Forecasting mycotoxins in cereals

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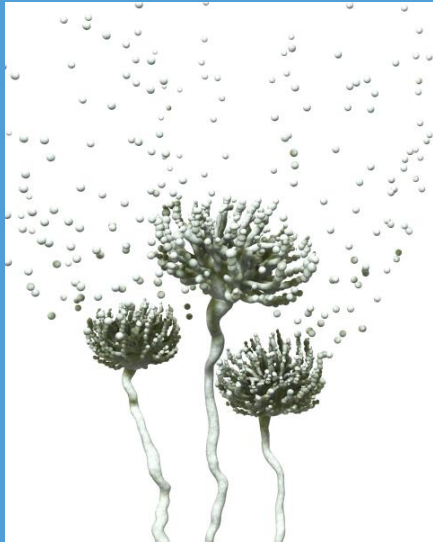
1. What is mycotoxin?

A toxic secondary metabolite produced by fungus and is capable of causing disease and death in both humans and animals.

Aspergillus – aflatoxin

Fusarium – deoxynivalenol (DON), zearalenone (ZEA), fumonisin

Istock.com/selvanegra

Mycotoxin impacts

- Economic loss
  - Due to impaired health of stock animals
  - Lower price of infected crops
    - e.g. the price of infected wheat was 67 euros/ton lower than normal in 2014 (NL)
- Illness
  - Diarrhea, immune suppression, nose bleeds etc., and vary by species
- Death

Why mycotoxins can not be avoided?

- Lack of visible appearance of fungus does not negate presence of mycotoxins. Toxins can remain in the organism after fungus has been removed.

- Mycotoxin is chemically stable contaminant. Not destroyed by canning or other processes.

- Spore transmission
  - Airborne, wind or indoor ventilation systems
  - Via transportation e.g. trucks, machinery, etc.
  - Via insects, birds, etc.

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Why mycotoxins can not be avoided? (2)

- Fungal infection can occur at any stage in crop production:
  - In the field
  - Harvesting
  - Silo and storage
- Certain weather conditions and agronomical practices will trigger the germination, even after spores lay dormant for months to years.
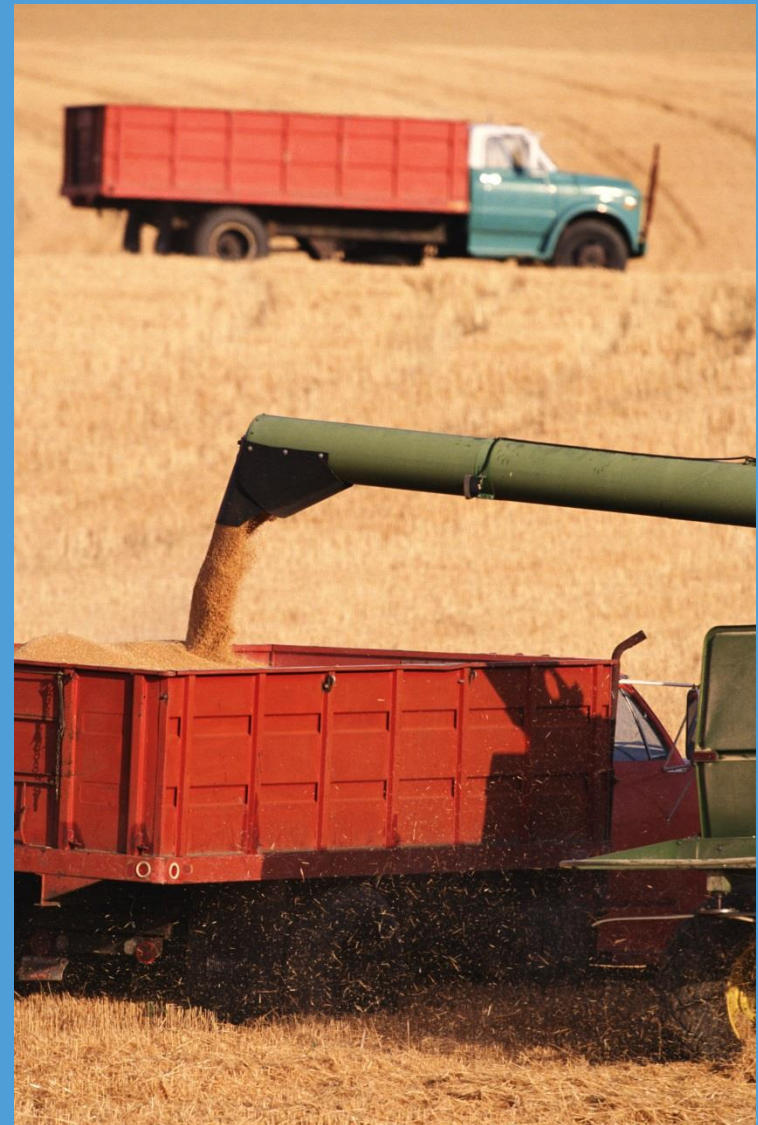
Mycotoxin predictions for decision support

