Cloud detection and quality checks for stand alone ground based microwave radiometer

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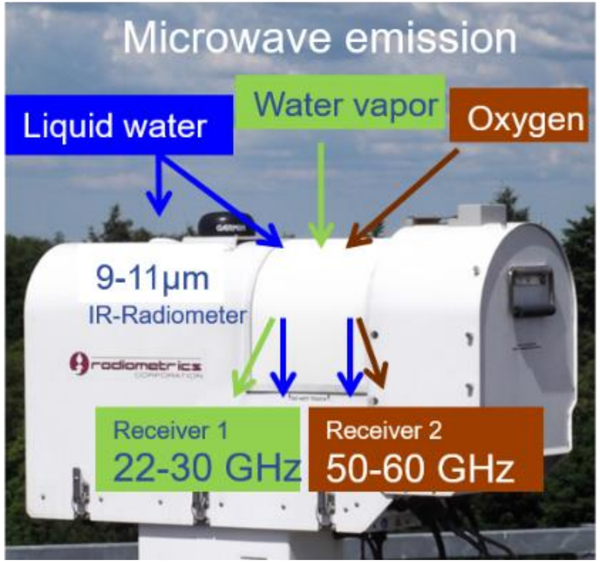
BMD Seminar

14.6.2022

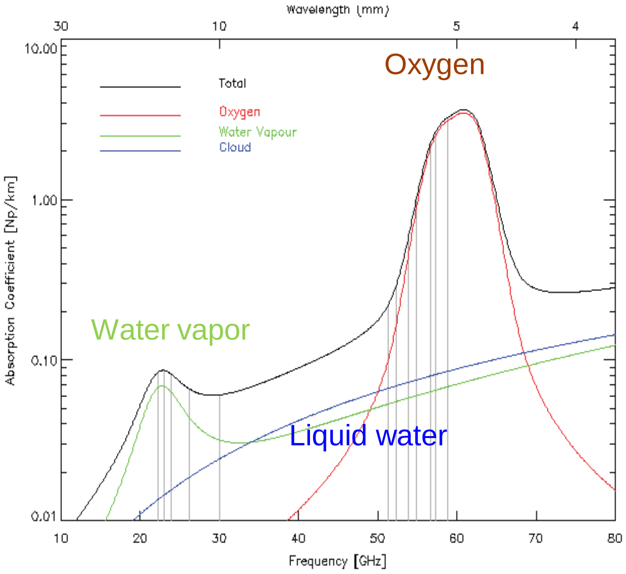
Microwave Radiometer (MWR)

Deutscher Wetterdienst
Wetter und Klima aus einer Hand



→ LV1: Brightness temperatures (T_b)

→ LV2: Temperature and water vapor profile
Liquid water path (LWP)



Microwave Radiometers in Weather Prediction

Going Towards Operational Assimilation of gb-MWRs

System operational

System demonstration in a quasi-operational environment

Technology demonstration in a relevant end-to-end environment

Brightness temperatures (Tbs)

DWD, Meteo Swiss

DA development

NWP impact studies

Operational Assimilation

EUMETNET's

realisation of a MWR network

Technical centre in Jülich/Cologne

standard operating procedures/quality assurance for ACTRIS sites

DWD

Pilotsite for ground based remote sensing. Developing a concept for operational deployment

