GLEAM4: Improving global terrestrial evaporation estimates with hybrid modelling

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1. Introduction

Terrestrial evaporation

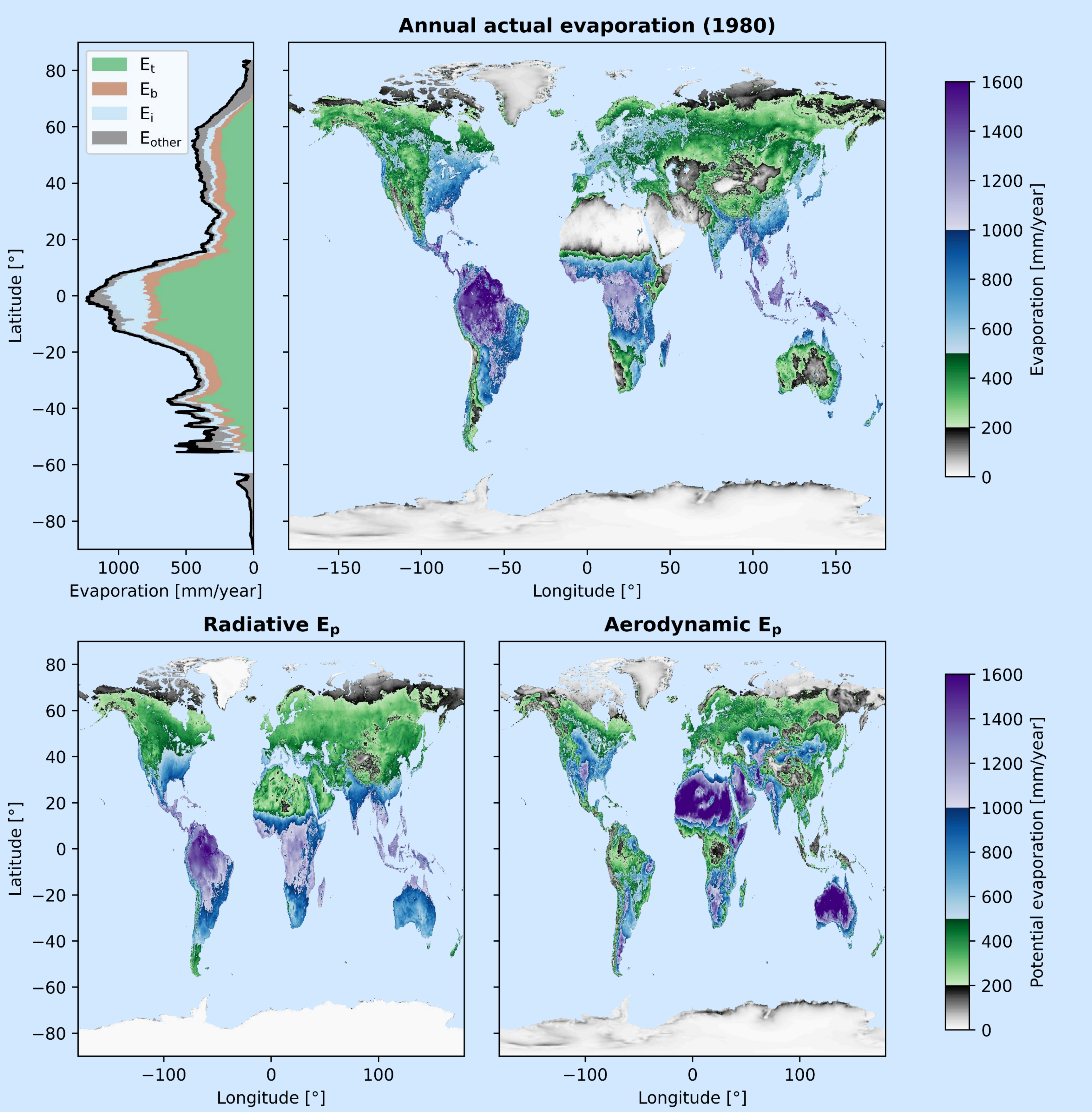
- Crucial role in modulating climate dynamics and water resources
- Not directly observable from space, limited in-situ observations
- Challenging to model due to variety of atmospheric drives and environmental stressors

Approaches to modelling evaporation

- Complex land surface models (e.g. HTESSEL, CLM)
- More observational approaches:

Process-based models	Hybrid modelling	Machine learning
PT-JPL, PM-MOD, GLEAM v3	GLEAM4	FLUXCOM

3. Global patterns of terrestrial evaporation



2. Model advancements: GLEAM v3 to GLEAM4

Following modules were revised and updated since GLEAM v3 (Martens *et al.*, 2017)

Zhong *et al.* (2022)

- Gash analytical model (Gash 1979) → Revised Gash model by van Dijk & Bruijnzeel (2001).
- Short and tall vegetation interception

Penman (1948)

$$E_p = \overbrace{\frac{\Delta(R_n - G)}{\lambda(\Delta+\gamma)}}^{(1)} + \overbrace{\frac{\rho_a c_p g_a VPD}{\lambda(\Delta+\gamma)}}^{(2)}$$

(1) Radiative component

- GLEAM v3: $E_p = \alpha \times (1)$
- Driven by the available energy $(R_n - G)$

(2) Aerodynamic component

- Function of the atmospheric surface layer
- Requires modelling of aerodynamic conductance

$$g_a = \frac{k^2 u}{\ln\left(\frac{z-d}{z_{0,m}}\right)\ln\left(\frac{z-d}{0.1\, z_{0,m}}\right)}$$

