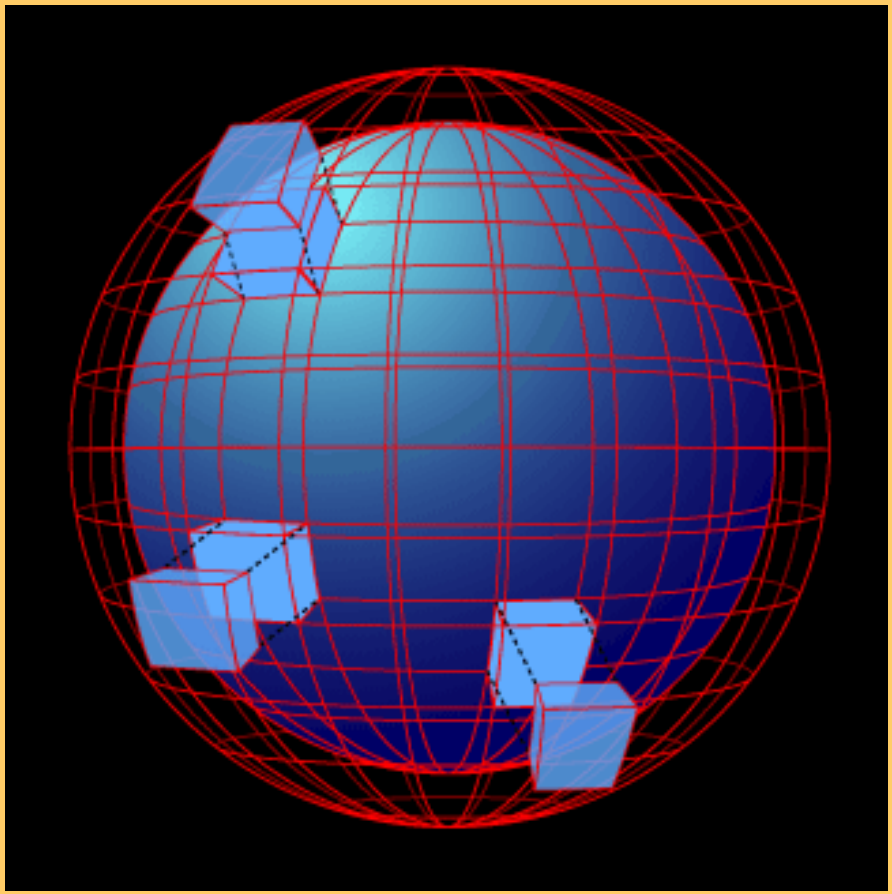
Application of the Integrated Aerobiology Modeling System to Soybean Rust Forecasting in 2006

Scott A. Isard
Penn State University

&

Joseph M. Russo
ZedX Inc.

Integrated Aerobiology Modeling System (IAMS)



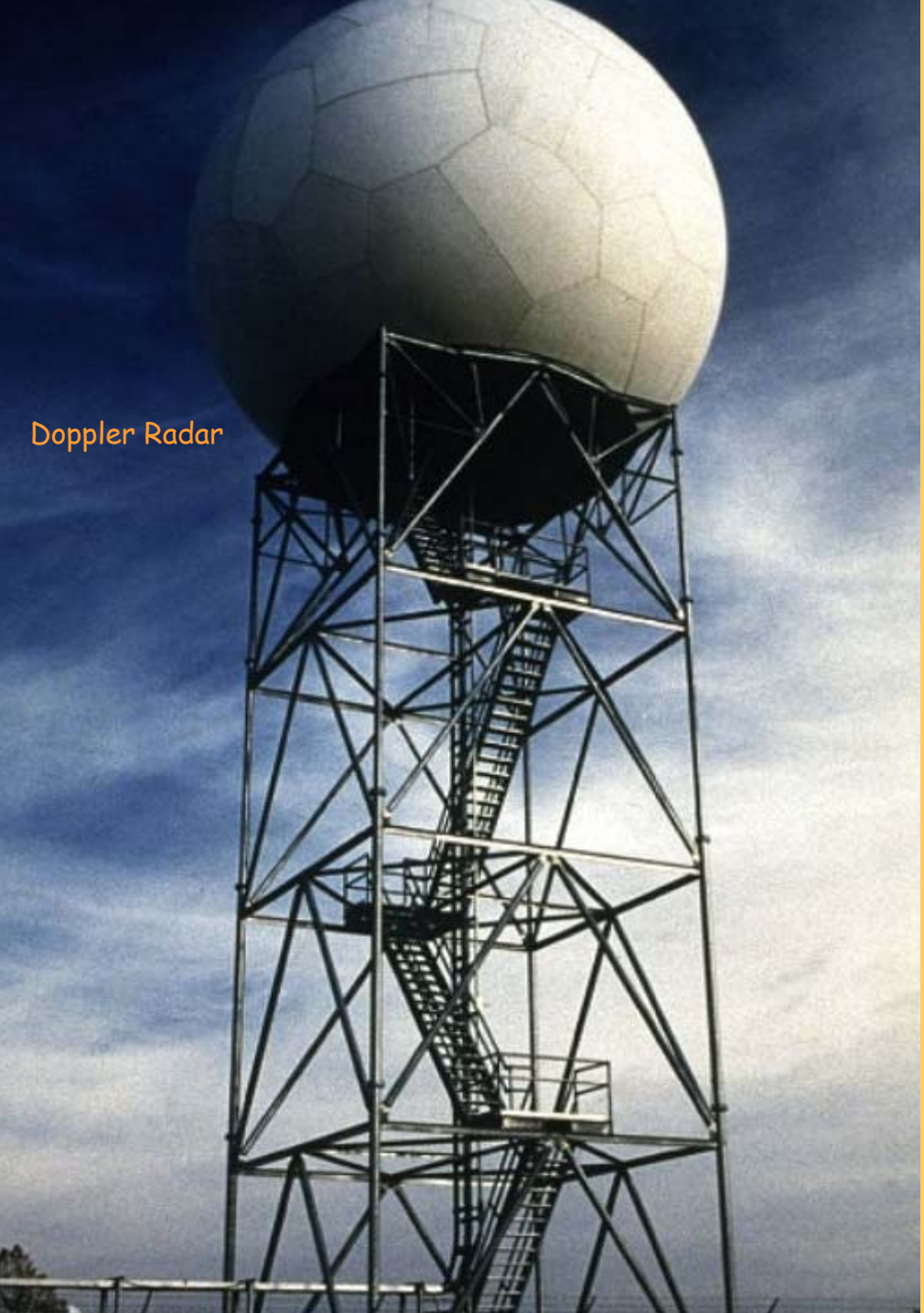
Spatial and Temporal Considerations

Model domain is 7-50 ^{O}N latitude and 60-130 ^{O}E longitude

Grid resolution = 10 km^2

Standard pressure levels (surface, 1000, 900, 800, 700, 600, 500 mb)

Model time step = 1 hr



Data Sources

NOAA Models (winds, temperatures…)
- Rapid Update Cycle Forecast (RUC)
- North American Mesoscale (NAM)
- Global Forecast System (GFS)

NEXRAD stage-4 radar (precipitation)

NOAA satellites (precipitation)

USDA crop statistics (soybean acreage for counties)

Sentinel plot and mobile scout observations (crop stage, disease severity)

Epidemiology field studies (aerobiological and epidemiological relationships)

Spore Release in Source Areas

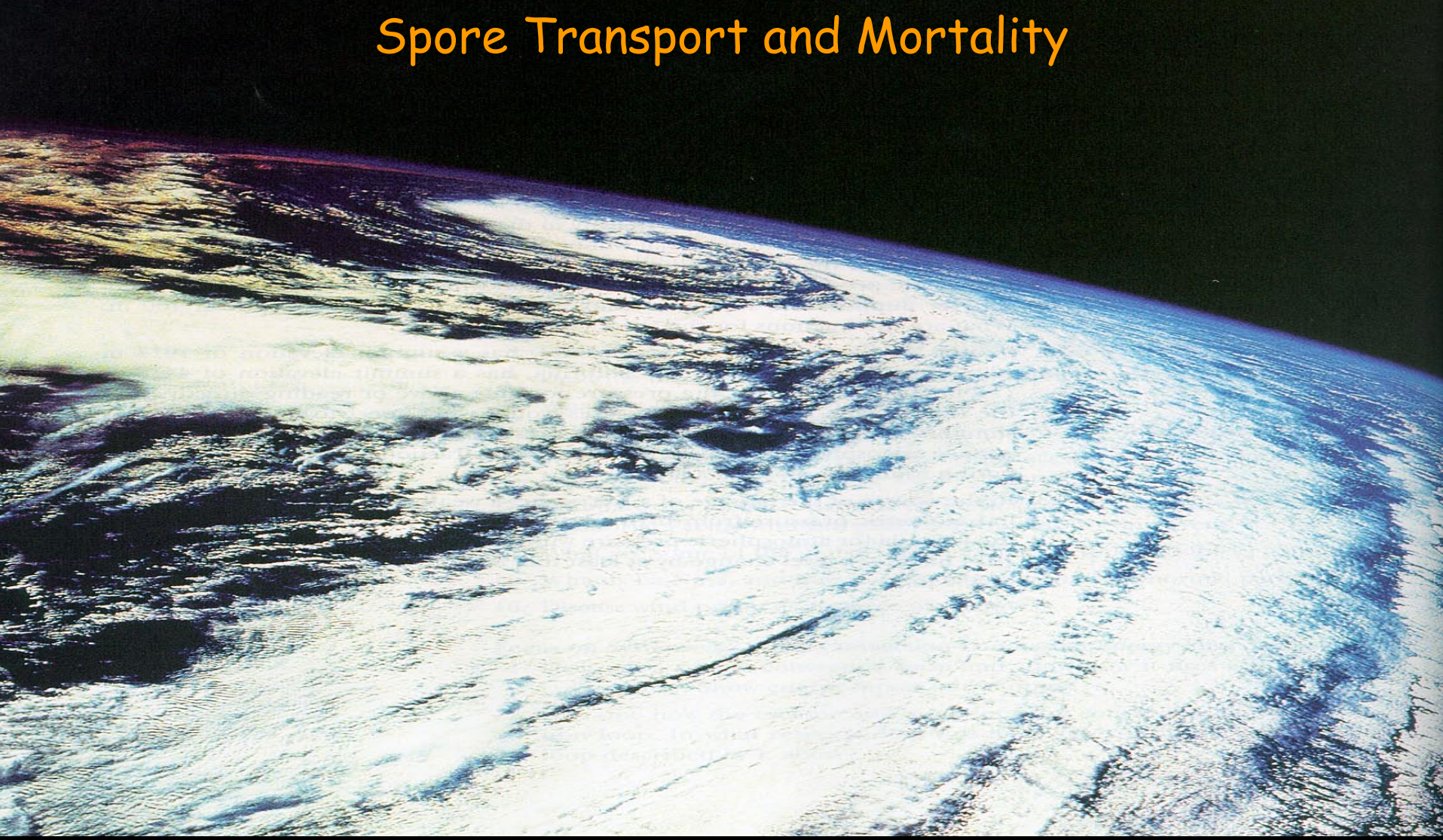
Source area, growth stage, and disease incidence and severity derived from observations

Spore release occurs over a 6 hr mid-morning to mid-afternoon period

Escape of Spores from Infected Soybean Canopy

Spore escape fraction is calculated as a function of surface wind speed

Spore Transport and Mortality



Escaped spores spread out from mid-point of a grid cell along radi comprising a 15 ^{O} arc centered on the wind vector

Transport distance along each radi equals the wind run for the period of calculation

