

2018 Mars Global Dust Storm – Effects of Airborne Dust and Particle Deposition on Mars Science Laboratory SAM (Sample Analysis at Mars) Instrument Inlet Cover Actuator Temperatures

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Abstract

The Sample Analysis at Mars (SAM) instrument is a suite of instruments aboard the Mars Science Laboratory that landed on Mars in 2012. Recent measurements of SAM inlet cover actuator temperatures during the 2018 Mars Global Dust Storm have shown less extreme, more benign effects that are beneficial to mechanism performance. These in-situ measurements and models developed from the current study can guide development of actuators and mechanisms on future robotic and manned mission to Mars. Deck-mounted actuators saw drastic, factor of two reduction in diurnal temperature range from 70C to 35C. Maximum temperatures were reduced from +10C to -10C due lower daytime air temperature and attenuation of solar flux absorbed by the actuator body due to increased opacity. Minimum temperatures increased from -60C to -45C due to warmer night-time air temperatures and an enhanced downwelling atmospheric radiation at the surface also caused by dust in the air. Another demonstration of the effects of the dust storm on inlet cover actuator temperature is the linear relation of optical depth plotted against logarithmic diurnal temperature range. Air-fall dust deposition on the white rover deck during the dust storm is indicated by scatter on this linear trend. Other constantly-monitored SAM temperatures include sensors on a second actuator that also shows the effects discussed above and two sensors mounted internally to SAM with less pronounced effects. In this work we will present an overview of the dust storm effects superimposed on the seasonal variation of actuator and other SAM temperatures.

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Introduction

- Recent Temperature Sensor Measurements From SAM Inlet Cover Actuators Aboard Mars Science Laboratory, Providing Data From Mars Since 2012, Show Global Dust Storm Effects.
- Actuator Sensors During The Storm Show Less Extreme, More Benign Temperatures Beneficial To Mechanism Performance.
- These In-Situ Measurements Can Guide Robotic And Manned Mission Instrument, Actuator And Mechanism Development.

Actuators

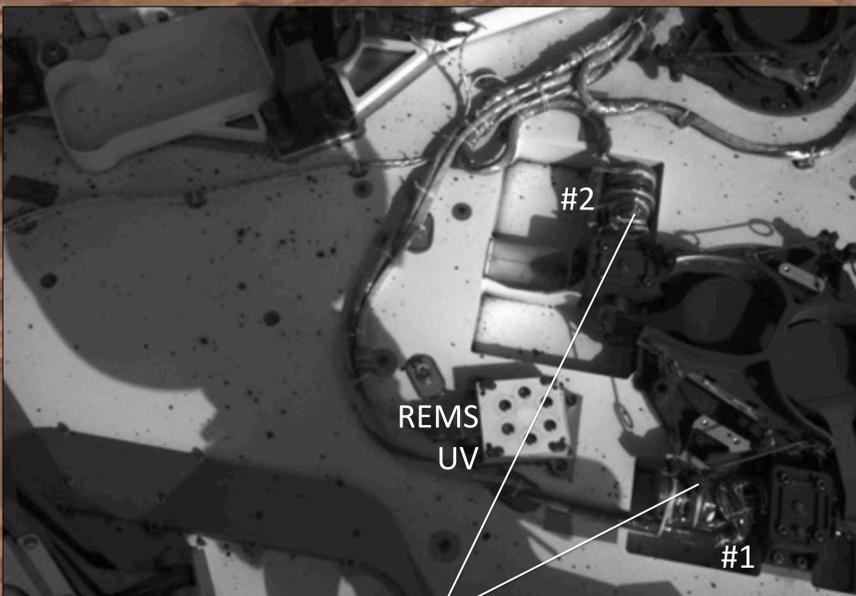


Figure 1. SAM Inlet Cover Actuators w/Embedded Temp. Sensors, Sol 36

- Sensors Allow Heater Control To -40°C For SAM Inlet Cover Operation During Cold Nighttime Conditions. See Figure 1.

Measurements During Dust Storm

- Deck-Mounted Actuators Saw Drastic Temp. Range Reduction From a Normal Of 70°C Range To a 35°C Range. See Figure 2.
- Max. Temp. Around +10°C Was Reduced To -10°C Due To Cooler Daytime Air Temp. & Attenuation Of Solar Flux Due To Increased Opacity Resulting In Less Heat Absorbed By Actuator.
- Min. Temp. Of -60°C Increased To -45°C Due to Warmer Nighttime Air Temp. & Enhanced Downwelling Atmospheric Radiation at Surface Also Caused by Dust Lofted in The Air.
- Onset to The Min. Temperature Range Was Sudden At 10 Sols.
- Return To Normal Was Longer At 100 Sols As Shown In Figure 2.
- Figure 3 Shows Sudden Increase In Aerosol Opacity (MastCam).
- Figure 4 Shows Semi-Logarithmic Relation of Aerosol Opacity Vs. Temperature Range Of SAM Inlet Cover Actuator Motors.

