Modelling of ecosystem respiration with proximal sensing data and meteorological measurements

Bruna Oliveira
Center for Environmental and Marine Studies
University of Aveiro, Aveiro, Portugal

Bruna.Oliveira@ua.pt

The Host

Mirco Migliavacca

Biosphere-Atmosphere Interactions and Experimentation
@ Biogeochemical Integration Department

Max Planck Institute for Biogeochemistry
Jena, Germany

The STSM objective

- Simulate ecosystem respiration using proximal sensing data and meteorological measurements;
- Determine if basal respiration is more related to:
  - Structural indices (NDVI, MTCI, ND, EVI)
  - Physiological activity indices (Fy760 or PRI)

Ecosystem Respiration – R_{eco}

- CO_2 production by all organisms in a ecosystem

    Soil respiration (heterotrophic + roots)

    Above ground respiration (leaves, branches, stems…)

- Diverse and changing array of organisms
- Peak during night time → no photosynthesis
- Major influence in global C cycle

Gross Primary Production – GPP

- Total energy produced by plants and cyanobacteria
  - Photo- and chemosynthesis
  - Part is used by primary producers for cellular respiration
  - Part is the net primary production – NPP
- Empirical evidence for the link between GPP and R_{eco} for most ecosystems

GPP as driver of R_{eco}

- Network of eddy covariance and chamber measurements increased the estimates of ecosystem-scale GPP
- Upscale of GPP to regional and global scales relies on remote sensing information about:
  - Ecosystem structure
  - Light use efficiency
  - Sun-induced chlorophyll fluorescence
  - … more being explored!

VIs → GPP → R_{eco}

- Vegetation Indeces – VIs – from proximal sensing to model GPP and Rb
  - Avoids the dependence on ground measurements
  - Less disturbance of the ecosystem
  - Application at regional and global scales

The Reco models

$$R_{eco} = R_b \times f(T) \times f(P)$$

- Simple models:
  - One C pool
  - Overall system state
  - Different formulations for dependency on GPP
  - Estimation of Rb from VIs

Table 1 Different model formulations of the dependency of ecosystem respiration (R_{ECO}) on gross primary productivity (GPP) used in this analysis

Model	Formula
LinGPP	$R_{ECO} = (R_0 + k_2\mathrm{GPP}) \times e^{E_0\left(\frac{1}{T_{ref}-T_0} - \frac{1}{T_A-T_0}\right)} \times \frac{\alpha k + P(1-\alpha)}{k + P(1-\alpha)}$
ExpGPP	$R_{ECO} = \left[R_0 + R_2\left(1 - e^{k_2\mathrm{GPP}}\right)\right] \times e^{E_0\left(\frac{1}{T_{ref}-T_0} - \frac{1}{T_A-T_0}\right)} \times \frac{\alpha k + P(1-\alpha)}{k + P(1-\alpha)}$
MicMenGPP	$R_{ECO} = \left[R_0 + \frac{R_{MAX}\mathrm{GPP}}{\mathrm{GPP} + hR_{MAX}}\right] \times e^{E_0\left(\frac{1}{T_{ref}-T_0} - \frac{1}{T_A-T_0}\right)} \times \frac{\alpha k + P(1-\alpha)}{k + P(1-\alpha)}$
addLinGPP	$R_{ECO} = R_0 \times e^{E_0\left(\frac{1}{T_{ref}-T_0} - \frac{1}{T_A-T_0}\right)} \times \frac{\alpha k + P(1-\alpha)}{k + P(1-\alpha)} + k_2\mathrm{GPP}$
addExpGPP	$R_{ECO} = R_0 \times e^{E_0\left(\frac{1}{T_{ref}-T_0} - \frac{1}{T_A-T_0}\right)} \times \frac{\alpha k + P(1-\alpha)}{k + P(1-\alpha)} + R_2\left(1 - e^{k_2\mathrm{GPP}}\right)$
addMicMenGPP	$R_{ECO} = R_0 \times e^{E_0\left(\frac{1}{T_{ref}-T_0} - \frac{1}{T_A-T_0}\right)} \times \frac{\alpha k + P(1-\alpha)}{k + P(1-\alpha)} + \frac{R_{MAX}\mathrm{GPP}}{\mathrm{GPP} + hR_{MAX}}$

