Understanding the Terrestrial Ecohydrological Complexity: Integrating Remote Sensing, Modeling and Observations

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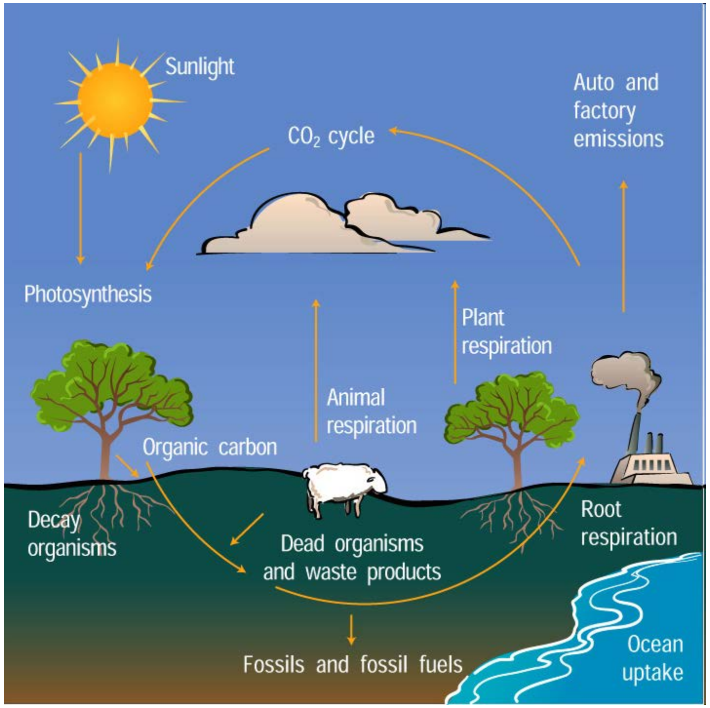
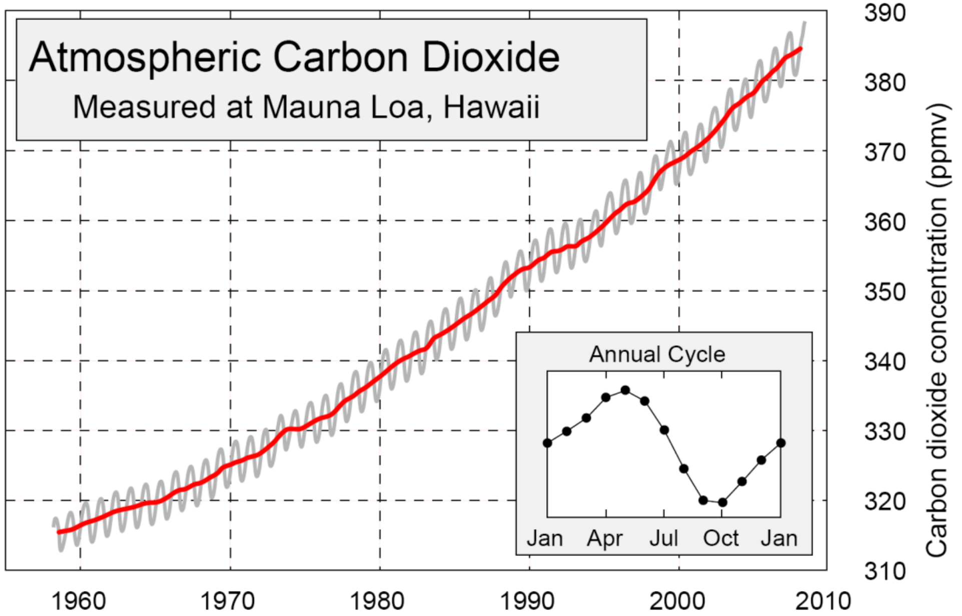
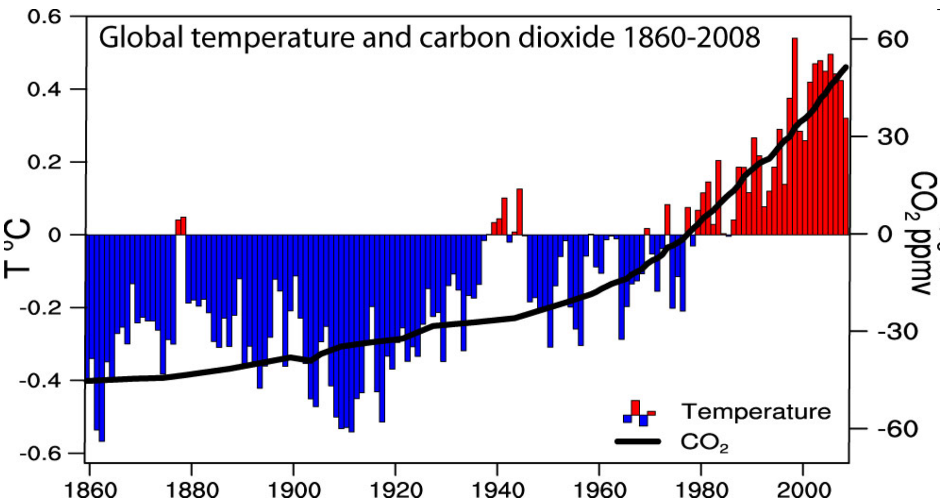
Why Terrestrial Ecohydrology?



Courtesy: NCAR





Terrestrial vegetation greatly controls Carbon, Water and Energy fluxes at the Atmosphere –Biosphere interface

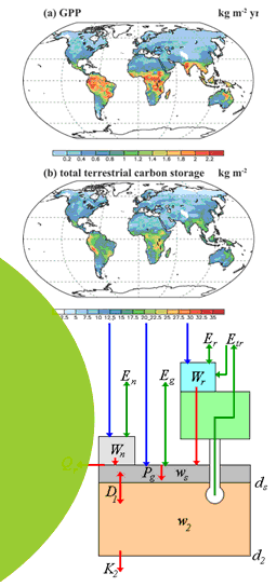
How to Understand This Complexity?

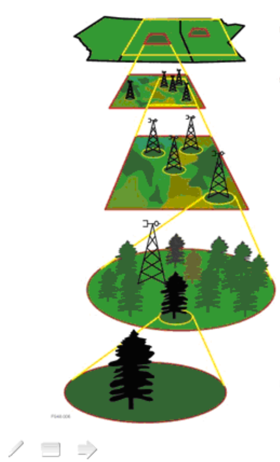
Remote Sensing

- Upscaling (point to global)
- Landsurface biophysics
- Human impacts on landsurface
- Human/natural Disturbances
- Spatio-temporal analysis

Integrated Modeling

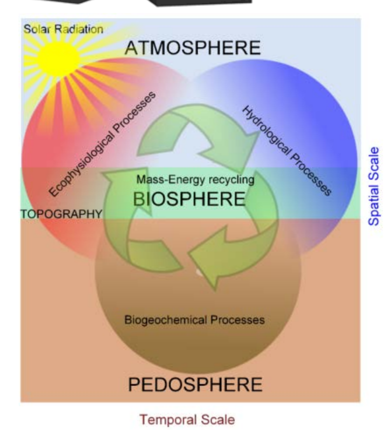
- Point scale
- Watershed scale
- Regional scale
- Global scale





