Chapter 1. Overview of the 2003 Pacific TOST

1.0 Introduction.

The 2003 Pacific THORPEX Operational Science Test, http://www-angler.larc.nasa.gov/thorpex/ is the first in a series of Pacific and Atlantic observation campaigns in support of the WWRP/USRP THORPEX Program. THORPEX – a Global Atmospheric Research Program, is a 10 year international research program under the auspices of the World Meteorological Organization/World Weather Research Program (WMO/WWRP) to accelerate improvements in short range (up to 3 days), medium range (3-7 days) and extended range (two week) weather predictions and the societal value of advanced forecast products. THORPEX will examine predictability and observing system issues, and establish the potential to produce significant statistically-verifiable improvements in forecasts of high impact weather. The program builds upon and coordinates advances being made in the operational forecasting and basic research communities.

1.1 THORPEX Objectives

THORPEX objectives are, 1) to evaluate the potential of various in situ and remote sensing observation systems to provide the observations needed to accelerate improvements in operational weather predictions, 2) to evaluate model sensitivity studies and test the impact of targeted observations by participant systems on the performance of those operational models, and 3) to begin to acquire the observational data needed to develop intelligent observing systems and the models and data assimilation systems that will interact dynamically with those observing systems.

1.2 Collaborating organizations and research groups

Collaboration is a hallmark of this TOST. Complimentary measurements are provided by the various ground-, airborne-, and space based observing systems participating in the campaign. These measurements provide information that can be used directly as targeted input to operational forecast models, as validation data for observing system evaluations or as research data for nowcasting, forecasting and numerical model data assimilation research.

1.2.1 NOAA Winter Storms Research Program Overview

The purpose of the NOAA WSRP is to reduce uncertainty in 24-96 hour forecasts for specific weather events associated with potentially large societal impact over the continental US and Alaska by taking supplemental adaptive observations

over the northeast Pacific ocean. These observations are based on the use of nonlinear ensemble forecasts generated operationally on a daily basis at NCEP and ECMWF. Ensemble members are linearly combined in such a way that their variance is reduced at observation time over the observational area. The same linear combination is used at verification time to see where the variance in the transformed ensemble is reduced. All possible pre-designed flight tracks are considered and the one where the dropsondes are expected to reduce forecast error variance at verification time within the verification region most is selected. As such, this highly effective program constitutes a particularly complimentary effort to THORPEX by directly providing a significant subset of THORPEX's overall objectives. WSRP flight requests have to be issued 24 hours in advance of take-off so flight planning usually takes place 36-48 hours in advance of the actual flights. For general planning purposes, the flight facilities also require a general outlook for the second day (i. e., whether a flight is expected or not). To prepare such an outlook, sensitivity calculations need to be run 60-72 hours before flight time. WSRP uses a series of pre-selected tracks to obtain their targeted observations. These tracks are shown in figure 1.1 below. The WSR program can be found at:
http://wwwt.emc.ncep.noaa.gov/gmb/targobs/target/wsr2003.html .

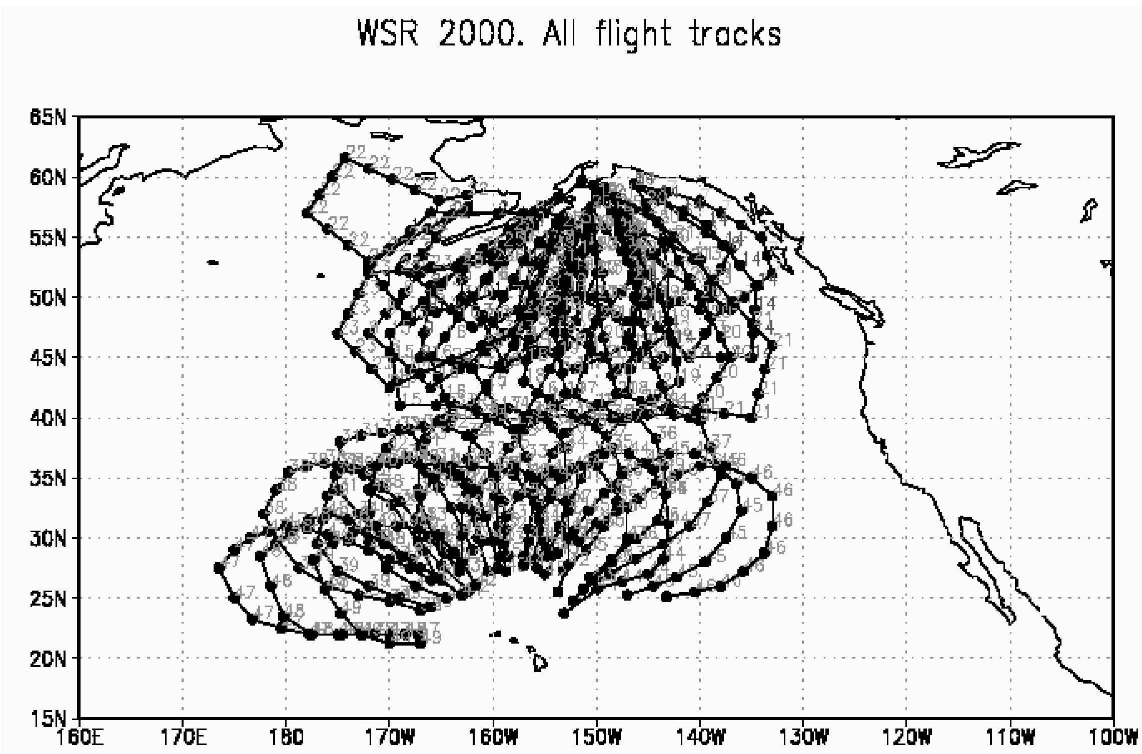

Figure 1.1. NOAA Winter Storm Research Program Flight Tracks

1.2.2 NASA EOS Program Objectives – TERRA, AQUA and ICESat Validation

Aqua underflights are incorporated into the THORpex field campaign plan to assess MODerate resolution Imaging Spectroradiometer (MODIS) and Atmospheric Infrared Sounder (AIRS) L1B and L2 science products from the Aqua satellite. MODIS and AIRS science products including earth-atmosphere radiance, atmospheric profiles (temperature and moisture), cloud top heights, cloud coverage or mask, and cloud particle phase are being collected globally and studied for signatures of Global Climate change under NASA's Earth Science Enterprise. During the experiment, data will be collected from a NASA high altitude (20 km) ER-2 aircraft equipped with remote sensing instruments looking down at the earth's atmosphere and surface. Optimally, the ER-2 will be flown underneath Aqua (Figure 1) on each ER-2 mission, collecting measurements that can be compared directly to the MODIS and AIRS science products.

Comparisons of ER-2 based and Aqua based observations will be used to demonstrate the accuracy of the satellite products for usage in monitoring long term Global Climate change as well as suggest ways of fine tuning the MODIS and AIRS science product algorithms. One of the most important unknowns in Global Climate prediction is the percentage and type of cloud cover over the global domain. Greenhouse gas warming of the earth-atmosphere system is expected to increase the atmospheric water vapor content, providing new material for the development of clouds (2°C temperature increase translates to 10% more water vapor holding capacity in the atmosphere). This additional water vapor may reside as vapor in the atmosphere (a very effective heat trapping gas), be condensed into low to mid level water droplet clouds, or be transported in thunderstorm updrafts to cold upper tropospheric levels where it will reside as cirrus cloud (ice particles). The physical state of the water (gas, liquid, solid) is an important consideration as vapor, water clouds and ice crystal clouds all have different influences on the radiation budget. Water vapor is a highly efficient heat trapping gas (approximately 10 times more effective than CO_2); water clouds are very effective sunlight reflectors and are thought to lead to a net cooling effect on the global climate, though this is not proven. Ice clouds meanwhile are thought to be net heat trapping clouds, as much of the incident sunlight is transmitted and scattered downward into the earth-atmosphere system heating the earth. MODIS and AIRS are both designed to provide insight on global cloud and atmospheric water vapor and temperature trends. However, before the L1B and L2 science products can be confidently interrogated for global change signatures, the accuracy of the science products must be demonstrated.

