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SMOS RFI EXPERIENCE IN THE 1400-1427MHz PASSIVE BAND DUE TO RADIATIONS AT INTERMEDIATE FREQUENCY OF SATELLITE HOME-TV RECEIVERS

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Abstract

SMOS is the European Space Agency's (ESA) mission addressing the need for high-quality global observations of soil moisture and ocean salinity from space. SMOS operates in a dusk-dawn sun synchronous near circular orbit at 763 km, with 6pm descending node. The payload consists of the Microwave Imaging Radiometer with Aperture Synthesis (MIRAS) operating in the 1400-1427 MHz purely passive band. This band is a primary allocation to the passive remote sensing in the Earth Exploration Satellite Service (EESS (passive)) by the ITU Radio-Regulations (RR). Although all emissions are prohibited in this band (RR No. 5.340), since its launch in November 2009, the SMOS science data have been polluted by Radio Frequency Interference (RFI) worldwide. Among the causes of interference detected by SMOS, one of the most unexpected and difficult to eliminate, is due to the aggregate radiations from the intermediate frequency (IF) circuits of satellite home-TV receivers in Japan. Since October 2011, this type of interference case is detected in SMOS observations over the country, in particular in urban areas with high density of population.

1 Introduction

From the beginning of SMOS operations until October 2011 a limited number of RFI sources had been detected over Japan. However, between October 2011 and March 2012, a sudden increase was detected extended over most urban areas and, since then, no improvement has been observed (see Figure 1). This interference case has been affecting not only SMOS data but also other Earth observation missions, such as Aquarius and SMAP operated by NASA [1, 2, 3, 4].

2 Interference Source

This case of harmful interference was reported to the Japanese Administration (Ministry of Internal Affairs and Communications, MIC) in accordance to the procedure described in the ITU RR (Article 15, Section VI). The appearance of the interference happened simultaneously to the beginning of operations of a new broadcasting satellite, which by the first time was using two new channels recently assigned to digital TV. The satellite broadcasting system operates at 12 GHz [5], and the satellite home-TV receivers down-converts the RF signal channels to an intermediate frequency (IF) in the L-Band [6]. The IF associated to two of the Digital TV channels is overlapping with the 1400-1427 MHz EESS (passive) band. Tests facilitated by the Japanese authorities, and involving SMOS and the broadcasting satellite, confirmed that the cause of this interference was the aggregate impact of radiations at the intermediate frequency from a very high number of home-TV receiving equipment.

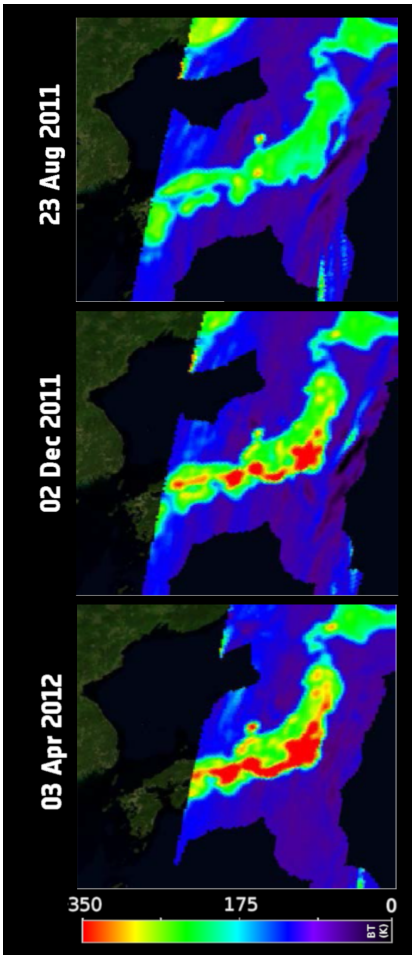

Figure 1. Comparison of SMOS RFI swath images before the Broadcasting Satellite (BS) channels 19 and 21 started operations (top), when the transmission of BS ch.19 started (middle) and by the time when both channels (BS ch.19 & 21) were operational (bottom) [7]. Source: ESA.

The main problem of the home-TV receiver equipment seems to be inadequate installations, in particular in the routing at intermediate frequency between the outdoor and indoor systems (e.g. poor-quality cable and connectors, or inadequate installation practices resulting in insufficient shielding).

3 Interference Mechanism

This type of interference source had not been reported previously. ESA asked for advise to the ITU-R Study Groups (Working Party (WP) 1A, expert in spectrum engineering techniques and WP 7C expert in remote sensing systems). The problem was initially considered as a problem of Electro-Magnetic Compatibility (EMC). Within the International Electro-technical Commission, the CISPR (International Special Committee on Radio Interference) is dealing with issues related to interference and standarisation in the field of EMC. CISPR informed WP 1A that product based standards take no account of interactions that may arise in an installation comprising several separate product elements and interconnections. As such, this confirmed that no problem was identified with the EMC standards of the individual equipment, the problem seemed to come from the connection between units.

This interference mechanism does not fall strictly into the category of spurious emissions, since it is caused by a 12 GHz signal down-converted to 1.4 GHz within a satellite TV receiving installation. The interference is not an intentional emission of a radio-communication service within their allocated frequency band. And neither does it fit within current EMC assessment methods, since the observed disturbances could be caused by the combined effect of radiation from all the equipment units, the interconnecting cabling and the connectors comprising the complete satellite receiving installation, rather than from a single product.

