The Ground RFI Detection System (GRDS), A New Concept For RFI Detection In Earth Observation Missions

R. Onrubia(1), R. Oliva(1),

A. P. Weston(2), P. de Rosnay(2), S. English(2),

B. J. Barbosa(3), I. Nestoras(3)

C. A. Martellucci(4), F. Jorge(4), Y. Soldo(4),

(1): Zenithal Blue Technologies, Barcelona, Spain
(2): ECMWF,
(3): RDA, Zurich, Switzerland,
(4): European Space Agency,

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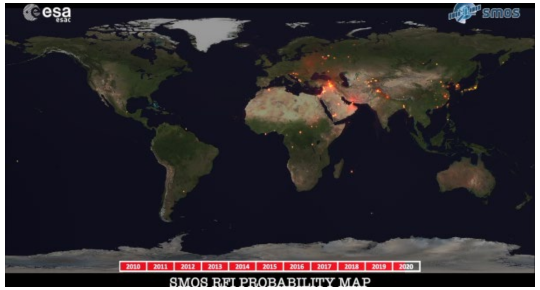
Introduction

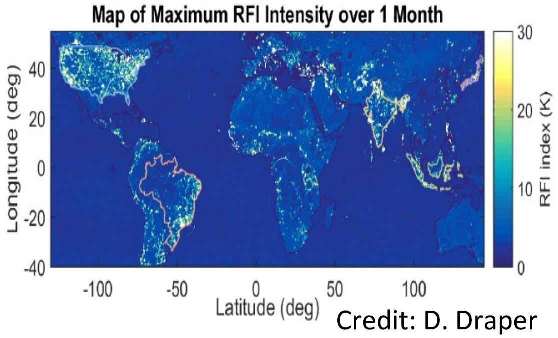
- Microwave passive remote sensing has been experiencing more and more instances of RFI
- RFI can vary widely in terms of intensity, extension, geographical regions, polarization, bandwidth, active duty cycle, etc.
- No single RFI algorithm is capable of detecting all RFI
- Best strategy is to use a combination of techniques and use the most of external information available

1.4 GHz



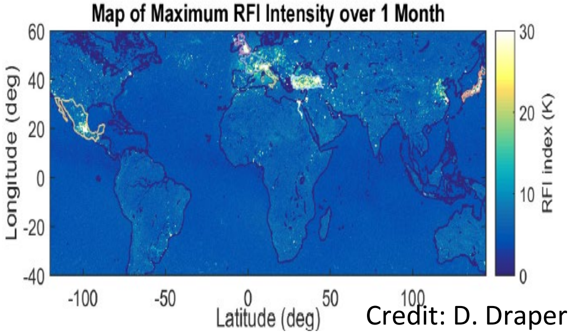
Credit: SMOS RFI team. ESAC

6.9 GHz



Credit: D. Draper

10.65 GHz



Credit: D. Draper

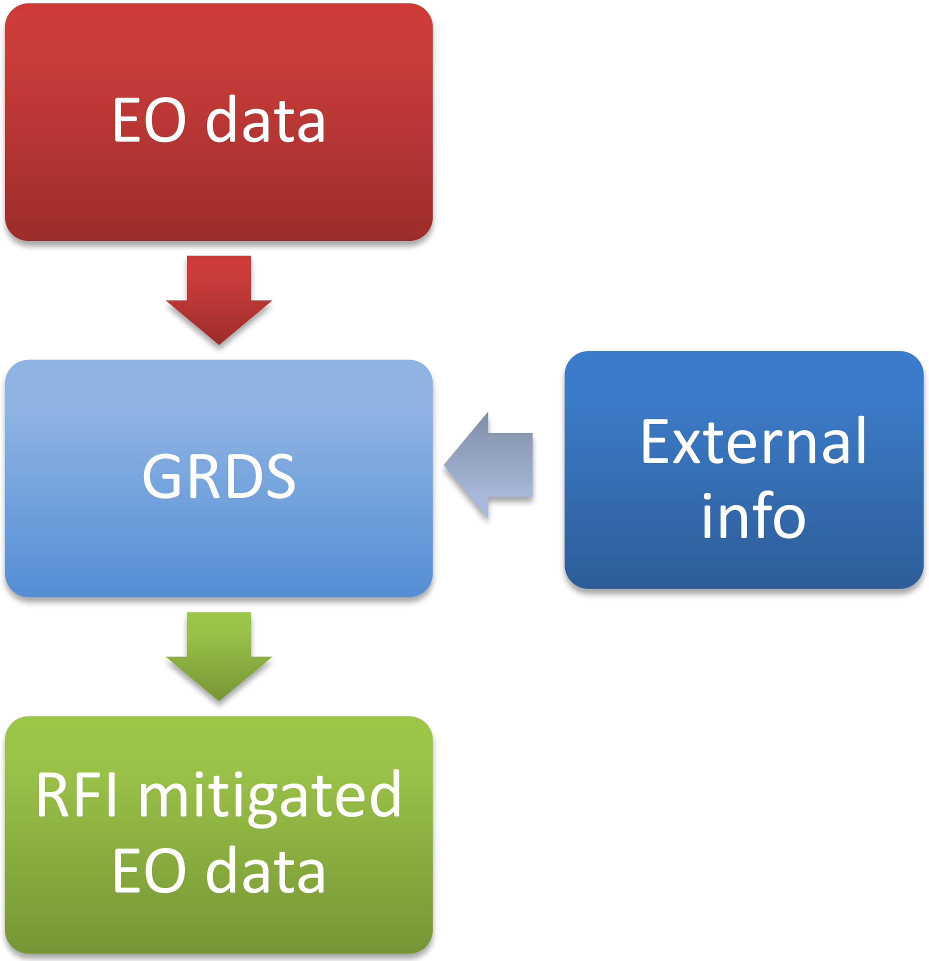
GRDS system description

- GRDS is a system developed by ZBT, and RDA, and validated by ECMWF, under ESA contract 4000127267/19/NL/AF supervised by Antonio Martellucci. Its purpose is to detect low level RFI on EO data.

- The system has been developed with a flexibility in the design to be able to ingest data from any EO microwave missions (currently SMOS and AMSR2).

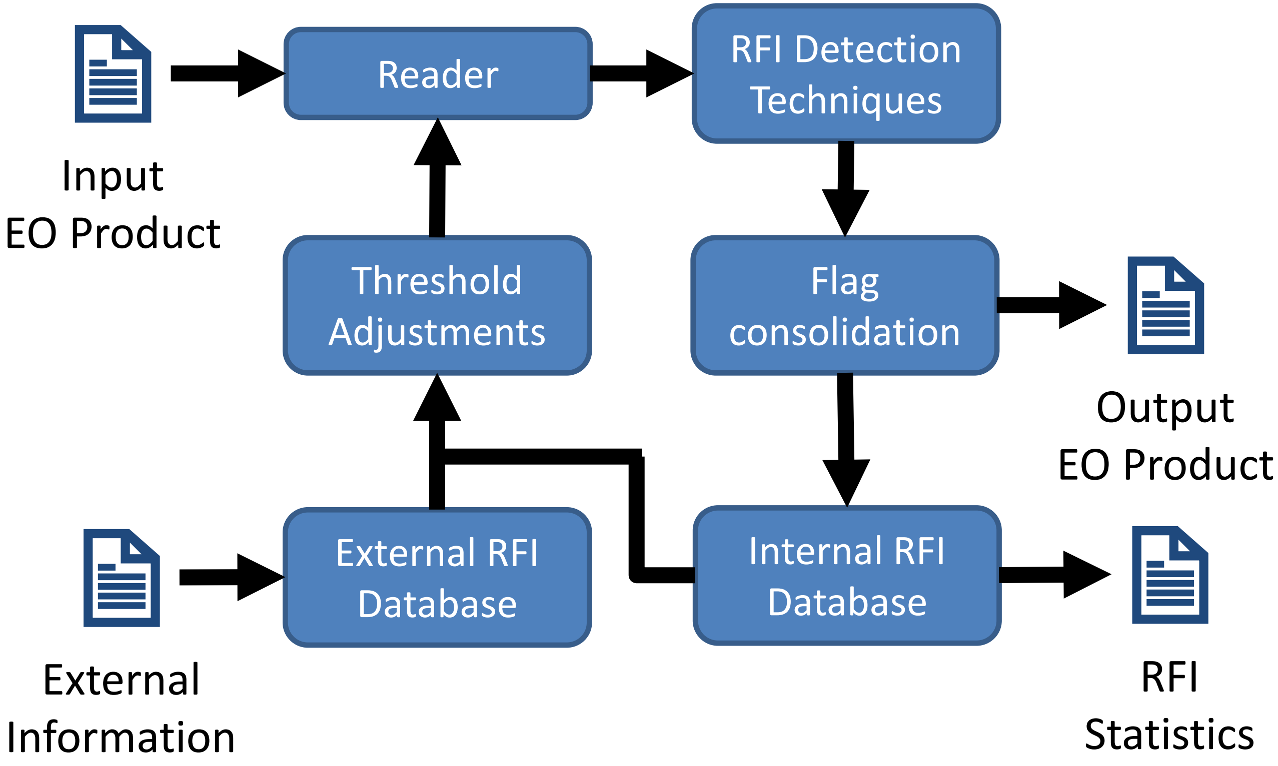
- It makes use of external and internal information to detect presence of RFI.

