

The NCAR CAM 3 simulation error of Arctic Sea Level Pressure

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1. Introduction

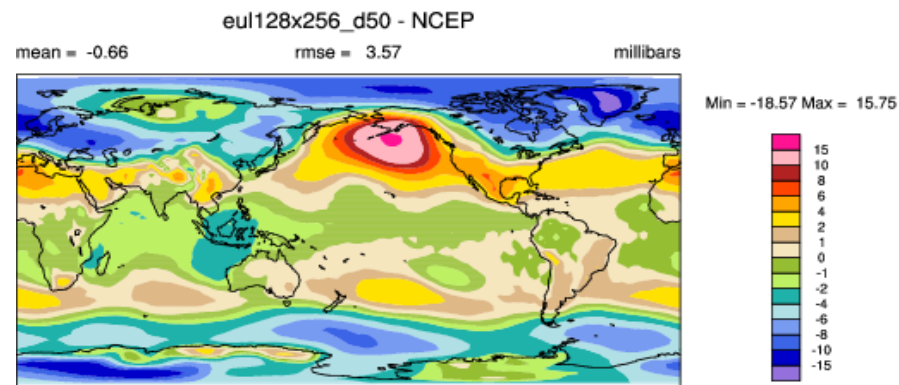
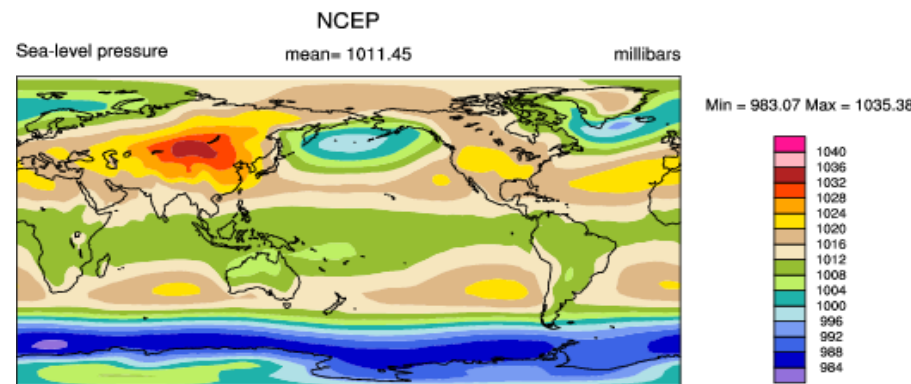
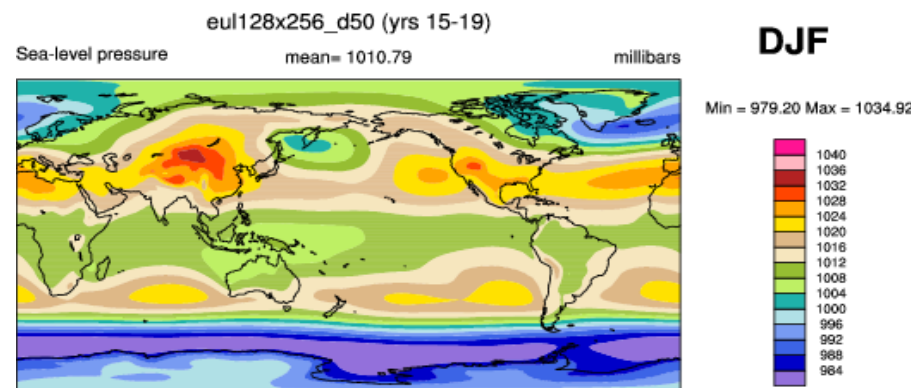
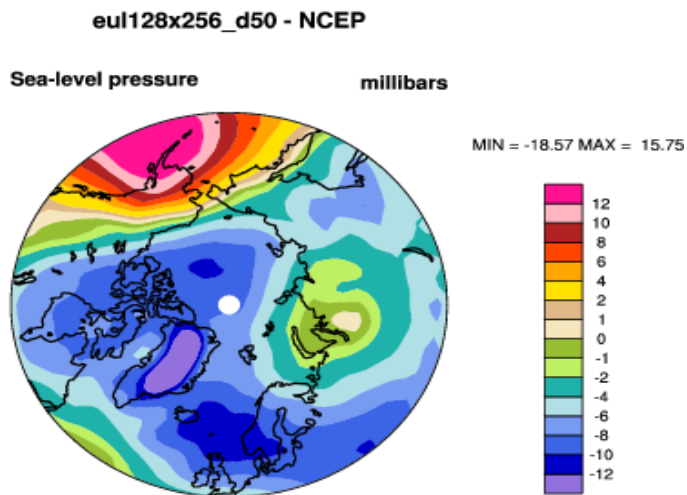
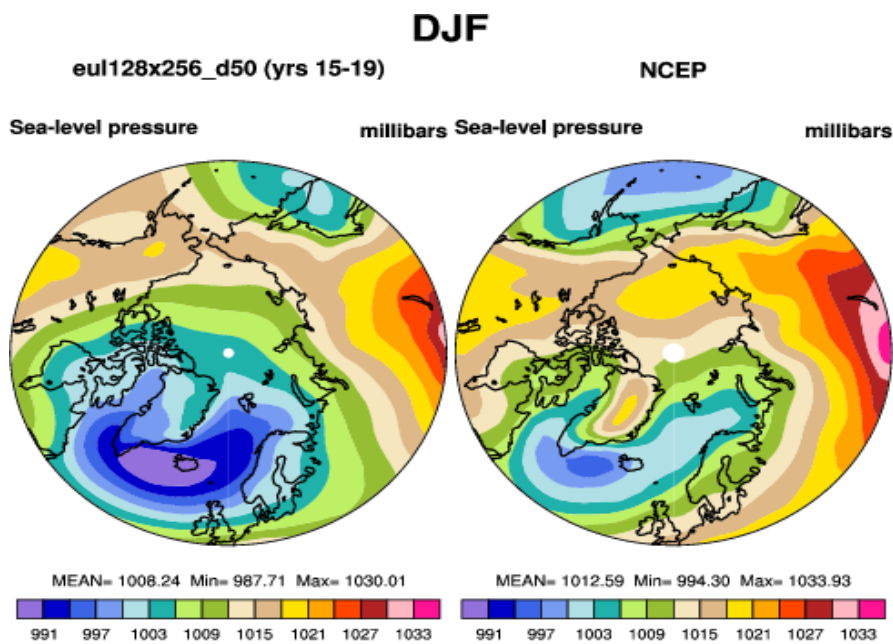
The current and previous versions of NCAR CCSM models have consistent simulation errors on the Arctic surface climate (like sea level pressure and low-level wind). And these errors also can lead to other important consequences, such as unrealistic spatial distribution and thickness of sea ice over Arctic.

In this study, we approach the origin of simulation errors by examining the remote mechanisms that affect the Arctic sea level pressure in both observation and model output. We only used uncoupled (CAM 3.0) model outputs, since the couple runs might introduce additional error brought by ocean model climate drift.

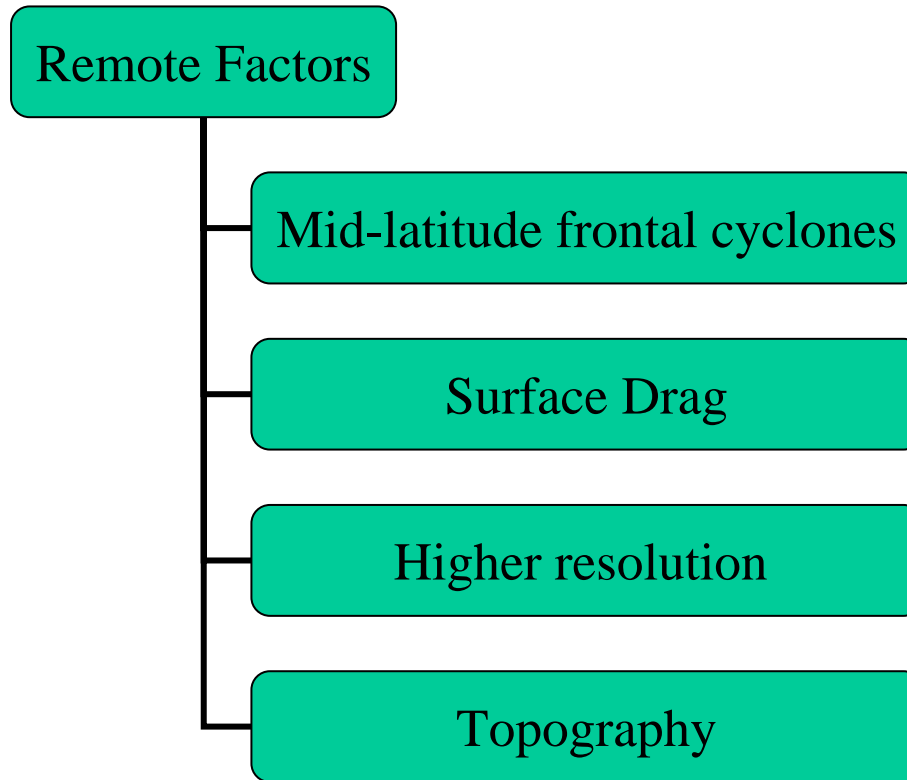
SLP bias (Figure 1) apparently shows the model simulates the Beaufort High too low. And the Icelandic low is much stronger and extends much further towards northern Europe.

The difference of Arctic SLP bias between CAM T85(eu128x256_d50) and NCEP/NCAR Reanalysis

-from <http://www.cesm.ucar.edu/models/atm-cam/>



Four remote candidate factors for explaining the model bias in SLP



Rationale for the remote factors

- **Frequency and Intensity of mid-latitude frontal cyclones:** The stationary wave forced by transient eddy fluxes and associated diabatic heating extends into the Arctic region. Compared to observations, recent versions of NCAR models tend to have too many and too intense frontal cyclones.
- **Surface drag:** Surface roughness and boundary layer drag of Alaska and Eastern Siberia may be too small (no difference between flat plain and mountainous regions) allowing too much low-level flow between Arctic and north Pacific.
- **Topography:** Similar to surface drag in that interaction with the Pacific may be too easy. In this case, ‘small’ mountain ranges in Eastern Siberia and Alaska (such as the Brooks range) are poorly resolved including their envelope height.
- **Resolution in the spherical surface:** Model (grid) may be tuned for middle latitudes and tropics, higher resolution in Arctic may cause misrepresentation of SLP (and other variables) over Arctic region.

