Alabama Mesonet based plant available water, plant water use and soil water deficit index

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5/17/2016

Outline

- **Resources of Alabama Mesonet (ALMNet)**
- **Specific-site soil water deficit index based on ALMnet**

ALMNet Resources

25 scan stations

USDA NRCS SCAN network

Meteorological: Tair, RH, Precip, Rn, Wind, ea, es

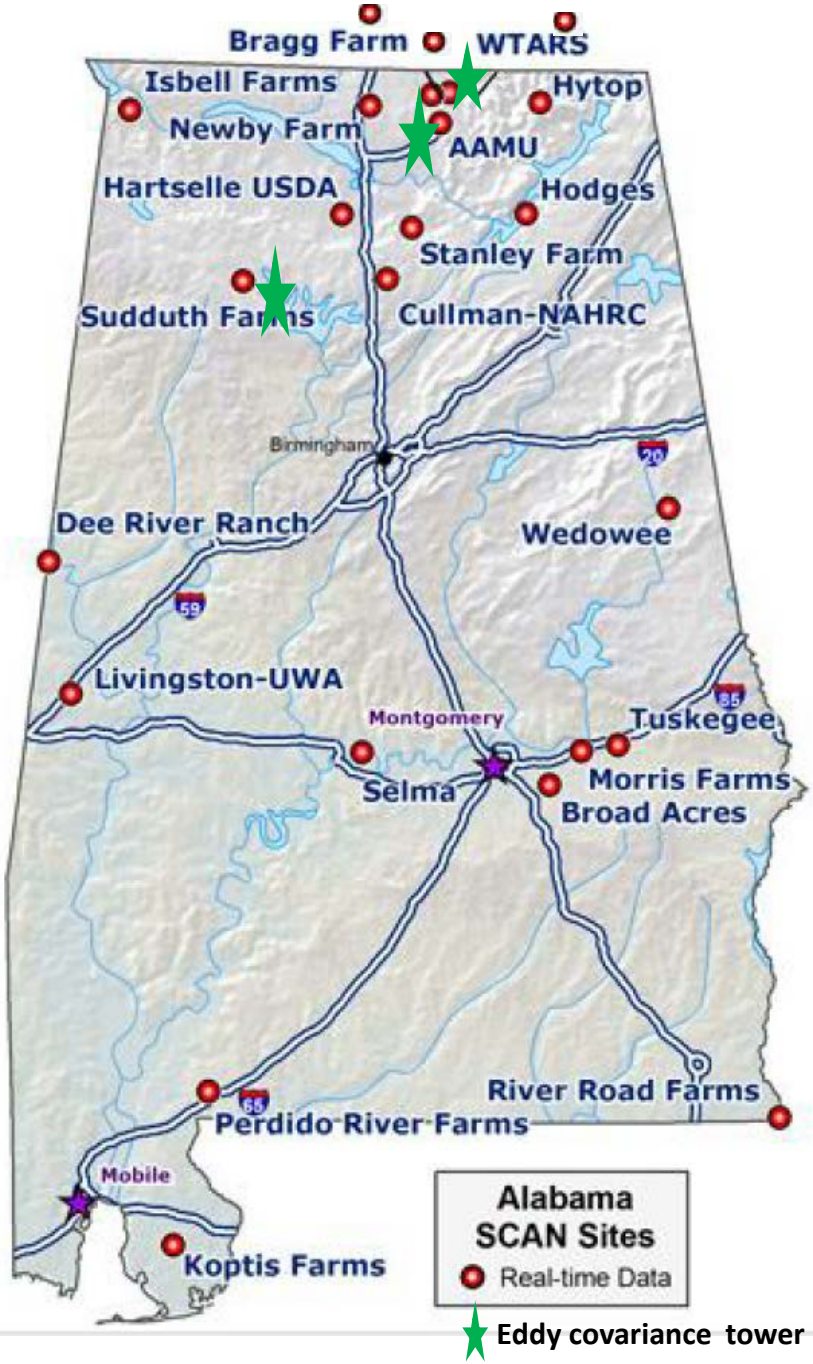
Soil profile: Soil T, Θ

Soil properties: texture, ρb, SWRC

3 eddy covariance

Agriculture, Forest, Urban

CO2/H2O (CH4/N2O/O3)



Motivation

- Increasing interest in irrigation to expand crop production for food, feed, fiber. (150,000 acres)
- Drought (lost $360 million in 2000)
- Sustainable approaches are needed in Alabama

Working Research

Site specific soil water deficit index based on Alabama Mesonet

Atmospheric Water Deficit (AWD)

$$AWD = Rain - ET_0$$

Soil Water Deficit(SWD)

$$SWD = \left(\theta_{fc} - \theta\right)\Delta Z$$

Soil Water Deficit Index (SWDI)

