The Center for Satellite Applications and Research (STAR): Climate and Air Quality Theme Discussion

Goals

- Discuss and expand the long existing partnership between NOAA/NESDIS/STAR and CREST, and review NESDIS' research and applications, future satellites, science goals, and the CREST program and its accomplishments since its inception in 2001.
- Leverage and explore new opportunities
- Expansion of existing NESDIS-CREST research collaborations
- CREST Students' Mentoring by NOAA/NESDIS/STAR scientists
- Enhance/explore NOAA/NESDIS Scientists visits/exchange to CREST
- Joint seminars/webinars; short-course teaching/training

Meet these goals

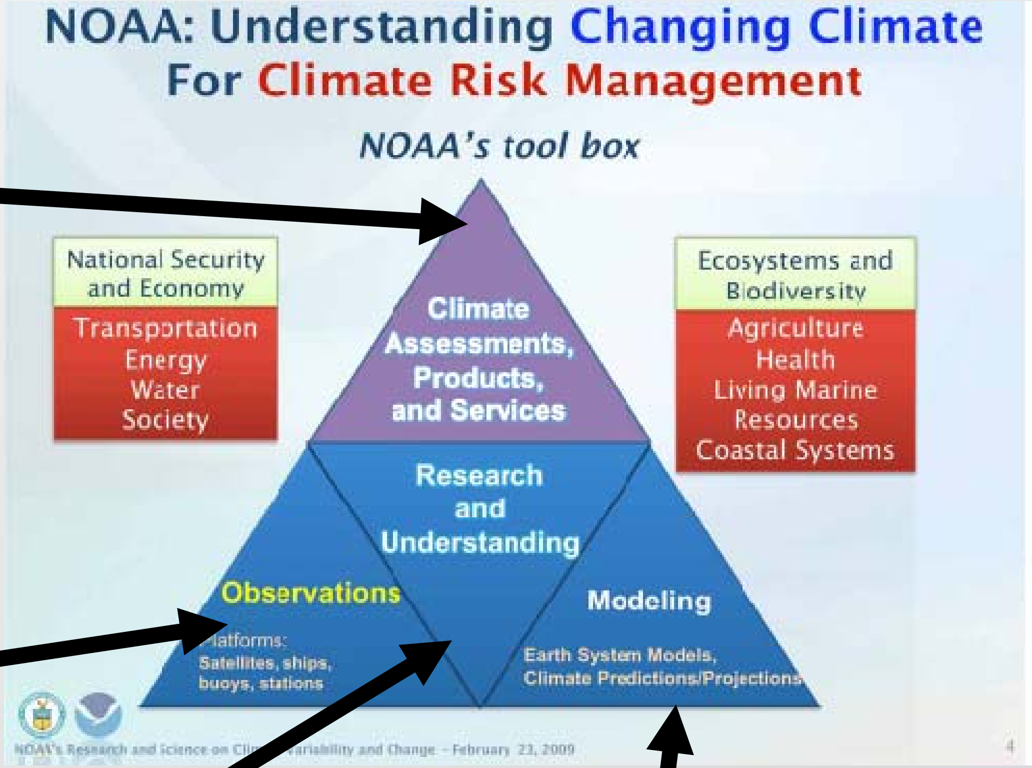
- Review STAR activities in Climate and Air Quality
- Review collaborative projects with CREST
- What is the big picture??

Big Picture

- Products and Services
  - Provide accurate information to users/stakeholders in order to make assessments on climate – past, present and future (predictions).
- Climate - Essential Climate Variables (GCOS)
  - GCOS-107 provides accuracy and precision requirements for satellite-based ECVs -- Climate Data Records
- Fundamental Work
  - Accurate and well calibrated/intercalibration satellite observations
  - Derive products - scientific algorithms to convert level 1 to level 2 to level 3
  - Thorough validation and intercomparisons
  - Document and preserve (provenance)
  - User feedback and independent validation

Moving to a National Climate Service

Contributing to national and international assessments

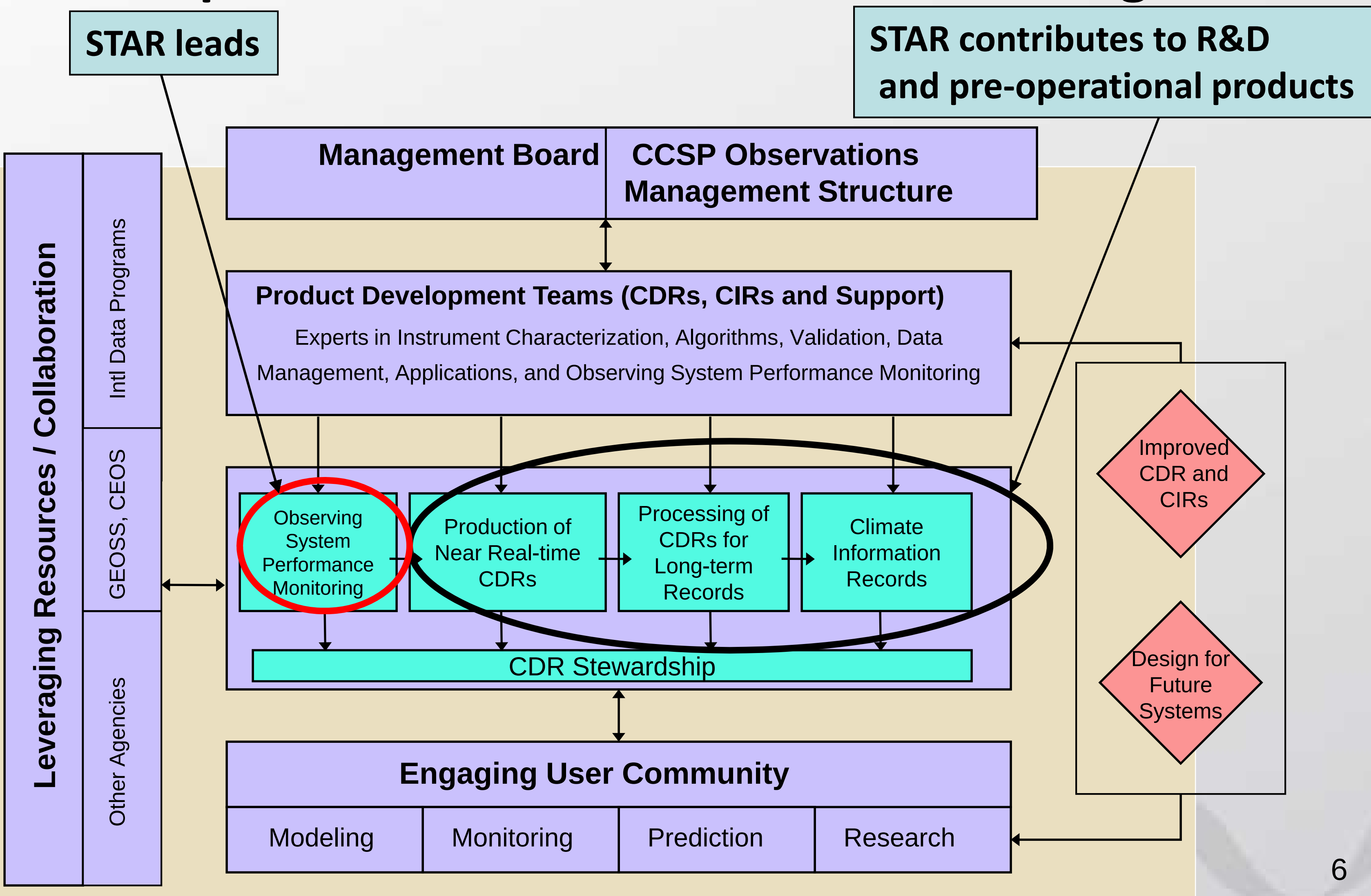


Ensuring climate quality measurements and data records from the satellite observing system

Analyses of satellite observations for improved understanding of climate system

Providing satellite data sets for testing and improving climate models

NOAA is proceeding with an Operational Climate Data Records Program



Sustained Observing System Monitoring

Pre- and Post-Launch Calibration Activities

- Pre-launch calibration
  - Oversight and checking of vendor's pre-flight instrument calibrations (with NIST)
- Post-launch calibration
  - Real time monitoring of instrument performance
  - Instrument intercalibrations using Simultaneous Nadir Overpasses (SNOs) and Conical Nadir Overpasses (CNOs)
  - Vicarious calibration using stable reference sites: MOBY, moon, deserts, Antarctic ice dome
  - Calibration checks against aircraft underflights, special observations
  - Comparisons with NWP model simulations

STAR performs end to end calibration services to assure reliable data from the U.S. operational satellite system

Satellite Intercalibration

STAR Activities

- Leading the WMO Global Space-based InterCalibration System (GSICS)
  - Eight agencies collaborating on the intercalibration and generation of stable instrument climate data records
- Responsible for on-orbit cal/val of NOAA satellite instruments and product validation
- Operate Marine Optical Buoy (MOBY) to characterize ocean color measurements to meet user requirements
- Active role in CEOS Working Group on Cal/Val
- Leading GOES-R Cal/Val Working Group
- Support the NPOESS Operational Algorithm Teams (OATS)

STAR plays a leading role in intercalibrating the satellite component of the global observing system

What is GSICS?

- Global Space-based Inter-Calibration System (GSICS)
- Goal - Enhance calibration and validation of satellite observations and to intercalibrate critical components global observing system
- Part of WMO Space Programme
  - GSICS Implementation Plan and Program formally endorsed at CGMS 34 (11/06)

GSICS Mission

- To provide sustained calibration and validation of satellite observations
- To intercalibrate critical components of the global observing system to climate quality benchmark observations and/or reference sites
- To provide corrected observations and/or correction algorithms to the user community for current and historical data

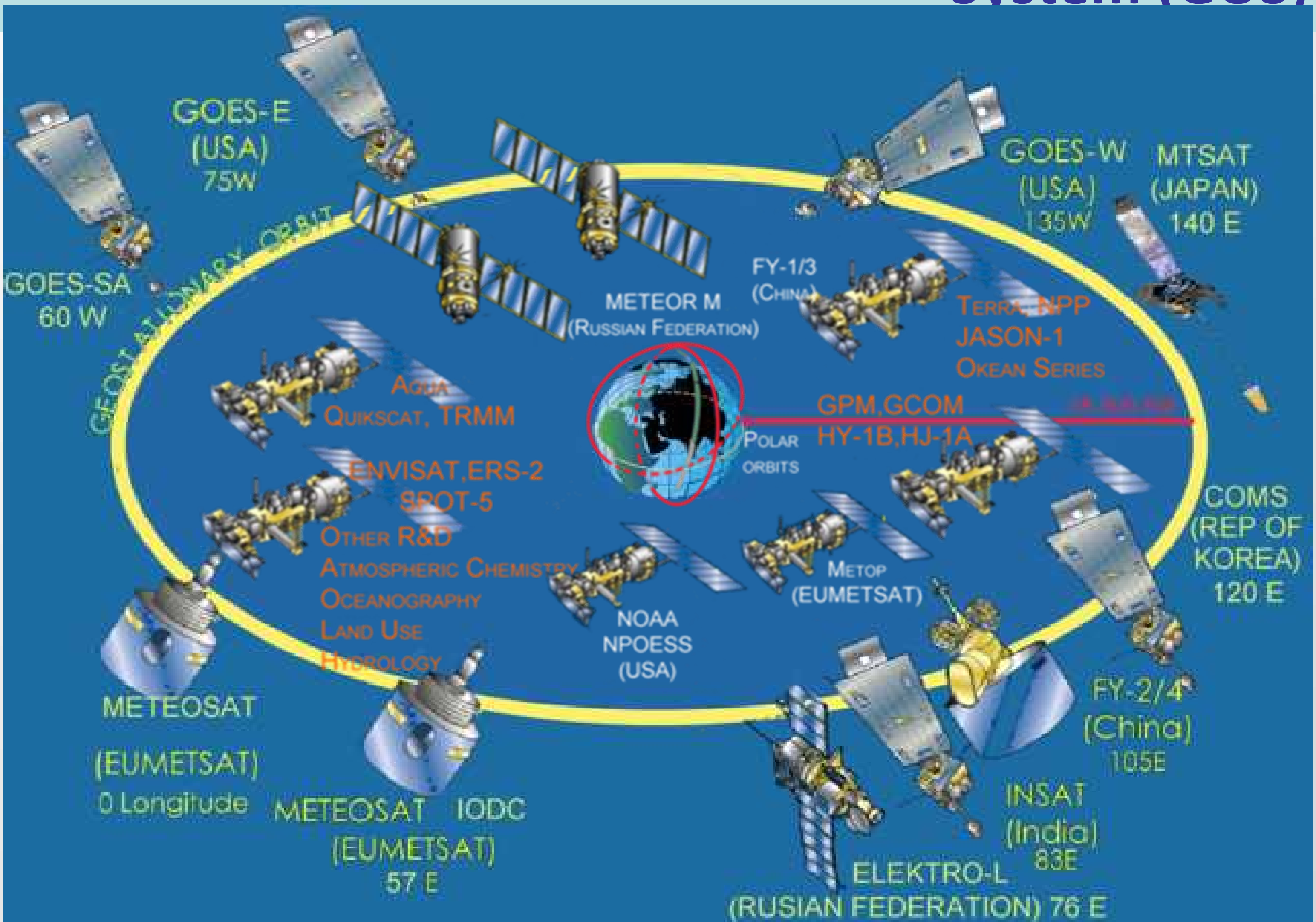
Or in technical terms:

- Quantify the differences – magnitude and uncertainty
- Correct the differences – physical basis and empirical removal
- Diagnose the differences – root cause analysis

Motivation

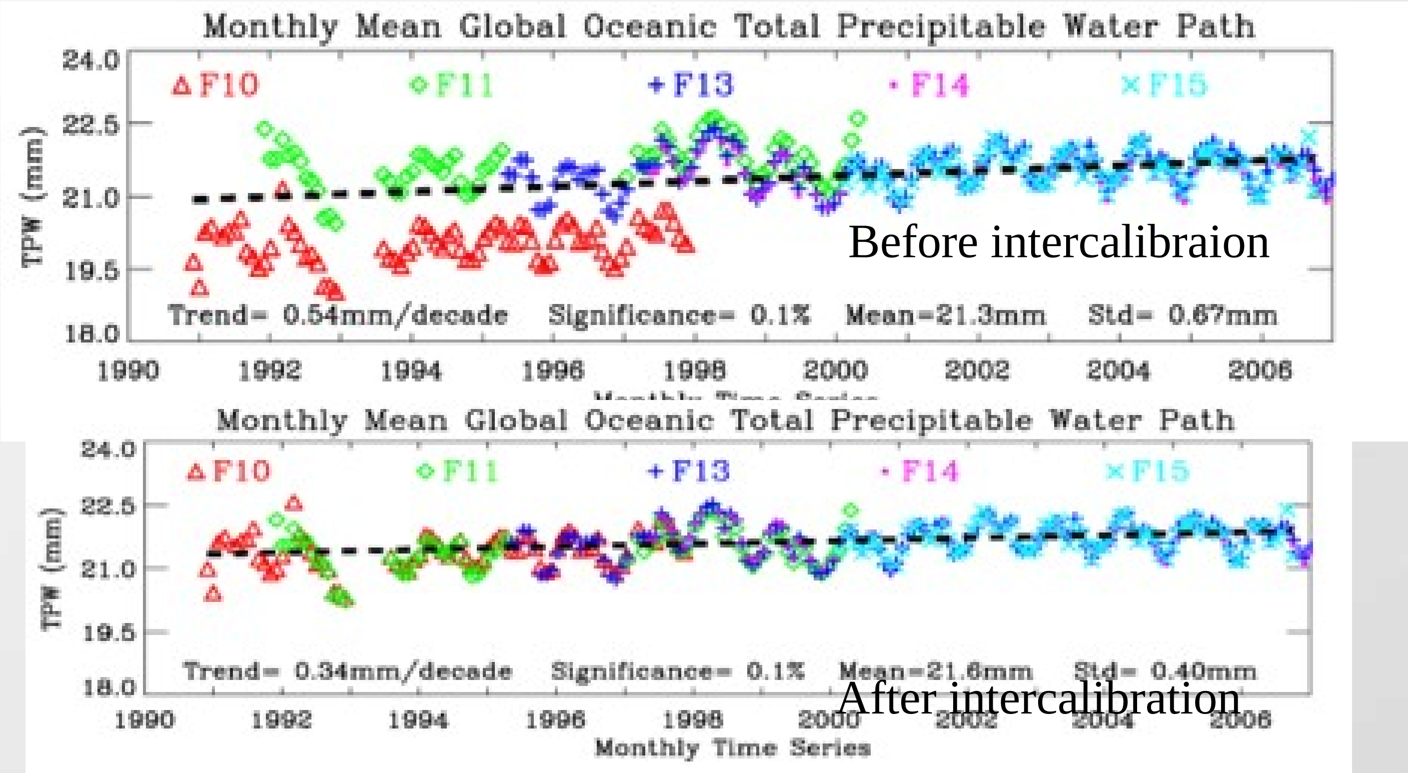
- Demanding applications require well calibrated and intercalibrated measurements
  - Climate Data Records
  - Radiance Assimilation in Numerical Weather Prediction
  - Data Fusion
- Growing Global Observing System (GOS)
- Intercalibration of instruments achieves comparability of measurements from different instruments

Space-Based component of the Global Observing System (GOS)



Intercalibration of instruments achieves comparability of measurements from different instruments

Calibration is Critical for Climate Change Detection



Trend of global oceanic total precipitable water decreases from 0.54 mm/decade to 0.34 mm/decade after intercalibrations! Calibration uncertainties translate to uncertainties in climate change detection

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Do we Care about Satellite Biases in NWP?

After McNally, Bell, et al. ECMWF, 2005 & 2009

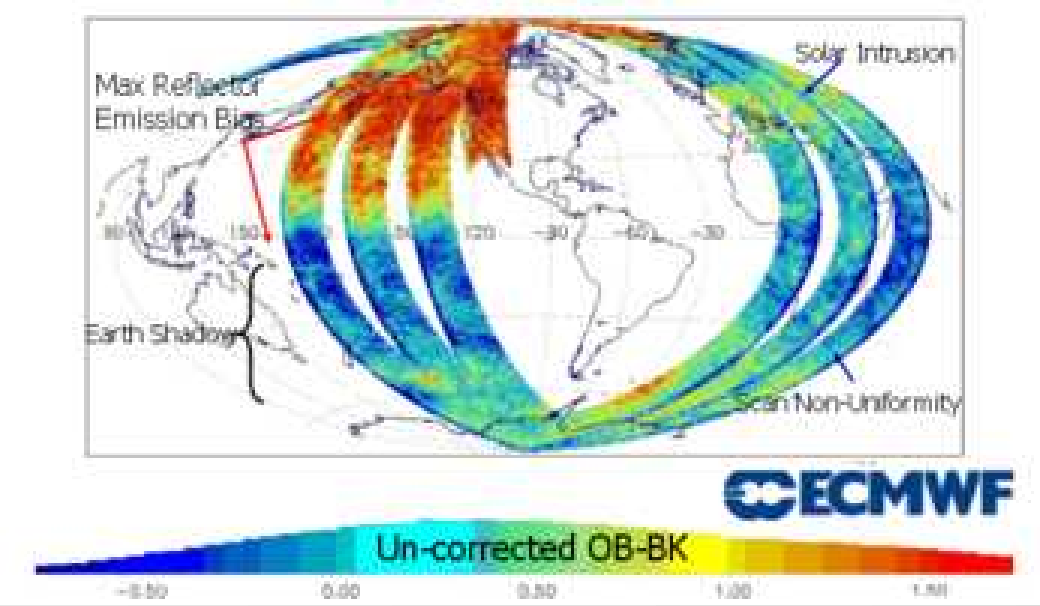
Yes! Because:

1) We wish to understand the **origin** of the bias and ideally correct instrument / RT / NWP model **at source**

2) I*n principle* **we do not wish to apply a correction to unbiased satellite data if it is the NWP model which is biased**. Doing so is likely to:

  – **Re-enforce the model bias** and degrade the analysis fit to other observations

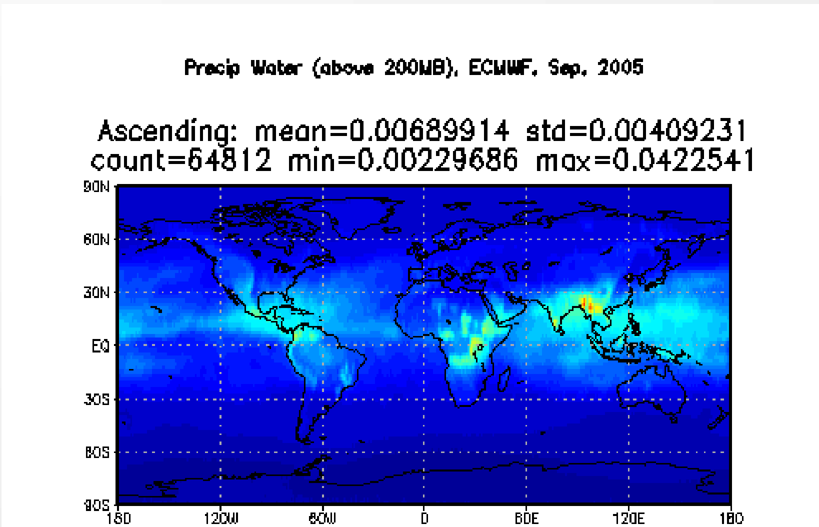
  – Produce a **biased analysis** (bad for re-analysis / climate applications)

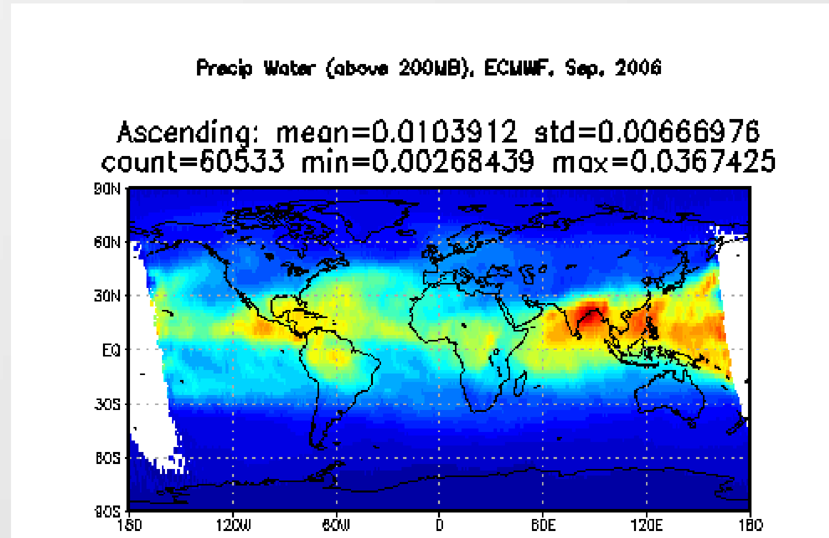


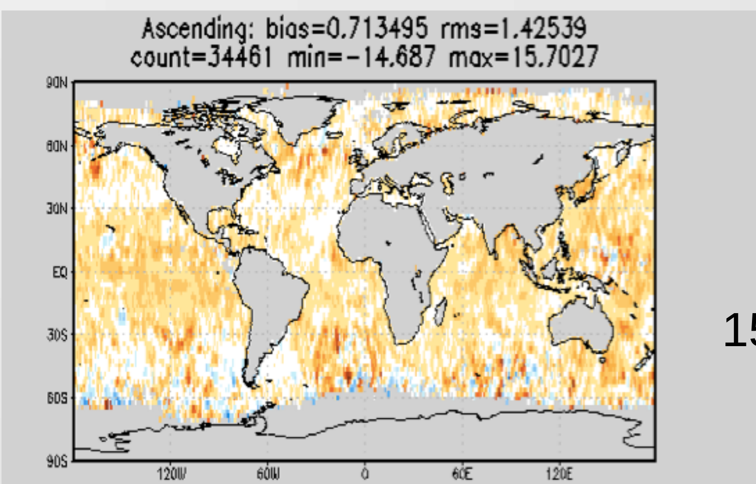
SSMIS calibration biases cause regional weather patterns

More accurate satellite observations will facilitate discovery of model errors and their correction. Additional gains in forecast accuracy can be expected.

