

# Soybean Rust Dispersal Prediction and Analyses in the US for 2005 Growing Season

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## Acknowledgments

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- This project integrates four sub-models developed by various organizations. We would like to thank NOAA/Air resource Lab., Scripps Institution of Oceanography/ECPC, National Center for Atmospheric Research (NCAR).
- The authors appreciate supports from **United Soybean Board**, **Iowa Soybean Association**, and **Syngenta Corporation**.

# Outline

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## ➤ Spore and Rust Prediction

Model system

Prediction experiments 2005

Validation, mostly qualitative

## ➤ Analyses of disease spread - climate conditions

Transport conditions

Spread conditions

## ➤ Improvements for 2006

Source specification

Model improvements

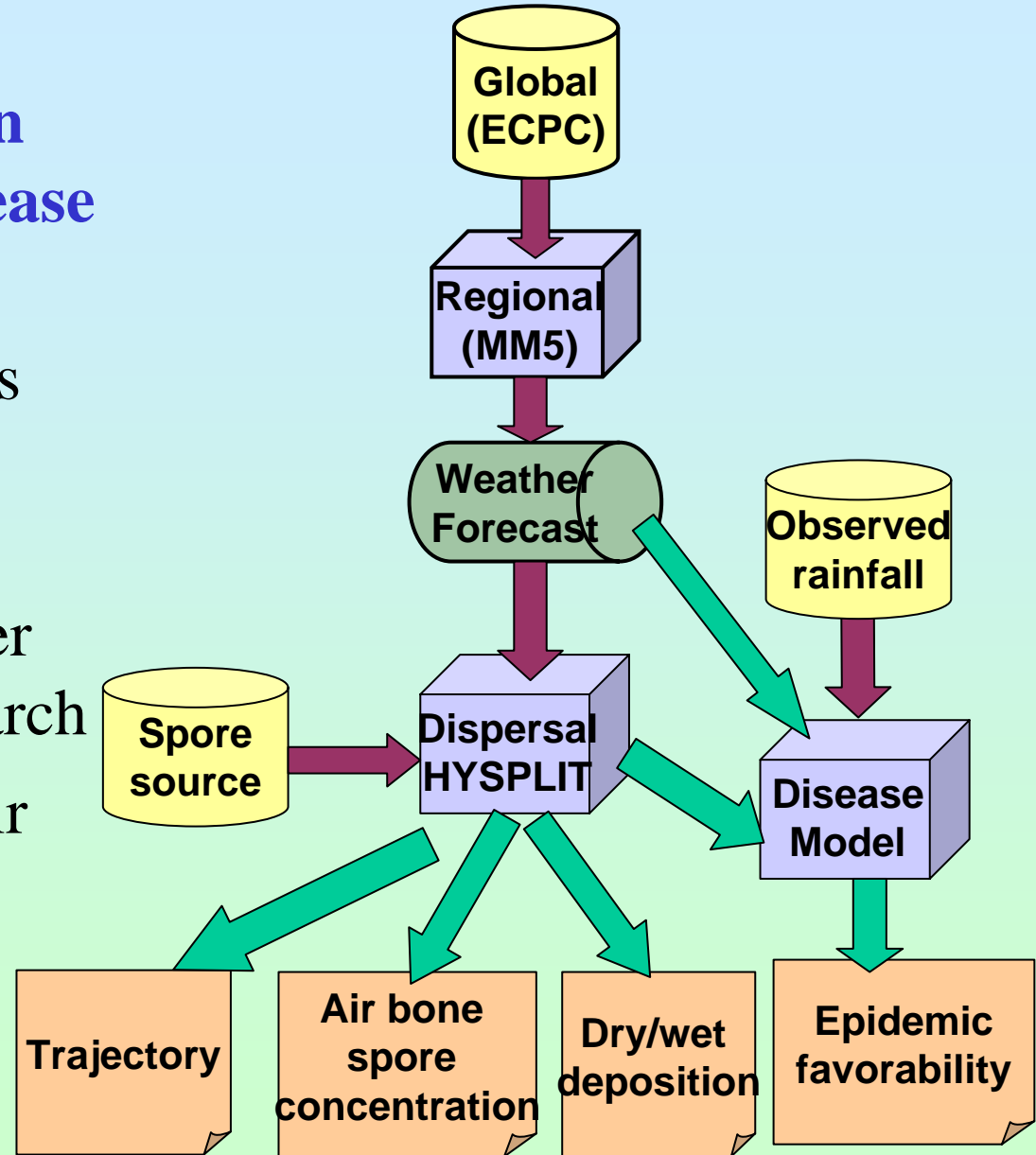
# ISU/SLU Rust prediction model – An climate-dispersal-disease integrated system

**Global model** – Scripps Institution of Oceanography

**MM5** – National Center for Atmospheric Research

**HYSPLIT** – NOAA Air Resource Lab

**Disease model** – Iowa State University



## HYSPLIT model

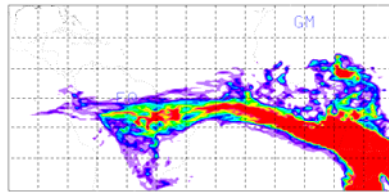
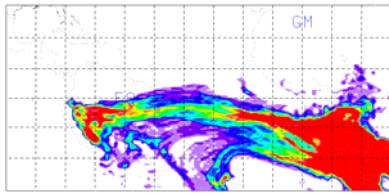
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- ✓ **Runs in trajectory or concentration modes**
  - trajectory – forward/backward tracking
  - concentration – airborne and at surface
- ✓ **Treats spores as particle or plume**
  - particle passively moves along atmosphere
  - plume or puff dilutes, splits, merges according to advection and diffusion rules
- ✓ **Considers dry and wet deposition**
  - gravitational settling
  - rainfall washout
- ✓ **Incorporate simple aerobiological viability criteria**
  - VU-B radiation, temperature, etc.

# Simulated spore dispersal from Africa to S. America

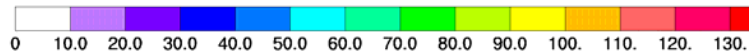
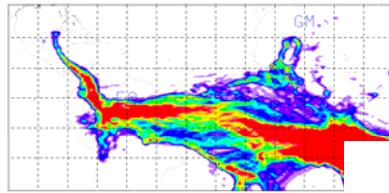
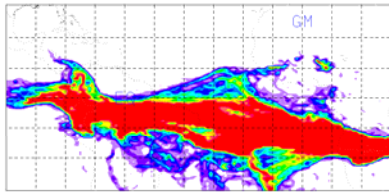
Jan.

Feb.



Mar.

Apr.

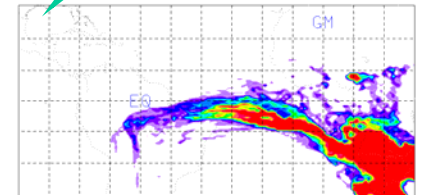
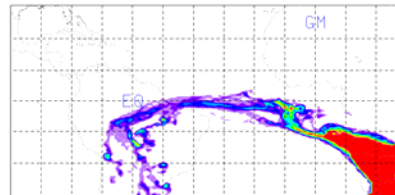


1999

2001

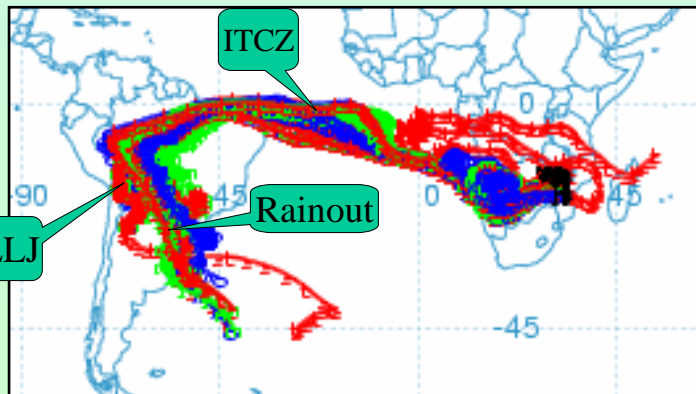
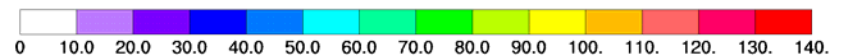
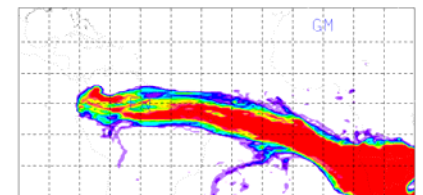
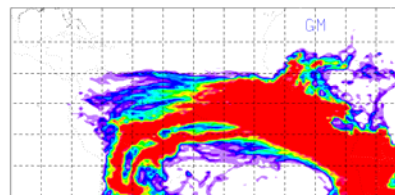
Jan.

