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Daily Mean and Extreme Temperature Changes over East Asia Associated with Global Warming

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1. Introduction

The 2001 IPCC (Intergovernmental Panel on Climate Change) report suggested that the global mean surface air temperature has been gradually increased and it records as much as 0.6°C by the end of twentieth century. And also East Asia mean surface air temperature rate of increase since last 40 years is about 1.7°C. Property losses have also enlarged corresponding to the global warming trend, especially increase of extreme weather event occurrence. Many previous studies focused on changes in long-term average temperature and precipitation by the Global Circulation Models (GCMs). Another important aspect involves characteristics of daily temperature, precipitation and in particular, changes to the extreme events of the daily temperature and precipitation distribution.

Most of studies on climate changes, Atmosphere-Ocean General Circulation Models (AOGCMs) have been considered as the primary tool commonly. However, it may not be easy to figure out regional climate conditions due to their coarse horizontal resolution. To overcome this spatial limitation of large-scale model a dynamic downscaling by nesting regional climate model to AOGCMs is considered as one of promising solutions (Giorgi, 1990: Jones et al., 1995: Christensen et al., 1997). In this study, we attempt to develop a methodology to provide relatively accurate future regional information over East Asia with regional downscaling technique. Therefore, the main objective of this study is to examine characteristics of daily mean and extreme temperature changes associated with global warming. Particular emphasis is placed on analyzing trends and variability in the extreme events of the daily minimum and maximum temperature distribution.

2. Experiment design and data

For regional climate simulation, we used the Mesoscale Model Version 3.4 (MM5) which has developed at the Pennsylvania State University (PSU) and National Center for Atmospheric Research (NCAR) (Anthes and Warner, 1978). The MM5 model computational domain approximately encompasses the region of 109°E~148°E and 24°N~48°N with a grid point spacing of 27km using Lambert Conformal Projection. Terrain height and land use data are generated from a global data set produced by the United State Geological Survey (USGS) at 5 minute resolution. In this study, a topographic blending technique is applied to all out most grids to inner direction to avoid inconsistency in exchanges of momentum, heat, and moisture at the lateral boundary caused from the RCM topography and large-scale model topography(Hong and Juang, 1998).

The climate change simulations are based on the IPCC SRES (Special Report on Emission Scenarios) A2 scenario. The initial and boundary conditions for MM5 are driven from ECHAM Hamburg Atmosphere model version-4 coupled with the Hamberg ocean primitive equation global ECHAM4/HOPE-G (after ECHO-G) model of Max Planck Instituteof Meteorology (MPI) for IPCC SRES (Special Report on Emission Scenarios) A2 given in Oh et al. (2004). In the regional simulations, MM5 was driven by updating the lateral boundary conditions at every 6 hour intervals using the interpolated ECHO-G data for 100 years (2001~2100). The list of ECHO-G variables to the initial and lateral boundary conditions for MM5 are sea level pressure (Pa), U-V winds (m/s), specific humidity (kg/kg), temperature (K) and geopotential height (gpm). The ECHO-G is the fourth generation version of the Hamburg atmospheric general circulation model, which was modified from ECMWF AGCM for the use of long term climate simulations. A detailed description of ECHO-G is given in Zorita et al. (2003), Oh et al. 2004, Min et al. (2004).

3. Results

For the purpose of our study, we have performed 100 years integration (2001~2100) with the MM5 regional climate model. The results present not only focused on the mean surface air temperature but also temperature extreme events response to climate change, based on daily minimum and maximum temperature. Trends analysis was performed extremes (5th and 95th percentiles).

Fig 1. presents daily mean temperature distribution in 2000s (2001~2010) and 2090s (2091~2100) over East Asia. In such a distribution, we can fine an increase in both the mean and the variability, which affects the probability of hot and cold extremes, with less change for cold weather and more hot weather. Consequently as distribution change from 2000s to 2090s, there is more frequent hot events with more extreme high temperature and fewer cold events. Extremes are defined as follows: "summer day(SD)" if the maximum temperature exceeds 25°C calculated for all days within annual and " frost day(FD)" if minimum temperature is found below 0°C. Average over East Asia, negative trends were obtained in the number of frost days, while the number of summer days has increased for 100 years. That is 31 fewer frost days and 41 more summer days(Fig 2.). The most significant decrease of frost days occurs over 35 latitude. Especially, the largest decrease is found in Japan about over 80. And the summer days increase is more strongly in Korea, Japan, and continent of China.

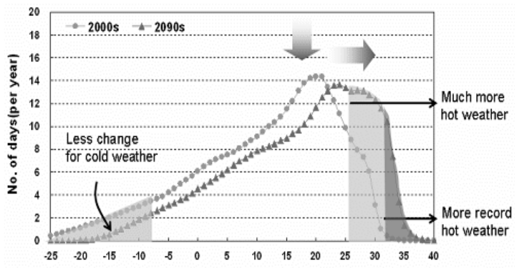

Fig. 1. Change in daily mean temperature distribution both 2000s and 2090s over East Asia.

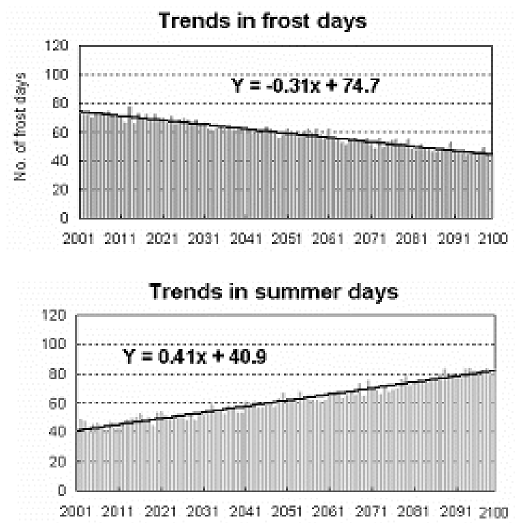

Fig. 2. Trends of frost days and summer days from 2001 to 2100 over East Asia.

Trends over 2001~2100 of extreme (5th and 95th percentiles) maximum and minimum temperature are analyzed. We sued indices of the temperature extreme from the internationally agreed WMO/CLIVAR list of climate change indices (http://www.knmi.nl/samenw/eca). The warm temperature extremes averaged over East Asia, warm days and warm nights was found increase, there is 72 more warm days and 59 more warm nights. The region with the largest increase of warm nights was found at low latitude, while the increase of warm days shows generally whole region over 50 days. And changes in cold temperature extremes are also analyzed. Cold days and cold nights show negative trends over the 2001 ~ 2100 period. The largest decrease is found in Japan over 90 fewer days. Averaged over East Asia, the decrease of cold days is 44 days and cold nights are 50 days for 100 years.

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