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

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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
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 percentage over years with trend line and data points labeled SAGE and HALOE.](image)

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

WMO: Ozone Assessment 2010
Stratospheric Aerosol Layer

Increased Planetary Albedo

Insolation

Main Stratospheric Aerosol Layer

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

Graph showing transmittance against wavelength (nm). The graph includes markers for SAGE II and SAGE III channels, with specific wavelengths highlighted for various gases and aerosols.

- 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

The graph indicates the transmittance values across the wavelength spectrum, with peaks and valleys indicating different gas and aerosol absorption characteristics.
NOTE: New hardware in blue
ISS Orbit is Ideal!

Solar
Lunar

Occultation Coverage

Time (Month of Year)

Latitude

Alt.  350  350
Inc.  51.6°  51.6°
Rad.  0°  0°
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.