Abstract 82123

Carbon Accumulation in a Two Year Sugarcane Rotation in Hawai‘i, USA

Ray G. Anderson[1,2,3] , Rebecca Tirado-Corbalá[1,4], Dong Wang[1,5], James E. Ayars[6]

[1]USDA-Agricultural Research Service, San Joaquin Valley Agricultural Sciences Center,
Water Management Research Unit, 9611 S. Riverbend Ave., Parlier, CA, 93648-9757 USA
[2]USDA-Agricultural Research Service, U.S. Salinity Laboratory,
Contaminant Fate and Transport Unit, 450 W. Big Springs Rd., Riverside, CA 92507-4617, USA
[3]ray.anderson@ars.usda.gov, [4]rebecca.tirado-corbala@ars.usda.gov, [5]dong.wang@ars.usda.gov, [6]james.ayars@ars.usda.gov

Water Management Research Unit ~ Parlier, CA

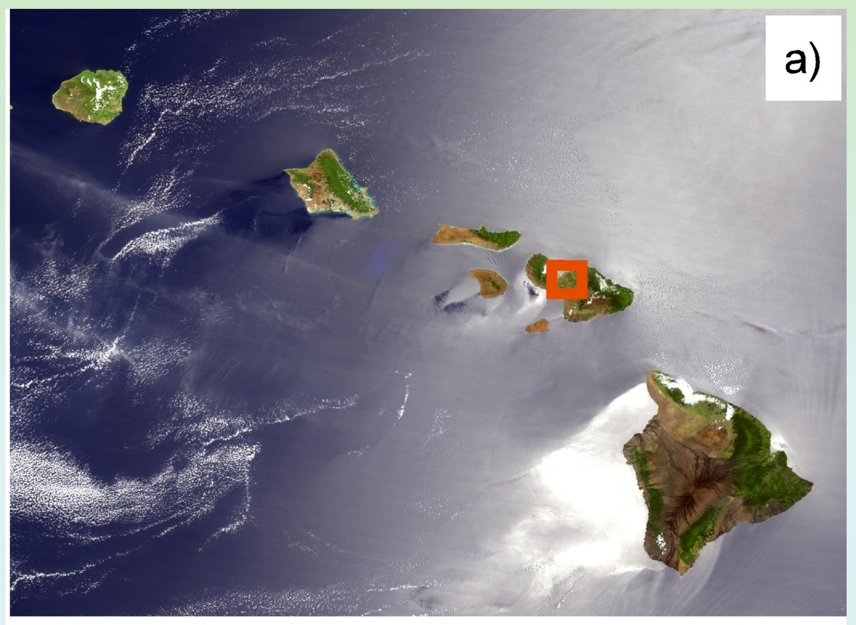
Introduction

-Understanding and assessing net productivity and radiation use efficiency is key for 2nd generation (advanced) biofuel systems that can use the entire plant as opposed to a single component.

-Irrigation-dependent, Hawaiian commercial sugarcane (*Saccharum officinarum L.*) has been recognized as one of the most productive agronomic systems [*Evensen et al.,* 1997], and is being actively explored for biofuel production. Currently uses a longer (18-24 month) cropping cycle.

-Most productivity studies were done at plot scale with periodic sampling. Need to understand controls on field productivity at daily time scales.

-Eddy Covariance (EC) allows real-time assessment of field productivity with minimal interference. Can combine with ancillary data to assess meteorological, cultivar, and management practices on productivity and radiation use efficiency (RUE), potentially allowing for optimization of productivity.