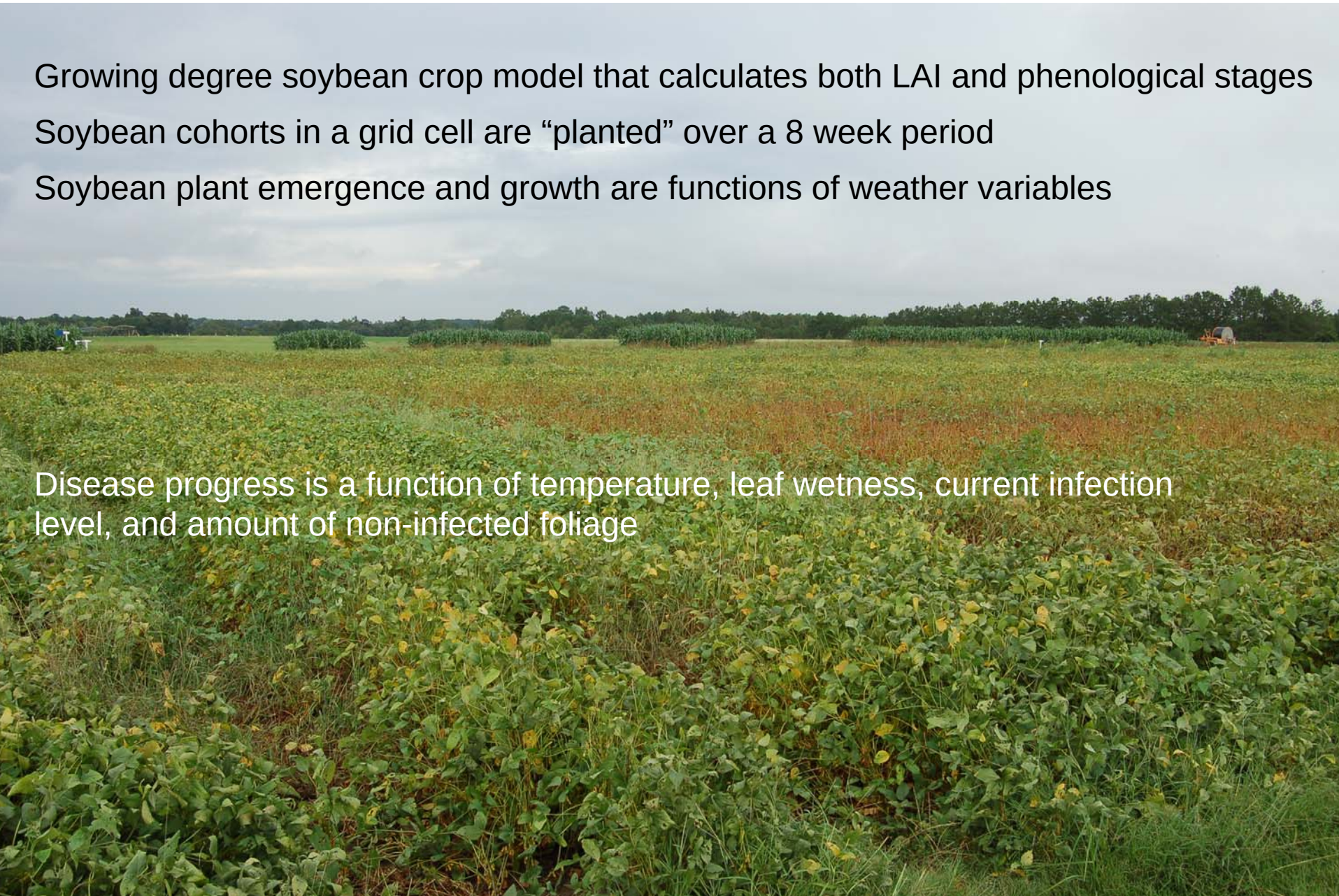
Mortality by UV radiation is proportional to cloud-adjusted, surface solar radiation

Wet and Dry Deposition of Soybean Rust Spores

Dry deposition occurs when it is not raining and is calculated as a linear function of mean downward vertical velocity for the period of calculation

Wet deposition occurs when it is raining and is proportional to the precipitation total for the period of calculation

Soybean Plant Growth and Soybean Rust Disease Submodels



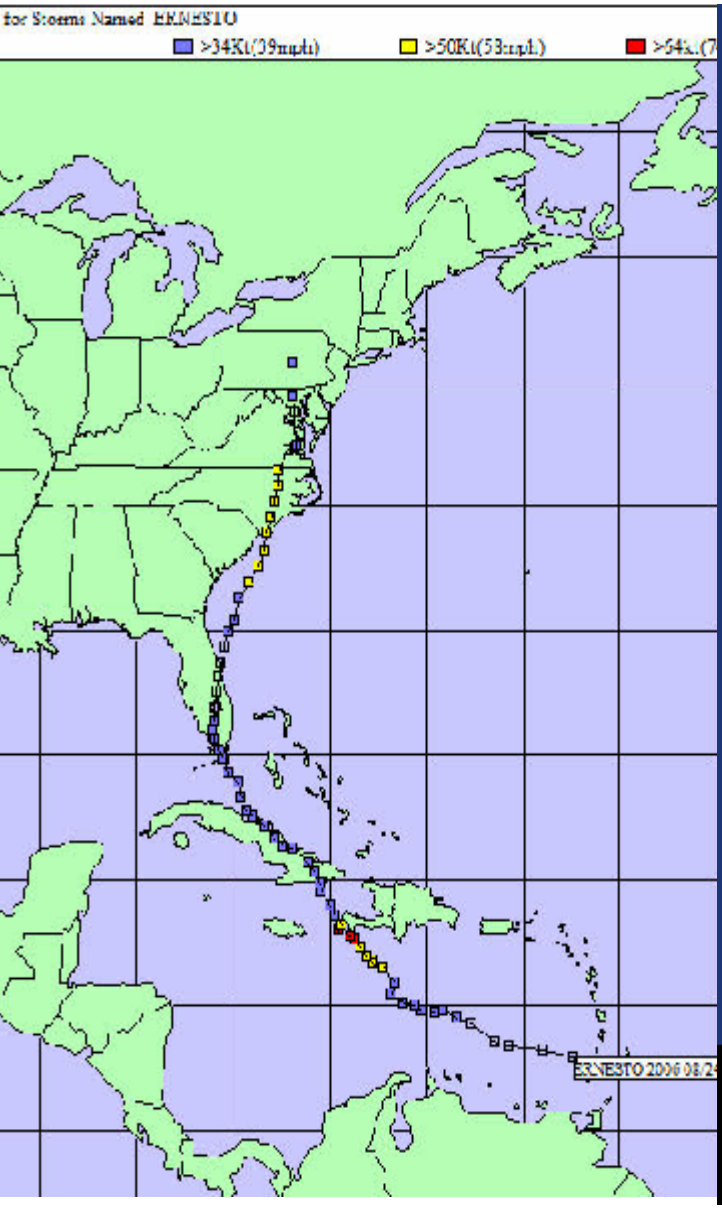
Growing degree soybean crop model that calculates both LAI and phenological stages

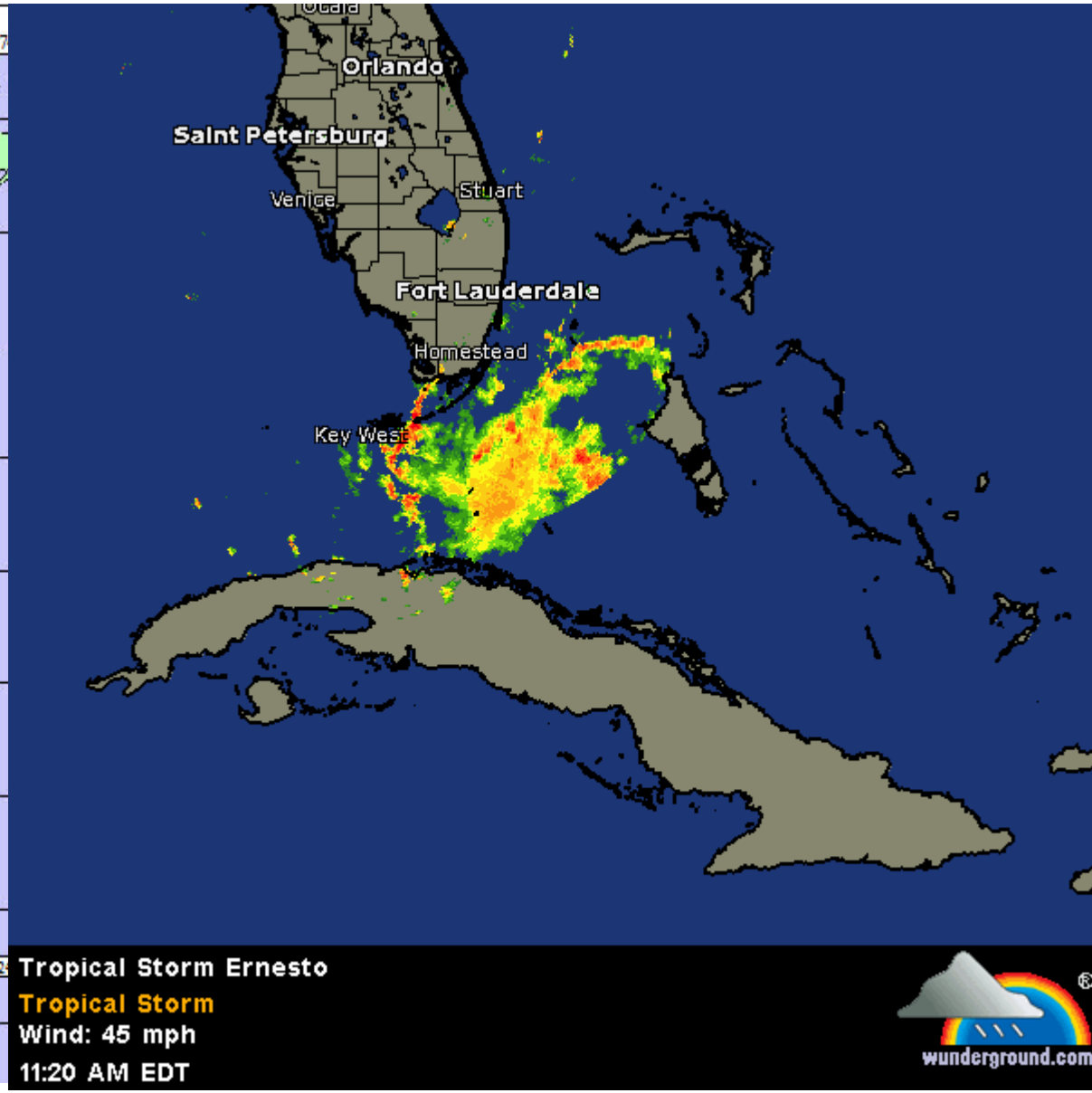
Soybean cohorts in a grid cell are “planted” over a 8 week period

Soybean plant emergence and growth are functions of weather variables

Disease progress is a function of temperature, leaf wetness, current infection level, and amount of non-infected foliage

Tropical Storm Ernesto (Aug 29-Sept 2)

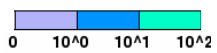




Integrated Aerobiology Model System

August 31, 2006

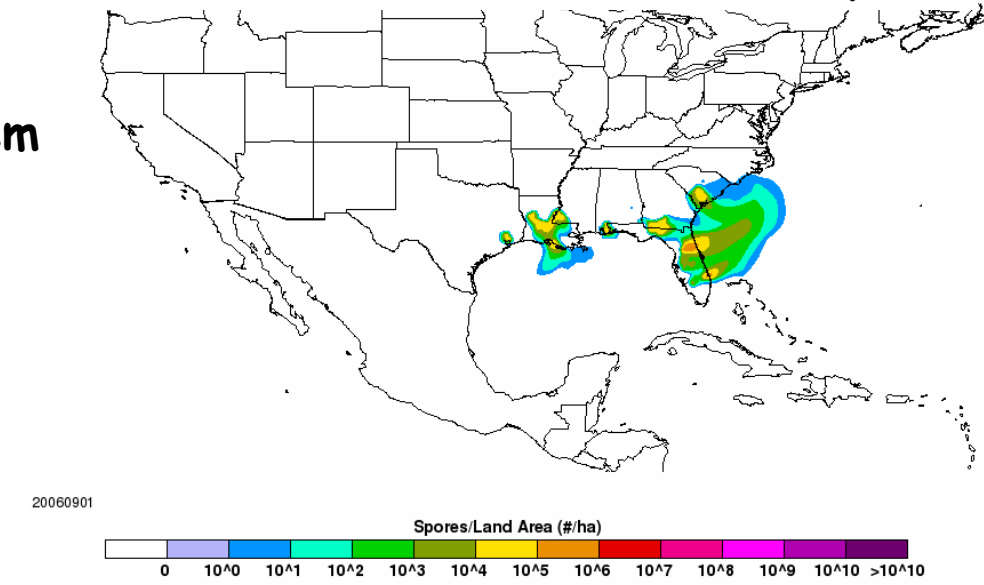
Map Interpretation



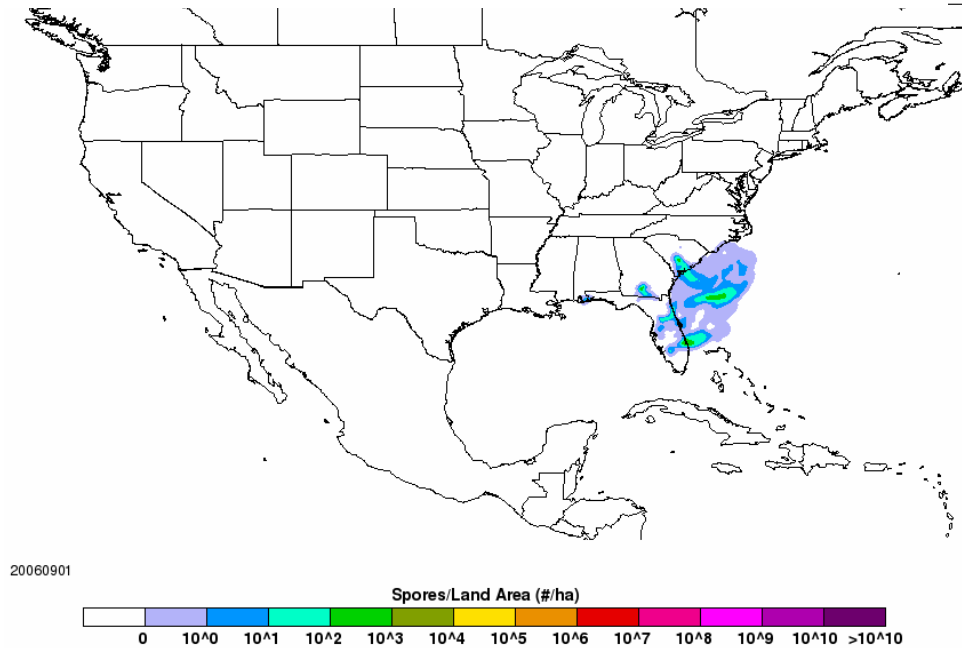
Extremely low levels

Moderate levels

Aerial Concentration of Viable SBR Spores



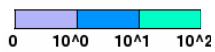
Daily Wet Deposition of Viable SBR Spores



