Paper ID: 41441
student

EARTH OBSERVATION SYMPOSIUM (B1)
Future Earth Observation Systems (2)

Author: Mr. Ahmed Kiyoshi Sugihara El Maghraby
University of Southampton, United Kingdom

Dr. Angelo Grubisic
University of Southampton, United Kingdom
Dr. Camilla Colombo
Politecnico di Milano, Italy
Dr. Adrian Tatnall
University of Southampton, United Kingdom

SYSTEM REQUIREMENTS FOR A NOVEL GEOSTATIONARY INTERFEROMETRIC MICROWAVE RADIOMETER USING SATELLITE FORMATION FLIGHT FOR ATMOSPHERIC SOUNDING

Abstract

Passive microwave radiometry is a highly versatile tool for remote-sensing of the Earth delivering a variety of data products for both the surface and the atmosphere. It is particularly vital for meteorology and Numerical Weather Prediction (NWP) for its capability to provide atmospheric temperature and humidity sounding measurements under all weather conditions. Short-term NWP however requires high temporal resolution, i.e. a few minutes. This resolution is unachievable with the currently available microwave sounders at low Earth orbits. To achieve this resolution, a full microwave sounding capability in the geostationary orbit is highly desired, and has been considered for several years.

The challenge in geostationary microwave radiometry is the required aperture size. Due to the diffraction limit at microwave frequencies, antennas of a few to tens of metres are required. To achieve these apertures, GeoSTAR (NASA), GAS (ESA) and GIMS (China) instrument concepts are currently being developed using aperture synthesis techniques. However, since these concepts are based on single-satellite platforms, the achievable aperture size is fundamentally constrained by the physical size of the satellite. This limits the achievable spatial resolution to levels below that achievable from LEO.

In this paper we propose a novel aperture synthesis technique to surpass this limit, in which geostationary satellite formation flight is used to synthesise large apertures that may not be synthesised using single satellites. We explore several formation flight configurations using this technique, and compare their advantages and system requirements.

The two main classes of configurations are: formations of single full-sized satellites with several microsatellites; and formations of several full-sized satellites. The latter class is capable of synthesising much larger apertures, while the former can be much lighter. For one configuration, the achievable spatial resolutions are 16.7 km and 7.5 km respectively from the geostationary orbit at 53 GHz, with an anticipated constellation total mass of 1.3 tonnes and 4.0 tonnes in the geostationary orbit respectively. All configurations require sub-mm inter-satellite tracking in three dimensions, and relative position control to within a few centimetres. Simulation results show measurement error of 0.1 λ, approximately 2 mm at 53 GHz, may cause up to 1.5 K error RMS in the recovered brightness temperature measurement. High fidelity orbital propagation with feed-back control under the influence of relevant orbital perturbation forces at the geostationary orbit shows that the annual ΔV requirement for formation control is under 3 m/s, depending on the type and configuration of the propulsion subsystem.