- It allows to configure the level of flagging to set the user preference between missing RFI and false alarm detection.



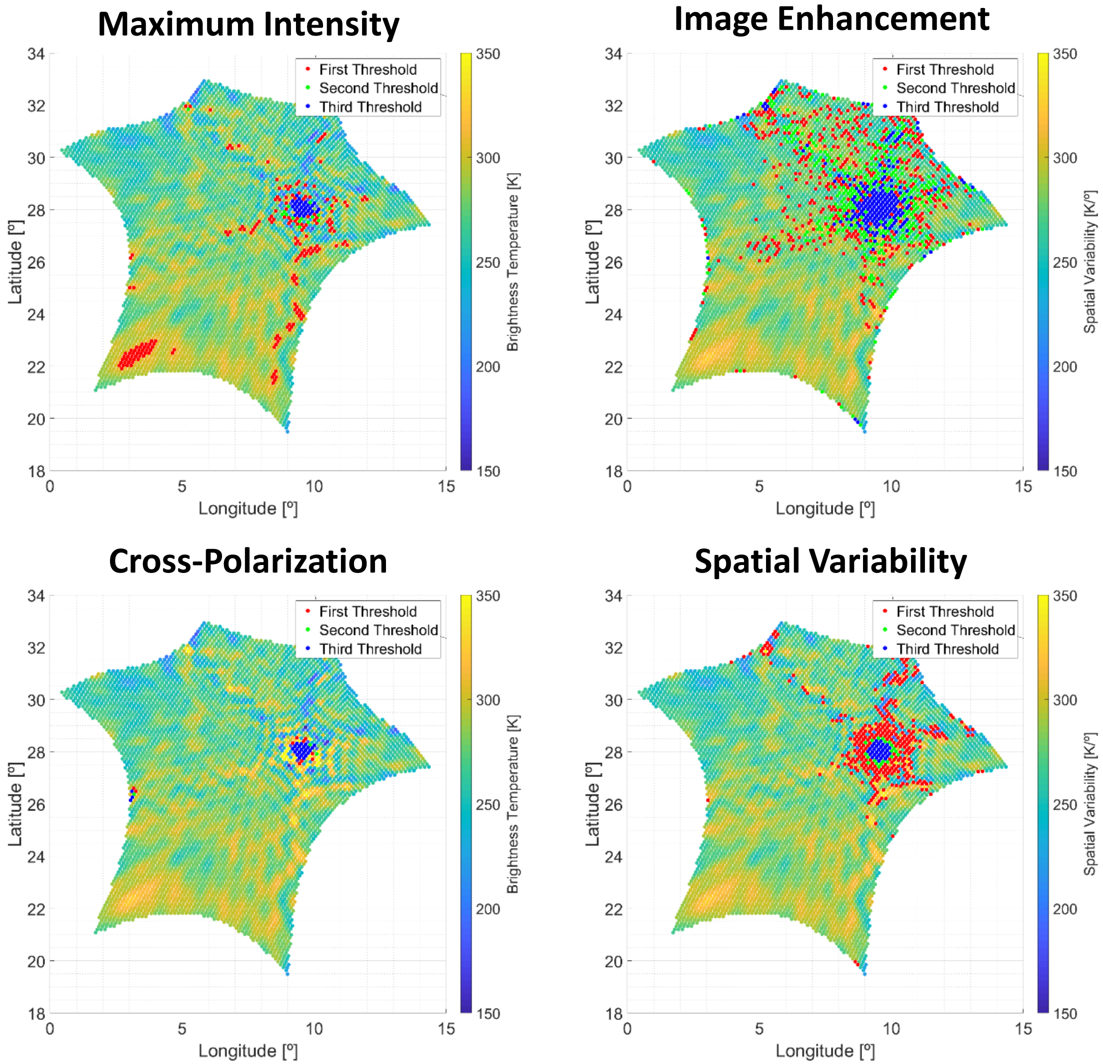
GRDS system description

- Data ingested from multiple EO sensors and converted to a common data format
- Flags are combined and added to the original EO file
- RFI instances are added to an internal RFI databases
- RFI Detection thresholds are adjusted based on previous detections and external information, such as:
  - IEEE GRSS RFI Database
  - Population density map
  - Airports and Air navigation aids
- GRDS on purpose does not use NWP models in order to be NWP-independent.



GRDS system description

- GRDS scans all observations using a library of RFI detection algorithms, including:
  - Intensity (HH, VV, ST3, ST4)
  - Outlier
  - Cross-polarization
  - Cross-frequency channels (RFI Index)
  - Spatial variability
  - Image Enhancement using High Pass filter
  - Kurtosis
  - Skewness
- Up to three different threshold levels
  - Statistically determined using products over mostly clean regions and removing RFI flagged data



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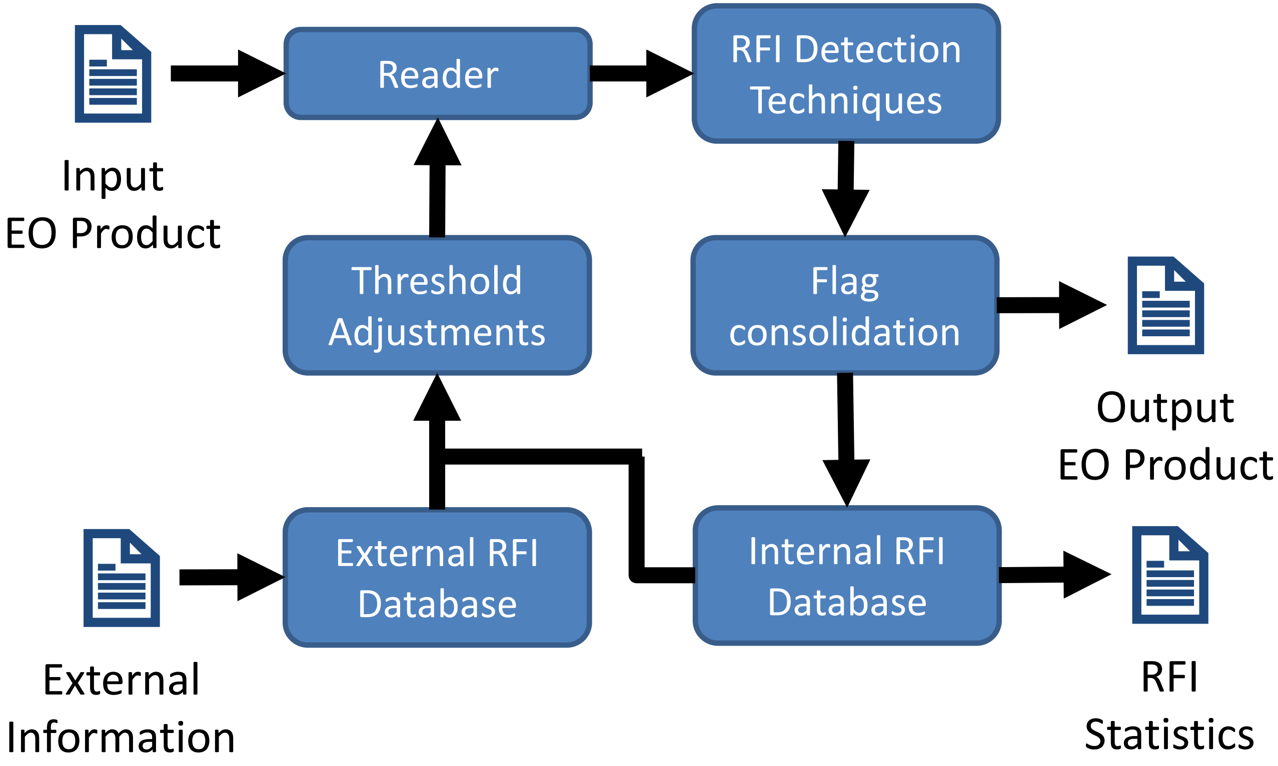


