Sea Surface Temperature in the Baltic Sea in 2011

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Key message

In sea surface temperature (SST) the year 2011 was characterized by negative anomalies in the months January to March, a relatively warm June and a warm second half of the year in the northern and eastern Baltic. On average February was the coldest month in the western and March in the central Baltic Sea with maximum ice coverage on 24th February. Positive anomalies were determined for June in the entire Baltic before in July and August cyclones with extreme precipitation and wind dominated the weather conditions in the southern Baltic Sea. The maximum temperature was observed at the beginning of August with 20-22°C in the central and 18-19°C in the western Baltic Sea. In September and October persistent westerly winds caused prominent upwelling along the Swedish coast from the Arkona Sea to the northern Gotland Sea with strong temperature gradients.

Background

Sea Surface Temperature (SST) of the Baltic Sea derived from data of the Advanced Very High Resolution Radiometer (AVHRR) of the National Oceanic and Atmospheric Administration (NOAA) weather satellites and from the European Weather satellite MetOp-2 was provided by the German Federal Maritime and Hydrographic Agency Hamburg (BSH) since 1990. The SST data evaluation procedure is described by Siegel et al. (2008). Systematic studies on seasonal and inter-annual variations in SST are published by Siegel et al. (2006, 2008). SST was implemented in the yearly assessment of the Baltic Sea since 1996 provided by the Baltic Sea Research Institute Warnemünde (Matthäus et al. 1997). This fact sheet is based on the results of the German assessment of the state of the Baltic Sea of 2011 (Nausch et al. 2012).

Results and assessment

The characteristics in the development of the air temperature are reflected in the cold and heat sums. The cold sums of air temperature in Warnemünde showed that the winter 2010/2011 was with 177.7 Kd (average 105.4 Kd) after the winter 2009/2010 the thirteen coldest winter since 1948. To this cold sum December 2010 contributed significantly with 109.2 Kd. The total heat sum of the summer 2011 amounted to 174.5 Kd, which was above the long-term average (148.8 Kd), but is in the ranking of the warmest summers only number 20 since 1948.

The monthly mean SST anomalies of the year 2011 are presented for the entire Baltic Sea in Fig. 1. Seasonal course in the monthly mean temperatures in the central regions of the Arkona-, Gotland- and Bothnia Seas are compared in Fig. 2 to the long-term monthly averages (1990-2009). In December 2010, heavy frost prevailed throughout Europe, which strongly influenced also the Baltic Sea. The cooling continued in the period January to March. February was the coldest month in the Arkona Sea and March in the Gotland Sea. This led to negative anomalies of up to -2 K from January to March in most parts of the Baltic Sea. With the onset of warming in March from the western parts, the monthly means in the Arkona Sea were already slightly higher than in the Gotland Sea. In April and May, the monthly means remained in all regions in the

range or slightly below the long term average values. In June, the anomalies were positive in the Baltic Sea, except parts of the Gulf of Finland and Gulf of Bothnia.

