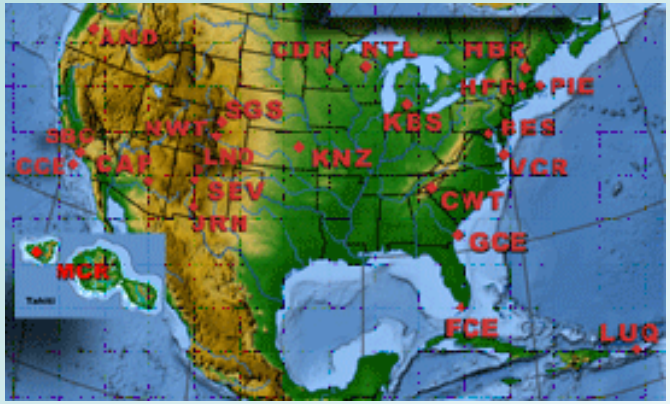
Phenology of Net Ecosystem Exchange: A Simple Estimation Method

Mark Losleben (1), Geoff Henebry (2)

(1) National Phenology Network, Tucson, AZ, (NWT) (losleben@email.arizona.edu); (2) South Dakota State U, (KNZ)



The seven test locations are LTER sites, shown above.

INTRODUCTION

The measurement of carbon sequestration is important to global carbon budget and ecosystem function and dynamics research. Direct measurement of Net Ecosystem Exchange (NEE), or carbon sequestration, is instrument, labor, and fiscally intensive, thus there is value to establish a simple, robust estimation tool. This study investigates the potential of the "Climate Envelope" as such a tool.

OVERVIEW

The Climate Envelope is defined as the graphical representation of annual accumulated daily precipitation versus annual daily accumulated degree growing days above a zero degree C base. Its relationship to NEE is explored at two forest sites, NWR and HFR (Fig. 1) by asking, "Do the Climate Envelope inflection points correspond to the onset of spring (start of carbon uptake) and fall (cessation of carbon uptake)?" The study period is1997-2006.

This exercise explores the use of the Climate Envelope inflection points (points of major slope changes) as defining metrics.

Additionally, to evaluate the applicability to other ecosystems, the Climate Envelopes of seven ecosystems across the United States and Puerto Rico, encompassing deciduous, coniferous, and tropical forests to desert shrub land and grasslands, are compared.

FOREST ECOSYSTEMS

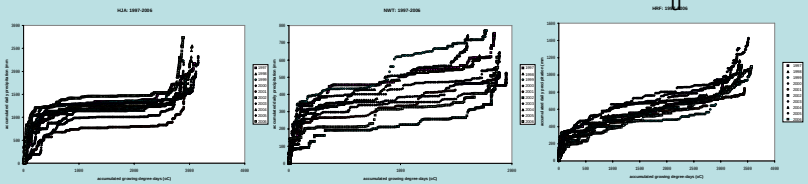


Fig. 1. HJ Andrews (AND) forest, OR (conifer), Niwot Ridge (NWT), CO (sub-alpine conifer), Harvard Forest (HFR), MA (mixed conifer/deciduous).

DESERT SHRUB, GRASSLAND ECOSYSTEMS

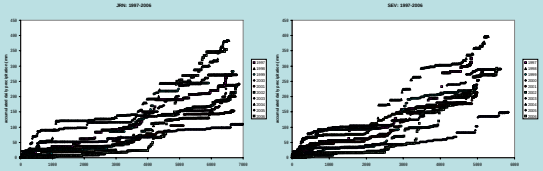


Fig. 2. Climate Envelopes of Jornada (JRN) and Sevilleta (SEV) graphs may reflect monsoon conditions.

PRAIRIE GRASSLAND (KNZ) TROPICAL FOREST (LUQ)

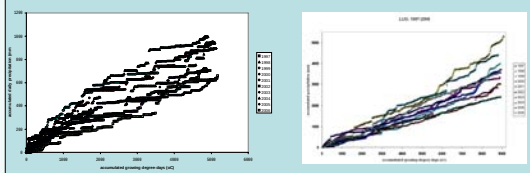


Fig. 3. Konza (KNZ) and Luquillo (LUQ) Climate Envelopes lack clear inflection points, suggesting T and PPT do not limit growth (LUQ), or there is high seasonal variability (KNZ).

