JULES
Joint UK Land Environment Simulator

Science Annual Meeting
7-11th September 2020

Proposed JPEG on soil evaporation

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New JPEG soil evaporation

- Spin-off JPEG from “Soil Moisture Stress on Vegetation” JPEG
- **Main objective**: Improve evaporation from bare soil tile

Key issues (from GEWEX Evaporation meeting):

- Evaporation dynamics (stages)
- Use resistances?
- Separation of Evaporation and Transpiration
- Nighttime contribution of E
- ..

Solutions/new approaches:

- using e.g. approach by Or and Lehmann, WRR 2019
- Re-visit vapour flow in JULES following on from efforts by Garcia-Gonzalez et al. 2012 (WRR) and vapour modelling by John Edwards (UKMO)
- Evaporation changes in very wet soils (Sarah Chadburn, Exeter)

Water Resources Research

RESEARCH ARTICLE
10.1029/2018WR024050

Special Section:
Advancing process representation in hydrologic models: Integrating new concepts, knowledge, and data

Surface Evaporative Capacitance: How Soil Type and Rainfall Characteristics Affect Global-Scale Surface Evaporation

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Key Points:
- A novel method for estimating surface evaporation from soil properties and accounting for internal drainage dynamics is presented
- A soil-dependent evaporative characteristic length defines an active surface evaporative capacitor (SEC) depth
- The ratio of surface evaporation to potential evapotranspiration is relatively constant across climates, biomes, and soil types

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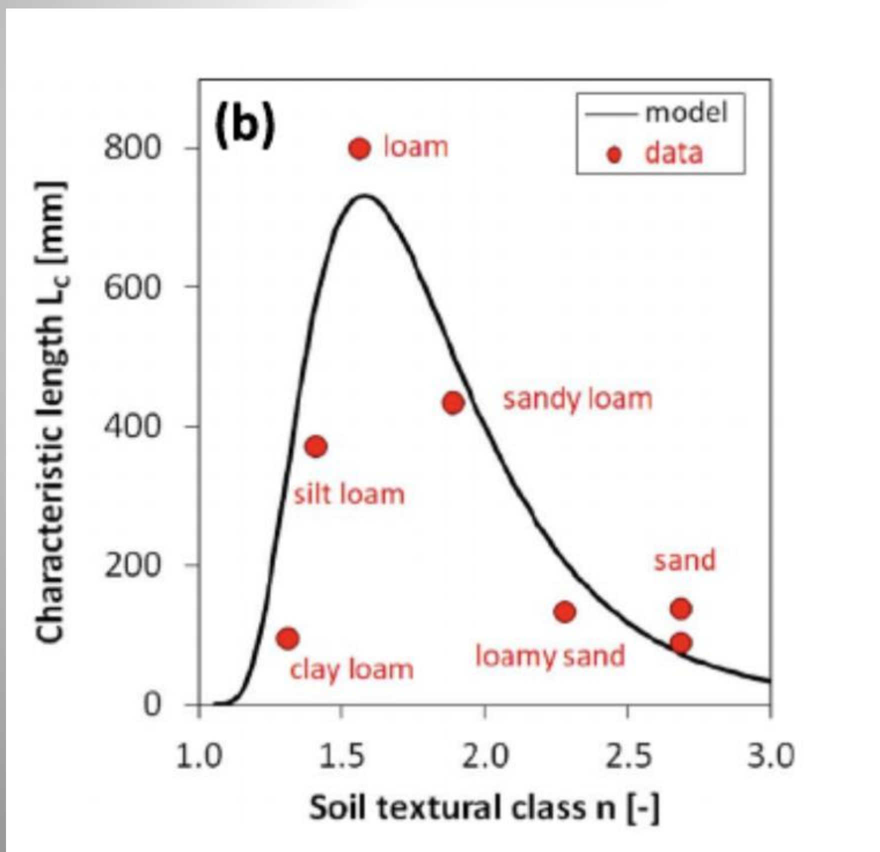
Citation:
Or, D., & Lehmann, P. (2019). Surface evaporative capacitance: How soil type and rainfall characteristics affect global-scale surface evaporation. *Water*

