Coupling Lagrangian Stochastics and Large Eddy Simulation to Predict Long Distance Dispersal of Pollen

Mark Westgate
Raymond Arritt
Susana Goggi
Jeff Wolt

Funded by: USDA – Biotechnology Risk Assessment Grants Research Grants Program

Project Plan

- Objective 1: Development of a coupled Lagrangian-Stochastic Large-Eddy Scale simulation model for maize pollen dispersion
- Objective 2: Verify Lagrangian-Stochastic LES simulation predictions under management conditions required for confined crops
- Objective 3: Evaluation of a mesonet as an early warning system for real time prediction of probable confinement loss

Modeling Out Crossing Probabilities for Maize in Iowa

Daryl Herzmann
Jeff Wolt
Iowa State University

Motivation

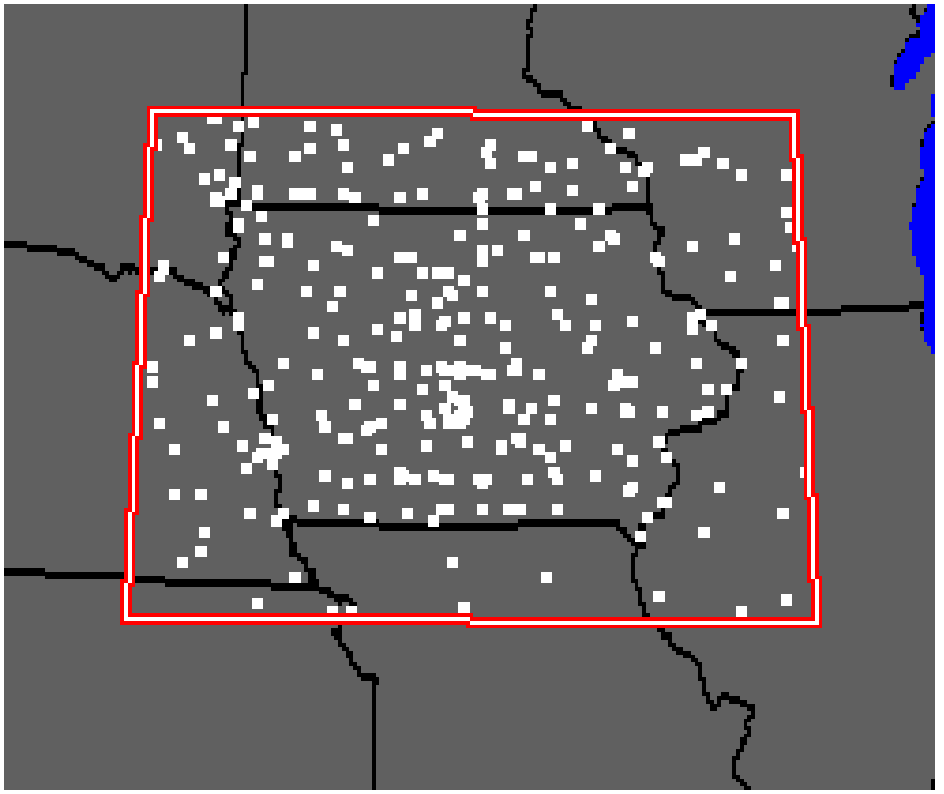
- Development of transgenic crops depends on successful isolation and confinement.
- Maize presents a challenging confinement problem due to open pollination and prevalence in Iowa.
- Directly monitoring Out Crossing (OC) at each field of interest is impractical.
- Can a regulatory air dispersal model be utilized with Iowa Mesonet data and our knowledge of maize physiology to predict/analyze OC events?

AERMOD, Regulatory Model

- Models air dispersal based on planetary boundary layer turbulence structure and scaling
- Preferred model of the EPA replacing the ISC3 model
- Utilize the relatively new dry deposition algorithms of the system to model pollen dispersal
- Input weather data taken from the Iowa Environmental Mesonet

IEM Data Representativeness

- The Iowa Mesonet collects, processes, checks and archives environmental data produced from disparate networks.
- An analysis was performed to determine the spatial scales IEM data could be utilized at.



