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Estimation of feedbacks in Northern Eurasia climate system on the base of coupled model ocean-atmosphere-vegetation-soil under global climate changes

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1. Introduction

This report focuses on the questions: how global change (due to GHG) might alter ocean current, temperature, sea ice, terrestrial surface hydrology and arctic vegetation to and within the Russian Arctic; to access feedback between these processes. We seek here observations and projections of global change that seem most likely to play a significant role in Arctic Climate System, particularly of Russian's Arctic/Northern Siberia. There is widespread recognition that Arctic Climate System, particularly Arctic hydrology is sensitive to global warming, understanding the basic mechanisms that control the terrestrial climate and water cycle is still research need. Arctic System has been identified Arctic hydrology and its feedbacks to the Earth system as a high-priority area for advancing the integration high latitude research. Scientific community recently developed science plan, outlining several issues with respect to Arctic change, which included consideration of the terrestrial water cycle.

2. Background

According to IPCC-2001/2007 reports and numerous works ([1-2], for example), the observed climate changes are primarily due to anthropogenic forcing mainly related to the elevation of greenhouse gases and aerosols. The models are only available tools for forecasting plausible climates in years and decades ahead. Accurate estimates of feedbacks can be obtained with the complex climate system models [3, 4].

The impact of precipitation anomalies on soil moisture anomalies is well known, rains induce wet soil, whereas extended dry periods induce dry soil. It is not obviously that there is impact of soil moisture anomalies on the precipitation itself. Conceivably, a wetter soil can produce higher evaporation, which in turn can induce additional precipitation through local influence and modifications in the large-scale circulation. This land-atmosphere feedback is of great interest. The feedback between soil moisture and precipitation is one manifestation of the coupling between the land surface and the atmosphere. This coupling occurs over a wide range of temporal scales. At shorter time-scales, variations in surface temperature can induce variations in evaporation and sensible heat flux that can in turn strongly affect the evolution of the atmospheric boundary layer. Rainwater intercepted on the vegetation canopy evaporates very quickly and thus has its own impact on short timescales. At very long timescales, variations in climate can induce variations in vegetation structure [4], which in turn can feed back on the climate itself.

Climate model simulations can be diagnosed to assess contributing causes of particular phenomena. Climate is not controllable system. The biosphere plays pivotal role in the climate system. Land ecosystems are a dynamic component of the global carbon and water cycle. More than one third of CO2 in the atmosphere is exchange annually with the land biosphere. Land ecosystem processes also control exchange of energy and momentum between atmosphere and surface. We must better understand the global evolution land ecosystem as main agent in Earth Climate System dynamics. The model will help to assess impact of climate changes on natural vegetation patterns, surface characteristics and land carbon storage.

3. Method, results

For these aims dynamic global Lund-Potsdam-Jena dynamic global vegetation model [6] coupled with INM (RAS)/ICMMG (SB RAS) climate model [3, 5] and Model of Intermediate Complexity [7] are described and resulting prediction are discussed in this presentation. For example, the results show that the positive feedback from the greenhouse effect of water vapor in the model agrees with that from observations (~8.0 W/m2K).

A numerical experiment with the coupled ice-ocean model covering the period from 1948 to 2003 based on NCEP/NCAR atmospheric forcing was run to reproduce the observed Arctic Ocean climate changes [6, 7]. In a course of numerical simulations the following results were obtained:
1. The hypothesis of the Arctic two-state sea ice circulation, linked with a corresponding atmospheric circulation type, were confirmed
2. The beginning of Arctic Ocean circulation changes was in the middle of 1970s and corresponds to the first signal of a positive North Atlantic Oscillation (NAO) period
3. The further development of a continuous positive NAO phase leads to
a. the increasing of the Atlantic Water inflow into Arctic
b. the eastward shift of the Atlantic-Pacific water type boundary
c. the change of Canadian Basin circulation from anticyclonic to cyclonic type
d. the increasing of intermediate water temperature
e. the reduction of ice covered area
4. During the negative NAO phase in 1960s, due to the dominating anticyclonic circulation in Canadian Basin, the pool of fresh water grows in this area contributed by river discharges. After positive NAO phase this fresh water is gradually replaced by the saline Atlantic Water
5. The ice and fresh water transport from Arctic to the Nordic seas of North Atlantic leads to the freshening of a top ocean layer and formation of salinity anomalies
6. According to the numerical results the maximum thermal signal, caused by Atlantic transport in Norwegian Sea, obtained in the period of an intensity decreasing of positive NAO phase

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