2. Data

Observed data

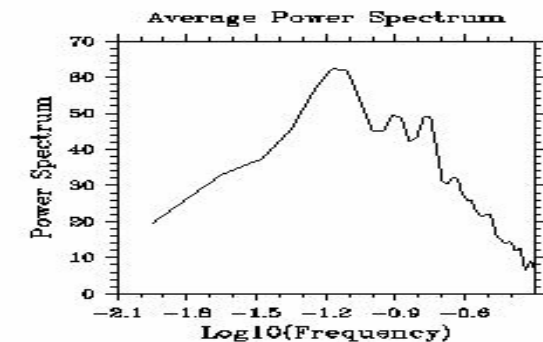
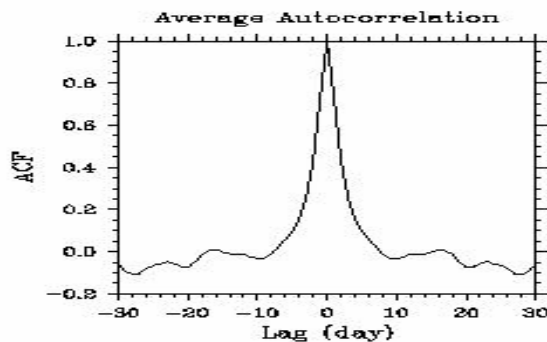
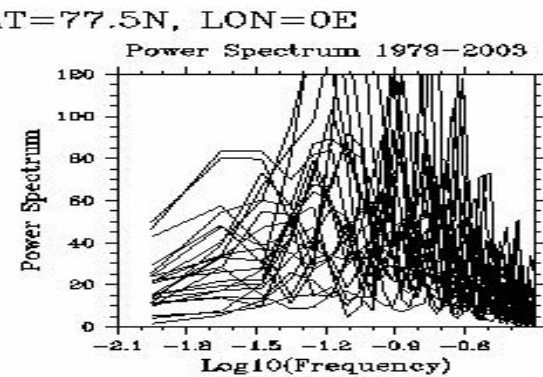
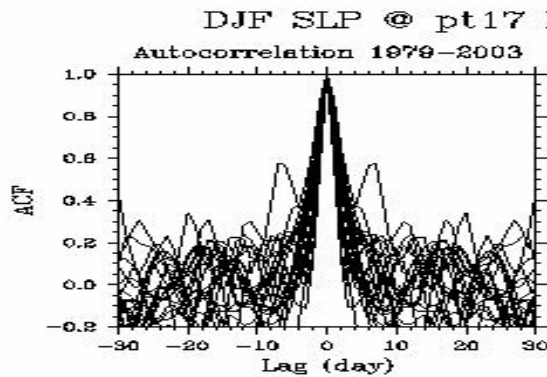
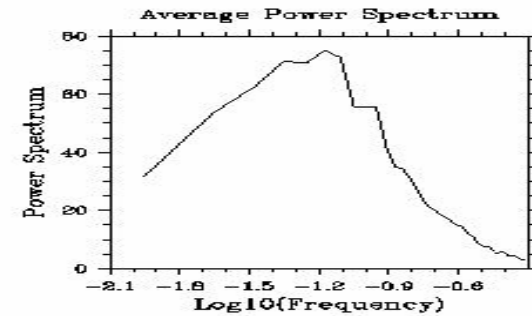
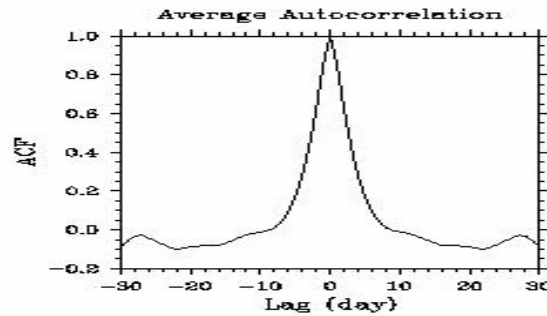
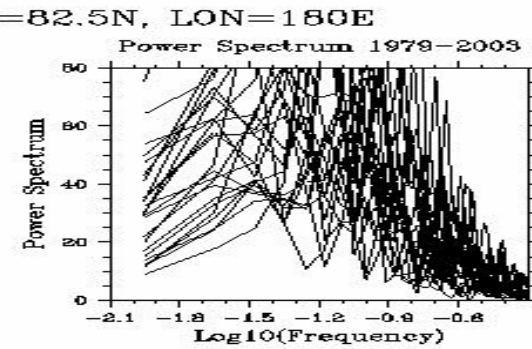
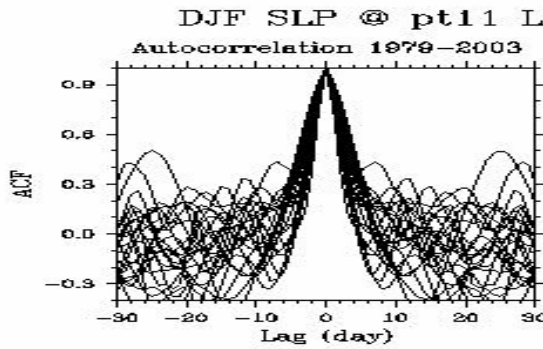
In this study we used NCEP/NCAR reanalysis daily average as our observational data. The time period is from 1979 to 2003. The long-term daily mean of that period has been subtracted. In order to pick up the low-frequency signals, a Lanczos filter with 10-day cut-off frequency has been applied. In addition the data has been subsampled every 5th day. Sea Level Pressure (SLP), Skin Temperature (skinT), and 500 mb Geopotential height (Z500) have been examined.

Model data

For the model output, we used AMIP T85 simulation from 1979-2000 of CAM3. Similarly, the data was filtered and subsampled. SLP, skinT, Z500

Filtering

- Monthly data show remote associations
- Daily data without filtering:
 - autocorrelations mainly local
 - remote correlations with other variables small.
 - power spectra have sharp drop or relative min near 10d ($\log(f)=-1$)
- Lanczos filter using 10-day cut-off
 - long enough to remove higher frequencies,
 - Short enough to allow lag/lead testing



3. Early Results and Discussions

- The points near the Beaufort high have much stronger association with the tropical Pacific and North Pacific in CAM 3 than in observation. The kind of contrast is even more pronounced in the lag-correlation.
- The result above might be explained by our hypotheses about the surface drag and topography. In CAM 3, the small surface roughness and low mountain barriers over Alaska and Eastern Siberia will allow extra North Pacific frontal cyclones come further into the Arctic region to lower the SLP over the Beaufort Sea.

Early Results and Discussion (cont.)

- As we seen the ring shape pattern in SLP bias, SLP autocorrelation in CAM 3 also has this pattern. This has not been seen in observation. This might indicate the forcing of a spherical harmonic due to the higher resolution applied to Arctic region in the model
- The tropical correlation (eg. skinT) in CAM 3 are stronger and little different from 5 to -5 days lag, suggesting slow frequency relation that is stronger in model.
- For the testing point near GIN sea , the pattern is opposite with the points discussed above. The negative correlation across mid-latitude Atlantic and over southern Europe is much strong in NCEP reanalysis than in CAM 3. However, the model still have strong ring pattern all over the tropics.

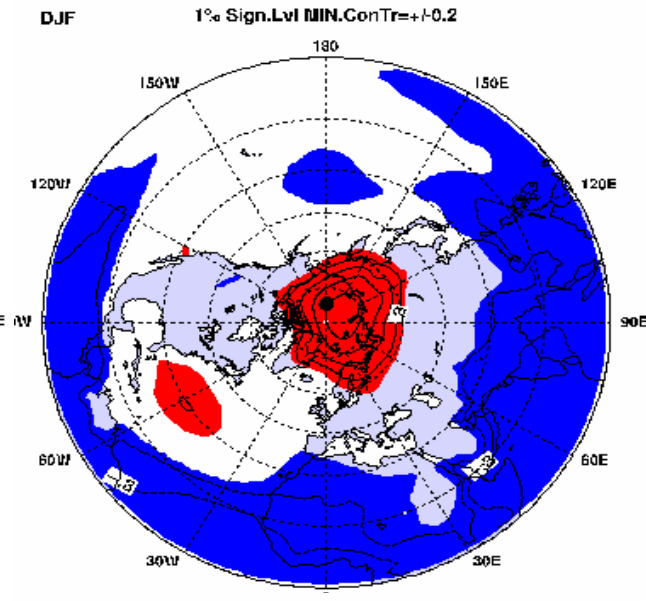
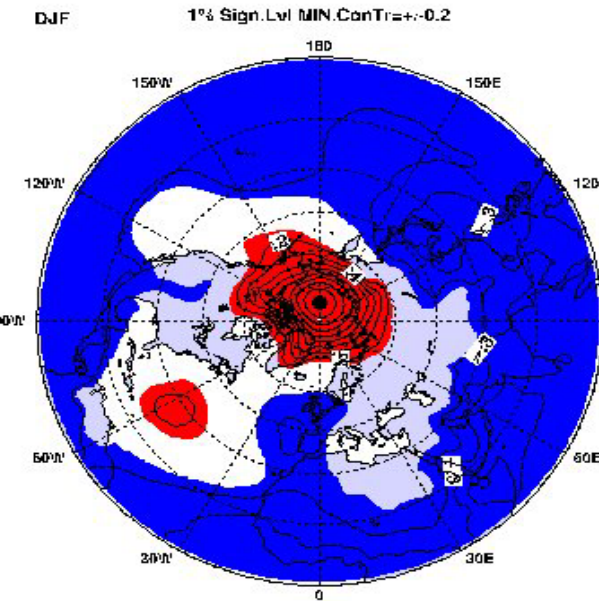
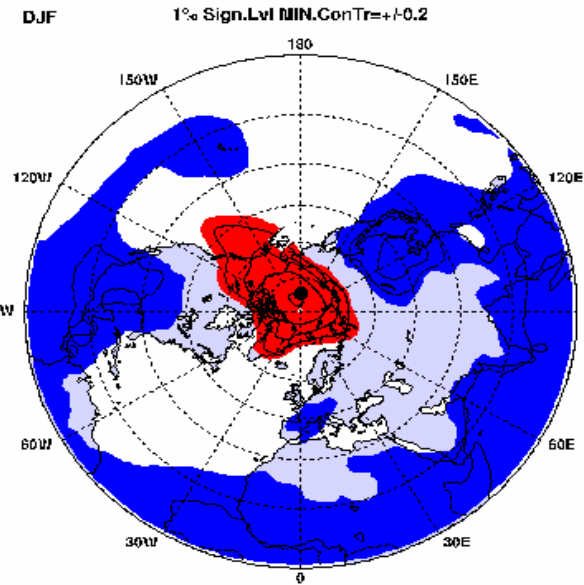
SLP auto-corr at Pt 11

