Quantifying Regional Climate Extremes: Weather at Home

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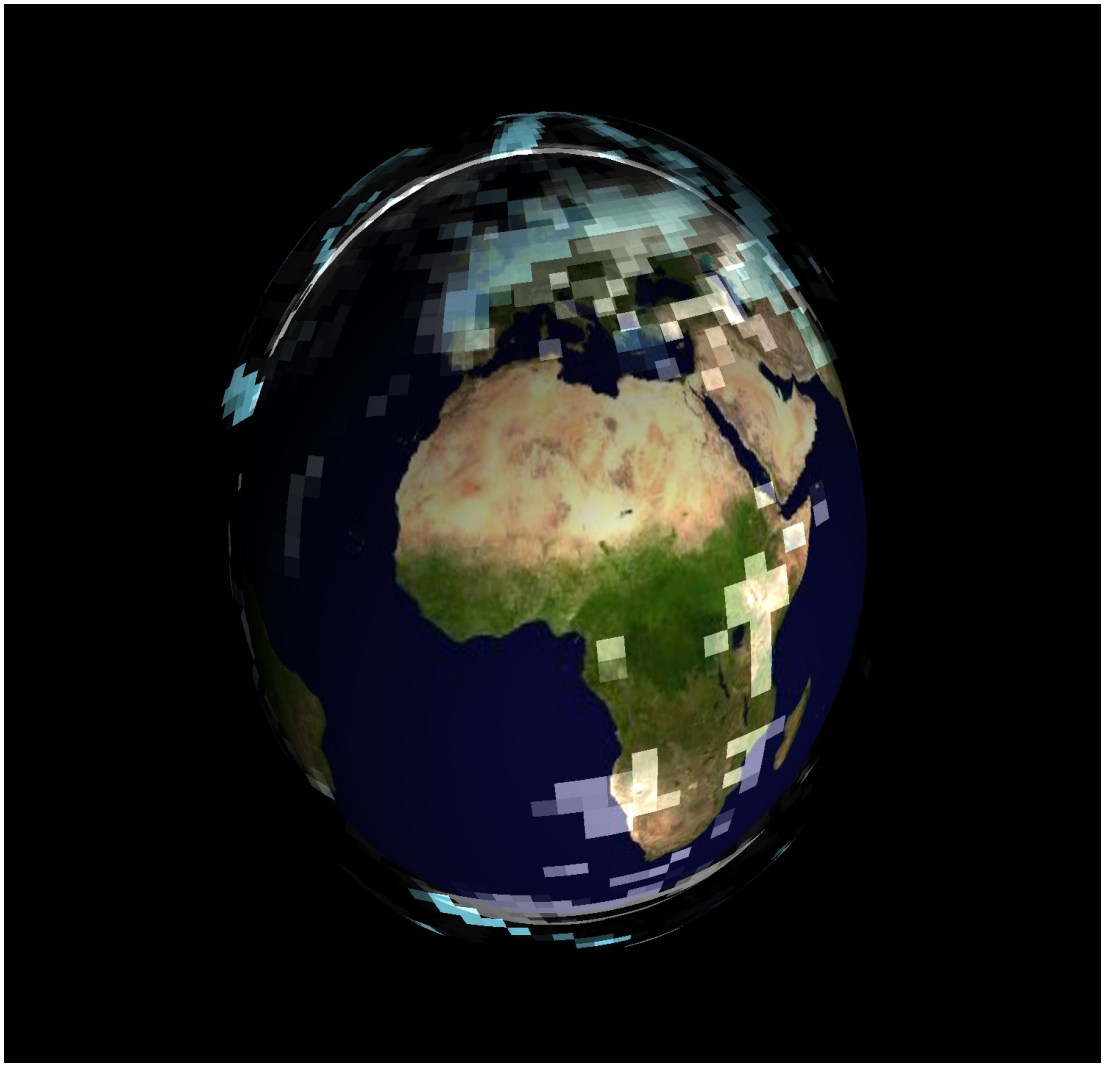
Probabilistic Event Attribution

