Available North Sea Data Sources for Offshore Wind Farm Development

Job C. van Noorloos.

Delft University of Technology, Wind Energy Research Group
PO Box 2600 GB Delft, the Netherlands

j.c.vannoorloos@lr.tudelft.nl

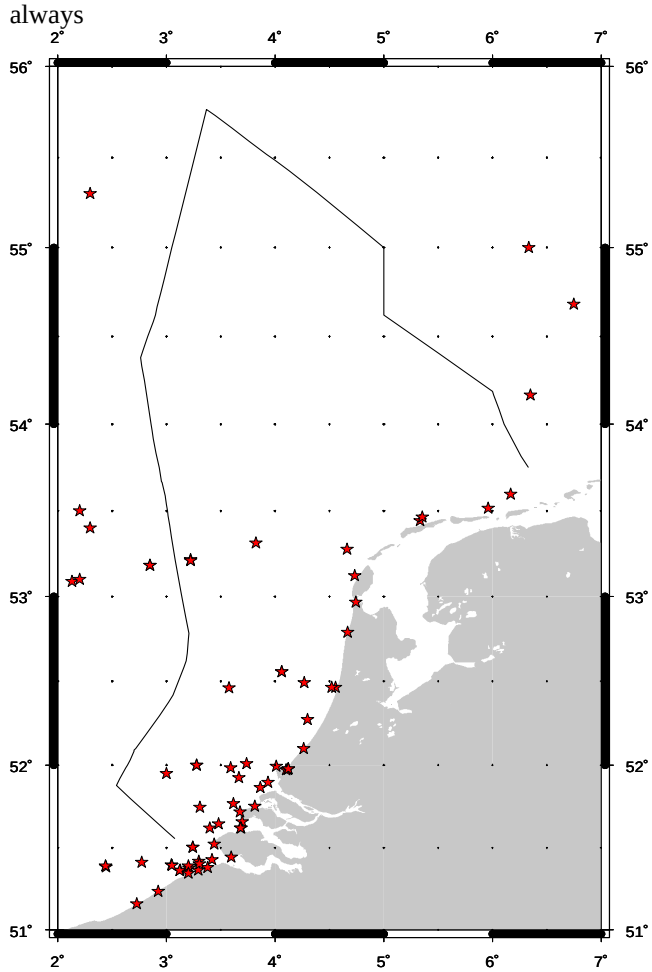
ABSTRACT

The Dutch government formulated a 6000 MW target for offshore wind power in 2020. However, current design practice of offshore wind farms is characterized by uncertainties concerning site data. Wind, waves and especially soil conditions can vary radically on spatial scale, which disables the possibility to simply extrapolate, or copy the conditions to other locations. Measurement campaigns can reduce the uncertainties, but are time-consuming and very expensive. This paper will give a an overview of the publicly available data concerning the North Sea with their specifications. Furthermore, data sources are highlighted Current PhD-research activities aim at a firm connection between the supply and demand for this offshore wind energy data.

This research is part of a large PhD-programme coordinated by WE@SEA[1]. Central objective of WE@SEA is to create a structural basis for long-term business development in the Netherlands. Therefore, this research is primarily focused on application of data in the Dutch North Sea. In this report the supply of data needed for offshore wind farm development is addressed. Main objective is to classify current data availability. Temporally changing conditions, such as wind and waves, are emphasized in this analysis, although constant conditions (e.g. soil parameters) also play an important role in the development process. Focus is also on the local mean values, not on forecasting meteorological conditions or sea states. Since many organizations, commercial and governmental, record site conditions in the North Sea the overviews in this report cannot be considered as all-comprising.

In-situ measurements

Although every measurement principle has limits on accuracy, in-situ measurements are considered to be the best representation of the quantity measured. In the Dutch Exclusive Economic Zone (EEZ) at numerous locations (see Figure 1) various data is collected. Rijkswaterstaat is a governmental body collecting many hydrological and meteorological characteristics in the Dutch area. This collecting process is standardized and defined in [1]. It deals with the data collection from sensor to distribution and validation. The standard creates uniform data provision downstream of the measurement process, regardless of the sensor type. The resolution of the resulting data will always



[1] Wind Energy at Sea.

Figure 1. In-situ measurement locations in Dutch EEZ, also SEANET locations.

be lower than the accuracy of the measurement equipment used and so preventing wishful values. The exact procedures and details on both hydrological and meteorological parameters are also described in [1].

