

Proceedings for the 2018 EUMETSAT Meteorological Satellite Conference, 17-21 September 2018, Tallinn, Estonia

Preliminary studies of MTG potential in satellite based fog and low cloud detection

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Abstract

Fog is a common weather phenomenon especially in autumn and winter season. A very low visibility can be an impairment and hazard for ship and motor traffic and can lead to disruptions in aviation transports. Additionally it hampers the productivity of photovoltaic systems and is therefore an important issue for power delivery forecasts made by electricity grid operators. Due to these risks an area-wide monitoring and forecasting of ground fog is required to prevent the danger of accidents and economic costs. The German weather service DWD is responsible to issue warning about hazardous weather conditions to the public. Therefore consistent information about meteorological parameters like visibility is required with high timeliness.

Introduction

The standard workflow for fog detection in the forecasting office at DWD includes the usage of weather station data in combination with satellite RGB images. Within the scope of a modernization and automation initiative a satellite based fog detection algorithm was developed to deliver fast decision support to the forecasters.

This sophisticated fog and low cloud detection algorithm uses geostationary SEVIRI data and was adapted from the Satellite-based Operational Fog Observation Scheme (SOFOS) by Cermak and Bendix (2008, 2011). The algorithm is based on successively applied filters and is separated into three main parts. First all unwanted objects, e. g. snow, ice and cirrus clouds are excluded and cells which exhibit low cloud properties are determined. Afterwards a coherent cloud cluster analysis is performed and the cloud top height of these clusters is determined. Finally a low cloud model is applied to estimate the cloud base height from calculated micro-physical cloud properties.

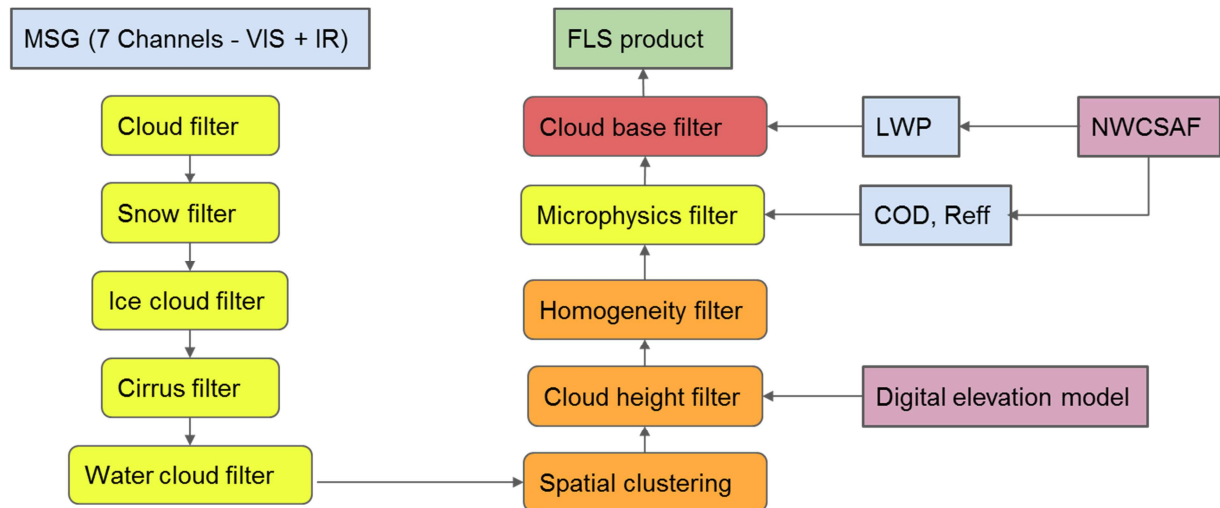


Fig 1: Fog Detection with SOFOS (Satellite-based Operational Fog Observation Scheme)

COD: Cloud Optical Depth

Reff: effective Radius

LWP: Liquid Water Path FLS: Fog/Low Stratus

The Fog-Low Stratus-detection algorithm (FogPy) is implemented as open source software package in Python. It utilizes several methods and packages from the PyTroll (www.pytroll.org) framework. In the present form FogPy provides algorithms for Meteosat Second Generation (MSG) data. Furthermore, it supports Day- & Night detection algorithms, is developed for operational application, simplified maintenance and prepared for adaptations/extensions (MTG). An early version of FogPy is available with documentations on Github (<https://github.com/m4sth0/fogpy>)

The implementation features abstract classes with flexible design to be able to adapt to new satellite data from the Meteosat Third Generation (MTG) mission and its featured Flexible Combined Imager (FCI). This instrument will continue the mission of the SEVIRI instrument from MSG and will provide improved spatial and temporal resolution as well as increased spectral coverage with additional channels. Particularly, the increased spatial resolution with up to 500 m for visible and 1000 m for infrared channels, can be a major improvement for early detection of ground fog structures in small hill and river valleys. In addition, new channels in the near infrared spectral range (2.2 μm and 1.3 μm) can improve the quality of derived micro-physical cloud products and allow better cirrus detection. This could help to prevent false classification and reduced uncertainty of the fog algorithm, described above. Moreover, the Infrared Sounder (IRS) instrument will deliver temperature and humidity profiles that could be used to improve the low cloud top and base height estimation of the algorithm.

