Investigating the spatial scaling effect of the non-linear hydrological response to precipitation forcing in a physically based land surface model

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Abstract

Precipitation is the most important component and critical to the study of water and energy cycle. In this study we investigated the propagation of precipitation retrieval uncertainty in the simulation of hydrological variables, such as soil moisture, temperature, runoff, and fluxes, for varying spatial resolution on different vegetation cover. Two remotely sensed rain retrievals were explored (one based on satellite IR-only data and the other one based on ground radar data) and three spatial grid resolutions: 0.25°, 0.5° and 1.0°. This investigation was facilitated by an offline Community Land Model (CLM) which is forced by *in situ* meteorological data from Oklahoma Mesonet and high-resolution (0.1°/hourly) rain gauge-calibrated WSR-88D radar (Nexrad) based precipitation fields. In turn, radar rainfall is replaced by the satellite rain estimates at coarser resolution (0.25°, 0.5° and 1°) to determine their impact on model predictions. A fundamental assumption made in this study is that CLM can adequately represent the physical land surface processes. Results show how uncertainty of precipitation measurement affects the spatial variability of model output in various modelling scales. The study provides some information on the uncertainty of hydrological prediction via interaction between the land surface and near atmosphere fluxes in the modelling approach and hopefully it will contribute to water resource redistribution due to climate change in the Korean Peninsula.

Keywords: precipitation, non-linear, remote sensing, CLM

Introduction

The change and redistribution of water resources due to climate change are of main interest in the hydrological society and the Korean Peninsula is no exception.

Traditionally the long-term climate was regarded as unchanging during the normal lifetime of water resource systems. But significant changes in greenhouse-effect gases and their likely effects on temperature and other climate variables, especially precipitation, have suggested that climate change needs to be considered in water resource planning (Maidment, 1992). The dominant approach was to use a sensitivity analysis and examine the differences according to climate change in a system. A physically based numerical modelling approach has been an alternative to studying the effect of climate change on the regional and global water resource budget.

Land surface-atmosphere interaction processes such as evaporation from bare soil or from soil beneath vegetation, infiltration into the soil, and surface runoff are important aspects for weather/climate forecasting and these features are controlled by surface variables such as soil moisture and temperature, soil texture, biomass, surface roughness, and, most importantly, meteorological condition. Precipitation as a driving force is arguably the most important component of the land-vegetation-atmosphere system accountable for shaping the state of the climate and variability of water in the hydrological cycle. Thus, correct precipitation estimation is crucial in the land-atmosphere interaction. There have been some attempts to predict temporal and spatial variation of precipitation using a physically based atmospheric modelling approach but it is unfortunate that the atmospheric modelling approach is not satisfactory. Quantitative precipitation information is important in the evaluation of the simulation data and/or initialisation and/or assimilation of the land surface and atmospheric modelling approach. However, the existing quantitative precipitation information is scarce, which leads to frustration for the hydrologist and atmospheric scientist. Recently, the remote sensing technique is being seen as a promising tool for large-scale precipitation observation and studies have been successfully conducted in this field. This technique is especially promising for undeveloped countries where there have not been many observations.

In general there are several factors that affect the modelling results (Arnaud et al, 2002), namely the physical structure of the model; the model parameters; the numerical resolution; and the accuracy of input data. The choice of the precipitation retrieval data to be used is the first step in land-surface simulation study and the choice is often made on a largely subjective and intuitive basis.

The impact of precipitation retrieval error on the simulation of hydrological variables (hereafter called error propagation) has been the subject of a number of studies (Sharif et al., 2002; Borga et al., 2000). These studies by Borga et al. and Sharif et al. focused on error propagation in runoff prediction driven by radar rainfall observations. Guo et al. (2004) intensively investigated the spatial variability of the radar-based precipitation measurement and showed the impacts of the different precipitation sources (radar- and ground-based measurement) based on the modelling approach. Yu et al. (1999) simulated streamflow with a model-derived and observed precipitation and they

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