Toward a Satellite Algorithm Test Bed

Report of a Workshop Organized by National Oceanic and Atmospheric Administration (NOAA), Cooperative Institute for Research in the Atmosphere (CIRA), Cooperative Institute for Meteorological Satellite Studies (CIMSS), Cooperative Institute for Oceanographic Satellite Studies (CIOSS), Cooperative Institute for Climate Studies (CICS), Cooperative Remote Sensing Science and Technology Center (CREST) at the National Satellite Operations Facility, Suitland, MD, February 26-27, 2008

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1. Executive Summary

The goal of the Satellite Algorithm Test Bed (SATB) is to provide the scientific community access to all publicly available primary earth observing satellite data streams and associated infrastructure and funding so that they are able to conduct applied research for NOAA. This does not currently exist and will provide significant benefits as individual centers will not redundantly have to obtain satellite data streams and independently create infrastructure to conduct research. In addition, tools to manipulate the data will be shared as well as techniques to successfully move algorithms and software into bridging programs that transition research into operations. As measurements, instruments, and satellites are confirmed for launch, the SATB will begin development of new or enhanced algorithms to deliver the best science and applications enabled by the growing national and international constellation of earth observing satellites.

A workshop was held at the National Satellite Operations Facility in Suitland, MD, on February 26 - 27, 2008 to discuss how an SATB could be established, demonstrated, and maintained. Participants included those who have experience and insight regarding the technical and programmatic aspects of operating test beds and using or coordinating the use of satellite data.

The Workshop's top outcomes and recommendations are:

1) Strong endorsement toward the establishment of the SATB.
2) Implementation of a SATB organization structure similar to the Joint Hurricane Test Bed, but with a stronger emphasis on research and identifying the best research and algorithms for promotion to transition-to-operations programs.
3) Use of Science Algorithm Working Groups to coordinate science within the SATB and identify operational research transition opportunities.
4) Create and support a common SATB computing environment that enables the NESDIS Cooperative Institutes and Cooperative Science Center to more easily access and transition their software into NOAA operational environments.

The NESDIS CI and CREST Director's endorsed the concept of the SATB based upon the workshop recommendations at their annual meeting in June 2008. In addition they added the following recommendations:

1) The SATB must have a Science Advisory Panel to identify stakeholders and have them guide SATB priorities
2) A Helpdesk (middleman) is key to making the SATB functional
3) The components of the SATB should not reside at a single facility

2. Overview

Satellite Algorithms

Algorithms transform raw satellite data (bits and bytes) into useful information such as the cloud images that we see on The Weather Channel, and the temperature and moisture information that go into numerical weather and climate prediction models. Scientists at NESDIS, working with their partners in academia, international agencies, national agencies, commercial and non-profit sectors, generate these algorithms and ensure their quality for operational environmental satellites.

NESDIS and its Cooperative Institutes – A Long History of Algorithm Support

NESDIS and its Cooperative Institutes (CIs) have long worked collaboratively to transition research algorithms to operational code. There are many examples of algorithms developed at the CIs for both geostationary and polar orbiting satellites. In 1980 NESDIS and the Cooperative Institute for Meteorological Satellite Studies used GOES-4 to generate the first geostationary satellite temperature and moisture profiles. In 1989 NESDIS and the Cooperative Institute for Climate Studies used the High-resolution InfraRed Sounder on operational polar satellites to develop a highly accurate technique to measure Earth's outgoing longwave radiation. In 1993 NESDIS and the Cooperative Institute for Research in the Atmosphere installed the first GOES-8 digital satellite display system at a NWS Office. In 1994 NESDIS and CIMSS implemented the highly acclaimed GOES-8 wind products operationally and continue to provide updates such as using rapid scan imagery and improving height information. The successes of the NESDIS CI program continue today with the formation of the Cooperative Institute for Oceanographic Satellite Studies in 2003 and strong interactions with the NOAA Cooperative Remote Sensing Science and Technology (CREST) Center, a NESDIS-focused Cooperative Science Center formed in 2001 by NOAA/OAR. Transitions to operations continue to improve at NESDIS due to more interactions between CIs and CREST with STAR's Operational Products Development Branch which works closely with Satellite Operations personnel to tailor research code and ideas to operational standards and use.

The Challenge - Increasing Complexity and Number of Satellites

There is currently an enormous increase in the complexity and number of earth observing satellites. According to recent fly-out charts (Appendix D), there will be approximately 45 e satellites on-orbit in the 2010-2020 era versus the approximately 30 satellites on-orbit today, a 50% increase. In addition many of the satellite instruments are growing in complexity. For instance, the NPOESS hyperspectral (1000+ channels) Cross-track Infrared Sounder (CrIS) is decidedly more complex than the approximately 20 channel POES sounder. Increased temporal and spatial resolution is evident as well. NPOESS and GOES-R imager data will have 2-4 times the spatial resolution of current POES and GOES imager data.

Shortcomings Related to Algorithm Research Funding Mechanisms

While transitions into operations have been improving with time for current GOES and POES algorithms, the research that should be done prior to deciding to transition the algorithms is frequently missing. This is the case for POES algorithms because they have a robust Product Systems Development and Integration ("PSDI") program to allow algorithms to move into operations but they do not have the Product Assurance Program that is currently in place for GOES to provide support for scientific studies.

In addition, algorithm development funds are currently piecemeal from sources that are dominated by acquisition-centric programs such as POES, GOES, NPOESS, GOES-R, and NPP. This "stovepipe" structure does not facilitate consistency of products across platforms or a truly science-centric development of multi-instrument, multi-platform products. In order to obtain the highest quality products in the future the use of blended products (e.g. combinations of polar and geostationary data), merged products (composites reflecting the 'best' spatially, spectrally, and temporally integrated products) and 'same science' approaches (e.g. use the same physics techniques to process similar observations from geostationary, polar, aircraft, etc.) are necessary. Algorithms should be funded in a manner that provides optimum flexibility in approach, delivers consistent product processing, and improves product accuracy.

Missing Pieces Related to Infrastructure

The infrastructure for generating algorithms from several types of satellite data streams is currently available at the CIs, CREST and NESDIS. However each location collects data from a different set of satellites using different software and techniques. Additional infrastructure is needed to allow access to all the primary earth observing satellite data streams for research and development of algorithms by the CIs, CREST and NOAA. Tools to manipulate the data and techniques to move algorithms from research into operations (and from operations into research) also need to be made accessible and shared.

Concept of the Satellite Algorithm Test Bed

The concept of the Satellite Algorithm Test Bed (SATB) is to fill in the missing pieces related to research funding and infrastructure and provide the scientific community access to all publicly available primary earth observing satellite data streams, associated infrastructure and competitive funding opportunities to conduct applied and useful research for NOAA. For instance, the Satellite Algorithm Test Bed would consist of **currently existing funding opportunities** (GOES-R3 and GIMPAP), **currently existing infrastructure** at CIs and NOAA plus **new funding opportunities** to allow for multi-sensor and POES-related research, **new infrastructure** to connect and increase sharing of data, tools, algorithms and techniques, and **enhanced coordination** to standardize scientific review, selection and oversight of work conducted.

To further illustrate how the SATB and the Research to Operations (R2O) process relate to each other, the components of R2O are broken down in Figure 1. The focus of the SATB is the early stages of R2O, applied research and assessments or "R2R2O". The GOES-R Risk Reduction program is currently an example of R2R2O. The GOES-R Proving Ground effort is an example of the middle stages of R2O and the GOES-R Algorithm Working Group is an example of the later stages of R2O (staging algorithms for operational implementation) or "R2O2O".

An example of a potential future "pathfinder" project for the Satellite Algorithm Test Bed is focusing on the science question ("R") of deconvolving the diurnal cycle. This requires GOES (hourly or more frequent measurements) and POES (global and frequently of higher resolution/quality measurements) blended products to study. The natural R2O partner for successful products/applications resulting from the findings is NOAA's Climate Test Bed. The scientific knowledge resulting from the studies would have wide interest for the climate community inside and outside of NOAA. More examples of projects that had attributes of an SATB and/or would have benefited from the existence of an SATB, along with examples of how the different components of R2O could be described, are in Appendix F.

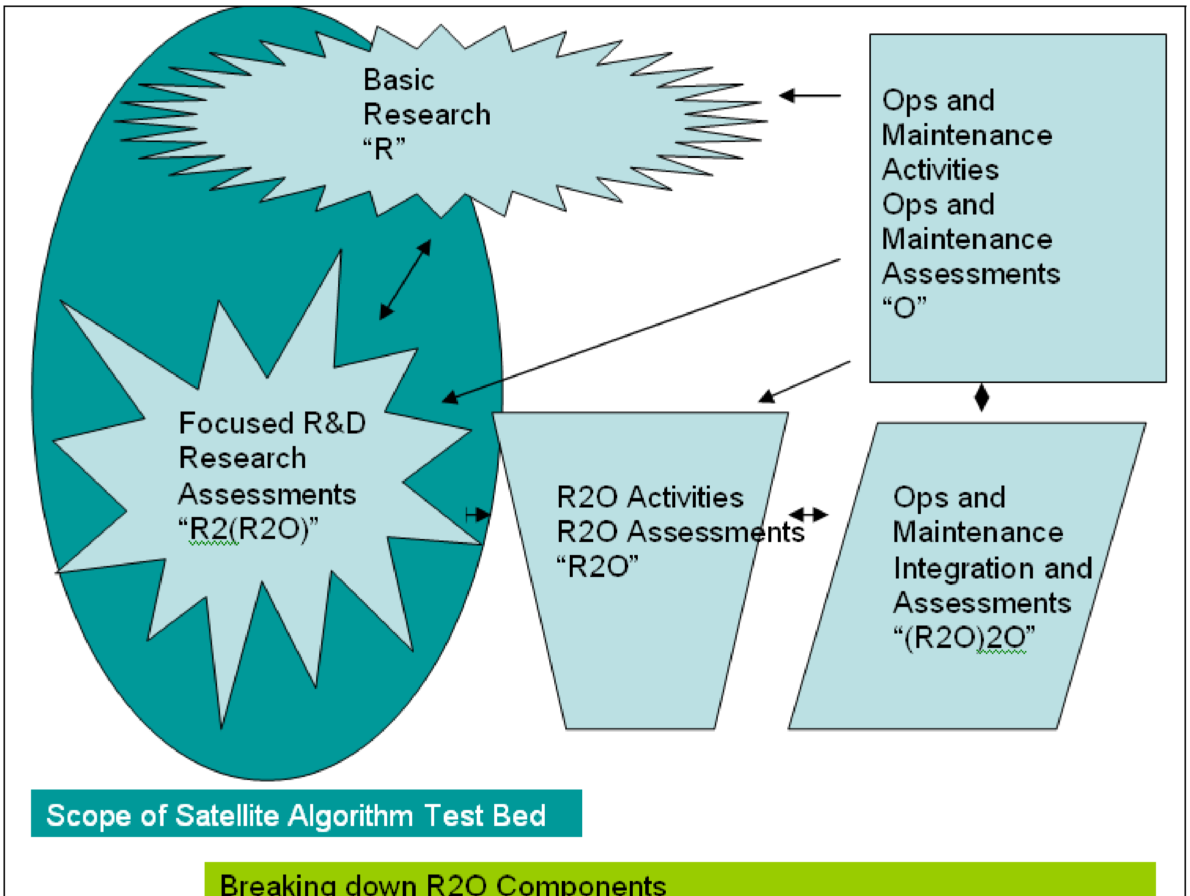


Figure 1: Components of Research to Operations (R2O) and associated phases. The Satellite Algorithm Test Bed encompasses the early stages of R2O and facilitates the orderly progression of science into later stage R2O processes.

Potential Performance Indicators

Potential metrics for the SATB (which should begin collections now, before the establishment of the SATB to obtain a baseline and identify improvements) for both the "R" and the "R2R2O" stages are:

"R" (Research) Stage:

1. Length of time after being funded to generate scientific peer reviewed paper that describe multi-sensor algorithms/products/applications that have potential for operational use. This should *decrease* if an SATB is successful because obtaining and using the data will be more straightforward and work achieved will be with higher impact.
2. Number of research projects for multi-sensor algorithms/products/applications being funded. This should *increase* if an SATB is successful because funders and researchers will consider the SATB a useful environment to conduct their work.

"R2R2O" (Research that is being staged for (if successful) an R2O program such as a Proving Ground or Climate Test Bed) Stage:

1. Length of time after a peer-reviewed publication describing multi-sensor algorithms/products/applications is accepted to acceptance of a project in an R2O program. This should decrease if an SATB is successful because research will have been targeted for R2O programs early on.
2. Number of multi-sensor algorithms/products/applications being funded in an R2O program. This should increase if an SATB is successful because the R2O partners will have been involved in choosing the direction of research via the SATB advisory structure.

These metrics feed into the higher level metrics "Number of Research Applications Transitioned into Operations" and "Reduce the amount of time for new satellite sensors to be used in operations". There are many more possible metrics. Work with a focus group and some seed money for this effort is required to generate the appropriate metrics to use.

Potential Milestones and Schedules Related to a Satellite Algorithm Test Bed

A potential schedule is included to provide more clarity on the specific activities and timing. It is anticipated the NESDIS/STAR Cooperative Research Program would be in charge of the program management.

Q1 FYA0 (where "A0" is the first year concept has been endorsed with funds allocated)
Identify Science Advisory Panel members
Identify Technical Working Group members

Q2 FYAA
Science Advisory Panel Charter is finalized
FYA0 and FYA1 (where A1 is one year after year A0) Funds/activities to create and carry out charter are identified
FFO for June publication (FYA1/A2 funds that are available to researchers outside of existing CIs) is prepared
Procedures to compete internal funds (FY A1/A2 funds that will be available to researchers inside of NOAA and CIs) is prepared
Technical Working Group Charter is finalized
FYA0 and FYA1 Funds/activities to create and carry out charter are identified
FYA0 and FYA1 Funds/activities to set up SATB infrastructure by Q1 FYA1 are identified
Identify Science Algorithm Working Groups needed and appropriate members

Q3 FYA0
FYA1 FFO and internal fund opportunities announced/proposals requested

Science Algorithm Working Group charters are finalized
FYA0 and FYA1 Funds/activities to create and carry out charters are identified
SATB Helpdesk members and duties identified
FYA0 and FYA1 Funds to create and carry out duties are identified

Q4 FYA0
FYA1/A2 funding is determined for FFO and internal NOAA opportunities
Winners of FYA1/A2 internal NOAA opportunities are announced

Q1 FYA1
Infrastructure for SATB is set up and available for use

Q2 FYA1
Winners of FYA1/A2 FFO items are announced
FYA1 Projects begin
Science Advisory Panel
- Funds/activities to carry out FYA2 and FYA3 duties are identified
- FFO for June publication (FYA2/A3 funds that are available to researchers outside of existing CIs) is prepared
- Procedures to compete internal funds (FYA2/A3 funds that will be available to researchers inside of NOAA and CIs) is prepared

Technical Working Group
- Funds/activities to create and carry out FYA2 and FYA3 duties are identified
- Funds/activities to improve SATB infrastructure by Q1 FYA2 are identified

Q3 FYA1
FYA2/A3 FFO and internal fund opportunities announced/proposals requested
Science Algorithm Working Groups
- Funds/activities to carry out FYA2 and FYA3 duties are identified

SATB Helpdesk
- Funds to carry out FYA2 and FYA3 duties are identified

Q4 FYA1
FYA2/A3 funding is determined for FFO and internal NOAA opportunities
Winners of FYA2/A3 internal NOAA opportunities are announced

Q1 FYA2
Infrastructure upgrade for SATB is implemented
FYA1/A2 Testbed interim research findings presented
Feedback received from Science Advisory Panel
Potential R2O target programs are identified for projects ready for R2O
FYA2 Testbed work recommended for projects to get them to a state where an R2O program could pick them up in FYA3 or an additional 2-years in the testbed would be competitive in FYA3.

