Intra-seasonal rainfall prediction for agricultural applications during growing season

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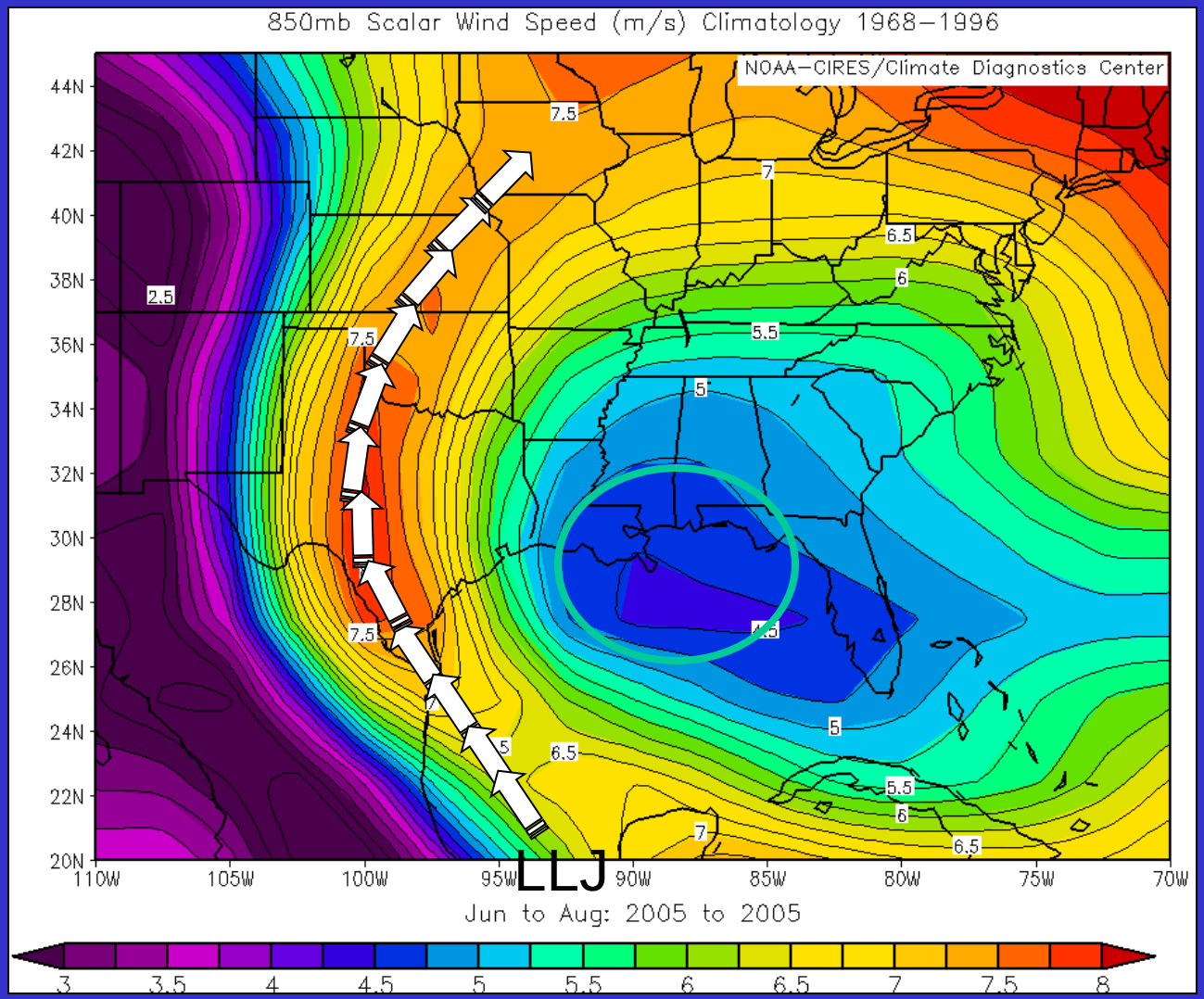
Motivations

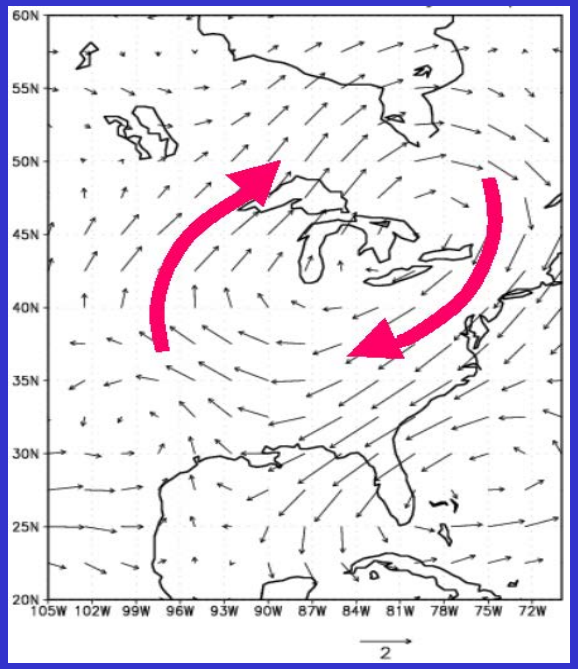
- The U.S. agricultural production contributes $200 billion yearly.
- In 2012, disease caused 10.9 % losses of corn yield in 22 U.S. states and Ontario, amounting to 1.3 billion bushels.
- Plant diseases are sensitive to weather/climate conditions, particularly temp. and rainfall.
- Predicting plan pathogen dispersal and thus probability of disease outbreak provide early warning.
- We try to provide month-long forecast of statistics of precipitation and temperature.

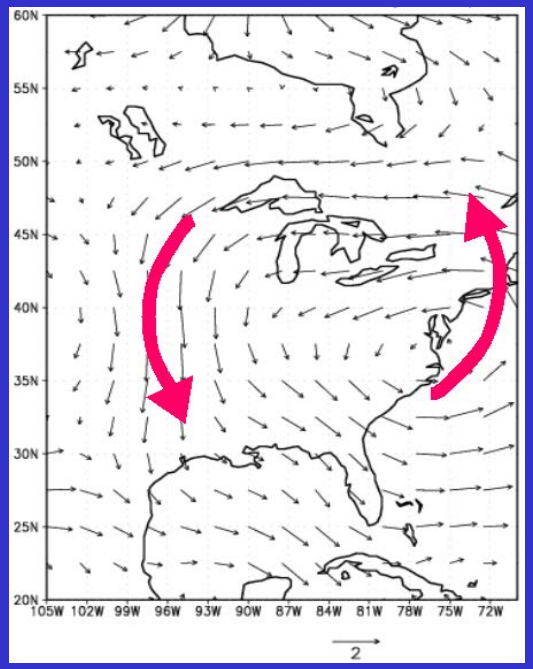
Low-level jet is conducive to spore spread



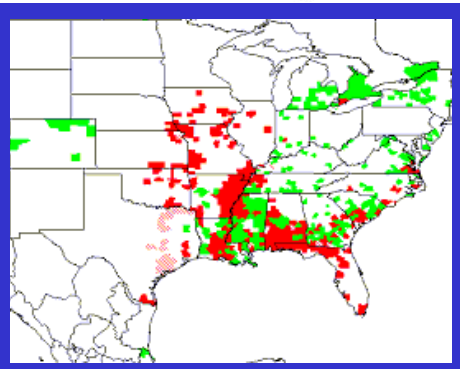
Atmospheric circulation affects disease spread

