Canopy capacity in JULES

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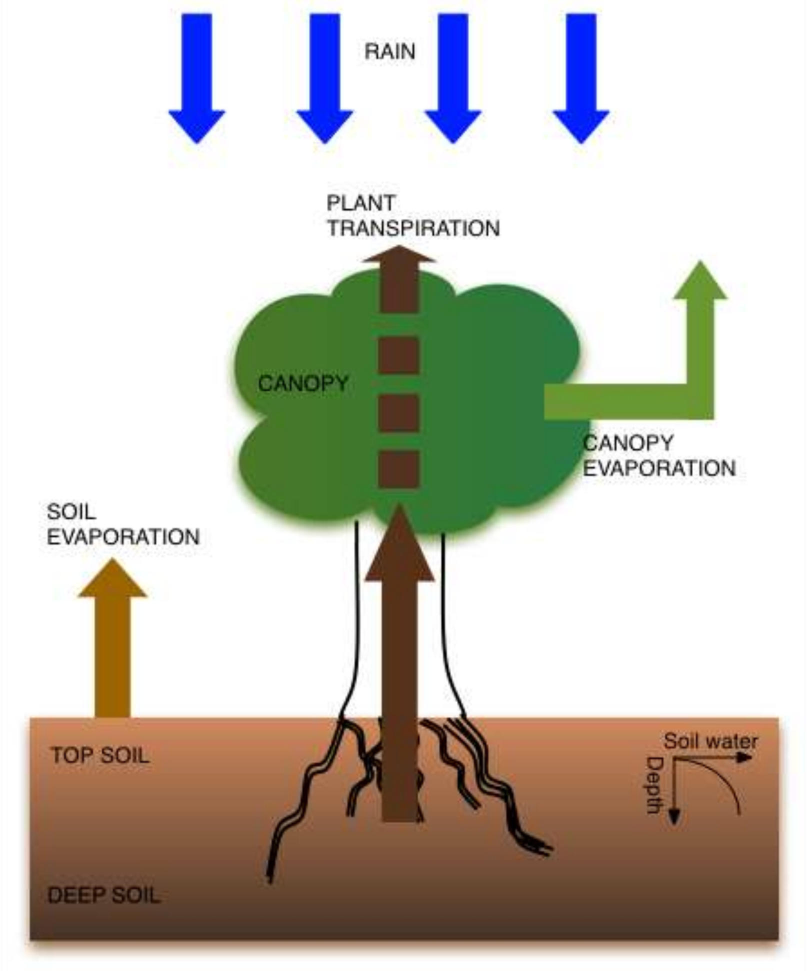
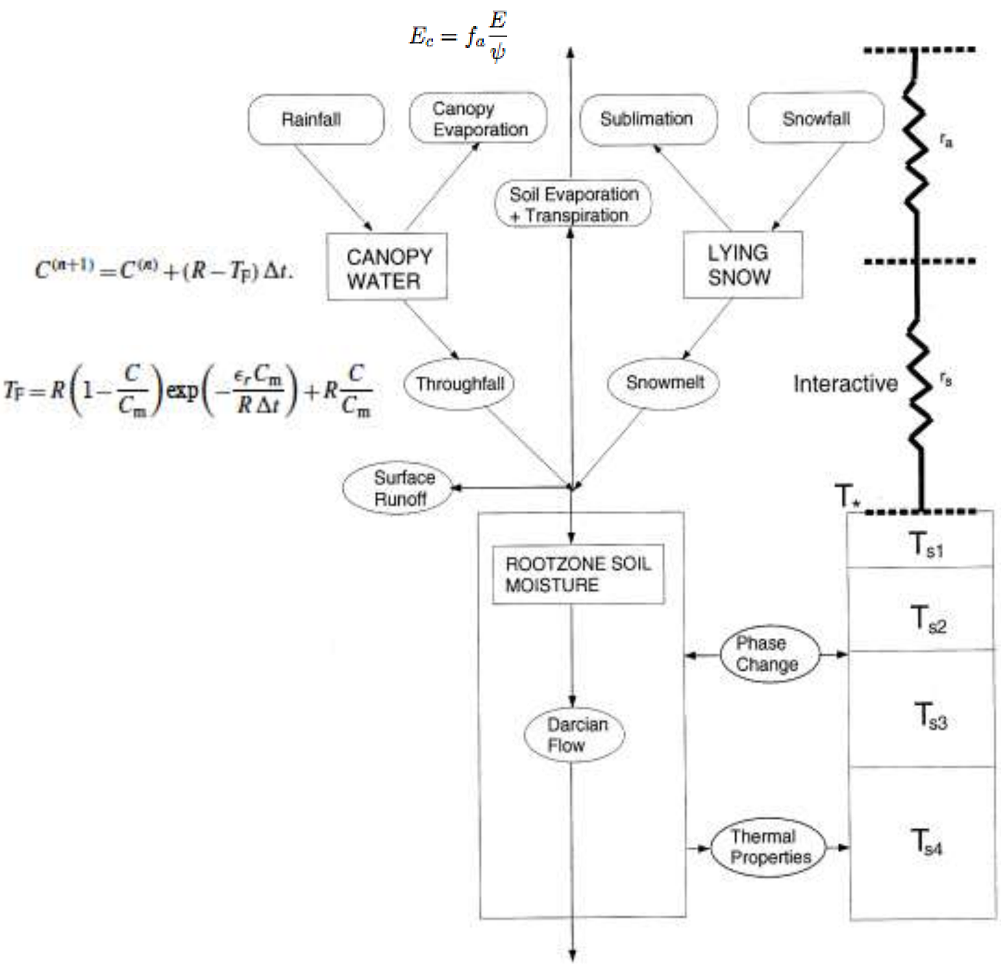
Outline

- Background and motivation
- Effect of different formulations of canopy capacity on latent heat simulation in JULES
- The knock-on effect on soil moisture and NPP
- Conclusions and recommendations



