International IAHS-PUB Workshop
6.-8. July 2004, Loveno, Italy
Uncertainty Analysis in Environmental Modeling

Data-Based Mechanistic Modelling Strategies for PUB
- Land Surface Flux Predictions -

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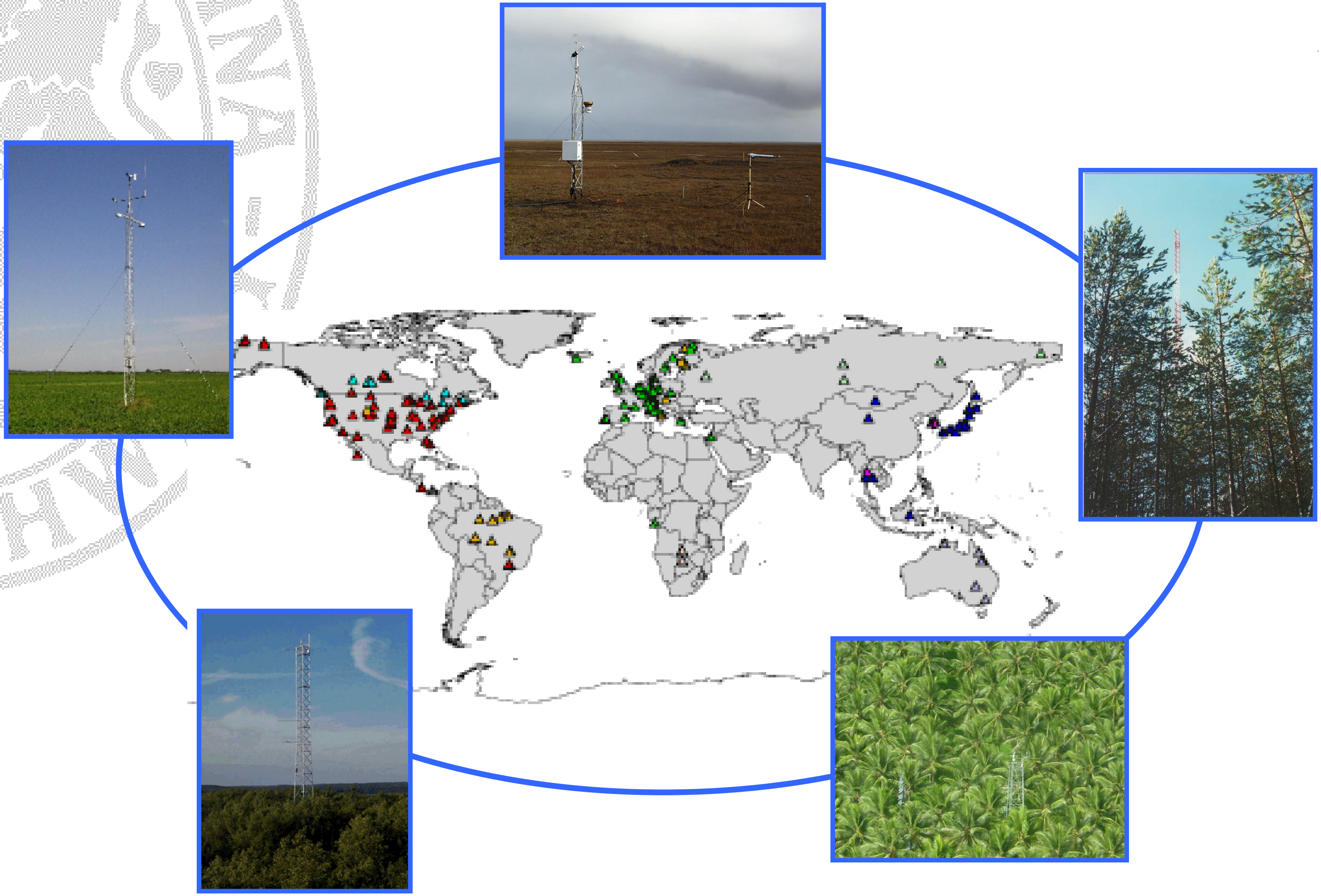
FLUXNET