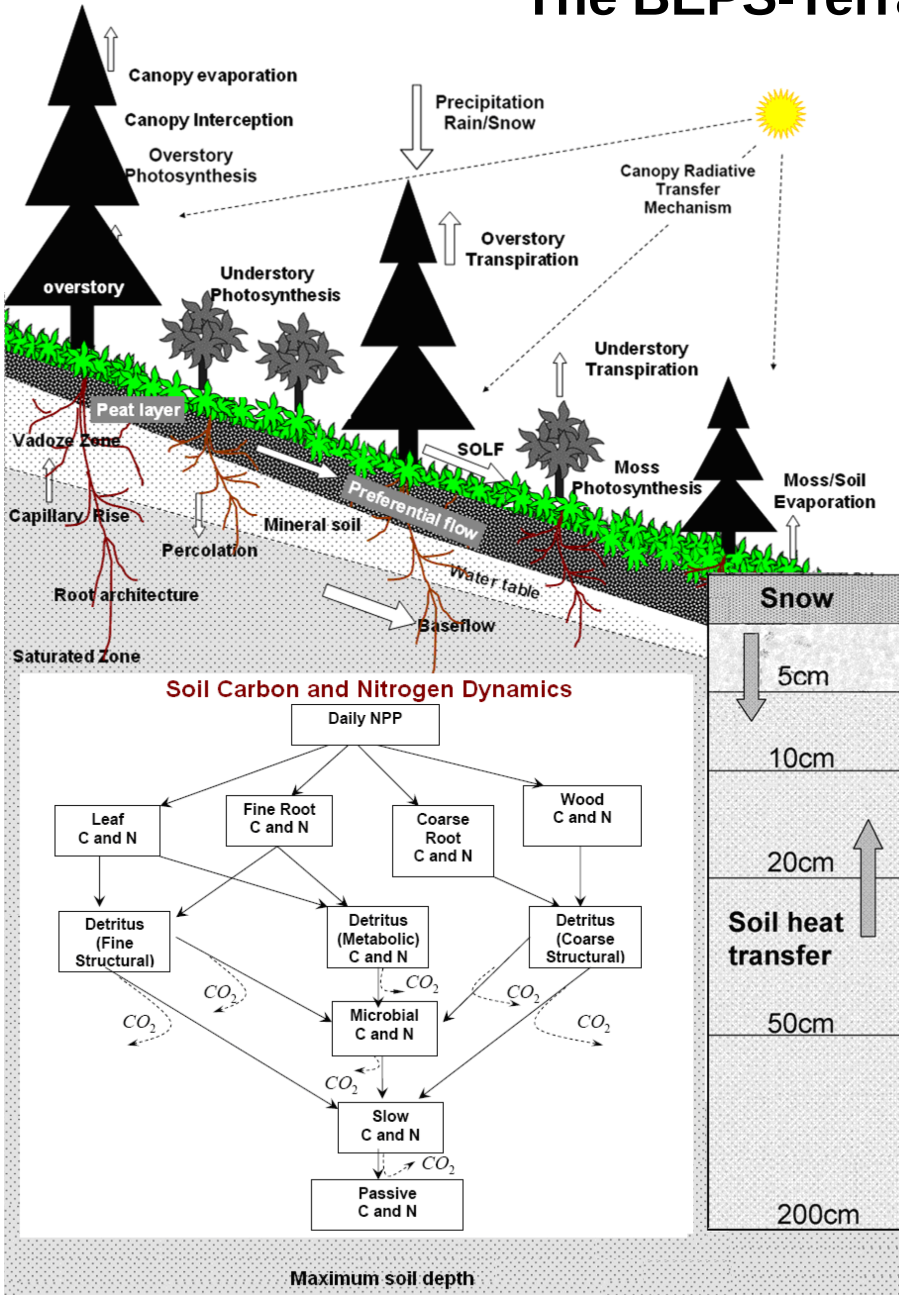
Biophysical Measurements

- Point scale
- Ecosystem scale (Eddy covariance)
- Regional Scale (Tall towers)
- Aircraft sampling
- Balloon-borne

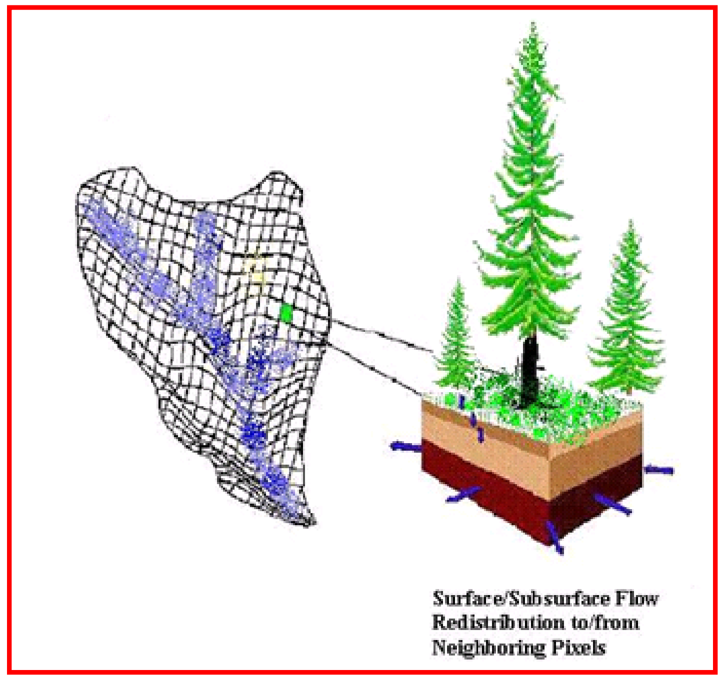


Govind & Kumari [2014], Int. J of Ecol.

The BEPS-Terrainlab V2.0 Model



- Spatially- Explicit
- Spatial resolution is flexible
- Daily model
- Process-based and generic
- Feed-back mechanisms addressed
- BGCs (C,W,N cycles) are tightly coupled



Govind et al. [2009a], J of Hydrology

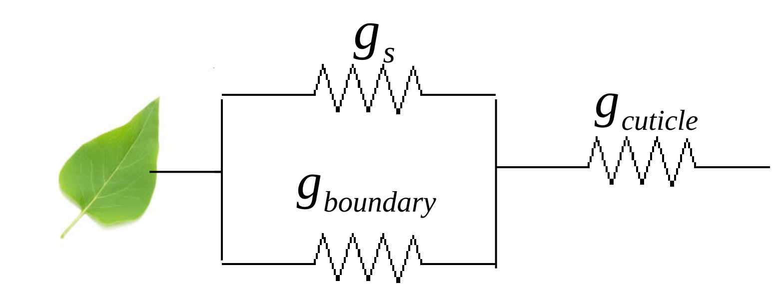
Govind et al. [2009b], J of Geophysical Res.

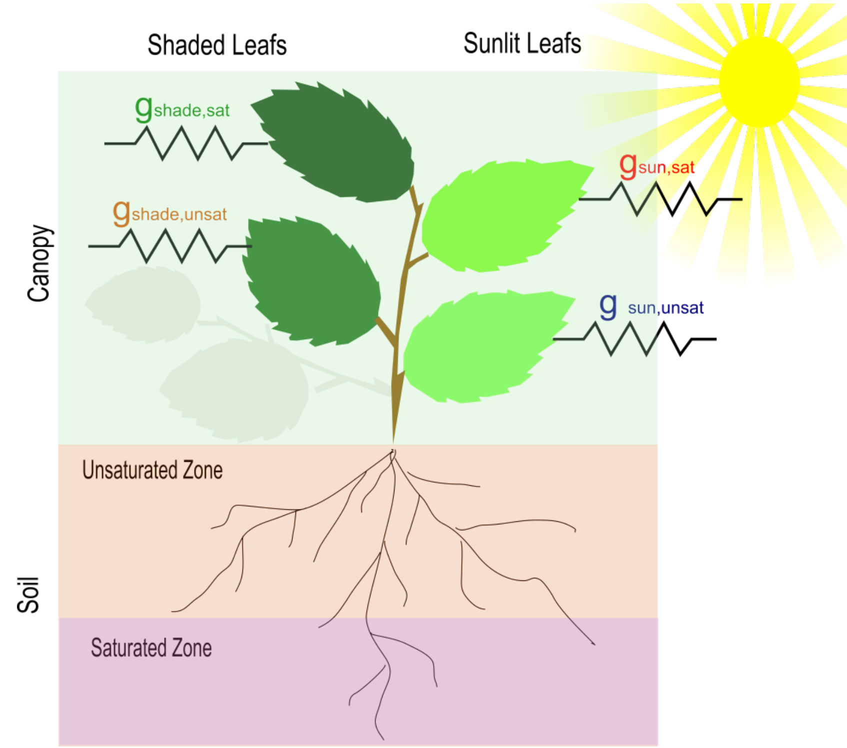
Upscaling Leaf-scale Ecophysiological Processes to the Canopy Scale

Intra-canopy physiological variability due to:

1. Variability in Light regime
2. Variability in Water regime

Other environmental factors also considered



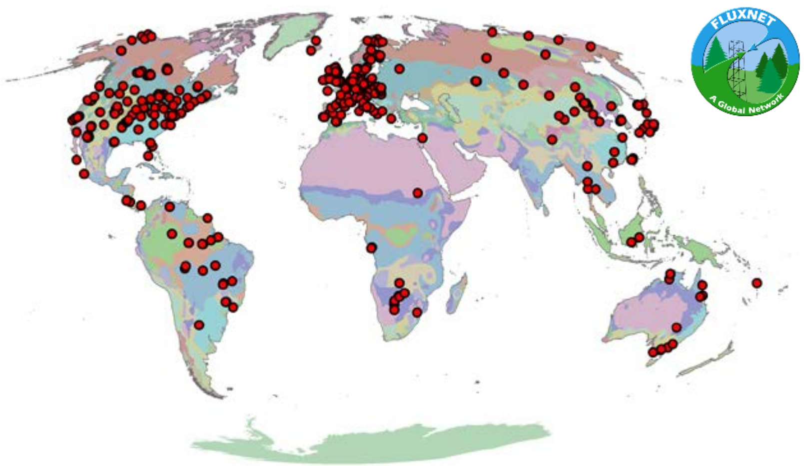


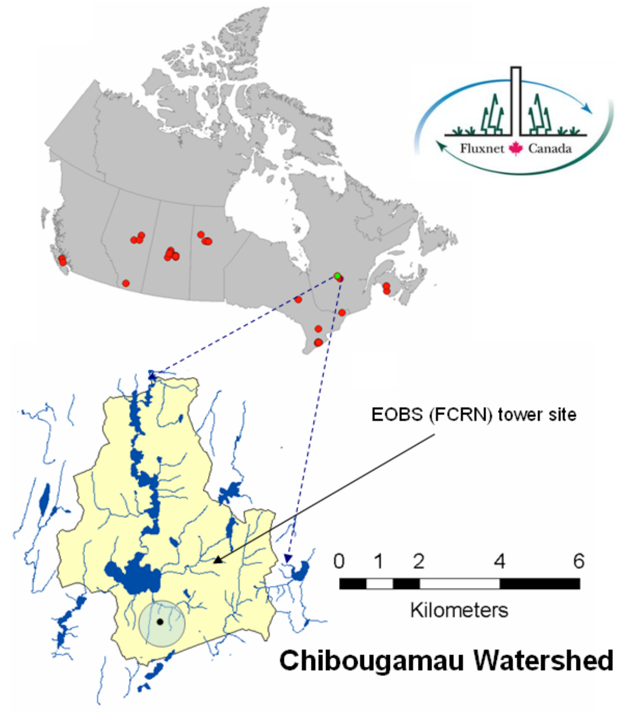
Light A.Temp VPD VSMC S.Temp

$$g_s = g_{s\max} \cdot \left[f(F_p).f(T_a).f(D_v).f(\theta_{sw}).f(T_s) \right]$$

$$P_o = \left[P_{sun,unsat} LAI_{over,sun} .\mu + P_{sun,sat} LAI_{over,sun} (1-\mu) \right] + \left[P_{shade,unsat} LAI_{over,shade} .\mu + P_{shade,sat} .LAI_{over,shade} (1-\mu) \right]$$

