CEDAR Postdoc: Meteor Smoke Particles detected using the Poker Flat ISR

…and some additional aeronomy

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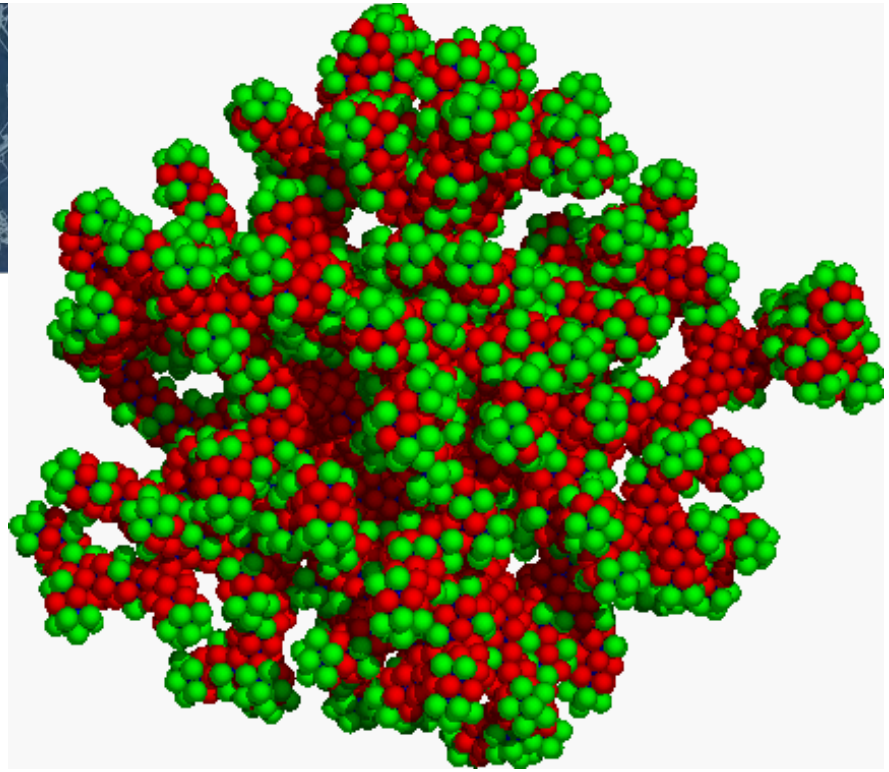
6/28/12

JOHNS HOPKINS UNIVERSITY
Applied Physics Laboratory

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/)

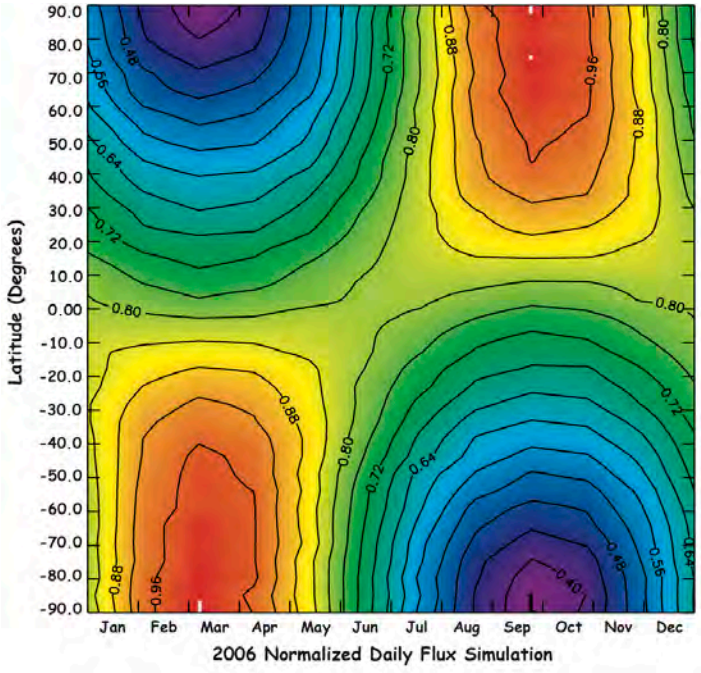
Science Question(s)

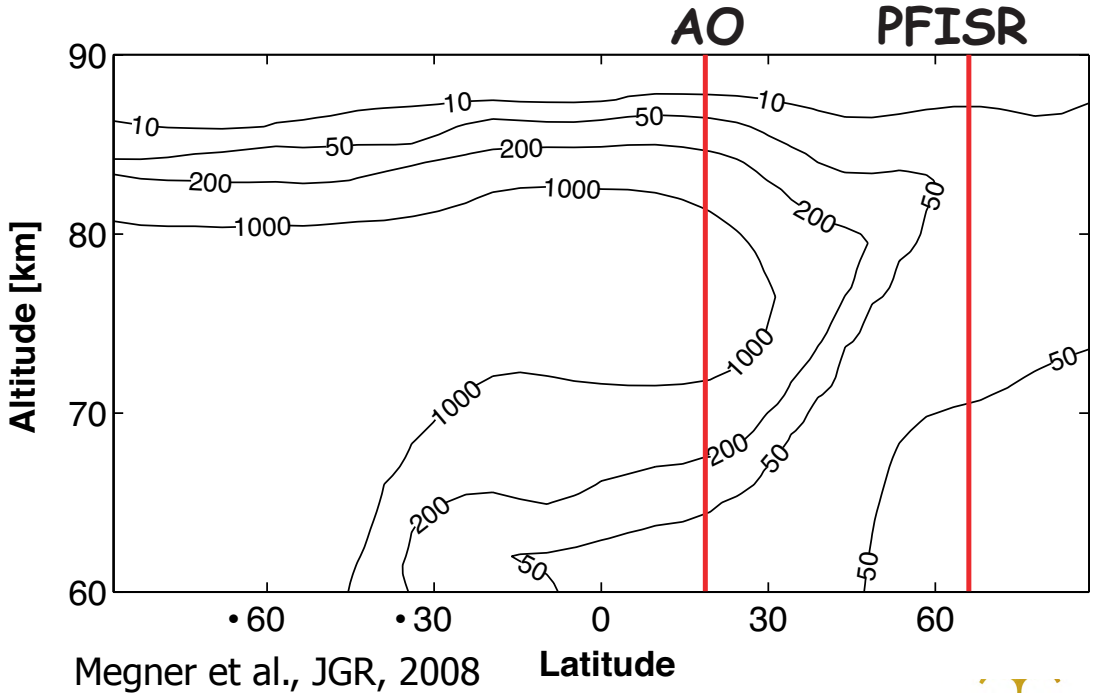
Can AMISR Detect Meteor Smoke Particles?

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?





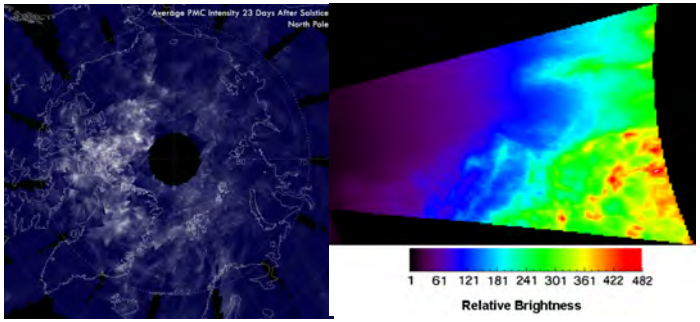
Megner et al., JGR, 2008

Overview of MSP related Phenomena

or why should you care?...

