Comparing semi-parametric models for partitioning incident photosynthetically active radiation into its direct and diffuse component

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Problem
The diffuse fraction of photosynthetic proton flux density (PPFD) presents an advantage over its direct component for canopy photosynthesis for a given quantity of total PPFD [*Gu, et al.*, 2002; *Gu, et al.*, 2003; *Gu, et al.*, 1999]. However, many FLUXNET sites do not measure the diffuse component of PPFD, or have not measured it continuously. It is uncertain which existing models for partitioning PPFD, or improvements thereon, are ideal for quantifying the impacts of solar radiation on the terrestrial carbon cycle across space and time.

Aims and Approach
Determine which 'semi-parameteric' model for estimating the direct / diffuse ratio of PPFD shows the best fit to data across FLUXNET research sites, and suggest improvements to these model if applicable. 'Semi-parametric' models are those that use simple functions to model atmospheric transmissivity (τ). This class of models has been chosen because the required inputs are (usually) available from FLUXNET sites.

Co-authorship strategy
Members of the 'radiation' working group at the FLUXNET meeting are welcome as coauthors provided that they provide academic input or data for the analysis. The group members who expressed the most interest are listed above. Any collaborator wishing to provide radiometer data not in the FLUXNET database, or any FLUXNET member who is willing to provide substantial intellectual input to the analysis is also welcome as a co-author. If a site PI would rather their data not be used in the synthesis activity, data from their site will not be analyzed.

A brief outline with sample figures and tables is included below to demonstrate that basic progress has been undertaken on this project. This includes a partial (European-only) list of sites that have the necessary measurements to perform the proposed analysis.

Note 1: The data, particularly the quality control flags, need to be closely examined as there are many instances of spurious diffuse radiation data. I can help provide a small MATLAB program to automatically flag data and share this code with Viterbo. Hopefully these flags can be incorporated into the FLUXNET data as a whole to aid in future analyses.

Note 2: At the present, only data from European sites are available. Data from other FLUXNET sites will be included in the analysis when they are incorporated into the database.

Outline

1. Abstract

2. Introduction
    a. Introduce problem:
        i. importance of diffuse radiation in controlling long-term C flux
        ii. not all sites measure diffuse radiation, or have not throughout the lifetime of the research site
            1. reanalysis of existing FLUXNET data is critical for advancing our knowledge of the terrestrial carbon and water cycles. A global analysis of the effects of direct / diffuse radiation on canopy photosynthesis would be forthcoming (note ongoing work by Cescatti and others).
    b. Many simple models for partitioning direct / diffuse PPFD exist
        i. FLUXNET provides the opportunity to test these models across space and time.
        ii. *what is the best (i.e. simplest and best – fitting) model for direct / diffuse radiation (e.g. PPFD) for application across FLUXNET*
        iii. Do temporal / spatial model biases exist? why?
            1. models generally created in temperate zone / pollution-free skies
            2. will these relationships hold in non-temperate and / or polluted skies?

3. Methods
    a. 'Semi-parametric' models (Table 1, forthcoming)
        i. [*Erbs, et al.*, 1982]
        ii. [*Weiss and Norman*, 1985]
        iii. [*Spitters, et al.*, 1986]
    b. Sites (Table 2)
        i. Note: only European data is in the FLUXNET database at the present.
    c. Sensors used at different sites? (Table 2)

4. Results
    a. R^2 and/or modeling efficiency (EF) for different models and sites (see Fig. 1)
        i. Example of data analysis procedure (Figure 2)
    b. ability to capture long-term sums (e.g. Fig. 2)
    c. r^2 vs. averaging interval (Figure 3)
    d. Comparison of models
    e. Kriged EF / r^2 map
        i. Are there obvious latitudinal or likely air pollution related biases?

5. Discussion
    a. which model works best and why?
    b. tendency for long-term sums to be better (e.g. Fig. 3) due to high EF (low bias, error) despite high r^2 due to difficulty capturing half-hourly variability.
    c. (likely) recommendation that models be used for long-term studies, not short-term dynamics, and a brief discussion of error
    d. Improvements on existing models depending on outcome.

Table 2: Sites (*momentarily Europe only*)

