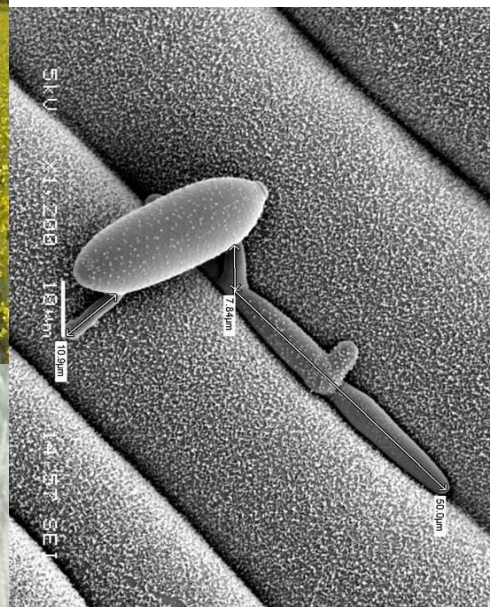
Monitoring air and rain for plant pathogens

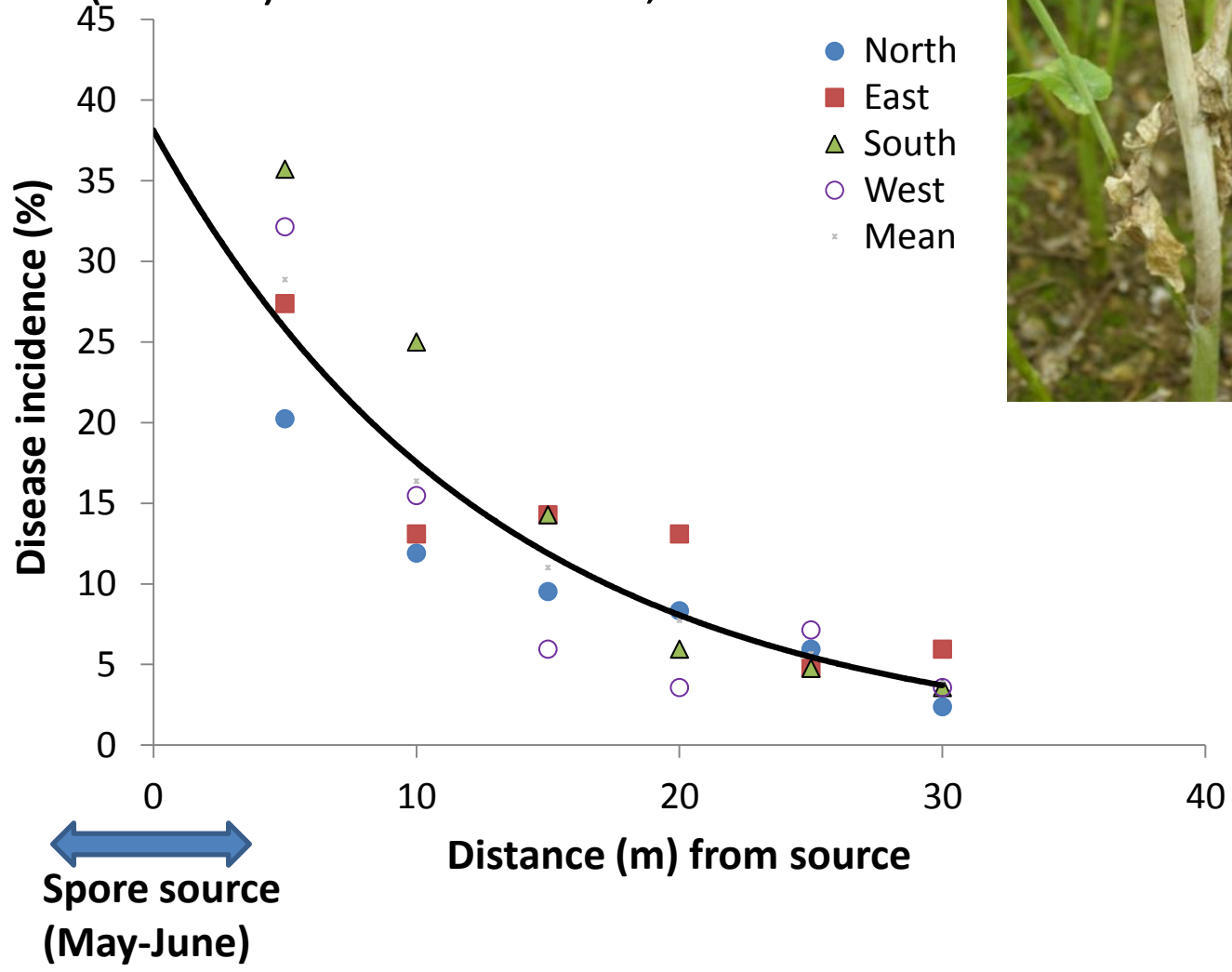
Jon West,
Rothamsted
Research



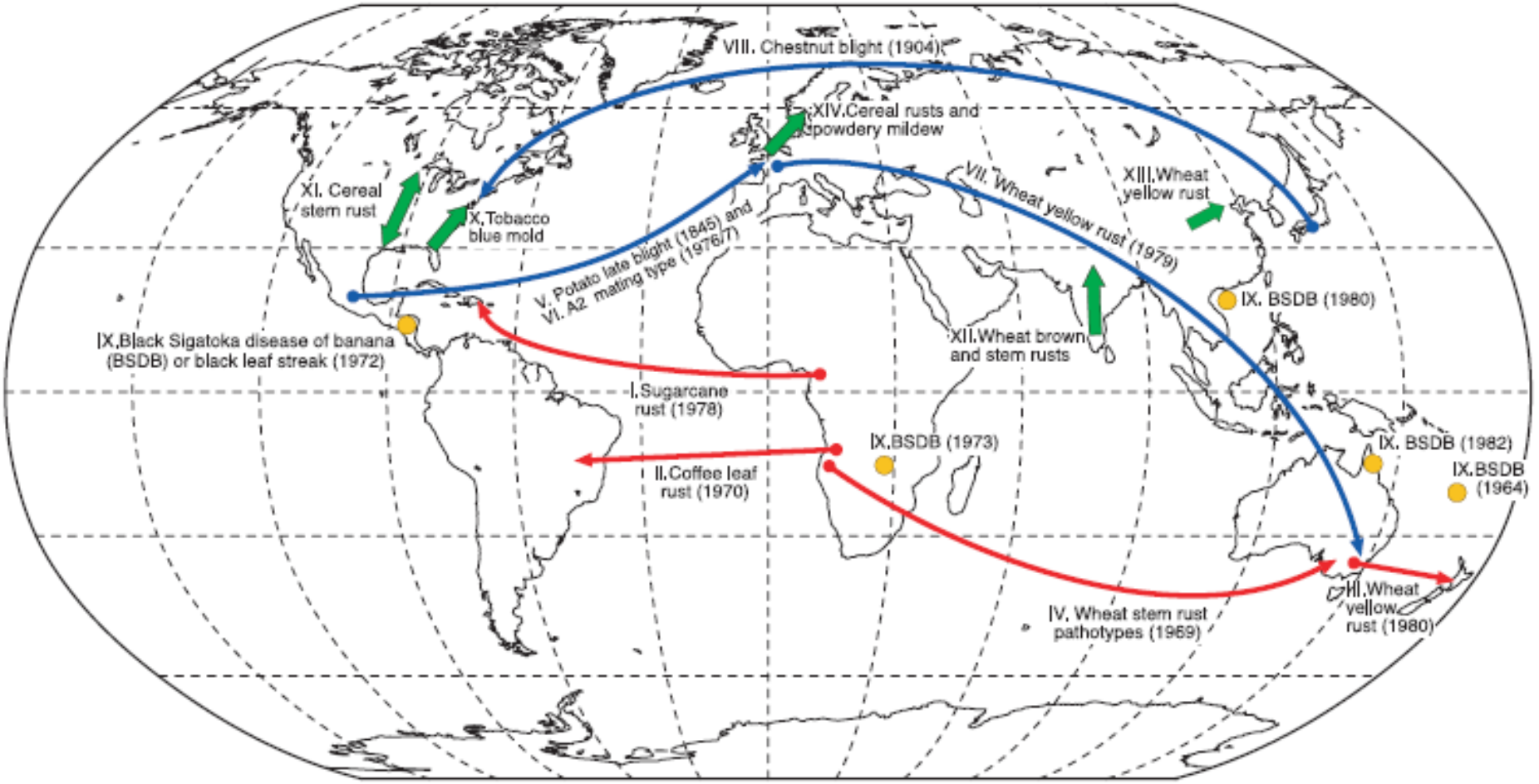
jon.west@rothamsted.ac.uk

Airborne spores and disease: a direct link

Sclerotinia disease gradient in oilseed rape (canola) at Rothamsted, 2012



Disease epidemics caused by introduced inoculum

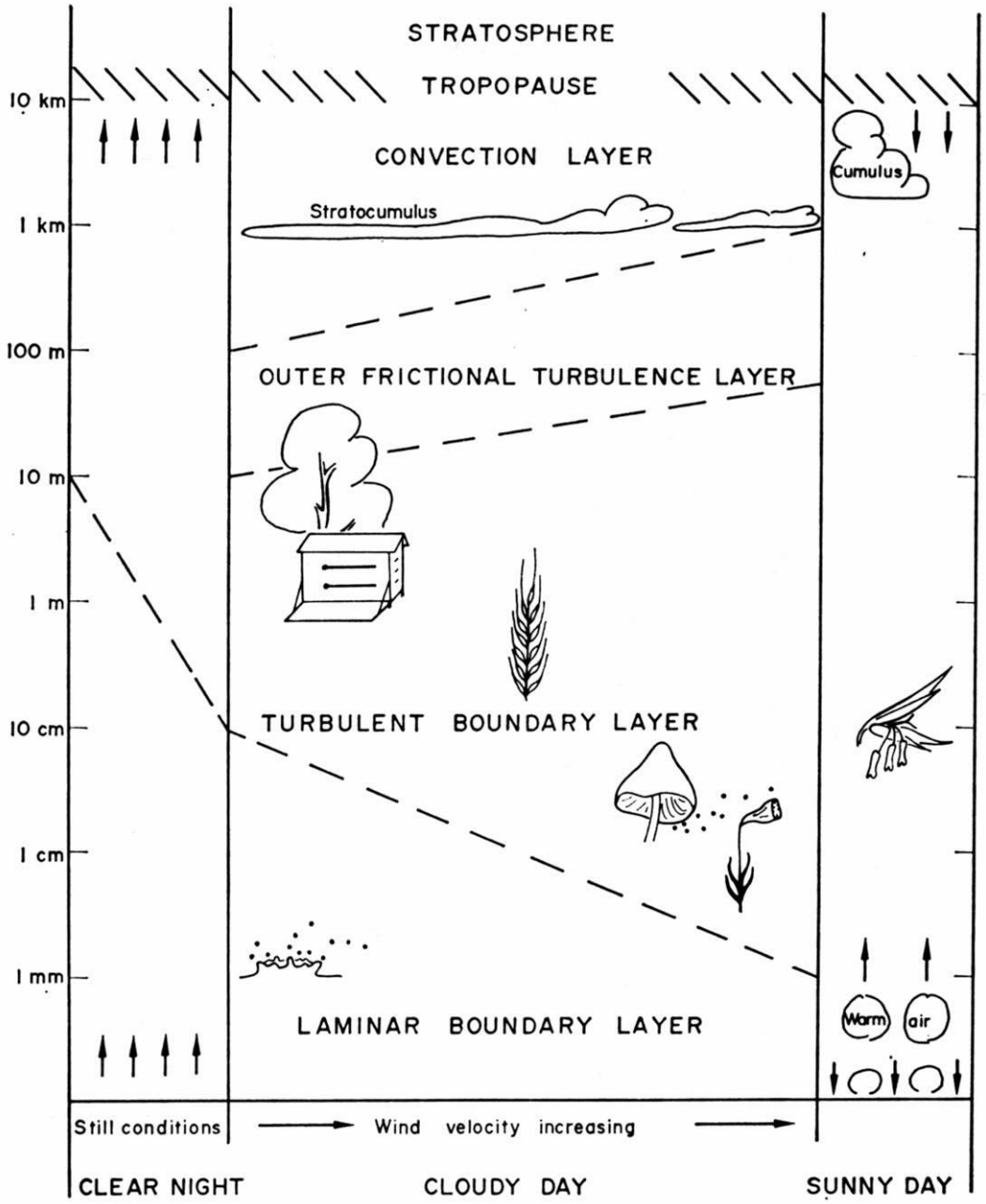


