



# 2016 APEC Climate Symposium

16 - 18 September, 2016 Piura, Peru

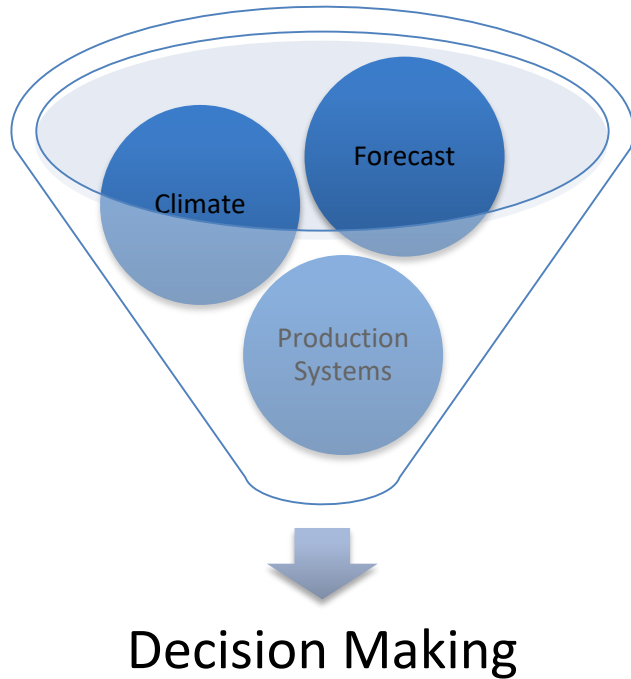
## Climate information tools for decision making

Willingthon Pavan

[pavan@upf.br](mailto:pavan@upf.br)

+55 54 3316-8354 x 8789

# Mosaico Research Group

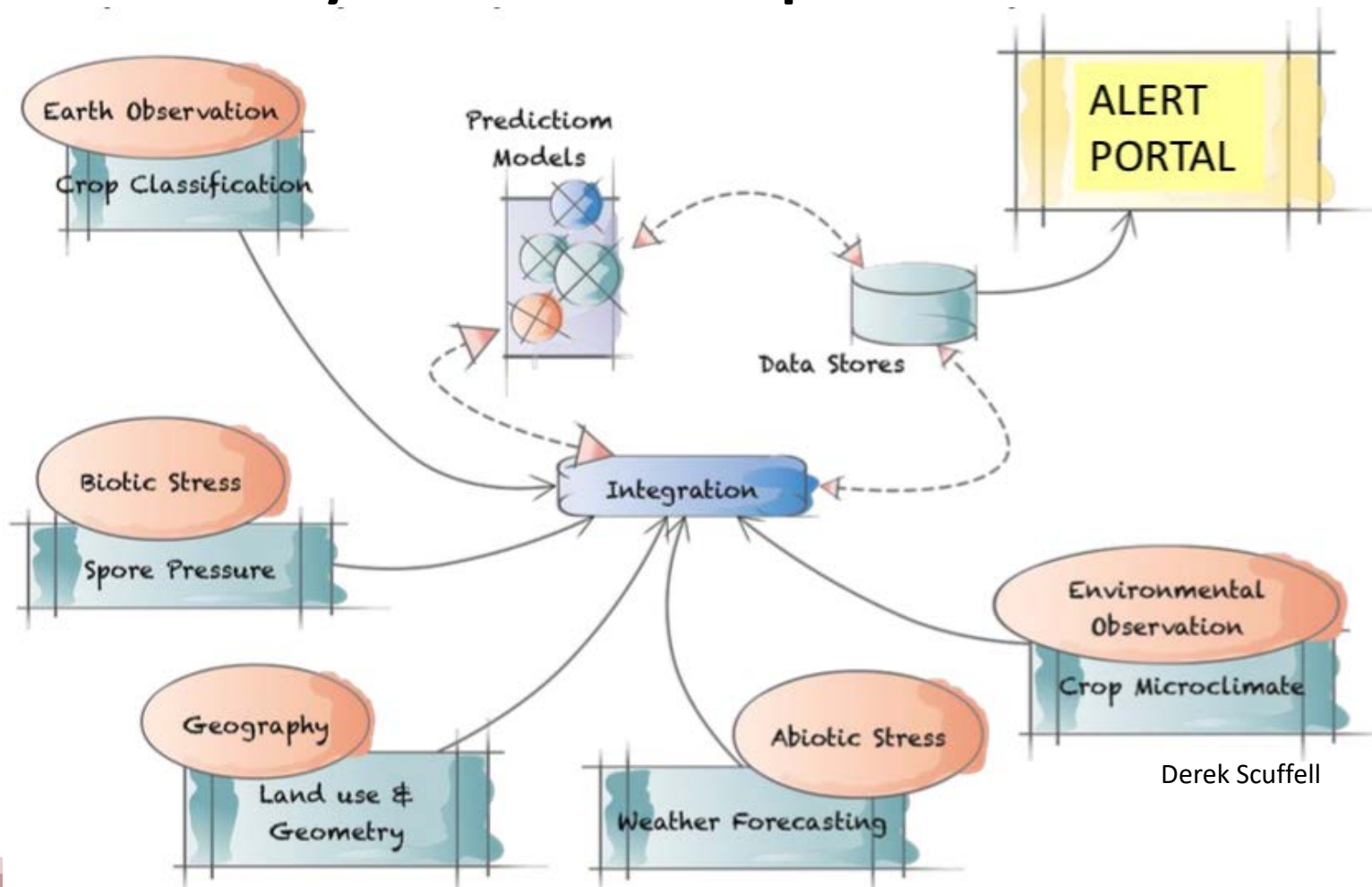


*"We have been working to develop systems to help growers to make decisions, using past and current weather conditions and forecast for some specific commodities (wheat, apple trees, vine and others)..."*



Grupo de Pesquisa  
**MOSAICO**

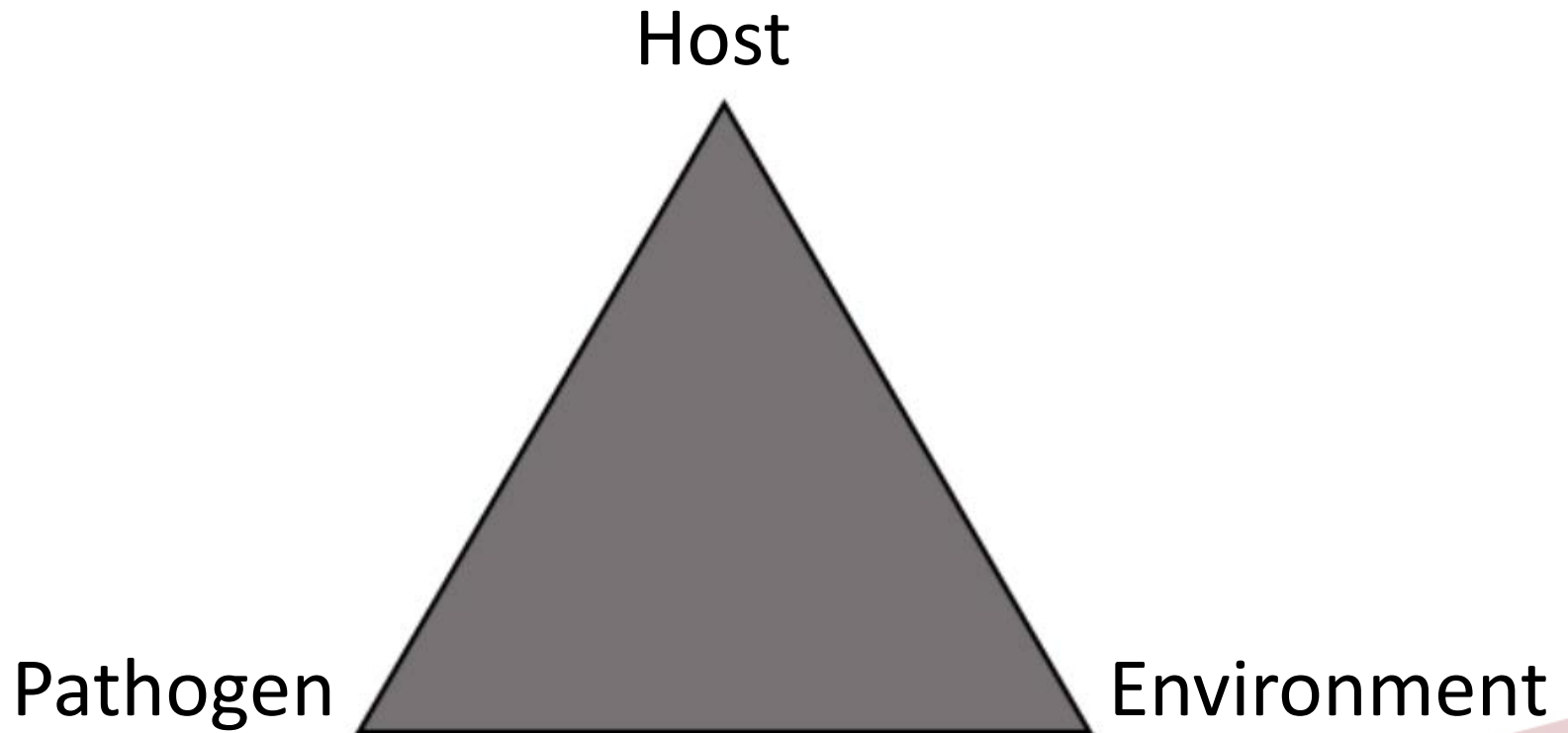
# System Components



Derek Scuffell

# To Develop Disease Forecast Systems...

## What we need to know?



# Environment

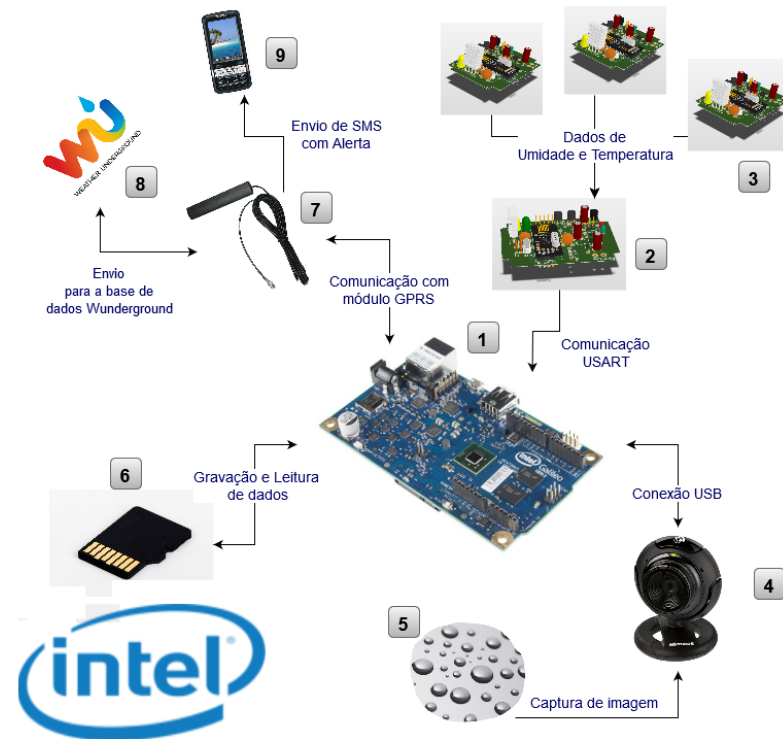
# Environment



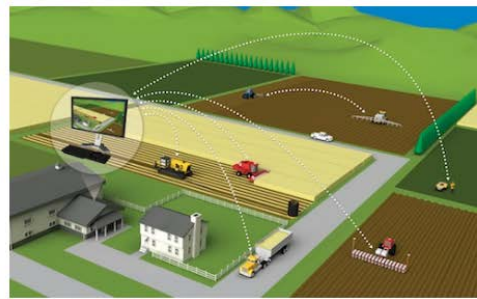
Temp, Prec, RH,  
Wind, etc



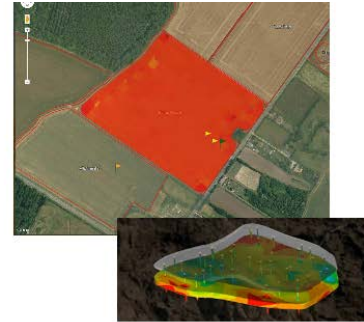
- Weather Stations Network and Leaf Wetness system



