



NAIRAS@Mars: Initial Baseline Steps



- **Galactic Cosmic Rays (GCR)**
 - H-BON10 free-space GCR model
 - Set radial distance from Sun (~1.5 AU) from Mars Climate Database
- **Solar Energetic Particle (SEP) Events**
 - Use GOES differential/integral proton/alpha flux measurements
- **Atmospheric Transport and Interaction Physics**
 - Create input atomic and nuclear cross section databases for Mars atmosphere and regolith
 - At each time-step and ray direction: solve ~120 coupled Boltzmann transport equations with ~10,000 interaction terms
 - Adapt current multi-directional transport and response function procedure for Mars atmosphere which **includes surface (regolith) albedo neutron and light-ion contributions**
- **Mars Atmospheric State Variables (computing depth along ray directions)**
 - Mars Climate Database (MCD) version 6.1
 - GCM simulations with annual and diurnal cycles
 - Accurate surface pressure by postprocessing of MCD data with high-resolution Mars orbiter Laser Altimeter (MOLA) topology data and smoothed InSight pressure records to correct atmosphere mass and reconstruct vertical pressure levels
 - Must haves: profiles of pressure and temperature at latitude/longitude grid points
 - Nice haves: profiles of density, altitude varying atmospheric gas constant, altitude above areoid for altitude and horizontal (surface) dependence of gravity