Fluxnet and the Canadian Carbon Program (*Fluxnet-Canada*)



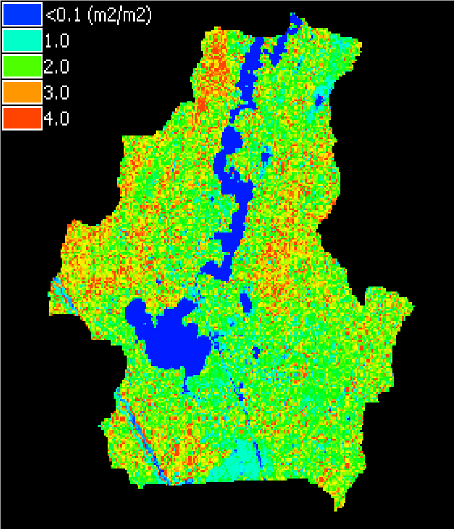


Science Questions

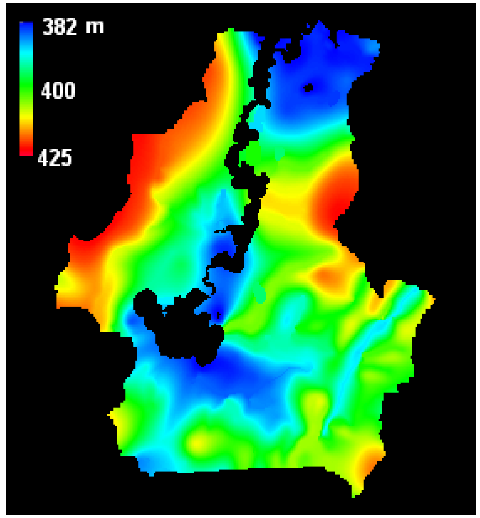
1. How the ecohydrological indicators vary in space and time in this boreal landscape and how well we can model them?

2. What are the mechanisms of hydrological controls on ecophysiology and biogeochemical processes?

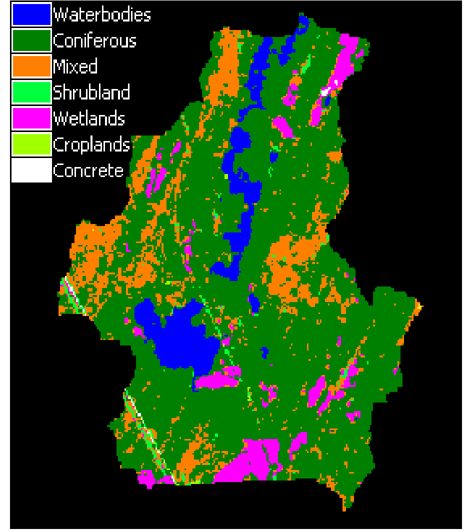
3. What are the potential uncertainties in the simulation of C-cycle under abstracted hydrology?



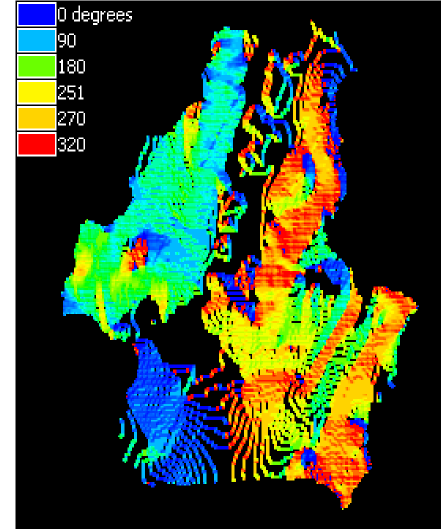
Leaf Area Index



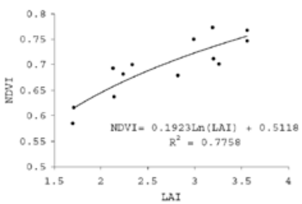
DEM



Land-cover

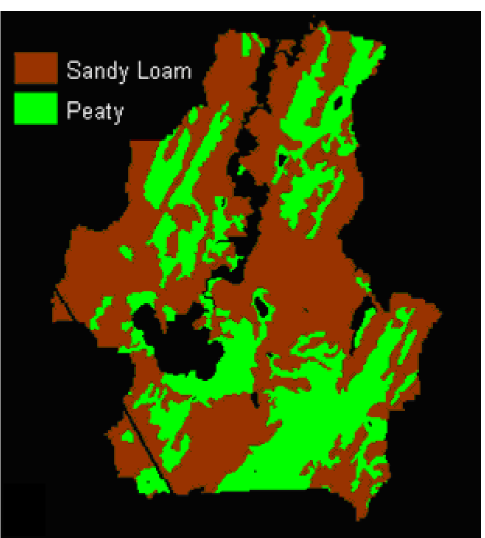


Aspect

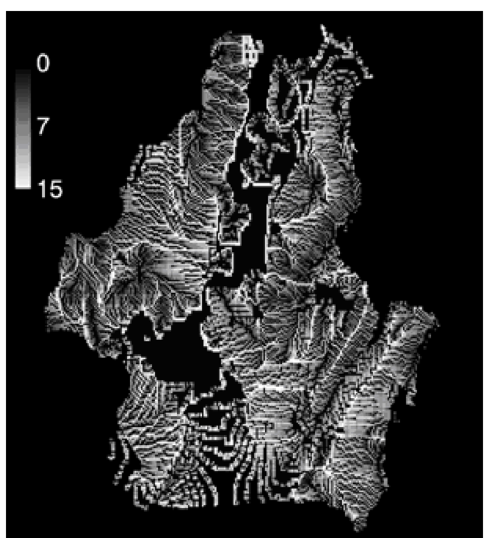


Input data for the *BEPS-TerrainLab V2.0* model (daily time step)

