SPECIAL PROJECT PROGRESS REPORT

All the following mandatory information needs to be provided. The length should *reflect the complexity and duration* of the project.

Reporting year	2021
Project Title:	Downscaling extreme sea-surge events from climate models using Harmonie
Computer Project Account:	spnlbrin
Principal Investigator(s):	Henk van den Brink (henk.van.den.brink@knmi.nl)
Affiliation:	KNMI (Royal Netherlands Meteorological Institute)
Name of ECMWF scientist(s) collaborating to the project (if applicable)	-
Start date of the project:	1 January 2021
Expected end date:	31 December 2022

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)			20M	8,5M
Data storage capacity	(Gbytes)			5,000	1,750

Summary of project objectives (10 lines max)

In order to use the 8000+ years of SEAS5 stresses for the calculation of extreme surges and sea levels along the Dutch coast, the effect of the spatial and temporal resolution of SEAS5 on the outcomes, as well as the effect of the limited resolution of DCSM5 has to be explored. For this purpose, we select the ~250 most extreme events and downscale them with HARMONIE (from 7 days before till 3 days after the maximum surge).

Summary of problems encountered (10 lines max)

Quite some time was spent in a careful selection of the most appropriate events, which had to be downscaled first from EC-Earth2.3 with RACMO. Downscaling with HARMONIE started therefore in May 2021. However, the downscaling process is going smoothly, so not problems are expected for the rest of the year.

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

Downscaling of 250 events are planned for this year, 100 are already done; It is probable that analysis of those events indicates that additional events have to be downscaled (e.g., with a specific wind direction, a specific season, or for a specific location). This can be done in 2022, as we have requested another 20MSBU for 2022.

List of publications/reports from the project with complete references

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Summary of results

The whole procedure consists of the following steps:

1. Downscale the whole 2416-year (16 members for 1950-2100) dataset of EC-Earth2.3 with RACMO. These 16 members were generated for the CMIP5 dataset.
2. Calculate the surge levels for the whole 2416-year dataset
3. Select approximately 250 depressions that cause the most extreme surges.
4. Downscale these 250 events from about 7 days before till 3 days after the maximum surge with HARMONIE.
5. Calculate the surge for:
    1. The un-altered HARMONIE fields
    2. The HARMONIE fields downgraded to the SEAS5 horizontal resolution
    3. The HARMONIE fields downgraded to 6-hourly timesteps (i.e. the timestep of the SEAS5 output)
    4. the HARMONIE fields downgraded to both the spatial and temporal resolution of SEAS5.
6. Intercompare the most extreme surges for steps 1 to 4 (in which intercomparison of step 4 with step 1 is the most important one). It is likely that the extreme surges in step 4 will be lower than in step 1, but the amount of reduction may well depend on the coastal location, as well as on the type of depression (size, track, track speed, etc).

In order to try to cover all possible surge-related depression types (which we don't know beforehand!) we paid a lot of attention to step 3 (selection of 250 depressions); For this selection it is important to know whether the depressions that cause the most extreme surges differ per location. We focused on a comparison of Hoek van Holland (in the south) with Harlingen (in the North).

Analysis

First, the climatology of the mean sea level pressure (mslp) in winter (DJF) is determined from the RACMO output (see step 1 above):