The radiometric accuracy of the recently (May 2002) launched Aqua MODIS and AIRS instruments will be evaluated to diagnose any fine tuning of the thermal infrared (TIR) band calibration. MODIS cloud products and AIRS atmospheric temperature/moisture profiles from Aqua will be evaluated. A recent ER-2 experiment named TX-2002 (fall, 2002 based in San Antonio, TX) was used to evaluate L2 MODIS cloud products from Terra; THORpex extends the evaluation to Aqua. ER-2 based observations by MAS, S-HIS, and NAST-I instruments measure upwelling TIR radiance from the earth-atmosphere system in much the same way that MODIS and AIRS measure the earth-atmosphere system. The MAS instrument provides high spatial resolution (50 m) data for revealing the MODIS 1 km subpixel variation. S-HIS and NAST-I provide high spectral resolution data and excellent radiometric accuracy to which MODIS and AIRS TIR band calibration assessments are ultimately pinned. Together, NAST-I (infrared) and NAST-MTS (microwave) form a complement to characterize atmospheric temperature/moisture in clear and cloudy scenes. Dropsondes from the NOAA G-IV aircraft will contribute to this characterization. The CPL (lidar) measurements include cloud parameters such as cloud height, thickness, optical depth, and cloud particle phase (ice or liquid water); these highly accurate measurements from CPL will be directly compared to MODIS L2 cloud products. This activity will contribute to bridging early years of NOAA/NESDIS satellite observations to the latter day observations of NASA's Terra and Aqua satellites, extending the data record from years to decades, and facilitating the task of uncovering Global Climate change signatures.

THORPEX is the fifth in an ongoing series of ER-2 field experiments designed in part to assess MODIS and AIRS L1B TIR band calibration and science products. The WISC-T2000 (Madison, WI, March 2000), SAFARI-2000 (Pietersburg, SA, Aug/Sep. 2000), TX-2001 (San Antonio, TX, March 2001), and TX-2002 (San Antonio, TX, November 2002) experiment data sets have contributed to the MODIS TIR band calibration and L2 product assessment on Terra. THORPEX will make a new contribution to EOS product validation by providing exclusive measurements (by advanced instrumentation) of tropical and midlatitude cloud systems and the atmosphere over the expansive water background of the Pacific ocean, with it’s attendant climatic characteristics, for an assessment of Aqua MODIS and AIRS L1B and L2 science products.

Satellite validation requires precise coordination with satellite orbital ephemerii. This is especially challenging since the target satellites, AQUA (and TERRA) and ICESat are in opposition in ascension and descension. This will provide for approximately six dual satellite validation opportunities between AqQUA and ICESat during the campaign exclusive of any WSRP considerations. It is anticipated that single satellite validation measurements will probably be the norm and that sufficient opportunities will exist for validation studies for both satellites. In the event that opportunities become limited, AQUA will have first priority, however every attempt will be made to accommodate ICESat.

Underflights of GLAS on ICESat will be used to verify performance of the 1064 nm laser after initial turn-on about Feb 17. The 532 nm laser is anticipated to become active on about March 1. Scenes of thick broad cloud coverage provide good validation opportunities as these cases minimize uncertainties associated with co-location of sensors. All scenes are however considered useful validation targets early in the operation of GLAS. A significant challenge of GLAS validation is to pulse the CPL beam from the ER-2 into the narrow 120 m wide swath of GLAS on ICESat. The Inertial Navigation System on the ER-2 is anchored to GPS and is anticipated to be able to meet this challenge though external forcings on the ER-2 aircraft (e.g. crosswinds, ambient temperature fluctuations) always influence the aircraft positioning and 3-axis orientation on short timescales.

1.2.3 IPO Objectives – National Polar Orbiting Environmental Satellite System (NPOESS) Atmospheric Sounder Test-bed (NAST) Data Validation

The objectives of NAST are to, 1) simulate candidate instruments for NPOESS: CrIS, ATMS satellites, 2) evaluate key Environmental Data Records (EDRs) algorithms, 3) preview high-resolution products—spectral and spatial and to 4) provide flight validation of operational satellites. The NAST-I is a high-resolution interferometric sounder which retrieves upwelling atmospheric radiance in the 3.6 to 17 micrometer spectral range. The NAST-MTS is a 28 channel microwave temperature sounder that flies with the NAST-I.

The following science measurements will be made by the NAST-I:

- Infrared and microwave spectral radiance
- Atmospheric thermodynamic properties
- Surface temperature and emissivity features
- Precipitation characteristics
- Cloud properties: spectral radiance, phase, optical depth, and microphysical properties (particle size) and geometrical properties (height and depth)
- Trace species (e.g. CO & O_3) and aerosol amounts
- Aviation safety meteorological parameters (associated with, e.g., turbulence and icing conditions)

The following validation [radiance, geophysical, sensor, new research products] objectives will be pursued:

- Validate radiance measurements, forward radiative transfer models, and retrieval algorithms of existing research (e.g., Aqua AIRS/AMSU/HSB and

Terra/Aqua MODIS) and forthcoming experimental and operational remote sensing systems (e.g., CrIS/ATMS and GIFTS)

- Compare remotely sensed NAST thermodynamic state parameters, species amounts, and cloud and aerosol characteristics with those from Terra, Aqua, ICESat, and GOES and in-situ data, including drop-sonde observations from the NCAR drifting gondola along with dropsonde and in-situ ozone from the G-4 aircraft (i.e. radiometric versus in-situ determination)
- Airborne sensor intercomparison: ER-2 (NAST-I, NAST-M, S-HIS, MAS, CPL, in-situ ozone)
- Turbulence, icing, winds, etc. (ASAP support).

These objectives will be pursued through:

1. Temporal & spatial coordination with NOAA G-4
   –horizontal leg overflight of high-density dropsondes across H_2O gradient
   –vertical ascents/descents coincident with in-situ measurements of interesting O_3 structure (trop. fold event, i.e. strat-trop exchange)
   –Remote turbulence characterization

2. Overflight of ground-based facilities
   –Radiosondes, buoys, etc.
   –ER-2 racetrack pattern over UNH wind LIDAR

3. Underflight of satellite-based sensors
   –e.g. Terra & Aqua coincident observations in clear to partly cloudy
   –Compare NAST-I-derived cloud & aerosol spatial distribution information with that from CPL and ICESat (GLAS)

4. Overflight mapping of main island
   –Volcanic emissions (H_2O, CO_2, SO_2, H_2S)
   –Mauna Loa & Mauna Kea observatories (FTIR, LIDAR, GPS PW, etc.)

1.2.4 NASA ASAP Objectives – Aviation Weather Product Development

The objectives of ASAP are 1- to fill a critical gap in the integration of current Geostationary Operational Environmental Satellite GOES imagery and sounding data in the production of operational aviation weather products that are developed by the FAA Aviation Weather Research Program (AWRP) and 2- to bridge the gap between developing aviation weather products using current satellite imagery and sounding data to integrating the next generation of of high-resolution, hyperspectral satellite data into aviation weather product development. ASAP will fundamentally employ data obtained by the NPOESS Airborne Sounder Test-bed (NAST) and Scanning Hyperspectral Infrared Sounder (S-HIS) instruments, the Airborne Infrared Sounder (AIRS), the Cross-track Infrared Sounder (CrIS) as well as Polar and Geostationary Orbiting

Environmental Satellites (POES and GOES). The goal of these efforts is to support FAA AWRP Product Development for ground and airborne product production and to conduct applications product demonstrations including a NASA Geosynchronous Imaging Fourier Transform Spectrometer (GIFTS) AWIN demonstration in FY2007.

Since the NASA ASAP project is developing applications for hyperspectral sounding data such as that which the NASA New Millenium Program's EO3 GIFTS Project will provide. The production of a high quality simulated hyperspectral sounding data cube is a key ASAP objective of this campaign. The success of the first Pacific THORPEX Operational Science Test is particularly important to the GIFTS Project since THORPEX will be the primary over-water validation experiment for the GIFTS satellite during its validation year and the THORPEX program has identified GIFTS and its operational successor, GOES-R as key observing systems. This year's field campaign presents an opportunity to collect data for the production of simulated GIFTS data cubes that will aid in the production and testing of the GIFTS instrument. It is an invaluable opportunity to develop and refine the field measurement process that will take place during GIFTS validation.

