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GRENE-ARCTIC CLIMATE CHANGE RESEARCH PROJECT: STRATEGY AND IMPLEMENTATION

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GRENE-Arctic project is a new initiative of Arctic study by more than 30 Japanese universities and institutes as the flame work of GRENE (Green Network of Excellence) of MEXT (Ministry of Education, Culture, Sports, Science and Technology, Japan). The new Arctic Climate Change Research Project “Rapid Change of the Arctic Climate System and its Global Influences” has started in 2011 with strategic research targets:

- Understanding the mechanism of warming amplification in the Arctic
- Understanding the Arctic system for global climate and future change
- Evaluation of the effects of Arctic change on weather in Japan, marine ecosystems and fisheries
- Prediction of sea Ice distribution and Arctic sea routes

This project aims to realize the strategic research targets by executing following studies:

・Improvement of coupled general circulation models based on validations of the Arctic climate reproducibility and on mechanism analyses of the Arctic climate change and variability
・The role of Arctic cryophere in the global change
・Change in terrestrial ecosystem of pan-Arctic and its effect on climate
・Studies on greenhouse gas cycles in the Arctic and their responses to climate change
・Atmospheric studies on Arctic change and its global impacts
・Ecosystem studies of the Arctic ocean declining Sea ice
・Projection of Arctic Sea ice responding to availability of Arctic sea route

  ➢ Changes in the Arctic ocean and mechanisms on catastrophic reduction of Arctic sea ice cover
  ➢ Coordinated observational and modeling studies on the basic structure and variability of the Arctic sea ice-ocean system
  ➢ Sea ice prediction and construction of ice navigation support system for the Arctic sea route.

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ARCTIC CHALLENGE – OUR RESEARCH STRATEGY FOR ARCTIC CLIMATE CHANGE

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The changes in the Arctic are highly substantial and rapid, and different parts of the Arctic climate system are involved. The Arctic sea ice extent is retreating at an alarming rate, reaching its new record low in September 2012. The ocean and surface temperatures are rising. The recent temperature rise in the Arctic is about twice as much as the global average. Concurrent with these changes the Greenland ice sheet is thinning, and permafrost is thawing, which inevitably bring other changes in the Arctic hydrological cycle and ecosystems.

The Arctic is said to be the precursor of our changing planet. There is no doubt that the ice-albedo feedback can accelerate warming of the ocean and melting of sea ice. But beyond that, the Arctic change likely results from a complex combination of different factors. The roles of solar activities, ozone depletion, aerosols, water vapor, clouds, carbon and land processes and other factors involved in the Arctic change await better explanation and clarification.

In this presentation we will provide an overview on part of the GRENE Arctic Climate Project, a joint perspective from Modeling, Land Process, Atmosphere, Cryosphere, and Carbon Cycle Groups, and discuss our integrated strategy for investigating underlying mechanisms and relative contributions from different factors relevant to Arctic change and global impacts. In particular three steps, identification, assessment and synthesis, are set. The key in the identification step is to fully appreciate Arctic climate as complex and woven in the global climate system. For the synthesis step we address the question of how much of contributions are from different feedback processes and mechanisms to the recent (post 1970s) Arctic warming, before extending the question to the early 20C Arctic warming and to future prediction. The critical step is the assessment of temporal, for instance seasonal, dependence among different feedbacks and processes from both observational and modeling views. By this, we look into the picture of how multiple feedback processes act as an interacting process – a view perhaps necessary to explain the rapidness of the Arctic change.

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How vegetation change contribute to polar amplification in warm climate?

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In projections of future global change induced by CO2 emission using general circulation models (GCMs), globally averaged surface air temperature increase is ranged between at the end of 21st century range from 2K to 4.5K, even higher in the high latitudes, known as the 'polar amplification'. We investigated the contribution of vegetation change to global warming and polar amplification in elevated atmospheric CO2 condition and orbit-induced condition using an atmosphere-ocean-vegetation coupled GCM. Paleo-evidences indicate that mid-Holocene (6ka) and the last inter glacial (125ka) were warmer and more humid than present-day, caused by a different shortwave radiation pattern which corresponds to earth's orbit at that time. For example, annual averaged temperature over northern hemisphere continent is about 2K warmer in 6ka than that of today. By comparing the role of CO2 and orbital elements, we suggest difference mechanisms of vegetation feedback to the atmosphere in these two kinds of warming

experiments.