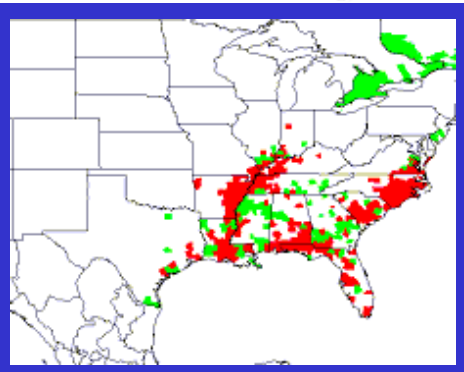
2007





2006





Top: the 850 hPa wind anomaly during growing season (May-September), contrasting the flowing patterns of the two years. Bottom: USDA detected disease at the end of season (www.sbrusa.net)

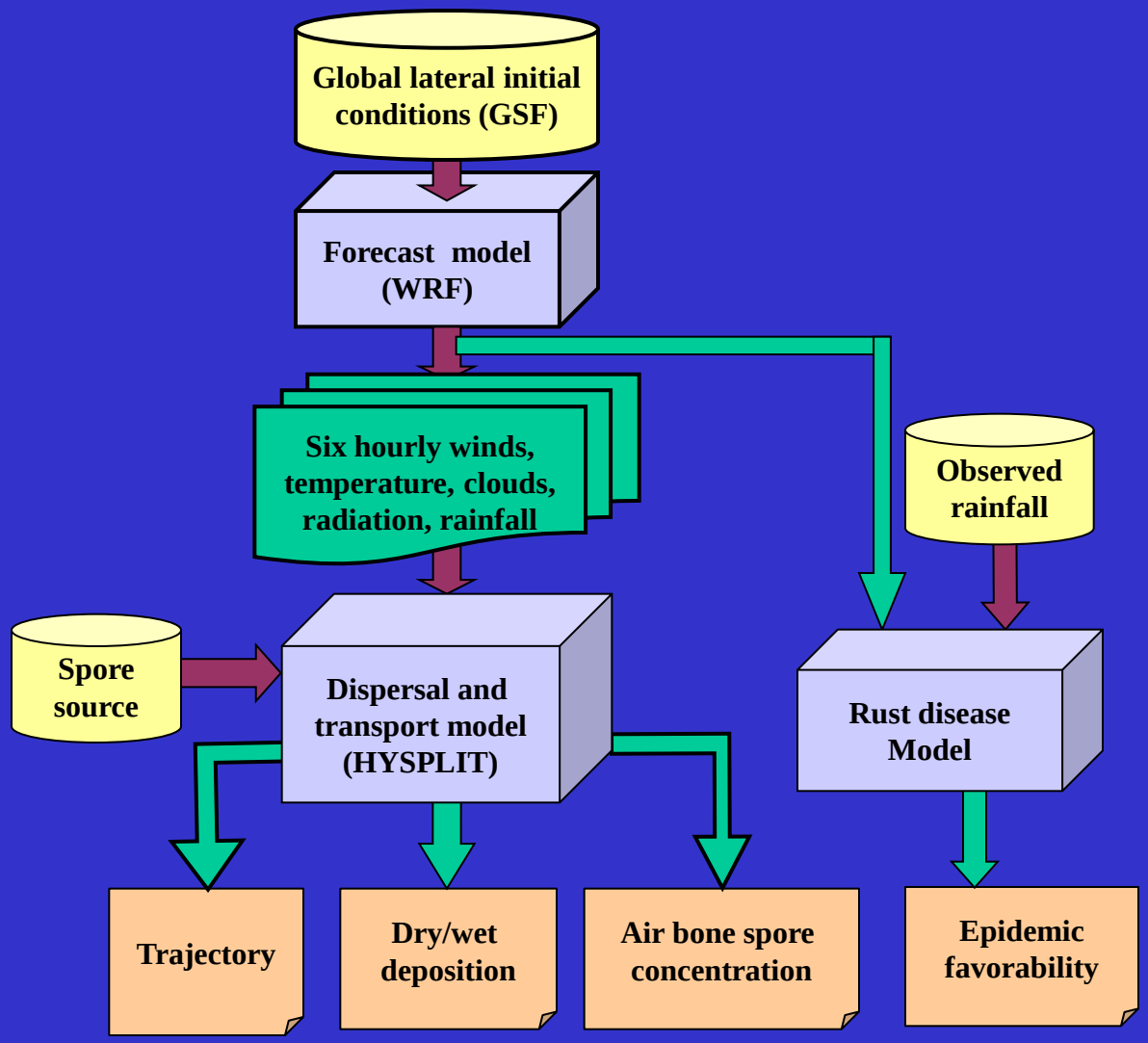
A climate-dispersal-disease integrated system

WRF model - NCAR

HYSPLIT* model – NOAA Air Resource Lab

Disease model Iowa State Univ.

*: HYbrid Single-Particle Lagrangian Integrated Trajectory



Why global WRF vs. so many GCMs?

✓**What is global WRF?**

- WRF has a built-in global capability that is unfortunately underused.
- Largely same settings as regional runs except for gird configuration such as polar filtering.

✓**Pro and cons of global WRF vs. GCM**

Advantages: - two-way, same-model nesting
- ample physics parameterizations
- simple, economical