Q2 FYA2
Winners of FYA2/A3 FFO items are announced
FYA2 2nd year internal NOAA opportunities and FFO funds are released
FYA2/A3 Projects begin
FY A1/A2 Projects begin 2nd year
FYA1/A2 research ready for next steps are submitted to R2O target programs
First Testbed peer-reviewed publications submitted
Science Advisory Panel
    Funds/activities to carry out FYA4 and FYA5 duties are identified
    FFO for June publication (FYA3/A4 funds that are available to researchers outside of existing CIs) is prepared
    Procedures to compete internal funds (FYA3/A4 funds that will be available to researchers inside of NOAA and CIs) is prepared
Technical Working Group
    Funds/activities to create and carry out FYA3 and FYA4 duties are identified
    Funds/activities to improve SATB infrastructure by Q1 FYA3 are identified

Q3 FYA2
FYA3/A4 FFO and internal fund opportunities announced/proposals requested
Science Algorithm Working Groups
    Funds/activities to carry out FYA4 and FYA5 duties are identified
SATB Helpdesk
    Funds to carry out FYA4 and FYA5 duties are identified

Q4 FYA2
First Testbed peer-reviewed publications accepted
FYA3/A4 funding is determined for FFO and internal NOAA opportunities
Winners of FYA3/A4 internal NOAA opportunities are announced
First testbed projects accepted into R2O programs (we hope!)

Q1 FYA3
First Testbed peer-reviewed publications published
Infrastructure upgrade for SATB is implemented
Testbed research findings presented
Feedback received from Science Advisory Panel
Potential R2O target programs are identified for successful projects
Winners of FYA3/A4 FFO announced and FYA3 obligated
FYA3 internal NOAA opportunities obligated
2nd year of FYA2/A3 projects obligated

Q2 FYA4
First testbed projects make it into operations

Summary of Workshop Outcomes, Findings and Recommendations

1) Strong endorsement toward the establishment of the SATB.

2) Implementation of a SATB organization structure similar to the Joint Hurricane Test Bed, but with a stronger emphasis on research and identifying the best research and algorithms for promotion to transition-to-operations programs.

3) Use of Science Algorithm Working Groups to coordinate science within the SATB and identify operational research transition opportunities.

4) Create and support a common SATB computing environment that enables the CIs and CREST to more easily access and transition their software into NOAA operational environments.

5) NOAA invest in hardware assets to facilitate the network connectivity of the CIs and CREST to the SATB and the STAR Collaborative Computing Environment, as well as provide some mirror SATB and data repository capabilities at the CIs and CREST to minimize network bandwidth requirements and contingency planning.

6) The CIs and CREST consolidate their computational configurations through similar hardware and software libraries (where possible) to simplify their interactions to the SATB, through coordination lead by SATB technical working groups.

7) The standards, interfaces, and other technical material and tools be created by the SATB for use by the SATB community.

8) The initial SATB projects focus on the build-out of the SATB infrastructure and tools to facilitate future long-term SATB interactions. This requires that real science problems are used for real-time testing purposes in a quasi-operational environment.

9) The SATB user community, which includes acquisition offices and other NOAA testbeds as well as traditional satellite product end-users, be engaged throughout the entire process.

10) The satellite operational community be able to use output from the SATB to determine priorities for operations as well as priorities for product/algorithm retirement to make room for new products and algorithms.

11) The SATB promote the development of students by supporting graduate research.

The CI/CSC Director Recommendations are:

1) The SATB must have a Science Advisory Panel to identify stakeholders and have them guide SATB priorities

2) A Helpdesk (middleman) is needed to making the SATB functional

3) The components of the SATB should not reside at a single facility

3. Goals and format of Satellite Algorithm Test Bed Workshop

The purpose of the Workshop was to enable STAR, the CIs, CREST, and their partners move from the conception of the SATB to the development of a plan for it to be established and implemented. To go forward in the NOAA Programming, Planning, Budgeting, and Execution System (PPBES), the plan needs to address how unmet NOAA requirements will be uniquely satisfied through the creation of the SATB.

Thus, foremost among the high-level objectives for the Workshop was to determine whether there is broad consensus that the SATB is in fact needed. The organizers first sought confirmation that no provision exists either to (a) explore, develop, and improve environmental data products from many satellites where observations are or will be available to NOAA and its stakeholders or to (b) develop blended products from combined observations from NOAA and non-NOAA satellite sensors, and that this lack of a comprehensive algorithm development capability reduces NOAA's ability to address its strategic goals.

Anticipating that the need for the Testbed would be confirmed quickly, the Workshop organizers allotted most of the schedule for gathering information to lay the foundation for drafting a complete and compelling plan for the SATB. For example, the scope of the proposed SATB (who should participate, in addition to STAR and the CIs and CREST) was to be considered. The boundaries between current algorithm development and implementation efforts and those envisioned for the SATB need to be drawn so as to avoid redundancy, encourage innovation, and support the eventual transition to operations. The scope and size of the enterprise must be estimated in order to determine the nature and amount of the resources required to conduct its activities. Finally, the workshop was intended to glean the "lessons learned" in other NOAA testbed activities to ensure successful planning, management, and "operation."

To achieve these objectives, the overarching emphasis of the workshop was on open and inclusive exchange. Invitations were sent to stakeholders who might not be involved with the SATB directly, but whose missions will be complemented and enhanced by the Testbed. Representatives of successful testbeds were invited to provide the lessons learned. While a solid line-up of invited speakers ensured that key topics were addressed in detail, substantial blocks of discussion time allowed for unforeseen and diverse points of view to be heard and considered. In pursuit of full inclusion, the original plan to meet in smaller break-out sessions was altered to discussing break-out topics among the full assembly.

4. Required Capabilities of a Satellite Algorithm Test Bed

To be successful, the SATB must have several capabilities.

a. Real-time data access (satellite and in-situ)

The SATB must have access in real time to satellite data and other data so that real-time research products can be generated and evaluated. These data should include all of the data which are available at NSOF, and those which are available at other government, university, and industry sites which might be necessary for product generation and testing. The real-time nature is crucial, because the only way to test whether one can produce products that are reliable and useful to forecasters and decision makers is to produce them in real time. Case studies (non-real time) are useful for determining which algorithms should be evaluated in the SATB, but only real-time production is useful for the evaluation itself.

b. Operational-like environment, tools and standards

A major advantage of the SATB concept is that once an algorithm has been evaluated and chosen for operational implementation, it should be easily transferable to a research-to-operations transition program. This can be accomplished if the algorithm is tested in an operational-like environment using tools and standards which are available (or will be available) in the operational setting. The SATB probably cannot have the exact equipment that the operational center or the research-to-operations transition program will have, but it should be as close as possible.

c. Beltway and outside-the-beltway data access

Since some of the implementation and testing of the algorithms will be done outside of STAR (for example, at CIs), it is essential that organizations inside and outside of the "Beltway" have access to data. The transfer must be capable of going both ways such that algorithm implementation at a CI, for example, can access data at STAR and those implemented at STAR can access data and products at external sites.

d. Beltway and outside-the-beltway software access and compatibility

Due to the highly collaborative nature of the related software development, it is also essential that common software libraries be based on an open architecture that facilitates movement of software by portable software libraries and interfaces. These libraries should be systematically tested and evaluated for their intended function within the SATB systems. These libraries should be built upon a well-defined subset of compiler languages and development tools. The goal should be to incrementally develop the common libraries through use and modification of existing software capabilities (where possible) as experience is gained and communicated through the SATB developer community.

e. Consistency with the STAR Collaborative Environment

Many of the components of satellite algorithms involve common tasks, such as doing radiative transfer calculations, orbital and geometric calculations, statistical analysis, database functions, and mathematical functions. The STAR Collaborative Environment will provide most of these common capabilities, and the SATB should use (and be able to use) them. This will speed algorithm development/implementation and aid in the transition to operations for proven algorithms.

f. New observation exploratory research environment, tools and standards

New observations are a major reason for the establishment of the SATB. New observations should reach forecasters and decision makers as soon as possible. These days, instrument manufacturers are being required to supply day-one algorithms which will work soon after new instruments are launched. However, these algorithms must be tested after launch before they can be operational. The SATB must be capable of acquiring new observations and any products generated from them as soon as possible after launch so that they can be vetted for accuracy. This will require an environment, tools, and standards which can easily ingest new observations and quickly test them.

g. New algorithm exploratory development environment, tools and standards

Day-one algorithms are necessary, but not sufficient for the successful utilization of space hardware. First, day-one algorithms will need tuning and modification to make them the best that they can be. Producing potential day-two algorithms must be a major goal of the SATB. Also, new ideas are constantly being produced. These include ways to calculate new products and ways to blend products from different sensors or different platforms to make a unified product which can replace older products. This, too, must be a major goal of the SATB, and it can only be accomplished with the proper environment, tools and standards developed for this task.

h. Algorithm test and assessment environment, tools and standards

Algorithm testing and assessment is a specialized activity. It is imperative that it be done in an appropriate environment—not the operational environment, and not the research environment—so that the quality of the algorithm can be thoroughly assessed. Tools and standards are necessary for this task, as well.

i. SATB output should be available to NOAA and NOAA partners, in particular to other NOAA test beds.

The algorithms under test at the SATB need to be tested by a variety of users: NOAA personnel, NOAA partners, and other NOAA test beds, to name a few. The SATB output must be made available to these groups.

5. Related Current and Future Systems and Organizational Structures

Several organizational structures and systems are available at NOAA and the CIs and CREST for leveraging toward the SATB purposes. Most of these were not designed to be cross-institutional structures or systems, therefore they will need to be either adapted or leveraged in ways consistent with their root purpose.

a. NESDIS/STAR Working Groups

The Standards Working Group (Lead: Maurice McHugh): This group recommends standards to the SPSRB for adoption among participating organizations. Topics include documentation standards, coding standards, life cycle development (SPSRB and CMMI), and delivery standards.

The STAR IT Advisory Committee (Lead: Ingrid Guch): This group organizes efforts within STAR associated with IT Security, Data Management, Common Standards, and the Collaborative Computing Environment.

The STAR Data Management Group (Lead: Celso Barrientos): This group organizes the data within STAR to enhance research performance. Data formats and metadata standards are addressed by this group.

The STAR Satellite Meteorology and Climate Division (SMCD) Integration Team (Lead: Hank Drahos): This team addresses issues associated with actual transition of algorithms to operations, including software development, and day-to-day issues of transition. It is closely aligned with STAR's Operational Products Development Branch.

b. Satellite Analysis Branch

The Satellite Analysis Branch (SAB) serves as the operational focal point for real-time imagery products and multi-disciplinary environmental analyses within NESDIS. Customer support is a critical function. User interactions and feedback are a critical component of any future SATB activity.

c. Sensor-specific Science Teams

STAR and the CIs have personnel that participate on numerous sensor-oriented science teams. It would be a natural extension of the science teams to access and contribute to the SATB algorithm working teams within the SATB on an as-needed basis. Main constraints are finding funding sources for such activities, and compliance with standards compatibility requirements due to the wide range of users and sponsors. We recommend that such leveraging be explored, and that targeted SATB activities be created. A specific example of a science team that could be leveraged toward interactions with the SATB is the CIMSS Cloud Algorithm team (among many other possible examples).

d. NESDIS/STAR Collaborative Computing Environment

The STAR Collaborative Computing Environment (CCE) includes a suite of configuration management, computational hardware, software tools, and test data sets for STAR usage. There is limited external network access, and most computational configurations are oriented toward NESDIS ESPC operational systems. However, the STAR CCE can and should be leveraged into the SATB concepts, where key requirements for external use by SATB participants are:

1) Greater network access to the STAR CCE.
2) Distribution of some data sets to the CIs and CREST as mirror backup hosts for the STAR CCE. This could also be used to foster specialized science teams at each CI and CREST oriented around science themes unique to the CI/CREST (or group of collaborating CIs/CREST) and reduce SATB network bandwidth requirements.
3) Extension and adoption of the STAR CCE software standards by the CIs and CREST to facilitate software interchange.
4) Expansion of the STAR CCE educational and training aspects to better include the CI and CREST capabilities and needs as related to the SATB.

e. CoastWatch

The CoastWatch program has national distribution of central operations and six regional nodes. This system is used by numerous operational users for a variety of coastal environmental satellite products. The strong user community of CoastWatch should be exploited in a future SATB framework.

f. GOES-R Proving Ground

The GOES-R proving ground is a forecaster/AWIPS focused system used to prepare for future GOES-R information leveraging existing resources. It is coordinated with the NWS and NOAA operational offices. The emphasis of this system is not on algorithm development as much as on the use of the new data by operational users. The transition-to-operations lessons are valuable from this system.

g. GOES-R Framework

This software system will become the real-time processing software core for testing GOES-R algorithms at NESDIS. As such it impacts many GOES-R Algorithm Working Groups, and is developing a set of tested, high I/O demand software tools that can be exploited into the SATB framework. We consider the GOES-R framework to be of significant leverage value into the SATB concepts. Interactions with other CI teams will allow the GOES-R software interfaces to be adapted across a range of CI systems that will interface with the SATB. Since the GOES-R framework will meet the operational standards for NOAA, by definition all software that can successfully mimic the interface could leverage the GOES-R framework parallelisms, standards, and software scheduling and event handling capabilities.

h. CIRA DPEAS System and other unique CI/CREST-developed data processing systems

The CIRA Data Processing and Error Analysis System (DPEAS) is a collaborative computing environment for parallel satellite data processing. It is currently used for cross-sensor blended satellite product generation. The DPEAS software framework should be modified to interface to the GOES-R framework to leverage the operational capabilities of that system and to buffer the CIs and CREST from the NOAA operational requirements.

Such leveraging of similar CI/CREST-based systems would encourage a simplification of the cross-portability issues that occur at each CI/CREST. Each CI/CREST will be unique in their needs, and could be addressed by STAR/CI/CREST-teams that have similar interests and system requirements. Such teaming and sharing of systems within the SATB should be encouraged. We do not anticipate that all CIs and CREST will converge to a single collaborative system due to the nature of the scientific needs, but a few of these systems strategically located is certainly possible and highly desirable.

i. Other NOAA Test beds

A large number of NOAA test beds already exist; however, none are focused on integrating multi-platform satellite sensors into a "best product" capability. Some have similar operational user interactions, and we have selected several as potential role models for the SATB.

i. Joint Hurricane Test Bed

The Joint Hurricane Test Bed (JHT) is a joint activity by NOAA and the Navy. A conclusion from the Workshop was that it was deemed to have the best science-oriented organizational structure, and that the SATB should leverage those lessons into its organizational planning. The key to the JHT's success was a willingness to accept science risk as a necessary precondition for good science. Therefore, some JHT projects are expected to fail. The JHT also had very good turn around times on their science activities by selecting small "doable" tasks. The JHT is different from the SATB in that the JHT is also a bridge between research and operations and the SATB is not. There are numerous successful bridges between research and operations for satellite algorithms already and the SATB will partner with them but not duplicate their work. The SATB will be more focused on the research that is needed to decide whether or not an algorithm is worthy to move forward.

ii. Joint Center for Satellite Data Assimilation Test Bed

The JCSDA Test Bed is focused on satellite/model data assimilation needs, and thus has extensive Radiative Transfer Modeling (RTM) experience and tools. This provides a way for the SATB to standardize RTM tools within selected satellite algorithms. Impacts of sensor data to NWP operations is high-lighted by the center activities. Combined

NOAA/NASA data assimilation systems and output from such systems would provide the SATB with very useful baseline model state information for algorithms to use in a consistent manner across many algorithms. Sharing of such capabilities to the CIs would also benefit the scientific interactions and speed research progress by consolidating the model output interactions. The JCSDA would be the SATB's primary point of contact for model expertise and research interactions. It is also possible that SATB access to parallel High Performance Computing (HPC) resources could be coordinated with the JCSDA so that SATB computational needs could be met through a reduced cost sharing mechanism. Their roles and interactions are highly complementary.

iii. Hydrometeorology Test Bed

Several lessons were learned from the Hydrometeorology Test Bed (HTB) in terms of scope, numbers of participants, and administrative requirements related to formation of a test bed. We anticipate that the HTB will have science interactions with the SATB as a matter of facilitating their functional goals that blended “best-of” satellite products can fulfill.

iv. Hazardous Weather Test Bed

The Hazardous Weather Test Bed is focused on severe weather impacts, and collaborates with a variety of University researchers and operational forecasters. It conducts spring field experiments annually bringing together a broad range of research interests on short-term weather forecasting problems. The user base and research community of the HWTB should be interfaced into the SATB activities to provide better feedback to satellite algorithm developers and operational users.

v. NASA SPoRT Center

SPoRT is a NASA-funded center whose mission is to apply NASA measurement systems and unqiue Earth science research to improve the accuracy of short-term (0-24 hr) weather prediction at the regional and local scale. SPoRT has strong NWS operational ties, and leverages numerous University and other Govt. Agencies into its mission. In particular SPoRT has had success with AWIPS transitions to regional field officies, and software and experiences that should be leveraged into the SATB.