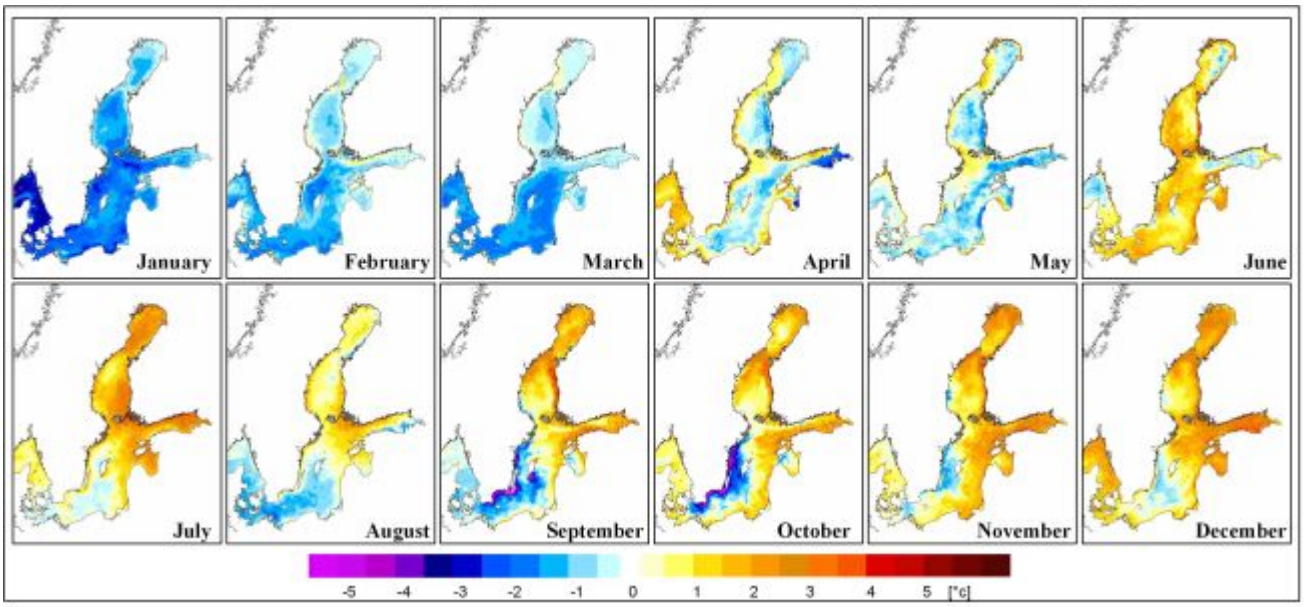

Figure 1. SST- Anomalies of the monthly mean temperature of the Baltic Sea in 2011 referring to the long-term means 1990 - 2010

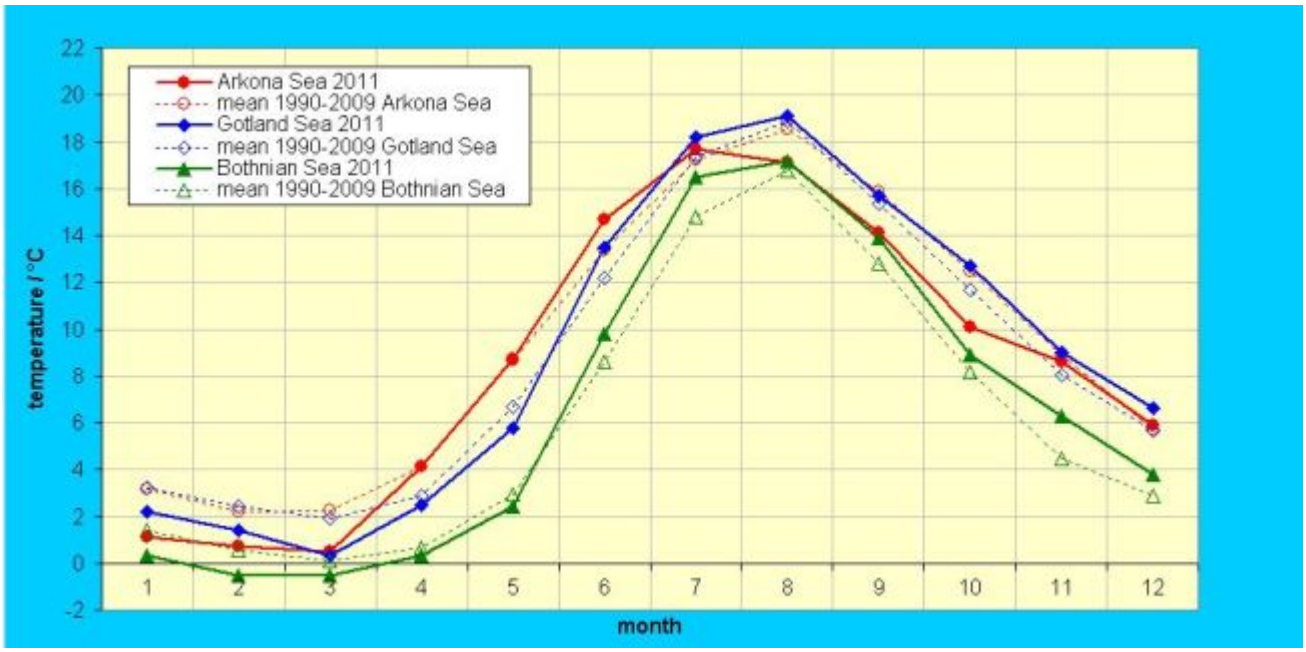

Figure 2. Seasonal course of sea surface temperature (NOAA-SST) in the central Arkona-, Gotland- and Bothnian Sea in 2011 in comparison to the mean values of the last 20 years (1990-2009)

