CGMS-XXIX USA-WP-07
Prepared by USA
Agenda Item: B.3
Discussed in Plenary

Report on the Geosynchronous Imaging Fourier Transform Spectrometer (GIFT) Instrument

This paper provides a summary of the Geosynchronous Imaging Fourier Transform Spectrometer (GIFTS) that is the basis for future GOES sounding instruments.

Report on the Geosynchronous Imaging Fourier Transform Spectrometer (GIFT) Instrument

The Geosynchronous Imaging Fourier Transform Spectrometer (GIFTS) combines a number of advanced technologies to observe atmospheric weather and chemistry variables in four dimensions. Large area format Focal Plane detector Arrays (LFPAs) provide near instantaneous large area coverage with high horizontal resolution. A Fourier Transform Spectrometer (FTS) in front of the LFPAs enables atmospheric radiance spectra to be observed simultaneously for all detector elements thereby providing high vertical resolution temperature and moisture sounding information. The fourth dimension, time, is provided by the geosynchronous satellite platform, which enables near continuous imaging of the atmosphere's three-dimensional structure. The key advance that GIFTS achieves beyond current geosynchronous capabilities is that the water-vapor winds will be altitude-resolved throughout the troposphere. GIFTS, will be launched in 2005, as NASA's third New Millennium Program (NMP) Earth Observing (EO-3) satellite mission, and will serve as the prototype of sounding systems to fly on future operational geosynchronous satellites. After a one year validation period in view of North America, the GIFTS will be repositioned to become the Navy’s Indian Ocean METOC Imager (IOMI).

1. Introduction

The Geosynchronous Imaging Fourier Transform Spectrometer (GIFTS), selected for flight demonstration as NASA’s New Millennium Program (NMP) Earth Observing-3 (EO-3) mission, combines new and emerging sensor and data processing technologies to acquire geophysical measurements that lead to revolutionary improvements in meteorological observations and forecasting. The NOAA, Navy, and Air Force are partners with NASA in the GIFTS program; the NOAA will provide the ground processing system to demonstrate the operational utility of the data, the Navy will provide the spacecraft and support the operation of GIFTS after the NMP phase of the program as its Indian Ocean METOC Instrument (IOMI), and the Air Force will provide the launch of the GIFTS-IOMI satellite to geosynchronous orbit using a new Delta IV rocket multiple payload launch capability developed under their Space Test Program (STP).

The GIFTS uses large area format focal plane (LFPA) infrared (IR) detector arrays (128 x 128) in a Fourier Transform Spectrometer (FTS) mounted on a geosynchronous satellite to gather high spectral resolution (0.6 cm^{-1}) and high spatial resolution (4-km footprint) Earth infrared radiance spectra over a large geographical area (512-km x 512-km) of the Earth within a 10-second time interval. A low visible light level camera provides quasi-continuous imaging of clouds at 1-km footprint spatial resolution. Extended Earth coverage is achieved by step scanning the instrument field of view in a contiguous fashion across any desired portion of the visible Earth. The radiance spectra observed at each time step are transformed to high vertical resolution (1-2 km) temperature and water vapor mixing ratio profiles using rapid profile retrieval algorithms. These profiles are obtained on a 4-km grid and then converted to relative humidity profiles. Images of the horizontal distribution of relative humidity for atmospheric levels, vertically separated by approximately 2 km, are constructed for each spatial scan. The sampling period will range from minutes to an hour, depending upon the spectral resolution and the area coverage selected for the measurement. Successive images of clouds and the relative humidity for each atmospheric level are then animated to reveal the motion of small-scale thermodynamic features of the atmosphere, providing a measure of the wind velocity distribution as a function of altitude. The net result is a dense grid of temperature, moisture, and wind profiles which can be used for atmospheric analyses and operational weather prediction. O_3 and CO features observed in their spectral radiance signatures, provide a measure of the transport of these pollutant and greenhouse gases. It is the unique combination of the Fourier transform spectrometer and the large area format detector array (i.e., an imaging interferometer), and the geosynchronous satellite platform, that enables the revolutionary wind profile and trace gas transport remote sensing measurements.

2. The GIFTS Instrument

The imaging FTS produces the interferometric patterns for spectral separation of scene radiation reaching the detector arrays. To limit the background signal, the FTS is cooled by the first stage of the cryocooler to <150 K. The high data rates generated by the focal plane arrays (FPAs) are reduced by loss-less compression techniques and then passed to the telemetry system by low-power, low-volume, next-generation electronic components.

GIFTS will view areas of the Earth with a linear dimension of about 500-km, anywhere on the visible disk, for a period between 0.125 and 10.0 sec, depending on the data application (i.e., imaging or sounding). GIFTS uses two detector arrays within a Michelson interferometer to cover the spectral bands, 685 to 1130 cm^{-1} and 1650 to 2250 cm^{-1}, to achieve a wide range of spectral resolutions. These spectral characteristics are optimized to achieve all technology/scientific validation objectives of GIFTS, as well as the sounding accuracy desired for a future operational sounding system. The Michelson interferometer, or FTS, approach for geosyncronous satellite applications allows spectral resolution to be easily traded for greater area coverage or higher temporal resolution. The 4-km footprint size of the IR LFPAs enable sounding to the ground under most broken-to-scattered cloud situations and resolving small scale atmospheric water vapor and cloud features required for wind profiling.

3. Summary

The first hyper-spectral imaging spectrometer designed for atmospheric sounding, GIFTS, will be orbited aboard a geosynchronous satellite to usher in a new era of high space and time resolution measurements of the atmosphere. Such measurements will lead to revolutionary improvements in our ability to forecast weather and climate.

Reference: W. Smith, D, Hinton, J. Miller, D. Zhou, H. Revercomb, F. Best, H. Huang, R. Knutson, D. Tobin, C. Velden,G. Bingham, R. Huppi, L. Zollinger, and R. Epstein: 2001: The Geosynchronous Imaging Fourier Transform Spectrometer (GIFTS), Submitted to the American Meteorological Society 11th Satellite Meteorology Conference, October 15-19, 2001, Madison, Wisconsin, 8pp.