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熱帯雨林観測のための低軌道傾斜角 SAR システム案
A Proposal on low inclination orbit SAR system for tropical rainforest monitoring

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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.

7. Full polarimetry in full swath

To realize full polarimetry, SAR signal transmission polarization must be switched like H pol to V pol and vise 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