Complex clouds in retrieval in the JWST era

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Awaiting the pending launch of the James Webb Space Telescope (JWST), which will enable probing exoplanet atmospheres from 0.6 to 28.0 μm with an unprecedented high resolution from 100 to 1550, it is of a crucial importance to develop tools that will allow us accurate characterization of exoplanetary atmospheres. These tools and observations will give us an opportunity to revolutionize what we currently know about planetary atmospheres, their composition, cloud properties, thermal structures, and their formation and evolution histories. To adequately constrain a physically plausible atmospheric structure, one must account for the uncertainties coming from our limited knowledge of the chemical, physical and dynamical processes at play. Thus, combining a retrieval framework (an observation-driven approach) and detailed theoretical models is crucial to accurately constrain atmospheric thermal structures, abundances, and cloud coverage. In particular, the formation of clouds in planetary atmospheres plays an important role in atmospheric modelling as clouds cause significant compositional and morphological changes. Being highly ubiquitous in solar system planets, clouds are also theoretically expected to be present in most temperature regimes in exoplanetary atmospheres. Regardless of their chemical composition; water, methane, sulfur in solar system planets, or iron, magnesium, silicates in hot exoplanetary atmospheres; clouds are quite difficult to model. To date two main scenarios have been proposed to understand the formation of clouds in exoplanetary atmospheres: (1) the equilibrium cloud formation scenario occurring upon vapor pressure saturation and (2) the microphysical kinetic cloud scenario that accounts for the seed particles growth and transport. We have implemented both approaches within our open-source retrieval framework, and we investigate which approach make most of the use of the current observations and which one of the future JWST observations.

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