CAM 3 has stronger tropical connection

CAM3 SLP(da) AutoCorrelation 5days Lag

CAM3 SLP(da) AutoCorrelation 0days Lag

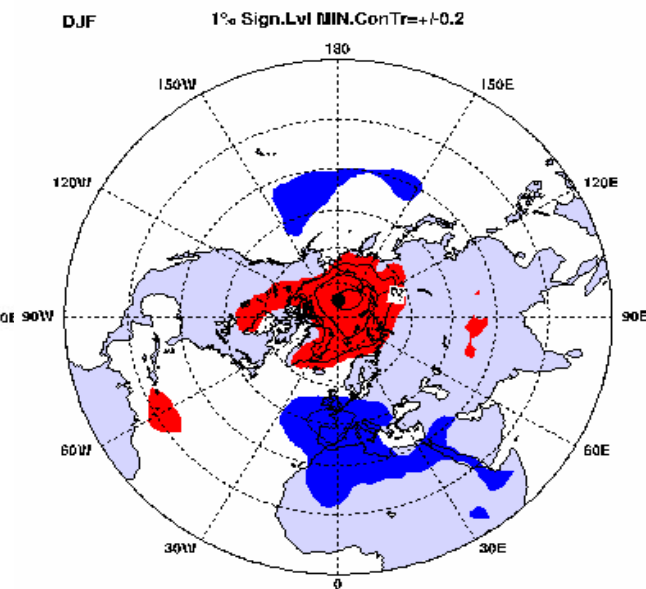
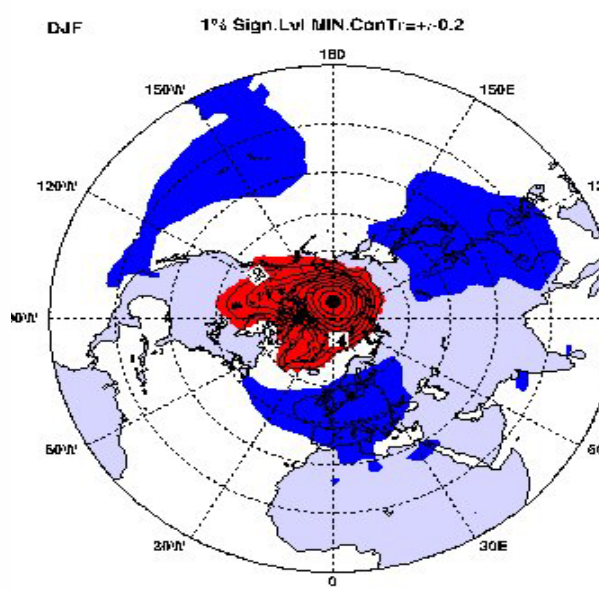
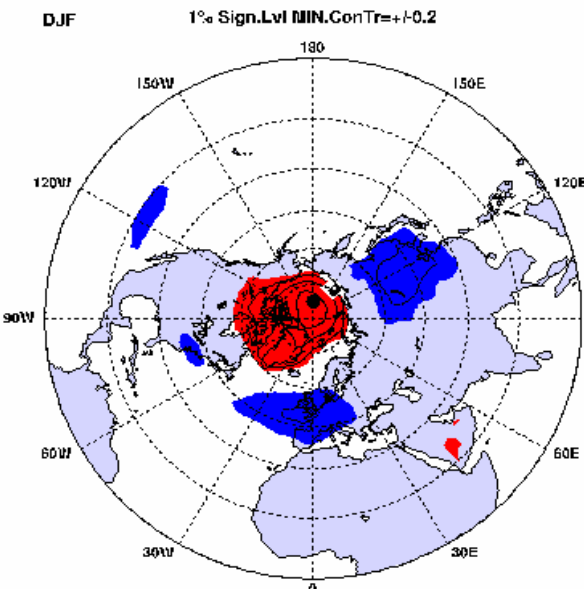
CAM3 SLP(da) AutoCorrelation -5days Lag



NCEP SLP(da) AutoCorrelation 5days Lag

NCEP SLP(da) AutoCorrelation 0days Lag

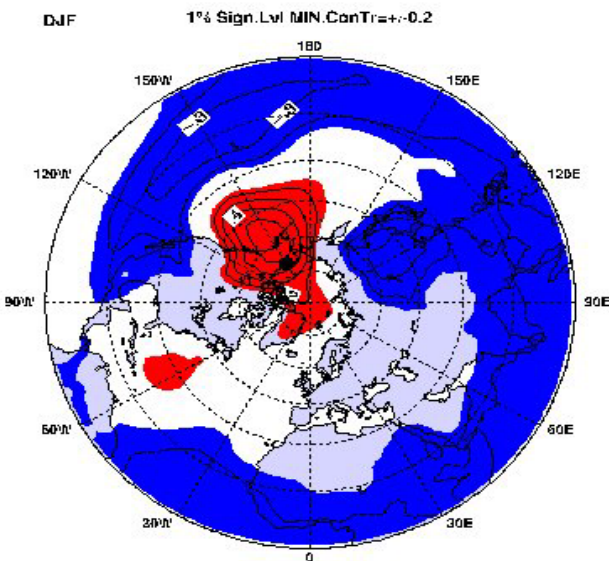
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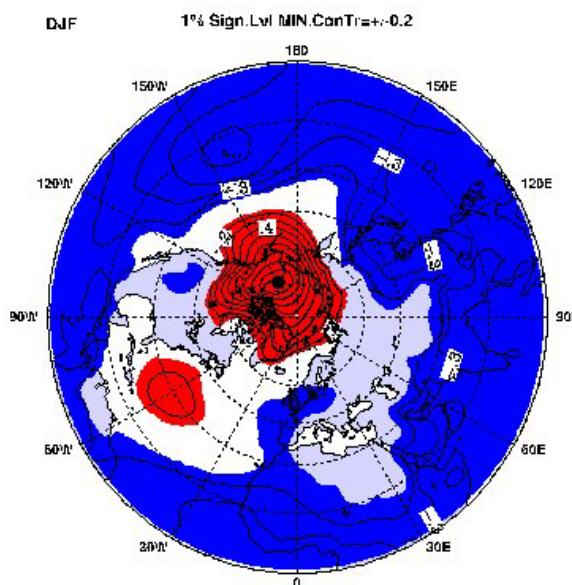
SLP auto-corr at Pt 5

Much stronger connection to N Pacific than in NCEP

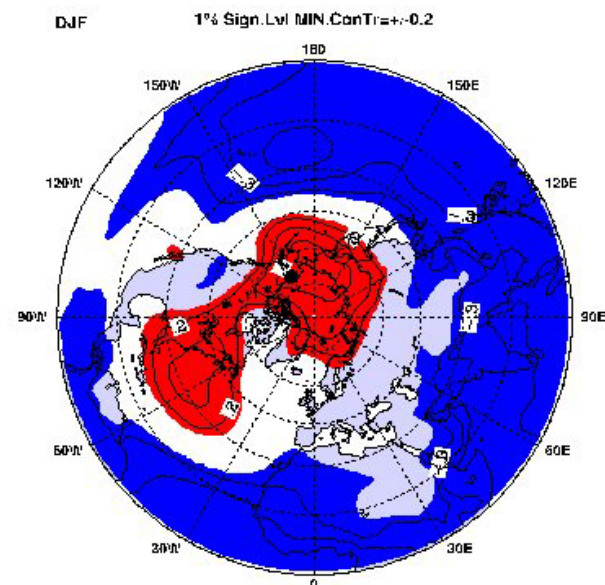
CAM3 SLP(da) AutoCorrelation 5days Lag



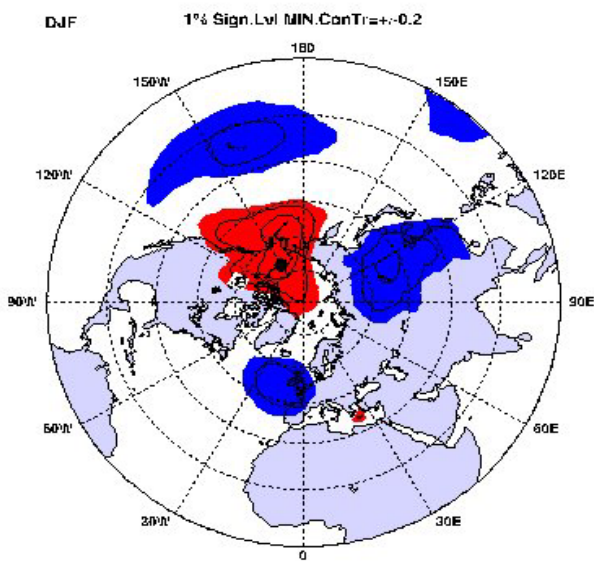
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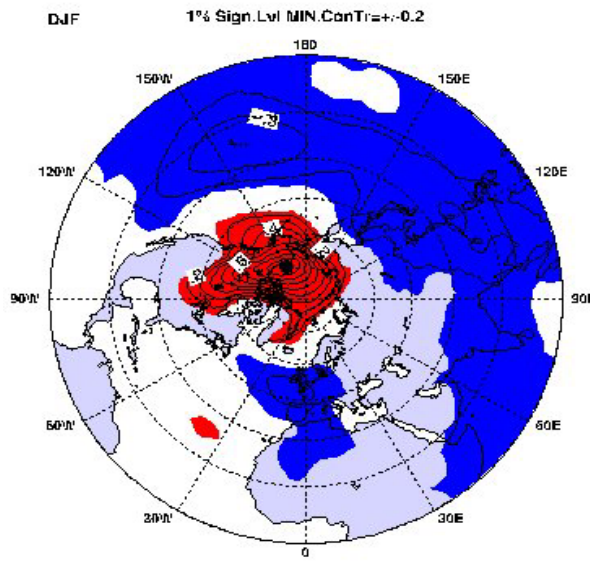
CAM3 SLP(da) AutoCorrelation -5days Lag



