

Forecasting the spread of soybean rust using a nested climate model

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Outlines

- Prediction model system
 - Prediction experiments
 - Validation
- Analyses of disease spread pattern
 - West Kentucky hot spot
 - Mississippi route
- 2006 climate conditions for rust dispersion and looking ahead
 - “Wind hole”
 - Rainfall/humidity
 - Future model improvements

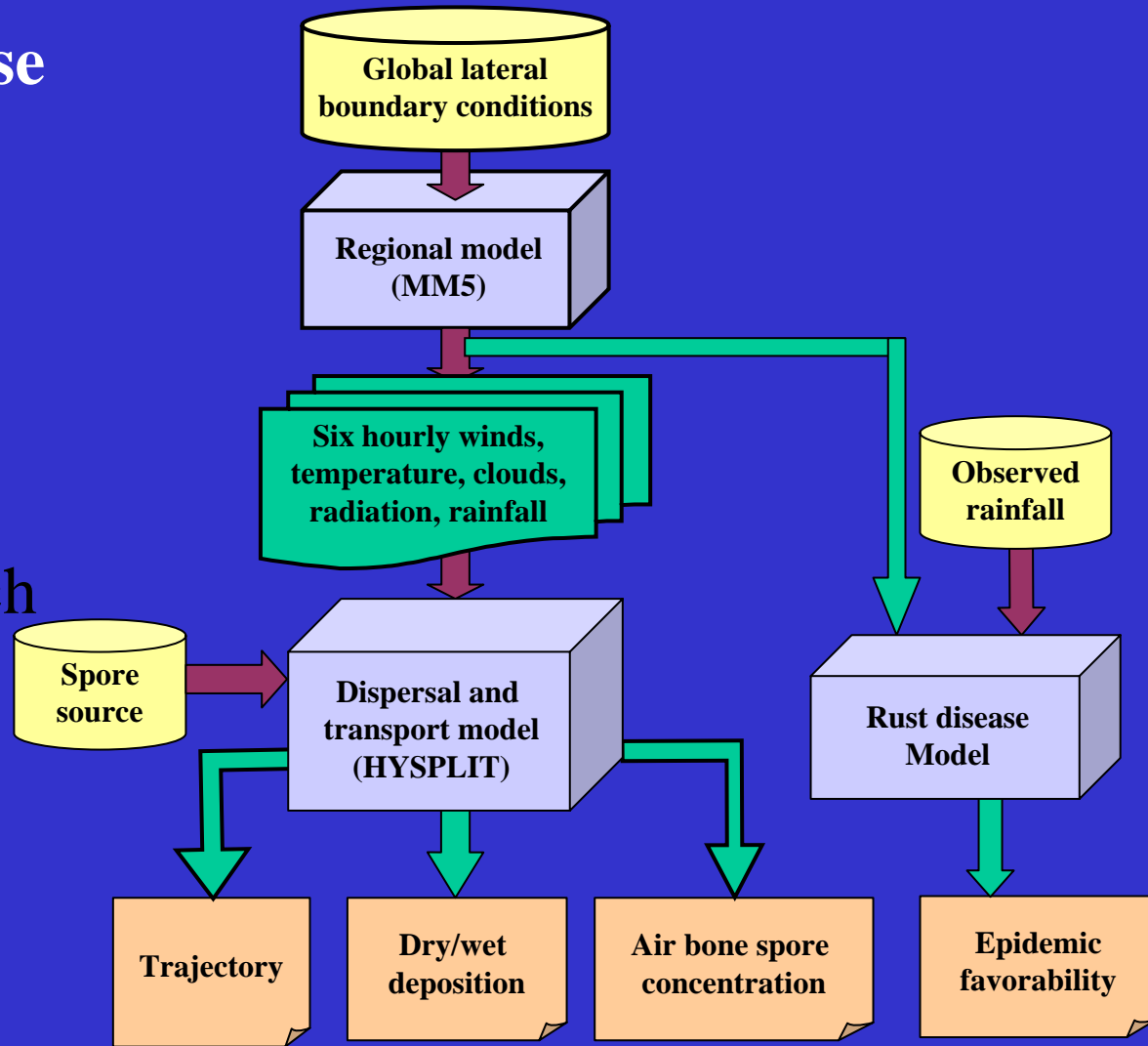
SLU/ISU Rust prediction model – An climate-dispersal-disease integrated system

