Examination of “Yamase” events using d4PDF climate ensemble simulations.

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“Yamase”, are defined as cold, northeasterly winds periodically observed in Hokkaido and Tohoku region of northern Japan. Because Yamase conditions are most pronounced during the summer, prolonged events can and have resulted in substantial damages to rice crops, especially during the ripening phase (late-July to mid-August). During the strong Yamase year of 1993, the eastern Tohoku region experienced nearly a 70% deficit in rice yield. In 2003, the same region experienced a 35% deficit, despite the expanded use of cultivators such as “Hitomebore”, which were implemented to withstand lower temperatures. With projected average temperature increases in northeastern Japan ranging anywhere from 2.8 –5.0 ˚C at the end of the 21st century, agricultural practices will need to adapt in order to mitigate the impacts of a warmer climate. However, it is equally important that events such as Yamase be taken into consideration when climate change information is provided to stakeholders and policy makers.

This study aims to evaluate the ability climate models have in replicating Yamase events seen in observations, their changes in the future climate, and how regionally downscaled models provide important physical characteristics not captured at coarser resolutions. To accomplish this, we use large member ensemble of global (GCMs) and regional climate models (RCMs) from the Meteorological Research Institute (MRI), as part of the “database for Policy Decision-making for Future climate change (d4PDF)”. GCM results come from MRI-AGCM3.2, resolved at 60km horizontal resolutions, while RCM results come from the NHRCM, which is regionally downscaled to a horizontal resolution of 20km. For scenario climates, global mean surface air temperature is prescribed to be either 2K or 4K warmer than the pre-industrial climate, equivalent to emission scenarios from the Representative Concentration Pathways, RCP4.5 and RCP8.5, respectively. The performance of these models is evaluated using observational data from AMeDAS, and from the JRA55 and ERA-interim reanalysis datasets.

d4PDF models general reproduce well the environmental characteristics of Yamase events seen in observations. This consists of an enhancement of Okhotsk high and the weakening of the western Pacific high, easterly/northeasterly surface winds near the eastern Tohoku region, and negative temperature anomalies across eastern Japan, especially near the coastline. These characteristics remain relatively unchanged in future climates, as well as the frequency of Yamase events. The lack of substantial differences between current and future Yamase events highlights the importance not to neglect such events and will be the focus of this talk.

Keywords: Yamase, d4PDF, Climate change

Risk evaluation and prevention of complex flood disaster with earthquake subsidence and storm surge in Kagami river of Kochi plain.

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After the Great East Japan Earthquake, it was widely recommended that disaster phenomena have to be evaluated as multiple integrated disasters with complexity. Flood prevention law has also revised to assume extreme flood event in response to recently frequent shiver flood. So we should change the assumption which has been thought of as a single event.
In this research, we simulated complexly integrated multiple disasters with flood. Sea surge and earthquake subsidence which is expected as Nankai Trough Earthquake by using discharge model and river channel model were integrated.
This model is including distributed discharge model and river channel model. In low yield area river channel, this model can represent the effect of seatide and sea storm surge.
According to this model, the effect of seatide and sea storm surge is severe for flood preventation. And flood risk is exacerbated by earthquake subsidence becoming a phenomena of lost river channel capacity. Earthquake is predicted, and the remaining time is small, so it is difficult to build new Flood control facilities to avoid this complex risk.
Now dam limits discharge as fixed rate according to operation rule. We suggest new operation rule that dam limit discharge strongly for sea tide and sea surge. This rule is effective to reduce sea-tide effect and disaster damage with the same flood control volume.
This method is reasonable from the aspect of “time”, because earthquake subsidence is temporary and permanent facilities can be wasted. Dam operation rule optimization is adaptive measure.
On the other hand, climate change is severe problem for flood risk. According to previous studies, maximum discharge may not increase but frequency of historical maximum level flood will increase in Kagami river basin.
If we consider only a single flood risk, “maximum discharge may not increase” is “good news” ,because flood control facilities is in place for historical maximum level flood, and these facilities can prevent flood damage.
But if we consider the risk of complex flood disasters, “frequency of historical maximum level flood will increase” is “bad news”. It is because the probability of floods when the flood control facilities lost function by the earthquake disaster.
This is new perspective that flood risk does not increase by only climate change, but risk will increase with complex disasters with earthquakes.

Keywords: climate change, hydrological model, earthquake, complex disaster, Ground subsidence, dam management

Development of a database system for near-future climate change predictions

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A database for Policy Decision making for Future climate change (d4PDF) is a large volume of simulation data about 2 PB produced by Program for Risk Information on Climate Change. The d4PDF is published on Data Integration and Analysis System Program (DIAS). Analyses of ensemble data of the d4PDF are quite useful in order to produce probabilistic effect prediction of climate change. Considering that a data volume of the d4PDF is too large to download to a local computer of users, a user-friendly system is required to search and download data which satisfy requests of the users.