Feb.



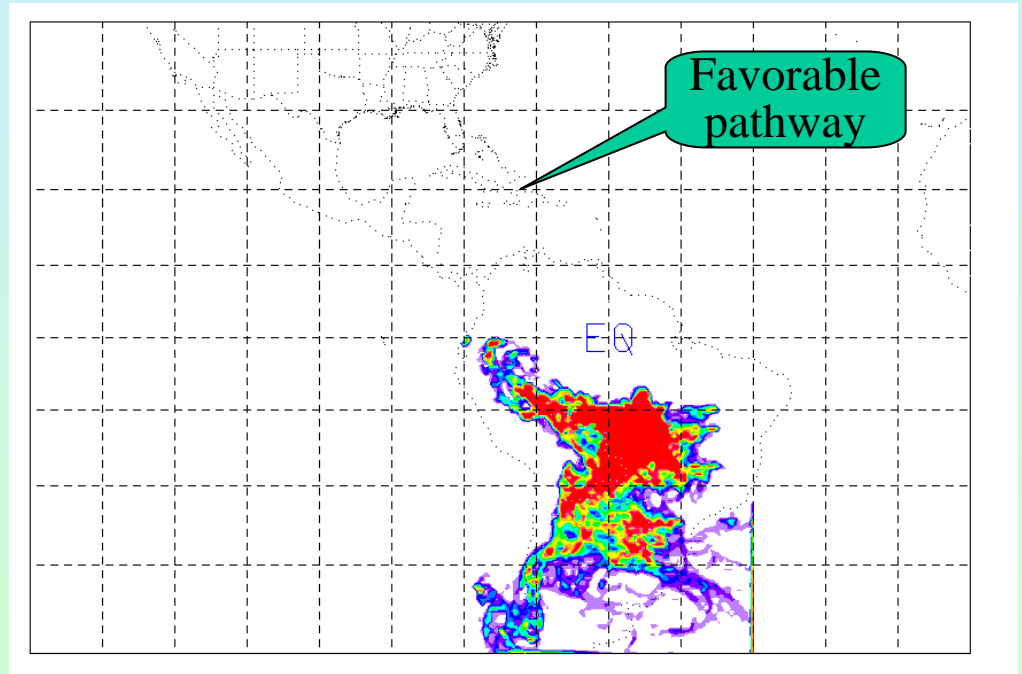
Mar.

Apr.

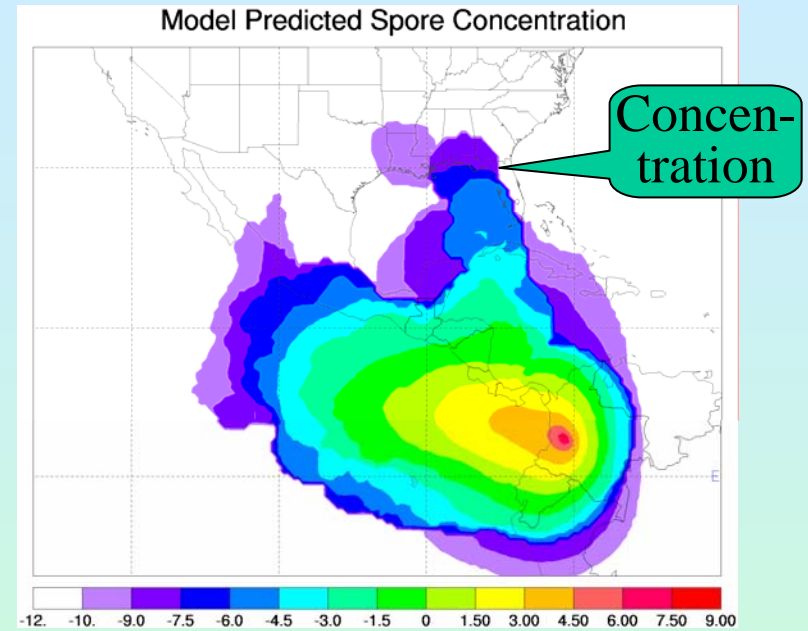
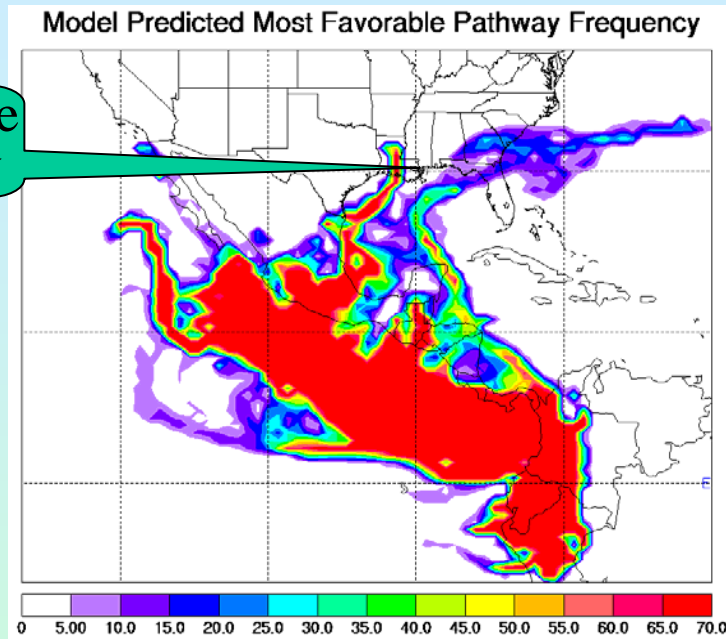


March 2004 prediction, showing a favorable pathway from S. America toward Cali, Columbia

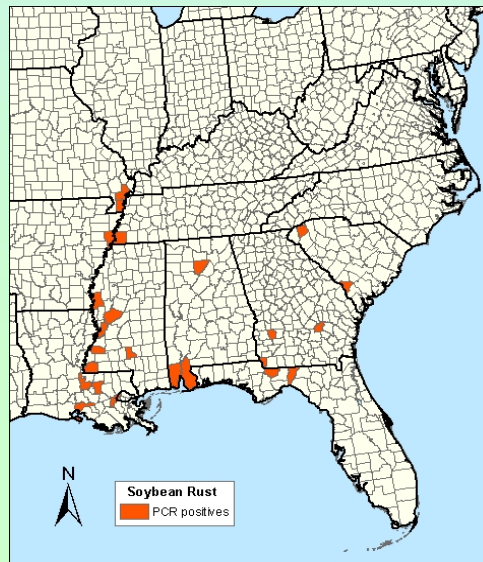
Cali,  
Columbia



# Predicated spore dispersal showing the favorable pathway form Cali, Columbia to US in fall 2004



Soybean rusts  
detected by  
USDA, 2004

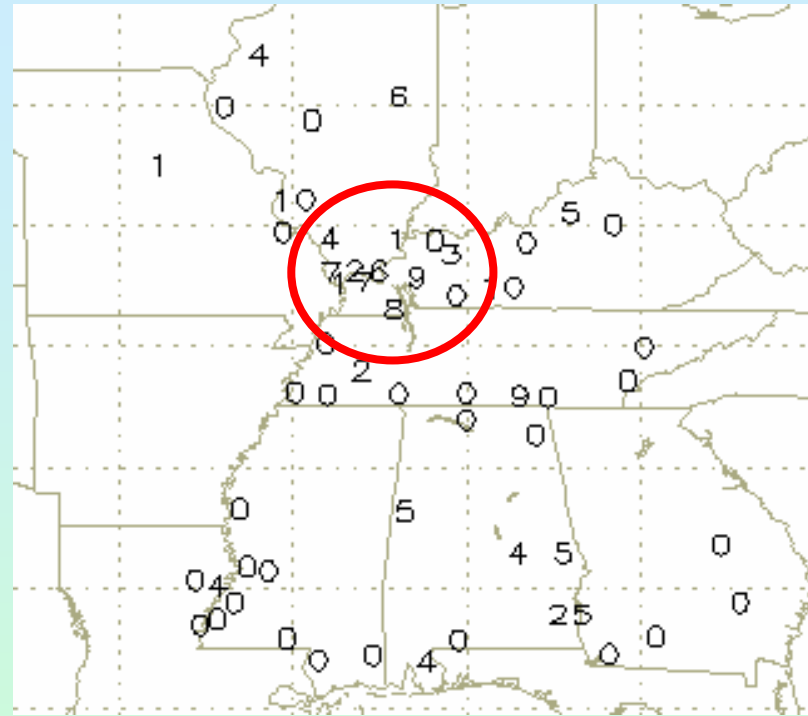
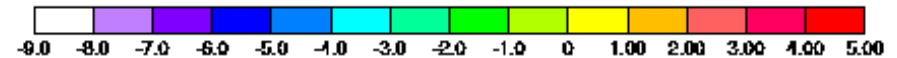
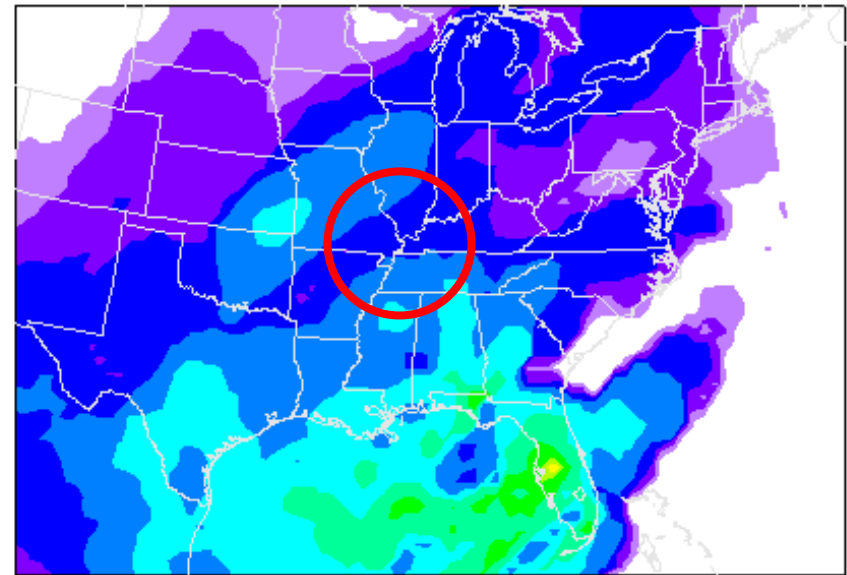


