Modelling of the response of forest soil respiration fluxes to the main climatic variables

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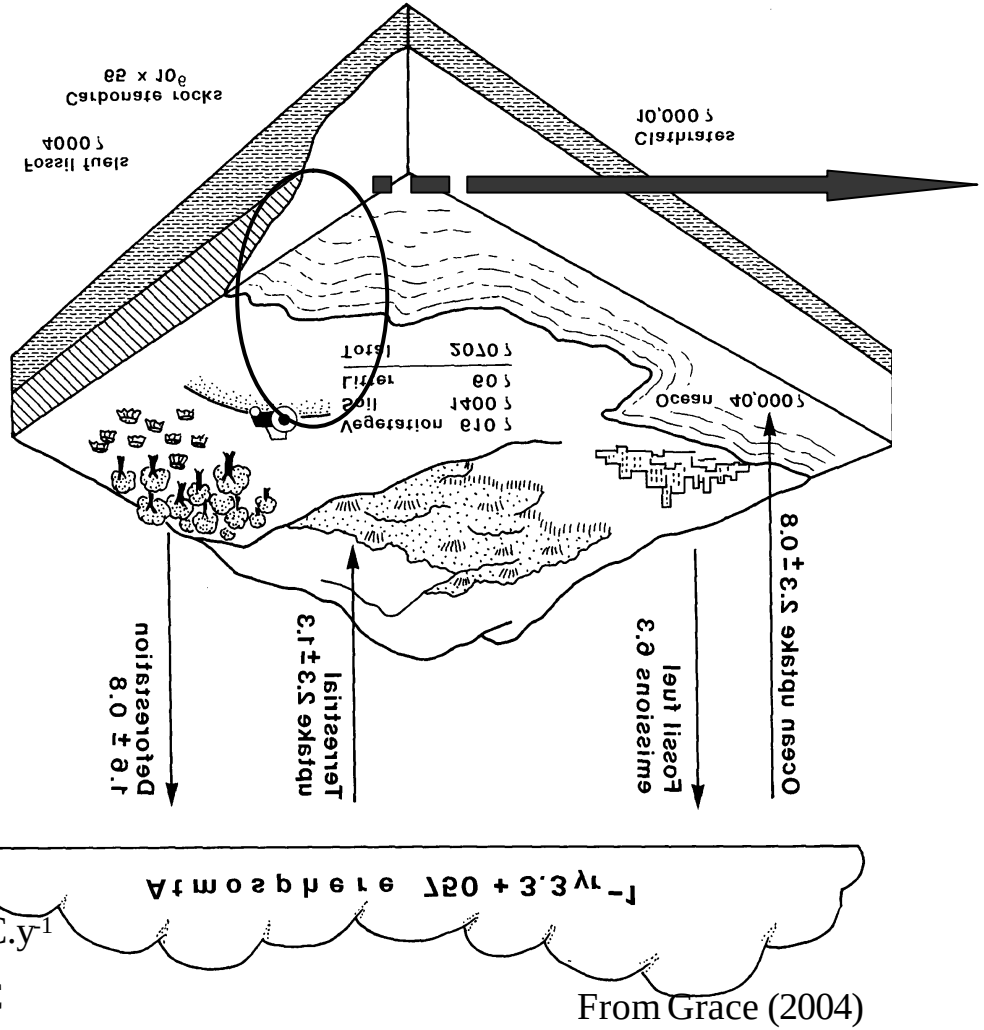
Plan

- Global carbon cycle and soil respiration
- Automatic closed dynamic chamber
- Soil respiration annual and daily variability
- Model
- Main tendencies and future development

Global carbon cycle



Fluxes in GtonC.y^{-1}

Stocks in GtonC

From Grace (2004)

Gross Primary Productivity (GPP ~ -120 GtonC.y-1)

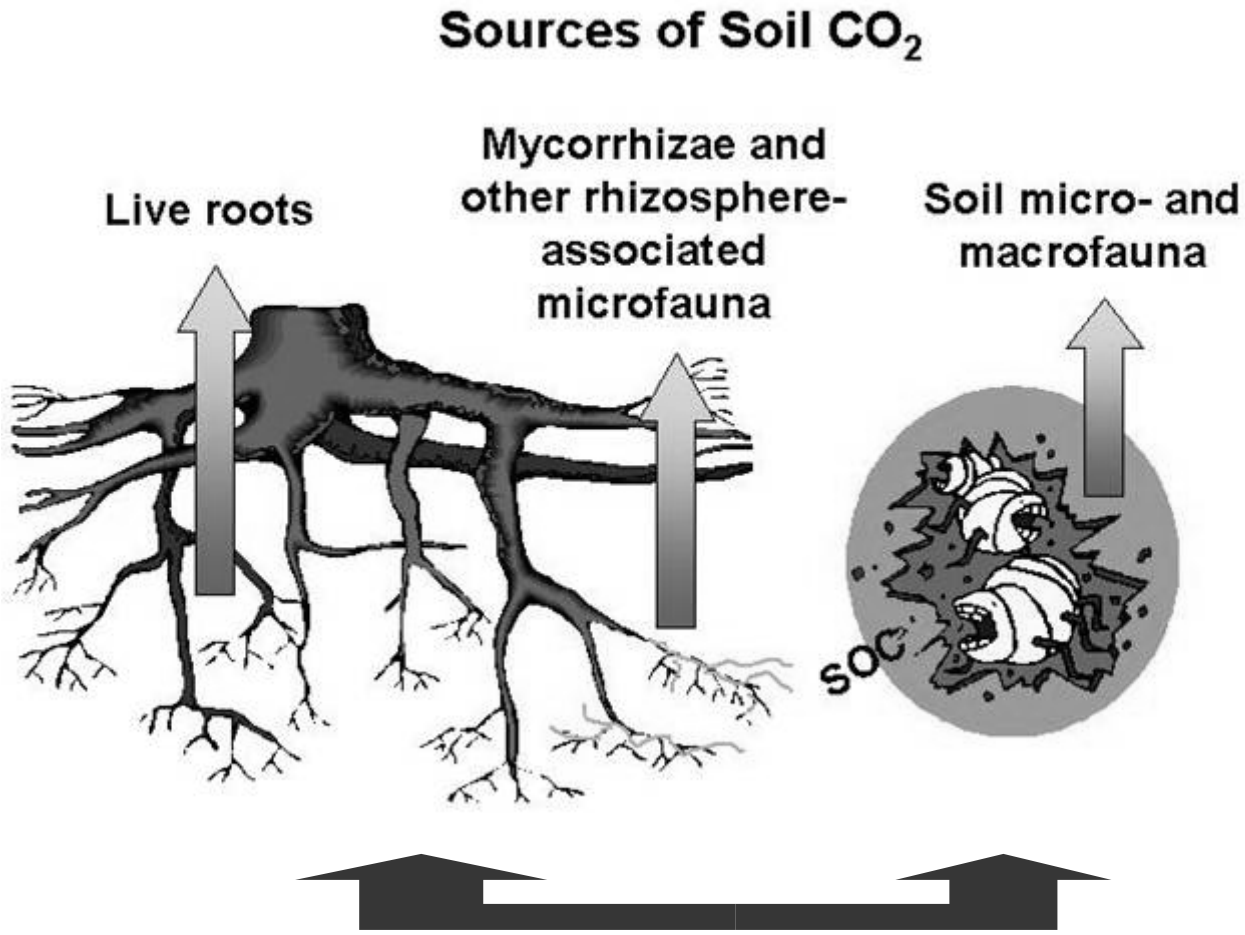
–

Autotrophic respiration (R_a ~ 60 GtonC.y-1)

–

Heterotrophic respiration (R_h ~ 60 GtonC.y-1)

Soil respiration (Sr)



Between 10 % to 90 % (!)