Airborne spores (regular spore influxes)

Infected plant material then spores locally

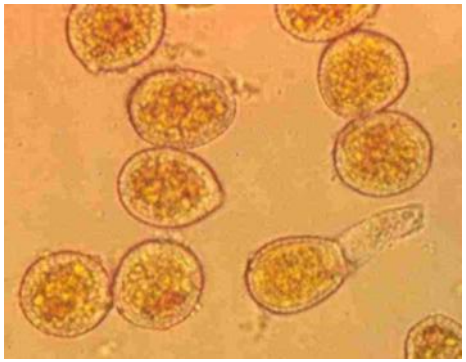
Black Sigatoka of banana

Brown & Hovmøller
SCIENCE **297** (2002)

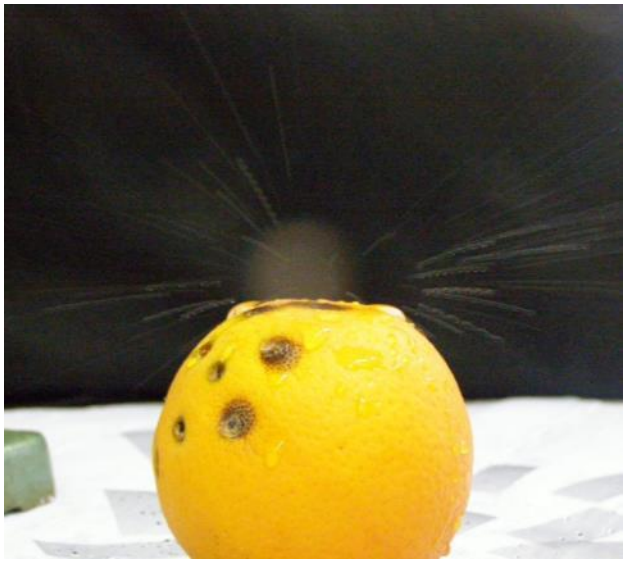


Some bacteria and fungal spores have fantastic ice nucleation activity

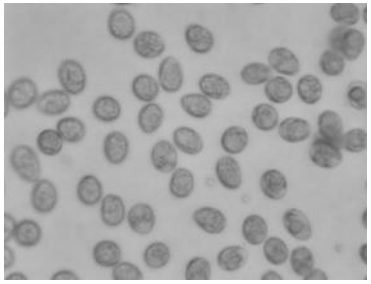
Morris C. E. (2013) Atmospheric Chemistry and Physics



