Satellite-constrained land model for the CliMA Earth System framework

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Program: FY21 R&TD Strategic Initiative **Strategic Focus Area: Land Modeling for the CliMA Earth System Framework**

Background

The grand challenge: understand the fate of carbon in the terrestrial biosphere. Currently, the terrestrial biosphere takes up about 25% of the CO_2 emitted by humans, thus mitigating some climate effects of anthropogenic emissions.
Key Questions: Will the biosphere continue to provide this service as a carbon sink in the face of land-use changes, climate change, and increasing CO2 concentrations? Or will the capacity of the land carbon sink be reduced, or even will the land become a net carbon source?
Relevance to NASA Earth Sciences: the above questions are of fundamental importance for our common climate future because the increasing amount of atmospheric CO2 will change the global Earth System.

Our technical objectives

(1) Development of an "online" JPL-CliMA land model capability: adaptation and integrtation of the existing CARDAMOM land model into the CliMA framework to facilitate JPL-CliMA ESM capability, as informed by the satellite POR.
(2) Development of an "offline" JPL land model capability, based on the JPL land model adaptations and enhancements achieved in TO1, to facilitate dedicated scientific and mission formulation OSSE investigation.

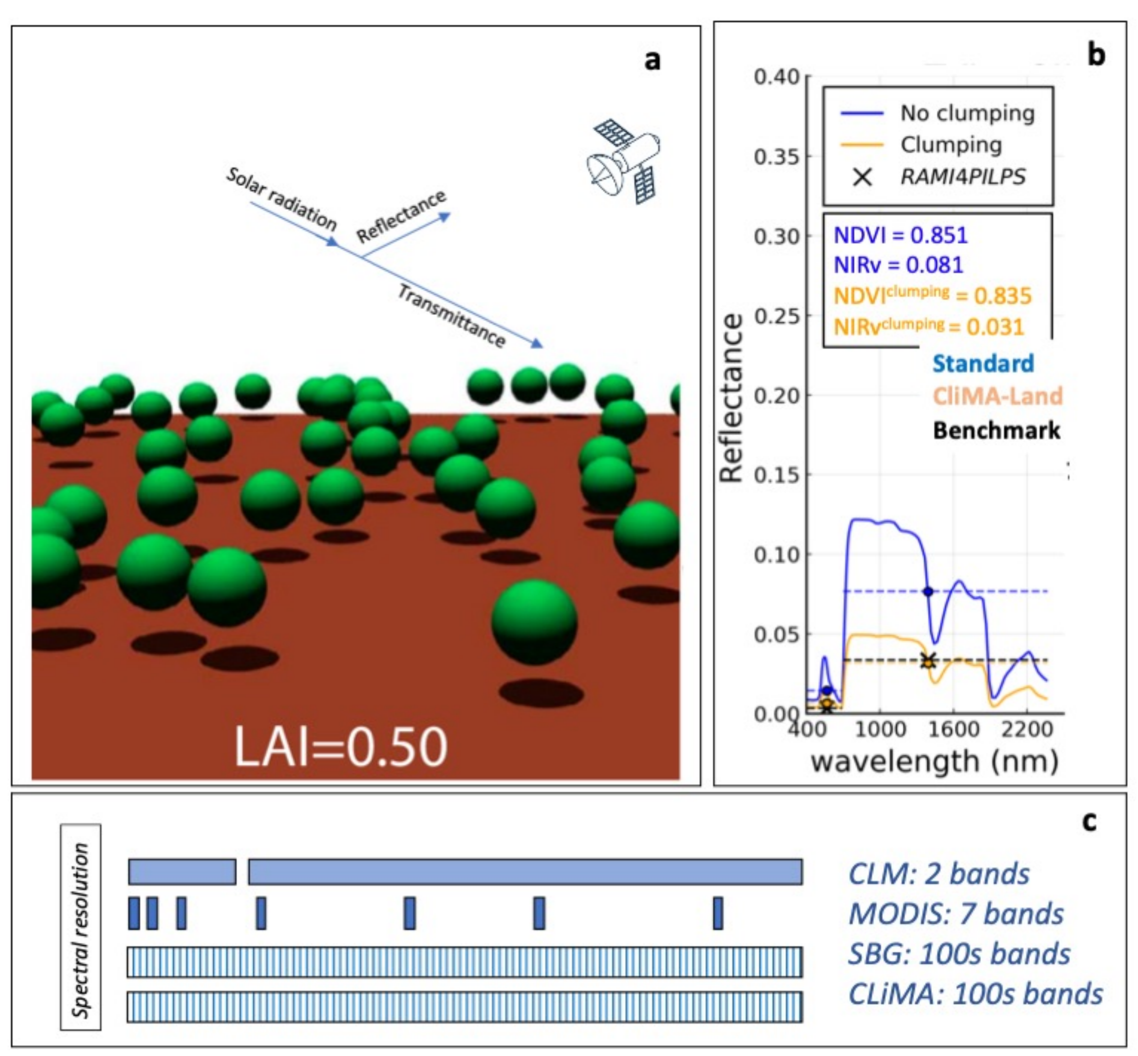


Figure 3. Interaction of solar radiation with plant structure and biophysical processes (photosynthesis, leaf area, vegetation water content) and their response to climate are critical for ES prediction (panel a). In the above example, the vegetation biophysics radiative transfer model (Braghiere et al., in prep., developed jointly with collaborator Christian Frankenberg at Caltech) allows for accurate estimation of plant biophysical states and fluxes. The CliMA-Land model spectral resolution (panel c) is being tailored to accommodate existing observing systems (MODIS, TROPOMI) and upcoming missions (SBG).