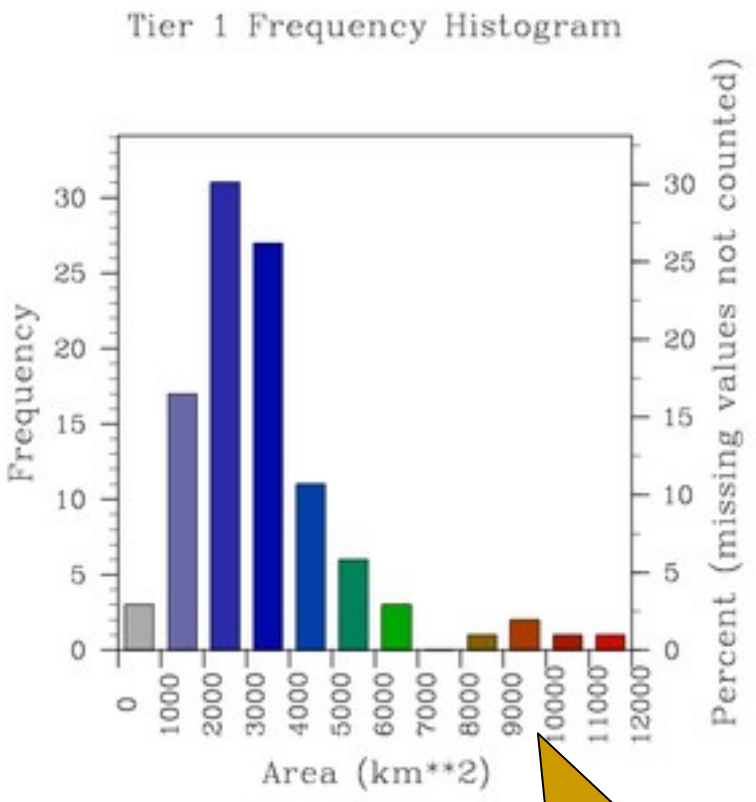
Nearest Neighbor Index

Network	Sites	NNI	Z	Avg Min Distance [km]	Expected Min Distance [km]
ASOS	38	1.05	0.76	38.3	36.5
AWOS	76	1.14	2.12	40.9	36.0
RWIS	101	1.10	1.88	34.2	31.0
SchoolNet	102	0.69	5.54	21.4	31.0
ISUAG	12	0.76	1.44	74.7	98.8
Tier 1	114	0.82	3.83	20.6	25.2
Tier 2	215	0.72	7.57	13.9	19.2
Tier 3	329	0.76	7.98	12.0	15.7

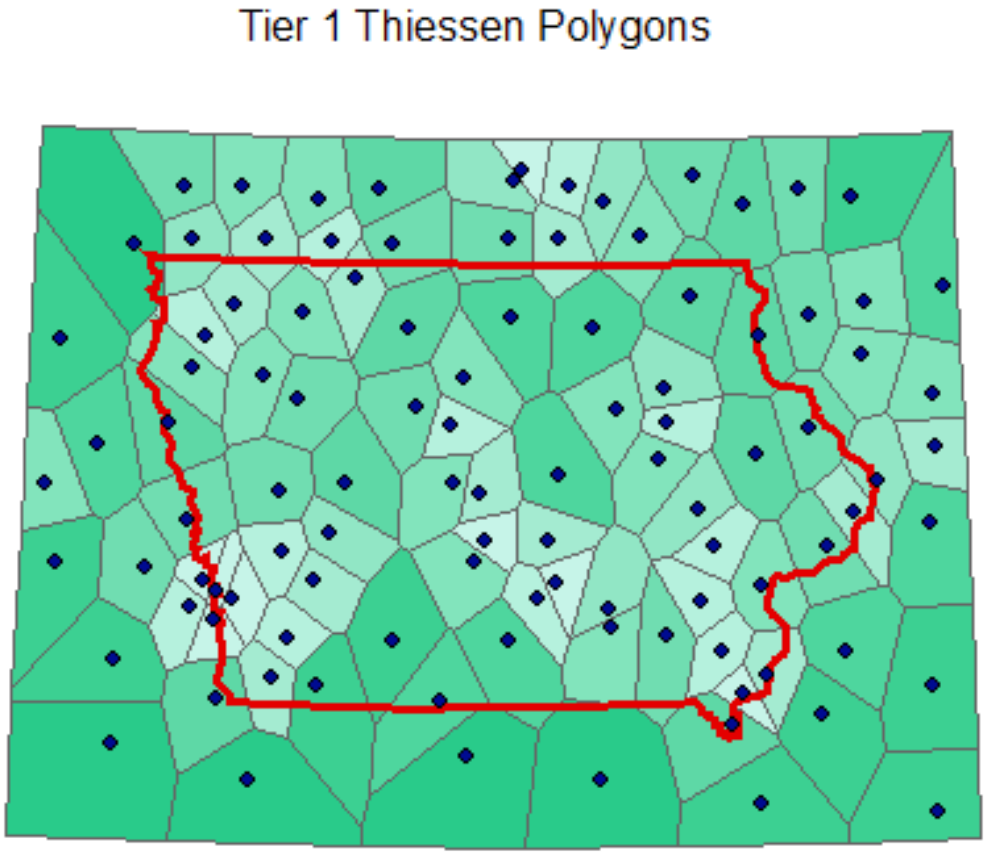
NNI Value	Details
> 1	increasing values greater than 1 indicate more dispersion
= 1	indicates sampling points have a uniform distribution
< 1	decreasing values less than 1 indicate more clustering

