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	2014
Project Title:	An extreme wind climatology for Dutch Water Defences ………………………………………………………………
Computer Project Account:	spnlburg…………………………………………………….
Principal Investigator(s):	Reinout Boers, since Sep 2013 [formally Gerrit Burgers]……………………………………………. ………………………………………………………………
Affiliation:	Royal Netherlands Meteorological Institute (KNMI)…….
Name of ECMWF scientist(s) collaborating to the project (if applicable)	NA………………………………………………………. ………………………………………………………………
Start date of the project:	January 1, 2013………………………………………….
Expected end date:	December 31, 2015………………………………………

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 until June 18
High Performance Computing Facility	(units)	NA	NA	3000000	2888574.56 [98%]
Data storage capacity	(Gbytes)	NA	NA	3000	218440

June 2014

Summary of project objectives

- The objective of the special project is to make high-resolution simulations of all major storms over the Netherlands from the period 1979-2012 using the Harmonie-Arome model (2.5km grid) for dynamical downscaling the ERA-Interim re-analysis.

- The special project contributes to a joint project of KNMI and Deltares that is funded by the Netherlands National Water Authority RWS and has the following objectives
  - Assessment how well high-resolution models can represent storm fields.
  - Production of a long-term (~ 30 year) storm data set that can be used for deriving extreme wind statistics needed for the design of Dutch water defenses.
  - Extreme value analysis of storm fields, including a proper space and time dependence.

Summary of problems encountered (if any)

None.

Summary of results of the current year

R. Boers, with contributions from P. Baas, H. van den Brink and G. Burgers

The Harmonie model set-up for this special project simulation is version CY37h1. In selecting a model set-up for Harmonie_Arome, we have stayed as close as possible [but not the same] to the version that is used for NWP at KNMI The model is run on a domain with 500x500 grid points and a grid-spacing of 2.5 km. The domain is centered on 54°N 2°E. In order to keep the computational costs of the special project manageable, the domain is smaller than in the version that is used at KNMI for NWP. The domain covers a substantial part of the North Sea because that is an area that is relevant for storms that have impact on the Netherlands.

Rest of the set-up of the model was described in the Burgers' progress report of last year [June 2013] which we will not repeat.

The calculation capacity of the ECMWF special project is estimated to be sufficient to hindcast about 2500 days with HARMONIE, which is equivalent to about 20% of the full ERA-interim period (1979-2012). Therefore a strategy was developed how to proceed in the ERA-interim model data base so that at least the most relevant storms would be calculated.

A short outline of this strategy was presented in the report of Burgers last year, but the procedure was altered to accommodate comments from the Project Manager. The revised procedure which has now been implemented in 2013 - 2014 is described below:

This procedure called for the designation of a set of parameters used to indicate relevant situations at specific locations: all these parameter influence (directly or indirectly) the determination of the Hydraulic Boundary Conditions. It may be clear that most of these parameters are (strongly) correlated: The event that causes the highest skew surge along the coast for a certain location, is likely to cause also high surges at other locations; also the still water levels will be high, as well as the waves and the (North-Westerly) winds. Table 1 shows the set of parameters.

Table 1: Parameters that (indirectly) influence the Hydraulic Boundary Conditions.

Still water level along the coast
Skew surge along the coast
Significant wave height along the coast
Omni-directional wind speed (sea & land)
Directional wind speed

The locations used are indicated in Figure 1. The green locations are used for wave observations, the red locations for water level and surge and the blue locations for wind. The black square indicates the location used for direction-dependent geostrophic wind.

