CLIMAR-II

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FORECASTING DANGEROUS SEA-STATES: BEYOND H_S AND T_P

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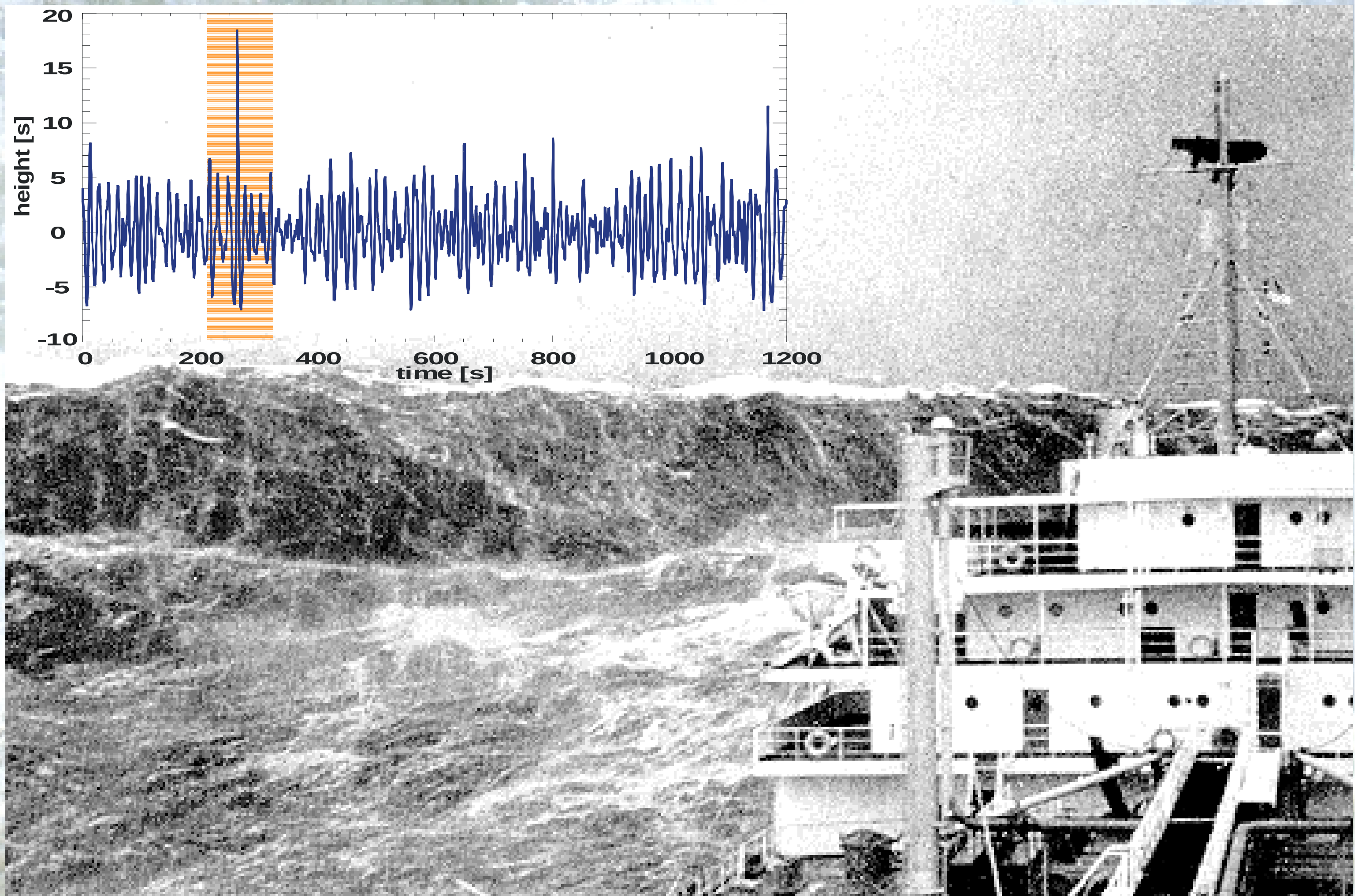
CONTENTS

EU Project MaxWave

- **Forecasts and Statistics of Rogue Waves**
- **Investigation of Accidents due to Rogue Waves**



Partners:

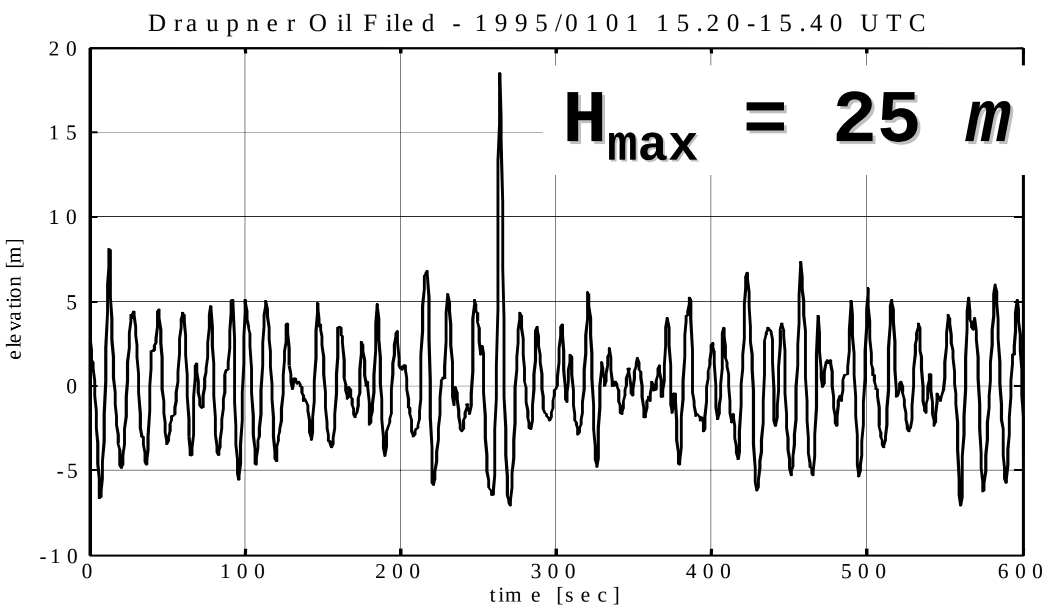
- **GKSS**
- **DLR**
- **DNMI**
- **DNV**
- **IST**
- **K.U. Leuven**
- **MeteoF**
- **OSW**
- **TuB**
- **UKMet**
- **IBWPAN**