## Two kinds of prediction – Lorenz theory

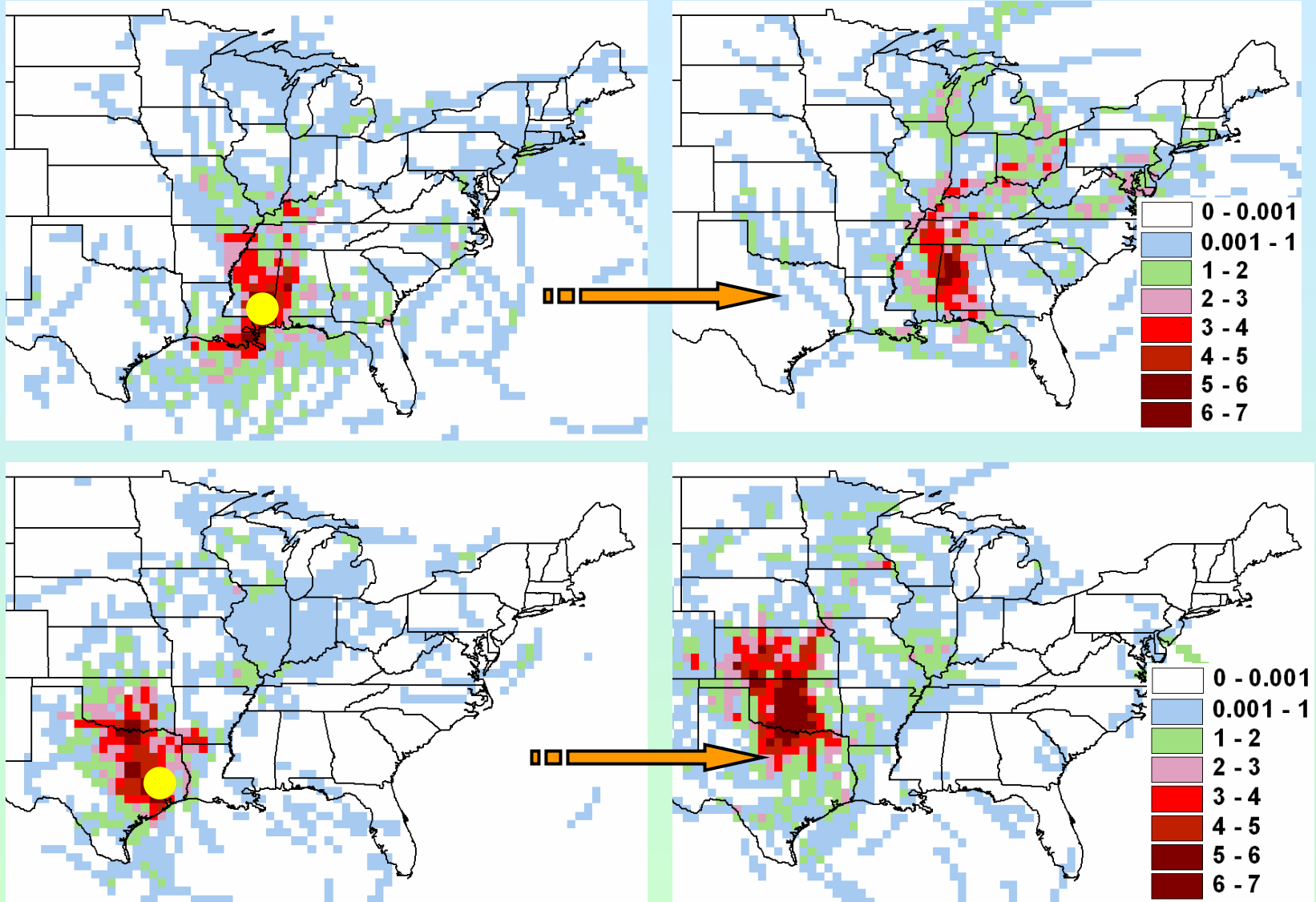
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- First kind: day-to-day **weather** prediction based on initial conditions
- Second kind: long-term **climate** prediction based on boundary conditions
- First kind prediction is limited to **7-10 days** whereas the second kind can be as long as **months to years**.
- Lower latitudes have more predictability than mid-latitudes due to long thermal memory of oceans

Projected Spore Concentration (log N/m<sup>3</sup>)  
starting April 30, 2005

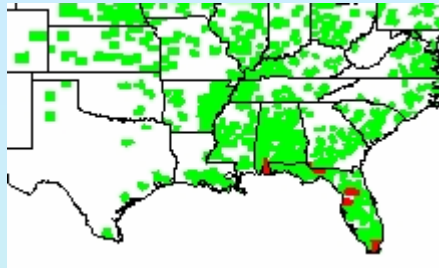


Spore counts which are visually inspected as SBR positive, but **not confirmed** by PCR because of low spore density (Courtesy of Syngenta)



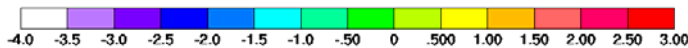
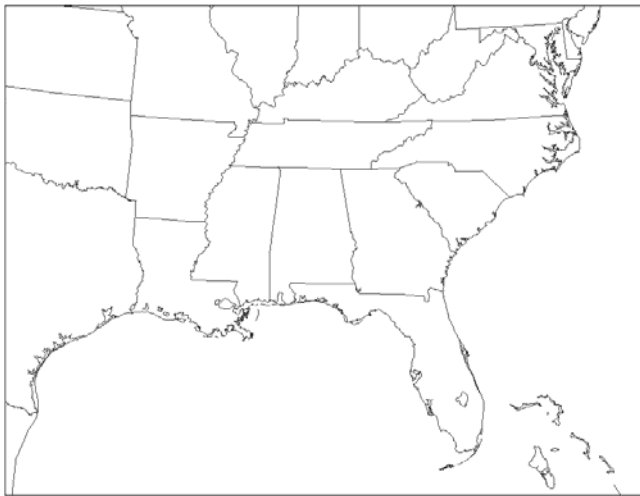
Climatic dispersal pattern from hypothetical source in southern LA and western TX as denoted by the yellow dots (Kim et al.)