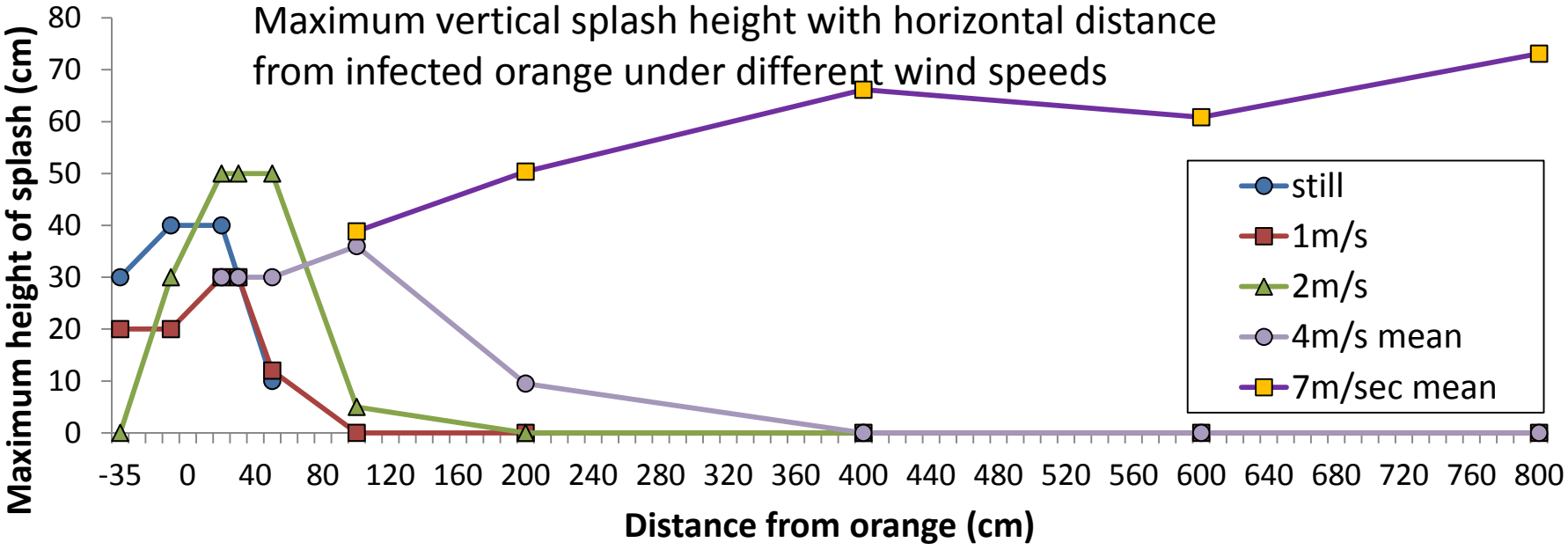
Gregory P. H. (1973)



Rain-splash dispersal of *Phyllosticta citricarpa* - Citrus blackspot



European Food Safety Authority



Perryman & West, 2014

Why Air Sampling?

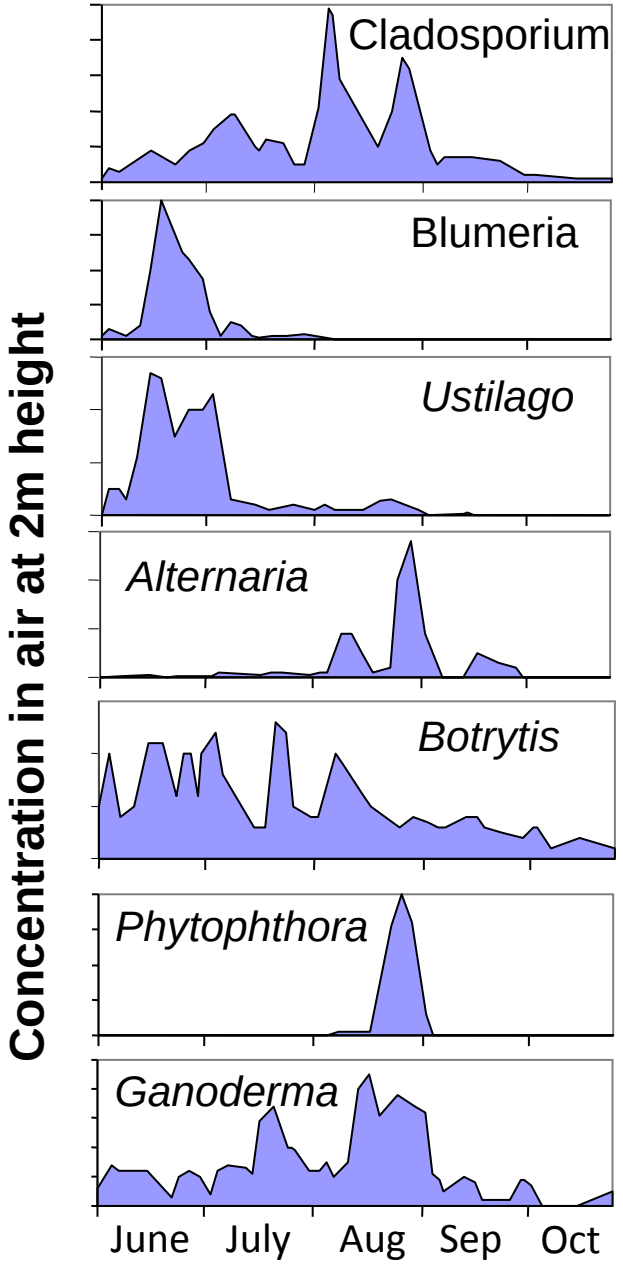
Timing of spore production

often seasonal - synchronised with crop growth-stage and infection conditions

Spatial variation in inoculum sources

Some pathogens have patchy spore release at the field and regional scales, while others are relatively homogeneous at these scales

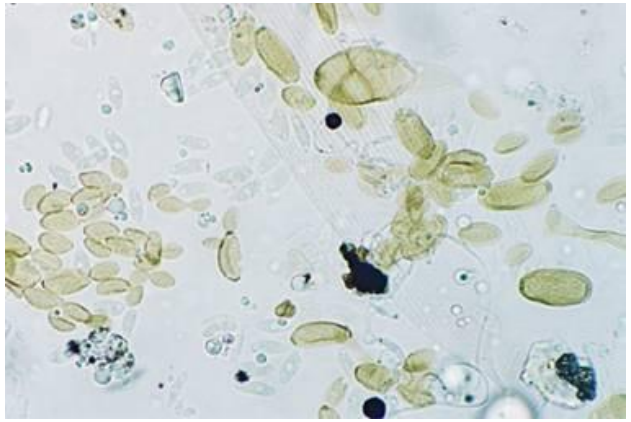
Genetic traits such as fungicide resistance and pathotype or race can be monitored which helps with control decisions and improves understanding of epidemics and disease forecasting



Data from Gregory & Hirst (1957)

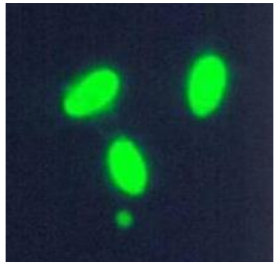
Spore detection and quantification

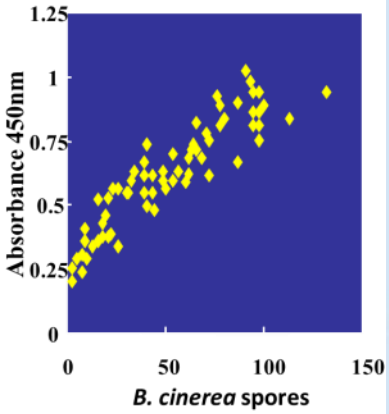
Our standard air samplers



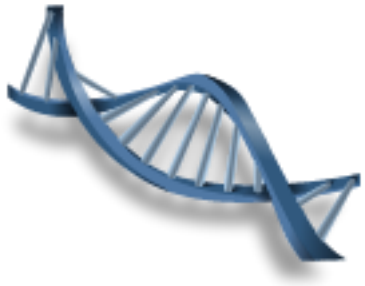
Microscopy

- Lab-based and difficult to identify to species level





Immunological techniques – rapid, on-site test but difficult to design specific antibodies …until now?



