Data preparation for applying terrestrial carbon flux models to Korean ecosystem using ArcGIS.

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Abstract

Forest sequestrates carbon dioxide (CO_2), one of the major factors of global warming, in vegetation and soils through photosynthesis process. In addition, woods deposit CO_2 for a long term until the harvested wood is decomposed or burned, and deforested areas could be expanded the carbon sinks through reforestation. Consequently, forests are considered as one of the major sinks of greenhouse gases for mitigating global warming. So it is very important to quantify carbon dynamics and budget for preparing adaptation measures to climate change. Terrestrial carbon flux models have been used for investigating the carbon dynamics.

The objective of this study is to prepare input data for applying previous carbon flux models to Korean ecosystem using GIS-based spatio-temporal data set such as precipitation, maximum and minimum temperature, soil properties and others. After applying models, we have a plan to compare the each model results with observed field data. We will be able to understand a suitable model for Korean ecosystem.

Key word : Climate change, Carbon flux model, Input data preparation

1. Introduction

The change in global carbon cycle, caused by climate change, has influenced on terrestrial and marine ecosystem. Carbon is one of the major factors of photosynthesis by vegetation, and carbon dioxide has also been regarded as major cause for global warming. Many countries have made an effort to reduce a carbon dioxide emission for mitigating human-induced global warming. To reduce and manage carbon emission, it needs to understand carbon dynamics precisely and quantify an amount of carbon emission and vegetation carbon budget as a carbon sink. Many researchers have developed process-based models to estimate carbon budget of vegetation. Terrestrial ecosystem models have been regarded as essential tools for carbon cycle studies ranging from the fine scale to the global scale, because they allow integration of a variety of observation data, sensitivity analysis to specify key processes and parameters, and prediction of changes in the near future. In general, model-based evaluation is advantageous in conducting full-carbon accounting, in which whole carbon dynamics (aboveground biomass and belowground root and soil organic matter) must be quantified. This modeling approach will be helpful for preparing adaptation measures to climate change.

In this study, we prepared suitable input data for simulating previous carbon flux models to Korean terrestrial ecosystem using ArcGIS 9.2 programs

2. Material and Method

2.1 The model input parameters

In general, most of the process-based carbon cycle models have a common input dataset for simulation. These input datasets(Table1.) are available for applying previous models like BEAMS(Sasai et al. 2007), CASA(potter et al. 2006), VISIT(Ito et al. 2009) and others. There are four types of dataset; climatic data, soil data, remote sensed data, ancillary data. Climatic data include maximum and minimum temperature and precipitation, VPD, shortwave radiation and wind speed with daily level. Soil dataset contains physical and hydraulic properties as showned below table 1. A remotely sensed dataset includes land cover types and albedo data. Finally, Ancillary data have information about location and elevation in simulating area.

Table 1. Input parameters commonly used for simulating carbon flux models(Itoh et al).

class	**Input parameters**	
Climate	Maximum temperature Minimum temperature Daily precipitation Daily Vapor pressure deficit Daily shortwave radiation Wind speed	6
Soil	Rooting depth Soil depth Percent clay content Percent sand content Percent silt content Saturated water content Field capacity Wilting point	8
Remote sense	Land cover type Albedo	2
Ancillary	Area, Elevation Latitude, longitude	4

2.2 Study area and Data source and method

Study area was defined to be a square region from 33.09° to 38.72° and 125.76° to 129.66°(Fig.1), including entire of south Korea. A Spatial resolution of each grid cell for simulation is 2 minutes which gives an area of each grid cell of approximately $10km^2$. This region is characterized by warm climate and quite heterogeneity in seasonal climate and different elevation. The 65% of area is covered with forest vegetation.