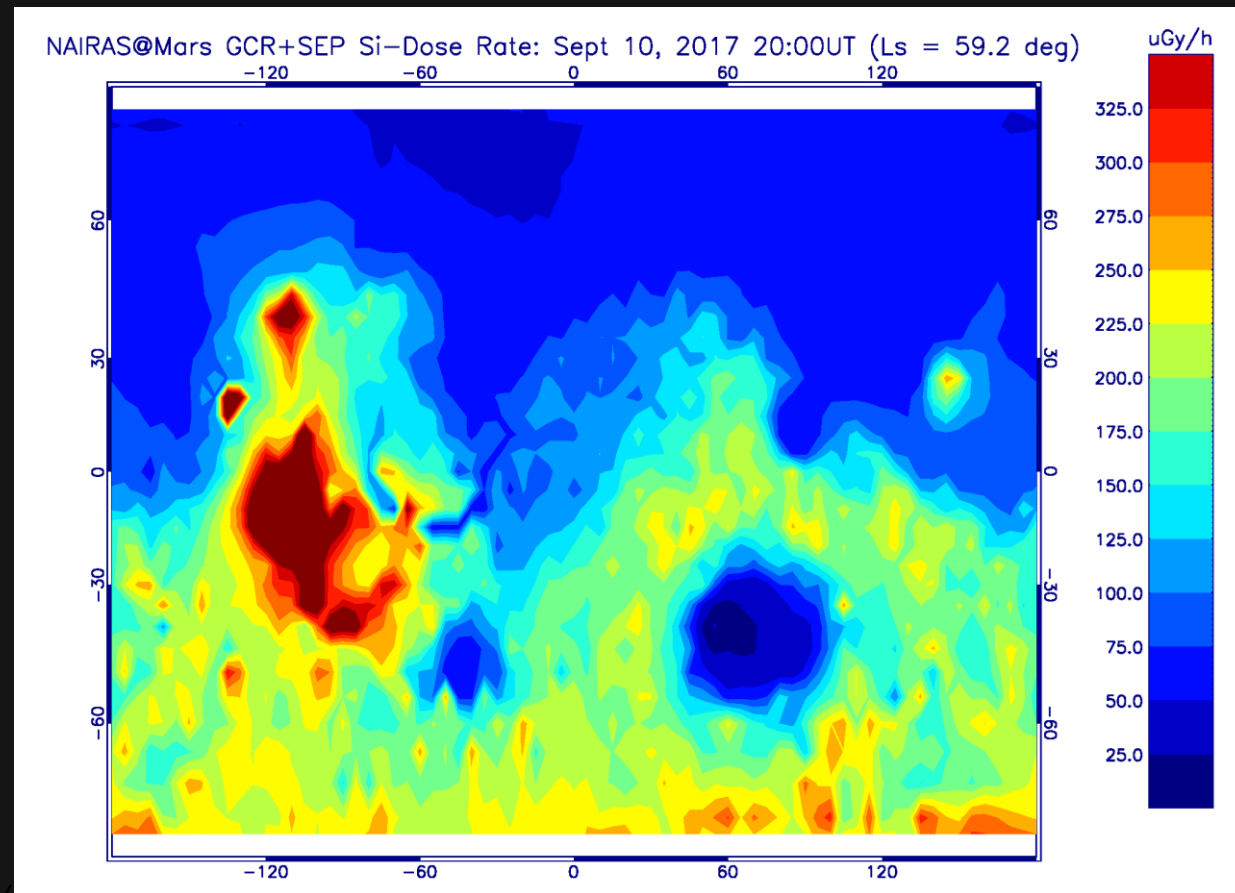
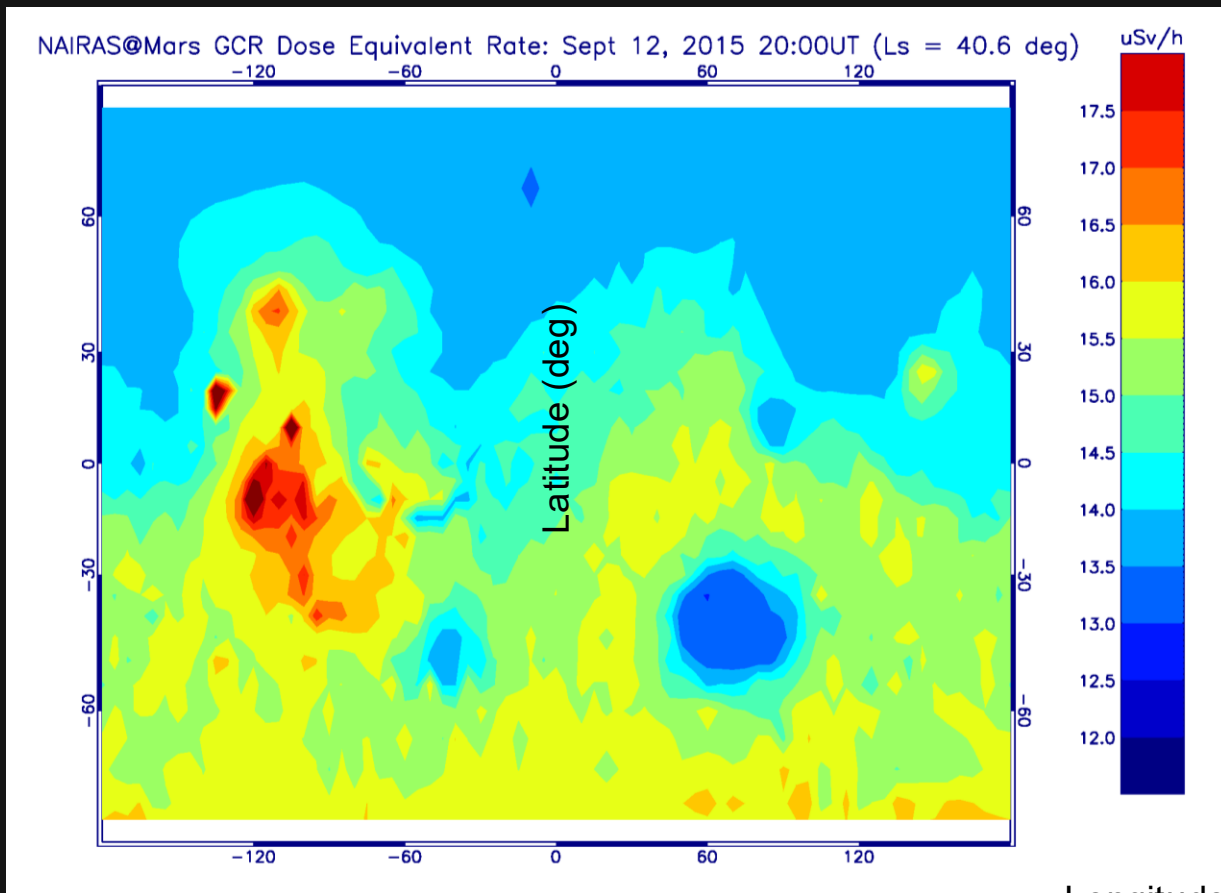
NAIRAS@Mars



GCR Dose

The Sep 2017 Event

GCR +SEP Dose





Summary



- NAIRAS adapted to Mars environment (atmosphere + regolith) and the initial dose rates look like the Mars radiation environment!
- NAIRAS@Mars GCR dose equivalent rates (Sep 12, 2015) within 25% of Slaba et al. (2017) results for solar modulation averaged over Nov 2025 – Jan 2026.
- NAIRAS@ Mars total (GCR+SEP) silicon absorbed dose rate comparisons to Mars Science Laboratory Radiation Assessment Detector (MSL-RAD) measurements for Sep 2017 SEP event: NAIRAS predictions higher and different time-profile. See next steps.
- **NAIRAS@Mars Next Steps**
 - H-BON10 GCR Model: use **MAVEN solar wind measurements** to parameterize solar modulation parameter for Earth-Mars longitudinal separation
 - **Use MAVEN measurements to set up/constrain SEP spectra (got data from Christina Lee)**
 - Earth-based inferred SEP spectra: implement Lario et al. (2006) empirical radial and longitudinal dependence of SEP proton intensities when Mars measurements not available
 - Validation with MSL-RAD measurements