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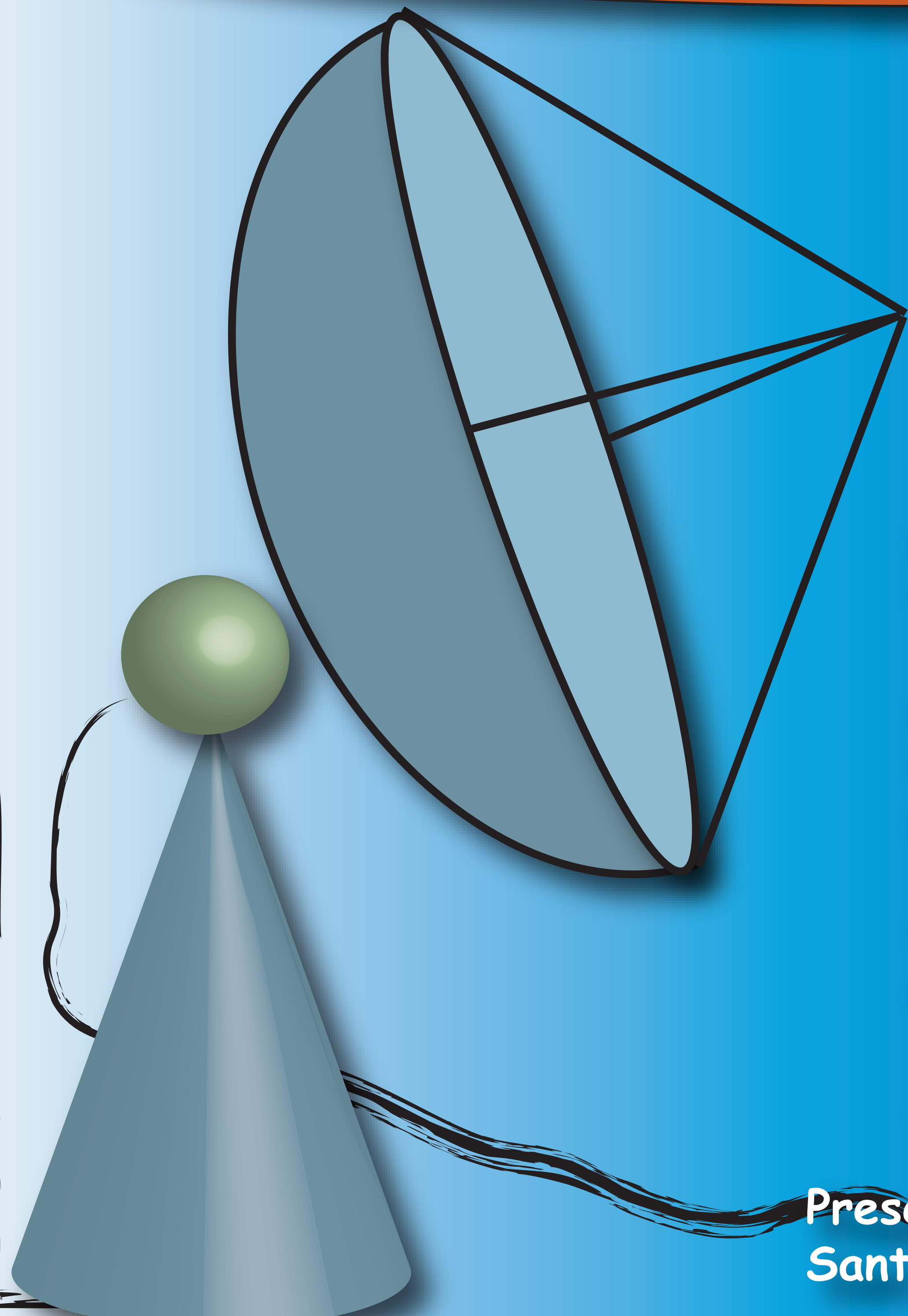
The micrometeor flux in the MLT

Diego Janches
CoRA Division/NWRA



Thanks to:
Jonathan Fentzke and Jonathan Sparks
CoRA Division/NWRA
University of Colorado
Sigrid Close
Los Alamos National Lab
Lars Dyrud
Center fro Remote Sensing, Inc
John Plane and Tomas Vondrak
University of Leeds
Craig Heinselman and Mike Nicolls
SRI International
Jorge L. Chau and R. Woodman
Instituto Geofisico del Peru

Presented at CEDAR 2007
Santa Fe, NM June 24-28, 2007

Several decades of measuring winds by detecting meteor trails

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Meteors and the CEDAR Community

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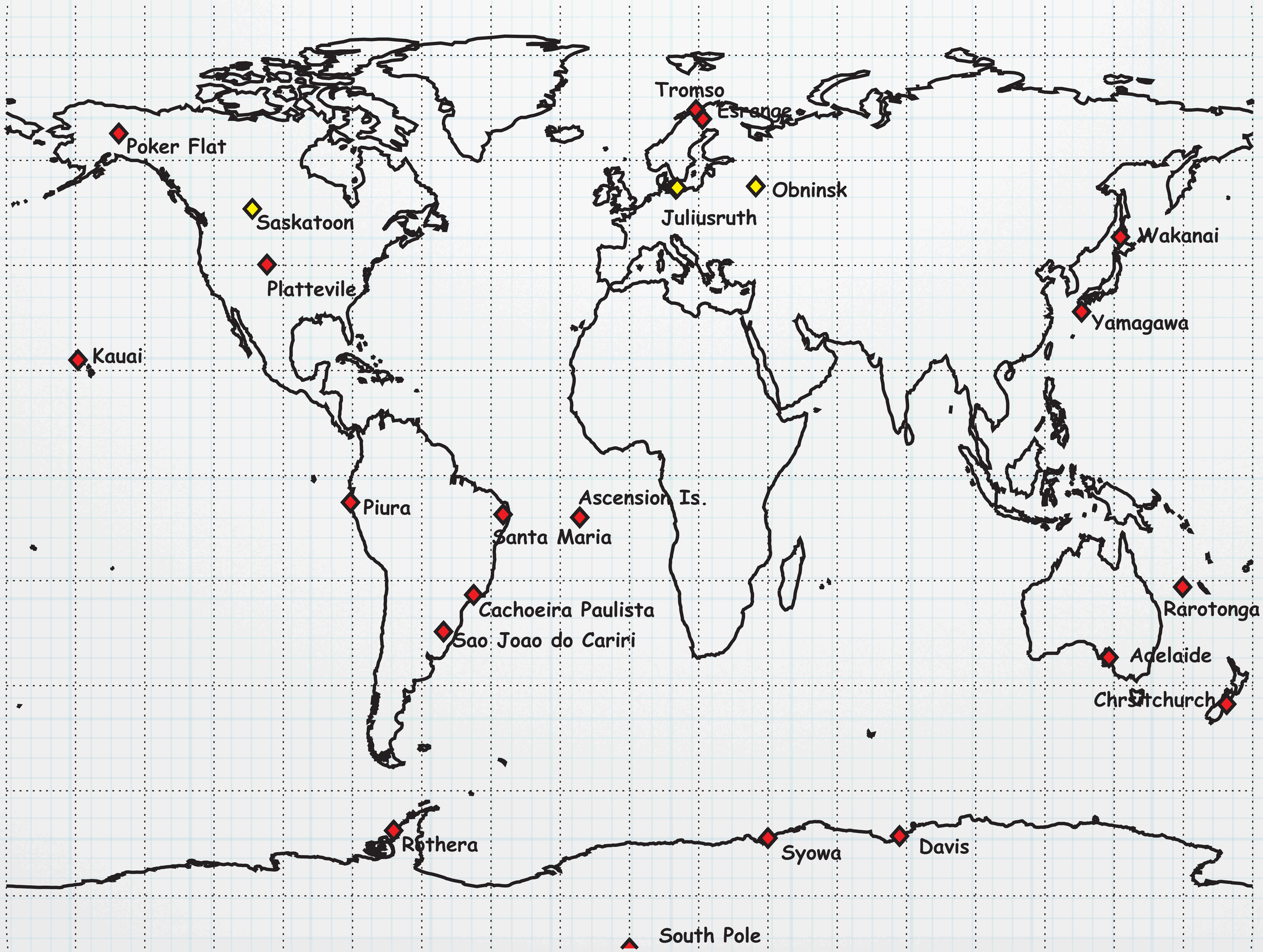
Several decades of measuring winds by detecting meteor trails



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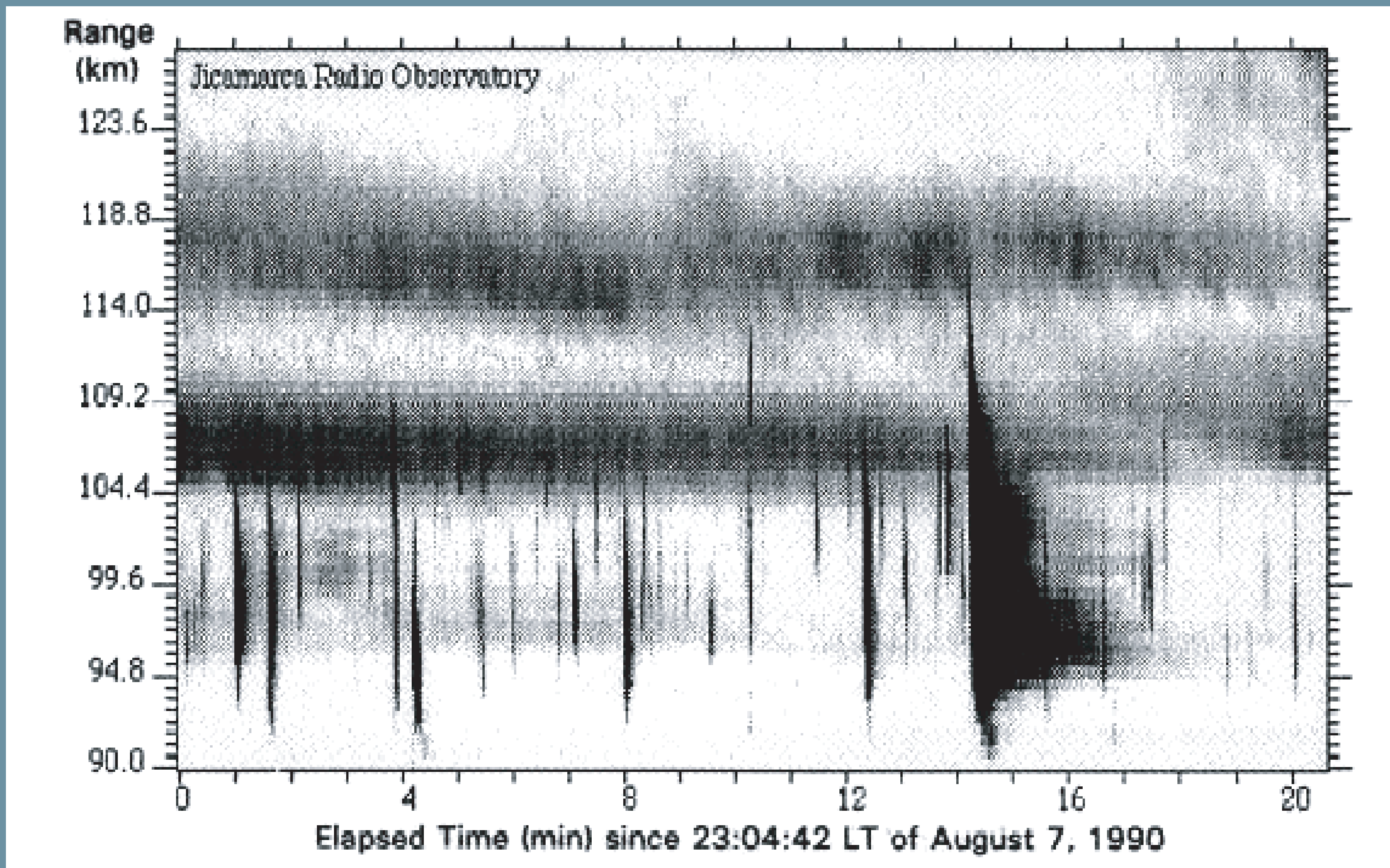

Chapin and Kudeki, JGR, 1994

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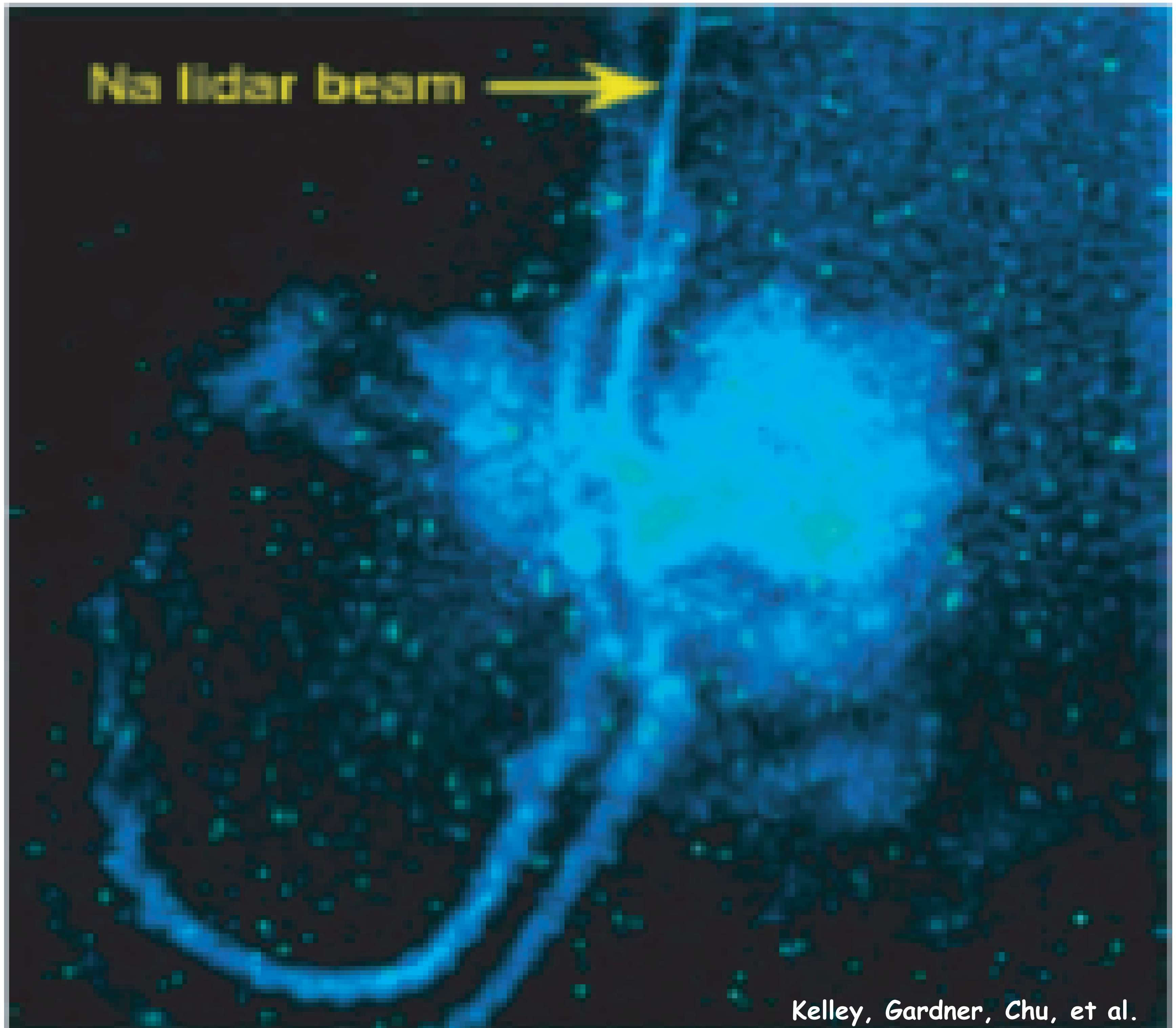

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2001: Diego Janches got the CEDAR Postdoc award for meteor related research

Why meteors are important at CEDAR?

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-Large scale atmospheric dynamics

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-Meteoric Mass input is the source of a number of atmospheric phenomena- Yet to be determined how much mass

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-Space hazard

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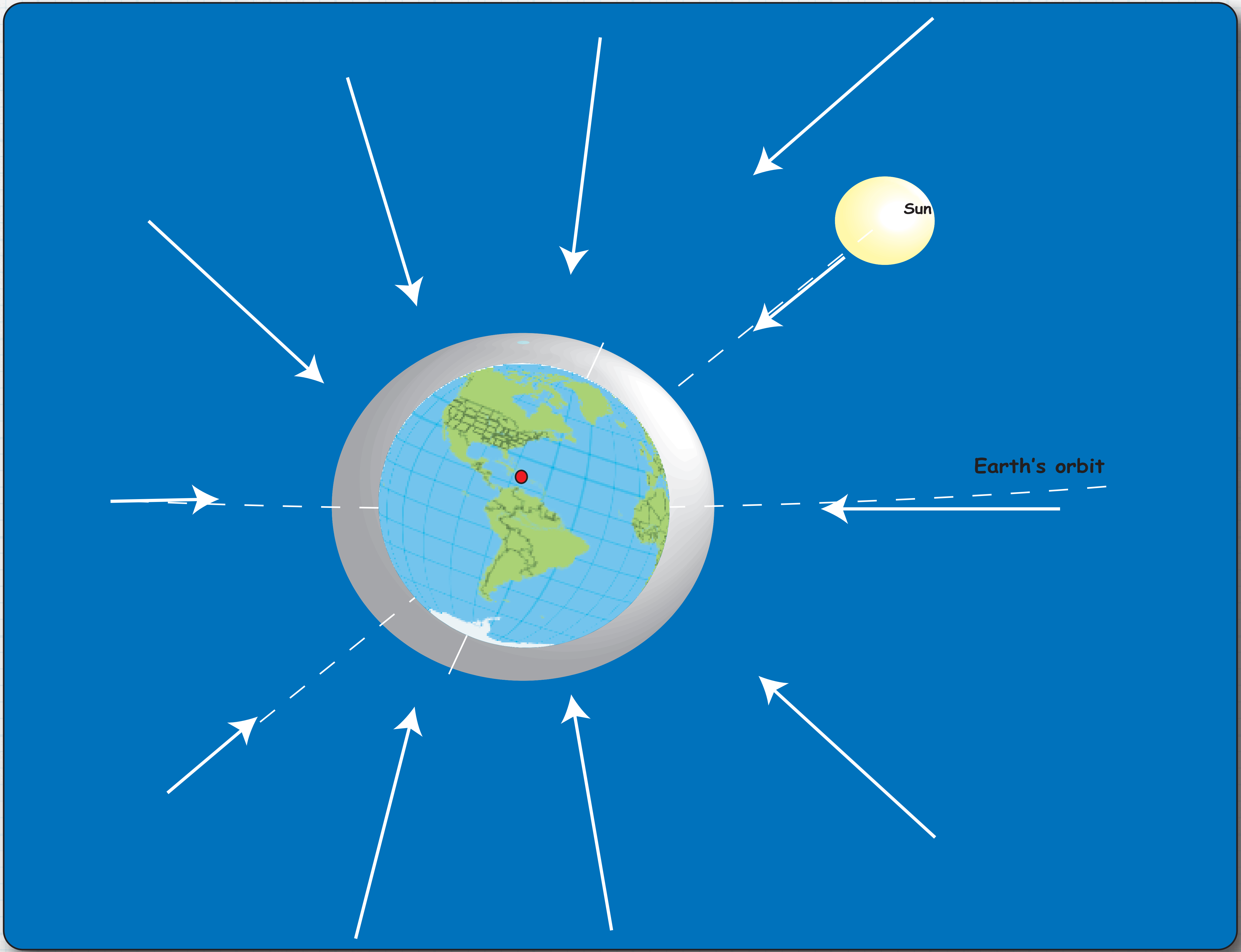

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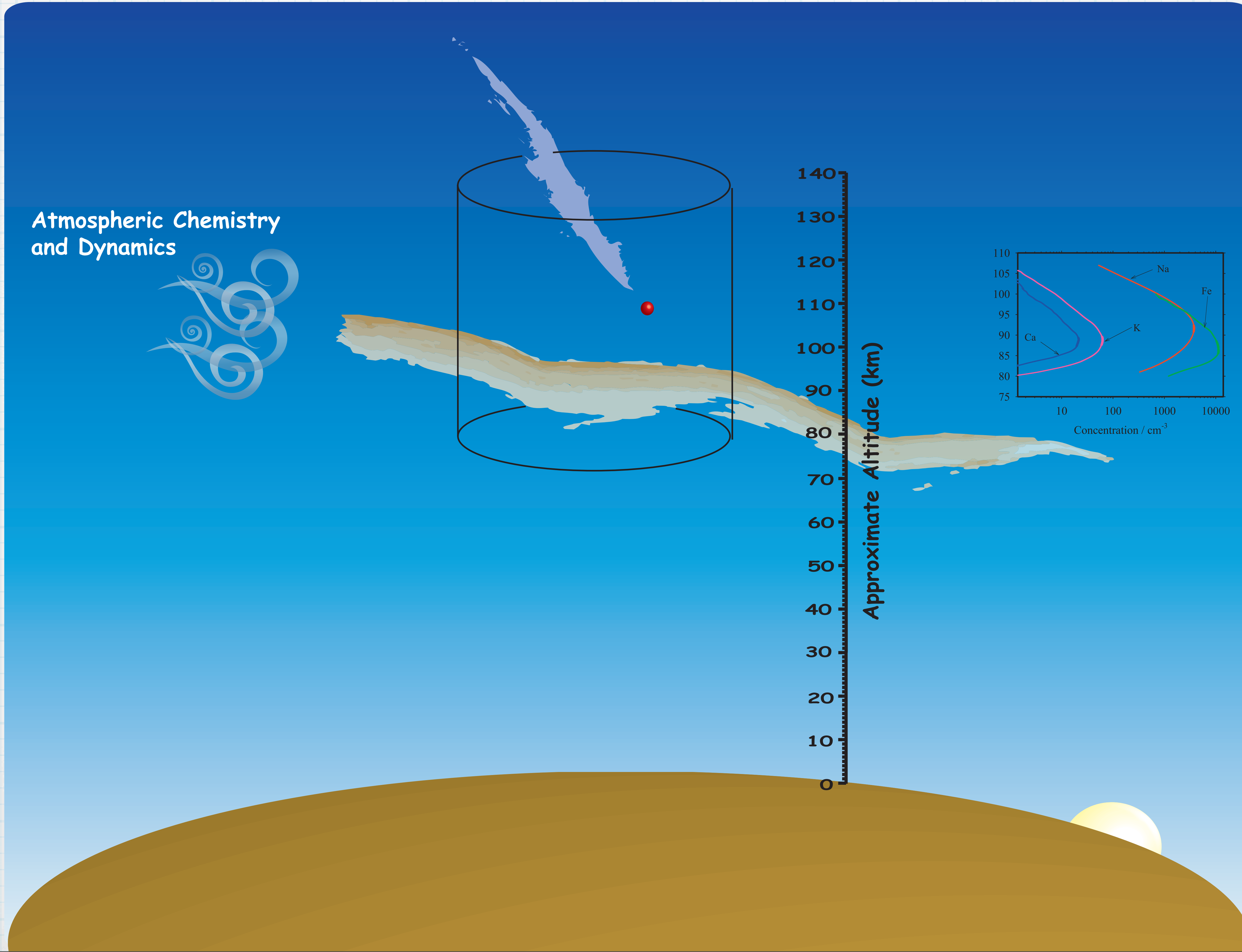

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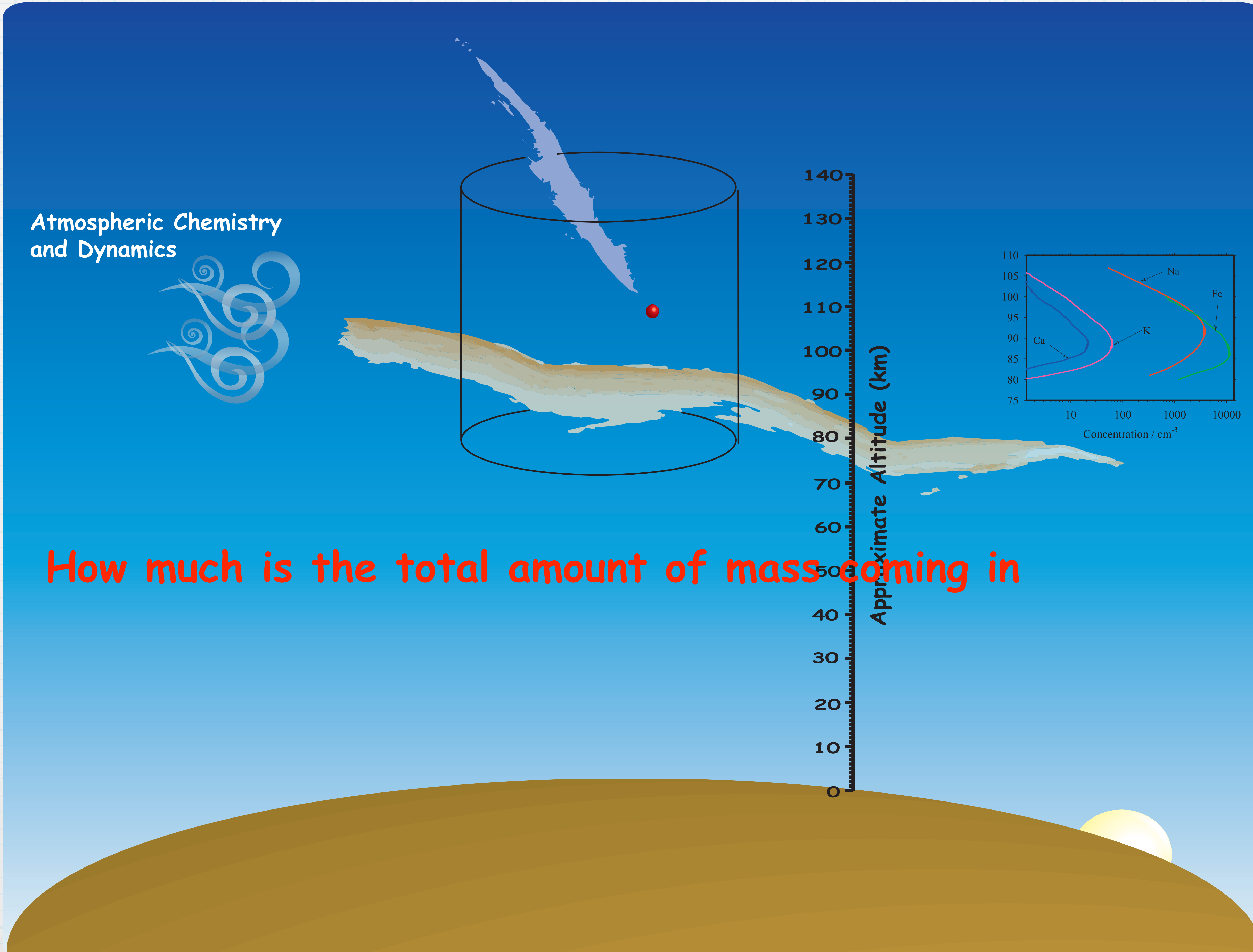

