

Technical sub-group reports

Frequency protection

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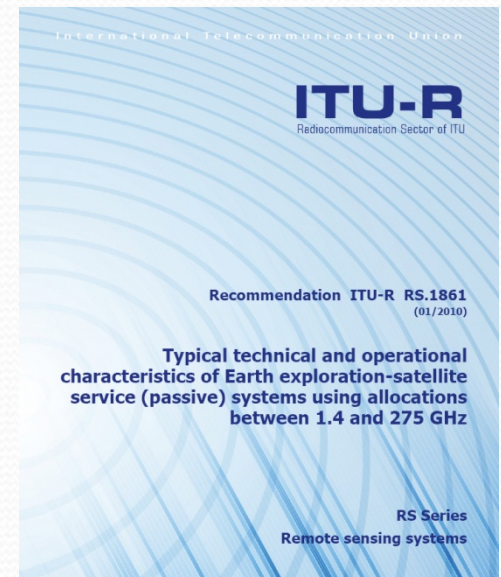
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New ITU-R report

- “Identification of degradation due to interference and characterization of possible interference mitigation techniques for passive sensors operating in the Earth exploration satellite service (passive)”
- main outcomes
 - discusses products and the effects of rfi
 - Audience
 - Non-technical in the earth scientist sense
 - In many cases in competition for spectrum with passive remote sensing

New ITU-R recommendation

- Characteristics of your passive sensors
- Used by active services in interference analyses
- A key document because the active “opposition” uses this to determine if they will interfere with you
- Ask Dave, Rich, or Jean for a copy



