

PASSIVE MICROWAVE PROTECTION: IMPACT OF RFI INTERFERENCE ON SATELLITE PASSIVE OBSERVATIONS

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Summary

Description of the agenda items 1.2 and 1.20 for the next WRC-2007

Proposed “best” method to solve both agenda items

Impact of wrong or missing data

Examples of RFI at 6 and 10.6 GHz

Conclusion

Characteristics of the passive bands: regulatory

Two kinds of passive bands

① P= primary exclusive 5.340 « All emissions are prohibited in the following bands ... »

The passive sensors are unable to discriminate between these natural radiations and man-made radiations. Article 5.340 of the RR enables the passive services to deploy and operate their systems

② p = primary passive bands shared with other active services, in general terrestrial services (FS, MS), not space services (MSS, FSS)

Objective of the passive bands

- **1400-1427 MHz: salinity (ocean), soil moisture (ground)**
- **10.6-10.7 MHz: rain, snow, ice, sea state, ocean wind**
- **23.6-24 GHz: total content of water vapour**
- **31.3-31.5 GHz: the lowest cumulated effects due to oxygen and water vapour in the vicinity of the 50 GHz band. Optimum window channel to see the Earth's surface: reference for the other channels.**
- **36-37 GHz: cloud liquid water, vegetation structure, surface roughness**
- **50.2-50.4 GHz: temperature profile**

Objective of the passive bands: ITU-R SA. Recommendations

SA. 1028 Performance criteria

**SA.1029 Permissible interference criteria levels for
frequency bands P and p**

- 1400-1427P MHz: -174 dBW, 27 MHz, 99.9%, **0.05K**
- 10.6-10.68p,
10.68-10.7P MHz: -156,-166 dBW, 100 MHz, 99.9%, **1/0.1K**
- 23.6-24P GHz: -166 dBW, 200 MHz, 99.99%, **0.05K**
- 31.3-31.5P GHz: -166 dBW, 200 MHz, 99.99%, **0.05K**
- 36-37p GHz: -166 dBW, 100 MHz, 99.9%, **1/0.1K**
- 50.2-50.4P GHz: -166 dBW, 200 MHz, 99.99%, **0.05K**
- 52.6-54.25P GHz: -169 dBW, 100 MHz, 99.99%, **0.05K**

Objective of the passive bands: Data availability

Data availability is the percentage of area or time for which accurate data is available for a specified sensor measurement area or sensor measurement time.

For a 99.99% data availability, the measurement area is a square on the Earth of 2,000,000 km², unless otherwise justified.

For a 99.9% data availability, the measurement area is a square on the Earth of 10,000,000 km² unless otherwise justified.

