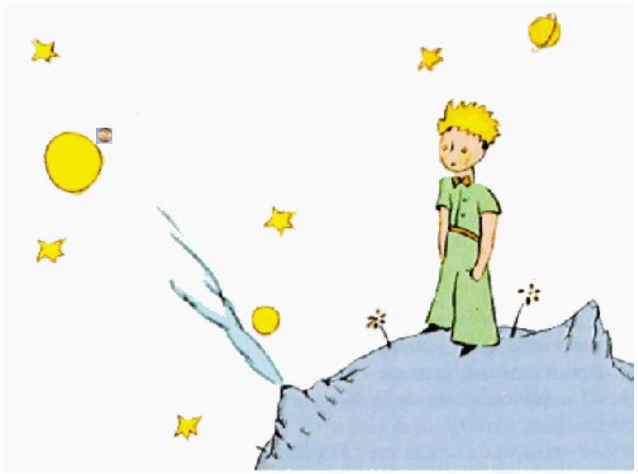

Rarefied Gasdynamics of Planetary Atmospheres by the ASE/Astro Group

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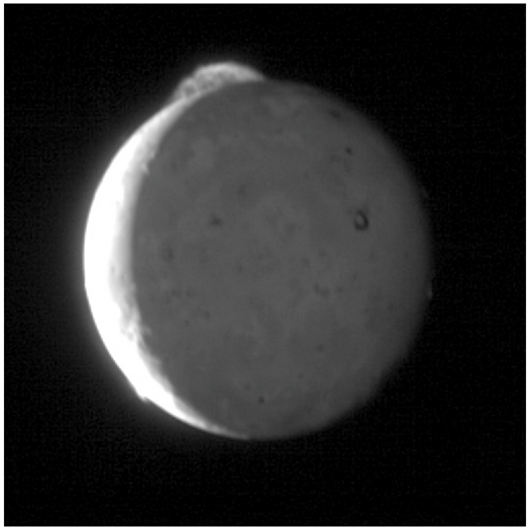


Current Project Funding

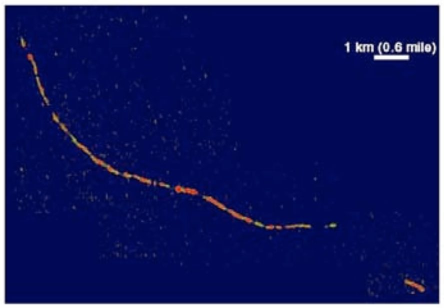
- "3-D simulations of plume dynamics on Enceladus," *NASA Cassini Data Analysis Program*.
- "Simulations of Cassini/Galileo nightside and eclipse observations of Io's aurorae," *NASA Outer Planets Research Program*.
- "Simulation of the Effects of Vent Geometry and Canopy Interactions on the Plumes and Deposits on Io," *NASA Planetary Atmospheres Program*, (with co-I S. Kieffer at UIUC).
- "Direct numerical simulation of the gasdynamics of the LCROSS impact," *NASA Ames Research Center*.
- "Simulation of Rocket Plume Impingement and Dust Dispersal on the Lunar Surface," *NASA LASER Program*.
- "Direct Numerical Simulation of Comet Impacts and Low Density Atmospheric Flow on the Moon and the Effects on Ice Deposition in Cold Traps – Phase 2" *NASA LASER* , (with Co-I E. Pierazzo at PSI).
- "Simulation of Io's Atmosphere", *NASA Outer Planets Research*, (with Co-I D. Levin at Penn State).
- "Modeling the Plumes on Enceladus," *NASA Cassini Data Analysis Program* (new start).

The Codes and the Physics

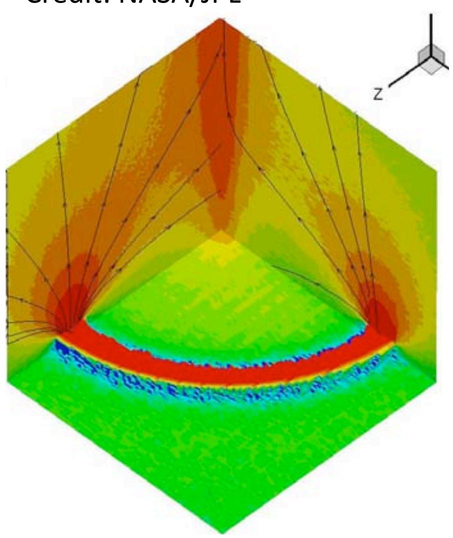
- For collisional flows: DSMC
- For collisionless flows: Free Molecular
- For electron motion, excitation, radiation: Aurora code
- For radiation transport: RASSVET (Penn State)
- For continuum impacts: SOVA (PSI)
- For continuum gas dynamics: DPLR or UIUC code