REMS Comparison

- Figure 5 Shows Similar Temperature Range For Air And Ground REMS Measurements^C And Actuator During Global Dust Storm.
- Typically, w/o Dust, Actuator & Air Temp. Ranges Also Similar.
- Ground Temp. Max w/o Dust Similar To Max Actuator Temp.

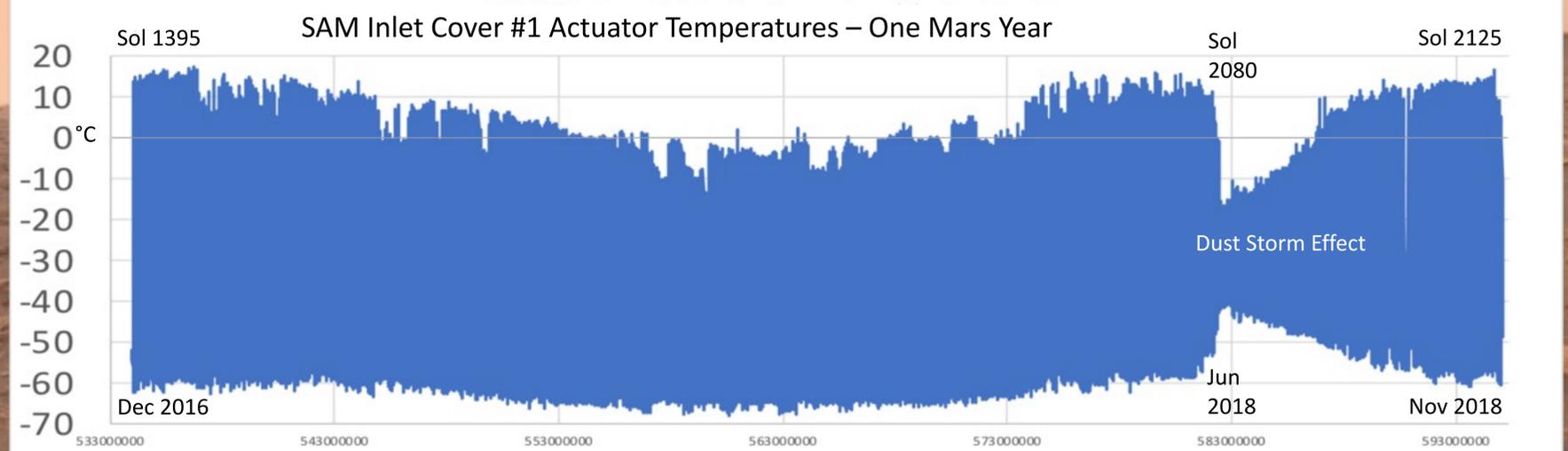


Figure 2. SAM Inlet Cover #1 Actuator Motor Temperature Measurements Over One Mars Year Showing Dust Storm Effect

- Min. Temp. Influenced By Enhanced Downwelling Atmospheric Radiation, Wind, Local Air & Ground Temp.
- Max. Temperatures Influenced By Solar Flux, Mast Shadow, SAM Experiments And Local Air Temperatures.
- Min. Temperature Data Show Increase Due To Reduction of Nighttime Radiation To Space Due To The Dust.
- Max. Temperature Data Show Decrease Due To Reduction of Solar Flux Due Increased Opacity Of The Dust.
- Both Min & Max. Temp. Affected By Changes In Local Air And Ground Temperatures Due To Dust Storm.

Optical Depth – Tau & Temp. Range

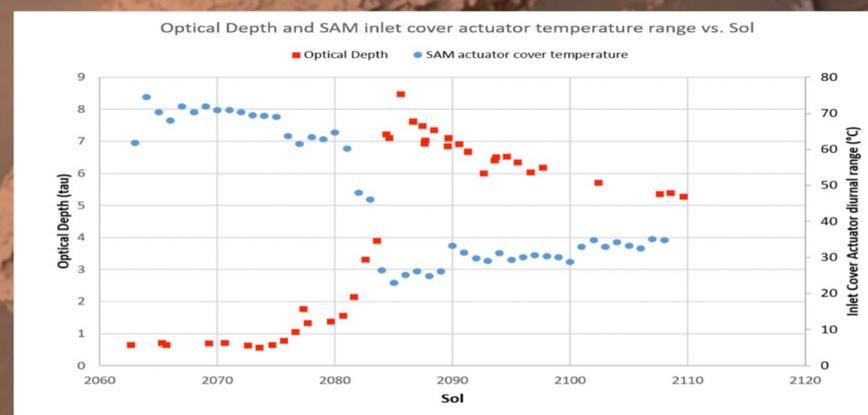


Figure 3. Drop In Temp. Range (Blue), Increase In Tau (Red) Vs. Sol

- Figure 6 Shows Dust On SAM Inlet Covers And Actuator After The 2018 Mars Global Dust Storm. Compare With Figure 1.

