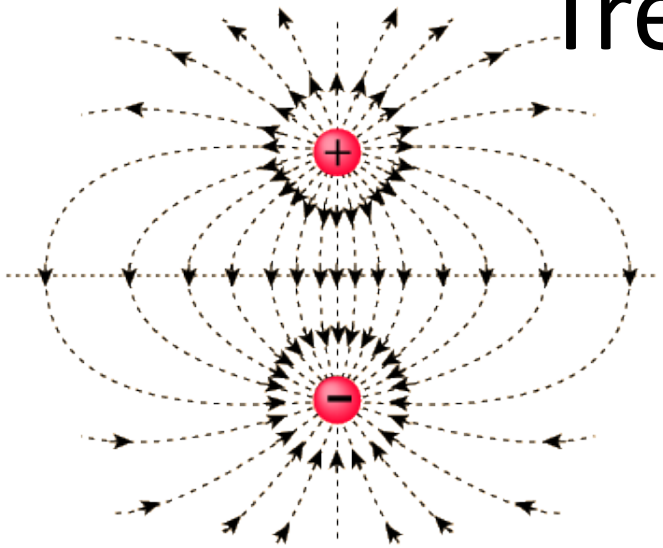
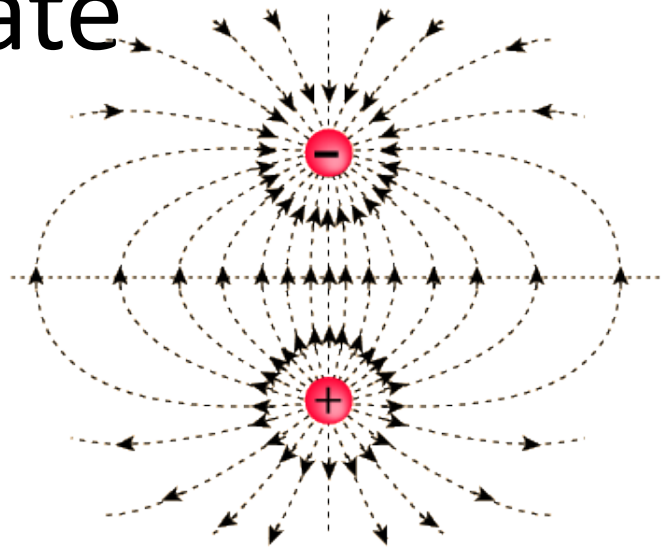
Interactions of Dipoles and Trends in Climate





Stefan Liess

Contributors:

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Graham Smith, Peter Snyder, Michael Steinbach (UMN)

Auroop Ganguly (UTK), Nagiza Samatova, Fred Semazzi (NCSU)

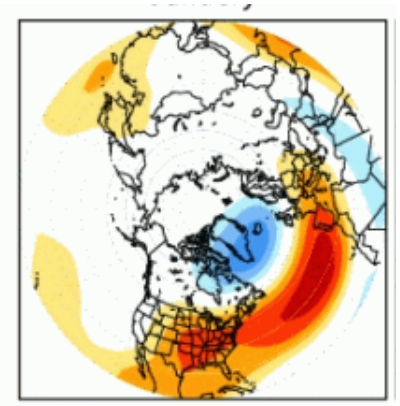
"Atmospheric teleconnection patterns can be characterized by their dipole structure and possible trends (conservation of mass)."

Teleconnection Patterns

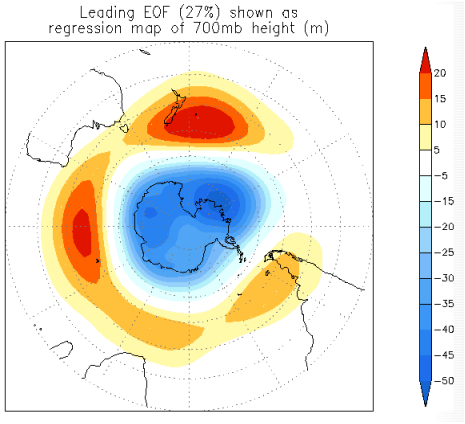
As Defined by the Climate Prediction Center

1. **Southern Oscillation Index** (SOI – also defined as ENSO in SSTA)
2. **Antarctic Oscillation** (AAO – also known as Southern Annular Mode)
3. **Arctic Oscillation** (AO – AO&NAO: also known as Northern Annular Mode)
4. **North Atlantic Oscillation** (NAO)
5. **East Atlantic** (EA)
6. **East Atlantic/Western Russia** (WR)
7. **Scandinavia** (SCAND)
8. **Polar/Eurasia** (PE)
9. **West Pacific** (WP)
10. **East Pacific-North Pacific** (EP-NP)
11. **Pacific/North American** (PNA)
12. **Tropical/Northern Hemisphere** (TNH)
13. **Pacific Transition** (PT)

NAO



AAO



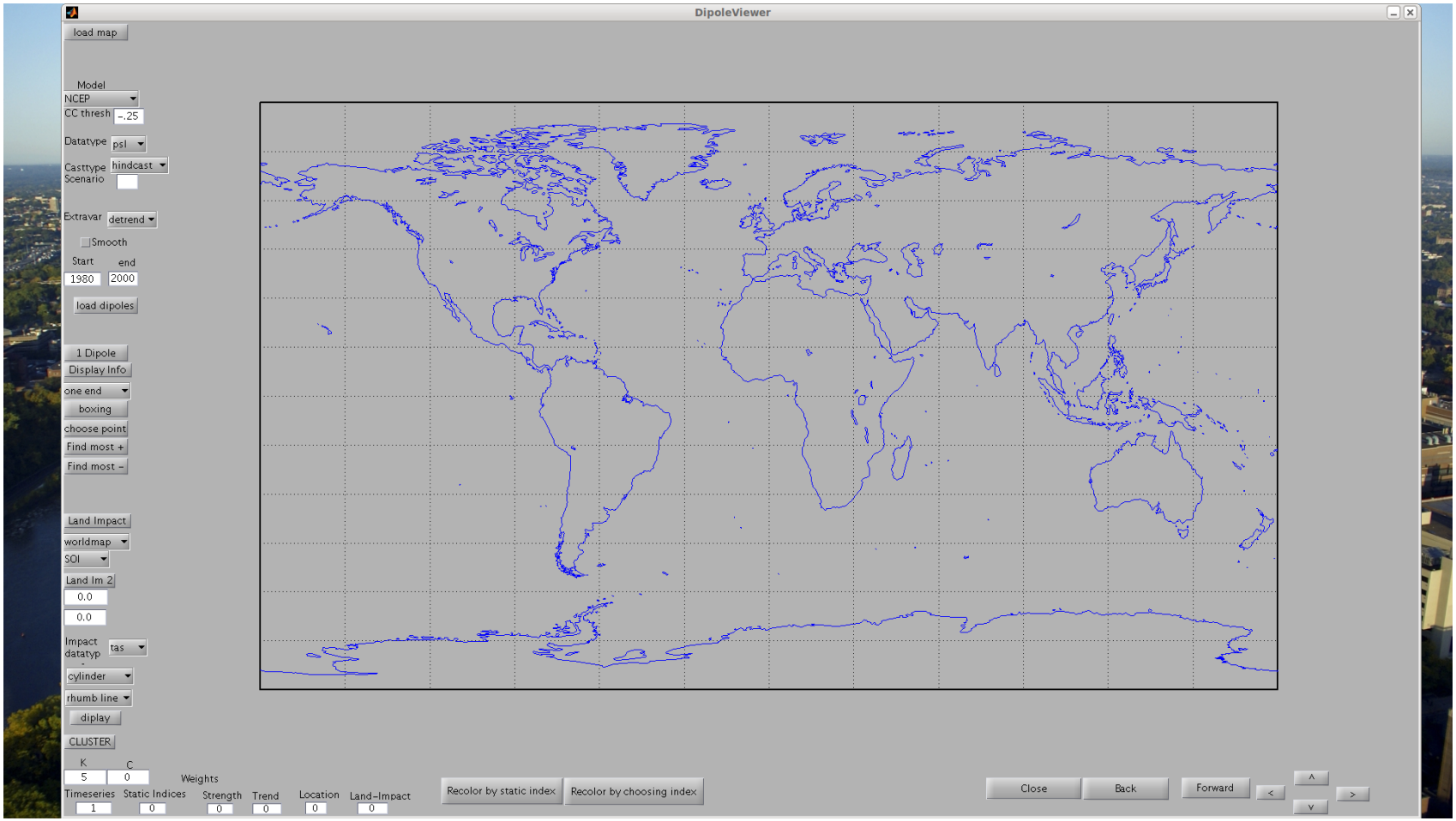
http://www.cpc.ncep.noaa.gov/data/teledoc/telecontents.shtml

Teleconnection Patterns in Reanalysis Data

- Reanalysis projects the state of the atmosphere as known from observations onto a regular grid
- NCEP Reanalysis (1948-present): Longer time series (Kalnay et al. 1996)
- ERA 40 Reanalysis (1957-2002): Higher resolution (Uppala et al. 2005)

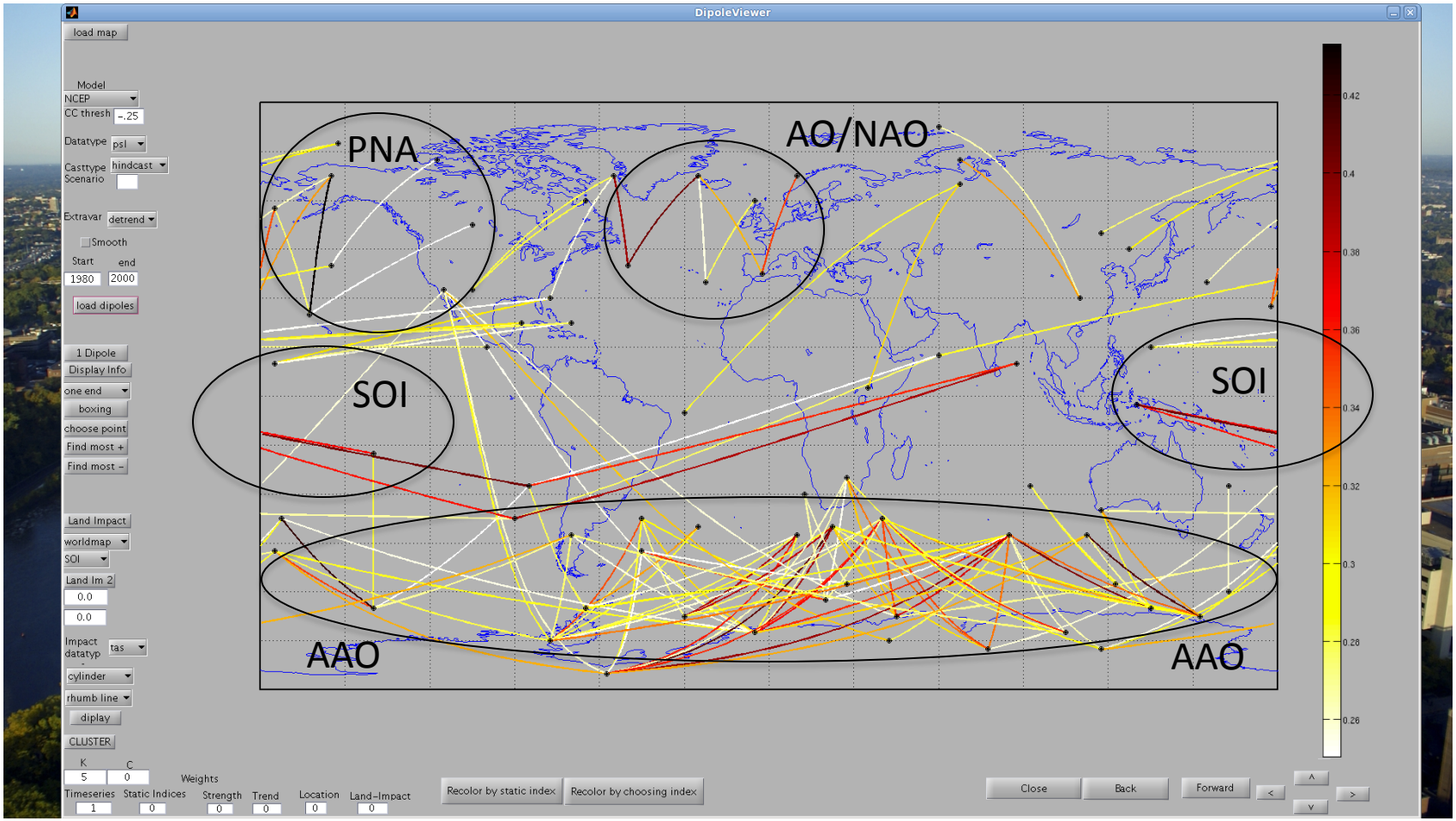
Analysis	Reanalysis
- numerical model is regularly updated with latest version - consistent in space (3DVAR)	- numerical model does not change over the entire period of the reanalysis - consistent in space and time (4DVAR)

