

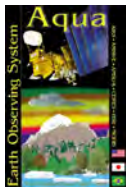
NASA Earth Science Operating Missions 2013 Senior Review for Aqua and Terra

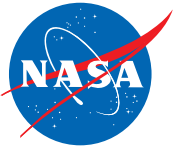
MODIS Science Team Meeting

April 15, 2013

Robert Wolfe - Terra Deputy Project Scientist
and
Claire Parkinson - Aqua Project Scientist

NASA GSFC





Senior Review Process and Schedule

- Overview
 - Purpose: Review the Earth science missions that are beyond their prime-mission lifetimes, to determine which should continue and at what funding levels.
 - Missions reviewed: ACRIMSAT, Aqua, Aura, CALIPSO, CloudSat, EO-1, GRACE, Jason-1, Jason-2/OSTM, QuikSCAT, SORCE, Terra, and TRMM.
- Schedule
 - 12/15/12, call letter received from NASA Headquarters (HQ)
 - 3/1/13, proposals due to NASA HQ
 - 4/8 to 4/11/13, Technical & Cost and National Interests Panels meet
 - 4/12/13, initial meeting of the Senior Review Panel
 - ~ 4/15/13, questions received from the Senior Review Panel
 - 4/30 to 5/2/13, Senior Review Panel meets and each mission gives a presentation
 - 6/13, Panel report released
 - 7/13, new budget guidelines and instructions from NASA HQ
 - 8/13, revised project implementation plans due to NASA HQ

ACRIMSAT = Active Cavity Radiometer Irradiance
Monitor Satellite

CALIPSO = Cloud-Aerosol Lidar and Infrared Pathfinder
Satellite Observations

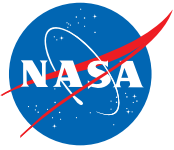
EO-1 = Earth Observing-1

GRACE = Gravity Recovery and Climate Experiment

OSTM = Ocean Surface Topography Mission

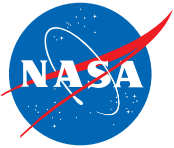
SORCE = Solar Radiation and Climate Experiment

TRMM = Tropical Rainfall Measuring Mission



What Does the MODIS Team Get from the Senior Review Funding?

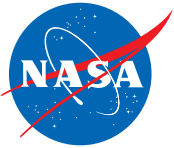
- Operation of the Terra and Aqua spacecraft by the Earth Science Mission Operations (ESMO) at NASA GSFC
 - All spacecraft operations, including all spacecraft maneuvers
 - All communications with the spacecraft
 - Data flow from the spacecraft
 - Information Technology (IT) security upgrades
 - Space debris avoidance
- MODIS-specific funding
 - MODIS Characterization Support Team (MCST), including instrument operations
 - MODIS Science Data Support Team (SDST)
 - MODIS Administrative Support team (MAST), including MODIS Science Team coordination and meetings, and the MODIS website
 - Science Team Leader support
 - Total 35 person years/year
- Aqua and Terra Project Science Management
- Education and Public Outreach (EPO), e.g., the Dynamic Planet