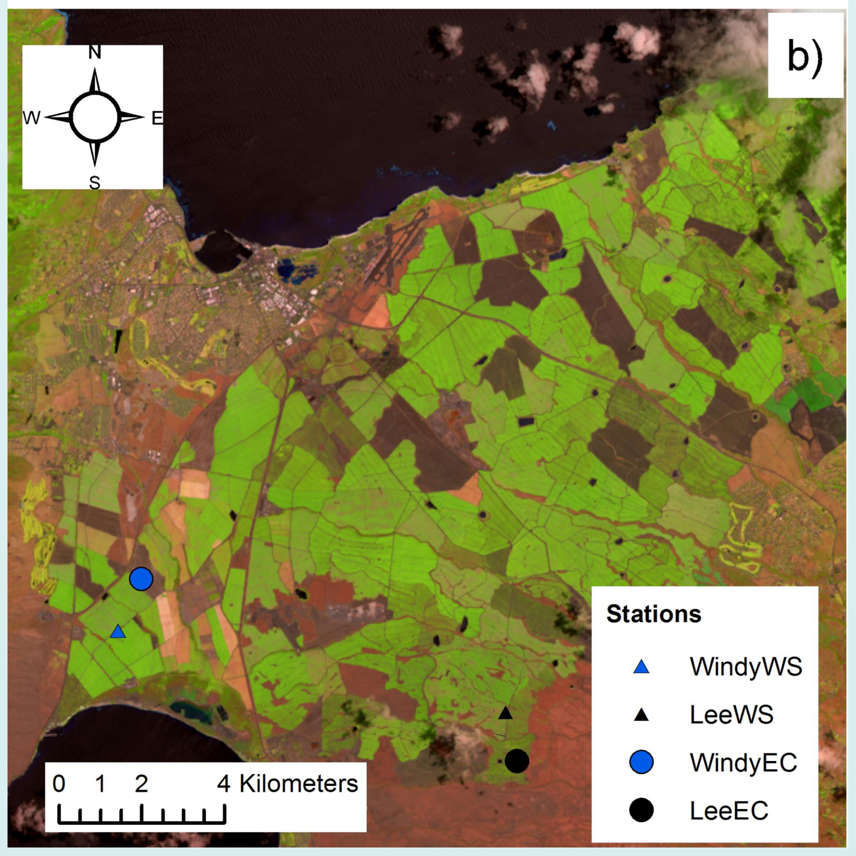


Figure 1: (a) MODIS true color image of the Hawaiian islands. Study area inset in red box. (b) Landsat 8 false color image (bands 6, 5, and 4 corresponding to red, green, and blue) showing EC and weather station (WS) in relation to the sugar plantation.

Study Region and Data

-We established two EC towers in contrasting low and high elevation sugarcane fields at a commercial plantation in Maui, Hawaii [*Anderson and Wang*, in revision; Anderson et al., submitted] (Fig. 1; Table 1). Fields were identical cultivars (H65-7052) and planted 45 days apart.

Net Ecosystem Productivity (NEP) fluxes gap-filled and partitioned into Gross Primary Productivity and Respiration following *Reichstein et al.* [2005].

-Incoming solar radiation data from plantation's weather stations.

-Periodic (6-month) plant and soil C and final root and shoot biomass from destructive sampling and analysis (Tirado-Corbalá et al., 2012; in prep).

-Satellite Vegetation data from MODIS to calculate fraction of solar radiation intercepted by canopy using Wide Dynamic Range Vegetation Index [*Gitelson et al.*, 2007].

-Observed existing farm practice designed to maximize sugar production.

Table 1 (below): Site information about the EC and weather station (WS) towers in this study as well as field soil texture, planting date, and EC observational period.

	Windy-EC	Windy-WS	Lee-EC	Lee-WS
Latitude (°N)	20.824633	20.813333	20.784664	20.795361
Longitude (°W)	156.491278	156.496694	156.403869	156.406444
Elevation (m)	44	24	203	142
Field	**Planting date**	**EC installed**	**EC removed**	**Soil Texture**
Windy	May 11, 2011	July 23, 2011	April 19, 2013	Sandy clay loam
Lee	March 28, 2011	July 21, 2011	November 7, 2012	Clay