- Question: is the risk of an extreme weather event (EWE) occurring increased by anthropogenic climate change (ACC)?
- Probabilistic Event Attribution provides a framework to assess the change in risk of an EWE due to ACC
- Based upon the change of probability of an extreme event occurring between two climate scenarios
- Weather at Home uses very large ensembles of regional climate models to assess the change

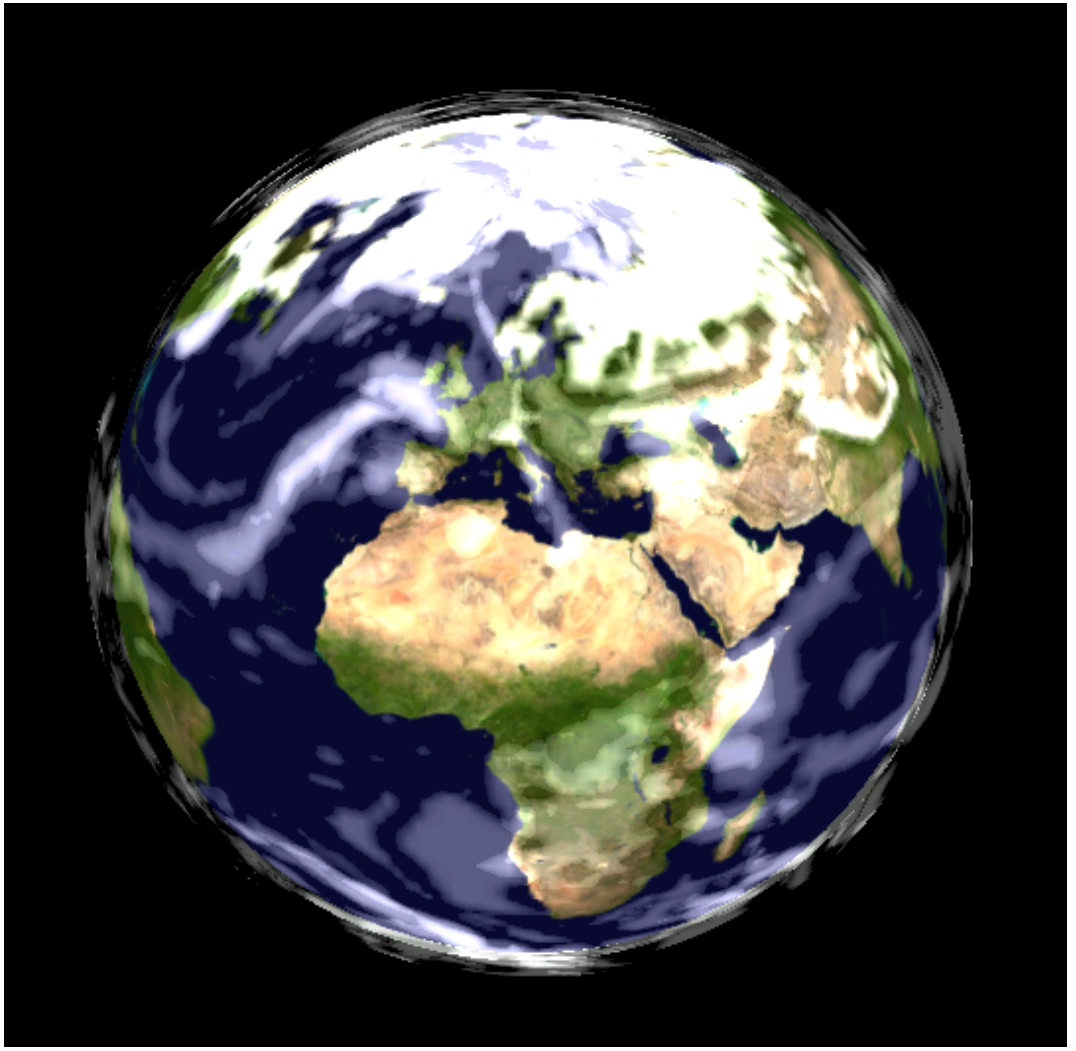
WaH – The models

- WaH uses two nested models:
  - HadAM3P atmosphere-only global climate model (GCM) at 1.875°λ x 1.25°θ
  - HadRM3P atmosphere-only regional climate model (RCM) at either 50km or 25km
- Both models have the same forcing scenario, parameter perturbations, initial conditions, etc.
- Coupling between global and regional model every 6 hours