As of 7/7



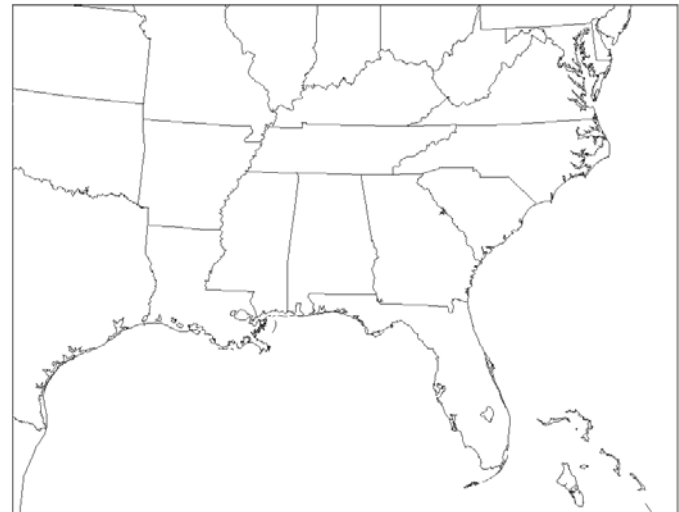
Hindcast Instantaneous spore concentration for June 2 – 11, 2005 (one from per day)

Predicted Spore Concentration (log N/m<sup>3</sup>)  
starting June 2, 2005



ground

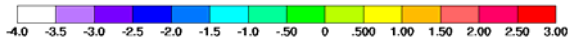
Predicted Spore Concentration (log N/m<sup>3</sup>)  
starting June 2, 2005



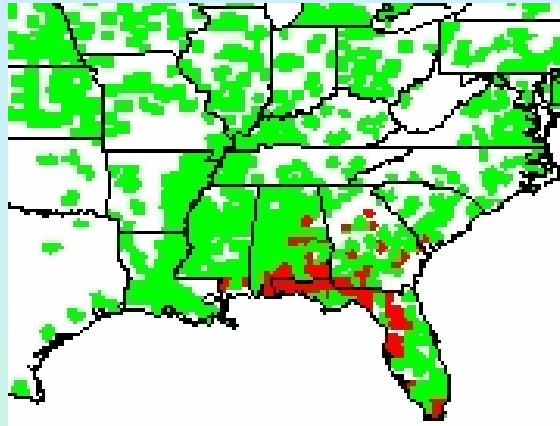
500 meter

# Spore dispersal handcast for first two weeks of July

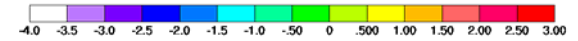
Predicted Spore Concentration (log N/m<sup>3</sup>)  
starting June 2, 2005



## Disease as of 8/31/05

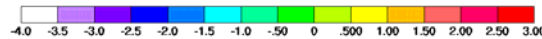


Predicted Spore Concentration (log N/m<sup>3</sup>)  
starting June 2, 2005



500 meter

Predicted Spore Concentration (log N/m<sup>3</sup>)  
starting June 2, 2005



100 meter

Ground

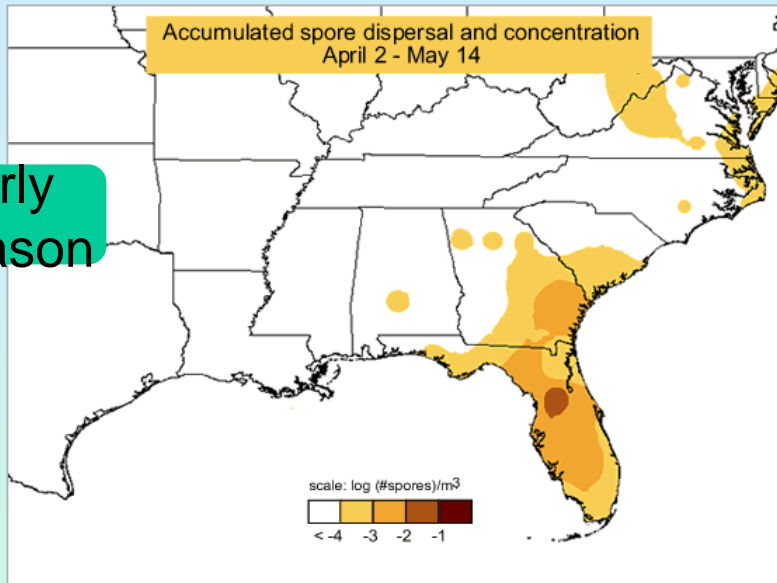
## Disease favorability outlook

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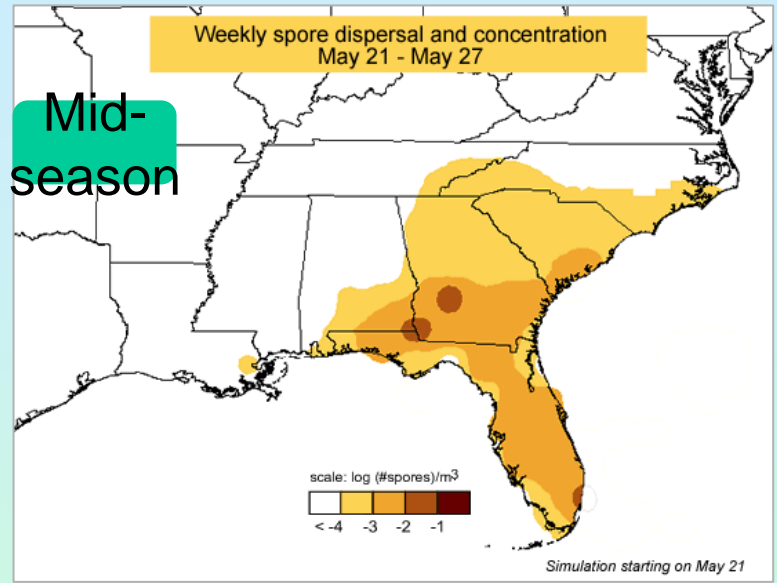
- What does it mean if certain amount of rust spores have arrived and deposited on the ground?
- The **disease model** would determine the fate of these spores based on *in situ* environment conditions including host availability.
- As part of the disease model, we adopted an expert system originally developed for China to project the disease outlook.
- In 2005 the expert system used mainly rainfall frequency and amount, while spore concentration was used subjectively.

# Sample of weekly instantaneous and cumulative spore concentration predicted during 2005

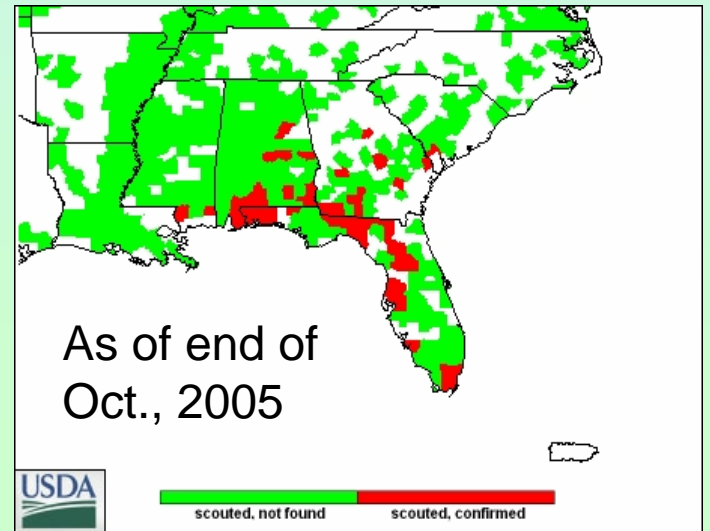
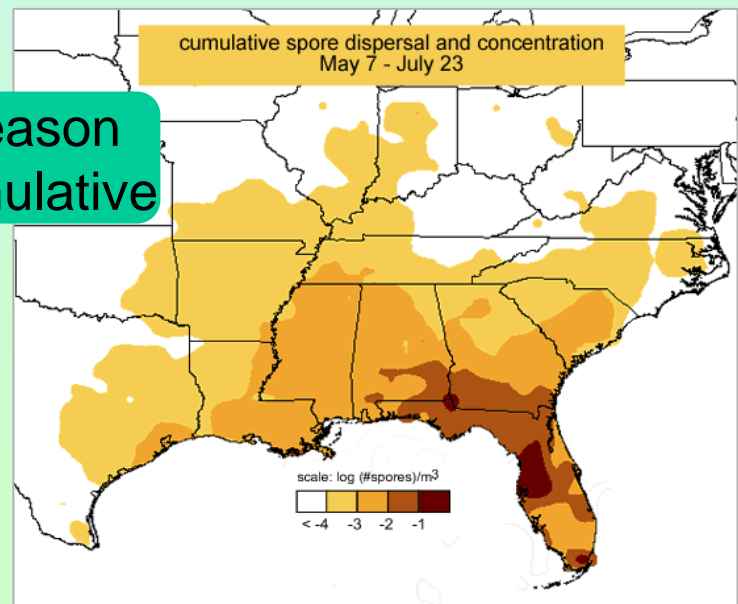
Early season