Dipole Viewer



Dipole Viewer

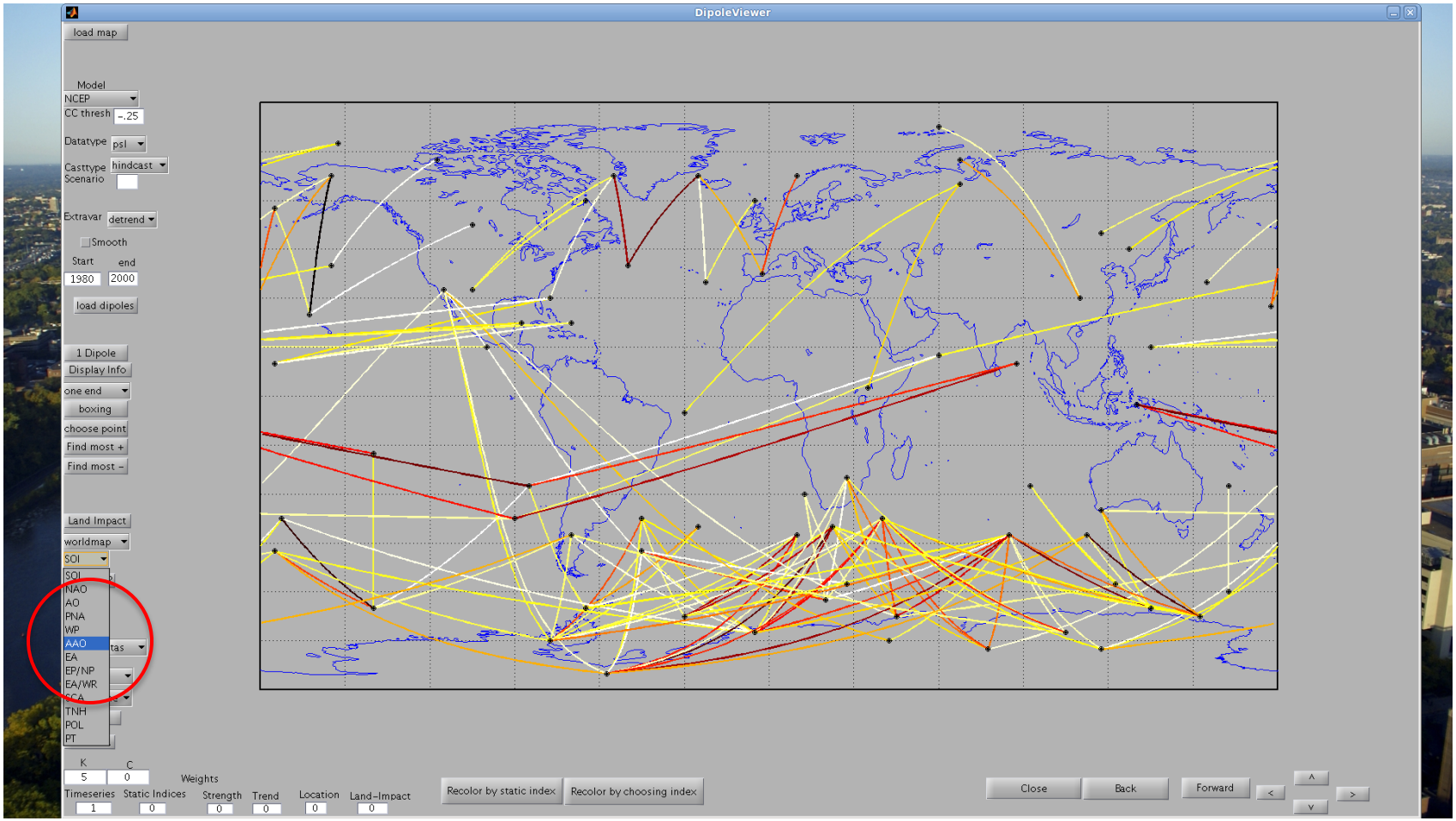
Loading NCEP Data for 1980-2000



1. Calculate Anomalies and Z-scores to Normalize Time Series 2. Remove Linear Trend

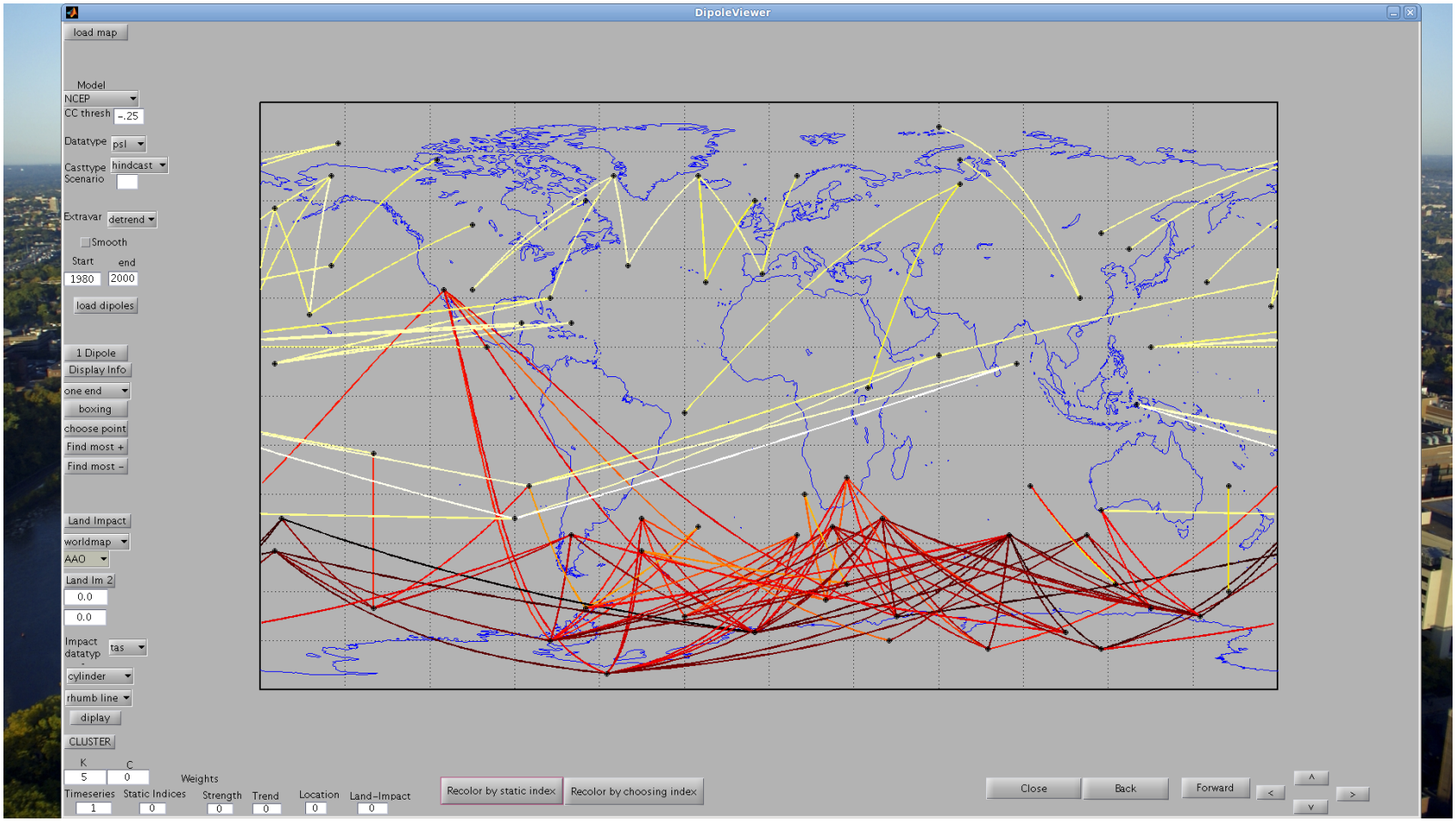
Dipole Viewer

Selecting Comparison to AAO



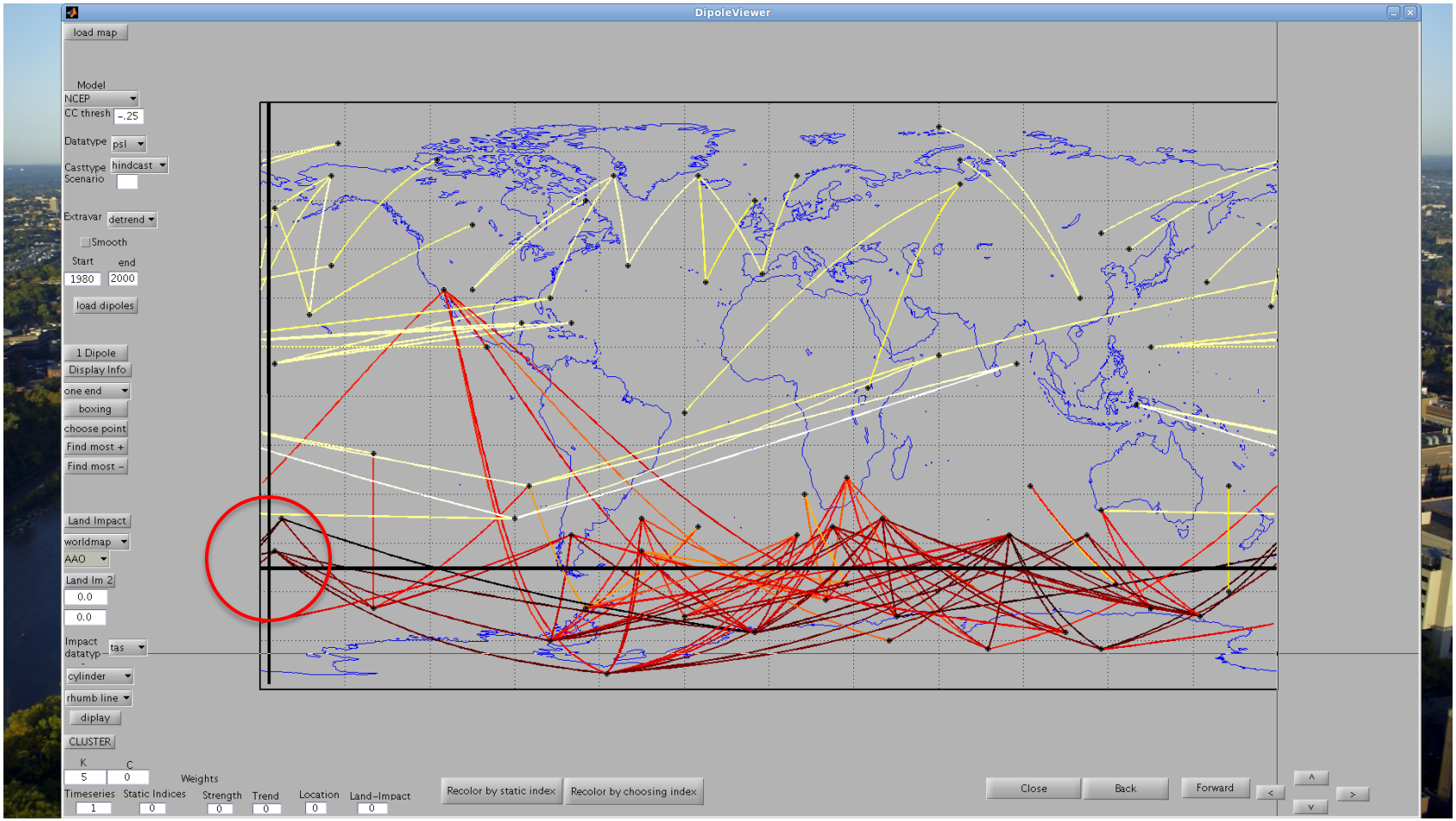
Dipole Viewer

AAO Related Dipoles are Strongest



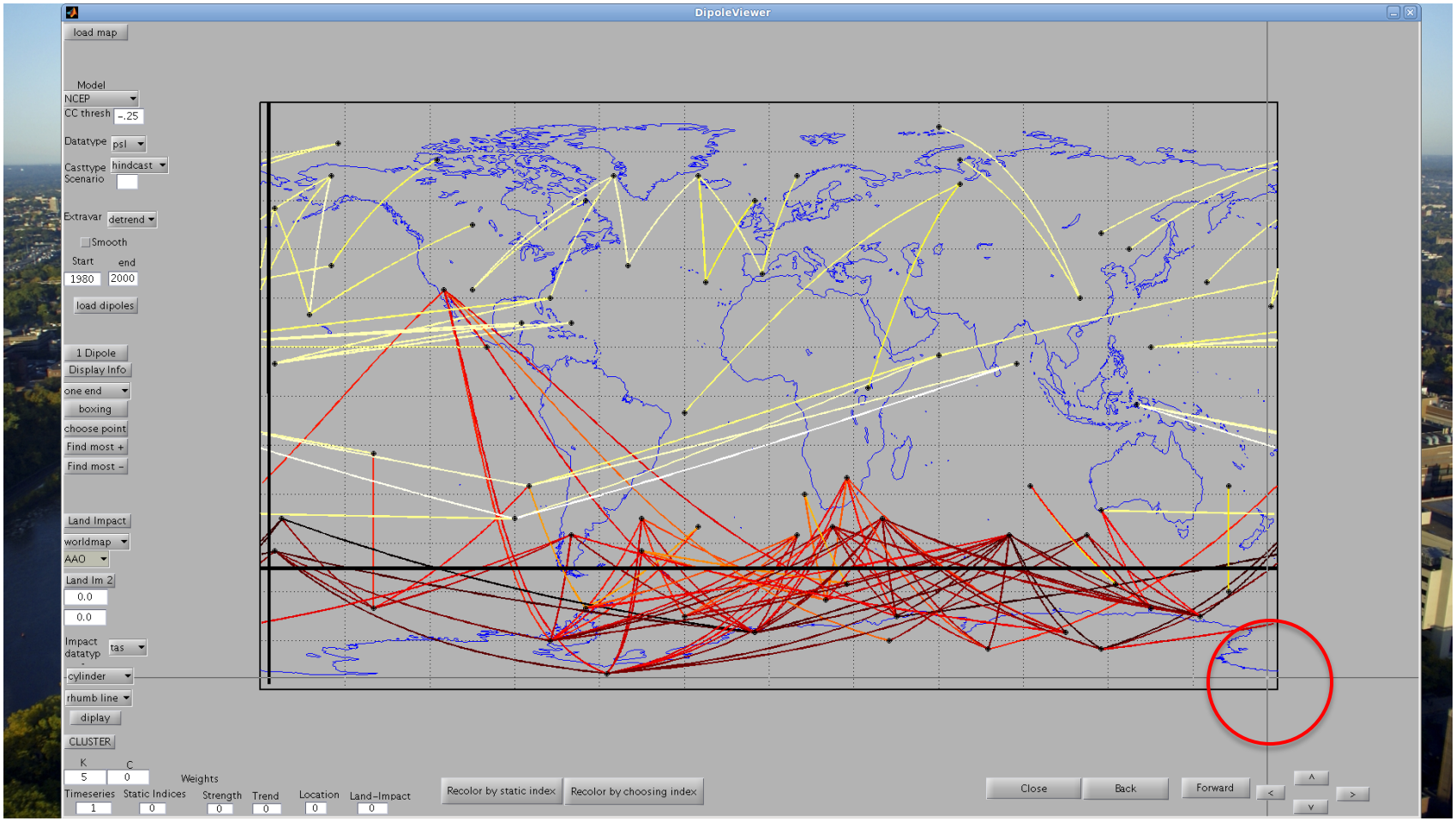
Dipole Viewer

Selecting Region of Interest



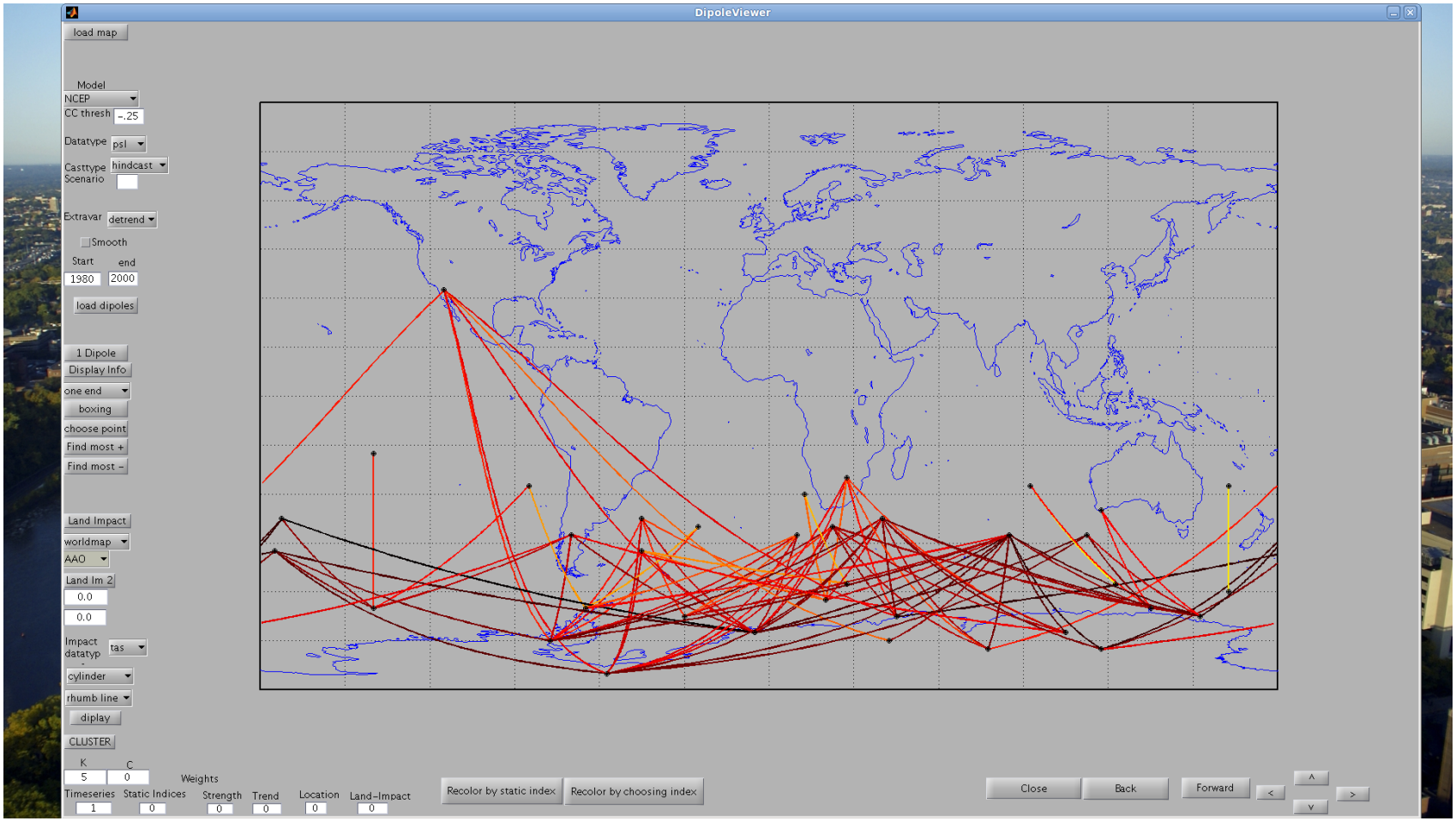
Dipole Viewer

Selecting Region of Interest



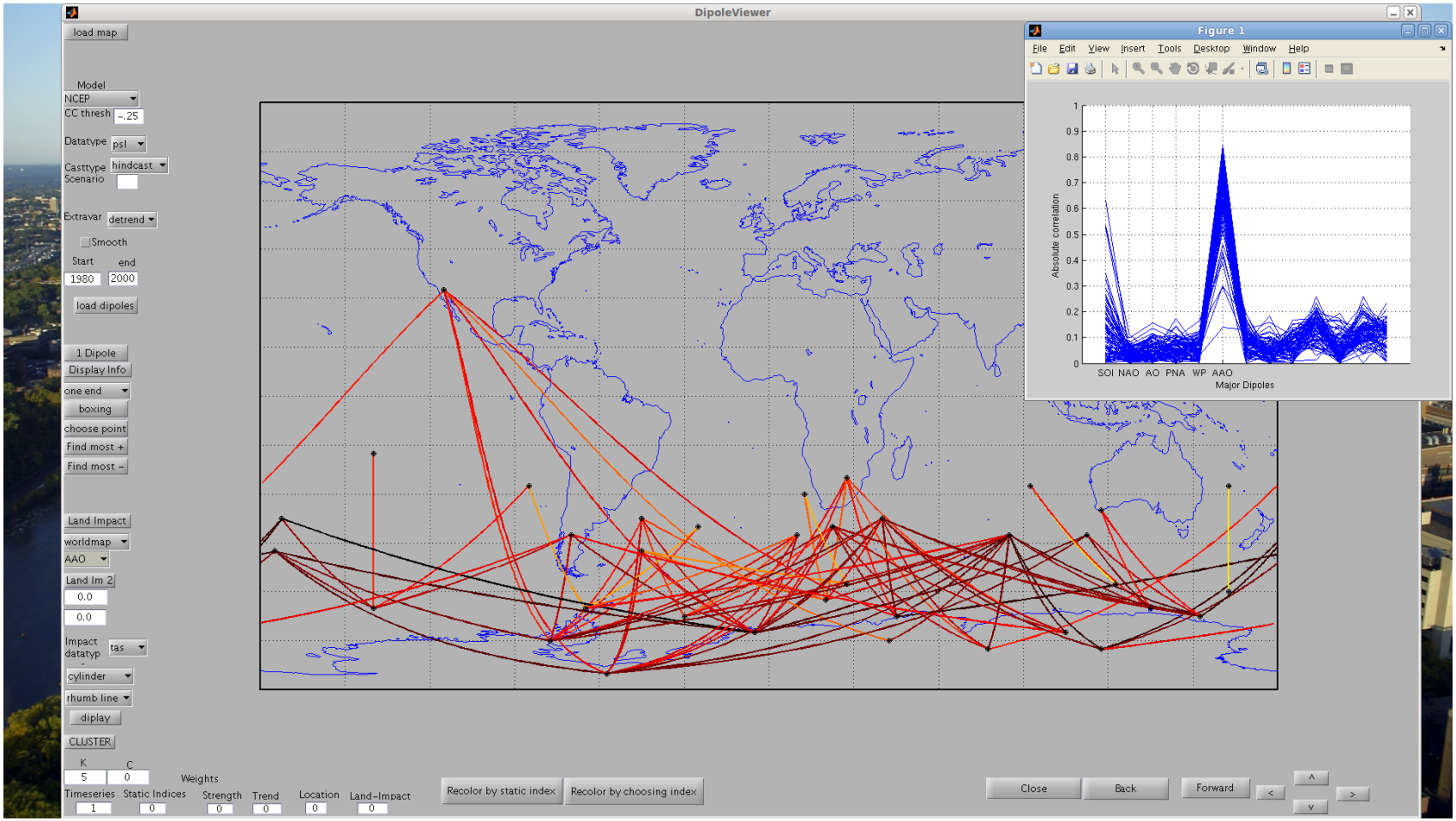
Dipole Viewer

Dipoles with One Pole in Region of Interest



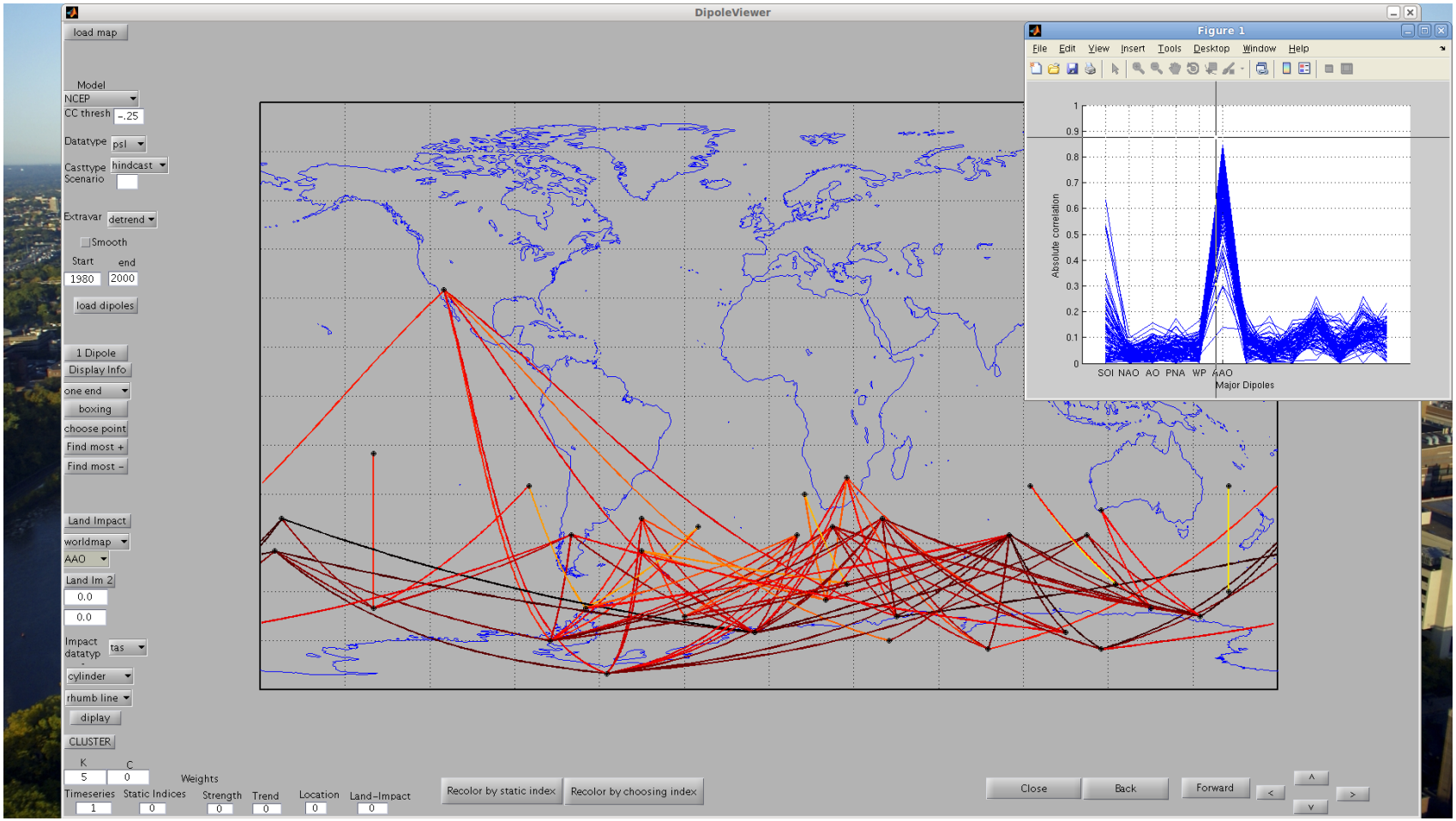
Dipole Viewer

Viewing Correlation to Climate Indices