The hydrological cycle in JULES

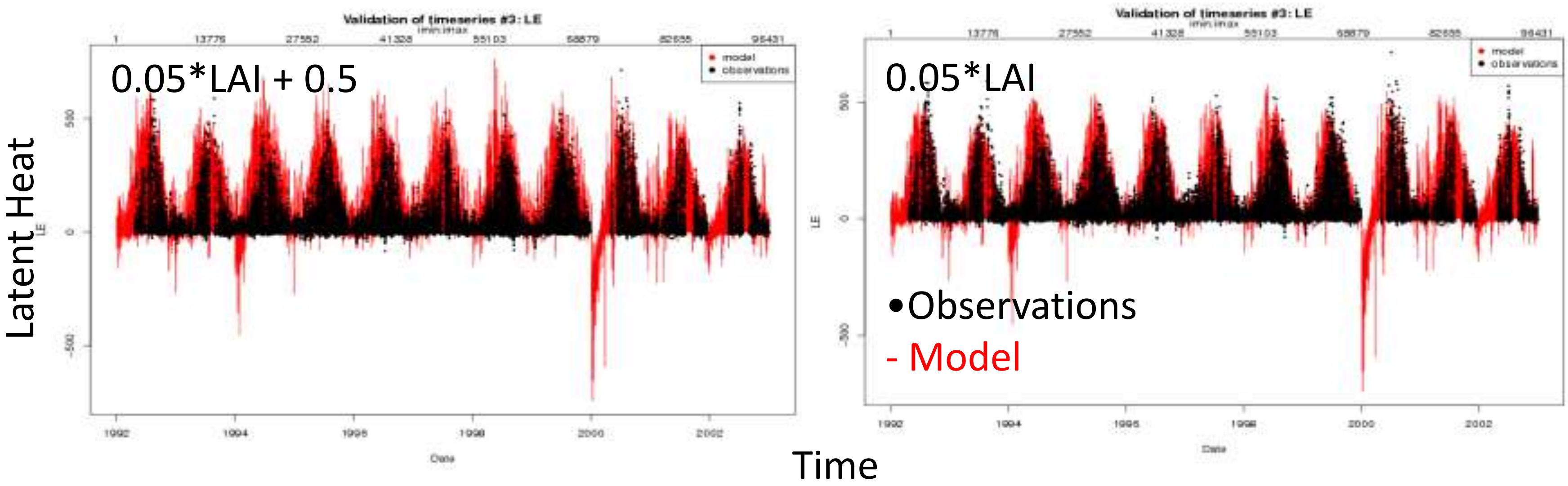


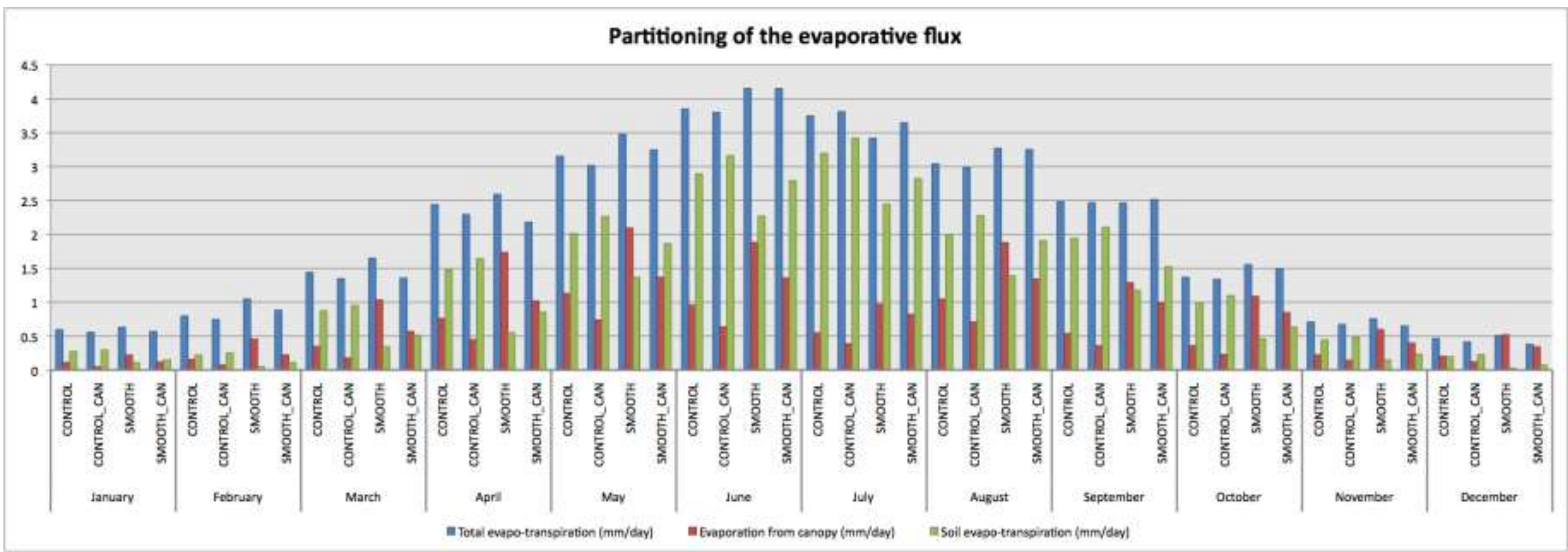
It is important to get canopy capacity right because it determines how moisture is exchanged between surface and atmosphere within a time step, and hence the degree of land-surface - atmosphere coupling.

Default canopy capacity in JULES is 0.5 + 0.05*LAI. BUT:

1. In temperate regions, the seasonal variation in canopy capacity may not be well-represented
2. The canopy capacity may be too high.
3. It is at odds with other LSMs (eg SiB and NCAR-LSM), which define canopy capacity as A * LAI

Canopy capacity and evaporative fluxes





Methodology

Driving/validation data:

- Benchmarking fluxnet sites
- Hourly/half hourly meteorological driving data
- Vegetation/soils based on observations
- Short data periods (up to 13 years)

