ANNUAL CARBON DIOXIDE DRAWDOWN AND THE NORTHERN ANNULAR MODE

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ABSTRACT

Year-to-year variations in summer drawdown of northern hemisphere atmospheric carbon dioxide (CO_2) are compared with corresponding year-to-year variations in sea- level pressure (SLP), surface air temperature and the productivity of land vegetation as inferred from the satellite-derived normalized difference vegetation index (NDVI). Annual values of CO_2 drawdown for the years 1980-2000 are estimated from smoothed time series derived directly from individual flask samples at the 9 northern hemisphere monitoring stations with the most continuous records. The leading principal component of the 9 standardized drawdown time series, in which all stations exhibit positive loadings, is used to represent the hemispheric signal in the CO_2 drawdown. Linear regression analysis is used to infer the spatial patterns of anomalies in sea level pressure, surface air temperature and the NDVI observed during various seasons of years in which the drawdown is anomalously strong.

Winters preceding anomalously high drawdown seasons exhibit patterns characteristic of the high index of the Northern Annular Mode (NAM). SLP tends to be anomalously low over the Arctic and high over midlatitudes, and Eurasia tends to be anomalously warm. The pattern of the NDVI observed during the early months of the growing season in years with anomalously high drawdown is indicative of high productivity over Eurasia. These results support the notion that the wintertime NAM with influences the annual drawdown of CO_2 by modulating the winter temperatures that, in turn, affect the productivity of the terrestrial biosphere during the subsequent growing season.

These results are compared to results for the same time period from the recently developed land model, LM3. LM3 is capable of simulating the global distribution and functioning of terrestrial carbon sources and sinks as well as the exchange of water and energy between land, vegetation, and atmosphere. The land model tracks carbon dynamics of vegetation and soil in response to environmental conditions, ambient concentration of CO_2, natural disturbances, and anthropogenic land use changes (e.g. deforestation and agricultural cropland abandonment). Additionally, changes in the distribution of vegetation structural characteristics affect key land surface parameters such as albedo and surface roughness with climate feedbacks.