Data for Assimilation

Data Aquisition

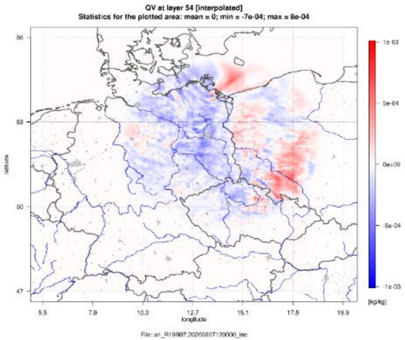
Quality Checks

Liquid Water Cloud in Sky

Clear-Sky or Ice Cloud only

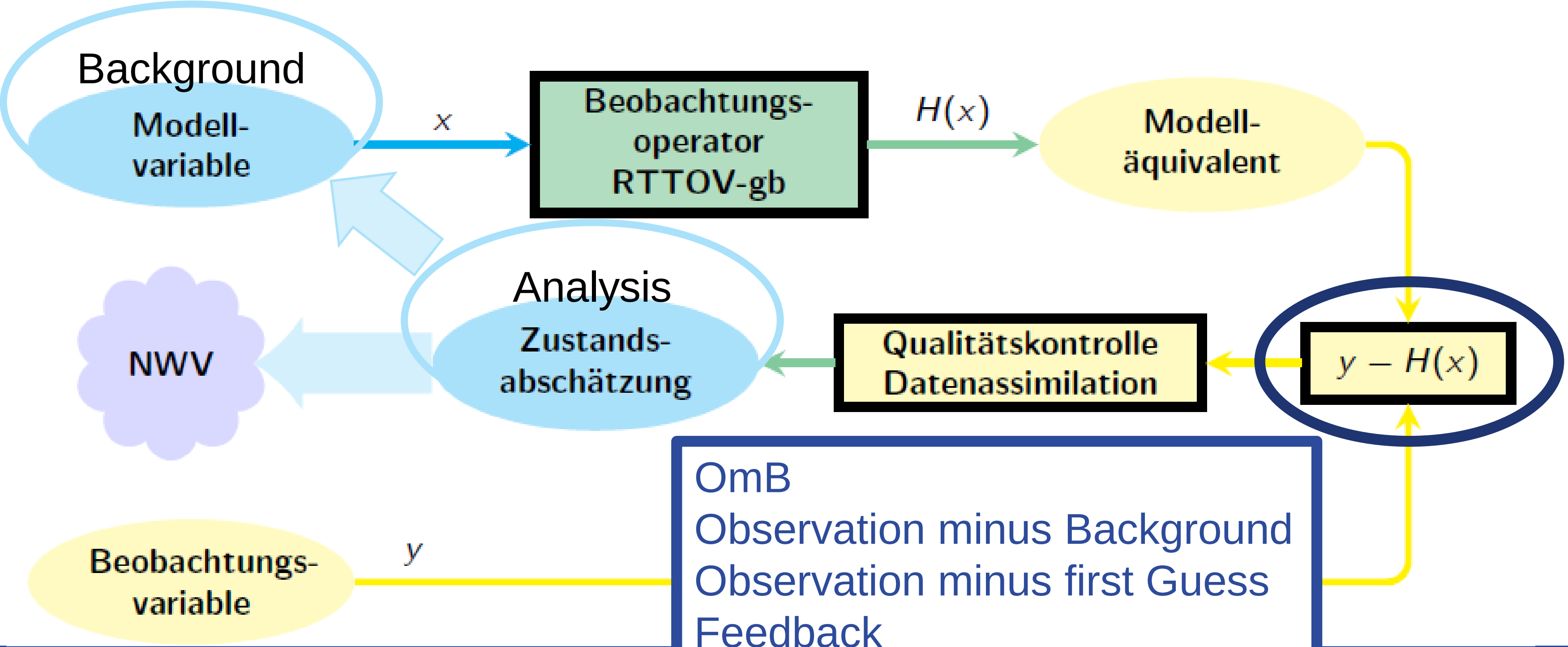
Sprectrum Inconsistent

Data Assimilation



All steps performed in the observation space i.e. Brightness Temperatures (Tb) rather than retrieved thermodynamic profiles.