$$SWDI = \left(\frac{\theta_{fc} - \theta}{\theta_{fc} - \theta_{wp}}\right)10$$

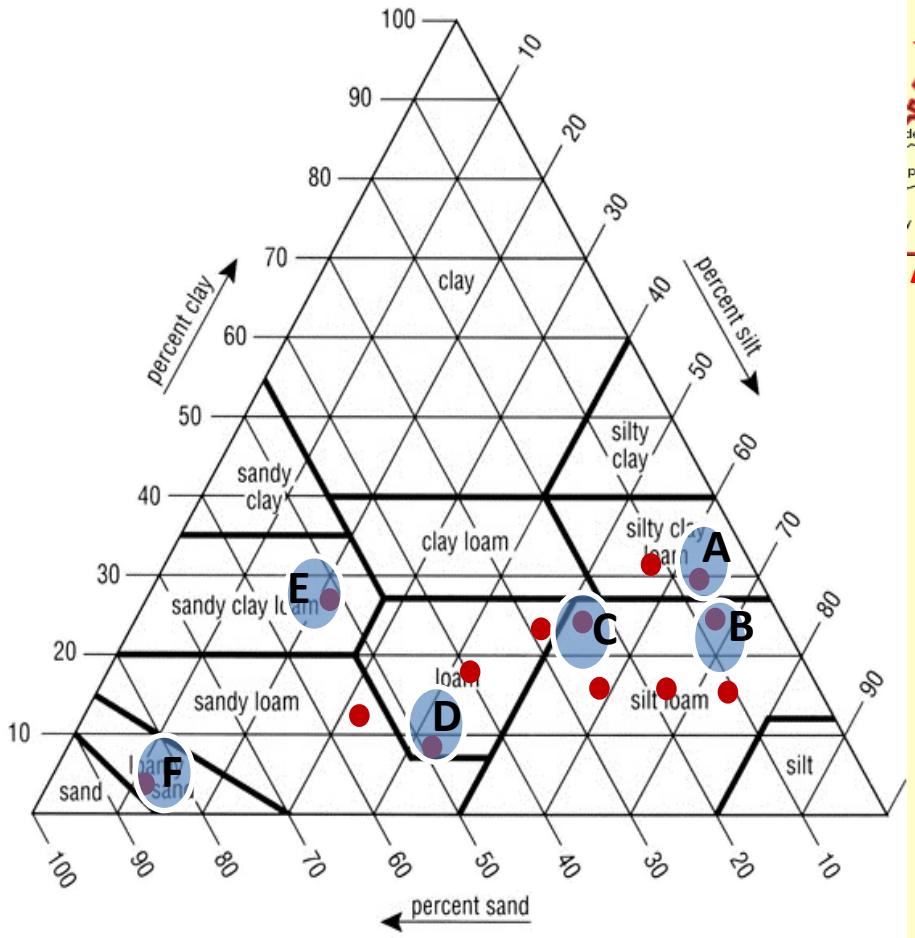
$\boldsymbol{\theta}$, $\boldsymbol{\theta_{wp}}$, $\boldsymbol{\theta_{fc}}$ are observed soil moisture, wilting point, and field capacity soil moisture, $\boldsymbol{\Delta z}$ is the depth of soil layer.

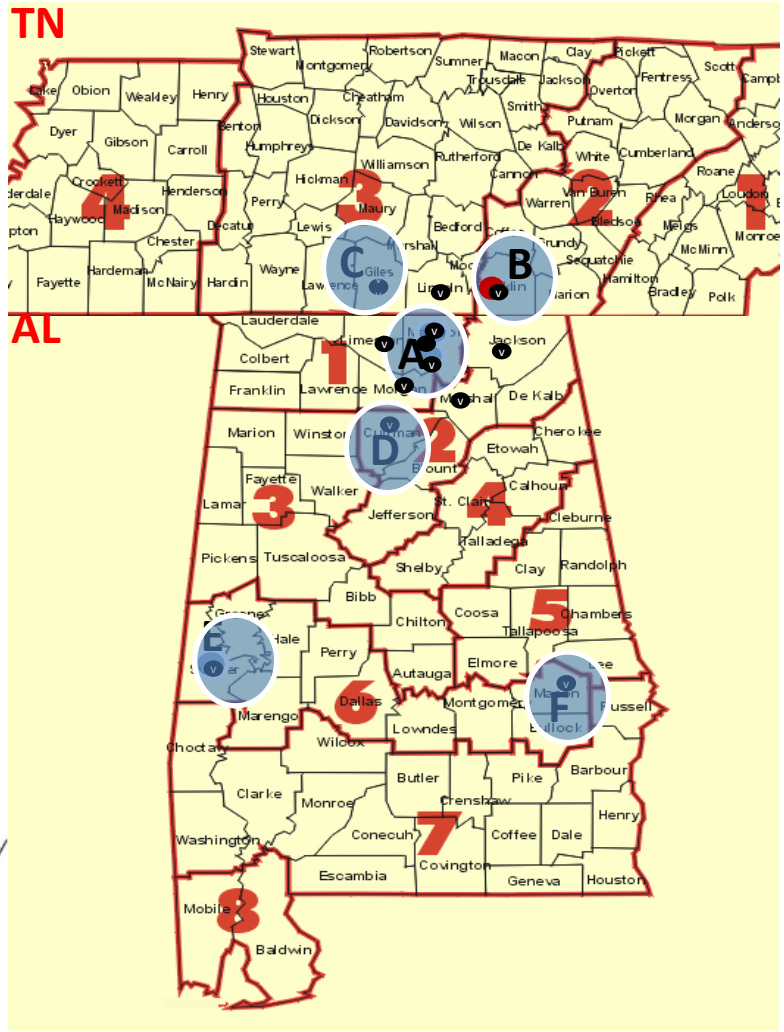
Potential Evapotranspiration (ET0), estimated from the standardized Penman-Monteith method (ASCE-EWRI, 2005)

$$ET_0 = \frac{0.408\Delta\left(R_n - G_0\right) + \gamma \frac{37}{T_{air} + 273} U_2 \left(e_s - e_a\right)}{\Delta + \gamma\left(1 + C_d\, U_2\right)}$$