Vielsalm experimental site

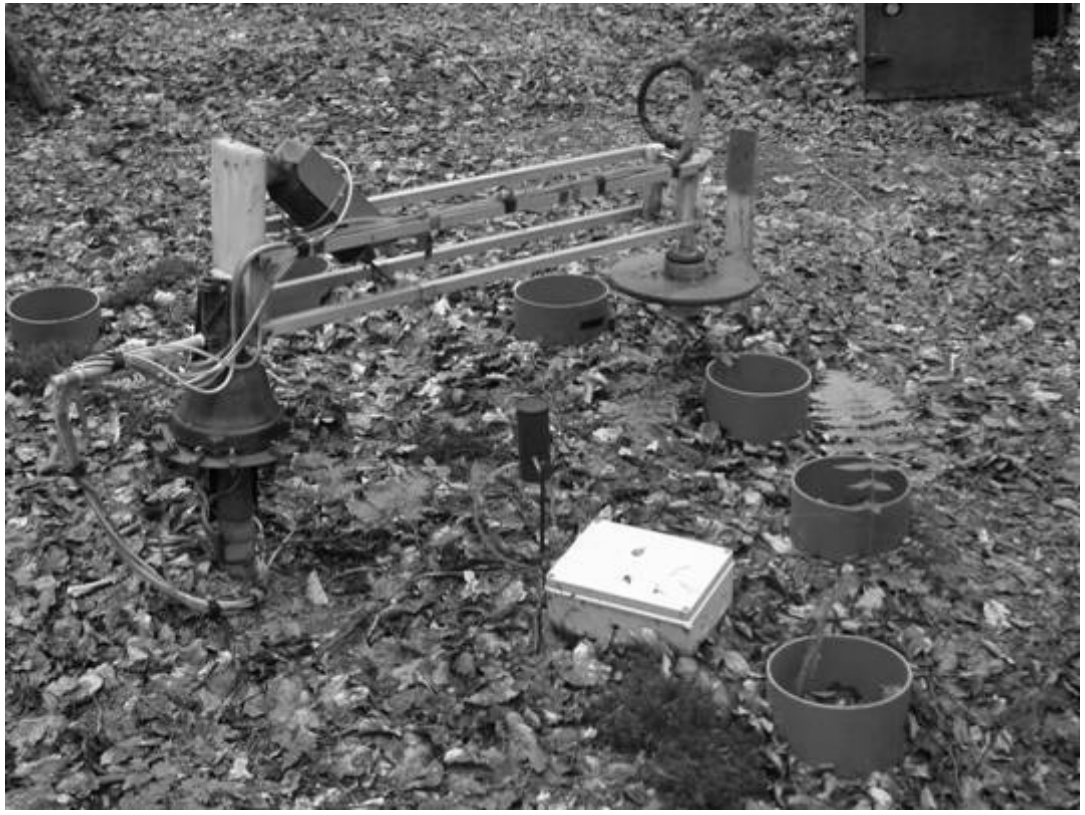
Carboeuroflux tower BE1

2 plots :

Beech (27m, 97 y)

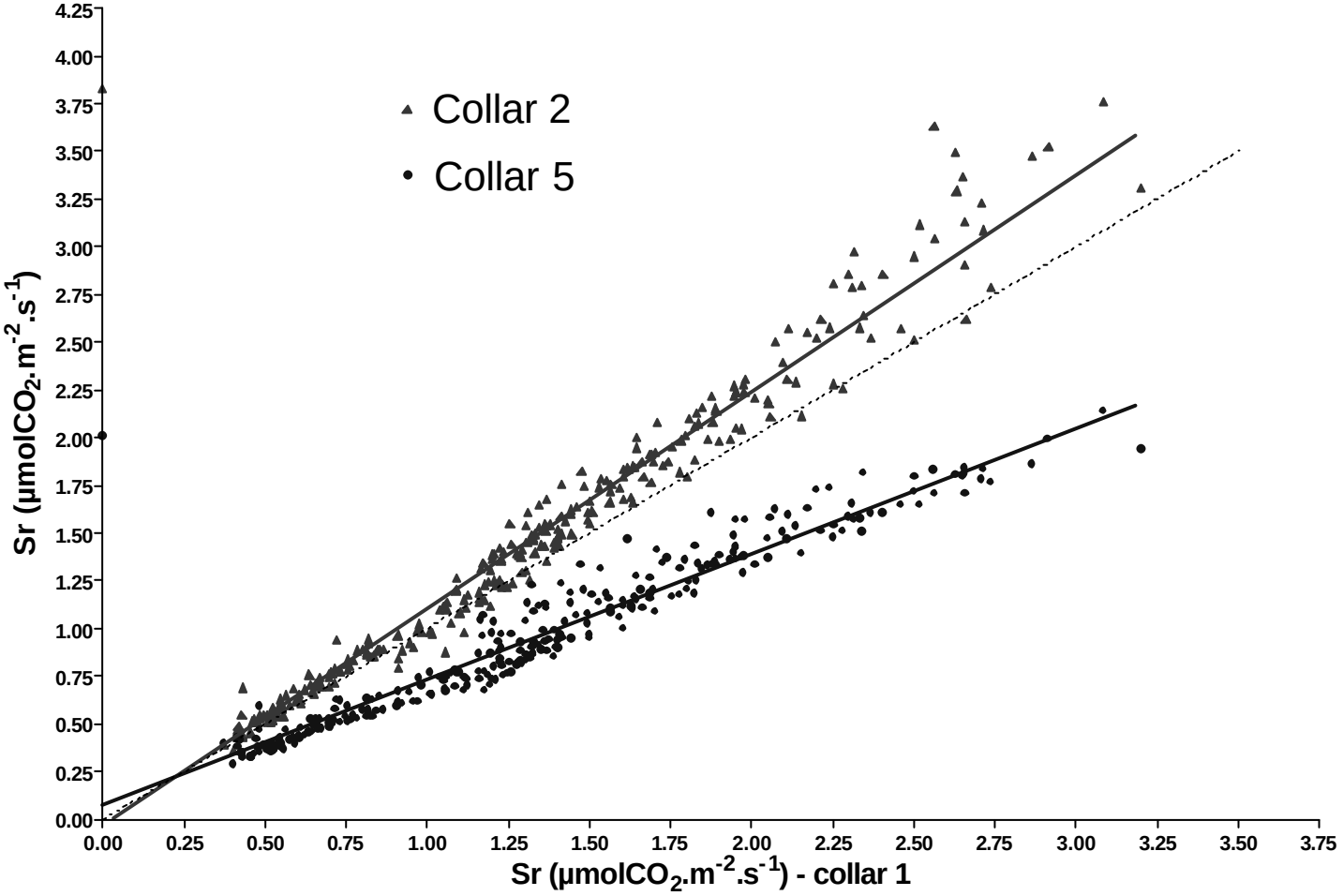
Douglas fir (34m, 73y)

