NWP monitoring of RFI

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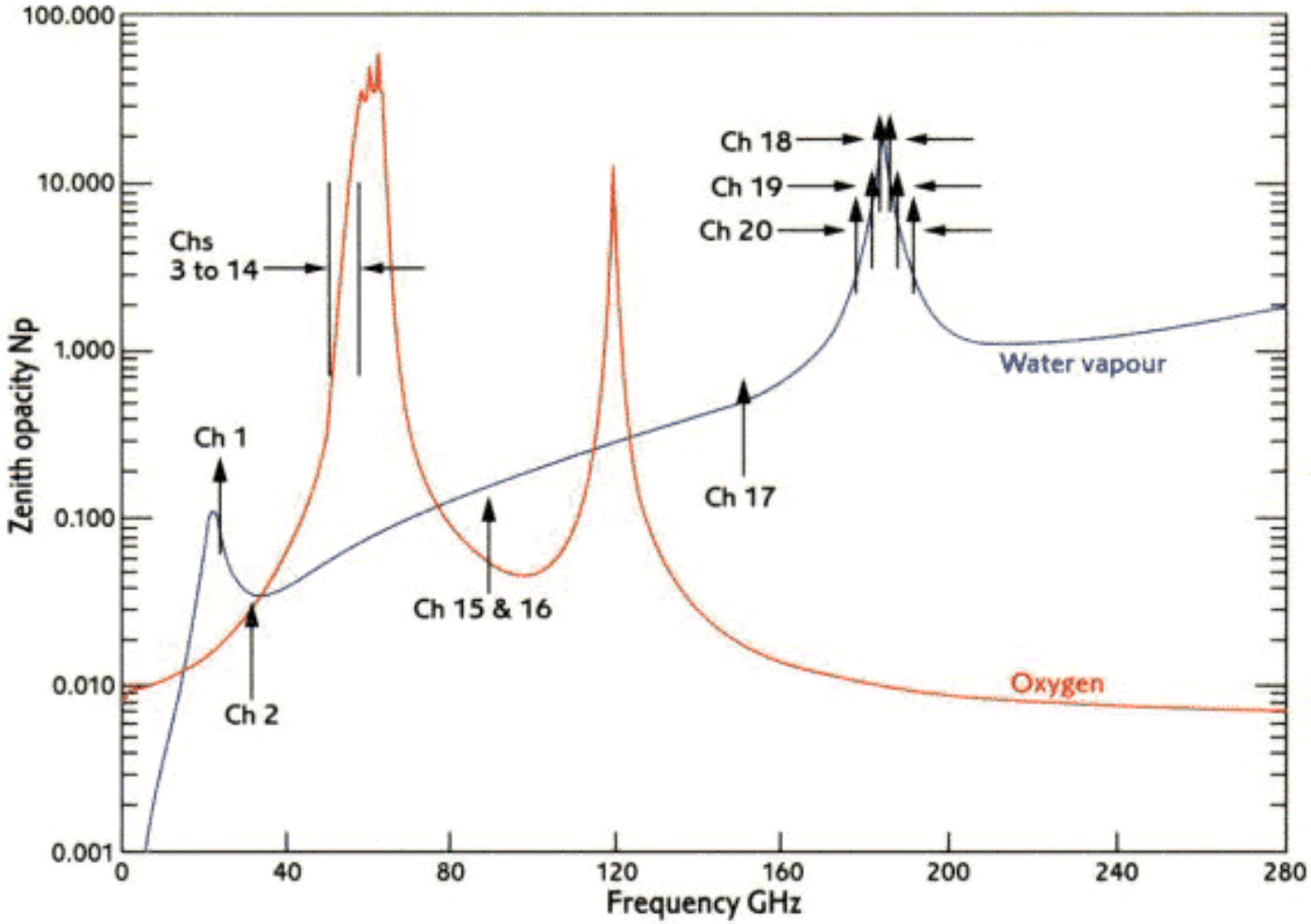
Outline

1. Introduction
2. Proposed NWP Monitoring of RFI
3. Proposed Machine learning for RFI detection
4. Conclusion

- Microwave passive radiation inform about a wide range of earth physical parameters: temperature, humidity, surface roughness, soil moisture, surface temperature, etc.

- Contamination by non-natural radiation can increase the errors affecting inferred geophysical parameters (e.g. wrong estimation of water content)

- The magnitude of RFI induced errors depends on frequency, type of contamination (in-band, out-of-band, geometry, etc)



Sub-millimetre radiation is expected to be exploited with upcoming instrument such as EPS-SG ICI

– As a system Microwave observations are vital to NWP globally

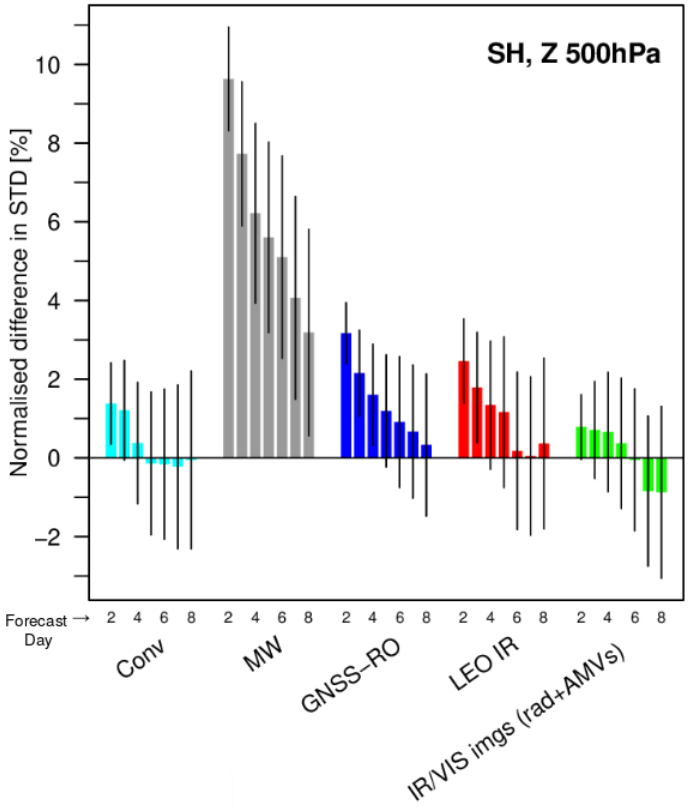
– NWP continuously improve and extend the use of MW (use of more frequencies, extend to more surface types, etc). A lot of potential

