RESPONSES OF NET CARBON DIOXIDE EXCHANGE IN MOUNTAINOUS TERRAIN OF THE NORTHERN HEMISPHERE

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Abstract

Reducing uncertainty on future climate change requires that we quantify the global land carbon cycle. Many researchers measure net ecosystem exchange (NEE), the amount of carbon entering and leaving the ecosystem. Yet, global carbon modelers are likely to be incorrectly simulating NEE in mountainous terrain if they assume ecosystems behave the same as in flat terrain. Research on mountainous NEE is growing; however, no synthesis on how NEE varies in mountainous terrain has been performed. NEE values in mountainous terrain in the mid latitudes of the northern hemisphere were identified from related articles. These values were then compared against elevation, latitude, mean annual temperature (MAT), and mean annual precipitation (MAP). The results reveal a variety of responses of NEE in mountainous terrain, providing insights to hypotheses that suggest NEE is controlled most by MAP from sites at 31.59° to 50.1°N.

Introduction

•CO2 poses a challenge to society due to its contribution to global warming; since measurements of atmospheric CO_2 began late in the nineteenth century, its concentration has risen over 20%. [1]

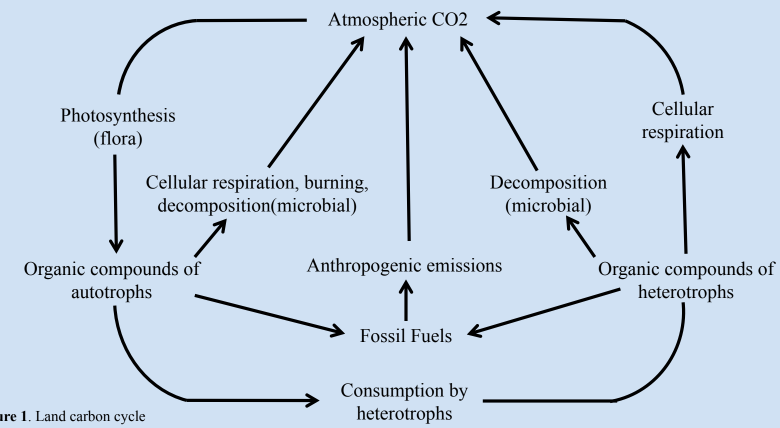

Figure 1. Land carbon cycle

•NEE of CO2 is the difference of photosynthetic uptake of CO2 and respiration by flora and decomposition by microbes [2].
•Negative NEE= photosynthesis uptake > respiration=ecosystem accumulate carbon(sink).
•Positive NEE = photosynthetic uptake < respiration= ecosystem release carbon(source).
•Quantifying NEE is complex, requires accounting for phenological variability, temporal variation in moisture availability, seasonal and interannual temperature variation, forest structure, and variation in light intensity.[3]
•Flat terrain continues to be intensely researched; mountainous terrain was been under-researched due to the difficulty of maintaining instrumentation at high elevations, but with technological advances research in mountainous terrain is growing. [4]
•Previous studies on flat terrain show that precipitation and temperature are the main contributors in affecting NEE, in lower latitudes soil moisture tends to be the greatest controlling factor, while soil temperature is the controlling factor at higher latitudes. [5]
•There has not been a synthesis on how NEE varies in mountainous terrain.

Hypothesis: *We expect that for mid-latitude Northern Hemisphere ecosystems in mountains that just like in flat terrain mean annual temperature (MAT) explains a greater proportion of site-to-site variability in NEE than mean annual precipitation (MAP).*

Methods

•Data was obtained from peer reviewed articles that used eddy covariance flux towers to measure annual NEE.

Methods Continued

Location	Latitude(°)	Elevation(m.a.s.l)	MAT(°C)	MAP(cm)
New Mexico, USA[7]	34.34	1596	13.4	24.4
	35.84	3049	3.1	66.7
Colorado, USA[3]	40	3050	4	80
California, USA[8]	38.5	1315	12.25	129
Changbai Mountains, China[9]	42.24	2000	2.45	70.5
Sierra Nevada Mountain, Spain[10]	37.05	2300	5.5	80
Alinya, Spain[11]	42.2	1770	6.1	106
Laqueuile ext. ,France[11]	45.6	1040	8.6	101
Rigi-Seebodenalp, Switzerland[11]	47.2	1025	7.32	132.7
Monte Bondone, Italy[11]	46	1550	5.5	118.9
Neustift, Austria[11]	47.11	970	6.5	85.2
Malga Arpaco, Italy[11]	46.11	1699	5.49	181.6
Amplero, Italy[11]	41.86	900	9.5	124
Collelongo,Italy[12]	41.51	1550	6.3	118.6
Bayreuth, Germany[12]	50.1	780	5.8	88.5
Oregon, USA[7]	44.45	1253	4.34	76
California, USA[7]	33.37	1392	6.95	138
Arizona, USA[13]	31.59	1469	14.9	27