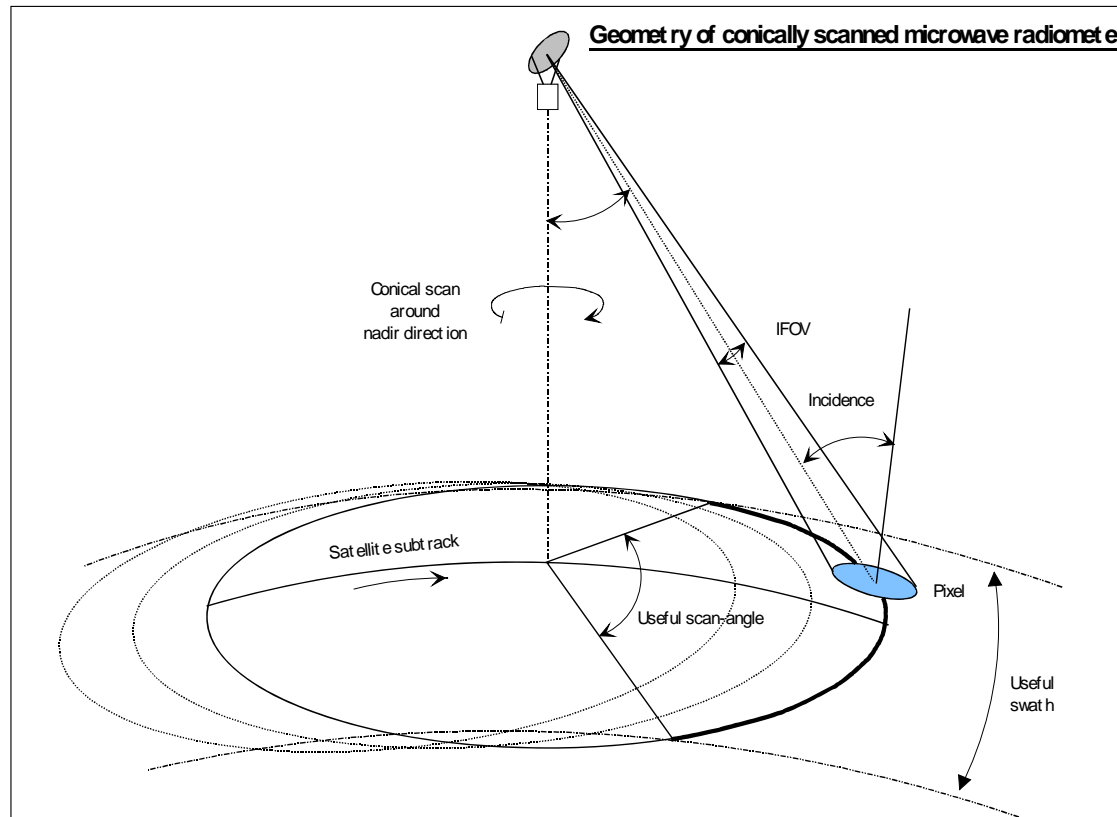
For a 99% data availability the measurement time is 24 hours, unless otherwise justified.

Agenda item 1.2 of WRC-07

- *to invite ITU-R to conduct sharing analyses between the EESS (passive) and the SRS (passive) on one hand and the fixed and mobile services on the other hand in the band 10.6-10.68 GHz to determine appropriate sharing criteria*
- *to invite ITU-R to conduct sharing studies between the passive services and the fixed and mobile services in the band 36-37 GHz in order to define appropriate sharing criteria*

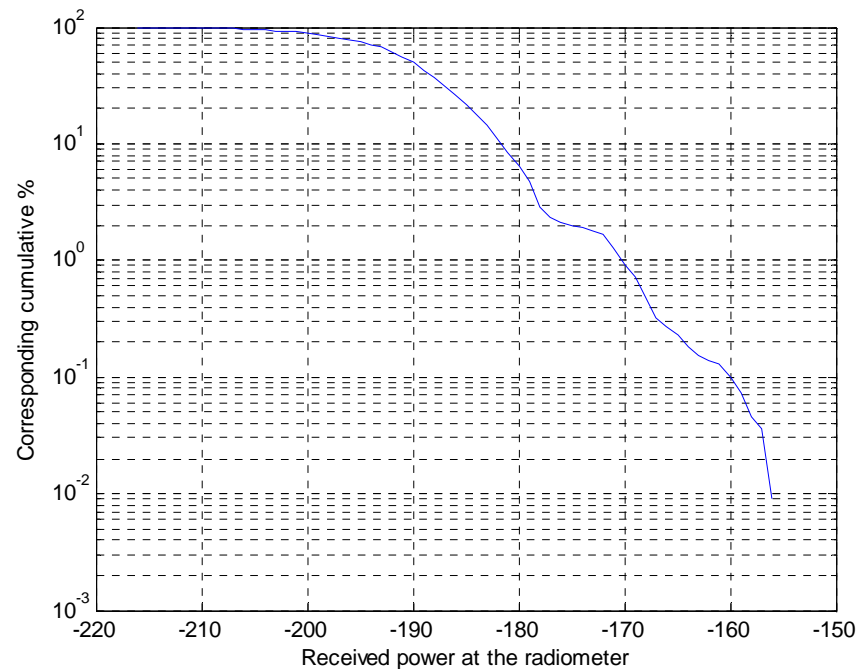
Agenda item 1.2 of WRC-07

- For the bands 10.6-10.68 GHz and 36-37 GHz, the corresponding radiometers are all conical scan (rotating).