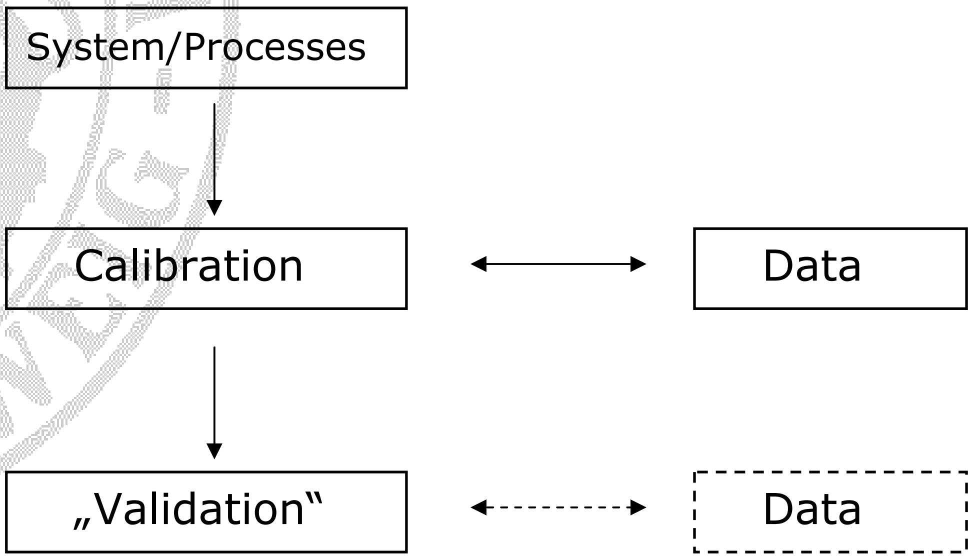
Difficulties

- Models are often overparameterised
- Impossible to identify parameters

- Extrapolation:
  - Location
  - Boundary conditions

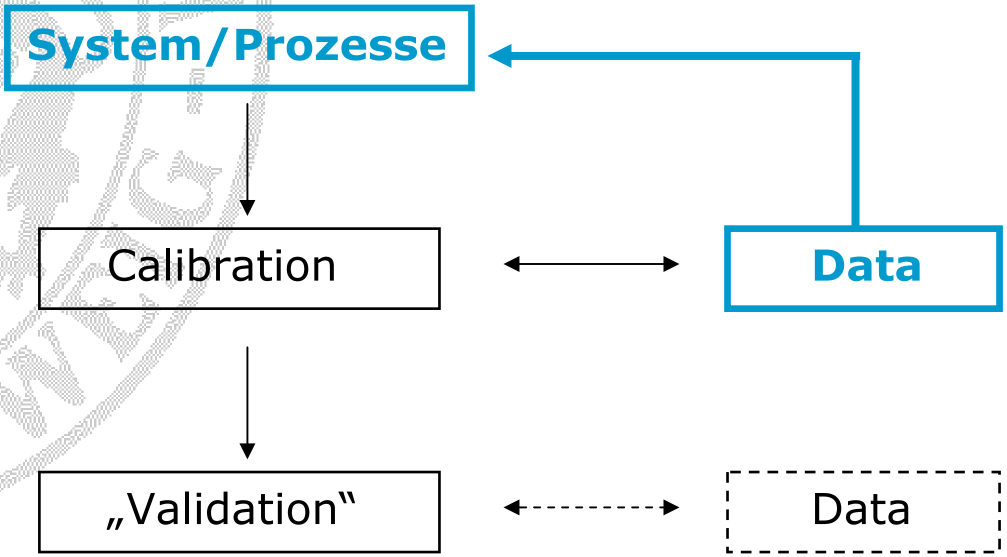
Data Based Mechanistic Modeling

„classic“



Data Based Mechanistic Modeling

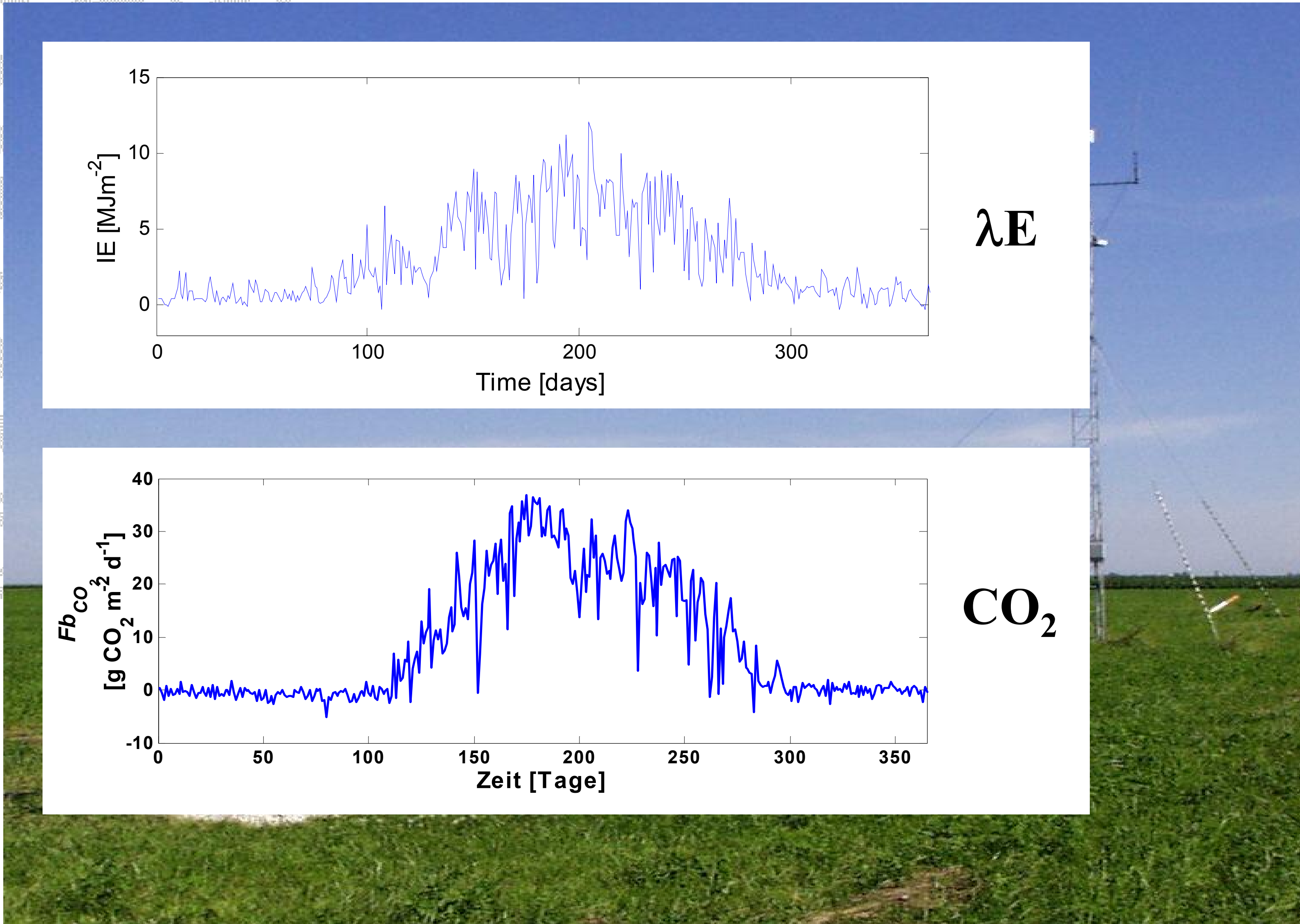
„Data-based“



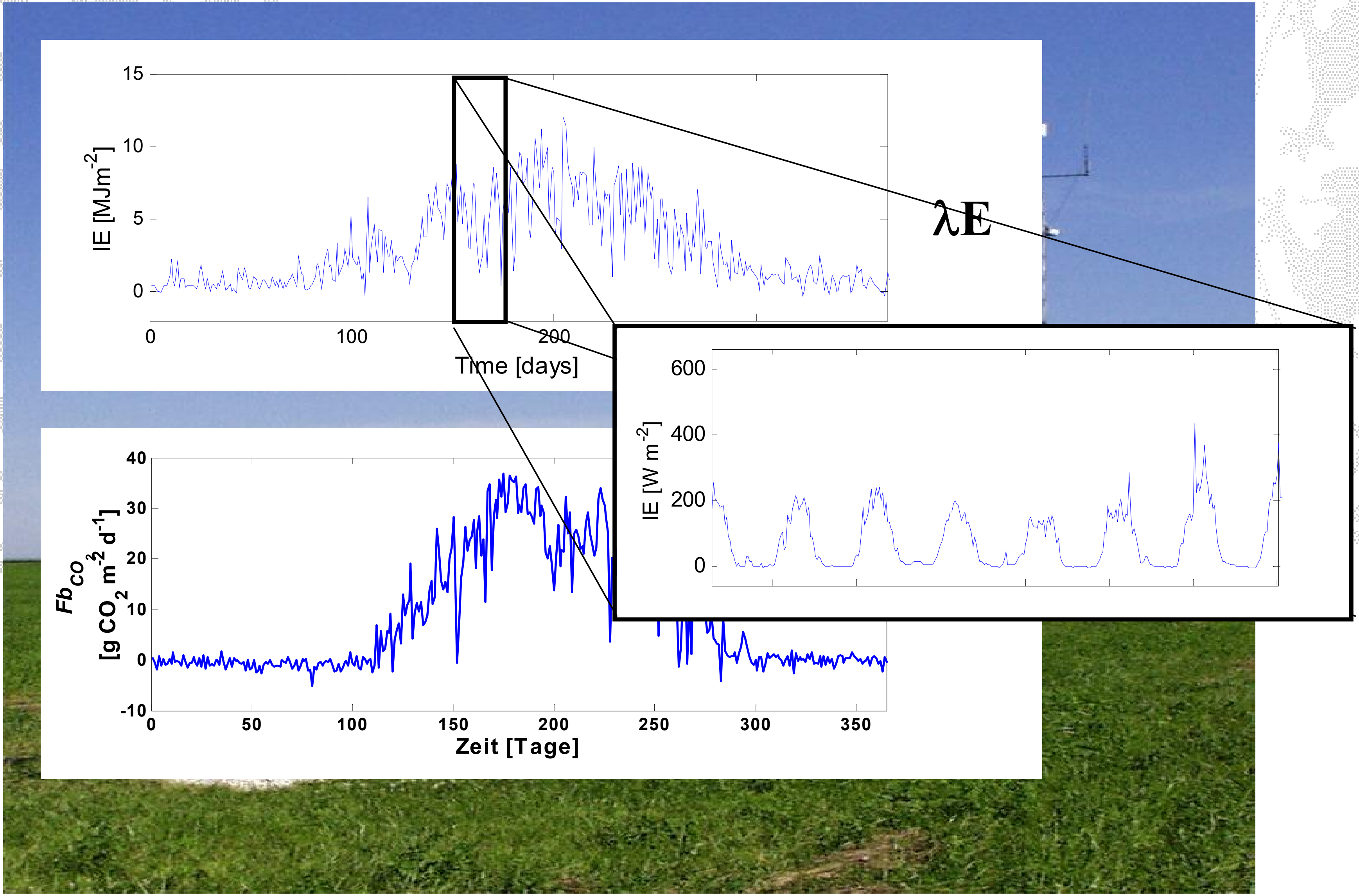
Data Based Mechanistic Modeling (Young, 2003)

1. Definition of modelling objectives
2. Model structure identification
3. Constant parameter estimation
4. Nonparametric time variable or state dependent parameter estimation
5. Parameterization of state dependency and optimization of non-linear model
6. Physical interpretation of model structure
7. Testing, „Validation“ – uncertainty and sensitivity analysis

1. Modelling Objectives



1. Modelling Objectives



2. Model Structure Identification

Generic class of Transfer Function Models (TFM):

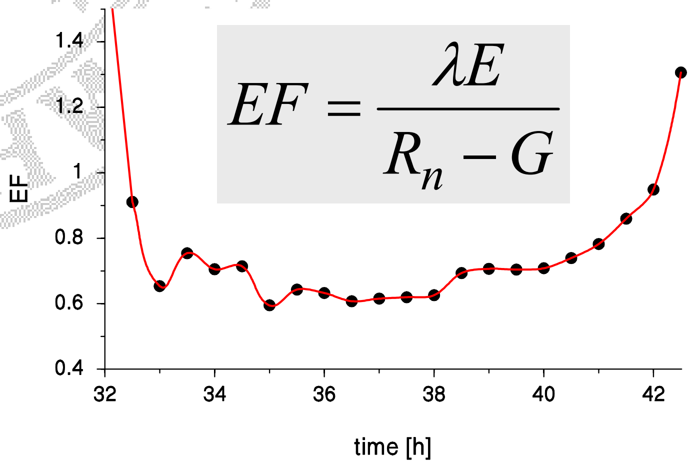
$$y_t = \frac{b_0(s_t) + b_1(s_t)z^{-1} + \ldots + b_m(s_t)z^{-m}}{1 + a_1(s_t)z^{-1} + \ldots + a_n(s_t)z^{-n}} \cdot x_{t-\delta} + \xi_t$$

2. Model Structure Identification

$$\lambda E \propto R_n \; bzw. \; S_0 \longrightarrow \lambda E(t) = EF \cdot R_n(t) + \xi_{\lambda E}(t)$$

Evaporative Fraction (EF):

$$EF = \frac{\lambda E}{R_n - G}$$



2. Model Structure Identification

$$\lambda E \propto R_n \; or \; S_0 \quad \longrightarrow \quad \lambda E(t) = EF \cdot S_0(t) + \xi_{\lambda E}$$