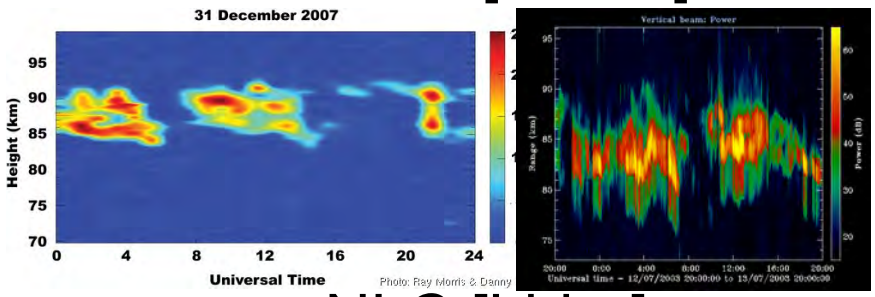
Ice/Dust Layered Phenomena

PMC [Satellite]

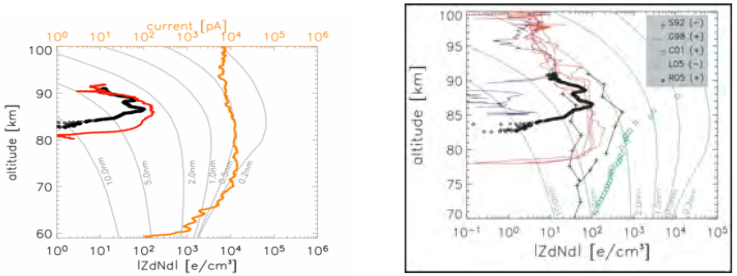


NLC [Optical]

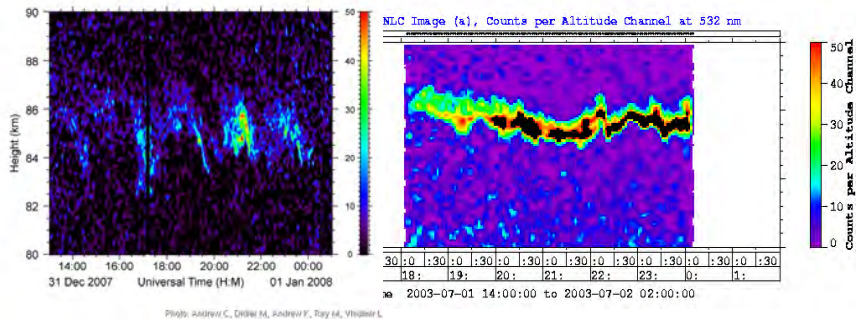
PMSE [Radar]



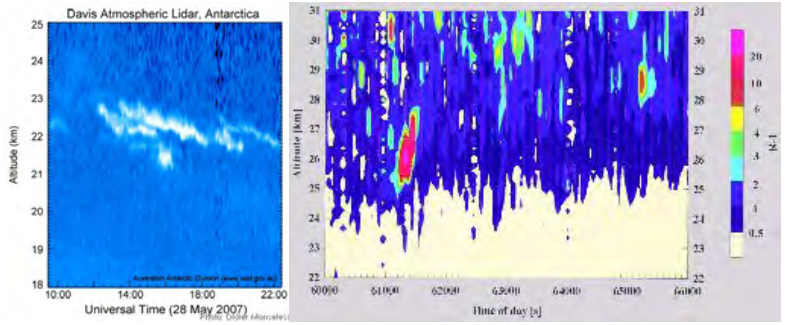
Aerosols [Rocket]



NLC [Lidar]



PSC [Lidar]



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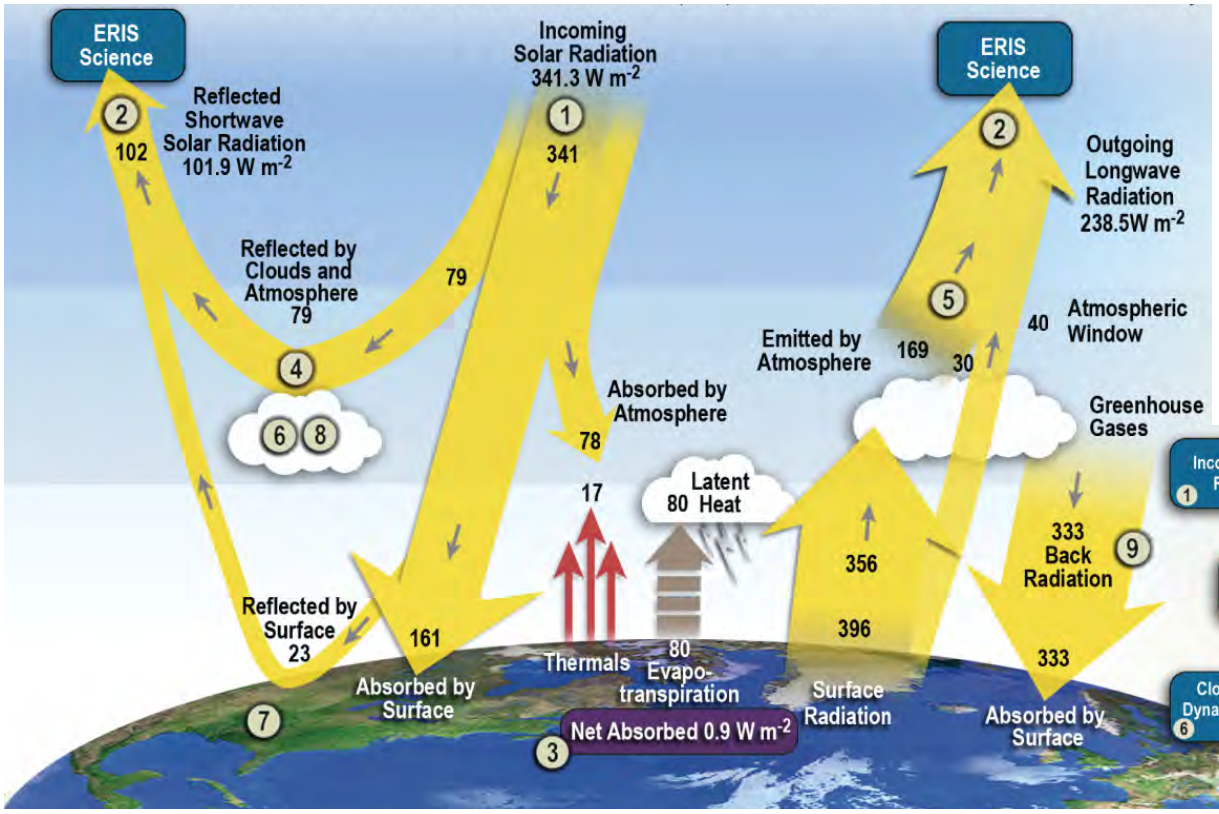
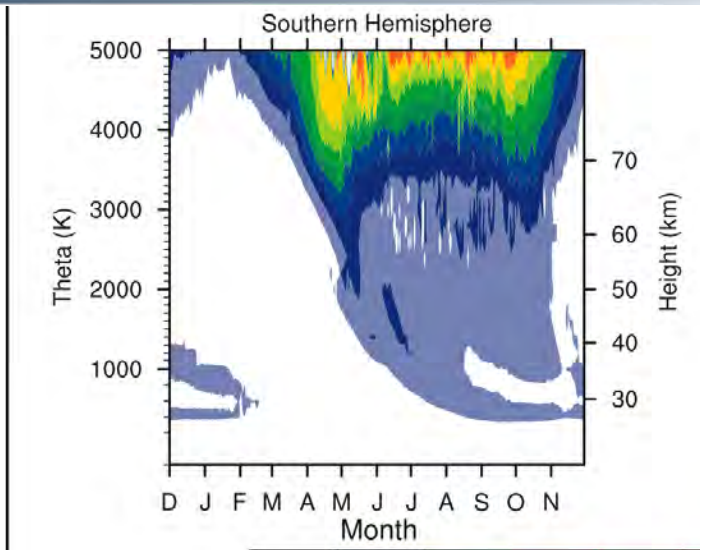
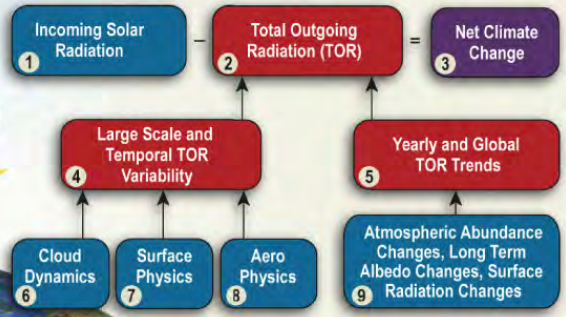
Overview of MSP related Phenomena

or why should you care?...

Chemistry/Climate/Mass Loading







Overview of MSP related Phenomena

or why should you care?...