Two international projects aiming for more collaboration in offshore measuring campaigns have been started during the 1990's. These projects have resulted in a comprehensive overview of the measuring equipment deployed by the project partners.

SEANET

In 1993 a foundation was created for the SEANET project by all North Sea countries. Their main objectives were:

- a homogeneous distribution of fixed monitoring sites,
- exchange between fixed monitoring networks, standardization of data collection,
- processing methods and validation techniques,
- cooperation in the development of new measuring techniques and sensors,
- promotion of on line data and testing of existing sensors,
- exchange of experience in data communications,
- exchange of experience in data collection, particularly on fixed structures.

The project has focus on the North Sea region and is a part of a larger project called EuroGOOS , started in 1994, dealing with similar objectives on a larger scale. Since the scope of this report in on the Dutch North Sea, EuroGOOS will not be discussed further. The SEANET measurement locations are shown in the Dutch EEZ are shown in Figure 1. The parameters measured structure type and covered period for the Dutch SEANET locations can be found in Appendix A. A searchable database of this SEANET data is available on www.seanet-workshop.org .

EDIOS

A second project also within the EuroGOOS frameworks is called EDIOS . The objectives are more or less identical compared to the SEANET-project, however the project is open to any organization having data on the European seas. The published information of EDIOS is very detailed and contains entries of private companies. This makes the EDIOS website (www.edios.org) a valuable source of (meta)information.

For selected locations the Rijkswaterstaat-data is available on-line. A good overview of all public resources can be found at www.watermarkt.nl which is the portal to more detailed sites. For wind farm development the following sites can provide the valuable information, due to the rapid changes of these sites, no detailed information is available in this paper.

www.getij.nl – offers information on (theoretical) tides

www.actuelewaterdata.nl – this site offers the following variables on a near real-time basis (latency of 30 min) for the offshore area:

www.golfklimaat.nl – offers wave data of Dutch measurement locations

www.knmi.nl/samenw/hydra – offers historical wind data of various offshore locations

Details on all offshore locations involved in the above sites, are available via SEANET or EDIOS. Since all presented data is processed by Rijkswaterstaat or KNMI, the Royal Dutch Meteorological Institute, it complies with the aforementioned standard on accuracy and format.

Remote Sensing

Remote sensing is a characterization of a measurement method which can measure a certain phenomenon without having the measuring device physically on the location where the phenomenon occurs. In this section only satellite-measurements will be discussed, although platform mounted sonic wave measurement devices are basically also remote sensing devices.

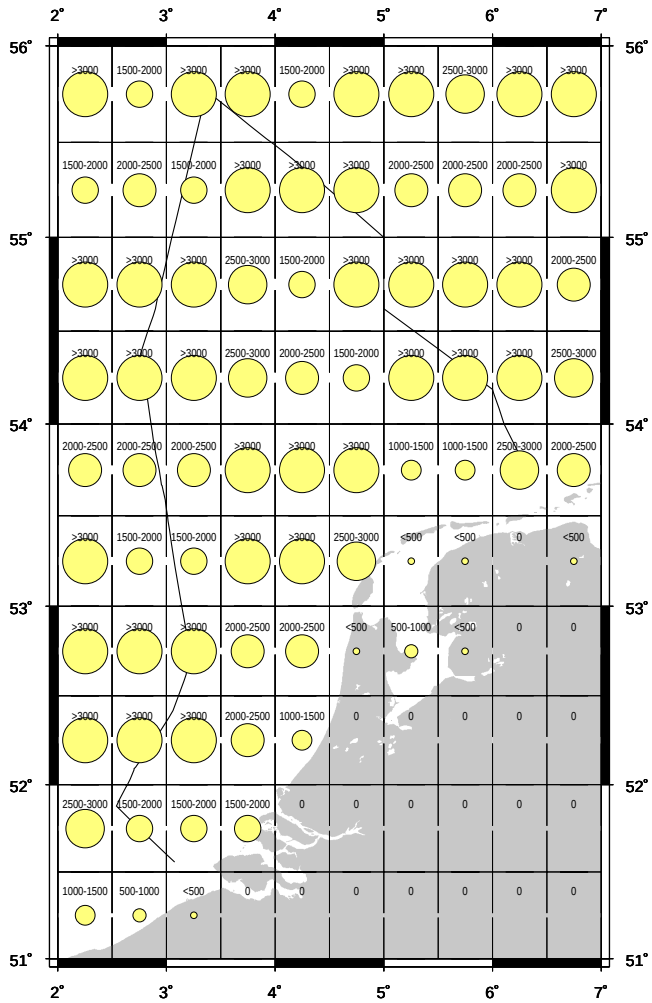


Figure 2. Number of Argoss altimeter measurements per 0.5° x 0.5°. The size of the circles indicates the number of measurements.