How much is the total amount of mass coming in

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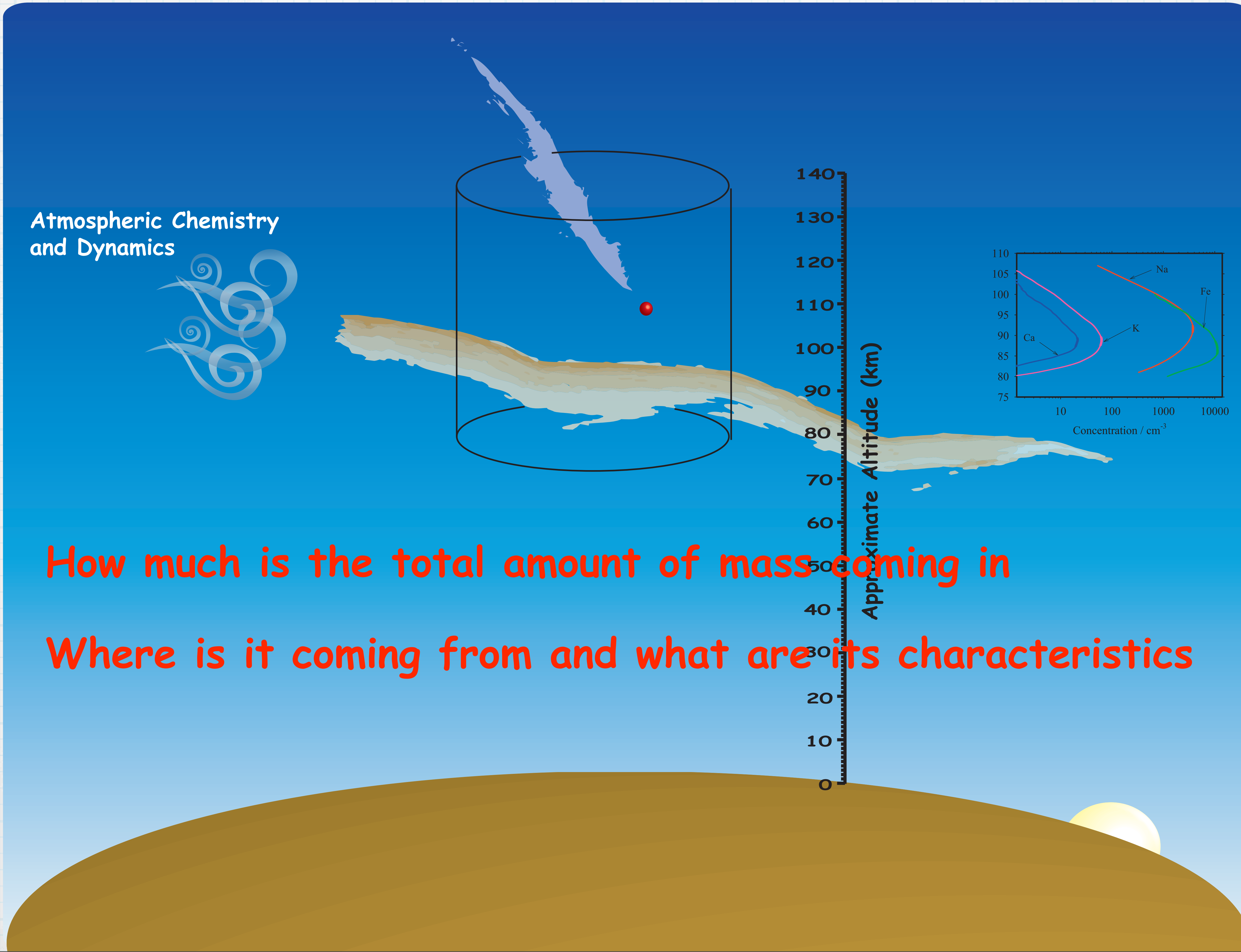

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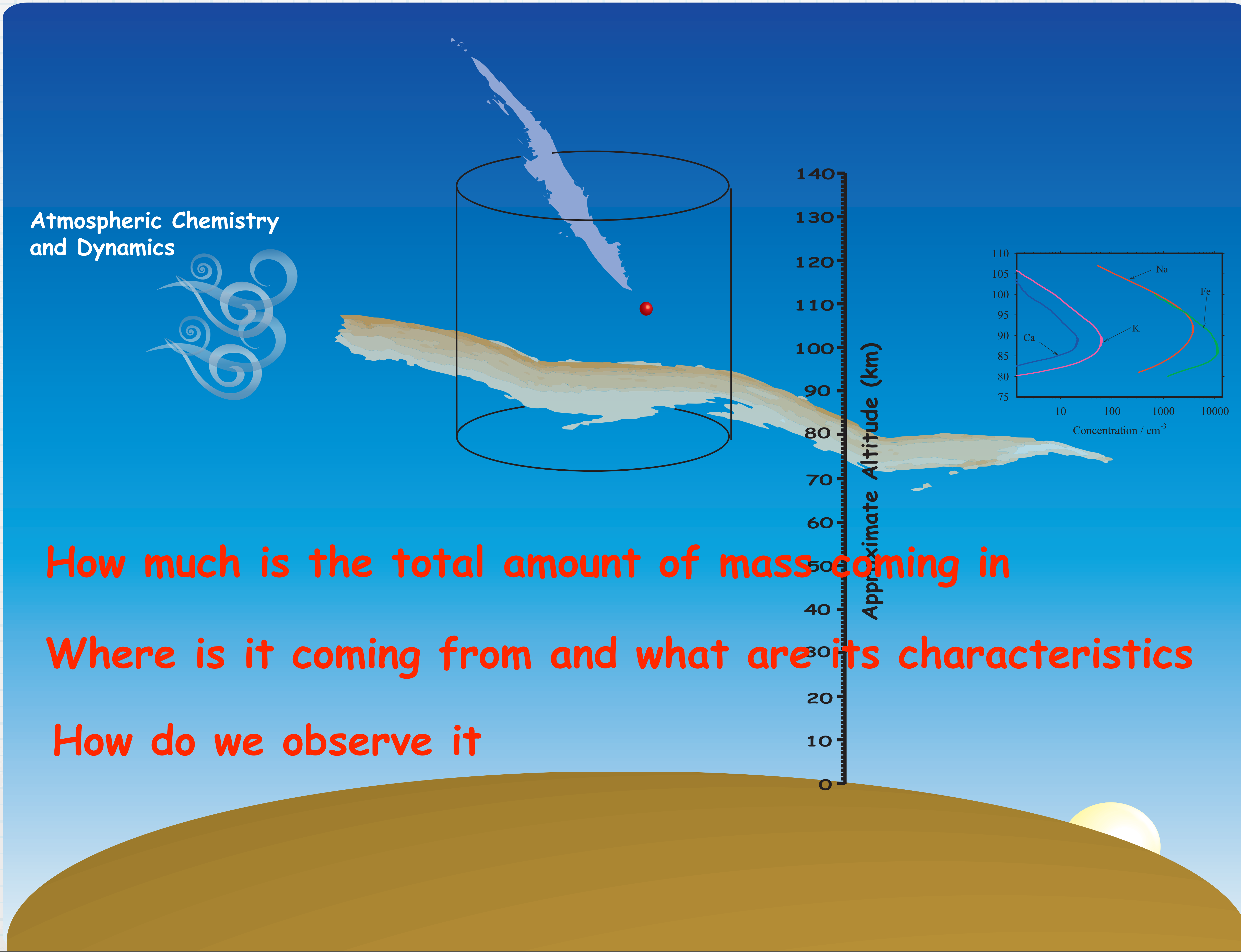
Atmospheric Chemistry and Dynamics



How much is the total amount of mass coming in

Where is it coming from and what are its characteristics

How do we observe it

Uniform flux no good to explain:

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1) Seasonal and global behavior of metal layers. In particularly the seasonal asymmetry of the metals (maximum in late autumn/early winter in the NH

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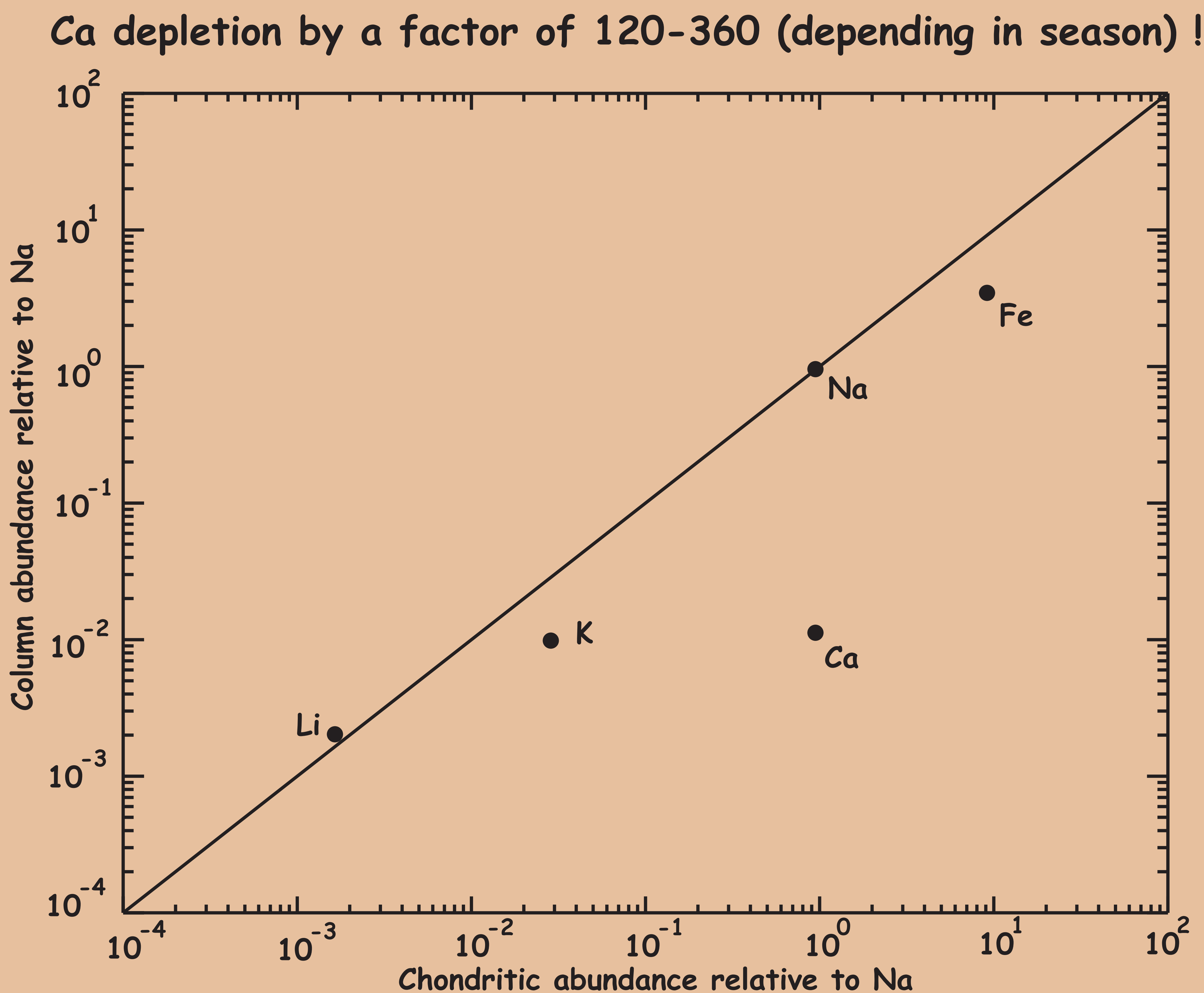

Plane, Chem. Rev., 2003

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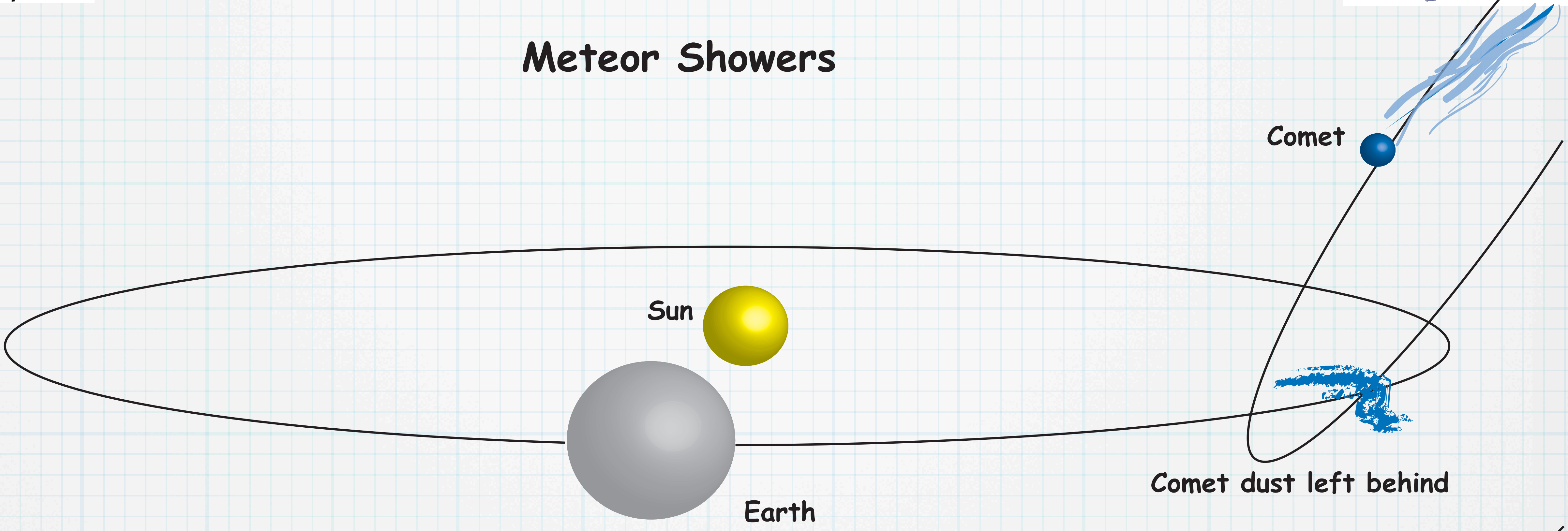
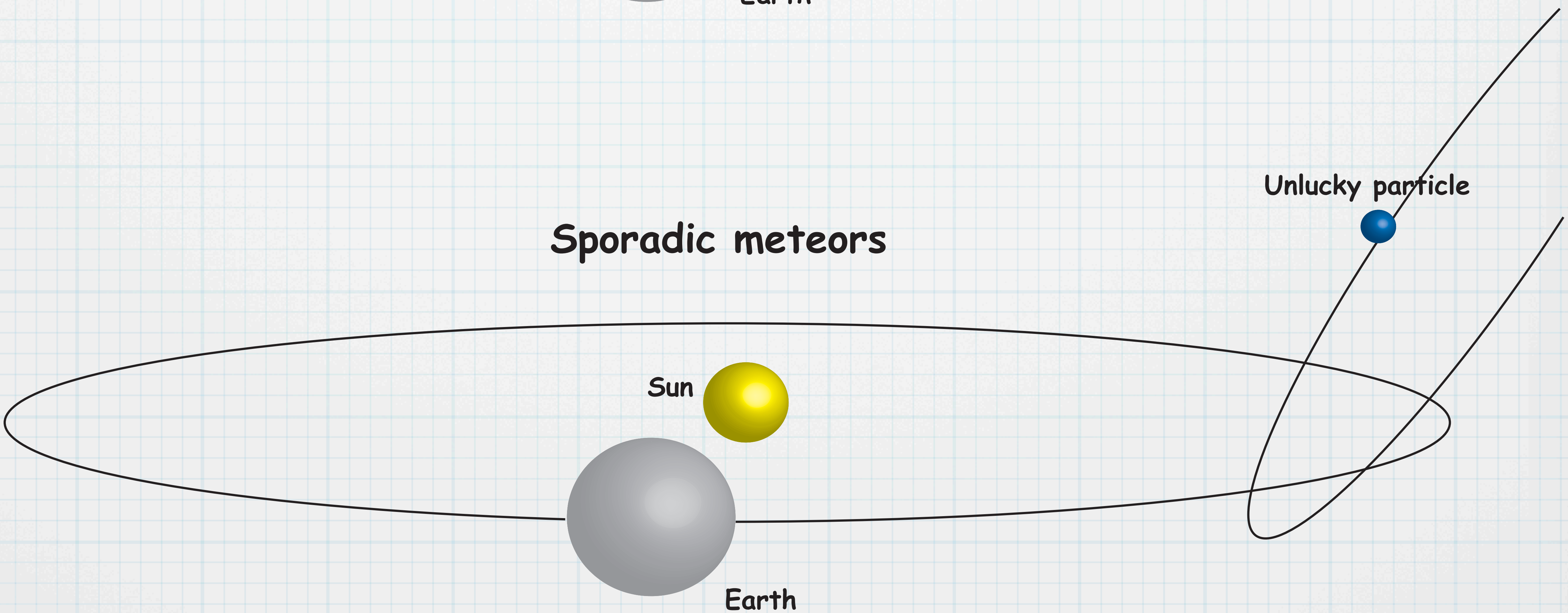
4) Meteoric smokes may have influenced paleoclimates

Meteor Showers



Sporadic meteors



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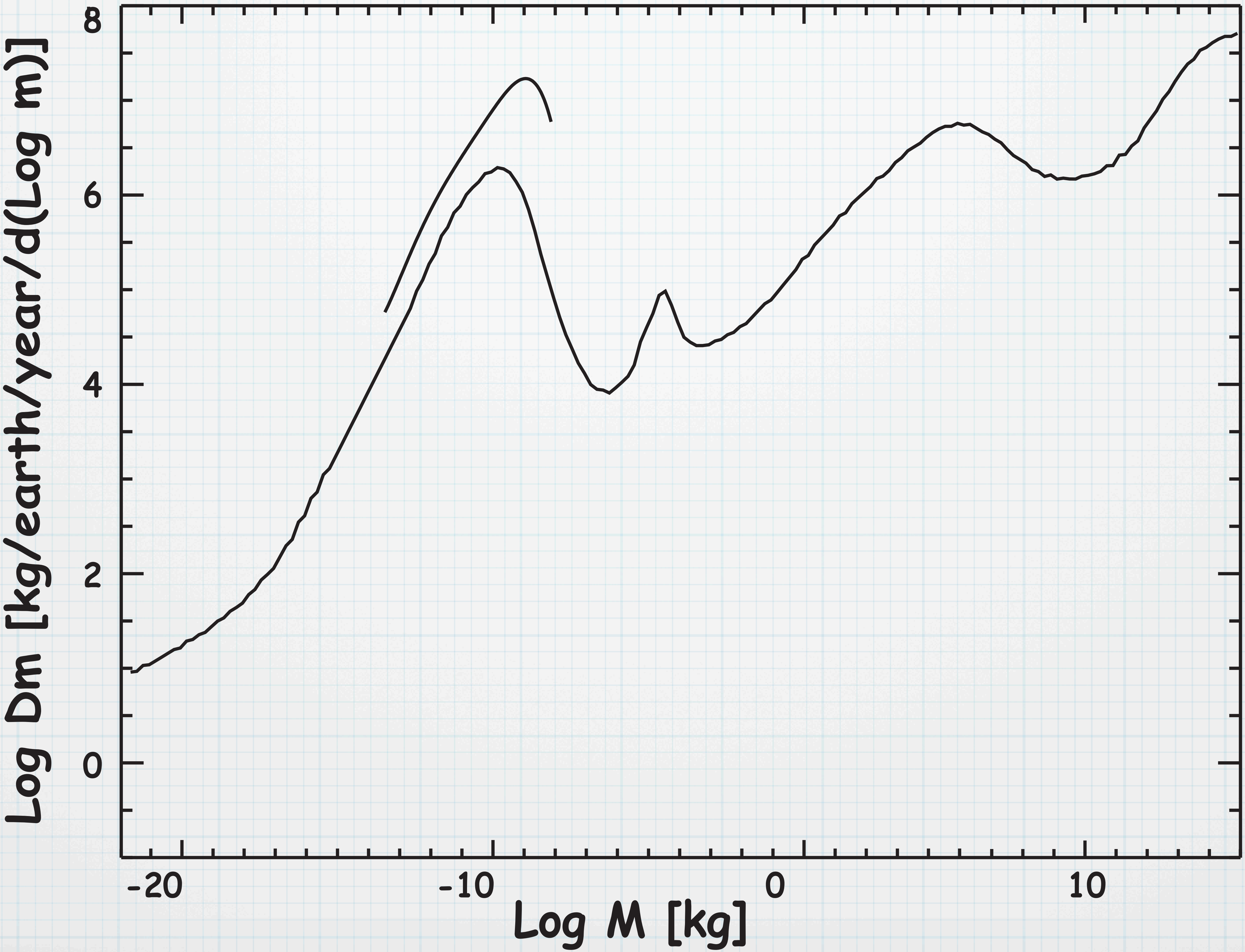
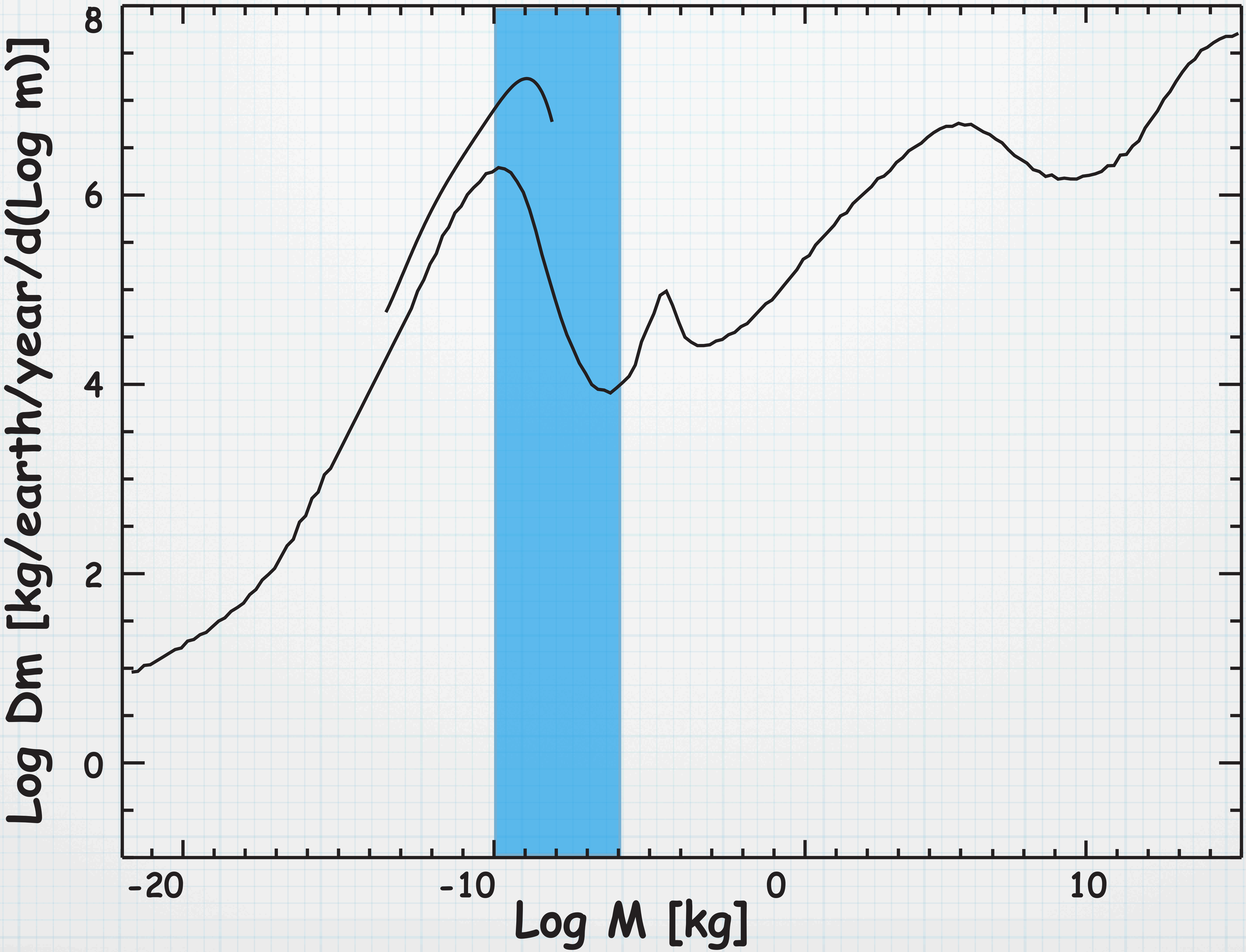
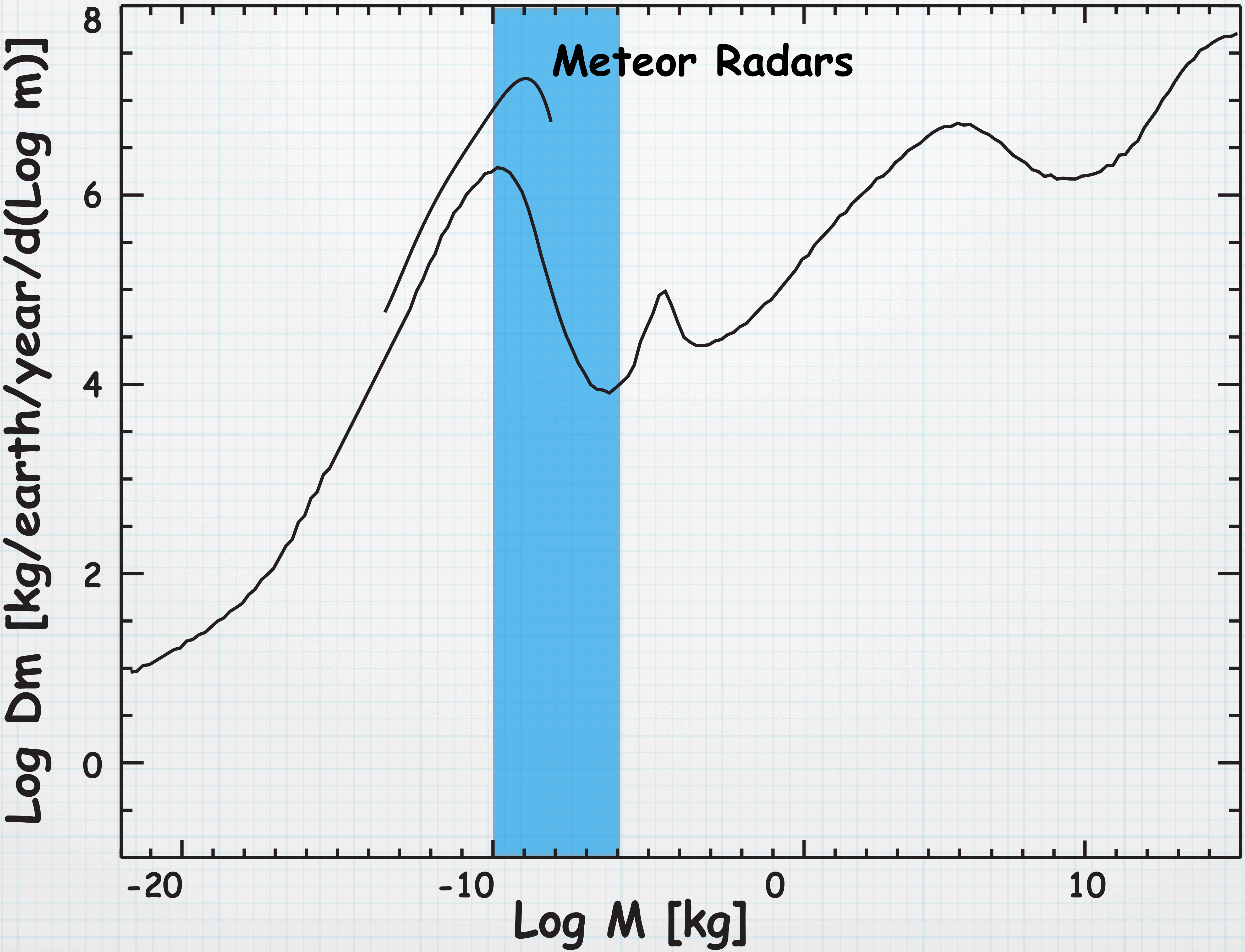




