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	2024
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)	N/A	N/A	262,000,000	approx. 3,360,312.89
Data storage capacity	(Gbytes)	N/A	N/A	317,000	approx. 4,525

Summary of project objectives (10 lines max)

The goal of this special project is to expand our work on forecast-based event attribution and improve its reliability. Forecast-based event attribution uses numerical weather prediction models such as IFS and creates counterfactuals by changing the initial and boundary conditions of the model to represent warmer or colder climates. So far, our method adjusts the 3d ocean temperatures, salinity, and CO2 concentrations in the atmosphere. With the allocation of the special project, we aim to adjust the atmospheric temperatures in the initial conditions, thereby reducing the time the model needs to adjust to the warmer/colder climate forcing. Additionally, we are implementing a recursive way for the initialisations which would enable a continuous simulation of counterfactual weathers instead of single case studies (also see Figure 1).

Summary of problems encountered (10 lines max)

Because some of our team have experience in working with the ECMWF system, we have had minimal problems so far except the expected hurdles of getting used to working with the targeted pieces of the IFS code. This includes difficulty with files in the GRIB format (e.g. moving from spherical harmonic representation to a gridded representation, or changing the format of the files). So far, these problems could be solved using the ECMWF confluence.

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

We are currently working on implementing a way to introduce a perturbation into the atmospheric initial conditions of the temperature. To break this problem down, we are first adding a (physically unrealistic) 2K temperature increase ("temperature blob") in a latitude-longitude box. This is to check how the model reacts to changes in temperatures and whether we need to implement additional measures to prevent gravity waves disturbing the forecast. After this we will be running a short simulation of our current setup (a current climate and two counterfactual climate simulations) of two days, calculate the difference in the 3d atmospheric temperatures between the current and counterfactuals and add these fields to a following simulation. If this step succeeds, we plan to run a full season as outlined in our application with the suggested recursive approach.

List of publications/reports from the project with complete references

Ermis, Shirin, Nicholas J Leach, Fraser C Lott, Sarah N Sparrow, and Antje Weisheimer. 'Event Attribution of a Midlatitude Windstorm Using Ensemble Weather Forecasts'. Environmental Research: Climate 3, no. 3 (1 September 2024): 035001. https://doi.org/10.1088/2752-5295/ad4200.

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 Eunice case study

Our previous special project (`spgbleac`) allowed us to run simulations of storm Eunice which caused intense winds over the South of the UK in February 2022. In the publication, which was published earlier this year, we show that IFS was demonstrably able to predict the storm, significantly increasing our confidence in its ability to model the key physical processes and their response to climate change. Using our current approach of modified greenhouse gas concentrations and changed initial conditions for ocean temperatures, we created two counterfactual scenarios of storm Eunice in addition to the forecast for the current climate. We compared the intensity and severity of the storm between the pre-industrial, current, and future climates. Our results robustly indicate that Eunice has become more intense with climate change and similar storms will continue to intensify with further anthropogenic forcing. These results are consistent across forecast lead times, increasing our confidence in them. Analysis of storm composites shows that this process is caused by increased vorticity production through increased humidity in the warm conveyor belt of the storm. This is consistent with previous studies on extreme windstorms. Our approach of combining forecasts at different lead times for event attribution enables combining event specificity and a focus on dynamic changes with the assessment of changing risks from windstorms. We acknowledge in the publication that further work is needed to develop methods to adjust the initial conditions of the atmosphere for the use in attribution studies using weather forecasts, but we show that this approach is viable for reliable and fast attribution systems. The extension of this work is what we aim to do with the current special project.

Storm Babet case study

Following on from our work on storm Eunice, we have decided to also look into storm Babet. This more recent storm (October 2023) affected Ireland, the English Midlands and Scotland with intense flooding. We are interested in this as it constitutes a different type of impact (rain and flooding instead of wind) and because there were discussions by forecasters that the storm might have been impacted by tropical cyclone activity at the time of genesis. With the longer lead time simulations we have of this storm, we could investigate how this relationship might change with climate change.

Work on this case study is currently ongoing, in particular with an international collaboration of attribution scientists keen to compare different methods for storyline attribution that have evolved over the past decade.

The resources from the special project allowed us to run additional lead times for this case study.

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. Currently, we are testing how to add a perturbation in the initialisation of the model.

We are aiming implement the setup outlined in Figure 1.

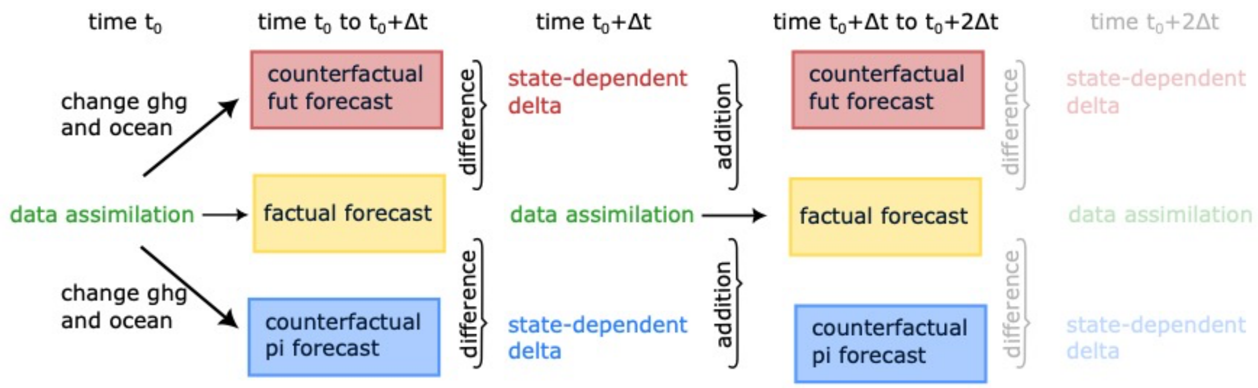

Figure 1: Suggested recursive approach for adjusting the atmospheric initial conditions. In the first step, start with the currently used setup where only 3d ocean temperatures, salinity and CO2 concentrations are changed. After a first simulation of 3-4 days (Δt), calculate a state-dependent delta of temperatures in the atmosphere and add that to a new initialisation. Move through a season repeating this last step.