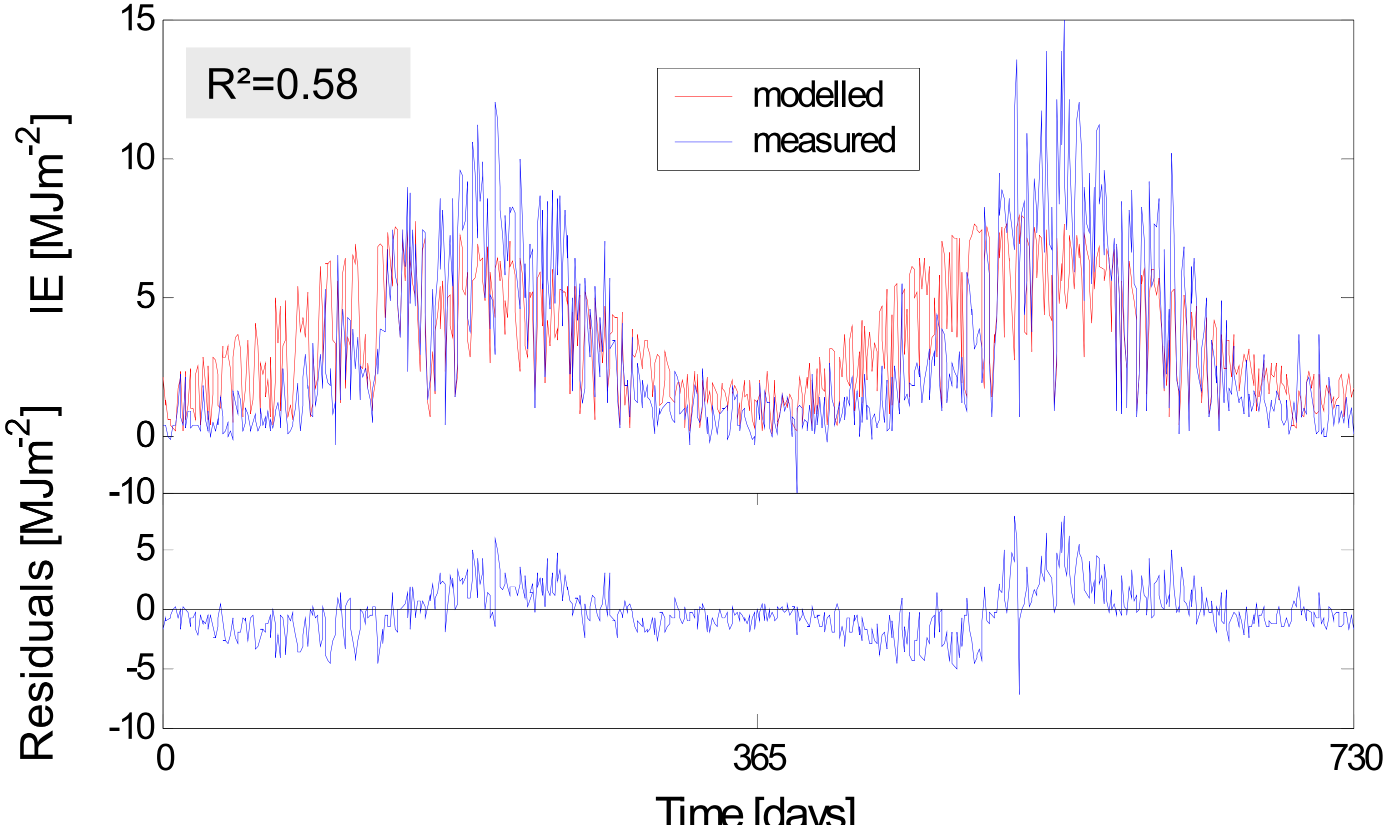
$$Pb_{CO_2} \propto PAR \; or \; S_0 \quad \longrightarrow \quad Pb_{CO_2}(t) = LUE \cdot PAR(t) + \xi_{Pb}$$

Light Use Efficiency (LUE):

$$LUE = \frac{Pb_{CO_2}(t)}{PAR(t)}$$

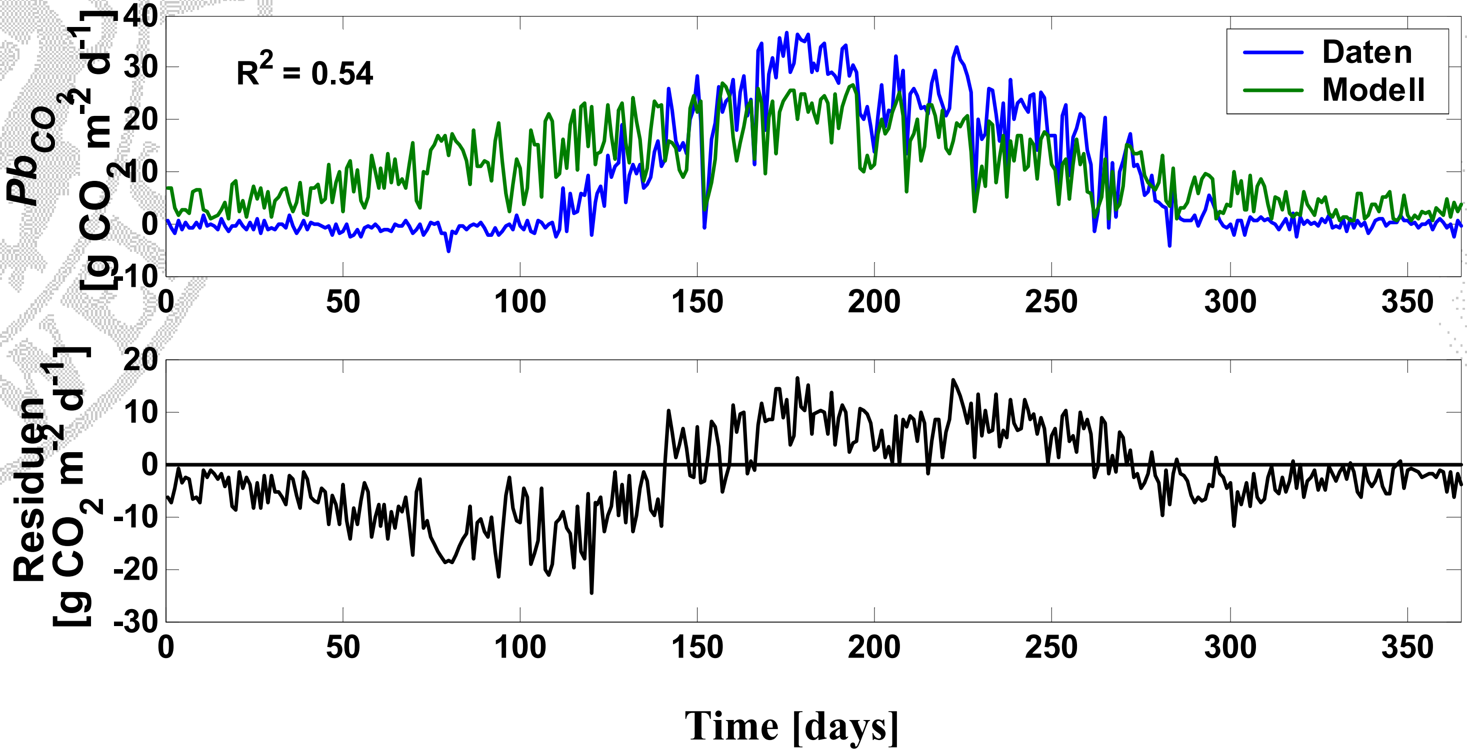
3. (Constant) Parameter Estimation

λE, Havard Forest 1998-99:



3. (Constant) Parameter Estimation

CO_2, Havard Forest 1994:



