ICE-PPR SAWG, 21/19/2021

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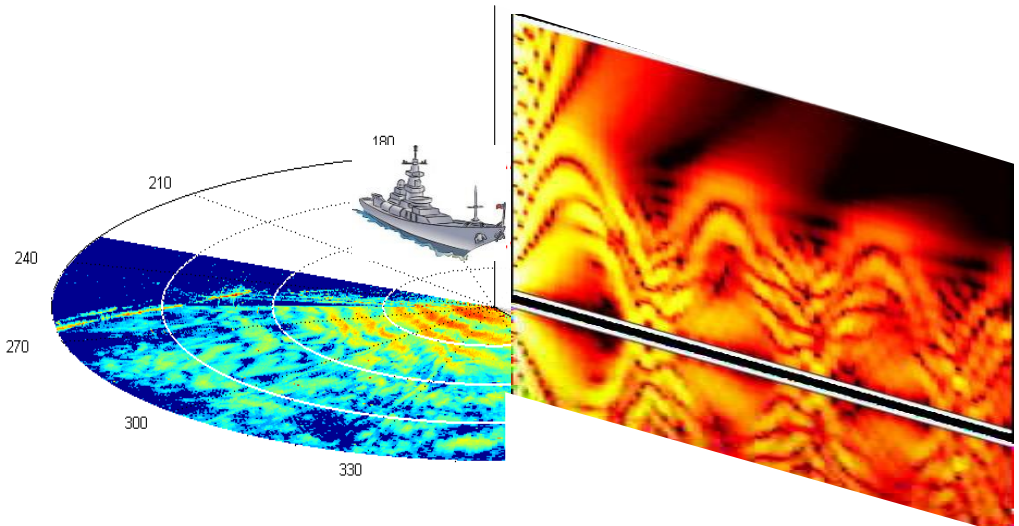
Tech Suggestions for Finnish PA proposal for Studies of Ducting in the Arctic

Ducting has been studied outside the Arctic, and is generally a result of an atmospheric inversion, including inversions of humidity and temperature.

Previous ONR studies have included the Equatorial Mixing Experiment (Oct. 2012) and Trident Warrior (July 2013)(PI Ken Melville, SIO), and CASPER, (Coupled Air-Sea Processes & EM Ducting Research) projects East (Oct./Nov. 2015) & West (Sept./Oct.2017)(PI Qing Wang, NPS), data from those studies has input, in real-time to the NPS/NRL/SIO Coupled Ocean/Atmosphere Prediction System (COAMPS) model.



- Evaporative duct prediction has been based on the Monin-Obukhov Similarity Theory (MOST), assumes T & rH profiles are stationary & homogenous - based on terrestrial measurements. That is often not the case over the ocean. MOST fails particularly in a highly unstable atmosphere, but even moreso in highly stable conditions. The latter conditions are more likely in the Arctic due to ice cover and fogs, and the former in the presence of leads.
- The problem has been a lack of high resolution (Order 1km) data to understand anomalies and improve models.

