GEOMAGNETIC ACTIVITY AND POLAR SURFACE AIR TEMPERATURE VARIABILITY

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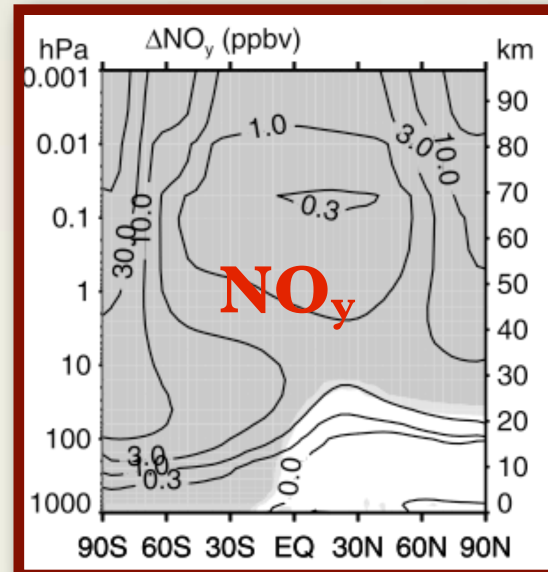
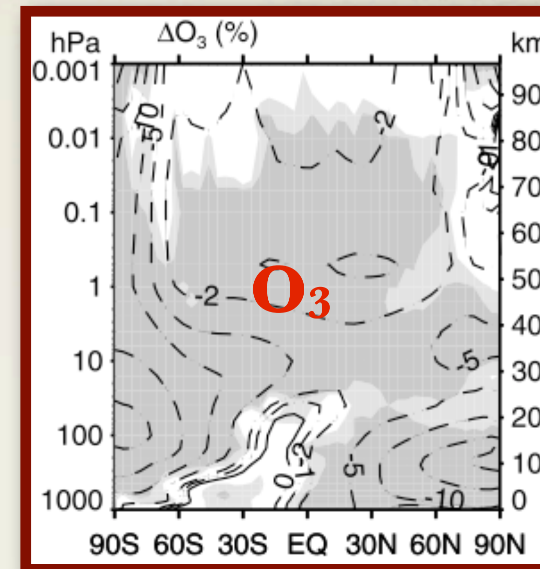
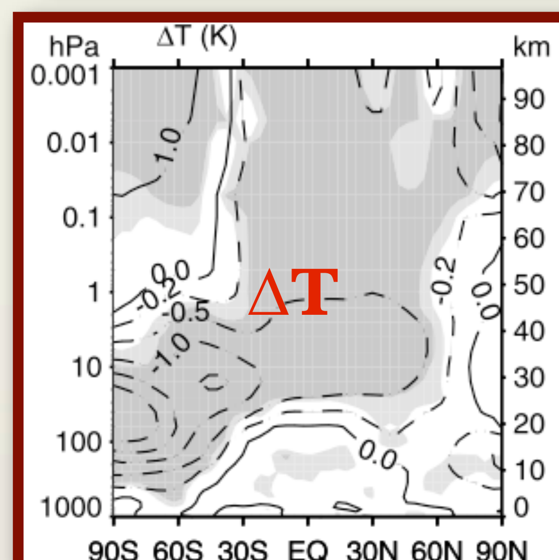
Background to this study: Results from a climate model study

- Model studies have suggested that NO_x, created by EPP, and consequent ozone loss through catalytic loss cycles could have an indirect effect on stratospheric and tropospheric (e.g. surface level) temperatures.
- Rozanov et al. (2005): Chemistry-Climate Model, two 10-year runs; 1. no electron precipitation, 2. Energetic Electron Precipitation based on 1987 observations.
- Model results predicted **up to 5 degree variation in polar winter time Surface Air Temperature** and 50 hPa Geopotential Height (meteorological variable) due to precipitating energetic particles.







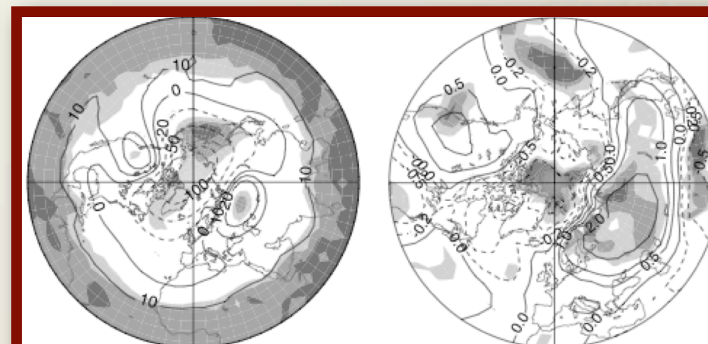
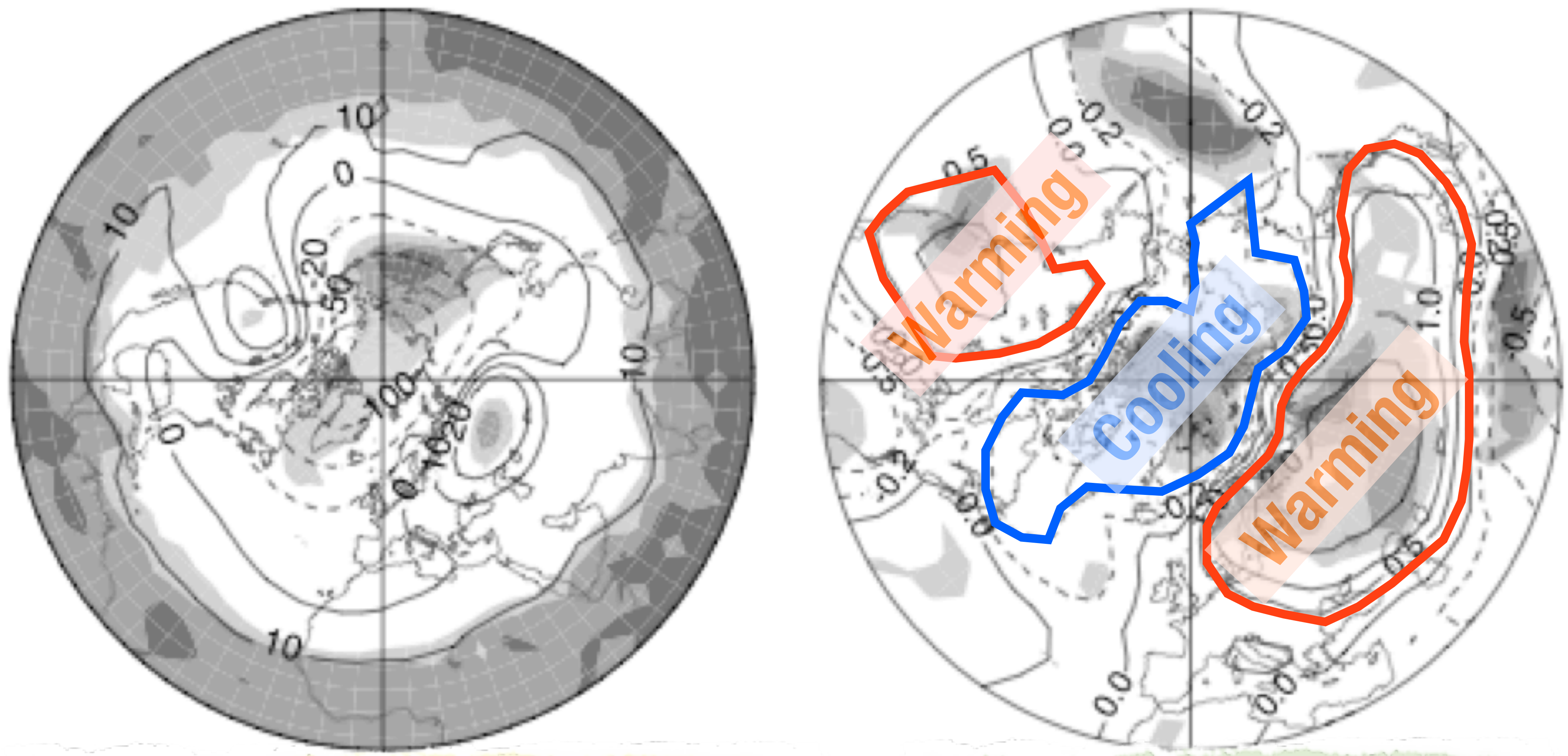


Figure 6. Changes in geopotential height at 50 hPa (m), and SAT (K) for boreal winter due to EEP. The light/dark/heavy shading shows the regions where the changes are judged statistically significant at or better than the 20%/10%/5%) levels.

Rozanov, et al., Atmospheric response to NO_y source due to energetic electron precipitation, Geophys. Res. Lett., 2005.

