

## Executive Summary

### **Vision**

The vision of EUPHEME is to place extreme weather events in the context of climate variability and change, thereby helping European citizens adapt to a changing climate and mitigate its worst effects.

### **Objectives**

EUPHEME has three main objectives:

- 1) Develop state of the art methods for the attribution of extreme weather and climate events on a range of timescales, and new techniques for evaluating their reliability (WP2).
- 2) Develop a scientific platform which hosts data, supports data processing and provides collaboration space for scientists from the partner institutions to carry out attribution analyses using complementary methods and data sources (WP3).
- 3) Provide a user-oriented synthesis, disseminate consistent attribution assessments through a prototype attribution service website and demonstrate the potential of attribution products to a wide variety of stakeholders (WP1, WP4).

These objectives relate to the call under Topic B of ERA4CS as follows:

- By the development of common tools and methods for the attribution of extreme weather events to climate variability and change.
- Through the production of new information and knowledge on the impacts and risks associated with changes in weather and climate extremes.
- By integrating the efforts of leading institutions in Europe including those with expertise in attribution of extreme weather and climate events and with operational weather and climate prediction capabilities.
- By enhancing the information content of attribution products via the harmonisation of methods and the development of evaluation procedures.
- By engaging stakeholders in a continuous dialogue in the development of attribution products thereby enhancing uptake of such information.
- By supporting the development of an enhanced Copernicus product portfolio which could be later operationalised under the Copernicus Climate Change Service.

EUPHEME will deliver a prototype platform on which future operational attribution services can be built. The new system will be used to demonstrate the potential benefits of a future operational event attribution system for Europe. Assessments will be produced both in the immediate aftermath of some specific extreme events and on a regular seasonal basis. This will be made possible through the cooperation and integration of leading research and development centres in Western and Eastern Europe. The result will be a platform that delivers harmonised and well evaluated attribution assessments for the benefit of European citizens across Europe.

### **Excellence**

Our predecessor project, EUCLEIA (European Climate and weather Events: Interpretation and Attribution), funded under the FP7 Space Call and due to finish in December 2016, has advanced the science of event attribution. Methodologies have been developed to assess how anthropogenic climate change has altered the magnitude and probability of heatwaves, cold events, floods, droughts and storm surges. Advances have been made in modeling tools and observations and in techniques for assessing the reliability of attribution results. In the final stage of EUCLEIA, to be completed later this year, a set of test cases investigating six specific extreme weather or climate events in Europe will be carried out, integrating all the methods developed.

With the successful completion of EUCLEIA, the time is ripe for the development of an integrated prototype operational attribution system to demonstrate the potential benefits of an operational attribution system for Europe. All too often scientists, policy makers and companies continue to be

caught out by events as extreme weather damages the livelihoods of European citizens, but clear advice on the link to climate change is lacking. Only through the integration of work from different institutions across Europe will it be possible to provide the scientifically consistent evidence required to meet the needs of diverse stakeholders.

EUPHEME will integrate existing methods developed from EUCLEIA, routinely apply them semi-operationally, and carry on further developing innovative methods for attribution and apply them to recent extreme weather and climate events in a prototype demonstration system to deliver attribution products.

### **Quality and efficiency of the implementation**

EUPHEME will benefit immensely from links to its predecessor project EUCLEIA while also bringing in additional elements needed to develop a prototype attribution system. It involves some of the major partners from EUCLEIA (Météo France, KNMI, UK Met Office), ensuring that the main operational prediction centres with expertise in event attribution are involved. EUPHEME engages with Eastern Europe through involvement of the Czech Global Change Research Institute of the Czech Academy of Sciences, enabling the development of stakeholder involvement from across Europe. This project is also facilitated by the involvement of Met Éireann, the University of Reading, BRGM and CNRS/CEA. Particular stakeholder groups of interest include scientists, media/public, policy (both national and EU) and the insurance sector.

The incorporation of the leading expertise in event attribution in the project will ensure that the assessments are based on cutting edge science. The appropriateness and feasibility of the event attribution enterprise has been endorsed recently by the publication of a report by the US National Academies of Science into event attribution. It concluded that “It is now possible to make and defend quantitative statements about the extent to which human-induced climate change has influenced either the magnitude or the probability of specific types of events or event classes”. But it also noted that “Still further advances are necessary, particularly with respect to evaluating and communicating event attribution results and ensuring that event attribution studies meet the information need of stakeholders.” Meeting this challenge is a core component of EUPHEME. EUPHEME is very well placed to ensure that scientific research is pulled through into the demonstration system developed under the project given the engagement of EUPHEME PIs in the relevant international scientific networks. These include the International Detection and Attribution Group (IDAG) and the International C20C+ detection and attribution project. EUPHEME has been designed to ensure an ongoing feedback loop from stakeholders to the research and development of attribution products. This will support the transition of research into attribution of extreme events into operational services as required under Copernicus.

In ancient Greek mythology, Eupheme was the ancient Greek spirit of good omen. She was one of the sisters of Eucleia. As such she stands as a fitting representative of this shared endeavor that seeks to integrate the efforts of leading centres in Western and Eastern Europe in the development of a prototype operational event attribution system for Europe. EUPHEME thereby picks up the baton from the previous FP7 project EUCLEIA that advanced the underpinning science of event attribution.

## **Project Description**

### **State-of-the-art**

There is an increasing interest worldwide in assessing the extent to which recent extreme weather and climate events can be solely linked to natural climate variability or be significantly altered in frequency or intensity by human-induced climate change (Stott, 2016). Whether it be the Paris floods in June 2016, the drought in Central Europe in Summer 2015, or the extremely cold European winter of 2009/10, European citizens are asking to what extent such extremes are linked to climate change, and whether they are becoming more or less frequent as a result. The science of event attribution that seeks to address this question has developed rapidly in recent years (Stott et al., 2016). While it used to be said that it wasn't possible to attribute individual weather events, a recent assessment by the US National Academies of Science concluded that "it is now often possible to make and defend quantitative statements about the extent to which human-induced climate change has influenced either the magnitude or the probability of occurrence of specific types of events or event classes" (NAS, 2016). This influential report, published earlier this year, concluded that the science of event attribution is evolving rapidly. However it points out that "further advances are necessary, particularly with respect to evaluating and communicating attribution results and ensuring that event attribution studies meet the information needs of stakeholders."

Since its inception in January 2014, the FP7 Research project EUCLEIA (EUropean CLimate and weather Events: Interpretation and Attribution) has been instrumental in advancing the science of event attribution and applying such science to answer topical questions about real-life extreme events. A key objective of EUCLEIA, which has been successfully achieved, was to make a major contribution to the annual report published in the Bulletin of the American Meteorological Society, explaining extreme events of the previous year from a climate perspective (Herring et al., 2014; 2015). These reports which are co-edited by the Leading PI of EUPHEME, have demonstrated the capability for such science to support regular peer-reviewed assessments. The widespread dissemination of such information has also shown the appeal of such information to a wide range of stakeholders seeking to better understand their weather related risks. Partners in EUCLEIA have also made quick-look rapid attribution statements on the timescale of media interest, about one week, for events including storm 'Desmond' in the UK on 5 December 2015 (van Oldenborgh et al, 2016a) and the precipitation that led to flooding in France and Germany in May/June 2016 (van Oldenborgh et al, 2016b).

