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Introduction: Atmospheric condensates are common in the Solar System, and on Earth the latent heat exchange during evaporation and condensation of aerosols helps to stabilize our climate. 1D climate models for Earth-like exoplanets typically prescribe Earth's tropospheric lapse rate for water, and sometimes the adiabatic lapse rate of CO_2, but ignore the aerosol formation from condensates [1]. However, a variety of condensates could exist in terrestrial atmospheres—the condensation of H_2O and CO_2 determine the edges of the habitable zone [2][3]. We present a 1D radiative-convective-equilibrium (RCE) climate model [4] enhanced with a generalized treatment of condensates. We apply this model to the potential climates of Proxima Centauri b [5], which may or may not be habitable [6], and to the TRAPPIST-1 system, which has planets spanning throughout and outside both ends of the habitable zone [7]. Applying condensate thermodynamics coupled with self-consistent aerosol treatment to modeling exoplanets will allow us to better characterize their potential climates, habitability, and observational discriminants in advance of observations by the *James Webb Space Telescope* and ground-based observatories.

Methods: The VPL Climate model, originally presented by [4], employs mixing length theory for condensate vertical mixing and uses thermodynamic data (saturation vapor pressure, temperature, and heat of formation) to determine phase changes and heating rates. To complete the condensate cycle, we add evaporation and sedimentation. We also add self-consistent optical depth calculation of condensates existing in the atmospheric layers at each radiative timestep for each atmospheric layer. To account for the changing optical depths of aerosols due to phase changes during timestepping, we employ Jacobians describing the layer-by-layer, wavelength-dependent response of the radiative source functions and layer absorption, reflectivity, and transmissivity to changes in optical depth. In this way, our climate model self-consistently takes into account immediate feedback between the phase change of condensible gas and radiative effects of the associated aerosol.

Results: We applied our enhanced 1D RCE climate model to potential climates for Proxima b [6] and to model to the TRAPPIST-1 system, whose planets have the potential for a variety of climates and are only constrained to not have extended hydrogen envelopes [8]. These climates span hot, Venus-like atmospheres with sulfuric acid (H_2SO_4) condensation to cold, Mars-like atmospheres with CO_2 condensation.

We present reflectance and transmission spectra to demonstrate the observable discriminants of these condensates, primarily through the impact of their associated aerosols and applicability to Proxima Centauri b and TRAPPIST-1 c and d.

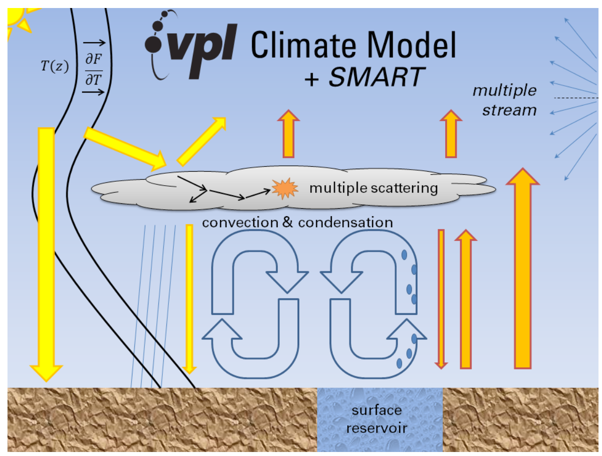

Figure 1: Diagram of our sophisticated 1D RCE climate model, which includes multi-stream, multi-scattering, line-by-line radiative transfer, mixing length convection, full generalized condensate cycle with surface reservoir, vertical mixing, condensation, evaporation, and sedimentation. This versatile model has been validated on Solar System terrestrial planets and can be applied to a variety of terrestrial exoplanets, including those very different than Earth.

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