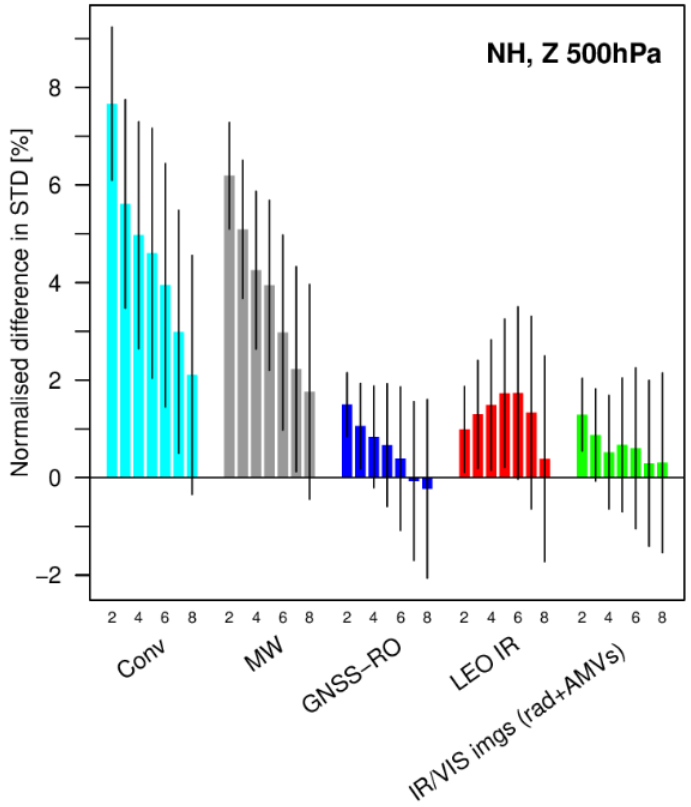
– RFI impact on NWP shouldn't be limited to the current usage of the data (limited and sub-optimal in some aspects)

– Demand on MW spectrum is increasing: RFI evolution needs to be monitored (characterization/detection and trends)

Forecast impact, day 2-8: 500 hPa geopotential

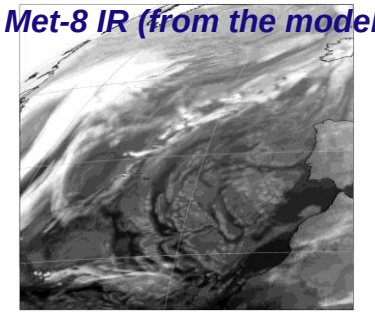
Verified against operational analyses, 3 periods combined



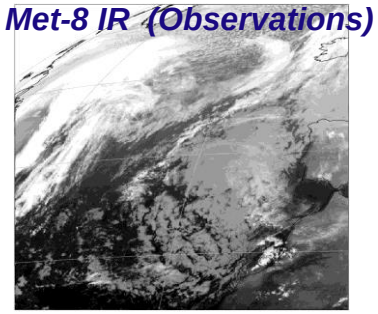


N. Bormann

NWP data assimilation



Met-8 IR (from the model)



Met-8 IR (Observations)

Good reference (info from past observations

Model Fields

H

Simulated data

Observed data

Observation operator:
Interpolations (+ RTM for RAD)

Comparison O-B

Combined uncertainties from data, Model and Obs operator

6 hour forecast

Assimilation Algorithm (all data types)

Using lin. model operators

Data selection

Forecast model

Initial state

Monitoring/features detection

NWP monitoring of observations

https://www.ecmwf.int/en/forecasts/quality-our-forecasts/monitoring-observing-system

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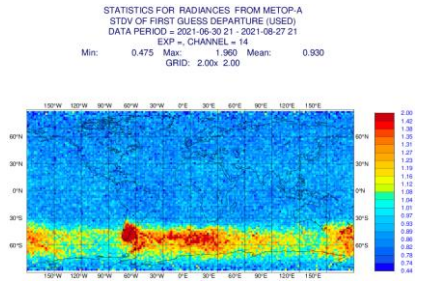
Monitoring

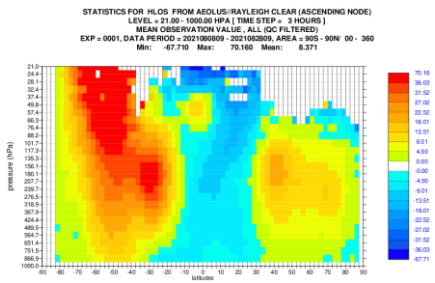
Monitoring of the observing system

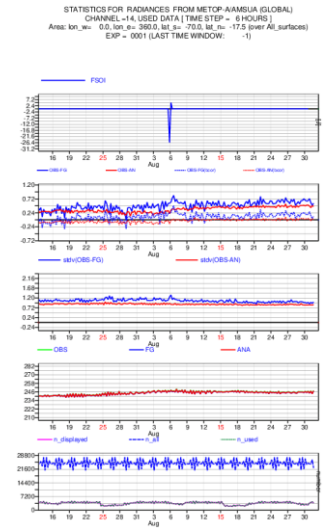
The purpose of the monitoring is to provide a detailed statistical information on the quality and availability of the different components of the observing system used/monitored by ECMWF. The monitoring results are primarily produced to help impr the usage of observations within the ECMWF data assimilation systems. Most of the products are updated on a daily basis.

In this page

- Availability
- Satellite data monitoring
- Conventional data monitoring
- Ocean observation monitoring
- Data automatic checking
- Monitoring of GUAN stations
- ECMWF Global Data Monitoring Report Archive







- Almost all earth system observations supported
- Various types of plots for each data type
- Not tailored to monitor RFI

Automatic data checking system

Observations with model feedback info (ODB)

Current statistics
Selected Obs quantities

Past statistics
Selected Obs quantities

Hard limits
(only for satellites)
Detects slow drifts

Soft limits
computed dynamically
Detects sudden changes

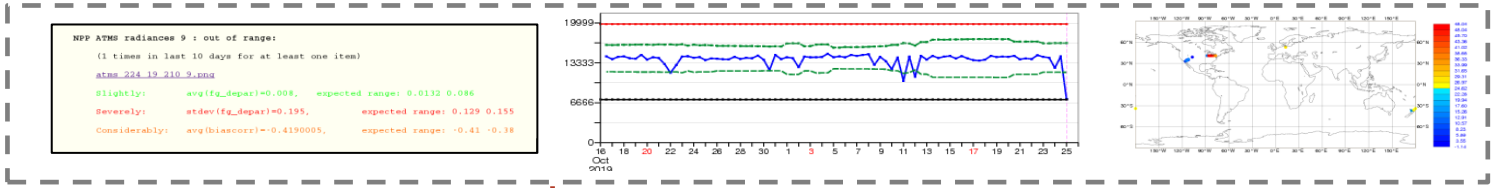
anomaly detection

- **Thresholds based tests**
- **Static tests**
- **Filters**
- **Flexibility to add other tests**