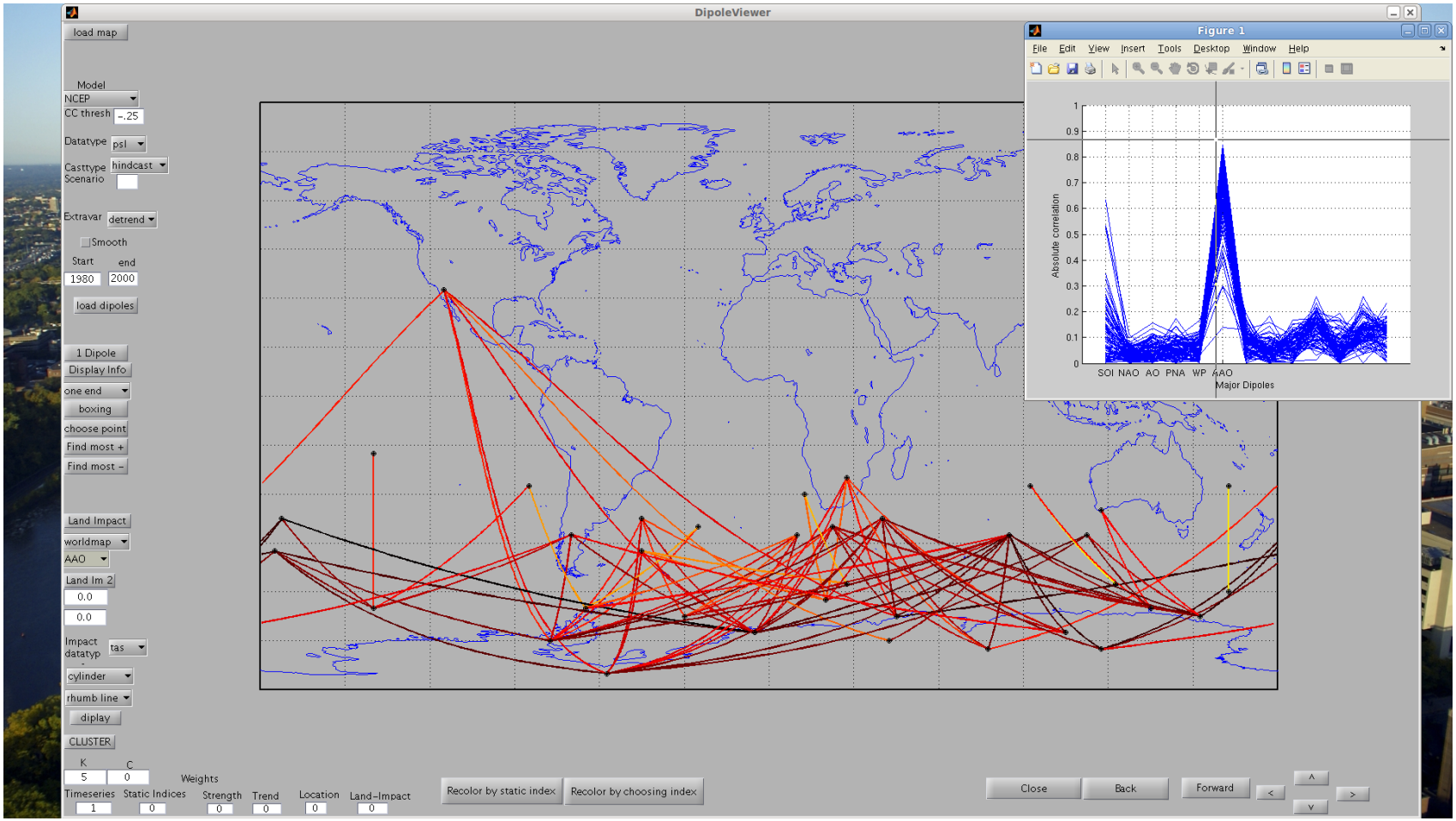
Dipole Viewer

Selecting Dipoles with Strong Correlation to AAO



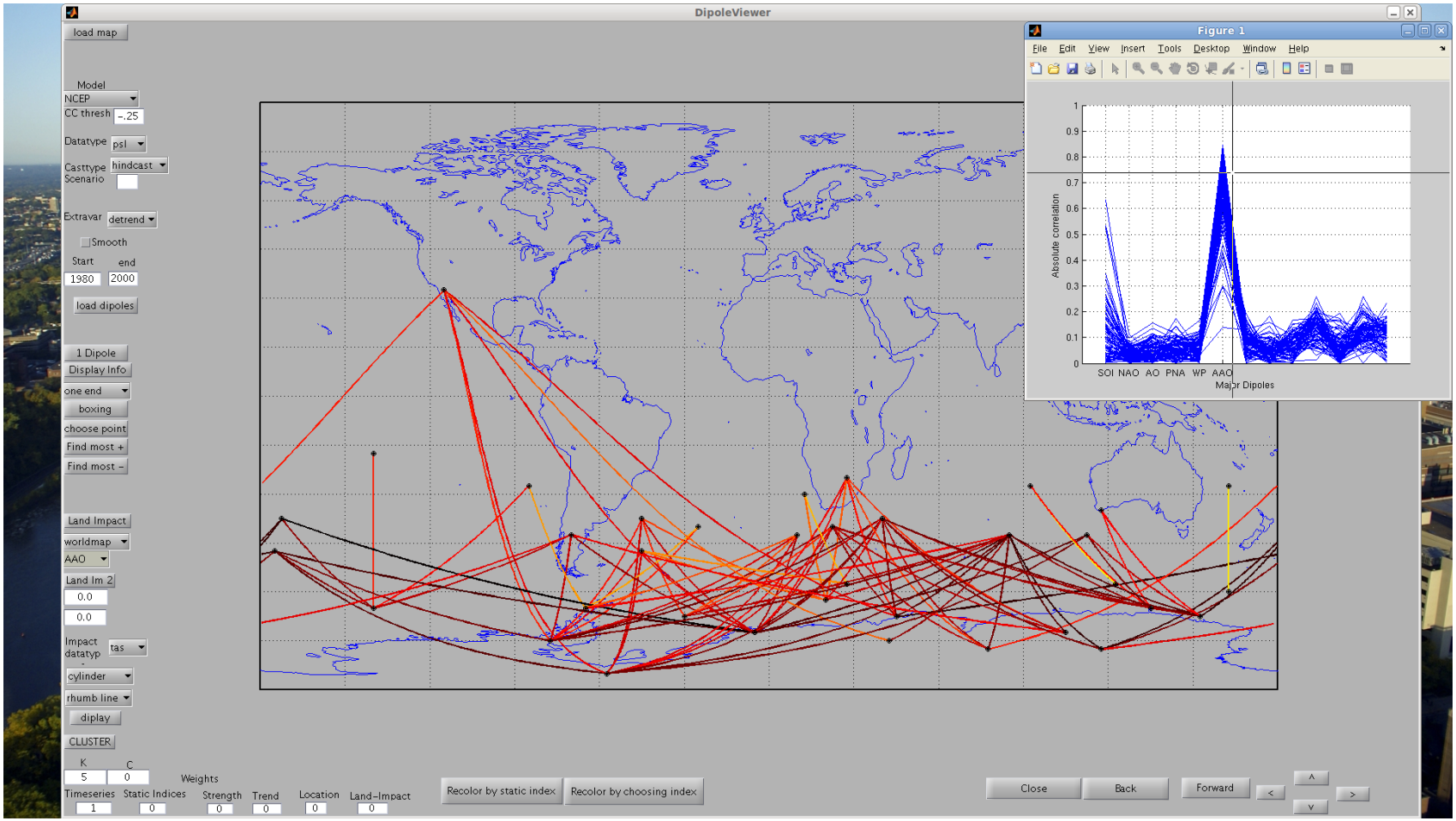
Dipole Viewer

Selecting Dipoles with Strong Correlation to AAO



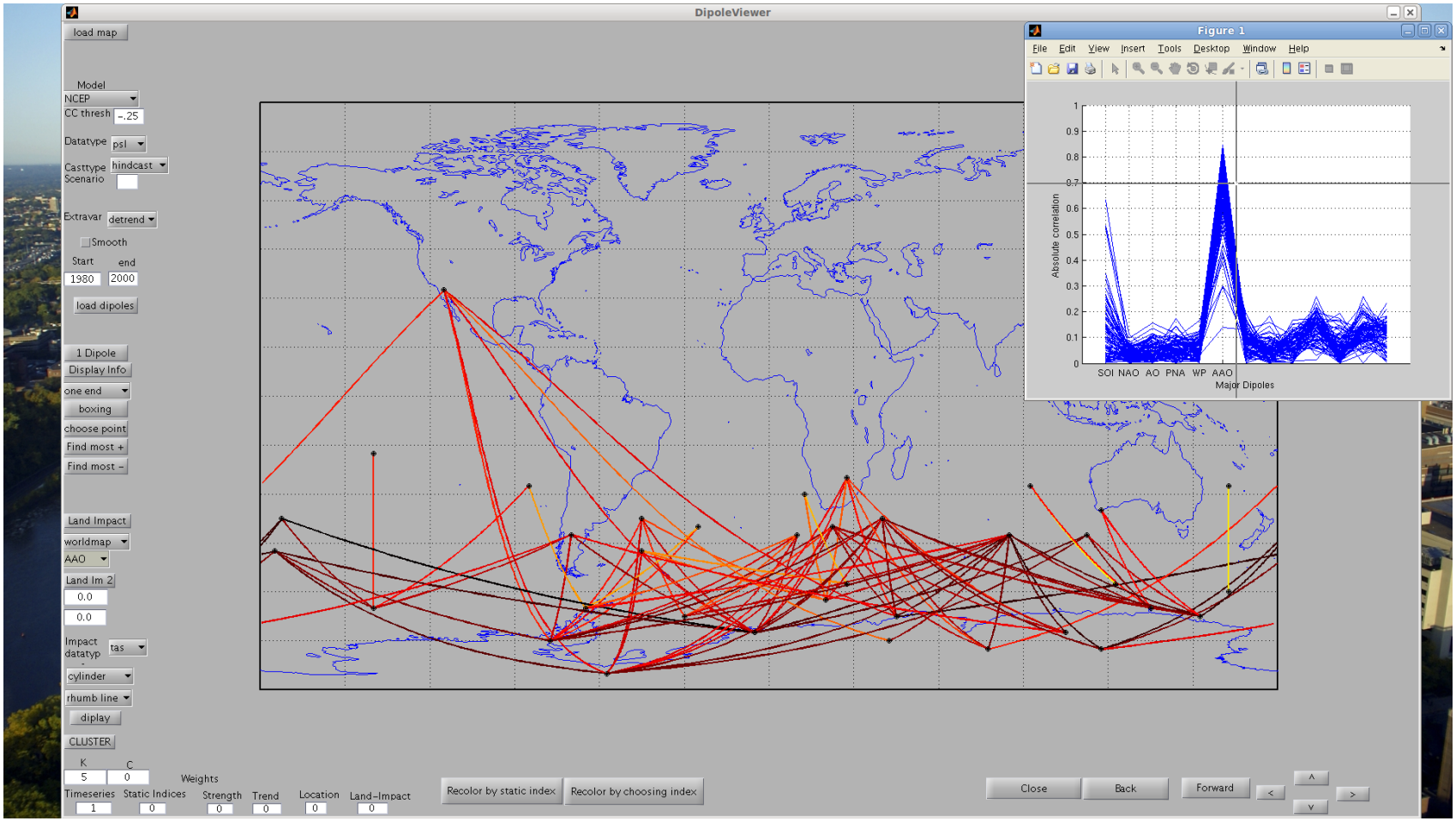
Dipole Viewer

Selecting Dipoles with Strong Correlation to AAO



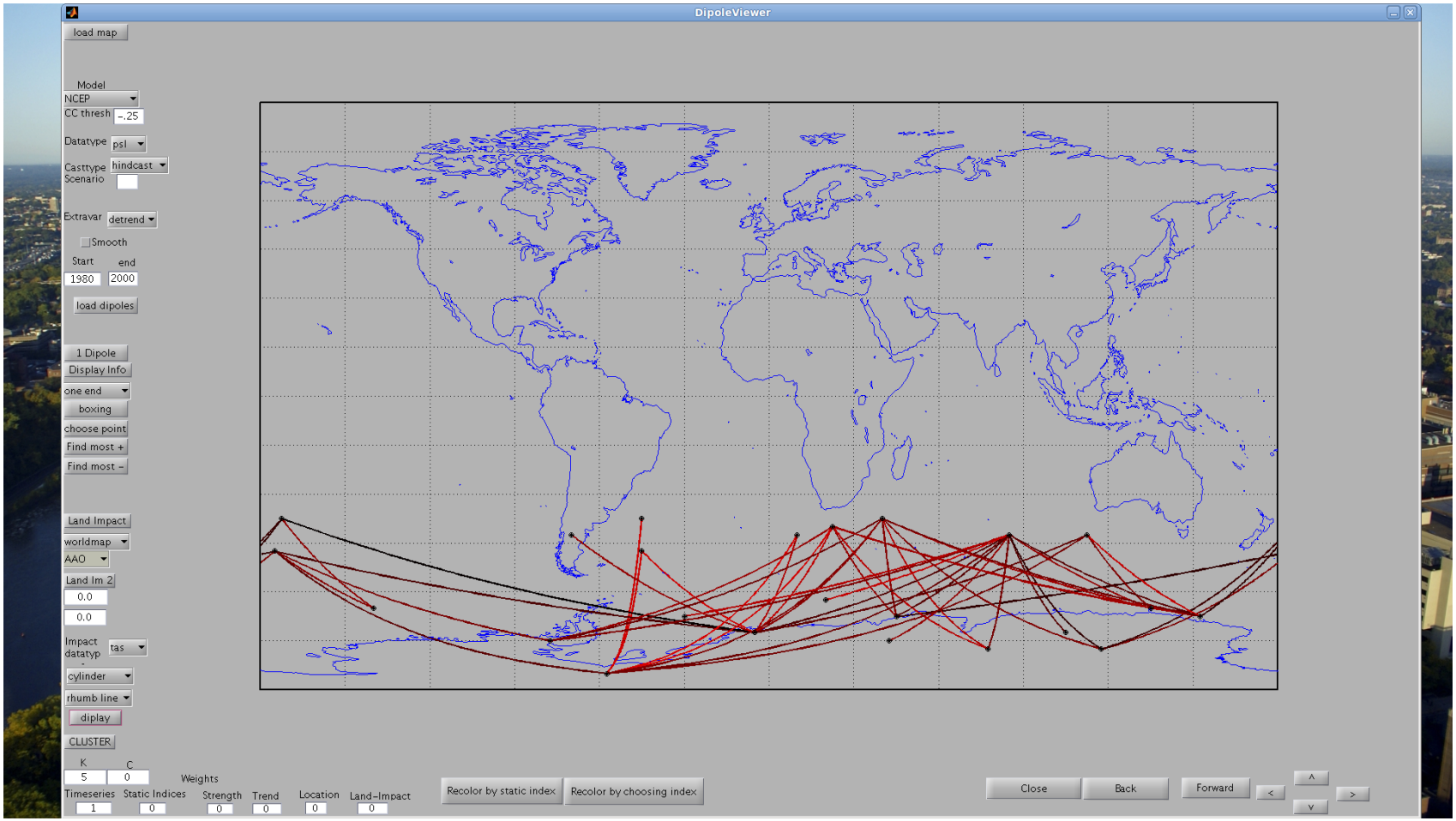
Dipole Viewer

Selecting Dipoles with Strong Correlation to AAO



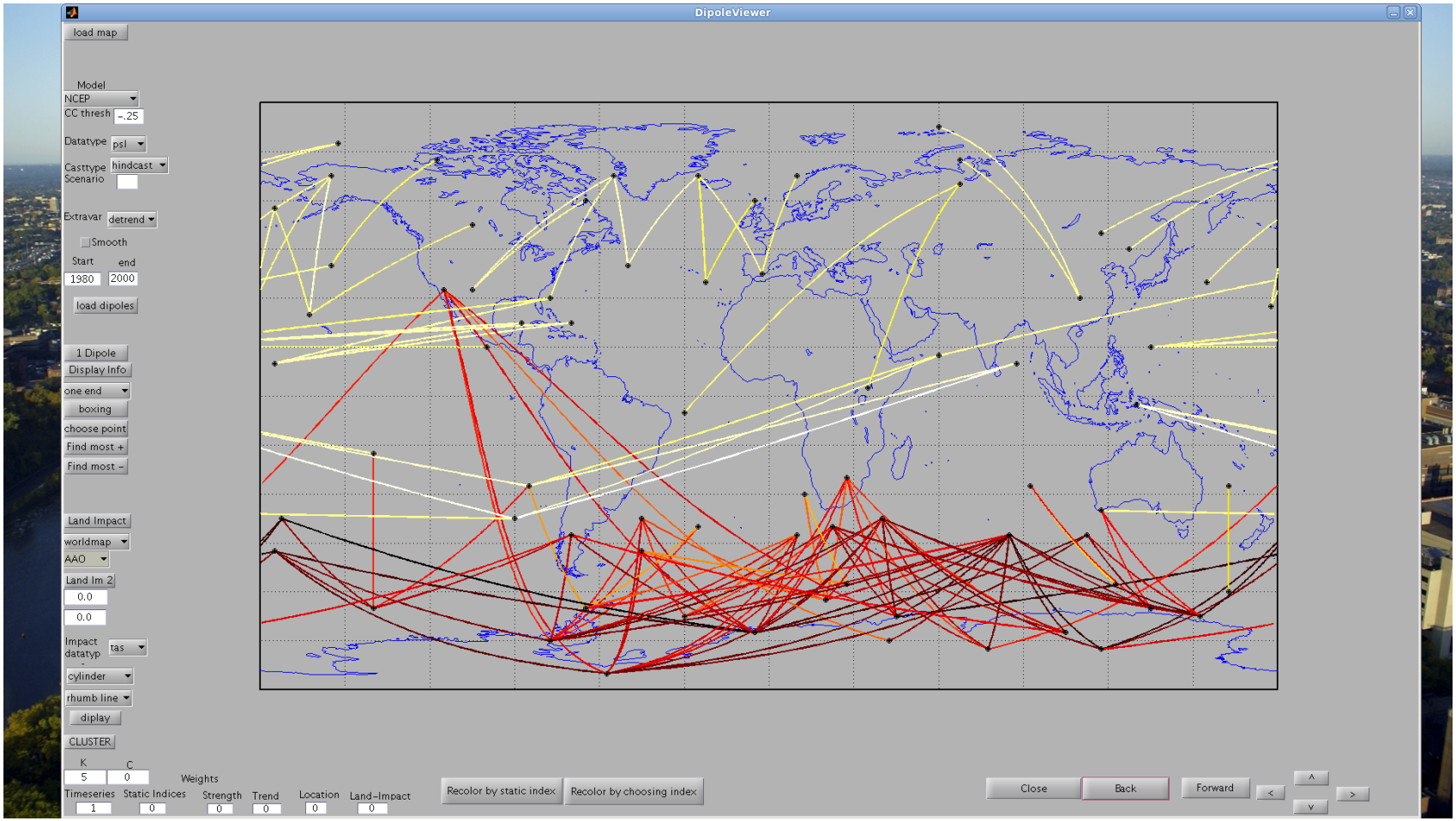
Dipole Viewer

Viewing Dipoles with Strong Correlation to AAO



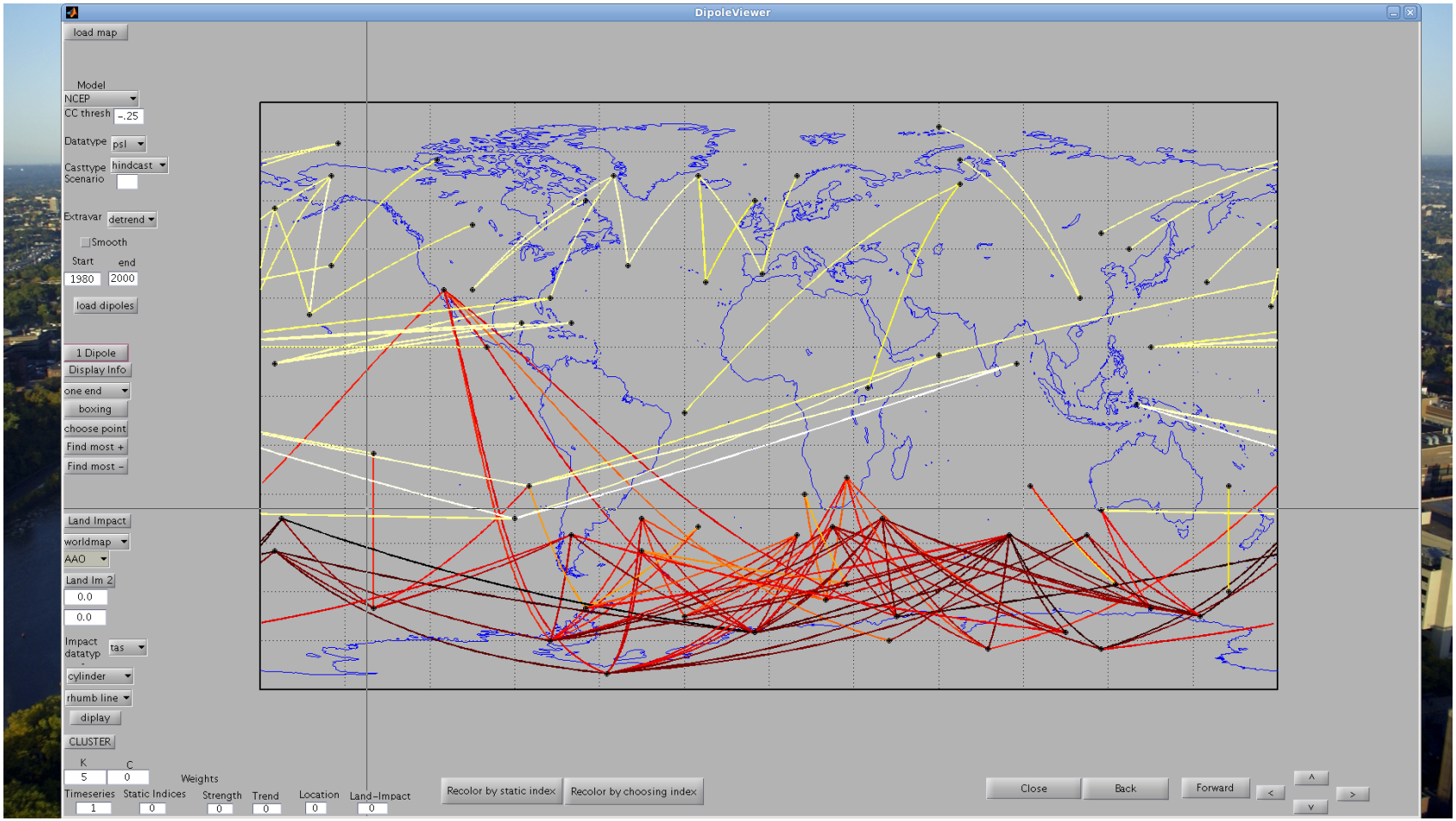
Dipole Viewer

Going Back



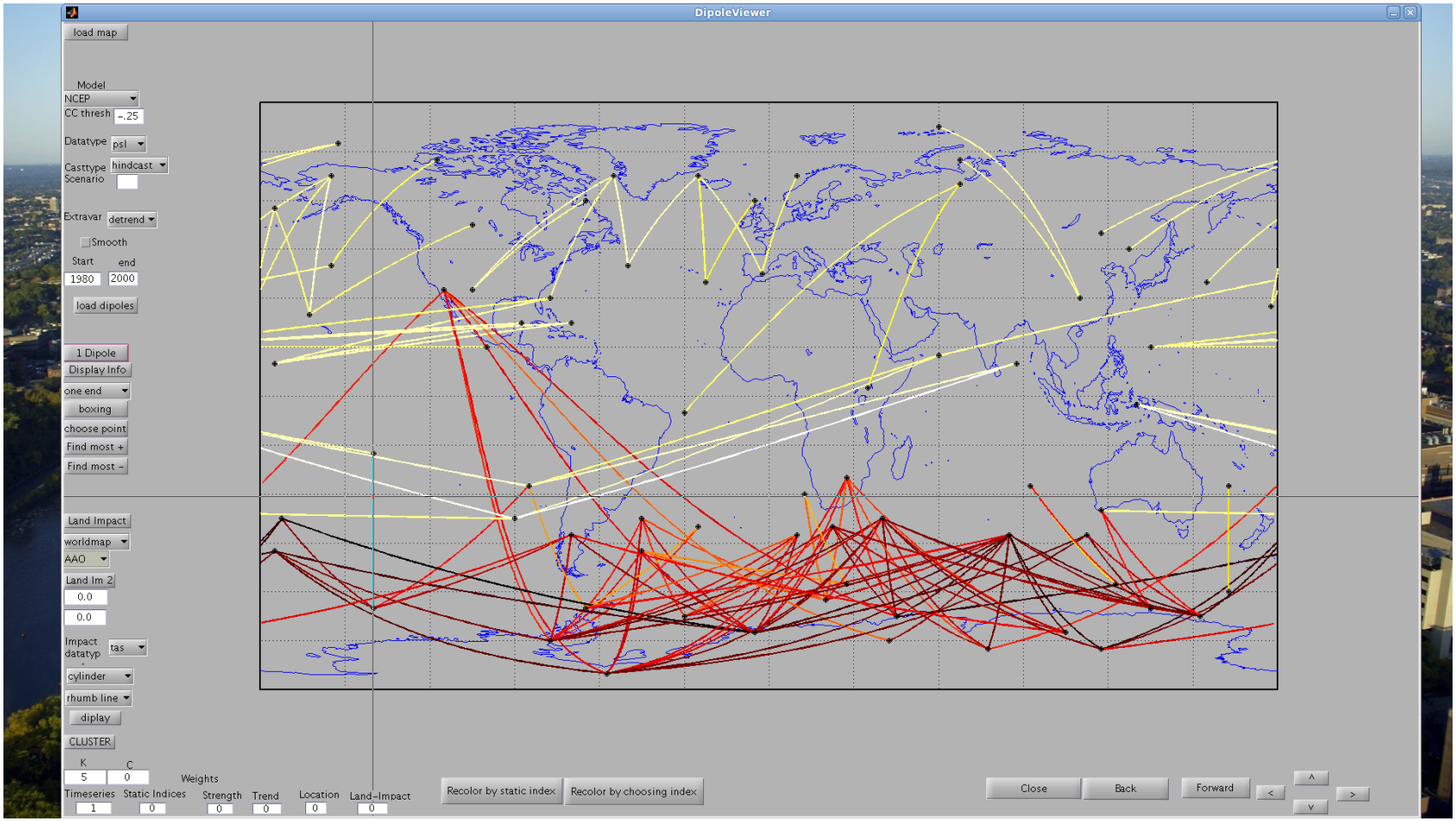
Dipole Viewer

Selecting a Single Dipole



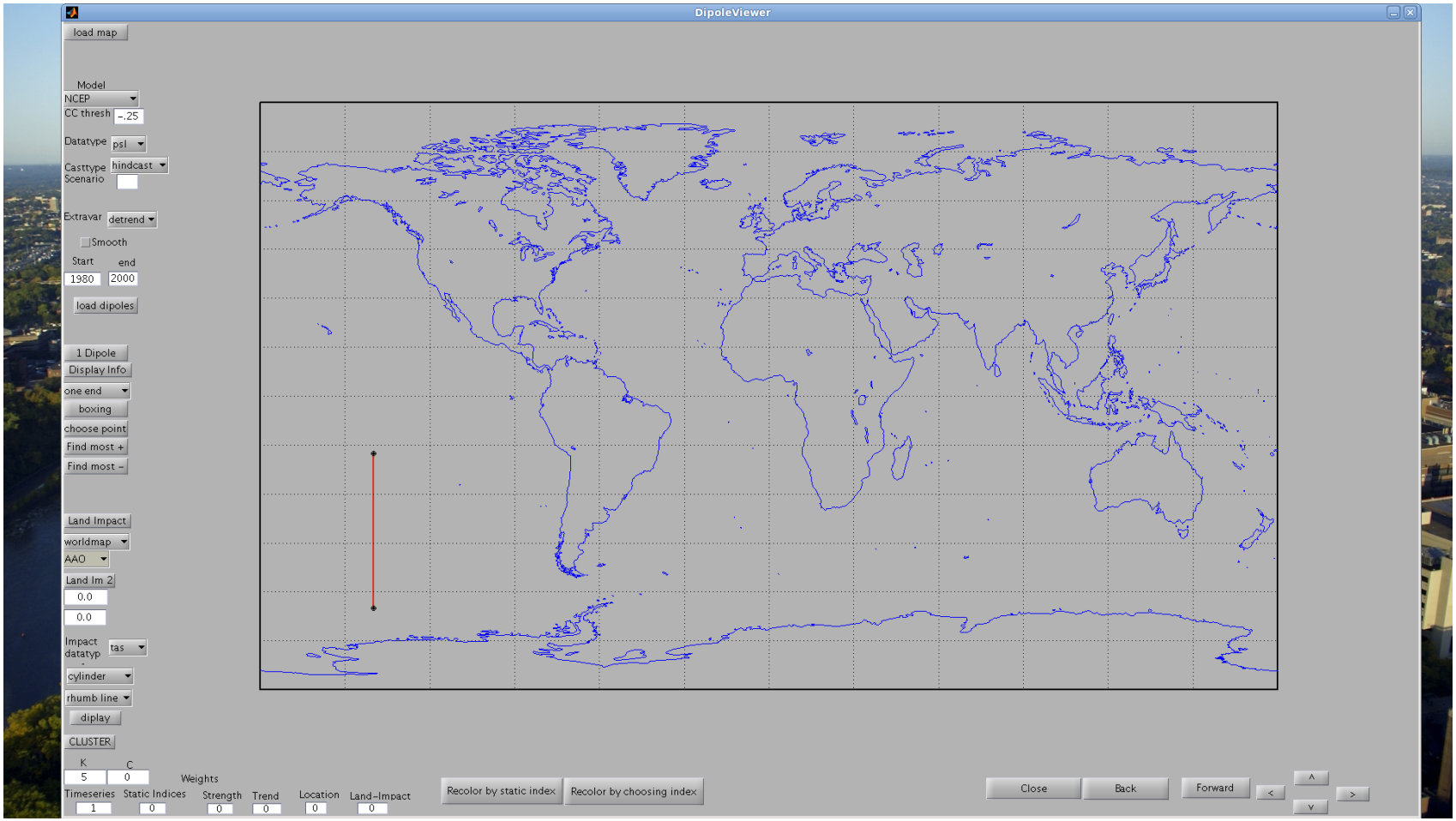
Dipole Viewer