Interesting missions and rfi

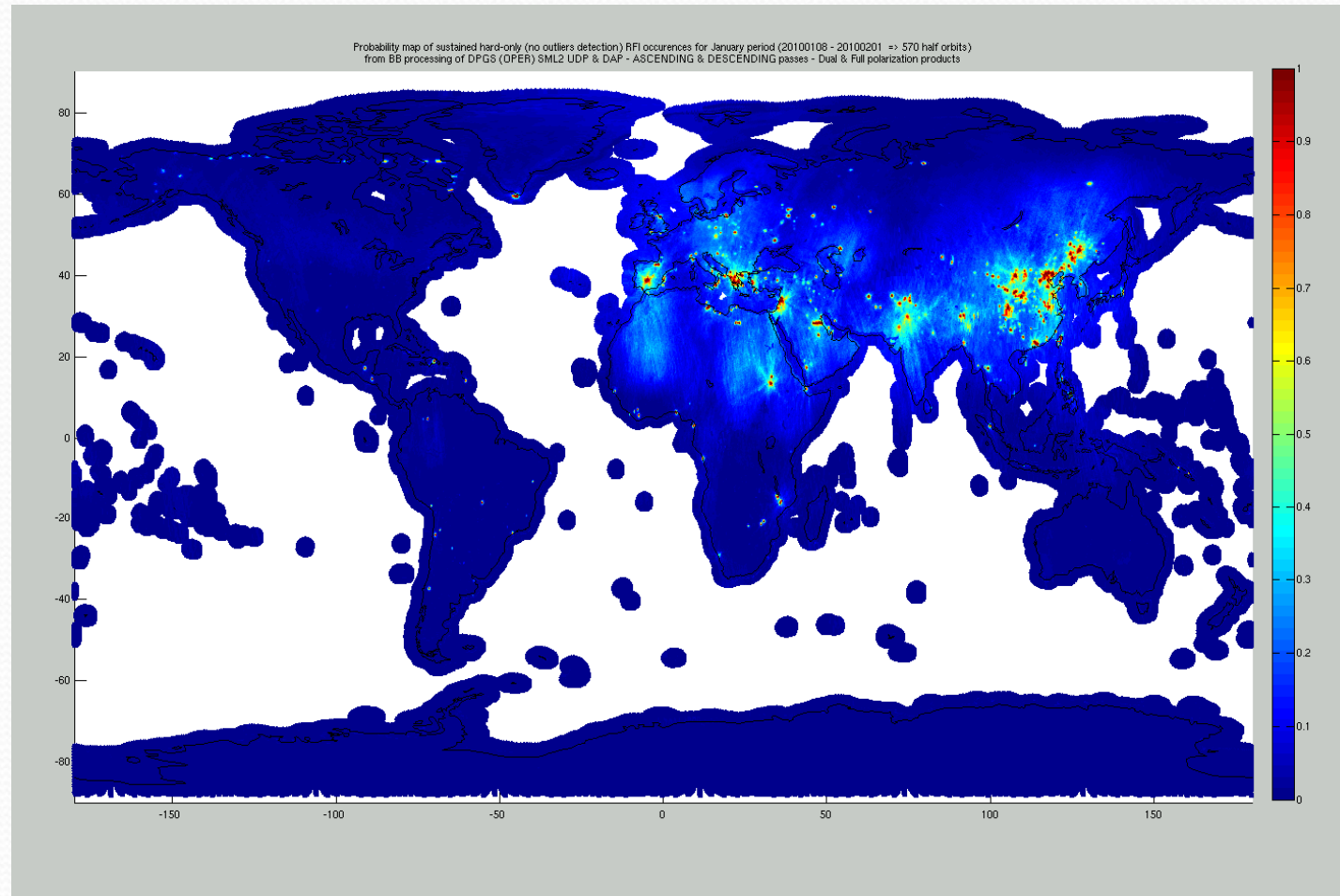
- SMOS
- Aquarius
- SMAP

SMOS Soil Moisture and Ocean Salinity Satellite

- Launched November 2009
 - sub band of 1400 -1427 GHz
- rfi detection techniques¹
 - High Tb ($> 340\text{K}$)
 - non flat stokes 1 at angles $< 40^\circ$
 - anomalous TB (i.e., $\text{TBh} > \text{TBv}$)
 - anomalous angular behaviour
 - High values for stokes 3 or 4

¹ personal correspondence with Yann Kerr (Director of *Centre d'Etudes Spatiales de la BIOsphère*, CESBIO, Principal Investigator on the SMOS project, yann.kerr@cesbio.cnes.fr)

SMOS image of strong RFI probability



SMOS RF band pass filter centre frequency is 1413.5 MHz with a 3 dB passband of 20 MHz

ITWG needs to realize

- rfi even in 5.340 bands is something real that could be catastrophic.
- ongoing action in Europe to
 - Eliminate RFI
 - make the limits in radio regs compulsory for the 1.4 GHz (now, they are just recommended)

*RESOLUTION 750 (WRC-07) Compatibility between the Earth exploration satellite service (passive) and relevant active services

Aquarius

- scheduled for launch 2010
- mission - measure global sea surface salinity to better predict future climate conditions
- rfi detection and removal
 - Software filter to detect
 - flag indicates how much data was removed
 - threshold detection filter
 - Similar to asynchronous pulse blanking (after Joel Johnson)
 - based on work by C. Ruf¹
 - does not assume a pulse-like structure for the RFI
- RFI processing on the ground
- two RFI issues, one for the scatterometer (1.26 GHz) and one for the radiometer (1.413 GHz)²
 - radiometer data is processed in 10 and 20 ms samples and data identified as contaminated with RFI will be removed from further processing; but all data will be stored and nothing will be lost
 - something similar done for the scatterometer - software not completely defined

¹"Detection of Radio-Frequency Interference for the Aquarius Radiometer", Sidharth Misra and Christopher S. Ruf., IEEE TRANSACTIONS ON GEOSCIENCE AND REMOTE SENSING, VOL. 46, NO. 10, OCTOBER 2008

²personal correspondence with David Levine, GSFC

³AQUARIUS low Earth orbiting mission is intended to produce global maps of sea surface salinity for use in climate studies. It includes a microwave radiometer operating at 1.4 GHz to measure SSS

Soil Moisture Active-Passive (SMAP)

- recommended for launch 2010-2013
- Mission - surface soil moisture and freeze-thaw state
- L-band radar and L-band radiometer
- rfi detection
 - Significant oversampling in time to implement peak detection algorithm
 - Agile digital detector (ADD)¹
 - kurtosis algorithm with sub banding provides more robust detection when dealing with varying RFI duty cycle and power
- rfi processing on spacecraft
- Recent developments
 - Completed design, build and test of a spaceflight prototype
 - transcontinental airborne RF survey flights using ADD
 - As a result of the technology readiness from the prototype development, plus the unpleasant (high level of rfi) results of the field campaigns, a flight version of ADD has been incorporated into the upcoming NASA spaceborne SMAP radiometer.
- ADD should work with multichannel instruments

¹“Microwave Radiometer Radio-Frequency Interference Detection Algorithms: A Comparative Study” Sidharth Misra, Priscilla N. Mohammed, Bari's Güner, Christopher S. Ruf, Jeffrey R. Piepmeier, and Joel T. Johnson, IEEE TRANSACTIONS ON GEOSCIENCE AND REMOTE SENSING, VOL. 47, NO. 11, NOVEMBER 2009

Want to learn more

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Backup slides

Stokes parameters

- From Wikipedia, the free encyclopedia
- a set of values that describe the polarization state of electromagnetic radiation
- defined by George Gabriel Stokes in 1852
 - mathematically convenient alternative to the more common description of incoherent or partially polarized radiation in terms of its total intensity (I), (fractional) degree of polarization (p), and the shape parameters of the polarization ellipse.

