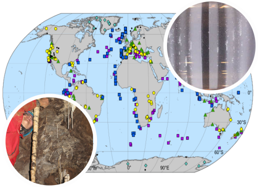

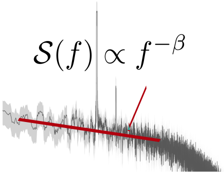

Understanding and modeling the scaling spectrum of climate

▷ Beatrice Ellerhoff, ▷ Kira Rehfeld

18 March 2020

🔈 01_Intro.mp3 ▸ Play Sound

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A few instructions on the use of this document:

- The white triangles ▷ mark clickable contents
- Play Sound and indicate short audio explanations
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- Alternatively, the audio records can be listened to under this link

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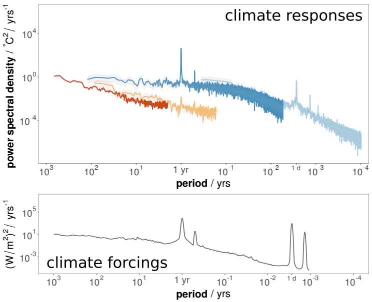
A quick summary of central questions of our research:

- How can we model & understand the scaling background continuum of temperature variability?
- How is variability on short timescales linked to variability on long timescales?
- What is the contribution of forcing mechanisms to climate variability on different scales?



The climate - a highly interactive, continuously evolving & complex system

▷ Femkemilene / CC BY-SA; Freepik from ▷ www.flaticon.com

The very different physical characteristics of climate subsystems are coupled through the transfer of energy, momentum & mass. Perturbations affect the many subsystems differently.

This variety meets challenging questions of physics such as turbulence & non-linear interactions. The need for modeling future climate conditions and the effects of global heating makes it even more important to understand the highly complex climate system.

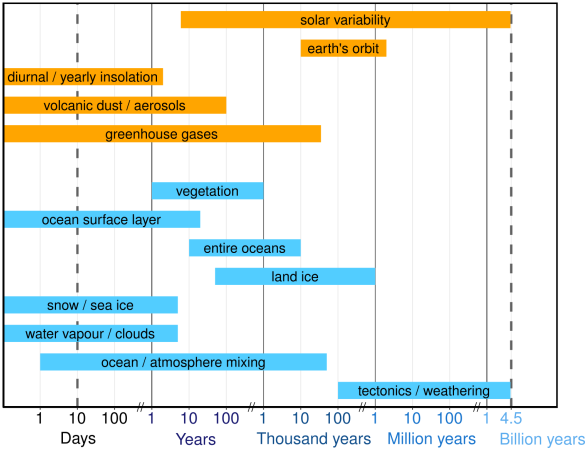
03_ClimateSystem.mp3 ▸ Play Sound

Climate forcings and responses act on all timescales

The climate is constantly changing as a result of the interplay between many characteristic timescales associated to external & internal forcings as well as to the subsystems' responses.

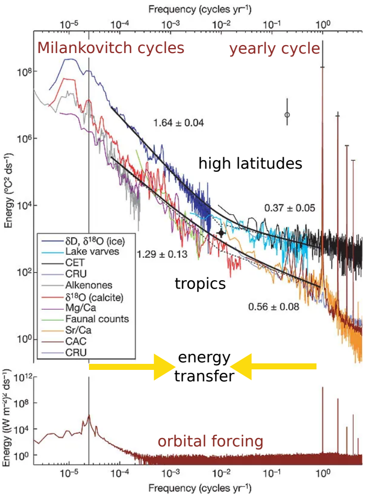
This interplay makes it hard to model climate variations in time. Climate variability still remains insufficiently explained. It is, however, expected to be at least as relevant to the society as changes in the mean temperature [▷ Katz and Brown, 1992].

04_Timescales.mp3 ▸ Play Sound



Adapted from ▷ Peixto and Oort, 1984; Rohling et al., 2018, 2012

Scaling continuum of temperature variability follows power laws $\mathcal{S}(f) \propto f^{-\beta}$



▷ Huybers and Curry, 2006, annotations added

Spectral analysis of climate signals makes it possible to assess the characteristic features of climate variability.

The background continuum of temperature variability follows different power-laws on monthly to decadal versus millennial to longer periods. Moreover, the scaling is spatially dependent [▷ Huybers and Curry, 2006].

This finding has major implications on our understanding of climate variability. We aim to update and to extend this result using proxy and instrumental data in order to gain further insights into the scaling spectrum of climate.