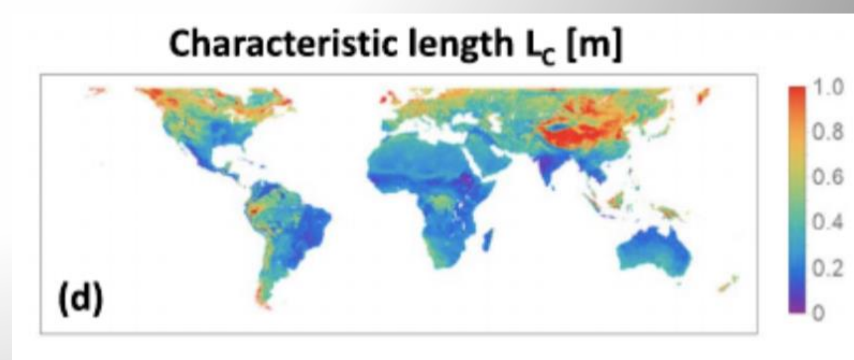
Abstract The separation of evapotranspiration (ET) into its surface evaporation (E) and transpiration (T) components remains a challenge despite its importance for linking water and carbon cycles, for water management, and for attribution of hydrologic isotope fractionation. Regional and global estimates of surface evaporation often rely on estimates of ET (e.g., Penman-Monteith) where E is deduced as a residual or as a fraction of potential evaporation. We propose a novel and direct method for estimating E from soil properties considering regional rainfall characteristics and accounting for internal drainage dynamics. A soil-dependent evaporative characteristic length defines an active surface evaporative capacitor depth below which soil water is sheltered from capillary pull to the evaporating surface. A site-specific *evaporative capacitor* is periodically recharged by rainfall and discharges at rates determined by interplay between internal drainage and surface evaporation. The surface evaporative capacitor concept was tested using field measurements and subsequently applied to generate a global map of climatic surface evaporation. Latitudinal comparisons with estimates from other global models (e.g., Penman-Monteith method modified by Leuning et al., 2008, https://doi.org/10.1029/2007WR006562 [PML]; Moderate Resolution Imaging Spectroradiometer [MODIS]; and Global Land-surface Evaporation: the Amsterdam Methodology [GLEAM]) show good agreement but also point to potential shortcomings of present estimates of surface evaporation. Interestingly, the ratio of surface evaporation (E) to potential evapotranspiration (ET_0) is relatively constant across climates, biomes, and soil types with $E/ET_0 < 0.15$ for 60% of all terrestrial surfaces, in agreement with recent studies.

Soil Evaporation Characteristic Length

- A soil dependent **evaporative characteristic length**, L_C, defines an **active surface evaporative capacitor** depth below which soil water is sheltered from capillary pull to the evaporating surface
- L_C : **The depth of a region that can be drained by stage-1 evaporation** and concurrent redistribution to deeper soil layers



$$L_C = \frac{h_{crit} - h_b}{1 + {E_0}/{4K(h_{crit})}} = \frac{\frac{(1-m)}{\alpha}\left(1 + \frac{1}{m}\right)^{(1+m)}}{1 + {E_0}/{4K(h_{crit})}}$$



Incorporation of water vapor transfer in the JULES land surface model: Implications for key soil variables and land surface fluxes

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[1] This study focuses on the mechanisms underlying water and heat transfer in upper soil layers, and their effects on soil physical prognostic variables and the individual components of the energy balance. The skill of the JULES (Joint UK Environment Simulator) land surface model (LSM) to simulate key soil variables, such as soil moisture content and surface temperature, and fluxes such as evaporation, is investigated. The Richards equation for soil water transfer, as used in most LSMs, was updated by incorporating isothermal and thermal water vapor transfer. The model was tested for three sites representative of semiarid and temperate arid climates: the Jornada site (New Mexico, USA), Griffith site (Australia), and Audubon site (Arizona, USA). Water vapor flux was found to contribute significantly to the water and heat transfer in the upper soil layers. This was mainly due to isothermal vapor diffusion; thermal vapor flux also played a role at the Jornada site just after rainfall events. Inclusion of water vapor flux had an effect on the diurnal evolution of evaporation, soil moisture content, and surface temperature. The incorporation of additional processes, such as water vapor flux among others, into LSMs may improve the coupling between the upper soil layers and the atmosphere, which in turn could increase the reliability of weather and climate predictions.

Citation: Garcia Gonzalez, R., A. Verhoef, P. Luigi Vidale, and I. Braud (2012), Incorporation of water vapor transfer in the JULES land surface model: Implications for key soil variables and land surface fluxes, *Water Resour. Res.*, *48*, W05538, doi:10.1029/2011WR011811.

Next steps

- Start meeting regularly and share information
- Contact a.verhoef@reading.ac.uk if you want to be involved
- WIKI pages:

https://code.metoffice.gov.uk/trac/jules/wiki/JPEGSoilEvaporation