SPECIAL PROJECT PROGRESS REPORT

All the following mandatory information needs to be provided. The length should *reflect the complexity and duration* of the project.

Reporting year	2025
Project Title:	Towards an operational service for extreme weather attribution and projection
Computer Project Account:	spgberm
Principal Investigator(s):	Shirin Ermis
Affiliation:	University of Oxford
Name of ECMWF scientist(s) collaborating to the project (if applicable)	Antje Weisheimer
Start date of the project:	01/01/2024
Expected end date:	31/12/2025

Computer resources allocated/used for the current year and the previous one

(if applicable)

Please answer for all project resources

		Previous year		Current year	
		Allocated	Used	Allocated	Used
High Performance Computing Facility	(units)	262,000,000	262,000,000	228,000,000	31,111,651
Data storage capacity	(Gbytes)	317,000	Approx. 317,000	593,000	Approx. 77,090

Summary of project objectives (10 lines max)

The aim of the special project is to develop our existing method of extreme event attribution using operational weather forecasts. Our current setup allows us to use IFS simulations in which we perturb the initial conditions of the ocean temperatures and change CO2 concentrations in the atmosphere. We proposed to improve the method by adjusting the atmospheric initial conditions in an iterative way (see Figure 2 for details) where we would add the adjustment from a previous forecast to the next forecast iteration. Additionally, we aim to adjust the aerosol forcing in the counterfactual simulations to reflect a past and future climate, in particular to study heat waves and extreme precipitation events.

Summary of problems encountered (10 lines max)

When we moved from CY47R3 to CY48R1, we encountered a new piece of code in `ifs-scripts/surf/module/farquhar_mod.F90`, ll. 436. The new code caused the model to run in an endless loop, producing large log files, when we adjusted the CO2 concentrations in our future climate forecasts to 625ppm. We found that the simulations ran fine when we adjusted this threshold to be higher.

We encountered additional problems recently when moving from netcdf to grib files (which we use to perturb atmospheric initial conditions in our counterfactual forecasts) and will contact the service desk if the problems persist.

Summary of plans for the continuation of the project (10 lines max)

We are currently designing an experiment to test the sensitivity of the attribution result to initial atmospheric adjustments. Once these tests are run, we aim to implement the iterative adjustment of the atmosphere. For this, we are now able to perturb initial atmospheric temperatures and specific humidity. We aim to test the effect of the number of iteration steps on the attribution results next. After tests, the simulations with adjusted aerosol forcing our now imminent.

List of publications/reports from the project with complete references

Ermis, Shirin, Nicholas J Leach, Fraser C Lott, Sarah N Sparrow, and Antje Weisheimer. 'Comparison of event attribution methods for the midlatitude storm Babet'. (in prep)

Ermis, Shirin; Ginesta, Mireia; Stuart-Smith, Rupert; Franta, Benjamin. 'Economic damages from storm Irene in the Northeastern United States attributable to climate change'. (in prep)

Summary of results

If submitted **during the first project year**, please summarise the results achieved during the period from the project start to June of the current year. A few paragraphs might be sufficient. If submitted **during the second project year**, this summary should be more detailed and cover the period from the project start. The length, at most 8 pages, should reflect the complexity of the project. Alternatively, it could be replaced by a short summary plus an existing scientific report on the project attached to this document. If submitted **during the third project year**, please summarise the results achieved during the period from July of the previous year to June of the current year. A few paragraphs might be sufficient.

Storm Babet case study

The midlatitude cyclone Babet (October 2023) affected Ireland, the English Midlands and Scotland with intense flooding. We have modelled this storm in our forecast-based attribution approach using IFS CY47R3 and CY49R1. In an international collaboration of attribution scientists (including KNMI, World Weather Attribution, and Australia's Bureau of Meteorology) we are completing work to compare different methods for (storyline) attribution that have evolved over the past decade. The comparison is the first of its kind and will help make attribution statements more reliable. The resources from the special project allowed us to run additional lead times for this case study and a counterfactual forecast for a 1950 climate. Our results based on the IFS forecasts are shown in Figure 1.

