Generation of long-term ground fog time-series using harmonized time series cross-calibrating two Meteosat generations

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Motivation:

- *Fog has a severe socio-economic impact as well as significant influence on the environment (Bendix et al. 2011).*
- *Current long-term research on fog occurrence based on station data suggests that fog over Europe have decreased since 1960s due to the climate change (Vautard et al., 2009).*
- *Due to a limited number of ground-based observations from SYNOP stations and airports, primarily located in low-altitude areas, there is insufficient evidence to support the hypothesis that fog is decreasing throughout Europe.*
- *In order to scientifically investigate different factors which might be responsible for long-term changes in fog frequency over space and time, there is a need of long homogeneous satellite data time series (~30 years) to analyze fog distribution.*
- *The final goal of this project is to generate a long-term ground fog time series over Europe.*

Methods

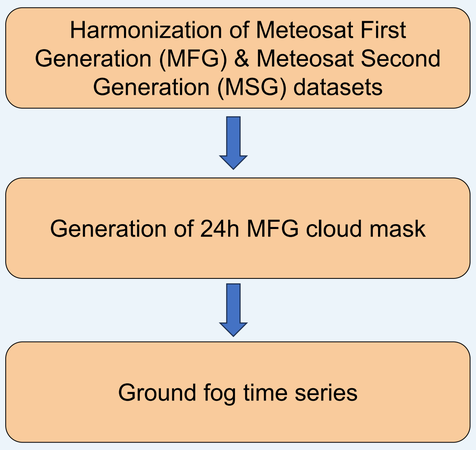


Figure 1. Different stages of the project

1. For climatological studies, a long-term spatio-temporally harmonized dataset is needed due to changes in the sensor characteristics of the satellite systems.
2. Generation of a homogeneous cloud mask which can be finally used to classify fog occurrences.
3. Generation of long-term ground fog time series using harmonized and homogeneous cloud mask in combination with METAR & SYNOP datasets.

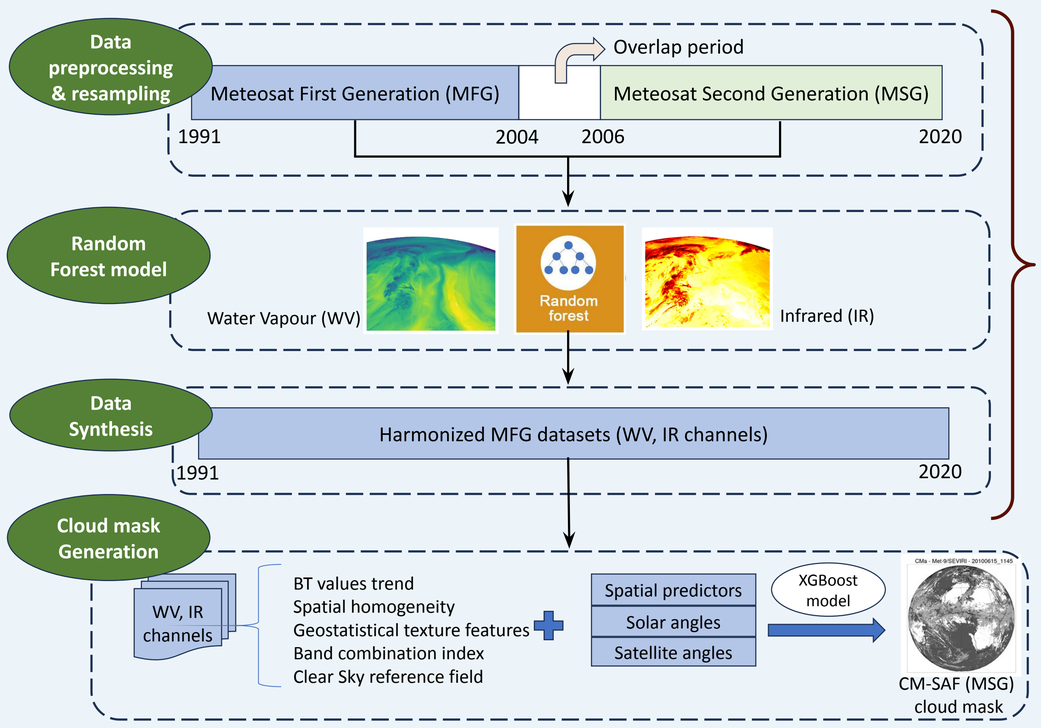


Figure 2. Simplified overview of the steps involved (current progress)