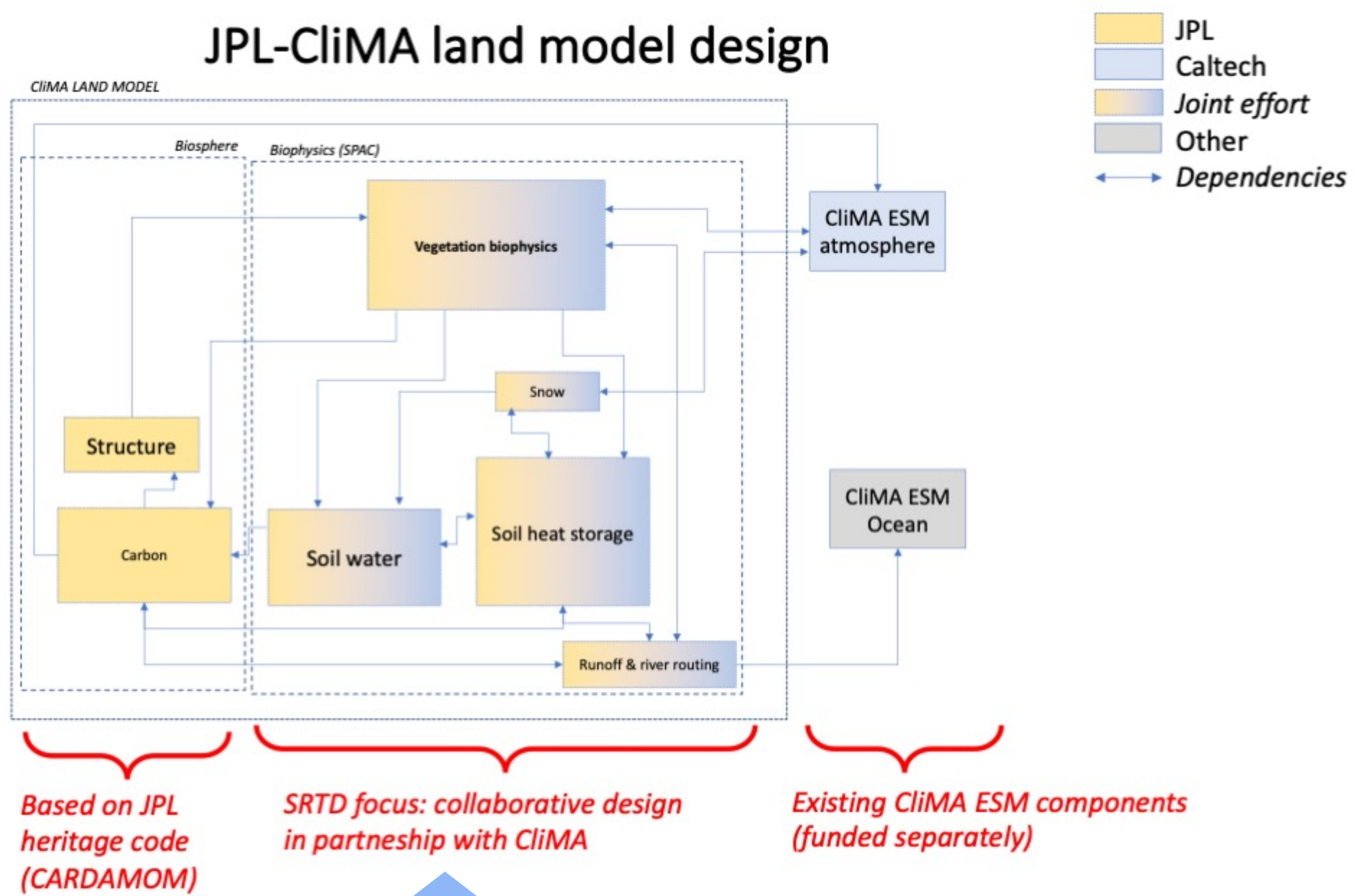


Figure 1 Depiction of interfaces between the CliMA ESM atmosphere and the land model. We will couple and adapt the existing CARDAMOM land biosphere model (currently represents carbon and soil water) with the vegetation biophysics model interface developed at Caltech to explicitly represent physical processes driving land-atmosphere interactions. Both interfaces will be implemented and tested with re-analysis data first (as place-holder meteorological drivers). Following the VVUQ of the finalized CARDAMOM-SPAC version, the model will be fully coupled into the CliMA system. Yellow (Blue)-colored boxes denote JPL(Caltech)-led activities, yellow-to-blue shading indicates joint activities.

