'Modeling microscopes' and 'macroscopic parameterizations' for planetary atmospheres: lessons from solar system studies and challenges for exoplanets

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Extrasolar planets' weather and climate, much like solar system planets, are governed by a complex mix of global-scale and smaller-scale phenomena. While details of the former, and impact thereof on the thermal structure, can be resolved by combining Global Climate Models (GCM) with exoplanet observations, the latter escapes characterization by exoplanet observations and GCMs. We know, however, how large-scale an impact the small-scale phenomena can have: global transfer of heat and momentum can be exerted by mesoscale eddies, moist convective storms/clouds, gravity waves, turbulence in the Planetary Boundary Layer. All the above means that to study all those crucial small-scale phenomena on planets and exoplanets we have to rely on either small-scale three-dimensional modeling resolving those phenomena for the specific phenomena (what we would like to name a 'modeling microscope') or one-dimensional modeling where the small-scale phenomena are represented by ad-hoc tunable simplified models (what we would like to name 'macroscopic parameterizations', what thermodynamics is with respect to atoms or psychology with respect to neurons). Could we assume that, on the one hand, the 'modeling microscopes' developed for Earth can be applied to planets and exoplanets and, on the other hand, the 'macroscopic parameterizations' obtained and validated for Earth would work elsewhere? How could we use modeling microscopes to create, develop and validate new 'macroscopic parameterizations' to replace questionable approaches used widely for a lack of better solutions? An infamous example being the Kzz approach in one-dimensional models used to represent transport and mixing by a mix of very different contributions from the global circulations to small-scale turbulence. To foster a debate on those questions, we will provide examples from both 'modeling microscopes' and 'macroscopic parameterizations' in solar system studies of telluric planets (Earth, Mars, Venus, Titan) and giant planets (Jupiter, Saturn) and reflect on the challenges and lessons learned to possibly transfer this knowledge to exoplanet studies.