Global model – Scripps Institution of Oceanography

MM5 – National Center for Atmospheric Research

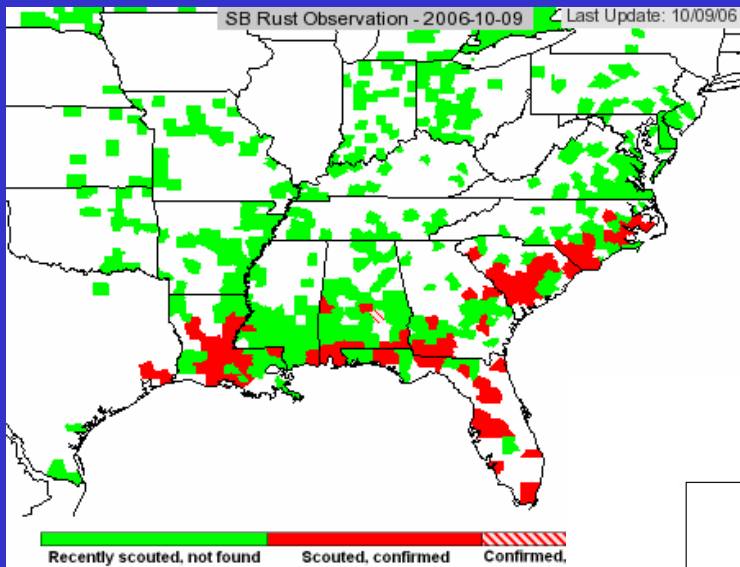
HYSPLIT – NOAA Air Resource Lab

Disease model – Iowa State University

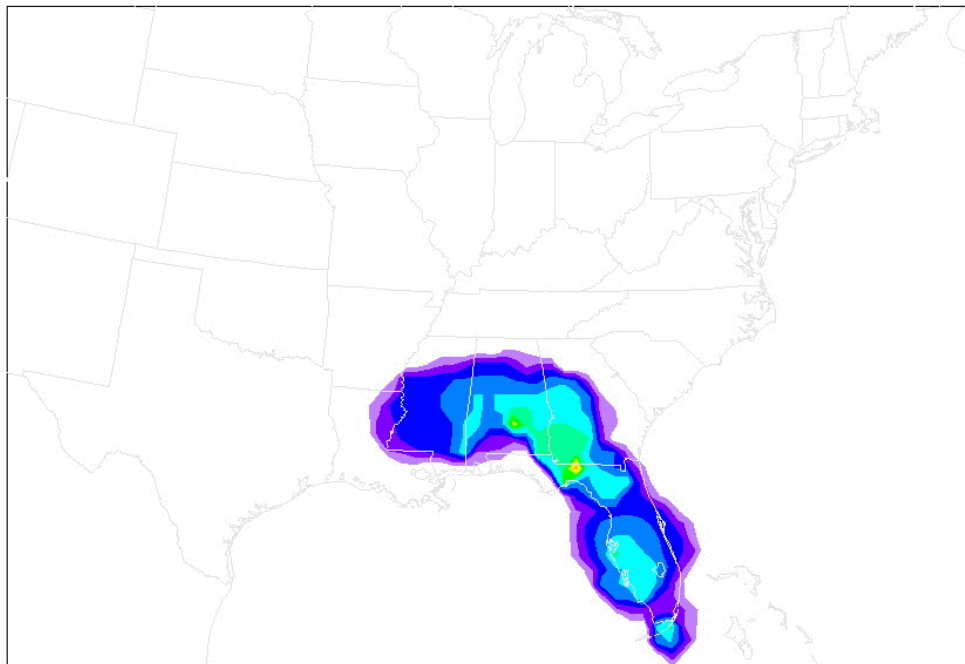


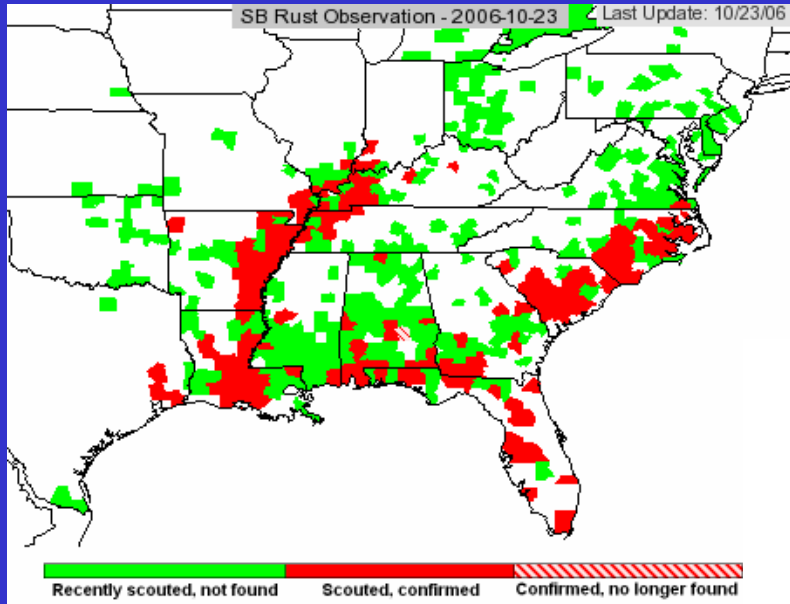
The Coupled Dispersal Model

- ✓ **Runs in trajectory or concentration mode**
 - trajectory – forward/backward tracking
 - concentration – airborne and at surface
- ✓ **Treats spores as particles of plumes**
 - spores passively move in with atmosphere once lifted
 - spore plumes dilute, split, merge according to advection and diffusion physics
- ✓ **Considers dry and wet deposition**
 - gravitational settling
 - rainfall washout
- ✓ **Incorporates simple aerobiological viability criteria**
 - UV radiation, temperature

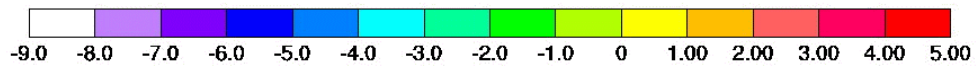
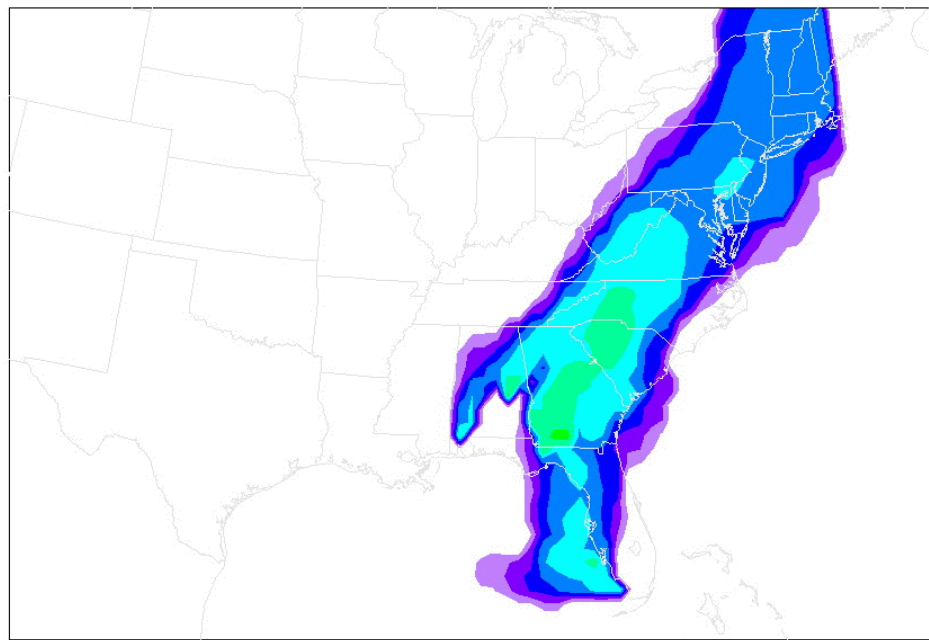


Weekly forecast airborne spore concentration during 6/24-7/29

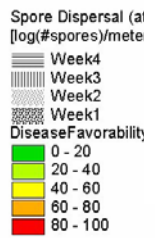
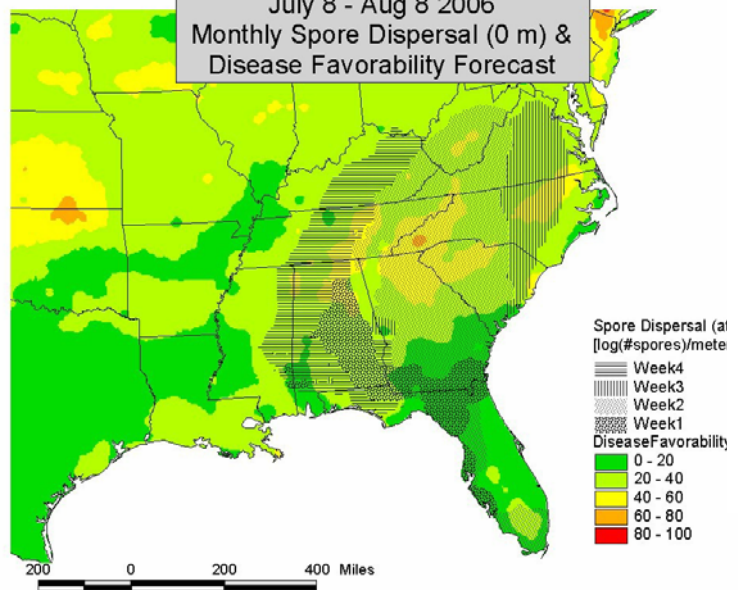