Modelled surface level effect from EPP

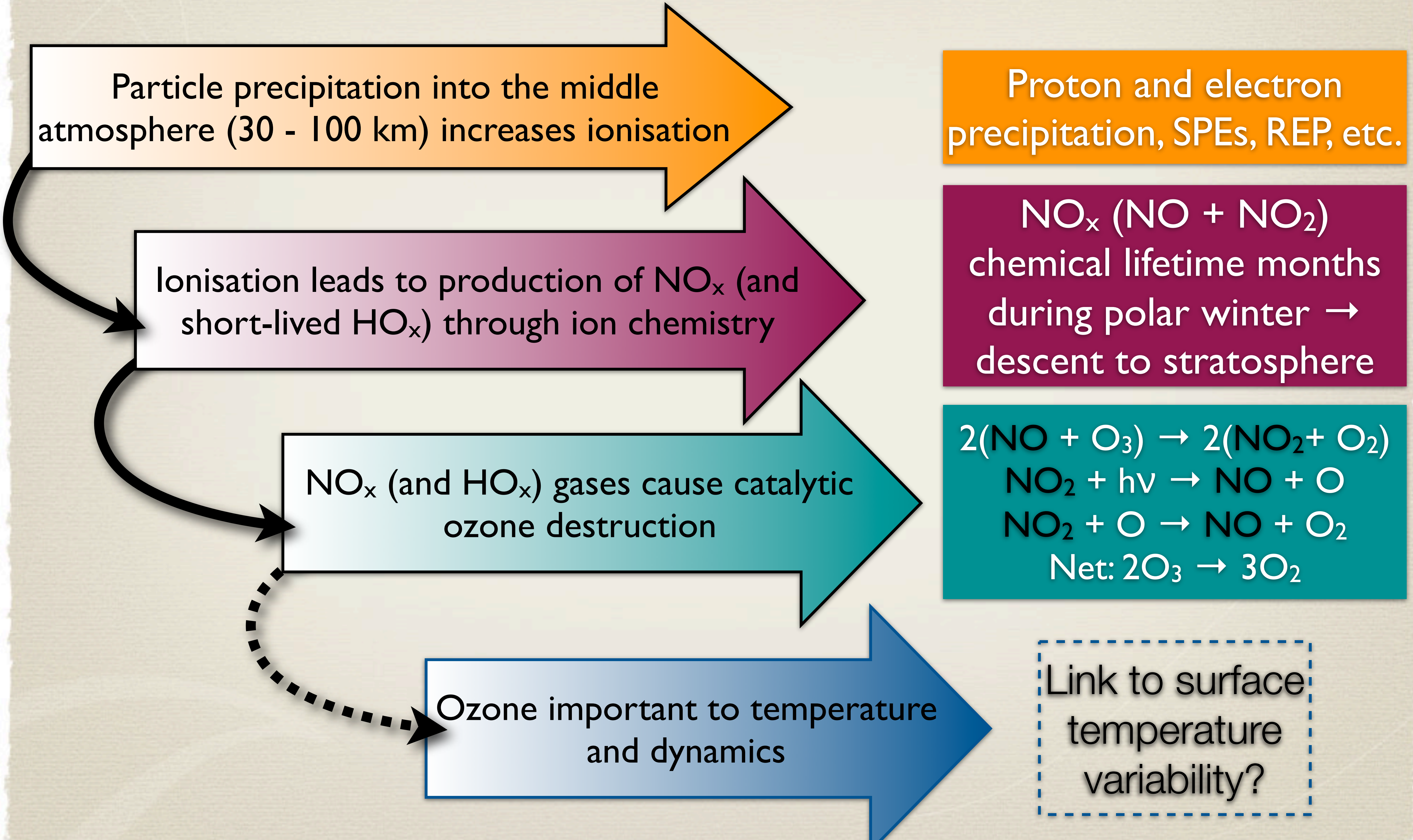


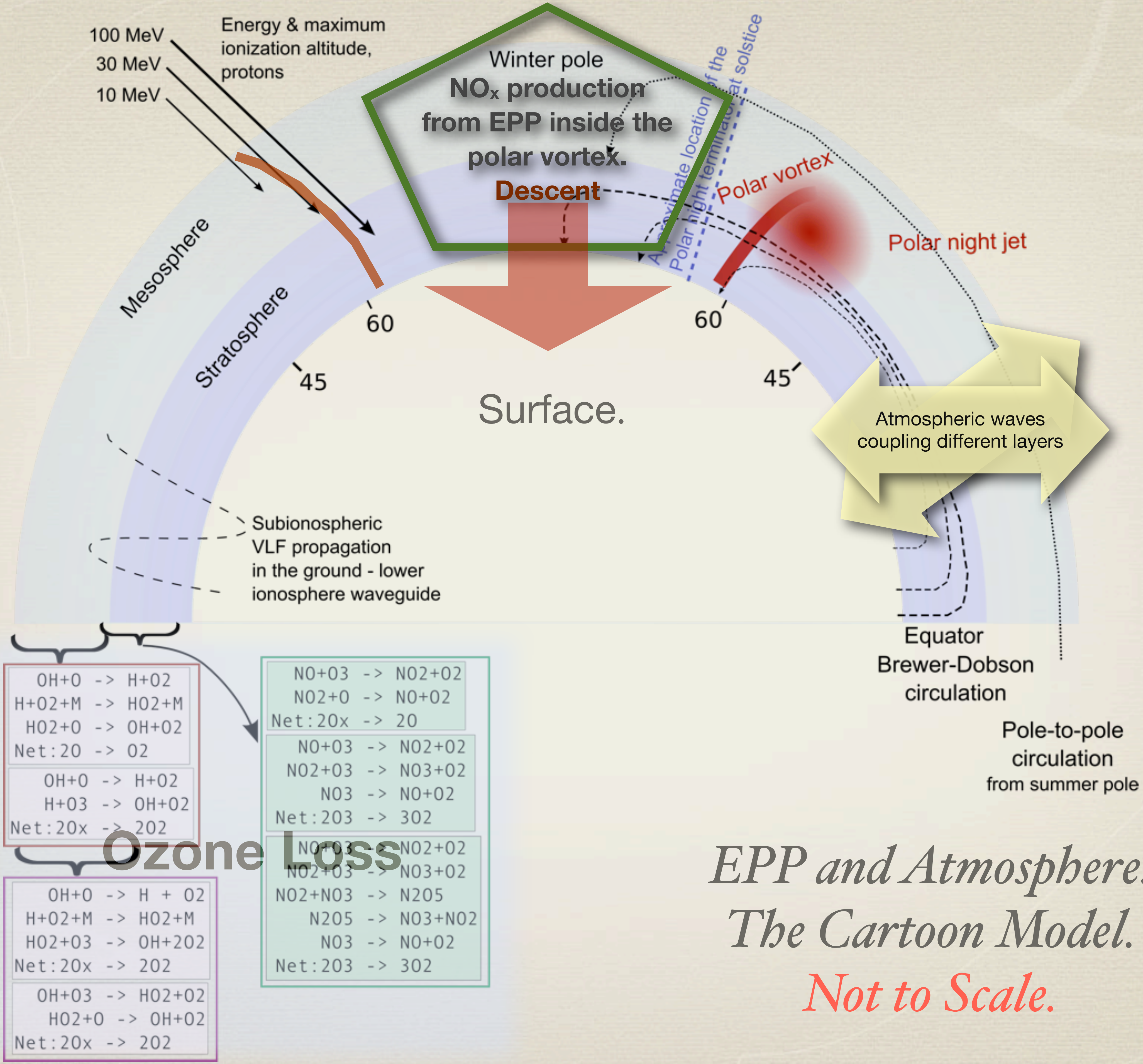
Geopotential height at 50 hPa

Surface Air Temperature

Figure 6. Changes in geopotential height at 50 hPa (m), and SAT (K) for boreal winter due to EEP. The light/dark/heavy shading shows the regions where the changes are judged statistically significant at or better than the 20%/10%/5%) levels.

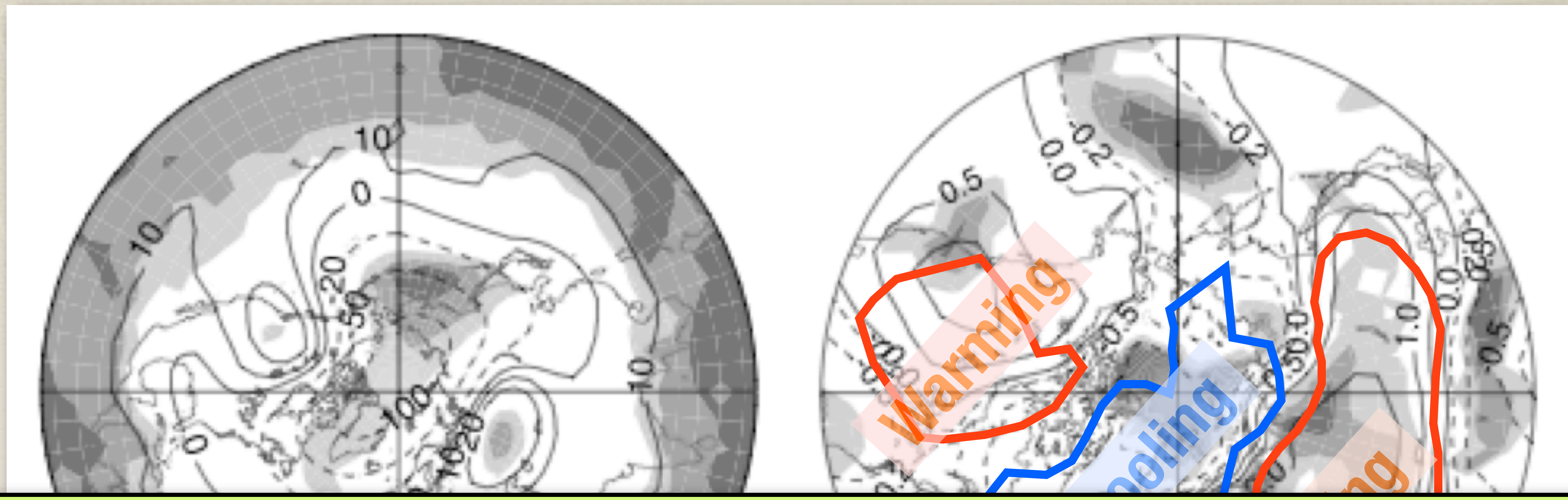
Energetic particle precipitation and the atmosphere





EPP and Atmosphere. The Cartoon Model. Not to Scale.

