

REQUEST FOR A SPECIAL PROJECT 2014–2016

MEMBER STATE: UK

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Project Title:

Investigation of large scale precursor conditions for extreme cyclone development in the extra-tropics

If this is a continuation of an existing project, please state the computer project account assigned previously.	SPGBLECK	
Starting year: <small>(Each project will have a well defined duration, up to a maximum of 3 years, agreed at the beginning of the project.)</small>	2012	
Would you accept support for 1 year only, if necessary?	YES <input checked="" type="checkbox"/>	NO <input type="checkbox"/>

Computer resources required for 2014-2016: <small>(The maximum project duration is 3 years, therefore a continuation project cannot request resources for 2015.)</small>	2014	2015	2016
High Performance Computing Facility (units)	5000	5000	5000
Data storage capacity (total archive volume) (gigabytes)	2000	2000	2000

An electronic copy of this form **must be sent** via e-mail to:

special_projects@ecmwf.int

Electronic copy of the form sent on (please specify date):

2.7.2014

Continue overleaf

¹ The Principal Investigator will act as contact person for this Special Project and, in particular, will be asked to register the project, provide an annual progress report of the project's activities, etc.

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Preamble

This special project request is an updated version of the project application from 2012, when this project started.

The project originally commenced in summer 2012. The member of staff mainly foreseen to work on this special project arrived unfortunately much later than originally anticipated. This is partly due to some late starts of new projects as well as to identify the most suitable candidate to work on the related topics. Consequently, so far only reduced use was made of the facilities of ECMWF, with no use of the allocated computer resources, as given in our related report (attached). Since April 2014 a new collaborator joined the group (D. Befort) and he started to work on his new ECMWF special project account. Nevertheless, no real use of **compute** facilities were made thus far but an overview of activities making use of general ECMWF facilities in the context of this project is given in the related report.

With this request we intend to prolong the project by 2 years, in order to fulfil the project work we intend to do originally. Consequently the project description is quite similar, but we updated it at the relevant places to reflect the latest state-of-the-art of research in this field. We are aware of the 3 year limit in general terms, but as we did not use the allocated time/resources yet, we would pretty much appreciate, if we could continue this project by two years.

If this would not be possible, we would probably apply for a new special project with quite similar scientific objectives.

Extended abstract

This project aims at the investigation and diagnosis of severe storm events in different geographical regions of the earth. Several kinds of dynamical systems are highly affecting social and technical infrastructures and for a proper risk assessment analysis the estimation of wind storm related risks for e.g. Europe or other wind storm affected regions is of crucial interest. Thus, this project addresses extreme Polar Lows, severe mid-latitude winter storms, and tropical cyclones. Basically, studies on (historical) wind storms suffer from a lag of comparable knowledge about meteorological conditions responsible also for the storm developments and thus for related impacts.

Consequently, studies to the main physical processes for the generation and transition to severe storms are performed in order to estimate their risk of occurrence for different regions over Europe, the northern oceans, and the tropics. In the project key circulation patterns will be identified and related to their physical origins with respect to different characteristics of polar, extra-tropical (e.g. Nissen et al., 2011&2013), and tropical storm events (e.g. size, area of maximum destructive wind speed, maximum wind gusts, rate of intensification, etc.). Responsible large to synoptic scale precursor parameters (e.g. baroclinicity, latent heat release, upper-tropospheric divergence) will be related to the occurrence of extreme cyclones (e.g. Ulbrich et al., 2001). In this research area, integrating the existing knowledge of understanding for the occurrence of extreme storms, also potential storm situations will be investigated by use of the storms included in the Ensemble Prediction System (EPS) and actual reanalysis products of the European centre for medium range weather forecast (ECMWF). Basis for the relevant storm identification will be the storm identification algorithm developed by Leckebusch et al. (2008, 2011).

Work programme

In principle, the project will address three research questions for three main types of systems.

- O1: Investigation of the main physical processes for the generation and transformation of cyclones into severe, damage prone wind storms
- O2: Identification of key circulation patterns and their relation to different physical characteristics of polar, extra-tropical, or tropical cyclone systems.
- O3: Analysis and Quantification of large-scale to synoptic scale precursor parameters (e.g. baroclinicity, latent heat release, upper-tropospheric divergence) for the modulation of the frequency of occurrence of extreme cyclones.

A) Polar Lows

Polar lows originate over open waters of the northern polar region due to high local baroclinicity, and/or katabatic outflow from ice covered land areas, especially at ice edges, and do have severe impact on the maritime activities in the Arctic Ocean. Additionally, they contribute to the energy transports to high latitudes. Beside the actual difficulties in forecasting this meso-scale meteorological phenomenon, information derived from climatological observations remains also sparse. Actual studies often make use of satellite based information by a manual analysis of available data for certain periods. With the wind storm identification algorithm (cf. above) an objective detection also of these small scale atmospheric vortices is possible in suitable re-analysis data. An assessment of interannual variability and long term trends are planned here.

B) Mid-latitude extreme cyclones and cyclone development

Cyclones and their developments leading to storms will be investigated in a more detailed way. Especially, this includes analyses of the typical characteristics of storms, e.g. the investigation of the development of the cyclones with respect to path velocities, spatial extension, time duration, intensity (Laplace p, wind speed) in reanalysis and ECMWF EPS and seasonal prediction (depending on data availability) data. In order to achieve a more homogeneous classification of the characteristics of different wind storms a Storm Severity Index (SSI) as developed in Leckebusch et al. (2008), will be applied. Additionally, investigations to the relationship between large/synoptic scale cyclone systems and local wind speeds, including the identification of the link between cyclone tracks and wind speed tracks (Leckebusch et al., 2006a; Nissen et al., 2010), will be carried out.

