Climate Dynamics
Summer Semester 2018

UNIVERSITÄT LEIPZIG

Homework 7
Due 6 June 2018

Problem 1 Heat capacities

On short time scales, land surfaces and the mixed layer of the ocean act as heat buffers in the climate system. In this problem, we will compare their heat capacities.

(a) Assume the mixed layer of the ocean extends to a depth of 100 m. Using a specific heat for water of 4×10^3 kJ kg^{-1} K^{-1} and density 10^3 kg m^{-3}, find the heat capacity of the mixed layer.

(b) Assume that the seasonal cycle of air temperature penetrates the land surface to a depth of 1 m. Using a specific heat for rock of 800 J kg^{-1} K^{-1} and density 3×10^3 kg m^{-3}, find the heat capacity of the land surface.

Problem 2 Arctic Oscillation

The Arctic Oscillation (AO) refers to an opposing pattern of pressure between the Arctic and the midlatitudes: If the atmospheric pressure is high in the Arctic, it tends to be low in the midlatitudes. In such cases the AO is in its negative phase. In the positive phase, the pattern is reversed. The phase has an important effect on weather in northern locations.

Your task is to identify the AO pattern in the atmospheric pressure field. In order to do so you need to use empirical orthogonal function (EOF) analysis. EOF is a statistical method used to emphasize variation and bring out strong patterns in a dataset. It is often used in climate studies to study spatial patterns of variability and how they change with time. The method is described in Appendix B of Peixoto and Oort. Many analysis packages provide a function to perform EOF analysis.

(a) The AO is most pronounced in the 1000 hPa geopotential height. Reanalysis of the 1000 hPa geopotential (not geopotential height!) for the winter months (DJFM) of the years 1979–2015 is available in `/home_local/tgoren/ex5/geop_1000_DJFM.nc`. Average the data for each year and then apply the EOF method on the data north of 20°N. In order to ensure an equal area weighting, weight the data by $\sqrt{\cos\phi}$. Don't forget that the input to the EOF analysis is the pressure anomaly. Plot the first EOF and describe how wind direction, storm tracks, and jet stream curvature and strength in the upper atmosphere relate to the pattern that you see.

(b) Plot the time series of the AO index. Based on your conclusions from part (a), under which AO phase (positive/negative) you would expect to have warmer/colder winters in northern Europe and the US?

(c) Use the 1000 hPa temperature in `/home_local/tgoren/ex5/temp_1000_DJFM.nc` to plot the difference in the temperature between positive and negative AO index years for grid points north of 20°N. Explain the geographical patterns that you see with respect to the AO phase.