# The qualitative modelling IPSIM platform to predict injury profiles

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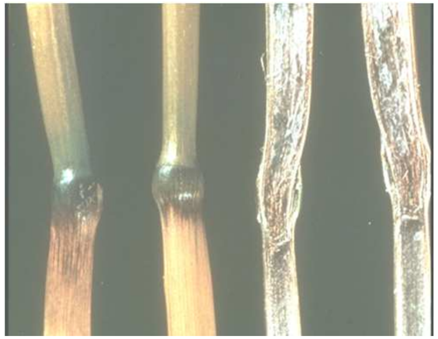
endure
diversifying crop protection

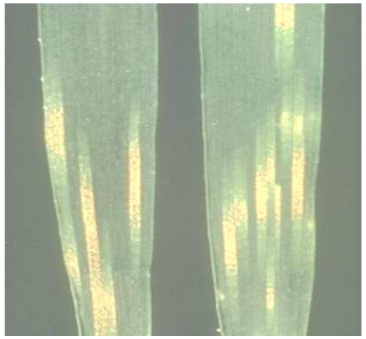
**Summer School 2016**

**The role of IPM in mitigating pest development under climate change–modelling approaches**

# Multiple pests









**IPSIM-WHEAT (Injury Profile SIMulator), a hierarchical , aggregative and qualitative model to predict wheat injury profile as a function of cropping practices, soil, climate and field environment.**