6. Requirements and Architecture for a Satellite Algorithm Test Bed

a. Key functional processes

i. Communication and education requirements

The architecture concepts are new to many in the academic research community, and without a vision and communication of that vision, change will be slow and confusing. It will be necessary to have routine small technical group meetings between STAR/SATB staff and the CI/CREST SATB collaborators to address a variety of challenges that are to be overcome. The solution must focus on technologies that will promote collaboration between STAR and the CIs/CREST. Communication strategies need to be developed that should also include the dissemination of SATB information to a wider community, once a technical challenge has been addressed and initially overcome. This will validate the technical progress, and ensure that requirements for the SATB remain up to date with NOAA and CI/CREST needs and technical realities "on the ground".

Requirement: The SATB shall have regular technical group meetings between its members to address both the technical challenges to develop the SATB and communication challenges to involve the wider scientific community.

ii. Architecture alignment issues (i.e., technology-related change)

The SATB and CIs/CREST environments have unique technologies that many times are driven by non-NOAA centric forces (e.g., NASA or DoD program requirements), therefore the technology used to incubate new algorithms may be created from outside of the SATB environment. Thus the SATB needs to foster a continuous technology dialog with the CIs/CREST environments that may have technologies that are simply "different". There is little to no possibility that the SATB can issue hardware requirements upon the CIs/CREST, since their computational infrastructures are entirely managed via other non-NOAA sources, especially given their own security requirements imposed from within their own University-wide networks. How the technology interfaces are handled is a key driver of future SATB successes. The use of evolving technology and standards must be actively managed and facilitated by the SATB for NOAA-wide benefits.

Requirement: The SATB shall develop and incorporate software that will enable CIs/CREST using differing hardware configurations to interface with the SATB environments.

iii. Continued adherence to SATB architecture guidelines

As technologies change and mature, and as personnel changes are made, adherence to standards defined in an earlier period will be difficult to adhere, thus communication efforts must be strong, and interface standards selected to minimize the amount of change required by the CIs/CREST (essentially simple standards are best – with strong interface definitions that are updated as needed). It is important that the SATB standards process not become an all-consuming effort of defining detailed requirements, but that the key interfaces be defined so that creativity is not stifled, while allowing SATB systems to interface in a predictable manner.

Requirement: The SATB shall develop a standards and software process that will be easy to follow and efficient to implement while enabling the development of algorithms.

Requirement: The SATB processing systems shall have well defined interfaces that will enable a plug and play algorithm capability between SATB organizations.

iv. Common SATB software libraries

This is one of the most critical efforts that will ensure that strong interface standards are meaningful and practical to use. The common software libraries will necessarily define a minimal subset of compiler languages, script tools, and data type definitions, and serve a wide variety of systems, enabling CI/CREST-developed software to be transitioned into the SATB environment and subsequently into the operational-to-research environments such as the PSDI program. The emphasis should be on generalized common libraries for specific hardware platforms used at the CIs/CREST that function well within the SATB/STAR Collaborative Environment. It is essential that the common libraries be well tested.

Requirement: The SATB shall create a list of tools that will be used within the SATB that will enable code portability between organizations.

Requirement: The SATB shall implement software libraries that will be used for algorithm development within the SATB environments to enable portability of the algorithms.

v. SATB Teaming Concepts – Algorithm Working Groups

It was recommended at the Workshop that the SATB form algorithm teams focused around particular subdiscipline areas. This will enable natural scientific communities to form that address particular science needs independent of sensor hardware or acquisition program limitations. Interactions between algorithm team areas should be encouraged where needed, but formal structures could enhance the communication flows. This process is being used within the GOES-R program with great success.

Requirement: The SATB shall form algorithm teams focused around particular subdiscipline areas.

vi. Prioritized list of function processes for the SATB architecture design

All of the above processes are essential to the SATB architecture design. Most fundamental is the lack of control of the hardware at the CIs/CREST by the SATB.

Therefore it is recommended that the SATB foster a common environment which can be accessed remotely to test a variety of software libraries and data processing needs using virtual private network (VPN) access. This core functionality will be closely integrated with the STAR Collaborative Computing Environment. However, due to the size of the satellite data sets, and the need many times to process long periods of data, we recommend that a 2nd tier of hardware located at the CIs/CREST be accepted as necessary to the SATB functionality. Currently, NOAA funds CI/CREST activities project by project with the necessary computational support for each individual project. It is recommended that CIs consolidate their SATB computational interactions where possible to streamline SATB interactions via the use of similar hardware and software libraries where possible. For example, a CI might choose to voluntarily limit their own computational architecture to a small subset of hardware systems and software tool sets. CIs/CREST with similar needs could easily leverage SATB successes as interface standards are defined for handle each subgroup of technical configurations (e.g. a Linux/C++/Perl combination, or similar). When similar hardware is not pragmatic at a CI/CREST, they should place extra focus on using common software libraries that are portable to the SATB hardware systems. Testing of the common libraries in the SATB environment is essential.

Requirement: The SATB shall implement a common environment within the STAR Collaborative Environment that may be accessed using virtual private network (VPN).

Requirement: The SATB shall implement a main computing environment within the STAR Collaborative Environment and a secondary computing environment distributed across selected CIs/CREST according to scientific subdisciplines.

The second most important need naturally occurs within the scientific community, and that is communication, education, and scientific teaming by subdiscipline. The SATB requires an organizational structure to manage such interactions, and foster an communication environment that improves interactions as needed in NOAA priority areas. The SATB should be responsive to NOAA needs as a normal part of operations, and should augment STAR's already deep scientific reach by providing cross-institutional capabilities that can best solve the scientific problems. Each CI/CSC has areas of expertise that will continue to grow in such an environment.

Requirement: The SATB shall implement an organizational structure that will be responsive to the NOAA goals while improving communication and education within the scientific community.

The third most important topic is generally forgotten in most circles. That is the sustainability of the SATB. The SATB is to be continually updated. The SATB is focused on gaining and exploiting new knowledge. Without anticipating future changes, the SATB will die. The SATB must have change as a core value. This includes reevaluation of science teaming, methods of communication, education, interactions with NOAA partners, etc. Such change will require an adaptive management structure, and an ability to accept a bit of risk and chaos necessary to obtain the required flexibility to survive and even thrive in such an environment. The SATB will by definition be an academic "meeting place" for getting real work done in the presence of "real users/customers". STAR and the CIs/CREST have had great success with similar customer-oriented programs. The SATB will become a focus for NOAA-oriented customers to gather and have the same experience at a larger-scale and breadth without the acquisition program limitations on finding the "best solutions".

Requirement: The SATB shall implement an organizational, management, and technological structure that is sustainable

7. Organizational needs and resource requirements

The SATB requires program interaction with key existing operational and research-to-operations programs such as NOAA's PSDI, NDE, HMT, Proving Grounds and AWIPS. These programs have priorities and objectives that need to be addressed by the SATB community. Therefore the SATB requires a management structure to accomplish the ordering of the SATB customers, so that work can progress in an orderly manner. Metrics for determining the success of the SATB are also needed in determining how many of the SATB projects have delivered products into NOAA operations or NOAA research-to-operations programs, and how many have failed (some failures are necessary – and indicate that the program is taking at least "some risk") – without failures the program would lose its scientific value, and "best products" would certainly be a misnomer in that case.

Requirement: The SATB shall interface with existing NOAA programs (i.e. PSDI, NDE, AWIPS)

Requirement: The SATB shall implement metrics for determining its success.

Allocation and approval of initial SATB projects should incorporate the intent to build a collaborative SATB computational environment. Therefore, scientific projects of great merit but without pushing the SATB collaboration envelop and capabilities should be ranked lower for SATB participation than say a project that is solving collaborative scientific problems that can leverage the new technologies into future SATB-wide improvements. **The goal of the SATB is to facilitate the orderly creation and movement of science (without acquisition program limitations) into NOAA research-to-operations programs, therefore the technologies and standard interfaces used to make that happen are needed first.** This message needs to be communicated often to the community, and reinforced with transparent project selection actions demonstrating the type of projects that SATB is facilitating.

Requirement: The SATB shall encourage scientific projects that leverage new technologies into future SATB-wide improvements.

Requirement: The SATB shall facilitate the orderly creation and movement of science.

An important role of the SATB will be to assess algorithm quality. This can be used to make decisions about which algorithms should move to research-to-operations programs as well as to make decisions about which algorithms should move out of operations. The satellite operations component at NESDIS is frequently near-saturation and retiring processes will be necessary to keep them sustained.

Requirement: The SATB shall encourage projects that assess potential algorithms for retirements as well as for implementation into operations.

The SATB should promote and encourage research to be conducted by undergraduate and graduate students collocated with CIs/CREST. This will enable the development of future scientists as well as entrench the CIs/CREST more firmly within the SATB. The exciting work made possible by the SATB should allow the CIs/CREST to attract top students into the satellite-related atmospheric and oceanographic sciences.

Requirement: The SATB shall support the development of algorithms by both graduate and undergraduate students.

As the SATB matures, it is likely that the SATB standards and interface definitions, and architecture guidelines can be extended to future acquisition programs as “Govt. furnished goods” to facilitate the technical integration of the Global Earth Observing System of Systems (GEOSS) data flows into the “best satellite product available” – using any number and combination of GEOSS sensors, thus opening up a new satellite era without the previous acquisition program constraints. This will enable other NOAA test beds to be better integrated into a single NOAA data systems concept in the future, since the SATB will simplify the satellite interface and multiple satellite product issues for the other NOAA test beds. This is one the most formidable issues at hand today, as exemplified by the size and complexities of the NPOESS and GOES-R programs. The SATB is needed by the rest of NOAA to ensure that they don’t reinvent their own SATB for each major NOAA program element.

8. Concluding Remarks

The SATB workshop was successful in identifying several key points, including:

(1) Despite several successful single-satellite, single-sensor algorithm research development programs (GIMPAP, GOES-R Risk Reduction) there is currently no location or funding source to conduct algorithm research using multi-satellite, multi-sensor approaches that are need to meet NOAA observational requirements.
(2) Multi-satellite, multi-sensor algorithm approaches are needed to meet NOAA observational requirements. Numerous NOAA Test Beds and Proving Grounds require products chosen based upon the quality of the observational estimate rather than based upon the particular satellite or sensor.
(3) A Satellite Algorithm Test Bed (SATB), accessible by NESDIS and NESDIS partners, would ease the satellite research community’s transition toward multi-satellite, multi-sensor algorithm approaches, both with respect to cost and complexity.

The workshop also provided an opportunity to explore frameworks, structures and capabilities required for a successful SATB. The Joint Hurricane Testbed was chosen as a model to promote a science-driven approach. Other testbeds such as the Hydrometeorology Test Bed expressed interest in using the outputs of a successful SATB as inputs for their testbeds. In addition, acquisition-specific satellite product program managers (NPOESS Data Exploitation, GOES and POES Product Systems Development and Integration) expressed that the outputs of the SATB could help them choose which products should be transitioned into operations. The satellite operations components expressed interest that the SATB could help them determine which products should be retired from operations to make room for new ones. The entire community was enthused about the possibility to exploit the upcoming satellite constellation in a new, science-driven and more efficient manner.

Numerous activities must occur post-workshop. NOAA management must buy-in to the concept so that the initial activities needed (Preliminary Design Review, etc) can begin in a coordinated and inclusive manner and the testbed can become part of NOAA's budget plans. In addition, workshop participants must continue to gather information and feedback about the SATB concept. It will not be frozen in time, it will need to meet numerous requirements from numerous types of users to be successful. NOAA must provide a location for feedback and new information to be shared. The current location for this is http://www.star.nesdis.noaa.gov/star/meetingSATBWkshp2008.php and is managed by Ingrid.Guch@noaa.gov and Steve.Goodman@noaa.gov . Please send items to them to post, and they will share information about how the concept is progressing and future activities.

9. Acknowledgements

The committee would like to acknowledge the presenters, attendees, the managers of the various already-existing NOAA, NASA and Cooperative Institute Test Beds, the Cooperative Research Program branch chiefs, the NPOESS Data Exploitation team and the NESDIS Cooperative Institute and Center directors for their support of this concept.