DNA-based methods

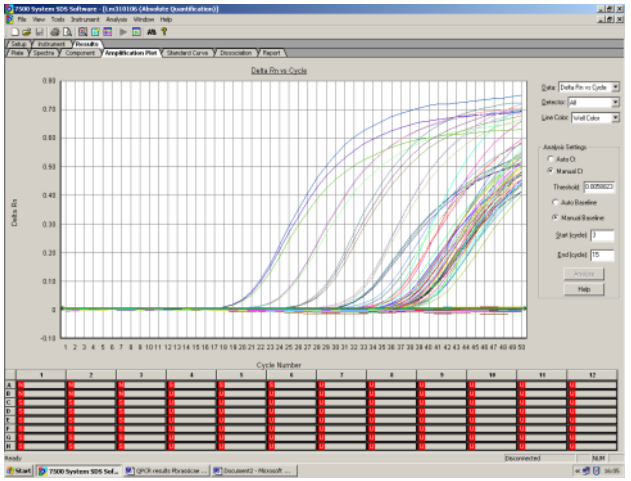
West et al 2008, Trends in Microbiology

Inoculum detection and molecular diagnostics

Spore traps - air particles impacted onto waxed tape

Air particles on waxed tape

DNA extraction step



Quantification of target DNA by qPCR

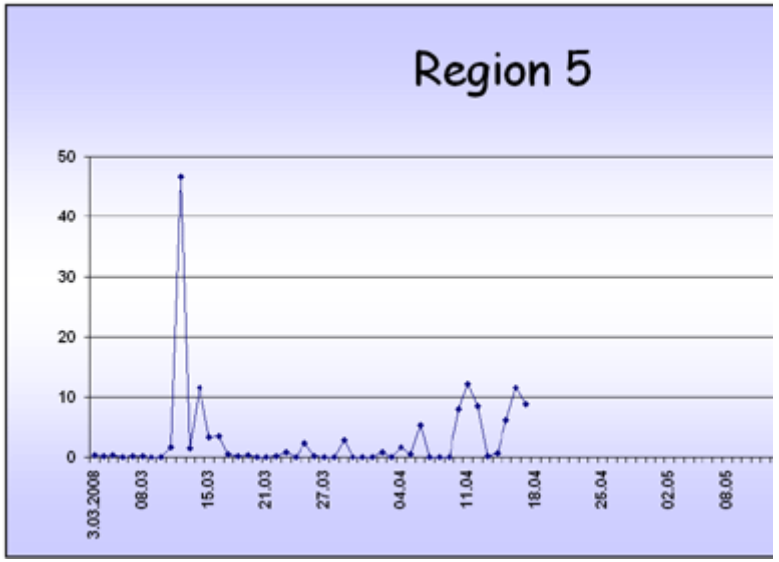
- Expensive and until recently, the sample needed to be taken to a lab + detects DNA of dead spores

- Microarrays can detect multiple targets -
384 BioRad system under evaluation in EU Pure project

- Isothermal methods can be very rapid and show great promise with costs now reasonable

Network for forecasting disease epidemics in Poland: SPEC

Region selected



***L. maculans* spores**

www.spec.edu.pl

http://www.syngenta-crop.co.uk/brassica-alert/

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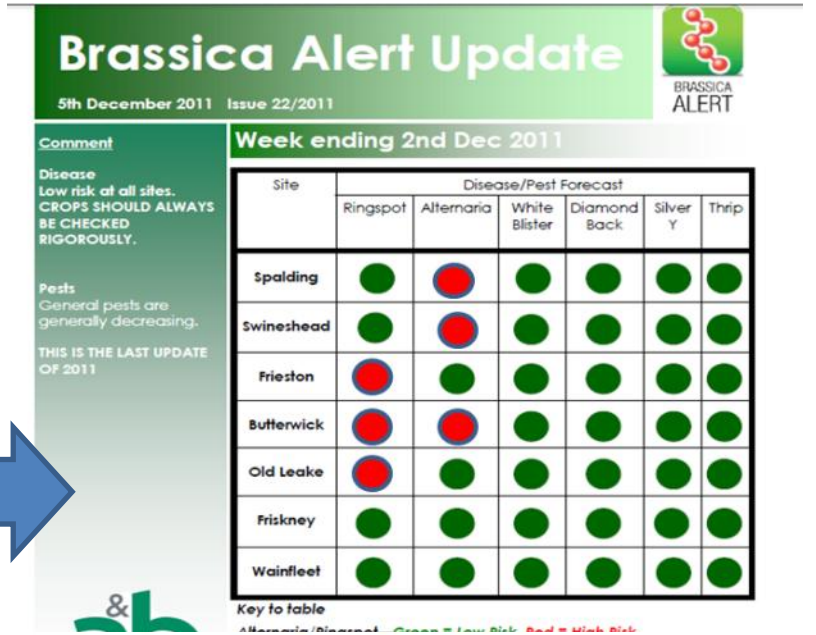
- Video Galleries

Social Media
- Crop Blog
- Business Blog
- In-Field Focus

Brassica Alert

You can now get early disease risk warnings of the three key brassica diseases before they hit your crops, sent direct to your computer.

Click the map to view or download the latest weekly disease alert



Brassica Alert Update

5th December 2011 Issue 22/2011

BRASSICA ALERT

Comment

Disease
Low risk at all sites.
CROPS SHOULD ALWAYS BE CHECKED RIGOROUSLY.

Pests
General pests are generally decreasing.

THIS IS THE LAST UPDATE OF 2011

Week ending 2nd Dec 2011

Site	Disease/Pest Forecast					
	Ringspot	Alternaria	White Blister	Diamond Back	Silver Y	Thrip
Spalding						
Swineshead						
Frieston						
Butterwick						
Old Leake						
Friskney						
Wainfleet						

Key to table

Brassica Alert 05/07/2013
Download (168KB)

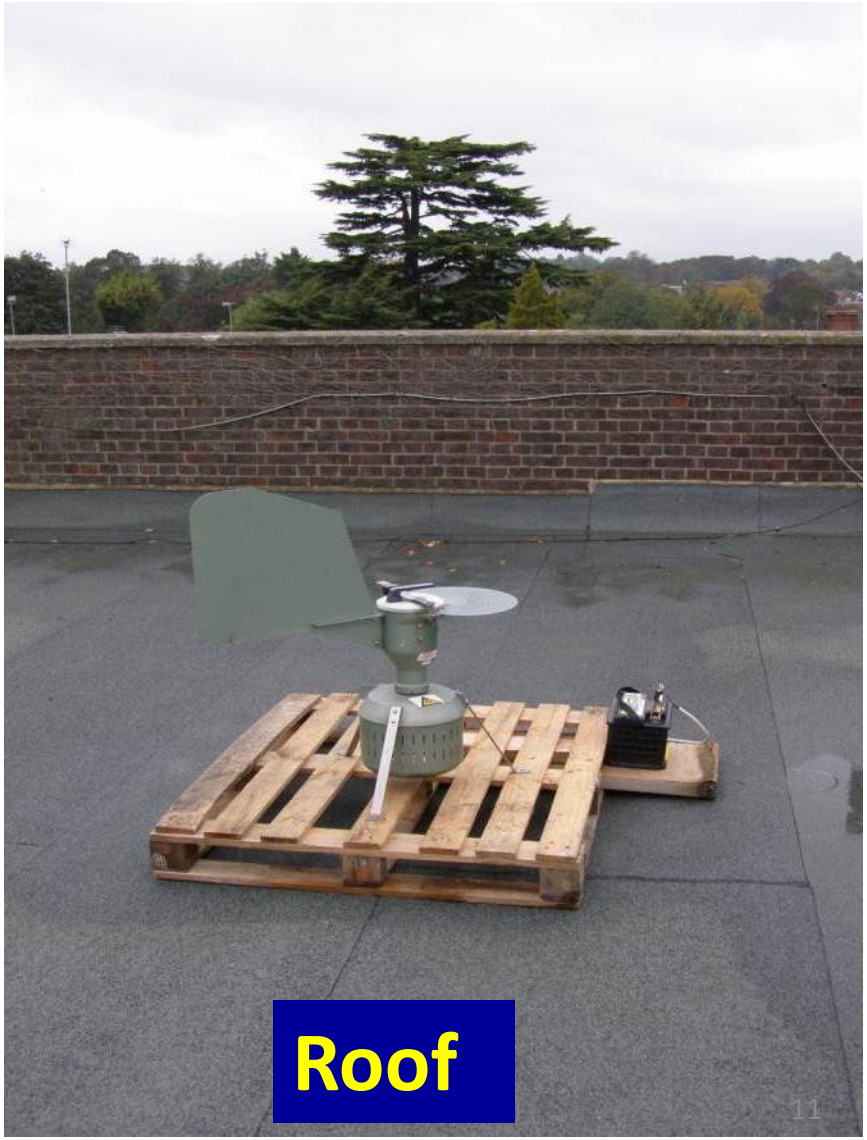
* Information supplied by Brassica Alert is provided in good faith. It is neither intended, nor is it implied, to provide specific advice to growers on disease or pest management decisions.

