

# **A Microphysics-Based Approach to Fog / Low Stratus Detection and Discrimination Using Satellite Data**

*Jan Cermak & Jörg Bendix*

*Laboratory for Climatology and Remote Sensing (LCRS)  
University of Marburg / Germany  
www.lcrs.de / cermak@lcrs.de*

Fog is of considerable economic and ecological importance, especially in terms of traffic safety and air quality. Still, its spatial extent and dynamics cannot always be adequately nowcasted using interpolation and modelling techniques. To overcome this problem, this paper introduces a scheme for the automated detection of fog from satellite data.

The algorithms presented make use of MSG (Meteosat 8) SEVIRI, NOAA AVHRR and Terra/Aqua MODIS data received at the Laboratory for Climatology and Remote Sensing (LCRS). Of these systems, MSG SEVIRI has the greatest potential for nowcasting, given its excellent temporal resolution of 15 minutes.

Different algorithms are used for retrievals in night, daytime and twilight conditions. For the initial detection of fog and low stratus areas, a number of individual tests are applied sequentially to the satellite imagery. These comprise both, pixel-based spectral and spatial feature assessments. Optical and microphysical parameters are retrieved for each picture element and tested against the range known to occur in fog (cf. Kawamoto et al. 2001 for the microphysics retrieval, Cermak & Bendix forthcoming for the scheme).

From the satellite perspective, ground visibility impairment cannot be observed directly. However, an estimate can be produced based on geometrical parameters. In order to estimate whether ground visibility is impaired below a fog-type cloud, *surface elevation*, *cloud top height* and *cloud thickness* need to be known. To determine cloud top height, surface elevation around spatially discrete and coherent fog-type cloud objects is interpolated. Cloud thickness is derived using a parameterization based on a pseudo-profile of liquid water path and a liquid water content estimate.

In this fashion, fog and low stratus clouds with ground contact can be detected with good spatial and temporal accuracy. The algorithms presented are implemented in operational satellite data processing at the Laboratory for Climatology and Remote Sensing.

## References:

Cermak, J. and Bendix, J.; A novel approach for the nowcast of fog / low stratus by means of Meteosat 8 data, in prep.

Kawamoto, K. and Nakajima, T. and Nakajima, T. Y.; A global determination of cloud microphysics with AVHRR remote sensing. *Journal of Climate*, 2001, 14, 2054-2068.

# **COST ACTION 722**

**'Short-range forecasting methods of fog, visibility, and low clouds'**

## **Mid-term Workshop 20 October 2005 - Langen, Germany**

**'Input, modeling and understanding the processes  
in forecasting of fog, visibility and low clouds'**

**Topic: Input Data**  
Satellite data and ground observation to distinguish fog and low clouds

**Title: Fog detection using satellite data and ground observations**

**Authors: Diane TZANOS & Vincent GUIDARD**

**Institution: Météo-France, DSO**

**Corresponding author's full address:**

**Vincent GUIDARD**

**Météo-France, DSO/RESO/CEP**

**42 avenue G. Coriolis**

**31057 TOULOUSE CEDEX**

**FRANCE**

**Speaker: Vincent GUIDARD**

**Météo-France aims at producing an hourly map to provide the risk of fog occurrence over land, using satellite data and ground observations.**

**The cloud type product of the EUMETSAT's Satellite Application Facility for Nowcasting provides information on low and very low cloud detection. In this study, surface analyses are used for 2m relative humidity and 10m wind speed (so called Diagpack analyses), and radar data indicate precipitation occurrences.**

**For pixels where the cloud type is low or very low, fog occurrence is considered to be possible if there is no precipitation, a wind speed less than 7 m/s, and a relative humidity greater than 90 %; otherwise, fog occurrence is considered to be impossible. For other pixels, if one of these three criteria is not satisfied, fog occurrence is set to impossible; otherwise, the result is set to "unestimated".**

**If the fog occurrence is possible, the relative humidity is used to give a risk level of fog occurrence: low level between 90 % and 95 %, medium level between 95 % and 97 %, high level above 97 %.**

**This product has been evaluated on a 1-year set of hourly ground observations. The results are quite encouraging. In particular, the three above-mentioned criteria lead to a good distinction between low or very low cloud and fog: for the low-level risk, the potential of detection is 93 %, and for the high-level risk, the false alarm rate is 63 %.**

**The overall rate of non estimated pixel is 12 %.**

# LM-PAFOG : three-dimensional fog forecasting with the Lokal Modell

Matthieu MASBOU & Andreas BOTT  
Meteorological Institute – University Bonn – Germany

The presence of fog and low clouds in the lower atmosphere can have a critical impact on both airborne and ground transports. High quality predictions of fog formation and dissipation, together with the associated changes in visibility, would therefore be of immense operational value in the field.

However, the many physical processes involved in fog formation interact in a complex and highly non linear fashion. These interactions are not adequately resolved by current operational mesoscale models. Numerical simulations require high horizontal and vertical resolutions combined with a sophisticated cloud microphysics. A new microphysical parameterization based on the one dimensional fog forecast model, PAFOG (Bott & Trautmann, 2002) , was implemented in the “Lokal Modell” (LM), nonhydrostatic mesoscale model of german weather service. The implementation of cloud condensation nuclei as a new prognostic variable into the dynamical core of LM, integrates the new microphysics into the three-dimensional frame. LM-PAFOG runs over a small, local area (50x50 km) with a horizontal resolution of 1km. The high vertical resolution is concentrated near the ground : In LM-PAFOG 25 of 35 levels are located in the first 2000 meters.