Selecting a Single Dipole



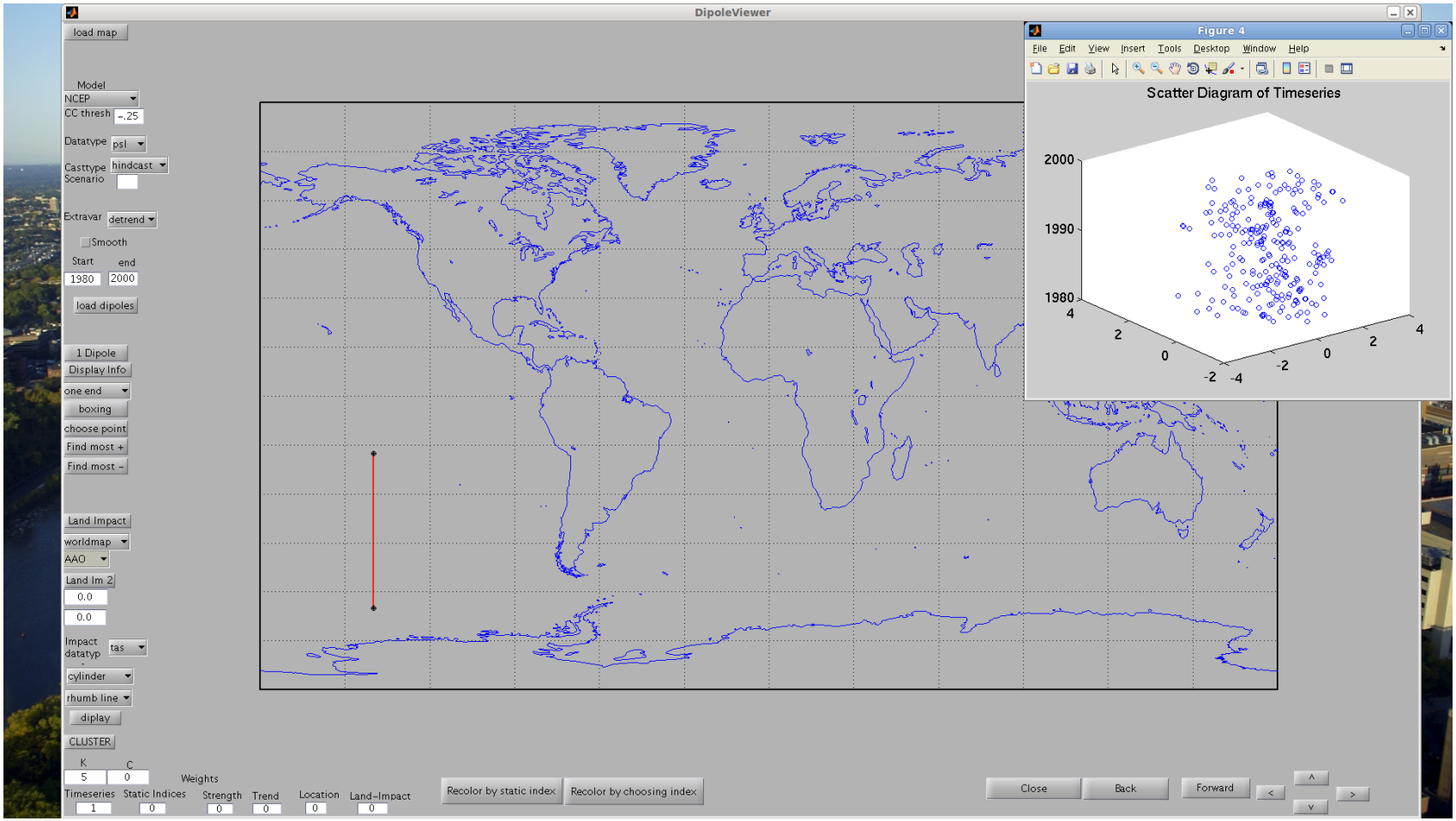
Dipole Viewer

Selecting a Single Dipole



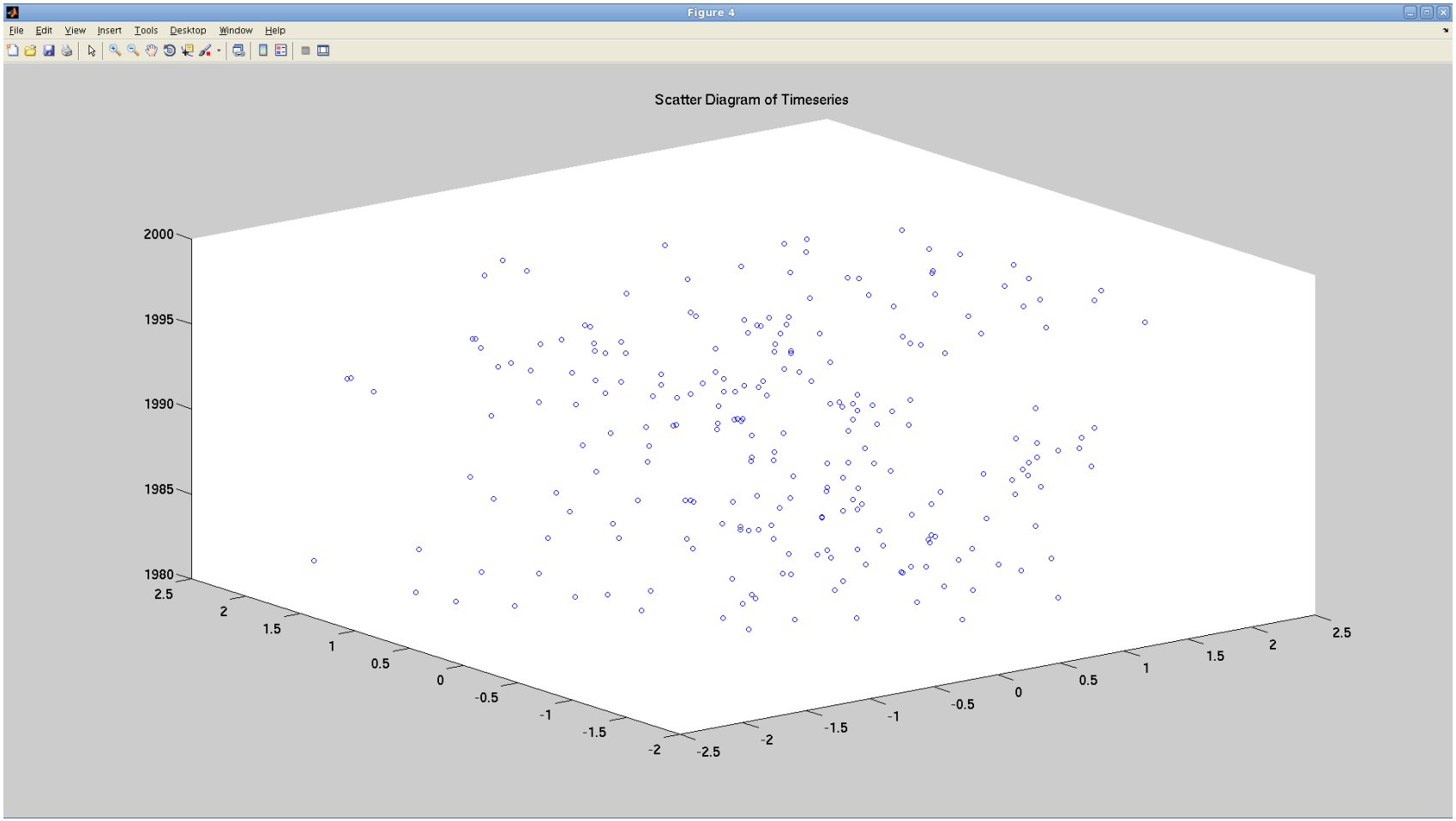
Dipole Viewer

Obtaining Information about Dipole



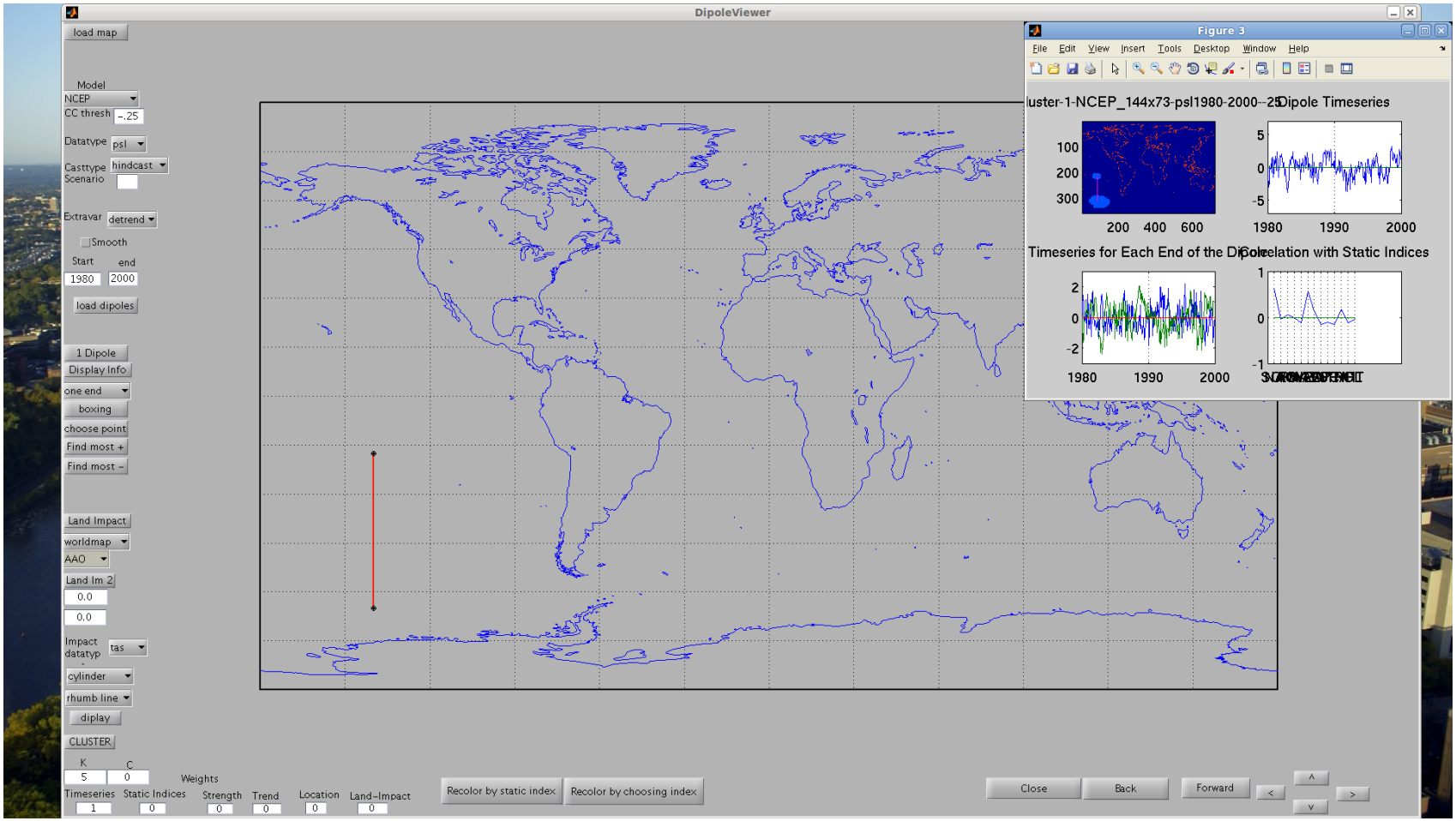
Dipole Viewer

Obtaining Information about Dipole



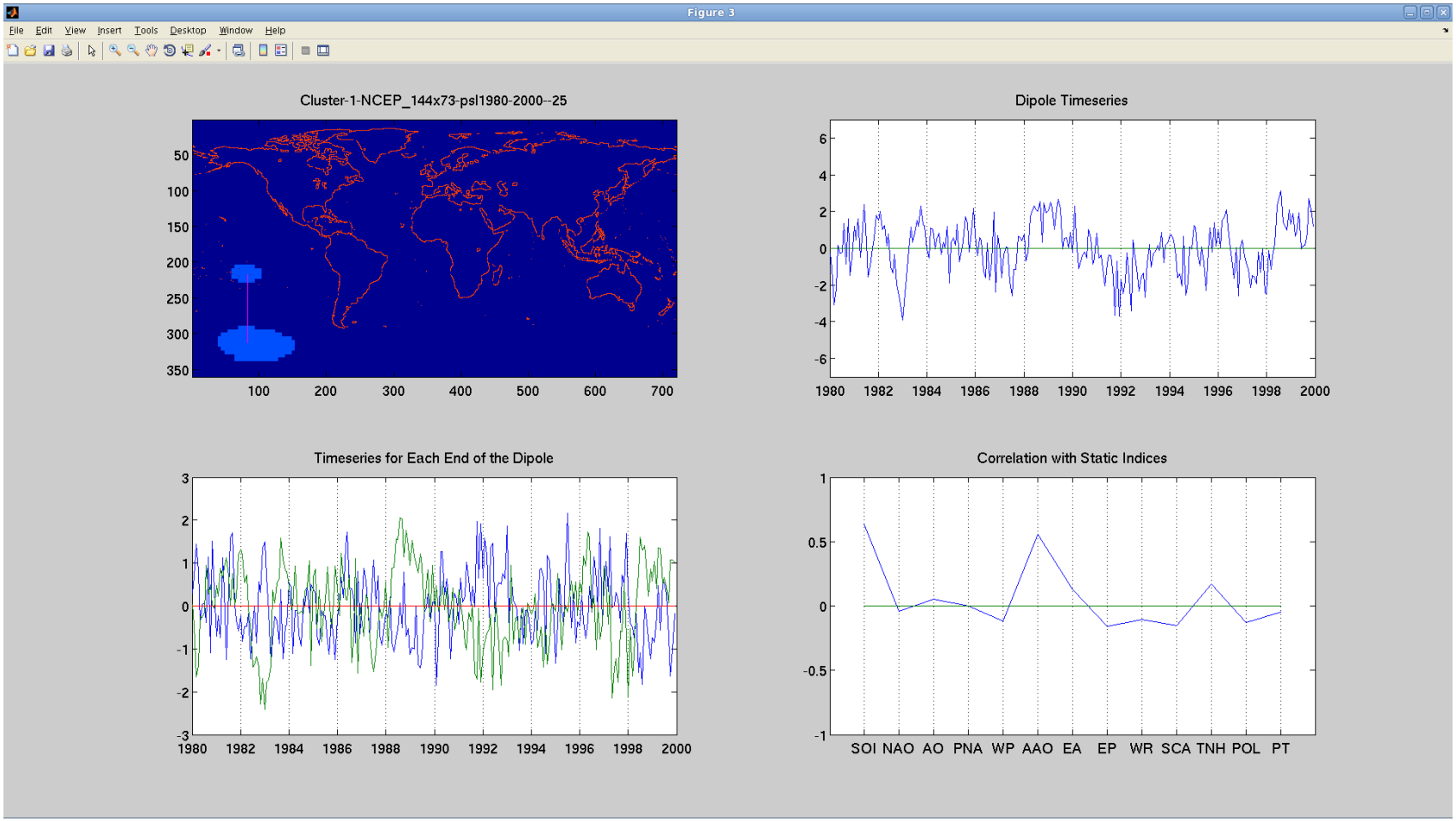
Dipole Viewer

Obtaining Information about Dipole



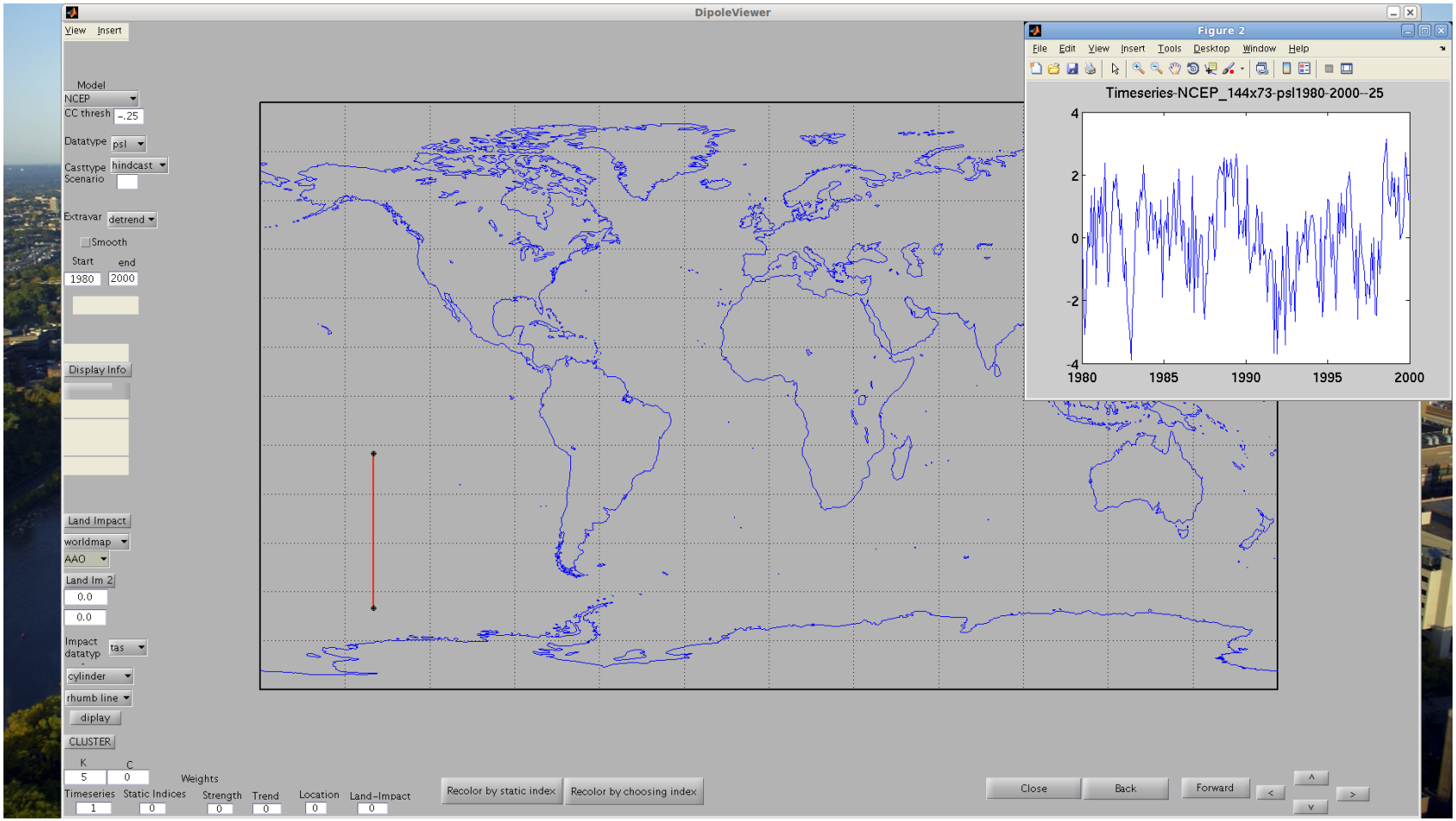
Dipole Viewer

Density, Time Series, and Correlation Plots



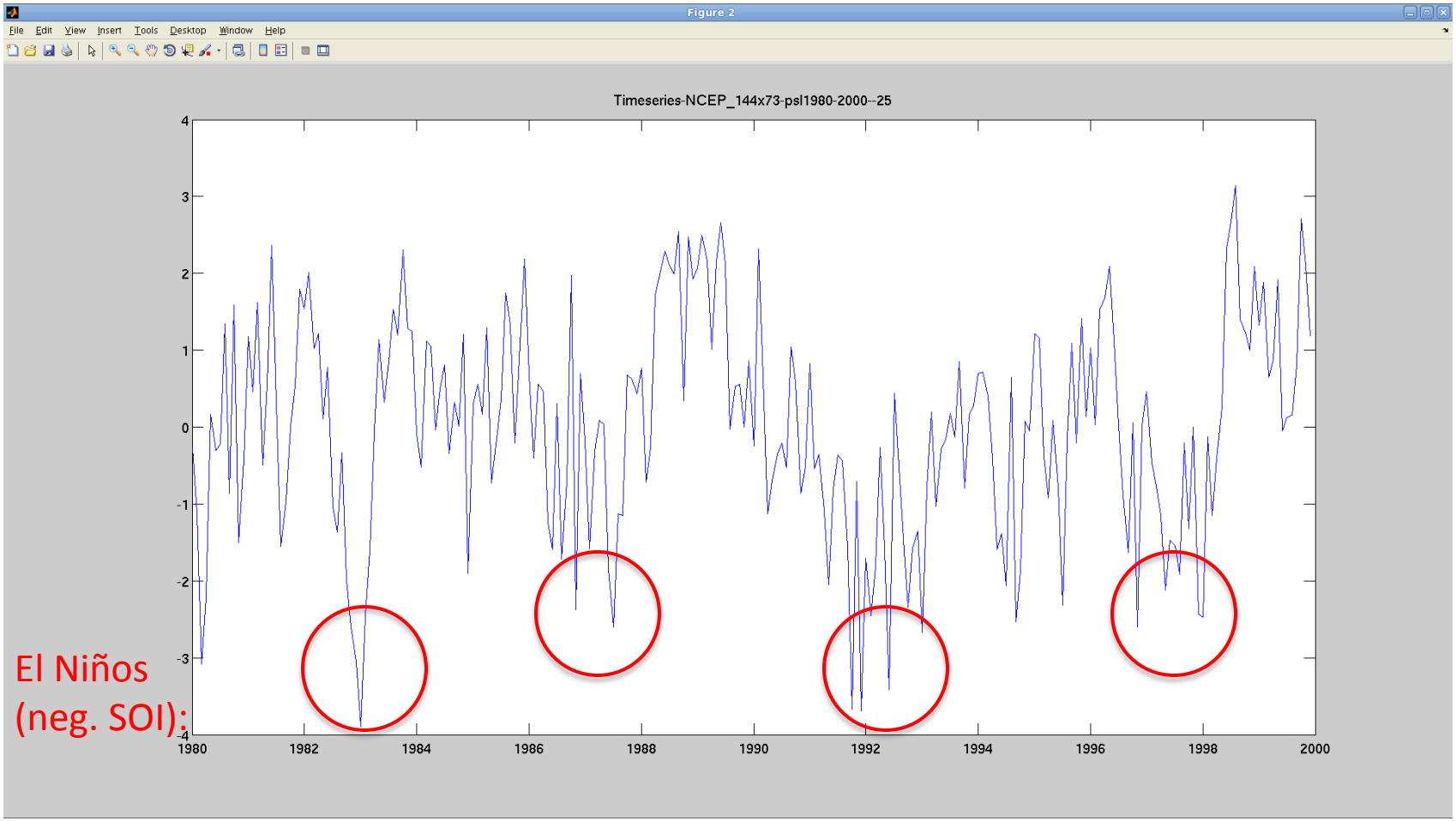
Dipole Viewer

Obtaining Information about Dipole



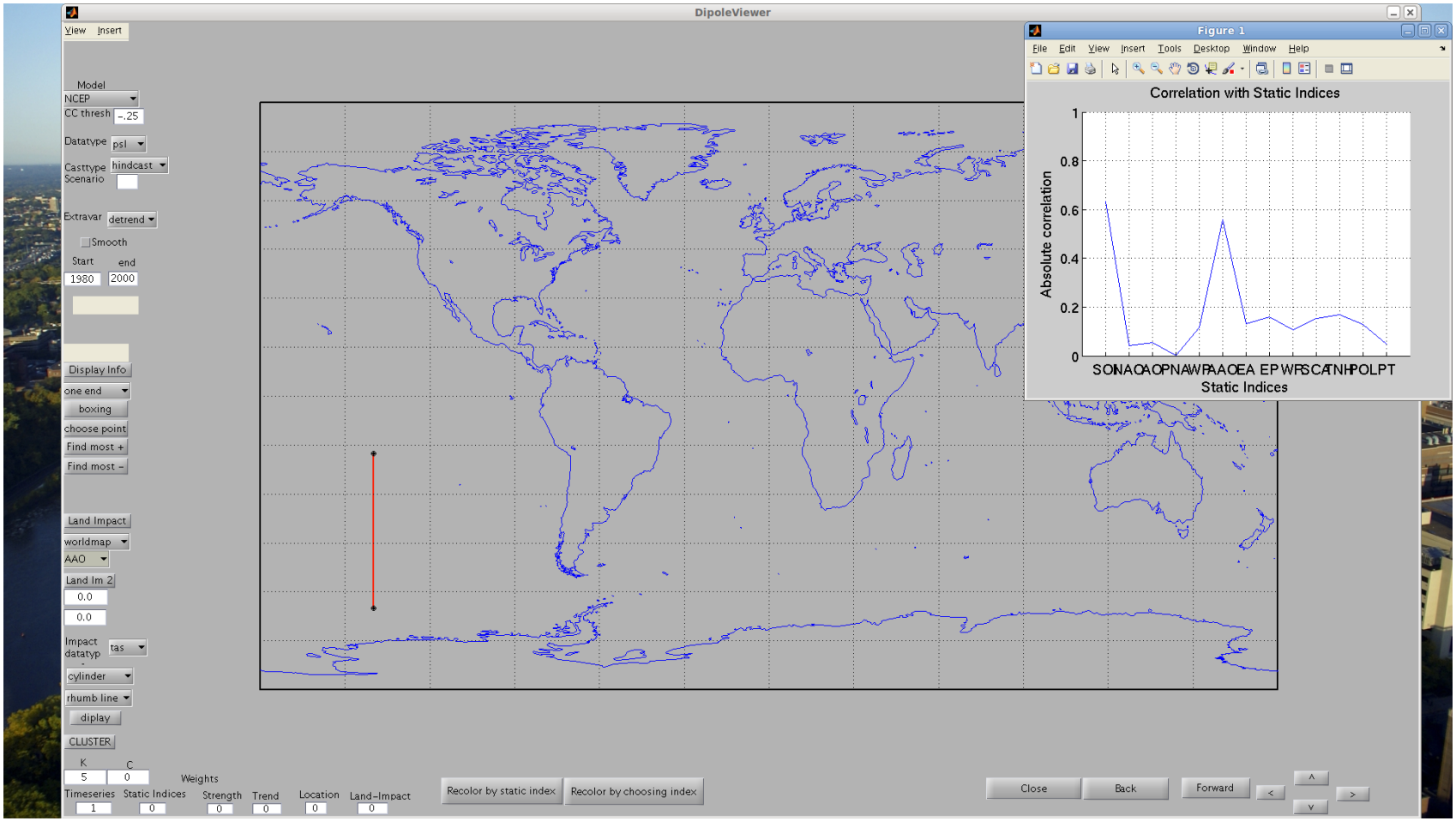
Dipole Viewer

Time Series



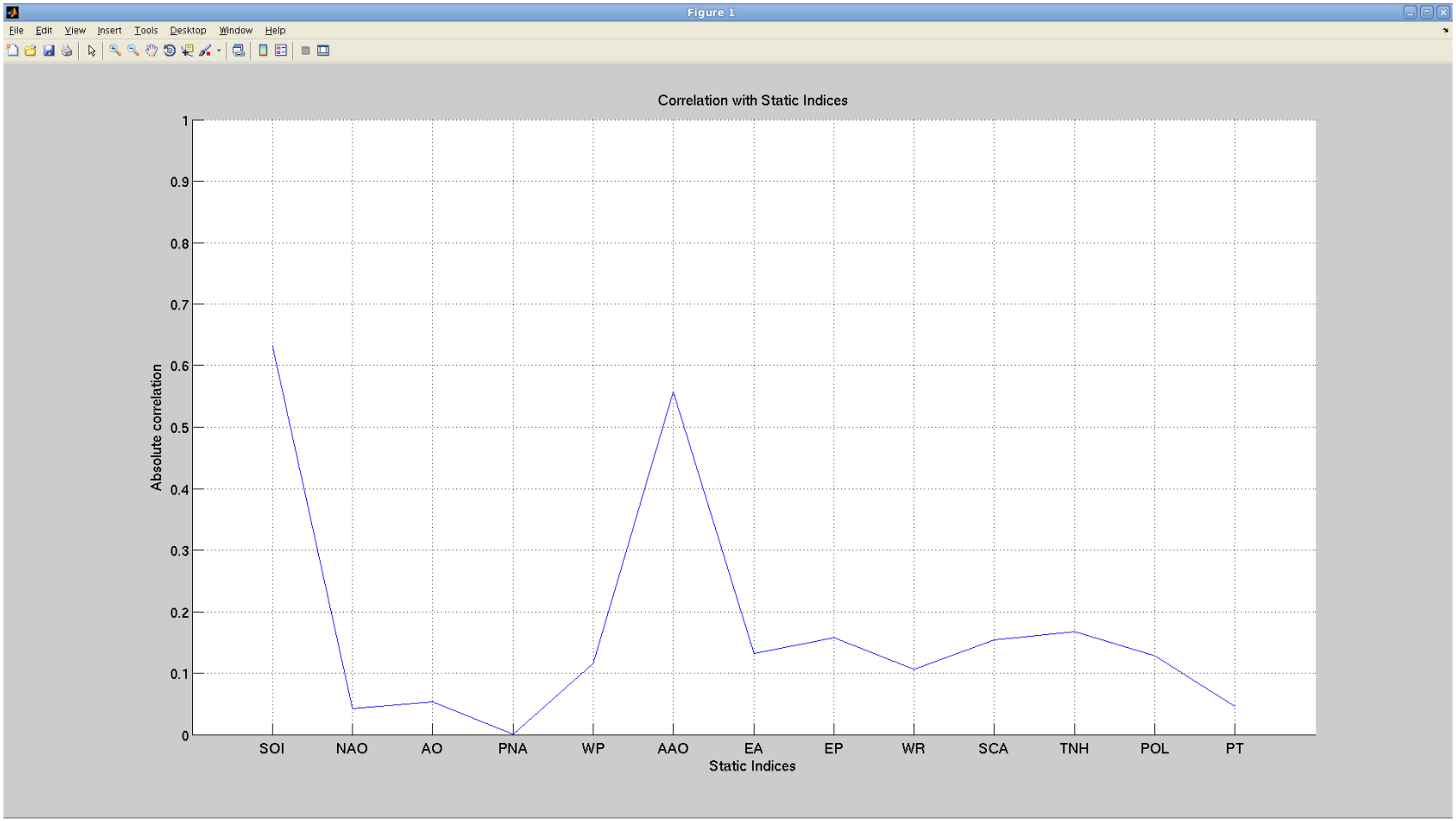
Dipole Viewer

Obtaining Information about Dipole



