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# Model optimization with the 5PM model

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1. Why this model, while there are so many already?
   - Simple and fast
   - 5PM = 5 Parameter Model
   - Flexible time steps
   - Fast for optimization and Monte Carlo simulations

2. Some routines/processes added for LBA-MIP
   - Previously focus on photosynthesis and transpiration relations
   - Comparison with other models
   - Influence of soil moisture

# Model overview

1. Estimate respiration from nighttime NEE
   - Radiation to determine nighttime
   - Temperature
   - Optimization of the Lloyd & Taylor (1994) model, $R_{ref}$ and $E_0$ parameters

2. Use GPP and LE to optimize the photosynthesis and transpiration (next slide)

3. Soil water can be limiting GPP and LE

## Optimizing the Photosynthesis and Transpiration Model

1. Optimize transpiration (E) and photosynthesis (A):

- $C_i = f(vpd, C_s, \mathit{WUE})$ (Cowan, 1977)
- $A = f(C_i, PAR, T, V_{cm}, \mathit{LUE})$ (Farquhar et al., 1980)
- $g = A/(C_s-C_i)$
- $E = f(g, vpd)$

2. Optimize E and A:

- *WUE* in equations above plus

3. Iterate step 1 and 2 till parameter values converge

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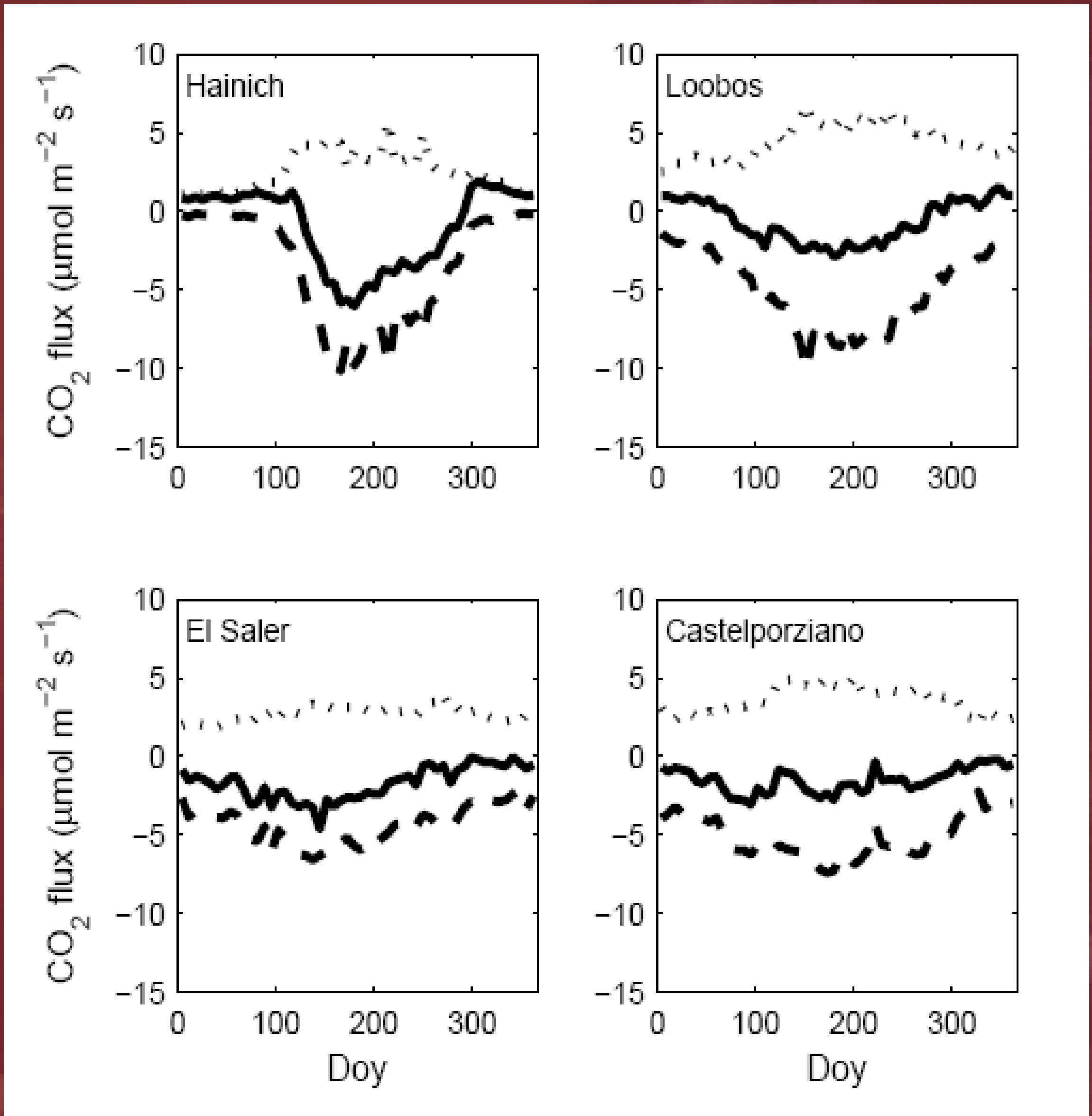
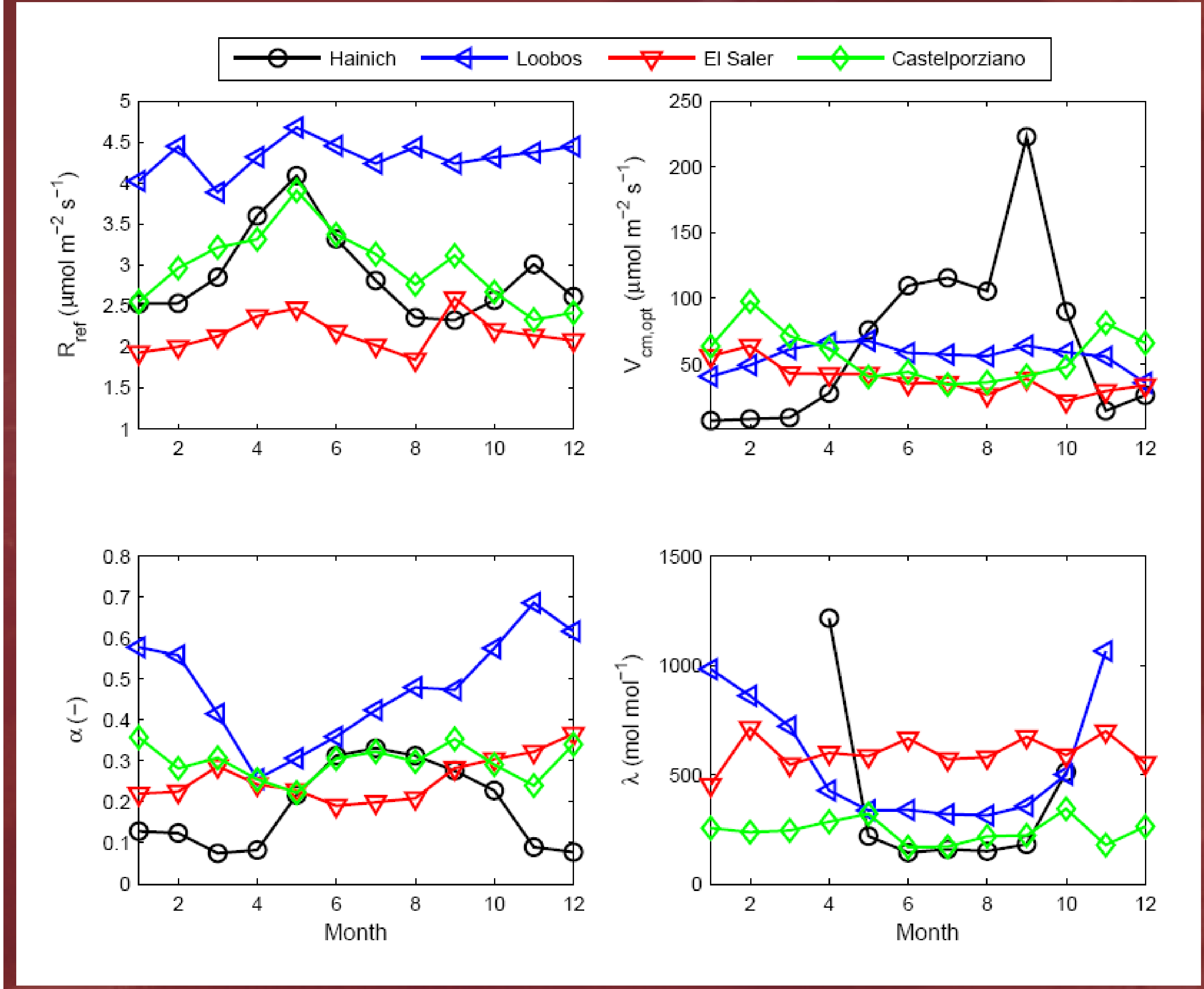
# Seasonality in European carbon fluxes