Validation

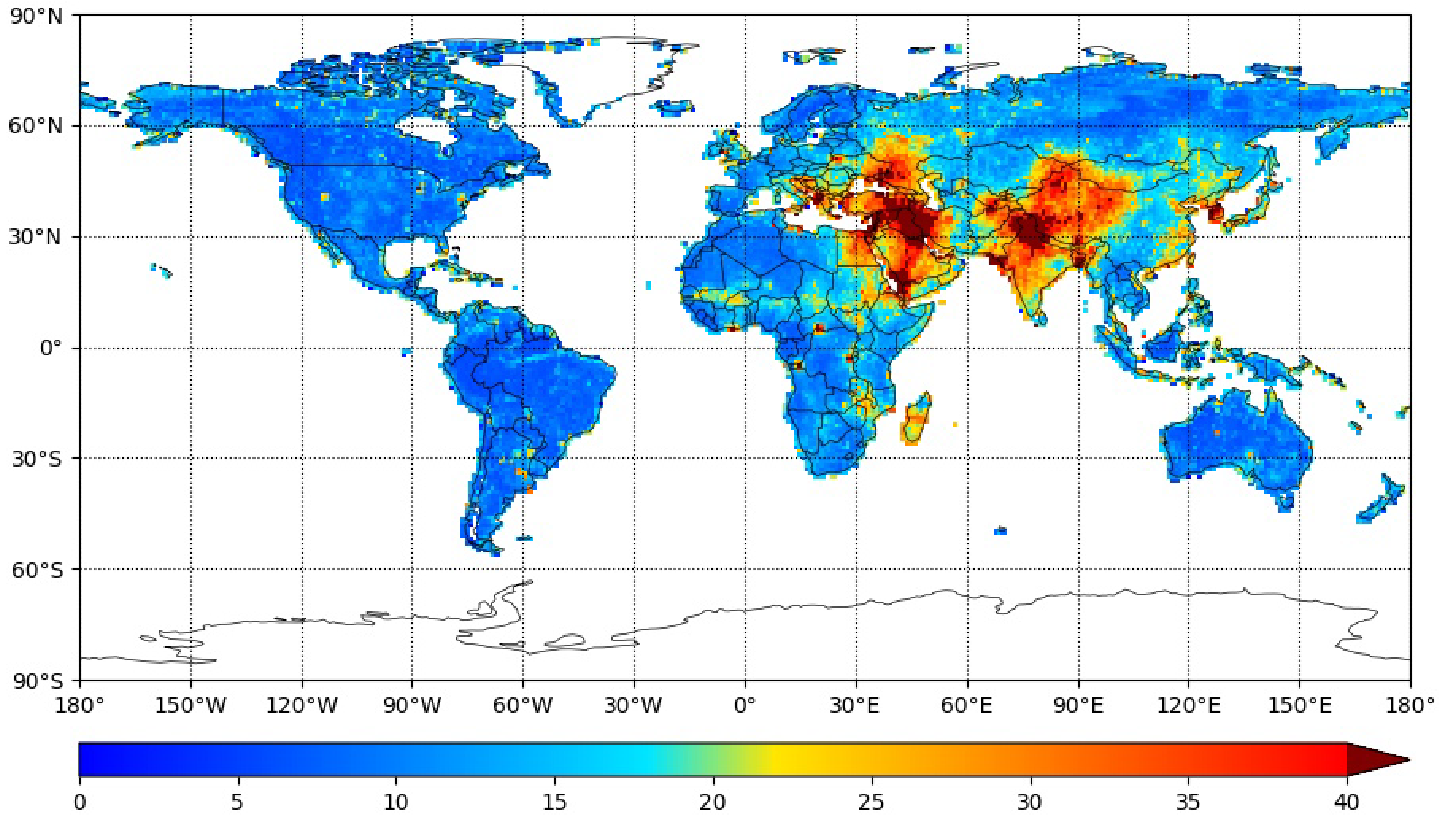
- Validation conducted independently by ECWMF
  - SMOS data
  - July 2019

- ECMWF Metric for evaluation: std(First Guess Departures)
  - Observed Brightness Temperature collocated to 40x40 km grid
  - Expected value computed from numerical methods
    - Use of physical temperature, atmospheric pressure, precipitation, etc.
  - Std(FGD): std(Error computed w.r.t. expected values)

Map results

- Screening Method
  - None
  - SMOS Processor
  - GRDS Threshold 3
  - GRDS Threshold 2
  - GRDS Threshold 1

Std(FGD) SMOS V Polarization – July 2019



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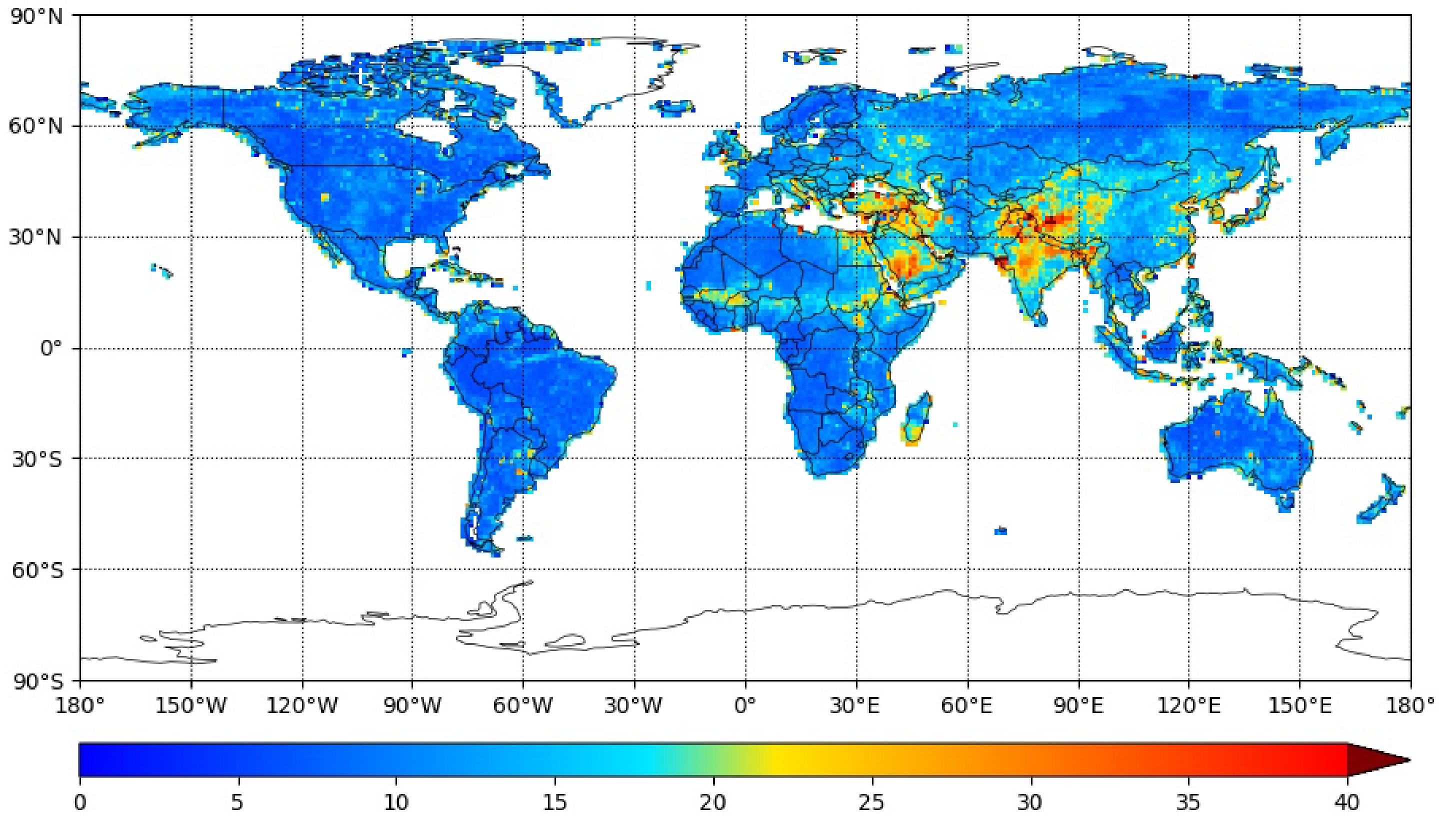