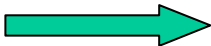


Agenda item 1.2 of WRC-07

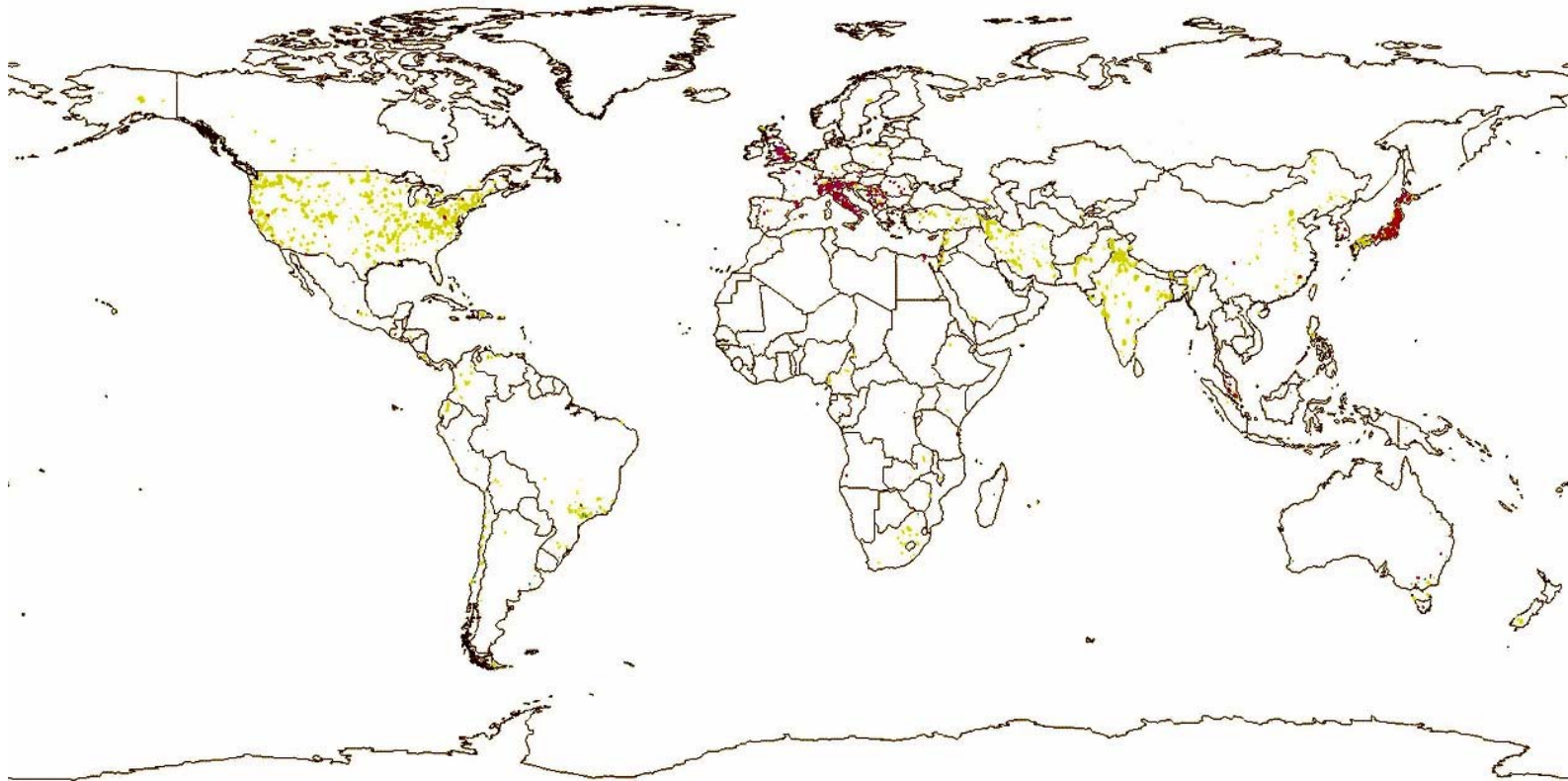
- For both bands 10.6-10.68 GHz and 36-37 GHz, dynamic simulations are conducted for specific passive sensors (AMSR-E, AMSR, CMIS, MADRAS) and for typical deployments of terrestrial systems.
- Example of a dynamic simulation