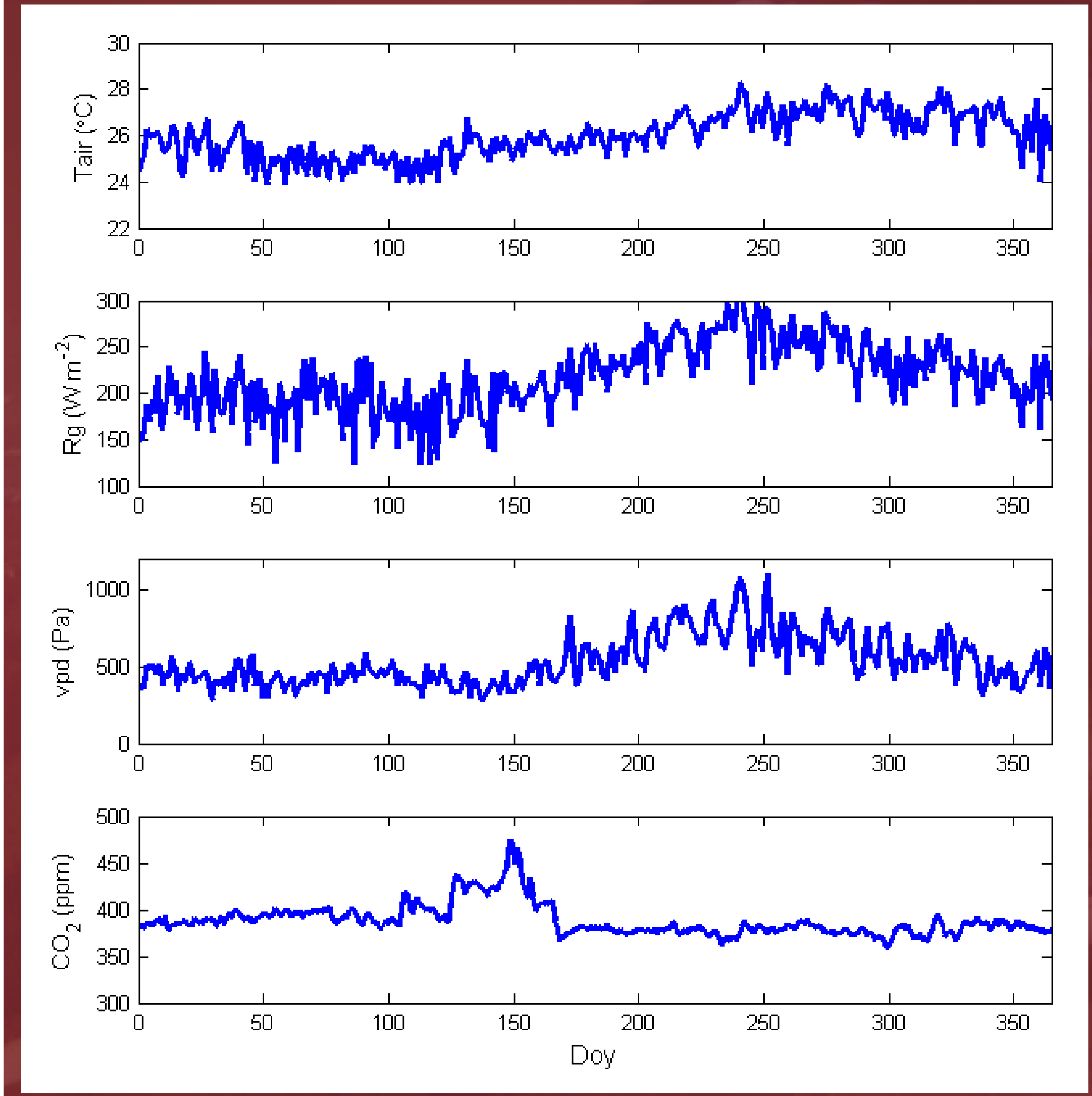

Weekly average showed

Fluxes partitioned with Lloyd & Taylor model, with weekly parameter timesteps

# Seasonal variation in Europe improved model results



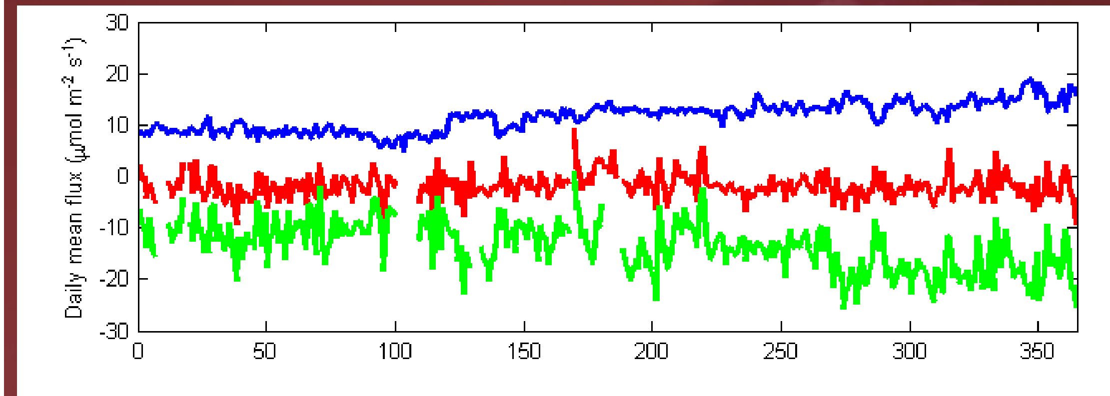
# Input data Manaus K34




Daily average showed

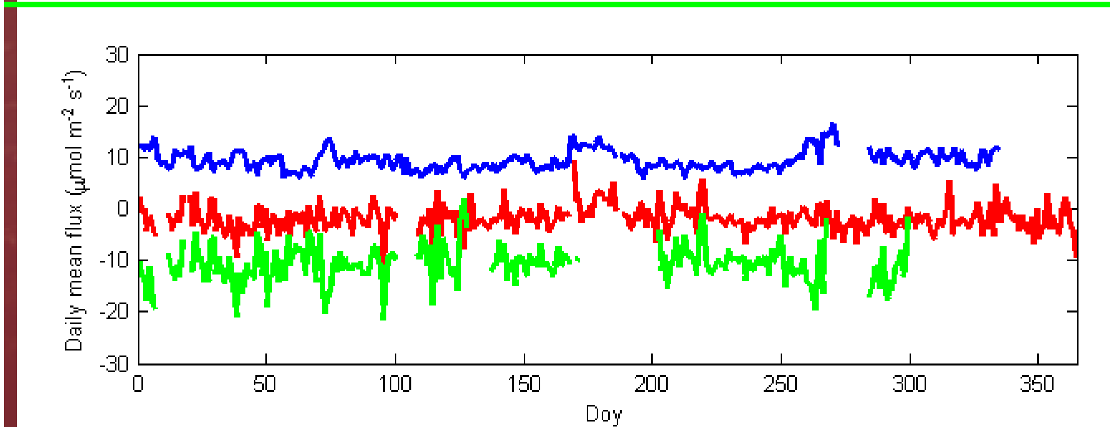
Model time step is one hour

# NEE = GPP + Re (Manaus)

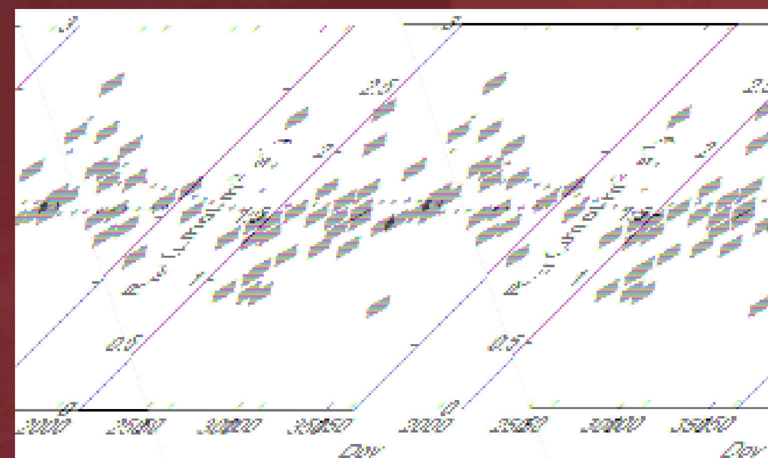



**Annual $R_{ref}$**

| | |
|---|---|
| 1999 | 2.53 |
| 2000 | 1.61 |
| 2001 | 2.14 |
| 2002 | 1.30 |




**Weekly $R_{ref}$**



$E_0$ = 450 K

# Difference between wet and dry season

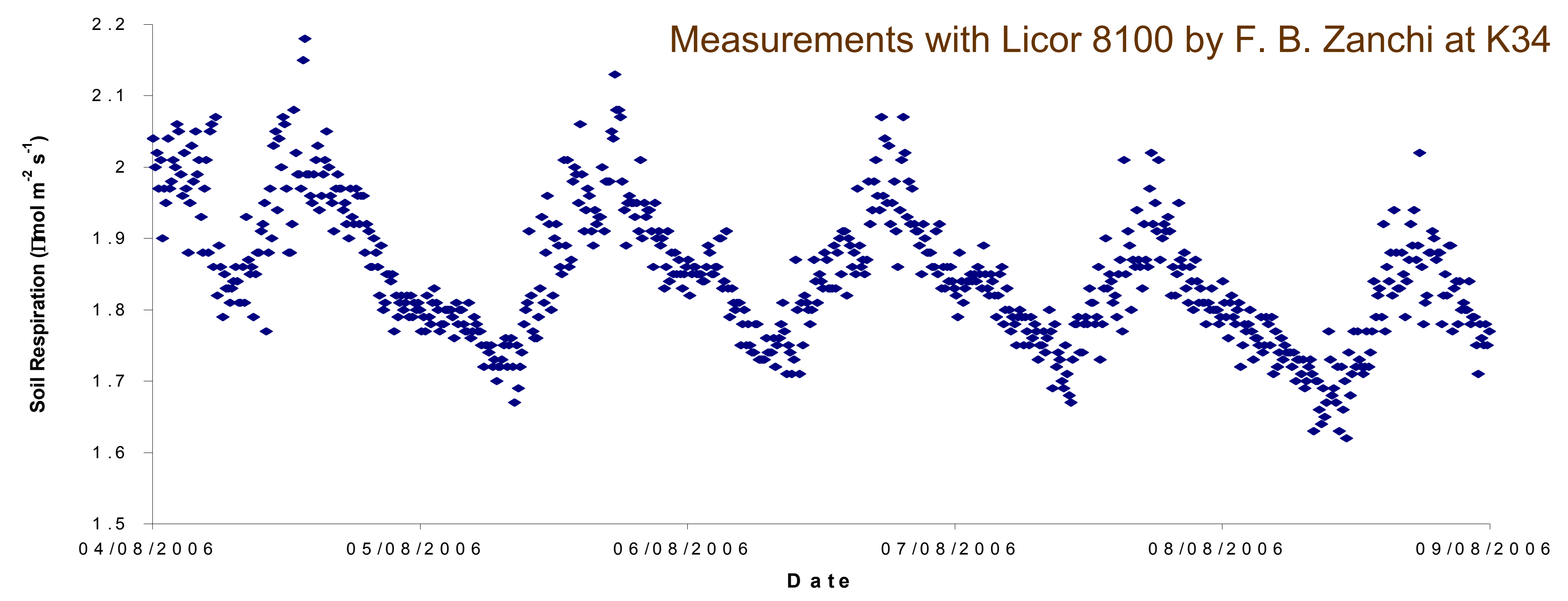
Dry season doy 152 until 273 (June - September):

