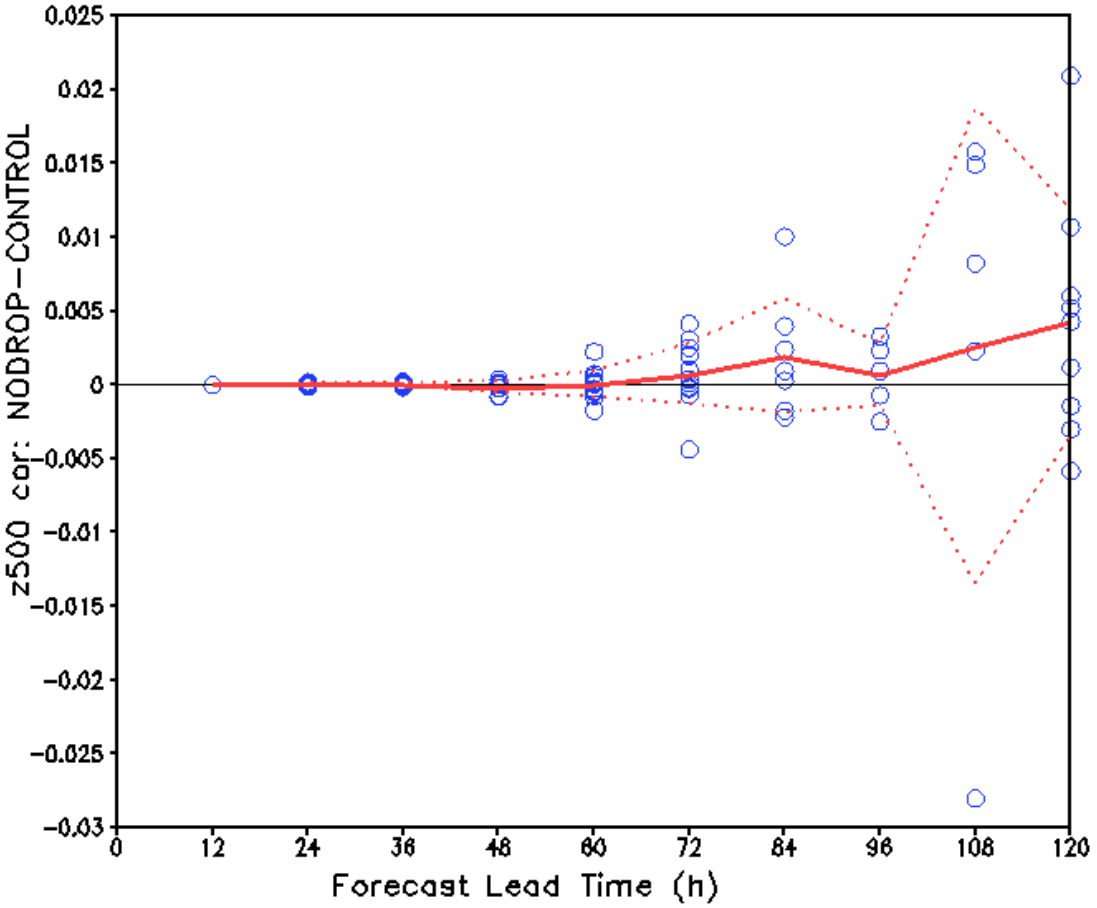






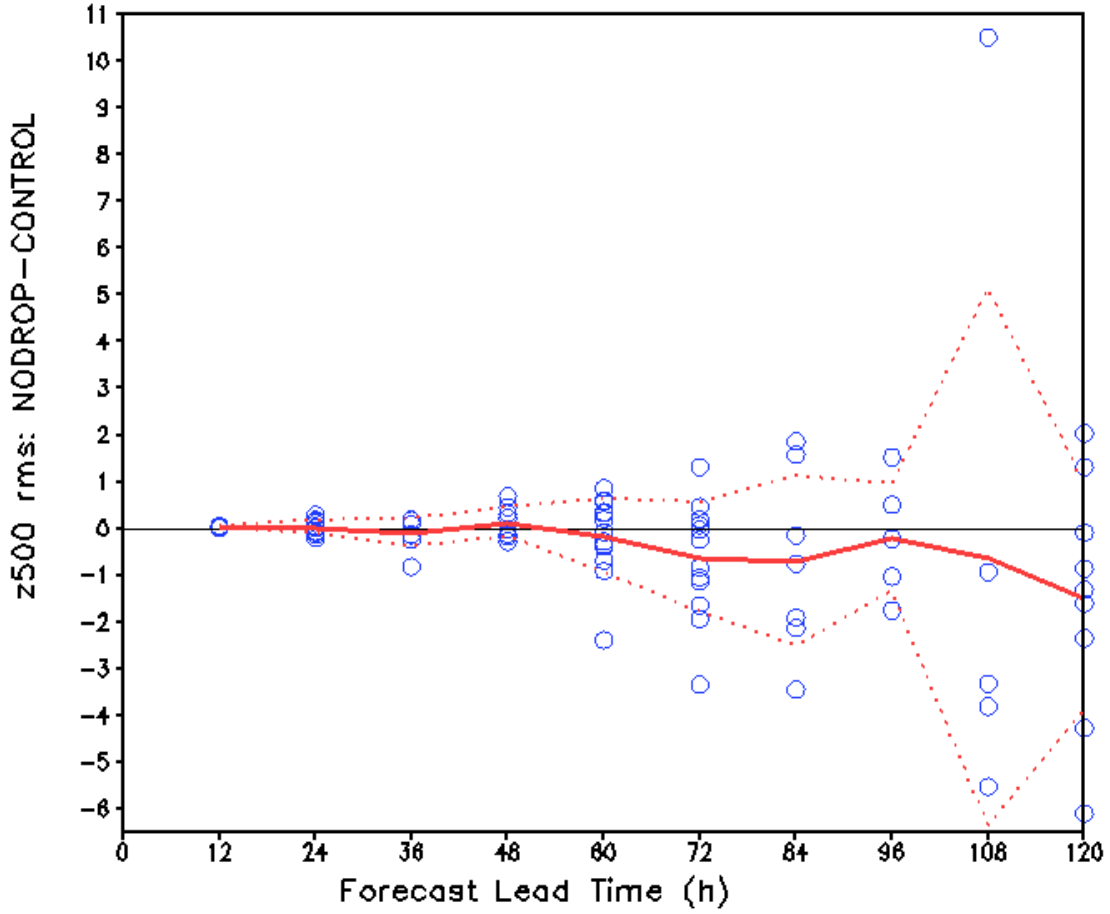
"nodrop" has larger RMSE than "cntl" at initial forecast hours.
Again, probably fictitious increase in skill.

Z500 AC, NODROP-CONTROL PNA region



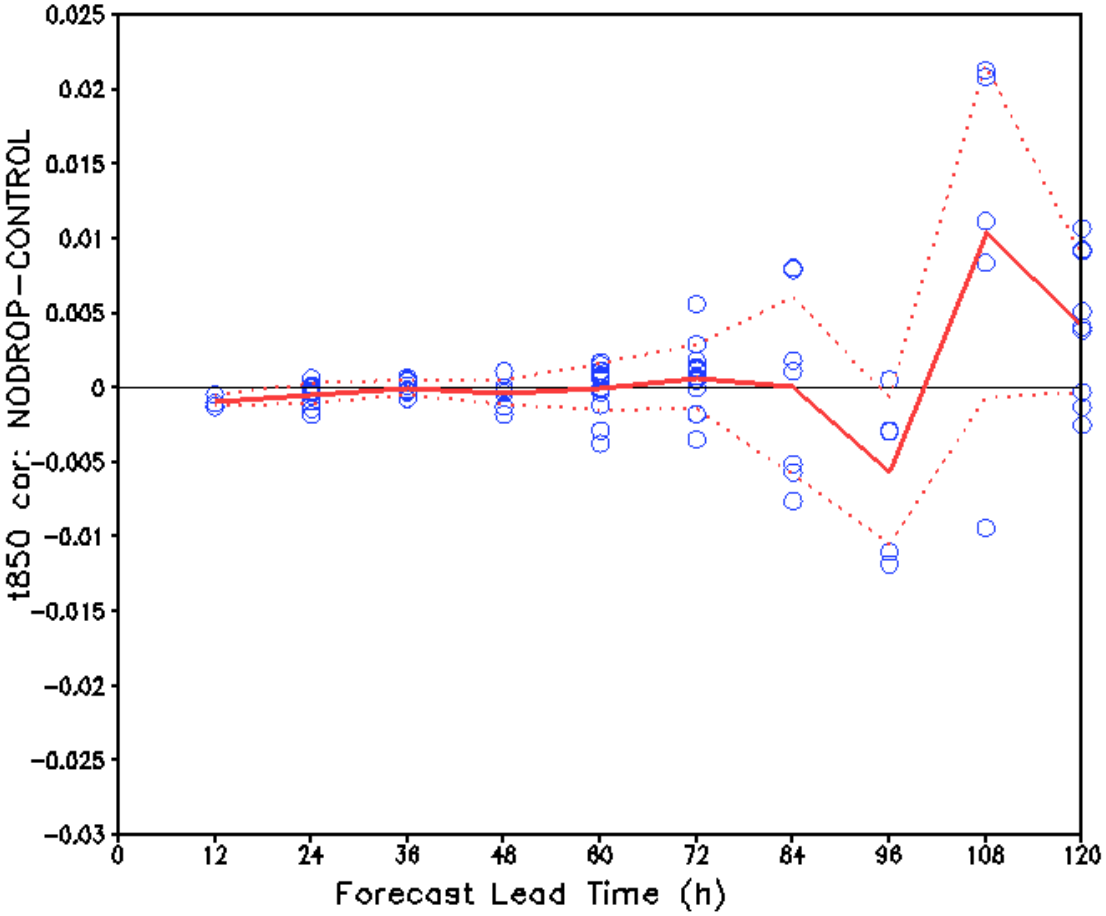
Below 0 line = + impact from targeted obs

