Pan Arctic Water Vapour Measurements using the Microwave Humidity Sounder

**Introduction**

Water vapour is one of the most important greenhouse gases in terms of its effect on radiation. Up until recently there has only been measured at a small number of ground-based stations, especially in the Arctic. 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 new MHS instrument. It removes the dependency of the surface emission thereby producing high spatial/temporal resolution Pan-Arctic images of integrated water vapour any interference.

**Technique**

Using a combination of three different frequencies that are on the same absorption line the surface emissivity can be dropped from the radiative transfer equation when solving for the precipitable water. Along with using the Rayleigh–Jens approximation and separating out the vertical dependencies ($F_i$ and $F_j$) the following equation can be determined:

$$W\sec \theta = C_0 + C_1 \log \frac{\Delta T_{ij} - F_{ij}}{\Delta T_{jk} - F_{jk}}$$

where:
- $\theta$ = viewing angle
- $W$ = precipitable water (mm)
- $C_0$, $C_1$, $F_{ij}$, $F_{jk}$ = Calibration Constants
- $\Delta T_{ij}$ = Brightness Temperature difference between channel i and j
- $\Delta T_{jk}$ = Brightness Temperature difference between channel j and k

The analysis of precipitable water is split into three regimes as shown below. The maximum value for each range occurs when one of the three brightness temperature channels are saturated so there is no longer a contribution from the surface.

<table>
<thead>
<tr>
<th>i</th>
<th>j</th>
<th>k</th>
<th>PW (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>190.311</td>
<td>183.311 ± 3</td>
<td>183.311 ± 1</td>
</tr>
<tr>
<td>Mid</td>
<td>157</td>
<td>190.311</td>
<td>183.311 ± 3</td>
</tr>
<tr>
<td>High</td>
<td>89</td>
<td>157</td>
<td>190.311</td>
</tr>
</tbody>
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**Precipitable Ice Clouds**

A common feature seen by the CANDAC RMR Lidar at Eureka, Nunavut during the winter season is deep precipitating ice clouds which range from the surface to the Tropopause. A possible reason for their existence is due overlapping water vapour masses. A case from March 5-8, 2011 is shown to the left where there is a deep precipitating ice cloud at Eureka for 3 days.

MHS Pan-Arctic measurements show a large water vapour mass coming up from the Pacific Ocean which agrees with the FLEXPART backtrajectory below 6 km. There are also hints of water vapour being picked up from the Atlantic Ocean due to the strait of water vapour connecting between water vapour masses from the Pacific and Atlantic Oceans.

**References**


**Future Work**

1. Create calibration for high water vapour regime
2. Attempt to temporally track changes in water vapour to see dehydration of atmosphere
3. Surface Water Vapour Budget
4. Investigate more deep precipitable ice cloud events

**Acknowledgements**