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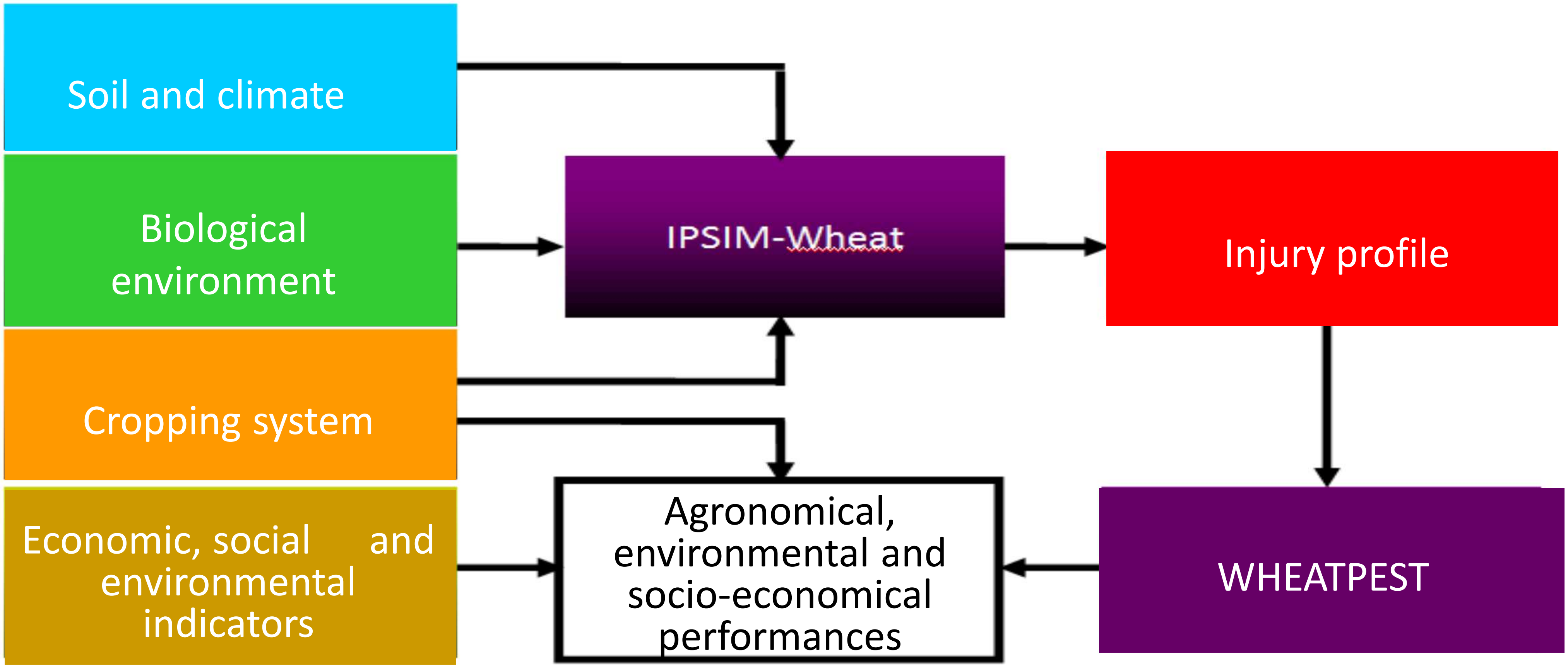
