

## Data assimilation system for food production estimation

HIGUCHI, Atsushi<sup>1\*</sup>, Takahiro Sasai<sup>2</sup>, Shin Nagai<sup>3</sup>

<sup>1</sup>Center for Environmental Remote Sensing, Chiba University, <sup>2</sup>Graduate School of Environmental Studies, Nagoya University, <sup>3</sup>JAMSTEC

Recent progress in satellite data productions, such as solar radiation, precipitation rate, soil water contents, enable us to generate more useful information through the data assimilation systems. In addition, next generation satellites will improve both time and spatial resolution. Thus data assimilation system with terrestrial modeling will be made the output for food production estimation in the near of future. We will try to discuss the role of super-high resolution optical sensors and SAR data for data assimilation system, and how to establish the validation system including in-situ observation networks.

Keywords: Terrestrial Studies, Remote Sensing, Data Assimilation

## The possibility of new science program creation for the land under the operational satellite programs

KAJIWARA, Koji<sup>1\*</sup>

<sup>1</sup>Center for Environmental Remote Sensing, Chiba Univ.

Operational satellite projects, such as weather satellites and disaster monitoring satellite is always required in the future, also easy to obtain public understanding. Discussion point this presentation is examination of the possibility of creating a researchers community of plan to create a new science field of land at the beginning of these satellite projects.

Keywords: land, satellite program

## Satellite Mission Proposal for Ocean Color Observation in the Next Generation

HIRATA, Takafumi<sup>1\*</sup>

<sup>1</sup>Hokkaido University

The Coastal Zone Color Scanner (CZCS) onboard Nimbus-7, which is the first satellite sensor specifically targeting ocean color observation, is launched by the National Aeronautics and Space Administration (NASA) on 24th October 1978. Since then, biological and biogeochemical observation in coastal and oceanic waters has dramatically changed from economically-oppressing and time-consuming in situ observation to the automated global observation. The satellite ocean color observation is practically only the way to observe biological and biogeochemical variables in the ocean globally, and therefore the success of the satellite ocean color observation has highly been appreciated among biological and biogeochemical oceanographers. Japan Aerospace Exploration Agency (JAXA) also launched an ocean color sensors such as the Ocean Color and Temperature Scanner (OCTS) onboard the Advanced Earth Observation Satellite (ADEOS) in 1996, and the GLobal Imager (GLI) onboard the ADEOS-II in 2002. From these missions, not only valuable global data of ocean color was obtained but also domestic and oversea ocean color scientists were teamed up and young students specifically in the ocean color science were educated, which led to the most recent mission, the Global Climate Observation Mission-Climate (GCOM-C). On the other hand, ocean color observation itself is evolving. Until GLI, the main product obtained from the color observation was a phytoplankton pigment called Chlorophyll-a, which is often used as an index of phytoplankton biomass in the ocean. In the recent missions (including GCOM-C) in the world, however, novel attempts to retrieve new products (e.g. marine productivity, phytoplankton functional types, harmful algae bloom or red tide, particulate organic carbon, particulate inorganic carbon, particle size distribution, light absorption and scattering properties of biogeochemical matters, euphotic zone) have also been begun. Thus, the satellite ocean color observation has great potential to derive many products to contribute to a wide variety of applications. In aim to apply the ocean color observation to those issues related to climate change, coastal environment issue, inland water issue, fisheries resource and management, harmful algae, marine disaster, a new ocean color mission will be proposed in this presentation and a hardware requirement for the next generation ocean color observation will be discussed.

Keywords: ocean color, satellite observation, New Mission

## The next step of the satellite remote sensing of sea ice

KIMURA, Noriaki<sup>1\*</sup>, Kazuhiro Naoki<sup>2</sup>, Naoto Ebuchi<sup>3</sup>

<sup>1</sup>Graduate School of Frontier Sciences, The University of Tokyo, <sup>2</sup>Japan Aerospace Exploration Agency, <sup>3</sup>Institute of Low Temperature Science, Hokkaido University

Satellite remote sensing is a powerful tool for monitoring sea ice, which is difficult to observe in the field. Especially, temporal and spatial variability of large-scale sea-ice extent and ice motion have revealed mainly by using data from passive microwave sensors. However, variability of ice thickness and contribution of small-scale ice processes have not yet been understood well. Those are essential for understanding sea ice nature and predicting the future change of ice cover.

