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The importance of fog . . .

and how to measure it

At some time in our lives most of us will be affected by reduced visibility from fog; when our flight has been grounded or difficulty when driving on roads or navigating waterways. Poor visibility conditions not only require greater concentration on the task at hand, which can lead to increased stress levels, but also have a cost implication. The amount of money lost annually around the world due to time delays or damage caused by reduced visibility are beyond normal calculation.

Visibility, in terms of general meteorological applications, is the horizontal distance that an average human eye, at 2 m height above the ground, can distinguish the contrast between a dark object in the distance against a bright background. This distance is then considered to be the day time visibility at that location and a simple formula to determine this is known as Koschmieder's Law.

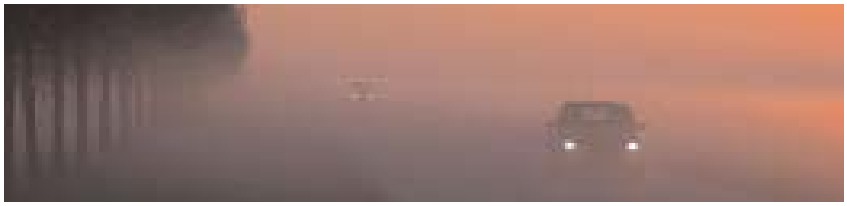
This contrast of a dark object against a light background will vary from one location to another depending on the topography and conditions, even over a few miles not to mention around the world. Because of this the 'standard' environment is defined as: a cloudless day at 12:00 noon, during high summer, at the equator in a location with a very flat topography and a light, consistent coloured surface with a strongly contrasting large forest covered hillside in the distance.

The method used to determine night time visibility is based on the contrast between a bright point light source against a dark or black background and the mathematical representation of this is known as Allard's Law.

Visibility can be reduced by heavy rainfall, dust or even smoke but the largest cause is from the naturally occurring weather phenomenon of fog or haze.

There are generally accepted to be five types of naturally occurring fog: radiation fog, frontal fog, orographic fog, advection fog and steam fog. For a full definition of each of these and how they are formed you may like to look at American Meteorological Society's Online Glossary of Meteorology at: http://amsglossary.allenpress.com /glossary.

For our purposes here, fog is defined as the visible portion of small water droplets suspended in the atmosphere on or near the earth's surface. It is caused by the reduction of the air temperature down to or near the dewpoint and reduces visibility to 1 km or less. Haze can be described as fog that has a lower relative humidity and does not reduce visibility as much, generally from 10 km down to a minimum of 1 km. Beyond 10 km the visibility is considered to be good.



Visibility can be measured by several methods although all are partially limited to some degree. The most common and readily available methods are by: trained human visual observers, transmissometers and forward scatter / backscatter meters. There are also instruments that take samples of the air volume and look at the scattering capability of the chemical constituents of that air sample to determine visibility. However, for the purpose of this article we will ignore these.

- the trained human observer

The human observation of visibility is naturally subjective and can be costly if this method is used for more than a few hours and in more than one location. However, humans do have an incredible ability to process information and evaluate the continuously changing face of the weather as it passes any location and are therefore still the standard to which all other visibility measurements are compared.

However, no two human eyes are the same and even the ability to determine contrast, which is known as the minimal liminal contrast threshold, can vary from values of 0.018 to over 0.042 and is one of the factors that has a major impact on visibility calculations.

- transmissometers

transmissometers are the instrument reference equivalent to humans as they look at the total extinction of light over a relatively short predetermined opposed path using a visual light source such as halogen or xenon. They do not determine *what* is scattering light away from the receiver but can determine *how much* is being scattered away and then relate this information to visibility for that particular path length or a short multiple thereof.

As with any instrument of reference quality, there needs to be considerable care taken with installation and calibration as well as ensuring that conditions remain constant. For example if the measurement path is not exactly opposed or there are electrical deviations of components due to temperature changes, the accuracy of the instrument will be affected. Additionally, transmissometers tend to be calibrated to perform best in dry conditions and have different characteristics in precipitation, which are hard to factor into the measurement values.

Cost is also an important point when considering this technology. The cost of a transmissometer is over a hundred thousand pounds sterling, which is justified for a reference class instrument used on large airports with important safety implications. However, for short term projects or where consideration of visibility measurements is only a small factor this price is prohibitive.

- forward and backscatter meters

Forward and backscatter meter technology has come a significant way towards a suitable compromise of acceptable performance at low cost. Both types of scattering meters use the relationship of the amount of light received at a known given angle from a transmitted light source (mostly infra-red) to determine the extinction coefficient (EXCO) of the atmosphere which is then used to calculate visibility (using Allard's or Koschmieder's law). These sensors are compact and reliable as well as being very economical at only a few thousand pounds per unit. They have the limitation that they are still only able to measure a relatively small sample volume and are assuming that this is representative of the area around that sample volume. For most cases this is fine but when there are fast moving fog banks rolling through the sample volume the measurements will not be truly representative of the actual conditions. Nevertheless for the level of technology available today these instruments provide an increasingly good price and performance capability that work in most environmental conditions.

Taking into consideration all three methods human observation still has the edge because of the ability to adapt to changing conditions, but when time and costs are restricted measurements by automated, objective equipment, with their ever increasing capabilities, can provide a better solution.

There are several sources for more information:

Book:
- **Vision through the atmosphere by W. E. Knowles Middleton University of Toronto Press**

Websites:
- **Met glossary http://amsglossary.allenpress.com /glossary.**
- **Royal Met Society www.royal-met-soc.org.uk**
- **UK Met Office www.met-office.gov.uk**

All these links are also available from our own site:

- **www.biral.com/newsletter**

If you would like to find out more about automated visibility measurements please contact Biral.

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