Mid-season

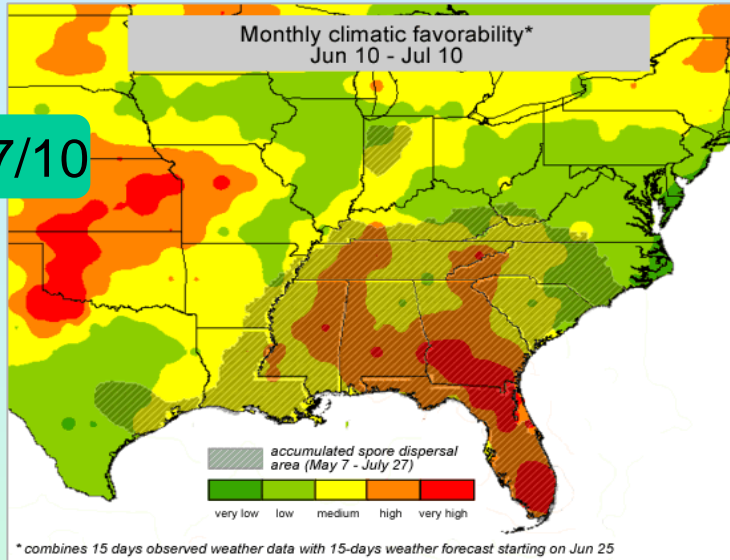


Season cumulative

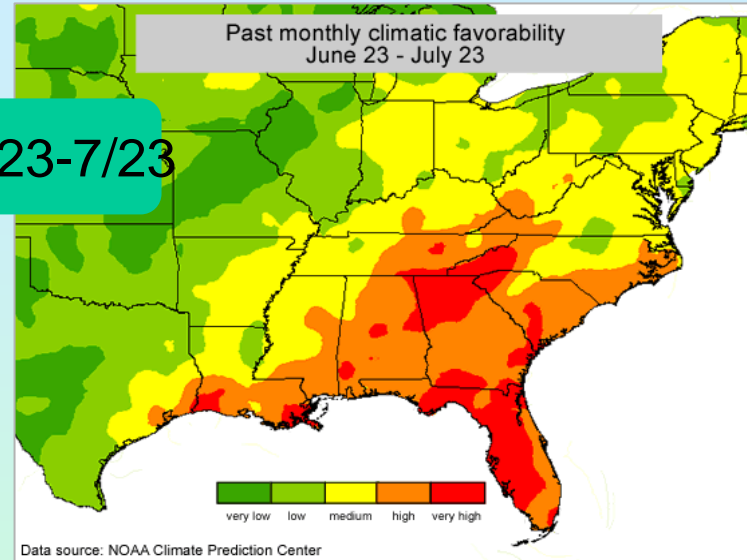


# Sample of predicted favorability for epidemics based observed and modeled rainfall

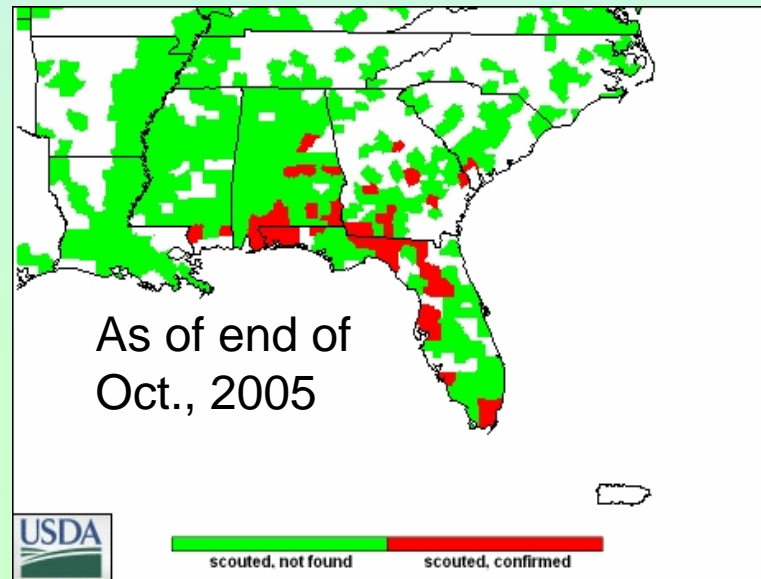
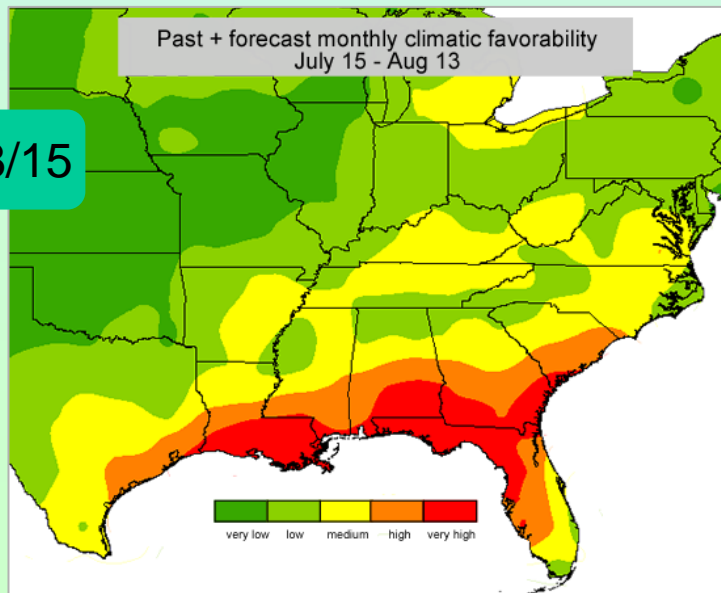
6/10-7/10



6/23-7/23



7/15-8/15



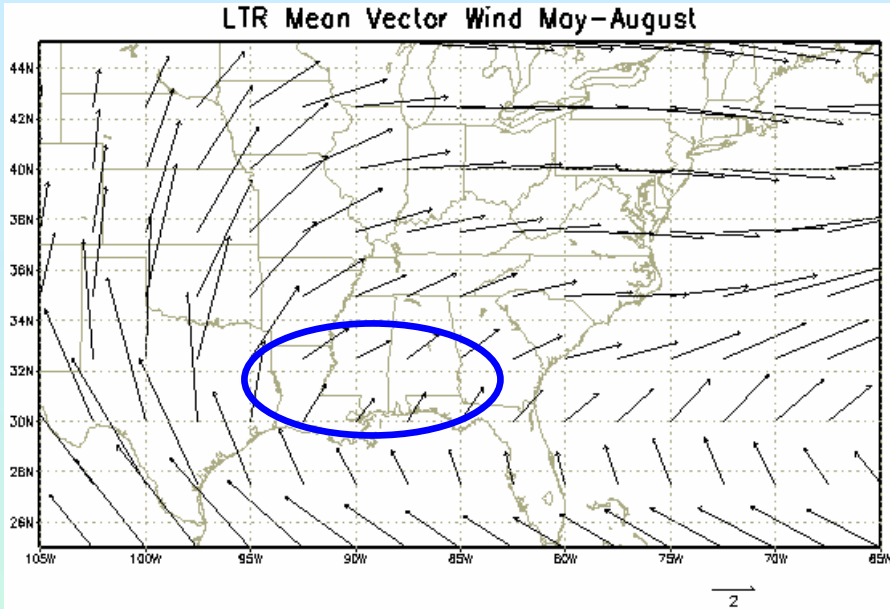
## Some unfavorable **climate** conditions in 05

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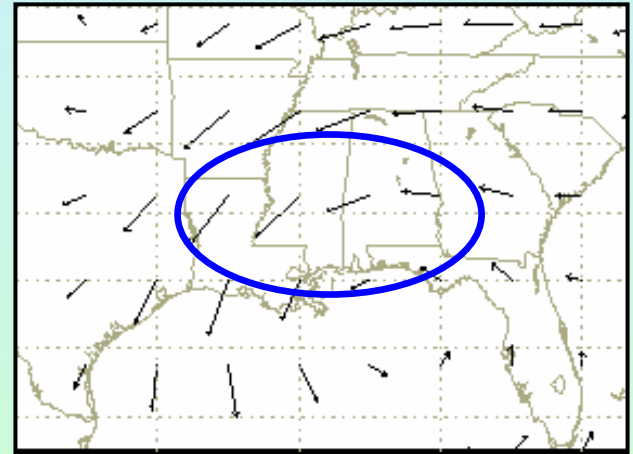
- Wind direction was less northward – possibly suppressing transport to central US
- Wind speed was lighter – likely reducing turbulent lifting
- West of Mississippi in costal states was dry – contributing to local confinement of the disease
- Biological factors may also have contributed the limited rust spread this year.