Different types of satellites are used to obtain information of the earth's surface, scatterometer, altimeter

and synthetic aperture radar (SAR). An altimeter emits a pulse toward the earth's surface and measures the reflection of that pulse. From the reflection characteristics (significant) wave height can be derived. Using a relation between wind and waves, altimeter data is used to derive wind speeds. The altimeter cannot measure directionality, in contrast to the scatterometer which measures the reflection of radar pulses emitted in three different dependent directions. Combination of the reflected pulses yields directional information of wave conditions. For reliable wave data originating from a scatterometer the complete reflecting area (approximately 500 x 1400 km) must be a water basin. Furthermore, the wave conditions are assumed to be equal in this area. This limits the usability of the scatterometer in coastal waters, where a change in bathymetry highly affects the wave conditions.

The third satellite type is the SAR, an imaging radar creating high resolution images of the earth's surface. The width of the imaged area is approximately 100 km.

Argoss

Argoss offers a wide range of data measured across the globe and available on-line. Similar services are offered by e.g. OceanWeather and many others. Data availability on the Dutch North Sea region is shown in Figure 2. Table 1 shows the parameters available and from which observations they are originating.

Table 1. Argoss parameters and data sources.

statistic for total seastate	data-source
histogram	
prob. distribution of wind speed	altimeter
prob. distribution of wave height	altimeter
prob. distribution of mean period	SAR
prob. distribution of zero-crossing period	SAR
monthly distribution	
monthly prob. distribution of wave height	altimeter
monthly prob. distribution of wind speed	altimeter
scatter table	
joint prob. distribution of wind speed and wind direction	scatterometer
joint prob. distribution of sign. wave height and wind speed	altimeter
joint prob. distribution of sign. wave height and mean period	SAR
joint prob. distribution of sign. wave height and zero-crossing period	SAR
joint prob. distribution of sign. wave height and wave direction	SAR
extreme value analysis	
extreme value distribution of sign. wave height	altimeter
extreme value distribution of wind speed	altimeter

A study conducted by Garrad Hassan and Argoss [2] showed that the accuracy of the remote sensed data is suitable for feasibility studies and site screening, for later stage developments a higher accuracy is needed.

Hindcast

Re-analysis or hindcast studies combine and process information originating from various sources. These sources can comprise visual observations, satellite measurements and in-situ measurements. All data which can contribute to the improvement of the hindcast results are used. Most hindcast studies treat a time period of several years, large studies can even study a few decades. Source data is preferably available during this period, in practice this will rarely be the case for the sources used.

The hindcast procedure consists in general of the following parts:

- data collection
- data preparation
- process data in model
- validate results
- disseminate results

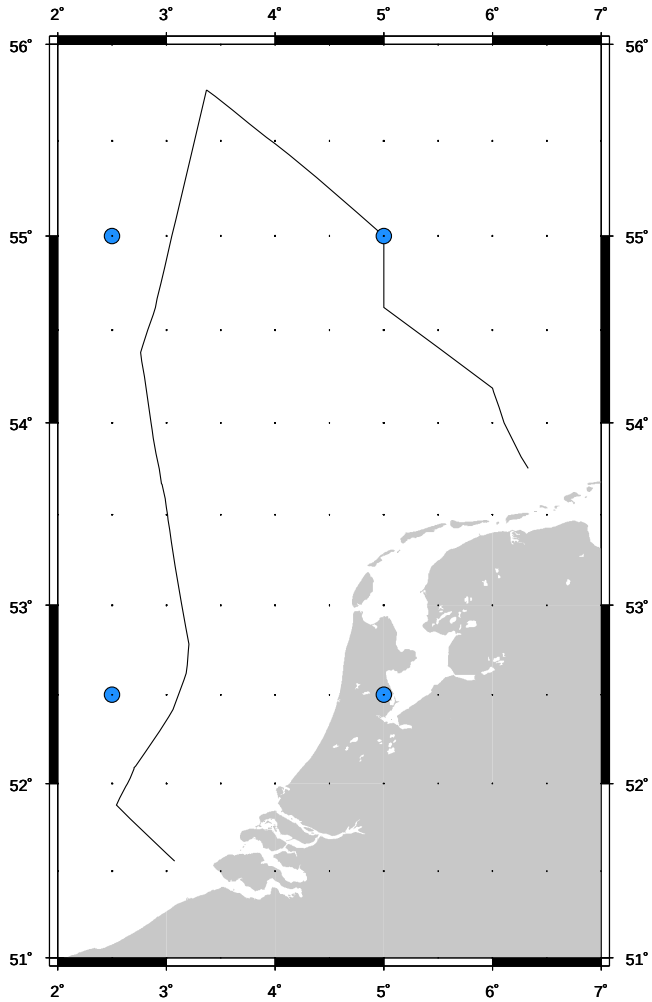


Figure 3. ECMWF and NCEP data locations.