1.3 Resource summary

1.3.1 NOAA Gulfstream IV

The NOAA G-IV is a state of the art, high altitude research platform with a certified ceiling of 45,000 ft (12 km), range of 4075 nm (7000 km) and true air speed of 440 kt (240 m/sec). Aircraft position and attitude is provided by a high altitude radar altimeter, GPS-PPS (precision positioning system) and flow angle pressure transducers. Primary instrumentation includes a PRT-5 downward radiometer and a C-band nose radar. Soundings of basic meteorological state parameters (temperature, humidity and wind) are provided by the Airborne Vertical Atmospheric Profiling System (AVAPS). Onboard data processing is performed by two systems – Main Aircraft Data System (MADS) or Hurricane Analysis Processing System (HAPS). Communications equipment include SATCOM, HF, UHF, and VHF radio communication

1.3.1.1 AVAPS Dropsonde recorder and processor

The NCAR GPS Dropsonde system, also known as AVAPS (Airborne Vertical Atmospheric Profiling System), debuted in 1997. It has flown on numerous missions in support of operational weather forecasting and atmospheric research. AVAPS uses dropwindsonde and Global Positioning System (GPS) receivers to measure the atmospheric state parameters during the its descent.

Dropwindsondes measure vertical profiles of pressure, temperature, humidity, and wind during their descent through the atmosphere.

□

1.3.1.2 NOAA Aeronomy Laboratory

The Aeronomy Laboratory (AL) conducts fundamental research on the chemical and physical processes of the earth's atmosphere, concentrating on the lower two layers□known as the troposphere and stratosphere. Through laboratory, modeling, and field research, AL scientists are advancing the scientific understanding of chemical and physical processes related to the ozone layer, the□climate system, and air quality. The overall aim of Aeronomy Laboratory research is to improve the capability to observe, understand, predict, and protect the quality of the atmosphere.

1.3.2 NASA ER-2

The ER-2 is a civilian version of the Air Force's U2-S reconnaisance platform. These high-altitude aircraft are used as platforms for many investigations that cannot be accomplished by sensor platforms of the private sector. Aircraft and spacecraft have proven to be excellent platforms for remote and *in situ* sensing. The ER-2, flying at the edge of space, can profile the atmosphere very much the same way as a satellite.

The Lockheed ER-2 was developed for the National Aeronautics and Space Administration (NASA), to serve as a high altitude scientific research aircraft. The ER-2 designation was first applied to NASA's version of the U-2C model. NASA has since acquired and used the U2-R or TR-1 model, but has retained the ER-2 descriptor. The ER-2 differs from the U.S. Air Force's U-2 in the lack of defensive systems, absence of classified electronics, completely different electrical wiring to support NASA sensors, and, of course, a different paint scheme.

The ER-2 is an extremely versatile aircraft well suited to multiple mission tasks. The ER-2 is thirty percent larger than the original U-2 with a twenty foot longer wingspan and a considerably increased payload over the older airframe. The aircraft has four large pressurized experiment compartments and a high capacity AC/DC electrical system, permitting a variety of payloads to be carried on a single mission. The modular design of the aircraft permits rapid installation or removal of payloads to meet changing mission requirements. The ER-2 has a range beyond 3,000 miles (4800 km); is capable of long flight duration and can operate at altitudes above 70,000 feet (21.3 km) if required. A summary of the aircrafts operating characteristics follows in table 1.1.

Crew:	One Pilot
Length:	62 feet, 1 inch
Wingspan:	103 feet, 4 inches

Engine:	One Pratt & Whitney J75-P-13B
Altitude:	70,000 feet
Range:	2200 nautical miles, 3000 on exception
Duration:	6.5 hours, 8 hours on exception
Cruise Speed:	~400 knots above 65,000 feet altitude ~210 meters/sec

Table 1.1. ER-2 Characteristics

During the three weeks of THORPEX, the ER-2 will fly approximately ten missions in the 0° - 40°latitude belt of the central Pacific Ocean. The ER-2 payload will consist of the MODIS Airborne Simulator (MAS), the Scanning High-resolution Interferometer Sounder (S-HIS), the NPOESS Atmospheric Sounder Testbed – Interferometer (NAST-I) and – Microwave Temperature Sounder (NAST-MTS), the Cloud Physics Lidar (CPL) and a fast in situ ozone probe.

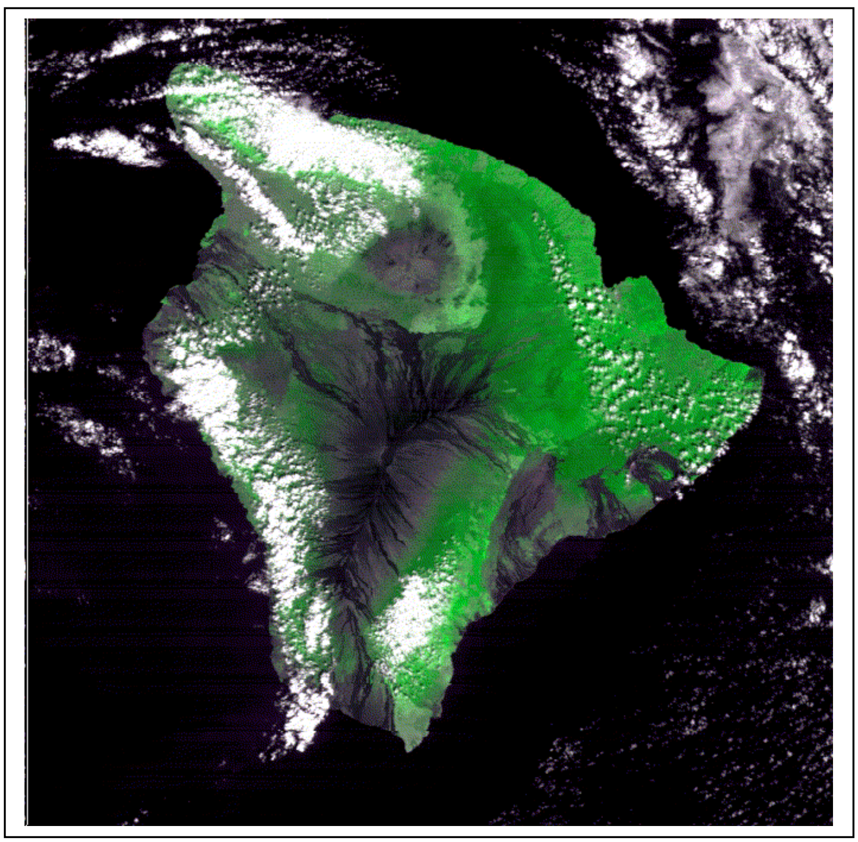

Figure 1.2 MODIS 250 m 013101

1.3.2.1 MODIS Airborne Simulator

The MODIS Airborne Simulator (MAS) is a 50 channel (VNIR – TIR) airborne scanning spectrometer that acquires high spatial resolution imagery of cloud and surface features from its vantage point on-board a NASA ER-2 high-altitude research aircraft. MAS collects 50 m (nadir) spatial resolution data across a 37 km swath (+/- 43° view angle) from the nominal ER-2 20 km altitude. MAS uses dichroics and four gratings to separate upwelling earth scene radiance into VNIR (9 channels: 0.47 – 0.96 μm), SWIR (16 channels: 1.6 – 2.4 μm), MWIR (16 channels: 3.1 – 5.3 μm) and LWIR (9 channels: 8.5 – 14.2 μm) spectral regions.

MAS reflectance channels (VNIR, SWIR) are calibrated using laboratory measurements collected from a calibrated integrating sphere at NASA Ames Research Center (ARC) both before and after aircraft deployments. These measurements are supplemented by ground-based measurements collected during pre-flight of each ER-2 mission. Thermal IR channels (MWIR, LWIR) are calibrated using two flat plate onboard blackbody sources, one of which is typically heated to about 20°C, the other being allowed to settle to ambient conditions at altitude in the scan cavity of the MAS scan assembly. Blackbody emissivity is characterized periodically in a laboratory setting to maintain performance. The onboard blackbodies are viewed on each scan line; an additional view upward into the MAS scan head is used to characterize background radiance in the scan cavity for use in the L1B calibration algorithm. MAS TIR band radiometric calibration accuracy is about 0.5 to 1.0°C depending on channel (best in window bands); however, MAS accuracy can be improved to within 0.5°C through comparisons to co-incident S-HIS and NAST-I observations. MAS reflectance channel calibration accuracy is conservatively estimated to be within 10%.