REMS Comparison Before/During Storm

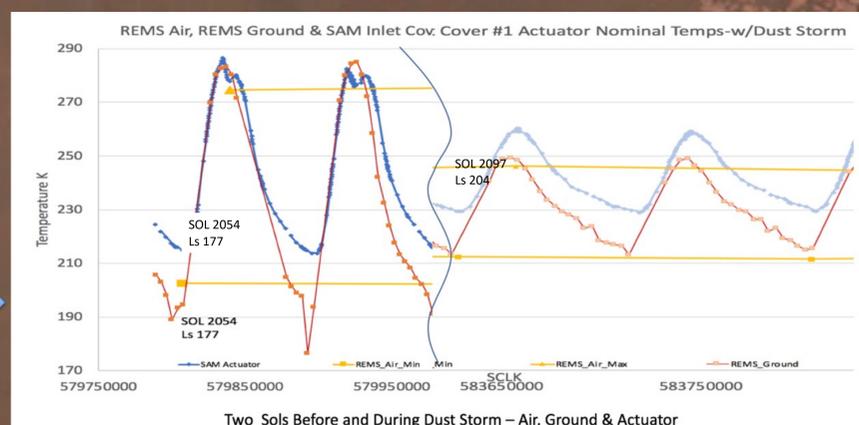


Figure 5. Actuator (Blue), Air (Gold), Ground (Orange) Vs. Time

Optical Depth – Tau vs Temp.

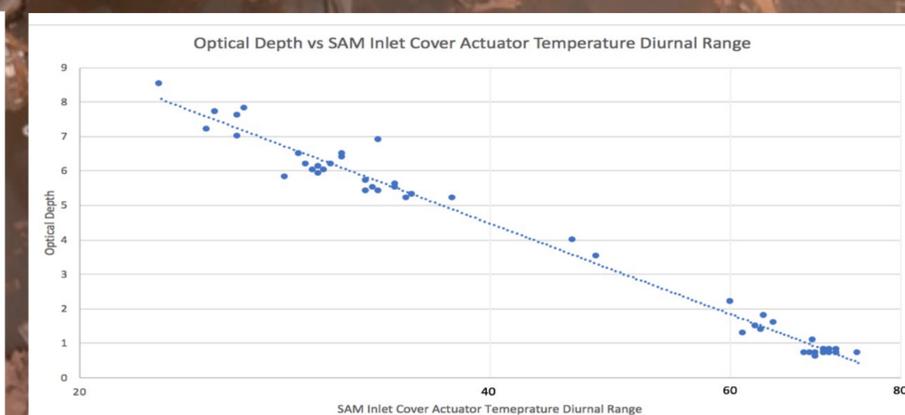


Figure 4. Semi-Logarithmic Relation Of Tau Vs. Temperature Range

Actuator & Inlets After Storm

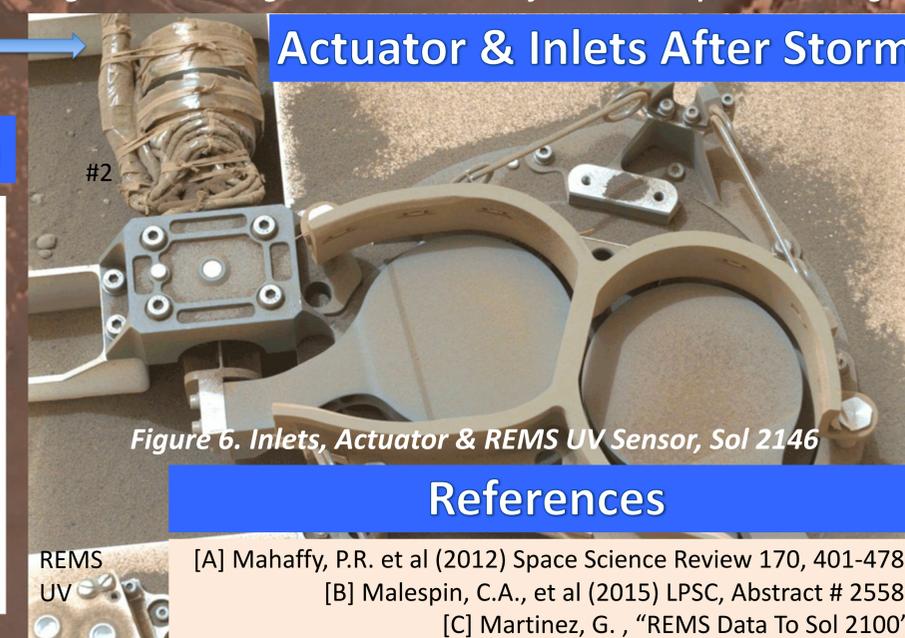


Figure 6. Inlets, Actuator & REMS UV Sensor, Sol 2146

References

- [A] Mahaffy, P.R. et al (2012) Space Science Review 170, 401-478.
- [B] Malespin, C.A., et al (2015) LPSC, Abstract # 2558.
- [C] Martinez, G., "REMS Data To Sol 2100"