4. Time and State Dependence

$$\lambda E(t) = EF \cdot S_0(t) + \xi_{\lambda E}(t)$$

non-stationary, dynamic

$$Pb_{CO_2}(t) = LUE \cdot PAR(t) + \xi_{Pb}$$

4. Time and State Dependence

$$\lambda E(t) = EF \cdot S_0(t) + \xi_{\lambda E}(t)$$

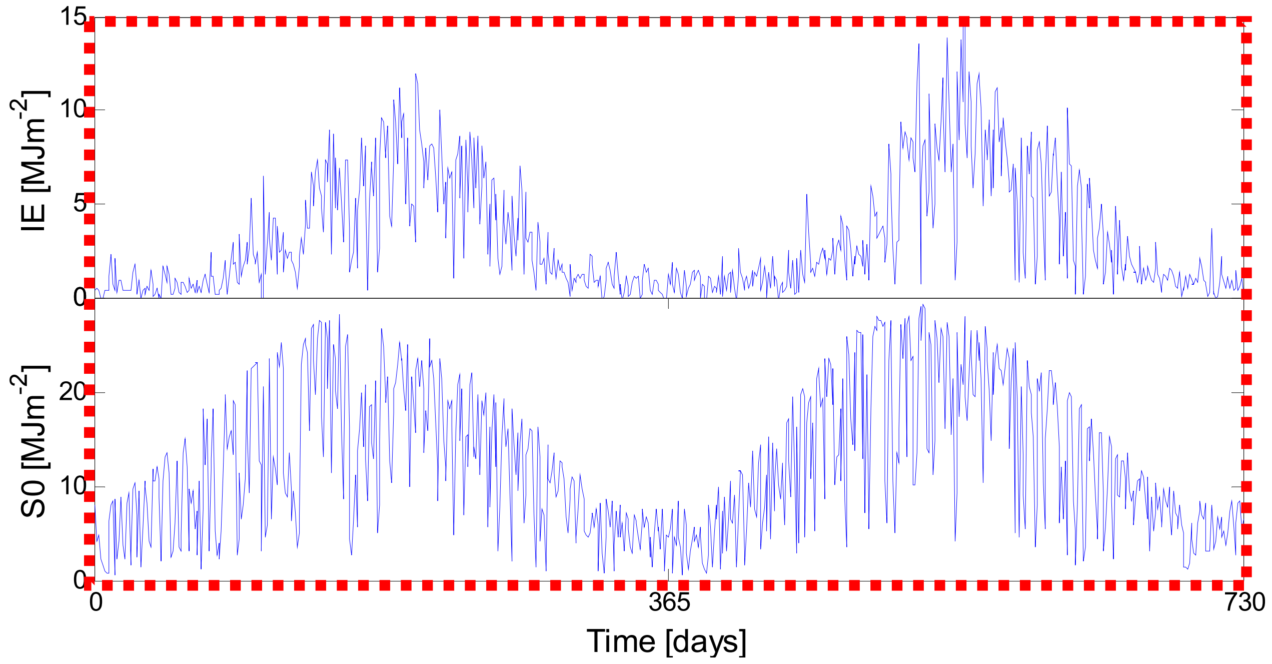
non-stationary, dynamic

Dynamic Linear Regression (Young, 1999)