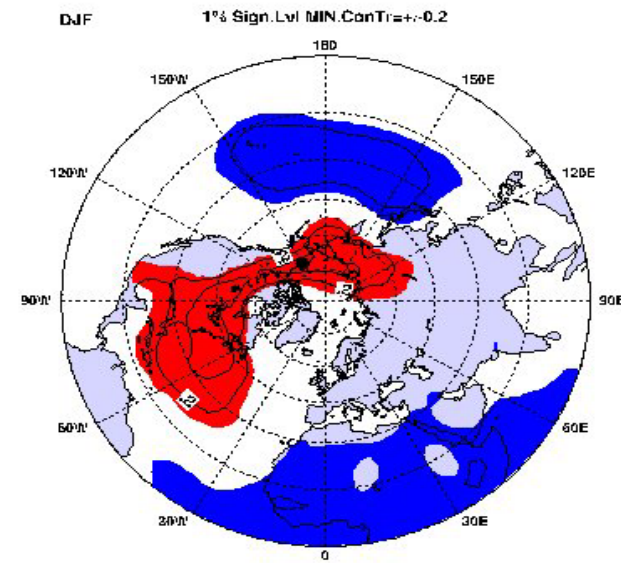
NCEP SLP(da) AutoCorrelation 5days Lag



NCEP SLP(da) AutoCorrelation 0days Lag



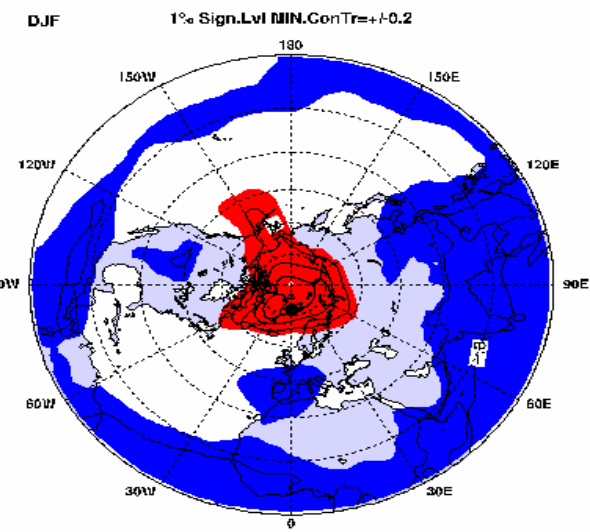
NCEP SLP(da) AutoCorrelation -5days Lag



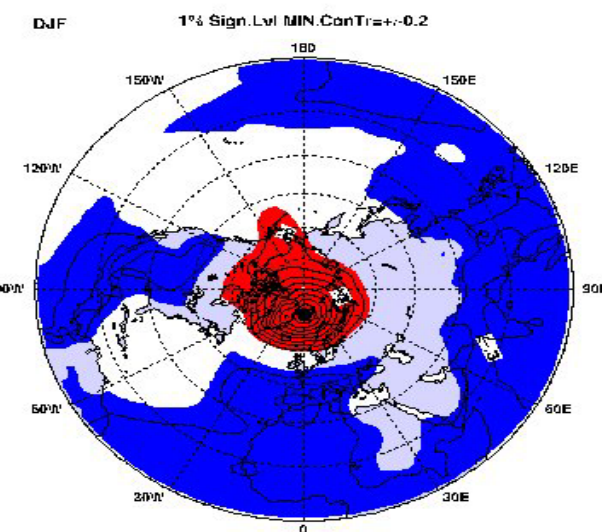
SLP auto-corr at Pt 17

NCEP has stronger mid-lat connection

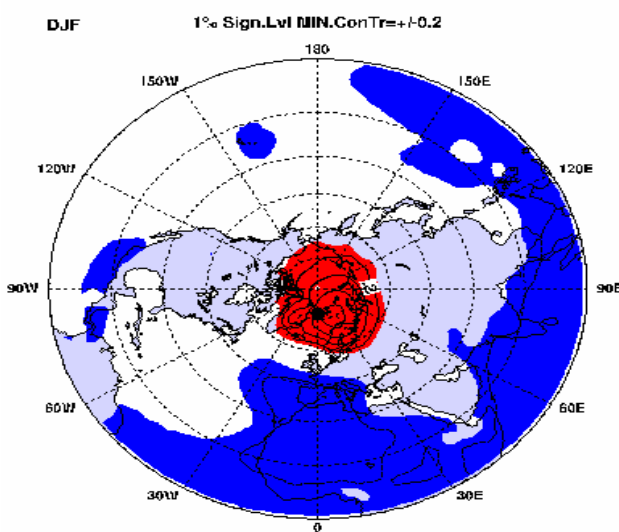
CAM3 SLP(da) AutoCorrelation 5days Lag



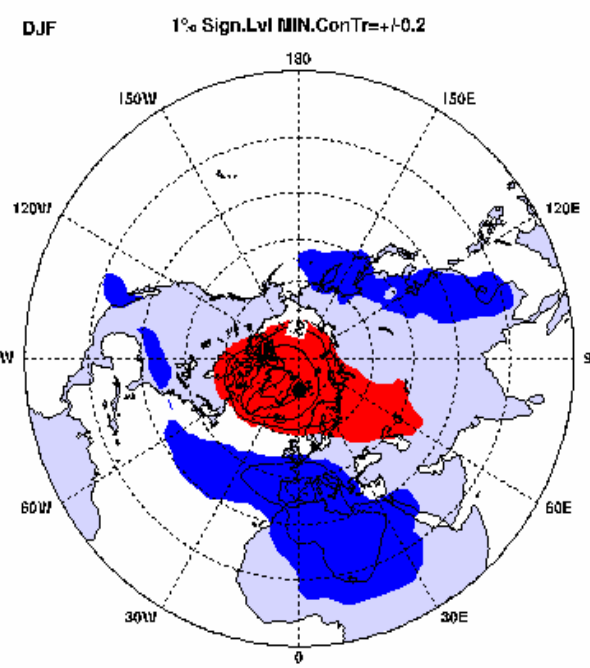
CAM3 SLP(da) AutoCorrelation 0days Lag



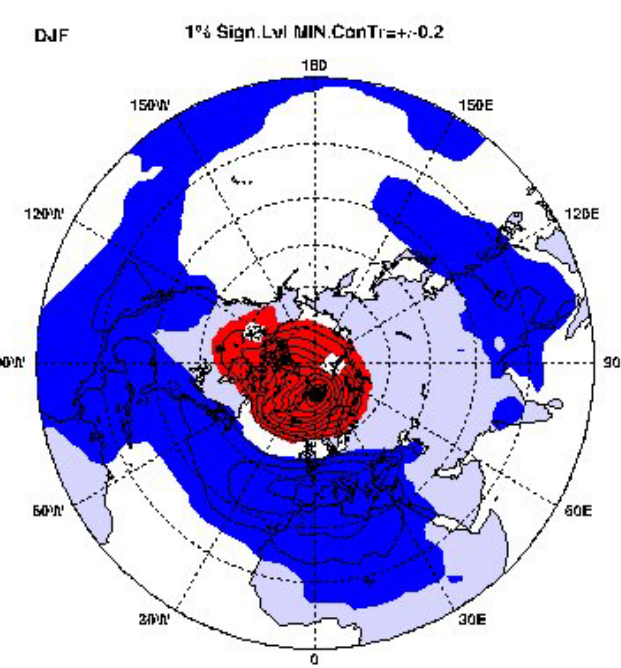
CAM3 SLP(da) AutoCorrelation -5days Lag



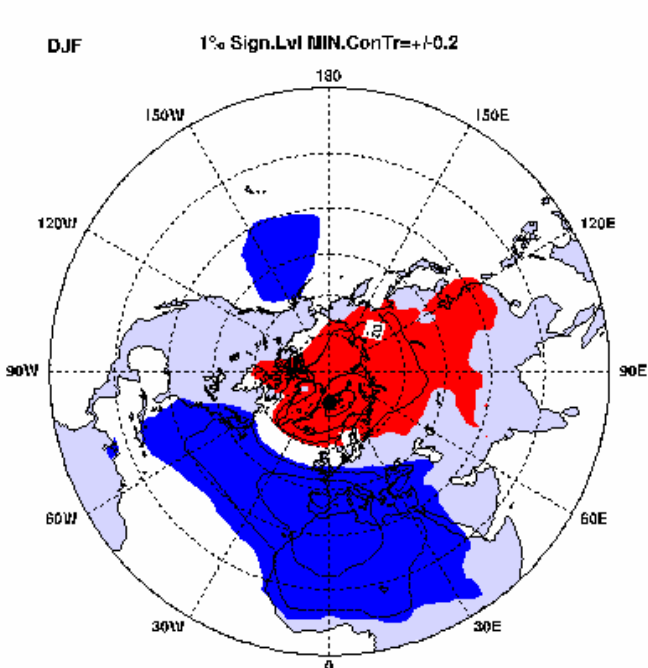
NCEP SLP(da) AutoCorrelation 5days Lag



NCEP SLP(da) AutoCorrelation 0days Lag



NCEP SLP(da) AutoCorrelation -5days Lag

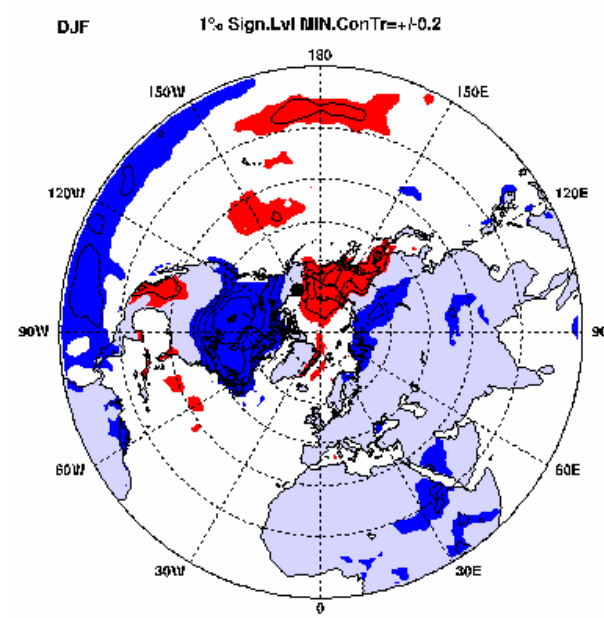
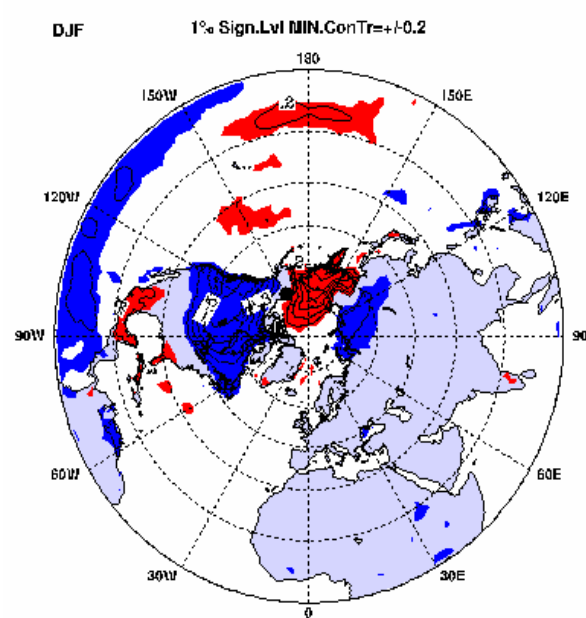
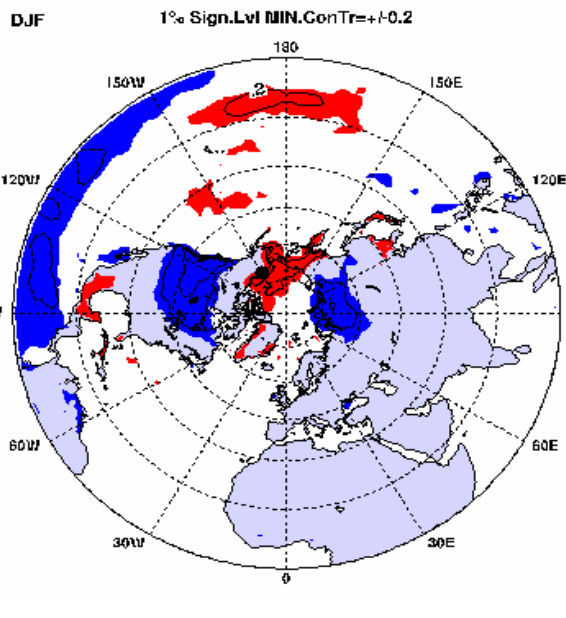


SLP corr-with SkinT at Pt 3 with tropical links in model, but not in obs.