http://w3g.gkss.de/projects/maxwave/

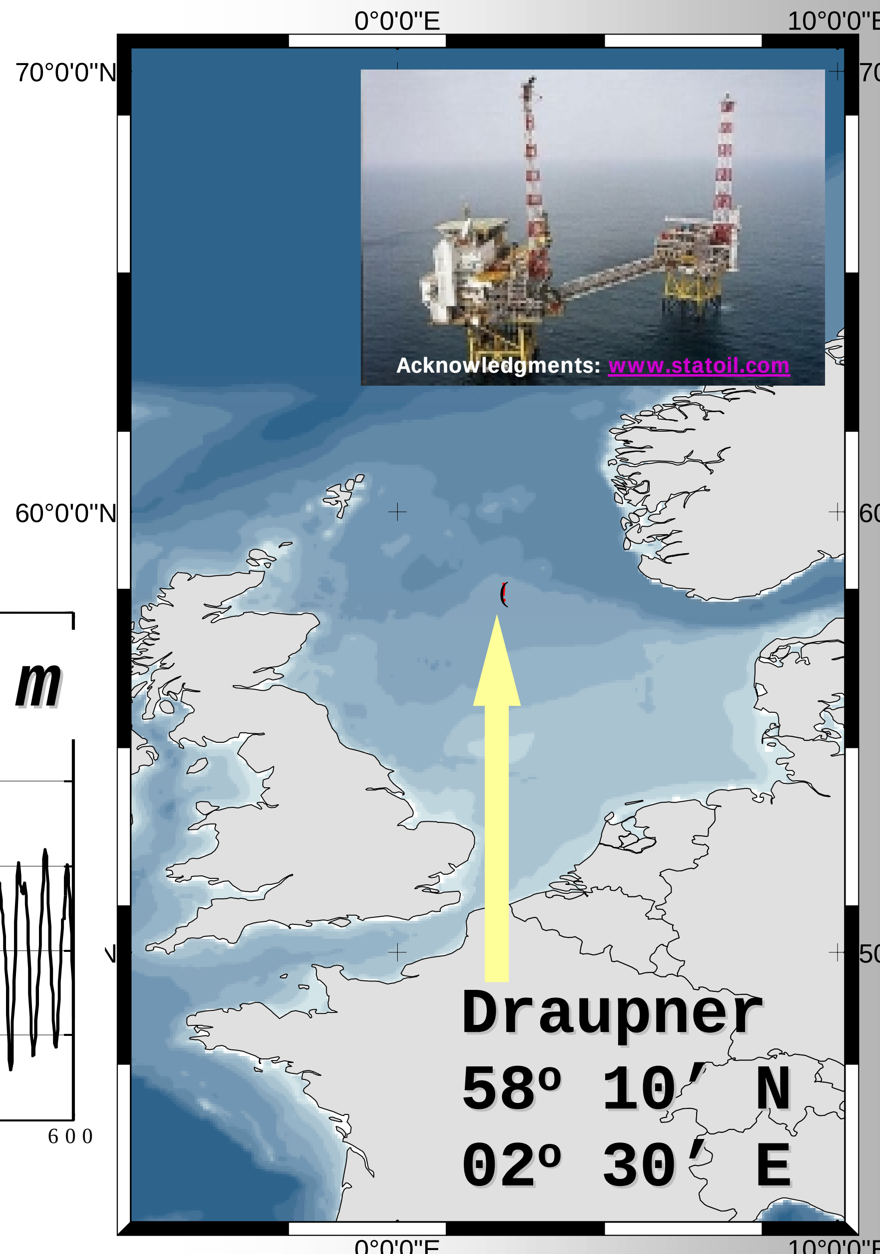
New Year's Wave

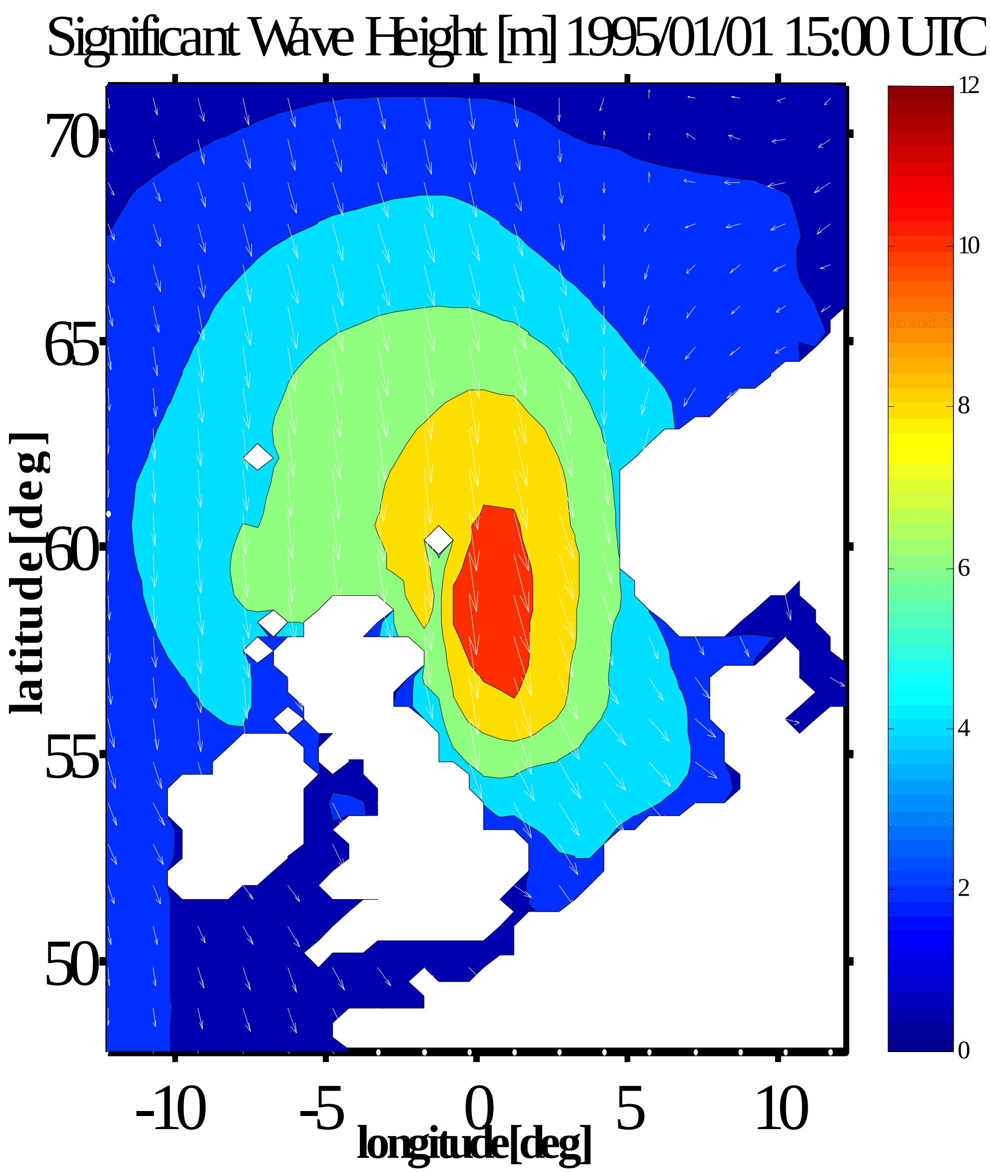
- 1^{ST} January 1995

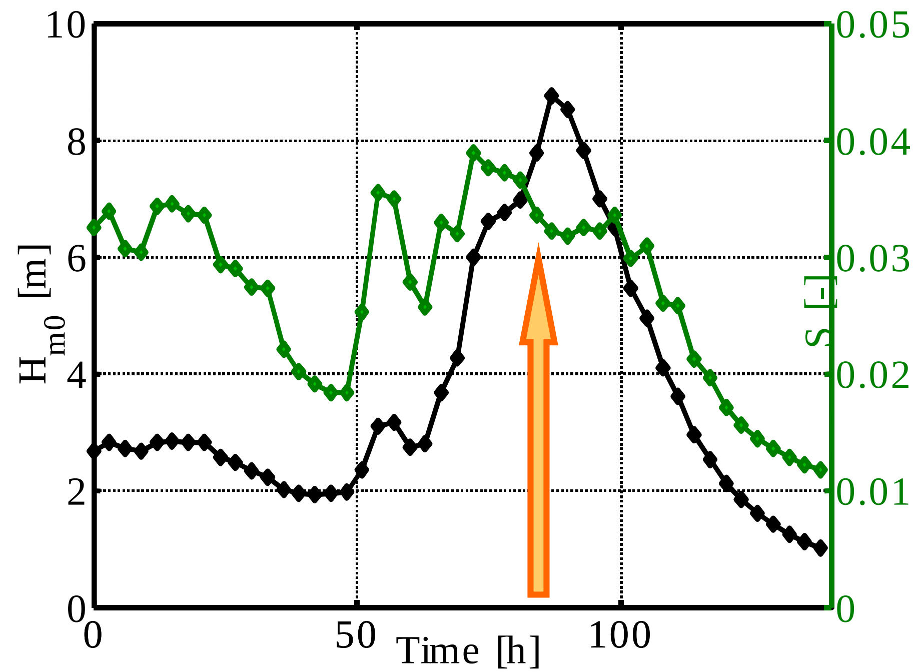
$$\begin{cases} H_S = 11.93\ m \\ T_P = 16.84\ s \end{cases}$$