ECMWF implemented adaptive bias correction of AIRS in 2006 which resulted in doubling water vapor in upper troposphere







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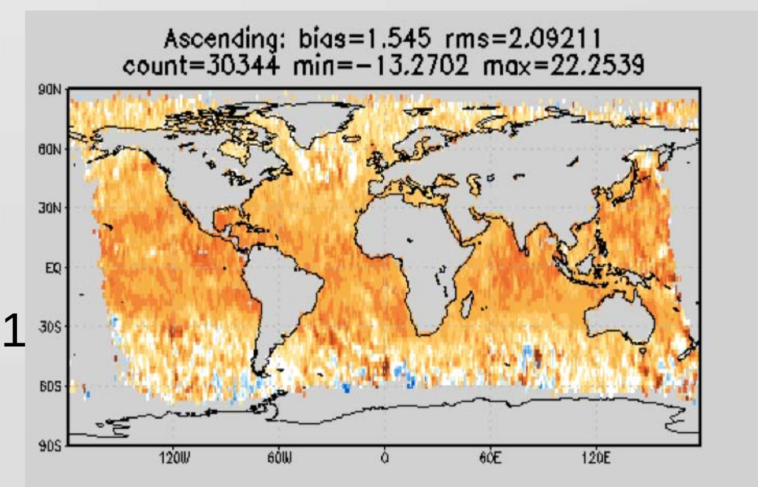
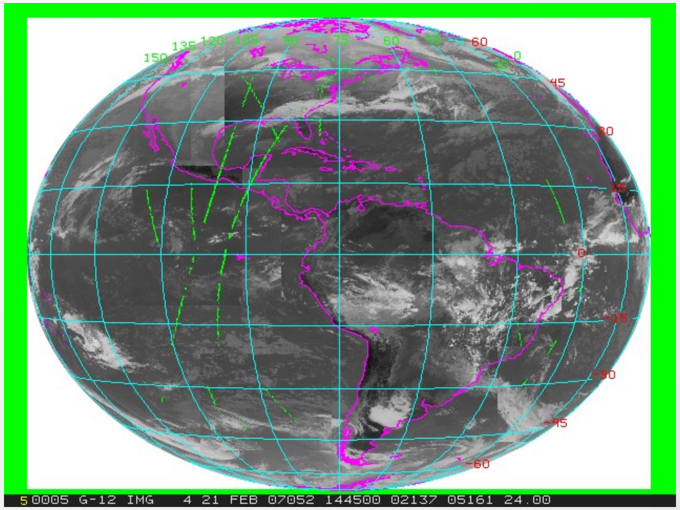
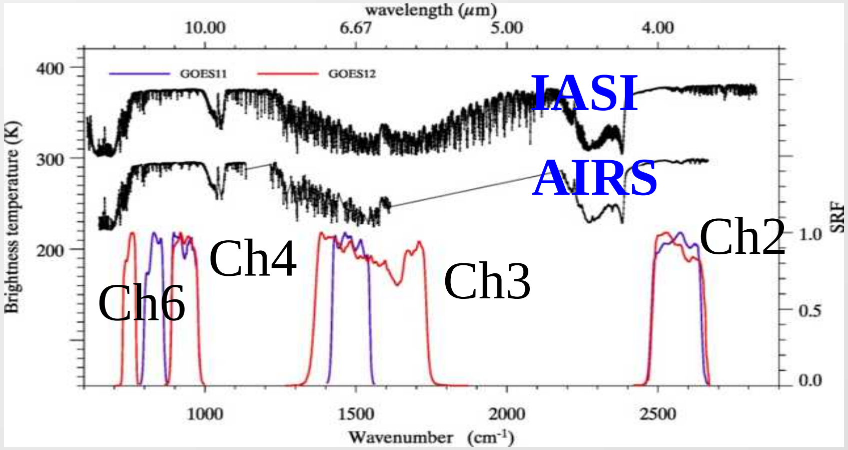
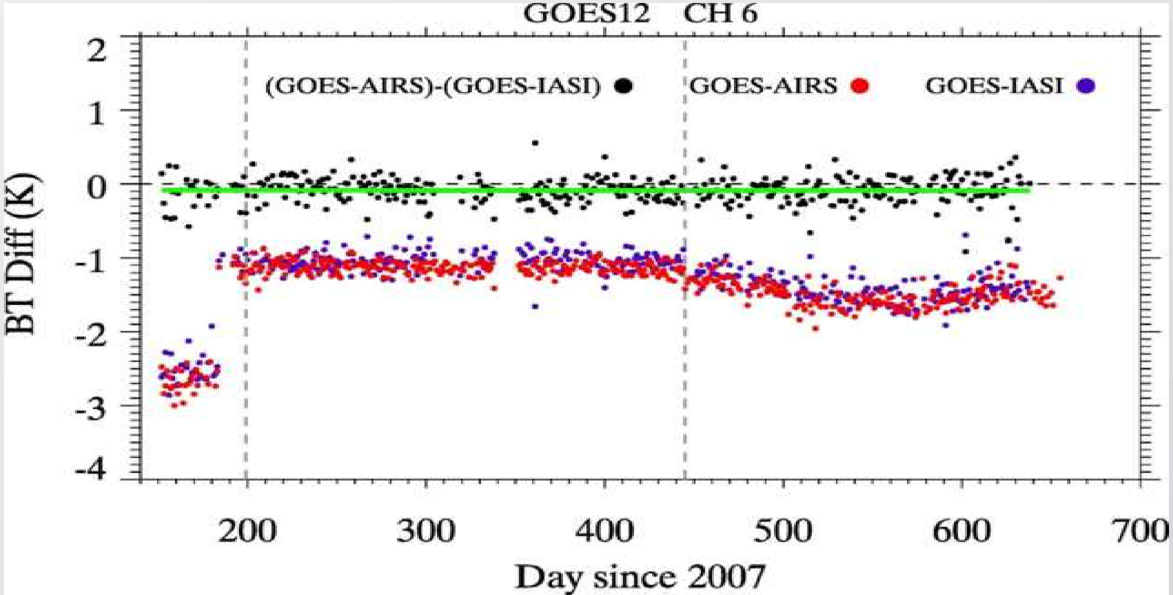


First agency-wide coordinated GSICS project is the intercalibration of geostationary infrared channels with IASI and AIRS







Web Accessible

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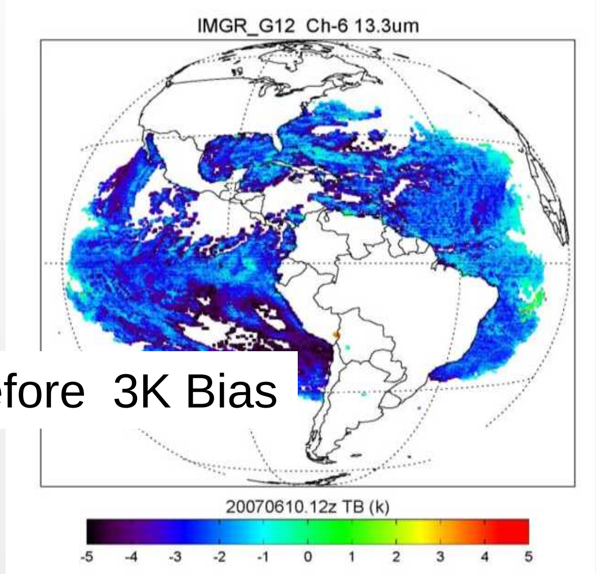
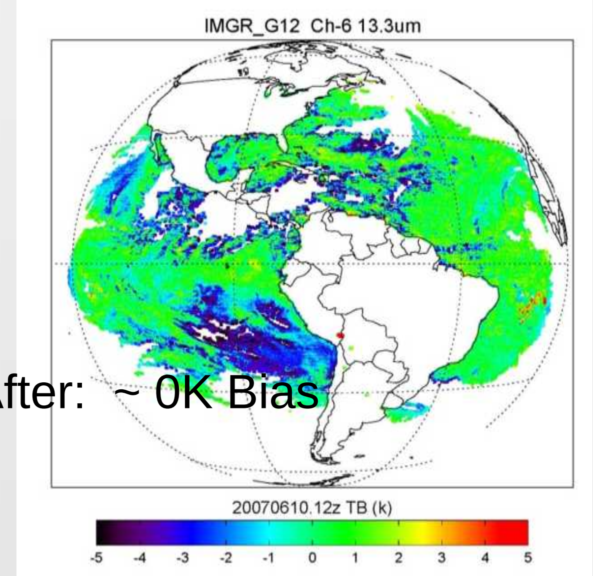
GSICS Correction Algorithm for Geostationary Infrared Imagers



Before 3K Bias



After: ~ 0K Bias

The first major deliverable to the user community is the GSICS correction algorithm for geostationary satellites.

The user applies the correction to the original data using GSICS provided software and coefficients.

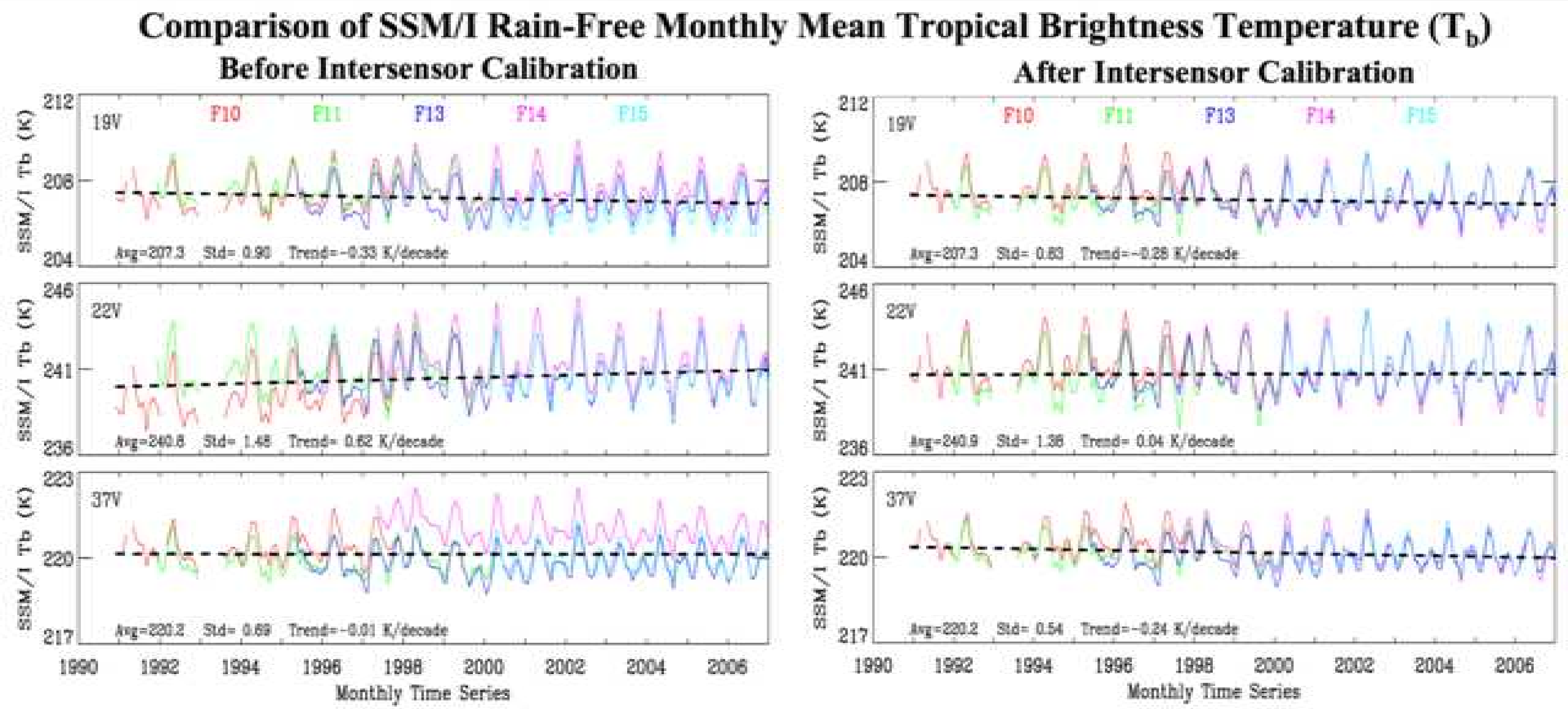
The correction adjusts the GOES data to be consistent with IASI and AIRS.

The figures to the left show the difference between observed and calculated brightness temperatures (from NCEP analysis) correction, respectively.

The bias is reduced from 3 K to nearly zero.

Satellite Intercalibration

SSM/I Observations (Yang et al., J. Appl. Meteor. and Climo., submitted)



STAR's Simultaneous Conical Overpass (SCO) intercalibration technique has facilitated development of a stable long term data set of SSM/I brightness temperatures from which many CDRs can be produced

Satellite Intercalibration

Calibrating Ocean Color Sensors with the Marine Optical Buoy (MOBY

- More than 10 years of observations
- NIST Radiometric Traceability and Collaboration
- Hyperspectral to band match any ocean color sensor
- Provides continuity between SeaWiFs, MODIS, and VIIRS
- Provides link with international ocean color sensors
- Provides validation of vendor produced ocean color data during NPOESS Era

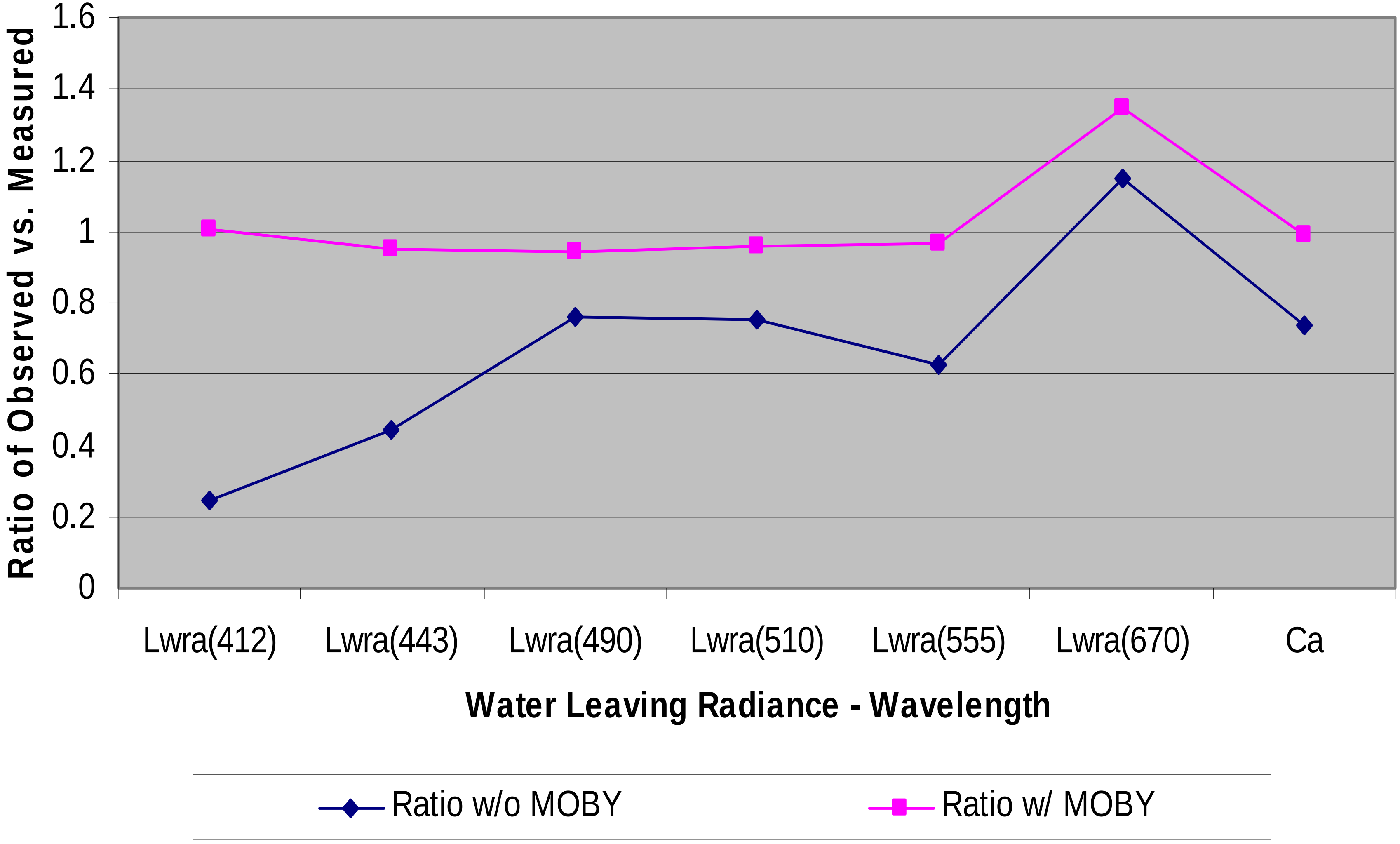
Ocean Color Sensors Validated with MOBY Scale:

Europe – MERIS
France – POLDER
Japan – OCTS
U.S. – SeaWiFS, MODIS (Terra), MODIS (Aqua)

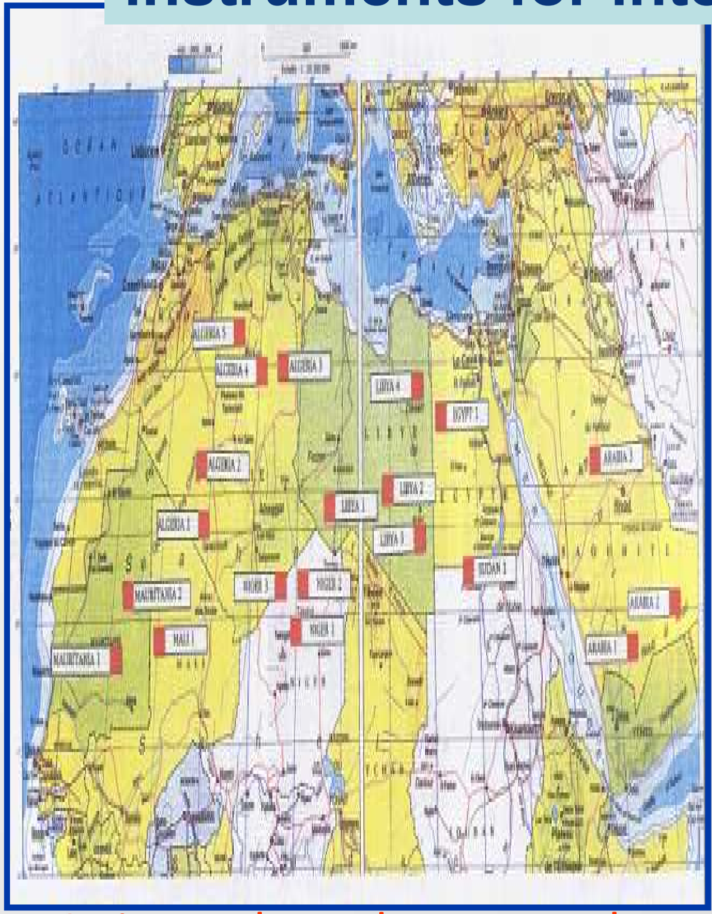
MOBY is the international primary reference standard for climate quality ocean color data

SeaWiFS Ratio of Observed vs Measured Without & With MOBY

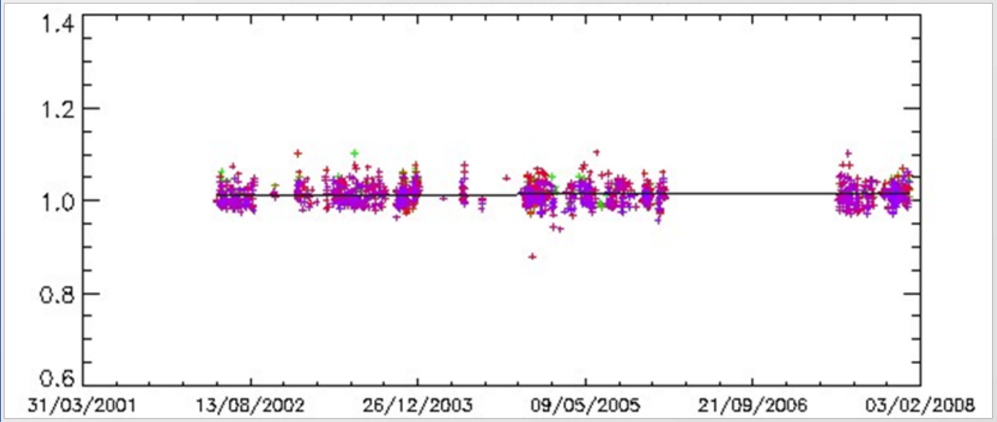
(Franz et al. 2007, Appl. Optics)



CNES SADE Data Base is critical for assessing stability of visible/near infrared reference instruments for intercalibration



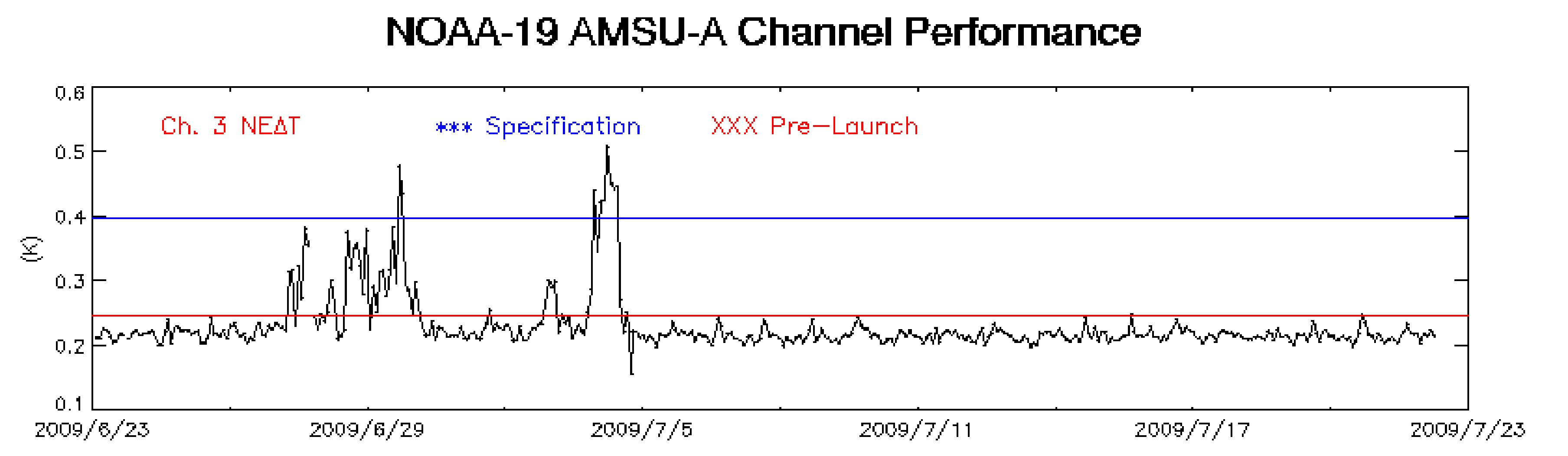
- 19 sites selected over North Africa and Arabia



Time series of the ratio of the ESA MERIS to NASA MODIS 0.665 micron visible channel reflectance from observations at 19 desert sites in North Africa and Saudi Arabia.

