Development of land ecosystem carbon balance model component for carbon dioxide transport calculations

*Ryoichi Imasu[1], Satoshi Ito[1], Hiroaki Kondo[2]

1. Atmosphere and Ocean Research Institute, The University of Tokyo, 2. National Institute of Advanced Industrial Science and Technology

Recent progress in satellite measurements of greenhouse gases enhances the inversion analysis of the strengths of gas emissions from mega-cities. For these analyses, regional scale transport model is necessary. Greenhouse gases Observing SATellite (GOSAT) data have been used as input to a regional scale model, National Institute of Advanced Industrial Science and Technology Meso-scale Model (AIST-MM), to calculate CO_2 transport in Kanto Plain area. However, this model was not optimally designed to simulate the effects of land-ecosystem. That is because it had been originally developed to simulate the transport of air pollutants. In this model, formulae of photosynthesis of vegetation and respiration of plants and soil are coded to be simply calculated based on the fixed parameters for each vegetation type, and it is not enough for precise calculation of emission and uptake of CO_2 by the ecosystem. Although the atmospheric CO_2 concentrations calculated by AIST-MM fairly agree well observations for winter season, AIST-MM overestimate both respiration in night time and photosynthetic uptake of CO_2 during day time are overestimated for summer season. Therefore, it is necessary to develop a land ecosystem carbon balance model which can realistically simulate vegetation activities to be embedded into AIST-MM as a calculation component. In this study, we have developed a gross primary production (GPP) calculation component as a part of the carbon balance model based on the algorithm of the "Biosphere model integrating Eco-physiological And Mechanistic approaches using Satellite data (BEAMS)" which can calculate GPP using satellite data explicitly representing daily variation of vegetation activities and diurnal variation of solar flux (Sasai, 2005; 2011). The fundamental inputs for the model is meteorological data, land cover type, Photosynthetically Active Radiation (PAR), the fraction of absorbed PAR (fPAR). As the meteorological data, GPV-MSM provided by Japan Meteorological Agency (JMA) is used, As the land cover type and fPAR, MODIS level-3 (MCD12Q1) and level-4 (MCD15A3H) are respectively used. PAR data provided by JAXA Satellite Monitoring for Environmental Studies (JASMES) are normalized referring the ground based measurements at Tsukuba site, and its scaling factor is applied to whole area. Then diurnal variation of PAR is calculated based on the solar zenith angle at each location. Spatial resolution of calculation is set to be 500 m based on the resolution of MODIS data, and temporal resolution is set to be 1 hour referring the GPV-MSM data. GPP values calculated by the method are compared with ground based measurements provided by Forestry and Forest Products Research Institute (FFPRI) flux net. Comparison at "Yamashiro", "Fujiyoshida", and "Kawagoe" stations show that over estimation by the original component of AIST-MM is drastically improved, and annual amounts are agree well with measurements in about 20 %. As it is shown through the comparison that not only seasonal variation but also variation in a few days scale (synoptic scale) variation can be represented by the calculation, the component can be valuated to be in a quality level to be able to be used in the regional scale model of which spatial and temporal resolution is very high. As the next step of the development of the carbon balance model, we started to develop a calculation component which can calculate the vegetation and soil respirations with the same order of the special and temporal resolutions as for GPP.

Keywords: Carbon dioxide, gross primary production, BEAMS