Low pressure weather conditions with heavy precipitation determined the weather in July and August 2011 in the southern Baltic Sea. In July, the monthly mean SST was still in the range of long-term average values, in August up to -1.5 K below. The northern Baltic Sea was excluded from the low pressure conditions that the SST anomalies were positive in these two months. This resulted in both months in a very homogeneous temperature distribution in the entire Baltic with SST between 16-19°C in contrast to other years. The July

was the warmest month of the year in the western Baltic, whereas August was the warmest month in the Gotland Sea and in the northern Baltic Sea. September and October were characterized by persistent westerly winds, which caused strong upwelling along the Swedish coast from the Arkona Sea to the northern Gotland Sea. The upwelling partly induced negative anomalies of up to -5 K. The strong influence of cyclones and upwelling in the central Arkona Sea can be seen in SST in Fig. 2. From September to December large parts of northern and eastern Baltic Sea were characterized by positive anomalies. In December, the SSTs were in the Arkona Sea in the range of long-term mean values and in the Gotland Sea and in the Gulf of Bothnia about 1 K above.

With the strong cooling phase in December 2010 severe ice formation started already on 20 December in the northern Baltic and end of December in the western parts (Schmelzer & Holfort, 2011). This resulted also in a further decrease of SST reaching early January values of about 0°C in the western Baltic, 2°C in the Arkona Sea, 3°C in the Gotland Sea and slightly above 0°C in the Bothnian Sea. Until the end of January, SST was reduced by approximately 1 K in each area. The further ice formation continued mid-February in the entire Baltic and reached the maximum ice cover on 24 February. The entire northern Baltic, large parts of eastern Baltic and also parts of the western Baltic were covered. The monthly mean SST of February along the section through the central basins of the Baltic Sea from the Mecklenburg Bight to the Bothnian Bay is compared in Fig. 3 to the last year, the long-term average 1990 - 2009 and the variation range. The SST was in the entire Baltic Sea below the long-term average, but especially in the western Baltic, the low values of the previous year could not be achieved.

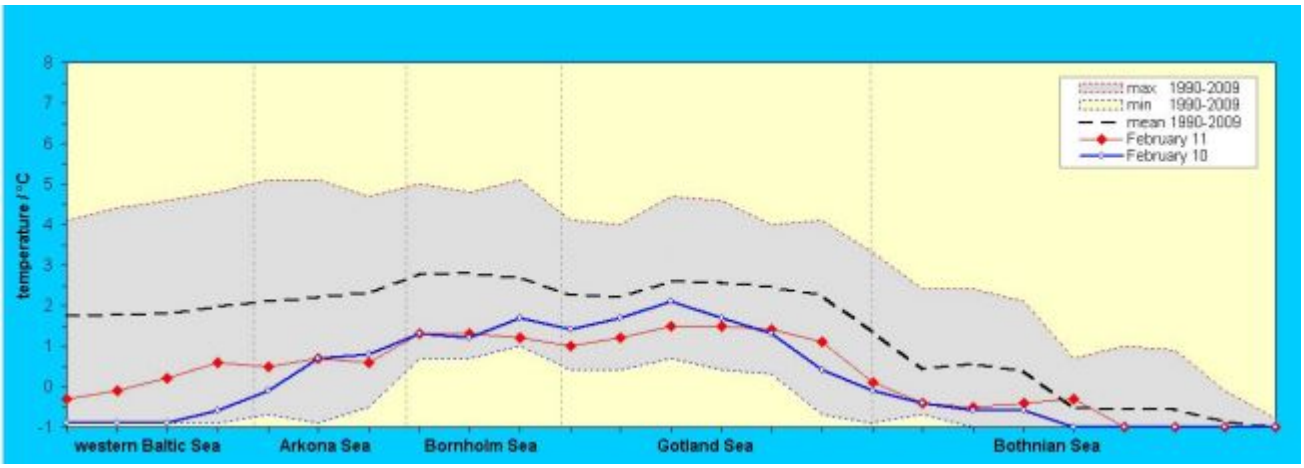

Figure 3. Temperature distribution along the transect through the Baltic Sea in February 2011 in comparison to the previous year, to the long-term mean value of 1990 – 2009, and to the variation range of the investigation period.