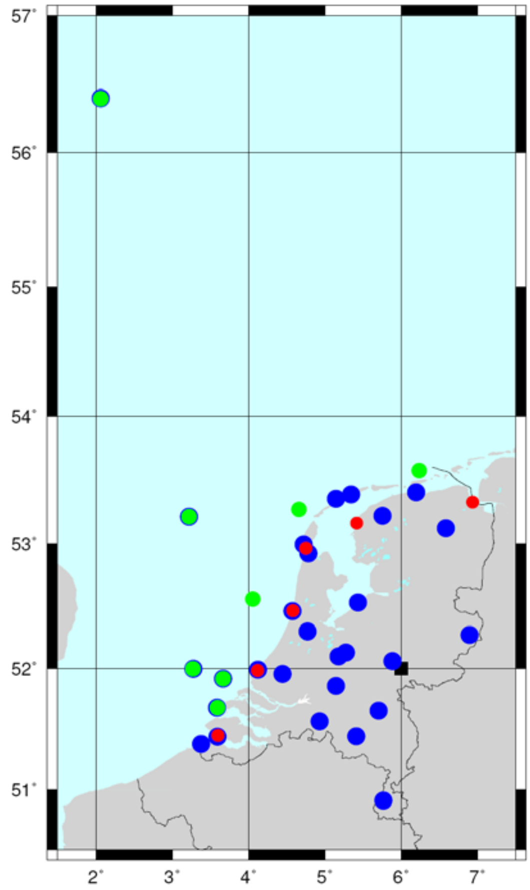

Figure 1: locations of the stations used. The green locations (8) are used for wave observations, the red locations (6) for water level and surge and the blue locations (28) for wind. The black square indicates the location used for direction-dependent geostrophic wind.

The prioroty settings for hindcasted set of HARMONIE days has to comprise the following:

- All annual extremes for all parameters *p* for all locations *l.*
- As much as possible extremes for all parameters *p* for all locations *l.*
- At least one full representative year *Y*, preferably two years. This dataset is necessary to intercompare climatological statistics.
- A minimum temporal window *T* around the extremes, with 2/3*T* before the extreme value is reached, and 1/3*T* afterwards.

For every location per parameter we determine the independent extremes using a moving window of 49 hours. The purpose was to find optimal values for the time window *T* around every extreme, the number of hindcasted extremes *n* for every parameter and every location, and the most representative year(s) *Y* for the full-year hindcast. Theoretically, the variables *T* and *n* may be parameter- and location-dependent; however, for clarity and simplicity, we kept them parameter- and location-independent.

Figure 2 shows how many days have to be hindcasted as a function of the required number of hindcasted extremes per parameter, both for the individual parameters (colors) as well for all parameters together. For example: reproduction of the 60 most extreme events for the direction-dependent geostrophic wind requires 1150 hindcast days.

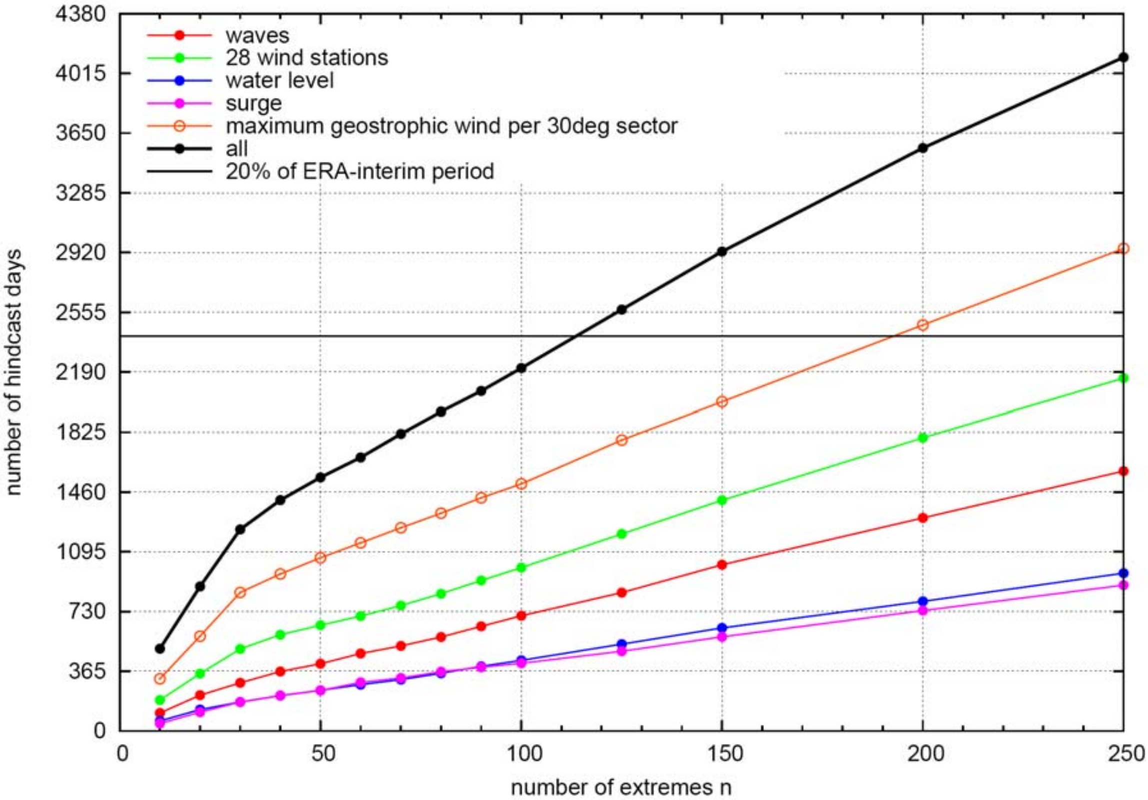

Figure 2: Effect of the number of extremes *n* per parameter on the number of hindcast days if the time window *T* around every extreme is chosen to be 72 hours. The colored lines show the relation for the individual parameters, the black line shows the number of hindcast days if for every parameter the same number of extremes is hindcasted. The horizontal black line indicates 2400-days constraint (20% of ERA-Interim).

