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Titan's surface-atmosphere system before and after Huygens

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Speculation about the nature of Titan's surface-atmosphere interactions goes back to the discovery of methane in its atmosphere in 1943 but beginning in the early 1970's surface models began to grapple more quantitatively with the source of methane and its instability in the atmosphere. The role of molecular nitrogen in the atmosphere was first quantitatively considered at that time as well. The Voyager 1 flyby put a thick atmosphere of molecular nitrogen and methane on an observational footing, and made an atmospheric descent probe quite feasible. The measured high methane humidity made seas of methane and possibly other constituents an attractive possible source of methane and sink of its photolytic products, influencing the choice of instruments for a descent probe. At the time of Huygens' actual descent to the surface, global seas had been ruled out, and the Cassini Orbiter was just beginning to gather imaging and radar data of the surface. The fluvial nature of the Huygens landing site and presence of volatiles just below the surface were important discoveries of Huygens itself. Together with Cassini, Huygens painted a picture of a cryogenic desert with occasional violent methane rainstorms feeding streams that tumble pebbles of ice and organics downhill, the whole surrounded by dunes whose organic-rich particles are harvested from the chemical conversion of methane to more refractory compounds high in the atmosphere. And yet many mysteries remain. The large bodies of liquid methane are restricted to high latitudes. Most of the river valleys seen in Cassini radar data seem to run down to nowhere. And the ultimate source and replenishment of methane, although seemingly more strongly tied to the interior than before Cassini-Huygens, remain unresolved. Huygens gave us the only imaging of Titan's surface with a resolution good enough to follow fluvial processes all the way from the contextual geology, to channels, to the stream debris washed out into the plains. What would we see if we could image even just 10% of Titan at Huygens resolution? Conversely, what might we have concluded about Titan were only the Cassini Orbiter data available, without Huygens? It is clear that Huygens gave us one tantalizing look through the keyhole at a mysterious room, but to truly understand what was glimpsed will require a future mission to open wide the door.