

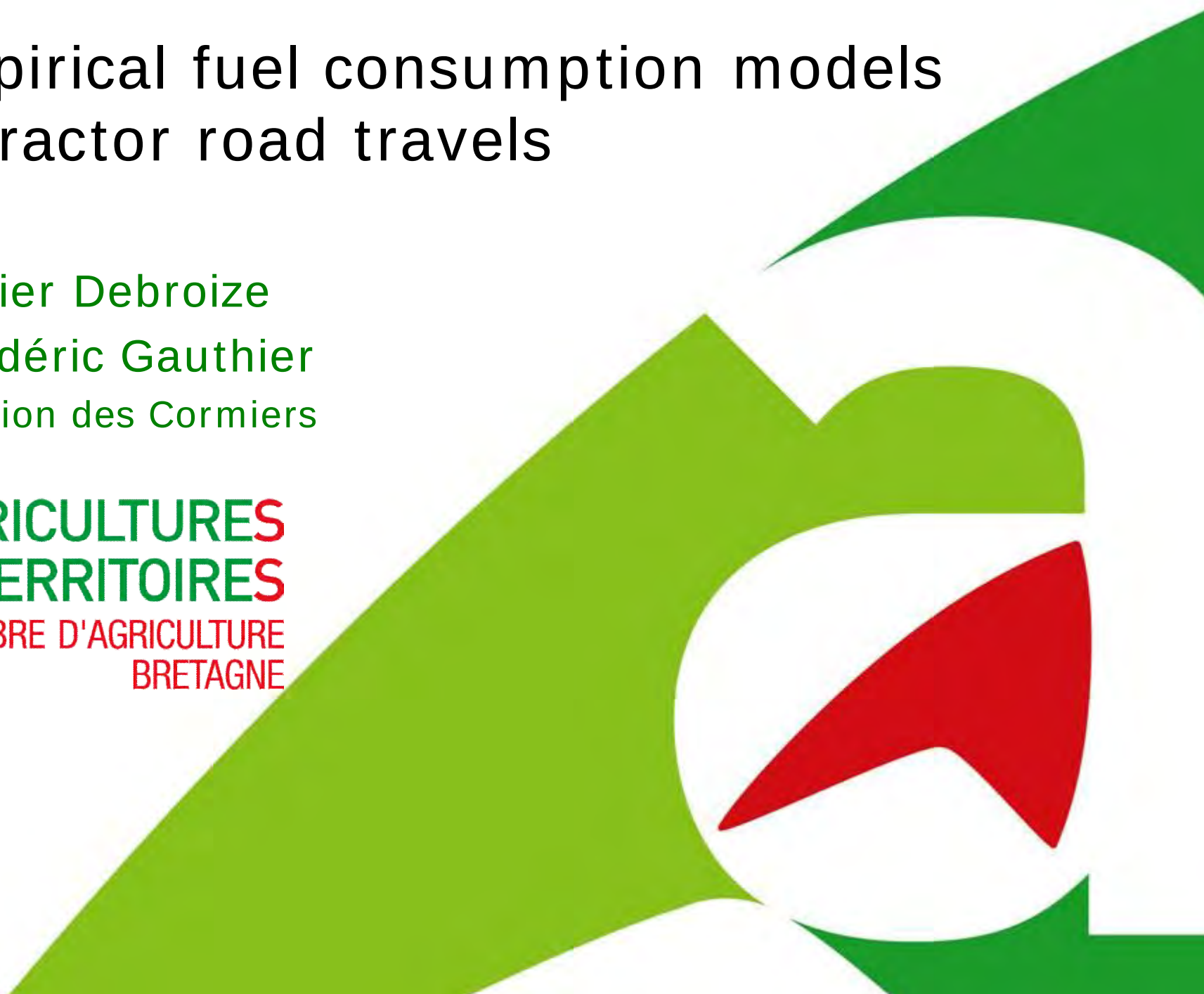
Empirical fuel consumption models of tractor road travels

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Plan of the presentation



- From Ecofuel to AgriSim : the origins of this work
- Steps to empirical fuel consumption models

Ecofuel project



- Context

- fuel for tractors represents more than half of direct energy used by agriculture
- power of new tractors are increasing (+29 % between 2006 and 2016)
- operating costs are increasing
- variability between farms are very important
- technical messages are less attractive than the beauty of a tractor !