Modelled surface level effect from EPP



Can similar signatures be seen in observations?

We looked into the ECMWF (1958 - 2006) ERA-40 meteorological re-analysis and operational surface air temperature dataset for EPP signatures in the Northern and Southern hemispheres.

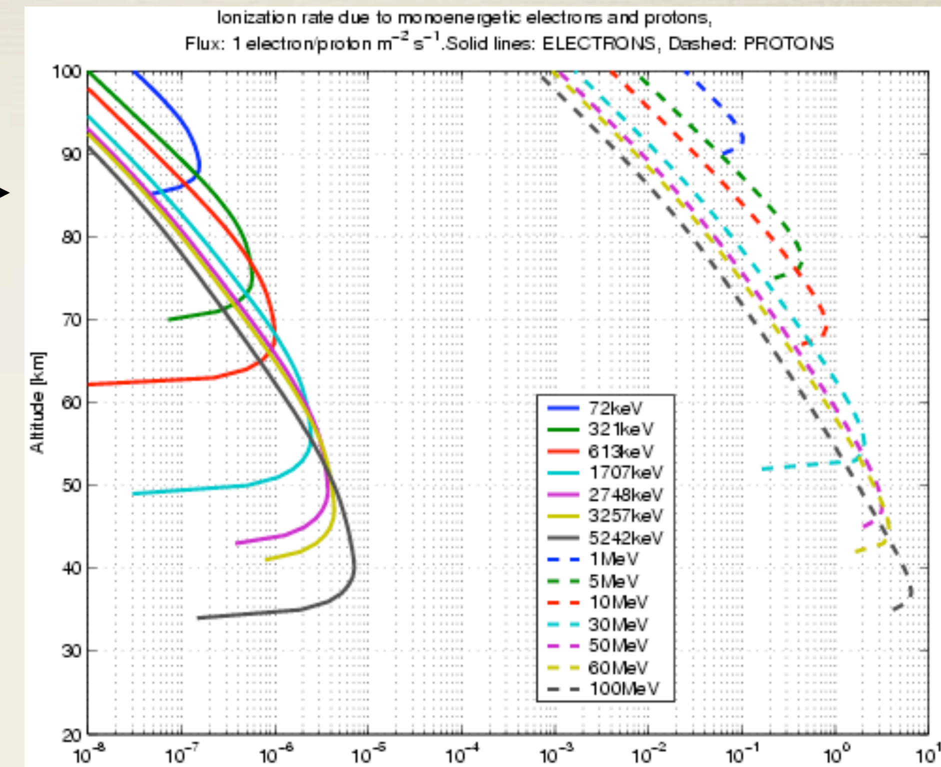
But....

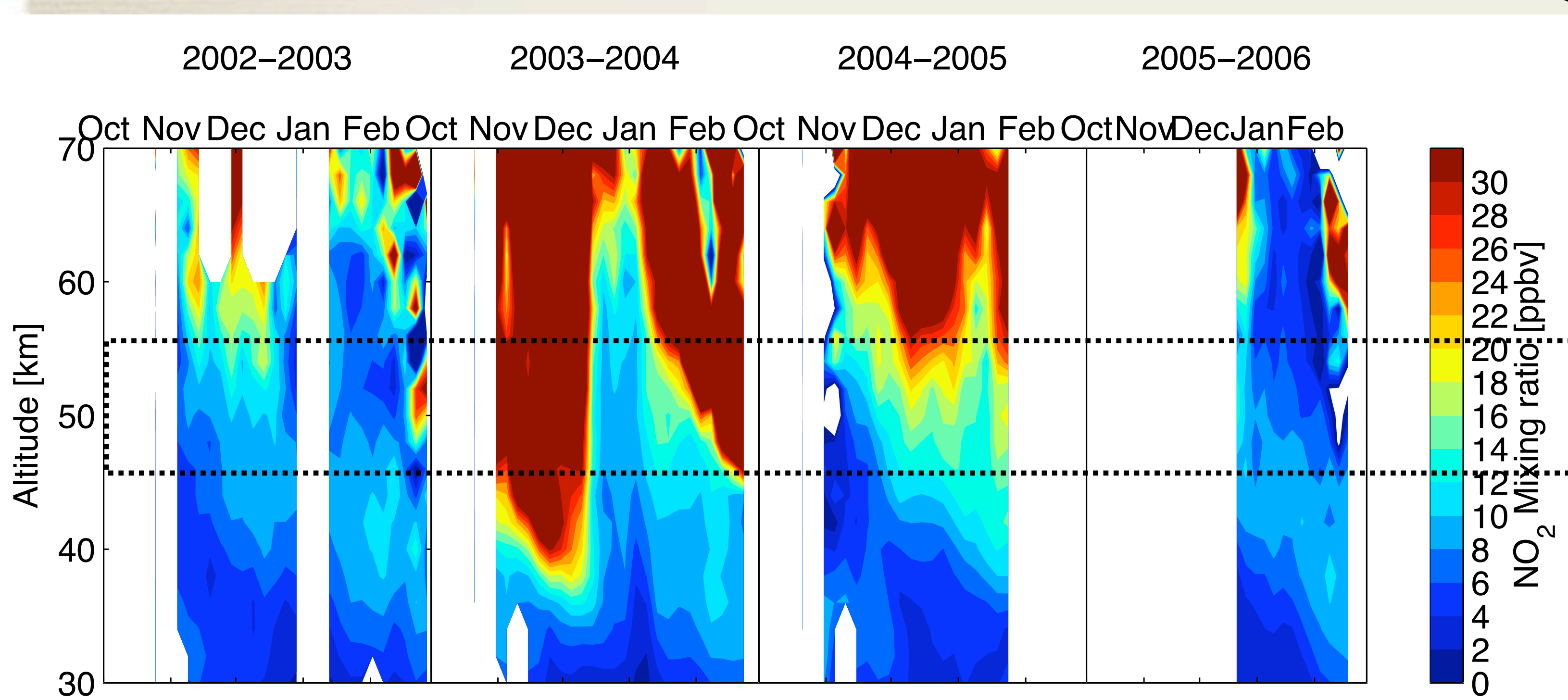
1) We need an estimate for the level of EPP.

2) Solar irradiance variation affect atmospheric temperatures, we need to somehow exclude that effect.

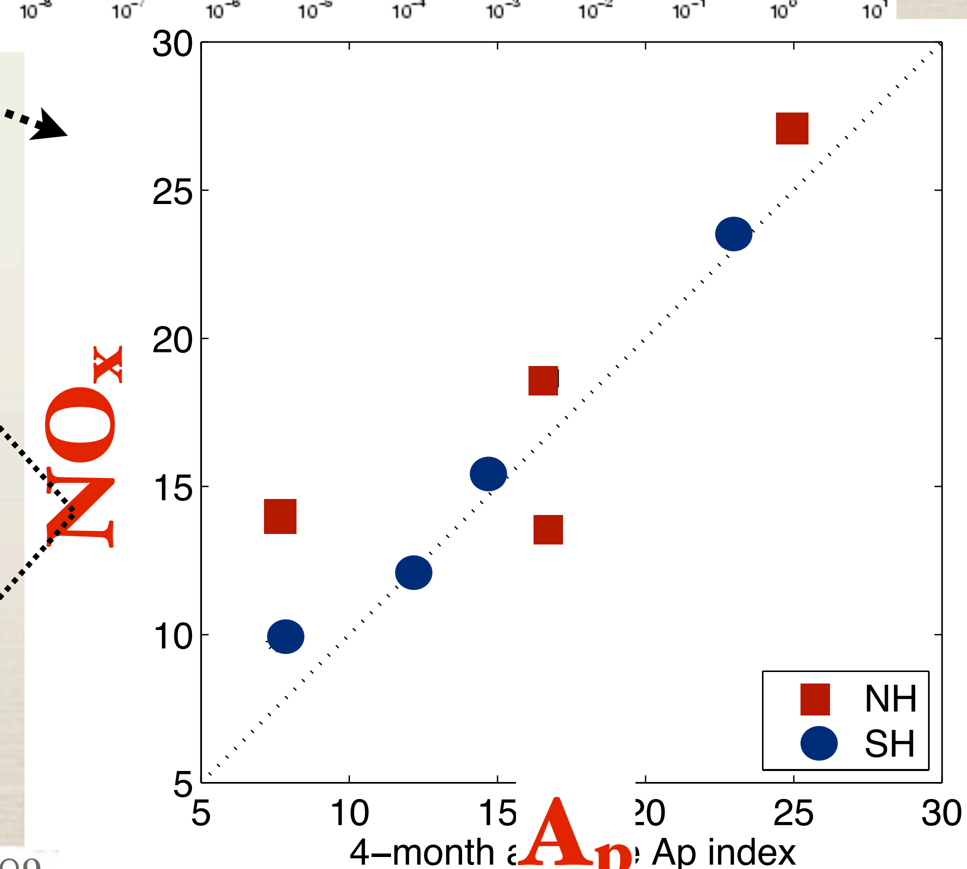
EPP into the atmosphere - estimating the source strength