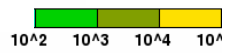
Integrated Aerobiology Model System

September 1, 2006

Map Interpretation

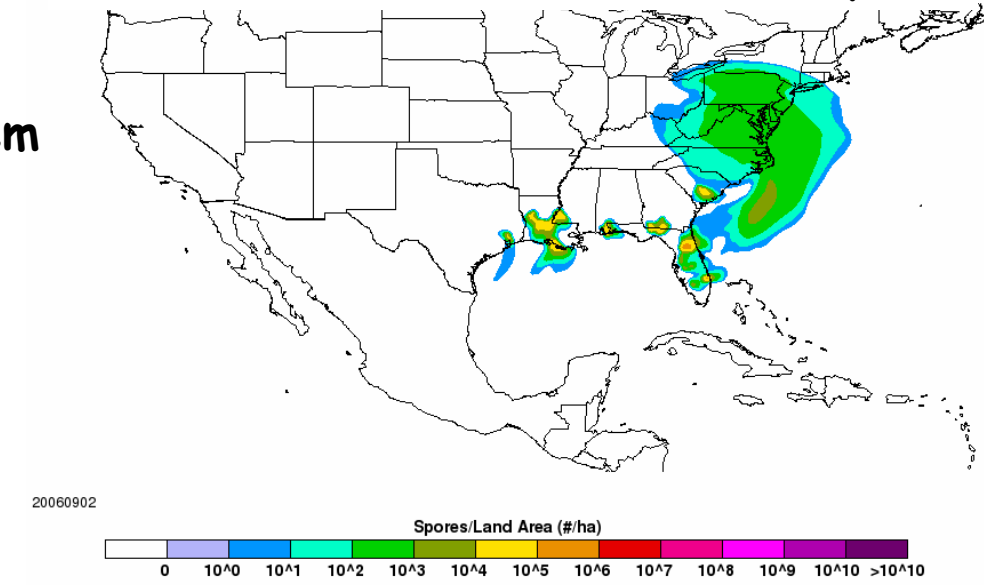


Extremely low levels

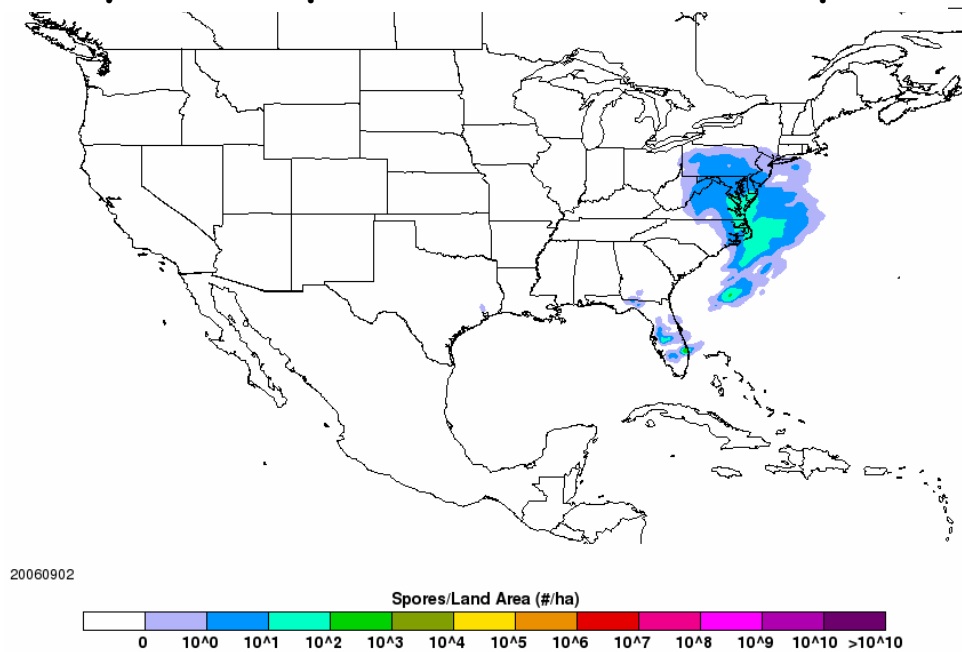


Moderate levels

Aerial Concentration of Viable SBR Spores



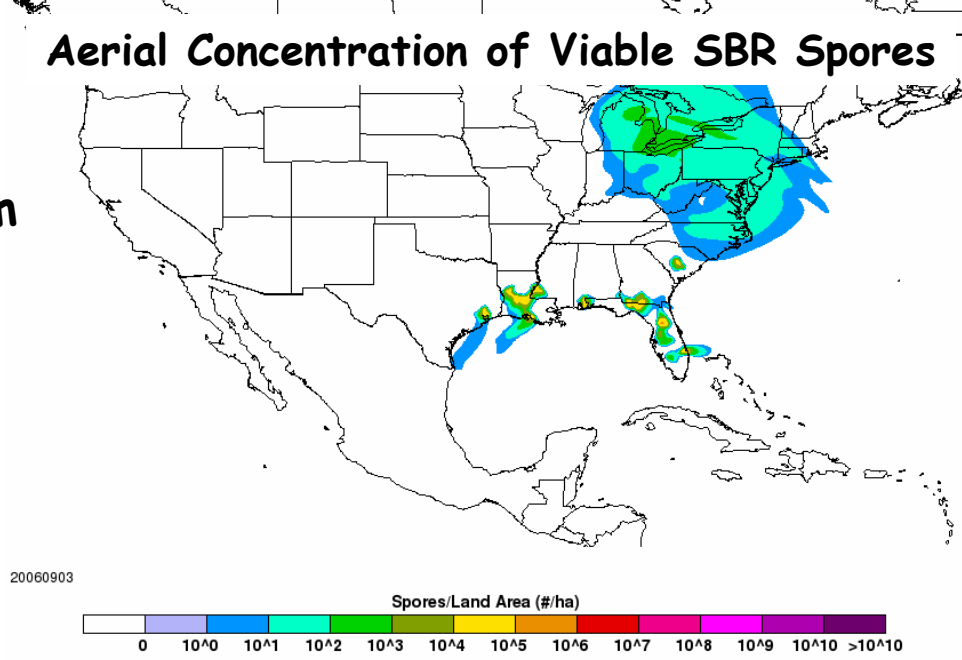
Daily Wet Deposition of Viable SBR Spores



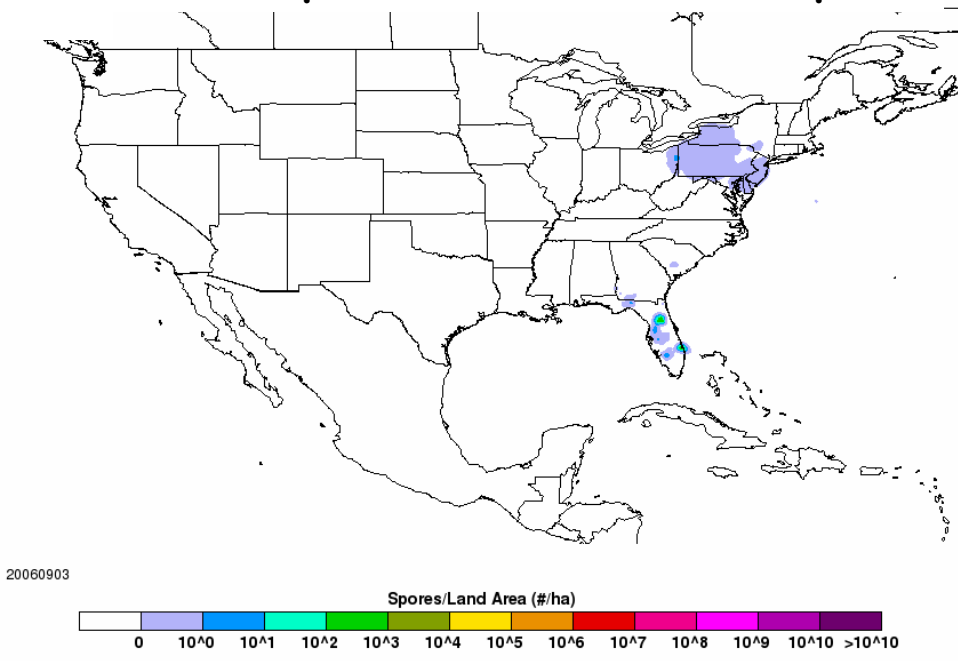
Integrated Aerobiology Model System

September 2, 2006

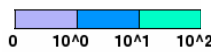
Aerial Concentration of Viable SBR Spores



