**Research Scientist: EERIE**

**Further Details**

## Introduction to Horizon Europe’s “European Eddy-Rich ESMs (EERIE)

The EERIE ambition is to build a new generation of Earth System Models (ESMs) that are capable of explicitly representing a crucially important, yet unexplored regime of the Earth system – the ocean mesoscale (~100 km at the equator to few km at high latitudes). Leveraging the latest advances in science and technology, this will substantially improve the ability of such ESMs to faithfully represent the centennial-scale evolution of the global climate, especially its variability, extremes and how it may approach tipping points.

*Two overarching hypotheses will be investigated in EERIE:*

**H1:** Explicit representation of the ocean mesoscale has profound consequences for projecting the evolution of global processes (e.g. ocean heat uptake, sea level rise) and for regional climate variability and change.
**H2:** The explicit representation of the ocean mesoscale produces significantly different responses to tipping point scenarios, for instance in terms of the climate of Antarctica (e.g. West Antarctic Ice Sheet, WAIS), both via the ocean (e.g. undersea melting of ice shelves) and the weather and climate at the surface (e.g. warming, snowfall).

**Specific objectives of EERIE are (with relevant work packages):
O1:** Make a leap forward in modelling and understanding the climate impacts of ocean mesoscale processes.
**O2:** Develop novel experimental designs, aiming to enrich CMIP in support of future national and international (e.g. IPCC) climate change assessments
**O3:** Reduce by at least 50% the time and energy needed to produce climate information with the highest level of process fidelity
**O4:** Increase the reliability of regional climate change attribution by developing improved estimates of background natural variability
**O5:** Carry out frontier climate change projections with mesoscale-resolving ESMs
**O6:** Produce actionable climate information
**O7:** Sustain and enhance European cooperation and leadership in climate sciences

**Main duties of the post**

The post-holder will contribute to the analysis of climate model experiments developed and run within the newly funded EU Horizon Europe EERIE (UK partners funded by UKRI), of which Vidale and Roberts were coordinators during grant preparation, all the way to award (post-award coordinator is Prof. T. Jung, AWI, Germany), as in the previous project, PRIMAVERA.

The focus of the post holder’s research will be on air-sea interactions at the mesoscale. More specifically, the post-holder will work in a team that will investigate the role and upscale effect of the ocean mesoscale on the atmospheric mean state, weather and climate variability. We will compare eddy-rich ESMs to a hierarchy of existing simulations including HighResMIP models and CMIP6. Idealised experiments in a dedicated EERIE work package make it possible to isolate the impact of the ocean mesoscale on the atmosphere mean state and variability, while suppressing the feedback of the atmosphere on the ocean and also preventing a drift of the ocean mean state.

The post holder will be responsible for a specific EERIE task: **“Emergent mechanisms linking the ocean mesoscale and atmospheric variability”**, which will propose new pathways connecting the ocean surface to the deep troposphere (above the BL). The role of atmospheric weather systems and mesoscale air-sea-ice interactions on the Southern Annular Mode (SAM, which may be time dependent as sea ice retreats) will be investigated. The role of eddies on climate persistence (longer than 12 months) will also be investigated.

The post-holder will also be responsible for the analysis of EERIE mainstream and sensitivity experiments and process-based analyses, using tools such as feature tracking (TRACK, Hodges 2007, Hodges et al. 2017) and diagnostics contained in ESMValTool (Eyring) and the Met Office Auto-Assess suite, as well as metrics developed as part of the PRIMAVERA project. It is expected that these investigations will results in high-impact peer-reviewed publications.

Further, the post-holder will engage in collaborations that analyse the EERIE hierarchy of high-resolution global climate models, with the aim of linking the research to the more general topic of emerging weather and climate processes. EERIE’s coupled atmospheric GCMs, utilise a horizontal resolution of ~10km, thus beginning to resolve convective systems in the so-called atmospheric “Grey Zone”. The UK EERIE research team has already developed a 10km AGCM, standalone as well as coupled to 1/12o NEMO, and possess all necessary experience and tools for completing EERIE experiments.