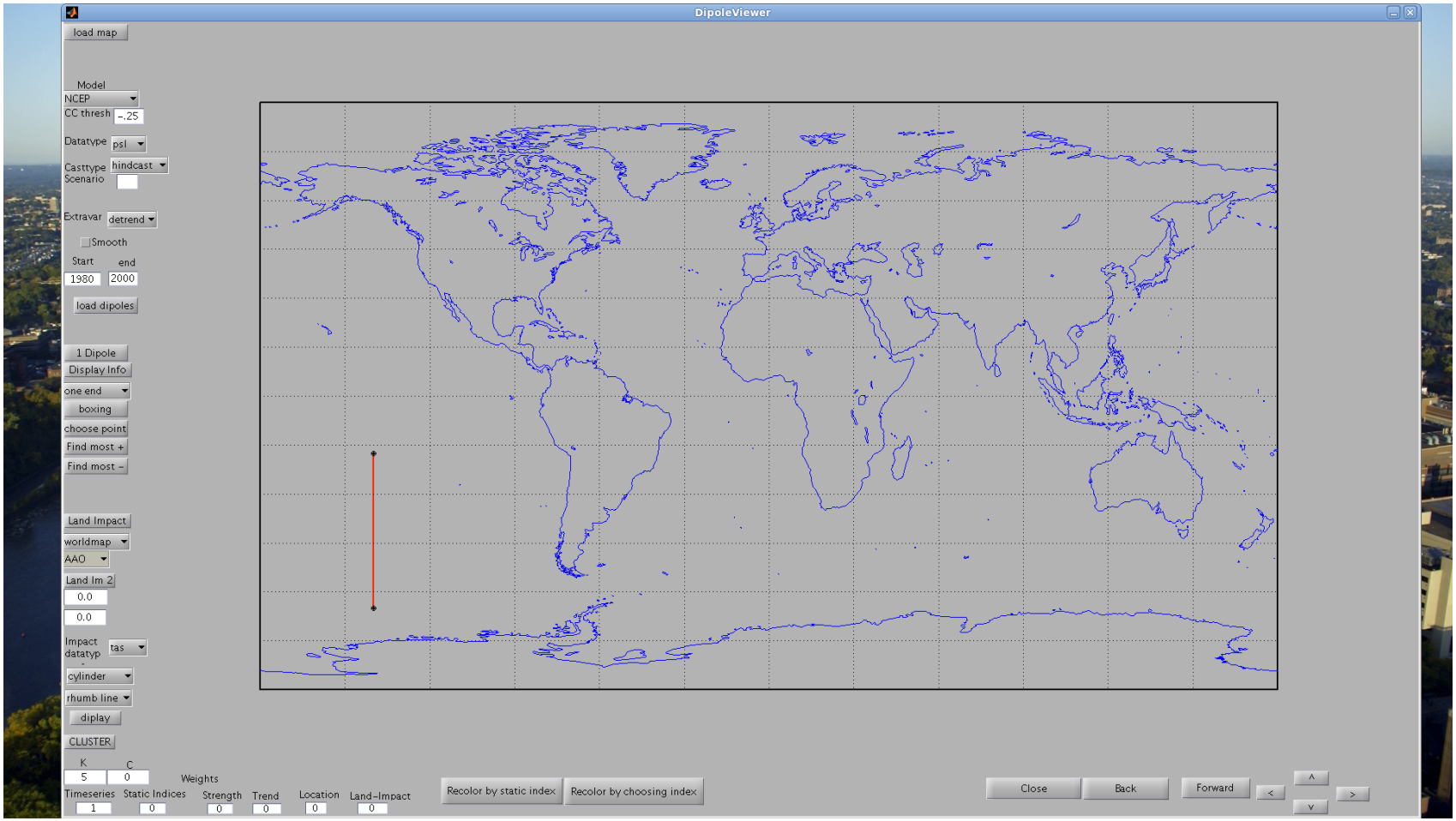
Dipole Viewer

Viewing Correlation to Climate Indices



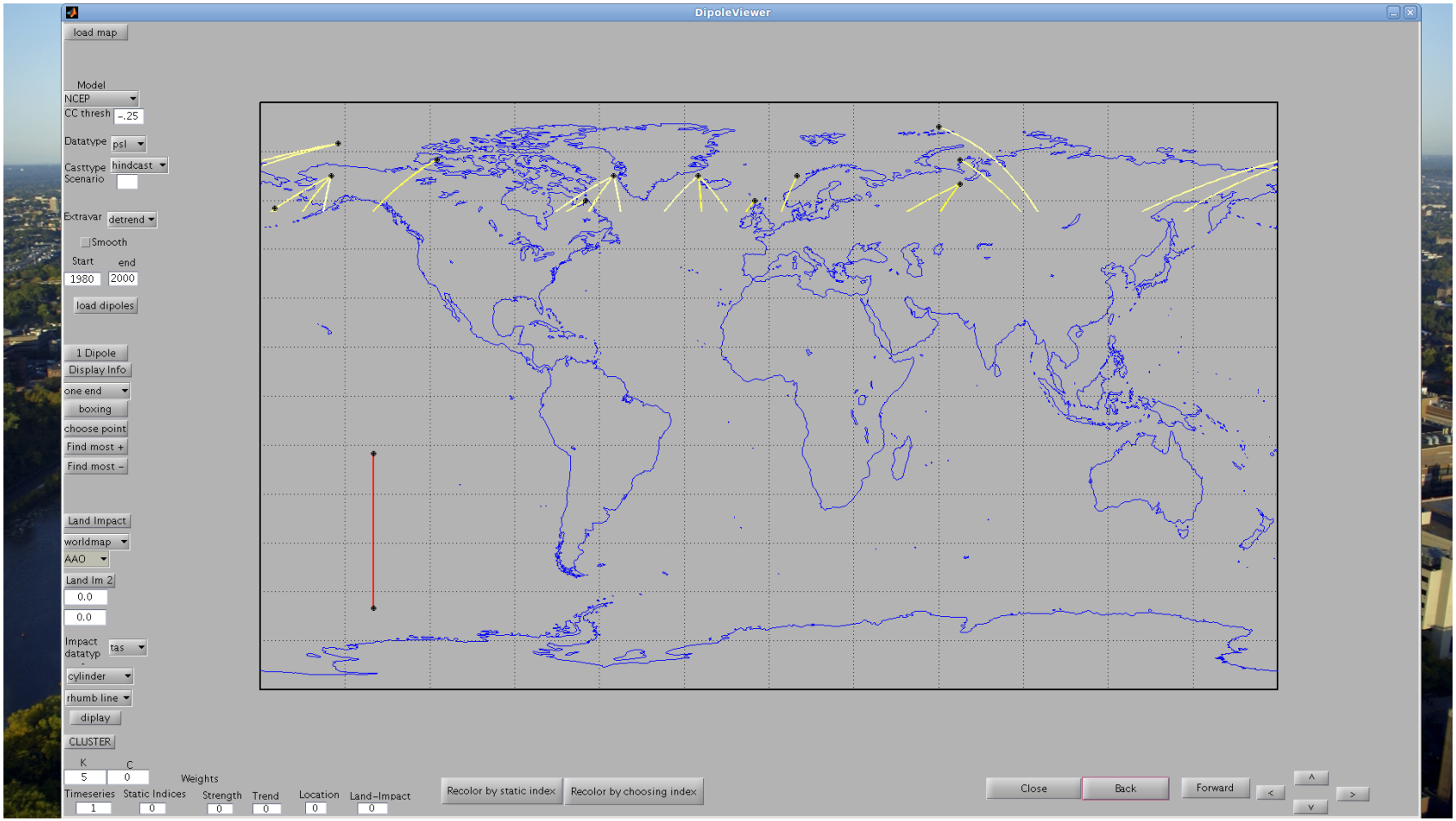
Dipole Viewer

Going Back



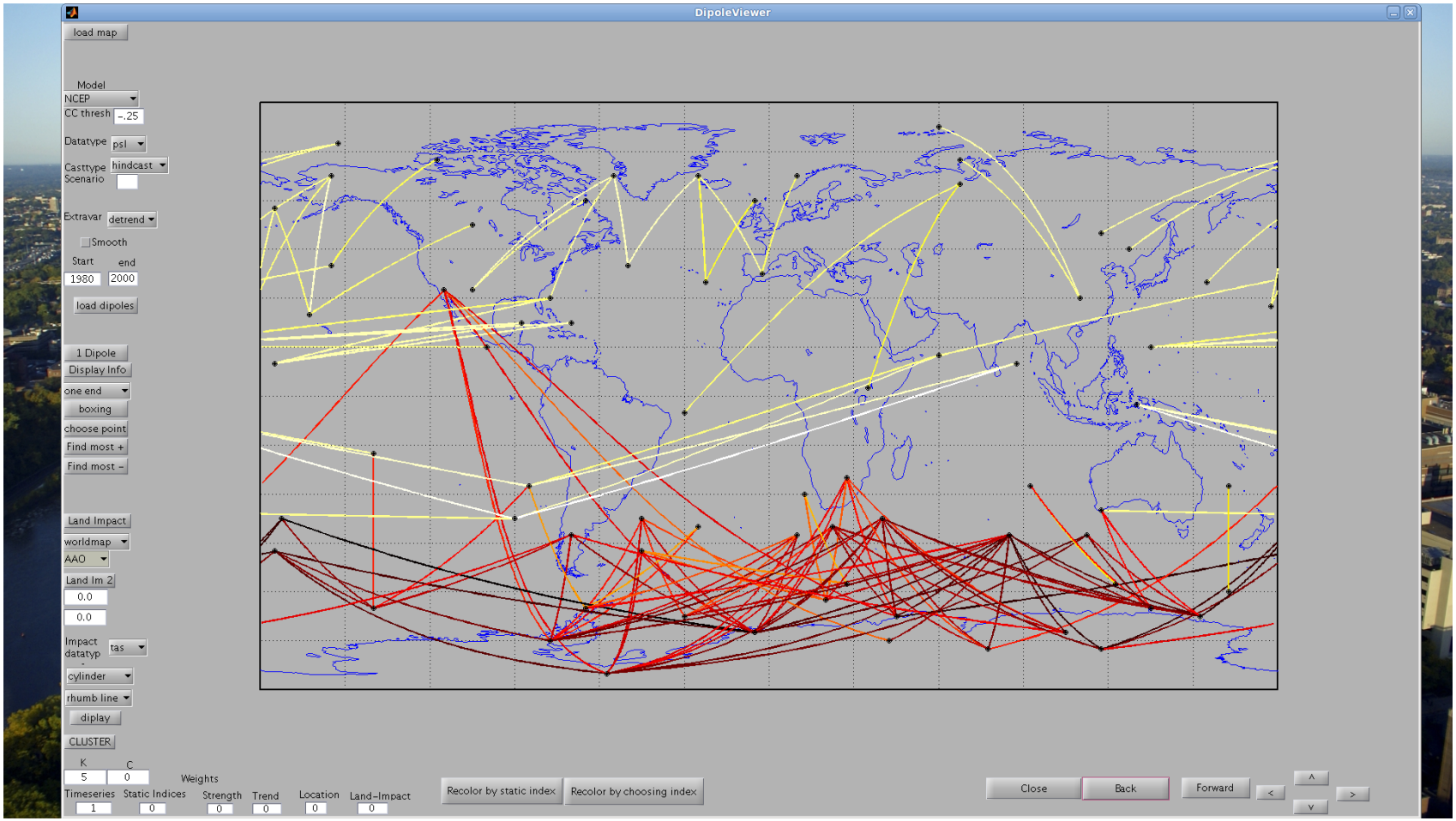
Dipole Viewer

Going Back



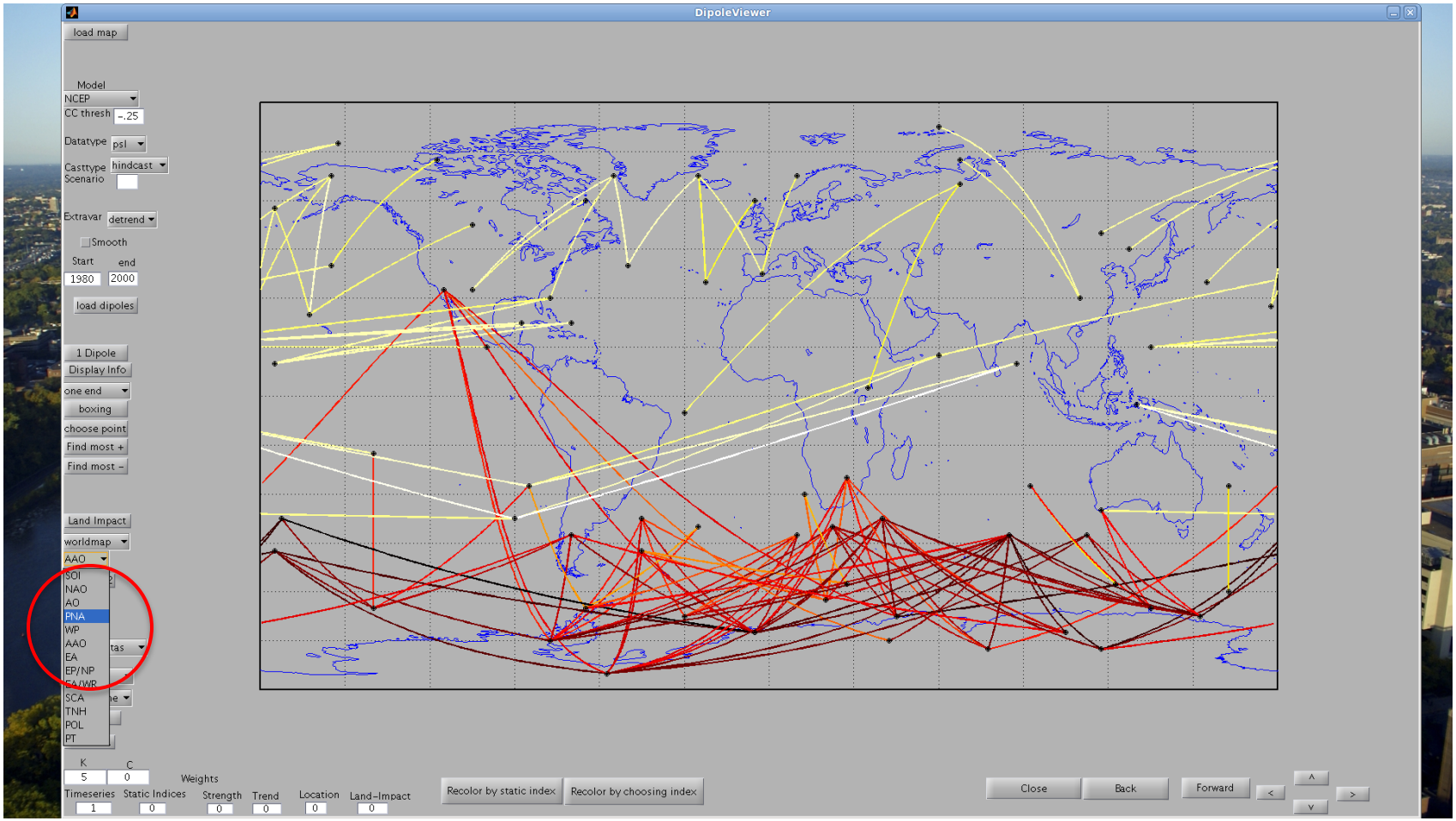
Dipole Viewer

Going Back



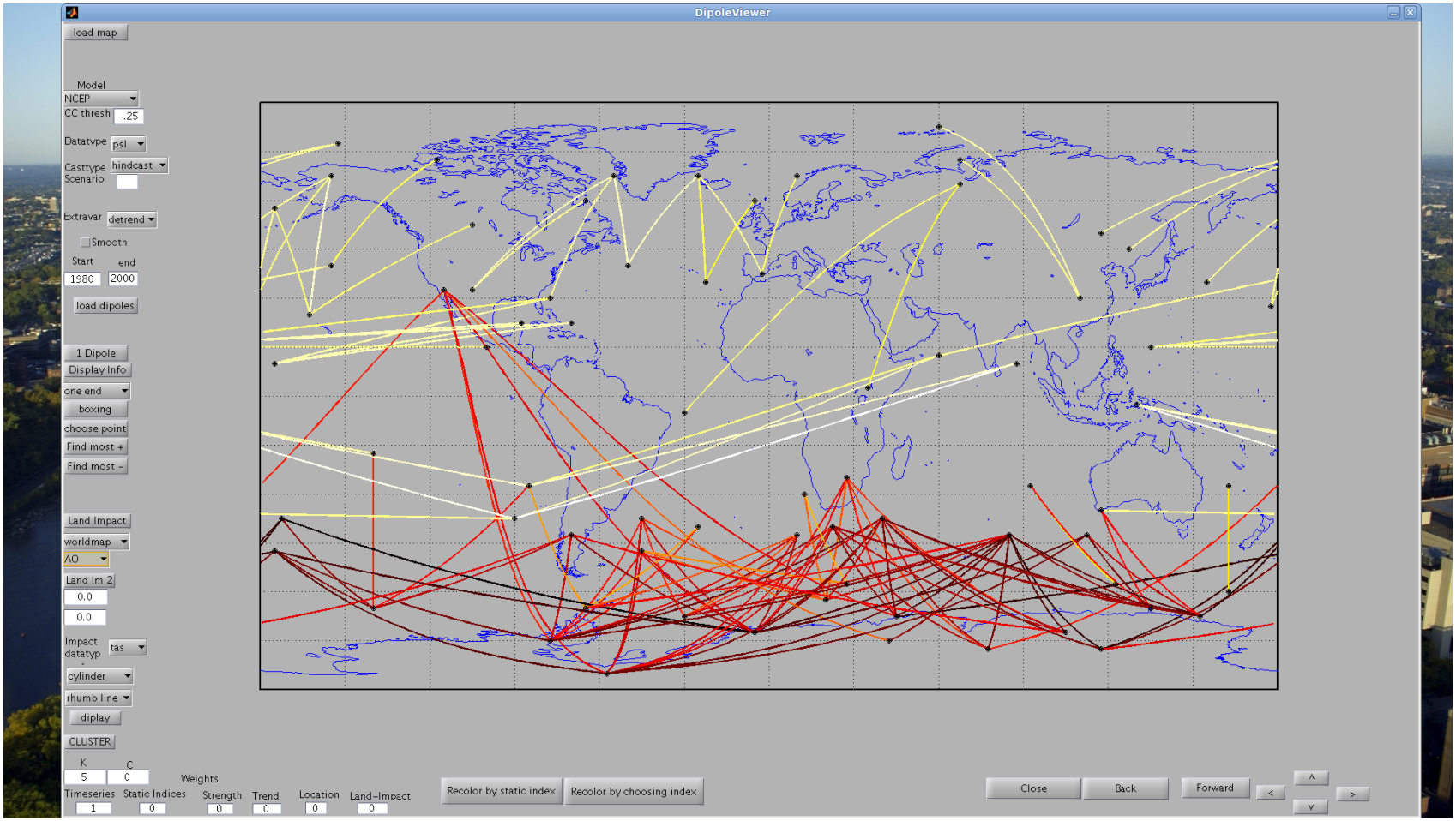
Dipole Viewer

Selecting Comparison to AO



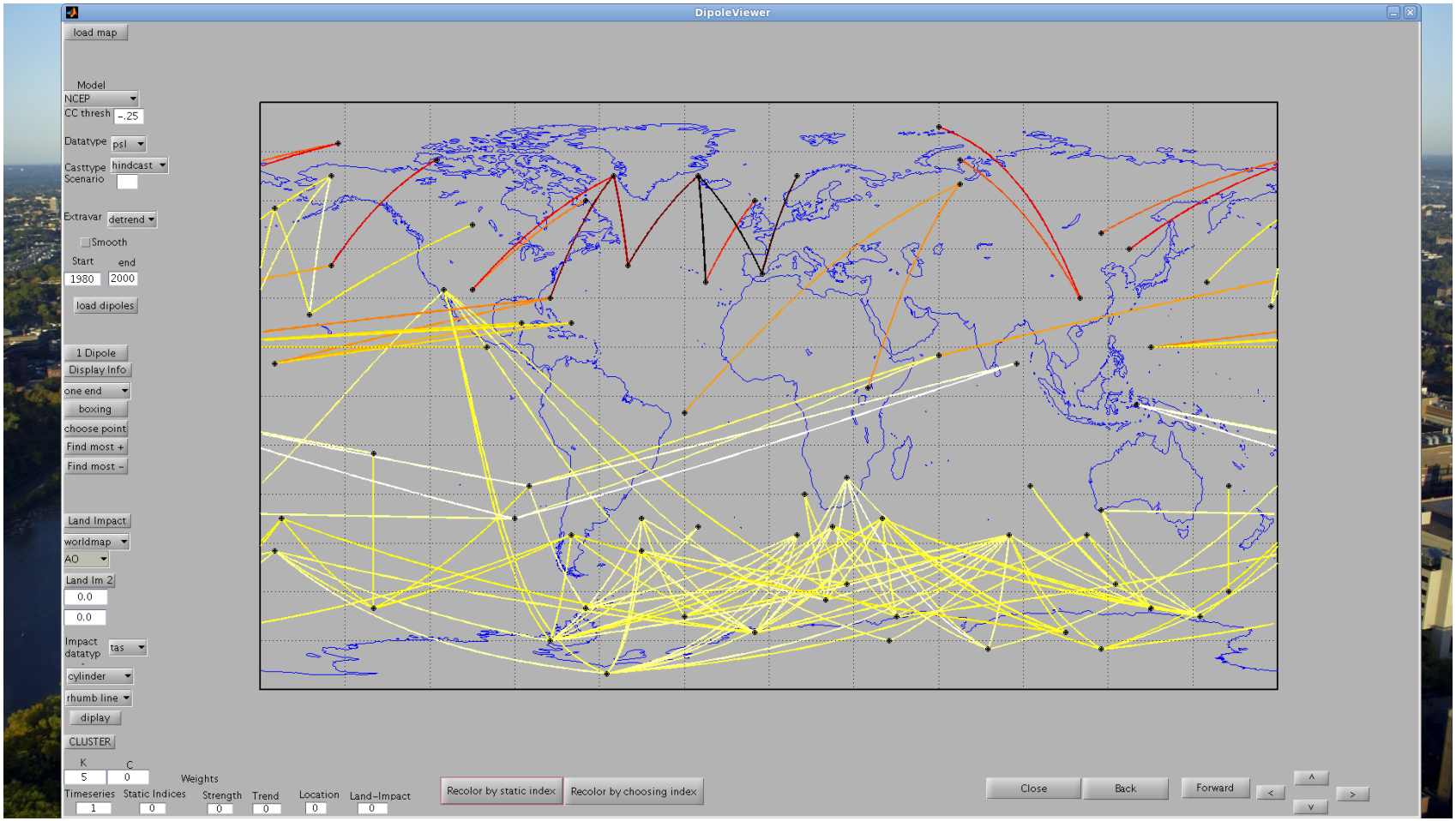
Dipole Viewer

Selecting Comparison to AAO



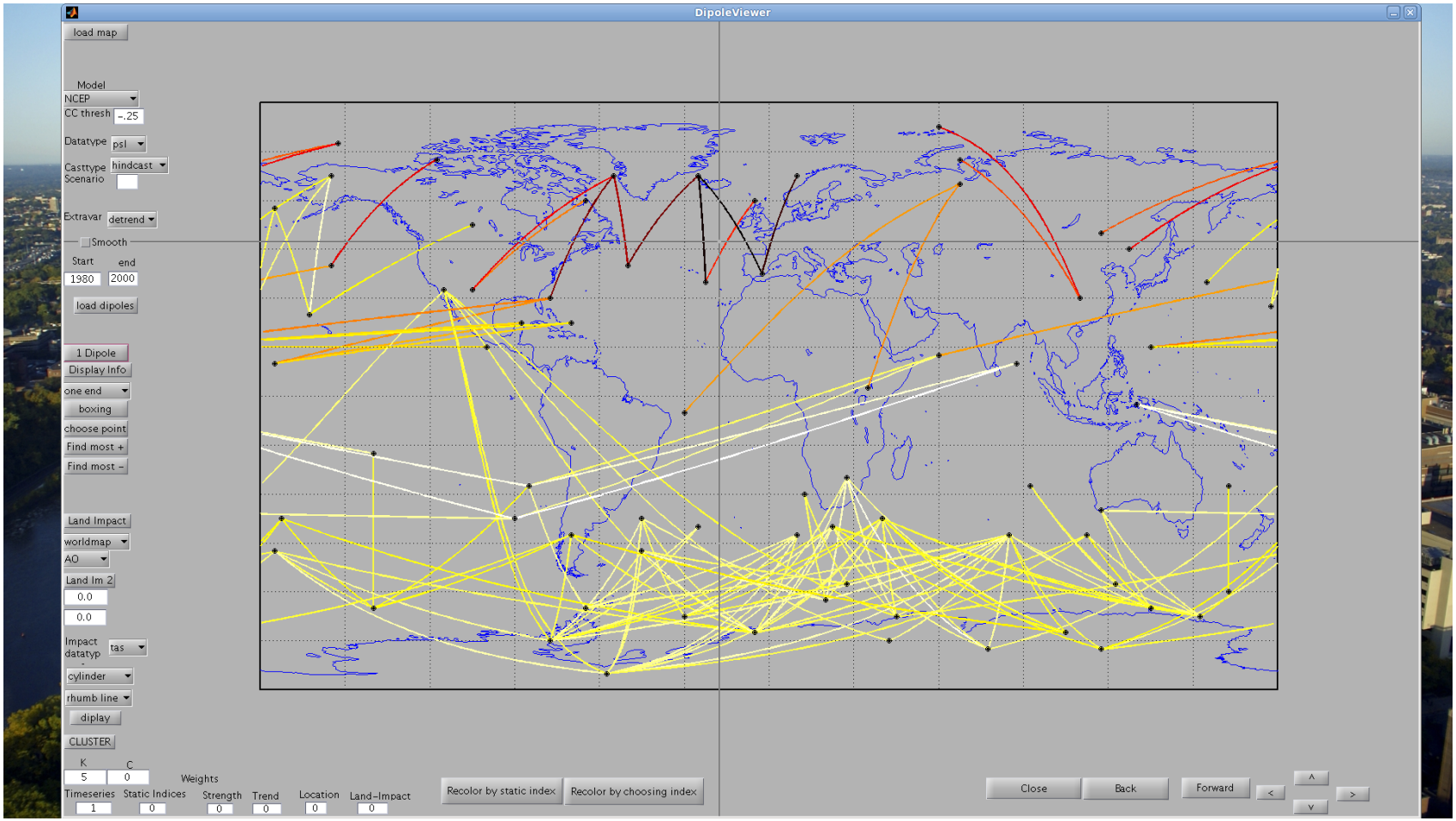
Dipole Viewer

AO Related Dipoles are Strongest



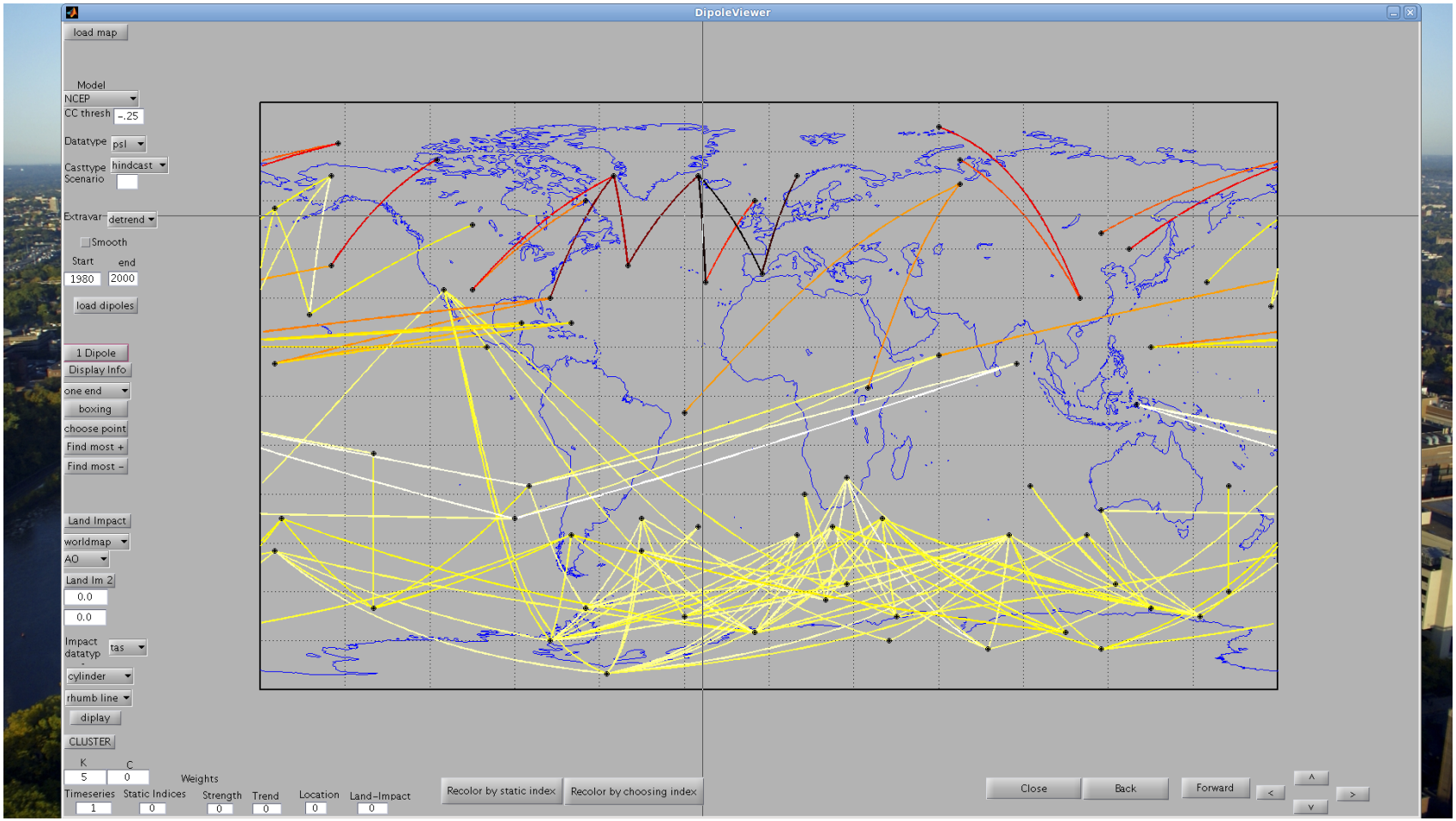
Dipole Viewer

Selecting a Single Dipole



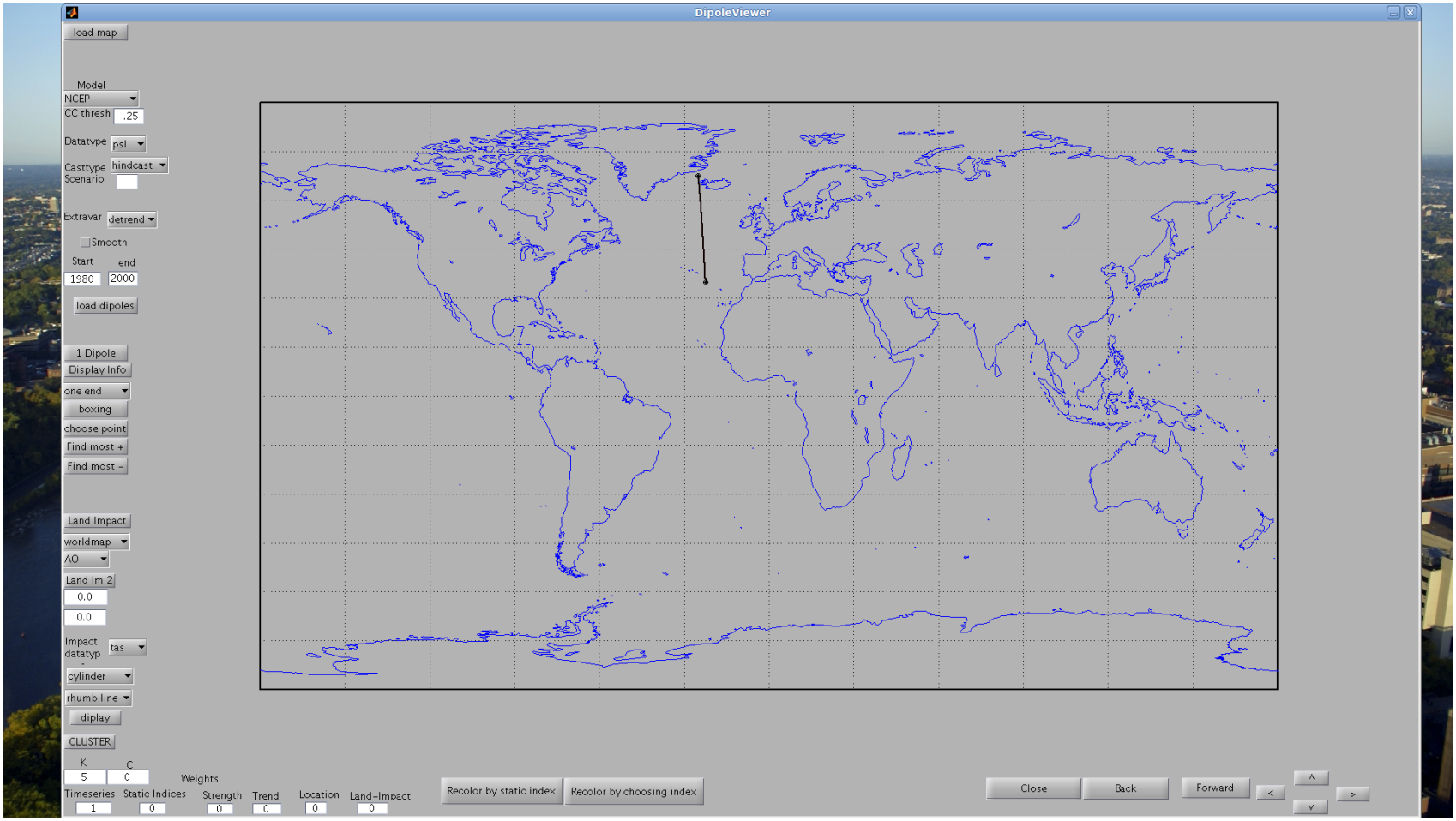
Dipole Viewer

Selecting a Single Dipole



