Long term carbon dioxide exchange above a mixed forest in the Belgian Ardennes: evaluation of different approaches to deduce total ecosystem respiration from Eddy covariance measurements

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1. DATA BASE

- **11 complete years** (1997 to 2008) of CO_2 flux measurements at the Vielsalm forest site (Belgium).
- Mixed forest: Beech, Douglas fir, Spruce.

2. OBJECTIVES

- **Long term:** to analyze inter annual net flux (Total Ecosystem Respiration-TER and Gross Primary Productivity-GPP) variability.
- **This study:** to compute TER and compare different estimation approaches and procedures.

3. DATA TREATMENT

- Only original flux data (not gap-filled).
- Stationary and u_* filtering.
- Night and Day data discrimination based on PPFD criterion.
- Data of 2006 discarded for technical reasons.

4. METHODS: Flux-partitioning approaches

Extrapolation of respiration to the entire day from a limited data set:

2 approaches

Night-time approach (TER_N)

- Based on half-hourly night-time values (Reichstein et *al.*, 2005).
- 2 procedures based on:
  - ✓ long term data ($TER_{N,LT}$),
  - ✓ short term data ($TER_{N,ST}$).
- 2 temperatures for data extrapolation:
  - ✓ Air temperature (TA),
  - ✓ Soil temperature (TS).

Daytime approach (TER_D)

- Based on intercept of NEE/PPFD response during day (Wohlfahrt et *al.*, 2005).
- 2 models to fit NEE/PPFD:
  - ✓ Linear ($TER_{D,LR}$),
  - ✓ Mitscherlich ($TER_{D,MR}$).
- 2 temperatures for data extrapolation:
  - ✓ Air temperature (TA),
  - ✓ Soil temperature (TS).

5. RESULTS: Annual Total Ecosystem Respiration estimates

A. Night-time approach

- All night-time procedures reproduce the same inter annual variability.
- Systematic differences between models lower than **7%**.
- Estimates based on TA are **7%** larger than those based on TS.
- "Long term" estimates **3%** larger than "short term" estimates.

B. Daytime approach

- All daytime methods reproduce fairly interannual variability.
- Systematic difference between procedures can reach **25%**.
- Impact of temperature is limited and depends on the model.
- Impact of the model varies from 2% to **25%**.

C. Comparison of the two approaches → *Figure 1*

- The two approaches do not give the same interannual variability.

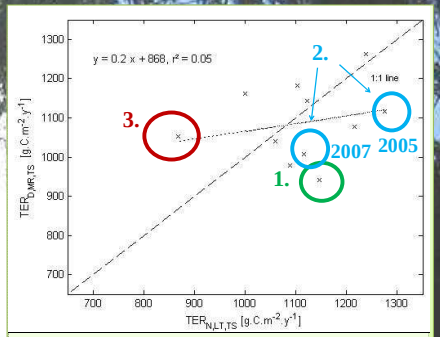

Fig. 1: Relationship between TER calculated using the night-time (TER_N) or the daytime approach (TER_D). Dots show mean annual values of TER; solid line show linear regression; and dashed line show 1:1 relationship.

→ ***Figure 1***

- **No correlation** between annual TER_D and TER_N values.
- Approaches are also **not consistent in their ranking** of annual values.
- Annual differences ranged from 2% in 2008 (20 g.C.m^{-2}) to 18% in 1998 (205 g.C.m^{-2}).

→ **The night-time and the daytime approaches give disagreeing pictures of TER inter-annual variability.**

→ **The choice of the approach alters understanding of TER inter-annual variability.**

D. Monthly differences between approaches

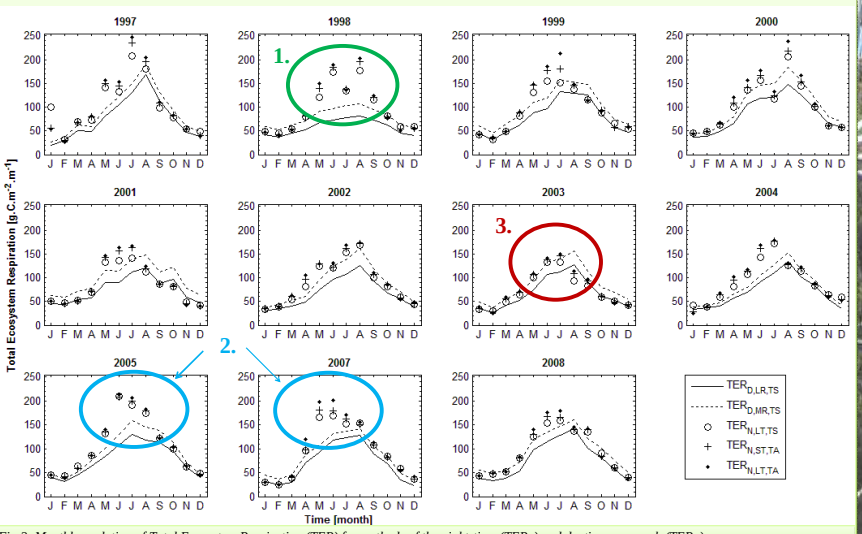

Fig.2: Monthly evolution of Total Ecosystem Respiration (TER) for methods of the night-time (TER_N) and daytime approach (TER_D).

Possible causes of differences (Figure 2):

1. Unexpected TER_D evolution during summer 1998

- Probably due to the respiration response to temperature used for the extrapolation in the daytime approach.

2. Monthly TER_N values particularly high in Summer 2005 and 2007

- With some night-time methods, daily maximal TER_N values could reach 16 g.C.m^{-2}.d^{-1}, which is not plausible for a forest site.
  - → Overestimation of R_{10} in the night-time approach?
  - → Problems of extrapolation from night to day conditions?

3. Decrease in TER_N in August 2003

- Underestimation of R_{10} in the night-time approach?

6. PERSPECTIVES

- Necessity to better understand the reasons why approaches differ in their estimations of TER.

→ To define the best approach to obtain a robust TER estimate → GPP.

→ To link TER interannual variability with the variability of climatic conditions.

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