Record of new/missing datasets

Ignore facility

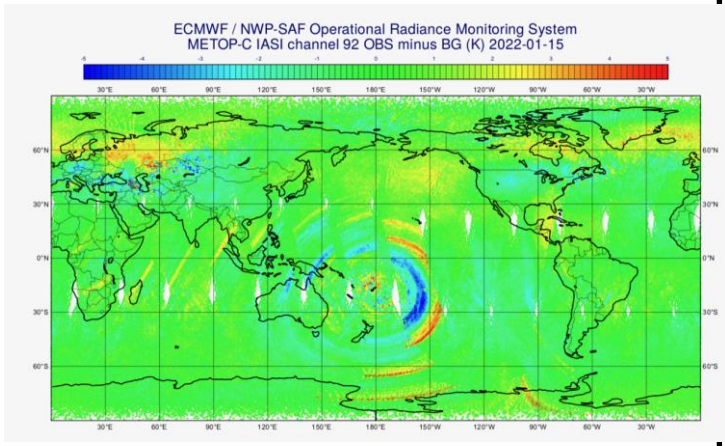
Past warnings



Periodic reporting

Email | **Web** | **Event Data base** → **Blacklist procedure**

Signature of Tonga eruption

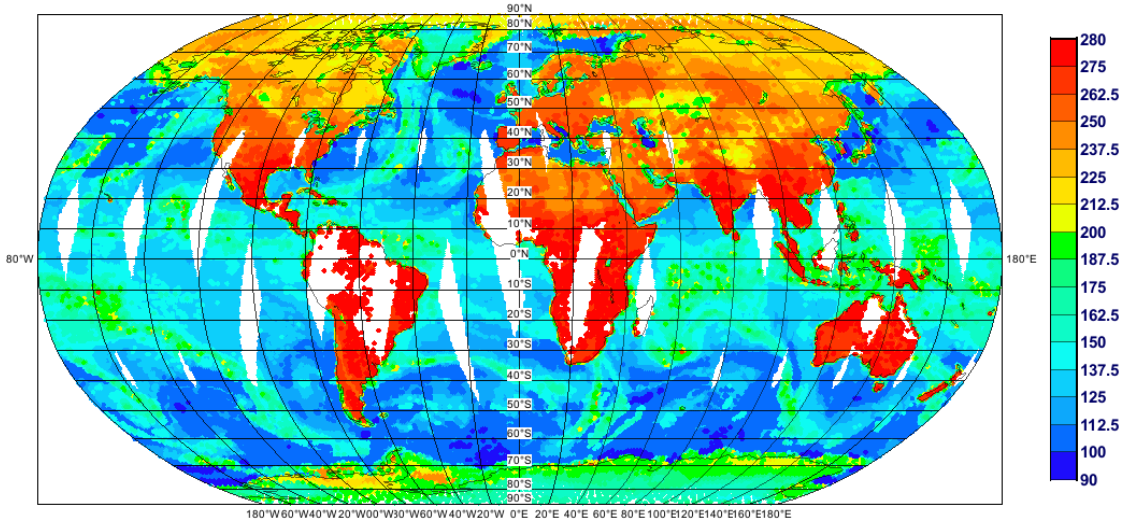


NWP monitoring and RFI detection

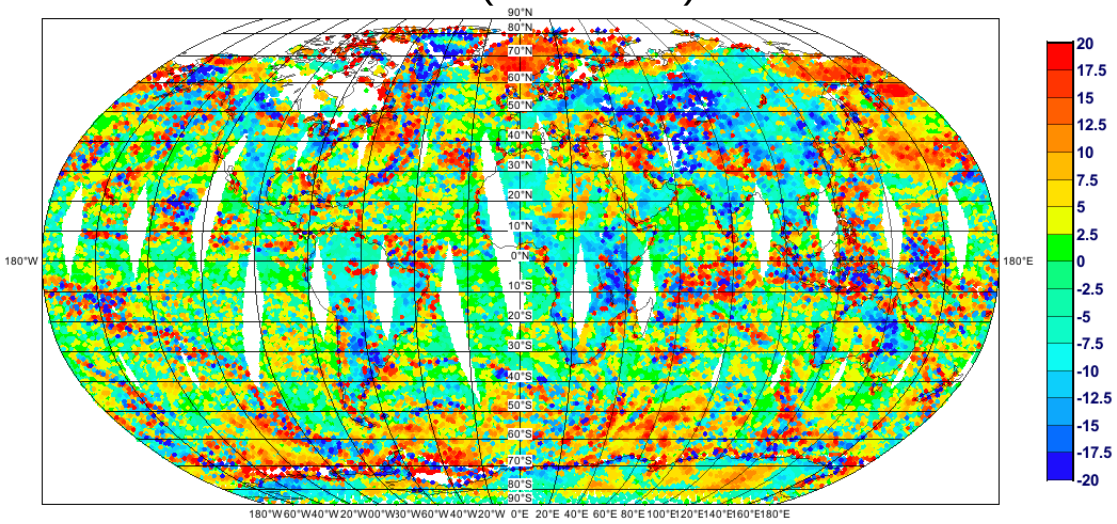
- RFI can be detected using the observed signal itself: on-board algorithms, digital signal processing, inter-channel comparison, etc

- NWP is a powerful alternative to identify RFI and assess trends:
  - Good quality reference benefiting from combined use of millions of earth system observations
  - Simulated signal is realistic and unaffected by RFI
  - Use of reanalysis (fixed model version) is ideal for assessing trends
  - RFI signal is often smaller or comparable to natural weather variability (scene selection + time averaging is essential)
  - Small and intermittent RFI are difficult to identify