COMPARISON OF XCO_2 SIMULATED BY NIES TRANSPORT MODEL AND OBSERVED BY GOSAT IN POLAR REGIONS

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The Polar Regions are large carbon reservoirs in the world. However, carbon cycle in the Polar Regions remains poorly investigated due to the insufficient observations. The Greenhouse gases Observing SATellite (GOSAT) was launched on 23 January 2009 to monitor the global distributions of greenhouse gases (CO_2 and CH_4) from space. The main aim of GOSAT is to fill gaps in the ground-based observation network. However, the GOSAT retrieval algorithms are under continuing development and require reliable data for evaluation.

In this work, we compared column-averaged dry air mole fractions of atmospheric carbon dioxide (XCO_2) simulated by the National Institute for Environmental Studies (NIES) offline three-dimensional chemical transport model (TM) and observed by GOSAT in Polar Regions. The GOSAT data were retrieved using the photon path length probability density function (PPDF) method developed by Oshchepkov et al., 2008. We performed multi-annual simulations of CO_2 using NIES transport model (version NIES-08.1i), driven by JRA-25/JCDAS reanalysis data (Belikov et al., 2011). In the study NIES TM was implemented with a 2.5˚ × 2.5˚ horizontal resolution and 32 vertical levels in a hybrid sigma-isentropic ($\sigma-\theta$)) coordinate system consisting of terrain-following and isentropic levels switched smoothly near the tropopause.

The CO_2 simulation was started with the initial distribution derived from GLOBALVIEW-CO2 observations using prescribed fluxes. The following source components of CO_2 were considered in the three different scenarios: 1) Fossil fuel emissions are derived from the EDGAR-1998 distribution and scaled using the growth rate obtained from the Carbon Dioxide Information Analysis Center (CDIAC). The climatological inversion flux represents all non-fossil source/sink distributions over land and ocean, derived by inverse modelling with 12 TransCom3 models and from observational data obtained from GLOBALVIEW-CO2 at 87 sites during 1999–2001. This combination was used in the Comprehensive Observation Network for Trace gases by AIrLiner (CONTRAIL) Transport Model Intercomparison (TMI) (Niwa et al., 2011). 2) Monthly mean CO_2 fluxes for 64 regions from June 2009 to May 2010 are estimated by inverse model of atmospheric transport based on Fixed Lag Kalman Smoother using monthly averaged Globalview-CO2 observations (Takagi et al., 2011). 3) The 3-hourly inverse model-adjusted fluxes obtained by optimizing the surface fluxes of CO_2 using the LMDZ model for the period 2000-2010 on a 3.75x2.5 deg lat/lon grid (Chevallier et al., 2010).

Before comparison with GOSAT data the simulated XCO_2 was evaluated against daily ground-based high-resolution Fourier Transform Spectrometer (FTS) observations measured at twelve sites of the Total Carbon Column Observing Network (TCCON).

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FORECAST OF SUMMER SEA-ICE EXTENT IN THE ARCTIC BASED ON WINTER ICE MOTION

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With recent attention to the decrease of the Arctic ice area in the context of global warming, a greater understanding of sea-ice processes is required. Interannual variability with sorter timescales is more noticeable than the long-term reduction. This study examines one of the factors controlling the variability, the relationship between interannual difference in winter ice motion and ice area in the following summer.

Daily ice velocity products with resolutions of 37.5 and 75 km are prepared using the satellite passive microwave sensors Advanced Microwave Scanning Radiometer for EOS (AMSR-E) and Special Sensor Microwave Imager (SSM/I). The ice motion becomes more active in the last several decades. Derived daily ice motion reveals the dynamic modification of the winter ice cover. The winter ice divergence/convergence is strongly related to the summer ice cover; the correlation coefficient between the winter ice convergence and summer ice area ranges between 0.5 and 0.9 in many areas. This relation indicates that the winter ice redistribution controls the spring ice thickness and the summer ice cover. Based on this relation, we propose a method to predict the summer ice area in the Arctic. This medium-term forecast (looking several months ahead) is useful for human activity in the Arctic, for example to determine whether or not the shipping route through the Arctic will be navigable.