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Atmospheric chemical and thermal structure evolution after one Titan year

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Our radiative transfer code (ARTT) was applied to Cassini Composite Infrared Spectrometer (CIRS) data taken during Titan flybys from 2004-2010 and to the 1980 Voyager 1 flyby values inferred from the re-analysis of the Infrared Radiometer Spectrometer (IRIS) spectra [1], as well as to the intervening ground- and space- based observations (such as with ISO, [2]), providing us with a new view of the stratospheric evolution over a Titanian year (V1 encounter Ls=9° was reached in mid-2010). CIRS nadir and limb spectral [3,4] show variations in temperature and chemical composition in the stratosphere during the Cassini mission, before and after the Northern Spring Equinox (NSE). We find indication for a weakening of the temperature gradient with warming of the stratosphere and cooling of the lower mesosphere. In addition, we infer precise concentrations for the trace gases and their main isotopologues and find that the chemical composition in Titan's stratosphere varied significantly with latitude during the 6 terrestrial years investigated here, with increased mixing ratios towards the northern latitudes. In particular, we find a maximum enhancement of several gases observed at northern latitudes up to 50°N around mid-2009, at the time of the NSE. We find that this raise is followed by a rapid decrease in chemical inventory in 2010 probably due to changes in the cross vortex mixing or northward migration of the vortex boundary [5,6,7] consistent with the weakening thermal gradient. The finding also ties into the location of the maximum temperature gradient, which appears to be moving northward over the winter/spring season. The return of today's abundances close to the Voyager values (at the same season) is an indication that, as for the Earth, the solar radiation dominates over the other energy sources even at 10AU [8]. Nevertheless, the differences observed for some complex hydrocarbons in the North pole indicate that the other processes could be at play as well, for example the variability of the solar insolation itself through the 11-year solar cycle. We show indeed that wrt V1 the stratospheric composition shows higher values near the northern fall equinox (1997) and lower ones at the spring equinox (2009). An additional cause could be spatial changes (due to Titan's inclination) in the energy input to Titan's atmosphere as a driver for changes in the advection patterns, circulation, etc which eventually provide a stronger variability in the latitudinal abundances of photochemical species. Circulation and photochemical models must satisfy the constraints set by these results, but further observations will have to come from the next summer solstice (2017) and for a complete new Titan year in 2027.

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