Z500 RMS, NODROP-CONTROL PNA region



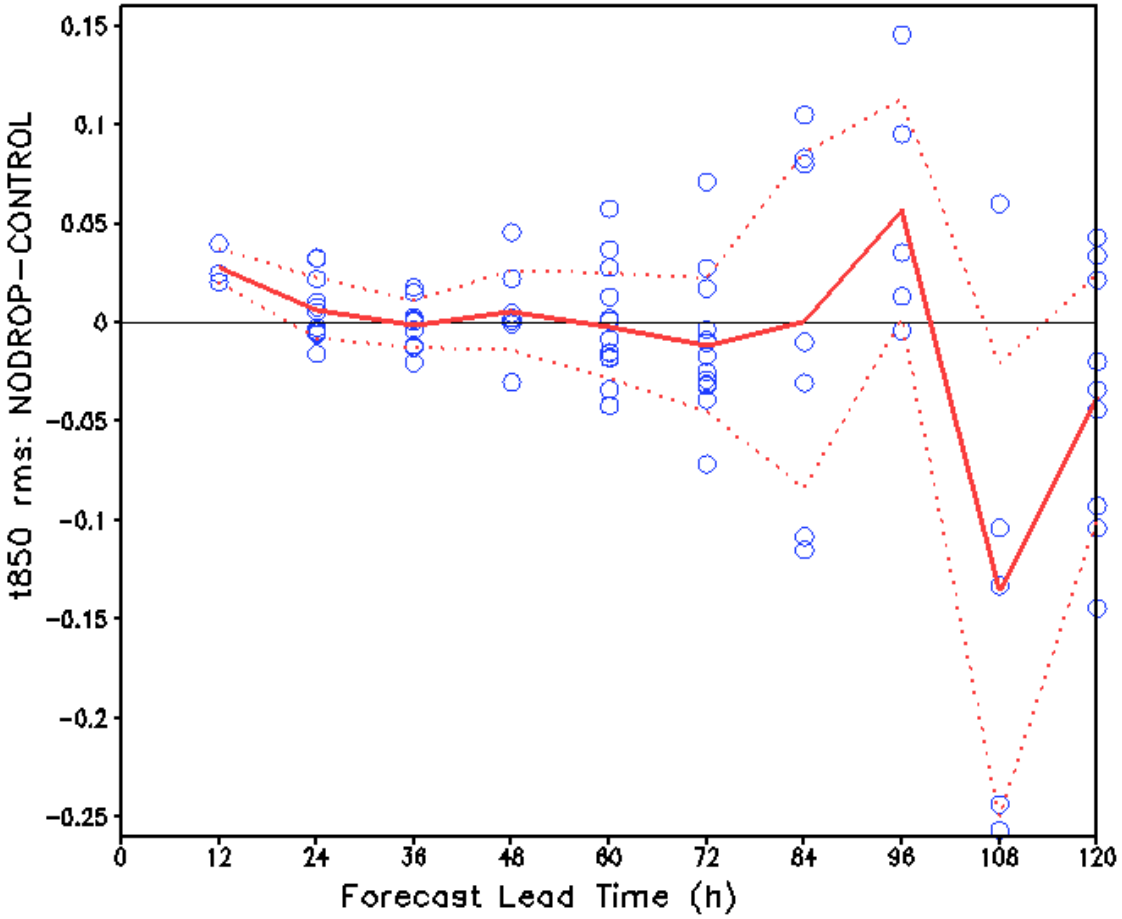
Above 0 line = + impact from targeted obs

T850 AC, CONTROL-NODROP, PNA region



Below 0 line = + impact from targeted obs

T850 RMS, NODROP-CONTROL PNA region



Above 0 line = + impact from targeted obs

Conclusions

- No evidence from this study that targeted observations has a statistically significant positive impact on forecasts.
- Possible reasons:
  - + impact might be there w. larger sample size.
  - Not fully sampling target region with ~ 8 dropsondes/flight.
  - Abundance of other data, higher-quality assimilation systems.
- Recommendation: WSR cannot be justified as currently configured based on improvement to forecasts. Reallocate resources to higher priorities?

Weather Forecast Maps

from Selected Cases

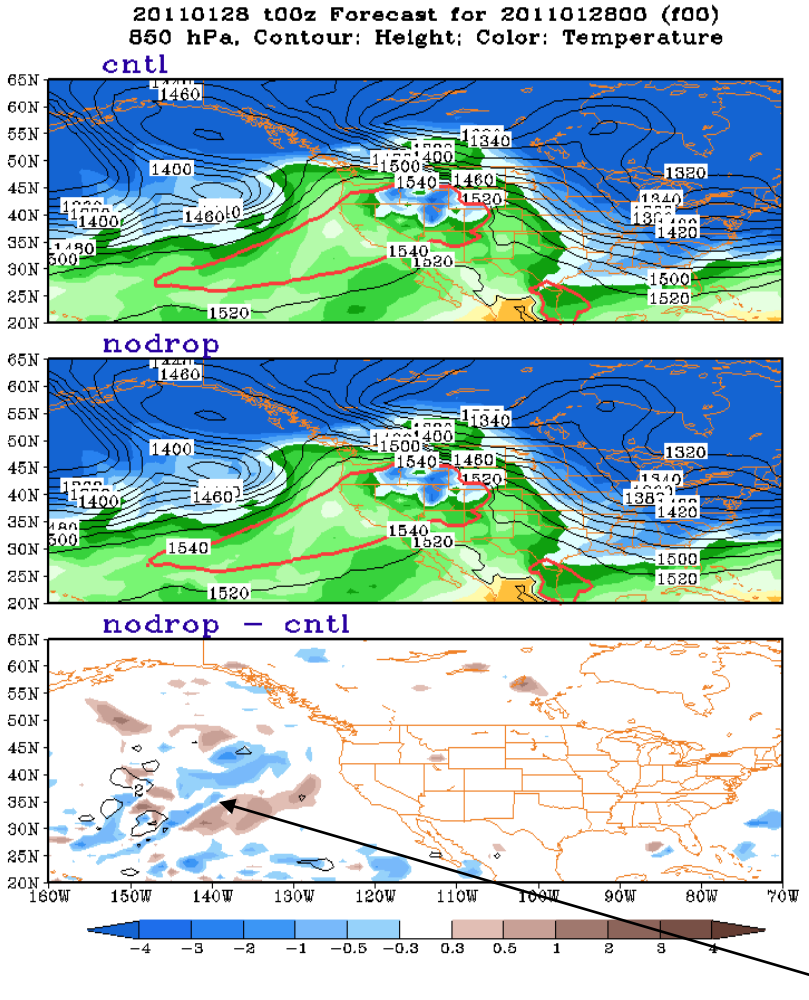
Please visit
http://www.emc.ncep.noaa.gov/gmb/wx24fy/vsdb/wsr2011_00Z/fcstmaps/fcstmap.html
to see all cases for the period from 09Jan2011 through 28Mar2011.

Cases I: 2011012800 Cycle

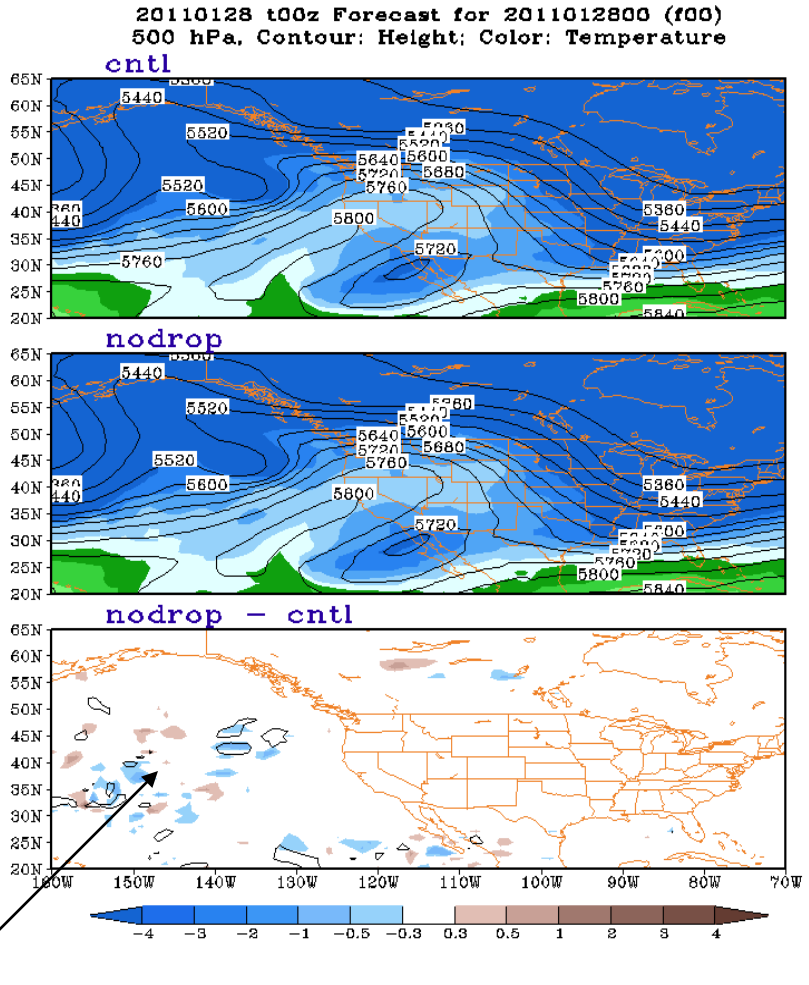
January 31 – February 2, 2011 Groundhog Day Blizzard