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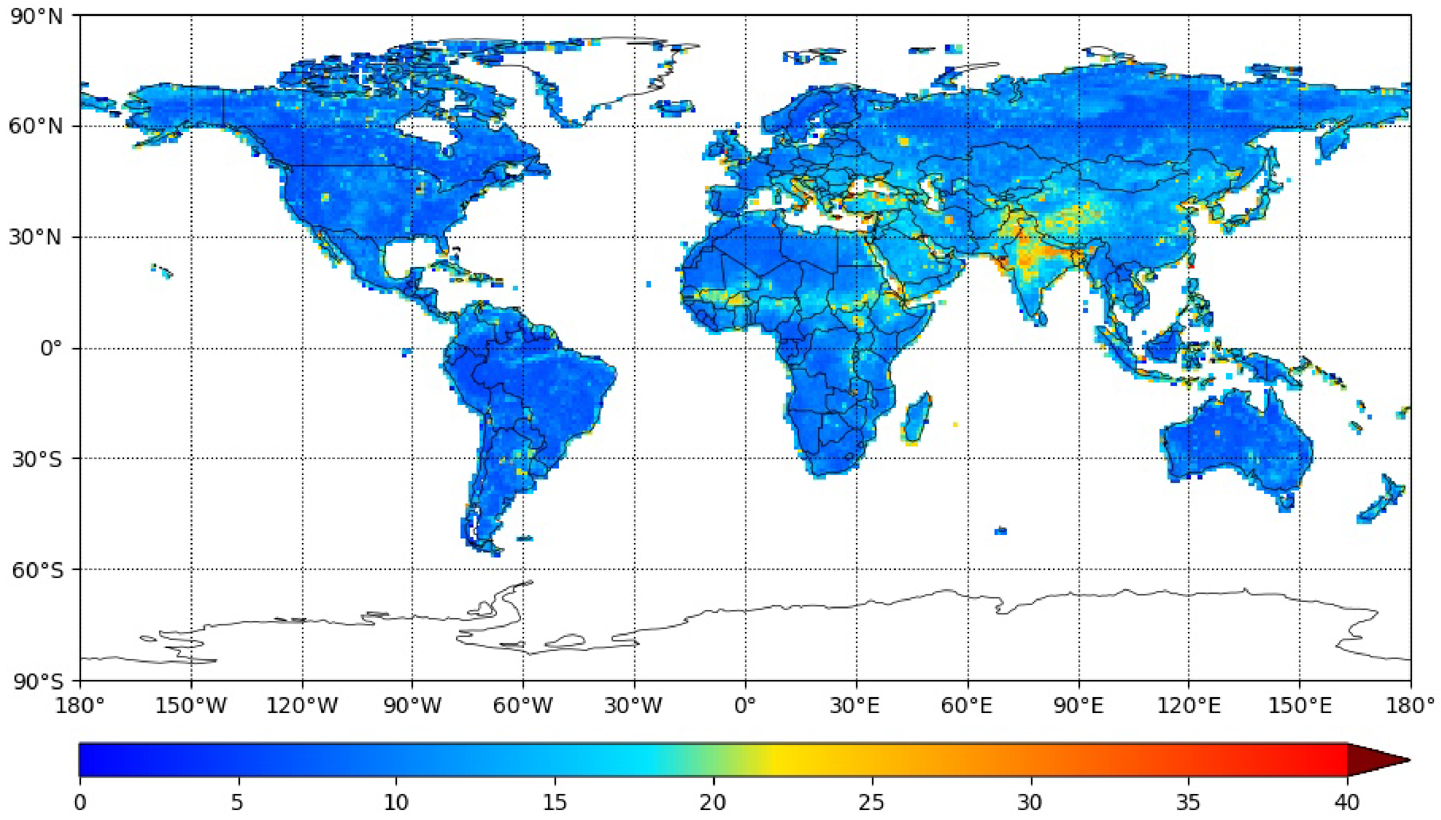

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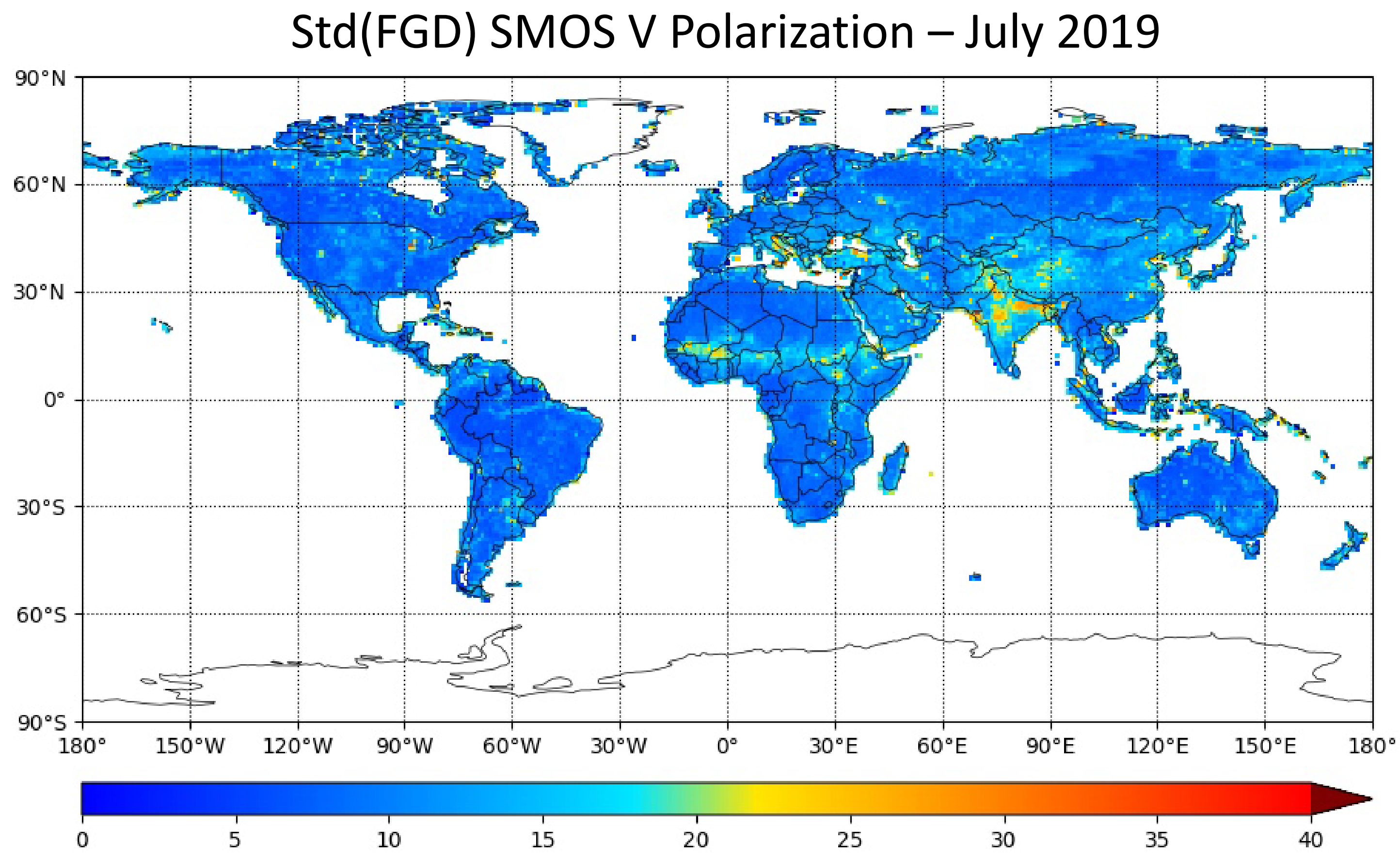