Log Dm [kg/earth/year/d(Log m)]
8
6
4
2
0
-20
-10
0
10
Log M [kg]


Meteor Radars
Log Dm [kg/earth/year/d(Log m)]
8
6
4
2
0
-20
-10
0
10
Log M [kg]

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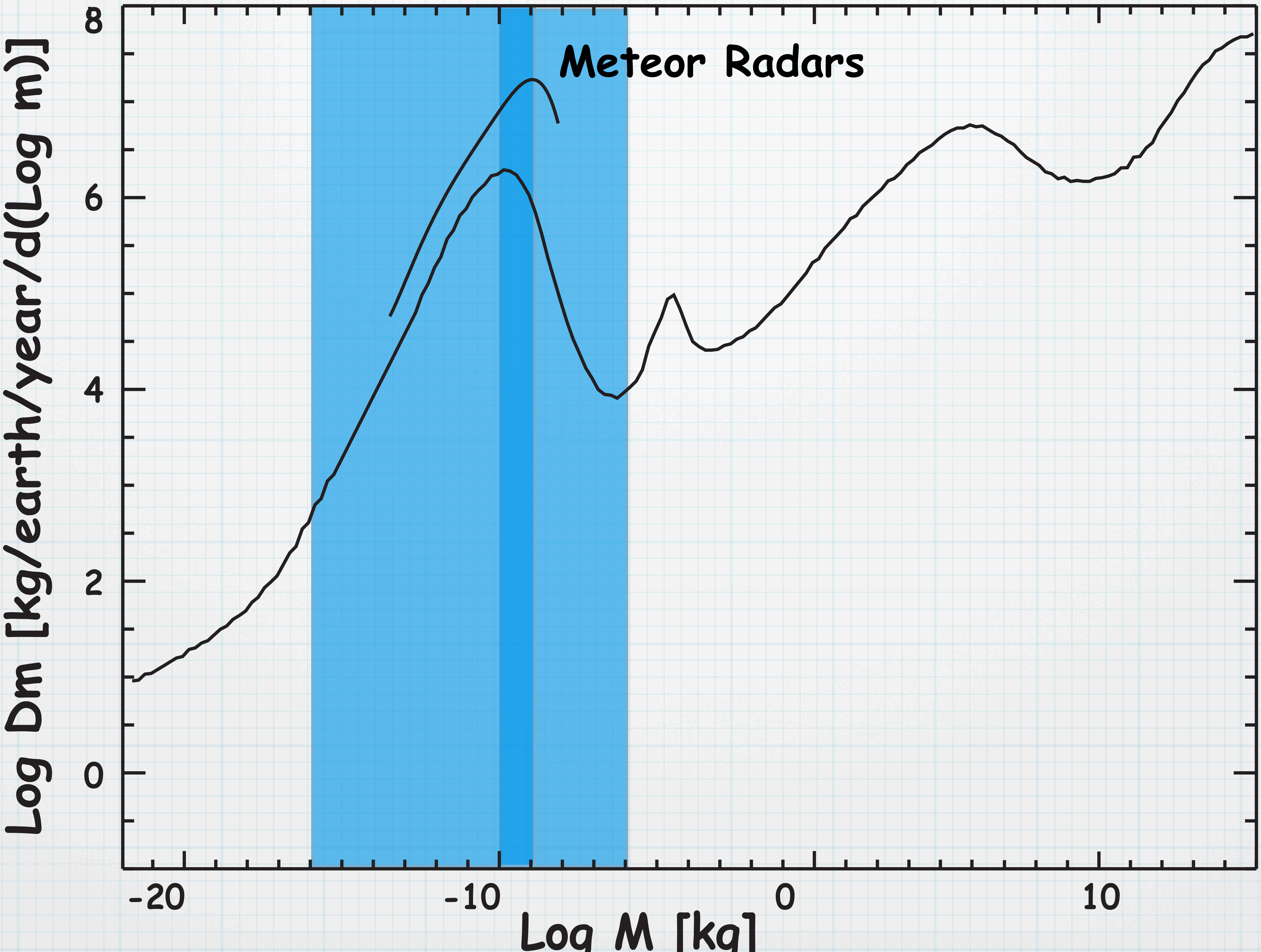
CoRA



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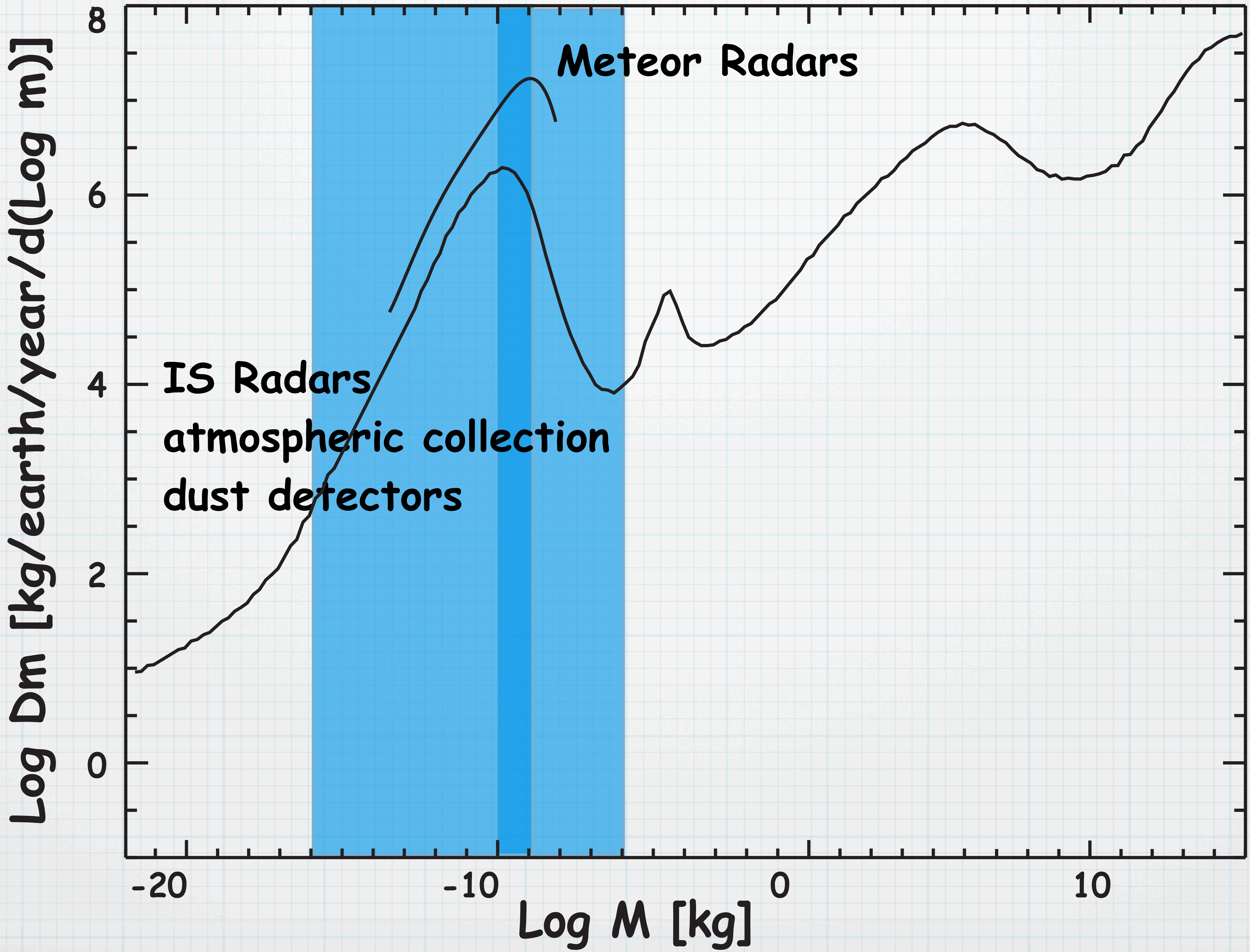

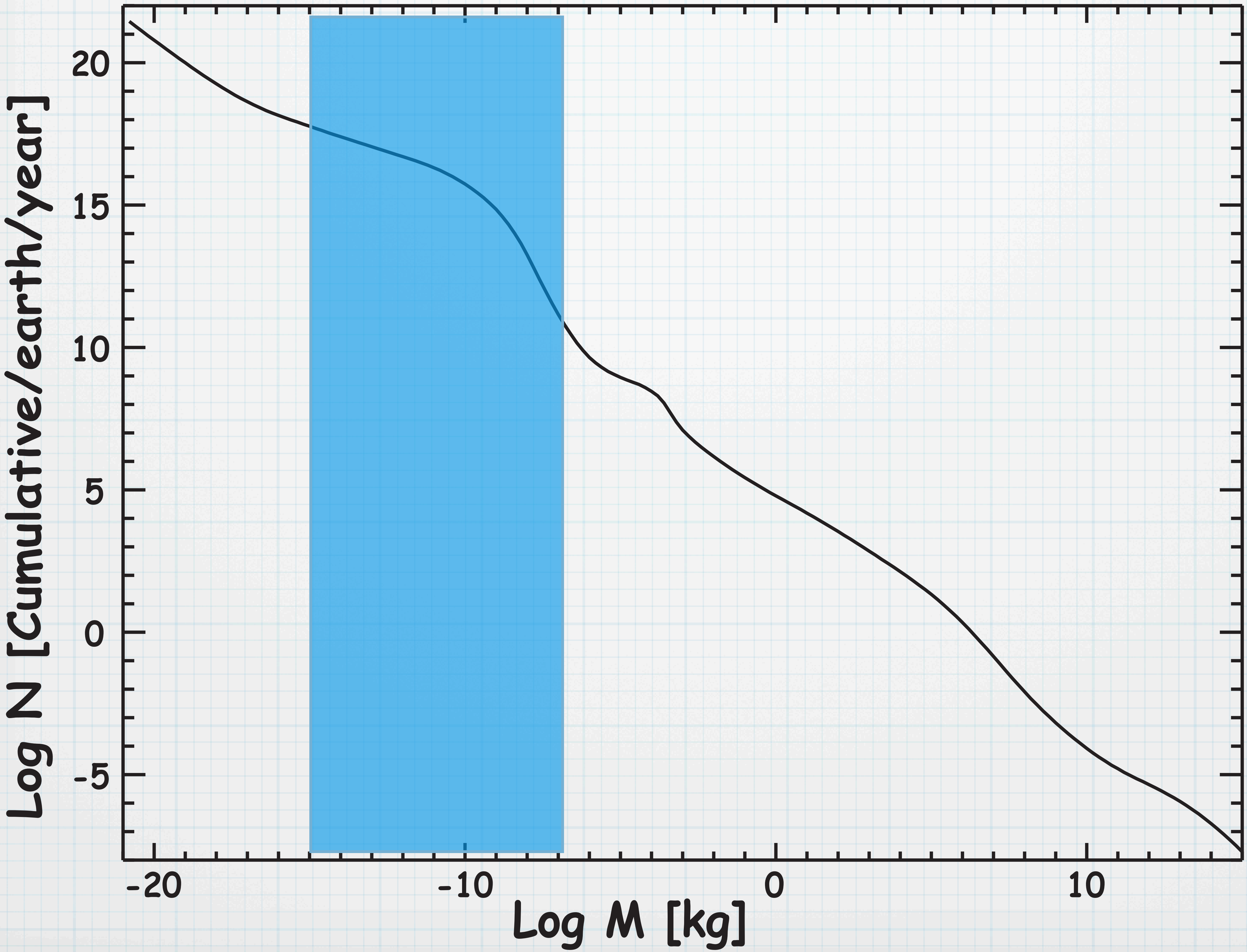
Log N [Cumulative/earth/year]
20
15
10
5
0
-5
-20
-10
0
10
Log M [kg]

NWRA
Since 1984

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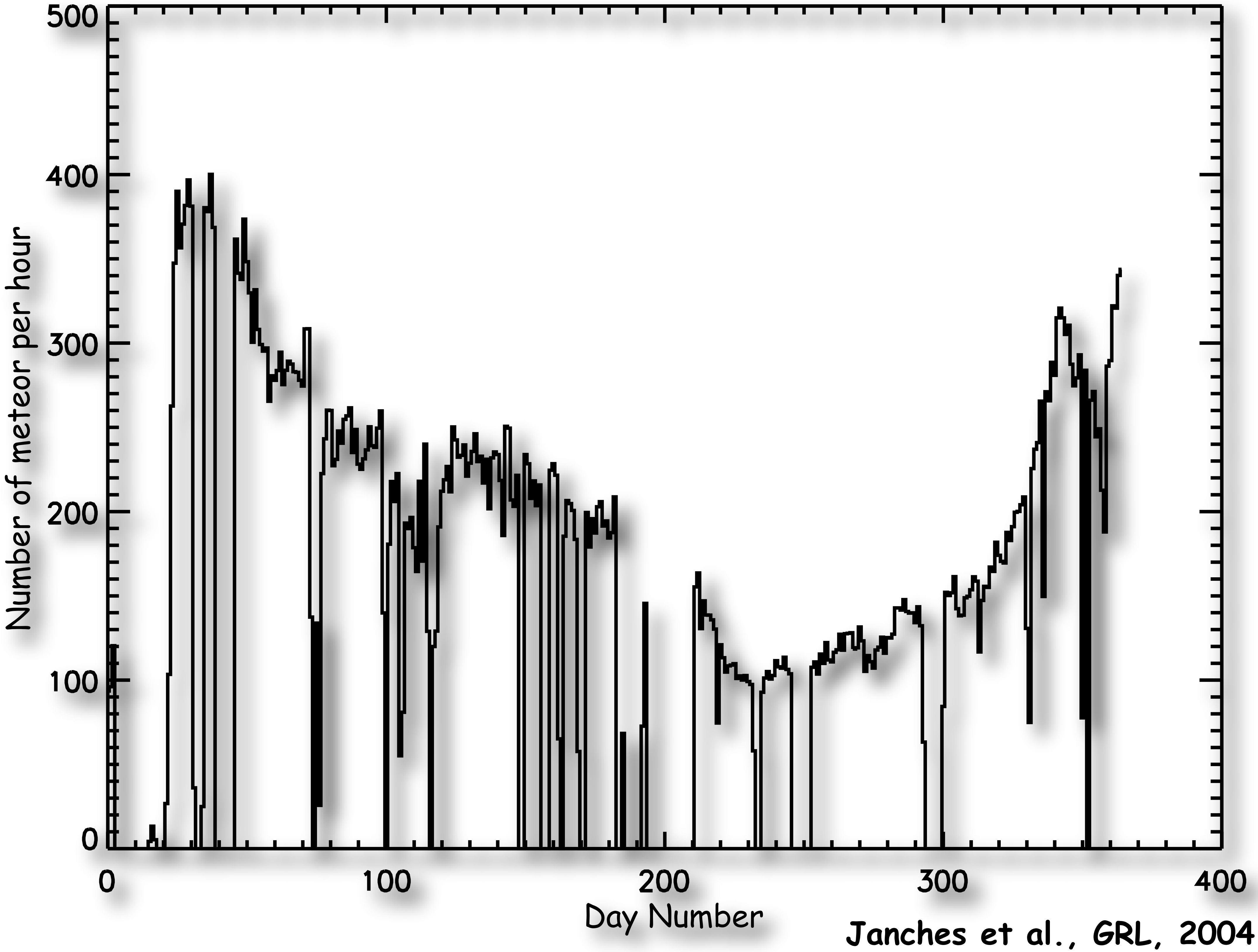

Janches et al., GRL, 2004
Lau et al, JGR, 2006

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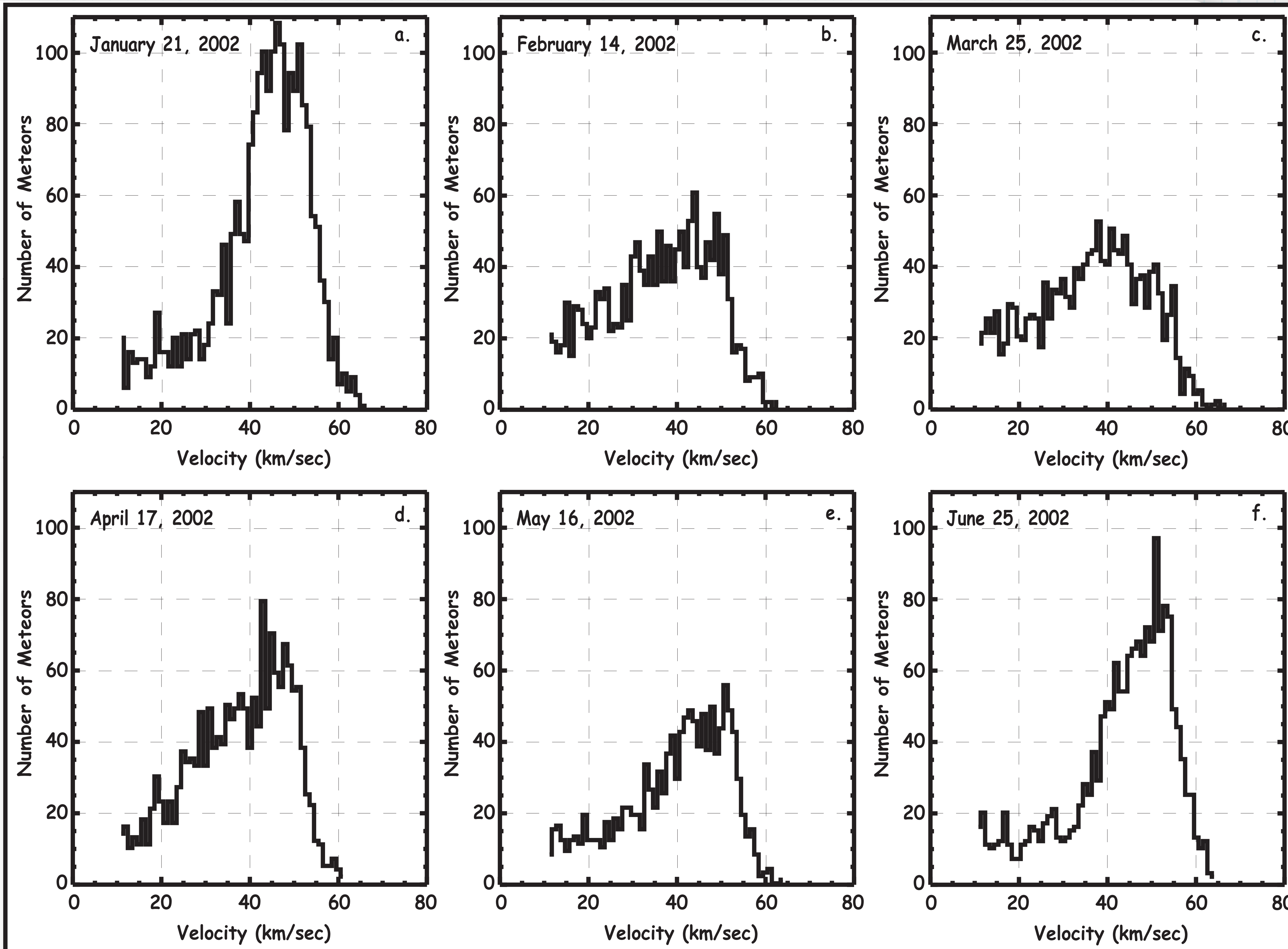

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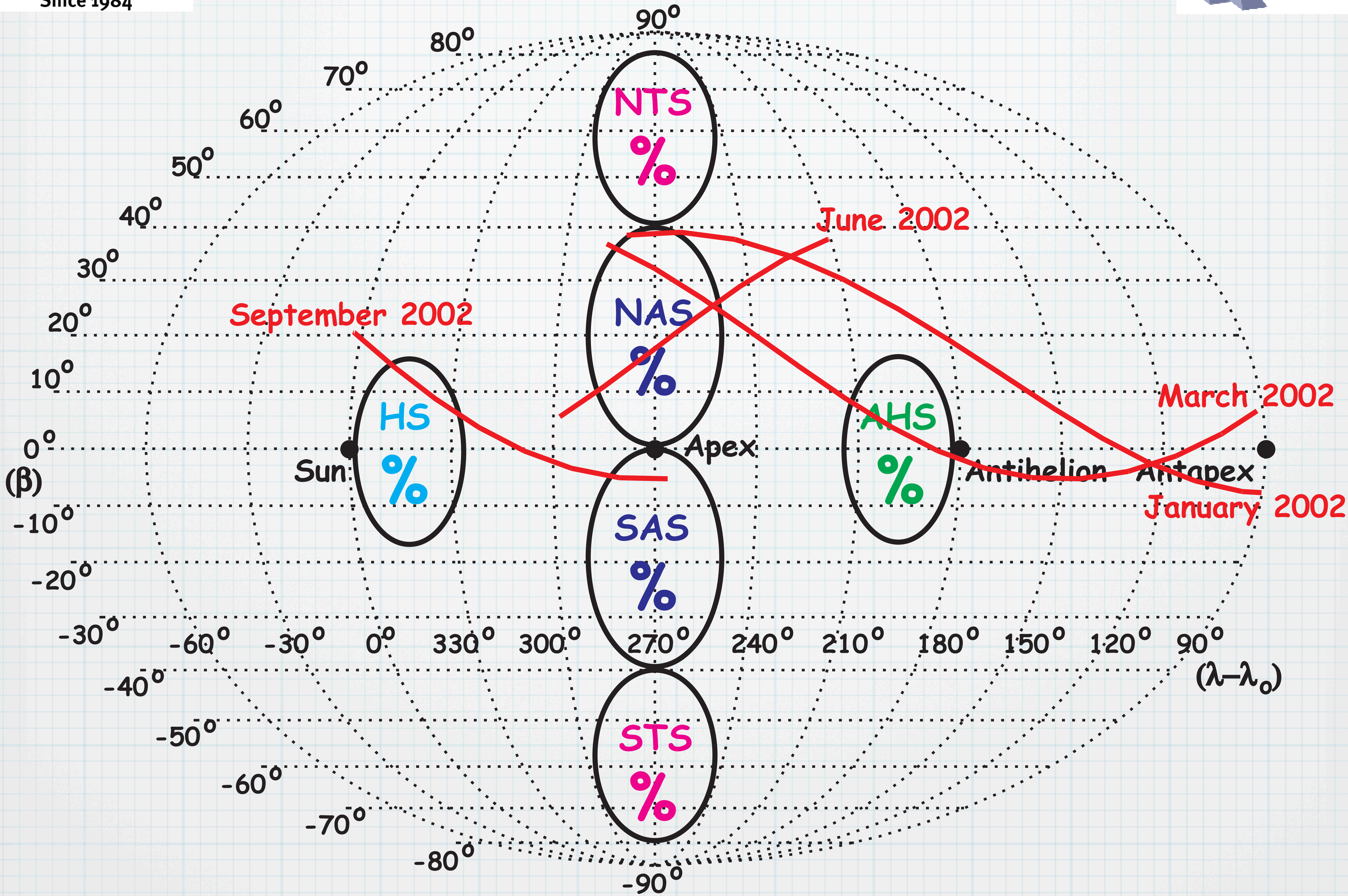