Automatic closed dynamic chamber



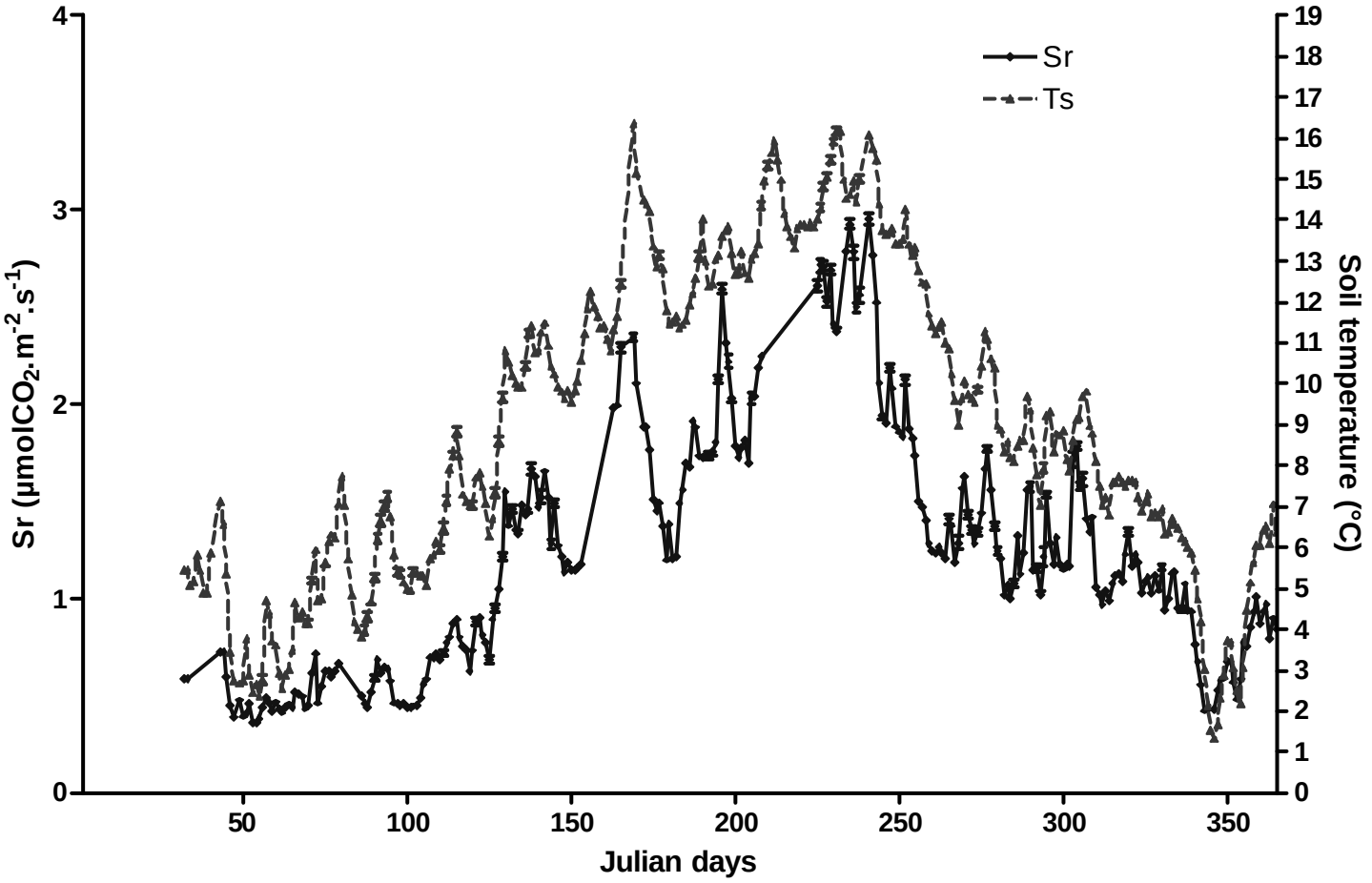
- **Installed in the beech plot**
- **Validation phase in 1999 (comparison with Licor 6200© results)**
- **Half hourly measurements on six collars from june 2000 to june 2003**
- **Data selection based on minimum r^2 and absence of pressure difference**
- **Climatic data from the tower support**

