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Multi-temporal Scale Analysis of Environmental Control on Net Ecosystem Exchange of CO_2 in Forest Ecosystems

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Multi-temporal scale analysis of environmental control on forest ecosystem carbon budget is a basis for understanding the responses and adaptation of forest carbon cycle to climate change. In this study, we chose two typical forest ecosystems, Changbaishan temperate mixed forest (CBS) in northeastern China and Dinghushan subtropical evergreen broad-leaved forest (DHS) in southern China to identify the changes in environmental control on net ecosystem exchange of carbon dioxide (NEE) with the temporal scales. The analysis was made based on the flux and routine meteorological data measured during the period from 2005 to 2008. These time series data were analyzed using wavelet and cross wavelet transform. The results showed that NEE had significant daily and annual periodic variation in the two types of forest ecosystem. NEE at CBS and DHS showed semi-annual (176 days) and seasonal (88-104 days) periodic variations, respectively. Photosynthetically active radiation (PAR), vapor pressure deficient (VPD), air temperature (Ta), soil temperature (Ts, at 5-cm depth) controlled daily variation of NEE as indicated by the significant high common power of cross wavelet transform spectrums between NEE and these factors. Similarly, Ta, VPD, and precipitation (P) controlled annual variation of NEE at CBS. However, Ta, PAR, and soil water content (SWC, at 5-cm depth) dominated the annual variation of NEE at DHS. An anti-phase between NEE and PAR at daily scale in the two forest ecosystems demonstrated an agreement of the variation of NEE with PAR, with rising sunlight corresponding with increased net carbon uptake. At annual scale, phase angles between NEE and Ta and between NEE and P were –170° and 176°, respectively at CBS. At DHS, phase angle between NEE and VPD was smallest at annual scale. The results indicated that the peak of net carbon uptake seasonal variation and the peaks of P and Ta seasonal variations occurred at the same month at CBS. But, at DHS, seasonal variation of net carbon uptake was in agreement with that of VPD at annual scale. This study showed that wavelet analysis was an effective approach to identifying the temporal pattern of environmental control on carbon exchange between ecosystem and the atmosphere.