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How we can predict unmodelable processes based on climate simulation: application to the problem of meteorological hazards projection

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For modern climatology the fundamental challenge are the methods developing for predicting severe weather events. Users and consumers are interested in events such as catastrophic floods, storm wind speeds, waves of great height, severe snowstorms, etc. The properties of mentioned events have a small (subgrid) spatial scale and may not be clearly reproduced by the climate models. However, in some cases they can be almost uniquely associated with large-scale meteorological fields (LSMF), which can be well simulated by the models. The projecting technique can be based on the following steps. First, we have to select those hazards that may be associated with LSMF. Second, we have to establish a relationship in quantitative terms based on observations. Third, we will test how well current models reproduce the desired features of LSMF using the hindcasting technique. Fourth, to determine what changes occur in the LSMF climate forecast. Fifth, we have to make the transition to the prediction of the studied hazard form. Note that this technique cannot be implemented for all possible hazards, and probably it must be developed independently for each particular region. As a concrete example, we consider the possibility of predicting hazardous storm wind speeds on the shores of the Black Sea. Storms over the Black Sea area are the result of specific synoptic situations. They have been studied for the last 60 years based on reanalysis data and coastal observations. A wind speed of 15 m/s is chosen as a threshold to detect the storm situation (partly because it causes waves of great height). EOF analyses of sea-level pressure (SLP) and other statistical methods are applied to identify the main types of atmospheric circulations causing severe winds and storm waves. The study shows that two main specific situations of the SLP distribution are typical for the storm situation. The main feature of the first is the fast movement of a Mediterranean cyclone or its trough towards the Black Sea and simultaneously a large and stable anticyclone located over the Eastern Europe. The second one is accompanied by an abrupt quasi meridional intrusion of a cyclone or a trough from Scandinavia. Then very often in both cases a local Black Sea cyclone appears. The first three EOFs cover more than 70% of the total dispersion in all cases. This fact allows to create a ‘data bank’ of filtered SLP pattern for previous storms and to compare any single case with the data base. We find that the prevailing 1st type of the SLP fields for storms took place for the last 60 years.
The ECHAM5 data (20C3M (1961-2000) and A2 (2046-2065)) were used for investigating the SLP peculiarities of the current and future climate. They show good agreement with the assessment of storms frequencies in the coastal zone of the Black Sea for the years 1961-2000 and were used for projection of storm frequencies in the 21th century. On the basis of our analysis it is expected that 1st type of the SLP will be prevailed during the 21 century. The announced above the detection scheme based on the weather types were applied. It allows to realize projecting of the storm probability according to the degree of proximity of predicted SLP field to the ‘storm types’.