Efforts to detect the ice thickness have been carried out using the passive microwave sensors based on the relation between ice thickness and ice surface condition. Additionally laser altimetry measuring the freeboard height of sea ice is also used for the ice thickness observation. On the other hand, there already are high-resolution sensors such as AVNIR-2, which provide the data sufficient to examine the small-scale ice processes. In these observations, a major problem is low frequency of observation. Based on these considerations, we will propose the new monitoring system of sea ice.

Keywords: satellite remote sensing, sea ice

## Towards the realization of spaceborne lidar mission program in Japan

ISHII, Shoken<sup>1\*</sup>, Tomoaki Nishizawa<sup>2</sup>

<sup>1</sup>National Institute of Information and Communications Technology, <sup>2</sup>National Institute for Environmental Studies

Various atmospheric phenomena cross borders and have undesirable effects on earth environment issues such as global warming, long-range air pollutant, acid rain, ozone destruction, and so on. An aerosol particle derives from human activities, sea spray, dust, and biogenic activities, and it play an important role in the local and global and local circulations. The aerosol particle can scattering and absorb the light and it has highly influence directly on the Earth's energy balance. Water soluble aerosol can serve as cloud condensation nuclei and it determines the initial concentration, distribution, phase of cloud. The aerosol particles can have influence indirectly on the Earth's energy balance. The chemical reactions affect optical properties of aerosol particle. It also results in the influence of the radiation budget from the microscopic view. The network of aerosol observatory as meteorological weather stations is limited. The aerosol observation from space is one of the promising methods for the earth observation. Lidar is one of the most useful active remote sensing techniques that can be used to detect small particulates. The lidar can be used to detect molecules, aerosols and clouds, water vapor, minor atmospheric constituents, and wind. The National Space Development Agency of Japan which was the predecessor of the Japan Aerospace Exploration Agency planned the Experimental Lidar in Space Environment (ELISE) loaded onto the mission demonstration satellite II. The ELISE program was a two-wavelength backscatter lidar and it was a first full-scale spaceborne lidar mission program. One of objectives of the ELISE program was to observe tropospheric and stratospheric aerosol particles, multiple-layered cloud, and cirrus. The ELISE program was aborted through some reasons. Japanese spaceborne lidar mission programs for the purposes of the atmospheric science have not been planned since the ELISE mission program. The ideas on the Japanese earth observation mission program after 2020 are discussed in the land, oceanic and atmospheric disciplines. In the atmospheric discipline, Doppler wind lidar, high spectral resolution lidar, multi-wavelength polarization backscatter lidar, scanning lidar, and differential absorption lidar for green gases are discussed as candidates for future spaceborne lidar mission programs. In presentation, we will report on the ideas of the future spaceborne lidar mission program, and also discuss the ideas with various scientific and engineering experts interested in the active optical remote sensing technique.

Keywords: spaceborne observation, lida, aerosol/cloud, wind, trace gas

## New proposals for observing atmospheric environment from space - GMAP-Asia and APOLLO

KITA, Kazuyuki<sup>1\*</sup>, KASAI, YASUKO<sup>2</sup>, KANAYA, Yugo<sup>3</sup>, AKIMOTO, Hajime<sup>4</sup>, Working group for satellite observation of atmospheric environment,<sup>5</sup>

<sup>1</sup>Faculty of Science, Ibaraki University, <sup>2</sup>NICT, <sup>3</sup>JAMSTEC, <sup>4</sup>Asia Center for Air Pollution Research, <sup>5</sup>The Japan Society of Atmospheric Chemistry

Tropospheric ozone has been increased in the northern hemisphere in recent years, although emission of precursor gases has been reduced in Japan, Europa and US. The increase of tropospheric ozone and aerosols may cause the increase of mortality risk and the climate change. In Japan, surface ozone concentration often exceeds the environmental standard at most monitoring sites. Recently, the frequency of photochemical smog alert increases in Kyushu and prefectures face to the sea of Japan, implying that the transboundary transport from China and other Asian countries significantly contributed to the increase of the tropospheric ozone.