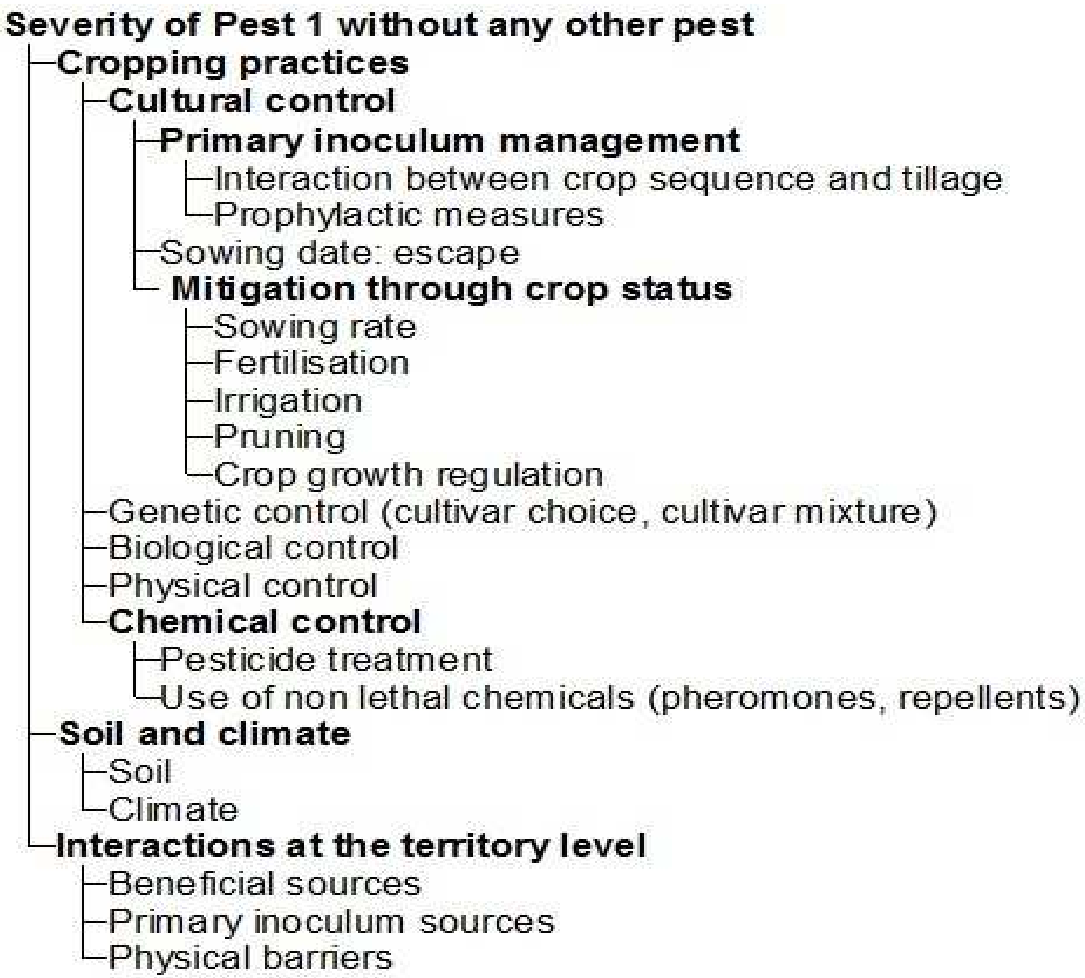
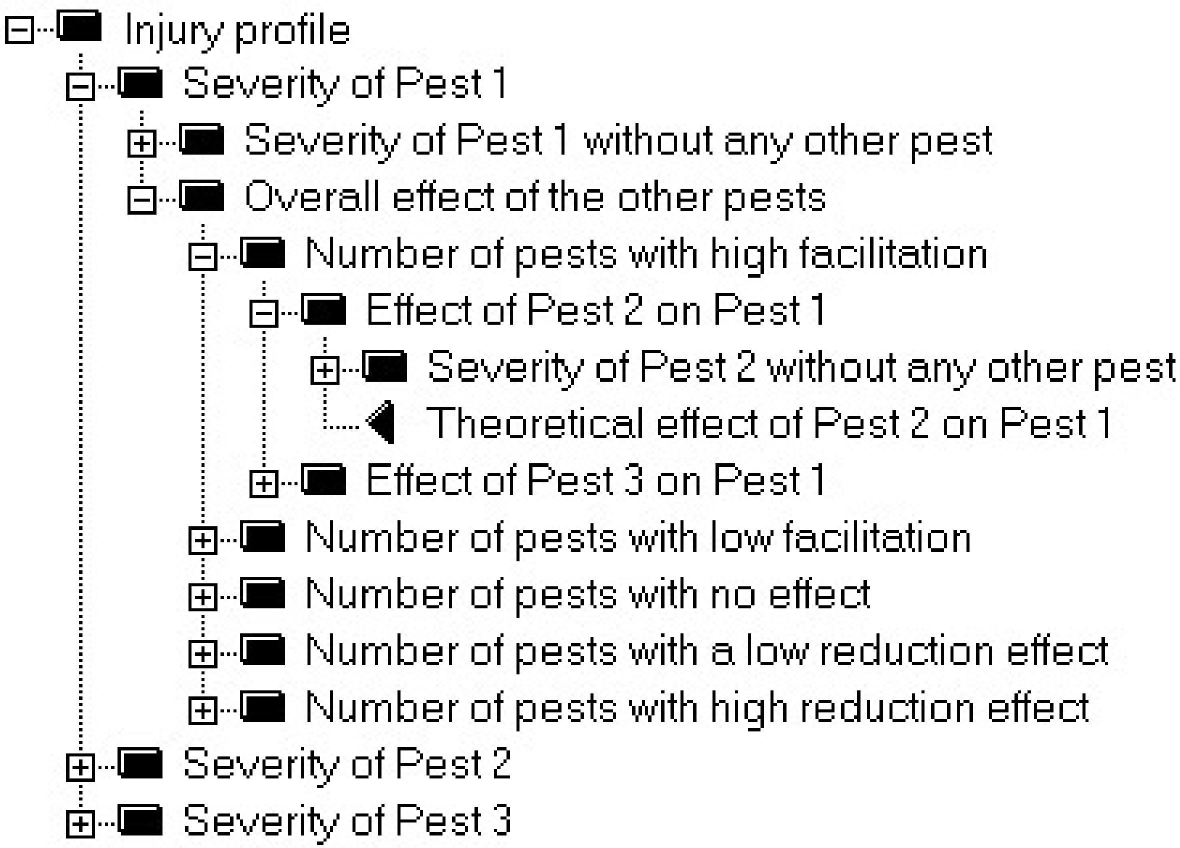