- The particle energy determines the altitude where the main *in situ* impact (ionisation) will take place.
- **Particle observations exist, determining the quantity of those precipitating into the atmosphere???**
- To estimate the over all EPP level over a long time period → *use an index of the overall geomagnetic activity, A_p*. This corresponds to the level of upper stratospheric-lower mesospheric polar winter NO_x.

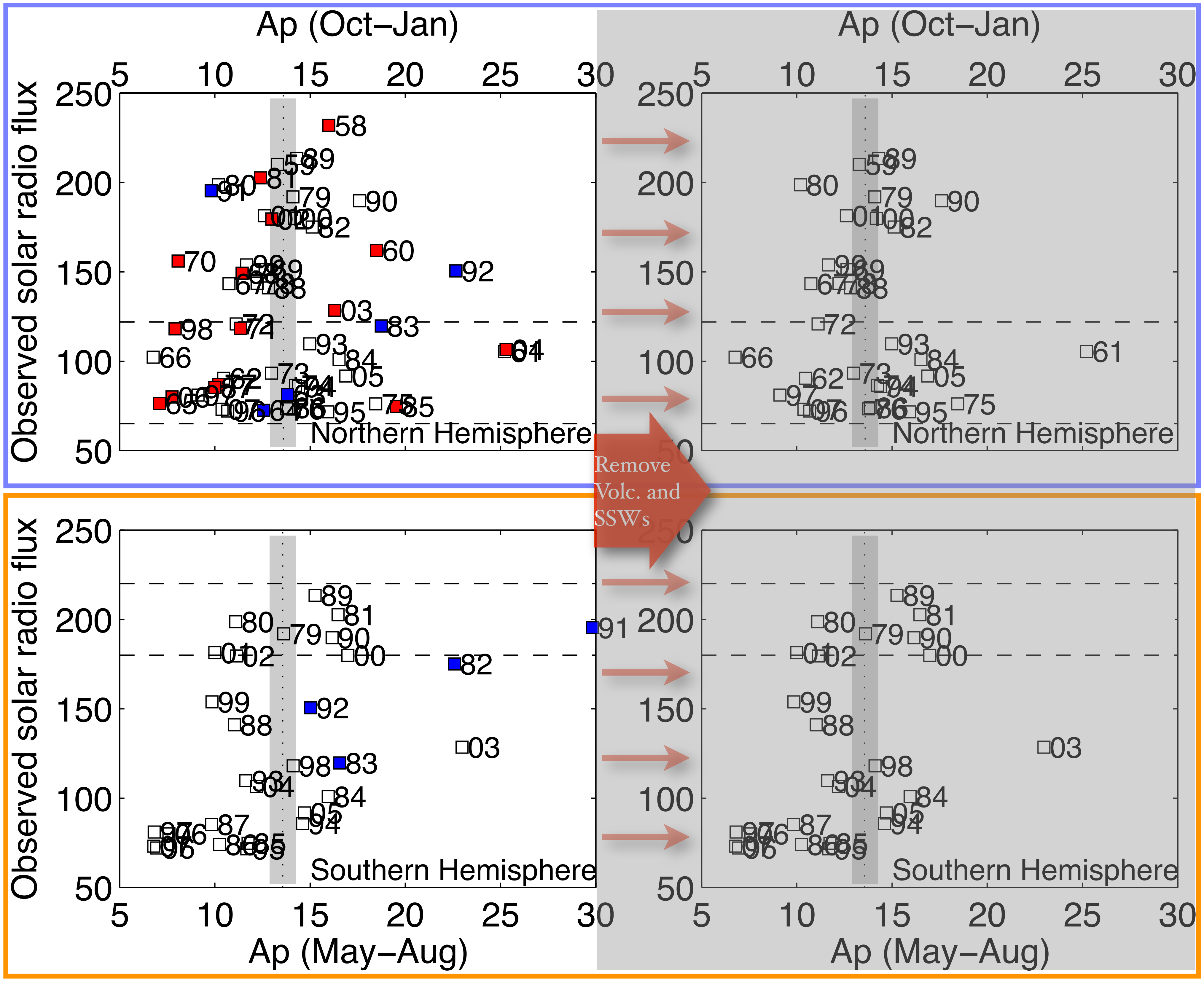




NH night time NO_2 60N-90N from GOMOS



Geomagnetic activity and solar cycle. Polar winters



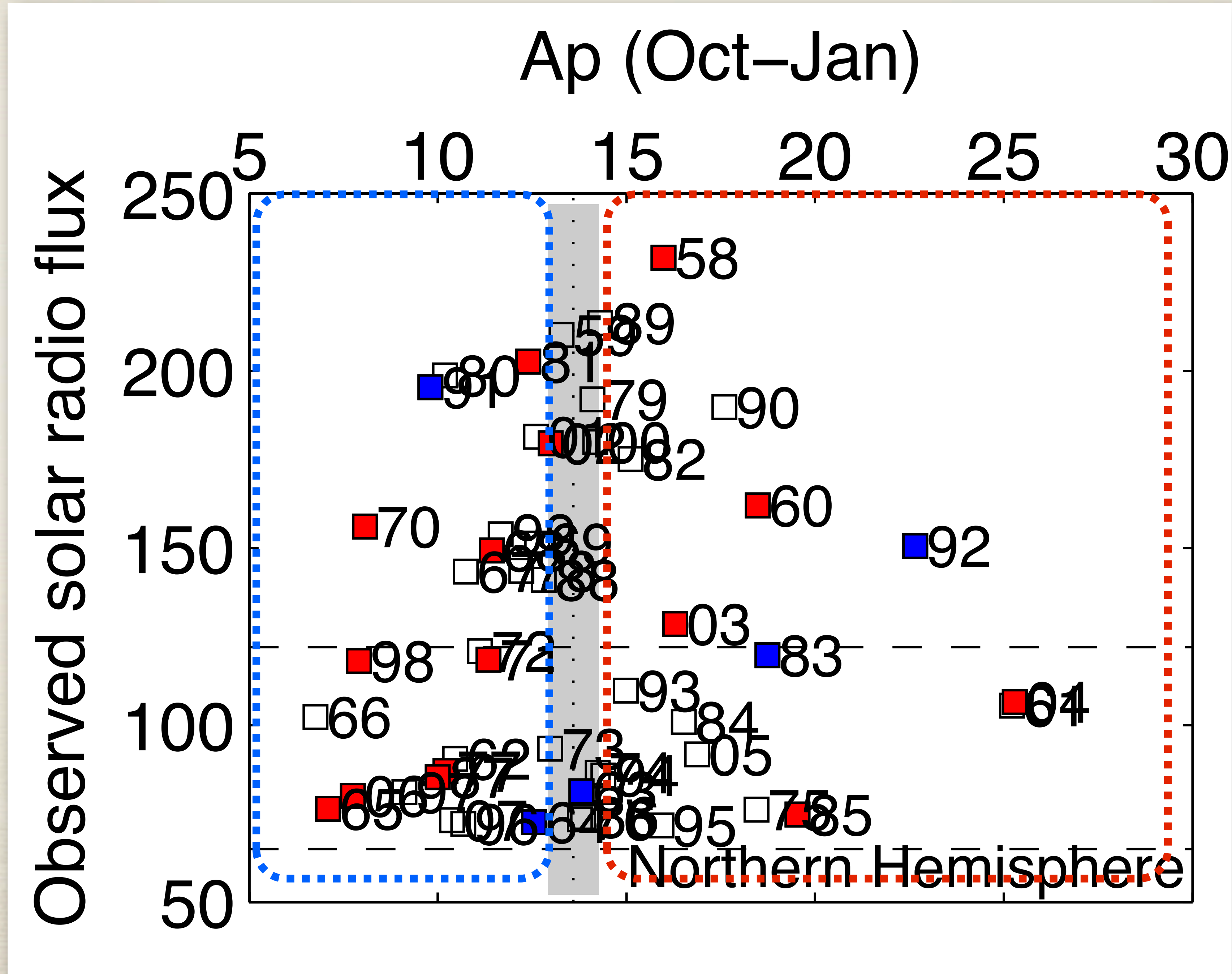
Volcanic eruptions, known to significantly disturb atmospheric temperatures - **Always Excluded**!