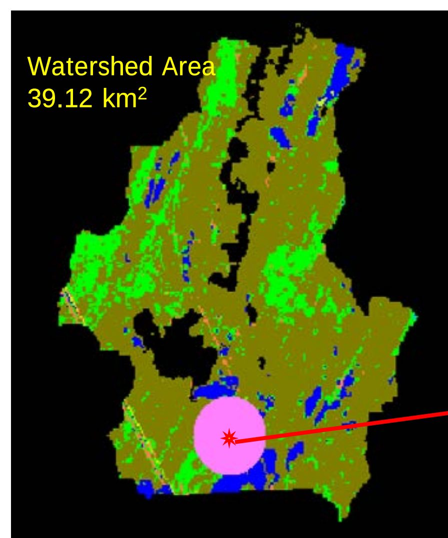
Soil Texture



Wetness Index



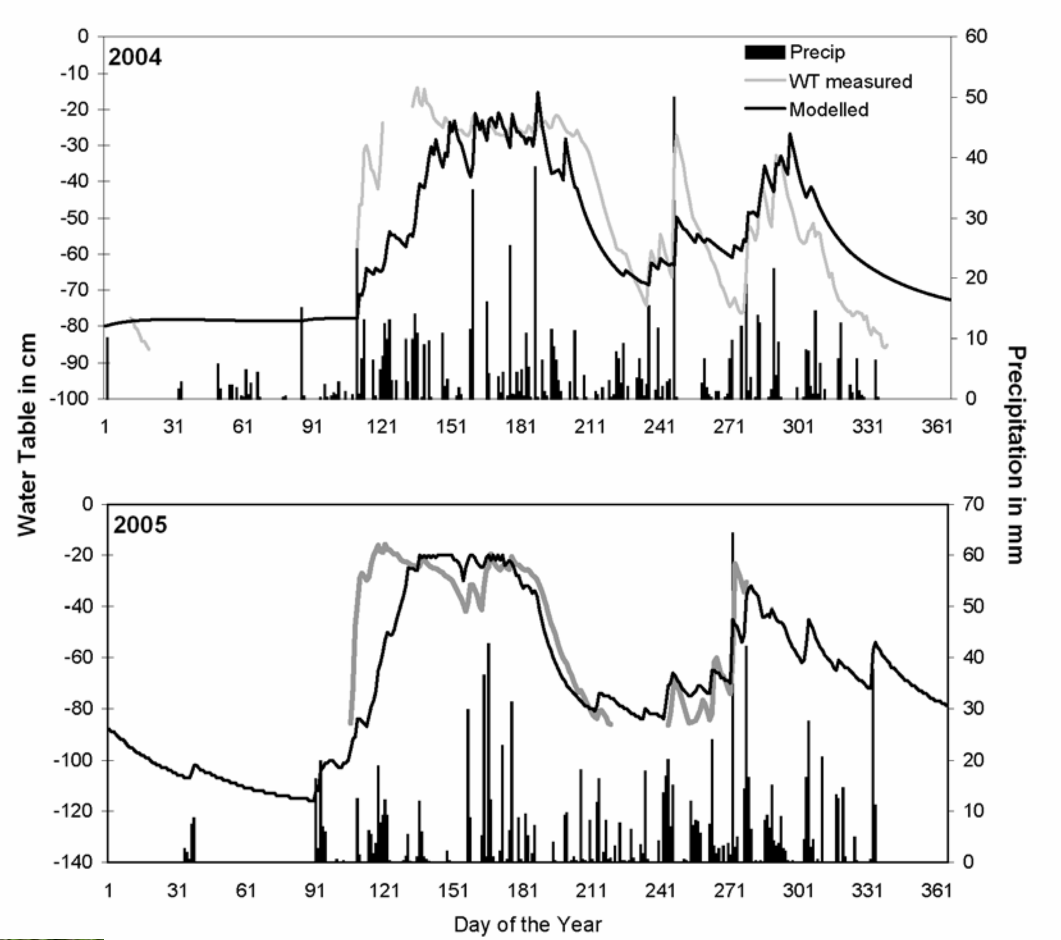
EC-Tower Footprint



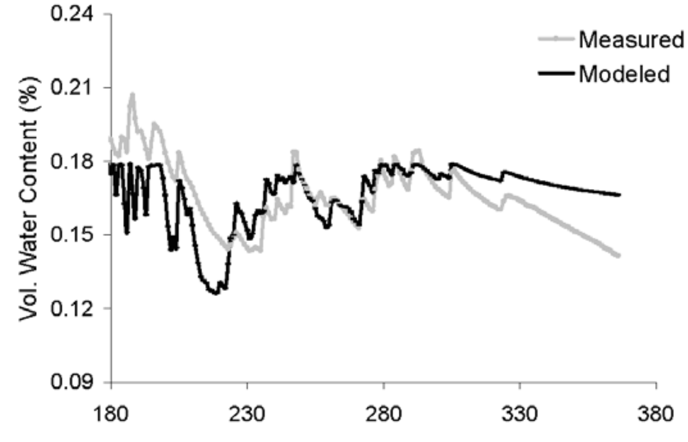
Met. Data at tower

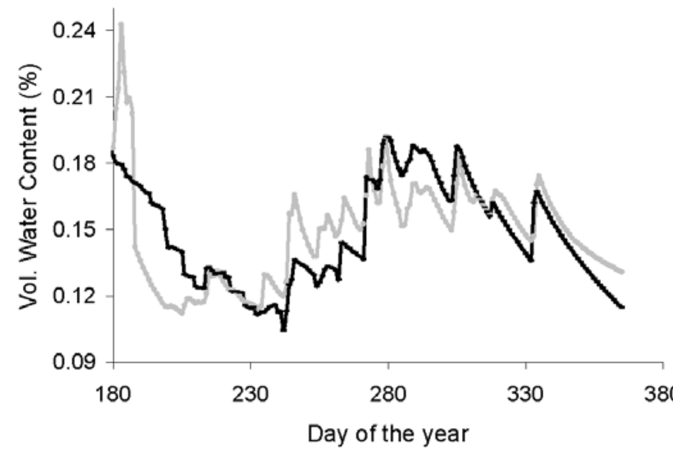
Validation of Hydrological Parameters at the EOBS site