R_n: net radiation (MJ m^{-2} h^{-1})
G_0: the surface soil heat flux density (MJ m^{-2} h^{-1})
T_{air} : the air temperature at 2 m height (°C)
U_2 is the wind speed at 2 m height (m s^{-1})
e_a , e_s: actual and saturation vapor pressure (kPa)
Δ: the slope of the relationship between saturation vapor pressure and air temperature (kPa K^{-1})
γ: is the psychrometric constant (0.067 kPa °C^{-1})
C_d =0.24 daytime, C_d = 0.96 nighttime

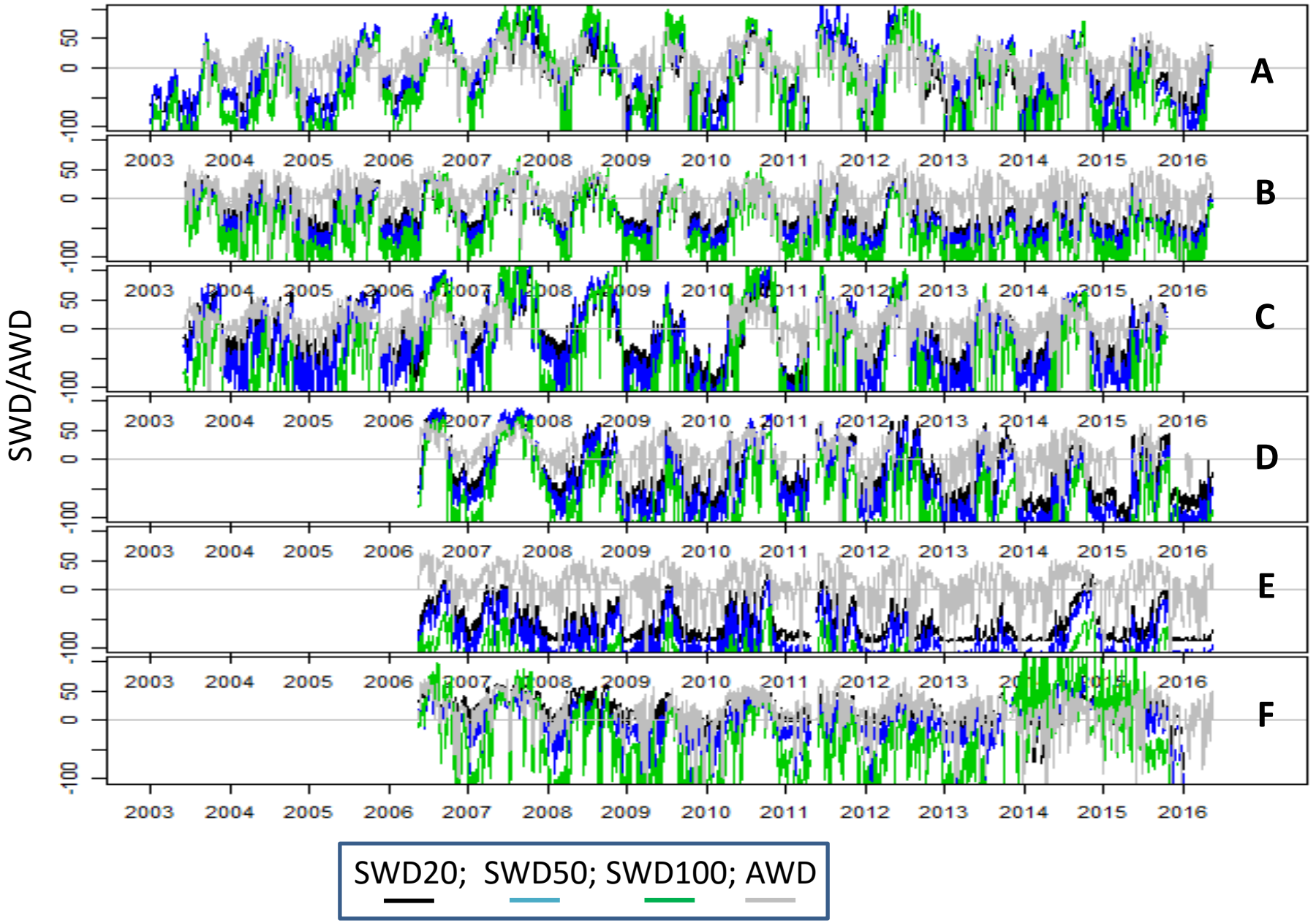
ALMNet stations by soil types and climate divisions



