Earth Science with the Stratospheric Aerosol and Gas Experiment III (SAGE III) on the International Space Station

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SAGE III Science Objectives

NEED – enhance our understanding of ozone recovery and climate change processes in the upper atmosphere

HOW – monitor the vertical distribution of aerosol, ozone, and other trace gases in the Earth’s stratosphere and troposphere

SAGE III/ISS provides data to:

- Assess the recovery in the distribution of ozone
- Extend aerosol measurement records needed for climate and ozone models
- Gain further insight into key processes contributing to ozone and aerosol variability
Ozone is Central to the Stratosphere

- Stratospheric ozone screens-out biologically harmful UV-C & UV-B sunlight.
- Ozone absorption of sunlight produces thermal structure of the atmosphere.
Stratospheric Science Needs

- This simplified schematic illustrates the parameters and process that control ozone
- Ozone Depleting Substances and Green House Gases can be measured from the ground as long as the dynamics can be modeled
- Ozone and Aerosol Profiles need to be measured
- Trends in Temperature and Water Vapor are inadequately measured

WMO: Ozone Assessment 2010
• The multi-decadal SAGE data are the international standard for ozone and aerosol.

• SAGE III predecessors have documented the effectiveness of the Montreal Protocol ban on Ozone Depleting Substances.

• Stratospheric aerosol time series is a vital component to understanding ozone changes.

Yang et al., 2006
Ozone loss varies greatly with altitude and latitude.
Model estimates of the loss and eventual recovery differ.
Aggregate uncertainty due to modeling processes, and future ODS & GHG changes.
2015-2020 measurements of ozone will improve understanding.
Stratospheric Aerosol Layer

- **Increased Planetary Albedo**
- **Insolation**
- **Deep Convection**
- **Surface cooling**

- **Main Stratospheric Aerosol Layer**
- **Aerosol Nucleation and Growth**
- **Slow Ascent**

**Key Processes:**
- **Rainout of Ash**
- **Ash • SO₂**
- **Human Activity**
- **Biomass Burning**
- **Ocean and Wet Lands**
- **Biomass**

**Aerosols**
• Isolated colossal volcanic eruptions have significant cooling for a limited time.

• Increased background loading during 2000-2010 likely cause of global warming slow-down (Solomon, 2011).
Solar Occultation Geometry
SAGE III Instrument Features

- A UV-Vis-NIR spectrometer
- Multiple modes of operation
  - Solar, lunar, limb scatter
- Surface/cloud top to 50 km, <1 km vertical resolution
- 87 channels (~1-3-nm resolution) between 280 and 1040 nm in solar occultation mode
- 64 kg, 102 watts, 0.12 Mbps
Spectral Sampling

Graph showing transmittance against wavelength (nm) with peaks at various wavelengths indicating different channel measurements for ozone ($O_3$), aerosol, water ($H_2O$), and nitrogen dioxide ($NO_2$) for SAGE II and III channels.
Instrument Payload: NASA SMD, HEOMD & ESA contributions

- Sensor Assembly (SMD)
- Hexapod Mechanical Assembly (ESA)
- Contamination Monitoring Package (SMD)
- Disturbance Monitoring Package (SMD)
- Instrument Controller Electronics and Bracket (SMD)
- Hexapod Electronics Unit (ESA)
- Contamination Monitoring Package (SMD)
- Interface Adapter Module (SMD)
- ExPRESS Payload Adapter (HEOMD)

NOTE: New hardware in blue
ISS Orbit is Ideal!

Occultation Coverage

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<th>Alt</th>
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Solar
Lunar
SAGE III Climate Continuity Mission is empowered by NASA SMD & HEOMD, and ESA
Launch Configuration

Manifest: February, 2016

Dragon Trunk
(Unpressurized Cargo Area)
SAGE III on ISS, an Earth Science Mission on the International Space Station
The SAGE series has a long heritage and history of delivering outstanding and unique science products. 

SAGE III/ISS is a climate continuity mission addressing critical science needs. 

The ISS is an exceptional national asset in an ideal orbit for SAGE III to contribute internationally. 

SAGE III/ISS is designed to meet the core science objectives, while capturing data for additional science discoveries.