Disadvantages: ocean decoupled

Global WRF model configuration and prediction runs

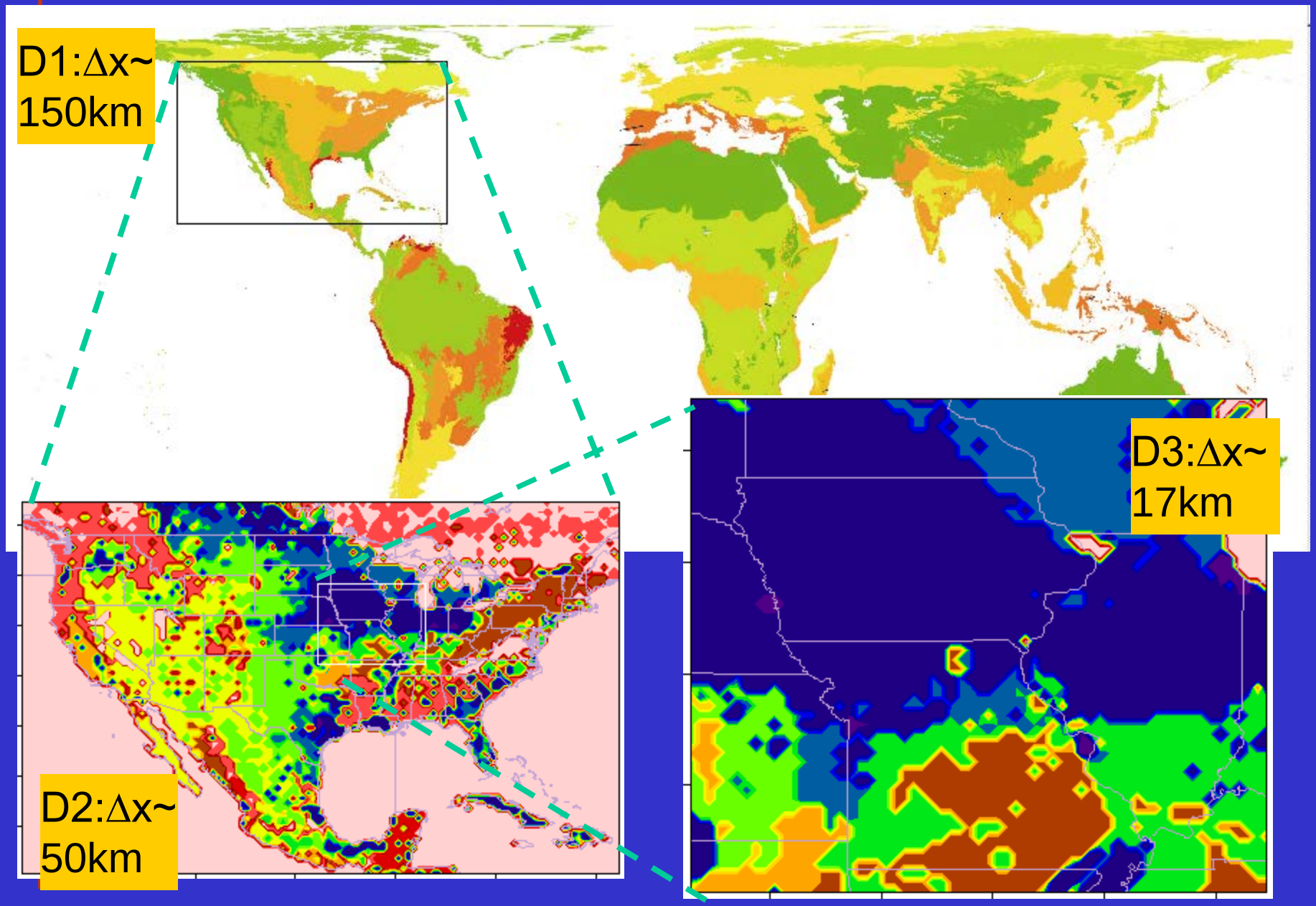
- **Global WRF model configuration**
  - ✓Initial condition – GSF forecast fields
  - ✓Domain/resolution – global 150 km, U.S. 50 km, Midwest 17 km
  - ✓Runs and frequency – runs weekly for 30 days
- **Main model output variables**
  - ✓30-day mean temperature
  - ✓30-day cumulative precipitation amount
  - ✓Total number of rainy days
- Post-processing
  - ✓Bias correction and space disaggregation (BCSD)
  - ✓Statistical downscaling to specific form site (on-going)

The Integrated Dispersal Model (HYSPLIT)