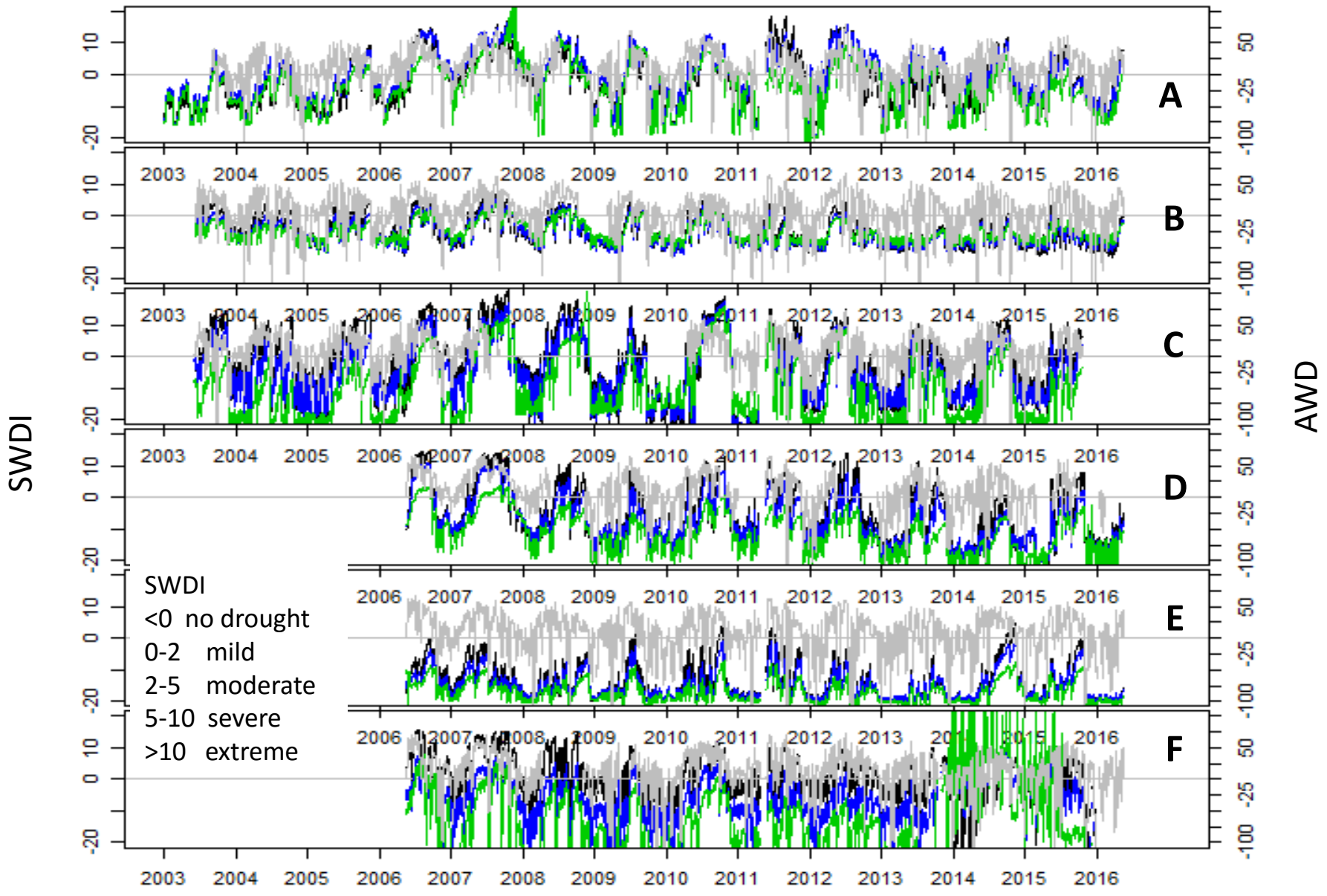


- 13 out of 24 stations with both soil properties and 10+ years of monitoring data
- 6 out of 13 chosen for current work