# Environment



Coleta e visualização de informações do campo



Gerenciamento e visualização de informações Georreferenciadas



Armazenamento e processamento dos dados coletados no campo



Coleta de informações de maquinários agrícolas



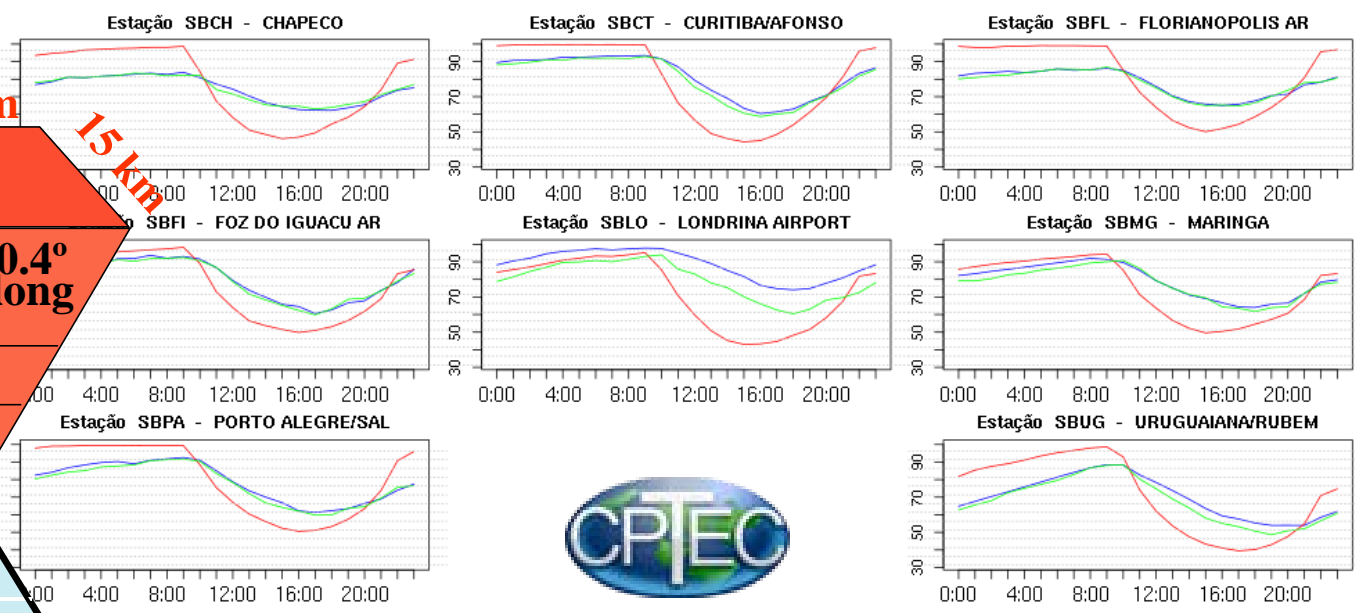
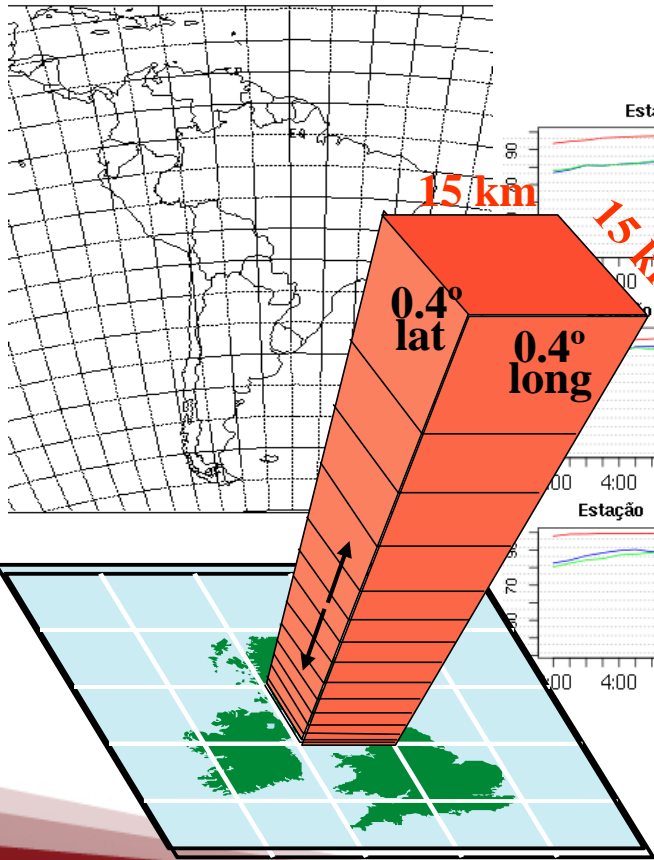
Coleta de informações de estações meteorológicas

Service-oriented architecture and data storage technology

# Environment -> Forecast

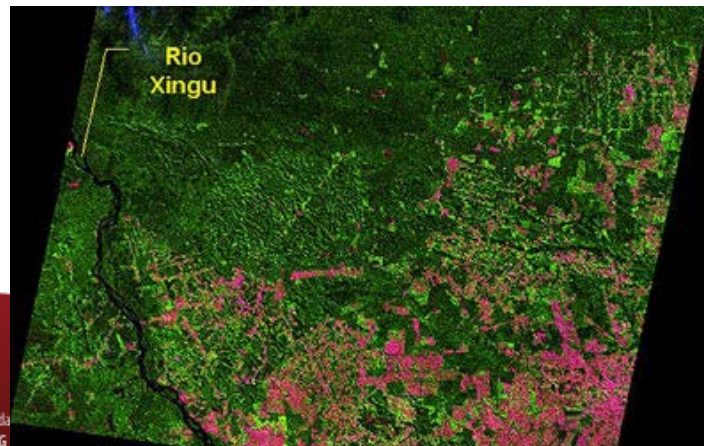
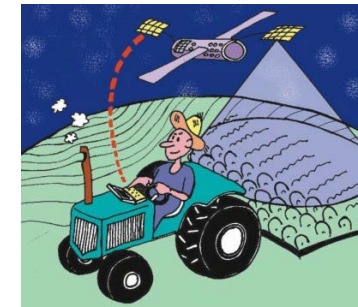
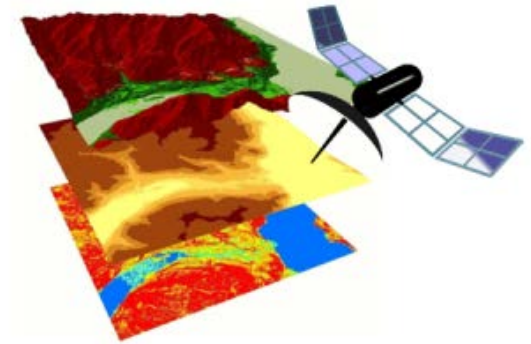
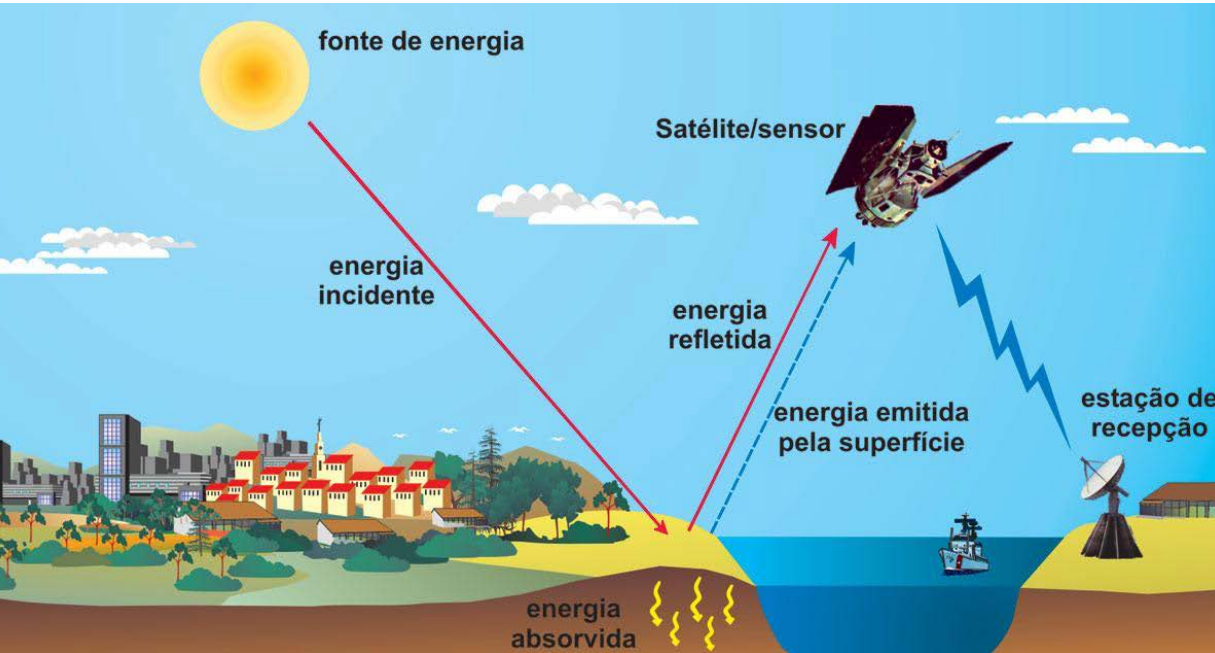
## Eta Regional Model and Model Output Calibration (MOC)

### CPTEC-INPE

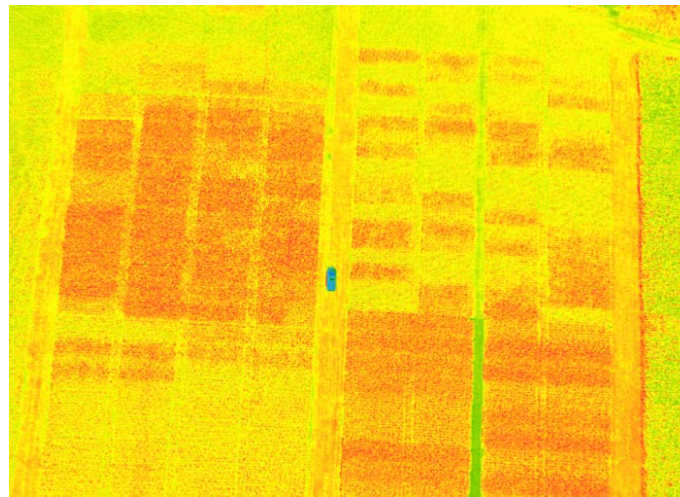


— Observed      — Forecast      — Calibrated

# Environment -> Remote Sensing



# Environment -> Remote Sensing using Drones

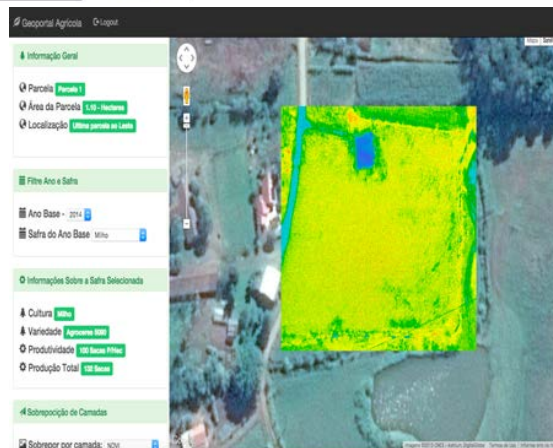
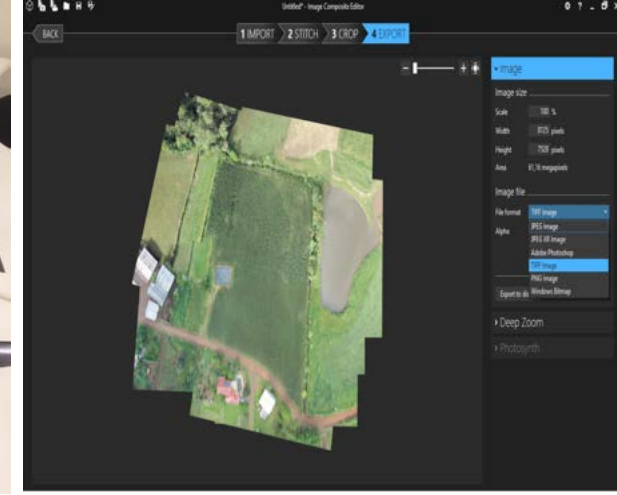
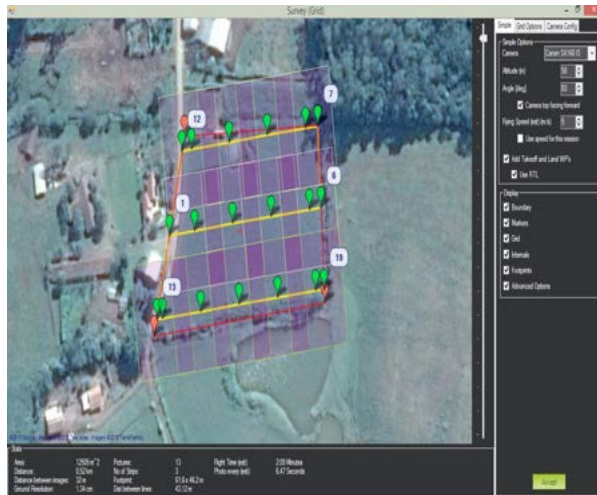