A. Application of fungicides

- Use by farmers

- Prediction needed around wheat flowering

B. Routing and processing within the chain

- Use by collectors and buyers

- Prediction needed at/just before harvest

C. Risk based inspection

- Use by industry and food safety authorities

- Prediction needed at/just before harvest

Societal, economic and scientific relevance !

2. Partners PPS project

Public Private Partnership
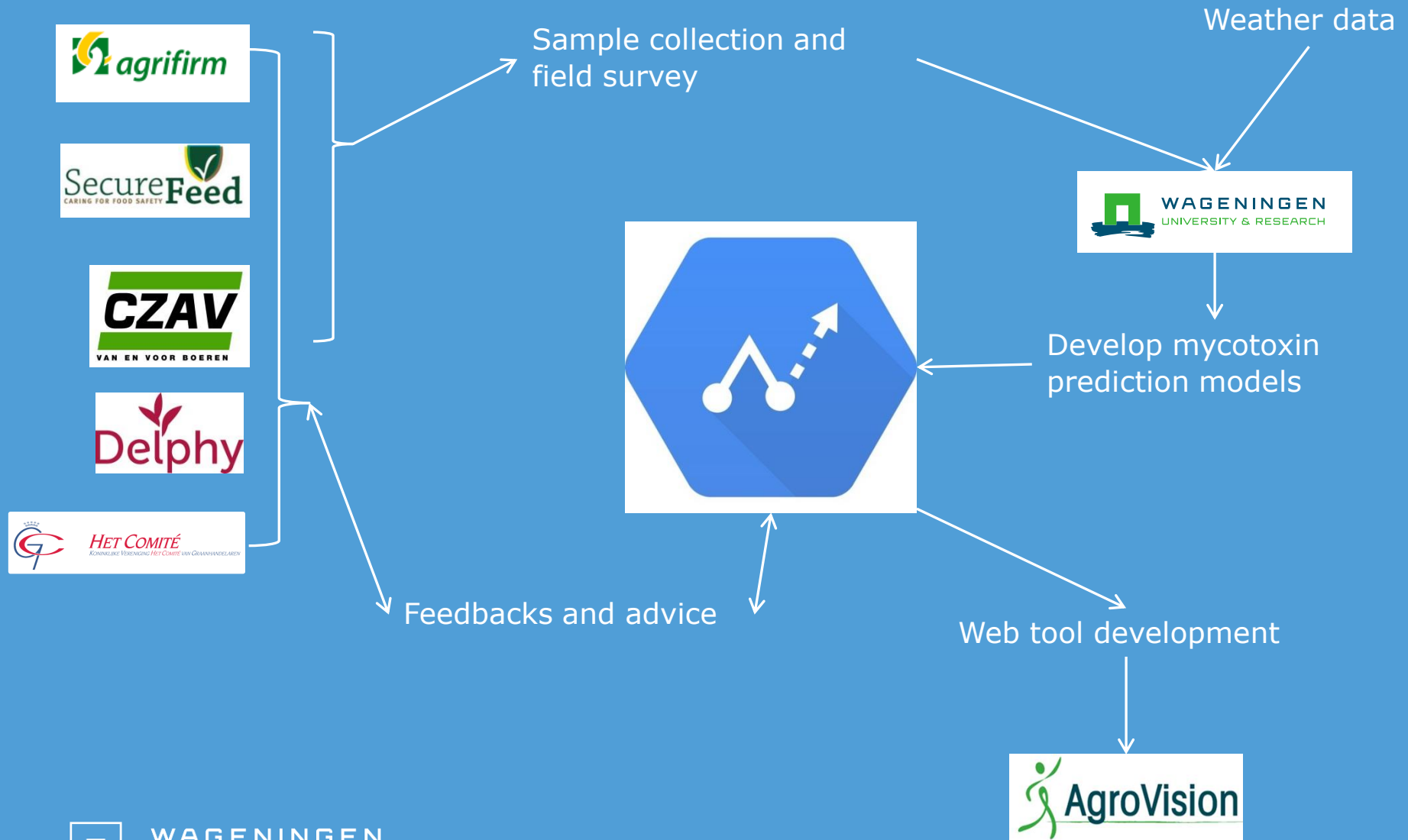
'Voorspellen mycotoxinen in granen'