Results

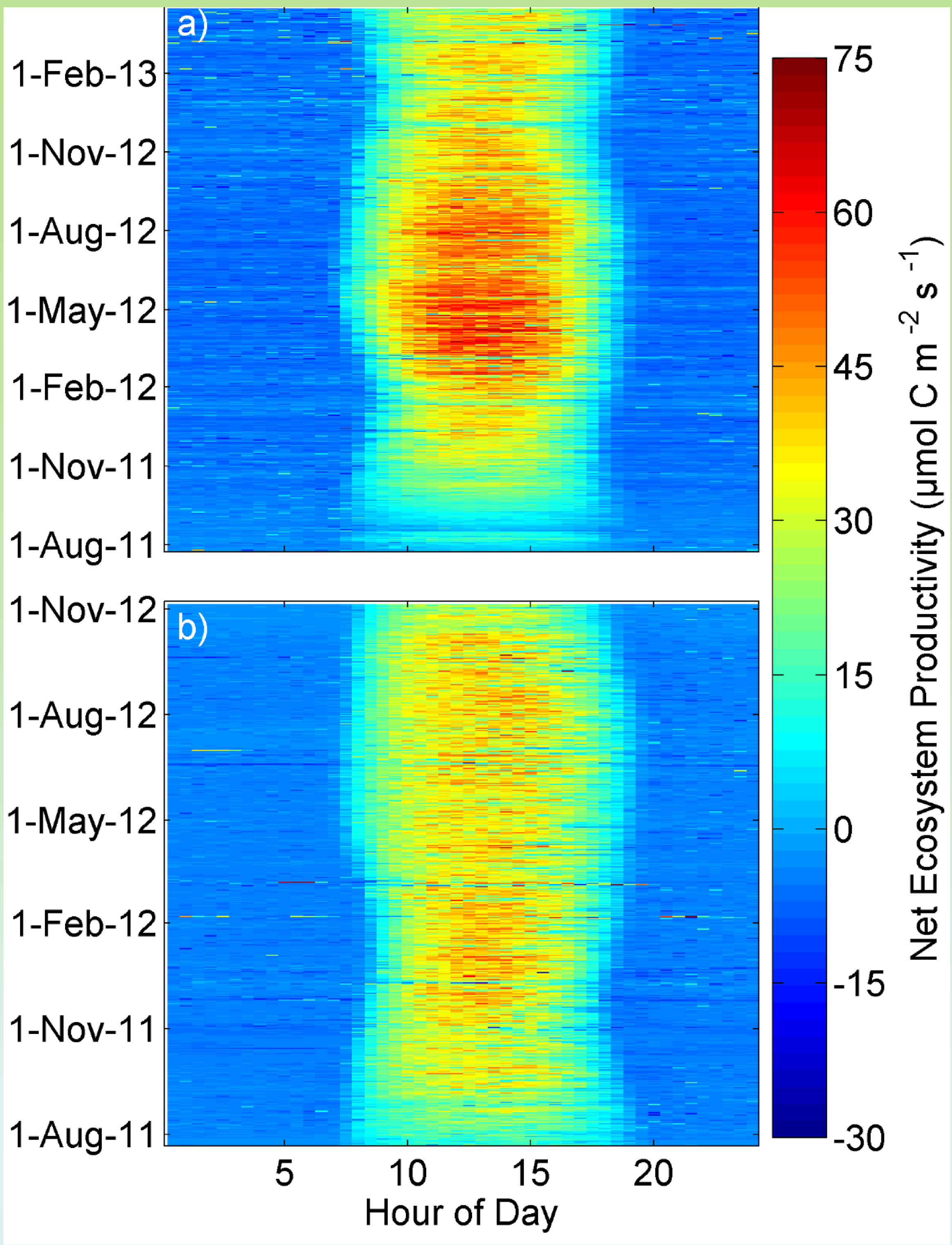