MAS is spectrally calibrated before deployments at the NASA ARC facility using both monochromator-based and FTIR-based measurements. The four gratings are each aligned to specific spectral positions. These measurements are repeated at ARC after the ER-2 deployment to confirm that the spectral characterization has not changed during the deployment.

Data acquired by the MAS have been a key element in defining, developing, and testing science product algorithms for the Moderate Resolution Imaging Spectroradiometer (MODIS), a key sensor of NASA's Earth Observing System (EOS). MAS continues to function as a validation tool in complement with the S-HIS, NAST-I, and CPL instruments for MODIS and AIRS L1B and L2 science products. The MODIS and AIRS programs emphasize the use of remotely sensed data to monitor variation in environmental conditions for assessing both natural and human-induced global change.

1.3.2.2 Scanning High-resolution Interferometer Sounder

The Scanning High-resolution Interferometer Sounder (S-HIS) is a scanning interferometer which measures emitted thermal radiation at high (0.5 cm^{-1}) spectral resolution between 3.3 and 18 microns (specifications). The measured emitted radiance is used to obtain temperature and water vapor profiles of the Earth's atmosphere. S-HIS produces sounding data with 2 kilometer resolution (at nadir) across a 30 kilometer ground swath (+/- 35° view angle) from a nominal altitude of 20 kilometers onboard a NASA ER-2 aircraft or 15 kilometer ground swath from a nominal altitude of 10 kilometers aboard the NASA DC-8 aircraft.

The S-HIS radiometric accuracy is a key component of its usage in validating science products from MODIS and AIRS. S-HIS is calibrated in flight using two onboard high emissivity (.996, known to within .001) cavities with temperature knowledge to better than 0.1 K. The S-HIS in-flight reference cavities have been characterized using National Institute of Standards and Technology (NIST) traceable standards. The S-HIS scene mirror surface is gold coated to minimize reflectance variation and polarization as a function of scan angle. The performance of S-HIS has been routinely tested in the laboratory environment to ensure ongoing high accuracy radiances during in-flight data collection. These tests include component characterization as well as system testing such as data collection over ice baths, and side by side comparisons with other interferometers. A typical radiometric uncertainty of the S-HIS observations using the estimated uncertainty of S-HIS cavity performance (i.e. 0.1 K for cavity temperature, 0.001 for cavity emissivity) during in-flight data collection conditions is less than 0.2 K for atmospheric window regions and less than 0.3 K for atmospheric absorption regions (some exceptions for saturation on strong absorption lines).

1.3.2.3 NPOESS Atmospheric Sounder Testbed

The National Polar-orbiting Operational Environmental Satellite System (NPOESS) Aircraft Sounder Testbed – Interferometer (NAST-I) is a high resolution Michelson interferometer, developed at MIT Lincoln Laboratory, that derives its heritage from the non-scanning High resolution Interferometer Sounder (HIS) developed by researchers at the University of Wisconsin. The NAST-I instrument scans the earth from beneath the ER-2 with a nominal spatial resolution of approximately 2.5 km with a total of 13 earth views in the cross-track direction (the resultant swath width covers about 45 km). The unapodized spectral resolution of NAST-I is 0.25 1/cm within a 590-2810 1/cm (3.6-17 micron) spectral range. The instrument flies in the right superpod of NASA's high altitude ER-2 research aircraft. The infrared radiance measurements obtained from the NAST-I instrument will provide detailed spectral characteristics of the atmosphere and land surface along with providing detailed atmospheric temperature and water vapor profiles derived from either physical or regression based retrieval algorithms.

The National Polar-orbiting Operational Environmental Satellite System (NPOESS) Aircraft Sounder Testbed- Microwave Temperature Sounder (NAST-MTS) is an aircraft-mounted Microwave Temperature Sounder. The instrument, built by Massachusetts Institute of Technology's Research Laboratory of Electonics (RLE), is about the size of a footlocker, and is mounted inside the forward section of one of the wing mounted 'superpods' of the NASA ER-2 aircraft. NAST-MTS is a scanning radiometer which sweeps from side to side viewing a path that is sixty five degrees either side of nadir. MTS covers 16 microwave frequencies in the vicinity of 54 gigahertz and 118 gigahertz in each of its scans. This results in an image that is approximately 80 kilometers wide measured from the aircraft altitude (~20km). The radiometer 'sees' in the microwave portion of the elecromagnetic spectum. Images produced by the instrument represent the thermal radiation emitted by the environment at these microwave frequencies. Each microwave frequency responds differently to temperatures at different altitudes as well as to the different constituents such as water vapor, precipitation and ice. By combining the information gathered from MTS with information derived from the sensors in both the visible and infrared regions of the spectrum, the structure and composition of the atmosphere in the field of view as well as surface characteristics may be determined. Since microwave frequencies penetrate clouds much more readily than do infrared or visible, internal structure becomes apparent. By measuring the location, intensity

1.3.2.4 Cloud Physics Lidar

The Cloud Physics Lidar (successor to the Cloud Lidar System) is an airborne lidar system designed specifically for studying clouds and aerosols using the NASA ER-2 aircraft. Because the ER-2 typically flies at 65,000 feet (20 km), its instruments are above 94% of the earth's atmosphere, thereby allowing ER-2 instruments to function as spaceborne instrument simulators. The Cloud Physics Lidar provides a unique tool for atmospheric profiling and is sufficiently small and low cost to include in multiple instrument missions.

The Cloud Physics Lidar provides a complete battery of cloud physics information. Data products include:

- Cloud profiling with 30 m vertical and 200 m horizontal resolution at 1064 nm, 532 nm, and 355 nm, providing cloud location and internal backscatter structure.
- Aerosol, boundary layer, and smoke plume profiling at all three wavelengths.
- Depolarization ratio to determine the phase (e.g., ice or water) of clouds using the 1064 nm output.
- Cloud particle size determined from a multiple field-of-view measurement using the 532 nm output (off-nadir multiple scattering detection).

- Direct determination of the optical depth of cirrus clouds (up to ~OD 3) using the 355 nm output.

The CPL provides information to permit a comprehensive analysis of radiative and optical properties of optically thin clouds. To determine the effects of particulate layers on the radiative budget of the earth-atmosphere system certain information about the details of the layer and its constituents is required

1.3.2.5 Langley In Situ Fast-Response Ozone Measurements

The In Situ Fast-Response Ozone sensor is capable of fast, sensitive ozone measurements over a large dynamic range and a wide variety of atmospheric conditions. The measurements are performed by combining pure reagent nitric oxide (NO) with incoming sample air in a small volume reaction chamber, and by measuring the resulting chemiluminescence. This chemiluminescence is light emitted in the near-infrared spectral region by relaxation of nitrogen dioxide (NO2) that has been excited by the chemical reaction of NO and ozone (O_3) in the sample. The chemical equations for this set of reactions are:

(1) $NO + O_3$ ® $O_2 + NO_2^*$

(2) NO_2^* ® NO_2 + hn

This technique is very well established [Pearson and Stedman, 1980, Gregory et al., 1987, Eastman and Stedman, 1997] and is a reverse application of a standard nitric oxide (NO) detection technique [Clough and Thrush, 1967]. The near-infrared light emitted by relaxation of the excited NO_2 (chemiluminescense) is measured with a sensitive photocathode and photomultiplier tube (PMT). The amplified signal from the PMT is proportional to the amount of O_3 in the sampled air.

The reaction chamber is maintained at constant temperature and pressure (17 Torr) and sampled air enters the aircraft through a forward-facing, J-shaped probe. Sample flow from the prechamber into the reaction chamber is 500 cm^3/minute. We maintain a laboratory reference O_3 photometer that is regularly taken to NIST for intercomparison with their standard O_3 photometer. The residual between the NIST-referenced linear regression and our O_3 measurements in the laboratory is 1 ppbv or less over the range of our measurements.