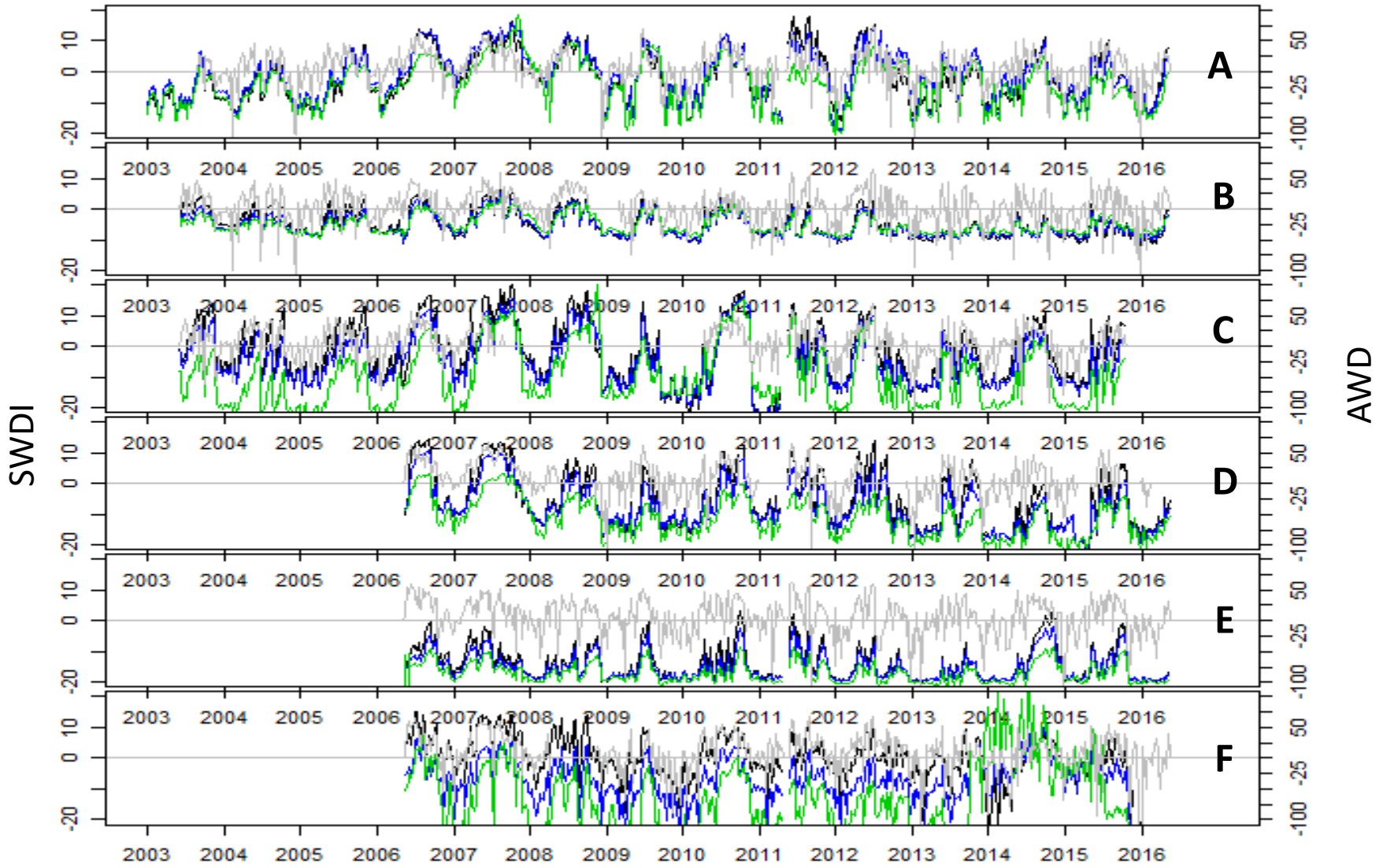
Daily SWD and AWD



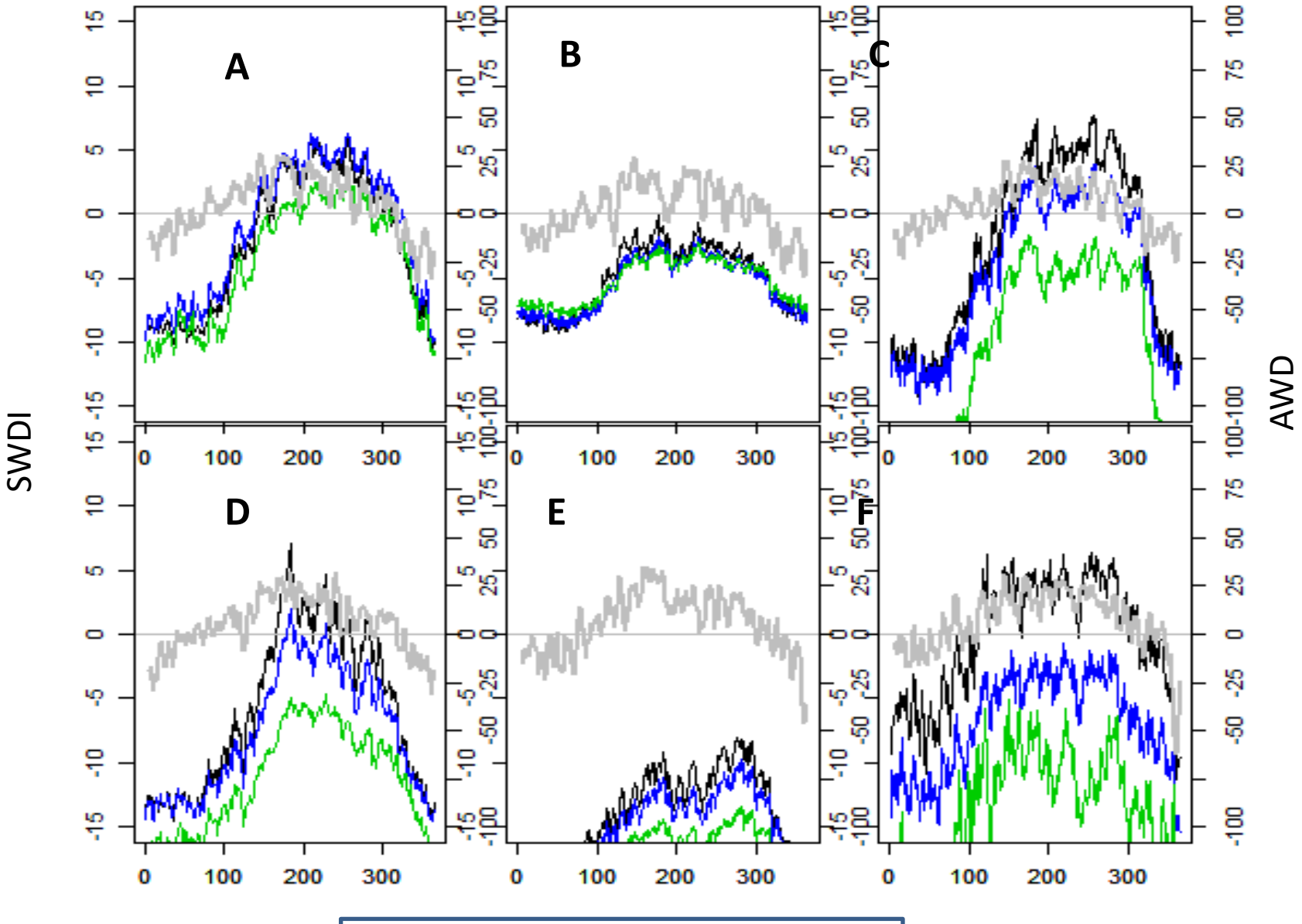
Daily SWDI and AWD



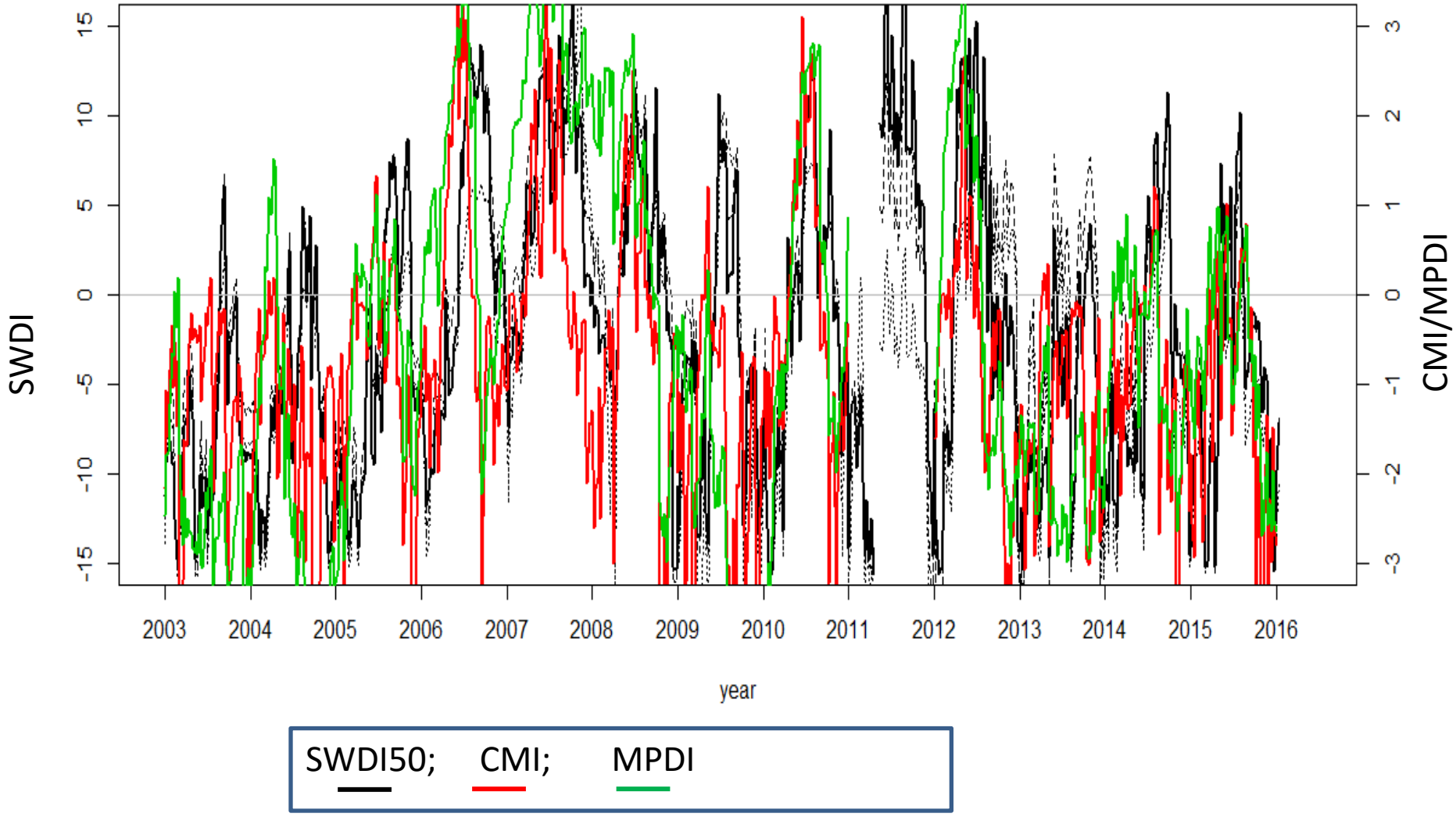
Weekly SWDI and AWD



Yearly SWDI and AWD (DOY-based average)



Comparison with other indicators: weekly scale (WTARS as example)



Summary

- **ALMnet resources allow to develop site-specific soil water deficit index (SWDI) based on soil moisture and properties.**

- **SWDI generally agreed well with atmospheric water deficit (AWD) and other water deficit index.**

- **SWDI varies with different soil type and climate and can be used to guide and help to make irrigation and water managements.**

Future Research Plans

ALMNet Resources

25 Scan Stations

- Simulate soil available water/plant use water/soil T/moisture/heat flux
- Spatial and temporal variability of soil T/Θ/heat flux/soil available water/plant water use/ soil water deficit under various land cover
- Forecast ET, soil moisture, T and soil available water and plant water use

3 Eddy Covariance

- Soil C sequestration dynamics under different ecosystems in AL
- Carbon/water/energy balance at different ecosystems