The figure shows that surge and water level require much less hindcast days than the wind locations. This is caused not only by the fact that the surge and water level are represented by only 6 locations, and the wind by 28 locations, but also due to the higher correlation between the surge/water level locations than between the wind locations. The black dots indicate the number of hindcast days for all parameters simultaneously, showing that maximally 115 extremes for every parameter can be hindcasted within the calculation capacity constraint (leaving no space for the full year *Y* hindcast). This number holds if *T*=72 hours per extreme (2 days before, 1 day after) are hindcasted; extending the temporal window around the extreme will naturally reduce the number of extremes that can be hindcasted.

At least one full year should be included as well. For the representativeness of that certain year compared to the whole ERA-Interim period, we consider both the wind speed and the wind direction. The wind speed is considered to be representative if the Weibull scale and shape parameter for the specific year are close to the Weibull parameters of the whole period.

Figure 23 shows the scatter plot of the scale and shape parameter for all years separately (red/green) and for the whole period (blue) for the grid-point (3E,55N).

It indicates that the wind speed of the year 1996 is most representative.

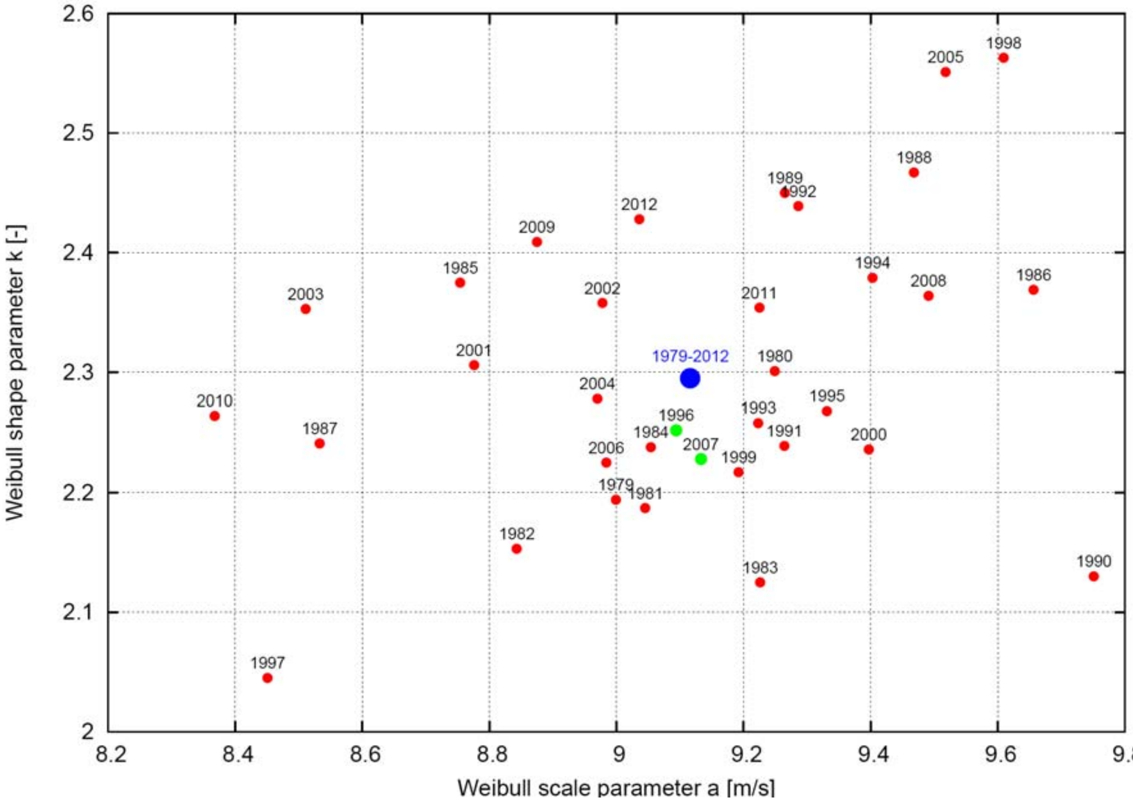

Figure 2: Scatter plot of the Weibull shape parameter against the Weibull scale parameter for all years in the ERA-interim period, both for each year separately (red/green) and for the whole period (blue) for the grid point (3E,55N).