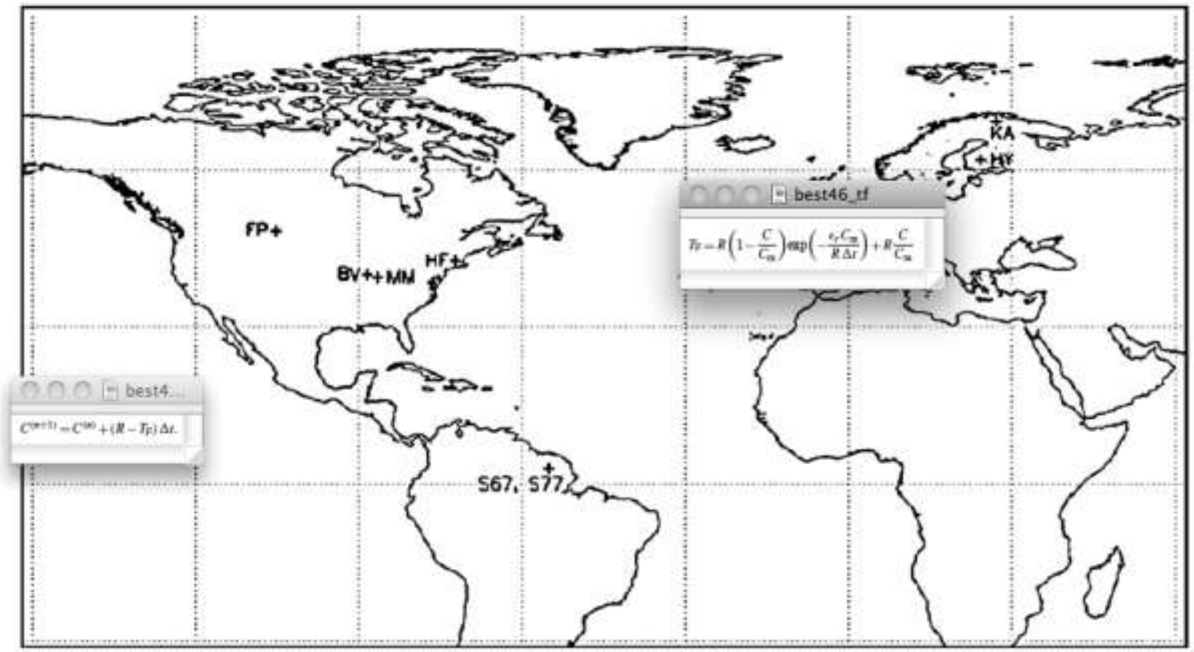
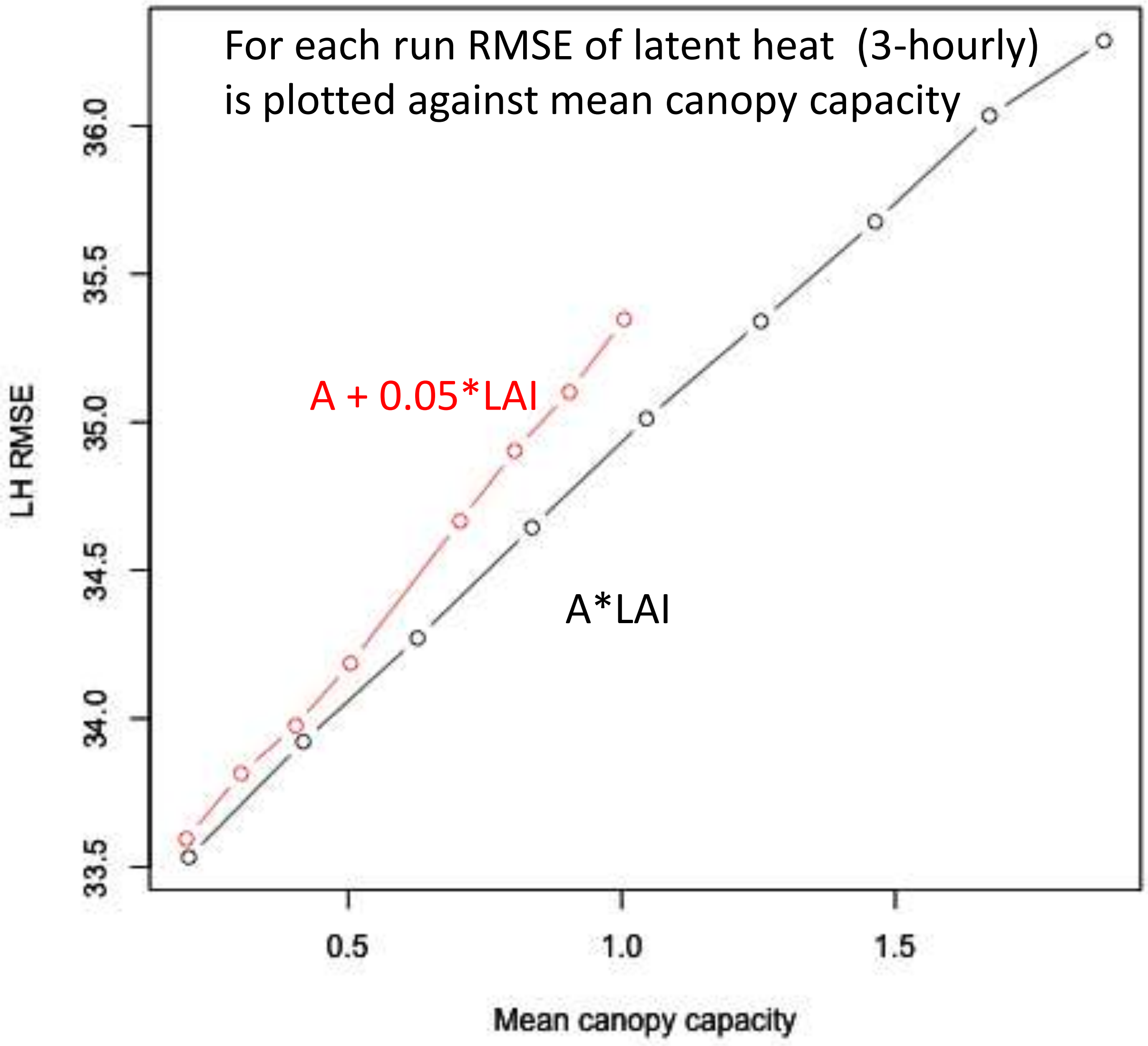


FIG. 1. Location of the FLUXNET sites used in this study labeled as follows: FP = Fort Peck; BV = Bondville; MM = Morgan Monroe; HF = Harvard Forest; S67 = Santarem km 67, Brazil; S77 = Santarem km 77, Brazil; KA = Kaamenen; HY = Hyytiälä; TH = Tharandt; and ES = El Saler.

JULES set up:

- Phenology ON
- Canopy model 4
- Full spin up

Effect of canopy capacity function on the simulation of Latent Heat

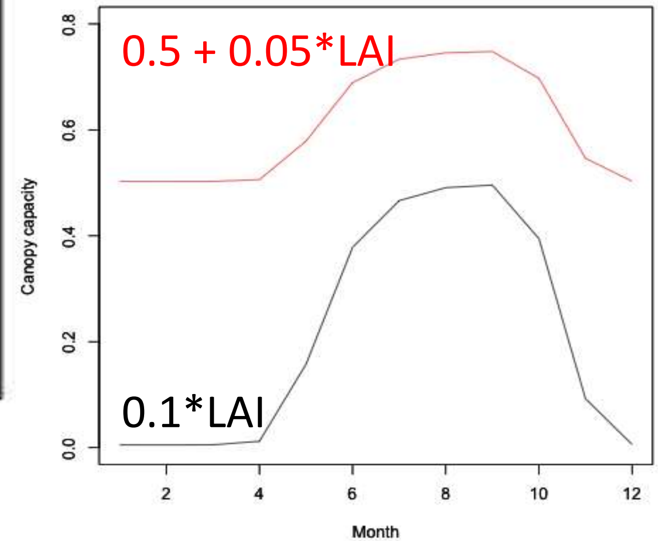


JULES forced with fluxnet data. Canopy capacity function of the form:

(i) A + 0.05*LAI

(ii) A * LAI

The constant ‘A’ varies from 0.1-0.9



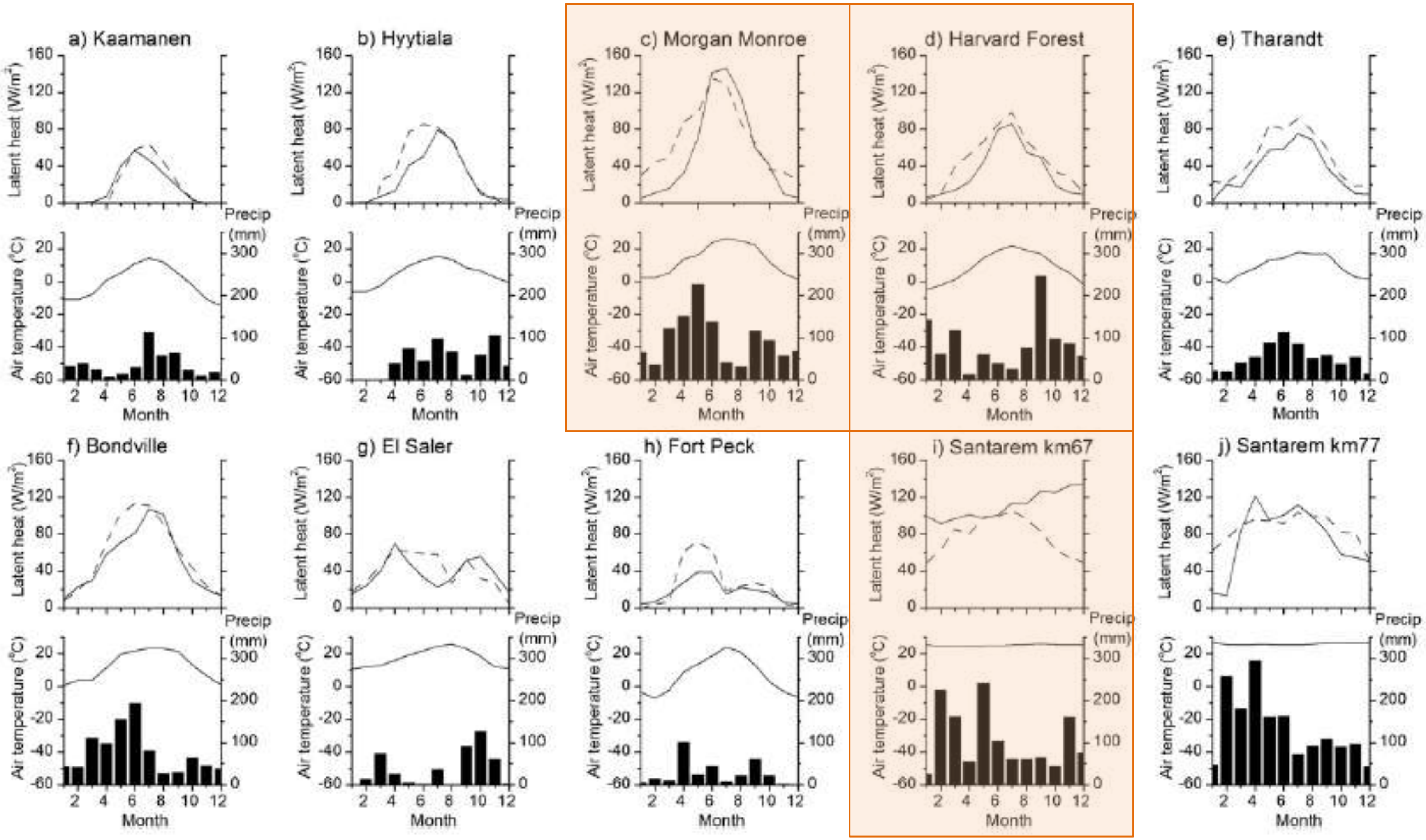
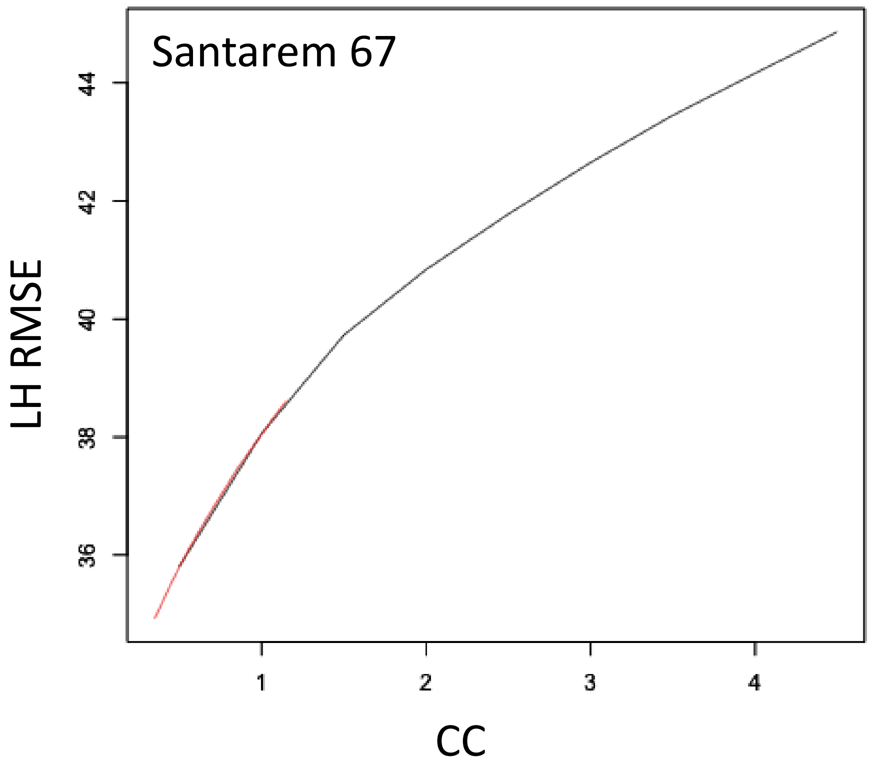
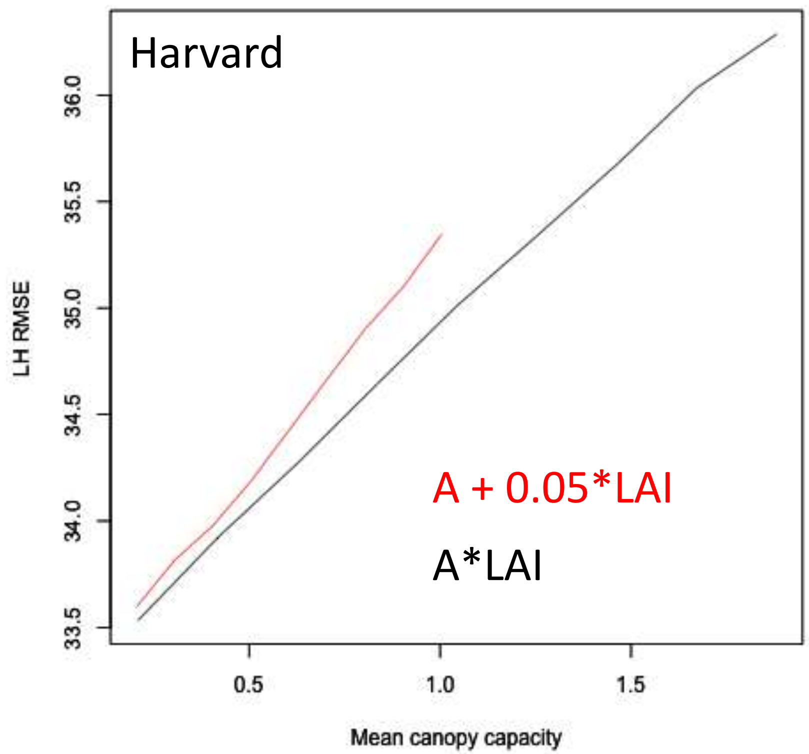


FIG. 2. Monthly-mean observed evaporation (E_{OB}, solid thick line) and modeled evaporation (E_{MOD}, solid thick broken line) air temperature (thin solid line), and rainfall (bar chart) for the following FLUXNET sites: (a) Kaamanen, (b) Hyytiälä, (c) Morgan Monroe, (d) Harvard Forest, (e) Tharandt, (f) Bondville, (g) El Saler, (h) Fort Peck, (i) Santarem km 67, and (j) Santarem km 77.