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

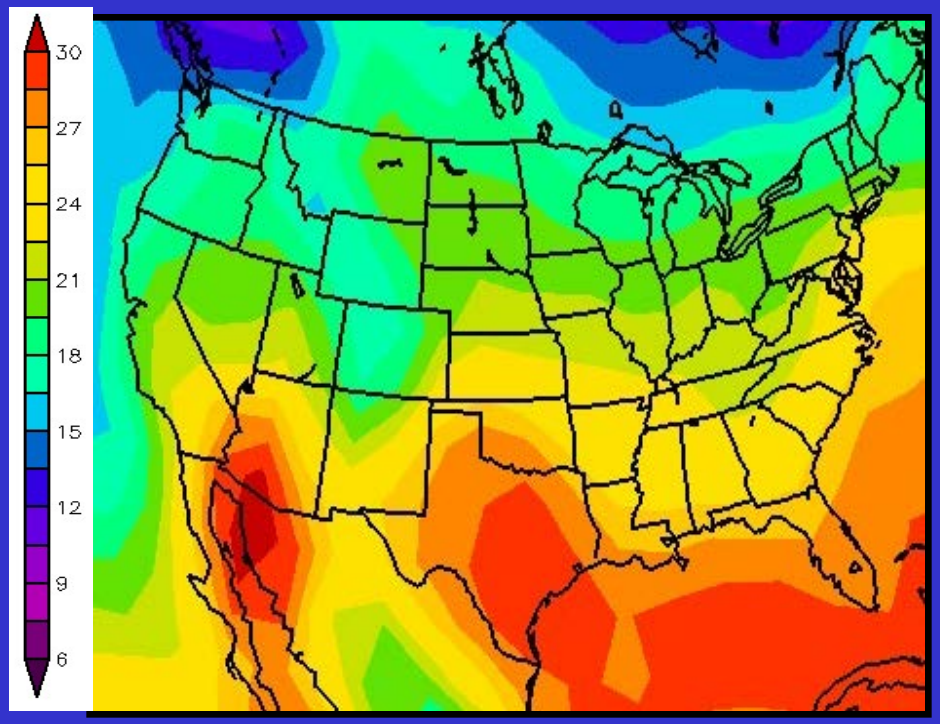
  UV radiation, turbulence transfer

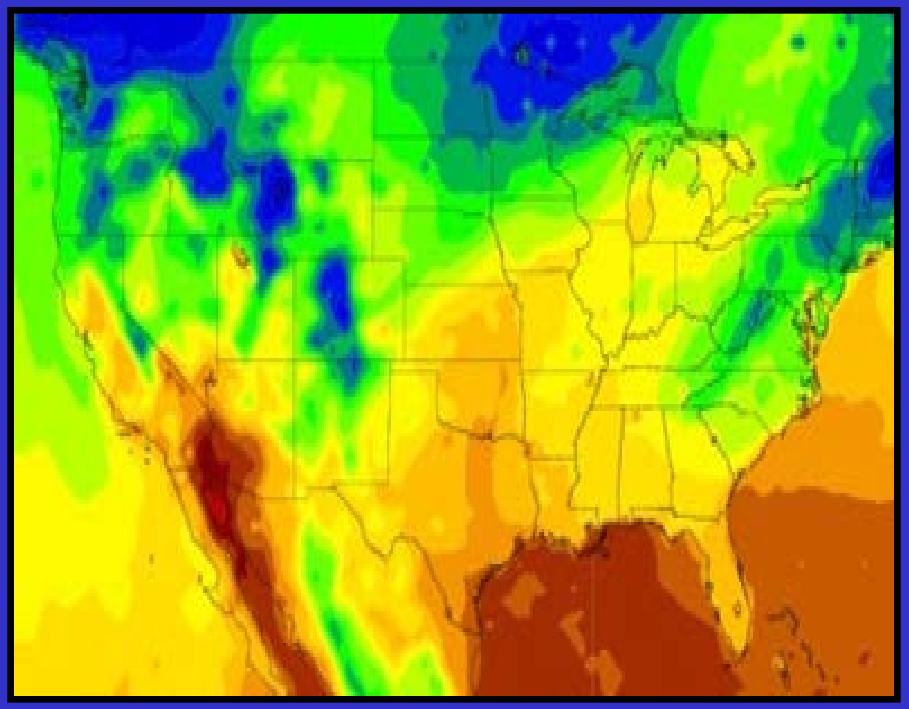
Nesting of model domains



A sample of 30-day surface temperature prediction

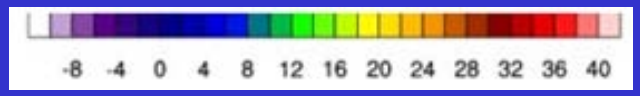
Aug. 6 to Sep. 5, 2009



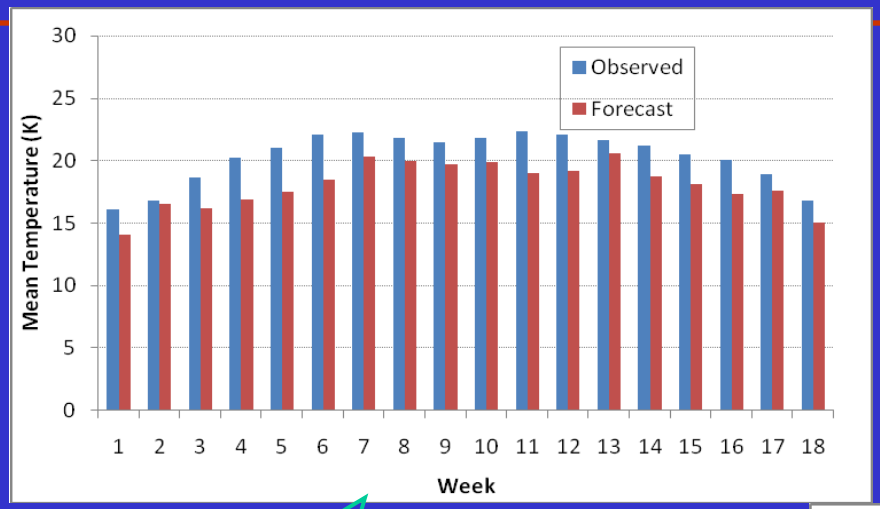


Observed

Forecast