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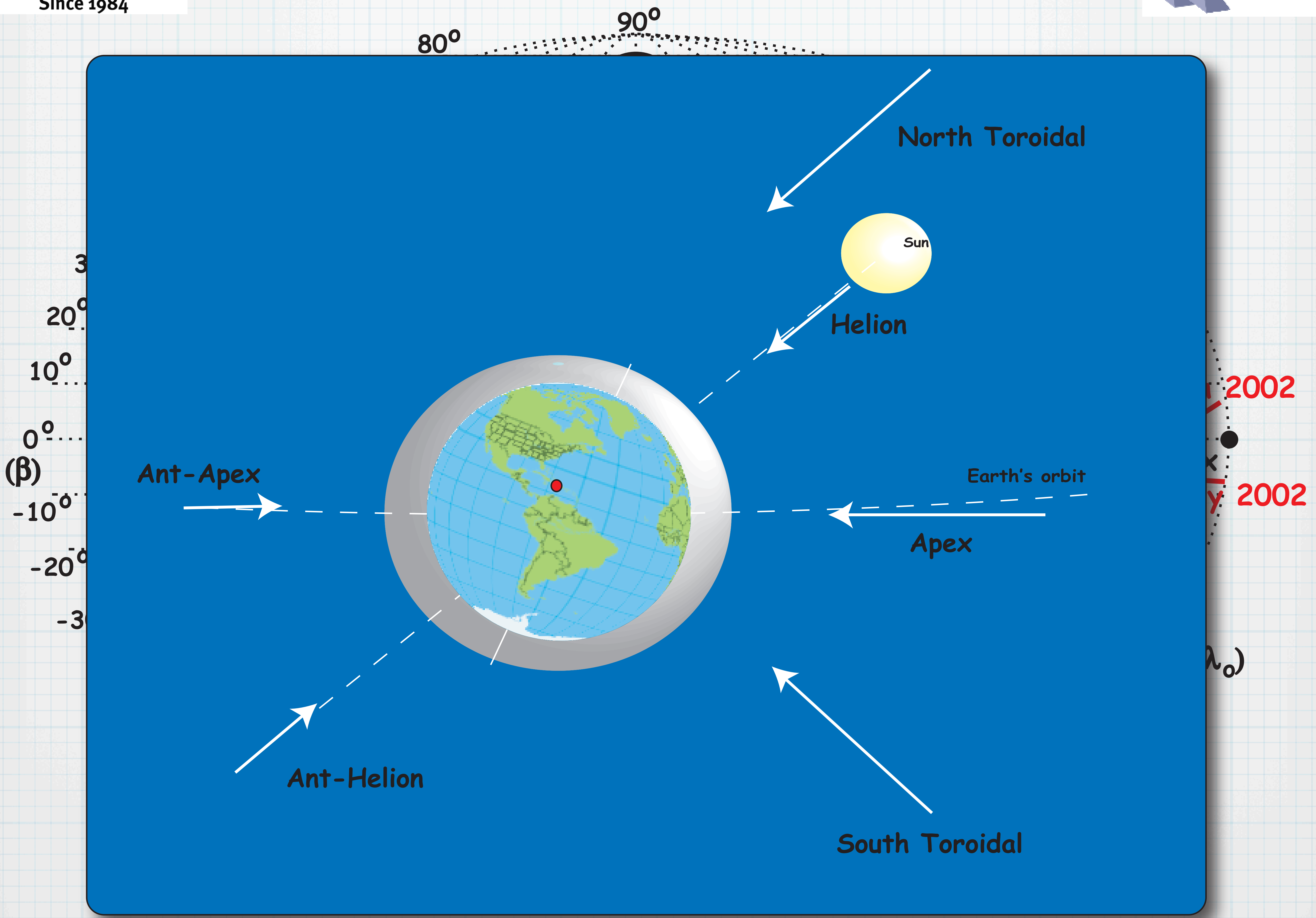

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Sources of radar signal scattering from a meteor event

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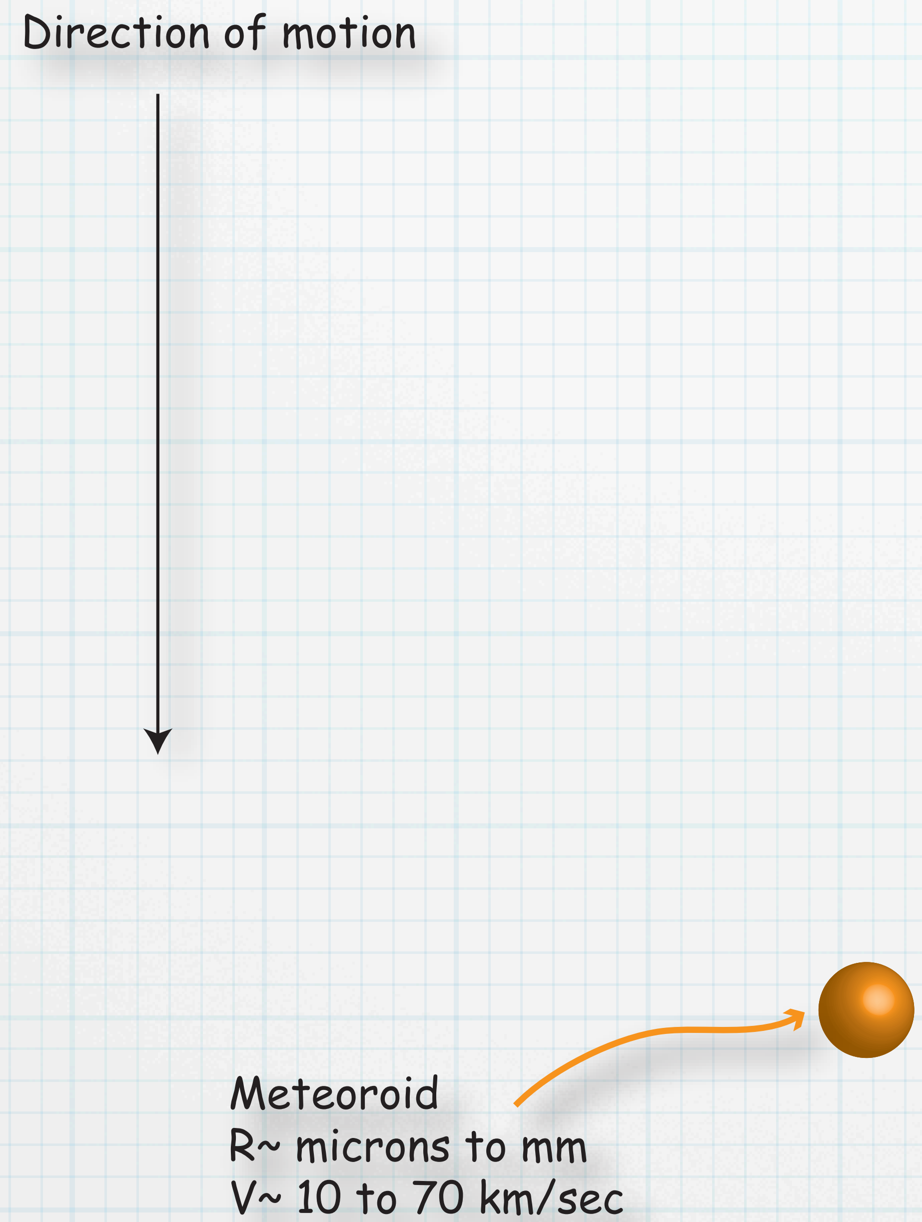

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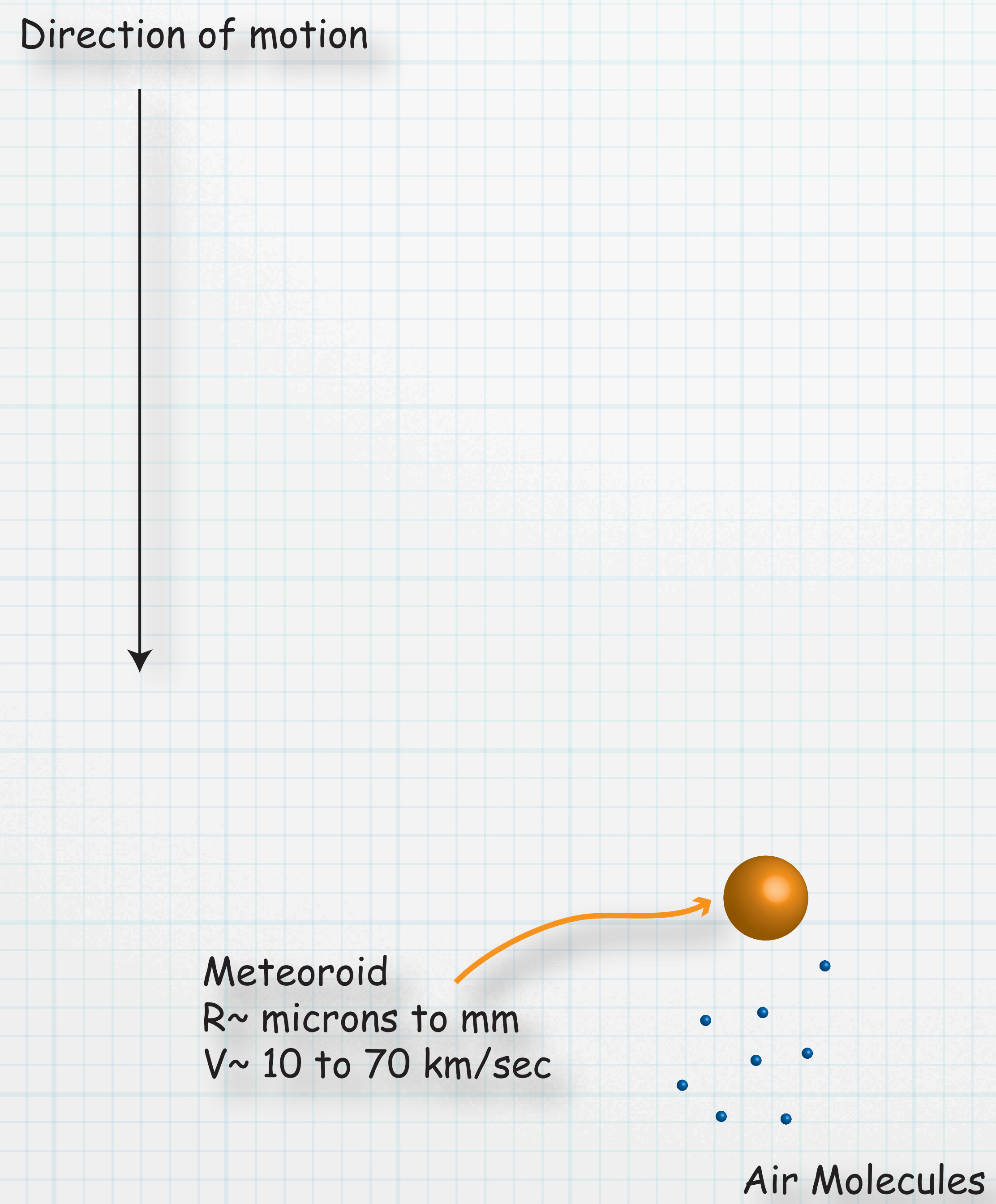

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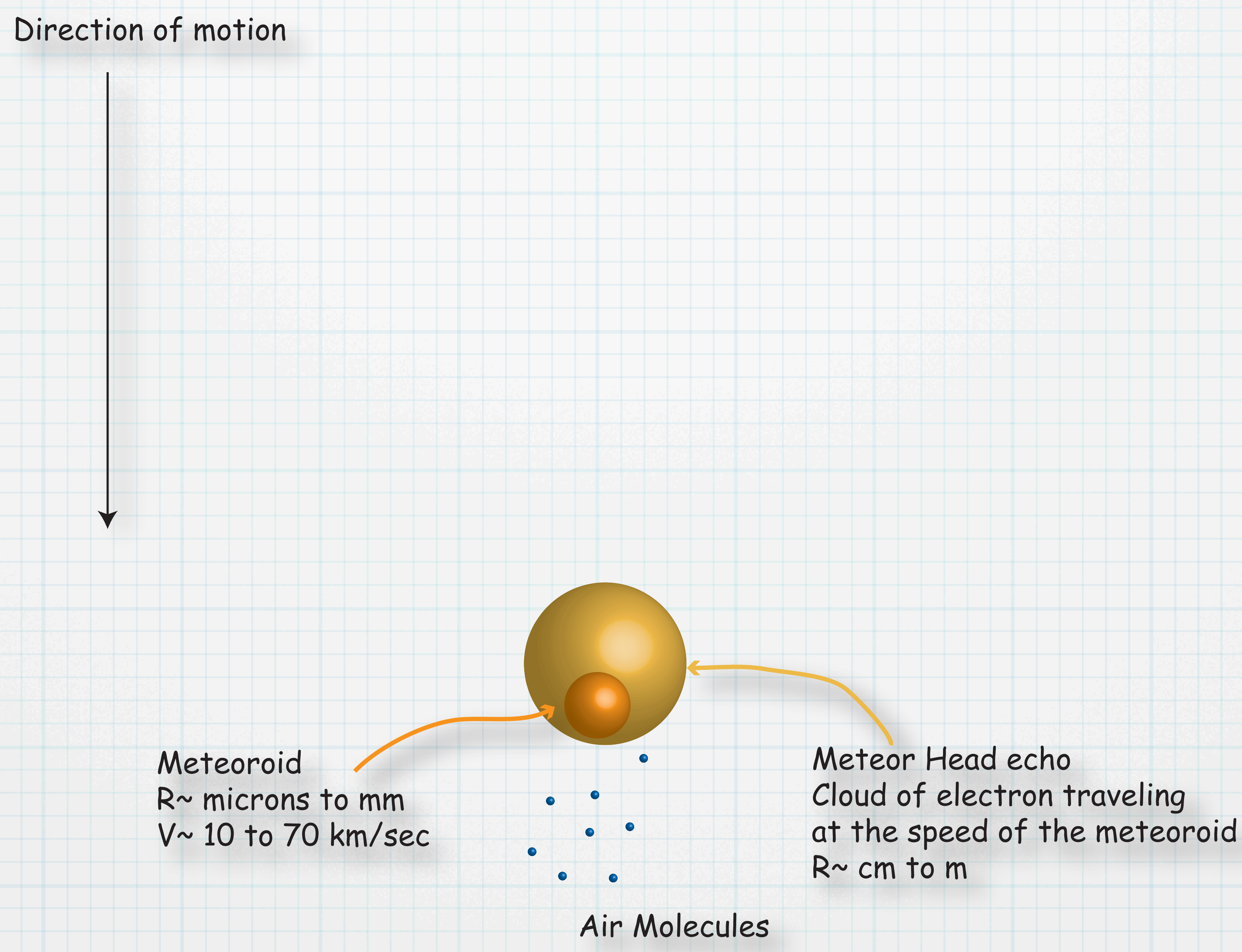

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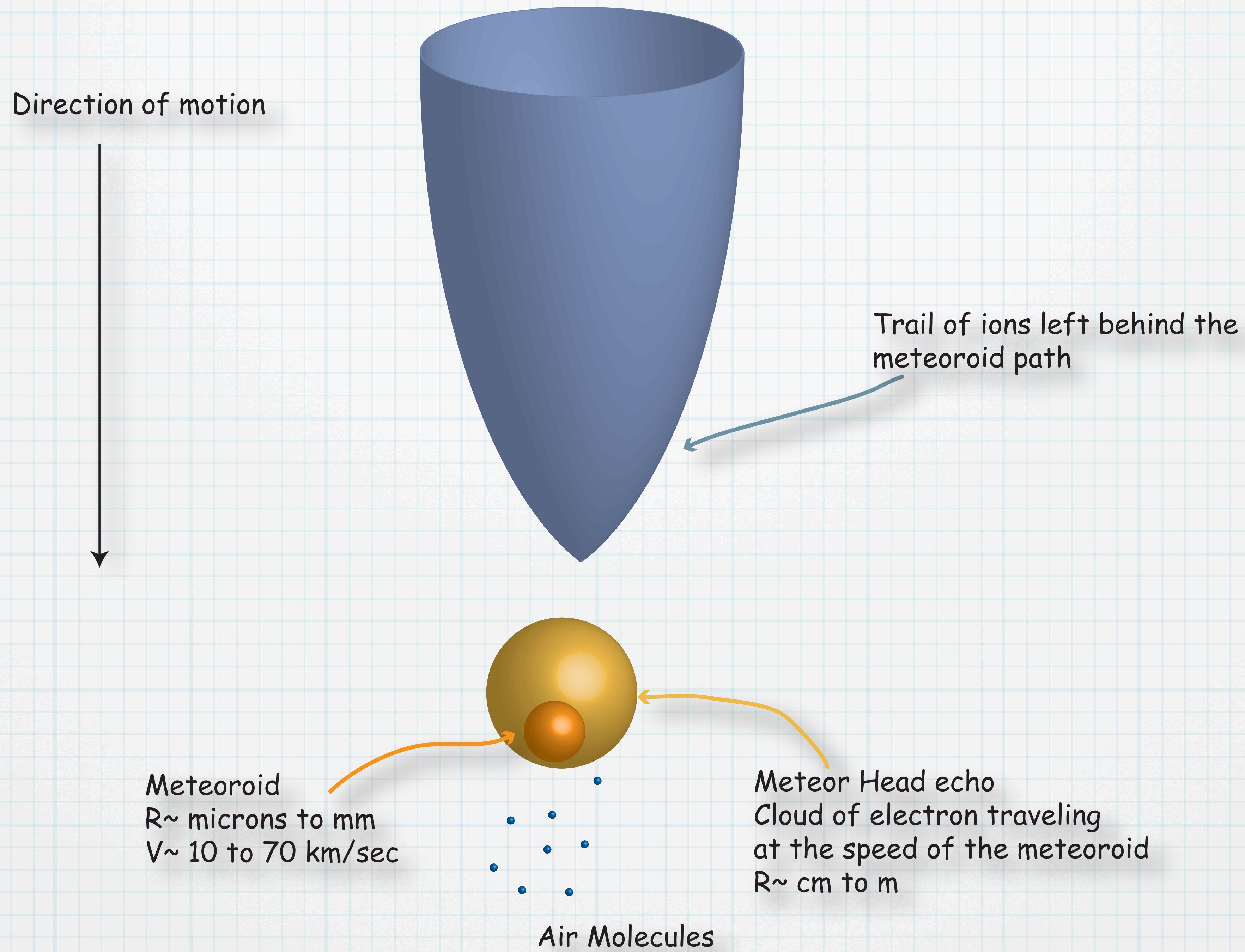

Specular Meteor Radar Observing Geometry

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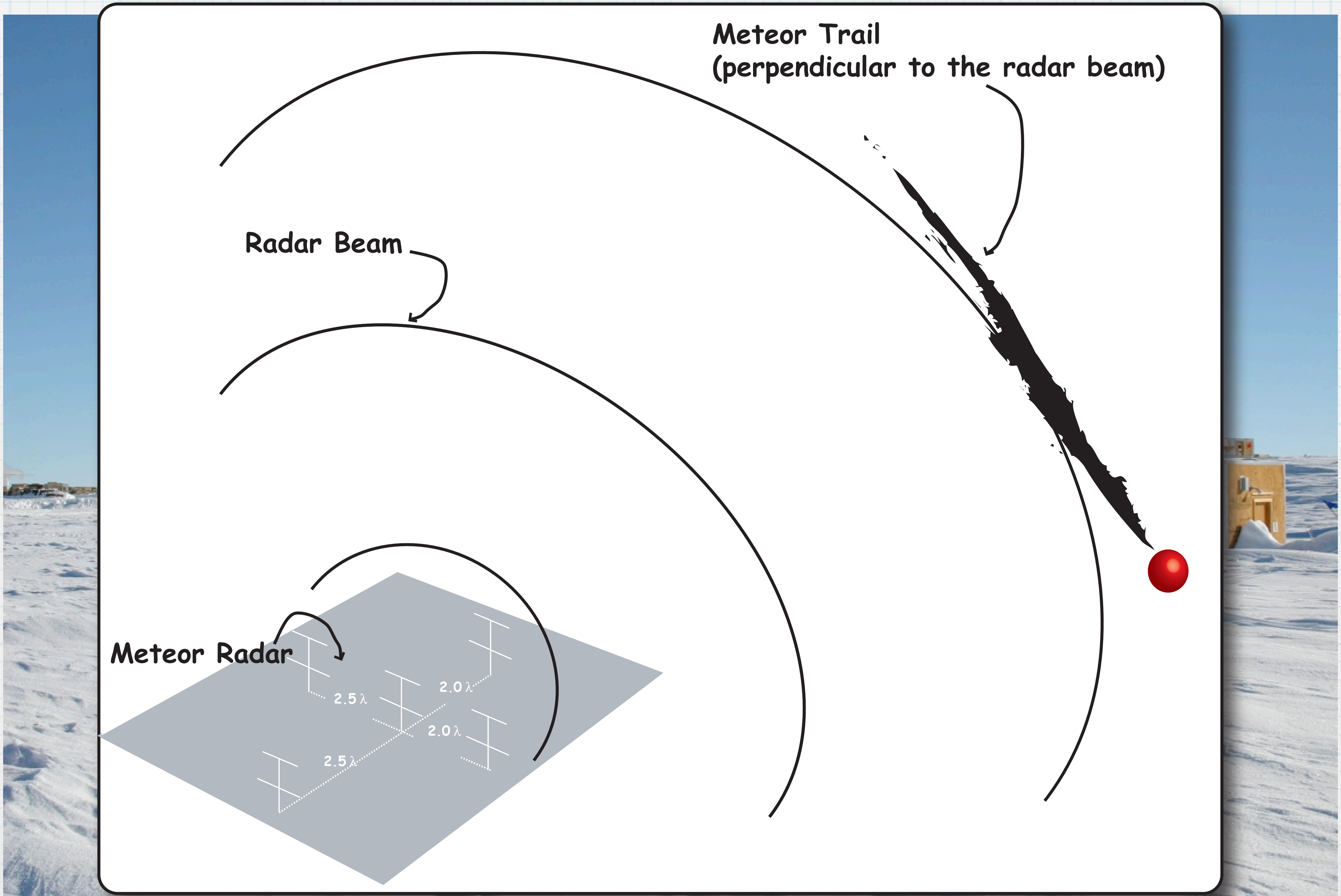

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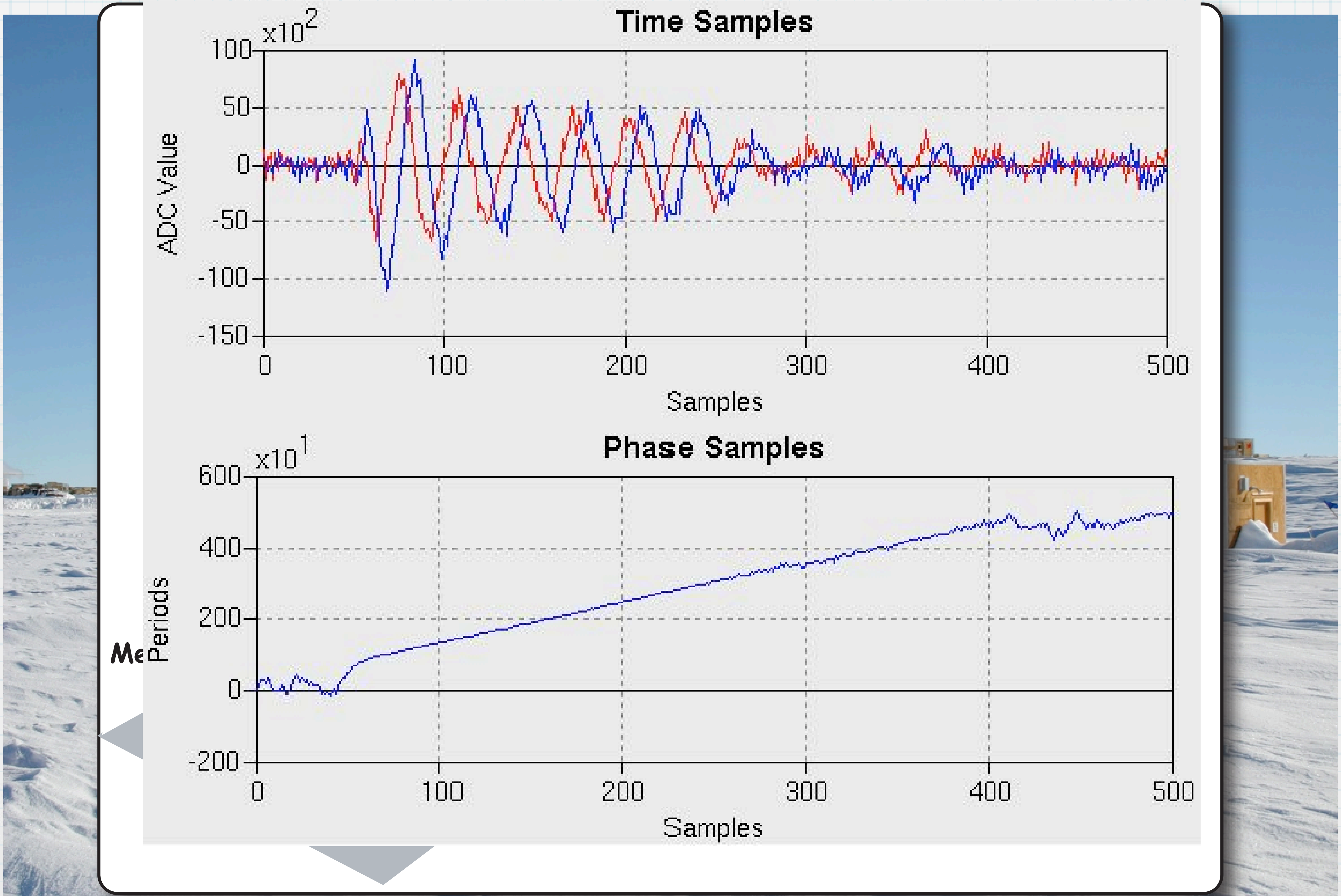
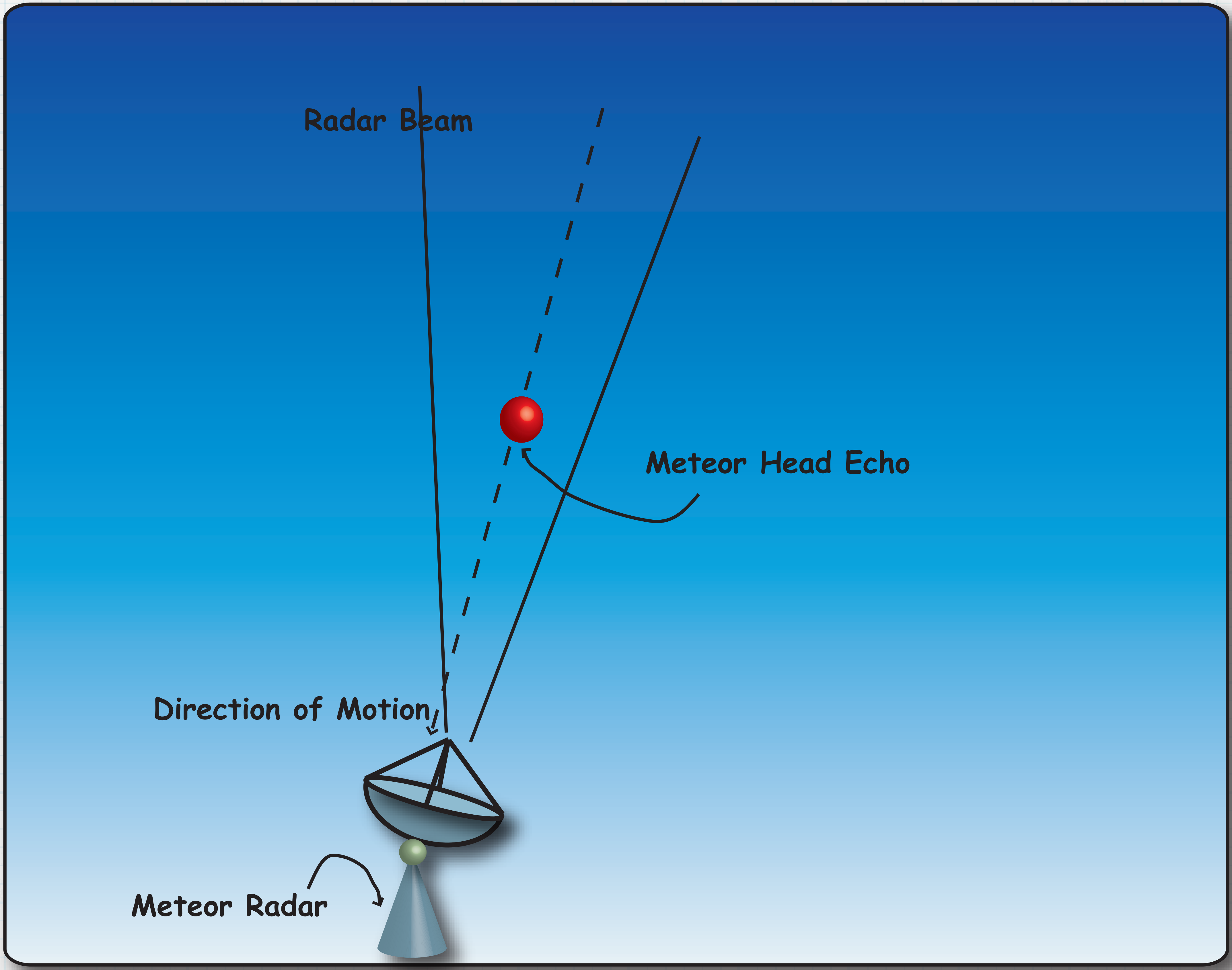


