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Using large ensembles to investigate the impacts of climate extremes

Nathalie Schaller and many others!

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Motivation

- Studying extreme events begs for a large sample size
- Impossible to say something about a 1-in-100 year event with 30 years of data
- (Ok, ok, there is extreme value theory)
- But extreme events often also call for high spatial and temporal resolution
- Convection-permitting models needed to investigate flash floods or cloudbursts
- How to balance both given limited computer ressources?

A few key messages

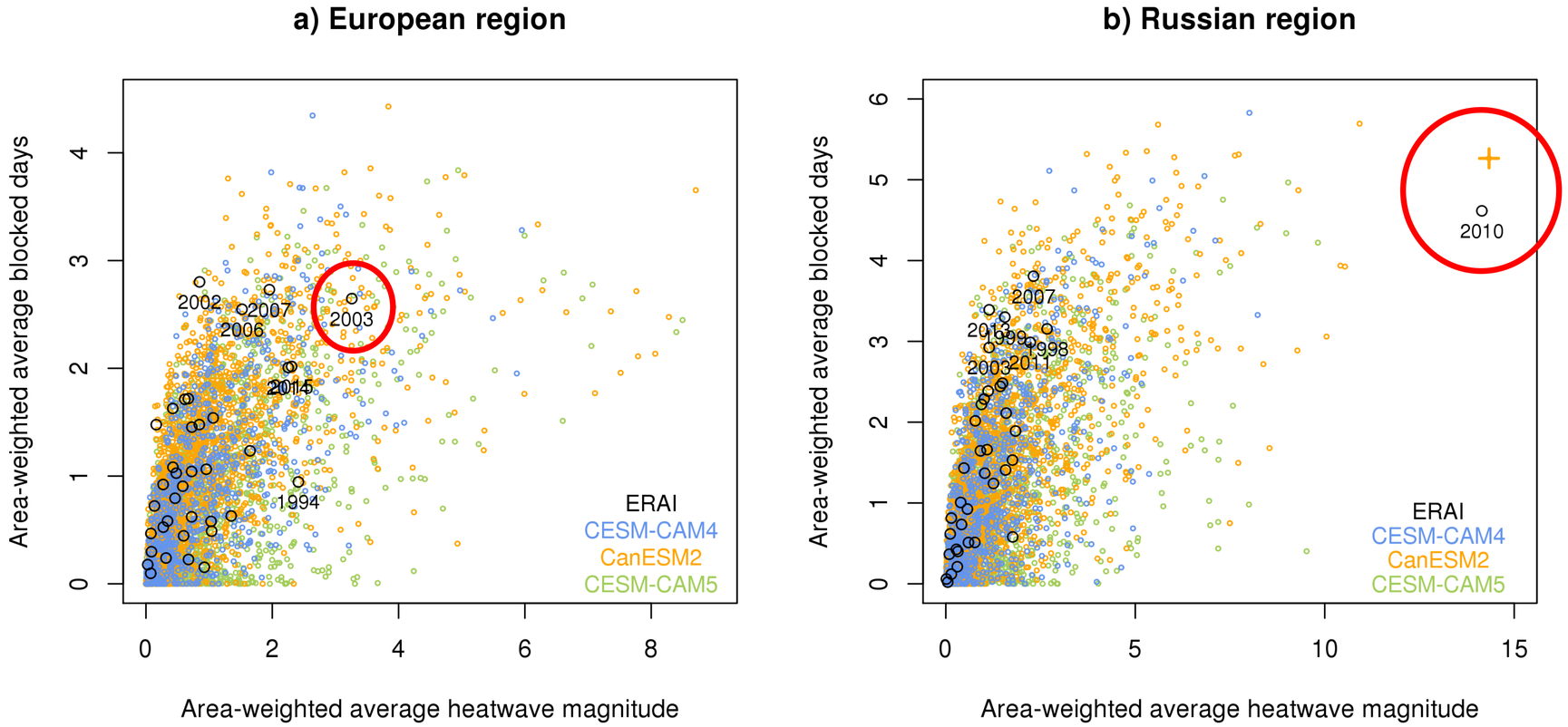
- Assessing changes in **frequency/intensity/duration of heatwaves** usually does not require high spatial resolution but a large ensemble
- However, **health impacts of heatwaves** might be better served by a small sample of downscaled events