$$\lambda E(t) = EF(t) \cdot S_0(t) + \xi_{\lambda E}(t)$$

with $EF(t) = EF(t-1) + \eta_{EF}(t)$

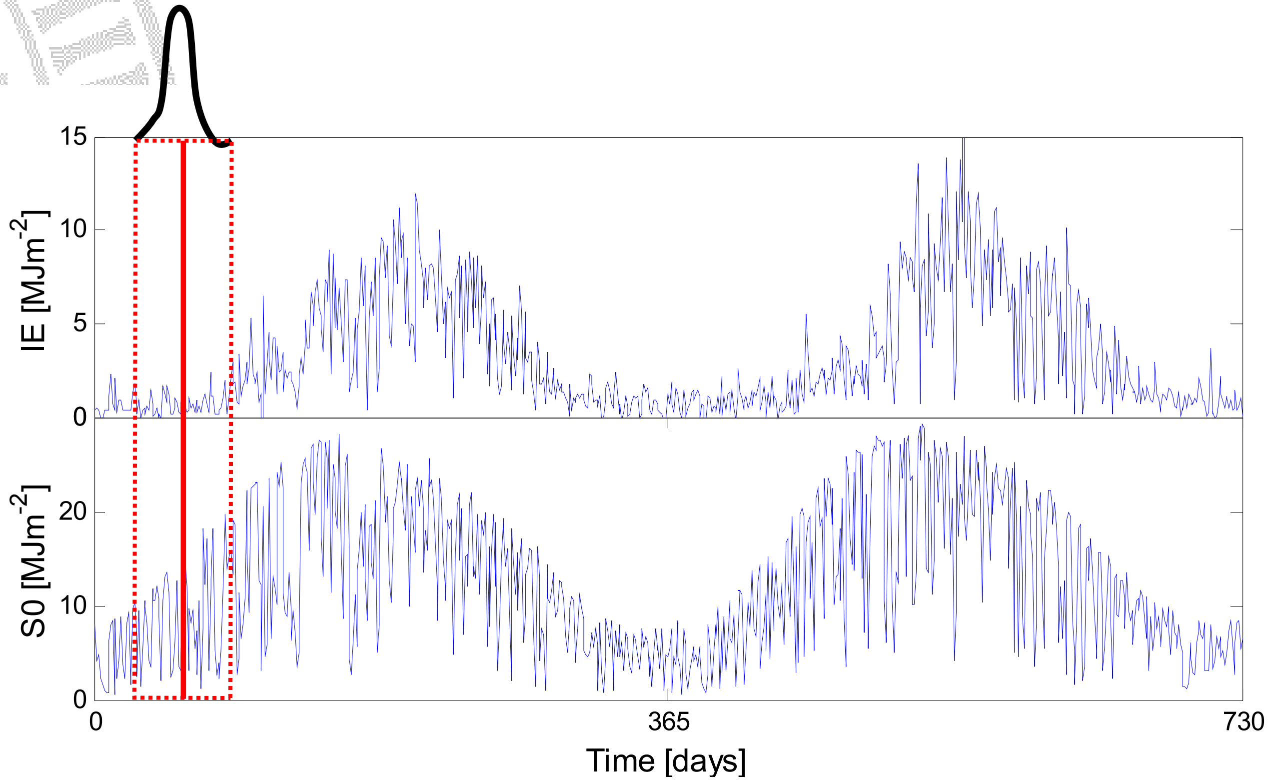
4. Dynamic Linear Regression



$$\lambda E(t) = EF(t) \cdot S_0(t) + \xi_{\lambda E}(t)$$

$$EF(t) = EF(t-1) + \eta_{EF}(t)$$

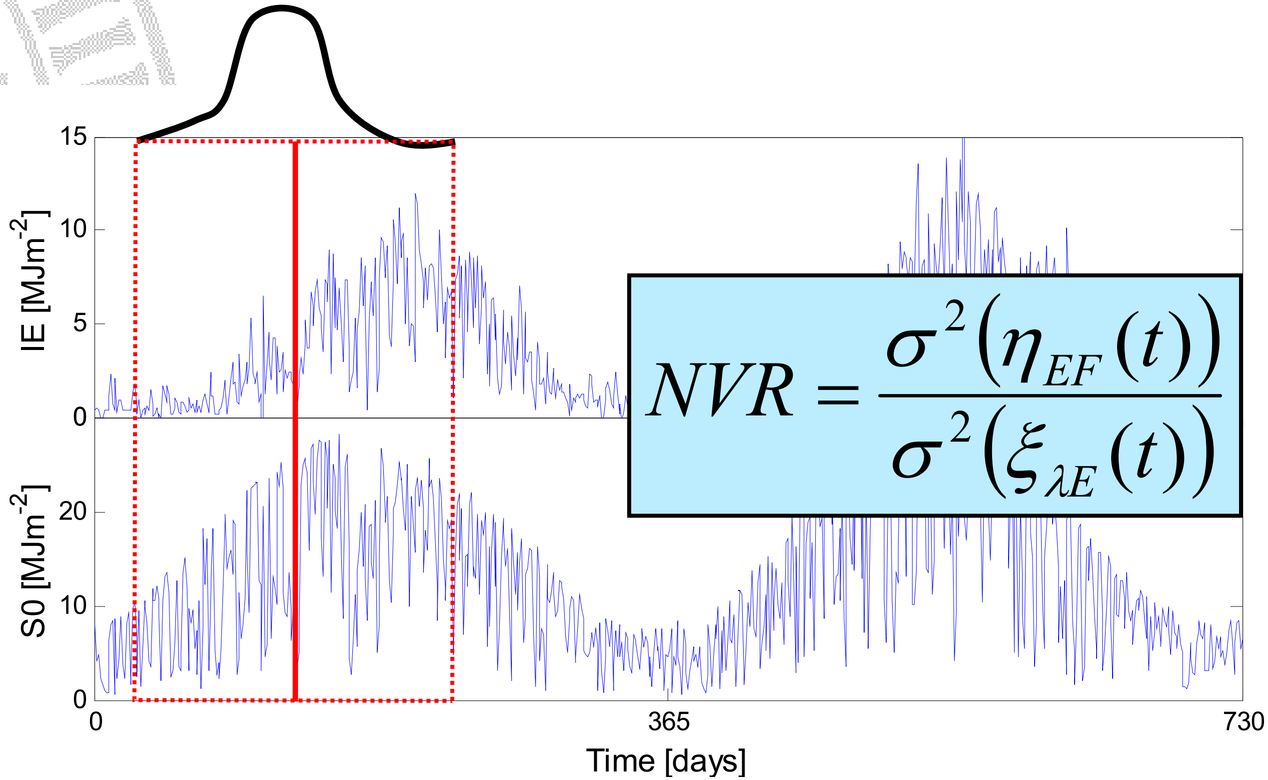
4. Dynamic Linear Regression



$$\lambda E(t) = EF(t) \cdot S_0(t) + \xi_{\lambda E}(t)$$

$$EF(t) = EF(t-1) + \eta_{EF}(t)$$

4. Dynamic Linear Regression

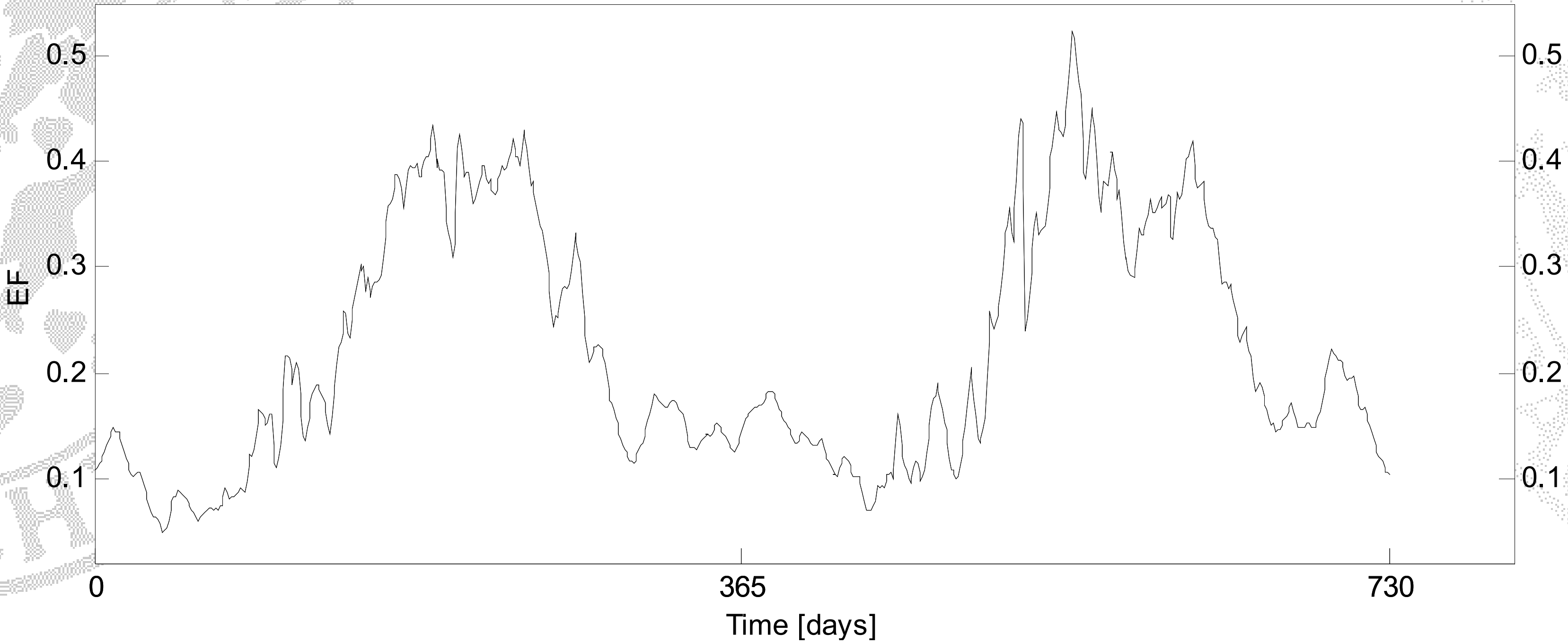


$$NVR = \frac{\sigma^2\left(\eta_{EF}(t)\right)}{\sigma^2\left(\xi_{\lambda E}(t)\right)}$$