Equations and Conditions for EM Propagation in Marine Atmospheric Boundary Layer

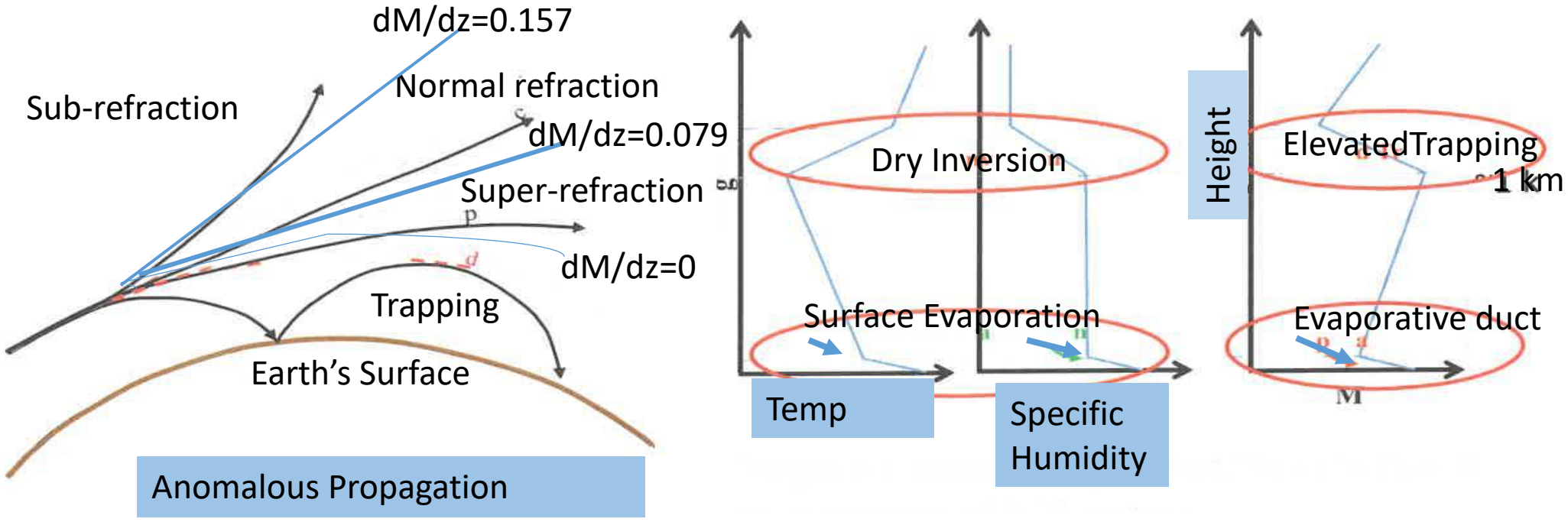
Marine Atmosphere

p, e, T: Press., H20 vapor press., temp.

$$M = (77.6/T)(p + 4810(e/T)) + (z/Re)x10^{6}$$

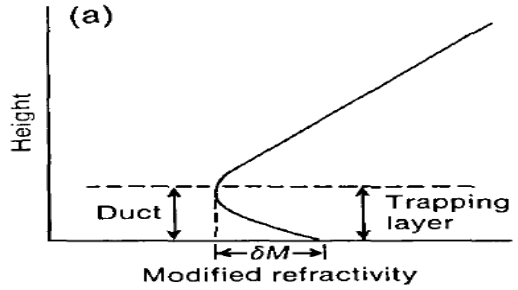
EM Propagation

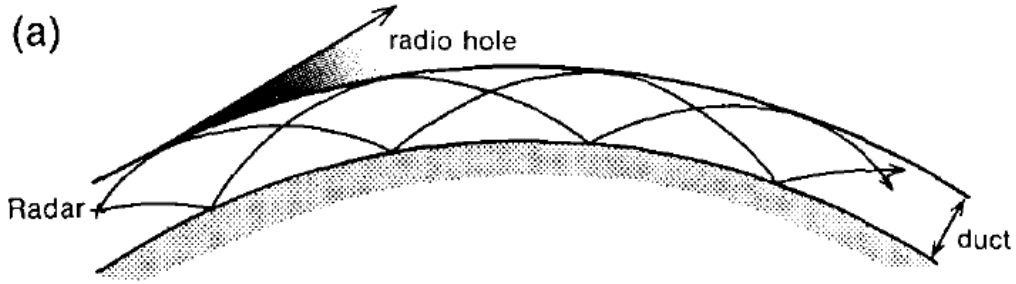
Modified Refractivity (M)



