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Geosynchronous Imaging Fourier Transform Spectrometer
(GIFTS)

Measurement Concept Validation Plan

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Executive Summary

The Geosynchronous Imaging Fourier Transform Spectrometer (GIFTS) represents a revolutionary step in satellite based remote sensing of the Earth. Following launch in November 2004, GIFTS will be positioned over or near the Continental United States for 12 to 18 months. This Measurement Concept Validation Plan (MCVP) describes the various tasks and data sources associated with the validation of the GIFTS Measurement Concept Objectives under the scope of the New Millennium Program (NMP) Earth Observing 3 (EO3) Mission. The goal of the resulting Measurement Concept Validation activities during the year following launch is an accurate and timely assessment of the accuracies of the core GIFTS products for a representative set of observation conditions. In particular, this plan addresses the GIFTS Measurement Concept Objectives in the areas of navigated and calibrated high spectral resolution radiances, temperature and water vapor profile retrievals, wind retrievals, carbon monoxide and ozone concentration retrievals, cloud property retrievals, and data compression. Specifically, this plan:

* Presents the scope of these NMP MCV activities and their relation to other validation efforts associated with GIFTS (Section 3).
* Defines the areas addressed by this plan and the specific approaches to validation for each area (Section 4.1).
* Defines observation sequences and associated data volumes and processing capabilities that will produce the collocated GIFTS/validation data required for the validation analyses (Section 4.2).
* Describes season dependent validation objectives (observation of Atlantic hurricanes, severe storms in the Central Plains, Pacific winter storms, etc.) (Section 4.3.2).
* Describes factors affecting the implementation scenarios (Section 4.3).

As defined by the focus of the NMP program and its concentration on technology development and validation, the NMP funded efforts of the Measurement Concept Objectives validation are limited in scope. This plan describes the GIFTS data to be collected and processed that will allow for a meteorologically representative dataset and a meaningful validation analysis. The validation approaches are focused on comparisons of the GIFTS products to selected high quality validation data for GIFTS product accuracy assessment. The GIFTS data volume associated with the MCV effort is estimated at ~20,000 data "cubes", which is approximately 0.7% of the total GIFTS interferogram data volume. The approaches include comparisons to data from ground based networks and high quality validation sites (e.g. ARM CART, Wind Profiler network), airborne observation networks (e.g. ACARS), other satellite based radiance sensors (e.g. AIRS, IASI) and retrievals (e.g. MOPITT, TES, AIRS), and data collected as part of a dedicated field campaign. Other approaches include internal checks such as blackbody view analyses and specific pointing exercises.

This plan will be updated as needed to be consistent with programmatic requirements and other constraints.

Table of Contents

1. Introduction

1.1 Purpose

The purpose of the GIFTS Measurement Concept Validation Plan (MCVP) is to define the various tasks and data sources associated with the validation of the GIFTS Primary and Secondary Measurement Concept Objectives under the scope of the NMP program.

1.2 Change Control

Once approved by the project, the GIFTS Measurement Concept Validation Plan will be placed under configuration control. Any proposed changes to the MCVP will require Configuration Control Board approval as per the Configuration Management Plan. Requests for changes to the MCVP should be submitted to the authors, who will coordinate the appropriate review process.

1.3 Relevant Documents

The MCVP is responsive to information presented in the EO-3 Mission Requirements Document (EMRD, GIFTS-01-002), the IOMI Mission Requirements Document (GIFTS-01-003), the GIFTS-IOMI Mission System Requirements Document (GMSRD, GIFTS-01-008), and the GIFTS Instrument Requirements Document (GIRD, GIFTS-04-001). These documents define the measurement concept and instrument performance objectives that are relevant to the MCVP. Should the MCVP conflict with any of these documents, the requirement documents take precedence. While the MCVP is not a requirements document, the MCVP suggests viewing and data processing requirements, is subject to programmatic constraints (orbital positioning, viewing requirements imposed by other objectives, etc.), and should therefore be consistent with other project documents including:

GIFTS-02-001	Technology Validation and Infusion Plan
GIFTS-03-024	Mission Operations Segment Requirements Document
GIFTS-06-004	Spacecraft Operations Requirements Document
GIFTS-03-025	Ground Systems Segment Requirements Document

Additionally, the NOAA *GIFTS Product Assurance Plan* describes efforts led by NOAA which include evaluation and validation of the GIFTS products, product enhancements, user training, and evolution toward future products and sensor systems. The NOAA efforts compliment the NMP efforts so that the combined NMP and NOAA plans form a whole.

2. Overview and Contents

The Geosynchronous Imaging Fourier Transform Spectrometer (GIFTS) is a revolutionary step in satellite based remote sensing of atmospheric parameters. Using a combination of a Fourier Transform Spectrometer (FTS) and Large Area Focal Plane Arrays (FPA), GIFTS will measure the Earth emitted infrared radiance at the top of atmosphere (TOA) from geosynchronous orbit with an unprecedented combination of spectral, temporal, and spatial resolution and coverage. In the nominal Regional Sounding and Chemistry mode, GIFTS will measure the infrared spectrum in two bands (14.6 to 8.8 μm, 6.0 to 4.4 μm) at a spectral resolution of ~0.6 cm^{-1} for a 128 × 128 set of ~4-km footprints (a ~512 × 512 km area) every 11 seconds. The instrument will have the capability of taking successive measurements of such data to scan desired regions of the globe, and tradeoffs in the desired spectral resolution and spatial and temporal sampling can be performed. From these measurements, thermal and gaseous concentration profiles, cloud properties, wind field profiles, and numerous derived products can be retrieved.

While the NMP EO3 GIFTS program is primarily a technology validation program, the GIFTS Primary Measurement Concept Objectives provide the driver for the required accuracies in the retrieved atmospheric parameters, the derived accuracies in the radiometric, spectral, and spatial accuracy of the measured radiance spectra, and the underlying instrument design. The goal of this Measurement Concept Validation Plan is to lay out the various tasks and data sets that will be used to assess whether the desired accuracies in the primary GIFTS products are being attained. In these efforts, the term "validation" refers to product accuracy and resulting instrument performance assessments performed (primarily) by comparisons to external data sources of comparable or higher accuracy. A simple example is the comparison of GIFTS retrieved temperature profiles to those of coincident research grade radiosondes for a statistically representative set of conditions and resulting conclusions regarding the accuracy of the GIFTS retrieved profiles. While external data is the primary tool of these efforts, some validation can be performed using GIFTS data alone. For example, analysis of spectra of the on-board calibration blackbodies can be used to assess the radiometric calibration and noise performance. Naturally, the resulting product accuracy assessments can be compared to the product accuracy goals. Logical outcomes are closure, or problem identification leading to feedback to the instrument, algorithm development and/or data processing efforts.

The remaining content of this document includes a discussion of the scope of these NMP Measurement Concept Objectives validation efforts and their relation to other validation efforts associated with GIFTS (Section 3), further introductory information regarding GIFTS and validation (Section 4), the plans described by measurement parameter (Section 4.1), the observation sequences and associated data volumes and processing requirements required for these efforts (Section 4.2), implementation issues and season-specific validation objectives

(Section 4.3), Measurement Concept Validation deliverables (Section 5), references (Section 6) and a list of acronyms (Section 7).

It should be noted that although a best effort is provided here to lay out the plans associated with the validation, the plans are subject to change as they evolve as required to meet programmatic or other needs.

3. Scope of NMP Validation and Relation to Other GIFTS Validation Efforts

The NMP validation of the GIFTS Measurement Concept Objectives is a subset of validation efforts associated with GIFTS. This section describes the scope of the efforts under NMP and their relation to the other efforts. There are a number of related areas of validation associated with GIFTS. These include NMP Technology validation efforts, NMP Primary and Secondary Measurement Concept Objective Validation (what this plan addresses), NMP Applications Measurement Concept Objectives Validation, demonstration of IOMI viewing scenarios and products over CONUS, and an optional period of NOAA Demonstration of Operational Utility. While this plan addresses only one of these areas, the intent is to formulate a MCVP that is compatible with the viewing requirements and objectives associated with the other efforts.

Because NMP is a technology program, the majority of the NMP GIFTS validation efforts are naturally focused on the validation of the technologies that are being flight validated by GIFTS. These efforts are specific to the details of the technology demonstration goals and are described in detail in the GIFTS Technology and Infusion Validation Plan. While the MCVP addresses the performance of these technologies (indirectly through their impact on the resulting GIFTS products), the MCV activities can, in general, be distinguished from the technology validation efforts by their use of *external* data sources and comparisons in the approach to validation.

The following summarizes the Measurement Concept Objectives and their definitions as given in the EMRD. The GIFTS Measurement Concept Objectives are divided into three groups: Primary, Secondary, and Applications Objectives. The primary objective establishes the baseline instrument performance and operational requirements. The secondary objectives fall within the measurement capability of the baseline GIFTS instrument and are considered a secondary priority with respect to mission operations and validation activities. The applications objectives fall outside the scope of the funded NMP EO3 mission, require participation by organizations outside NMP, and as such are dependent upon funding by NASA, NOAA, or other organizations following the completion of the NMP technology and measurement concept validation.

For GIFTS, the primary Measurement Concept Objective is to provide frequent, high spatial resolution temperature and water vapor sounding, allowing the vertical profile of wind velocity to be obtained by tracing the horizontal displacement of water vapor and cloud features. The secondary objectives are to a) provide time-dependent ozone and carbon monoxide concentrations within layers of the troposphere and stratosphere, and b) to provide high temporal resolution measurements of radiative properties of clouds (augmented by a higher spatial resolution visible low-light-level camera to provide quasi-continuous imaging). The applications objectives of GIFTS are numerous and are to a) enable demonstration of improvements in weather and climate observation, analysis and prediction, b) add to knowledge of the global water cycle and supporting research contributing to risk reduction from intense weather disasters, c) demonstrate the benefit to the commercial airline industry by using GIFTS data for better weather hazards forecasting that can reduce the risk to safe flight, as well as to reduce fuel costs through improved flight management as a result of increased availability of wind data, and d) provide measurements that enhance other new Earth systems scientific investigations, especially the EOS Aqua and Aura and Earth Systems Science Pathfinder missions.

Various parameters and their required accuracies which are relevant to these validation efforts are described in the EO-3 Mission Requirements Document (EMRD), the GIFTS-IOMI Mission Systems Requirements Document (GMSRD), and the GIFTS Instrument Requirements Document (GIRD). Selected product uncertainties are summarized in the following tables.

