## PLUME SURFACE INTERACTION ENVIRONMENT PREDICTIVE CAPABILITY Marshall Space Flight Center Travis Rivord, Jeff West/ER42 Fluid Dynamics Branch – ER42

## **CFD Plume Validation**

Successful validation of Loci/Chem for plume impingement was conducted in 1999. Loci/Chem-Boltzmann achieved a successful validation assessment for Martian and Lunar-like (p<1 Pa) ambient pressures in 2022.

Validation Comparison for Martian-like conditions



Validation Comparison for Lunar-like conditions



Loci/Chem-Boltzmann is validated for Martian and Lunar applications of plume structure and impingement environments.

## **Hybrid CFD-Engineering Modeling**

Loci/CHEM-DIGGEM is a hybrid CFD-Engineering tool that models viscous shear erosion caused by propulsive landing plumes impinging on planetary surfaces. For lunar landings, this model has been calibrated to data derived by Lane and Metzger from Apollo landing footage. Loci/CHEM-DIGGEM is being used to predict cratering for CLPS (commercial lunar payload services) and HLS (human landing system) vehicles

 $\dot{m}_{erosion} = C \phi (\tau_w(x, y) - \tau_{threshold})^n dA$ 





Loci/CHEM-DIGGEM was used to predict the erosion caused by the landing of Firefly's Blue Ghost Vehicle. These preflight predictions will soon be validated using imagery obtained by **SCALPSS** (stereo cameras for lunar plume surface studies).

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## **Gas Granular Flow Model**

A microscopic soil description is used within the Gas Granular Flow Solver (GGFS) to predict plume impingement, soil erosion and ejecta transport from basic principles. Interactions between microscopic regolith particles are determined from a particle-particle interaction database.





Loci/GGFS validation assessment using data from Physics-Focused Ground Test **(PFGT-1)** 





Loci/GGFS predicted both crater depth and width to within 10% of experiment during initial validation assessment. **Predicted ejecta velocity was within 25%** and likely better.