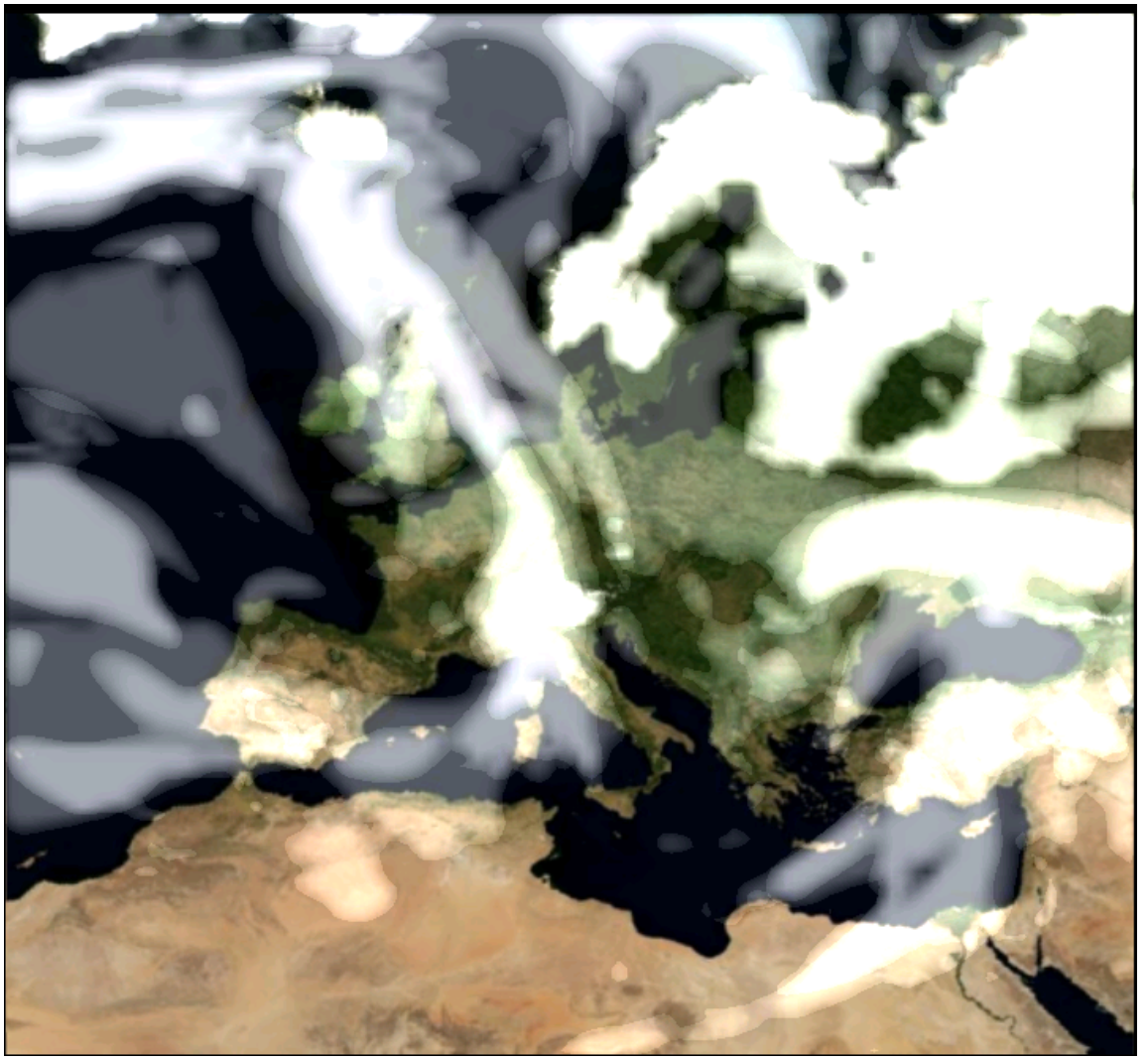
Previous CPDN model



WaH - GCM



WaH – RCM @ 50km



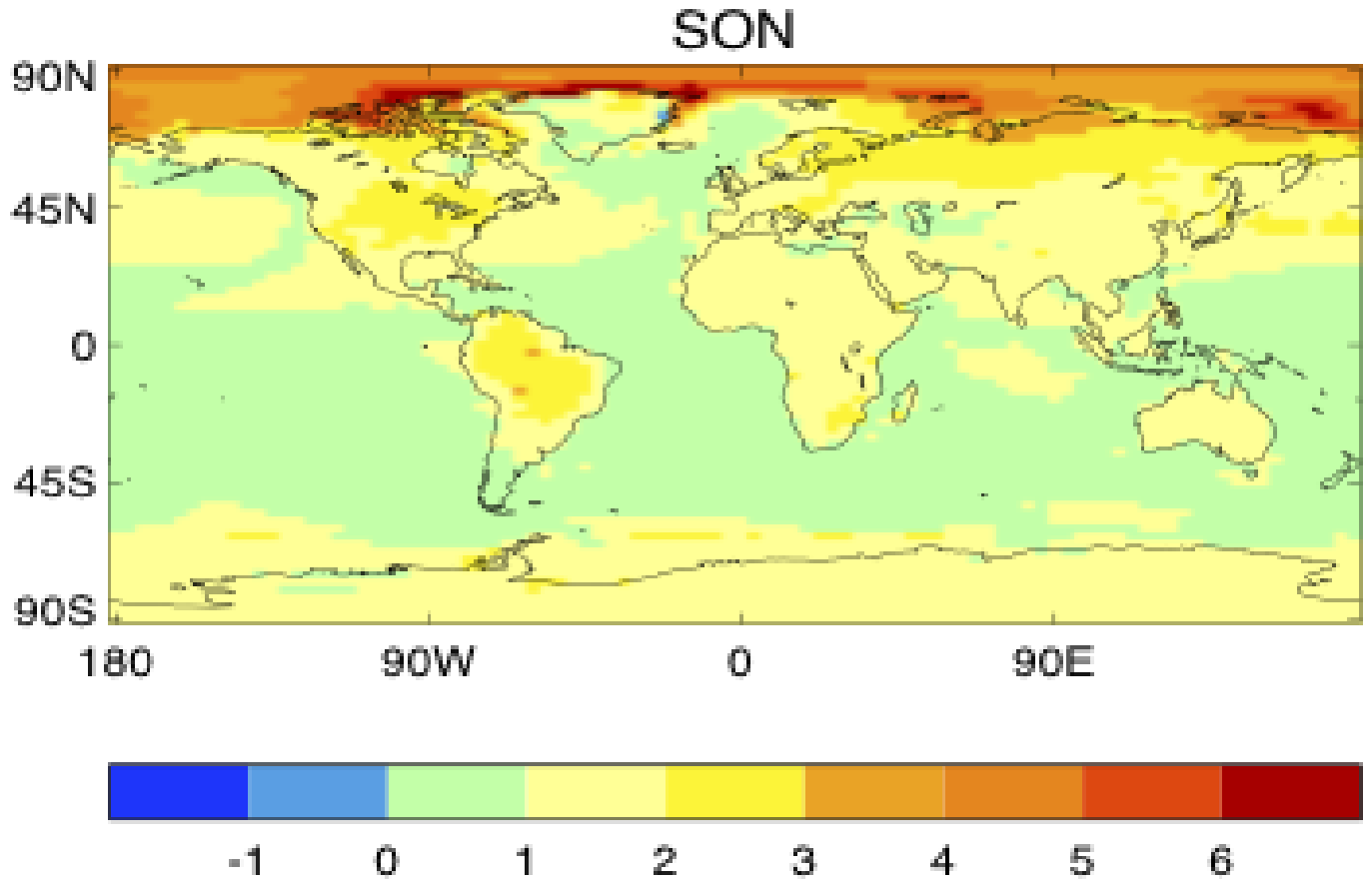
WaH – the models

- Both models are atmosphere only, 19 levels
- Models include:
  - Atmospheric chemistry – sulphur cycle and volcanic
  - Land surface scheme (MOSES-I)
- Require forcing at the lower boundary
  - Sea surface temperatures (SST)
  - Sea ice fraction (SIF)
- Require concentrations of atmospheric gases
- Support varying the solar forcing

