Past, present and future climate variability in the Pacific Northwest and its influence on carbon exchange in an old-growth forest

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Carbon uptake in evergreen conifer forests of the Pacific Northwest (PNW) has been shown in the past through micrometeorological and modeling methods to depend strongly on both total water-year precipitation amounts and the seasonality of precipitation, in addition to annual temperature variability. In this study, we examined the historical climatic variability at meteorological stations in close proximity to the Wind River Canopy Crane Research Facility (WRCCRF) to examine what influence such variability could have on old-growth forest ecosystem carbon exchange. The WRCCRF provides a unique opportunity to study carbon exchange between an old-growth temperate seasonal-rainforest and the atmosphere in a region which has experienced a significant amount of historical regional climate variability. Considering that temporal variability in climate can have a profound impact on forest carbon uptake and that the PNW climate variability is heavily influenced by ocean-atmosphere circulations, trends in the two dominant oscillations, the Pacific Decadal Oscillation (PDO) and the El Niño-Southern Oscillation (ENSO) were examined.

Carbon fluxes measured with eddy-covariance techniques at WRCCRF since 1998 have shown significant interannual variability with the forest switching from a net carbon sink of 1.6 tC ha^{-1} yr^{-1} in 1999 to a net carbon source of 0.6 tC ha^{-1} yr^{-1} in 2003. Maximum net carbon uptake was measured during the 1998/1999 La Niña year. As anticipated, historical precipitation and temperature trends in this region were closely linked to PDO and ENSO phases. Precipitation was 10.2% above average during La Niña years and 9.5% above average during negative-phase PDO years, while 5% below normal during El Niño years and 9.5% below normal during the positive-phased PDO. Further analysis is needed to isolate the regional climatic differences from varying ENSO intensities and to study the coupled forcing mechanisms of in-phased ENSO and PDO events, though initially it appears that ENSO and PDO phase events have equal influence on regional precipitation (r-square = 0.2, water-year precipitation totals regressed separately against winter PDO and ENSO phase indices). Considering that global circulation models prediction increased future climate variability in the PNW, increased interannual variability of carbon exchange is also expected. This impact of interannual and interdecadal climatic variability on old-growth forests is of particular interest considering that old-growth forest ecosystems in the Pacific Northwest represent an upper limit on carbon storage in this region and that old-growth forests are expected to be particularly sensitive to any regional climatic changes.

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