In house codes

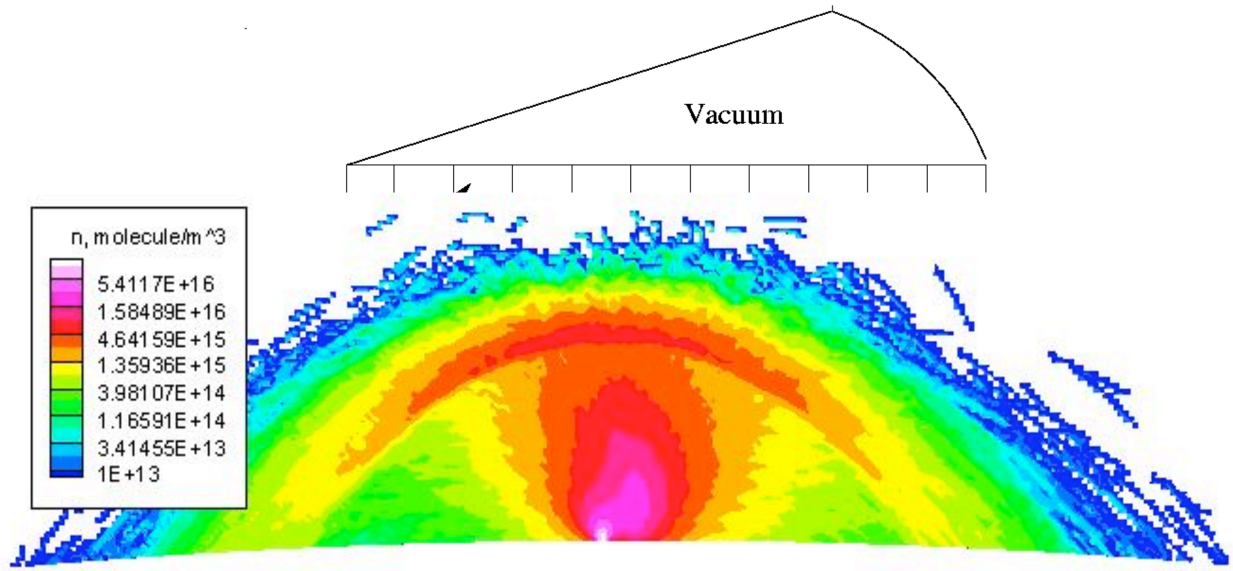
Direct Simulation Monte Carlo Simulation of Ionian Plumes



Infrared Galileo image of Pele's source (all regions shown >600 Celsius). Credit: NASA/JPL



3D simulation of a volcanic plume with a complex source geometry



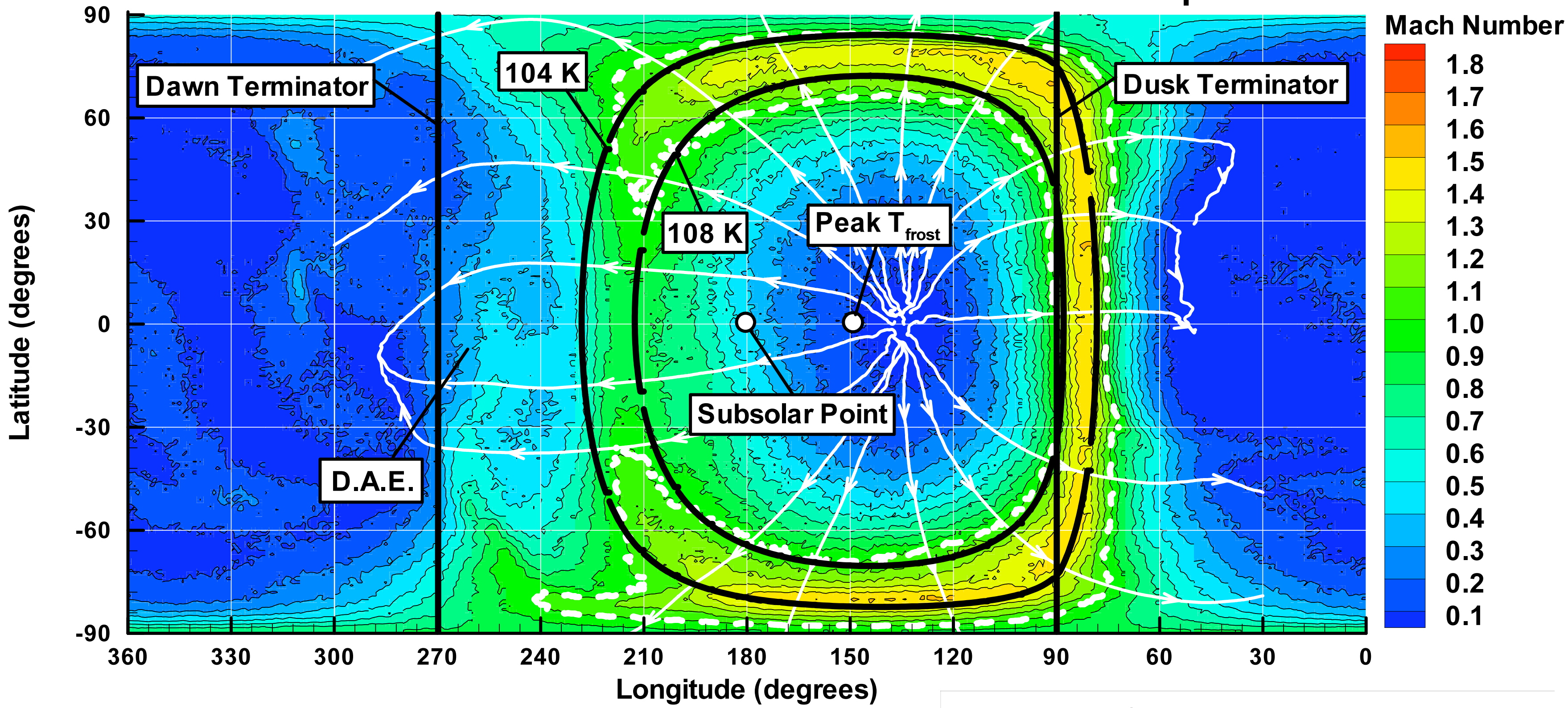
Slice through the middle of a simulated plume. The flow expands outward from a C-shaped slit (white)~~, forms a focused jet to the right of the source~~ (purple), and falls back on itself in a dome-shaped canopy shock.