The broader scientific context, and the questions to be tackled with these new datasets and tool are discussed below, in the *Introduction to the NCAS HRCM programme*.

## Background on the global High Resolution Climate Modelling (HRCM) research programme.

HRCM is internationally regarded as a leader in global high-resolution climate modelling. By necessity we have a relatively narrow focus, because of personnel resources, technically challenging deliverables, and a comparatively expensive model (HadGEM3). Even so, HRCM has delivered internationally competitive i) “Frontiers” (development) and ii) CMIP-mainstream (e.g. CMIP6-HighResMIP) high resolution, atmosphere-only and coupled simulations, in ensemble mode. HRCM also leads a) international collaborations; b) high impact publications, as well as c) the international community (e.g. HighResMIP and currently HighResMIP2). As part of this international projection, HRCM also maintains strong and long-term collaborations with other research groups in our own institutions, for instance with the seasonal group at the Met Office, who tend to use the same resolution configurations, with K-scale and with the JWCRP CoMorph project.

## HRCM pioneering climate system science: a few milestones

In 2006 the UK-Japan Climate Collaboration developed an N216 (60km) climate model on the Earth Simulator, which guided the configuration of GloSea a few years later, as well as investigating coupled simulations with a sub-1˚ ocean model. UJCC was rebranded as HRCM after our return to the UK in 2008;

In 2012 HRCM were first to run an ensemble of N512 (25km) climate simulations (PRACE-UPSCALE), having won UPSCALE, a landmark PRACE award, and these simulations have been used to participate in the CLIVAR Hurricane Working Group experiment, as well as exploited by a wide variety of groups in the Met Office and NERC. UPSCALE is still generating publications in 2022, 10 years after the experiment was completed;

In 2014, in recognition of HRCM expertise, Roberts and Vidale were chosen to lead the writing of EU Horizon 2020 PRIMAVERA, which was successful, and for the next four years led ~100 scientists across 19 institutions;

In 2017 HRCM developed N1280 (10km globally) configuration of HadGEM3-GA7.1 for PRIMAVERA (Frontiers Simulations), which hints at improved NAO performance in NWP and seasonal prediction, ascribed to eddy-mean flow interactions. We also developed the coupled 1/12˚ model with the ocean group, which is now being taken up by coupled NWP. Coupled N1280-ORCA12 is the target for GloSea on the next Met Office HPC and is the foundation for EU Horizons Europe “EERIE”, led by Roberts and Vidale;

In 2018 HRCM developed N2560 (5km globally) to take part in the DYAMOND campaign. It was used to demonstrate the potential for treating convection explicitly in global simulation, in comparison with other leading global models, and as important foundation for CoMorph. Starting in June 2019, N2560 was used to test the new CASIM microphysics module, hence to better understand global cloud-aerosol-microphysics interactions. EU-H2020 NextGEMS is a clear consequence of the N2560 development and of DYAMOND;

In 2021-2022, having delivered 140 papers so far, **PRIMAVERA demonstrated high impact on the 6th IPCC Assessment Report**, via proposing and coordinating HighResMIP, the most innovative and challenging CMIP6 protocol, cited 156 times in IPCC AR6, and recently chosen by the international community as the 2nd most useful CMIP6 protocol after ScenarioMIP. HighResMIP also inspired the first Digital Twin for Climate protocol.

Long-term HRCM science questions

Main science question: *What is the role of multi-scale interactions in the global climate system?* Specifically:

1. Do weather and climate processes shape climate through individual episodes and/or extremes? Examples: transports+fluxes by Tropical Cyclones (atmosphere) and eddies (ocean).
2. Can we improve (s2d) predictability of mid-latitude weather by resolving mesoscale atmosphere+ocean processes in the tropics, and/or mid-latitude air-sea interactions?
3. What is the climatic role of convective organisation, and its contribution to the upscale energy cascade?
4. Are our estimates of climate sensitivity sensitive to model resolution, particularly in the CP regime?