Measurement Concept Objective	Parameter	Measurement Uncertainty (rms)	Reference
Primary Objective 1: Atmospheric profiles	Temperature	$\leq$ 1 K for 1-km layers	EMRD, EO76
	Water vapor	$\leq$ 20% for 2-km layers	EMRD, EO76
	Wind velocity	$\leq$ 3 m/s for 2-km layers	EMRD, EO76
Secondary Objective 1: Ozone and carbon monoxide concentrations	O_3 concentration	10-20% for 6-km mid-tropospheric layers 10-20% for three 6-11 km stratospheric layers	EMRD, EO68
	CO concentration	10-20% for three 3-8 km tropospheric layers	EMRD, EO68
Secondary Objective 2: Cloud Properties	Cloud mask	Cloud or clear, 3%	EMRD, EO68
	Cloud top height	20 mbar (pressure altitude)	EMRD, EO68
	Cloud top temperature	$\leq$ 2 K	EMRD, EO68
	Cloud emissivity	10%	EMRD, EO68
	Cloud top phase	Ice or water, 10%	EMRD, EO68

Table 1. Level 2 product accuracy goals for the Regional Sounding and Chemistry (0.6 cm^{-1}) mode.

Parameter	Measurement Uncertainty	Reference
Radiometric Calibration		
Absolute	≤ 1.0 K (3σ) for T_{scene} ≥ 190 K (LW)	GMSRD, MR595
	≤ 1.0 K (3σ) for T_{scene} ≥ 240 K (SMW)	GMSRD, MR595
Reproducibility	≤ 0.2 K (3σ) for T_{scene}≥190 K (LW) over 1 day	GMSRD, MR597
	≤ 0.2 K (3σ) for T_{scene}≥240 K (LW) over 1 day	GMSRD, MR597
Radiometric Noise, NEN	≤ 0.2 mW/(m^2 sr cm^{-1}) (1σ) for T_{scene} ≤ 280 K (LW)	GMSRD, MR586
	≤ 0.06 mW/(m^2 sr cm^{-1}) (1σ) for T_{scene} ≤280 K (SMW)	GMSRD, MR261
Spectral Calibration		
Knowledge	≤ 5 parts in 10^6 (3σ)	GMSRD, MR599
Reproducibility	≤ 1 part in 10^6 (3σ) over 30 days	GMSRD, MR608
Pointing		
Frame-to-Frame Pointing Knowledge	≤ 25 μrad over a 1 hour period	GMSRD, MR505
Pointing Stability	≤ 11.2 μrad (1σ)	GMSRD, MR511
Pointing Jitter	≤ 11.2 μrad (1σ)	GMSRD, MR512
Geolocation Knowledge	≤ 1 km at nadir	GMSRD, MR506
Geolocation Pointing Accuracy	≤ 50 km	GMSRD, MR513
Channel-to-Channel Knowledge	≤ 11.2 μrad (1σ)	GMSRD, MR583

Table 2. Selected Level 1 product accuracy objectives for the Regional Sounding and Chemistry (0.6 cm^{-1}) mode.

Under the scope of the NMP Measurement Concept Validation, this plan addresses the basic validation of the core GIFTS products relevant to the Primary Measurement Concept Objective as stated above. This includes the validation of a) the navigation of the radiance data to Earth located geographic footprints, b) the spectral, radiometric, and spatial accuracy of the measured radiance spectra, c) the retrieved temperature and water vapor profiles, d) the retrieved wind fields, and e) the accuracy of the compressed data stream. These areas are chosen due to their direct relevance to the Primary Measurement Concept Objective; the navigation accuracy has a direct impact on the retrieved winds, the accuracy of the measured radiances impacts directly on the retrieved temperature, water vapor and resulting wind profiles, and the data compression assessment is relevant to the ability to perform such soundings operationally. This plan also addresses validation of the Secondary Measurement Concept Objectives regarding carbon monoxide and ozone concentrations and cloud properties.

As defined by the focus of the NMP program and its concentration on technology development and validation, the NMP funded efforts of the Measurement Concept Objectives validation are limited in scope. Generally, the NMP efforts will not require a relatively large percentage of the overall GIFTS data volume and are not intended to replace or duplicate additional efforts, which are more related to operational applications and use of the data. Rather, the NMP efforts are targeted in scope to provide enough data and analysis for a timely post-launch assessment of the accuracy of the core GIFTS products for a representative set of observation conditions. These efforts will occur during the first 12 months after launch while the GIFTS is stationed in various positions over or near the continental United States.

These NMP MCV efforts will be supplemented by NOAA participation in the GIFTS program. This effort, the NOAA Demonstration of Operational Utility, will nominally take place 6 months after launch to 18 months after launch. These efforts are similar to the NMP Measurement Concept Validation efforts but are distinguished by the larger scope and data volume associated with operational or quasi-operational use of the GIFTS data. Along with traditional validation (e.g. comparison with in-situ sensors) the NOAA efforts draw largely on the assimilation of the GIFTS data into numerical models to assess the impact of the data on predictions. NOAA involvement also plays a role in determining the desired orbital positions and resulting geographical areas and meteorological conditions observed by GIFTS. Details of these efforts are given in the *NOAA GIFTS Product Assurance Plan.*

Additionally, the NMP Measurement Concept Validation efforts are expected to be supplemented by a solicitation for proposals and resulting funding for further validation and algorithm development of the scientific products and goals of GIFTS. Specifically, this would provide additional funding for the Secondary and Applications Objectives Validation, as well as further validation of the Primary Objectives.

A final area of validation is that of demonstrating the IOMI viewing scenarios and derived products while over CONUS in preparation for operational use over the Indian Ocean. The viewing requirements for this effort are given in the IOMI Mission Requirements Document (IMRD).

4. MEASUREMENT CONCEPT VALIDATION PLANS

This section describes the specific efforts associated with the NMP Measurement Concept Objectives Validation. In Section 4.1, specific issues addressed by the validation and approaches related to the individual validation areas (navigation, radiance, temperature, water vapor, winds, carbon monoxide, ozone, cloud properties, and data compression) are described. Section 4.2 describes the GIFTS observation sequences and associated data volumes involved in the MCV; operating and collecting GIFTS data in the given sequences will produce the GIFTS and collocated validation data necessary for the validation analyses. In Section 4.3, candidate plans for positioning and repositioning of the GIFTS satellite during the EO-3 phase of operations and their relation to the MCV efforts are presented. Seasonal specific validation objectives are also discussed.

4.1 Approaches to Validation, by Measurement Parameter

The following sections describe the relevant GIFTS products, or performance specifications, to be validated and the various approaches that will be used in the validation process. A summary table is given in Section 4.1.8.

These plans draw upon experience gained through previous and ongoing validation efforts of geostationary and polar orbiting (e.g. GOES, HIRS, IMG, AIRS, CrIS) and aircraft based (HIS, NAST-I, S-HIS) sounders. The plans also draw upon numerous advances in the instrumentation required for obtaining high quality validation data, as well as advances in the characterization of the accuracy of existing, traditional sources of validation data. In addition, due to the non-operational aspect of the NMP GIFTS mission, the validation will benefit from being able to influence, and in some cases, dictate the orbital positioning of the GIFTS satellite during the first 12 to 18 months in orbit. Additionally, specific observation sequences (Section 4.2.4) and spectral/temporal/spatial tradeoffs (Section 4.2.5) can be tailored for the purpose of validation.

The general approaches to validation include a) internal checks (e.g. blackbody view analyses, pointing exercises), b) comparison of GIFTS products to products available from high quality validation sites and networks (e.g. Atmospheric Radiation Measurement (ARM) sites, Wind Profiler Network), c) comparison of GIFTS products to data collected as part of a dedicated field campaign including instrumentation and measurements not otherwise available, and d) comparison of the GIFTS products to other satellite observations of equal or comparable accuracy. It should be noted, as evident in the definition of validation as used here, that these efforts do not include the comparison of the GIFTS products to products of known lower accuracy. That is, when comparisons are made, the implication is that the differences between the GIFTS and the validation data can be used to infer the accuracy of the GIFTS products.

For the majority of this effort, the desired validation data are available from routine operations and as such does not require special arrangements for performing and/or obtaining the measurements. A notable exception to this statement is the desire to conduct a field campaign as described in Sections 4.1.2.2 and 4.3.2.2.

4.1.1 Navigation

For the area of navigation, the relevant GIFTS performance specifications are the frame-to-frame pointing repeatability, the bore-sight pointing knowledge, and the pointing stability (during an OPD scan).

The primary validation approach to address the frame-to-frame repeatability is to repeatedly attempt to point the instrument at a specific site or sites which have distinct features whose positions are known very accurately and which do not vary with time. Comparisons of the measured data to other views of the same scene and to the known features can then be used to assess the error in each of the measurements and compile statistics of the pointing repeatability. Potential scenes include TBD coastlines, TBD rivers, and TBD planets and/or star fields. Infrared MODIS imagery will be used to select suitable Earth targets.

The primary validation approach to address the pointing stability during an OPD scan is to infer the stability from the visible images collected during the OPD scan. In normal operations the visible data will be collected at the same rate as the infrared data (e.g. one image every 10 seconds in the 0.6 cm^{-1} mode). The ability to collect visible data at a faster rate exists, however, for this type of validation effort.

The primary approach to validating the absolute pointing knowledge is to compare the LW, SMW, and visible images to each other and to known surface and other features. Surface features include coastlines and rivers. Other features include planets, star fields and the moon. In this analysis, the comparisons of the visible and infrared images are performed using auto-correlation techniques and the comparisons to the known features are performed by traditional landmark navigation methods.

Shoreline and topography datasets which can be used for this analysis include ETOPO-5, GSHHS (Global Self-Consistent Hierarchical High-Resolution Shorelines), and GLOBE (Global Land One-km Base Elevation).

4.1.2 Radiance

Radiance validation includes the validation of the spectral, radiometric, and spatial performance of GIFTS based on the observed radiances and their comparison to external data sources.

4.1.2.1 Spectral

Validation of the GIFTS spectral calibration will be performed with comparisons of clear sky GIFTS radiance spectra to line-by-line calculations of the upwelling radiance based on collocated validation atmospheric profiles in spectral regions containing well known (carbon dioxide and nitrous oxide) spectral features. The comparisons result in an estimate of the effective frequency of the metrology laser, and in the resulting wavenumber sampling scale. This analysis will be performed repeatedly throughout the one-year validation period.