Diagram illustrating basic components of DSMC method

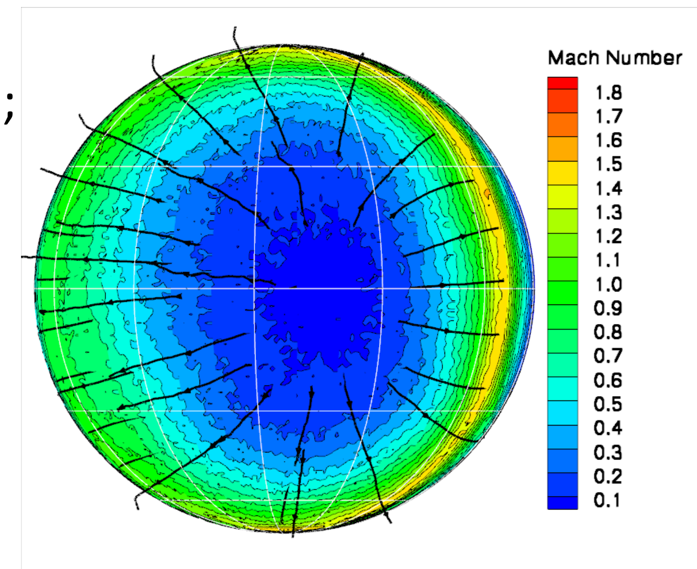
Direct Simulation Monte Carlo (DSMC) physics:

- Vibrational and rotational energy exchange.
- Infrared and microwave radiation.
- Two phase gas/particle flow.

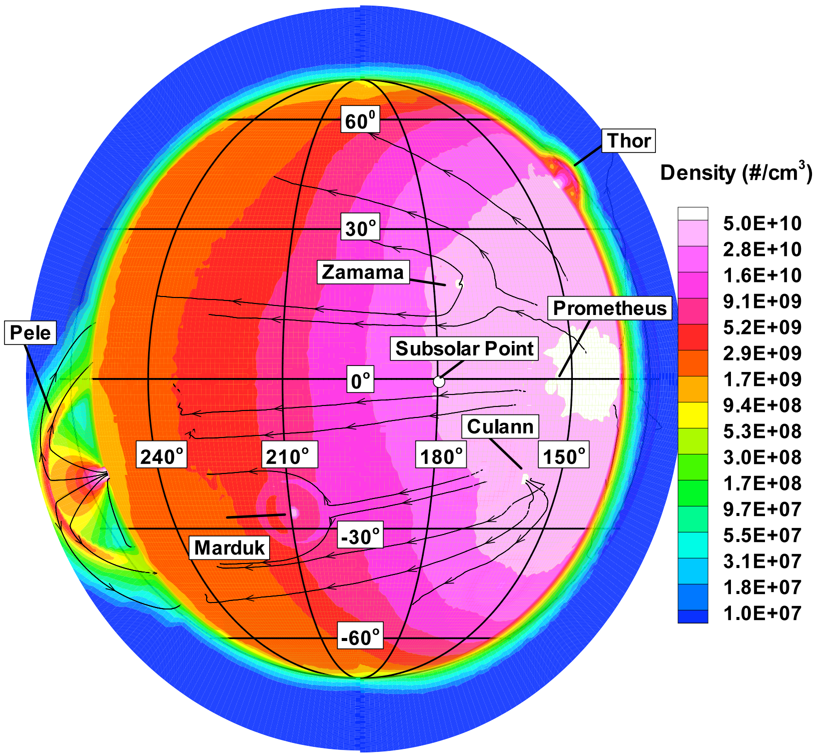
Ionian sublimation and volcanic atmosphere