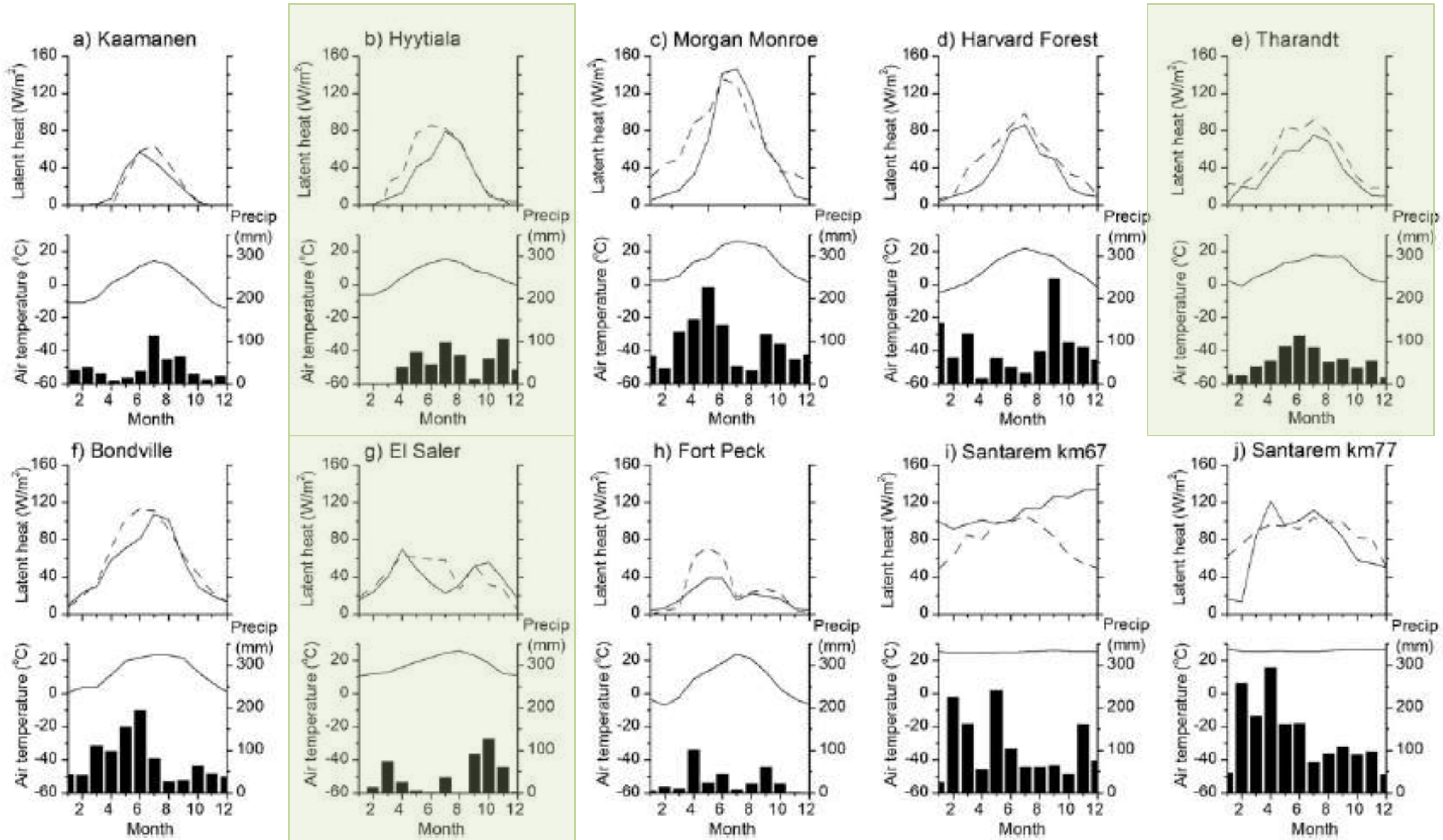
BT

Broad-leaf tree sites





- Most error arises from the systematically high latent heat in JULES – not from canopy capacity.
- The higher the canopy capacity, the higher the error
- It is evident, however that the errors are lower for canopy capacity of the form A * LAI



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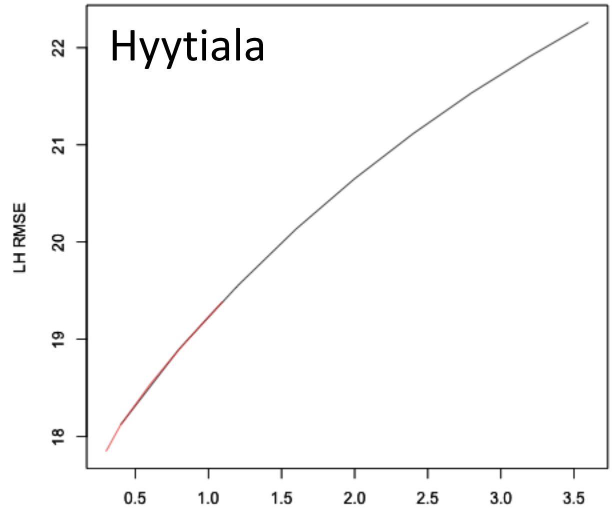
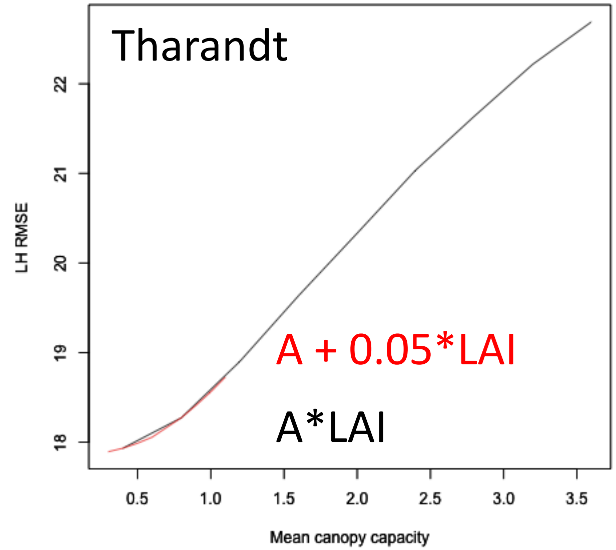
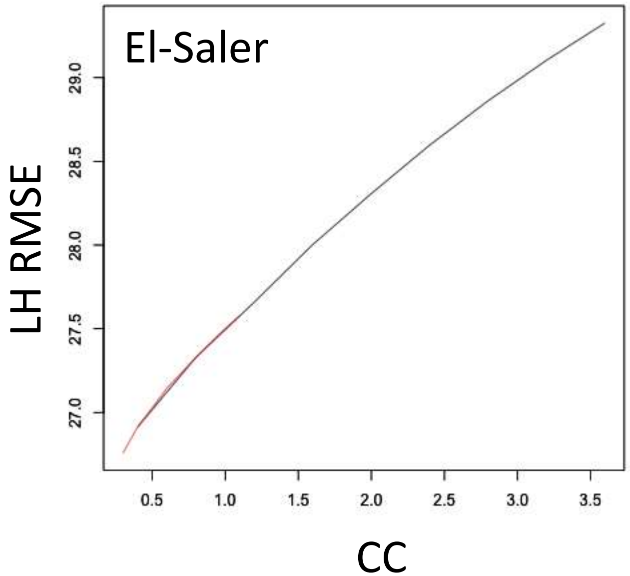
NT

