ACG34-01 Room:213 Time:May 1 14:15-14:45

Frontier of using stable water isotopic information in studies on land-ecological, hydrological, and atmospheric process

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In this study, it was clearly shown that vapor isotope data retrieved by satellite sensors or in situ monitoring networks have the potential to constrain the atmospheric fields. The results of this study can be applied in two directions. The first direction is a better analysis skill in current weather forecasting systems. Though our understanding of the atmosphere is improving, understanding the hydrological cycles of the mid- to upper troposphere and lower stratosphere in association with convective clouds remains difficult. Because it is apparent that water vapor isotopic information has unique characteristics with regard to the atmospheric hydrological cycle and technical improvements in satellite and in situ instruments are occurring rapidly, this direction is indeed quite promising. The second direction, regarding proxy data assimilation, is even more challenging and is significant in several disciplines. In the past, we lacked direct measurements of the Earth and were forced to rely on proxy data. Interpretation of proxy data is important but can be over-simplified. By using data assimilation for proxy data, an objective analysis of the past (specifically before the nineteenth century) can be achieved without simplifying the empirical relationship between proxy data and climate/environment information. Although there are many technical and theoretical obstacles in both directions, the authors strongly believe that scientific benefits can be achieved.

Keywords: stable water isotope ratio, data assimilation, hydrologic cycle, climate proxy, climate reanalysis, spectroscopic analysis

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ACG34-02 Room:213 Time:May 1 14:45-15:15

Significance of hyper spectral solar radiation observation

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Land plants exhibit relatively weak absorbance of green light at around 550 nm, for reasons which remain elusive. Most research, however, has assumed that the solar radiation spectrum can be averaged without considering the spectral dynamics. The relations between the spectrum of incident radiation and light-harvesting pigments of organisms are crucial to understanding photosynthesis and light use efficiency. Although several light-harvesting pigments exist, most land plants use specific light harvesting chlorophylls, Chl a and Chl b, and carotenoids. Wavelengths longer than 700 nm or shorter than 400 nm are scarcely absorbed by chlorophylls, and cannot be used for photosynthesis. Radiation within the 400 to 700 nm waveband is defined as photosynthetically active radiation (PAR). However, chlorophylls do not absorb photons in the PAR waveband evenly. Only a few per cent of relative absorbance occurs in the green region (500 to 600 nm), nevertheless the photosynthetic quantum yields are equivalent to those from blue and red light.

Incident PAR comprises two main components, direct PAR (PARdir), which arrives directly from the sun, and diffuse PAR (PARdif), which is sunlight scattered by sky and clouds. These components are characterized by large differences in light quantity, directional characteristics and spectral quality. PARdir is highly directional and its energy can be concentrated and localized on a surface. PARdif is non-directional and its incident energy is well-averaged across a surface, allowing it to penetrate deeper into canopies. Consequently, PARdir and PARdif play different roles in the photosynthetic process both at the scale of individual leaves and of canopies. Most research, however, has assumed that the solar radiation spectrum can be averaged without considering the spectral and directional dynamics.

We had developed a precise solar tracking device for detecting direct and diffuse radiation. Direct and diffuse radiations were measured separately by two grating spectroradiometers (MS700, EKO Instruments Co. Ltd., Tokyo, Japan) fixed to sun trackers (STR-22G-S, EKO Instruments Co. Ltd.) equipped with a collimation tube (angle of view 5 degrees) for measurement of PARdir, and a shadow ball for measurement of PARdif.

Analyzing the relative absorption spectra of chlorophyll, we found that Chl a does not absorb direct solar radiation, while diffuse solar radiation is efficiently up-taken by Chl b. The spectrum of diffuse solar radiation is almost fixed with a peak wavelength (λmax) around 460 nm. However, that of direct solar radiation shifts from a broad peak with λmax around 700 nm towards a narrower peak around 540 nm, as solar zenith angle decreases. The absorption spectrum of Chl a lies outside the strongest energy regions of direct solar radiation. The λmax of the Chl b absorption spectrum matches that of diffuse solar radiation; therefore, Chl b can absorb the most energetic parts of this radiation. The spectral differences between direct and diffuse solar radiation elucidate the meaning of slight spectral differences in pigments for terrestrial organisms.

Strong light is known to enhance accumulation of carotenoids. We found that β-carotene consistently absorbed more energy per photon than other pigments, indicating that it effectively filters (i.e. accepts) the 350-500 nm waveband, independently of PAR class.

Overall, the spectral differences between PARdir and PARdif, as well as the steady λmax of PARdif, exert multiple effects on terrestrial organisms and may be effective drivers of diversification in pigment distribution and function. Further spectral-directional radiation observation at various sites is needed to reveal the effects of the dynamics of incident solar radiation on the terrestrial ecosystem.