Site Abbrev.	Country	Site Name	Sensor(s)	Years	Lat	Long
ATNeu	Austria			2002-2005	NaN	NaN
BELon	Belgium	Lonzee		2004-2005	50.55219	4.74494
CHOe2	Switzerland	Oensingen2 crop		2005	47.28628	7.73433
CZBK1	Czech Republic	Bily Kriz- Beskidy Mountains		2005	49.50263	18.53842
DEGeb	Germany	Gebesee		2004	51.1001	10.9143
DEHai	Germany	Hainich		2004	51.07927	10.452
DEMeh	Germany	Mehrstedt1		2003-2005	51.27531	10.65547
DETha	Germany	Tharandt- Anchor Station		2004-2005	50.96361	13.56694
DEWet	Germany	Wetzstein		2004-2005	50.4535	11.45753
DKLva	Denmark	Lille Valby (Rimi)		2005	55.68333	12.08333
DKSor	Denmark	Soroe- LilleBogeskov		2004-2005	55.48694	11.64583
ESES2	Spain	El Saler-Sueca		2005	39.27553	-0.31522
ESLMa	Spain	Las Majadas del Tietar		2004-2005	39.9415	-5.77336
FIHyy	Finland	Hyytiala		2003-2005	61.84742	24.29477
FIKaa	Finland	Kaamanen wetland		2005	69.14069	27.29503
FRAur	France	Aurade		2005	43.54944	1.10778
FRFon	France	Fontainebleau		2005	48.47634	2.78015
FRGri	France	Grignon		2005	48.84404	1.95243
FRHes	France	Hesse Forest- Sarrebourg		2004-2005	48.67422	7.06462
FRLam	France	Lamasquere		2005	43.49333	1.23722
FRLBr	France	Le Bray		1998, 2003,2005	44.71711	-0.7693
FRPue	France	Puechabon		2000-2005	43.74139	3.59583
HUBug	Hungary	Bugacpuszta		2002-2005	46.69113	19.60133
IECa1	Ireland	Carlow1		2004-2005	55.85879	-6.91814
ITAmp	Italy	Amplero (after 6/28/2004)		2002-2005	41.9041	13.60516
ITBCi	Italy	Borgo Cioffi		2005	40.52375	14.95744
ITCol	Italy	Collelongo- Selva Piana		2004-2005	41.84944	13.58806
ITCpz	Italy	Castelporziano		2004-2005	41.84944	13.58806
ITLav	Italy	Lavarone (after 3/2002)		2004	45.95526	11.28118
ITMBo	Italy	Monte Bondone		2003-2005	46.01466	11.04583
ITPT1	Italy	Zerbolo-Parco Ticino- Canarazzo		2004	45.20087	9.06104
ITRen	Italy	Renon/Ritten (Bolzano)		2004-2005	46.58778	11.43472
ITRo1	Italy	Roccarespampani2		2004-2005	42.39026	11.92093
ITRo2	Italy	Roccarespampani1		2004	42.40812	11.93002
ITSRo	Italy	San Rossore		2004	43.72972	10.28694
NLLoo	Netherlands	Loobos		2004-2005	52.16786	5.74396
NLMol	Netherlands			2005	NaN	NaN
PLWet	Poland	Polwet		2005	52.76222	16.30944
PTMi1	Portugal	Mitra (Evora)		2004	38.5407	-8.0004
PTMi2	Portugal	Mitra IV Tojal		2004-2005	38.47654	-8.02455
SENor	Sweden	Norunda		2005	60.08622	17.49883

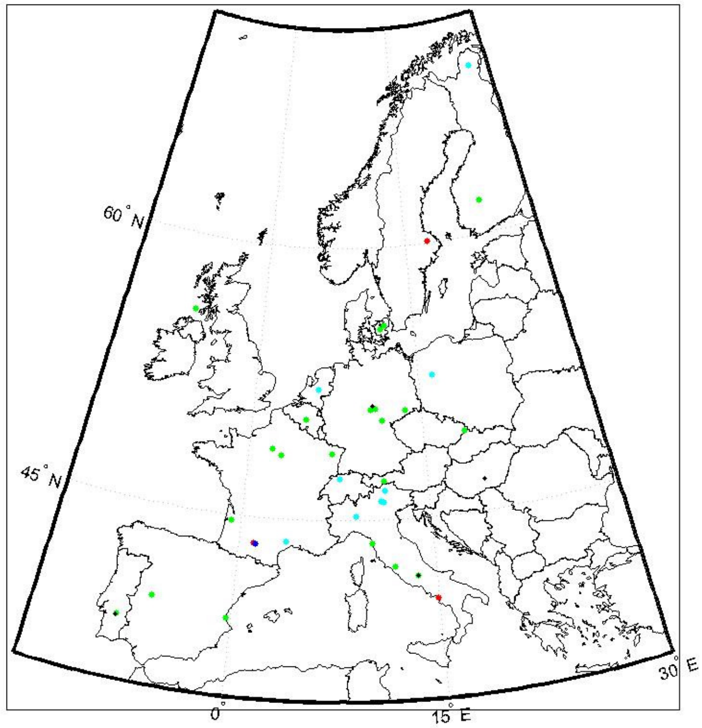

Figure 1: Locations of the European FLUXNET sites that measure direct and diffuse PAR. (*Note: color is currently r^2 for the Erbs model, but due to spurious qc flags, these are not the final results and I do not mention what the colors represent. Note also that there are currently only European data in the FLUXNET record.)*