Technique	Chemiluminescent Reaction of Ozone with Nitric Oxide
Dynamic Range	0.5 – 3500 ppbv
Accuracy	5 percent or 5 ppbv
Precision	3 percent pr 2.5 ppbv
Response Time	2-3 Hz

Data Rate	1 Hz
Spatial Resolution	~200 m horizontal (vertical – depends on ascent rate)
Weight	260 lbs
Power Required	Less than 10 A 110V/60 Hz

Table 1.2 Ozone Instrument Specifications

1.3.3 NCAR ATD Driftsonde System

The engineering activities associated with the driftsonde development have focused on developing the onboard electronics, a communication system for sending instructions to the driftsonde and transmitting data back to earth, design of the gondola, design of the balloon and associated safety systems (transponder, parachute, and the method for balloon cut-down). The first test of the driftsonde balloon, electronics, and communication system took place on February 28th 2002 from the balloon manufacturer's facility (GSSL) in Tillamook, Oregon. This first test flight was very successful and verified proper operation of the onboard computer system, sensor system, ballast control system, battery power system, partial verification of the satellite communication system, and confirmation of the passive thermal control of the electronics. There were no dropsondes launched during this first test. Complete system testing, including the dropping of sondes took place with two short duration flights (48 hour) in the fall of 2002 (October/November) and early 2003 (January) from the balloon manufacture's facility in Tillamook, Oregon. At the completion of these tests the system completed prototype testing and is underwent final modifications prior to the 2003 Pacific TOST. These tests included the first attempt at developing the operational procedures for balloon inflation and launch as well as onboard dropsonde data processing, data communication through the satellite to a ground station and placement of the data on the Global Telecommunications System (GTS).

The driftsonde system objectives for the 2003 Pacific TOST are to further explore the overall utility of observing system within the context of the THORPEX program and to assess its utility in satellite data validation and applications efforts being conducted by NASA, who is sponsoring the driftsonde deployment. The TOST will employ two driftsonde systems to drop GPS dropsondes over the Pacific Ocean. The two driftsonde flights over the Pacific Ocean from the GSSL launch facility in Hawaii will be coordinated with proof of concept test flights with airborne remote and in situ sensors and dropsondes as scientific tools for the refinement of driftsonde operations. The deployment is for two gondolas and 40 dropsondes total (20-per flight). ATD technical staff and two staff members from GSSL will go to Hawaii to run the launch and monitor the system to help reduce the chance of failure and to continue the development of the operational launch techniques. The following is a list of the key activities associated with the 2003 Pacific TOST driftsonde operation.

- RTF and two GSSL technical staff will go to Hawaii to assemble and launch the driftsonde balloon systems.
- RTF data management and engineering staff will monitor the flight and process the data.
- The data will be inserted into the GTS in near-real-time and provided to the PI.
- A 10 day operational period will be conducted coinciding with PTOST to launch two gondolas.
- 20 sondes per balloon flight will be dropped
- The Driftsondes will be launched from the GSSL facility on the Big Island of Hawaii (South Point) during early March.

Figure 1.3

Driftsonde and Payload Prior to Launch in November 2002

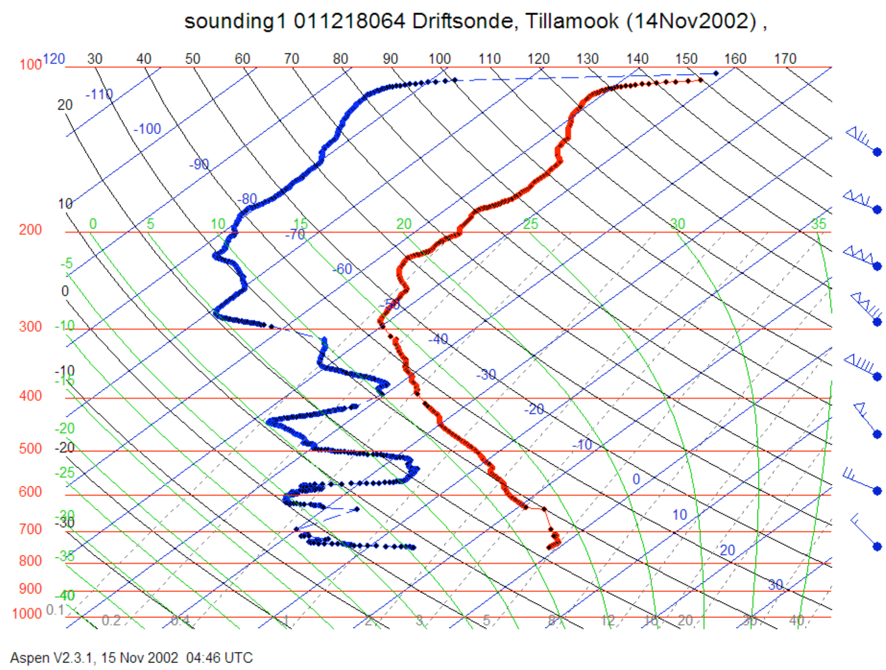

Figure 1.4

Sounding from November 2002 Driftsonde Test

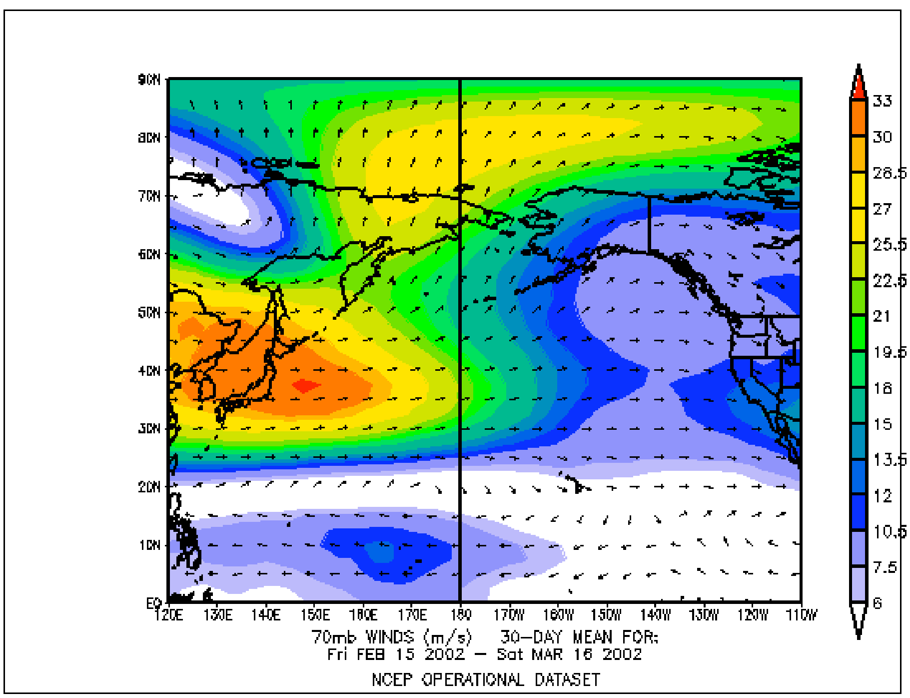

Figure 1.5

70 mb Average Winds for the Northern Pacific February 15th to March 15th 2002

1.3.4 Mauna Loa Groundwinds LIDAR

The GroundWinds Hawaii (GWHI) lidar is a groundbased molecular Doppler lidar located on Mauna Loa in Hawaii. During operation, the instrument continuously measures the velocity of the air in the direction parallel to an outgoing laser beam. The laser beam is oriented at a 45 degree vertical angle, relative to the ground, and can scan horizontally over approximately a 300 degree range. The instrument can be used to deduce an average three-dimensional velocity field by scanning. The vertical resolution and a temporal integration can both be adjusted prior to operation.

The overarching goal of the GroundWinds progam is to develop and demonstrate incoherent ultra-violet lidar technology for a future based system that will measure the vertical structure of global winds from molecular backscatter. Successful retrievals of zonal winds profiles form the Hawaii facility have been obtained to altitudes greater than 20 km and ranges near 30 km.