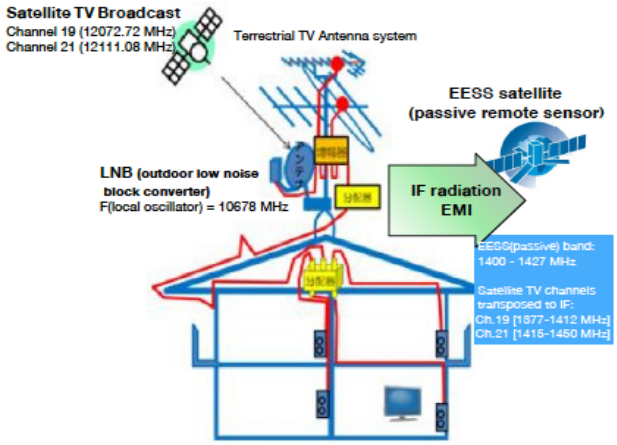

Figure 2. Schematic of the RFI mechanism due to IF radiations of home-TV receiver equipment. Source: Doc. 7C/218, 14 Dec 2017, ITU Study Groups.

This is a problem involving the quality of cabling and installation practices in setting up the satellite receiving equipment. This case shows how individual-product based standards are not sufficient to cover disturbances caused by multi-part installations and connections. EMC standards generally only address individual elements, but not the complete assembly of the outdoors/indoors installation.

4 Actions to Solve this RFI Issue

The Japanese regulatory authorities are committed to resolve this interference problem. As part of the action plan put in place, following initiatives are on-going [8]:

- **New installation guidelines** for the installation of satellite broadcast receiving facilities were published by MIC in June 2018. Regular briefing sessions about these guidelines given to the installation companies.
- **New authorization systems for highly shielded satellite receiving facilities** have been recently enacted by the JEITA (Japan Electronics and Information Technology Industries Association).
- **Promotion of the replacement of inadequate receiving facilities.** MIC has started in 2018 a financial support programme to renew more tan 60000 systems within 2019-2020.

However, the problem involves probably millions of users and the economic interests of satellite TV makes impossible the possibility to stop the emissions of the two channels triggering this extended interference.

Another reason of concern is the fact that similar situation observed in Japan could also be extended to other countries using similar satellite receiver equipment. Meanwhile, large amounts of climate science data have become unusable, the continuity of the monitoring of soil moisture in the area has been interrupted and the interference is impacting not just the ground, but also the surrounding sea waters.

4 Conclusions

It is very important the early characterization and analysis of these potential interference cases, and whenever possible, put in place strategies to mitigate the problem. The experience is showing that once this type of RFI has started, it is very difficult to reverse the situation involving probably millions of equipment.

The difficulties of extending testing methods to cover installations that are assembled on site rather than marketed as a complete package need to be addressed by the regulatory authorities and actions taken accordingly, to avoid the impact that poor installations may have in other services using their allocated band, thus ensuring the conformity and integrity of the radiocommunication services.

5 References

1. E. Daganzo, R. Oliva, Y. Kerr, S. Nieto, P. Richaume and S.M. Mecklenburg, “SMOS radiometer in the 1400–1427-MHz passive band: impact of the RFI Environment and approach to its mitigation and cancellation”. IEEE Transactions on Geoscience and Remote Sensing, 51(10), pp. 4999–5007. 2013

2. Alvaro Llorente, Elena Daganzo, Roger Oliva, Ekhi Uranga, Yann. Kerr, P. Richaume, Antonio de la Fuente, Manuel Martin-Neira, S. Mecklenburg, “Lessons learnt from SMOS RFI activities after 10 years in orbit: RFI detection and reporting to claim protection and increase awareness of the interference problem in the 1400-1427 MHz passive band”. RFI2019 Coexisting with Radio Frequency Interference, Toulouse, 2019

3. Y. Soldo, P. de Matthaeis and D. M. Le Vine, “L-Band RFI in Japan”. IEEE RFI Workshop. 978-1-5090-6201-0/16. 2016

4. Report ITU-R RS.2315-0, “Global RFI survey observed by Aquarius scatterometer at 1260 MHz, and Aquarius and SMOS radiometers at 1 413 MHz”, ITU, 2014

5. ITU Radio Regulations (RR). Available: https://www.itu.int

6. Rec. ITU-R BO.790, “Characteristics of receiving equipment for the broadcasting-satellite service”, ITU, 1992

7. “Radio Interference of some types of BS Broadcasting Reception Systems”, Press Release Telecom, MIC, Feb 2009.

8. E. Daganzo, R. Oliva, P. Richaume, A. Llorente, E. Uranga and Y. Kerr, "SMOS RFI Experience in the 1400-1427 MHz Passive Band: Case of Extended Interference Caused by Broadcasting Satellite Home-TV Receivers," IGARSS 2019 - 2019 IEEE International Geoscience and Remote Sensing Symposium, Yokohama, Japan, 2019, pp. 4455-4458. doi: 10.1109/IGARSS.2019.8897873