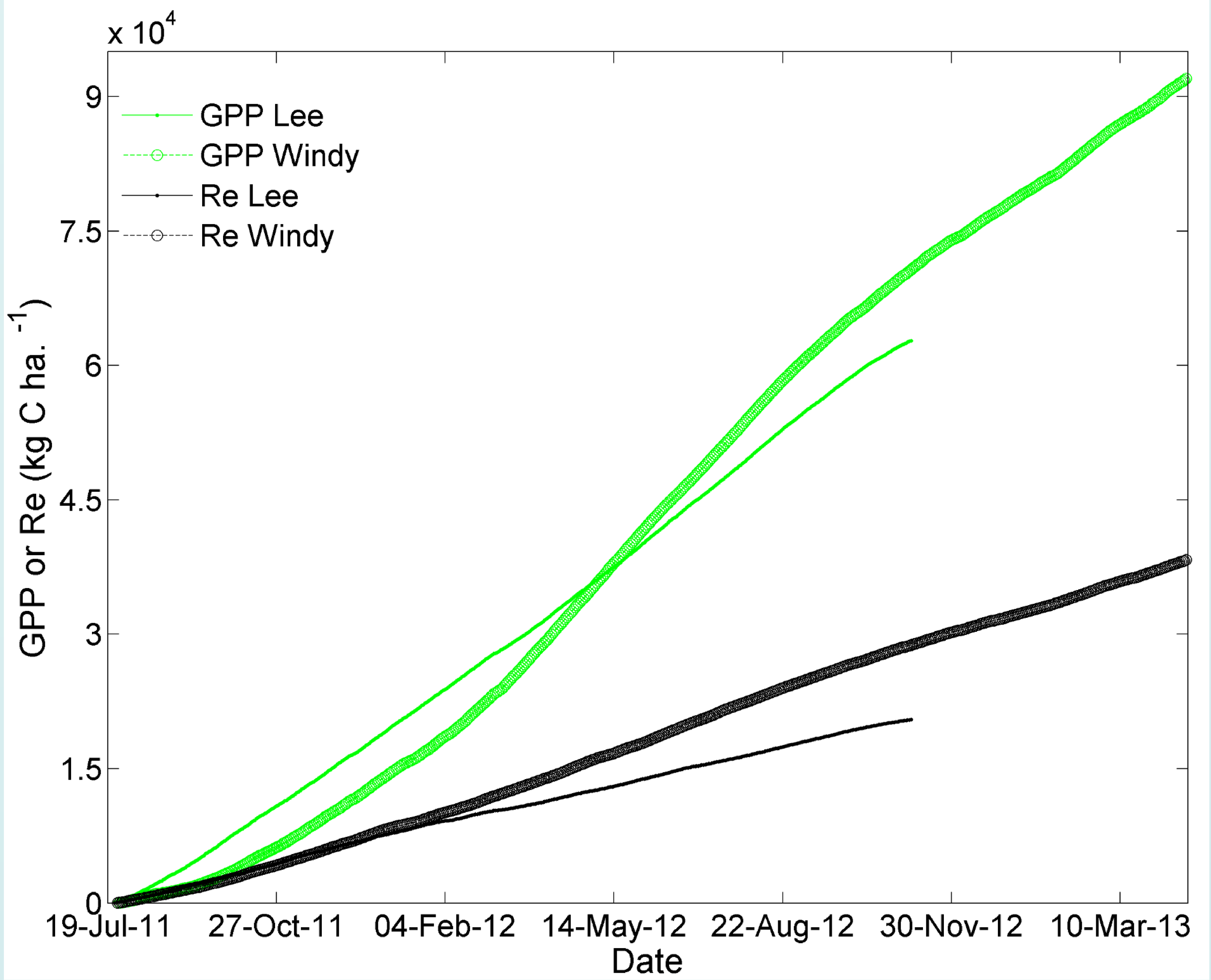


