COMBING MSG THERMAL CHANNELS WITH METEOROLOGICAL DATA FOR FOG FORECASTING AND MAPPING OVER DESERT AREAS IN THE UAE

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1. INTRODUCTION

This paper deals with the development of a satellite-based tool for forecasting, detecting and monitoring fog events in the United Arab Emirates. The developed algorithm uses a system of neural networks trained with METEOSAT SEVIRI channels and gridded meteorological data as inputs. Fog over land develops primarily during the late-night and pre-dawn hours. Therefore infrared and thermal channels were used in detecting fog formation at night, while visible channels were used to monitor the extent and density of fog after sunrise. The temperature difference between the two infrared bands (11 µm and 4 µm) forms the basis for fog detection and classification [1]. Neural networks were selected as primary tool due to the complex and non-linear relationship between the multisource inputs (satellite and meteorological data) and the system output (fog presence and fog density). Additionally, neural networks can be easily converted to an automatic detection tool that can be operated without the need for human intervention (after rigorous calibration and validation) [2]. Fog forecasting and detection require the analysis of thermal images from the early night hours. This data is provided by SEVIRI-MSG sensor at 15-minute interval. Also, the detection approach has to take into account the dynamic behavior of fog by considering all resources available (ground-based and satellite-based measurements). Indeed, it was proved in numerous studies that the addition of ground-based measurements of meteorological parameters to satellite-based measurement increases the accuracy of prediction and detection models [3-12].

2. METHODOLOGY

Fog forecasting is performed before sunrise using multi-temporal thermal imagery collected at night. The thermal-based forecasting algorithm will be operated from midnight to one-hour before sunrise. The algorithm will be fed with thermal bands images received each 15 minutes from the European Geostationary Satellite Meteosat-SEVIRI. The satellite images will not be enough to build a proper fog warning system. Therefore, meteorological data provided by some local weather stations spread over the UAE was gridded and used in the forecasting phase. It was found that, during foggy days, the humidity doesn't fall below 80% and the visibility doesn't exceed 0.5 km/m.

In order to avoid any spatial extrapolation of meteorological data during the gridding process, the study area selected for neural network training and calibration was located between three weather stations. These stations are located in Dubai, Al-Ain and Abu Dhabi. 10 neural networks were trained and calibrated with different sets of foggy and non-foggy scenes. In order to avoid the randomness of a single net output, the final system decision is based on the outcome of all 10 nets.

3. PRELIMENARY RESULTS AND DISCUSSION

The maps presented in figure 1 show the simulation of the trained system during a foggy day (14^{th} of December 2008). During that day, the system was able to identify the area covered with fog (brown), where the majority of the ten nets have correctly identified all foggy pixels over land. The sea pixels were masked out (green) during this test. The neural-network system was also tested under cloudy conditions. The maps presented in figure 2 show the simulation output during a non-foggy and cloudy day (22^{nd} of February 2009). It can be noticed that the thermal difference can give a clear identification to separate clouds with high altitude than low altitude fog. The last output was the critical validation of the system since the analysis showed how there might be a misclassification between clear and foggy days due to the overlap in the thermal difference generally observed during non-foggy days. The results of the third simulation (clear day) are presented in figure 3 (2^{nd} of February 2009).

The system performance was also evaluated on pixel-by-pixel basis. The confusion matrix presented in Table 1 was generated by averaging the output of the 10 nets. All nets have one hidden layer and were trained with both thermal difference and the humidity. The confusion matrix shows an overall accuracy of 95% with misclassification not exceeding 5% for both fog and non-fog pixels. It's important to mention here that these results were obtained over a homogeneous area. This test has also shown that the use of humidity as additional input has improved the overall accuracy by an average of 10%.