Analyses

850hPa T and Z



500hPa T and Z



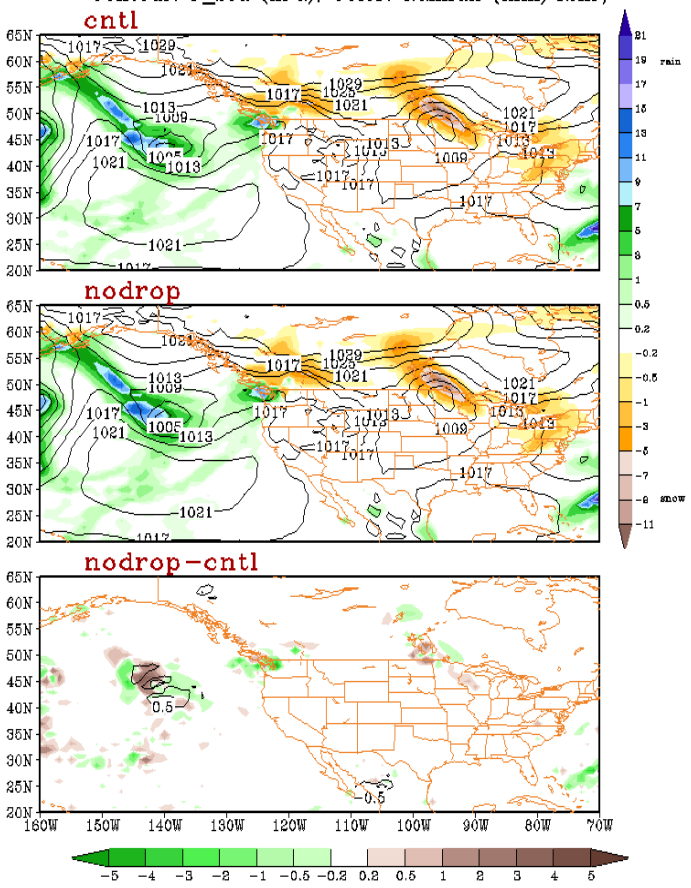
Notice the differences in northeastern Pacific, presumably caused by the differences in dropsondes

Cases I: 2011012800 Cycle

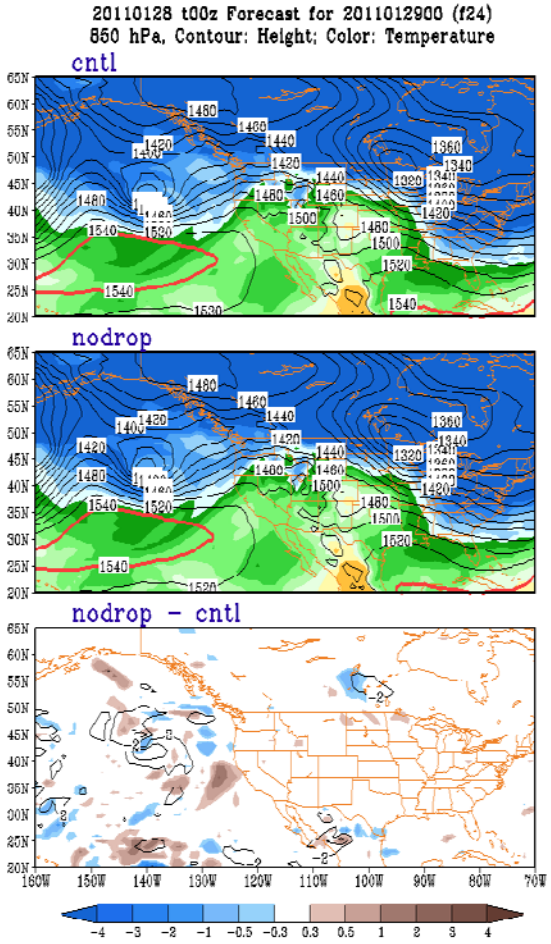
January 31 – February 2, 2011 Groundhog Day Blizzard

24-hr Fcst

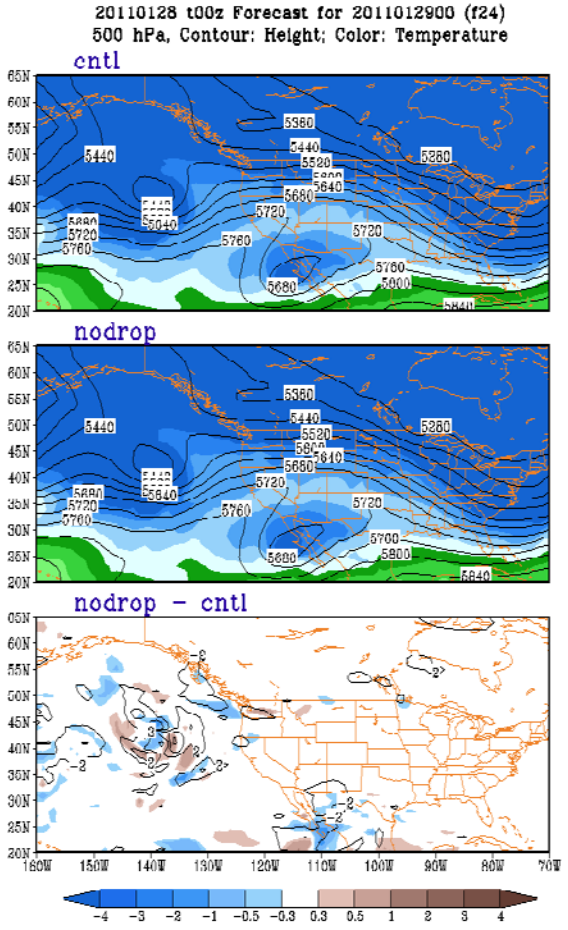
Precip and SLP



850hPa T and Z



500hPa T and Z



Differences still in Northeast Pacific

Cases I: 2011012800 Cycle

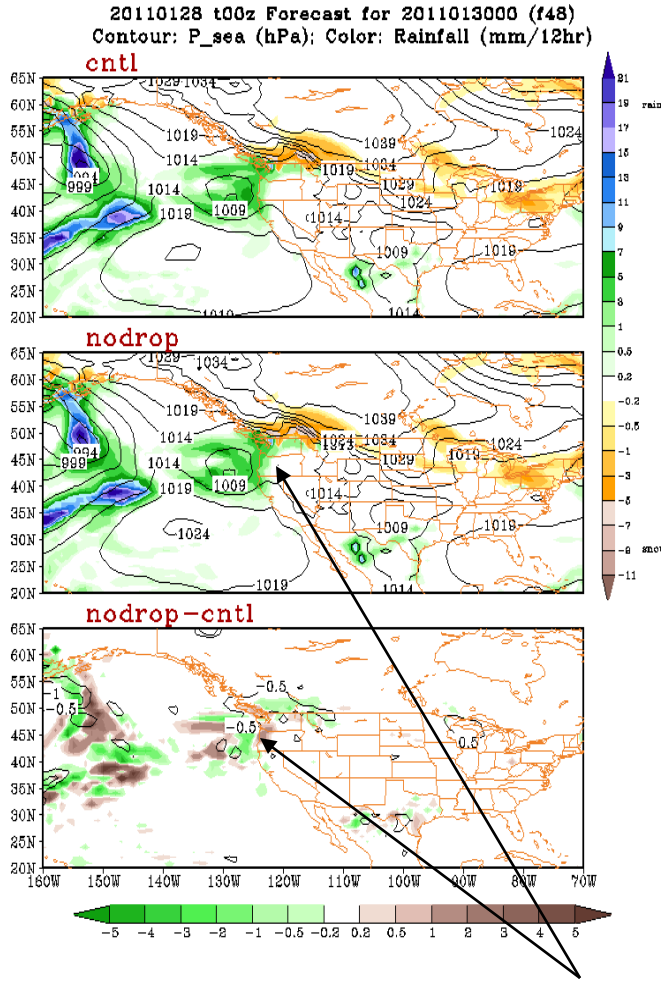
January 31 – February 2, 2011 Groundhog Day Blizzard