ICE-PPR SAWG, 21/19/2021: Types of Anomalous Propagation

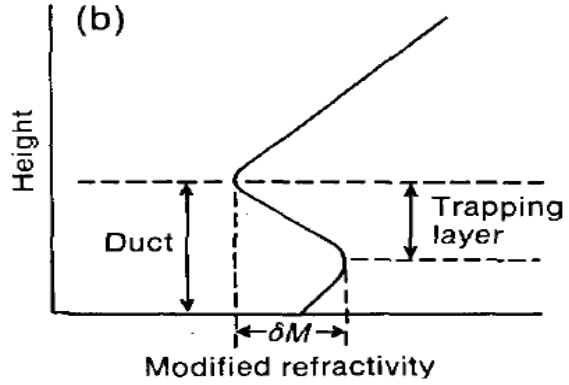
Evaporation Duct

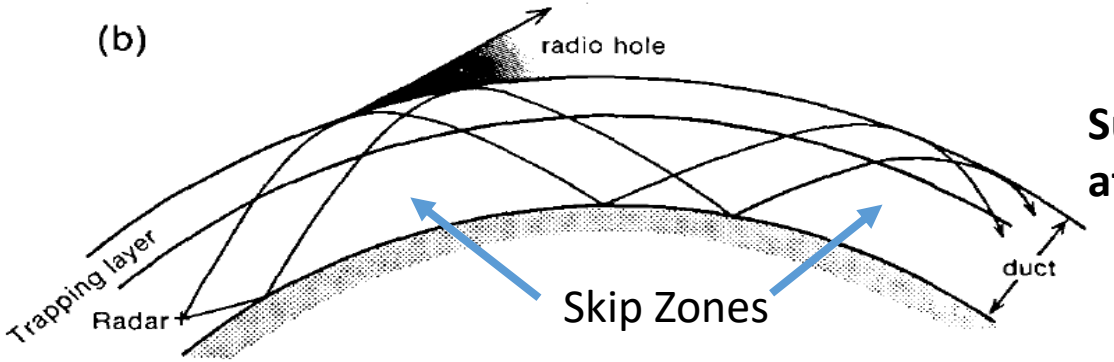




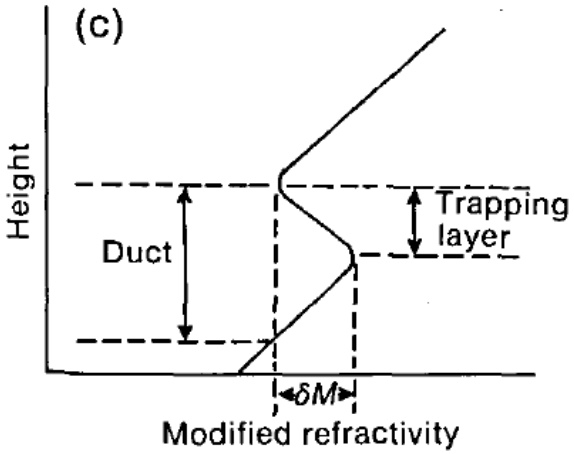
Enhanced signal level within duct
Reduced signal level above and below duct (radar hole)

