Reconstruction, modeling and future implications of changes in past climate variability: II

Heidelberg Physics Graduate Days 2019

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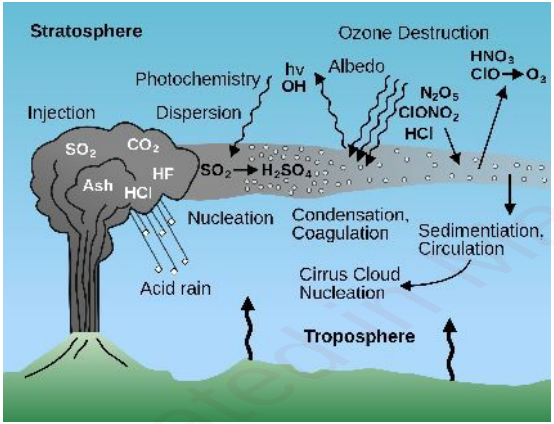
Common Era and volcanic forcing

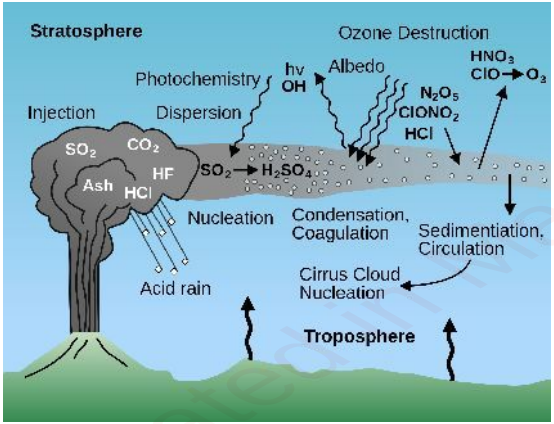
Monday	Tuesday	Wednesday	Thursday	Friday
Past	**Present**	**Future**	**Experiments**	**Summary**
• Climate reconstruction • Variability • Tsc: 10^5 to 10^3a	• Common Era • Volcanoes • Tsc: 10^3a to days	• Models • Climate sensitivity • Projections	• Hypotheses • Experiment • Assessment	• Your results • Knowns & Unknowns • Feedback

Volcanoes and Climate



Source:http://www.weather.gov.hk/blog/en/img/20110829_fig2e.jpg

Volcanoes and Climate



Eruption: HCl, SO_2, CO_2, HF, Ash

$\Downarrow$

If into stratosphere: Stability $\rightarrow$ persistence of ash and gas injection

$+$

Formation of **sulphate aerosol** with OH and radiation (photochemistry)$\rightarrow$ absorption and reflection