$$\lambda E(t) = EF(t) \cdot S_0(t) + \xi_{\lambda E}(t)$$

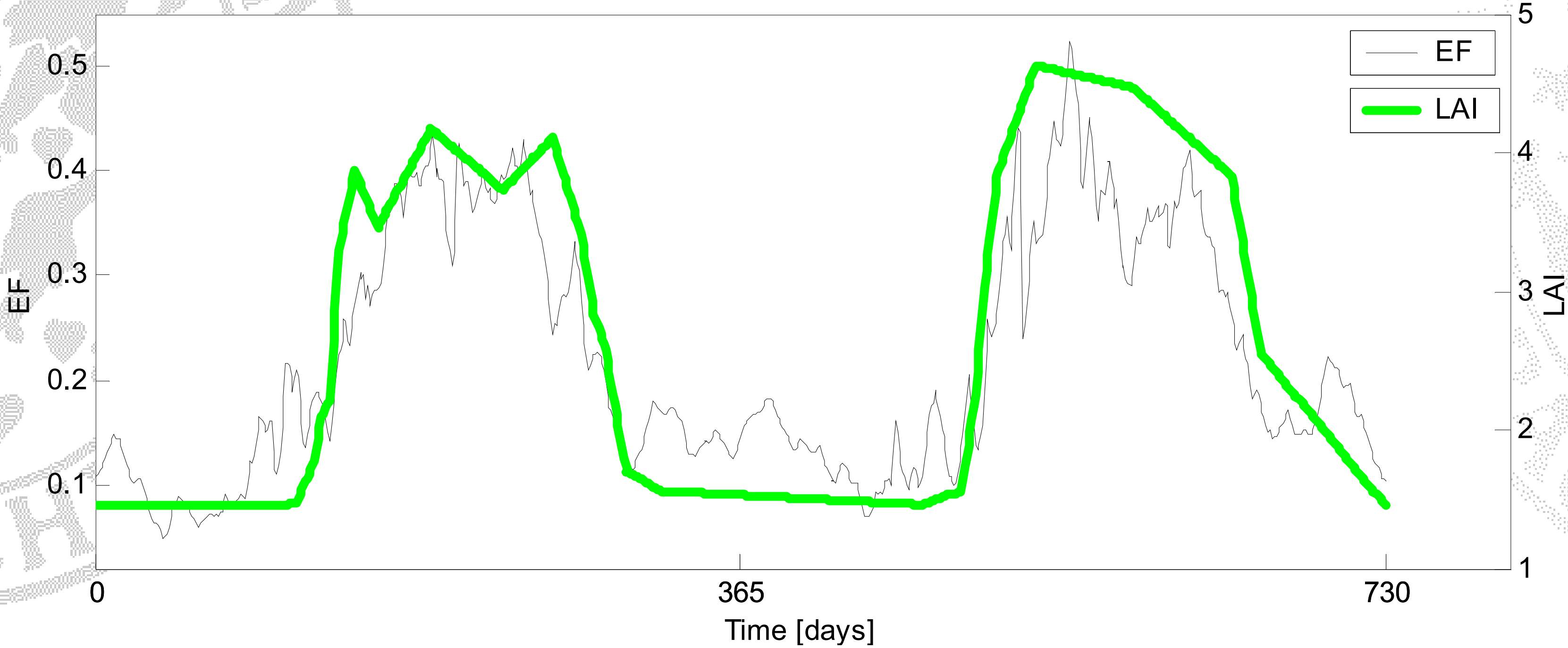
$$EF(t) = EF(t-1) + \eta_{EF}(t)$$

4. Time and State Dependence

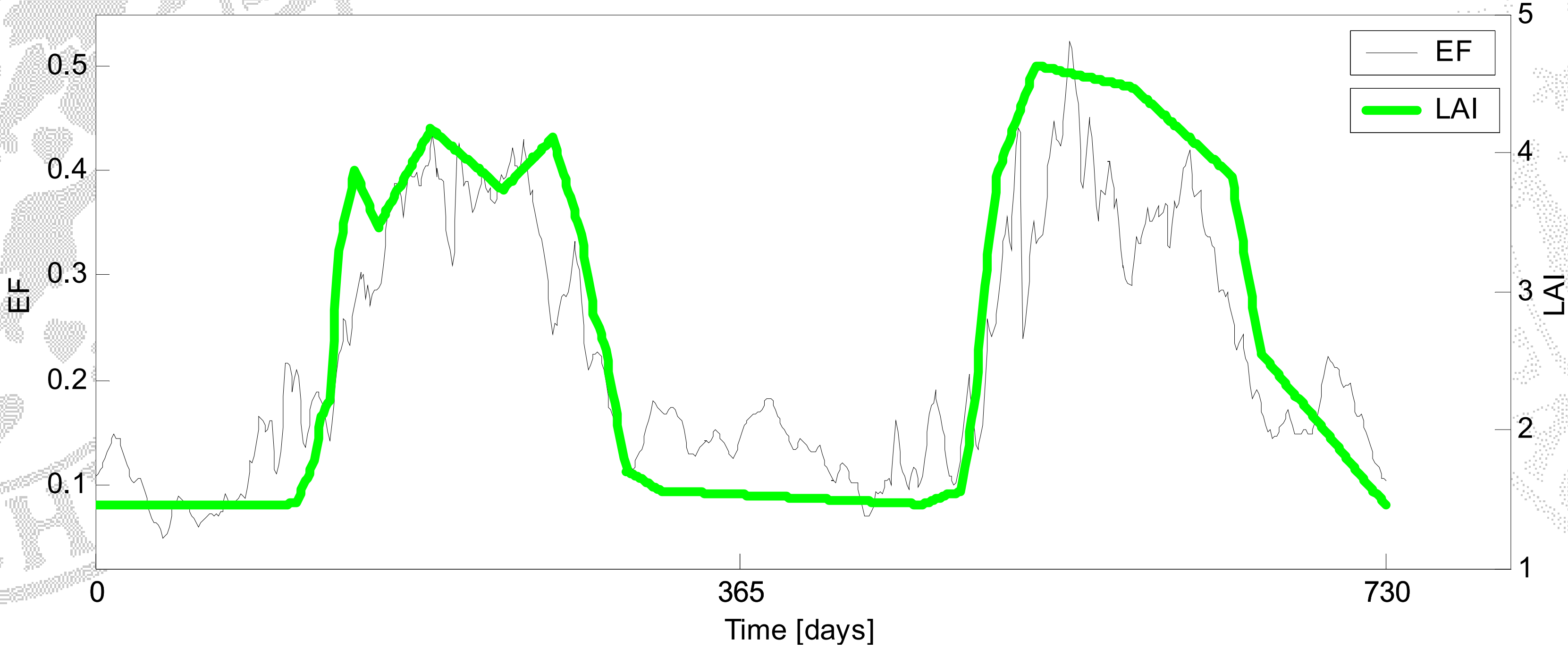


$$\lambda E(t) = EF(t) \cdot S_0(t) + \xi_{\lambda E}(t)$$

4. Time and State Dependence

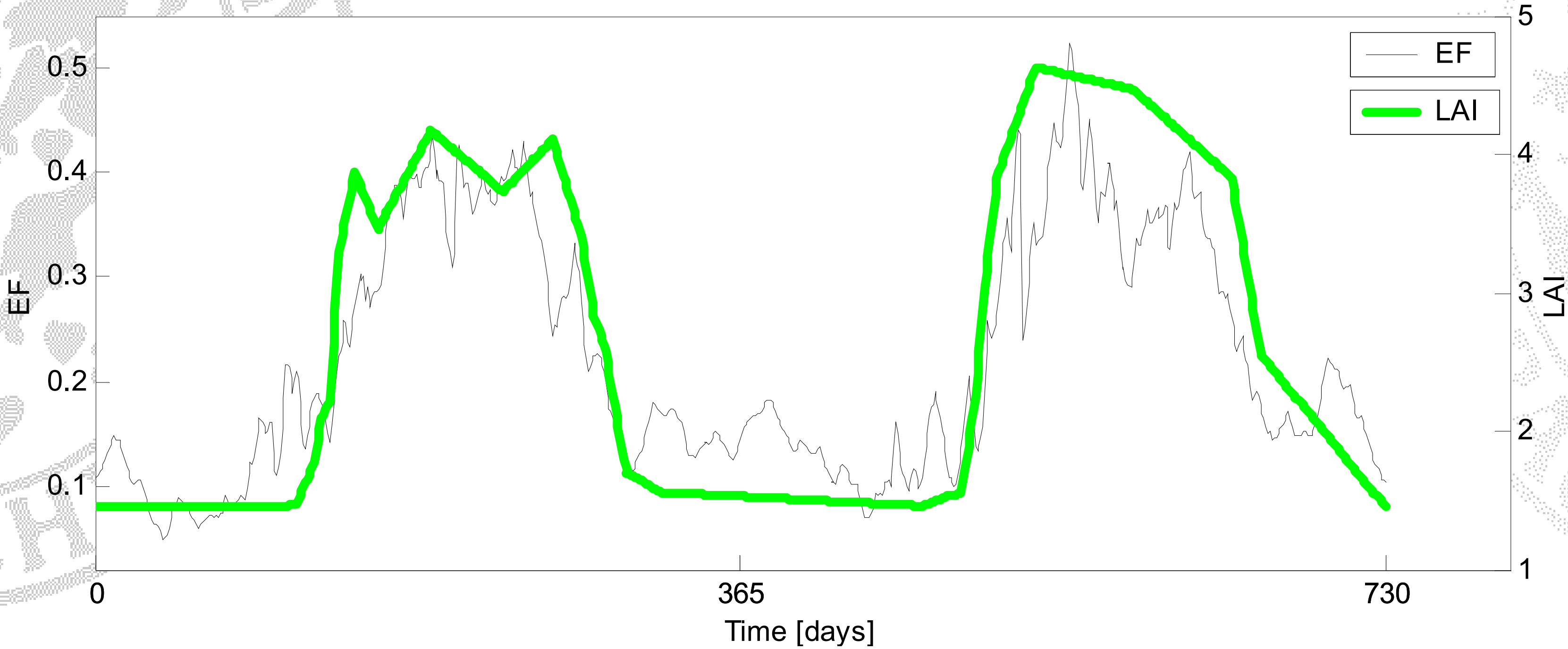


4. Time and State Dependence



$$EF(t) = a_1 + a_2 \cdot LAI(t)$$

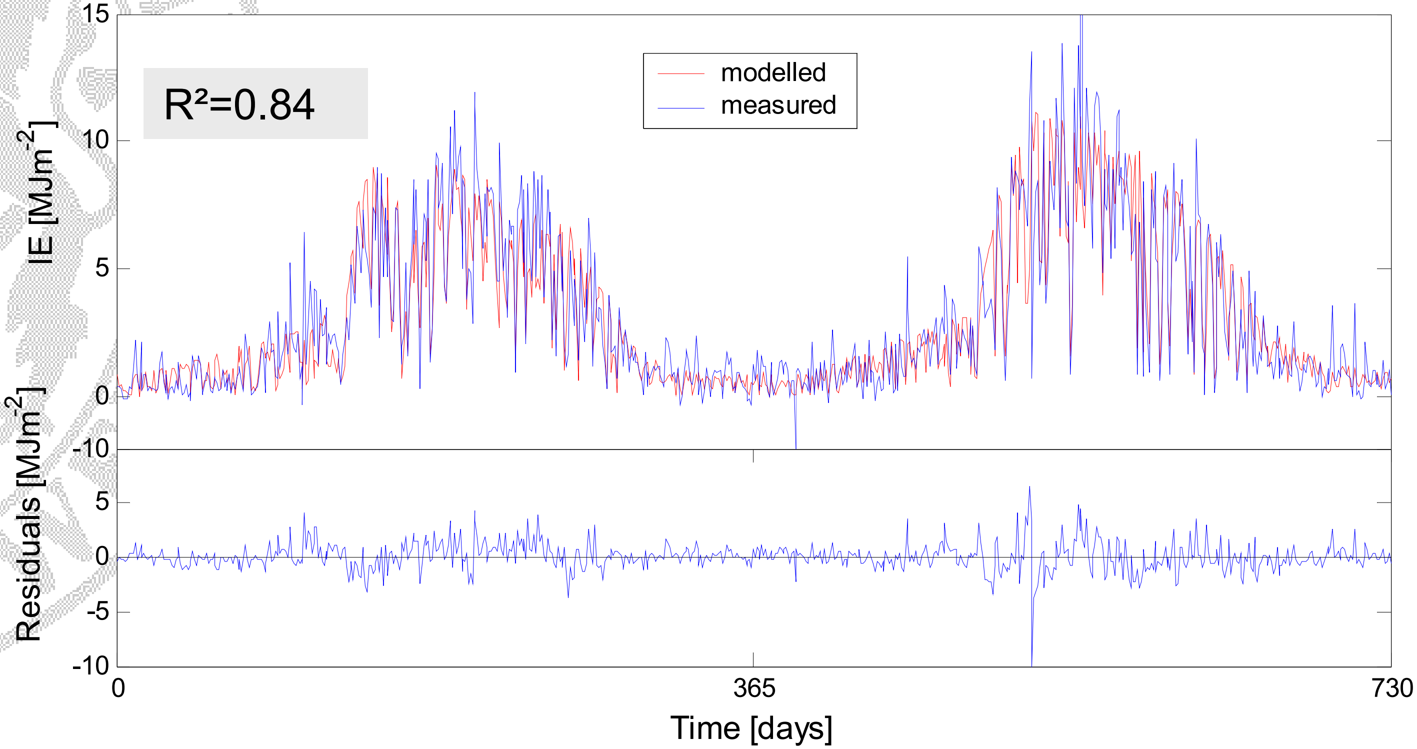
4. Time and State Dependence



$$EF(t) = a_1 + a_2 \cdot LAI(t)$$

$$\lambda E(t) = (a_1 + a_2 \cdot LAI(t)) \cdot R_n(t) + \xi_{\lambda E}(t)$$

