Ultra High Spectral Resolution Satellite Remote Sounding -
Results from Aircraft and Satellite Measurements

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Ultraspectral Atmospheric Sounders

- Broad Spectral Coverage
- Thousands of Spectral Channels
- High Spectral Resolution
- High Information Content
Today’s
Ultraspectral Resolution
IR Sounding Capability

ER-2
NAST/SHIS
Proteus

AIRS
NAST and AIRS Characteristics

- **Spatial Resolution**
  - 130 m/km flight alt.
    (2.6 km from 20 km)
  - Swath Width
    - 2 km /km flight alt.
      (40 km from 20 km)

- **Instrument Characteristics**
  - infrared Michelson interferometer
    (~9000 spectral channels)
    3.5 – 16 microns @ 0.25 cm⁻¹

- **Aircraft Accommodation**
  - ER-2 Super pod & Proteus Underbelly pod

- **Radiative Measurement Capability**
  - calibrated radiances with
    - < 0.5 K absolute accuracy, < 0.2 K precision

- **The NPOESS-I Aircraft Sounder Testbed – Interferometer (NAST-I)** consists of a 9000 spectral channel infrared interferometer (600-2850 cm⁻¹) with a spectral resolution of 0.25 cm⁻¹. NAST-I spatially scan and provide a ground resolution of about 2.6 km and a swath width of approximately 40 km, from an aircraft altitude of 20 km.

- **The Aqua AIRS instrument** is a ~2500 spectral channel cooled grating spectrometer with a spectral resolving power of ~ 1200 (0.5 – 2 cm⁻¹ spectral resolution) operating within the spectral range 650 – 2700 cm⁻¹. The spatial resolution of the AIRS is about 15 km, at nadir, and its cross track scan providing a swath width of approximately 1400 km.
NAST-I & AIRS Spectral Characteristics

**NAST-I (Fourier Transform Spectrometer)**
- Spectral Range: 3.5 - 16 Microns
- Spectral Resolution: $\delta \nu = 0.25 \text{ cm}^{-1}$

**AIRS (Grating Spectrometer)**
- Spectral Range: 3.7 – 15.4 Microns
- Spectral Resolution: $\nu / \delta \nu = 1200$

Spatial Resolution:
- NAST-I: 2.6 km @ 20 km with 40 km swath
- AIRS: 13.5 km @ nadir over 1650 km swath width

Quasi-continuous Measurements Over Broad Spectral Regions Enable High Vertical Resolution
Data and Algorithms Used for Inter-Comparisons

**AIRS DATA**
- AIRS Team CC Radiance (3x3 FOVs)
- NAST Team Algorithm (Zhou et. al., 2002)
- N-Team AIRS CC Retrievals
- AIRS and AMSU Data
- AIRS Team Algorithm (Susskind et. al., 2003)
- A-Team AIRS CC Retrievals

**NAST DATA**
- NAST-I Original Radiance
- NAST Team Algorithm (Zhou et. al., 2002)
- N-Team NAST-I Retrievals

**Thermodynamic Parameter Inter-comparisons**

In-situ measurements by radiosonde and dropsonde
Inter-Comparisons at Trapani/Birgi, Italy (04/09/08)

Trapani/Birgi (37.92N 12.5E)

Retrieved Surface Skin Temperature

Deviation from RAOB

- Raob 23Z
- N-team NAST 00Z
- N-team AIRS 01Z
- N-team CC AIRS 01Z
- A-team AIRS 01Z
(1) NAST-Team NAST Retrieval

(2) NAST-Team AIRS Retrieval (CC)

(3) AIRS-Team AIRS Retrieval (CC) ..ver. 4.0
Moisture Cross Section Inter-Comparison (04/09/08)

(1) NAST-Team NAST Retrieval

(2) NAST-Team Retrieval (CC)

(3) AIRS-Team Retrieval (CC) ..ver. 4.0
United Kingdom (Air Chemistry)

SW Sea of Wales, UK
(September 14 & 18, 2004)

Proteus
UK BAE-146

Four day interval measurements taken at the same geographical location and local time

Day-to-day variations shown by NAST-I retrievals are validated with aircraft in-situ measurements
Geostationary Imaging Fourier Transform Spectrometer

New Technology for Atmospheric Temperature, Moisture, Chemistry, & Winds

4-d Digital Camera:

**Horizontal:** Large area format Focal Plane detector Arrays

**Vertical:** Fourier Transform Spectrometer

**Time:** Geostationary Satellite
• Two 128x 128 Infrared focal plane detector arrays with 4 km footprint size
• A 512 x 512 Visible focal plane detector arrays with 1 km footprint size
• Field of Regard 512 km x 512 km at satellite sub-point
• Ten second full spectral resolution integration time per Field of Regard
• ~ 80,000 Atmospheric Soundings every minute
Primary Objective of the Geo-Sounder - Winds Profiles

GIFTS - Simulation

GOES - Observation
Although GIFTS waits for a space flight opportunity, GIFTS-like instruments are expected to fly on next generation operational geostationary weather satellites.
Summary

- New ultra spectral remote sensing capabilities enable accurate atmospheric weather and chemistry depictions.
- Latest (Ver 4.0) Aqua AIRS retrievals have been validated with radiosonde, dropsonde, and high vertical resolution airborne NAST-I soundings.
- Future satellite ultra high spectral remote sensing instruments will provide most of the temperature and water vapor profile data for global data assimilation.
- Wind profiles will be provided by future ultra high spectral resolution geostationary satellite spectrometers.