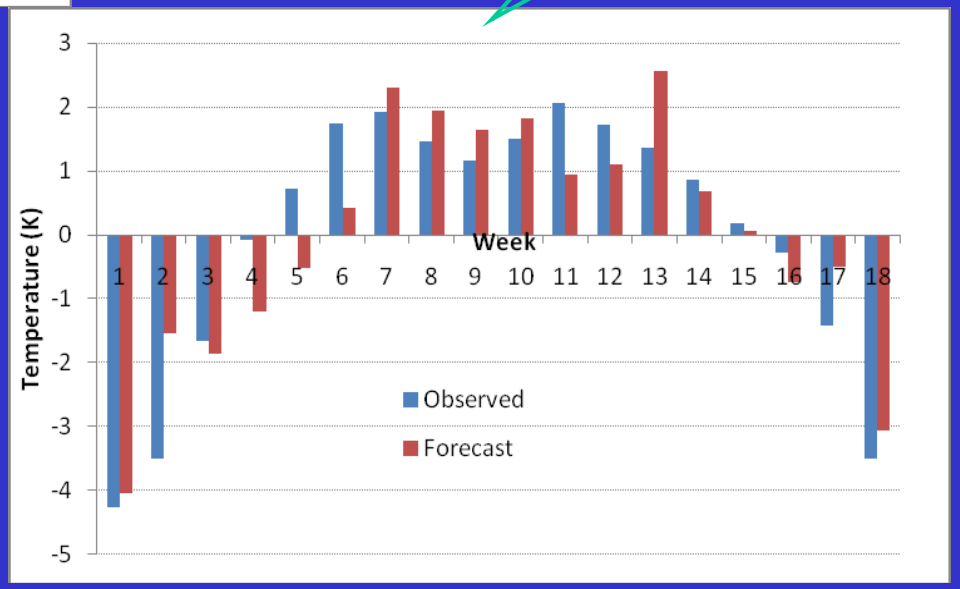


Central U.S. temperature forecast validation (2009)



Raw comparison

After bias correction in anomaly



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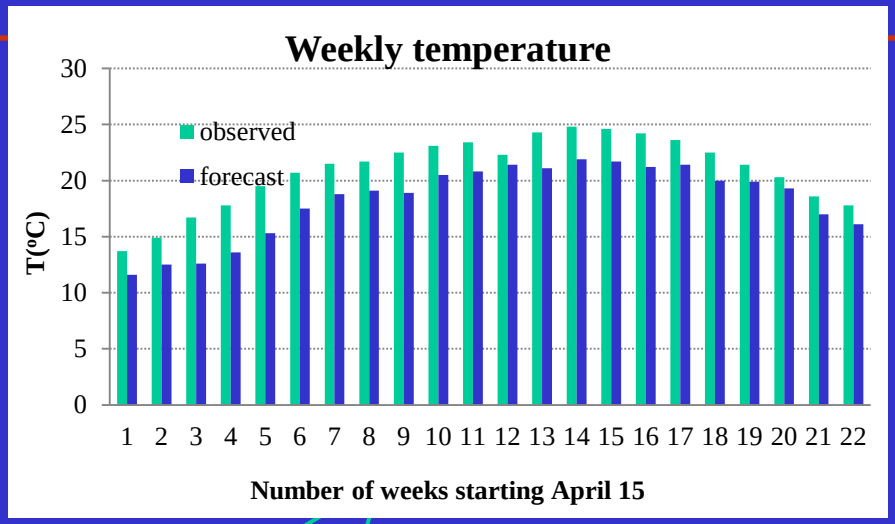

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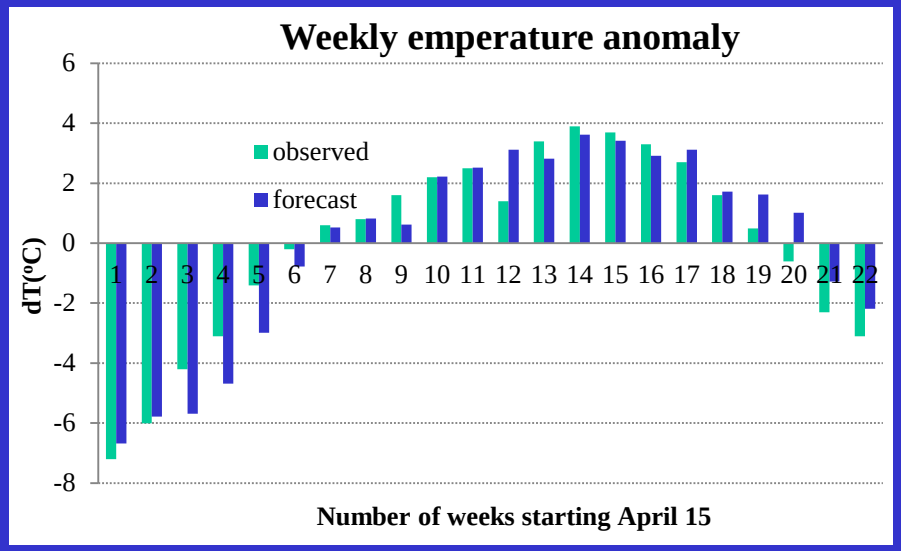
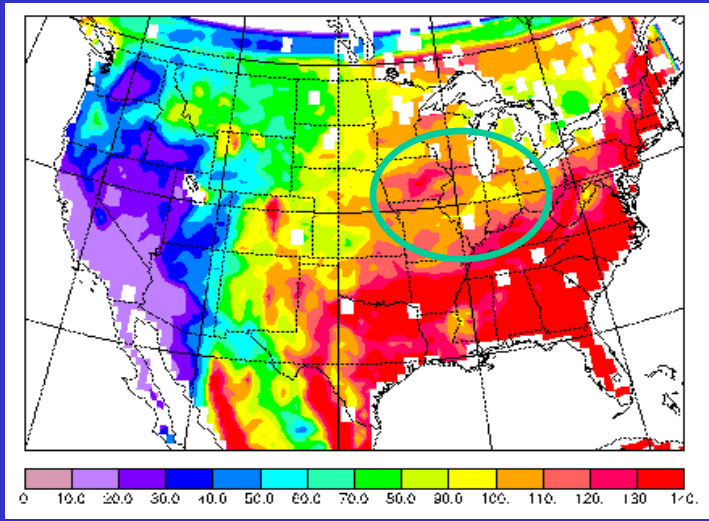
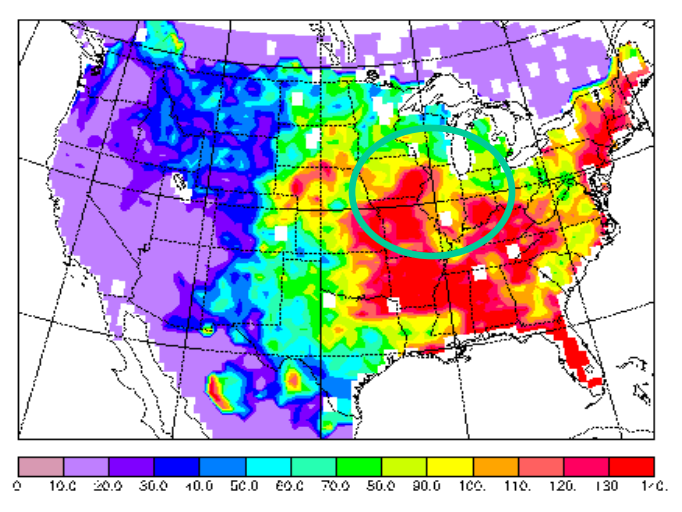


