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Diurnal variations of Titan's ionosphere

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We present our analysis of the diurnal variations of Titan's ionosphere (between 1,000 and 1,400 km) based on a sample of Ion Neutral Mass Spectrometer (INMS) measurements in the Open Source Ion (OSI) mode obtained from 8 close encounters of the Cassini spacecraft with Titan. Though there is an overall ion depletion well beyond the terminator, the ion content on Titan's nightside is still appreciable, with a density plateau of $\sim$700 cm^{-3} below $\sim$1,300 km. Such a plateau is associated with the combination of distinct diurnal variations of light and heavy ions. Light ions (e.g. CH_5^+, $HCNH^+$, $C_2H_5^+$) show strong diurnal variation, with clear bite-outs in their nightside distributions. In contrast, heavy ions (e.g. c-$C_3H_3^+$, $C_2H_3CNH^+$, $C_6H_7^+$) present modest diurnal variation, with significant densities observed on the nightside. We propose that the distinctions between light and heavy ions are associated with their different chemical loss pathways, with the former primarily through "fast" ion-neutral chemistry and the latter through "slow" electron dissociative recombination. The INMS data suggest day-to-night transport as an important source of ions on Titan's nightside, to be distinguished from the conventional scenario of auroral ionization by magnetospheric particles as the only ionizing source on the nightside. This is supported by the strong correlation between the observed night-to-day ion density ratios and the associated ion lifetimes. We construct a time-dependent ion chemistry model to investigate the effects of day-to-night transport on the ionospheric structures of Titan. The predicted diurnal variation has similar general characteristics to those observed, with some apparent discrepancies which could be reconciled by imposing fast horizontal thermal winds in Titan's upper atmosphere.