The off-axis self-apodization effects and their calibration/normalization are a significant and important effort in the data processing algorithms. The accuracy of this processing will be addressed by comparing radiance spectra of the same clear sky scenes, but with different off-axis effects. This will be accomplished by comparing spectra from the data collected such that the scene is viewed with the (near) on-axis pixel to data collected such that the same scene is viewed with an off-axis pixel. If the self-apodization effects are accounted for correctly, the two spectra (after spectral calibration/normalization) should agree. These two (or more) data cubes should be obtained close in time for clear sky scenes for which validation profiles are available.

4.1.2.2 Radiometric

Validation of the radiometric performance includes assessments of the radiometric noise performance and the absolute radiometric calibration accuracy.

To assess the radiometric noise performance, analyses of calibration blackbody and space views (for which the source radiance is not changing rapidly) can be performed. The variability of these views will be used to compute the radiometric noise, which can be used to assess the performance of the detectors as well as to assess any spectrally correlated interferometric noise. Similarly, data collected over uniform Earth scenes can be used for similar analyses.

The absolute radiometric calibration accuracy validation will be performed with comparisons of the GIFTS radiances to a) collocated data from high altitude aircraft with high spectral resolution infrared spectrometer measurements (NAST-I, S-HIS) of the upwelling radiance, b) collocated satellite observations of comparable accuracy (AIRS, IASI), and c) top-of-atmosphere clear sky line-by-line calculations with validation site atmospheric profiles and surface characterization. Each of these approaches is described in more detail below.

a) Aircraft Underflights

This approach provides estimates of the top-of-atmosphere upwelling radiance using high altitude aircraft FTS (e.g. NAST-I and/or Scanning-HIS) observations combined with line-by-line calculations. Ancillary data sources include image data from MODIS or the Aircraft-based Imager (MAS) to assess spatial variations over the

GIFTS field-of-view and atmospheric state (from radiosondes supplemented by other high altitude data sources, even including GIFTS retrievals above the aircraft altitude) for input to models used to simplify spectral comparisons. The technique is to conduct an aircraft field campaign in which under-flights are made during clear sky conditions and collocated with the GIFTS measurements. The aircraft flight path and sensor view-angle can be adjusted to match the appropriate GIFTS slant path angle. Reasonably uniform targets with a range of radiance levels (e.g. uniform ocean for a range of latitudes, deserts, and uniform cloud decks) are possible sites. The higher spatial resolution aircraft pixels are summed with appropriate weights to represent the larger GIFTS spatial response function. Unsampled regions are represented by using imager data to assign spectra from similar sampled regions. The aircraft and GIFTS data are then reduced to the same spectral resolution (after accounting for self-apodization effects in both cases) and the above-altitude contribution to the GIFTS radiances are accounted for with a line-by-line calculation using a high altitude temperature sounding or the GIFTS retrieval itself as input to the calculation. Comparison of the two radiance spectra can then be used to assess the GIFTS radiometric accuracy.

Vertical profiles of radiance spectra obtained during aircraft ascents and descents can be used to define atmospheric temperature and absorbing gas profiles with high vertical resolution. For example, opaque channels in the 15µm CO_2 spectral region can be used to retrieve the air temperature directly below the aircraft, and when combined with an aircraft ascent or descent, a very accurate atmospheric temperature profile can be derived. With the temperature profile defined, the concentrations of other infrared absorbing gas concentrations can also be derived. This particular approach can therefore be used for radiance, temperature, water vapor, and trace gas validation. These results can also be used to verify the forward radiative transfer models including the assumed mixing ratios of uniformly mixed gases (e.g. CO_2, N_2O, CH_4, etc) as well as the spectral transmittance functions used in the calculations of the TOA radiance spectra.

The comparison of GIFTS to aircraft spectrometers is based on comparing the spectra as outlined above. If the calibration of both instruments were perfect and the scene were uniform, the difference between residual spectra would be noise. It would be nearly uncorrelated with wavelength and dominated by the GIFTS single sample noise (many aircraft samples are averaged to match GIFTS spatial sampling). Differences that are correlated with wavelength that represent consistent radiometric or spectral calibration differences are the focus of this investigation. For reasonably uniform scenes, we expect to be able to detect differences that are on the order of the peak calibration uncertainties for both instruments (less than 1 K brightness temperature for the critical spectral regions). By achieving a number of comparisons, it will be possible to separate consistent, significant differences from differences attributable to spatial sampling errors. A meaningful aircraft campaign would require approximately 50 flight hours. More information on the field campaign is given in Section 4.3.2.2.

b) Satellite Intercomparisons
This approach consists of making comparisons of polar orbiting satellite based measurements with those of GIFTS. Candidate measurements are those from AIRS and IASI, due to their high spectral resolution and expected radiometric accuracy. The general approach is to select reasonably uniform targets with a range of radiance levels (e.g. uniform ocean for a range of latitudes, deserts, and uniform cloud decks) for the comparisons and to utilize the GIFTS tracking mode to obtain the collocated data. The GIFTS data can be collected to minimize the effect of view angle differences between the two platforms. Note that the view angles can be matched exactly using data collected over the equator. The spectra are then reduced to similar spectral resolutions. For IASI, this can be done by reducing to identical maximum optical path differences and accounting for self-apodization effects. For AIRS, this requires a slightly more complicated approach as defined in Reference [1]. Calculated spectra from GIFTS retrievals will be used to fill in any spectral gaps in GIFTS coverage. GIFTS data can be summed appropriately to match the spatial responses of each instrument. Because of the spectral and spatial averaging involved in these comparisons, the noise should be quite small. The differences for carefully chosen uniform scenes should be dominated by calibration errors of GIFTS and the comparison instrument. Differences of less than 1 K with a predictable dependence on radiance level are expected. Tens of comparisons will be selected monthly to track the relative radiometric calibration among these observations over the NMP validation period.

c) Clear Sky Line-by-line Calculations
The basic approach is to compare clear sky GIFTS radiance spectra to calculations of the upwelling clear sky radiance of GIFTS data collected over the ARM sites. The calculations will be performed using input from the ARM site temperature and water vapor best estimate products from the Southern Great Plains (central facility) site. Line-by-line radiative transfer codes will be used to perform these clear sky calculations. The input surface emissivity is derived from a number of sources including USGS land type maps, temporal and spatial collocated ground-based SAERI measurements, and calculated sea-surface values. The input surface skin temperature is derived from broadband infrared measurements at the ARM sites or determined from the GIFTS observations themselves. The differences between the

observed and calculated radiances are then analyzed with respect to the calculation uncertainties (spectroscopic accuracy, fast model parameterization, atmospheric state uncertainty, and surface emissivity and temperature characterization) to assess the accuracy of the observed radiances.

The accuracy of the calculated radiances will depend largely on the specification of the surface temperature and emissivity, as well as the atmospheric state. The surface emissivity and temperature used in the calculations will likely be determined by fitting a linear combination of the known pure scene type emissivities and the effective, area weighted surface temperature such that window region residuals (GIFTS – calculation) are minimized. In this sense, this validation activity does not address absolute calibration accuracy, but rather has an emphasis on spectral and relative radiometric accuracy. That is, the technique of fitting the surface characteristics to the observed radiances sets the residuals to zero in specific spectral regions in the 10μm region, but allows for meaningful comparisons of the observed and calculated radiances in spectral regions which do not see the surface. The spectral calibration of the GIFTS will be assessed by taking differences between the observed and calculated spectra. Using a large number of comparisons, radiometric differences between the observed and calculated radiances will be analyzed statistically using, for example, scatter plots of radiance differences, or distributions of radiances for selected, limited wavenumber regions.

4.1.2.3 Spatial

Spatial performance of the Imaging FTS addresses the Point Spread Function (PSF), cross-talk within the LW and SW FPAs, and LW/SMW FPA co-alignment knowledge accuracy.

The knowledge of the PSFs will be evaluated using cross-correlation of the infrared and visible images.

FPA cross-talk will be addressed by viewing scenes, which have isolated, known bright features, such as selected planets. Using data collected for such scenes, the data can be analyzed to assess whether pixel cross talk is occurring. That is, if pixels that are not (intentionally) viewing the planet within the scene view have a high signal, this could be an indicator of some level of cross talk. This approach can be combined with pointing exercises to address the cross-talk for different pixels.

LW/SMW FPA co-alignment knowledge accuracy can be assessed using data and analysis similar to that used to assess the absolute pointing knowledge (Section 4.1.1). The absolute pointing knowledge is assessed independently for the LW and

SMW FPAs and the residual differences between the two sets of images, after accounting for the known FPA offsets, are used to assess the co-alignment knowledge.

4.1.3 Temperature and Water Vapor

The temperature and water vapor retrieval validation is performed using comparisons of the retrievals to in-situ and remotely sensed profiles.

For temperature profiles, operational and research grade radiosondes will serve as the primary source of validation data. Other data sources include ground-based remotely sensed profiles (e.g. AERI) and commercial aircraft based in-situ sensors (e.g. ACARS).

For water vapor profiles, operational and even research grade radiosondes are generally not accurate enough for reliable validation of the GIFTS retrievals. As such, the radiosonde profiles need to be collocated with other measurements that can be used to effectively calibrate the sonde measurements (via scaling of the relative humidity profiles based on surface or tower in-situ observations, or by integrated column measurements with a microwave radiometer or GPS). As a result, water vapor validation will be performed using data collected over high quality validation sites such as the ARM site in Oklahoma, operational radiosonde data which is collocated with GPS or MWR measurements, ACARS data, and data collected as part of a dedicated field campaign. Desired water vapor measurements from a field campaign include ground based Raman Lidar, aircraft based active and in-situ sensors (e.g. LASE, frost point), and high quality sonde-based profiles (e.g. chilled mirrors, Vaisala RS-90s).

4.1.4 Winds

One of the measures of success for the overall GIFTS mission will be based on the ability to derive wind fields with performance characteristics that meet the following criteria: 1) do the winds meet pre-launch accuracy specifications? 2) are the resultant wind fields superior to existing satellite-based products in three-dimensional spatial coverage and also quality? and 3) do the superior wind measurements lead to reduction in analysis and forecast errors? A wide array of evaluation tests can be used to answer these questions. These include statistical assessments of GIFTS wind vector accuracies by comparison to proven in-situ observations, direct comparisons with wind measurements from existing satellite-based platforms such as GOES, and numerical model impact studies to assess the value of the added/advanced observations on forecasts.