Water Table Depth



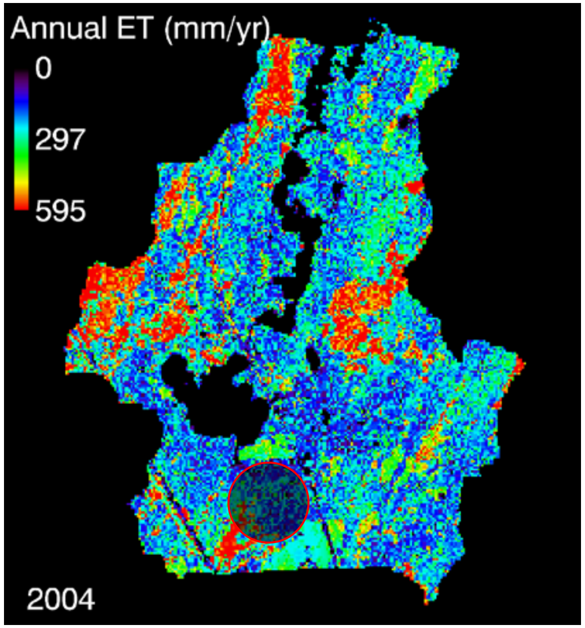
Volumetric Water Content

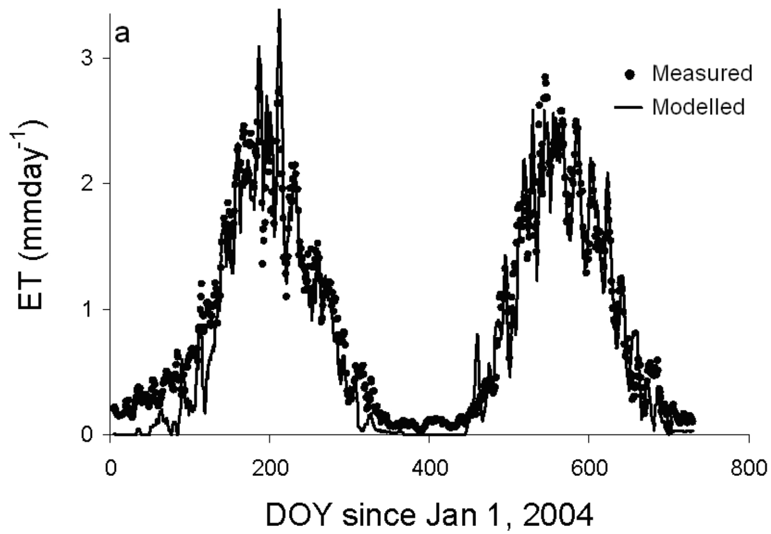


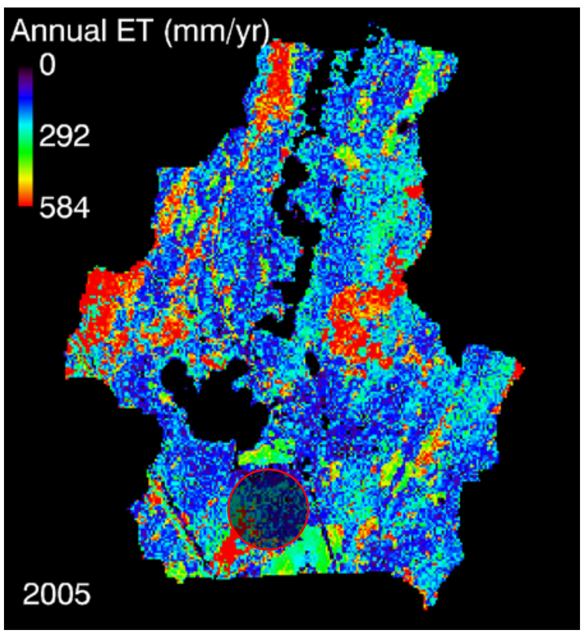


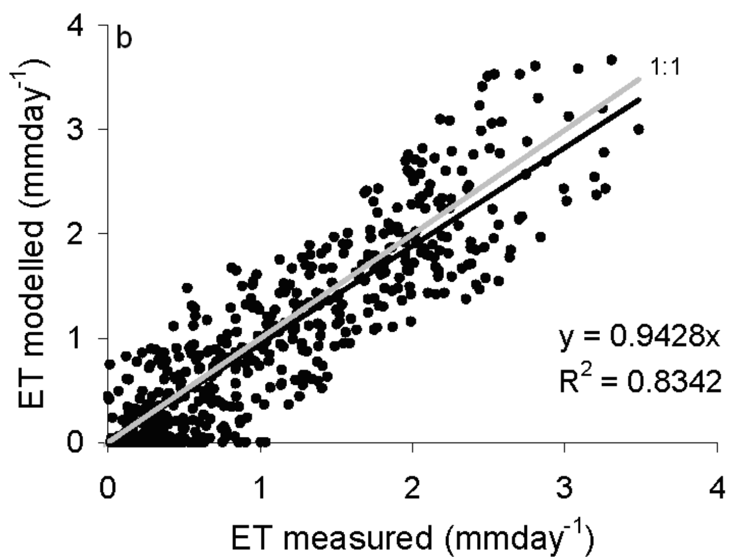
Govind et al. [2009a] J of Hydrology

Validation of Simulated Evapotranspiration with EC-Measurements



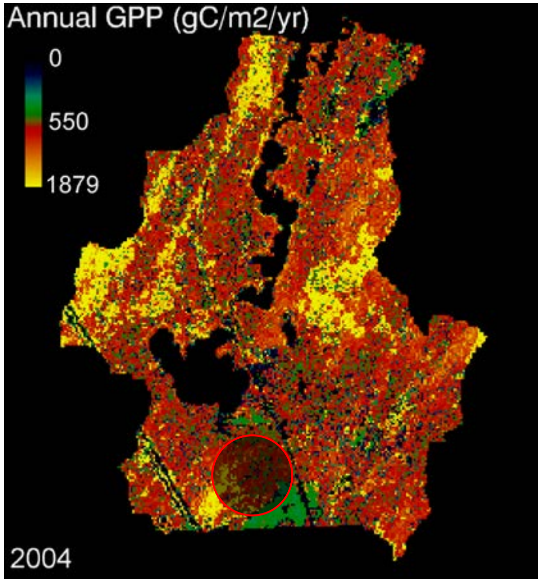


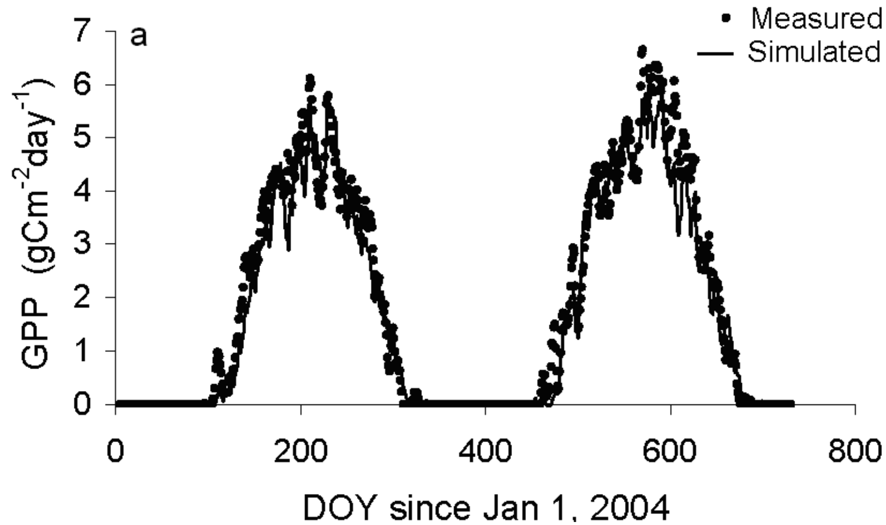


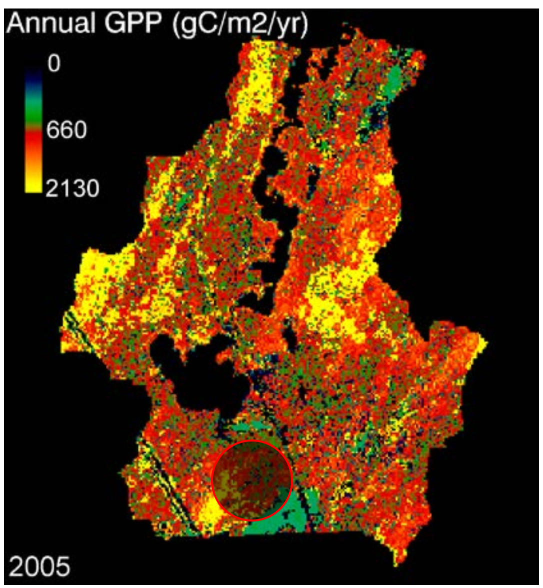


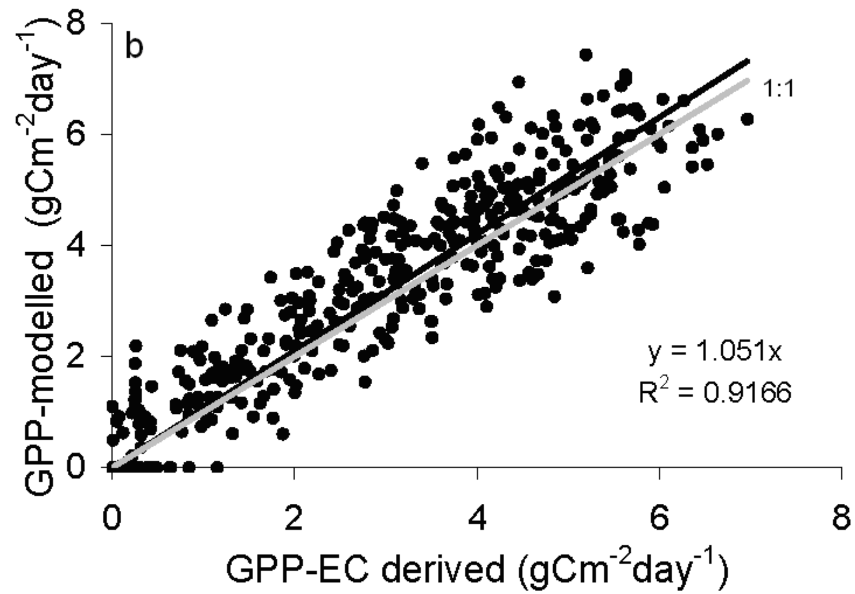
Govind et al. [2009a] J of Hydrology