Energy Balance

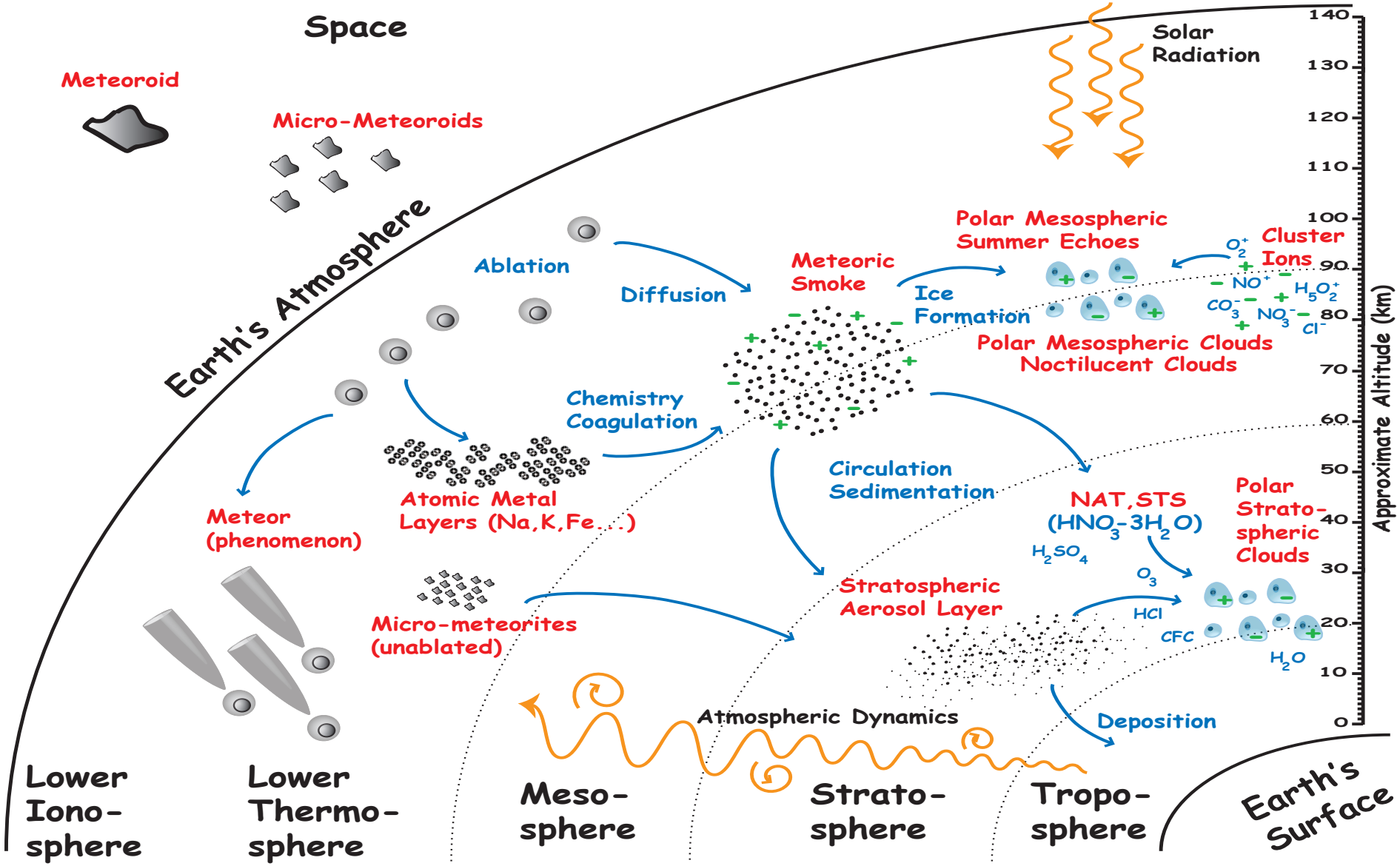
Where Does the Atmosphere Get Its Energy?

Heat Source	Heat Flux* [W/m^2]	Relative Input
Solar Irradiance	340.20	1.000
Heat Flux from Earth's Interior	0.0612	1.8E-04
Radioactive Decay	0.0480	1.4E-04
Geothermal	0.0132	3.9E-05
Infrared Radiation from the Full Moon	0.0102	3.0E-05
Sun's Radiation Reflected from Moon	0.0034	1.0E-05
Energy Generated by Solar Tidal Forces in the Atmosphere	0.0034	1.0E-05
Combustion of Coal, Oil, and Gas in US (1965)	0.0024	7.0E-06
Energy Dissipated in Lightning Discharges	0.0002	6.0E-07
Dissipation of Magnetic Storm Energy	6.8E-05	2.0E-07
Radiation from Bright Aurora	4.8E-05	1.4E-07
Energy of Cosmic Radiation	3.1E-05	9.0E-08
Dissipation of Mechanical Energy of Micrometeorites	2.0E-05	6.0E-08
Total Radiation from Stars	1.4E-05	4.0E-08
Energy Generated by Lunar Tidal Forces in the Atmosphere	1.0E-05	3.0E-08
Radiation from Zodiacal Light	3.4E-06	1.0E-08
Total of All Non-Solar Energy Sources	*0.0810*	*2.4E-04*

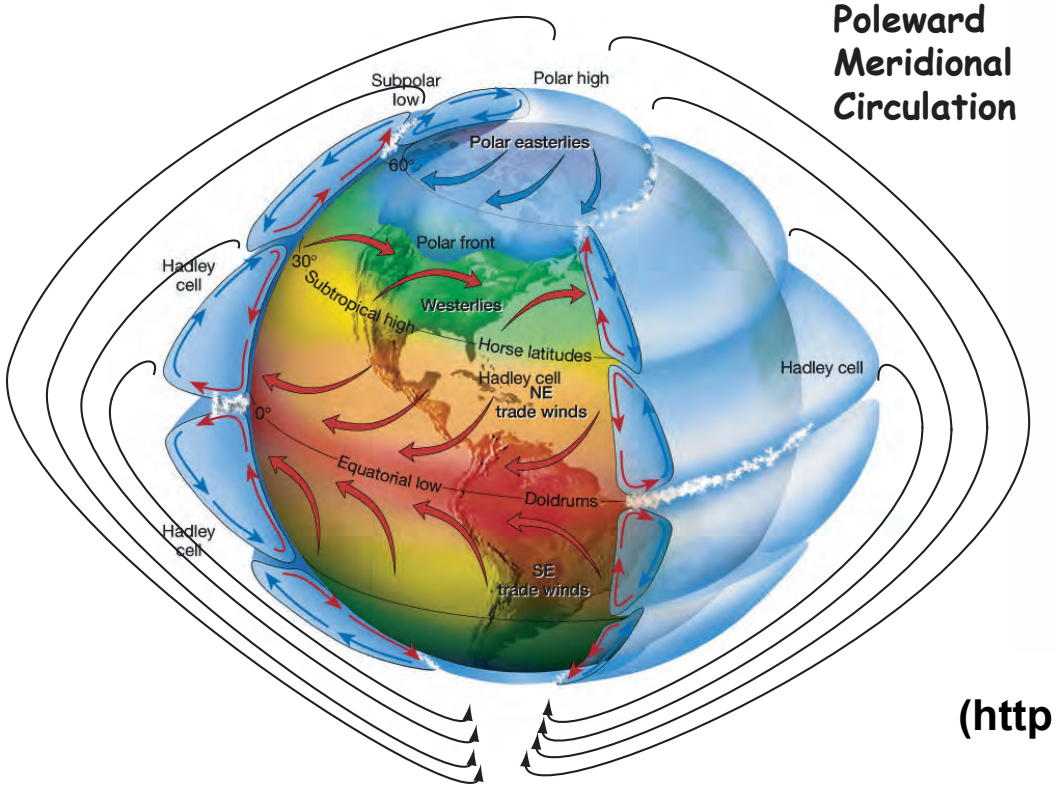
* global average

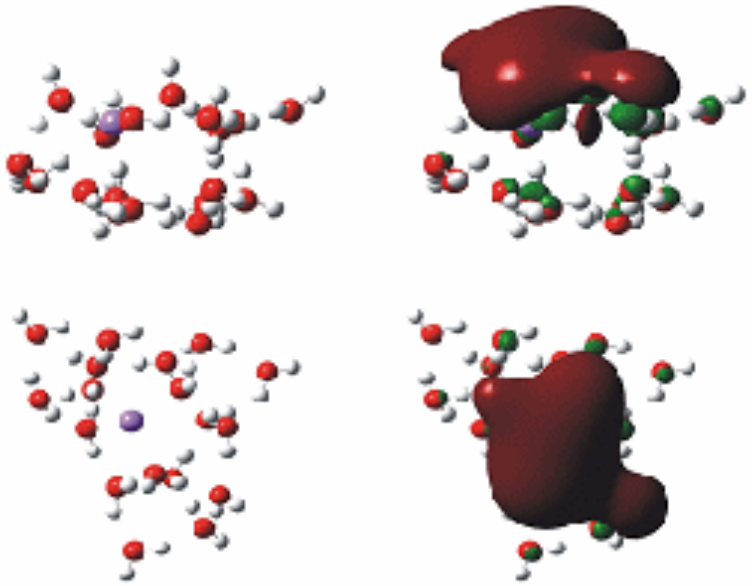
Physical Climatology, W.D. Sellers, Univ. of Chicago Press, 1965
Table 2 on p. 12 is from unpublished notes from
H.H. Lettau, Dept. of Meteorology, Univ. of Wisconsin.