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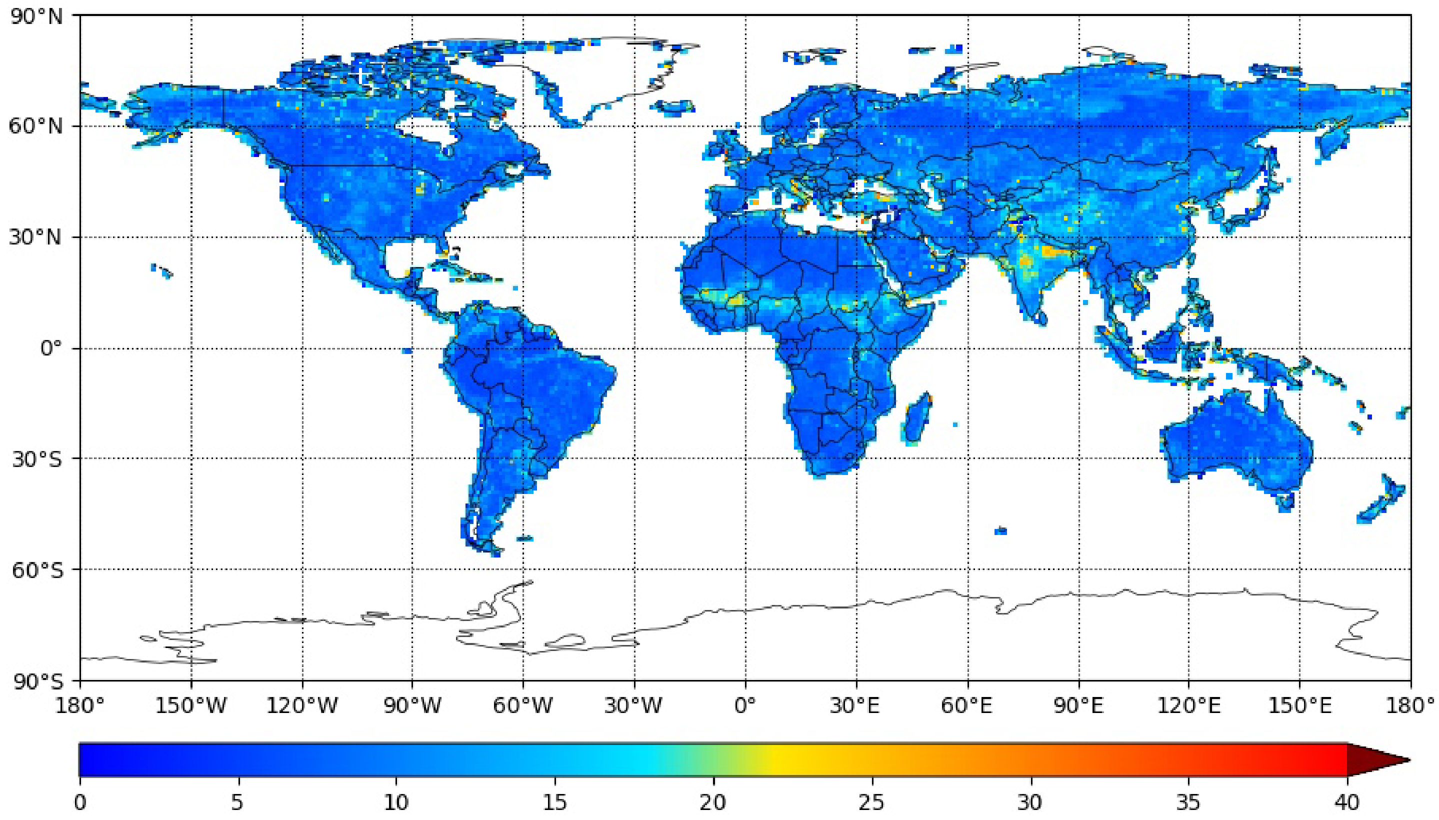
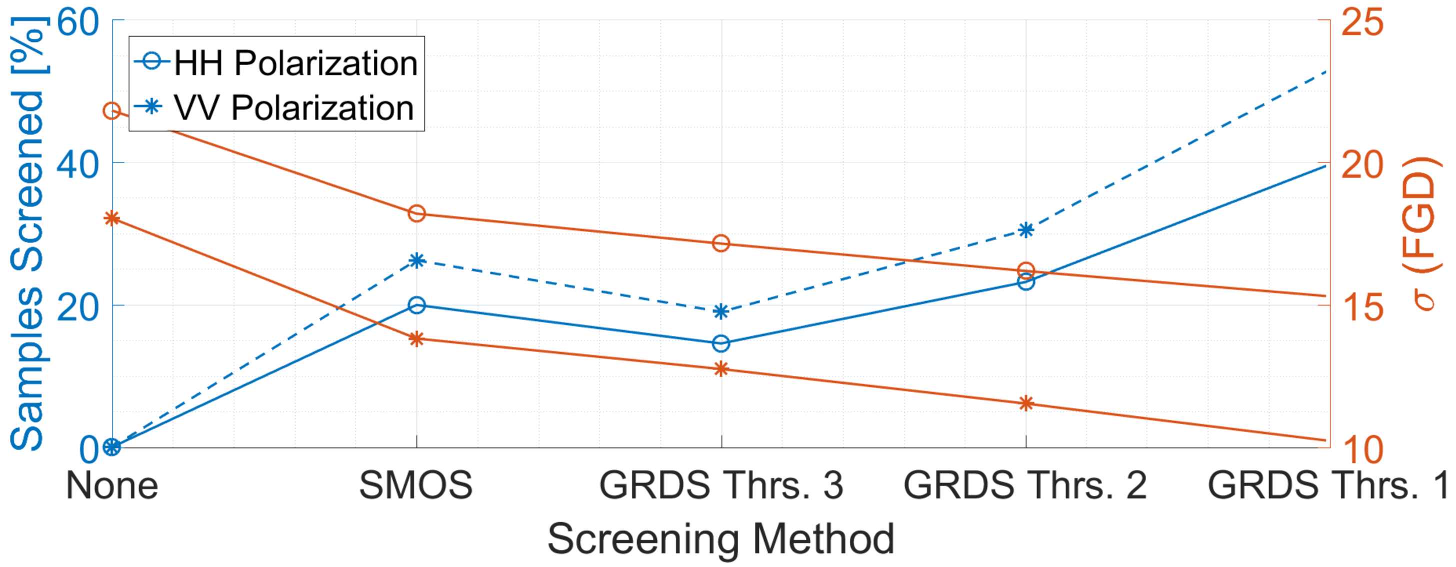


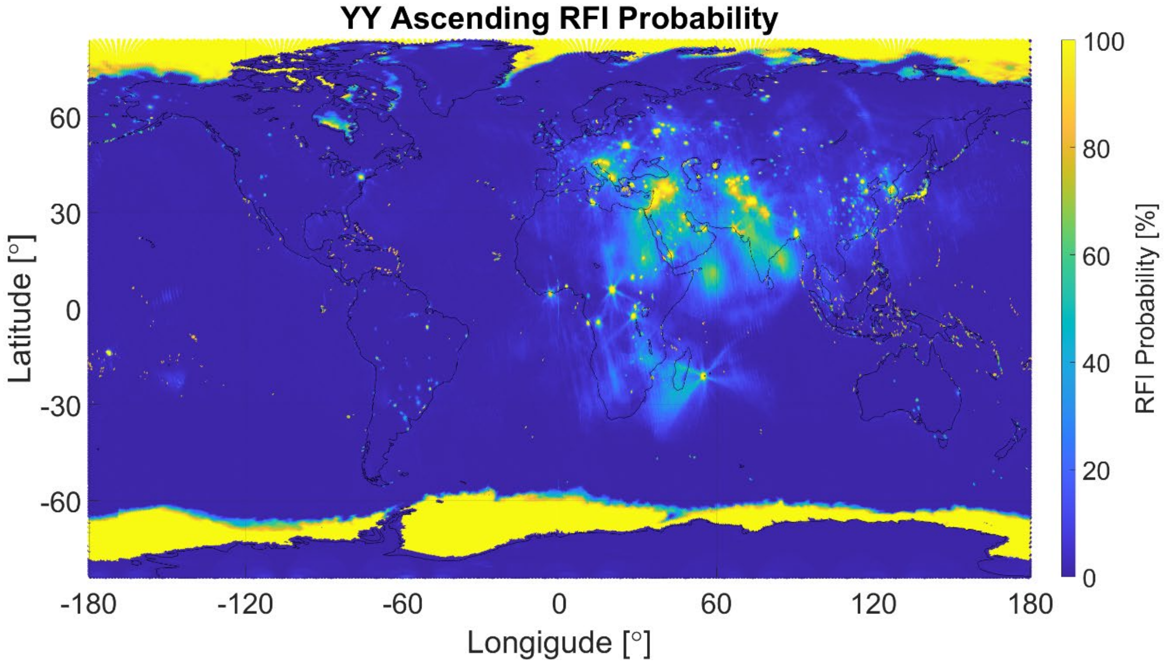
Map results

- Screening Over Europe
  - GRDS Threshold 3
    - More selective than SMOS



Results

- RFI Probability map
  - Used to adjust thresholds
  - Monthly statistical monitoring
  - False positives near the poles caused by terrain misclassification on sea ice