**DIÁRIO DA MANHÃ**  
MUNICÍPIO DE CASARILHO



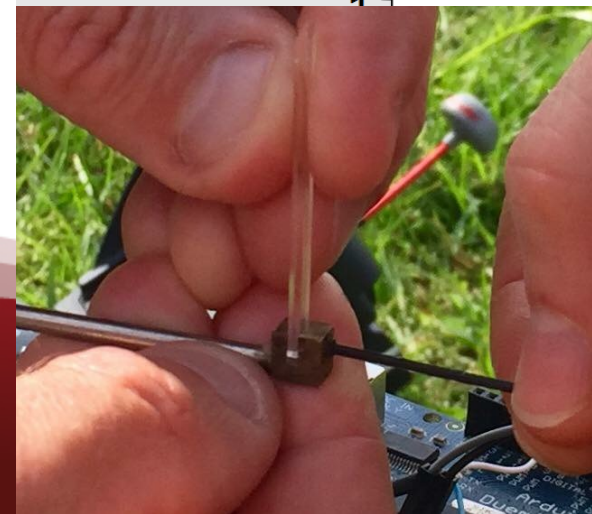
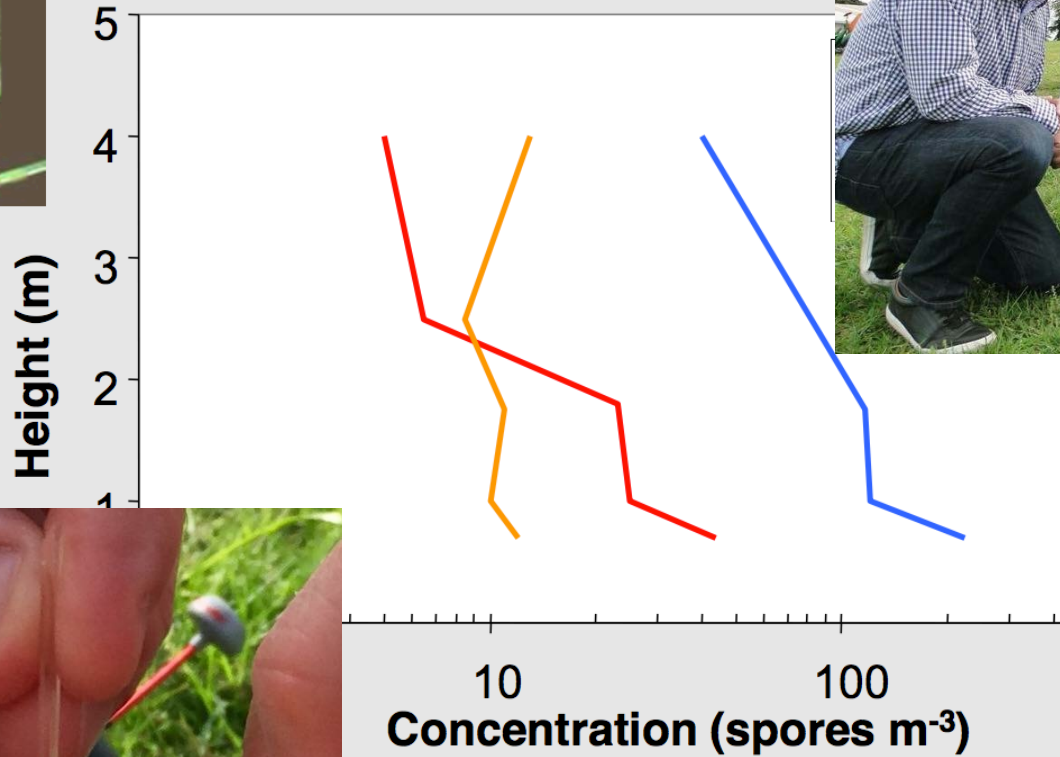
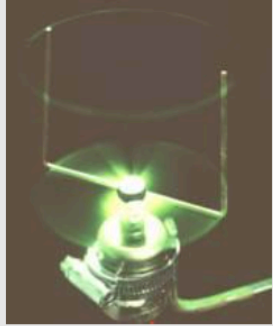
Embrega uma alta precisão em lavouras de Casarilho. Projeto, que desenvolveu de três a quatro anos, busca melhorar técnicas de crescimento do trigo. Nesta semana, um drone foi utilizado no auxílio da plantação. Foto: [unreadable]

# Environment -> Geoportals

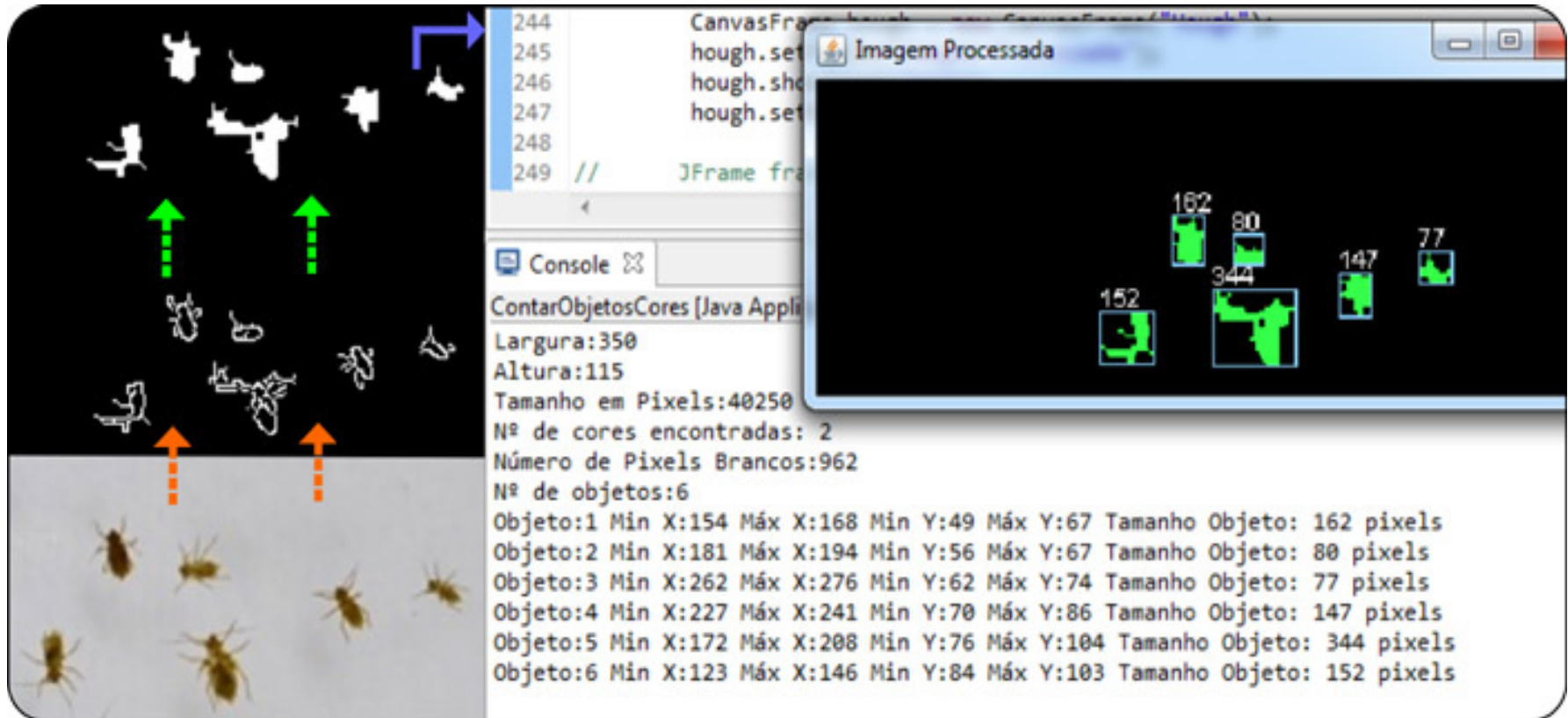


# Pathogen

# Pathogen -> Aerobiology



# Pathogen -> Morphology and counting



CanvasFrame  
244  
245 hough.set  
246 hough.sho  
247 hough.set  
248  
249 // JFrame fra

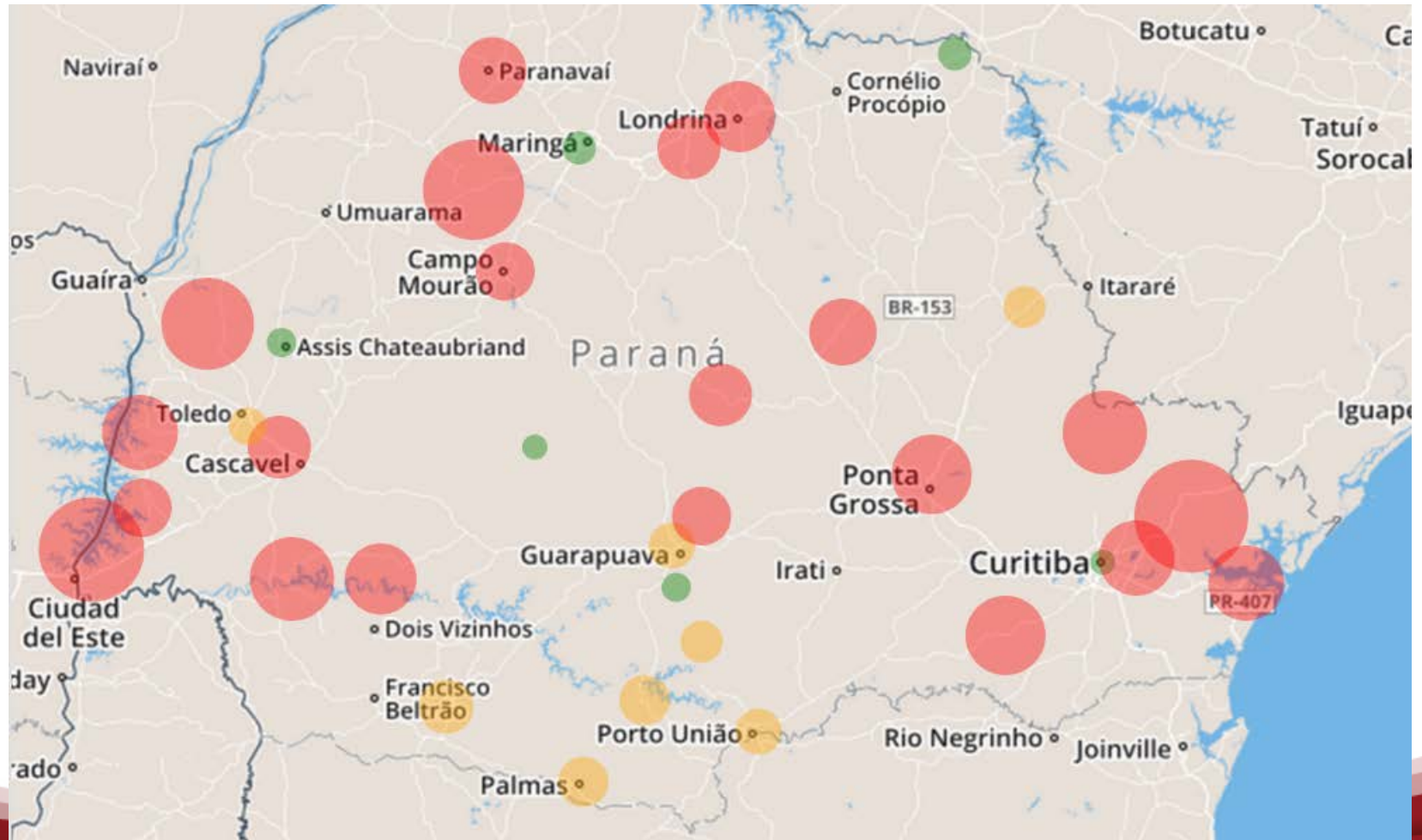
Imagem Processada

162  
80  
77  
147  
344  
152

Console

ContarObjetosCores [Java Appli  
Largura:350  
Altura:115  
Tamanho em Pixels:40250  
Nº de cores encontradas: 2  
Número de Pixels Brancos:962  
Nº de objetos:6  
Objeto:1 Min X:154 Máx X:168 Min Y:49 Máx Y:67 Tamanho Objeto: 162 pixels  
Objeto:2 Min X:181 Máx X:194 Min Y:56 Máx Y:67 Tamanho Objeto: 80 pixels  
Objeto:3 Min X:262 Máx X:276 Min Y:62 Máx Y:74 Tamanho Objeto: 77 pixels  
Objeto:4 Min X:227 Máx X:241 Min Y:70 Máx Y:86 Tamanho Objeto: 147 pixels  
Objeto:5 Min X:172 Máx X:208 Min Y:76 Máx Y:104 Tamanho Objeto: 344 pixels  
Objeto:6 Min X:123 Máx X:146 Min Y:84 Máx Y:103 Tamanho Objeto: 152 pixels

# Pathogen -> Simulation (inoculum pressure)



# Pathogen -> Dispersion Tracking

## Pic-a-wheatfield: Mobile and Web Platform

<http://picawheatfield.ensoag.com>

The image displays the Pic-a-Wheat Field web and mobile application interface. The top navigation bar includes links for 'Wheat Field', 'Map', 'Welcome', 'Wheat Blast', 'Photo Gallery', 'Video', 'Reading Material', 'About', 'Contact', and 'Log out'. The main content area features a large map of South America with several red location pins. Overlaid on the map are three mobile application screens: 1) The 'Main' screen showing the 'Pic-a-Wheat Field' logo and buttons for 'View Wheat Fields', '+ Add a Wheat Field', and 'Description'. 2) The 'View Wheat Fields' screen showing a map of South America with a red pin and a 'Back' button. 3) The 'Add a Wheat Field' screen showing a grid of image thumbnails (Field View, Head, and two Optional) and dropdown menus for 'Disease' (set to Blast) and 'Grow stage' (set to Heading), with 'Cancel' and 'Save' buttons at the bottom.