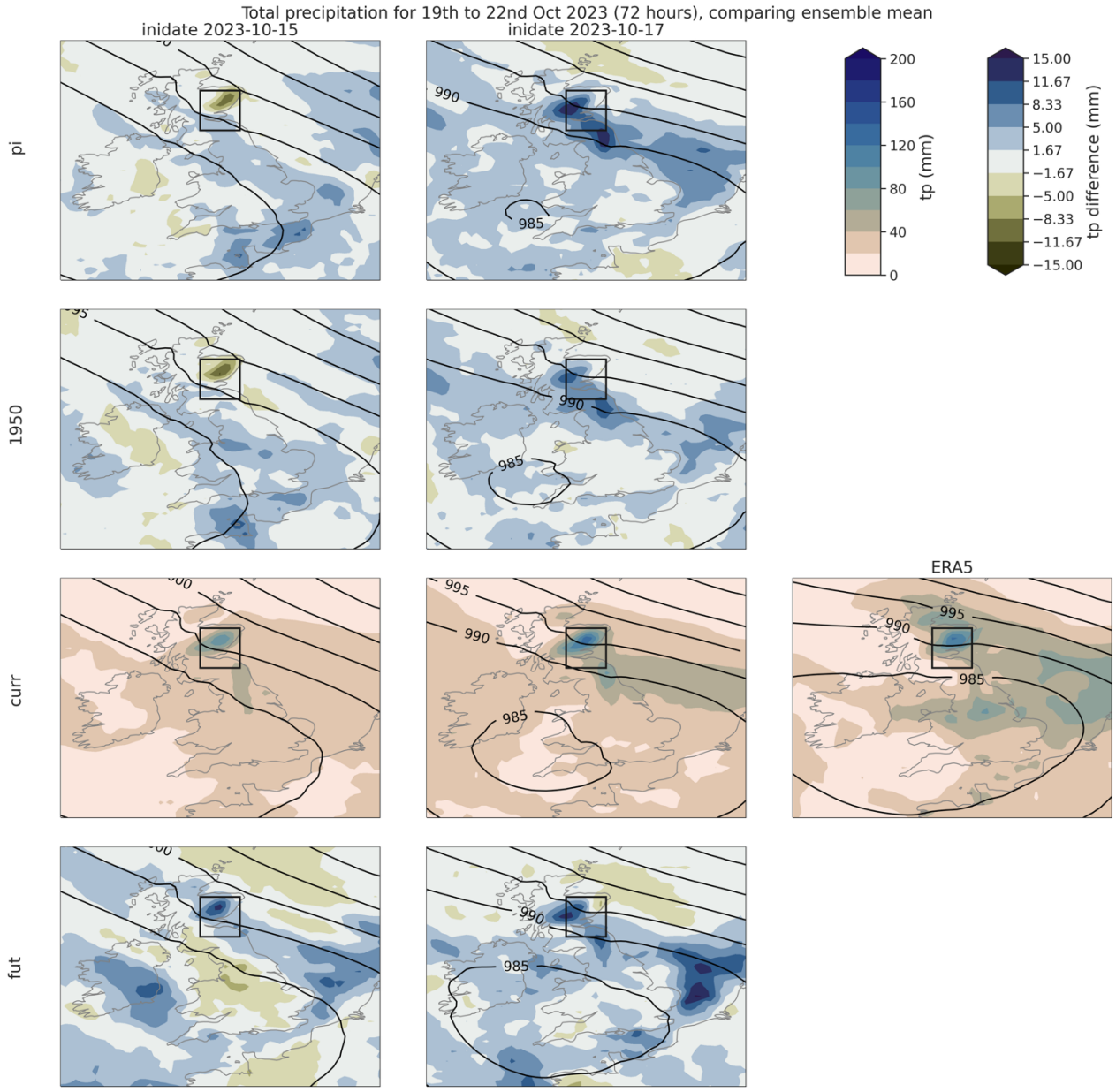

Figure 1: Total cumulative precipitation from storm Babet (as calculated between 2023-10-19 00 UTC to 2023-10-22 00UTC) in the third row and the differences to the counterfactual forecasts for a preindustrial (1870) climate, 1950 climate and a future climate (2100 in a medium emissions scenario, 625ppm). The differences in precipitation are all calculated in the direction of warming i.e. present—past, future—present. Results for simulations for two initialisation dates are shown in columns. ERA5 data is shown in the third column for comparison.