Weekly forecast ground spore concentration during 7/1-8/11

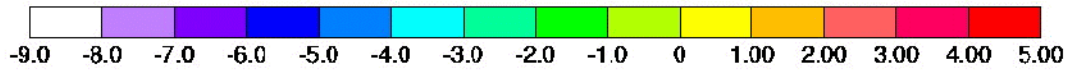
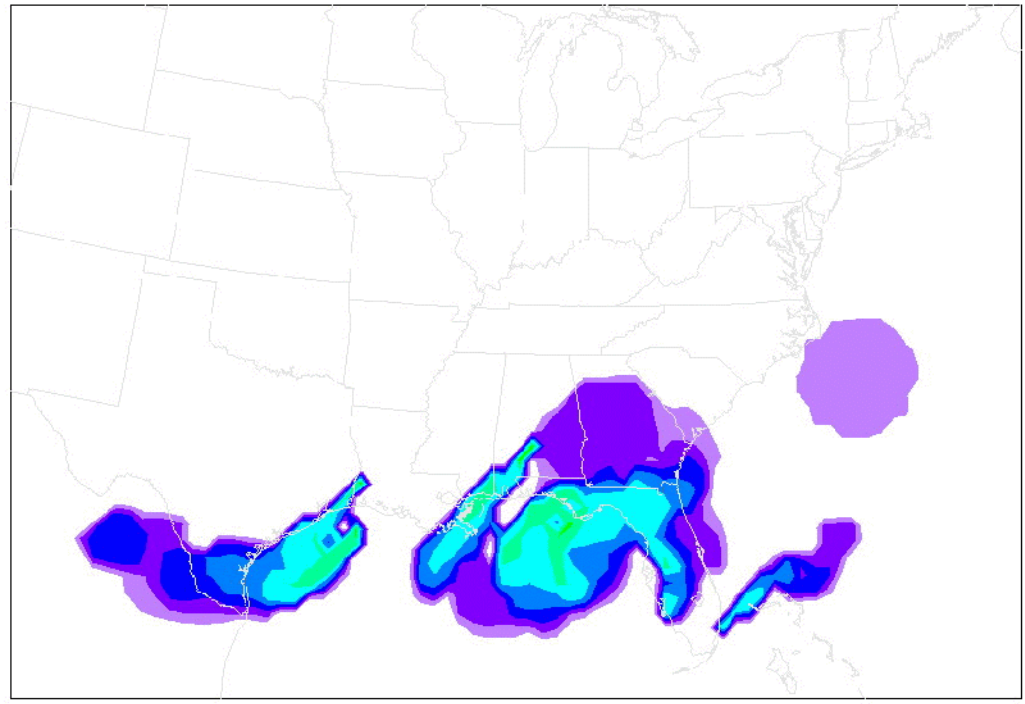
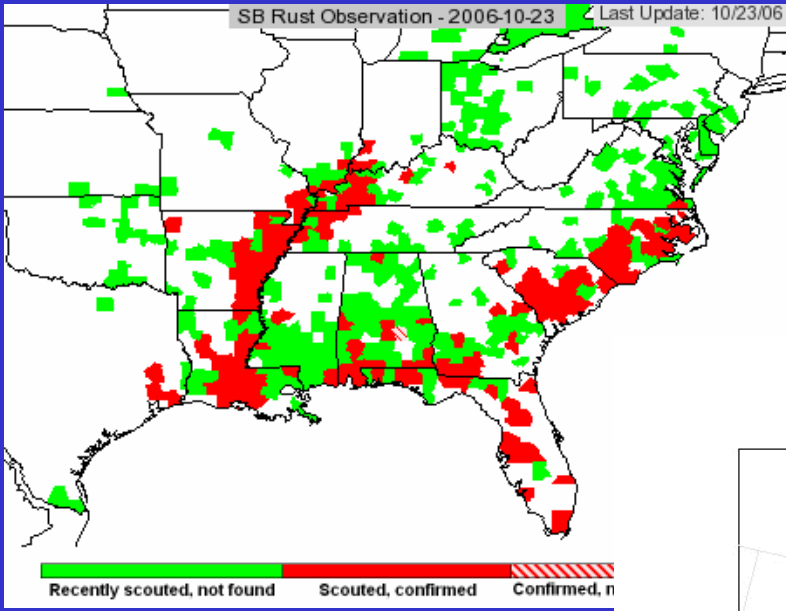


July 8 - Aug 8 2006
Monthly Spore Dispersal (0 m) &
Disease Favorability Forecast

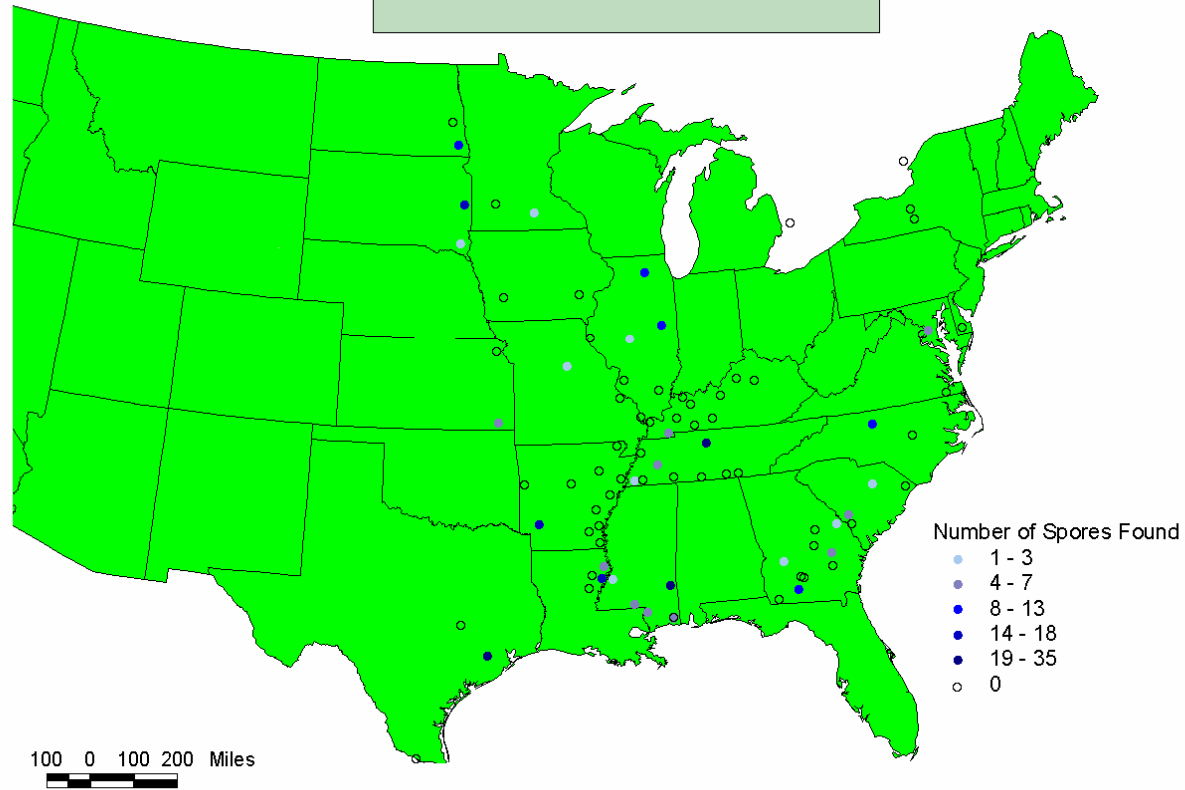


SB Rust Observation - 2006-10-23 Last Update: 10/23/06

Weekly forecast of ground spore concentration during 8/12-9/22



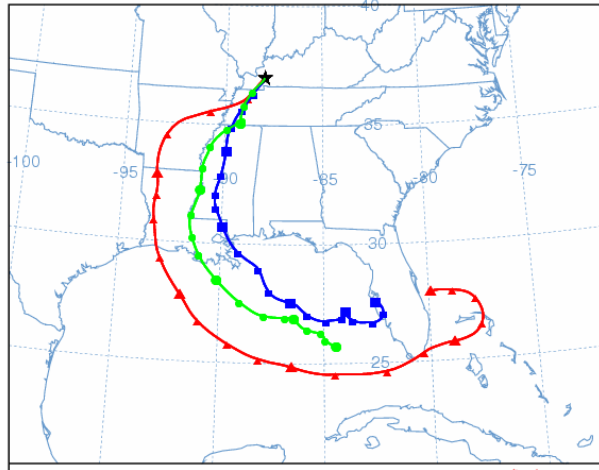
SporeTrap Total Spores Found



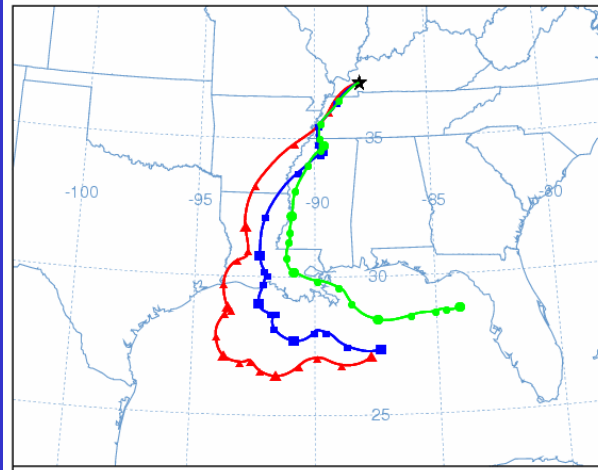
Courtesy of Marshall Beatty, Syngenta
(Spore counts are based on morphology only)

