Geophysical Research Abstracts
Vol. 19, EGU2017-1099-12, 2017
EGU General Assembly 2017

PoPSat: The Polar Precipitation Satellite Mission

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The terrestrial water cycle is one of many unique regulatory systems on planet Earth. It is directly responsible for sustaining biological life on land and human populations by ensuring sustained crop yields. However, this delicate balanced system continues to be influenced significantly by a changing climate, which has had drastic impacts particularly on the polar regions. Precipitation is a key process in the weather and climate system, due to its storage, transport and release of latent heat in the atmosphere. It has been extensively investigated in low latitudes, in which detailed models have been established for weather prediction. However, a gap has been left in higher latitudes above 65°, which show the strongest response to climate changes and where increasing precipitations have been foreseen in the future. In order to establish a global perspective of atmospheric processes, space observation of high-latitude areas is crucial to produce globally consistent data. The increasing demand for those data has driven a critical need to devise a mission which fills the gaps in current climate models.

The authors propose the Polar Precipitation Satellite (PoPSat), an innovative satellite mission to provide enhanced observation of light and medium precipitation, focusing on snowfall and light rain in high latitudes. PoPSat is the first mission aimed to provide high resolution 3D structural information about snow and light precipitation systems and cloud structure in the covered areas. The satellite is equipped with a dual band (Ka and W band) phased-array radar. These antennas provide a horizontal resolution of 2 km and 4 km respectively which will exceed all other observations made to date at high-latitudes, while providing the additional capability to monitor snowfall. The data gathered will be compatible and complementary with measurements made during previous missions.

PoPSat has been designed to fly on a sun-synchronous, dawn-dusk orbit at 460 km. This orbit enables the required optimal instrument resolution for precipitation events occurring within the troposphere, between 8 and 12 km altitude. Additionally, with an 18° instrument half-cone angle capability, both phased-array radars can provide a 300 km swath width at this altitude. This results in an optimal atmospheric layer coverage of 91% for latitudes above 50° N after 72 hr. A required total system power of 1021 W of the satellite will be sustained using 7.2 m^2 of solar arrays, housed on the sunward side of the spacecraft. The mission has an expected total cost of an M-class mission for a nominal lifetime of 5 years.

The PoPSat mission has been developed by 15 students of Team Blue supported by a group of experts at the Alpbach Summer School 2016, a ten-days design challenge organised by FFG and ESA and devoted to ‘Satellite Observations of the Global Water Cycle’. PoPSat was selected by the jury to be further developed at the Post-Alpbach design challenge at the ESA Redu Centre for an additional four days, with 15 students out of all 4 teams from the Alpbach Summer School.

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