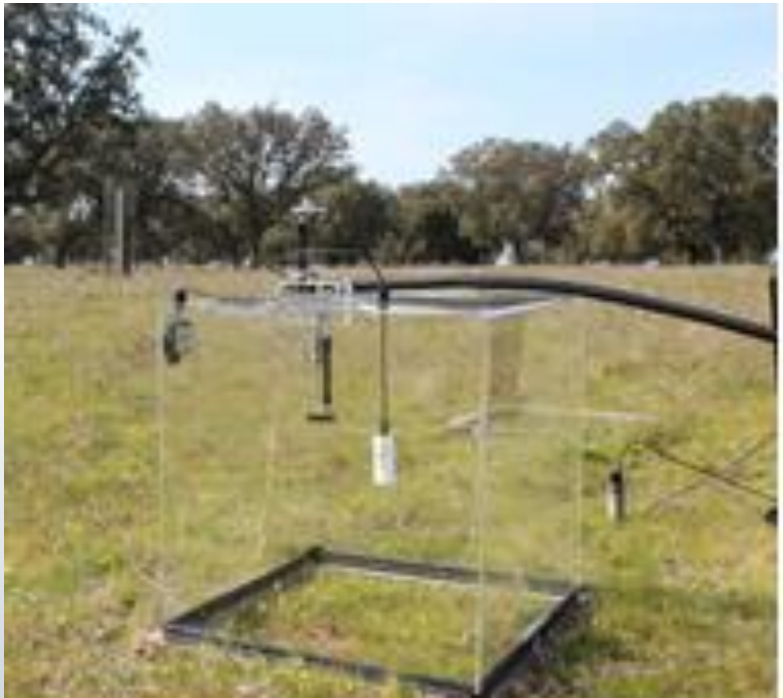
From Migliavacca, M. *et al.* (2011)

The data – SMANIE project

- SMANIE – **S**mall-scale **MANI**pulation **E**xperiment;
- Mediterranean savannah in Caceres – Spain:
- Effects of N and P fertilization on ecosystem level

The data – SMANIE project

- Manual static chambers (Perez-Priego *et al,* 2015):
  - Net CO_2 fluxes
  - Photosynthetically active radiation (PAR)
  - Air and vegetation T
  - Atmospheric P
  - Soil T @ 5 and 10 cm
  - Vapor pressure deficit