Samples of model simulated spore tracks ending at western Kentucky - hindcast

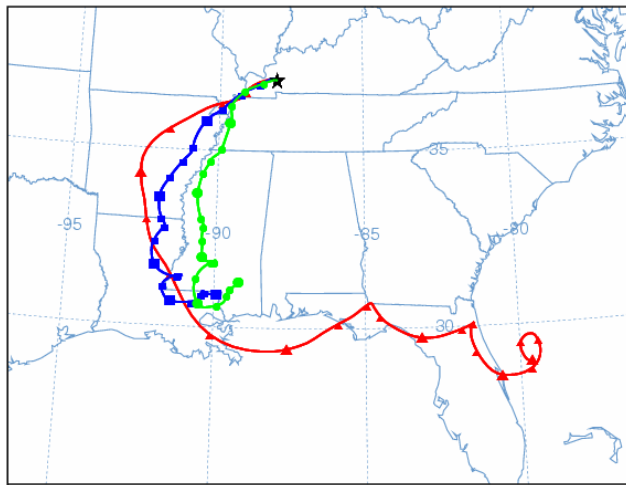
Backward trajectories ending at 00 UTC 30 Jul 06
EDAS Meteorological Data



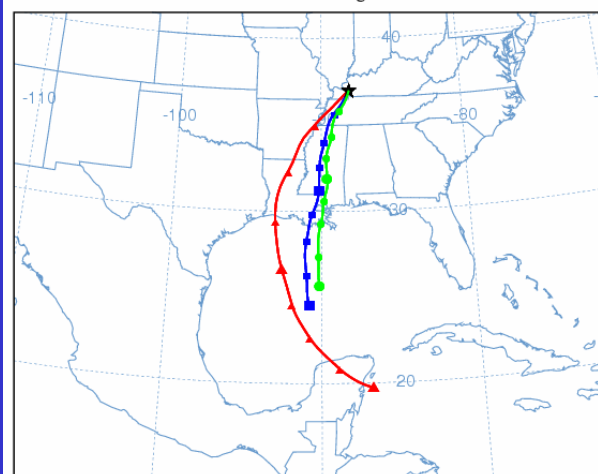
Backward trajectories ending at 00 UTC 15 Jul 06
EDAS Meteorological Data



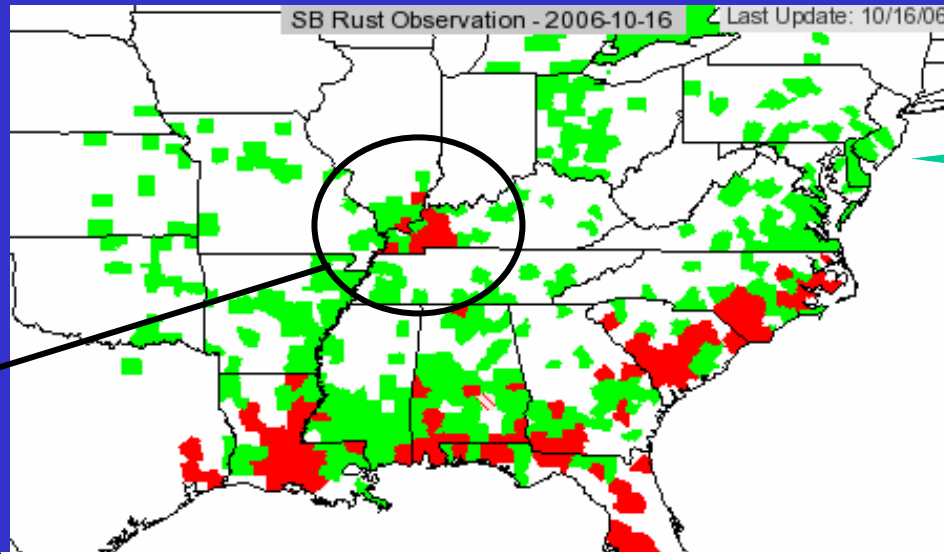
Backward trajectories ending at 00 UTC 05 Jul 06
EDAS Meteorological Data



Backward trajectories ending at 00 UTC 24 Sep 06
EDAS Meteorological Data

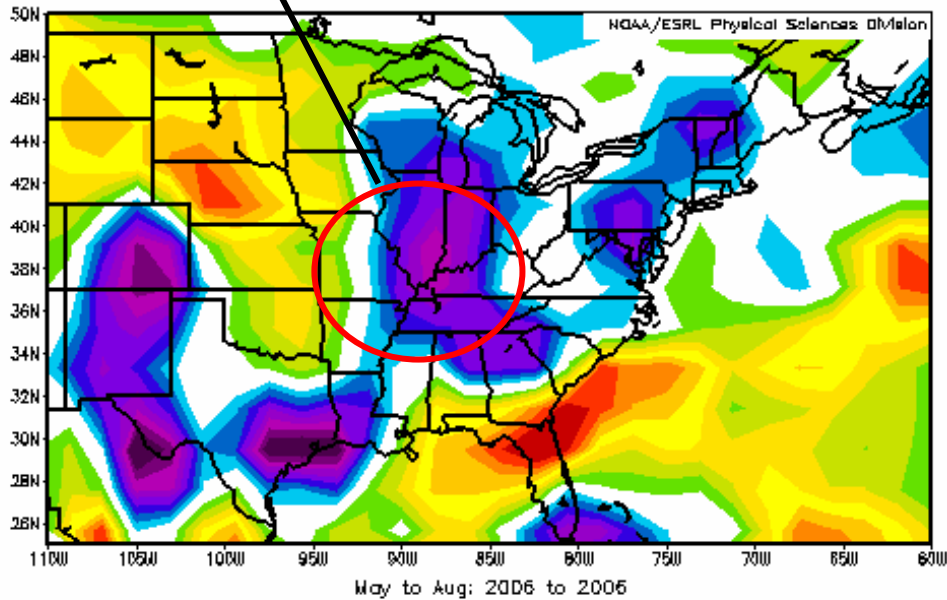


Comparison of disease detection with rainfall anomaly



SBR infection as of 10/16/2006

NCEP/NCAR Reanalysis
Surface Precipitation Rate (mm/day) Composite Anomaly 1968-1998 climo