PPS Voorspellen mycotoxinen in granen

- 4 years project: 2015-2018
- Prediction models for three crops:
  - Winter wheat (DON) in NL
  - Grain maize (AFLA) in EU
  - Barley (DON) in NL/EU

- To reduce economic and health losses

Good cooperation between partners

Sample collection and field survey

Weather data

Develop mycotoxin prediction models

Feedbacks and advice

Web tool development

3.2 DON-Wheat–NL models

Three different modelling types:
- Empirical
- Mechanist
- Bayesian

3.2 DON-Wheat–NL models
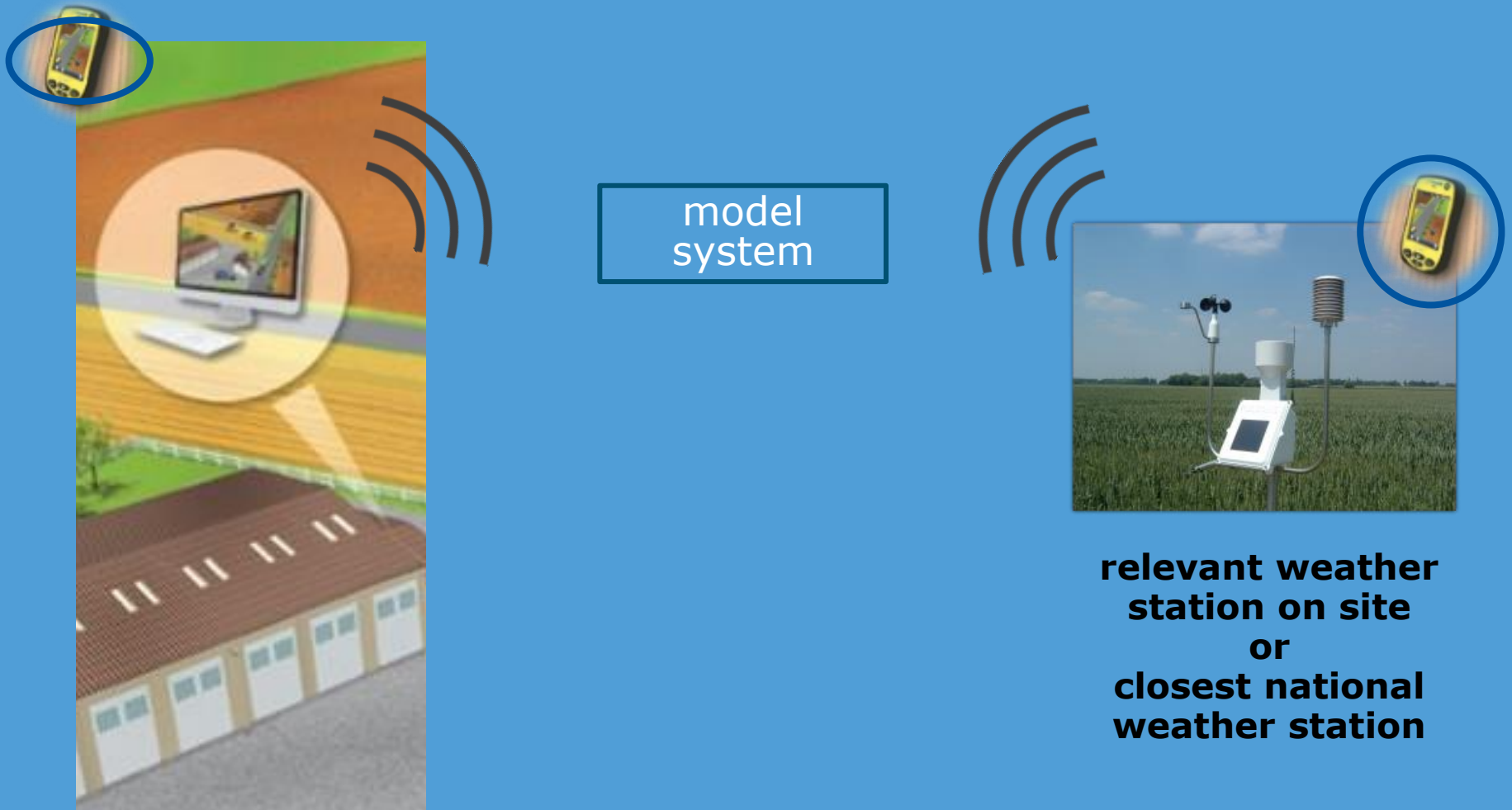
General empirical model input and output:

- Input, several of:
  - Weather variables (temperature, relative humidity, rainfall) during different stages of grain cultivation
  - Grain variety
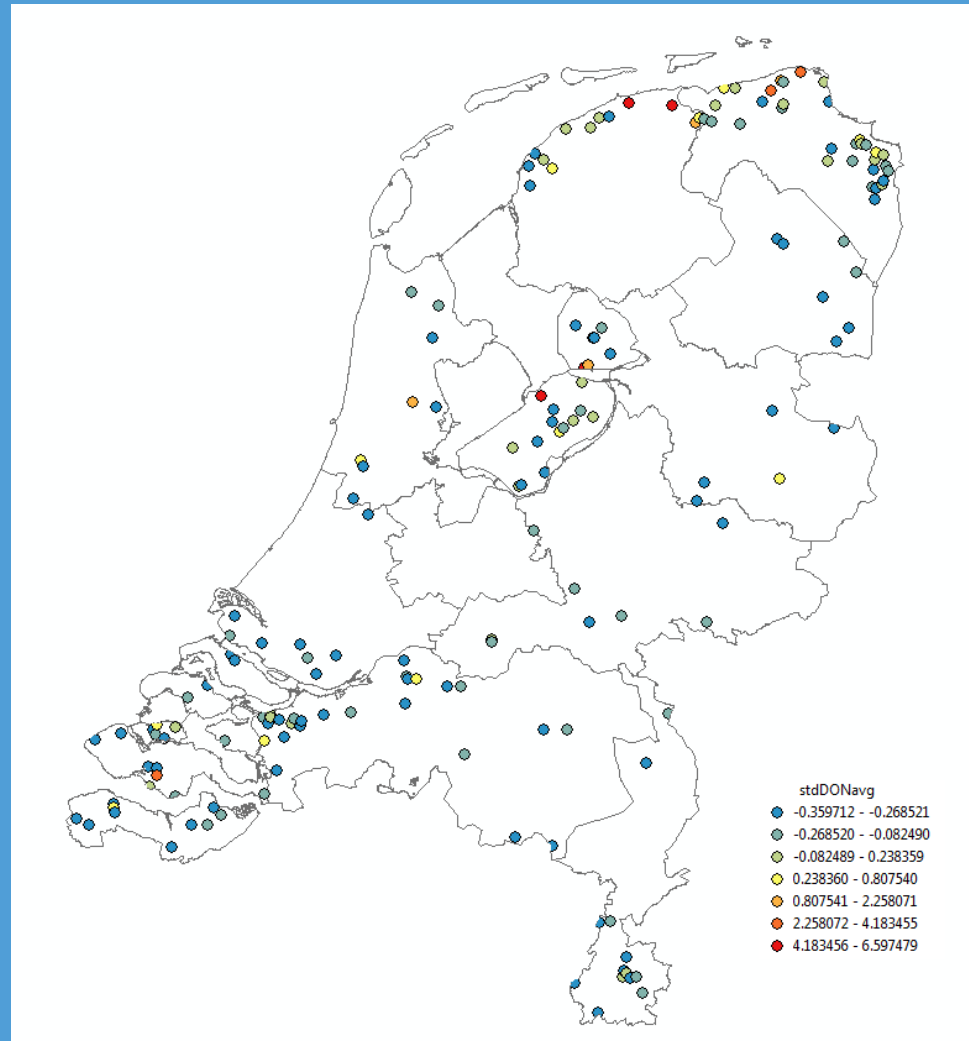 - Country, region, farm location
  - Fungicides use
- Output
  - Daily predictions – during grain cultivation – for levels of mycotoxins at harvest
  - Optimal harvest time