The hindcast studies described in the following section are all considered large re-analysis projects which have taken years.

NCEP/NCAR

The reanalysis study conducted by the National Centers for Environmental Prediction (NCEP) and the National Center for Atmospheric Research (NCAR) aimed for began in 1991 and ended in 1997. Main objective is to produce a 40-year record of global analyses of atmospheric fields in support of the needs of research and climate monitoring communities as was described by [3]. The reanalysis period was from 1957 to 1996.

Since the objective is of a climatological origin, oceanographic parameters are not available from this study. The meteorological parameters, such a pressure fields on a number of levels are used as input for many other hindcast studies e.g. NESS. The covered area was global on a fixed 2.5°x2.5° fixed grid. The grid points within the Dutch North Sea area are shown in Figure 3 The parameters included in this study are shown in Appendix B, the reliability of the data is also indicated with indexes as was done by [3]. Explanation of those indexes can also be found in Appendix B. All hindcast results are available for download from http://cdc.noaa.gov . as 6-hour values, daily averages and monthly averages.

ECMWF

More or less similar to the NCEP/NCAR reanalysis is the ERA-40 project conducted by the European Centre for Medium Range Weather Forecasts (ECMWF). The hindcast covers the description of land and ocean atmosphere including wave conditions during the 45-year period from September 1957 to August 2002 and is described in detail in [4].

The public results of the study are 4 times daily analysis and forecast data on a 2.5°x2.5° global grid on various isentropic, pressure and surface levels (see Figure 3). Monthly means are also available. The coupled wave model resolved 25 wave frequencies and 12 wave directions on a 1.5°x1.5° model grid. Important surface parameters for offshore wind development available from this study:

- 10 m eastward wind component
- 10 m northward wind component
- wind gust at 10 m
- boundary layer height
- mean wave period from 1st moment
- wave spectral directional width
- mean wave period from 1st moment of wind waves
- mean wave period from 2nd moment of wind waves
- wave spectral directional width of wind waves
- mean wave period from 1st moment of swell
- mean wave period from 2nd moment of swell
- wave spectral directional width of swell
- significant wave height
- mean wave direction
- peak period of 1D spectra
- mean wave period
- coefficient of drag with waves
- significant height of wind waves
- mean direction of wind waves
- mean period of wind waves
- significant height of primary swell
- mean direction of primary swell
- mean period of primary swell
- 10 m wind speed modified by wave model
- gridded ERS altimeter wave height (from 1991)

Monthly means:

- wind gusts at 10 m
- 10 m wind speed

All above public data is accessible, via www.ecmwf.int/data.