Daily Wet Deposition of Viable SBR Spores



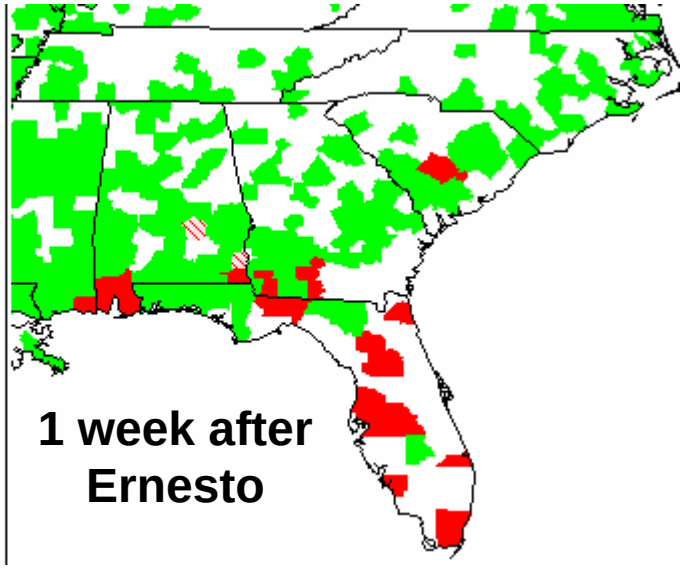
Map Interpretation

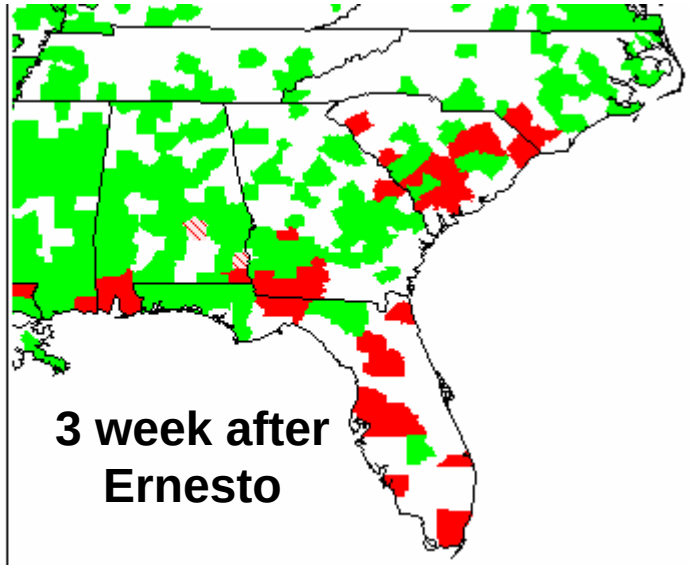


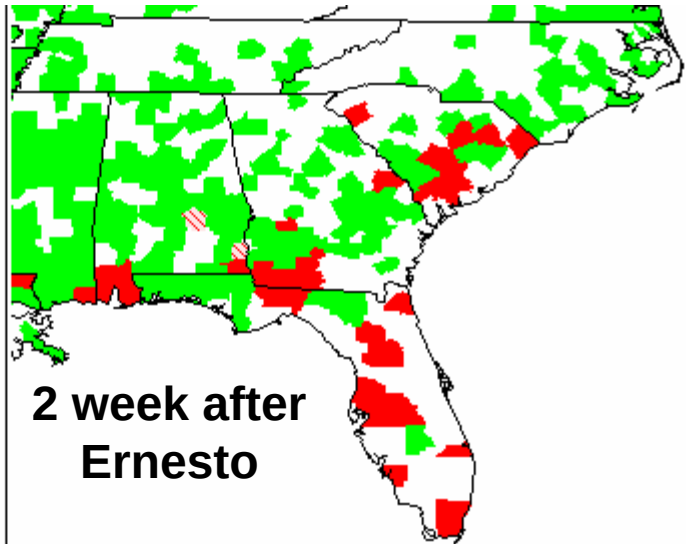
Extremely low levels

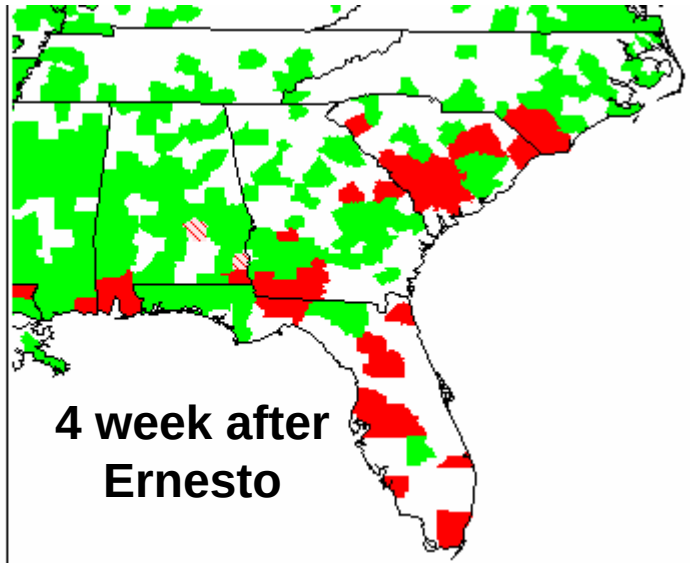
Moderate levels

Soybean Rust Observation Maps

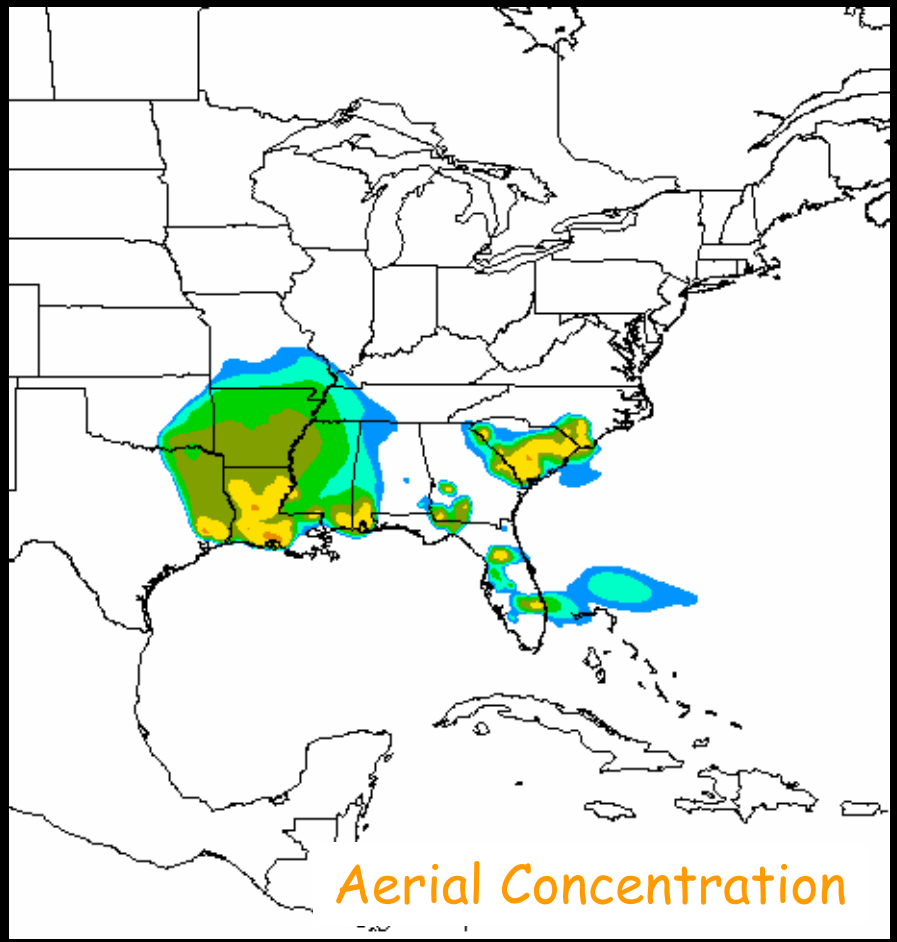


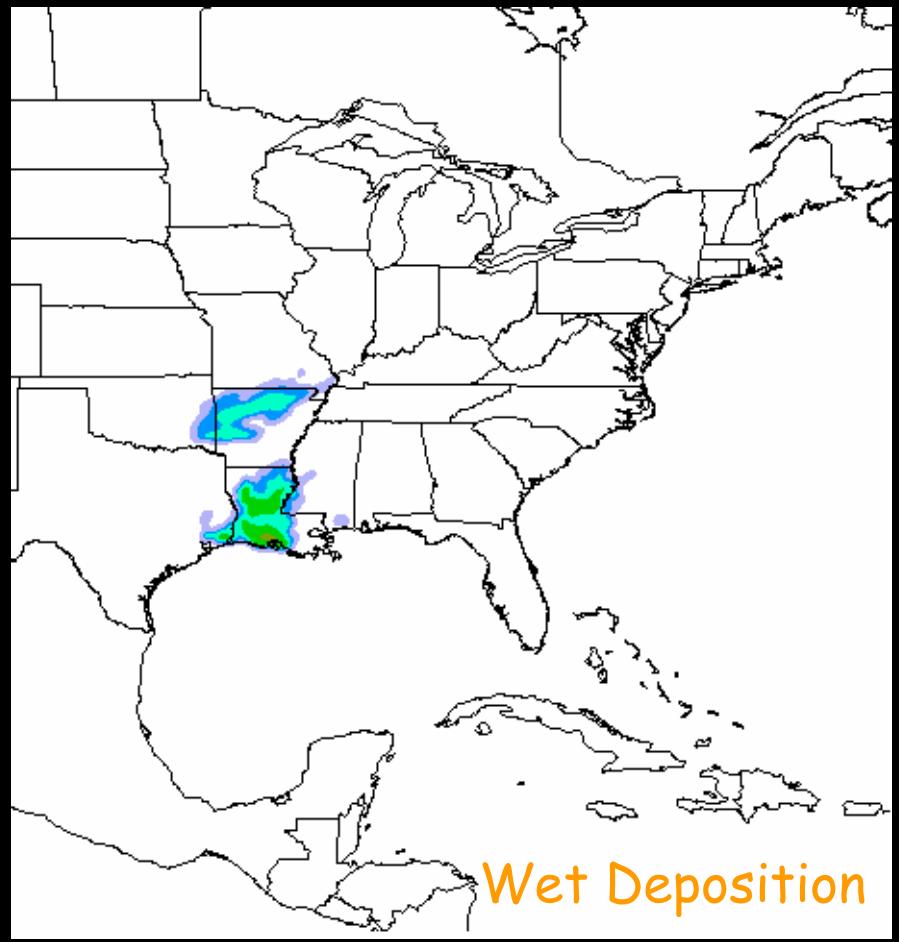


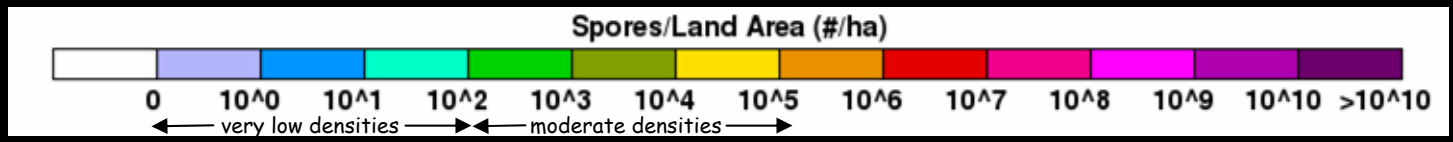




Integrated Aerobiology Modeling System Output

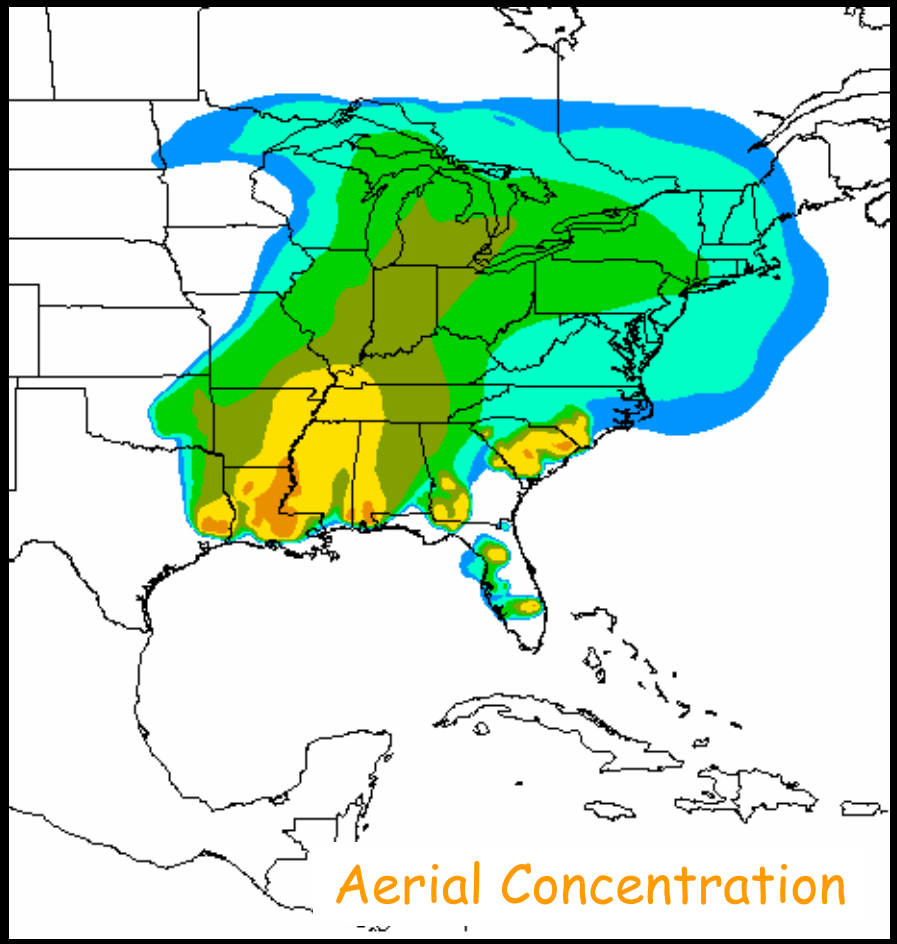


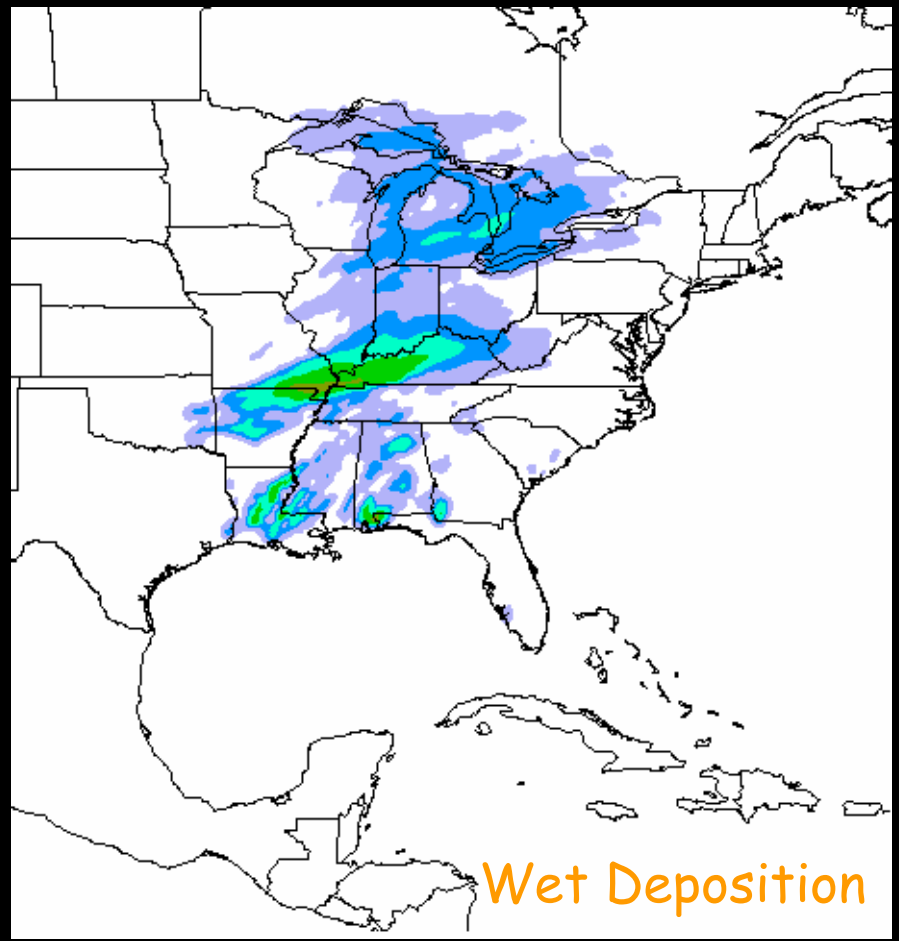


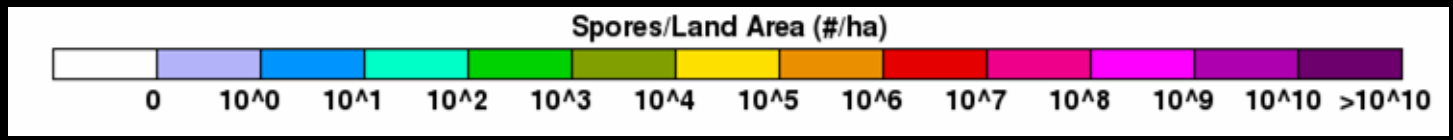


22 September 2006

Integrated Aerobiology Modeling System Output

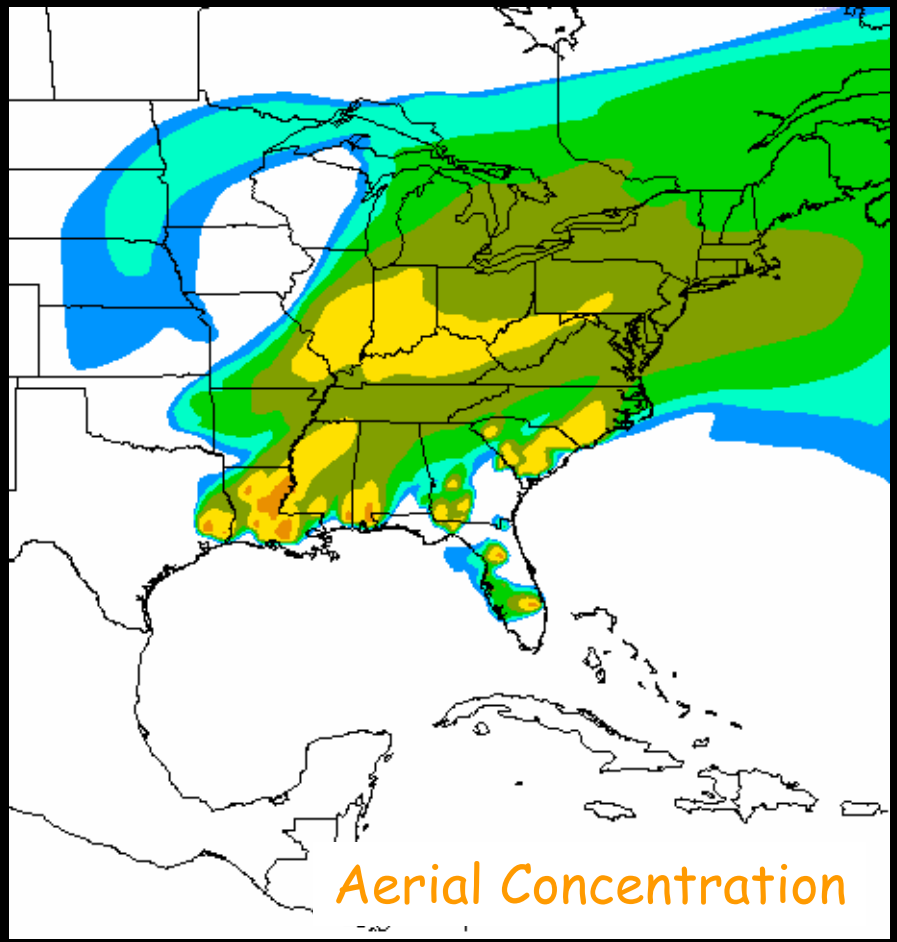


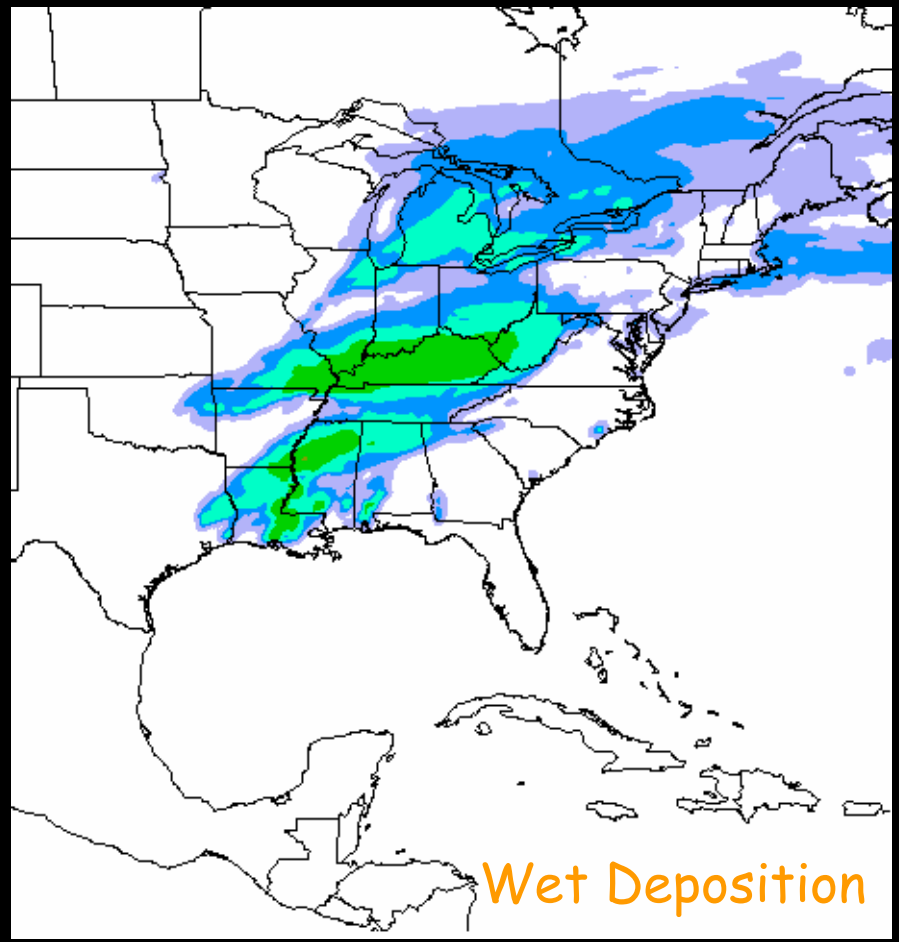


