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	2013
Project Title:	An extreme wind climatology for Dutch Water Defences …………………………………………………………..……
Computer Project Account:	spnlburg………………………………………………..
Principal Investigator(s):	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	2000000	311000
Data storage capacity	(Gbytes)	NA	NA	3000	pm

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 defences.
  - 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

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

Some of the work reported here was carried out in the 2nd half of 2012, before the formal start of the special project.

Selection of Harmonie model set-up

In spring 2013, we have finished the Harmonie model set-up for the special project simulations. In selecting a model set-up for Harmonie_Arome, we have stayed as close as possible to the version that is used for NWP at KNMI. In this way, we can gain from experiences with Harmonie in NWP.
- We use HARMONIE version CY37h1.1 (released in June 2012).
- 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 (see *Figure 1*). 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.
- The model time step is 1 minute, the vertical grid consists of 60 levels (the five lowest levels are at 10, 30, 60, 90, 130 m above ground level).
- Output frequency is once per hour.
- Every 6 hours a forecast with a forecast length of 6 h is initialized from the ERA-Interim reanalysis dataset from the ECMWF.
- Longer time series are constructed by combining the +001 to +006 lead-times of the subsequent HARMONIE runs. We checked that, although not complete, spin-up after 1 h is sufficient for representing storm wind fields.
- As in the default HARMONIE set-up we use the ECUME drag formulation (Weill *et al.*, 2003) over sea and a Charnock formulation ($\alpha = 0.015$) for lakes and rivers. The ECUME formulation is roughly equivalent to a Charnock formulation with $\alpha = 0.020$. Note that the wave-dependent drag formulation that is used in ERA-Interim gives rise to drag coefficients that corresponds on average of about $\alpha = 0.030$.

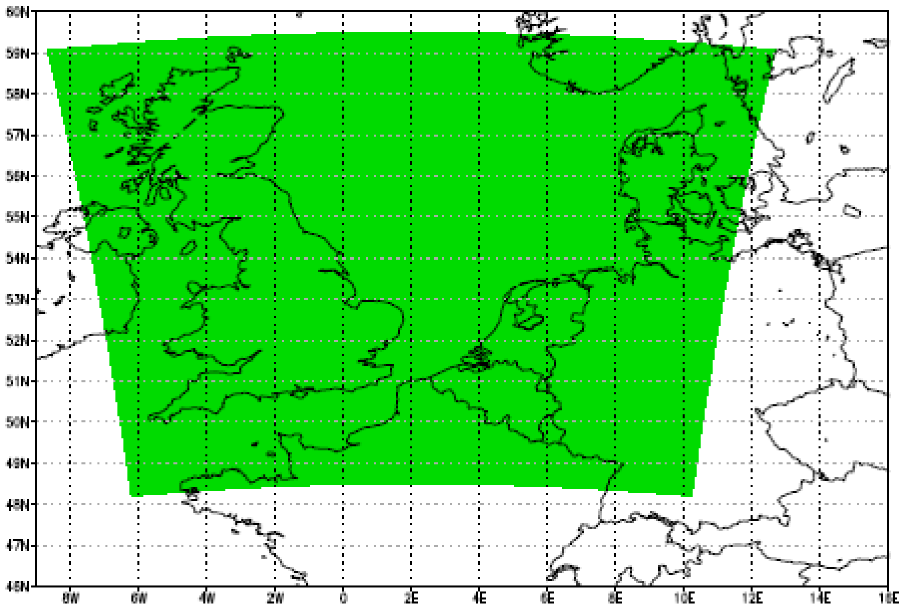

Figure 1. Harmonie domain used for the simulations.

Evaluation of Harmonie on 16 historical storms

In fall 2012, we have carried out a first evaluation of 14 storms from the period 1979-2012. From a comparison with surface observations, we found that Harmonie could adequately represent the wind speed maxima of the storms, but that one should be careful in comparing observations to model values at mixed land-sea points. In the first half of 2013, we have made a much more extensive comparison for 16 storms (the original 14 plus two extra).

Model results have been compared with in-situ observations and with scatterometer observations. In case of observing stations that behave as a water station, we compare to the model gridpoint in a 3x3 grid box environment that has the largest water fraction. Based on this comparison, we conclude that wind fields produced by the model have sufficient quality for the purpose of our special project. *Figure 2* shows the distribution of modelled and observed wind speed for the 16 storm and all in-situ stations. Temporal and spatial characteristics of the model are generally wel captured. Discrepancies with observations are largest for small storm depressions, which develop explosively and that pass close to the Netherlands.