Soil and climate
Biological environment
Cropping system
Economic, social and environmental indicators
IPSIM-Wheat
Injury profile
Agronomical, environmental and socio-economical performances
WHEATPEST




**Hierarchical sub-tree to predict the severity of a single pest without any interaction with other pests (screenshot of the DEXi software).**




**Overall output attributes of IPSIM: description of an IP (screenshot of the DEXi software).** For the sake of simplicity, only 3 pests are represented in this figure. The severity of a given pest is first calculated independently by IPSIM as if no other pest was present. The aggregated severity of a given pest is then calculated by taking into account the combined effects of all other pests. This is done by considering the theoretical effect of one pest on another according to five levels: high facilitation, low facilitation, no effect, low reduction, high reduction.

## EXAMPLE OF IPSIM SUB-MODEL DEVELOPMENT WITH DEXI…

http://www-ai.ijs.si/MarkoBohanec/dexi.html

**Attribute**

- **Final incidence of eyespot**
  - **Effects of cropping practices**
    - **Primary inoculum management: interaction between crop sequence and tillage**
      - Preceding crop
      - Pre-preceding crop
      - Tillage after harvest of the previous crop
      - Tillage after harvest of the pre-previous crop
    - Escape: effects of the sowing date
    - **Mitigation through crop status**
      - Cultivar choice
      - Level of N fertilisation
      - Sowing rate
    - Chemical control: use of fungicide
  - **Effects of soil and climate**
    - Soil
    - **Climate**
      - Autumn/winter
      - Spring
  - **Interactions with the territory**
    - Beneficial sources
    - Primary inoculum sources

**Step 1: definition of the structure for the model**

| Attribute | Scale |
|---|---|
| **Final incidence of eyespot** | 100%; 80-100 %; 60-80 %; 40-60 %; 20-40 %; *0-20 %*; *0%* |
| ├ **Effects of cropping practices** | Favourable; Moderately favourable; *Unfavourable* |
| ├ **Primary inoculum management: interaction between crop sequence and tillage** | Favourable; Moderately favourable; *Unfavourable* |
| ├ Preceding crop | Host; Risk amplifying non-host; *Non host* |
| ├ Pre-preceding crop | Host; Risk amplifying non-host; *Non host* |
| ├ Tillage after harvest of the previous crop | Non-inversion tillage; Inversion tillage |
| └ Tillage after harvest of the pre-previous crop | Non-inversion tillage; Inversion tillage |
| ├ Escape: effects of the sowing date | Early sowing; Normal sowing date; *Late sowing* |
| ├ **Mitigation through crop status** | Favourable; Moderately favourable; *Unfavourable* |
| ├ Cultivar choice | Very susceptible to susceptible; Moderetely susceptible; *Quite to very resistant* |
| ├ Level of N fertilisation | Excess level; *Balanced level* |
| └ Sowing rate | High; Normal; *Low* |
| └ Chemical control: use of fungicide | None; *One* |
| ├ **Effects of soil and climate** | Very favourable; Favourable; *Unfavourable* |
| ├ Soil | Favourable; *Neutral* |
| └ **Climate** | Very favourable; Favourable; *Unfavourable* |
| ├ Autumn/winter | Very favourable; Favourable; *Unfavourable* |
| └ Spring | Very favourable; Favourable; *Unfavourable* |
| └ **Interactions with the territory** | Favourable; *Neutral* |
| ├ Beneficial sources | Normal; *Important* |
| └ Primary inoculum sources | Important; *Normal* |