Appendix A: Workshop Agenda

Satellite Algorithm Testbed Workshop
Feb 26-27, 2008
Suitland, MD

Session 1: Introduction

Time	Presentations	Speakers & Affiliations
8:30 - 8:35 a.m.	Welcome and Logistics	Jim Yoe / OSD
8:35 - 8:50 a.m.	Expectations for Future, (PDF, 2.8MB)	Al Powell, Director, NOAA / NESDIS / STAR

Session 2: Current SATB-Relevant Activities in NESDIS

Time	Presentations (all files are PDFs)	Speakers & Affiliations
9:20 - 9:35	Satellite Products & Services Review Board (PDF, 2.5MB)	D. Benner
9:35 - 9:50	Product System Development & Implementation (PDF, 71KB)	T. Schott
9:50- 10:10	Algorithm Standards for Implementation (PDF, 1A3KB)	Walter Wolf
10:10- 10:25	NESDIS Satellite Analysis Branch Testbed Activities (PDF, 1.9MB)	G. Serafino
10:25- 10:40	Coffee Break	
10:40- 10:55	CoastWatch (PDF, 2.2MB)	Paul DiGiacomo / Phil Keegstra
10:55- 11:10	GOES-R Proving Ground (PDF, 1.4MB)	Tim Schmit / Mark DeMaria

11:10-11:20	GEOCAT, The Geostationary Cloud Algorithm Test-Bed (PDF, 1.4KB)	Andrew Heidinger
11:20-11:30	Joint Center for Satellite Data Assimilation (PDF, 57KB)	Jim Yoe
11:30-11:40	Session Summary (PDF, 52KB)	Ingrid Guch, session leader

Session 3: Other Test Bed Experiences

Time	Presentations (all files are PDFs)	Speakers & Affiliations
11:40-11:55	Hydrometeorological Test Bed (PDF, 1.7MB)	Timothy Schneider
11:55-12:10	The SPoRT Center - Infusing NASA Technology Into NWS WFOs (PDF, 1.7MB)	Gary Jedlovec
12:10-12:25	Hurricane Test Bed (PDF, 7.8MB)	Mark DeMaria
12:25-12:35	Test Bed Lessons Learned Questionnaire results (PDF, 92KB)	Ingrid Guch
12:35-12:40	Session Summary	Andrew S. Jones, session leader
12:40 - 13:35	Lunch Break	

Session 4: SATB Desirables from Developers & Stakeholders

Time	Presentations (all files are PDFs)	Speakers & Affiliations
13:35 - 13:50	CIMSS Activities Relevant to the Satellite Algorithm Testbed Concept (PDF, 1.1MB)	Jeffrey Key
13:50 - A2:05	Desirable Attributes of a SATB (PDF, 47KB) SATB Desirables: CIRA Part II (PDF, 26KB)	John Knaff / Andrew Jones
A2:05 -	Global Systems Division / Advanced Weather	Darien Davis

A2:20	Interactive Processing System (AWIPS) (PDF, 1.9MB)	
A2:20 - A2:35	Presentation Canceled	
A2:35 - A2:45	A "User's" Perspective: NPOESS Data Exploitation (NDE) (PDF, A47KB)	Jim Silva / Jim Yoe
A2:45 - A2:55	Session Summary (PDF, A5KB)	Steve Goodman, session leader
A2:55 - A3:A3	Coffee Break	

Session 5: Open Feedback Session
Steve Goodman, moderator

Time	**Presentations (all files are PDFs)**
A3:A3 - A3:35	Observations from group
A3:35 - A3:45	Considerations for Breakouts & Assignments
	Breakout Sessions (PDF, 13KB)
A3:45 - A5:00	• Implementation (include IT issues) NSOF 2001 • Program Considerations NSOF 2005 • Other? NSOF 2007
A5:00	End of Day 1 & dinner considerations

Day 2: Wednesday, February 27

Time	**Presentations (all files are PDFs)**
8:00 - 8:30	Coffee
8:30 - 10:A3	Break-out Sessions - Continued (PDF, 10KB)

- Implementation (include IT issues) NSOF 2001
- Program Considerations NSOF 2005
- Other? NSOF 2007

10:A3 - 10:30	Coffee
10:30 - 11:30	Break-Out Team Reports NSOF 2001
11:30 - 12:00	Next Steps • Single-Slide Contributions • Low-Hanging Fruit Identification
12:00 - 12:30	Summary and Adjourn
12:30 - A2:00	Organizing Committee Wrap-up

Appendix B: Workshop Participants

Jim Yoe, NOAA/NESDIS/OSD
Al Powell, Director, NOAA/NESDIS/STAR
Dave Benner, Chief, NOAA/NESDIS/OSDPD/SSD
Tom Schott, Manager, Product Systems Development and Integration
Walter Wolf, NOAA/NESDIS/STAR
George Serafino, Chief, NOAA/NESDIS/OSDPD/SSD/SAB
Paul DiGiacomo, Chief, NOAA/NESDIS/STAR/SOCD/MEB
Tim Schmit, NOAA/NESDIS/STAR
Mark DeMaria, Chief, NOAA/NESDIS/STAR/CoRP/RAMMB
Andrew Heidinger, NOAA/NESDIS/STAR
Ingrid Guch, Chief, NOAA/NESDIS/STAR/CoRP
Timothy Schneider, Manager, NOAA Hydrometeorological Test Bed
Gary Jedlovec, Manager, NASA SPoRT Center
Andrew S. Jones, CIRA
Jeffrey Key, Chief, NOAA/NESDIS/STAR/ASPB
John Knaff, CIRA
Darien Davis, NOAA/OAR/GSD
Jim Silva, Manager, NOAA NDE Program
Steve Goodman, NOAA/NESDIS/STAR
Brian C. Motta NOAA/NWS/OCWWS
Barry Gross NOAA/CREST
Brian Vant-Hull NOAA/CREST
Maurice McHugh IMSG
Hank Drahos NOAA/NESDIS/STAR
Donna McNamara NOAA/NESDIS/OSDPD
Eric Bayler, STAR / JCSDA
Sid Ahmed Boukabara, SMCD / SPB
Ralph Ferraro, CoRP / SCSB
Andy Heidinger, CoRP / ASPB
Eileen Maturi, SOCD / MEB
Huan Meng, CoRP / SCSB
Tony Reale, SMCD / OPDB
Frank Tilley, SMCD / OPDB
Yong Han, SMCD / SPB
Bill Sjoberg, NOAA/NWS/OCWWS
Linda Stathoplos, NOAA/NESDIS/OSDPD
John Paquette, NOAA/NESDIS/OSDPD
Jason Tuell, NOAA/NWS
Brian Gockel, NOAA/NWS
Kent Hughes, Chief, NOAA/NESDIS/STAR/SOCD
Jaime Daniels, NOAA/NESDIS/STAR
Thomas J Kleespies, NOAA/NESDIS/STAR
Geoffrey P Goodrum, NOAA/NESDIS/OSD

Thomas Renkevens, NOAA/NESDIS/OSD
Chris Velden, CIMSS
Hai-Tien Lee, CICS
Peter Romanov, CICS
David Billingsley , NWS/SR/SSD
Stephan Smith, NWS/OST/MDL/DAB
Murty Divikarla

Appendix C: Workshop Synopsis

Below are descriptions of all the presentations given at the workshop for a Satellite Algorithm TestBed (SATB). Key ideas are highlighted, particularly those that could be useful for the SATB workshop whitepaper. All the presentations are available in their entirety at http://www.star.nesdis.noaa.gov/star/meetingSATBWkshp2008.php.

8:35 - 8:50 a.m. Expectations for Future, Al Powell, Director, NOAA / NESDIS / STAR

This presentation highlighted several key expectations for the future, including

1. Increasing Resolution for satellite instruments: Temporal, Spatial and Spectral Examples: GOES R Series (5x greater coverage, 2x higher resolution, 3x number of channels, Multiple sounding tasks, Full disc images in 5 min). NPOESS (30x higher resolution, 6x faster data relay)

2. Increasing requirements for research and operational support related to Next Generation Satellite Observing Systems. Examples: More efficient computers, Better algorithms, Direct Ties to User Applications, Better filtering of information, Increasing numbers of tailored products, and Changing definitions of "products"

3. New needs for decision support via geospatial and environmental analysis, combining Environmental Data, Maps, Imagery, Census Data, Community Data, Property Information, etc.

4. Outcomes of the SATB: Improved Collaboration, Faster Product Development, Faster Research to Operations, Improved Product Quality, Integrated Data Environment, Service Oriented Architecture

9:20 - 9:35 Satellite Products & Services Review Board D. Benner

This presentation highlighted the current process to transition user requests into operational satellite products and/or services.

The primary mechanism overseeing the transition is the Satellite Products and Services Review Board (SPSRB) composed of principals from OSDPD, STAR and OSD. It's mission is to provide oversight and decision authority to effectively manage NOAA's satellite product life cycle process. It addresses user requests to enhance current products or generate new products in line with requirements of NOAA Mission Goals, focuses on the transition of research into operations, Manages product development projects, allows for divestiture and retirement of products, and provides a powerful evaluation mechanism to enable a more efficient use of personnel, fiscal and information technology resources. It meets monthly (third Wednesday in Room 707 NSC) and is moderated by executive secretary.

The SPSRB process starts when there is a need to move a capability from research to operations. There are 3 paths that can trigger the SPSRB: (1) User Request: Users can identify a need for new or improved observations or products, (2) Mature Science Development: Scientists can identify maturing scientific development or algorithm thought to provide significant user benefit and (3) NOAA Program/NESDIS Project Manager Directed Project: NOAA/NESDIS program or project managers can provide requirements to develop new or improved products. These acquisition managers formulate plans to acquire the new products.

[Discussion: The SATB could play a role in providing a location and funds to conduct scientific research that would, if successful, result in a user request or mature science development that triggers the SPSRB.]

In addition to putting in new products to operations, the SPSRB has a process for Product Retirement to retire products no longer deemed of value to the user or cost effective to produce. There are 3 categories that would trigger a product retirements (1) System-driven - satellite failure; new satellite instrument; new improved product or new IT system, (2) User-driven - annual product revalidation/customer satisfaction; agreed decommissioning or replacement product and (3) Fiscally-driven – inadequate funding for production operations; development/implementation funding not realized or refocus of organizational mission. In the case of (3) there will be a user notification and assessment phase to determine impact on users, request user comments, review and seek SPSRB decision, and a final notification and appeal process if necessary.

[Discussion: The SATB could play a role in quantifying the impact and quality of an operational product versus proposed replacement products. The ability to do this is critical users (and therefore providers) can feel comfortable with the decisions to decommission products.]

This presentation also covers: Resource Identification Assessments, Request Assessments, Technical Assessments, Operational Decision-making, Product Development Reporting, NOAA Partnership Policy Requirement, Solution Analysis and Selection, and Integrated Project Teams.

9:35 - 9:50 Product System Development & Implementation T. Schott

This presentation covered briefly the Product System Development and Implementation (PSDI) projects that are funded by the NESDIS Office of Systems Development (OSD) and conducted using the SPSRB processes. It also covered the difference between OSD Development PAC funding (such as PSDI) and OSD Ground Systems PAC funding.

OSD PAC Product Development funds are to develop and implement new or improved products to meet validated operational user requirements and transition from research to operations. The focus is software development. OSD Ground System funds are for New or upgraded IT capabilities. The focus is IT hardware, but it can involve software development if developing a significantly new system capability (e.g., MetOp project). PAC funding is not for research, operations or maintenance.

Two options were presented for the system development of an SATB. (1) Small IT investment (<50K), where the initial capability could be STAR base and/or PSDI funding and the Long term maintenance would be STAR base. (2) Larger IT investment Initial capability could be STAR base, Ground Systems and/or PSDI funding. PSDI would focus on software development. Gnd Sys would focus on hardware. Long term maintenance would be STAR base.

Since PAC funds do not support research, all the research would need to come from ORF funds (i.e. STAR base).

9:50-10:10 Algorithm Standards for Implementation Walter Wolf

This presentation went over the steps STAR is taking to improve the software development and integration scientific algorithms, including:

The Standards Working Group
» Lead: Maurice McHugh
» The SPSRB common standards group recommends standards to the SPSRB for adoption among the participating organizations
» Leads the effort to bring standards and consistency between development efforts
» Topics includes documentation standards, coding standards, life cycyle development (SPSRB and CMMI), and delivery standards

The STAR IT Advisory Committee
» Lead: Ingrid Guch
» Organizing the efforts within STAR associated with IT Security, Data Management, Common Standards, and the Collaborative Environment

The STAR Data Management Group
» Lead: Celso Barrientos
» Organizes the data within STAR such that research and validation efforts have the data required. Data formats and metadata standards are addressed by this group.

The STAR SMCD Integration Team
» Lead: Hank Drahos
» Address the issues associated with the actual transition of algorithms to operations. This team looks at the software development side and the day to day issues of transition

The STAR Collaborative Environment
» Lead: Joe Brust, Ingrid Guch
» Host algorithm research and development in a consistent and near operational environment

– Same compilers, operating systems
– One set of standardized documentation
– Extensive test input & output data sets
– Same ancillary data sets as the operational environment
– Common software
» Data Server(s) associated with the CE where research/experimental products are made available to users

This presentation also had several questions for the SATB architects:

• How many types of satellite data do you want to process?
• What operating systems should it run on?
• What type of languages should be allowed?
• How do you want to run the test bed? Scheduler?
• Will there be one program on the testbed or will each algorithm have it own main program? If one program, who will integrate the algorithm into the test bed?
• How will product validation be organized?
• Will the hardware be sized?
• How much data will be required?
• How many algorithms will be run on the testbed?
• Will the testbed address data distribution?
• Will there be user participation with the research products?

10:10-10:25 NESDIS Satellite Analysis Branch Testbed Activities G. Serafino

The Satellite Analysis Branch (SAB) serves as the operational focal point for real-time imagery products and multi-disciplinary environmental analyses within NESDIS. The Branch's primary mission is to support hazards mitigation and warning services for U.S. Federal agencies, the international community and other users by providing around-the-clock, quality-controlled environmental analyses for decision support applications. The Branch schedules and continuously monitors real-time satellite imagery products from global geostationary and polar orbiting environmental satellites for dissemination to customers. The Branch collaborates closely with its research partners to test, evaluate and validate the results of new interpretive satellite analysis techniques and satellite-derived products, and to assess their suitability for operational implementation and utility to existing and potentially new user communities. The Branch coordinates with internal and external partners to infuse new technology into science operations to better meet customer needs for products and services. Branch personnel are heavily engaged in outreach activities designed to increase customer awareness and use of environmental satellite data products.

SAB currently focuses on the analysis and applications of operational satellite products related to tropical meteorology, volcano eruptions and ash, smoke products, precipitation products and snow/ice products.

The SAB has the following attributes and duties that may be useful for the SATB: Highly skilled multi-disciplinary meteorologists and physical scientists with many years experience in operational satellite analysis for various applications, Established, long-term working relationship with research partners (STAR, CIRA, CIMSS, OAR,NWS/EMC, etc), provides crucial link between operational customers engaged in decision support and the algorithm developers, Serves as a "beta test" site for new and enhanced products and their applicability to customer needs, frequently included in PSDI and NASA ROSES proposals as a test and evaluation site for new automated and interpretive products, Through continuous customer contact SAB Outreach and Team Leads obtain first hand feedback from users and is used to advocate for customer needs, Provides important feedback to developers on improvements needed (functional and performance) to be of use in an operational setting, Experience with GOES and POES will be a valuable asset in upcoming NPOESS/ NDE and GOES-R algorithm evaluation.

The SAB also presented the following testbed lessons learned:

• Ground truth is critical! SAB's tropical testbed has benefited tremendously from Atlantic reconnaissance missions which provide ground truth from which to derive homogeneous comparisons between experimental products and SAB's subjective TC classifications
• Awareness of current research efforts is a vital component. Over the last decade the tropical testbed has attended professional conferences to increase such awareness and to establish initial collaboration which successfully builds upon itself
• The researcher needs assurances that their algorithm will get an independent and unbiased hearing if the testbed is to thrive and expand. Experienced analysts become critical as is ongoing open and honest communication between the researcher and the testbed.
• The end-user must be able to trust the testbed. The V&V methodology must be acceptable to the end-user, requiring an understanding of the their operation and communication with them throughout the validation process.
• Metrics matter! The formulation of sound metrics depends upon an accurate understanding of the end-user's operations. What is important to them?
• Infrastructure support is vitally important to the testbed, especially in the case of SAB where operational products are being generated according to short-fuse deadlines. The testbed needs to be able to gather the data with as minimal an impact as possible on the analysts while they generate their operational products.
• The testbed needs to conduct outreach efforts to ensure that the research community realizes that the testbed exists. The existence of a funding mechanism (e.g. PSDI) is very helpful.
• The testbed can serve as a conduit for useful feedback to the development organization for product or system improvements; there are many cases that can be cited in support of this in SAB
• Continuous dialog with the development organization and early embedding of the testbed personnel in the development process will help to reduce the number of iterations and ensure adherence to operational needs, thus serving to accelerate the research-to operations transition.

• Testbed should continuously engage users especially as an algorithm approaches maturity
– development of training material using expertise from operational satellite analysts provides real world experience. Example: inclusion of operational perspective at NPOESS Curriculum Workshops
– Regular information exchange and updates on testbed efforts with customers. Example: bi-monthly SSD-NWS Center telecons including working level representatives from all NCEP centers, NCO, CPHC, and SSD staff serves to engender true team work between customer and provider.

10:40-10:55 CoastWatch Paul DiGiacomo / Phil Keegstra

The CoastWatch program has national distribution: Central operations & six regional nodes. They have a research machine and an operational machine, but no parallel test capability in the operational environment, resulting in confusion over whose responsibility it is to compensate for configuration differences. Such a system would provide a place to adjust delivered code to the production configuration and perform final testing without risking disruption of operational processing.

