Application of the MIKE SHE Model to Assess the Hydrology Criteria for Defining Wetlands :

Wetland Distribution in Watershed WS80 on the Santee Experimental Forest

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Wetland Definition

- Vegetation – At least 50% of the vegetation must be hydrophytic (obligate, facultative).

- Soil – The soil must be hydric (evidence of mottling, organic matter accumulation or reduced conditions near the surface).

- Hydrology – Water table must be within 30 cm of the surface for a continuous period of 14+ days during the growing season in 50% of the years.

Issue: How does the growing season definition affect the hydrology criteria? The normal definition is soil temperature > 5°C; however, for the Atlantic and Gulf Coastal Plain a 365 day growing season is suggested for "areas near the ocean". (COE 2010)

How to Assess Changes in the Growing Season Designation on Water Table Depth Criteria?

a) Long-term water table data, preferably along an upland – wetland gradient.

b) Simulation of the water table across a watershed.
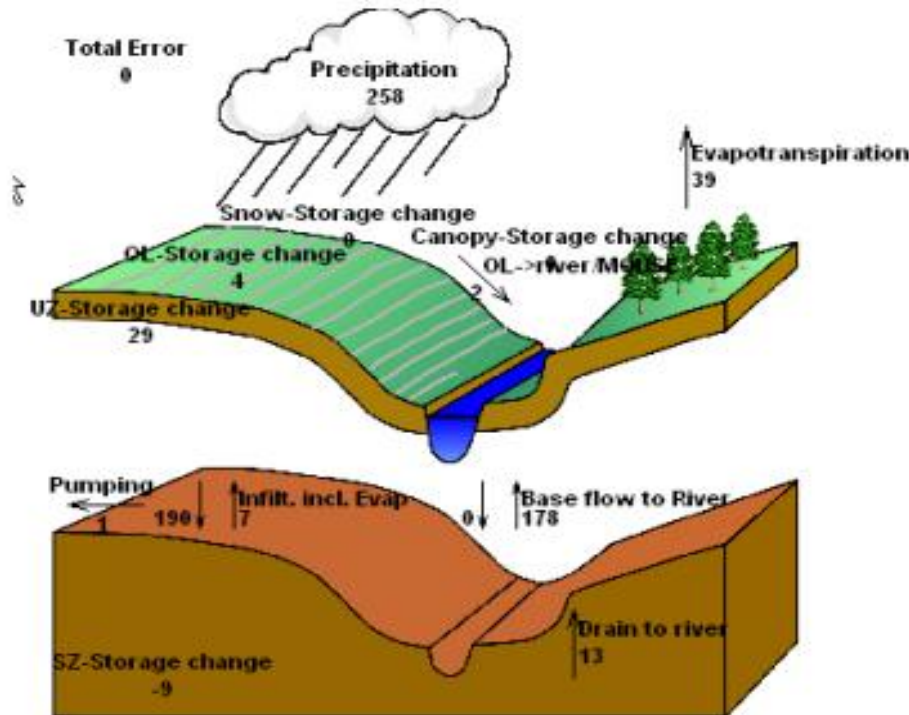
MIKE SHE

- Physically-based, distributed;
- Spatially and temporally explicit;
- Complete terrestrial water cycle, including 3-D water movement in saturated and unsaturated zones, 2-D water movement of overland flow, 1-D water movement in river/stream flow, and evapotranspiration (ET).
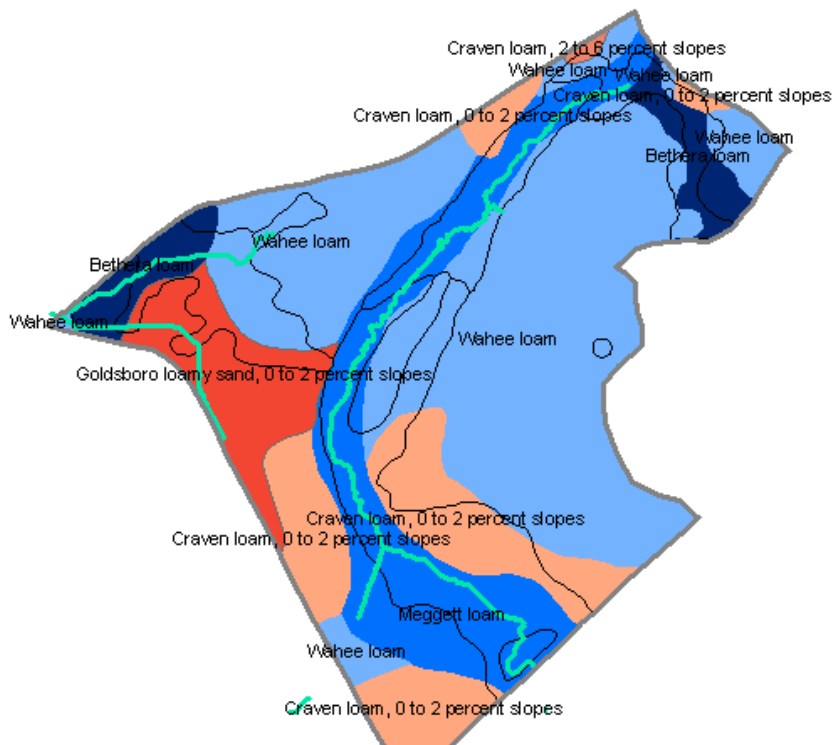
Santee Experimental Forest

≈10 m

≈8.5 m

≈9.0 m

≈5.5 m

Watersheds on SEF
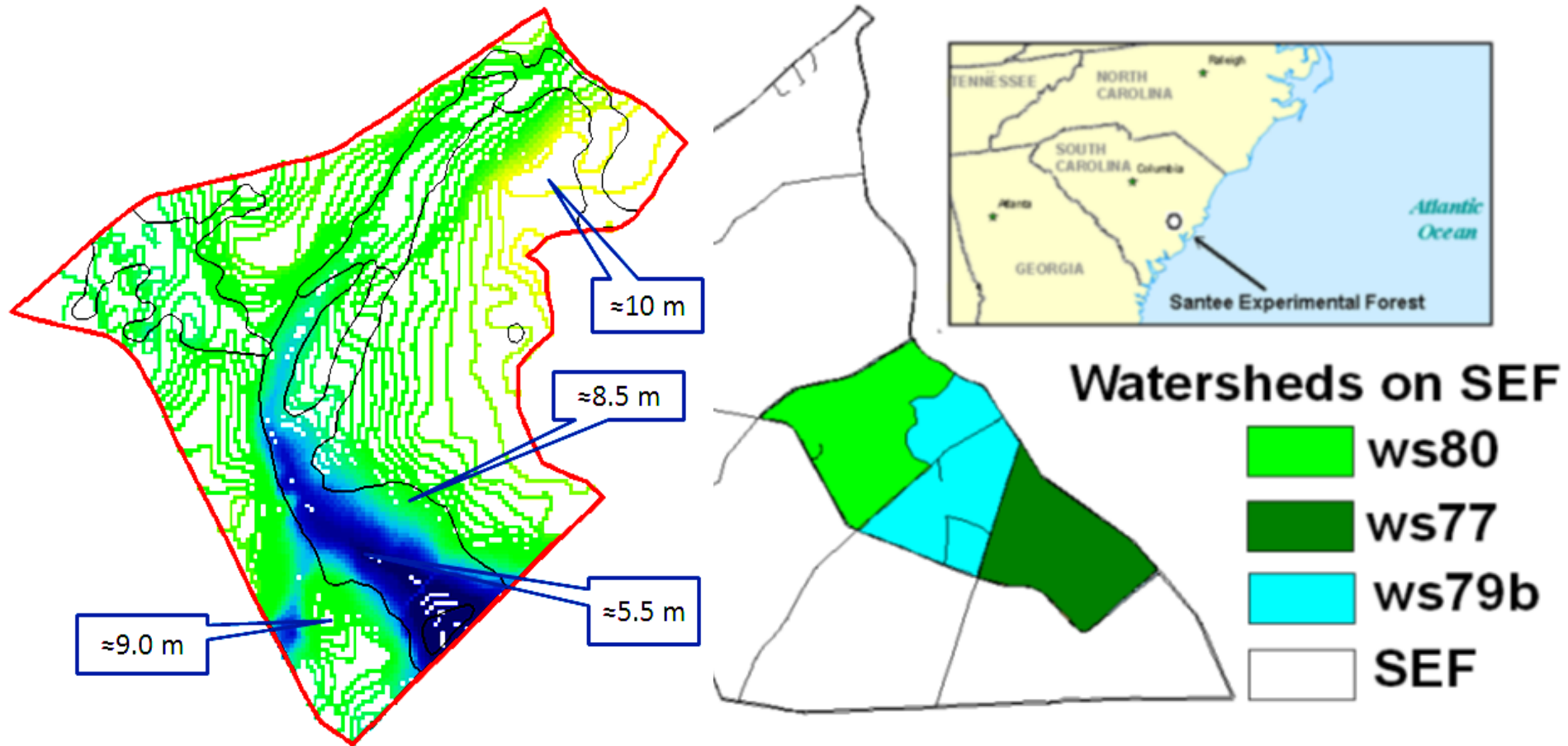
- ws80
- ws77
- ws79b
- SEF

The study area is the first-order watershed (WS80) on Santee Experimental Forest on the Atlantic Coastal Plain in South Carolina, USA (33.15°N, 79.8°W).
WS80 has gauging records since 1969, and long-term water table measurements.