Sudden Stratospheric Warmings (SSW), disturb atmospheric dynamical and chemical balance. "**Extreme events**" - *Will investigate effect to SAT results.*

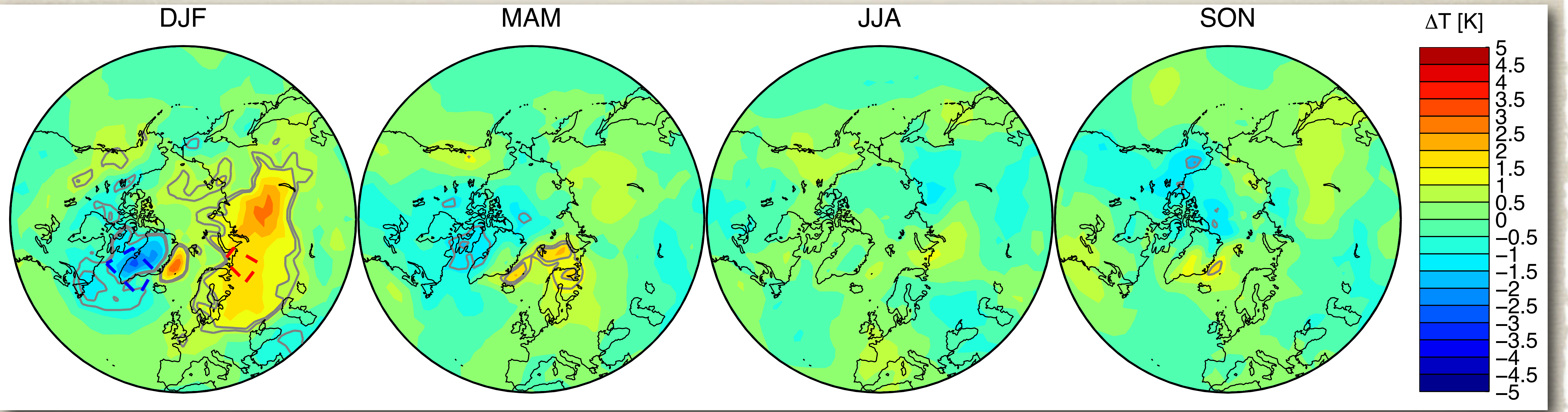
Seppälä, et al. (2009), Geomagnetic activity and polar surface air temperature variability. In press., J. Geophys. Res.

Nh Surface Air Temperatures. All solar cycle phases

High Ap - Low Ap

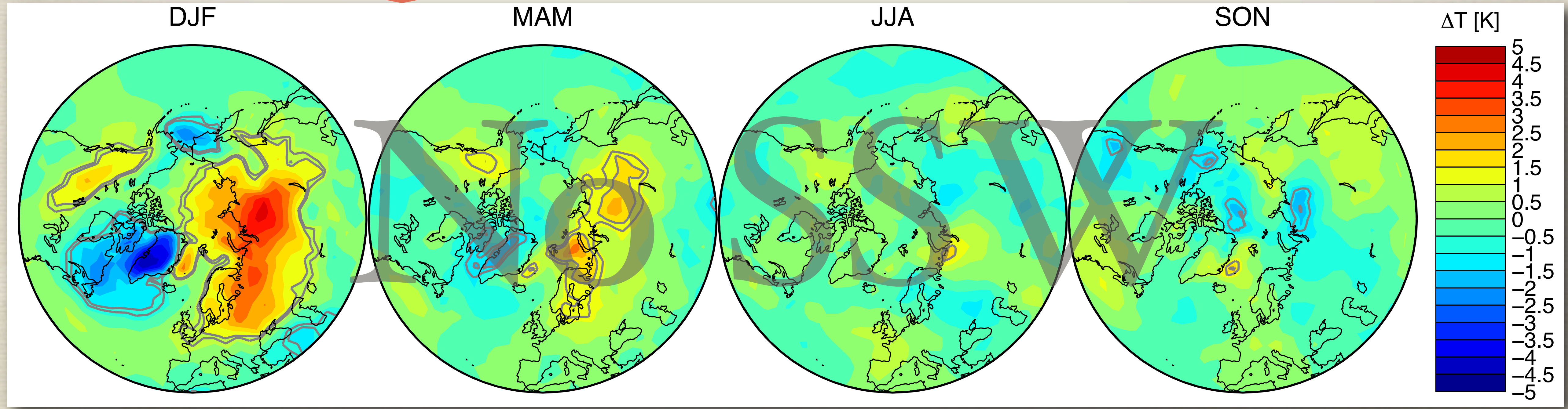


NH Surface Air Temperatures. All solar cycle phases, High A_p - Low A_p



Remove SSW

"Remove neutral atmosphere extreme events"



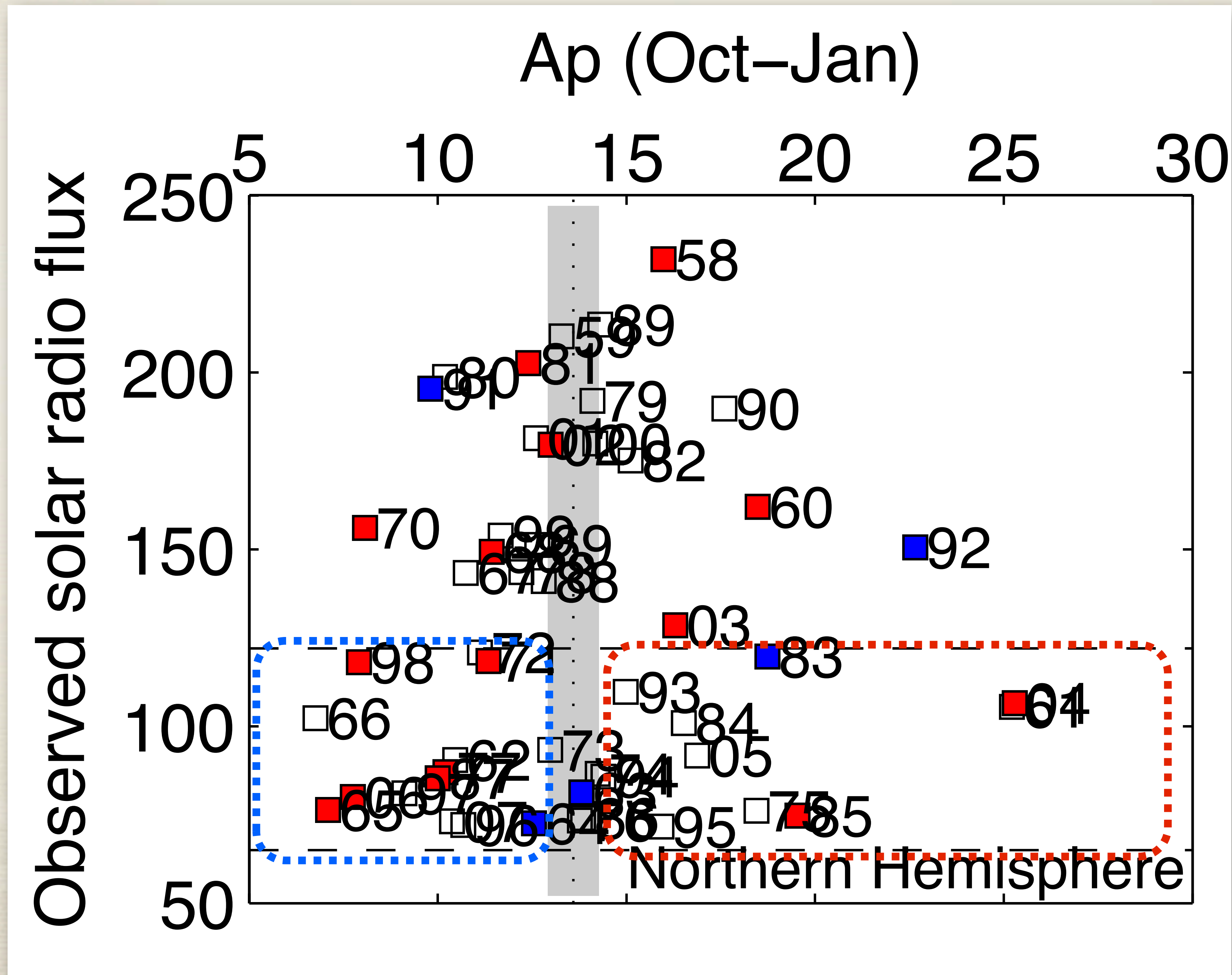
→Temperature variability increases

Seppälä, et al. (2009), Geomagnetic activity and polar surface air temperature variability. In press,, J. Geophys. Res.

