The role of volcanic forcing on northern hemisphere decadal to multidecadal climate variability and future carbon cycle

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Decadal to multidecadal climate variability is an important feature of the observed northern hemisphere climate record. For instance, decadal variations in Atlantic SSTs have been suggested to affect a number of important regional climates, such as North American droughts, summer temperatures in Europe, changes in the monsoon systems and the intensity of hurricanes. In addition, decadal-scale SST variations in the North Pacific, the so-called Pacific Decadal Oscillation (PDO), have been associated with low-frequency changes of climate patterns over North America, Australia and East Asia. The ultimate causes and governing mechanisms for these observed decadal to multidecadal SST variations are not fully understood, although they are likely caused by a combination of changes in forcing, atmospheric and oceanic processes. Here, we present findings from historical simulations with Bergen Climate Model (BCM) covering the last 600 years highlighting the potential important role played by natural and anthropogenic forcing factors in modifying and controlling these patterns. In particular, the results suggest that volcanoes play an important role in decadal SST variations in the Atlantic through their direct radiative forcing on tropical SSTs. In addition, volcanic eruptions tend to strengthen the Northern polar vortex, which in turn forces a positvie response of the so-called North Atlantic Oscillation (NAO) at the surface. A more positive NAO is associated with increased production of intermediate to deep water masses in the high northern sinking regions (i.e. Labrador Sea) and thus leads to a post-volcanic strengthening of the Atlantic thermohaline circulation. In the North Pacific, it is found that volcanic eruptions tend to push the simulated PDO into its cold phase. Finally, idealized simulations are used to assess the potential role of volcanic eruptions on future projection of climate change and its associated carbon cycle feedback. The analysis show that potential future eruptions induce positive feedbacks (i.e., more carbon sink) on both the terrestrial and oceanic carbon cycle.