The results show very good agreement and stability between the two sensors

Promoting access to instrument performance monitoring is also part of GSICS



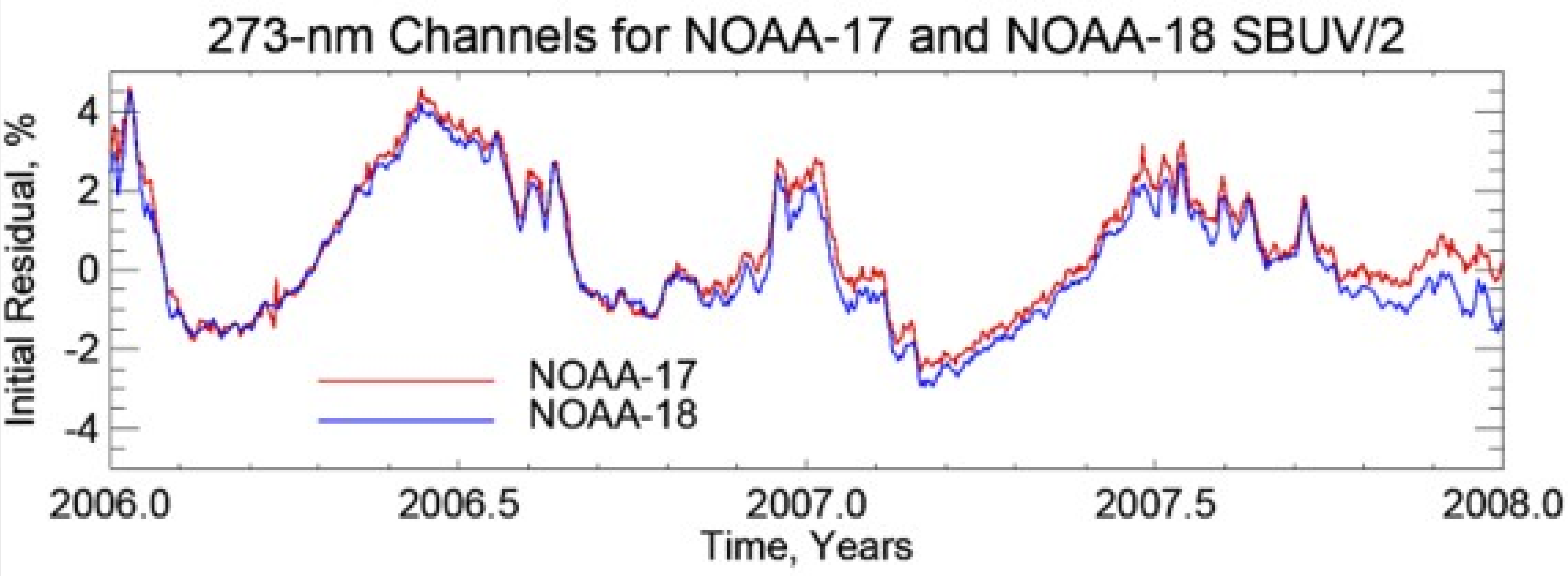
- **GSICS beginning to develop observing system monitoring tools for all GSICS partners. Above is example of NOAA tool for NOAA-19 OV and long-term monitoring**
- **The system has detected instrument anomalies, provided an important tool for diagnoses, data quality assurance, and for short and long term applications**

Courtesy of F.Weng

Sustained Observing System Monitoring

Checking SBUV/2 Stability with Calculations

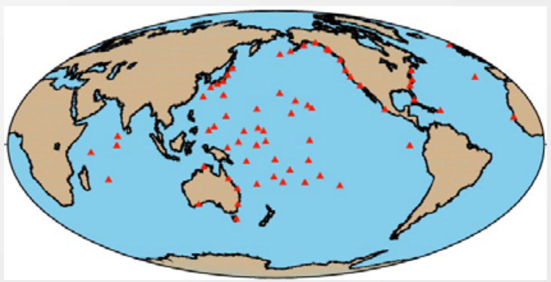
Relative differences between calculated (from climatological ozone) and observed (NOAA-17 and NOAA-18) UV reflectances

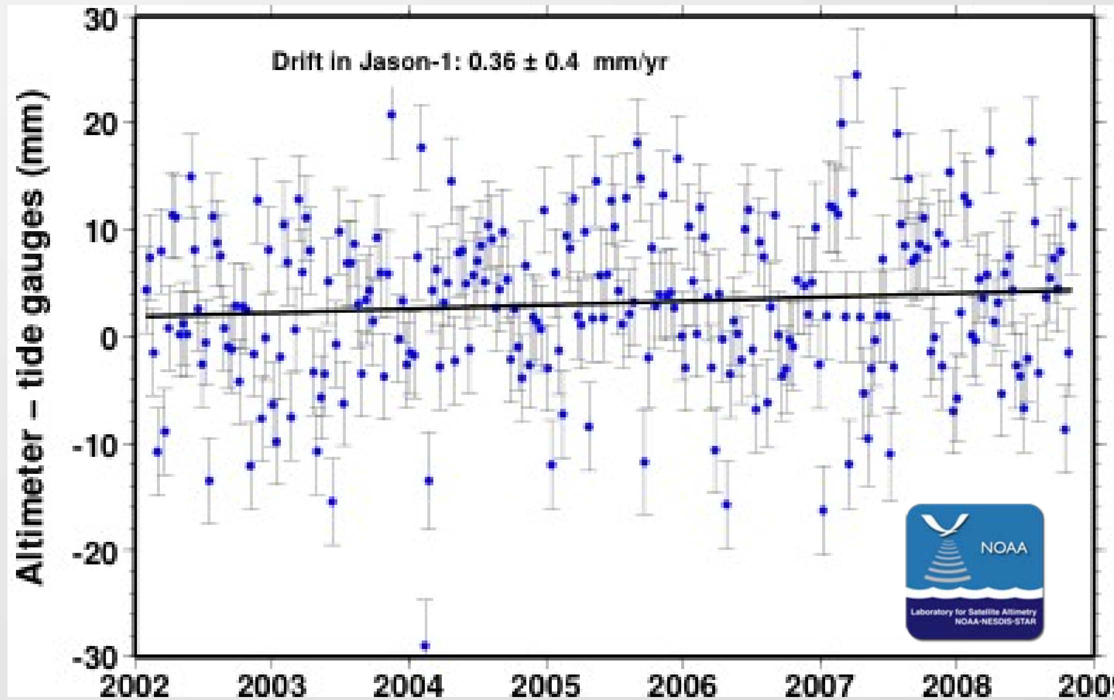


- Differences track each other quite well, validating stabilities of both instruments
- Ozone variations and trends from both instruments would be similar

Sustained Observing System Monitoring

Checking Stability of Altimeter with Tide Gauge Observations (G. Mitchum, Univ. South Florida, STAR grantee)

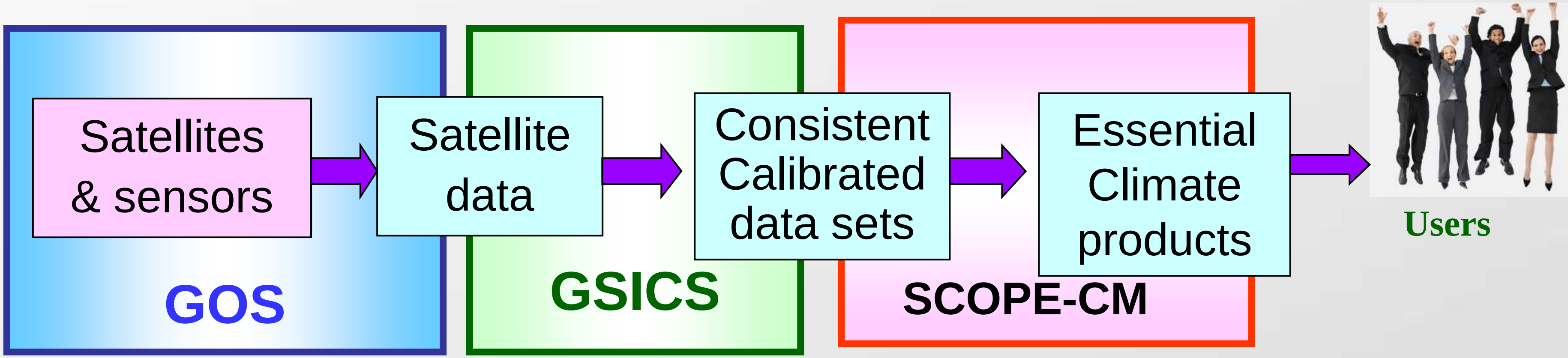




Tide gauges indicate that Jason 1 had no significant drift

SCOPE-CM to maximize data usage

Sustained and Coordinated Processing of Environmental Satellite Data



- Regional/Specialized Satellite Centres
  - Address the requirements of GCOS in a cost-effective, coordinated manner, capitalising upon the existing expertise and infrastructures.
  - Continuous and sustained provision of high-quality ECVs
  - GSICS enables the generation of Fundamental Climate Data records and provides the basis for sustained climate monitoring and the generation of ECV satellite products.

National Climate Service Priorities (1/2)

STAR Activities

1. Address the needs of public and private decision makers for projections of 21st century regional and national climate trends and extremes for risk management, adaptation and mitigation. → **Validation of climate models**

Enhance high performance computing and climate modeling.

2. Develop comprehensive monitoring, analysis and attribution capabilities in order to provide regular, authoritative, analyses, outlooks, and warnings about current climate conditions, trends, and events. → **Sustained observing system monitoring**
Satellite intercalibration
Climate Data Records
Climate trends and analyses

Enhance ocean, atmosphere and space observing systems with expanded data management capacity.

Begin development of Jason-3 altimeter satellite. → **Jason-3 participation**

3. Facilitate access to and education about authoritative local and regional climate information. Coordinate, integrate, enhance regional services.

4. Provide early warning systems about current or changing conditions for water resources and coastal sectors. → **Extreme event assessments**

National Climate Service Priorities (2/2)

STAR Activities

1. Begin organizational change within NOAA and develop key partnerships.
2. Develop carbon monitoring system to detect exchanges between atmosphere, land and ocean, as well as emission impacts. → **AIRS/IASI GHG Products; BIOMASS Characterization; CO_2 sea air exchange**
3. Provide routine monitoring and notifications about changing conditions in the Arctic. → **Arctic climate data records**
4. Monitor ocean acidification impacts on marine ecosystems. → **Ocean acidification**
5. Develop services related to impacts on living marine resources, such as sea level rise, ocean warming, loss of sea ice (at both poles), changing ocean currents, and fresh water runoff. → **Coral bleaching, sea level, and sea ice**
6. Build a capability to monitor changes in air quality to inform decision making on mitigation and public health. → **Air Quality Products**
7. Continue Development of Jason-3 mission. → **Jason-3 (discussed earlier)**

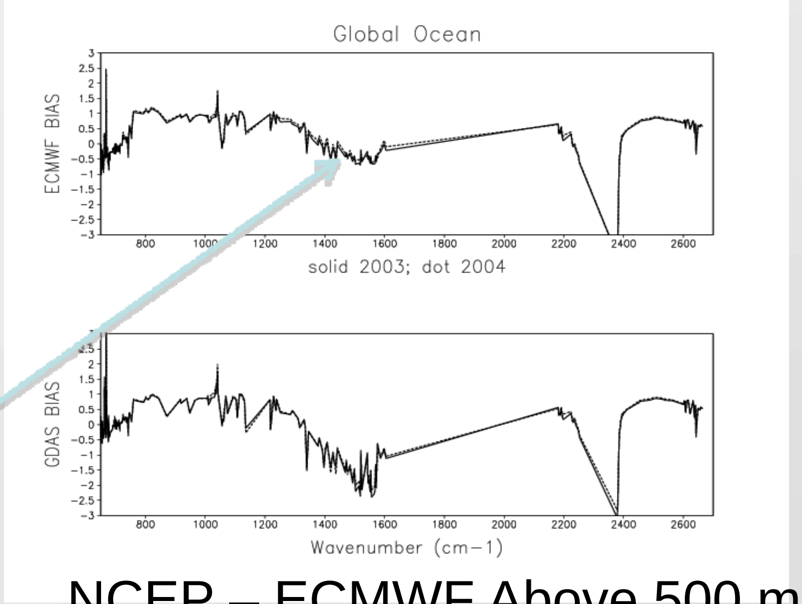
A Sample of STAR Activities supportive of a future National Climate Service

Validation of Climate Models

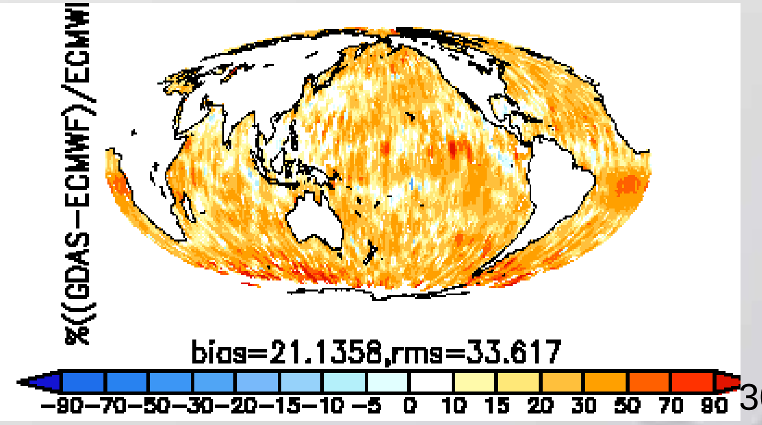
Comparison of Observed and Predicted Spectra

- Compare different years to see how the spectrally resolved infrared radiances have changed compared to models

- AIRS spectra determines ECMWF water vapor analysis is more accurate.



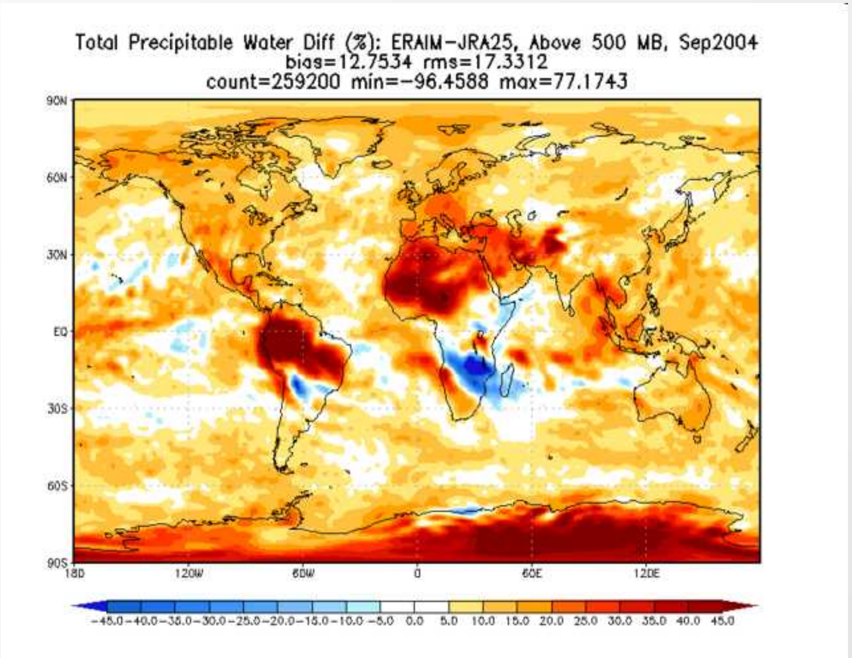
NCEP – ECMWF Above 500 mb



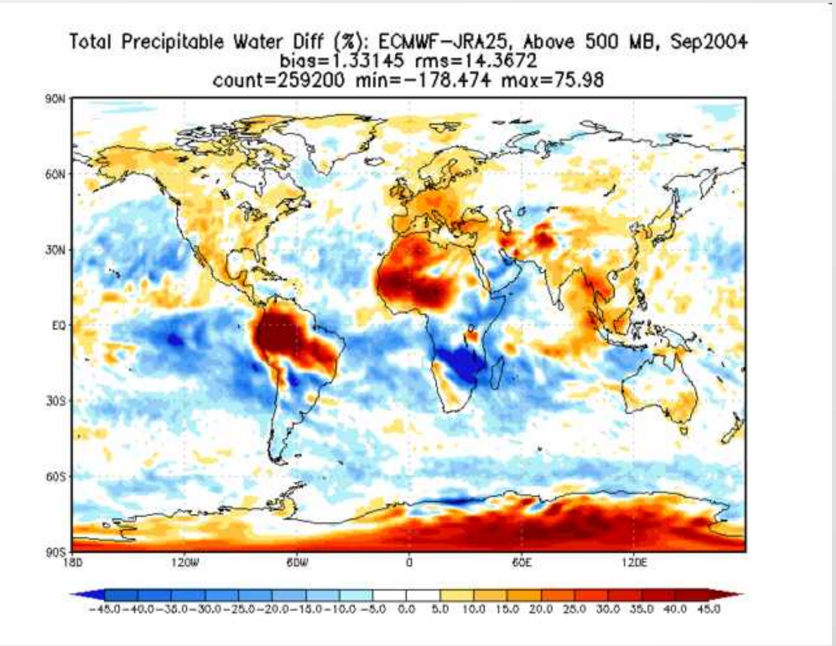
H_20 % difference (NCEP-ECMWF)

Comparison of observed and predicted spectra will facilitate identification of credible models and model defects, and lead to improvements of all models

JRA25 vs ECMWF and ERA Interim (above 500 mb)



ERAIM - JRA25



ECMWF - JRA25

Climate Data Records

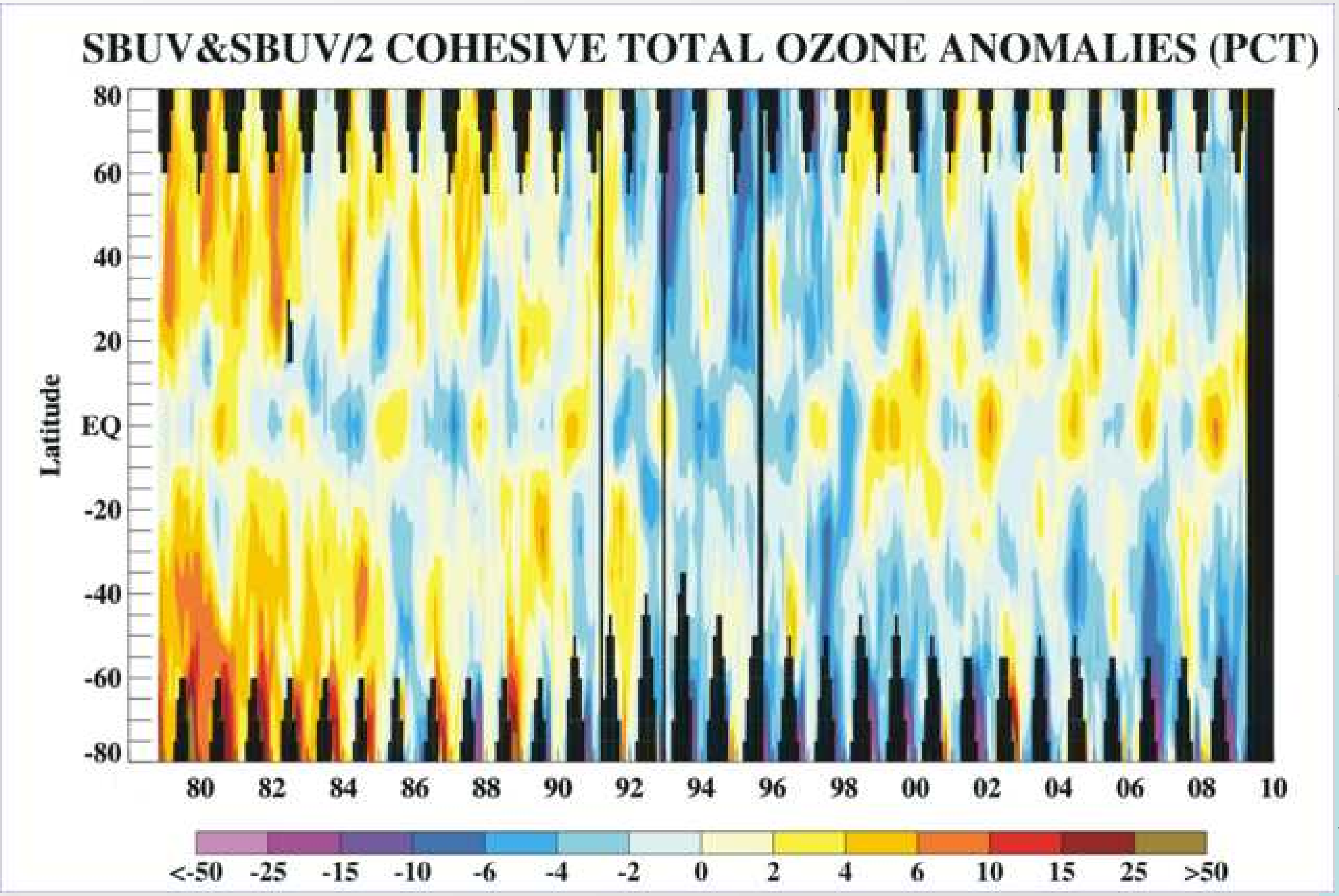
STAR Satellite-based CDRs and Other Information Products

- Atmospheric temperature
- Ozone
- Precipitation
- Vegetation
- Sea ice
- Snow cover
- Total precipitable water (oceans)
- Cloudiness
- Aerosols
- OLR
- Cloud liquid water
- Surface wind speed (ocean)
- Ocean Color – MOBY
- Sea surface temperature
- Sea surface height
- Coral Reefs
- Polar winds

STAR develops climate information products, largely from operational satellites, assuring data in perpetuity

Climate Trends and Analyses

Ozone



- Seven SBUV & SBUV/2 instruments were intercalibrated to produce this time series of zonal means

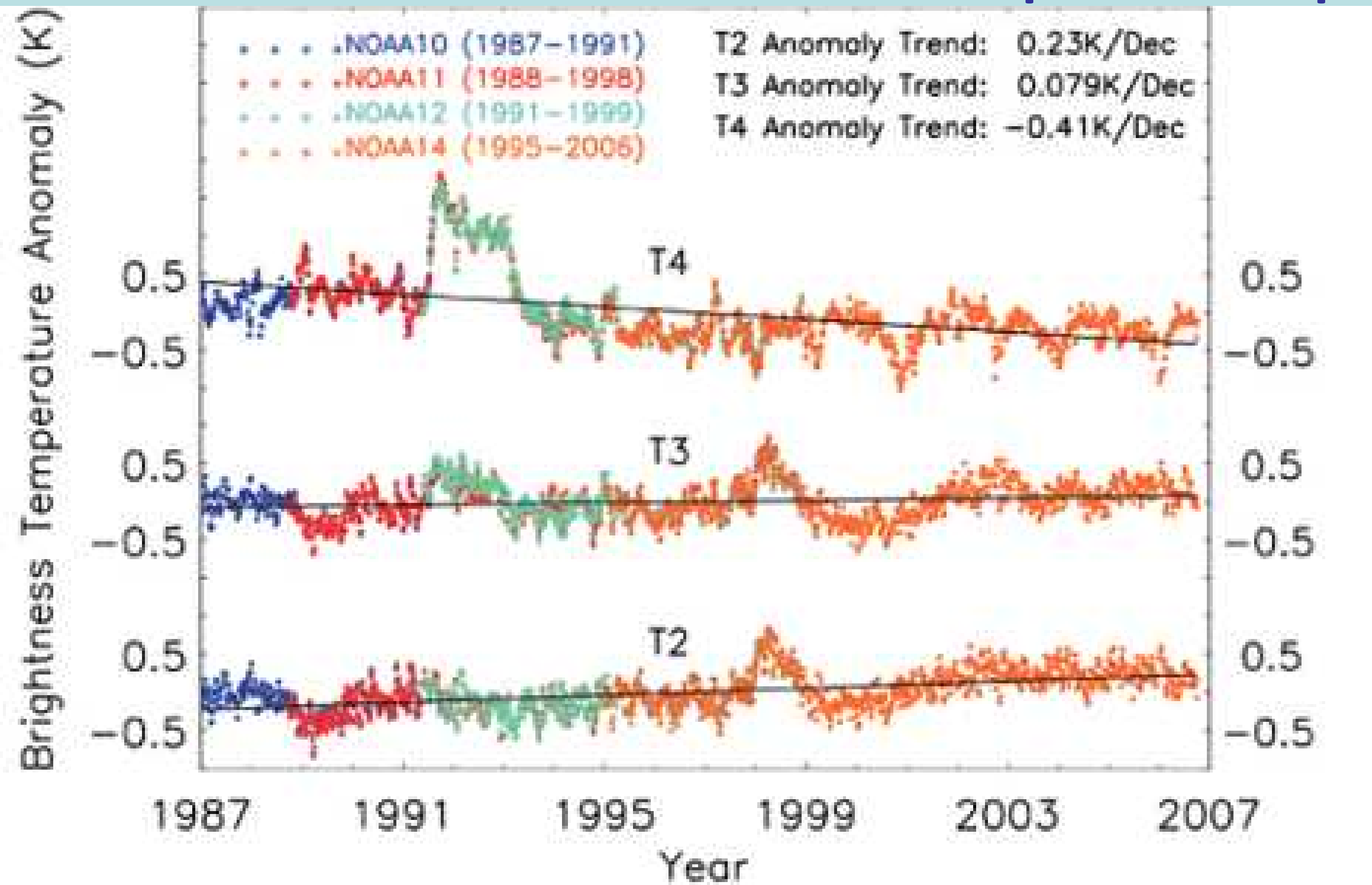
- Change from reddish to bluish colors highlights destruction of ozone layer

STAR'S SBUV & SBUV/2 ozone data records are major contributions to the WMO-UNEP assessments of ozone depletion

(www.cpc.ncep.noaa.gov/products/stratosphere/winter_bulletins)