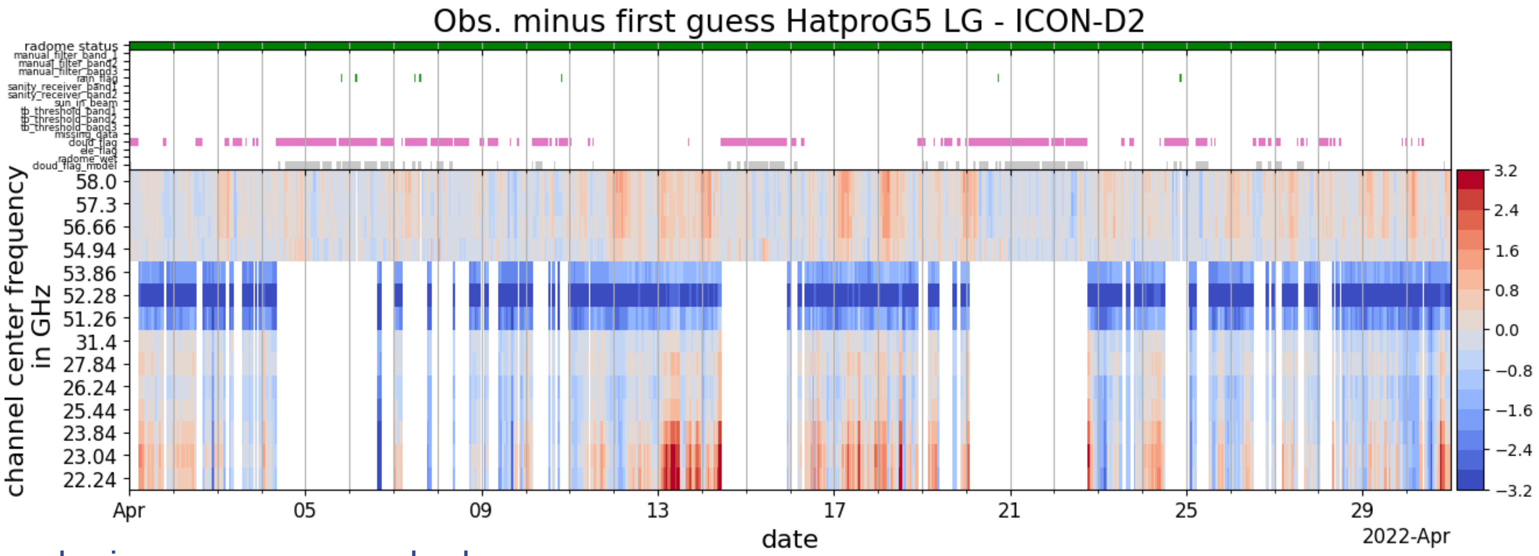
Assimilation of MWR Tb



OmB
Observation minus Background
Observation minus first Guess
Feedback

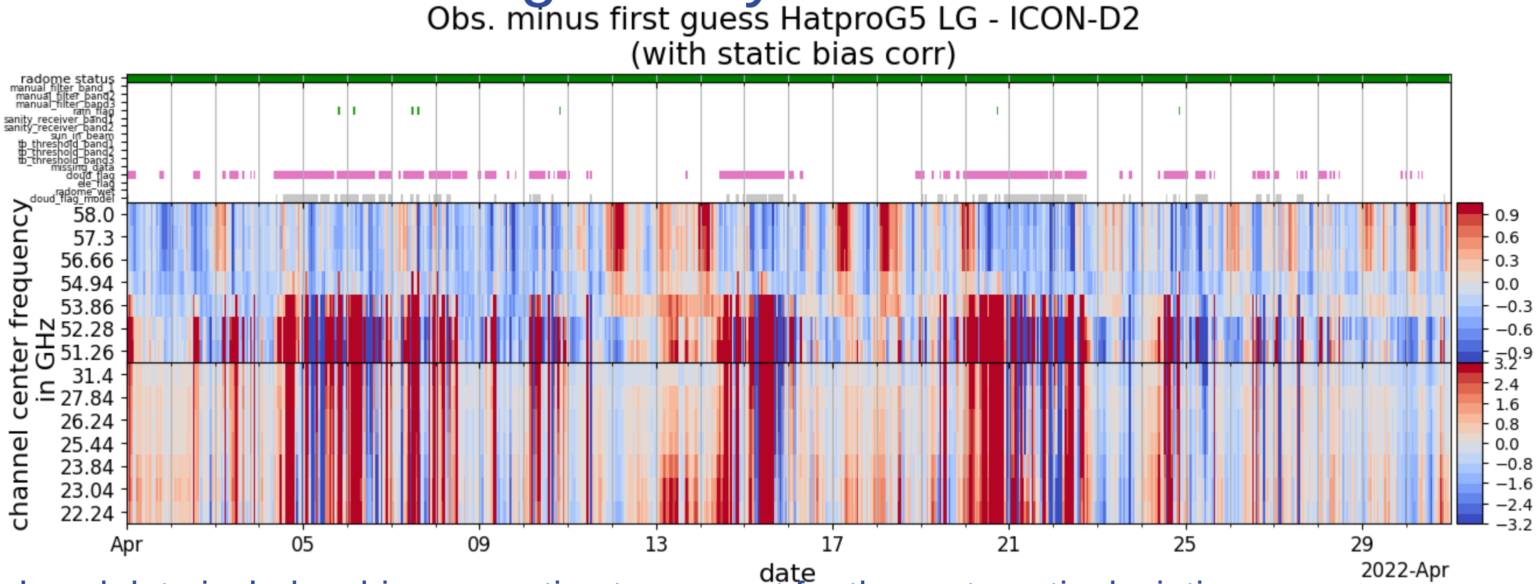
*Jasmin Vural (DWD)

MWR Observations minus Background (OmB)



Cloudy and rainy cases are masked

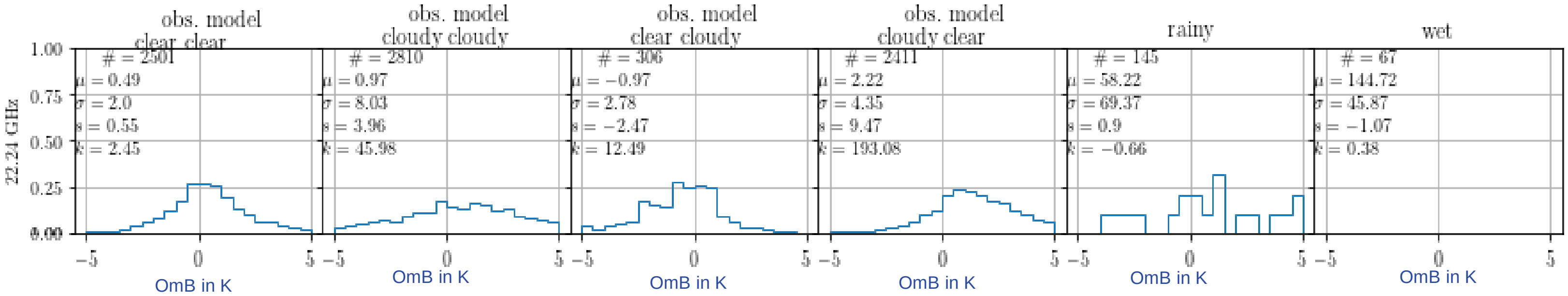
MWR OmB including cloudy data



The displayed data include a bias correction to account for the systematic deviations

- ➢ Significant differences in presence of liquid water are visible
- ➢ Transient deviations (clear-sky) indicate the information content with respect to the model background

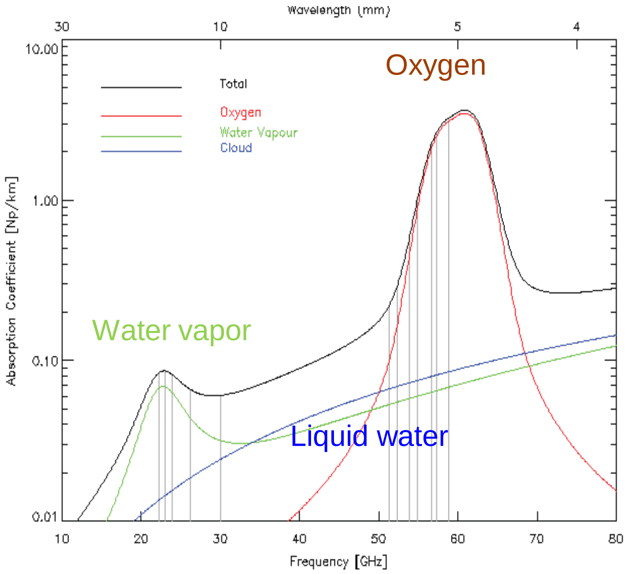
Impact of Cloud Liquid Water and Rain



Histogramme von Beobachtung (MWR @ Lindenberg) minus Background (ICON-D2) from Okt. '20 to Dez. '21 sortiert nach detektiertem Einfluss von Flüssigwasserwolken in Beobachtung bzw. Model . Nur TB_{MW} @ 22.2GHz.