CAM3 SLPda~SkinTda Correlation 5days Lag

CAM3 SLPda~SkinTda Correlation 0days Lag

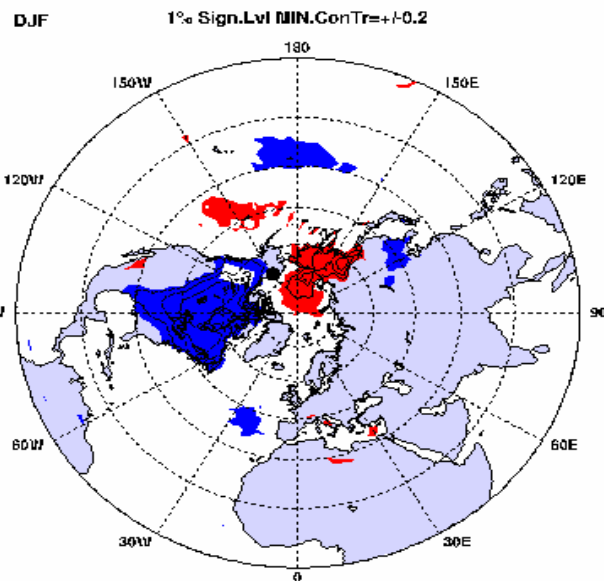
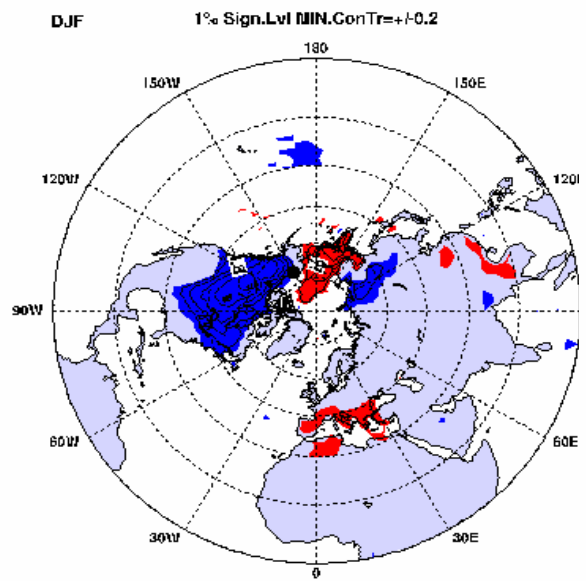
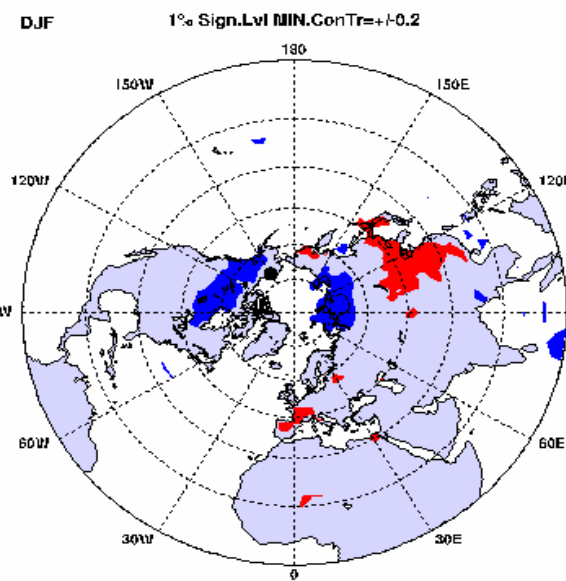
CAM3 SLPda~SkinTda Correlation -5days Lag



NCEP SLPda~SkinTda Correlation 5days Lag

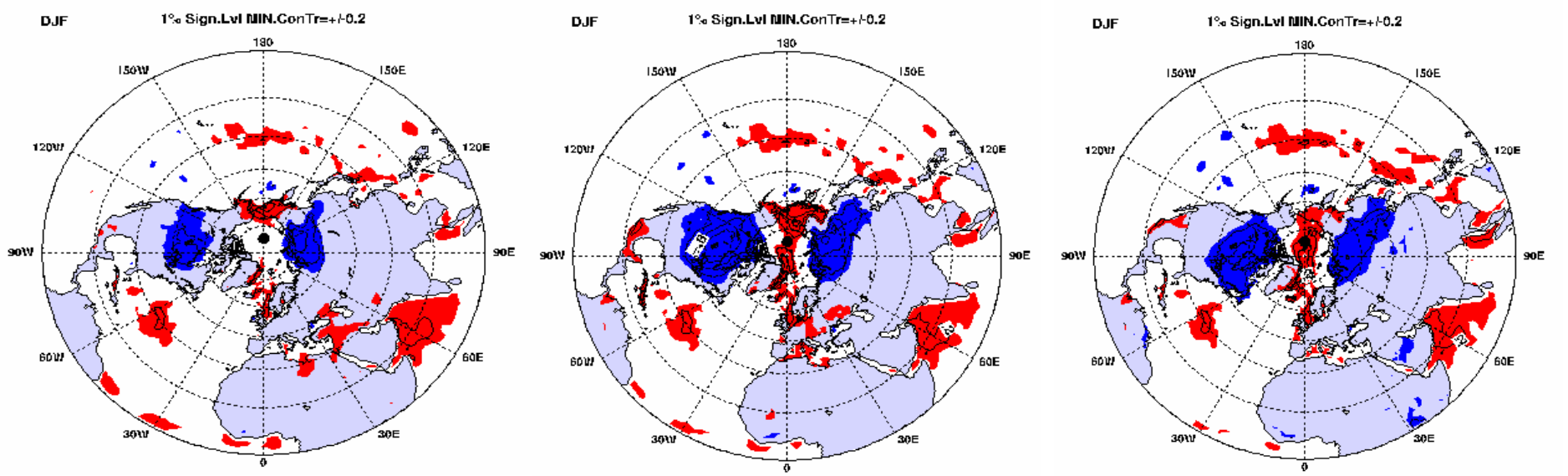
NCEP SLPda~SkinTda Correlation 0days Lag

NCEP SLPda~SkinTda Correlation -5days Lag

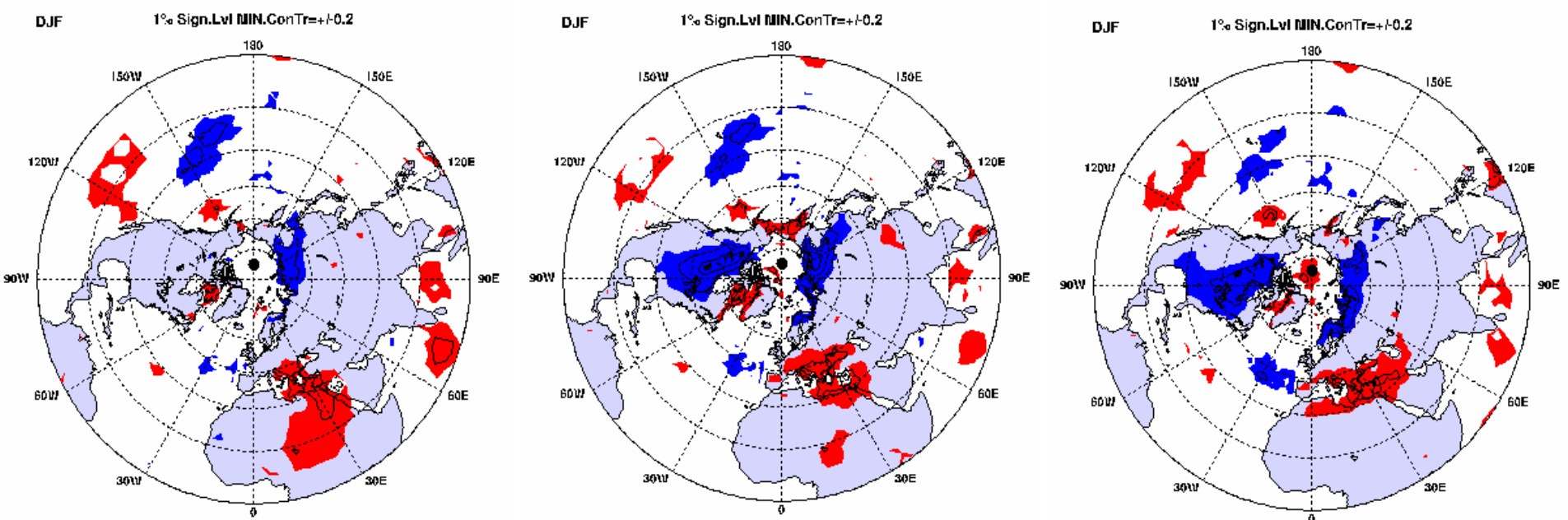


SLP corr-with SkinT at Pt 11 over the center of the Beaufort High

CAM3 SLPda~SkinTda Correlation 5days Lag CAM3 SLPda~SkinTda Correlation 0days Lag CAM3 SLPda~SkinTda Correlation -5days Lag