30-day rainfall forecast validation averaged over ~20 weeks

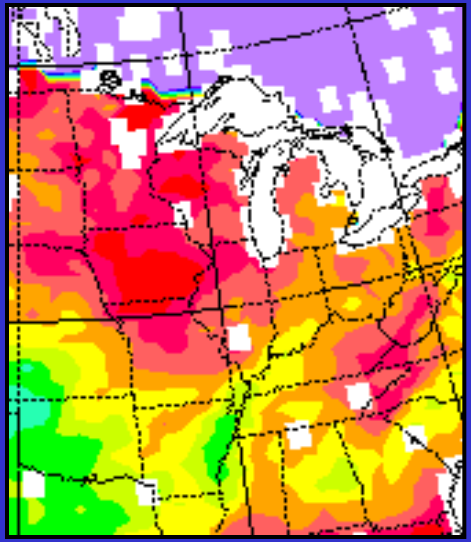
Forecast

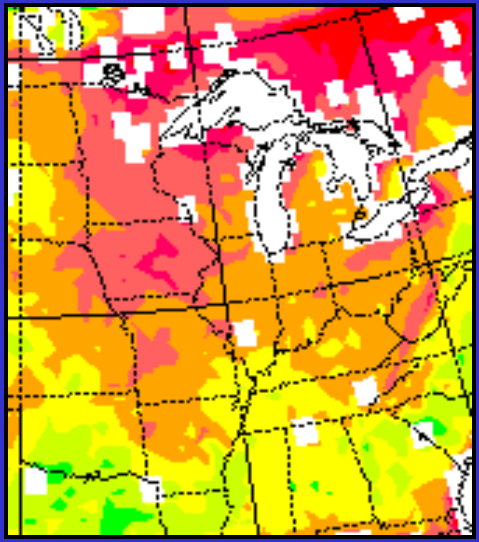
Observed



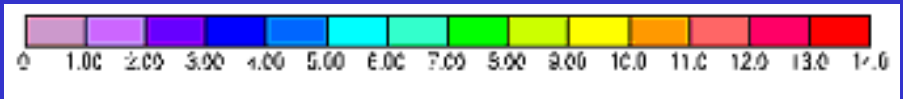


2009

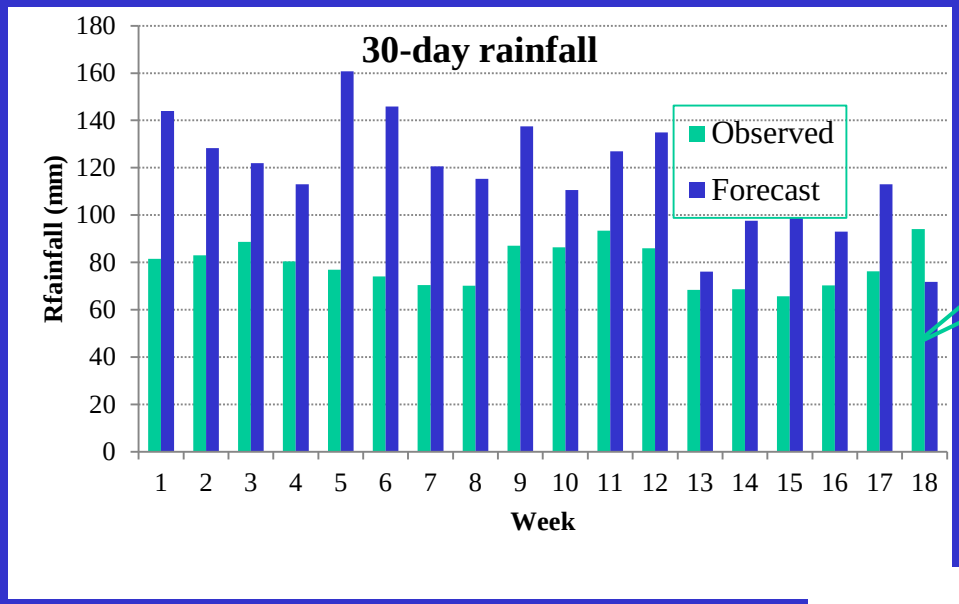




2010

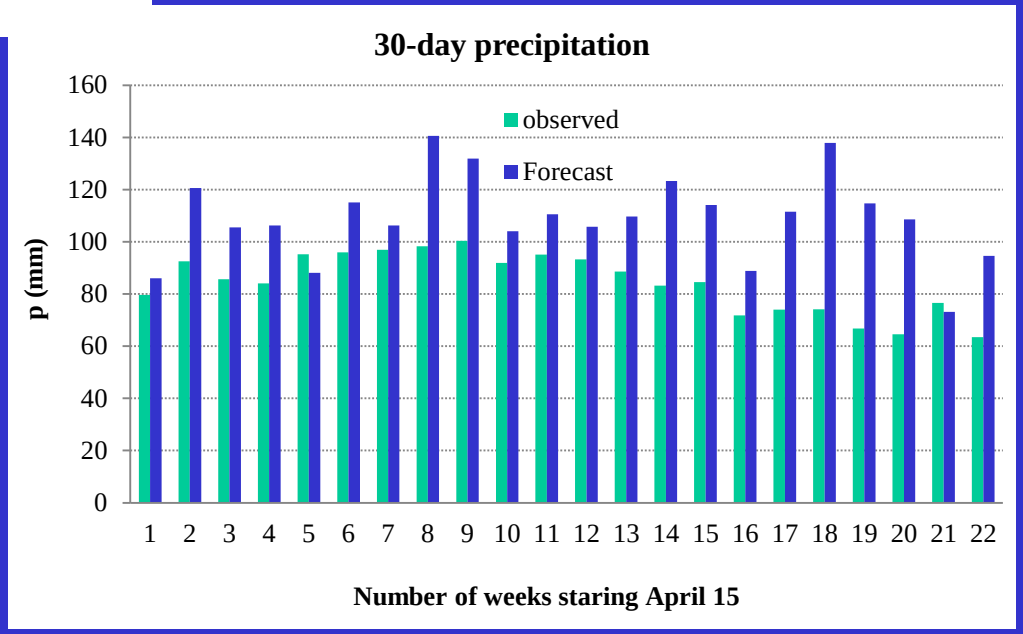


30-day rainfall amount forecast validation



2009

2010

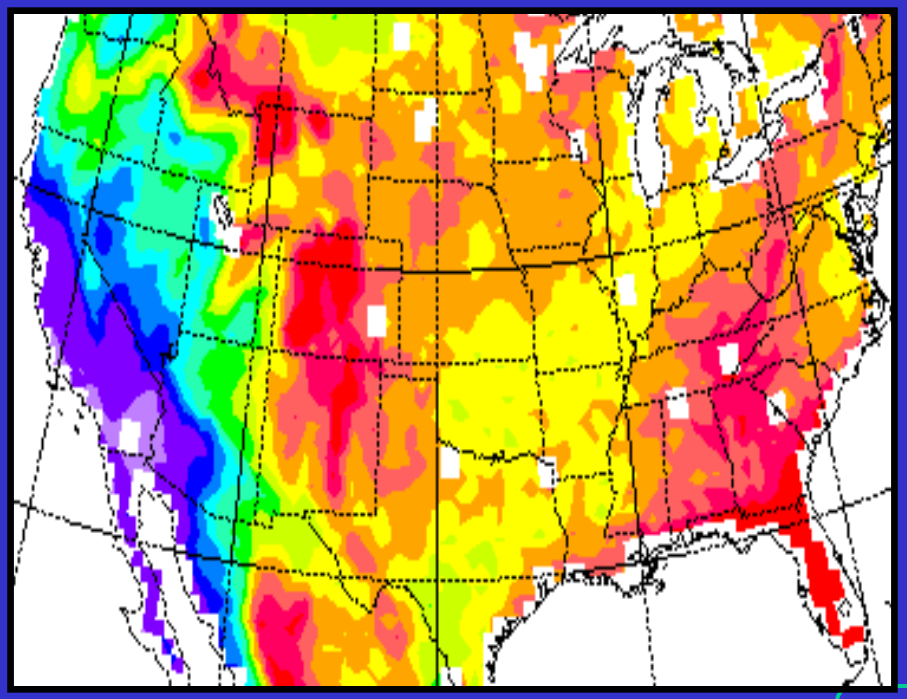


Challenge: how to define a rainy day

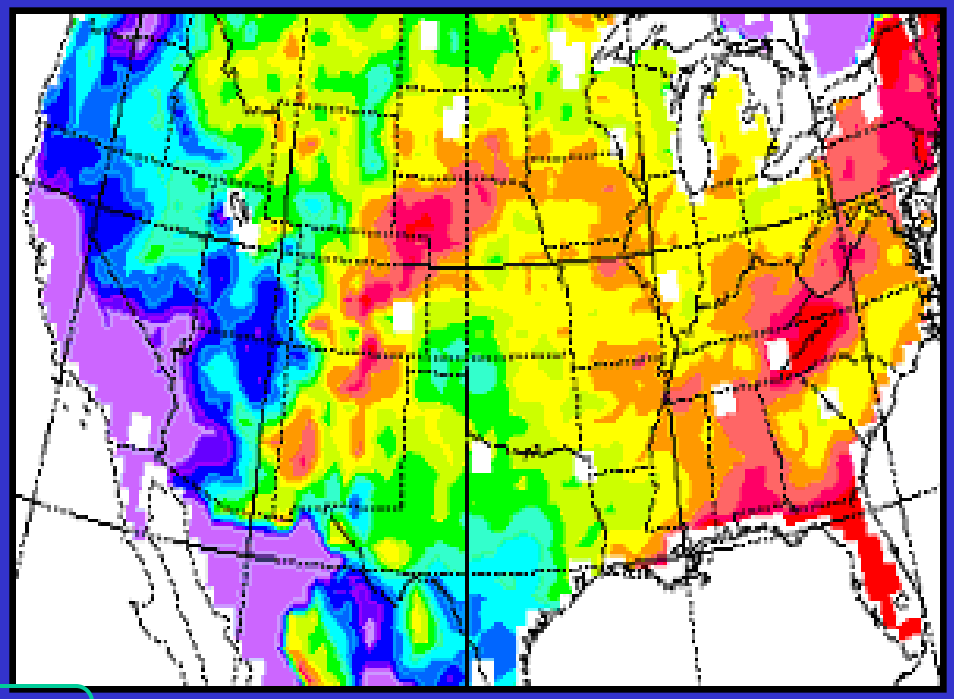
- Because of model's "drizzling" problem, WRF (or any other models) can produce lots of rainy days.
- By try and error, currently we set the cutoff at 1 mm per day as a rainy day.