$H_{max} = 25\ m$







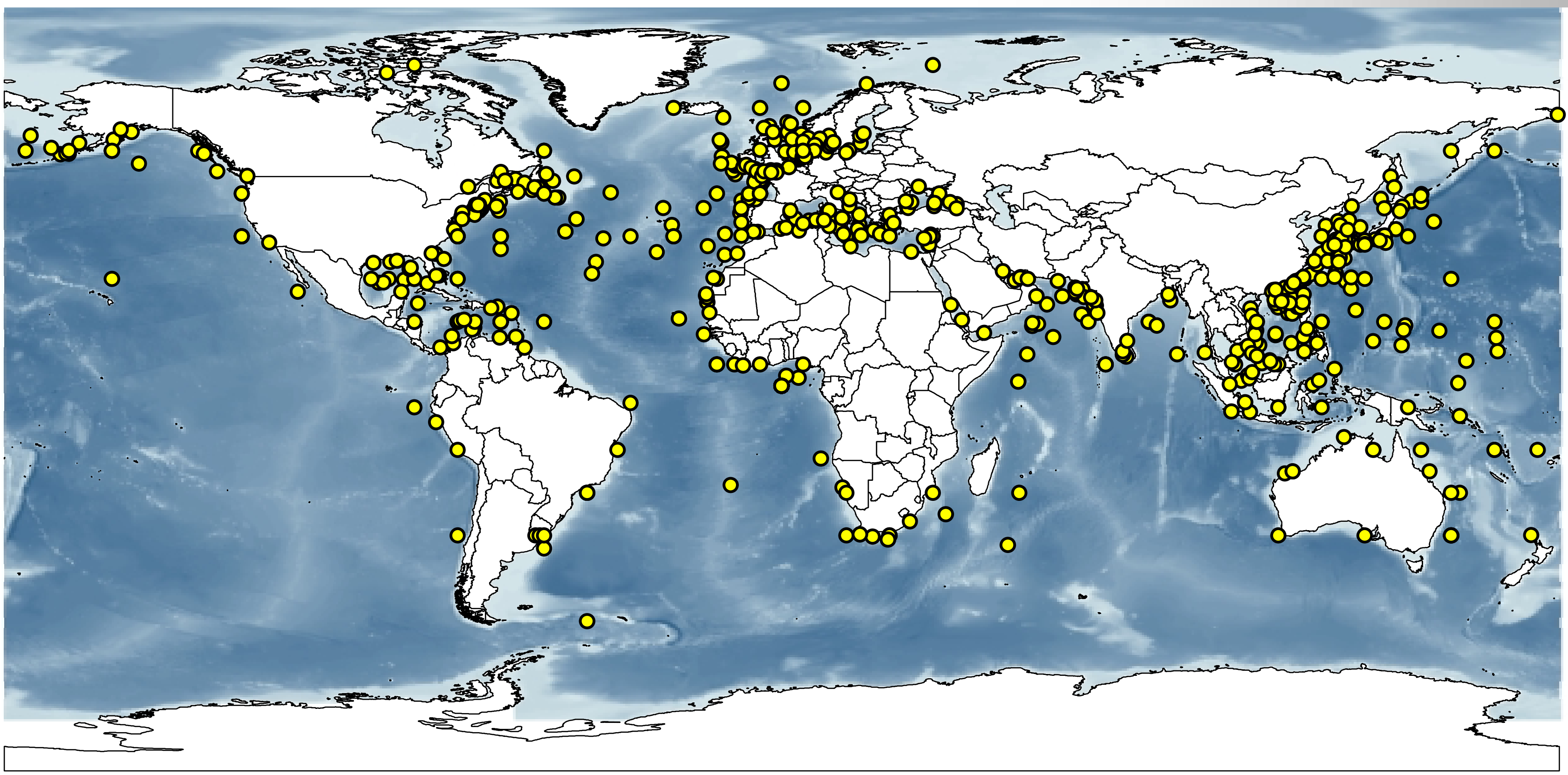
- **At the peak of the storm:**

$$H_{m0} = 4.01\sqrt{m_0}$$

$$S = \frac{2\pi\, H_S}{g\, T_{m-10}^2}$$

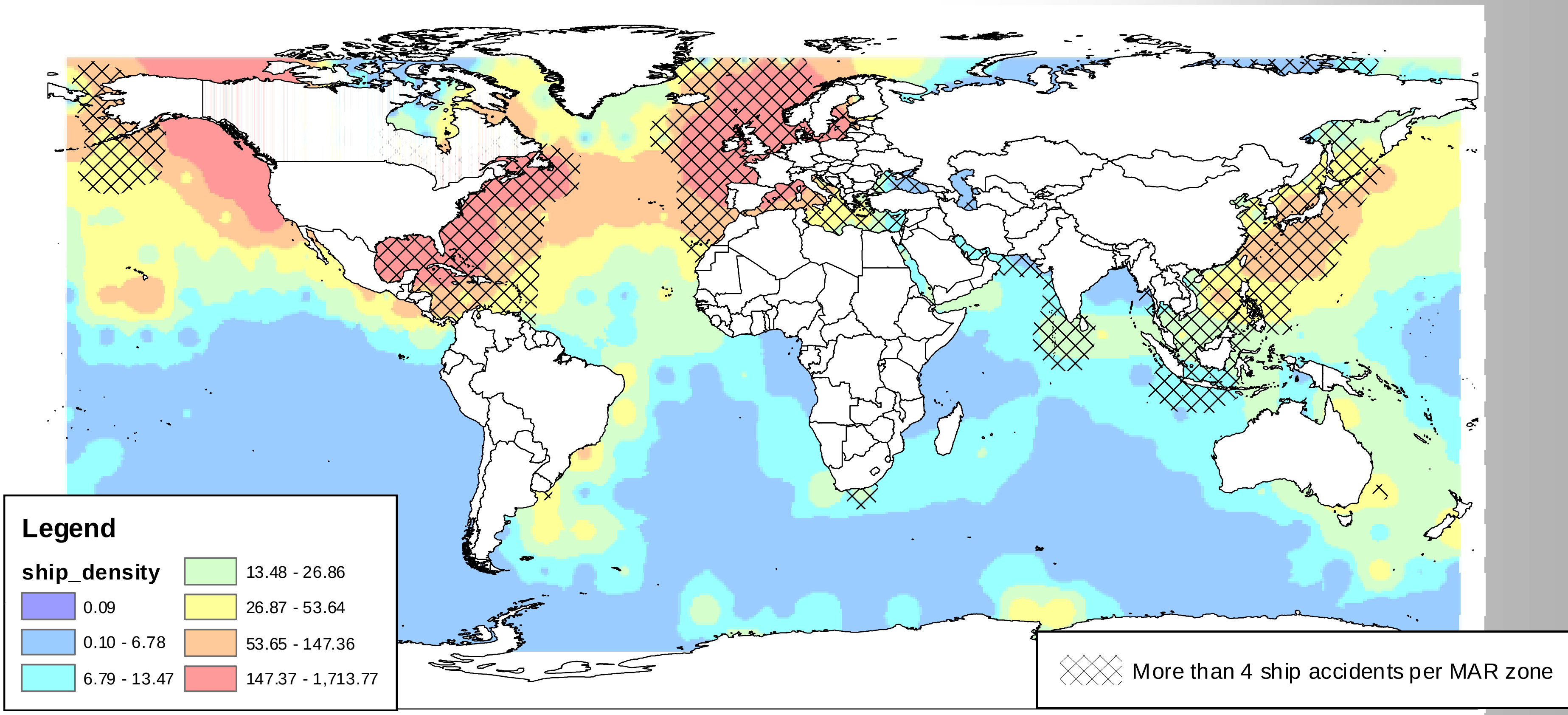
SHIP ACCIDENTS

Five years of ship accidents (1995-1999)due to bad weather were collected from the Lloyd's Marine Information Service (LMIS) and Lloyd's Casualty report.



Shipping Activities and Accidents

The ship density is computed assigning index of 100 if 8 call signs are counted in an area of 500 X 500 km² per day. A call sign is the name that a ship uses for radio transmissions. A database containing ship tracks was kindly provided by JCOMMOPS.



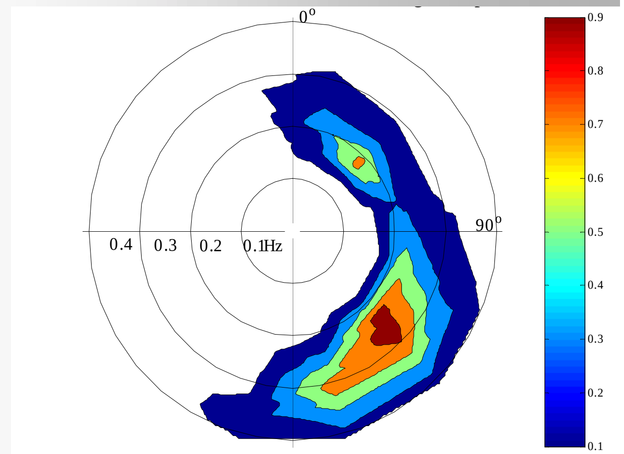
Casualties & Sea-State

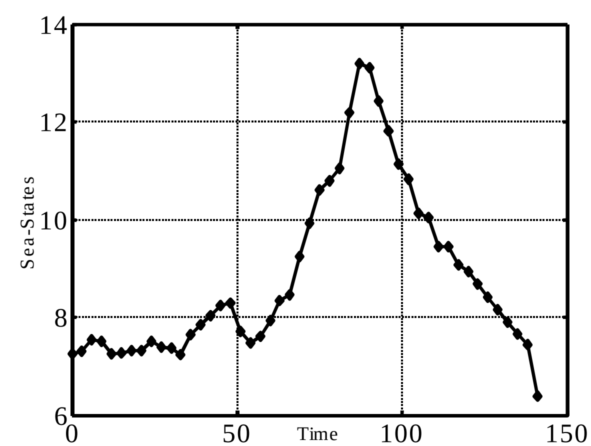
1. Ship accidents Database

- **Location:**
  - MAR zones
  - Latitude & Longitude
- **Time:**
  - Day of the events (local time)
- **270 Accidents analyzed**