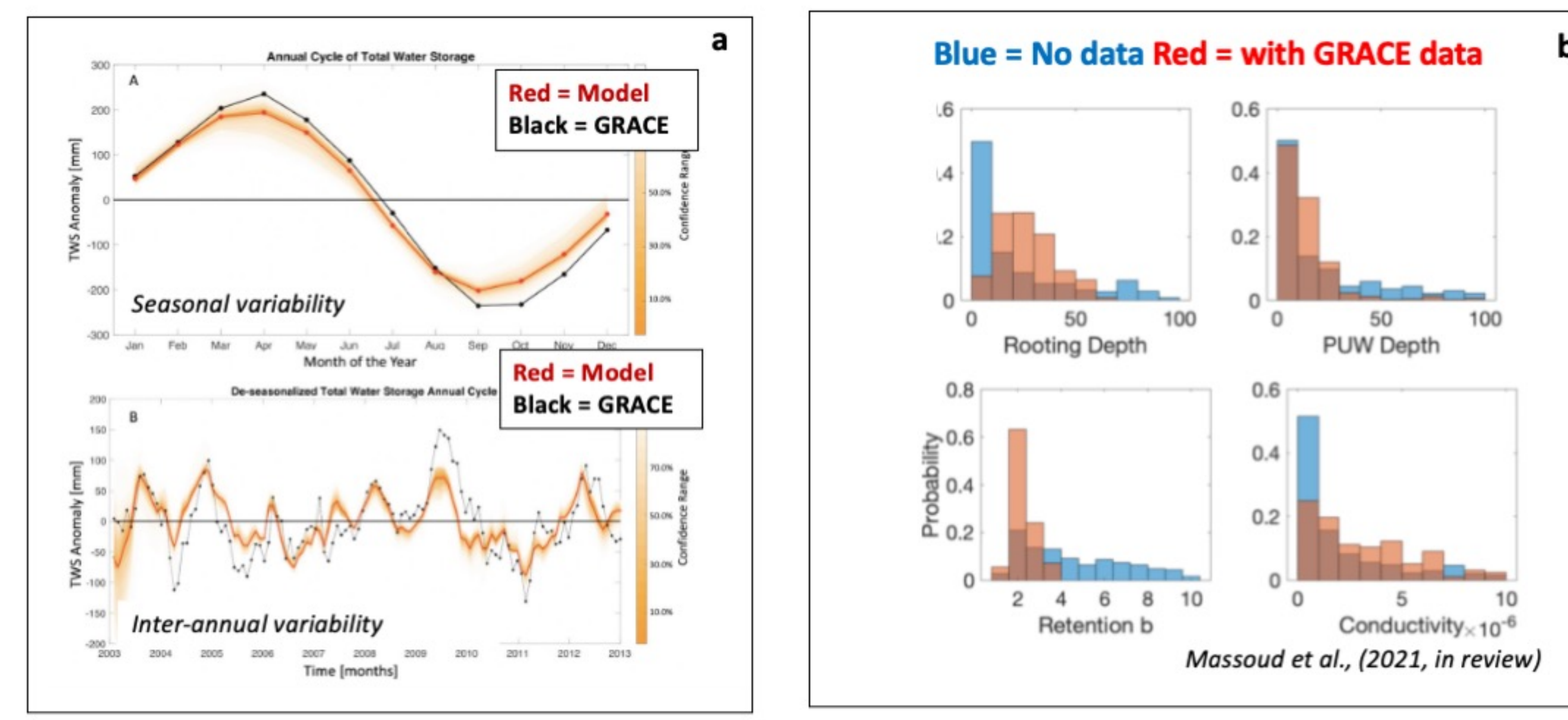