System Science



System Science: Processes





From the website of J.M.C. Plane:
(http://www.chem.leeds.ac.uk/JMCP/ice.html)

Ablated meteoric constituents grow to nanometer size under the influence of the chemistry and dynamics of the MLT region.

CS

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Theory

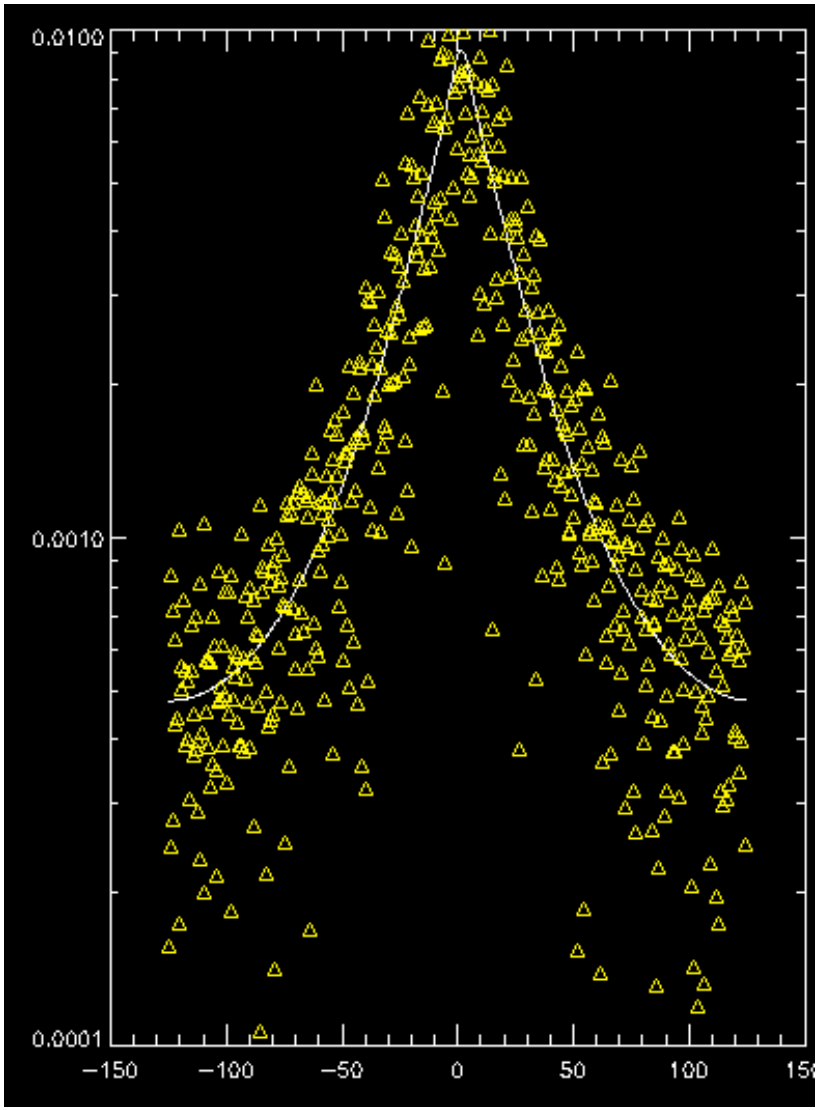
$$ACF(t) = A_0 \cdot \exp(-t/\tau_0) + A_1 \cdot \exp(-t/\tau_1)$$

← Background

← Smoke

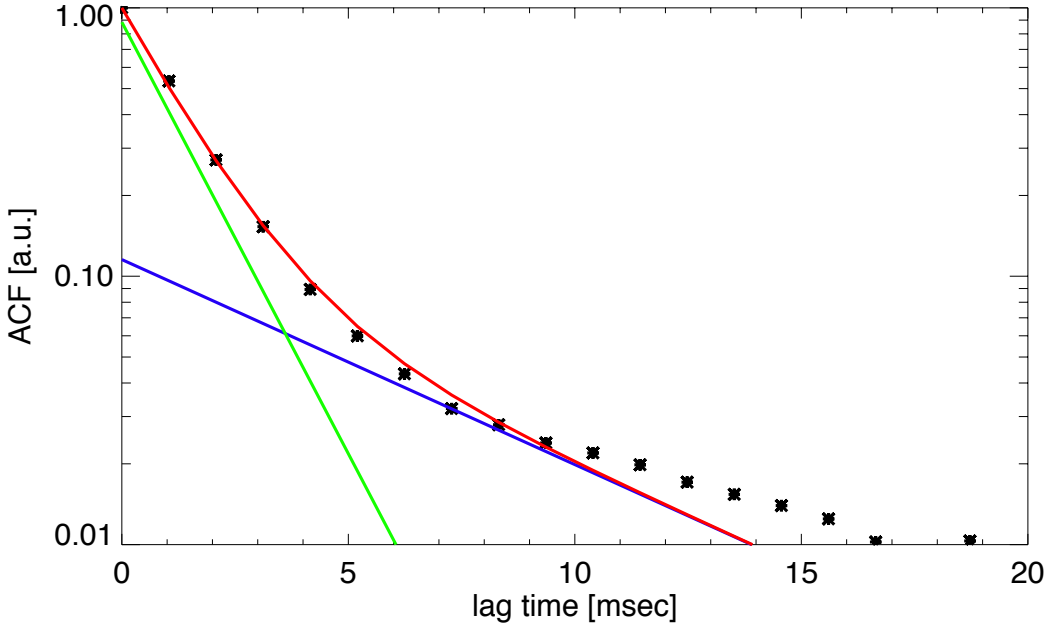
$$N_p/N_e = A_1/(A_0 + A_1)$$

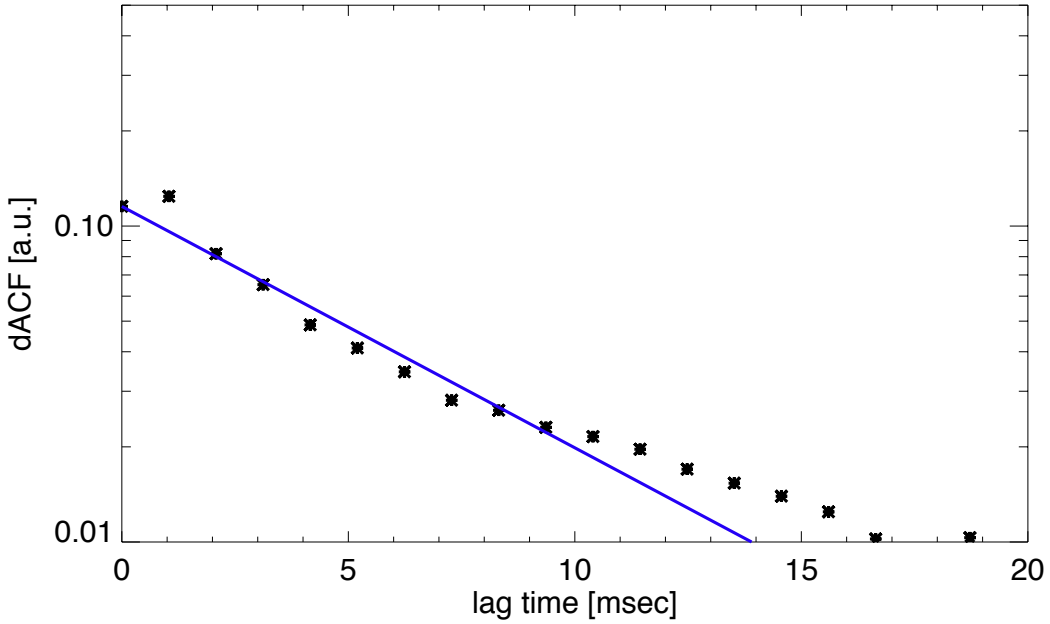
$$r_{msp} = \frac{k}{2}\sqrt{\frac{3\tau_1}{N_n}\sqrt{\frac{k_b T}{2\pi M_n}}} - r_n$$