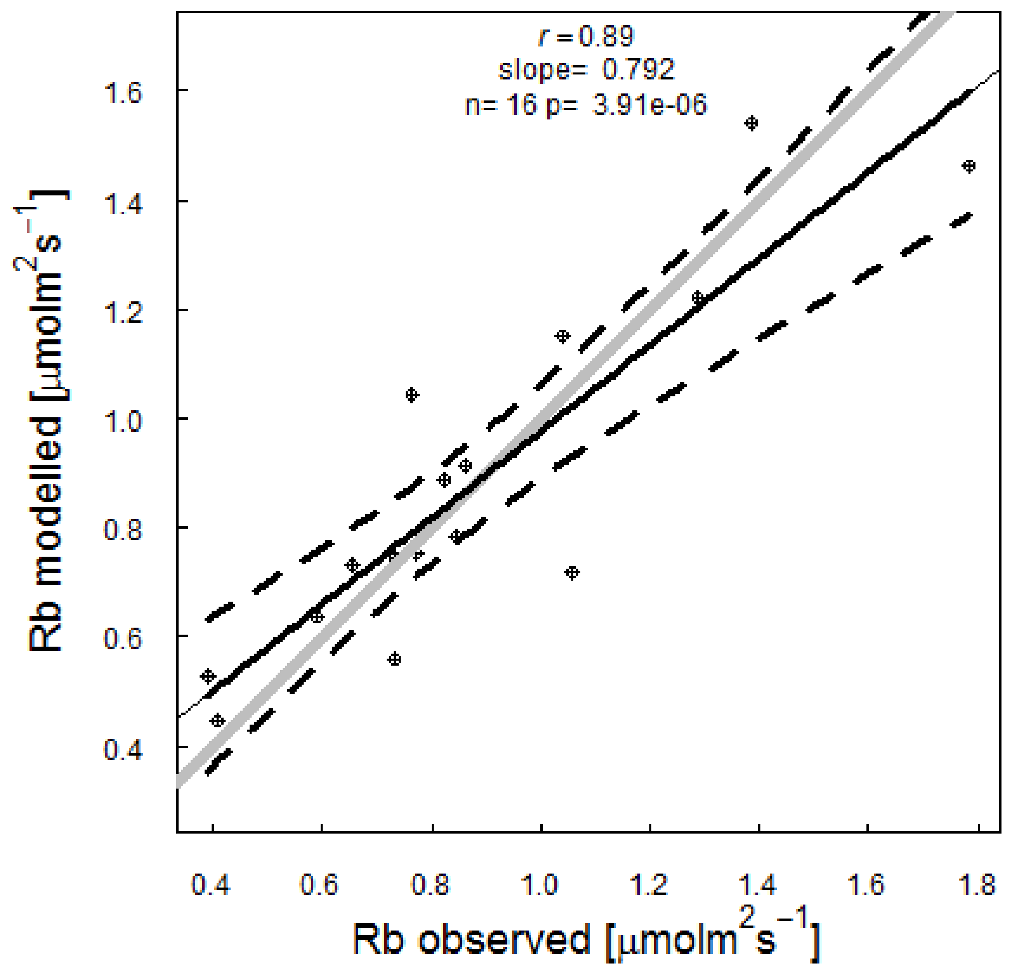
The data – SMANIE project

- Manual field spectrometer (Perez-Priego *et al*, 2015):
  - Sun-inducedchlorophyll fluorescence yield at 760nm – Fy760
  - Scaled photochemical reflectance index – sPRI
  - Normalized difference vegetation index - NDVI
  - MERIS terrestrial-chlorophyll index – MTCI

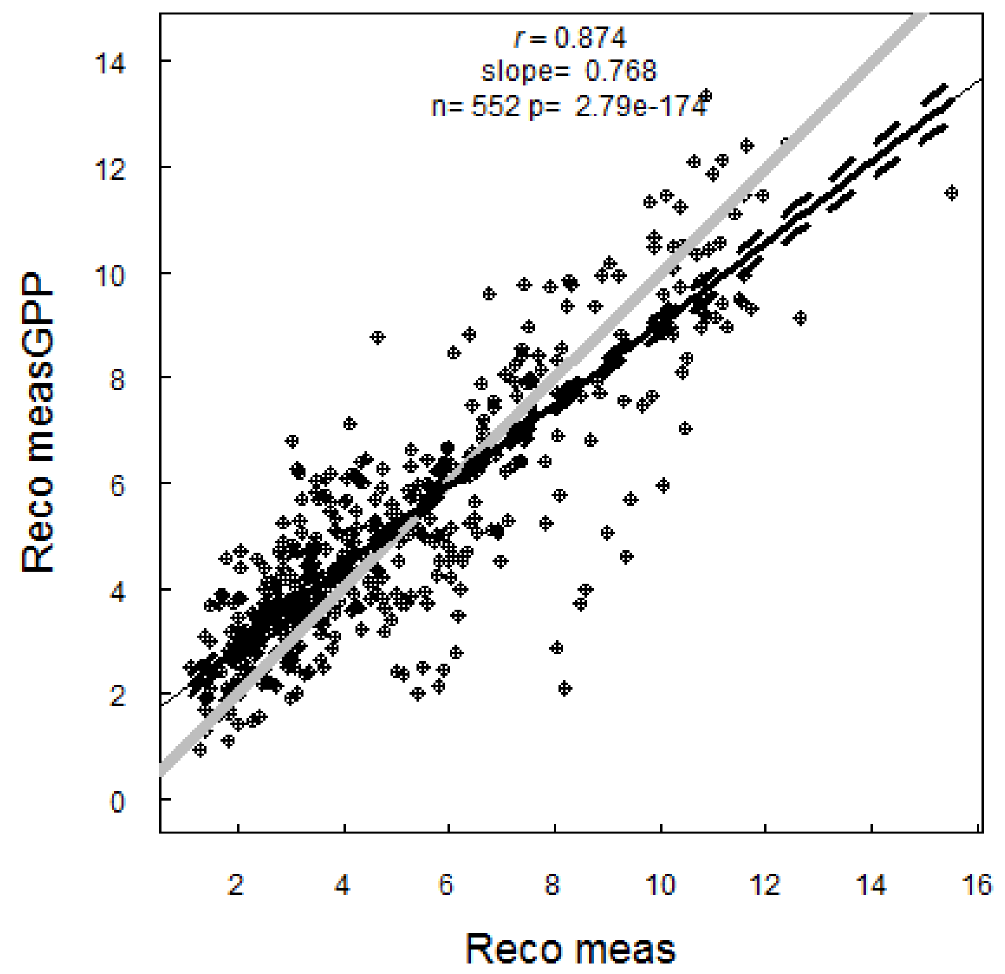
The data – SMANIE project

- Net CO_2 fluxes
- Air, vegetation, soil temperature
- Structural indices (NDVI, MTCI)
- Physiological activity indices (Fy760, sPRI)
- 4 Campaigns:
    - C1: Before fertilization
    - C2: 3 weeks after fertilization, peak of growing period
    - C3 and C4: Drying period