Soils and NWI Wetlands

- All soils on WS80 are hydric (NRCS criteria);
- Water table depth can be ≤ 30 cm during the growing season **- if the saturated hydraulic conductivity is <15.24 cm/hr in any soil layer within a depth of 50 cm**.

Soil Series	Area (ha)	Fraction (%)	Hydraulic conductivity (cm/hr)			Drainage*
			Min	max	mean$	
Bethera	9.6	6.0	0.15	5.04	1.49	VP
Craven	26.8	16.8	0.50	15.12	4.16	MWD
Goldsboro	13.3	8.3	1.44	50.76	13.63	MWD
Meggett	30.0	18.8	0.50	15.12	5.63	P
Wahee	79.9	50.1	0.50	5.04	1.54	SWP

*Drainage: MWD – Moderately well drained, SWP – Somewhat poorly, P – Poorly, VP – Very Poorly
$: The mean hydraulic conductivity is depth weighted
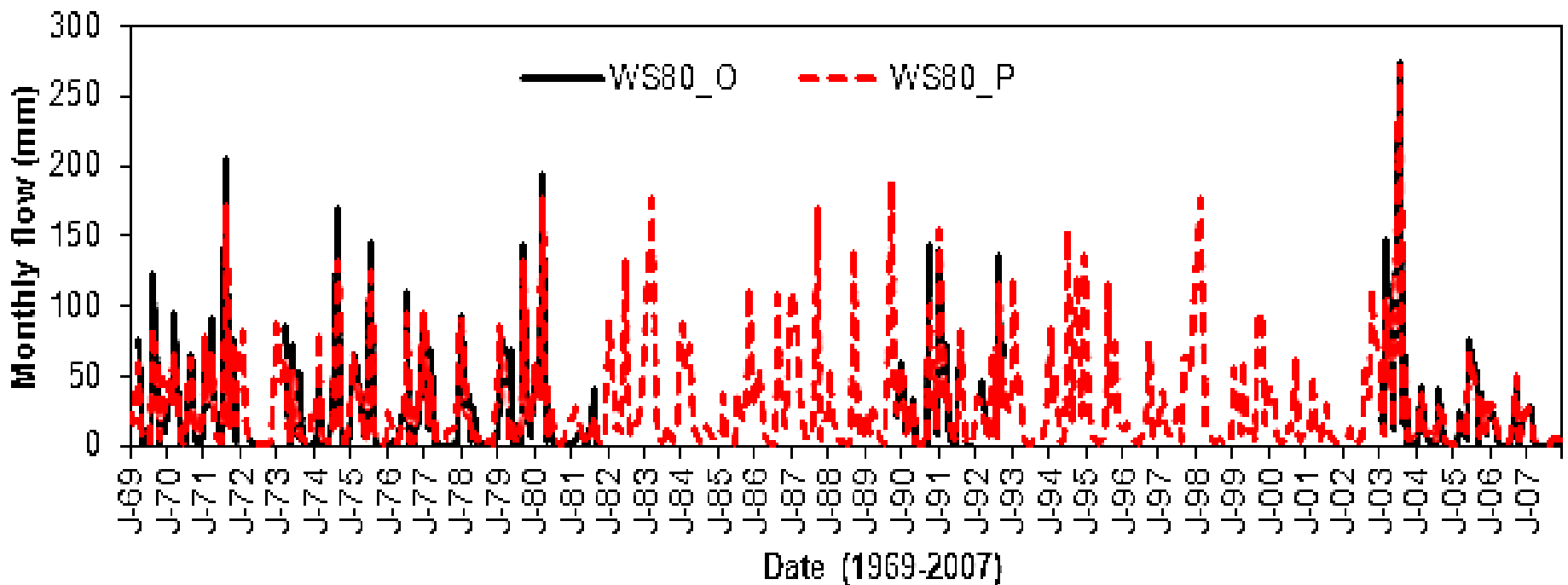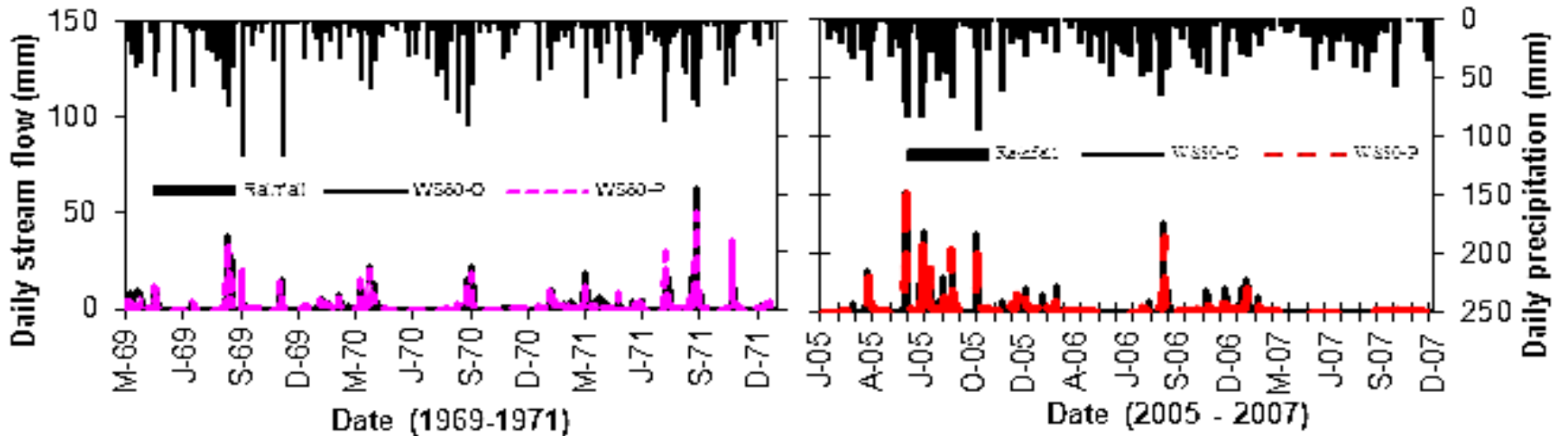
Distribution of Wells on WS80*
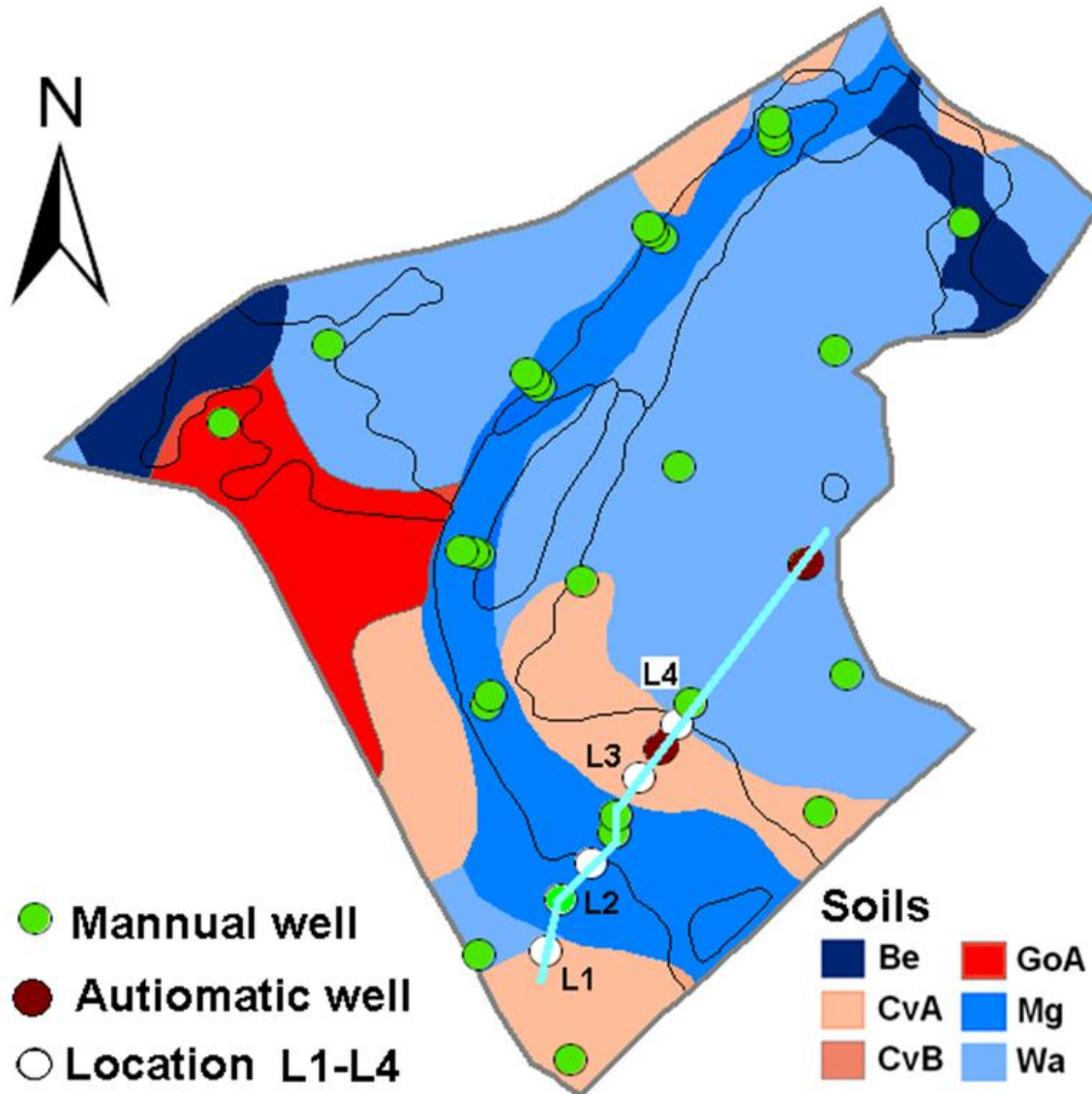
Background: Soil distribution on WS80 (SCS, 1980)

