Temporal Sensitivity of Satellite-Based Remote Sensing Products to Rainfall Pulse Events in Dryland Ecosystems

Andrew L. Neal[1], Shirley A. Kurc[2], Paul D. Brooks[1]

[1]Department of Hydrology and Water Resources,University of Arizona, Tucson.

[2]School of Natural Resources and the Environment, University of Arizona, Tucson.

Introduction

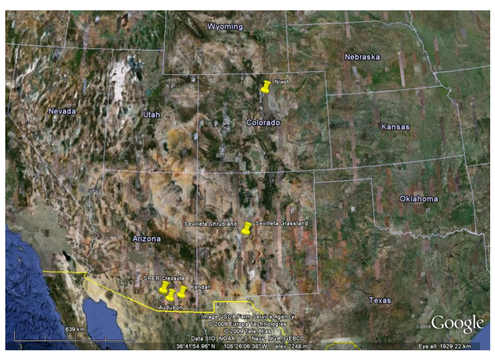
Dryland ecosystems are spatially extant (over 30% of the land surface is arid or semi-arid) and exhibit spatial heterogeneity and temporal variability with regard to land surface interactions. The need for improved up- and downscaling for improved analysis is critical. Thus, improving the ability to scale between flux tower and remote sensing data will lead to deeper understanding of that variability in the way ecosystems respond to precipitation events. This information will aid management decisions by clearly describing that response and relating it to global daily measurements made by satellite remote sensors.

Here, we consider the timing of ecosystem response to rainfall events in dryland ecosystems as related to remote sensing data. This timing is assessed by analyzing the time scale of exponential drydown at several flux tower sites in the southwest. Timing and magnitude of carbon release (respiration) and uptake (photosynthesis) is also included.

Flux Measurement Sites

Site	Research Unit	Vegetation Type	Mean Precip (mm)	Mean Temp (°C)	Length of Record (yrs)
Sevilleta Grass	Sevilleta LTER	Grassland	250	17.7	3 (2002-2004)
Sevilleta Shrub		Grassland			3 (2002-2004)
Kendall Grass	Walnut Gulch Exp. Watershed	Grassland	357	17	4 (2004-2007)
SRER Mesquite	Santa Rita Experimental Range	Woody Savanna	310	19.1	4 (2004-2007)
SRER Creosote		Open Shrubland			
Audubon Grass	Appleton-Whittell Research Ranch	Grassland	350	15.96	4 (2002-2005)
Niwot Ridge	Niwot Ridge LTER	Evergreen needleleaf forest	800	1.5	4 (2004-2007)

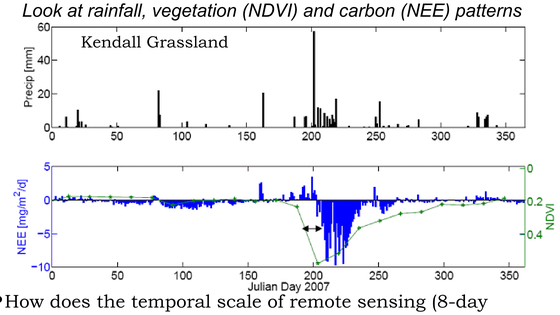
Summary data for Ameriflux sites used in this study



Map of flux tower sites.

1. Can we link remotely sensed greenup to dryland ecohydrology?

Look at rainfall, vegetation (NDVI) and carbon (NEE) patterns

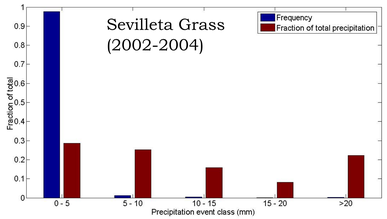


- How does the temporal scale of remote sensing (8-day composite) data depict these pulse responses?
  Is the timing of greenup accurate?
- Timing is broadly captured but is the onset of carbon uptake related to pulses by precip, soil moisture and/or greenup?

2. What are the characteristics of pulse events?

a. Rainfall

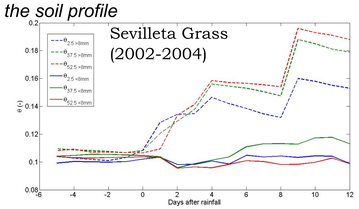
Frequency and fraction of total annual rainfall show importance of large, rare storms



- Large, low frequency storms account for a large proportion of total rainfall.
- These events strongly influence soil moisture availability for vegetation.

b. Soil Moisture

Large, rare storms generate response in mean soil moisture along the soil profile



- Soil moisture at all depths is more sensitive to large storms (>8mm) than small storms (1-8mm).

