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Linking Rainfall Variability With the Flux and $\delta^{13}C$ Signature of Ecosystem Respiration

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I: Introduction

The accurate determination of the seasonal variability in the isotopic signature ($\delta^{13}C$) of biosphere-atmosphere CO_2 exchange is critical for quantifying sources and sinks of atmospheric CO_2 based on its carbon isotope composition.

Climate models predict that the amount and timing of rainfall in California will change due to warming induced effects of increased atmospheric carbon dioxide (CO_2) concentrations (Snyder et al. 2002).

We performed both field and laboratory studies to understand the consequences of altered precipitation patterns on the flux and ^{13}C of ecosystem respiration in a water-limited grassland in California.

Figure 1. Field plots near Ione, CA.

II: Methods

1. Keeling Plots

Gas samples were collected on a monthly basis from the headspace of large chambers (170 L) place over the plots. Samples were analyzed for their carbon isotopic ratio ($\delta^{13}C$, ‰) and CO_2 concentration.

The source signature of ecosystem respiration was determined by using the Keeling plot approach (Figure 3).

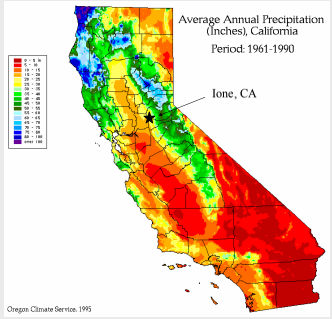

Figure 2. Location of field plots in the Central Valley of California

2. Laboratory Incubations

Soil cores were divided into 4 depths and incubated separately at room temperature and non-limiting moisture contents for 24 hours.

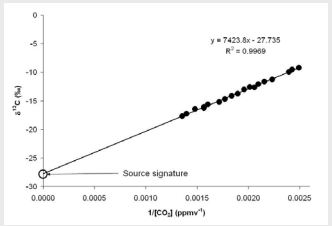

Figure 3. Keeling plot for Feb 25, 2005.

III: Results

- Seasonal variations in this signature were linked to the amount and timing of precipitation events. Ecosystem $\delta^{13}C$ respiration signatures changed from -24‰ in the dry season to -28‰ in the wet season (Figure 4).
- During wet periods rainfall induced plant growth and the signature of ecosystem respiration (heterotrophic + autotrophic) reflected recently fixed C substrates ($\delta^{13}C$ was -29 to -28‰) (Figures 4 & 6). In dry periods, $\delta^{13}C$ signatures solely reflected subsurface decomposition of older soil organic matter ($\delta^{13}C$ of -26 to -23‰) (Figure 5).
- The overall rate of respiration was also much reduced in the dry season (0.1-0.5 µmol CO_2 m^{-2} s^{-1}) relative to the rainy season (3-5 µmol CO_2 m^{-2} s^{-1}) (Figure 4).
- The timing of the shift back to the plant-dominated signal was determined by the occurrence of the first fall rain event that allowed the decomposition of surface litter.

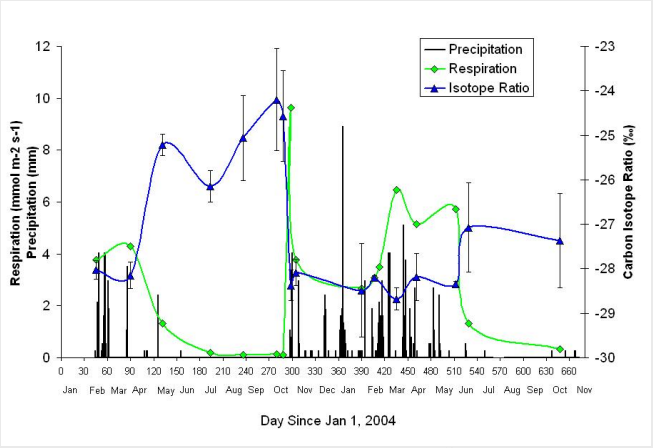

Figure 4. Seasonal dynamics of respiration and $\delta^{13}C$ signatures.

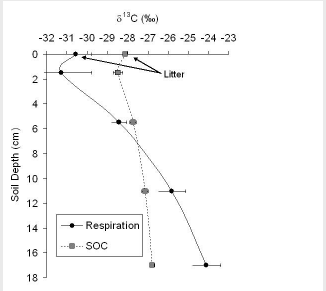

Figure 5. Depth distribution of respiration and soil organic C signatures.

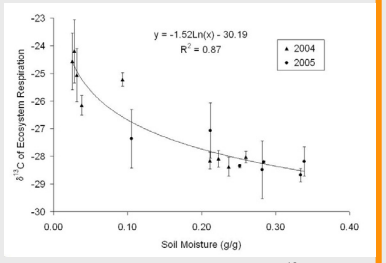

Figure 6. Relationship between $\delta^{13}C$ signatures and soil moisture.

Figure 7. Chambers and gas exchange system in the field.

IV: Conclusions

- Seasonal changes in the isotopic composition of whole ecosystem respiration were strongly related to the amount and timing of precipitation, and the nature of this relationship depended on the seasonal dynamics of plant growth, litter decomposition, and the depth distribution of water in the soil profile.
- Whole ecosystem respiration was dominated by plant respiration in the winter wet months and by microbial decomposition during the dry months of summer and early fall.
- Microbial activity appeared to shift to progressively deeper depths in the soil profile throughout the summer and fall following the availability of soil moisture.
- Results indicate that surface litter and soil organic matter should be represented as two distinct pools in models attempting to capture the dynamics of soil respiration in response to climate change.

Reference

Snyder MA, JL Bell, LC Sloan, PB Duffy, and B Govindasamy. Climate responses to a doubling of atmospheric carbon dioxide for a climatically vulnerable region. *Geophysical Research Letters*, *29*, 4431-4156, 2002.

Acknowledgements

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