Photochemical uncertainties in modeling planetary atmospheres: Review and consequences for Titan's case

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Low-temperature photochemistry of planetary atmospheres is still poorly constrained by laboratory evidence. Such uncertainties carried by the different parameters included in photochemical models of planetary atmospheres have yet rarely been considered even if they are supposed to be contributing mostly to the inconsistencies between observations and computed predictions. We review exhaustively and originally these uncertainties included in an up-to-date 1D model of Titan's atmosphere, focusing on the integration of recent laboratory measurements and theoretical breakthroughs in a relevant description of the photochemical scheme at representative conditions.

Since photochemical models of planetary atmospheres are strongly non-linear systems, traditional sensitivity studies - varying each parameter in turn - are not representative of the overall uncertainty in the computed results. Monte-Carlo calculations were thus performed on photochemical rates coefficients to introduce randomly their uncertainties in order to investigate their true significance on the modeling of Titan's atmosphere. Despite the crude approximations adopted in the implemented physical processes and without adjusting artificially neither the eddy diffusion coefficient nor any surface fluxes, this model may seem at first to better fit existing stratospheric observations over more elaborate models. We conclude however that overall modeling uncertainties related to photochemical rates coefficients are important enough to question indeed any such comparisons with observations and any potential conclusions subsequently inferred. Especially since the latest missions, such as Cassini-Huygens, are already inducing an ever-increasing interest for such kind of comparing studies. Whatever the stakes are, our conclusions show that it is crucial to reform the way we think of, and use, current photochemical models to understand the processes occurring in the atmospheres of the outer solar system.