Ecofuel project



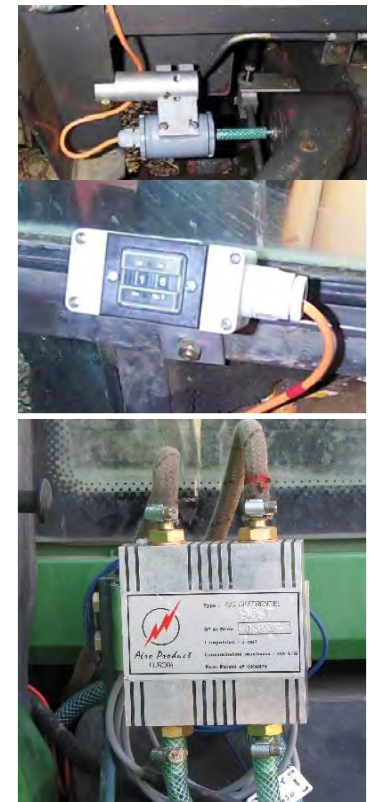
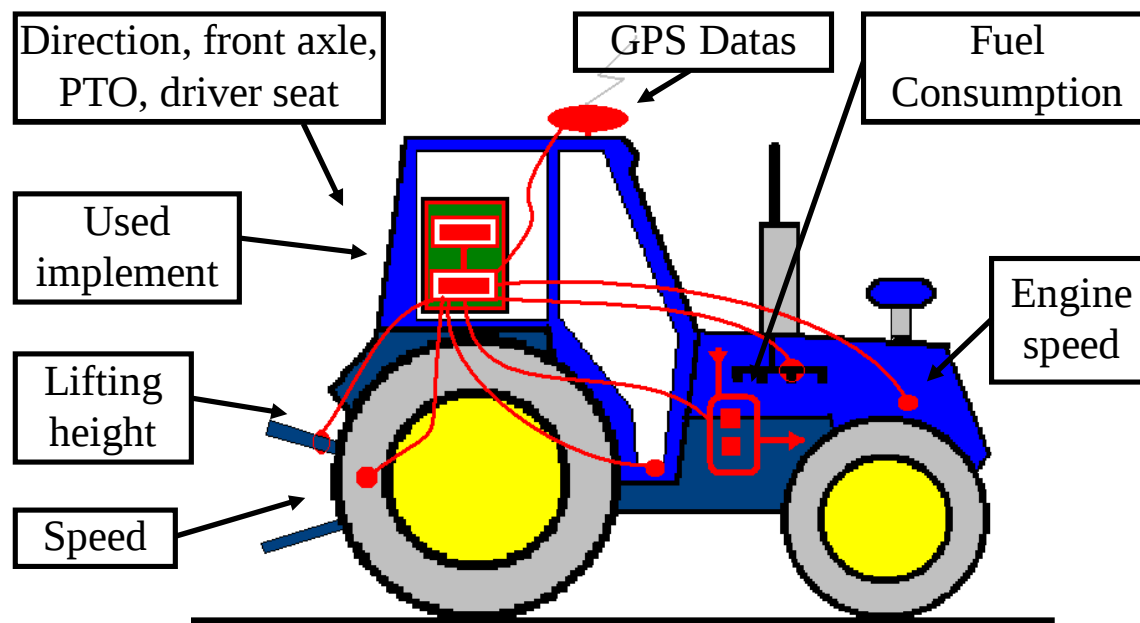
- **Project objectives**

- quantify the consumption of fuel and power of farm operations including Cuma or contractor
- quantify working time
- offer a precise view to be able to analyze the operations

Ecofuel project



- Record data on all the tractors of farms every second during at least one year



Ecofuel Project



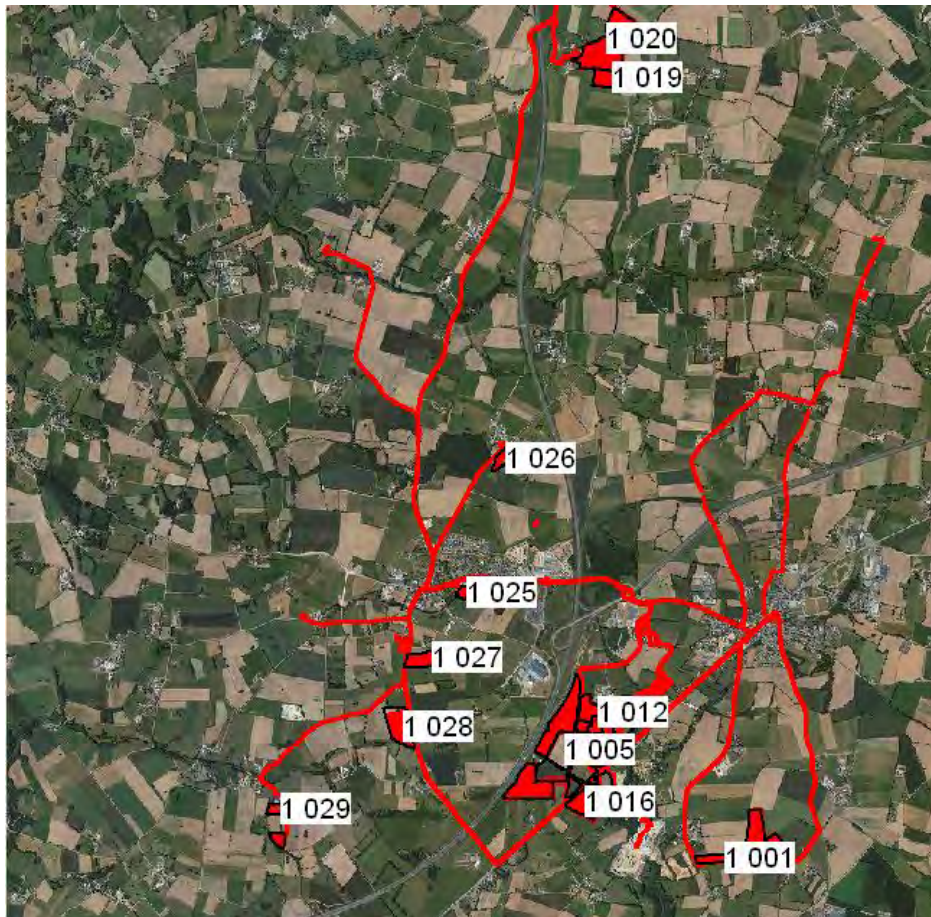
- 25 tractors were recorded
 - Built from 1972 to 2008
 - With a power within 44 to 209 kW
 - With more than 500 implements
 - In more than 3400 plots
 - During more than 17,000 hours
 - Collecting more than 64 billions lines of data