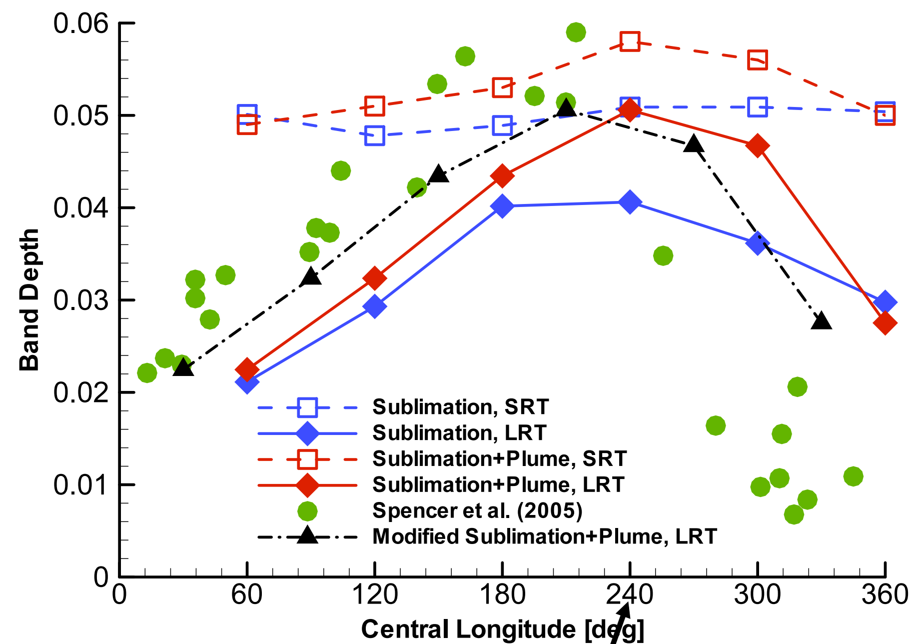


- DSMC (direct simulation Monte Carlo) Method;
- Vibrational and rotational energy exchange;
- Infrared and microwave radiation;
- Two phase gas/particle flow
- Plasma Heating
- Unsteady due to rotation
- Dual component surface



Composite Atmosphere and Validation





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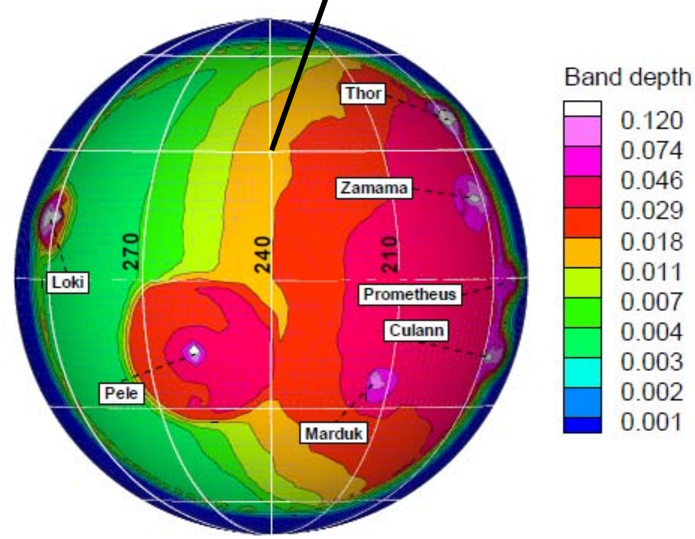
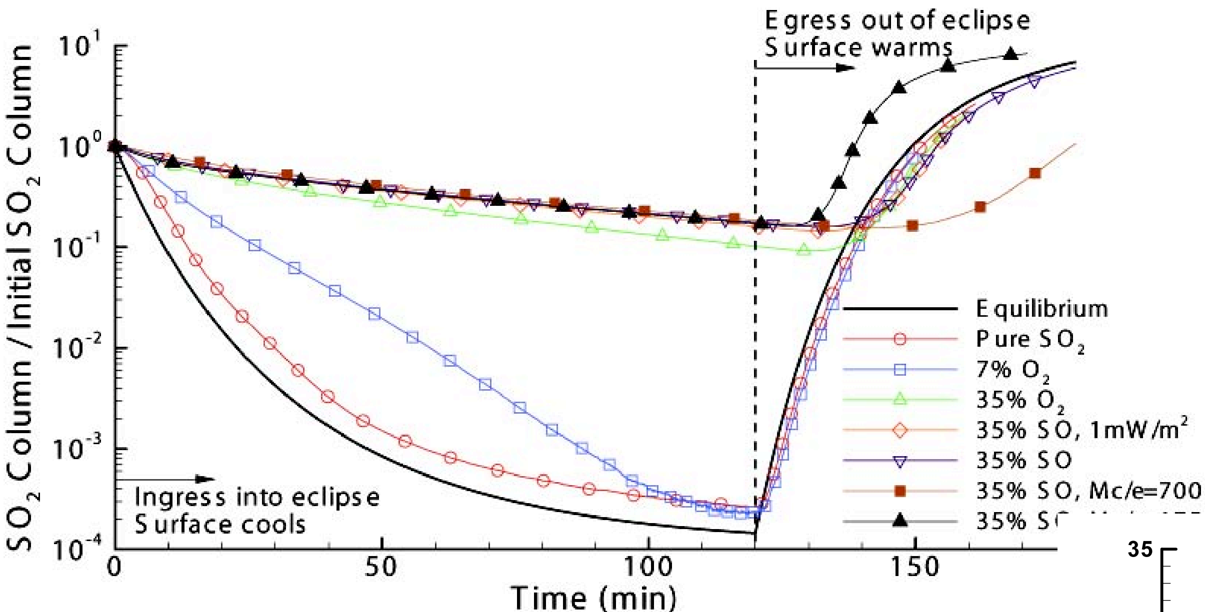