Atmospheric adjustments in the initial conditions

A key goal of this special project is to adjust the atmospheric initial conditions in the simulation to better reflect a counterfactual climate. We are aiming to implement the iterative re-initialisation setup outlined in Figure 2. In the past year, we have completed tests in which we added perturbations to the initial atmospheric temperatures and specific humidity. An initial test for storm Eunice, which we previously studied, shows that our approach works in general. We are currently refining the method for further case studies.

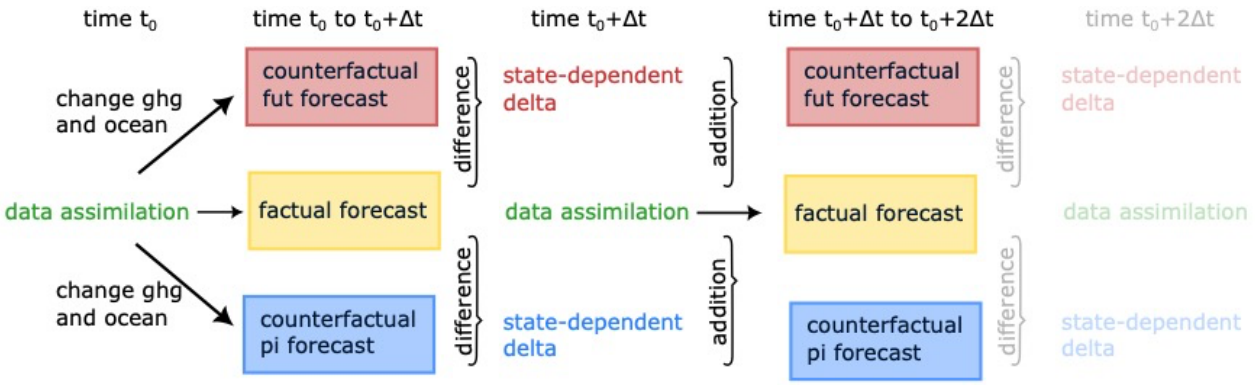

Figure 2: Suggested recursive approach for adjusting the atmospheric initial conditions. In the first step, start with the currently used setup where only 3d ocean temperatures, salinity and CO2 concentrations are changed. After a first simulation of 3-4 days (Δt), calculate a state-dependent delta of temperatures in the atmosphere and add that to a new initialisation. Move through a season repeating this last step.

Aerosol counterfactual simulations

We are actively working on changing the aerosol forcing in the counterfactual forecasts according to the time period we model. The implementation of this has been delayed due to technical difficulties in CY48R1 but we are now ready to run simulations, e.g. on the Dubai flood event of 2024.

Storm Irene case study

A new case study focusses on the attribution of rainfall and flooding of the tropical cyclone, later cyclone of tropical origin, Irene. The storm caused severe flooding and extensive damage in the Northeastern United States in August 2011. We used IFS CY48R1 for its high resolution for an event attribution study using our existing methodology. In this interdisciplinary study, the results from the meteorological attribution study are fed into hydrological and economic models to attribute the economic damage based on the changing flood extent and depth. In Figure 3 we show initial results from the meteorological attribution.