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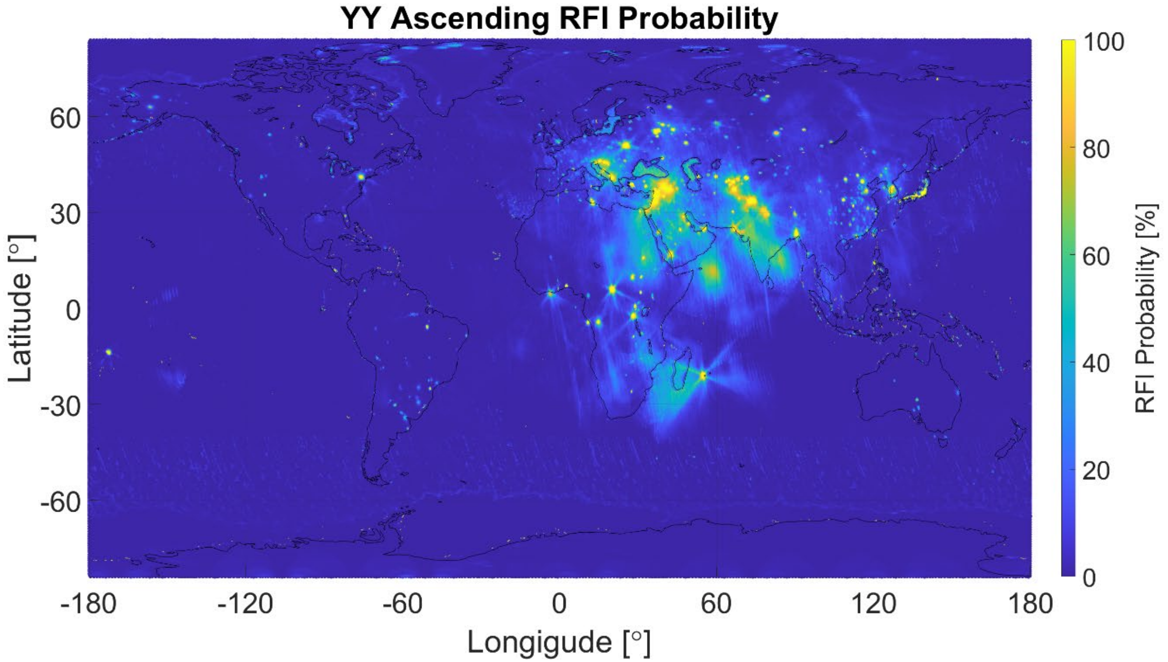
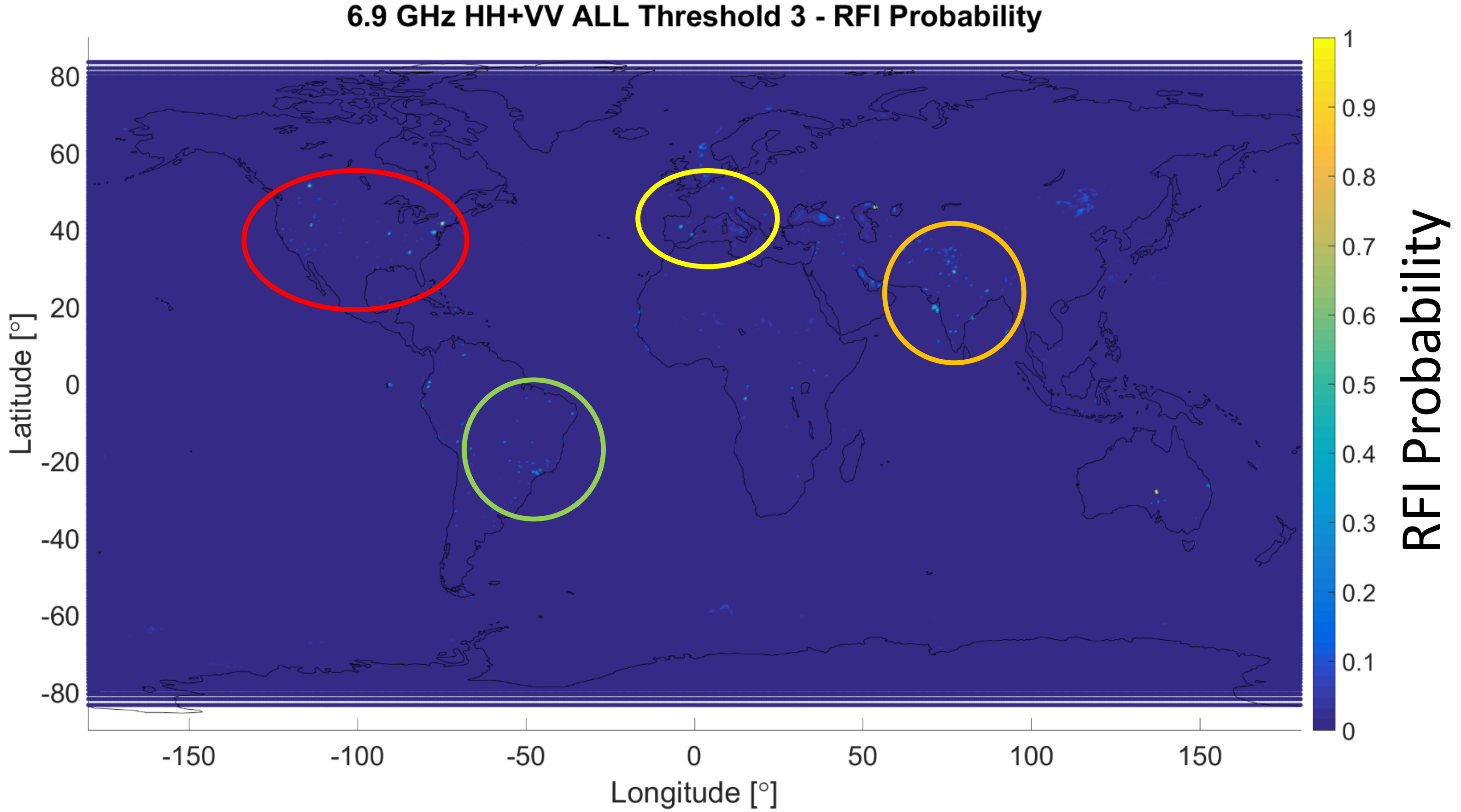
<u>Use of Artificial Neural Networks for sea ice detection</u>