MIKE SHE Calibration and Validation Using Observations of Water Table Depth across the Watershed and Stream Flow
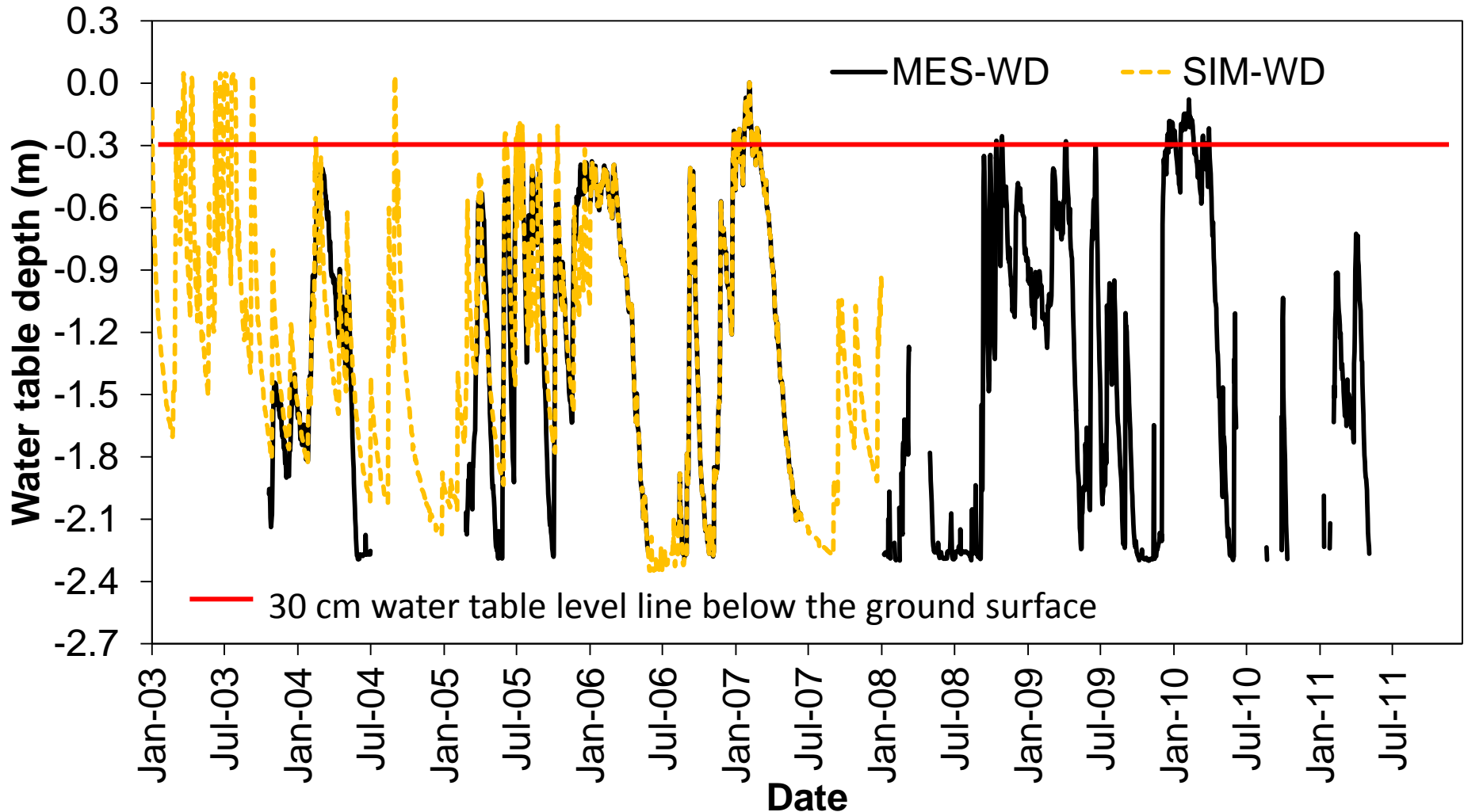
The calibrated and validated model was employed to simulate daily spatial water table dynamics in the period from 1950-2007