Allium & Brassica Agronomy Ltd | University of Worcester | HDC

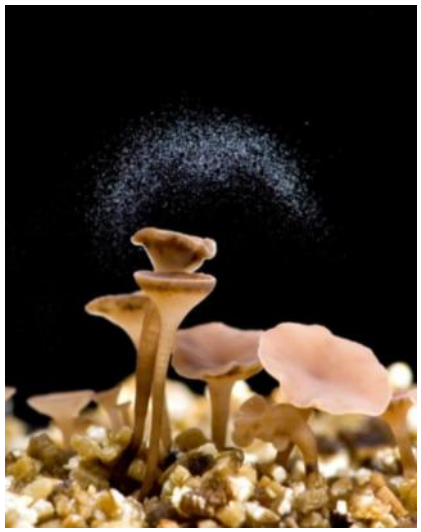
Multivial cyclone

4th November 2011

Comparing spore concentrations at different sampling locations, May 2012



Comparison of Sclerotinia DNA in air samples in field and rooftop 1km away



First Apothecia

New Zealand DNA (ng)

North Roof DNA (ng)

New Zealand 1

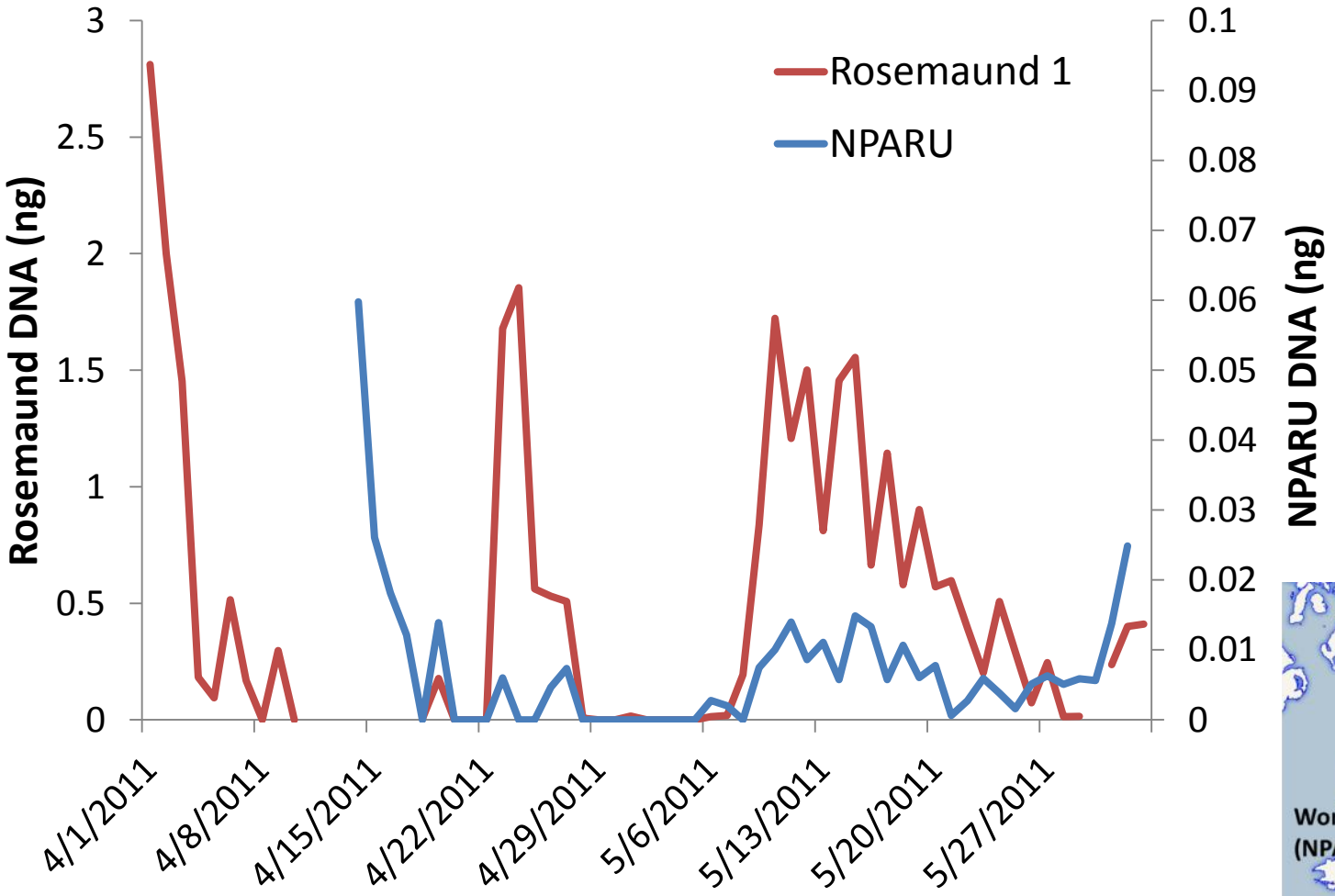
New Zealand 2

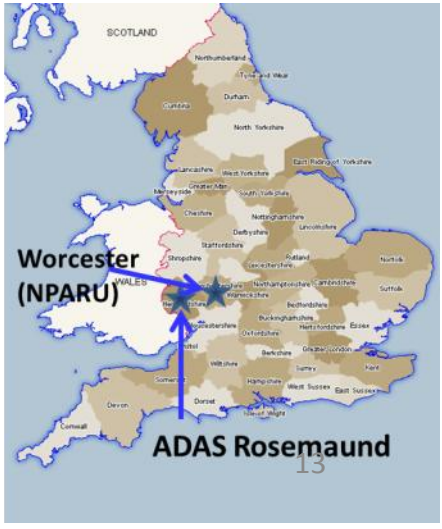
North Roof

08/04/2...
15/04/2...
22/04/2...
29/04/2...
06/05/2...
13/05/2...
20/05/2...
27/05/2...
03/06/2...
10/06/2...
17/06/2...
24/06/2...
01/07/2...