Agenda item 1.2 of WRC-07

- **The received power are compared to the thresholds contained in Recommendation SA.1029-2 according to a cumulative corresponding % of 0.1 for a limited area of 10000000 km² **
- **Proposed methodology in the Conference preparatory text: development of sharing criteria based on single entry emission limits to be included in a footnote of Article 5 of the Radio Regulations. Those limits are suggested to be non-retroactive for terrestrial active systems brought into use before WRC-07.**

Agenda item 1.2 of WRC-07: examples of RFI at 10.6 GHz



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Agenda item 1.2 of WRC-07: impact of RFI at 10.6 GHz, lack of data

Same areas of the world are corrupted by man made RFI in the band 10.6-10.68 GHz. It means that some areas of the world will suffer from a lack of data, since it is acknowledged that those corresponding data are totally unusable, taking into account the existing high level of interference.

The question is: **what is the impact of this lack of data on the overall output products if some data are systematically excluded on the same geographic areas?** Are the output data still acceptable or reliable?

Agenda item 1.20 of WRC-07

- ***to consider the results of studies, and proposal for regulatory measures, if appropriate, regarding the protection of the Earth exploration-satellite service (passive) from unwanted emissions of active services in accordance with Resolution 738 (WRC-03)***

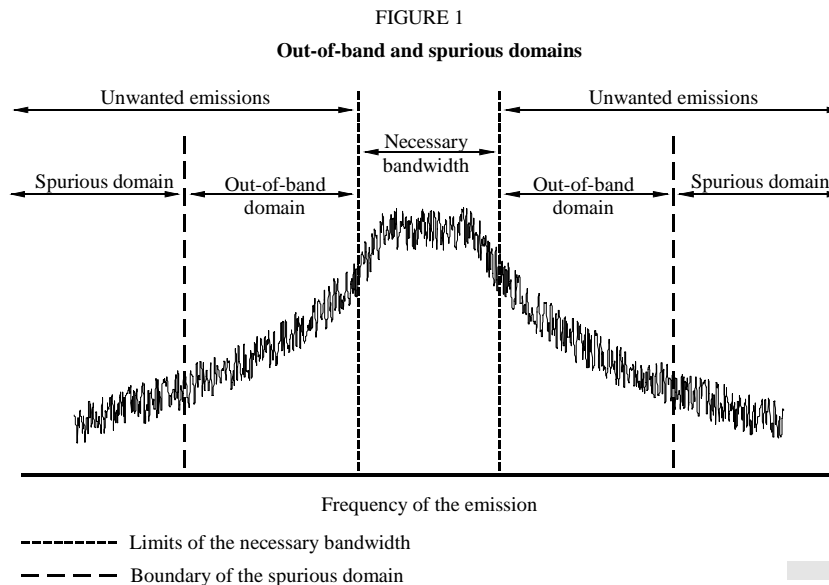
Agenda item 1.20 of WRC-07

Bande attribuée au SETS (passive)	Bande attribuée à un service actif	Service actif
1 400-1 427 MHz	1 350-1 400 MHz	Service fixe (SF), service mobile (SM) et service de radiolocalisation (RL)
1 400-1 427 MHz	1 427-1 429 MHz	SF, SM (sauf mobile aéronautique) et service de recherche spatiale (Terre vers espace)
1 400-1 427 MHz	1 429-1 452 MHz	SF et SM
23,6-24 GHz	22,55-23,55 GHz	Service inter-satellites
31,3-31,5 GHz	30-31 GHz	SFS (Terre vers espace)
50,2-50,4 GHz ¹	50,4-51,4 GHz ¹	SFS (Terre vers espace) ¹
50,2-50,4 GHz ¹	47,2-50,2 GHz (Régions 2 et 3) 49,44-50,2 GHz ¹ (Région 1)	SFS ¹

