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Low Temperature Photosynthesis. Light Response Curves from the High Arctic

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Estimates of Gross Primary Productivity (GPP) by terrestrial biosphere models (TBMs) rely on accurate model representation of photosynthesis. In the Arctic model uncertainty over GPP is the dominant driver of an uncertain Arctic carbon cycle. At the heart of many TBMs is the Farquhar, von Caemmerer and Berry (FvCB) model of photosynthesis. In this model CO_2 assimilation is limited by one of two (or in some cases three) processes; carboxylation limited photosynthesis, and electron transport limited photosynthesis. Previously we have shown large model variation in key parameters associated with carboxylation capacity ($V_{c,max}$) and electron transport (J_{max}) and a large discrepancy between model assumptions and measured values of these parameters in Arctic vegetation. Here we extend this work to evaluate current TBM parameterization associated with the empirical relationship between potential electron transport rate and irradiance, which is typically represented in models as a non-rectangular hyperbola. We measured photosynthetic light response curves and the leaf optical properties of six species on the Barrow Environmental Observatory, Barrow, Alaska to determine key parameters associated with the relationship between irradiance and electron transport i.e. leaf absorbtance, the convexity term, and apparent quantum yield. Most existing measurements of these parameters have been made within a narrow temperature range (20-30°C) and the scarcity of data collected at low temperature has been highlighted as an important driver of model uncertainty in high latitudes. In addition, model estimates of apparent quantum yield rarely consider real world conditions where low temperature stress may substantially reduce apparent quantum yield in comparison to the theoretical maximum value used by several models. Therefore, to further evaluate the relationship between electron transport and irradiance, and potential low temperature stress we measured light response curves at both 5°C and 15°C.