To accomplish the above, several approaches are envisioned. The first approach is to process GIFTS measurements over the CONUS radiosonde network for an extended period in order to build a statistically significant comparison dataset for vector accuracy evaluation. Comparisons to aircraft based ACARS measurements and Wind Profiler observations in the Central Plains states can also be used for this purpose. The second approach is to process GIFTS measurements coincident with current operational satellite-derived wind datasets for direct comparisons on coverage and quality. This can involve both a qualitative assessment and diagnostic studies from initial condition improvements. A third possible approach (but not included under NMP) involves numerical models and the assimilation of the GIFTS winds. The numerical model studies can range from mesoscale forecasts over the CONUS region during the severe weather season, to synoptic studies over the tropics during hurricane season, to hemispheric impact studies over the oceans (which could include field programs such as THORPEX, described later in Section 4.3.2.5). The latter approach also involves Observing System Experiments (OSE) which are designed to test and optimize the impact of specific measurements on objective analyses and numerical forecasts. Of these three approaches, the first two will comprise the majority of efforts related to winds validation under NMP. Due to the large effort associated with the use of these data in numerical models, the latter approach involving numerical model impact studies will not be included in the NMP wind validation efforts. The NOAA efforts are expected to be more comprehensive in this approach.

4.1.5 Carbon Monoxide and Ozone

The ozone and carbon monoxide retrieval validation is performed using comparisons of the retrievals to in-situ and remotely sensed profiles.

For ozone profiles, operational and research grade ozonesondes will serve as the primary source of validation data. Other data sources include spaceborne, airborne, and ground-based remotely sensed profiles (e.g. TES on EOS Aura, ozone lidar, solar FTS and microwave sounders).

Validation of retrieval of carbon monoxide profiles will be performed using various remote sensing and airborne in-situ techniques. A network of ground-based solar FTS and zenith viewing emission spectrometers (AERI) is currently used for the validation of the MOPITT carbon monoxide measurements, and can be used for the GIFTS carbon monoxide validation. NOAA Climate Monitoring and Diagnostics Laboratory (CMDL) performs regular in-situ aircraft carbon monoxide profile measurements at three sites over CONUS. By the time of the GIFTS launch, at least three carbon monoxide measuring satellite instruments should already be in space (e.g. MOPITT, AIRS, and TES). Claimed accuracy of these instruments allows us to consider them as sources of potential data for GIFTS validation.

The ARM site in Oklahoma is considered a prime site for temperature and water vapor validation. Fortunately, it is also equipped with an ozonesonde launch facility, solar FTS instrument and AERI. As a result, temperature, water vapor, ozone and carbon monoxide validation will be performed simultaneously using data collected over this high quality validation site. Quality of validation can be also improved by collocation of a dedicated airborne campaign (see Section 4.3.2.2).

4.1.6 Cloud Properties

The cloud property retrievals addressed by the MCV efforts include cloud mask, cloud top height, cloud top temperature, cloud emissivity, and cloud top thermodynamic phase.

There are a number of candidate approaches to GIFTS cloud property validation. The general approaches include comparisons to other satellite retrievals and comparisons to remotely and actively sensed products from operational ground based instruments and from aircraft based sensors during a field campaign. Specific approaches include comparisons to retrievals from ground-based sensor systems at the ARM and FARS [2] sites, comparisons to satellite-based lidar (PICASSO-CENA) and radiation (MODIS, AIRS, GOES, HIRS, etc.) observations, and comparisons to aircraft-based lidar observations.

For the NMP GIFTS MCV efforts, cloud property validation efforts will be based on comparisons to cloud retrievals from MODIS and AIRS. Although GIFTS and MODIS/AIRS cloud algorithms (will) use the same basic approach, the MODIS/AIRS cloud products will be evaluated and well understood by the time of GIFTS launch for this effort. Collocated data will be obtained using the Satellite Collocation (Section 4.2.4.3), CONUS-A (Section 4.2.4.7), and CONUS-B (Section 4.2.4.8) observation sequences. Limited comparisons to aircraft based FTS (NAST-I/S-HIS) observations of cloud properties (particularly cloud top temperature and spectral emissivity) from a dedicated field campaign (ARM Field Campaign, Section 4.2.4.2) will also be performed.

4.1.7 Data Compression

The data compression validation is performed by comparing the products (interferograms, spectra, and/or retrieved products) from the uncompressed data stream to those from the compressed data stream. Naturally, this relies on having products derived from both data streams for the same scene views. This can be done using a statistically representative set of Earth scene and calibration blackbody data, which has been collected and processed for other purposes.

In addition to the direct comparisons of measurements/products from the uncompressed and compressed data streams, indirect compression effects such as the correlation between spectral and spatial signal and noise will also be evaluated. This task will evaluate the signal and noise in both spectral and spatial domains and their differences from the original uncompressed data stream, since the experimental compression algorithms employ both interferogram/spectral and spatial approaches.

4.1.8 Summary

Product/Parameter	Validation Approach
Navigation	
Repeatability	Comparison of repeated views of stable scenes.
Stability	Stability of visible images during an OPD scan.
Knowledge	Comparison of LW, SMW, and visible images to each other and to known surface and other features: coastline crossings, planets, star-fields.
Radiance	
Spectral	Comparisons to line-by-line calculations. Specific pointing exercises to assess off-axis effects.
Spatial	Planet/star-field/moon views, coastline crossings. Combined with pointing exercises. Comparison of LW/SMW/Vis images.
Radiometric	Variability and spectral correlation of blackbody and space views. Uniformity over homogeneous scenes. Comparison with aircraft based FTS sensors, other satellite based radiance observations, and line-by-line calculations.
Temperature	Comparisons with national radiosonde network, ARM sondes, ACARS, AERI, FTS based retrievals using aircraft profiling, aircraft based in-situ sensors.
Water Vapor	Comparison to "scaled" national radiosondes (collocated with GPS or uplooking radiometer), "scaled" ARM sondes, ACARS, Raman Lidar, FTS based retrievals using aircraft profiling, aircraft based active and in-situ sensors.
Winds	Comparison to national and ARM radiosondes, Wind Profiler network, aircraft based Doppler radar, ACARS, and winds derived from operational satellites.
Trace Gases	O_3: Comparisons to research grade ozonesondes, satellite based retrievals (TES), ozone lidar, solar FTS, microwave sensors, and FTS based retrievals using aircraft profiling. CO: Comparison to AERI retrievals, NOAA CMDL aircraft in-situ

	observations, and satellite based retrievals from MOPITT, AIRS, and TES, and FTS based retrievals using aircraft profiling.
Cloud Properties	Comparison to MODIS/AIRS cloud products. Comparison to retrievals from aircraft-based FTS observations.
Data Compression	Comparison of products from the uncompressed and compressed data streams.

Table 3. Summary of validation approaches described in Section 4.1.

4.2 Observation Sequences

This section describes the various GIFTS viewing sequences and data volumes associated with the validation efforts. The logic behind the creation of the following observation sequences is that they provide enough GIFTS data and collocated validation data in order to address the basic validation in all of the areas discussed in Section 4.1. The majority of the data is collected over CONUS to make use of the national radiosonde and ozonesonde networks, the ARM validation sites in the central US, and various other sources of validation data. The data collection is distributed over a one-year time period in order to sample a representative set of meteorological conditions.

4.2.1 Estimated Data Volume

The estimated GIFTS data volume associated with the NMP validation efforts is approximately 20,000 "cubes" of data. This is to be distributed equally (more or less) across the first year of operations (5000 cubes per season). Here, a "cube" is defined as the data collected by GIFTS in its Regional Sounding and Chemistry mode (0.6 cm^{-1} spectral resolution) for one 11 second period (10 s for the OPD scan and 1 s to move the pointing mirror). That is, a cube consists of a 128 × 128 array of 2048 point interferograms for the LW band, a 128 × 128 array of 4096 point interferograms for the SMW band, the 512 × 512 arrays of visible data collected during the eleven seconds, and any associated auxiliary or metadata (observation times, locations, view angles, etc). This data for the MCV analysis represents only a small fraction of the total GIFTS data volume (roughly 0.7 percent of the total data volume assuming a full data rate of 1 cube every 11 seconds for one year). At the same time, this is an enormous amount of data; if you are familiar with NAST-I data, 20,000 GIFTS cubes are equivalent in interferogram data volume to roughly 37,600 hours (~4.3 years) worth of continuous NAST-I data. In the following, when accounting for total data volume, approximately 5 percent needs to be added to the stated Earth scene data volumes to account for the blackbody views required for calibration (assuming 1 set of blackbody views per 20 scene views). Both the compressed and uncompressed data streams are needed to support the data compression validation.

4.2.2 Data Browse Capability

The current theory of operations includes a weekly and/or daily plan of scheduled GIFTS viewing sequences. After and/or during the selected data collection periods, there will be a need to "browse" or evaluate the current data based on the instrument performance and observed meteorological conditions. This information could then be used to determine if the collected data is suitable for MCV analysis. For example, GOES imagery could be viewed to determine if the ARM validation site was clear or cloudy during an observation period, and depending on the validation issue at hand, the GIFTS data could be selected for processing, or rejected. (The ~20,000 cube figure discussed in the previous section is an estimate of the amount of data which would be selected for processing). This implies the need for a temporary storage buffer that would allow the data to be temporarily (or permanently) stored while this evaluation occurs. Implicit in the need for this capability is that the specific scenes required for MCV cannot be specified far in advance, and that not all of the data can be processed within the scope of NMP.

4.2.3 Data Processing Capability

For each of the cubes which is selected for MCV analysis, the baseline would be to process the data to the basic Level 1 and Level 2 products (navigated, calibrated radiance spectra, temperature and water vapor retrievals, wind retrievals, and trace gases.) In light of any data processing/instrument/etc. complications, the capability to re-process the data needs to be taken into account.

In order to meet the needs of the MCV efforts, Level 1 products (calibrated/navigated radiances) shall be produced within approximately one week of receipt of the Level 0 data. Additionally, the processing and delivery of Level 2 data products (atmospheric profiles, winds) shall be performed on the 5000 data cubes during each of the four seasons within 2 months of receipt of Level 1 products.

4.2.4 Observation Sequences

The following sub-sections describe the main observation sequences associated with the MCV. A summary table relating these sequences to the validation objectives and their data volumes is given in Section 4.2.4.9.