Ecofuel project



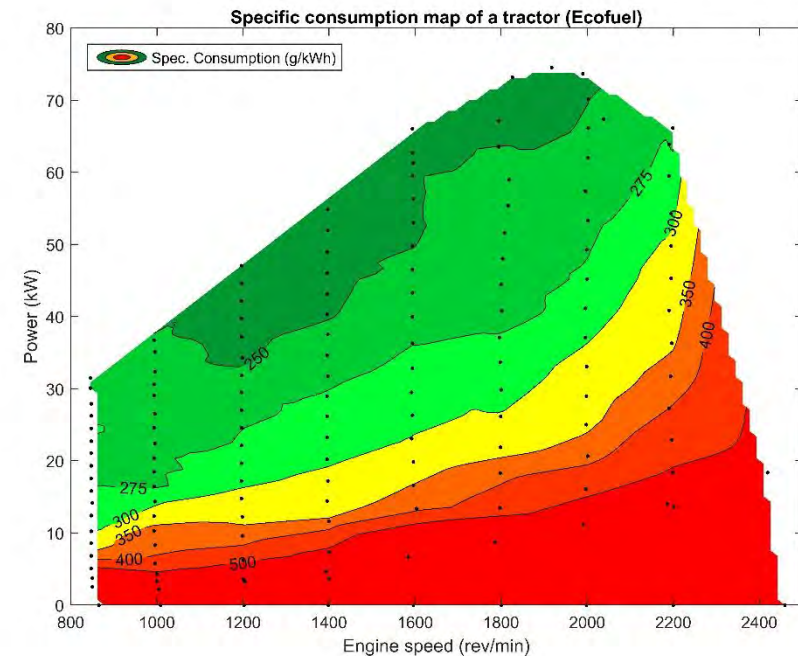
- Spatial procedures to link data with plots



Ecofuel project



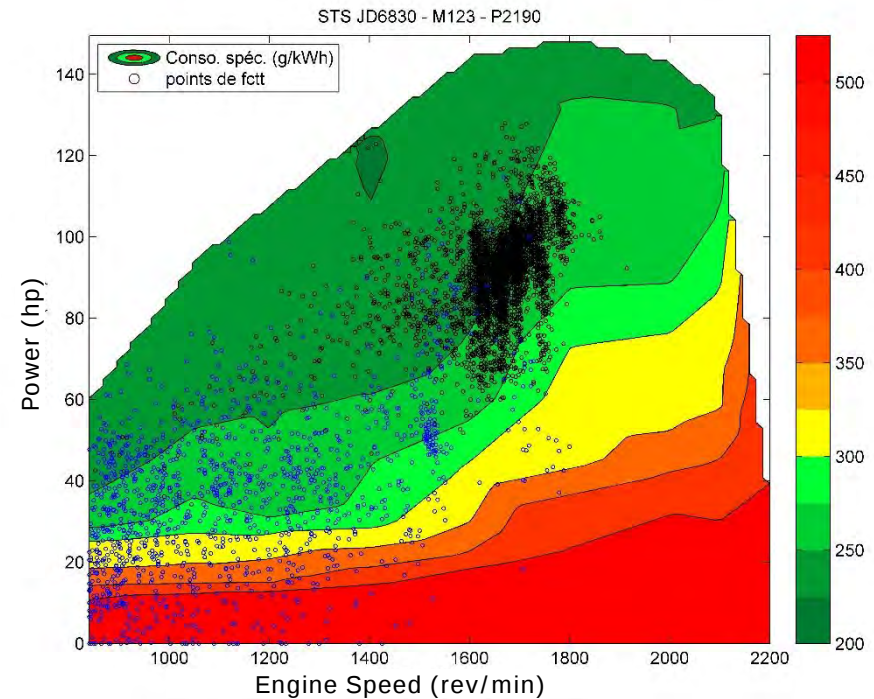
- Power measurements to know used power
 - Approximately 100 measurements points / tractor
 - Possibility to quantify used power