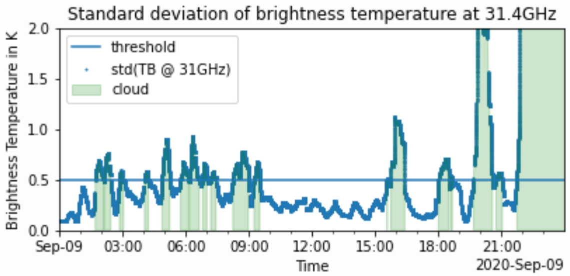
- In presence of clouds, the distributions are skew, asymmetrical und broad.
- In presence of rain or dew: very large mean deviations due to signals of non atmospheric origin

Impact of Cloud Liquid Water (and Rain)

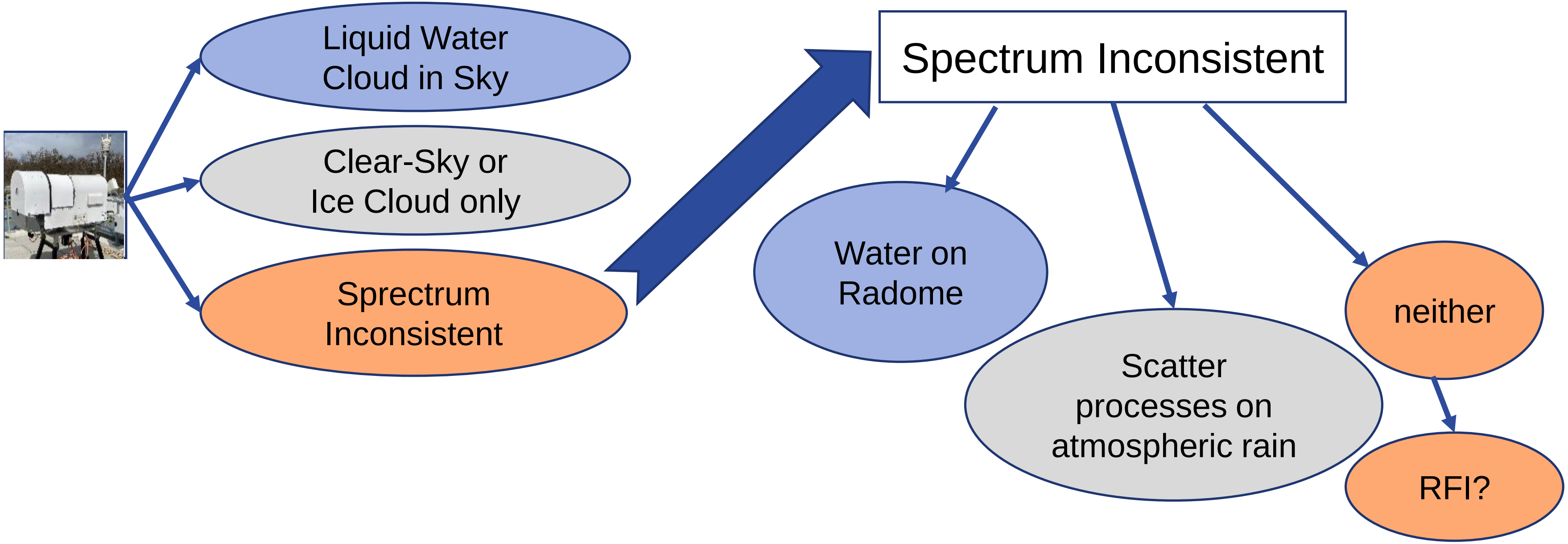


- K-Band and transparent part of V-Band are sensitive to cloud liquid water
- Small scale variability of liquid water causes a error of representativity in model comparisons
- Variability of Tb and Liquid water path are known indicators for detecting cloud liquid water.

Std of T_b @31 GHz

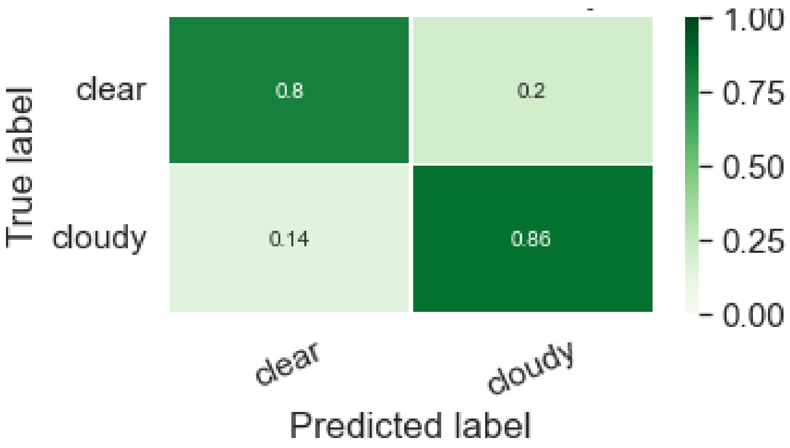


Cloudy/Clear-sky Classification



Detect Liquid Water Clouds

Performance of the empirical method



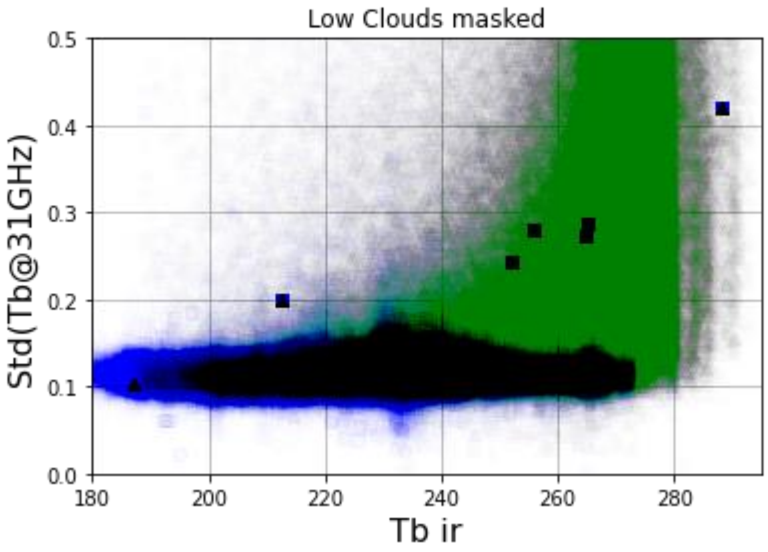
Rate of detection of liquid water clouds using the CloudNet target classification as a ground truth reference.