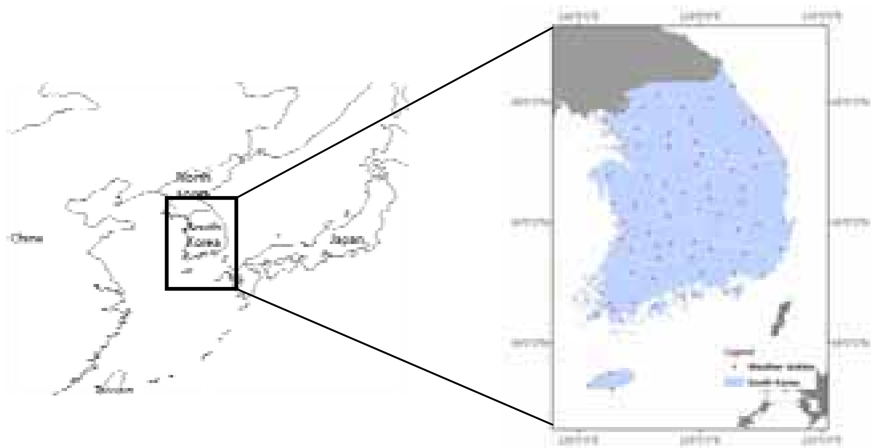

Fig 1. The study area and location of weather observing stations operated by Korea Meteorological Administration

The data of ancillary data was provided by Ministry of Environment(MOE), Korea. We could get the location and boundary information of south Korea from the MOE. The elevation data was acquired from the internet site of ASTER GDEM(METI and NASA).

Climatic data was offered by Korean Meteorological Administration(KMA). The data were acquired in 75 weather observing stations, and offered climatic data using input parameters except vapor pressure deficit. For converting point to grid raster data, interpolation method was applied according to input parameters properties. For interpolating temperature data, kriging method was used, while for the other data, Inverse Distance Weighted(IDW) method was applied(eq 1).

$$z = \sum_{i=1}^{n} \lambda_i z_i \qquad W = \frac{\Sigma \frac{W_i}{d_i^2}}{\Sigma \frac{1}{d_i^2}} \qquad \text{Eq 1.}$$

Temperature datasets, were prepared concerning the absolute temperature lapse rate(eq 2), because the temprature declines according to the increment of elevation. These equations are estimated by Yun et al. 2001.

$$|\Gamma| = 0.00708 + 0.003\cos 0.0172\,(i-120)$$
$$|\Gamma| = 0.00688 + 0.0015\cos 0.0172\,(i-60)$$
$$|\Gamma| = 0.00695 + 0.0013\cos 0.0172\,(i-30) \qquad \text{Eq 2.}$$
$$T = T_i + Elevation\,(m) \times |\Gamma|$$

$|\Gamma|$: absolute lapse rate

i : the number of date (Jan 1st = 1,….. , Dec 31th = 365)

And vapor pressure deficit(VPD) was derived from average temperature and relative humidity using the conversion of equation suggested by Allen et al., 1998(eq 3).

$$e_s = 6.1121 \times \exp\frac{17.502\,T}{240.97 + T}$$
$$VPD = e_s(1 - RH) \qquad \text{Eq 3.}$$

These two equation(eq2, eq3) were embodied in ArcMap interface using ArcGIS 9.2 model builder tool. They were the combinations of single output map algebra tool and interpolation tools (IDW and Kriging).