This UV Lidar can measure altitude resolved line-of-sight wind velocities, turbulence power spectra, areosol content and faint cirrus clouds among other things of interest to the astronomers of the nearby Mauna Kea Observatories.

Data from the incoherent LIDAR are used in a custom forecasting project (Mauna Kea Weather Center) that provides operational support for the world-class group of astronomical observatories located on the summit of Mauna Kea.

1.3.5 Other Surface Data

Other sources of surface met data include:

1. Mauna Kea and Mauna Loa Observatories (big island)
2. Mees Solar Observatory (Maui)
3. Hilo (big island) and Lihue (Kauai) Radiosondes
4. Ground-based FTIR from Mauna Loa
5. Buoy data
    a. NDBC: air and sea temperature, wind speed and direction, air pressure, and wave period, height, and spectra
    b. USACE: wave info
    c. SCDIP: Sea temperature, wave info

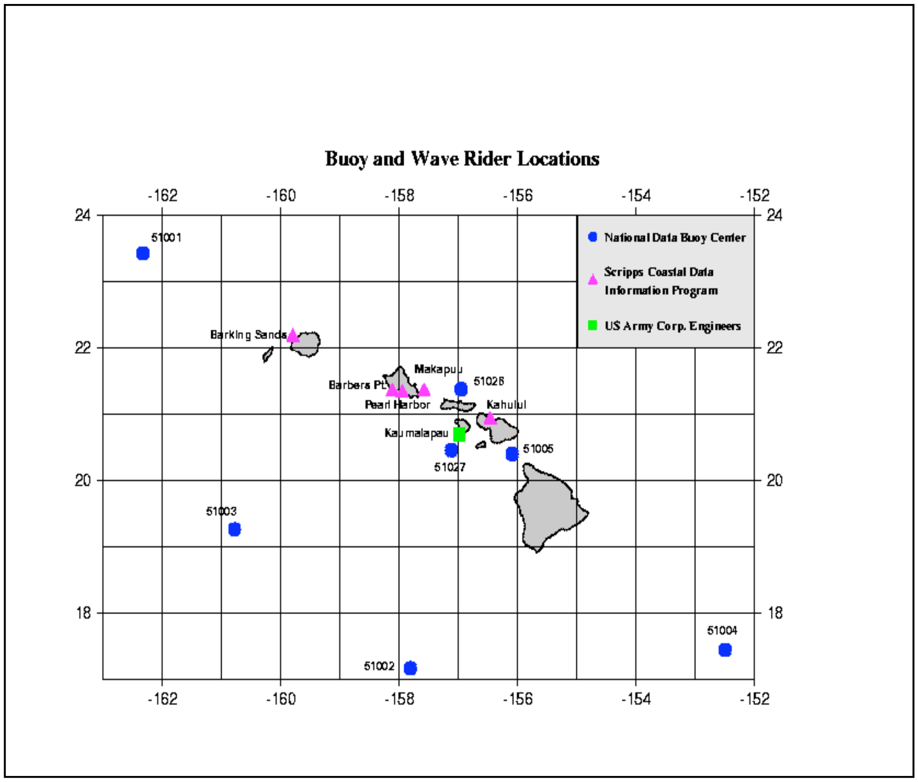

Figure 1.6 Drifting Buoy Stations

1.4 Deployment and Operations Schedule

1.4.1 The following is a schedule of major campaign dates:

Feb 15 Langley Team departs Norfolk VA
Feb 16 Check out offices in hangars for aircraft and instrument teams
Feb 17 Set up offices and conduct comm checks with participating facilities
Feb 18 ER-2 arrive Hickam.
Feb 19 Down-day. Hazmat (dimethylhydrazine fuel) briefing to Hickam Fire Dept.
Daily Operations Schedule Begins
Feb 20 First available measurement flight day
Mar 12 Last available measurement flight day and THORPEX departure day
Mar 13 WSRP deployment ends

Chapter 2. 2003 Pacific TOST Operations

2.0 Introduction

Daily Pacific TOST operations will be coordinated from Hickam AFB, Building 2055. Morning weather briefings and daily planning meetings will also be conducted there. ER-2 base operations will be in building 1045, where pre-flight and post-flight briefings will be held. Additional office space for the NAST team, other THORPEX participants and NOAA G-4 flight crews and scientists is located at the Air Service Hawaii FBO.

2.1 Primary functional areas and responsibilities

2.1.1 TOST Operations Coordinator and Deputy Operations Coordinator
The 2003 Pacific THORPEX Operational Science Test Coordinator is John Murray of the NASA Langley Research Center (j.j.murray@larc.nasa.gov , (757) 329-4484). The Deputy Operations coordinator is Chris Moeller of the University of Wisconsin (chris.moeller@ssec.wisc.edu , (608) 263-7494).

2.1.2 NOAA NCEP Winter Storms Research Program

The WSRP is directed by Dr. Zoltan Toth of the NOAA NCEP Environmental Modelling Center (Zoltan.Toth@noaa.gov, (301) 763-8000/ext. 7268). It is staffed 24/7 by the Senior Duty Meteorologist who can be reached for operational coordination at Sdm@noaa.gov, 301-763-8298 (or 301-763-8000/ext. 7361). Administrative issues between THORPEX and the WSRP can be coordinated with Lacey Holland (Lacey.Holland@noaa.gov).

2.1.3 Aircraft Coordinators

2.1.3.1 The NASA ER-2 Mission Manager is Jeanette Vandenbosch of the NASA Dryden Flight Research Center (jeannette_vandenbosch@dfrc.nasa.gov, (661) 816-9516.

2.1.3.2 The NOAA Gulfstream IV coordinator for THORPEX is the Flight Director of the NOAA AOC, Jack Parrish (jackparrishwx@netscape.net). Daily G-IV operations will be coordinated through the WSRP G-IV project manager, beginning with Mark Finke ((813) 833-2405).

2.1.4 Instrument Coordinators

2.1.4.1 The NAST Instrument PI is Bill Smith of the NASA Langley Research Center (william.l.smith@larc.nasa.gov, (757) 897-9597. The NAST Manager is Allen Royal (A.C.Royal@larc.nasa.gov, (757) 864-7927).

2.1.4.2 The Scanning HIS Instrument PI and manager is Hank Revercomb of the University of Wisconsin (hankr@ssec.wisc.edu, 608-263-6758) and MODIS Airborne Simulator Instrument PI is Chris Moeller (for Michael King) of the University of Wisconsin (chris.moeller@ssec.wisc.edu, (608) 263-7494). MAS is managed by Jeff Myers of NASA Ames Research Center (jmyers@mail.arc.nasa.gov, (650) 604-6252)

2.1.4.3 The Cloud Physics LIDAR Instrument PI is Matthew McGill of the NASA Goddard Space Flight Center (Matthew.J.McGill@nasa.gov, (301) 614-6281).

2.1.4.4 The In Situ Fast Ozone Detector Instrument PI is Melody Avery of the NASA Langley Research Center (m.a.avery@larc.nasa.gov, (757) 864-5522).

2.1.5 The operational Driftsonde Coordinator is David Parsons, the Director NCAR ATD (parsons@atd.ucar.edu, (303). Administrative coordination should be addmatters may be addressed to Melinda Finch Cagle at the NASA Langley Research Center (m.f.cagle@larc.nasa.gov, (757) 864-7211).

2.1.6 The Mauna Loa Groundwinds LIDAR Coordinator is John McHugh of the University of New Hampshire (jpm@cisunix.unh.edu, (603) 862-1899). The Techincal Support coordinator is Ivan Dors, UNH, idors@comptel.sr.unh.edu , (603) 862-2867. The U. Hawaii POC is Steve Businger, businger@hawaii.edu , (808) 956-2569. The Hawaii field coordinator is Tiziana Cherubini, U. Hawaii, tiziana@hawaii.edu , (808) 956-4593. Additional points of contact are James Foster, U. Hawaii, jfoster@soest.hawaii.edu , (808) 956-4593
and Ryan Lyman, U. Hawaii, rlyman@hawaii.edu , (808) 956-4593

2.1.7 The 2003 THORPEX OST Satellite Support Coordinator is Louis Nguyen of the NASA Langley Research Center (l.nguyen@larc.nasa.gov, (757) 864-9066).