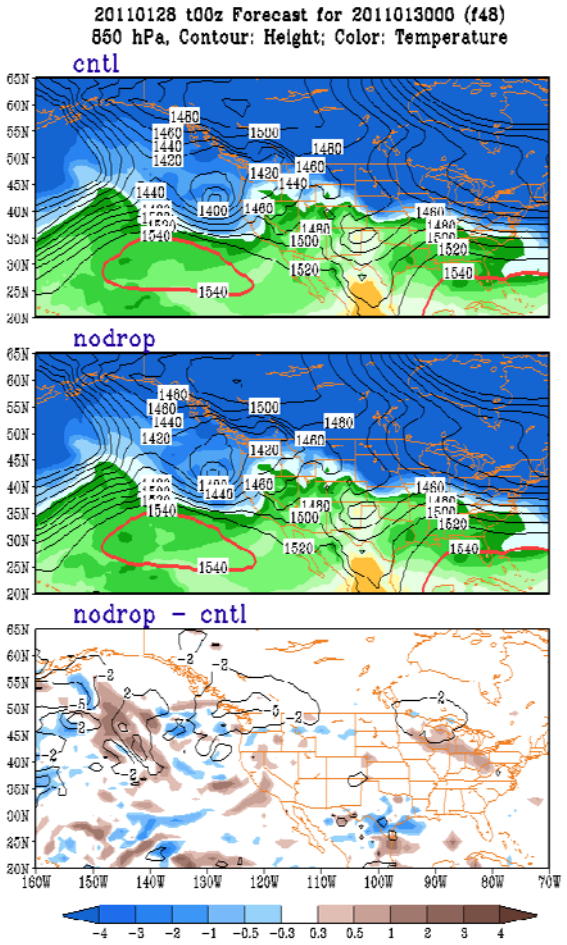
48-hr Fcst

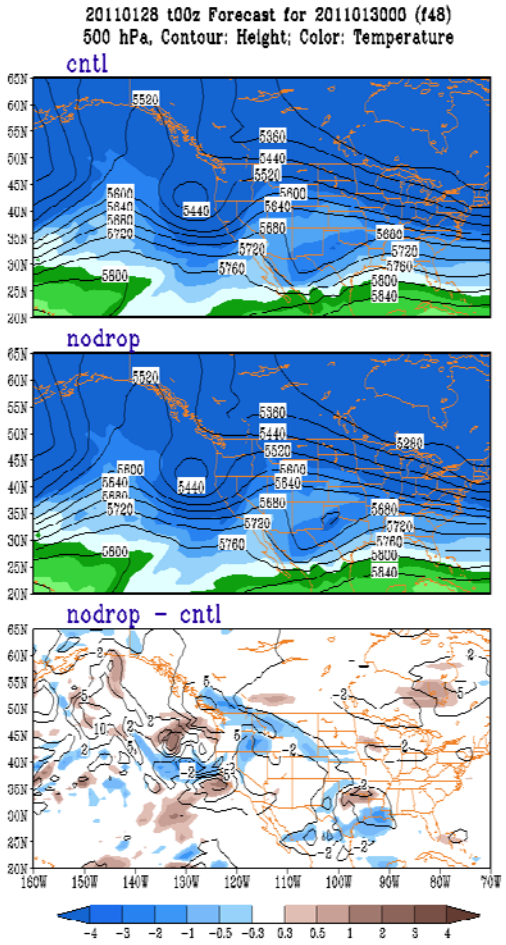
Precip and SLP

850hPa T and Z

500hPa T and Z







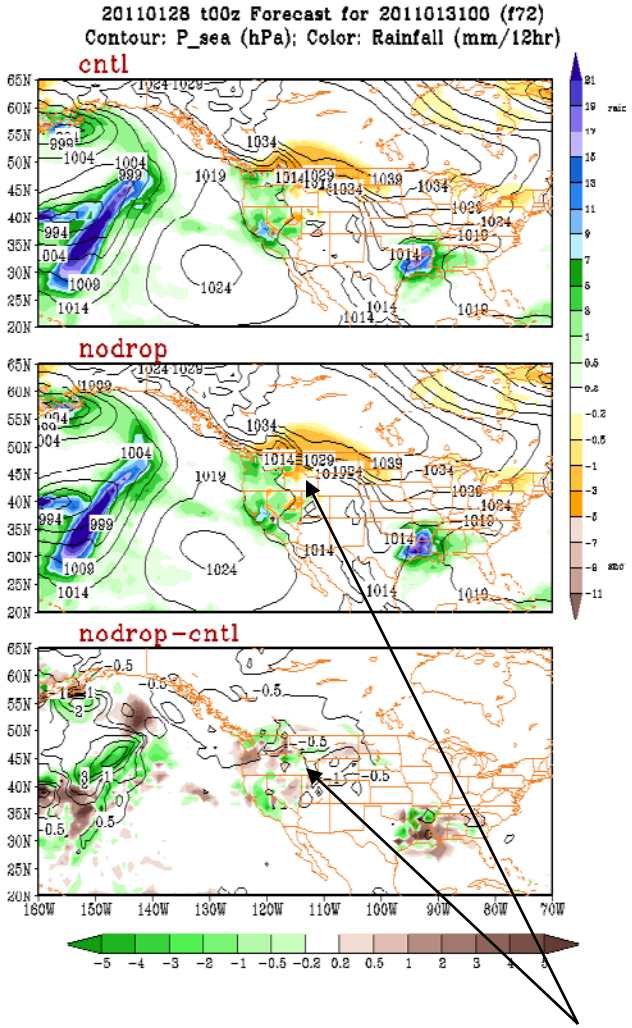
Differences near the northwest coast

Cases I: 2011012800 Cycle

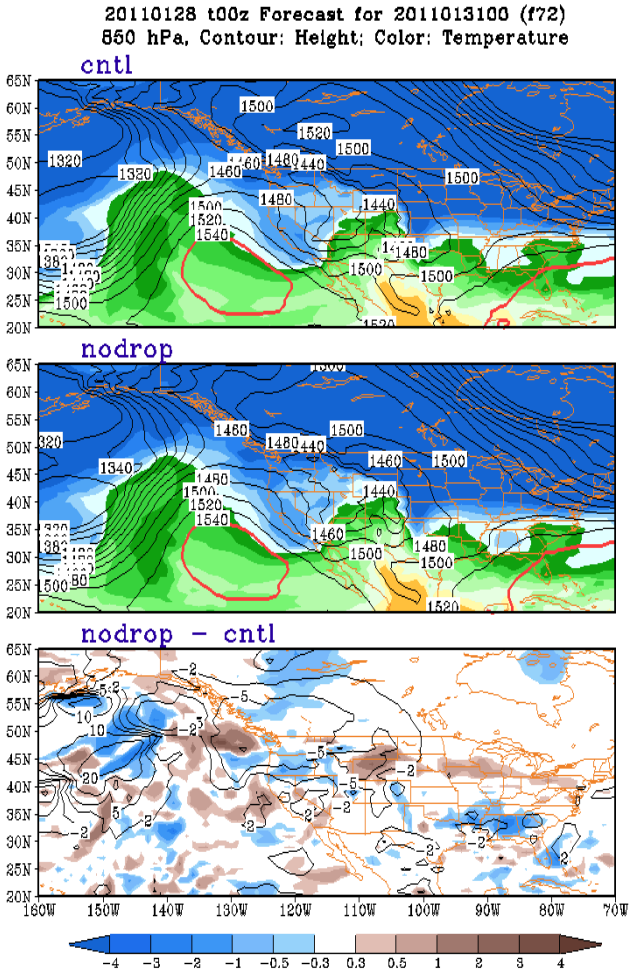
January 31 – February 2, 2011 Groundhog Day Blizzard

72-hr Fcst

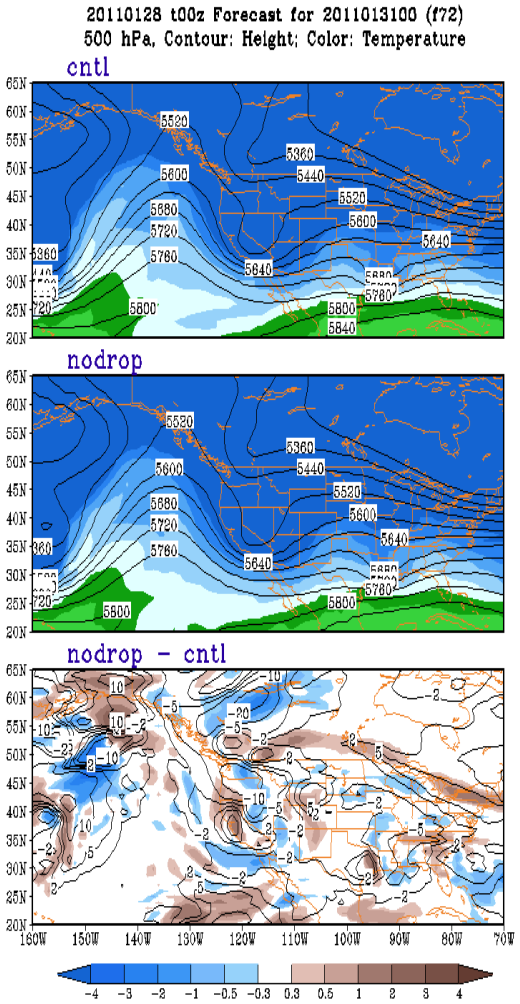
Precip and SLP



850hPa T and Z



500hPa T and Z



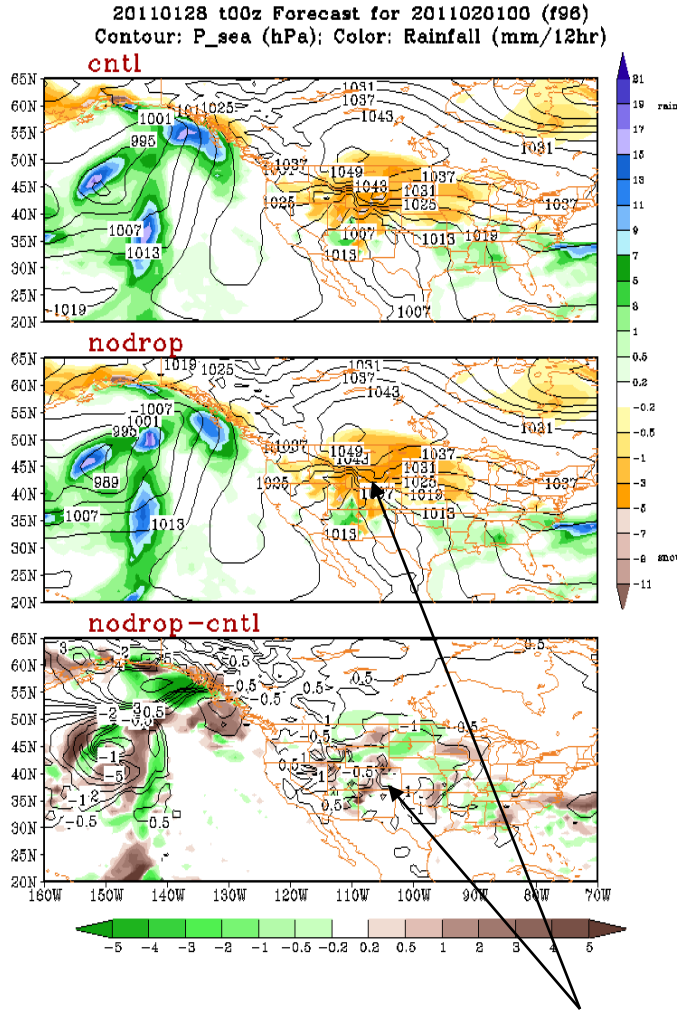
minor snowfall differences in Northwest

Cases I: 2011012800 Cycle

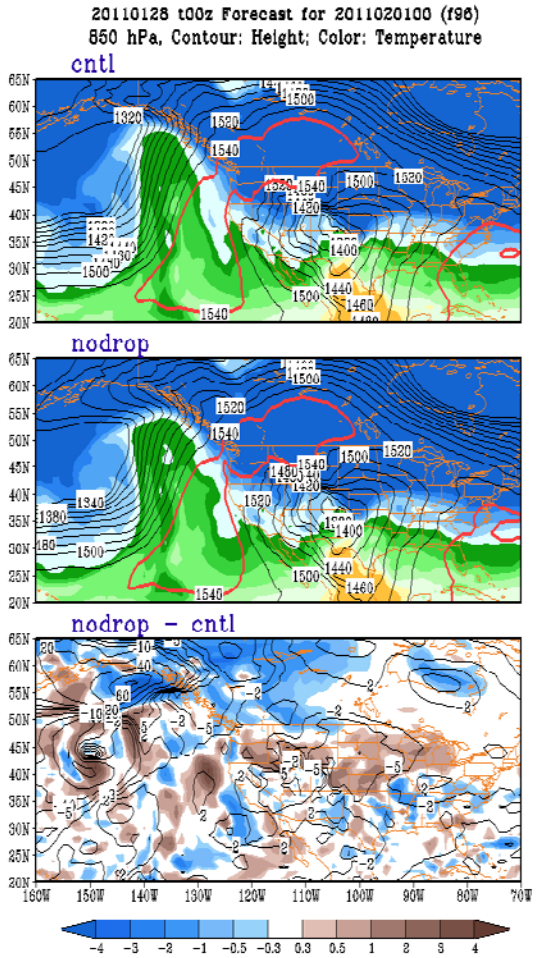
January 31 – February 2, 2011 Groundhog Day Blizzard

