Observations and Data Analysis (Session IV) Plenary Discussion

The observation and data analysis talks focused on the current capabilities and needs for atmospheric science. For solar system science, focused on the four giant planets, this included visible and IR wavelengths, with the need for global, high resolution imaging and probes are desired to feed into retrievals where the *a priori* assumptions about temperature profiles, composition (with corresponding line lists), hazes, etc., can affect the results. We don't have all the needed information on our own solar system bodies at this time. Characterization of not only the clouds and hazes but also the environment in which they reside is crucial to understanding. Polarization techniques were also discussed, and have been useful for the Earth, challenging for the solar system, and currently near impossible for exoplanets – but can give much information about atmospheric particle size, shape and composition, as well as surface properties in some cases. Lastly, recent advances in instrumentation now allow for a 4-D view of the earth's atmosphere, but still without global coverage except for long-term geostationary satellite records.

A surprising aspect of the discussion was how Earth science has suffered from a lack of spectral and time-domain coverage, with only a few exceptions, until very recently. Even for Earth, *in situ* information from the extensive radiosonde network is still an invaluable complement to satellite data. For other planets, which have mostly been sampled *in situ* once or not at all, the risk of over-interpreting a single profile is large; multiple probes on future missions would be extremely useful. Each planet (and exoplanet) is likely a very complex system, and no one observational or analysis technique will answer all the questions. This may mean prioritizing which area to address first – do you observe first and then model, or use models and theory to predict and then try to observe? Really need to approach from both sides simultaneously, which requires data sharing across disciplines, and an understanding of each other's data format, limitations, and databases.

A statistical approach was discussed for exoplanets – having a flexible model that can quickly run through parameter space, with enough objects that Monte Carlo techniques may work. Such an approach has been applied in recent years to terrestrial climate models to estimate the breadth of possible climate sensitivities consistent with available observations. However, a caveat mentioned was that various evolutionary states may be present, expanding the possible parameter space, but also allowing for examples similar to paleo-Earth or paleo-Mars studies. Sensitivity studies can show which observational parameters may have the biggest impacts. The biggest point made was not to limit our techniques to the current state of the art. By asking for an "impossible" measurement, innovative techniques and instruments will be developed, reducing the need for *in situ* characterization of every body and every parameter.