References

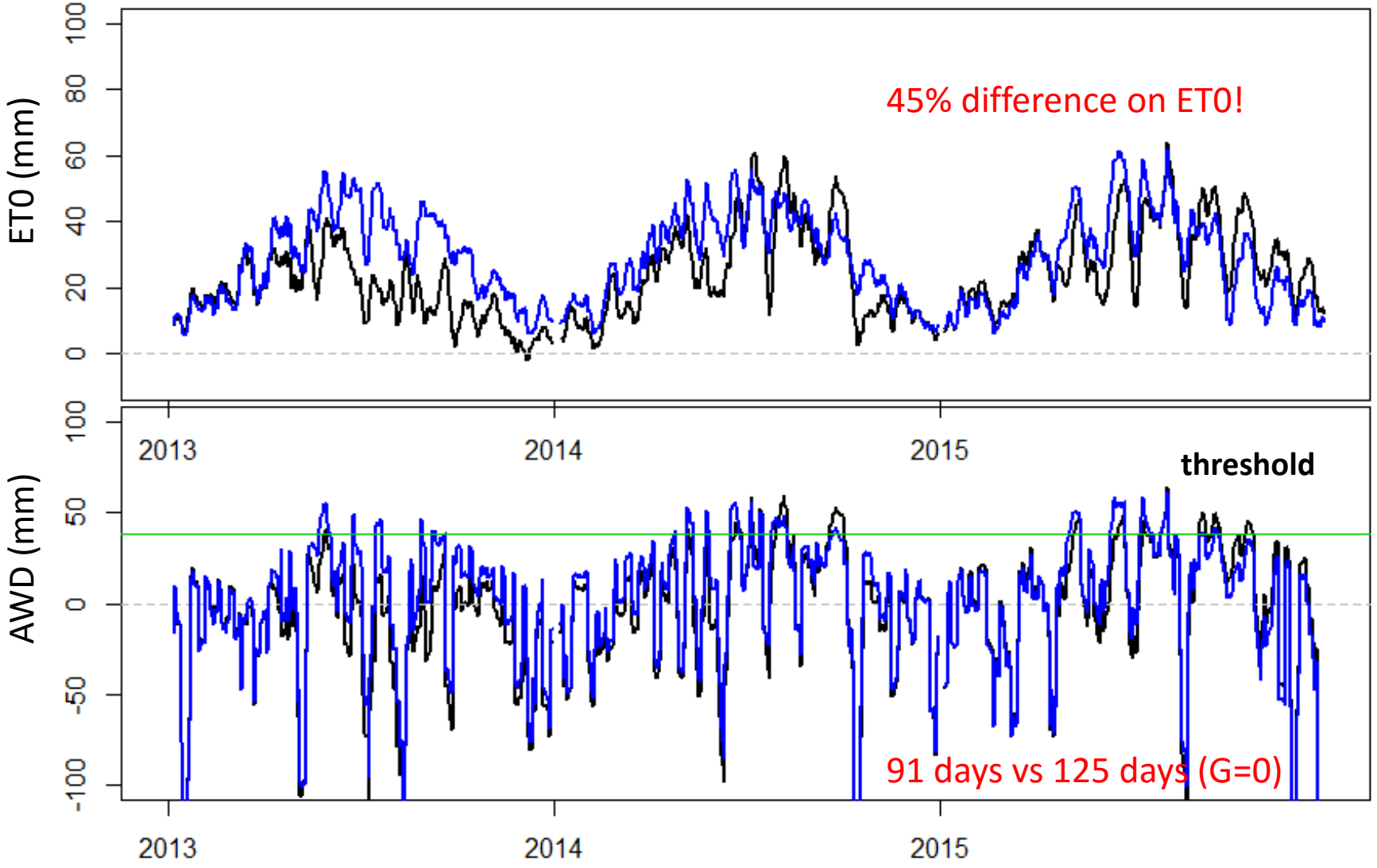
J. Martínez-Fernández, , A. González-Zamora, N. Sánchez, A. Gumuzzio. 2015. A soil water based index as a suitable agricultural drought indicator. Journal of Hydrology. 522:P265–273.

Guilherme M. Torres, Romulo P. Lollato, and Tyson E. Ochsner. 2013. Comparison of Drought Probability Assessments Based on Atmospheric Water Deficit and Soil Water Deficit. Agronomy Journal 105(2):428-436