AMSR2 18.7 GHz V (19 Jan 2022)
Obs values

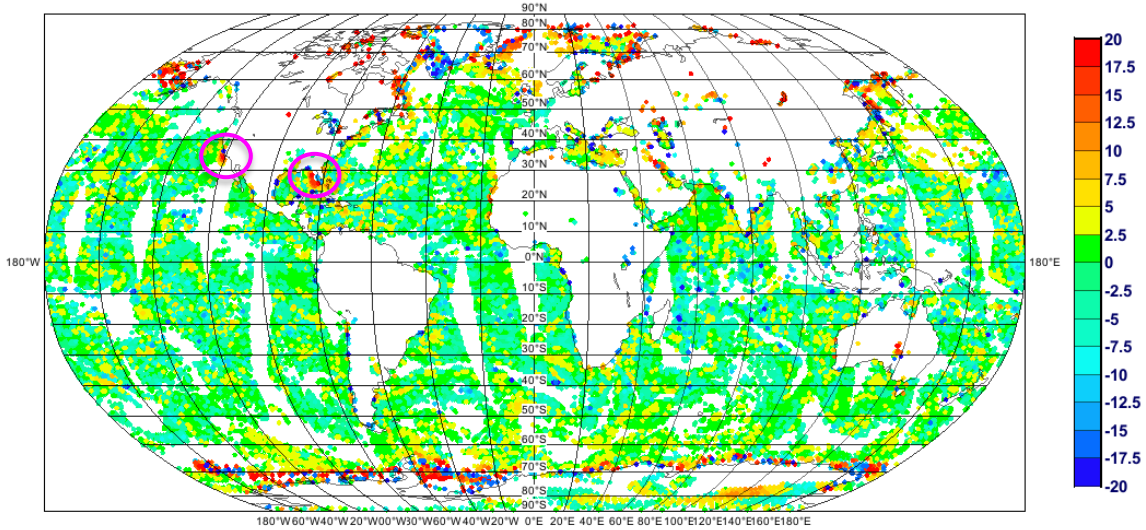


AMSR2 18.7 GHz V (19 Jan 2022)
O-B (all scenes)

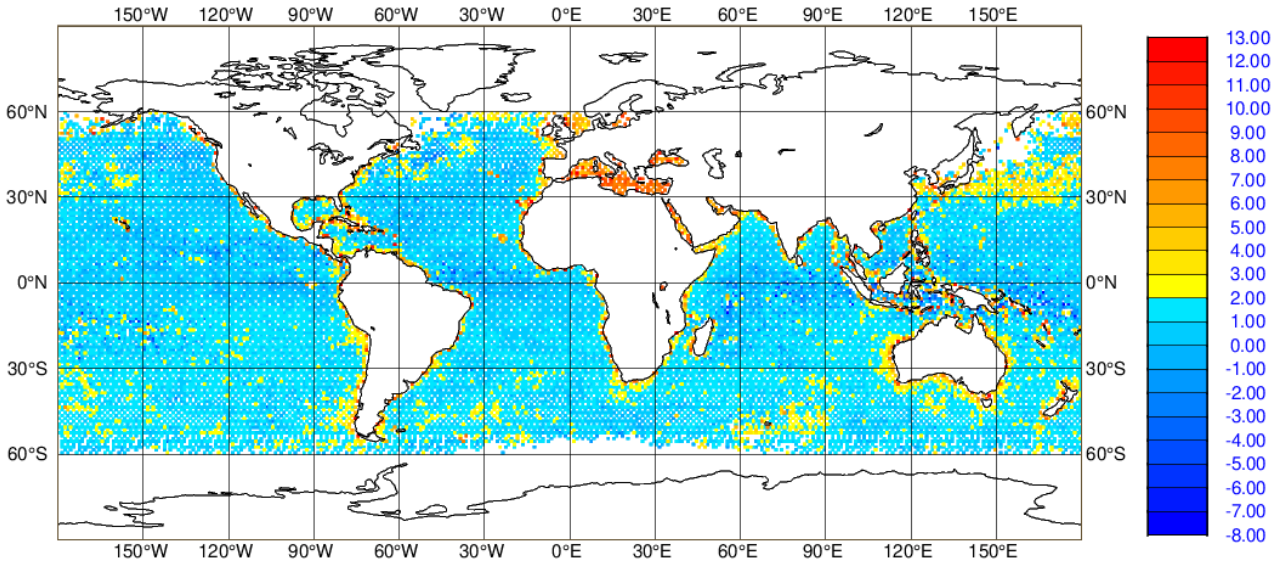


- Microwave observations inform about a wide range of earth system geophysical parameters
- O-B are significantly affected by the type of weather, underlying surface and how NWP is handling the associated processes.
- Monitoring of RFI should be restricted to well modelled scenes: such as “clear sky”

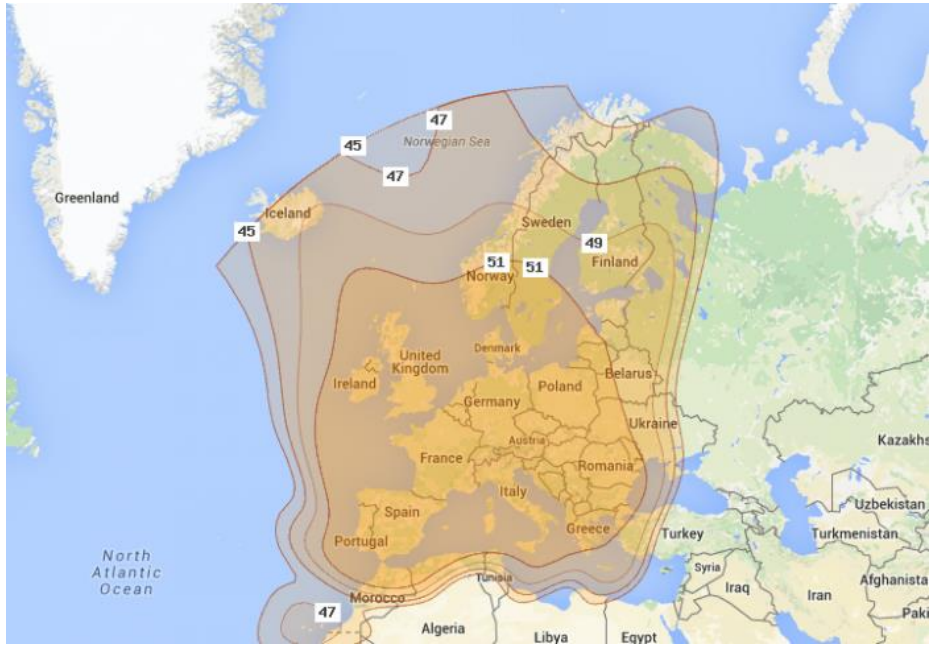
AMSR2 18.7 GHz V (19 Jan 2022)
O-B (clear scenes)