Climate Trends and Analyses

Atmospheric Temperature

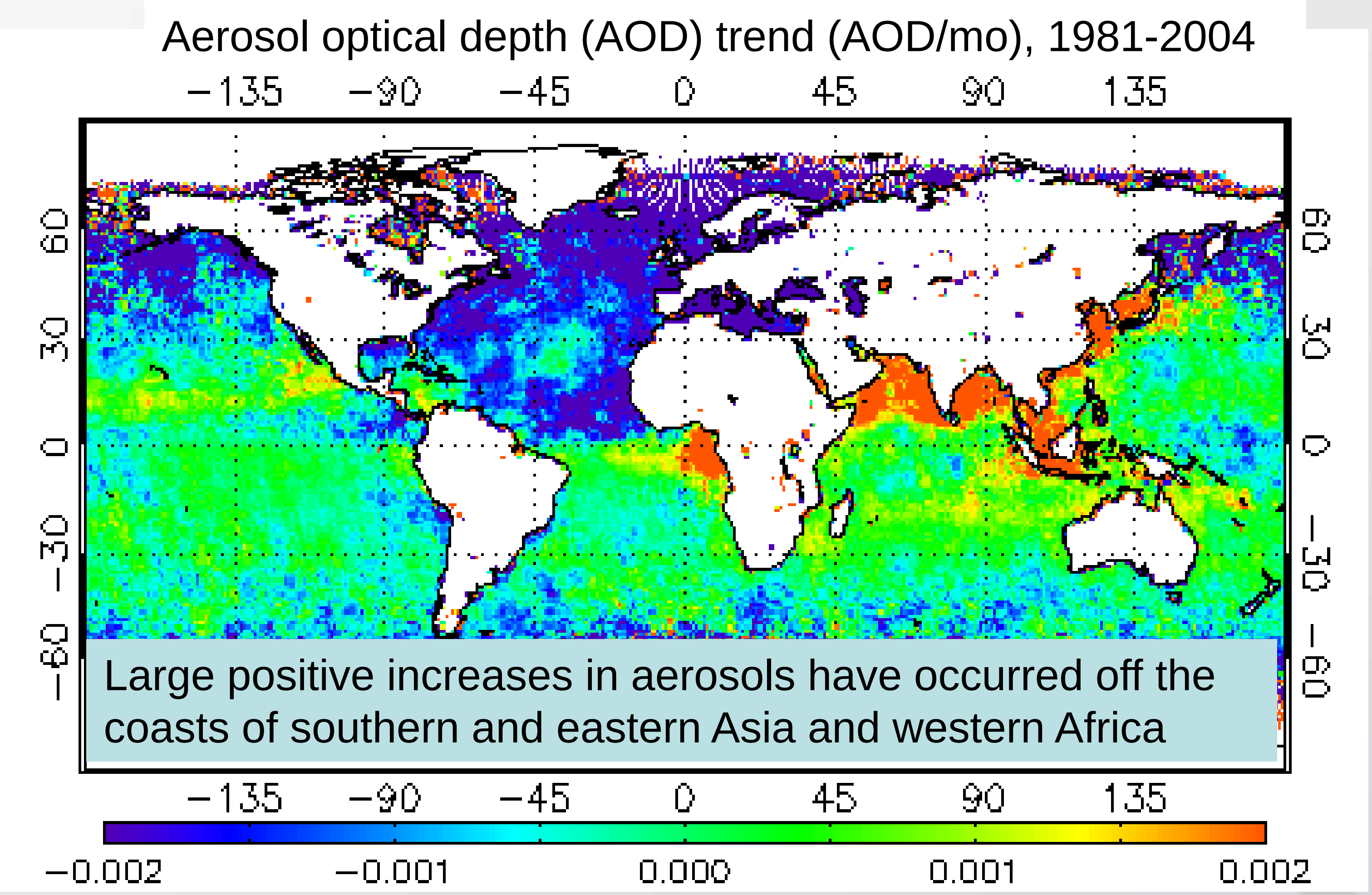


Temperature trends over oceans in the mid-troposphere (T2), tropopause region (T3), and lower stratosphere (T4) from MSU channel 2, 3, and 4 observations (Zhu, Gao, and Goldberg, *J. Clim*., In Press)

After careful intercalibration of the four MSU instruments, reliable decadal trends are obtained

Climate Trends and Analyses

Oceanic Aerosol Optical Depth Trends from AVHRR (Zhao et al., 2008, JGR)

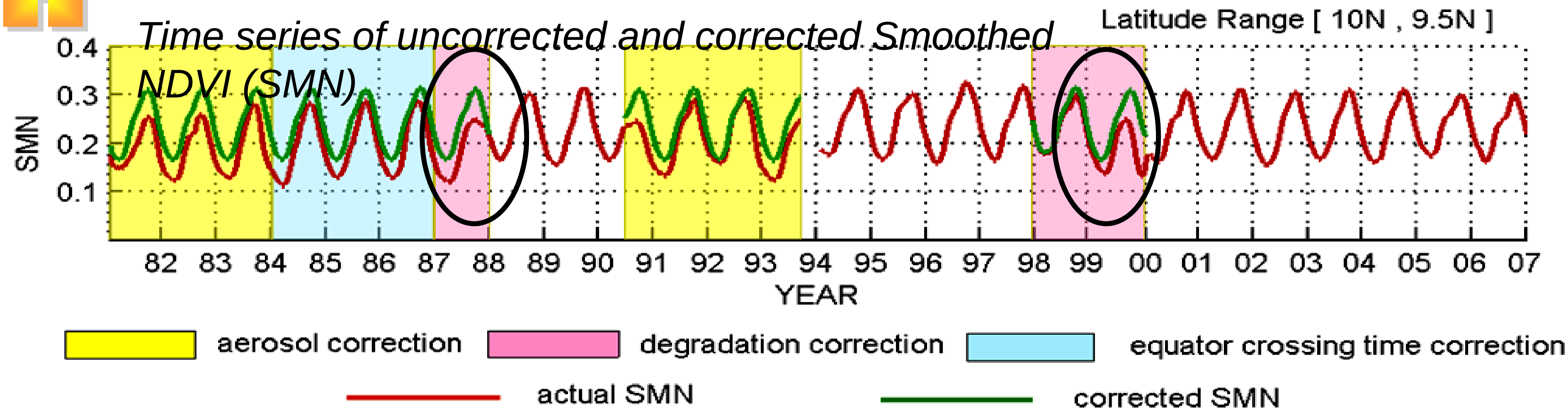


Large positive increases in aerosols have occurred off the coasts of southern and eastern Asia and western Africa

Climate Trends and Analyses

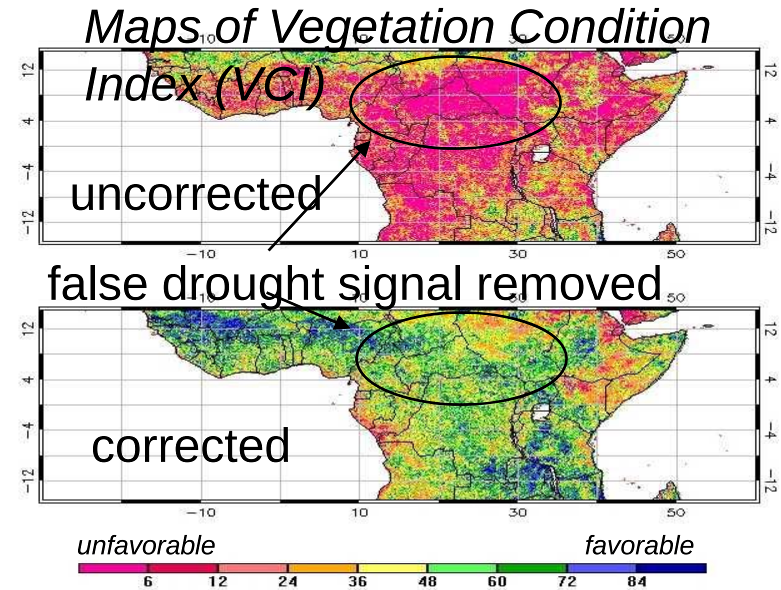
Vegetation

Time series of uncorrected and corrected Smoothed NDVI (SMN)



- The current NDVI time series have not been corrected for the effect of volcanic aerosol (El Chichon and Mt. Pinatubo) and satellite orbital drift.
- A statistical method was applied to correct these errors.
- The NDVI correction allows for improved applications such as vegetation health, fire risk, malaria risk, and agricultural yield

Maps of Vegetation Condition Index (VCI)



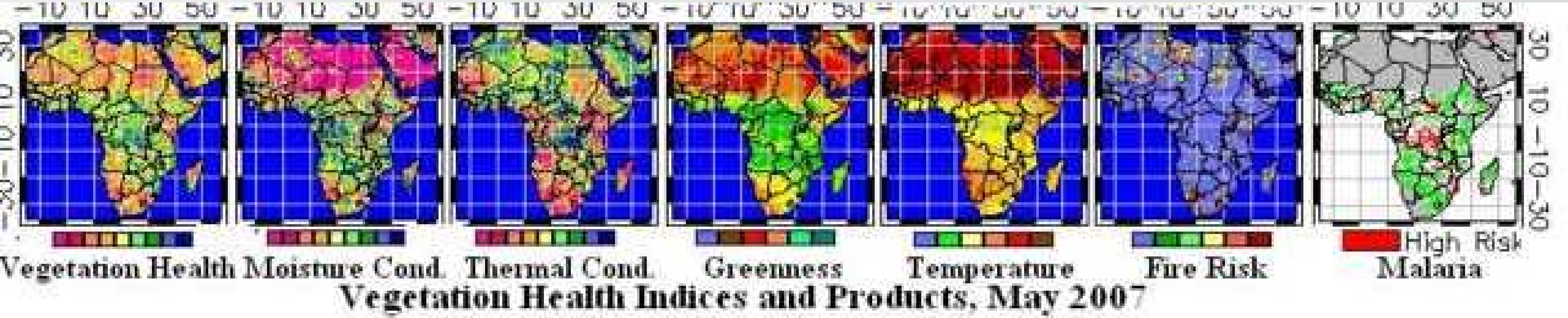
Significance: Provides improved dataset and more consistent time series for climate and environmental applications.

Satellite-based Vegetation Health Indices (VHI) for Drought Monitoring

- Products:

Vegetation Health	Moisture Condition
Thermal Condition	Greenness
Temperature	Drought
Fire Risk	Malaria Risk

- http://www.star.nesdis.noaa.gov/smcd/emb/vci/VH/



Wheat yield in Morocco from AVHRR-based VH & in situ data

CHINA

RUSSIA

INDIA

MONGOLIA

KAZAKHSTAN

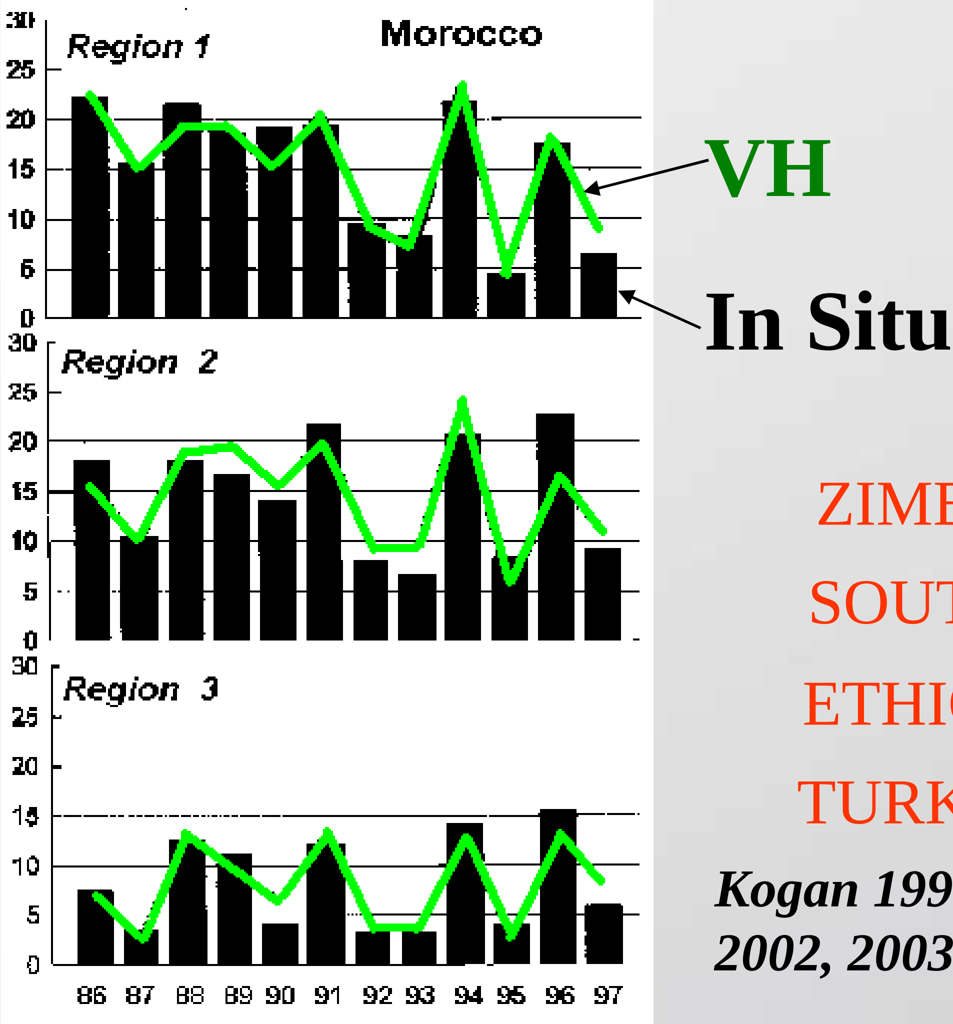
ARGENTINA

BRAZIL

USA

POLAND

HUNGARY



ZIMBABWE

SOUTH AFRICA

ETHIOPIA

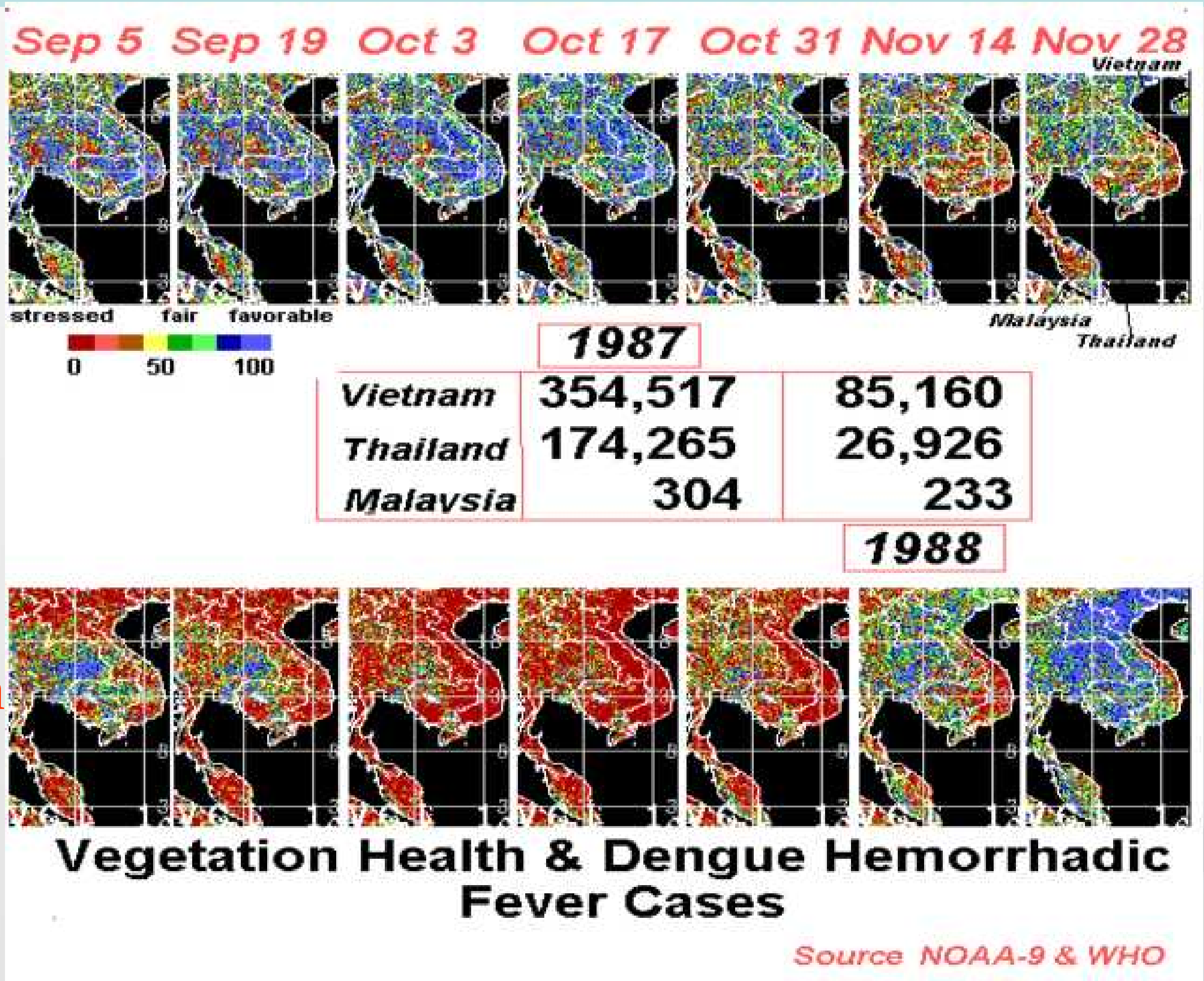
TURKMENISTAN

Kogan 1990, 1997, 2001, 2002, 2003, 2004, 2005

Vegetation Health and Dengue Fever Disease

No Stress

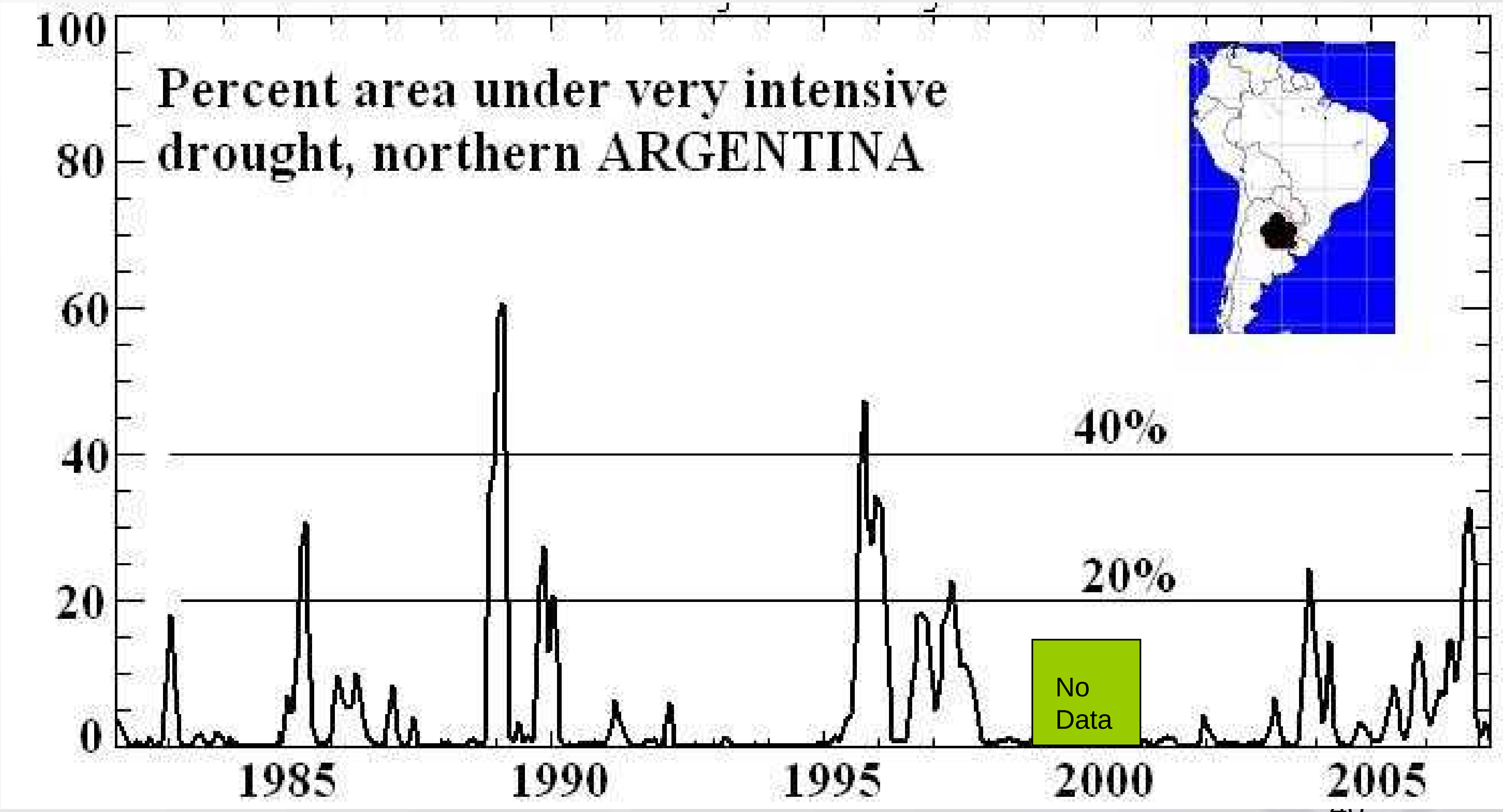
Vegetation Stress



Center for

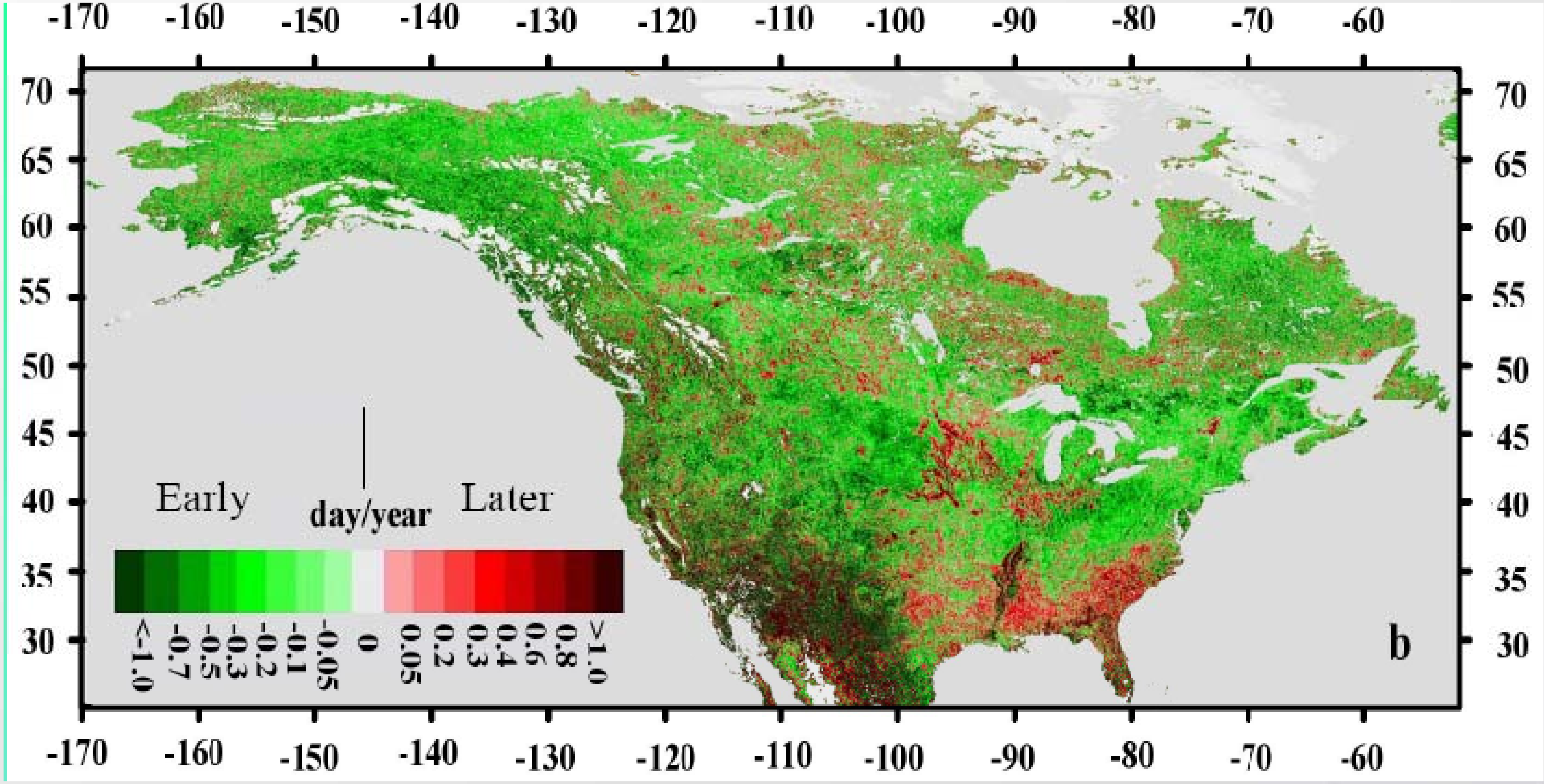
Drought Area & Intensity

Estimated from AVHRR-based Vegetation Health Index



Climate Trends and Analyses

Trend in Greenup Onset (days/year) (Zhang et al., 2007, GRL)