Remote sensing from space is quite useful for measuring regional-global distribution of the atmospheric constituents. The tropospheric species such as NO<sub>2</sub> was measured with sensors onboard a low, sun-synchronous orbit satellite. However, there are some defects for these observation. In the Japan society of atmospheric chemistry, a working group was made for examining next-generation satellite observation of atmospheric environment from the space. This group with some other institutes (NNIES, MRI and others) proposed the Geostationary missions for Meteorology and Atmospheric pollution over Asia (GMAP-Asia), which measure tropospheric ozone, aerosol and their precursors from the geostationary orbit. Spatially and temporary continuous measurement by an geostationary satellite observation will enable us to understand both photochemical and transport processes on the ozone and aerosols, especially long-range/transboundary transport of pollutants. This observation will also enable us to understand the diurnal variation of emission of precursor gases. By assimilation of the observed data, this observation will improve the model simulation of atmospheric environment.

As a complimentary mission, this group also proposes the Air Pollution Observatory (APOLLO) mission from the international space station (ISS). A very low, non-sun-synchronous orbit of ISS provides us another unique observation of the atmospheric ozone and aerosols. The low orbit enables us to observe with higher horizontal resolution (4km by 4km) to understand ozone and aerosol concentration as well as the precursor emissions at urban, suburban, agricultural areas more precisely. Non-sun-synchronous orbit enables us to measure these species at various local times. In addition, simultaneous observation of tropospheric ozone and carbon monoxide (CO) with full-wavelength, UV/visible/SWIR/MIR/sub-mm, is planned in APOLLO mission for separating lower/middle/upper tropospheric ozone and CO. It is essential to measure the lower tropospheric ozone separately to estimate mortality risk by the ozone. Separate measurement of middle and upper tropospheric ozone and CO enable us to understand the long-range/transboundary transport of pollutants and the climate influence.

Keywords: Geostationary satellite, International space station, lower tropospheric ozone

## Future GEO missions for cloud and precipitation measurements by microwave instruments

MASUNAGA, Hirohiko<sup>1\*</sup>, NAKAJIMA, Takashi<sup>2</sup>, Keiji Imaoka<sup>3</sup>, USHIO, Tomoo<sup>4</sup>

<sup>1</sup>Hydrospheric Atmospheric Research Center, Nagoya University, <sup>2</sup>School of Information and Design Engineering, Tokai University, <sup>3</sup>Earth Observation Research Center, Japan Aerospace Exploration Agency, <sup>4</sup>Graduate School of Engineering, Osaka University

Earth observing satellites fly in either a low Earth orbits (LEO) or the geostationary orbit (GEO). GEO satellites make temporally continuous observations at the expense of limitation in spatial resolution due to its great distance from the Earth. Only visible and infrared imagers are feasible for GEO instruments at present. On the other hand, LEO satellites, orbiting much closer to the Earth, have the advantage to accommodate technologically challenging remote sensors such as spaceborne radars.

While visible and infrared images are unable to directly detect rain drops below overlying cloud layers, microwave radiation penetrates the cloud layer to reach rainfall beneath. Extreme rainfall events, developing quickly within a half to one hour, are difficult to detect directly by the current GEO satellites because of the lack of microwave sensors. LEO microwave instruments, however, are not optimal for such purposes either since the revisit frequency of LEO satellites is no better than twice daily. Microwave remote sensing from the GEO orbit, if realized, would bring a breakthrough to the monitoring of extreme meteorological events from the space.

In this paper, major challenges and expected impacts of GEO microwave remote sensing on the social and research communities will be discussed.

