SPECIAL PROJECT PROGRESS REPORT

Progress Reports should be 2 to 10 pages in length, depending on importance of the project. All the following mandatory information needs to be provided.

Reporting year	2016
Project Title:	Investigation of large scale precursor conditions for extreme cyclone development in the extra-tropics
Computer Project Account:	SPGBLECK
Principal Investigator(s):	Dr. Gregor C. Leckebusch
Affiliation:	University of Birmingham School of Geography, Earth and Environmental Sciences University of Birmingham Edgbaston Birmingham B15 2TT
Name of ECMWF scientist(s) collaborating to the project (if applicable)	…… ……
Start date of the project:	January 2015
Expected end date:	December 2016

Computer resources allocated/used for the current year and the previous one (if applicable)
Please answer for all project resources

		Previous year		Current year	
		Allocated	Used	Allocated	Used
High Performance Computing Facility	(units)	--	--	5,000	0
Data storage capacity	(Gbytes)	--	--	2,000	0

Summary of project objectives
(10 lines max)
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 mainly extreme, severe mid-latitude winter storms. 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. In the project key circulation patterns will be identified and related to their physical origins with respect to different characteristics of extra-tropical storm events.

Summary of problems encountered (if any)
(20 lines max)

No principle problems encountered.

Summary of results of the current year (July 2015-June 2016)
This section should comprise 1 to 8 pages and can be replaced by a short summary plus an existing scientific report on the project

In the first 18 months of the special project, no allocated computer resources have been used. Nevertheless, an overview of activities so far making use of general ECMWF facilities in the context of this project is given here. In the course of special project, we intend to make use of the allocated storage and compute serve resources.
In the SPGBLECK project multiple datasets are used, especially for the investigation of extra-tropical cyclones and wind storm events. These datasets include: 1) ERA-Interim, 2) ECMWF Seasonal Forecasts (system3 & 4) and 3) ERA-20C. All datasets have been obtained via the MARS archive.
Our project mainly focuses on the investigation of extra-tropical cyclones in the European / North Atlantic region. Two algorithms to detect cyclones as well as wind-storm events are used for the identification in the above data sets.
In the previous report we focused on the analysis of potential and real predictability of extreme storms in actual state-of-the-art seasonal forecast suites, e.g. the ECMWF (system3&4) forecasts. In this report, we describe results for a recent analysis on the storminess of the 20th century. The MARS archive has been used to obtain the respective data set. Northern hemispheric cyclones are identified by using 6-hourly MSLP data, whereas near-surface (or lower pressure levels) wind speeds are used to detect wind storm events.
ECMWF facilities have also been used for a study analysing the newly released ERA-20C dataset. Extra-tropical cyclones and wind storms over both hemispheres have been identified for the period from 1901 until 2008. The aim of this study is to investigate differences of longer- and shorter-term variability in ERA-20C and the NOAA-20CR dataset regarding these events. First results indicate partly different long-term trends in both sign and magnitude for cyclones and wind storm events in the respective re-analyses. A publication summarizing this work is submitted (Befort et al., 2015b) and currently under review. The following section gives an overview of the related core findings for the Northern Hemisphere (NH):

<u>All Cyclone Events</u>
The cyclone track density pattern (for the 1961-1999 period) is characterised by the two well-known centres of activity over the North Atlantic and North Pacific. We assume that the quality of both reanalyses is best for this most recent period. Consequently, we expect largest agreements between both datasets for the last period. However, we find more cyclone tracks for ERA-20C than

in NOAA-20CR (about 29% between 1961 and 1990 over the Northern Hemisphere). This is partly related to the finer resolution of ERA-20C (see Pinto et al., 2005). Consistently, we only find about 11% fewer cyclones over the northern hemisphere when interpolating the ERA-20C data to the coarser NOAA-20CR grid compared to the original ERA-20C data.
Trends of cyclone tracks over the NH differ drastically between the two datasets for the first and second period. As a measure of lower-frequency variability (LFV) agreement, the difference of regression coefficients of the linear models derived from both datasets is calculated and expressed as change of events per decade. For the first period we find and increasing trend of cyclones for both datasets, but the increase in ERA-20C is about 46 events/decade smaller compared to NOAA-20CR. For the second period the long-term trend reverses in NOAA-20CR and the differences of the long-term trends are above 129 events/decade. However, small changes of only -5.9 events/decade are found for both datasets in the last period. The disagreement in the first and second period is due to a distinct increase of events over the Polar region and (to a lower degree) over the North Atlantic around the year 1920 in the NOAA-20CR dataset. This increase is not present in the ERA-20C. The NOAA 20CR maximum is followed by a decreasing trend until the end of the century, again mainly influenced by the polar region, while ERA-20C shows a positive trend from 1900 until 1960 both over the entire hemisphere and over the pole. Over Northern Europe the sign of the long-term trends differ for the first and second period, but these trends are not significant ($p>0.05$). The sign of the long-term trends agree for the third period between both datasets, but their magnitudes differ by around 6 events/decade. For the North Atlantic, the sign of the long-term trend agrees for the first and second period but they differ for the third (5.31 events/decade), with only ERA-20C showing a significant trend. Over the Polar Region, results are similar to the complete Northern Hemisphere, with opposite trends in both datasets for the second period.
The agreement of the higher-frequency variability (HFV) is expressed by the correlation between both high-pass filtered time series. In general, we find positive correlations for all periods for all regions, with highest coefficients (above 0.7) found for the third period.

