Evaluating radiative transfer schemes treatment of vegetation canopy architecture in land surface models

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01 | Why does vegetation structure matter?

- Vegetation canopy structure affects radiation partitioning and land surface processes, as energy and water exchanges (Loew et al., 2014).

02 | Methodology: the ‘structure factor’

- Using a straightforward approach, which introduces a parameterisation in a 1D radiative transfer (RT) scheme (Q(θ)) (Pietry et al. 2008), it is possible to recreate the vegetation radiative balance consistently with 3D representations. To find the additional parameter, Eq. 1 describes the probability of beam penetration in a vegetation canopy.

\[ P_{gap}(θ) = \exp \left( -\frac{G(θ) \cdot LAI \cdot C(θ)}{\cos(θ)} \right) \]  

(1)

Where \( C(θ) = a \cdot b \cdot (1 - \cos(θ)) \), also expressed as \( a \beta \).

- A comparison between the performance of the structure factor parameterisation and state-of-art 3D RT schemes was conducted, following a set of virtual scenarios described in the RAM4PILPS experiment (Midgley et al., 2011).

03 | Measuring canopy gap fraction

- The canopy gap fraction was obtained with two different methods:
  a) A 3D tree based model (MAESPA) with canopy structural data derived from airborne LIDAR, and
  b) the average of 52 Digital Hemispherical Photographs (DHP) equally spaced acquired at the same area (300 m x 300 m) around the micrometeorological tower.

04 | Retrieving the ‘structure factor’

- In order to derive the ‘structure factor’ through the inversion of Eq. 1, it is necessary to have previous knowledge about:

  \( C(θ) = 0.5 \) spherical distribution assumption
  \( LAI = 0.82 \pm 0.10 \text{m}^2\text{m}^{-2} \) litterfall measurement (Nyuetal., 2010)

05 | Impacts on the radiative balance

- For the period from 7th to 16th of May 2001, the average maximum value of absorbed amount of PAR was calculated with the default two-stream approximation (JULES RT scheme), \( \sim 140 \text{Wm}^{-2} \), twice as much as obtained with MAESPA (\( \sim 70 \text{Wm}^{-2} \)).

JULES parameterised with observed data (<DHP> Manual) showed an average maximum value of \( \sim 90 \pm 20 \text{Wm}^{-2} \) for APAR.

06 | Conclusion

- The ‘structure factor’ parameterisation improved the partitioning of PAR of the 1D RT scheme JULES.
- The \( P_{gap} \) obtained via DHPs was comparable to 3D modelling and it was used to overpower the 1D model.
- Improved calculated absorbed and reflected PAR, while the 1D model tended to overestimate and underestimate up to 50%, respectively.

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