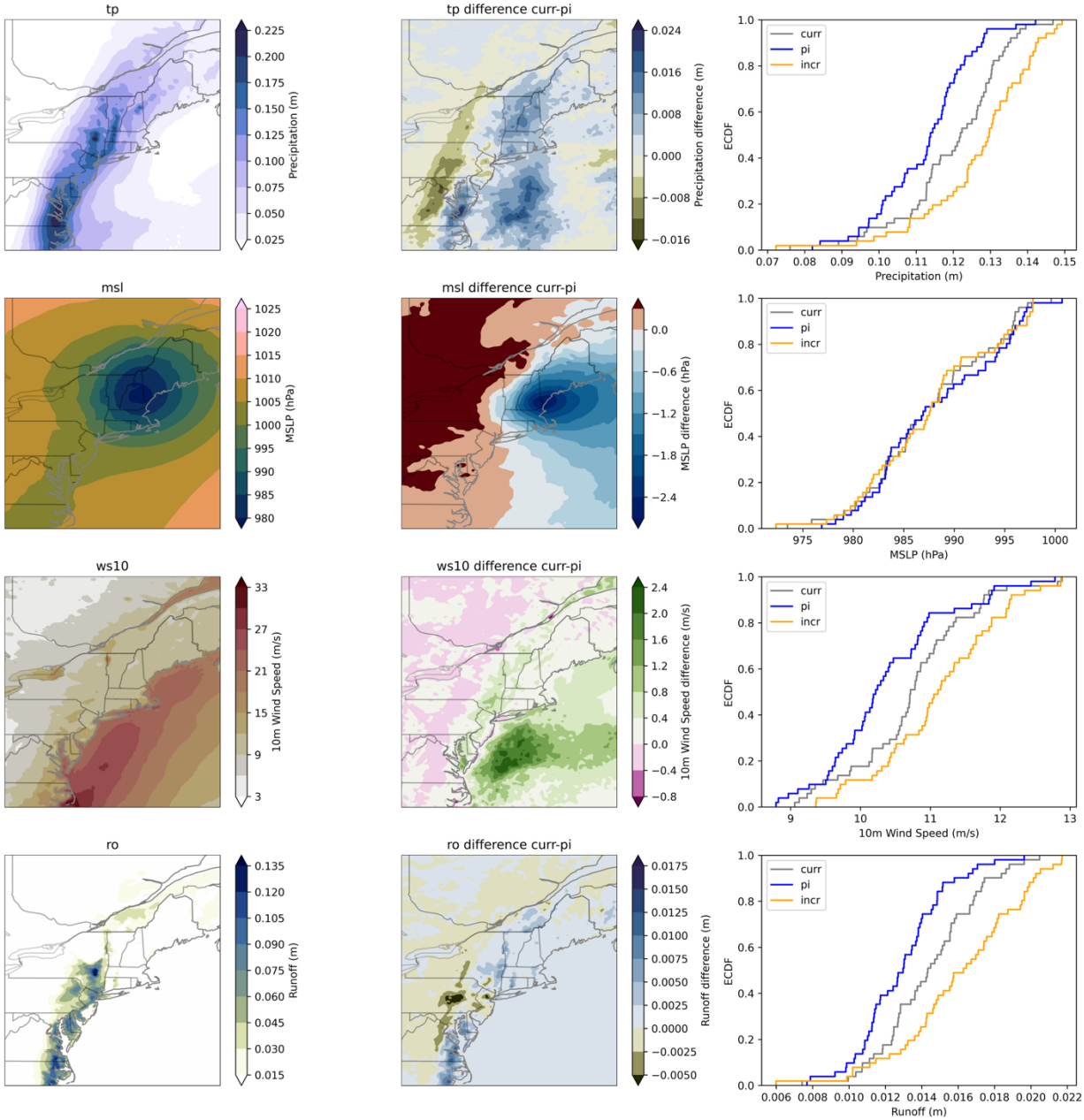

Figure 3: Total precipitation (cumulative 72 hours, first row), mean sea level pressure (instantaneous at 2011-08-29 00 UTC, second row), wind speeds at 10m (instantaneous at 2011-08-29 00 UTC, third row), and runoff (cumulative 72 hours, fourth row) for storm Irene over the US East Coast. The first column shows the present day forecast, second the difference between the present day and preindustrial forecast. The final column shows the cumulative distribution function for a gridpoint over Vermont. Shown are results from simulations initialised on 2011-08-27 00 UTC.