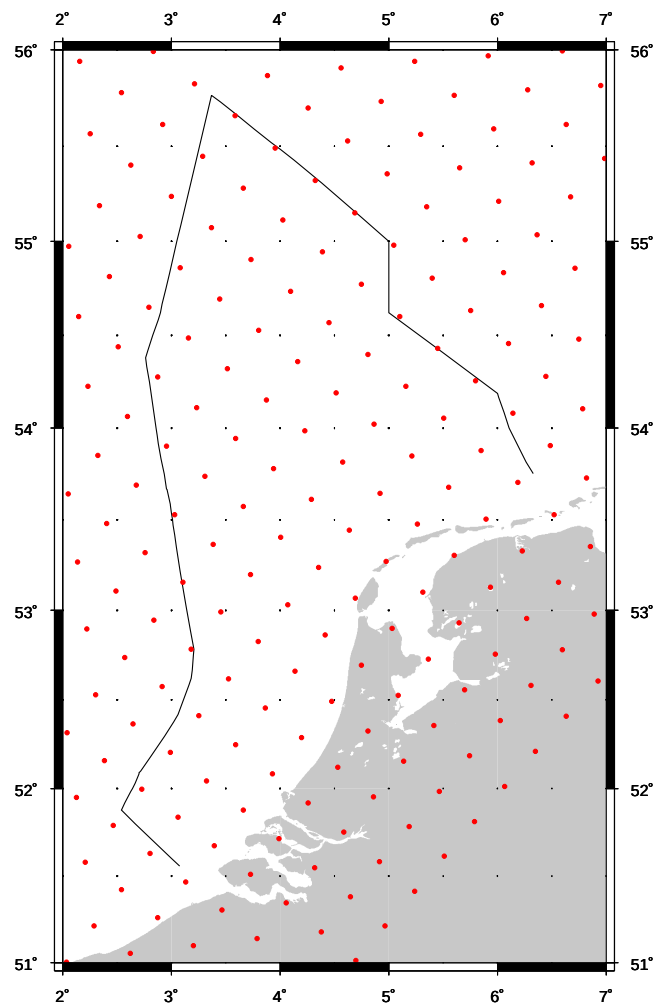


Figure 4. NESS locations.

NESS

The North European Storm Study (NESS) was conducted to obtain consistent metocean criteria and operational statistics for offshore areas of the UK, Norway and the Netherlands. See Figure XX for spatial coverage in the North Sea area. This hindcast study was funded by nine oil companies and the results are propriatory.

This study produced, as was described by [5]:

- wind and wave conditions at 3 hour intervals for 25 winters (October to March) from 1964 to 1989
- wind and wave conditions at 3 hour intervals for 3 summers (April to September) from 1977 to 1979
- wind and wave conditions during 50 summer storms
- surge height and depth integrated surge and tidal currents for 250 winter storms (occuring during the winters from 1964 to 1989)

Normal condition statistics were derived for the three complete years (1977-1979). Joint frequency table were developed for the following pairs of variables.

- significant wave height and spectral peak period
- significant wave height and wave direction
- unfavorable significant wave height and its duration
- favorable significant wave height and its duration
- significant wave height and mean wind speed
- mean wind speed and wind direction
- significant wave height and misalignment of wind and wave direction
- unfavorable mean wind speed and its duration
- favorable mean wind speed and its duration

Extreme value analysis was also performed for the following variables on:

- significant wave height
- mean wind speed
- current speed
- maximum wave height
- surge height
- mean wind speed (in line with significant wave height)
- current speed (in line with significant wave height)

Conclusions

Data sources for offshore wind development are investigated. Currently data sources are sufficient for wind farm development in the North Sea. Especially the region between 52° and 54° latitude is extremely well measured in terms of in-situ measurements. Furthermore, correlation with satellite data, which is abundantly available all over the North Sea combines the accuracy of the in-situ measurements with the spatial spread of the satellite measurements. Depending on the accessibility of proprietary hindcast databases the aforementioned, data sources can be extended. For the North Sea the NESS project is an extensive hindcast data source and will improve data provision especially on more remote locations (56° latitude and higher) in the Dutch North Sea. Figure 5 shows all measurement and data locations including the NESS database.