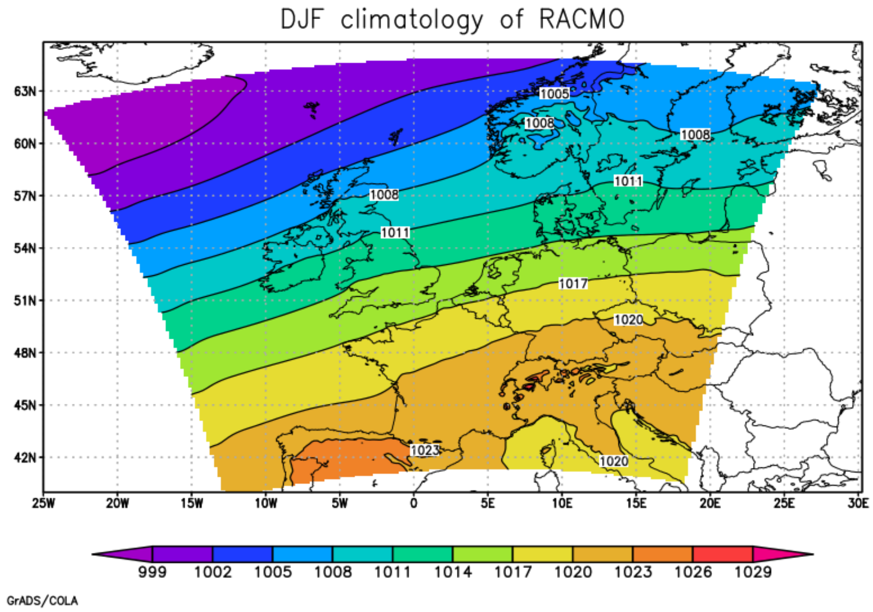

Figure 1: Climatology of the DJF mslp according to RACMO.

Second, the difference in mslp with respect the climatology is used to track the center of all depression that causes an annual maximum on any of the 14 locations along the Dutch coast[1].

The locations of the minimum mlsp 18 hours before the maximum surge for the 50 most extreme cases are indicated in Figure 2. The red numbers indicate the extremity of the corresponding surge in Hoek van Holland (in the south of The Netherlands), and blue in Harlingen (in the north of The Netherlands). The figure shows a large scatter, so there is a large variety in positions of depressions that cause extreme surges. This is further illustrated with the two insets, which shows the mslp patters for depression 4 (lower panel, center over Ireland) and 8 (upper panel, center over Finland).

1 Cadzand, Goeree,Westkapelle ,Vlissingen, HoekvanHolland, Scheveni, Meetpost Noordwijk, IJmuiden Denhelder, Texelnoord, Harlingen, Westterschelling, Huibertgat, Delfzijl

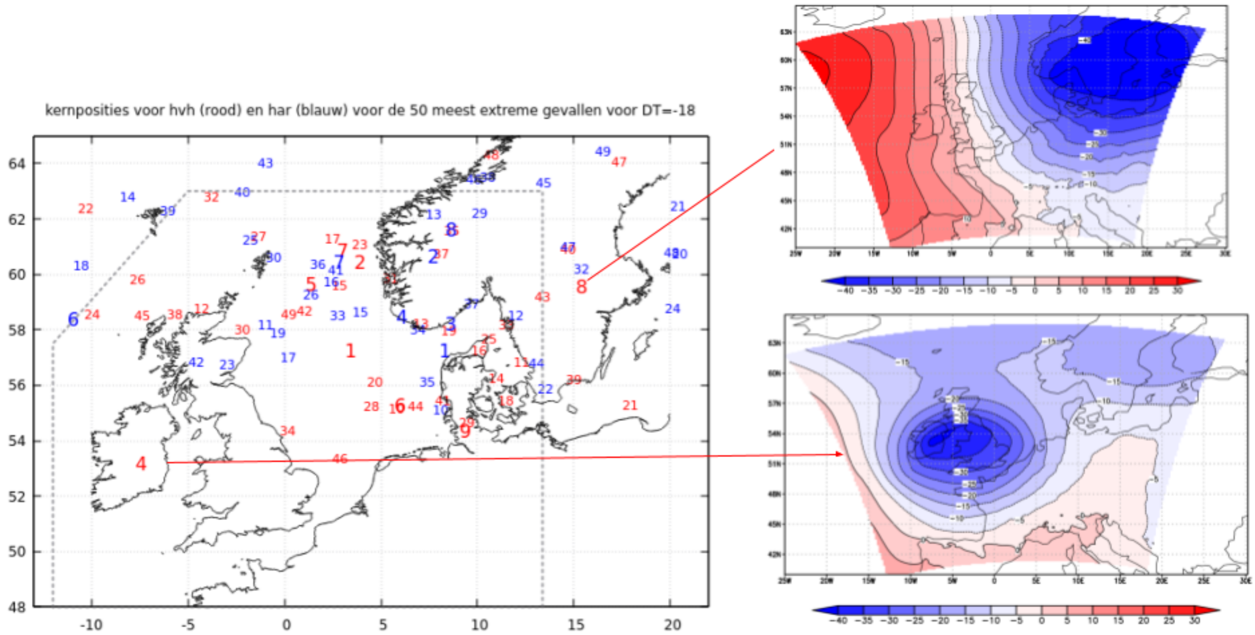

Figure 2: Locations of the centers of the depressions that cause the 50 highest surges in Hoek van Holland (red) and Harlingen (blue). The insets (right) illustrate 2 mslp patters for events 4 and 8 for Harlingen.

