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CoRA Division

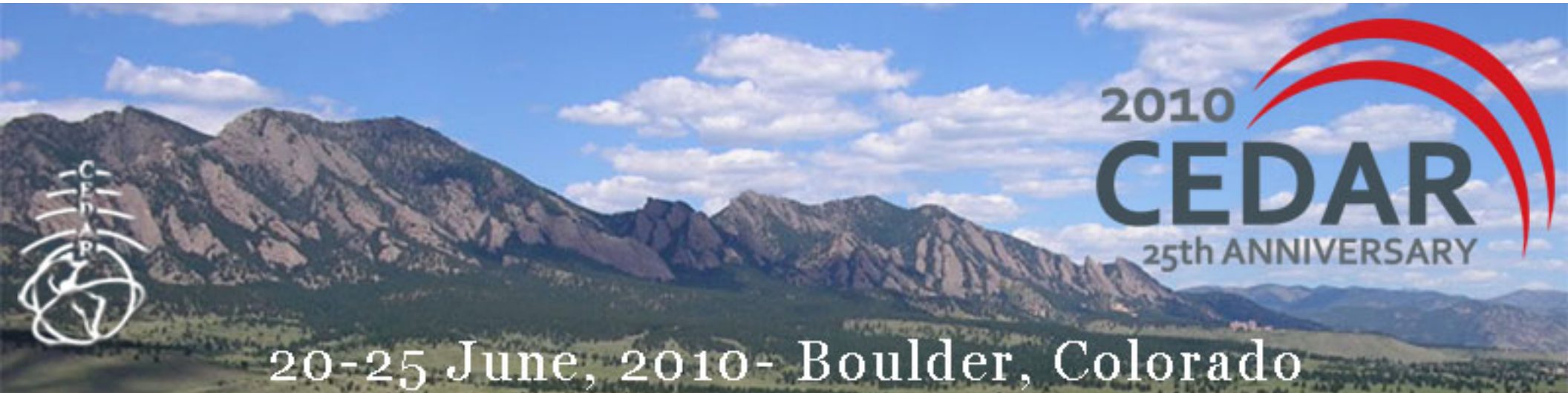
3380 Mitchell Lane, Boulder, CO 80301

CEDAR Student Workshop Tutorial: 06/20/10

Equatorial Meteor Science Using Radar Techniques

Related Session: Tuesday 1600-1900 MLT Poster Session #1

Related Session: Wednesday 1330-1530 Meteoroids Session



Jonathan T. Fentzke

Contributions from a number of authors

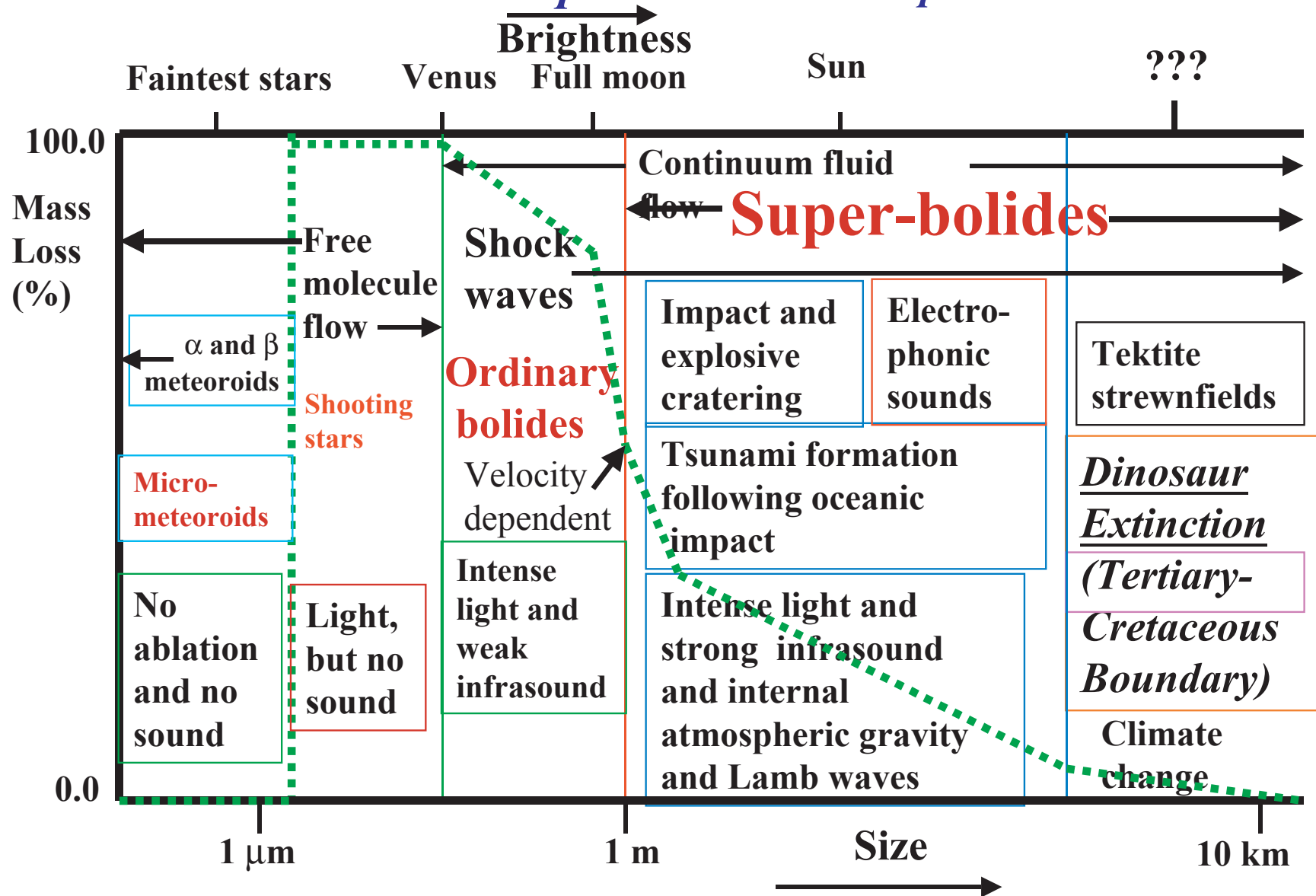
Equatorial Meteor Science

- ⦿ First, Bore you with this outline
- ⦿ Second, enlighten you with brief topical overview of meteor science
- ⦿ Next, excite you about the current open questions and related research
- ⦿ Finally, some concluding remarks



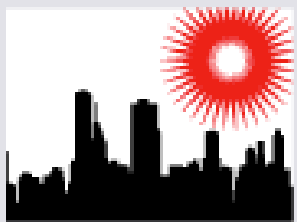
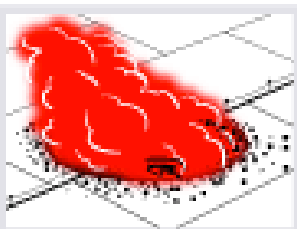
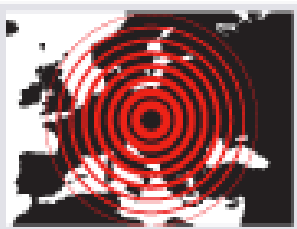

Meteoritic Input

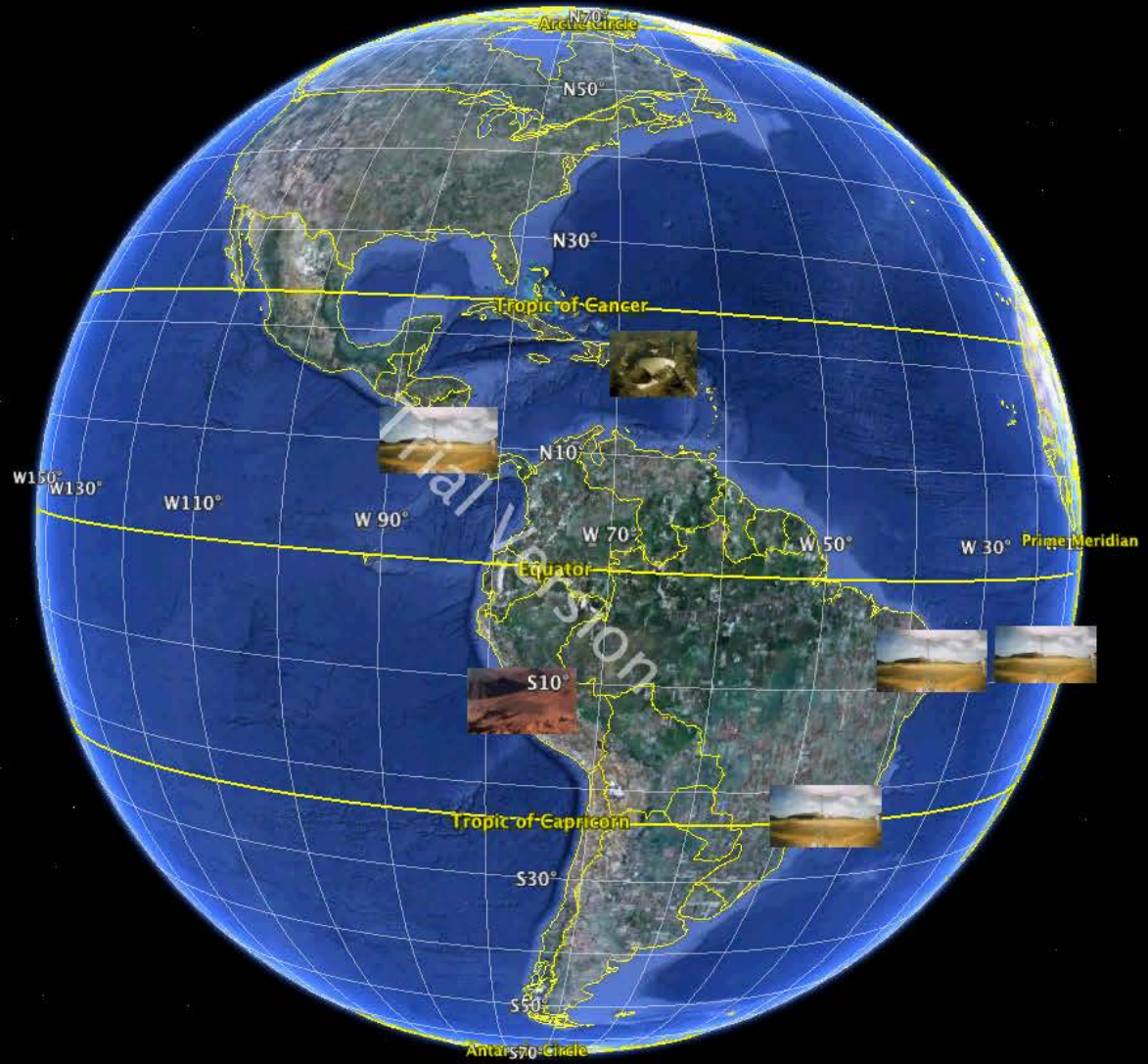
Meteor-Atmosphere Interaction Spectrum



Meteoric Input: >30 Million Meteors per Second

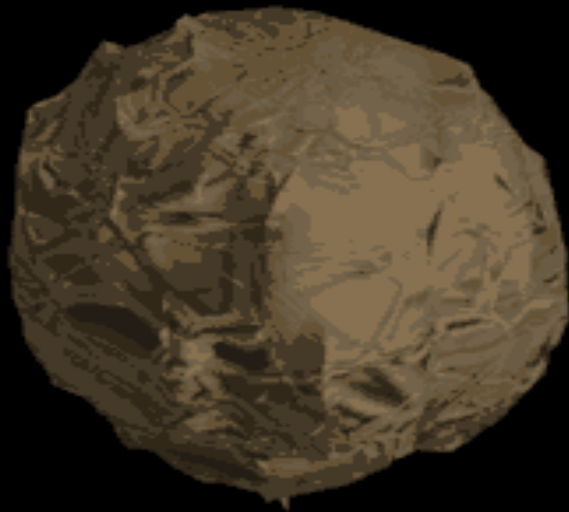
Sizing Up the Space-Debris Hazard

	Event	Diameter (meters)	Impact energy (megatons)	Frequency
	Shooting star	0.00006	5×10^{-16}	1 second
	Brilliant fireball	0.1	0.01	1 year
	Aerial burst with modest damage	25	1	200 years
	Local (10-km) devastation	50	10	2000 years
	Regional-scale devastation	140	300	30 000 years
	Continental-scale devastation	300	2000	100 000 years
	Possible global catastrophe	1000	100 000	700 000 years
	Global extinction	10 000	100 million	100 million years



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So What Are We Talking About?