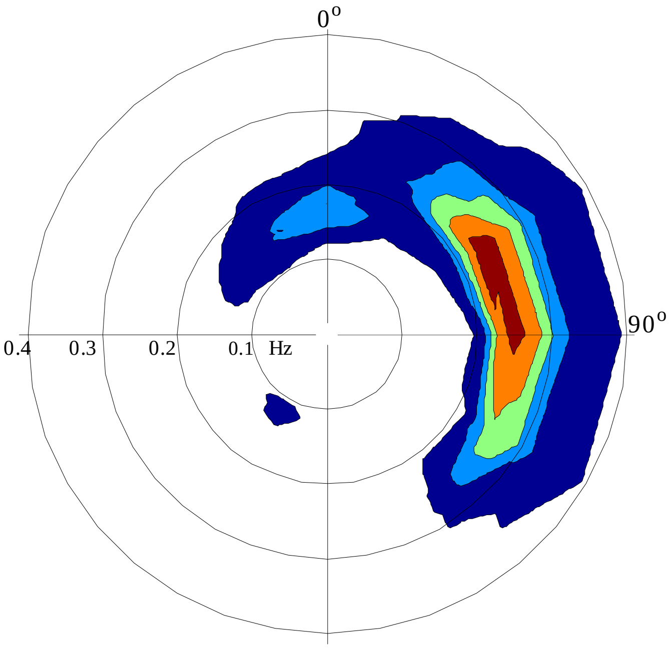
2. Sea-State at the time of the accidents:

- **ECMWF – ERA40 (grid = 1.5°X1.5°)**
- **Integrated parameters before and at the time of the casualties**





Wave Parameters



- Total Sea
- Wind Sea
- Swell

$$T_{m-10} = \frac{m_{-1}}{m_0}$$

$$T_P = \frac{2\pi}{\{\omega | \max S(\omega)\}}$$

$$H_{m0} = 4.01\sqrt{m_0}$$

$$S = \frac{2\pi H_{m0}}{gT^2}$$

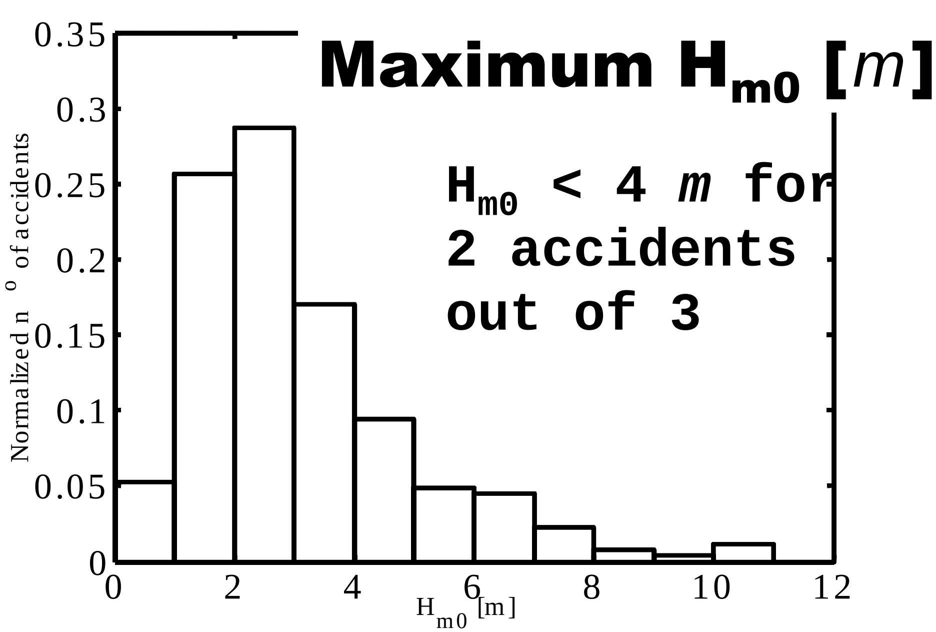
$$\frac{m_{0\ \ wind\ sea}}{m_{0\ \ total}}$$

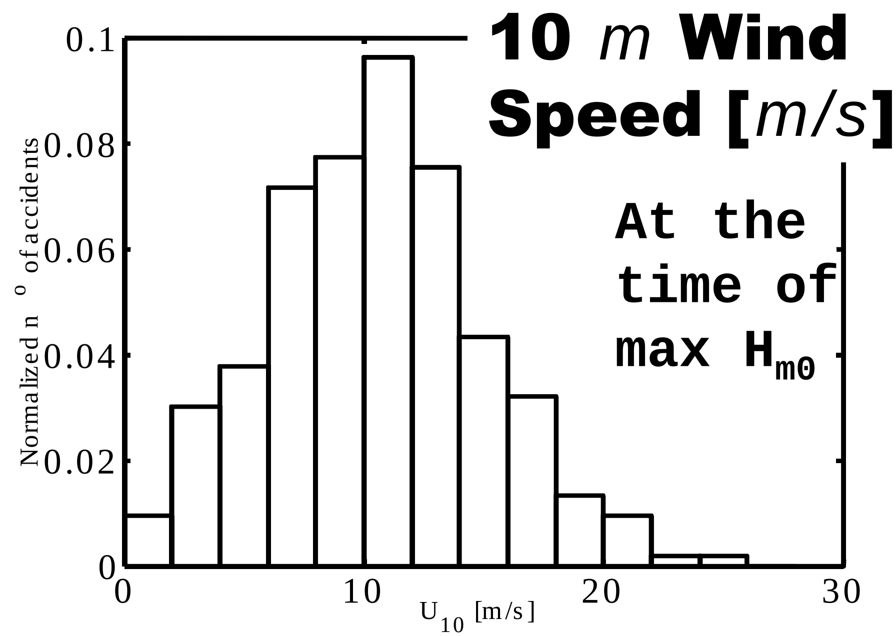
(ϑ) *mean wave direction*

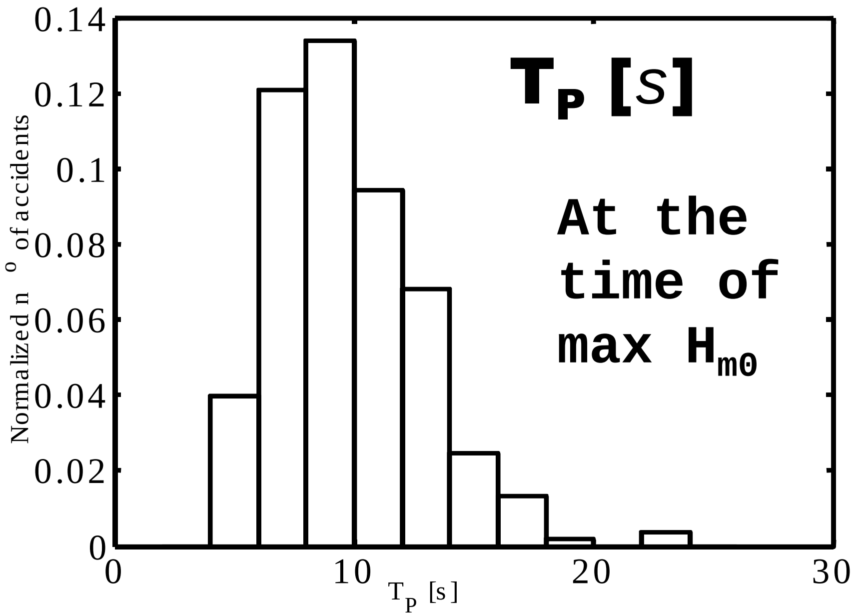
Parameters were retrieved for:

A <u>space window</u> of 3°x3° around the casualty

A <u>time window</u> involving 2 days before, the day of the casualty and the day after <u>(UTC time)</u>