Beginning of March, a slight warming occurred in the western Baltic leading to 2°C on 7 March in the Bornholm Sea. On 15 March another warming extended the region with 2°C to the entire western and southern Baltic Sea. After a stagnation period the warming continued on 25 March in different phases and reached around 20 April during westerly winds 8-10°C in the inner western parts, 3-5°C from the Arkona Sea to the southern Gotland Sea and only 0-2°C from the central Gotlandsee to the northern Baltic Sea. The SST declined end of the month there again to 5-8°C and in the Baltic Proper to 3-6°C. To 20 May, the SST rose to 10-14°C throughout the western Baltic and 7-12 °C in the central Baltic Sea. Thus, the SST was by 3-5°C higher than during the same time in the year before. End of May in many parts of the western Baltic 13-14 °C were observed with exception of the Swedish coast where westerly winds induced coastal upwelling. The influx of warm and humid air from the south on 6 June caused a sudden increase in the SST west of

Darss Sill and in the Pomeranian Bight to 17-18°C. Subsequent low pressure situations induced changing weather and relatively constant temperatures from the western Baltic Sea to the northern Gotland Sea of 13-16°C. On 29 June, southerly winds transported again very warm air masses to Germany and the Baltic region. This increased the SST in the Baltic Sea to 15-18°C, except the Bothnian Bay with 9-16°C only. In July, the southern Baltic Sea was strongly influenced by cyclones with only very few weak wind and cloudless high pressure phases. Thus, the SST stagnated at the beginning of the month. Only in the northern Baltic Sea, Gulf of Finland and in the Gulf of Riga a marked increase in SST was recorded after 6 July. In the entire Baltic Sea, the SSTs were in the range of 17-21°C on 8 July that retained until 12 July. After slight cooling, a high pressure area influenced the Baltic Sea proper on 19 July and the SST was distributed fairly uniformly with 17 to 20°C. Particularly in the eastern Baltic Sea, the warming continued leading to SST of 20-23°C. End of the month the SST dropped down again to 17-19°C. The averages of July in Fig. 4a clearly show the described differences between the northern and southern parts. The monthly mean SSTs are compared to the average of July 2010, presented to the long-term average from 1990 to 2009 and the range of variation in the investigation period along a section through the entire Baltic Sea. Throughout the western and southern Baltic to the central Gotland the SST was in the range of long-term mean values and to the north by up to 3°C above.