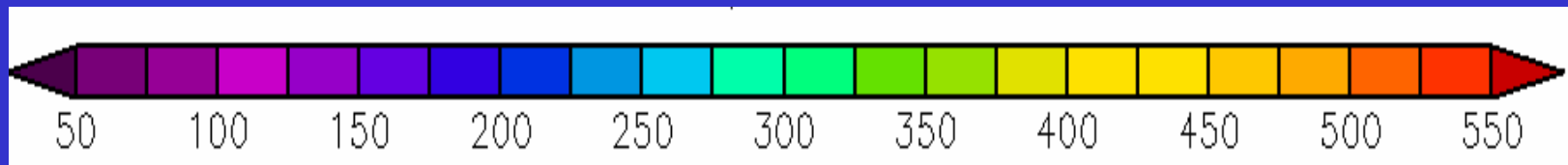
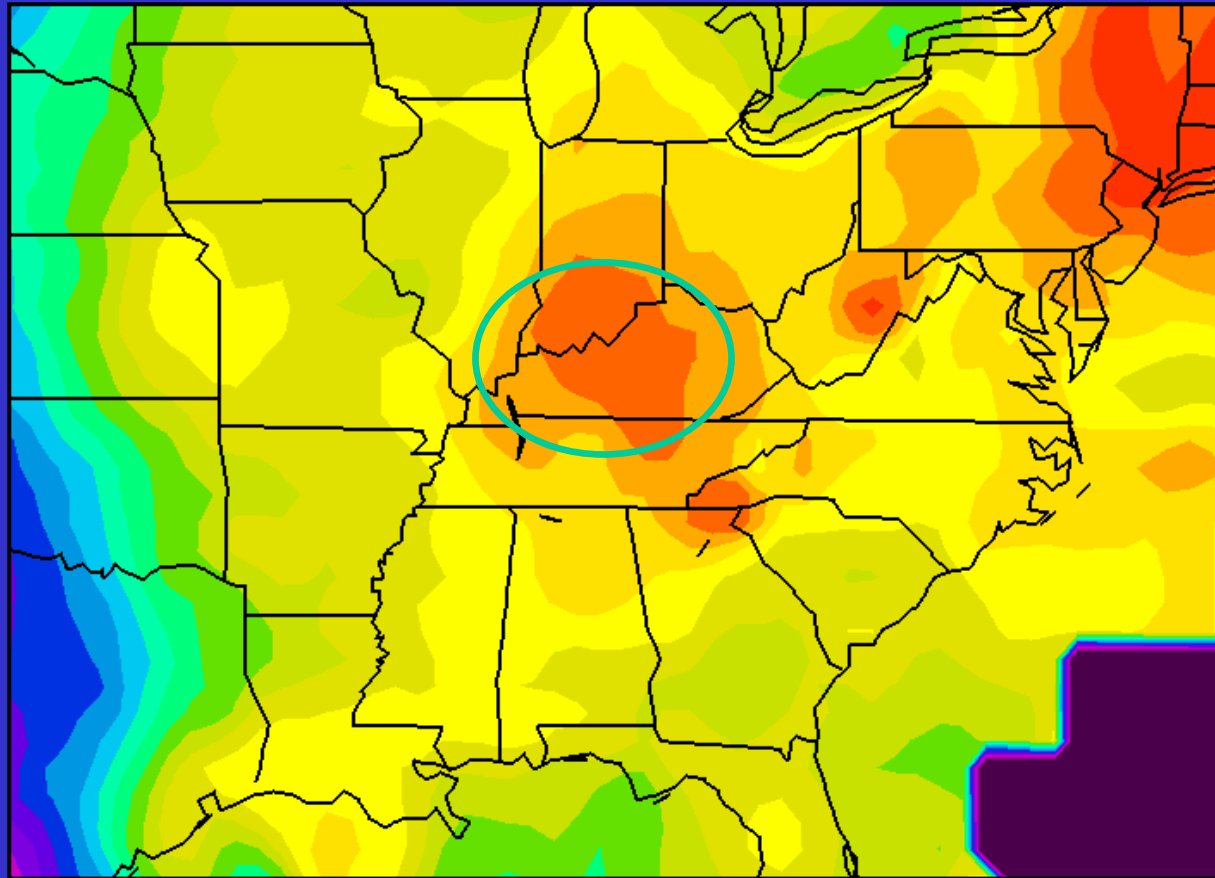