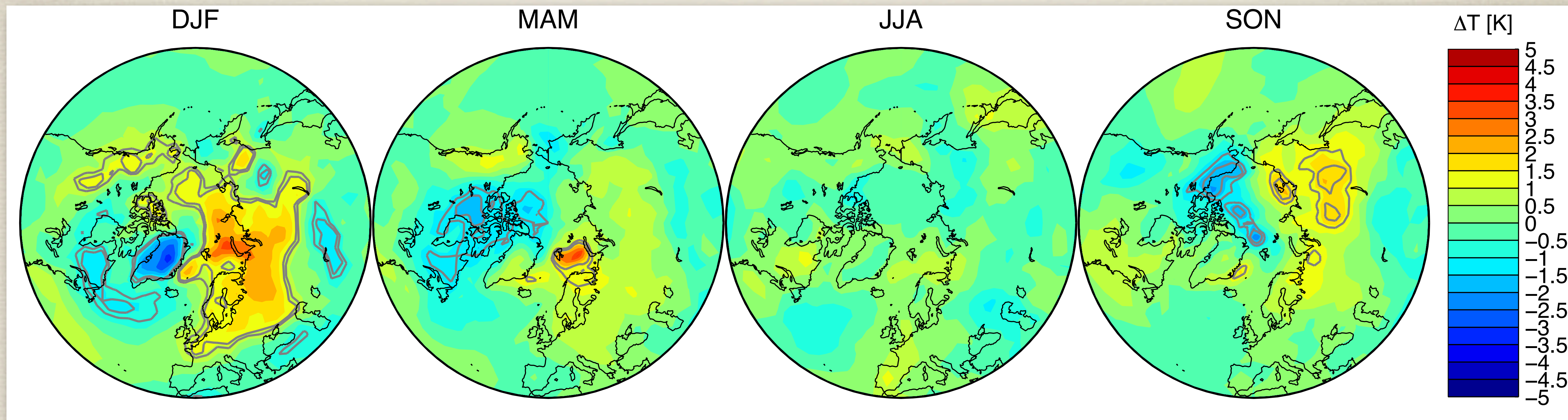
NH Surface Air Temperatures. Limited solar cycle phase

High Ap - Low Ap

Remove temperature variations caused by solar irradiance variability.



NH Surface Air Temperatures. Limited solar cycle phase, High A_p - Low A_p



Remove SSW

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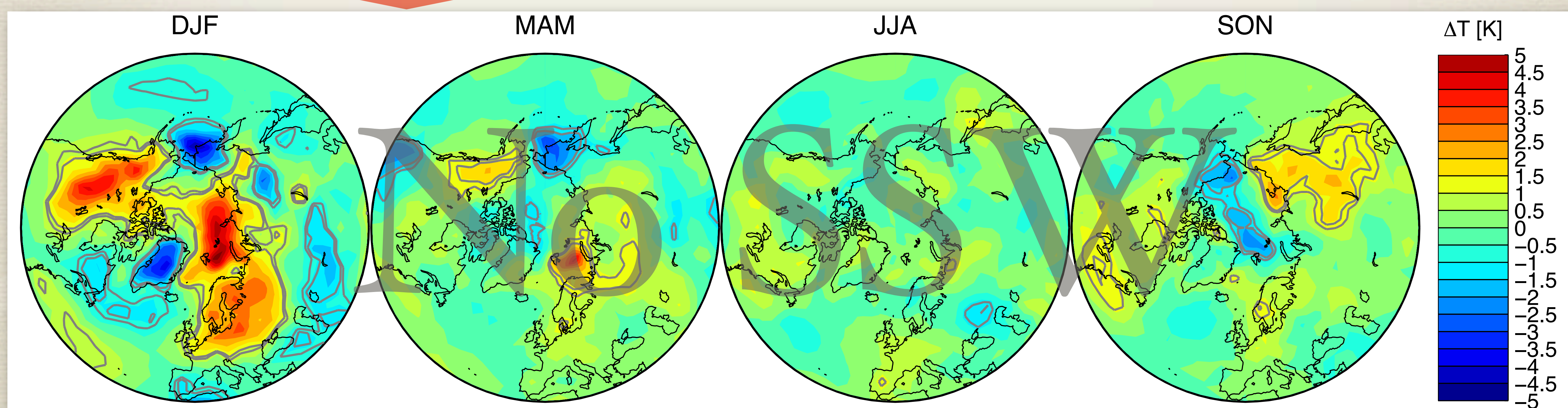
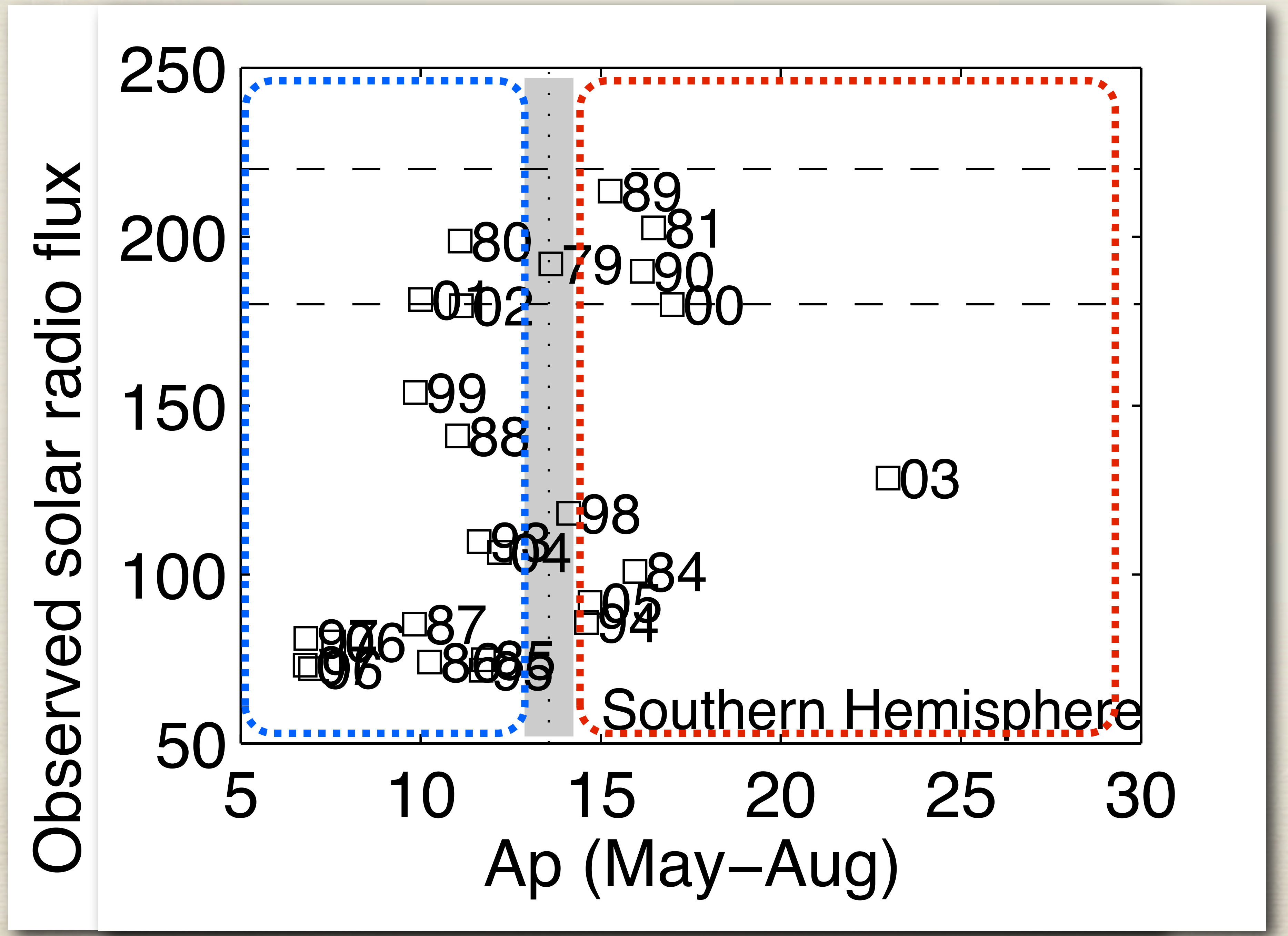


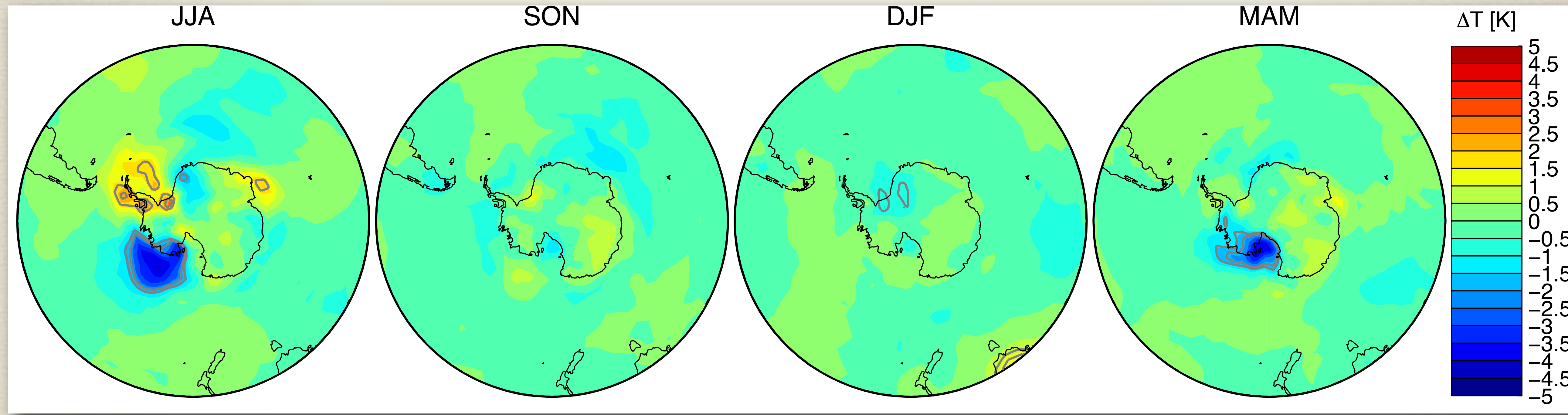
Seppälä, et al. (2009), Geomagnetic activity and polar surface air temperature variability. In press,, J. Geophys. Res.