4.2.4.1 ARM Site

This viewing scenario consists of a sequence of data cubes collected over the ARM site in Oklahoma/Kansas. This ARM site consists of a central ground site facility (located at ~36.5N, 97.5W) which is unique with respect to its state-of-the-art capabilities for measuring the atmospheric state and associated radiative properties. There are also four "boundary facilities" which are slightly less equipped and numerous "extended facilities" surrounding the central facility. Including the boundary facilities, the ARM site is approximately 250 km × 250 km, and so a single GIFTS cube can cover it and the surrounding area. Single cubes centered on the site will be collected every 15 minutes for 2 hours to coincide with a radiosonde's ascent through the atmosphere. This would be done for a number of sonde launches for various clear and cloudy sky conditions for a range of temperature and water vapor conditions. This data can be used to address radiance, temperature and water vapor, winds, trace gas, and cloud property validation. In addition to the radiosonde data, a variety of other important data (ARM and otherwise) will be used. This includes various surface and tower based in-situ sensors, uplooking microwave radiometers, GPS, Raman Lidar, cloud radar and lidar, AERI, and the Wind Profiler and Mesonet networks. To obtain data over a range of conditions, the data collection would be distributed over the 1 year period. The ARM central facility currently launches four sondes per day during normal operating conditions. To sample 15 days out of each season, the estimated cube volume is 2160 cubes (4 sondes per day × 9 cubes per sonde × 15 days per season × 4 seasons per year).

4.2.4.2 ARM Site Field Campaign

This data would also consist of a series of GIFTS cubes collected over the ARM site domain. These data would be collected during an intensive field campaign that would involve aircraft and ground based instrumentation. In particular, this scenario would focus on GIFTS radiance validation using aircraft based FTS observations (e.g. NAST-I and/or S-HIS) from a high altitude aircraft. Additional ground-based and aircraft sensors would be used for temperature, water vapor, and winds validation as well. To estimate the GIFTS data volume, a field campaign with ~50 flight hours (10 flights at 5 hours per flight) is envisioned. During the flights, a GIFTS cube would be collected every 5 minutes for a cube volume of 600 cubes (50 hours × 12 cubes per hour). Details of the prescribed field campaign are discussed in Sections 4.1.2.2 and 4.3.2.2.

4.2.4.3 Polar Satellite Collocation

In this scenario, GIFTS data would be collected in the GIFTS tracking mode (or some other mode which would effectively produce GIFTS data collocated both temporally and spatially with the satellite in question) to collect collocated data with AIRS (on EOS Aqua), IASI (on the EUMETSAT payload), and other relevant satellite based sensors including MOPITT, TES, and MODIS. The high spectral resolution satellite data would be used primarily for radiance validation under clear sky conditions. Other uses are comparisons of retrieved profiles and cloud properties. These data would be collected over TBD CONUS locations, over the ARM sites, and over ocean

(Gulf of Mexico, western Atlantic, or eastern Pacific). Note that the view angles from the two sensors can be matched using data collected over the equator. The estimated cube volume is 200 cubes (1 cube per overpass × 200 overpasses).

4.2.4.4 Navigation Sequences

Three specific viewing scenarios are proposed for navigation validation. Navigation validation will also be performed using coastline and other data collected during the CONUS observations (e.g. CONUS-A, discussed below).

NAV-1: Absolute Pointing Knowledge

Specific coastline and/or planet and/or star field and/or moon views will be used to assess the absolute pointing knowledge. These views will be performed periodically throughout the year and will be interwoven with other viewing scenarios to assess the navigation before and after other sequences. The estimated cube count is 100 cubes (1 cube per sequence × 100 sequences).

NAV-2: Repeatability

To assess the pointing repeatability, a sequence of views of the same scene will be collected. This scene should be clear sky, very stable in time, and have sharp IR features (e.g. clear sky coastline). A single sequence would consist of ~20 views of the same scene, with the instrument pointing at other scenes in-between each of the 20 views. The instrument pointing sequence used to produce the consecutive views can be adjusted to determine effects of the spacecraft and instrument momentum on the pointing repeatability. This scenario would be repeated periodically throughout the year. The estimated cube volume is 240 cubes (20 cubes per sequence × 1 sequence per month × 12 months).

NAV-3: Stability

The purpose of this sequence is to provide views of stable, clear sky scenes. The pointing stability during an OPD scan can then be assessed by looking at the stability of the GIFTS visible imagery during the ~10 second OPD scans. (Using a visible sampling rate of one visible image every 1 to 2 seconds). The desired scenes would be similar to those chosen for NAV-2: stable clear sky with sharp IR features. Most of these views can be selected from single cubes that have been collected for other purposes. To obtain longer sequences of visible images, this sequence would also consist of consecutive views of the same scene. For example, 30 to 60 consecutive visible images of the same scene could be collected during a 60 second view (6 cubes) before re-pointing the instrument. The estimated cube volume is 72 cubes (6 cubes per sequence × 1 sequence per month × 12 months).

4.2.4.5 Blackbody and Space Views

This sequence consists of consecutive views of the internal blackbodies and cold space. This data will be used primarily to assess the radiometric noise performance as well as for radiometric calibration checks. For each sequence, 20 to 30 consecutive views of each source are required to derive statistics on the noise performance. The estimated cube volume is 1440 cubes (20 views per source × 3 sources (two blackbodies and space) × 2 sequences per month × 12 months).

4.2.4.6 Spectral Normalization

The purpose of this scenario is to provide data required to assess the spectral calibration/normalization of the GIFTS spectra as described in Section 4.1.2.1. A sequence would consist of 5 cubes with the first cube collected such that the on-axis pixel views a specific point (x,y) on the ground, the second such that the upper right hand corner pixel sees the same point (x,y) on the ground, and so on for the other corner pixels of the FPA. The target would be the ARM site under stable, clear sky conditions. This would be performed only a small number of times. The cube volume is 25 cubes (5 cubes per sequence × 5 sequences).

4.2.4.7 CONUS-A

This CONUS observation sequence is used for the basic winds validation. It also serves as a way to validate the navigation using the coastline and other landmark data available for CONUS. Temperature and first order water vapor validation can also be performed. The basic sequence allows one to perform GIFTS water vapor and cloud wind retrievals for the CONUS area. CONUS, defined here as a ~5000 × ~2500 km area, can be covered with a 10 × 5 array of GIFTS cubes. Each water vapor winds sounding requires 3 views of the same geographic site, with a time step of ~30 minutes (e.g. observations at 0000, 0030 and 0100 UTC produces 1 water vapor wind sounding for each pixel). Cloud winds sounding can be performed using lower spectral resolution data but with a faster time step (~15 minutes). A CONUS wind sounding would then consist of a water vapor wind sounding with an embedded cloud wind sounding. These would be performed at 0 and 12 UTC to be synchronized with the national radiosonde network observations. There are currently ~90 national radiosonde launch sites which can be incorporated in this analyses. Other validation data available at these times (e.g. ACARS, routine ARM observations, GPS network, Wind Profiler, Mesonet, operational ozonesondes, AERIs, and a number of satellite based observations) can also be used for the validation analysis. An example CONUS-A sequence would consist of

- 0.6 cm^{-1} CONUS observations collected at 0000 UTC
- 0.6 cm^{-1} CONUS observations collected at 0030 UTC

- ~15 cm^{-1} CONUS observations collected at 0045 UTC
- 0.6 cm^{-1} CONUS observations at 0100 UTC

The 0.6 cm^{-1} observations at 0030 and 0100 UTC can be processed at lower spectral resolution and combined with the 0045 observations to provide the embedded cloud wind sounding. The data volume for the ~15 cm^{-1} observations is negligible when compared to the 0.6 cm^{-1} observations. The cube volume for such a wind sounding is therefore 150 cubes (50 cubes to cover CONUS × 3 views per sounding). These observations would be collected for different meteorological conditions during the one year period. The estimated cube volume is 12000 cubes (150 cubes per sounding × 2 soundings per day × 10 selected days per season × 4 seasons per year). This example provides twice daily soundings for 10 days out of each of the 4 seasons.

As discussed later in Section 4.3, the actual GIFTS orbital position(s) are still being evaluated. If all of CONUS is not viewable from a given orbital position, the figures used to compute these data volumes will be adjusted to allow more frequent views of the viewable percentage of CONUS.

4.2.4.8 CONUS-B

An observation sequence similar to CONUS-A is one where the wind soundings are produced every hour for a full day. This observation sequence would specifically allow for the demonstration and validation of near continuous *time sequencing* of the GIFTS wind retrievals – the fourth dimension afforded by geosynchronous observations. Although named "CONUS-B", the data collected here could also include data from the viewable portions of the Pacific and/or Atlantic Oceans. This sequence would allow for data collection and validation/demonstration of GIFTS during, for example, the landfall of an Atlantic hurricane or development of severe storms in the central plains. This would be done for a few case studies and the estimated cube volume is 4800 cubes (50 cubes per CONUS × 24 views per day × 1 day per case × 1 case per season × 4 seasons). The time step (1 hour), duration (1 day), and number of case studies can be adjusted to allow for the observation of other meteorologically relevant events. This observation sequence is applicable to the season-dependent validation objectives discussed in Section 4.3.2.

4.2.4.9 Summary

Observation Sequence	# cubes/sequence	# sequences	# cubes	Radiance, Spectral	Radiance. Spatial	Radiance, Radiometric	Pointing Knowledge	Pointing Repeatability	Pointing Stability	Temperature	Water Vapor	Winds	CO, O_3	Cloud properties
ARM Site	9	240	2160	X		x			x	X	X	X	X	
ARM Site Field Campaign	12 /hr	50 hrs	600	X		X				X	X	X	X	
Satellite Collocation	1	200	200	x		X							X	X
NAV-1	1	100	100		x		X							
NAV-2	20	12	240		x			X						
NAV-3	6	12	72		x				X					
Blackbody & Space	60	24	1440			X								
Spectral Norm	5	20	100	X										
CONUS-A	150	80	12000	x		x	x	x	x	X	x	X	X	x
CONUS-B	1200	4	4800	x		x	x	X	x	X	x	X	X	x

Table 4. Summary of GIFTS MCV observation sequences, their associated data volumes, and validation areas addressed. Large X's imply a primary objective.

4.2.5 Spectral/Spatial Modes

The GIFTS can be operated in different spectral resolution modes to perform tradeoffs in the spectral resolution and spatial and temporal coverage. In the previous description of observation sequences, the majority of the data is collected in the default "Regional Sounding and Chemistry" mode with a spectral resolution of ~0.6 cm^{-1}. The MCV efforts do not attempt to address all operating modes equally, and most of the validation efforts will focus on this main observing mode. Data collected as part of the ARM Site, CONUS-A, and CONUS-B sequences, however, explicitly include the collection of data at lower spectral resolution, and this data and its derived products can be used to validate the other modes. Subsets of the data collected at 0.6 cm^{-1} can also be processed at lower spectral resolution to produce products similar to those from the other modes.

