Overview of the proposal to the master plan 2017 on the aircraft observation of climate and earth system sciences

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The science council of Japan announced for proposal for the master plan 2017 in March 2016. The meteorological society of Japan proposed “Promotion of Scientific Research on Climate and Earth System Sciences Using Aircrafts.” In this report overview the proposal and current activities.

“Promotion of Scientific Research on Climate and Earth System Sciences Using Aircrafts”
The aim of this proposal is to promote the climate and earth system research in the area of atmospheric science, oceanography including sea ice, glaciology, volcanology and ecology by a dedicated aircraft observation system.
Although in-situ measurements by the state-of-the-art instruments on board aircraft has great advantages to provide accurate data for estimating key parameters with high temporal and spatial resolutions, which lead to improve our understanding of the critical processes, Japan does not have an aircraft dedicated to the Earth observation. This is the motivation of this proposal.
The expected research area in which a breakthrough is achieved with aircrafts is the mechanism of the changes in the climate and the earth system. The climate change, especially the global warming, is caused by changes in the Earth radiation balance due to greenhouse gases such as carbon dioxide. On the other hand, aerosols, clouds and their interaction are known as the most uncertain factor on the radiation balance. Response of clouds to precipitation sometimes appears as heavy rainfalls and typhoons and it is also urgent issue. Since Japan has been leading the world by the sophisticated numerical modeling and the satellite observations, synergetic use of the aircraft observations with them will lead great progress of research in this area. Furthermore, Asian region remains an observational gap of aircrafts though it is the “hotspot” of aerosols including PM2.5 and greenhouse gases and most frequently experiences strong tropical cyclones, so that Japan’s contribution and leadership of the aircraft observation in this region is highly anticipated.
The aircraft which we think most suitable for our research is the Mitsubishi Regional Jet (MRJ) since it has enough space to simultaneously equip several observational instruments and it can be relatively easily refurbished for equipping the instruments by taking advantage of the domestic production.
Having an aircraft for exclusive use for earth sciences has great advantages for both types of researches which requires long-term monitoring such as greenhouse gases and agile observations of hazardous events such as typhoons, heavy rainfalls and volcanic eruptions.
The Center for Orbital and Suborbital Observations, Institute of Space-Earth Environmental Research, Nagoya University will lead the program in the framework of the “Joint Usage/Research Center (JURC)”.
A JURC steering committee that consists of specialists of each research area from various organizations will be responsible for the research and operational plan.
Having the dedicated aircraft for the earth observation benefits the research fields other than the atmospheric sciences such as hydrology, ecology, oceanography, glaciology, volcanology, and Earth surface remote sensing.

Future activities

On the future activity, based on the activities of the aircraft observation promotion committee, strengthen cooperation with related organizations in order to establish the activity base.

Keywords: aircraft observation

Observation of Lightning by Aircraft

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Observation of lightning from aircraft has been used to design a satellite sensor to detect and locate lightning discharge. Optical Transient Detector (OTD), and Lightning Imaging Sensor (LIS) are all designed based on the data obtained in the field campaing using ER2 aircraft NASA and these measurement provides the characteristics of peak amplitude, optical pulse duration, and pulse interval from the illuminated cloud by lightning. Based on the success of these missions, recently GLM (Geostationary Lightning Mapper) was successfully launched into the geostationary orbit and is in operational mode this year. The GLM is expected to give us time and location of lightning discharges with more than 90% detection efficiency, and the data is useful to have early warning to tornado and hazardous pheonomena cause by lightning producing thunderstorm.
On the other hand, GLIMS (Global Lightning and Sprite Measurements) mission showed that the multi frequencies observation of optical lightning from space could discriminate cloud to ground and cloud lightning by taking the ratio of amplitude between the different wavelength (Adachi et al. 2016), which is not possible with the GLM sensor.
In this presentation, a proposal on the optical observation of lightning at multiple frequencies with high temporal resolution from aircraft will be presented. Also some scientific and social background are also presented.

Keywords: Lightning, Aircraft

Airborne remote sensing in active fault research

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Aerial photograph interpretation at 1:40,000 to 1:20,000 scales has introduced to geomorphology since 1960s, which brought significant progress in active research in Japan. Tectonic Geomorphologists intensively observed aerial photographs and recognized active faults throughout Japan. As a result, "Active fault in Japan" was published by University of Tokyo Press in 1980, and revised in 1991. In 1980s, it was said that "the era of active fault discovery is over". However, several active faults have been newly discovered since the 1990s after the introduction of 1:10,000 aerial photographs, seismic reflection, and excavation studies to active fault research.

