Geophysical Research Abstracts,
Vol. 10, EGU2008-A-04128, 2008
SRef-ID: 1607-7962/gra/EGU2008-A-04128
EGU General Assembly 2008

Mismatch of trends of average wave activity and extreme wave conditions in the northern Baltic Sea

T. Soomere, I. Zaitseva and L. Kelpšaite

Centre for Nonlinear Studies, Institute of Cybernetics at Tallinn University of Technology, Akadeemia tee 21, 12618 Tallinn, Estonia (soomere@cs.ioc.ee)

1 Introduction

Several cases of extremely rough and unexpectedly hazardous wave conditions at the turn of the millennium (Kahma et al. 2003) and ferocious winter storms in 2004/2005 (Suursaar et al. 2006, Soomere et al. 2008) have reinforced the discussion as to whether the wave conditions in the Baltic Sea have become rougher compared to a few decades ago.

There exists a number of contradicting evidence on wave activity in this area. For example, Orviku et al. (2003) conclude that the apparently increasing storminess in the Baltic Sea (Alexandersson et al. 1998) has already caused extensive erosion of depositional coasts although the changes in the wave climate have been found marginal, at least, until the mid-1990s (WASA Group 1995). This paradox suggests that the trends of the long-term average wave activity and of the extreme wave conditions may be different in the northern Baltic Sea.

We report results of a study of interannual variations of average wave conditions and extreme wave storms in the northern Baltic Sea. The analysis is based on (1) long-term time series from Almagrundet (1978–2003) and Vilsandi (1954–2005), (2) wave statistics from the northern Baltic Proper, and (3) simulations of wave properties in cyclone Gudrun in January 2005.

2 Decadal variations of the average wave height

The longest instrumental wave data set in the northern Baltic Sea (Almagrundet, 59˚09' N, 19˚08' E, 1978–2003) has been recorded with the use of an upward-looking echo-sounder. An estimate of the significant wave height was found from the 10th highest wave in each record under the assumption that wave heights are Rayleigh distributed (Mårtensson and Bergdahl 1987).

The data from this partially sheltered site may give a slightly biased picture of the open-sea wave properties (Kahma et al. 2003). However, they evidently reflect the changes of the long-term wave patterns (Broman et al. 2006). These data were compared with the longest available wave data set in this area – visual wave observations from 1954–2005 from the island of Vilsandi at the eastern coast of the Baltic Proper (Soomere and Zaitseva 2007).

The most representative wave data the northern Baltic Proper stem from a directional waverider operated by the Finnish Institute of Marine Research at 59˚15' N, 21˚00' E from September 1996 during the ice-free seasons (Kahma et al. 2003).

The overall course of the annual mean wave height at Almagrundet and Vilsandi reveals nearly synchronous, substantial decadal-scale variation. The interval between subsequent periods of high or low wave activity is about 25 years. The annual mean wave height varied insignificantly in the 1960s–1970s. Its rapid increase occurred from the mid-1980s until the mid-1990s. The increase was well over 1% per annum in 1979–95 (1.8 % at Almagrundet, Broman et al. 2006, and as high as 2.8 % at Vilsandi, Soomere and Zaitseva 2007). This trend existed only for about 1.5 decades and was replaced by a drastic decrease of the mean wave height since 1997.

3 Extreme wave conditions

The only storm during which the significant wave height definitely exceeded 7 m at Almagrundet occurred on 13–14 January 1984 (Broman et al. 2006). This threshold was most probably also exceeded in January 1993. It was reached only four times in the northern Baltic Proper since 1996: twice in December 1999, and again twice in three weeks during the 2004–05 winter storms (Kahma et al. 2003, Soomere et al. 2008).

Extreme storms with significant wave heights close to or exceeding 7 m therefore occur roughly twice a decade. Their frequency of occurrence is roughly the same

during the periods of overall high and low wave intensity: only two such storms were registered in 1994–2002 when the mean wave height was considerably larger than in the 1980s. Extreme wave conditions therefore are not necessarily well-correlated with the mean wave activity. This (somewhat counter-intuitive) feature apparently has its origin in the specific features of wave generation conditions in this complex-shaped water basin.