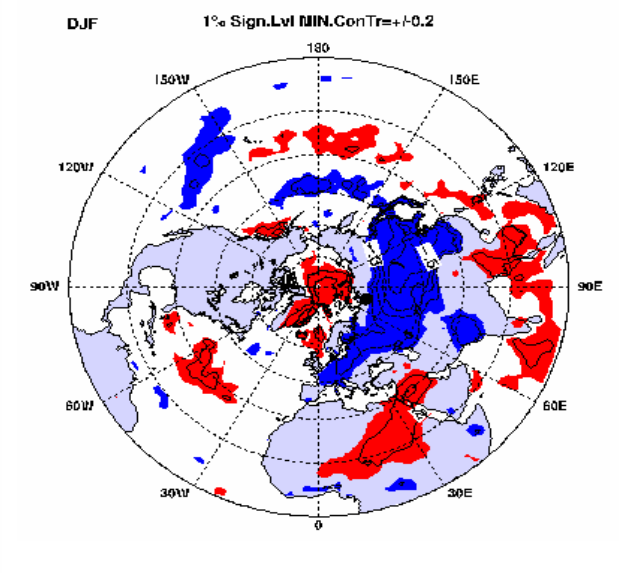
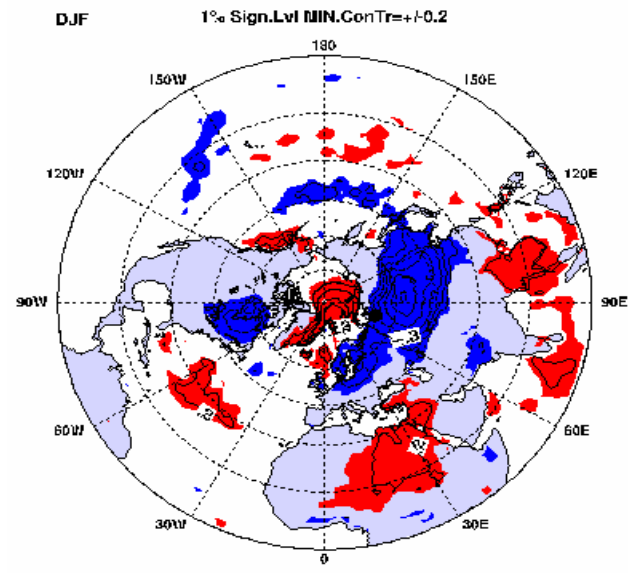
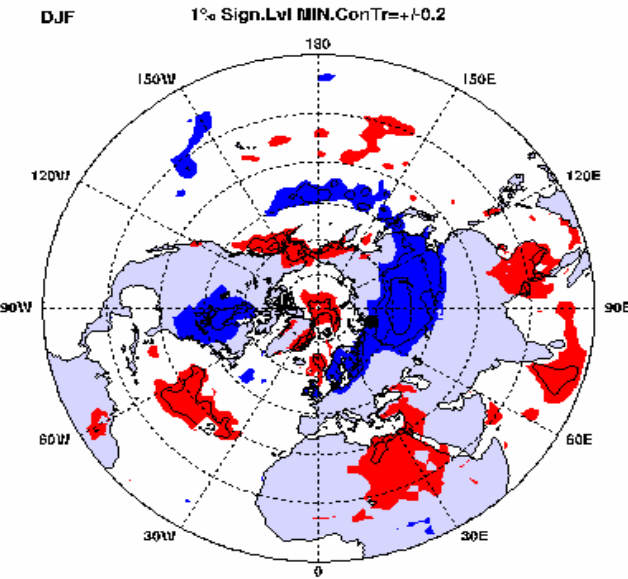


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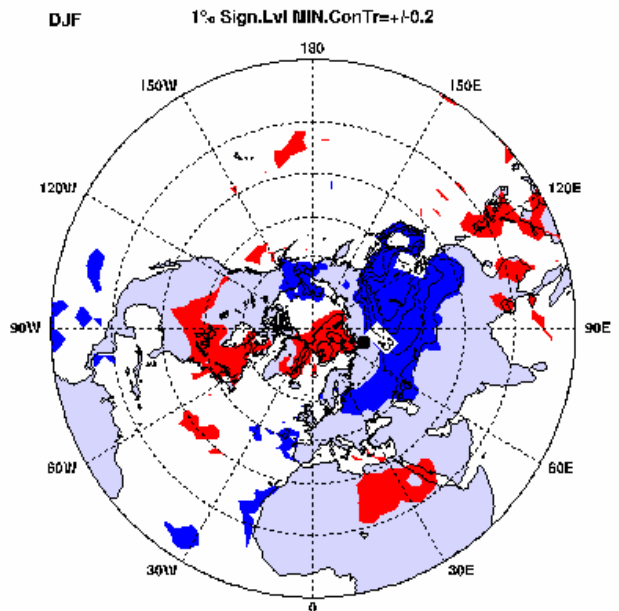
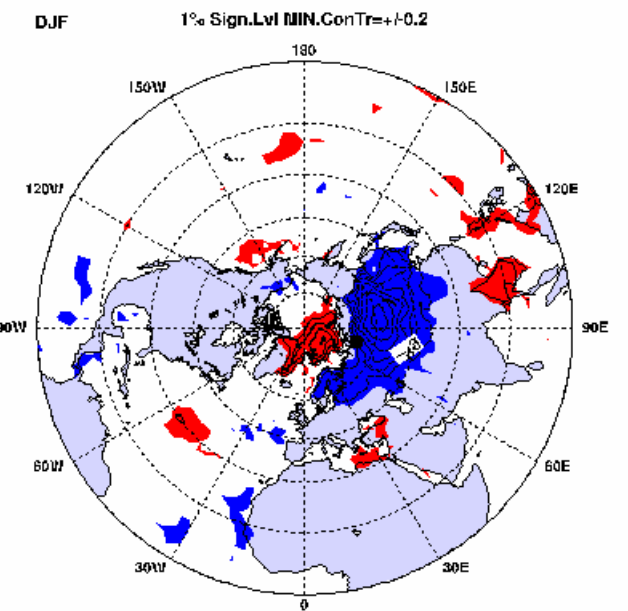
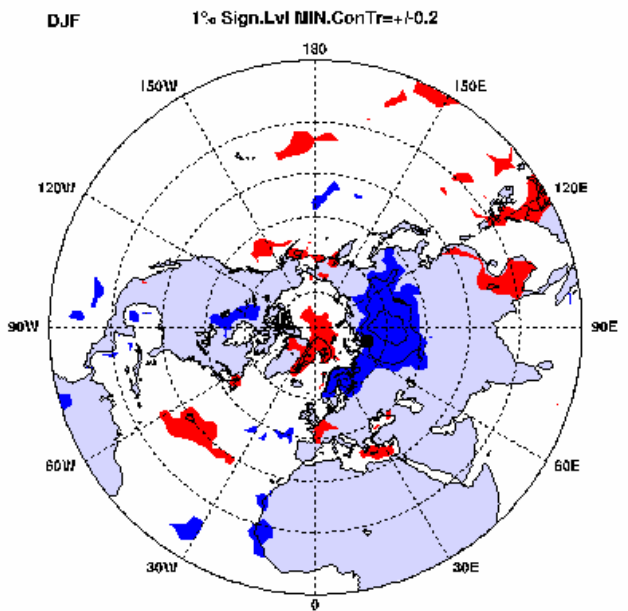


SLP corr-with SkinT at Pt 18 where bias has positive center

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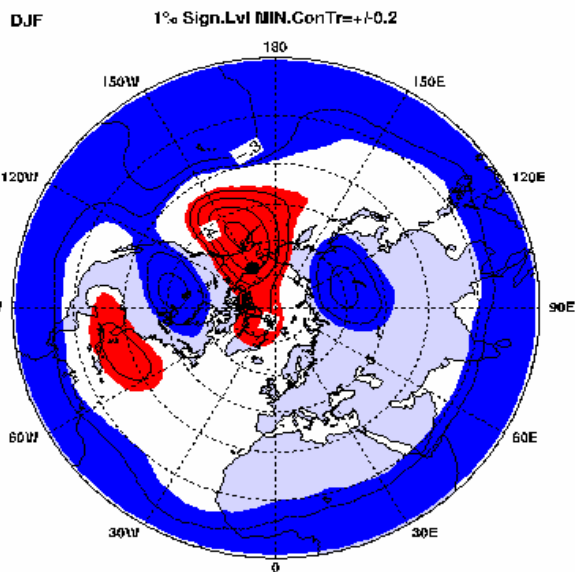


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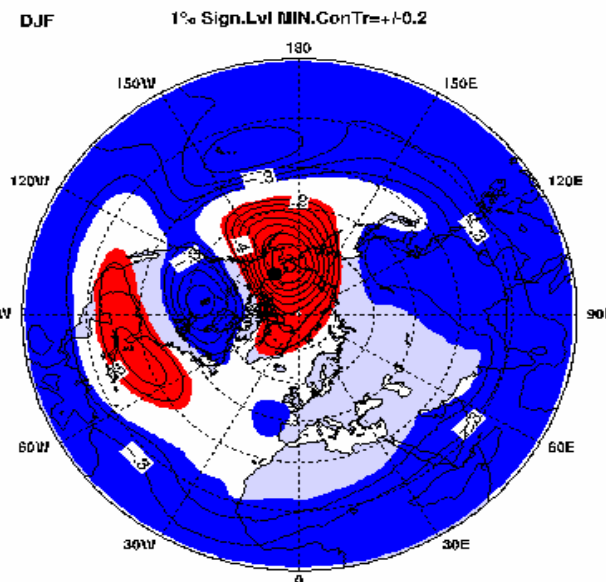


SLP corr-with Z500 at Pt 3

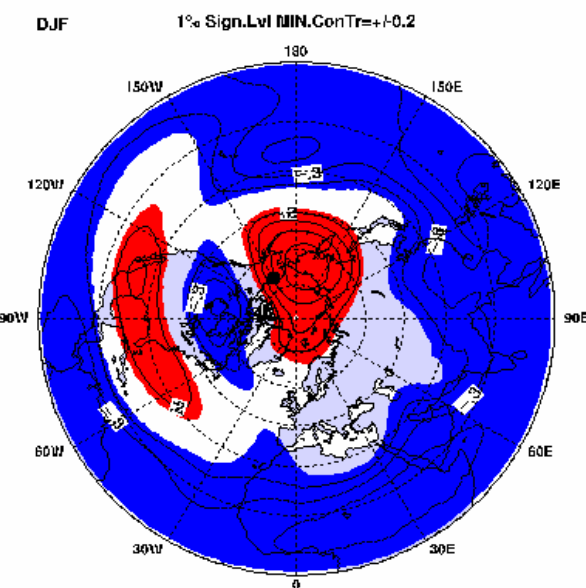
CAM3 SLPda~Z500da Correlation 5days Lag



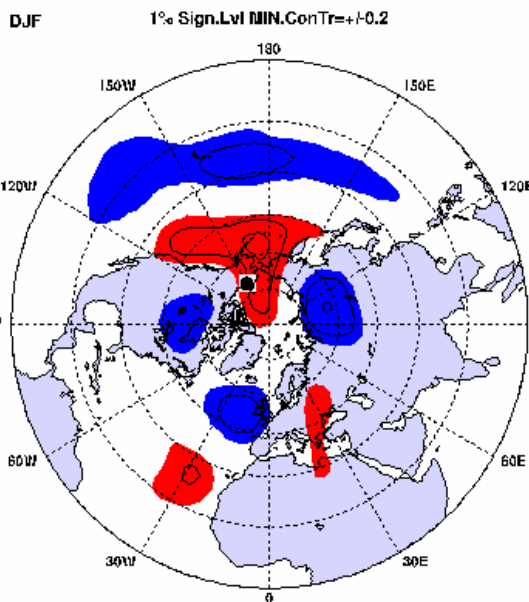
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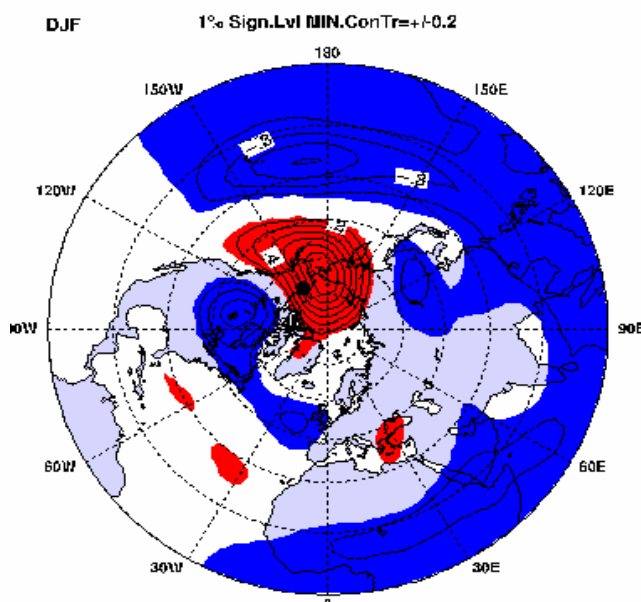
CAM3 SLPda~Z500da Correlation -5days Lag