Table 1. Site characteristics from data obtained from eddy covariance flux tower measurements. MAT= Mean Annual Temperature, MAP= Mean Annual Precipitation, m.a.s.l = meters above sea level

Results

Figure 3 shows that annual NEE has a higher correlation with MAP than MAT, Figure 4. Figures 5,6, and 7 show how well one variable predicts another meaning that if elevation was a perfect predictor of MAP then there be a straight line of points going from low elevation and low MAP to high elevation and high MAP or vice versa. Additionally, Figure 5, 6, and 7 show how well the variable on the horizontal and vertical axes predict NEE ; a perfect predictor would transition from hotter to cooler colors or vice versa despite how scattered the points are. The correlation between annual NEE and latitude, elevation, MAP, and MAT. MAP shows the highest r value of -0.46. Another point to make is that by removing the Switzerland improves the correlation of MAP and NEE to r=-0.65.

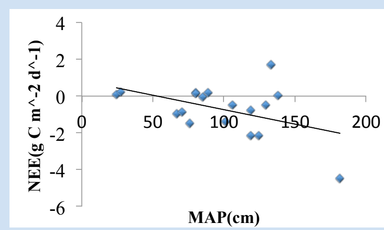

Figure 3. Annual NEE as a function of MAP at 18 sites of the northern hemisphere. Sites with positive NEE are sources, negative NEE are sinks.

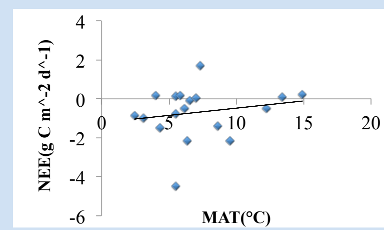

Figure 4. Annual NEE as a function of MAT at 18 sites of the northern hemisphere. Sites with positive NEE are sources, negative NEE are sinks.

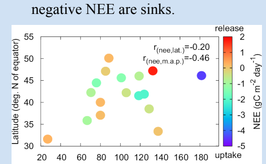

Figure 5. Cool colors indicate CO2 uptake. Warm colors indicate release

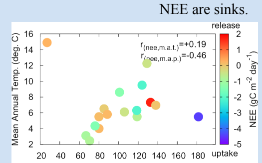

Figure 6. Cool colors indicate CO2 uptake. Warm colors indicate release

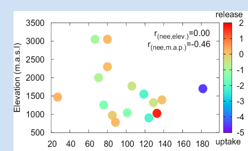

Figure 7. Cool colors indicate CO2 uptake. Warm colors indicate release

Discussion

•In contrast to flat terrain and our hypothesis, we find that MAP explains more variability in NEE than MAT.
•One reason may be that many mountain sites are more dependent on winter precipitation to support summer forest growth
•Additionally data showed that as elevation increases NEE shows less variation and is closer to zero.
•In latitudes from 31.59° to 50.1°N, more sites are sinks at higher latitudes.
•Figures 5,6,7 indicate that the order of the best to least predictors of NEE are: MAP > Latitude > MAT > elevation.
•The synthesis of articles showed that there is lack of sites at mountainous terrain in low and high latitudes in the northern hemisphere.
•The effects of climate change in mountains can be devastating to the flora, fauna, bring outbreaks of disease, and lack of water.
•However, in northern mid latitudes increasing temperature are predicted to lead to increasing precipitation, which can improve the site's capability to store carbon

Literature Cited

1.Houghton, J.T. *et al*. 2001. Climate changes: the scientific basis. Published by Intergovernmental Panel on Climate Change.
2. Baldocchi *et al*. 2001. FLUXNET: A new tool to study the temporal and spatial variability of ecosystem-scale carbon dioxide, water vapor, and energy flux densities .
3.Monson R. K. *et al*. 2002. Carbon sequestration in high elevation, subalpine forests.