Carbon cycle mapping of terrestrial ecosystems in East Asia with a high resolution model

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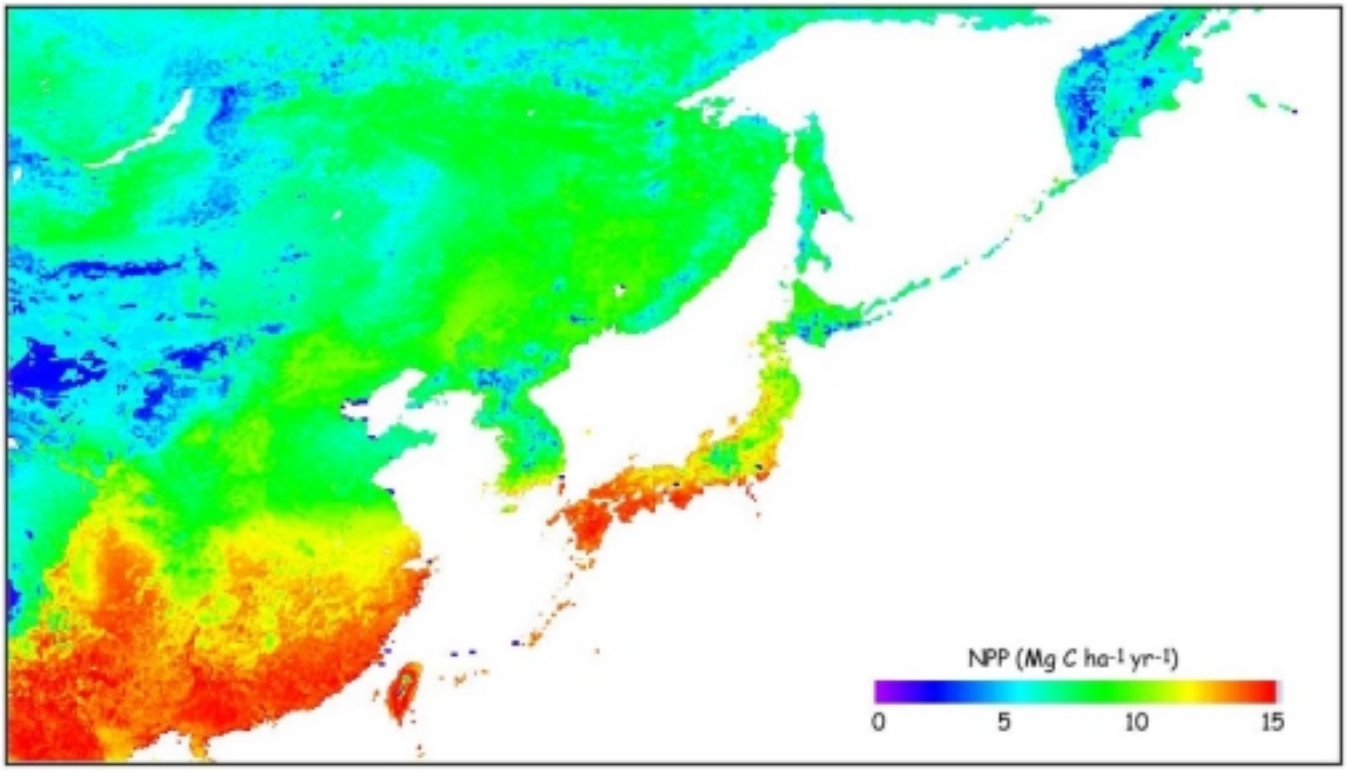
Carbon sequestration into the terrestrial ecosystem may play an important role in the mitigation of global warming. Actually, the mitigation of climate change taken by the Kyoto Protocol largely includes carbon sequestration into forest ecosystems, stimulating carbon cycle researches related to forest management. However, there remain a number of difficulties in our evaluation of carbon budget in terrestrial ecosystems, because of their complexity and diversity. During the last 15 years, terrestrial carbon cycle has been addressed by numerical models at the global scale, with respect to carbon stock and productivity. Because these model studies adopted coarse spatial resolutions due to the deficit of computational ability (e.g. 0.5-degree mesh), they could not take the heterogeneity of vegetation distribution in a realistic manner, especially in regions with complex topography and severe land-use change. Therefore, constructing a high-resolution model is essential for estimating the carbon cycle of terrestrial ecosystems at broad scales. Accordingly, we developed a regional model with 5-minute (i.e. about 9 km) mesh, which may work on high-performance computers. In simulations with the model, vegetation distribution was derived from the 1-km mesh data after the United States Geological Survey, which include 94 land-cover categories (80 natural biomes, 13 croplands, and 1 urban area). The 1-km mesh data was aggregated into a 5-minute mesh data with 94 layers; this may minimize aggregation error. Soil properties (wilting point and water holding capacity) were derived from the 5-minute soil data set of the Data and Information Services, a core project of the International Geosphere-Biosphere Program. Topography was derived from the ETOPO-5 data after the U.S. National Geophysical Data Center. Climatology was derived from the reanalysis data set by the U.S. National Centers for Environmental Prediction and the U.S. National Center for Atmospheric Researches. The climate data, originally in T62 Gaussian mesh (about 1.9-degree), was interpolated into the 5-minute grid points. Using these 5-minute data sets, a carbon cycle model of terrestrial ecosystem (called Sim-CYCLE) was performed to obtain the potential state of carbon budget in the East Asian region: in latitude, from 60 to 20 deg. N, and in longitude, 100 to 170 deg. E. The Sim-CYCLE model is composed of 6 compartments representing ecosystem carbon pools: atmospheric CO2, foliage, stem, root, dead biomass (litter), and humus. Among these compartments, carbon flows, such as photosynthesis, respiration, litterfall, and decomposition, are calculated for each month. Gross photosynthetic production is estimated based on the Monsi-Saeki theory, taking into account of the effect of atmospheric CO2 concentration, temperature, air humidity, and soil moisture availability. It is emphasized that the model is a mechanistic model, based on ecophysiological relationships, leading to predictability of carbon budget under environmental change and human influence. This is one of the advantageous points of modeling approach, compared with the remote sensing approach. At this stage, the model was used to estimate the equilibrium carbon budget, and the outcome was compared with our former one of 0.5-degree map. In consequence, we obtained a high-resolution map of East Asian terrestrial ecosystems. The new map seems more realistic than the former one, with respect to shoreline and topographic effect, such as central mountains in Japan. Effect of heterogeneous cultivation intensity was also captured in a realistic manner, even in some highly cultivated areas, such as southern China. Because the new land-cover map was derived from remote sensing data, we may easily update the map to consider land-use change in the future. Using higher performance computers, we can perform global simulations to acquire the highest resolution map of terrestrial carbon budget, in the near future.


NPP (Mg C ha-1 yr-1)
0
5
10
15