COE CST Sixth Annual Technical Meeting

Task 186: Space Environment MMOD Modeling and Prediction

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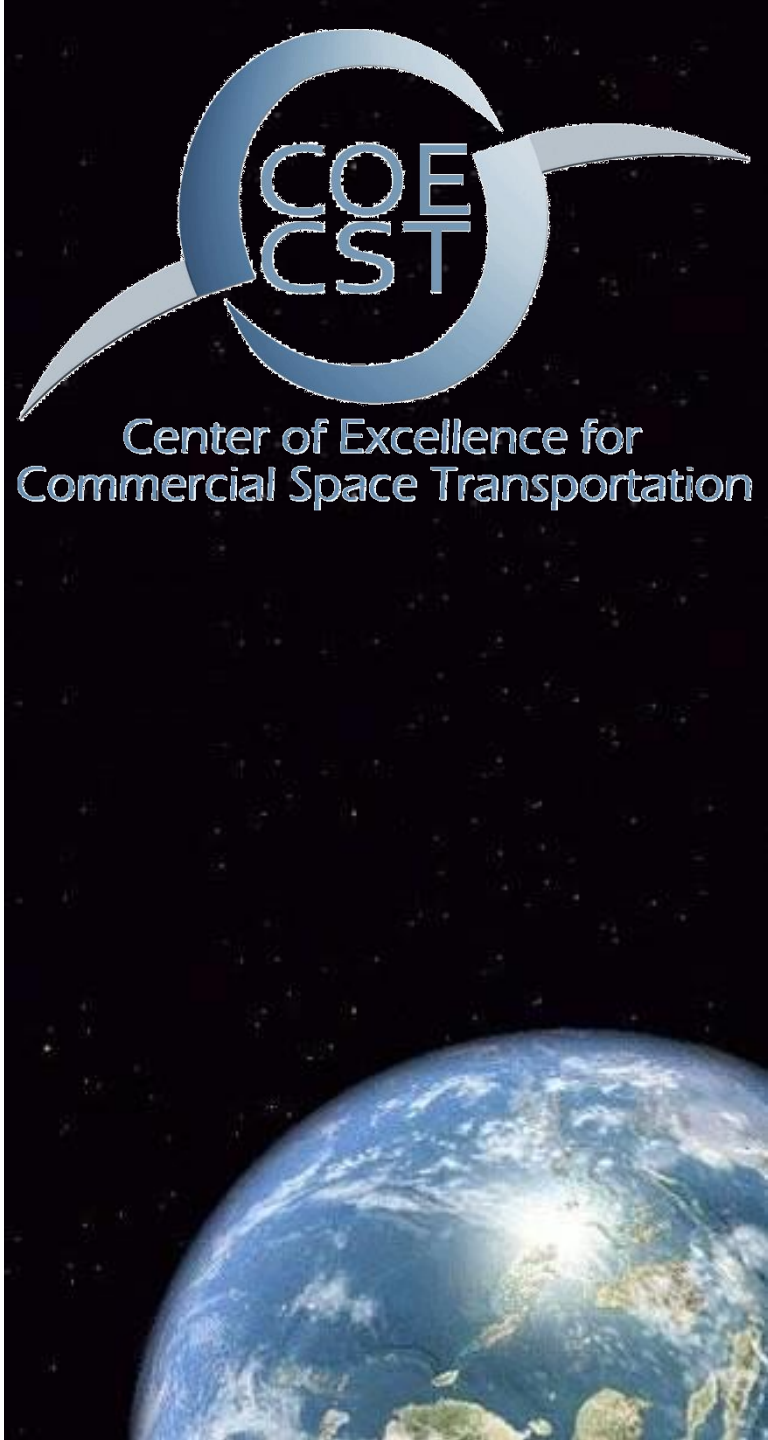
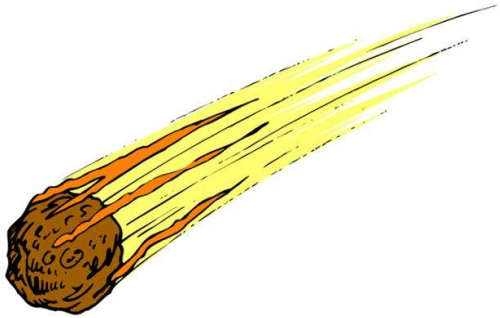