WaH – forcing scenarios

- Current scenarios:
  - Historical 1960 to 2010
  - Counter-factual (CF), with anthropogenic warming removed
- Both rely on HadISST v1.1 to force the SSTs and SIF
- CF removes pattern of warming derived from CMIP 5 ensemble runs

Pattern of warming



WaH – initial conditions

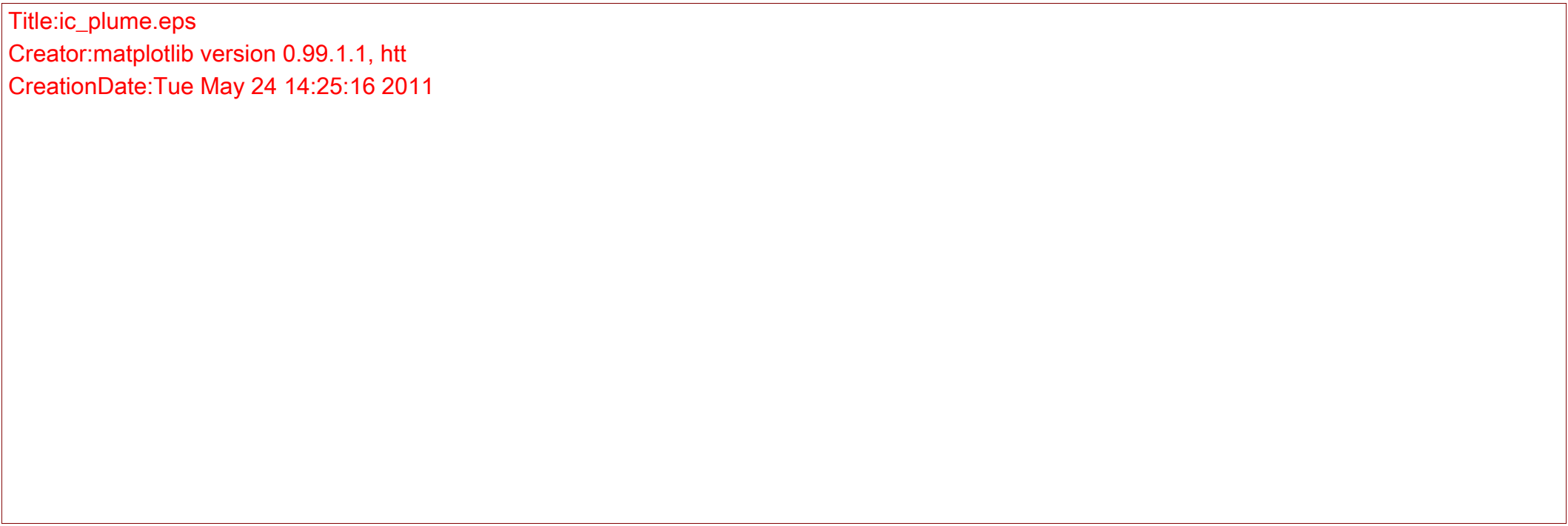
- The model requires the state of the atmosphere to begin its integration
- This is gained from a reconfiguration of a coupled model run from 1959 that is then run to 1968 using the GCM (more on this later) on a desktop computer
- RCM starting conditions regridded from 1968 GCM

WaH – initial condition perturbation

- To explore the uncertainty in starting conditions and to allow the models to explore all state space consistent with the forcings
- Initial conditions (IC) are taken as next day differences in potential temperature from a single year in the 1959->1968 run
- IC is a 3D field, tapering occurs at the tropopause and 5 scaling factors are applied
- 1740 different IC perturbations!

