Mechanisms and effects of decadal climate variability

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Project background

The recent slowdown in climate warming has brought the question to the forefront if we fully understand why climate varies on timescales of decades and longer. There are many gaps in our understanding that are caused by limited data availability and limited accuracy of climate models in representing longterm variability. Yet this variability is of great importance for climate predictions over the next few decades, and for understanding the climate of the 20th century. Climate variability can dramatically enhance or suppress the effect of global warming locally (see Deser et al., 2012), and even accelerate or reduce warming globally. The early 20th century warming, for example, is rather unusual in the context of climate model variability, as is the recent hiatus, and it is unclear to what extent this is due to missing exernal influences in the models, or due to exceptionally strong climate variabilty. Now is an excellent time to make advances:

- longterm instrumental data and computer analyses are becoming available to diagnose longterm variability more reliably and to determine its mechanisms
- we have better understanding of the effect of external forcing, hence we can remove the effect of forcing in order to study the remaining variability, yielding an observational dataset of variability
- new models show greater fidelity in reflecting such variability, yet show different levels of longterm variability

This project aims to determine the structure and causes of global scale climate variability that extends over decades, and to quantify to what extent climate models reflect it correctly. It focuses on surface temperature, but the analysis will extend to ocean variables and atmospheric variables when determining mechanisms and the effect of variability on the energy budget of the climate system. Lastly, the impact of key modes on regional weather variability and climate extremes such as heat waves, drought or heavy rainfall will be explored, as they can substantially tilt the probability for extremes that are very damaging (see Kenyon and Hegerl, 2008 and references therein). Key modes that have been identified in the literature include the Pacific Decadal Oscillation and the Atlantic Multidecadal Oscillation (AMO; see eg Folland et al; 2006). The latter may play a key role in events such as the early 20th century warming and the slowdown of warming in the 60s and 70s, but it may have been influenced by external drivers such as aerosols.

Key Research Aims

1. Determine the dominant patterns of climate variability from observations on annual and seasonal variability, and identify which climate model simulations that are available on the CMIP archive exhibit consistent variability
2. Determine the mechanisms and energy exchange between ocean and atmosphere involved in these key modes
3. Quantify the contribution by decadal variability to events of the 20th century such as early 20th century warming and hiatus, using the results from (2)
4. Determine the consequences of these modes on rainfall and temperature extremes.

Methodology

The work will rely on monthly observed and simulated temperature data, and on a new dataset of observed variability from which the effect of external forcing has been subtracted. Climate model data from a multimodel archive (CMIP5) of climate model simulations of the 20th century using combined and individual forcings will be used. Analysis techniques will include Empirical Orthogonal Function analysis, covariances, correlations, and multivariate analysis, including detection and attribution methods. The student should be comfortable with computer-based data analysis, for example, using Matlab or R (or similar languages) to perform statistical analyses of space-time data.

Research Training

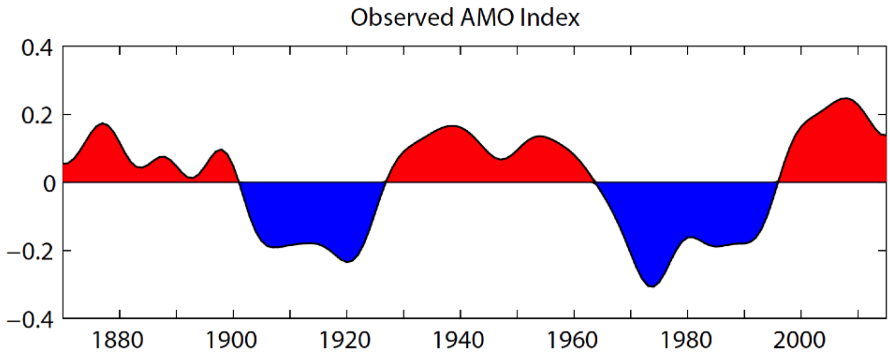
The project will train the student in climate research, familiarizing the student with state of the art climate models and analysis tools for climate model and observed data. The student will also obtain a broad background in climate change. The student will be part of a vibrant research team around the project team of the ERC project TITAN (to be concluded in early 2018), but also the UKwide NERC funded project SMURPHs (Securing Multidisciplinary UndeRstanding and Prediction of Hiatus and Surge events).

Requirements

The project would suit a student with a strong quantitative background (e.g. meteorology, geophysics, or physics or mathematics). The student should be familiar with programming, and have an interest in climate science and modelling.

Project Summary

This project determines the causes, mechanisms and expressions of climate variability on long timescales. Doing this yields more reliable predictions of future climate change.



Atlantic Multidecadal Oscillation index from NCAR dataguide
(https://climatedataguide.ucar.edu/climate-data/atlantic-multi-decadal-oscillation-amo)

References

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