Micro spatial variability

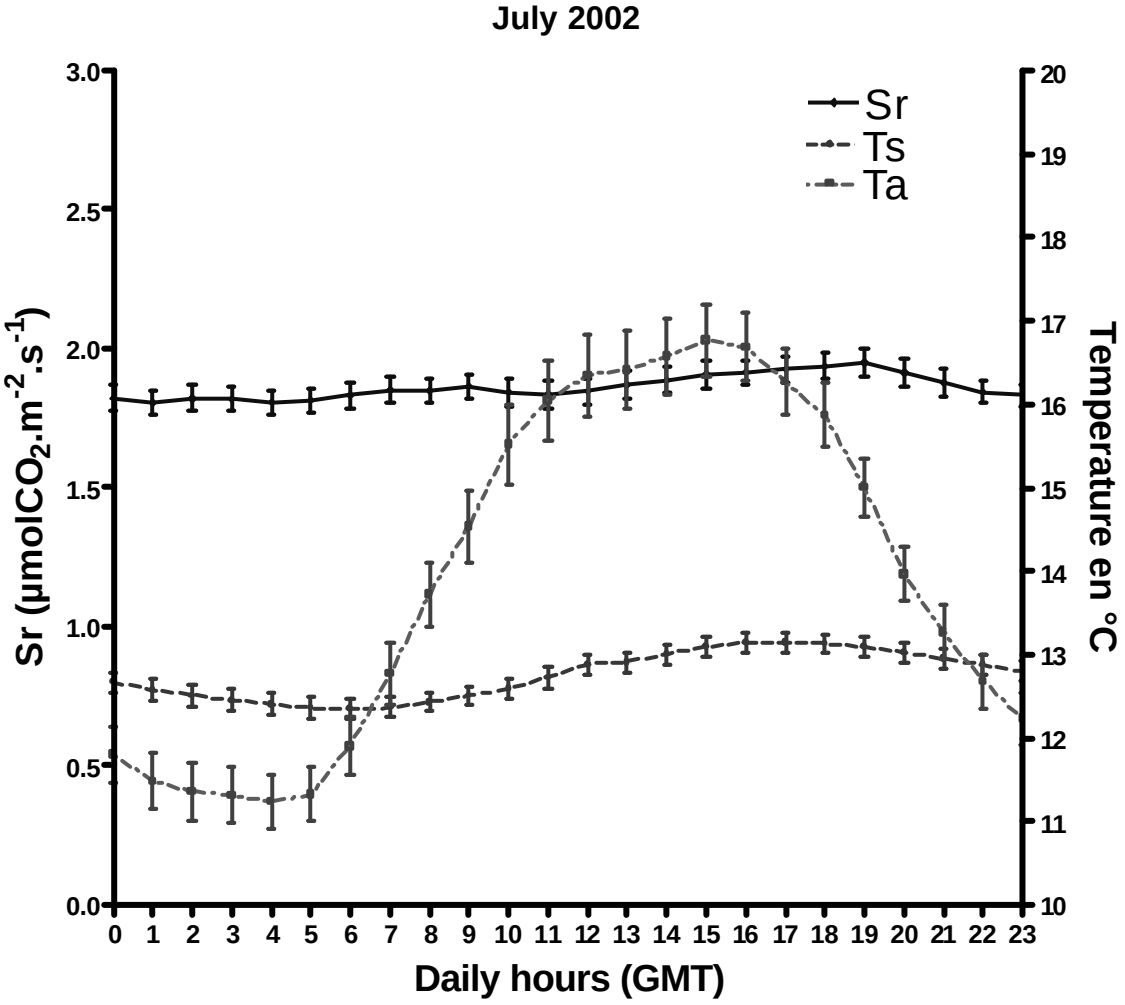


Results : annual cycle (eg 2002)

32096 half hourly means – 799 daily means



Daily cycle (eg July 2002)



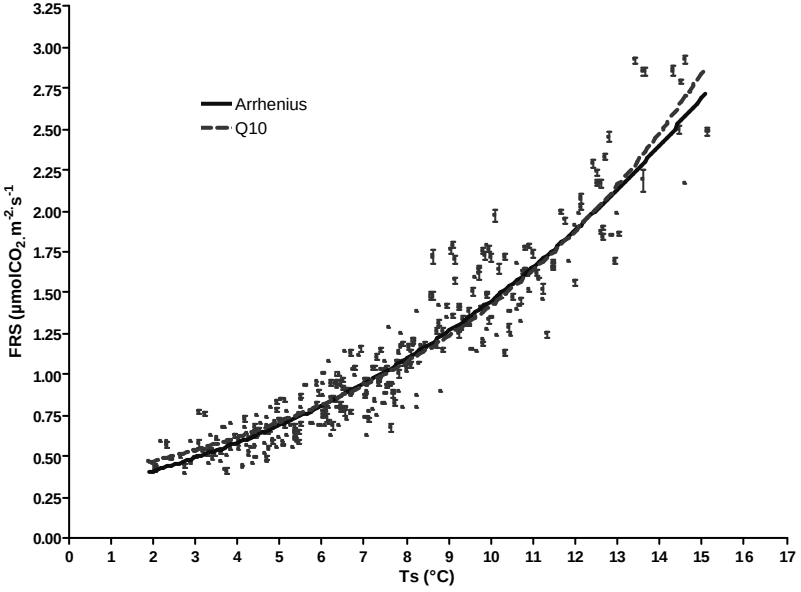
Model

- Multiplicative model : assess the synergic effects of climatic variables
- Sr = F (Ts) . F (SWC) . F (Pr)
- Work with daily mean = 799 values
- Procedure :
  - F(Ts) : fit on Sr selected (SWC>0.26 m3.m-3, rainy days or 1 day after rain) (461 values)
  - F(Hs) : fit on Sr . $F(Ts)^{-1}$ selected during rainy days or 1 day after rain (110 values)
  - F(Pr) : fit on Sr . $F(Ts)^{-1}$. $F(SWC)^{-1}$

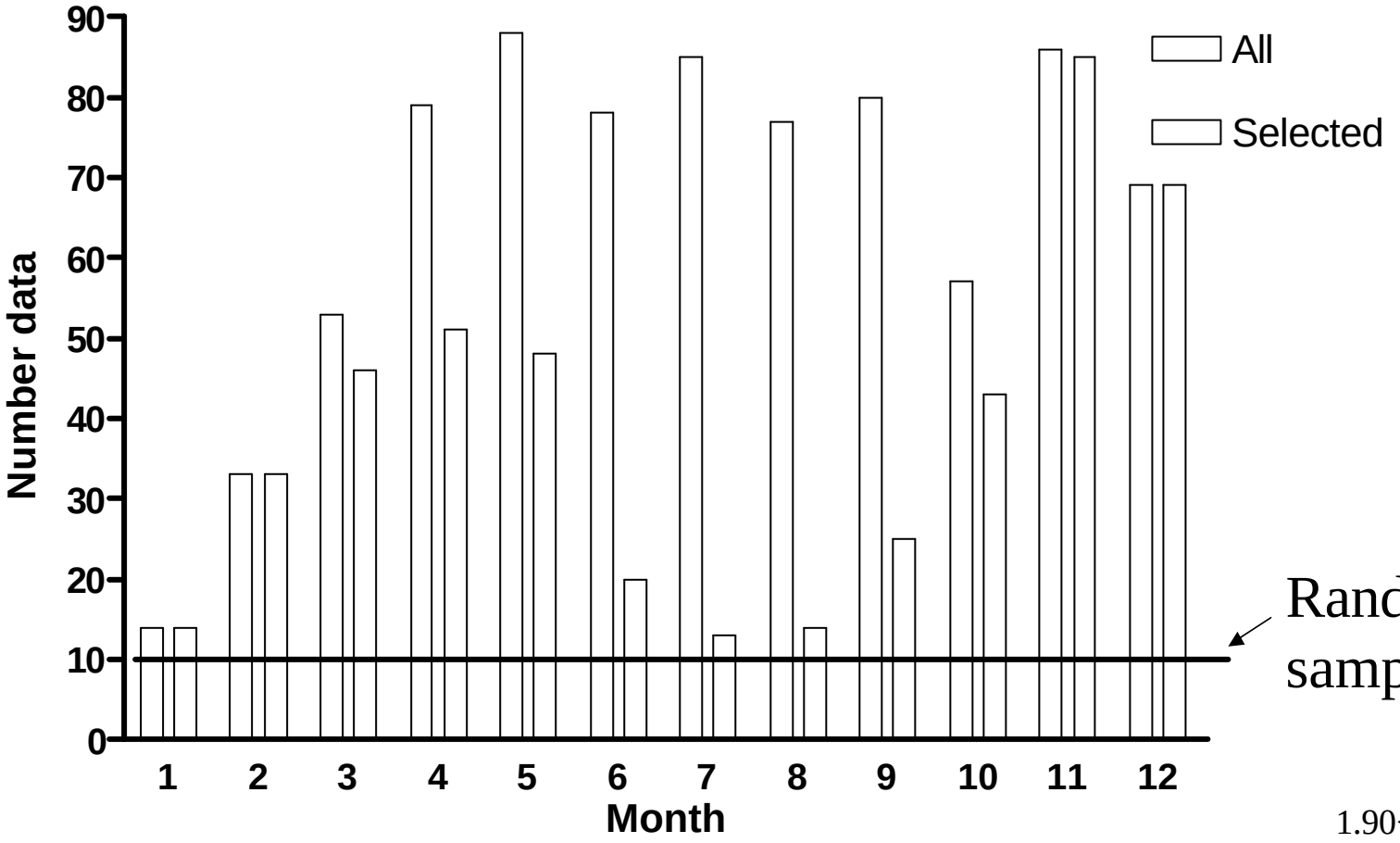
F(Ts) : equations

- Empirical models
  - Q10 → $Rs = Rs_{10} * Q_{10}^{\left(\frac{Ts-10}{10}\right)}$
  - Arrhenius → $Rs = Rs_{10} * e^{\left(Ea * \left(\frac{(Ts+273.2)-283.15}{283.15*(Ts+273.2)*Rg}\right)\right)}$
  - Others : sigmoïd, ...