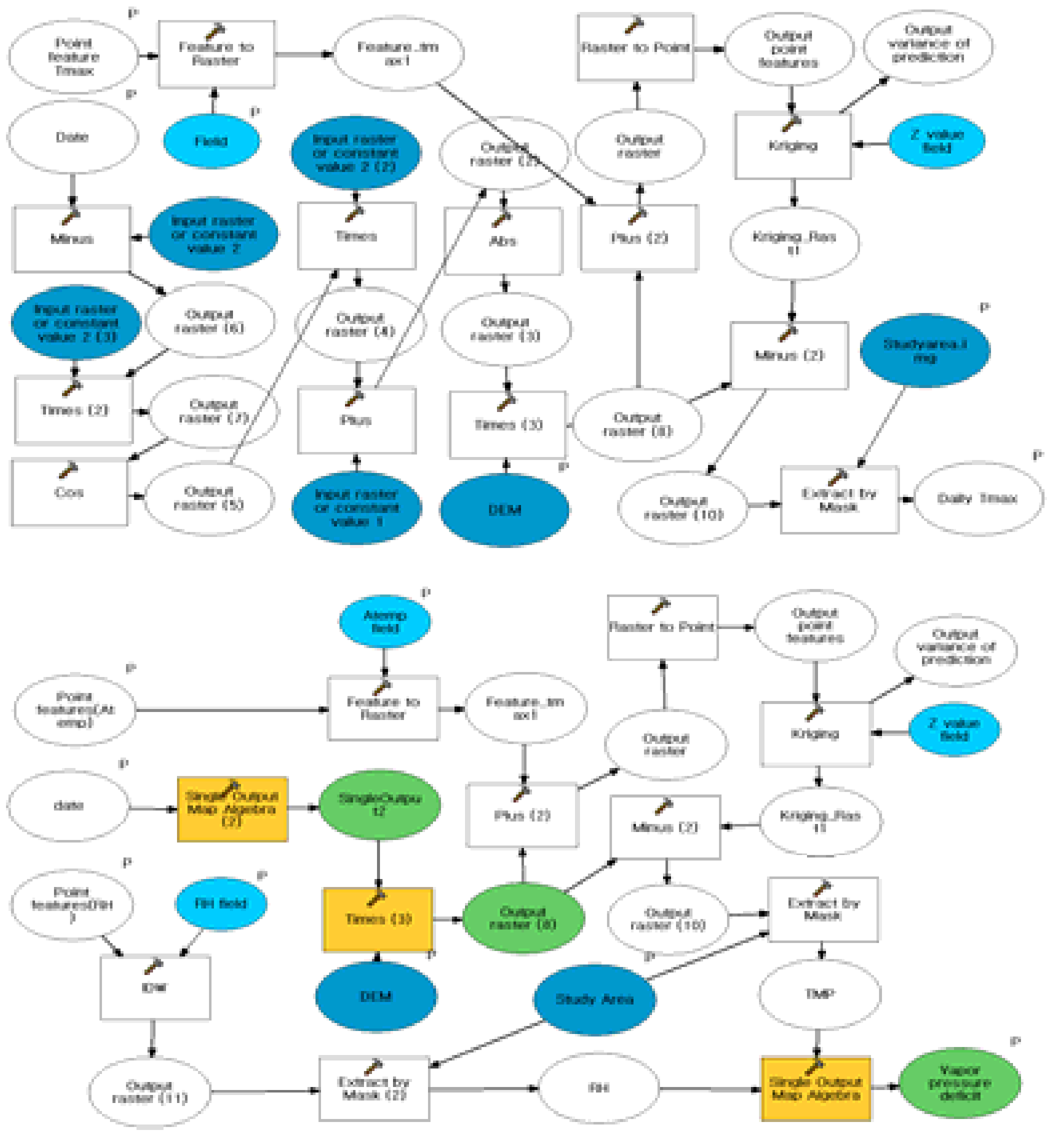

Fig 2. Diagram of absolute lapse rate and vapor pressure deficit calculation using ArcGIS 9.2 model builder

Soil data were acquired from National Academy of Agricultural Science(NAAS) of Korea. The data have been provided to be various soil properties but there was no hydraulic data information. Therefore, it was derived using the programs including pedo-transfer functions. Rosetta(1999) developed by USDA and Soilpar(2002) developed by CRA were used to estimate saturated water content, field capacity and wilting point data.

Finally, Remotely sensed data were collected from MODIS website. MOD12Q1(Friedl et al. 2002), one of the MODIS land products, was used for Land cover data, and MCD43B3 for deriving surface albedo data(Fig 3).