HPLA Radar Meteor Observing Geometry



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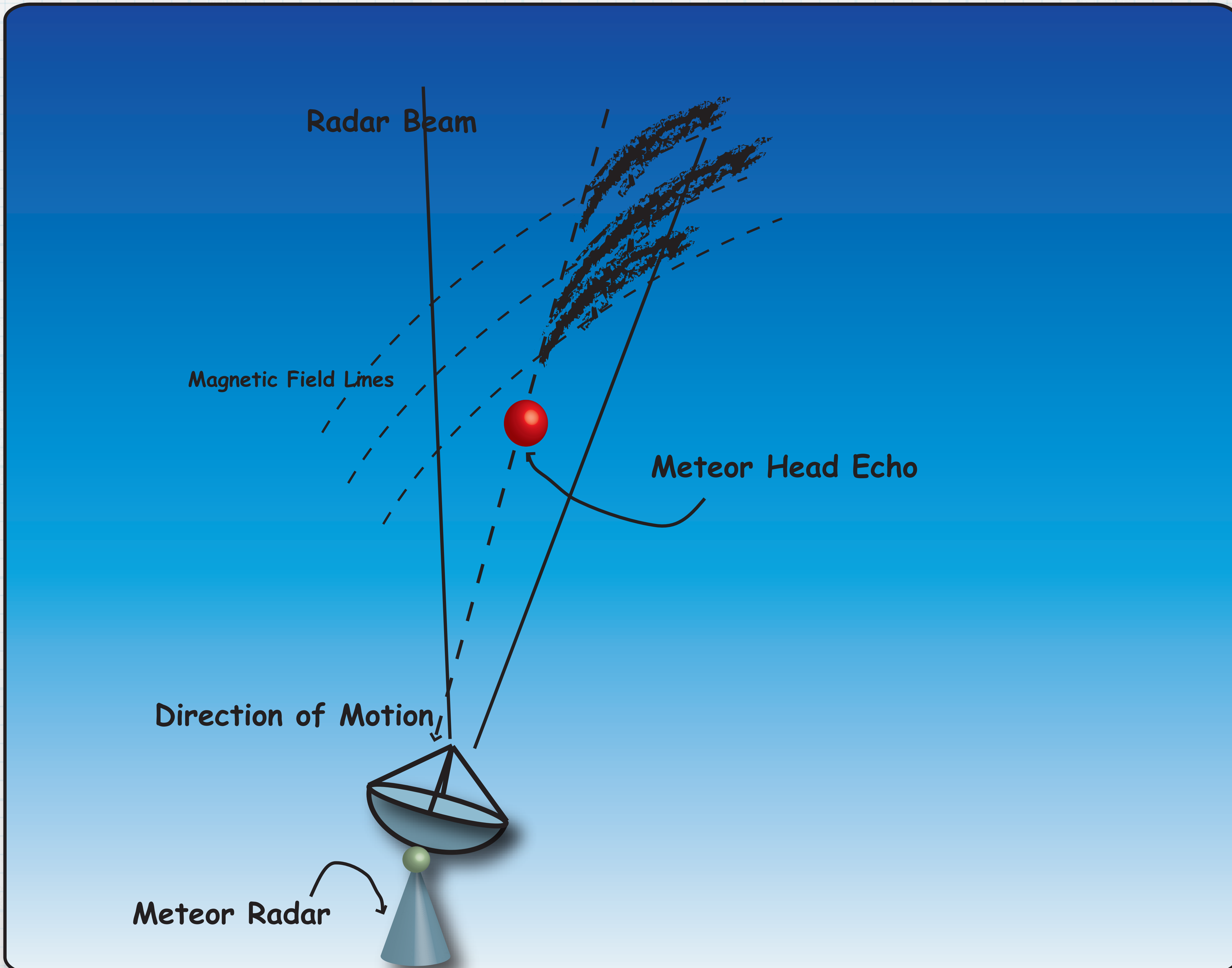
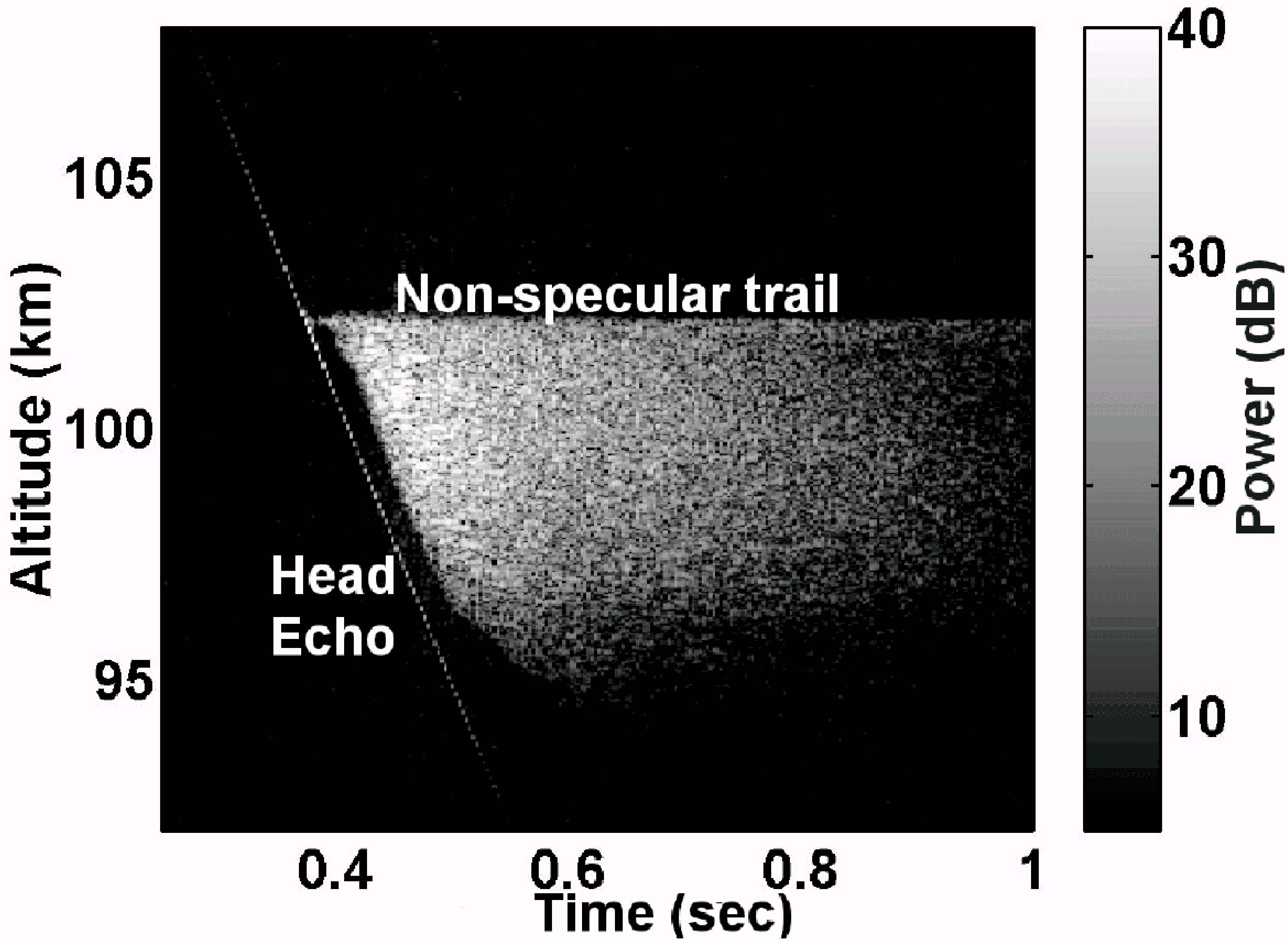
HPLA Radar Meteor Observing Geometry

CoRA



HPLA Radar Meteor Observing Geometry

Close, Dyrud, Oppenheim, et al.



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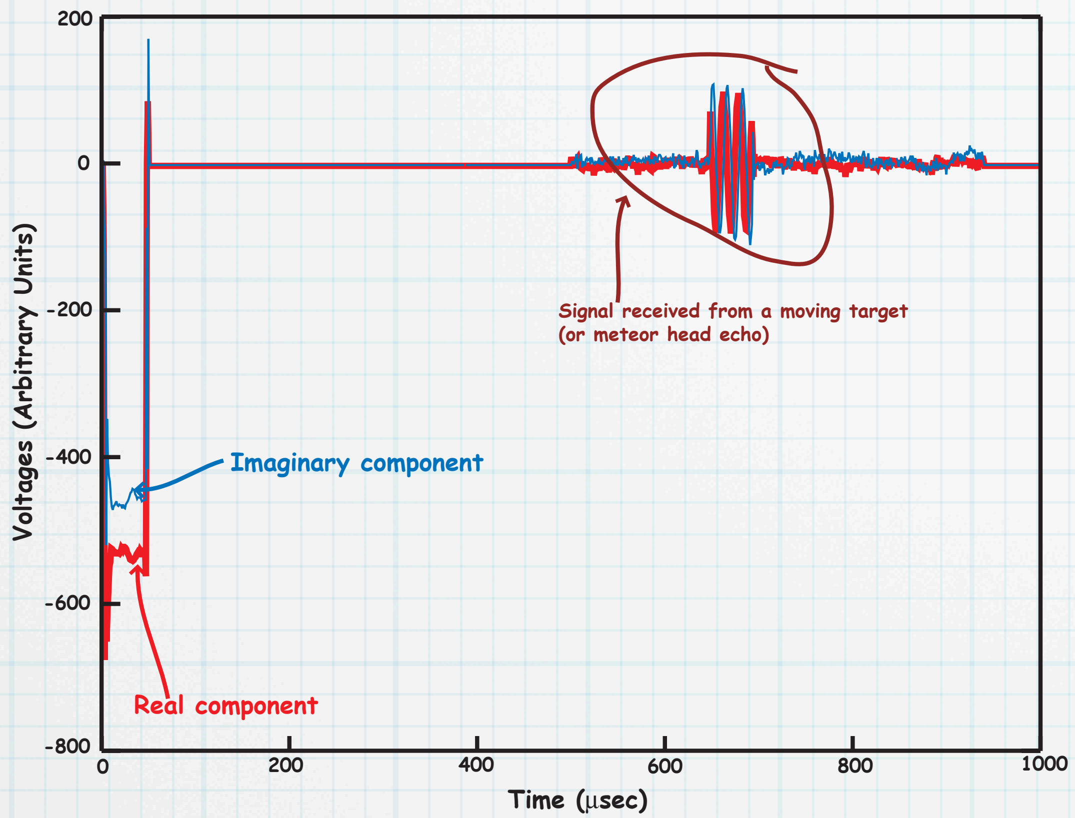
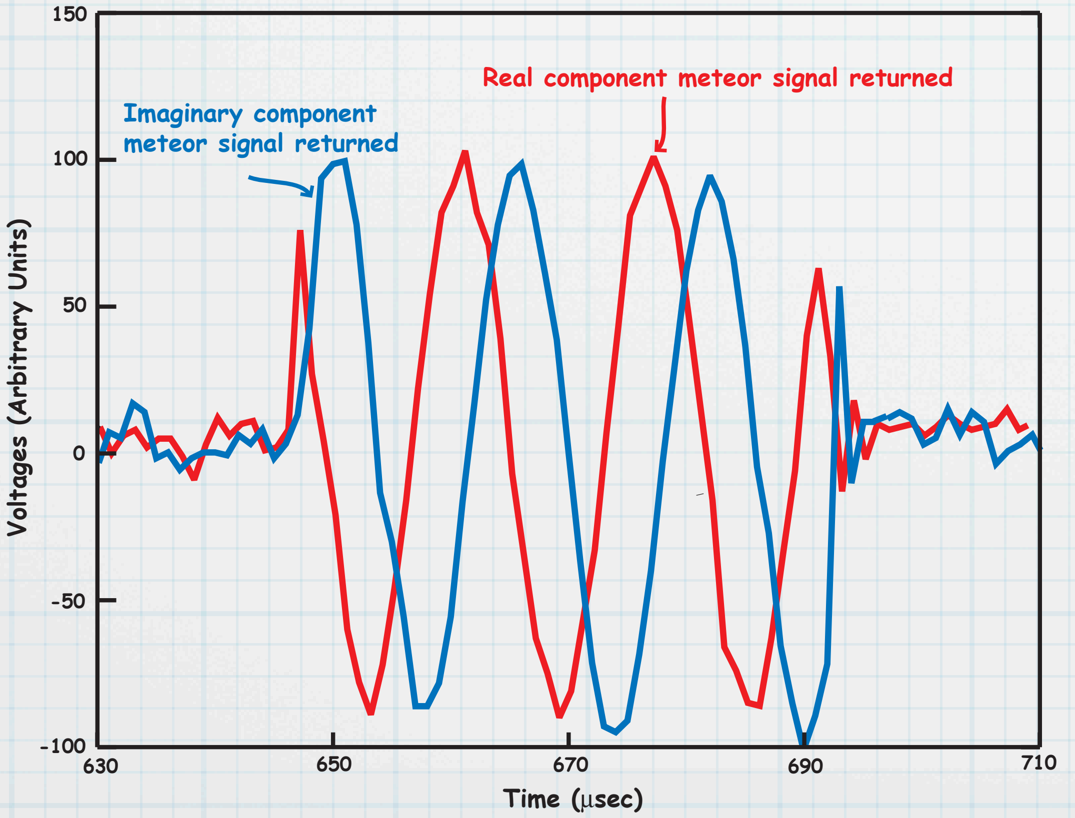
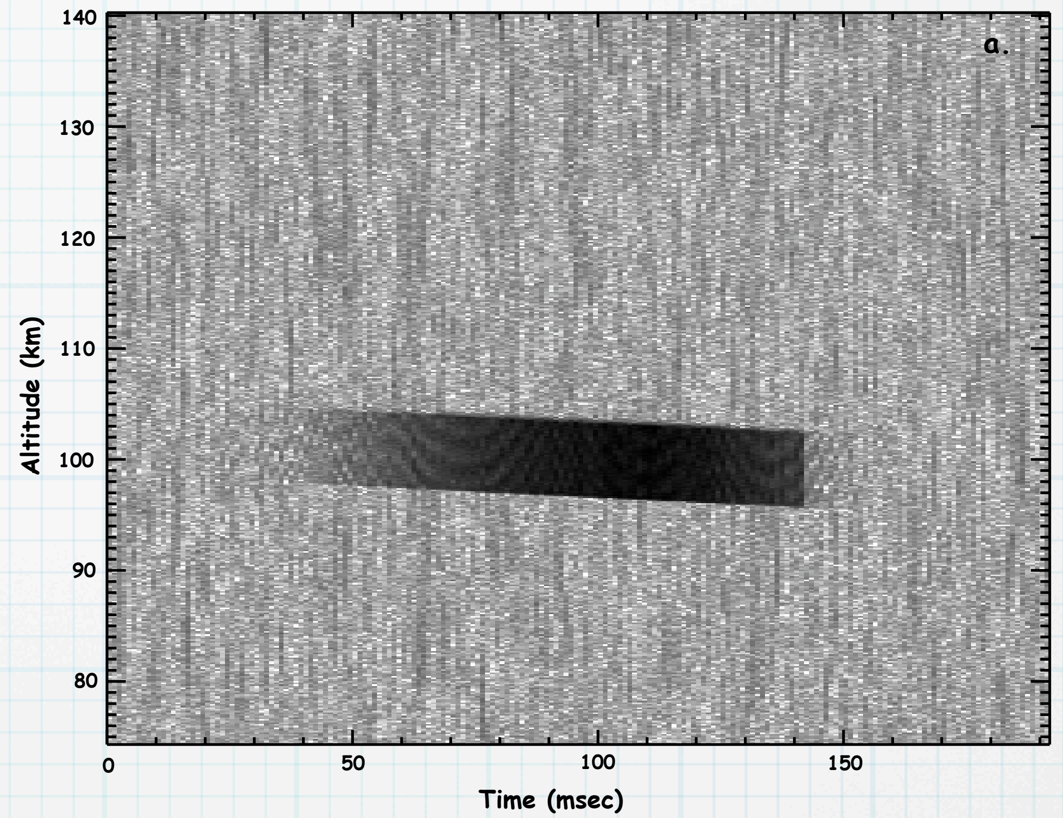
Meteor Detection at Arecibo

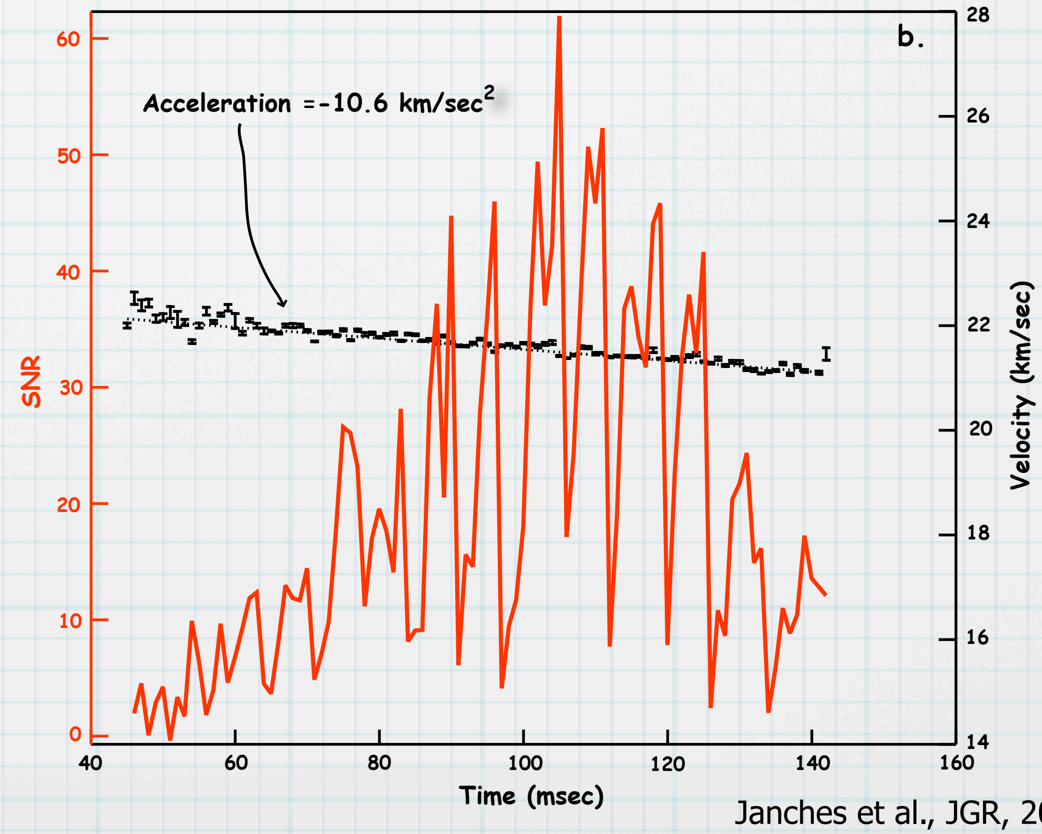
AO 430 MHz Meteor Experiment





Meteor Detection Example





Janches et al., JGR, 2003

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Meteor Motion/State Equations

Deceleration

$$M\frac{dV}{dt} = -\Gamma S \rho_{air} V^2 + gM\left(\frac{R_{Earth}}{R_{Earth}+z}\right)^2 \cos(\theta)$$

Energy Transfer

$$\frac{1}{2}C_h \rho_{air} V^3 = \underbrace{\sigma_{\mathbf{sb}} \mathcal{R} \varepsilon \left(T_{Melt}^4 - T_{Air}^4\right)}_{radiation} + \underbrace{\frac{4}{3} R_{Met}\, \rho_{Met}\, C_{sh} \frac{dT_{Met}}{dt}}_{heating}$$

Vertical Velocity

$$\frac{dz}{dt} = -V\cos(\theta)$$

Electron line Density

$$q_{line}(z) = \frac{\tau_{ion} \rho_{Air}(z) \mathcal{A} \sigma(z) \Gamma}{2\eta} \left(\frac{M(z)}{\rho_{Met}}\right)^{2/3} V^4(z)$$

Mass Loss

$$\frac{dM}{dt} = \frac{-C_h S \rho_{air} V^3}{2Q_{Heat}}$$

Electron Volume Density

$$q_{vol}(z) = \frac{q_{line}(z)}{\pi r_{mfp}^2}$$

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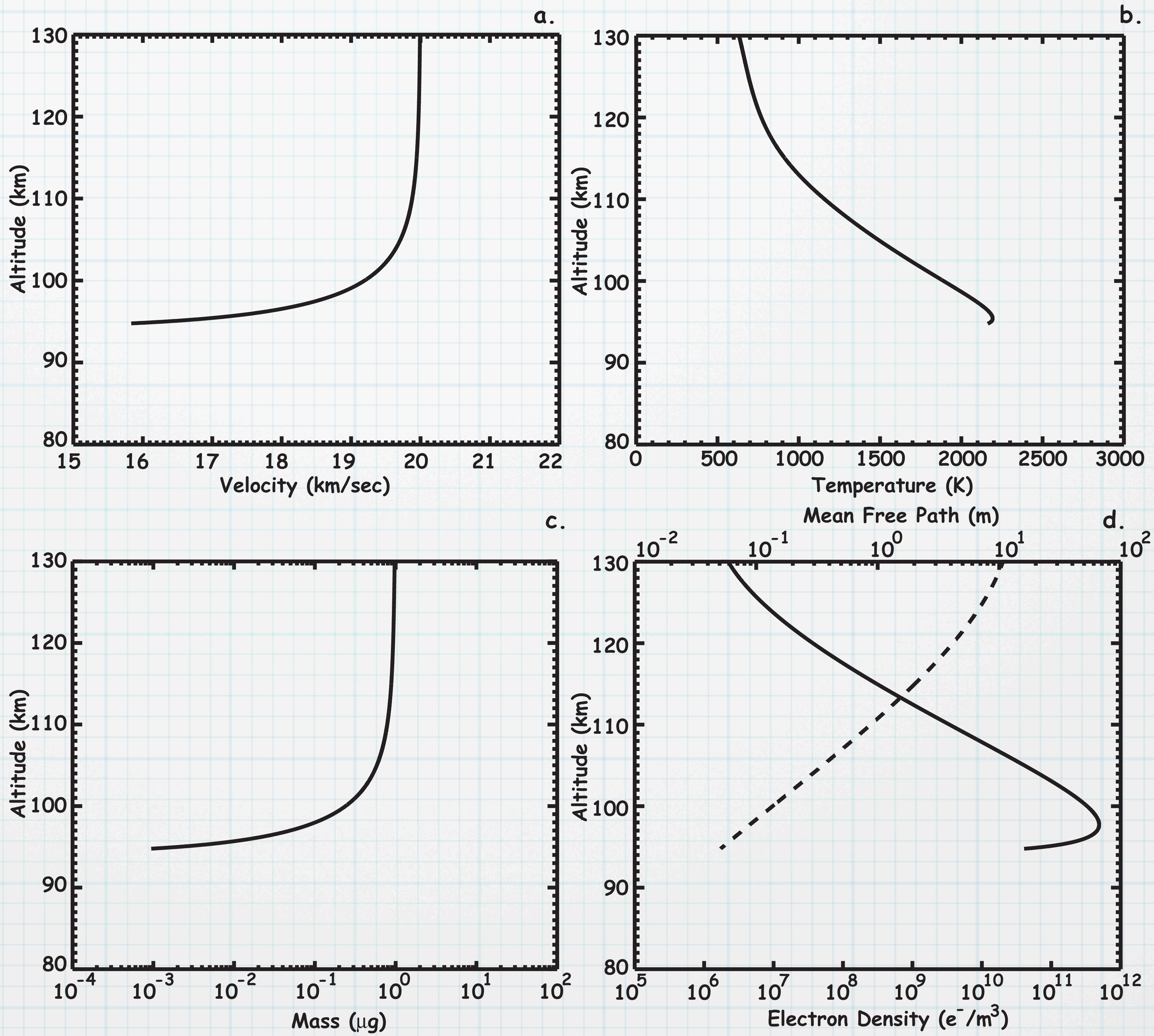
MIF Modeling Equation Integration

