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

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Sept 17, 2015
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
Stratospheric Science Results

- 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.

![Graph showing residual ozone (1979-1996 trend = -2.3 +/- 0.2 %/decade)](Yang et al., 2006)
Model Ozone Uncertainties

- 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

- Stratosphere
- Tropopause
- Ash • SO$_2$
- Rainout of Ash
- Increased Planetary Albedo
- Insolation
- Aerosol Nucleation and Growth
- Slow Ascent
- Deep Convection
- Surface cooling

Human Activity • Biomass Burning • Ocean and Wet Lands • Biomass
• 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).
Measurement Strategy

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

Transmittance

Wavelength (nm)

SAGE II channels
O\textsubscript{3}  Aerosol  H\textsubscript{2}O  NO\textsubscript{2}

SAGE III channels
Aerosol  Meso O\textsubscript{3}  NO\textsubscript{2}
O\textsubscript{3}  O\textsubscript{2} (T, p)  H\textsubscript{2}O
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!

Solar

Lunar

Occultation Coverage

Latitud

Time (Month of Year)

Rise  Set
Sun    Moon

NASA

SAGE III • ISS
Ball Aerospace & Technologies Corp
International Space Station

NASA Langley Research Center • Assenaa
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
Summary

• 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.