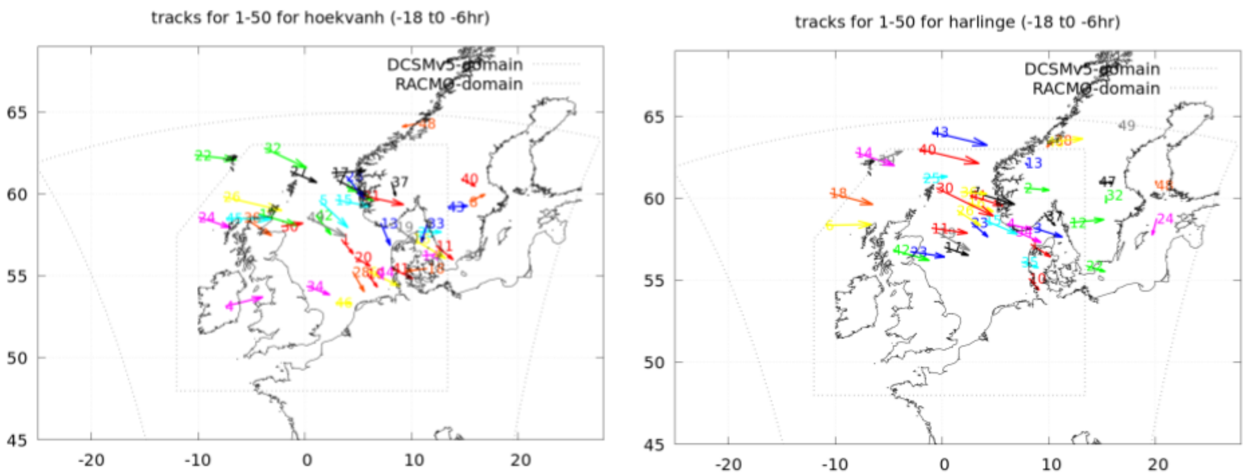

Figure 3: Tracks for the depressions that cause the 50 most extreme surges in Hoek van Holland (left) and Harlingen (right). The arrows point from the location of lowest mslp at 18 hours before the maximum surge to the location at 6 hours before the maximum surge.

The tracking speed of the depressions that correspond with the 50 most extreme surges in Hoek van Holland and Harlingen are shown in Figure 3, the arrows indicate the shift in the center of the depression form 18 hour to 6 hours before maximum surge.
For Hoek van Holland quite some events move much southerly (and also with a more southward component) than the events for Harlingen. These arrows are also closer to Hoek van Holland than is the case for Harlingen. This gives rise to the hypothesis that the extreme surges in Hoek van Holland are more often caused by relatively small (but intense) depressions than in Harlingen.

Selection procedure

From the above analysis it becomes clear that the selection of the most important 250 depressions cannot be limited to a single location, as surge-generating depressions of Hoek van Holland and Harlingen behave differently.

We therefore followed the procedure below:

1. Select 250 most extreme (skew) surges for all 14 locations along the Dutch coast (see footnote 1 for locations). This leads to 614 different depressions.
2. From these 614 events, select 250 events with highest return periods. The return period is the average of the return period over all 14 stations and the highest return period of those 14 stations.
3. Additionally, downscale the following events:
    1. the 5 largest events
    2. the 5 smallest events (with surges in the top-250)
    3. the 5 most northward centers
    4. the 5 most southward centers
    5. the 5 highest geostrophic wind speeds over the North Sea
    6. the 10 highest easterly wind speeds
    7. the 10 highest southerly wind speeds

The focus for 2021 is on the downscaling of the 250 events, the additional events (and possibly extra events if distinct types of depressions are found that need extra analysis) will be done in 2022.