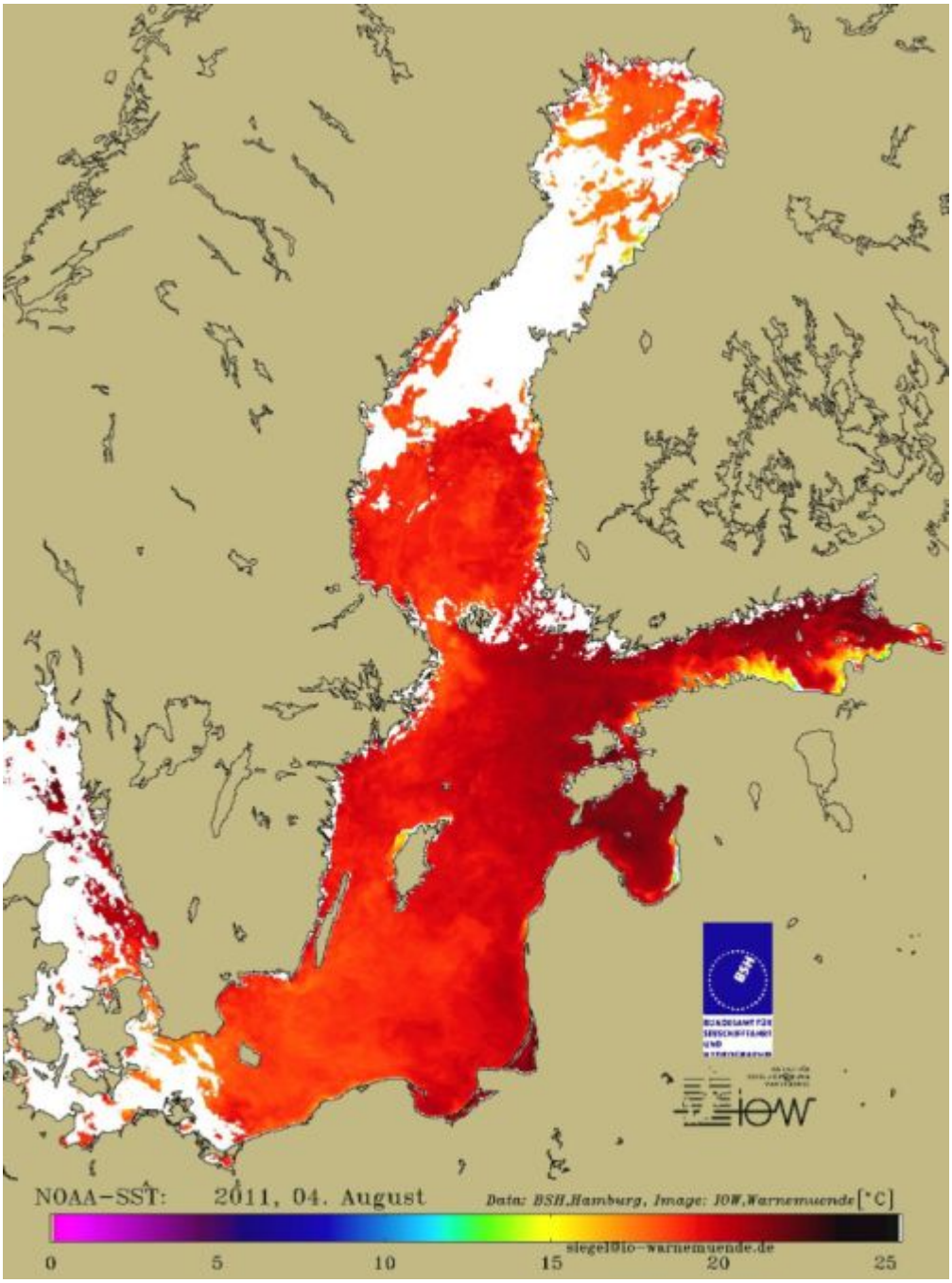

Figure 4. Temperature distribution in the Baltic Sea on the warmest day of the year (4 August 2011)