The CoastWatch group presented the following as representative SATB Case Studies:

• NASA Standard Ocean Color Community Algorithms; NOAA-tailored Modifications
• Regionally tailored ocean color algorithms
– partnership of local researchers & users
• STAR internal R&D efforts, RESEARCH TO OPERATIONS Transition
• Use of Foreign Ocean Colour Data Streams

The CoastWatch group also had experience with algorithm selection by a consortium of interested regional users for Region-Specific Chlorophyll Algorithm (federal, state and academia). This is working fairly well and presently active only for Chesapeake Bay. The algorithm presently selected is subject to change should this consortium identify one which better meets its needs. NOAA PSDI is used to make the algorithm operational.

[For discussion: the SATB could play a critical role in providing metrics for algorithm selection groups like the one mentioned above].

10:55-11:10 GOES-R Proving Ground Tim Schmit / Mark DeMaria

GOES-R Proving Ground – forecaster/AWIPS focused, to prepare for the GOES-R information. Get real-world experience by leveraging existing resources to prepare for the GOES-R era. Product tailoring. Coordinate with the NWS. Connections with NOAA operational offices are critical!

What it is not – another algorithm development testbed, basic research, researcher-focused, product algorithm development, science fair, etc.

This presentation also lists current NOAA testbeds for reference:

• NOAA Hazardous Weather Test Bed (HWT)
• National Wx Radar Test Bed (NWRT) http://www.nssl.noaa.gov/hwt/
• NOAA Hydrometeorological Test Bed (HMT) http://hmt.noaa.gov/
• NOAA, Navy, NASA (USWRP) Joint Hurricane Test Bed
(JHT)
http://www.nhc.noaa.gov/jht/index.shtml
• NOAA Climate Test Bed - www.cpc.noaa.gov/products/ctb/
• NOAA Aviation Weather Test Bed http://aviationweather.noaa.gov/testbed/
• NOAA/NCAR Development Test Center (DTC-WRF)
http://www.dtcenter.org/index.php
• NOAA Joint Center for Satellite Data Assimilation (JCSDA)
http://www.jcsda.noaa.gov/
• NOAA High Impact Weather Test Bed (HIWT)
• NOAA/USAF Space Weather Test Bed
• NPOESS Aircraft Sounder Test Bed
• NOAA Unmanned Aircraft Systems Test Bed
• NOAA/NCAR/DOD NWP Test Bed, Boulder, CO

11:10-11:20 GEOCAT, The Geostationary Cloud Algorithm Test-Bed Andrew Heidinger

Running multiple algorithms simultaneously while using the same input allows us to isolate algorithmic differences.
• LEOCAT was developed under our NPOESS/IGS project as a VIIRS algorithm test-bed based on MODIS data. LEOCAT has been adopted by the NPP PEATE.
• GEOCAT was developed for the GOES-R AWG cloud application team but has been used by several non-cloud AWG algorithms.

GEOCAT is the basis of all AWG cloud application team work and the vehicle for several other non-cloud algorithms (fire, ozone, SO2, ash, winds). GEOCAT has been demonstrated on MTSAT, GOES-10, GOES-11, GOES-12 and MSG-1. GEOCAT is running in real-time on GOES-11 and GOES-12.

11:20-11:30 Joint Center for Satellite Data Assimilation Jim Yoe

Mission of JCSDA is to accelerate the use of satellite data in operational and research environmental models. Specifically, to use more of the available satellite data, use new data more quickly and reduce from 2 years to 1 year the time between launch and operational assimilation of satellite data. Partners include NASA, NOAA and DoD. Standardization such as the Community Radiative Transfer Model is key to success.

Accomplishments include trusted impact studies of advanced sensor data including AIRS, COSMIC and WindSat, the Community Radiative Transfer Model that made possible many of the advanced sensor triumphs and reduced cost and effort for all partners, and the NOAA-NASA Common Data Assimilation System.

Challenges include maintaining a balance of research and implementation resources (the research results may far outpace implementation, for example in Land Surfaces), Data Assimilation System (DAS) and Model differences mean that not all partners are benefiting equally from successes, differing missions and priorities among the partners. Also limit the likelihood of equal benefits per partner, access to operational (parallel) HPC environments for external partners is difficult and impeded by hardware costs, security issues, access issues and a lack of training.

11:30-11:40 Session Summary Ingrid Guch, session leader

Wrap Up Points

It was noted that SPSRB, SAB, JCSDA and CoastWatch are all example of programs that are not acquisition-driven and it allows them the flexibility to choose the best that the satellite program has to offer to focus on. However, PSDI is acquisition focused but uses the SPSRB as a framework, so both types of activities can co-exist.

It was also noted that there is a difference between attendees for the definition of "operations". Is it when the production of the observation is deemed "operational" or when the user has deemed it "operational"? How to communicate between the groups?

11:40-11:55 Hydrometeorological Test Bed Timothy Schneider

Major Activity Areas of HMT include Quantitative Precipitation Estimation (QPE), Quantitative Precipitation Forecasts (QPF), Snow level and snow pack, Hydrologic Applications & Surface Processes, Decision Support Tools, Verification, Enhancing & Accelerating Research to Operations, Building partnerships

Test beds defined. The Testbed Working Group developed the following consensus definition of
a test bed:
– A testbed is a working relationship in a quasi-operational framework among measurement specialists, forecasters, researchers, the private sector, and government agencies aimed at solving operational and practical regional _____problems with a strong connection to the end users. Outcomes from a testbed are more effective observing systems, better use of data in forecasts, improved services, products, and economic/public safety benefits. Testbeds accelerate the translation of R&D findings into better operations, services, and decision-making. A successful testbed requires physical assets as well as substantial commitments and partnerships.

Performance Measures Help HMT Link Science and Technology Advances To Service Improvements. For instance, HPC & RFC Formal QPF GPRAs and Technology performance measures such as "# of systems developed/tested". HMT provides a framework to accelerate improvements in existing NOAA Corporate GPRA measures and to develop new GPRA measures.

11:55-12:10 The SPoRT Center - Infusing NASA Technology Into NWS WFOs Gary Jedlovec

Mission of the SPoRT Center: Apply NASA measurement systems and unique Earth science research to improve the accuracy of short-term (0-24 hr) weather prediction at the regional and local scale.

Main focus on short-term weather forecast improvement on a regional and local scale -- complementary to JCSDA
• conduct focused research
• evaluate in “testbed” mode
• transition priority products
An External advisory committee is used to help guide work. Players include Universities (UW, UW, UAH, USF,FIT, FSU), ENSCO, NWS (Southern Region, HQs), NESDIS (STAR, NDE), JCSDA, JPL, GSFC.

Keys to success were that they were able to link data / products to forecast problems, integrate capabilities into AWIPS, and provide training / forecaster interaction & feedback.

Testbed was defined as
• Physical entity or “virtual” environment
• Simulate operational constraints
• Focus on “low hanging” fruit – early success stories
• Build a working relationship with end user
– all levels in organization
– involve end user in testbed activities (personnel exchange)
– training
– continued involvement post-transition
• Preliminary performance assessment

12:10-12:25 Hurricane Test Bed Mark DeMaria

The mission of the Joint Hurricane Test Bed is to transfer more rapidly and smoothly new technology, research results, and observational advances of the United States Weather Research, its sponsoring agencies, the academic community and other groups into improved tropical cyclone analysis and prediction at operational centers.

JHT Process: (1) Principal Investigators apply for funding through NOAA (2 year projects) (2) A seven member Steering Committee rates all proposals (3) Funded projects are tested during one or two hurricane seasons in conjunction with NHC/Environmental Modeling Center points of contact (4) At the project’s end, each are evaluated by

NHC/EMC staff (5) Implementation of successful projects are then carried out by NHC/EMC staff/PIs

JHT has accomplished the following from 2001-2008: 50 projects funded, 39 completed, 28 accepted for implementation, 21 implemented. Dedicated NHC & JHT staff, and close collaborations between the PIs, NHC forecasters and support staff has been the key.

What does it take to support the JHT?

JHT Staff of 4, JHT Steering Committee of 7, JHT principal investigators and other funded participants, John Gaynor (US Weather Research Program), NHC and EMC forecaster and technical points of contact, NHC/Technical Support Branch IT staff

Implications for Satellite Testbed
• Structured project environment is important
– Well defined beginning, evaluation criteria and end
• Oversight by a steering committee is important
• Users assigned from project start is important
• Parallel infrastructure and data provided for real time tests is important
• Problems are likely
  - Funding level declining
  - Saturation of operations
  - Little or no funding for high risk ideas

[For discussion: SATB workshop attendees very much liked the structure of the JHT and felt something similar would be appropriate for the SATB. For instance, rather than ensuring operational (NHC or EMC in the JHT case) folks were points of contact our test bed, because it is addressing an earlier phase in the research process would have other Testbed (JHT, HMT, HWT, CTB) or Testbed-like (SAB, STAR Operational Products Development Branch, JCSDA) federal points of contact, so the results of research conducted in the SATB could be transferable to the next phase which has stronger interactions with operations and possible transition to operations.]

12:25-12:35 Test Bed Lessons Learned Questionnaire results Ingrid Guch

9 participants in a short questionnaire from folks who considered themselves owners of a test bed (Climate Testbed, Hazardous Weather Testbed, TOVS, ATOVS, MIRS, NDE, PROFS, TETHYS/OKEANOS, and "no-name"). All participants agreed that their test bed was a good idea. Most popular intent and success attributed to test beds: "a mechanism to evaluate and choose the best research ideas for operations to implement". IT compliance and attracting funds were least likely to be the intent of the test bed and least likely to be successful.

Selected and condensed comments from surveys

• Only a full parallel dynamic test bed affords the testing in a manner consistent with the environment in which the new or upgraded science will be expected to run operationally while fully testing the science under realistic extremes for the entire earth
• Algorithm scientists have to improve their code to standard with help from the system developers, otherwise only the system developers will do it and there will become a disconnect between the research code and the operational code
• Some suggest test beds are too costly but they will pay the price later on
• Parallel operations is an objective of our test bed but is currently too costly to implement
• Test beds came to be established via ground-up or top-down or sometimes both methods ("Top down push established the test bed, ground-up and top-down advocated")

13:35 - 13:50 CIMSS Activities Relevant to the Satellite Algorithm Testbed Concept Jeffrey Key

Components of the SSEC Data Center:
CIMSS Processing Computers User Workstations
Tape Archive and Tape Retrieval
Meta Database/inventory

Data at the SSEC Data Center
Modis Direct Broadcast, GOES East (GOES-12),GOES West (GOES-11), GOES SH (GOES-10), Meteosat-5 (63 E), Meteosat-8 (0), NOAA-14, NOAA-15, NOAA-16, NOAA-17,NOAA-18, FY1D, Aqua-EOS, Terra-EOS, NOAAPORT ch1 and NOAAPORT DVB.

(Inter)Calibration: Routine satellite-to-satellite cross-calibration is an essential part of satellite data processing. We need tools for intercalibration (e.g., shifting response functions).

Product Generation: Many existing satellite products use algorithms that have evolved to operate universally with new satellites/sensors. Sample algorithms and products that have achieved this include:
– Winds from GOES, MSG, MTSAT, AVHRR, MODIS
– HIRS cloud products (AIRS)
– AVHRR cloud products (MODIS)
– Biomass burning
– ITPP (AAPP)
Multisensor products must be explored. Some already exists, e.g., APP-x that uses AVHRR and TOVS for cloud and surface properties.

Validation: A key component of algorithm development and advancement is an ongoing program of validation to determine uncertainties. Proxy data, in situ, and other validation/verification data should be available.

Visualization is an important part of any algorithm development environment.
SSEC/CIMSS visualization systems include:

HYDRA
McIDAS-X
McIDAS-V

It is most useful if visualization tools are available to not only display data, but to explore it.

SSEC Data Center archive includes:
• Weather satellite archive holdings
– GOES 26 Jan 1979 - present
– GMS-5 9 Nov 1998 - 21 May 2003
– MET-5 (Indoex) 9 Mar 1999 – present
– MET-7 9 Mar 1999 - present
– MET-3 1 Jan 1993 - 1 Jan 1995
– MET-8 A3 Mar 2004 - present
• Global products from web
– Montage Apr 1997 - present
– IR composites Apr 1997 - present

How does CIMSS fit into the SATB concept?
• Experience in the end-to-end process, Basic research and algorithm development.
• System development, including the Cloud and Surface Parameter Retrieval (CASPR) system (1995-present), Low Earth Orbit Cloud Algorithm Testbed (LEOCAT) and GEOCAT (Covered earlier by Andy Heidinger), NPP Atmosphere Product Evaluation and Test Element (PEATE), GOES-R Analysis Facility Instrument for Impacts on Requirements (GRAFIIR)
New Paradigm at SSEC
• Data from different sensors processed using common science algorithms and ancillary data.
• Software designed to work in generic environments (e.g., require only Linux and HDF4/5).
• Software is freely available to the community (e.g., SeaDAS).

Thoughts on the SATB Concept
• The idea of a common programming interface and tool kit is good.
• Centralized processing might be functional, but not in a government facility (cumbersome security).
• Multi-sensor approaches may be the only way to solve some problems. So breaking out of the instrument-specific funding stovepipes is desirable. But do we need a testbed concept to achieve this? Why not an initiative for innovative approaches to satellite product development?
• Shared test and validation data is desirable and efficient.
• Avoid too many constrictions, taking away the freedom of algorithm developers and visionaries. The testbed should ultimately make the life of a developer easier, not more difficult.

• Avoid overlap with, or better yet leverage, existing activities that have testbed-like components (i.e., GOES-RRR & AWG).
• There will never, ever be a single algorithm, or model (cloud detection, NWP model, etc.). That is not a bad thing.
• Don't take money from existing programs for this

We need to consider: To what extent is this initiative for basic, innovative research versus system development?

– It is (in the white paper) the "Advanced Satellite Algorithm Research" initiative.

– Arguably the most attractive component is the cross-sensor and cross satellite algorithm development.

– PSDI and Ground Systems are PAC funding, and not for research.

Is this simply another hardware/software system development project, or is it more?

[Note for discussion: attendees indicated that this initiative is more than system development, that it is filling the missing pieces that currently do not allow for cross-sensor and cross satellite algorithm development or development on sensors that are not in the NOAA acquisition program]

13:50 - A2:05 Desirable Attributes of a SATB A developers point of view
John Knaff

Desirable Attributes of a SATB
• Data access
– A common set of tools to access all of the meteorological observations, analyses and forecasts (e.g., GRIB, BUFR, MCIDAS fmts, NETCDF, HDF*, etc…) - Standard and supported in operations as well
– Allow remote access from places other than ".gov", non-Federal Personnel - SATB should be placed outside the firewall
• Common display tools
– A wide array of software to display products and output (IDL, NCAR graphics, gnuplot, GrADS, MCIDAS, etc…) – Standard and supported in operations to help with eventual transition.
• Dissemination tools
– A set of common tools to appropriately disseminate experimental products (e.g., GRIB (1&2), BUFR, MCIDAS fmts, NETCDF, HDF*, etc…)
• Local Liaisons
– A technically and meteorologically sound person or a team to help developers implement their algorithms and disseminate their results.

Examples of applications that would benefit from the above items include the Satellite Only Tropical Cyclone Surface Wind Analysis product that has 6 data input types with 8 data sources. The Tropical Cyclone Genesis product has 6 products to display and 3 product display tools.

SATB Desirables: CIRA Part II   Andrew Jones

Q: What is Success?
Q: How do you measure it?
Critical Factors?
- Scope/Expectations (Faster Transition to Users?)
- Funding (Specialization allows for more productivity?)
- Why use this testbed? (Access to New Capabilities?)