We develop “a database system for near-future climate change predictions” for providing functions to find necessary data for the users under Social Implementation Program on Climate Change Adaptation Technology (SI-CAT). The database system for near-future climate change predictions mainly consists of a relational database, a data download function and user interface. The relational database using PostgreSQL is a key function among them. Temporally and spatially compressed data are registered on the relational database. As a first step, we develop the relational database for precipitation, temperature and track data of typhoon according to requests by SI-CAT members. The data download function using Open-source Project for a Network Data Access Protocol (OPeNDAP) provides a function to download temporally and spatially extracted data based on search results obtained by the relational database. We also develop the user interface for using the relational database and the data download function. The database system for near-future climate change predictions will be released on DIAS in fiscal year 2017. Techniques of the database system for near-future climate change predictions might be quite useful for simulation and observational data in other research fields.

Keywords: Climate Change, Relational Database

Development of the North Pacific Ocean Model for Near-Future Projection of Ocean State

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Near-future projection of ocean state is one of the key products in the MEXT sponsored project, Social Implementation Program on Climate Change Adaptation Technology (SI-CAT). In this project, we are aiming at producing projected ocean state around Japan coast under near-future climate change using the North Pacific Ocean circulation model. During the first one year of SI-CAT, we have conducted extensive survey with our project partner from local governments, Ibaraki, Tottori and Saga, and other research institutes. Based on the feedback from our partners, we identified key variables to be assessed under near-future condition. The most desired variable is sea level along Japan coast and we have implemented tools to diagnose impact of atmospheric change on coastal sea level change from atmospheric external forcing based on Sverdrup theory. Using the tools we have selected a subset of atmospheric forcing models based on d4PDF and CMIP5 data. In this presentation, we will make a report on preliminary results from our near-future ocean state projection experiments.

Keywords: Near-future ocean prediction, North Pacific ocean model, Sea level, CMIP5

Long-term impact assessment of storm surges around the southeastern Korean Peninsula based on a large-ensemble of climate projection of d4PDF

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This study examine long-term impact assessment of storm surges due to typhoons around the southeastern area in Korean Peninsula considering climate change. The analysis is carried out by using outputs of large-ensemble experiments so-called d4PDF for a past and +4K future climate conditions over 5000 years by MRI-AGCM3.2H with 60 km spatial resolution to obtain probabilistic future changes in low-frequency of extreme storm surge events. The historical climate simulation from 1951 to 2010 was conducted with 100 ensemble members and the future climate simulation from 2051 to 2110 was conducted with 90 ensemble members considering warmer +4℃ global mean temperature in d4PDF. The characteristics of tropical cyclones (typhoons) which may directly and indirectly have an effect on Korean Peninsula from d4PFD for past and future climate condition is extracted. The reproducibility of historical typhoon and storm surge is evaluated by comparing with the observed data. The typhoon properties extracted from d4PDF are employed as the driving force to simulate storm surges. The extreme storm surge heights with specific return periods are examined. It was found that the potential future changes of the extreme storm surges along the southeastern area in the Korean Peninsula have a strong regional dependency.

Keywords: storm surge, climate change, large-ensemble climate projection, d4PDF

Does a RCM add value to its driving parent GCM simulated extreme precipitations linked to temperature over Japan?

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The frequency of extreme precipitation events are now of serious concern which are expected to increase in a warmer climate (IPCC 2012), because atmosphere can hold more water vapor in warmer air temperature according to the principle of Clausius-Clapeyron (CC) relationship (~7% per degree rise in temperature). As a consequence, more extreme precipitation events may occur under warmer climate and may impact on agriculture, the economy, the human health and also animal habitats. Simulations by Regional Climate Models (RCMs) are often used for impact assessments because they are presumed to simulate the regional climate, especially extreme events, better than their driving General Circulation Models (GCMs). Thus there is a growing debate on the added value by RCMs to their driving GCMs over various regions. Our study explores whether a RCM reproduces the extreme precipitation linked to temperature over Japan better than its driving parent GCM by analyzing 330 ensemble experiments [140 experiments with NHRCM at 20km (50 experiments for current climate: 1951-2010 & 90 experiments for future climate with 4˚C warming: 2051-2110) and 190 experiments with the MRI-AGCM at 60km (100 experiments for current climate & 90 experiments for future climate)]. We find that the extreme precipitations linked to temperature basically follow the CC relationship over Japan for a certain temperature (for instance ~24˚C) and a further increase of temperature decreases the precipitation intensity. These results are consistent with AMEDAS station observations and the past research conducted over various regions. All the individual ensemble experiment results of RCM and GCM show a similar qualitative behavior. Further we find that RCM ensemble experiments overestimated the extreme precipitation intensities for the temperatures above 24˚C, while GCM underestimated the same particularly at the peaks (18-26˚C). However, for the temperatures between 20-24˚C RCM added ~35% to the extreme precipitations linked to temperature over Japan compared to GCM ensemble experiments. The overestimation of precipitation intensity at higher temperatures simulated by RCM is associated with strong vertical velocity (i.e. upward motion of air) and much availability of water vapor, while the underestimation of the same by the GCM is associated with weak vertical velocity and less availability of water vapor compared to the RCM. This may lead to contribute the added value by RCM over GCM. Additions to this, the zonal and meridional winds in RCM are noticed stronger compared to that in GCM at higher temperatures. This may bring more moisture from the ocean towards Japan land and cause more precipitation in RCM. Furthermore, all ensemble experiment results in RCM and GCM show a significant increase of precipitation intensities (~30mm/d in RCM and ~15mm/d in GCM) for the temperatures roughly above 24-26˚C under future climate scenario over Japan and RCM added ~15mm/d amount of precipitation intensity to this future change. This increase of extreme precipitation intensities at higher temperature may be due to the increase in temperature under future climate (4˚C warming). The added value of RCM will be further discussed through the column-averaged total kinetic energy and column integrated moisture flux convergence by spectral analysis.