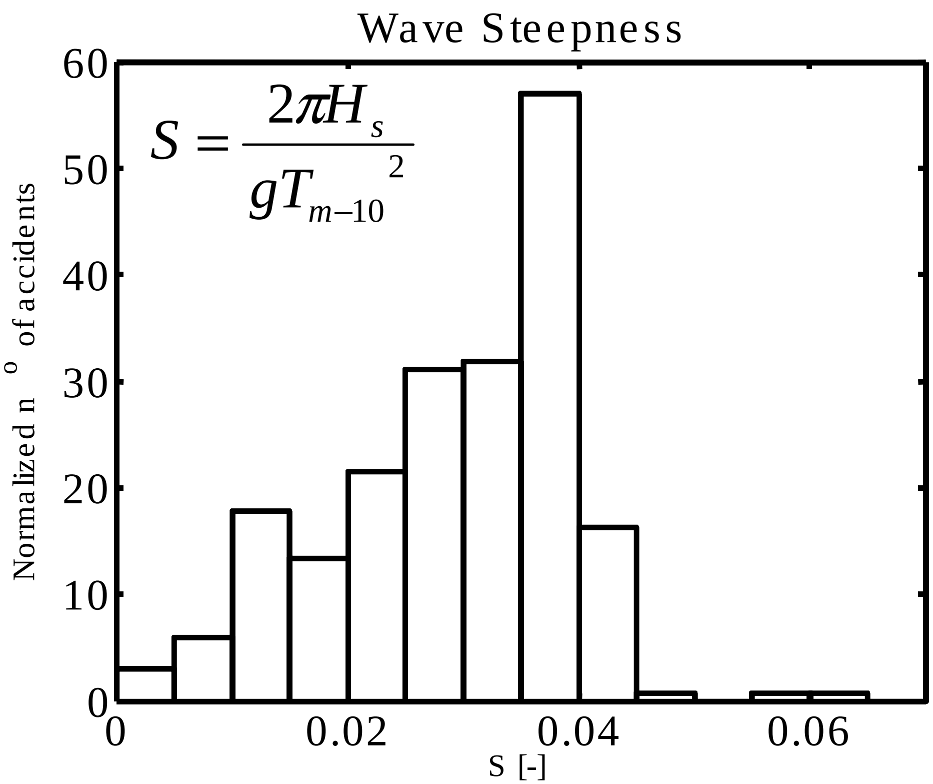


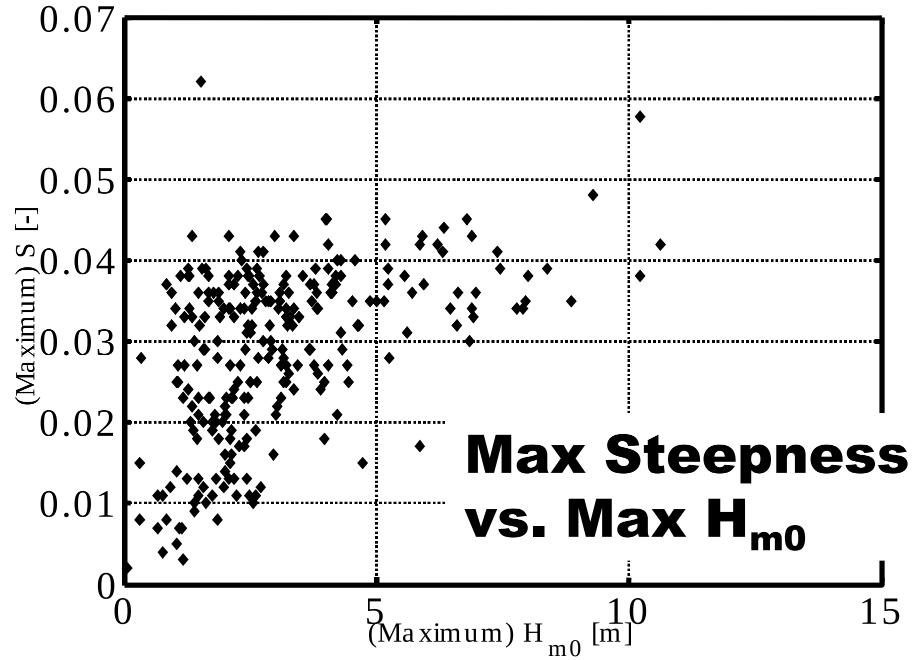


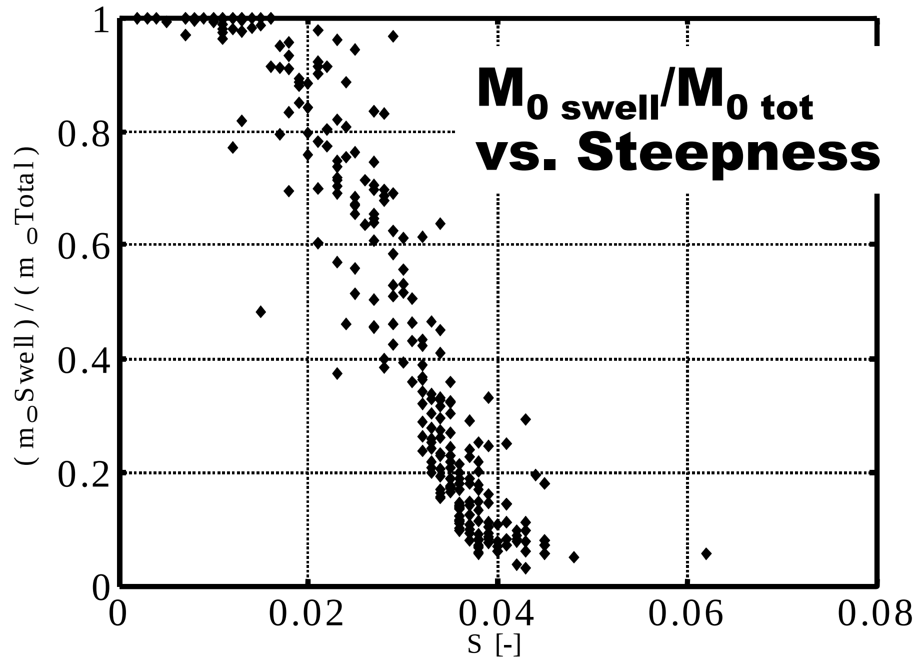


SEA-STATES

Maximum significant wave height recorded within 3 days (the day before, the day of the casualties and the day after) and the related peak period and wind speed







WAVE STEEPNESS

S > 0.035 for 2 accident out of 5

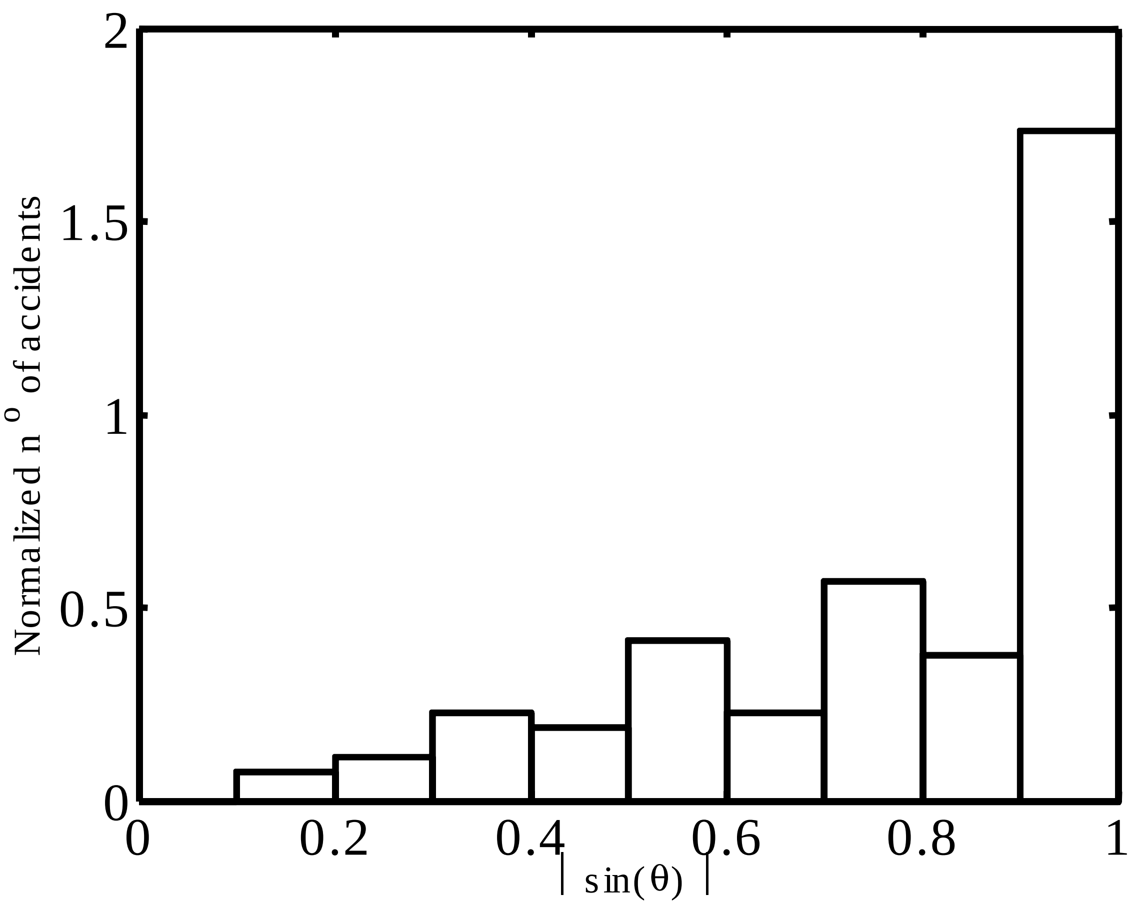
From Pierson-Moskowitz spectral formulation:

S = 0.04 (const.)