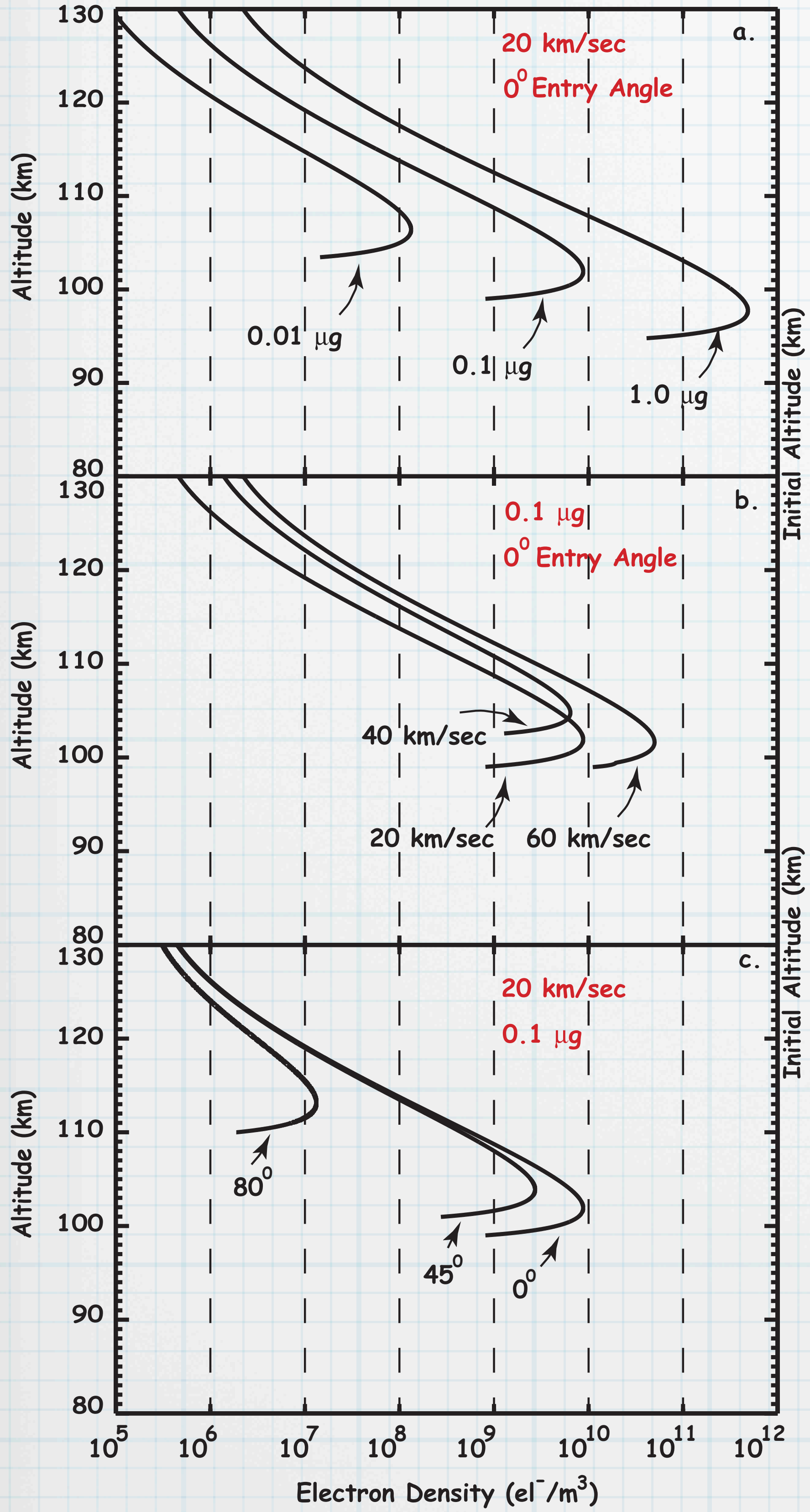
Initial Conditions

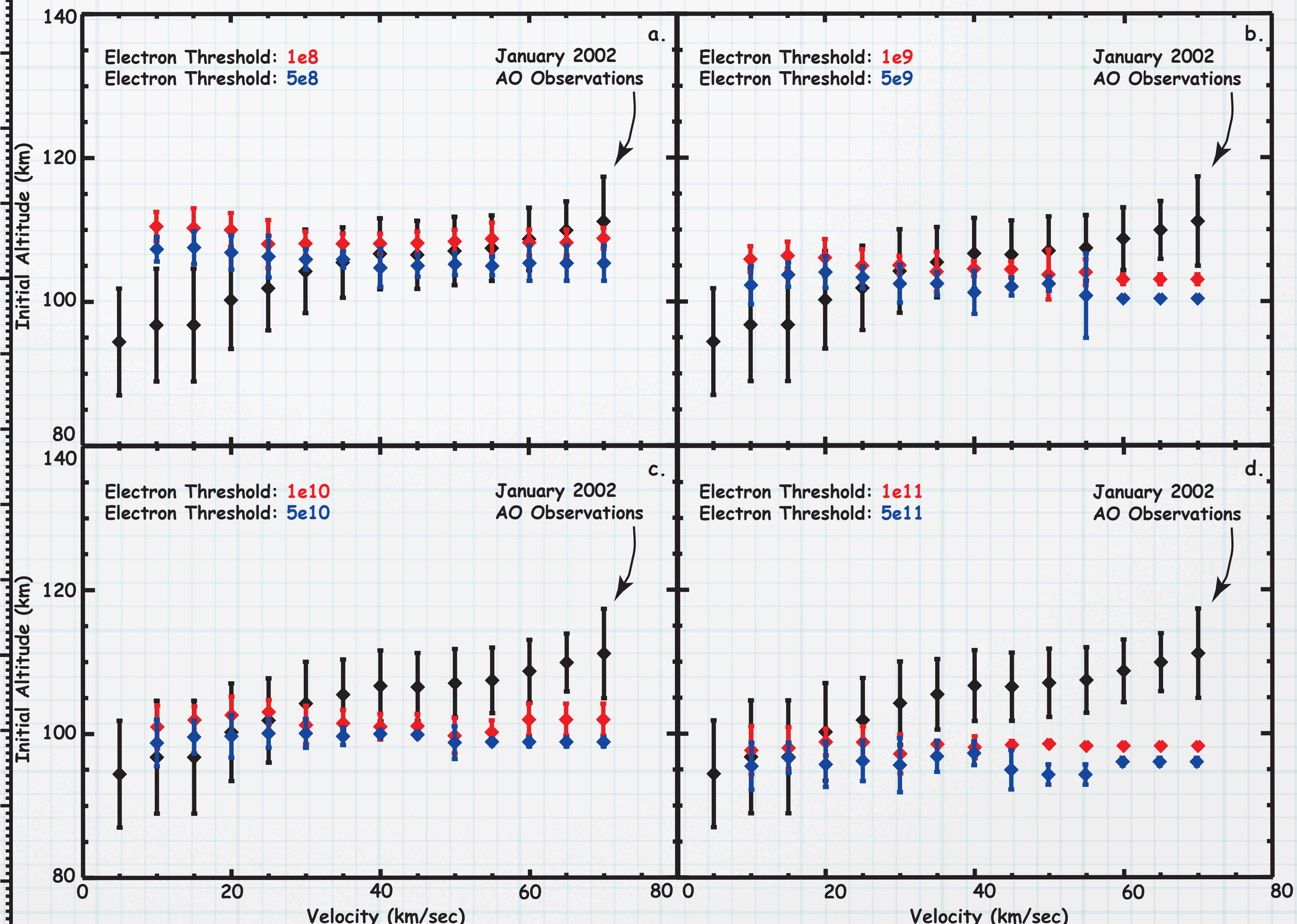
1 Microgram
20 km/sec
0 Entry Angle
T_{int} =300 K
Alt_{int} =200 km



Fentzke and Janches, JGR, Submitted 2007

Electron Threshold





Fentzke and Janches, JGR, Submitted 2007

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Altitude distributions

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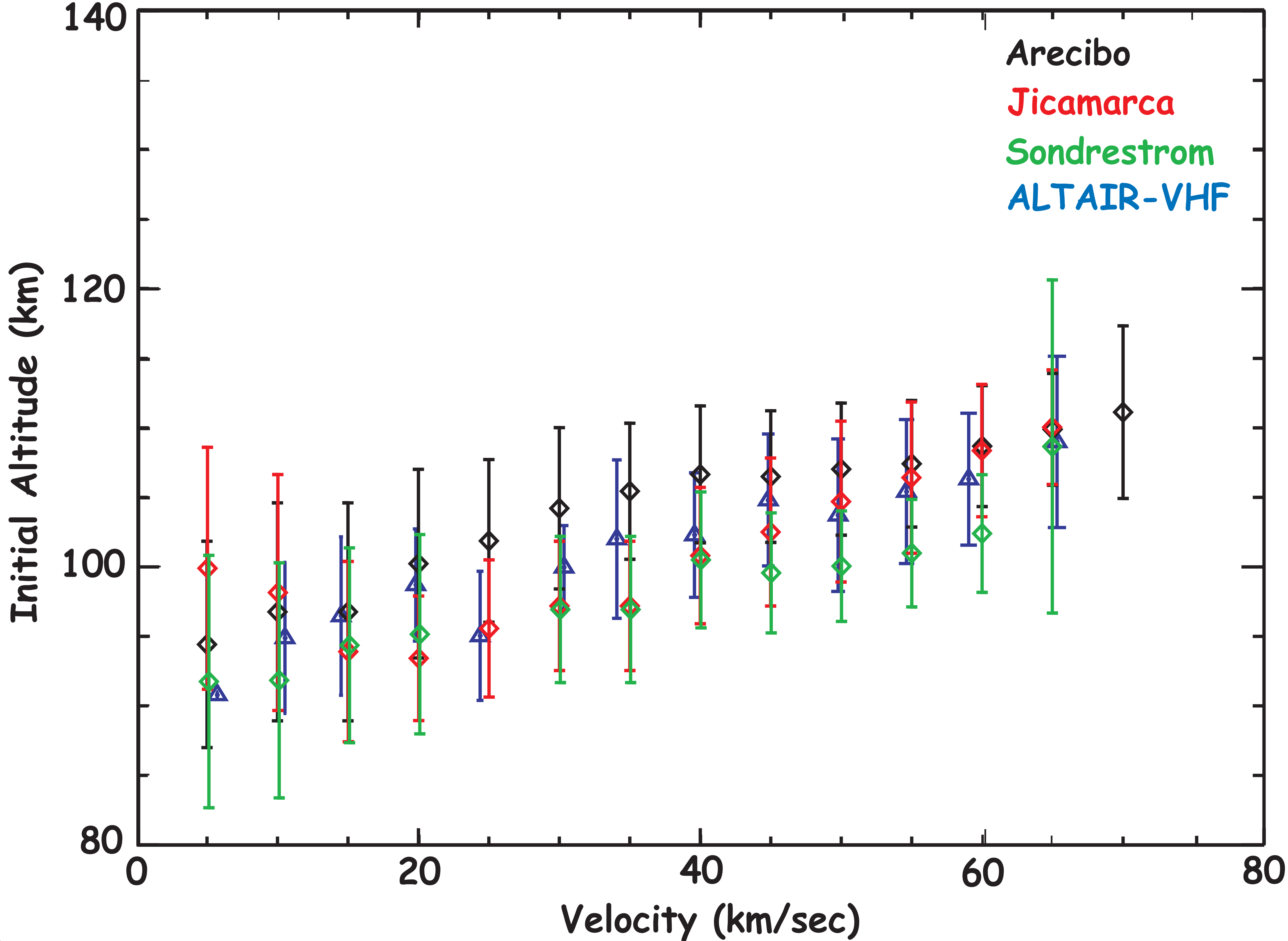
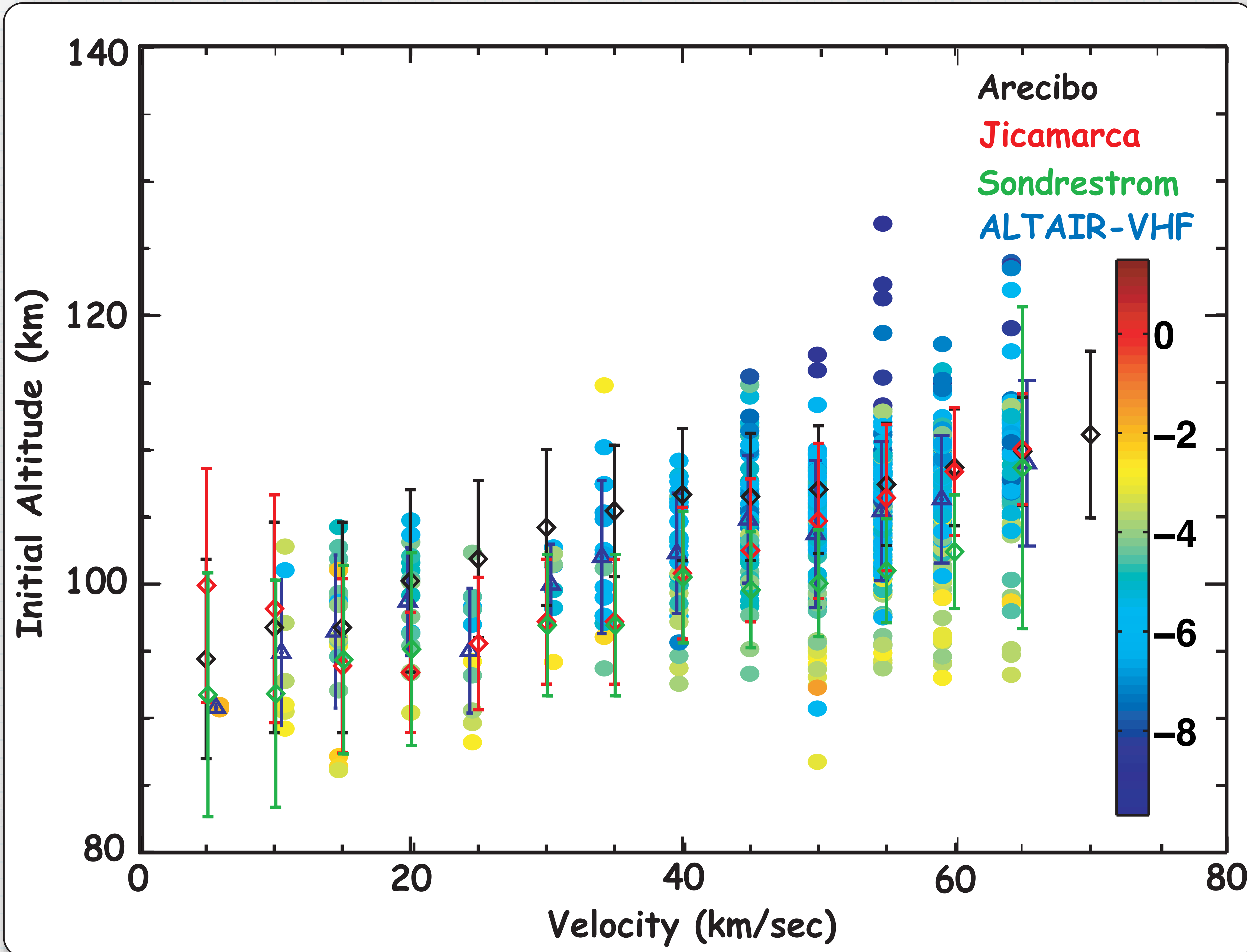
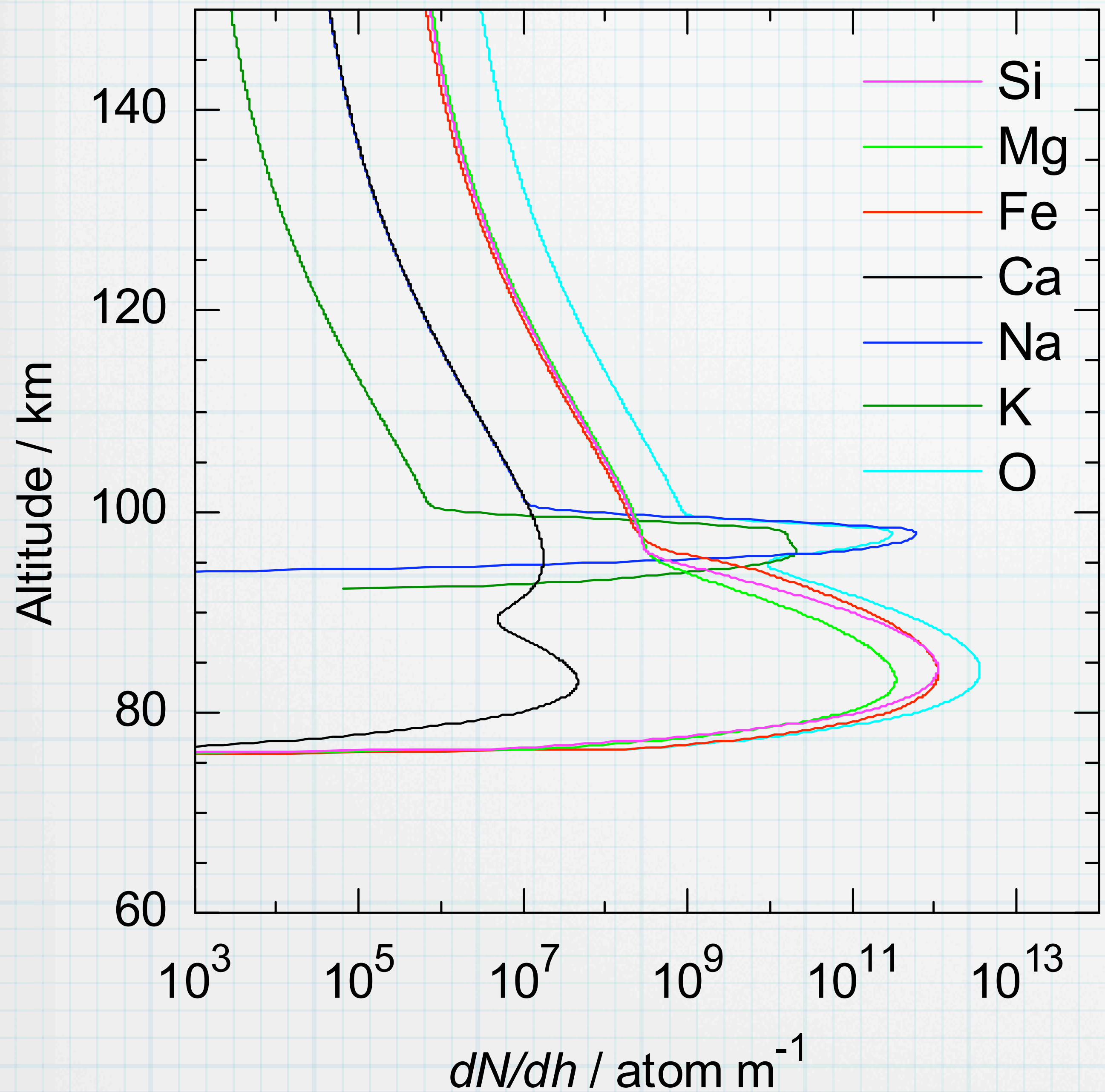


Altitude distributions



Differential Ablation of Meteoroids

5 µg 20 km s^{-1}



	Ablated At %	Centroid km	FWHM km
Si	100	84.7	5.6
Mg	100	84.0	5.4
Fe	100	84.5	6.4
Ca	61	(83.2)	4.7
Na	100	100.5	1.7
K	100	96.5	3.2
O	96	84.2	5.8

Ca/Na = .62

Courtesy of J. Plane and T. Vondrak

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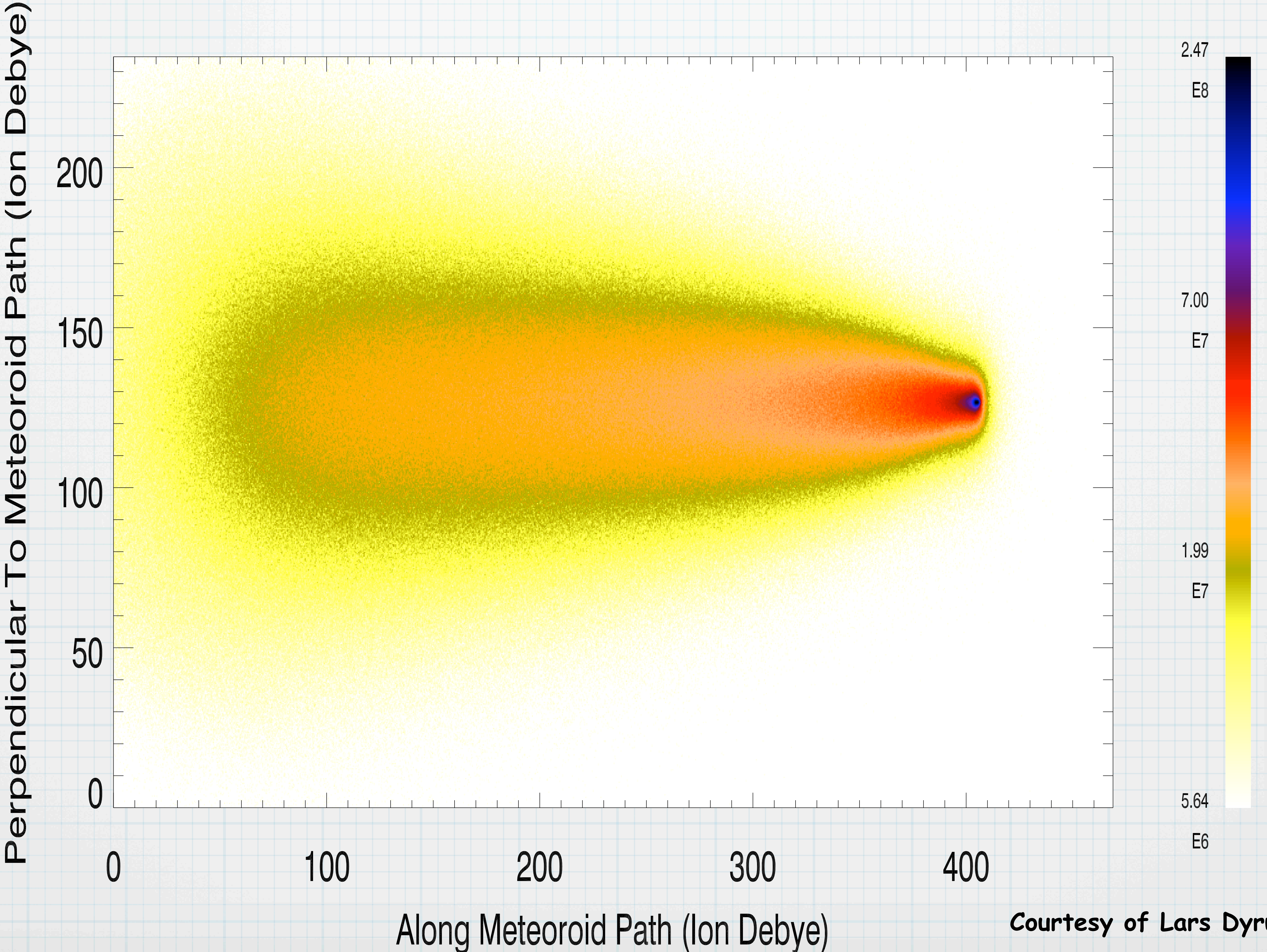
Model of the meteor head-echo



Courtesy of Lars Dyrud

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FDTD Radar Simulations

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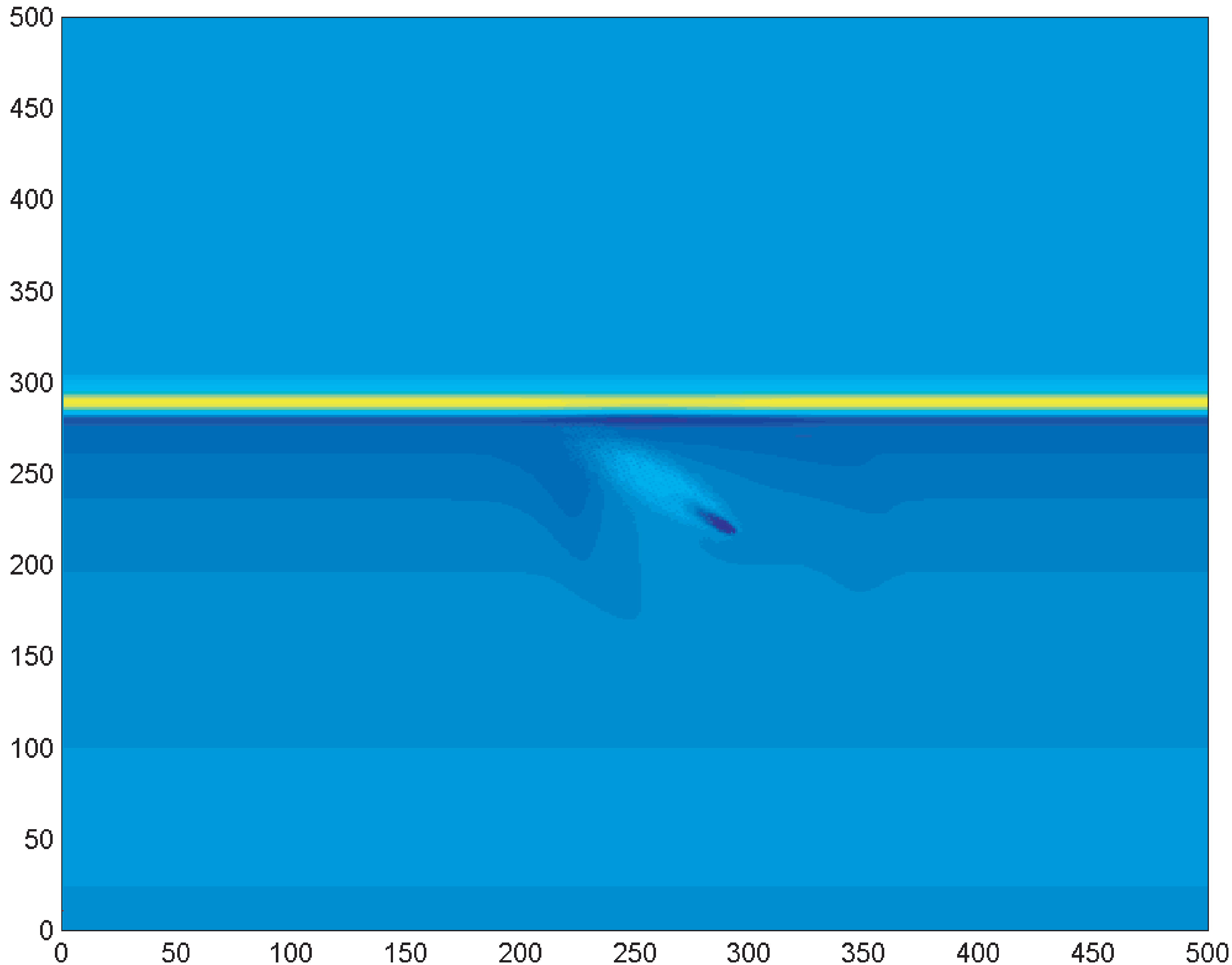
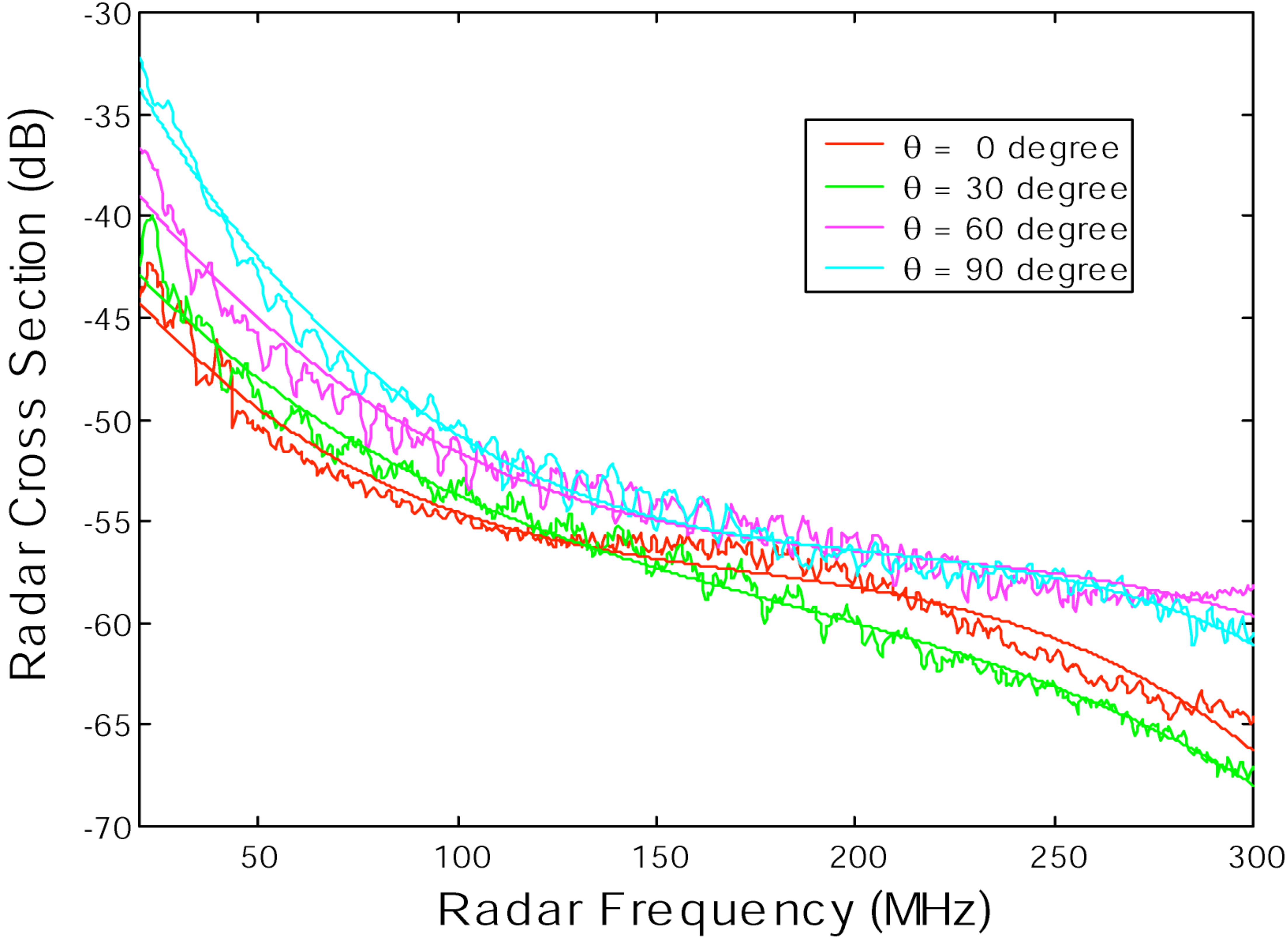


