The Characteristics of Marine Fog Offshore Newfoundland and Labrador

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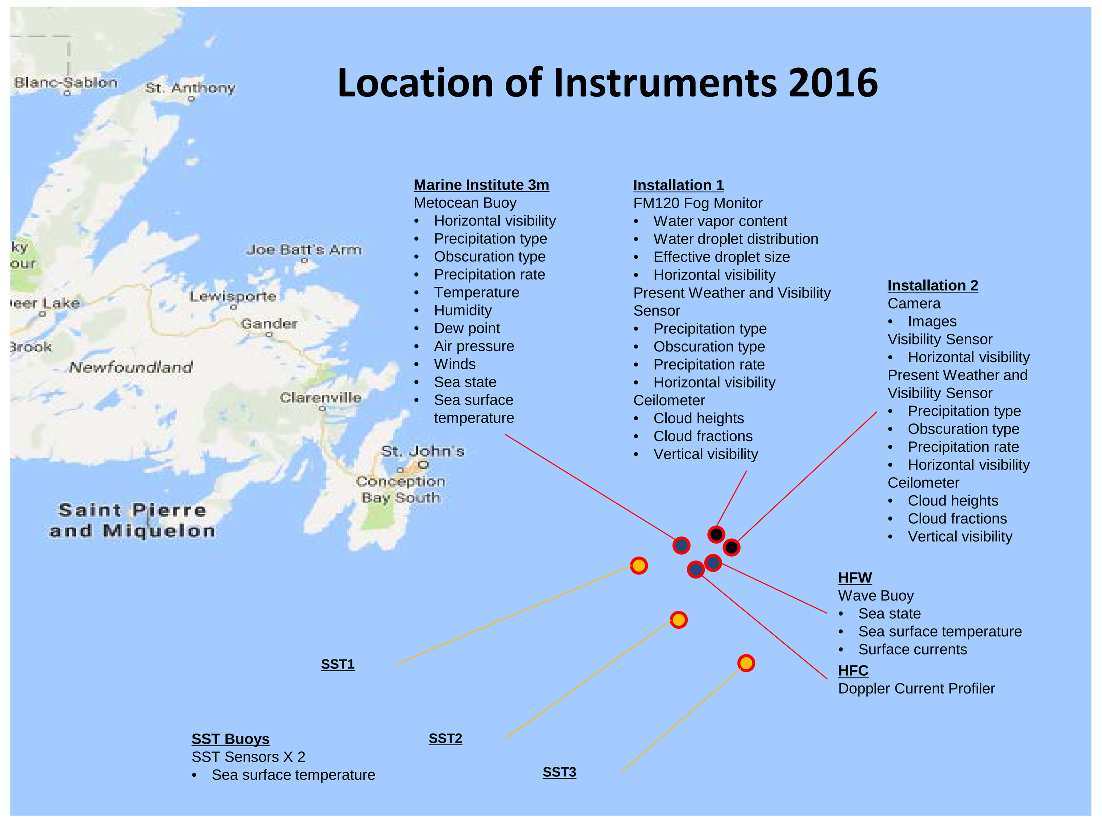
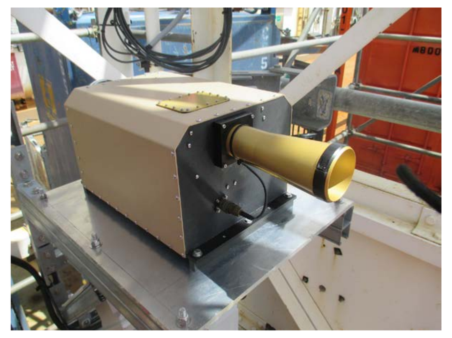
INTRODUCTION