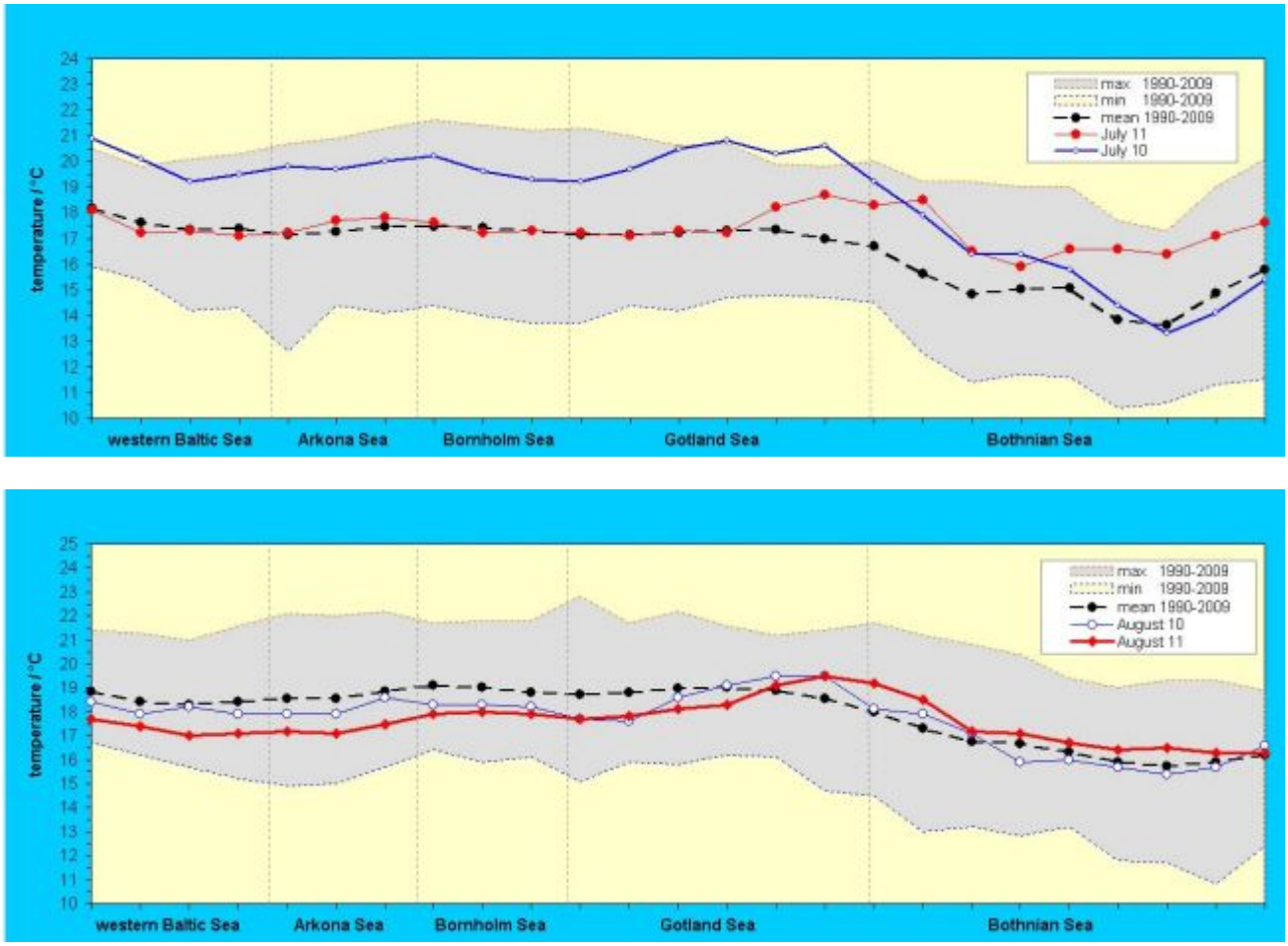

Figure 5. Temperature distribution along the transect through the Baltic Sea in July (a) and August 2011 (b) in comparison to the previous year, the long-term mean value of 1990–2009, and the variation range of the investigation period.

As a result of a short calm weather period the SST reached on 2 August in the western Baltic, the maximum values of the summer 2011 of 18-20°C. The high pressure area moved slowly eastward across the Baltic Sea, that the maximum temperature of the year was achieved there on 4 August with 18-21°C (Fig. 5). Thereafter, cyclones with strong winds mixed the surface water and temperatures decreased until 22 August to 15-18°C. A short episode on 25 and 26 August transported humid warm air masses into the Baltic region, accompanied by a calming and intermittent heating to 16-20°C. The averages of August in Fig. 4b show that the differences between the northern and southern parts still existed. They are compared to the average of August 2010, to the long-term average from 1990 to 2009 and the range of variation in the investigation period on the longitudinal section through the Baltic Sea. In the central and western Baltic the SST was 1-2°C below the long-term mean values and to the north up to 2°C above. From about 5 September onset of SW and W winds caused upwelling along the Swedish coast from the Arkona to the northern Gotland Sea. The filaments extended to the centers of the adjacent seas. In the core of the upwelling the SST was about 5-8°C and the southern and eastern coasts of the Baltic had still up to 16°C end of the month. The Bothnian Bay was already cooled down in the central part to 8-10°C. The upwelling could be observed during the entire October and extended into the northern Baltic Sea. SST was at the beginning of October in many parts still 13-15°C and only in the upwelling regions 8-10°C. The influenced areas increased and covered on 15 October the entire Arkona Sea and on 17 October the entire western Baltic. The cooling continued and in December particularly from the west and north. End of the year the western

Baltic had about 5°C which corresponded to the long-term average. In the northern and eastern parts of the Baltic Proper the SST was with 6-7°C slightly higher than the long-term average values. Thus, there were no specific starting conditions for the winter 2011/2012.
Overall, the year was despite the cool early months and the rainy summer relatively warm particularly in the northern Baltic. In the ranking of the annual mean temperature 2011 was on 7th place of the warmest years since 1990.

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