Keywords: Satellite remote sensing, cloud and precipitation measurements, future satellite missions

## A Proposal on low inclination orbit SAR system for tropical rainforest monitoring

KAMEI, Masatoshi<sup>1\*</sup>, Makoto Ono<sup>1</sup>, Ryoichi Furuta<sup>1</sup>, TOMIYAMA, Nobuhiro<sup>1</sup>, KOIZUMI, Eisuke<sup>1</sup>, Takashi Ogawa<sup>1</sup>

<sup>1</sup>Remote Sensing Technology Center of Japan

### 1. Background

Mitigation and adaptation of climate change caused by greenhouse gases have been a serious issue for more than decades and forest has been focused in the context of REDD. In particular, the roll of tropical rainforest is more important than ever as a vast reservoir of carbon dioxide. Since monitoring area is global and wide, satellite is a key to realize true monitoring. This paper shows a result of a parametric study on SAR system to realize frequent and consistent monitoring based on our experience of a forest monitoring project in Brazil.

### 2. Requirement

Most of tropical rainforests lie in areas which are covered by thick cloud during rainy season and optical sensors are useless to realize timely monitoring. Time series analysis of tropical rainforest is a key technology to detect changes happening in the forest. We set the time series monitoring as well as frequent monitoring first priority in this proposal.

### 3. Proposed Solution

A space borne SAR sensor is the most possible and realistic instrument to meet the requirement. In order to maximize the information extracted from SAR data and track deforestation and degradation, capability of full polarimetry and differential interferometry is needed. In addition, P-band or L-band is preferable to detect volume scattering from tree canopy. The required specification of space borne SAR system can be summarized as below.

- a. Ground resolution is 20-30m.
- b. Revisit time to a certain area of interest is around 2 weeks.
- c. Time series of differential interferometry must be conducted within 3 month time difference.
- d. Full swath and full polarimetry in arbitrary incident angle.
- e. Ascend and descend coverage of arbitrary target area.

### 4. Proposed Orbit

In order to realize more frequent observation and cover tropical rainforest areas with limited observation resources, lower orbit inclination is preferable.

In the case of low orbit inclination, the direction of satellite orbit rotation will be opposite to the earth rotation direction around the sun. But it is possible to make sub orbit locus on the earth returns to same place in some time intervals, which makes SAR enable to provide repeated path interferometry pairs.

In our case study, an example of orbit inclination is 25.12 degree, which can meet the requirement and its recursion time is 49 days and locus distance is 23.7km. If the swath of SAR sensor onboard is designed as 120km, arbitrary target point in the orbit coverage is observed 5-10 times in different incident angle per recursion cycle, which means almost every 10 days target area is observed with out affected by cloud cover.

### 5. Proposed SAR antenna

The cylindrical parabola antenna (Not phased array) is preferable in order to make it simple and reduce its weight and power consumption. The parameter of the antenna will be as below.

- Mass: 500-1,000kg
- Solar power: 2kw (SAR power = 750w with 50% margin)
- 3 axis stabilized (apply yaw maneuver)
- SAR antenna: extendable dual polarized antenna

### 6. SAR Interferometry

Interferometry pair can be obtained with recursion cycle data pairs because the satellite orbit is designed to revisit same point every recursion cycle. Since a target area is observed 5-10 times with different incident angle, interferometry pair, which was obtained 49 days before, is frequently obtained for different incident angles as well. Frequent interferometry pair will provide more accurate change detection with differential interferometry and coherence evaluation.



# Japan Geoscience Union Meeting 2012

(May 20-25 2012 at Makuhari, Chiba, Japan)

©2012. Japan Geoscience Union. All Rights Reserved.



---

ATT34-08

Room:202

Time:May 20 16:15-16:30

## 7. Full polarimetry in full swath

To realize full polarimetry, SAR signal transmission polarization must be switched like H pol to V pol and vice versa. Our study for full polarimetry is to operate pol. switch as burst mode, which realizes full swath in full polarimetry in any designed incident angles.