Validation of Simulated GPP with EC-Derived GEP Measurements



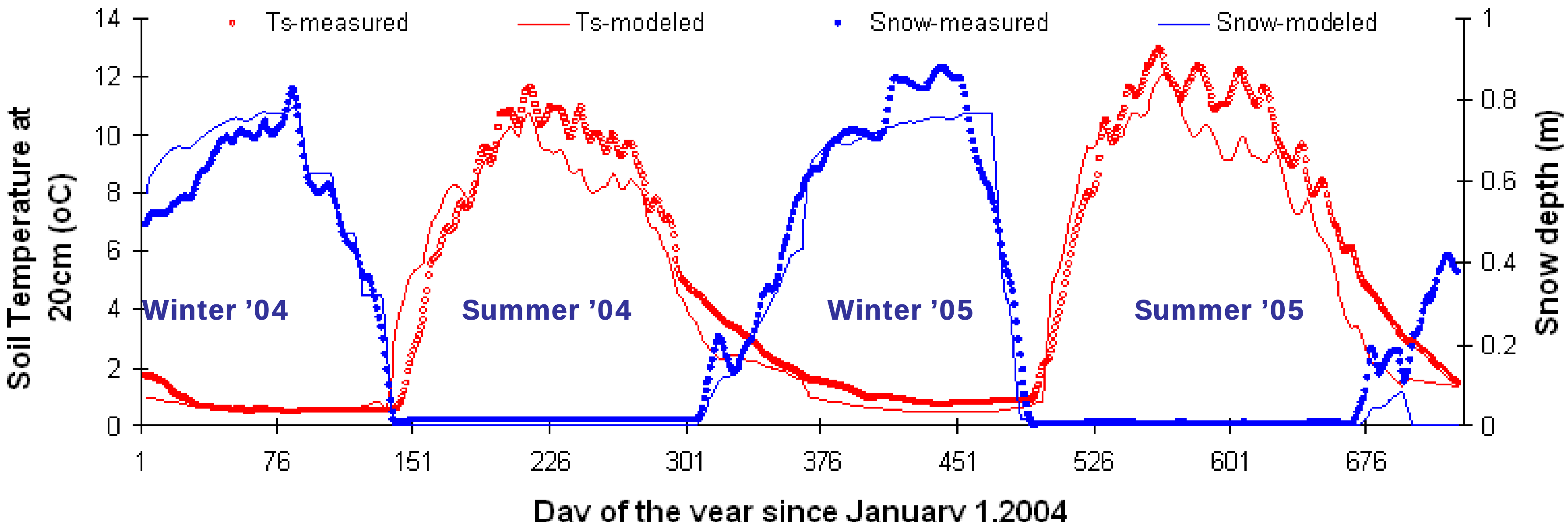






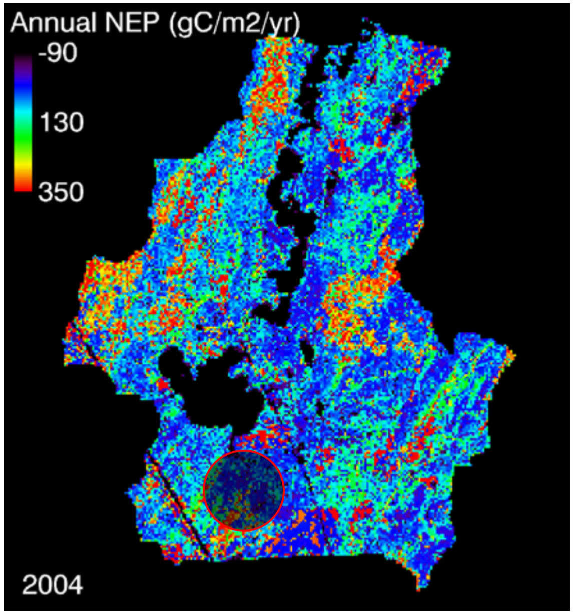
Govind et al. [2009a] J of Hydrology

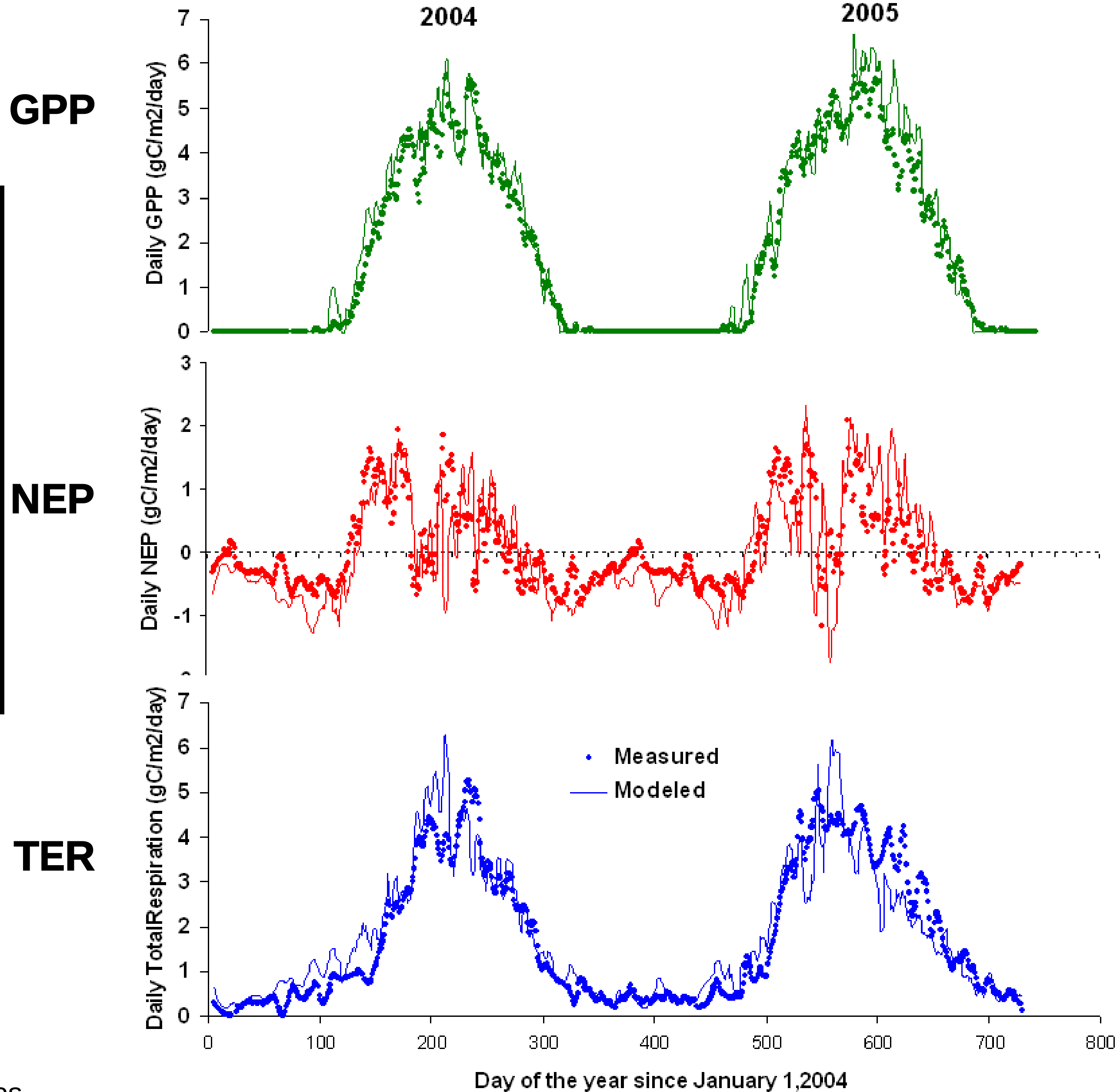
Snow and Moss Mediated Soil Thermal Modification is Critical for Modeling Boreal Biogeochemical Processes



Govind et al. 2009 J of Geophysical Res.

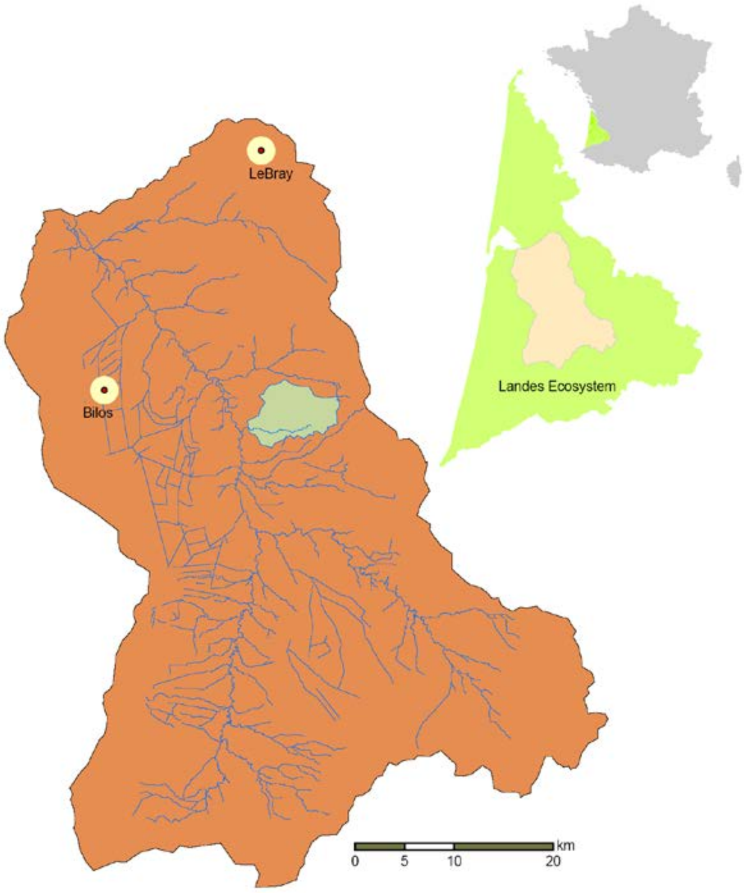
Simulated C-Fluxes at the EOBS Site by *BEPS-Terrain Lab V2.0*





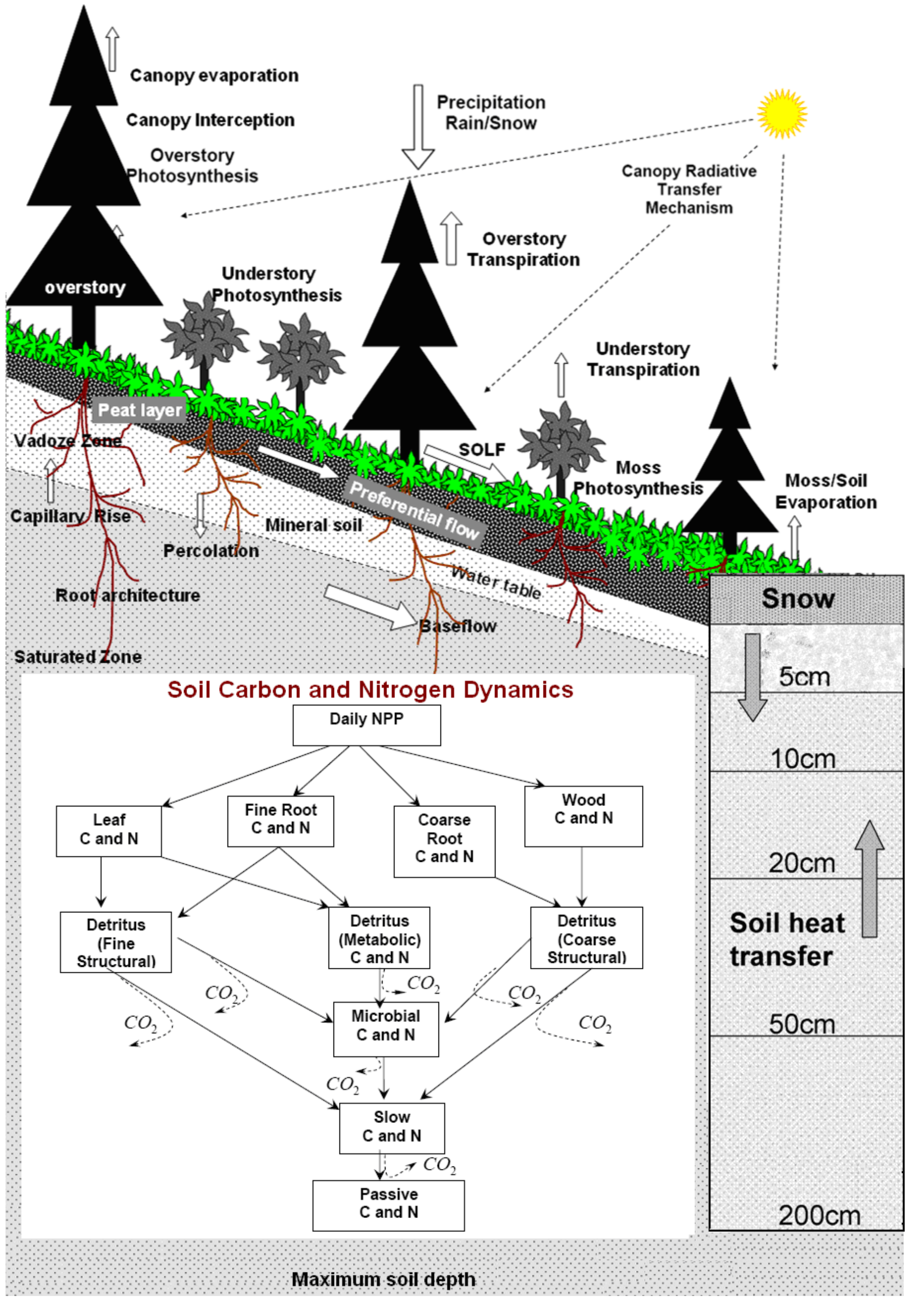
Govind et al.[2009b], J of Geophysical Res.