Table 1: System accuracy validation

10 NNs	Fog	No Fog
Fog	**95.74**	**4.26**
No Fog	**5.66**	**94.34**
Accuracy	**95.04**	

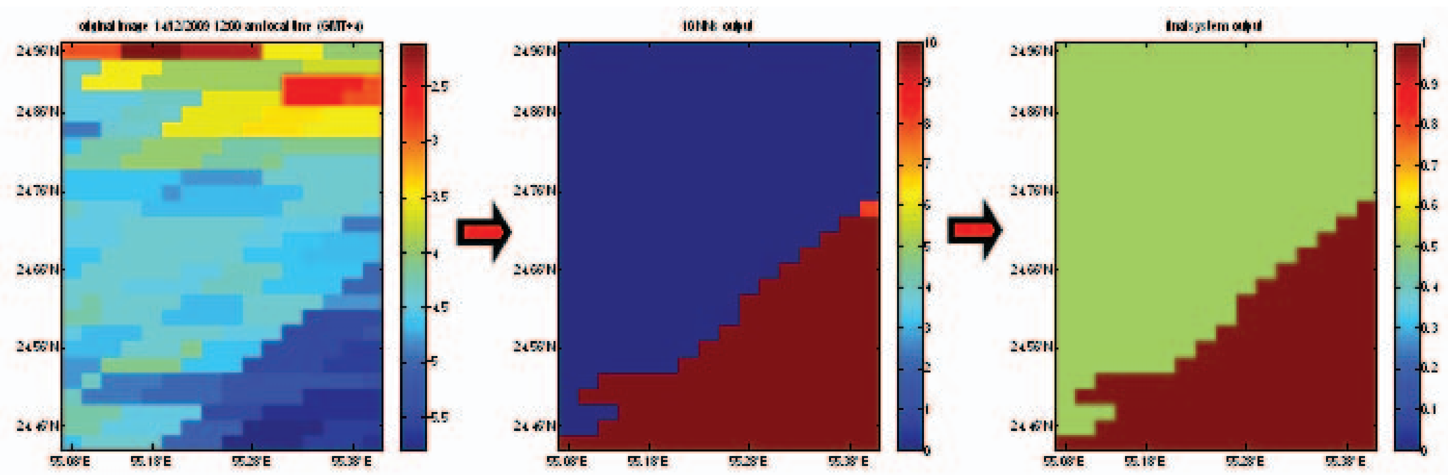

Figure 1: Foggy day

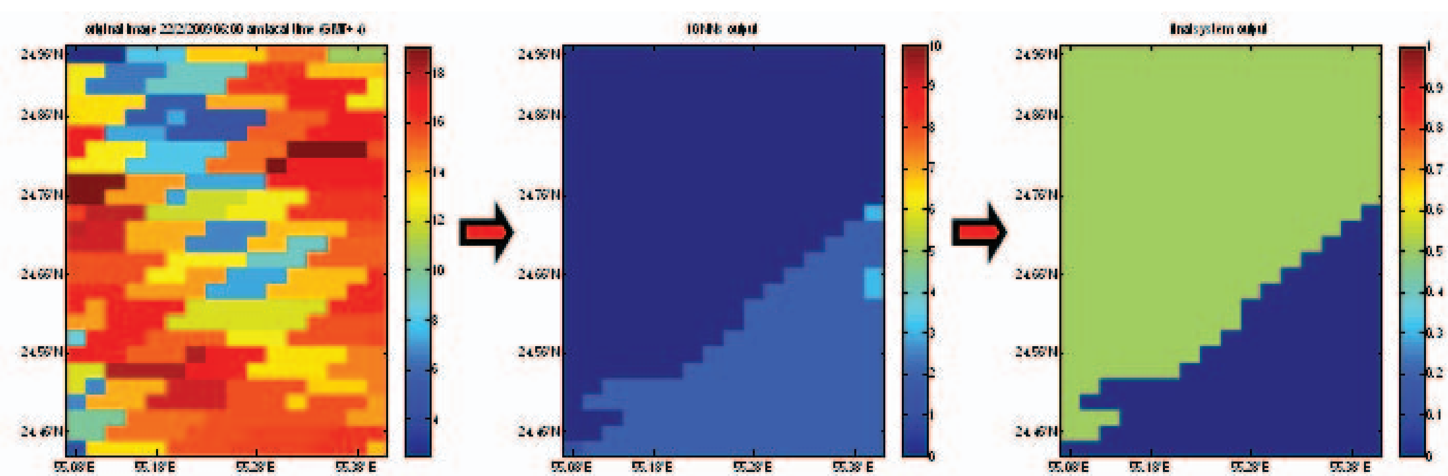

Figure 2: Cloudy day

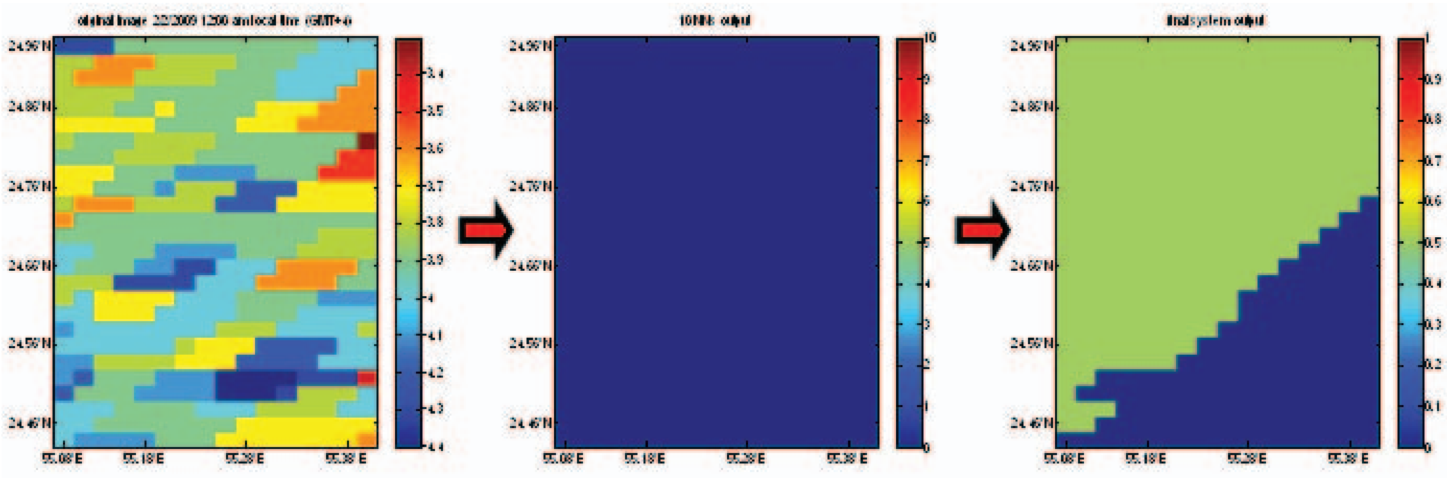

Figure 3: Clear day

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