### **Main limitations at present**

Despite rapid advances in the science of event attribution in recent years, a unique methodology to provide attribution statements does not exist, and confidence should be built from multiple lines of evidence from several methods, models and datasets. This, if not properly coordinated, can lead to confusion, for example apparently contradictory analyses of the Russian heat wave of 2010 have been produced which appear to show both that climate change was and was not responsible (Dole et al, 2011; Rahmstorf et al, 2011). In fact these results are not contradictory when it is understood that the way in which the attribution is framed is crucial to the interpretation of the result (Otto et al, 2012). With the development of multiple methods for event attribution the potential for such confusion has grown rather than lessened in recent years.

The predecessor project to EUPHEME, EUCLEIA, which ends in December 2016, is testing out several innovative attribution approaches on a set of test cases. What this has demonstrated is the need of several methods and model ensembles to reach robust conclusions, and the importance of a coordinated synthesis of results produced using these different methods. This requires a shared infrastructure and a common agreed set of procedures. Such a shared infrastructure and agreed procedures do not currently exist. Only when different methodologies are compared and distributed expertise brought together in a common endeavor will Europe be provided with adequate information on the current risks faced from weather and climate extremes.

Event attribution has made great strides in recent years but there remain important gaps in understanding. As outlined in the National Academies of Science report, while attribution science is relatively well advanced for temperature related extremes, scientific uncertainties are much larger for the attribution of extreme rainfall events and drought, and attribution science currently has only an extremely rudimentary capability to assess severe convective storms, wildfires, and tropical and extra-tropical cyclones (NAS, 2016). Also many stakeholders are interested in the impacts of extreme weather and climate events rather than the events themselves. More research is needed to develop the science of event attribution.

Furthermore, despite the rapid advancement of event attribution science in recent years, the potential benefits of such science to a wide variety of stakeholders have not yet been fully demonstrated (Stott and Walton, 2013). This is partly because there is insufficient understanding of the emerging science in stakeholder communities and partly because scientists are insufficiently aware of the decision making contexts in which information could be applied. The EUCLEIA project has made important strides in understanding stakeholder needs. But only through the practical development and implementation of a prototype attribution system in a context in which stakeholders are intimately involved will their requirements be fully addressed.

### **Moving beyond state of the art**

EUPHEME will move beyond state of the art in the following ways:

1. Development of event attribution products that have identified benefits to stakeholder groups. Up to now, the development of event attribution products has been science led rather than user driven. EUPHEME will work with stakeholders in an iterative manner to clearly identify their requirements and develop attribution products that have utility for them (WP1)
2. Development of new scientific tools for event attribution. This includes the development of new methods to define the aspects of the weather and climate events to be assessed, new methods for deriving attribution results from climate model output and for accounting for changes in dynamical regimes, and new techniques for evaluating the current risk of historical reference climate events to identify if such risks have changed between now and then. This research will support the robust attribution of a wider range of event types than currently possible. (WP2)
3. Development of new methods to evaluate the reliability of attribution assessments. Until quite recently it has been claimed that event attribution results are fundamentally unverifiable because they are model based (Solow, 2015). However, research carried out under EUCLEIA has shown that observations do provide useful information about the reliability of event attribution results (Bellprat and Reyes, 2016; Lott and Stott, 2016). Further work is needed to identify errors in attribution results and to develop techniques to recalibrate results in error. (WP2)
4. Development of a shared platform and agreed protocols to enable project scientists working across different institutions to prepare agreed attribution products. This will enable the project team to synthesize results using different methods and come to robust and traceable attribution assessments. This trans-national cooperation will add significant value to the attribution assessments produced which may be of most value to the countries concerned where the extreme weather event concerned took place. (WP3)
5. Development of a prototype attribution service website and delivery of event attribution assessments. This will require the development of agreed procedures for the publication of attribution statements. For this two timescales are envisaged: first a rapid response (a few days) in the immediate aftermath of chosen extreme weather events, and second a regular production of seasonal updates assessing extreme climate events of the season just gone. (WP4)
6. Development of the attribution of impacts of extreme weather and climate events. The focus in EUPHEME will be on the economic impact of extreme events but other impacts will also be considered including effects on human health. The use of impacts model introduces additional uncertainty which will also be assessed. (WP4)

### Research plan

EUPHEME (see Figure 9.1) has been carefully structured in order to address the four main challenges of event attribution:

- Understanding user requirements and co-designing products (WP1);
- Continuously developing new methods of attribution to support future attribution services (WP2);
- Promoting and enabling sharing of data, methods and results to support a synthesis of current state of knowledge (WP3);
- Properly communicating attribution results to society and stakeholders (WP4).

Initial guidance from the EUPHEME stakeholder panel (WP1) will be used to inform development of methodologies (WP2) and the design of a shared platform upon which coordinated attribution assessments can be made over two timescales (near real time and seasonal; WP3) and disseminated to stakeholders (WP4) for their comments and suggestions for improvement (WP1) thereby initiating a new cycle of innovation and development. WP5 provides project management and sits at the centre of the project to ensure successful coordination and reporting to funders.

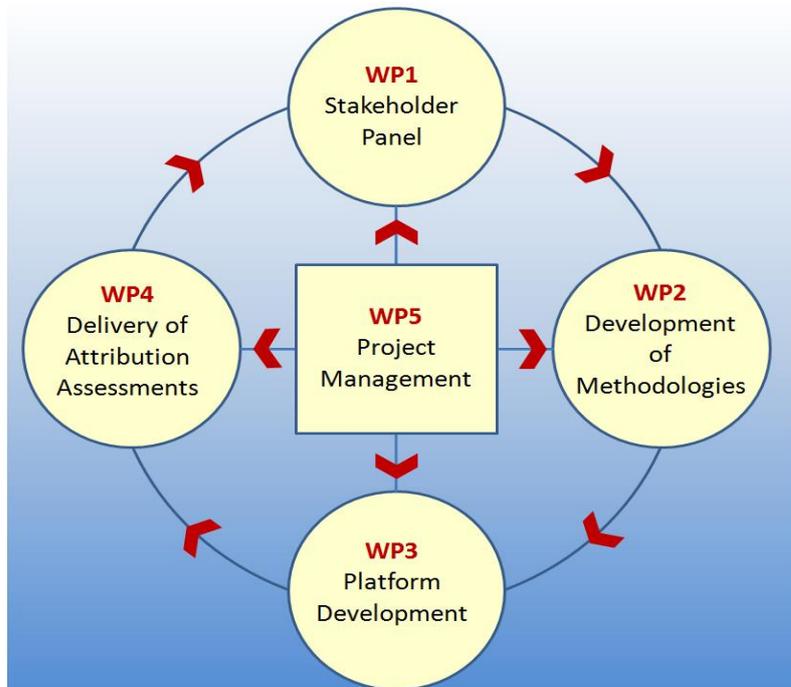


Figure 9.1: EUPHEME project structure

### WP1: Stakeholder interactions and attribution service co-design ( Met Éireann (leader); Czech Global Change Research Institute (co-leader))

Climate services are needed to translate scientific findings and provide reliable information by engaging the stakeholders in their definition and communication. This workpackage aims at bridging the gap to tailor climate change attribution answers to specific sectors, such as the insurance, agriculture and energy sectors. Linking to the Copernicus C3S SECTEUR proposal on user needs for Copernicus, for example, will be of particular interest. WP1 aims at identifying sectorial issues to demonstrate the potential benefits of an operational attribution system for Europe in contact with sectorial stakeholders. This objective will integrate the stakeholders from different sectors to pursue attribution issues relative to each sector. The WP 1 work will involve the participation of several public and private end-users at various stages of the project and, by continuous dialogue, will ensure a focused development towards the real needs of the stakeholders.