Over sea, modelled wind speeds show a positive bias of about 0.5 m/s. For most stations the rms error is between 1.5 and 2.0 m/s. For wind speeds over 17.2 m/s (8 Bft or higher) these values hardly change. The bias in wind direction is a few degrees, rms scores range from 15° when all data are taken into account to order 10° for winds of 8Bft and higher. These numbers are rather similar to those derived in operation practice. Note that the observational error is about 1 m/s in the wind speed and 10° in wind direction. Bias and rms error scores based on satellite winds over open water from Quikscat agree with scores derived from station observations.

Over land, the wind speed bias is mostly close to zero with rms errors between 1.0 and 1.5 m/s. However, for wind speeds over 8 Bft generally a negative bias of about 2 m/s is identified with rms errors varying from 1.5 to 4 m/s. Temporal correlation between modelled and observed wind speed is 0.95 over sea. Spatial characteristics are generally wellcaptured. Spatial correlation between observations valid at the same time amounts 0.87 on average. HARMONIE represents spatial gradients between a selection of stations in 10-m wind speed and surface pressure rather well. Wind patterns over Lake IJssel are accurately reproduced by the model, including the impact of stability on the near-surface wind speed. It is demonstrated that for high wind speeds stability effects leave the vertical wind speed ratio relatively unaffected, while the water/land ratio changes significantly.

A draft version of a report "Evaluation of HARMONIE simulations for 16 historical storms" has been written by P. Baas.

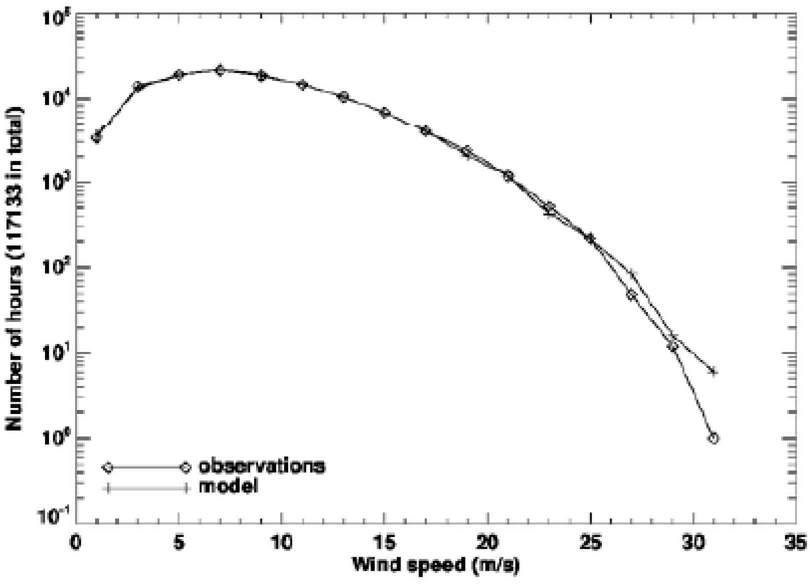

Figure 2. Distribution of modelled and observed 10-wind speed (m/s) for all storms and all in-situ stations for bins of 2m/s.

Approach for selection of storm periods that will be simulated

The resources of the Special Project are sufficient for approximately 6 years of Harmonie simulations, much less than the 30+ year length of ERA-Interim. So the idea is to simulate storm periods only. The question is how to select storm periods if one is interested in determining hydraulic boundary conditions for Dutch Water Defenses.
The length of a storm period should be long enough to allow for the spin-up of wave and surge models. In selecting the periods, we want to capture events with extreme winds, surges and waves. Although the emphasis is on strongest wind speeds, we also wish to cover winds from all wind directions. Another consideration is that we want to include the annual extremes of wind, surge, wave, as this is input for some statistical methods. Finally, we want to include one full year, in order to have an estimate of the wind climate in non-storm periods, and to compare this full year with ERA-Interim. Of the above requirements, capturing wind extremes from all directions is the most stringent (see *Figure 3).* But we are much more interested in the very strong maxima from the South West and North West than the relatively weak maxima from the South East. For this reason, we keep the top-100 extremes per variable, except for wind-per-sector where we keep the top-10. In addition, we will keep all annual maxima. For the complete year we will take 1996 which is a rather "average year" in terms of extreme wind statistics, and possibly 1998. Making the above choices implies that we can take 72h for the length of the storm period, which is the minimum length that allows for a proper spin-up of wave and surge models (after a "pre-spinup" based on ERA-Interim).
So our approach can be summarized as: make 72h simulations of the annual maxima and top-100 of wind speed, surge and wave (top-10 wind-per-sector), plus a simulation of the complete year 1996.