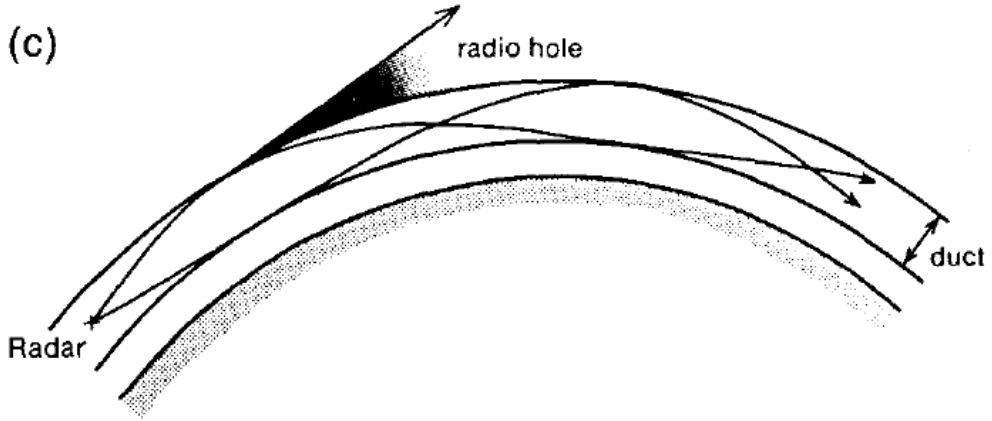
Elevated Trapping Layer





Surface-based duct, affects surface operations

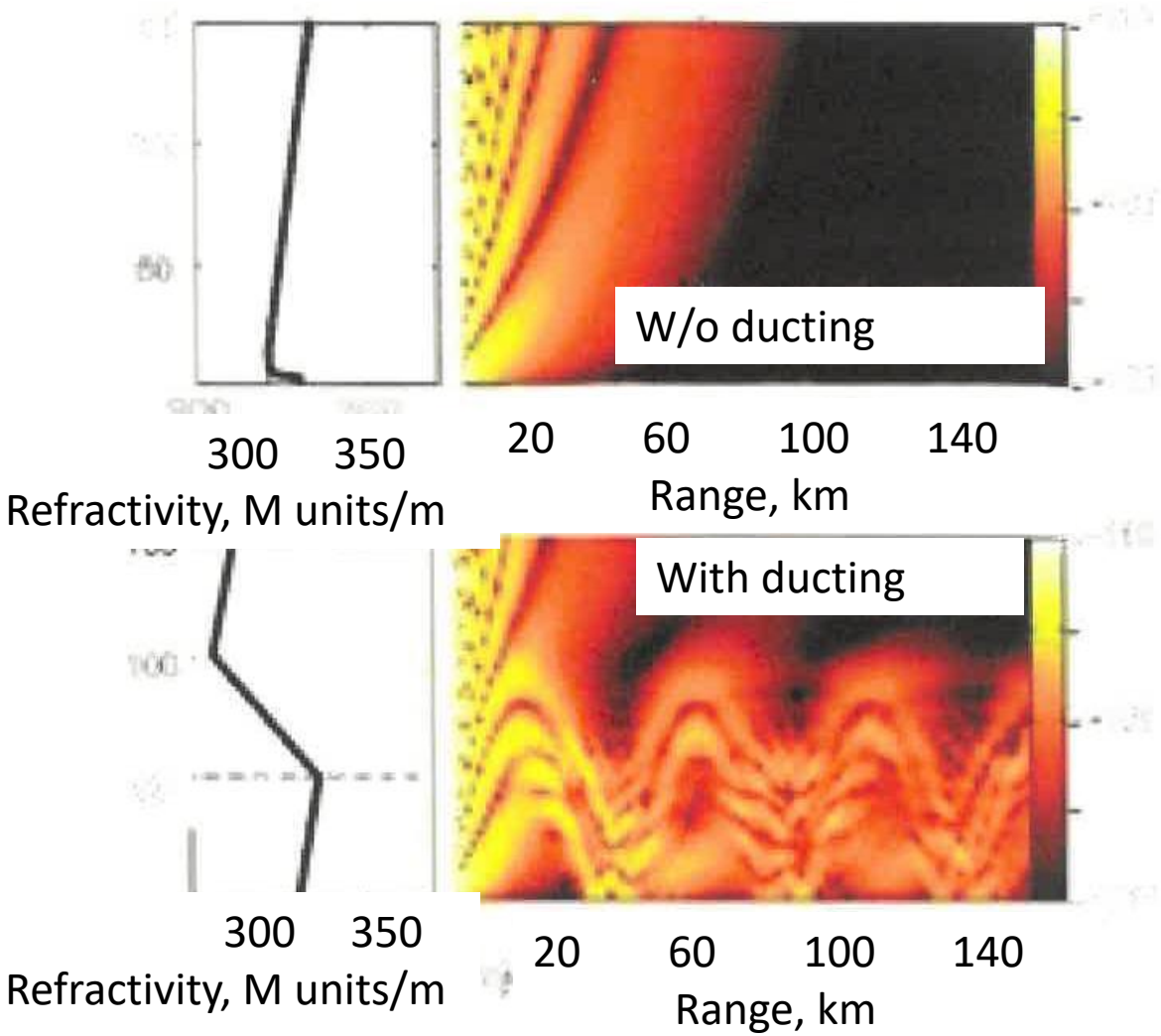




Elevated Duct, affects low level flying ops

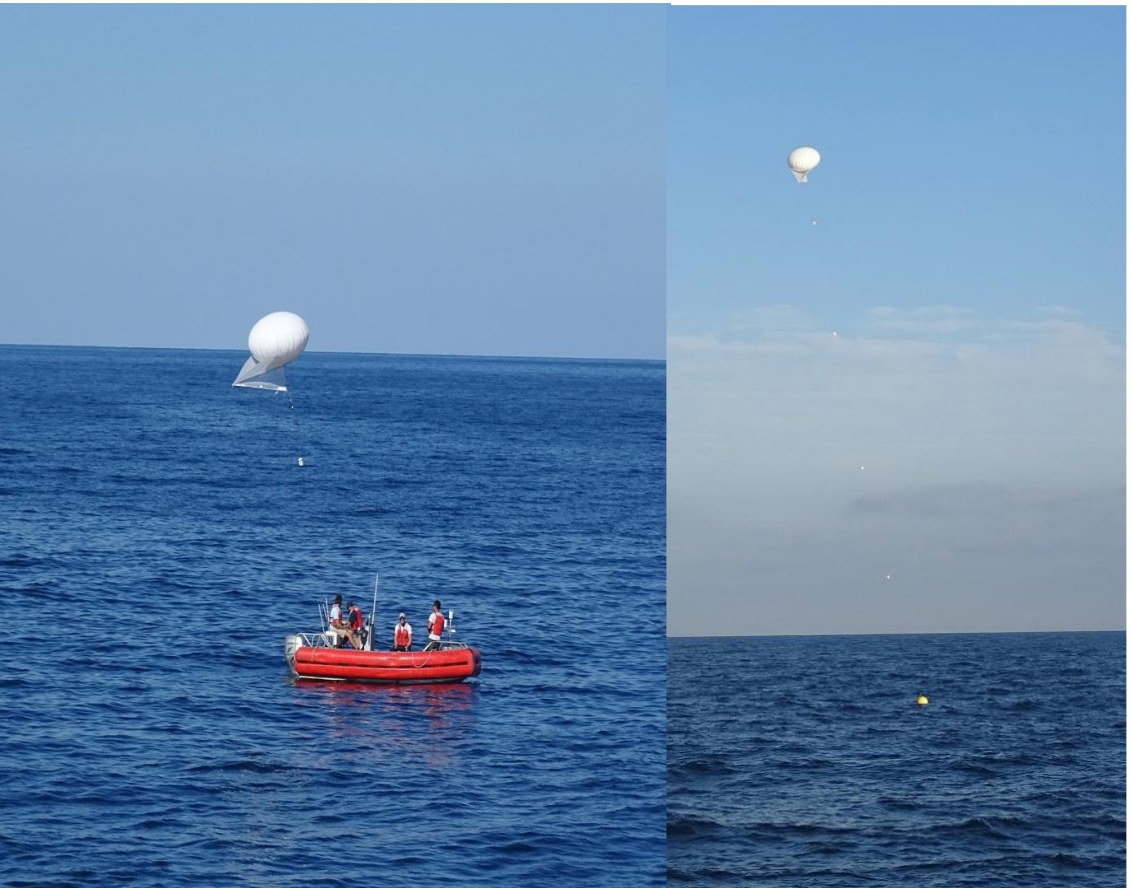
From: Turton, et al., 1988

Inversions in the M-profile with altitude lead to EM trapping in an evaporation duct (Graphic from L. Lenain, SIO)

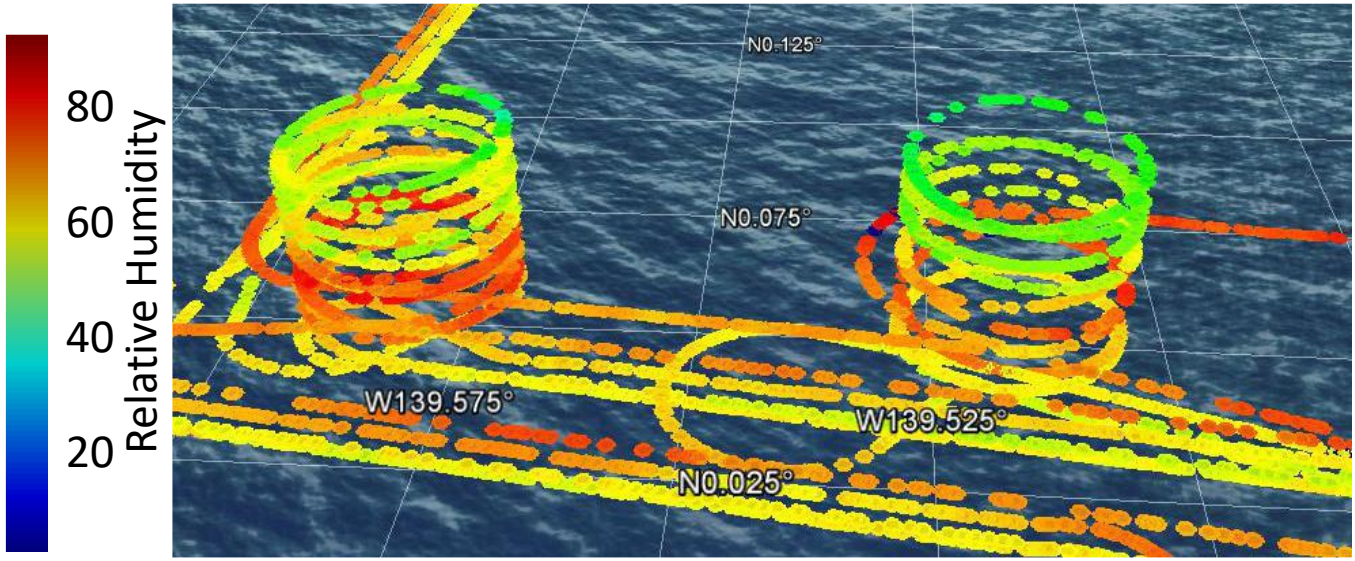


For ducting studies you need to have vertical profiling of T and rH. This has been done by Helikites, which can be used for profiling, and then can be deployed at an inversion altitude for monitoring. Or, unmanned aircraft systems can be used for profiling vertically, by flying in vertical spirals.

Allsopp Helikite for rH profiling from small boat, or at fixed altitude monitoring from drift buoy (Q.Wang,2017)



ScanEagle rH vertical profiles to 1400m altitude, showing boundary layer at 400m. Equatorial Mixing Expt, Oct. 2012, Ben Reineman, SIO.



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