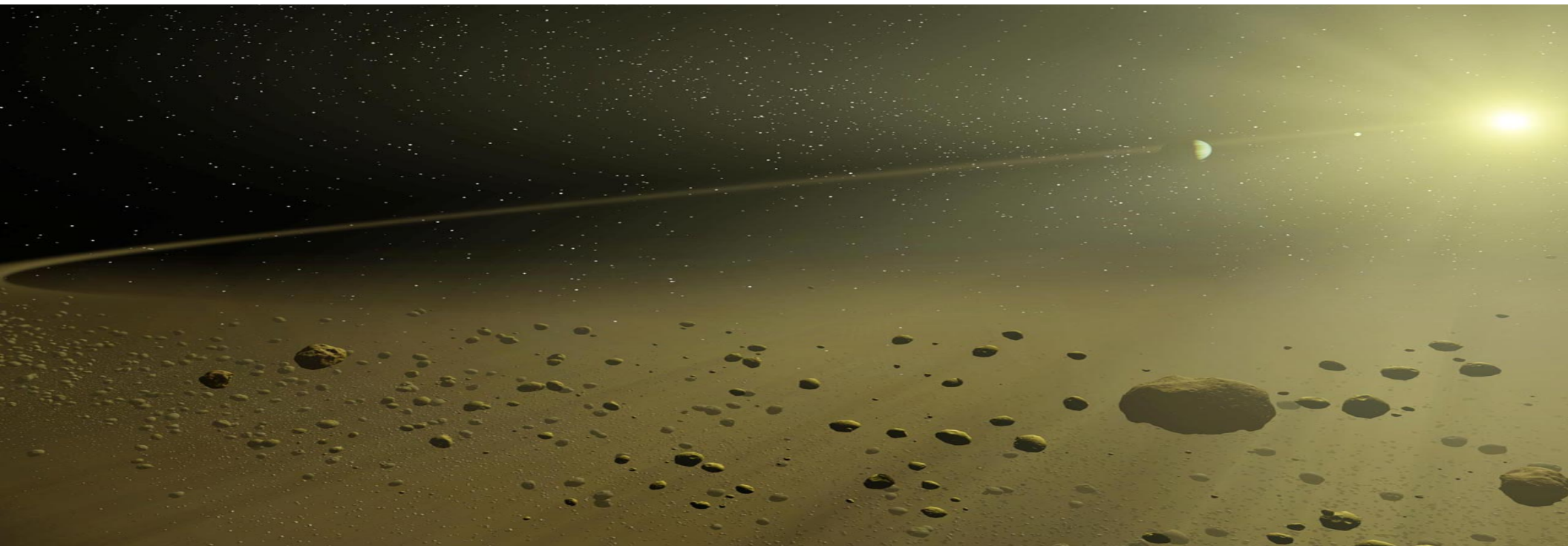


Meteoroid

Meteoroid

“A solid object moving in interplanetary space, of a size considerably smaller than an asteroid and considerably larger than an atom” – International Astronomical Union

...a micrometeoroid is just a tiny meteoroid.



Meteor

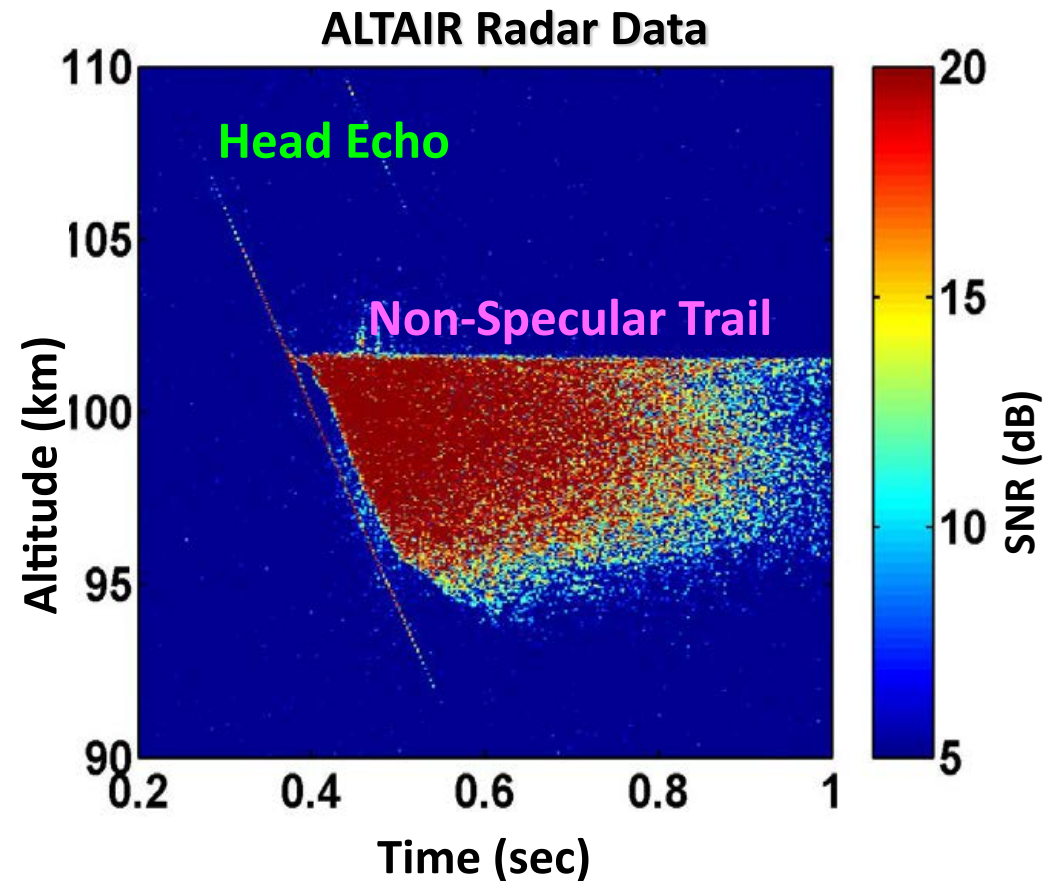
“in particular, the light phenomenon which results from the entry into the Earth's atmosphere of a solid particle from space; more generally, as a noun or an adjective, any physical object or phenomenon associated with such an event.”

– International Astronomical Union

- ⊙ **Radar-wise: Observable (sub-)visible path of meteoroid in atm.**
 - ⊙ **Specular, Non-Specular**
 - ⊙ **Trail-echo, Head-echo**



Meteor



- **Head Echo**

- Radar signature from plasma region around meteoroid
- Moves with velocity of meteoroid
- Scattering from dense, sphere-like plasma

- **Non-Specular Trail**

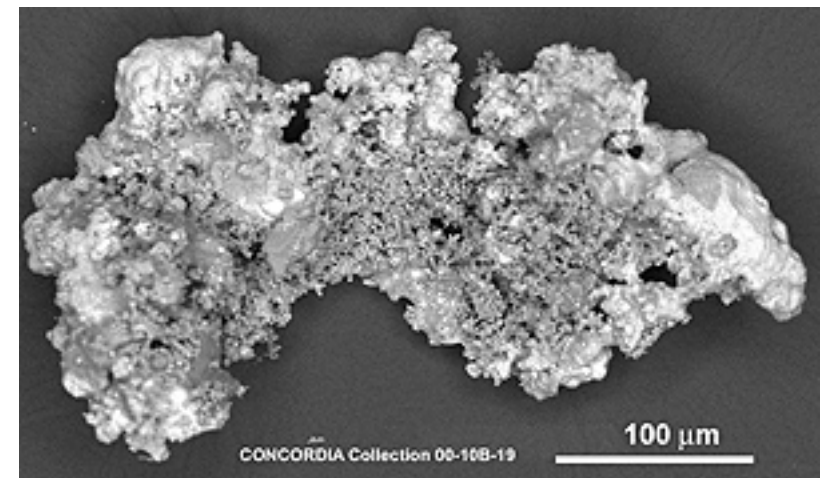
- Plasma column immediately behind meteoroid
- Relatively stationary, effected by neutral winds
- Scattering from field-aligned-irregularities (FAIs)

(Micro)Meteorite

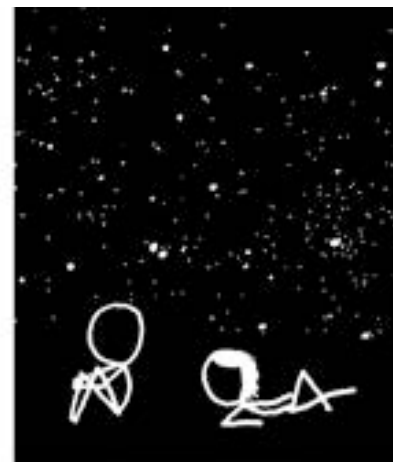
“Any object defined under meteoroid which has reached the surface of the Earth without being completely vaporized.

Micrometeorite: a very small meteorite or meteoritic particle with a diameter in general less than a millimeter.”