Large-scale fields influencing cyclones and storms will be analysed. Based on ECMWF ensemble forecasts, ERA40 data (analyses + forecasts), and GCM data from IPCC 4AR investigations of the role of different large scale (dynamic) parameters like baroclinicity (Eady parameter), latent heat release, upper tropospheric divergence, relevant terms of the Lorenz energy cycle (local energy transformations) and how they influence the path, duration, intensity and spatial extent of extreme cyclones will be carried out. Estimations of a typical time lag between relevant atmospheric conditions and the occurrence of extremes will be deduced.

Further on, in the North Atlantic region, high cyclone rates are often associated with strong jet streams [i.e., positive phase of the North Atlantic Oscillation (NAO)] and NAO has traditionally been regarded as the principal large-scale pattern that explains the variation in the rate of cyclones arriving in western Europe on decadal as well as seasonal scales (Renggli et al., 2011). Variability in the NAO will be linked to the occurrence of extreme cyclone systems over the Northeast Atlantic and Europe and investigated with respect to the work planned on seasonal to decadal timescales (Leckebusch et al., 2006b, Pinto et al., 2008).

C) Tropical cyclone systems

At third, an objective identification of damage prone tropical cyclones is possible. First tests have shown the suitability of this method with respect to the identification of the typical characteristics of tropical vortices, like effective radius, affected area, travel speed, etc. This study will help to understand spatial and time based variability patterns in tropical cyclone activity.

References

- Leckebusch, G.C., B. Koffi, U. Ulbrich, J.G. Pinto, T. Spanghehl, S. Zacharias, 2006: Analysis of frequency and intensity of European winter storm events from a multi-model perspective, at synoptic and regional scales. *Climate Research*, Vol. 31, 59-74.
- Leckebusch, G.C., D. Renggli, and U. Ulbrich, 2008: Development and Application of an Objective Storm Severity Measure for the Northeast Atlantic Region. *Meteorol. Z.*, Vol. 17, No. 5, 575-587. DOI: 10.1127/0941-2948/2008/0323.
- Leckebusch, G.C., S. Zacharias, J.G. Pinto, U. Ulbrich, A.H. Fink, 2006: Factors for the development of extreme north Atlantic cyclones and their relationship with a high frequency NAO index. Second THORPEX International Science Symposium (STISS), Landshut, 4.-8.12.2006. WMO/TD No. 1355, WWRP/THORPEX No. 7, 200 – 201.
- Nissen, K.M., G.C. Leckebusch, J.G. Pinto, U. Ulbrich, **2013**: Mediterranean cyclones and wind storms in a changing climate. *Reg Environ Change*, DOI 10.1007/s10113-012-0400-8.
- Nissen, K.M., G.C. Leckebusch, J.G. Pinto, D. Renggli, S. Ulbrich, and U. Ulbrich, 2010: Cyclones causing wind storms in the Mediterranean: characteristics, trends and links to large-scale patterns. *Nat. Hazards Earth Syst. Sci.*, 10, 1379-1391.
- Palmer, T.N., A. Alessandri, U. Andersen, P. Cantelaube, M. Davey, P. Délecluse, M. Déqué, E. Díez, F.J. Doblas-Reyes, H. Feddersen, R. Graham, S. Gualdi, J.-F. Guérémy, R. Hagedorn, M. Hoshen, N. Keenlyside, M. Latif, A. Lazar, E. Maisonave, V. Marletto, A. P. Morse, B. Orfila, P. Rogel, J.-M. Terres, M. C. Thomson, 2004. Development of a European multi-model ensemble system for seasonal to inter-annual prediction (DEMETER). *Bulletin of the American Meteorological Society*, 85, 853-872
- Pinto, J.G., S. Zacharias, A.H. Fink, G.C. Leckebusch, U. Ulbrich, 2008: Factors contributing to the development of extreme North Atlantic cyclones and their relationship with the NAO. *Clim. Dyn.*, DOI 10.1007/s00382-008-0396-4.
- Renggli, D., G.C. Leckebusch, U. Ulbrich, S.N. Gleixner, E. Faust, 2011: The skill of seasonal ensemble prediction systems to forecast wintertime windstorm frequency over the North Atlantic and Europe. **Monthly Weather Review**, Vol. 139, 3052–3068. doi: 10.1175/2011MWR3518.1
- Ulbrich, U., A.H. Fink, M. Klawns and J.G. Pinto, 2001: Three extreme storms over Europe in December 1999. *Weather*, 56, 70-80.

It is expected that Special Projects requesting large amounts of computing resources (500,000 SBU or more) should provide a more detailed abstract/project description (3-5 pages) including a scientific plan, a justification of the computer resources requested and the technical characteristics of the code to be used. The Scientific Advisory Committee and the Technical Advisory Committee review the scientific and technical aspects of each Special Project application. The review process takes into account the resources available, the quality of the scientific and technical

*proposals, the use of ECMWF software and data infrastructure, and their relevance to ECMWF's objectives. -
Descriptions of all accepted projects will be published on the ECMWF website.*