New Development

- Develop a machine learning based algorithm with
  - low latency,
  - geographic independence,
  - few requirements to additional instrumentation
  - applies to all elevation angles
- Aiming to obtain a standard algorithm which is accepted and used within ACTRIS and E-profile.
- Develop a method which assesses the spectrum consistency and can also be used for quality checks.

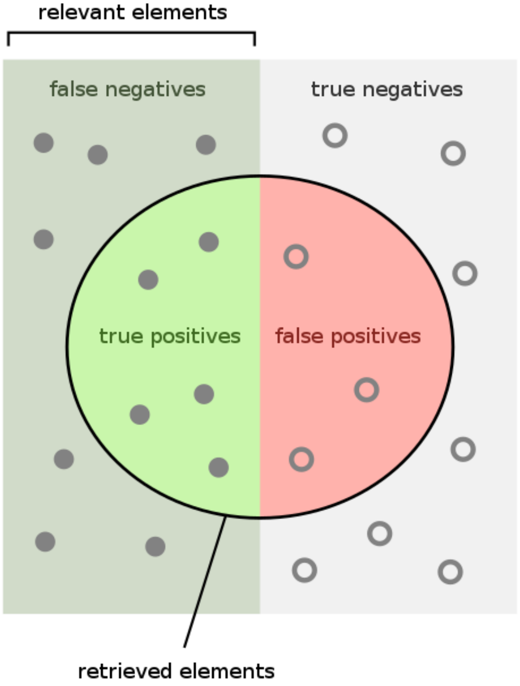
First look into data and filtering

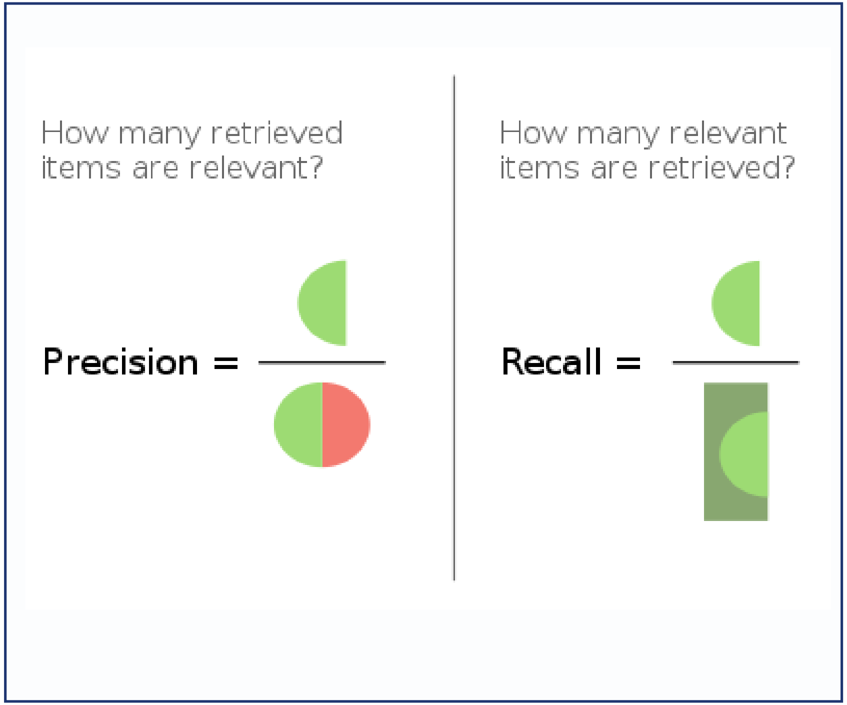
Observed data with cloud info



- Using CloudNet target classification as a ground truth for evaluating classification algorithms.
- clear-sky, cloudy and **overlapping**
- Removing cases with rain (rainsensor)
- Removing cases with rain (distrometer)
- Add undetected low clouds to CloudNet classification
- Final dataset which I'll be using in the following