Here we present results from several preliminary studies to assess the above mentioned innovation potentials of MTG for fog and low cloud detection and forecasting. For this, we use satellite data from available instruments like AHI, ABI and IASI to emulate the different upcoming MTG properties and evaluate the degree of improvement. We also combined available ground station data with satellite-based fog products. This integration improves the overall quality and provides information for regions where an identification of ground fog with satellite data is not possible due to overlaying high clouds. The results show significant improvements for fog classification and provide useful information for future MTG preparation activities towards a reliable and consistent operational fog detection algorithm.

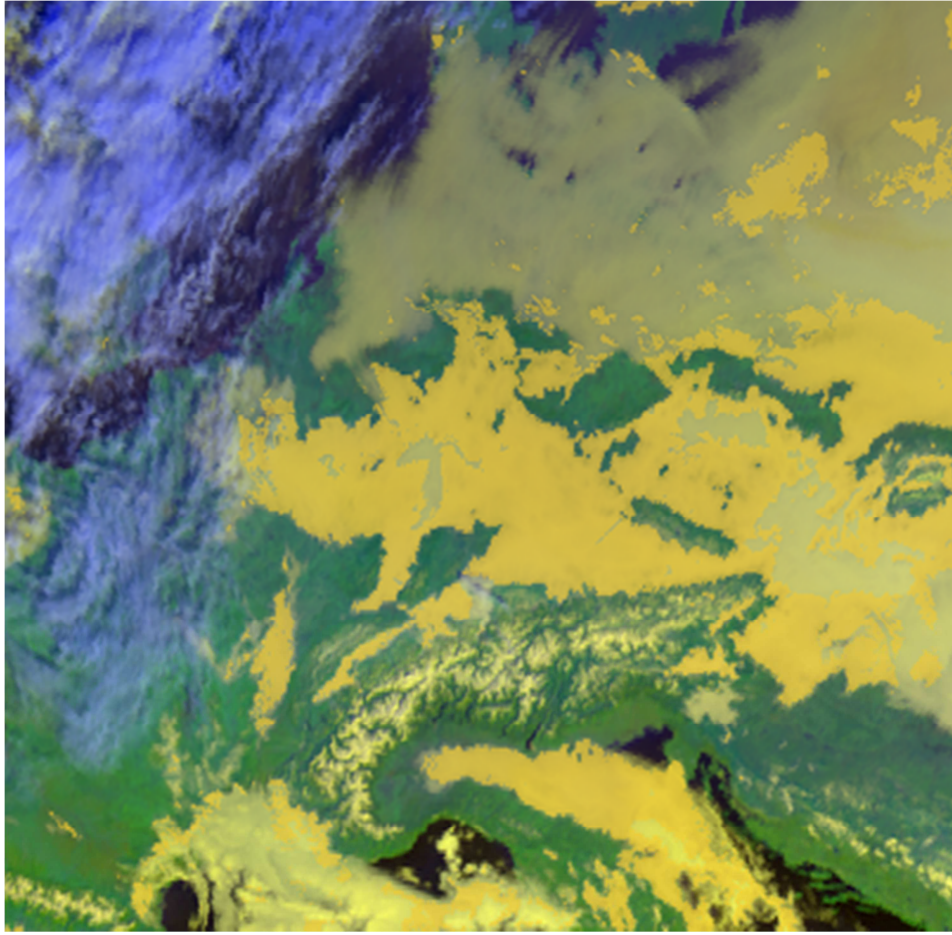


Fig 2: Fog detection (yellow) with FogPy

The validations of FogPy's ground fog and low cloud detection algorithm has been done by comparing the satellite based algorithm results to visibility data from weather stations (SYNOP). The threshold was set to visibilities below 1000 m for observed ground fog and the cloud base height below 2000m for low clouds. In addition the mid and high level Cloud covered areas were excluded. Around 400 satellite scences between 2010 and 2015 were used (Fig 3). The resulting probability of detection (POD) for ground fog and low clouds range from 71 – 74 % and corresponding to an high detection rate. While the false alarm rates (FAR) were quite low (15 %) for low clouds and doubles (34 %) for the ground fog distinction.

	Low Clouds	Ground Fog
POD	74%	71%
FAR	15%	34%

Fig 3: Results of validation with around 400 scenes

With MTG more accurate fog detection is to be expected due to higher spatial and radiometric resolution.

Conclusion

The Implementation of fog algorithm FogPy based on SOFOS shows with MSG data in the central European region some promising results. The next steps are to improve the FogPy algorithm with ABI and AHI data as preparation for MTG data. Fog nowcasting (dissipation of fog) would be also a part of futures developments.

Reference:

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