Project "Erlkönig": the detection of fog along motorways

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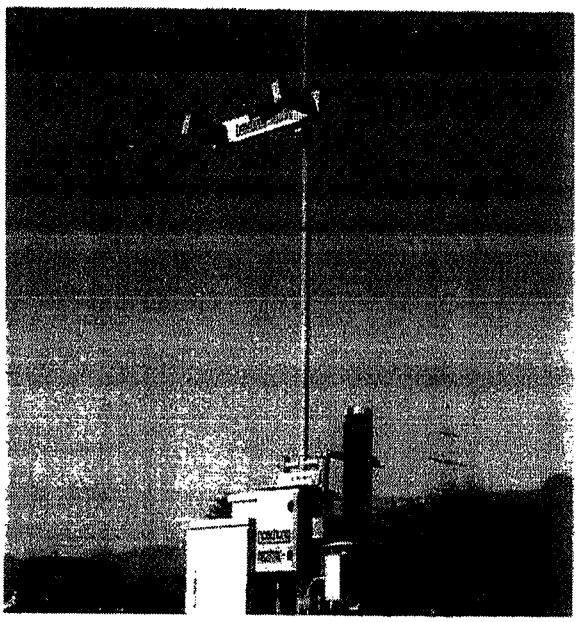
Abstract

Fog induced visibility reduction along main roads often leads to spectacular multiple crashes. Advanced warnings can be of help in situations where visibility loss is sudden and unexpected. In the project "Elf King" (named after a tragic poem "Erlkönig" by Goethe) two types of fog sensors were tested along a stretch of motorway in the Swiss Plateau during the winter half years of 1995/6 and 1996/7. One of the sensors works on the classical principle in which light is back-scattered by the fog droplets. But it is the second, revolutionary type of sensor which makes the project unique. It comprises a special hygrometer which allows the liquid water content in the form of droplets to be measured thermodynamically. The fog density can be derived from these. Since the measurements do not require the equipment to be optical cleanly, it is very robust and can function over long periods without maintenance. Reference data for the comparison was supplied by visual observation. In the two winter periods of the project both systems provided results which compared favourably with the visibility measured by eye.

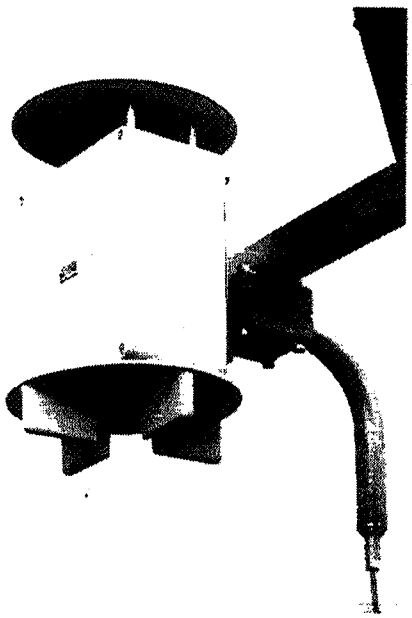
1. Configuration for the trials

1.1 Instrumentation

The instrument which measured visibility optically, illuminates a path of some metres or tens of metres with a short wave infrared light source. The light is attenuated very little by clear air. If the illuminated volume contains particles of solid or liquid material (e.g. fog droplets), then these scatter the light. A part of the scattered light reaches a light detector which is mounted next to the light source. The intensity of the light detected is transformed by an in-built computer into a visibility reading of between a few metres and several kilometres.



Visibility Sensor



Thermohygrometer THYGAN

The second instrument taking part in the trials was the THYGAN thermohygrometer. The sensors which measure the air temperature and dew point accurately and reliably, are artificially ventilated. The dew point is determined by means of a (cooled) dew point mirror. Unwanted side effects due to dampness, icing and soiling are reduced to such an extent that the quality of the measurements remains very high even under difficult ambient conditions. This is achieved by heating both the sensors and their housing depending on the air temperature and humidity, and by automatic mechanical cleaning of the surface of the mirror. As a result the instrument requires no maintenance for several years.

Due to the method of taking the measurements, recalibration of the equipment is also unnecessary. THYGAN is capable of measuring the humidity of the air accurately even under near-saturated conditions, i.e. at the limit at which fog starts to form. Due to its construction it is even able to detect fog.

The air sample is passed through the instrument's sensor tube. As it enters the tube its temperature is measured using an air thermometer. A small part of the sample flows through a special measuring chamber inside the instrument in which the mirror is situated. When the ambient humidity is high, all the surfaces are warmed by a computer controlled heating system. The air sample is warmed at these surfaces and any fog droplets which are present evaporate. In that part of the sample which is not heated, the air temperature and dew point are the same (saturation, 100% relative humidity). Because the fog droplets in the remainder of the sample are evaporated *before* it passes over the mirror, the dew point temperature indicated by the mirror is higher than the air temperature of that sample prior to being warmed. Hence the humidity calculated from these measurements reaches values in excess of 100%. This allows fog to be detected with certainty.

1.2 Location of the experiment

The Swiss Plateau lies between the Alps (to the south) and the Jura mountains (to the north). Under certain conditions this has a canalising effect on the air, whilst under other weather situations the mountains act as an efficient barrier to thr air flow. The precence of surface water in the

Installation of the instruments for the "Erlkönig" experiment at motorway A1

form of lakes and rivers supplies the moisture which enhances the formation of fog over large areas of the plateau under stable winter weather regimes. Both widespread fog and local banks of fog occur. The location for the project was chosen on the basis of long term meteorological observation and the experience of the motorway maintenance service. It lies close to an exit of the Swiss motorway A1 in the Canton of Solothurn. The instruments are installed 5 m from the hard shoulder on grass covered terrain. The data are transferred to a motorway maintenance depot 10 km from the site where they are recorded. Posts were erected at 25 m intervals to allow the visibility to be measured by eye.