*The main goal of this smartphone application is to encourage wheat blast surveillance and to convene in a single place information on wheat blast occurrence.*

# Pathogen -> Dispersion Tracking

## Anti-rust consortium

**CONSORCIO Antiferrugem**  
 Ferrugem da Soja  
 Parceria público-privada no combate à ferrugem asiática da soja

> O Mapa da Dispersão Ferrugem em números Informativos de risco Laboratórios credenciados Produtos e informações Sobre o site Usuários

### > O Mapa da Dispersão



Legenda: número detecções

- 1
- 2-5
- 6-10
- 11-20
- >20

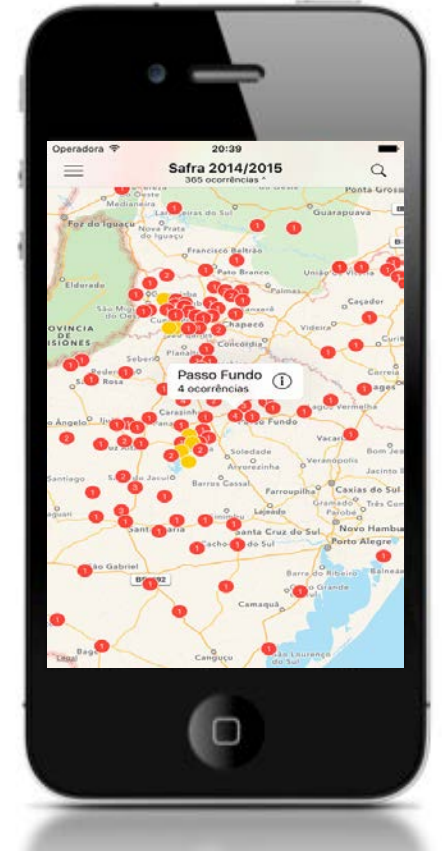
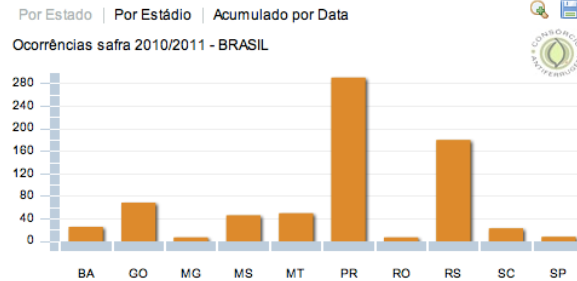
2010/2011

BRASIL Seleccione o Estado Seleccione a Cidade

Ocorrências | Comentários

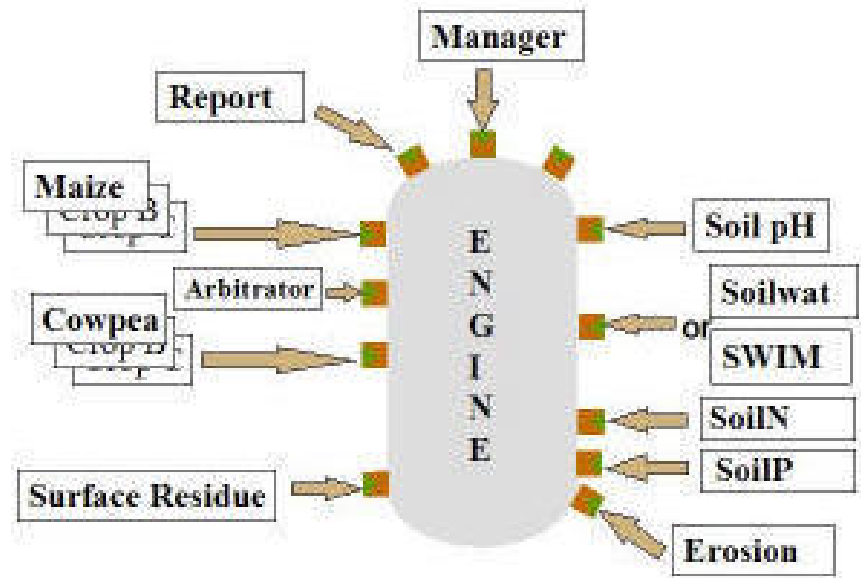
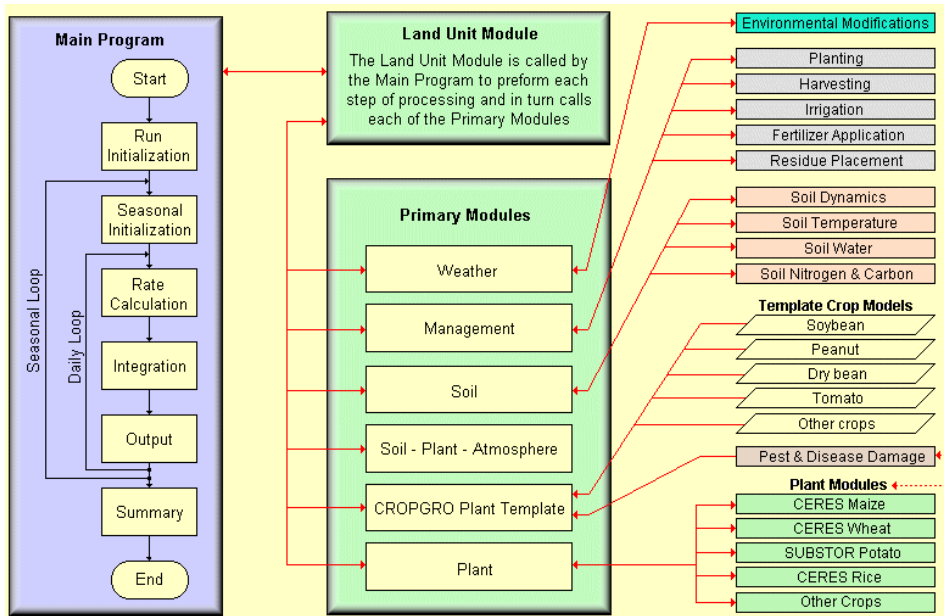
Encontradas 707 ocorrências

Data	Município	Laboratório	Estádio	Estado
09/03/2011	Ajuricaba	CCGL-FUNDACEP	R5	RS
09/03/2011	Ajuricaba	CCGL-FUNDACEP	R5	RS
05/03/2011	Cachoeira do Sul	ADM agro consultoria	R5	RS
03/03/2011	Wenceslau Braz	SEAB/PR - Secretaria de	R7	PR
03/03/2011	Wenceslau Braz	SEAB/PR - Secretaria de	R3	PR
03/03/2011	São José da Boa Vista	SEAB/PR - Secretaria de	R4	PR



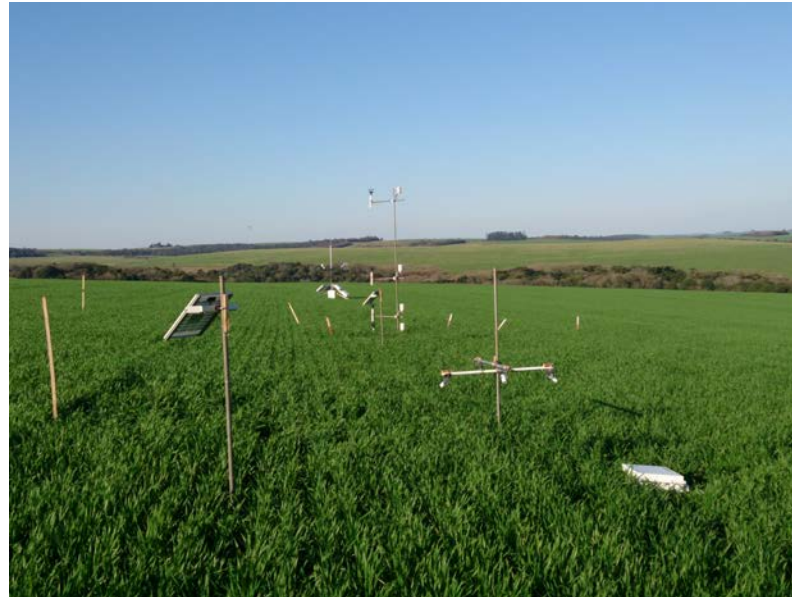
# Host

# Host -> Crop Models



APSIM, DSSAT, EPIC, etc.

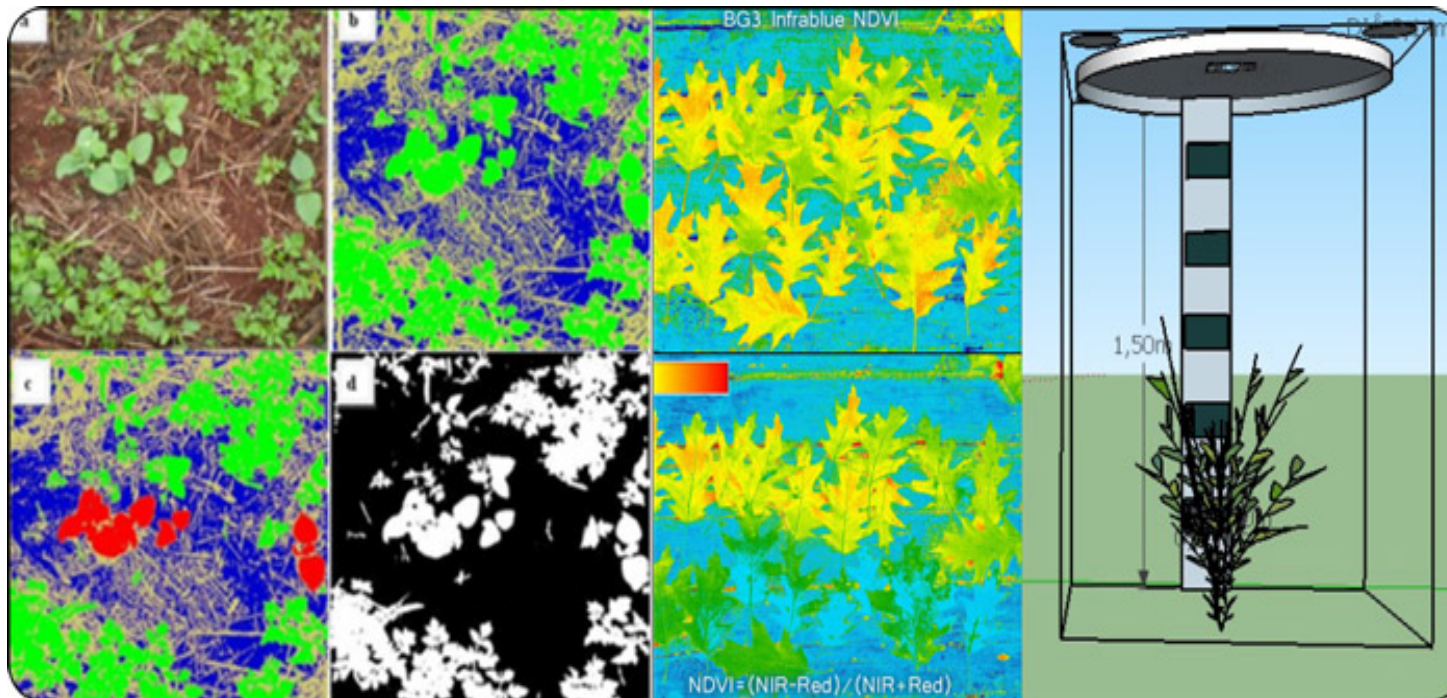
*Host -> First of all, we need to have a well calibrated and validate crop model... (input data)*



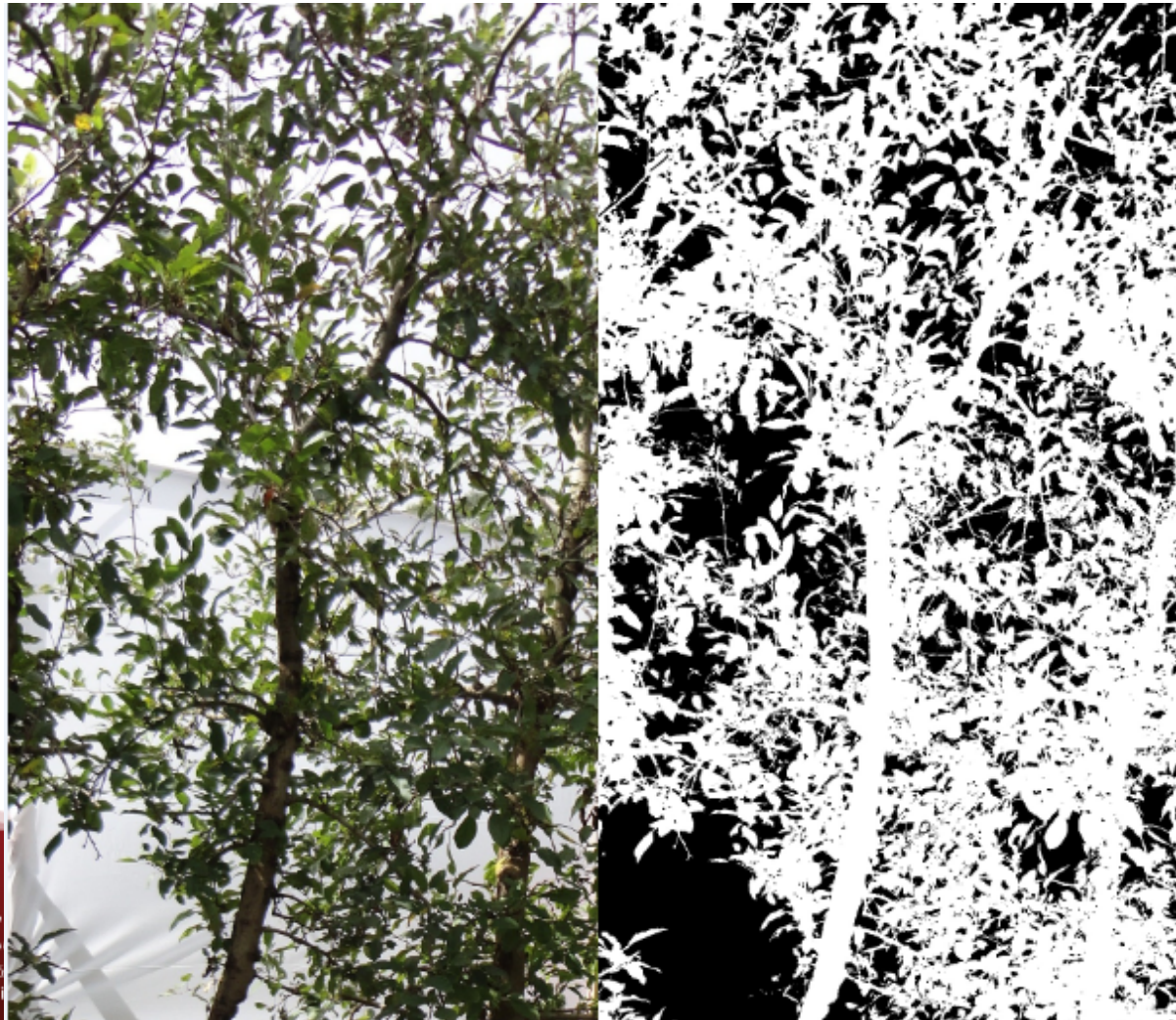
Wheat, Soybean, Maize, ...