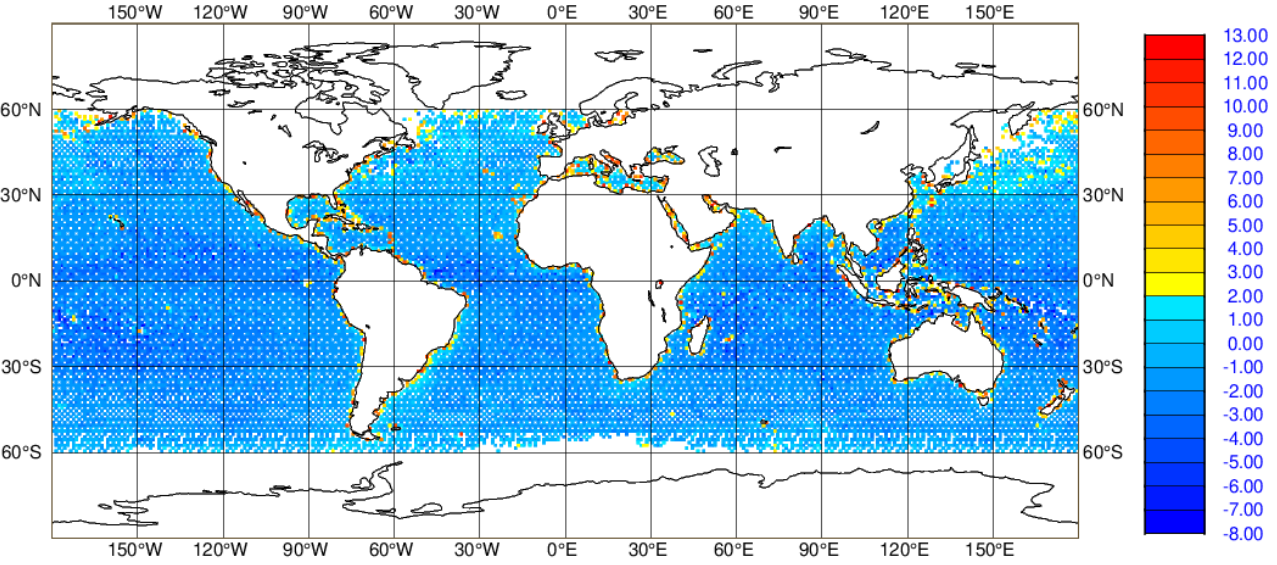
O-B from FY-3D MWRI 10.65 GHz H Descending (Jan 2022)

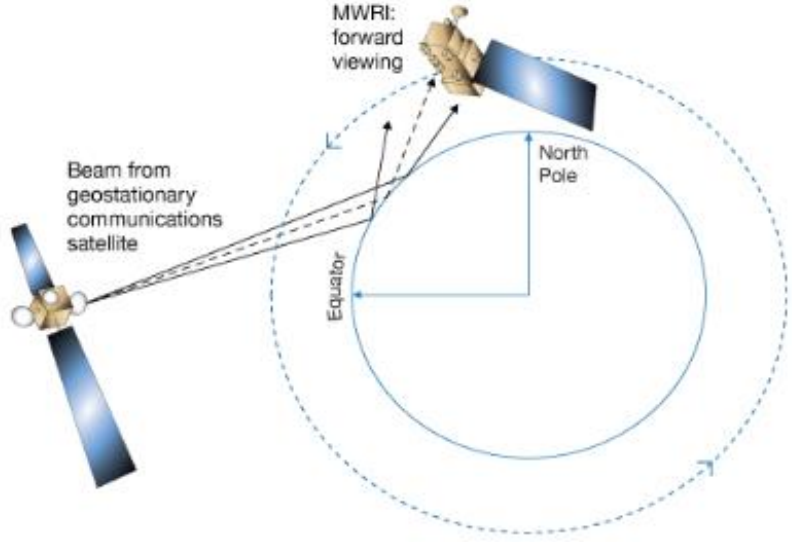


ASTRA 19.2 E 10.7 GHz

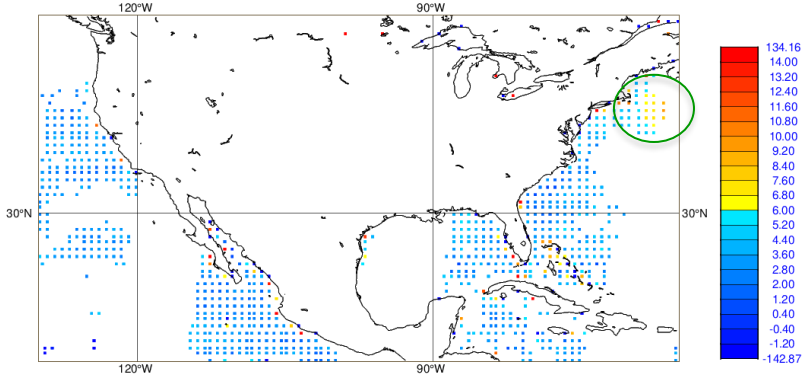


O-B from FY-3D MWRI 10.65 GHz H Ascending (Jan 2022)

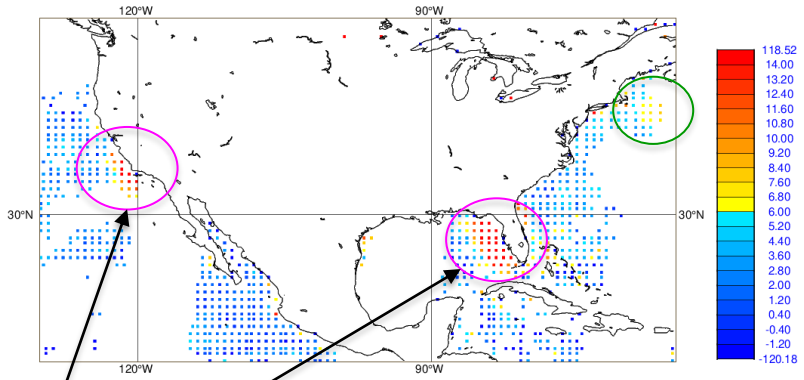




AMSR2 10.65 GHz V (19 Jan 2022)
O-B (clear)

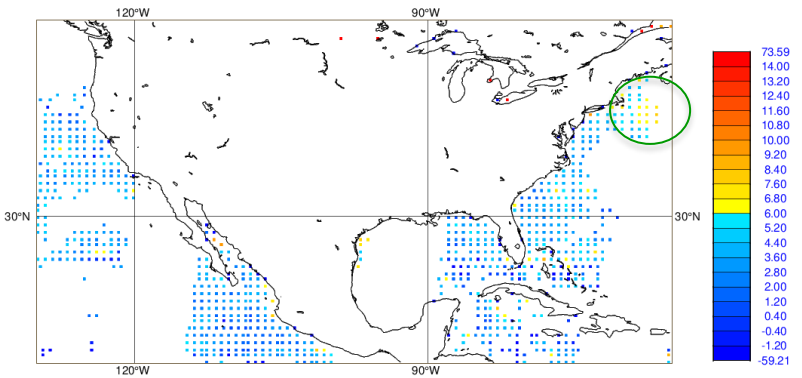


AMSR2 18.7 GHz V (19 Jan 2022)
O-B (clear)



RFI

AMSR2 23.8 GHz V (19 Jan 2022)
O-B (clear)



NWP monitoring and RFI detection

- Routine production of O-B statistics:
  - Monthly statistics over selected large geographical areas
  - Monthly statistics over coastal areas
  - Maps and timeseries over selected areas around big cities (subject to improved cloud detection over land)