Outline

- Team Members
- Task Description
- Methodology
- Results
- Conclusions and Future Work



Team Members

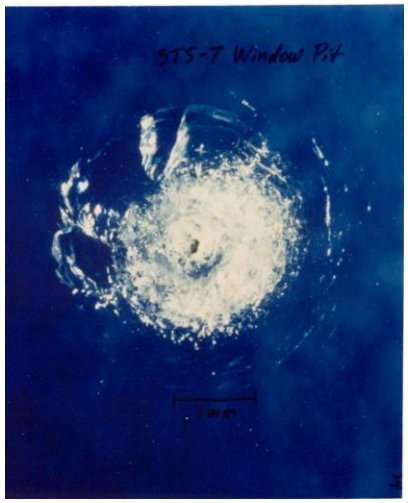
- **PI: Sigrid Close (Stanford University)**
- **Graduate Students (Stanford University)**
  - Diana Hernandez Juarez-Madera

  - Lorenzo Limonta (supported by NSF)

- **Collaborators**
  - University of Western Ontario
  - NASA Marshall Space Flight Center

Purpose of Task

- **Spacecraft are routinely impacted by micrometeoroids and orbital debris (MMOD)**
  - Mechanical damage: "well-known", larger (> 120 microns), rare
  - Electrical damage: "unknown", smaller/fast, more numerous



- **Growing need to characterize MMOD down to smaller sizes and provide predictive threat assessment**

MMOD – Classification

- **Meteoroids**
  - **Speeds**
    - 11 to 72.8 km/s (interplanetary)
    - 30-60 km/s (average)
  - **Densities**
    - ≤1 g/cm^3 (icy) or > 1 g/cm^3 (rocky/stony)
  - **Sizes**
    - < 0.3 m (meteoroid)
    - < 62 μm (dust)

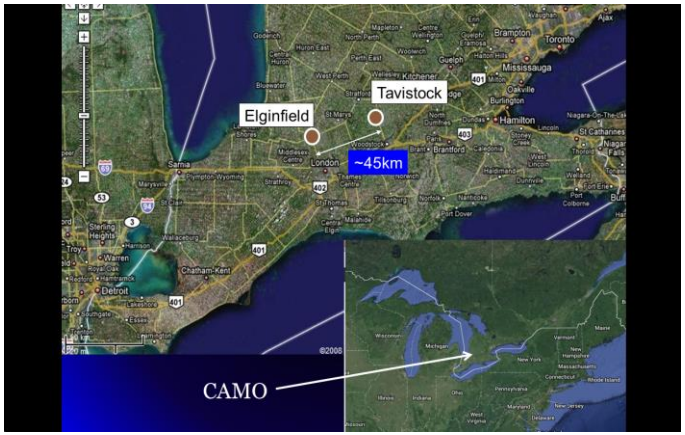
- **Space Debris**
  - **Speeds in LEO**
    - < 12 km/s
    - 7-10 km/s (average)
  - **Densities**
    - > 2 g/cm^3
  - **Sizes**
    - < 10 cm (small)