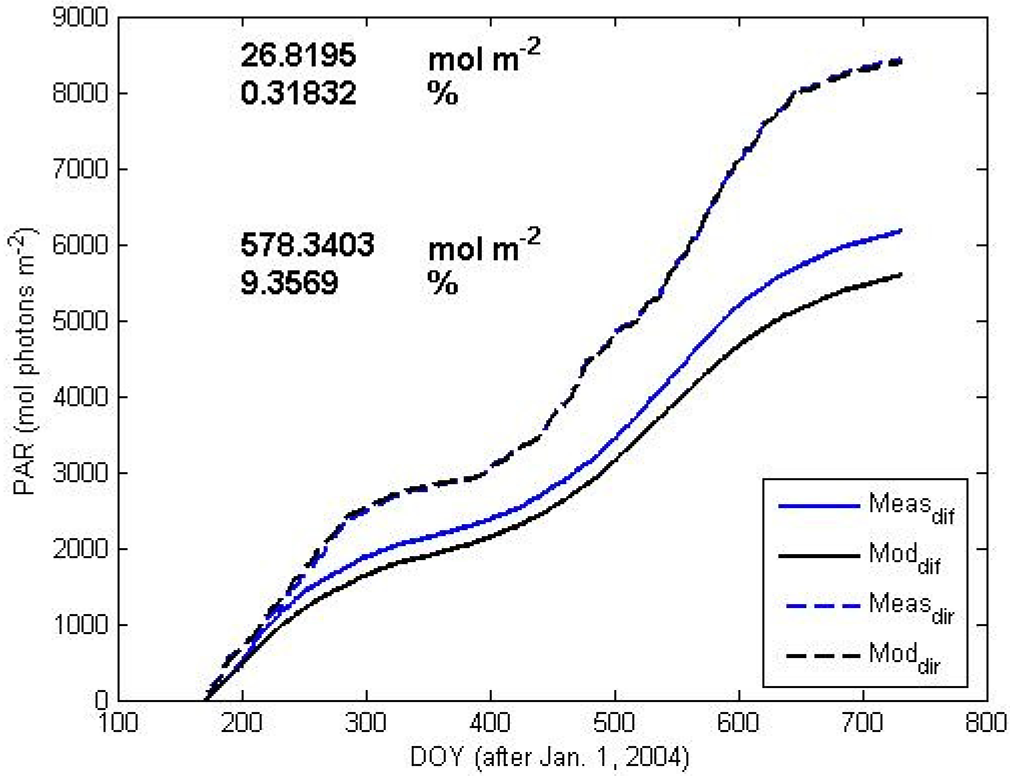

Figure 2: An example of the ability of a model (in this case the Erbs model) to accurately replicate the direct (if not diffuse) component of PPFD over annual time scales. These data are from Bartlett.

The cumulative sum of measured and modeled diffuse (solid lines) and direct (dashed lines) PAR over the June 18 2004 to Dec. 31, 2005 measurement period at Bartlett. In both cases, the top number is the difference in total PAR over the measurement period and the bottom number is the percent difference between measured and modeled PAR.

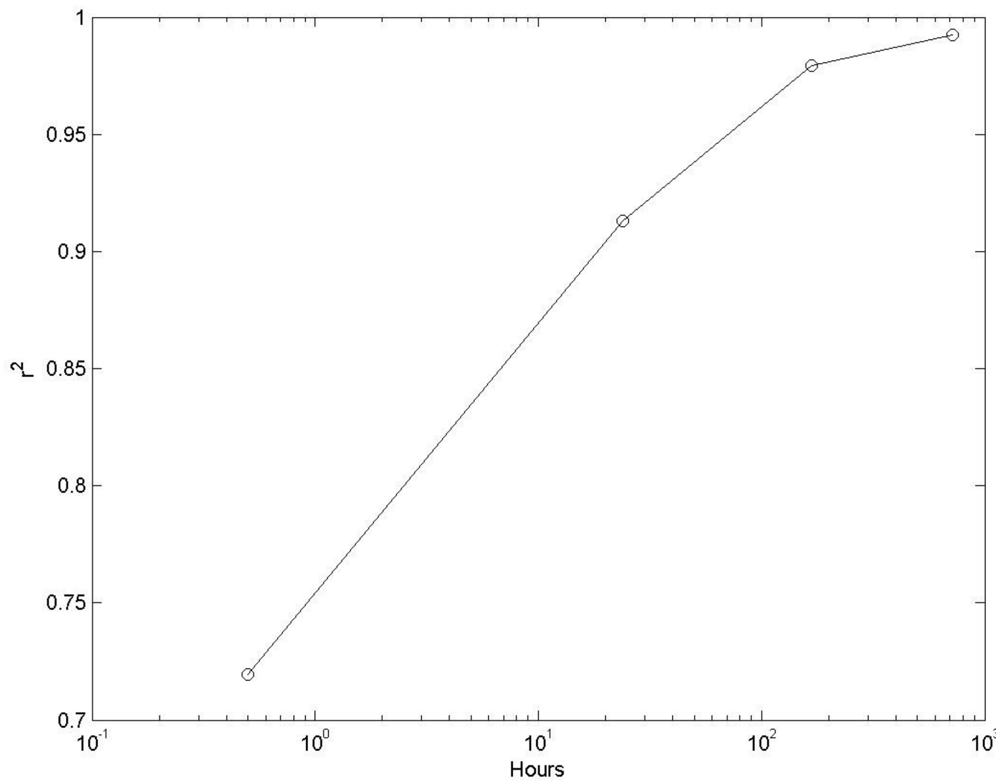

Figure 3: r^2 as a function of averaging period. This is a generic example for the discussion of the appropriate averaging period.

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