4.3 Implementation Issues and Season Specific Validation Efforts

The previously described GIFTS observation sequences and validation approaches require collocated GIFTS and validation data from various geographical locations. Specific issues of the validation plan are dependent on the GIFTS launch date and orbital positions. At the time of this writing, the actual GIFTS orbital positions, repositions, and the timing of the repositions have not yet been determined. Their determination is dependent upon the MCV viewing requirements, as well as the available satellite fuel load, orbital slot availability, communication downlink capability, and other factors. Specific factors include a) a launch date in November 2004, b) an initial positioning and instrument check-out period of ~45 days, c) a reposition speed of ~1.4 degrees per day, and d) that the spacecraft and instrument will be operational over the Indian Ocean on or before 1 April 2006. Note the possibility of more than one position over or near CONUS during the EO3 phase of the mission.

For the MCV activities, the selected orbital positions should allow for good views of the ARM sites in Oklahoma and Kansas and a large percentage of CONUS. The view angle constraint imposed by atmospheric sounding is illustrated in Figure 1. These plots show the contours of local zenith angles (LZA, angle from local zenith to line of sight to the satellite) of 45, 50, 55, and 60 degrees for three sample orbital positions. Currently, GOES soundings are performed to a maximum LZA of 62.5 degrees. The contours in Figure 1 therefore depict the approximate geographic areas for which soundings can be produced from each of the example positions. These positions (0N/130W, 0N/97.5W, 0N/65W) were chosen as examples here because they span the range of positions for which the LZA from the ARM site is less than or equal to ~55 degrees. This also ensures that a large percentage of CONUS is viewable with an LZA less than ~60 degrees and that an array of coastlines (for navigation validation efforts) are available. Because the ARM site and CONUS observations will be used extensively throughout the MCV efforts, the selected orbits should allow for views of the ARM site with local zenith angles of ~55 degrees or less.

Although there are advantages and disadvantages to particular orbital positions and repositions, the Measurement Concept Validation can be performed from any position as long as the LZA constraint as described above is met. The following sub-sections describe season dependent and independent validation activities. The possibility of performing some of these efforts depends upon the chosen orbital position(s), including their timing and duration. For example, observation of an Atlantic hurricane is not possible with an orbital position of 130W. In these sections, the initial validation (Section 4.3.2.1) and field campaign (Section 4.3.2.2) activities are important components of the MCV. It should be noted that the activities described in the other sub-sections (4.3.2.3, Severe Storms; 4.3.2.4 Atlantic Hurricanes; 4.3.2.5, Pacific Storms and THORPEX), while very relevant to the overall GIFTS demonstration goals, are not necessary for MCV under the NMP scope. These activities, however, would add greatly to demonstrating the relevance and impact of the GIFTS data (e.g. using CONUS-B observation sequences) and the NOAA effort to demonstrate the importance of GIFTS for operational use. An implementation scenario which provides for the activities described in Section 4.3.2 (including observation of Pacific storms in Winter, Central Plains severe storms in Spring, and/or Atlantic hurricanes in Autumn) is therefore *desired* for both the NMP and NOAA efforts. A more complex scenario however would require a larger satellite propulsion budget, more time spent in repositioning maneuvers, and the actual availability of the orbital positions.

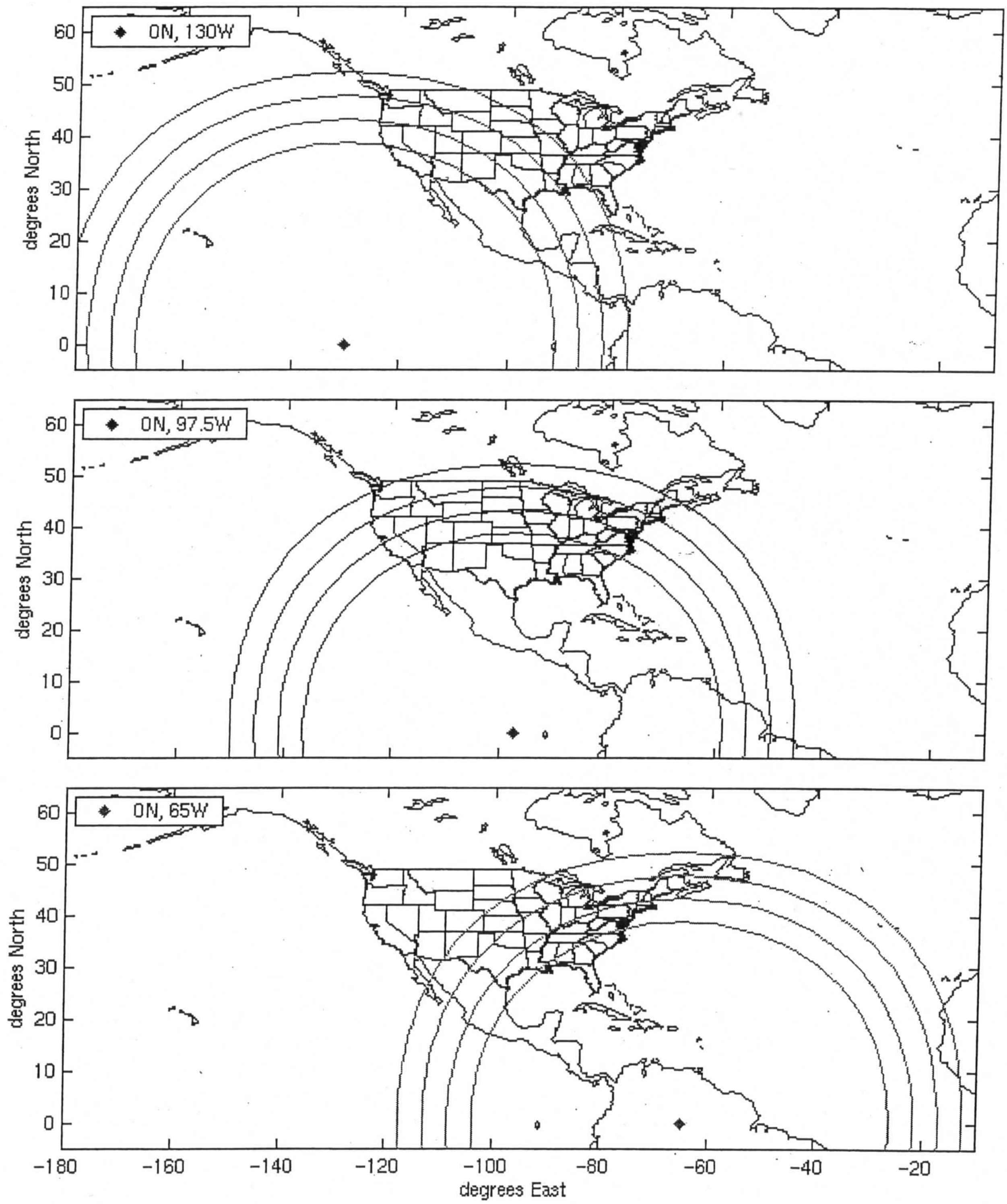

Figure 1. Illustration of the geographic areas viewable by GIFTS for three potential orbital positions, as discussed in Section 4.3. For each position, contours of 45, 50, 55, and 60 degree local zenith angles are shown.

4.3.1 Season Independent Validation Activities

The NMP validation efforts during the one-year after launch are distributed chronologically and geographically across the northern hemisphere seasons in order to sample a meteorologically relevant and representative set of conditions. Following the launch of GIFTS in November 2004, GIFTS will be stationed over the continental United States and adjacent oceans during the NMP validation period prior to positioning over the Indian Ocean. The NMP validation activities will be conducted during the first twelve months. As described in Section 4.2, there are a number of observation sequences that will be repeated throughout the year after launch in order to sample a range of meteorological conditions, as well as to continually monitor the performance of various aspects of GIFTS. These observations sequences include the ARM Site (Section 4.2.4.1), Satellite Co-location (Section 4.2.4.3), NAV-1, NAV-2, and NAV-3 (Section 4.2.4.4), Blackbody and Space View (Section 4.2.4.5), Spectral Normalization (Section 4.2.4.6), and CONUS-A (Section 4.2.4.7) sequences.

4.3.2 Season Dependent Validation Activities

In addition to the observation sequences and validation objectives described above, there are several season and location specific validation goals. Following an initial instrument check-out period, the first several months will focus on viewing CONUS, the ARM sites, and other navigation specific sites to get an initial evaluation of the GIFTS data and products in all areas. The focus of the analysis will go from navigation and radiance validation, to temperature and water vapor sounding, and then to winds. The trace gas and cloud property retrievals will also be assessed. During northern hemisphere Winter, storms in the Pacific ocean will be targeted (using for example, the CONUS-B observation sequence), as well as continued views of CONUS and the ARM site. During northern hemisphere Spring, severe storms in the Central Plains states will be targeted. Another period will feature a dedicated aircraft and ground based field campaign conducted in the ARM site domain. The emphasis of this campaign is a more refined radiance validation, as well as further temperature, water vapor, carbon monoxide, ozone, clouds, and winds validation. Yet another period during northern hemisphere Autumn will use an orbital position allowing for views of the Atlantic ocean. Views of eastern CONUS, the ARM site, and developing hurricanes in the Atlantic will be obtained. The actual sequencing and duration of each of these periods is dependent upon a number of factors (including the actual launch date, the duration of the initial instrument check-out period, and the chosen orbital position(s)), and are therefore not yet defined. The prioritization of these activities with respect to NMP and NOAA validation objectives was discussed previously in this section. Each of these activities is described in more detail in the following sub-sections.

4.3.2.1 Initial Validation Efforts

After an initial check-out period, GIFTS data and coincident validation data will be collected to optimize algorithms for navigation, calibration, and retrieval. GIFTS data and validation data will be collected in order to obtain initial validation in each of the core areas: navigation, radiance, temperature and water vapor retrieval, winds retrieval, carbon monoxide and ozone retrieval, cloud property retrieval, and data compression. The goal is an initial algorithm and instrument assessment within a few (2 to 3) months of operation.

The GIFTS data collected for validation during this period will consist primarily of a combination of CONUS observations coincident with 0 and 12 UTC radiosonde launches and data collected over the ARM sites in Oklahoma and Kansas. Specific data will also be collected for coincident observations with polar orbiting satellites, for specific navigation efforts, for spectral calibration efforts, and to assess the radiometric noise performance.