The representativeness of the wind direction is quantified by calculating the frequency of the wind direction per sector of 30 degrees, and comparing this frequency per year with the frequency over the whole ERA-Interim period.
The left graph of Figure 3 shows the windrose for the whole ERA-Interim period (1979-2012, red), and for the years 1996 and 2007. It shows that the windrose for 2007 is rather similar to the whole ERA-Interim period, but that 1996 has much more Northerly winds, and much less southerly winds. The right graph of Figure 3 shows the difference between the individual years and the climatology, expressed as the Mean Absolute error, summed over the 12 sectors. It shows that 1996 has the most extraordinary distribution of the wind direction, whereas 2007 is much closer to the climatological windrose.

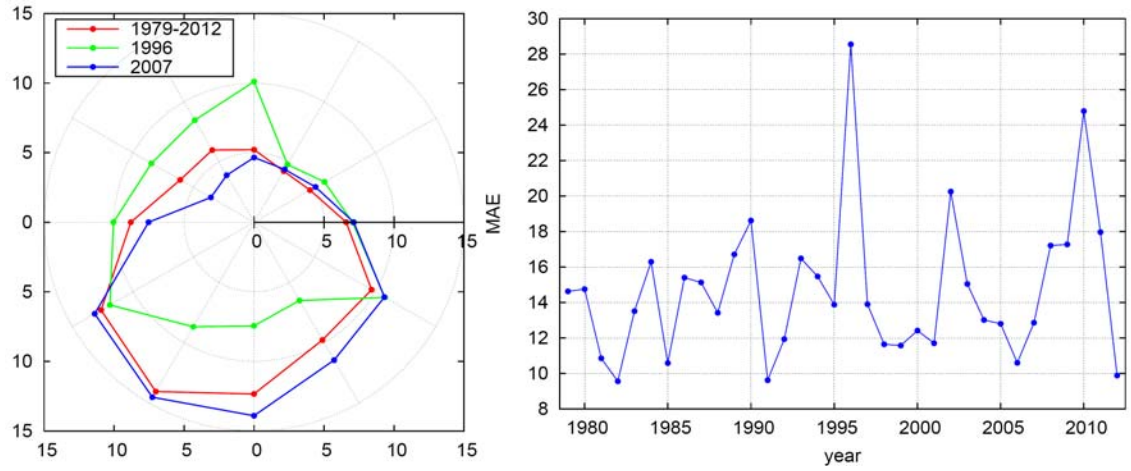

Figure 3: Left: windrose for the grid point (3E,55N) for the whole ERA-Interim period (1979-2012, red), and for the years 1996 (green) and 2007 (blue). The values are expressed in percentages. Right: Mean Absolute Error between the individual years and the climatological windrose.

We therefore choose to use 2007 for the full hindcast. If (calculation) time permits [at present not very likely], 1998 will be added, which is an extreme year with respect to the wind speed (see Figure 22).

Considering the annual maxima plus the 100 most extreme events in the ERA-interim period (based on observations) for all available locations and parameters, each over a period of 72 hours, plus 2007 as a whole, leads to hindcasting about 19% of the ERA-interim period, which turned out to be just within the computational capacity.

The procedure outlined above has now been implemented. Up to now [June 2014] much of the 19% of the Era-interim period has been hindcasted using HARMONIE.

List of publications/reports from the project with complete references

1) The added value of the high-resolution HARMONIE model for deriving the HBCs
Contribution to WP 1 of the WTI 2017 Wind Modelling Project Burgers, G., P. Baas and H. van den Brink. Internal project summary document, available on request.

2) Final Report WP1 of the WTI Wind Modelling project, Peter Baas, draft [June 2014]

3) How atmospheric stability affects the near-surface wind over sea in storm conditions. P Baas, FC Bosveld, and G Burgers, submitted to Wind Energy, presently in revision.

Summary of plans for the continuation of the project

At present the required 20% of hindcasted days is nearing completion. Yet, it was found that about 1% of runs aborts without completing the runs. It is not clear why this is so and investigations are under way to understand this issue. This will mean rerun of a small percentage of hindcasted days. Further on into the rest of 2014 and into 2015, we will continue to fill in the rest of the ERA – interim period. However, the requested ECMWF-computer time will not suffice to do so, and parallel to the requested ECMWF-computer time we use KNMI-budget as well.