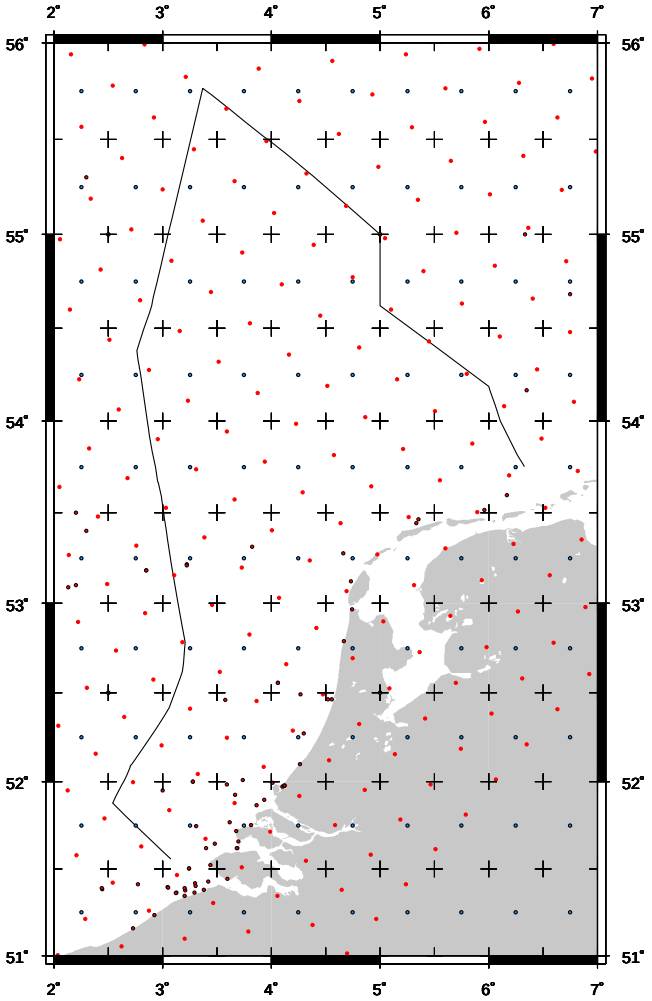


Figure 5. Data locations in Dutch North Sea area, originating from in-situ, remote sensing and hindcast sources.

This work is part of the project PhD@SEA, which is substantially funded under the BSIK-pro gramme of the Dutch Government and supported by the consortium WE@SEA.

References

[1] De RIJKSWATERSTAAT standaard voor de inwinning, verwerking en uitgifte van hydrologische en meteorologische gegevens uit operationele meetnetten, Herziene versie1.2, juli 1999. RMI

[2] Evaluation of Earth Observation Data in the Prediction of Offshore Wind Regimes, Argoss & Garrad Hassan, February 2004.

[3] The NCEP/NCAR 40-year Reanalysis Projects, E. Kalnay, M. Kanamitsu R. Kistler W. Collins D Deaven L. Gandin M. Iredell S. Saha G. White J. Woollen Y. Zhu M.Chelliah W. Ebizuzaki W. Higgins J. Janowiak K.C. Mo C. Ropelewski J. Wang A. Leetma R. Reynolds Roy Jenne Dennis Joseph, Bulletin of the American Meteorological Society, 1996, vol 7 pp 437-471.

[4] ERA-40 Project Report Series No. 17, Kållberg, P., A. Simmons, S. Uppala and M. Fuentes. The ERA-40 archive. September 2004. http://www.ecmwf.int/publications/library/do/references/list/192

[5] Modelling the North Sea through the North European Storm Study , D.J. Peters C.J. Shaw, C.K. Grant, J.C. Heideman and D. Szabo, Offshore Technology Conf 1993

Appendix A Dutch SEANET locations and measured parameters.