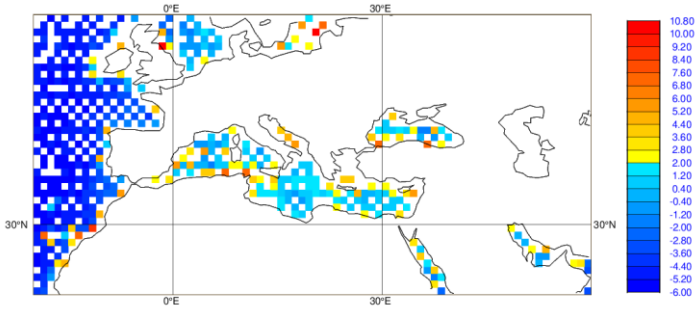
- Maps to be inter-compared routinely to assess trends (statistically and visually). Use of a fixed model version (such as reanalysis) is an option to avoid the impact of model improvement on statistics

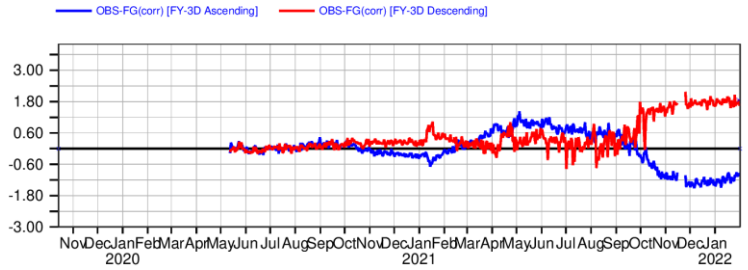
- Monitoring of all MW sensors, polarisations and orbital modes (ascending/descending). Inter-comparison of statistics from different instruments would be useful to properly attribute changes

- Long archive (backward generated would help to better assess trends)

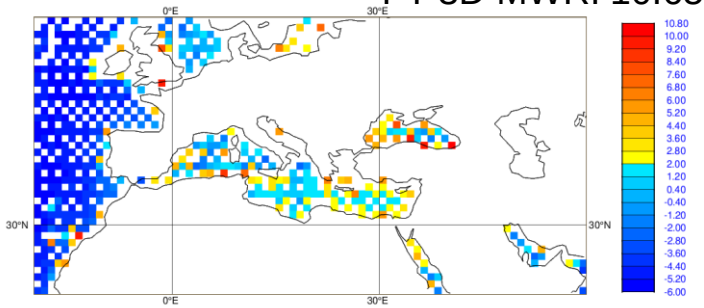
No commitment yet to implement such activity

FY-3D MWRI 10.65 GHz H Descending (Sep 2021)



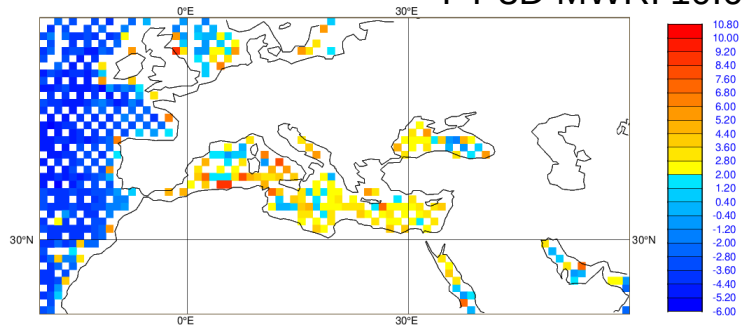


FY-3D MWRI 10.65 GHz H Descending (Oct 2021)

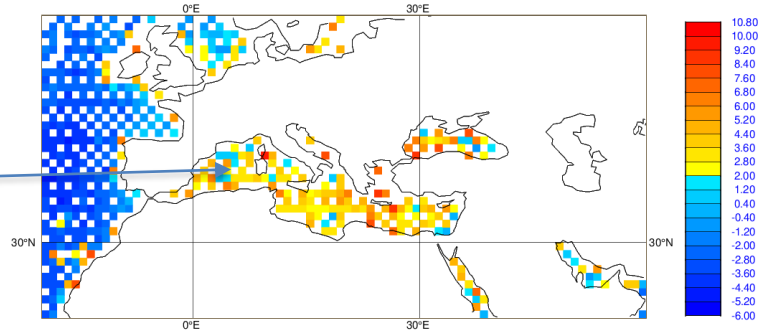


The recent increase of O-B is not related to RFI but has a global nature

FY-3D MWRI 10.65 GHz H Descending (Nov 2021)

