Functional Unit Testing in the Investigation of Black Spruce Foliar Dark Respiration

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Understanding the temperature response of net photosynthesis, of both gross photosynthetic assimilation and foliar dark respiration (R_d), is needed in formulating informed hypotheses about vegetation response to temperature manipulations at the SPRUCE (Spruce and Peatland Responses Under Climatic and Environmental Change) site in northern Minnesota. Similarly, proper representation of temperature response is required of models like CLM-SPRUCE used to predict response to treatments and to extrapolate those responses spatially and into the future. It is generally quite difficult to interrogate fundamental processes such as leaf-level temperature response in integrated, fully coupled, operating earth system models, particularly under the controlled environmental conditions of field experiments. Site-specific models such as CLM-SPRUCE, with more flexible coding and shorter execution times, help in this regard but do not fully mitigate the issues. Thus the productive interplay between model and experiment is hampered. In response, we are using a functional testing framework to evaluate the functional representation of photosynthesis and R_d in CLM-SPRUCE and the land model of the Accelerated Climate Model for Energy (ACME). Here we report on results for pre-treatment (2010-2013) observations of the temperature response of Rd for black spruce (*Picea mariana*) at the SPRUCE site. In the functional unit testing framework, functional representations at the finest level of code granularity and the scale of observations are isolated as modular units. Results from these modules, under the controlled environmental conditions of experimental field (and laboratory) measurements, can be generated quickly and compared directly with experimental observations. Alternative formulations, observed and hypothesized, can be easily incorporated and evaluated. The framework also enables much easier data assimilation and sensitivity analysis at the level of functional units. Using this functional unit testing we have found that the observed temperature response of black spruce foliar R_d is not duplicated by the foliar R_d module of CLM-SPRUCE. The model simulates a reduction in $\ln R_d$ at temperatures > 30 °C not seen in the observations where $\ln R_d$ increases approximately linearly over the range 5-40 °C. The "acclimation" of R_d coded into the model may not appear in the observations because historically, black spruce at the site experience the warmer temperatures infrequently and only briefly. We use the functional unit testing to evaluate alternative representations of the R_d temperature response and discuss how insights obtained from the functional unit testing might inform hypotheses of black spruce R_d response to SPRUCE temperature treatments over the duration of the experiment.