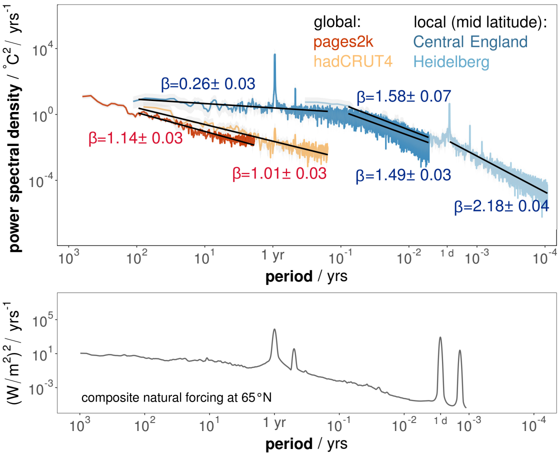
🔈 05_ScalingBackground.mp3 ▸ Play Sound

Spectrum of local and global SAT as well as forcings for the Common Era

Here, we present results for the Common Era:

$1/f$-noise is found for global spectra at monthly to centennial periods and $\beta \approx 0.3$ for the mid latitudes. At the weather regime, we find $1.49 \leq \beta \leq 2.18$, confirming previous results [▷ Fredriksen and Rypdal, 2016; Fredriksen and Rypdal, 2017; Lovejoy, 2015].

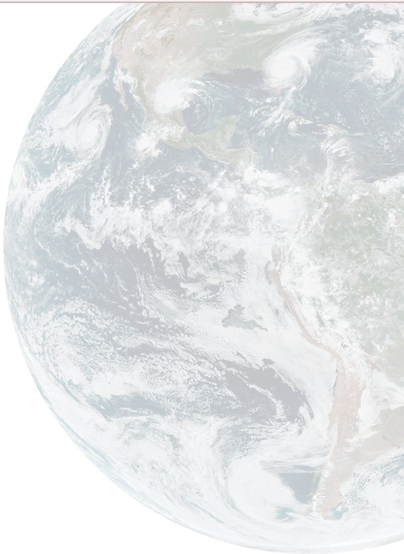
The forcing spectrum is modeled as a composite of total solar irradiance, CO_2, volcanic & orbital forcing. The characteristic peaks at yearly and diurnal periods are reflected in the response spectra.



06_CommonEra.mp3 ▶ Play Sound

▷ Overview of data references at the end of the slides

Outlook



We would like to take the above results and the discussions from the EGU sessions as a starting point for further investigations of the scaling spectrum of climate.

This could be based on higher order spectral analysis, testing for correlations between forcings & responses. The modeled forcing could be further used for single-forced experiments with energy balance models. All in all, we seek to evaluate the potential of these methods to reveal dynamical processes governing the continuous spectrum of surface temperature.

We would be happy to receive your questions & to discuss related topics with you: ▷ live chat ▷ e-mail

07_Outro.mp3 Play Sound

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Thanks to:

▷ STACY colleagues & ▷ Marie-France Loutre for discussions

The ▷ ICOS lab (B. Kromer, S. Kühr & S. Hammer) for data support

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Data

Name	Calibration	Ref. (Calibration)	Ref. (data)
Volcanic Forcing			
Crowley	$1\,\text{AOD} = -25\,\mathrm{W/m^2}$	IPCC, 2014	Crowley and Unterman, 2013
Total Solar Irradiance			
Steinhilber			Steinhilber, Beer, and Fröhlich, 2009
CMIP5			Schmidt et al., 2011
Fröhlich (2006)			Fröhlich, 2006
CO_2			
MaunaLoa	$5.35\ln(\frac{\mathrm{CO_2}}{278ppm})\,\mathrm{W/m^2}$	Köhler et al., 2017	Tans and Keeling, 2019
Köhler			Köhler et al., 2017
Meinshausen	$5.35\ln(\frac{\mathrm{CO_2}}{278ppm})\,\mathrm{W/m^2}$	""	Meinshausen et al., 2017
Insolation			
Orbital forcing			Berger, 1978; Crucifix, 2016; Laskar et al., 2004
Local temperature			
Central England record			Parker, Legg, and Folland, 1992
Heidelberg record			IUP Heidelberg (ICOS Lab)
Global temperature			
pages2k multi-proxy reconstruction			Neukom et al., 2019
hadCRUT4 record			Morice et al., 2012

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