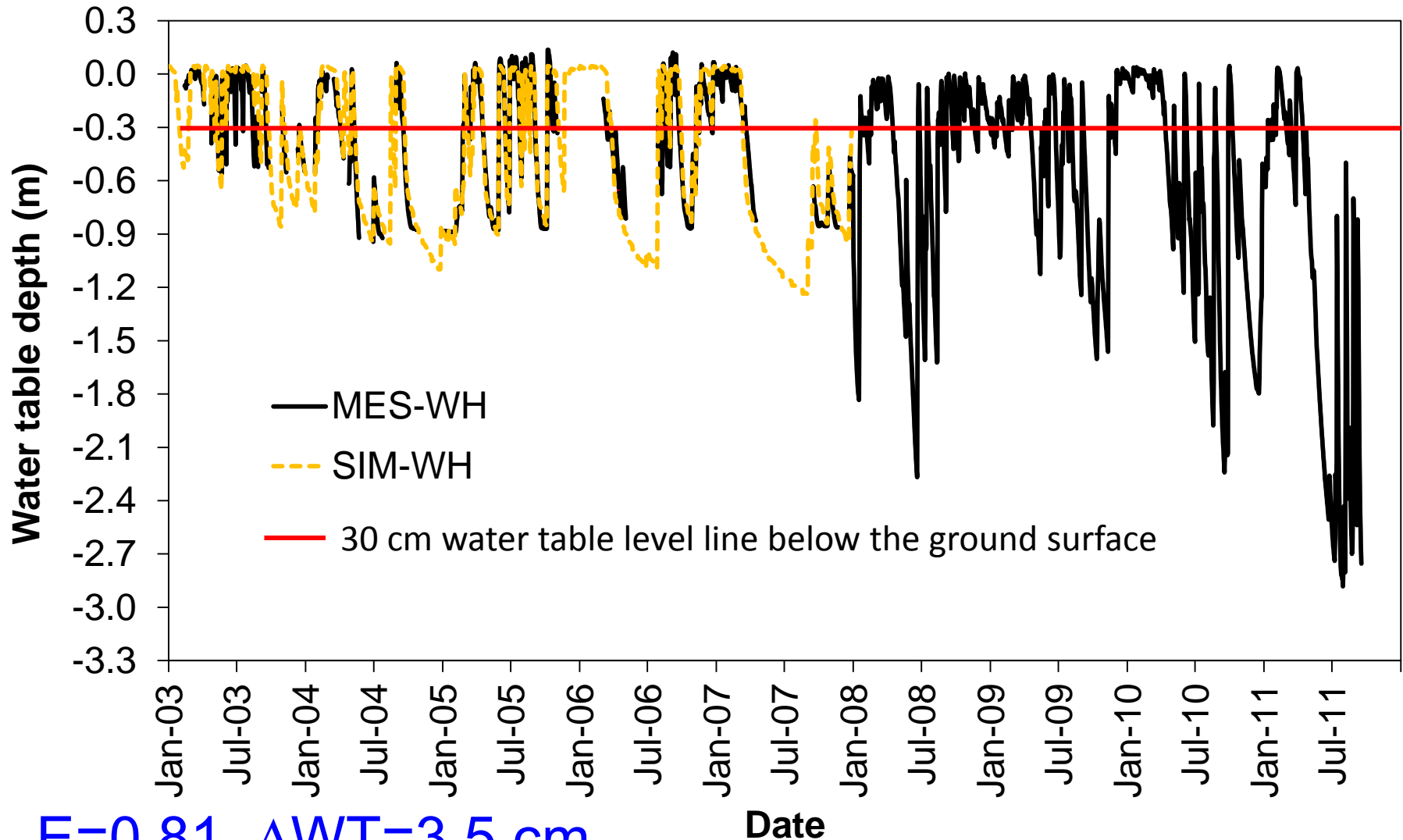# Observed (O) vs. Simulated (P) Stream Flow

# Observed and Simulated Daily Water Table Depth at Well D (Upland)

E=0.79, ΔWT=3.9 cm on average, ΔWT=mean error

Observed and Simulated Daily Water Table Depth at Well H (Wetland)

E=0.81, ∆WT=3.5 cm

Observed and Simulated Spatial Water Table Depth at 33 Manual Wells and Two Automatic Wells on Watershed 80

$y = 0.964x + 0.003$
$R^2 = 0.776$

X-axis: **Predicted daily water table (m)**
Y-axis: **Observed daily water table (m)**
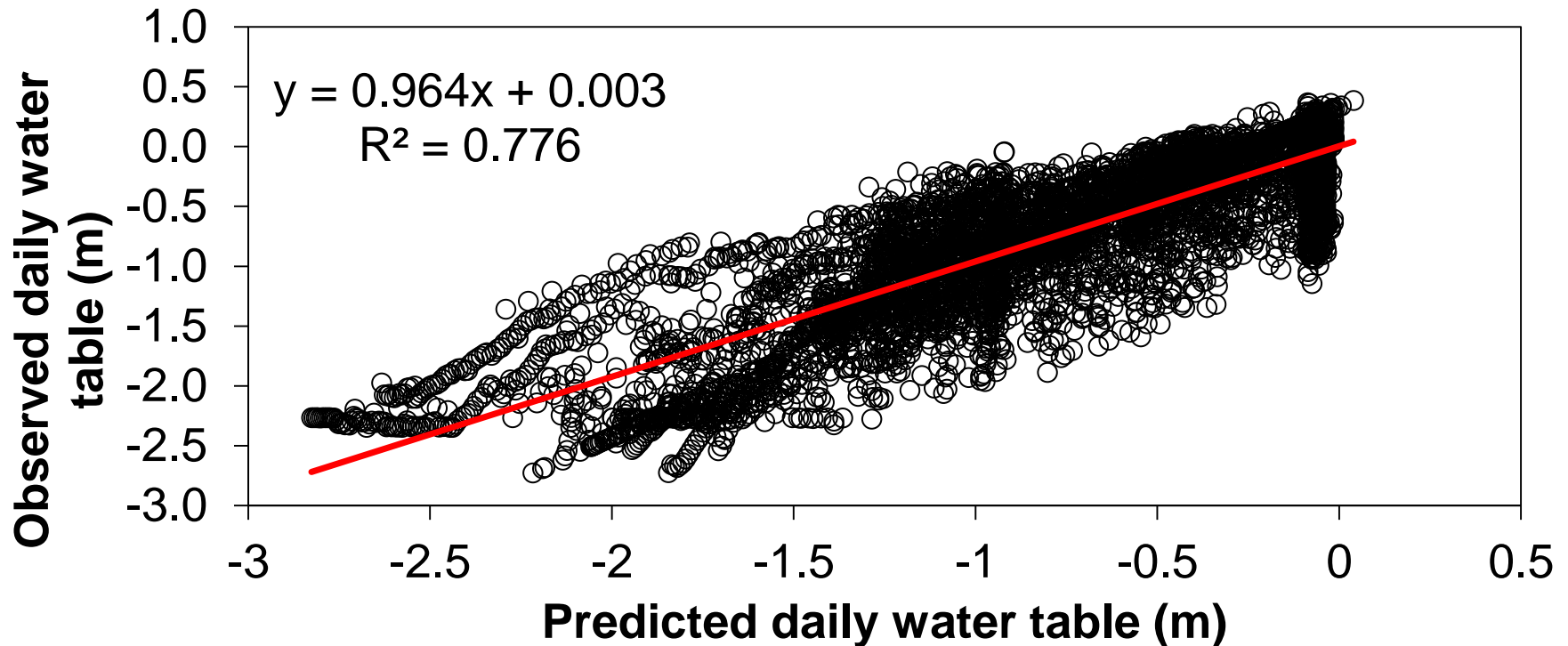
Mean water table
    Observed: -0.64 m
    Simulated: -0.67 m
Model performance:
    E = 0.77 R^2 = 0.78

Observation periods:
   1992-1994 (manual, 33 wells)
    2003-2005 (manual, 10 wells)
    2003-2007 (automatic, 2 wells)
Samples: n = 6644

How Does the Growing Season Length Affect the Hydrology Criteria?

- The normal criteria is that the growing season is defined the period when soil temperature is > 5 °C at 30 cm depth, or between the median dates of 28 °F air temperature in spring and fall.

  – This is typically the period of March -December.

- For the southeastern Coastal plain the COE suggest that the period be 365 days.