Thiessen Polygons

- Polygons represent optimized areas closest to an observation point
- This and further analysis allows design of a representative data grid for Iowa



Skew in polygon size indicates opportunity for improvement of regional representativity



Representativity Results

- The IEM is spatially representative at a scale of roughly 25-30 km.
- Arbitrary combination of all data sources leads to clustering and degradation of data quality at finer scales.
- http://mesonet.agron.iastate.edu/info/nni.phtml or Google “IEM Representativity”
- Representativity results are used to produce quality information to drive our OC modeling effort.

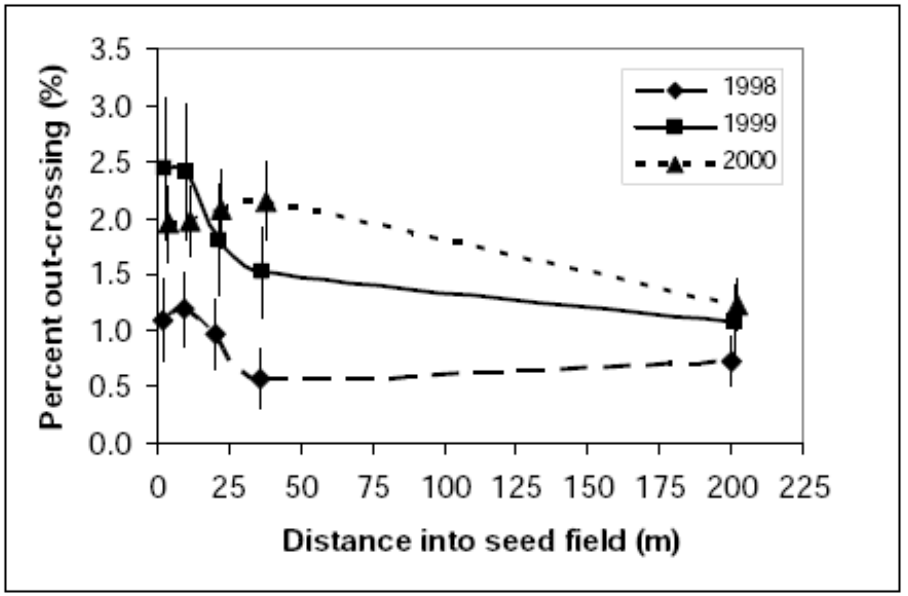
Developing OC knowledge

1. Measure OC for seed production in Iowa
2. Model OC with a regulatory compliant model (AERMOD) and validate result
3. Interface model with a regional weather monitoring network (IEM)
4. Develop retrospective and prospective tools for regionally based OC monitoring & Prediction