CROSSING SEAS

Histogram of $|\sin(\vartheta)|$ for accidents characterized by: $0.2 \le \frac{m_{0\ wind\ sea}}{m_{0\ total}} \le 0.8$

(40% of the events)



Assumptions

1.

$$\vartheta = |\vartheta_{windsea} - \vartheta_{swell}|$$

$$|\sin(\vartheta)| > 0.7071$$

$$(\vartheta = +(-)\,90^o \pm 45^o)$$

$$|\sin(\vartheta)| > 0.8660$$

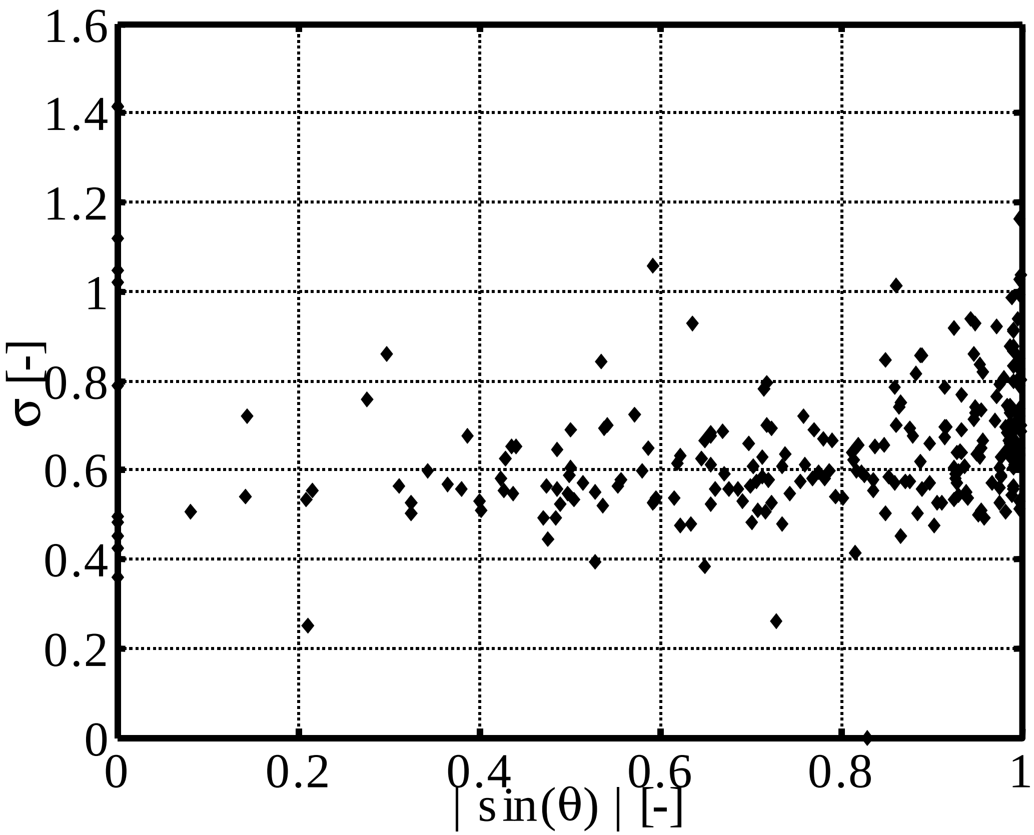
$$(\vartheta = +(-)\,90^o \pm 30^o)\,*$$

2. $$0.2 \le \frac{m_{0\ wind\ sea}}{m_{0\ total}} \le 0.8$$

Crossing Seas

Spectral Directional Width

Directional information of the different wave components can be obtained from the circular standard deviation (σ).



$$F(f,\varphi) = D(f,\varphi)\,E(f)$$

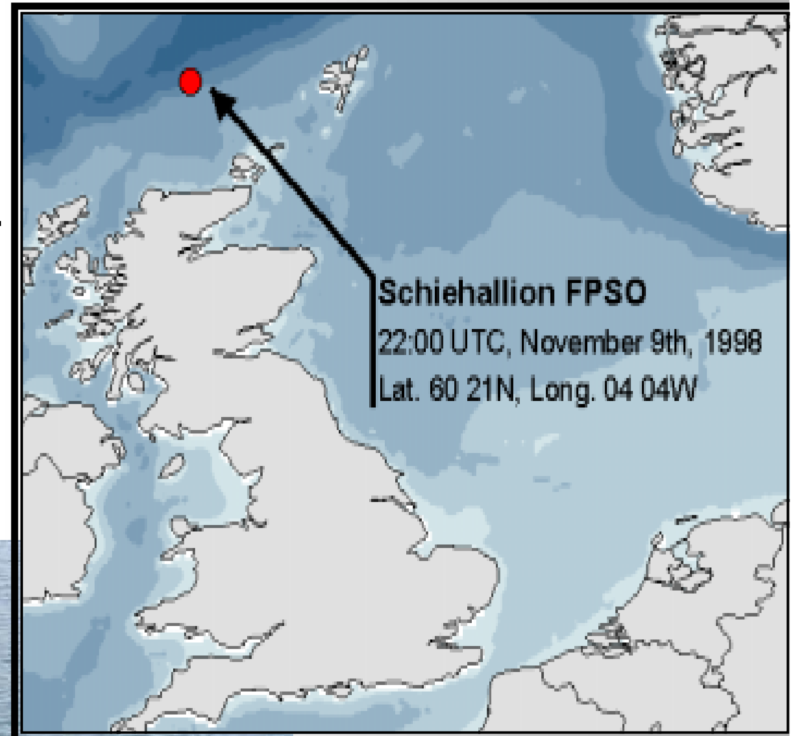
$$0 \le \sigma \le \sqrt{2}$$

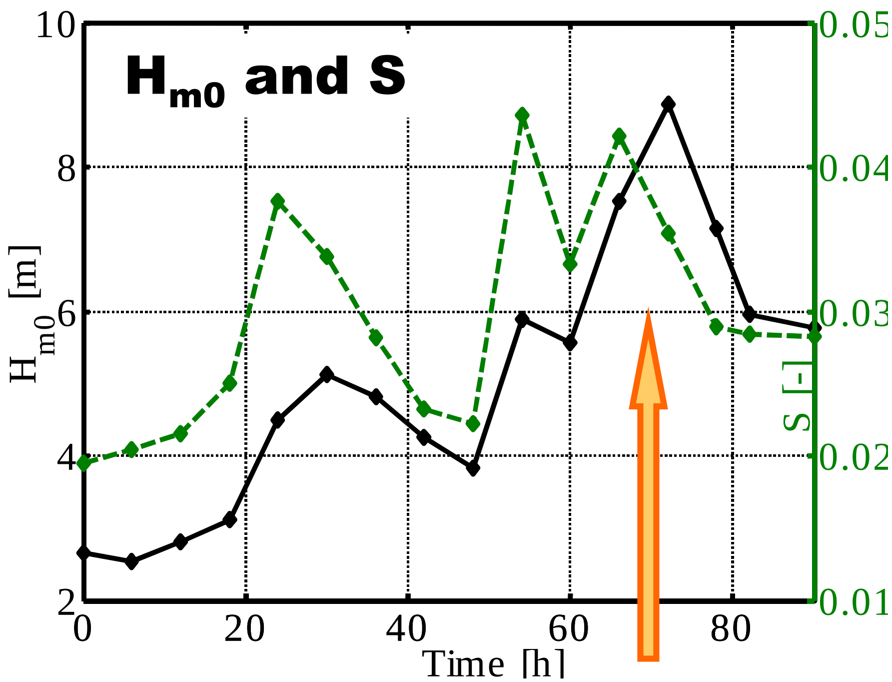
0 = unidirectional spectrum

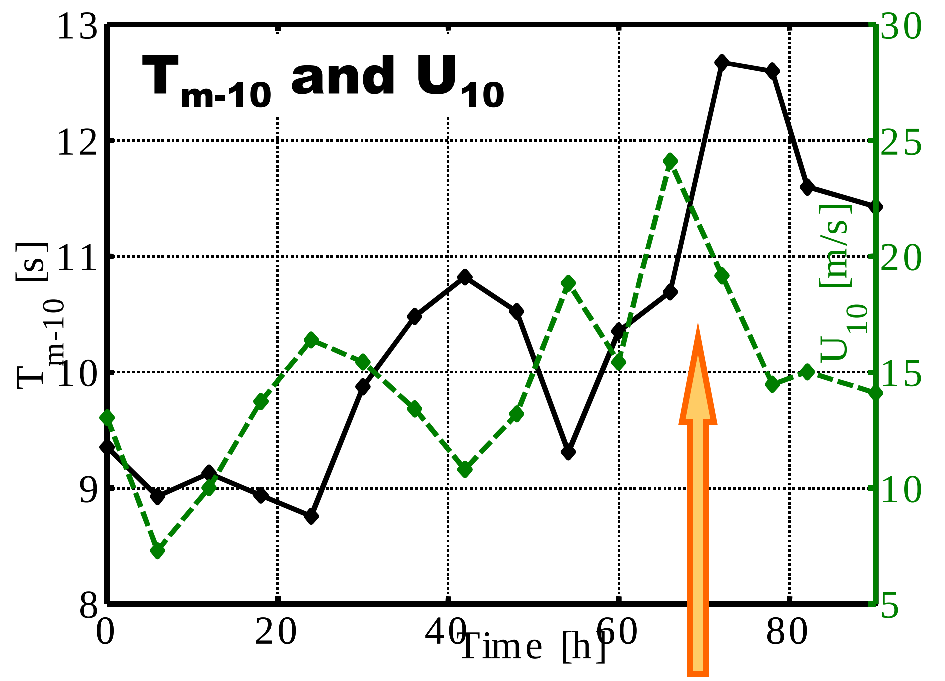
$\sqrt{2}$ = uniform spectrum

SCHIEHALLION FPSO

Location: West of Shetland Isles
Time: 9th November 1998, 22:00 UTC
Damage: an area of the bow, *__20 m above the water line__*, was pushed in by 0.25 *m* (Gorf *et al.* 2000, Proc. Int. Conf. "Rogue Wave 2000").