Reliable, continuous and personal communication of information is essential to properly co-design attribution products. WP1 will establish a dialogue between users and scientists to develop a clear common understanding of event attribution and its uses including the full range of methodological uncertainties and potential implications for decision making.

### **Tasks**

#### **Task 1.1 Stakeholder identification (Met Éireann, Met Office, CGCRI) / Month 1 – Month 18**

A rigorous process of stakeholder identification mapping and segmentation, led by Met Éireann and in partnership with the Met Office and CGCRI, will occur in the project's 1<sup>st</sup> half. A three step approach will be followed: from Month 1 to Month 3, a small group of so-called “friendly users” (e.g. stakeholders involved in previous related projects) will be identified, while from Month 3 to Month 6, a larger number of stakeholders will subsequently be identified. Finally from Month 15 to Month 18 a small group of fully engaged stakeholders will be mapped to test the prototype attribution service website's functionality. The sample population will be drawn from sectors interested in whether there is evidence for changes in extreme events. Sectors, such as policy makers, insurance and media, who have already expressed an interest in the EUPHEME project will be included.

#### **Task 1.2 Prototype attribution service website interaction (Met Éireann, Met Office, CGCRI) / Month 1 – Month 36**

In partnership with WP4 and through an iterative feedback loop process with developments taking place in WP2 and WP3, a prototype attribution service website will be developed and the chosen stakeholder groups will be exposed to the same testing of the public website. Having identified the key aspects associated with design, functionality, accessibility, these will form the basis on which to develop the website. A regular newsletter will be used to keep stakeholders informed with developments of the website and also of any scientific developments that may be occurring.

#### **Task 1.3 Group discussions (CGCRI, Met Éireann) / Month 1 – Month 18**

An initial online workshop, where participants will be shown a number of existing climate portals and websites and asked to identify the positives and negatives for each site, will be organised. Group discussions will also be subsequently conducted whenever possible as they will enable high quality conversations and allow for complex information to be presented in plain language and face to face.

#### **Task 1.4 Interviews (CGCRI, Met Éireann) / Month 12 – Month 30**

A series of in-depth interviews with stakeholders will be carried out in WP1 to identify their perspectives and to determine what kind of attribution information might be relevant and useful. Iterative process: interviews will be conducted on a real time basis during the project commenting on specific events, operating on feedback loop with other WPs. Regional conditions, including that of Eastern Europe, will also be considered.

#### **Task 1.5 Events (Met Éireann, CGCRI, Met Office, Météo France, CNRS-CEA, UREAD, KNMI) / Month 18 – Month 36**

Events, such as mid-term and full-term review meetings alongside major international conferences, will give an opportunity to expand further on issues raised at the interview and group discussion stages. These events will also provide an opportunity to demonstrate an operational attribution system for Europe to stakeholders.

#### **Task 1.6 Media interaction (Met Office, Met Éireann, CGCRI, Météo France, CNRS-CEA, UREAD, KNMI) / Month 12 – Month 36**

Engaging and building relationships with the media is an important way in which EUPHEME will communicate the information generated. A communications strategy will form a part of WP1 and communication methodologies through stakeholder interactions and test cases will be developed. The most appropriate media (printed, electronic, etc.) and the effective use of websites (including social media websites) will be selected for each stakeholder group and end-user community.

### *Deliverables*

- D1.1** Engagement and dissemination plan (Month 3) - Met Éireann
- D1.2** Stakeholder feedback report n°1 (Month 6) – Met Éireann
- D1.3** Stakeholder feedback report n°2 (Month 18) – CGCRI
- D1.4** Stakeholder feedback report n°3 (Month 30) – Met Éireann

#### *Milestones*

- M1.1** Initial release of a prototype attribution service website (Month 12) – Met Office / Met Éireann
- M1.2** Second iteration of the prototype attribution service website (Month 24) – Met Office / Met Éireann

### **WP2: Development of attribution methodologies, systems and evaluation techniques (UREAD (leader); Météo France (co-leader))**

One of the aims of EUPHEME is to “bring together up to date data and state of the art methods and include a rigorous evaluation of the methods used.” WP2 will address this aim by developing the attribution and evaluation methods that will be used in EUPHEME. This will be achieved by:

- Developing methods to define events to analyse (Task 2.1);
- Developing new methods for event attribution, especially for complex phenomena that have not yet been considered, for events with multiple pre-cursors including unusual atmospheric flow configurations and for estimating risks of past remarkable events in current climate (Task 2.2);
- Making quasi-operational established event attribution methods that will be used in the shared event attribution platform in WP3 (Task 2.3);
- Developing evaluation techniques to ensure attribution statements are robust (Task 2.4).

In the FP7 EUCLEIA project, a framework for real-time event attribution was developed: event definition, event attribution and synthesis (see WP3 for more details). EUPHEME will bring this framework to life. The tasks in WP2 will develop new methods and systems to support these steps.

#### **Tasks**

##### **Task 2.1 Developing new methods for Event Definition (Météo France, KNMI, UREAD) / Month 1 – Month 24**

The first step in a real-time attribution study is to objectively define the event. This is important as the results from an event attribution study can be strongly dependent on the specific event definition. This task will provide guidance on objectively defining an event, including the choice of variable and the spatial and temporal scales. We will also explore methods for characterizing the spatial and temporal scales at which an event can be considered extreme. Previous attribution studies have mostly considered event definitions for meteorological variables and this task will also consider defining events more closely associated with socioeconomic impacts and more complex meteorological phenomena (anti-cyclonic blocking, storms, etc.).

##### **Task 2.2 Development of new attribution methods (Météo France, CNRS/CEA, UREAD, BRGM) / Month 1 – Month 36**

- i. Development of flow attribution methods, which will address whether the flow frequency has changed due to climate change. Methods based on analogues will be developed to characterize flow changes and will be applied to both observations and climate model simulations (in particular HadGEM3-A).
- ii. Development of new methods to account for a non-stationary climate. Stochastic weather generators (SWG) driven by dynamical systems properties will be used to improve confidence and uncertainty assessments of analogues for flow attribution. This will allow an evaluation of the contribution of changes in the flow dynamics to the changes in extreme events and their distributions. Assessments will account for various metrics, such as rarity, entropy and stability of the flows encountered in extreme events. Extreme values associated with such metrics will generally correspond to specific atmospheric patterns and match extreme weather occurrences.

iii. Development of “inverse attribution” methods i.e. estimating whether the probabilities of notable past extreme events have increased or decreased due to climate change. Notable past events are often taken as references for industry risk evaluations. EUPHEME will use classical attribution techniques (e.g. using analogues, statistics already calculated from climate model ensembles, etc.) to address these issues.

iv. Development of a new methodology to attribute temperature extremes based on the E-OBS observational dataset. The methodology involves producing stochastic realisations of E-OBS daily temperatures based on sampling from observed covariance statistics. This would allow a GCM-independent estimate of the change in risk of particular events.

v. Development of a new methodology to attribute extreme sea levels by examining the observed spatial and temporal variations in both the intensity and the frequency of sea level extremes that are unrelated to mean sea level changes and tides. A new time-dependent statistical model combining extreme value distributions and the non-homogeneous Poisson process will be developed, supported by coastal data in the harbor of La Rochelle, France (Bulteau et al 2015) with special attention paid to the changes over time of the recurrence rate of extreme sea levels like the one of the devastating Xynthia storm (2010). This method will take full advantage of upper tail information from both hindcast atmospheric or wave reanalysis and instrumental records (e.g. Miguez and Jesus, 2015).