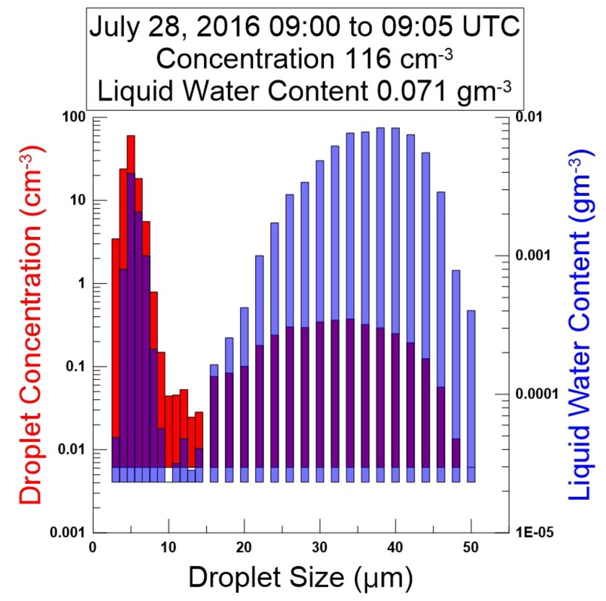
A workshop on Metocean Monitoring and Forecasting for the Newfoundland & Labrador Offshore held 22-24 September 2014, identified reduced visibility in fog and high seas as being the most significant metocean issues affecting operations in this area. The recommendations of this Workshop helped in forming the workscope of a multi-phase Metocean Research and Development Project which is currently ongoing. The area offshore Newfoundland & Labrador has one of the highest frequency of fog worldwide (Dorman et al., 2017). The fog usually covers a large area and can persist for days..

The location of the instruments in 2016 is shown below. For 2017 Installation 2 was moved and the SST Buoys were not deployed. For this study data from Installation 1 and the Marine Institute Buoy were used.

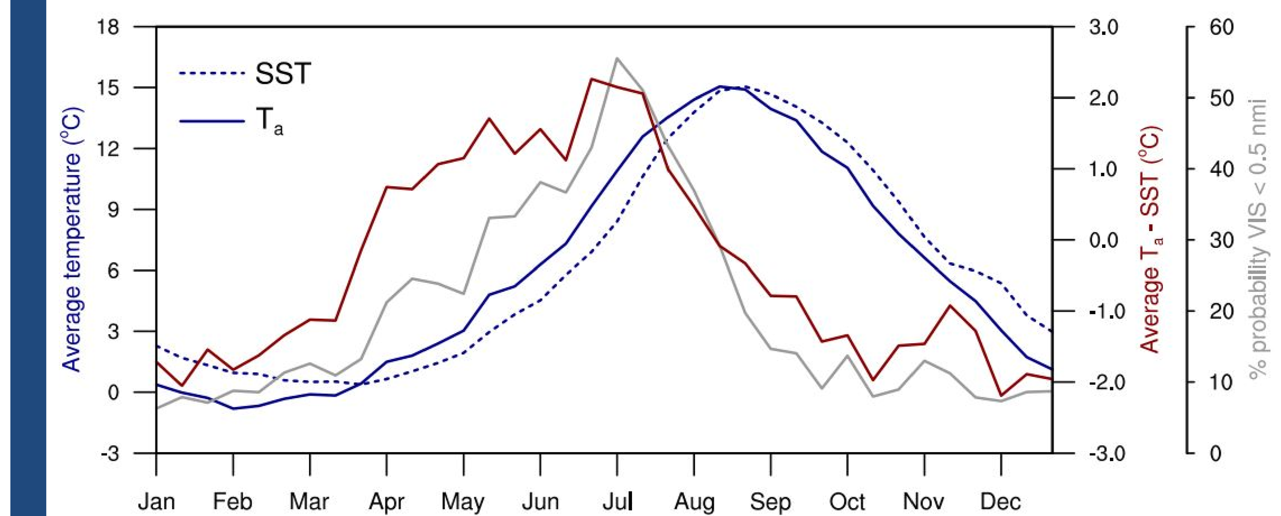


Data from a DMT Fog Monitor on Installation 1 is used and it was placed on the platform so that it could sample air coming from 180 to 270°. Photos of the instrument and a sample of the data are shown below. This equipment is being used to characterize the microphysics of the fog offshore and to develop improved forecast models of visibility. Current models are not accurate both in forecasting fog and the intensity of the fog.