Water Table Dynamics from Observations (9 years) and Simulations (57-years)– Wetland Soils
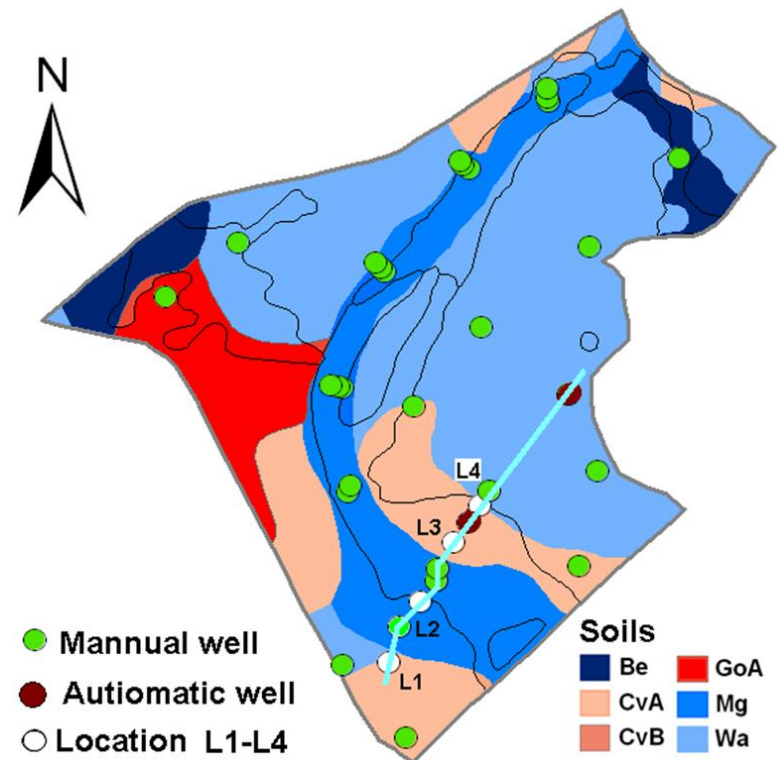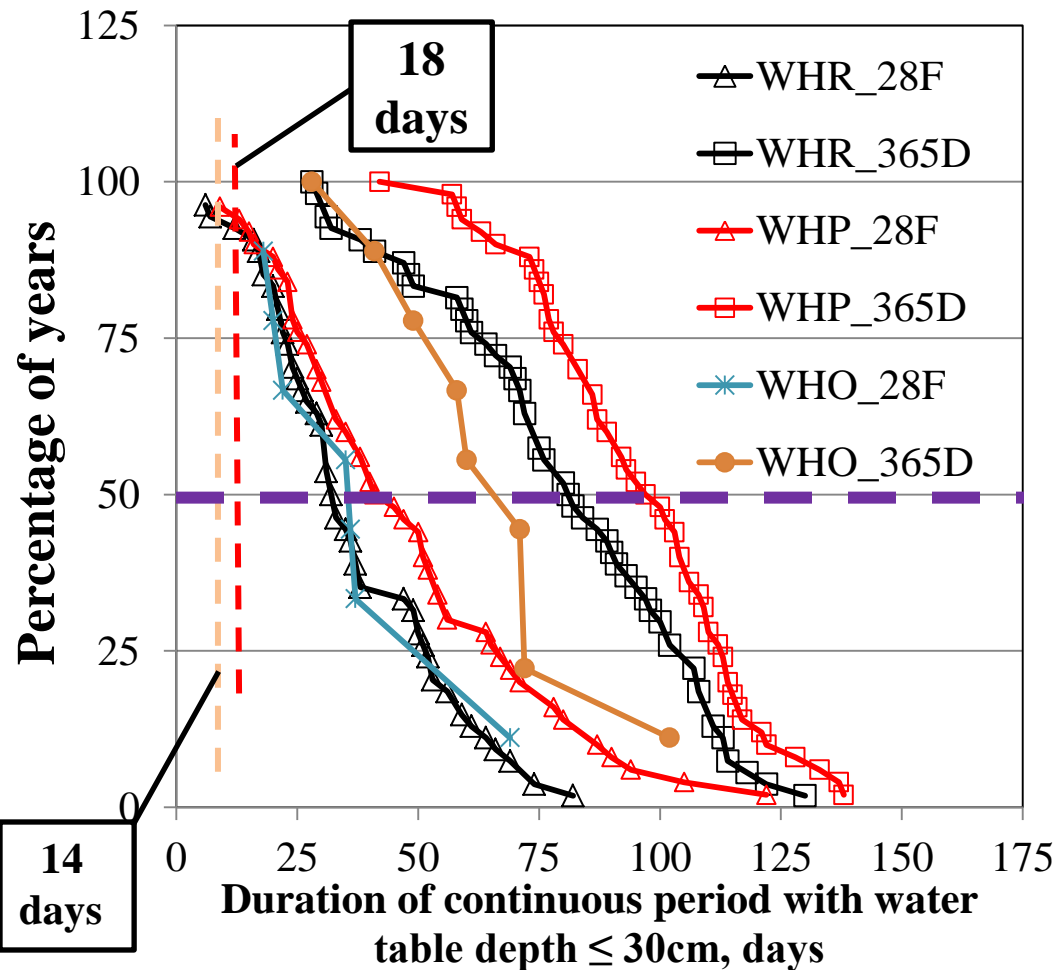
WDR and WHR are regressed WT using the regression models; WDP and WHP are the simulated WT