$$Ea = a * \left(\frac{(Ts+273.2)}{(Ts+273.2)-227.13}\right)$$



F(Ts) : data accuracy

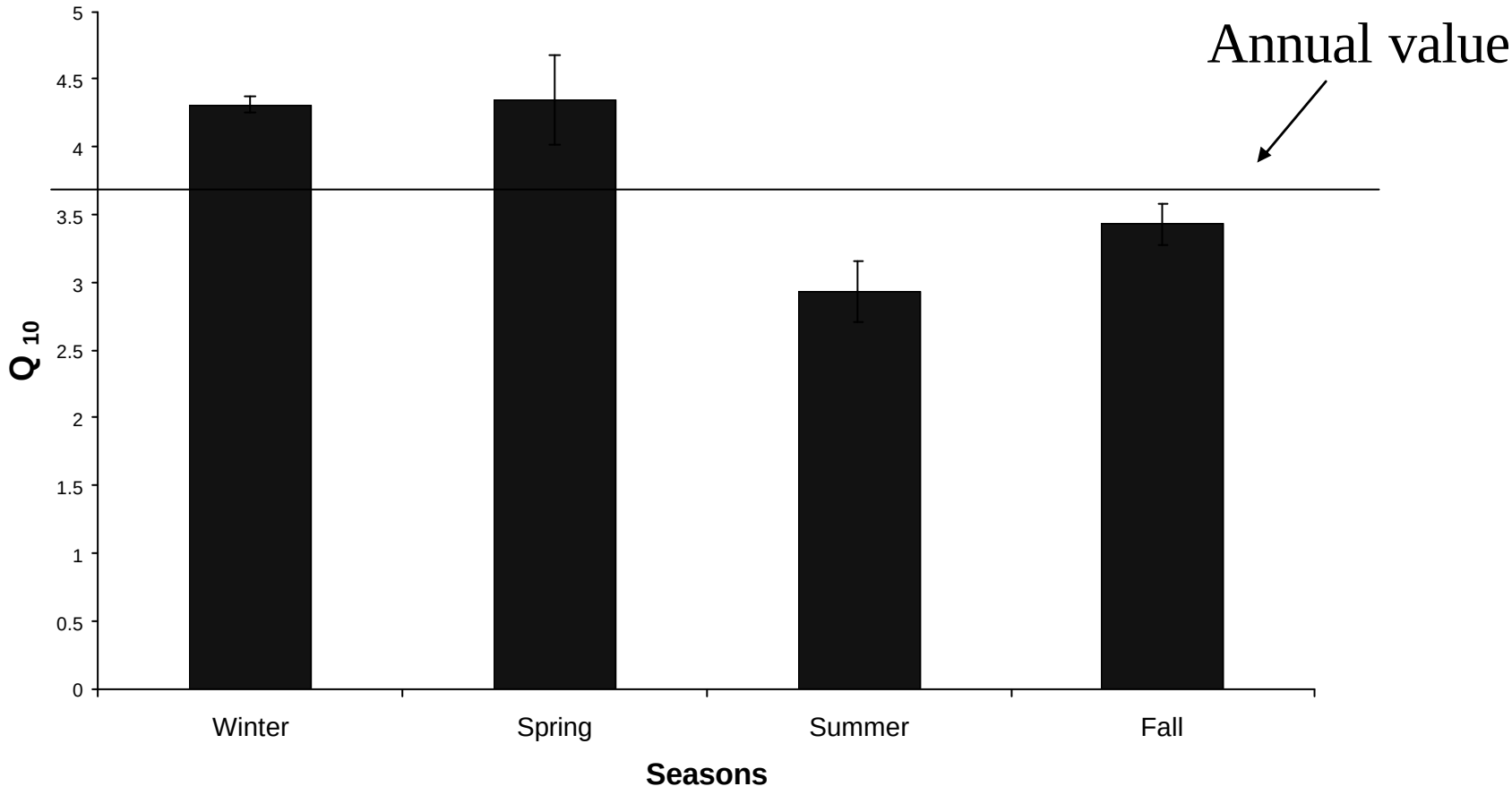


1.90<Ts<15.15 °C

F(Ts) : results

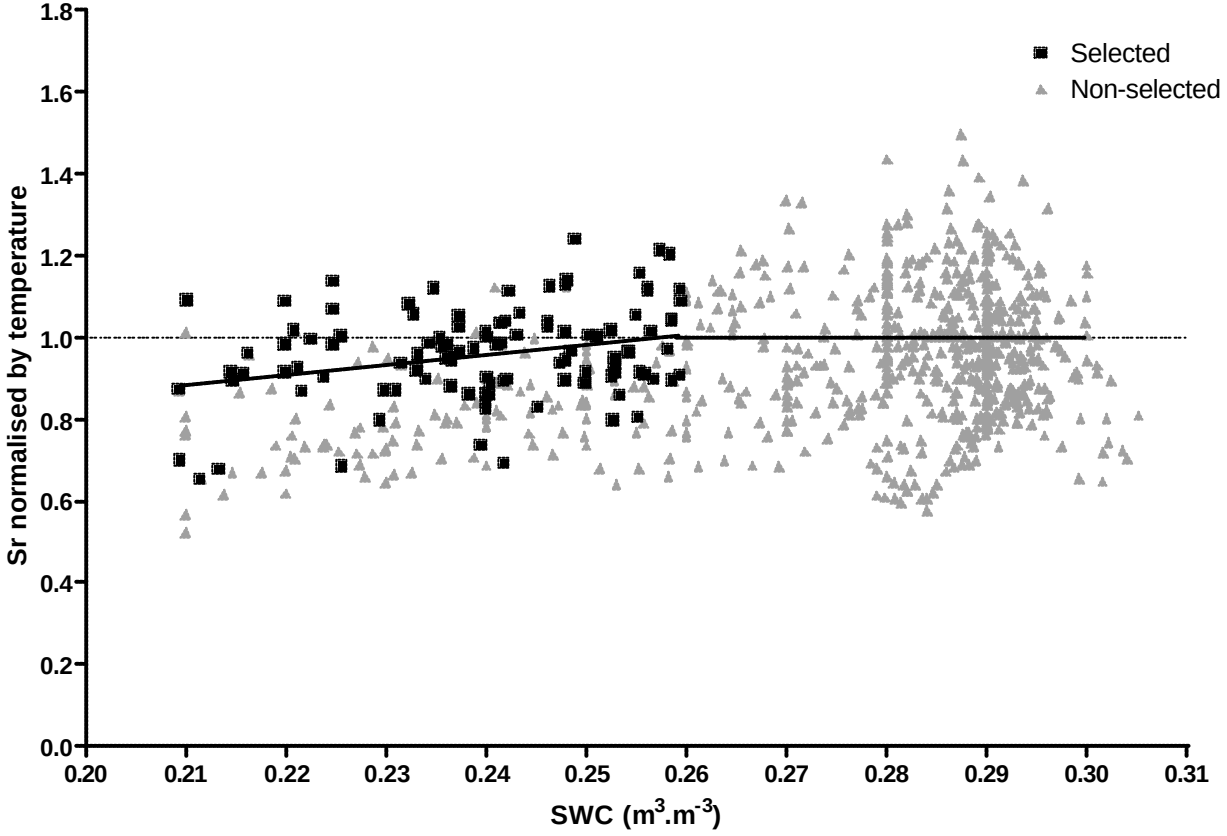
- Results :
  - **Q10 = 3.7** +-0.1 and **Rs10 = 1.4** +-0.01 $\mu molCO_2.s^{-1}.m^{-2}$
  - **A = 16972** $j.mol^{-1}$ and **Rs10 = 1.5** +-0.01 $\mu molCO_2.s^{-1}.m^{-2}$
  - Q_{10} = 3.0 for all data (without selection)
  - Q_{10} = 3.9 for selected data without random sampling
- 92 % variability explained by F(Ts)