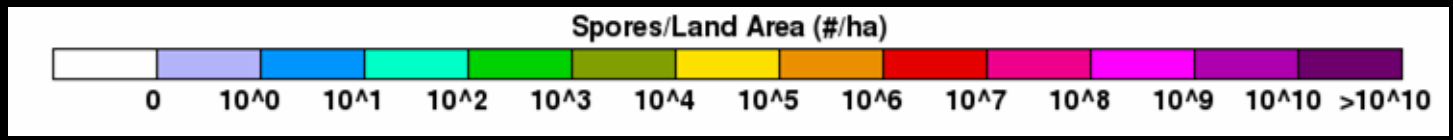


23 September 2006

Integrated Aerobiology Modeling System Output

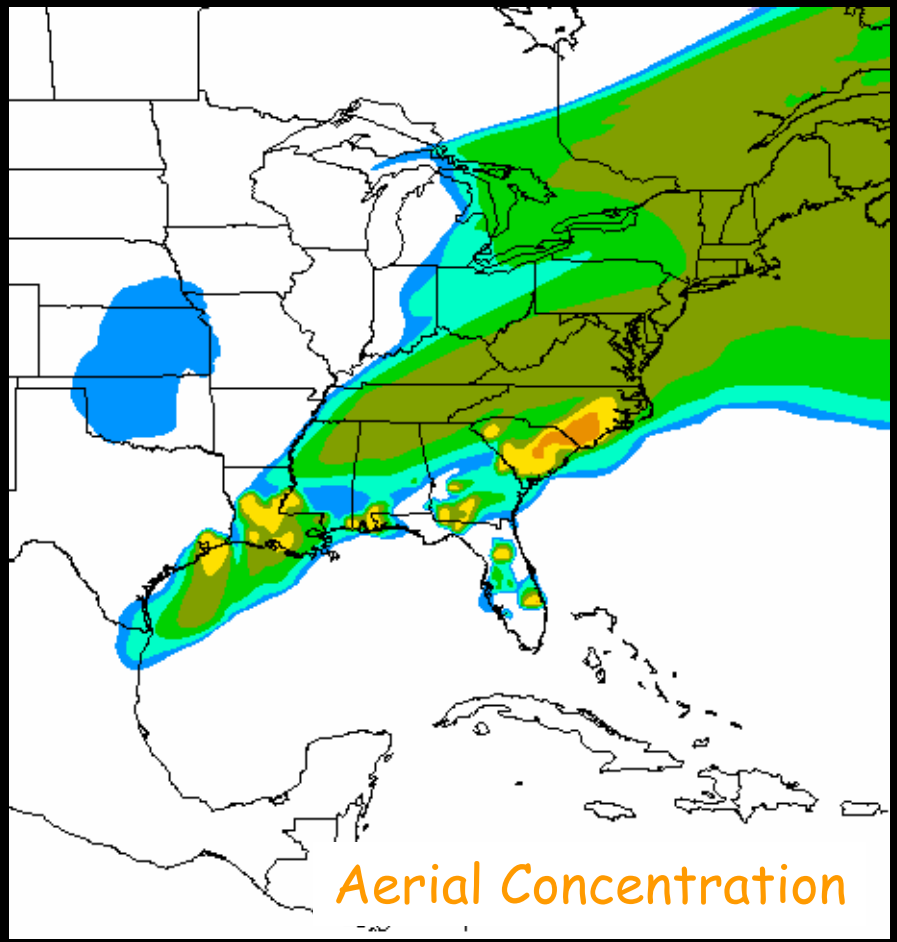


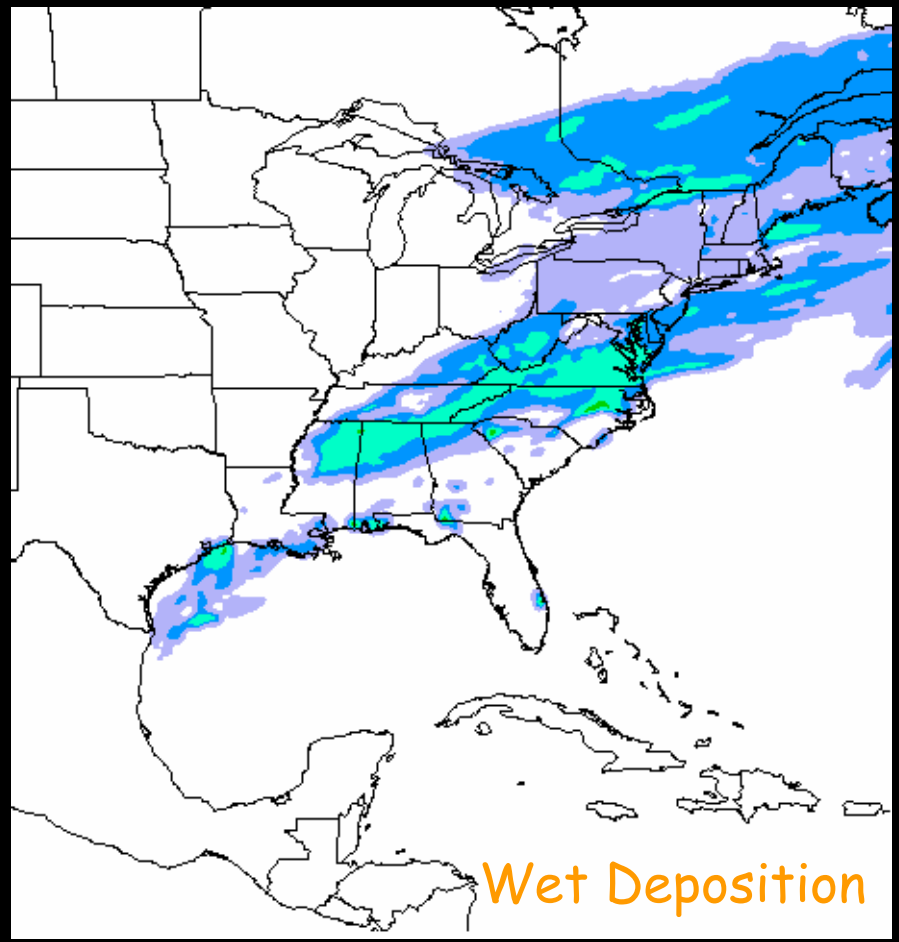


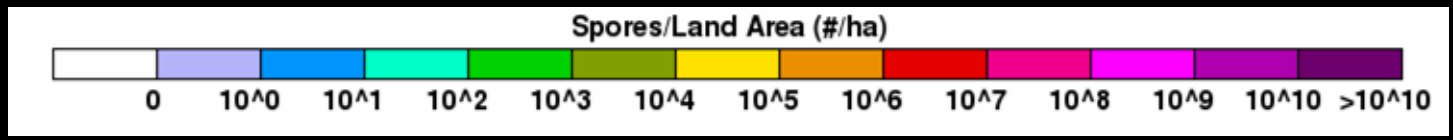


24 September 2006

Integrated Aerobiology Modeling System Output



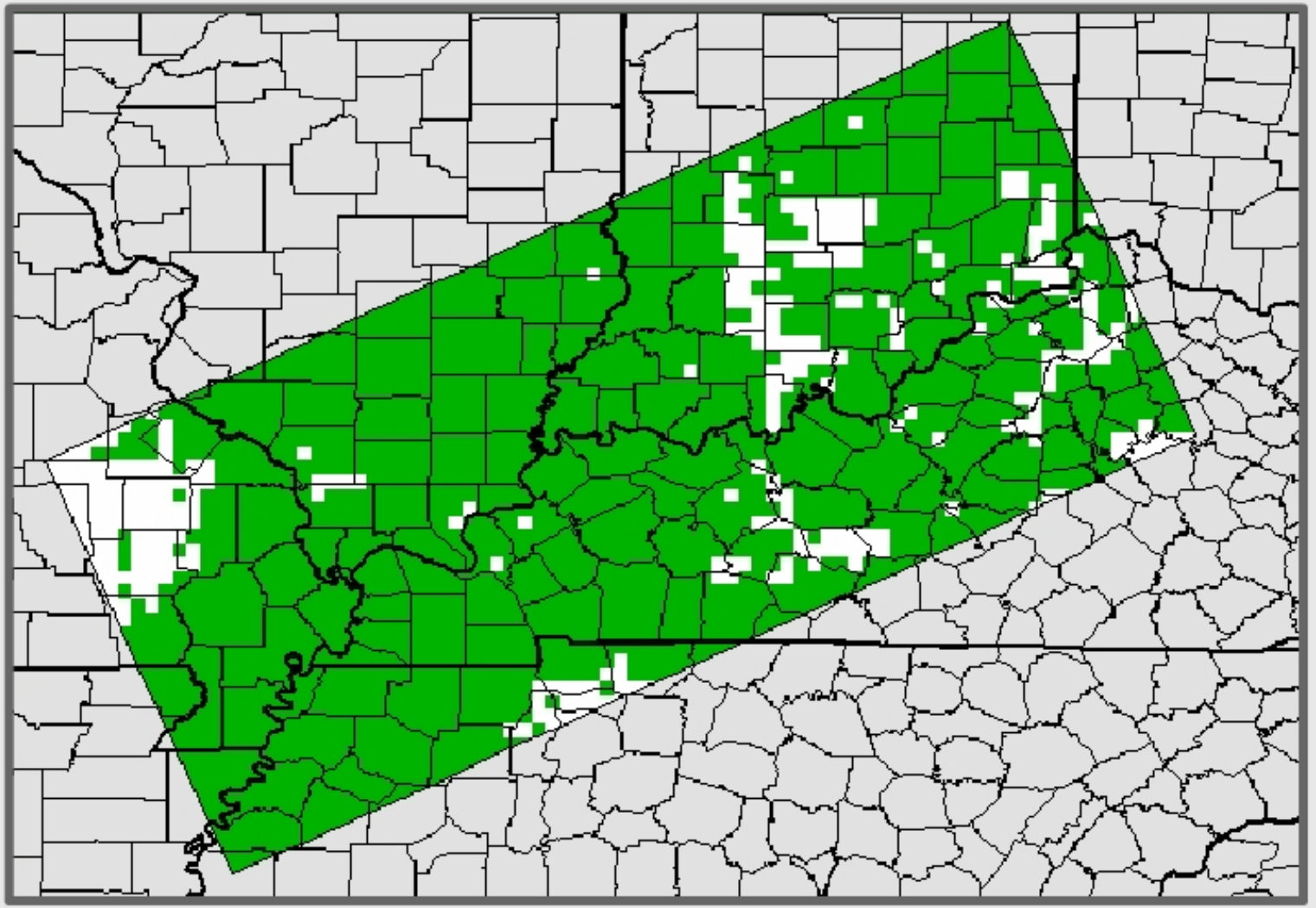




25 September 2006

Sentinel Plants - early to mid reproductive stage ("infection ready")

Aerobiology Model Predictions of Soybean Rust Disease Severity



Days on the calendar below are clickable

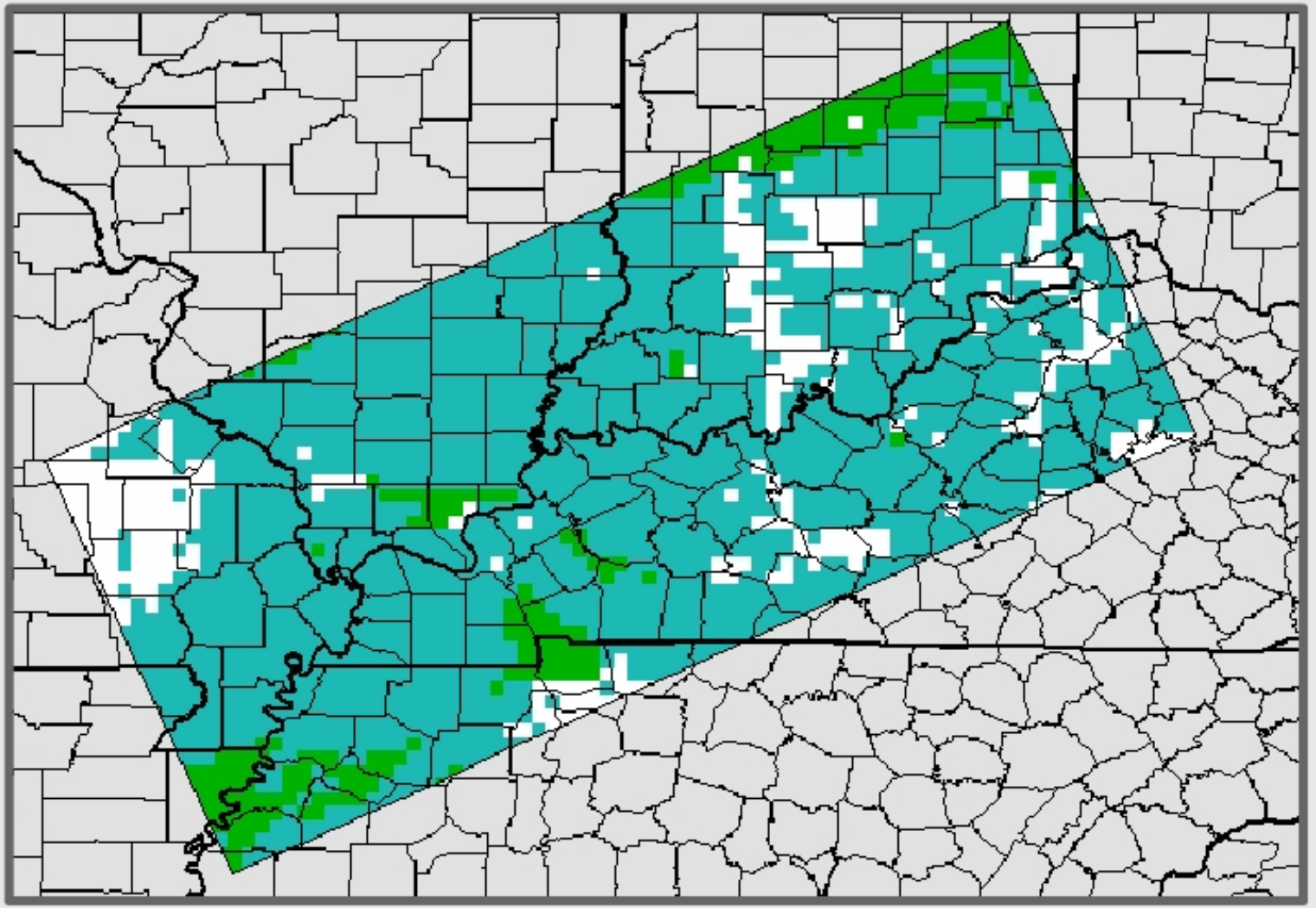
21 Sep	22 Sep	23 Sep	24 Sep	25 Sep	26 Sep	27 Sep	28 Sep	29 Sep	30 Sep	01 Oct	02 Oct	03 Oct	04 Oct	05 Oct	06 Oct	07 Oct	08 Oct	09 Oct	10 Oct