# Observed wind vector at ~1500 m height in summer

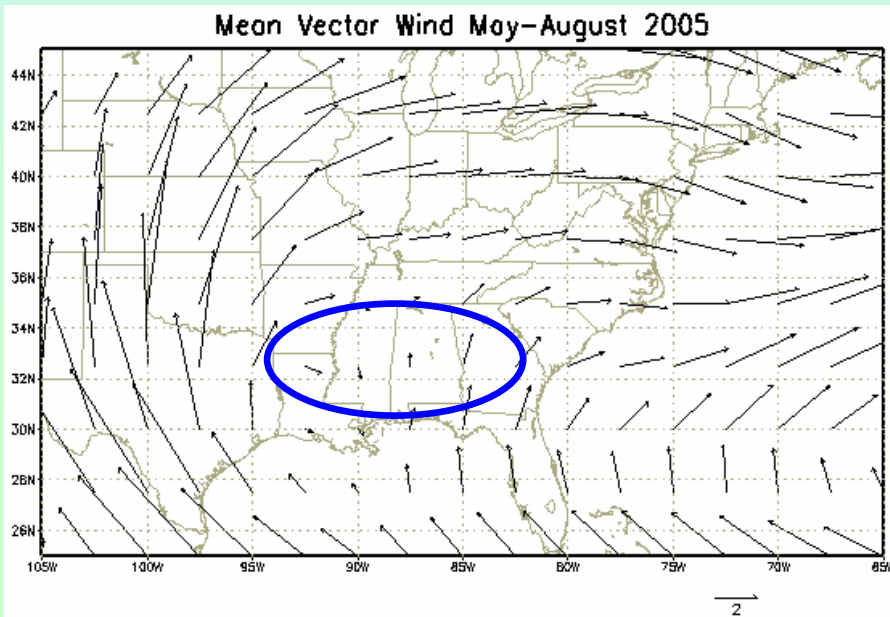
Mean climate



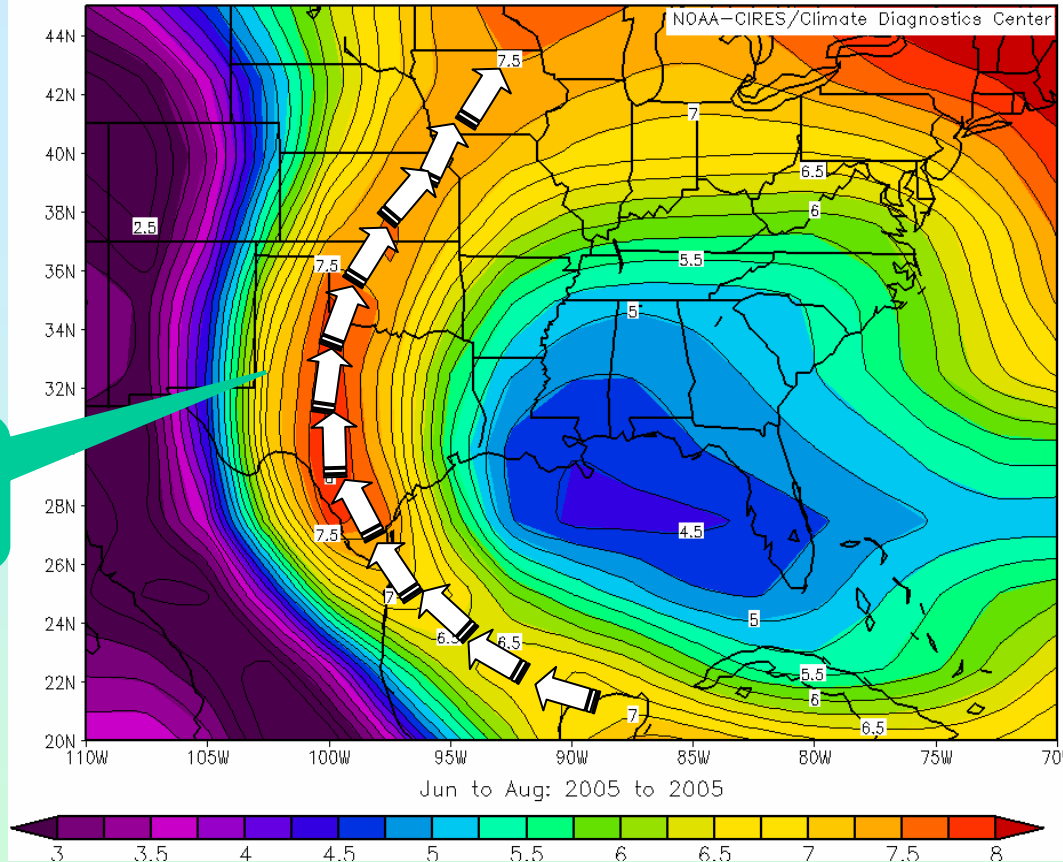
Anomaly: 2005 minus climatology



2005

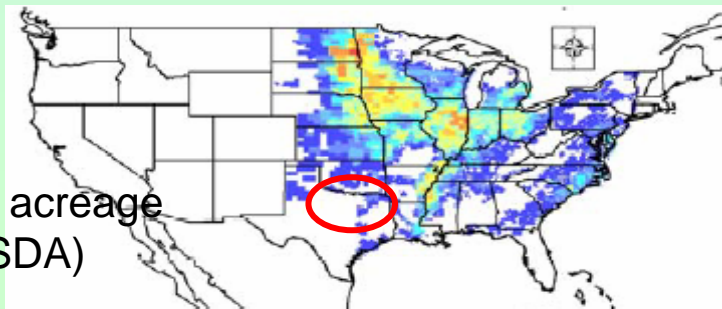


850mb Scalar Wind Speed (m/s) Climatology 1968–1996

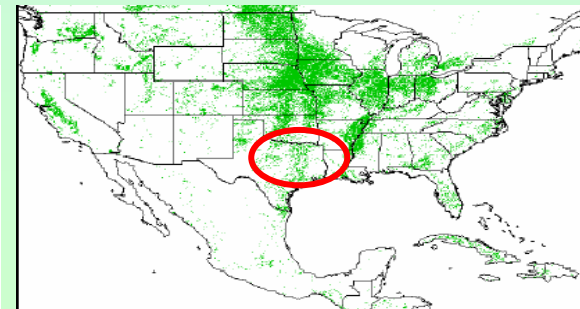


Low-level jet

Mean summer wind speed (m/s) at ~1500 m

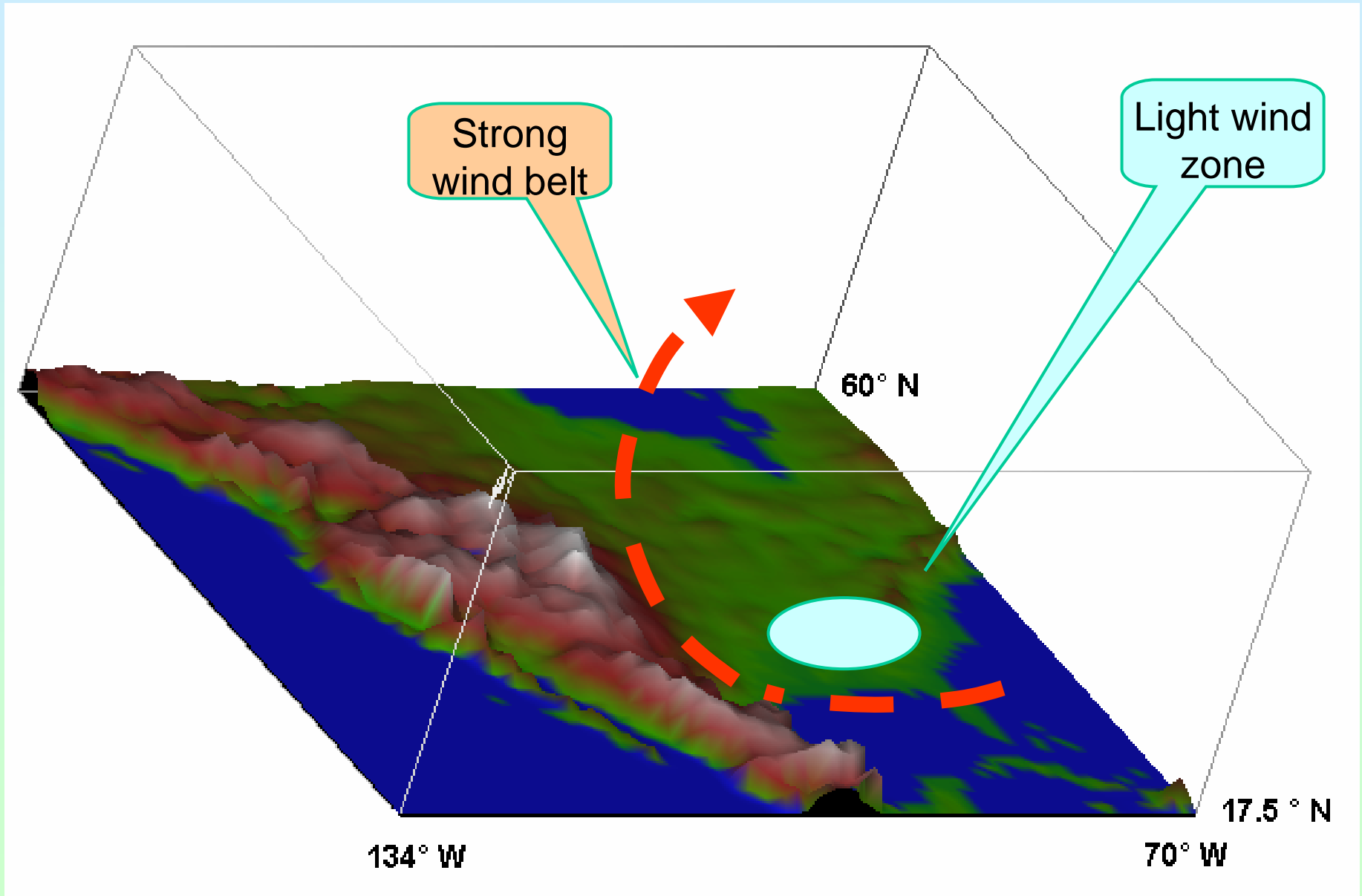


Soybean acreage (from: USDA)

