Improvement of Canopy Parameterization and Impact on Land-Air Exchange Based on Noah-MP Model

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Objectives

Due to the fact that vegetation in nature is typically composed of three-dimensional (3D) structures, there are significant differences in the representation of radiation transfer, resistance, and surface flux calculations between vegetation composition and canopy geometry processed in land surface models.

1. How to obtain different vegetation canopy?
2. How to improve model expression?
3. What's the influence on land-air exchange?

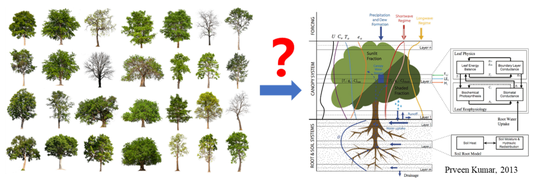
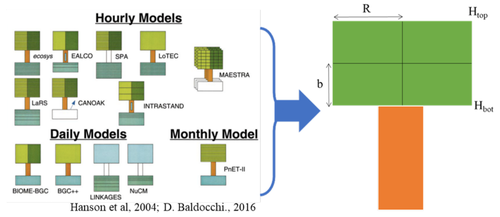


Figure 1: From trees to models, how?

Motivation

The current canopy structure in Noah-MP and other LSMs are represented by simple geometric shapes which are not accurate enough to represent the actual structure and lead to uncertainties.



Hanson et al, 2004; D. Baldocchi., 2016

NAME	Short description [units]
CH2OP	Maximum water intercepted by canopy [mm]
DLEAF	Leaf dimension [m]
Z0MVT	Momentum roughness length [m]
HVT	Canopy top [m]
HVB	Canopy bottom [m]
DEN	Tree density [number/m^2]
RC	Crown radius [m]
... ...	
FOLNMX	Maximum foliage nitrogen factor (see FOLN setting in code) [unitless]
WDPOOL	Wood pool factor used to determine relative wood presence [unitless]
WRRAT	Wood to non-wood ratio [kg/kg]
MRP	Microbial respiration in fast soil carbon pool at 10°C [umol/m^2/s]
SAIM	Monthly stem area index when prescribed [m^2/m^2]
LAIM	Monthly leaf area index when prescribed [m^2/m^2]
SLAREA	Stem-to-leaf area density [unitless]
EPS	Emission capacity for up to 5 different BVOC fluxes at 30°C [ug C/g foliar mass/hour]

Figure 2: Parameterization of canopy in LSMs

Results

The description of the canopy characteristics was still set by a landcover map with an attribute look-up table in the Noah-MP model.The main differences among forest types were the tree canopy top height, canopy bottom height and the crown radius. The quantities of tree heights and crown radiuses observed by the UAV method are also shown in Figure 3. This shows that the distribution of the Dinghushan forest appeared to present two stages, which could indicate the characteristics of a successional subtropical forest.

It was found that the influence on the simulation of energy fluxes could not be negligible, and the main influence of these canopy parameters was on the latent heat flux, which could decrease up to −11% in the midday while increasing up to 15% in the nighttime. This will have an impact on the subtle ecological activities in the forest canopy.

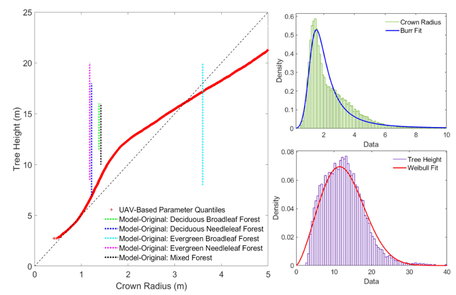


Figure 3: The distribution of canopy parameters

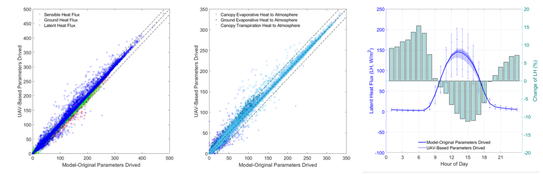


Figure 4: Comparison of surface heat flux items

Workflow

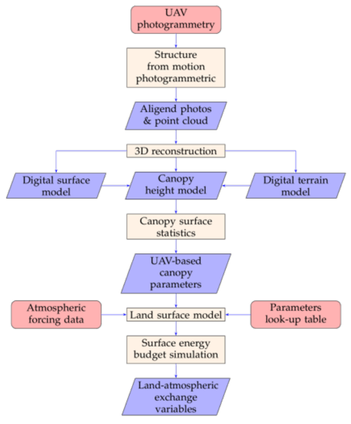


Figure 7: Workflow of this study

Materials

- Area: Dinghushan Forest Research Station
- Fluxnet Code: CN-Din
- Majority: Subtropical Evergreen Broadleaf
- UAVs: DJI Matrice 600Pro + Phantom 3
- Lidar: Green Valley LiAir V

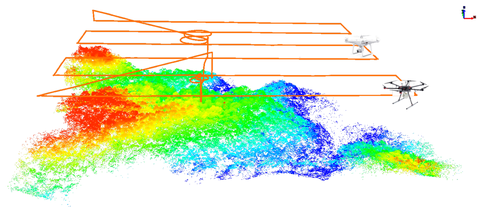


Figure 6: Flight path of UAVs

Conclusion

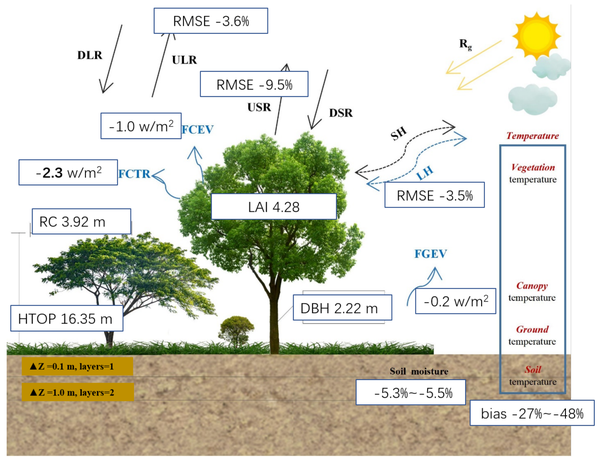


Figure 5: Impacts on land-air exchange variables

- Obtain local canopy parameters by UAVs photogrammetry was applied, and simulation test with the Noah-MP model was performed over a typical subtropical forest area.
- The updating of local canopy parameters would significantly affect the simulation of energy fluxes, especially for the latent heat flux through the transpiration.
- The simulation of canopy parameters affecting radiation flux by changing vegetation gap ratio, while the disturbance of sensible heat and latent heat flux driving by changing the exchange coefficient and tree heights.

References

[1] Wu et al. Uav-lidar measurement of vegetation canopy structure parameters and their impact on land–air exchange simulation based on noah-mp model. *Remote Sensing*, 14(13):2998, 2022.

Future Research

With the refinement of observation data and the advancement of lidar photography technology, further refinement of modeling can be considered for the model representation of forest canopy.

For colleagues engaged in ecosystem research, the neglect of the impact of climate on ecology caused by the internal structure of the canopy deserves further exploration.

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