Simulation of Io’s atmosphere during eclipse

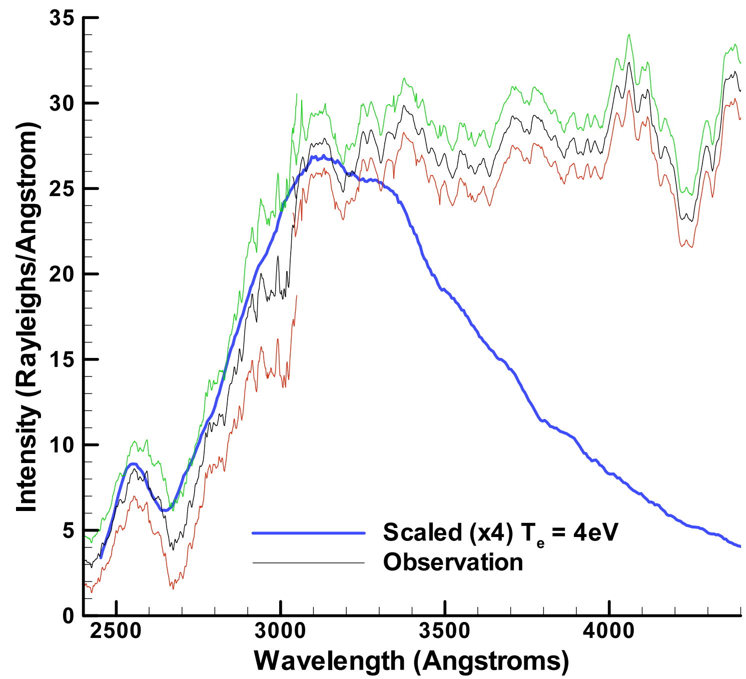
1D DSMC atmospheric collapse simulation



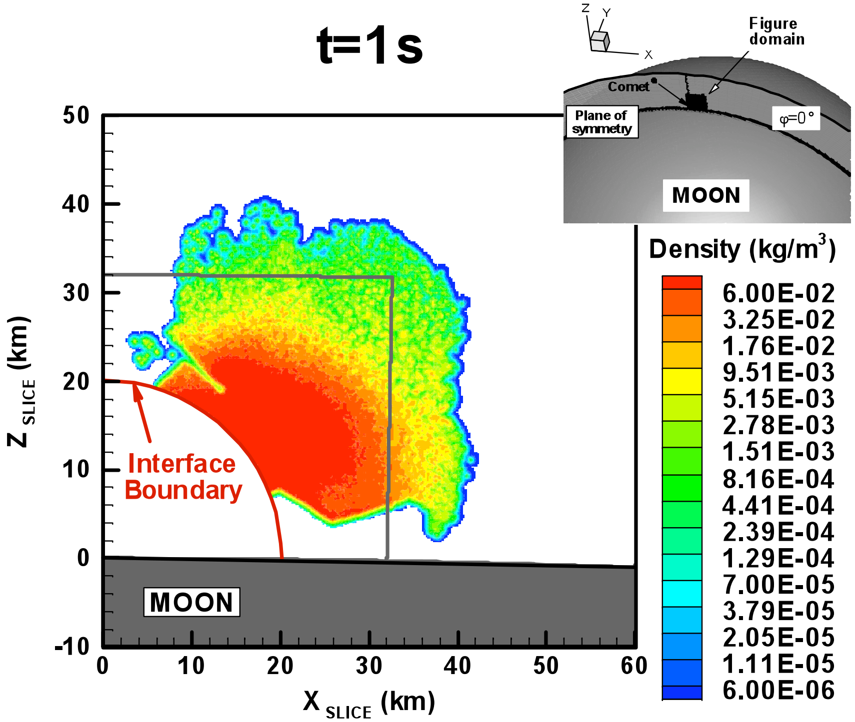
- ▪SO_2 vapor pressure sensitive to Io’s day-night temperature range
- ▪Model includes time varying surface temperature, radially incident plasma heating, species dependent surface interaction
- ▪SO_2 column decrease rate dominated by amount of non-condensable (O_2, SO)