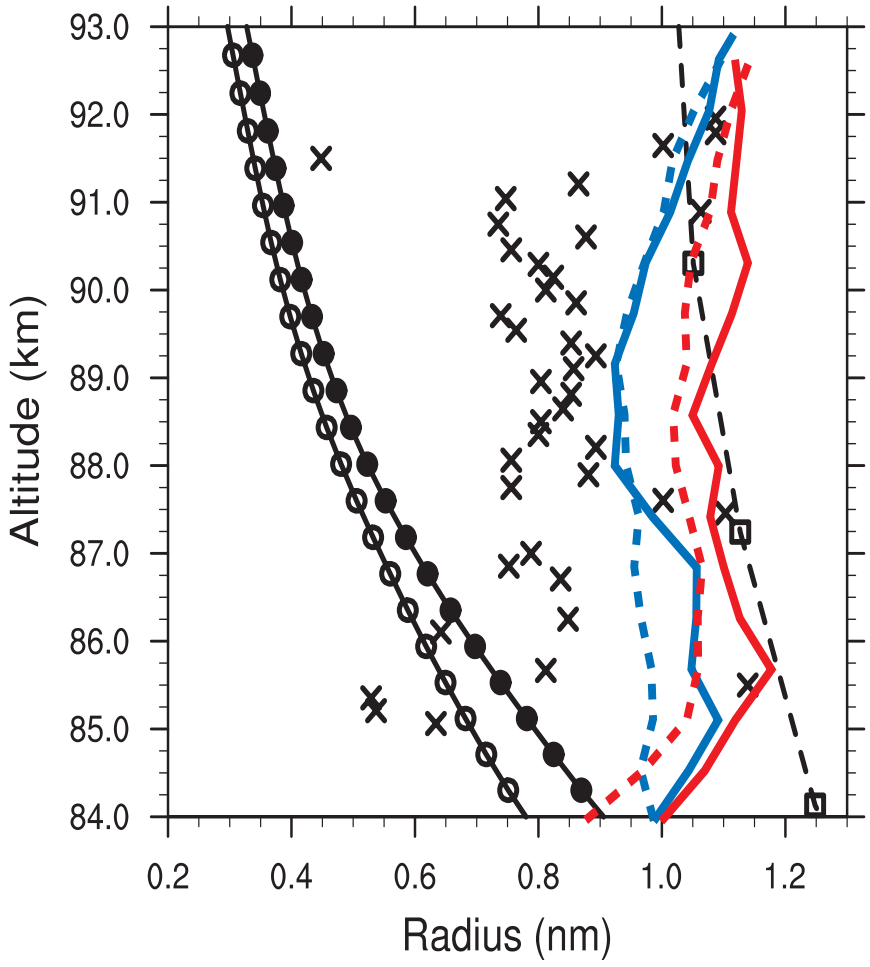
Theory

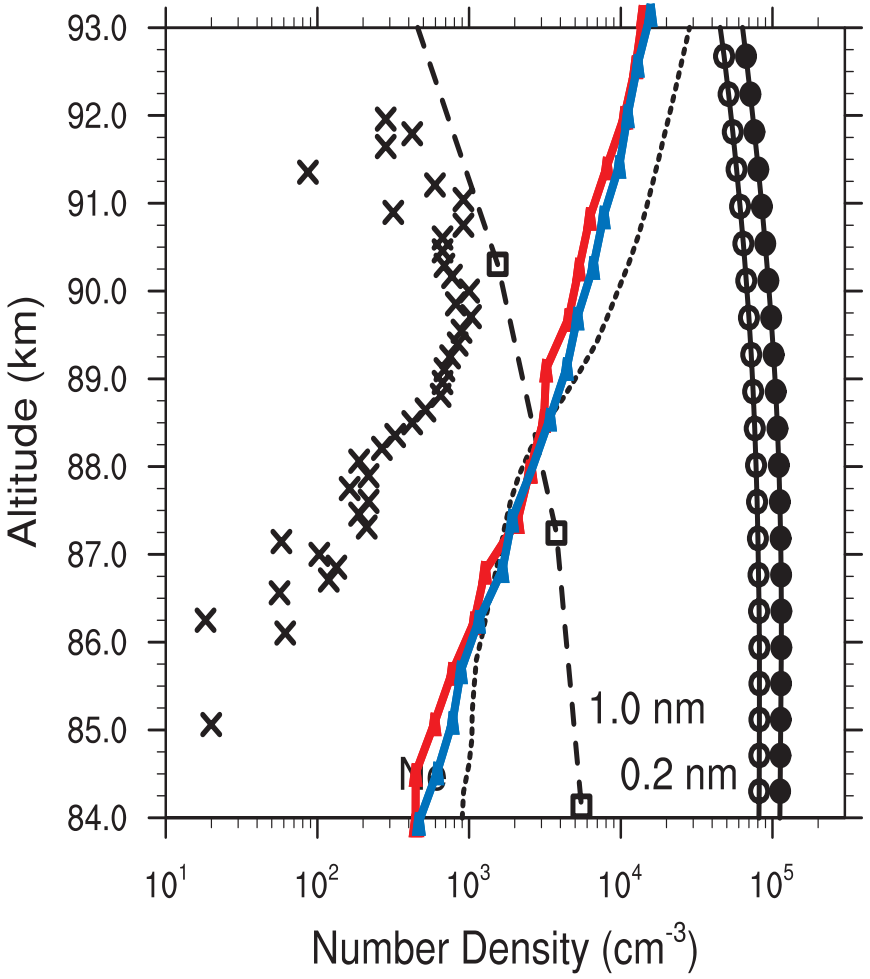
$$r_{msp} = \frac{k}{2}\sqrt{\frac{3\tau_1}{N_n}\sqrt{\frac{k_b T}{2\pi M_n}}} - r_n$$