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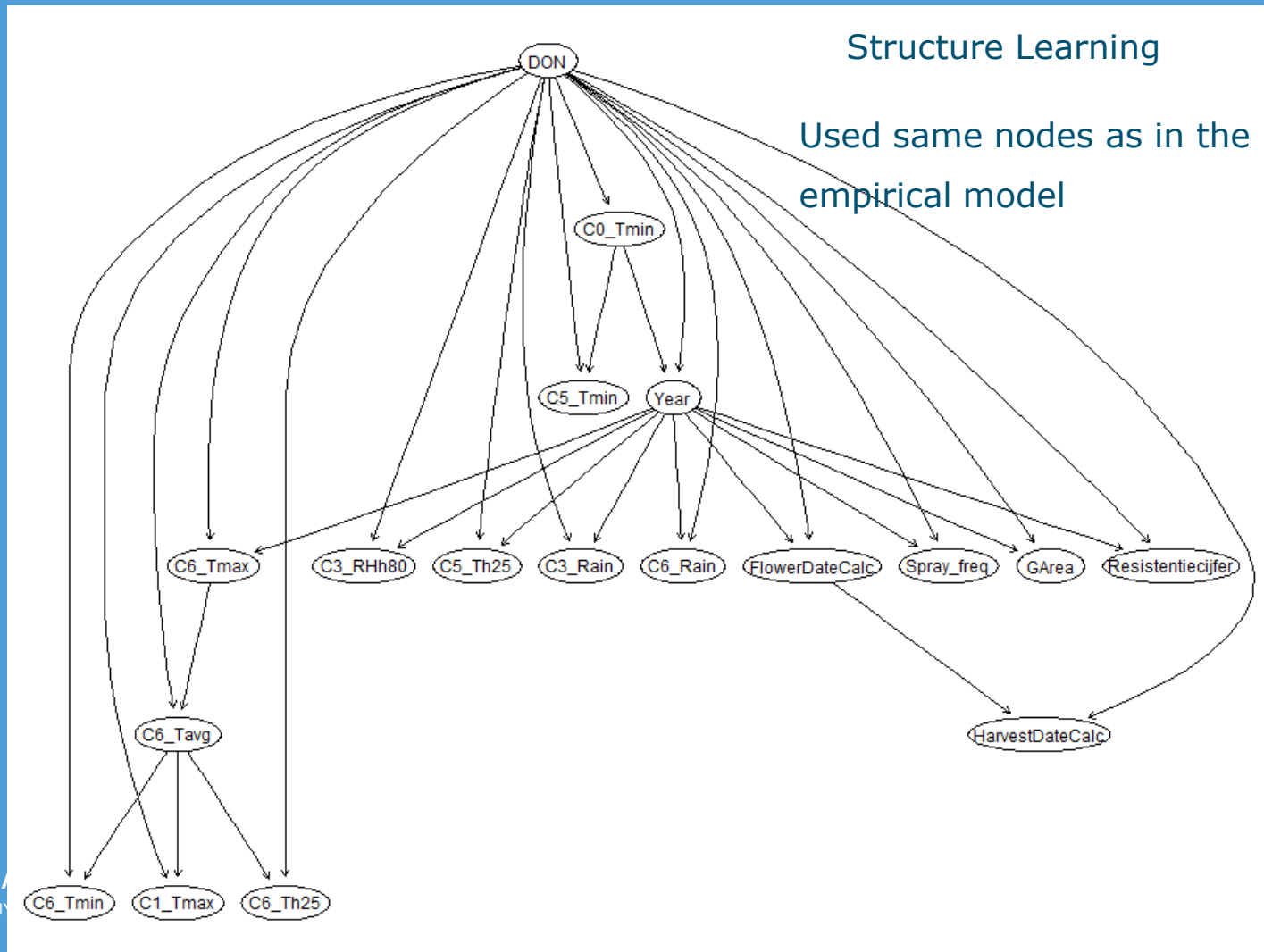UNIVERSITY & RESEARCH