Effect of initial condition perturbation

- 100 model integrations:



- Takes about 7 days before they diverge

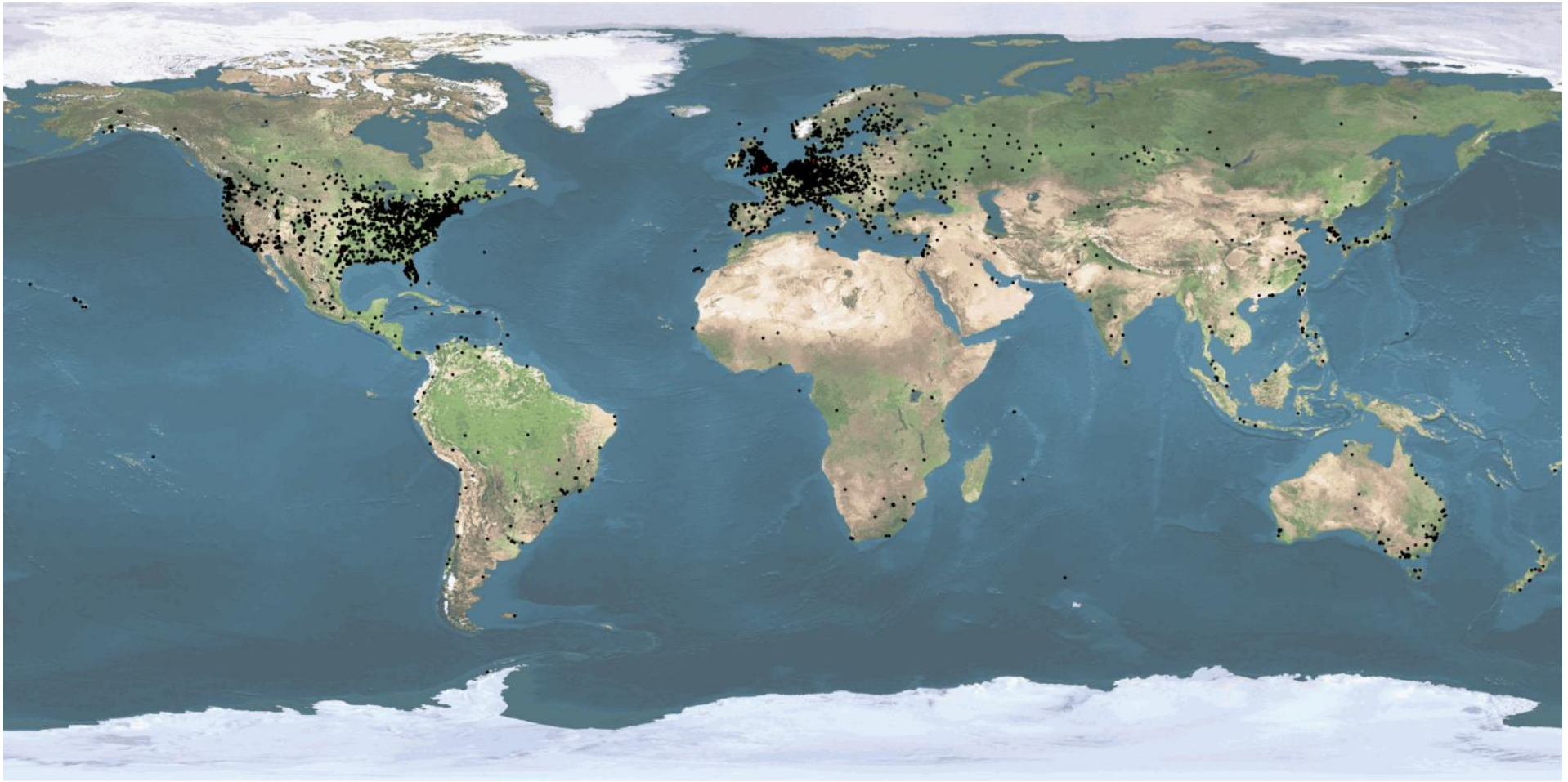
WaH – perturbed physics

- Model has modification allowing 12 constants in the physics parameterisation schemes to be varied
- Models are constrained by top of atmosphere (TOA) flux
- TOA allowed to be ±2 W/m² of the initial condition ensemble members