The current research involves fog events around the Lindenberg area (Germany) for the last quarter of 2004. The results have been compared with satellite data and measurements taken at the Observatory of the german weather service.

Reference :

Bott, A. & T. Trautmann, 2002 : PAFOG – A new efficient forecast model of radiation fog and low level stratiform clouds, *Atmos. Res.*, **64**, 191-203.

# Canadian Testbeds And Observations During The FRAM Fog Field Project

I.Gultepe

Cloud Physics and Severe Weather Research Division,  
Environment Canada, Toronto, Ontario M3H 5T4, Canada  
Ismail.gultepe@ec.gc.ca

## Abstract

Canadian testbed sites during the Fog Remote Sensing and Modeling (FRAM) field project will focus on two areas: 1) in Ontario during the 2005-2006 time period and 2) in Nova Scotia during the 2006-2007 time period. Extensive field campaigns at each location will involve several point measurements. These measurements will cover ice particle concentration ( $N_i$ ), liquid water content (LWC), droplet number concentration ( $N_d$ ) and size, aerosol concentration ( $N_a$ ) and type, visibility, LWC profiles and liquid water path (LWP), cloud base height, precipitation amount and type, and other conventional weather-related measurements, including relative humidity (RH), temperature (T), and wind. In addition to these measurements, remote sensing observations from lidar, cloud radars, and satellites, including MODIS, GOES, and CloudSat, will also be collected. In-situ observations of microphysical parameters at the surface point locations will be used for microphysical parameterization development, and then they will be utilized in model applications. Observations from surface sites located mainly at nearby airports will also be collected to verify remote sensing retrievals and validate model simulations.

# Validation of a GOES satellite based fog algorithm with surface observations

I. Gultepe<sup>1</sup>, G. Isaac and J. Reid

Cloud Physics and Severe Weather Research Division,  
Environment Canada, Toronto, Ontario, M3H 5T4, Canada  
Ismail.Gultepe@ec.gc.ca

## Abstract

In this work, a warm fog detection algorithm based on both GOES-12 satellite observations and model forecast data was tested against reported surface observations. Both GOES-12 satellite observations and output from the Canadian Meteorological Center (CMC) Regional Global Multi-scale Model (GEM) have been used in the analysis. The resolution of the GOES imagery was reduced to 25 km<sup>2</sup>. Hourly forecast data from the 00 UTC GEM model runs were used in the analysis and the output, originally 24 km resolution, was interpolated to the same location and resolution as the satellite imagery. Daytime surface observations from four weather stations in southern Ontario between March and September 2004 were used in the assessment. The total number of cases studied was 198 that included both clear and foggy cases. The calculated hit rates for fog were 26-32%. This included cases when high and mid-level clouds obscured potentially foggy conditions at the surface. After removing the effect of these clouds using an absolute difference of 10°C between model-based surface ( $T_s$ ) and satellite-based cloud top temperatures ( $T_t$ ), the hit rates increased to 55-100%. It is concluded that there were four main reasons for failing to forecast warm fog areas within satellite images: 1) the effect of model-based temperatures, 2) the presence of overlying clouds, 3) the assumption of the absolute  $\Delta T$  criteria, and 4) natural variability at small scales. It is suggested that the accuracy of model-based  $T_s$  should be forecasted to better than 2°C.

---

<sup>1</sup> Dr. Ismail Gultepe, Cloud Physics and Severe Weather Research Division,  
Environment Canada, Toronto, Ontario, M3H 5T4, Canada.  
[Ismail.Gultepe@ec.gc.ca](mailto:Ismail.Gultepe@ec.gc.ca) and tel: 1-416-739-4607

# Fog and low clouds forecasting at Casablanca-Nouasseur

Driss Bari (Direction de la Météorologie Marocaine)

Thierry Bergot (Météo-France / CNRM)

This work takes place in an ongoing research field program involving a collaboration between the meteorological services of Morocco and France. The goal of this research program is to study fog mechanisms and to improve the fog forecasting at the Casablanca-Nouasseur international Airport (Morocco). In fact, the occurrence of fog and low-level stratus clouds plays an important role for the safety of ground and air transportation systems.

Firstly, some investigation of the local fog climatology was undertaken. It was shown that the predominant type of fog is the radiation one.

To improve the forecast of fog and low clouds, the Cobel-Isba numerical system (Bergot et al., *Weather and Forecasting*, **20**, 627-646) has been implemented at Casablanca-Nouasseur airport. This system includes an adaptive assimilation scheme at local scale, a detailed parameterization of soil-atmosphere exchanges and parameterization of turbulence in stable layers in order to correctly simulate the nocturnal atmospheric cooling. The local assimilation scheme has been adapted in order to use classical meteorological observations (METAR and SYNOP). In addition to the hourly standard meteorological data from SYNOP and METAR, the vertical profiles of temperature and specific humidity coming from radiosounding are also used only at 00 UTC.

Various sensitivity tests have been carried out to evaluate the influence of the main input parameters of the model on the predicted fog characteristics, and also the performance of the Cobel-Isba numerical system has been tested by comparing the model results with observations.

Abstract for COST722 Workshop *Input, modelling and understanding the processes in forecasting of fog, visibility and low clouds*