Geophysical Research Abstracts
Vol. 14, EGU2012-9708, 2012
EGU General Assembly 2012

Retrieval of Surface Emissivity in a Venus Coordinate Patch as Parameter Common to Repeated Measurements by VIRTIS/VEX

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ESA's planetary probe Venus Express has now been orbiting Venus for six years. It carries the most powerful remote sensing suite ever flown to the planet. The Infrared Mapping channel of the Venus Infrared Thermal Imaging Spectrometer, VIRTIS-M-IR, performs radiation measurements between 1 - 5 μm at a spectral sampling of 9.5 nm. Each exposure yields a frame of 432 spectral bands and 256 spatial samples. A number of consecutive exposures forms a spectrally resolved two dimensional image of a target.

In order to extract atmospheric and surface parameters from measurements, a line-by-line radiative transfer simulation model computes the expected observable radiance in dependence on these parameters as well as on instrumental parameters. It considers absorption, emission, and multiple scattering by gaseous and particulate constituents. An associated retrieval algorithm iteratively varies the parameters until the residual between measurements and simulations in terms of a certain cost function is locally minimized. As this is an ill-posed problem, it is regularized by taking into account a priori mean values and variances of the parameters as well as measurement and simulation errors. This is accomplished by using a Bayesian formulation of the cost function and basically acts to rule out subsidiary solutions with unlikely parameter values. Nevertheless, the retrievals are still affected by other subsidiary solutions. To further regularize the retrieval, multiple spectra can be fitted simultaneously by defining extended measurement and parameter spaces as the concatenations of the corresponding single spectrum spaces. This allows the introduction of additional a priori data defining the expected spatial-temporal correlations between parameters to be retrieved from contiguous measurements. This approach in effect rules out subsidiary solutions with unlikely spatial-temporal parameter distributions and also allows for the retrieval of parameters common to several spectra.

By treating surface emissivity at a certain surface coordinate bin as parameter common to repeated measurements covering this bin, the retrieval uncertainty can be greatly decreased in comparison to isolated retrievals from individual measurements. When several bins that sample a patch on the surface are analyzed at once, a local surface emissivity map can be determined. This map thus results from rigorous radiative transfer and retrieval, where each single measurement is parameterized by a consistent set of atmospheric, surface, and instrumental parameters. The combined parameter set of all analyzed measurements respects all available a priori data and the measurement/simulation error distributions and does not neglect the context between adjacent measurements. The declaration of surface emissivity as a parameter common to certain measurements from the outset represents an approach that is more rigorous as compared to a simple averaging of individual retrievals which implicitly allows inconsistent parameter sets. The results for a selected surface area in the vicinity of Idunn Mons are discussed exemplarily.