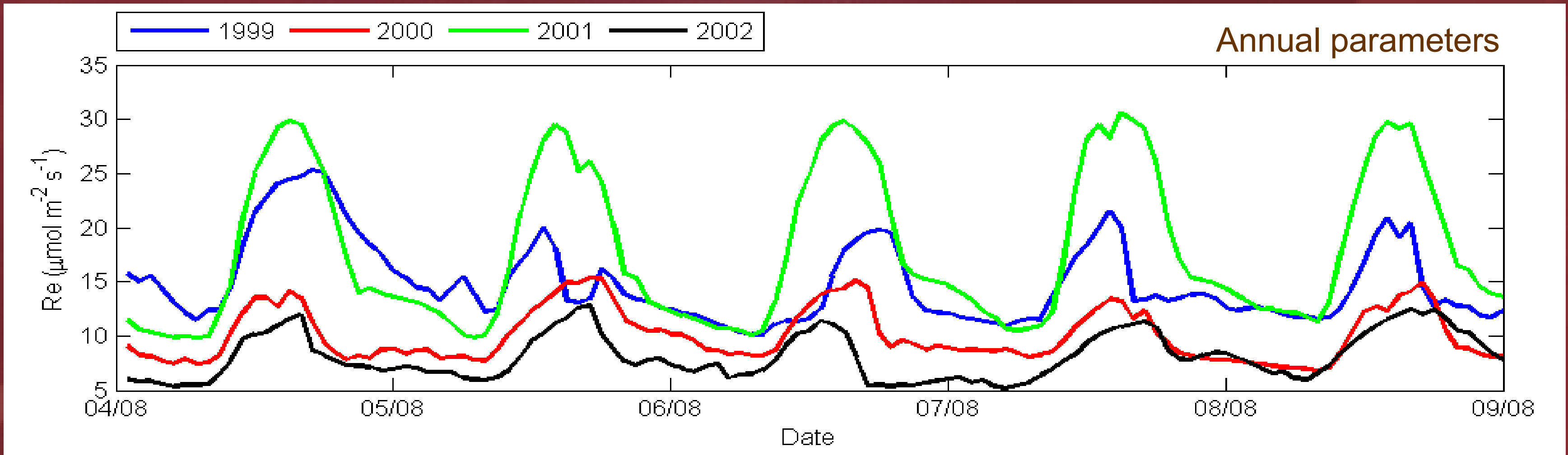
Rref = 1.54 ± 0.38

Wet season:

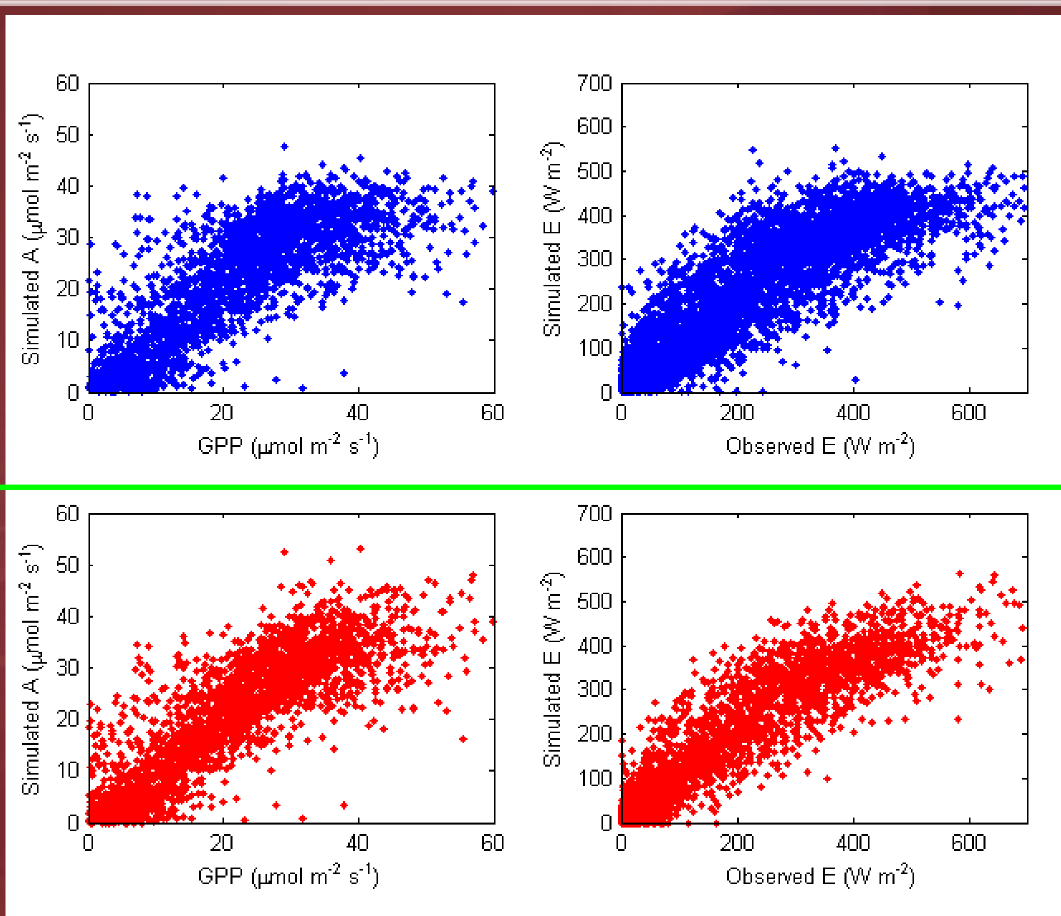
Rref = 1.64 ± 0.23

# Observed soil respiration and simulated Re



# Hourly photosynthesis and transpiration (Manaus)




**With annual parameters**

$r^2(A) = 0.75$

$r^2(E) = 0.86$

**With weekly parameters**

$r^2(A) = 0.70$

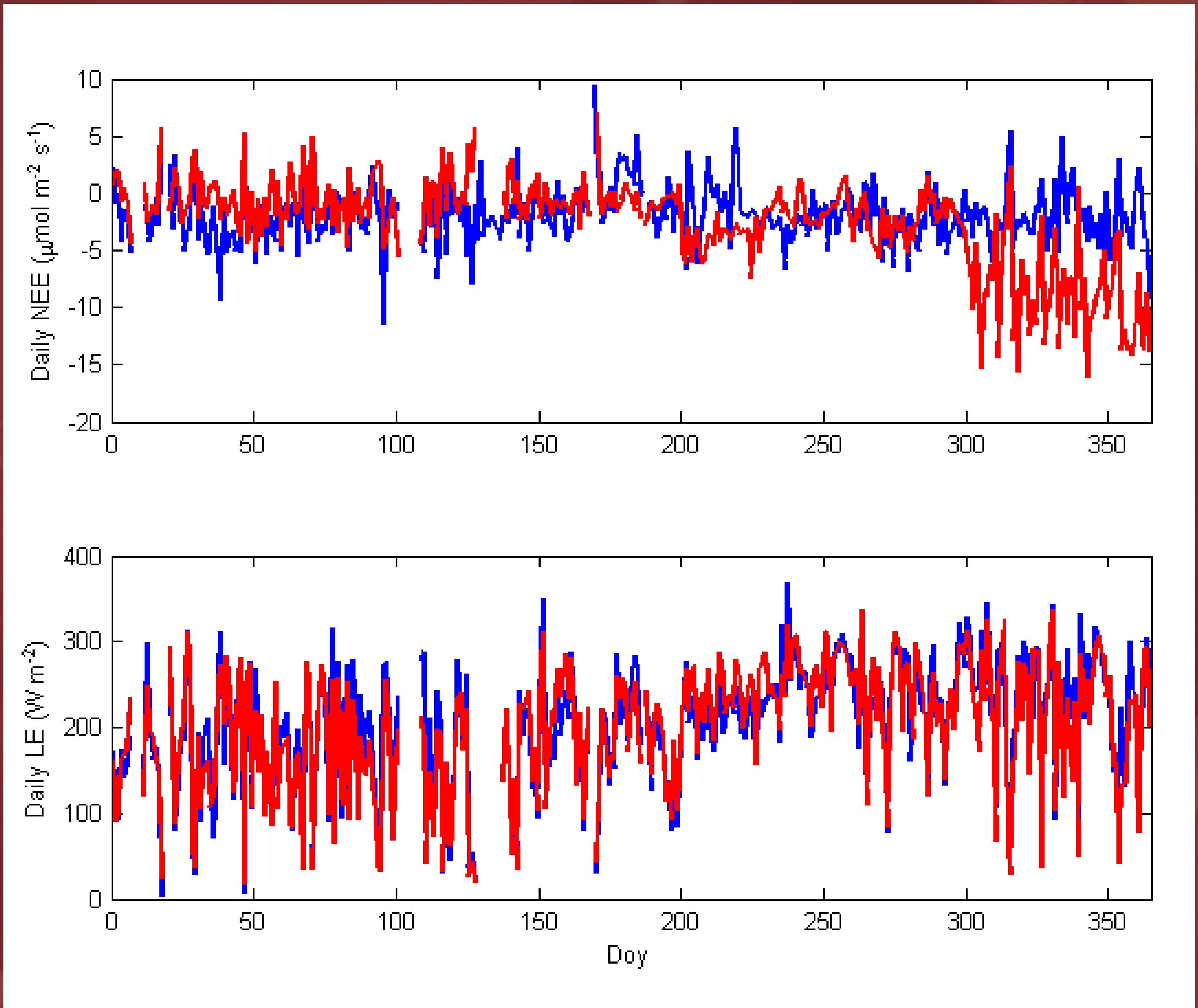
$r^2(E) = 0.89$

Example: Hainich

$r^2(A)$ 0.65 → 0.89

$r^2(E)$ 0.71 → 0.81

# Daily average fluxes

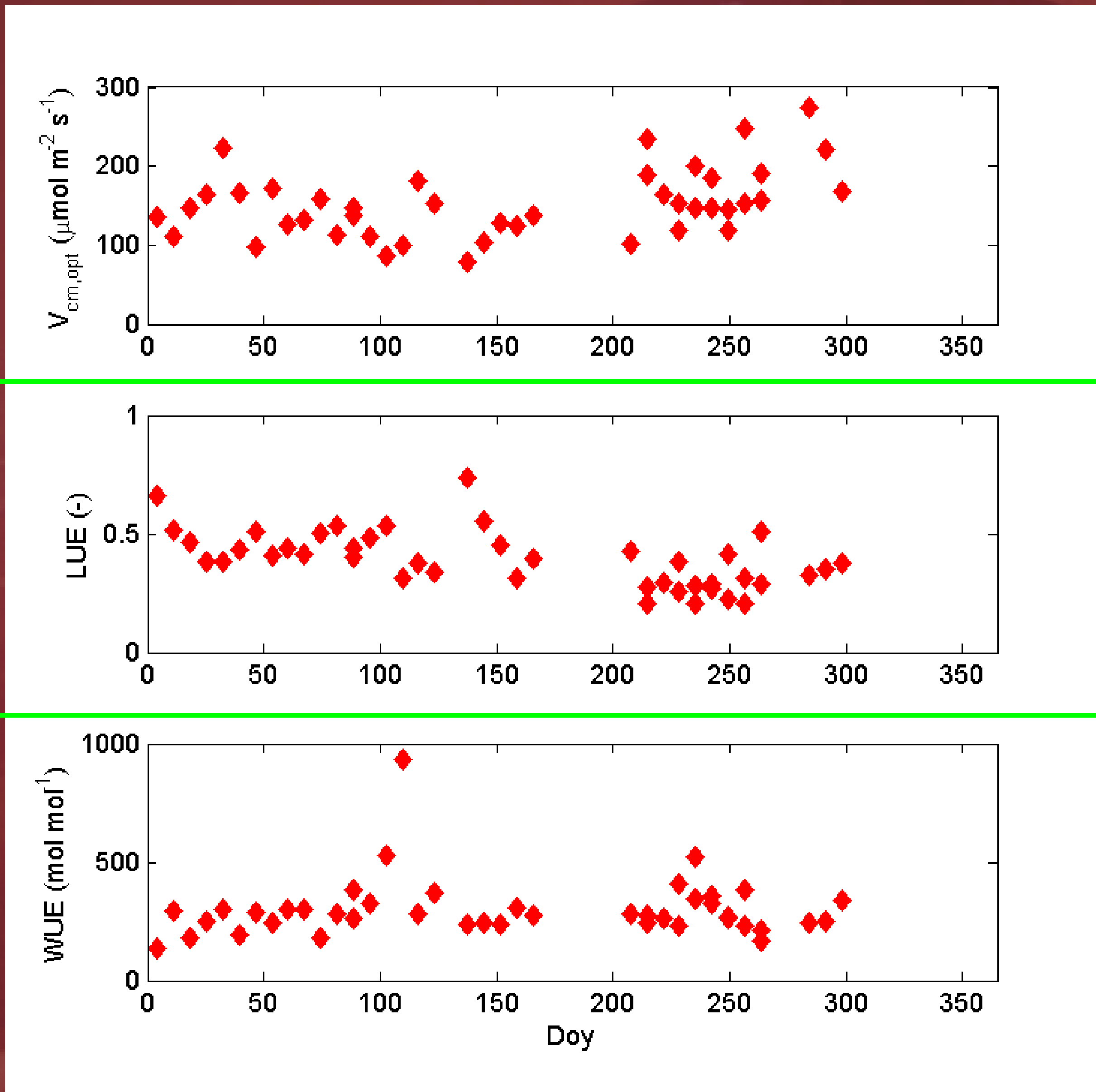



**Observations**

**Simulations**

**With annual parameters**

# Weekly parameters




| | |
|---|---|
| 1999 | 176 |
| 2000 | 143 |
| 2002 | 125 |

| | |
|---|---|
| 1999 | 0.54 |
| 2000 | 0.41 |
| 2002 | 0.35 |

| | |
|---|---|
| 1999 | 161 |
| 2000 | 258 |
| 2002 | 291 |

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Dry season doy 152 until 273 (June - September):

| | |
|---|---|
| Vcm,opt | = 160.0 ± 39.3 |
| LUE | = 0.32 ± 0.09 |
| WUE | = 295 ± 81 |