Sclerotinia LINK & Syield TSB projects, 2011

Comparison of Sclerotinia DNA at NPARU and ADAS Rosemaund (about 50 km apart in western England)

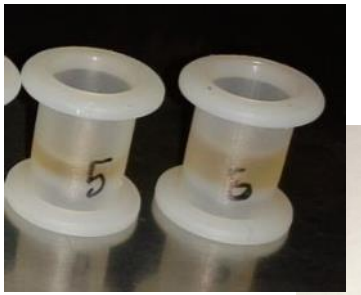


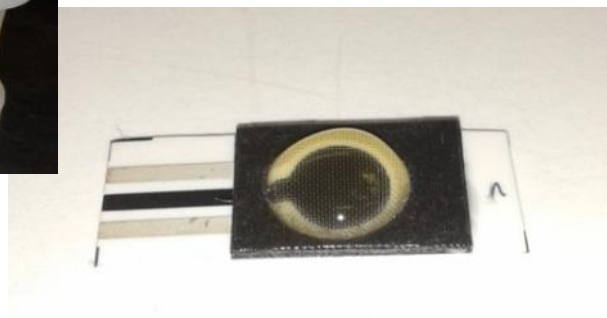


Sclerotinia LINK project, 2011

‘First, there was a dream, then – Reality’

The first fully automated device for the capture, detection and wireless reporting of airborne spores of *Sclerotinia sclerotiorum* – in the world





http://www.syield.net/home.html

SYield
Sensors for protecting crop Yield

Technology Strategy Board
Driving Innovation

MANCHESTER 1824
The University of Manchester

syngenta

Burkard

VELCOURT

pure
Innovative crop protection for sustainable agriculture

uniscan instruments

GWENT GROUP

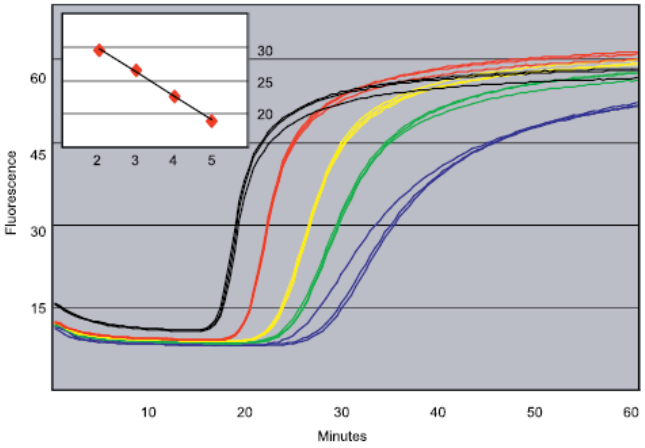
dmc
International Imaging

ROTHAMSTED RESEARCH

Future Work:

Automated, rapid detection of DNA from airborne spores

Miniature Virtual Impactor (patent pending), which samples at high flow rate into liquid (incubation media or extraction buffer)



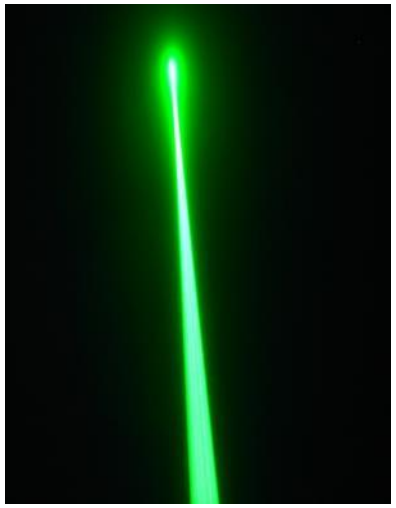
Isothermal DNA method e.g. LAMP assay

http://www.twistdx.co.uk/

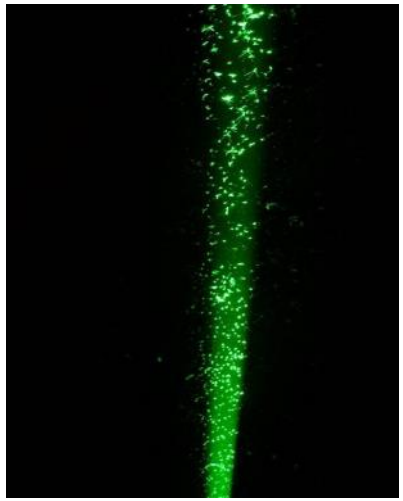
http://www.optigene.co.uk/

Potential remote sensing approaches?

Centre for Atmospheric & Instrumentation Research
Detlef Müller, University of Hertfordshire, Atmospheric Remote Sensing Laboratory

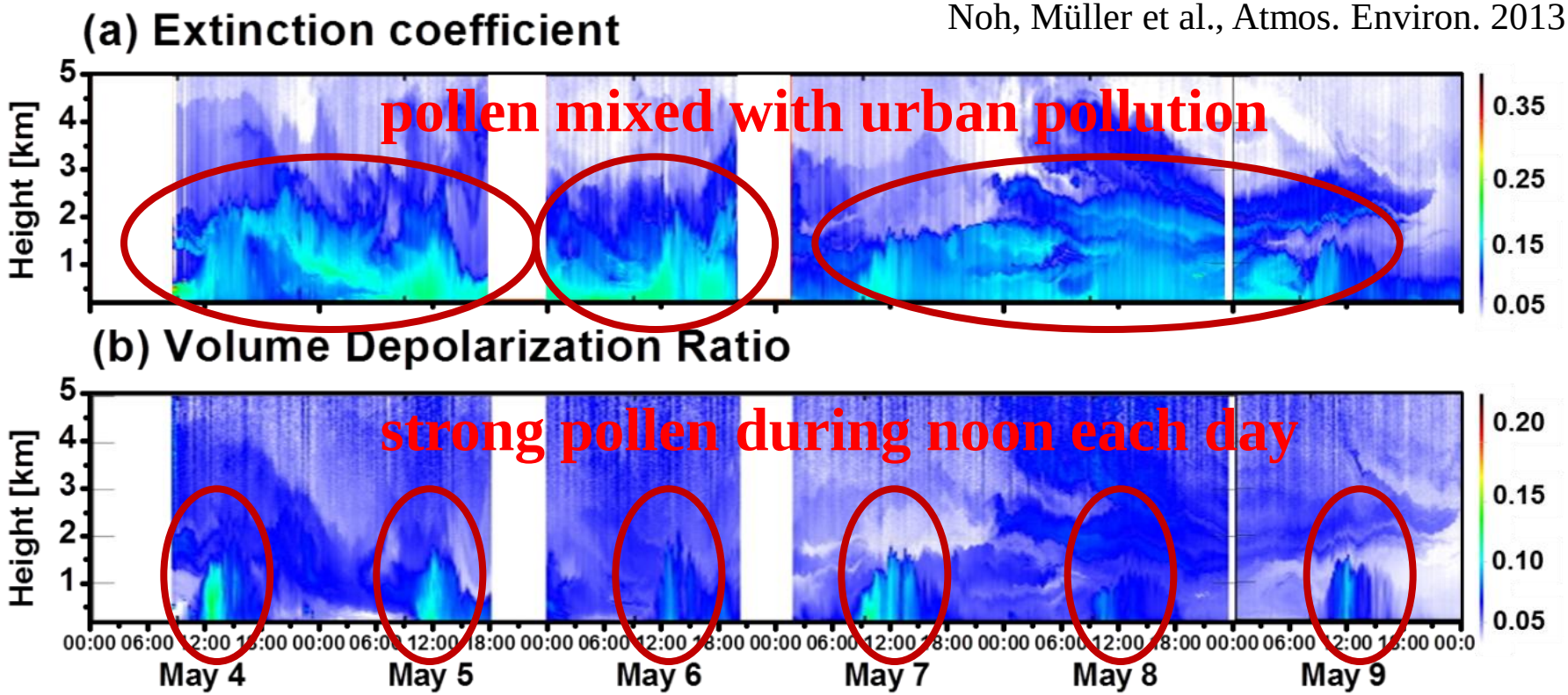


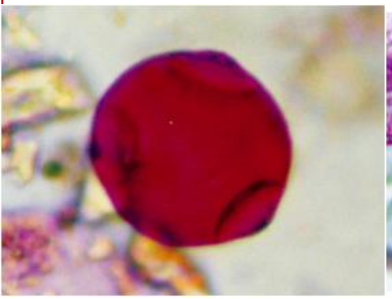
- Light Detection and Ranging = **LIDAR**
- identification of atmospheric particles **from ground to top of the atmosphere**
- allows us to specify in which height above ground particles and gases exists
- **Several lidar techniques allow for bio-aerosol identification:**
  - Raman lidar: chemical compounds
  - Fluorescence lidar: identification of e.g. pollen
  - Depolarization lidar: shape and thus type of pollen