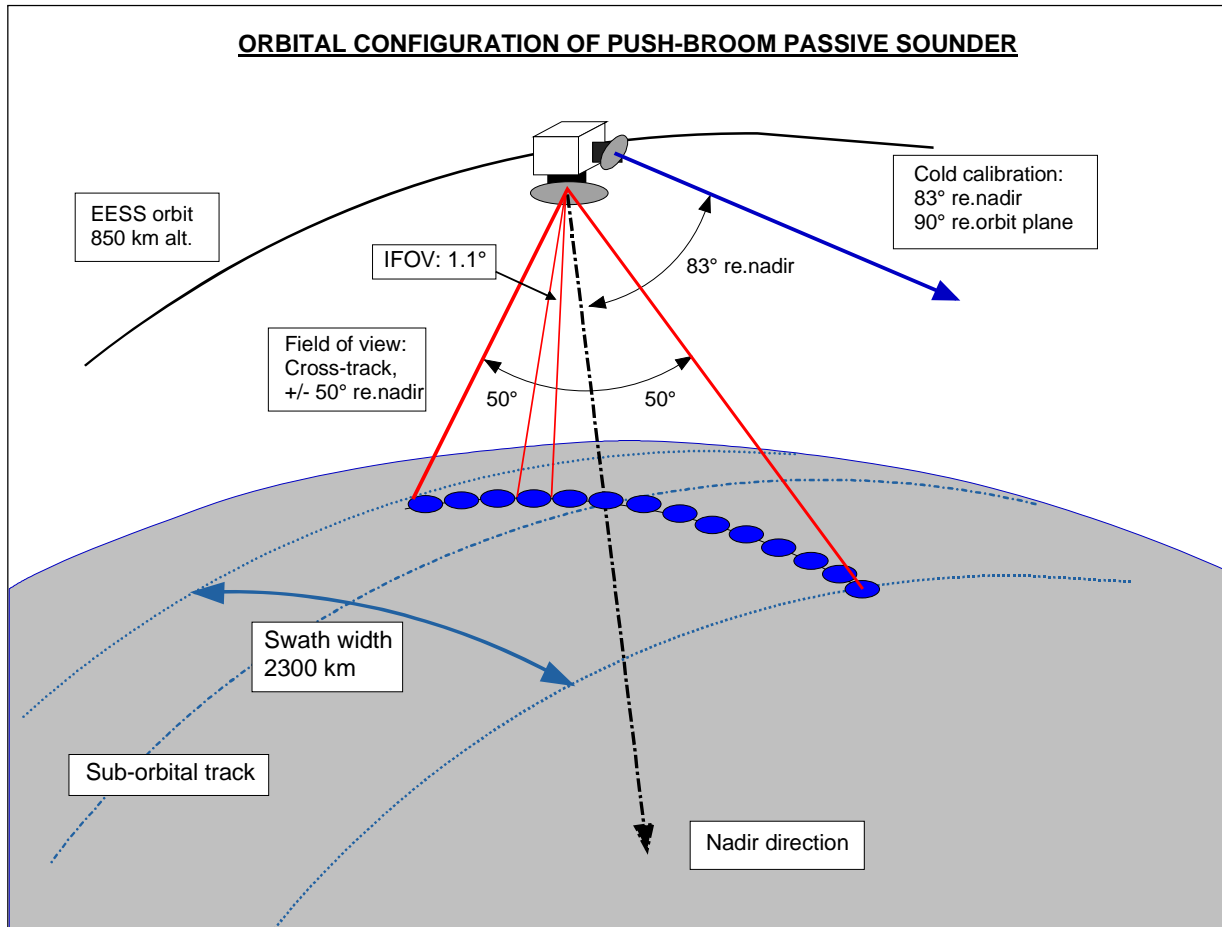
¹ LES ÉTUDES RELATIVES À CETTE BANDE DOIVENT TENIR COMPTE DU NUMÉRO 5.340.1 DU RÈGLEMENT DES RADIOCOMMUNICATIONS.