3. Can we define metrics to quantify pulse response in dryland ecosystems?

To quantify characteristic moisture, carbon flux response at each site

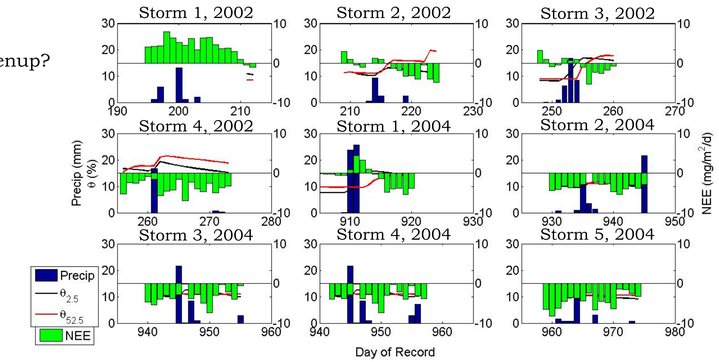
Site	T_{90ret} (days) All Year	T_{90ret} (days) Summer	T_{90ret} (days) All Year	T_{90ret} (days) Summer	Time to peak NEE+ All Year	Time to peak NEE+ Summer	Time to peak NEE- All Year	Time to peak NEE- Summer	Duration NEE+ All Year	Duration NEE+ Summer	Duration NEE- All Year	Duration NEE- Summer	Total NEE+ All Year	Total NEE+ Summer	Total NEE- All Year	Total NEE- Summer	Ratio NEE+/NEE- All Year	Ratio NEE+/NEE- Summer
Sevilleta Grass	3.89	2.55	3.78	3.8	--	1	--	4.5	--	3.75	--	6.625	--	6.388	--	21.801	--	0.29
Sevilleta Shrub	4.03	3.5	3.9	3.17	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Kendall Grass	3.43	1.46	4.24	n/a	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SRER Mesquite	3.37	3.68	3.03	3.43	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SRER Creosote																		
Audubon Grass	9.94	6.42	20.9	1.72	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Niwot Ridge	4.72	5.68	9.53	8.83	--	--	--	--	--	--	--	--	--	--	--	--	--	--

indicates $R^2 < 0.75$
$R^2 = 0.75$
$R^2 = 0.85$
all other fits at $R^2 >= 0.95$

- Exponential-fit for soil moisture drydown (3-4days for most sites)
- Quantifying timing of NEE dynamics-pulse may not include NEE+
  -Look more in-depth at individual pulse events

4. What is the link from pulses to NEE Partitioning?

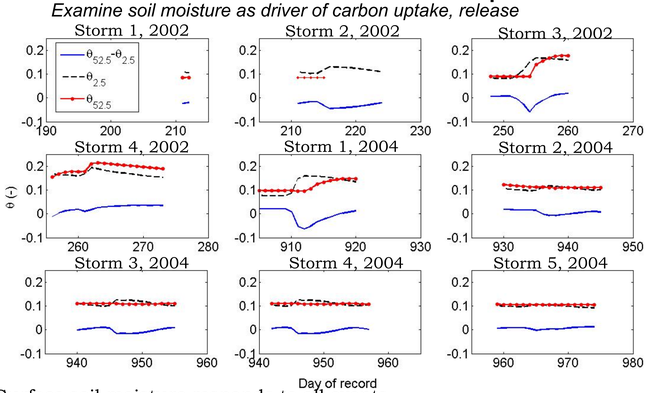
Event-level example for summer storms at Sevilleta Grassland Site



- Some events (Storms 1-3 in 2002, 1 in 2004) show respiration, then carbon uptake, others (4 in 2002, 2-5 in 2004) have only uptake
- Respiration/uptake patterns linked to soil moisture (see below)

5. Where/when is soil moisture important?

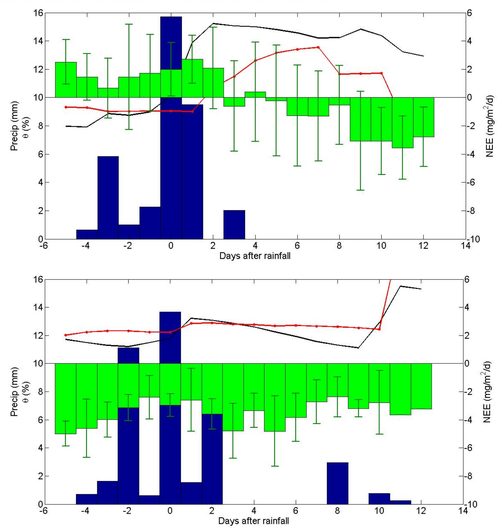
Examine soil moisture as driver of carbon uptake, release



- Surface soil moisture responds to all events
- Deep soil moisture responds occasionally, especially if less than 0.1 prior to event
- Timing of wetting at different depths drives release/uptake of carbon

6. What does an "average" pulse response look like?

Average behavior for pulses with or without carbon release
Consider antecedent moisture conditions



- Pulse identifiers--timing of peak soil moisture, positive and negative carbon fluxes--become apparent and can be developed as an index for response

7. Future Directions

- Perform analysis across all sites
- Examine behavioral differences in carbon flux:
  -by biome (grass/shrub)
  -by precipitation regime (bi-/unimodal)
- Develop metrics for carbon dynamics of pulses
  -time to peak release/uptake
  -time from peak release to peak uptake
  -magnitude of release/uptake

8. Expected Results

- Grasslands will have a stronger response in release and uptake of carbon
  -greater magnitudes of NEE+ and NEE-.
- All sites will have weak linkages between carbon, soil moisture and remote sensing data during non-summer months
  -NDVI and carbon flux are decoupled

Acknowledgements

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