Ecofuel project



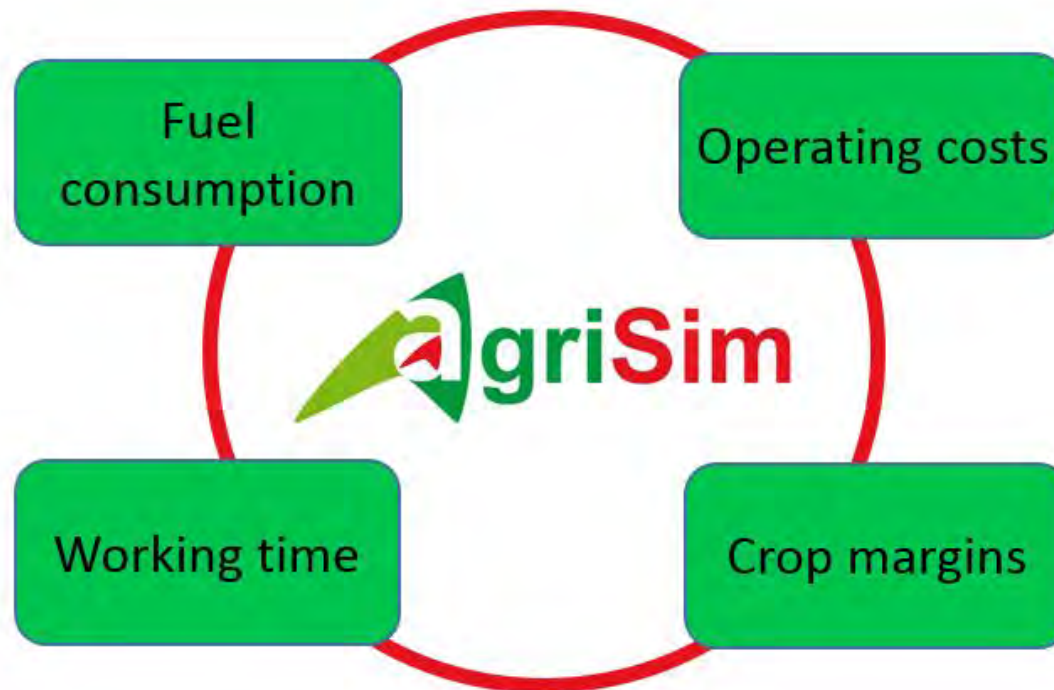
- Seed bed combination (Rot. Harr. + seeder) + Tracteur JD 6830
 - Mission profile



AgriSim project



- Advice tool to analyze strategies of mechanization



AgriSim project



- It simulates all mechanized operations of the farm
- It quantifies differences to allow comparisons

Fuel consumption model of tractor road travels



- The aim of this work is to build an empirical model to provide fuel consumption value
- Ecofuel project provides data to allow models validation
- Two sets of data with estimated weight
 - Displacements data : no load implements (plow, cultivator, mower, round baler, ...)
 - Transport data : slurry tanker (weight uncertainty is not so high).

Statistic method

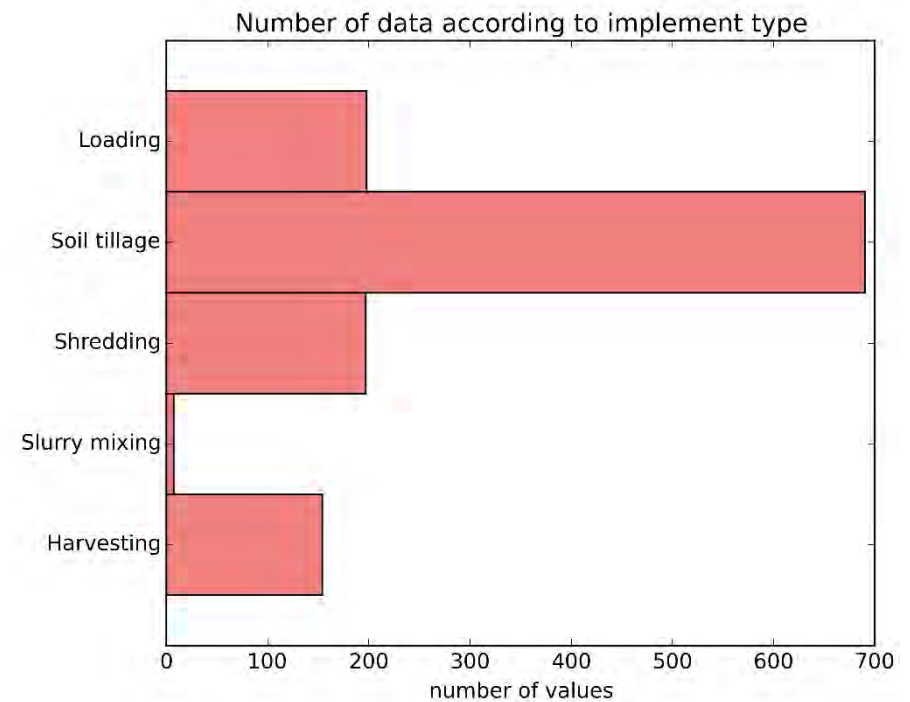
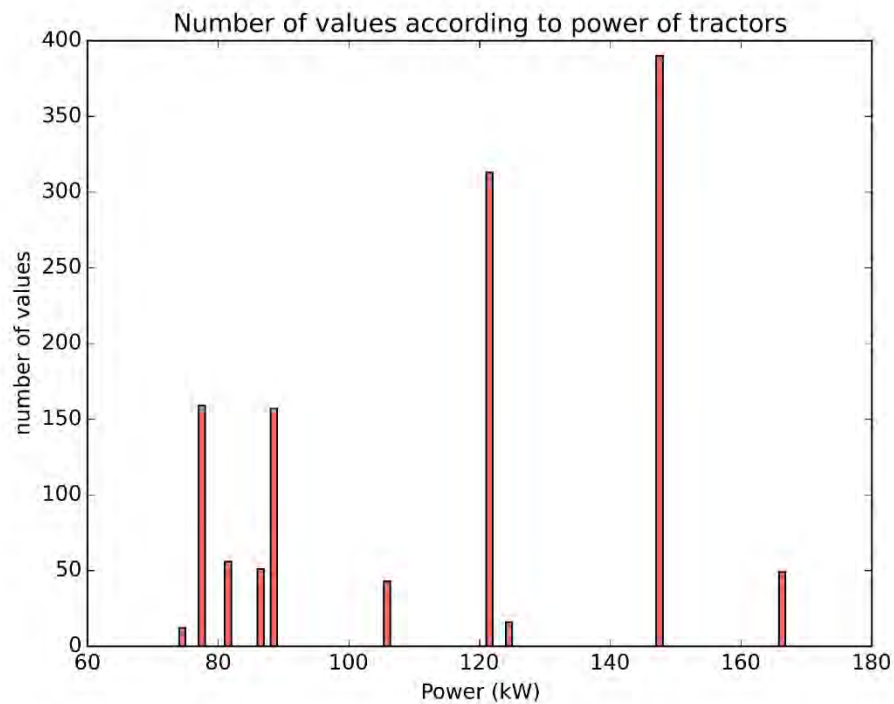