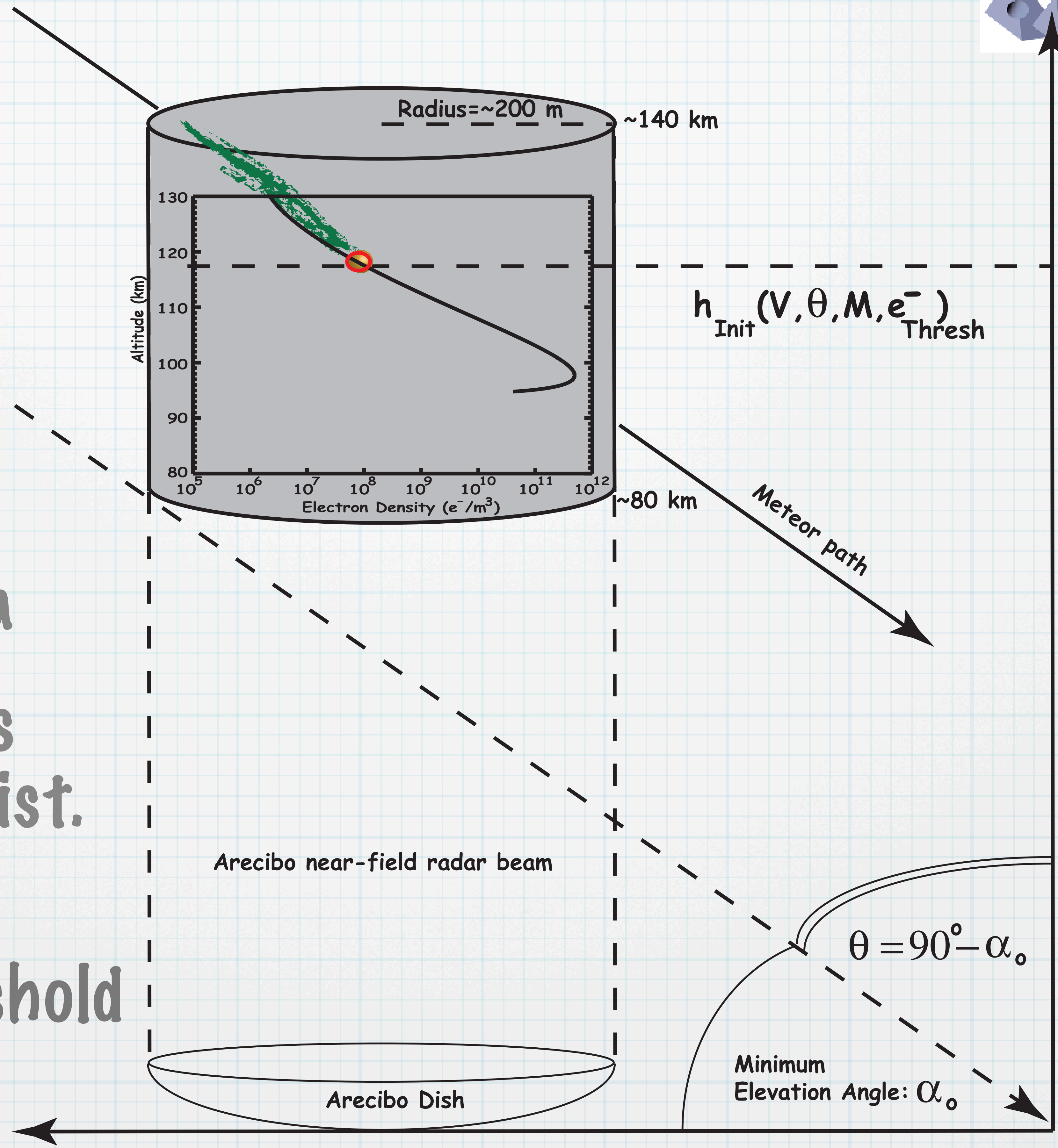
Courtesy of Lars Dyrud

Simulation of head-echo RCS

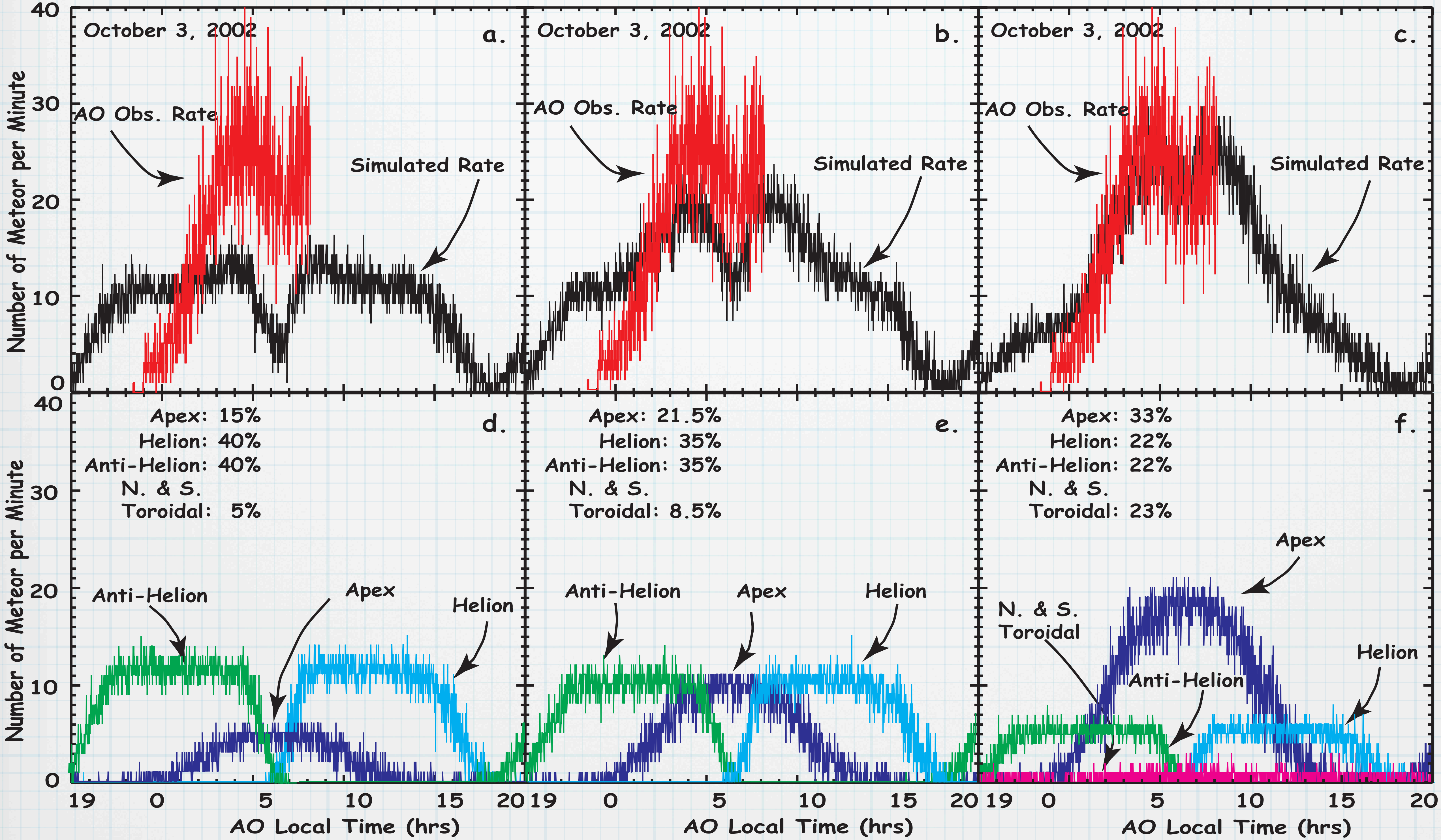


Courtesy of Lars Dyrud

* Global Mass Input-Ceplecha
* 6 Rad. Sources and Velocity Dist.
* Minimum Electron Threshold



Some promising results



Fentzke and Janches, JGR, Submitted 2007

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Model/Observation Flux Comparison at AO

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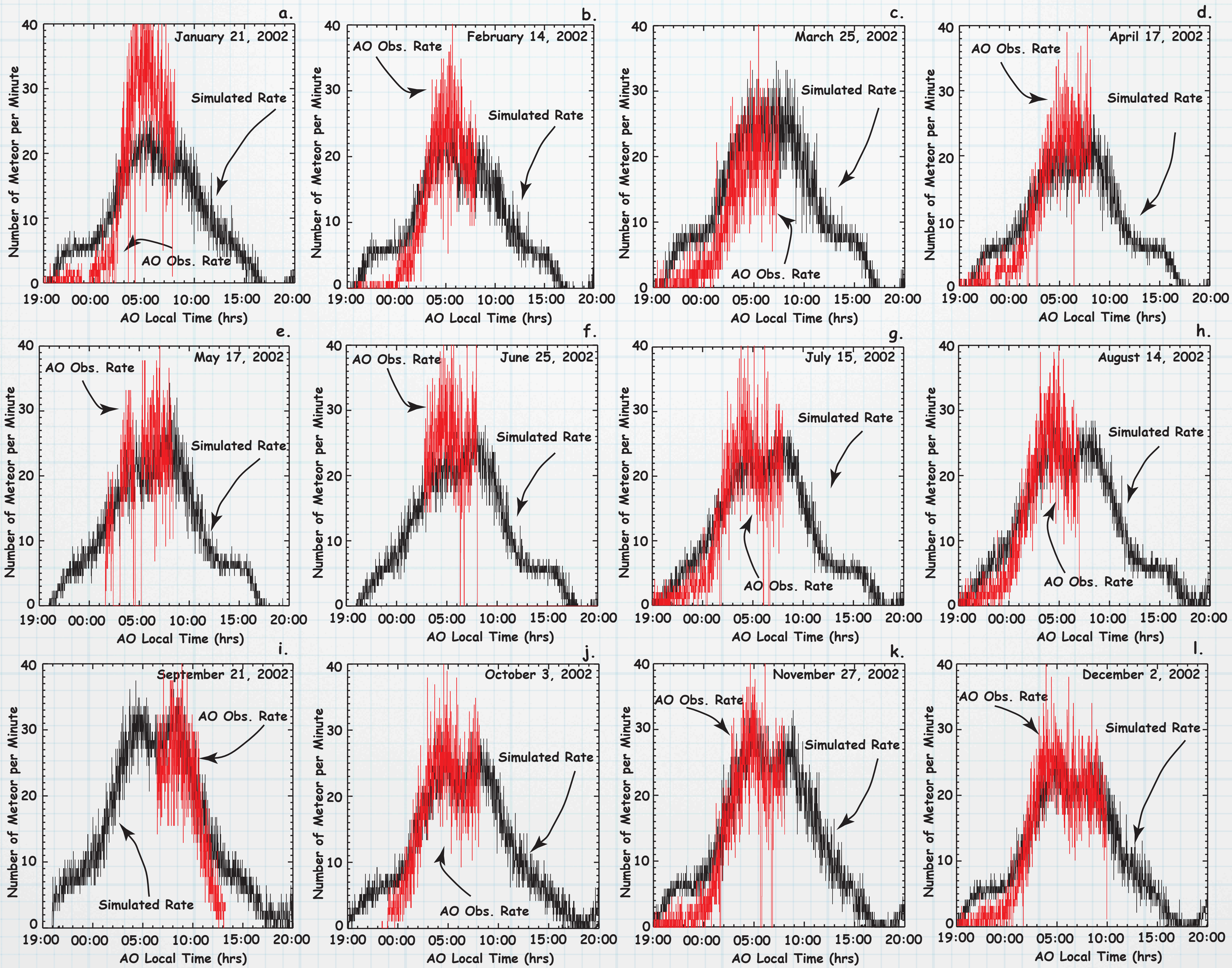

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More promising results

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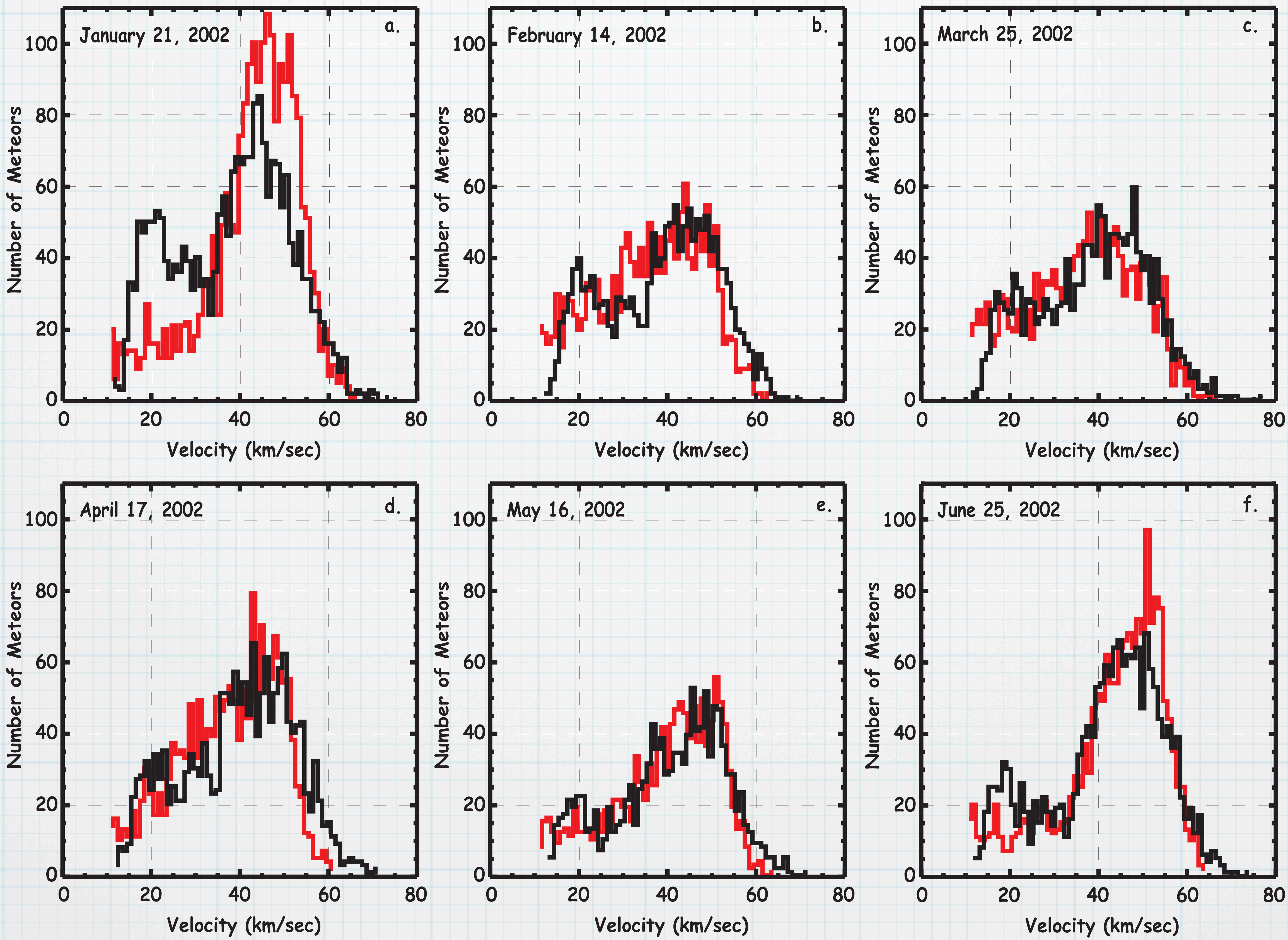

Fentzke and Janches, JGR, Submitted 2007

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Total and Local Observed Mass Input

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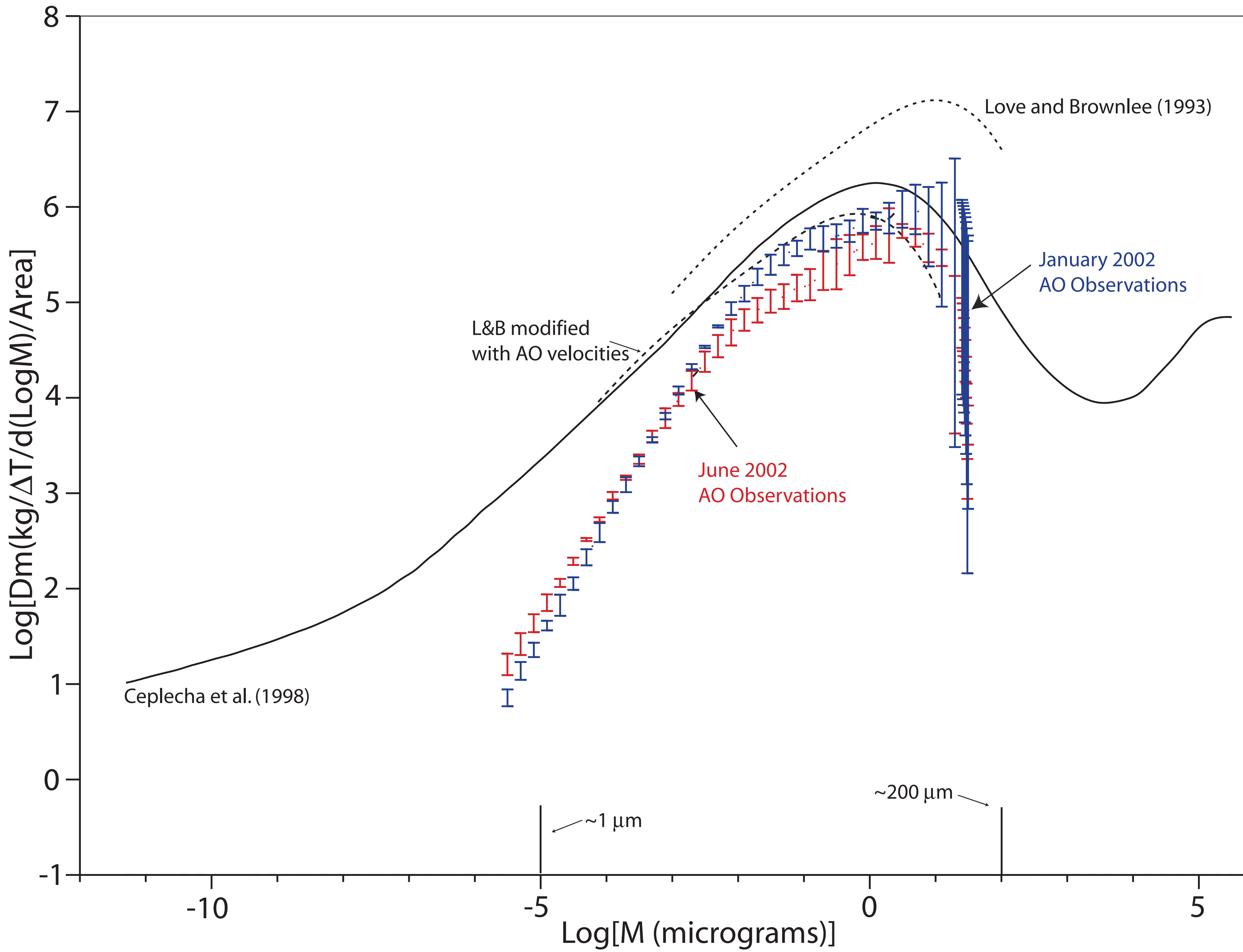
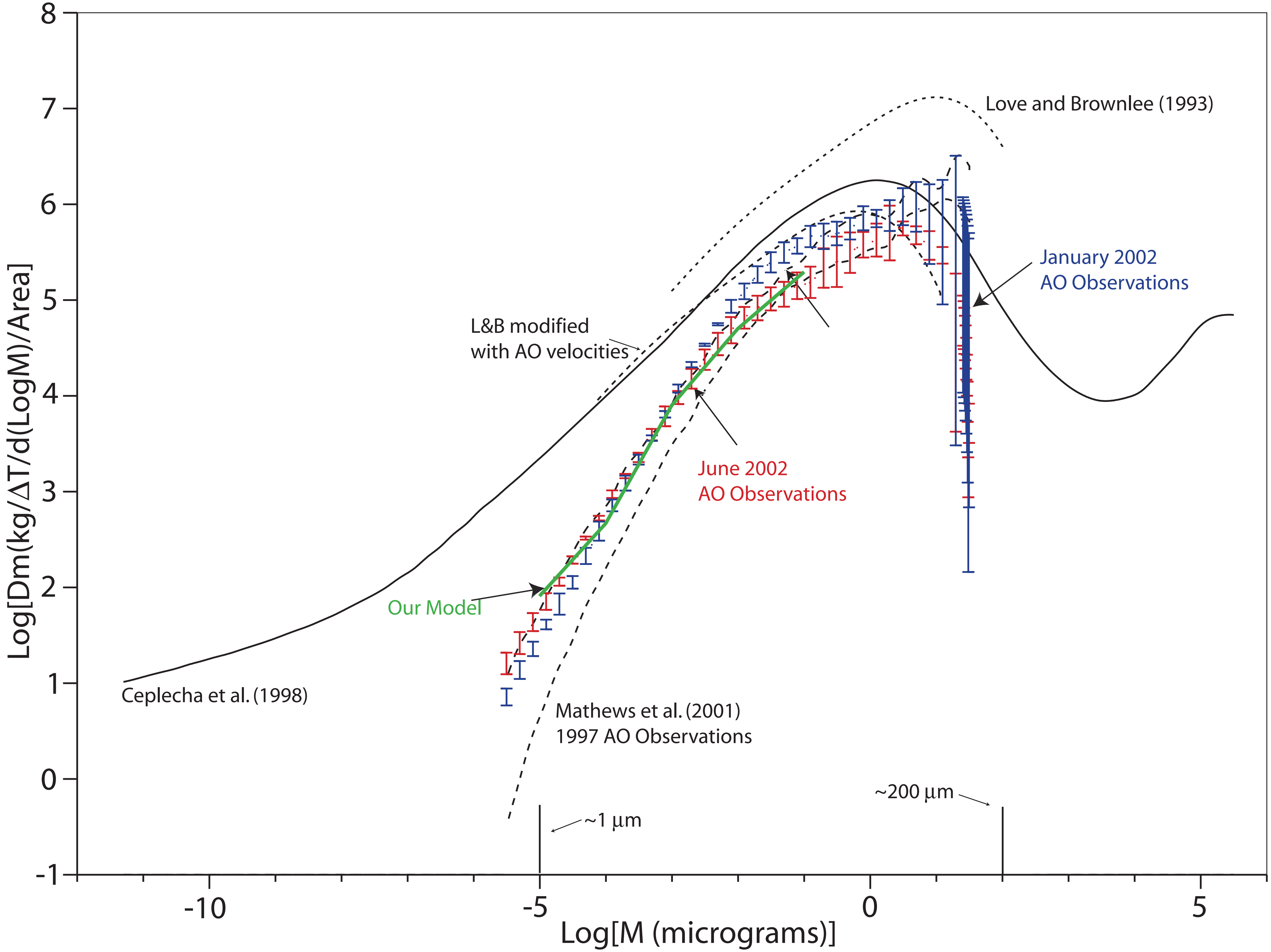