3.2 DON-Wheat–NL models:

model system

relevant weather
station on site
or
closest national
weather station

3.2 DON-Wheat–NL models: model results

- Mixed effect linear regression model
- Accuracy 91 %

stdDONavg
- -0.359712 - -0.268521
- -0.268520 - -0.082490
- -0.082489 - 0.238359
- 0.238360 - 0.807540
- 0.807541 - 2.258071
- 2.258072 - 4.183455
- 4.183456 - 6.597479

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3.2 DON-Wheat-NL models: Bayesian network (BN)

Structure Learning

Used same nodes as in the empirical model

3.2 DON-Wheat-NL models: Bayesian network (BN)

- Parameter learning

Conditional probability e.g. P(DON|GArea)

	DON		
GArea	<500ppb	500-1250 ppb	>1250ppb
Green	0.83	0.12	0.05
Yellow	0.67	0.18	0.15
Red	0.30	0.05	0.64

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3.2 DON-Wheat-NL models: Bayesian network (BN)

- … and add some evidence

GArea = 'red'

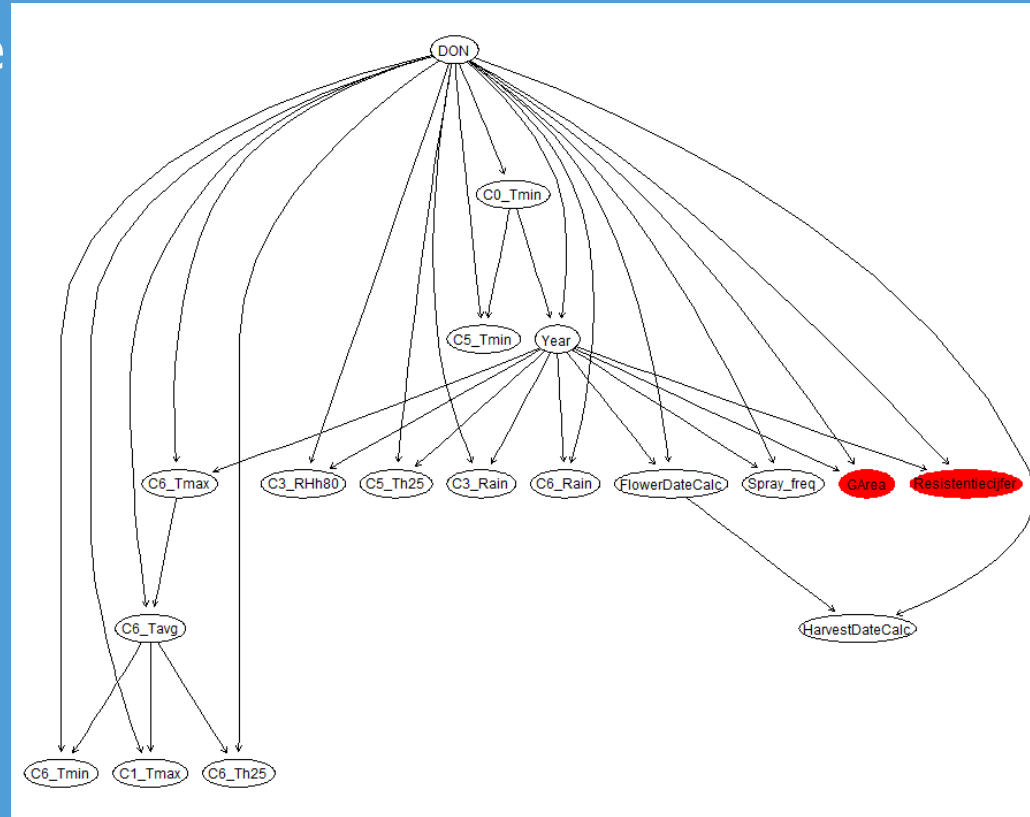

DON		
<500ppb	500-1250 ppb	>1250ppb
0.30	0.05	0.64

3.2 DON-Wheat-NL models: Bayesian network (BN)

- … and add some evidence

GArea = 'red'