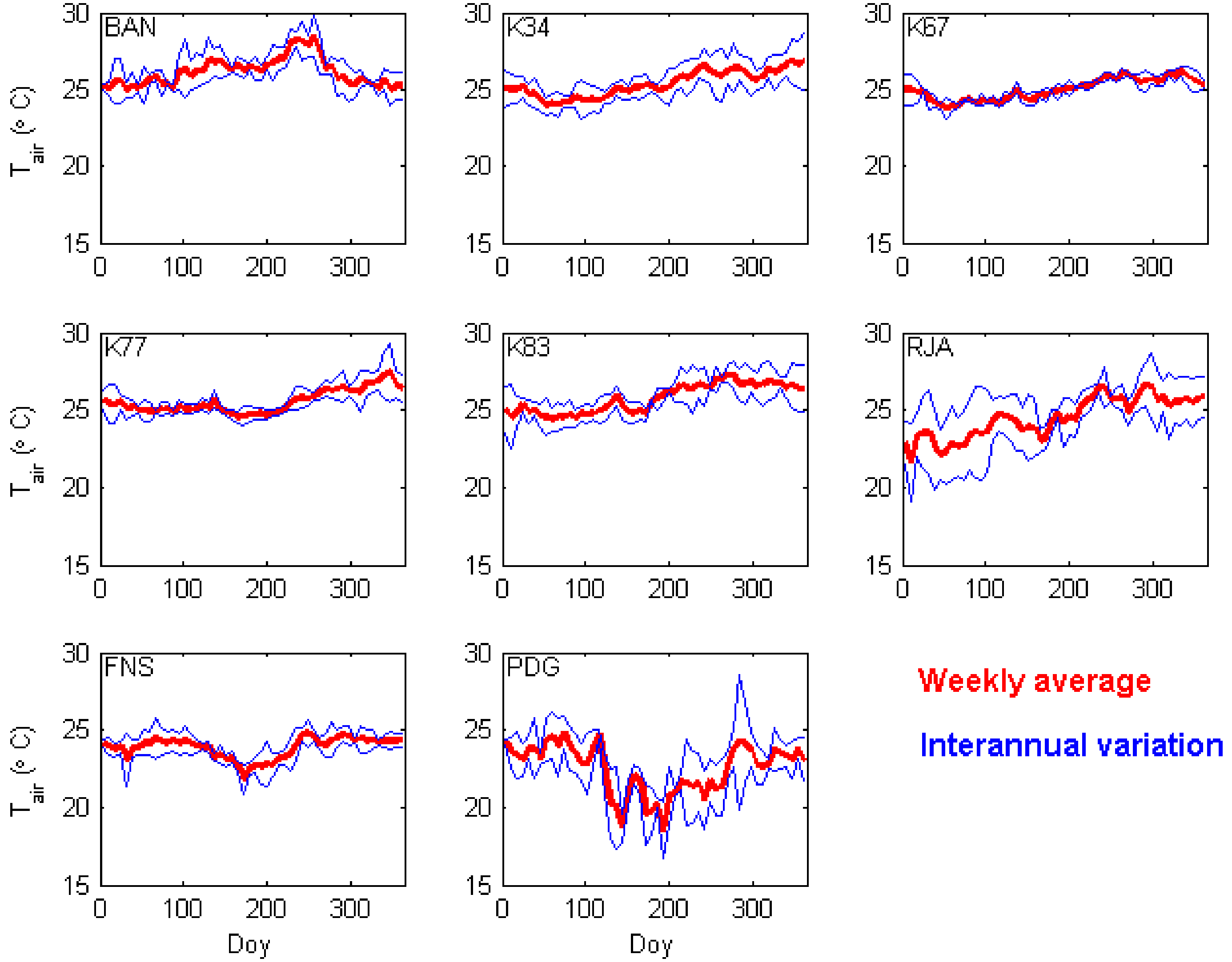
Wet season:

| | |
|---|---|
| Vcm,opt | = 146.2 ± 46.6 |
| LUE | = 0.45 ± 0.10 |
| WUE | = 306 ± 155 |

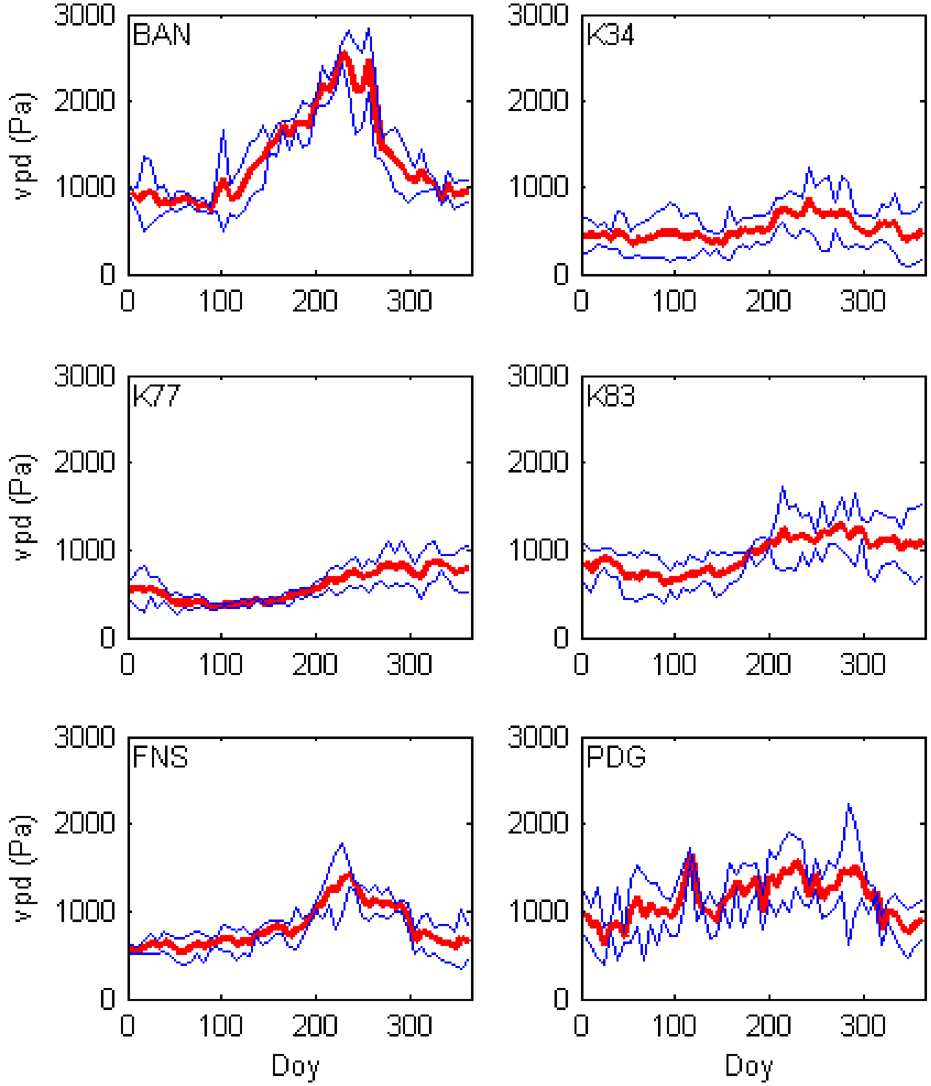
# 5PM (5 Parameter Model)