ed, no longer found

May-Sept rainfall, 2006

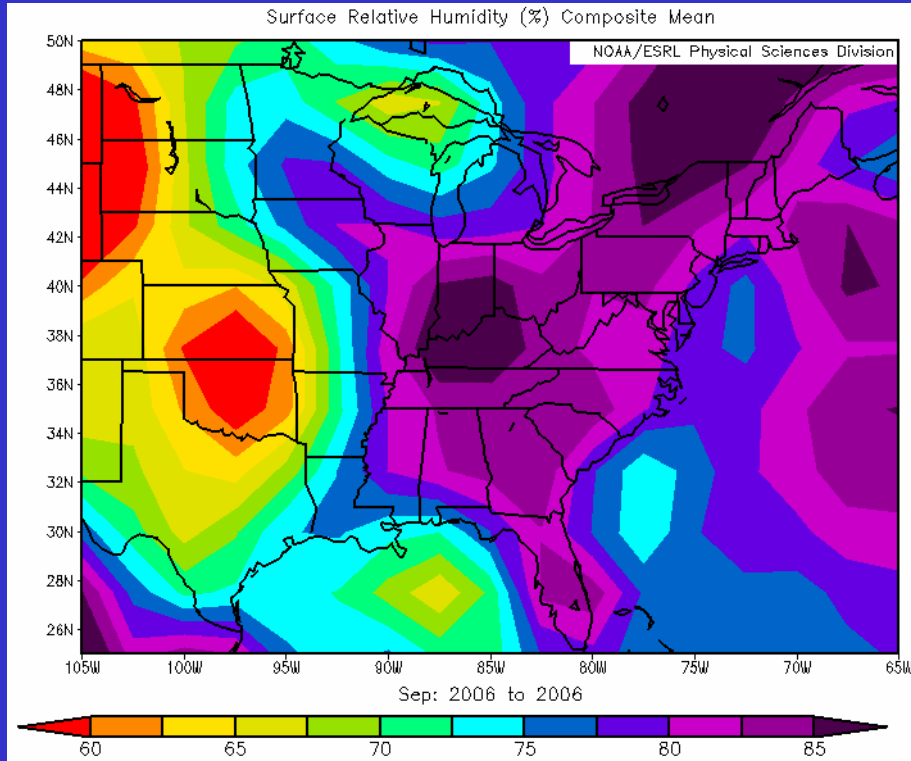


Soil Moisture(in mm) within top 2 m, May-October, 2006

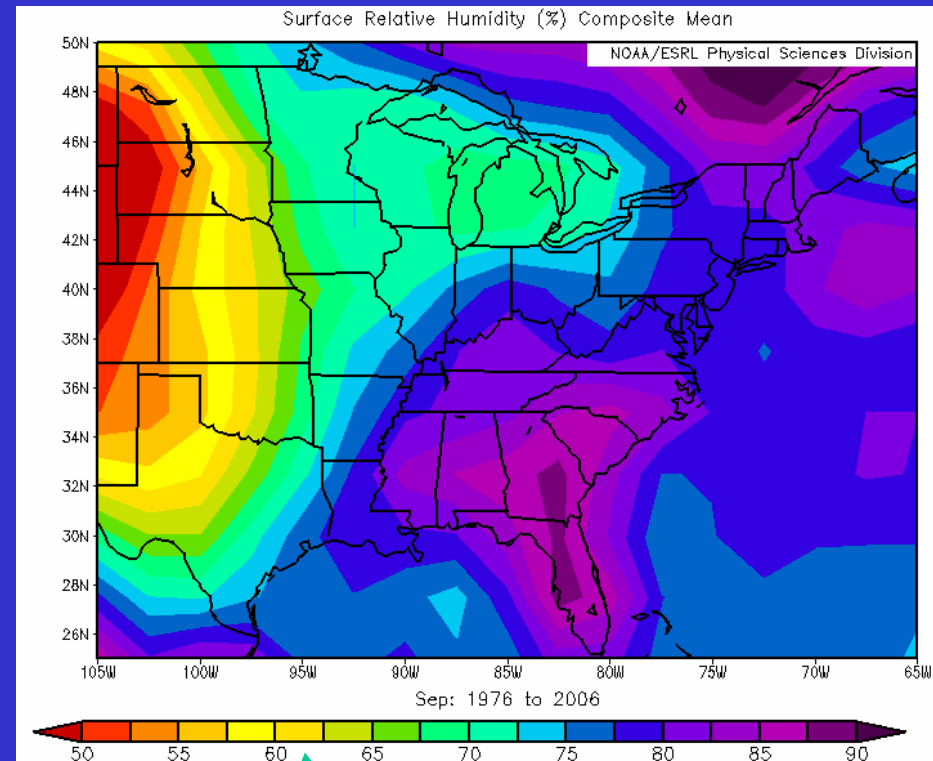


Source: NCEP/NOAA

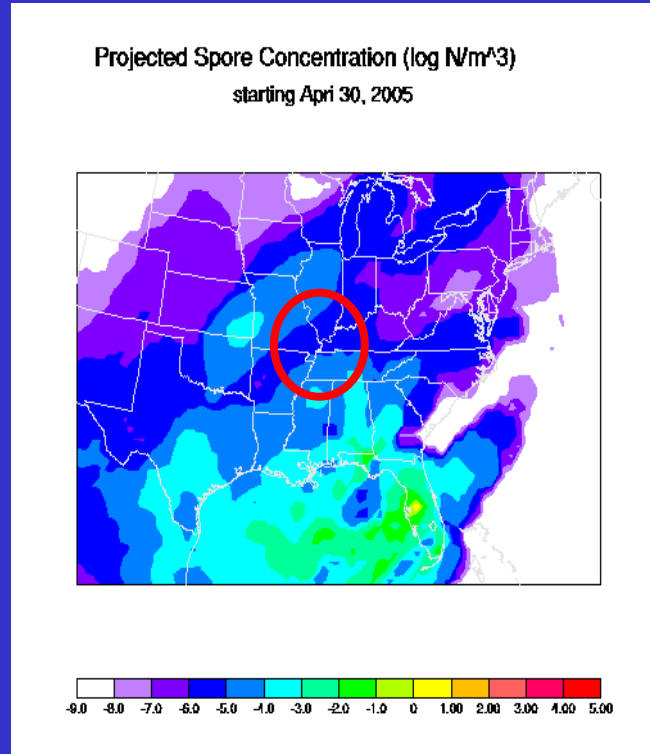
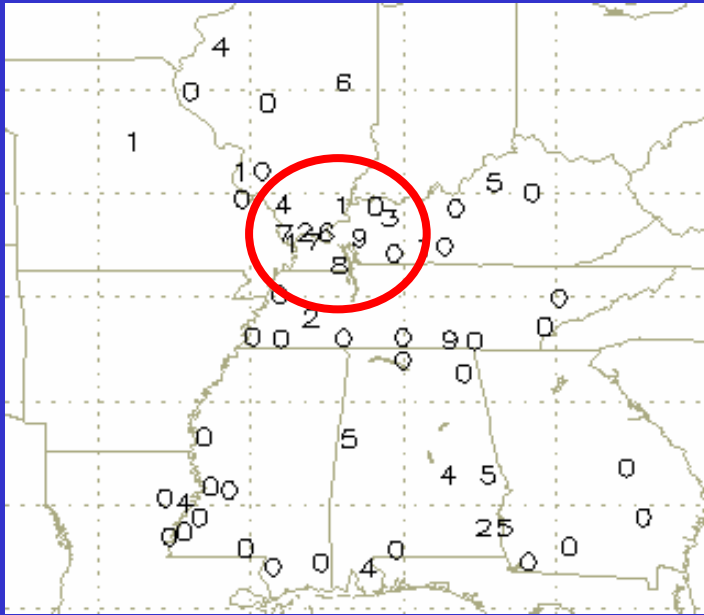
Surface relative humidity (%): 2006 vs. long-term mean



Sept, 2006

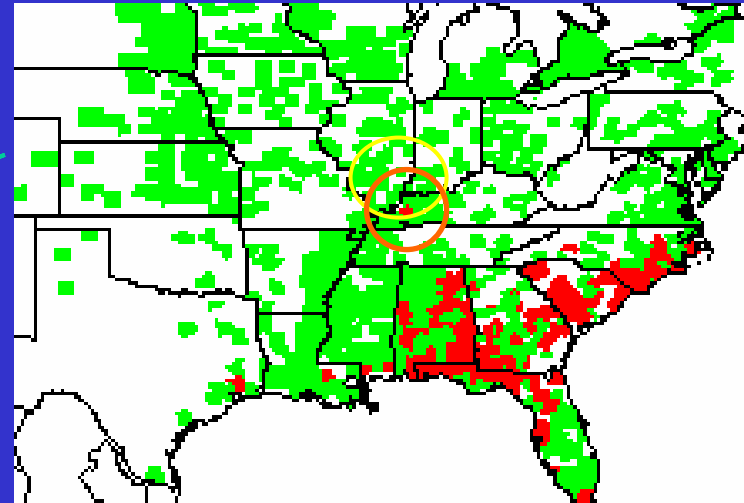


Sept, climatology

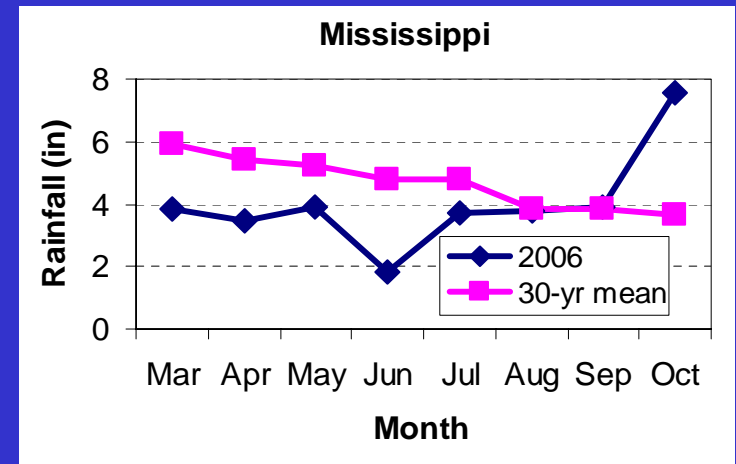
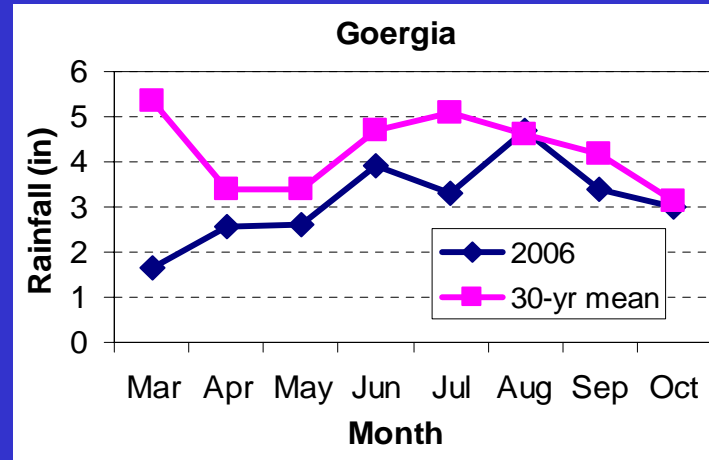
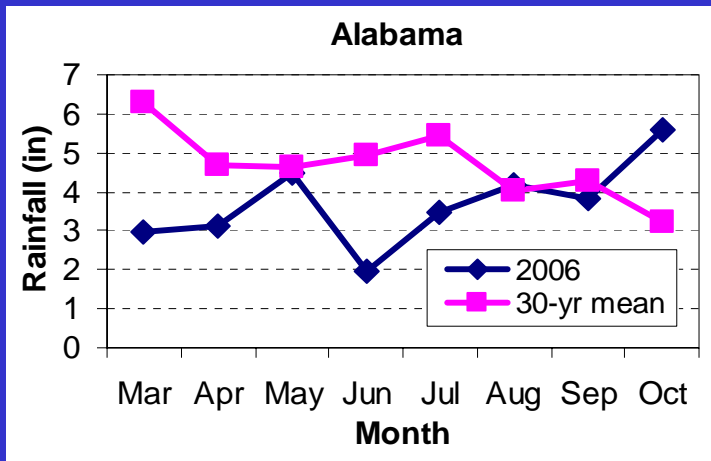


Spore counts: which are visually inspected, but not PCR checked. Courtesy of Syngenta

