Simultaneous Remote Sensing of a Probe Entry Site with Descent: Lessons Learned from Galileo

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Abstract

The experience of the Galileo mission probe measurements in the atmosphere of Jupiter provides some valuable lessons on the conduct of joint remote-sensing and in-situ measurements of any giant-planet atmosphere. The basis of my Galileo Interdisciplinary Science investigation was to use the Probe results to provide a measure of ground truth in the comparison with remote-sensing measurements. This turned out to be both particularly difficult to accomplish and particularly rewarding in its consequences. Besides providing a cross-check of remote-sensing systematic uncertainties, remote-sensing results establish a spatial and even temporal context for the Probe observations. Accomplishing this for the Galileo probe required overcoming several obstacles. The failure of Galileo's high-gain antenna to open fully meant that the project relied on a very small antenna only designed for communications with the Probe, inventive methods for data compression, and data storage on a physical on-board tape recorder allowing data to be stored before slow playback. Problems with tape recorder prior to Jupiter arrival motivated the project to use it conservatively: it was to be used to store Probe data and only Probe data. So no Galileo remote-sensing observations were to be made of the Probe entry site. This comparison had to be done from Earth-based observations, which were also challenging as Jupiter was only 9o from the sun at Probe entry on 1995 December 7. A 3-meter polypropylene "filter" was used to cover the primary mirror of NASA's Infrared Telescope Facility (IRTF) to protect the near- and mid-infrared instruments, as well as the telescope dome, from direct sunlight, allowing us to detect radiation from wavelengths at or greater than 5 mm. With a known drift rate for the Probe entry site's prevailing (zonal) winds, we were able to match the feature observed at the time of the Probe entry with the same feature just before and just after the Probe entry date, without the polypropylene filter and much better signal-to-noise ratios. This confirmed that the Galileo Probe entered a very anomalous region, a 5-mm "hot spot", one of the most anomalously dry and cloudless regions on the planet (Orton et al. 1998. J. Geophys. Res. 103, 22791). This provided desperately needed clarity to the Probe results showing few clouds and sub-solar abundances of water (e.g. Niemann et al. 1998. J. Geophys. Res. 103, 22831; Sromovsky et al. 1998. J. Geophys. Res. 103, 22929; Ragent et al. 1998. J. Geophys. Res. 103, 22891). This, in turn, provided one of the key motivations for the Juno mission, searching for the O/H ratio through the water abundance and characterizing its distribution across the planet. The lessons from this are: (1) simultaneous remote-sensing and Probe results of the entry site are very valuable, (2) besides providing general contextual information, they may turn out to be more critical to the interpretation of in-situ results that you ever imagined, and (3) prepare for the unexpected with a backup plan. For Uranus and Neptune, Voyager and Earth-based results show substantial variability in temperatures,

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cloud cover and composition. Although these are useful as a "backup" option, it is best to keep relevant instrumentation on the orbiter or flyby carrier spacecraft that can provide information on temperatures, clouds and volatile composition at the Probe entry site and elsewhere on the planet.

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