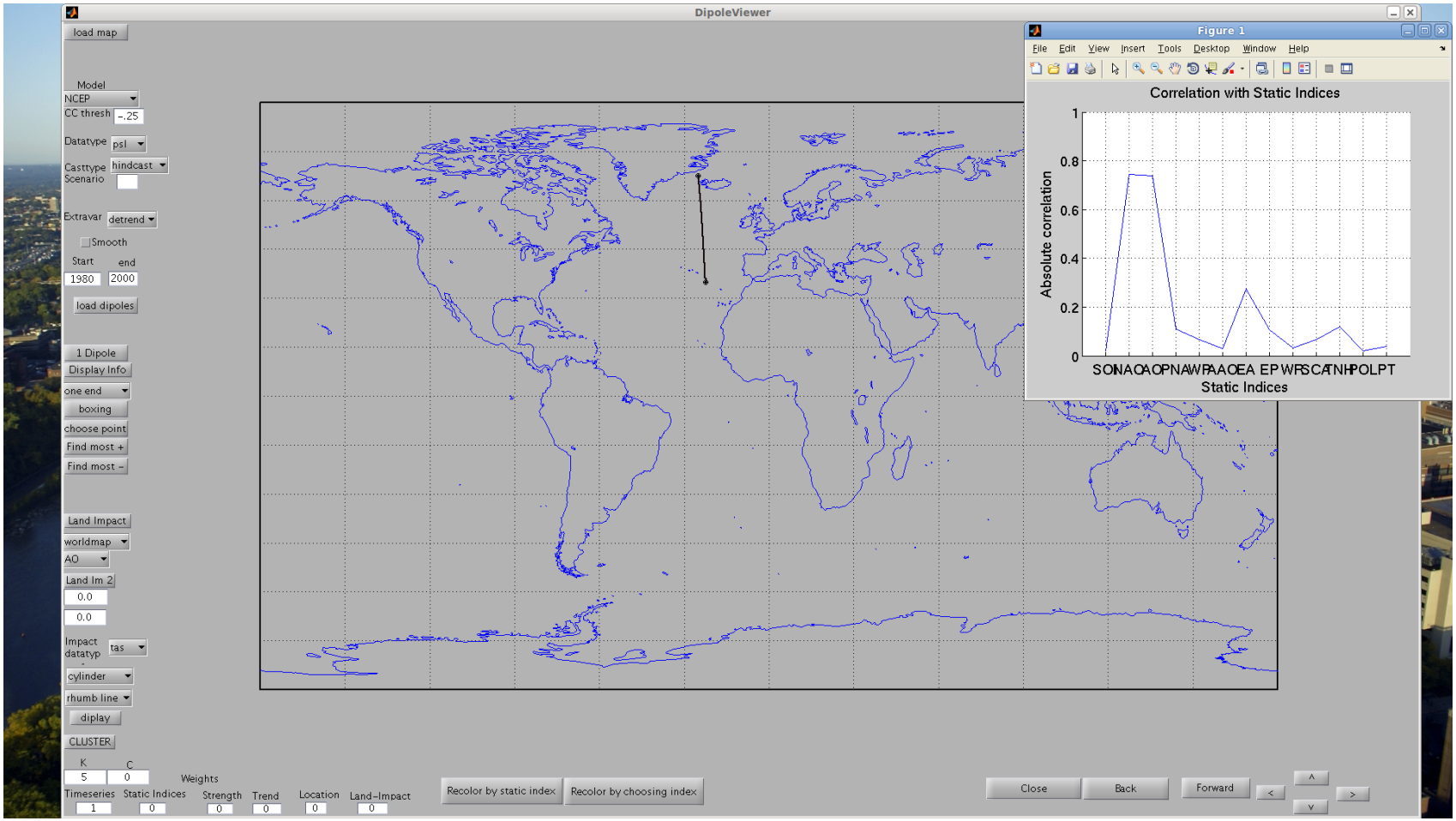
Dipole Viewer

Selecting a Single Dipole



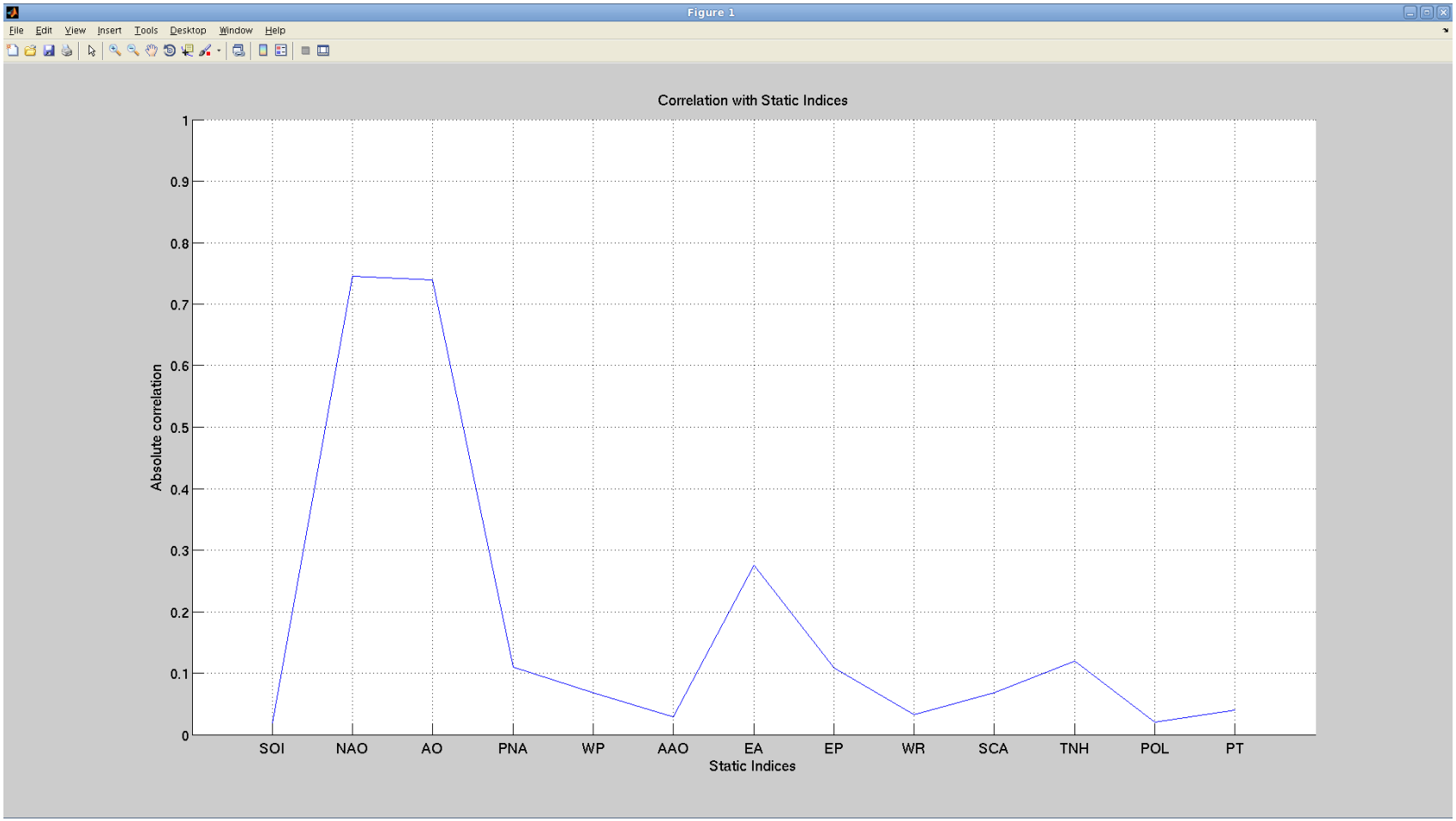
Dipole Viewer

Selecting a Single Dipole



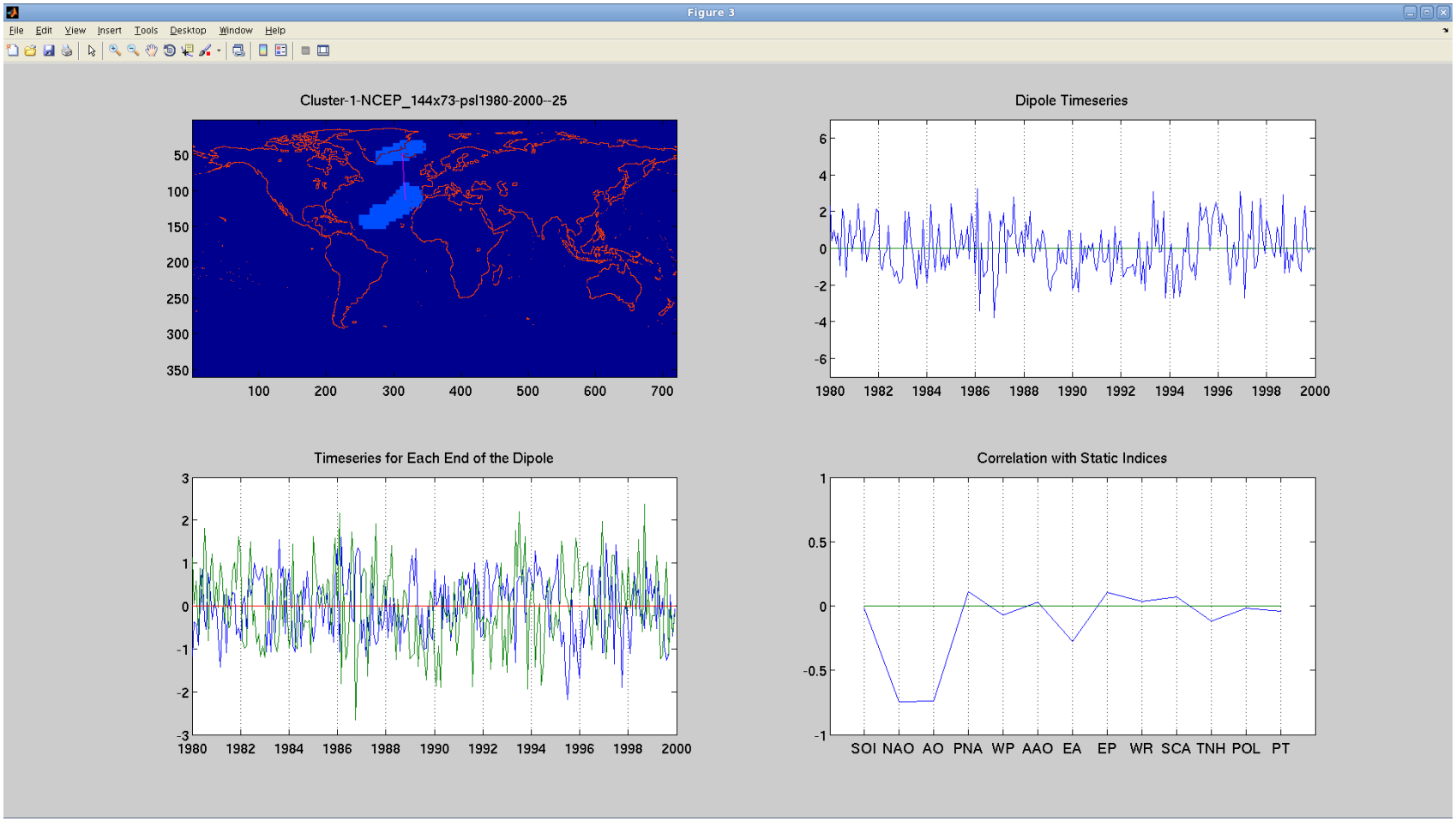
Dipole Viewer

Viewing Correlation to Climate Indices



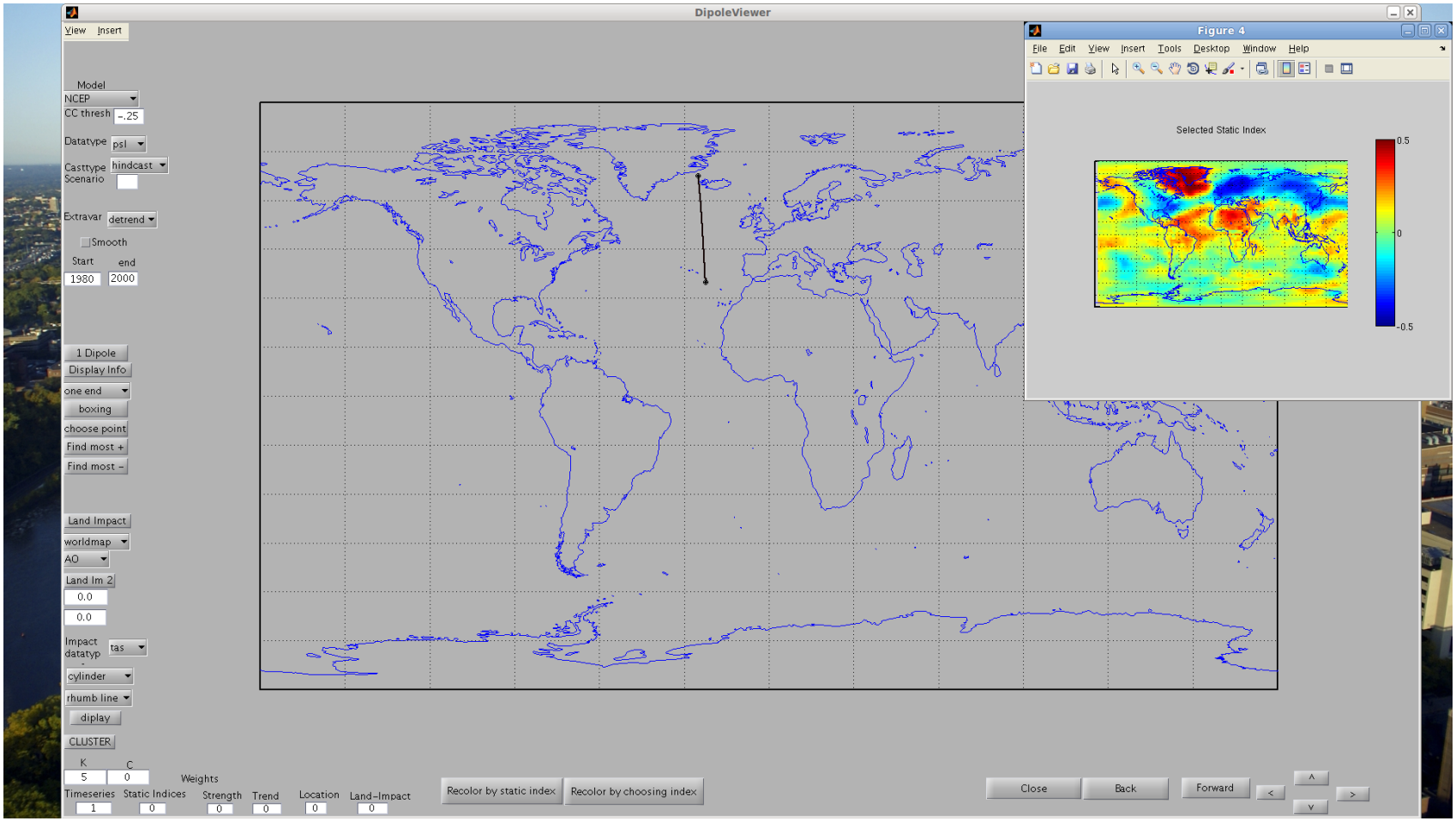
Dipole Viewer

Density, Time Series, and Correlation Plots



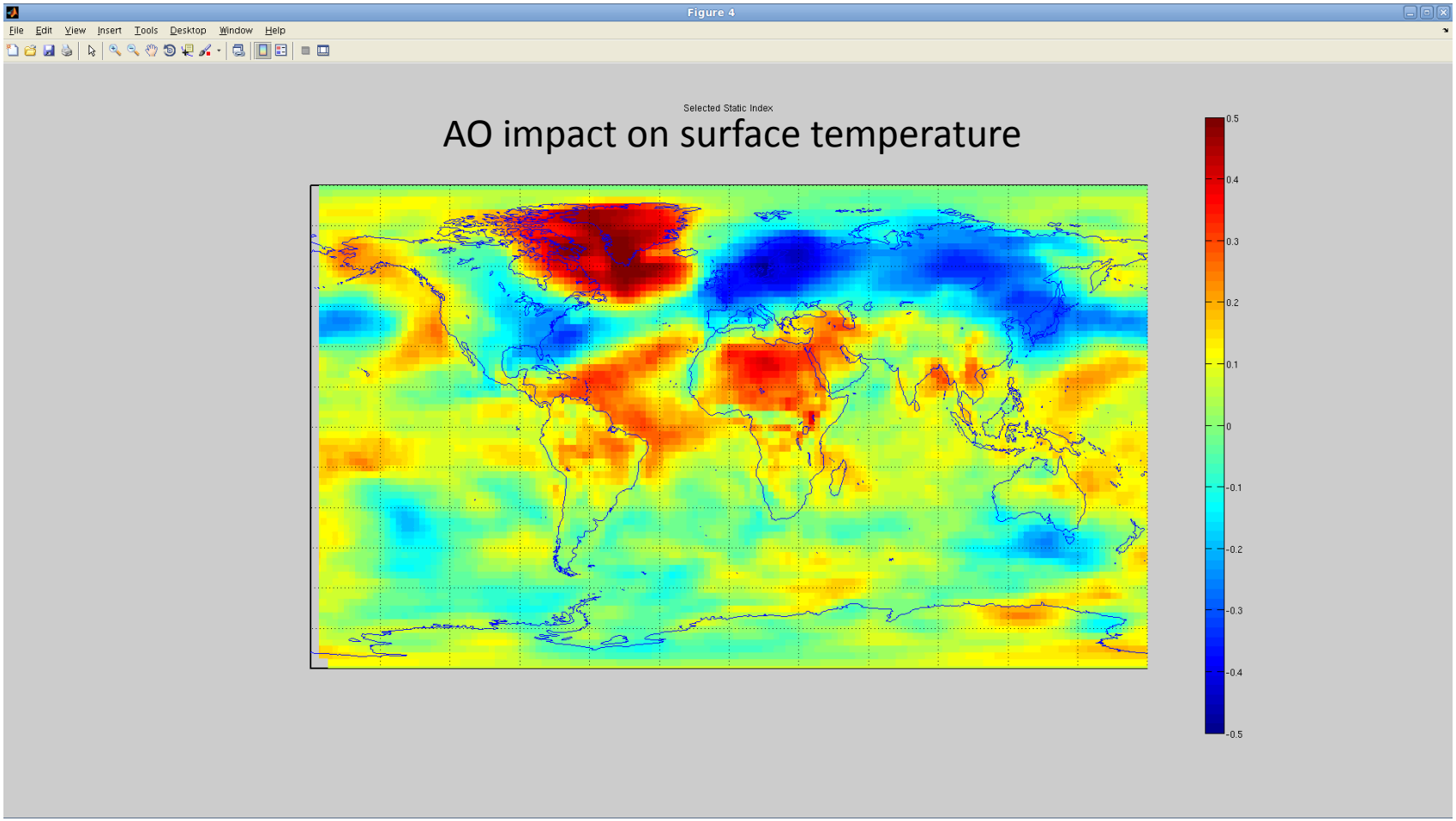
Dipole Viewer

Viewing Correlation to Global Temperature Data



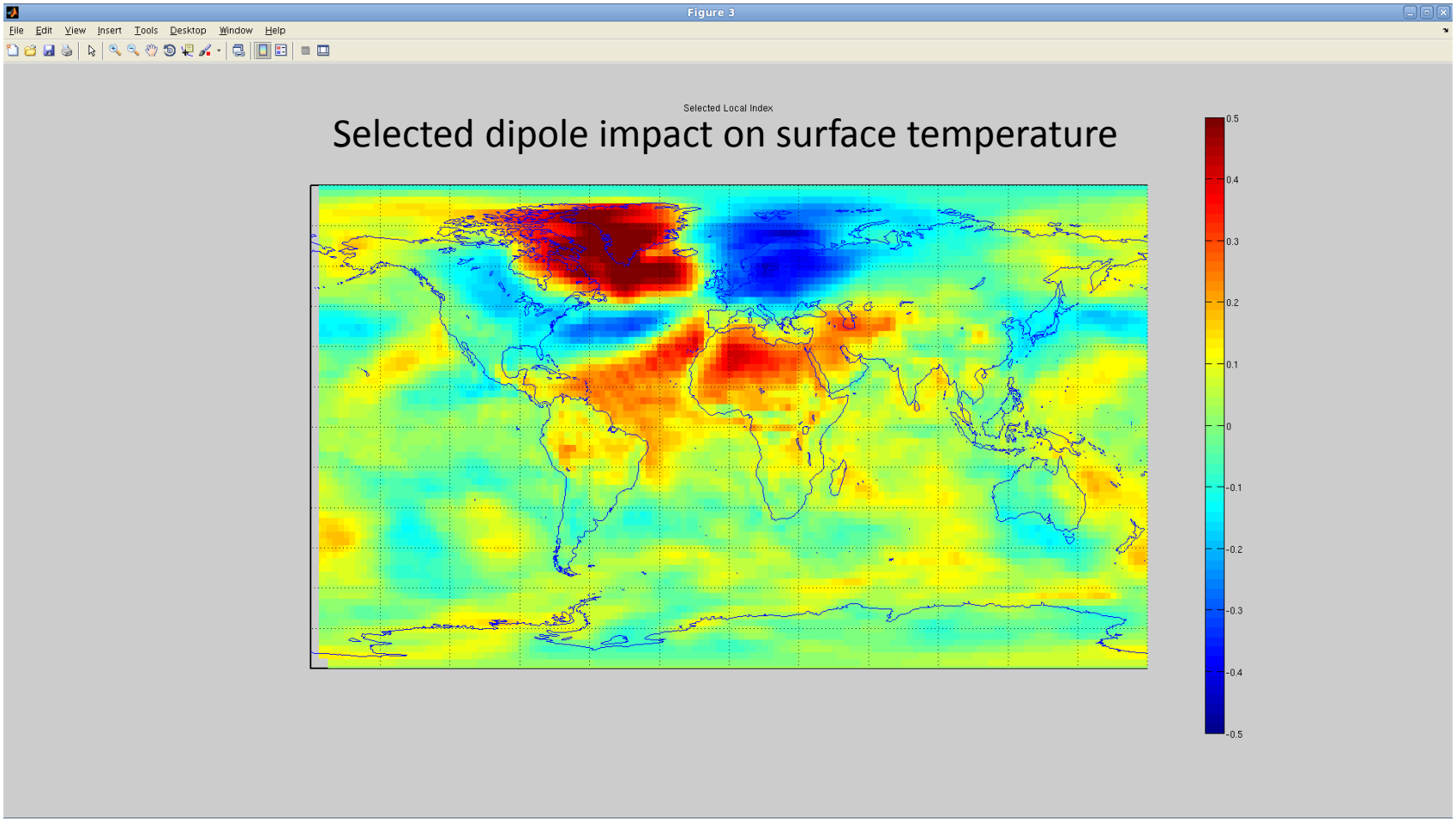
Dipole Viewer

Viewing Correlation to Global Temperature Data



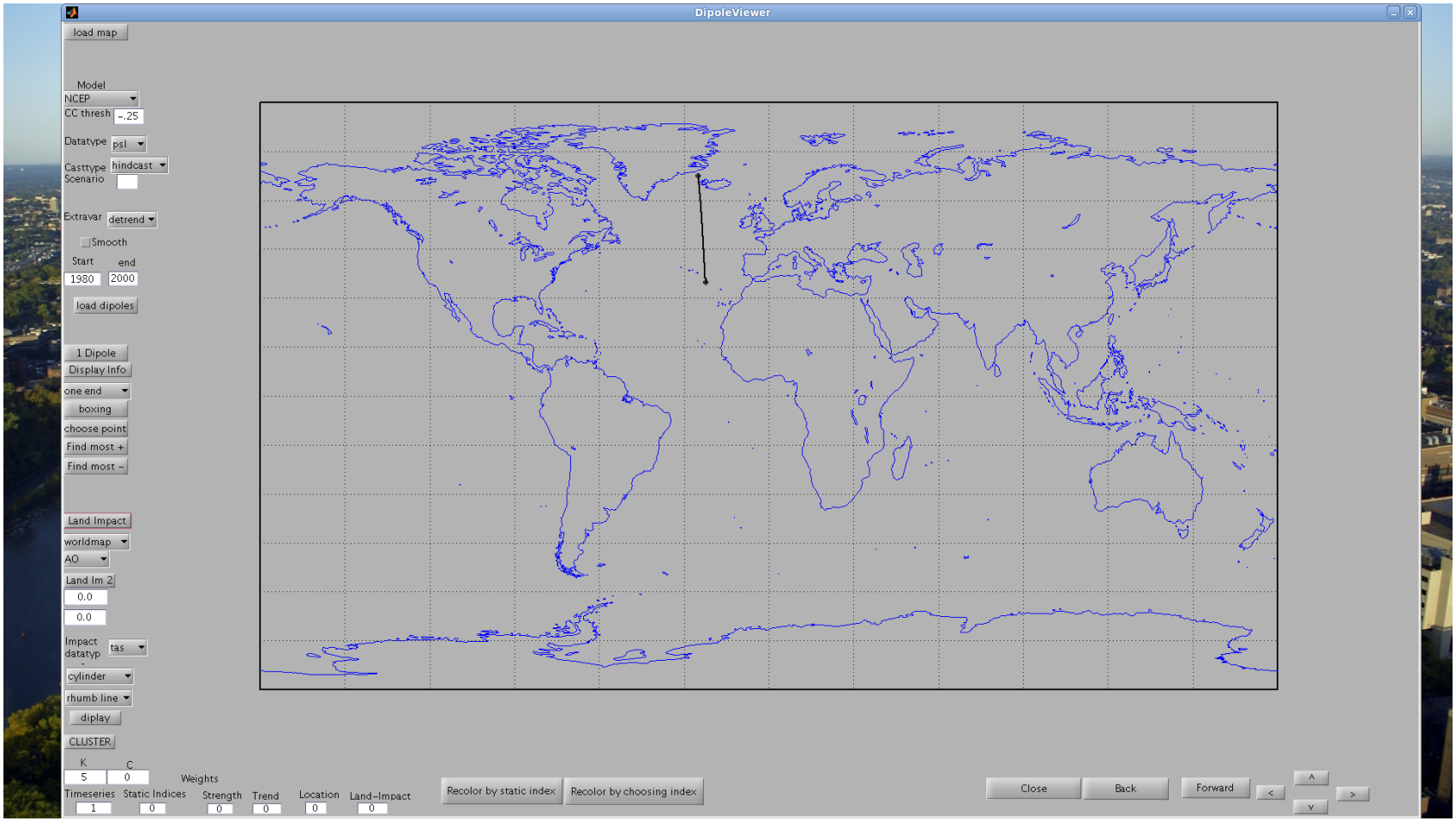
Dipole Viewer

Viewing Correlation to Global Temperature Data



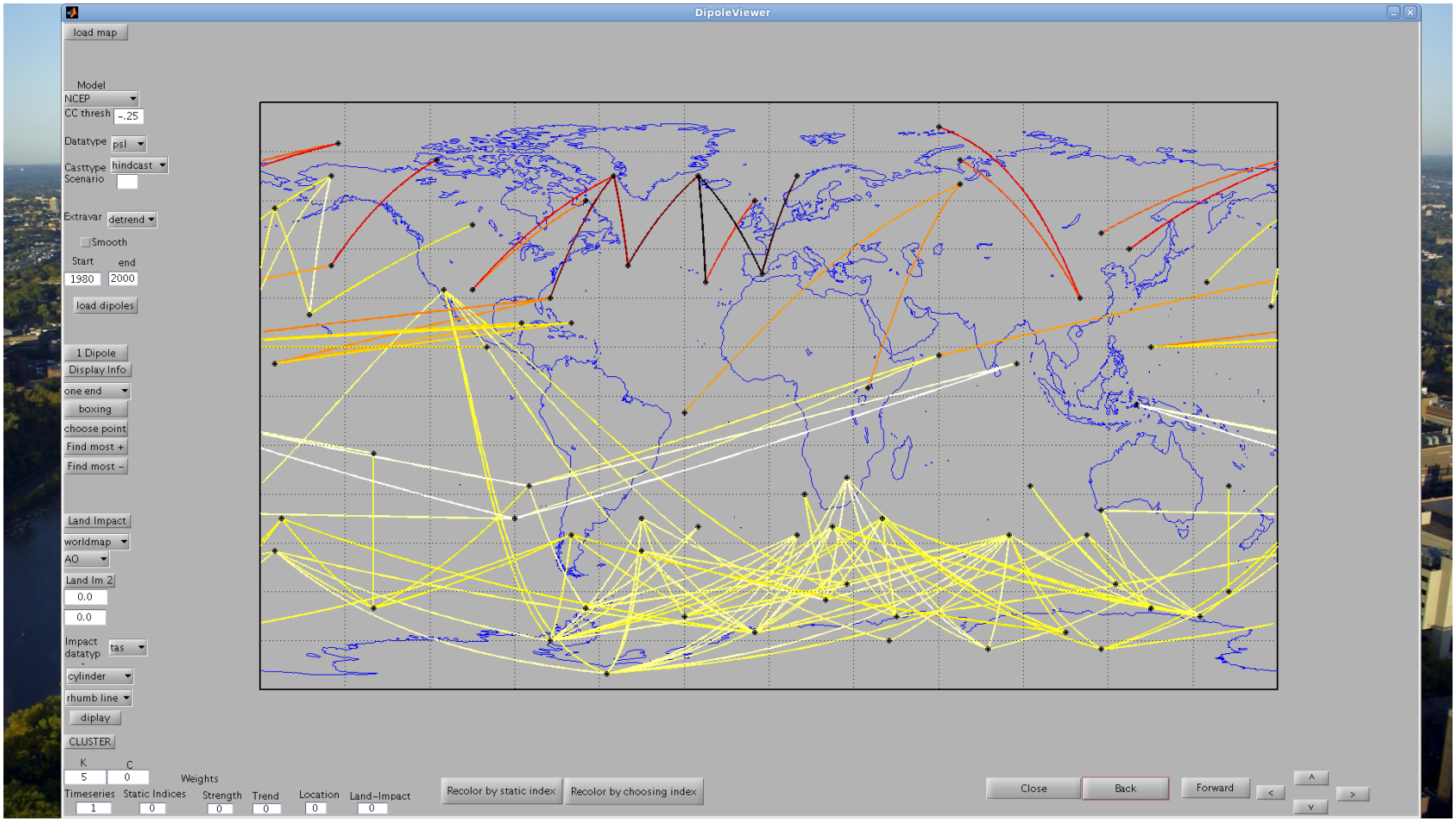
Dipole Viewer

Going Back