Ecohydrological Processes in the Landes de Gascogne in SW France



Science Questions to be Answered

1. What determines interannual variability of C and water fluxes in this ecosystem?
2. What's is the role of hydrology?
3. How nutrients, water and C interact?
4. How landuse change affect C and W fluxes?
5. How disturbances affect C and W fluxes?
6. What are the governing mechanisms of terrestrial-benthic connectivity?



Govind et al. [2014] , Ecological Modeling (in review)

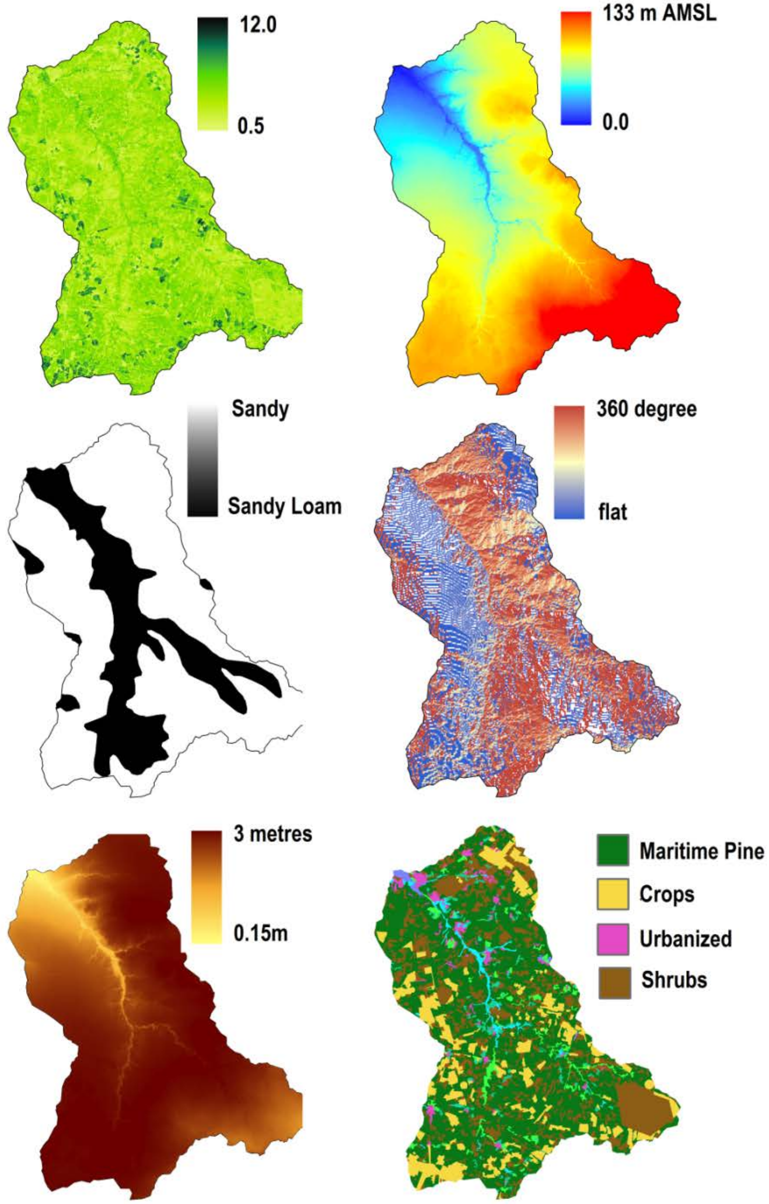
The STEPS model

STEPS- **S**imulator of **T**errestrial **E**cohydrological **P**rocesses and **S**ystems

STEPS is being developed at EPHYSE incorporating:

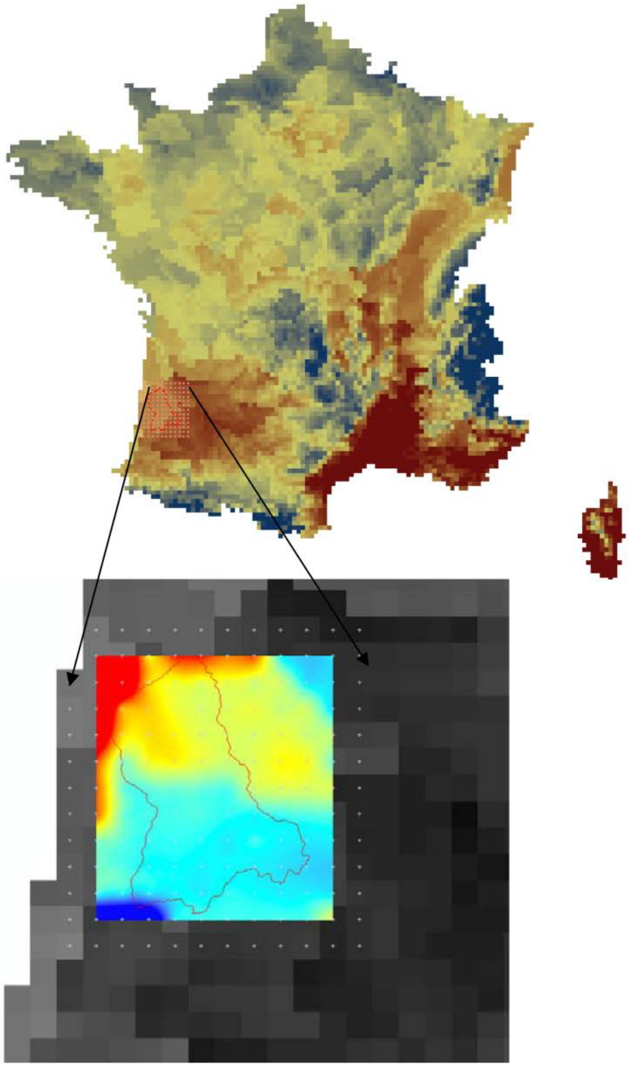
1. Agroecosystems (C3 and C4 plants)
2. Long-term simulations possible
3. DOC, DON etc
4. Fate of N Fertilizer transformations
5. Forest / Agroecosystem Management
6. Biotic Stresses- Population Dynamics of an endemic pest

Some of the Key Spatial Inputs Used



Gridded Meteorological Forcing

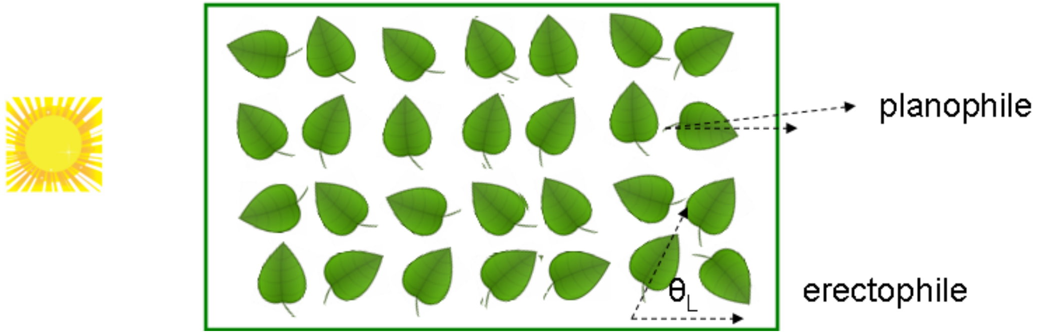
SAFRAN data was downscaled using geostatistical techniques



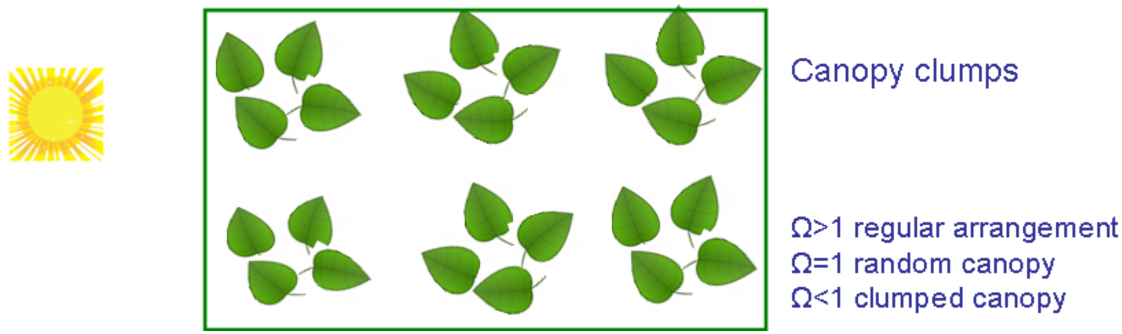
Improvements in the Description of the Canopy Radiative Transfer Mechanism (CRTM)