MSP micro-physical properties: Previous results





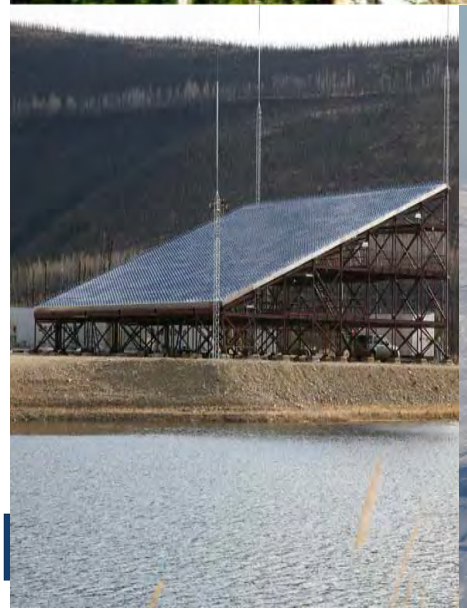
Strelnikova et al., GRL, 2007

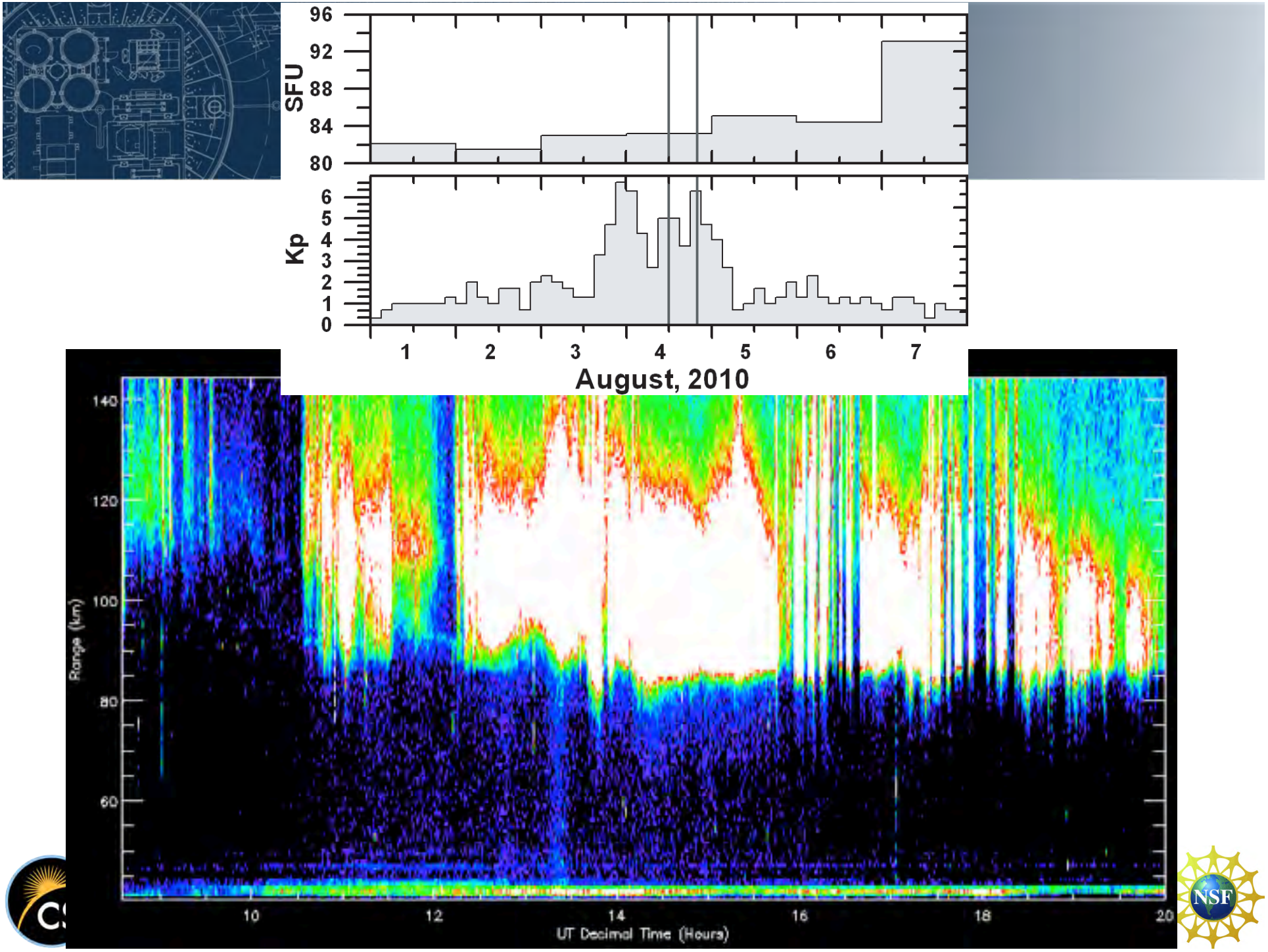
Bardeen et al., JGR, 2008

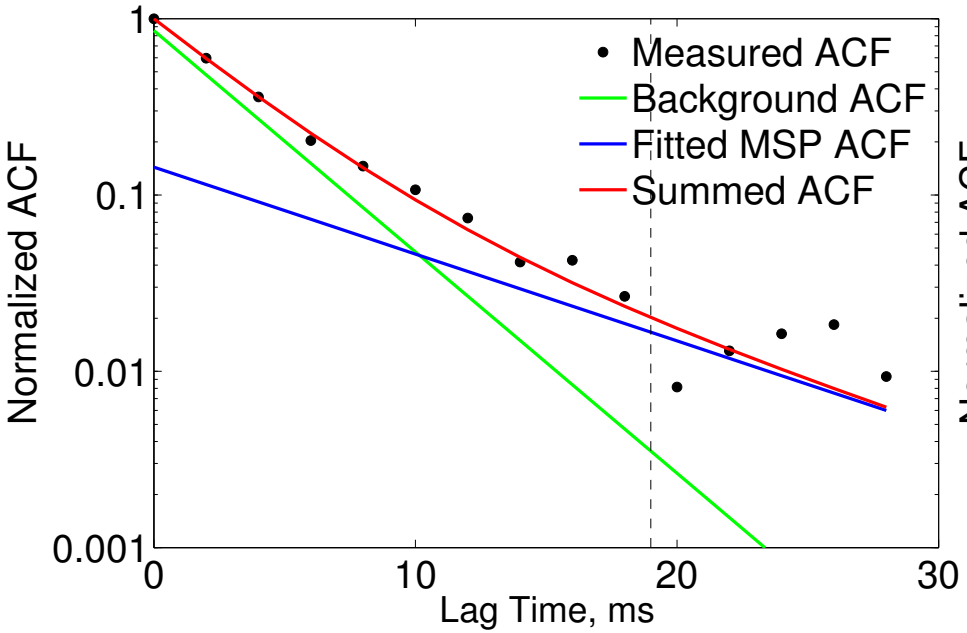
Fentzke et al., JASTP, 2009

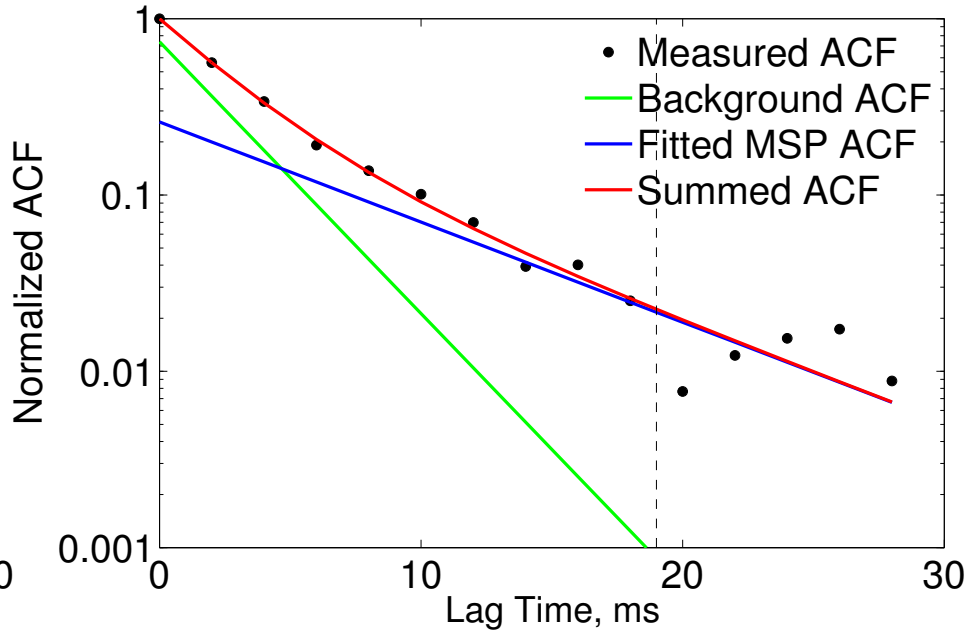
Experimental Setup

- 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




SFU
96
92
88
84
80
Kp
6
5
4
3
2
1
0
1
2
3
4
5
6
7
August, 2010
Range (km)
140
120
100
80
60
10
12
14
16
18
20
UT Decimal Time (Hours)


13 – 14 UT at 83.9709 km
Measured ACF
Background ACF
Fitted MSP ACF
Summed ACF
Normalized ACF
Lag Time, ms
1
0.1
0.01
0.001
0
10
20
30