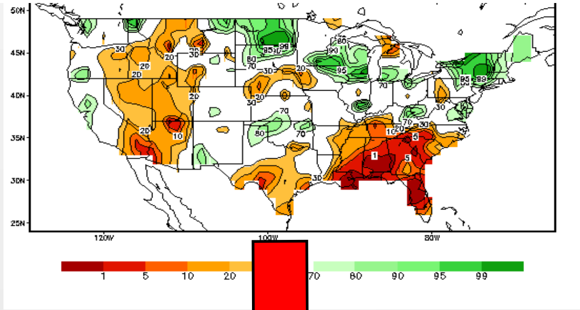


Phenological analyses of AVHRR vegetation index indicate that most of USA and Canada is greening up earlier in the spring

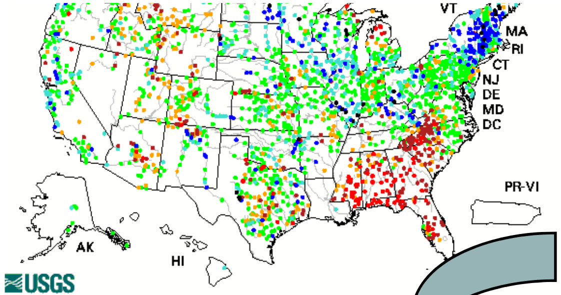
Extreme Event Assessments

Principal Inputs to U.S. Drought Monitor

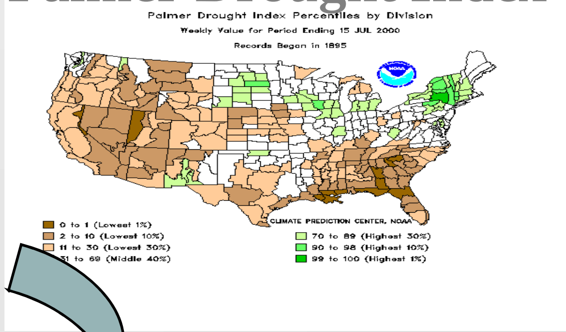
CPC Daily Soil Model

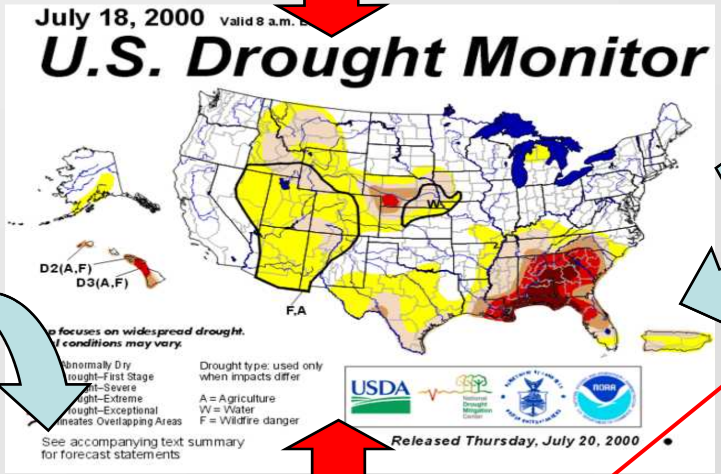


USGS Streamflow



Palmer Drought Index

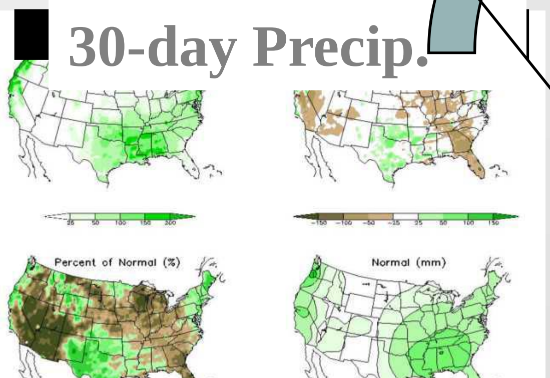


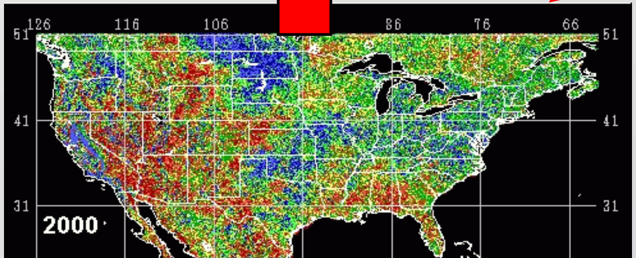


STAR's Vegetation Health Index is a principal input

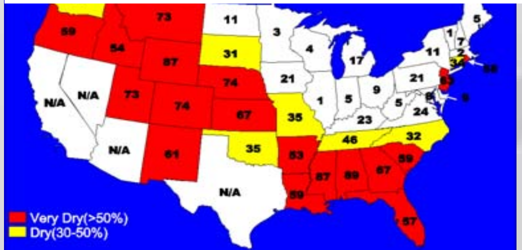
STAR Input

30-day Precip.





USDA Soil Ratings



Extreme Event Assessments

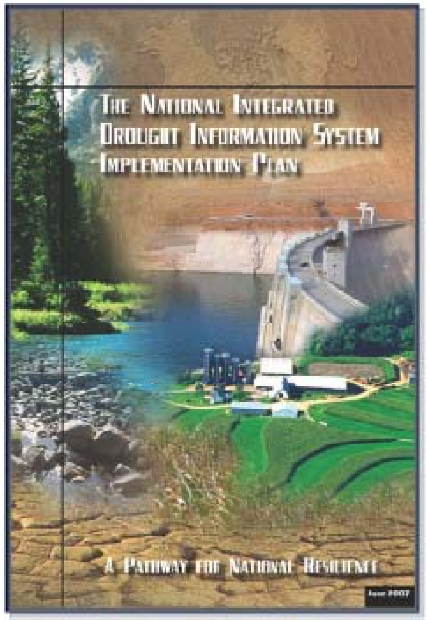
Drought: One of the Products of NOAA's Climate Service

Specific Products or Issue Focus Services

Drought

13

National Integrated Drought Information System (NIDIS)

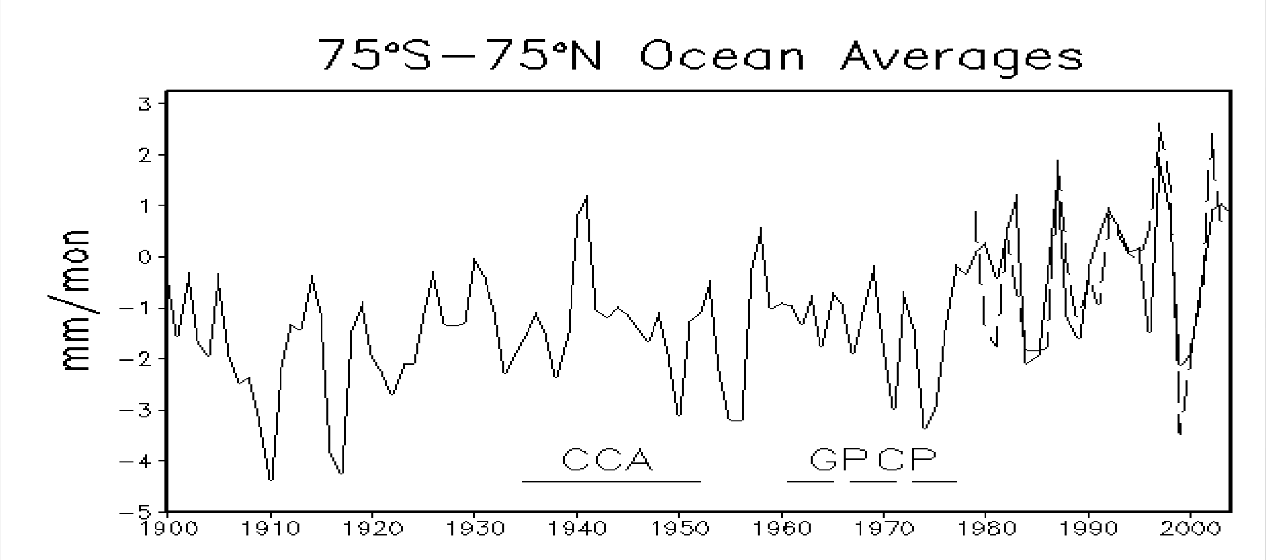


STAR's Vegetation Health Index and 30-day precipitation products are principal inputs to U.S. Drought Monitor

Climate Trends and Analyses

Ocean Area Precipitation Reconstruction (Smith et al., 2008, JGR)

- Precipitation over the ocean estimated from correlation of precipitation from GPCP data (largely satellite) with SST and SLP
- Time series of precipitation derived for the entire 20th century by applying equation to the SST and SLP time series
- The multi-decadal trend is about 2x larger than the AR4 reanalysis estimates

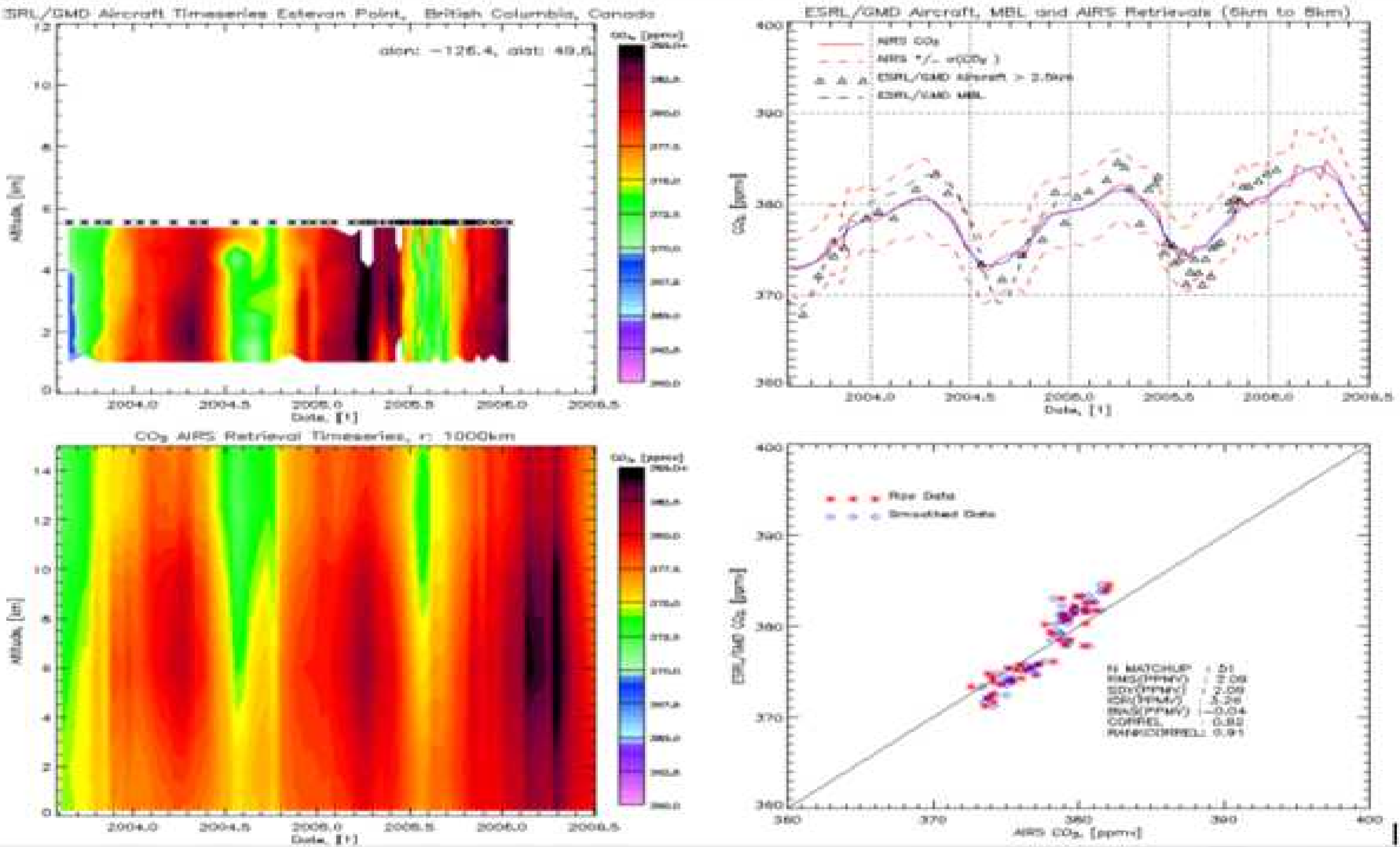


Reconstructed precipitation time series (solid line). GPCP data (dashed line) are shown for comparison.

Satellite data are used in a unique way to derive a precipitation time series extending back to1900

AIRS/IASI Greenhouse Gas Products

STAR is Cooperating with OAR/ESRL in Validating Satellite CO_2

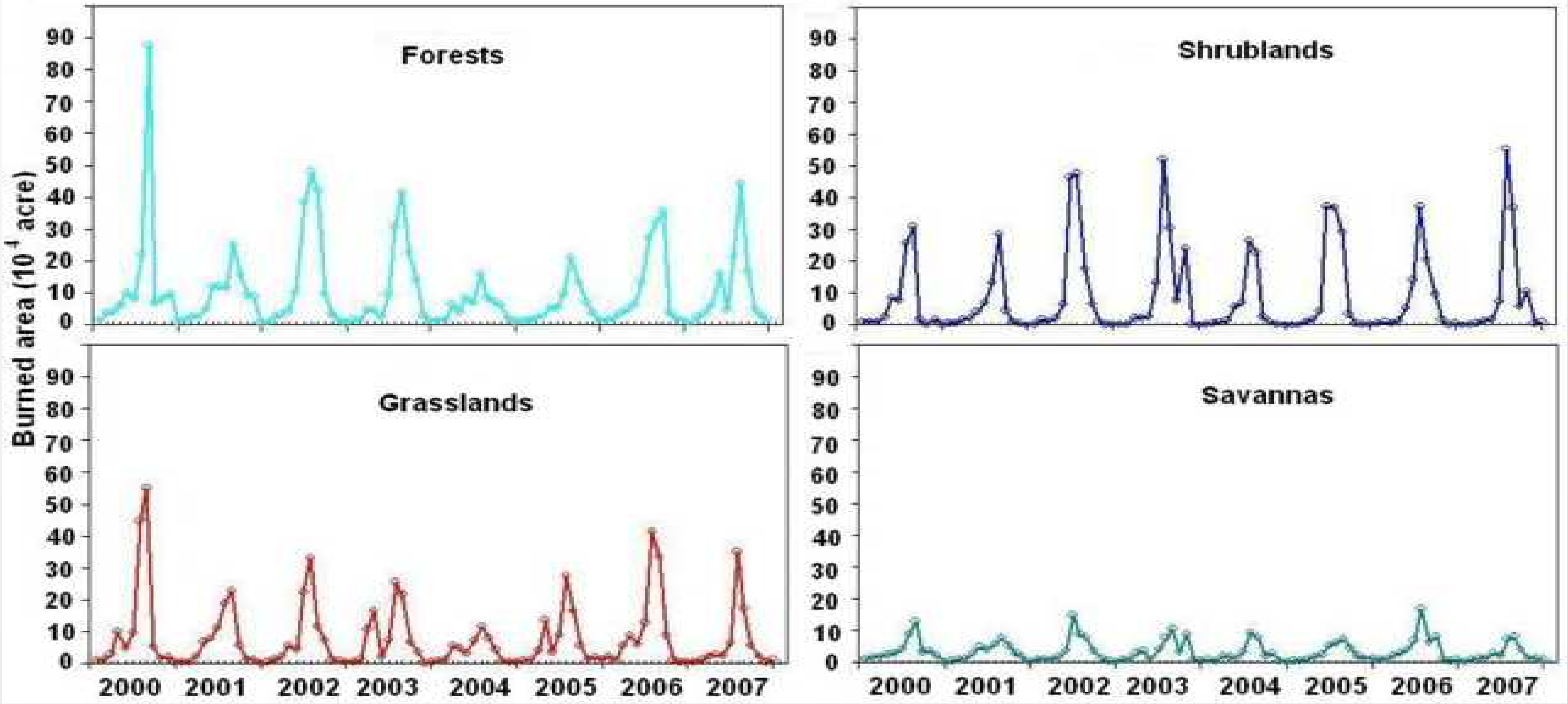


AIRS CO_2 agrees with aircraft observations, demonstrating hyperspectral sounder capability to monitor greenhouse gases

:SDIS and ERSL

BIOMASS Characterization

Long-term Monitoring of Biomass Burning over CONUS from GOES Satellites



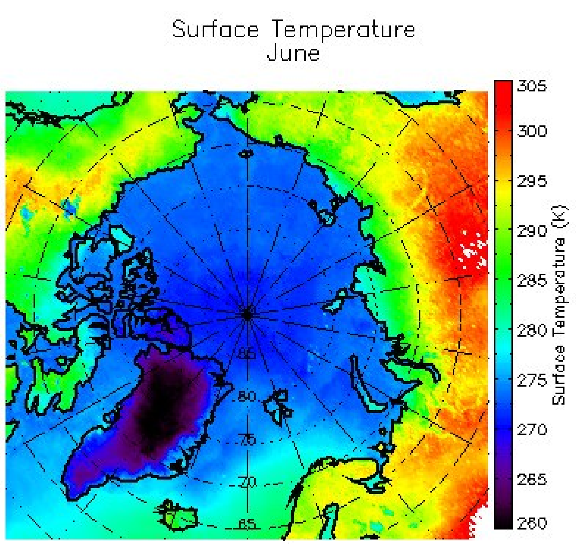
- Satellites have the ability to track natural and climate-induced variability in biomass burning in different ecosystems
- Variability in biomass burning impacts greenhouse gas (e.g., CO_2) emissions and air quality
- NOAA NPOESS/GOES-R sensors will extend this record and enable the scientific community to fully understand the linkages between climate change, ecosystems, and air quality

STAR is a leader in development of biomass burning data records from operational satellites

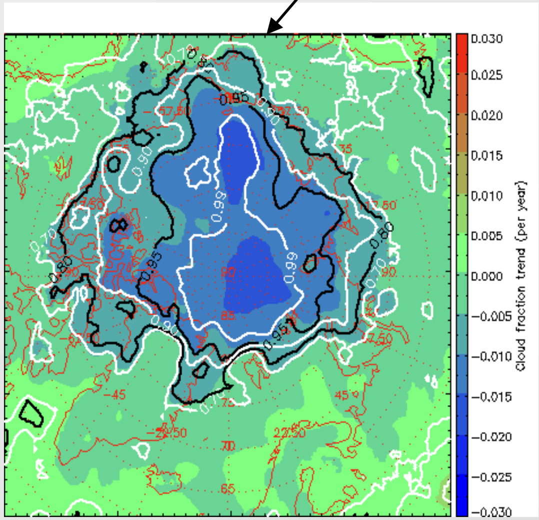
Arctic Climate Data Records

Surface Temperature, Cloud Fraction and Albedo (Wang and Key, 2003, Science)

- Based on 23 years of AVHRR observations
- Data set includes surface temperature, albedo, cloud amount, height, thickness, and phase, and surface radiation fluxes over both polar regions
- Winter cooling trend is due to winter cloud decrease

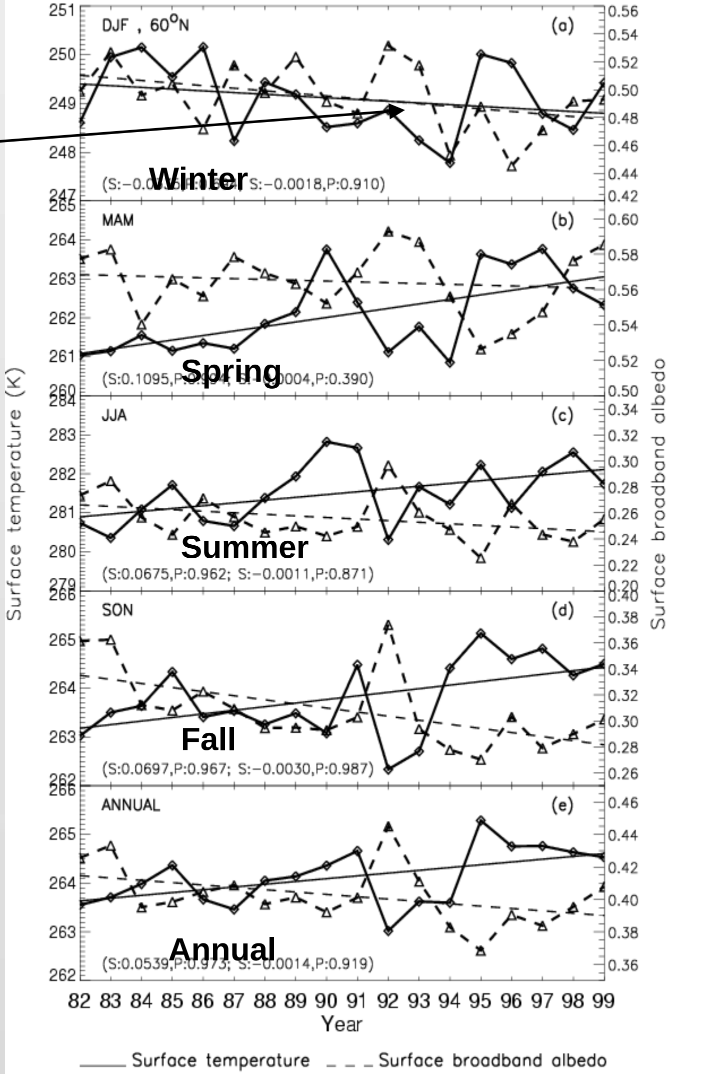


Average June temperature



Trend in winter cloud fraction

Temperature (solid) and albedo (dashed) tren

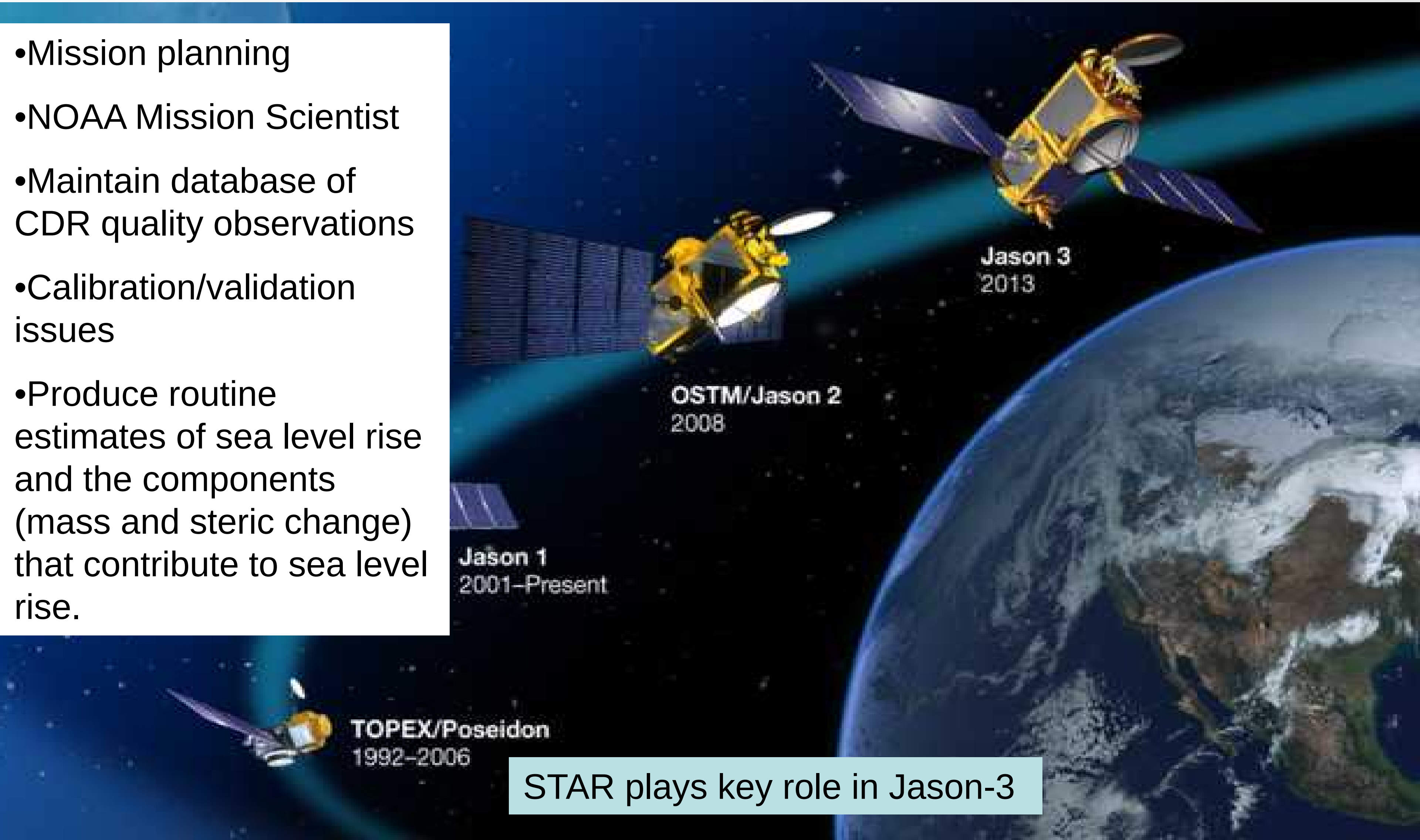


In a key climatic region, with few conventional observations, STAR's analysis of operational satellite data is providing unique information

Jason-3 Participation

STAR's Role

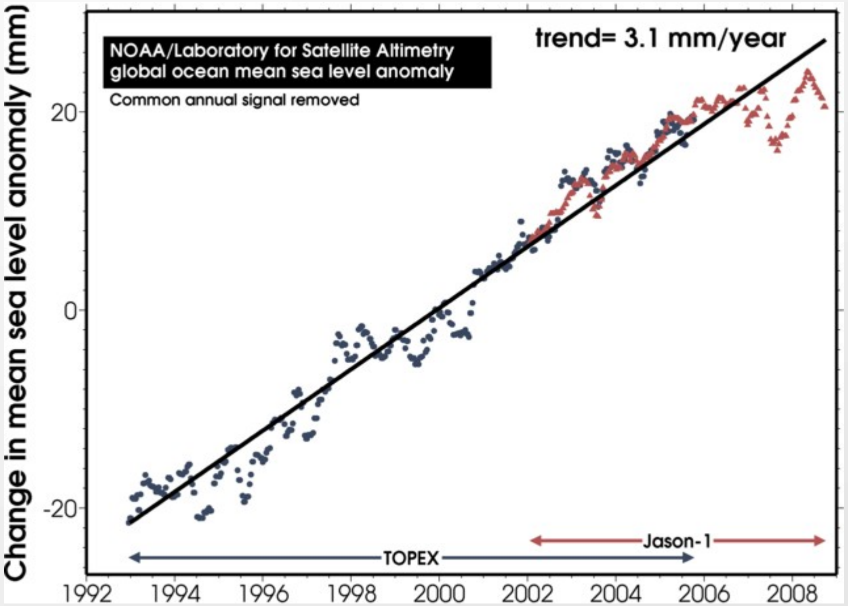
- Mission planning
- NOAA Mission Scientist
- Maintain database of CDR quality observations
- Calibration/validation issues
- Produce routine estimates of sea level rise and the components (mass and steric change) that contribute to sea level rise.

