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 2021/22……..……

Project Title: NUMERICAL WEATHER PREDICTION BASED ATTRIBUTION……..……

Computer Project Account: spgbleac……..……

Principal Investigator(s): Nicholas J. Leach……..……

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Affiliation: University of Oxford…..……

Name of ECMWF scientist(s) collaborating to the project (if applicable) Christopher Roberts……..……

Antje Weisheimer……..……

Start date of the project: 01/01/2020……..……

Expected end date: 12/31/2023……..……

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)	10,000,000	10,000,000	12,500,000	7,600,000
Data storage capacity	(Gbytes)	23,000	20,000	32,000	19,000

Summary of project objectives (10 lines max)

To demonstrate how the operational ensemble prediction system at ECMWF can be used to quantify anthropogenic influence on individual extreme weather events.
To extend the previous project experiments, in which we explored the direct influence of CO2 on an individual extreme event, to include a more complete estimate of human influence by removing an estimated anthropogenic fingerprint from the initial ocean state.

Summary of problems encountered (10 lines max)

There were two main problems encountered.
The first was the methodology by which the initial ocean state would be perturbed. Many different approaches were suggested during discussions with collaborators from ECMWF. In the end, we have used an approach suggested (and implemented previously, though not for this purpose) by Chris Roberts. This approach, involving perturbing the 3D temperature field and then adjusting the salinity to preserve density gradients, was chosen for its relative simplicity – and it worked.
The second was the estimation of the anthropogenic fingerprint in 3D ocean temperatures. Subsurface data is very sparse prior to ARGO, and so estimating a trend over the last century is difficult. We analysed a number of different data sources, including observations, reanalysis and combinations of the two, cross validating them against one another. We found that ocean reanalyses appear to have large and spurious trends, especially near the equator. We ended up using observation-based data from the World Ocean Atlas 18.

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

We want to focus on exploring how our approach, that we have successfully applied to two separate case studies, could be extended to provide an operational attribution service. In particular, we think that running successive counterfactual forecasts for attribution (a few days apart each time) could enable us to address one of the current issues with our "one-off" approach: the rapid atmospheric adjustment to the new perturbed initial conditions. We think that for the case of successive forecasts, we could perturb land-surface and thermodynamic atmospheric fields based on the previous factual and counterfactual forecasts.
We want to trial such an operational attribution service over the course of 1-3 months, initialising 15-day forecasts every few days.
This should allow us to answer another key outstanding question (though one that we are working on using the experiments we have already completed): how does our approach work for other types of extreme (ie. not heat events).

List of publications/reports from the project with complete references

European Centre For Medium-Range Weather Forecasts (ECMWF), & Leach, N. J. (2021). Perturbed CO2 forecasts of the February 2019 European heatwave [Application/xml]. NERC EDS Centre for Environmental Data Analysis. https://doi.org/10.5285/DD6A312C701F47778390DE50CD052071

Leach, N. J., Weisheimer, A., Allen, M. R., & Palmer, T. (2021). Forecast-based attribution of a winter heatwave within the limit of predictability. Proceedings of the National Academy of Sciences, 118(49). https://doi.org/10.1073/pnas.2112087118

Leach, N. J., Roberts, C. D., Heathcote, D., Mitchell, D. M., Thompson, V., Palmer, T. N., Weisheimer, A., & Allen, M. R. (2022). Successful operational weather forecast allows for a novel and reliable heatwave attribution. 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.

I have appended a manuscript (currently in prep., though to be submitted very shortly – so please do not distribute) detailing the work we have done using this special project to this report.