## Key goals and ambitions

We aim to continue to develop/explore “CMIP-mainstream” and “Frontiers” – atmosphere and coupled – simulations.

“CMIP”, 1/10o, requires ~100’s years of simulation (e.g. CMIP DECK in Horizon Europe EERIE);
“Frontiers”, sub-10km, requires ~O(10’s) years of simulation.

**HRCM milestones in 2022-2027**:

1. 2022: 1/10o coupled DECK-class simulation, to be completed in 2024/5 🡪 Q1,2
2. 2023: 5km HadGEM3 and LFRic simulations with ML ocean; NextGEMS simulations 🡪 Q1
3. 2025: 3km LFRic climate runs, physical mode, for AMIP simulation, matching NextGEMS 🡪 Q1,3
4. 2027: 1km global simulation based on LFRic 🡪 Q3,4

**HRCM infrastructure**

Our global modelling team, with over 30 core members (permanent staff), offers a range of talents, from scientific to technical, including HPC, data handling, data transmission, curation and dissemination of metadata.

The new Met Office supercomputer (xcs) is a CRAY-XC40 with a peak performance of 16PFlops; the NERC supercomputer, Archer2, also offers Petascale resources. The project PIs have a strong track record of winning HPC resources worldwide and rapidly deploying to a number of international centres in order to exploit exceptional supercomputing resources.

The JASMIN-CEDA service provides data access via a portal and data analysis via multi-core servers (3’000 cores) and full user support. CEDA-JASMIN has reserved capacity for up to 5PB of data (Vidale already holds 1PB, of which 480TB are UPSCALE data). The analysis team comprises O(100) European scientists and ~20 teams in the USA, Japan, China, Brazil.

**NCAS Computational Modelling Services**

The Dept of Meteorology hosts NCAS-CMS, comprising a team of computational scientists supporting and developing Climate, NWP, and Earth-System modelling infrastructure through the provision of services (workflow, HPC, and data), development of model simulation and data analysis codes, delivery of training and technical support.

The group manages resources for in excess of 300 users on a variety of HPC platforms including Archer and xcs and several regional clusters. Our expertise covers UM workflow management systems; UM installation, porting and optimisation; data manipulation and transfer. We are heavily invested in CF-Python (python implementation of the CF data model) and own several software tools highly regarded and used word wide. CMS has close working relationships with HPC vendors, service providers, and resource allocation bodies, placing us in a privileged position to understand

**Work environment**

The post-holder will be part of the Tropical Climate and High-Resolution Climate Modelling research groups within the National Centre for Atmospheric Science, based within the Department of Meteorology at the University of Reading. NCAS-Climate comprises approximately 50 scientists at Reading, and provides a core-strategic programme and national capability in modelling and understanding the climate system. The Department of Meteorology is a thriving centre for atmospheric and ocean science with around 200 research and academic staff and 80 research students. In the most recent Research Excellence Framework results (REF 2014), 86% of our research was graded as world leading or internationally excellent.

The post-holder will develop strong collaborations with scientists at the Met Office and internationally. The post-holder will make regular visits to the Met Office and annual visits to international conferences.

The University aspires to be an “Employer of Choice” and recognises that success is not simply determined by a competitive suite of terms and conditions of service, but by fostering a working environment that protects the physical and mental well-being of its staff. Full details of the University's Health and Well-being policy are available through the HR website. The University is committed to work-life balance and supportive of flexible working arrangements, and the School’s website gives examples of excellent practices in respect of flexible work as well as for maternity/parental leave within the School. The University supports its staff in many other ways:

* its Centre for Quality Support and Development,
* its excellent Nursery facilities,
* its SportsPark,
* its membership of Childcare+.

The University is a Stonewall Diversity Champion and is participating in Stonewall’s 2015 Workplace Equality Index.

The School of Mathematical and Physical Sciences was awarded an Athena SWAN Silver award in 2010, renewed in 2014, in recognition of its good employment practices in relation to women working in science, engineering and technology (SET).

Please follow thelink for more information.

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