Water Table Dynamics from Observations (9 years) and Simulations (57 years) – Upland Soils
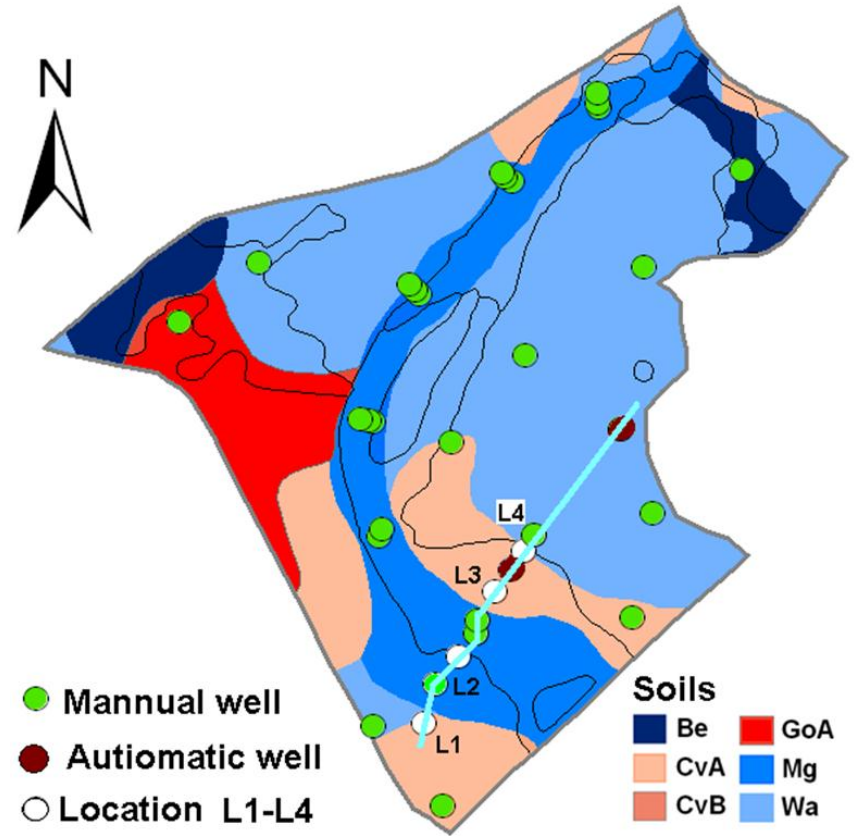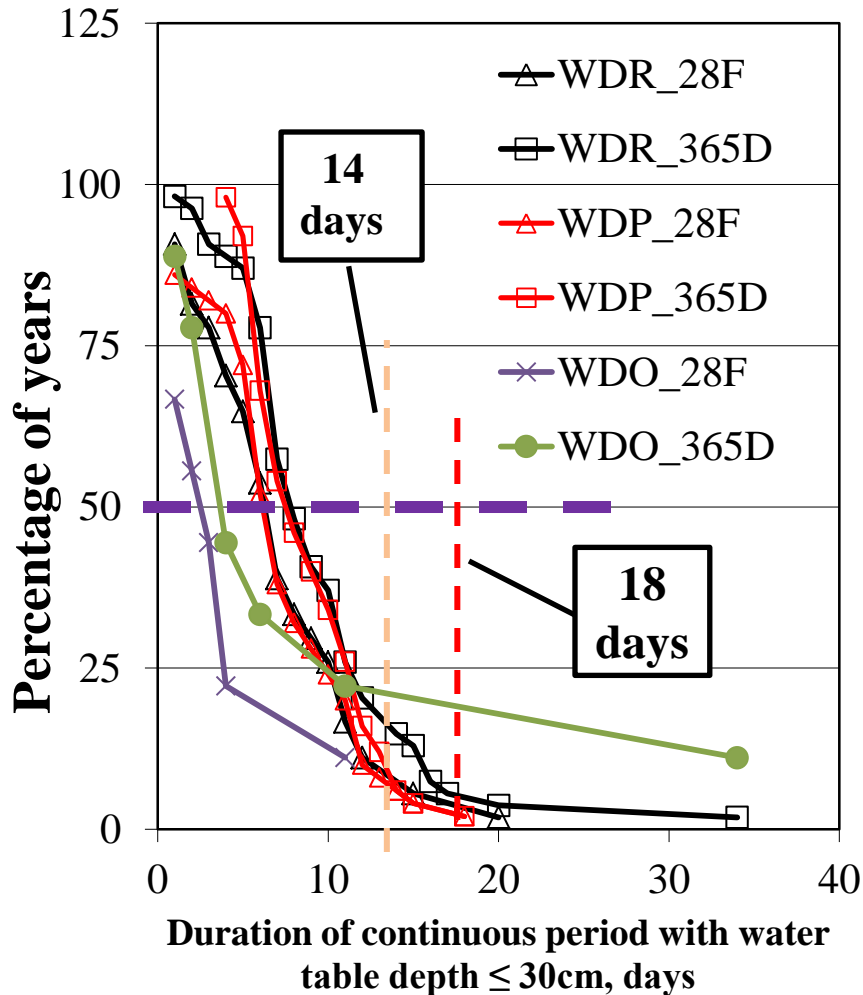
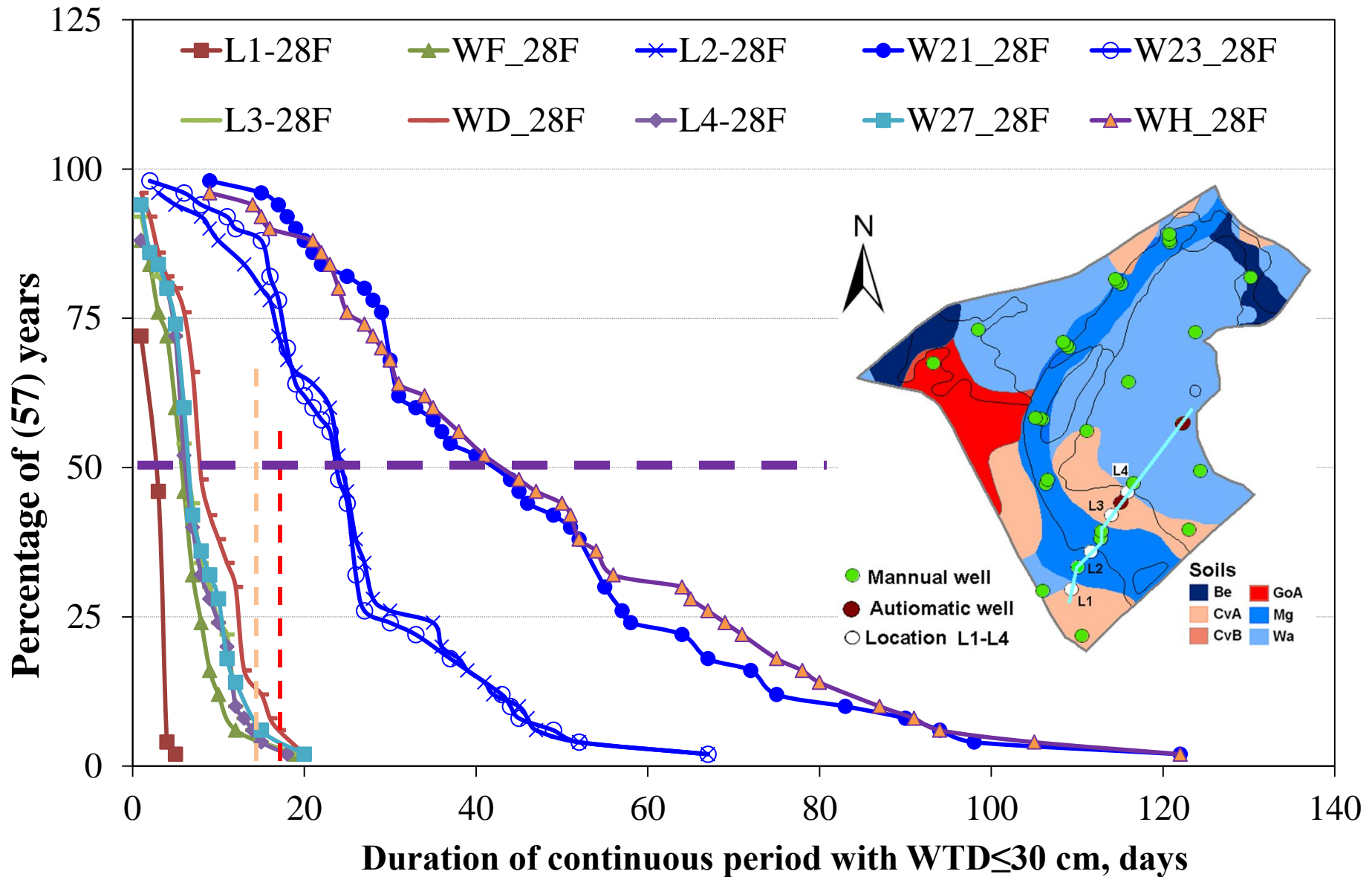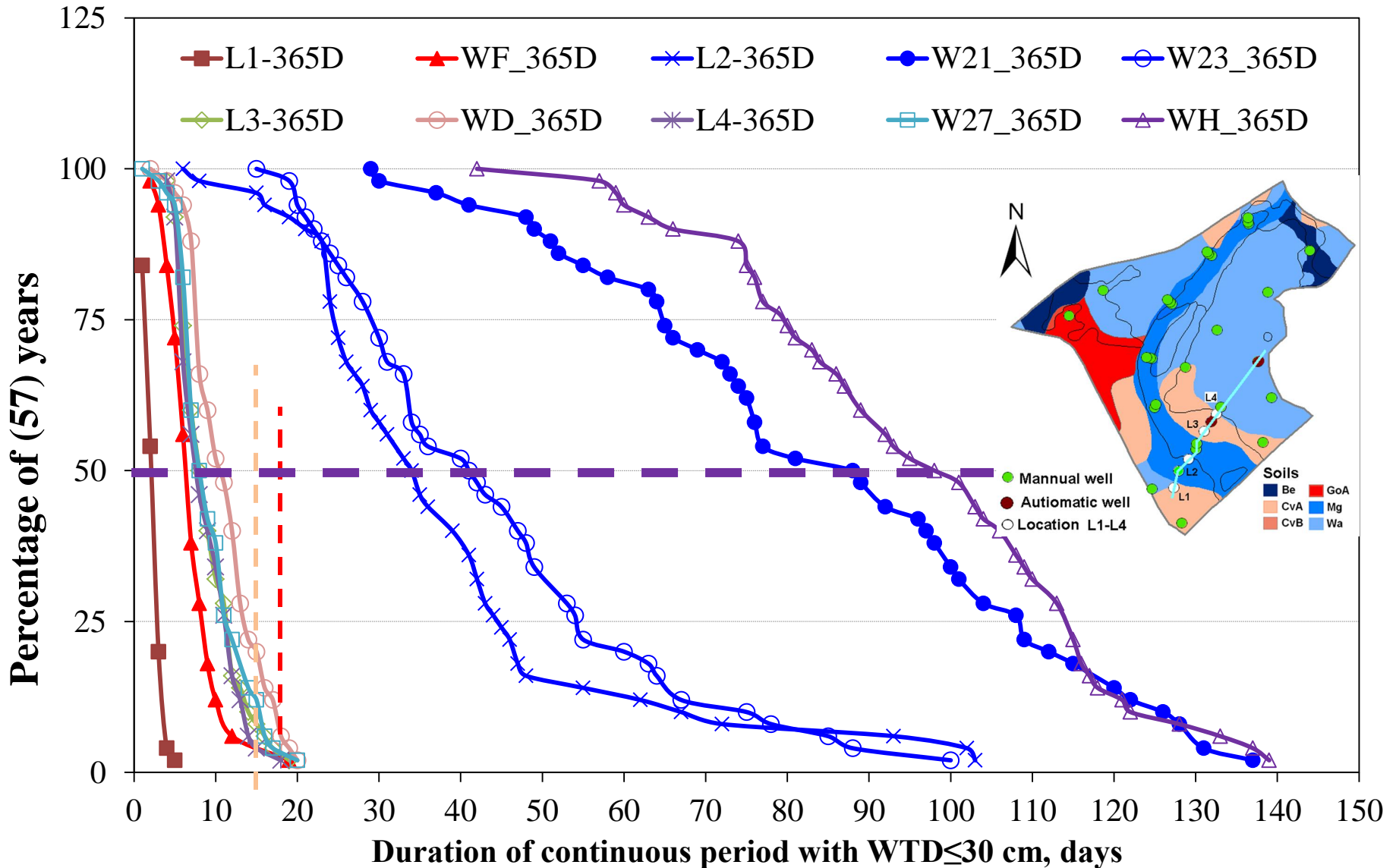WDR and WHR are regressed WT using the regression models; WDP and WHP are the simulated WT

Well Transect on WS80 (28F)

Well Transect on WS80 (365D)

Summary - Well transect

Well No	Forest Type[1]	Soil[2]	Duration Range[3]	Mean[4]	Land Type
Well F	Mixed HW	Mg	0 - 19	6.6	Upland
Well 21	Mixed HW	Mg	9 - 122	45.1	Wetland
Well 23	HW pine	Mg	2 - 67	25.4	Wetland
Well D	Pine HW	Cv	0 - 20	8.8	Upland
Well 27	Pine HW	Wa	0 - 20	7.5	Upland
Well H	Pine HW	Wa	9 - 122	48.3	Wetland

*: All wells were located on the line of the well transect on the last slide.