### **Task 2.3 Development of attribution systems for near-real time and seasonal time-scale assessments (Met Office, KNMI, Météo France) / Month 1 – Month 24**

i. Development of a near real-time event attribution system based on existing climate model output, including i) the KNMI EC-Earth runs, coupled at medium (T159) resolution for large-scale extremes and uncoupled at high (T799) resolution for small-scale extremes, and augmented by Regional Climate Model runs from KNMI and CORDEX (with CNRS/CAE) and ii) the transient coupled simulations from Météo France. This task will also fit non-stationary statistical distributions to these simulations in order to characterise changes in extremes, based on an appropriate covariate such as global mean temperature. This would be complementary to existing techniques based on ensembles of atmosphere-only experiments and will provide estimates of changes in the risk-ratio which do not depend on a specific pattern of SSTs.

ii. Development and updating of a quasi-operational seasonal timescale system for event attribution based on HadGEM3-A (Christidis et al., 2013). This modeling system is based on the latest Met Office Hadley Centre model and will be kept updated to be the same model as the Met Office operational seasonal forecasting model. The maintenance and development of this capability will enable synergies between seasonal forecasting and event attribution to be strengthened. In particular techniques for model evaluation from seasonal forecasting will be adapted for use in attribution, the abilities of models to predict events on seasonal timescales will help inform attribution conclusions, and understanding gained from attribution assessments will be used to inform future model development, thereby potentially improving future seasonal prediction capability.

### **Task 2.4 Developing new Evaluation methods (Met Office, UREAD) / Month 1 – Month 36**

First, a framework of climate model evaluation using statistical reliability will be developed (where reliability means that the probabilities of the extreme event occurring in the climate model are equal to observed probabilities). Climate models that are unreliable tend to overestimate the attributable risk from extreme events (Bellprat and Doblus-Reyas, 2013). Research will be undertaken to extend initial attempts at verifying attribution results using reliability metrics (Bellprat and Doblus-Reyas, 2013; Lott and Stott, 2013) so that more quantitative measures of robustness can be obtained and to develop methods to recalibrate attribution results based on reliability metrics.

Second, attribution statements in WP4 are made with atmosphere-only climate models. The sensitivity of attribution statements to ocean-atmosphere coupling will be evaluated. Attribution statements will

be produced for selected events considered in WP4 using a coupled event attribution framework based on the HadGEM3-KPP atmosphere-ocean mixed layer model.

*Deliverables:*

- D2.1** Report providing guidance on event definition for attribution studies (including more complex meteorological phenomena and impact relevant definitions) (Month 18) - Météo France
- D2.2** Report on new attribution methods (Month 24) - CNRS/CEA
- D2.3** Report on attribution systems for near-real time and seasonal timescale assessments (Month 24) – Met Office
- D2.4** Report on the approaches for evaluating attribution statements (Month 36) - UREAD

*Milestones:*

- M2.1** New guidelines on event definition (Month 18) - Météo France
- M2.2** Development of the non-stationary extreme value model with application on coastal data (Month 24) - BRGM

**WP3: Development of a shared event attribution platform (KNMI (leader); CNRS CEA (co-leader))**

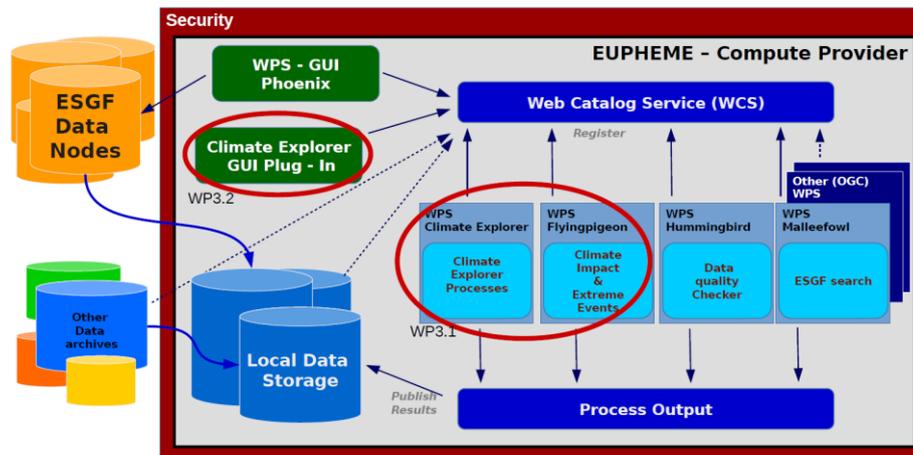
An operational service requires a common, distributed platform to support all stages of an attribution study: event definition, model evaluation, attribution analysis and synthesis. These elements then support, in collaboration with potential users of such information in WP4, the production of well-calibrated synthesis statements about the events in question, shortly after the event concerned or as part of a regular review of events over the previous season. So we plan a shared platform upon which each of these stages can be carried out by a distributed team of analysts, also from outside EUPHEME. It is important to be clear that this shared platform is an internal facing platform for the scientific analysts working on the attribution assessments. The public-facing component of the attribution service is dealt with in WP4.

**Event definition and framing:** For this we need access to up-to-date weather and impacts information, plus access to stakeholders and the impacts community to assess the magnitude of the impacts and their immediate meteorological causes. **Model evaluation and attribution:** The results, including their uncertainties, from each group are either computed here or communicated back to the group and archived on a common platform for reference in the later phases of the attribution process and traceability. **Synthesis:** The results from the different attribution groups need to be synthesised to a single conclusion, usually a scientific attribution statement with uncertainty information supported by underlying reasoning on physical processes and model quality, referring to previous scientific literature.

**Task 3.1 Development of an attribution web processing service for EUPHEME (KNMI) / Month 1 – Month 36**

The access to information and attribution functions will be made through a web processing service (WPS) made accessible through a graphical user interface (see the Figure 9.2). The WPS will be based on existing software of the Climate Explorer (<http://climexp.knmi.nl>) and the extreme event tool developed internally at LSCE for analogues and weather regime calculations. The deployed tool will be the WPS framework “Birdhouse”, which is a community based WPS framework keeping to the defined standard of the ocean geospatial consortium (OGC). Birdhouse can be combined with other OGC based WPS.

This task will progressively integrate each function of the Climate Explorer in the facility and harmonise them with already implemented analogue-based techniques developed in EUCLEIA. It will also provide a number of definitions and protocols including the catalogue of observed datasets, catalogue of simulation datasets, technical proposal for data formats, and protocol for scripts sharing. We will use as much as possible the protocols of the FP7 CLIPC and Copernicus information systems. A graphical user interface will be developed so that scientists can access the data and run attribution programs close to the data.



9.2:

Figure  
Schematic of web processing service and graphical user interface

### Task 3.2 Development of a scientific collaboration site (CNRS) / Month 6 – Month 36

This site will allow for the exchange of data and information, serve as a “lab-book” that underlies the conclusions, have a facility to collaboratively write scientific and derived texts, and contain a literature database. After the event attribution all the lab-books and formal texts will be archived to enable traceability and reproducibility. This site will be based on existing collaboration software, the main effort will be to select the right tools and impose a structure for the attribution studies in the form of templates, conventions and checklists. We will implement software that is as much compatible as possible with tools used in the framework of the C3S services.