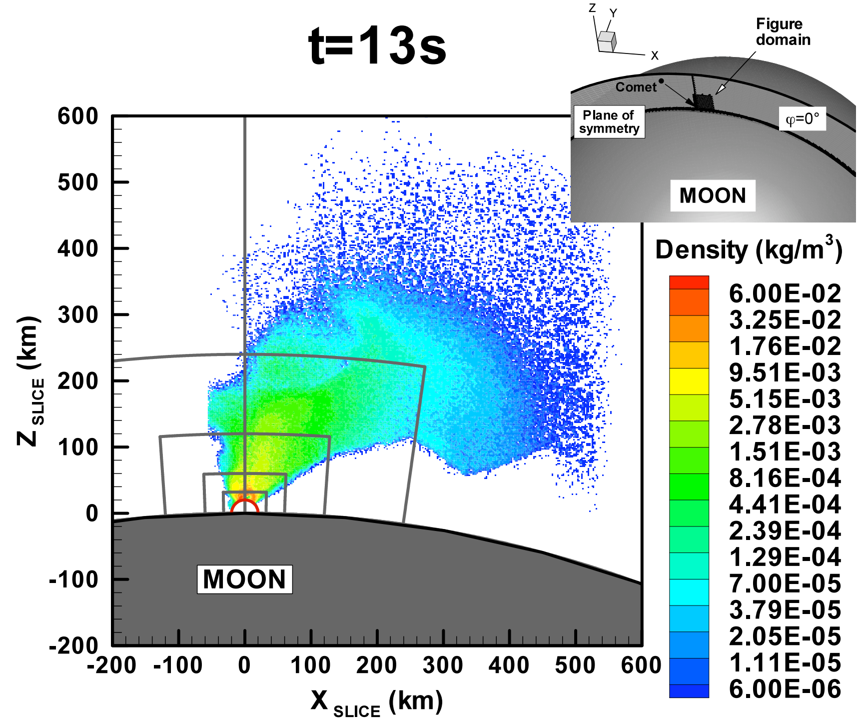
Io’s Aurora using 3D Monte Carlo electron transport

- ▪Torus electrons input upstream
- ▪Electrons move along field lines and collide with neutrals producing excited neutrals
- ▪Uses pre-computed magnetic field lines and multi-species asymmetric atmosphere
- ▪Account for collisional quenching and transport in atmosphere resulting in 3D emission map and spectra

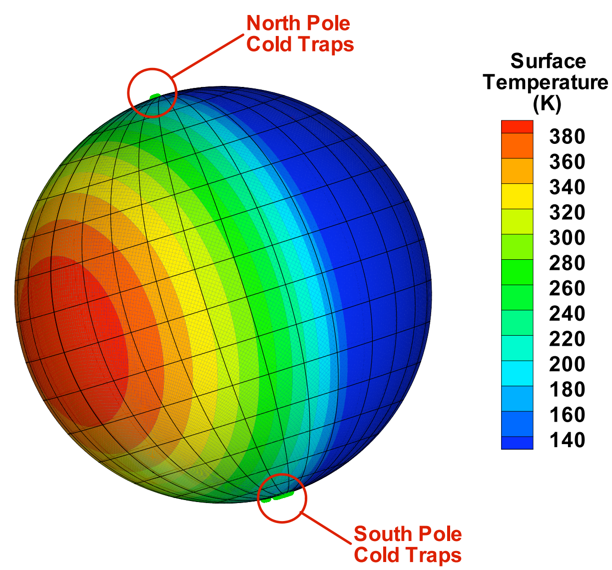


DSMC Simulations of the Late Stages of a Comet Impact on the Moon



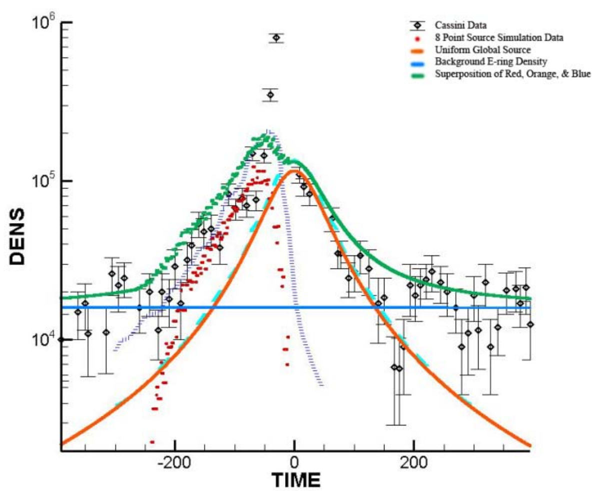


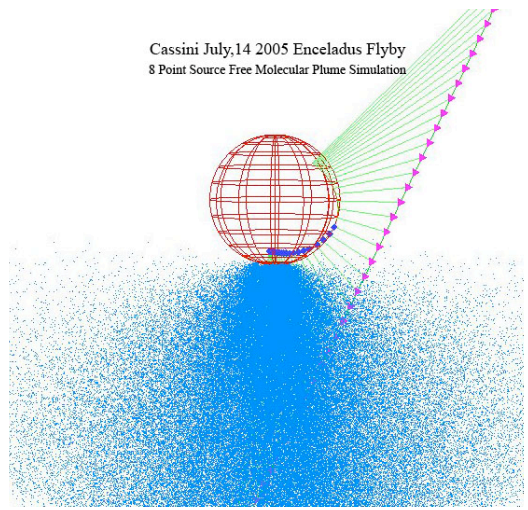
- 3D parallel simulations of the expansion plume and circum-lunar flow produced by a comet impact
- Uses hydrocode solution as input
- Simulates flow from 1s after impact to months later
- Aims to study the deposition rate of cometary water in the lunar cold traps after impact

