1. Introduction
Due to the cold temperatures in the Arctic winters, very little water vapour is present in the atmosphere making it difficult to measure and up to recently there has only been measurements at a small number of ground-based stations. Satellite measurements of water vapour have been able to improve the spatial resolution, but still have had their own limitations. Infrared measurements of water vapour are only possible in cloud-free conditions and microwave measurements are affected by thermal emission from the surface. A technique used for the older generation AMSU-B instrument is shown below but applied to the MHS instrument which measures on the strong 183 GHz water vapour absorption line. The technique removes the dependency of the surface emission thereby producing high spatial/temporal resolution Pan-Arctic images of precipitable water (PW).

3. Precipitable Water Retrieval Technique

\[ T_B = T_a + t_A \varepsilon T_s + T_D (1 - \varepsilon) t_A + T_C (1 - \varepsilon) t_A^2 \]

Combining 3 channels allows for a retrieval independent of surface emissivity. Each frequency must be able to measure a contribution of the surface so three different sets of frequencies are used depending on when a channel "saturates".

<table>
<thead>
<tr>
<th>i</th>
<th>j</th>
<th>k</th>
<th>PW (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Md</td>
<td>157</td>
<td>190.311</td>
<td>183.311 ± 3</td>
</tr>
<tr>
<td>High</td>
<td>80</td>
<td>157</td>
<td>190.311</td>
</tr>
</tbody>
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Calibration Coefficients: The five calibration coefficients are calculated using a least squares regression with radiosonde measurements of water vapour and temperature at Eureka, Nunavut.

5. AIRS Precipitable Water Comparison


No Cloud Mask: MHS retrieval has a smaller spread and bias than the AIRS retrieval when compared to the GVR.

Cloud Mask: MHS and AIRS retrieval have similar spreads, but AIRS will lose a significant number of measurements and still has a large bias for low precipitable water.

2. Microwave Humidity Sounder (MHS)

Frequency: 1) 89 GHz, 2) 157 GHz, 3) 183.311 GHz, 4) 183.311 GHz, 5) 190 GHz

Swaths: 1) 49.5 degree viewing angle, 2) 90 measurements, 3) 15 km to 26 km footprints

Satellites: 1) NOAA-18 and MetOP-AB

4. Arctic Radiosonde Assessment

MHS precipitable water retrieval is compared to Arctic radiosonde measurements during the last several Arctic winters to assess how well the radiosondes are measuring water vapour. Certain radiosonde stations have better agreement with the MHS than others as shown in the examples above. A possible reason for this is that different Arctic stations use different types of radiosondes.

6. March 5 - 9, 2011 Dehydration Study

Backscatter Coefficient: Thick precipitating ice clouds are often seen ranging from the surface to near tropopause altitudes at Eureka. Relative Humidity: Measurements are often over 100% throughout the ice cloud indicating there could be multiple masses of water vapour. Colour Ratio: Colour ratio increases with decreasing altitude meaning the ice cloud particles are growing. MHS: Precipitable water measurements match the FLEXPART back trajectories indicating there could be a contribution of water vapour from two locations.

7. Summary

1) Successfully derived calibration coefficients for precipitable water less than 7 mm for the MHS water vapour retrieval.
2) Discovered that certain radiosonde locations measure precipitable water better than others which could be due to the fact that each location uses different types of radiosondes.
3) Showed the possibility that precipitating ice clouds in the Arctic could be formed by multiple masses of water vapour.
4) Showed that MHS precipitable water retrieval is an improvement over current AIRS precipitable water analysis.

8. Future Work

1) Determine model of radiosonde used at each station and determine how well the radiosonde compares to the MHS.
2) Investigate more cases of precipitating ice clouds and look into the dynamics of the March 2011 case study.
3) Use the FY-3A, FY-3B, and SSM/I satellites and apply the retrieval technique for the MHS precipitable water.
4) Investigate possibility of measuring dehydration of the atmosphere with the MHS.
5) Create multiple calibrations depending on other atmospheric quantities.

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