Measure OC for Seed Production

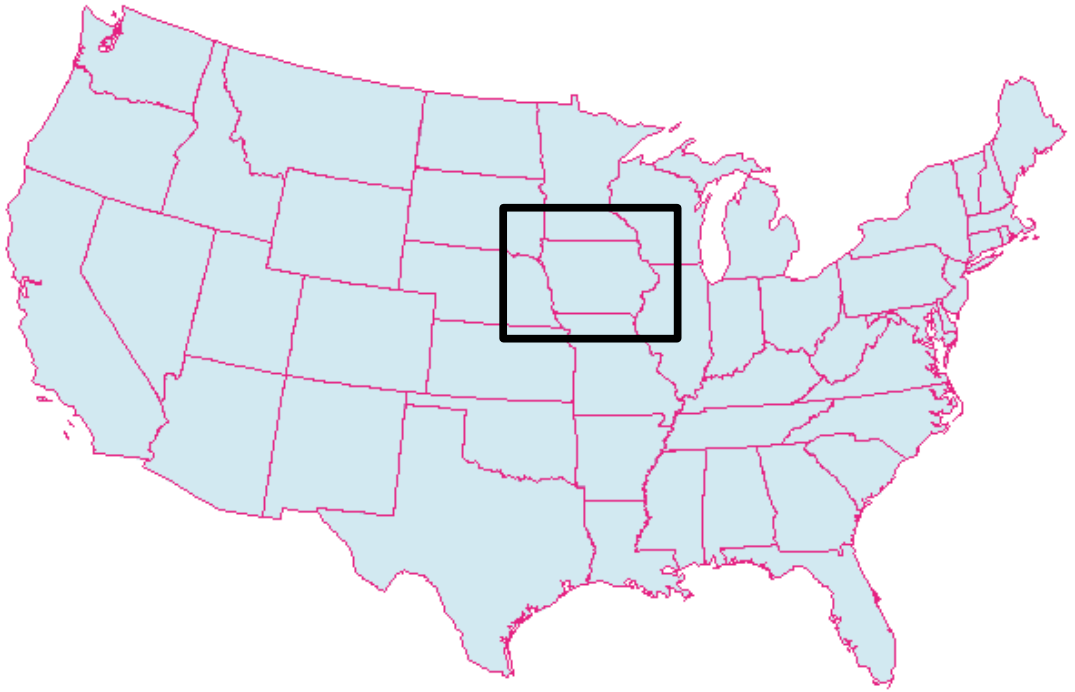
- Data collected during a 3 year monitoring of commercial seed production fields
- Out-crossing observations along in-field transects

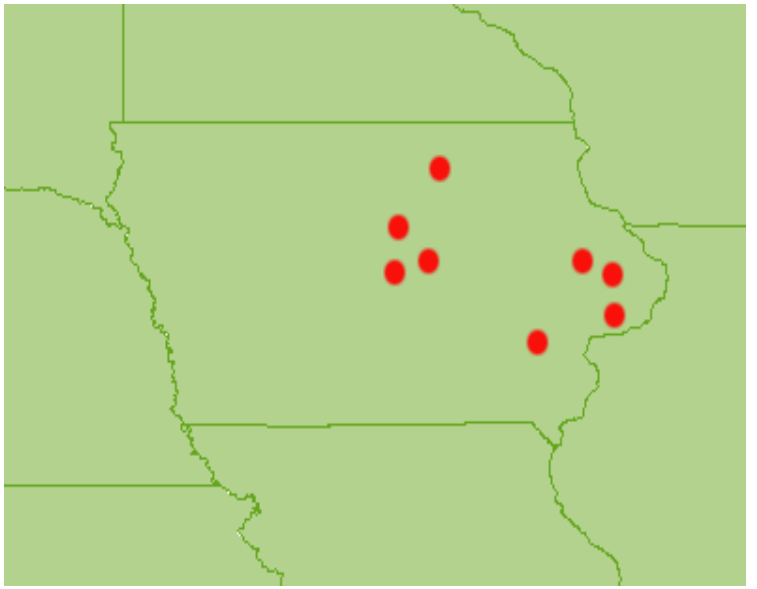
Ireland, D.S., et al: 2006. Managing Reproductive Isolation in Hybrid Seed Corn Production. Crop Science, **46**, 1445-1455.