Barriers that were overcome?
- Motivation (Was it built into the Testbed Design?)
- Governance / Host Culture Issues?
- Interface Definitions (Common Tools, Languages, Hardware, OS, Libraries, Docs, Testing, Training, etc.)

SATB Desirables: Objectives
- Clear Communications
- Univ. Usability and Accessibility (Accounts / Firewalls / Security)
- Transparent Governance
- Keep it simple (minimalist rules)
- Flexibility - must serve multiple users

What it is not: Hardware purchases

Long-term objectives (through and beyond NPOESS/GOES-R era)
- "Best" Science (not the best "stovepipe" given funding limit X/Y/Z)
- "Best" User Application / Impact
- Sustainable funding support for continuity and system integrity
- Institutionalize better science interactions by use of EDR teams re: algo. mprovements/ error sources / user feedback

SATB Desirables: Design
- Build Capabilities Incrementally
- Targeted Early Objectives: e.g., Cross-sensor
- Bottom-up Modular Coding (the low-level software, standards, and testing matters most)
- Must separate data I/O from algorithms
- Flexible enough to allow for Future Innovation
- Data Driven / Process Oriented / Team-Based

(NOUN) (VERB) (ADVERB)
- Benefits should eventually become more bi-directional (Research <-> SATB <-> OPS)

The SATB Design should answer the question: "What's in it for me?"

A Culture Shift is in Progress. In the Future it is very likely that:
- 1) Scientific staff will be unqualified to code on OPS systems.

□ 2) OPS CS staff will be unqualified to make science algorithm changes due to increasing algorithm complexities.

Participation should be Voluntary (not forced). The benefits of working together on “common ground” should be enough to entice early adapters, and to entice late adapters once mature enough. The SATB should have to earn its respect.

A2:05 - A2:20 Global Systems Division / Advanced Weather Interactive Processing System (AWIPS) Darien Davis

GSD Expertise

• Research Applications
– Assimilation
– Modeling

• AWIPS I Development
– Transition to NWS mission operations

• Evaluation
– Exercises
– Risk Reduction
– Demonstrations

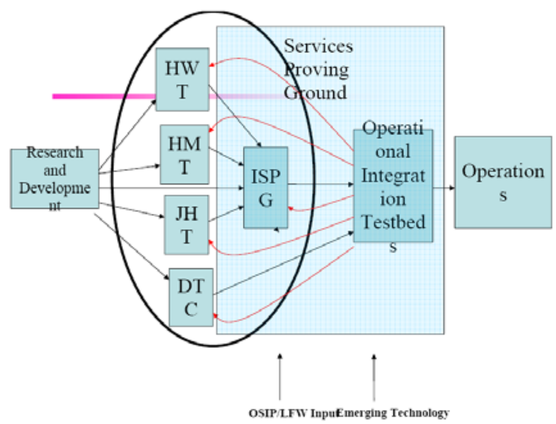


Figure above shows the Operational Integration Testbed and the Services Proving Ground relationship to other testbeds (Hazardous Weather Testbed, Hydromet Testbed, Joint Hurricane Testbed, Development Testbed Center)

[Note for discussion: SATB could be in the R&D box, feeding research and development ideas from satellites into more specific testbeds]

Lessons Learned from Services Proving Ground activities
• Evaluate capabilities empirically
– Usage logs
– Questionaires
– Observation

• Have comprehensive examples of products
• Real-time Real-time Real-time
– If real-time is not available simulate real-time data feeds as much as possible
• Account for seasonal/daily applications
– Visible during day
– Winter/Summer

A2:35 - A2:45 A "User's" Perspective:NPOESS Data Exploitation (NDE) Jim Silva / Jim Yoe

NDE Mission:

Assist NOAA and other civilian users to realize the potential of NPP and NPOESS observations

How SATB can help:

* Bring additional science expertise to bear on development of outstanding NOAA Unique Products ("NUP"s)
* Increase efficiency of moving science from research to operations by providing standard environment for development and testing
* Expand applicability by working with NDE users and (new) end users to focus product development efforts
* Local, regional, and application expertise

Questions from NDE:

* How can the SATB help NDE validate its NOAA Unique Products?
* What new science algorithms and tailoring tools can the SATB introduce to NDE?
* What SATB resources are available to help NDE transition new products into operations?

A2:45 - A2:55 Session Summary Steve Goodman, session leader

SATB Objective: A test bed to accelerate the development, implementation, delivery, and operational application of new/improved environmental satellite data products.
SATB
• Consistent with the NOAA Satellite Capitalization Plan roadmap
• Breaks down the stovepipe processing of GEO and LEO tied to satellite acquisition programs
• Accelerates transition from research to operations
• Inclusive of a broader community of developers and end users
• Moves us towards an integrated Observing System- GEOSS

SATB Benefits

• - It would allow research to focus on problems such as severe weather, soil moisture, ocean color without the artificial partitioning into acquisition program-related projects.

• - It would allow researchers to address remote sensing issues according to the physics involved and the skill sets required to solve problems associated with IR, microwave, visible channel, scatterometer etc disciplines.

• - It would allow emphasis for the first time on cross-sensor and cross-platform algorithm development which would maximize the utility of NOAA's satellite constellation for weather and climate.

• - It would allow algorithms to be developed or transitioned whose origins were outside of the normal POES/GOES mindset. Examples would be METOP and MSG development transitions

- It could exploit tools such as radiative transfer models, and innovative data processing technologies more effectively.

• - Unlike other contractor funded methods for algorithm, validation, and calibration efforts the SATB would improve corporate memory on critical elements of satellite operational technology. Algorithm developers and experts in calibration would not cease employment when a specific satellite programs effort was completed. This would not only improve the efficiency of satellite acquisition but it would also vastly improve the future stewardship of the data.

• - The SATB would interface well with NESDIS algorithm and satellite product "stewardship" activities as recommended to NOAA by several advisory panels and groups.

• - It could develop long-term relationships with other NOAA virtual laboratory activities such as the Joint Center for Satellite Data Assimilation

• - Allow research to be proposed/conducted that would cross cut the geo/polar platform issues not relevant to the phenomena being addressed Improve both research and operational efficiencies where remote sensing can be explored with the proper mix of polar and geostationary sensors without acquisition program surf arguments and prerogatives muddying the water.

• - It would allow sustained research in areas that are now terminated as part of satellite programs.

• - It would expedite the use of cross-sensor/satellite methods in the calibration and validation of specific satellite systems.

• - It would allow new applied research to be started up under the continuing umbrella of the AP/SATB thus avoiding the delays in algorithm exploitation and development associated with the 7-year PPBES process.

• - Resources for algorithm development would be consolidated across NOAA programs providing a greater level of program sustenance

SATB Workshop Outcomes

• White Paper that can be briefed to NESDIS AA Mary Kicza and NOAA Goal Team Leads

• Validate key drivers, gaps, benefits, required resources with input from community of developers and stakeholders

Notes from Discussion Sessions (All)

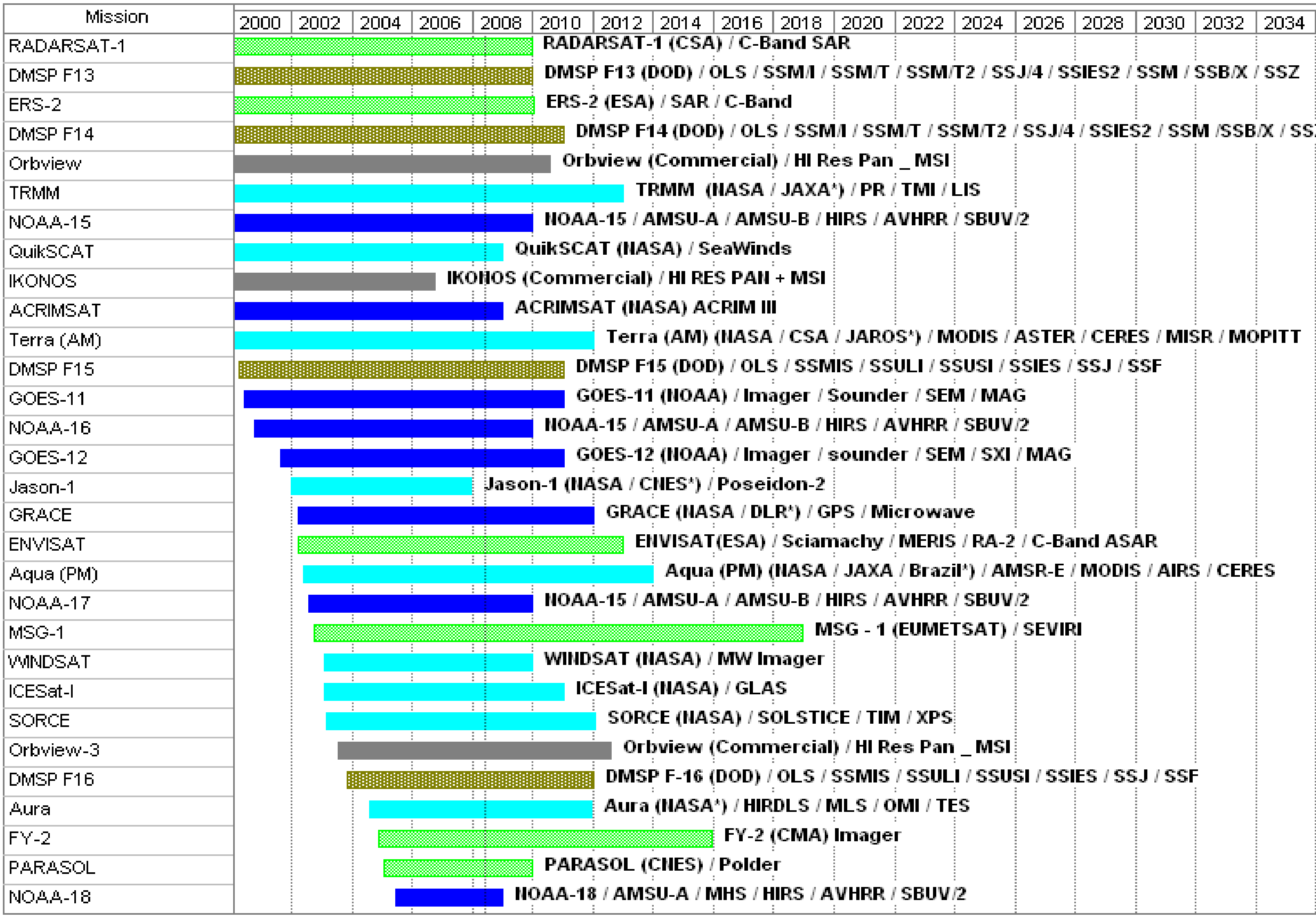
The following was deemed important to address in the white paper:

Implementation (IT issues)
• Program Considerations
• How much leveraging can we do? How much would be left that still needs to be done?
• What is scope?
• What is definition (operations, satb, etc?)
• How to get univ/ext partners to be able to work/improve/study operational algorithms in a timely way?
• How to address Access issues (IE Wash DC firewall)?
• Role of external community/universities? How do we make it inclusive?
• Desirable attributes of a test center
• How to keep this innovative/creative and merge platforms but also switch paradigms? Is this something complementary to our current psdi/etc processes?
• Part of the gap is getting to psdi process (in addition to cross-sensor)
• Is this a playground for new algorithms OR is this something that allows a scientist to get into operations? The concept of operational constraints will limit the playground but enhance the operational effectiveness. Is there a way to do both? The hurricane testbed appears to do both since failure is a real option unlike current psdi paradigm.
• Is the testbed a way to find out quickly if a new idea is going to be useful (allowing for more risk)?
• Note that both research and operations tend to be funded by operations whereas the research to operations is PAC… when looking for ORF don't forget to include both research and operations ORF components.
• How to best involve end-user (getting requirements from end user?) Is that part of SATB? Do we start with the assumption that there is a requirement before the testbed is involved? Or is part of the testbed to find new requirements? Can the testbed use noaa documents to identify problems that we could then map requirements to?
• Do we need an SATB? There are certainly gaps? No ORF for GEOSS-type projects (as opposed to systems acq projects). Lots of HW/SW type things happening.

SATB-What is the desired end state (circa 20A3) ?
Is a testbed the tool to get us to the end state? If not a testbed, what is it?
• NEXSAT?
• GOES-R AWG Framework for any sat?
• GEOSS Test Bed?
– Implies global test bed with integrated system of systems, more than satellite data, connection to societal benefits and beyond goal teams
• Scope?
• What pieces exist today- within STAR, NESDIS, NOAA
– Access to satellite data, in-house and university expertise through CIs, grants program
– GOES-R AWG Framework (currently tied to acquisition program)

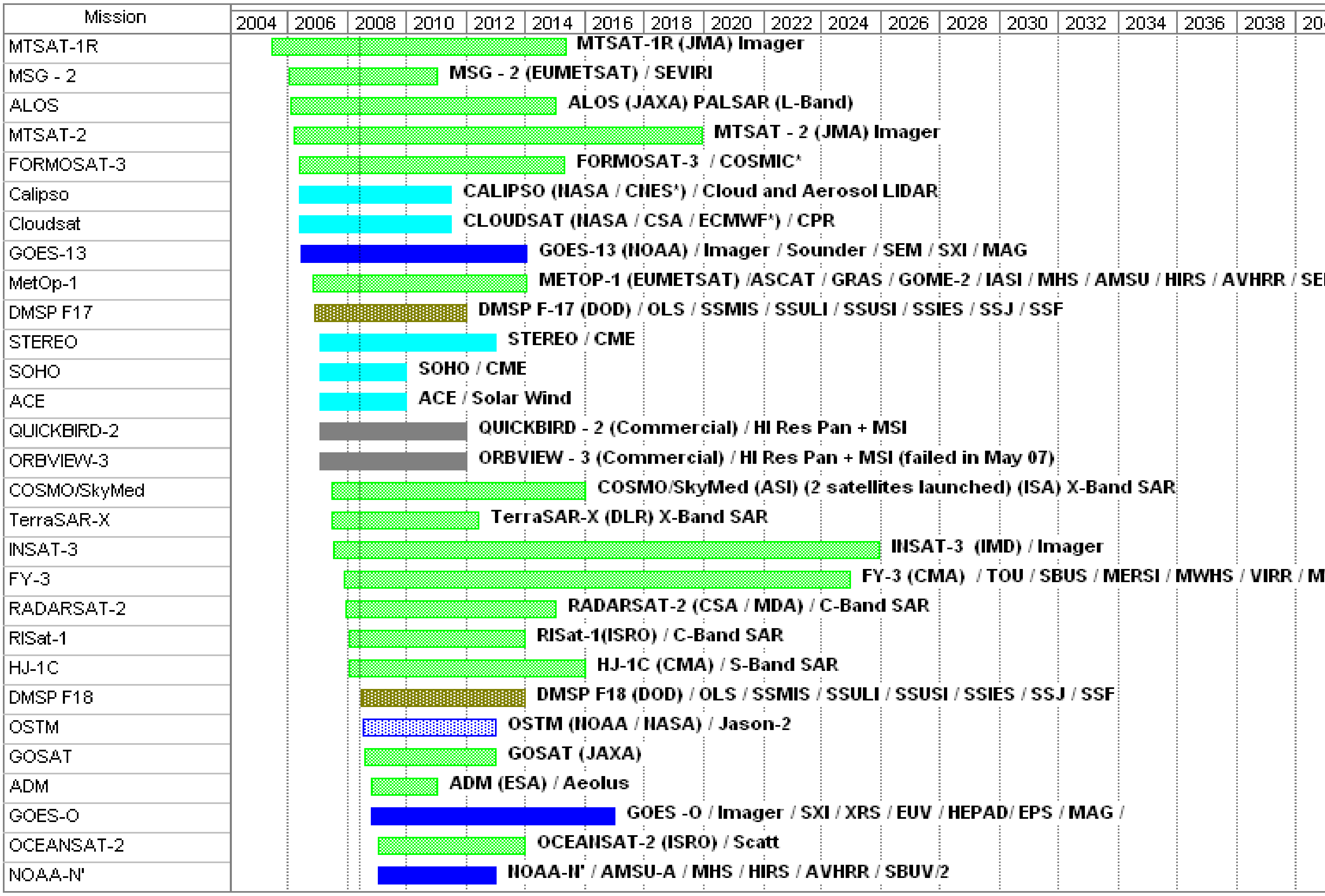
– SPSRB Process (handoff to OSDPD/operations when alg/product research completed)
– SAB/Proving Grounds- connection to end user for assessments
• What's missing (glue existing components together and fill gaps perhaps)
• Can we leverage existing testbeds, How?
• Implementation Strategy
–Strategic/program plan, proposals for ORF (people/algorithms) and PAC (IT infrastructure), other?
• Resources required