### Task 3.3 Application of methods and synthesis for a few test cases (KNMI, CNRS, Met Office) / Month 6 – Month 36

The attribution platform will be tested over a few test cases, and the two time scales described above. Two rapid attribution cases will be selected during the project, and seasonal timescale attribution will be launched at month 12 of the project providing seasonal updates. KNMI and CNRS/CEA will focus on rapid attribution cases and Met Office will focus on seasonal timescale cases. In the rapid attribution case, a few days after a number of analyses are done the partners involved in the analyses will meet on-line and summarise their findings in the form of scientific articles and a standardised sheet with results. This will include both results from classical methods and from new exploratory methods. In the seasonal timescale analysis regular updates will be provided and communicated via the prototype attribution service website from month 12 of the project using results from the HadGEM3-A quasi-operational attribution system (see Task 2.3ii).

#### Deliverables

- D3.1** Report on the definition of the protocols used for the distributed information system (Month 6) - KNMI
- D3.2** Demonstration of the data access and web processing service report (Month 24) - KNMI
- D3.3** Demonstration of the collaboration platform report (Month 18) - CNRS
- D3.4** Application cases and scientific synthesis report (Month 30) - KNMI

### WP4: Delivery of event attribution assessments and communication (Met Office (leader); CNRS CEA (co-leader)).

To provide actionable information to stakeholders, the results using different attribution methods need to be summarized into a single conclusion, usually an attribution statement with uncertainty information supported by underlying reasoning on physical processes and model quality, referring to previous scientific literature. This activity will draw upon the scientific synthesis of events made

under WP3 on a near-real time basis and on seasonal timescales. Feedback from the stakeholder panel in WP1 on assessments produced will enable further refinements to be made to the methodologies used and to the procedures used to synthesise and communicate the results.

### **Objectives**

Work package 4 of EUPHEME aims to:

- standardise the release of scientific information on different timescales and provide coherent assessments of events to be understood by stakeholder communities by giving a clear interpretation of the scientific findings from different methodologies, stating their associated uncertainty
- demonstrate attribution of socio-economic impacts
- develop and deliver a prototype attribution service website for the dissemination of event attribution assessments

#### **Task 4.1 Developing and demonstrating procedures for user-oriented communication of attribution statements on different timescales (CNRS, Met Office, KNMI, Met Éireann) / Month 1 – Month 36**

This task aims to develop and demonstrate effective procedures for the production of attribution assessments for stakeholders. WP3 will develop synthesis statements but these will be produced by, and for, the scientific community. While suitable for scientific papers the standardised sheets of results produced there will not be of direct use by many users. Rather the output of WP3 will form the basis for communication with users. This task will develop material from WP3 into a form suitable for dissemination to stakeholders.

The work for this task will comprise two strands corresponding to the two timescales of analysis considered in EUPHEME. The seasonal timescale component will develop standardized procedures for the analysis of information from the operational HadGEM3-A system and complementary quasi-operational methodologies that can be operated every season and translated into user relevant information. By design, the Met Office's attribution and seasonal forecasting systems will run in parallel and will be updated to use similar model configurations for consistency. This task will develop tools to enable the production of attribution information from the model simulations in an automated manner for different types of regional climate extremes. The fast-track component will translate the scientific papers and standardised sheets produced in Task 3.3 into user relevant information. This will be done in continuous consultation with the stakeholder group identified in WP1.

#### **Task 4.2 Delivering information on attribution of impacts (Met Éireann, Met Office, KNMI) / Month 1 – Month 36**

End-to-end attribution studies translating meteorological variables into impacts of climate change and estimating how human influence may modify the risk are still sparse, but could constitute a very useful component of climate services. WP4 will investigate how attribution products may be derived from impact studies and incorporate the first findings into its website as an early demonstration of this capability. The focus will be kept on the economic impact of extreme events, but other impacts may also be considered, such as the effects on human health. The use of impact models introduces an additional source of uncertainty which will also be assessed and quantified.

#### **Task 4.3 Setting up a website for selective trialling of a prototype operational attribution system (Met Office, CNRS, Met Éireann, / Month 1 – Month 36**

A prototype attribution service website will be set up and the production of attribution assessments will be trialled using output from synthesis statements. In consultation with stakeholders via WP1, information from attribution assessments will be visualised and presented on the website in ways found to be most effective for different users, bearing in mind that there will be users with little scientific background. To this end, high-level statements and simple graphics will be available, as well as links to more detailed assessments for specialist users. Information from tailor-made analyses of specific high-impact events will also be incorporated into the website as it becomes available. All

attribution results will include uncertainty estimates and links to supporting model evaluation assessments will be provided. Lessons learnt during the trialling period of the website will guide the further development of attribution methodologies and synthesis statements in the rest of the project.

Dr. Pete Walton, Knowledge Exchange Research Fellow at Oxford University, will be subcontracted in order to facilitate the production of this website. Dr Walton led the stakeholder user panel in EUCLEIA and has extensive experience of co-production of knowledge for attribution of extreme weather and climate events. Dr Walton will work with stakeholders, scientists and web developers to design, implement and test a web portal that, at the end of the project, can be used as a model of best practice. This will be achieved through a virtual workshop with a small user group drawn from selected stakeholders to identify the key features of a web site, which will then be implemented in coordination with sub-contracted web developers before being presented to the user group for initial feedback. Content developed under WP4 will be used to populate the website and the user group will then be asked to evaluate it using a similar virtual workshop scenario, and the results of the test used to inform further developments.

#### *Milestones*

**M4.1** Release of a prototype attribution service website to disseminate event attribution assessments on seasonal timescales and progress on the project (Month 12) – **Met Office**, Met Éireann, Dr. Walton

**M4.2** Incorporation of assessments on fast-track timescales and including improvements to website based on feedback from stakeholders (Month 24) – **Met Office**, CNRS, Dr Walton

#### *Deliverables*

**D4.1** Report describing the protocols for communication of synthesis assessments (Month 20) - **Met Office** with input from CNRS, KNMI and Met Éireann

**D4.2** Report on attribution assessments made so far including on seasonal and fast-track timescales (Month 26) – **Met Office** with input from CNRS, KNMI and Met Éireann

**D4.3** Report on attribution of climate change impacts (Month 34) **Met Éireann** with input from the Met Office and KNMI

### **WP5 Project management and Scientific Coordination (Met Office (leader))**

#### **Objectives**

WP5 is the top-level project management and science coordination of EUPHEME with the mission of ensuring that the impacts and objectives of EUPHEME are efficiently and effectively achieved, on time and within budget. This work package will establish and maintain an effective working relationship between EUPHEME and ERA4CS, through regular reporting on the project progress. The Met Office as WP5 leaders will coordinate and facilitate effective relationships, collaboration and coordination between partners within EUPHEME, including sharing of information on all aspects of project management. Individuals' responsibilities and decision making delegations will be clearly defined. The project will be led and coordinated by Professor Peter Stott, who has considerable experience in the international attribution community and in leading projects within large climate research and climate service work programmes (including European Commission funded projects such as EUCLEIA under FP7). A qualified and experienced project manager from the Met Office will also be appointed and support will be provided by experienced Met Office legal, finance and communication teams, with extensive experience of European Framework Programmes.