– International Astronomical Union

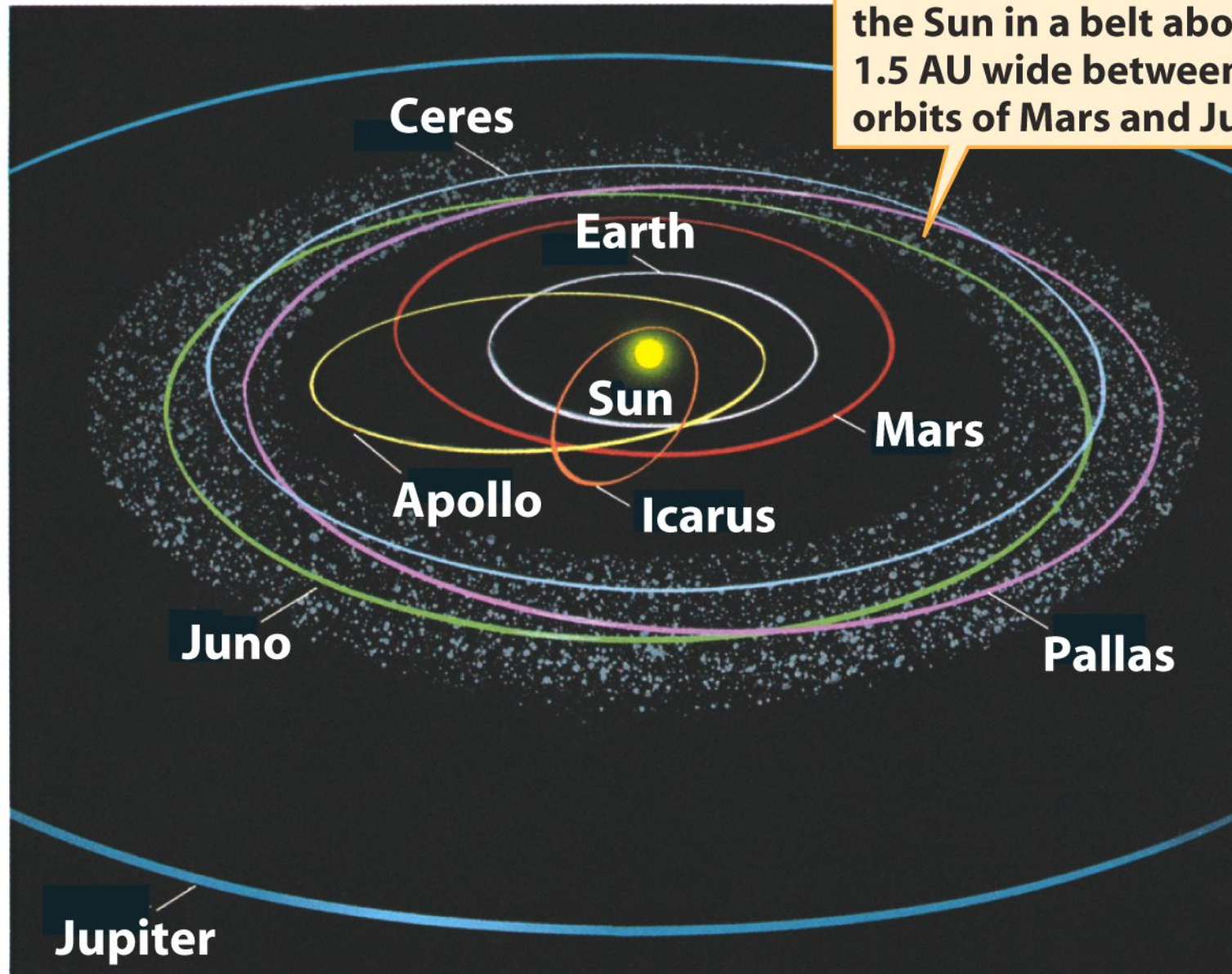


Astronomy 101-ish



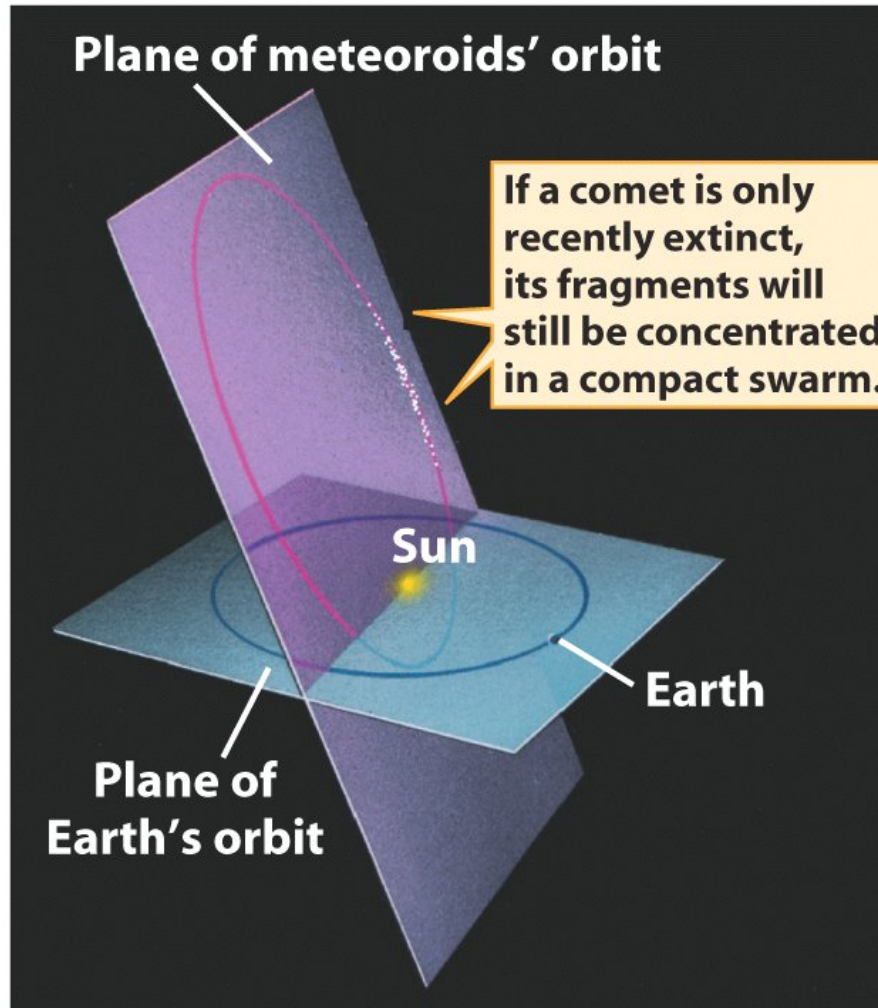
Asteroids: Main Belt

Most asteroids orbit the Sun in a belt about 1.5 AU wide between the orbits of Mars and Jupiter.

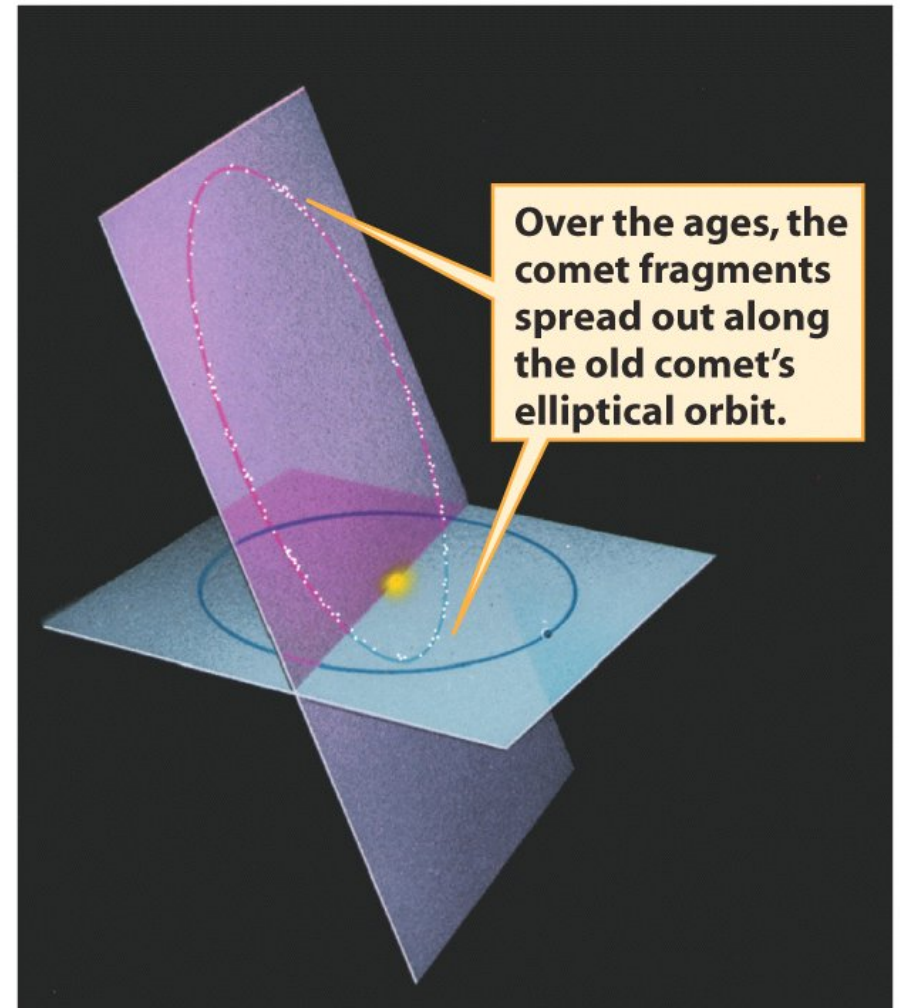


Comets

⊙ Short-Period, Long-Period, Halley-type

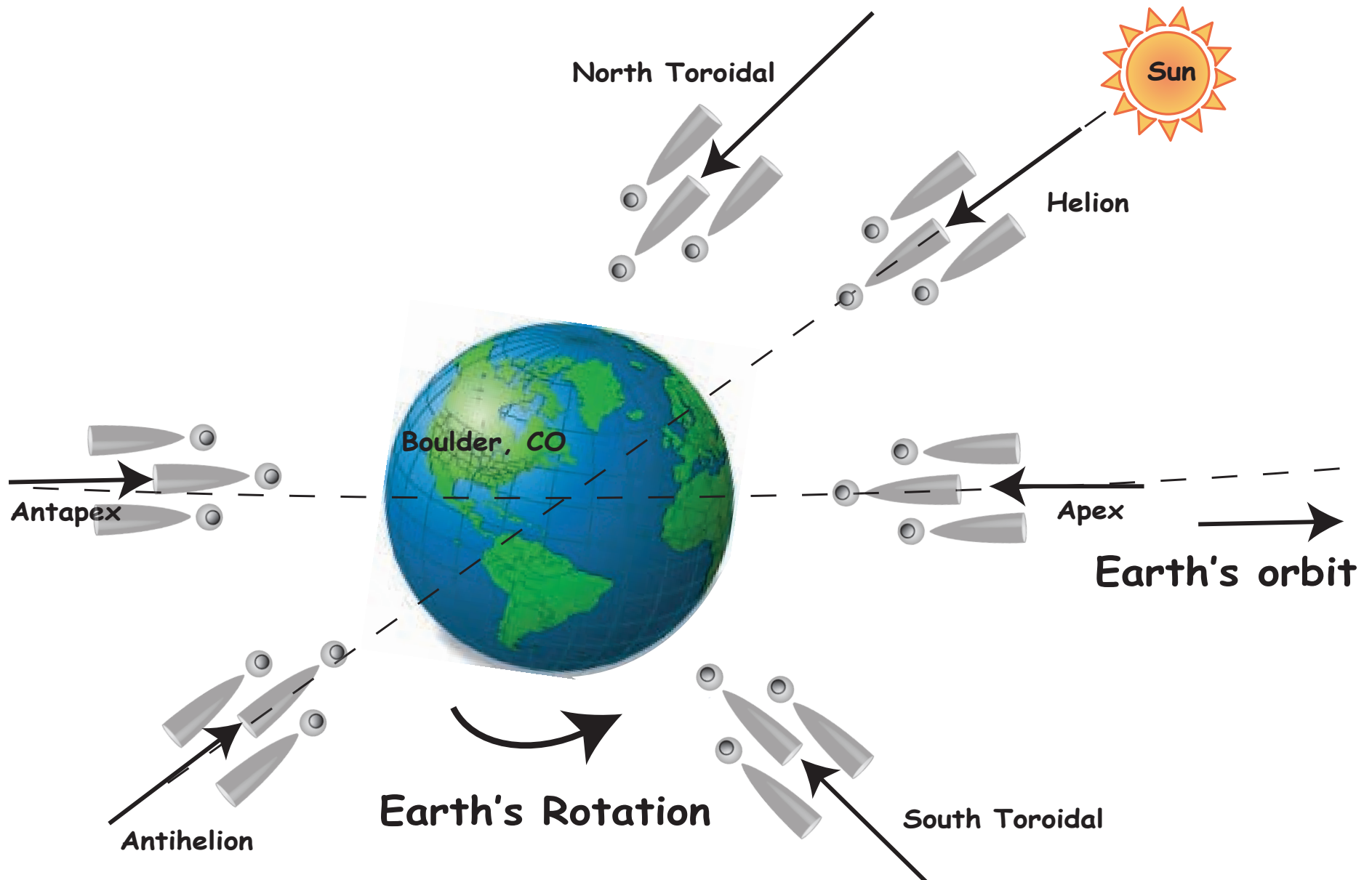


(a)



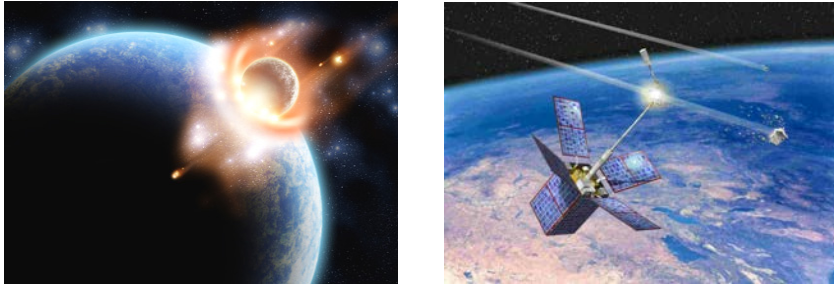
(b)

Sporadic Meteoroid Complex

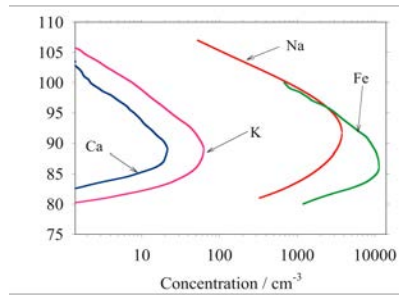
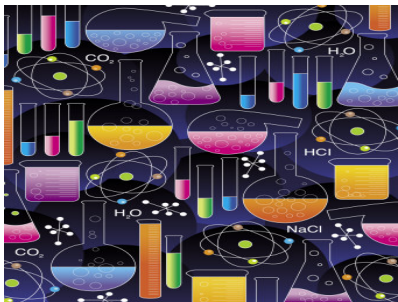


Who Cares?

