Development of hybrid stochastic-mechanistic models for the partitioning and extrapolation of land surface to atmosphere water and carbon fluxes

Project Team

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Project Description

The overall aim of this project/proposal is to deliver a database of robust parsimoneous process descriptions and parameterizations dependent on site characteristics as well as to provide regionalization strategies for the robust extrapolation of carbon and water vapor fluxes at the landscape scale. Major objectives formulated are: 1) identification of hybrid statistical-mechanistic models for water vapor and CO_2 fluxes from FLUXNET databases, 2) identification of robust and effective description for the availability of subsurface water and its control on water and CO_2 fluxes, 3) regionalization strategies for water vapor and CO_2 fluxes and their driving variables. In the following, we will elaborate the objectives named above:

1. The identification of hybrid statistical-mechanistic models for water vapor and CO_2 fluxes

While we have successfully established the techniques to identify statistical-mechanistic models for water vapor and CO_2 fluxes with different vegetation and climate conditions (Jarvis et al. 2004[1]), our analysis is still limited by the quality of data and number of sites that could be analyzed so far. Especially the analysis of vegetation type and climate specific parameterization and methods for their regionalization (see below) will highly benefit with the access to the synthesized FLUXNET database. Research questions that still need to be explored are:

- How do model complexity and/or parameter values differ between different vegetation types and climate conditions?
- Can model structure and/or parameter values be related to site specific conditions and can subsequent regionalization concepts be derived?

In order to account for the control of fluxes by the availability of water, surrogate information as provided by the next work step will be included in the analysis.

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[1] Jarvis, A., Stauch, V., Schulz, K., Young, P., 2004: The seasonal temperature dependency of phytosynthesis and respiration in two deciduous forests. Glob. Change Biol., 10:939-950

2. Identification of appropriate descriptions for water availability and its control on water, energy and carbon fluxes

This part of the project is very closely linked to the previous one. Having analyzed a few grassland-sites especially in semi-arid areas, we have – not surprisingly - seen a significant dependency of parameters developed under Objective 1) on water availability.

Again, this analysis would largely benefit by an extension to different sites and the use of remote sensing data for the derivation of “water availability surrogates” to allow a regionalization of flux predictions. Specific research questions are:

- What are the most effective surrogates to describe water availability?
- Do they vary with vegetation type and climate?
- Which of those are detectable from remote sensing in order to allow a regionalization of local scale measurements?

Especially in view of regionalizing fluxes it is intended to study the usefulness of remote sensing data. The NASA sensors MODIS and AMSR-E onboard Terra and Aqua are promising, since they deliver daily values with a reasonable spatial resolution and their data are ready-to-use and freely available for download and hence suitable for regionalization purposes. Also thermal information to derive surface temperature, evapotranspiration and drought related indices (Anderson and Kustas, 2008)[2] will be tested.

3. Regionalization of carbon and water vapor fluxes

After having identified suitable model structures and parameterizations for various FLUXNET sites, there are two general possible strategies to be explored:

The first one will try to use non-linear mapping techniques (e.g. multiple regression, neuronal network, fuzzy rules, modified nearest neighbor) to relate identified model parameters to site specific information. An approach by Hundecha and Bardossy (2004)[3] for the regionalization of parameters of a watershed model might be useful where the basic idea is to assume a predefined (linear, non-linear) type of transfer function between individual model parameters and site specific information given a suitable model structure. Rather than optimizing model parameters locally for each individual FLUXNET site, only the parameter of the transfer function will (globally) be optimized against the complete set of available flux data from different locations. Again, the availability of a large variety of data sets will be essential.

The second option is based on the successful incorporation of remote sensing information (such as LAI or water availability information) into the model identification and building process as described above. Using remote sensing data as input and parameter information will allow for an extrapolation of flux-prediction dependent on the coverage of the images.

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[2] Anderson, M., and Kustas, W., 2008. Thermal Remote Sensing of Drought and Evapotranspiration. EOS, 89(26), 233-234.

[3] Hundecha, Y., and Bardossy, A., 2004. Modeling of the effect of land use changes on the runoff generation of a river basin through parameter regionalization of a watershed model. J. Hydrol., 292(1-4), 281-295.

Both strategies will be intensively tested using cross validation and split-sampling techniques.

Sites

Initially we will focus on forest sites, but extending it to grassland and sites with water stress will be significant.

Outcome

It is anticipated to produce a series of three papers (one for each of the above outlined topics) that will be submitted according to the data use and publication policies of FLUXNET and in agreement with the individual PI's providing the data.