96-hr Fcst

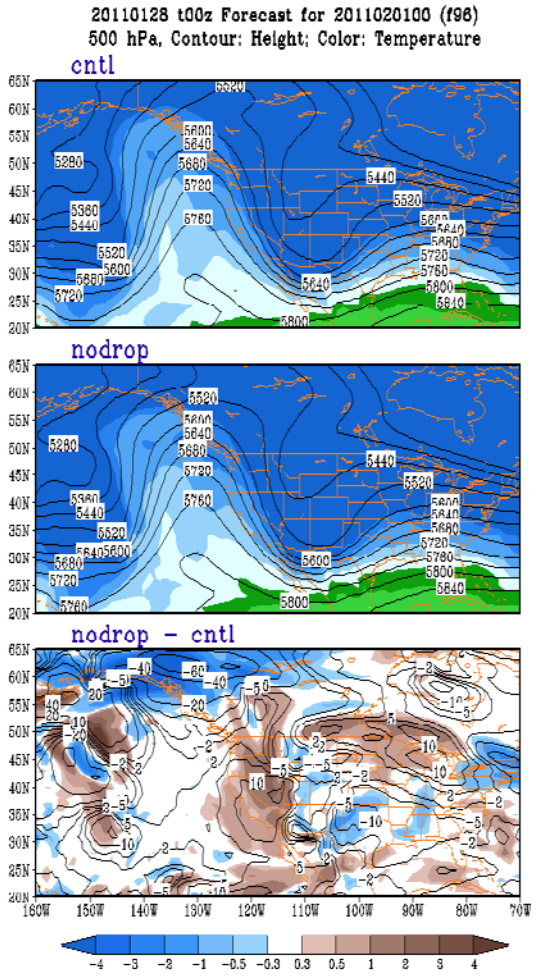
Precip and SLP



850hPa T and Z



500hPa T and Z



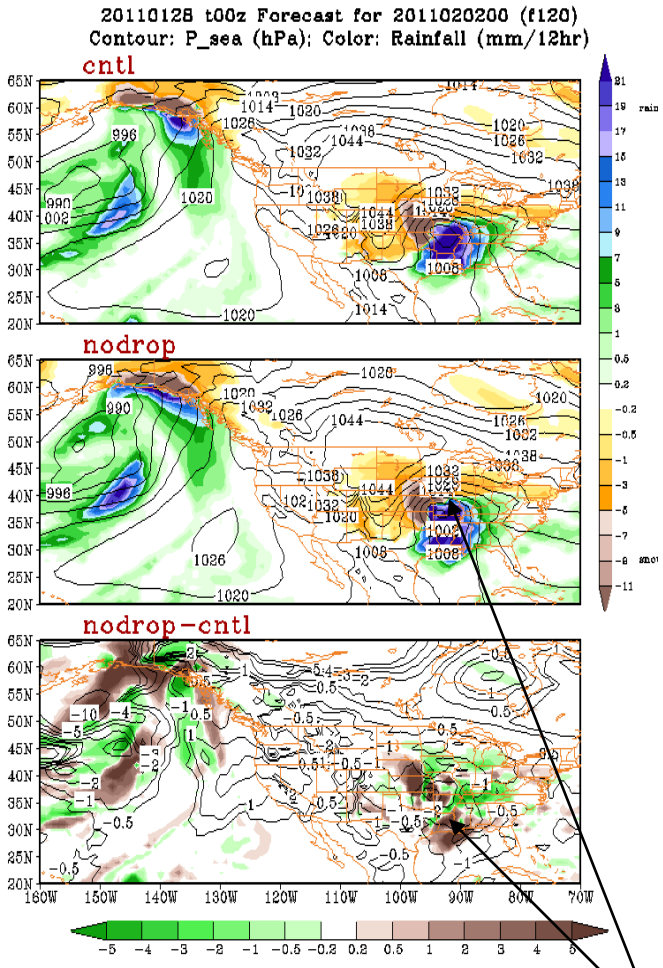
Snowfall differences are still negligible

Cases I: 2011012800 Cycle

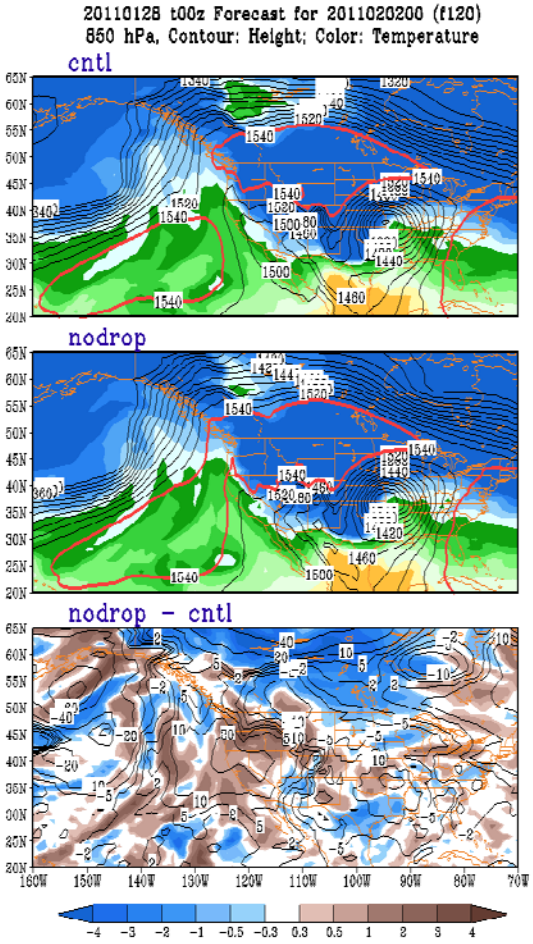
January 31 – February 2, 2011 Groundhog Day Blizzard

120-hr Fcst

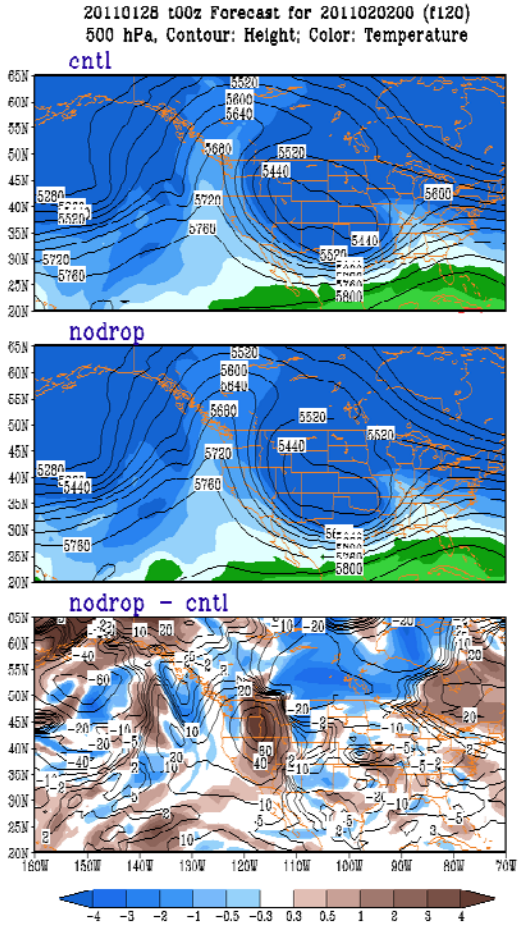
Precip and SLP



850hPa T and Z



500hPa T and Z



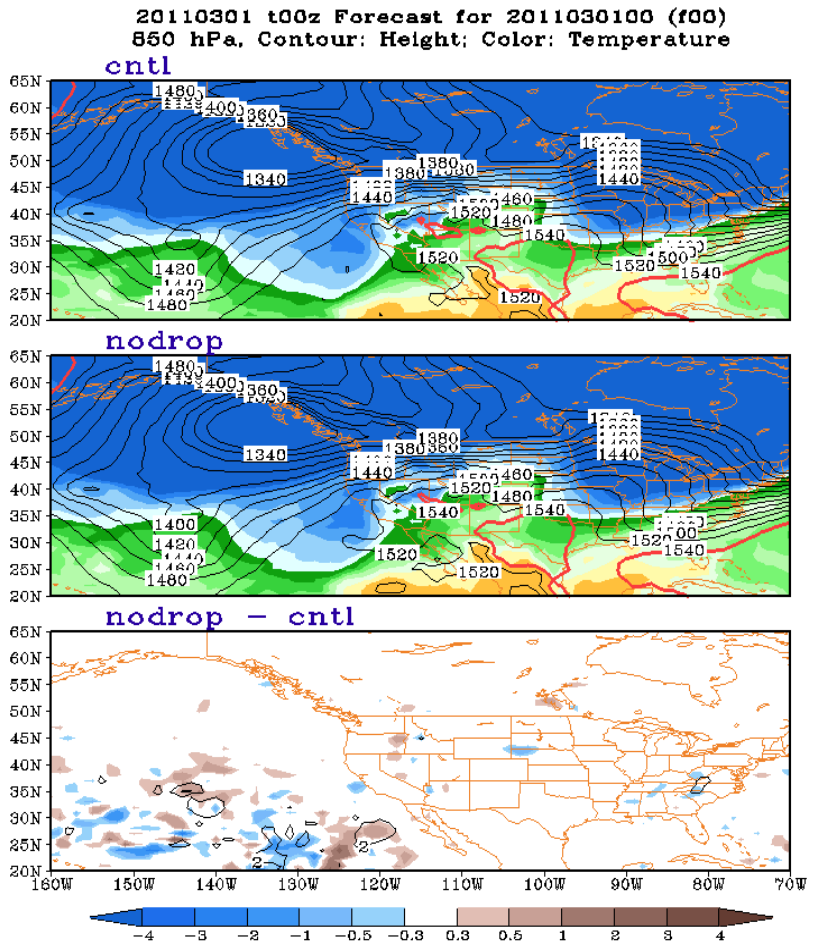
Rather large difference in precipitation; however, precip distribution pattern and the east-coast low pressure system aren't very much different.