$\Downarrow$

Stratospheric heating and troposphere cooling

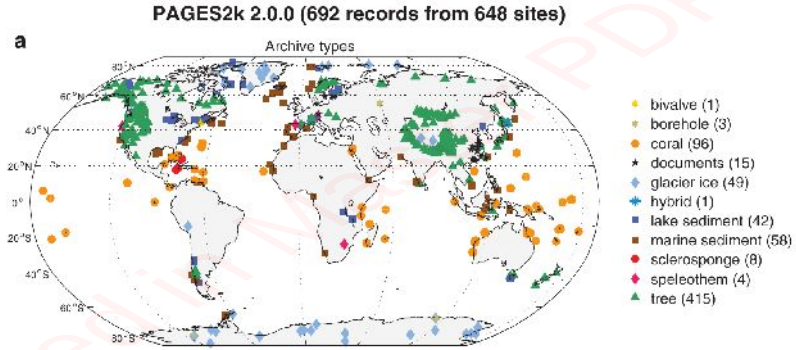
$\Downarrow$

Change in global circulation and temperature

Source:http://www.weather.gov.hk/blog/en/img/20110829_fig2e.jpg

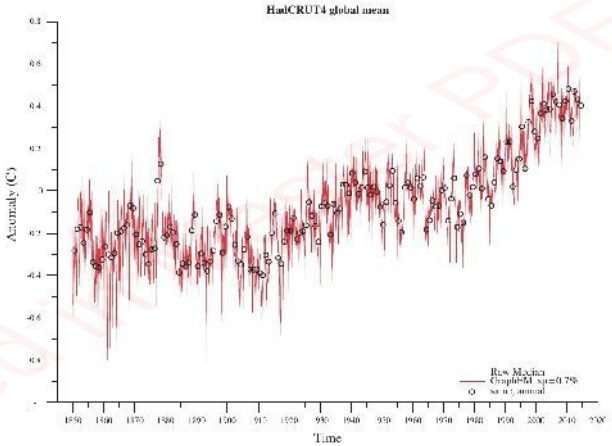
PAGES2k project

http://pastglobalchanges.org/science/wg/2k-network/intro

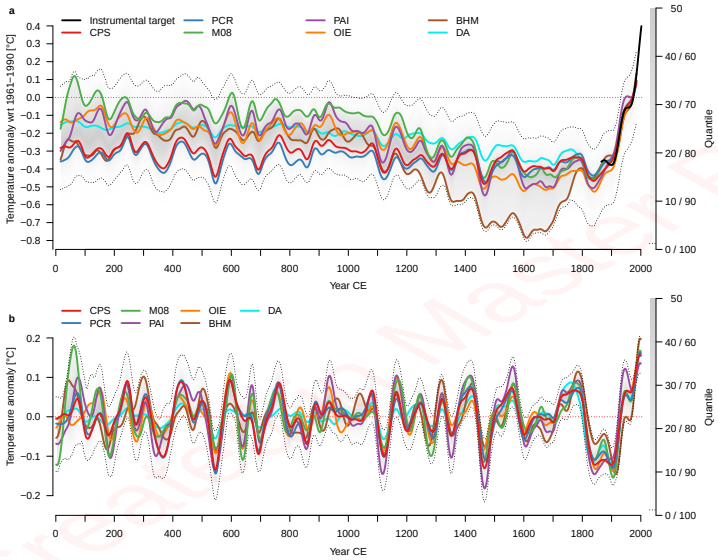


PAGES 2k Consortium, 2017

Calibration by instrumental overlap



Jones, Lister, et al., 2012; Jones, New, et al., 1999; PAGES 2k Consortium, 2017

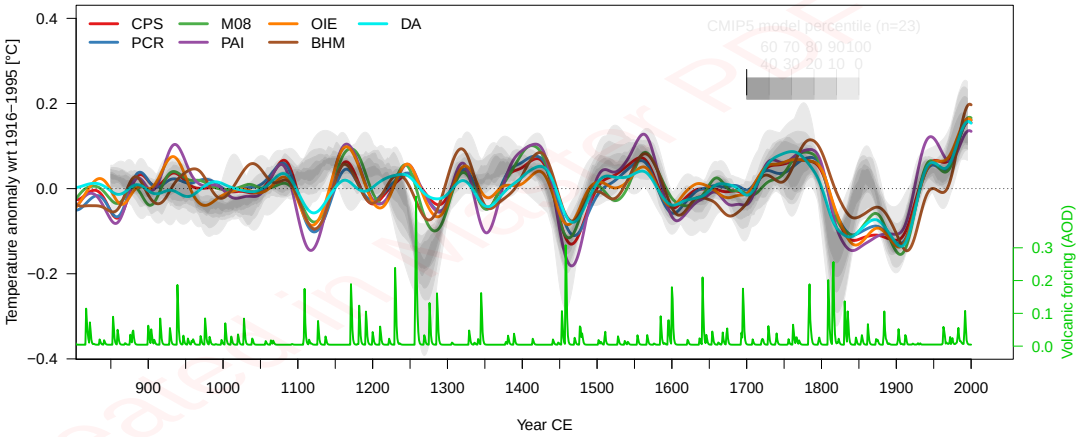


GMST

Global mean temperature reconstruction over the last 2000 years by 7 methods

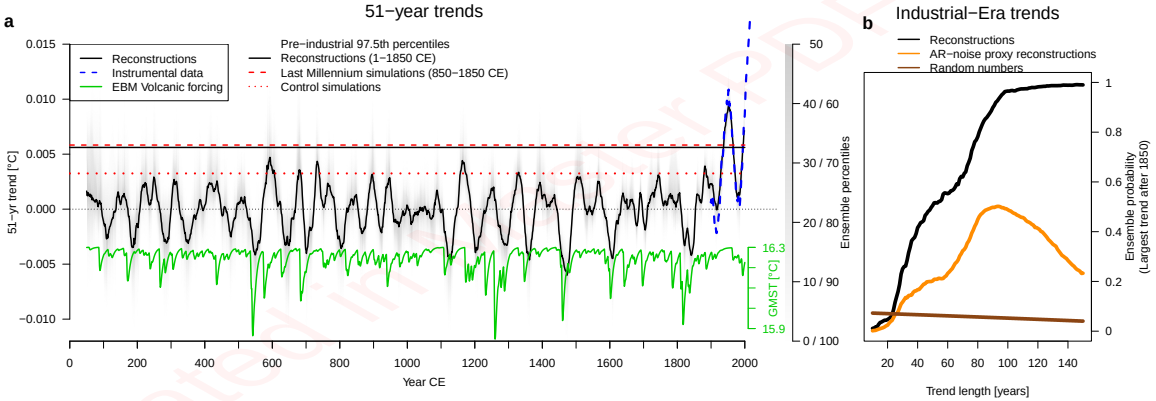
Pages2k-Consortium, 2019

Consistent decadal temperature minima and volcanic clusters



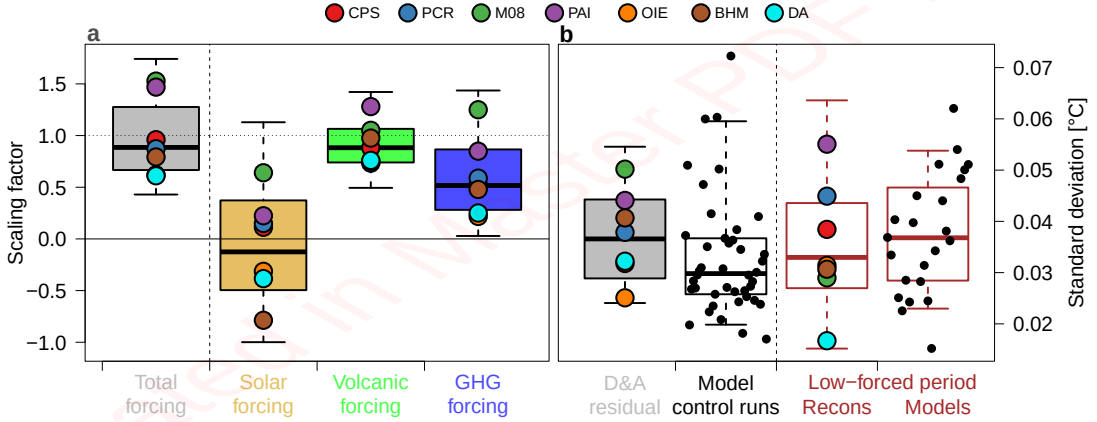
Pages2k-Consortium, 2019

Distribution of 51-year trends



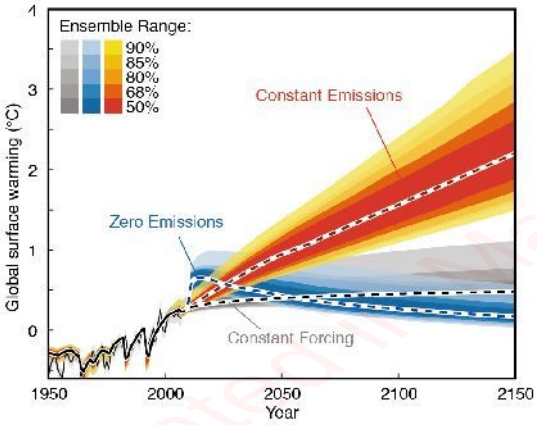
Pages2k-Consortium, 2019

Detection and attribution: Volcanic forcing



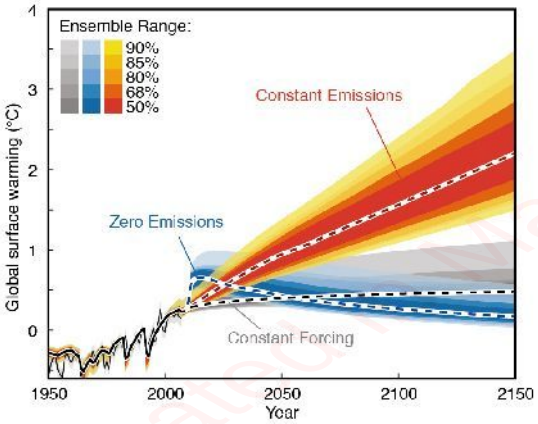
Pages2k-Consortium, 2019

Future climate variability and volcanism



Bethke et al., 2017; IPCC-AR5, 2013

Future climate variability and volcanism



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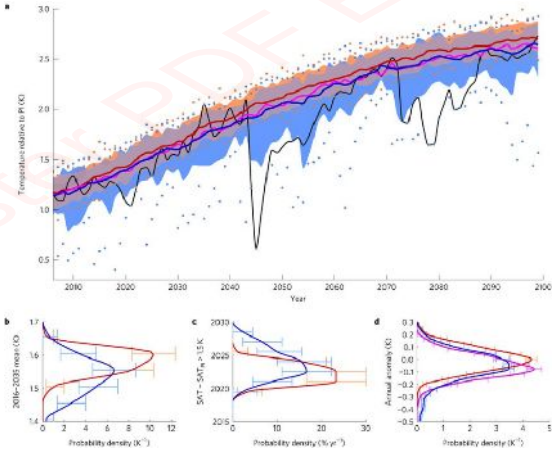
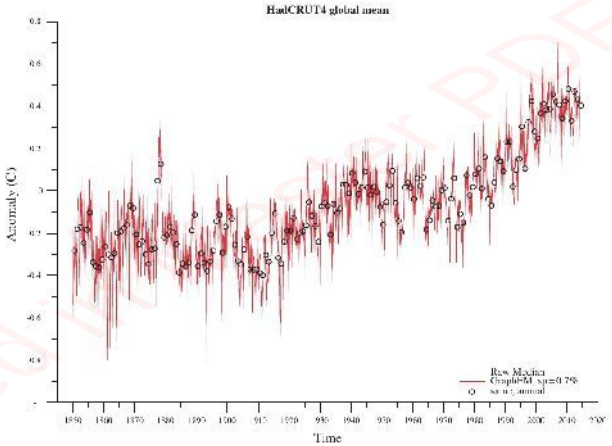


VOLC,NO-VOLC, black: most extreme member.

Calibration by instrumental overlap



Jones, Lister, et al., 2012; Jones, New, et al., 1999; PAGES 2k Consortium, 2017

Hands-on: Historical climate change

1. Assess the data availability based on met. observations over time.