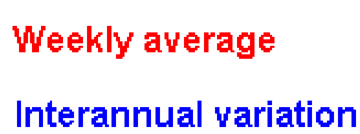
1. Radiation balance
2. Ecosystem respiration
3. Potential photosynthesis and transpiration (atmospheric demand)
4. Vegetation interception
5. Soil moisture, infiltration, soil evaporation, root uptake, drainage
6. Actual photosynthesis and transpiration (soil water limited)
7. Sensible heat and vegetation temperature

# Air temperature



# Vapour pressure deficit



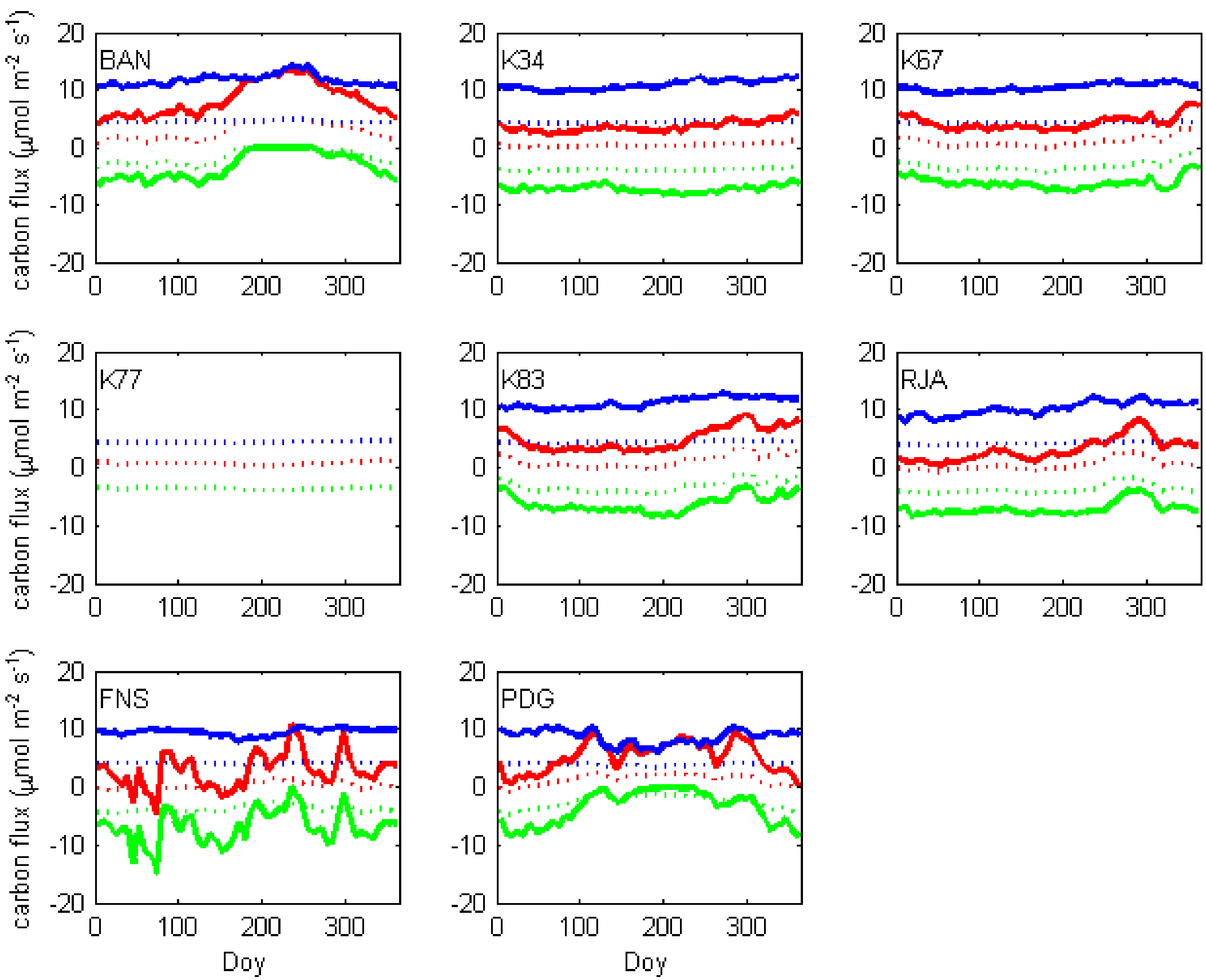



# Model parameters

| | Initial | After optimization |
|---|---|---|
| $E_0$ | 200 | 450 K |
| $R_{ref}$ | 2.0 | 1.9 μmol $m^{-2}$ $s^{-1}$ |
| $V_{cm,opt}$ | 50 | 148 μmol $m^{-2}$ $s^{-1}$ |
| LUE | 0.40 | 0.43 |
| WUE | 1000 | 237 mol $mol^{-1}$ |