Figure 2 (left): 30 minute Net Ecosystem Productivity (NEP) for the EC observation periods for both fields. Negative NEP indicates net respiration from field, while positive NEP shows net photosynthesis . Mean NEP is 8.14±0.21 and 8.66±0.22 μmol C m^{-2} s^{-1} in Windy and Lee, respectively over the entire, separate EC observation periods. a) Windy field. b) Lee field.

Figure 3 (below): Cumulative Gross Primary Productivity (GPP) and Respiration (Re) at Lee and Windy fields. GPP and Re determined from NEP following flux partitioning algorithm of *Reichstein et al.* [2005].



- Peak Net Ecosystem Productivity was ~75 μmol m^{-2} s^{-1}, which is similar to other high-productivity C4 agroecosystems.

-Unlike previous studies in Hawaiian sugarcane (e.g. *Evensen et al.* [1997]), there is no large scale decrease in NEP or GPP in the 2nd year of growth.

-NEP remains positive until tower removal prior to harvest (significant carbon uptake) despite sugarcane drydown and application of ripening agent.

-Harvest in Lee moved up due to irrigation issues.

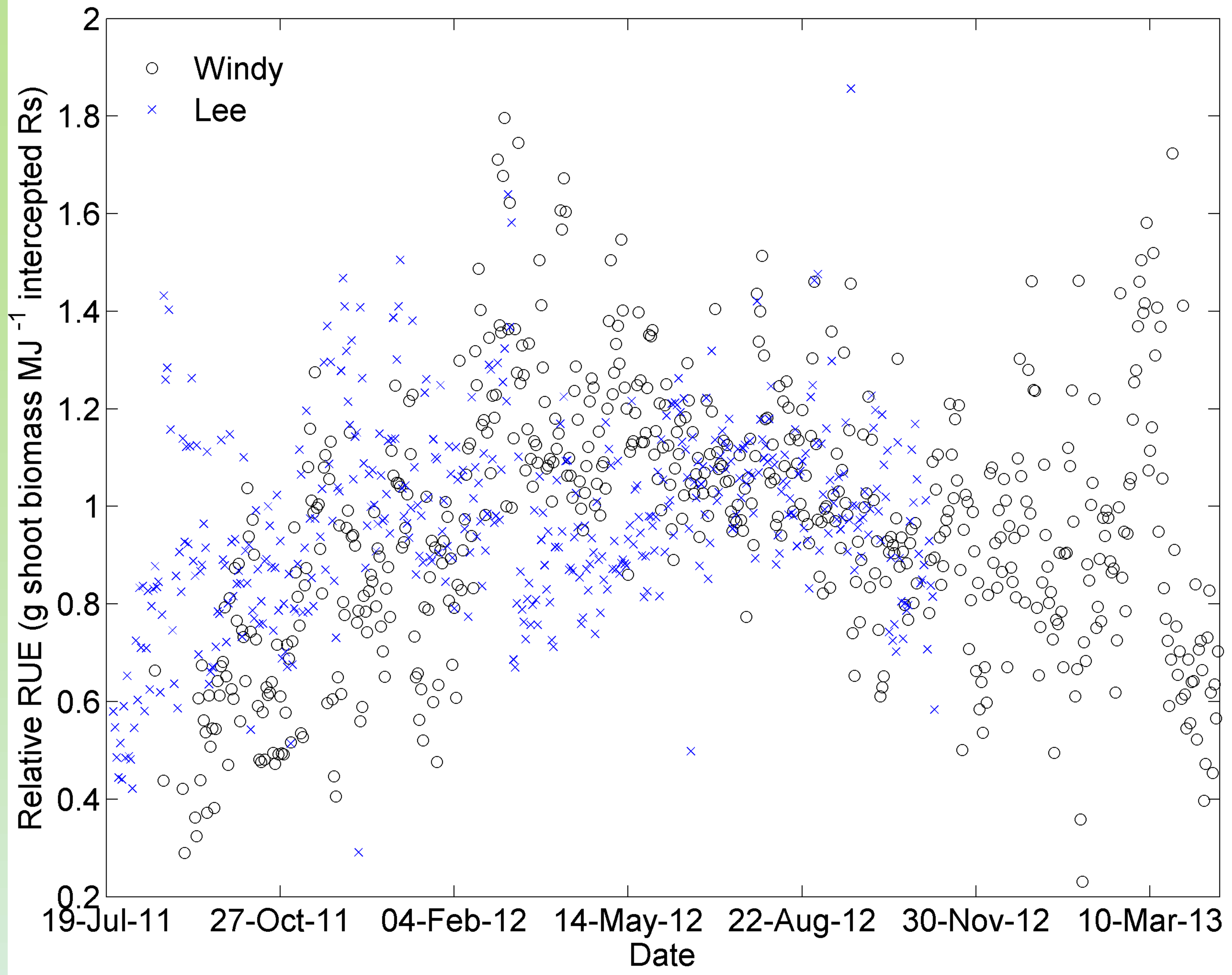


Figure 4: Mean daily relative Radiation Use Efficiency (RUE) for Windy and Lee fields. Shoot fraction biomass is calculated using a shoot/total biomass fraction of 0.933 in Windy and 0.959 in Lee and a carbon/biomass ratio of 0.500 and 0.489 in Windy and Lee, respectively.