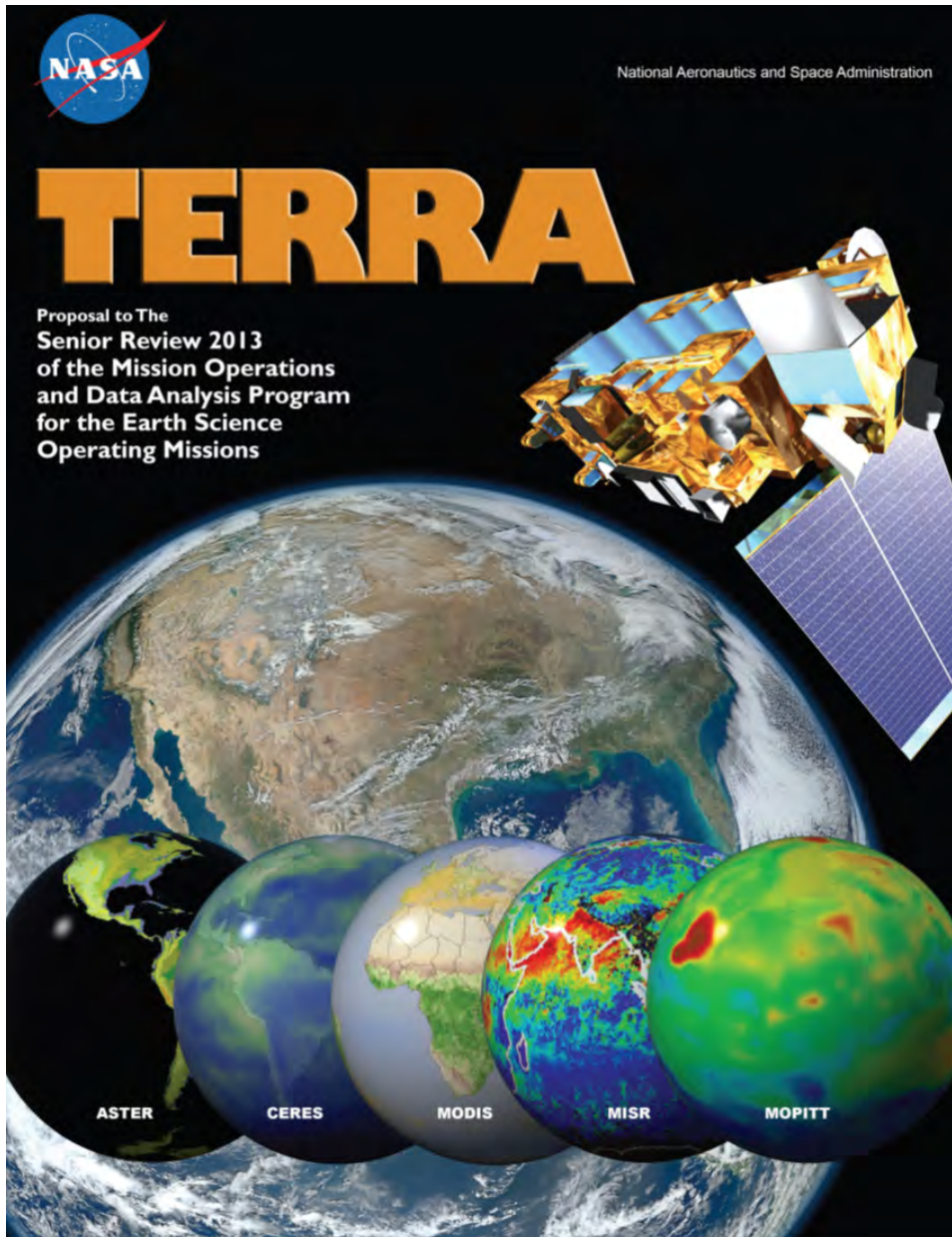
The Aqua Senior Review Proposal

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 - E. Engineering Data Tables and Figures ... 67
- **Budget Request**
 - \$32.0 M for FY14
 - \$33.2 M for FY15