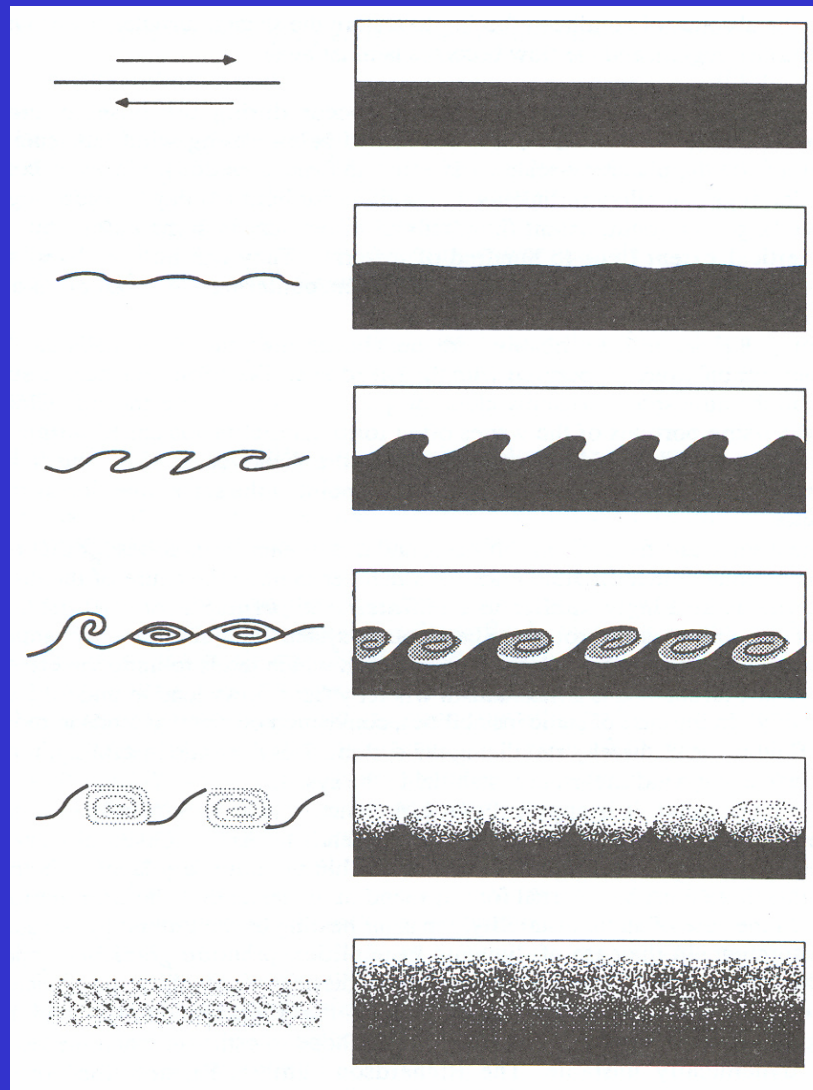
As of 11/18/2005



Monthly rainfall amounts anomaly in 2006

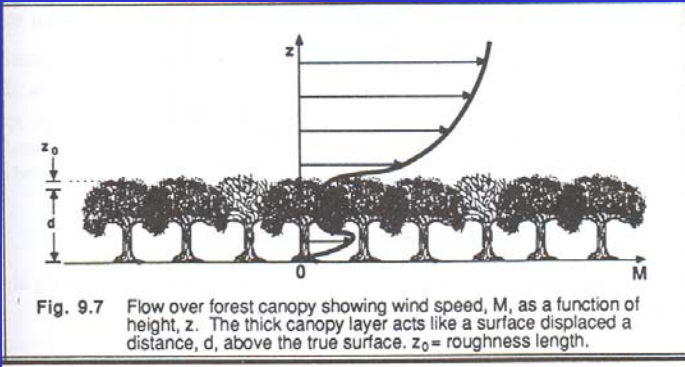
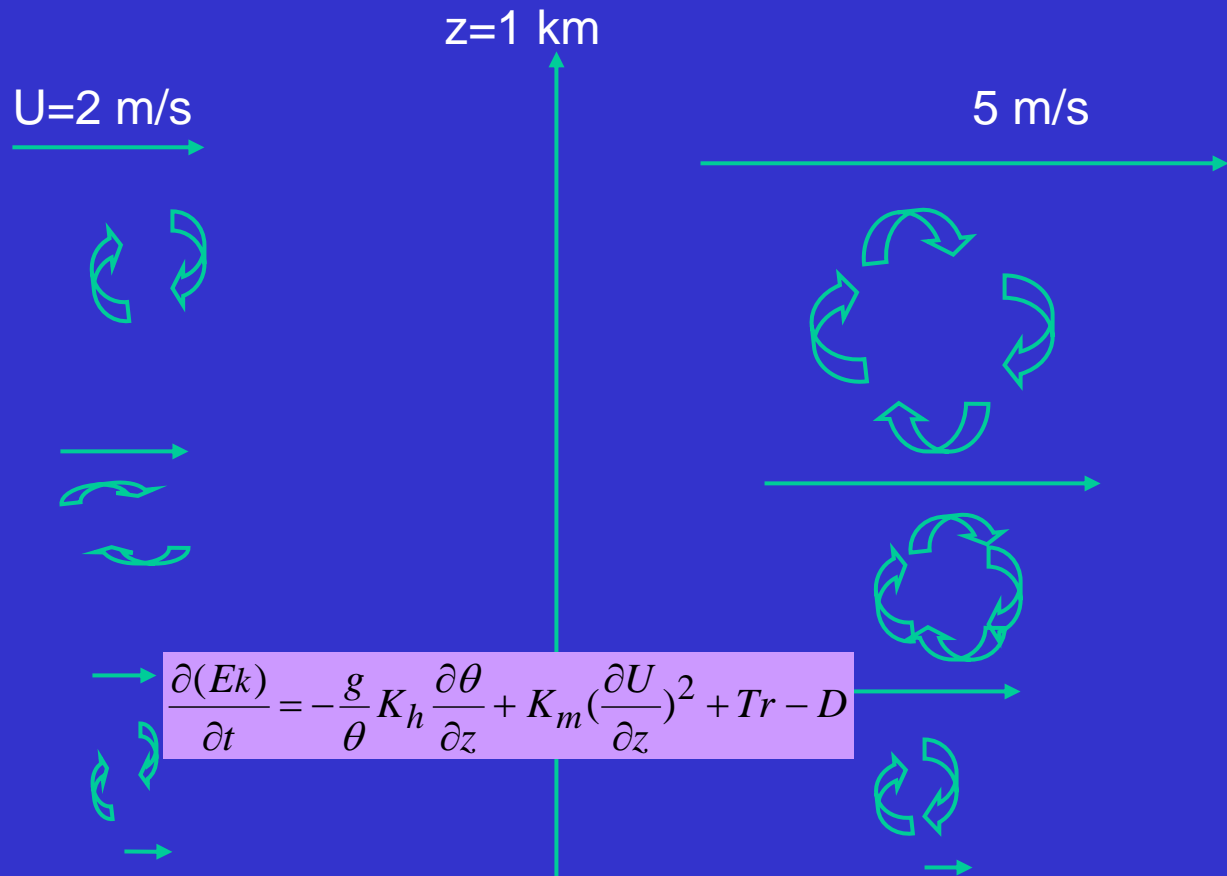


Schematics showing wind shear generating turbulence



Time sequence of shear-generated turbulence development

(adapted from Stull 1998)