Very rough wave conditions occurred in the north-eastern regions of the Baltic Sea during the 2005 January storm Gudrun. The observed significant wave height reached 7.16 m in the northern Baltic Proper. The highest waves apparently occurred off the coast of Saaremaa about 57ºN, 20.4ºE, where the significant wave height was around 9.5 m (Soomere et al. 2008). Waves were also remarkably long. Such storms exciting long and high waves and extreme water level conditions generally cause extremely large erosion pressure on the beaches.

4 Conclusions and discussion

The overall wave intensity in the northern Baltic Proper exhibits quasi-periodic decadal variation with a period of about 25 years. Quite surprisingly, the rapidly falling trend of the annual mean wave height at the observation sites 1998 does not match the evident increase of the mean wind speed over the area in question (Broman et al. 2006).

This mismatch of the wind and wave properties in the northern Baltic Proper is somewhat paradoxical. The match of the wave properties at the opposite coasts suggests that not secular changes in the dominating wind directions but certain other properties of the wind fields (such as the duration of winds from different directions or changes in wind patterns related to shifts of the trajectories of cyclones) may play an important role in creating the Baltic Sea wave fields. The drastic changes of the mean wave height on the background of the gradual increase of the mean wind speed (Broman et al. 2006) suggests that the local wave generation conditions have substantially changed within relatively short time intervals.

Another interesting feature is that the decadal trends of the average and extreme values of wave conditions seem to be different. The increase in wave activity between 1978–1995 was not accompanied by an increase in extreme wave heights. Instead, in December 1999 and at the turn of 2004/2005 extremely rough seas occurred although both instrumental wave data from Almagrundet and results of visual observations from Vilsandi suggest that a drastic decrease of the wave activity has occurred since 1997.

Financial support of the Estonian Science Foundation (Grant 7413) and EC-supported INNOVE project 1.0101-0208, Marie Curie RTN network SEAMOCS (MRTN-CT-2005-019374), and Marie Curie ToK project CENS-CMA (MC-TK-013909) is gratefully acknowledged.

References

Alexandersson H., Schmith T., Iden K., Tuomenvirta H. 1998. Long-term variations of the storm climate over NW Europe, *The Global Atmosphere and Ocean System* 6, 97–120.

Broman B., Hammarklint T., Rannat K., Soomere T., Valdmann A. 2006. Trends and extremes of wave fields in the north–eastern part of the Baltic Proper, *Oceanologia* 48(S), 165–184.

Kahma K., Pettersson H., Tuomi, L. 2003. Scatter diagram wave statistics from the northern Baltic Sea, *MERI – Report Series of the Finnish Institute of Marine Research* 49, 15–32.

Mårtensson N., Bergdahl L. 1987. On the wave climate of the Southern Baltic, *Report Series A:15. Department of Hydraulics, Chalmers University of Technology, Göteborg*.

Orviku K., Jaagus J., Kont A., Ratas U., Rivis R. 2003. Increasing activity of coastal processes associated with climate change in Estonia, *Journal of Coastal Research* 19(2), 364–375.

Soomere T., Behrens A., Tuomi L., Nielsen J.W. 2008. Wave conditions in the Baltic Proper and in the Gulf of Finland during windstorm Gudrun, *Natural Hazards and Earth System Sciences* (in press).

Soomere T., Zaitseva I. 2007. Estimates of wave climate in the northern Baltic Proper derived from visual wave observations at Vilsandi, *Proceedings of Estonian Academy of Sciences, Engineering* 13(1), 48–64.

Suursaar Ü., Kullas T., Otsmann M., Saaremäe I., Kuik J., Merilain M. 2006. Cyclone Gudrun and modelling its hydrodynamic consequences in the Estonian coastal waters, *Boreal Environment Research* 11, 143–159.

WASA Group 1995. The WASA project: changing storm and wave climate in the northeast Atlantic and adjacent seas? *GKSS Report 96/E/61, Geesthacht, Germany*.