- Linear model with input data
 - distance (km)
 - mass of tractor + implement (t)
 - cumulated positive elevation (m)
 - tractor power (kW)
 - specific consumption ($\text{g.kW}^{-1}.\text{h}^{-1}$)
- Data selection with Cook's distance
- K-fold Cross validation method (5 subsamples)
- Root Mean Square Error calculation
- Residuals vs predicted values presentation

Displacement data



- 1274 road travels
 - 10 tractors with 70 implements (from 9 to 14 t)
 - From 0.5 to 70 km

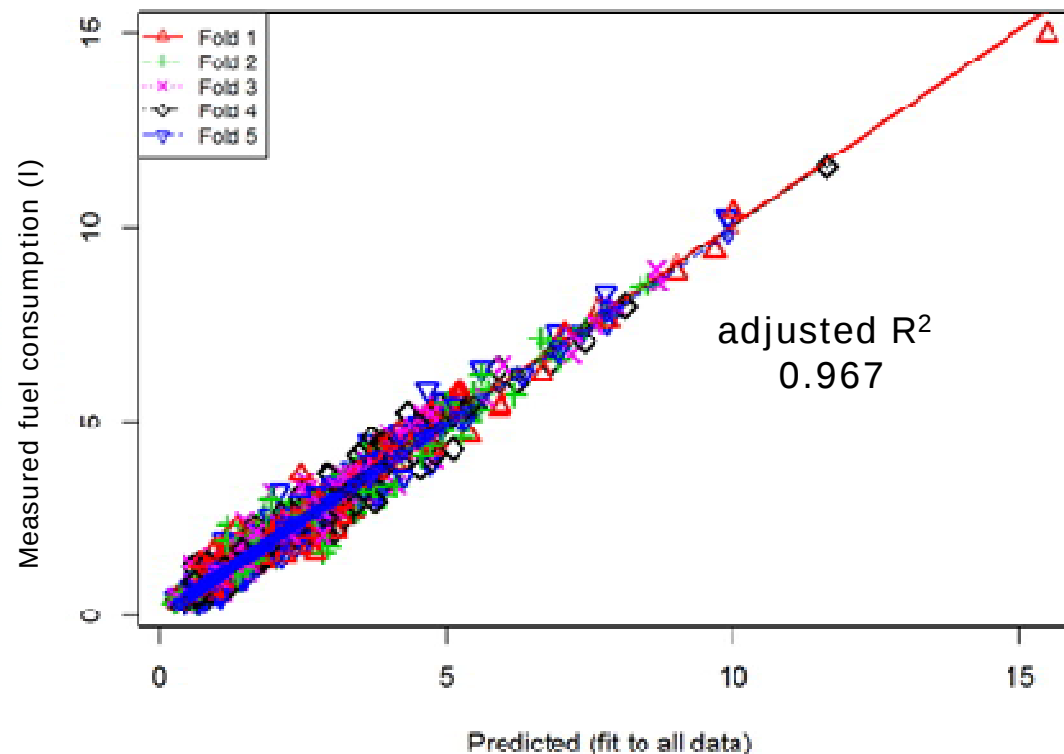


Displacement model



- Model values

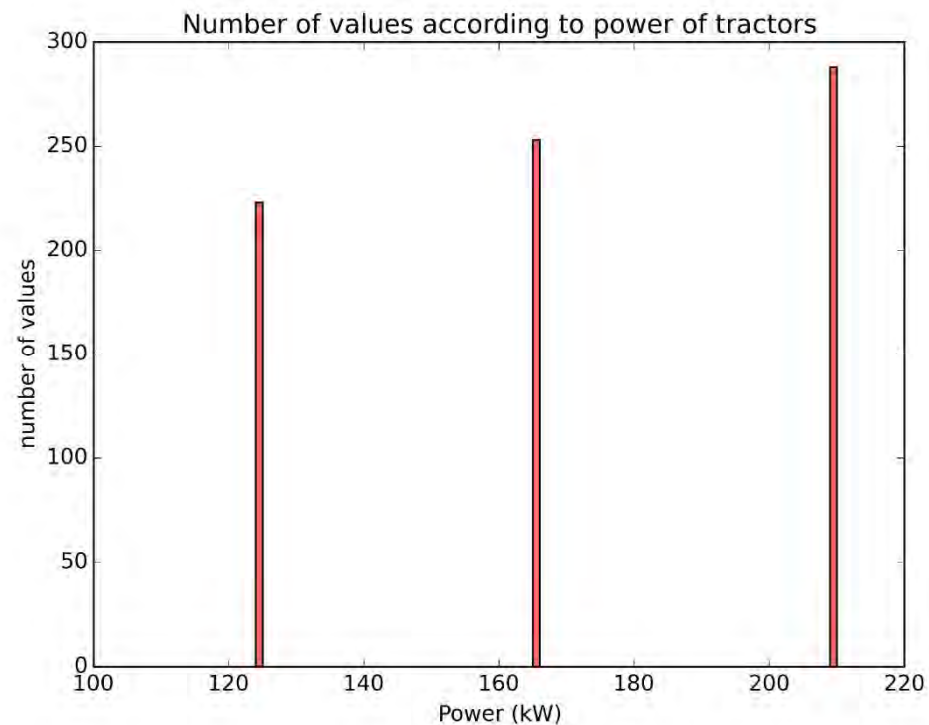