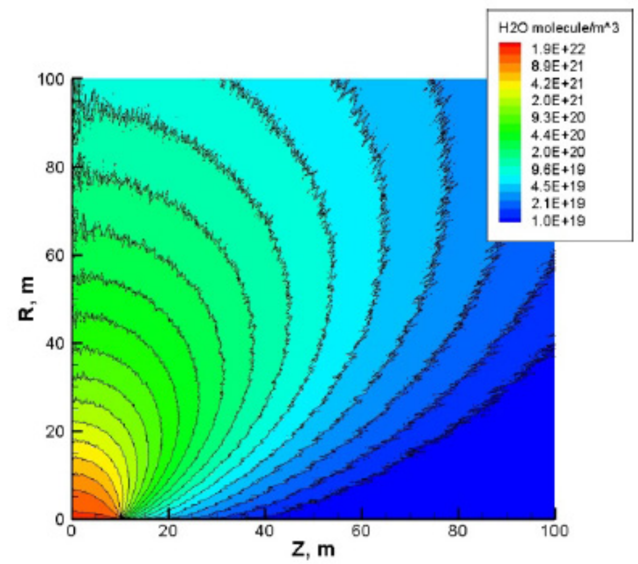


The Plumes of Enceladus

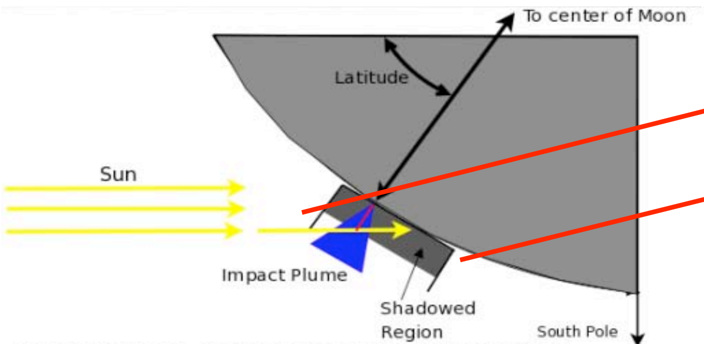
- Use DSMC to simulate gas/particle plumes at the near field region
- Use free molecular code for the non-collisional, far-field region
- Cassini flyby reconstruction to compare simulation results with data
- Use simulation results to study structure and composition of plumes
- Draw conclusions about nature of plume source



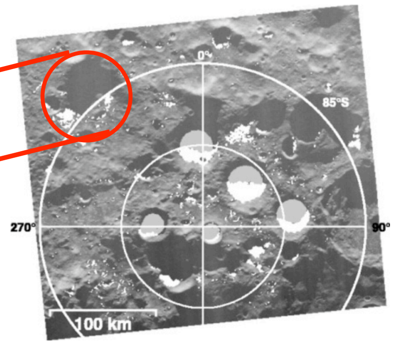




Modeling the LCROSS Impact in a South Polar Crater



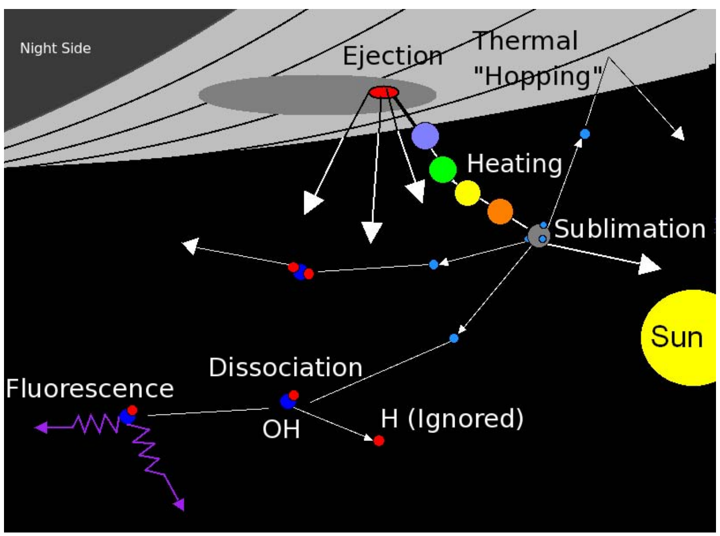
(b) Shadow model: Shadows are assumed to have uniform height for simplicity in short-term simulations.