Impact Hazards



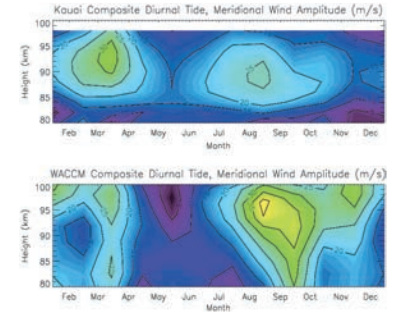
Atmospheric Chemistry



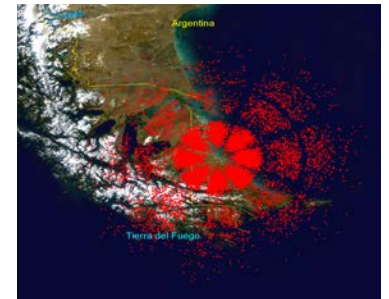
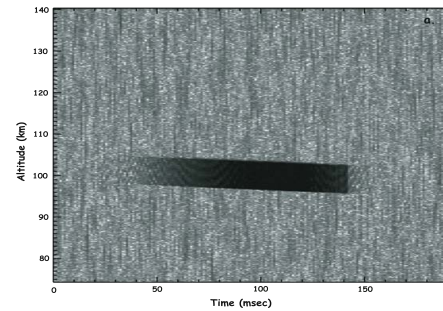
Origins of Life



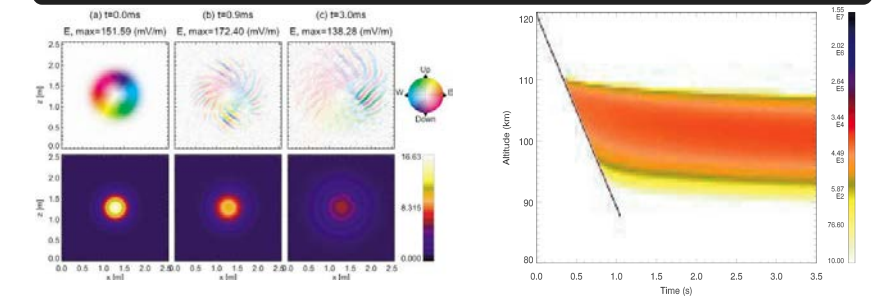
MLT Phenomena



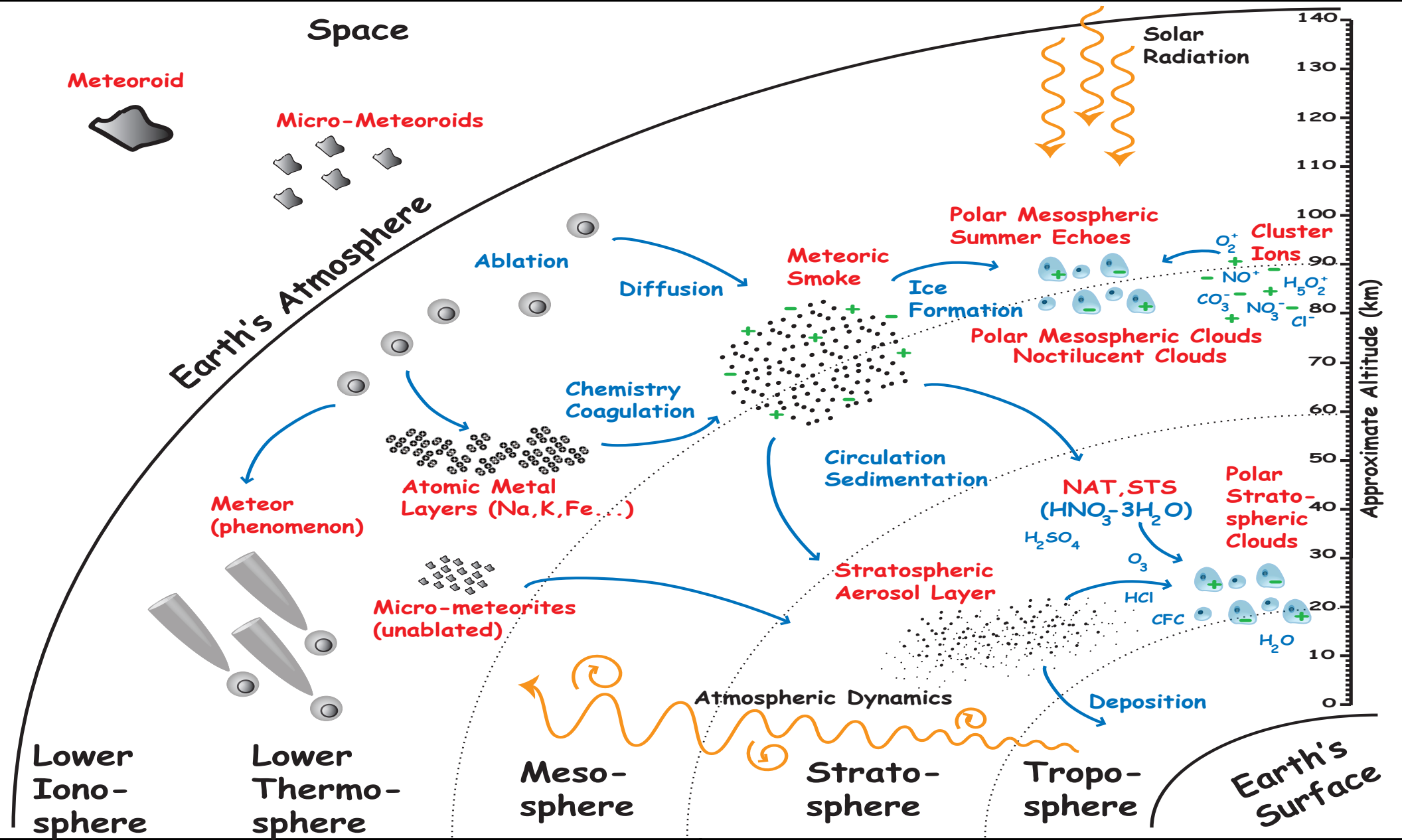
Radar/Astronomy Studies



Plasma Physics



What's the Connection?



You Can Help: If Your Advisor is into Meteors of Course

How much mass?

- ⊙ **Measurements disagree by more than 2 orders of magnitude**

What's it made out of?

- ⊙ **Density/Composition are highly variable and have implications for the fraction of cometary vs. asteroidal material**

Where does it all come from?

- ⊙ **NEOs, Orbits, Sources**

Atmospheric interactions:

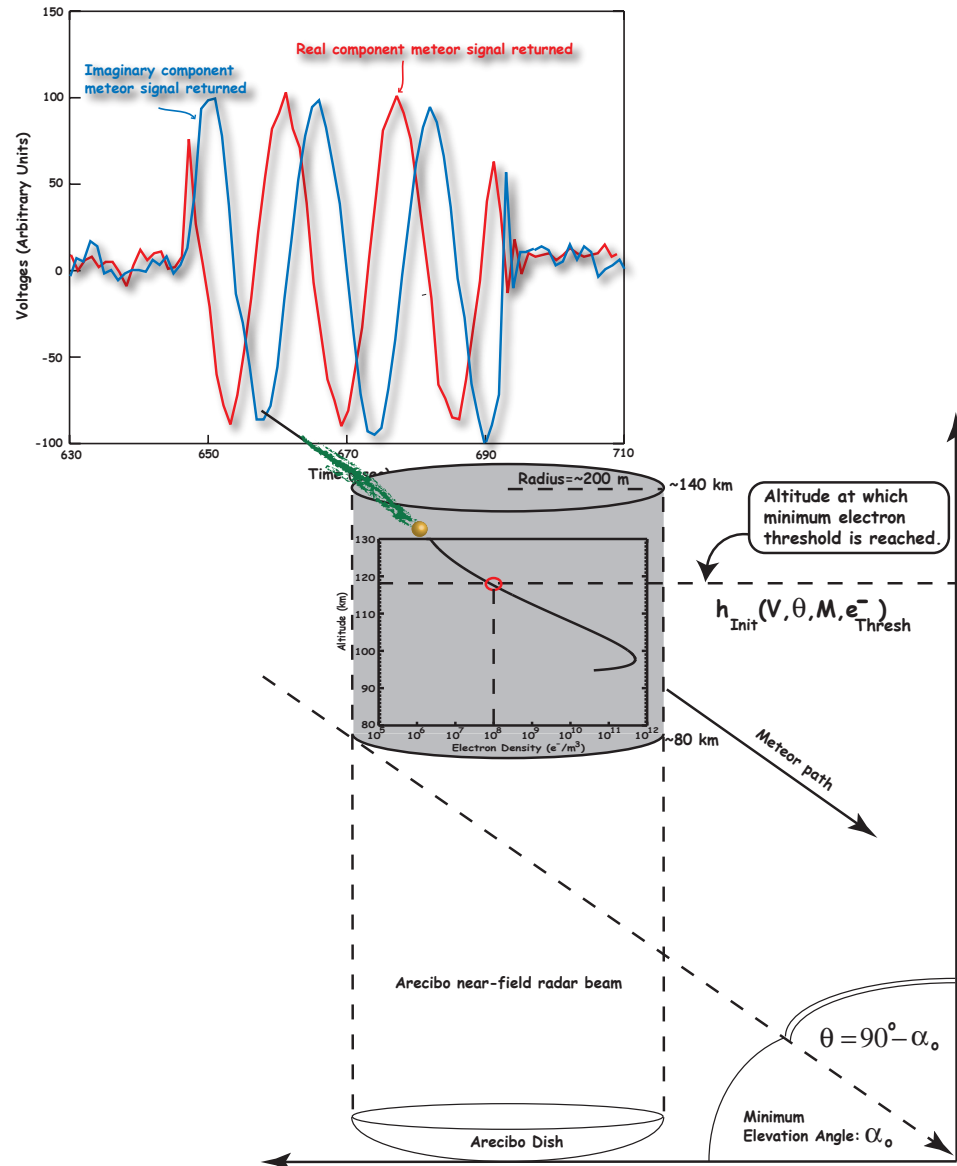
- ⊙ **Basic scattering processes, plasma instabilities, role of fragmentation, role of atmospheric wind/density variability**

Radar sensitivity:

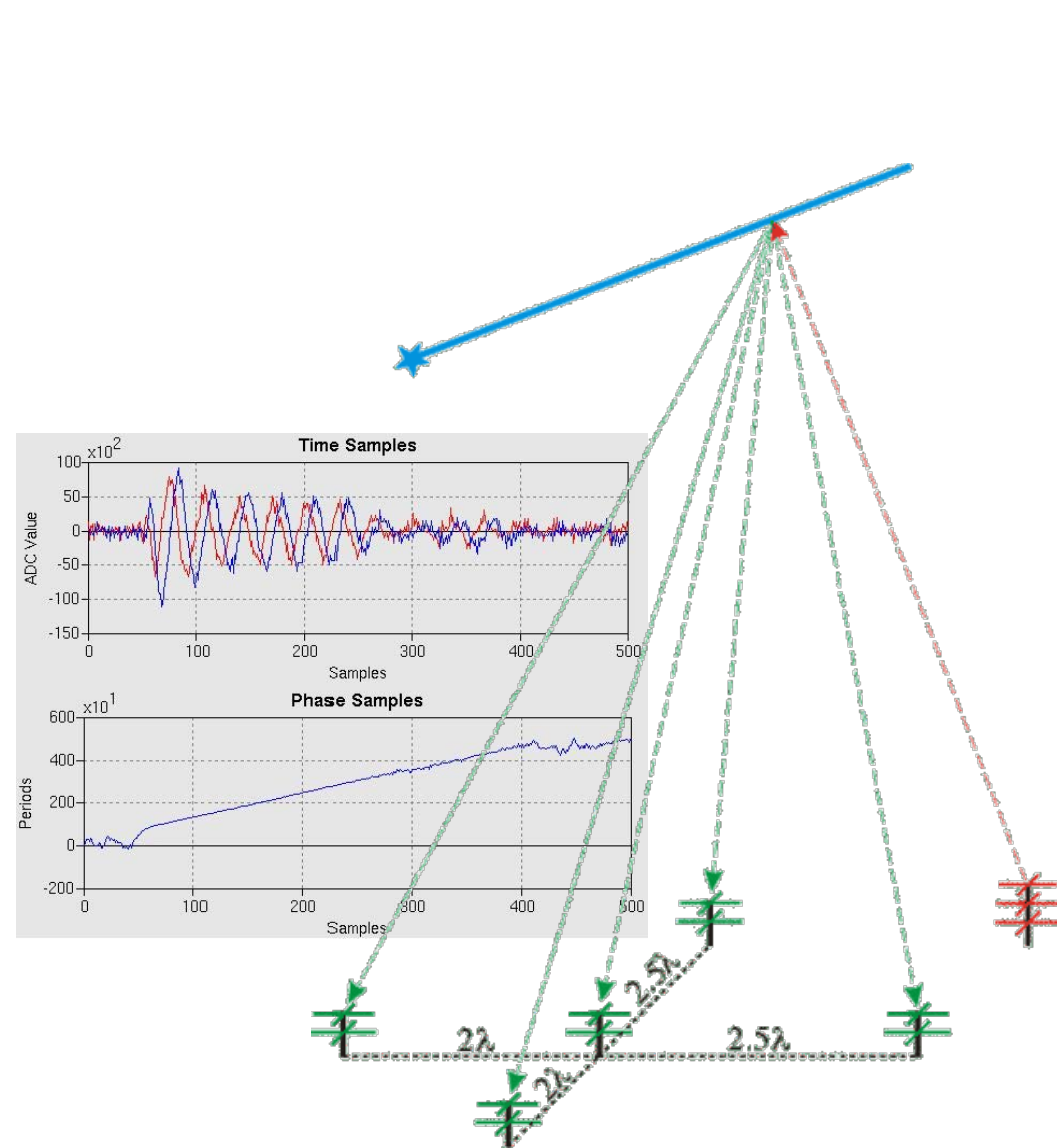
- ⊙ **Measurement comparisons, aspect/frequency sensitivity, etc.**

What Does a Meteor look like?

High Power Large Aperture



Specular Meteor Radar



What Measurements Can We Make?

Primary

Radar Parameters

- ⊙ Voltages, power, SNR, polarization

Spatial & Temporal Distributions

- ⊙ Altitude, particle flux, velocity, deceleration
- ⊙ Orbits from interferometry

Secondary

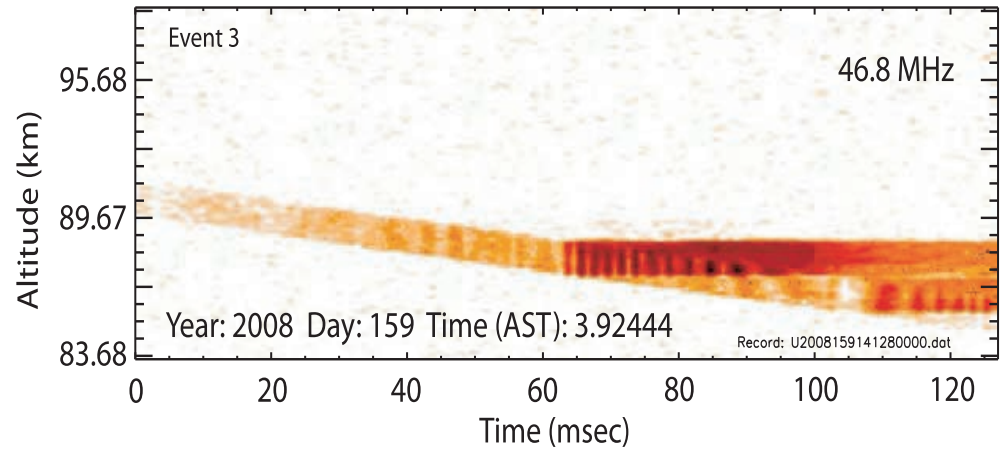
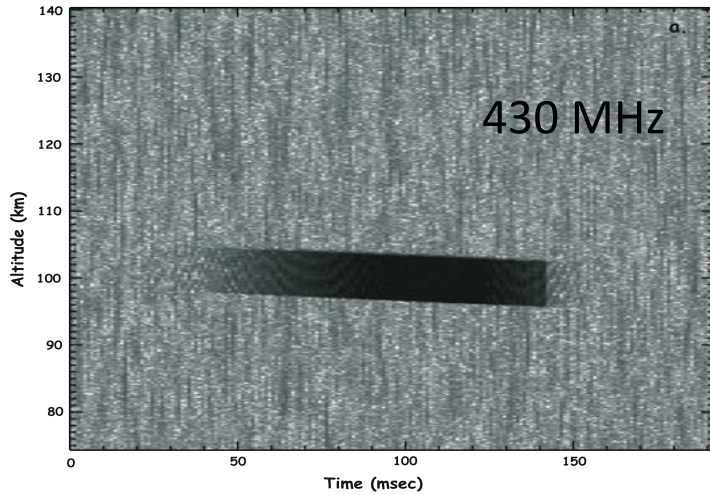
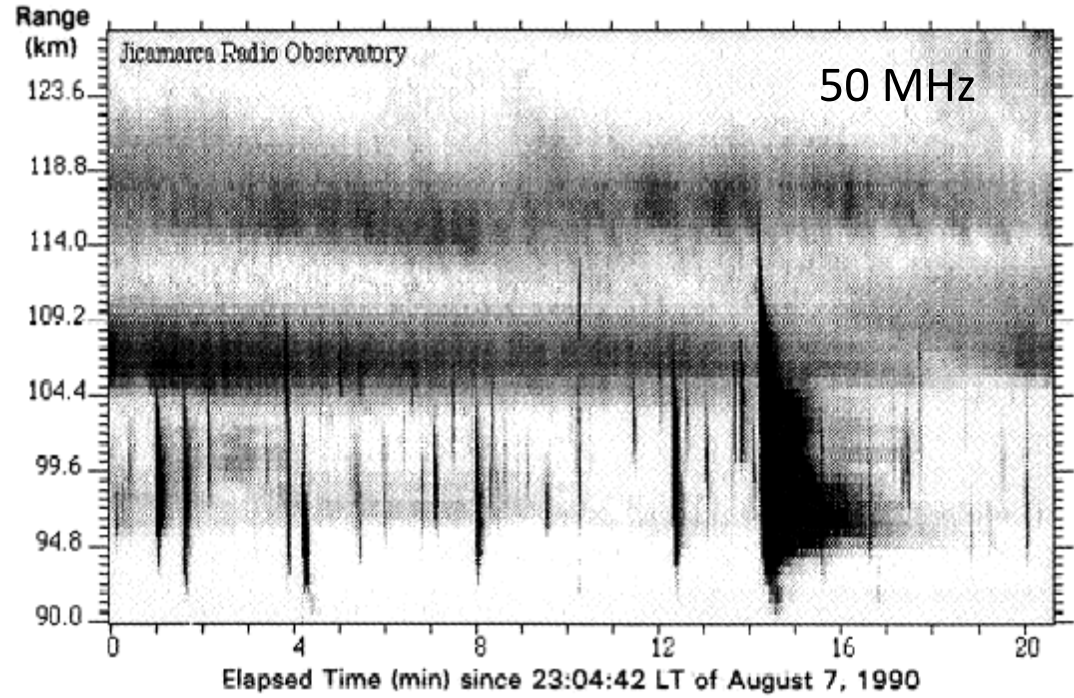
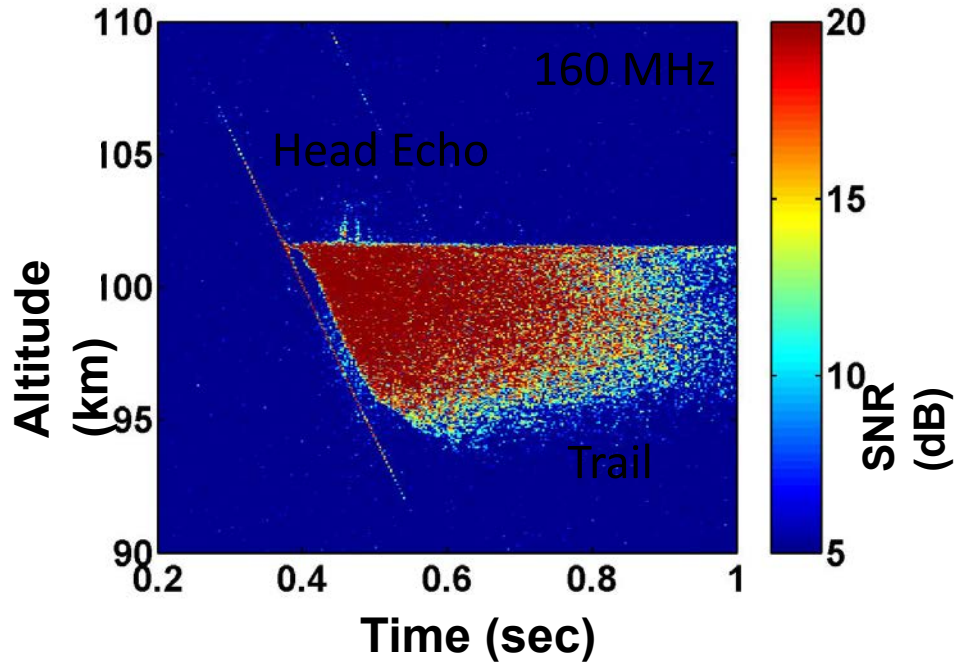
Atmospheric Parameters