#### **Description of work**

This Work Package will manage the day to day running of the project, ensuring that all obligations under the Grant Agreement and the internal Project Agreement (Consortium Agreement) are successfully fulfilled.

#### **Task 5.1 Project management (Met Office) / Month 1 – Month 36**

Manage the project using effective procedures based on the PRINCE2 (Projects IN Controlled Environments) formal methodology. This will primarily be the responsibility of the Met Office. Managing the project includes the following, non-exhaustive activities:

- (i) Implementation and maintenance of the Grant Agreement and the preceding Project Agreement
- (ii) Overall legal, financial, administrative management and reporting, including:
  - Designing and maintaining partner specific templates for collecting inputs to the required ERA4CS documents;
  - Implementing and maintaining a project-specific process for reporting;
  - Preparing for periodic reviews by ERA4CS and supporting the implementation of recommendations;
  - Handling of project correspondence and day-to-day requests from partners and external bodies;
  - Adaptation of project and management structure after changes in the work plan and the consortium;
  - Organisation of meetings relating to the management of the project; then executing, and post-processing, of major project meetings (i.e., agendas, invitations, locations, preparation, distribution and archiving of material, minutes and action lists);
  - Financial management – including transfer of project funds to partners (in compliance with directives from ERA4CS), providing clarification on any budget/financial issues, monitoring and controlling the budget.

**Task 5.2 Communication with ERA4CS (Met Office) / Month 1 – Month 36**

Provide regular and comprehensive communication with ERA4CS via the EUPHEME Coordinator and the Project Manager. This will be partly fulfilled through the provision of periodic reports outlining the project's progress and developments (D1.1).

This task will ensure the appropriate follow-up of obligations from the Grant Agreement (formal reporting – of science results, finances, project reviews, communication, and management). The EUPHEME Coordinator will ensure that the appropriate ERA4CS representative is invited to the mid and end point review meetings.

If there are any major problems within the project that cannot be resolved through the appropriate management structure, the Coordinator will liaise with ERA4CS in order to seek advice and a solution.

**Task 5.3 Coordination of internal communication (Met Office) / Month 1 – Month 36**

Share knowledge as widely as possible across the project, through regular and routine communications. For example, an information sharing platform in the form of a dedicated internal password-protected project website/Trac Wiki System will be provided and managed. This will also host links to milestones and deliverables, as well as templates, documents and tools that the project office will develop to aid the management and reporting of the project. There will be space for each partner and work package in order to encourage continual conversations, dialogue and knowledge exchange amongst the partners. This task will also ensure the implementing and maintenance of mailing lists for scientific contacts and administrative contacts.

**Task 5.4 Scientific coordination of EUPHEME (Met Office) / Month 1 – Month 36**

Maintain a holistic view of ongoing work, and provide direction. Carry out the scientific coordination and monitoring of work packages, work package leaders and project milestones. This task also includes verifying the quality, consistency and timeliness of the work and deliverables, and synthesising the results of the project. It includes reviewing the scientific element of the reports and deliverables to be submitted.

*Deliverables*

**D5.1:** Summary reports on project progress. Periodic reports to be produced at the mid point and end point of the project – Met Office

## **Impact, Engagement and Dissemination Plan**

### **User profile including envisaged societal impacts**

There are substantial potential impacts as a result of the institutional integration envisaged under EUPHEME. Through delivery of event attribution assessments in the aftermath of severe weather events the project will enable societies in Europe to be more resilient to extreme weather by facilitating a better understanding of weather and climate-related risks. As well as of relevance to the insurance industry, such information will better inform European policy makers about developing mitigation and adaptation strategies and will help European citizens become better informed and better motivated to protect themselves appropriately against such events. Thus the main user groups to be engaged will be the public (directly via press releases, website, social media etc and through the media), the insurance sector, and policy makers/actors (European and national government contacts, legal sector, etc).

A detailed investigation of insurance sectors needs has been carried out under EUCLEIA and a report entitled “Commercial Dimension of Attribution Products using the insurance and reinsurance sectors as proxy” came to some striking conclusions. Polling of insurance sector representatives showed that event attribution assessments could inform strategic decisions for the insurance sector, could improve risk modeling and premium calculation, and support public awareness raising and political leverage. The insurance sector representatives polled thought that taking account of insurance industry requirements and demonstrating that event attribution assessments provide credible and relevant information would overcome current hesitation in using such information. They expressed a preference for regularly updated assessments tuned to their needs rather than rapid turn round assessments produced irregularly for specific events. EUPHEME will carry out the necessary user-targeted research and development to develop such a prototype system.

The other main sector envisaged are the public and policy makers. An assessment of needs for attribution information was carried out under EUCLEIA and described in a report entitled “Social articulation of attribution”. This report, which included analyses of media articles and a focus group found that event attribution assessments are perceived by potential users to have value because they give a better idea of what the future has in store, they can help raise public awareness of the dangers of extreme weather, and they can give a clearer sense of the options available in order to reduce unwanted consequences of extreme weather. The report also found that more work is needed to provide assessments that find widespread application. In particular the report highlighted that a suitable protocol guiding communication between scientists and users is required. EUPHEME will develop such a protocol and will demonstrate the potential of a coordinated event attribution system for informing stakeholder decision making. For the general public and media, unlike the insurance sector, there is a demand for rapid turnaround assessments of high profile extreme events. Therefore EUPHEME will develop the capability to produce assessments on both rapid turnaround and seasonal timescales.

In developing a prototype operational attribution system EUPHEME will facilitate the transfer of knowledge about the links between extreme events and climate change from the research specialists to the wider user community. Institutional integration of most of the main institutes involved in the development of event attribution science will enable a consistent view and avoid fragmented and potentially contradictory assessments.

### **User engagement**

User engagement will be managed and coordinated by WP1 led by Patrick Fournet of Met Éireann; also engaging contractor Dr. Peter Walton of Oxford University through WP4, thereby drawing on Dr. Walton’s experience leading the stakeholder user group of EUCLEIA, and in consultation with the Leading PI and Science Coordinator of EUPHEME and the WP leads. User engagement will be operationalised in a pre-phase and two actual phases, each with a different focus:

- the pre-phase will consist of the testing of the initial results. Technical testing on the functionality of the tools developed will be conducted by a small group of stakeholders;

- the 1st operational phase will consist in a broad engagement so as to received feedback from as large an audience as possible;
- the 2nd operational phase will finally focus on a small group of individuals showing the highest level of interest and with the highest level of influence.

From Month 3 to Month 6, a small group of so-called “friendly users” (e.g. stakeholders involved in EUCLEIA and stakeholders such as Red Cross/Red Crescent involved in the World Weather Attribution and other related projects) will be targeted to carry out some user experience testing on the first version of the public website and tools. From Month 6 to Month 18, a larger number of stakeholders will subsequently be identified to analyse and test the EUPHEME prototype attribution service website’s functionality. Group discussions, interviews and a mid-term review workshop will constitute opportunities to deliver feedback from each stakeholder group identified.