# Host

## High resolution phenotype using computer vision



# Host -> Leaf area estimation and Apple Tree Leaves Fall (POMIPEST)

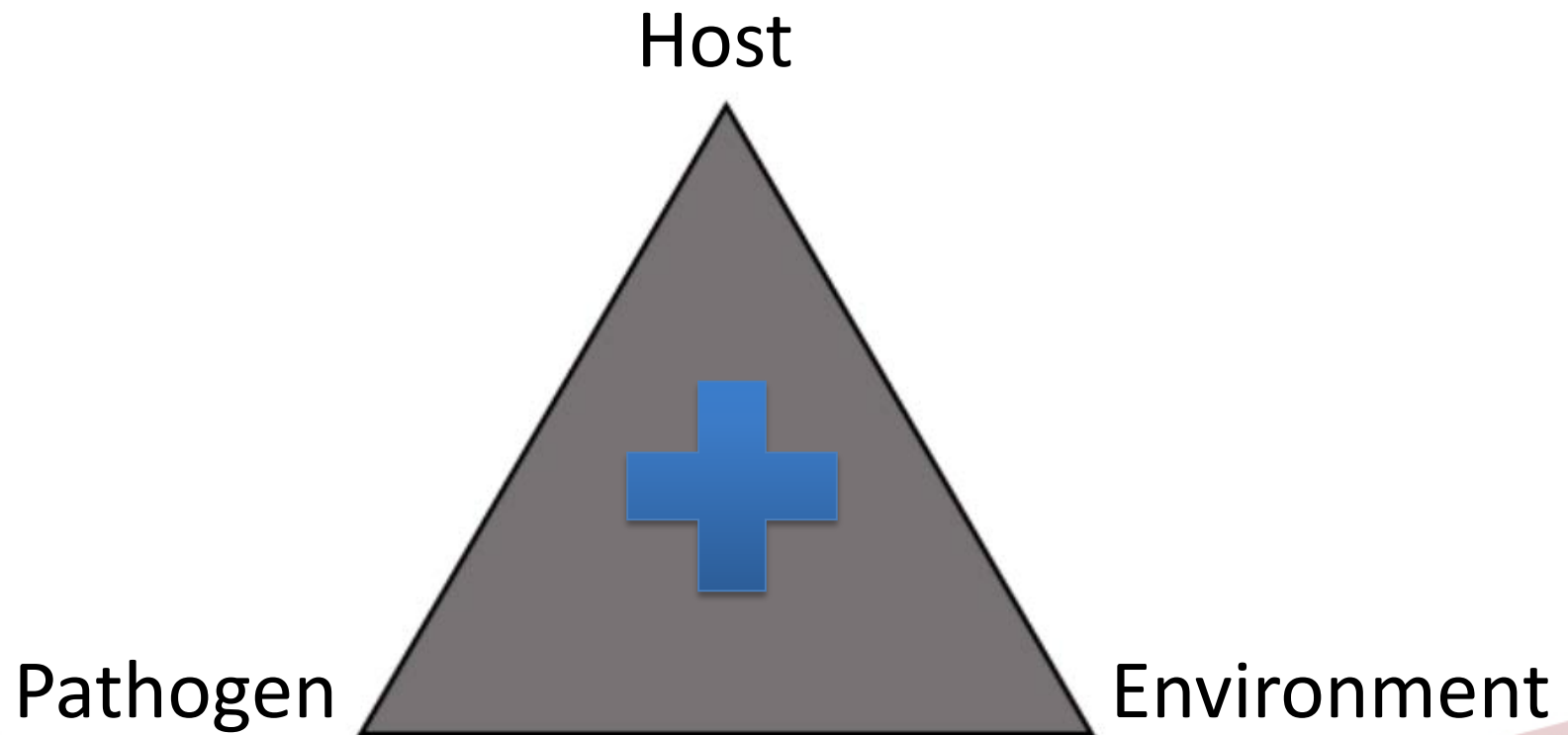


# Host

## Strawberry blooming auto-detection



# Putting all together



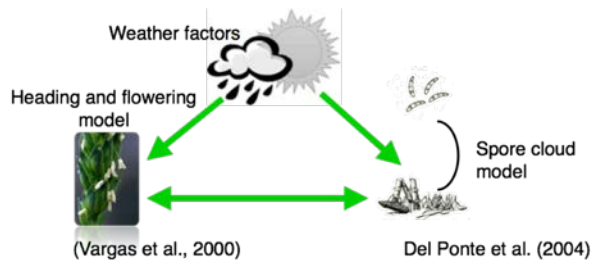
# Tools to help crop advisers and farmers to make decisions

Web-based system to forecast plant disease risk in Brazil

- Apple**
- Scab, leaf spots, rots
- Wheat**
- FHB and wheat blast
- Soybean**
- Soybean Rust
- Grapes**
- Downy Mildew
- Powdery Mildew
- Strawberry**
- Botrytis
- Anthracoze



# Advisory risk tool for FHB



GibSIM



CROPSIM Wheat

Trigo (Giberela):

Estado:

Estação:

Data do espigamento:

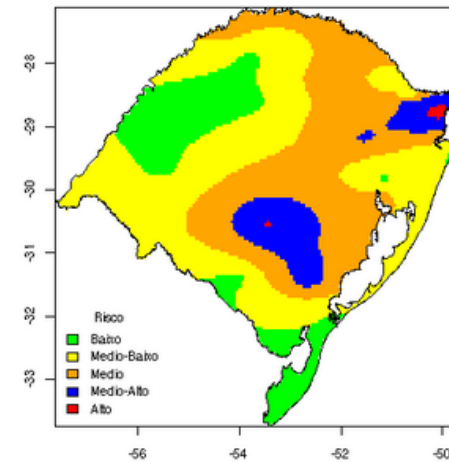
Espigamento: 16/09/2011

Severidade: 1.58

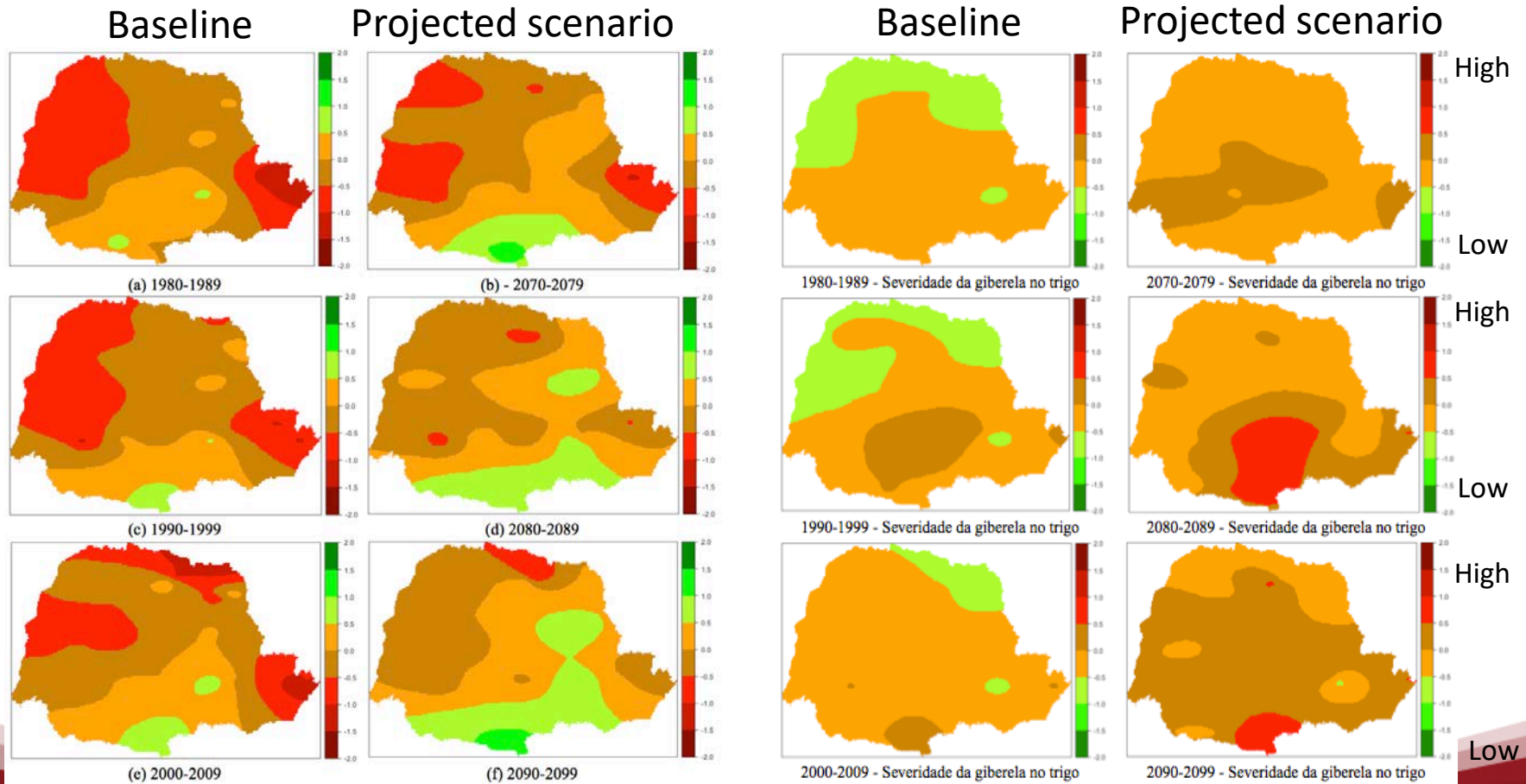
Risco: **BAIXO**

**LOW RISK**

Regional risk mapping for the selected heading date



# An integrative modeling framework to evaluate wheat production systems: Fusarium head blight

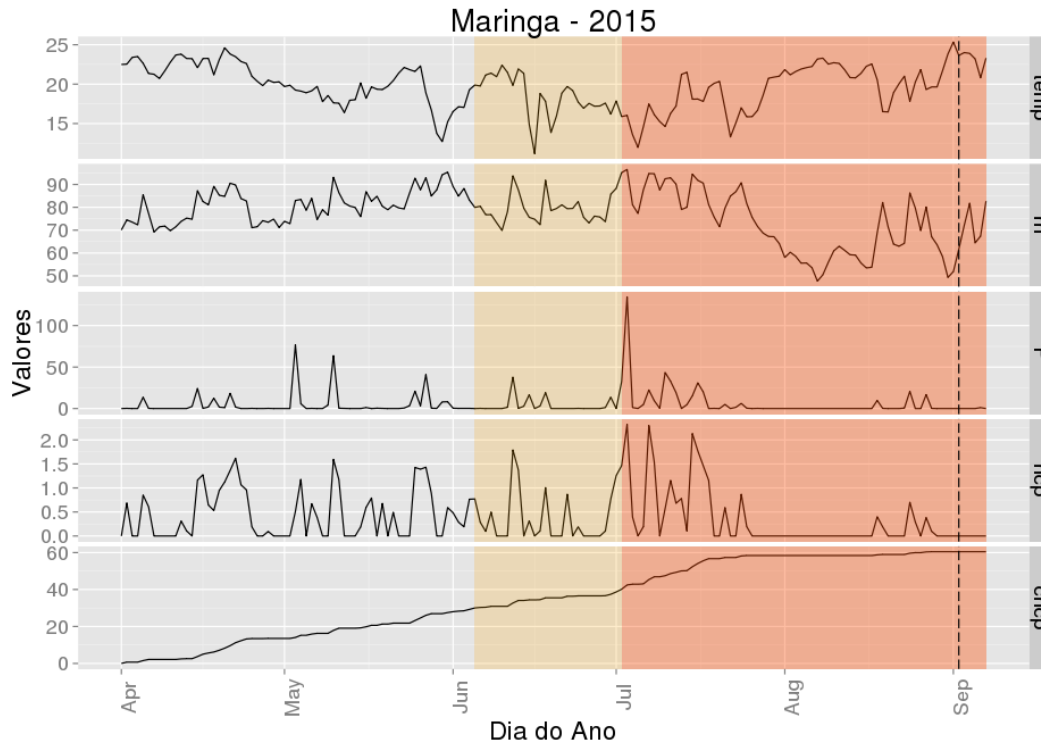


# Risk Monitoring for wheat blast

Estacao

Data inicial:

Previsao



VIVO TU Go 10:46 AM 91%

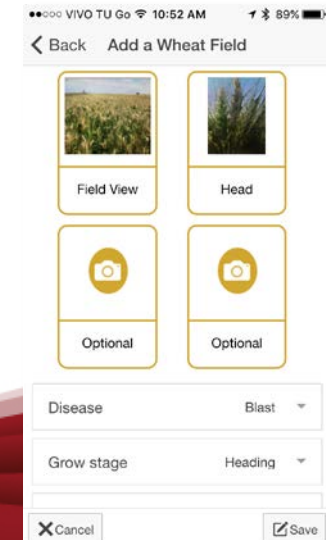
Main



View Wheat Fields

+ Add a Wheat Field

Description



# Computer models for Soybean Rust

Leaf wetness

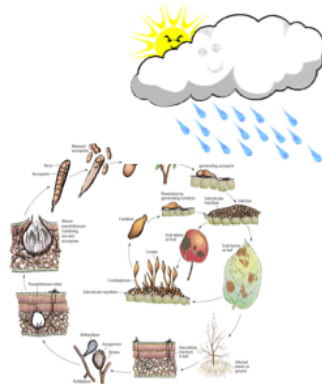
Rain, Dew and RH

Temperature

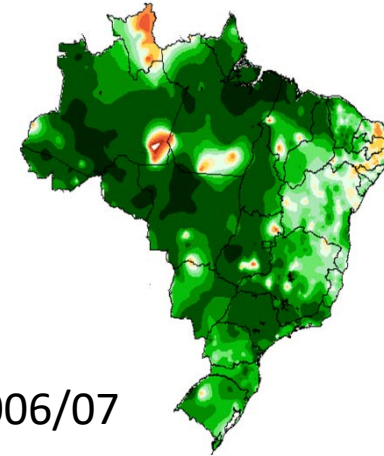


Affect the cycle process

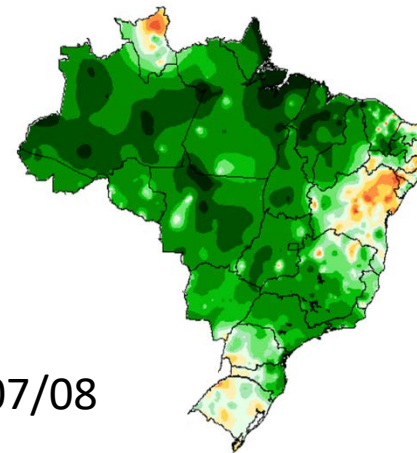
Survival, dissemination, infection, colonization and reproduction