Location name	Date operational	Structure Type	Latitude	Longitude	sea level (1)	wave height (2)	wave direction (3)	wave spectra (4)	water temperature	current speed (6)	current direction	conductivity (30)	wind speed (10)	wind direction (11)	wind gust (12)	air pressure (13)	air temperature (14)	humidity (20)	visibility (21)	sunshine (22)	cloud base (23)	salinity (24)	ph (25)	oxygen (26)	turbidity (27)	chlorophyl (28)	radioactivity (29	nitrates (31)	phosphates (32)
Anasuria	Existing	ship and buoy	57°15'33"	000°47'27"	0	1	1	1	1	0	0	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0
Auk Alpha	Existing	platform and buoy	56°23'59"	002°03'56"	1	1	0	1	0	0	0	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0
Auk Alpha	Existing	platform and buoy	56°23'59"	002°03'56"	1	1	0	1	0	0	0	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0
Beerkanaal	Existing	pile	51°58'19"	004°05'55"	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Brent Alpha	Existing	platform	61°02'06"	001°42'19"	1	1	0	1	0	0	0	0	1	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Brouwers-havensche Gat 2	Existing	pile	51°46'06"	003°37'06"	1	1	0	1	1	0	0	1	1	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Brouwers-havensche Gat 8	Existing	pile	51°45'06"	003°48'46"	1	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Cadzand	Existing	pile	51°22'48"	003°22'39"	1	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Den Helder	Existing	structure on shore	52°58'01"	004°44'30"	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Deurloo	Existing	buoy	51°30'13"	003°14'36"	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Domburger Rassen	Existing	buoy	51°37'13"	003°24'01"	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Europlatform	Existing	platform	51°59'55"	003°16'35"	1	1	0	1	1	0	0	0	1	1	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0
Europlatform - DWE	Existing	buoy	51°56'54"	003°00'01"	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Europlatform - Euro 5	Existing	buoy	51°59'04"	003°35'36"	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Europlatform - Wavec	Existing	buoy	51°59'55"	003°16'35"	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Haringvliet 10	Existing	pile	51°51'49"	003°51'42"	1	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Haringvliet-mond	Existing	pile	51°53'47"	003°56'04"	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hoek van Holland - Peilhuisje	Existing	structure on shore	51°58'42"	004°07'16"	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hoek van Holland - Splitsingsdam	Existing	pile	51°58'24"	004°06'59"	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hoek van Holland - Steiger	Existing	pile	51°58'42"	004°07'16"	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IJmuiden	Existing	structure on shore	52°27'44"	003°34'30"	1	0	0	0	0	0	0	0	1	1	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0
IJmuiden - Buitenhaven	Existing	structure on shore	52°27'47"	004°33'22"	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IJmuiden - IJ5	Existing	buoy	52°29'35"	004°16'05"	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IJmuiden - Munitiestortplaats 1	Existing	buoy	52°33'30"	004°03'30"	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IJmuiden - Munitiestortplaats 2	Existing	buoy	52°33'30"	004°03'30"	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
K13 Alpha	Existing	platform	53°13'04"	003°13'13"	1	1	0	1	0	0	0	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
K13 Alpha - Wavec	Existing	buoy	53°12'40"	003°13'12"	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Kittiwake	Existing	platform	57°28'06"	000°30'18"	1	1	0	1	0	0	0	0	1	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0
Lichteiland Goeree	Existing	platform	51°55'29"	003°40'06"	1	1	0	1	1	0	0	0	1	1	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0
Lichteiland Goeree - Euro 13	Existing	buoy	52°00'36"	003°44'13"	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Meetpost Noordwijk	Existing	platform	52°16'23"	004°17'50"	1	1	0	1	1	0	0	0	1	1	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0
North Cormorant	Existing	platform and buoy	61°14'26"	001°08'58"	1	1	1	1	1	0	0	0	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0
Oosterschelde 11	Existing	pile	51°38'39"	003°28'53"	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oosterschelde 14	Existing	pile	51°43'09"	003°40'41"	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oosterschelde 4	Existing	pile	51°39'24"	003°41'43"	1	1	0	1	1	0	0	1	1	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Petten	Existing	pile	52°47'21"	004°39'58"	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Roompot binnen	Existing	structure on shore	51°37'12"	003°41'16"	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Roompot buiten	Existing	structure on shore	51°37'13"	003°41'00"	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Scheur Oost	Existing	buoy	51°24'13"	003°18'12"	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Scheur West	Existing	buoy	51°23'32"	003°02'57"	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Scheveningen	Existing	structure on shore	52°05'59"	004°15'54"	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Schouwenbank	Existing	buoy	51°44'48"	003°18'24"	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sean P	Existing	platform	53°11'00"	002°51'00"	1	1	0	1	0	0	0	0	1	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Stroommeetpaal IJmuiden	1-11-1999	Pile	52°27'52"	004°31'07"	1	1	0	1	0	1	1	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stroommeetpaal Maasmond	Existing	pile	51°59'32"	004°00'30"	1	1	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Terschelling Noordzee	Existing	pile	53°26'36"	005°20'04"	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Texel Noordzee	Existing	pile	53°07'17"	004°44'04"	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Vlakte van de Raan	Existing	pile	51°30'16"	003°14'37"	1	0	0	0	1	0	0	1	1	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Vlissingen	Existing	structure on shore	51°26'35"	003°35'51"	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wadden - Eierlandse gat	Existing	buoy	53°16'37"	004°39'42"	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wadden - Schiermonnikoog	Existing	buoy	53°35'44"	006°10'00"	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wadden Terschelling	Existing	buoy	53°27'52"	005°21'19"	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Westkapelle	Existing	structure on shore	51°31'20"	003°26'29"	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wielingen	Existing	buoy	51°25'42"	003°25'00"	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Wierumergronden	Existing	pile	53°30'60"	005°57'34"	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

.

Appendix B

Appendix A NCEP/NCAR parameters

Reliability index as described in[ref]

A	strongly influenced by observational data
B	equal influence of observations and model
C	no directly affecting observations
D	fixed values, not model dependent

Pressure Level Data

Variables on pressure levels:	Reliability Index
Air temperature	A
Geopotential height	A
Relative humidity	B
Specific humidity	B
Omega (vertical velocity)	B
U-wind	A
V-wind	A

Note: These variables are instantaneous values at the reference time.

Spatial coverage:

- 2.5-degree latitude x 2.5-degree longitude global grid with 144x73 points.
- 90N-90S, 0E-357.5E

Temporal coverage:

- 1/1/1948 - present with output every 6 hours
- Data for the current year from the CDAS program is being made available along with the historical data. Files for the current year contain as many months as are currently available.

