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RETRIEVING 3D MICROPHYSICAL PROPERTIES OF SHALLOW CLOUDS WITH NANOSATELLITES FLYING IN FORMATION

Abstract

Formation flying enables innovative Earth observation missions. With a fleet of satellites in close formation, synchronized images from several viewpoints can be captured. CloudCT is implementing such a mission observing fields of warm, small clouds spanning a few 100s m each. These images are postprocessed to retrieve 3D microphysical properties of shallow clouds using computer tomography approaches considering multi-scattering and the sun as an uncontrolled light source. The retrieved data will be used as validation data to high resolution cloud resolving models dedicated to improving cloud parametrizations to reduce uncertainty in global climate models.
The retrieval method introduces requirements on both, the single platform as well as on the system of satellites. The payload selection is driven by optimizing the information content gained by the interactions of the electromagnetic radiation and the clouds droplets at the camera's wavelengths. Relationships exist between the cameras' spatial resolution and the orbit geometry. Besides, spatial resolution and overlapping area requirements affect attitude determination and control. Due to the interdependency of requirements and constraints in this mission, several trade-off studies were necessary to consolidate a feasible system design.
These trade-off studies were performed by application of classical system engineering methods in combination with computer aided approaches in simulation. Three computer simulation frameworks were utilized to analyse the effect of different parameters on the overall system: in a radiative transfer simulation we

analysed the effect of wavelengths, bandwidth and ground sampling distance on the accuracy of the retrieved physical variables. Simulations on formation acquisition and maintenance have been implemented to analyse the impact on low altitude operations and establish a preliminary Delta V Budget. Also, the satellite pointing was simulated to identify the impact of pointing errors on the overlapping area.
The trade-off studies have shown, that the mission can be implemented using a 3U design as originally planned. As a payload, a polarization sensor is preferred. Analysis of a String-of-Pearls formation has shown, that a 500km altitude orbit baseline is a good compromise on mission lifetime for the available thrusters and the achievable ground resolution. An overlap of 80% in images spanning +-30 degrees off nadir at this altitude is achievable without star sensor. This contribution further presents the preliminary 3U satellite design including a link, power and Delta-V budget.
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