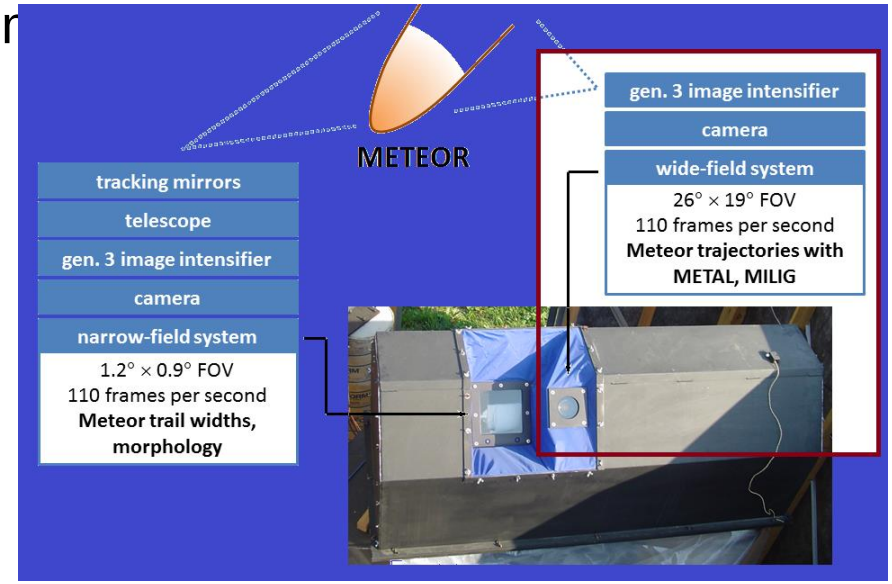
Definitions

- **Meteoroid**
  - A small, solid extraterrestrial body that hits the Earth's atmosphere
- **Meteor**
  - Signature of the meteoroid entering Earth's atmosphere ("Shooting Star")
- **Meteorite**
  - Meteoroid that has survived to hit the Earth's surface

Meteors: Experiment

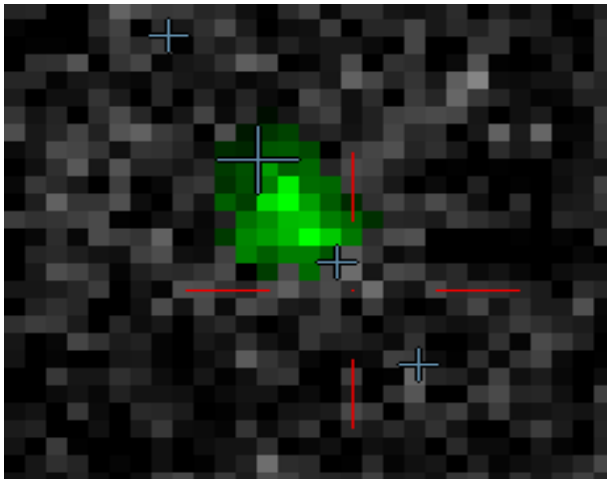
- **CAMO: Canadian Automated Meteor Observatory**
  - Two observatory stations separated by 44.9 km: Eigenfield and Tavistock
  - Wide field camera with FOV 26º x 19º
  - 110 frames per second, Meteor r