Levels:

- 17 pressure levels (hPa): 1000, 925, 850, 700, 600, 500, 400, 300, 250, 200, 150, 100, 70, 50, 30, 20, 10
- some variables not defined at all levels

Missing data: None

Surface Data

Surface Variables:	Reliability Index
Air Temperature	B
Surface lifted index	B
Best (4-layer) lifted index	B
Omega (vertical velocity)	B
Potential temperature	B
Precipitable water	B
Pressure	B
Relative humidity	B
Sea level pressure	A
U-wind	B
V-wind	B
Geopotential hgt (time invariant) *	D
Land-sea mask (time invariant) **	D

* = no year in file name

** = no year or level in filename

Note: These variables are instantaneous values at the reference time.

Spatial coverage:

- 2.5-degree latitude x 2.5-degree longitude global grid with 144x73 points
- 90N-90S, 0E-357.5E

Temporal coverage:

- 1/1/1948 - present with output every 6 hours
- Data for the current year from the CDAS program is being made available along with the historical data. Files for the current year contain as many months as are currently available.

Levels:

- Surface or near the surface (.995 sigma level)
- Also, precipitable water is included here, because it is a 3-D file on a 2.5 degree grid, but it is not a surface value, but rather for the entire atmospheric column

Missing data: None

Appendix C

Code	Parameter Name	Description	Units	Comments
27	CVL	Low vegetation cover	(0-1)	-
28	CVH	High vegetation cover	(0-1)	-
29	TVL	Type of low vegetation	-	Table index
30	TVH	Type of high vegetation	-	Table index
31	CI	Sea-ice cover	(0-1)	-
32	ASN	Snow albedo	(0-1)	-
33	RSN	Snow density	kg m**-3	-
34	SSTK	Sea surface temperature	K	_
35	ISTL1	Ice surface temperature layer 1	K	-
36	ISTL2	Ice surface temperature layer 2	K	-
37	ISTL3	Ice surface temperature layer 3	K	-
38	ISTL4	Ice surface temperature layer 4	K	-
39	SWVL1	Volumetric soil water layer 1	m**3 m**-3	ECMWF has a description of the soil water units on their web site
40	SWVL2	Volumetric soil water layer 2	m**3 m**-3	ECMWF has a description of the soil water units on their web site
41	SWVL3	Volumetric soil water layer 3	m**3 m**-3	ECMWF has a description of the soil water units on their web site
42	SWVL4	Volumetric soil water layer 4	m**3 m**-3	ECMWF has a description of the soil water units on their web site
129	Z	Geopotential	m**2 s**-2	At the surface - orography
136	TCW	Total column water	kg m**-2	Liquid + ice + vapour
137	TCWV	Total column water vapour	kg m**-2	-
139	STL1	Soil temperature level 1	K	Soil temperature (ST) before 19930804
141	SD	Snow depth	m of water equivalent	-
148	CHNK	Charnock	-	Surface stress (SS) before 19980519
151	MSL	Mean sea level pressure	Pa	-
160	SDOR	Standard deviation of orography	-	-
161	ISOR	Anisotropy of sub-gridscale orography	-	-
162	ANOR	Angle of sub-gridscale orography	rad	-
163	SLOR	Slope of sub-gridscale orography	-	-
164	TCC	Total cloud cover	(0 - 1)	-
165	10U	10 metre U wind component	m s**-1	-
166	10V	10 metre V wind component	m s**-1	-
167	2T	2 metre temperature	K	-
168	2D	2 metre dewpoint temperature	K	-
170	STL2	Soil temperature level 2	K	Deep soil temperature (DST) before 19930804
172	LSM	Land-sea mask	(0, 1)	-
173	SR	Surface roughness	m	-
174	AL	Albedo	(0 - 1)	-
183	STL3	Soil temperature level 3	K	Climatological deep soil temperature (CDST) before 19930804
186	LCC	Low cloud cover	(0 - 1)	-
187	MCC	Medium cloud cover	(0 - 1)	-
188	HCC	High cloud cover	(0 - 1)	-
198	SRC	Skin reservoir content	m of water	-
206	TCO3	Total column ozone	kg m**-2	Before 20010612 was in Dobsons. 1 Dobson = 2.1415E-5 kg m**-2
234	LSRH	Logarithm of surface roughness length for heat		-
235	SKT	Skin temperature	K	-
236	STL4	Soil temperature level 4	K	-
238	TSN	Temperature of snow layer	K	-