5. Model Optimization



$$\lambda E(t) = (a_1 + a_2 \cdot LAI(t)) \cdot S_0(t)$$

$a_1 = -0.0207 \pm 0.0093$

$a_2 = 0.0908 \pm 0.0027$

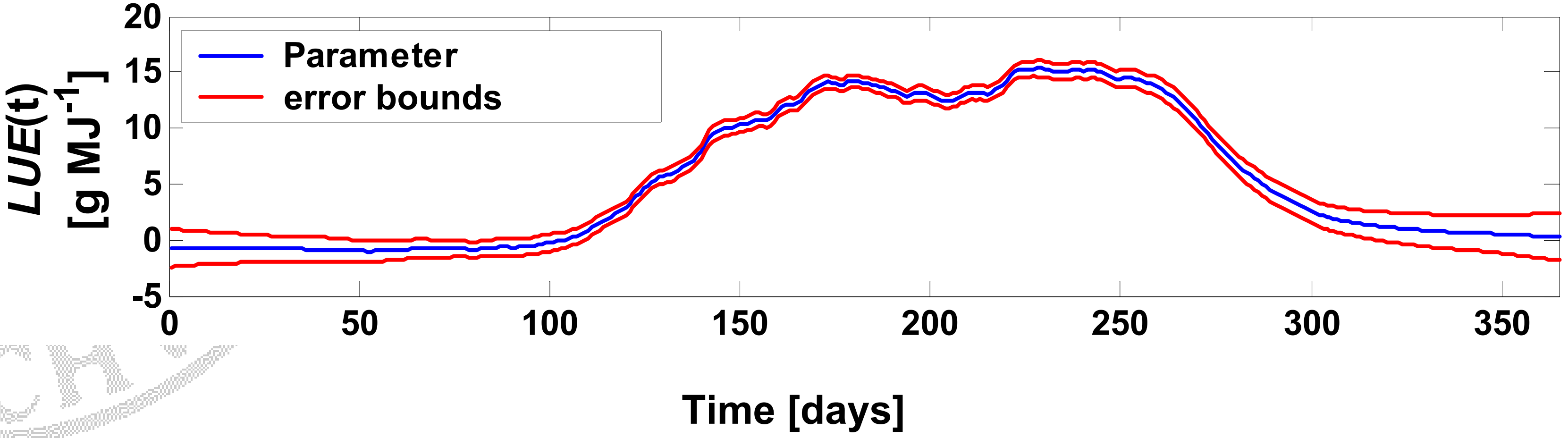
4. Time and State Dependence

non-stationary, dynamic

$$Pb_{CO_2}(t) = LUE \cdot PAR(t) + \xi_{Pb}$$

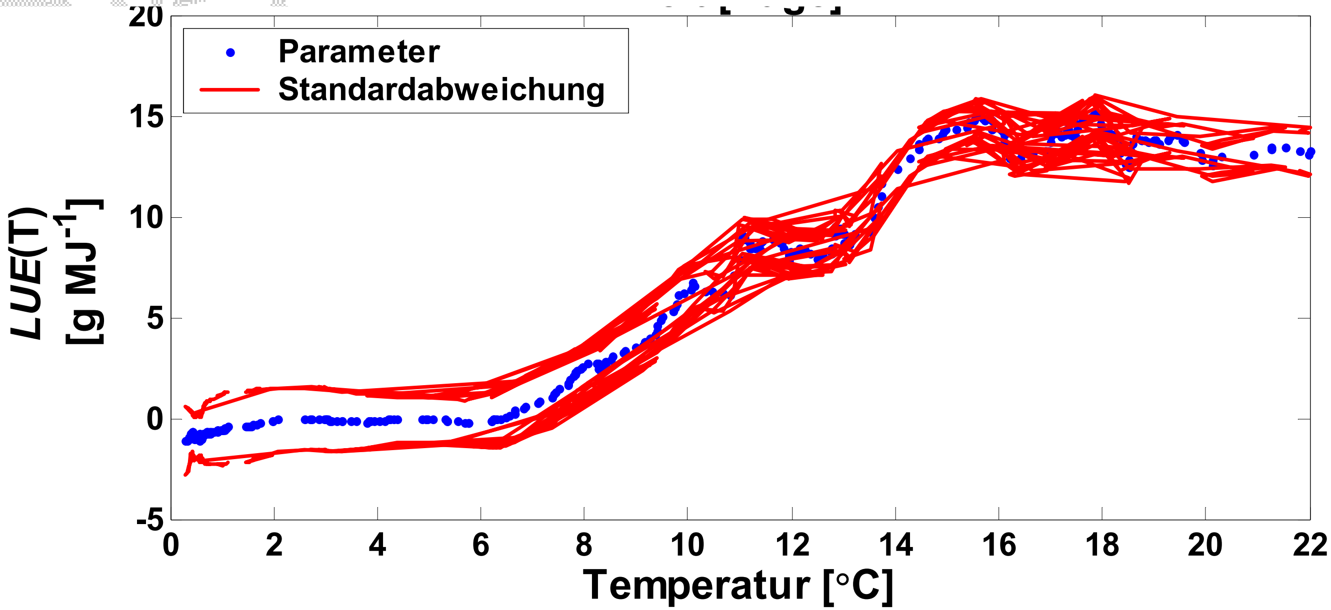
4. Time and State Dependence

CO_2, Havard Forest 1994:



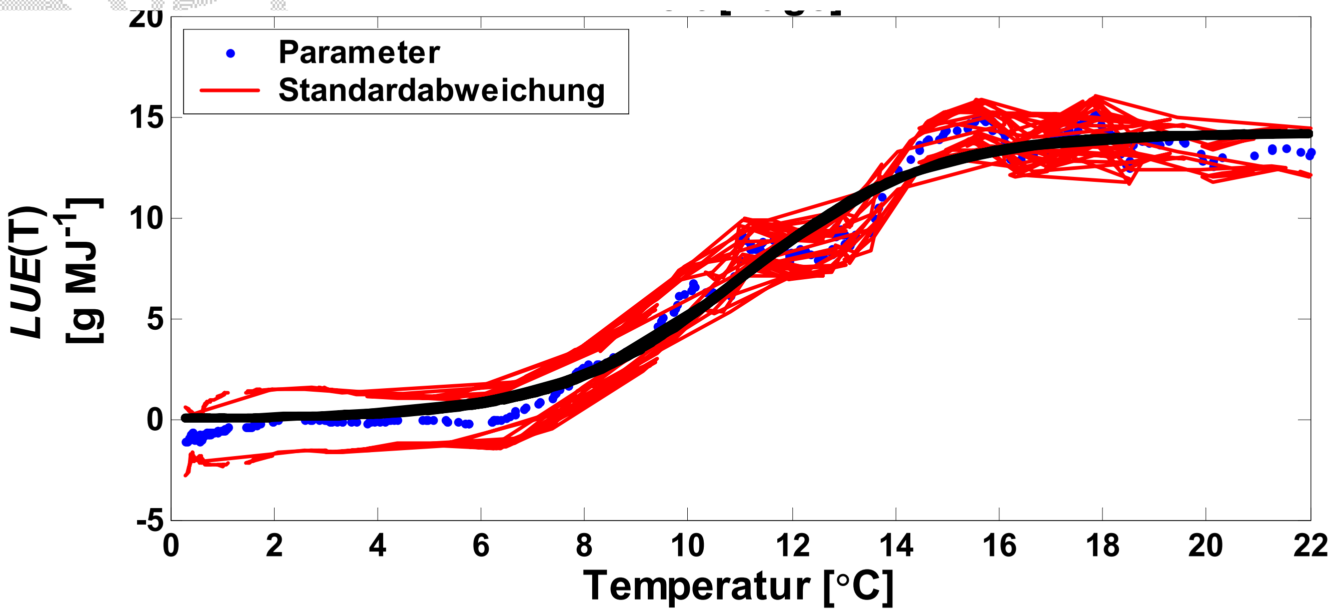
4. Time and State Dependence

CO_2, Havard Forest 1994:



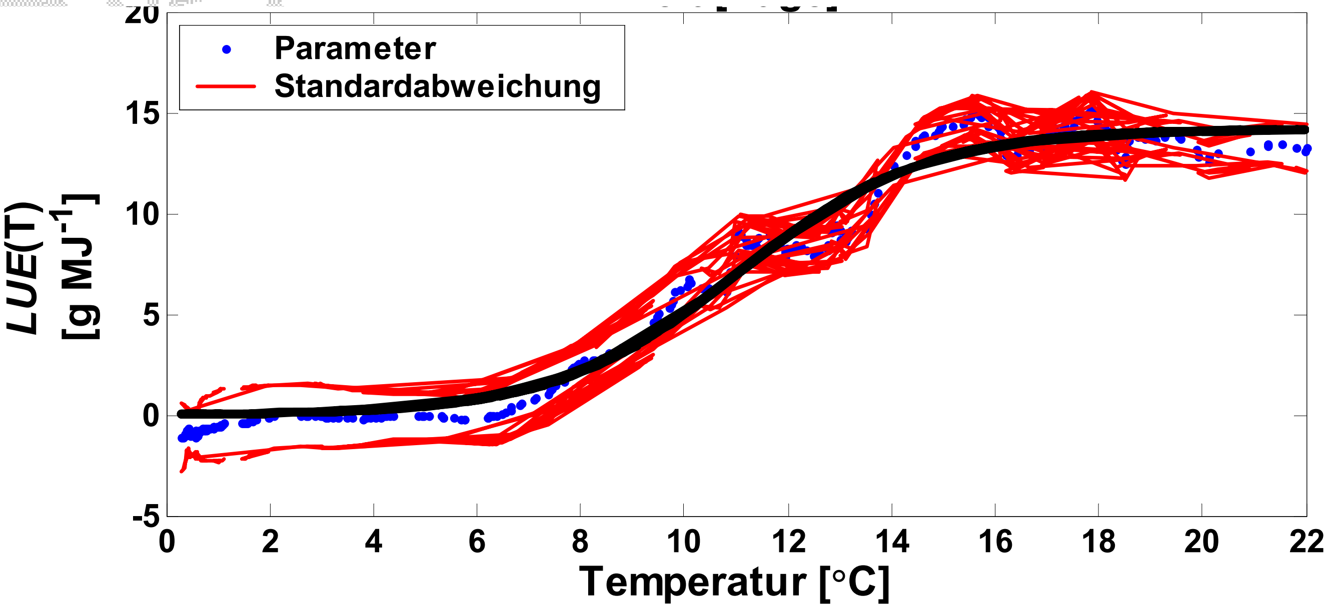
4. Time and State Dependence

CO_2, Havard Forest 1994:



4. Time and State Dependence

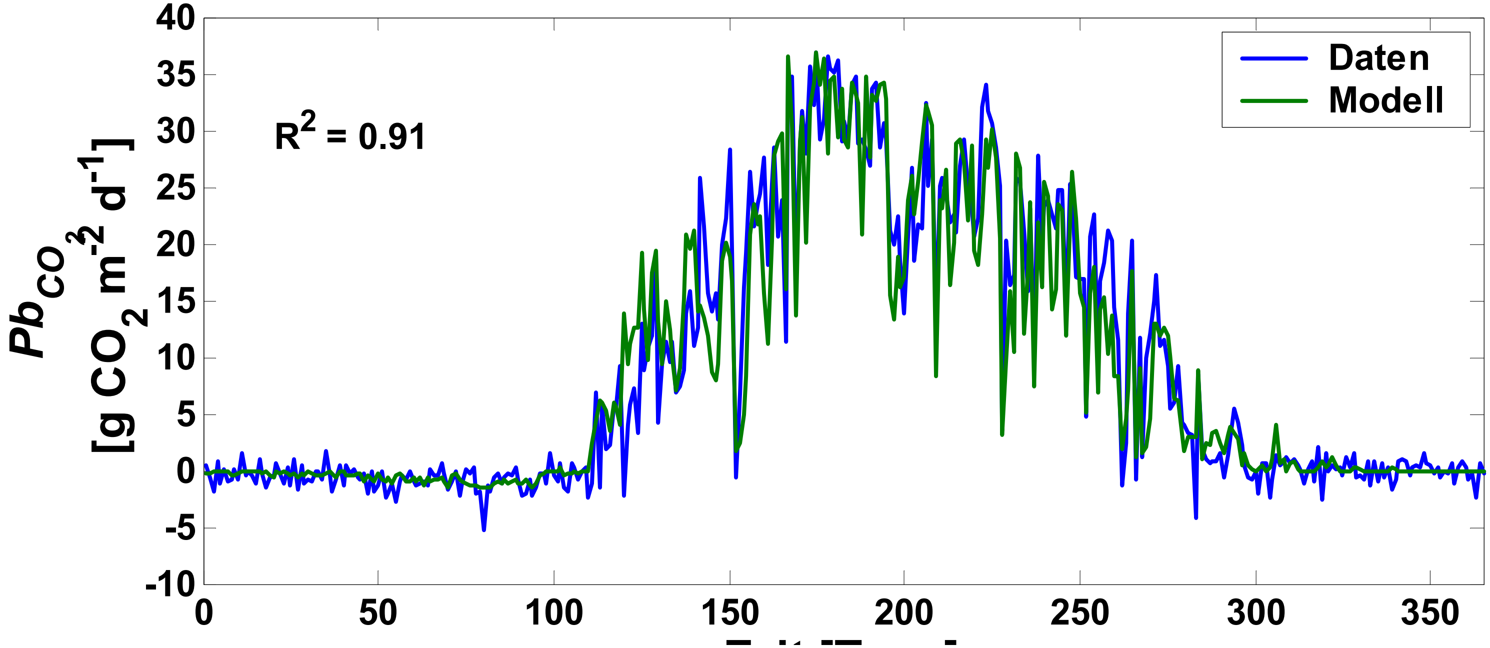
CO_2, Havard Forest 1994:



$$LUE(T_t) = \frac{LUE_{max}}{1 + e^{-k(T_t - T_{1/2})}}$$

5. Optimzation

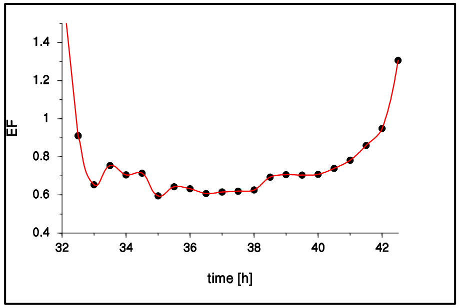
CO_2, Havard Forest 1994:



6. Physical Interpretation

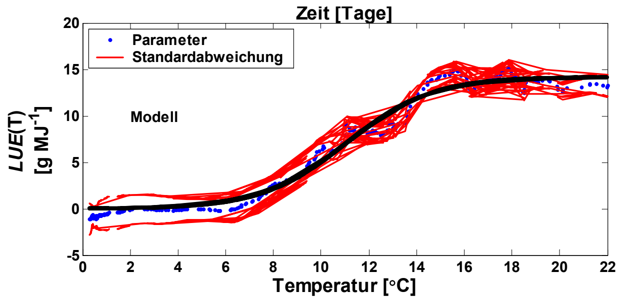
$$\lambda E(t) = EF(t) \cdot S_0(t) + \xi_{\lambda E}(t)$$

$$EF(t) = a_1 + a_2 \cdot LAI(t)$$

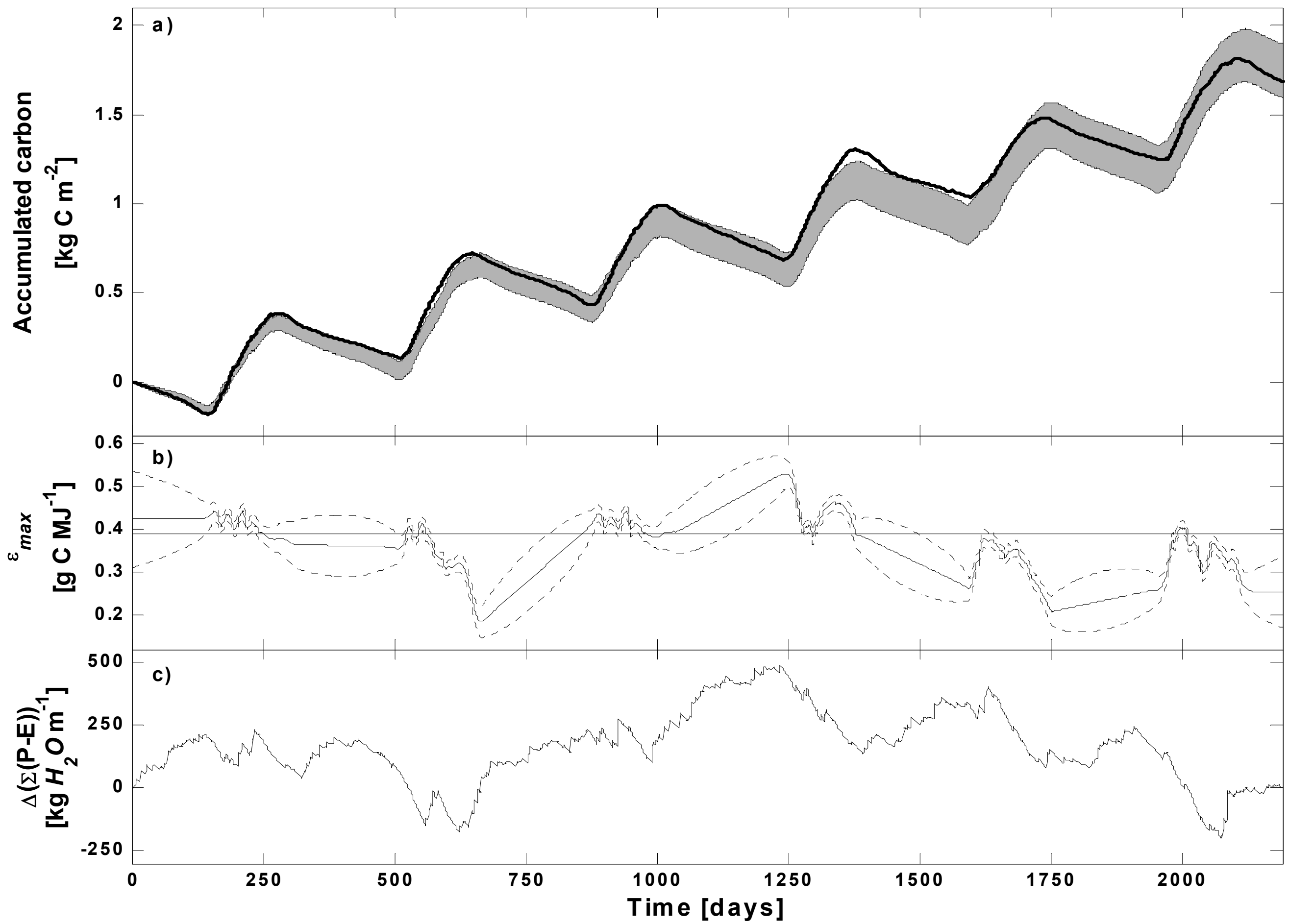


$$Pb_{CO_2}(t) = LUE(T_t) \cdot PAR(t) + \xi_{Pb}(t)$$

$$LUE(T_t) = \frac{LUE_{max}}{1 + e^{-k(T_t - T_{1/2})}}$$



7. Testing – “Validation”



Conclusions

- Data-based modelling strategies allow for identification:
  - Simplest possible structure
  - Effective parameter values
- Advantage for regionalization within PUB