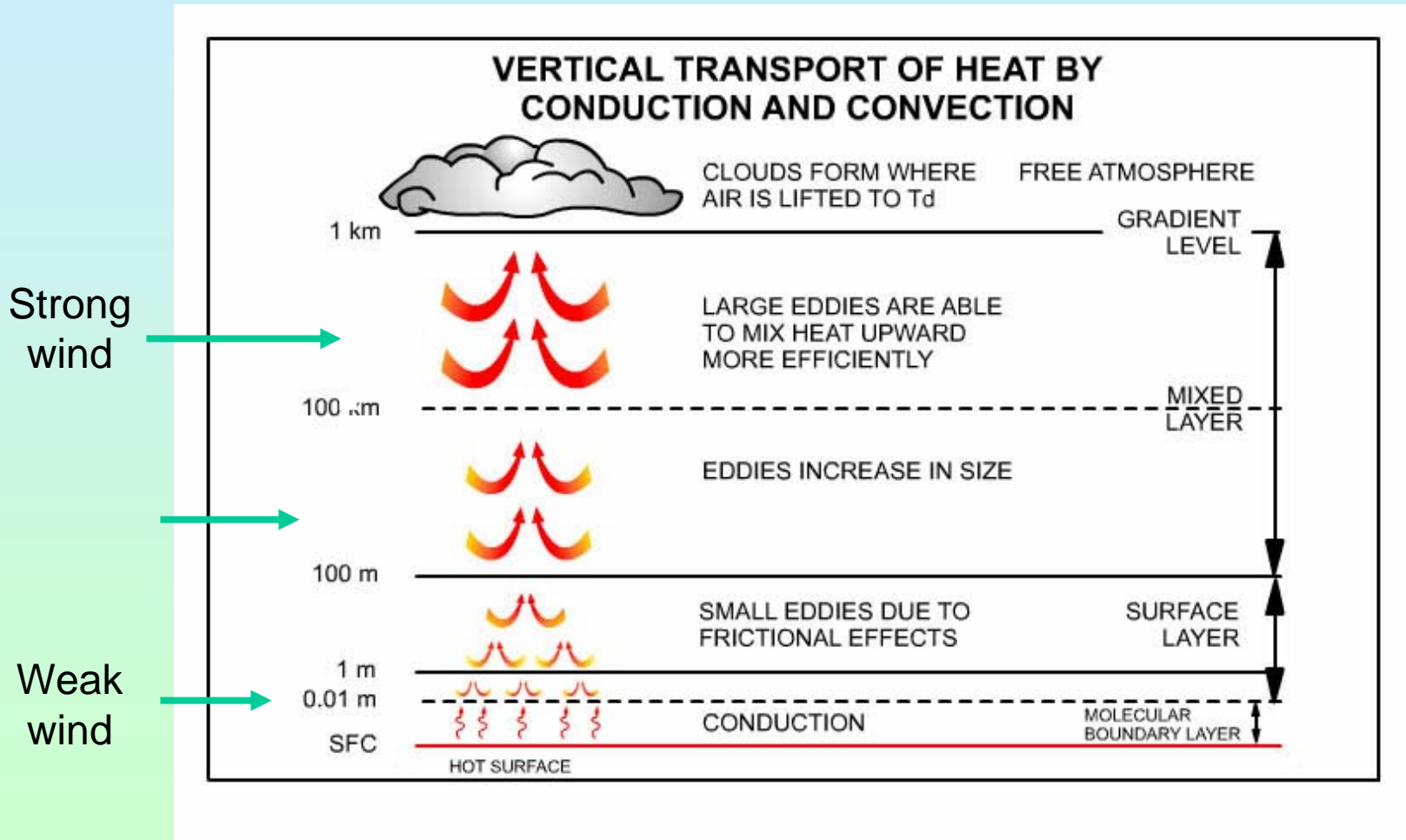


Alternative hosts (from: USDA ?)

Illustration of wind pattern in southeastern US showing strong jet belt west of a relatively light wind zone where the rust exited



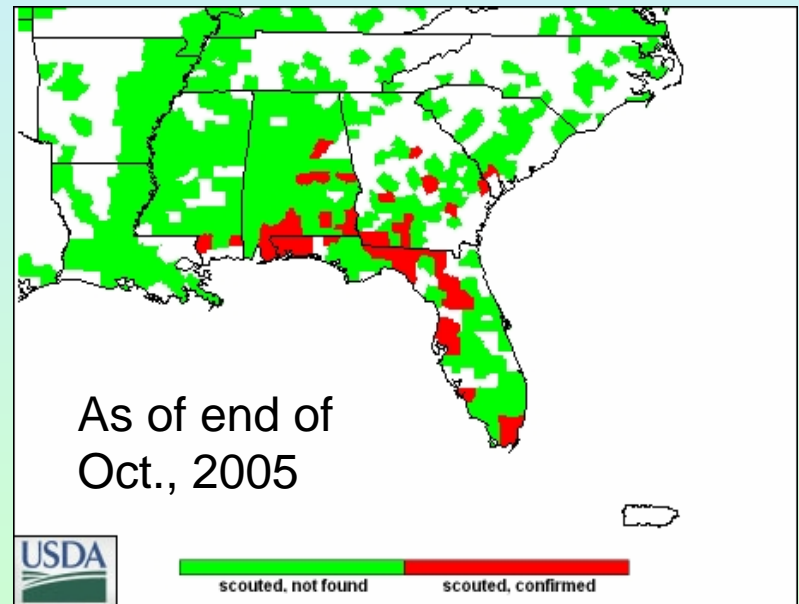
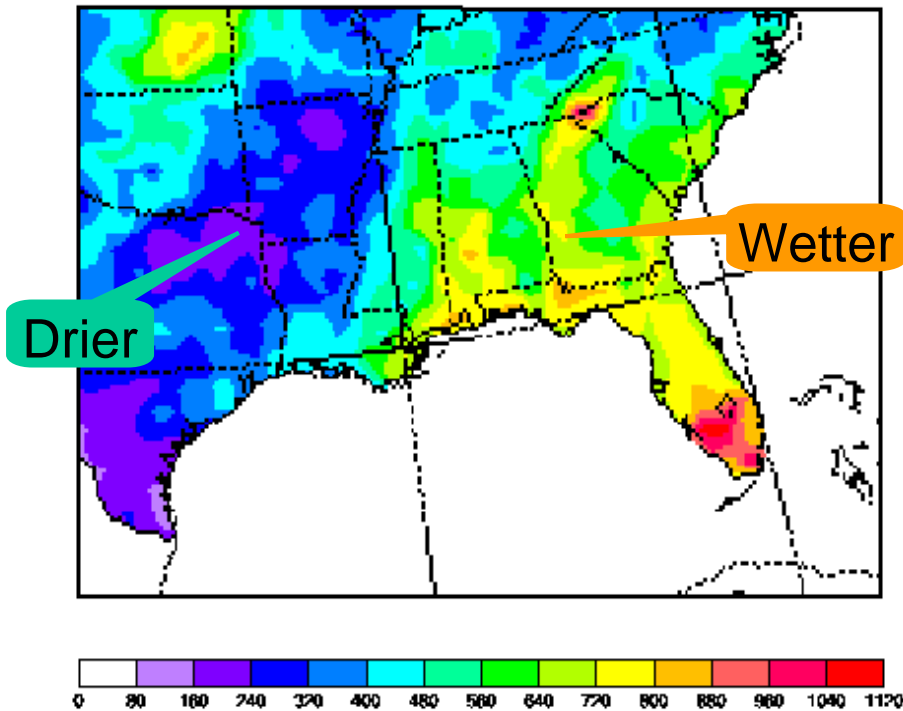
# Illustration of turbulent lifting that can carry spore clouds up high