Season 2006/07



Season 2007/08

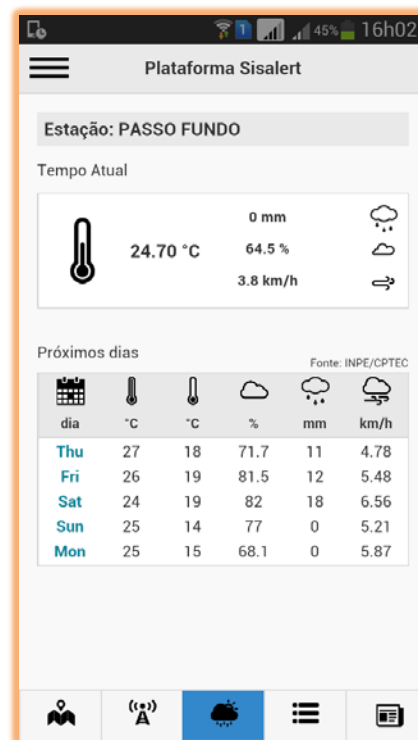
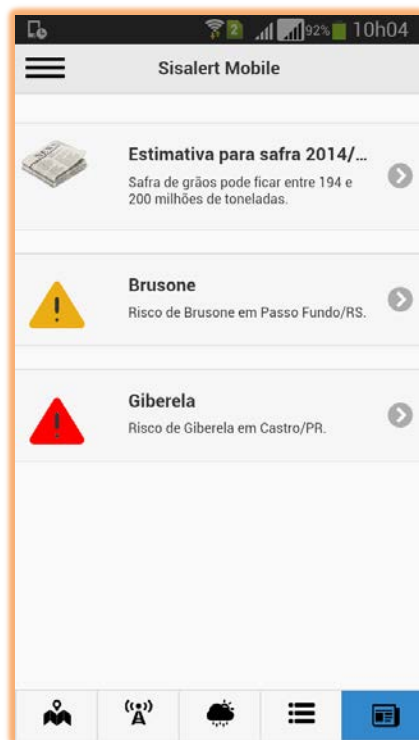
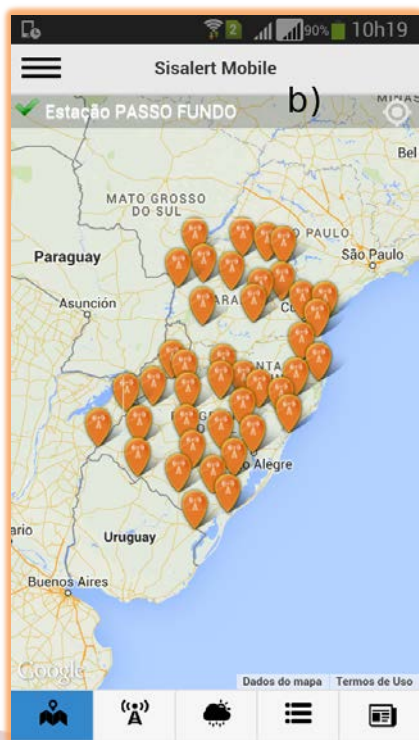


Reduction of  
58%

São Desidério, BA  
25/03/2003  
A.C.B. Oliveira

# Sisalert Mobile


## A multiplatform App to be used in agriculture



La Niña Watch Dropped

- Home
- Tools
- Forecasts
- State Summaries
- Management
- Climate
- 4-H
- Video
- About

Strawberry Advisory System (SAS)

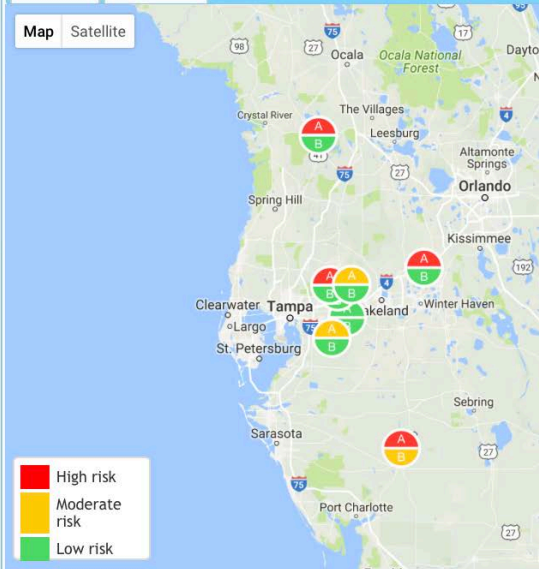


**Botrytis**

Map Recommendations Disease Simulation Daily Summary

Contact Disclaimer

Map Satellite




■ High risk  
■ Moderate risk  
■ Low risk


- Strawberry Fruit Rot diseases
  - \* Anthracnose Fruit Rot of Strawberry
  - \* Botrytis Fruit Rot or Gray Mold of Strawberry
- About the tool, publications
- Recommended fungicides

AgroClimate Tools

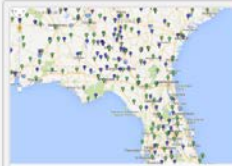
- All
- Climate
- Drought Indices
- Crop Yield
- Crop Diseases
- Degree Days and Chill Hours
- Footprint Calculators




**Rainfall and Temp. Monitoring**  
Observed rainfall and temperature.




**Climatology**  
Rainfall and temperature climatology (1950-2013).




**Weather Stations**  
Climatology and current observations for selected weather stations in the Southeast USA




**Freeze Risk Probabilities**  
Freeze probabilities based on El Niño Southern Oscillation (ENSO) phases




**ARID**  
Agricultural Reference Index for Drought



**LGMI**  
Lawn and Garden Moisture Index LGMI

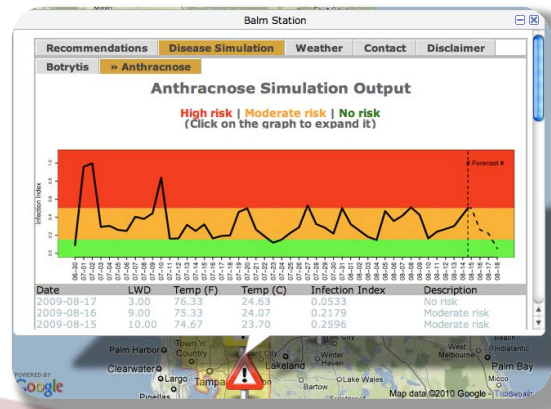
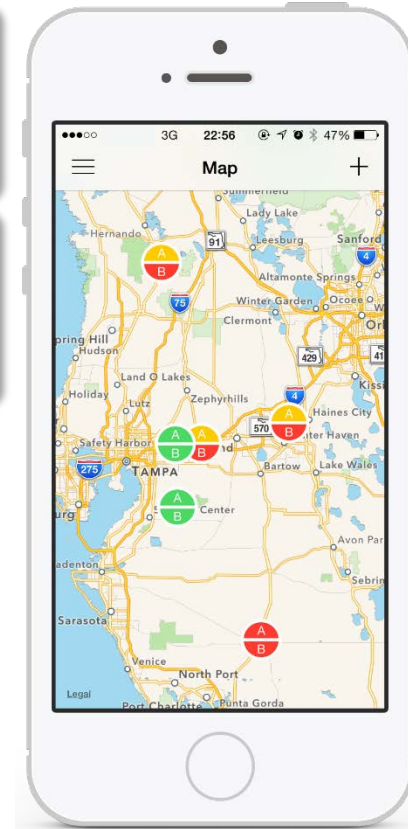
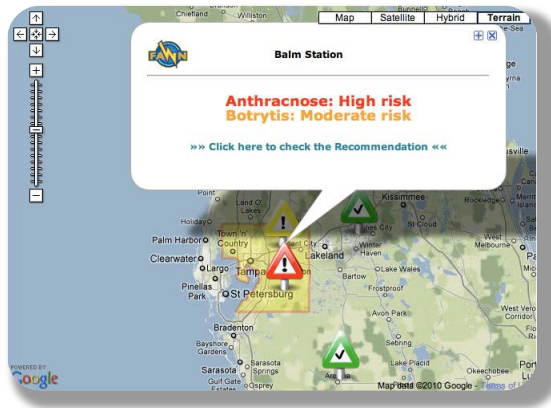


**County Yield Statistics**  
Crop yield series, trends and residuals at the county level



**Planting Date Planner**  
Probability of low, medium, and high yields based on planting dates

# Strawberry Advisory System (SAS)



- Alerts for Botrytis and anthracnose risk
- Constant monitoring of climatic conditions in producing regions
- Alerts by e-mail and text message
- Products Recommendation based on active ingredients to prevent resistance problems

# A DISEASE FORECAST SYSTEM FOR STRAWBERRIES AS A TOOL ON AGROCLIMATE



Willingthon Pavan<sup>(1)</sup>, Clyde W. Fraisse<sup>(1)</sup> and Natália A. Peres<sup>(2)</sup>

<sup>(1)</sup> University of Florida, Agricultural & Biological Engineering Dept., Gainesville, FL

<sup>(2)</sup> University of Florida, Gulf Coast Research and Education Center, Wimauma, FL



## INTRODUCTION

Strawberries are one of the most valuable crops in Florida. The state produces about 16 million flats of strawberries every year, which represents 15% of nation's berries and virtually all the berries grown during the winter. In 2004, over 7,000 acres were devoted to strawberries with an estimated return to the grower approaching to \$200 million. The high value of the crop often compels growers to protect their profits by applying fungicides on a weekly schedule, mainly for control of Anthracnose and Botrytis fruit rot, from December through March.

These are the most important diseases for production of annual strawberries in central Florida and worldwide. A predictive model for Anthracnose fruit rot was developed using disease incidence and weather data collected in previous years. For control of Botrytis fruit rot an existing model has been adapted and validated to the local conditions. These models were embedded in a web-based tool developed for use by growers to schedule their fungicide applications.

The implementation of this internet-based forecasting system to predict Anthracnose and Botrytis enable the growers to easily access the information necessary for them to decide on the need for a fungicide application.



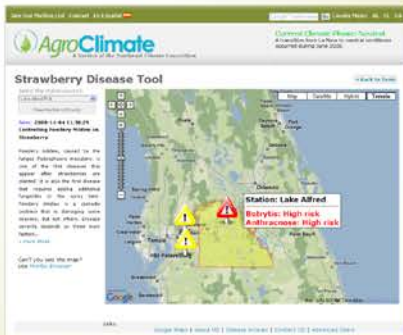
Weather station located at the Gulf Coast Research and Education Center Wimauma, FL.



Botrytis fruit rot symptom



Anthracnose fruit rot symptoms



The disease forecast system on AgroClimate

## DISEASE MODELS

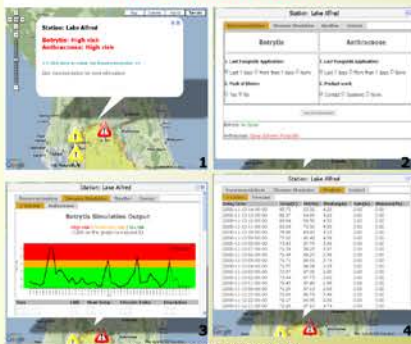
The model developed by Wilson et al. (1990) was used for Anthracnose fruit rot (AFR) disease simulation. It was evaluated in replicated field trials during the 2006-2007 and 2007-2008 strawberry seasons for timing fungicide applications. The model utilizes wetness duration and temperature to predict infection efficiency for *Colletotrichum acutatum* in growth chamber studies. To make the model applicable for controlling disease in the field, daily wetness intervals and average temperature during wetness periods were calculated from weather data collected over the previous five seasons. The objective was to establish a baseline infection threshold below which no fungicide applications would be needed with the goal of reducing fungicide sprays by approximately 50%. A second threshold that allowed infections which could be eliminated by curative fungicide applications, was also established.

For Botrytis fruit rot (BFR), two models were evaluated. One model was developed by Xu et al. (2000) for strawberry and one by Broome et al. (1995) for grape. An infection threshold of 50% for the Xu model and a disease index threshold of 0.50 for the Broome model were evaluated.

### Observed and Forecast Weather Data

The system uses recent and current weather conditions data collected by the Florida Automated Weather Network (FAWN - <http://fawn.ifas.ufl.edu>). Short term weather forecast is obtained from the National Weather Service - National Digital Forecast Database (NDFD - <http://www.nws.noaa.gov/ndfd>). Seasonal climate forecasts is provided by the Southeast Climate Consortium (SECC - <http://www.seclimate.org>).

## PRELIMINARY RESULTS



Web-based system components

### System Components:

1. Map of strawberry producing regions showing weather stations with current risk level flag.
2. Spray recommendations for Botrytis and Anthracnose based on a simple questionnaire about previous applications and development stage.
3. Model outputs in graphic and table formats, indicating risk levels (High risk, Moderate risk, or No risk) based on weather data observed at the station and forecast for the next 3 days (National Weather Service Pinpoint Forecast).
4. Display of weather data observed during the most recent 24-hours period and the forecast for the next 24-hours.

## LEAF WETNESS MODELING

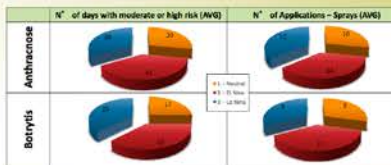
✓Penman-Monteith (PM) approach:

- Physical model based on energy balance principles.
- Input data: temperature, wind speed, relative humidity, and solar radiation.