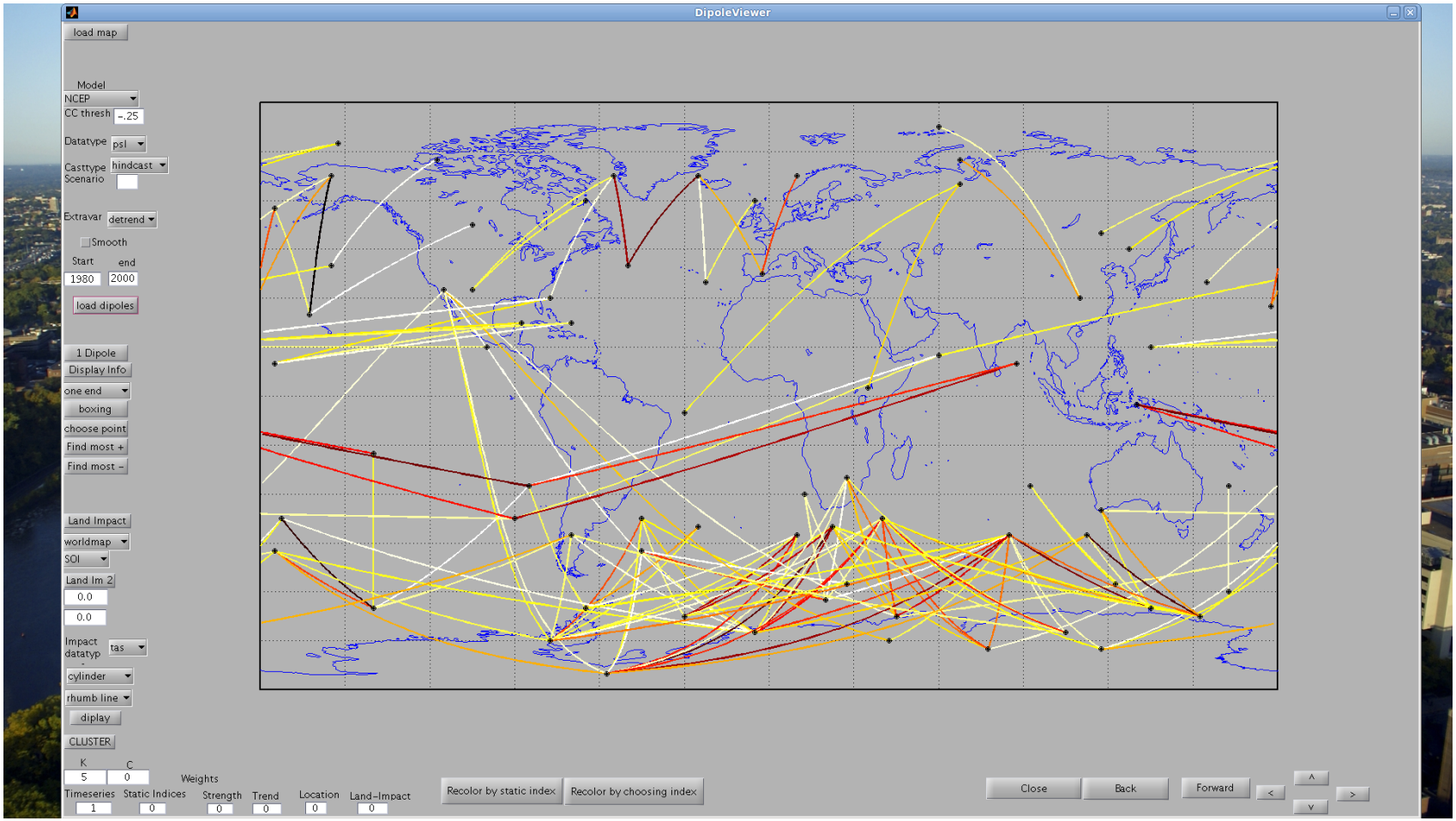
Dipole Viewer

Going Back



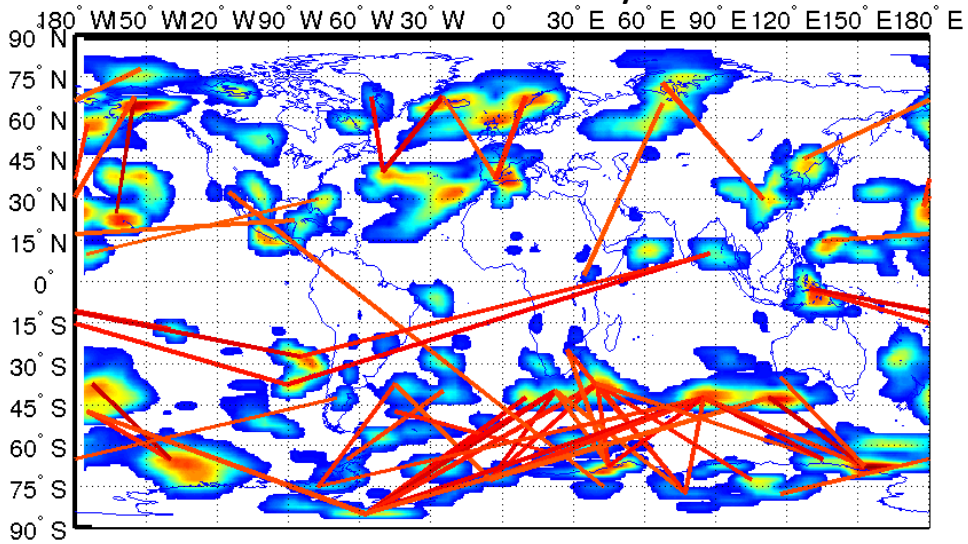
Dipole Viewer

Future Work: Adding Color Bars, Identifying Statistical Significant Dipoles, etc.

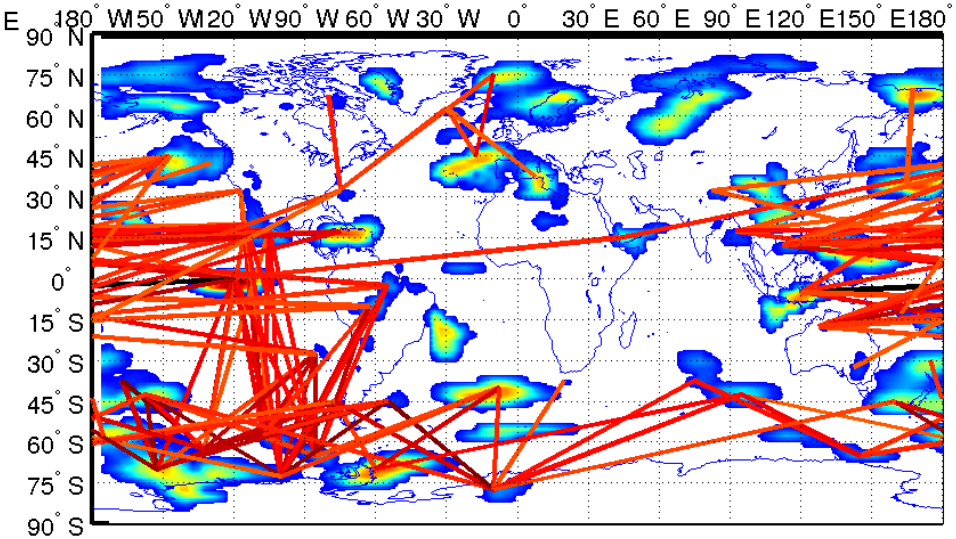


Comparison to GCMs (1980-2000)

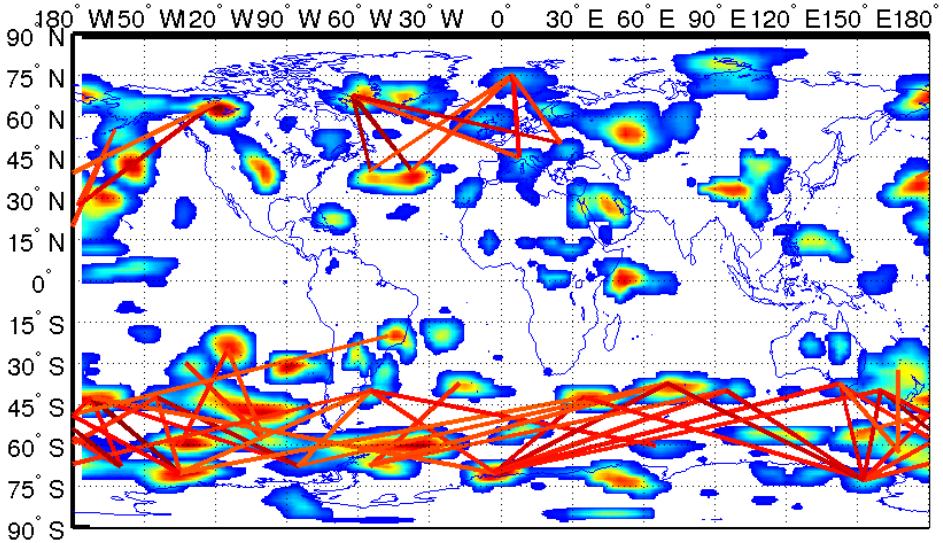
NCEP Reanalysis



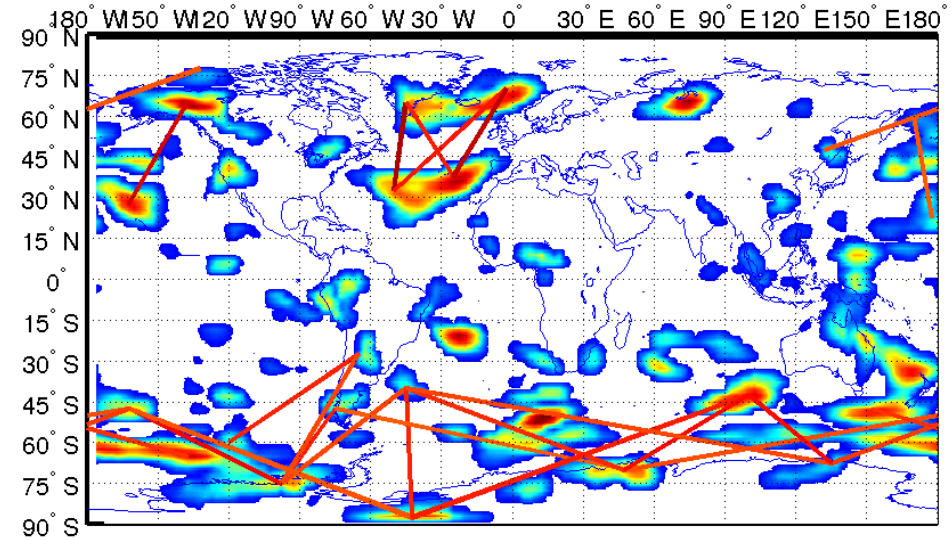
GFDL CM2.1



MPI-ECHAM5



UKMO-HadGEM1

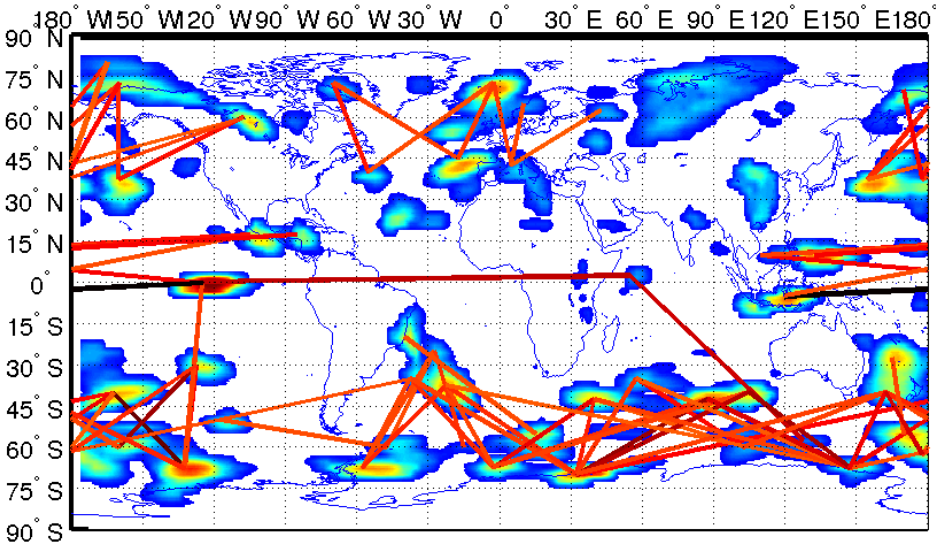


Threshold: -0.3

GCM Projections to 2080-2100

- Projections show more dipole activity in mid-latitudes and less over the tropics.
- Consistent with stronger meridional temperature gradient in winter and some paleo-climate records about permanent El Niño during Early Pliocene warming period.