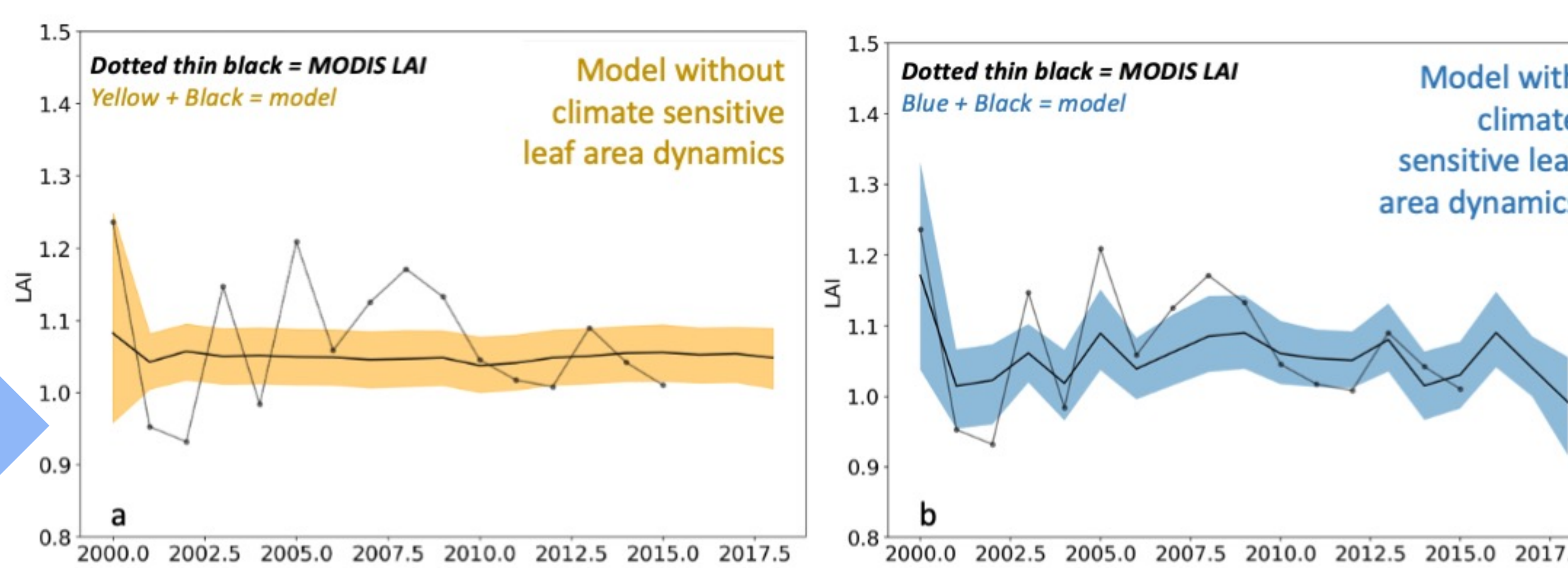