Seasonal variability



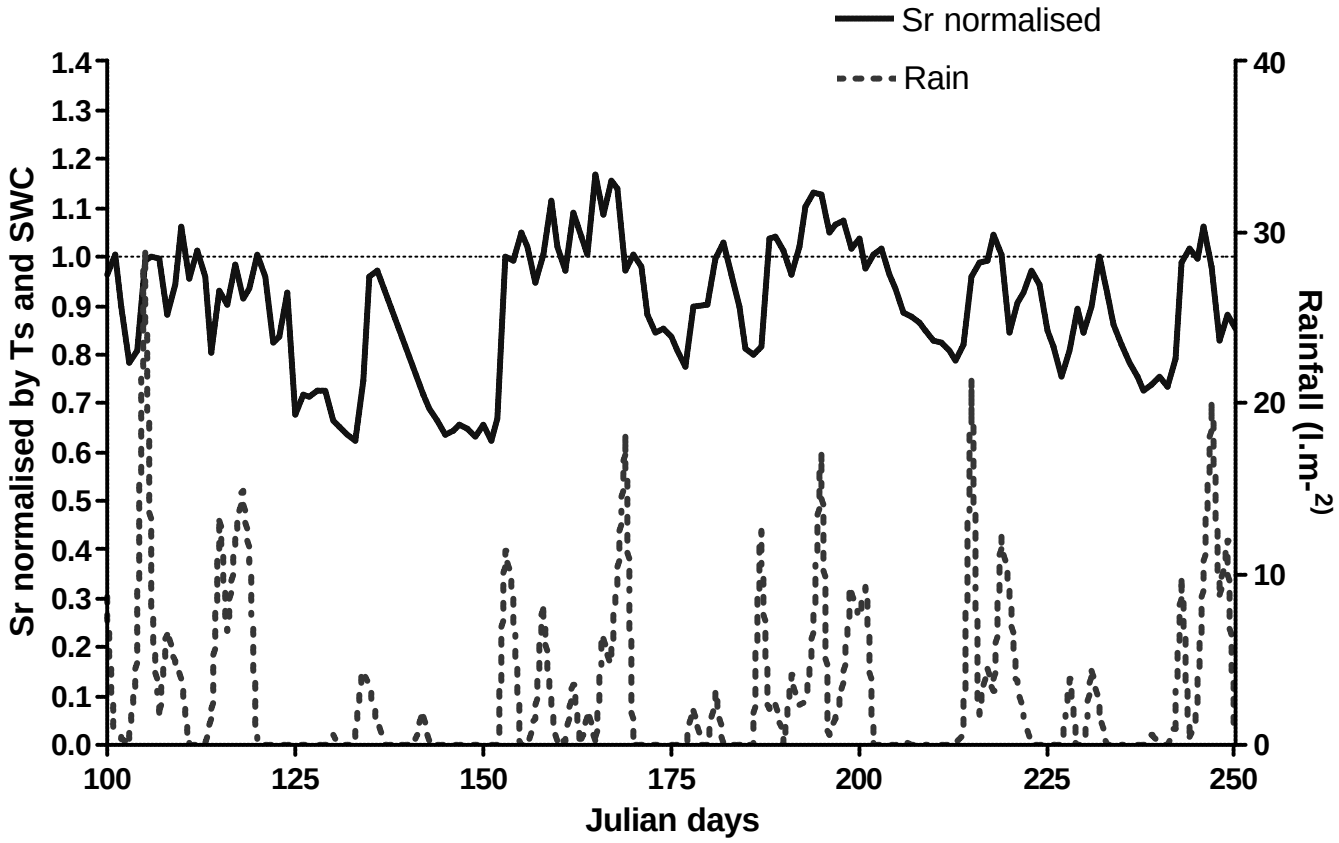
F(SWC)

- Linear relation
- Significant but high dispersion
- Improvement by 1% of the variability explanation
- SWC is measured at 21cm depth - no representative of litter humidity