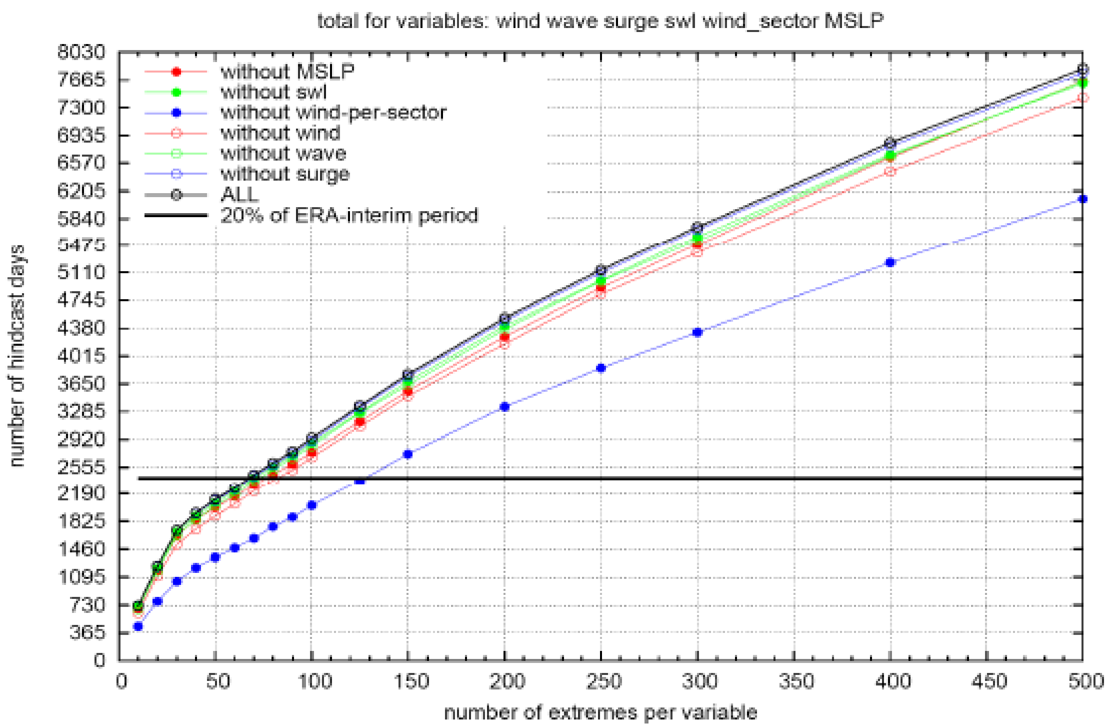

Figure 3. Time required for simulating top N events of 144h. Black open circles: all types, blue circles if one does not include wind speed extremes from each direction separately.

List of publications/reports from the project with complete references

H. van de Brink, P. Baas and Gerrit Burges, Towards an approved model set-up for HARMONIE Contribution to WP 1 of the SBW-HB Wind modeling.   KNMI – Deltares Internal Report, February 2013, Available from KNMI publication website.

Burgers, G., P. Baas and H. van den Brink, Towards an extreme wind climatology for The Netherlands based on downscaling ERA-Interim with the HARMONIE-AROME high-resolution model. Poster: EGU 2013, 11/4/2013, Vienna, EGU.

Summary of plans for the continuation of the project

Publication of the final version of the report "Evaluation of HARMONIE simulations for 16 historical storms" by P. Baas, summer 2013.

We will use much more computer time in the 2nd half of 2013 than in the 1st half of 2013. In July, we plan to start the production phase of the project, which will last until the end of the project in the first half of 2015. For the selection of which storms we simulate, we will use the approach outlined above in the Summary of results of the current year. We will start with the more extreme storms, and work progressively work towards the simulation of less extreme storms.