Since the onset of the 21st century, new active fault studies have started to combine aerial photography and LiDAR. Suzuki et al., 2003 conducted LiDAR measurements along the Itoigawa-Shizuoka Tectonic Line for the first time, and confirmed the technique’s efficiency in identifying small-scale tectonic landforms. They then produced detailed digital elevation models (DEMs) using old aerial photographs taken before artificial modification. Moreover, they took aerial photographs at 1:10,000 scale originally along the whole fault line with POS-IMU measurements. The purpose was to enable detection of co-seismic displacement with future earthquakes.

Recently, Suzuki et al., 2015 presented an innovative LiDAR study in which the uplift distribution caused by the 2013 Kamishiro fault earthquake was revealed. Moreover, they conducted to take aerial photographs again for the focal region, and crustal deformation was photogrammetrically measured by comparing aerial photos before and after the earthquake. The results indicated that the severely damaged Horinouchi area was remarkably uplifted and dislocated to the west due to low-angle reverse faulting.

For the 2017 Kumamoto Earthquake, satellite SAR is appreciated because it revealed co-seismic surface deformation in the wide area. However, airborne LiDAR data have significantly contributed to the detection of local surface deformation. Therefore, it is essential to upgrade crustal deformation analysis methods to combine airborne LiDAR, satellite SAR, and aerial photogrammetry.

Keywords: LiDAR, Aerial photograh, active fault

Promotion of solution-oriented remote sensing by the use of UAV

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The concept of UAV remote sensing was almost established. We will present several case studies trying to manage social requirements. Next challenge will be the combination of satellite and UAV remote sensings to establish total package for solution-oriented technology.

Keywords: Unmanned Aerial Vehicle (UAV), UAV Remote Sensing, Crop Monitoring, Ecosystem Monitoring, Land Surface Temperature Monitoring, Dose Rate Monitoring

Forest Canopy Structure Measurement Using close-distance Remote Sensing Technology

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In research on biodiversity, which has drawn attention in recent years, it is said that the diversity of tree species that constitute forests and the three-dimensional structure of forests are closely related to the diversity of the inhabitants. It is thought that grasping the three-dimensional structure of the forest canopy in the target area is important for development of a method to evaluate forest biodiversity by remote sensing technology. On the other hand, the three-dimensional structure of the forest canopy is important as a source of the influence of BRDF on the satellite received signal for the observation of vegetation by satellite remote sensing, and the importance of three-dimensional structure measurement for that has been recognized. So far, authors have used LIDAR and SfM technology to measure the canopy structure in various forests to estimate BRDF in the forest. We believe that the measurement method can be applied to biodiversity evaluation research in many cases.
In this research, we describe what can be clarified for the forest canopy structure measurement at present using the Terrestrial LIDAR, the close-measurement aerial LIDAR and by SfM technology, and the results of organizing the problems to be solved in the future.

Keywords: LIDAR, UAV, SfM, Remote Sensing

Pi-SAR2 observation of the disaster areas affected by volcanic eruption and earthquake

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Japan is an area where earthquakes often occur and volcanic activities are active. The sudden eruption of Mt. Ontake in 2014 and the 2016 Kumamoto earthquake are still fresh in our minds. For the estimation of damage scale and the preparation of restoration activities, it is important to quickly grasp the damage situation in disaster areas. However, the direct access to such areas is often difficult due to traffic situation, risk of secondary disaster, and so on. In this context, one of the effective means is the remote sensing from airplane and/or satellite, which allow us to widely observe disaster areas without direct access. Among the remote sensing instruments, the synthetic aperture radar (SAR) is especially interesting due to its capability for operating in day-and-night and all-weather conditions. NICT has developed the airborne SAR named Pi-SAR2 since 2006. Pi-SAR2 can perform full-polarimetric observations of the ground with the spatial resolution of 0.3 m. At the same time, height measurements and/or moving target detection can be performed owing to the interferometric SAR function of Pi-SAR2. Moreover, the onboard SAR processor enable us to send quick look images from the airplane via the commercial satellite network connection within approximately 10 min after the observation. In this presentation, we introduce the Pi-SAR2 observations performed for volcanos and disaster areas affected by earthquakes and discuss the differences between the satellite and airborne SAR measurements.

Keywords: volcano, earthquake, airborne SAR