13 – 14 UT at 83.9709 km
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Fitted MSP ACF
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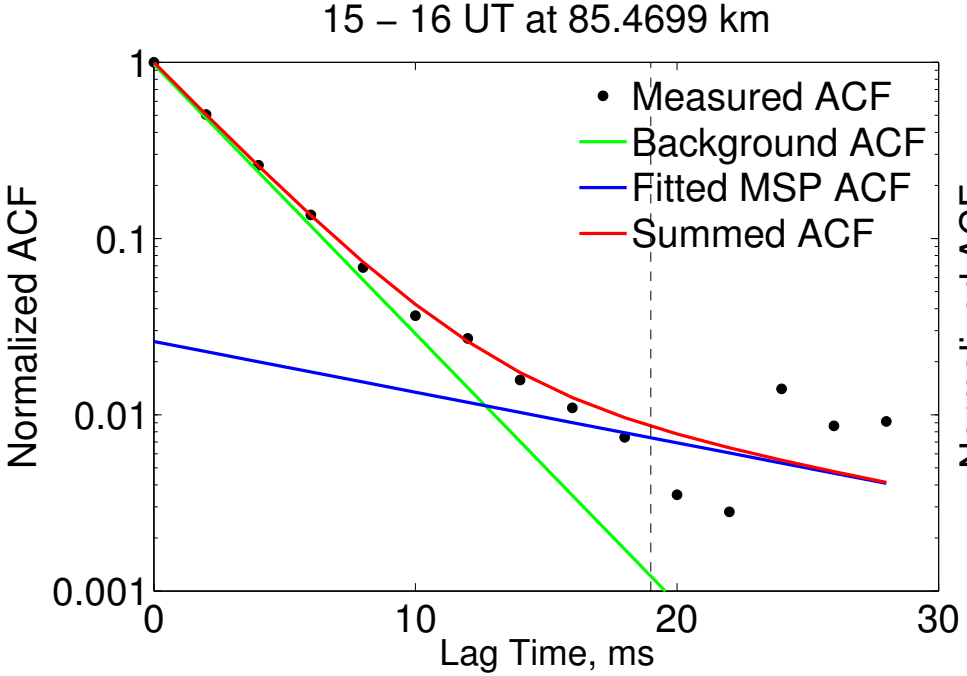
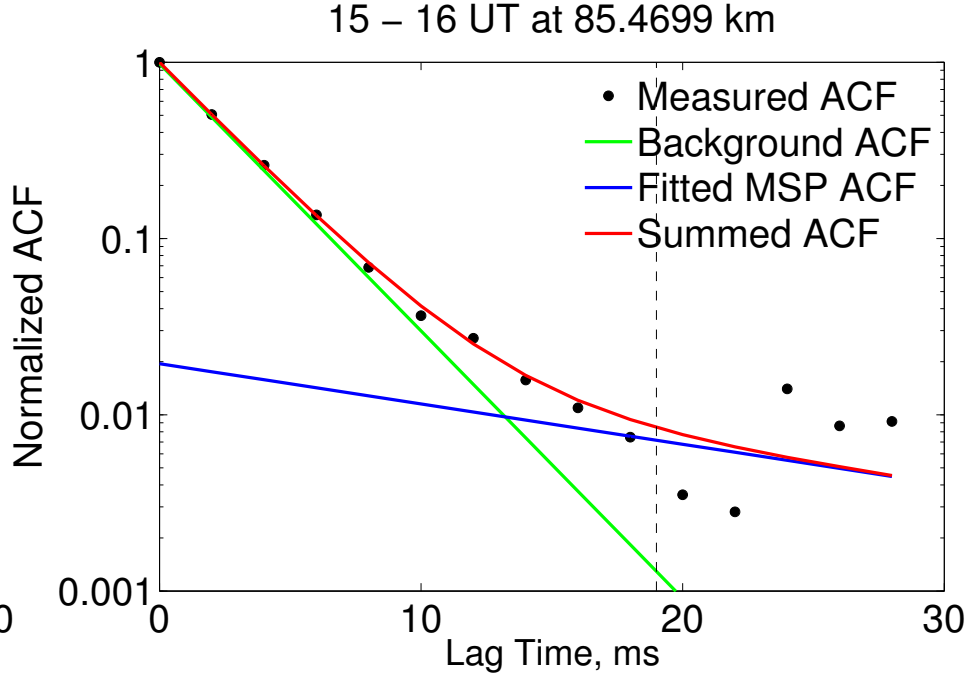
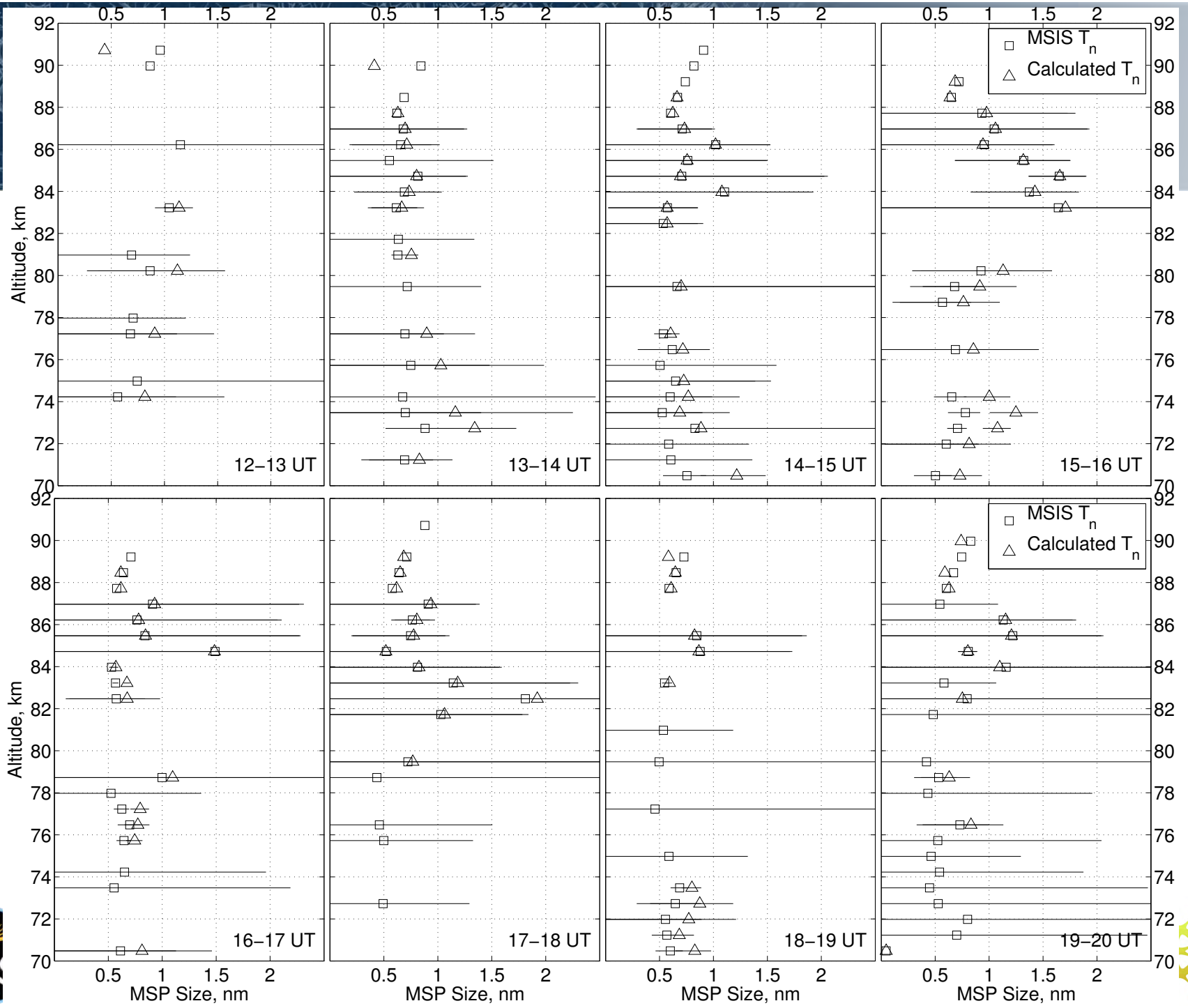
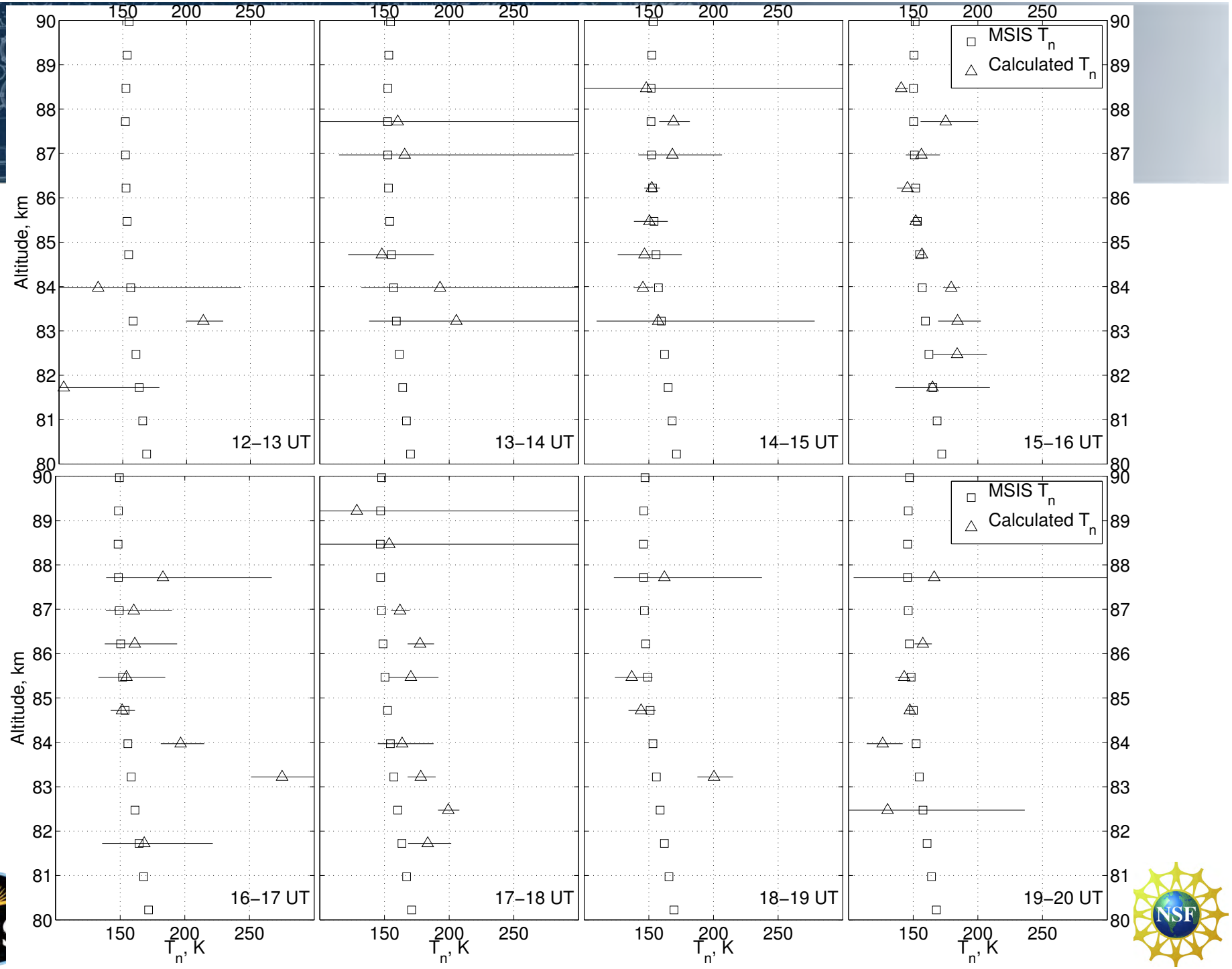
Normalized ACF
Lag Time, ms
1
0.1
0.01
0.001
0
10
20
30