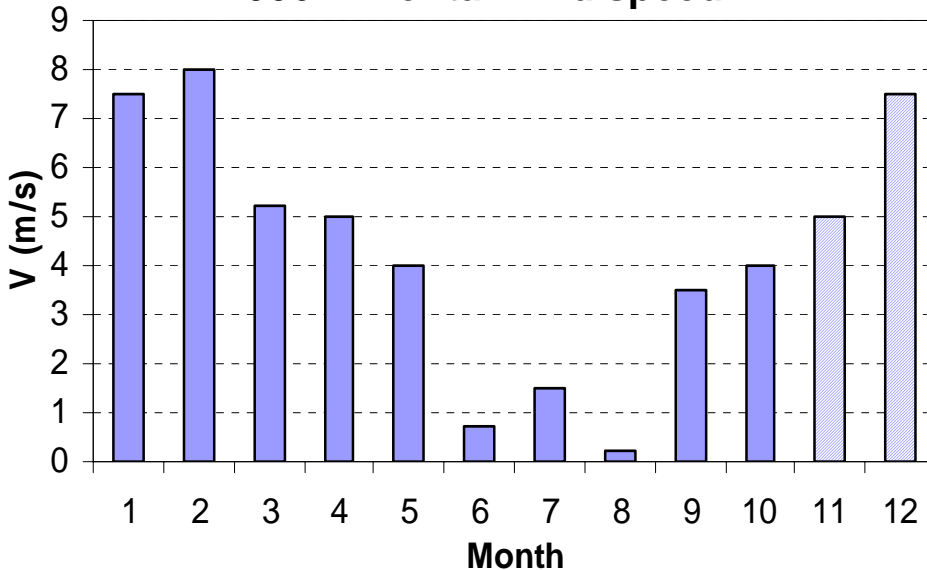
Schematics illustrating wind speed effects on turbulent mixing

Wind effects on spore escape rate through turbulence

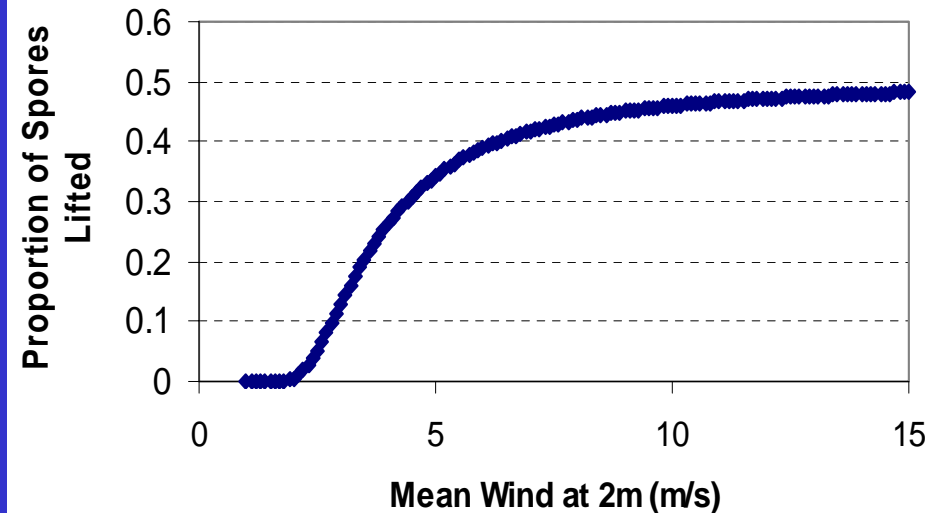
Monthly surface mean wind velocity near LA-MS border

Dependence of spore escape on wind speeds (theoretical)

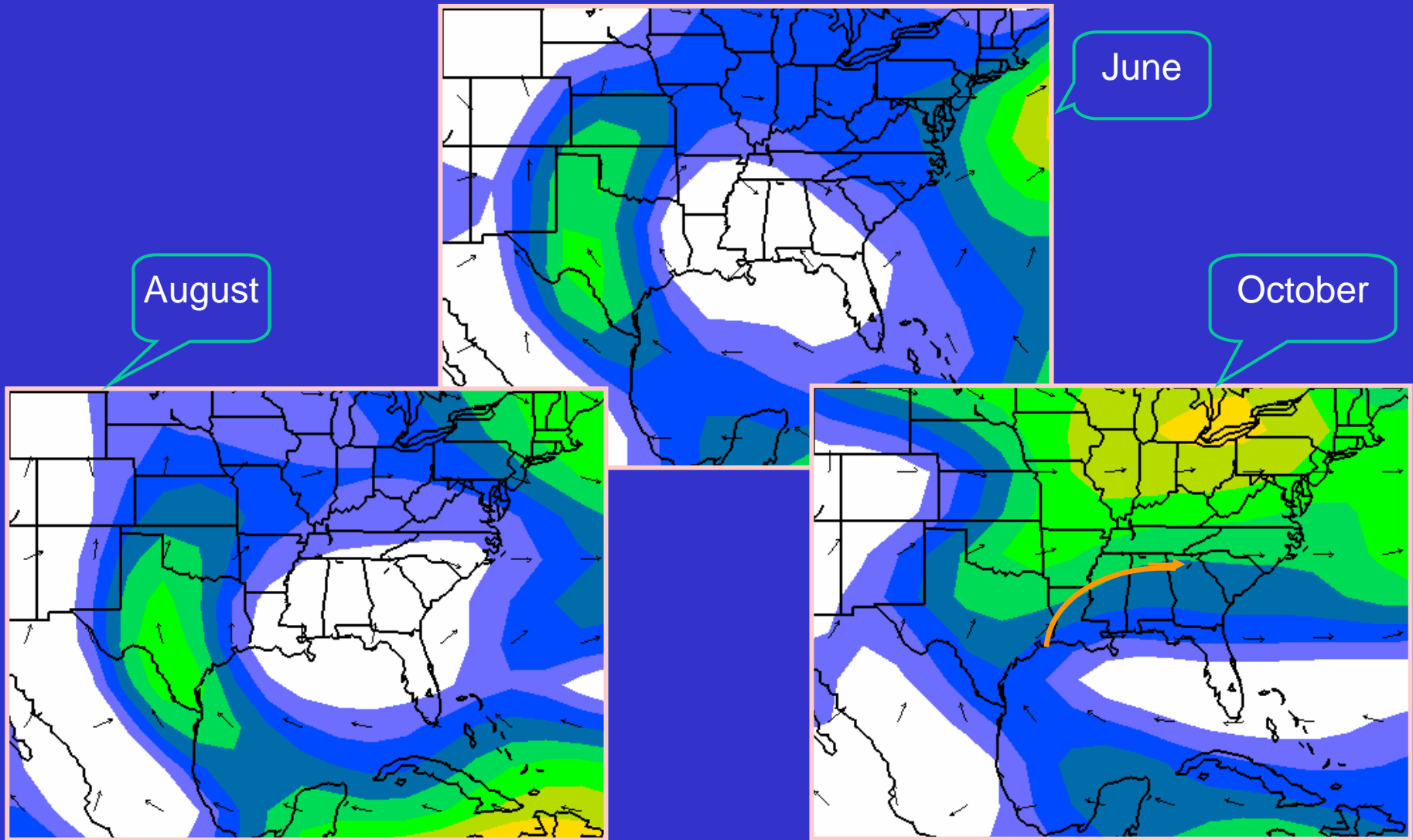
2006 horizontal wind speed



Proportion of Spores Lifted by Canopy Turbulence



Monthly wind velocity at 850mb (~1500m), showing “wind hole” in early season



M/s

Summary and Discussion

- The climate-dispersal coupled model was used to forecast spore movement and disease development up to 2-4 weeks in advance.
- The 2006 growing season forecasts suggest that the model can capture general patterns of spore dispersal, including the routes along the East Coast and lower Mississippi Basin.

Summary and Discussion - continued

- A “wind hole” was evident in early season, but diminished later, which possibly allowed the rust to spread northward near the end of the season.
- Western Kentucky was found to be conducive to the rust infection, likely due to the high humidity resulting from more precipitation and soil moisture.
- The South Coastal states were drier in early season 2006, partly explaining the lateness of the disease spread.

Future Work

- Further quantify spore releasing rate using canopy turbulence model.
- Use EPA's CMAQ and WRF chemistry models with different dispersal parameterizations, in addition to HYSPLIT.