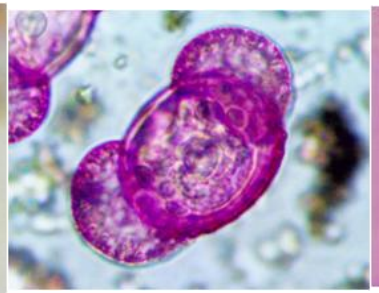
Pollen Measurements over South Korea: 4 – 9 May 2009: From ground to 1.5 km above ground

Noh, Müller et al., Atmos. Environ. 2013

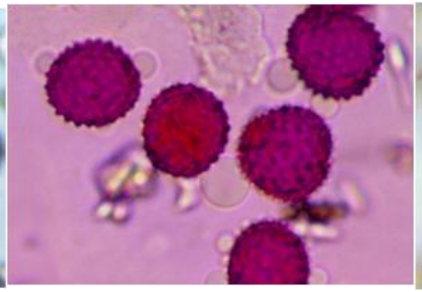




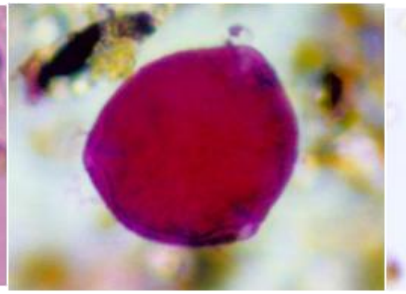
Hazelnut



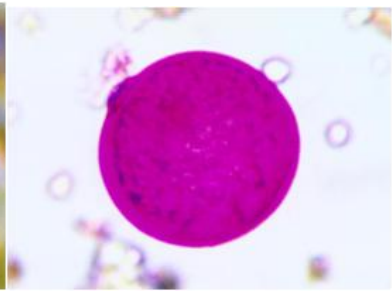
Pine



Ragweed

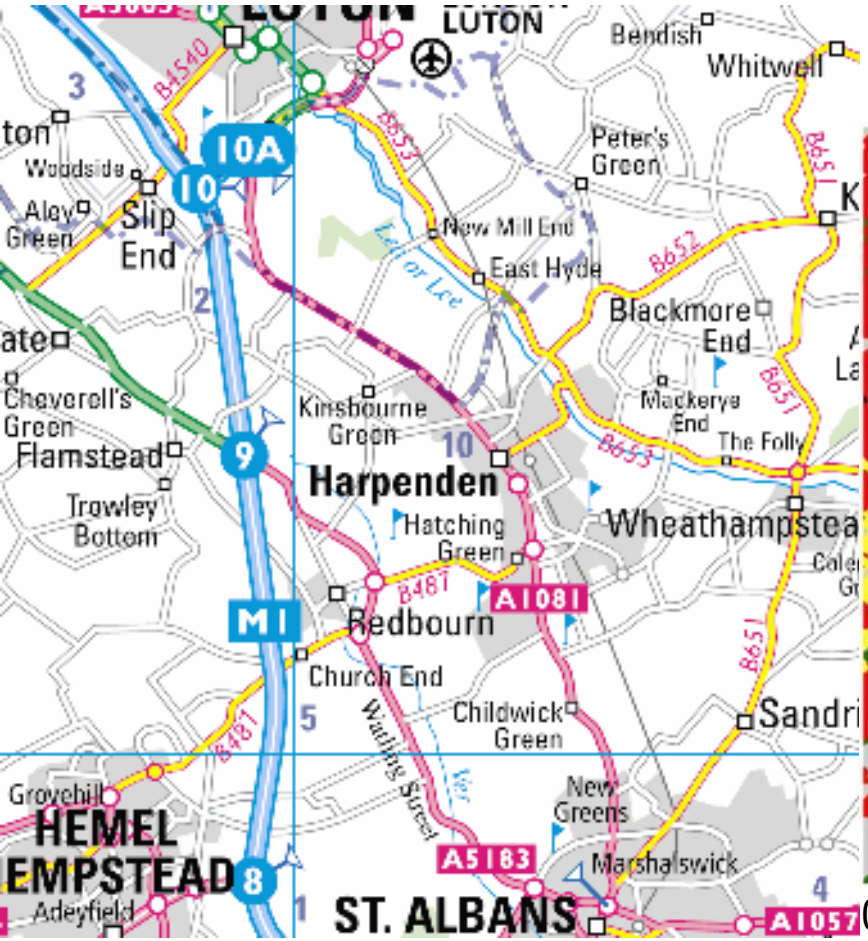


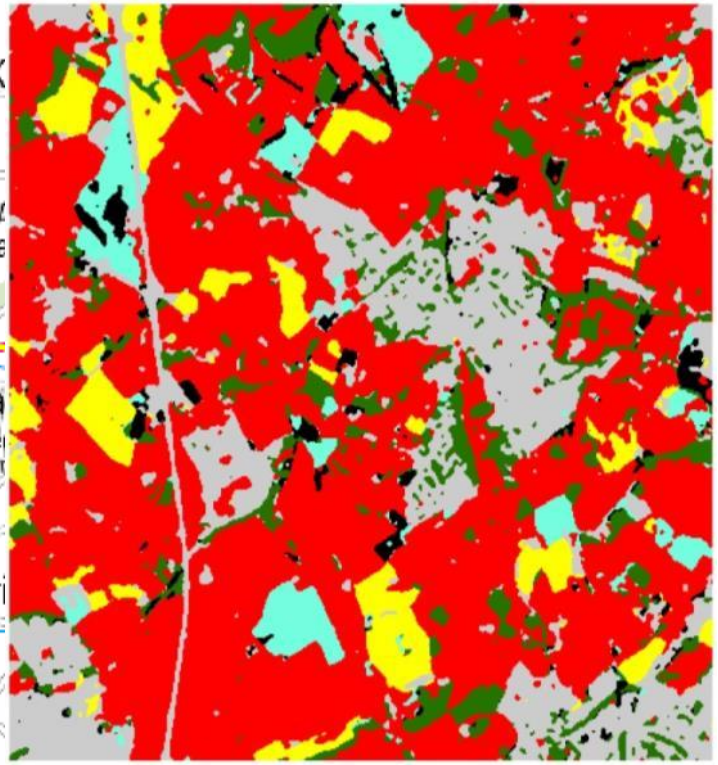
Oak



Grass

GIS & Satellite Image Management Tools for crop classification to integrate disease risk