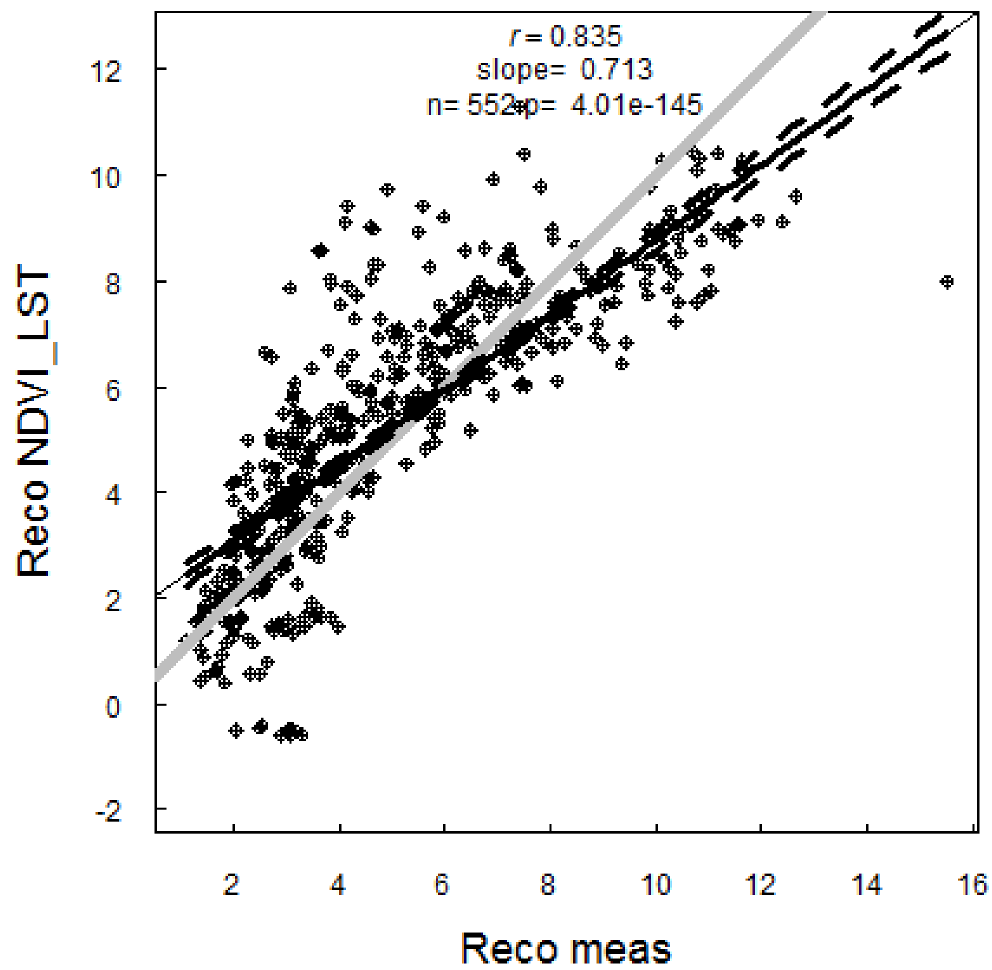
Results – Rb driven by sPRI



Results – R_{eco} driven by measured GPP and AirT



Results – R_{eco} driven by NDVI, LST and AirT



Conclusions

- Best performance of R_{eco} models with measured GPP
- NDVI is the best structural index to model R_{eco}
- sPRI is the best physiological index to model R_{eco}
- AirT gives better results than SoilT

For the future…

Collaborations and institutes involved

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training on Remote Sensing for **Ecosystem** modelling

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Comments & Suggestions

Bruna.Oliveira@ua.pt

Earth Surface Processes Team

CESAM
Centre for Environmental and Marine Studies
www.cesam.ua.pt

universidade de aveiro