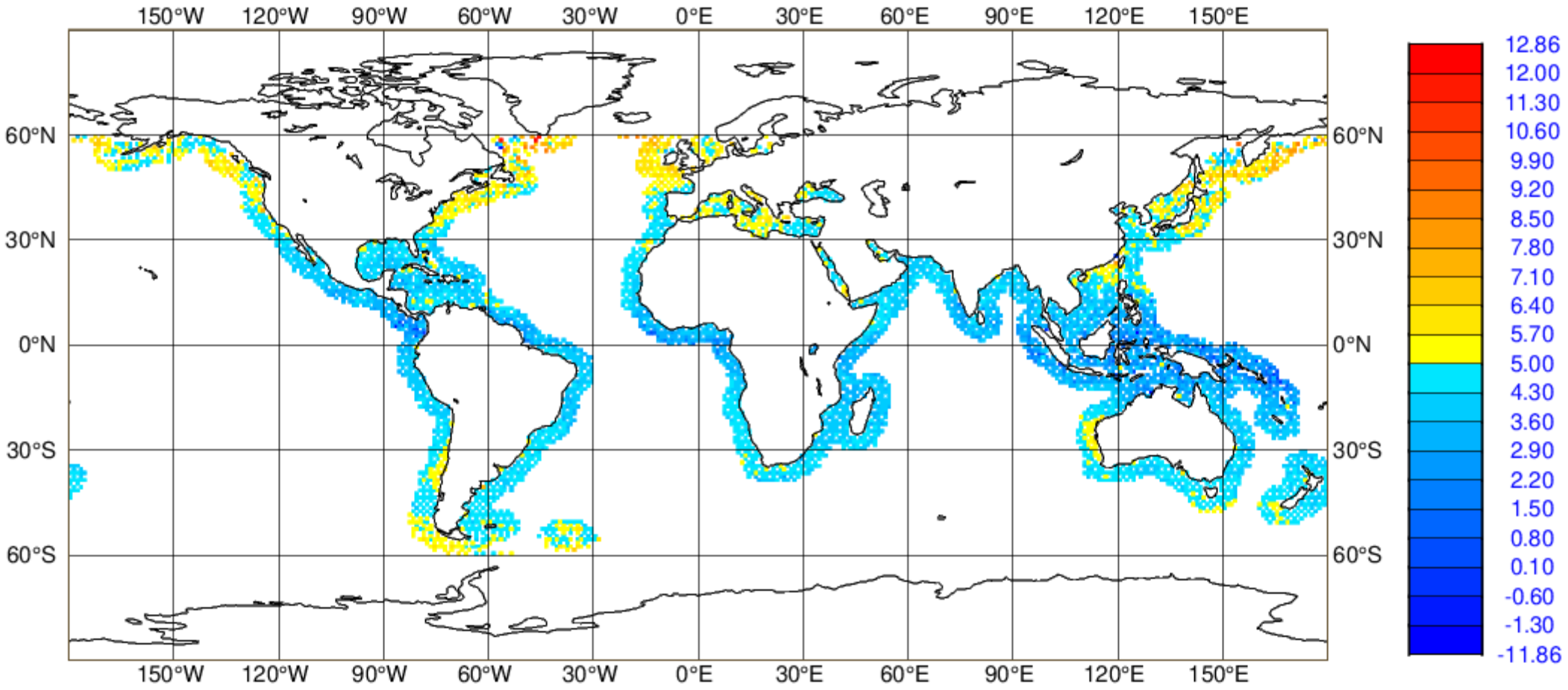


FY-3D MWRI 10.65 GHz H Descending (Dec 2021)

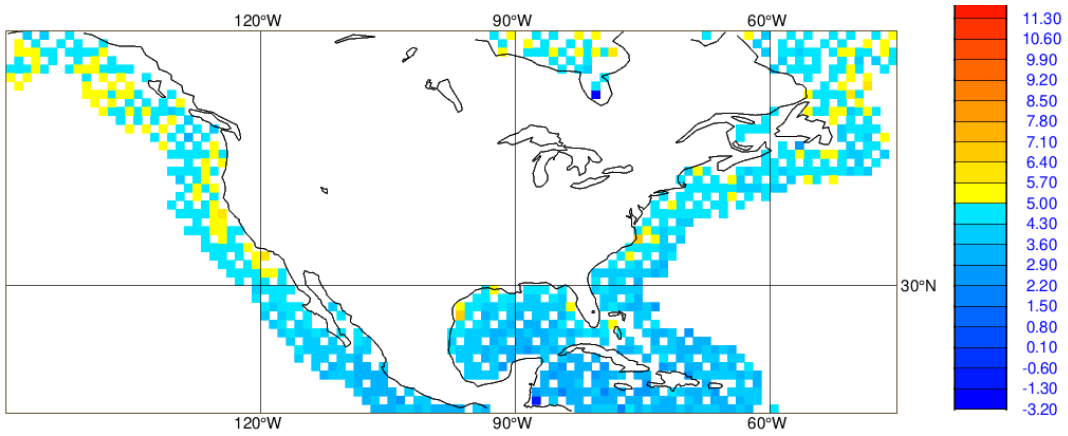


Change of bias of the data and not increase of RFI

AMSR2 18.7 GHz H (Dec 2021)

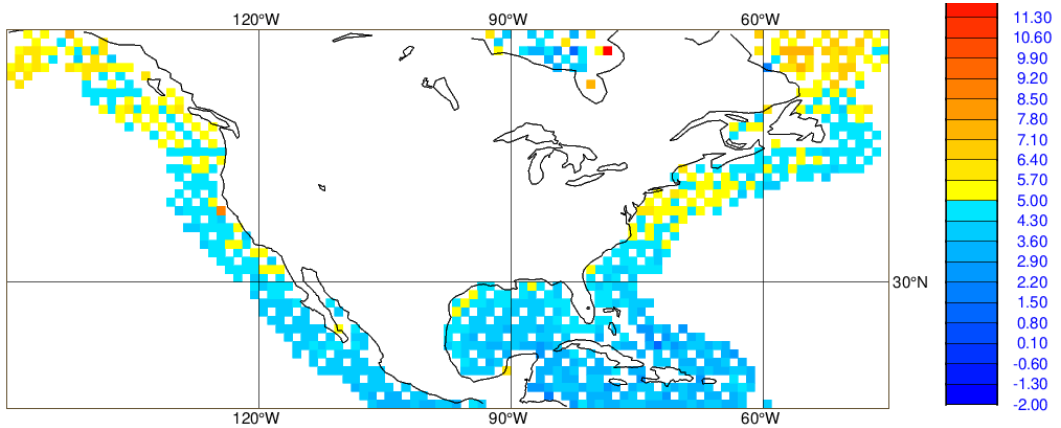


AMSR2 18.7 GHz H (Dec 2021)

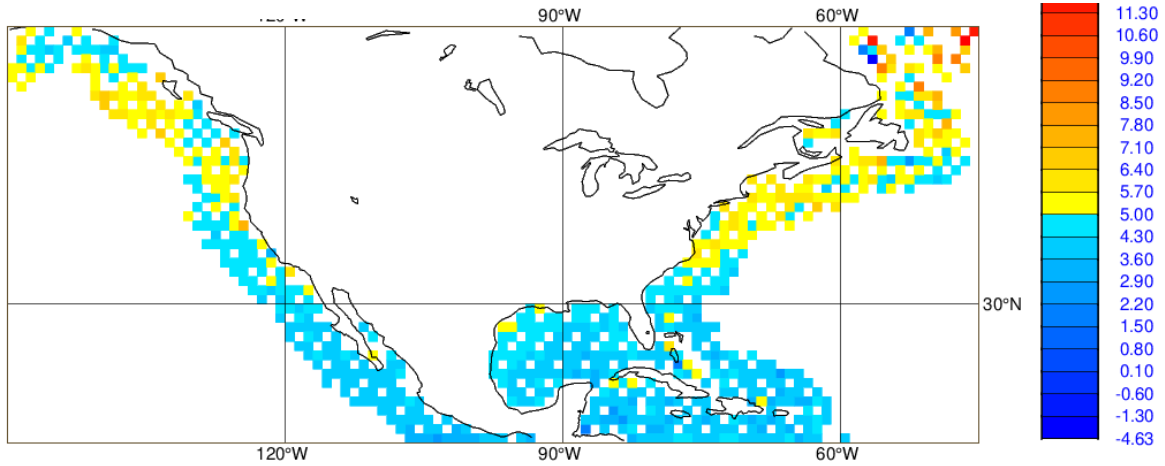


High resolution land-sea mask should be used in the data assimilation.