2. The trials themselves

2.1 Data collection programme

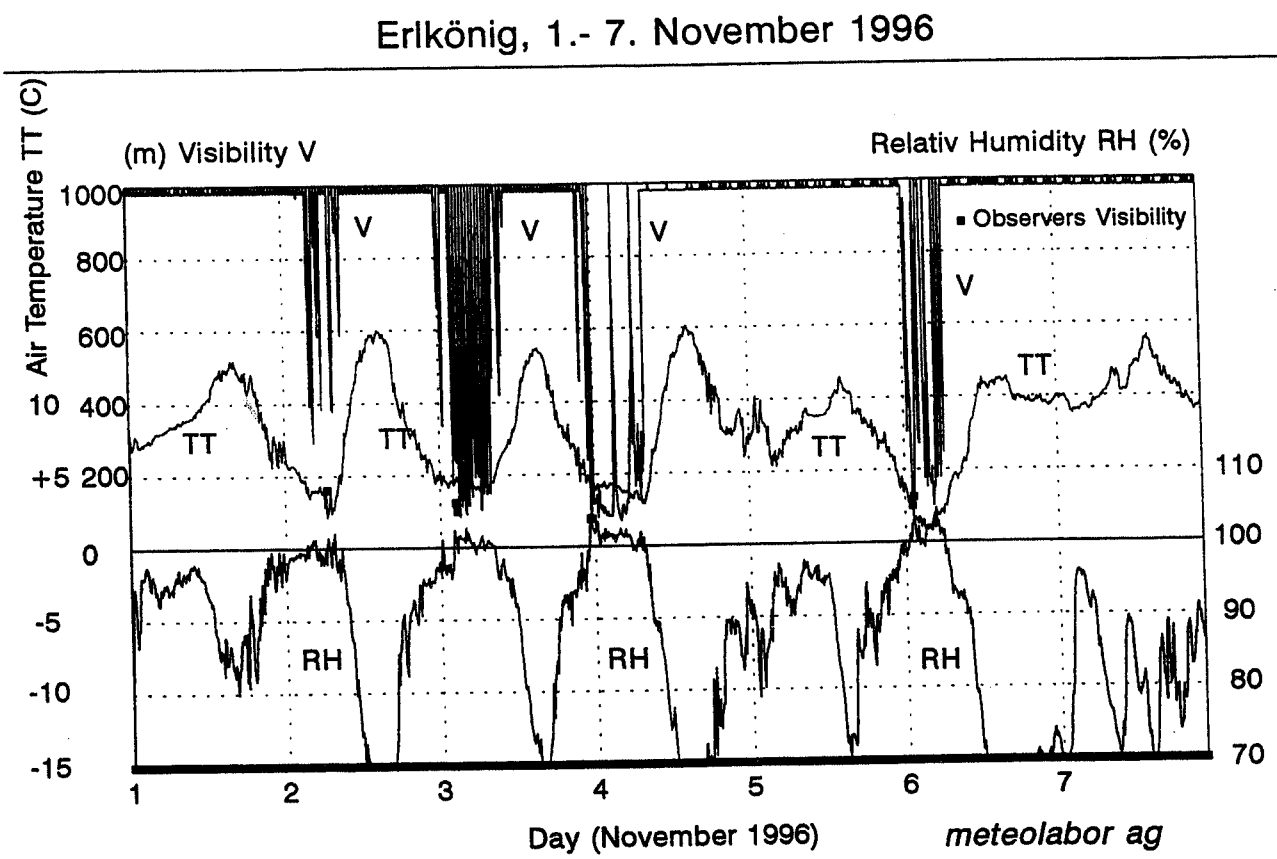
The instruments were in operation from October to March in the two winter seasons 1995/6 and 1996/7. The data packets from the two instruments registered by the recording system at ten minute intervals comprised:

Visibility meter	Visibility in metres
THYGAN	Air temperature to nearest 0.1°C
THYGAN	Dew point temperature to nearest 0.1°C
THYGAN	Relative humidity to nearest 0.1%
THYGAN	Status code (operational state)

Motorway depot staff measured the visibility by eye as part of their normal work. During the night and over holiday periods this work was entrusted to a volunteer.

2.2 Evaluation and results observations

The evaluation of the "Erlkönig" data supported the results expected in advance. The diagram below shows typical variations in the recorded parameters, in this case during the first week of November 1996.



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The relationship between the visibility V measured optically and the relative humidity RH is particularly clear at those times when the air reaches saturation. In general the visibility measured by eye agrees with the automatic measurements.

The differing characteristics of the two procedures are also clearly evident. While the distance measured optically reacts very strongly to the presence of fog droplets, the variations in the hygrometric measurements are much less intensive. As a result the detection of fog with a hygrometric instrument is only possible when measurements close to saturation are exact and long time stability is assured. Many of the humidity sensors currently on the market are therefore not suitable for this application.

3. Interpretation and future developments

The project "Erlkönig" was successful. It demonstrates the viability of a new method for detecting fog.

Both procedures make single point measurements. Particularly in the case of optical instruments, the quantitative measurements made over a distance of less then one metre are extrapolated to give a visibility of hundreds of metres! But in many cases where fog banks occur locally, the visibility measured at a point tend to be random and certainly not representative of conditions over a larger area. The problem applies in principle equally to both sensors. In the case of the hygrometric detection of fog however, an additional factor compensates somewhat for this problem. The very exact relative humidity measurement allows an estimate to be made of the danger of fog or its probability. Combined with addition sources of information the presence of fog can be reliably predicted.