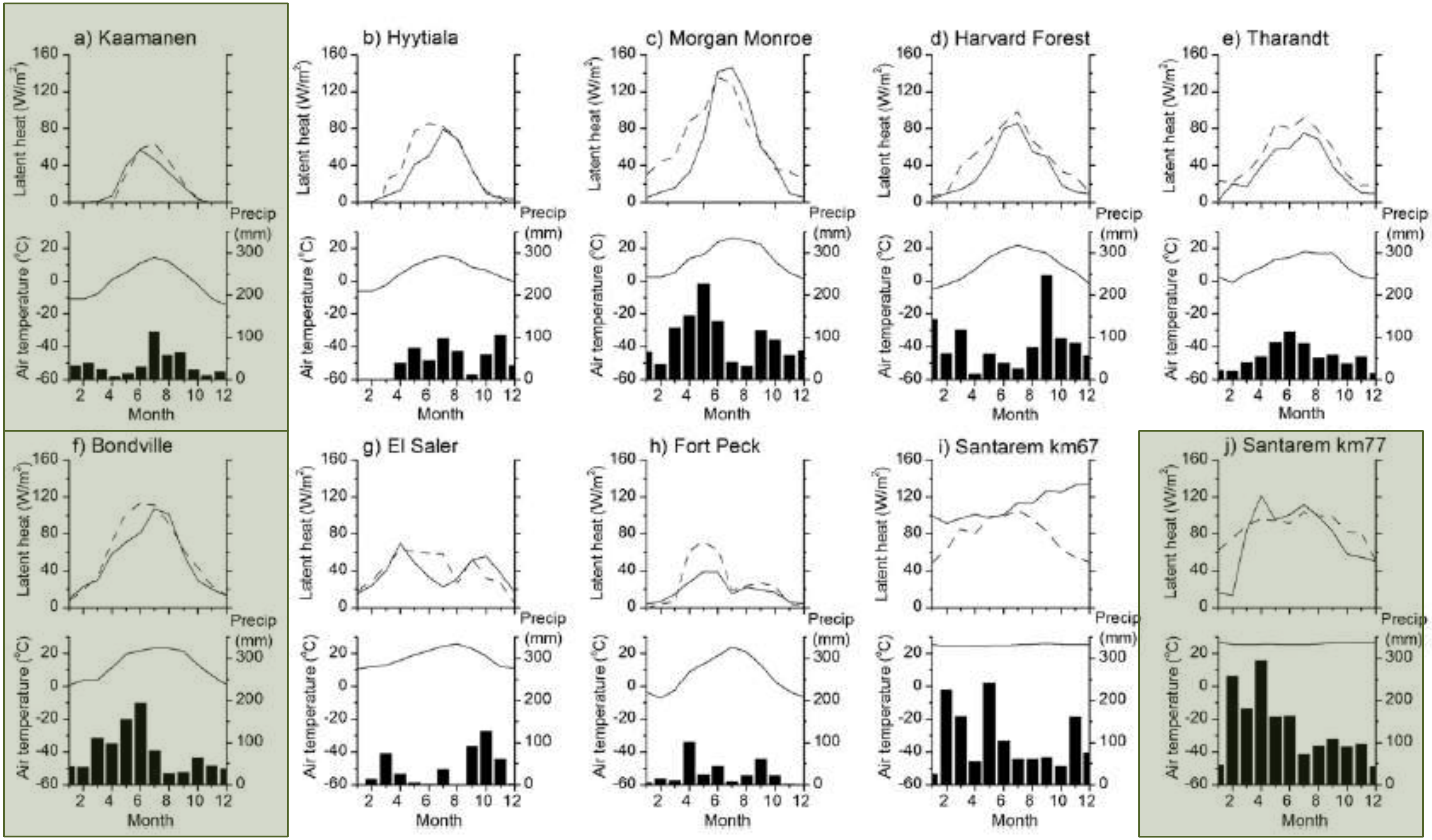
Needle-leaf tree sites







Not surprisingly, the form of the canopy capacity function does not matter for needle-leaf trees (LAI does not vary seasonally in JULES)



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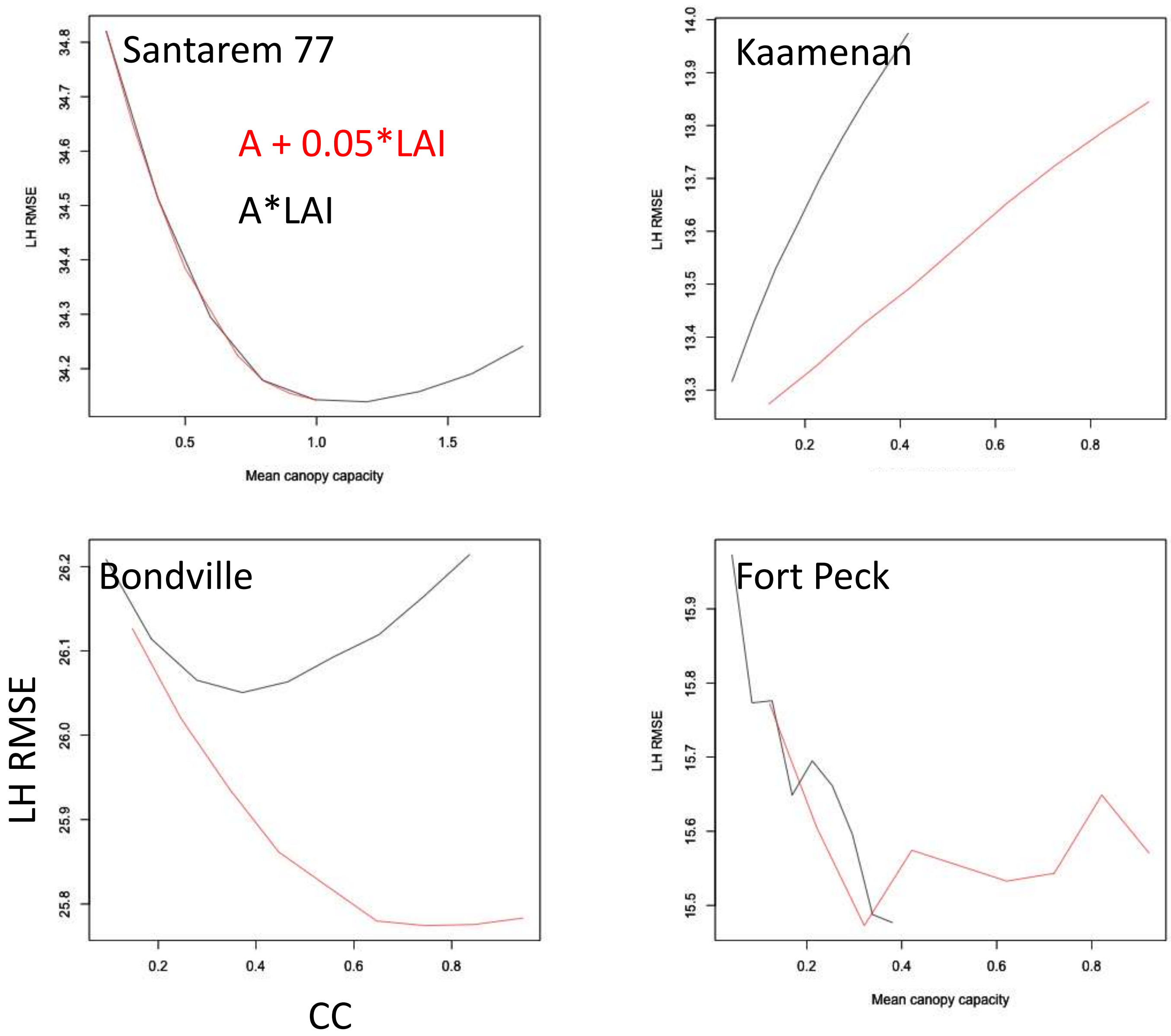
C3G