A very large ensemble of climate models

- To assess 1-in-1000 year events we require an ensemble size of > 1000 members
- To compute 50 years of historical scenario + CF scenario would require 100,000 years of climate model output for one region
- … and this is exactly what we do!
- Ensemble member models are computed by volunteers on their home PCs (Windows, Mac or Linux)

WaH volunteers



Distributed volunteer computing

- Volunteers (the clients) compute a single ensemble member per CPU core at once
- Using the BOINC network library
- Clients collect work from the project server
- Return results once they are finished
- Each ensemble member is integrated for one year
- So how do we compute 50 years of ensemble?

The continuation system

- Initial batches of ensemble members are created every 5 years (1960, 1965, ..., 2000, 2005)
- They have the generic starting condition
- An initial condition perturbation is applied
- = 1740 ensemble members per year

The continuation system

- These batches are computed by the client and the results are returned
- The final state of the model, in December, is also returned
- So, we have 1740 Dec. 1960, 1740 Dec. 1964, etc.
- These starting conditions are used to form new batches of the ensemble
- A continuous 50 years is computed piecemeal

The continuation system

- Using generic starting conditions for the first year in a 5 year block is problematic
- The state of the land-surface scheme is not consistent with the forcings in the first year
- Therefore, discard the first year before analysis

Results format

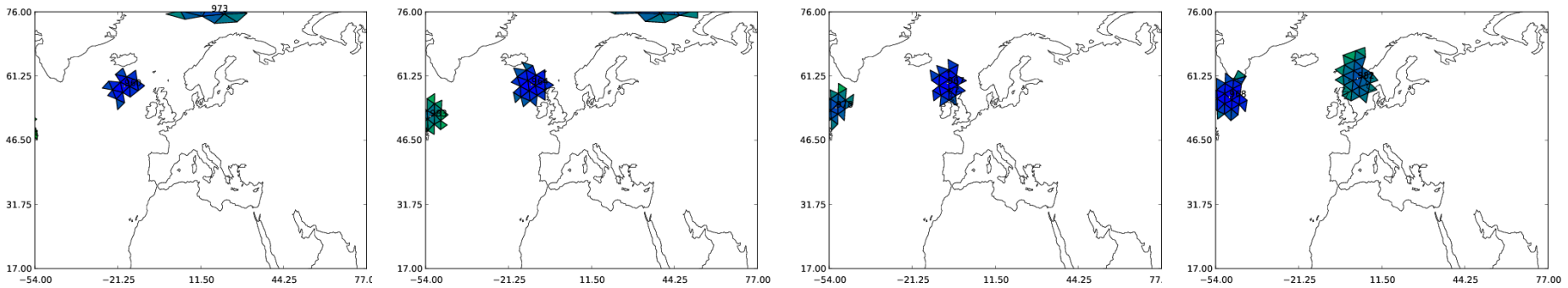
- Data is freely available from results.cpdn.org
- Data is in netCDF format, CF compliant
- Regional model has daily output of 6 variables (min temp, max temp, pressure, precip., MSLP, 10m wind speed)
- Global model has monthly output of 30 variables
- 3 regions so far: Europe, Western North America and Southern Africa

Future work

- WaH currently has four regions active:
  - Western Europe
  - Southern Africa
  - Western North America
  - Australia and New Zealand
- First new experiment is to generate an OSTIA forced historical dataset:
  - Daily, rather than monthly SSTs
  - 1985->present

Future work

- More counterfactual scenarios using a wider range of the CMIP5 ensemble
- Perturbed physics experiments (some have already been performed)
- Wind storm risk over Europe using storm tracking algorithm



WaH – South Asia

- Collaborative project with:
  - IITM, India
  - University of Oxford, UK
  - University of Reading, UK
  - UK Met. Office
- Use WaH to generate large ensembles of the CORDEX South Asia region at 50km RCM, with corresponding GCM data
- Results will be stored at IITM, Pune