[1]: LULC is the current Land Use Land Cover; HW is hardwoods.

[2]: The soil is occurred on the soil map of Soil Conservation Service (SCS, 1980)

[3]: Duration Range is the range of the annual longest duration (days) of continuous period with water table ≤30 cm in the 57 years from 1951-2007

[4]: Mean is the averaged annual longest duration (days) of continuous period with water table ≤30 cm in the period from 1951-2007

Soils
- Be
- CvA
- CvB
- GoA
- Mg
- Wa

Mannual well
Autiomatic well
Location L1-L4
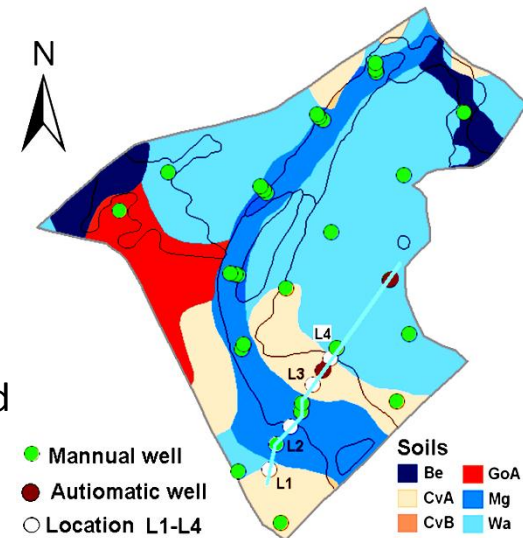
Water Table Level During High Precipitation in Growing Seasons (Changes in WT between 7 days)
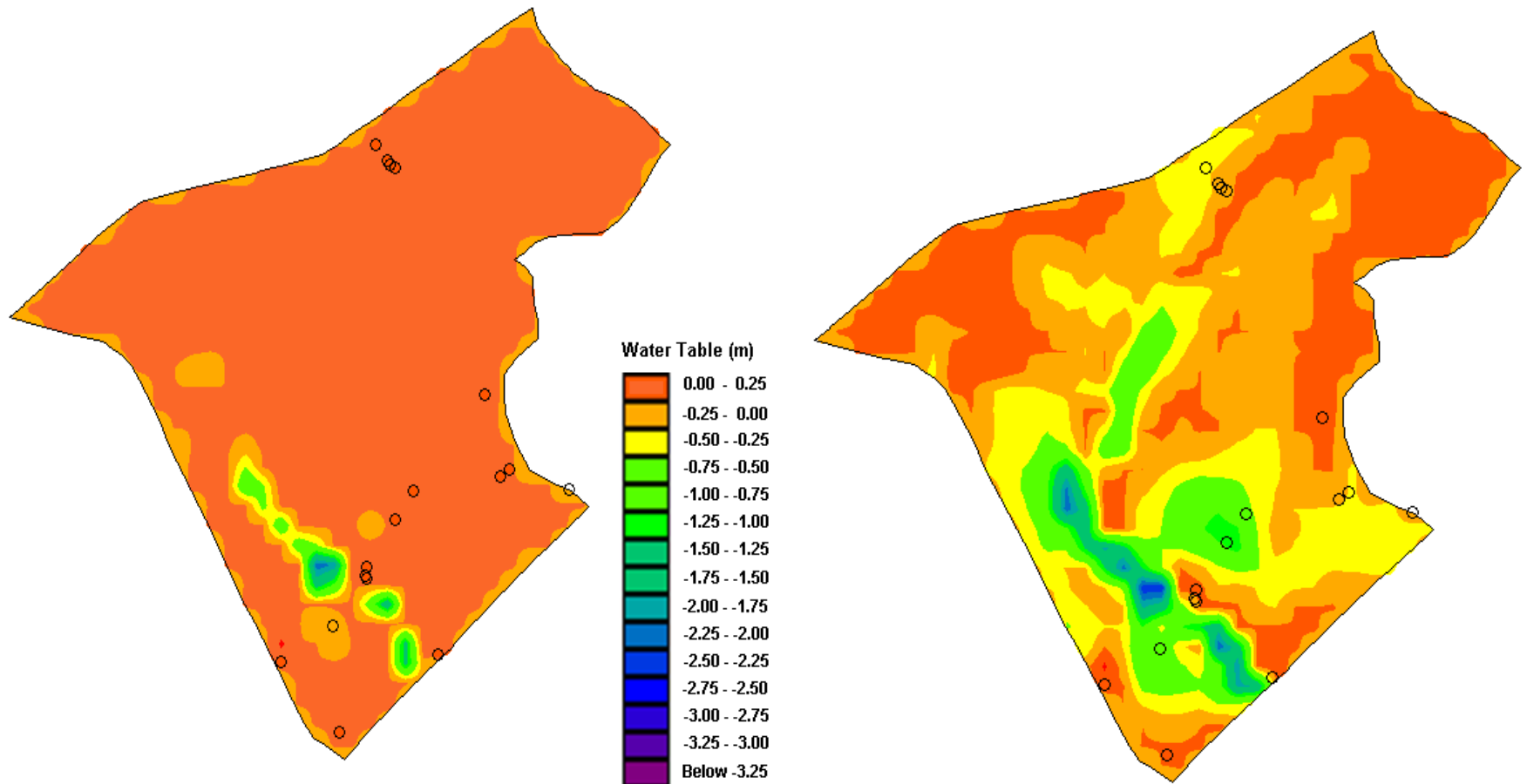
08-30-2004

09-05-2004

Water Table Level During High Precipitation in Growing Seasons (Changes in WT between 21 days)

Water Table (m)

- 0.00 - 0.25
- -0.25 - 0.00
- -0.50 - -0.25
- -0.75 - -0.50
- -1.00 - -0.75
- -1.25 - -1.00
- -1.50 - -1.25
- -1.75 - -1.50
- -2.00 - -1.75
- -2.25 - -2.00
- -2.50 - -2.25
- -2.75 - -2.50
- -3.00 - -2.75
- -3.25 - -3.00
- Below -3.25