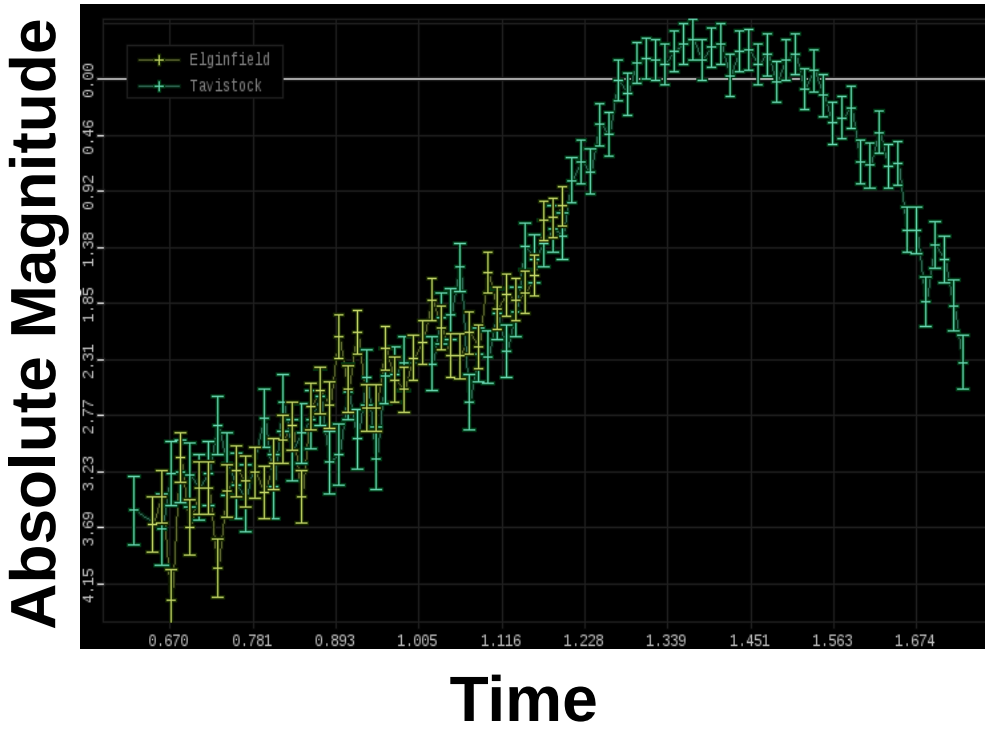




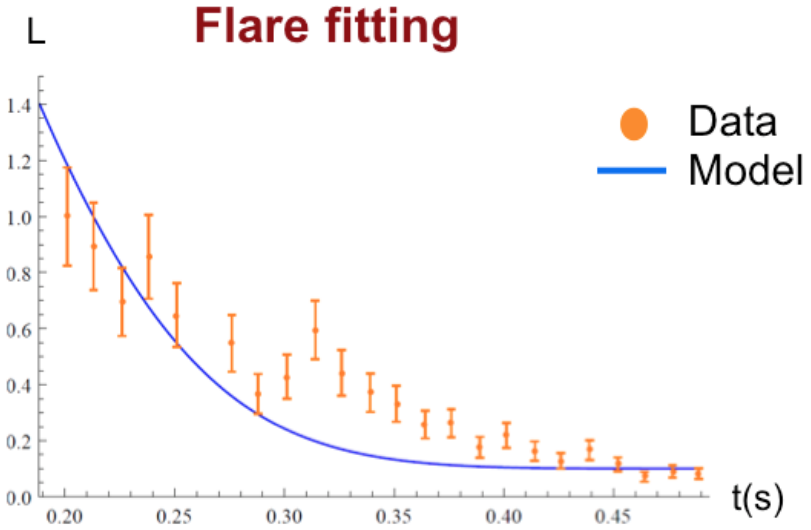
Meteors: Light Curve

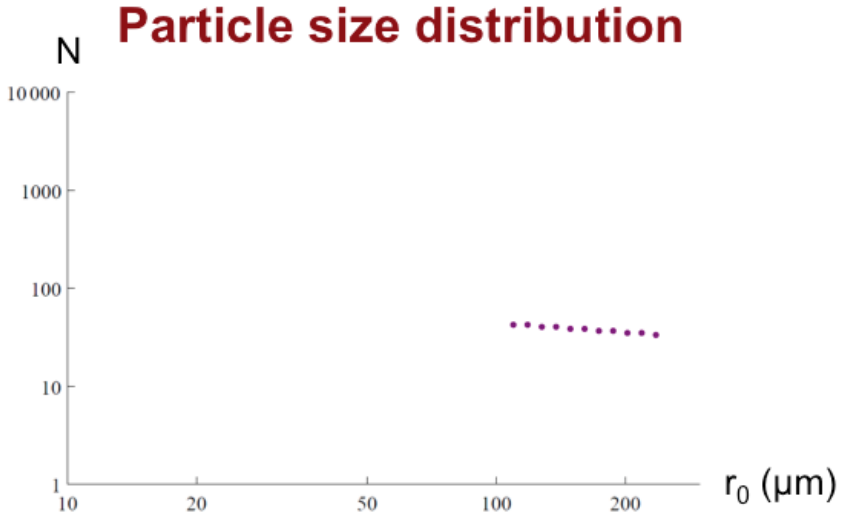
- **METAL: METeor AnaLysis software (UWO)**





Meteors: Preliminary Results





Event Label	Date & Time	δ (kg m^{-3})	σ (s^2 km^{-2})	m_{grain} $m_b - m_a$	α	h_d (km)	v (km/s)	
0	20110706_054233	3500	0.030	1E-09 - 1E-10	-3.5	119.369	68.770	stony
1	20150319_081706	1800	0.050	1E-07 - 1E-08	-1.1	83.489	20.770	stony
2	20150319_044203	5600	0.080	1E-07 - 1E-10	-1.4	83.860	30.270	stony
3	20101010_005932	2400	0.069	1E-06 - 1E-08	-1.3	85.519	30.018	stony
4	20150323_035632	800	0.080	4E-07 - 1E-07	-1.1	83.351	21.695	cometary

Conclusions and Future Work

- **New student (Diana) researching meteoroid and orbital debris fragmentation**
- **New optical observations for meteoroid fragmentation**
  - Model describe sudden and simultaneous detachment of the particle
  - Traditional models not capturing relevant physics
  - Additional data and modeling efforts needed
- **Next steps**
  - Combine optical and radar data
  - Develop new ablation models

Thank you!