4.3.2.2 Field Campaign

The validation efforts conducted and GIFTS data collected during this period are very similar to that of the previously described check-out period. During this period, however, the validation will benefit from a dedicated field campaign that will provide key observations for refined validation analyses, particularly in the area of radiometric performance. This field campaign should occur early in the mission, but following the initial validation activities described above.

The meteorological conditions desired for this campaign are primarily clear skies, and so a Autumn/Winter time period is desired. The dedicated field campaign should occur over and around the ARM site in northern Oklahoma and should include ground and aircraft based observations. The specific instrumentation will be chosen to supplement the routine ARM site observations. In particular, the field campaign should include high altitude aircraft-based observations from a highly accurate high spectral resolution infrared spectrometer capable of measuring the upwelling radiance at equal calibration accuracy and comparable spectral resolution and coverage (e.g. the NAST-I and/or S-HIS). These data will be used as a primary tool for validation of the radiometric calibration, as described in Section 4.1.2.2. The ARM site wind observations (sondes, Wind Profiler, in-situ) can also be supplemented by the field campaign by an airborne Doppler radar system (e.g., the NCAR Eldora). Additionally, Raman LIDARS and dedicated sonde launches from the ARM central and extended sites can be used with NAST-I/S-HIS and LASE for radiometric and temperature and moisture retrieval validation. The aircraft payload should also include in-situ and/or active sensors of temperature, water vapor, ozone and carbon monoxide. For cloud properties, the NAST-I/S-HIS can provide cloud top temperatures and emissivities and the lidar can provide cloud top heights. The campaign should also include measurements of the surface radiative properties (temperature and emissivity) synchronous with the aircraft overflights to provide a constraint on the surface terms in the validation analyses. Although a variety of meteorological conditions will no doubt be available during such a field campaign, the ideal conditions for radiance, temperature, and water vapor validation are those of homogeneous clear skies, and such conditions should therefore be the primary focus of the aircraft flights.

It should be noted that, at the time of this writing, a dedicated GIFTS field campaign as described here is not currently funded by the NMP program. It is, however, anticipated and highly likely that other programs will provide the relatively minimal funding required for this effort. In the unlikely event that a dedicated field campaign is not funded, more emphasis would be placed on leveraging existing planned ARM-site activities and polar satellite collocations (AIRS and IASI) to refine the radiometric validation.

4.3.2.3 Severe Storms

During northern hemisphere Spring, GIFTS data will be collected at a TBD combination of spatial and temporal sampling (e.g. CONUS-B observation sequence) to monitor the development and evolution of severe storms in the Central Plains states. In particular, any storms in the vicinity of the ARM sites in northern Oklahoma and Kansas will be targeted in order to compare the ability of GIFTS to monitor the storm's development to that of the ARM site observations (in particular, uplooking AERI and Raman Lidar, Wind Profiler and sondes).

4.3.2.4 Atlantic Hurricanes

The northern hemisphere Autumn season will include data collected over the western Atlantic for tropical cyclone coverage. A desired orbital position of GIFTS during this time period is between 65 and 75 degrees West. From this position, the entire Atlantic Ocean plus the Eastern and Central US (including the SGP ARM site) are viewable with acceptable viewing angles. Therefore, wind soundings over the central and eastern US and ARM site efforts can be continued, in addition to the opportunity to view developing tropical cyclones that may threaten the US.

During this period, GIFTS wind soundings will be performed over the Atlantic regions where tropical storms develop. In the event of an intensifying tropical cyclone, the temporal and spatial sampling of the targeted storm environment will be adapted to optimally monitor the temperature, water vapor, and wind fields.

4.3.2.5 Pacific Storms and THORPEX

During northern hemisphere Winter, winter storms in the Pacific Ocean will be targeted. In particular, collocated observations with The Hemispheric Observing System Research and Predictability Experiment (THORPEX) are desired. Given the charge of the THORPEX program outlined below, the GIFTS validation efforts would benefit greatly by including this important component, assuming GIFTS launch schedules are not severely delayed. Participation in THORPEX will strengthen the GIFTS validation for oceanic areas. GIFTS product validation would be performed using data from special THORPEX activities (aircraft and ship based observations, drifting gondola based dropsondes, aerosondes, etc.) over the Pacific Ocean.

THORPEX is envisioned as a five to ten-year, international, interagency program of theoretical and phenomenological research, atmospheric observing system development and testing, societal impact research, and experimentation with data assimilation and numerical forecasting systems. The primary objective of THORPEX is to test the hypothesis that 2 to10-day numerical forecasts of high-impact weather events can be significantly improved by adding high-quality observations in critical areas of the extra-tropical oceanic storm-tracks and other data-sparse remote areas, and that cost-effective new in-situ observing systems can be developed to provide these required observations.

THORPEX is expected to produce clear and statistically significant improvements to the most difficult forecasts of weather events with high societal impact over (at least) North America , Europe, and parts of Asia. The weather events to be considered are primarily synoptic-scale, but contain significant embedded mesoscale features, including heavy rain and snow, ice, and damaging winds. In contrast to limited-domain targeted observing programs for short-range forecasts, THORPEX aims to improve forecasts of high-impact weather over many regions of the northern hemisphere and for a wide range of forecast lead times (2 to 10 days).

THORPEX will coordinate efforts in observing system research and evaluation at civilian and military operational forecast centers, and will collaborate with other programs that require observations in remote and data-sparse regions, including Winter Storm Reconnaissance, PACJET, CLIVAR, and programs to validate and calibrate satellite observations. THORPEX will provide guidance for the design and use of future observing systems through the next decade and beyond. To maximize its influence, THORPEX will coordinate with the appropriate observing system oversight groups, including EUCOS and NAOS.

For more information on USWRP and THORPEX, see Reference [3].

5. Measurement Concept Validation Deliverables

The Measurement Concept Validation deliverable will be a final report detailing the validation efforts as described in this plan. This report will consist of the GIFTS and validation data, the validation analyses including all comparisons and relevant studies, and assessments of the GIFTS product accuracies. This includes the validation areas addressed in this plan: navigation, radiance, temperature, water vapor, winds, and trace gas retrievals, cloud property retrievals, and data compression. This report will be provided two weeks prior to Mission completion.

In addition to the final report, progress reports of the validation activities will also be provided every three months following the launch of GIFTS.

6. References

1. http://airs2.ssec.wisc.edu/astm/jul97_pvd.pdf
2. http://www.met.utah.edu/ksassen/fars.html
3. http://www.nrlmry.navy.mil/~langland/THORPEX_document/Thorpex_plan.htm.

7. Acronyms

ACARS - Aeronautical Radio Incorporated Communications Addressing and Reporting System
AERI - Atmospheric Emitted Radiance Interferometer
AIRS - Atmospheric Infrared Sounder
AMSU – Advanced Microwave Sounding Unit
ARM - Atmospheric Radiation Measurement (DOE)
CART – Clouds and Radiation Testbed
CMDL – Climate Monitoring and Diagnostics Laboratory
CNU – Christopher Newport University
CLIVAR – An International Research Program on CLImate VARiability and Prediction
CONUS - Continental United States
CrIS - Cross track Infrared Sounder
EMRD – EO-3 Mission Requirements Document
EO3 – Earth Observing 3 (NMP) Mission
EOS – Earth Observing System
ESA - European Space Agency
EUCOS – EUMETNET Composite Observing System
EUMETSAT - EUropean organization for the exploitation for METeorological SATellites
FARS - Facility for Atmospheric Remote Sensing (Univ. of Utah)

FPA - Focal Plane Array
FTS – Fourier Transform Spectrometer
FOV - Field Of View
GIFTS – Geosynchronous Imaging Fourier Transform Spectrometer
GIRD - GIFTS Instrument Requirements Document
GOES - Geostationary Operational Environmental Satellite
GPS – Global Positioning System
HIRS - High resolution Infrared Radiation Sounder
HIS - High spectral resolution Interferometer Sounder
IASI - Infrared Atmospheric Sounding Interferometer
IMG – Interferometric Monitor of Greenhouse Gases
IOMI - Indian Ocean METOC Imager
LASE – Lidar Atmospheric Sensing Experiment (LaRC)
LaRC – NASA Langley Research Center
LW - Longwave
LZA – Local Zenith Angle
M-AERI - Marine AERI
MCVP – GIFTS Measurement Concept Validation Plan
MODIS – Moderate resolution Imaging Spectroradiometer (EOS)
MOPITT – Measurement of Pollution in the Troposphere (EOS)
NAOS – North American Atmospheric Observing System Program
NASA - National Aeronautics and Space Administration
NAST-I – NPOESS Atmospheric Sounder Testbed - Interferometer
NCAR – National Center for Atmospheric Research
NEDT - noise equivalent temperature
NESR – noise equivalent spectral radiance
NMP – New Millennium Program
NOAA - National Oceanic and Atmospheric Administration
NPOESS - National Polar-orbiting Operational Environmental Satellite System
OPD – Optical Path Difference
PACJET – Pacific Landfalling Jets Experiment
PICASSO-CENA - Pathfinder Instruments For Cloud And Aerosol Spaceborne Observations-Climatologie Etendue des Nuages et des Aerosols
PSF - Point Spread Function
SAERI – Surface Atmospheric Emitted Radiance Interferometer
SDL – Space Dynamics Laboratory
SGP – Southern Great Plains (ARM site)
S-HIS – Scanning High Resolution Interferometer Sounder
SMW – Short/Midwave
TES – Tropospheric Emission Spectrometer
THORPEX - The Hemispheric Observing System Research and Predictability Experiment
TOA - Top of Atmosphere
USWRP – United States Weather Research Program
UW – University of Wisconsin-Madison

Appendix 5
Implementation Phase WBS

WBS #	WBS Description
1.0	Project Management
1.1	Project Management
1.1.4	Reviews
1.2	Planning & Control
1.3	Mission Assurance
2.0	Measurement Concept & Technology Team
2.3.1	GIFTS Project Validation Interface
2.3.2	Navigation Validation
2.3.3	Radiance Validation
2.3.3.1	Raw Radiance Data Analysis
2.3.4	Temperature and Water Vapor Validation
2.3.5	Winds Validation
2.3	Data Visualization
2.2.4.3	Onboard Data Compression Algorithms
2.3.7	Data Compression Validation
2.4.1	NMP Tech Validation and Infusion
2.4.2	GOES Tech Val & Infusion
2.4.2.1	Synthetic Data
2.4.2.1.1	Obtain Atmospheric State Data
2.4.2.1.2	Generate TOA Radiance Data
2.4.2.1.3	Document TOA Radiance Data
4.0	Payload Support
4.2.1.1	Instrument Subsystem
4.2.1.23	Testing, Evaluation & Problem Resolution

Appendix 6

IHOP 12 June 2002 Case Study Activity Plan

Contact: robert.knuteson@ssec.wisc.edu
Revision Date: 18 December 2002

1.0 Case Study Objective

The Geosynchronous Imaging Fourier Transform Spectrometer (GIFTS) will be capable of observing horizontal and vertical gradients of moisture with very high spatial and temporal resolution. To demonstrate the utility of such observations, SSEC/CIMSS will prepare a case study of an atmospheric event that occurred during the IHOP 2002 field experiment. The objective of this case study is to generate top of the atmosphere (TOA) radiances for a case study illustrating low-level convergence in a cloud-free environment leading to subsequent development of severe convective storms. The TOA radiances should be suitable for input to an instrument simulation (not included in this task).