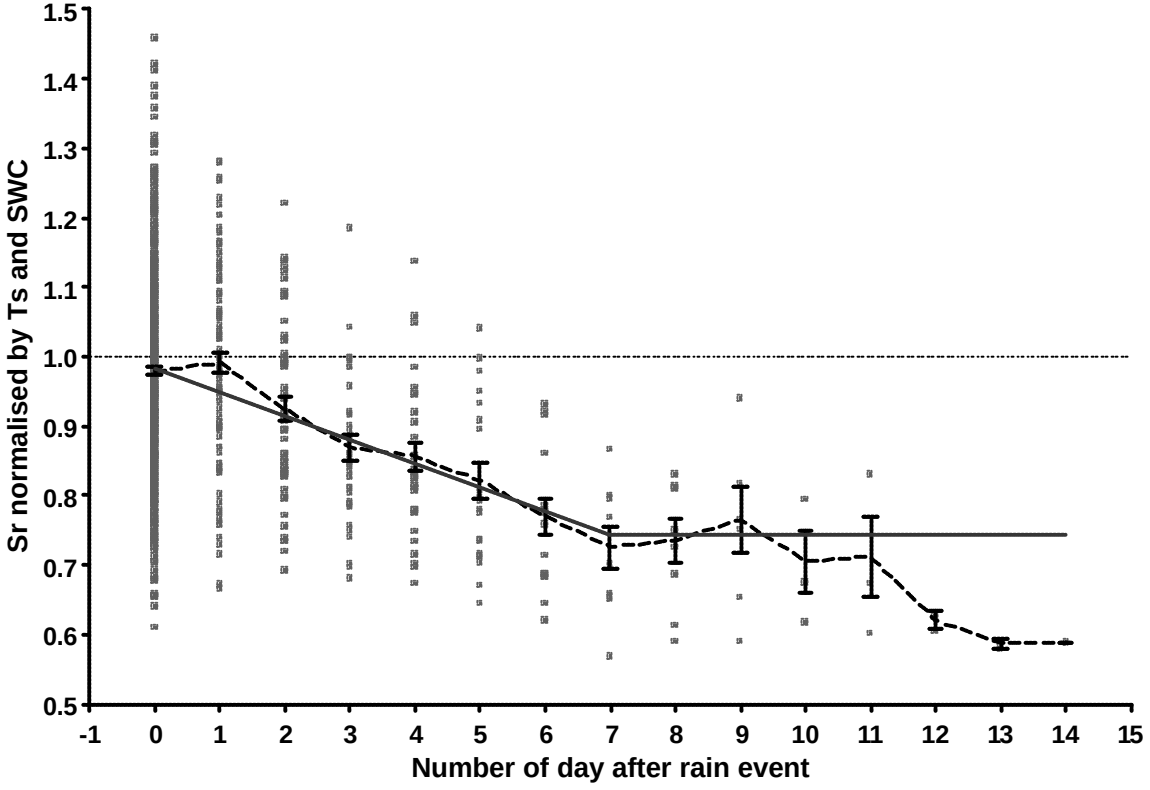
F (Pr)

- Small “peaks” effects on rainy days
- Decrease of normalised fluxes during period without rain



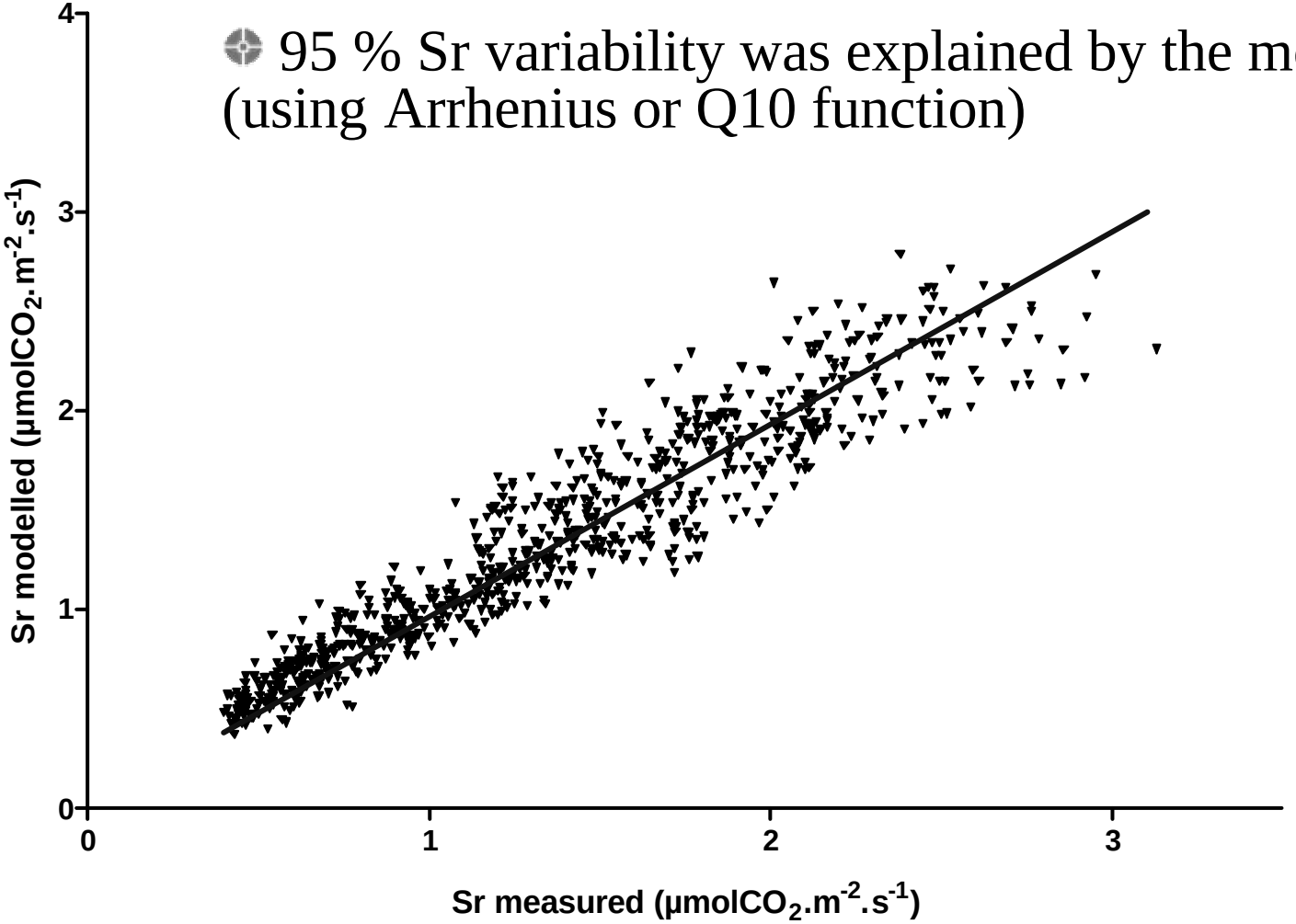
F (Pr)

- Best fit with the parameters « number of dry days after rain event »
- Hypothesis : drying of litter
- Linear relation untill 7 days and a plateau
- Increase of 2 % variability explanation



Model evaluation

- 95 % Sr variability was explained by the model (using Arrhenius or Q10 function)



Conclusion

- Ts is the main factors in our case
- The data must be representative of annual variability
- Improvement by 3% explanation with SWC and “Rain events” function
- Same result at the hourly time scale (little effect of daily variability
- Perspective :
  - Artificial drying – rewetting cycle
  - Soil CO_2 concentration measurement at different depth
  - Spatial variability : see the poster Longdoz *et al*