- **Winter precipitation events/floods** occuring at mid/high latitudes are likely caused by large-scale processes, no need for proper representation of convection
- **Summer precipitation events/floods** however... ideally both

- For floods: type of catchement highly important. If it is small, then high resolution needed

Heatwaves and blocking (*Schaller et al., 2018, ERL*)

- Three large ensembles: 2003 heatwave not that exceptional according to large ensembles but only 1 ensemble member similar to 2010 heatwave



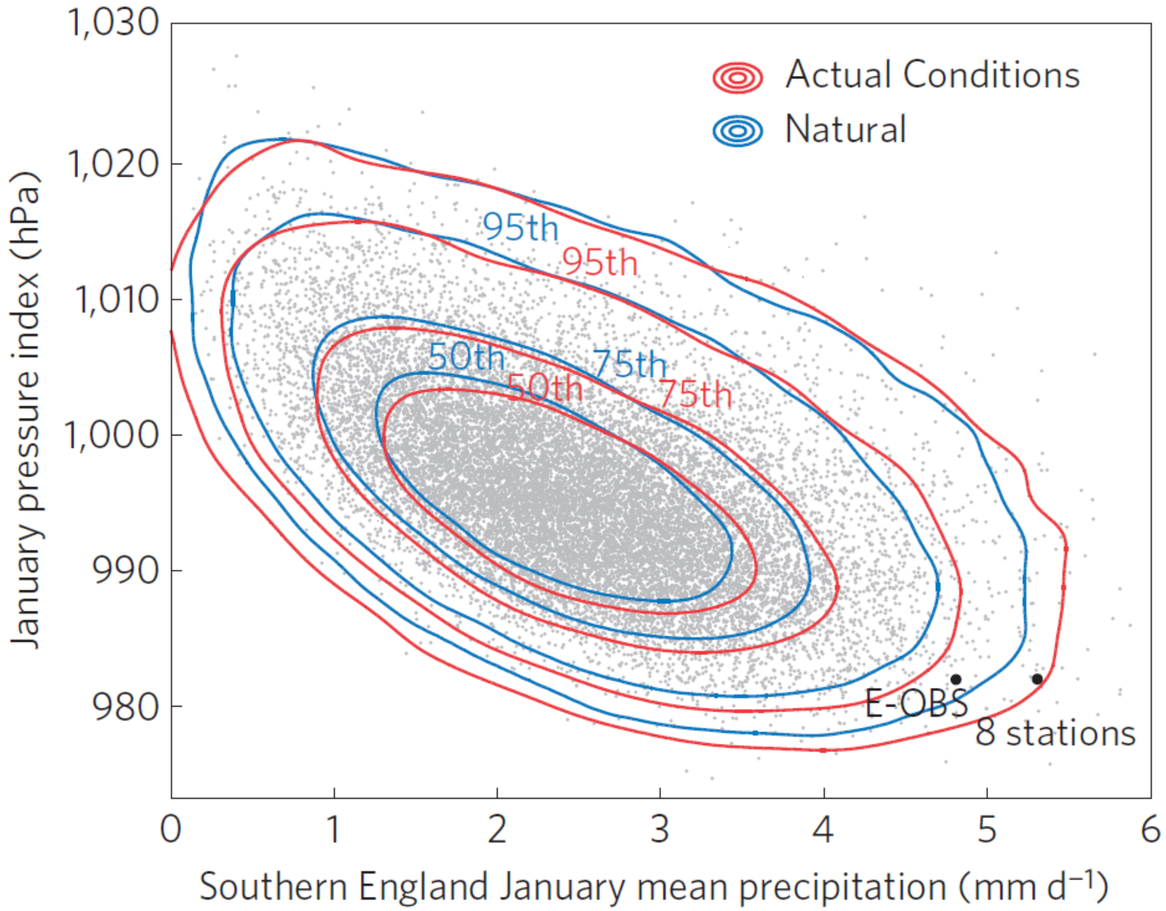
Heatwaves and health

- Ongoing H2020 EXHAUSTION project
- 1 single ensemble member with CESM2 (historical+three scenarios)
- Downscaling with WRF-Chem, DEHM and SILAM
- Hourly (!) output needed: large ensemble unfeasible
- Combined health impacts of heat and air pollution, mostly from wild fires
- See: www.exhaustion.eu