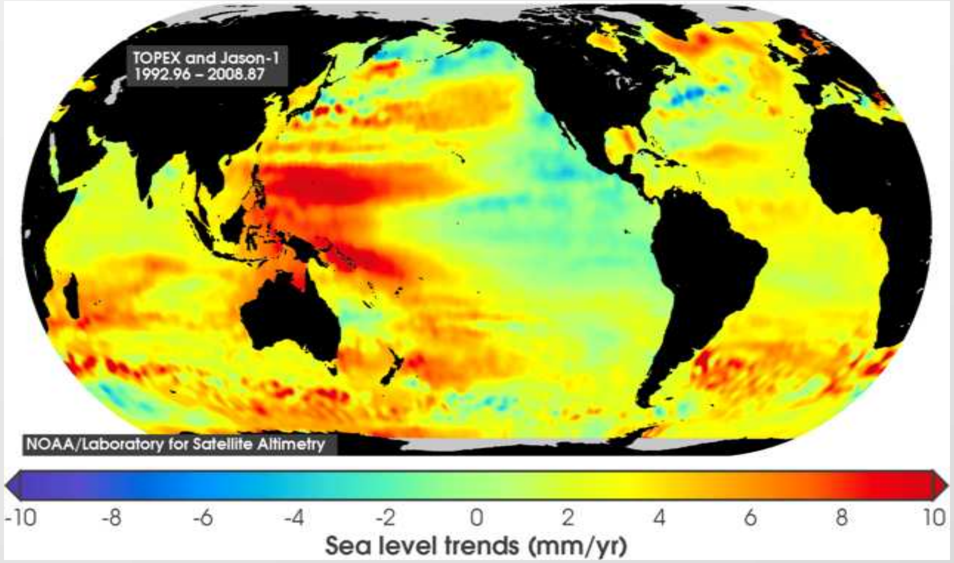


STAR plays key role in Jason-3

Sea Level

Global Sea Level (http://ibis.grdl.noaa.gov/SAT/slr)





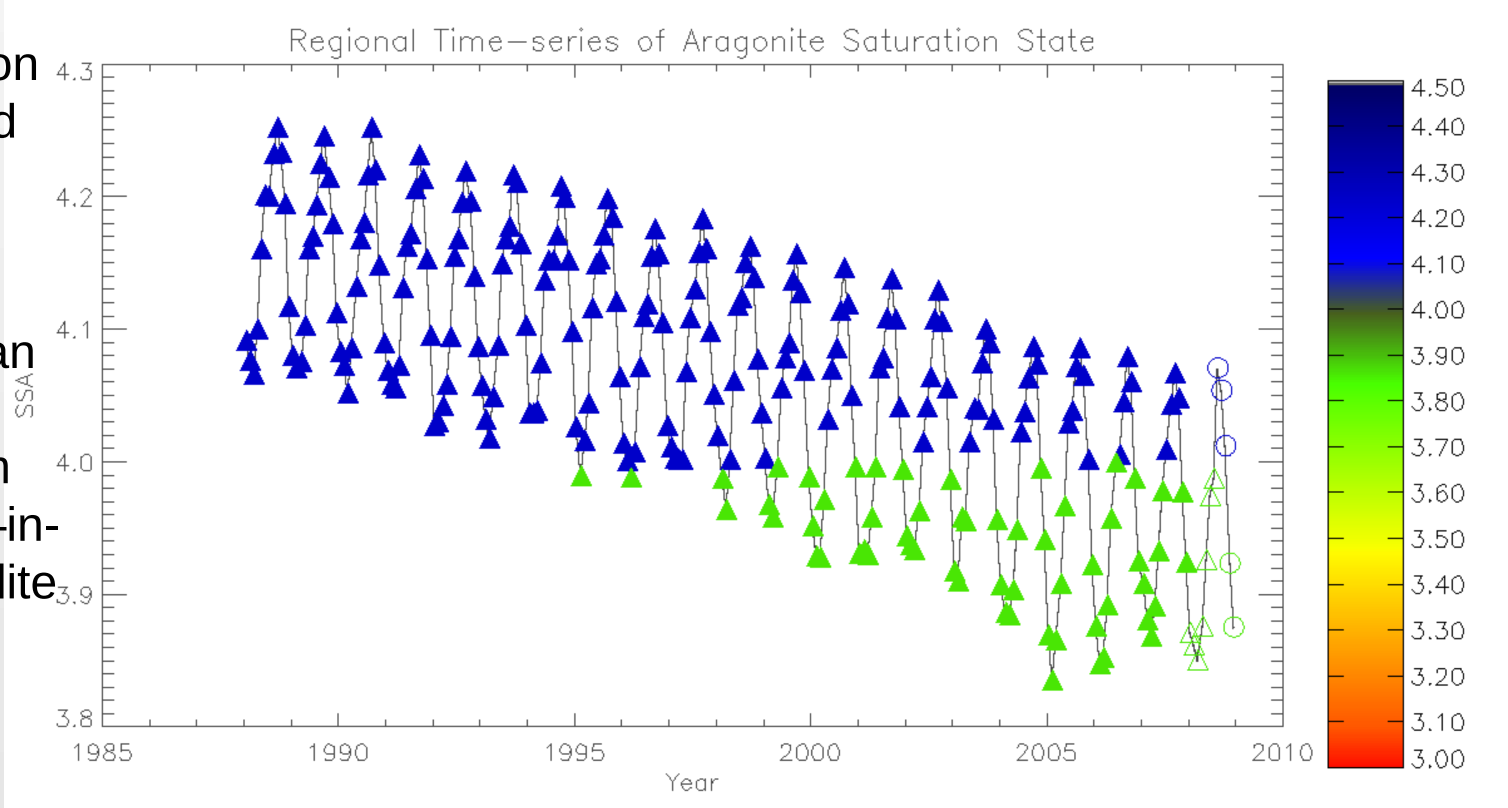
STAR's analysis of altimetry data indicates that global mean sea level has been rising over the past 16 years at 3.1 mm/yr, more than 50% faster than over the past century.

Ocean Acidification

Increasing Acidification in the Caribbean (Gledhill et al., 2008, JGR-Oceans)

- Argonite saturation is inversely related to acidification

- Saturation is determined from an equation that includes SST from blended satellite –in-situ analysis satellite based



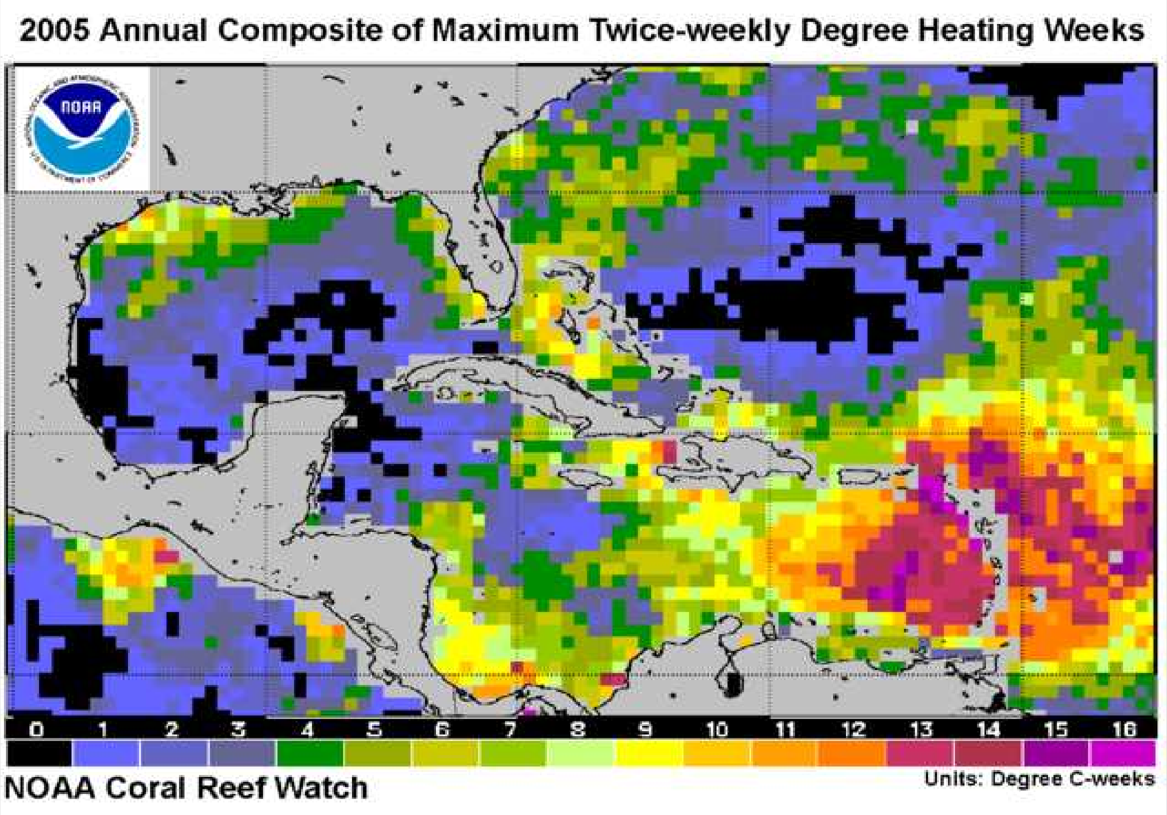
STAR plays a key role in NOAA's ocean acidification program

Coral Reef Bleaching

STAR plays key role in NOAA's Coral Reef Watch

Most severe Caribbean bleaching in 22 years occurred in 2005

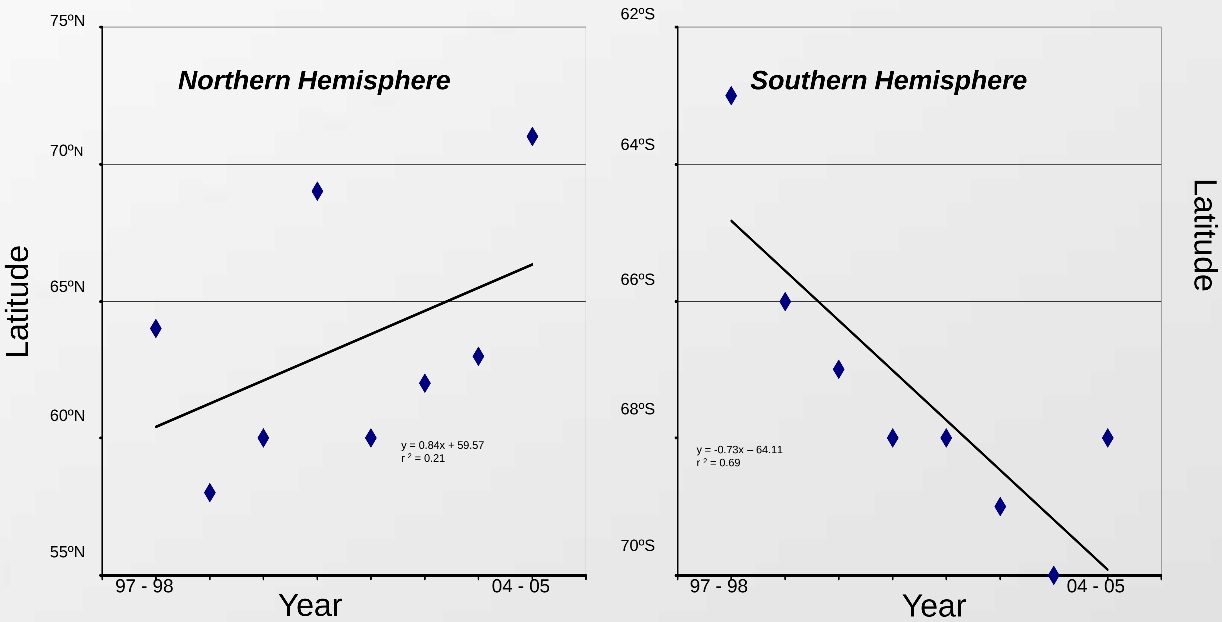
Bleaching index is based on AVHRR SST observations



STAR monitors coral reef conditions globally

Climate Trends and Analyses

Latitude of *E. Hux.* Phytoplankton Blooming (Brown, C., 2006: AGU Ocean Sciences Meeting)



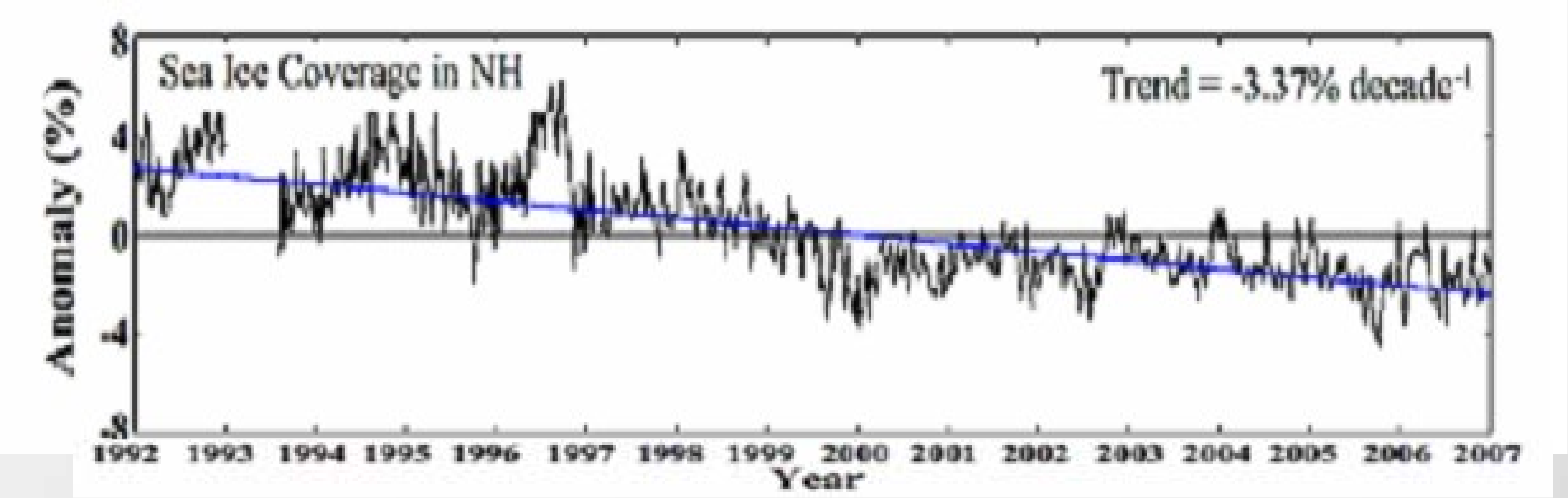
Latitude of maximum normalized surface area of classified *E. huxleyi* blooms in the Northern (30º - 80ºN) and Southern (30º - 70ºS) Hemispheres during the first eight years of the SeaWiFS mission.

Preliminary analysis indicates the latitude of maximum bloom area of the coccolithophorid *Emiliania huxleyi* migrated polewards.

The trend is statistically significant in the Southern Hemisphere, but not in the Northern.

Impact of global warming on phytoplankton can be traced with satellite ocean color imagery

Sea Ice from SSM/I



STAR's recalibration of the SSM/I's enables construction of a more reliable sea ice time series

CoastWatch to OceanWatch

- **Data types to be collected:**
  - Sea surface temperature from polar and geostationary spacecraft
  - Ocean surface vector winds
  - Ocean color radiometry
  - Altimetry
  - Ocean roughness (SAR)
  - Surface salinity (future)
- **Experimental climate products now maintained:**
  - Sea level rise
  - Ocean acidification
  - Ocean carbon dioxide flux (limited geographic demonstration – with AOML)
- **Capabilities envisaged:**
  - Product processing (operational products) and reprocessing (climate quality products).
  - Calibration including SI traceability as appropriate.
  - Archiving at national centers.
  - Science support for calibration support, product development, applications.

Based on over two decades of operational ocean remote sensing of the U.S. coastal ocean, STAR is embarking on an expansion of NOAA CoastWatch into the global ocean.

Key Users of STAR's Climate Products

- IPCC (Sample of Citations)
  - Leuliette, E.W., R.S. Nerem, and G.T. Mitchum, 2004: *Mar. Geodesy*
  - Miller, L., and B.C. Douglas, 2004: *Nature*
  - Zou, C.-Z., M.L. van Woert, C. Xu, and K. Syed, 2004: *Mon. Weather Rev.*
  - Zhao, T.X.P., I. Laszlo, P. Minnis, and L. Remer, 2005: *J. Geophys. Res*.
- WMO-UNEP Ozone Assessments
- NOAA's Climate Prediction Center
- National and international climate reanalysis projects
- National Integrated Drought Information System
- National and international climate modeling groups

STAR's contribution to climate

- Interact with climate community on requirements for and utilization of satellite data
- Assure reliable satellite instrument calibration/intercalibration and champion the establishment of a National Center for Calibration
- Create reliable satellite-based CDRs and other climate information products
- Analyze satellite data for trends and other climate applications
- Contribute to national and international climate and ozone assessments
- Focus new efforts on regional climate
- Plan future satellite climate sensors

Climate Trends and Analyses

Recent Advances in Climate Science Based on STAR Analyses

1. The Arctic has been warming generally but cooling in winter; changes in cloud cover have suppressed the warming trend. ***(Wang and Key, 2003, Science)***
2. The Atlantic has been warming in large part due to dust variability. This analysis revealed an unsuspected long-term linkage between dust and hurricane frequency. ***(Evan et al., 2006, Geophys. Res. Lett.)***
3. New products have revolutionized the way resource managers and scientists look at coral bleaching, and have revealed that rising ocean temperatures increased the frequency and intensity of coral bleaching and mortality. ***(Hoegh-Guldberg et al., 2007, Science)***
4. Unlike temperature, rainfall patterns have changed regionally but not globally. ***(Smith et al., 2006, GRL)***
5. Merged SST/land surface reanalysis data confirms global warming observed by surface stations. ***(Smith et al., 2008, J. Climate)***
6. Long-term temperature trend calculations have been improved by using satellite data to assess the urban heat-island effect. ***(Hale et al., 2008, JGR)***

Items #1-4 are discoveries of previously unknown interactions or patterns. Items #5-6 present new approaches to climate analysis.