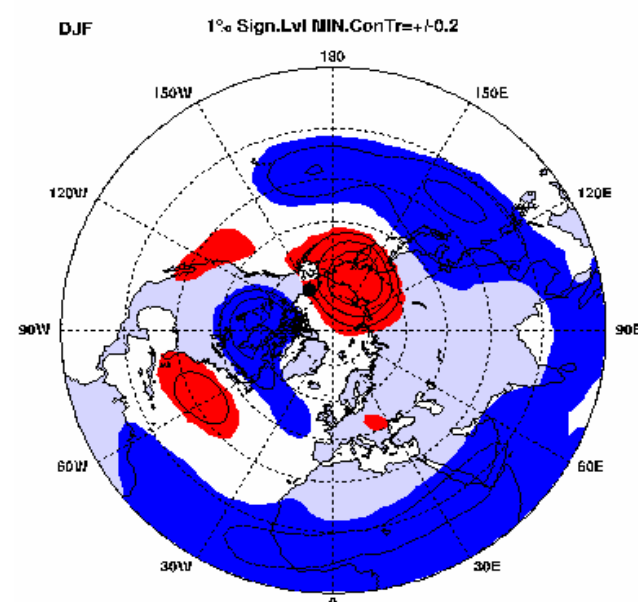
NCEP SLPda~Z500da Correlation 5days Lag



NCEP SLPda~Z500da Correlation 0days Lag

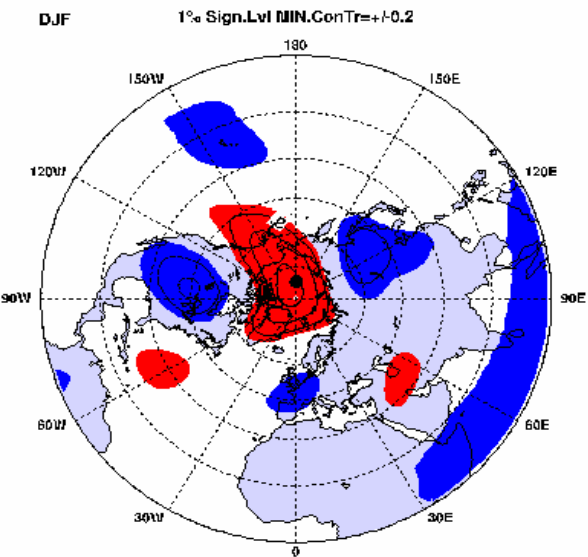


NCEP SLPda~Z500da Correlation -5days Lag

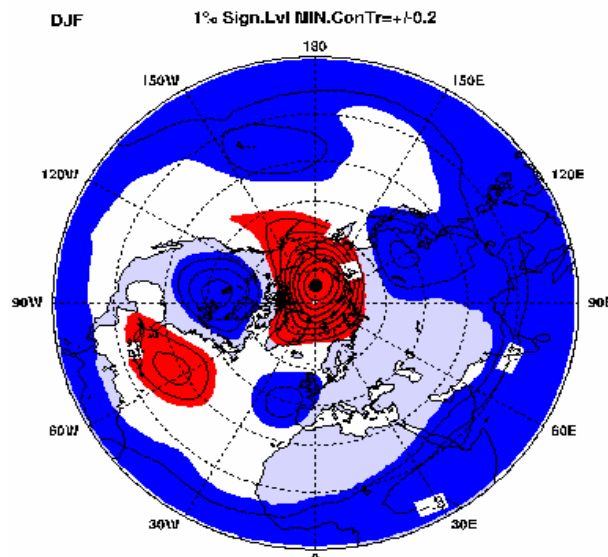


SLP corr-with Z500 at Pt 11

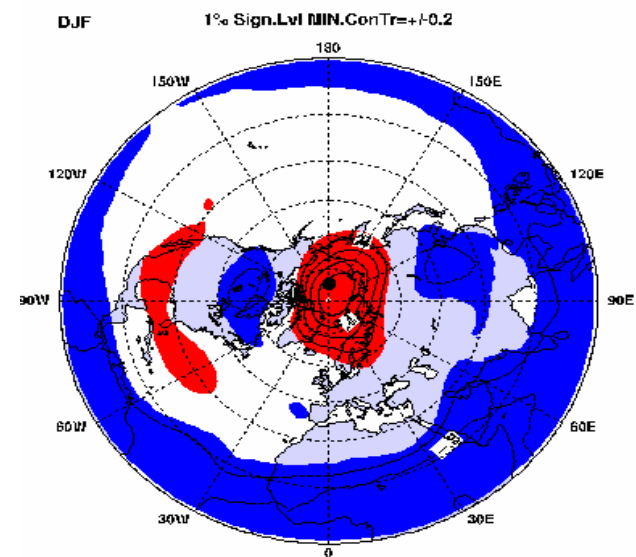
CAM3 SLPda~Z500da Correlation 5days Lag



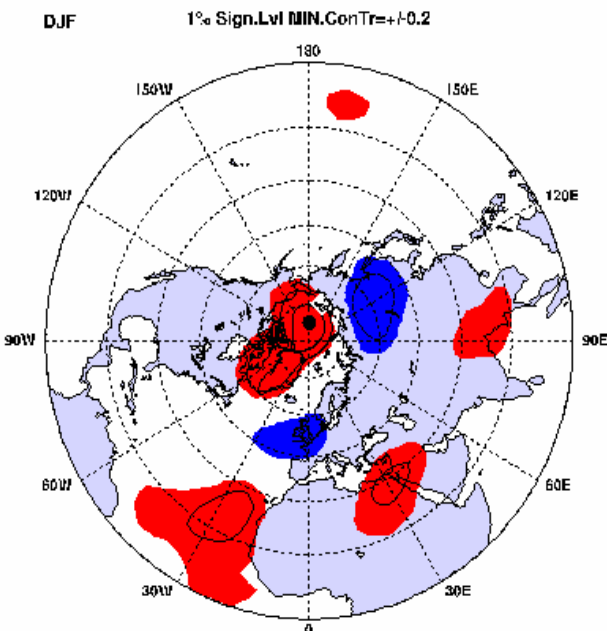
CAM3 SLPda~Z500da Correlation 0days Lag



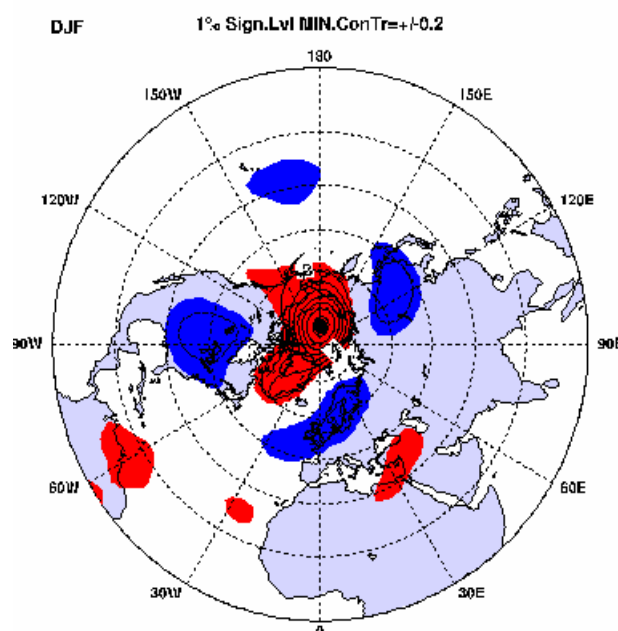
CAM3 SLPda~Z500da Correlation -5days Lag



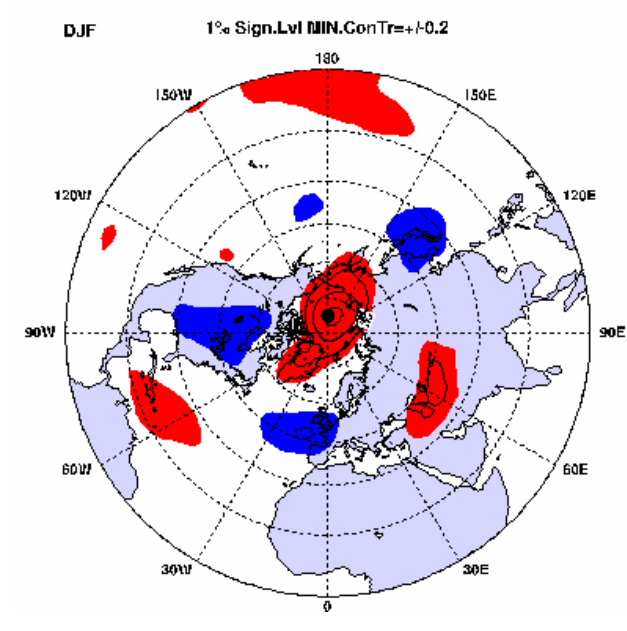
NCEP SLPda~Z500da Correlation 5days Lag



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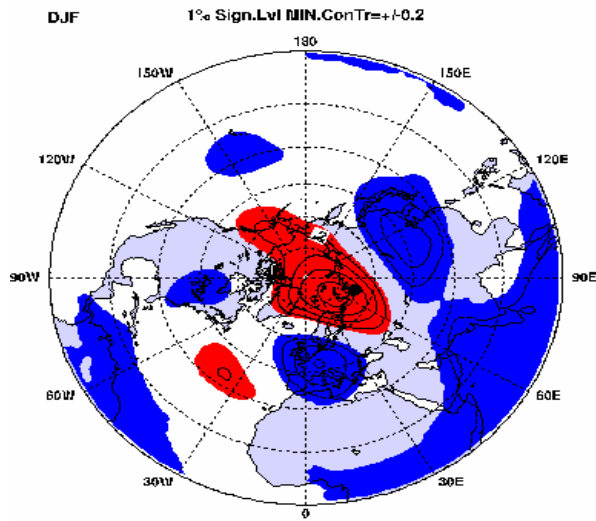


