Latitudinal Gradients of Atmospheric $\Delta^{14}C$: A New Window onto Dynamical Controls of the Southern Ocean

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Measurements of $\Delta^{14}C$ in tree rings indicate that there was a pre-industrial latitudinal gradient of atmospheric radiocarbon of 3.9- 4.5‰ (Hogg et al., 20002) and there was a substantial shift in this gradient between the Little Ice Age and the Medieval Warm period (Turney et al., 2007). Previous efforts to explain this shift in the latitudinal gradient have suggested that it is caused by changes in the frequency of ENSO in the tropics. We test the alternative hypothesis that the natural latitudinal gradient of $\Delta^{14}C$ is primarily controlled by ventilation of the Southern Ocean using fluxes from a suite of models based on the Modular Ocean Model version 3, which are used to force an atmospheric transport model. The results from this suite of simulations suggest that the atmospheric latitudinal gradient of $\Delta^{14}C$ is sensitive to wind stress in the Southern Ocean. Increased wind stress in this region leads to greater upwelling of strongly ^{14}C depleted waters to the surface, which take up more atmospheric ^{14}C. Plausible changes in the wind stress alone are sufficient to explain the observed changes in the latitudinal gradient between the Little Ice Age and Medieval Warm Period (Figure 1). These results may have significant implications for current efforts to use atmospheric radiocarbon observations to infer regional fossil fuel emissions.

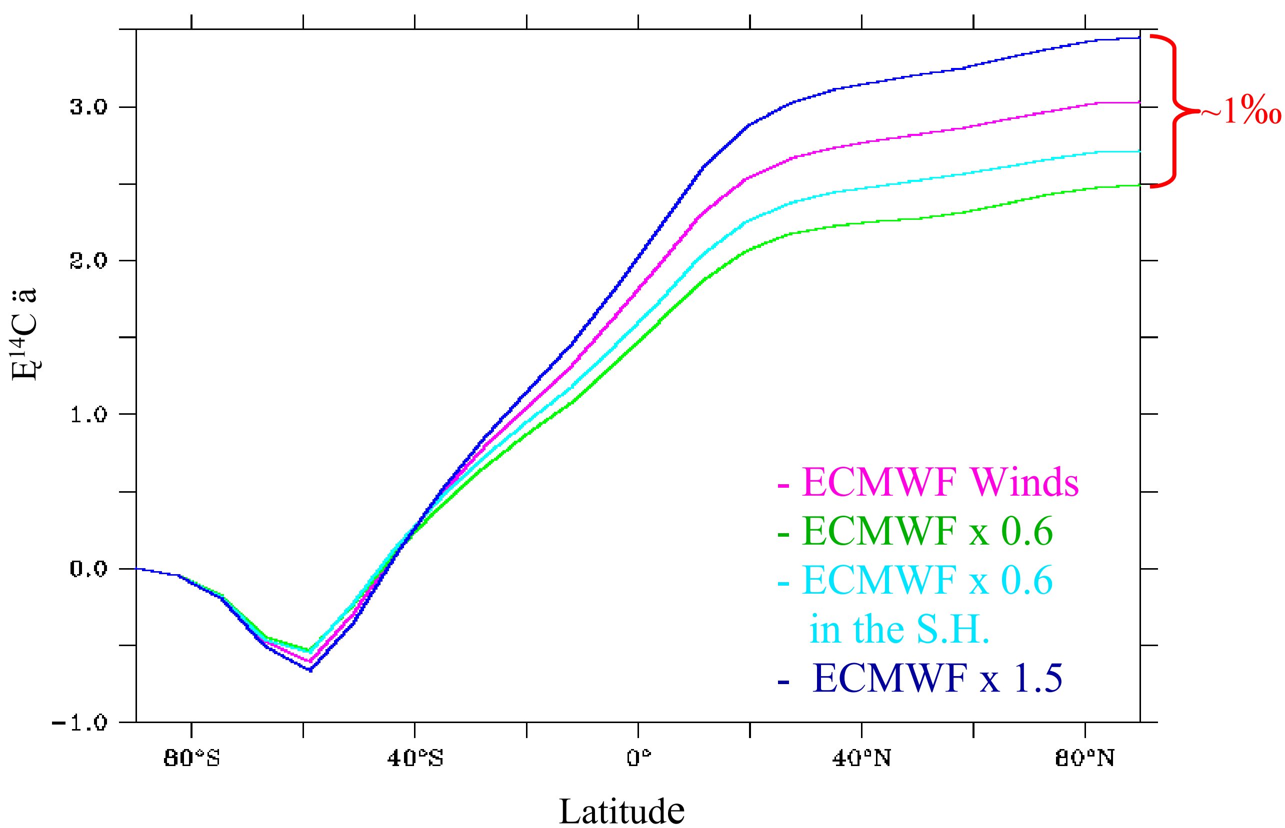

Figure 1. Preindustrial latitudinal gradient of atmospheric ^{14}C based on OGCM simulations in which the wind stress has been systematically increased from 0.6 times the ECMWF wind stress to 1.5 times the ECMWF wind stress. The range between the simulations is sufficient to explain the variability in the latitudinal gradient that has been observed in tree ring data.