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CLOUDCT – A FORMATION OF COOPERATING NANO-SATELLITES FOR CLOUD CHARACTERISATION BY COMPUTED TOMOGRAPHY

Abstract

As clouds are one of the key sources of uncertainty in global climate models, the CloudCT mission uses a formation of 10 nano-satellites to detect 3D properties of clouds. Computed tomography methods similar to medicine are used for observation of backscattered Sun light by the cameras of 10 satellites from different perspectives, in order to obtain high spatial and temporal resolution for water distribution in clouds. Thus in particular the detected physics of warm convective and stratiform clouds, and the clouds' sensitivity to environmental changes will improve inputs to global-climate models. CloudCT addresses a lack of sufficient sensing tailored to capture the 3D macro and microphysical properties of warm clouds, which are often spatially unresolved, leading to mayor uncertainties in climate models and predictions.

The CloudCT's innovative sensing approach uses cloud scattering-tomography of incident Sun light to fuse measurement data from a self-organizing formation of ten small satellites. The inputs are generated by simultaneous imaging of cloud fields from multiple directions with a resolution of 50 m. By the scattering tomography approach the 3D volumetric structure of cloud fields is derived, generating base-to-top profiles of droplets' size and their variance, volumetric distribution of optical extinction and rain indicators.

The 10 nano-satellites carry optical cameras. On basis of relative navigation methods, orbit corrections of the formation topology for optimal observation conditions are realized by an electric propulsion system. The novel tomography approach requires precision attitude determination and control. For this purpose energy-efficient miniature reaction wheels provide the required pointing and tracking capabilities at nano-satellite level. Distributed control algorithms enable the formation to appropriately self-organize via the inter-satellite links, without the need of a ground control station contact. Advanced in-orbit autonomy, distributed computing, and networked control are the key features to self-organization capabilities of the formation. In order to test the crucial attitude control of the formation and the computed tomography approach on ground, simulations by high precision turntables are used.

CloudCT integrates interdisciplinary synergies from nano-satellite system engineering, cloud modelling, and tomographic imaging to enable a sensor network approach to innovative Earth observation. This way an improvement of inputs to climate models is expected, leading to reduced uncertainties through a database of 3D macro and micro structure of warm cloud fields. The required coordinated observation by 10 distributed networked spacecraft raises challenging requirements for small satellite attitude and orbit control, which is currently tested in hardware-in-the-loop simulations on ground.