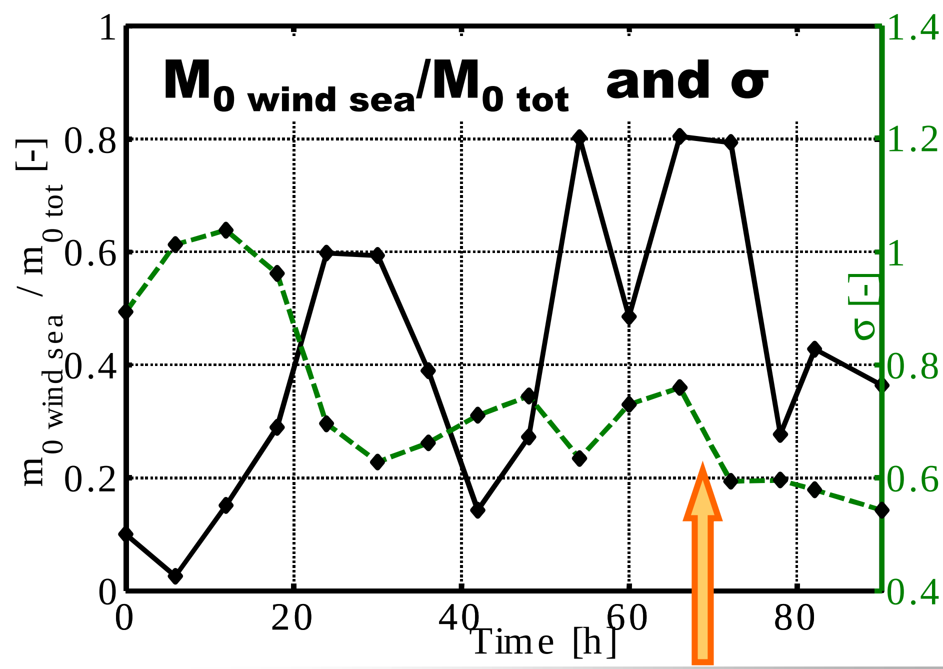




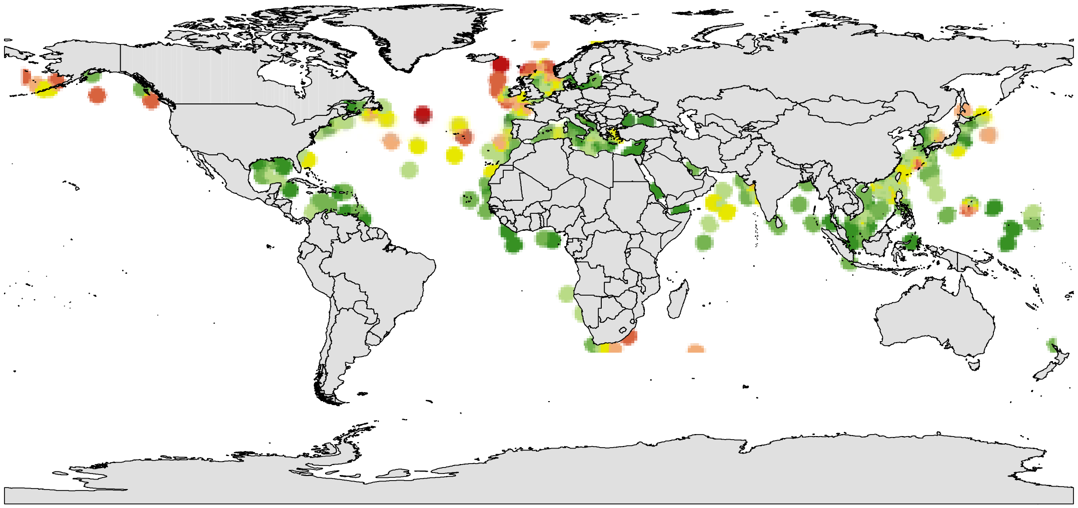


Sea-state from ECMWF-ERA40 database. Period between <u>1998/11/07</u> and <u>1998/11/10</u>

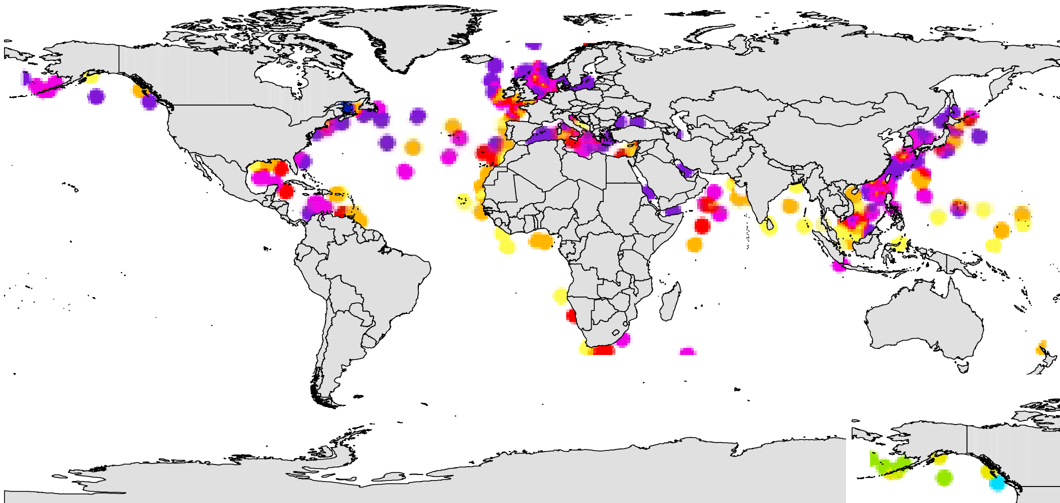
Rapid developments play an important role