No clear seasonality of the parameters found
Constant values used for all sites

# NEE = GPP + Re

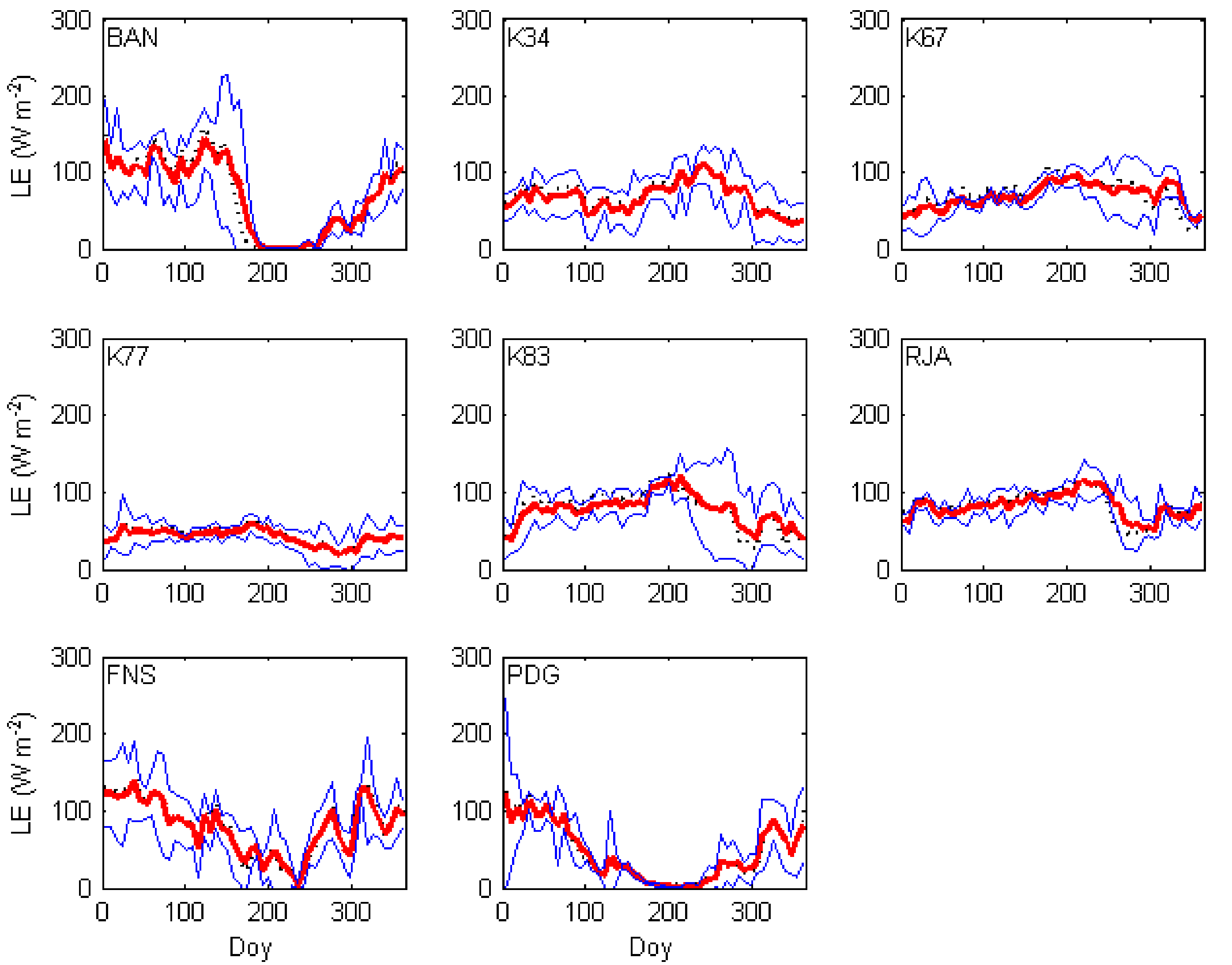



…. First calculations

---- After optimization

Limitation by soil water visible

Very sensitive to parameters

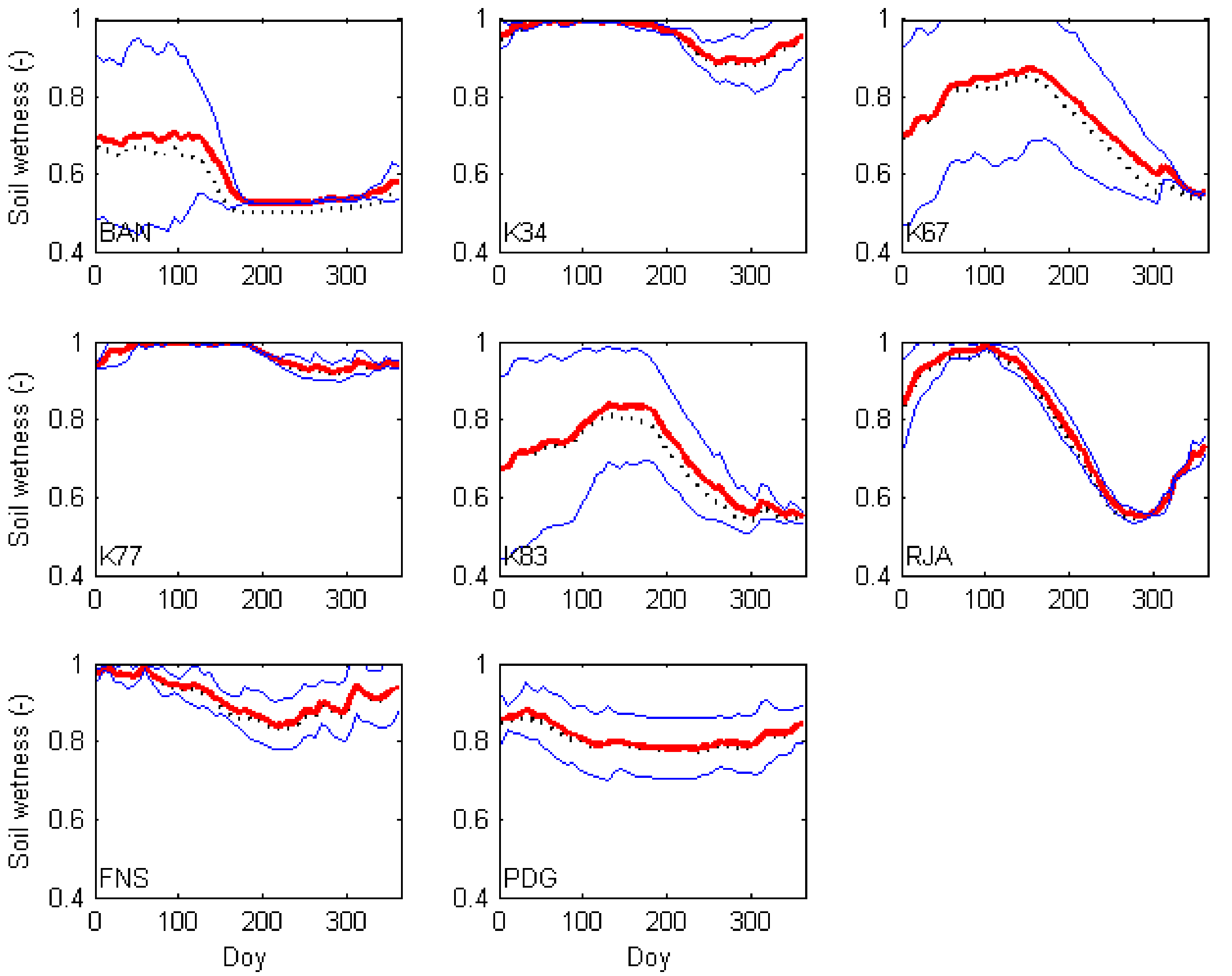



.... First calculations

---- After optimization

Not very sensitive to parameters

# Soil wetness




…. First calculations

---- After optimization

# How to go to regional parameters

- Optimized parameters of Manaus are most likely not valid at other sites
- Try to derive parameters for all 8 sites
- Look for relations between parameters and environment (climate, soil, vegetation…) across sites
- Use these relations to scale to whole region

# Conclusions

- Model parameters do not show seasonality for K34 tower. Single values can be used.
- Seasonality is simulated by soil water limitations
- Respiration is process most difficult to model, with largest uncertainties
- Carbon fluxes are more sensitive to model parameters than water fluxes

- Method can be useful to define regional parameters

# Acknowledgements


- Bananal Island: Borma, Cabral, Collicchio, Rocha
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- Santarem K67: Camargo, Saleska, Wofsy
- Santarem K77: Fitzjarrald, Moraes
- Santarem K83: Goulden, Miller, Rocha
- Reserva Jaru: Cardoso, Manzi
- Fazenda Nossa Senhora: Cardoso, Manzi
- Reserva Pe de Gigante: Rocha