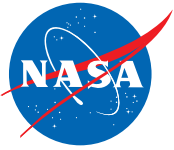




The Terra Senior Review Proposal

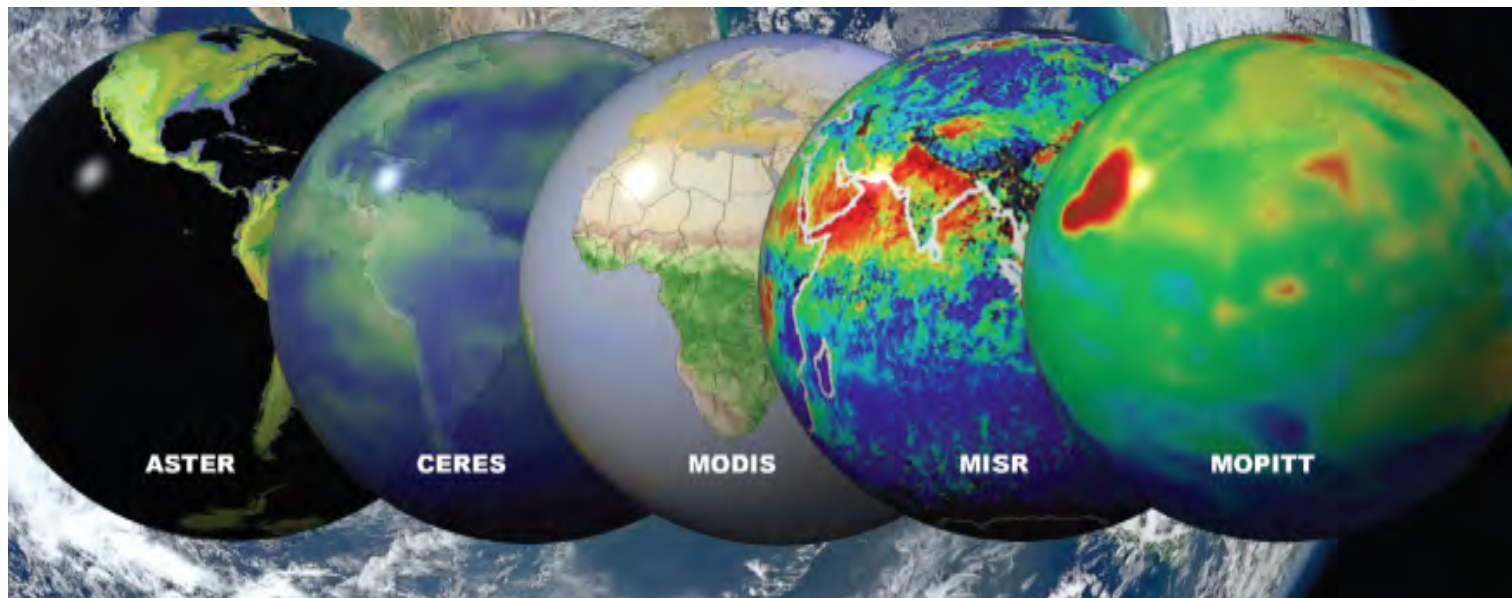


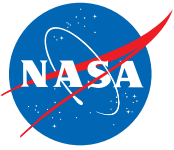
- Main sections
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 - A. Terra Product Contribution to Science Focus Areas (and Product Maturity)
 - B. Budget Materials
 - C. List of Acronyms
 - D. References
 - E. Terra Spacecraft Engineering Trends & Instrument engineering Data
- Budget Request
 - \$30.9 M for FY14
 - \$31.5 M for FY15



Terra and Aqua

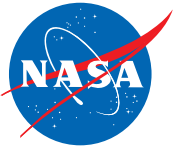
- Launched in December 1999 and May 2002, Terra and Aqua both have over a decade of accomplishments and the potential to do much more.
- Extending the data records to examine interannual variability, observe trends on the decadal scale, and gather statistics relevant to understanding climate will increase the value of the Terra and Aqua data sets.





Terra and Aqua Instruments

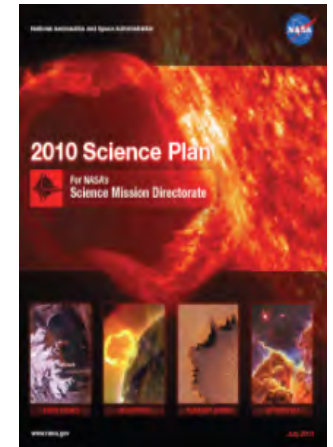
AIRS	Atmospheric Infrared Sounder (Aqua)
AMSR-E	Advanced Microwave Scanning Radiometer for the Earth Observing System (Aqua)
AMSU	Advanced Microwave Sounding Unit (Aqua)
ASTER	Advanced Spaceborne Thermal Emission and Reflection Radiometer (Terra)
CERES	Clouds and the Earth's Radiant Energy System (Terra and Aqua)
HSB	Humidity Sounder for Brazil (not working since 2003) (Aqua)
MISR	Multi-angle Imaging Spectroradiometer (Terra)
MODIS	Moderate-resolution Imaging Spectroradiometer (Terra and Aqua)
MOPITT	Measurements of Pollution in the Troposphere (Terra)



Mission Objectives

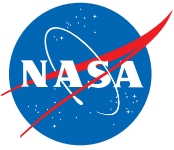
The primary purpose of Terra and Aqua is to continue enabling the science community to address fundamental questions from the 2010 Science Plan for NASA's Science Mission Directorate and to provide answers to the overarching question:

“How is the Earth changing and what are the consequences for life on Earth?”



Terra and Aqua will:

1. Extend the baseline of morning-orbit and afternoon-orbit collections for climate and environmental data records of derived parameters.
2. Enable comparison of future and past measurements of climate conditions and high-impact events, such as atmospheric oscillations, volcanic eruptions, floods, oil spills, and accelerated ice sheet changes.
3. Add value to recently launched and soon-to-be launched missions, and upcoming field campaigns.