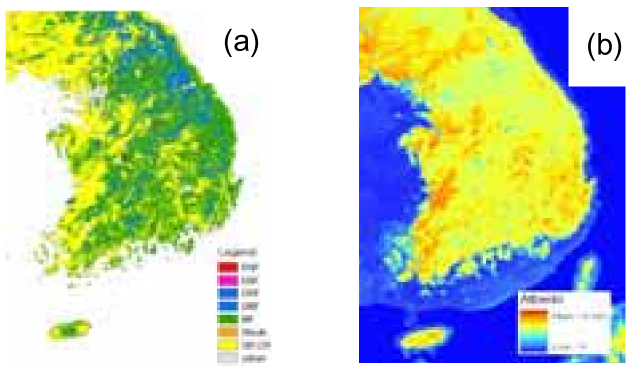

Fig 3. Land cover data from MOD12Q1(a) and surface albedo data from MCD43B3(b)

3. Results and Discussion

3.1 Ancillary data

Ancillary data were prepared including information of area, elevation, longitude and latitude (Fig 4). South Korea has a heterogenous properties in elevation ranging from 0 to 1,614m.

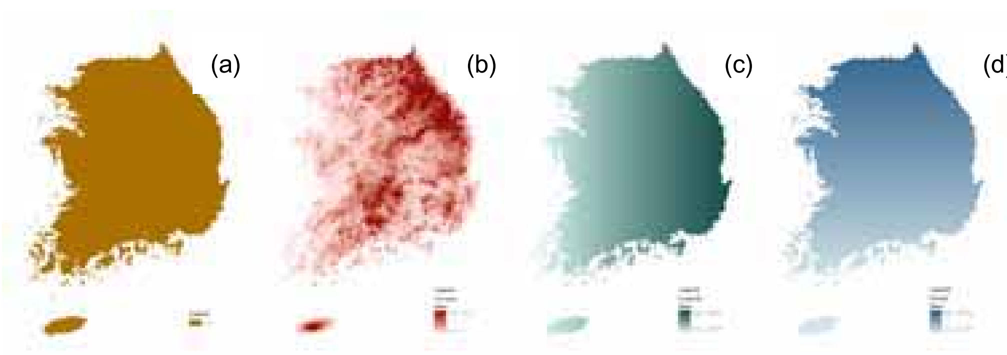

Fig 4. The results of ancillary data processing; (a) area (b) elevation (c) longitude (d) latitude

3.2 Climatic data

Climatic point data were converted to raster type with daily level for ten years from 1999 to 2008(Fig 5). The Climate of south Korea is characterized by distinguished seasonal variation.

In summer season, it shows high temperature and humidity. Whereas low temperature and high aridity in winter season.

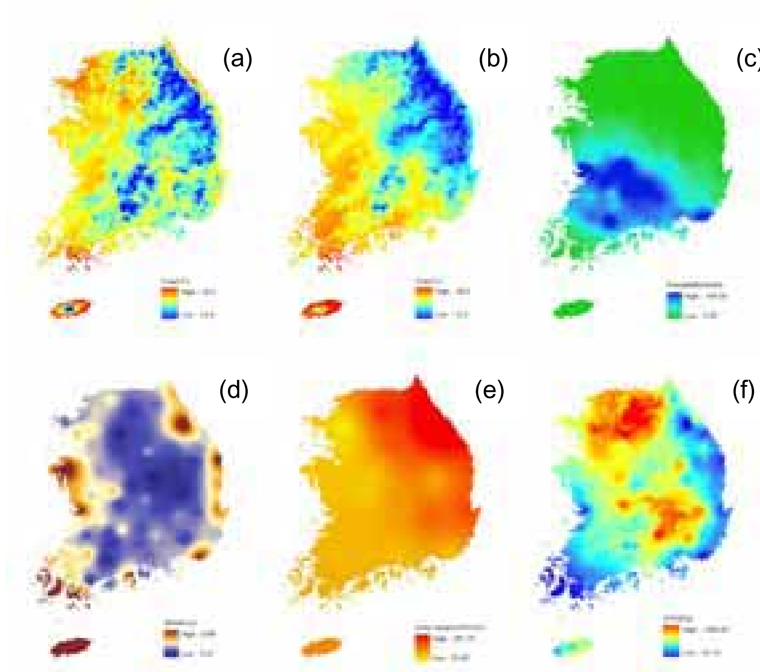

Fig 5. The results of climatic data interpolation in 1st July 2005; (a) maximum temperature, (b) minimum temperature, (c) precipitation, (d) wind speed, (e) shortwave radiation, (f) vapor pressure deficit.