- ⊙ Temperature, neutral winds, waves/tides, momentum fluxes

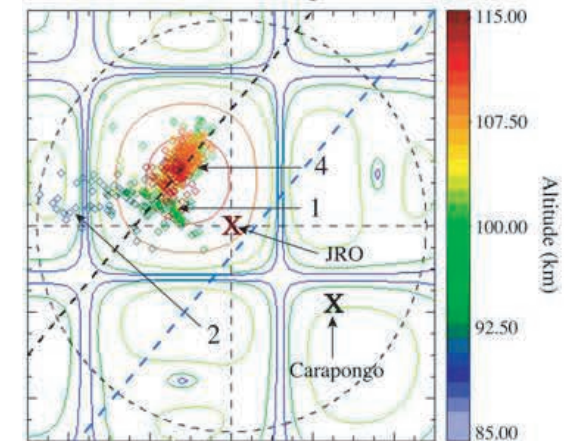
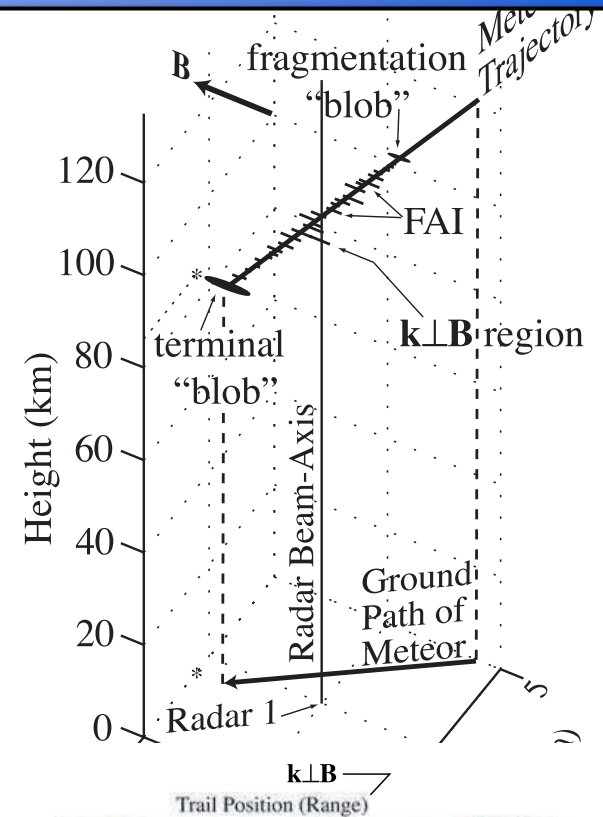
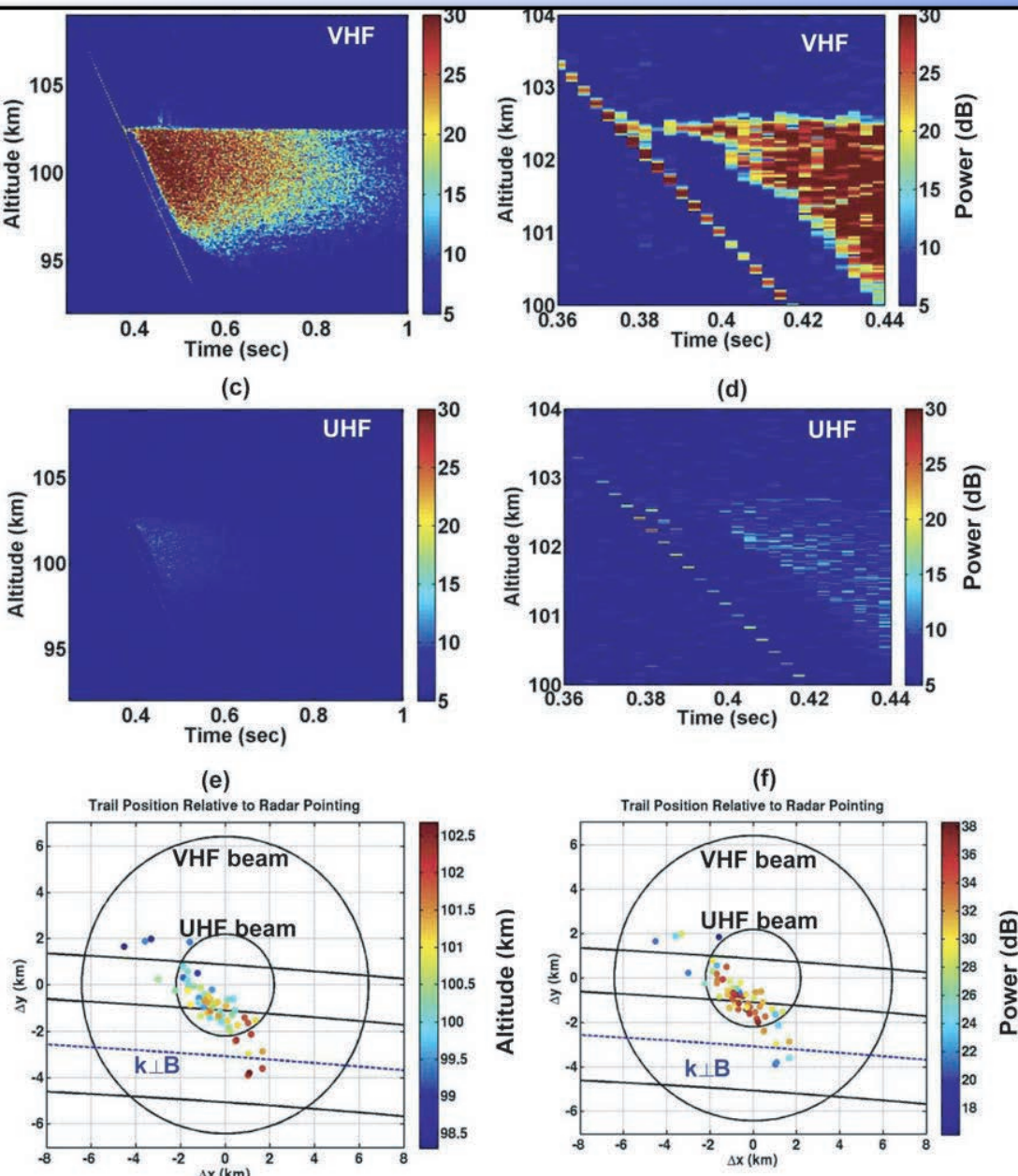
Meteor Properties

- ⊙ Composition, deposition, density, mass
- ⊙ Shape, plasma interactions

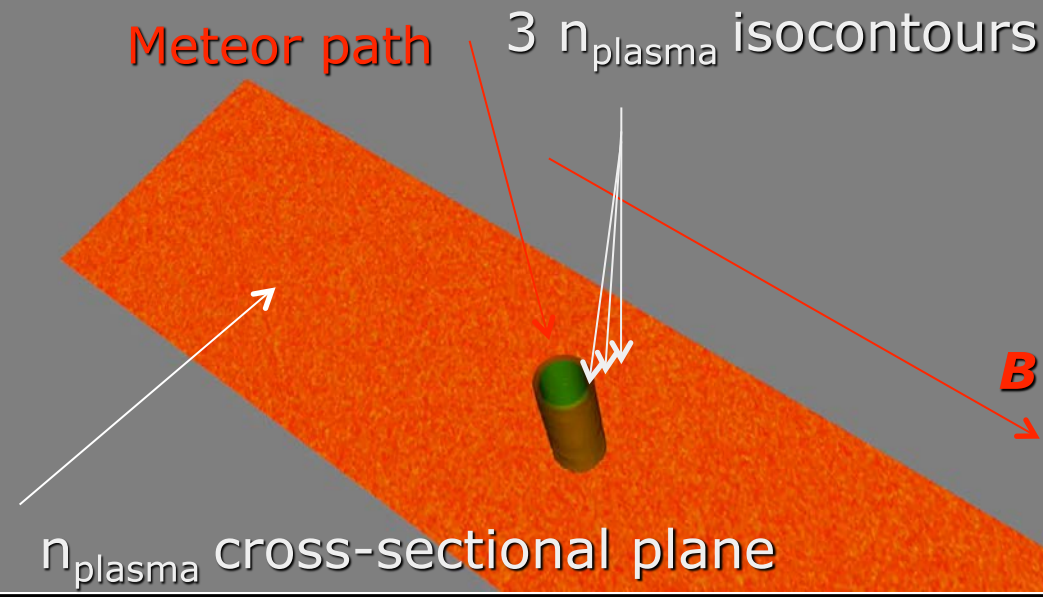
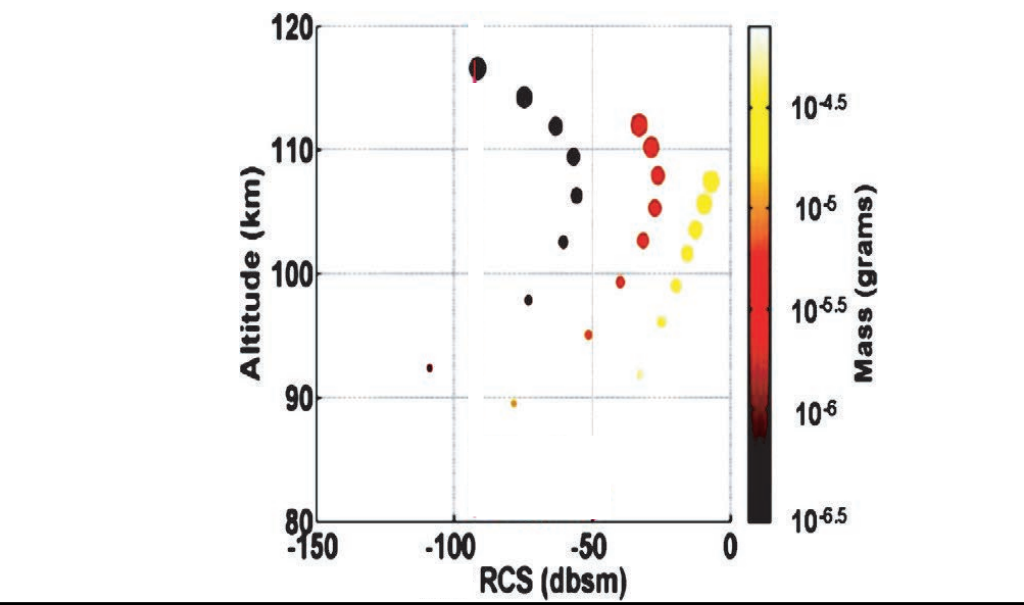
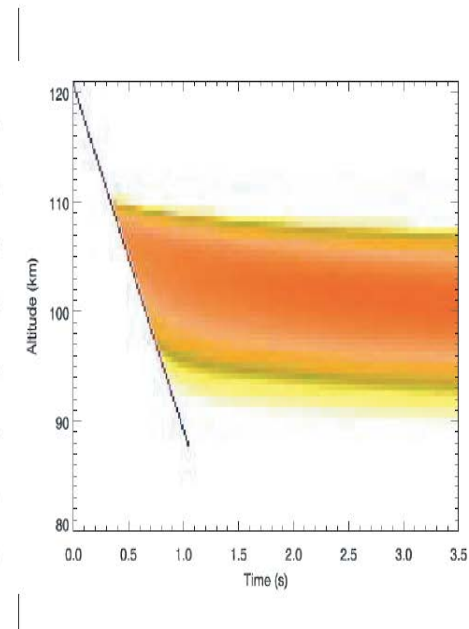
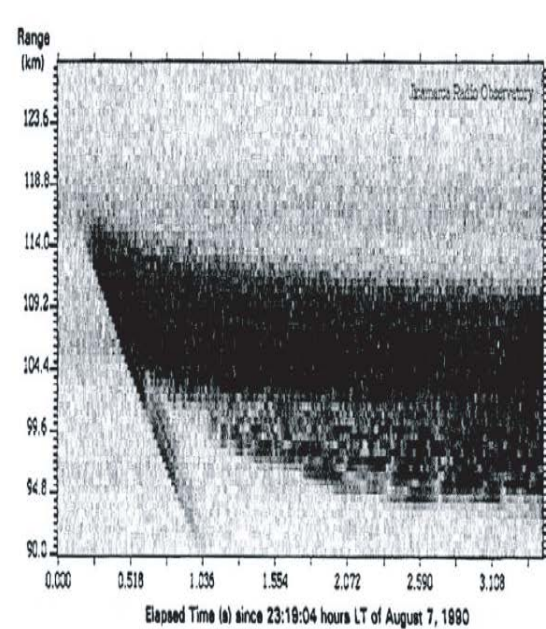
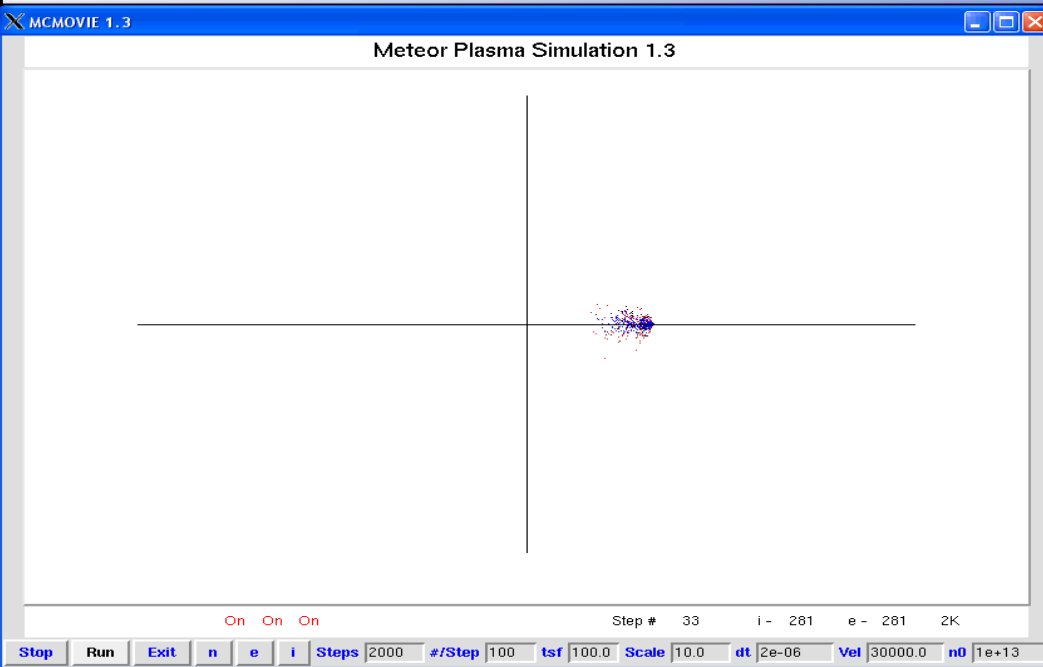
Head-Echoes and Trails



