SPATIAL PATTERNS OF CARBON RESIDENCE TIMES AND SEQUESTRATION CAPACITY IN ECOSYSTEM OF THE CONTERMINOUS USA

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ABSTRACT

To properly model carbon (C) sequestration capacity and its spatial pattern in the conterminous USA, the model parameters of C turnover times should be identified. In this study, we inversed the C turnover times based on a process-based model that combining Carnegie-Ames-Stanford Approach (CASA model) and vegetation and soil carbon transfer (VAST) model. The genetic algorithm was used in this study to search for optimal parameters of C turnover times. After inversing the spatial pattern of C turnover times, we modeled the carbon sequestration capacity by using a forward model under current NPP increase trend that derived from satellite data.

METHODS AND MATERIALS

In this study, the VAST model [*Barrett*, 2002] was applied to describe the relationships of C allocation and transfer among sub-pools, while the canopy C influx was modeled by CASA model [*Potter et al.*, 1993], as shown in Fig. 1. To inverse the parameters of C turnover times (τ_k, k=L for leaf, W for stem, R for roots, F for fine litter, C for coarse litter, S for soil organic carbon), twelve of data sets of observed NPP and C-pools were used in our inversion analysis, which included 3 net primary production data sets (NPP in leaves, stems, and roots), 5 biomass data sets (leaf, stem and 3 root pools in three soil layers), 1 fine litter data set, and 3 soil organic carbon data sets in three soil layers. After the C turnover times were retrieved by genetic algorithm, we adopted a first-order differential equations in our forward modeling to estimate carbon sequestration capacity under the current drive of NPP increase.

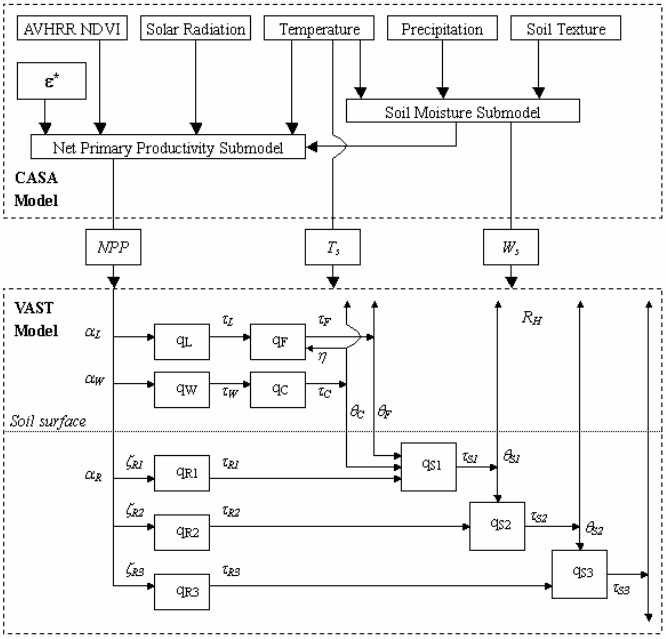

Fig.1 Model frame for inversion of C turnover times

RESULTS

Spatial pattern of C turnover times

The spatial pattern of C turnover times in ecosystems was illustrated in Figure 2. It indicated that C turnover times in conterminous US is highly heterogeneous, the values range from about 10 years to

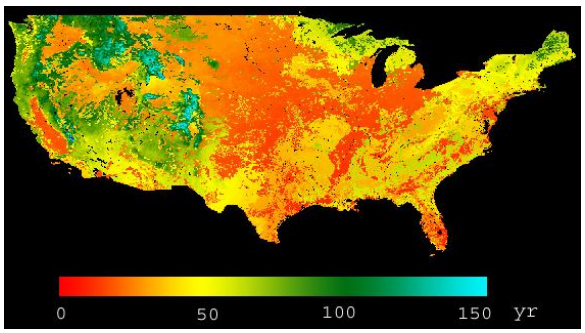

Fig.2 Spatial pattern of C turnover time in ecosystems

above 150 years, but most of regions have turnover times between 15 and 65 years. The lowest turnover times locate in Central Plains, with 28 years in average (Std. Dev. = 13 yrs). The highest turnover times appear in west conterminous US, with 64 years in average (Std. Dev. = 34 yrs). While the value in east conterminous US is about 41 years in average (Std. Dev = 20 years). For the whole conterminous US, the average turnover time of C is 46 years.

C sequestration capacity caused by turnover times

When a 0.5% increase of NPP per year was uniformly applied to the whole conterminous US, our forward modeling showed that most of eastern regions and some northwest regions have large carbon sequestration capacity in ecosystem (about 2 $kgCm^{-2}$ increase in 50 years), as shown in Fig. 3. Cropland and grassland sequestrated most of carbon in soil (Fig. 4), while forest and woodland sequestrated most of carbon in plant tissues.

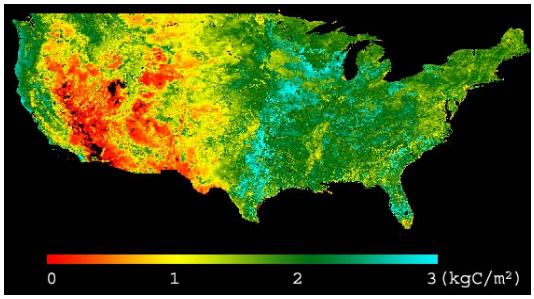

Fig.3 C sequestration capacity in ecosystem in 50 years

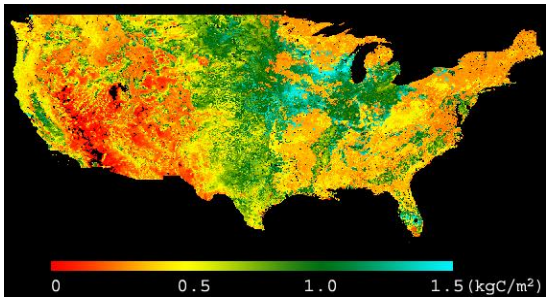

Fig.4 C sequestration capacity in soils in 50 years

C sequestration capacity caused by turnover times and NPP increase

When a satellite data-derived NPP increase [*Hicke et al.*, 2002] that has high spatial heterogeneity was applied in the forward modeling, results showed that cropland has the largest carbon sequestration capacity due to the highest NPP increase trend, which followed by deciduous broadleaf forest, grassland, wooded grassland, and mixed forest. The whole conterminous US sequestered approximately 0.26 PgC per year, similar to the estimate of carbon sequestration from inventory data (about 0.3 PgC/yr).

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