11 Oct	12 Oct	13 Oct	14 Oct	15 Oct	16 Oct	17 Oct	18 Oct	19 Oct	20 Oct	21 Oct	22 Oct	23 Oct	24 Oct	25 Oct	26 Oct	27 Oct	28 Oct	29 Oct	30 Oct	31 Oct

Disease Severity

no crop	no spores	latent	0-20%	21-40%	41-60%	61-80%	81-100%

"Sentinel Plants" on which viable spores were deposited showed latent infections the following week.

Aerobiology Model Predictions of Soybean Rust Disease Severity



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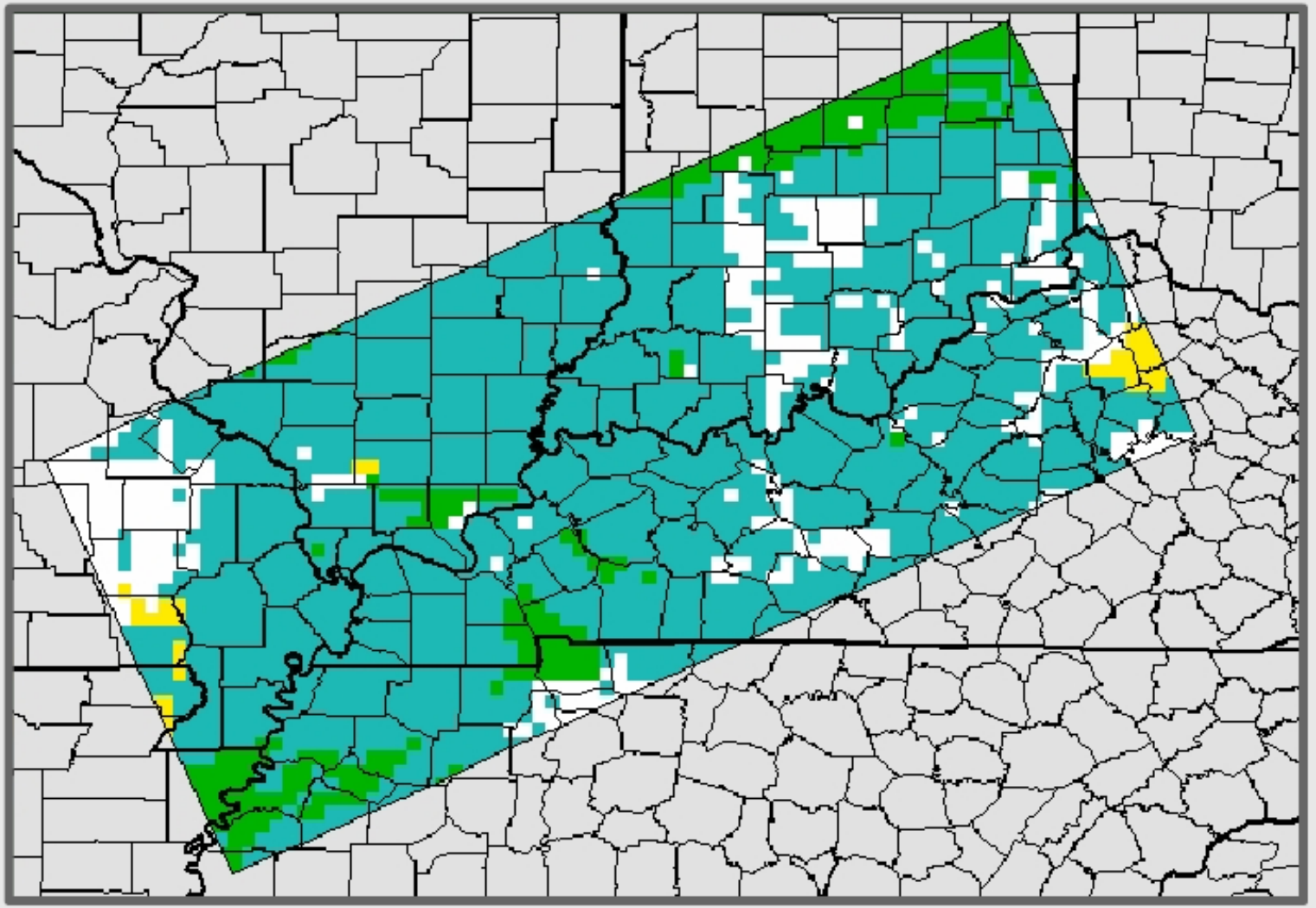
Disease Severity

no crop	no spores	latent	0-20%	21-40%	41-60%	61-80%	81-100%

The IAMS indicates that the first symptoms of soybean rust would become visible in a few counties scattered across the lower Ohio River Valley on the 11th day after spore deposition