## Step 2: definition of the attribute scales

| Factor | Direction of the effect | Intensity of the effect | Impact on eyespot development | References |
|---|---|---|---|---|
| Tillage | +/- | ++ | Contradictory results. For some authors, reduced soil tillage decreased eyespot infection. For others, eyespot was often more severe after ploughing than after non-inversion tillage. | [1-14, 29, 40] |
| Preceding and pre-preceding crop | + | ++ | Preceding and pre-preceding host crops are known to favour eyespot. However, the interaction between tillage and the crop sequence has to be taken into account. | [4, 9, 14-21, 29, 40, 59] |
| Sowing date | + | ++ | Eyespot has always been reported to be more severe in early sown crops. | [4, 14, 15, 17, 20-21, 40] |
| N fertilisation rate | + | + | High nitrogen availability generally favoured the disease. However these results were questioned. | [15, 20] |
| Sowing rate | + | + | Prevalence was increased by high plant density and/or low shoot number per plant. | [15, 17, 20] |
| Cultivar choice | + | +++ | The use of varieties with resistance could obviate the need for fungicide. | [4, 21, 22] |
| Cultivar mixture | 0 | 0 | No significant difference was found between the disease level in mixtures and the mean of disease level of the mixture components in pure stands. | [23-25] |
| Climate | + | ++ | Eyespot strongly depends on climate. Infections require periods of at least 15 h with T° between 4°C and 13°C and HR>80% (from October to April). | [13, 20, 26-29] |

## Step 3: definition of the aggregating tables using international literature and expert knowledge

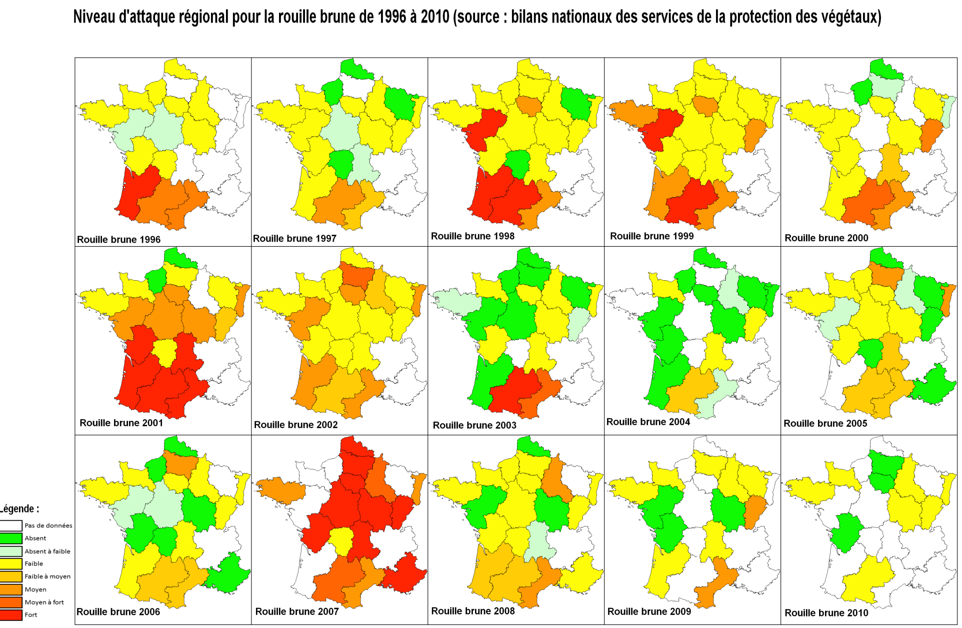
| | Cultivar choice | Level of N fertilisation | Sowing rate | Mitigation through crop status |
|---|---|---|---|---|
| 1 | Very susceptible to susceptible | Excess level | High | Favourable |
| 2 | Very susceptible to susceptible | Excess level | Normal | Favourable |
| 3 | Very susceptible to susceptible | Excess level | Low | Favourable |
| 4 | Very susceptible to susceptible | Balanced level | High | Favourable |
| 5 | Very susceptible to susceptible | Balanced level | Normal | Favourable |
| 6 | Very susceptible to susceptible | Balanced level | Low | Favourable |
| 7 | Moderetely susceptible | Excess level | High | Moderately favourable |
| 8 | Moderetely susceptible | Excess level | Normal | Moderately favourable |
| 9 | Moderetely susceptible | Excess level | Low | Moderately favourable |
| 10 | Moderetely susceptible | Balanced level | High | Moderately favourable |
| 11 | Moderetely susceptible | Balanced level | Normal | Moderately favourable |
| 12 | Moderetely susceptible | Balanced level | Low | Moderately favourable |
| 13 | Quite to very resistant | Excess level | High | Unfavourable |
| 14 | Quite to very resistant | Excess level | Normal | Unfavourable |
| 15 | Quite to very resistant | Excess level | Low | Unfavourable |
| 16 | Quite to very resistant | Balanced level | High | Unfavourable |
| 17 | Quite to very resistant | Balanced level | Normal | Unfavourable |
| 18 | Quite to very resistant | Balanced level | Low | Unfavourable |