Model validation fields

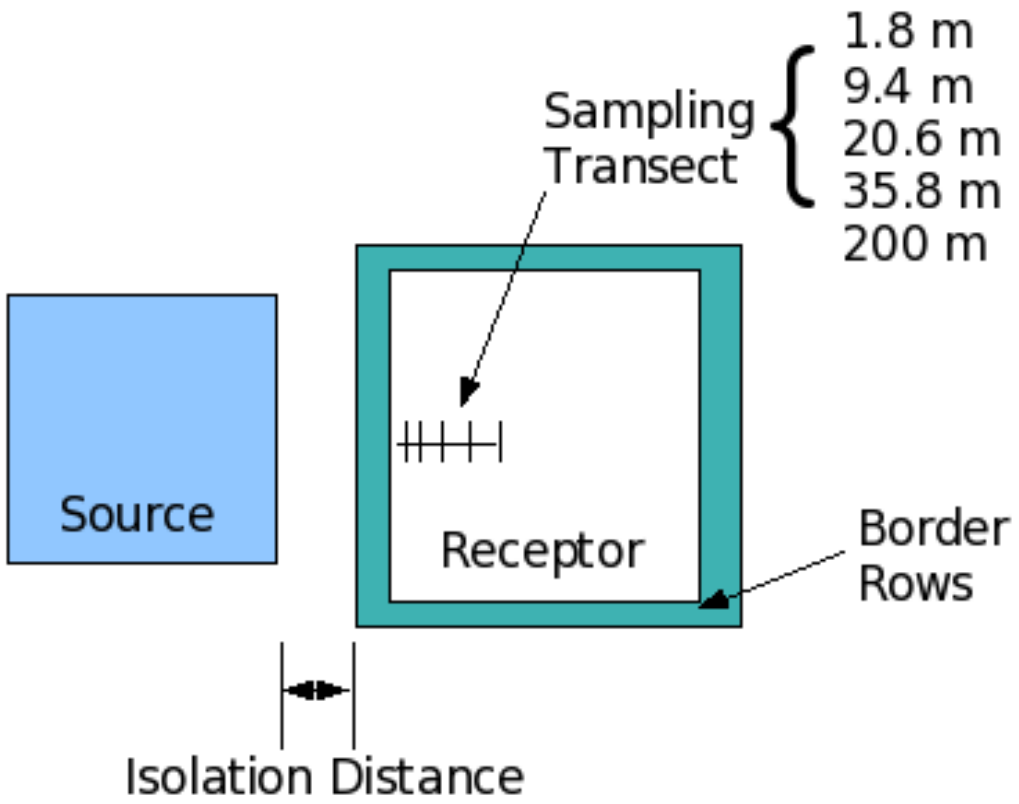
Validate modelling approach using AERMOD and IEM data against an observed pollen out crossing dataset.
Selected 8 sites in Iowa from datasets with adequate meta-data