From Month 18 to Month 36, a small group of fully engaged stakeholders will be targeted to improve the ease of access, functionality and relevance of the prototype attribution service website

### **Dissemination, publication and protection of results**

The management of dissemination and communication activities will be undertaken in WP1. An engagement and dissemination plan which will be produced early on in the project (Month 3) to provide initial guidance for the project on these important aspects. Typical activities will include presenting on, and promoting, EUPHEME at scientific events, as requested by ERA4CS. This will be the responsibility of the Science Coordinator and all partners, who will each undertake to do this as part of their work packages. These activities will ensure the continued awareness and exploitation of EUPHEME science during and after the project, meaning that it will be used in future decision making for next-generation programmes. Stakeholder engagement through the EUCLEIA project has revealed that there is a strong interest in the use of extreme event attribution science within Europe and also globally. Decision makers in a range of sectors have identified that understanding the changing risks of extreme weather events could play an important role in building capacity in a changing climate. The stakeholders currently engaged in the EUCLEIA project recognise that continued involvement in developing the science will be critical in ensuring that it is fit for purpose, and as a result would be keen in maintaining a commitment to the project. Relevant, key organisations that would potentially be interested in continuing engaging with extreme event attribution through the EUPHEME project include: Munich Re, CoreLogic, IBM, World Bank, Client Earth, University of Houston Law Centre, Public Health England, European Environment Agency, UK Government Department for Environment Food & Rural Affairs.

### **Communication plan**

Careful communication is a key aspect of EUPHEME. Communication among the project scientists will be facilitated by the Shared Event Attribution Platform developed in WP3. This will also enable carefully prepared synthesis statements to be shared with the EUPHEME stakeholders consulted in WP1. The form of such synthesis statements will be refined based on stakeholder feedback.

Communication to the wider public will be conducted via carefully calibrated information released on the public website in WP4. It is not the intention for EUPHEME to provide an operational attribution service for Europe directly as such an operational capability would be enabled as part of the Copernicus Climate Change Service. Rather EUPHEME will provide a prototype service in which the capability for attribution services will be demonstrated through the rapid timescales analysis of two selected extreme events and through the regular provision during the last year of the project of regular seasonal updates. Information produced by EUPHEME will be available for onward dissemination by trusted providers including the Press Offices of the partner institutions. The partners will work with their Press Offices to ensure that information that is released in the form of Press Releases and briefings is scientifically robust and consistent with the information produced in the project.

### **Visual identity – logo and slogan**

The development of a visual identity and a project logo ensures project outputs are consistent and easily recognisable. A brainstorming session with all the project partners will be used to find an appropriate concept for the project logo. For this, key aspects of the project will be considered. Based on this logo, a visual identity will be developed. This will include fonts, colour schemes and templates for documents and presentations for partners to use. All material which includes the EUPHEME logo



will be accompanied by the European Union emblem, the ERA4CS logo and acknowledgement of the funding source.

### **Website and social media**

The EUPHEME prototype attribution service website will use a content management system, which will be configured and adapted to meet the needs of the project. The website will serve as a central point for information about the project. The design will be developed on the basis of the EUPHEME logo and will be in keeping with the overall visual identity of the project. The structure will be conceived so as to minimise the number of clicks needed to reach key information.

In terms of content, the aim will be to provide frequent updates to the site with information that is up to date, relevant, trustworthy and written in an accessible language. Users will only re-visit the public website regularly if they can expect frequently updated news and the website's success is thus reliant on the provision of content from consortium partners. This will be ensured through the provision of information from the attribution assessments carried out in WP3 and WP4 (Task 3.3, Task 4.1) and through on-going progress reports on the scientific developments carried out in WP2. Multimedia elements describing the project's science, methods and results will be added where possible.

A twitter account will be a crucial tool for EUPHEME dissemination as it will provide access to a broad community of institutions and individuals interested in climate change attribution and provides a way to access stakeholders beyond the 'usual suspects' such as local communities acting at the ground level. It provides the opportunity to engage with the general public, media and decision makers. A LinkedIn group will provide the opportunity to network, discuss and engage with other professionals working in the private, public and non-profit sectors.

### **Project leaflet and newsletters**

An A5 landscape format project leaflet will be produced at the start of EUPHEME in line with the visual identity established and with the aim of promoting the EUPHEME project and giving a brief overview of its objectives. A small number of leaflets will be produced for distribution at EUPHEME events and other adaptation related events. The electronic version (PDF for web publishing and electronic files suitable for printing) will then provide the main form of distribution and will be sent as an attachment whenever communication regarding the EUPHEME project occurs.

A series of newsletters will contain news stories on findings of EUPHEME as well as broader developments relevant to climate change attribution, with a special focus on how the research of EUPHEME can support or provide insights for these developments. These newsletters will be sent out via email, linking directly to the stories on the website. The use of an e-mail newsletter (in contrast to a print newsletter) will allow for more detailed monitoring and evaluation data gathering.

### **Scientific publications and articles**

As a research-based project, it is important that EUPHEME results will be shared with a broad academic audience. Where these outputs are published will be determined in accordance to thematic content and quality and will be decided upon in discussion with the authors. However, EUPHEME will adopt the "gold" model for open access to peer-reviewed journal articles where possible. In parallel, "green" open access will also be adopted by using the institutional and subject-based repositories made available through the partners.

### **Stakeholder events**

Over the course of the project, EUPHEME will organise three events (one virtual and two physical) to bring together policy makers, insurance specialists, media and scientists to share information on the developments of attribution research and to foster dialogue and engagement. These events will include:

- 1) a stakeholder panel virtual meeting;
- 2) a midterm review workshop involving key scientists, key international and policy organisations;

3) a final EUPHEME international conference where intermediate findings and final results of the project will be presented and discussed with stakeholders.

The most appropriate methods and content for these events will be developed in coordination with the rest of the consortium. However, attention will be placed on approaches to improve inter-linkages between science-policy interfaces, and that focus on making scientific and experience-based information about climate change attribution easily accessible and usable for decision makers and civil society.

The organisation and planning of each event will generally include the following elements:

- strategic planning;
- organisation of venue;
- agenda development (including: topics, speakers, chair, working sessions, etc.);
- invitation management and registrations;
- preparation of delegate package;
- liaising with the media;
- on-site support;
- monitoring, note-taking and reporting;
- branding and distribution of information and promotional material.

In addition to international events, online workshops and activities will be carried out with stakeholders at local level via web-conference facilities and tools such as webinars will be used to stay connected to EUPHEME partners and stakeholders.

#### **Press releases**

Journalists will be invited to events and made aware of project outputs via the different distribution channels mentioned above. In addition events will be streamed where possible so as to increase the number of participants from European press agencies. If a project deliverable or event warrants a particularly high level of attention, WP1 partners will prepare a press release. If necessary, this may also be translated into local languages by partners. Materials for media professionals will be available for download in a specialised bundle from the EUPHEME public website.

#### **Data management**

The Leading PI will be responsible for the data and knowledge management. Some source data will be archived at Climate Explorer and the HadGEM3A data at the Met Office

#### **Complementarity to other initiatives**

EUCLEIA is one of the five FP7 GMES (Global Monitoring for Environment & Security) projects (along with UERRA, CLIPC, ERA-CLIM2 and QA4ECV) that are being developed to expand climate services that have the potential to become fully supported operational services under C3S.

Conversations have been had with ECMWF C3S directors who have responded positively regarding the expectation of a future call under C3S around an operational attribution service under C3S. Thus this proposal is a link between EUCLEIA and the potential C3S call, demonstrating the types of potential robust, useable attribution products and assessments that could be ultimately be available through the C3S Climate Data Store (CDS).