**Step 3: definition of the aggregating tables using international literature and expert knowledge**

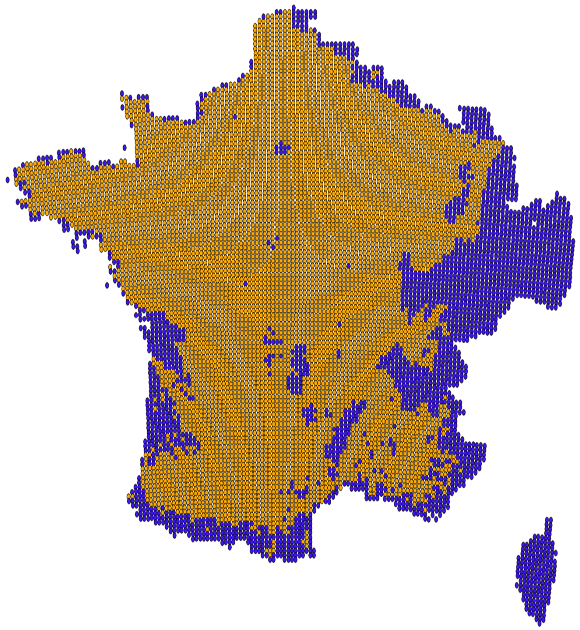
# Simulation examples

| Option | Organic system | High input system |
|---|---|---|
| . Final incidence of eyespot | 20-40 % | 60-80 % |
| . . Effects of cropping practices | **Unfavourable** | **Moderately favourable** |
| . . . Primary inoculum management: interaction between crop sequence and tillage | **Unfavourable** | **Favourable** |
| . . . . Preceding crop | Non host | Host |
| . . . . Pre-preceding crop | Non host | Host |
| . . . . Tillage after harvest of the previous crop | Inversion tillage | Non-inversion tillage |
| . . . . Tillage after harvest of the pre-previous crop | Inversion tillage | Non-inversion tillage |
| . . . Escape: effects of the sowing date | Late sowing | Early sowing |
| . . . Mitigation through crop status | **Unfavourable** | **Favourable** |
| . . . . Cultivar choice | Quite to very resistant | Very susceptible to susceptible |
| . . . . Level of N fertilisation | Balanced level | Balanced level |
| . . . . Sowing rate | High | Normal |
| . . . Chemical control: use of fungicide | None | One |
| . . Effects of soil and climate | **Very favourable** | **Very favourable** |
| . . . Soil | Favourable | Favourable |
| . . . Climate | **Very favourable** | **Very favourable** |
| . . . . Autumn/winter | Very favourable | Very favourable |
| . . . . Spring | Very favourable | Very favourable |
| . . Interactions with the territory | **Neutral** | **Neutral** |
| . . . Beneficial sources | Normal | Normal |
| . . . Primary inoculum sources | Normal | Normal |