2. Using station data, characterize global mean temperature change since 1850.
3. Compare global mean temperature change to that in
   - your team's median origins
   - Heidelberg
4. Do you see a role for internal variability?
5. Summarize the robust trends and the uncertainties that you see.
6. Compare this to the change in atmospheric CO_2.

Datasets in github repository

git pull `https://github.com/paleovar/graddays.git`

Climate data

- HadCRUT4 Jones, Lister, et al., 2012; Jones, New, et al., 1999; Jones, Osborn, et al., 2001 both as .txt and netcdf files. See R-Markdown script for an example on how to read.
- Additional
  - Pages 2k GMST reconstruction Pages2k-Consortium, 2019 (e.g. to re-create plots in this presentation)
  - Web access: `https://climexp.knmi.nl/selectstation.cgi?id=someone@somewhere`

Climate forcing

Mauna Loa CO_2 Keeling et al., 1976 from `https://www.esrl.noaa.gov/gmd/ccgg/trends/data.html`. See references for ice core extension.

Natural forcings past 2k: `/datasets/Tuesday/p2k_graddays/forcing2.csv` Pages2k-Consortium,

Workflow

1. Get data
2. Copy to separate folder + clean data
3. Formulate hypothesis (read the papers)
4. Inspect data (plot)
5. Analyze data
6. Summarize results (1-2 slides)
7. Submit (notebook or pdf)

Please put check on the board when you've completed a stage. If you need help, put a sticker on your computer.

Results

What did you find?
What were your main challenges?

$\Rightarrow$ submit results to krehfeld@iup.uni-heidelberg.de

References I

Bethke, I. et al. (2017). "Potential volcanic impacts on future climate variability". In: *Nature Climate Change* 7.11. DOI: 10.1038/nclimate3394.