Winter flood in UK *(Schaller et al. 2016, NCC)*

- Long-lasting event, big catchment: coarse resolution sufficient
- Attribution of a 1-in-100 yr event: large ensemble needed
- 134,354 simulations done through the citizen science project weather@home

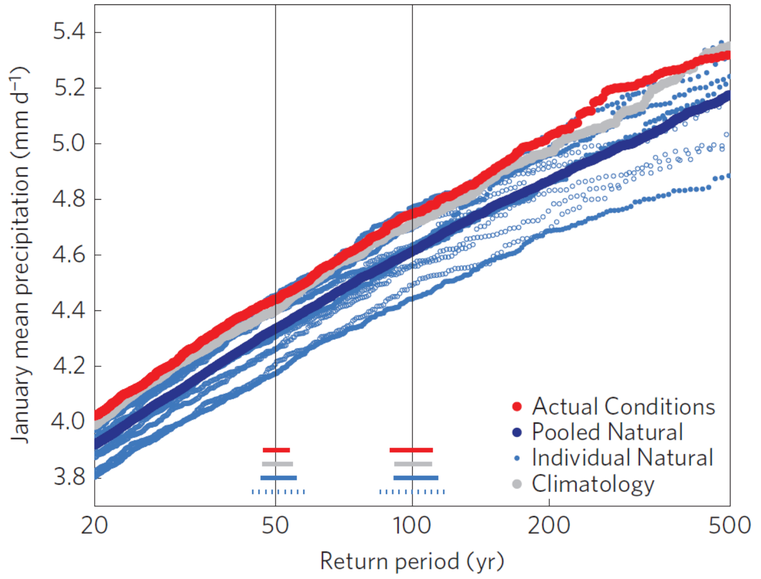
  (that was probably too many…)