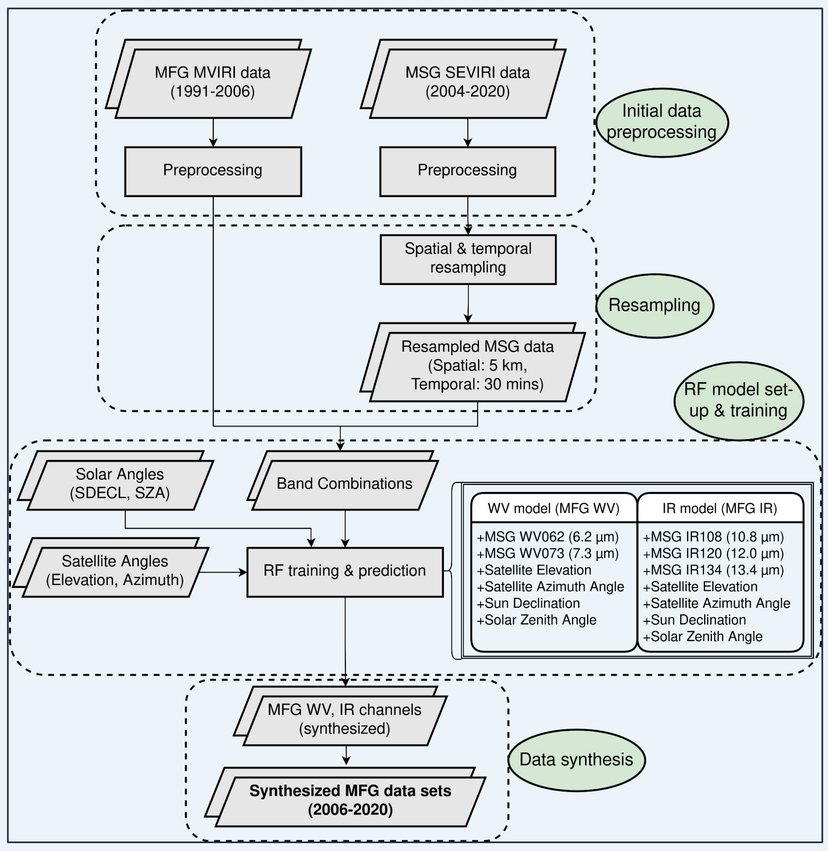


Figure 3. Flowchart depicting the methodology followed for the harmonization of MFG and MSG datasets

Results

Harmonization of MFG and MSG datasets

(Gaurav S, Egli S, Thies B, Bendix J. Harmonization of Meteosat First and Second Generation Datasets for Fog and Low Stratus Studies. *Remote Sensing*. 2023; 15(7):1774. https://doi.org/10.3390/rs15071774)

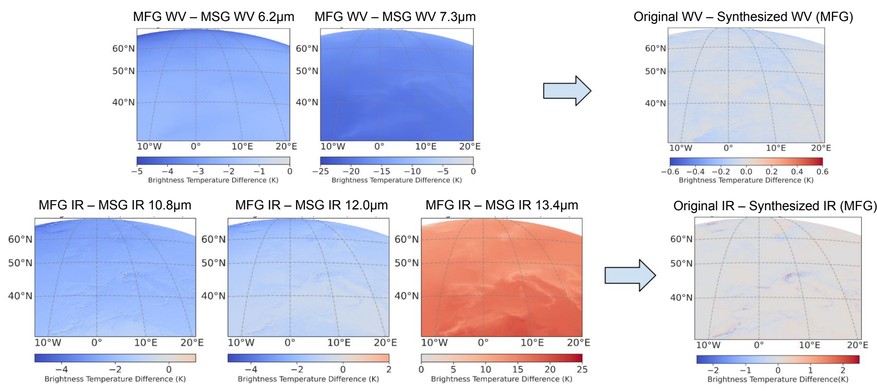
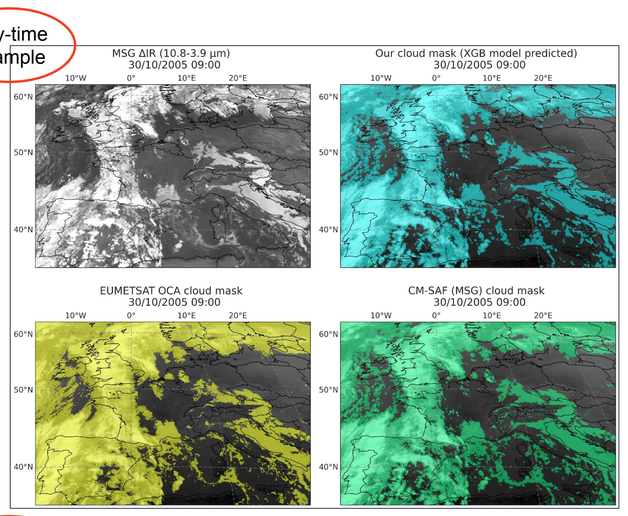