Most Extreme Cyclone Events

The analysis of the most extreme cyclones (core pressure of less than 970hPa) shows a reduced maximum of cyclone events around 1920 in NOAA-20CR, suggesting that the higher number of events seen for all cyclones is mainly due to weaker events. We find increased numbers of events around 1990 in both datasets and in all regions. In general, LFV of extreme cyclones is in better agreement between ERA-20C and NOAA-20CR compared to all cyclones, as longer-term trends show the same sign in all regions and all periods except for the second period over the Northern Hemisphere. However, only ERA-20C shows a significant trend different to zero for the second period over the Northern Hemisphere. Even when the sign of the trends agree, large differences in their magnitudes are found, e.g. of about 1.7 events/decade during the third period over Northern Europe.
A better agreement for the most intense cyclones and all cyclones is also found in terms of HFV. Correlations are higher for the most intense cyclones except during the third period over the North Atlantic region where both correlation coefficients are similar (all cyclones: 0.87; most extreme cyclones: 0.83).

Windstorm Events

The two main centres of windstorm activity over the Pacific and Atlantic oceans are well represented by ERA-20C during the period from 1961 until 1990. For this period differences between both datasets are comparably small and partly related to the different height level used to identify windstorm events. As expected, absolute differences between both datasets decrease from the beginning to the end of the 20th century. For the period from 1901 until 1930 we find more windstorm events in NOAA-20CR compared to ERA-20C mostly over the polar region, which is in line with the enhanced cyclone activity over the region found for this time period in NOAA-20CR.

Regional trends of windstorms are similar to extreme cyclone events. We find a maximum of windstorms around 1920 over the Polar region in NOAA-20CR. ERA-20C shows an increased number of windstorm events during the 20th century in all regions. This disagreement of the LFV is expressed in different signs of the linear regression coefficients for the first period in all regions except the North Atlantic. However, it should be noted that over Northern Europe linear trends do not differ significantly from zero in NOAA-20CR. Over the Polar Regions and the Northern Hemisphere different signs regarding the trend are found for the second period, too. For the third period of the century, long-term trends of both datasets have the same sign, except over the whole Northern Hemisphere. However, a Mann-Kendall test revealed only the positive trend in ERA-20C to be significant different from zero. Large deviations between the magnitudes of the trends are found for all regions, highest for the first two periods, reaching up to 100 events/decade over the Northern Hemisphere in the second period.
The HFV of windstorms is in good agreement, with positive correlations for all periods, again with in general higher correlations for the last period. This is similar to the results carried out for all cyclone and extreme cyclone events.

List of publications/reports from the project with complete references

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Peer-reviewed Publications:

Befort, D.J., G.C. Leckebusch, A. Weisheimer, J. Knight, H. Thornton, and J. Roberts, 2016: Verification of state-of-the-art ECMWF and Met Office Seasonal Forecast Suites in Simulating Wintertime Cyclone and Wind Storm Events over the Northern Hemisphere. in preparation

Befort, D.J., S. Wild, T. Kruschke, U. Ulbrich and G.C. Leckebusch, 2016, Long-term Trends of Extra-tropical Cyclones and Wind Storms in ERA-20C and NOAA-20CR, **Atmospheric Science Letters**, under review.

Conference contributions:

Leckebusch, G.C., Befort, D.J., A. Weisheimer, J. Knight, H. Thornton, J. Roberts and L. Hermanson, 2015: Extra-tropical cyclones and Windstorms in Seasonal Forecasts. EGU2015-11120. EGU General Assembly. Vienna, Austria.

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

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The project will continue as planned and described in the original project description. As we did not use any compute-server facilities, probably **wish to maintain access to the meteorological archive and ecgate after the end of this year** by asking our national meteorological service directly for a user registration outside the Special Project framework.