NCEP SLPda~Z500da Correlation -5days Lag

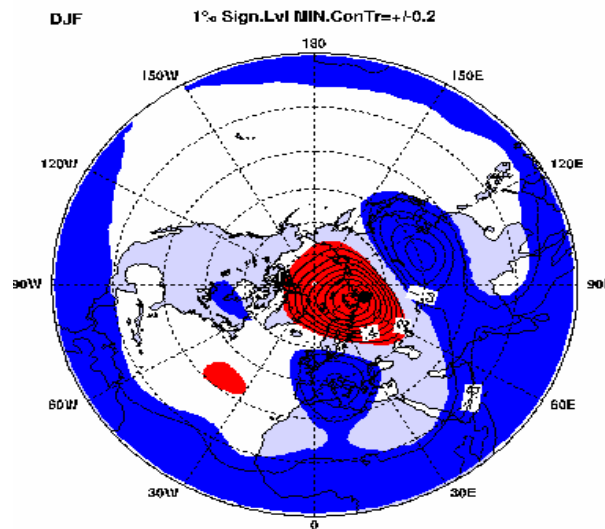


SLP corr-with Z500 at Pt 18

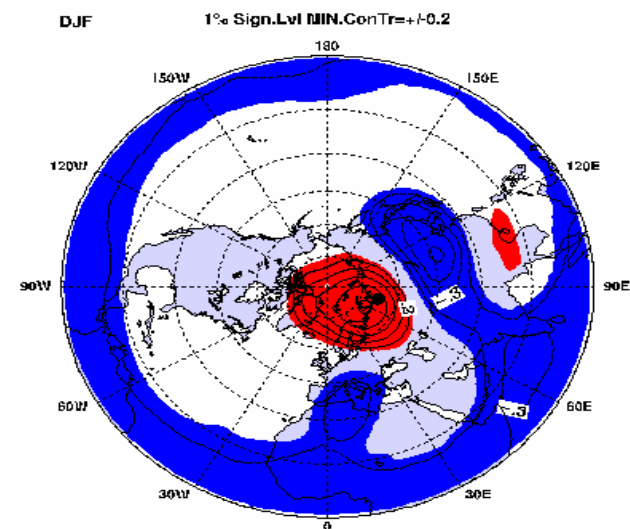
CAM3 SLPda~Z500da Correlation 5days Lag



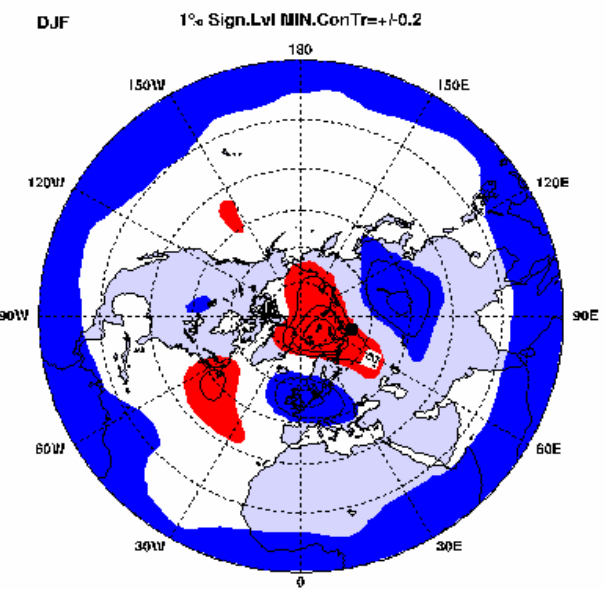
CAM3 SLPda~Z500da Correlation 0days Lag



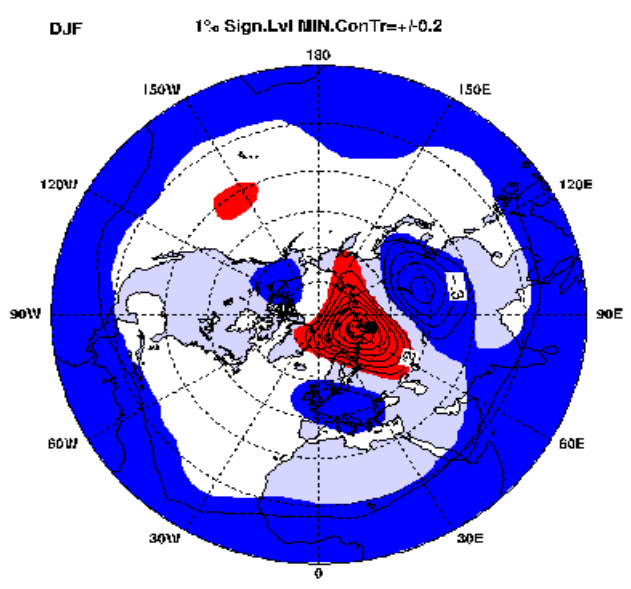
CAM3 SLPda~Z500da Correlation -5days Lag



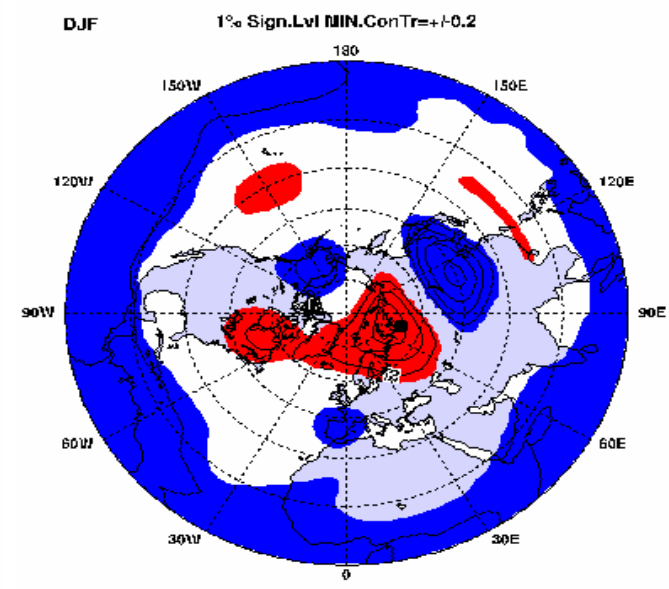
NCEP SLPda~Z500da Correlation 5days Lag



NCEP SLPda~Z500da Correlation 0days Lag



NCEP SLPda~Z500da Correlation -5days Lag



4. Ongoing and Future work

- Stationary wave model (SWM).
 - used in Branstator (1990, JAS)
 - updated for Fortran 90 with C Preprocessor
 - running on Linux workstation
- Storm track model (STM).
 - to be run iteratively with SWM
- Further study of remote forcing sources.
 - storm track markers
 - surface wind direction
 - mass flux

4. Ongoing and Future work

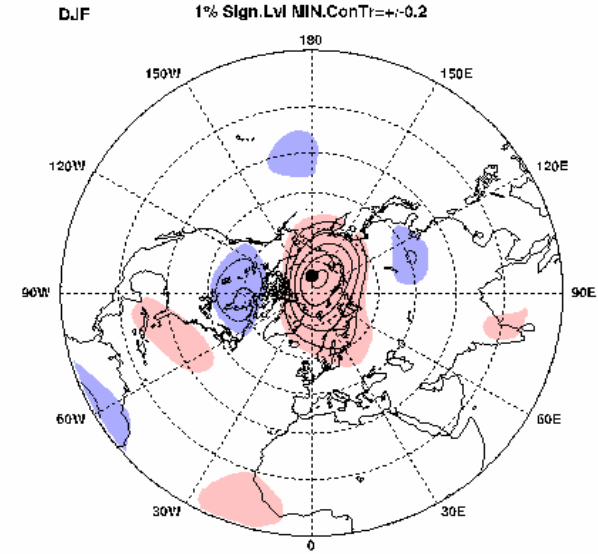
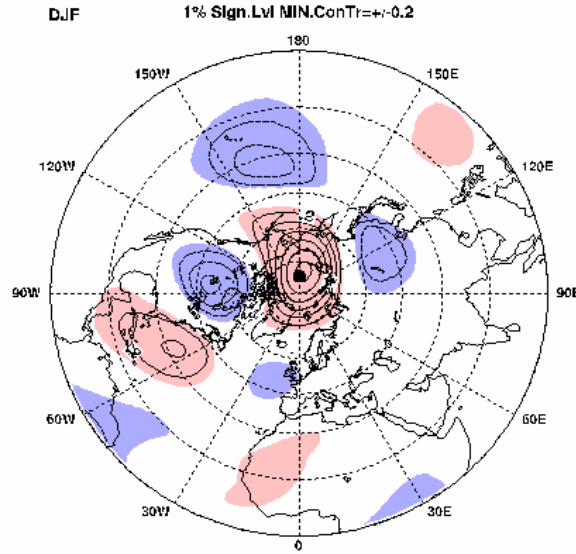
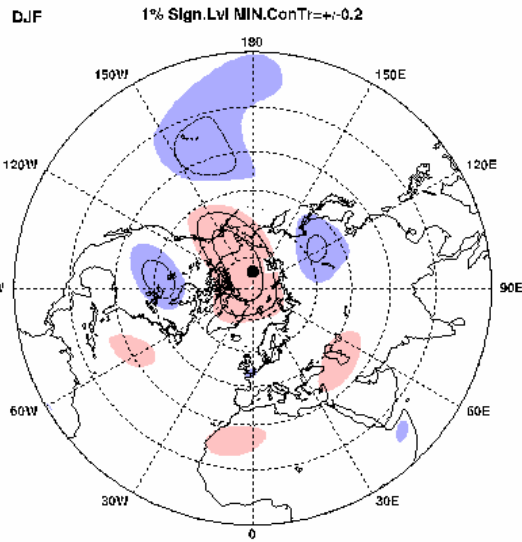
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SLP corr-with PSI at Pt 11

CAM3 SLP.da~PSI@200mb.da Corr. 5days Lag

CAM3 SLP.da~PSI@200mb.da Corr. 0days Lag

CAM3 SLP.da~PSI@200mb.da Corr. -5days Lag



SLP corr-with PSI at Pt 18

CAM3 SLP.da~PSI@200mb.da Corr. 5days Lag

CAM3 SLP.da~PSI@200mb.da Corr. 0days Lag

CAM3 SLP.da~PSI@200mb.da Corr. 5days Lag