C3 Grass sites

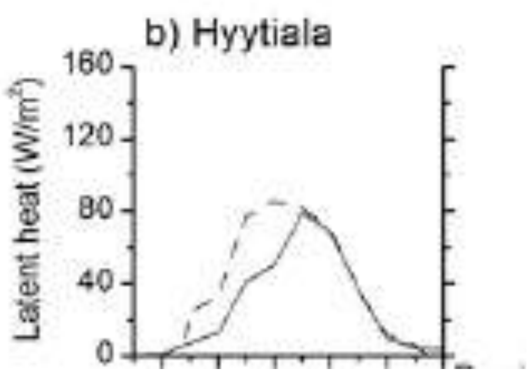


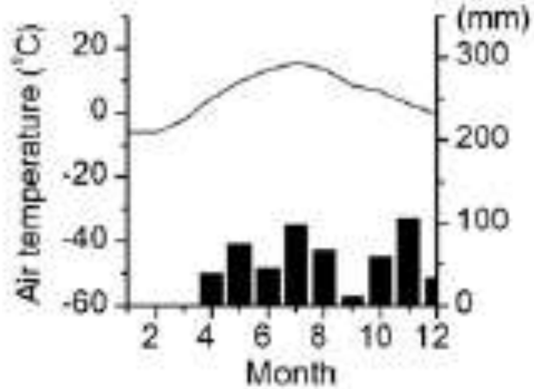
C3 grass results are difficult to interpret. There is considerable **variability between sites and regions**.

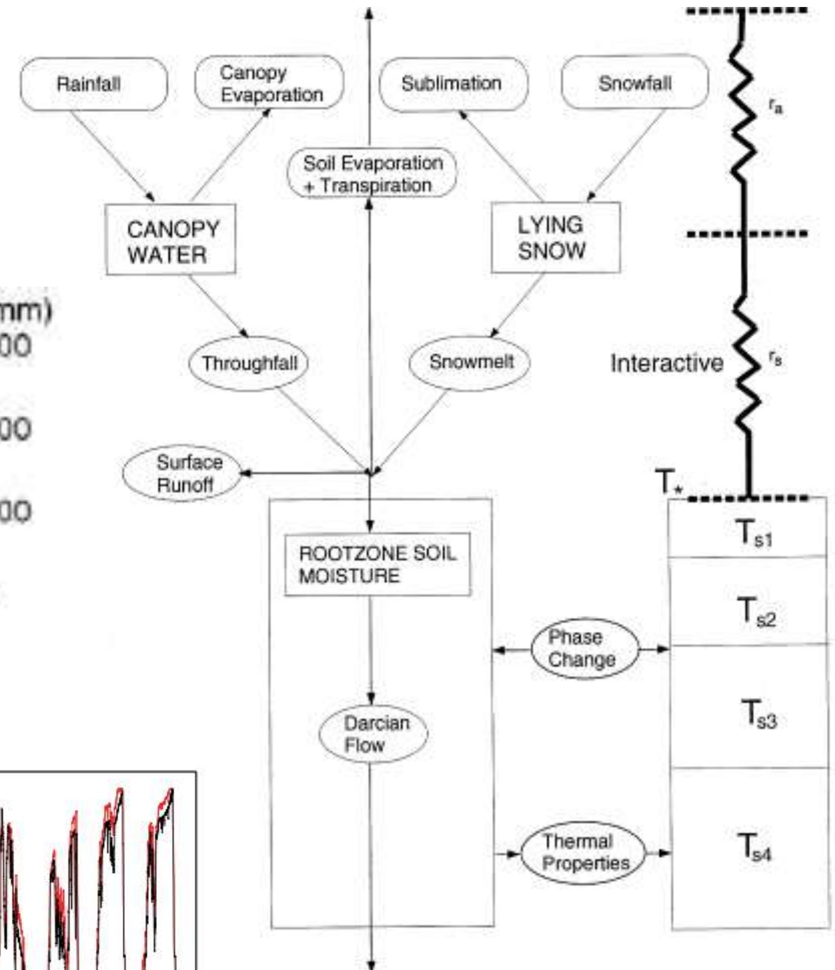
This may be related to JULES' simulation of the seasonal cycle in temperate regions.