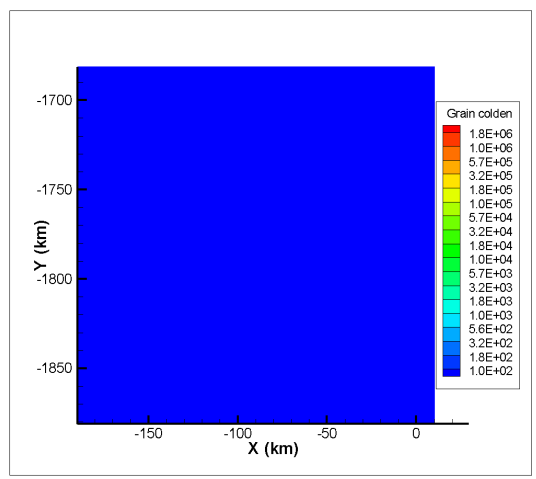


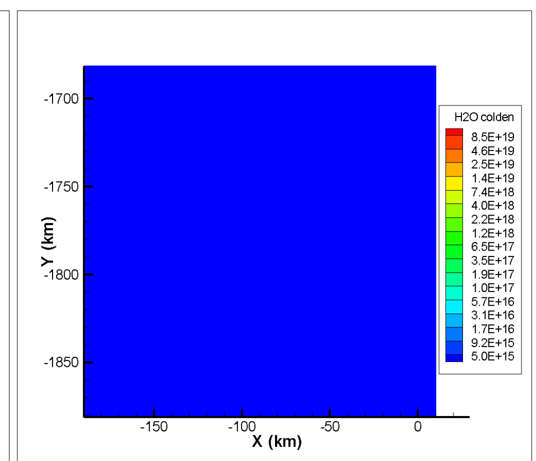
85° S

Oct. 9, 11:30 UT!!

- •Model water vapor sublimating from sun-warmed grains
- •H2O photodissociates, ionizes, interacts with surface
- •Compute line of sight images in support of mission

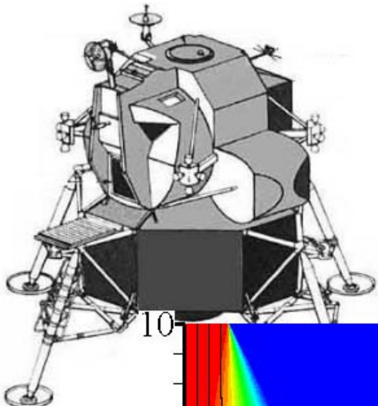




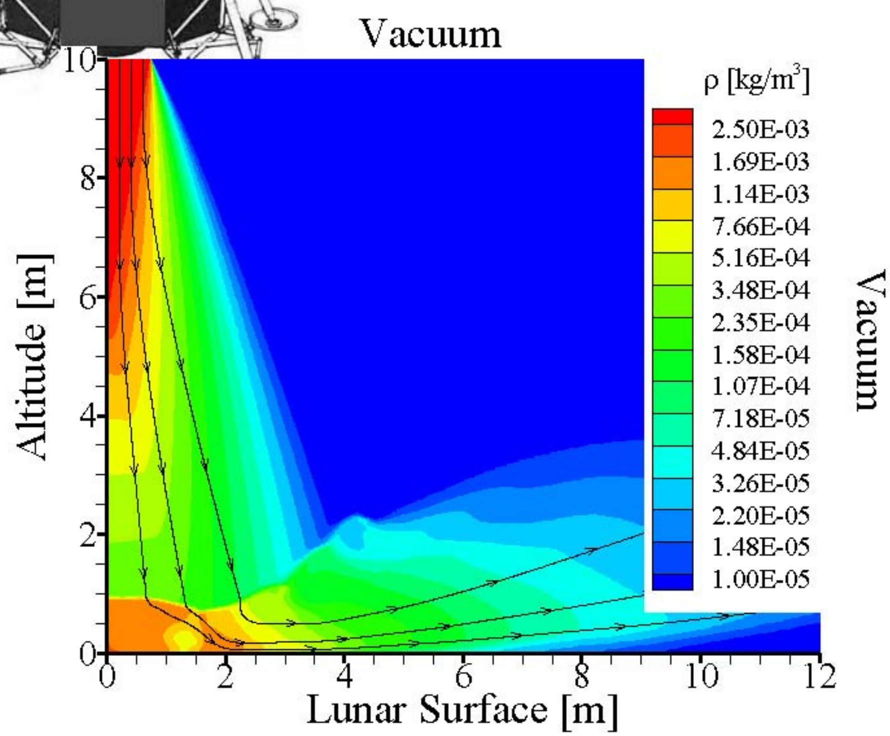


Lunar Landing

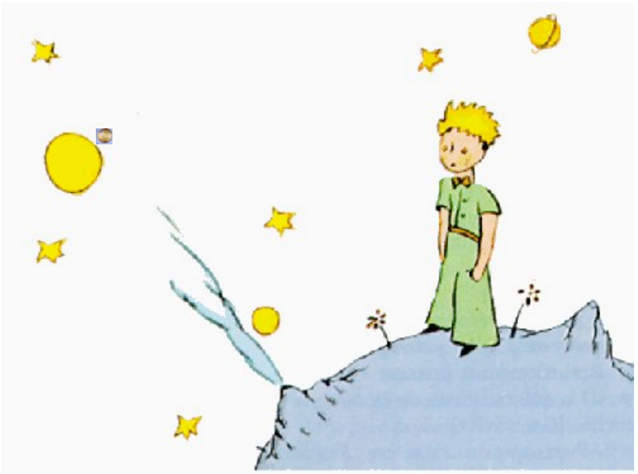
- Model the interaction between the rocket plume and the dusty lunar surface.
- Determine how much dust is lofted and where it goes.



Gene Cernan After Moon Walk



Apollo 12 LM Descent



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