30-day rainy day forecast validation averaged over ~20 weeks

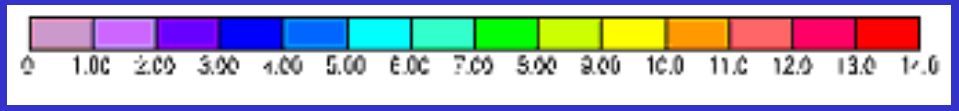
Forecast



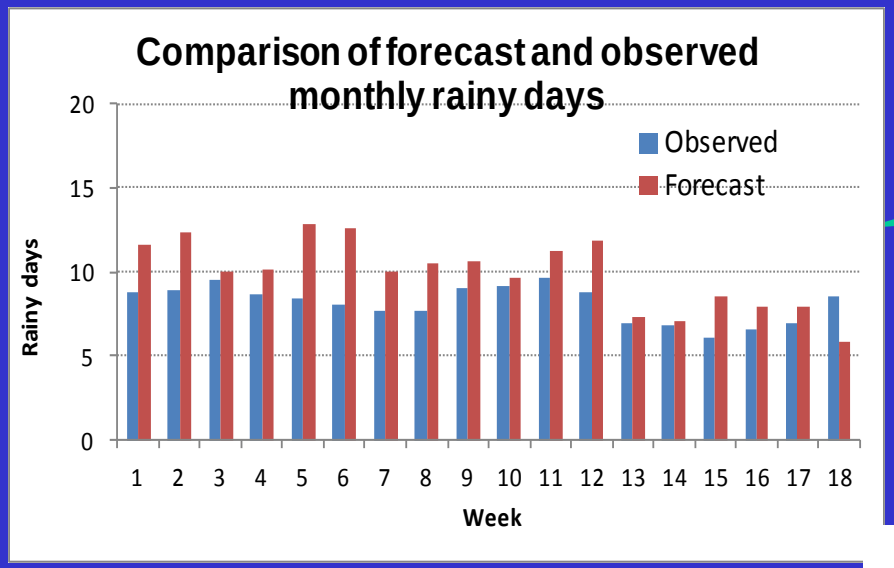
Observed



2009

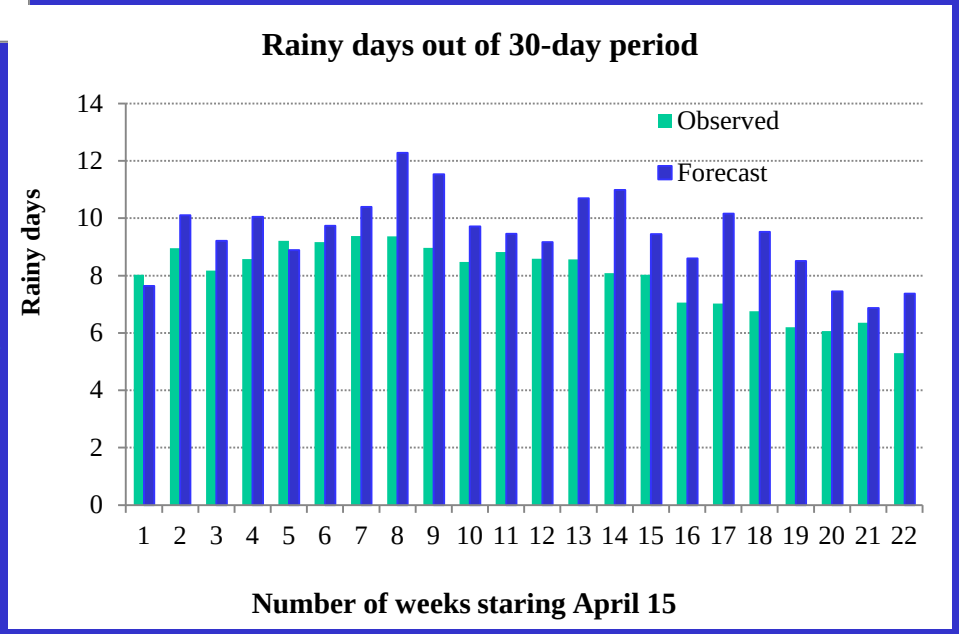


Rainy day validation for forecasts

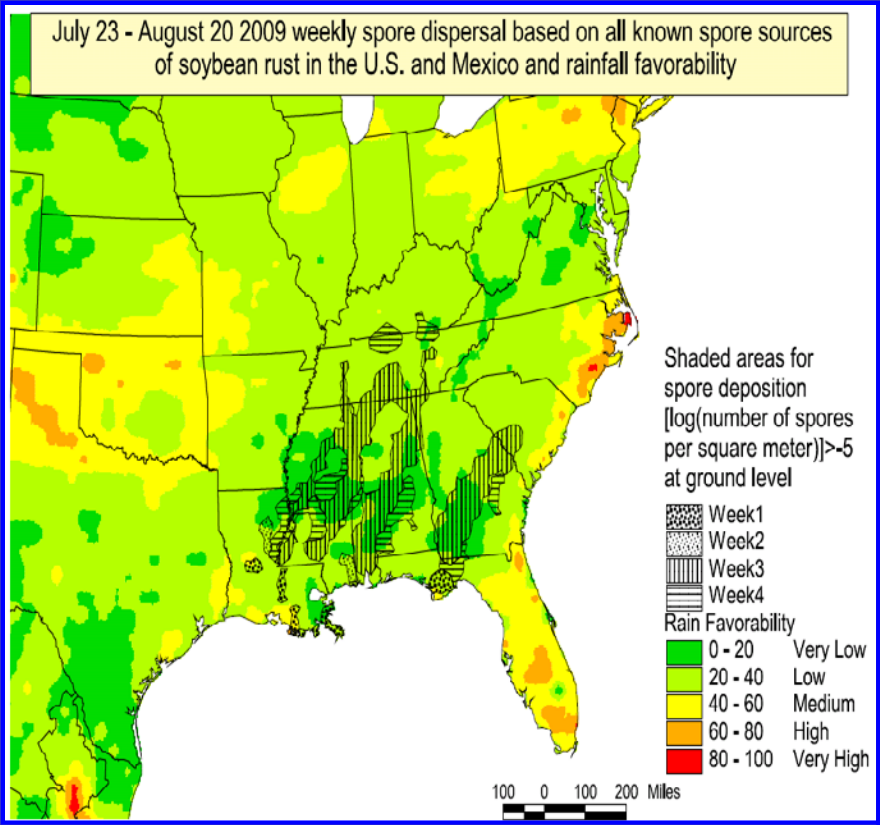


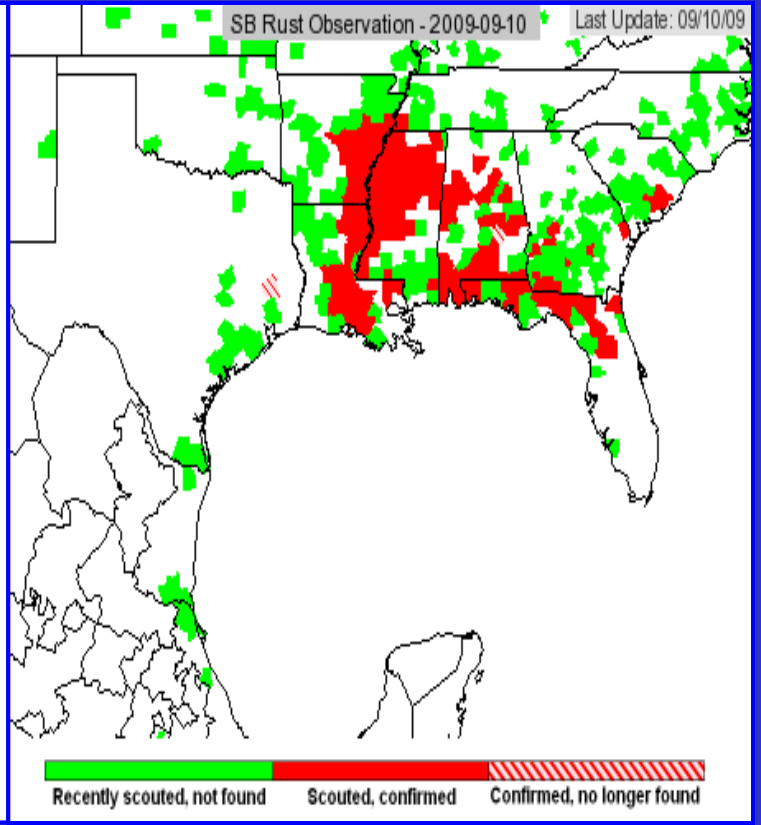
2009

2010



Forecast spore transport and disease detection

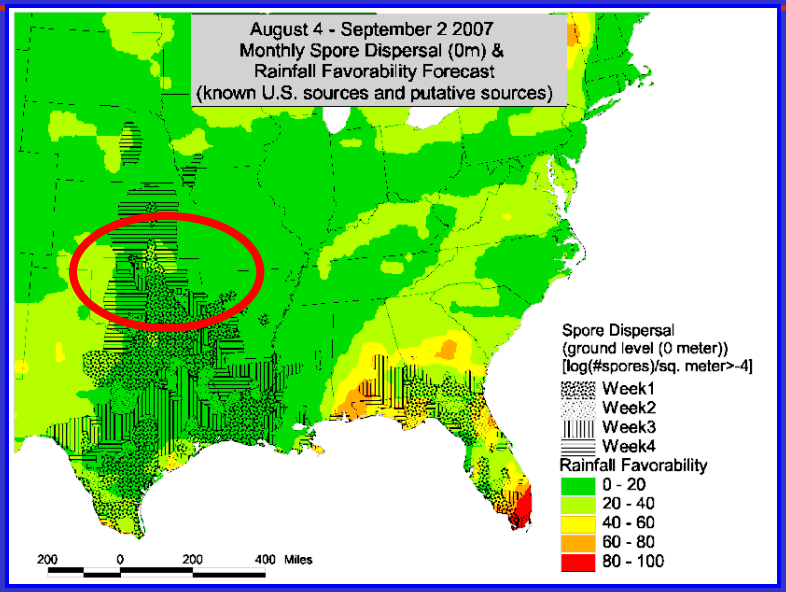




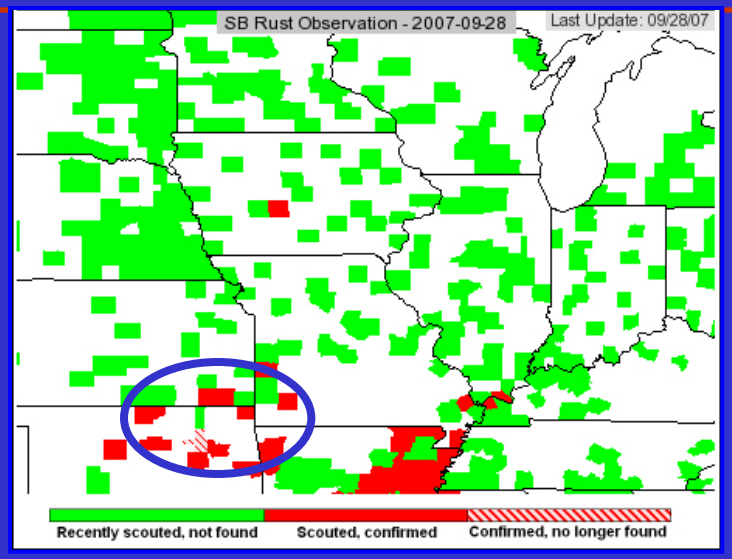
July 2009

September 2009

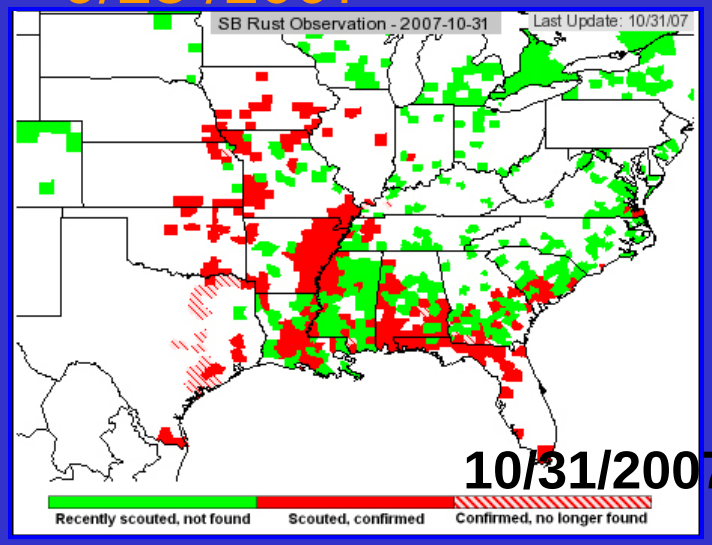
Another example



8/4-9/2, 2007

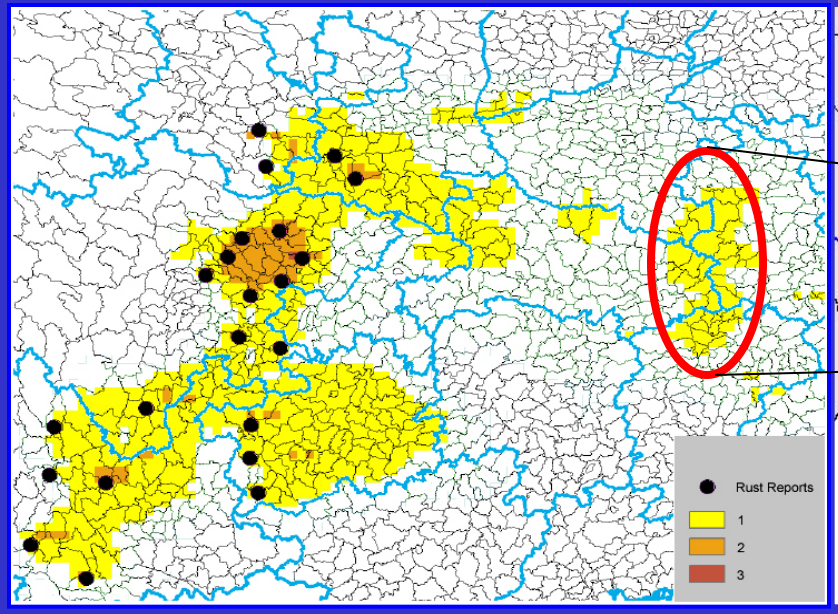


