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

Joe Zawodny, Jean-Paul Vernier, Larry Thomason, Marilee Roell, Mike Pitts, Randy Moore, Charles Hill, David Flittner, Rob Damadeo, Mike Cisewski

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.
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:**

- **1979-1996 trend = -2.3 +/- 0.2 %/decade**
- SAGE
- HALOE

*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

- Main Stratospheric Aerosol Layer
- Increased Planetary Albedo
- Insolation
- Aerosol Nucleation and Growth
- Slow Ascent
- Deep Convection
- Rainout of Ash
- Surface cooling
• 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$_3$  Aerosol  H$_2$O  NO$_2$

SAGE III channels
Aerosol  Meso O$_3$  NO$_2$
O$_3$  O$_2$ (T, p)  H$_2$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

- Alt: 330
- Inc: 51.6°
- RA: 0°

Time (Month of Year)

Latitude

Rise  Set
Sun  Moon
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.