Figure 2. Massoud et al., 2021 (in review). This study is a reduced-complexity representation of the CliMA soil hydrology processes tested out at an Amazon watershed, which includes key soil hydrogical parametrizations and associated uncertainties, including porosity, rooting depth, soil water retention and drainage parameters. The CARDAMOM framework was used to optimize the parameters and initial soil moisture conditions required to minimize mismatches between modelled and observed (GRACE) equivalent water thickness.

Figure 4. JPL-developed leaf area index (LAI) dynamics, and their sensitivity to climatic factors, namely their response to temperature, available water, radiation (Norton et al., in prep); the incorporation of climate sensitivity (panel b) is critical to represent year-to-year variations in LAI. State-of-the-art land models prescribe climate sensitivity on a plant-functional scale; in contrast, the JPL-CliMA LAI model is informed by co-located satellite-based LAI estimates.



Publications

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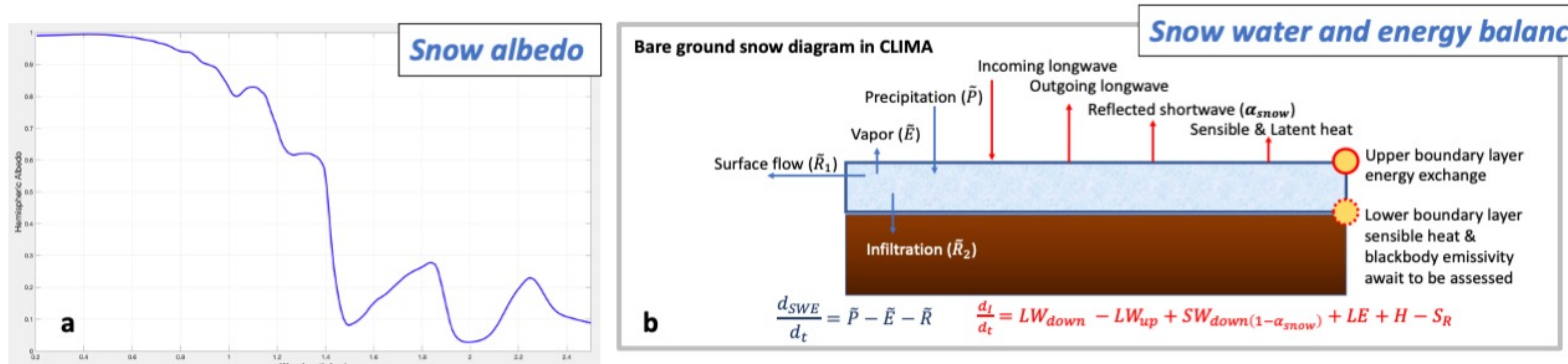

Figure 5. The CliMA land model snow module co-developed by JPL and Caltech, with an explicit hyperspectral representation of snow albedo (panel a) and snow water and energy states (panel b). The snow pack water and energy balance closure is a key component of the land-surface water and energy cycles and their impacts on the Earth System; furthermore, explicit dynamical representation of snow states is critical for integrating observations into the CliMA ESM framework.

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