Two Key Canopy Attributes Controlling the CRTM

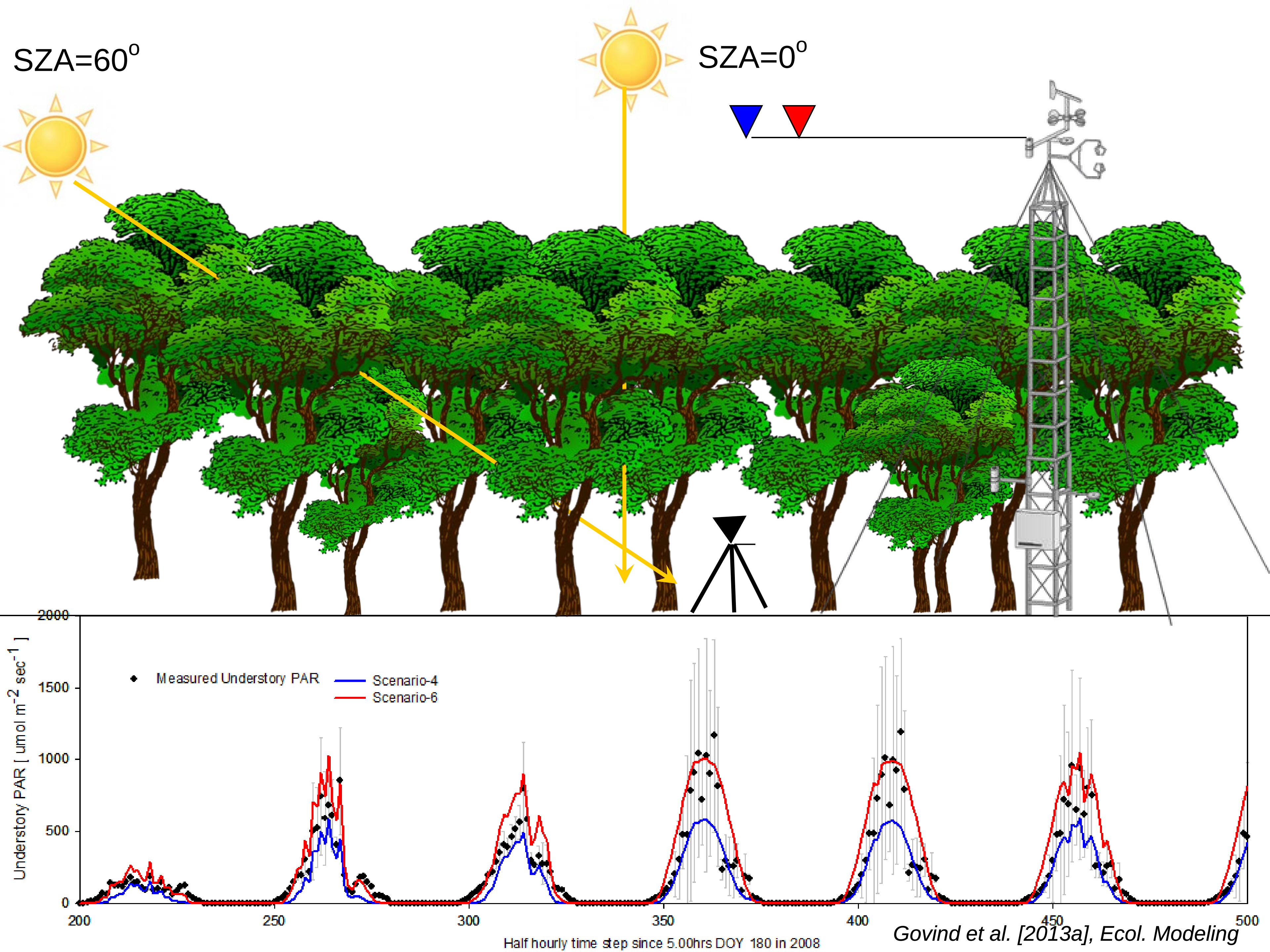
1. Element angular distribution affecting radiation transmission through the canopy at different angles (**G** factor)



2. Element spatial distribution (**Ω**) affecting the amount of radiation transmitted

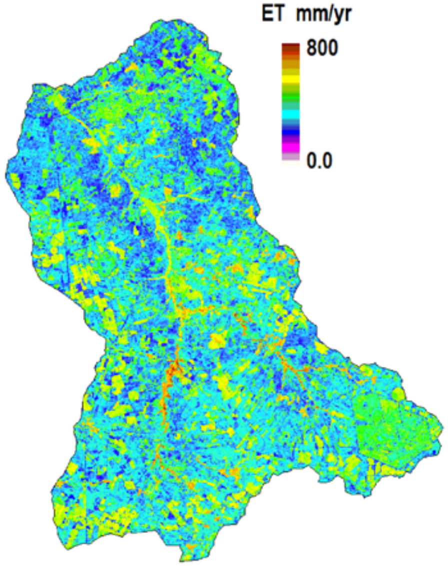


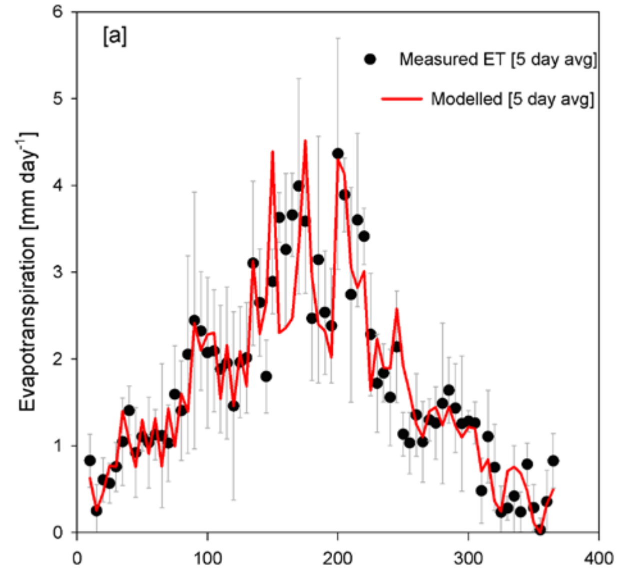
Govind [2013], Int J of Biometeorology



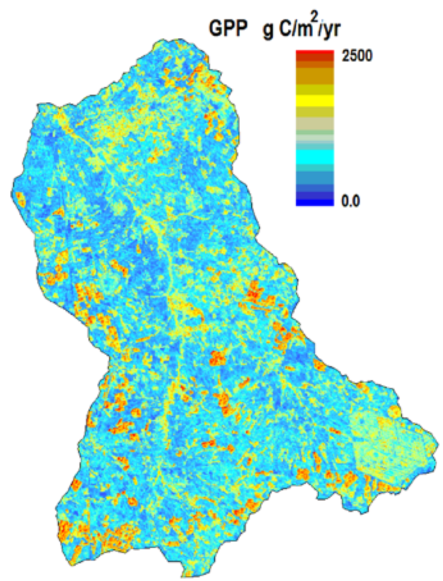
SZA=60°
SZA=0°
Measured Understory PAR
Scenario-4
Scenario-6
Understory PAR [umol m-2 sec-1]
2000
1500
1000
500
0
200
250
300
350
400
450
500
Half hourly time step since 5.00hrs DOY 180 in 2008
Govind et al. [2013a], Ecol. Modeling

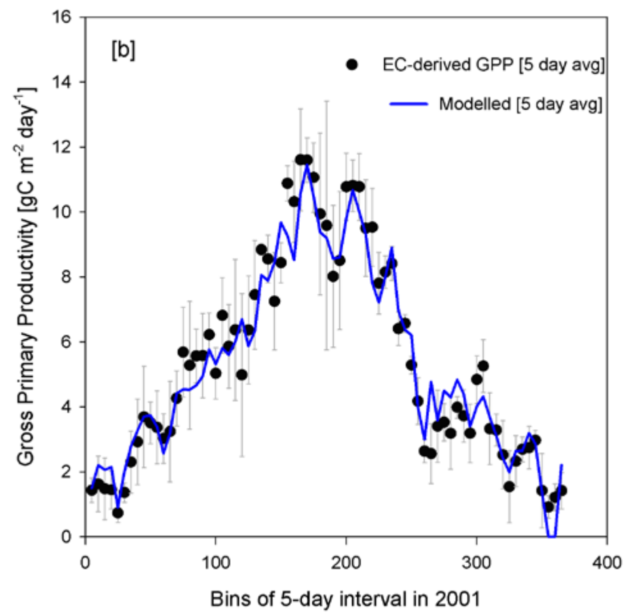
Spatial variation of annual ET and GPP over the Leyre Watershed





r^2=0.81
RMSE= 0.52 mm day^{-1}





R^2= 0.92
RMSE= 0.77 gC m^{-2} day^{-1}

Govind et al. [2014] , Ecological Modeling (in review)

Conclusions

- In boreal settings, ecological models that abstract hydrology returns biased estimates. Hence C, W and N cycles should be “tightly” coupled within models. The approach of the BEPS-Terrainlab V2.0 is ideal to address this uncertainity.

- Improved description of Canopy Radiative Transfer Mechanism is critical for modeling the terrestrial ecohydrological processes.

- Modeling of ecohydrological processes in agroecosystems poses many challenges.

- A new model (STEPS) is being created by modifying the BEPS-TerrainLab V2.0 model, accounting for the unique issues in agroecosystems (crop rotation, C4 photosynthesis, irrigation and N-fertilizer transformations). This platform serves for scientific, pedagogic and policy (DSS) actions.

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Prof. Bev Law	Oregon State University, USA
Mr. Olivier Reginiers	Univ of Bordeaux III, France
Mr. Pierre-Yves Caneill	Bordeaux Institute of Technology, France
Dr. Jan Pisek	Tartu Observatory, Estonia

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