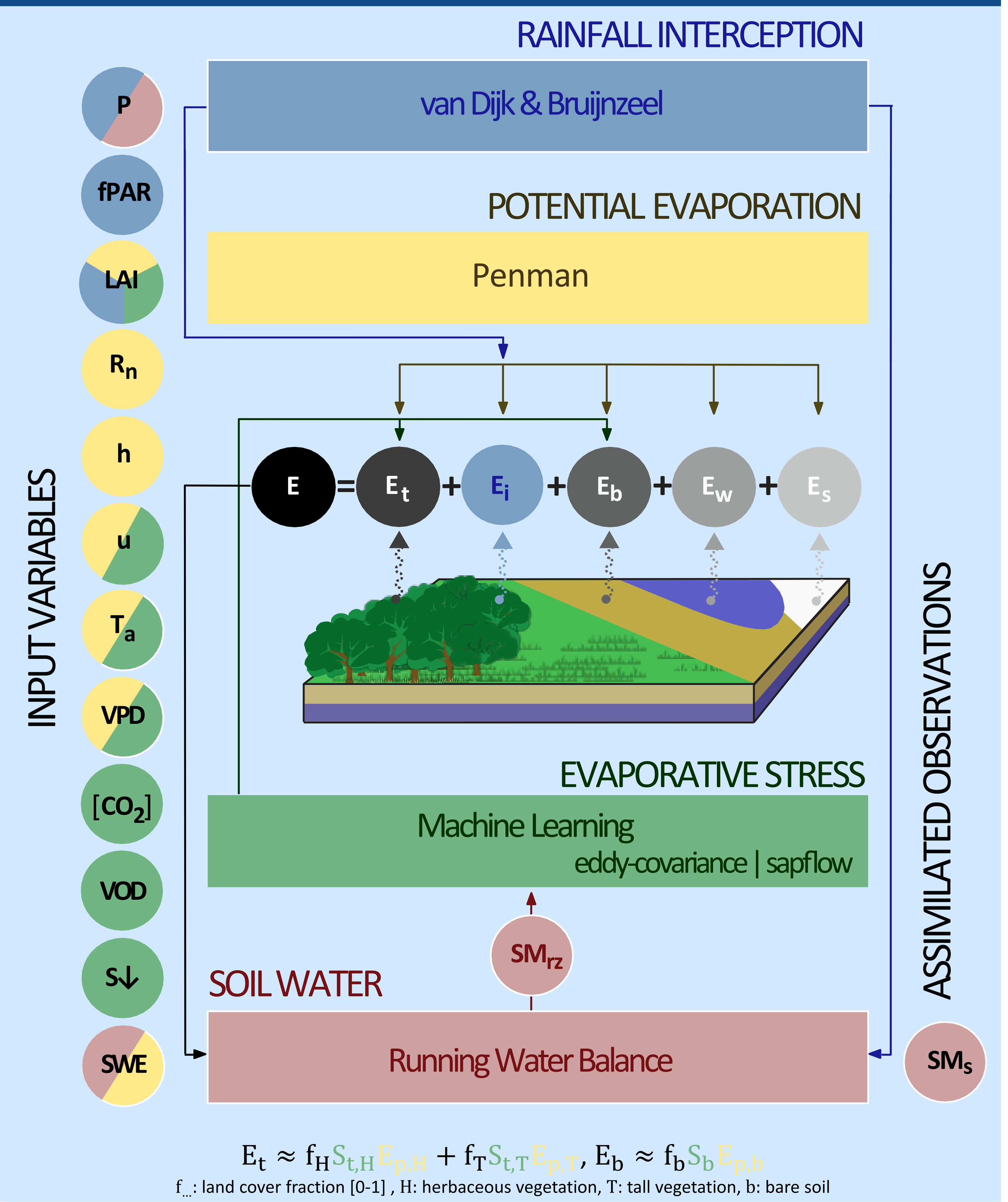
- $z_{0,m}$ and d dependent on vegetation height (i.e. surface roughness)

Modified version of Koppa *et al.* (2022)

GLEAM v3	Koppa *et al.* (2022)	GLEAM4
$S_t = f_{empirical}(VOD, SM_{rz})$	$S_t = f_{NN}(VOD, SM_{rz}, VPD, S\downarrow, T_a, [CO_2])$	$S_t = f_{NN}(VOD, SM_{rz}, VPD, S\downarrow, T_a, [CO_2], u, LAI)$
Training data: FLUXNET and SAPFLUXNET		

Hulsman *et al.* (2023)

- Linear reservoir model for groundwater
- Plant access to groundwater under water-limited conditions



4. Dataset

- Spatial resolution: 0.1° (vs. 0.25° for GLEAM v3)
- Temporal resolution: daily
- Spatial coverage: global (land)
- Temporal coverage: 1980-2023
- 11 distributed variables: actual evaporation, transpiration, bare soil evaporation, interception loss, open-water evaporation, evaporation over snow and ice, potential evaporation, evaporative stress, root-zone soil moisture, surface soil moisture and surface sensible heat flux.
- Miralles et al. (*in prep.*) for validation and info on data usage
- To be openly distributed soon via www.gleam.eu

5. Future perspectives

- Towards higher temporal resolution with the proposed SLAINTE mission (ESA):
  - HS 6.3: Assessing the potential of future sub-daily microwave observations for estimating evaporation (Tronquo *et al.*, 2024)
- Towards higher spatial resolution within HERMES (BELSPO STEREO IV project):
  - HS 6.3: Towards a continuous, multiyear, high-resolution dataset of evaporation over Europe and Africa (Baez-Villanueva *et al.*, 2024)
- Data assimilation of terrestrial water storage estimates:
  - HS 2.5.3: Improving global evaporation estimation using GRACE and GRACE-FO satellite data assimilation
- Explorative approach: Online (i.e. end-to-end) training of an evaporative stress NN on observed evaporation within a differentiable evaporation "toy" model (inspired by GLEAM4).

References:

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