$$\begin{aligned} \text{Cons.} = & -1.5049 + \text{Dist. (km)} \times 0.242 + \text{Elev. (m)} \times 0.0103 \\ & + \text{SC (g.kW}^{-1}\text{h}^{-1}) \times 0.0033 + \text{Power (kW)} \times 0.0055 \\ & + \text{Dist.} \times \text{Mass} \times 0.0107 \end{aligned}$$



Transport data



- 768 road travels
 - 3 tractors + slurry tanker (from 17 to 38 t)
 - From 0.5 to 30 km

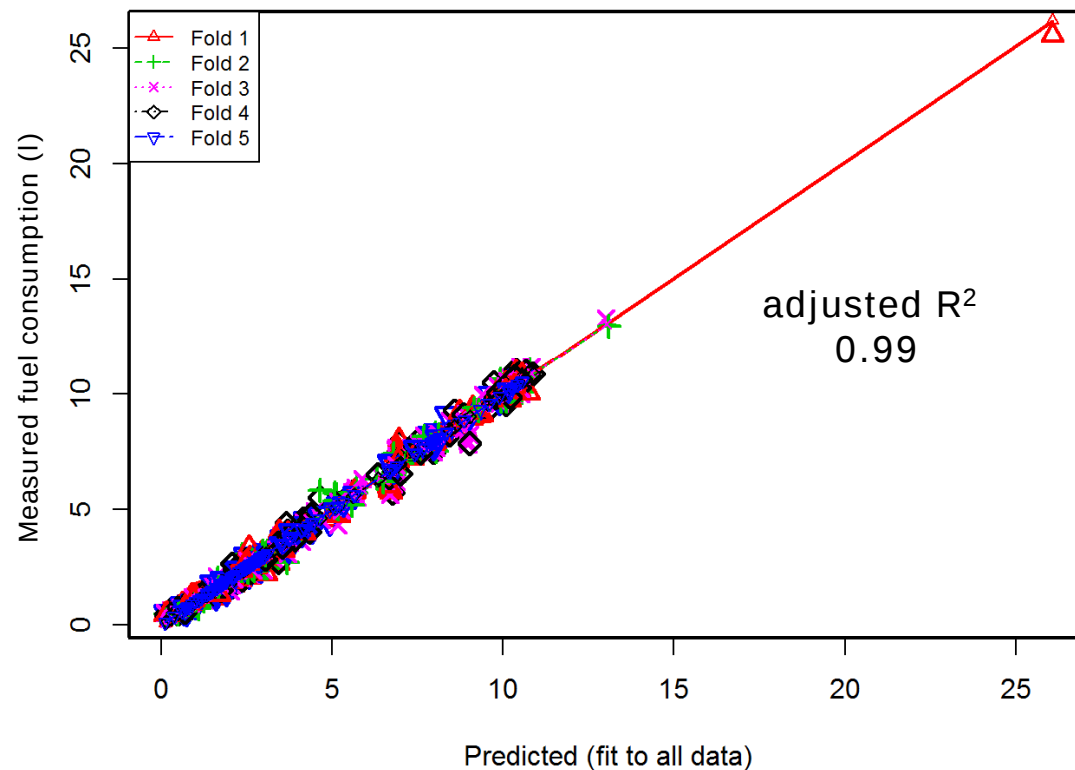


Transport model



- Model values

$$\begin{aligned}\text{Cons.} = & -5.4261 + \text{Mass (t)} \times 0.0183 + \text{Dist. (km)} \times 0.3267 \\ & + \text{Elev. (m)} \times 0.0251 + \text{SC (g.kW}^{-1}\text{h}^{-1}) \times 0.0126 \\ & + \text{Power (kW)} \times 0.0092 + \text{Dist.} \times \text{Mass} \times 0.0095\end{aligned}$$