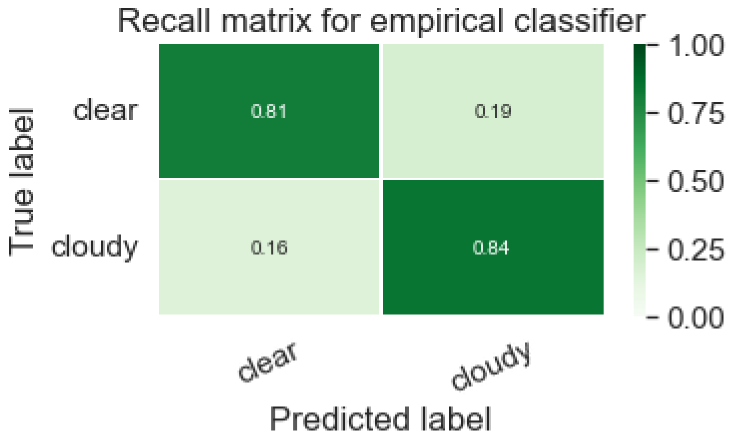
Precision and Recall





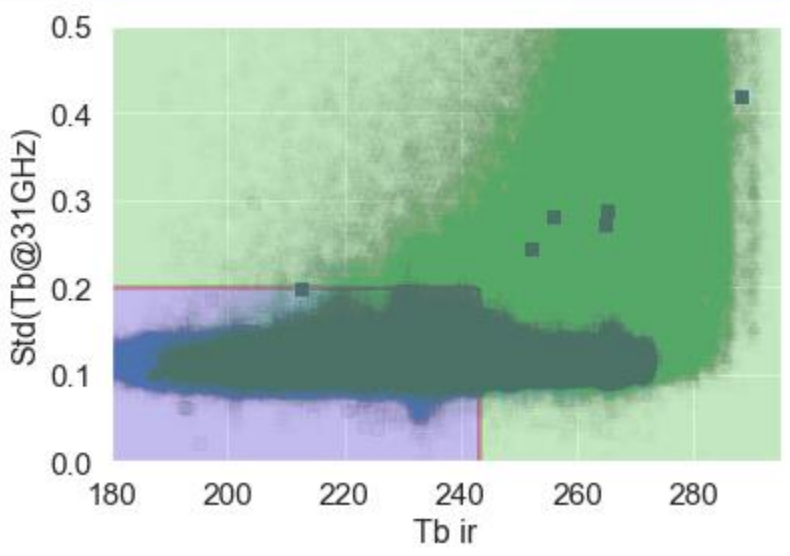
*https://en.wikipedia.org/wiki/Precision_and_recall

Empirical Method

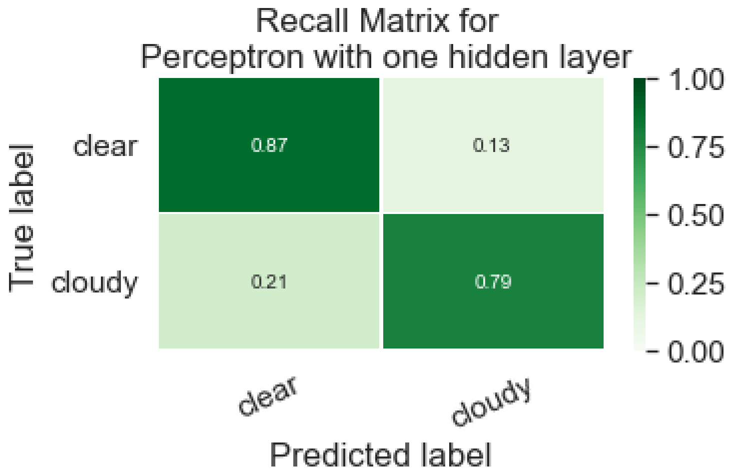


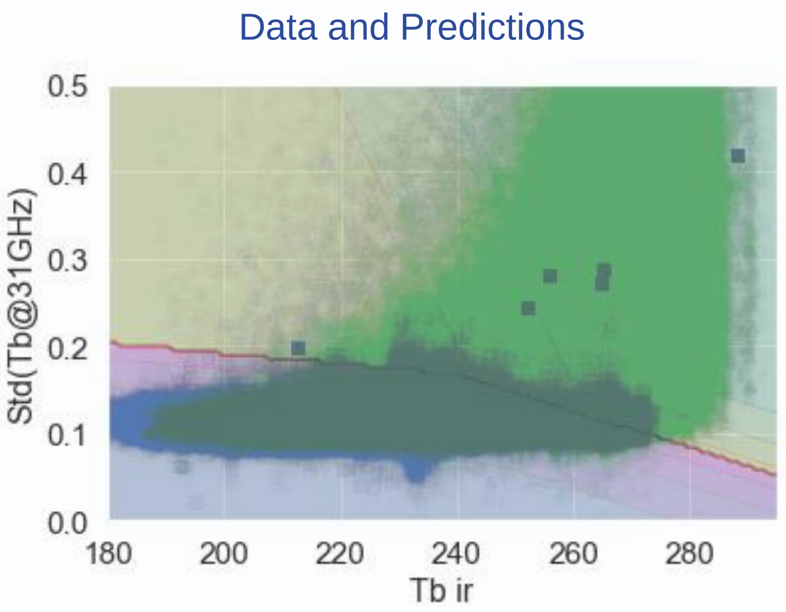
- Performance of empirical method is benchmark for new developments
- Overlapping structure of dataset complicates separation of clear and cloudy cases.
- The presence of liquid clouds at very low TbIR indicates issues with CloudNet classification as a „True“ reference

Data and Predictions



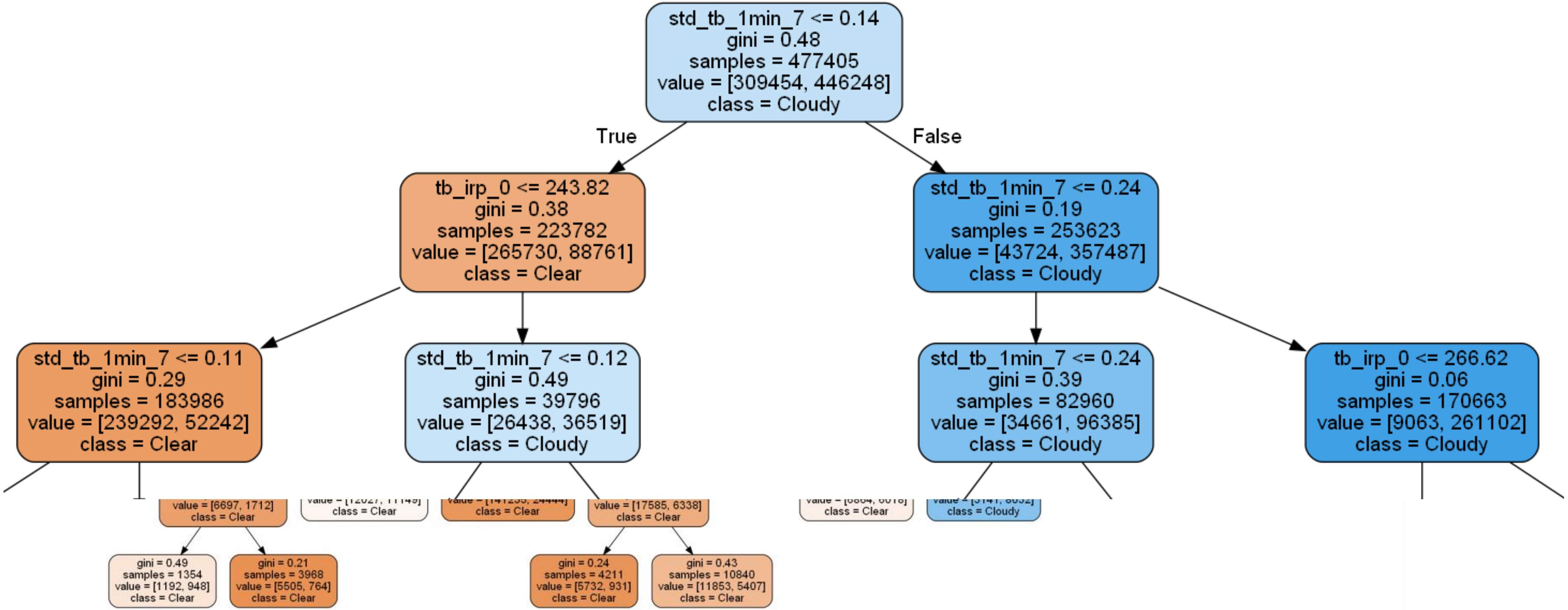
Neural Network with 1 hidden layer (Perceptron)