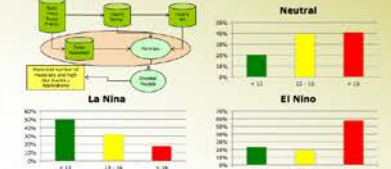
## SEASONAL FORECAST OF DISEASE PRESSURE

Dover Station (FAWN) - 1999 to 2009



## ANTHRACNOSE SEASONAL FORECAST

Plant City Station (COOP) - 1892 to 2009



## BOTRYTIS SEASONAL FORECAST

Plant City Station (COOP) - 1892 to 2008



## ECONOMIC ANALYSIS

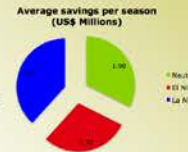
Plant City Station (COOP) - 1892 to 2008



## ECONOMIC ANALYSIS

Plant City Station (COOP) - 1892 to 2008

Seasons: 113  
Acres: 7,500  
Spray cost per acre: US\$ 30.0  
Standard: 19 sprays



ENSO	N° of Years	AVG Savings/Year*	Total Savings*
Neutral	59	1.90	112.17
El Niño	26	1.72	44.81
La Niña	28	2.25	63.00
<b>Total</b>	<b>113</b>	<b>1.92</b>	<b>219.98</b>

\* US\$ Millions

## CONCLUSIONS

✓ Use of models for timing fungicide sprays can reduce the number of applications for control of Botrytis fruit rot and anthracnose fruit rot on strawberries without affecting disease incidence or yield when compared to the current calendar-based recommendation.

✓ Fungicide applications for controlling AFR and BFR during the 2008/2009 strawberry season were reduced by half by following the recommendations of the system without affecting disease control and yield.

✓ The web-based system will be made available to growers during the upcoming 2009-2010 strawberry season to help growers to reduce the number of fungicide applications for control of AFR and BFR on strawberries.

✓ Preliminary economic analysis for a total area of 7,500 acres indicates an average savings per season of \$1.9M, \$1.72M, \$2.25M for Neutral, El Niño and La Niña years, respectively.

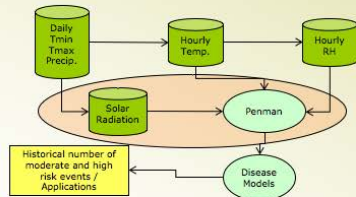
## REFERENCES

- Broome, J. C., English, J. T., Marois, J. J., Latorre, B. A. and Aviles, J. C. Development of an Infection Model for Botrytis Bunch Rot of Grapes Based on Wetness Duration and Temperature. *Phytopathology* 85: 97-102, 1995.
- Xu, X.-M., Harris, D. C., and Berrie, A. M. 2000. Modeling infection of strawberry flowers by Botrytis cinerea using field data. *Phytopathology* 90:1367-1374.
- Wilson, L.L., Madden, L.V., and Ellis, M.A. 1990. Influence of temperature and wetness duration on infection of immature and mature strawberry fruit by *Colletotrichum acutatum*. *Phytopathology* 80:111-116.

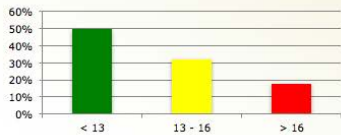
## ACKNOWLEDGMENTS

Funding for this project was provided by a partnership between the University of Florida and the United States Department of Agriculture Federal Crop Insurance Corporation (USDA-RMA).

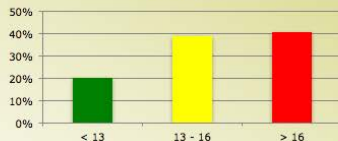
## ANTHRACNOSE SEASONAL FORECAST Plant City Station (COOP) – 1892 to 2009



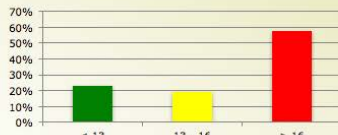
### La Nina



### Neutral



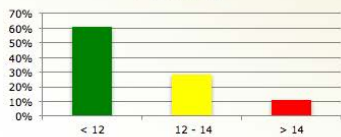
### El Nino



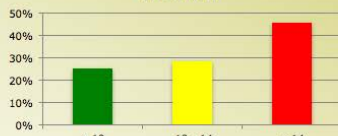
## BOTRYTIS SEASONAL FORECAST Plant City Station (COOP) – 1892 to 2008

# Applications to Control Botrytis			
Enso	< 12	12 - 14	> 14
1 - Neutral	25%	29%	46%
2 - El Nino	12%	31%	58%
3 - La Nina	61%	29%	11%

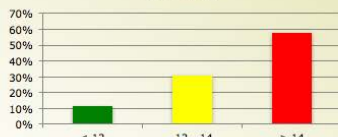
### La Nina



### Neutral

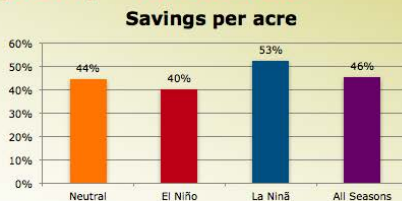


### El Nino



## ECONOMIC ANALYSIS Plant City Station (COOP) – 1892 to 2008

Seasons: 113  
Acres: 7,500  
Cost per acre: US\$ 30.0  
Standard: 19 sprays



ENSO	Sprays per acre		
	Min	Max	Avg
Neutral	1	19	10.5
El Niño	6	16	11.3
La Niña	3	14	9

## STRAWBERRIES AS A TOOL ON AGROCLIMATE

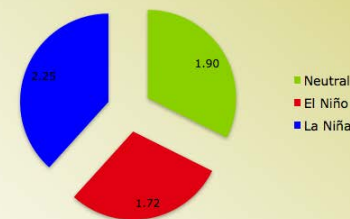
Fraisse<sup>(1)</sup> and Natália A. Peres<sup>(2)</sup>

Biological  
Research

## ECONOMIC ANALYSIS Plant City Station (COOP) – 1892 to 2008

Seasons: 113  
Acres: 7,500  
Spray cost per acre: US\$ 30.0  
Standard: 19 sprays

### Average savings per season (US\$ Millions)



ENSO	N° of Years	AVG Savings/Year *	Total Savings*
Neutral	59	1.90	112.17
El Niño	26	1.72	44.81
La Niña	28	2.25	63.00
Total	113	1.93	219.98

\* US\$ Millions

## CONCLUSIONS

✓ Use of models for timing fungicide sprays can reduce the number of applications for control of Botrytis fruit rot and anthracnose fruit rot on strawberries without affecting disease incidence or yield when compared to the current calendar-based recommendation.

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temperature and wetness duration on infection of immature and mature strawberry fruit by *Colletotrichum acutatum*. *Phytopathology* 80:111-116.

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# AgroClimate Open



Inicio Herramientas Pronóstico Climatología Monitoreamiento El Clima y El Niño Cambio



Agroclimate Fecoprod

AgroClimate Fecoprod es un sistema de información de tiempo y clima desarrollado para ayudar a los productores para la reducción de riesgos de origen climáticos. El clima es el mayor factor de riesgo en la producción agrícola de Paraguay y el mundo, por lo que Fecoprod ha tomado como iniciativa la implementación del sistema AgroClimate para proporcionar a sus asociados lo más avanzado en términos de sistemas de información climática.

AgroClimate Fecoprod está siendo implementado con apoyo del Instituto de Biotecnología (INBIO) con base a un trabajo inicial de investigación de la Universidad Católica Nuestra Señora de la Asunción y la Universidad de Florida con apoyo del Instituto Inter-Americano de Investigación para el Cambio Global (IAI).



Fase Actual:  
**Neutra**



Inicio Herramientas Pronóstico Climatología Monitoreamiento El Clima y El Niño Cambio Climático Contacto

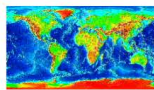


Agroclimate Fecoprod » Herramientas



### Datos Meteorológicos

Los datos climáticos almacenados en la base de datos de Agroclimate Fecoprod están disponibles por las herramientas de búsqueda proporcionadas aquí, lo que permite el acceso en cualquier momento.



### Mapas Climatológicos

Mapas del tiempo para el análisis histórico



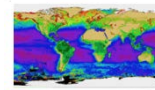
### Resúmenes de los datos

Datos de resumen que muestra diversa información meteorológica



### ARID

Índice de sequía desarrollado para monitorear estrés de agua en el cultivo



### Mapas de Monitoreamiento

Mapas de vigilancia del clima



### Riesgo Climático

Climatología de la precipitación y la temperatura. Variabilidad climática asociada con la Oscilación Sur de El Niño (ENSO).



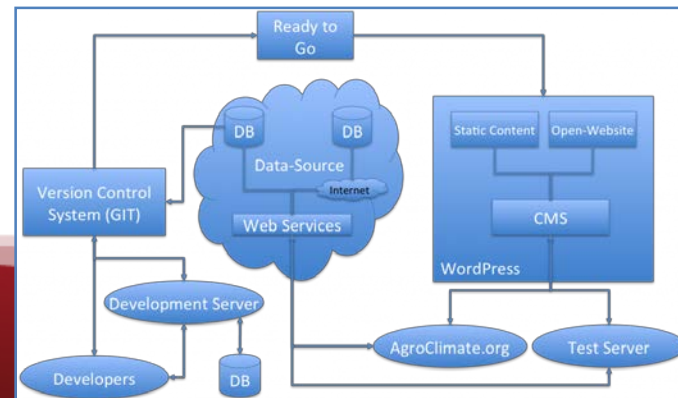
### Fechas de Siembra

Riesgo de rendimiento de la soja basado en ubicación, fecha de siembra, tipo de suelo y fase climática.



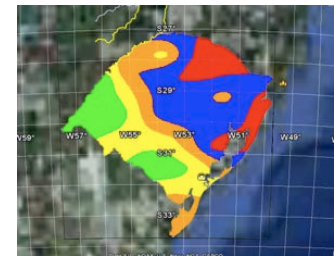
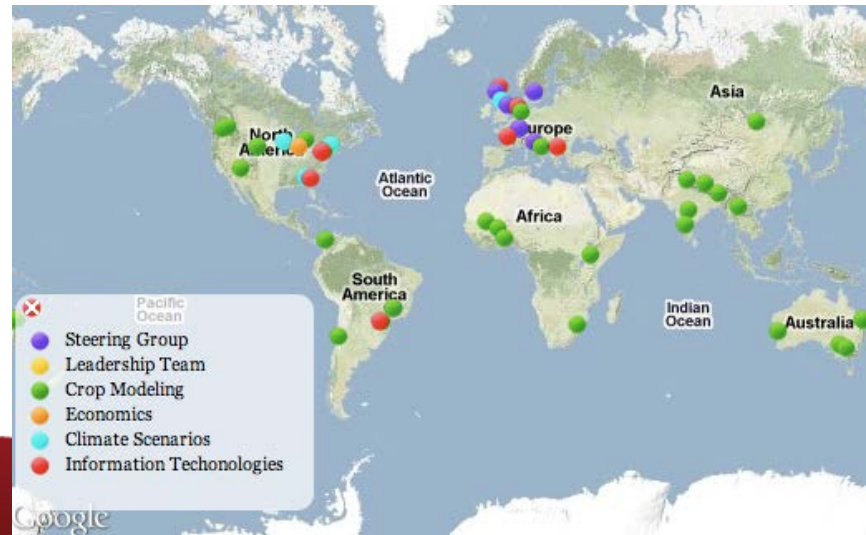
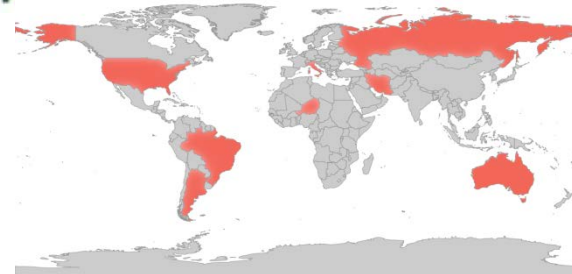
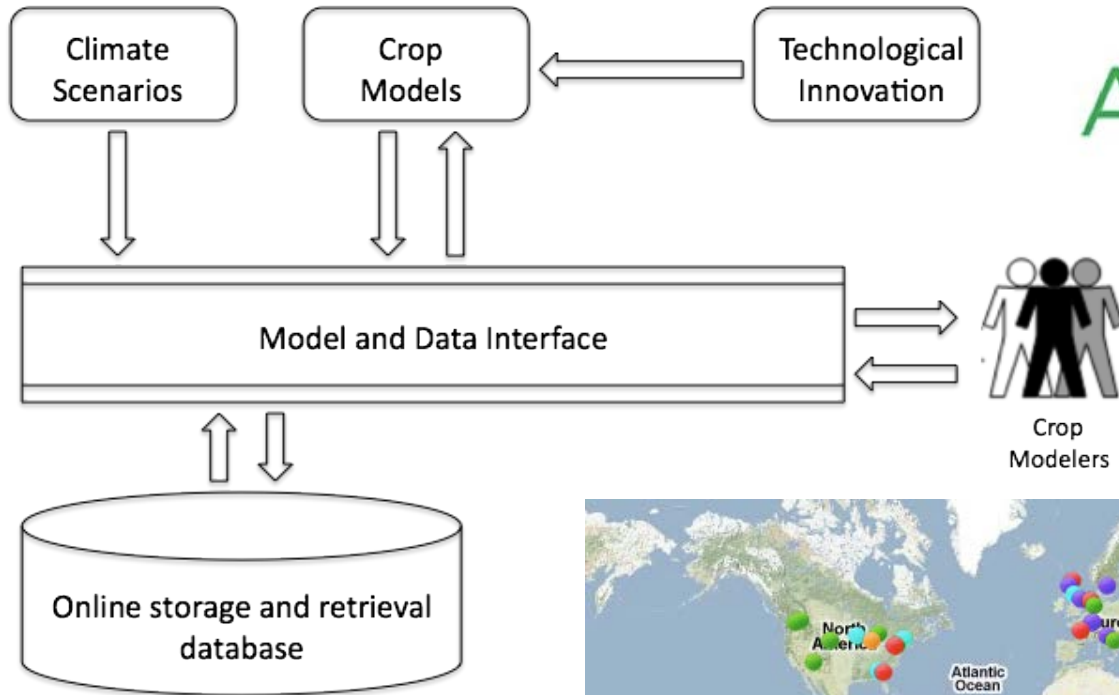
### Rendimiento de Cultivos

Series, tendencias y residuales de rendimiento de cultivos de acuerdo con el Ministerio de Agricultura y Ganadería.