Residuals values of models



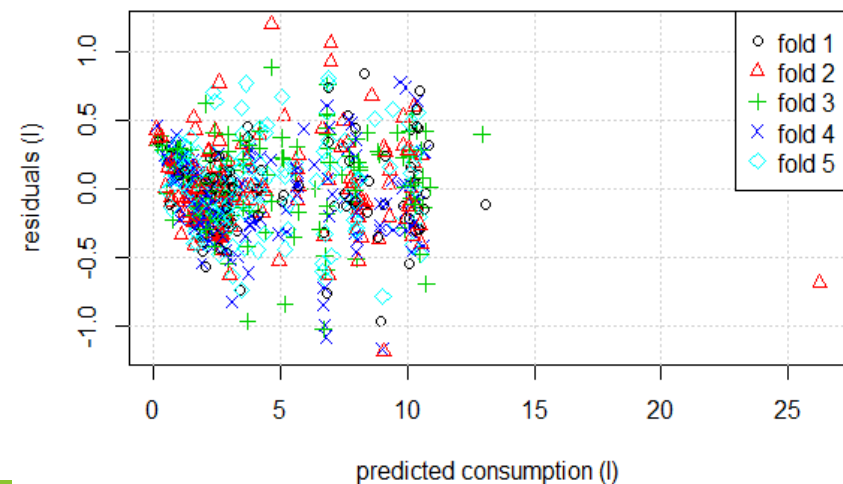
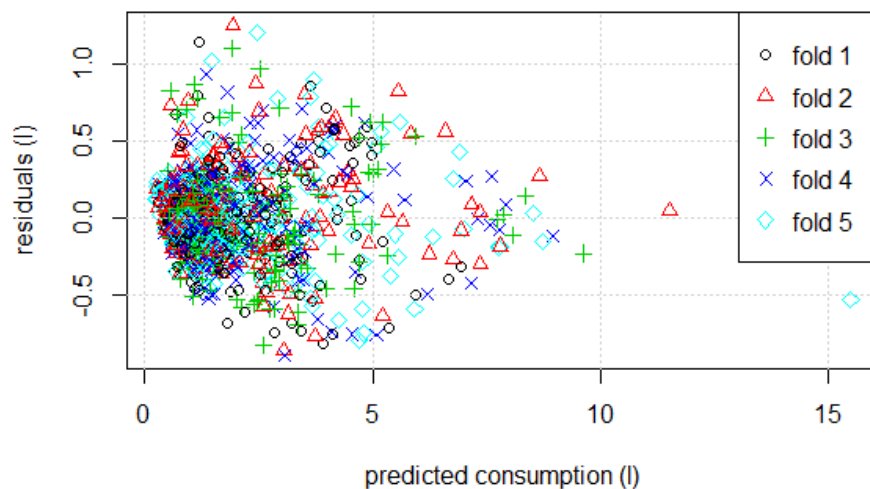
- Root Mean Square Error calculation

$$RMSE = \sqrt{\frac{\sum_{i=1}^N (C_i - \hat{C}_i)^2}{N}}$$

Displacement RMSE = 0.29 l

Transport RMSE = 0.31 l

- Residuals vs predicted values



Conclusion



- Models are simple to use
- RMSE are corrects (0.3 l) and accuracy is increasing for higher consumption values
- Be careful about the validity of the models regarding input data
- An improved knowledge of fuel consumption for AgriSim, our advice tool