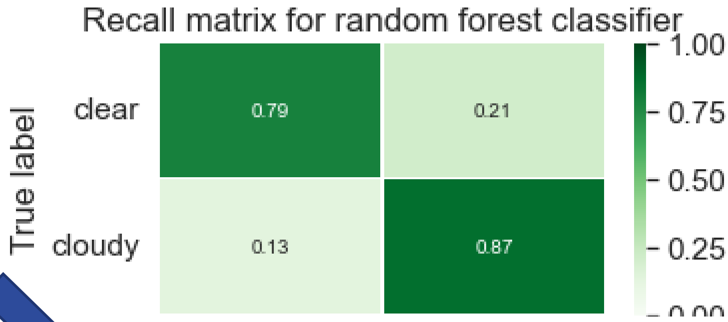


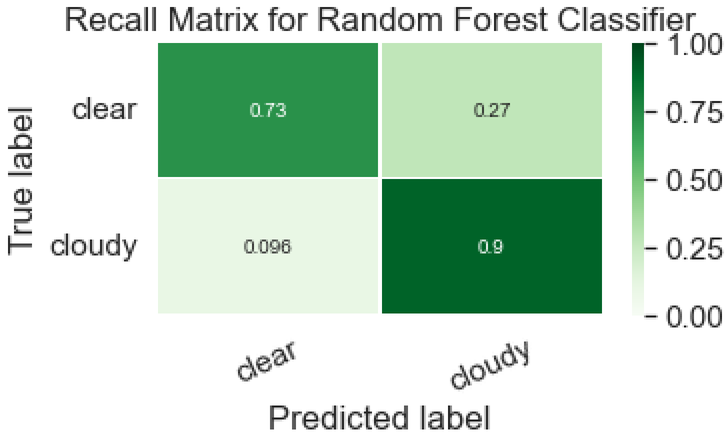
- Performance is typical for ML based algorithms.
- ML based approaches result in small improvements with respect to the empirical method.
- Including additional dimensions for predicting has a small impact on precision and recall

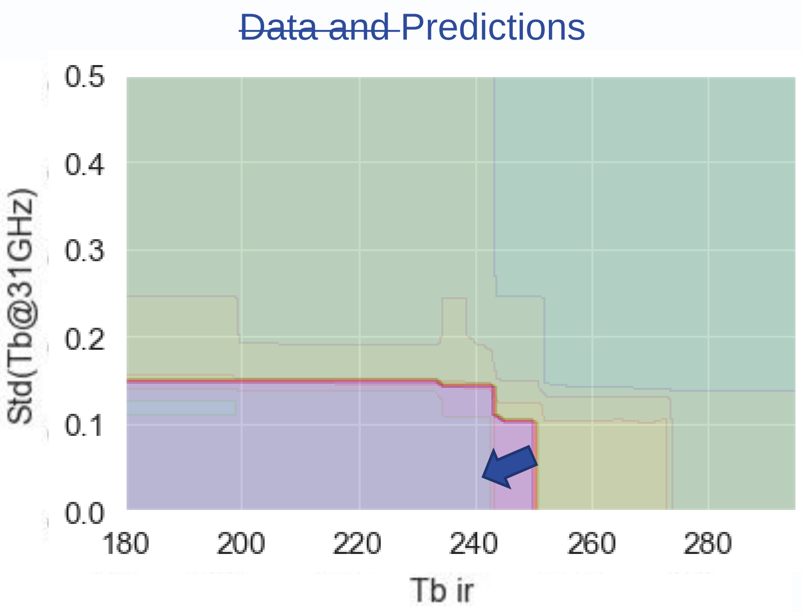
Descision tree -> random forest (tree ensemble)



Random Forest







Spectral consistency

Liquid Water Cloud in Sky

Clear-Sky or Ice Cloud only

Sprectrum Inconsistent

Spectrum Inconsistent

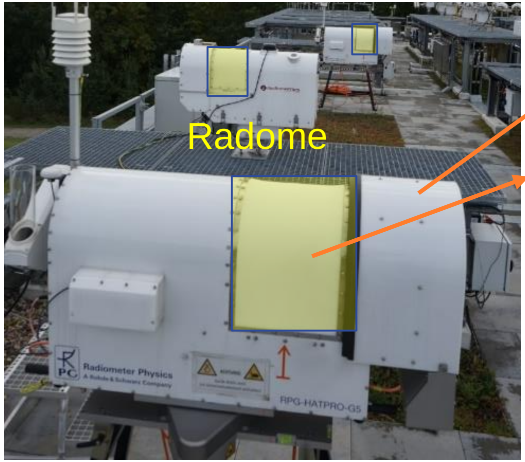
Water on Radome

Scatter processes on atmospheric rain

neither

RFI?