Aerobiology Model Predictions of Soybean Rust Disease Severity



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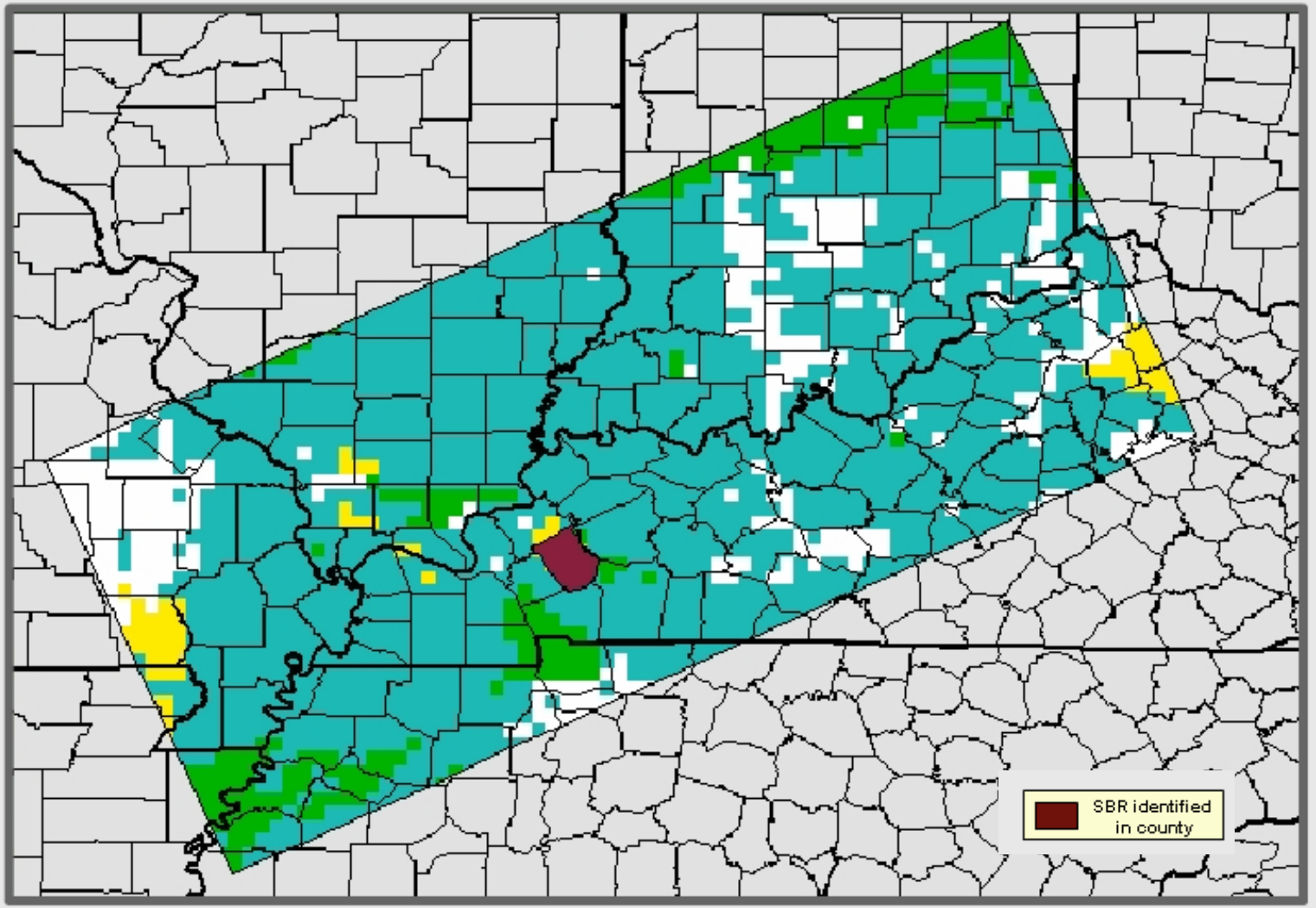
Disease Severity

no crop	no spores	latent	0-20%	21-40%	41-60%	61-80%	81-100%

The first discovery of soybean rust in the region was made on the 13th day after deposition

Aerobiology Model Predictions of Soybean Rust Disease Severity



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Disease Severity

no crop	no spores	latent	0-20%	21-40%	41-60%	61-80%	81-100%

One week later, soybean rust had been discovered in numerous counties within the region.

The model predicted pustules would become visible before infections were actually found.

Possible reasons for the discrepancy are:

1-Use of "sentinel plants" in IAMS

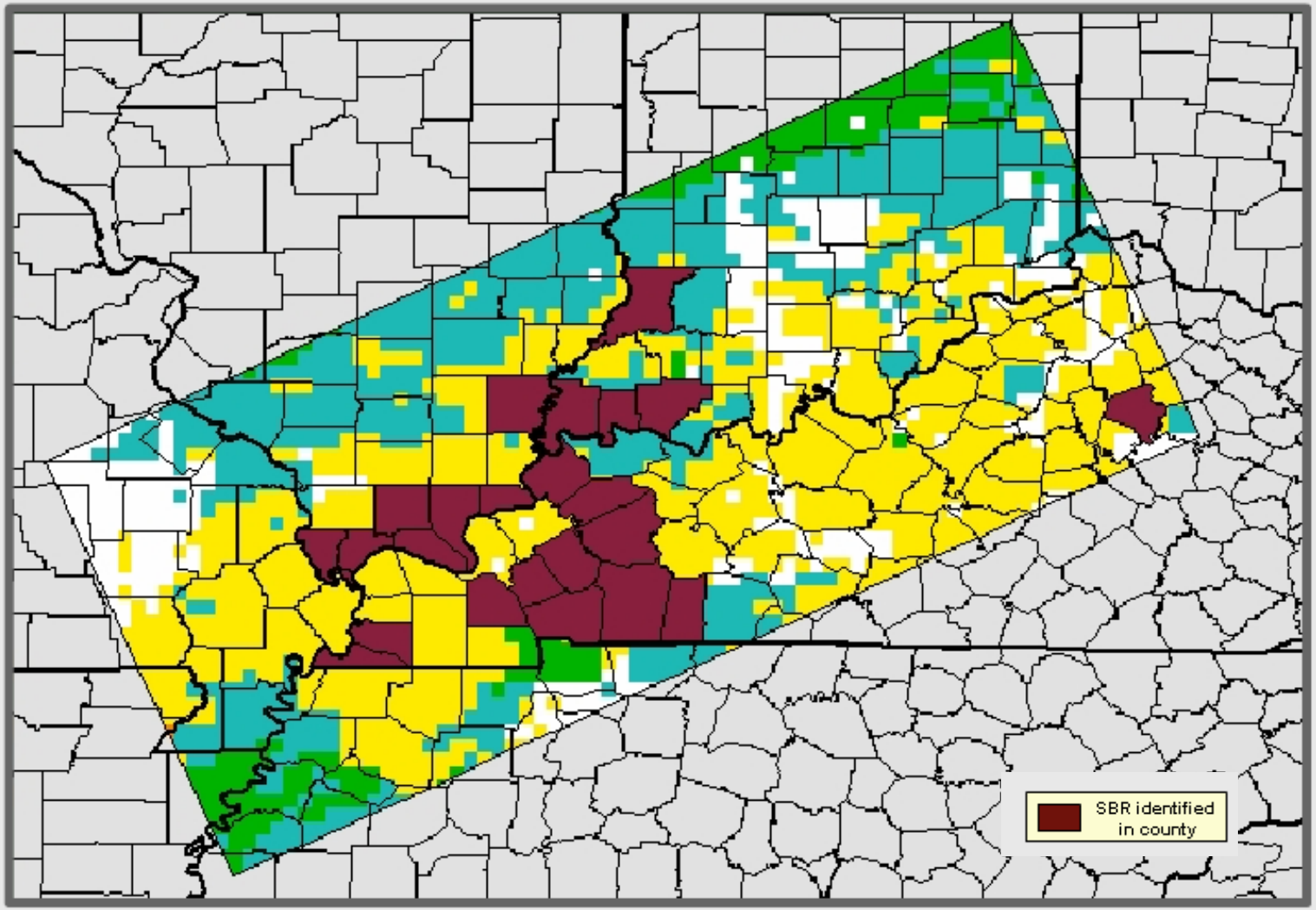
2-Paucity of green soybean plants in field

3-Little urgency to scout

4-Model simplifications

5-Lack of model validation

Aerobiology Model Predictions of Soybean Rust Disease Severity



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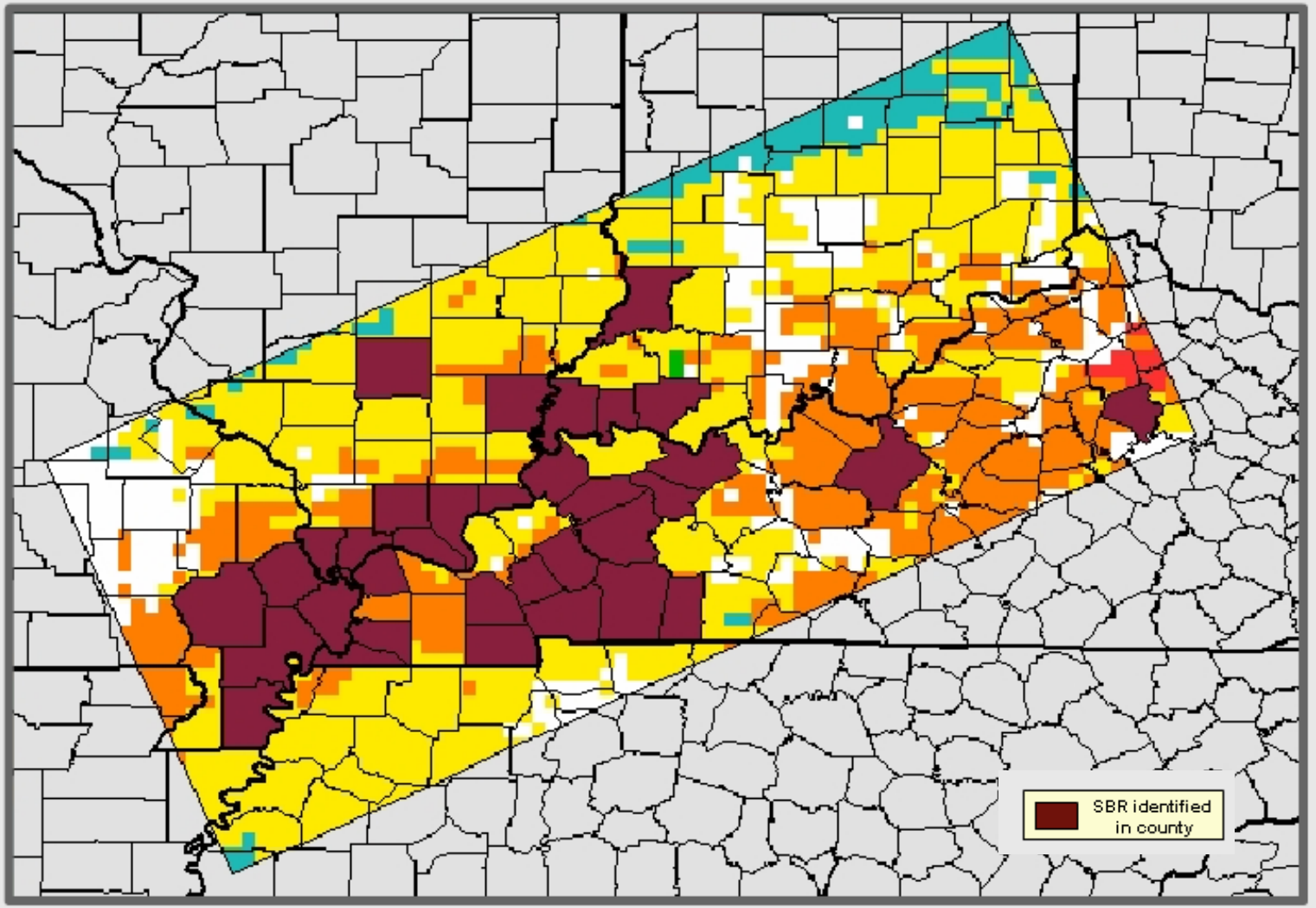
Disease Severity

no crop	no spores	latent	0-20%	21-40%	41-60%	61-80%	81-100%

One month after soybean rust spores had been deposited, symptoms of the disease had been discovered in 36 counties in the region