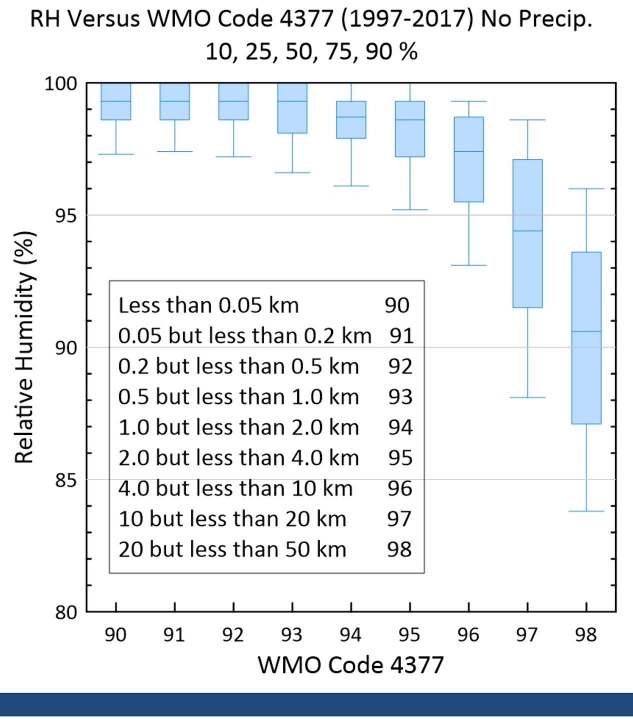
CLIMATOLOGY OF FOG OFFSHORE

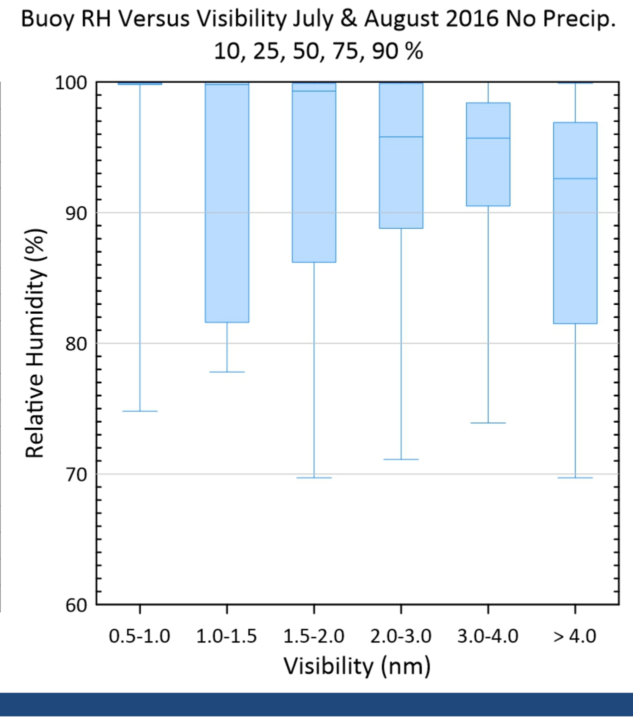


Using METAR observations from Installation 1, a climatology of the fog was produced. It shows a peak frequency of fog (visibility < 0.5 nm) in July near 50% of the time with a minimum in December. The air temperature minus sea surface temperature tracks the fog probability. There is **no diurnal variation** in fog frequency. This is primarily advection fog formed as air moves from the warm Gulf Steam over the Labrador Current. The dominant wind direction when fog occurs is from the SW. Winds as measured on Installation 1 typically are 20 to 30 kts at 139m.

VISIBILITY PARAMETERIZATION AS A FUNCTION OF RH

Some papers (e.g. Gultepe and Milbrandt, 2010; Boudala et al., 2012) have suggested that visibility can be parameterized as a function of relative humidity (RH). In order to test this method, the Installation 1 METAR observations were plotted against visibility, as were the Marine Institute 3m Buoy measurements of 2016 (see below). RH is not a good discriminator for visibility "intensity" remaining near 100% when visibilities are low. This a agrees with the results of Korolev and Isaac (2006) who showed that when cloud droplets are present the in-situ relative humidity always approaches 100%.