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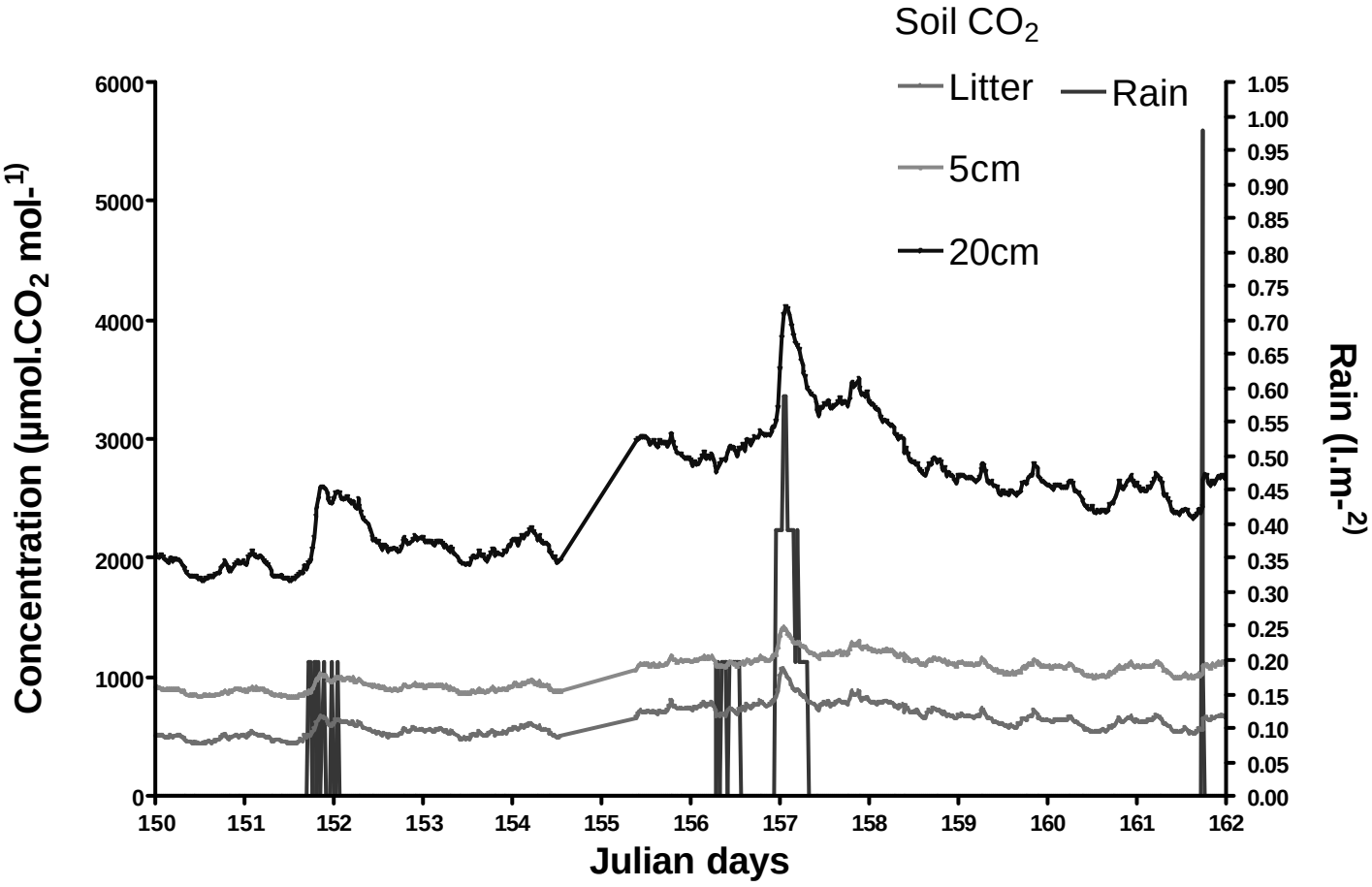
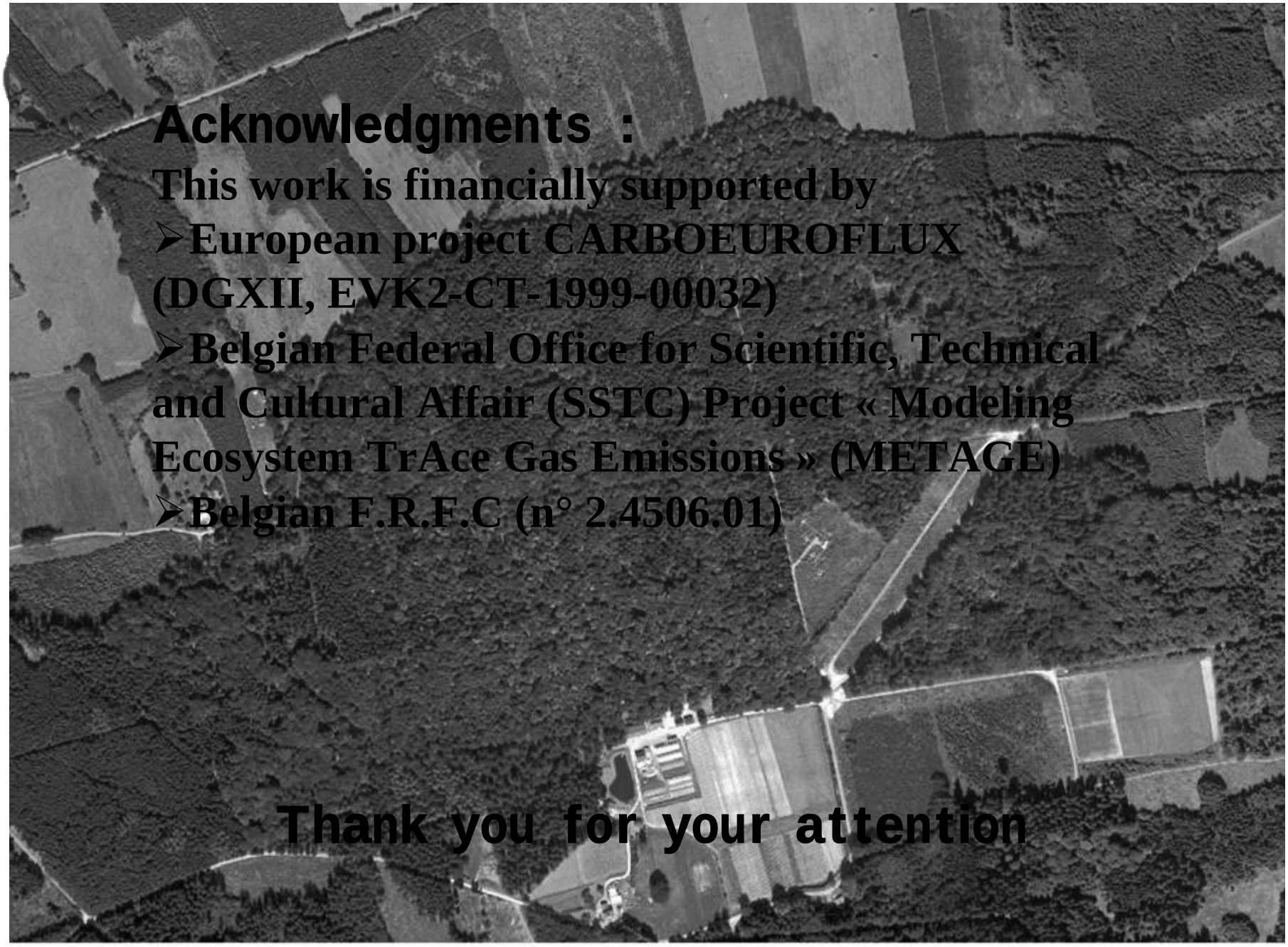
Soil concentration measurement : preliminary results (2004)





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Thank you for your attention