Cases II: 2011030100 Cycle

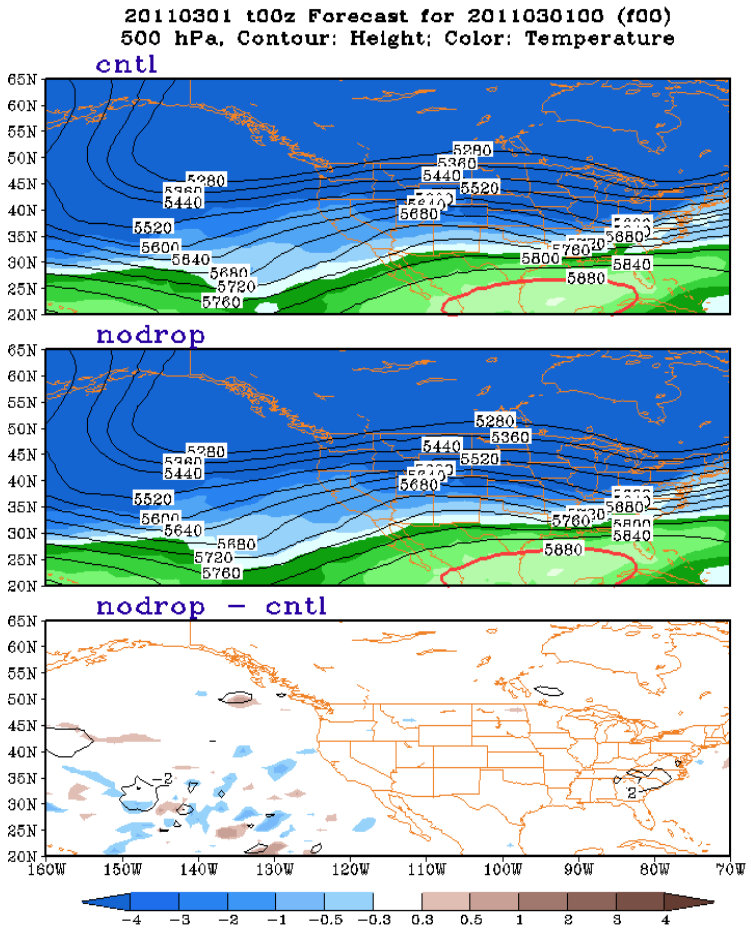
East Coast Storm

Analyses

850hPa T and Z



500hPa T and Z



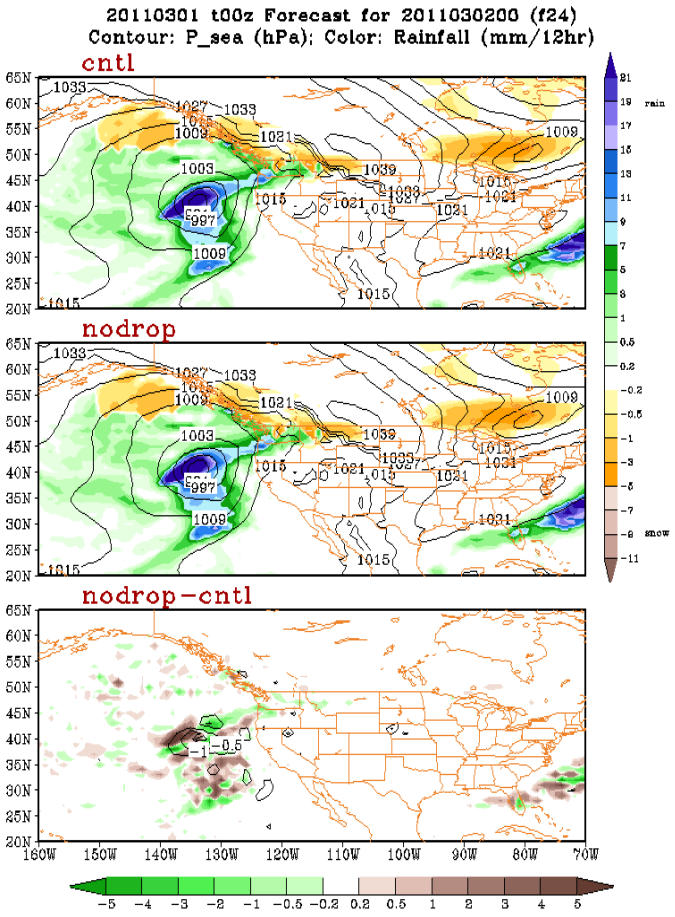
Notice the differences of a trough in eastern Pacific, presumably caused by the differences in dropsondes

Cases II: 2011030100 Cycle

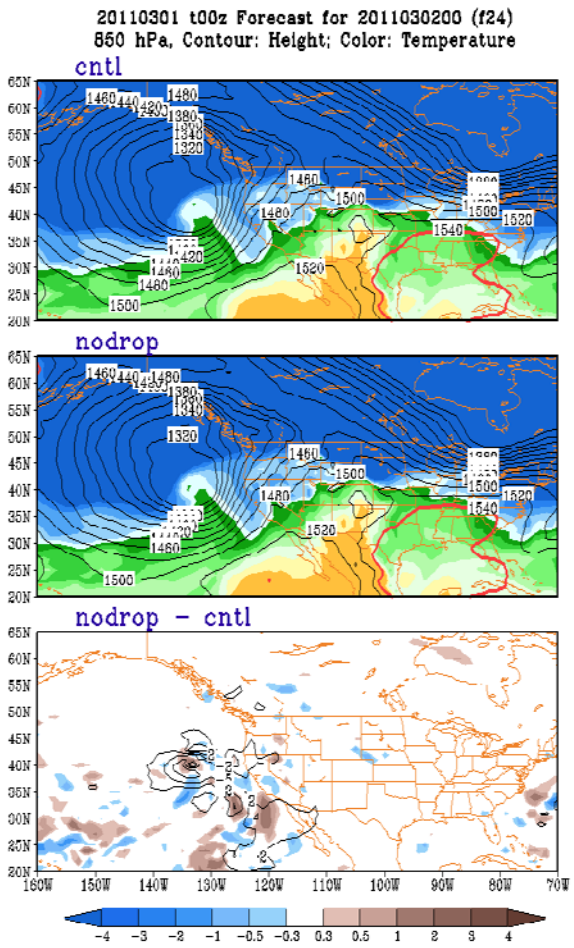
East Coast Storm

24-hr Fcst

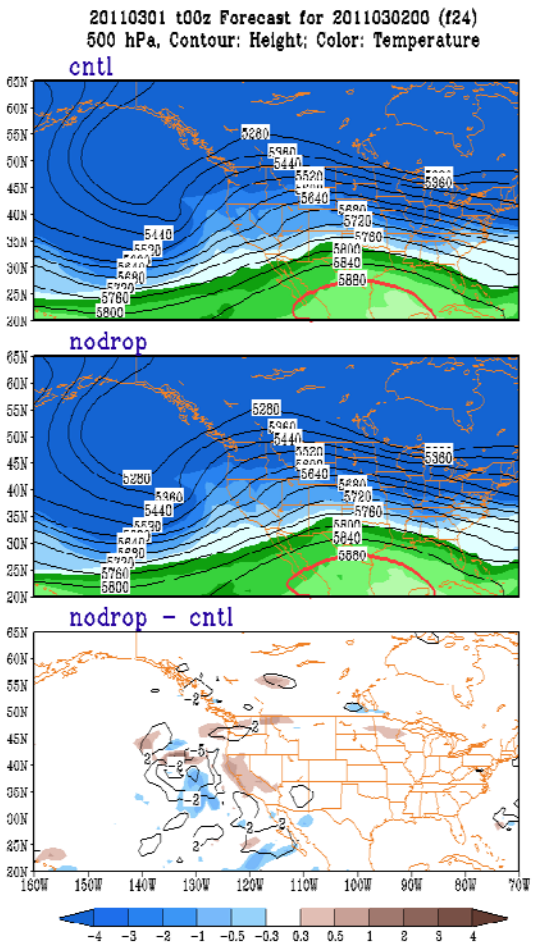
Precip and SLP



850hPa T and Z



500hPa T and Z



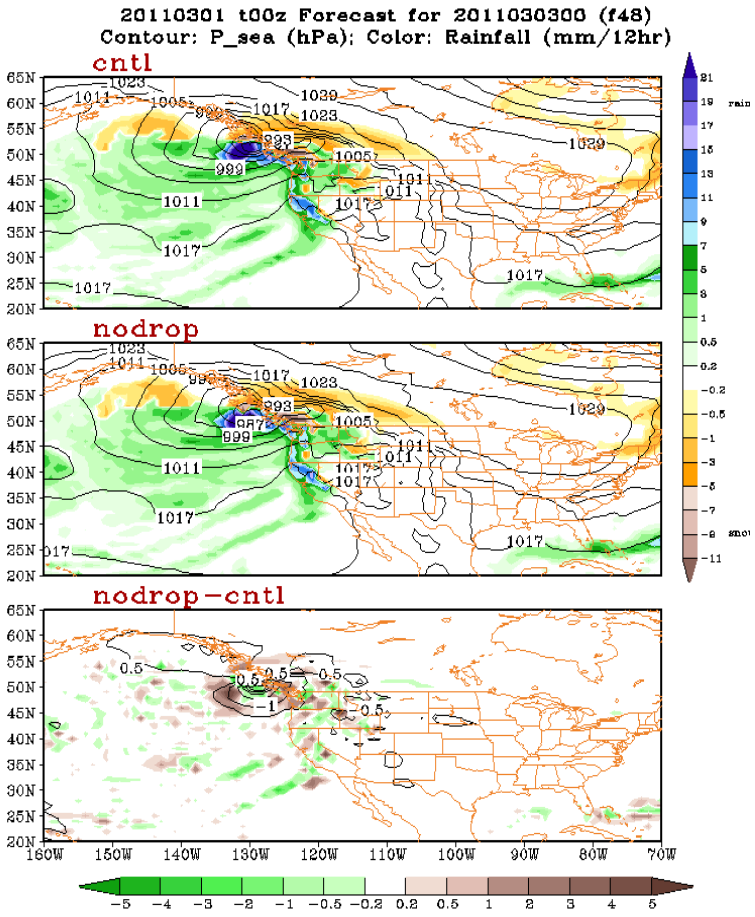
The “nodrop” forecast developed the low system slightly deeper than did the “cntl” forecast.

