Characterizing and Reconstructing 500 years of Climate in the Baltic Sea Basin

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Abstract

Climate has always attracted considerable interest, and climate observations have been made in various ways for most of human history. Regional climate and how it varies is of particular interest, as it sets the scene for our everyday life. This thesis analyses the past climate of the Baltic Sea Basin and relates ice coverage and river runoff to changes in atmospheric circulation.

The regional climate of the Baltic Sea Basin has been analysed using relevant climatic time series for the past 100–500 years. The time series used in the thesis describe parameters such as station-based and gridded air temperature, sea level, ice cover extent, river ice break-up dates, and river runoff. To describe the atmospheric circulation over the area, gridded sea level pressure data have been used to construct time series describing the occurrence of high- and low-pressure systems as well as westerly and northerly winds.

The definition of climate was analysed and a proper climate averaging time was found to be 15 years, corresponding to a loss of variability of 90 %. The analysis used annual averages and revealed positive trends in high-pressure activity and air temperature, possibly indicating a north-ward shift of the low-pressure tracks.

The winter climate of the past five centuries was examined through a comprehensive analysis of the longest time series, describing winter severity, available for the Baltic Sea Basin. The covariation of several climatic variables was examined using new statistical techniques. Over the last 500 years, 15 time periods stood out, giving a climatic imprint with respect to winter severity, circulation patterns, and interannual variability. Both warm and cold periods were identified in the past Baltic Sea climate; their onset was probably caused by perturbations of the system, although correspondences with solar and volcanic activity can be identified for certain of them. On the interannual timescale, describing year-to-year variability, warm periods are associated with less variability while cold periods are associated with more.

Two reconstructions have also been made, describing the past evolution of maximal ice cover extent in the Baltic Sea and river runoff from the Baltic Sea drainage area. Statistical modelling was used to link atmospheric circulation parameters to changes in ice and river runoff. High ice coverage in the Baltic Sea was demonstrated to be closely associated with high-pressure circulation and easterly winds, while low ice coverage was associated with westerly winds and low-pressure circulation. Runoff information was developed from three different models, each formulated to describe one of the three subdomains (north, south, and Gulf of Finland) using atmospheric circulation and temperature. The northern part was sensitive to changes in temperature and circulation characteristics, while the southern model was less affected by temperature. Correlation with observations is satisfactory, indicating that the derived statistical relationships are highly credible. The past 500 years of river runoff display no significant trend, but regional and temporal variability is large.

Key words: Climate, Baltic Sea, Atmospheric circulation, Statistical modelling, Wavelet, Sea Ice, River runoff,