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CS3 Extreme weather risks to maritime activities

In this case study, DNV GL, in collaboration with NORCE, looks at understanding extreme weather conditions in the context of maritime operations. The aim is to investigate ways to improve our awareness towards extreme weather formations and give notion to how the maritime industry can better utilize forecasts on severe weather impacting on safety and navigation in polar waters.

To assess and secure applicability and value of long-term weather predictions, DNV GL has identified the following criteria:

- Critical factors for navigation, including sea ice, winds, waves, satellite coverage, visibility, precipitation.
- History of accidents in polar waters
- Patterns in formation and trajectory of polar storms
- Breeding grounds for polar lows and other severe weather events
- Regions of pronounced commercial and geo-political interest
- Main fairways in Arctic shipping
- The Northern Sea Route
- Hazards and main Arctic risk influencing factors as noted in the IMO polar code

The following baseline data sources have been reviewed by DNV GL:

Source	Record/Reanalysis/Forecast	Variable/Parameter
DNV GL	World Offshore Accident Database. Historical records of world offshore accidents.	Chain of events, root causes and consequences
ECMWF	ERA-INTERIM Reanalysis data	Precipitation, Air Temperature, Winds, SST
ECMWF	ERA5 Reanalysis data	Air Temp, Winds, SST, Sea ice
ECMWF	Operational forecasts, seasonal forecasts, real-time products https://www.ecmwf.int/en/forecasts/datasets	Winds, Air Temp, SST, Precipitation
Copernicus/CMEMS	GLOBAL OCEAN 1/12° PHYSICS ANALYSIS AND FORECAST https://resources.marine.copernicus.eu/?option=com_csw&task=results?option=com_csw&view=details&product_id=GLOBAL_ANALYSIS_FORECAST_PHY_001_024	SST, Sea ice
ASR NCAR/UCAR	Arctic System Reanalysis v2 https://rda.ucar.edu/datasets/ds631.1/	Precipitation, SST, Air Temperature, Surface Pressure, Winds

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Source	Record/Reanalysis/Forecast	Variable/Parameter
Copernicus/CMEMS	Seasonal forecasts/In-Situ https://cds.climate.copernicus.eu/cdsapp#!/search?type=dataset&keywords=((%20%22Product%20type:%20Seasonal%20forecasts%22%20))	Winds, Air Temp, Sea ice, SST
MET/BarentsWatch	BarentsWatch Polar low forecasts https://www.barentswatch.no/en/polar-low/ MEPS/AROME Arctic forecasts https://www.met.no/en/projects/The-weather-model-AROME-Arctic	Polar lows (Barents Sea), Polar lows hit probability
STARS	Records of historical polar low events in the Norwegian Sea and Barents Sea http://polarlow.met.no/stars-dat/	Polar low event duration (hours)

DNV GL considers a wider set of dynamic weather forecasts. The primary interest is to identify products and datasets which can adhere to a risk model incorporating Arctic risk influencing factors. Polar lows are a specific case, but other features contributing to severe weather are equally relevant.

Requirements of DNV GL

This case study seeks to understand, capture and describe the environment in which severe arctic weather conditions are likely to unfold. The case study was designed based on the assumption that forecasting of polar lows was feasible. Project results have shown skill in forecasting PLs is severely limited and highly uncertain [for lead times greater than a day or two]. Consequently, the case study has refocused its' work to identifying and classifying large-scale atmospheric features which show skill in prediction.

In the context of risk assessments, and for the value of a climate service, capacity to recognize, describe and predict these "environments" is essential. A set of environmental predictors needs to be defined and tested. The predictors should capture unstable atmospheric conditions and/or potential for strong advection over sea. Indicators such as the MCAO index are useful in this regard. Links to stratospheric events (e.g. sudden stratospheric warming and polar vortex anomalies), although more esoteric, are also considered relevant.

Predictors for use in this case study should be assessed by their skill, lead times, stationarity and seasonal variability. The predictor [or signal] should also be qualified in terms of its' correlation and contribution (relevance) with the weather phenomenon in question (such as a cold air outbreak or polar low event). For implementation in a forecasting regime and for application purposes, the predictors need to be operational and online.

Data source Nr. 1

Provider: Martin King (NORCE)

What has been provided:

Dataset/Predictor	Description	Source
MCAO index	Calculation of monthly MCAO index values	ERA Interim 1979-2017, Sept-May
MCAO index percentiles	Monthly MCAO index percentiles	ERA Interim 1979-2017, Sept-May
STARS	Compilation of past polar low events: Single event duration, Monthly average duration (hours)	STARS database 2002-2011

Notes on compilation of case-specific data (NORCE): NORCE had received all the hindcast data needed from UHAM on temperature and pressure in Spring 2017.
NORCE has provided data calculated from ERA-INTERIM related to this in terms of percentiles values of the MCAO index for different months.
NORCE has provided data on return period values of MCAO events. According to NORCE, these fulfill criteria "severity", "frequency", and "geographical" information of MCAOs. *There is also a plan by NORCE to start using Copernicus hindcast data (not forecast) in WP1.*

Data repository: The data set of NORCE is called "Monthly frequency of polar lows in the Atlantic sector based on STARS"
Description: Based on PolarLow_tracks_North_2002_2011 from ftp://ftp.met.no/projects/STARS/stars-dat/v3. Value at each grid point is the total number of hours polar lows have been detected in the grid point in the month given by the time stamp. ERA-INTERIM grid is used.
DOI: https://www.zenodo.org/record/3757122

Data source Nr. 2

Other datasets *currently being considered for use* are listed here below.
Provider: University of Hamburg (UHAM)
What has been provided:

Dataset/Predictor	Description	Source	Contac person
Extreme Temperature Analysis	Likelihood maps of T < 0 degrees Celsius. Analysis of past extremes in June (T2min – Seasonal predictions). Ensemble forecasts.	**MPI-ESM**, ERA Interim.	Laura Schaffer, UHAM Please contact: iuliia.polkova@uni-hamburg.de
Persistence forecasting MCAOi	Persistence forecasts of MCAO index for winter months, lead time 1-2 weeks	Forecasting algorithm.	Yuliia Polkova, UHAM iuliia.polkova@uni-hamburg.de

If the CS decides upon use, the data sets will be identified with a unique identifier (DOI), and made available in open access.