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Measurement-based upscaling of Pan Arctic Net Ecosystem Exchange: the PANEEx project

Herbert Njuabe Mbufong (1), Antonin Kusbach (2), Magnus Lund (1,2), Andreas Persson (2), Torben R. Christensen (1,2), Mikkel P. Tamstorf (1), and John Connolly (3)

(1) Aarhus University, Arctic Research Center, Department of Bioscience, Roskilde, Denmark (henj@bios.au.dk), (2) Department of Physical Geography and Ecosystem Science, Lund University, Lund, Sweden, (3) Department of Geography, DCU St. Patrick's Campus, Dublin, Ireland

The high variability in Arctic tundra net ecosystem exchange (NEE) of carbon (C) can be attributed to the high spatial heterogeneity of Arctic tundra due to the complex topography. Current models of C exchange handle the Arctic as either a single or few ecosystems, responding to environmental change in the same manner. In this study, we developed and tested a simple pan Arctic NEE (PANEEx) model using the Misterlich light response curve (LRC) function with photosynthetic photon flux density (PPFD) as the main driving variable. Model calibration was carried out with eddy covariance carbon dioxide (CO_2) data from 12 Arctic tundra sites. The model input parameters (Fcsat, Rd and α) were estimated as a function of air temperature (AirT) and leaf area index (LAI) and represent specific characteristics of the NEE-PPFD relationship, including the saturation flux, dark respiration and initial light use efficiency, respectively. LAI and air temperature were respectively estimated from empirical relationships with remotely sensed normalized difference vegetation index (NDVI) and land surface temperature (LST). These are available as MODIS Terra product MOD13Q1 and MOD11A1 respectively. Therefore, no specific knowledge of the vegetation type is required. The PANEEx model captures the spatial heterogeneity of the Arctic tundra and was effective in simulating 77% of the measured fluxes ($r2 = 0.72$, $p < 0.001$) at the 12 sites used in the calibration of the model. Further, the model effectively estimates NEE in three disparate Alaskan ecosystems (heath, tussock and fen) with an estimation ranging between 10 – 36% of the measured fluxes. We suggest that the poor agreement between the measured and modeled NEE may result from the disparity between ground-based measured LAI (used in model calibration) and remotely sensed LAI (estimated from NDVI and used in NEE estimation). Moreover, our results suggests that using simple linear regressions may be inadequate as parameters estimated using multiple linear regression showed better agreement between measured and modeled data. We propose recalibrating the model using multiple linear relationships between environmental variables and LRC parameters. This model could contribute significantly to regional and global models of climate change by simulating fluxes from remote and inaccessible Arctic environments.