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VISIBILITY PARAMETERIZATION AS A FUNCTION OF LWC

Visibility has also been parameterized as a function of cloud liquid water content (LWC). The Stoelinga and Warner (1999) scheme has been used in many U.S. models. It is based on the measurements of Kunkel (1984) who proposed a relationship as follows:

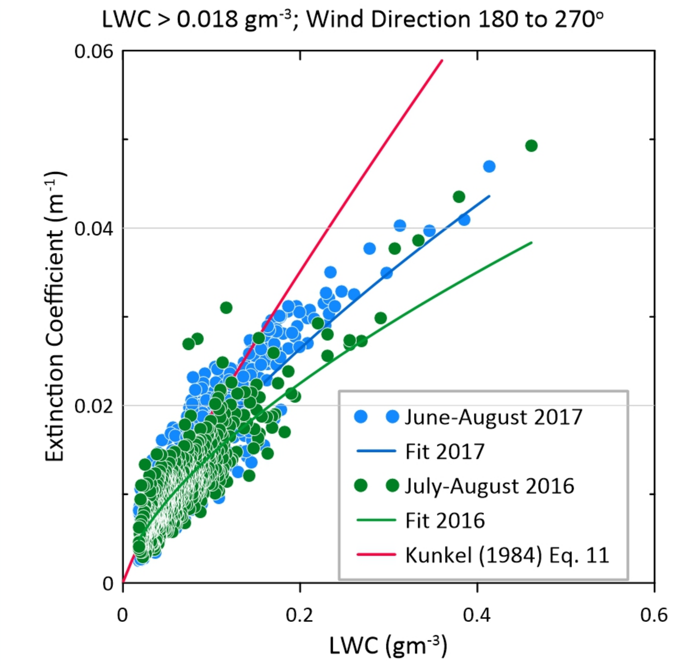
$$\beta = 144.7\ (LWC)^{0.88}$$

Where the extinction coefficient (β) can be related to the daytime visibility V_k as follows:

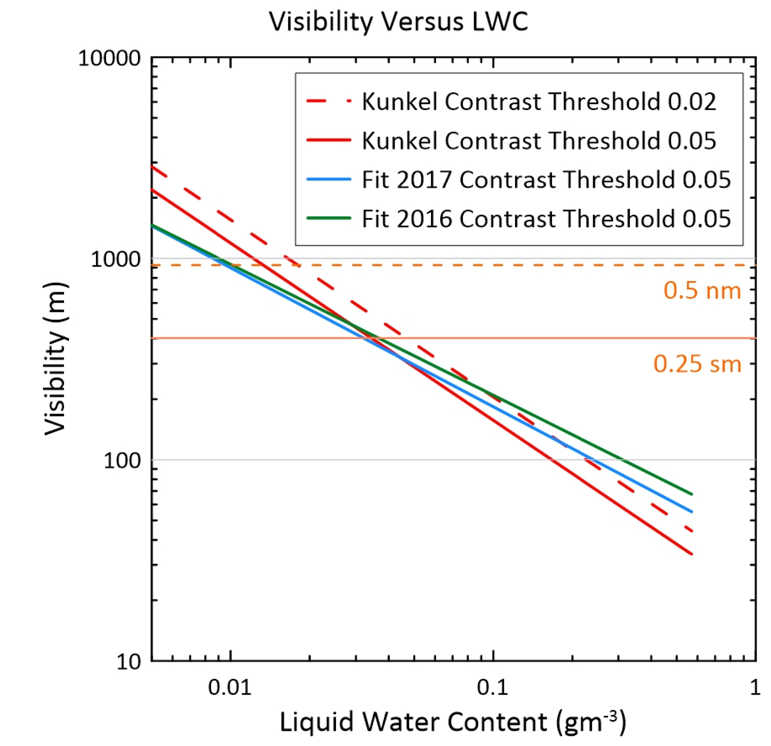
$$V_k = \frac{-\ln(\varepsilon)}{\beta} \qquad \beta = \frac{3LWC}{\rho_w D_{eff}} \qquad LWC = \rho_w N \frac{\pi}{6} D_{eff}^{\ 3}$$

where D_{eff} is the effective diameter of the droplets, N is the droplet concentration and ε is the contrast threshold normally taken to be 0.05.