SH Surface Air Temperatures.
All solar cycle phases
High Ap - Low Ap



SH Surface Air Temperatures. All solar cycle phases, High A_p - Low A_p

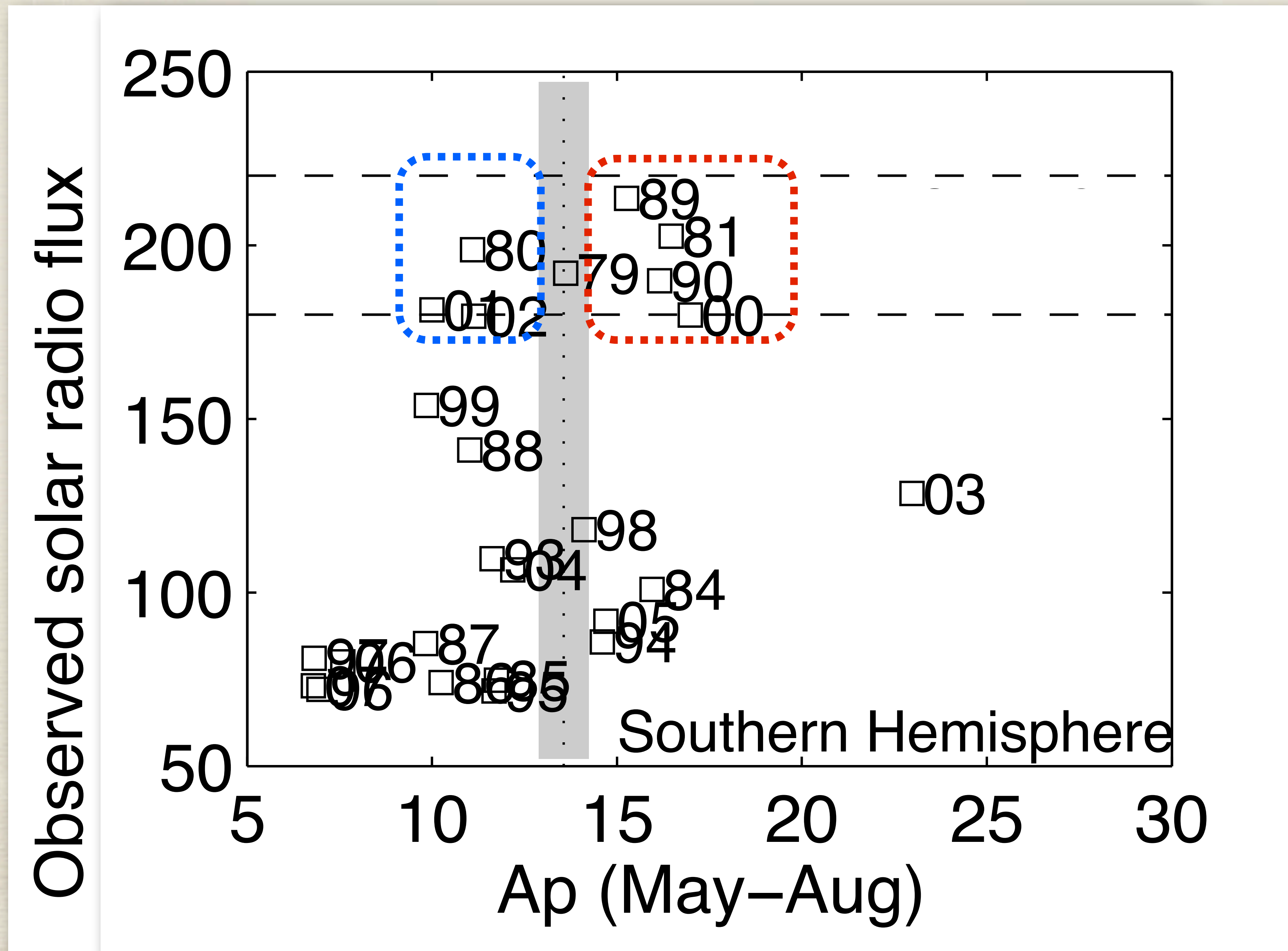
SH polar atmosphere more stable,
no SSW events during the winter period.



Seppälä, et al. (2009), Geomagnetic activity and polar surface air temperature variability. In press,, J. Geophys. Res.

SH Surface Air Temperatures.
Limited solar cycle phase
High Ap - Low Ap

Minimise temperature variations caused by solar irradiance variability.



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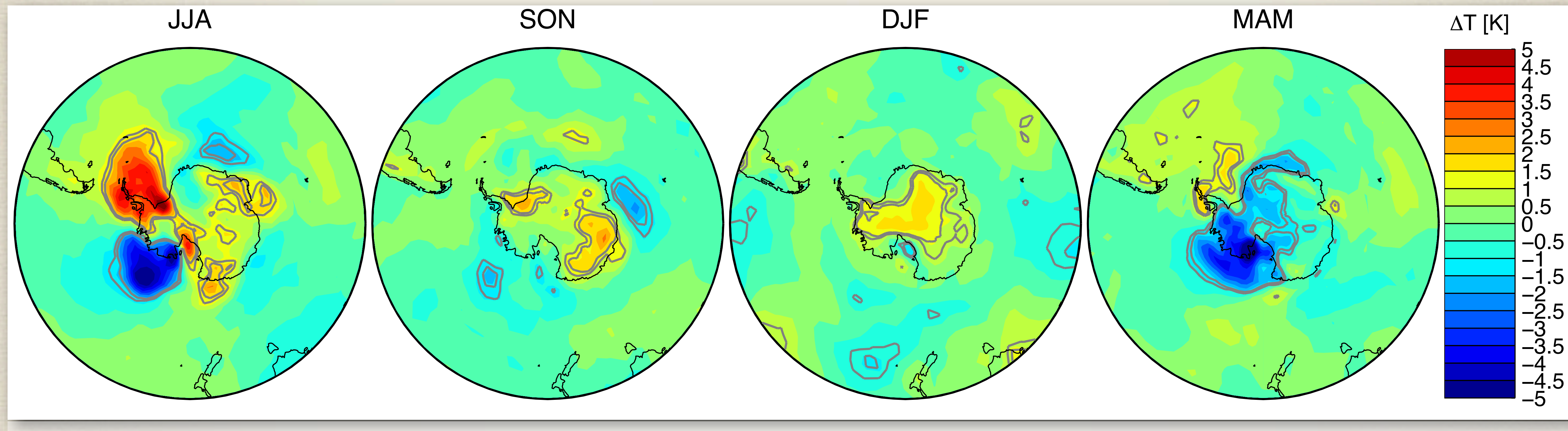
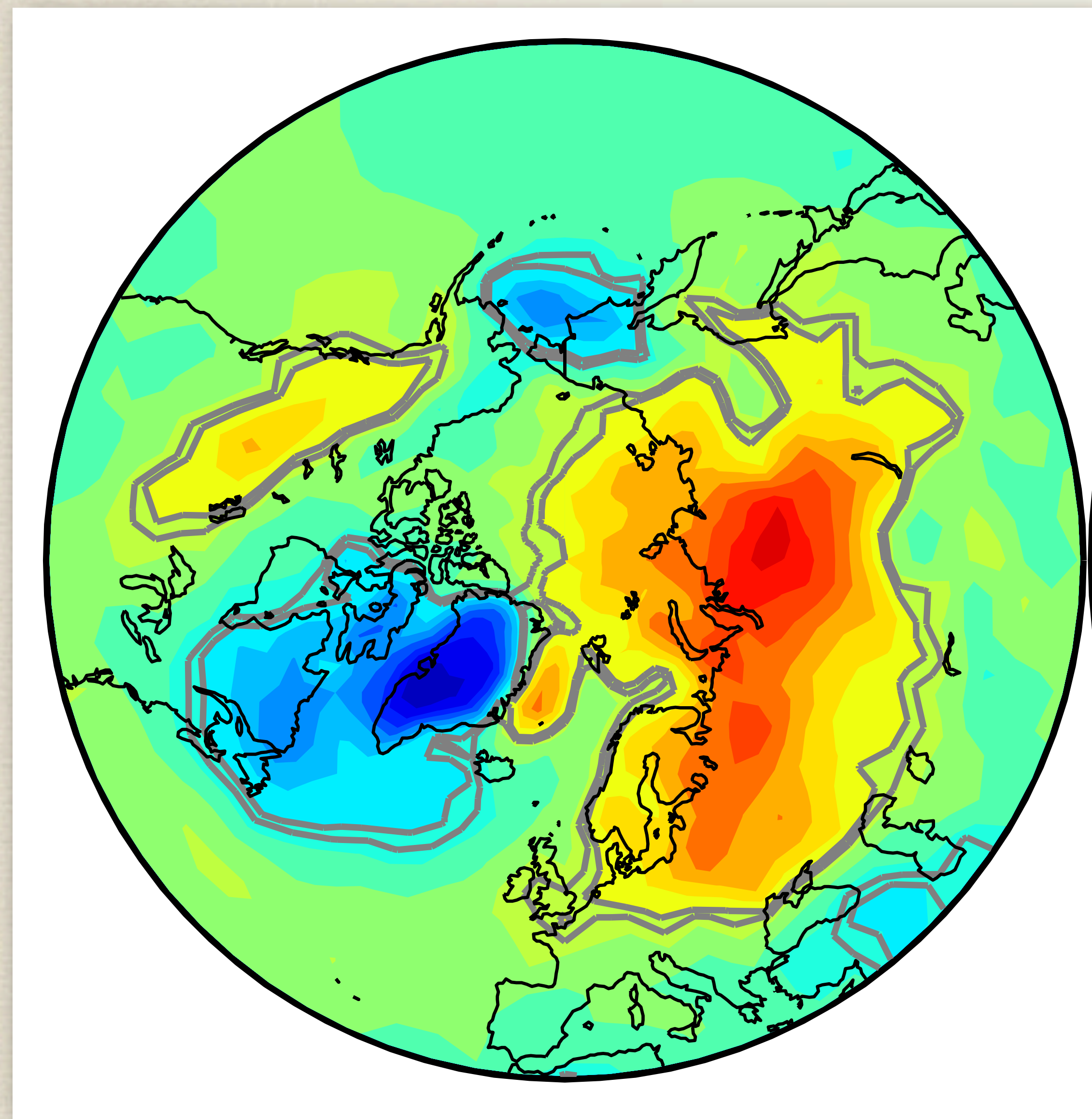