Figure 4. Mean composite differences between MFG original & MSG original channels (left) and MFG original & synthesized (right) showing how the inter-calibration brought the data sets closer

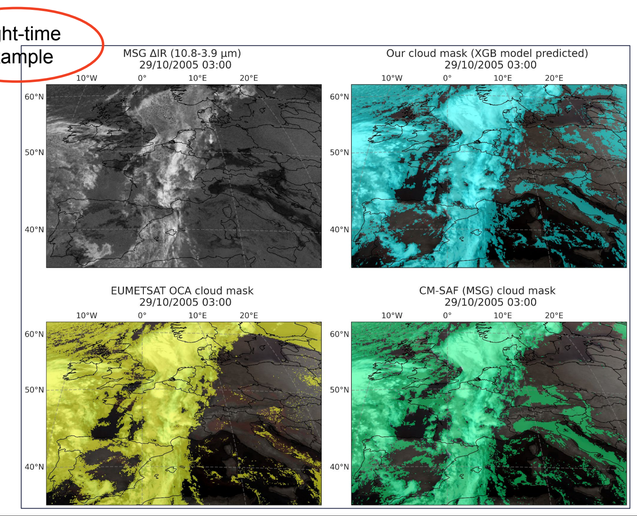
Figure 5. Scatterplots depicting relationship between the original and synthesized values for WV and IR channel respectively

Cloud classification using harmonized dataset

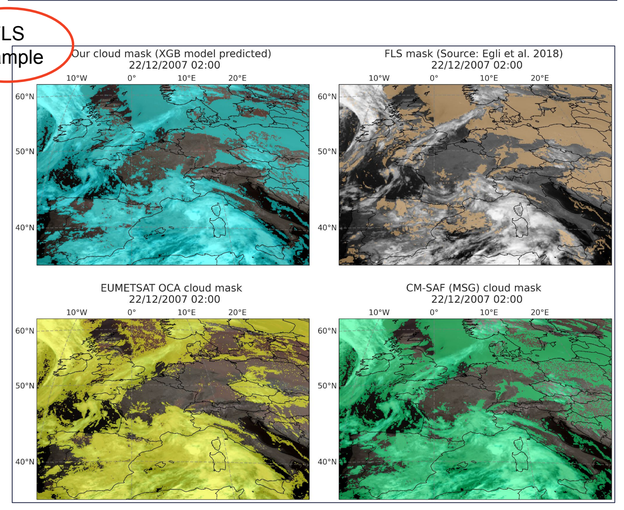
Day-time example



Night-time example



FLS example



Different cloud masks shown in the plots are:

- XGB model cloud mask - generated on the MFG harmonized dataset (our own cloud mask)
- OCA - available cloud mask based on MSG dataset using an algorithm developed by MeteoSwiss for COMET dataset (EUMETSAT 2022).
- CM-SAF MSG cloud mask - gold standard cloud mask based on MSG dataset (target)
- FLS mask (Egli et al. 2018)

	Day-time		Night-time	
	XGB	OCA	XGB	OCA
Percentage Correct	92.94	88.49	91.5	85.97
Probability of Detection	0.96	0.94	0.95	0.92
False Alarm Ratio	0.06	0.11	0.08	0.14
Heidke Skill Score	0.84	0.74	0.82	0.7

Summary

- The random forest models (WV and IR) are able to synthesize MFG WV and IR channels from MSG data sets with good accuracy.
- The generated long-term MFG time series (1991-2020) can be used for various climatological studies.
- The cloud classification scheme using XGBoost model is able to predict clouds for both day and night time with high accuracy. It outperforms available OCA cloud mask from EUMETSAT based on the accuracy assessment.
- In the next step, this MFG-based homogeneous cloud mask (containing information about both high-mid level clouds as well as low stratus) in combination with METAR and SYNOP datasets can be used to derive final ground fog product.

References

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