08-30-2004

09-19-2004
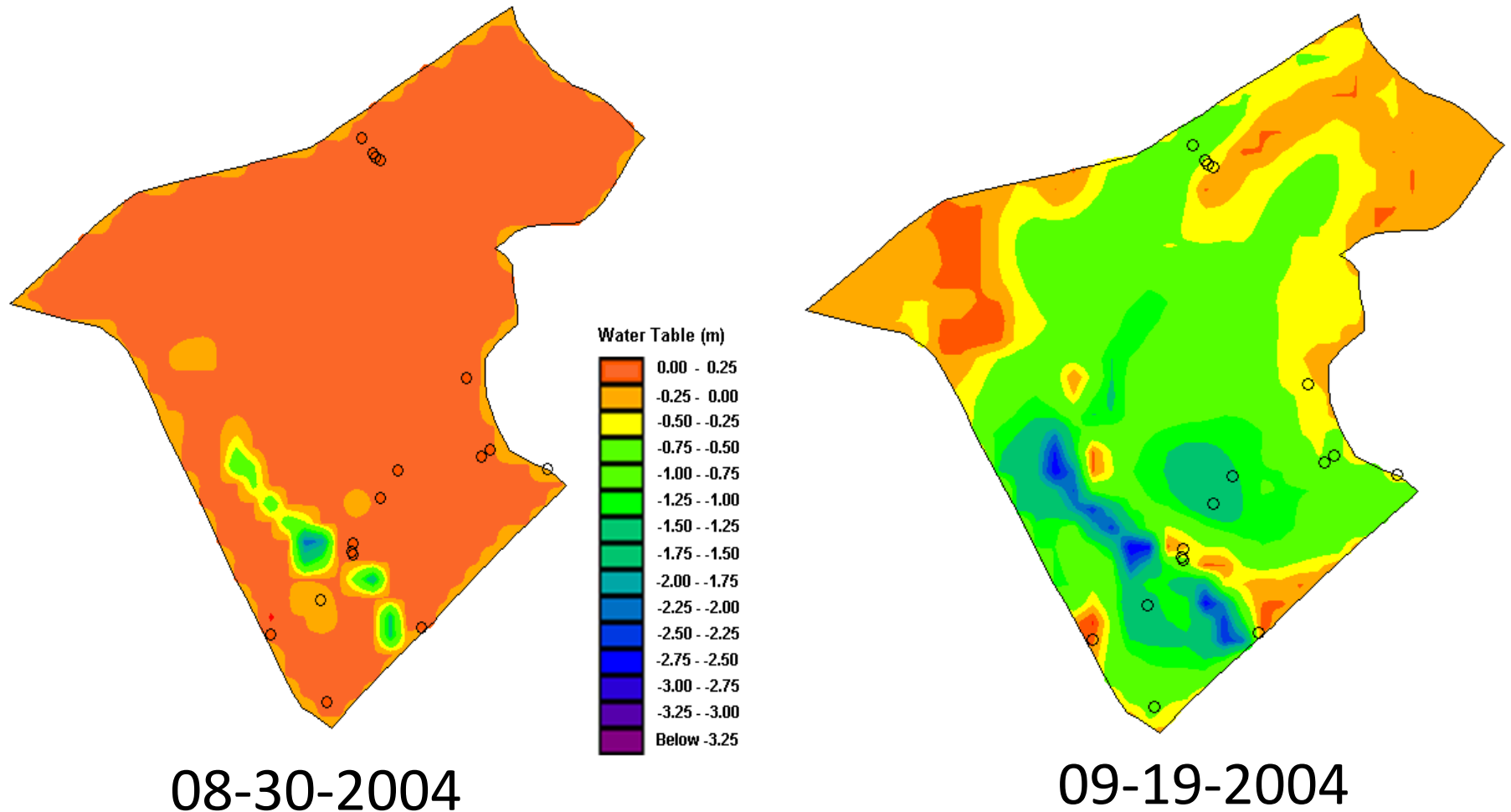
Difference in Water Table Level between Wet and Dry periods in Growing Season

Water Table (m)

- 0.00 - 0.25
- -0.25 - 0.00
- -0.50 - -0.25
- -0.75 - -0.50
- -1.00 - -0.75
- -1.25 - -1.00
- -1.50 - -1.25
- -1.75 - -1.50
- -2.00 - -1.75
- -2.25 - -2.00
- -2.50 - -2.25
- -2.75 - -2.50
- -3.00 - -2.75
- -3.25 - -3.00
- Below -3.25

08-30-2004

08-30-2007

Water Table Duration by Soil Series Using Simulated WT
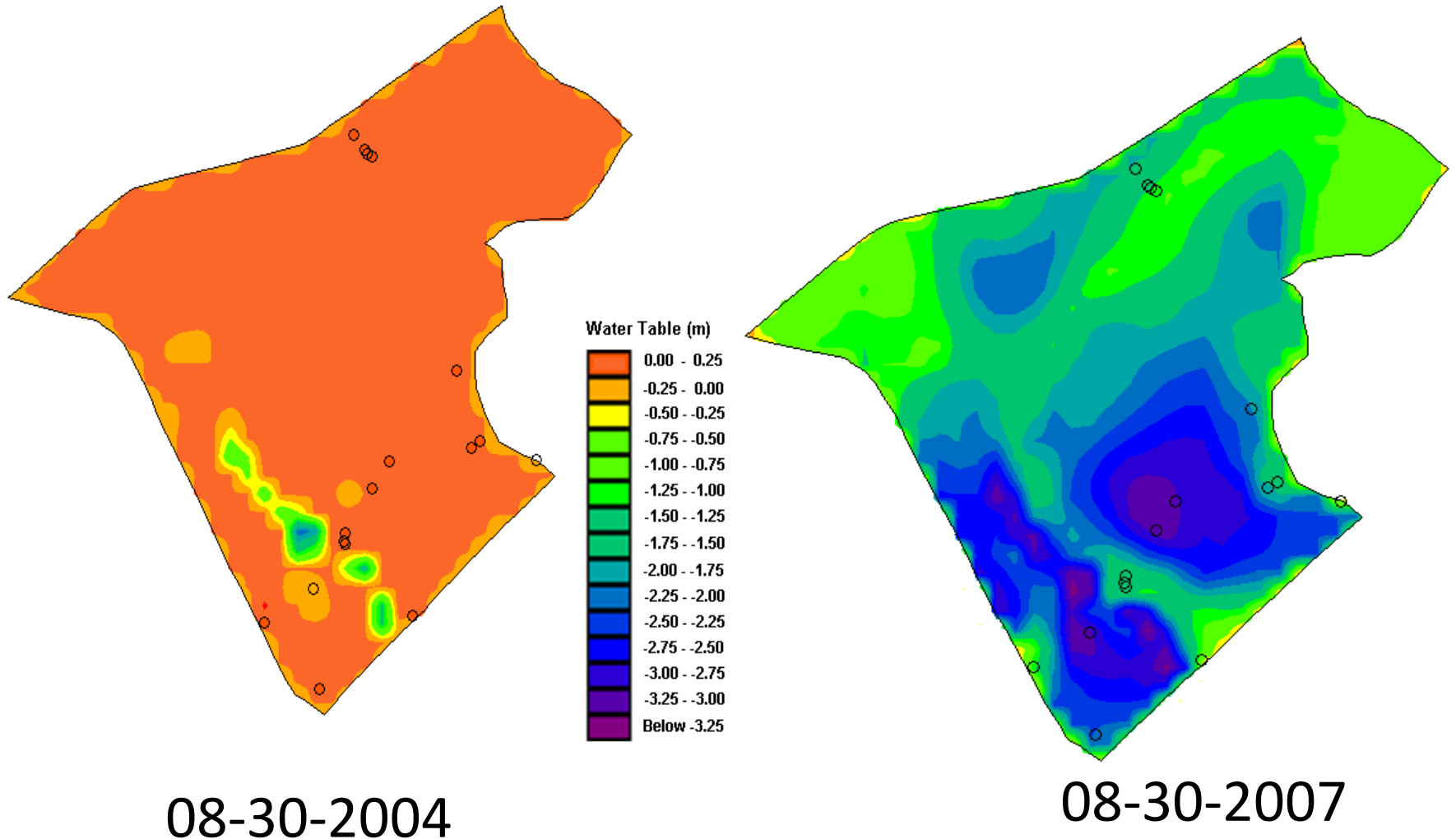
Wetland Fraction in WS80 based on Soils and Water Table Depth Using Two GS Criteria

Criterion	Percent growing season	Wetlands (ha)	Uplands (ha)	Wetlands (%)	Uplands (%)
28°F (-2.2°C)	5.0	110	49	69	31
	8.8	96	63	60	40
	12.5	62	97	39	61
365 days	5.0	116	43	73	27
	8.8	99	60	62	38
	12.5	87	72	55	45
Soil Type*		119	40	75	25
NWI		48	111	30	70

*: Very poorly drained soils are located in wetlands, including Bethera loam, Meggett loam and Wahee loam; other soils, located in uplands, are Goldsboro loamy sand and Craven loam with 0-2 percent slopes

Summary

- Models can be an effective tool to assess the wetland criteria:
  - The model validation using spatial water table depth (4.85 ha per well on average) showed that MIKE SHE predicted water table depth effectively, thereby providing a sound basis to assess wetland hydrology criteria on a first-order watershed.
- Expanding the growing season to 365 days did not change the wetland distribution in the lower coastal plain of South Carolina:
  - Both observations and simulations demonstrate that the difference in cumulative frequency of a high water table (< 30 cm) won't be affected by the growing season length.
- The NWI underestimates the jurisdictional wetland area in this forested wetland landscape:
  - The hydrology criteria are diagnostic in the lower coastal plain where imperfectly-drained soils and facultative vegetation are common.