Appendix D: Satellite Fly-out Schedule



*Joint/International Mission

NOAA | NASA | DoD | Interagency | Foreign | Decadal | Com



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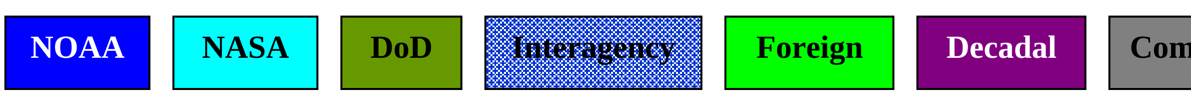
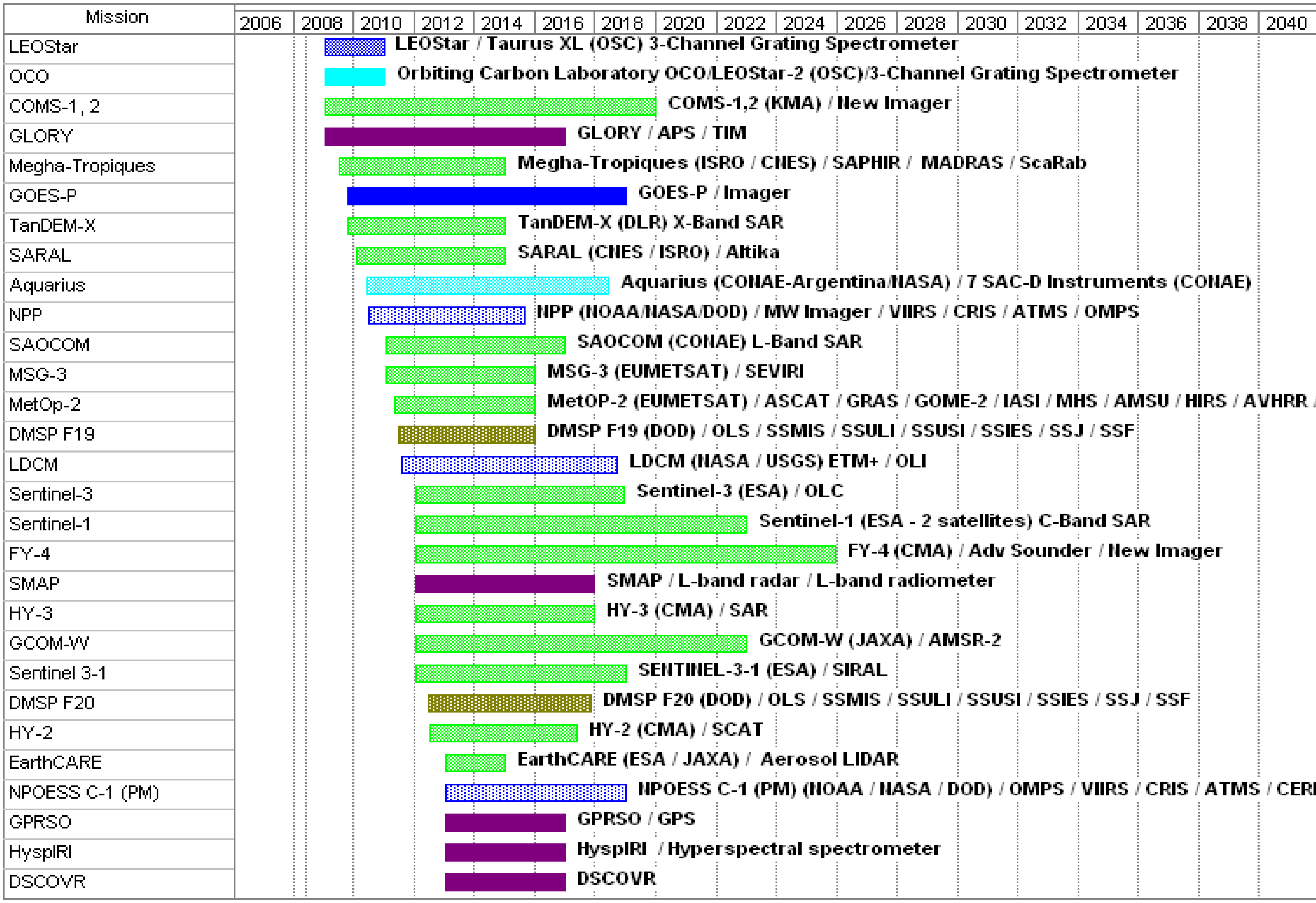
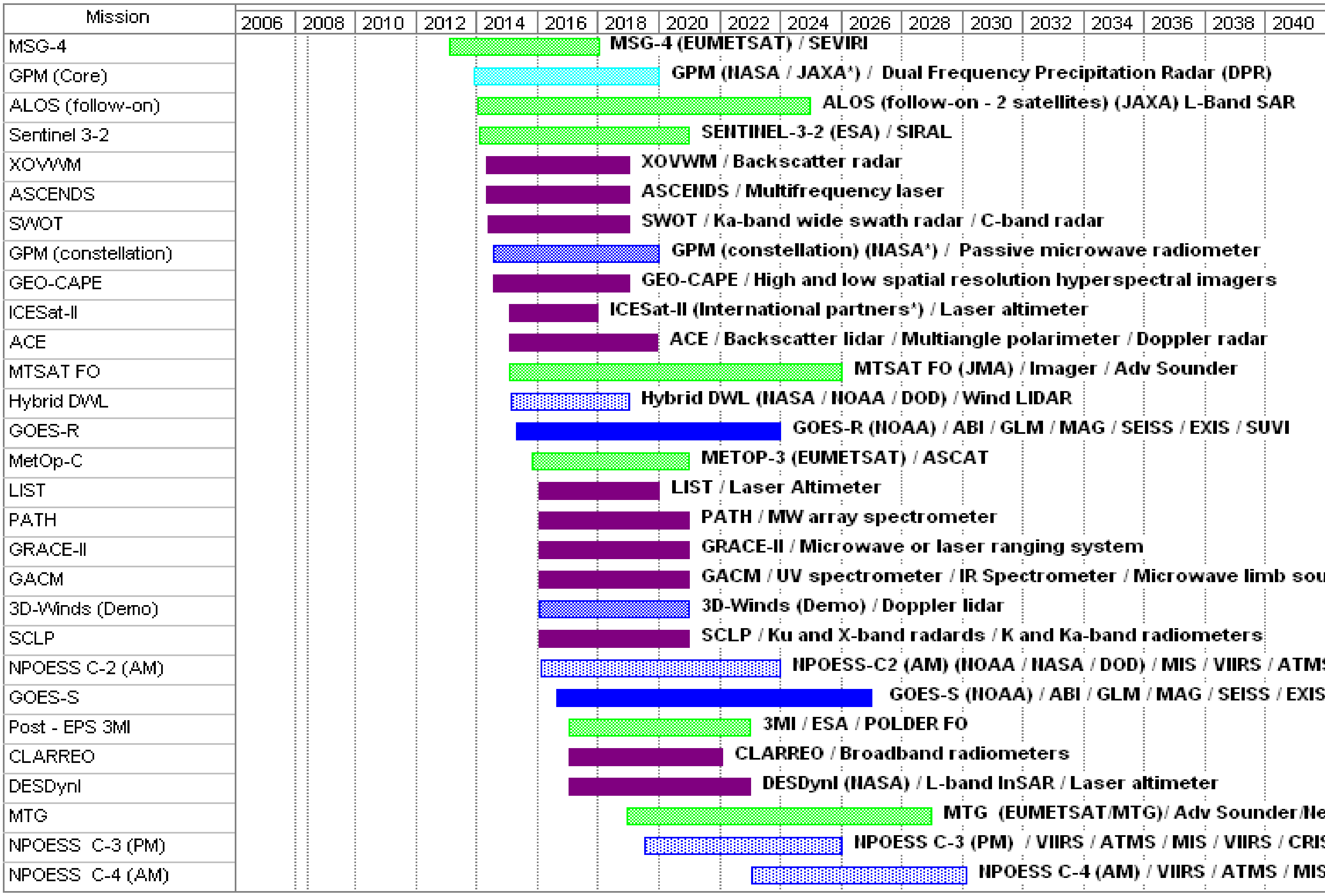




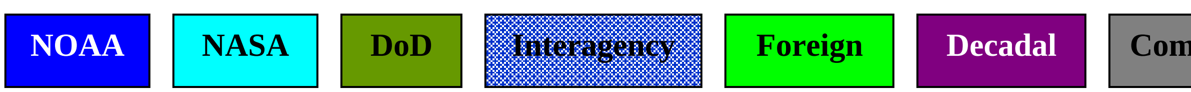
*Joint/International Mission

NOAA **NASA** **DoD** **Interagency** **Foreign** **Decadal** **Com**

Satellite Fly-out Schedule



*Joint/International Mission



Appendix E: Multi-Satellite Application

Many new techniques and technologies have been developed in the first decade or so to estimate ocean wind vectors and surface wind speeds from earth orbiting satellites. Examples include passive microwave sensors on Special Sensor Microwave Imager (SSM/I), active microwave or scatterometry (e.g., Quikscat, ERS-2, and A-Scat), AMSU-based non-linear balance winds (Bessho et al. 2005), and high resolution low-level feature tracked winds from geostationary satellites (e.g., Holmlund et al. 2001, and Velden et al. 1997). Despite these advances and the real-time availability of such datasets, there have been relatively few attempts to create a combined wind analysis in and around tropical cyclones.

Detailed tropical cyclone surface wind analyses, until recently, were only possible when aircraft reconnaissance data were available. Such analyses were constructed using H*Wind (i.e., Powell and Houston 1996, and Powell et al. 1996). The reliance on aircraft reconnaissance data to generate tropical cyclone wind analyses has been due to the general lack of methods to estimate the very strong winds within a 200 km of the tropical cyclone center. Without methods to estimate the inner region winds, accurate and realistic tropical cyclone wind analyses are not possible. Recent work, however, has led to a technique that can make estimates of flight-level wind analyses from infrared satellite data (Mueller et al. 2006).

With this new method to estimate tropical cyclone winds within 200km of the cyclone center in hand, an automated, objective, tropical cyclone surface wind analyses that makes use of these new techniques has been developed. This product combines information from five data sources to create a mid-level (near 700 hPa) wind analysis using a variational approach (cf., Thacker 1988). The resulting mid-level winds are then adjusted to the surface applying a very simple single column approach. Over the ocean an adjustment factor is applied, which is a function of radius from the center ranging from 0.9 to 0.7, and the winds are turned 20 degrees toward low pressure. Over land, the oceanic winds are reduced by an additional 20% and turned an additional 20 degrees toward low pressure. The result is the creation of a globally available multi-platform tropical cyclone surface wind analyses.

The five datasets used are the QuikScat scatterometer and SSM/I surface wind speeds, which are both adjusted upward to 700 hPa in the same manner as the surface winds are adjusted downward, feature track winds in the mid-levels from the operational satellite centers, 2-d flight-level winds estimated from infrared imagery (see Mueller et al 2006) and 2-d winds created from Advanced Microwave Sounding Unit (AMSU)- derived height fields and solving the non-linear balance equations as described in Bessho et al (2006). Table 1 shows the five datasets and their current real-time source. Tropical cyclone position and intensity information is provided by the real-time databases of the Automated Tropical Cyclone Forecast (ATCF; Sampson and Schrader 2000), which is available for all of the global tropical cyclone basins via secure ftp from the National Hurricane Center and the Joint Typhoon Warning Center.

Figure 1 shows the source datasets and Figure 2 (left) shows the resulting multi-platform tropical cyclone surface wind analysis of Hurricane Dean on 20 August 2007 at 06 UTC as an example. At the bottom of this figure the maximum radial extent of winds in each quadrant associated with 34, 50 and 64 knot winds created from this analysis is given. These compare well with the final best track estimates of these same quantities which are shown under the Infrared image of the same scale to the left. Verification versus H*wind analysis and operational tropical cyclone wind structure during the entire 2007 hurricane season shows that these satellite base analyses possess sufficient accuracy to be useful in the real-time operational setting (Knaff et al. 2008). Other examples of these wind analyses of past cases and in real-time can be found at http://rammb.cira.colostate.edu/products/tc_realtime/.

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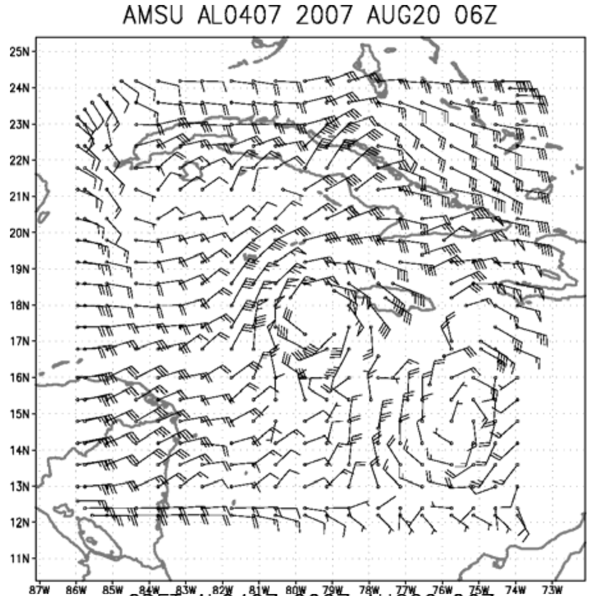
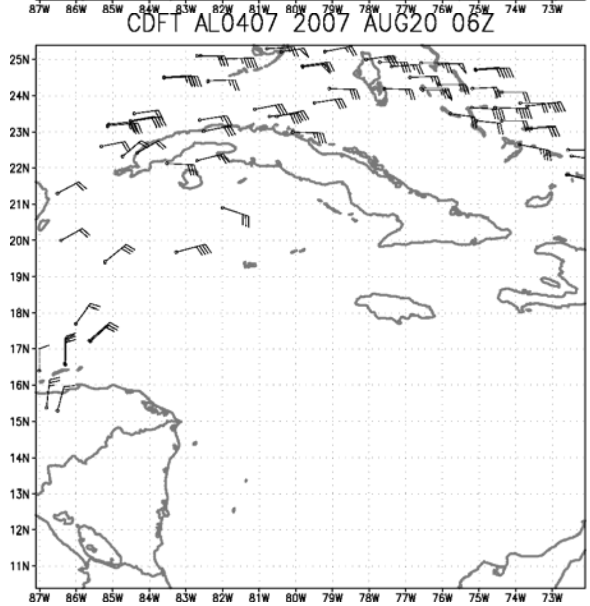
Table 1: Real-time near surface wind datasets used by the experimental multi-platform tropical cyclone surface wind analysis and their current real-time sources is shown.

