Investigating Mesospheric Wave Activities at High Latitude Stations and South Pole

CASS, Utah State University, USA
High-Latitude Research Using an Advanced Mesospheric Temperature Mapper (AMTM)

• The AMTM sequentially observes selected emission lines in the OH (3,1) band to derive high-quality temperature maps @ ~85 km.
• Temperature precision/pix ~2 K in 30 sec.
• High-latitude capability as emission lines avoid auroral contamination.
• 2 AMTM operational since 2011: ALOMAR, Northern Norway (69.3°N), and at South Pole (90°S) Antarctica.
• 3rd AMTM installed at McMurdo station (78°S) 2017.
• Oct 2017, one of the AMTMs was relocated from ALOMAR to Poker Flat Research Range (65°N)
AMTM Temperature Map

• Zenith temperature (20x20 central pixels)
Daily Temperature Measurements

>2,500 data pts/24 hours
High latitude Sites: South and North

- South Pole (90°S)
- McMurdo (78°S)
- Poker Flat (65°N)

![AMTM Observations at ÅLOMAR, Norway (69.3°N)](image1)

![McMurdo Station](image2)

![Poker Flat Station](image3)

![South Pole Station](image4)
# Sites and Data

<table>
<thead>
<tr>
<th></th>
<th>ALOMAR</th>
<th>South Pole</th>
<th>McMurray</th>
<th>PFRR</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Latitude</strong></td>
<td>69.3° N</td>
<td>90° S</td>
<td>78° S</td>
<td>65° N</td>
</tr>
<tr>
<td><strong>Season starting date</strong></td>
<td>Oct 1</td>
<td>April 19</td>
<td>March 21</td>
<td>Nov. 1 (2017)</td>
</tr>
<tr>
<td><strong>Season ending date</strong></td>
<td>April 15</td>
<td>August 31</td>
<td>September 30</td>
<td>April</td>
</tr>
<tr>
<td><strong>Season duration</strong></td>
<td>6.5 Months</td>
<td>4.5 months</td>
<td>&gt;6 months</td>
<td>~6 months</td>
</tr>
<tr>
<td><strong>Daily data duration</strong></td>
<td>longest ~16-17 hours</td>
<td>Mostly 24 hours</td>
<td>Some 24 hours</td>
<td>~16 hours</td>
</tr>
</tbody>
</table>
Winter Season Daily Mean Temperatures

ALOMAR 2012-13

211.0 ±12 K

South Pole 2012

212.7 ± 10 K

Poker Flat 2017-18

214.3 ± 10 K

McMurdo 2017

205.5 ± 8 K
The Major Sudden Stratospheric Warming (SSW): 12 February 2018

Poker Flat 2017-18

30hPa Temperature over the North Pole (2017–2018)

Kaoru Sato: 2nd Information related to ICSOM-3 and request of data
Planetary Wave Activities

- Rich spectrum from both sites
- Planetary waves with different periods were observed
Planetary Wave Activities

Poker Flat, 2017-18

McMurdo, 2017

Normalized Power vs. Period (day)
Mesospheric Planetary Waves Observed at South Pole

2012

Normalized Power

Period (day)

2013

Normalized Power

Period (day)

2014

Normalized Power

Period (day)

2012

Normalized Power

Period (day)

5 day, 18 day, 28 day, 45 day

2014

Normalized Power

Date

Rothera, Southpole, SOFIE_Rothera
Planetary Wave Activities at ALOMAR (a year later)

Similar wave was observed during the 2015-16 winter season at ALOMAR. Period~ 23 days
McMurdo 2017: the return of the 28 day Rossby wave?
Gravity Wave/Tide Spectrum

- **ALOMAR:**
  - Strong semi-diurnal tides
  - Gravity waves 3-10 hours

- **South pole:**
  - No/very weak tides
  - Strong gravity wave activities with periods 4-10 hours
GW/Tidal spectrum at PFRR and McMurdo

- Similar GW spectrum
- Clear tidal signature at Poker Flat
Gravity wave energy peaked in the middle of each winter season.
The variance from both sites are of similar values
ALOMAR: wave energy decreased
South Pole: wave energy increased

Yoshiki and Sato (2000): gravity wave energy peaked in spring in the stratosphere (SH)
Daily Temperature Variance (GW activities)
Multi-Year: South Pole vs. ALOMAR
Summary

- Winter time mesospheric temperature data from four unique sites, ALOMAR, PFRR, McMurdo and South Pole stations, showed similarities and differences during winter seasons.

- Similar winter time mean temperature for all stations but clear decrease through the winter for 3 stations other than PFRR which showed SSW signature in Feb.

- Different planetary waves were observed from all sites and year-to-year variability in planetary wave activities for South Pole and ALOMAR.

- Short-period gravity wave spectrum are similar. However, strong semi-diurnal tides were observed at 3 high latitude stations, while no/weak tidal signatures at South Pole during winter season.

- During the winter season, gravity wave energy increased at South Pole.

- The other three high latitude stations, wave energy peaked in the middle of the winter season except for 2012-13 season at ALOMAR where the wave energy decreased through the winter.

- **Questions:**
  What contribute to the change of the GW energy variation during the winter season? Lower atmospheric sources, filtering conditions?