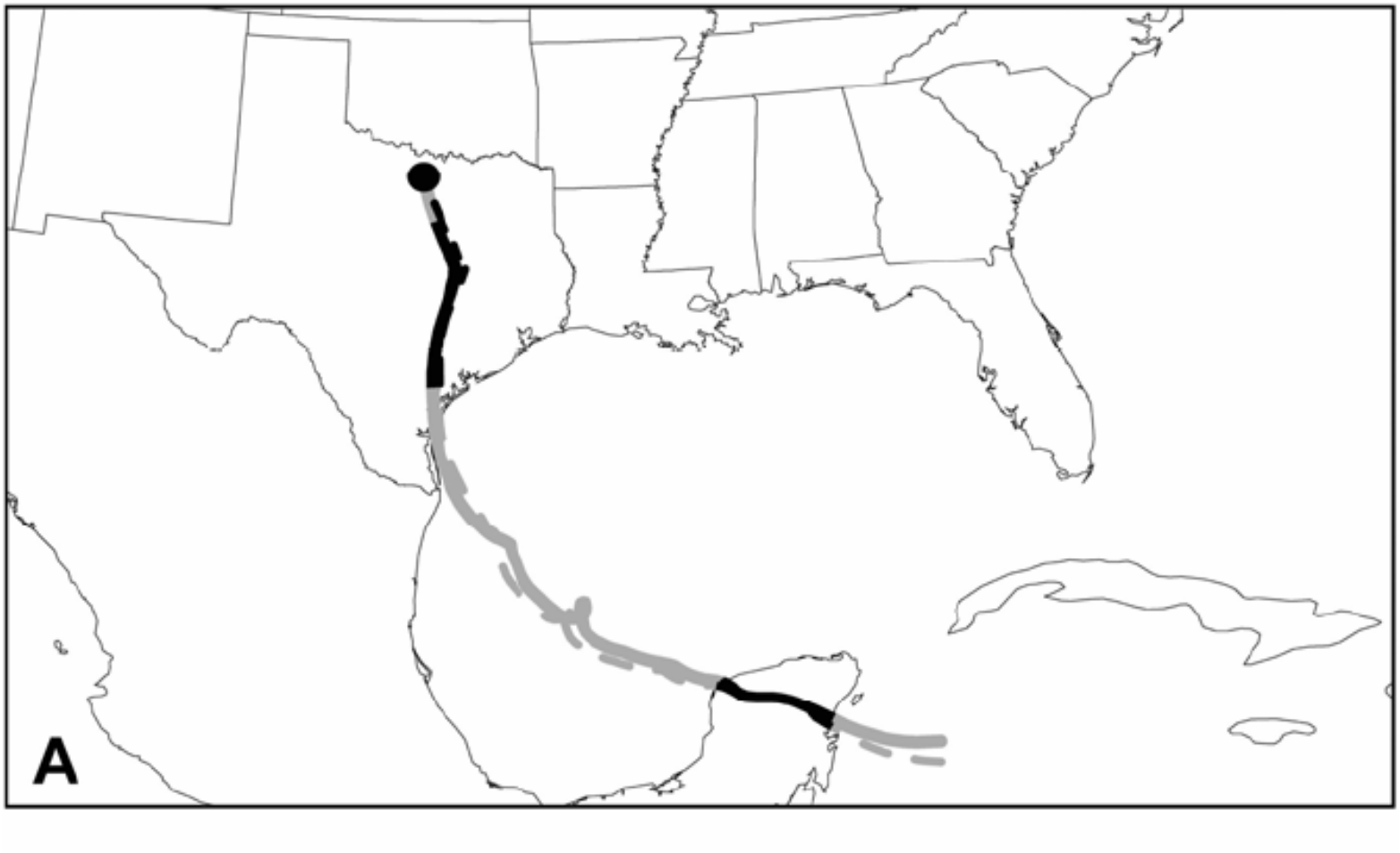
0 1 2 3 4 5 km

Unclassified
Oilseed Rape
Vegetables
Cereals and Grass
Forest and Waterbody
Urban, Suburban and Bare Ground

Image: Katherine Elsom, DCMii

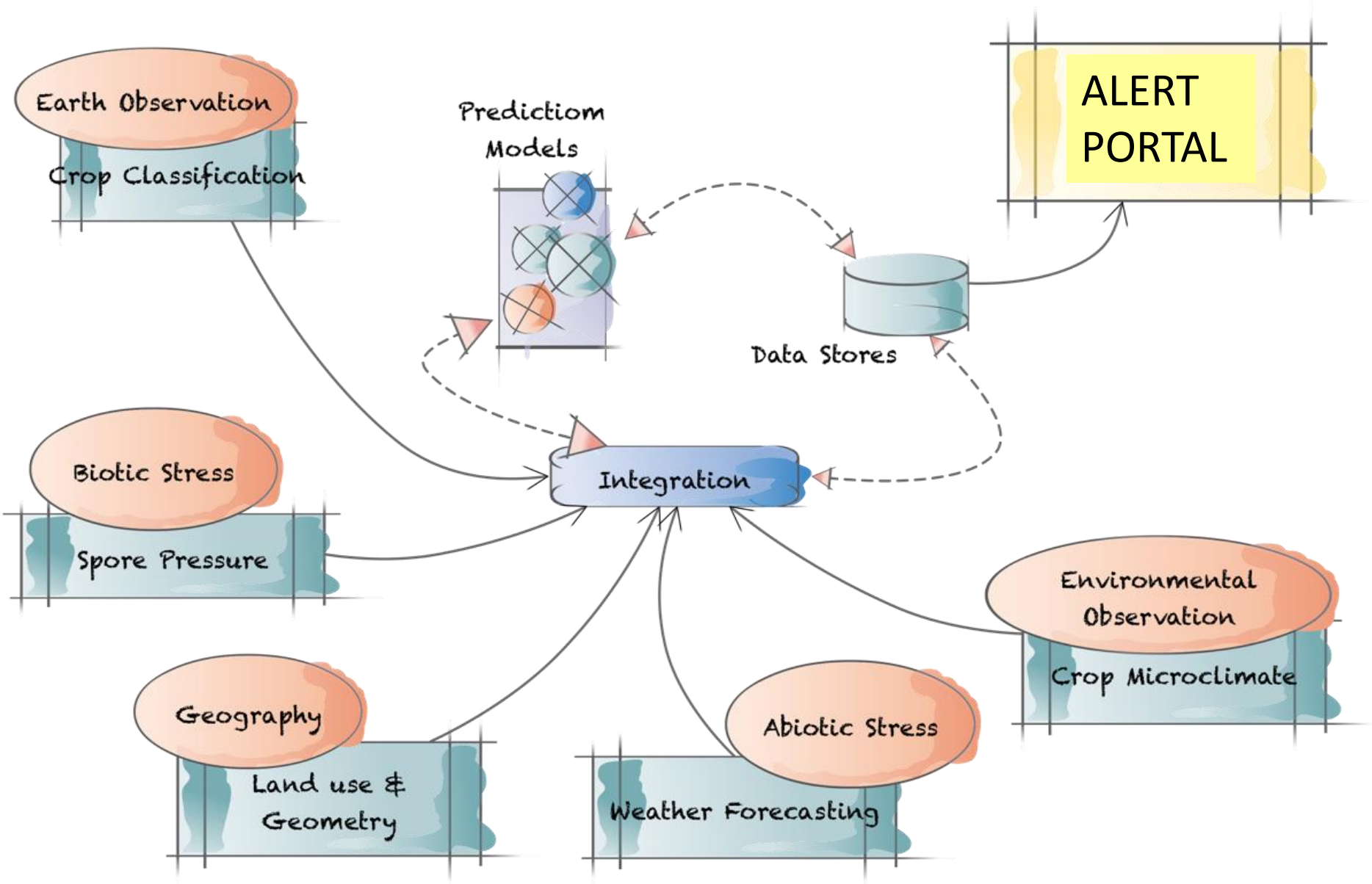
jon.west@rothamsted.ac.uk

Backtracking: where has air come from ?



Cereal Disease Laboratory web-publication: Introduction of Asian Soybean Rust Urediniospores into the Midwestern United States—A Case Study (Krupa et al (2006) Plant Disease

Components of a possible precision disease detection system



Source: Derek Scuffell, Syngenta

Aerobiology in plant pathology: Summary

- Many plant diseases are initiated by airborne dispersal of spores, which vary in time and space

- Recent advancements in diagnostic methods have driven inoculum-based disease forecasting – automated, rapid on-site detection is now a prospect using biosensors, rapid isothermal DNA-based methods or immunological tests

- DNA-based methods can also be used to monitor pathogen populations for changes in genetic traits

- Further research is needed to understand the variability in concentrations of airborne spores over field and regional scales and to deliver results quickly to make practical monitoring programmes effective

- GIS, crop classification and air trajectory analysis (from sources) needs to be incorporated into monitoring systems

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BBSRC 20 Years of Pioneering Great British Bioscience

ROTHAMSTED RESEARCH

Acknowledgements

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Detlef Müller (University of Hertfordshire)

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