IPCC-AR5 (2013). *Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. Ed. by T. Stocker et al. Cambridge University Press.

Jones, P. D., D. H. Lister, et al. (2012). "Hemispheric and large-scale land-surface air temperature variations: An extensive revision and an update to 2010". In: *Journal of Geophysical Research* 117.D5. DOI: 10.1029/2011JD017139.

Jones, P. D., M. New, et al. (1999). "Surface air temperature and its changes over the past 150 years". In: *Reviews of Geophysics* 37.2. DOI: 10.1029/1999RG900002.

Jones, P. D., T. J. Osborn, et al. (2001). "Adjusting for sampling density in grid box land and ocean surface temperature time series". In: *Journal of Geophysical Research* 106.D4. DOI: 200110.1029/2000JD900564.

References II

- Keeling, C. D., R. B. Bacastow, and A. E. Bainbridge (1976). "Atmospheric carbon dioxide variations at Mauna Loa Observatory, Hawaii". In: *Tellus* 28.6. DOI: 10.3402/tellusa.v28i6.11322.
- PAGES 2k Consortium (2017). "A global multiproxy database for temperature reconstructions of the Common Era". In: *Scientific Data* 4.170088. DOI: DOI:10.1038/sdata.2017.88.
- Pages2k-Consortium (2019). "Consistent multidecadal variability in global temperature reconstructions and simulations over the Common Era". In: *Nature Geoscience* (in press). DOI: 10.1038/s41561-019-0400-0.

Additional resources

https://a-little-book-of-r-for-time-series.readthedocs.io/en/latest/
https://www.ncdc.noaa.gov/data-access/paleoclimatology-data
Modified orbital illustrations after railsback.org
Used graphics: see references, openclipart.org, own work and wikimedia commons