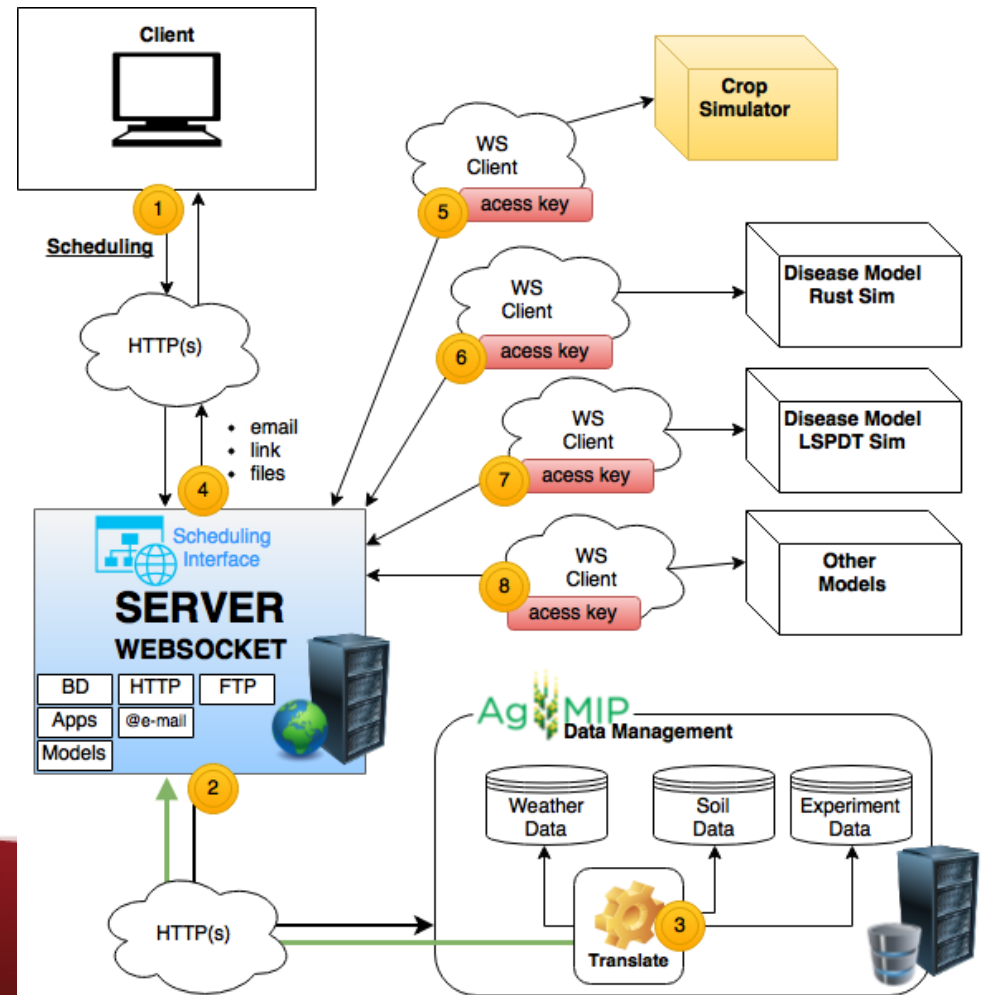
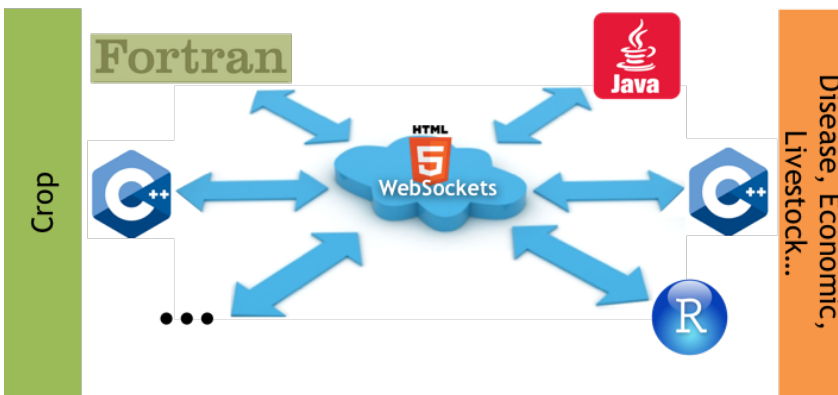
# Going one step further ...

# AgMIP-Pest

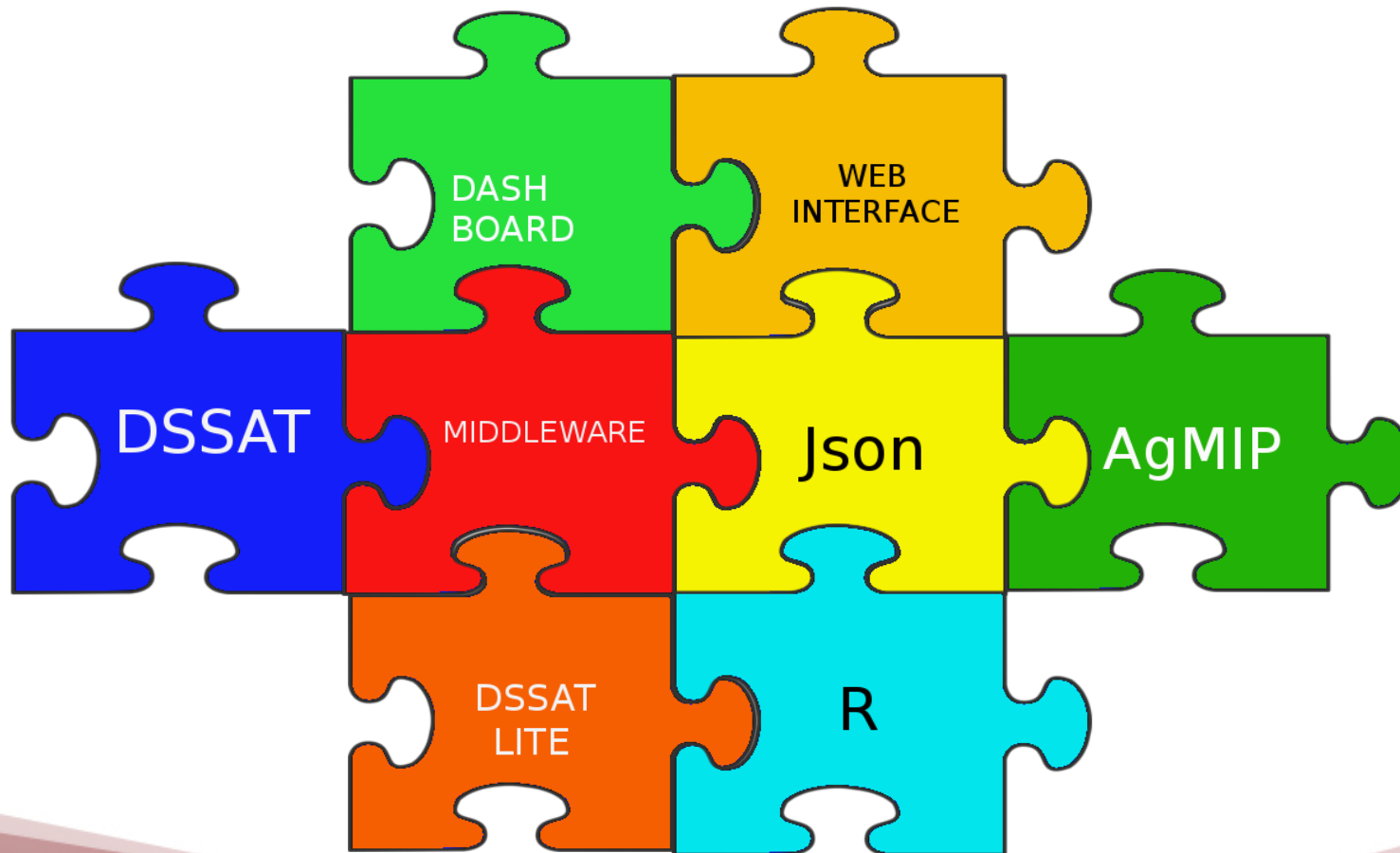


# AgMIP-Pest - Pest and Disease Coupling

## A software architecture to couple models



# DSSAT++



# Climate Change and Water Resources - scientific development to support decision making.

Generation of regionalized climate change projections and assess the impacts on water availability in the country, in different scenarios of emission at high spatial resolution with implications for food security and energy.

UEA, UERJ, UFRJ, UFLA, UNIFEI, UNICAMP, UPF, PUC-Rio, INPA, INPE, IPEF, CIRAD, EMBRAPA, CEMADEN, CEMIG, GDF, SUZANO



# Acknowledgements



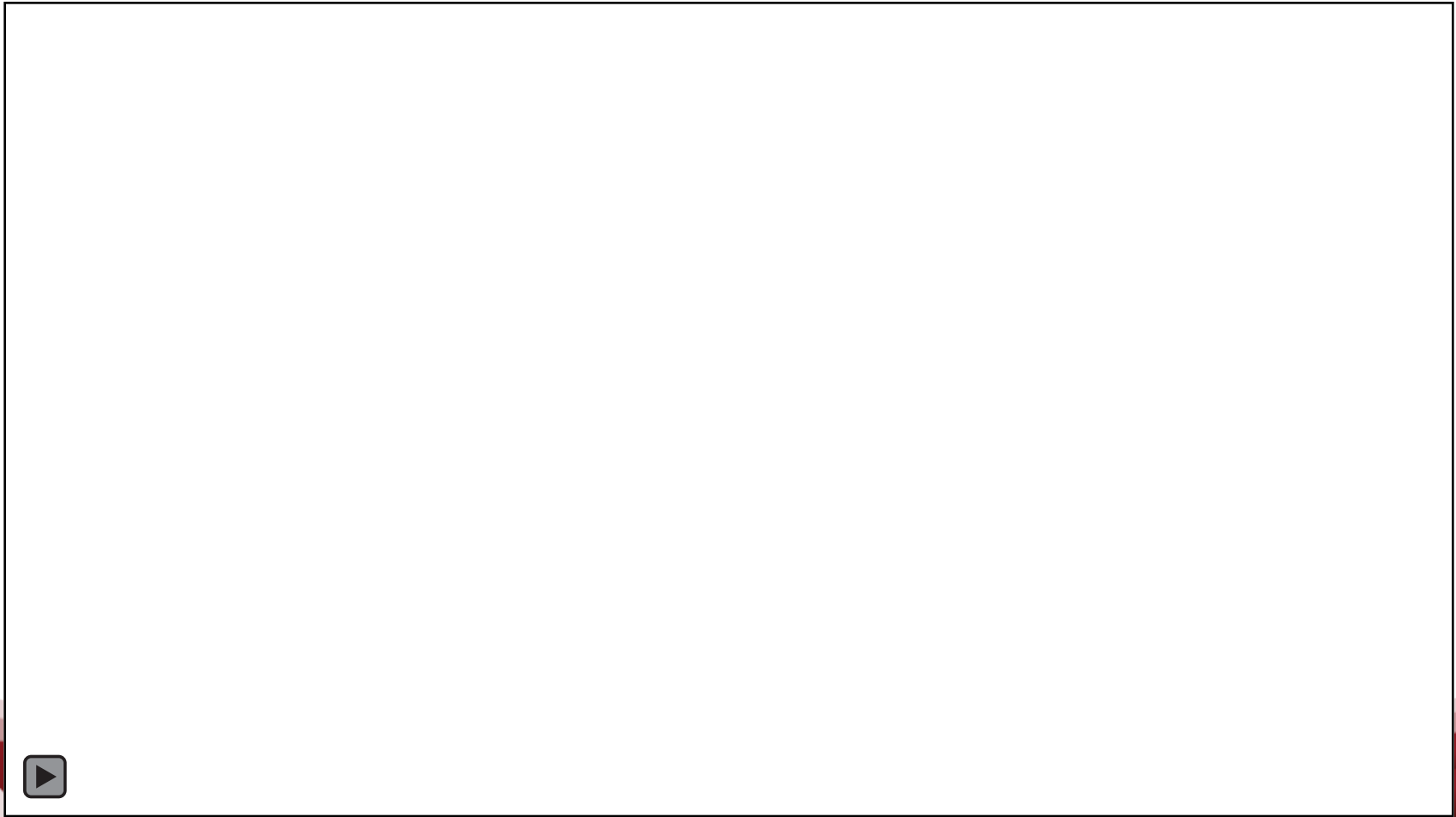


<http://agroclimate.org>

## WEATHER & CLIMATE DECISION TOOLS FOR FARMERS, RANCHERS & LAND MANAGERS



**Weather and Climate Decision Tools for Farmers, Ranchers and Land Managers**  
December 5-7, 2016 | University of Florida Campus | Gainesville, FL





# 2016 APEC Climate Symposium

16 - 18 September, 2016 Piura, Peru

## Climate information tools for decision making

Willingthon Pavan

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+55 54 3316-8354 x 8789