RESULTS

There appear to be three general Climate Envelope types: bi-modal inflections points in spring and fall (Fig. 1), bi- and tri-modal inflection points throughout the year (Fig.2), and no major inflection points (Fig. 3).

Comparison to NEE data was possible at two sites, NWR and HFR, both of the Fig. 1 type. Each annual trace has two major inflection points, coinciding with the spring start (Fig. 4) and fall end (Fig. 5), of the forest carbon sequestration (active photosynthetic) period.

Figure 6 shows the inflection points temporally lead the start, but lag the end of carbon sequestration, at both sites.

SUMMARY

The hypothesis that the Climatic Envelope will be an accurate estimator of onset and termination of ecosystem carbon sequestration (growing period) was examined at two mid-latitude sites, a sub-alpine conifer (NWR) and a mixed conifer/deciduous (HFR) forest.

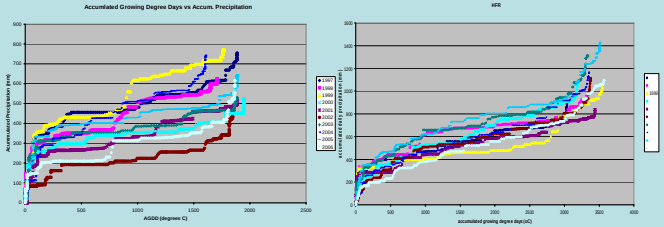
The work at NWR and HFR establishes a NEE (carbon sequestration)/Climate Envelope link. It does not establish causal mechanisms, or a link in tropical, desert, or grassland ecosystems where environmental drivers may be different, and much shorter response times to favorable and unfavorable conditions for growth exist.

Further study is clearly needed.

CONCLUSION

Based on this limited, preliminary investigation, a properly calibrated Climate Envelope may be a reasonable metric of carbon sequestration in some ecosystems, thus warranting further investigation as a quick, inexpensive measure. Future work is necessary to establish predictable NEE-Climate Envelope relationships, particularly on finer temporal scales and in diverse ecosystems.

Climate Envelope:NEE Relationship at NWT and HFR



The spring inflection point is where the nearly vertical rise begins to become mostly horizontal, and the fall point is the reverse

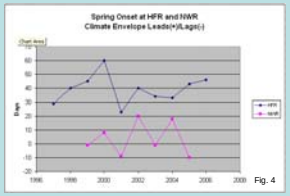
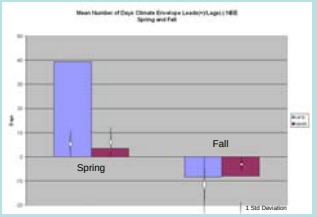


Fig. 4

Fig. 5

The time series of the difference between the T:Ppt inflection point method and actual NEE data. Positive values indicate the number of days the T:Ppt method leads the NEE data, and negative values indicate a lag.



Mean values show the the T:Ppt inflection point method leads the NEE data by 3.57 days at Niwot and 39.3 days at HFR in spring, and lags by 7.86 and 8.4 days, respectively, in fall.

FUTURE WORK

The results of this study warrant further investigation into the potential of this analysis tool for estimating NEE through:

- NEE-to-Climate Envelope comparisons in more diverse ecosystems. This is currently possible where NEE data exist, such as all Ameriflux sites.
- Examination at sub-seasonal time steps.
- Characterize the relationship in diverse ecosystems by peak NEE, length of growing season, and signal fidelity.

ACKNOWEDGEMENTS

This study was only possible through the fine efforts of many, particularly: John Anderson, NM State U (JRN), Julian Hadley, Harvard U (HFR), Mike Hartman, U Colorado (NWT), John O'Keefe, Harvard U (HFR), Dave Shaw, Oregon State U (AND), Kristin Vanderbilt, U NM (SEV), Karen Wetherill, U NM (SEV), Mark Williams, U Colorado (NWT), Jess Zimmerman, U Puerto Rico (LUQ), and workshop funding from the Long Term Ecological Network NCO.