## 8. Conclusion

Low inclination orbit SAR system without phased array antenna can realize frequent tropical rainforest observation with full polarimetry in full swath and provide frequent interferometry pairs.

Keywords: SAR, Tropical Rainforest, polarimetry, interferometry

## Future cloud and precipitation observation mission

TAKAHASHI, Nobuhiro<sup>1\*</sup>, KACHI, Misako<sup>2</sup>, Kinji Furukawa<sup>2</sup>

<sup>1</sup>NICT, <sup>2</sup>JAXA

The Tropical Rainfall Measuring Mission (TRMM) is Japan-US joint satellite mission that equips world first spaceborne precipitation radar (PR) as well as microwave imager (TMI) and has been producing very valuable precipitation data more than eleven years. This long term precipitation record from TRMM made it possible to provide not only the precise global precipitation amount but also improve the understanding the mesoscale tropical and sub-tropical weather system revolutionary. For example, diurnal cycles of rainfall is revealed by several studies using PR data both land and ocean. It is worth to note that the mesoscale climatology developed from PR data is used to evaluate the global cloud-resolving model such as NICAM. The follow-on mission of TRMM, which is called the global precipitation measuring (GPM) mission, is planned to start in 2014. GPM mission is consist of Core satellite which equips dual frequency (14 GHz and 35 GHz, the former is same frequency as TRMM/PR) radar to improve the estimation accuracy of rainfall and to observe the light rain and snowfall and constellation satellites which equip microwave radiometer to gain the sampling of precipitation. On the other hand, satellite cloud remote sensing started with optical sensors to estimate the effective radius of cloud and so on. In 2006, NASA's CloudSat satellite was launched to observe the cloud structure using 95-GHz cloud radar. CloudSat has been providing the vertical structure of clouds and even light rain and enables us to see the cloud and precipitation properties at the same time. In Japan, spaceborne cloud radar similar to the CloudSat but upgraded in terms of sensitivity, long life time and the additional Doppler capability is being developed for EarthCARE mission which is JAPNA-ESA joint program aiming to reveal the aerosol-cloud processes to realize more precise Earth radiation budget estimation using cloud radar and lidar.

Beyond the GPM and the EarthCARE targeting 2018, post-GPM mission is discussed under the GPM science team. First, scientific paradigm toward 2018 and beyond in discussed. For example, global water circulation and impact of global warming to the rainfall are recognized as very important study theme. In addition, long term accurate global rainfall record by spaceborne radar is also recognized as important. The importance of comprehensive and frequent of extreme events, especially for typhoons and hurricanes is pointed out. Based on these scientific requirements, sensor requirements are discussed and concluded the needs of both the cloud radar and the precipitation radar with Doppler measurement capability and wind measurements by Doppler Lidar. Alternative approach to the wind measurement is multiple satellites concept (e.g. train satellites) to see the development process of cloud-precipitation system by observing in a short time intervals. In the sensor requirement study phase, development item of the sensors are also summarized (e.g. pulse compression radar, scanning W-band radar). Base on the sensor requirements, several missions are proposed. For example, multiple satellite system is one of the solutions to fulfill the scientific requirements and the typhoon observation from geostationary orbit (it is recognized as the mission more than 10 years from now). With the help of JAXA's system engineering group, preliminary mission feasibility study was also performed. Based on these studies, detailed sensor study and trade-off will be done.

## Earth Observation Strategy by Small Satellites

KODAMA, Tetsuya<sup>1\*</sup>, SUZUKI, Makoto<sup>2</sup>, OBARA, Takahiro<sup>4</sup>, OYAMA, Koichiro<sup>4</sup>

<sup>1</sup>EORC/JAXA, <sup>2</sup>ISAS/JAXA, <sup>3</sup>Tohoku Univ., <sup>4</sup>NCKU

New strategy for earth observation by Small Satellites will be presented.

Keywords: Small Satellite, Small Scientific Satellite Bus, ASNARO, SDS, Microsatellite, Peer Review