2.2 Other TOST Facilities
2.2.1 Hickam AFB
2.2.1.1 2003 Pacific TOST Operations Center, Building 2055, Hickam AFB, HI
2.2.1.2 Hickam AFB, HI ER-2 Support Facilities
2.2.1.3 ER-2 Operations, Building 1045, Hickam AFB, HI
2.2.1.4 ER-2 Hangar, Hangar 35, Hickam AFB, HI

2.2.2 Air Services Hawaii, 95 Nakalo Place, Honolulu, HI, (800) 821-3122.
2.2.2.1 NOAA Gulfstream IV, Mark Finke, Project Manager, (813) 833-2405.
2.2.2.2 NAST Instrument Team and Project Scientists,

2.2.3 National Weather Service Honolulu Forecast Office, 2525 Correa Rd, Ste 250, Honolulu, HI 96822, http://www.prh.noaa.gov/pr/hnl/index.shtml

2.2.4 Naval Pacific METOC Center

2.2.5 GSSL Balloon Launch Facility

2.2.6 Mauna Kea Growndwinds LIDAR Site

2.3 Daily Mission Planning Process and Schedule

Coordination with the NOAA Winter Storms Research Program (WSRP) will drive the daily mission planning process. TOST mission planning will begin each afternoon after notification by the NOAA G-IV Project Manager or flight crew as to whether the next day has been tasked by NCEP as a WSRP flight day..The NOAA Gulfstream IV aircraft's primary tasking is in support Of the WSRP. On WSRP fly days the TOST will have the option to operate (fully or partially) in conjunction with the scheduled WSRP flight track or to operate independently. NCEP's WSRP tasking is received from CARCAH in Miami by 8:30 a.m. HI local time (13:30 EST) for the next day's work. The standard NOAA aircraft launch time is 20Z (10 a.m. HI local time) +/- one half hour. Flight duration is from 6.5 to 8 hours for the Gulfstream IV aircraft the same as for the NASA ER-2.

A TOST operations meeting will normally be held daily at 3 p.m. in building 2055, Hickam AFB. To accomodate participation by those at the Air Services Hawaii TOST Office and elsewhere, a telcon connection will be provided to the meeting.

Announcements	TOST coordinator, deputy, participants
Current Synoptic situation	NOAA or NASA duty forecaster
Aircraft and instrument status reports	A/C mission managers, instrument PI's
Today's TOST mission status	TOST coordinator or deputy
WSRP flight decision – next day/outlook	G-IV manager or representative
24 hour forecast	NOAA or NASA duty forecaster
TOST objectives and options	Directed discussion

Table 2.1 Daily TOST planning meeting agenda

2.3.1 Daily TOST Operations Schedule

Daily TOST operations will be posted on the campaign website the evening before. Generally, the elements of each day's operations are summarized in table 2.2. Specifically, the execution of each element of the mission and the relevant flight tracks and instrument operating modes and special procedures will be posted on the website.

ER-2 launch time –4 hours	Morning weather brief and go/no-go decision
ER-2 launch time –3 hours	ER-2 pre-flight brief
ER-2 launch time –2 hours	Hands off ER-2 aircraft
10:00 A.M +/- _ hour	NOAA G-IV WSRP launch time
3:00 P.M.	Daily TOSToperations planning brief
5:00 P.M. +/- _ hour	NOAA G-IV WSRP landing time
ER-2 launch time + 4-7 hours	ER-2 landing time
ER-2 shut down time + _ hour	ER-2 post-flight brief
TOST Science Meetings	To be scheduled
Evening updates	As required

Table 2.2 Daily TOST Operations Summary

2.4 Air Operations

2.4.1 NOAA Gulfstream IV

2.4.2 NASA ER-2

2.4.2.1 Pre-flight Operations

There are three general limitations to ER-2 operations:

1. Routine flight duration for the ER-2 is six and one half hours. Flights longer than six and one half hours require specific, compelling justification. If no alternative presents itself to accomplish the mission objectives (such as flying two sorties instead of one) a longer duration flight of seven to eight hours can be flown with specific approvals. Such flights may be approved by the mission manager or the branch chief of The High Altitude Branch. Sustained operations of this nature can quickly deplete crew resources and are therefore best avoided.
2. An ER-2 pilot is limited to twelve hours duty time. Duty time begins at pre-flight reporting and ends at engine shutdown.
3. ER-2 pilots and maintenance crews must have at least twelve hours of off-duty time between leaving the flight line after one flight and reporting back for the next flight.

Once a mission has been assigned on the previous day, the ground crew, pilots, and investigators meet three hours before the scheduled take off time. At this meeting, available weather information is reviewed, the investigators brief the pilots on the desired mission objectives, and the status of the aircraft and its instruments is reviewed. If the weather permits, and the investigators feel that there is a reasonable chance of meeting their science objectives, the preparation for a flight begins. Each instrument team, and the aircraft ground crew, begins their pre-flight inspections and preparations, while the aircraft is still inside the hangar. Aircraft systems and instruments are tested, and the ejection seat and related life support hardware are installed in the cockpit. Access to the ER-2 at Hickam AFB, Hangar 35 will be restricted to instrument technicians and PI's who are directly servicing their instruments.

Approximately two hours prior to flight the aircraft is towed from the hangar and fueled. During this operation, no electrical power will be available to the aircraft. For safety reasons, personnel whose tasks are not connected with this operation will not be allowed near the aircraft at this time. When fueling and oxygen replenishment are completed, external power will be connected to the aircraft (approximately one hour prior to launch). In order to prevent possible damage from voltage transients, the instruments will normally be shut off while external power is removed and internal power is selected. If continuous power is necessary for a particular instrument, arrangements must be made well in advance.

About one hour prior to flight, the mission pilot suits up and begins pre-breathing pure oxygen, to purge nitrogen from his bloodstream. Since the pressure suit worn by the mission pilot restricts mobility and makes pre-flight checks difficult, the mobile pilot inspects the aircraft approximately one hour prior to launch. With the pre-flight checks completed, the mission pilot will be driven to the aircraft in a support van approximately 30 minutes prior to scheduled launch.
The engine is started approximately fifteen minutes prior to launch. Once the pilot is disconnected from the ground oxygen supply, and the canopy is closed, heat will build rapidly in the pilot's pressure suit. For this reason the aircraft is taxied to the runway as soon as possible following post engine start-up checks.

2.4.2.2 Launch procedures

The ER-2's long, flexible wings are supported during ground taxi and takeoff by auxiliary wheels, called "pogos". These wheels, as well as the main gear, are locked in place during taxi. The mobile pilot and the ground crew accompanies the aircraft to the active runway in a van or jeep. This vehicle is equipped with radios to talk to both the airfield tower operators and the ER-2 pilot. Once the ER-2 has taxied onto the active runway in position for launch, the ground crew pulls the locking pins for the pogos and main gear. During the takeoff roll, when the ER-2's wings develop enough lift to flex upward, the pogos drop to the runway below. The ground crew recovers the pogos and returns to the hangar. The pogos can usually be used hundreds of times before needing to be replaced, although they must be carefully inspected for damage after each takeoff. To minimize the impact of the ER-2's flight profile on Air Traffic Control, the ER-2 strives to launch on time.

2.4.3 Aircraft scientific crews and instrument technicians

Except for pre-flight and post-flight briefings, access to the Hickam AFP ER-2 Hangar will be limited to designated technicians and PI's. Pre-flight and post flight briefings in building 1045 will accomodate additional personnel as permitted.

2.4.4 Flight patterns

2.4.4.1 NOAA WSRP flight patterns

The 2003 Pacific TOST will conduct joint WSRP missions in which the NASA ER-2 will overfly the NOAA G-IV on a standard WSRP flight track as illustrated in figure 1.1. During these missions, the ER-2 may deviate from the WSRP track for short periods of time to conduct measurements for satellite validation or other purposes.