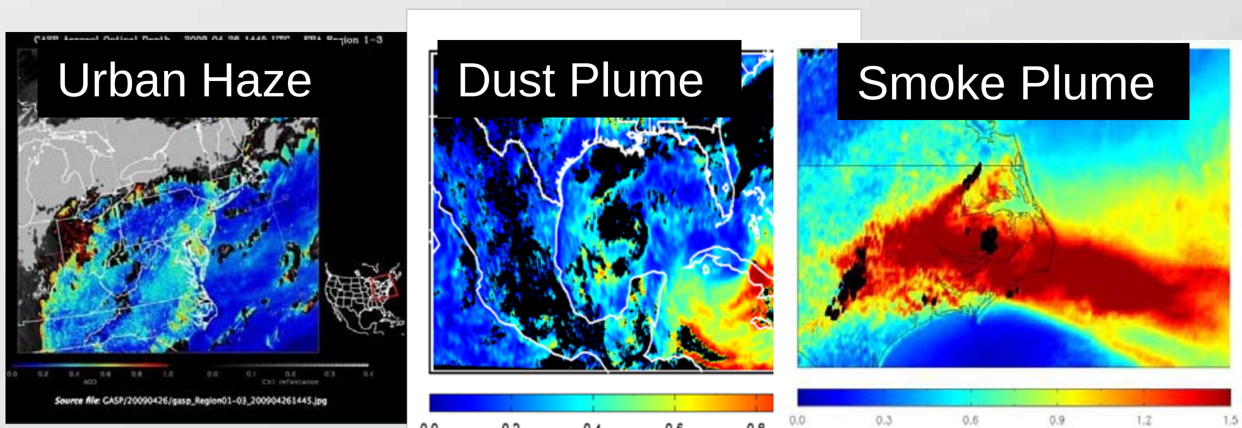
Air Quality Products

Climate Change

- Ecosystem changes
- Meteorological changes (e.g., temperature, rainfall)

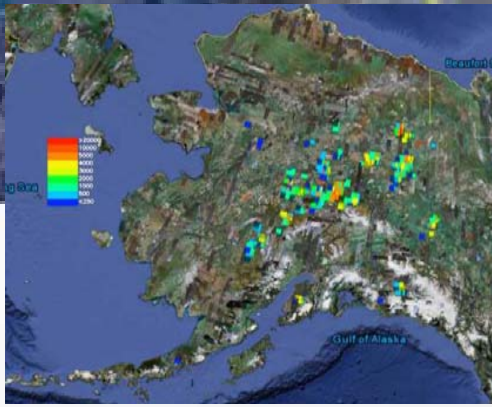
Atmospheric aerosols from anthropogenic activities induce climate change

Air Quality (aerosols/particulate pollution)

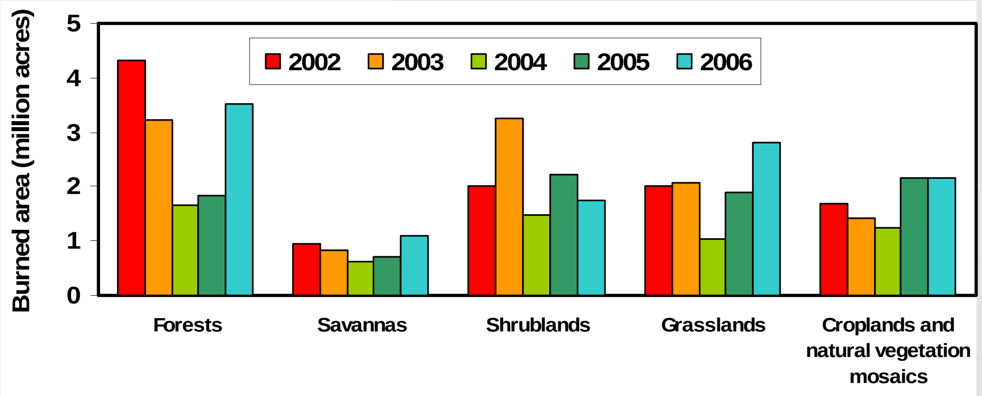


Impacts human health and economy

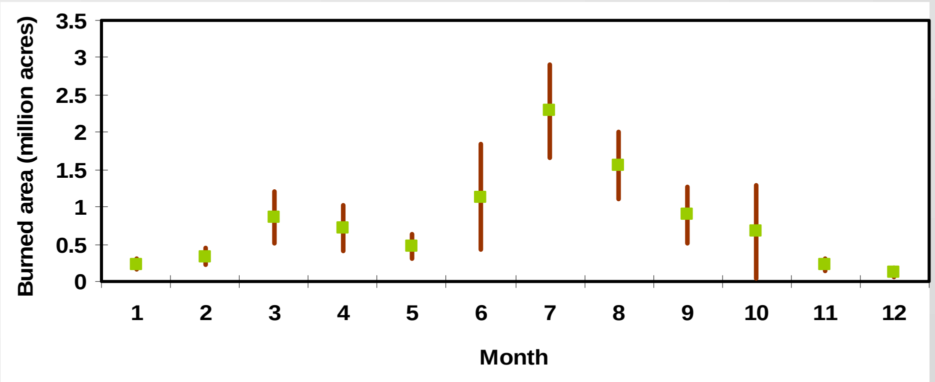
Long term monitoring of air quality will enable tracking linkages between A/Q and climate



Fire Hot Spot Detection and Characterization from Satellites



- Burned area estimates derived from NOAA GOES-E satellite from 2002 to 2006 show that:
  - Wildland fires peak between June and September
  - Annual cost to suppress the fires are substantial for all types of fires with a total cost of 8.6 billion dollars*

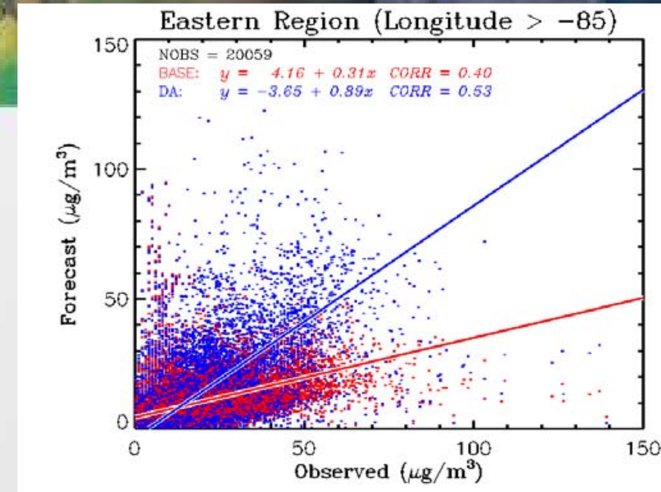


Vegetation Type	Cost (millions of dollars)
Forests	3155
Savannas	666
Shrublands	1487
Grasslands	1757
Croplands/natural vegetation	1405

Cost estimates (dollars per acre) were obtained from Gebert et al., West. J. of App. For., 22(3), 2007

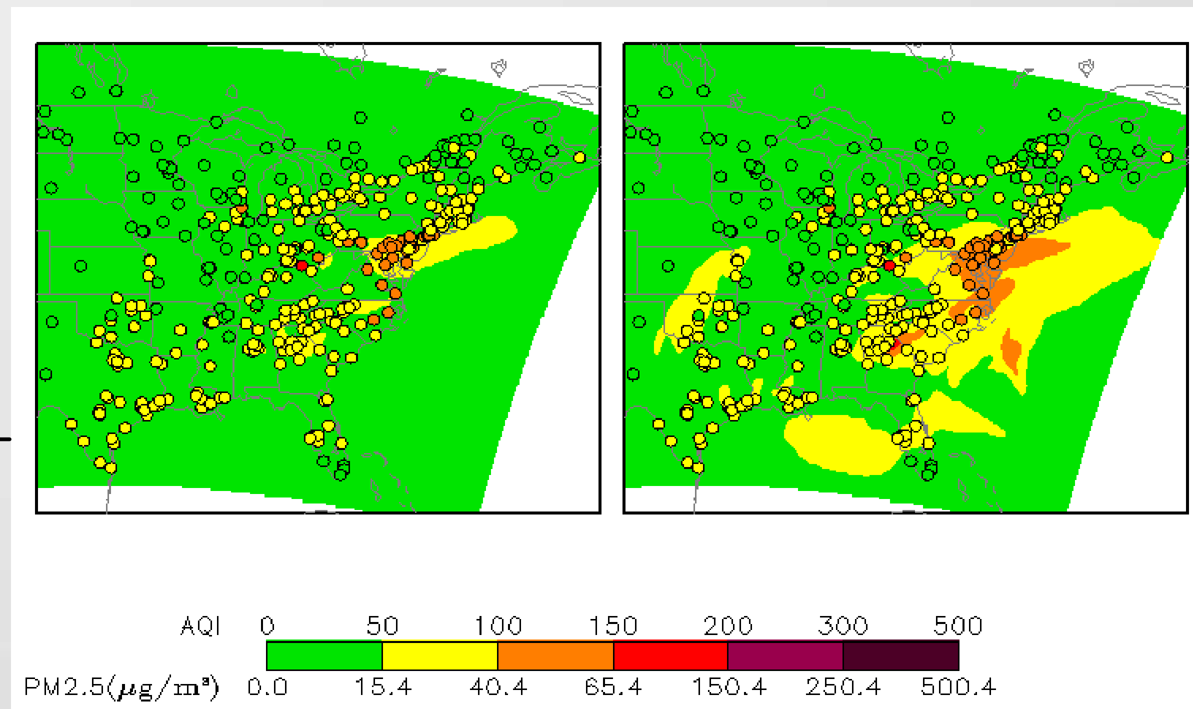
* Costs do not include impact of smoke from fires on human health and other costs associated with transportation and evacuation and loss of property

Improve Model Predictions with Satellite Data Integration



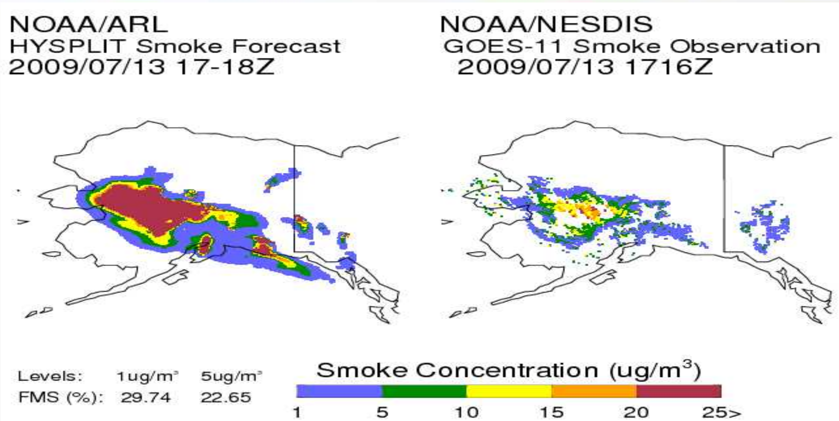
GOES Aerosol Optical Depth assimilation Improved CMAQ surface PM2.5 Predictions by ~25%

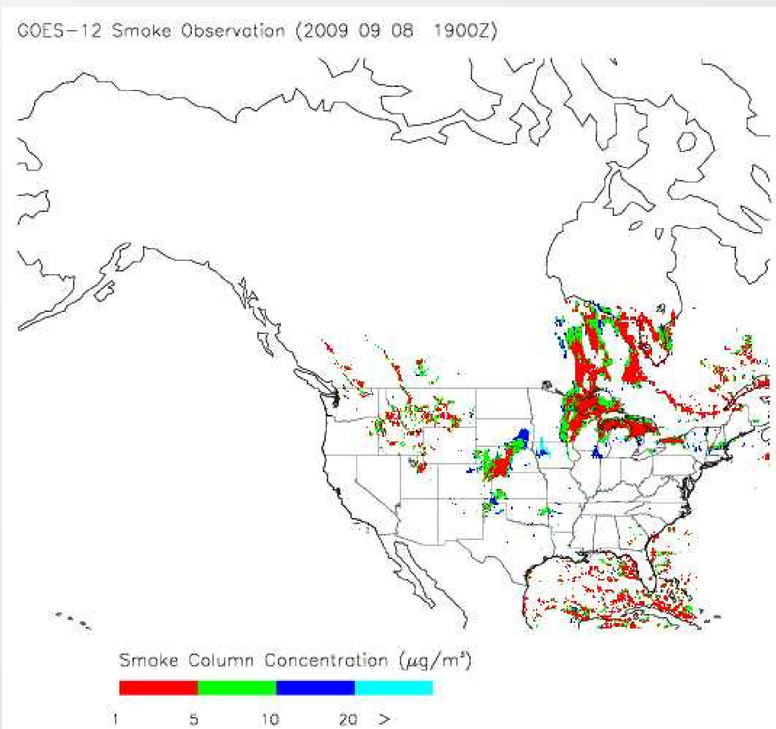
CMAQ (no assimilation) CMAQ (assimilation)

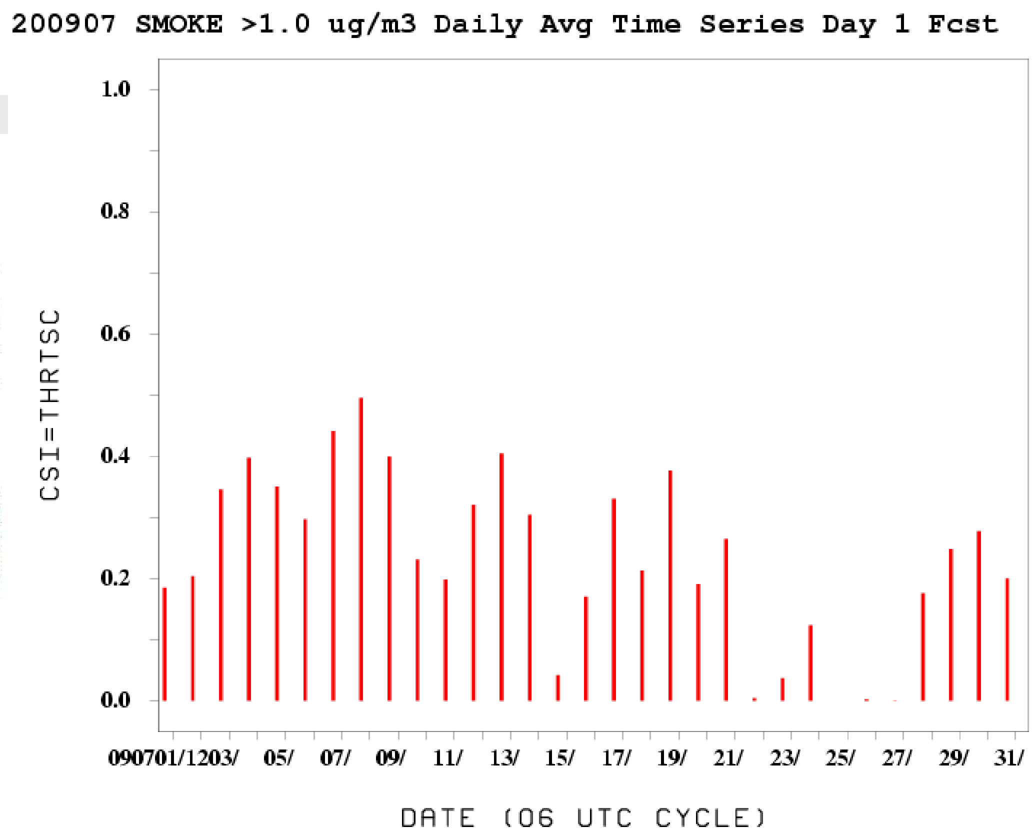


$$C^{ana} = C^{guess} \frac{\tau^{ana}}{\tau^{guess}}$$

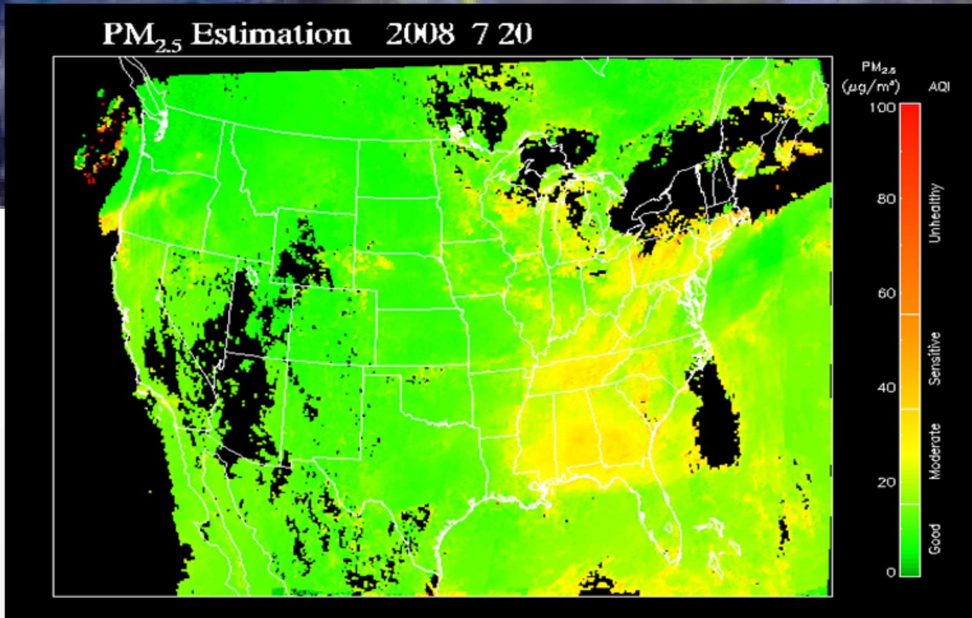
NWS testing of smoke verification for Alaska using NESDIS GOES-W smoke product



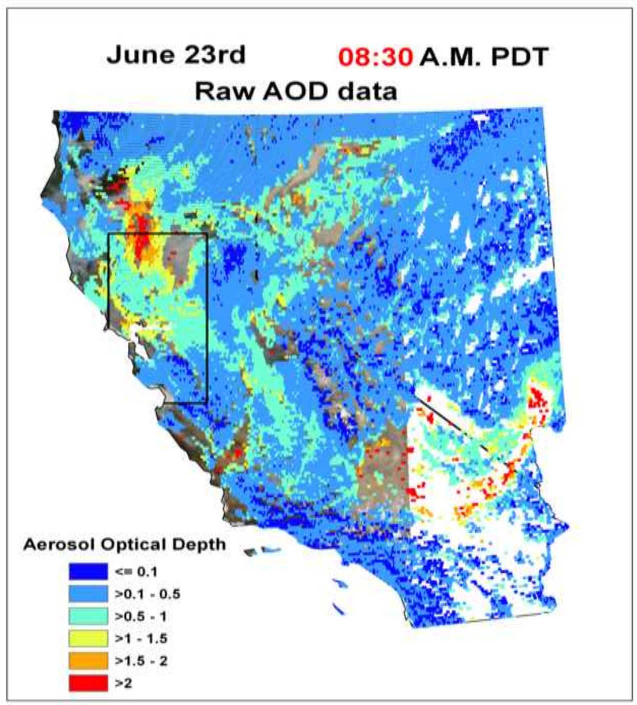


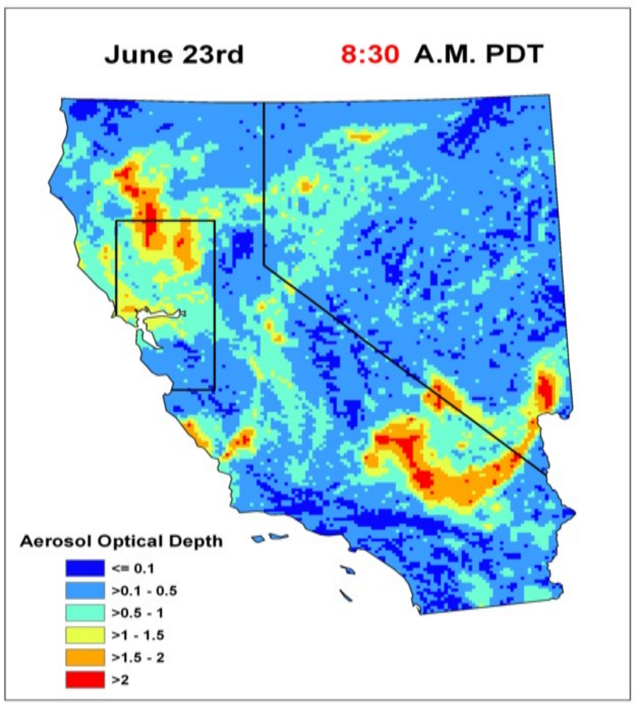


Estimating PM2.5 from Satellite Data



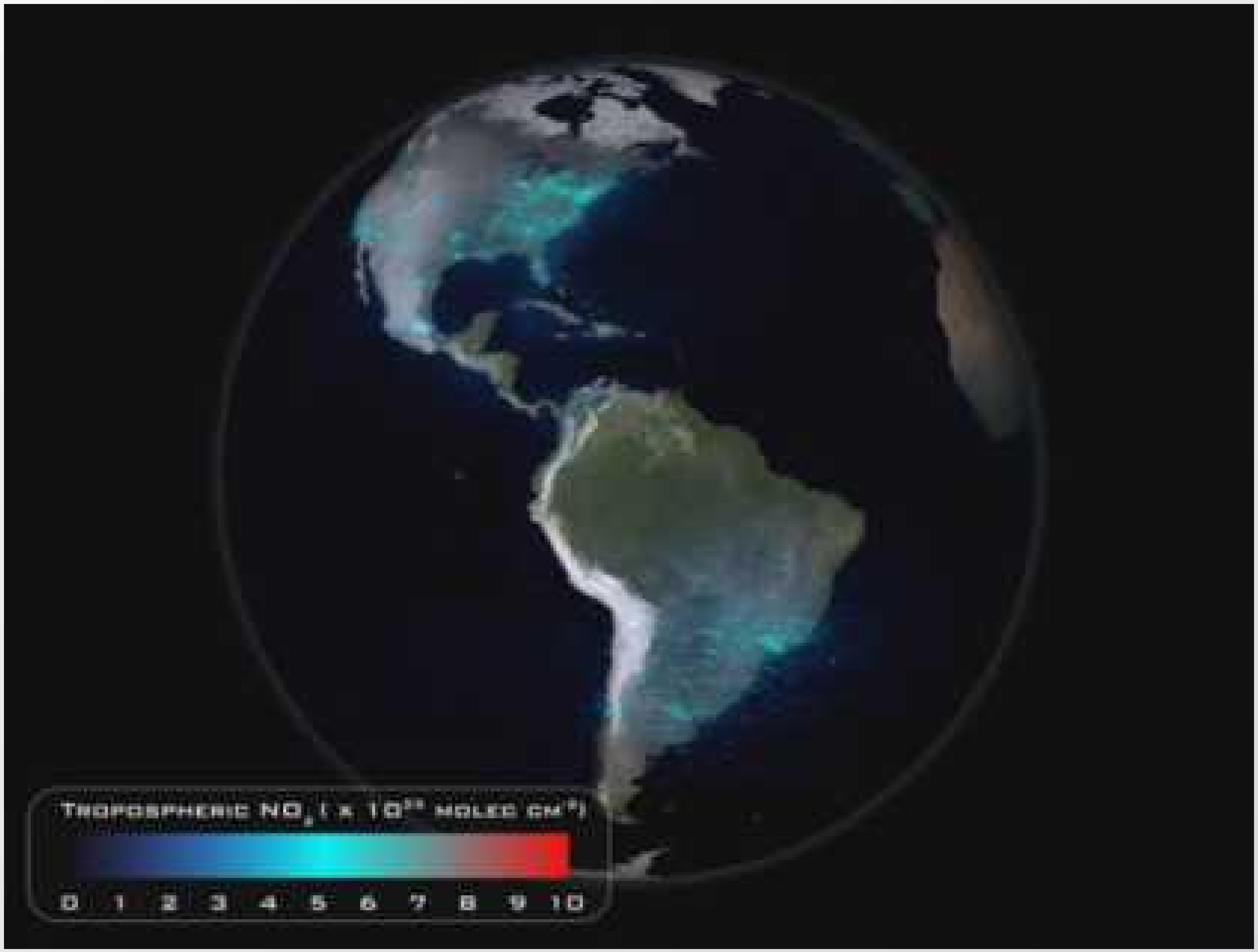
Courtesy of Hai Zhang, UMBC





Figures courtesy of Philip Morefield, EPA

Global NO2 Hotspots



NOAA Partnerships

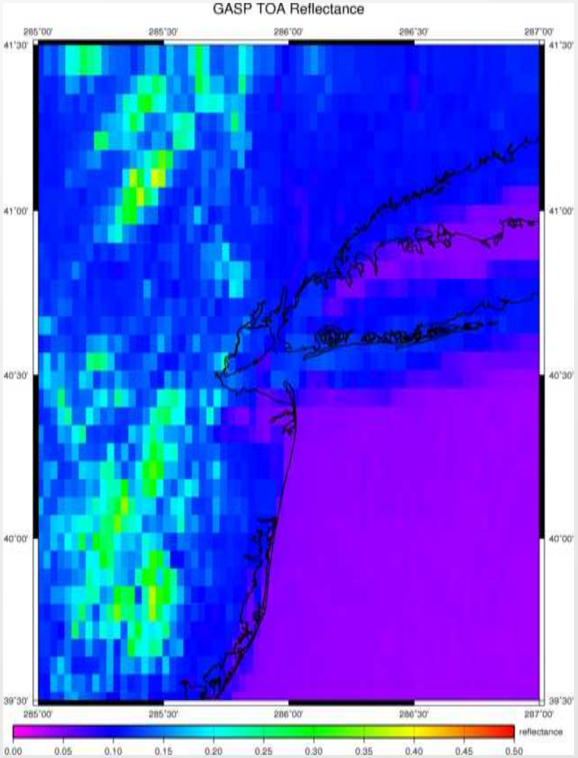
- NOAA operational satellite data are freely available to the public (http://www.osdpd.noaa.gov). Most products are available within hours of data capture.
- NOAA partners with NASA, EPA, USFS, and academia routinely to develop new applications of its satellite data
  - e.g., transition of NASA research algorithms to NOAA for operational implementation,
  - Daily download of NOAA GOES aerosol products by EPA Remote Sensing Information Gateway,
  - Planned enhancement of EPA AIRNow system with NOAA GOME-2 NO2 data,
  - Etc.
- GEO activities
  - NOAA leads several projects
    - E.g., CEOS Atmospheric Composition Constellation project on NO2 reported here,
    - Proposed tie in with EPA's AIRNOW-I by developing global IDEA (Infusing satellite Data into Environmental Applications),
    - Etc.