Total and Local Modeled Mass Input



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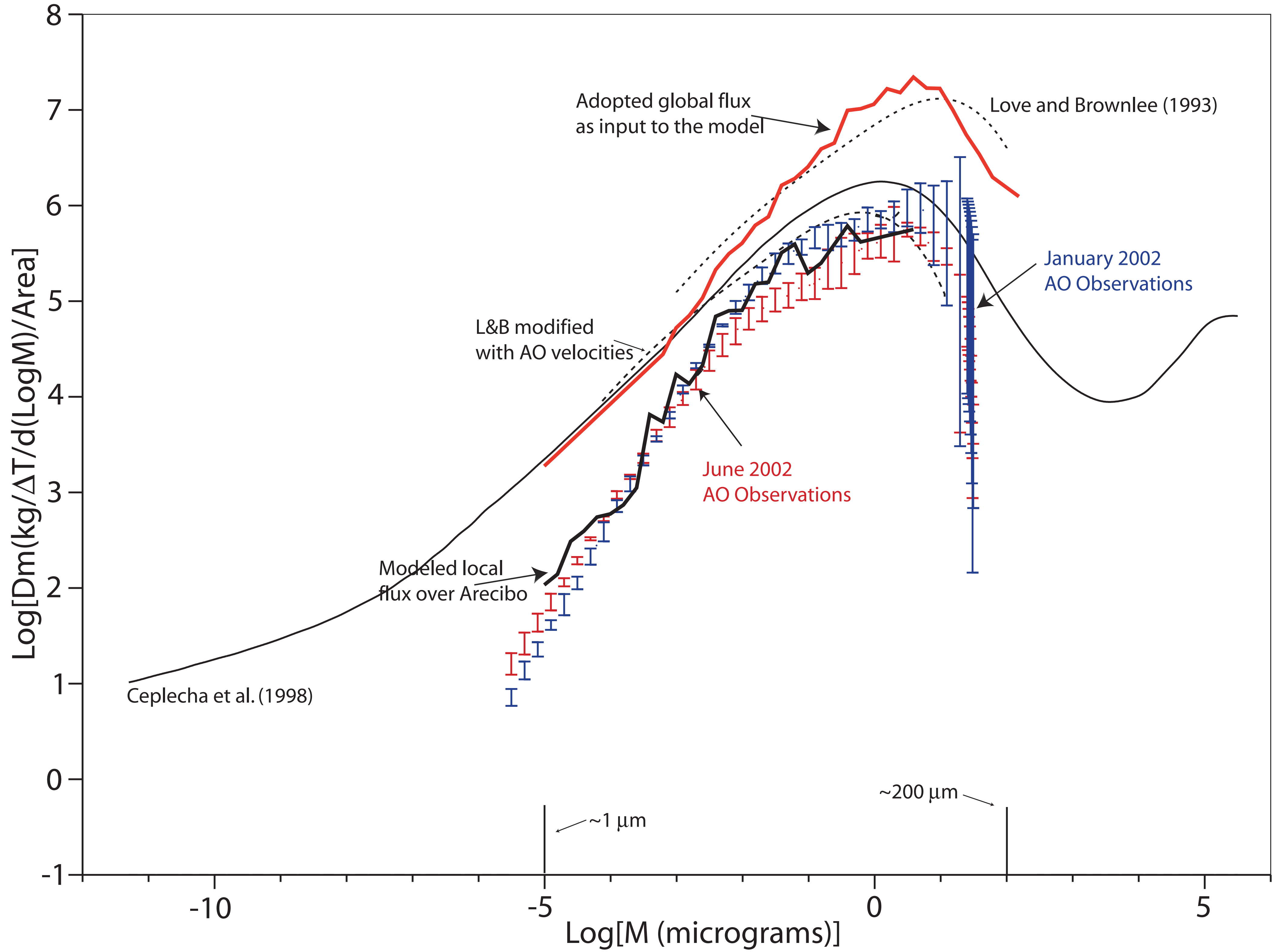
Total and Local Modeled Mass Input

CoRA



Seasonal Variability of MIF over Arecibo

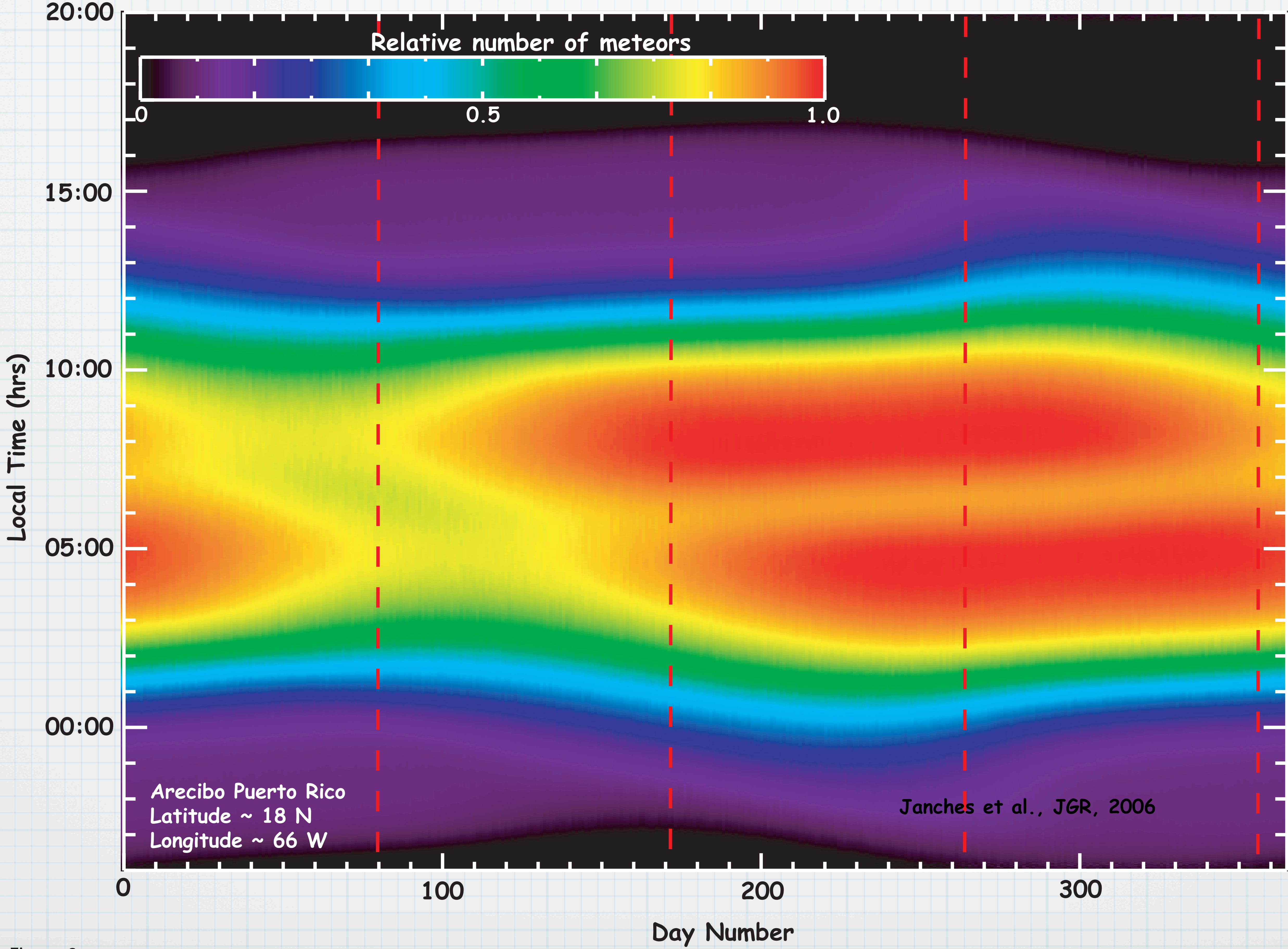
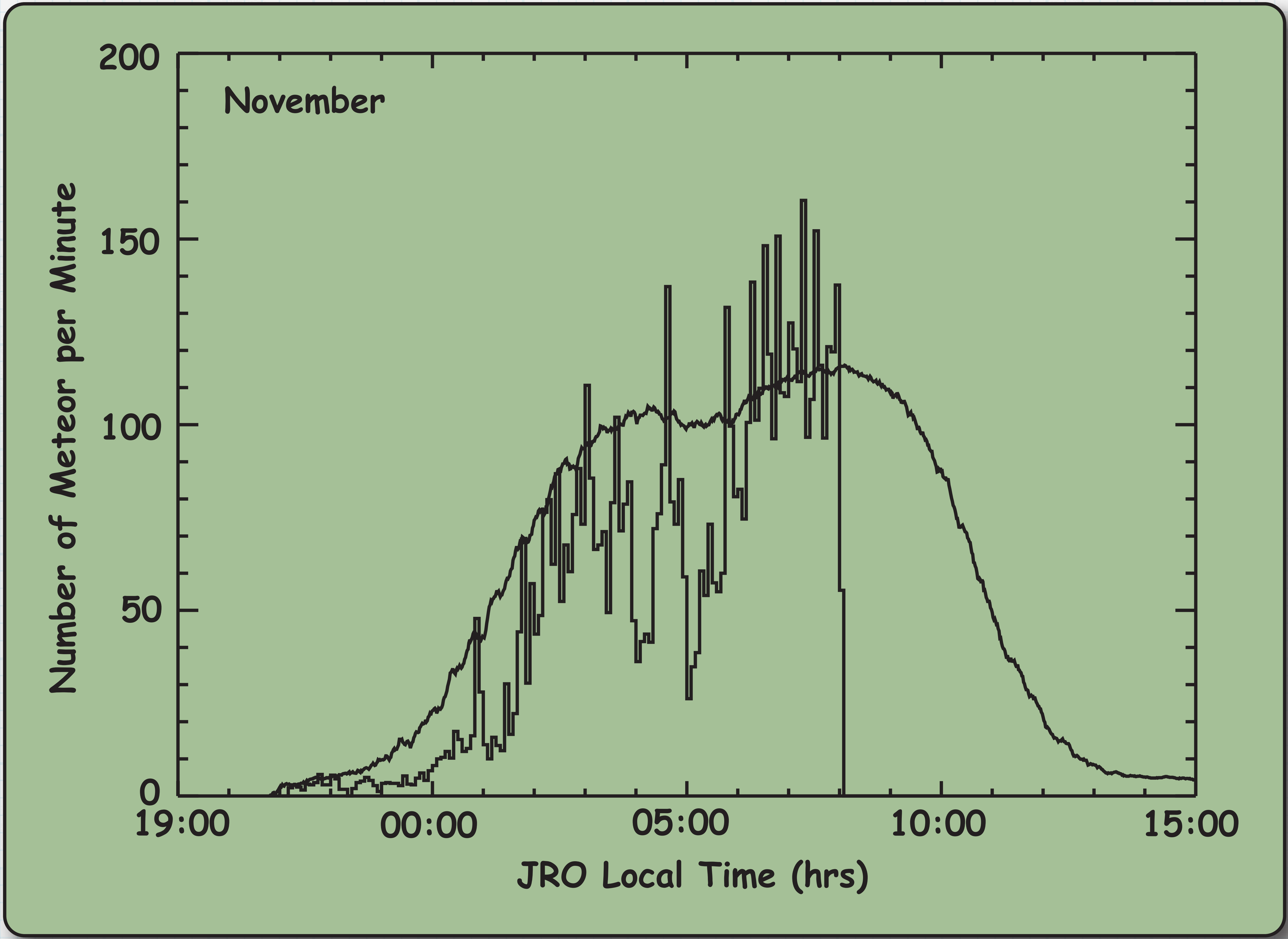


Figure 8

Diurnal Variability of MIF over Jicamarca



Janches et al., JGR, 2006

Seasonal Variability of MIF over Jicamarca

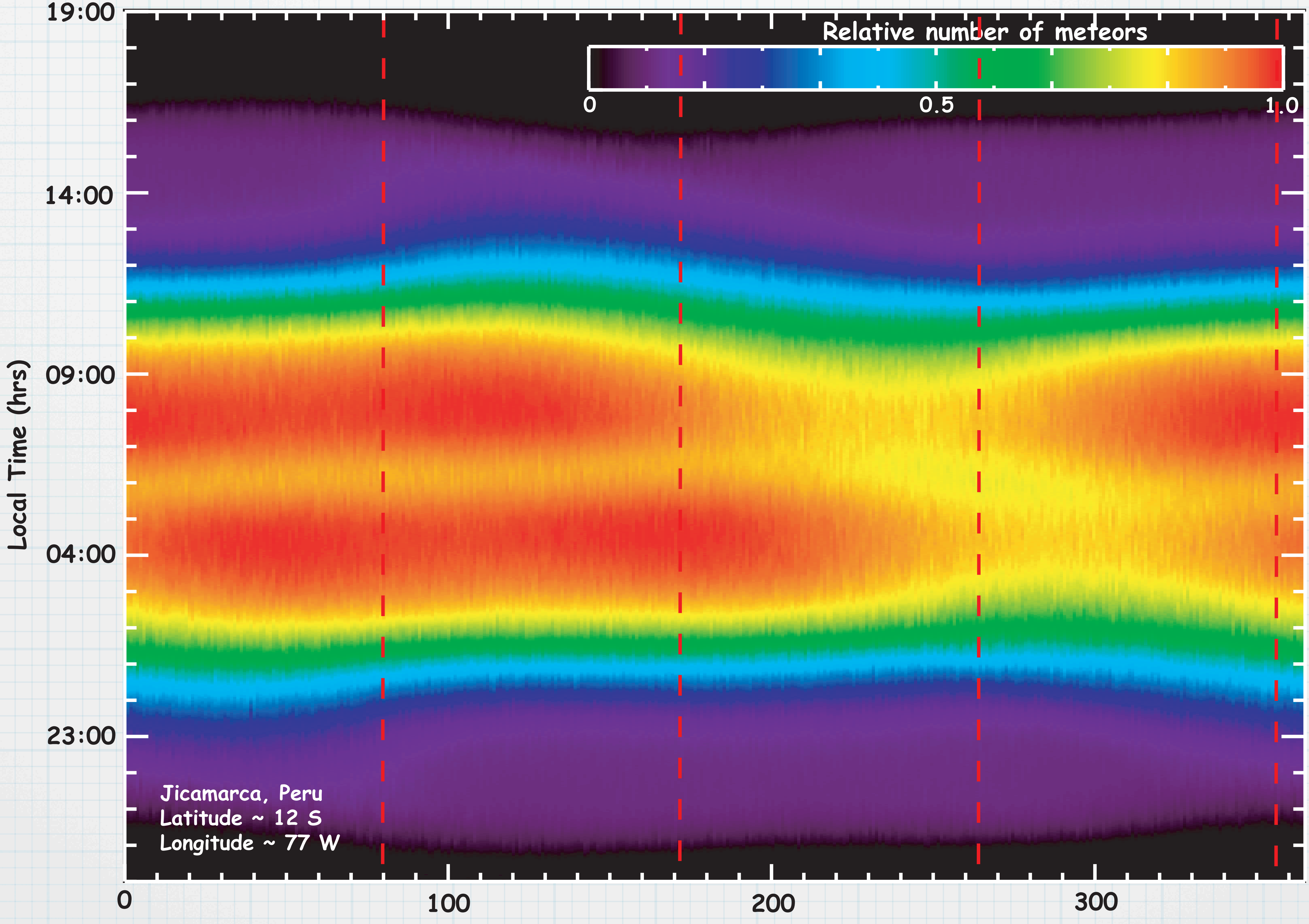
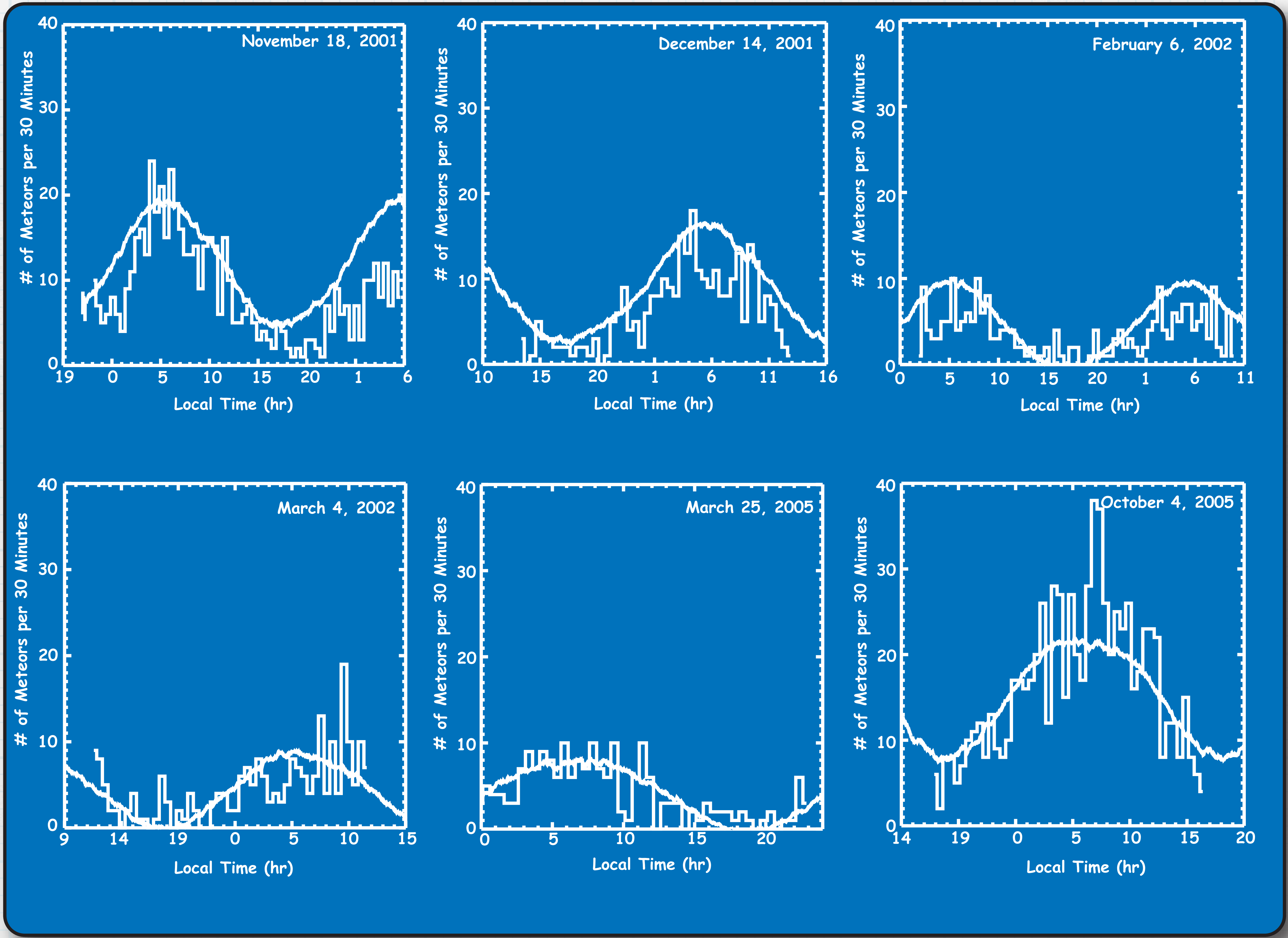


Figure 10

Janches et al., JGR, 2006

Dirunal Variability of MIF over Sondrestrom



Janches et al., JGR, 2006

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Seasonal Variability of MIF over Sondy

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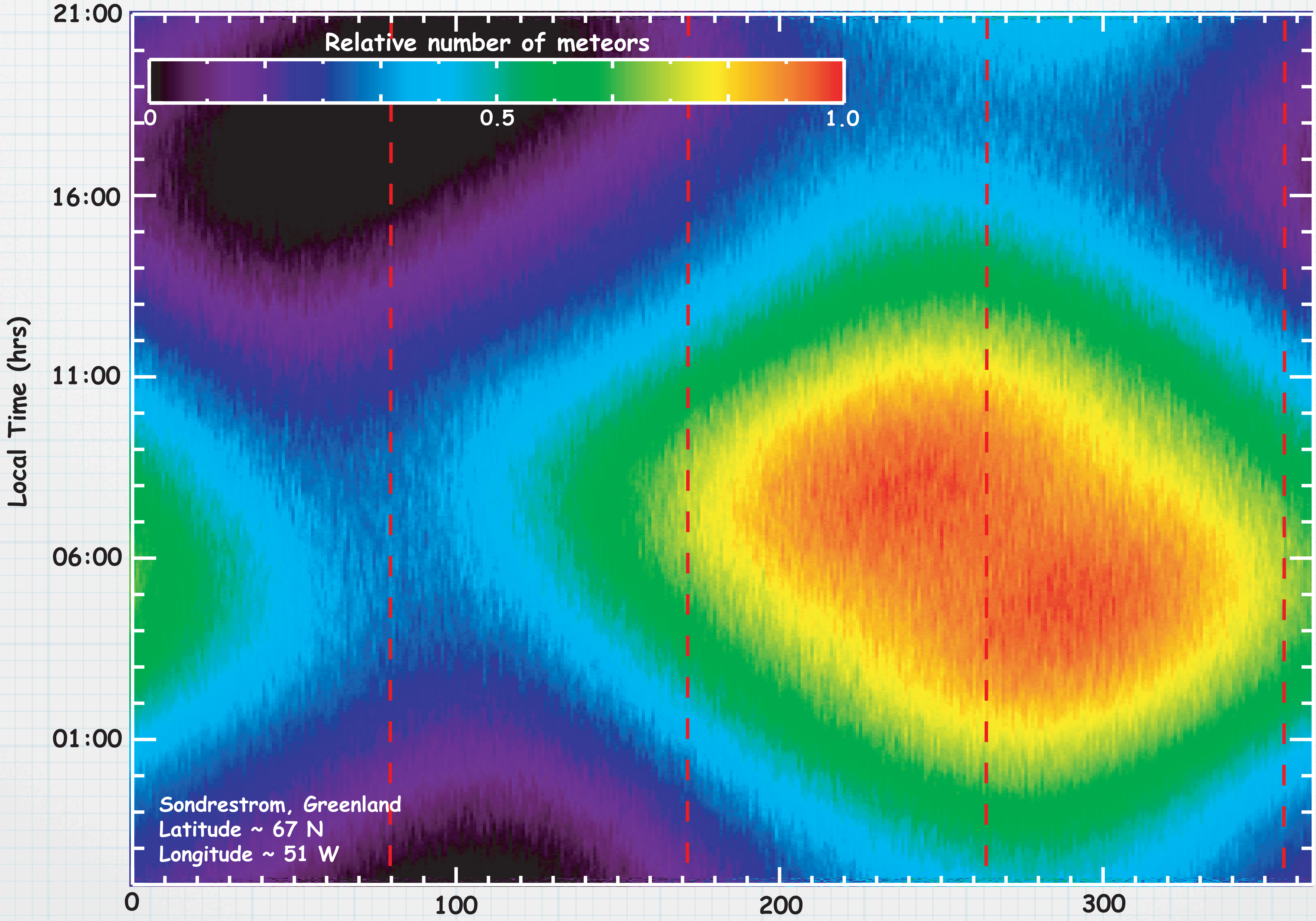

Janches et al., JGR, 2006

Figure 12

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Global, Seasonal and Diurnal Variability

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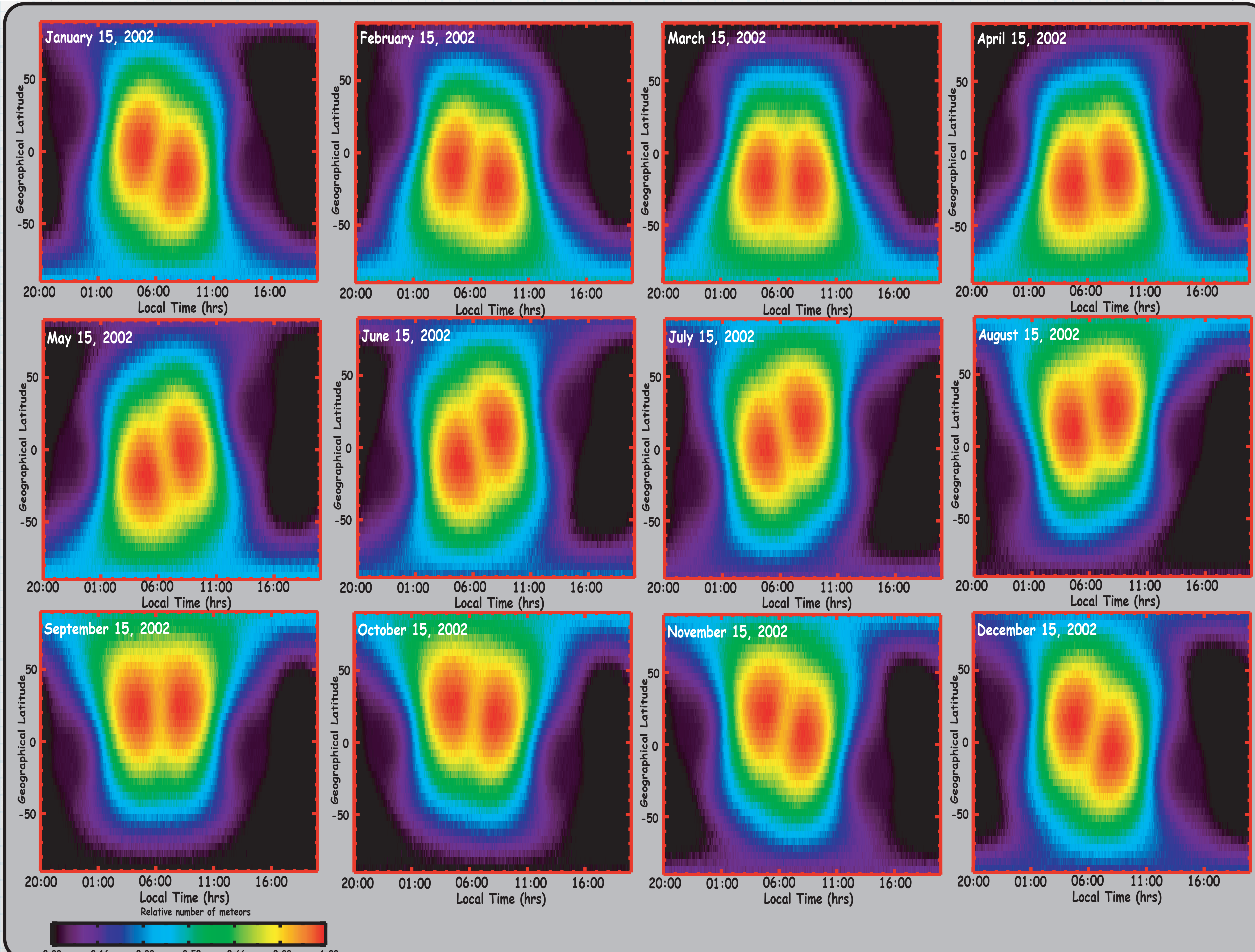

Janches et al., JGR, 2006

Conclusions and Final Remarks

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We are very close to accurately understand how much, when and where meteoric mass is deposited in the MLT