Seppälä, et al. (2009), Geomagnetic activity and polar surface air temperature variability. In press,, J. Geophys. Res.

Conclusions

- Geomagnetic activity signatures (indirect) in ERA-40 and ECMWF operational polar winter surface air temperatures.
- Temperature *variation* (not a *trend*) pattern and magnitude in agreement with model predictions. Similar temperature variation pattern observed regardless of the solar cycle phase, suggesting it is not a UV effect.
- Temperature differences increase when excluding years with SSWs (more stable atmosphere?).
- More information about the particle precipitation needed!
- We have considered contributions from atmospheric oscillation modes. Sea Surface Temperatures variations can not be excluded from our data. We are still working on the linking mechanism.
- For more information see: Seppälä, et al. (2009), *Geomagnetic activity and polar surface air temperature variability*. In press, J. Geophys. Res.

We are working on understanding the linking mechanism...



Global Climate Model, effect of thermospheric NO_x source to NH SATs. Everything else, including the Sea Surface Temperatures, were fixed!

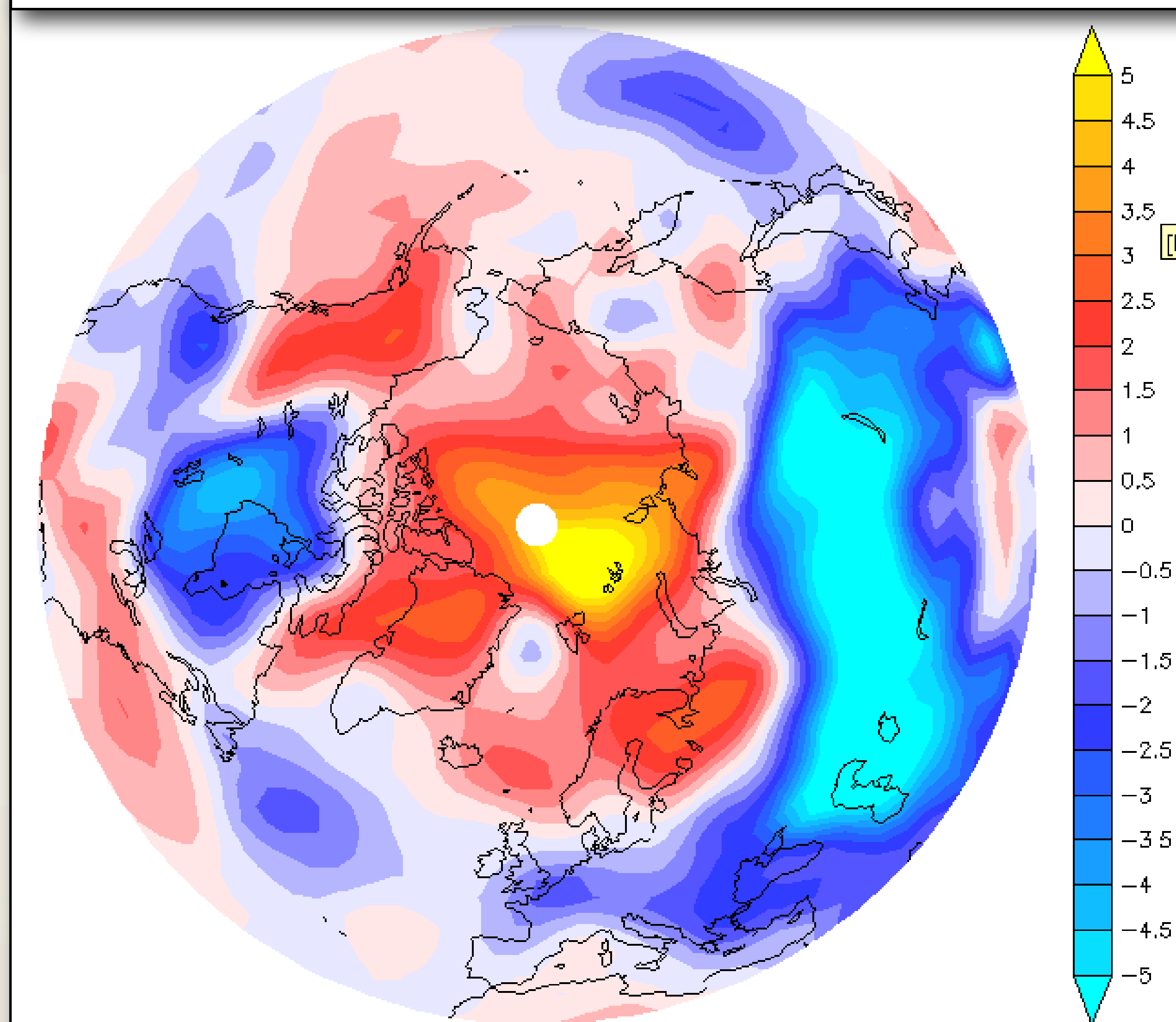


Figure courtesy of Andreas Baumgaertner, Max Planck Institute for Chemistry. **See poster!**

Atmospheric Oscillations

* Atmospheric Oscillations cause temperature variability. We consider the impact of four atmospheric modes to the SAT results:
  * QBO = Quasi Biennial Oscillation
  * ENSO = El Niño - Southern Oscillation
  * NAM = Northern Annular Mode
  * SAM = Southern Annular Mode
* Use indices provided for each of the above:

	OND		NDJ		DJF		AMJ		MJJ		JJA		
Index	N1	N2	N1	N2	N1	N2	S1	S2	S1	S2	S1	S2	Max/Min/σ
QBO[1]	-3.50	-0.58	-3.38	-1.50	-3.81	-2.28	-9.02	4.75	-11.94	3.61	-14.27	1.46	15.62/-29.55/11.11
ENSO[2]	-0.01	0.03	-0.03	-0.13	0.04	-0.13	-0.24	-0.60	-0.36	-0.65	-0.38	-0.72	3.15/-2.25/0.97
NAM[3]	0.28	0.44	0.84	0.98	0.83	0.83	–	–	–	–	–	–	3.04/-3.18/0.99
SAM[4]	–	–	–	–	–	–	0.03	0.23	0.21	0.51	0.15	-0.10	2.69/-3.01/0.99

[1] http://www.cdc.noaa.gov/Correlation/qbo.data
[2] Multivariate ENSO Index: http://www.cdc.noaa.gov/people/klaus.wolter/MEI/table.html
[3] http://www.cpc.noaa.gov/products/precip/CWlink/pna/norm.nao.monthly.b5001.current.ascii.table
[4] http://www.cpc.noaa.gov/products/precip/CWlink/daily_ao_index/aao/monthly.aao.index.b79.current.ascii.table