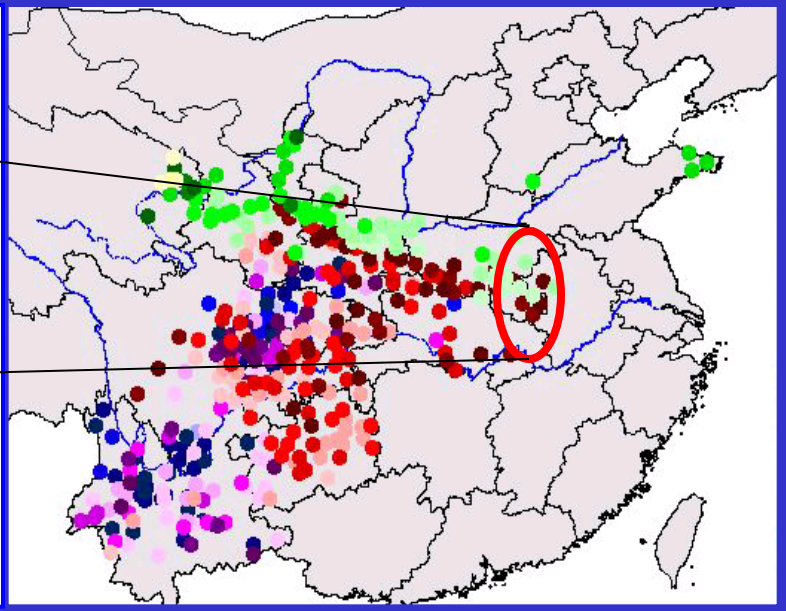
9/23 /2007



10/31/2007

Wheat stripe rust forecast in China





A forecast on April 10, 2010

Disease reports by late June

Summary

- Weekly 30-day forecasts were made during the growing season.
- The forecast temperature has cold bias, but it can be corrected as long as the bias is systematic.
- The model can capture overall pattern of rainfall, although amount and rainy day are over-predicted.
- Disease forecasts driven by model weather, thought imperfect, seem encouraging.

Next step

- Compare with other forecasts, i.e., CFSv2 hindcasts, NMME outputs.
- Ensemble approach.

Thank You