Atlantic Multidecadal Variability and hydrological cycle in the Caspian Sea watershed

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The Caspian Sea level (CSL) experiences large variations that highly impact society and environment. The CSL variations are determined by water cycle changes integrated over the huge (more than 3 million square km) watershed area. Volga River discharge (VRD) explains more than 80% of the CSL variations during the last century. Many different factors have been previously proposed to contribute to VRD change including major models of natural climate variability, e.g., NAO [Rodionov 1994] and ENSO [Arpe et al. 2000], and anthropogenic forcing [e.g., Arpe et al. 1999]. Recently, it has been suggested that Atlantic Multidecadal Variability (AMV), the major low-frequency climate variability mode in the North Atlantic, may strongly affect even the global climate variations [e.g., Semenov et al. 2010]. Analysis of coupled climate model simulations revealed a significant link between AMV and hydrological cycle over Eurasia on inter-decadal time scale [Mokhov et al. 2008]. Here, we focus on the AMV impact on hydrological cycle in the Caspian Sea watershed using global model simulations.

The simulations are performed using ECHAM5 atmosphere general circulation model of T31 spectral resolution (appr. 3.8° lat/lon) coupled to thermodinamical mixed layer (50 m) ocean model. The coupled model is forced by periodically (60-yr) time-varying anomalous oceanic heat convergence flux in the North Atlantic and Arctic representing AMV. The anomalous heat flux pattern, model and experimental design are described in [Semenov et al. 2010].

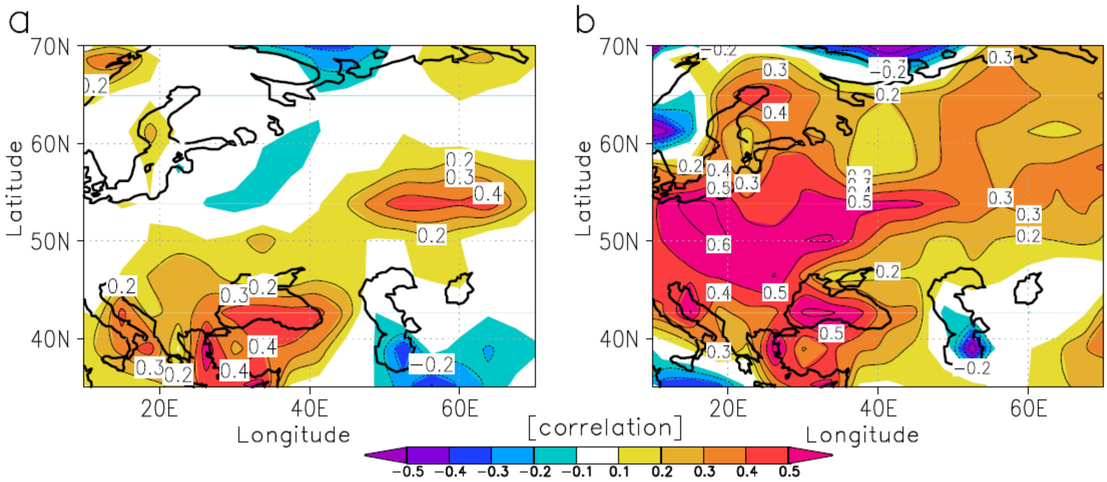

Figure 1: Correlations between simulated annual AMV SST index (see the text) and precipitation-minus-evaporation for realistic (**a**) and doubled (**b**) forcing experiments. Data have been smoothed with 15-yr running averages.

Two simulations of 500 yrs duration are performed. One uses realistic AMV amplitude (about 0.09 PW integrated heat transport). Another uses a doubled amplitude of the anomalous heat flux pattern. These simulations are idealized as they do not involve ocean dynamics and other internal variability modes essentially interacting with the AMO. From the other hand, such experiments allow one a clear separation of the AMV-related signal that is the only time-varying external forcing factor in the coupled system. The experiments start from the present-day climate conditions (2001-2010) and maximum of the AMV forcing.

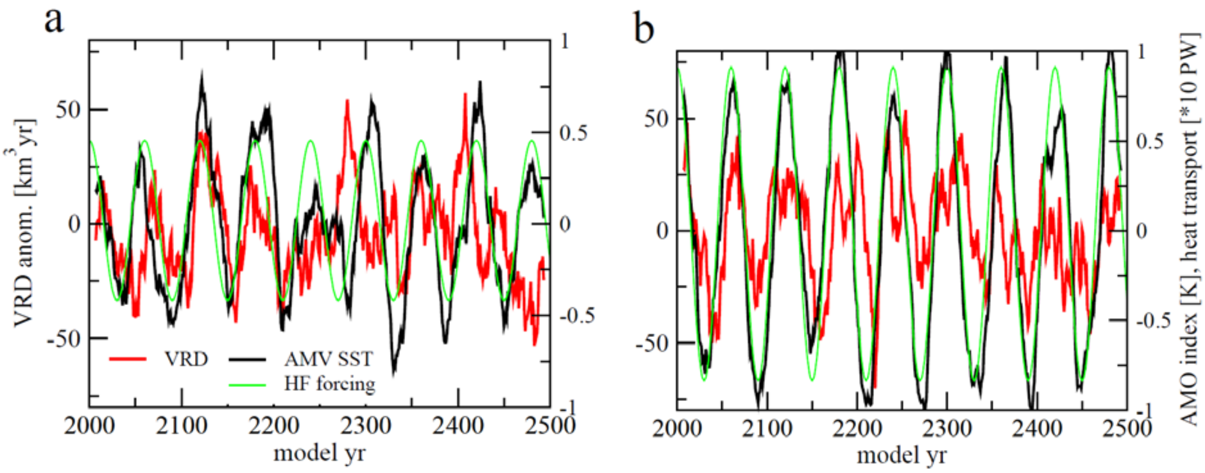

Figure 2: Simulated annual Volga River discharge anomalies (VRD, in km3/yr, red), AMV SST index (in K, black) and applied integrated heat flux (HF) forcing (in PW, green) for realistic (**a**) and doubled (**b**) forcing experiments. All time series are 15-yr running averages.

The results reveal a significant positive correlation between AMV, as represented by averaged sea surface temperature anomalies in [50W-10W,40N-60N] region, and precipitation-minus-evaporation difference over the Eastern Eurasia including Caspian Sea watershed (Fig. 1). Simulation with realistic forcing exhibits weaker correlations. However, area of stronger correlation is found in the eastern part of the Volga River watershed. Correlation of AMV SST index with precipitation is stronger for both simulations. Simulated VRD anomalies are shown in Fig. 2 together with AMV SST index and applied heat flux forcing. In doubled forcing simulation, variations of VRD are closely linked with the AMV SST index (Fig. 2b). The link is not robust in the realistic forcing simulation where periods of strong correlation (e.g. 2000-2250) and weak correlation (e.g., 2250-2350) alternate (Fig. 2a).

An estimate of the interdecadal variations of the annual Volga river discharge related to the AMV (estimated from linear regression) amounts to about 40 cubic kilometers per year which is comparable to the observed changes during the 20th century. This indicates a possible role of the AMV in driving CSL changes. The results imply a potential decadal predictability for CSL.

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