Keywords: Extreme precipitations, Clausius-Clapeyron relationship, Ensemble experiments, Added value, Spectral analysis

Numerical Simulation of Urban Heat Island in Sendai City with Land Use of the Potential Natural Vegetation, 1850s and 2000s

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This study examines the impact of urbanization over the past 150 years in Sendai City for three different land use cases: potential natural vegetation (PNV), 1850s, and 2000s. The Weather Research and Forecasting (WRF) model with 1 km horizontal resolution was used and the following results were obtained. Firstly, results of the control simulation were verified against observations. The WRF model reproduced well the observed temperatures in Sendai City and five additional locations in Miyagi prefecture. The bias is from -0.55 ºC to -1.30 ºC in August and from -0.02 ºC to -1.37 ºC in February. Secondly, impacts of urbanization were evaluated. The effect of urban heat island (UHI) in 1850s was almost not found even the existence of the small urban area of Sendai city. The sensitivity experiment, where the land use was replaced to PNV, was conducted and showed there was a slight temperature difference between 1850s and PNV. Thirdly, the simulated monthly mean temperature was compared between 1850s and 2000s land-use experimental cases. The results indicate that the monthly mean temperature in August (February) in 2000s is 1.4 ºC (1.5 ºC) higher than that in 1850s. Moreover, the considerable nocturnal temperature increase of 2.0 ºC (2.1 ºC) during the past 150 years was found in August (February).

Keywords: Urban heat island, urbanization, potential natural vegetation, land-use change

Uchimizu: A cool(ing) tradition to locally mitigate the urban heat island

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Urban heat island was first described 200 years ago but ways to mitigate heat in urban areas reach much further into the past. Uchimizu is a 17th century Japanese tradition, in which water is sprinkled around houses to cool the ground surface and the air by evaporation. Unfortunately, the number of published studies that have quantified the cooling effects of uchimizu is limited, and only use measurements of the surface temperature, or air temperature at a single height, as a measure of the cooling effect. In this research, a dense three-dimensional Distributed Temperature Sensing (DTS) setup was used to measure air temperature with high spatial and temporal resolution within once cubic meter of air above an urban surface. Six experiments were performed to systematically study the effect of (1) applied water amount, (2) initial surface temperature, and (3) shading on the cooling effect of uchimizu. The measurements showed a decrease in air temperature up to 1.5 K at 2 m height, and up to 6 K for near-ground temperature. Strongest cooling was measured for the experiment performed in the shade. For an amount of water applied of 1 mm and 2 mm, there was no clear difference in cooling effect, but after application of a large amount of water (>5 mm), the strong near-ground cooling effect was approximately twice as high as when only 1 mm of water was applied. The dense measurement grid used in this research also enabled us to detect the rising turbulent eddies created by the heated surface.

Representation of Southern African Monsoon In A High-Resolution AGCM and Its Future Projections

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A monsoon circulation exists over the southern part of the African continent during the austral summer with precipitation maximum stretching from Angola on the west coast of southern Africa to Madagascar. In some locations, southern African monsoon lasts up to six months. Studies about this monsoonal circulation are surprisingly sparse. To understand the mechanism involved in the development of Southern African Monsoon and its controls, the present study uses a high-resolution AGCM, High-resolution Atmospheric Model (HiRAM) which is developed at GFDL. Accurate simulation of the migration of ITCZ is crucial in the simulation of rainfall over Southern Africa. HiRAM simulations, which are conducted at ~25 km horizontal resolution, can simulate the structure and migration of ITCZ with sufficient accuracy. The seasonal cycle, spatial structure, and the associated dynamic features are examined. The study incorporates observations, gridded datasets, reanalysis products, and GCM simulations for this purpose. Additionally, the future projections using representative concentration pathways RCP 4.5 and RCP 8.5 are also conducted and analyzed.

Keywords: Regional Climate , Africa, Southern Indian Ocean