Cases II: 2011030100 Cycle

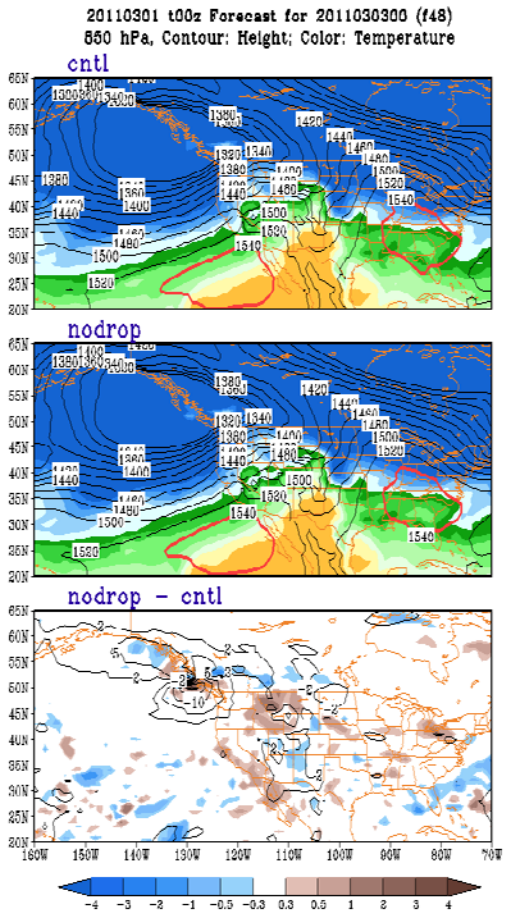
East Coast Storm

48-hr Fcst

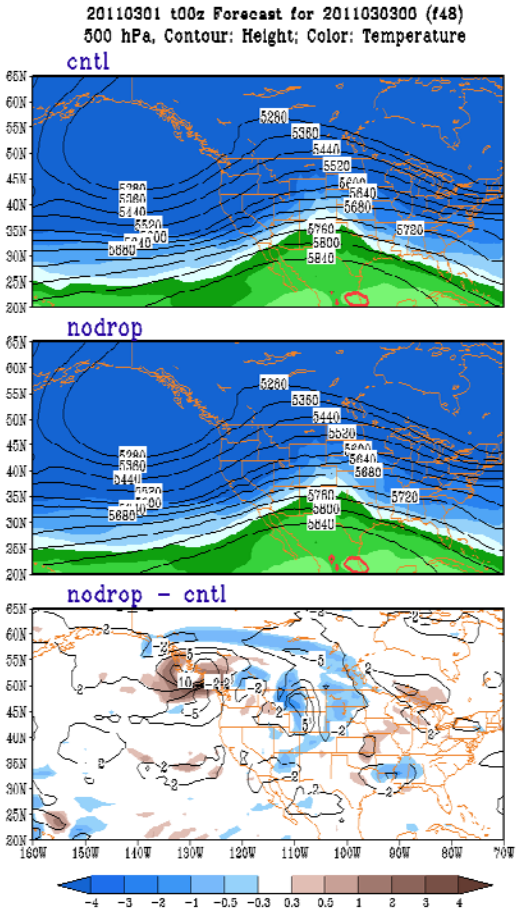
Precip and SLP



850hPa T and Z



500hPa T and Z



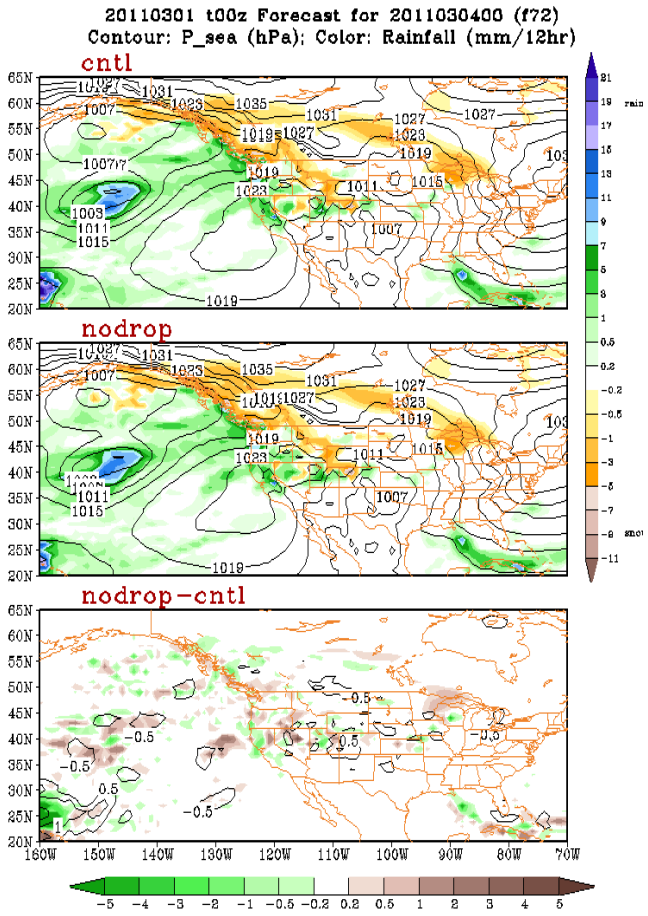
Minor differences in precipitation near the British Columbia coast.
“nodrop” had slightly less snow near the coast.