What's next

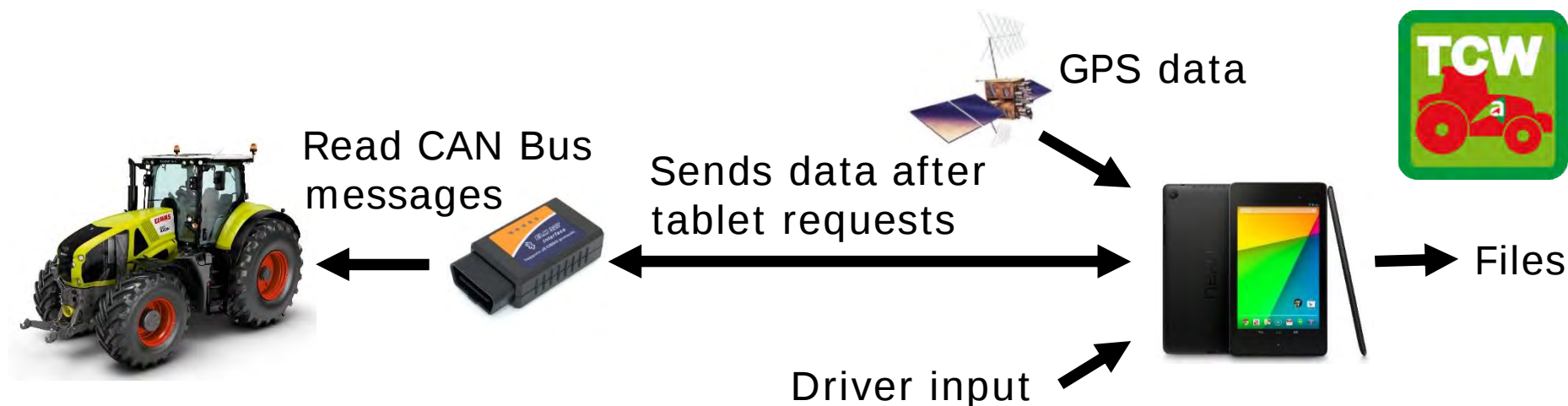


- A new validation stage for these models
 - compare Ecofuel farms consumption for roads travels to models value
- An analog work on in-field works
 - Need for analytic data

What's next



- We defined a new data acquisition system



- Used in a forage wagon project
 - Harvesting organisation
 - Plot distances
 - Operating costs





Thank you for your attention

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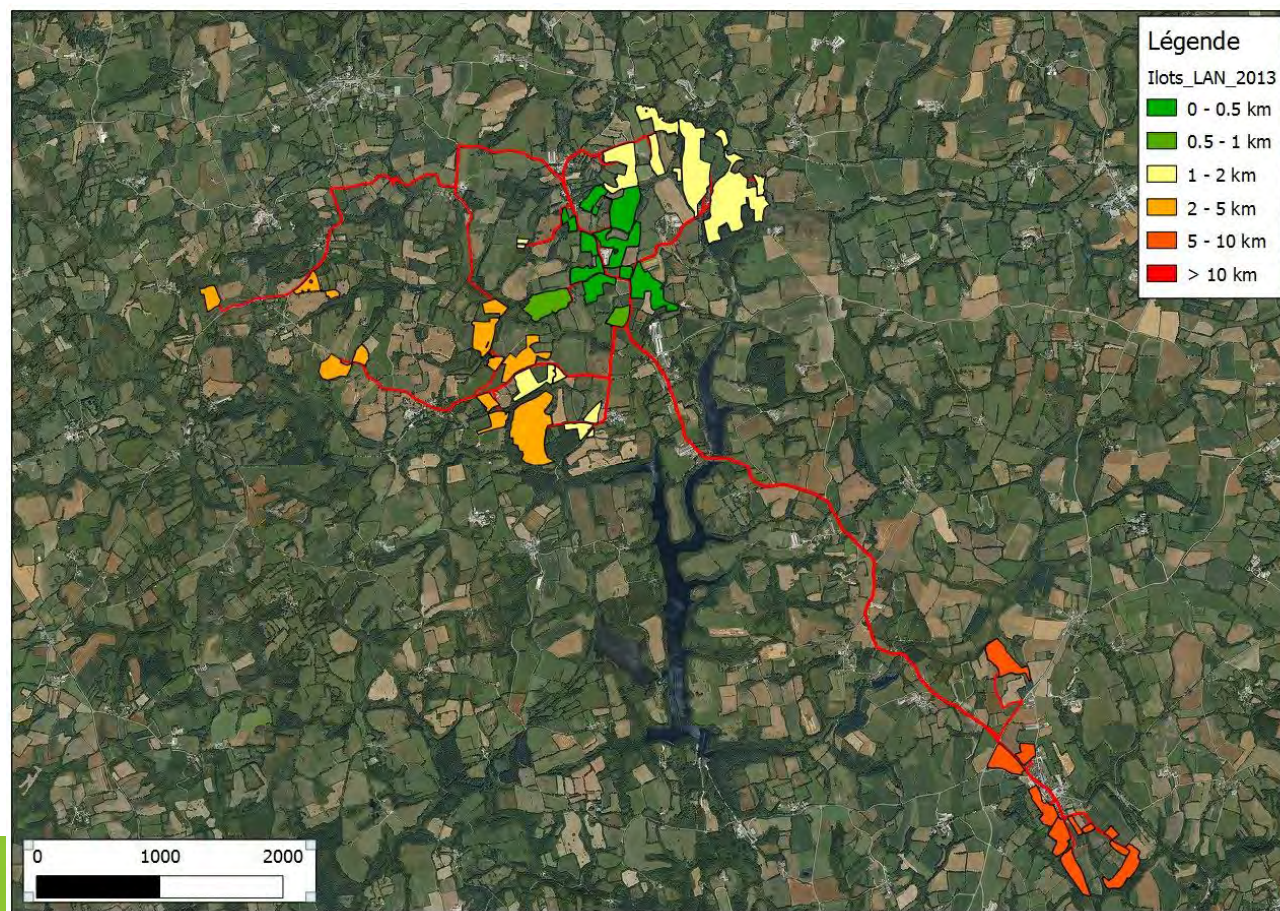
Frederic.gauthier@bretagne.chambagri.fr

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Plots analysis



- Roads that can be used to go to/from plots
- Distance from headquarters and between plots



Ecofuel project



- Browse the levers to potential savings (power, fuel consumption, working time, mechanization costs)