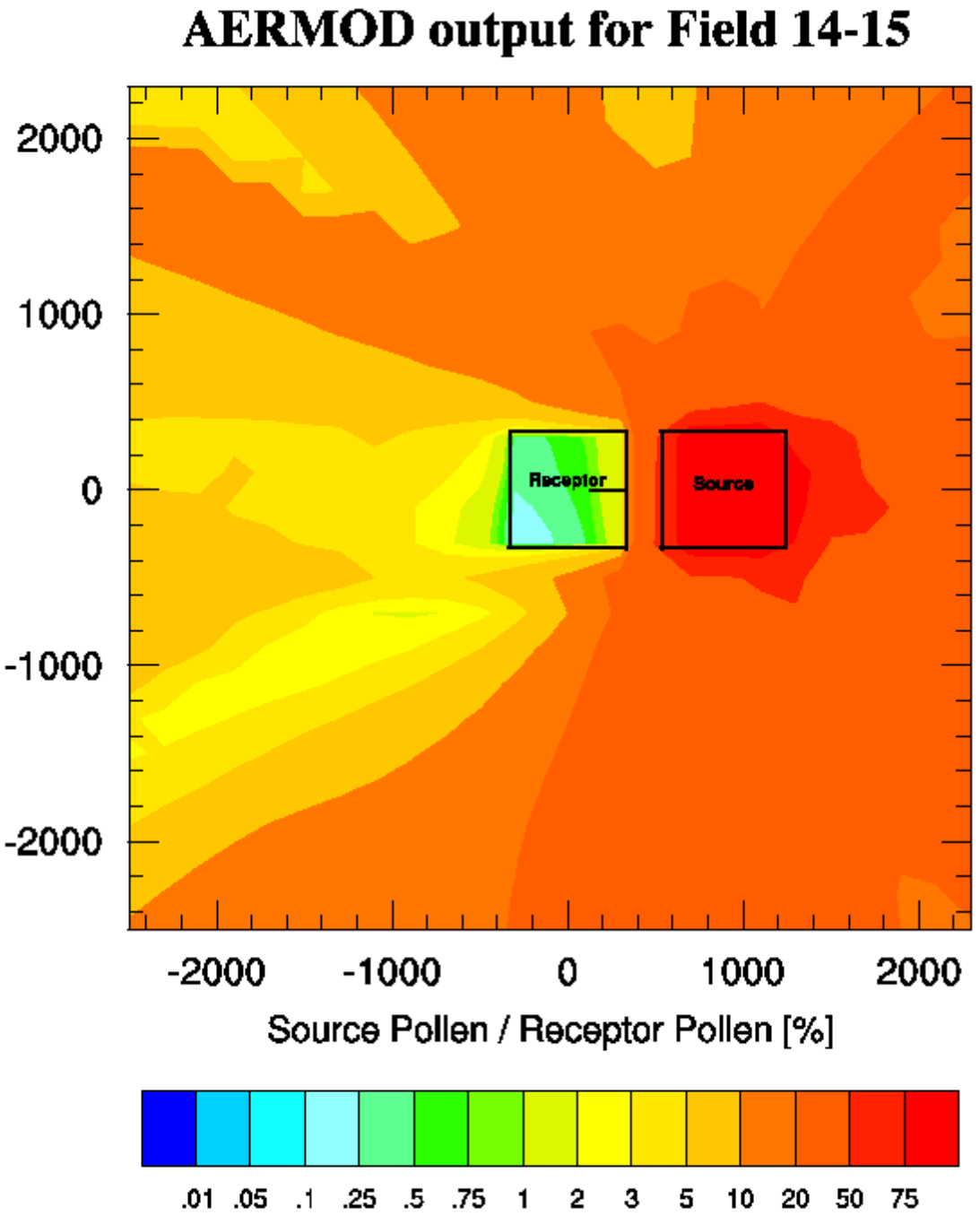




AERMOD “Field” Setup

- Develop idealized representation of OC field studies
- Use IEM weather for a uniform domain of 49km^2





- Presented is a simple ratio of pollen from source (adventituous) versus receptor fields.
- The line in the receptor field is the transect used for validation.

Validation – A work in progress

Field "14-29" – 130 m isolation distance

Distance within recepetor field (m)	Outcrossing (%)	
	Observation	Model
1.8	3.1	6.5
9.4	5.2	5.9
20.6	1.0	5.3
35.8	4.2	4.9
200	3.1	2.7

With no major modification AERMOD predicts directionally correct, order of magnitude correspondence to field observations – Thus, with further calibration AERMOD can be adapted as a first tier model

Regional Modeling

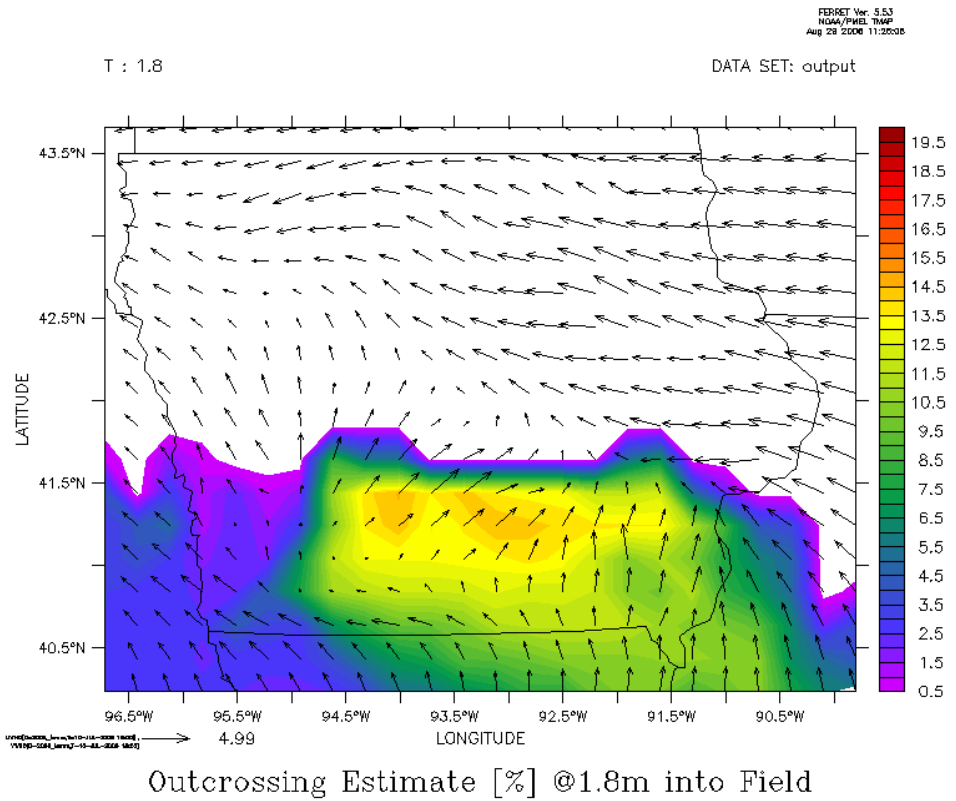
- Provide predictive and retrospective analyses of OC on a regional scale
- Identify areas in Iowa that need more refined modeling and monitoring (first tier)