2.0 Atmospheric State Data

The numerical weather prediction model used to simulate the convective environment is the fifth generation Penn State/NCAR mesoscale modeling system (MM5), version 3.5. The MM5 is a non-hydrostatic numerical model that integrates the full non-linear atmospheric primitive equations, and has been shown to reliably simulate the atmospheric state at horizontal resolutions of less than 5 kilometers.

2.1 Integrate RUC Data

Initial and boundary conditions for the MM5 are derived from three-hourly 10 km-resolution Rapid Update Cycle (RUC) analyses. To be able to use these analyses in the MM5, the following two tasks are necessary.

2.1.1 Obtain RUC2 data

The RUC analyses must first be obtained from researchers at Forecast Systems Laboratory (FSL) in Boulder, CO.

2.1.2 RUC2 integration into MM5

Once the RUC2 analyses have been obtained, it will be necessary to build an interface between the analysis data and the MM5 data ingest system. This task is necessary as the RUC2 is not included among the analyses supported within the MM5 system.

2.2 Perform MM5 sensitivity runs

Before running the high-resolution GIFTS/IHOP case study simulation, it will be necessary to perform sensitivity studies with the MM5. In this manner, the optimal MM5 configuration may be determined with minimal computing cost over a shorter period of time.

2.2.1 Horizontal resolution

Several simulations will be performed to assess the sensitivity of modeled moisture gradients and convection with respect to increases in horizontal resolution. The results will aid in choosing the horizontal resolution necessary to realistically reproduce the convective environment that occurred. The outcome of these experiments will additionally help to determine the temporal cost of running the full large-domain simulation on the current linux cluster.

2.2.2 Model parameterizations

In the MM5 system, there exist several different physical parameterization options. Many of these are applicable to grid resolutions on the order of a few kilometers, and it will be necessary to test each of the available options to determine which gives the most realistic performance.

2.2.3 Data Ingest

In addition to the RUC analysis data, measurements taken during the IHOP field campaign can be ingested into the MM5 during the simulation. Sensitivity studies must be performed to empirically determine the proper weighting parameters to be used in the observation ingest.

2.3 Execute model and monitor performance

Once the RUC data interface has been built and the optimal model configuration determined, the MM5 simulation must be set up and initiated. There exist several steps in the MM5 setup process:

- Determine the aerial extent of the domain
- Ingest RUC data
- Horizontally interpolate RUC data to the MM5 model domain
- Vertically interpolate initial analysis to model terrain-following sigma coordinates

After the MM5 setup is completed, the simulation may be initiated and run. During the simulation, the model must be periodically checked to ensure that the simulation is progressing in a realistic manner. To properly simulate the complex dynamics of CI conditions, 60 vertical levels will be used for this work rather than the usual 36.

2.4 Conform MM5 output to Fast Model

After the atmospheric simulation finishes, output from the MM5 must be converted into a format that can be interfaced with the GIFTS fast model.

3.0 Top of the atmosphere (TOA) Radiance Data

A regression transmittance calculation fast model will be used to calculate TOA radiances for each profile. The regression coefficients used in this model have been previously determined with LBLRTM calculations for 32 sample profiles.

3.1 Assess the Quality of the Input Profiles

Prior to execution of the fast model, input temperature and moisture profiles from the MM5 model will be tested to make sure that they do not exhibit discontinuities or other artifacts which will cause difficulties in running the fast model.

3.2 Execute Fast Model

Set up and run the fast model on the MM5 profiles. Collect input data into a standard netCDF format for archiving.

4.0 Documentation and Data delivery

The deliverable for this task will consist of two sets of simulated top of atmosphere radiance spectra (not including instrument effects) for the GIFTS SMW and LW bands at a spatial resolution of 4-km at a nominal spectral resolution of ~0.6 cm^{-1}. The data will be provided in netCDF format together with supporting documentation.

The radiance datacubes will each have the following characteristics:

- Spatial extent: 512 km by 512 km

- Timesteps (all times approximate; subject to change)

  30-minute intervals for the entire domain (12 UTC June 12 to 6 UTC June 13, 2002, 18 hour time period).

  A single subset cube for the CI region at 5-minute intevals for the entire time period (12 UTC June 12 to 6 UTC June 13).

The deliverables for this task are shown in Table 1. The preliminary datasets will be provided as early as possible in order to obtain customer feedback. The delivery dates for the preliminary datasets are indicated in Table 1 as "First release". The "Second release" or final datasets will be provided approximately three months later. The budget estimate for the "Second release" assumes that relatively minor changes are required to finalize the datasets.

Deliverable	**Due Date**
TOA Radiance Dataset #1 (First release)	Nov 15, 2002
TOA Radiance Dataset #2 (First release)	Sept 30, 2003
TOA Radiance Dataset #1 (Second release)	Feb 15, 2003
TOA Radiance Dataset #2 (Second release)	Oct 31, 2003

Table 1: TOA Radiance deliverables as they appear in Modification 16 to the NASA/UW contract.

Input data (i.e., arrays of temperature and water vapor profiles) will be included as part of the deliverable package.

4.1 Produce documentation

Documentation will be provided with the data set and will include, at a minimum:

- Synoptic description of the convective initiation event
- GOES-8 visible imagery at approximately half-hourly intervals from 19:32 UTC through 23:02 UTC showing the event.
- The settings of user-adjustable switches used in the MM5 calculations.
- MM5 and fast model version numbers.
- Datafile header examples

4.2 Manage data distribution and archiving

This sub-task covers data handling processes, including file management, production and shipping of CD-ROM(s) or file transfer support, and maintenance of internal long-term storage systems.

5.0 Computing Resource Requirements

5.1 Hardware Specification

SSEC currently has a commercial off-the-shelf (COTS) cluster comprised of 8 dual-processor PC computing nodes using commodity gigabit-ethernet interconnect fabric, which can be made available for much of the MM5 simulation work. Four additional nodes are available within the cluster by way of case-by-case cooperation with other programs within the center. This computing facility has demonstrated strong utility and economy for a variety of purposes.

To make generation of the radiance data feasible, additional hardware will need to be added to the existing infrastructure. An additional 16 compute nodes of equivalent capability to the existing nodes can be integrated in a matter of hours. This will significantly improve capacity of the system to service the extremely memory-, CPU- and interconnect-intensive nature of the atmospheric modeling required, and process jobs in a timely manner. Additionally, storage for the large volume of resulting data will be provided by a COTS storage server providing 2 terabytes of online, redundant storage.

5.2 Hardware Acquisition and Setup

This hardware will be purchased through UW contract vendors, and/or through bid to commodity system builders. It will be installed, configured and maintained by SSEC technical computing and engineering staff members. Hardware will be supported by on-site vendor service through at least a 2-year warranty period.

15.406-2 Certificate of Current Cost or Pricing Data.

(a) When cost or pricing data are required, the contracting officer must require the contractor to execute a Certificate of Current Cost or Pricing Data, using the format in this paragraph, and must include the executed certificate in the contract file.

Certificate of Current Cost or Pricing Data

This is to certify that, to the best of my knowledge and belief, the cost or pricing data (as defined in section 2.101 of the Federal Acquisition Regulation (FAR) and required under FAR subsection 15.403-4) submitted, either actually or by specific identification in writing, to the Contracting Officer or to the Contracting Officer's representative in support of Mo#16 of contract NAS1-00072* are accurate, complete, and current as of January 8th, 2003**. This certification includes the cost or pricing data supporting any advance agreements and forward pricing rate agreements between the offer or and the Government that are part of the proposal.

Firm Board of Regent of the University of Wisconsin System

Signature ____________________

Name: John P. Roberts

Title: Assistant Director—Space Science and Engineering Center

Date of execution:*** January 8th, 2003

* Identify the proposal, request for price adjustment, or other submission involved, giving the appropriate identifying number (e.g., RFP No.).

**Insert the day, month, and year when price negotiations were concluded and price agreement was reached or, if applicable, an earlier date agreed upon between the parties that is as close as practicable to the date of agreement on price.

*** Insert the day, month, and year of signing, which should be as close as practicable to the date when the price negotiations were concluded and the contract price was agreed to.

(End Of Certificate)

(b) The certificate does not constitute a representation as to the accuracy of the contractor's judgment on the estimate of future costs or projections. It applies to the data upon which the judgment or estimate was based. This distinction between fact and judgment should be clearly understood. If the contractor had information reasonably available at the time of agreement showing that the negotiated price was not based on accurate, complete, and current data, the contractor's responsibility is not limited by any lack of personal knowledge of the information on the part of its negotiators.

(c) The contracting officer and contractor are encouraged to reach a prior agreement on criteria for establishing closing or cutoff dates when appropriate in order to minimize delays associated with proposal updates. Closing or cutoff dates should be included as part of the data submitted with the proposal and, before agreement on price, data should be updated by the contractor to the latest closing or cutoff dates for which the data are available. Use of cutoff dates coinciding with reports is acceptable, as certain data may not be reasonably available before normal periodic closing dates (e.g. , actual indirect costs). Data within the contractor's or a subcontractor's organization on matters significant to contractor management and to the Government will be treated as reasonably available. What is significant depends upon the circumstances of each acquisition.

(d) Possession of a Certificate of Current Cost or Pricing Data is not a substitute for examining and analyzing the contractor's proposal.

(e) If cost or pricing data are requested by the Government and submitted by an offeror, but an exception is later found to apply, the data shall not be considered cost or pricing data and shall not be certified in accordance with this subsection.