Keywords: spectroradiomater, direct solar radiation, diffuse sky radiation, photosynthesis, spectral light use efficiency, PAR

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ACG34-03 Room:213 Time:May 1 15:15-15:30

Simultaneous Estimation of Hydrologic and Ecologic Parameters in an Eco-Hydrological Model Assimilating Microwave Signal

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To improve the skill of reproducing land-atmosphere interactions in weather, seasonal, and climate prediction systems, it is necessary to simulate correctly and simultaneously the surface soil moisture (SSM) and terrestrial biomass in land surface models. Despite the performance of hydrological and ecosystem models depends highly on parameter calibration, a method for parameter estimation in ungauged areas has yet to be established. We develop an auto-calibration system that can simultaneously estimate both hydrological and ecological parameters by assimilating a microwave signal that is sensitive to both SSM and terrestrial biomass. This system comprises a hydrological model that has a physically based, sophisticated soil hydrology scheme, a dynamic vegetation model that can estimate vegetation growth and senescence, and a radiative transfer model that can convert land surface condition into brightness temperatures in the microwave region. By assimilating microwave signals from the Advanced Microwave Scanning Radiometer for Earth Observing System, the system simultaneously optimizes the parameters of these models. We test this approach at three in situ observation sites under different hydroclimatic conditions. Estimated SSM and leaf area index (LAI) exhibit good agreement with ground in situ observed SSM and satellite observed LAI, respectively. The root mean square error of SSM and LAI at all sites, estimated by the model with optimized parameters, is much less than that estimated by the model with default parameters. Using microwave satellite brightness temperature data sets, this system offers the potential to calibrate parameters of both hydrological and ecosystem models globally. This global-scale and automated parameter optimization system may contribute to many other research activities related to land surface, hydrological, and ecosystem modelling although the global-scale applicability of this approach should be investigated as a future work.

Keywords: Eco-hydrological model, passive microwave remote sensing, parameter optimization, data assimilation

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ACG34-04 Room:213 Time:May 1 15:30-15:45

Changes of permafrost environment and the response to the long term climate change

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Permafrost is soil and sediment that is frozen more than two consecutive years, most of which is located in high latitudes. Ground ice is not always present, as may be in the case of nonporous bedrock, but it frequently occurs and it may be in amounts exceeding the potential hydraulic saturation of the ground material. Permafrost accounts for 0.022% of total water and exists in 24% of exposed land in the Northern Hemisphere.

permafrost contains 1700 billion tons of organic material equaling almost half of all organic material in all soils. This pool was built up over thousands of years and is only slowly degraded under the cold conditions in the Arctic.

Most of the permafrost existing today formed during cold glacial periods, and has persisted through warmer interglacial periods, including the Holocene. The time scale of the thermal process is different depending on the depth (i.e. distance from the ground surface) and the soil thermal properties, while the vegetation processes such as accumulation of organic material have yet different time scales.

In this presentation, we discuss those complex character of permafrost and show the outlook on the future research needs, showing an example study on the relationship between permafrost distribution and long-term climate change.

Keywords: Permafrost, climate change, ground ice, Carbon Cycle

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ACG34-05 Room:213 Time:May 1 15:45-16:00

Impacts of representation of stomatal conductance on vegetation distribution and functions under changing climate

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Stomata reponce is under control of light intensity, CO2 concentration, vapor pressure deficit, leaf water potential. For describing stomatal responses to such environmental factors, several empirical and semi-empirical models have been developed. How these models response to the changing environmental is an important issue, because between 80% and 90% of the total evapotranspiration from the land surface is caused by transpiration, and the process consumes almost half of the solar energy absorbed by the ground (Jasechko et al. 2013).

Here, we examined how representation of stomatal conductance pose impact on the forecast of geographical distribution of vegetation and its functions (i.e. carbon and water fluxes) under the forecasted climatic condition during the 21st century. We studied the African continent, because Africa is a useful target for assessing changes in vegetation due to climate change. The distribution of African vegetation is primarily regulated by soil moisture availability and thus is tightly coupled with climatic variability. For our study, we employed a dynamic vegetation model SEIB-DGVM. Our previous study shows that the model reproduced geographical distributions of the continent's biomes, annual gross primary productivity (GPP), and biomass over the African continent under current climatic conditions (Sato et al. 2012).