Liquid water on the radome



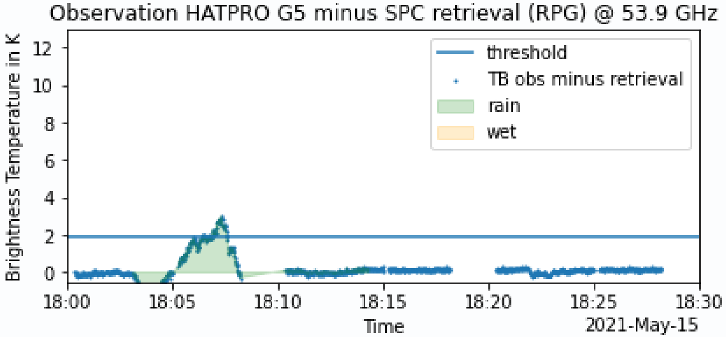
FESSTVaL campaign summer 2021
@Lindenberg

The radome is kept dry with:

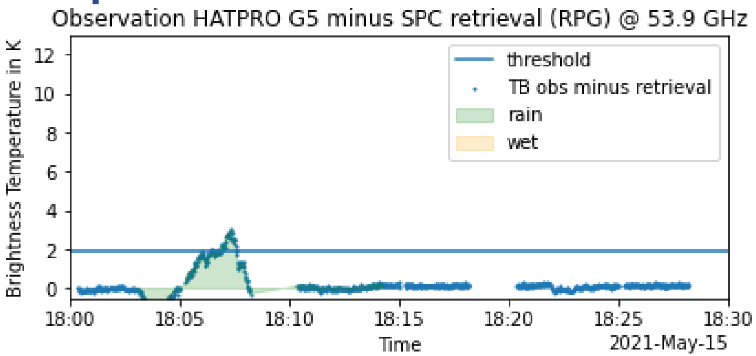
- heater, blower and rain sensor
- Hygroscopic coating

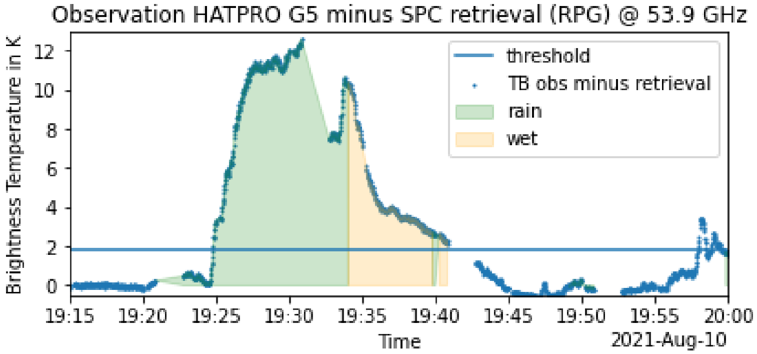
Automatic identification of water on the radome (e.g. after rain events):

Evaluation of spectral consistency of Tb data: Tb observations vs. Tb spectral retrieval from neural network retrieval algorithm (LV2 product)

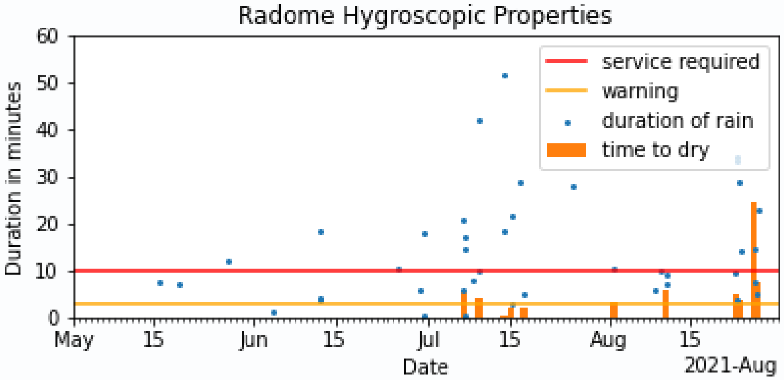


Liquid water on the radome



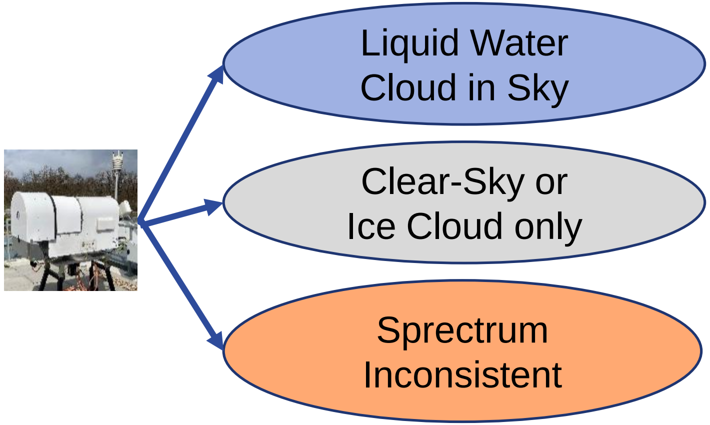


Continuous evaluation of spectral consistency of Tb data **during and after rain** provides an indication of radome degrading:



- Radom quality flag: Warnung und Wartung

Outlook



- Cloudy/clear-sky classification and spectral consistency checks based on
  - Reanalysis and radiative transfer modelling,
  - Observed data
- which
  - has few requirements to additional instrumentation
  - applies to all elevation angles
  - is simple and fast

Thank you!

Kontakt:

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