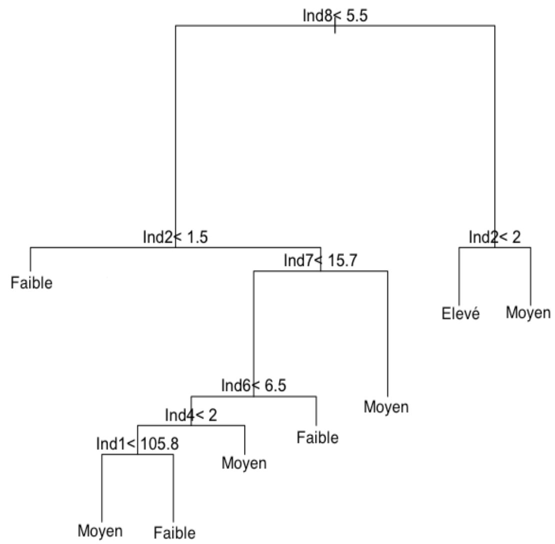
# Use of PESTOBSERVER to design a simple model to represent the impact of the yearly weather on brown rust risk on wheat




Potential severity o f brown rust on wheat (DGAL, 1996-2010)



Use of the climatic SAFRAN database (MétéoFrance)




Development of simple weather-based models (CART procedure in this example)

# Assessment of the quality of prediction of IPSIM models

$$Accuracy = \frac{1}{n}\sum_{i=1}^{i=n_c} n_{ii}$$

Weighted Cohen's κ (Spitzer et al, 1967, derived from Cohen, 1960) with:

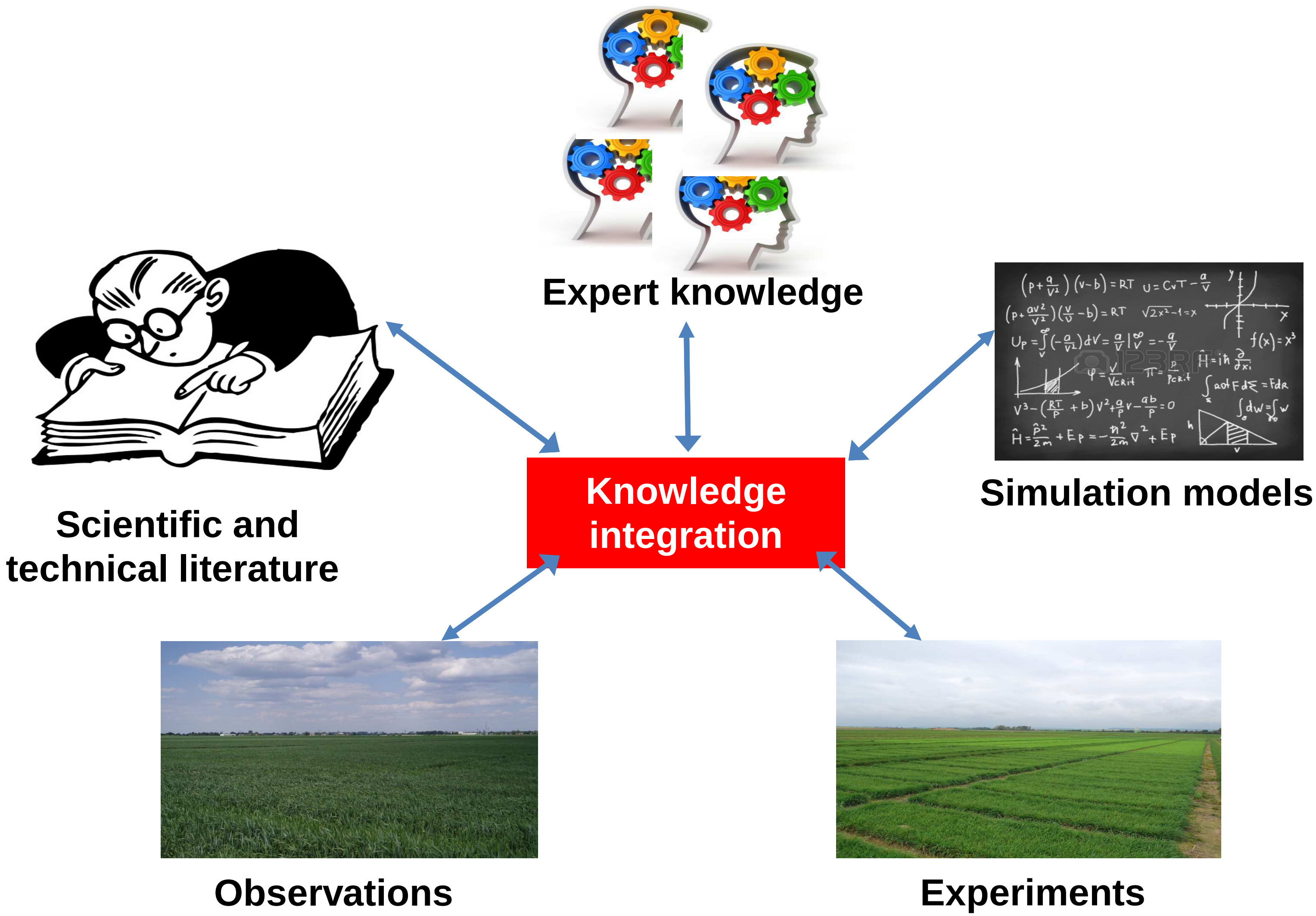
$$\kappa_w = \frac{\sum_i \sum_j w_{ij}\pi_{ij} - \sum_i \sum_j w_{ij}\pi_{i+}\pi_{+j}}{1 - \sum_i \sum_j w_{ij}\pi_{i+}\pi_{+j}},$$