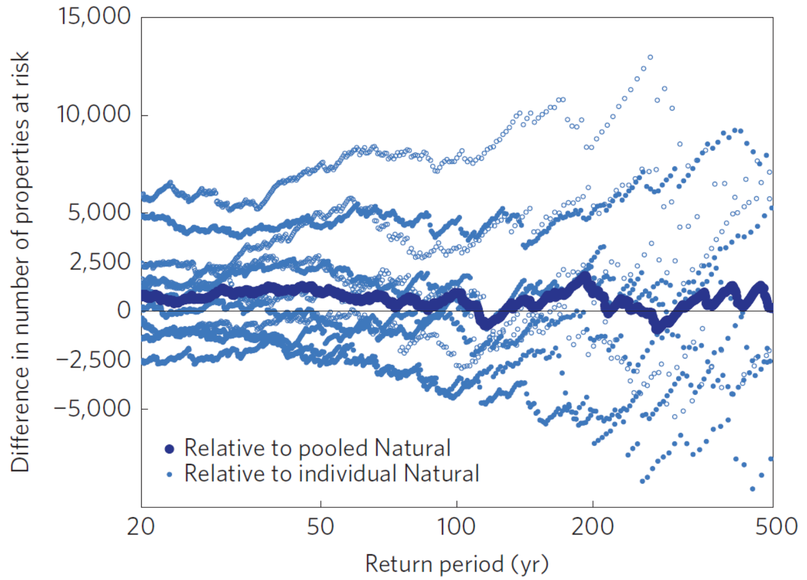


Winter flood in UK *(Schaller et al. 2016, NCC)*

- However, in impact studies, each step of the modelling chain adds uncertainty

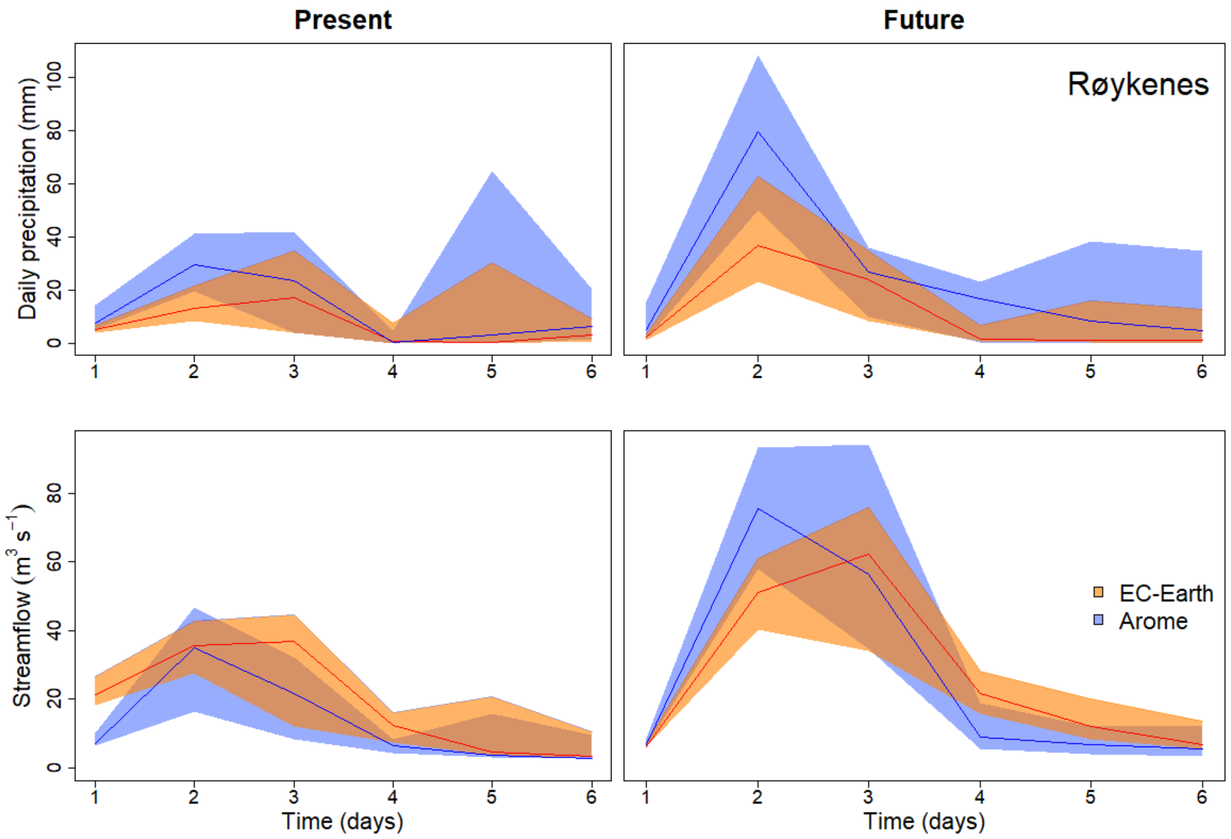
- In this case, there was a clear attributable signal in the RCM precipitation output, but not for the number of properties at risk of flooding in the Thames catchment





Autumn flood in Norway *(Schaller et al. in revision)*

- 3 days event, small catchment: high spatial and temporal resolution needed
- Storyline approach theoretically 1 single event, but we produced a 10 initial conditions ensemble nevertheless
- Main conclusions however not strongly affected by the ensemble size
- But peak streamflows more realistic thanks to the high resolution!



AROME is the high resolution regional model, EC-Earth the GCM

Conclusions

- Pretty obvious, but designing a study and its simulations is a very important step, there is no «one size fits all» method. Each extreme event is unique.
- Large initial conditions/perturbed physics ensembles, considering all scenarios and all CMIP6 models: having more is not always better!
- In fact, it might just make it impossible to draw a conclusion if there are too many degrees of freedom.
- Speaking as a, and to, climate scientists: don’t underestimate the uncertainties introduced by hydrological and other impact models. Often what happens in the atmosphere is the easy part!

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nathalie.schaller@cicero.oslo.no

cicero_klima
cicero.oslo.no
cicerosenterforklimaforskning