RFI Probability Maps

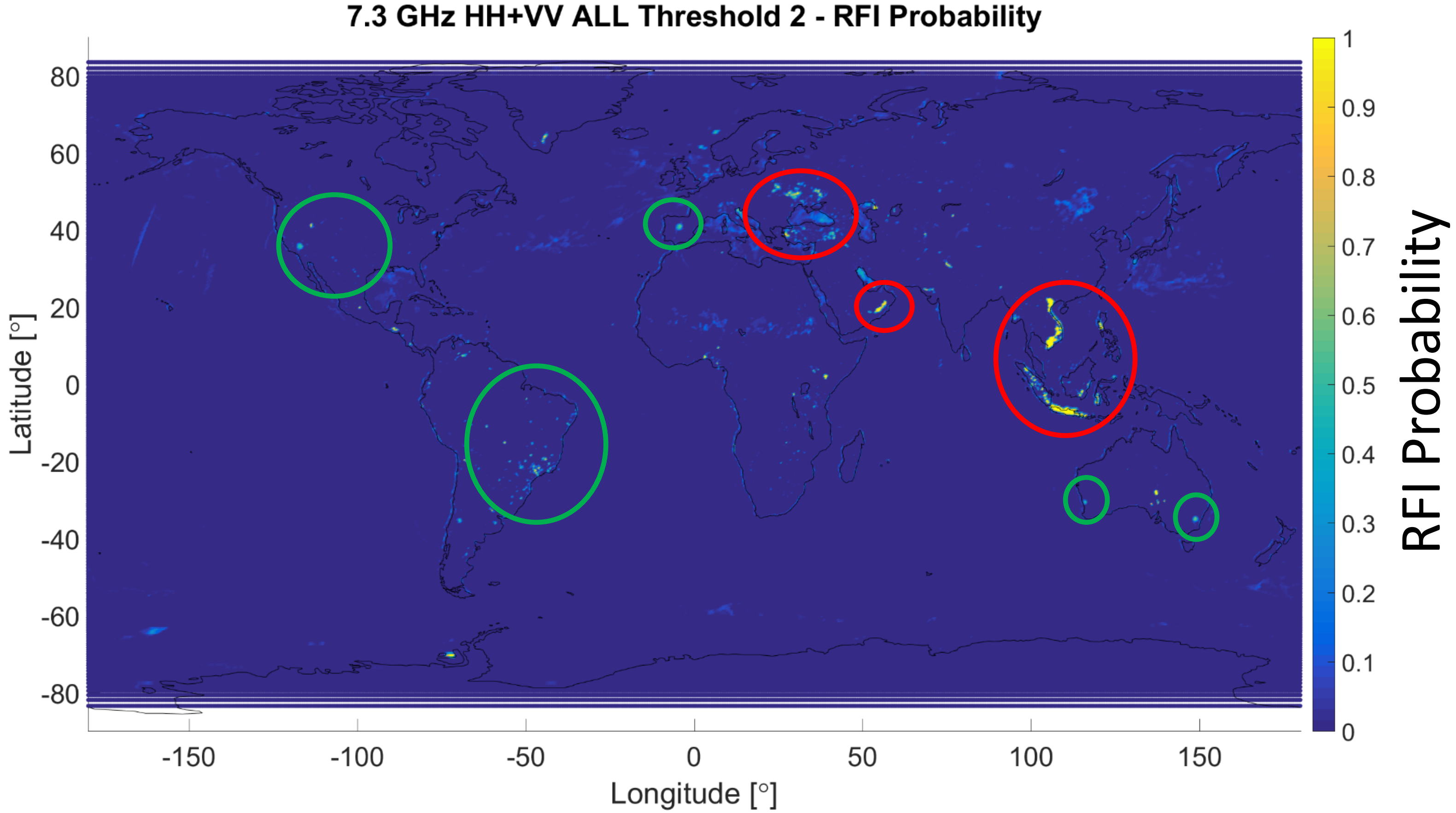
AMSR2 – 6.9 GHz channel



- Local RFIs observed in US, Brazil, Europe and India
- Considerably less strong than for SMOS case

RFI Probability Maps

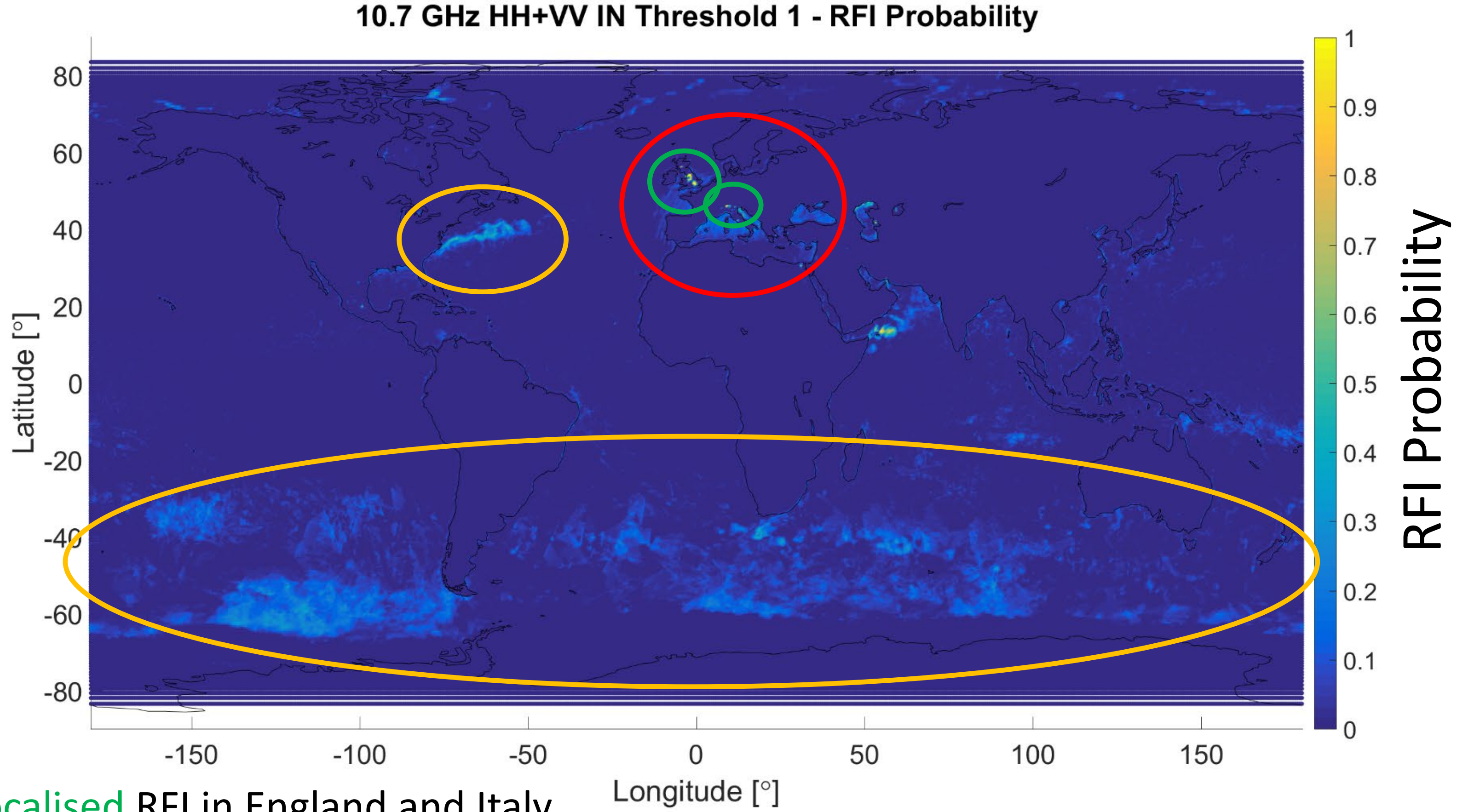
AMSR2 – 7.3 GHz channel



- Country-wide RFI in Vietnam, Sumatra island (Indonesia), Ukraine, Oman, Turkey
- Other isolated RFI in Spain, US, Brazil, Australia

