CEDAR Postdoc: Meteor Smoke Particles detected using the Poker Flat ISR
…and some additional aeronomy

Jonathan Fentzke
6/28/12
Outline

- Quick overview of MSPs
- MSP System Science
- 1 Slide on Theory
- Experimental Setup
- Results
- Conclusions
- Summary of grant activities
- Future Work
  - (a.k.a. shameless plug for a follow-up grant)

From the website of E.L. Wright: (http://www.astro.ucla.edu/~wright/dust/)
Science Question(s)

Can AMISR Detect Meteor Smoke Particles?

And if so…

1) what are the micro-physical properties of MSPs and what are their variability?

2) are observations dominated by local production or transport?

Megner et al., JGR, 2008
Overview of MSP related Phenomena

or why should you care?

Ice/Dust Layered Phenomena

- PMC [Satellite]
- PMSE [Radar]
- NLC [Optical]
- Aerosols [Rocket]
- NLC [Lidar]
- PSC [Lidar]
Overview of MSP related Phenomena
or why should you care?...
Chemistry/Climate/Mass Loading
## Energy Balance

Where Does the Atmosphere Get Its Energy?

<table>
<thead>
<tr>
<th>Heat Source</th>
<th>Heat Flux* [W/m²]</th>
<th>Relative Input</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Solar Irradiance</strong></td>
<td>340.20</td>
<td>1.000</td>
</tr>
<tr>
<td>Heat Flux from Earth's Interior</td>
<td>0.0612</td>
<td>1.8E-04</td>
</tr>
<tr>
<td>Radioactive Decay</td>
<td>0.0480</td>
<td>1.4E-04</td>
</tr>
<tr>
<td>Geothermal</td>
<td>0.0132</td>
<td>3.9E-04</td>
</tr>
<tr>
<td>Infrared Radiation from the Full Moon</td>
<td>0.0102</td>
<td>3.0E-05</td>
</tr>
<tr>
<td>Sun's Radiation Reflected from Moon</td>
<td>0.0034</td>
<td>1.0E-05</td>
</tr>
<tr>
<td>Energy Generated by Solar Tidal Forces in the Atmosphere</td>
<td>0.0034</td>
<td>1.0E-05</td>
</tr>
<tr>
<td>Combustion of Coal, Oil, and Gas in US (1965)</td>
<td>0.0024</td>
<td>7.0E-06</td>
</tr>
<tr>
<td>Energy Dissipated in Lightning Discharges</td>
<td>0.0002</td>
<td>6.0E-07</td>
</tr>
<tr>
<td>Dissipation of Magnetic Storm Energy</td>
<td>6.8E-05</td>
<td>2.0E-07</td>
</tr>
<tr>
<td>Radiation from Bright Aurora</td>
<td>4.8E-05</td>
<td>1.4E-07</td>
</tr>
<tr>
<td>Energy of Cosmic Radiation</td>
<td>3.1E-05</td>
<td>9.0E-08</td>
</tr>
<tr>
<td><strong>Dissipation of Mechanical Energy of Micrometeorites</strong></td>
<td>2.0E-05</td>
<td>6.0E-08</td>
</tr>
<tr>
<td>Total Radiation from Stars</td>
<td>1.4E-05</td>
<td>4.0E-08</td>
</tr>
<tr>
<td>Energy Generated by Lunar Tidal Forces in the Atmosphere</td>
<td>1.0E-05</td>
<td>3.0E-08</td>
</tr>
<tr>
<td>Radiation from Zodiacal Light</td>
<td>3.4E-06</td>
<td>1.0E-08</td>
</tr>
<tr>
<td><strong>Total of All Non-Solar Energy Sources</strong></td>
<td>0.0810</td>
<td>2.4E-04</td>
</tr>
</tbody>
</table>

* global average

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Physical Climatology, W.D. Sellers, Univ. of Chicago Press, 1965
Table 2 on p. 12 is from unpublished notes from H.H. Lettau, Dept. of Meteorology, Univ. of Wisconsin.
Ablated meteoric constituents grow to nanometer size under the influence of the chemistry and dynamics of the MLT region.

From the website of J.M.C. Plane: (http://www.chem.leeds.ac.uk/JMCP/ice.html)
\[ ACF(t) = A_0 \exp(-t/\tau_0) + A_1 \exp(-t/\tau_1) \]

\[ N_p/N_e = A_1/(A_0 + A_1) \]

\[ r_{msp} = \frac{k}{2} \sqrt{\frac{3 \tau_1}{N_n}} \sqrt{\frac{k_B T}{2\pi M_n}} - r_n \]
\[ r_{msp} = \frac{k}{2} \sqrt[3]{\frac{3\tau_1}{N_n}} \sqrt{\frac{k_b T}{2\pi M_n}} - r_n \]
MSP micro-physical properties: Previous results

- Bardeen et al., JGR, 2008
- Strelnikova et al., GRL, 2007
- Fentzke et al., JASTP, 2009
Experimental Setup

- **Arecibo**
  - 430 MHz (18 N, 67 W)
  - Single Dish
  - ~2 MW
  - 1 msec IPP / 150 m

- **PFISR**
  - 449 MHz (65 N, 147 W)
  - Phased Array
  - ~1.7 MW
  - 2 msec IPP / 750 m

- **RISR-N**
  - 443 MHz (74 N, 94 W)
  - Phased Array
  - ~1.7 MW
  - 2 msec IPP / 750 m
13 – 14 UT at 83.9709 km

15 – 16 UT at 85.4699 km
Conclusions

- Micro-physical properties of MSPs derived from PFISR / RISR-N
  - 0.5 – 2 nm sizes
  - # densities from about 100-10000 in ROI

- Variability at High latitude is greater than current observations from equatorial latitudes
  - Agrees with MIF prediction, but more analysis and modeling is required to verify seasonal trends

- New method for deriving neutral temperature using day-time radar D-region measurements
Summary of grant activities

- Other topics explored
  - Sporadic neutral metal layers (lidar/radar)
  - Ion-neutral collisions (radar)
  - Meteor studies (modeling/radar)
  - Neutral winds (optical)
  - Emergent platforms for transformative discovery
    - Hosted Payloads, CubeSats, Comm. Sub-Orbital…

- Journal/Conference Articles Published/Submitted
  - 3 - 1st Author (8 Total)

- Posters
  - 5 - 1st Author (11 Total)

- Talks
  - 12 - 1st Author (18 total)
Future Work

**Local Production vs. Transport**

- Analysis of more data to determine the seasonal / global trends
  - Requires modeling using GCM
  - Ground based ISR measurements
  - MIF modeling
    
    *Proposal currently in the works 😊*

- Vetting of Tn determination and additional theoretical development
A quick thank you to collaborators and mentors during this postdoc

Especially:
Lars Dyrud, Sixto Gonzalez, Marus Rapp, Diego Janches, Vicki Hsu, Mike Nicolls, Mary McCready

Thanks again to NSF and the community for this opportunity!
Questions?

DATA: BY THE NUMBERS

NUMBER OF YEARS TO GET DATA: 3
YES! FINALLY!

NUMBER OF YEARS TO INTERPRET DATA: 2
what does it all mean??

NUMBER OF YEARS TO WRITE ABOUT DATA: 1.5
blah blah blah...

NUMBER OF SLIDES TO PRESENT DATA: 1
RESULTS that's it?

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