

An open source tool to analyse heat waves using flow analogues

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Question

How much of the temperature anomalies during heat waves can be explained by large scale flow?

Data

- CMIP5 data from the ESGF archive
- GFDL model, 500 years preindustrial control simulation

Heat wave definition

yearly maxima of 15 days running mean temperature anomalies over the SREX central Europe (CEU) region (red box in figure 1)

Flow analogues

- Similar flow patterns lead to similar weather
- Simualte heat waves that might have been (uchronic) by resampling temperature from days with a flow similar to the flow observed during heat waves. (fig. 2)

Circulation Analogue Simulation Tool in fortran90 (CASTf90)

- Open Source software for calculating analogues
- NetCDF input
- 5 distances implemented
- Configurable paramenters such as number of analogues, distance to use, 2 output formats...
- available from github https://github.com/sradanov/castf90

Web Processing Service Flyingpidgeon

- Based on Python WPS
- Open Source (https://github.com/birdhouse/flyingpigeon
- Processes for climate- and extreme event analysis including flow analogues based on CASTf90 and weather regimes
- Process data close to the data source, download results only (figure 3)
- Test server at DKRZ mouflon.dkrz.de

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Figure 1: Domains for the definition of heat waves (red) and flow analogues (black)



Figure 2: Schema of flow analogue simulation for days belonging to a heat wave.



(a) Traditional: big download and processed "at home".

(b) With WPS: small download (only results), processing close to the storage.

Figure 3: Traditional data processing versus web processing service

Hempelmann, N., Ehbrecht, C., Alvarez-Castro, C., Brockmann, P., Falk, W., Hoffmann, J., Kindermann, S., Koziol, B., Nangini, C., Radanovics, S., Vautard, R., and Yiou, P. (2017). Web processing service for climate impact and extreme weather event analyses. flyingpigeon (version 1.0). Computers and Geosciences. under revision.

Jézéquel, A., Yiou, P., and Radanovics, S. (2017). Role of circulation in european heatwaves using flow analogues. Climate Dynamics. accepted.







Figure 4: Mean heat wave temperatures versus uchronic heat wave temperatures

Figure 5: Returntimes of temperature anomalies versus distance of flow analogues



- - region







Heat wave simulations 1. from each year of the 500 years model run select the 15 days period with the largest positive temperature anomaly over the CEU

2. search daily flow analogues (20) for this period on the 500hPa geopotential height field (black domain in figure 1) using CASTf90 with Euclidean distance in the other 499 years of the data 3. sample one out of the 20 analogues and take the temperature of the day 4. average over the 15 simulated days 5. repeat steps 3-4 500 times \rightarrow 500 uchronic temperatures per event Results

Very common events are quite well simulated (figs. 4, 6)

More severe events can only partly be explained by large scale flow (figs. 4, 6) • Other processes, for example soil moisture feedback are needed.

The mean distances of the analogues tend to be slightly higher for rare events, but not the minimum distances (fig. 5)

Conclusions

• With 499 years of archive the distances don't show much dependence on the return time of the events

• The part of a temperature anomaly that can be explained by large scale flow strongly depends on the return time of the event. • The CASTf90 software is able to efficiently calculate circulation analogues even for

large data sets - here 500 years of climate simulations.