Aerobiology Model Predictions of Soybean Rust Disease Severity



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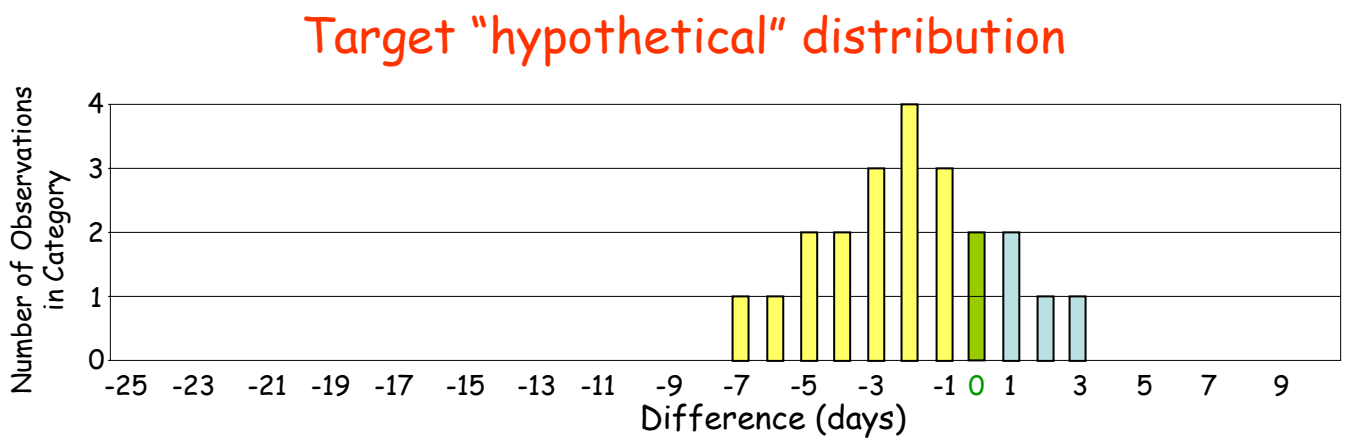
Disease Severity

no crop	no spores	latent	0-20%	21-40%	41-60%	61-80%	81-100%

Evaluation of Aerobiology Model

IAMS Model
Prediction of Symptom
Appearance
vs
Discovery

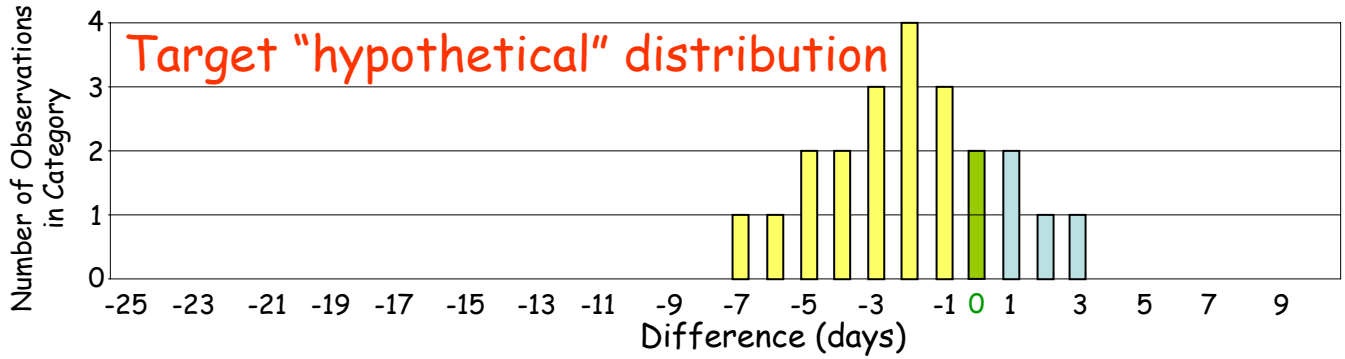


Each observation in the histogram above represents the first positive find in a county.

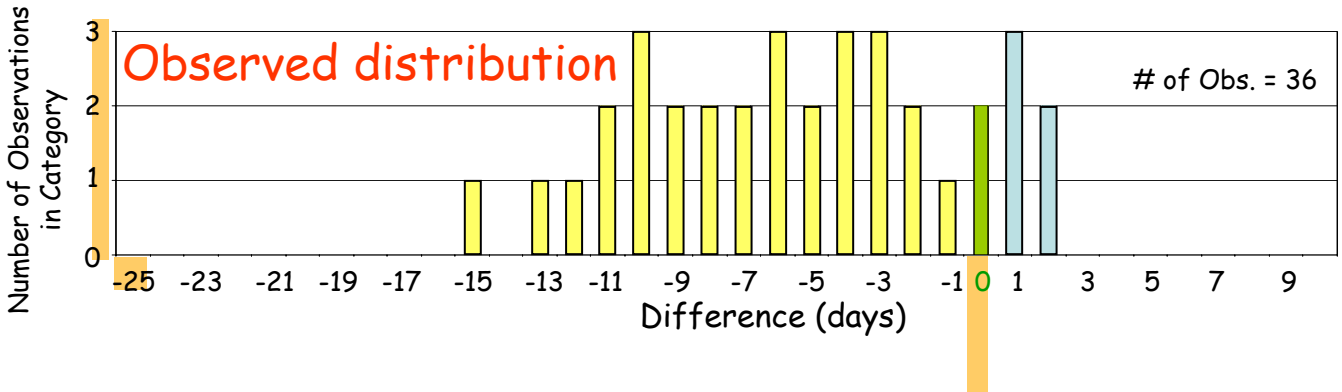
Negative differences (yellow bars) in the histogram indicate that the model predicts symptom appearance prior to observation (i.e., for 1 county the model was 7 days ahead, for 1 county the model was 6 days ahead, for 2 counties it was 5 days ahead…. Positive differences (observations precede model predictions are represented by blue bars.

Evaluation of Aerobiology Model Using Data from 23-24 September 2006 Soybean Rust Spore Incursion into the Lower Ohio River Valley (KY, IN, IL & MO)

IAMS Model Prediction of Symptom Appearance vs Discovery

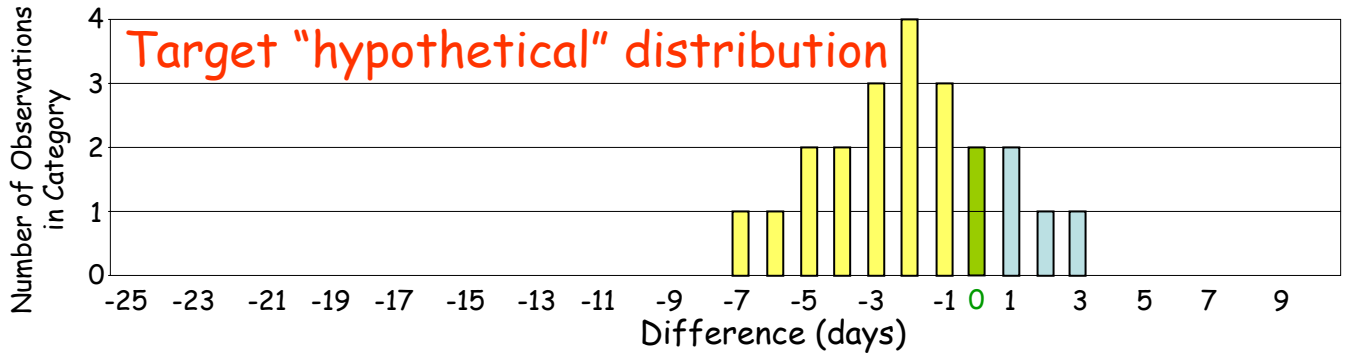


IAMS Model Prediction of Symptom Appearance vs Discovery

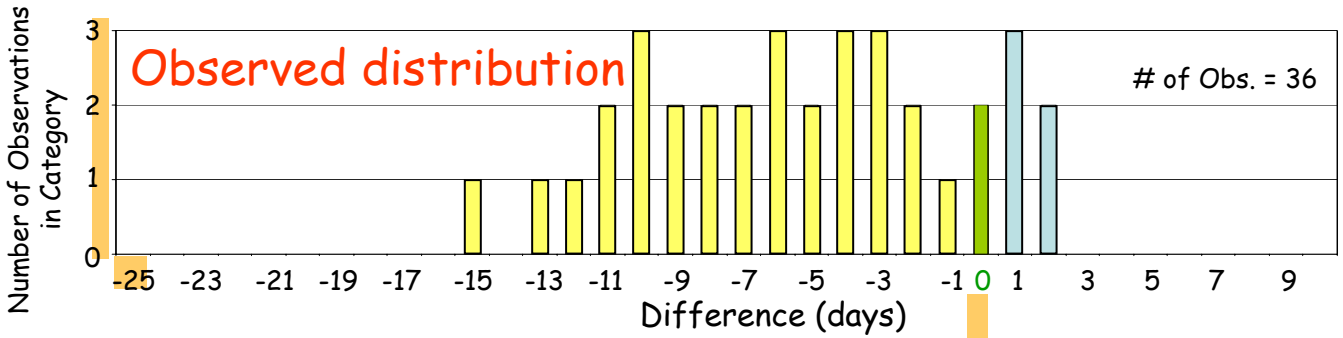


Difference Between Prediction and When County Turned Red on USDA Website

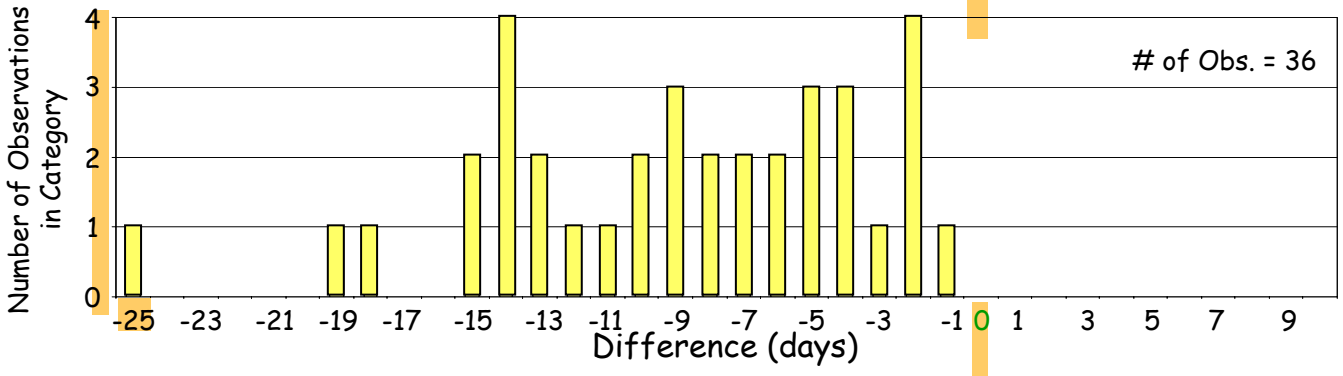
IAMS Model Prediction of Symptom Appearance vs Discovery



IAMS Model Prediction of Symptom Appearance vs Discovery



IAMS Model Prediction of Symptom Appearance vs Confirmation



Anticipated Changes in Aerobiology Model for 2007

- Sentinel soybean plant ("infection-ready") – risk assessment tool for mobile scouting.
- Improved canopy escape parameter – function of wind speed and crop stage (results of field research in FL).
- Automated soybean growth stage "biofix" for sentinel plot model runs.
- Adjustment of infection development for drought and extreme temperatures.
- Expanded multiple model ensemble approach with updated training for human interpretation.