Agenda item 1.20 of WRC-07: unwanted emission problem

- The boundary between the out-of-band and spurious domains occurs at frequencies that are indicated in Figure 1: in general, the boundary, on either side of the centre frequency of the emission, occurs at a separation of 250% of the necessary bandwidth, or at $2.5 BN$.



SATELLITES FOR THE BANDS 24, 31, 50 GHZ



Agenda item 1.20 of WRC-07: representation of unwanted emission spectra

- Use of RR No. 1.153 the unwanted emission power in the passive band to be no greater than 0.5% of the total mean power of the emission (23 dB attenuation).
- Recommendation ITU-R SM.1541 provides a worst-case analysis in which the OOB emissions from the active service are overstated.
- Usage of more realistic methodologies
 - Modulation filtering: DVB-S standard (40 dB attenuation) or usage of more traditional waveforms (20 dB attenuation) such as $\left(\frac{\sin \pi f T}{\pi f T}\right)^2$
 - Post-modulation filtering in most cases: between 25 and 40 dB attenuation
- Total expected attenuation (depending on bandwidth of the active service) within the adjacent passive band: between 23 and 80 dB.

Agenda item 1.20 of WRC-07: dynamic simulations, methodologies

Like agenda item 1.2, dynamic simulations are conducted in a co-frequency mode.

How much is the interference threshold exceeded according to ITU-R Recommendations?

The bandwidth scaling factor compares the necessary bandwidth B_n of the active service to the EESS (passive) bandwidth B_p .

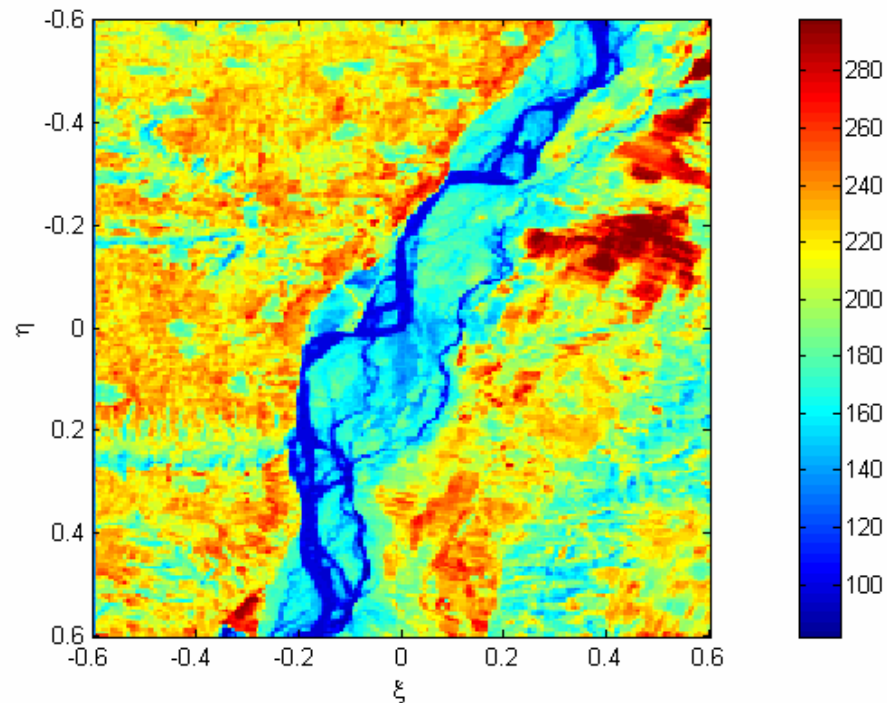
Attenuation provided by Recommendation ITU-R SM.1541 or other modulation/ post-modulation filtering (see before).

Method to solve the agenda item 1.20 of WRC-07

Proposed methodology in the Conference preparatory text: development of a single entry emission limit for each corresponding active service within the EESS (passive) band to be included in a footnote of Article 5 of the Radio Regulations. Those limits are suggested to be non-retroactive for active systems brought into use before WRC-07.