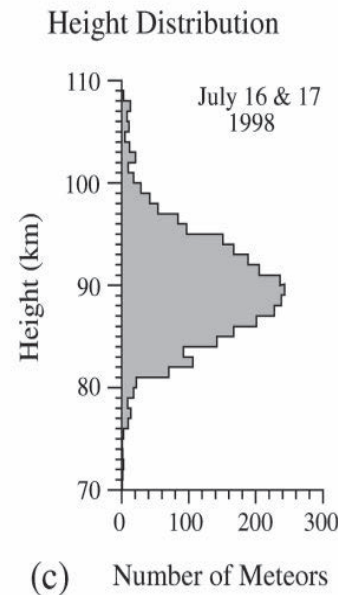
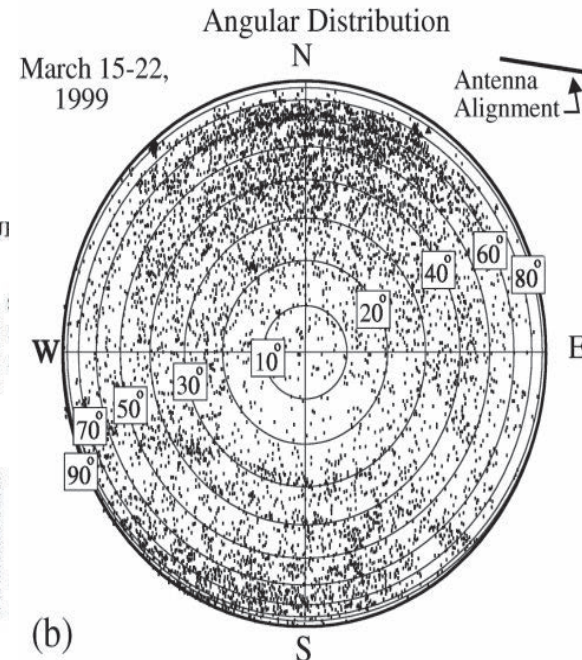
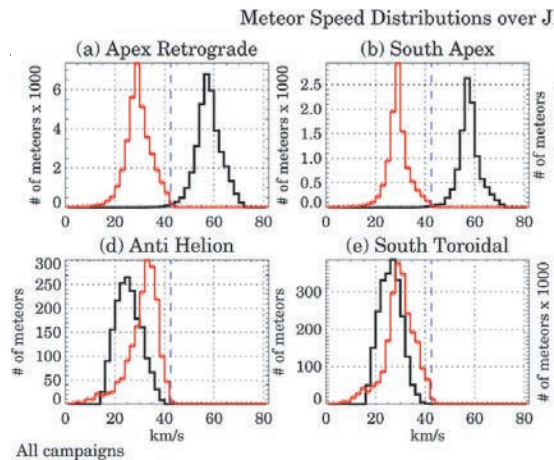
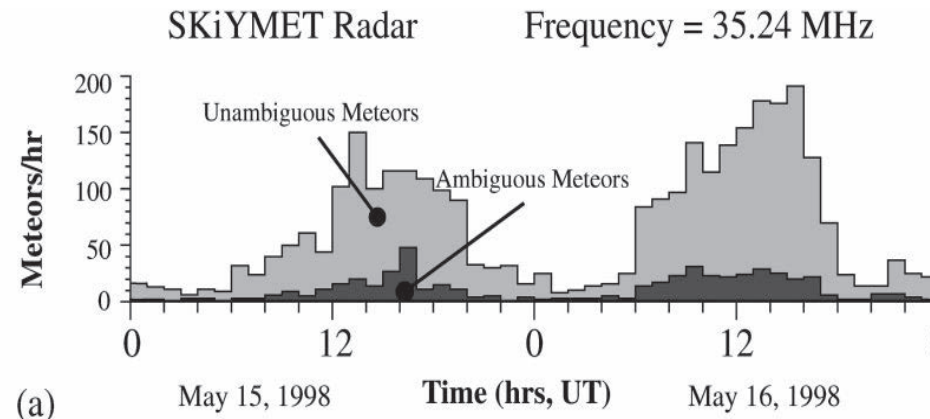
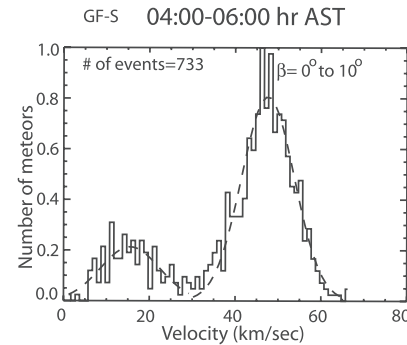
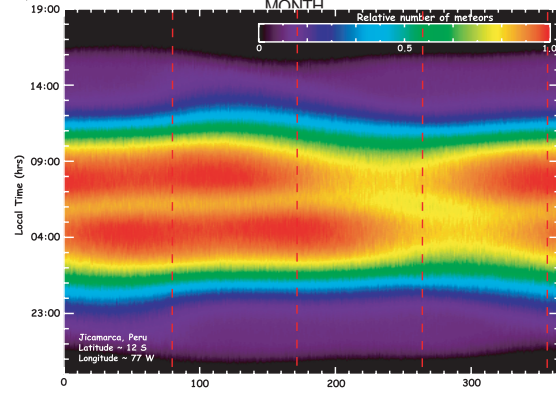
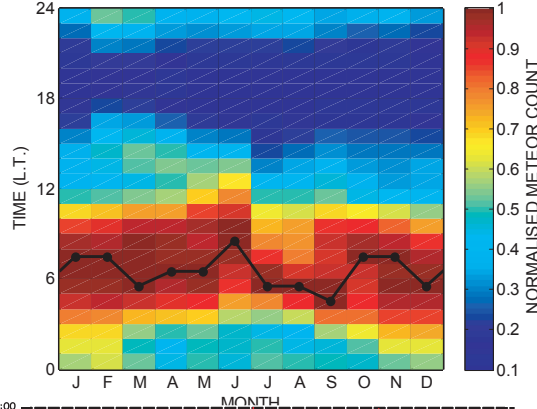
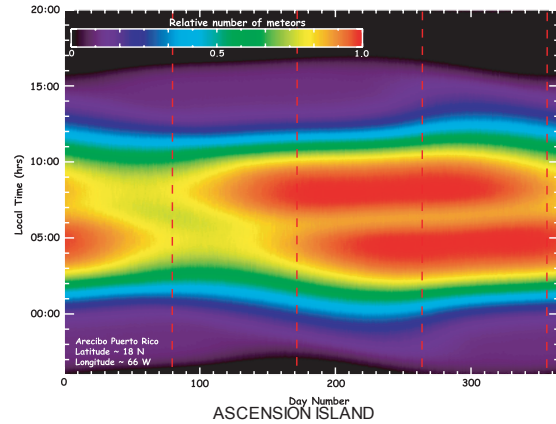
Long Duration Trails: $k \perp B$