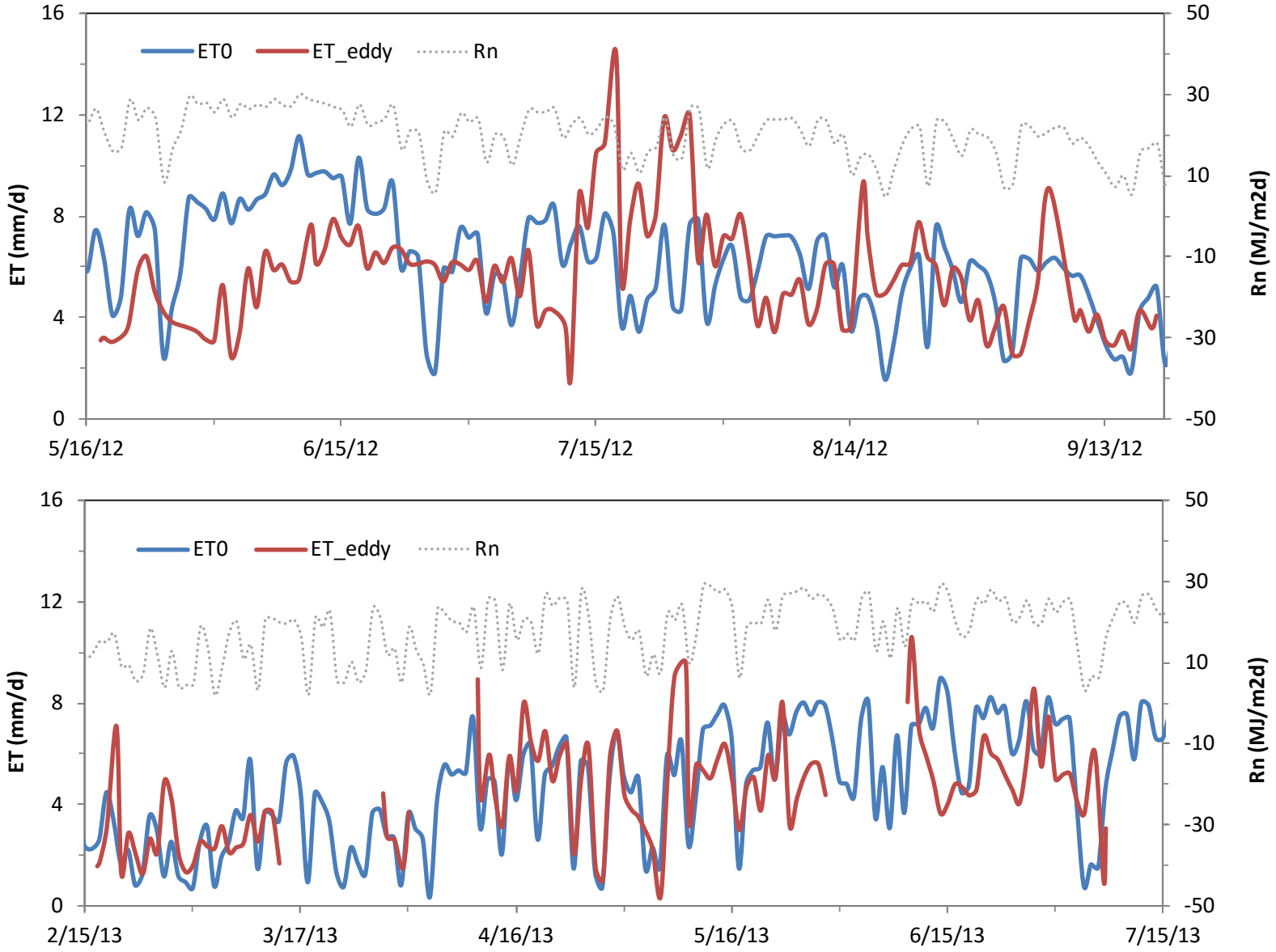
Comments and suggestions please!!

Thank you!!

G0 effects on ET0 and AWD-based drought



Validate ET with Eddy system at WTARS Farm.



A	type	Clay	Silt	Sand	FC	WP
0-10	SICL	31.5	61.5	7	24	13.5
10-20	SIL	26.3	67.9	5.8	21.4	10.4
23-48	SICL	38.6	57.1	4.3	25.7	15.5
48-69	SICL	36	58.6	5.4	28	15.2
69-86	SIC	43.3	48.8	7.9	23.7	17.9
86-122	SIC	46.6	43	10.4	28.3	20.7
122-152	C	42.9	39.2	17.9	26.9	20.4

B	type	Clay	Silt	Sand	FC	WP
0-20	SIL	26.6	67	6.4	24	11.6
20-56	SICL	37.2	57.1	5.7	29.8	15.4
56-86	SICL	34.6	55.7	9.7	26.1	14.4
86-114	SICL	33	56.2	10.8	25.8	13.6
114-152	SIC	48.7	43.7	7.6	24.9	19.7

C	type	Clay	Silt	Sand	FC	WP
0-10	SIL	25	51.9	23.1	35.1	14.1
10-20	CL	28	50.9	21.1	23.9	13.4
20-46	CL	35.5	42.9	21.6	22.2	16.7
46-60	C	56.7	27	16.3	31.2	23.8
60-90	C	62.3	20.2	17.5	29.9	25.1
90-107	C	61.8	24	14.2		24.6

D	type	Clay	Silt	Sand	FC	WP
0-15	L	8.1	43.1	48.8	14.8	5.6
15-25	L	14.3	43.6	42.1	15.8	6.2
25-41	L	16.7	39.4	43.9	15	7
41-58	L	24.6	33.8	41.6	17.8	10.2
58-79	CL	27.3	32	40.7	20.3	10.9
79-94	L	24.2	31.4	44.4	17	10
94-102	SCL	25.6	27.7	46.7	22	10.8

E	type	Clay	Silt	Sand	FC	WP
0-10	SCL	26.9	22.1	51	28.3	17.8
10-20	CL	35.5	23.7	40.8	23.3	15
20-36	C	44.2	27.9	27.9	26.5	16.8
36-58	C	43.8	32.9	23.3	23.5	16.1
58-107	CL	32.3	38.3	29.4	20	12.1
107-127	C	55.1	20	24.9	29.5	21

F	type	Clay	Silt	Sand	FC	WP
0-15	LCOS	3.2	11	85.8	6.4	1.6
15-25	COSL	11.6	16.3	72.1	9	4.2
25-48	COSL	17.8	12.8	69.4	12	5.9
48-79	SCL	20.2	9.2	70.6	14.2	7.3
79-91	SCL	26.7	8.8	64.5	15.7	9.7
91-152	SC	36.9	8.3	54.8	19.8	13.8