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Keywords: Stomatal Conductance, Hydrological Cycle, Carbon Cycle, Dynamic Global Vegetation Models, Global Warming, Africa

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Overview for terrestrial model intercomparison project in Arctic

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1. Introduction

The goals of the modeling group in the terrestrial research project of the GRENE Arctic Climate Change Research Project (GRENE-TEA) are to a) feed to the CGCM research project for the possible improvement of the physical and ecological processes for the Arctic terrestrial modeling (excl. glaciers and ice sheets) in the extant terrestrial schemes in the coupled global climate models (CGCMs), and b) lay the foundations of the future-generation Arctic terrestrial model development. To achieve these goals we are to conduct a model intercomparison project among the participating models, in which we will utilize the GRENE-TEA site observations data (stage 1) and GCM outputs (stage 2) for driving and validating the models. This project (GTMIP) is designated to 1) enhance communications and understanding of the "mind and hands" between the modeling and field scientists, 2) assess the uncertainty and variations stemmed from the model implementation/designation, and the variability due to climatic and historical conditions among the Arctic sites.

2. Data and models for GTMIP

At the stage 1, we will create data for forcing and validating the terrestrial model based on the extant and/or new observation data at GRENE-TEA sites to evaluate the inter-model and inter-site variations. However, the observation data are prone to missing or lack of the necessary variables or parameters to drive the model. Therefore, we create continuous forcing data (Ver. 0) taken from the reanalysis product (i.e. NCEP/NCAR) with the bias correction using the CRU data at the nearest grid to the GRENE-TEA sites. Then, it is merged with the observation data to create site-fit continuous data (Ver. 1) for each GRENE-TEA site (Fairbanks in Alaska, Yakutsk, Tiksi, Tura and Chokurdakh in Russia, Kevo in Finland). These data will be open at Arctic Data Archive System (https://ads.nipr.ac.jp/index.html).

The GTMIP participating models include a land surface model (MATSIRO, 2LM, CHANGE, HAL), a material cycle model (VISIT), a terrestrial ecological model (STEM-NOAHbgc), a dynamic vegetation model (SEIB-DGVM), a regional climate model (WRF), physical snow models (SNOWPACK, SMAP), and a permafrost model (FROST). The models enabled to couple with the CGCMs and regional climate model (RCM) consist of the 70% of the all participating models.

3. Results

The Ver. 0 data was compared with site observations near Fairbanks, Alaska, USA, to evaluate its reliability. The daily mean air temperature was well-reconstructed but the diurnal variation was underestimated. The total annual precipitation was close to the observed, but summer (DOY150-250) rain tended clumpy.

The observed ground temperature (Tg) at near surface showed the zero-curtain, while the simulated Tg failed to produce the zero-curtain except for 2LM. The 2LM reproduced the observed snow depth well while the CHANGE and MATSIRO-r showed later start and end of snow cover with lower snow depth than observed. The sensible heat flux was the dominant component of the energy budget in the simulation by 2LM. The daily net ecosystem exchange (NEE) simulated by CHANGE showed the large carbon uptake in summer. The annual gross primary production (GPP) simulated by CHANGE increased during 1988 to 2011. The simulated GPP by SEIB-DGVM using Tg by MATSIRO-r was similar to the GPP using air temperature. The wood biomass and grass biomass simulated by SEIB-DGVM using air temperature and Tg by MATSIRO-r was similar while it was lower when calculated using Tg by MATSIRO-c. The soil organic matter (SOM) simulated by SEIB-DGVM using MATSIRO-r was largest among the SOM using air temperature and Tg by MATSIRO-c.

Keywords: Arctic, Terrestrial model, Snow cover, Permafrost

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The assessments of projection uncertainties of global C budget in ISI-MIP study

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Global net primary production (NPP), vegetation biomass carbon (VegC), and soil organic carbon (SOC) changes estimated by six global vegetation models (GVMs) obtained from an Inter-Sectoral Impact Model Intercomparison Project study were examined. Simulation results were obtained using five global climate models (GCMs) forced with four Representative Concentration Pathway (RCP) scenarios. To clarify which component (emission scenarios, climate projections, or global vegetation models) contributes the most to uncertainties in projected global terrestrial C cycling by 2100, we applied analysis of variance (ANOVA) and wavelet clustering to 70 projected simulation sets. ANOVA revealed that the main sources of uncertainty are different among variables and depend on the projection period. We determined that in the global SOC and VegC projections, GVMs dominate uncertainties (90% and 60%, respectively) rather than climate driving scenarios, i.e., RCPs and GCMs. The clustering wavelet spectra of VegC and SOC time series data could identify more specific characterization of simulations in each GVM. Our study suggests that the improvement of GVMs is a priority concern for reduction of total uncertainties in projected C cycling for climate impact assessments.

Keywords: Model inter-comparison, Global carbon cycle, Uncertainties, RCP, GCM