Cases II: 2011030100 Cycle

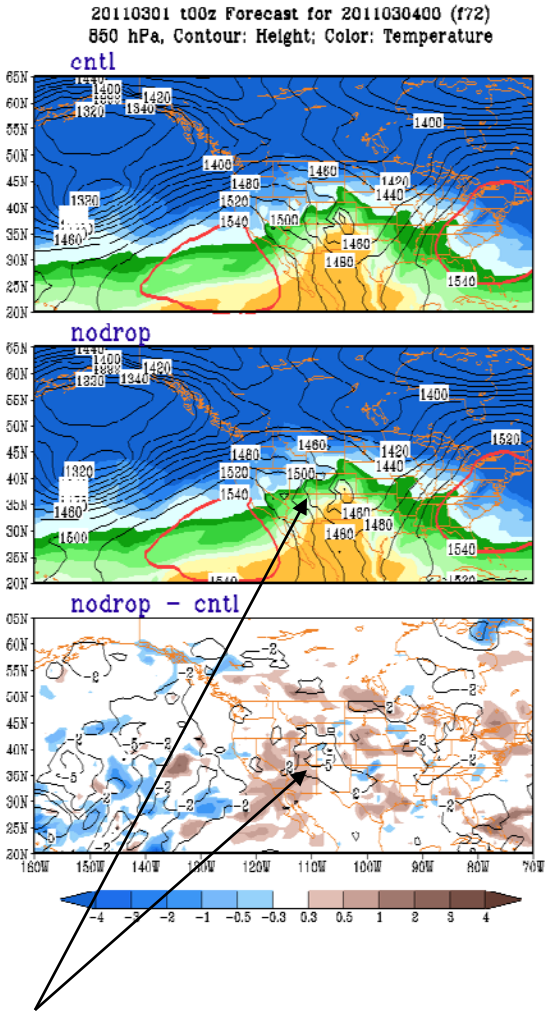
East Coast Storm

72-hr Fcst

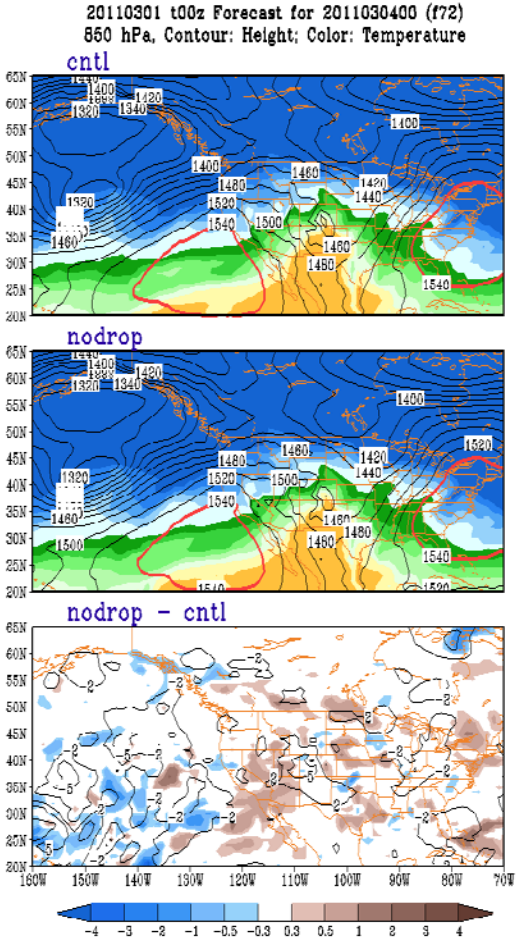
Precip and SLP



850hPa T and Z



500hPa T and Z



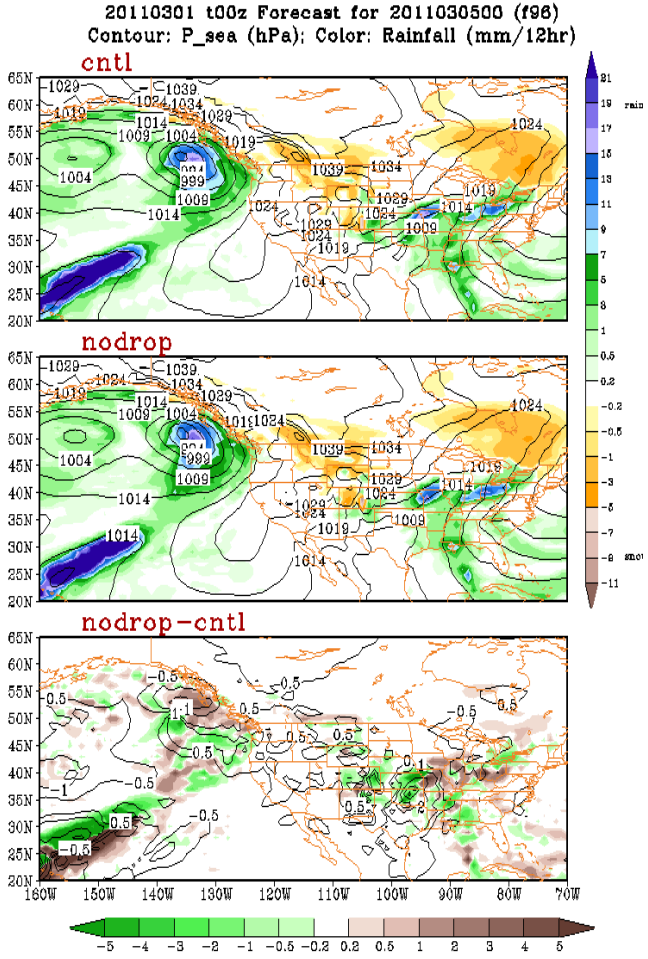
The trough moved to the east of Rockies

Cases II: 2011030100 Cycle

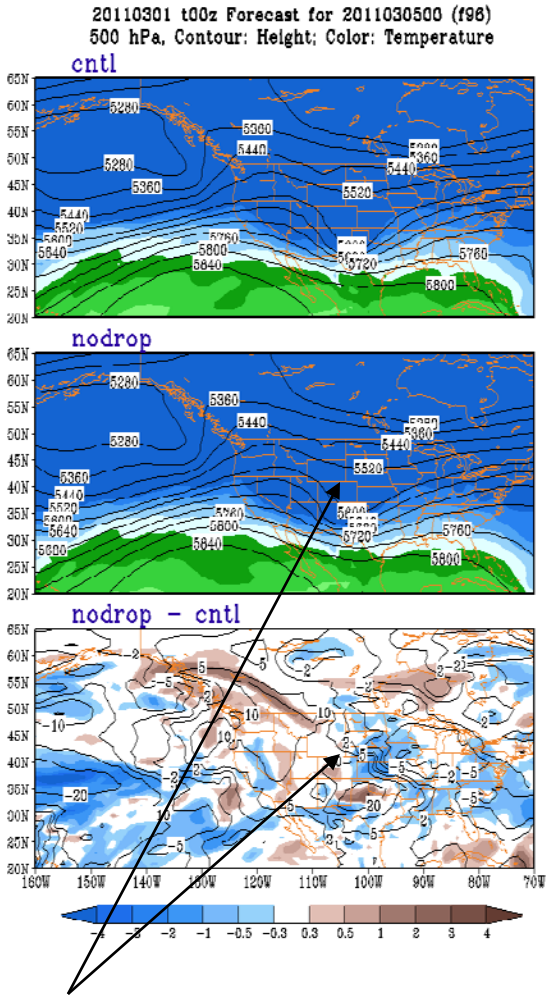
East Coast Storm

96-hr Fcst

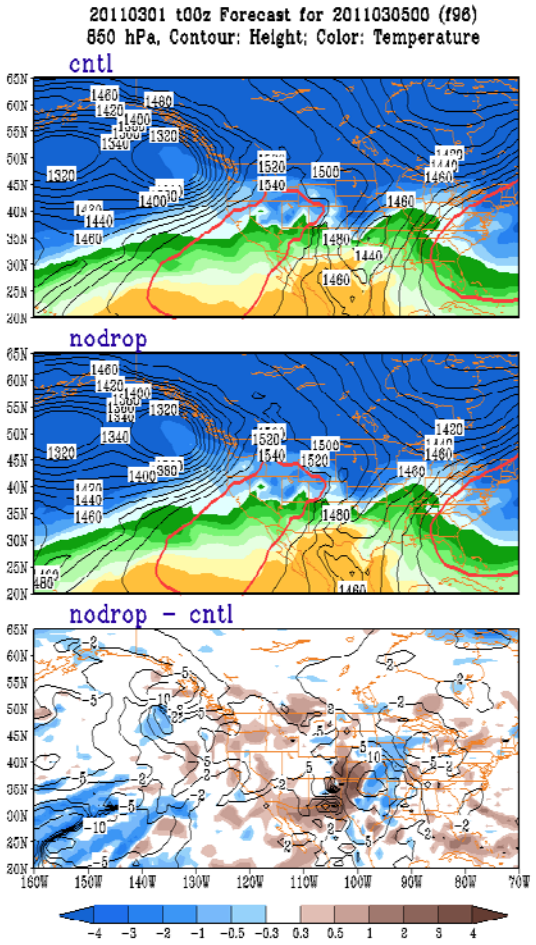
Precip and SLP



850hPa T and Z



500hPa T and Z



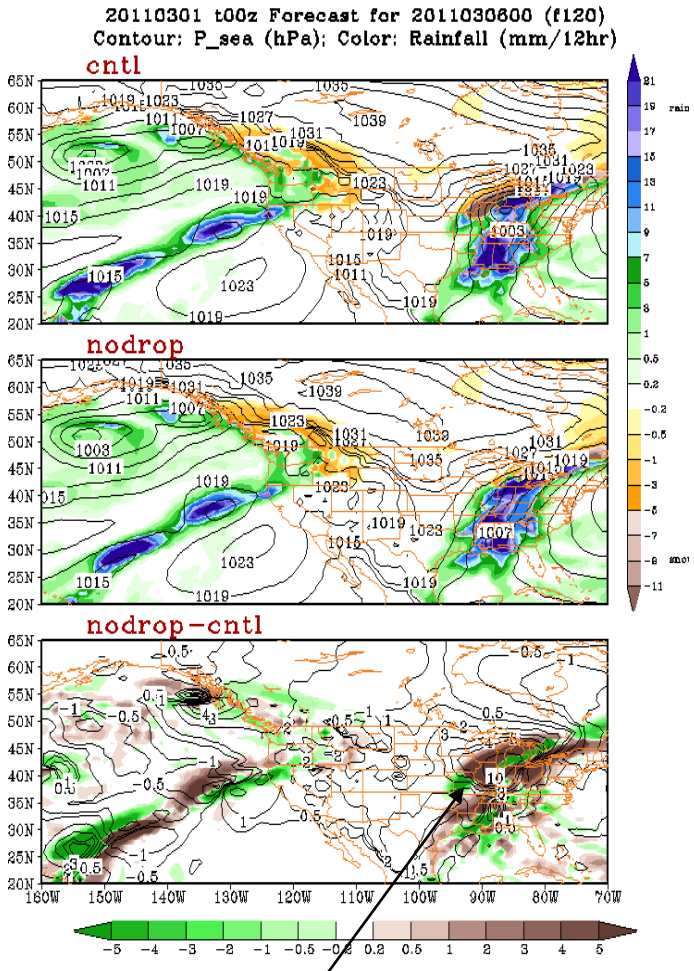
The trough moved to the central Great Plains

Cases II: 2011030100 Cycle

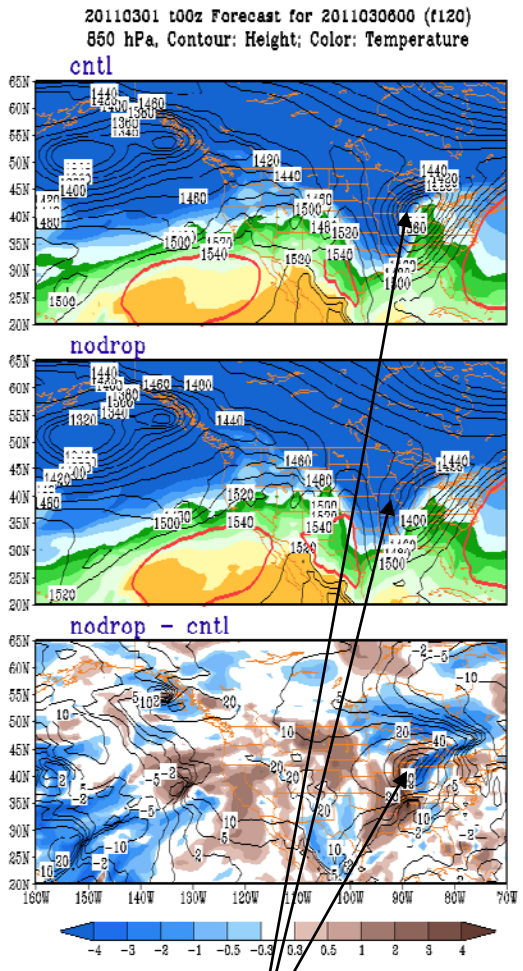
East Coast Storm

120-hr Fcst

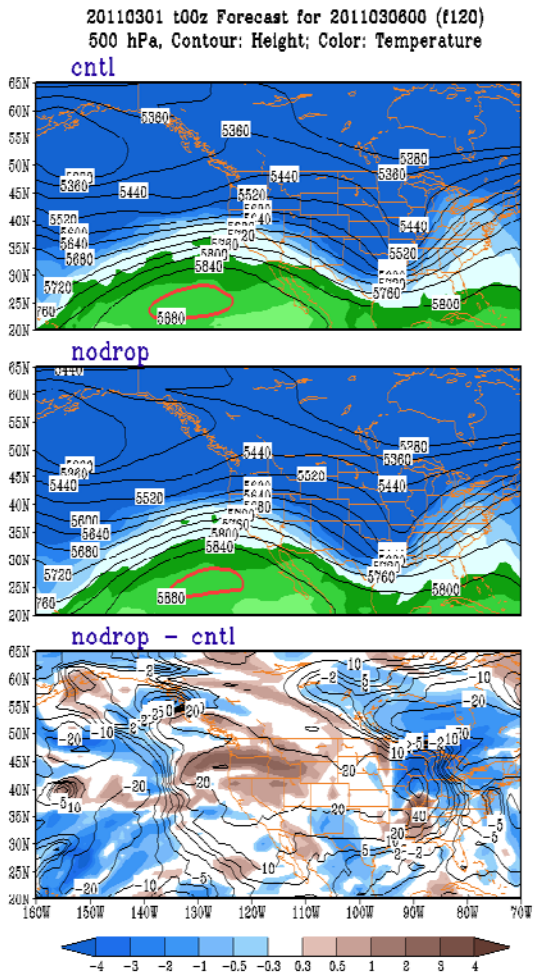
Precip and SLP



850hPa T and Z



500hPa T and Z



Large difference in east-coast precipitation

East Coast Low development differed

More information on project

- For background information about the WSR 2011 Project please visit http://www.emc.ncep.noaa.gov/gmb/targobs/wsr2011/wsr2011.html

- Decoded GRIB1 data are saved on NCEP CCS/Cirrus: /global/noscrub/wx24fy/WSR/ecmwf