Link AERMOD with IEM

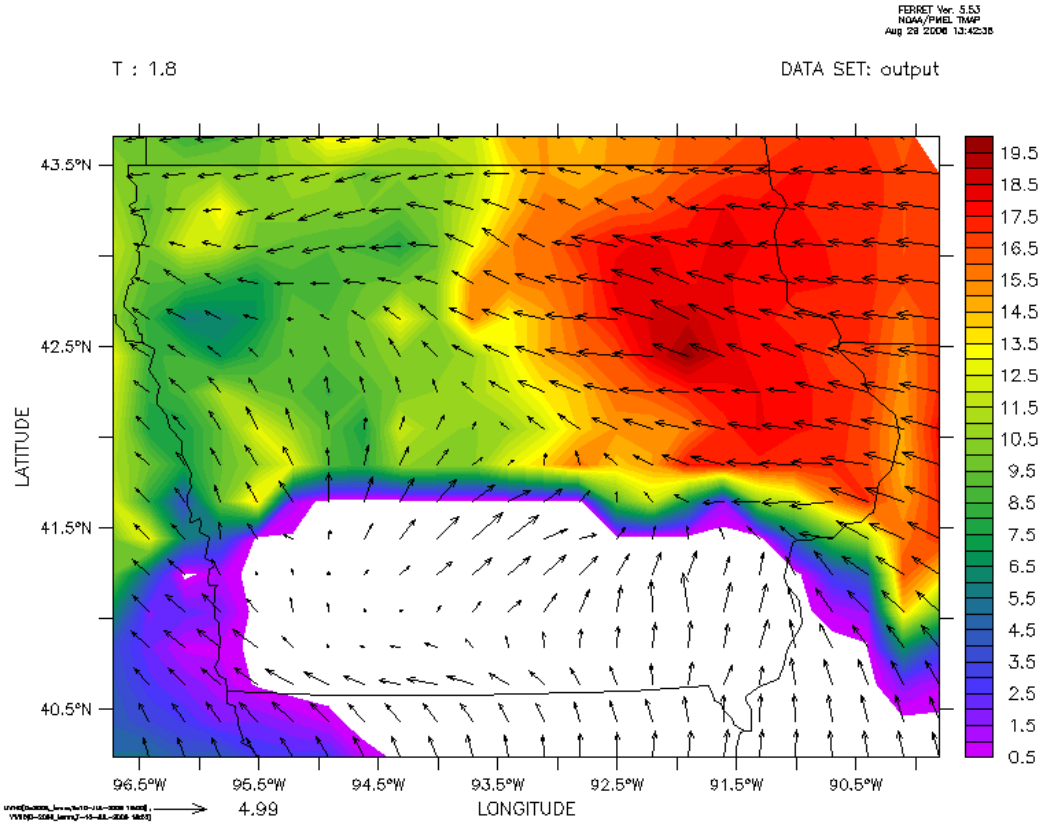
- Configure a representative field setup based on the Ireland validation dataset.
- Model is iterated over a 30km grid of points covering the state to produce an analysis
- 4 runs are made for each point. The adventitious source field is rotated in 4 directions from the receptor field (N,E,S,W)

10 Jul 2006: Example Results

- Outcrossing estimated at 1.8 meters into receptor field with 130 m isolation
- Vectors are mid-afternoon winds



Outcrossing Estimate [%] @1.8m into Field



Outcrossing Estimate [%] @1.8m into Field

A work in progress...

- Continue to test and refine AERMOD setup and post processing
- Implement more advanced algorithms for local pollen competition/viability
- Develop tools (online?) for others to use to access monitoring and response strategies
- Publish....

Insert smooth transition to Brian’s slides here