-Water use efficiency (WUE) is similar, but perhaps slightly lower, than peak sugarcane WUE as reported in *Sinclair and Muchow* [1999].

-No significant difference in relative WUE between Windy and Lee fields ($p=0.63$). Difference in daily NEP ($p<0.015$) likely due to higher Rs at Windy than Lee ($p<0.001$).

-The Lee field showed linearly increasing cumulative GPP and Re while Windy field showed more sigmoidal pattern. EC tower captured negative NEP early in cycle due to soil respiration from previous crop.

Conclusions and future work

-High shoot/root ratio (>15:1) and carbon content of biomass (~50%) further enhance cellulosic biofuel value of Hawaiian sugarcane.

-Unclear why EC NEP continues high growth in 2nd year. Biomass sampling at time of EC tower removal showed biomass accumulation at least as high as that measured by tower. Respiration may have been suppressed by extremely low (~25% of normal) precipitation at sites and surface/subsurface drip irrigation may reduce degradation of cane trash and stalk.

-Further work is needed to confirm sustained high productivity of Hawaiian cane in 2nd year of growth. If confirmed, this could increase the greenhouse gas reduction of Hawaiian cane by increased overall productivity and reduced emissions from farming operations.

ACKNOWLEDGEMENTS

Partial funding was provided by the U.S. Navy, Office of Naval Research. We thank Mae Nakahata for logistical guidance. Jim Gartung, Huihui Zhang, Adel Youkhana, Neil Abranyi, and Jason Drogowski provided assistance with the EC tower.

REFERENCES

Anderson, R.G. and D. Wang (2013), Energy budget closure observed in paired Eddy Covariance towers with increased and continuous daily turbulence. Revised manuscript under review in *Agricultural and Forest Meteorology*.

Anderson, R.G., D. Wang, R. Tirado-Corbalá, H. Zhang, Divergence of reference evapotranspiration estimates under advective tropical conditions, Submitted to *Agricultural Water Management*.

Evensen, C. I., R. C. Muchow, S. A. El-Swaify, and R. V. Osgood (1997), Yield Accumulation in Irrigated Sugarcane: I. Effect of Crop Age and Cultivar, *Agronomy Journal*, *89*(4), 638, doi:10.2134/agronj1997.00021962008900040016x.

Gitelson, A. A., B. D. Wardlow, G. P. Keydan, and B. Leavitt (2007), An evaluation of MODIS 250-m data for green LAI estimation in crops, *Geophysical Research Letters*, *34*(20), doi:10.1029/2007GL031620.

Reichstein, M. et al. (2005), On the separation of net ecosystem exchange into assimilation and ecosystem respiration: review and improved algorithm, *Global Change Biology*, *11*(9), 1424–1439, doi:10.1111/j.1365-2486.2005.001002.x.

Sinclair, T. R., and R. C. Muchow (1999), Radiation Use Efficiency, in *Advances in Agronomy*, vol. 65, pp. 215–265, Elsevier.

Tirado-Corbalá, D. Wang, J. Ayars, J. Gartung, R. Anderson, H. Zhang, A. Youkahana and M. Nakahata. 2012. Soil Carbon Stock and Total Nitrogen in Hawaiian Sugarcane Commercial Plantations. (Abstract). Accepted for poster presentation at the ASA-CSSA-SSSA International Annual Meeting-October 21-24, 2012.Cincinnati, OH.

Tirado-Corbalá, R.G. Anderson, D. Wang, J.E. Ayars, Nitrogen Fluxes and Nitrogen Use Efficiency in Two Hawaiian Soils under Irrigated Sugarcane Cultivations. In preparation for submission to *Agriculture, Ecosystems, and Environment.*