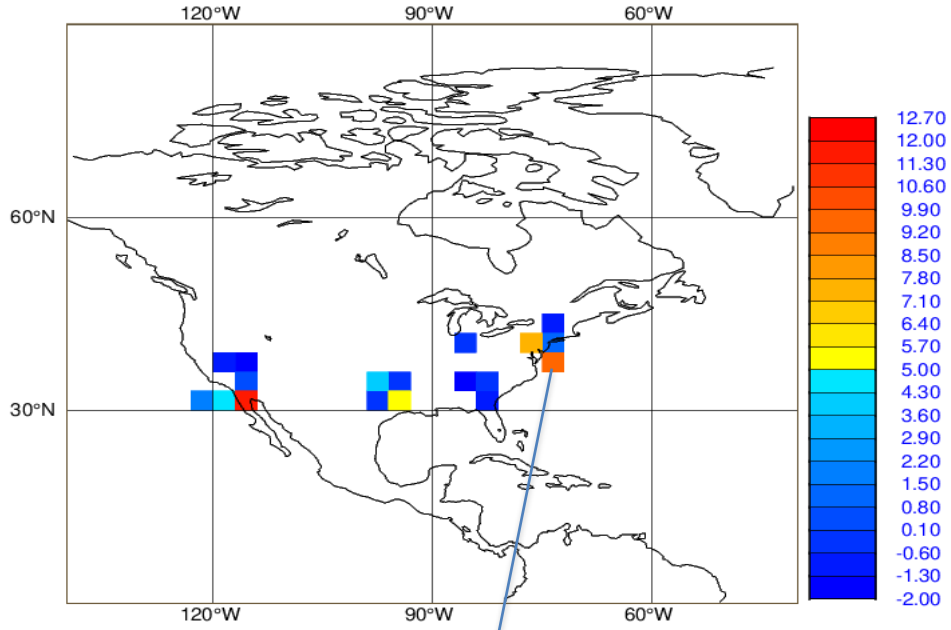
AMSR2 18.7 GHz H (Nov 2021)



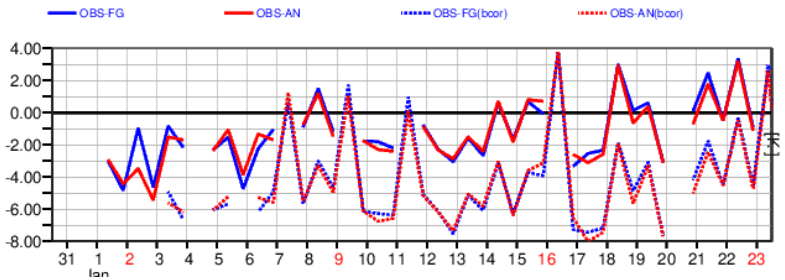
AMSR2 18.7 GHz H (Dec 2021)



- Statistics produced around big cities
- Currently for MW imagers the statistics for “clear” data are not reliable over land. Will require development.



STATISTICS FOR RADIANCES FROM GCOM-W1/AMSR2
CHANNEL =7, ALL DATA [TIME STEP = 12 HOURS]
Area (NEWYORK) : lon_w= 282.0, lon_e= 288.0, lat_s= 39.0, lat_n= 45.0 (over All surfaces)
EXP = 0001 (LAST TIME WINDOW: 2022012309)



Pre-requisites for NWP monitoring of RFI

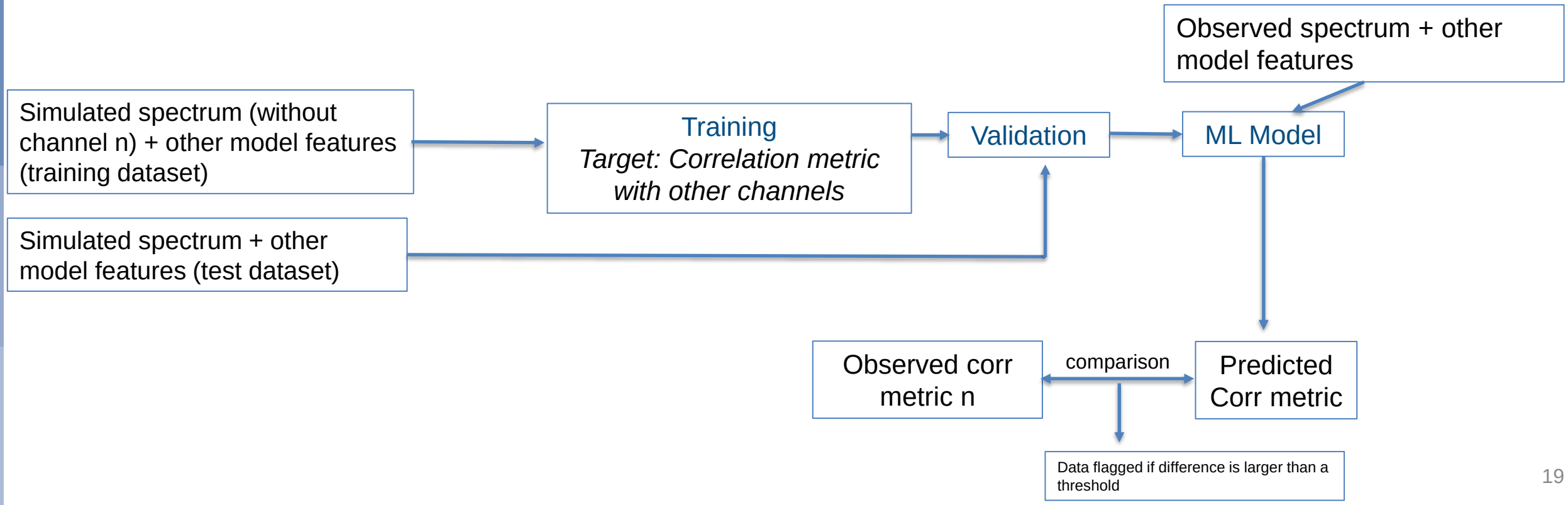
- Improved cloud detection over land
- Generation of O-B in native resolution of the data
- Use of high-resolution land sea mask
- Dedicated monitoring system

Requires resources and funding

Machine learning and RFI detection

- ML can exploit the correlations between Brightness temperature from the different channels in RFI free conditions
- NWP simulations are RFI free and therefore can be used to learn such correlations for a multitude of weather scenes and surface types. Without NWP a training set of observed RFI free data needs to be used
- RFI introduces decorrelation within the observed spectrum → ML predicted correlations should be significantly different from observed ones.
- The use of simulated spectrum for the training makes the algorithm quasi-unsupervised (no need for documented cases of RFI).

Machine learning and RFI detection



Conclusion

- With the increasing demand on MW spectrum, the monitoring of RFI and its evolution is important
- NWP offers a good alternative to monitoring RFI.
- Comprehensive NWP RFI monitoring requires resources and developments