Data Type	Real-Time Source
Water Vapor and Feature Track Winds	1)NESDIS FTP 2)NRL Monterey FTP
QuikScat Ocean Wind Vectors	MCIDAS MD files on NSOF servers
Global IR imagery for Flight-Level Proxy Winds	MCIDAS Images on NSOF servers
2-D AMSU-Based Winds	NCEP FTP
SSM/I Surface Winds	CIRA Local Ingest- DPEAS


AMSU AL0407 2007 AUG20 06Z
25N
24N
23N
22N
21N
20N
19N
18N
17N
16N
15N
14N
13N
12N
11N
87W 86W 85W 84W 83W 82W 81W 80W 79W 78W 77W 76W 75W 74W 73W


CDFT AL0407 2007 AUG20 06Z
25N
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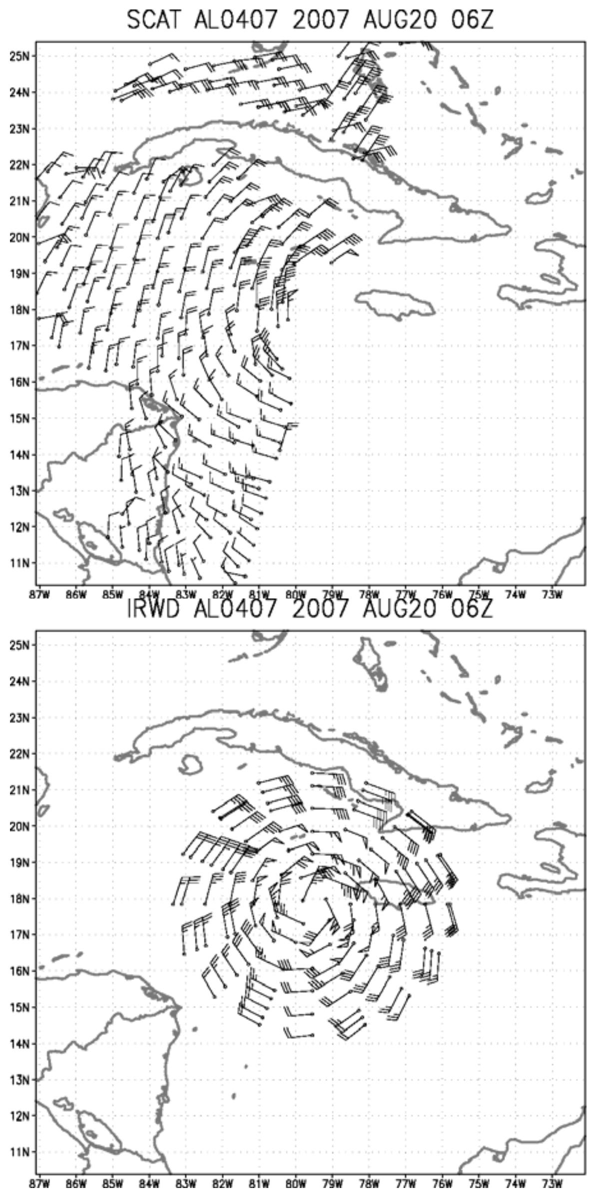

Figure 1. The input datasets to the multi-platform tropical cyclone surface wind analysis of Hurricane Dean on 20 August 2007 at 06UTC are the AMSU-based 2-D winds at 700 hPa (top left), cloud-drift and feature track winds (top right), QuickScat ocean wind vectors (bottom left) and the IR-base flight-level proxy winds (bottom right). All datasets are collected over a 12-hour period of time and moved to a storm relative position valid at 06 UTC 20 August.

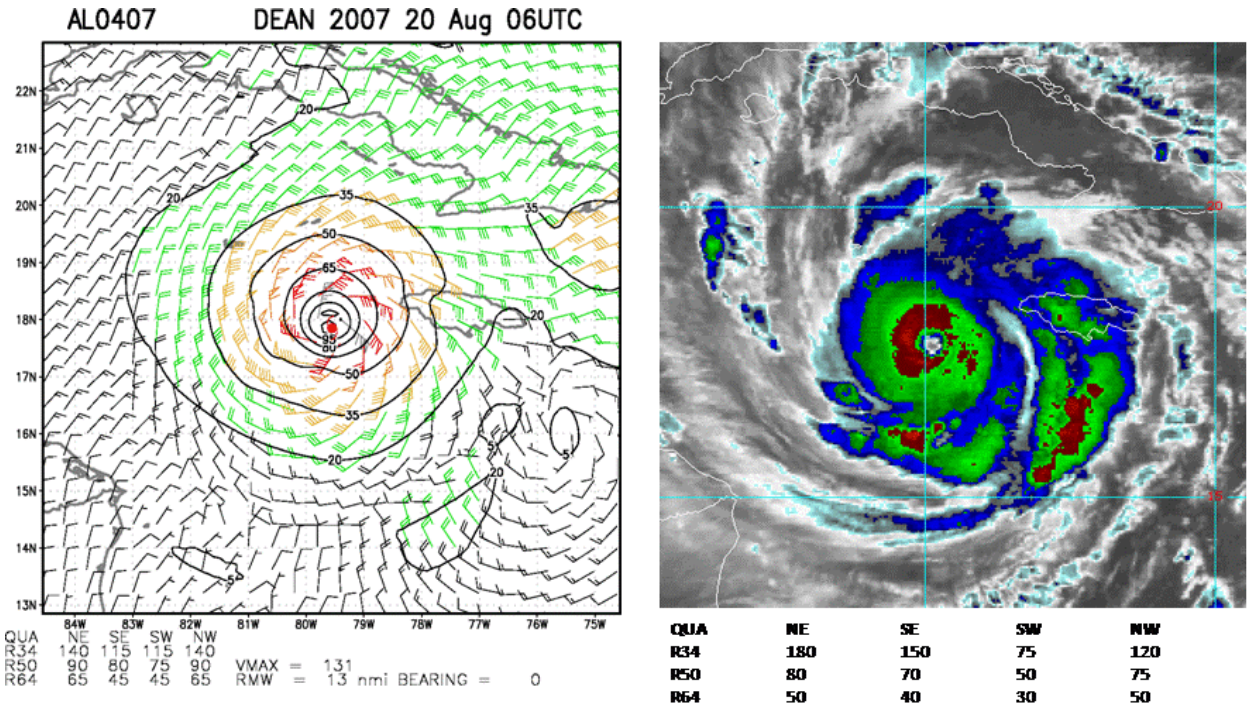

Figure 2. The multi-platform tropical cyclone surface wind analysis of Hurricane Dean on 20 August 2007 at 06 UTC is shown on the right and the corresponding IR image is shown on the left. At the bottom of each panel are the wind radii estimated from the wind analysis (right) and from the final best track (left).

Appendix F. Examples of projects and the components of R2O

- The International Satellite Cloud Climatology Project (ISCCP) was established to infer the global distribution of clouds, their properties, and their diurnal, seasonal and interannual variations. The ISCCP cloud datasets provided the first systematic global views of cloud behaviors.
  - "R": infer the global distribution of clouds, their properties, and their diurnal, seasonal and interannual variations.
  - "R2(R2O)": generating systematic global views of cloud behaviors
  - "R2O" (post-satellite algorithm test bed): Transition processing to NCDC.
- The Global Precipitation Climatology Project was established to quantify the distribution of precipitation around the globe. Precipitation information available from each of several satellite and in-situ sources is merged into a final product. The microwave estimates are based on Special Sensor Microwave/Imager (SSM/I) data from the Defense Meteorological Satellite Program (DMSP, United States) satellites that fly in sun-synchronous low-earth orbits. The infrared (IR) precipitation estimates are computed primarily from geostationary satellites (United States, Europe, Japan), and secondarily from polar-orbiting satellites (United States). Additional low-Earth orbit estimates include the Atmospheric

Infrared Sounder (AIRS data from the NASA Aqua, and Television Infrared Observation Satellite Program (TIROS) Operational Vertical Sounder (TOVS) and Outgoing Longwave Radiation Precipitation Index (OPI) data from the NOAA series satellites. The gauge data are assembled and analyzed by the Global Precipitation Climatology Centre (GPCC) of the Deutscher Wetterdienst and by the Climate Prediction Center of NOAA.
    - "R": quantifying the distribution of precipitation around the globe over many years
    - "R2(R2O)": generating monthly precipitation analyses combining satellite and in-situ data sources
- NASA A-Train: Each satellite within the A-Train has unique measurement capabilities that complement each other, including aerosols, clouds, temperature, relative humidity, and radiative fluxes. This ensemble of observations allow studies to understand how large scale aerosol and cloud properties are changed by and influence environmental conditions.
    - "R": understand how large scale aerosol and cloud properties change in response to environmental conditions
    - "R2(R2O)": generating weekly global analyses combining a-train and other satellite and in-situ data sources
    - "R2O" (post satellite algorithm test bed) using weekly analyses in NOAA Climate Test Bed
- CI-FLOW (the Coastal and Inland Flood Observation and Warning Project): A multi-agency, multi-institutional research group working to find a way to connect all the water monitoring and prediction systems available in coastal North Carolina. Their goal is to combine satellite, radar, and rain-gauge data with information on streams and rivers from their sources in the mountains to the ocean. Partners hope to develop and test techniques to accurately identify and predict floods and flash floods along the coast and inland, and their impacts on the ecosystem, especially when threatened by hurricanes.
    - "R" How can we understand and predict floods in N. Carolina ecosystems?
    - "R2(R2O)" Combining radar, satellite, rain-gauge data with hydrology models to generate daily flood probability maps
    - "R2O" (post satellite algorithm test bed) Using flood probability maps in NOAA Hydrometeorology Testbed
- Reynolds SST: A real-time global sea surface temperature (SST) analysis has been developed by Richard Reynolds from the National Climatic Data Center (NCDC). Also, a monthly one-degree global SST climatology was constructed using these analyses by the Climate Prediction Center (CPC/NOAA). This climatology derived from monthly Optimum Interpolation (OIv2) SST analyses with an adjusted base period of 1971-2000 was used in computing the SST anomaly field using a weighted monthly mean climatology and the current observed Reynolds SST field. The actual areal coverage of the analysis and the anomaly data is roughly between 60°S and 60°N globally. These analyses were based on ship and buoy SST data supplemented with satellite SST retrievals. The one degree climatology and analyses resolve equatorial upwelling and fronts.

- “R” Understanding equatorial upwelling and fronts
- “R2(R2O)” Blending ship and buoy SST with satellite SST for best real-time analysis
- “R2O” (post satellite algorithm test bed) Using SST climatology at CPC

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International Satellite Cloud Climatology Project (ISCCP)
http://isccp.giss.nasa.gov/overview.html

GPCP
http://www.gewex.org/gpcpdata.htm

NASA A-Train
http://aqua.nasa.gov/doc/pubs/A-Train_Fact_sheet.pdf

CI-FLOW
http://www.nssl.noaa.gov/ciflow/

Reynolds SST
http://www.nhc.noaa.gov/aboutsst.shtml

List of Acronyms and Abbreviations

AIRS	Atmospheric Infrared Sounder (no capital R in Infrared)
ATMS	Advanced Technology Microwave Sounder
ATOVS	Advanced TIROS Operational Vertical Sounder
AVHRR	Advanced Very High Resolution Radiometer
AWG	Algorithm Working Group
ASPB	Advanced Satellite Products Branch
AWIPS	Advanced Weather Interactive Processing System
BUFR	Binary Universal Form for the Representation of meteorological data
CICS	Cooperative Institute for Climate Studies
CIMSS	Cooperative Institute for Meteorological Satellite Studies
CIRA	Cooperative Institute for Research in the Atmosphere
CLAVR	Clouds from AVHRR
CMMI	Capability Maturity Model Integration
CoRP	Cooperative Research Program
COSMIC	Constellation Observing Satellites for Meteorology, Ionosphere, and Climate
CREST	Cooperative Remote Sensing Science and Technology Center
CrIS	Cross-track Infrared Sounder
CRTM	Community Radiative Transfer Model
CTB	Climate TestBed
DAS	Data Assimilation System
DPEAS	Data Processing and Error Analysis System
DTC	Development TestBed Center
EMC	Environmental Modeling Center
ESA	European Space Agency
ESPC	Environmental Satellite Processing Center
EUMETSAT	European Organisation for the Exploitation of Meteorological Satellites
FO	Field Office
GEO	Group on Earth Observations (international)
GEO IDE	Global Earth Observation Integrated Data Environment
GEOCAT	Geostationary Cloud Algorithm Testbed
GEOSS	Global Earth Observation System of Systems
GIS	Geographic Information System
GOES	Geostationary Operational Environmental Satellite
GOES-R	Geostationary Operational Environmental Satellite Series R
GPRA	Government Performance Results Act
GrADS	Grid Analysis and Display System
GRIB	GRIdded Binary

GSD	Global Systems Division
GSICS	Global Space-Based Inter-Satellite Calibration System
HDF	Hierarchical Data Format
HMT	Hydrometeorological Testbed
HPC	High Performance Computing
HPC	Hydrometeorological Prediction Center
HWT	Hazardous Weather Testbed
IASI	Infrared Atmospheric Sounding Interferometer
IPO	Integrated Program Office
JCSDA	Joint Center for Satellite Data Assimilation
JHT	Joint Hurricane Testbed
MATLAB	Matrix Laboratory (MathWorks, Inc.)
McIDAS	Man-computer Interactive Data Access System
MIRS	Microwave InfraRed Retrieval System
MODIS	Moderate Resolution Imaging Spectroradiometer
MOBY	Marine Optical Buoy
NCEP	National Centers for Environmental Prediction
NDE	NPOESS Data Exploitation
NESDIS	National Environmental Satellite, Data, and Information Service
NOS	National Ocean Service
NPOESS	National Polar-orbiting Operational Environmental Satellite System
NPP	NPOESS Preparatory Project (not Program)
NRO	National Reconnaissance Office
NSC	NOAA Science Center
NSOF	NOAA Satellite Operations Facility
NWP	National Weather Prediction
NWS	National Weather Service
OAR	Office of Oceanic and Atmospheric Research
OPDB	Operational Products Development Branch
ORF	Operations, Research and Facilities
OSD	Office of Systems Development
OSDPD	Office of Satellite Data Processing and Distribution
OPS	Operations
PAC	Procurement, Acquisition and Construction
PATMOS	Pathfinder Atmosphere
POES	Polar-orbiting Operational Environmental Satellite
POP	Product Oversight Panel
PPBES	Planning, Programming, Budgeting, and Execution System (NOAA)
PPI	Office of Program Planning and Integration (NOAA)
PROFS	Program for Regional Observing and Forecasting Services
PSDI	Product Systems Development and Integration

RAMMB	Regional Mesoscale Meteorology Branch
RFC	River Forecast Center
ROSES	Research Opportunities in Space and Earth Sciences
R2O	Research to Operations
SAB	Satellite Analysis Branch
SATB	Satellite Algorithm TestBed
SCSB	Satellite Climate Studies Branch
SeaWiFS	Sea-viewing Wide Field of view Sensor
SHIPS	Statistical Hurricane Intensity Prediction Scheme
SMCD	Satellite Meteorology and Climatology Division
SOCD	Satellite Oceanography and Climatology Division
SPB	Sensor Physics Branch
SPoRT	Short-term Prediction and Research Transition (NASA)
SPSRB	Satellite Products and Services Review Board
STAR	Center for Satellite Applications and Research (formerly Office of Research and Applications ORA)
TB	Terabyte
TOVS	TIROS Operational Vertical Sounder
TIROS	Television and Infrared Observation Satellite
USGS	United States Geological Survey
VIIRS	Visible/Infrared Imager/Radiometer Suite
WFO	Weather Forecast Office