2.4.4.2 EOS/IPO Satellite validation patterns

Coincident MODIS and NAST-I observations are important form enabling cloud studies for CrIS IFOV. Since a small window of opportunity may exist for the validation of satellite data each day, every opportunity will be made to accommodate it. Normally, the validation of a polar orbiting satellite will entail a transit to an anticipated nadir point and transit along the orbital axis in one or both directions depending upon the size of the satellite's footprint. In the event that there is more than one satellite of interest, such as AQUA and ICESat (GLAS) which are moving in opposition, timing will be especially important.

Underflights of EOS satellites (Aqua, ICESat) will be planned to allow the ER-2 to align itself along the orbital track approximately 10-15 minutes prior to satellite arrival, and continue along the track until about 10-15 minutes after satellite overpass, maintaining straight and level flight through the duration (exception of any maneuvers necessary to reverse direction). For GLAS validation, nadir underflights are required to collect co-incident CPL and GLAS observations in the GLAS 120 m wide swath. For Aqua underflights, both nadir and off-nadir underflights (parallel to the satellite orbital track) are sought for MODIS and AIRS science product validation.

2.4.4.3 ASAP and GIFTS data cube production patterns

2.2.4.3.1 Regional mapping presents the best opportunity to construct simulated GIFTS data cubes.For regional mapping it is often useful to operate the ER-2 in a pattern of 4 parallel flight lines oriented perpendicular to isoheights so that the gradient on each flight line can be seen. At the completion of the 4 lines, the pattern is typically re-flown in the same sequence so that the time offset of repeat pass for each line is approximately the same. This helps clarify temporal influences. Each run of a 4-line pattern typically takes 60 to 75 minutes depending on the flight line length (12 minute leg covers ~150 km along track), so two runs typically requires 2.25 to 2.75 hrs on site. The pattern is typically held to to 4-lines because it keeps the time offset from 1st pass to 2nd pass to about 75 minutes. In the across track direction, 4 parallel lines translate to about 150 km of contiguous coverage for MAS. For NAST-I and S-HIS it would be desirable to tighten the spacing of the flight lines to get contiguous coverage, especially when flying over a solid undercast which effectively reduces cross-track coverage by a factor related to the altitude of the cloud deck.

High density dropsonde observations from the NOAA G-IV would be highly desirable during regional mapping operations. The G-4 would be flown at maximum altitude (45kft) below the ER-2 flight track. Dropsondes observations would be distributed regularly throughout the 2 – 3 hour observation period.

2.4.4.4 ASAP Phenomenological Targeting (Turbulence, Icing, Convection, Ceiling and Visibility and Volcanic Ash).

ASAP objectives will be best met with a robust GIFTS data cube (2x2, 3x3, or even 3x4) simulation that covers areas possessing a range of weather. Aircraft in this TOST have to be flexible enough to fly in the vicinity of jet exit and entrance regions, as well as near mesoscale jet streaks, for the detection of turbulence. One possible set of flight paths should parallel the main polar jet with the ER-2 as it lies across the Pacific north of Hawaii. Concurrently, the NOAA G-4 would collect dropsondes by crisscrossing the jet axis at various altitudes to obtain profiles in and around the jet. Since the can jet meander significantly, it is very difficult to locate and to precalculate flight legs and/or flight distances.

Another option for the detection of CAT is to enhance flight profiles performed previously by the NOAA Gulfstream IV in SCAT-CAT missions by overlying the G-4 with an ER-2 grid of downward looking radiometric profiles and in situ ozone measurements to attempt to dept the propagation of inertial gravity wave-breaking associated with CAT. See http://www-frd.fsl.noaa.gov/mab/scatcat .

Other ASAP flight profiles may be southward of HI to overfly deep convection. All other convection over the Pacific will be shallow and associated with post-cold frontal advections of arctic air over the north Pacific south of Alaska. This is not a primary option since the convective storm objectives for ASAP are much better met by the IHOP data sets that are already starting to show great promise.

ASAP clouds and cloud microphysics objectives (e.g., icing, ceiling and visibility), will be satisfied if the EOS validation objectives are satisfied. Volcanic ash and gas detection validation opportunities exploiting MODIS and AVHRR split window techniques should be pursued wherever possible. Volcanic activity will be targeted by the ER-2 after takeoff and prior to landing whenever possible.

2.5 Driftsonde Coordination

2.5.1 Honolulu GSSL launch coordination

2.5.1.1 Honolulu ARTCC coordination

2.5.1.2 Notification procedures

2.5.1.3 Tracking and data provision requirements

2.6 Mauna Loa Groundwinds LIDAR Coordination

University of Hawaii personnel will be provided administrative space at the Air Services Hawaii facility to coordinate Groundwinds LIDAR operations with the THORPEX OST.

The tentative Operating Plan is for GWHI to provide the horizontal wind field, and for direct comparison with other airborne and driftsonde measurements. The GWHI instrument will be operated in a manner to optimize the data quality for average winds. This means a temporal integration time of 60 seconds, and a vertical resolution of 80 meters. The horizontal scan will include five angles, separated by 30 degrees. The resulting wind measurement is an average of these five angles. The instrument will record data for 30 minutes at each angle, making the duration of an entire scan 150 minutes. Variations on this scheme are possible, including a narrower field of view, shorter record length at each angle, and more or less angles for a given scan. Final data analysis can be performed with fewer angles than were recorded.

The operating plan for GWHI will be to take data during the daytime operating hours for the NOAA G4 and ER2 aircraft during the entire campaign. During the first days of the driftsonde, GWHI may additionally collect data at night. The final operating decisions will be made during the campaign, and will depend on weather, the availability of personnel, and other matters.

2.7 Data distribution Policy

THORPEX does not currently provide for centralized archiving of TOST data. Individual PI's are responsible for the archiving and appropriate distribution of the data obtained from their instruments and science teams.

Access to data files from the THORPEX OST Website and participant sites and experiments is controlled to protect the experiment PI's and others with rights to the data. All data obtained by individual PI's participating in the first Pacific THORPEX Operational Science Test will be freely shared among them, however,this does not imply permission for distribution to third parties. Requests from third parties should be referred to the individual instrument PI.

Use of any images and/or THORPEX data from participating websites and field experiments must be made with the authorization of the instrument's PI. An offer of co-authorship on any publications, presentations, etc. must be made to the PI and his/her team if images and/or data are used (even if they are freely accessed).

2.7.1 Science quicklooks

Science quicklooks will be made available on the 2003 Pacific TOST website on a daily basis. This will be facilitated via links to websites maintained by the various instrument PI's participating in the campaign.

Chapter 3. 2003 Pacific TOST Links

2003 PTOST	http://www-angler.larc.nasa.gov/thorpex/
THORPEX	http://www.mmm.ucar.edu/uswrp/thorpex/thorpex_plan13.pdf
NASA	http://www.nasa.gov
NASA DFRC	
NASA GSFC	
NASA LaRC	
NOAA	http://www.noaa.gov
Aeronomy Lab	http://www.al.noaa.gov/
WSRP	http://wwwt.emc.ncep.noaa.gov/gmb/targobs/target/wsr2003.html
RECON	http://www.nhc.noaa.gov/reconlist.shtml
THORPEX	http://wwwt.emc.ncep.noaa.gov/gmb/ens/NOAA_THORPEX_INITIATIVE.ppt
NCEP Ensemble Forecasting	http://wwwt.emc.ncep.noaa.gov/gmb/ens/canadaworkshop.ppt

Aircraft

ER-2	http://www.dfrc.nasa.gov/Research/AirSci/ER-2/fltops.html
G4	http://www.aoml.noaa.gov/hrd/jetgen.html

Observing Systems

AVAPS	http://www.vaisala.com/DynaGen_Attachments/Att2688/2688.pdf
MAS	http://mas.arc.nasa.gov/
CPL	http://virl.gsfc.nasa.gov/cpl/
S-HIS	http://deluge.ssec.wisc.edu/~shis/
NAST-I,M	http://spigot.ssec.wisc.edu/~nasti/NASTI/ins_overview/overview.html
Driftsonde	http://www.atd.ucar.edu/rtf/facilities/icaruss/icaruss.html
Groundwinds Lidar	http://www.groundwinds.com/

Satellites and Satellite Sensors

AQUA/TERRA
AIRS
MODIS
ICESat
EO3/GIFTS