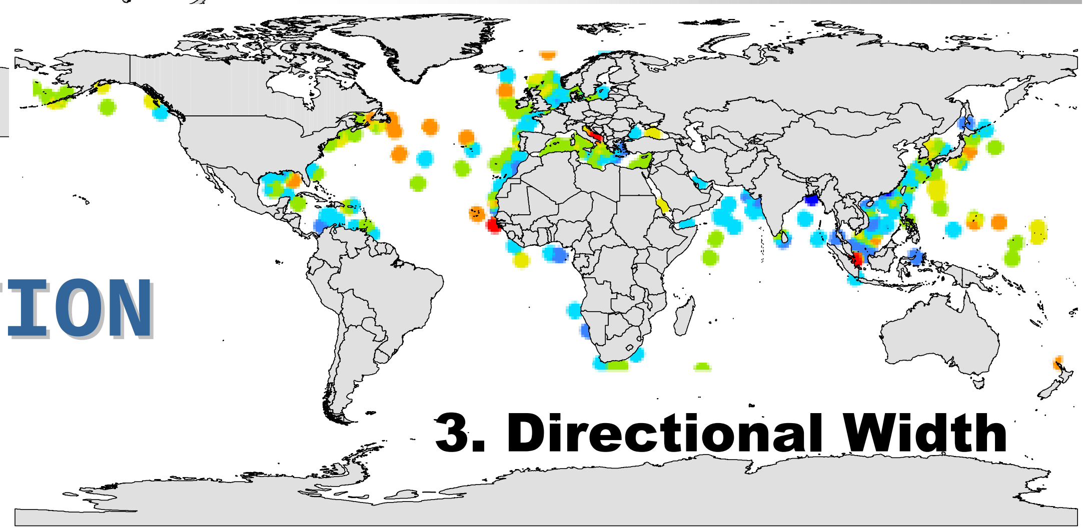
1. Significant Wave Height



2. Wave Steepness



3. Directional Width



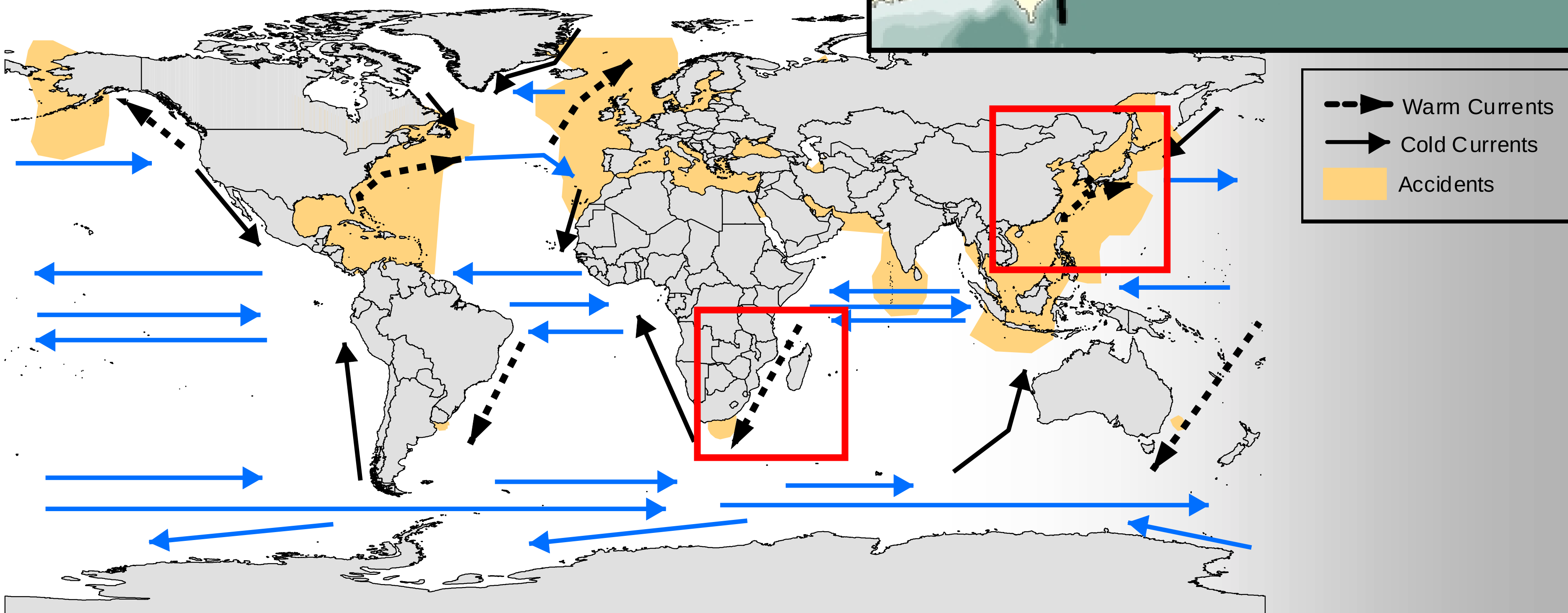
GLOBAL DISTRIBUTION

Forecasting Dangerous Sea-States

Ocean Currents

Strong ocean currents:

- Agulhas Currents (~ 2 m/s)
- Kuroshio Currents (~ 1.6 m/s)

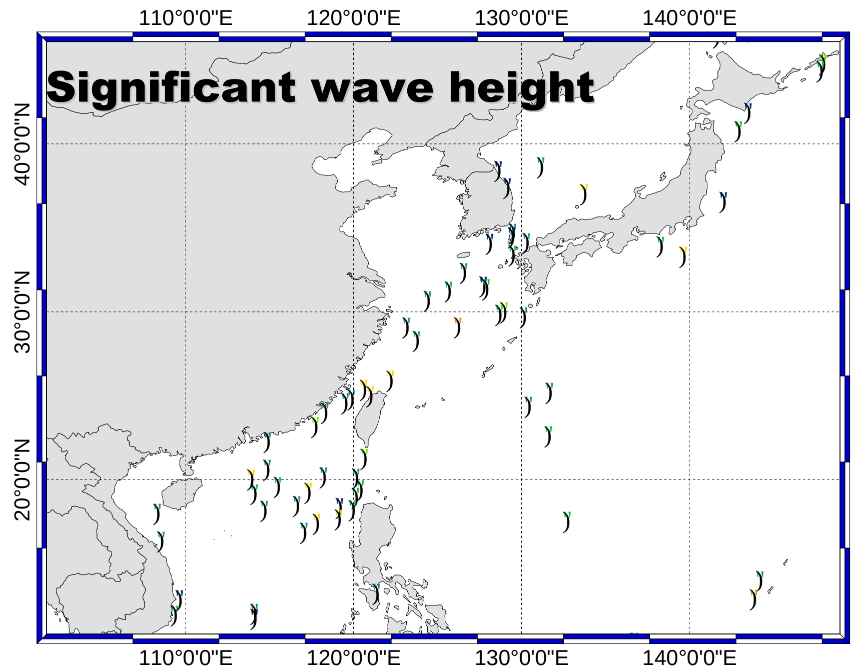


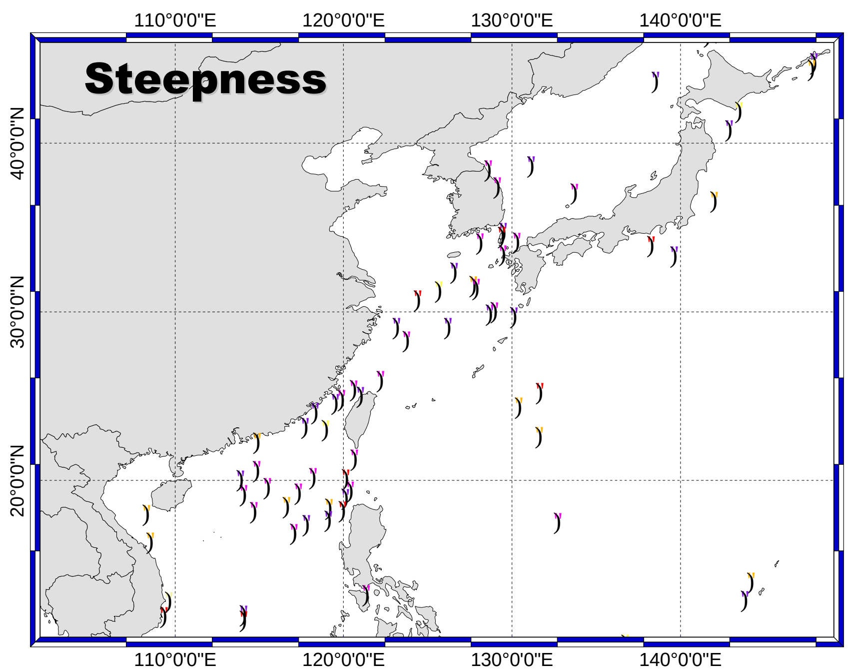
Wave Steepness
0.002 - 0.007
0.008 - 0.016
0.017 - 0.026
0.027 - 0.031
0.032 - 0.036
0.037 - 0.045
0.046 - 0.060

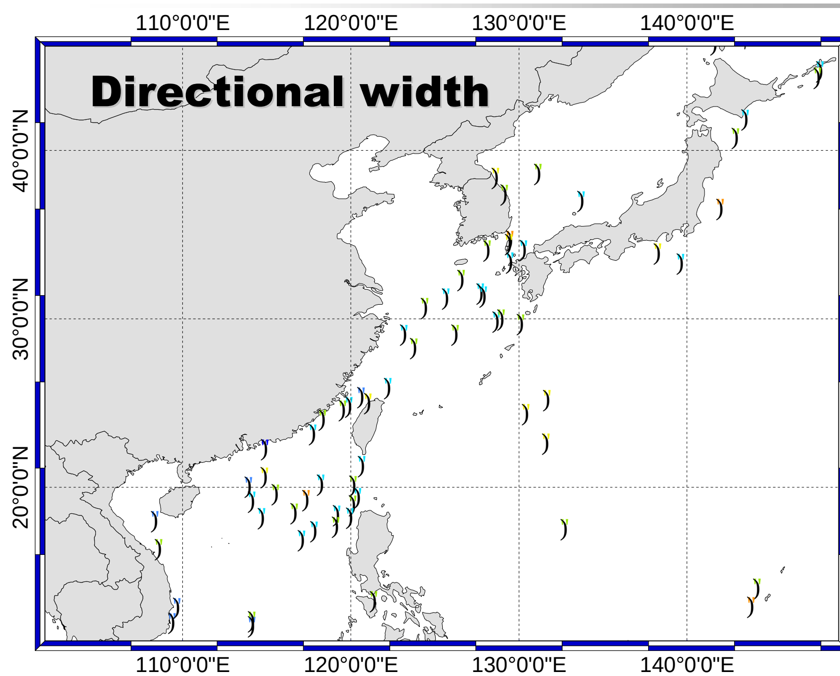
Significant Wave Height [m]
0.07 - 1.64
1.65 - 2.55
2.56 - 3.50
3.51 - 4.69
4.70 - 6.18
6.19 - 8.57
8.58 - 10.64

Directional Width
0 - 0.26
0.261 - 0.52
0.521 - 0.62
0.621 - 0.74
0.741 - 0.87
0.871 - 1.16
1.161 - 1.414

SEA-STATES ALONG THE KUROSHIO CURRENTS







Conclusions

- Wave fields were used in the analysis of accidents due to bad weather.
- The classical spectral parameters (e.g. H_{m0}) are not sufficient. (Apparently rather low sea-state were found)
- Additional parameters are needed:
  - Directional information (e.g. crossing seas)
  - Rapid developments
  - Environmental factors (e.g. ocean currents)
- Ships react differently to a certain sea-state and hence an interpretation of wave forecast will be needed for each type of ship and possibly for each individual ship.
- BB for ships