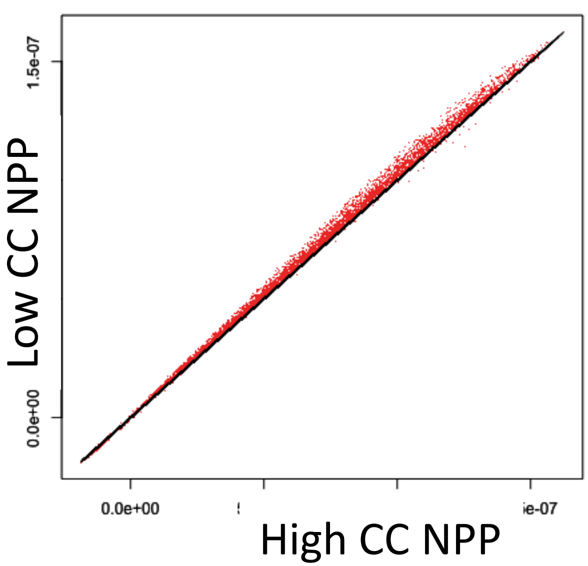
Vegetation and CC

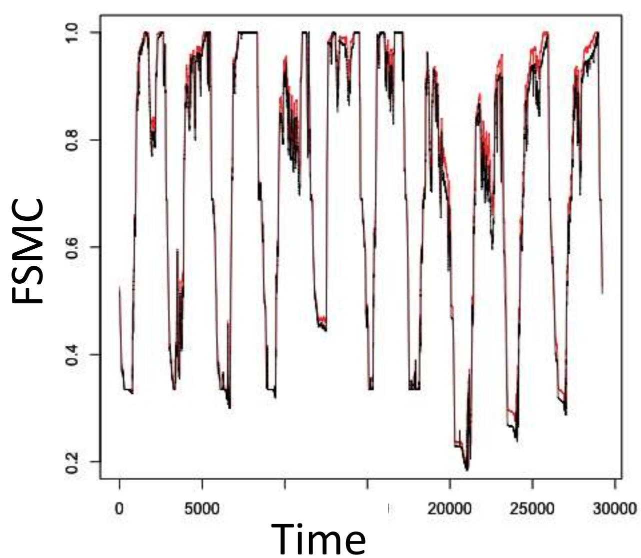
Hyytiala: Needle leaf trees









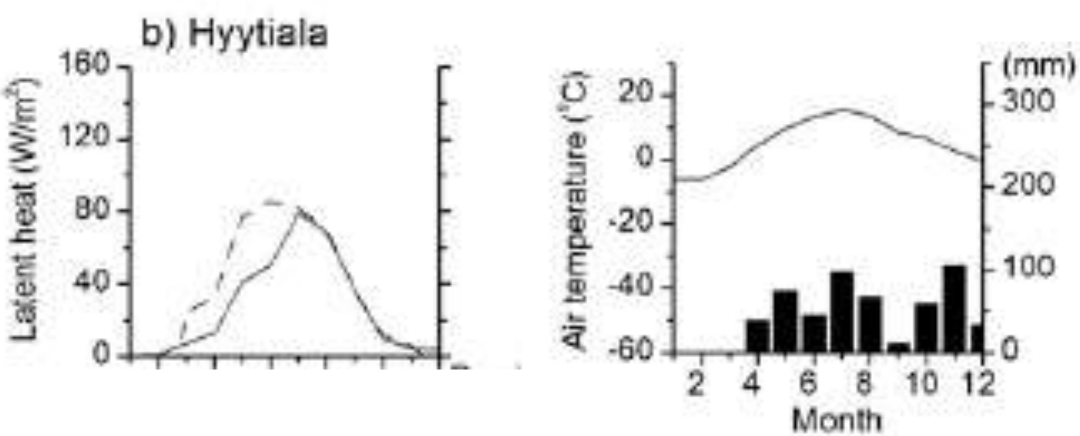


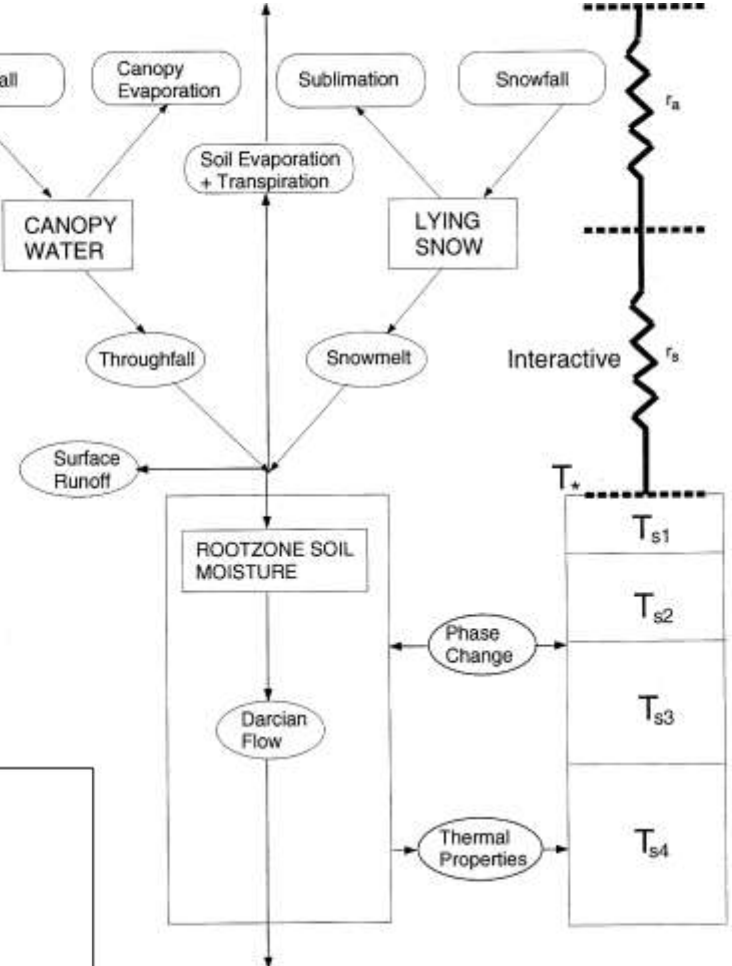
-High Canopy Capacity

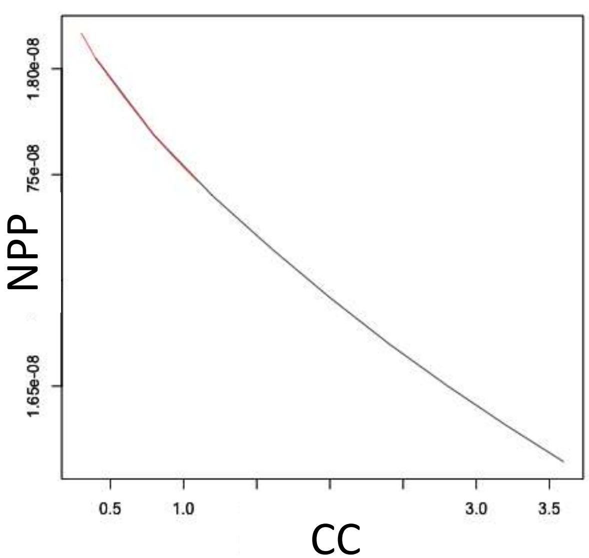
-Low Canopy Capacity

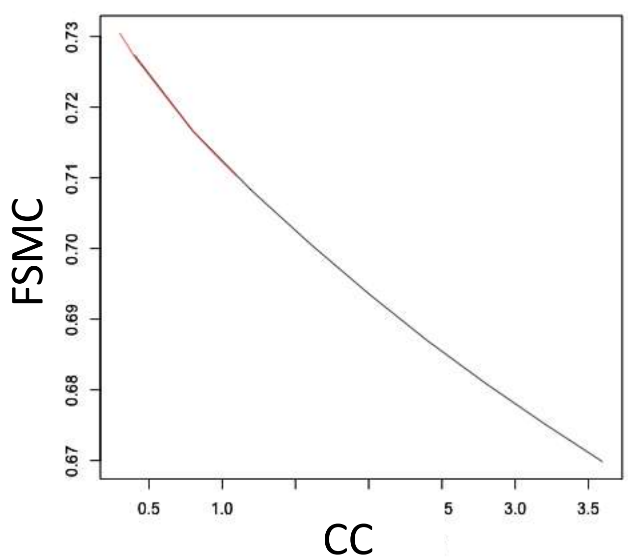
Vegetation and CC

Hyytiala: Needle leaf trees









Conclusions

•It is important to get canopy capacity right, because of its importance for land-atmosphere coupling.

•However, in the cases of needle-leaf and broadleaf trees, **canopy capacity is not the primary cause of error in latent heat**. Generally, reducing the canopy capacity will reduce errors mainly by compensating for excessively high evapo-transpiration.

•It is evident that canopy capacity of the form A*LAI is more appropriate in temperate BT/NT regions because it introduces a more realistic seasonal cycle in canopy capacity, which improves the seasonal cycle in latent heat.

•In the case of grasses, the situation is more complex. Canopy capacity has an effect on error over and above its impact on reducing evapo-transpiration.

Recommendations

- For broadleaf and needle leaf trees, canopy capacity should be defined as A* LAI, where A is between 0.1 and 0.2. This can be done in the .jin file
- Further work should be carried out to determine the best parameterization for grasses. For now, it would be best to stick to 0.5 + 0.05*LAI
- Sorting out the canopy capacity will not solve JULES' problem of high evapo-transpiration. Further work on the hydrological cycle in JULES (eg during SWELTER) is required.