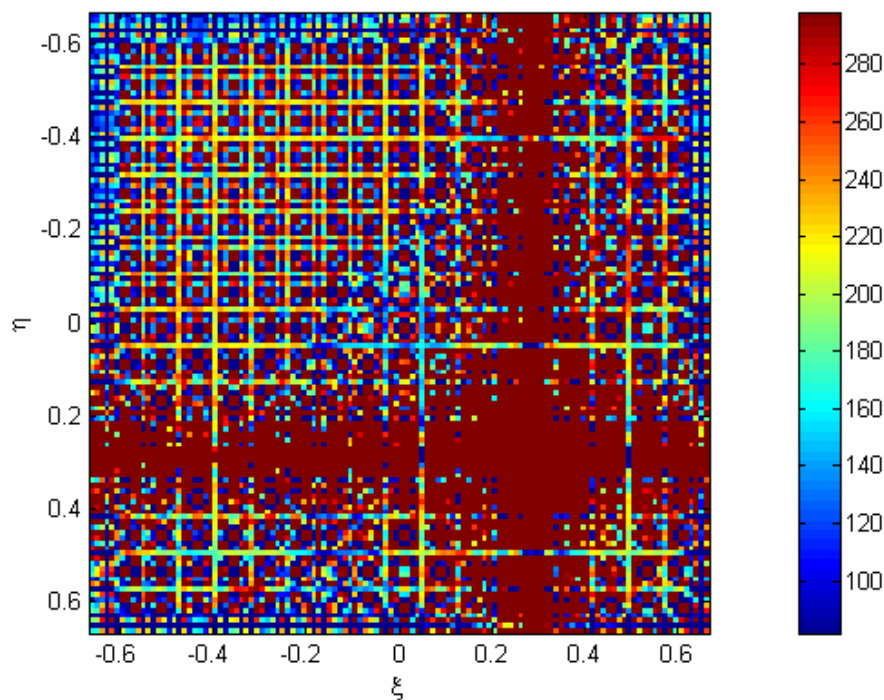
Agenda item 1.20 of WRC-07, impact of RFI at 1.4 GHz (simulation SMOS type) (1/2)

Input brightness temperature map depicting a segment of the Yellow River near Xi'an, a city located in the north-west of China



Agenda item 1.20 of WRC-07, impact of RFI at 1.4 GHz (simulation SMOS type) (2/2)

**Reconstructed brightness temperature map with RFI using
an average level of -10 dBW**



CONCLUSION (1/3)

- **IMPACT OF HIGH LEVEL OF INTERFERENCE**

Lack of data



what is the impact of this lack of data on the overall output products if some data are systematically excluded on the same geographic areas? Are the output data still acceptable or reliable?

- **IMPACT OF UNDETECTABLE LEVEL OF INTERFERENCE**

This is a situation that is more than likely to occur over large areas. It would imply that corrupted data will be actually used within NWP (Numerical Weather Prediction) models or other models making usage of both data derived from satellite and terrestrial observation. In that case, the data are actually used within the model because the data were initially known to be acceptable (or assumed to be derived from natural emission only).

What happens on the weather forecast (or other similar output products) if, for example, some EESS satellite pixels are corrupted with wrong data due to non-natural emissions at 24 or 50 GHz?

CONCLUSION (2/3)

- Method able to adequately protect the corresponding passive bands proposes hard limits (in-band ou out-of band): may constrain the existing or future systems in operation in those bands. **Some operators already explained the quantitative consequences of a possible limitation of the power of the fixed links.**
- **The ITU-R working party in charge of the passive sensors already provides a qualitative explanation of the consequences of various levels of aggregate interference received by a passive sensor.**

CONCLUSION (3/3)

- Urgent matter to get a quantitative explanation of those various levels of degradation. It is still possible to keep arguing that it is not so obvious to derive this kind of information since complex algorithms are needed to model the atmosphere which is known to be very unstable by nature. It is true that it is hard to distinguish between weak radio frequency interference and naturally geophysical variability.
- Space and meteorological agencies have to bring evidence that interference exceeding the interference quoted in RS.1029-2 will disrupt the existing or planned algorithms.