# Arctic surface climate associations in nature and NCAR community climate models

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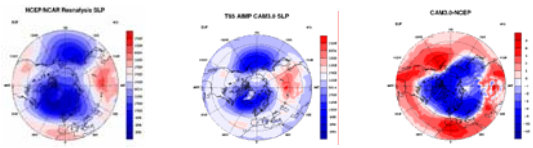
## 1. Introduction

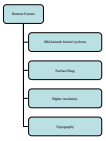
The current and previous versions of NCAR CCSM models have consistent simulation errors on the Arctic surface climate (like sea level pressure and low-level wind). And these errors also can lead to other important consequences, such as unrealistic spatial distribution and thickness of sea ice over Arctic.

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.




**Four remote candidate factors for explaining the model bias in SLP**



**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.

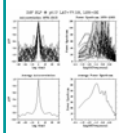
Model data

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)

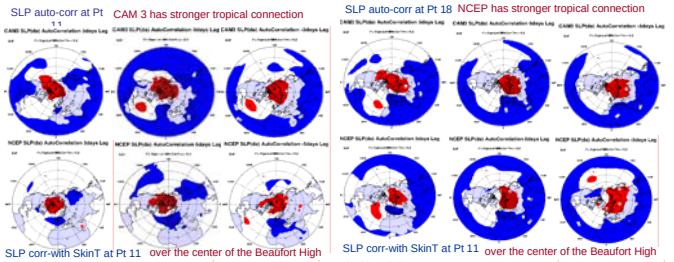


Lanczos filter using 10-day cut-off
- long enough to remove higher frequencies,
- Short enough to allow lag/lead testing

## 3. Early Results

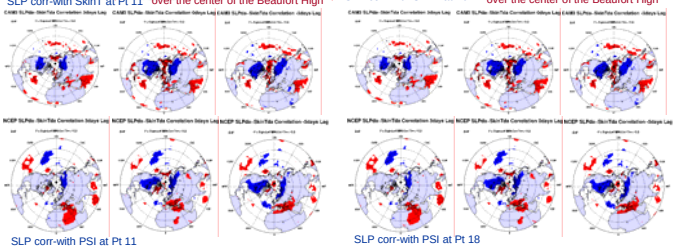
SLP auto-corr at Pt 11 — CAM 3 has stronger tropical connection

SLP auto-corr at Pt 18 — NCEP has stronger tropical connection



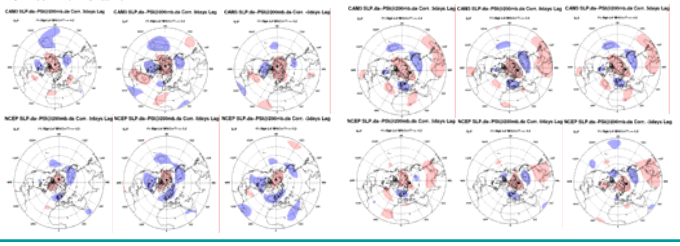
SLP corr-with SkinT at Pt 11 over the center of the Beaufort High

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



SLP corr-with PSI at Pt 11

SLP corr-with PSI at Pt 18



### Reverse Correlation

## 4. Discussion

- 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.
- 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.

## 5. 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