$$\left\{w_{ij} = 1 - \frac{|i-j|}{c-1}\right\} \quad \text{and} \quad \left\{w_{ij} = 1 - \frac{(i-j)^2}{(c-1)^2}\right\}$$

Fleiss et Cohen (1973) showed that this criterion could be interpreted as the proportion of variability explained by the model (quadratic weights).

| Observed \ Simulated | 0–5% | 5–10% | 10–20% | 20–50% | 50–100% | Total |
|---|---|---|---|---|---|---|
| 0–5% | 1422<br>*81.7* | 37<br>*2.13* | 15<br>*0.862* | 6<br>*0.345* | 0<br>*0* | 1480<br>*85.1* |
| 5–10% | 65<br>*3.74* | 16<br>*0.920* | 5<br>*0.287* | 0<br>*0* | 1<br>*0.0575* | 87<br>*5.00* |
| 10–20% | 29<br>*1.67* | 15<br>*0.862* | 13<br>*0.747* | 2<br>*0.115* | 0<br>*0* | 59<br>*3.39* |
| 20–50% | 18<br>*1.03* | 11<br>*0.632* | 15<br>*0.862* | 16<br>*0.920* | 3<br>*0.172* | 63<br>*3.62* |
| 50–100% | 4<br>*0.230* | 5<br>*0.287* | 9<br>*0.517* | 30<br>*1.72* | 3<br>*0.172* | 51<br>*2.93* |
| Total | 1538<br>*88.4* | 84<br>*4.83* | 57<br>*3.28* | 54<br>*3.10* | 7<br>*0.402* | 1740<br>*100.* |

Quadratic weights: 0, 0.4375, 0.7500, 0.9375, 1.000


Expert knowledge
Scientific and technical literature
Knowledge integration
Simulation models
Observations
Experiments

- Lack of precision
- Subjectivity when defining aggregating tables
- No explicit representation of underlying mechanisms
- Static models
- Threshold effects when translating quantitative input variables into qualitative variables

- Lack of precision
- Combination of expert knowledge, existing models and data
- Fair predictive quality considering that no calibration was performed
- Transparent
- Very easy to develop and to present
- Great for communicating and teaching
- Better vertical and horizontal integrations in IPM