# Correlation of rust map to rainfall distribution

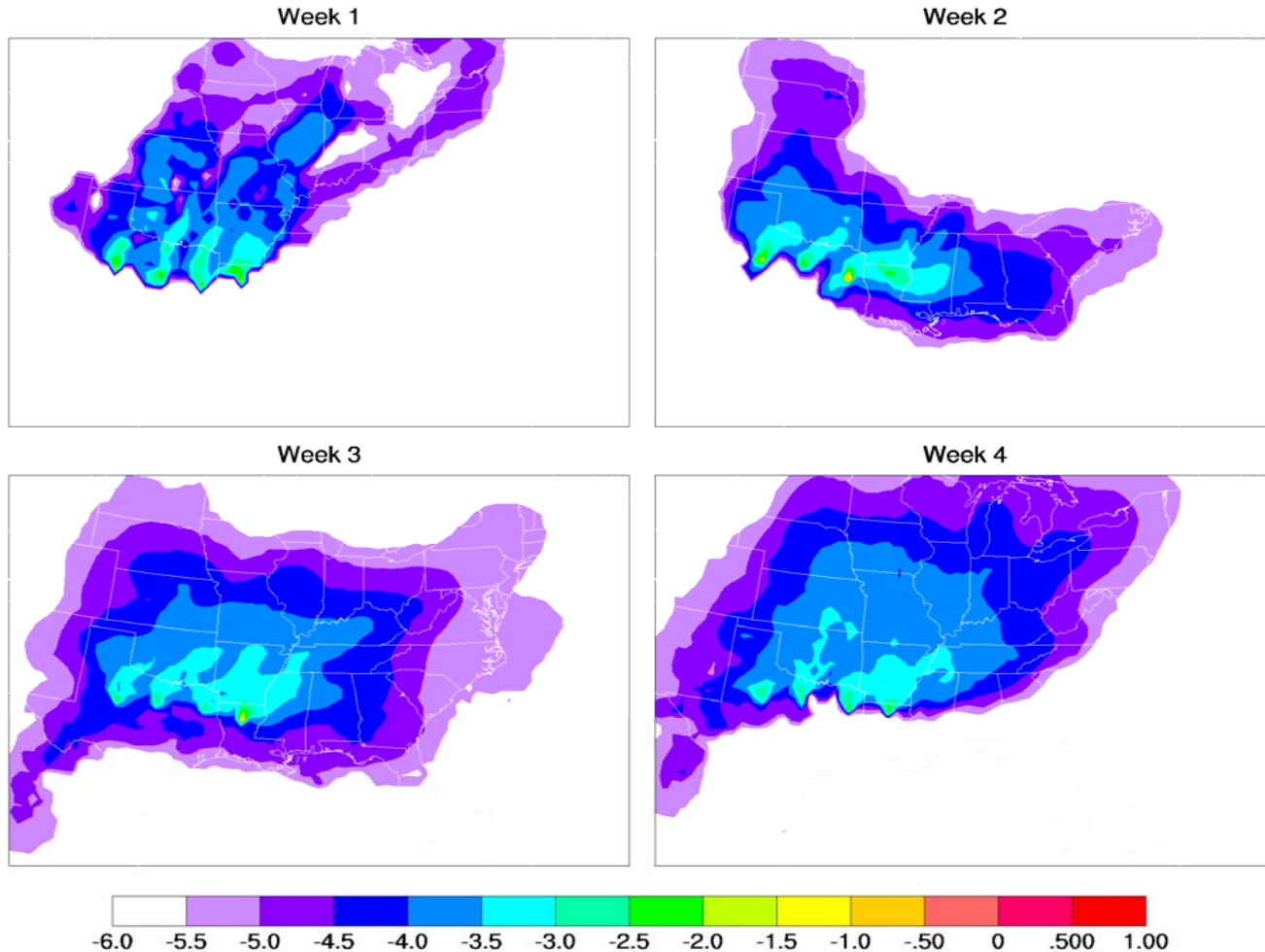
Accumulated Rainfall Amount (mm)

May 01 to Aug 31 2005



# Rust spore dispersal pattern with hypothetical source in western TX, LA

Projected Spore Concentration (log N/m<sup>3</sup>)  
starting April 30, 2005

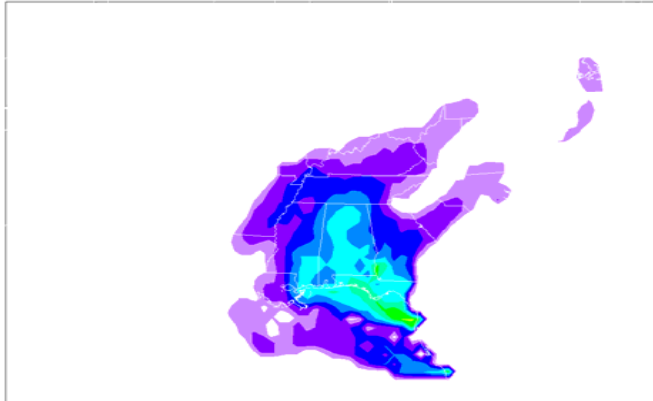


# Rust spore dispersal pattern with source in FL, GA, AL

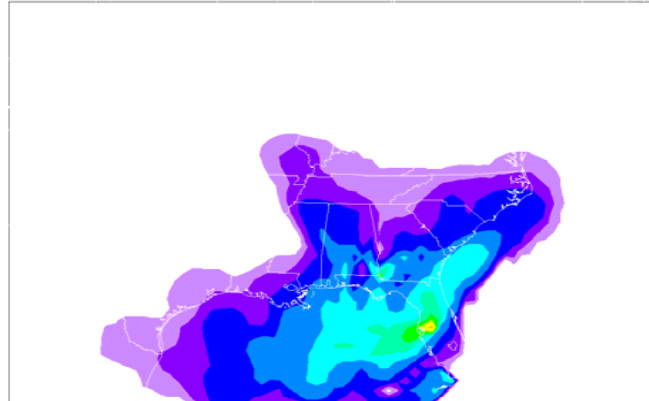
Projected Spore Concentration (log N/m<sup>3</sup>)

starting April 30, 2005

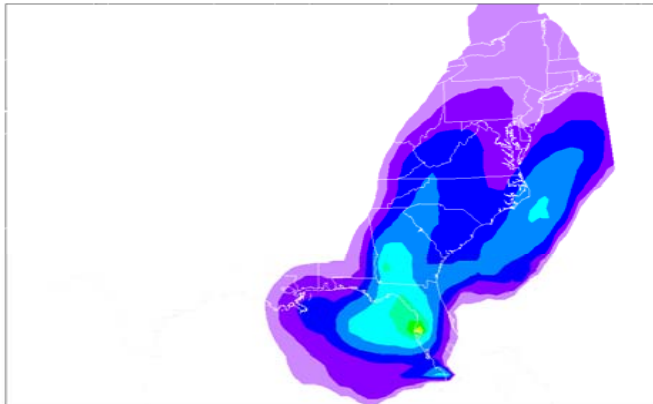
Week 1



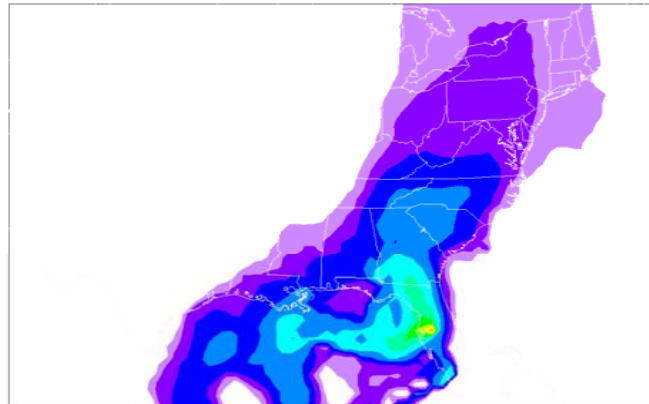
Week 2



Week 3



Week 4



# Summary and Discussions

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- ❑ A spore and disease prediction model system has been established to forecast spore dispersal and disease development up to 2-4 weeks in advance.
- ❑ The integrated model system consists of spore dispersal and rust development sub-models.
  - Dispersal model is an integration of HYSPLIT with MM5 that is fed on by a global seasonal forecast model.
  - Disease model is an expert assessment system based on rainfall characteristics, among others.
- ❑ The 2005 season prediction suggests that the model system can predict the general dispersal patterns although it often overpredicted spore concentration.

# Summary and Discussions - continued

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- ❑ Even if the predicted spore dispersal has large uncertainty, a well-adapted expert system of the disease model still appear to give a reasonable disease outlook, as seen this year.
- ❑ Among other factors, the 2005 climate conditions were somewhat unfavorable for SBR widespread:
  - Light wind speeds likely suppressed spore lifting
  - Wind direction may have demoted northward transport
  - Drier surface could limit the westward spread
- ❑ Largest uncertainties in the rust prediction seem to lie in accurate determination of spore production and lifting, their viability, and disease biology, which need to be improved in the coming years.

Thank you !