GFDL CM2.1



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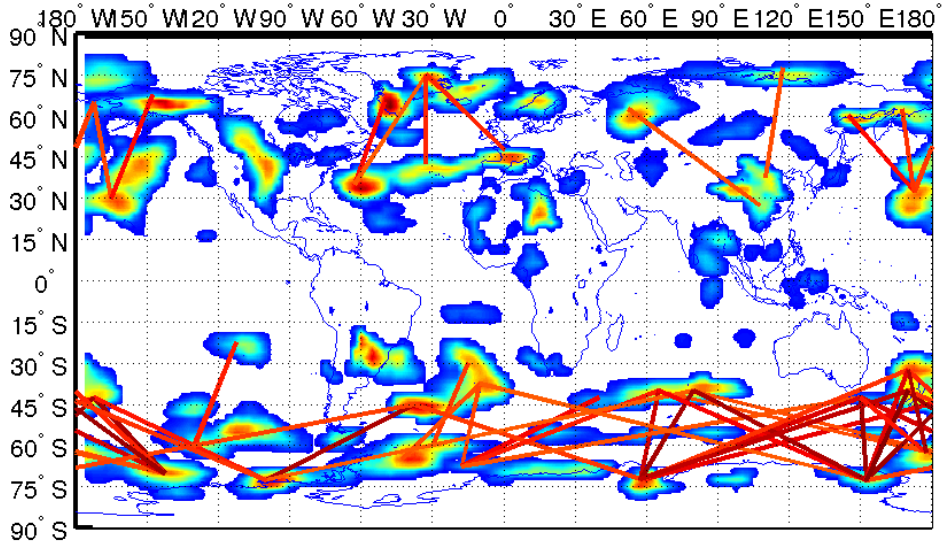
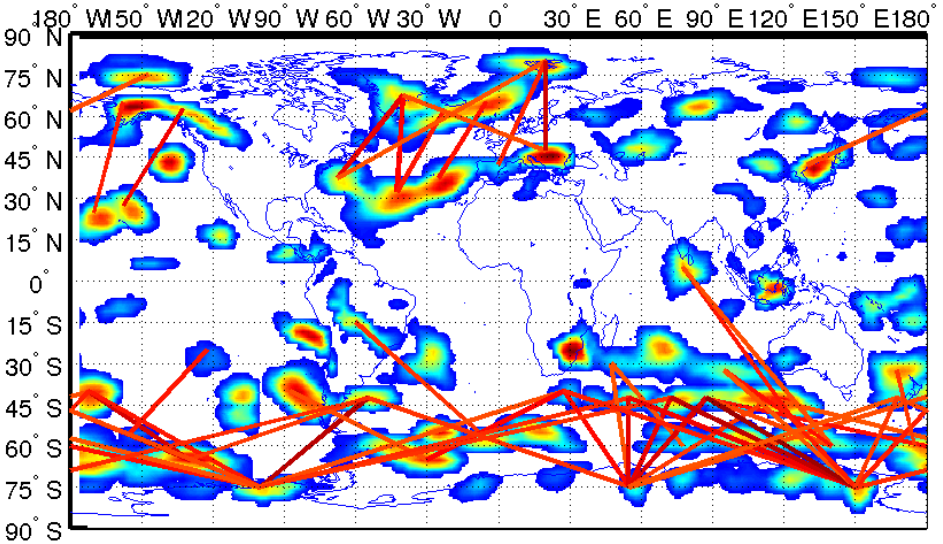
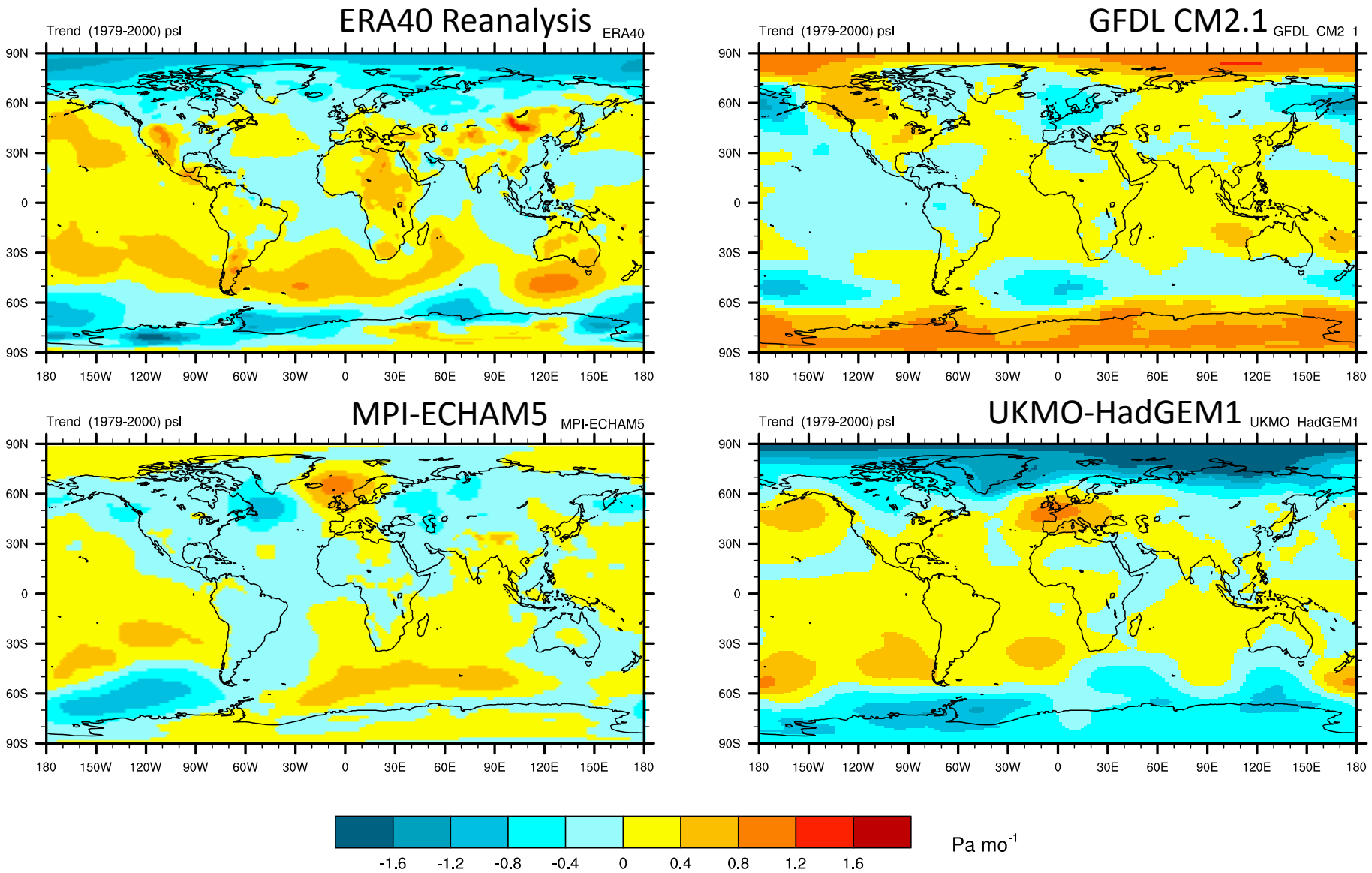


UKMO-HadGEM1

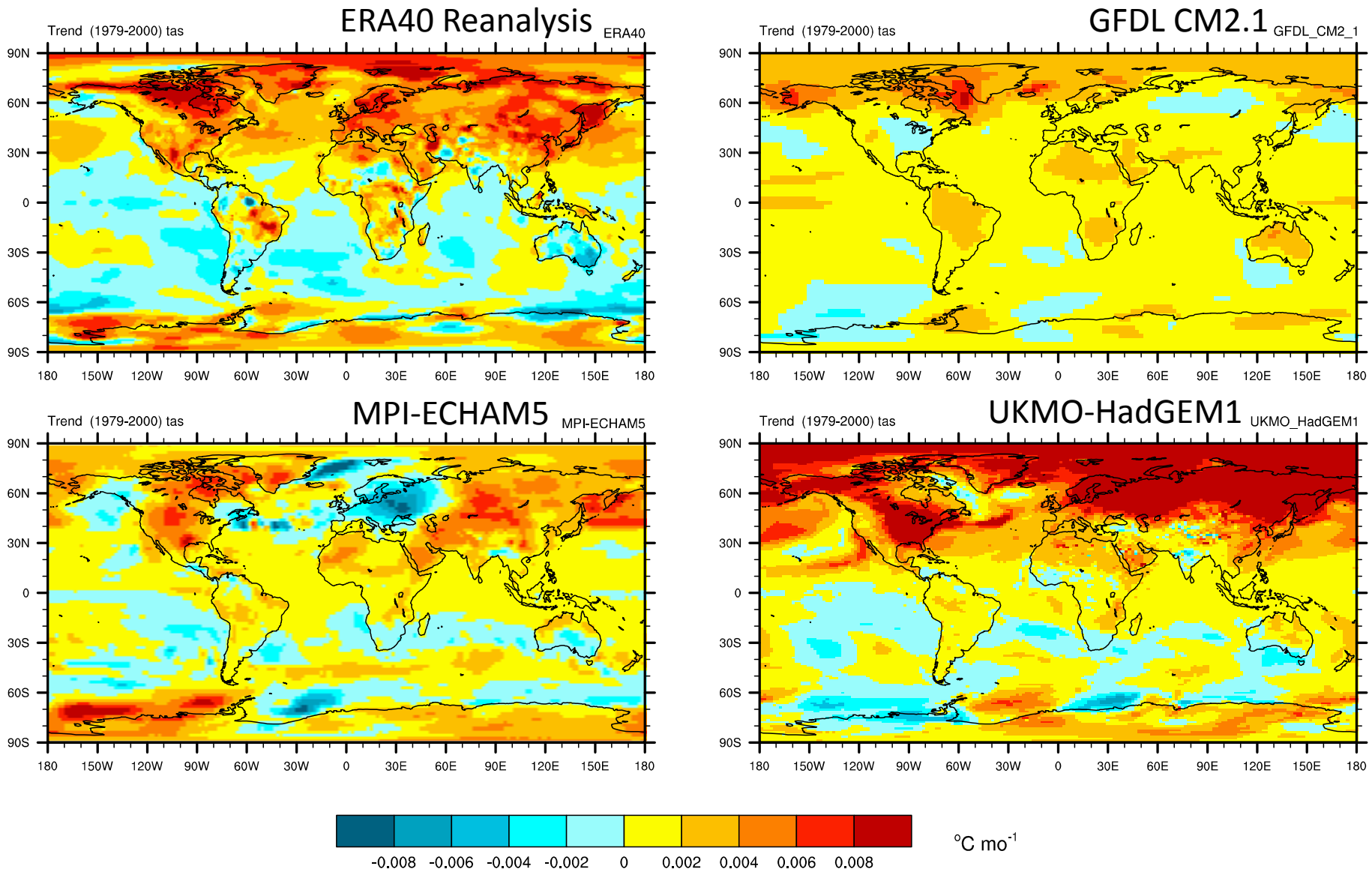


Threshold: -0.3

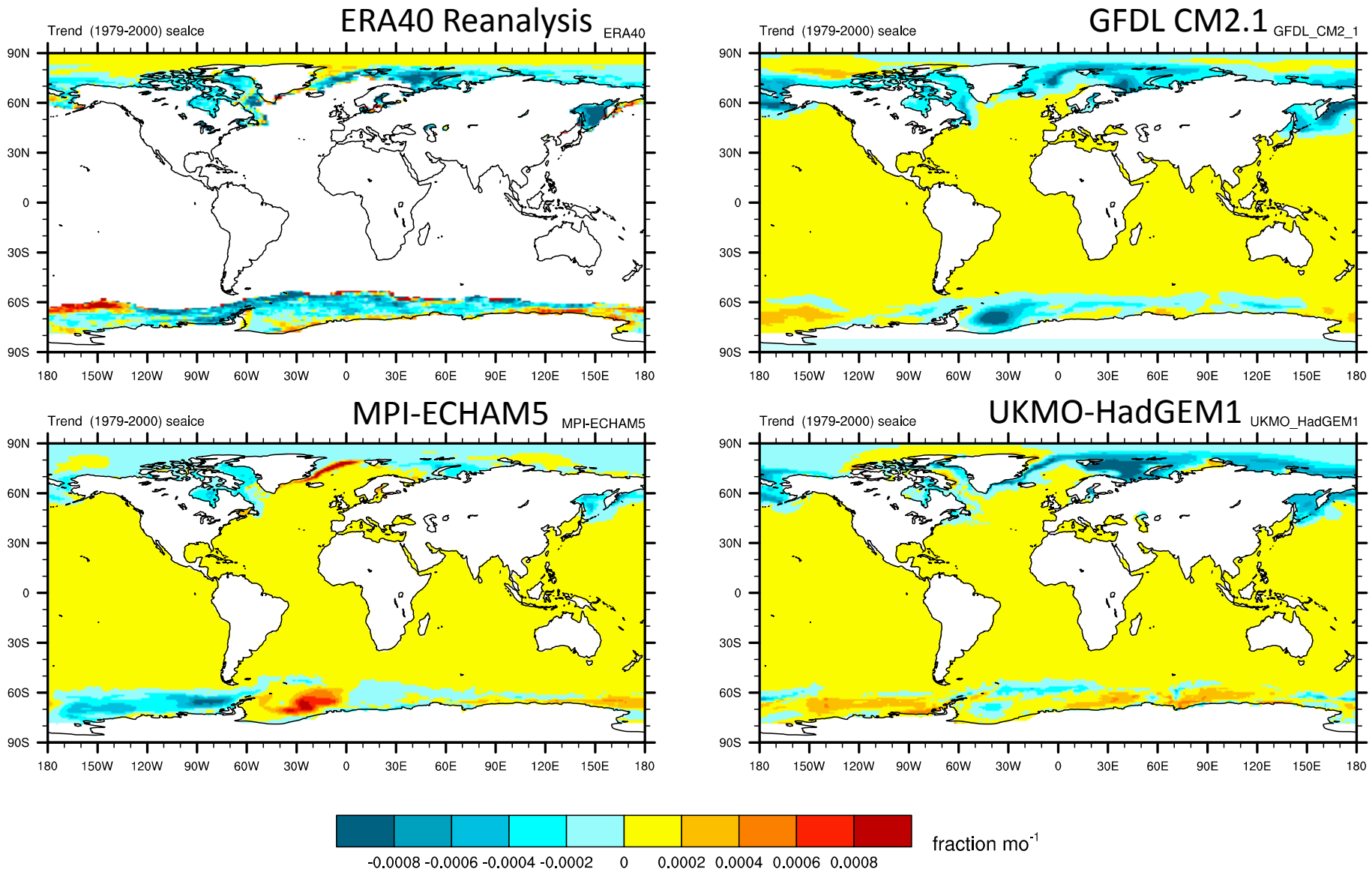
Trend in Sea Level Pressure



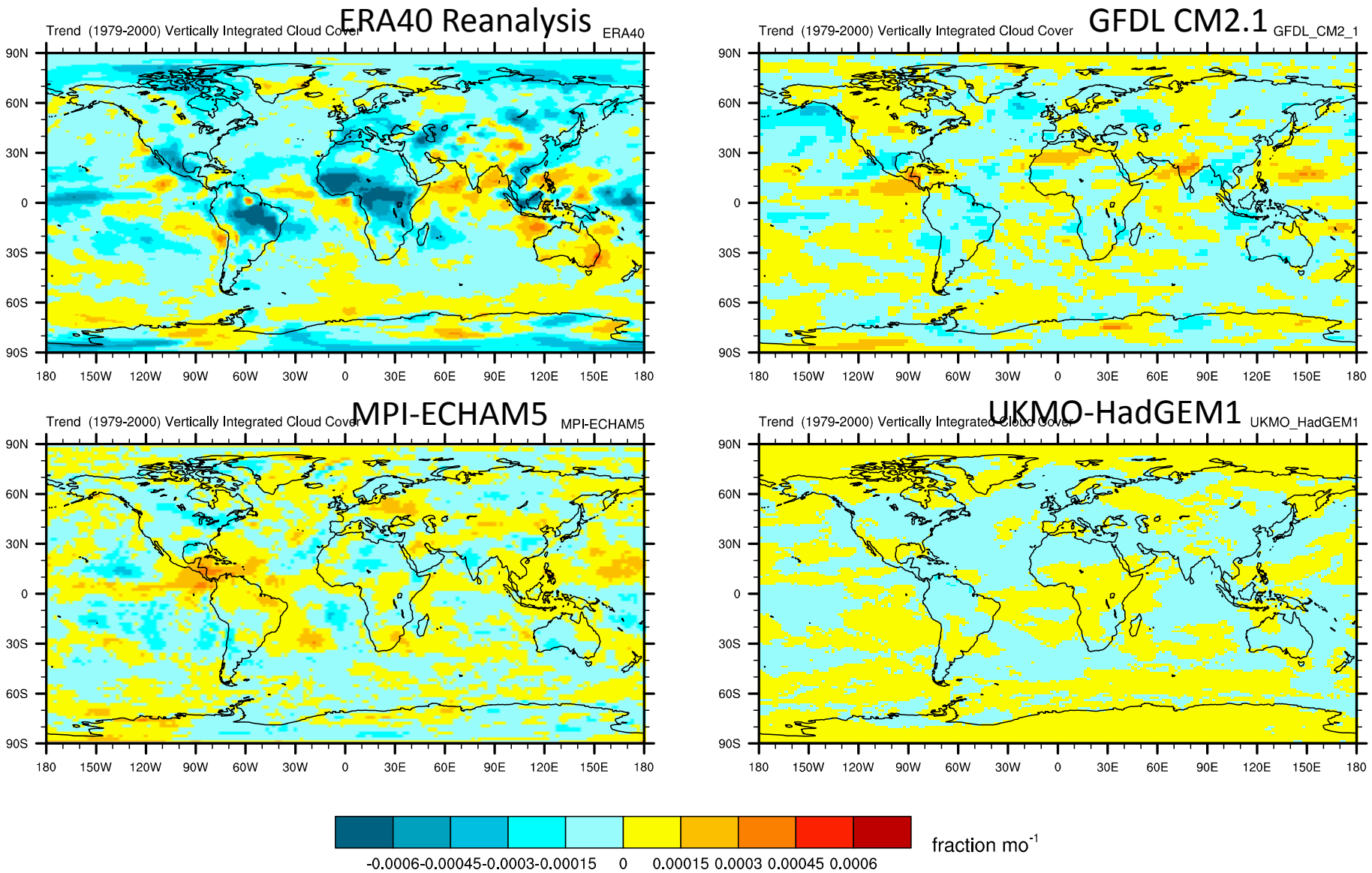
Trend in 2-meter Temperature



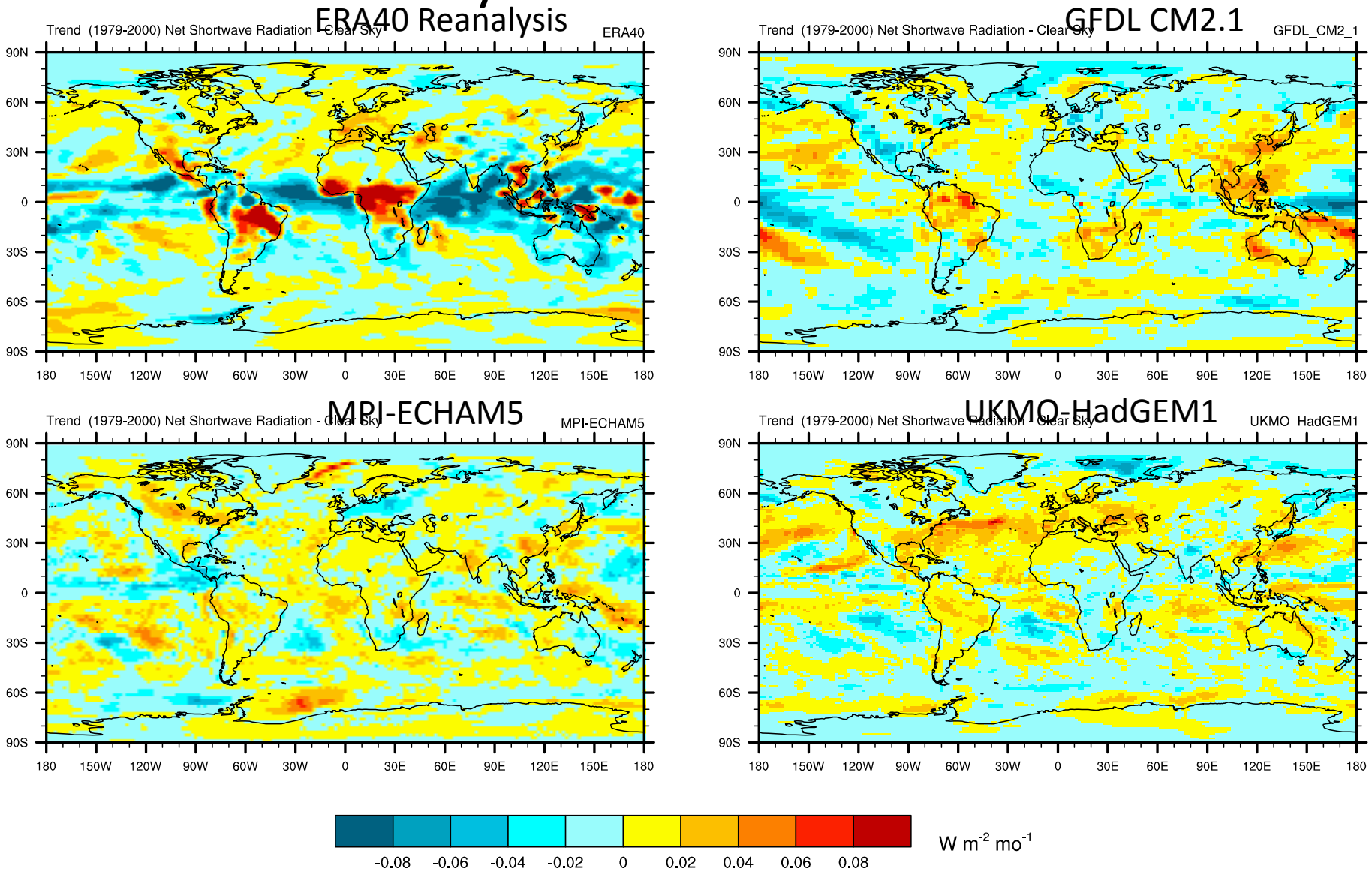
Trend in Sea Ice Cover



Trend in Cloud Cover



Trend in Surface Shortwave Radiation with Clear Sky Contribution Removed



Trend in Surface Longwave Radiation with Clear Sky Contribution Removed