15 – 16 UT at 85.4699 km
Measured ACF
Background ACF
Fitted MSP ACF
Summed ACF
Normalized ACF
Lag Time, ms
1
0.1
0.01
0.001
0
10
20
30


15 – 16 UT at 85.4699 km
Measured ACF
Background ACF
Fitted MSP ACF
Summed ACF
Normalized ACF
Lag Time, ms
1
0.1
0.01
0.001
0
10
20
30


MSIS T_n
Calculated T_n
12–13 UT
13–14 UT
14–15 UT
15–16 UT
16–17 UT
17–18 UT
18–19 UT
19–20 UT
Altitude, km
MSP Size, nm


MSIS T_n
Calculated T_n
12–13 UT
13–14 UT
14–15 UT
15–16 UT
16–17 UT
17–18 UT
18–19 UT
19–20 UT
Altitude, km
T_n, K
150
200
250
80
81
82
83
84
85
86
87
88
89
90

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

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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)

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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

APL

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

NWRA Since 1984 CoRA

APL Space Department

NATIONAL ASTRONOMY AND IONOSPHERE CENTER — ARECIBO OBSERVATORY

LEIBNIZ-INSTITUT FÜR ATMOSPHÄREN PHYSIK IAP

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Thanks again to NSF and the community for this opportunity!

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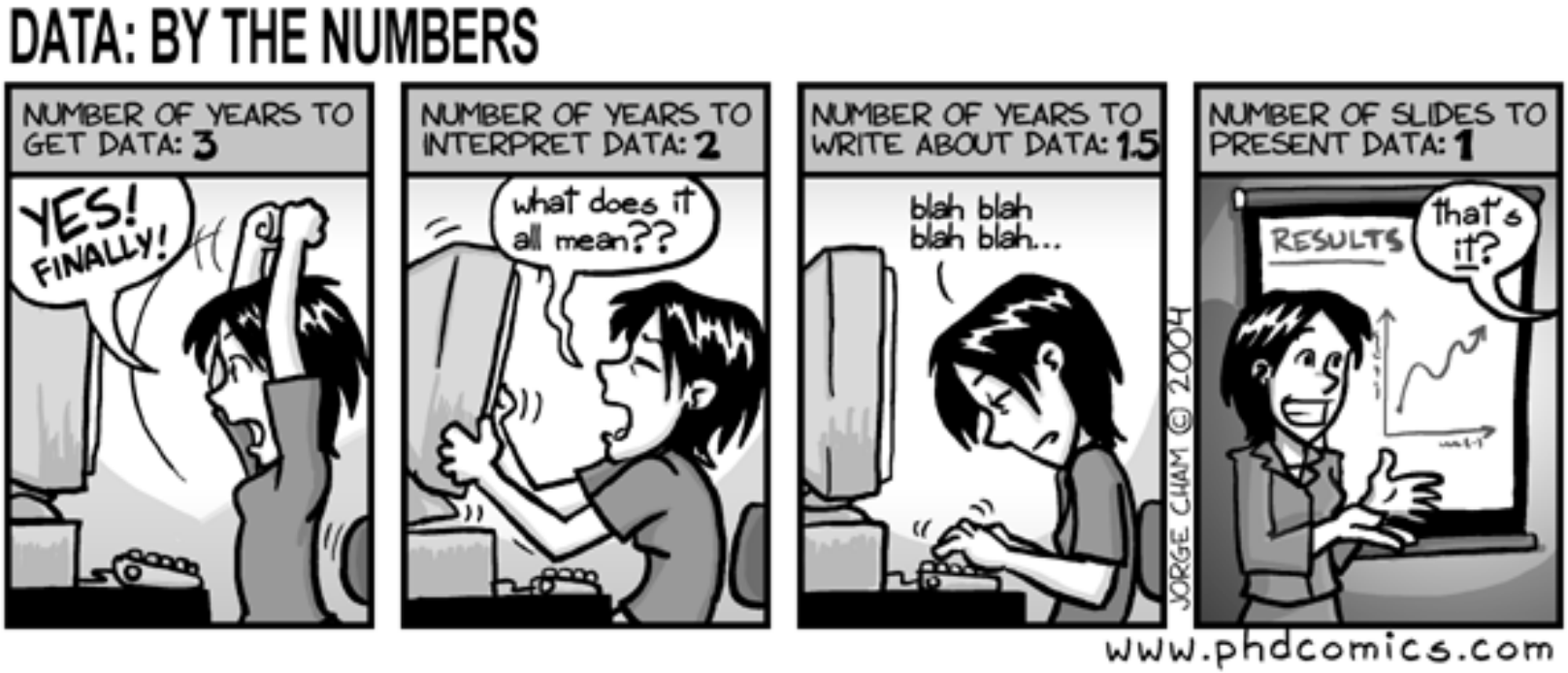
Questions?


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 blah...
NUMBER OF SLIDES TO PRESENT DATA: 1
RESULTS
that's it?
JORGE CHAM © 2004
www.phdcomics.com