Modeling Meteors

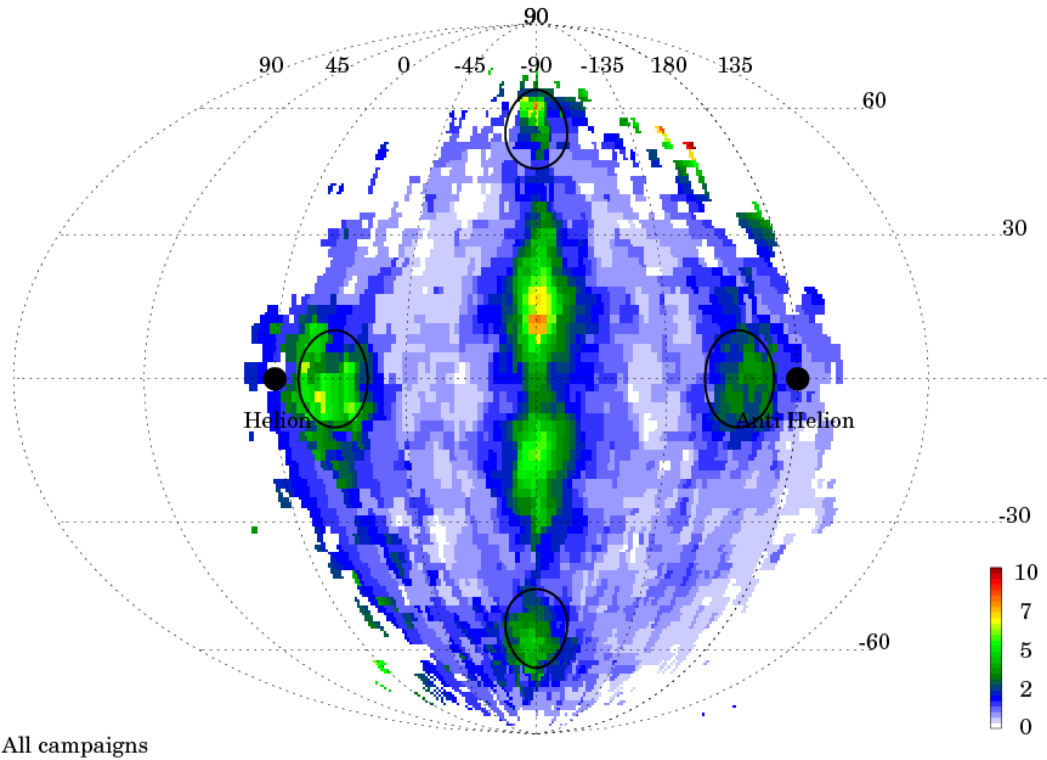


Some Distributions

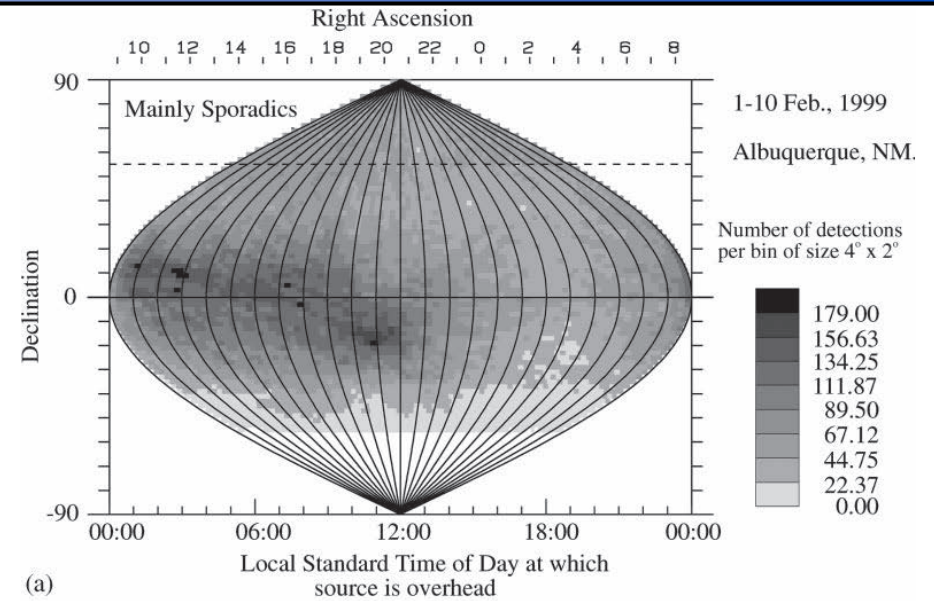
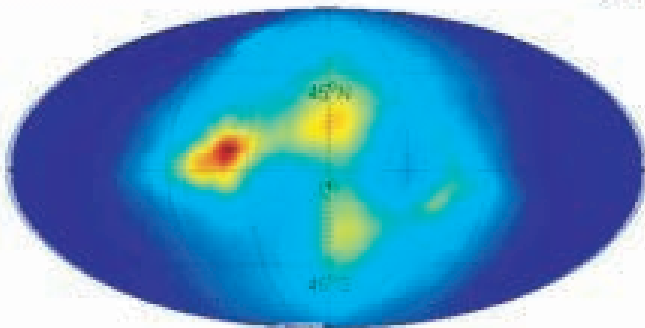


Meteor Radiants

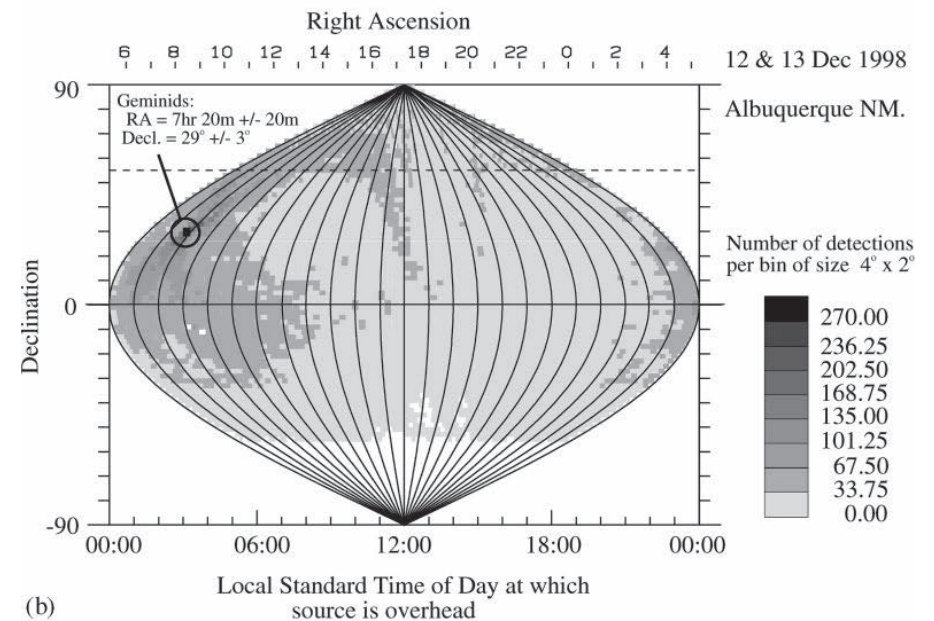
Distributions of all meteors before removing Earth velocity



CORRECTED RADIANT DISTRIBUTION - ASCENSION ISLAND JUNE

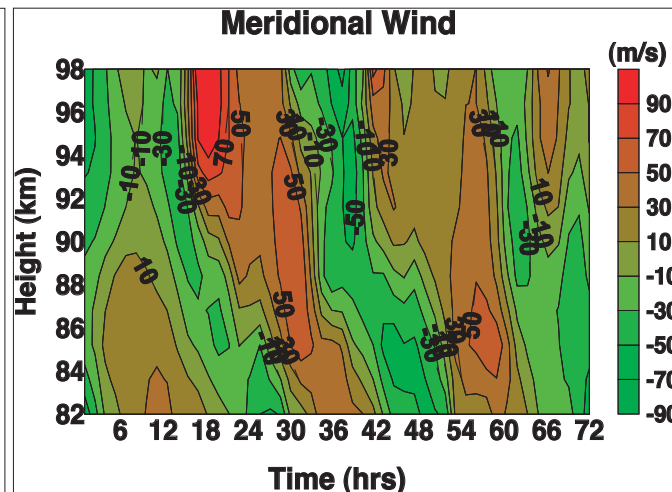
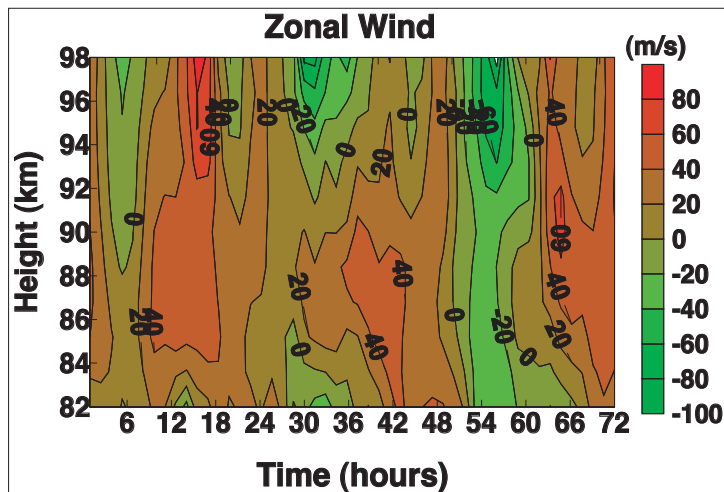
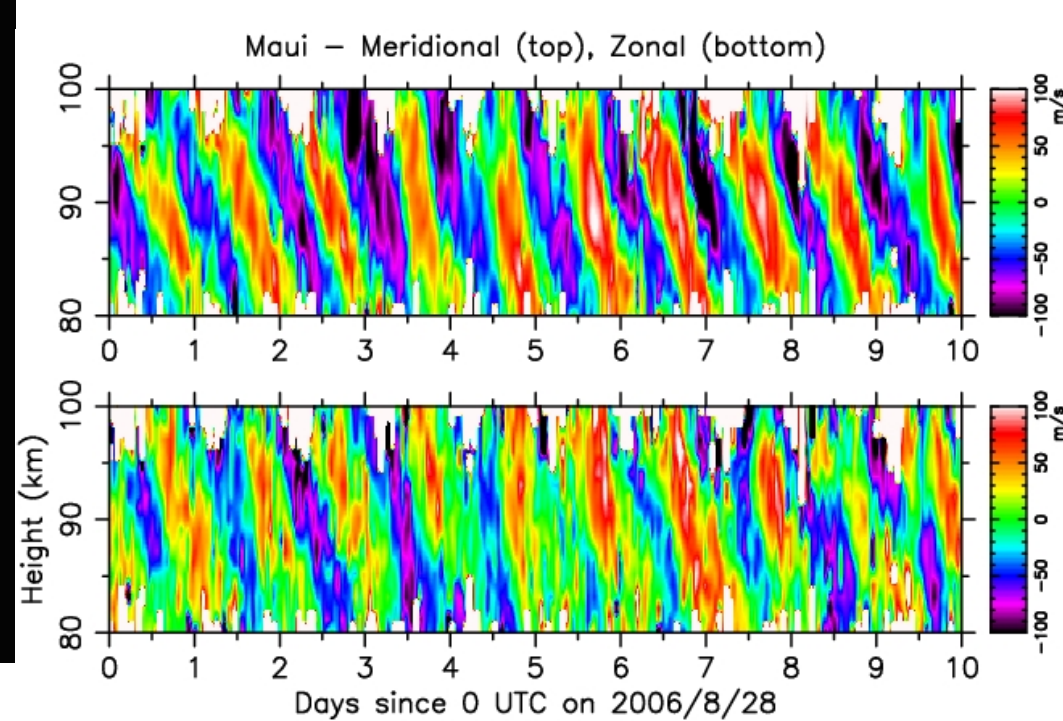
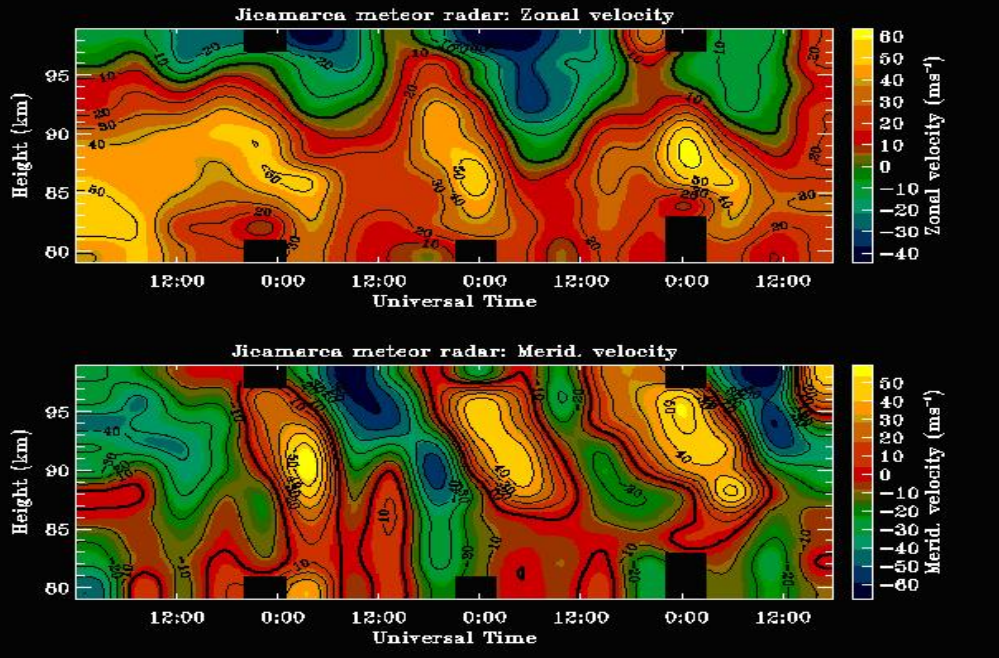


(a)



(b)

Meteor Derived Winds



Almost the End

- ⊙ Hopefully you've got a better idea of why people are studying meteors and a broader perspective on the field.
- ⊙ Meteor science encompasses a number of sub-disciplines within various physics and engineering fields.
- ⊙ There are a number of open questions and interesting problems that need to be addressed.
- ⊙ Radar is a powerful tool for studying meteors.

Thanks for Your Attention



Meteor Science
Rocks!

**...Time for
questions???**

Meteor Posters
Tuesday 1600-1900

Meteor Session
Wednesday 1330-1530