ResisL = 7.5

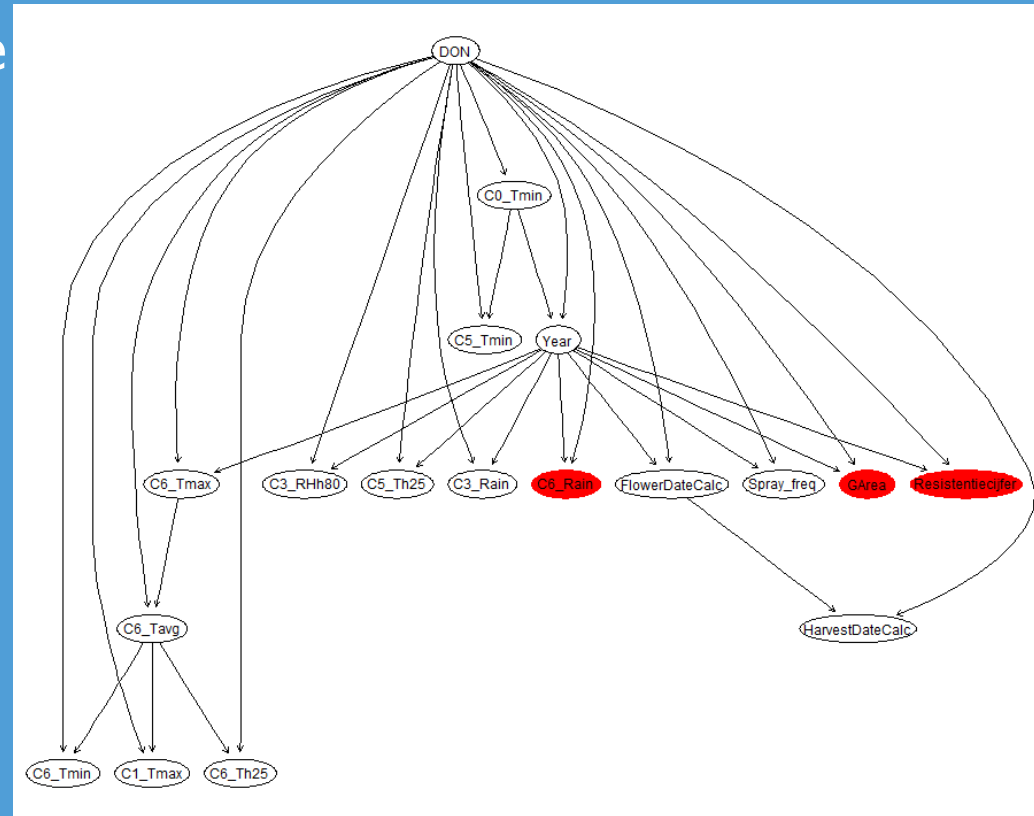| DON		
<500ppb	500-1250 ppb	>1250ppb
0.61	0.005	0.38

3.2 DON-Wheat-NL models: Bayesian network (BN)

- ... and add some evidence

GArea = 'red'

ResisL = 7.5

C6_Rain = (50.6, 67.5]

DON		
<500ppb	500-1250 ppb	>1250ppb
0.24	0.18	0.58

3.3 Aflatoxin-maize-EU model

- Mechanistic model, fungal ecology
- To be validated with EU data

3.3 Aflatoxin-maize-EU model

4. Highlights

- Step forwards in forecasting mycotoxins
  - DON in wheat in NL
  - Aflatoxins in maize in EU
  - For barley in development
- Models will be combined in Decision Support system for various actors within the chain
- Forecasting mycotoxins useful in combination with:
  - Monitoring,
  - Chain analysis
  - Good knowledge and management strategies from farmers and other actors in the chain

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Thank you

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