RFI Probability Maps

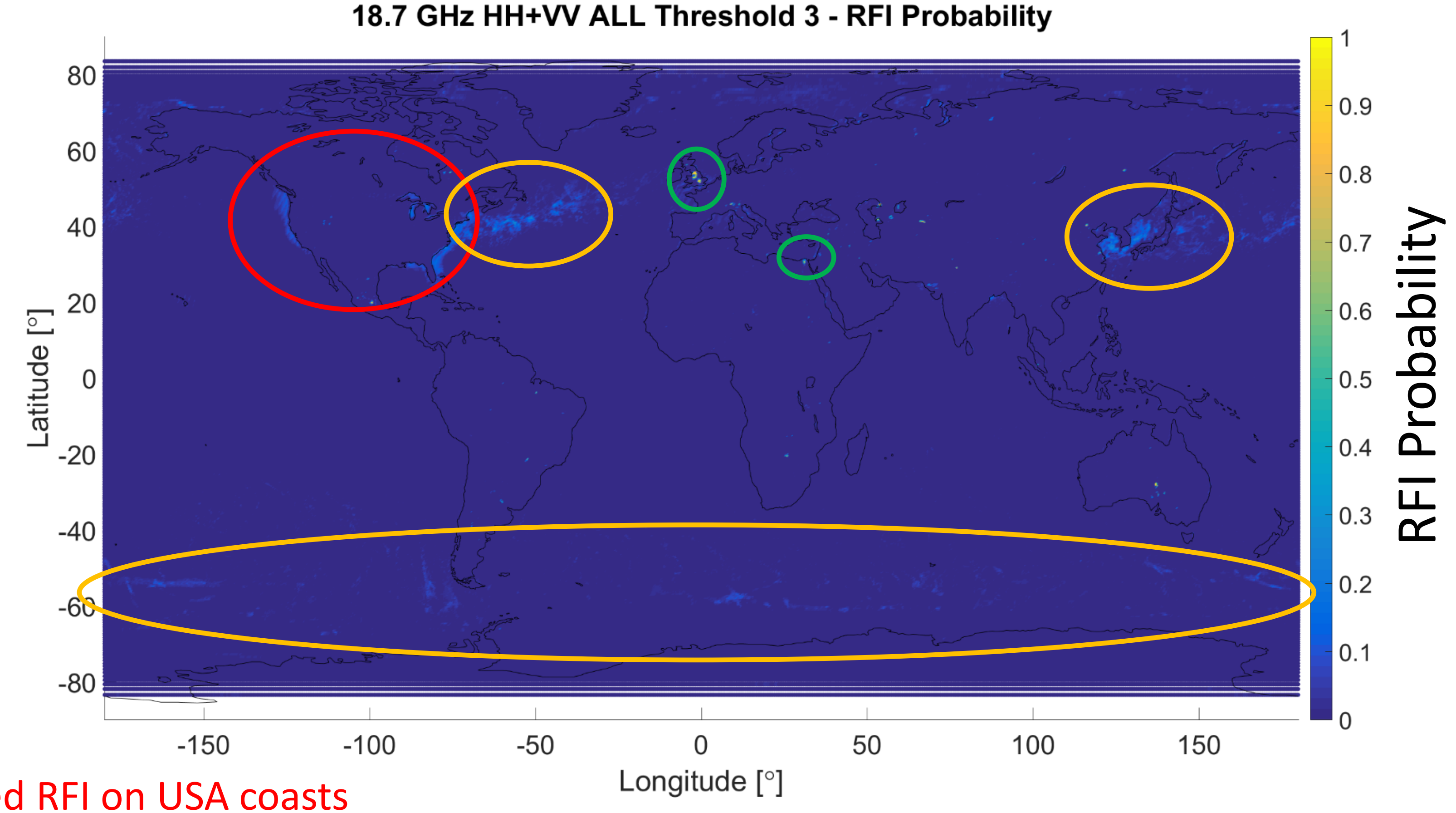
AMSR2 – 10.7 GHz channel



- Strong localised RFI in England and Italy
- Reflected RFI around Europe Seas, the Black Sea, the Caspian Sea and the Arabian Sea.
- False alarm detected over Southern Ocean clouds and the Gulf Stream

RFI Probability Maps

AMSR2 – 18.7 GHz channel



- Reflected RFI on USA coasts
- Other localised RFI over UK and Egypt
- False alarm detected over the Gulf Stream, East Asia and West Pacific.

Conclusions

- RFI are very diverse in nature and no single RFI detection technique is capable of properly detecting them all
- GRDS is a software that screens Earth Observation data for presence of RFI contamination.
- GRDS has been very successful in achieving its objectives :
  - Reducing RFI contamination to very low levels, with first guess departure variations compatible with regions with no RFI

THANKS FOR YOUR ATTENTION

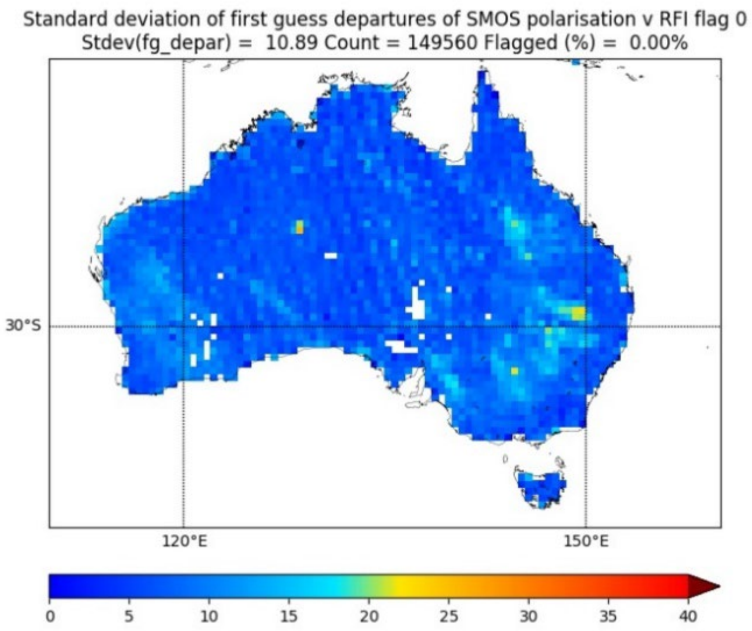
Questions?

We very much welcome feedback from the audience:

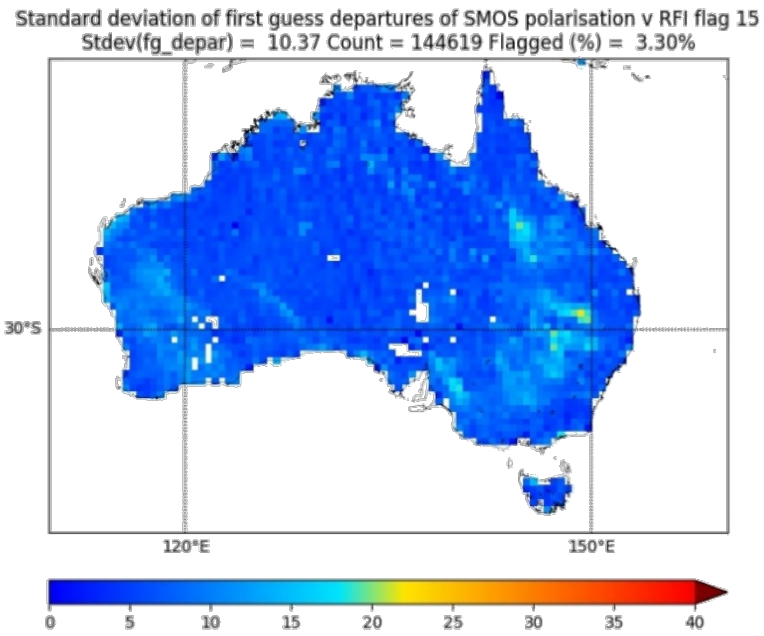
onrubia@zenithalblue.com

False Alarm Rate

- False alarm rate was estimated in Australia
  - Region with low presence of RFI
  - False Alarm Rate:
    - Threshold 1: 3.3 %
    - Threshold 2: 0.78 %
    - Threshold 3: 0.18 %



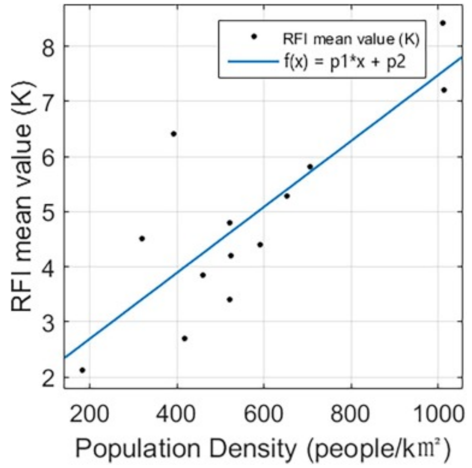
No screening

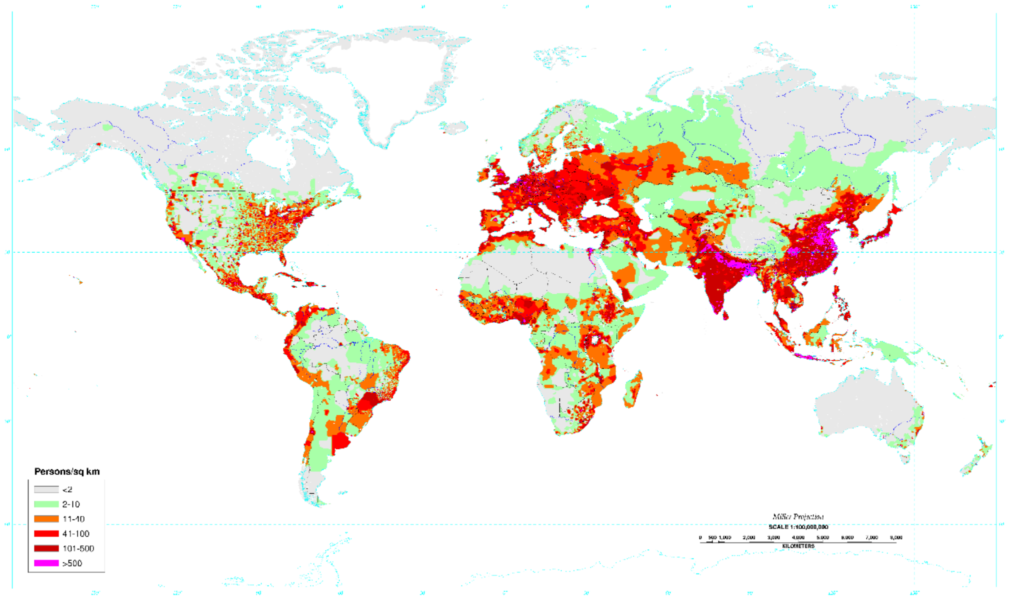


GRDS screened data

Population Density

- A correlation is observed between population density and RFI presence.
- Threshold are slightly adjusted to account for increase risk of RFI





Wei-Chen et al., 2019.: Characteristics of L-band radio frequency interference detected via the soil moisture active passive radiometer in China and its offshore areas, Results in Physics, Volume 12, 2019, Pages 1859-1865, ISSN 2211-3797