3.3 Remotely sensed data

The 65% of the total study area covered with forest vegetation, Most of these area are composed of mixed forest. Forest area showed a low surface albedo relatively while crop lands and settlement show a high surface albedo.

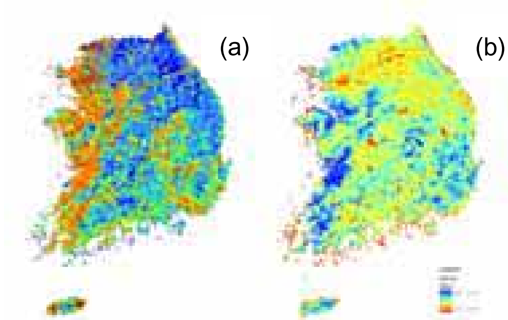

Fig 7. The results of processing with MODIS products; (a) Land cover types, (b) Surface albedo.

3.4 Soil data

The soil texture of South Korea was characterized by high proportion of sand and low proportion of clay. The saturated water content was typically low but high in Jeju island because of the volcanic rocks. A field capacity and wilting point were estimated low. The soil depth of south Korea is typically low ranging from 0.1 to 2m.

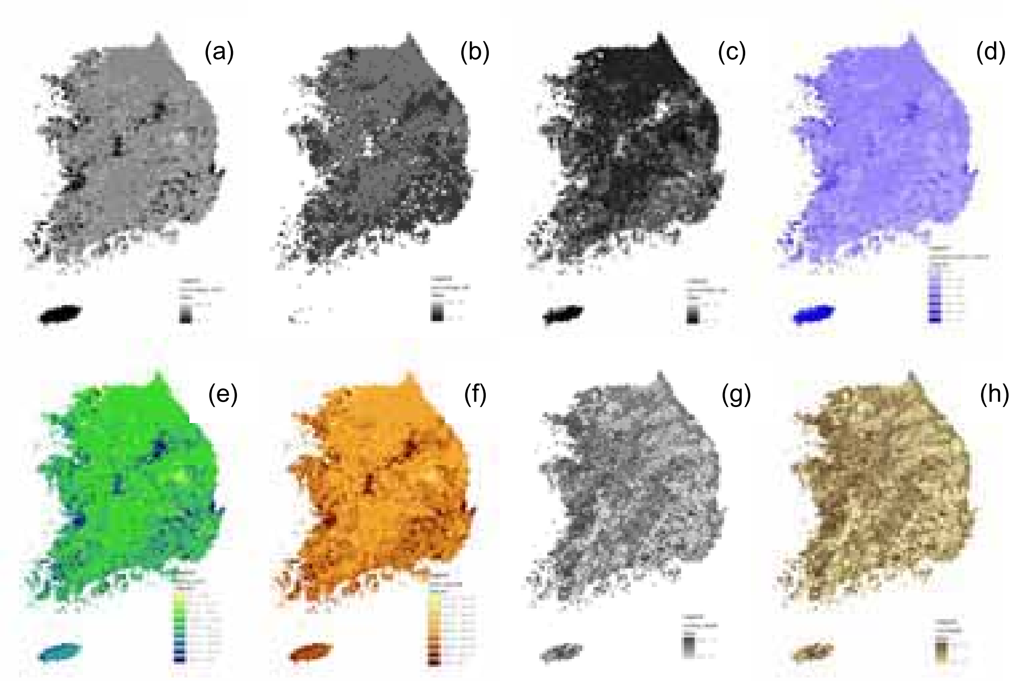

Fig 6. The maps of soil properties; (a) percentage of sand, (b) percentage of silt, (c) percentage of clay, (d) saturated water content, (e) wilting point, (f) field capacity, (g) rooting depth, (h) soil depth.

4. Future research

These input data will be applied to process-based carbon flux models. Therefore we can obtain the results related with terrestrial carbon flux values like gross primary products, net primary products, net ecosystem products and others. And then the each model results are going to be compared with observed data to find out which model explain real carbon flux well.

5. Acknowledgement

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