NOAA-CREST Activities in Air Quality Applications of Satellite Data

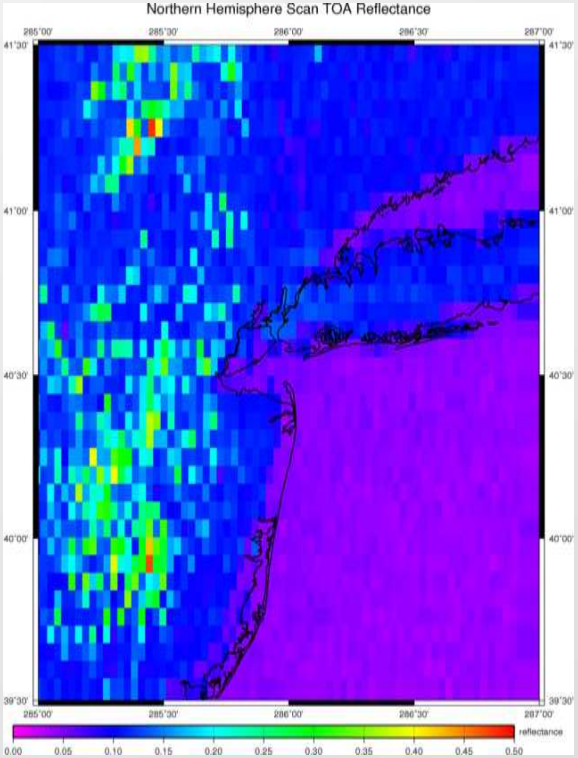
Summary of Ongoing Activities

- STAR provided GOES aerosol optical depth (AOD) datasets to CCNY (historical data reprocessed) for research work related to air quality
  - CCNY found navigational issues in GOES data that is under investigation
- UMBC smog blog regularly features NOAA satellite data. GOES aerosol products are downloaded daily and displayed with relevant description of air quality and other satellite data
- GOES-R air quality proving ground activities
  - Kondragunta to serve on Julia He’s (CCNY) Ph.D thesis committee
  - UMBC and CCNY developing GOES-R air quality test bed datasets
  - A regional GOES-R aerosol retrieval algorithm for air quality applications to be developed by CCNY
  - A GOES-R aerosol retrieval algorithm for all surface types to be developed by UMBC

GOES-12 Channel 1 Data used in GOES AOD retrieval algorithm (4 km X 4 km)



GOES-12 Channel 1 Data obtained by CCNY from NCDC archival (1 km X 1 km)



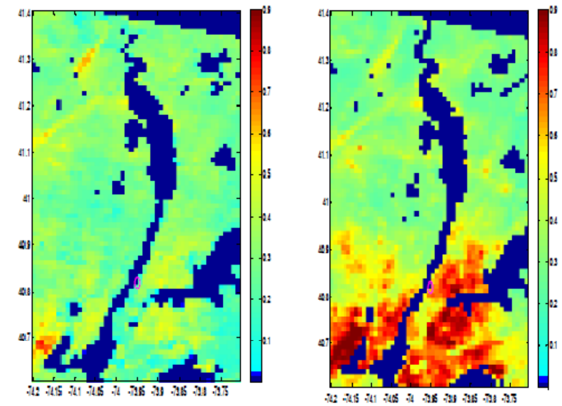
Adjacent plots show geolocation errors in operational GOES AOD data. STAR is investigating if there is a bug in GASP code associated with pixel averaging

LIDAR Network

- LIDARS provide boundary layer height which is useful in relating column optical depth measured by satellites to surface level pollution
  - CCNY and UMBC have developed algorithms to compute PBL height from LIDAR data
- STAR has been advocating simultaneous deployment of CCNY, UMBC, HU, PR, and UAH LIDARS to:
  - Provide data for air quality model validation,
  - Provide data to characterize air quality in different parts of the US in a comprehensive fashion,
  - Support validation of scaling of GOES-R AOD to suspended matter

CCNY Contribution to GOES-R Algorithm Development

1. Develop the radiometer network for ground-based monitoring of AOD for improved surface modeling in the Northeast US. Generate surface VIS-MIR correlation maps to be used in MODIS (and GOES-R) for improved and high resolution aerosol retrievals. Use the network to establish a validation test-bed for GOES-R products.
2. Work on developing surface BRDF models using MODIS/MISR/GOES and ground-based radiometry (radiometer network).



•A significant improvement can be observed as artificial hot spots in the AOD map are significantly reduced

Regional map of AOD (550nm) retrieval with modified VIS/SWIR ratio (left panel) and retrieval with Collection (5) algorithm (right panel)
Date: 10-03-2006.

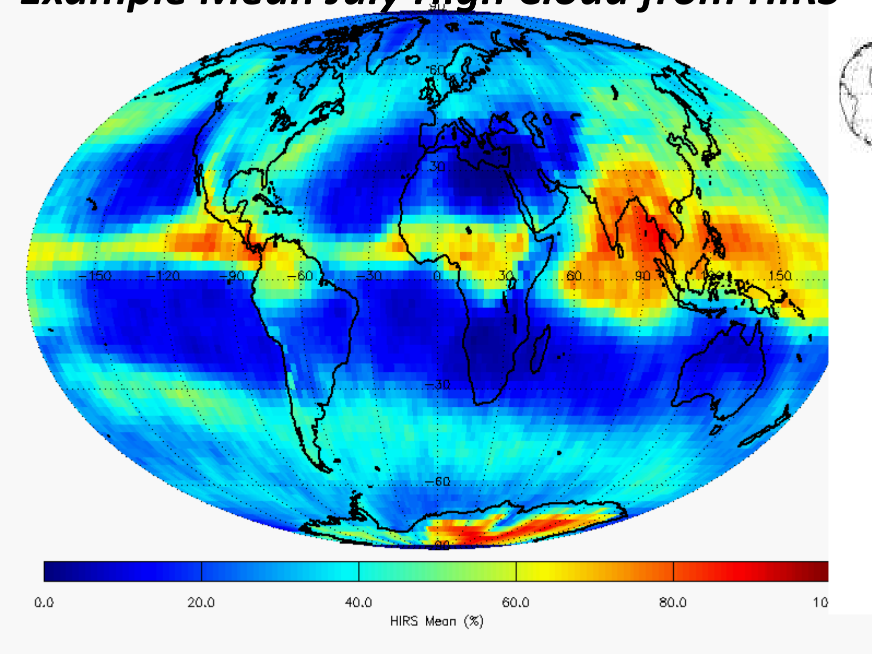
Figure courtesy of Barry Gross, CCNY

Cloud Climatologies available at NOAA/NESDIS & UW/SSEC/CIMSS:

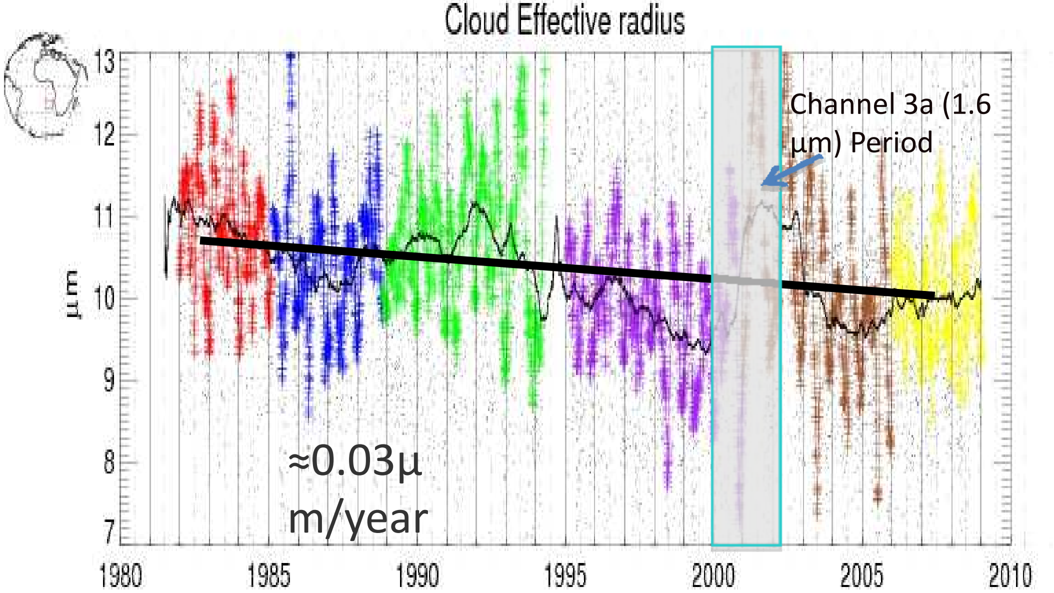
A resource for graduate study of the climate variability over the last three studies

- CIMSS is the home of two long-term cloud climatologies: the UW/HIRS and PATMOS-x .
- UW/HIRS and PATMOS-x are derived from 4x daily POES observations from 1978-2009.
- UW/HIRS provides Level-2 data at roughly 20 km resolution and Level-3 data at 1.0°.
- PATMOS-x provides traditional Level-3 data at 0.5° but also a new Level-2b data-set at 20 km that consists of sampled (not averaged) pixel level data.
- PATMOS-x provides information on cloud properties, aerosol amounts and some surface property information.
- HIRS provides information on cloud amount, height and opacity and is very skilled in the presence of semitransparent cirrus cloud.

Example Mean July High Cloud from HIRS



Example cloud particle size time-series from PATMOS-x (South Atlantic stratus)



Potential for CREST collaboration

- Both PATMOS-x and HIRS datasets are available and are designed to be easy to read. Please consider giving them a look as part of your graduate studies!

- PATMOS-x can be used for higher resolution regional studies. If there is a desire for generating an optimized PATMOS-x dataset to answer a specific question, please see us.

- The UW/HIRS data-set has been recently reprocessed to improve sensor-to-sensor continuity. We welcome collaboration with those interested in IR calibration, CO_2 slicing algorithms and validation.

- Examples of current work (*we welcome collaboration on these issues*)
  - Graduate students are analyzing PATMOS-x data to contribute observational constraints to several recent theories that predict changes in marine stratus due to anthropogenic climate influences. We are also studying cloud morphology changes.

  - We are developing methodologies to combine imager and sounder data to observe a fuller view of cloudiness.

- Contact Information
  - UW/HIRS: Paul Menzel (Paul.Menzel@ssec.wisc.edu)
  - PATMOS-x: Andrew Heidinger (Andrew.Heidinger@noaa.gov)

    cimss.ssec.wisc.edu/patmosx

Past/On-going work with CREST on Ozone

- Validation of ozone products
  - Intercomparisons of space-based products
  - Improvements to ground-based methods
  - Validation studies using G-B data sets
- Development and validation of UV/Vis/NIR Limb Profiler algorithms

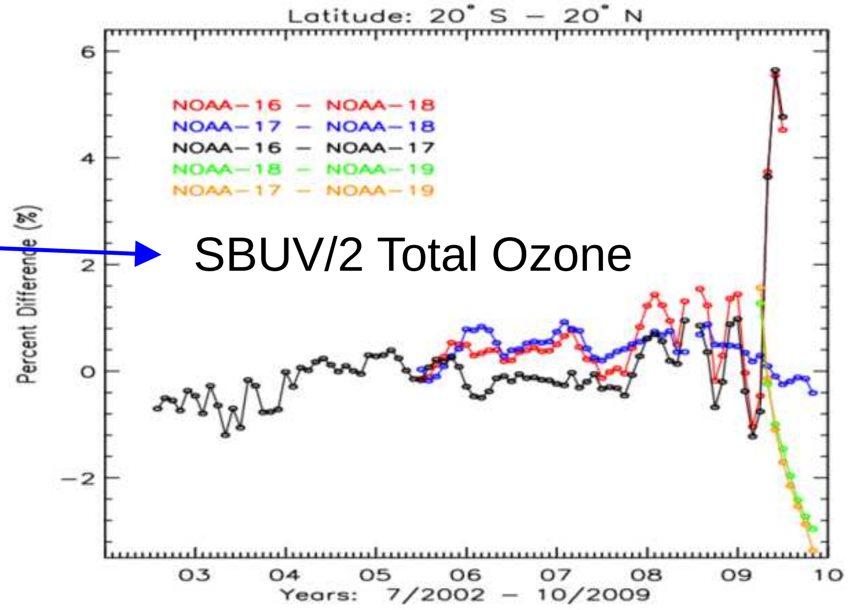


Figure 2. Time series of percent differences between the monthly zonal averages from the NOAA-16, NOAA-17, NOAA-18, and NOAA-19 SBUV/2 v8 total ozone data sets.

Figure by H. Nazarvan Hampton University

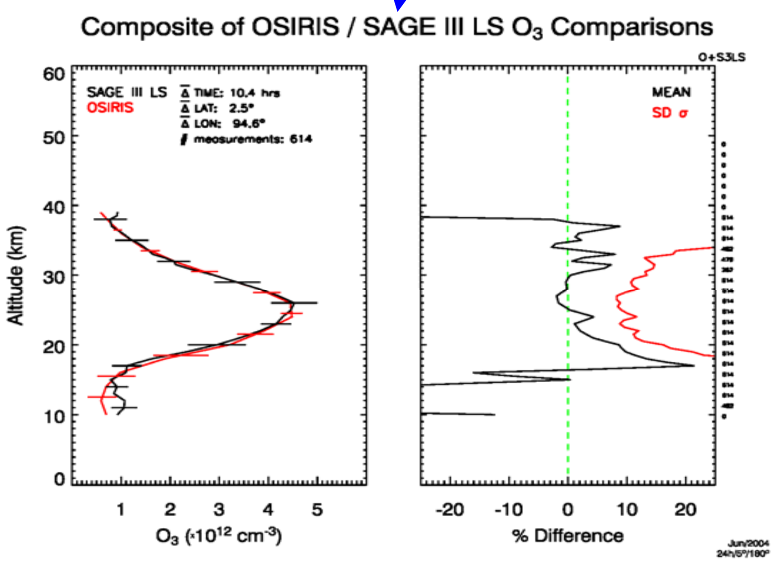


Figure by R. Loughman Hampton University

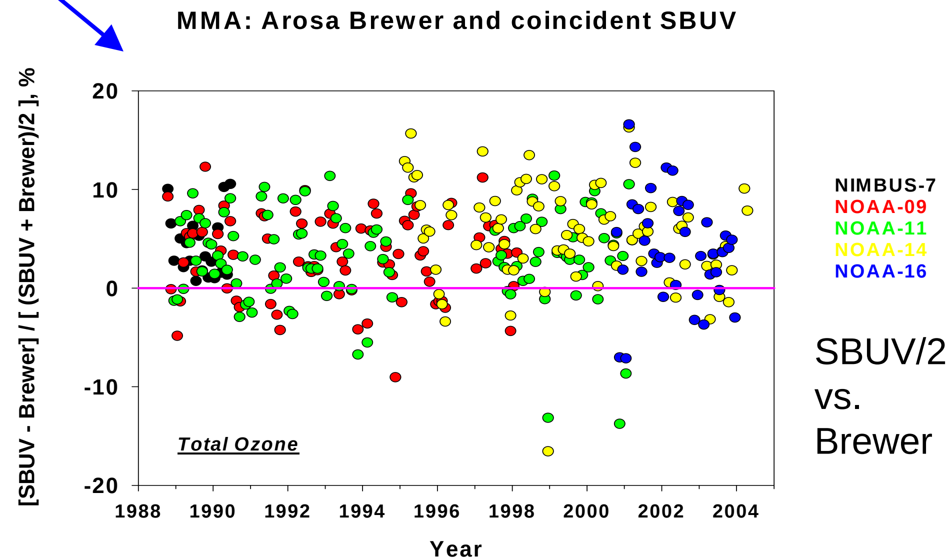


Figure by S. Kireev Hampton University

Future/Continued work with CREST

- Long-term intercomparisons and validation of space-based ozone measurements
  - This work should be extended to SNO and other comparison methods, to GOME-2 and OMPS products, and incorporated into the ICVS.
- Development of OMPS Limb Profiler algorithms
  - This work will continue as the NASA R&D on the OMPS LP algorithms is transitioned to NDE operations.
- Aerosol retrieval algorithms for UV instruments
  - We will be implementijng these algorithms for GOME-2 and OMPS. Assistance from the algorithm developer will be critical to successful transition.

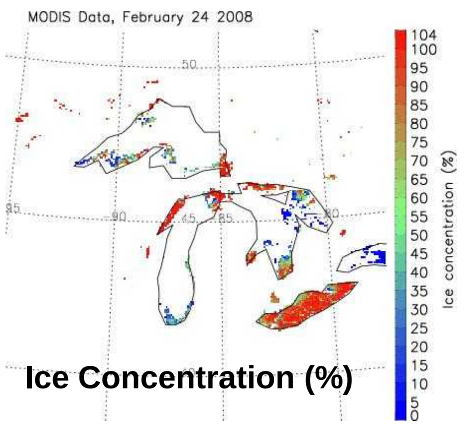
CREST-CIMSS/ASPB Collaboration on AWG Ice Products

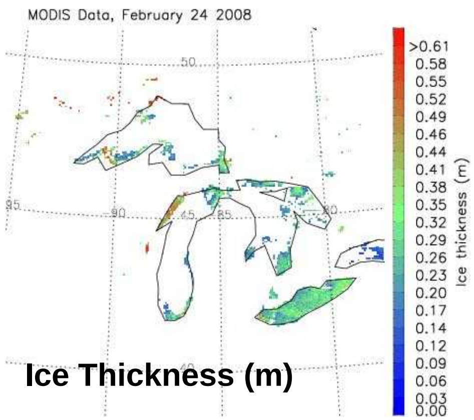
CREST is a part of the GOES-R Algorithm Working Group (AWG) Cryosphere Team. The STAR Advanced Satellite Products Branch (ASPB) and the Cooperative Institute for Meteorological Satellite Studies (CIMSS) are also part of the team.

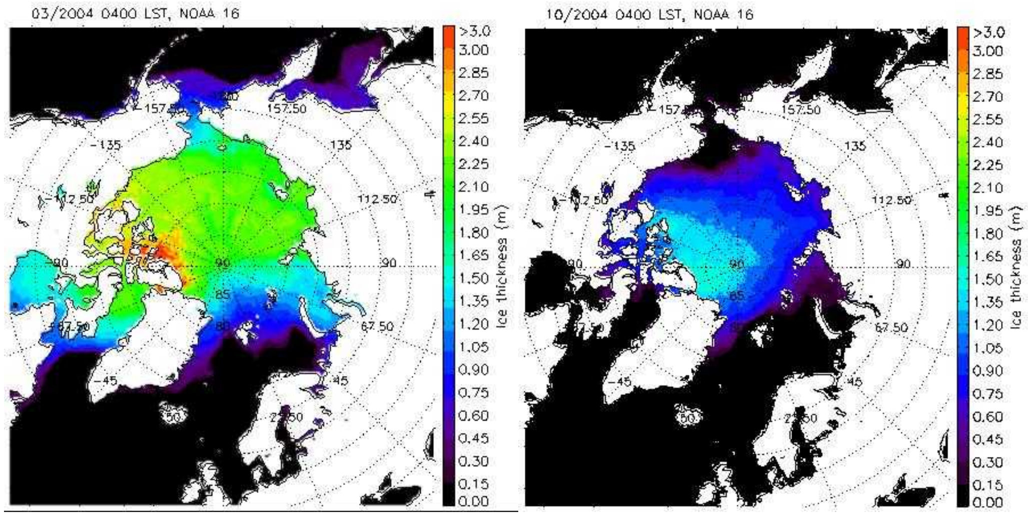
The current collaboration focuses on developing new algorithms for sea ice extent and concentration.

CIMSS/ASPB has recently generated a suite of ice products including ice extent, concentration, thickness/age, and volume for the Arctic Ocean for the period 1982-2004.

MODIS True Color Image





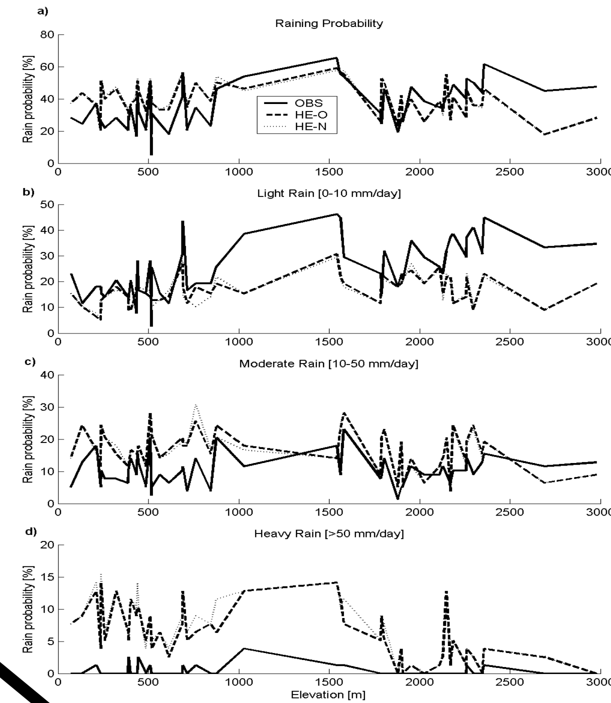


Arctic Sea Ice Thickness (m) for March (upper) and October (lower), 2004.

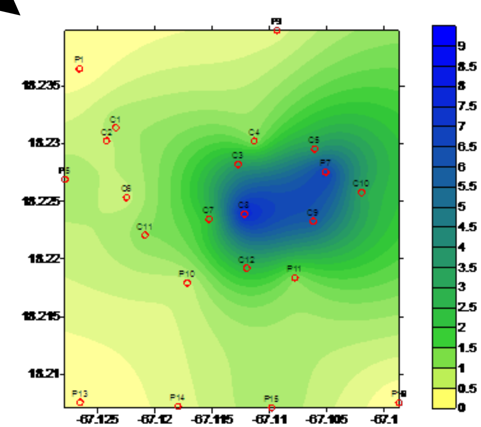
In the future, CREST research on ice extent could be incorporated into the algorithm used to generate this climatology.

Past / Ongoing Rainfall work with CREST

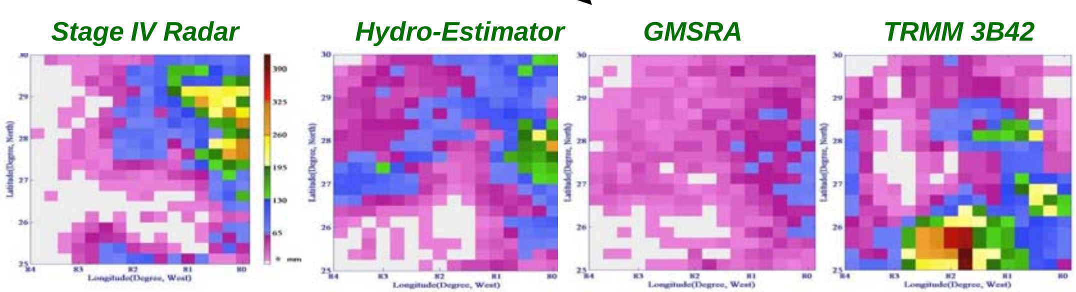
- Evaluation of the operational Hydro-Estimator (H-E) satellite rainfall algorithm over complex terrain in northwestern Mexico (Hampton U.; figure by I. Yucel)
- Evaluation of sub-satellite pixel rainfall variability (UPRM; figure by E. Harmsen)
- Evaluation of satellite rainfall nowcasting algorithms (CCNY)
- Validation of satellite rainfall algorithms for landfalling tropical storms (CCNY; figure by N. Nourozi)



Conditional probability of daily rainfall of various amounts for gauges and the HE during the summer of 2002 as a function of elevation



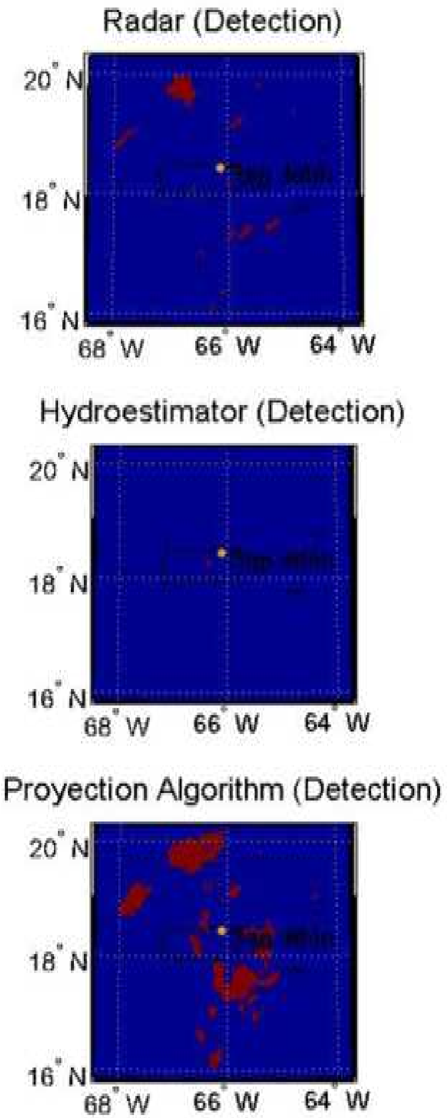
Spatial distribution of 5-min rainfall accumulation (mm) over a 4-km GOES grid box at 2:27 PM AST on 27 June 2007



Comparison of 24-h rainfall estimates from Hurricane Frances on 5 Sept 2004

Future / Continued Rainfall Work with CREST

- Development of new orographic correction for satellite rainfall (Hampton)
- Development and testing of cloud-following brightness temperature changes for use in rainfall estimation (CCNY)
- Development of improved rain detection using satellite data (UPRM; figure by N. Ramirez)



Areas of rainfall depicted by radar, the H-E, and the new algorithm at 0115 UTC 24 April 2005.