This proposal will be well placed to contribute towards CLIMATE-ADAPT (European Climate Adaptation Platform), which is a partnership between the European Commission (DG-CLIMA, DG Joint Research Centre) and the European Environment Agency. The CLIMATE-ADAPT platform aims to support Europe in adapting to climate change by helping users access and share data and information including access to EU, national and transnational climate adaptation risk assessments, strategies and actions. There is a strong expectation that CLIMATE-ADAPT will want to access the C3S CDS and climate attribution services.

The European Commission has launched the “Roadmap for Climate Services”. The Roadmap contains three main challenges: *enabling market growth; building the market framework; and enhancing the quality and relevance of climate services*. 25 specific actions are proposed to meet these main



activities. The proposal is well placed to help implement the Roadmaps' main activities and several of the specific actions, in particular:

- Assessing the nature of climate service market – Translating users' needs into services and access required (action 1.1b);
- Demonstrating the added value of climate services as standalone services and/or integrated into broader decision-support systems (1.3b);
- Communities and infrastructures to support and grow the climate services market (2.1a and 2.1b);
- Strengthening the scientific basis and relevance of climate services – Developing tools and supportive resources needed by users – local, national and transnational (3.2b)
- Climate information and end-users' needs; innovations and products – Making better use of available climate information and knowledge (3.3a).

EUPHEME is highly complementary to other scientific initiatives worldwide seeking to develop the science of event attribution. The 2016 National Academies of Sciences report on event attribution endorsed the feasibility and relevance of developing the science of event attribution and scientists and stakeholders around the world are now interested and engaged in this activity. Scientific coordination is enabled through the International Detection and Attribution Group (IDAG) which meets annually and involves all the experts worldwide in this specialism. Countries outside Europe with active groups pursuing this topic and whose scientists attend IDAG meetings include Australia, New Zealand, South Korea, China and Japan. All these groups have different regional requirements and are dealing with different regional climates. But by working together and meeting regularly in an annual intensive workshop setting under IDAG the core science is pushed forward as rapidly and efficiently as possible in a collaborative but critical environment. The forerunner of EUPHEME, EUCLEIA, has been recognized by IDAG collaborators including the EUCLEIA Expert Advisory Board (see letters of support) and by the National Academies of Science report, as being one of the international leaders in this field. EUPHEME provides the opportunity for Europe to continue to carry the baton as a world leader in event attribution.

### **Institutional integration**

Building upon the success of EUCLEIA, Europe stands ready to play a leading part internationally in the development of event attribution science, and to lead the world in translating that science into tools that can improve decision making for the citizens of the region. But this potential can only be realized through improved coordination amongst the relevant institutes of Europe. EUPHEME offers the opportunity to ensure integration of complementary capabilities of the leading institutes in Europe and to enable a coordinated rather than fractured response when societies ask if future extreme weather events in Europe are linked to climate change. If attribution products are going to take their place in a future climate service for Europe it is essential that there is a stepping stone between the research-based developments of EUCLEIA and the onerous demands of an operational climate service under Copernicus. Through the means of a shared event attribution platform, to be developed in EUPHEME, stakeholders will be able to gauge the benefits of well communicated and robust event attribution products. The leading players in event attribution across Europe will be working together under EUPHEME to develop a consistent approach to the delivery of event attribution assessments. This institutional integration offers the prospect of a much improved understanding of the risks of extreme weather under climate change by European citizens and institutions.

## References

- Bellprat, O, F Doblas-Reyes (2016) Attribution of extreme weather and climate events overestimated by unreliable climate simulations. *Geophys. Res. Lett.*, 43, 2158–2164
- Bellprat O and F Doblas-Reyes (2016), Unreliable climate simulations overestimate attributable risk of extreme events, *Geophys. Res. Lett.* 43, doi:10.1002/2015GL067189
- Bulteau, T., Idier, D., Lambert, J., and Garcin, M.: How historical information can improve estimation and prediction of extreme coastal water levels: application to the Xynthia event at La Rochelle (France), *Nat. Hazards Earth Syst. Sci.*, 15, 1135-1147, doi:10.5194/nhess-15-1135-2015, 2015.
- Christidis, N, PA Stott, A Scaife, A Arribas, GS Jones, D Copsey, JR Knight, WJ Tennant (2013) A new HadGEM3-A based system for attribution of weather and climate-related extreme events, *J. Climate*, 26, 2756-2783
- Dole, R, M Hoerling, J Perlwitz, J Eischeid, P Pegion, T Zhang, X-W Quan, T Xu, D Murray (2011) Was there a basis for anticipating the 2010 Russian heat wave? *Geophys. Res. Lett.*, 38, doi:10.1029/2010GL046582
- Herring, SC, MP Hoerling, TC Peterson, PA Stott, Eds. (2014) Explaining Extreme Events of 2013 from a Climate Perspective. *Bull. Amer. Meteor. Soc.*, 95 (9)
- Herring, SC, MP Hoerling, JP Kossin, TC Peterson, PA Stott, Eds. (2015) Explaining Extreme Events of 2014 from a Climate Perspective. *Bull. Amer. Meteor. Soc.*, 96(12)
- Lott, F, PA Stott (2016) Evaluating Simulated Fraction of Attributable Risk Using Climate Observations. *J. Climate*, 29, 4565-4575
- Mínguez, R. & Jesus, F.D. *Stoch Environ Res Risk Assess* (2015) 29: 1851. doi:10.1007/s00477-014-0937-9
- National Academies of Science (2016) Attribution of extreme weather events in the context of climate change. Washington DC: The National Academies Press, doi:10.17226/21852
- Otto, FEL, N Massey, GJ van Oldenborgh, RG Jones, MR Allen (2012) Reconciling two approaches to attribution of the 2010 Russian heat wave. *Geophys. Res. Lett.*, 39, L04702, doi:10.1029/2011GL050422
- Rahmstorf, S, D Coumou (2011) Increase of extreme events in a warming world. *PNAS*, doi:10.1073/pnas.1101766108
- Sollow, AR (2015) Extreme weather, made by us? *Science*, 349, 1444-1445
- Stott, PA (2016) How climate change affects extreme weather events. *Science*, 352, 1517-1518
- Stott, PA, P Walton (2013) Attribution of climate-related events: understanding stakeholder needs. *Weather*, 68, 274-279.
- Stott, PA, N Christidis, F Otto, Y Sun, J-P Vanderlinden, GJ van Oldenborgh, R Vautard, H von Storch, P Walton, P Yiou, FW Zwiers (2016) Attribution of extreme weather and climate-related events. *WIREs Clim. Change*, 7, 23-41



Eupheme

Trenberth, KE, JT Fasullo, TG Shepherd (2015) Attribution of climate extreme events. *Nature Clim. Change*, 5, 725-730

van Oldenborgh, GJ, FEL Otto, K Haustein, H Cullen (2015) Climate change increases the probability of heavy rains like those of storm Desmond in the UK – an event attribution study in near-real time. *Hydrol. Earth Syst. Sci. Discuss.*, 12, 13197–13216

van Oldenborgh, GJ, SY Philip, E Aalbers, R Vautard, FEL. Otto, K Haustein, F Habets, R Singh, H Cullen (2016) Rapid attribution of the May/June 2016 flood-inducing precipitation in France and Germany to climate change. *Hydrol. Earth Syst. Sci. Discuss.*, doi:10.5194/hess-2016-308, in review.