Analysis of the FM-120 data for 2016 and 2017 show that the extinction and thus visibility can be reasonably parameterized as a function of LWC, in a similar manner as Kunkel (1884).



<u>Fit June –August 2017</u>
$\beta = 0.080\ LWC^{0.69}$ (LWC > 0.018 gm^{-3})
$\beta = 0.082\ LWC^{0.70}$ (LWC > 0.005 gm^{-3})
1056 points; 176 h
<u>Fit July-August 2016</u>
$\beta = 0.063\ LWC^{0.64}$(LWC > 0.018 gm^{-3})
$\beta = 0.062\ LWC^{0.63}$ (LWC > 0.005 gm^{-3})
858 points; 143 h
<u>Kunkel (1984)</u>
$\beta = 0.144\ LWC^{0.88}$ (LWC > 0.018 gm^{-3})
1400 points; 90 h



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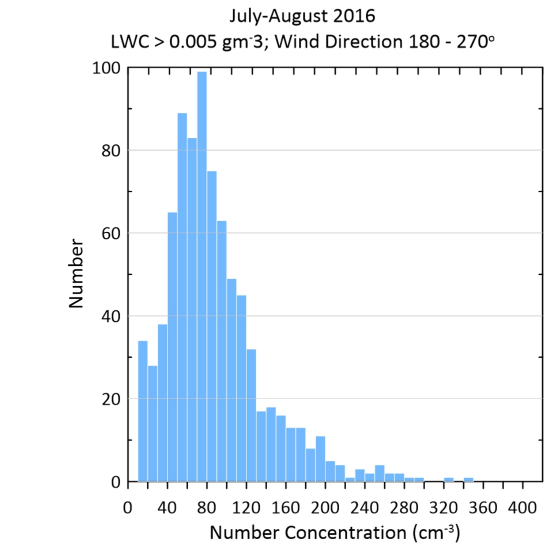
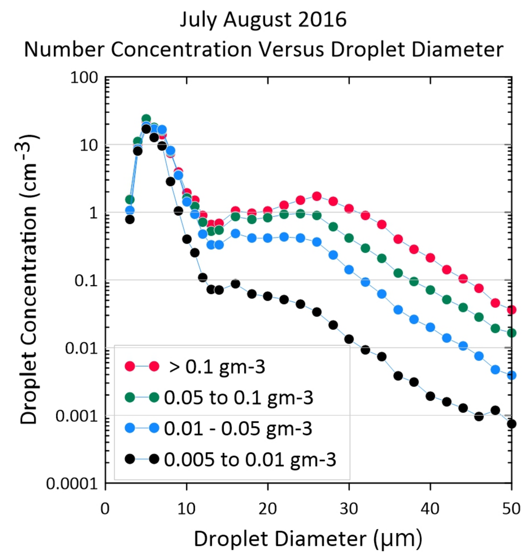
MICROPHYSICS OF MARINE FOG

The 2016 droplet number concentration histogram shows a broad distribution with a median concentration of 76 cm^{-3} and an associated median LWC of 0.049 g m^{-3} for 143 h of in-fog measurements during July and August. The 2017 median values for N and LWC were 97 cm^{-3} and 0.057 g m^{-3} respectively for 176 h of measurements during June to August (not shown). The droplet size distribution, grouped by LWC, shows that the bimodal nature of the distribution grows as the LWC increases.





CONCLUSIONS

The ultimate goal is to model both the droplet number concentration and liquid water content and thus forecast visibility in a prognostic manner, similar to the efforts of Wilkinson et al. (2013). In order to do this the aerosol needs to be characterized and the physics controlling droplet number concentration determined.

The physics controlling the growth and dissipation of the fog droplets also needs to be effectively modeled.

Work is ongoing to further characterize the fog and improve forecasts of visibility.

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