Stokes parameters

Definitions

[edit]

The relationship of the Stokes parameters to intensity and polarization ellipse parameters is shown in the equations below and the figure at right.

$$S_0 = I$$

$$S_1 = Ip \cos 2\psi \cos 2\chi$$

$$S_2 = Ip \sin 2\psi \cos 2\chi$$

$$S_3 = Ip \sin 2\chi$$

Here Ip , 2ψ and 2χ are the [spherical coordinates](#) of the polarization state in the three-dimensional space of the last three Stokes parameters. I is the total intensity of the beam, and p is the degree of polarization. The factor of two before ψ represents the fact that any polarization ellipse is indistinguishable from one rotated by 180° , while the factor of two before χ indicates that an ellipse is indistinguishable from one with the semi-axis lengths swapped accompanied by a 90° rotation. The four Stokes parameters are sometimes denoted I , Q , U and V , respectively.

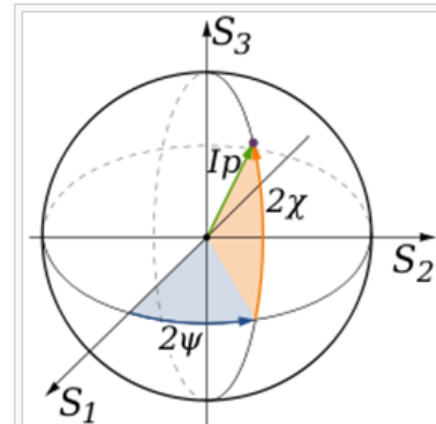
If given the Stokes parameters one can solve for the [spherical coordinates](#) with the following equations:

$$I = S_0$$

$$p = \frac{\sqrt{S_1^2 + S_2^2 + S_3^2}}{S_0}$$

$$2\psi = \text{atan} \frac{S_2}{S_1}$$

$$2\chi = \text{atan} \frac{S_3}{\sqrt{S_1^2 + S_2^2}}$$



The Poincaré sphere is the parametrisation of the last three Stokes' parameters in [spherical coordinates](#)

Stokes parameters

Stokes vectors

[\[edit\]](#)

The Stokes parameters are often combined into a vector, known as the **Stokes vector**:

$$\vec{S} = \begin{pmatrix} S_0 \\ S_1 \\ S_2 \\ S_3 \end{pmatrix} = \begin{pmatrix} I \\ Q \\ U \\ V \end{pmatrix}$$

The Stokes vector spans the [space](#) of unpolarized, partially polarized, and fully polarized light. For comparison, the [Jones vector](#) only spans the space of fully polarized light, but is more useful for problems involving [coherent](#) light. The four Stokes parameters do not form a preferred [basis](#) of the space, but rather were chosen because they can be easily measured or calculated.

The effect of an optical system on the polarization of light can be determined by constructing the Stokes vector for the input light and applying [Mueller calculus](#), to obtain the Stokes vector of the light leaving the system.

Stokes parameters

Examples

Below are shown some Stokes vectors for common states of polarization of light.

$$\begin{pmatrix} 1 \\ 1 \\ 0 \\ 0 \end{pmatrix} \text{ Linearly polarized (horizontal)}$$

$$\begin{pmatrix} 1 \\ -1 \\ 0 \\ 0 \end{pmatrix} \text{ Linearly polarized (vertical)}$$

$$\begin{pmatrix} 1 \\ 0 \\ 1 \\ 0 \end{pmatrix} \text{ Linearly polarized (+45°)}$$

$$\begin{pmatrix} 1 \\ 0 \\ -1 \\ 0 \end{pmatrix} \text{ Linearly polarized (-45°)}$$

$$\begin{pmatrix} 1 \\ 0 \\ 0 \\ 1 \end{pmatrix} \text{ Left-hand circularly polarized}$$

$$\begin{pmatrix} 1 \\ 0 \\ 0 \\ -1 \end{pmatrix} \text{ Right-hand circularly polarized}$$

$$\begin{pmatrix} 1 \\ 0 \\ 0 \\ 0 \end{pmatrix} \text{ Unpolarized}$$