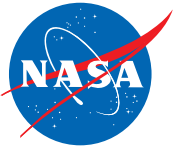


Science Merit

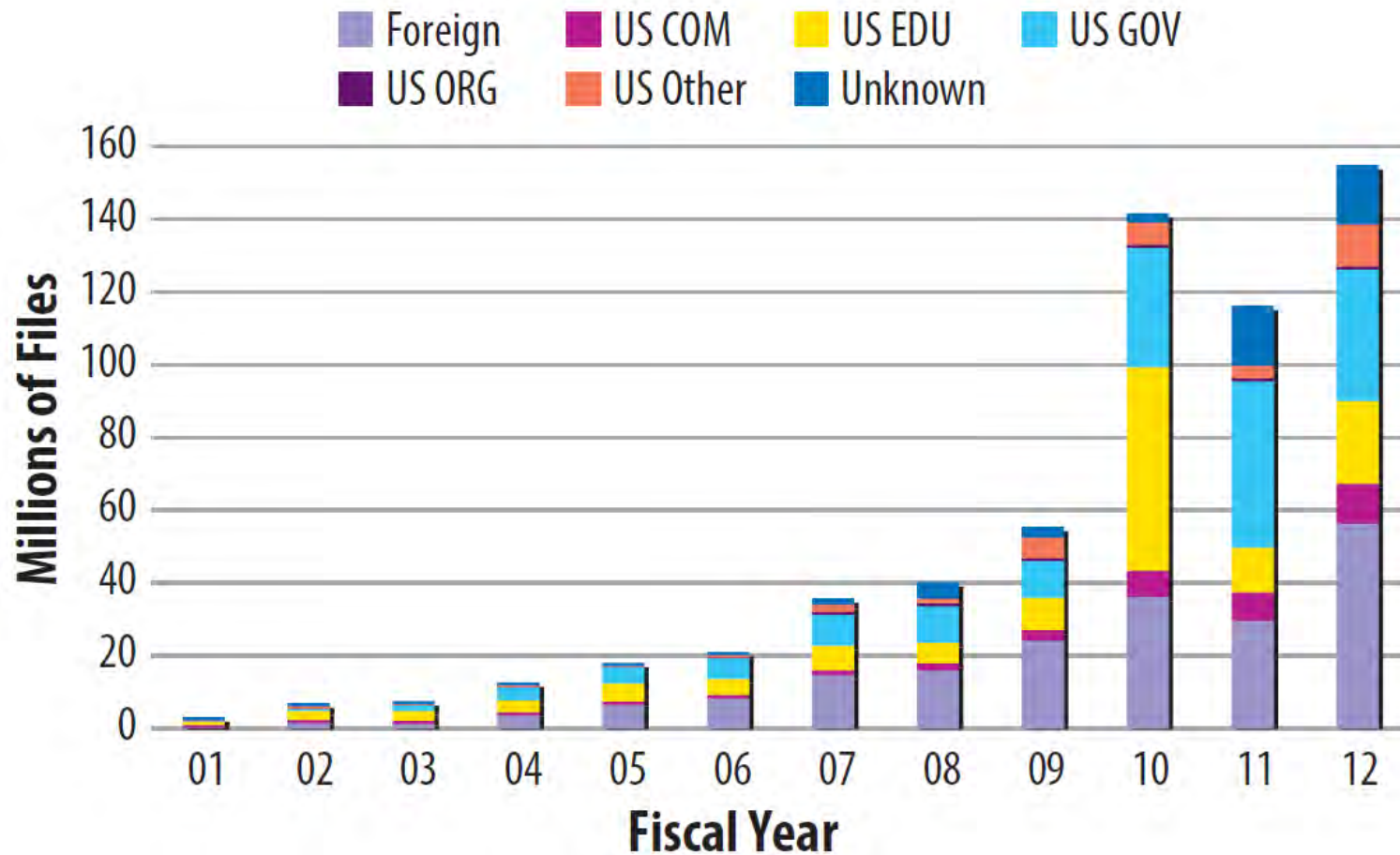
The Aqua and Terra Missions provide the world-wide scientific community with an unprecedented amount of quantitative data to study the Earth as a system, discover how the Earth is changing and explore human interactions with these changes.

They contribute to the following Earth science research areas:

1. Climate variability and change
2. Atmospheric composition
3. Carbon cycle and ecosystems
4. Water and energy cycle
5. Weather
6. Earth surface and interior

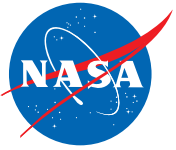


Terra - Data Distribution

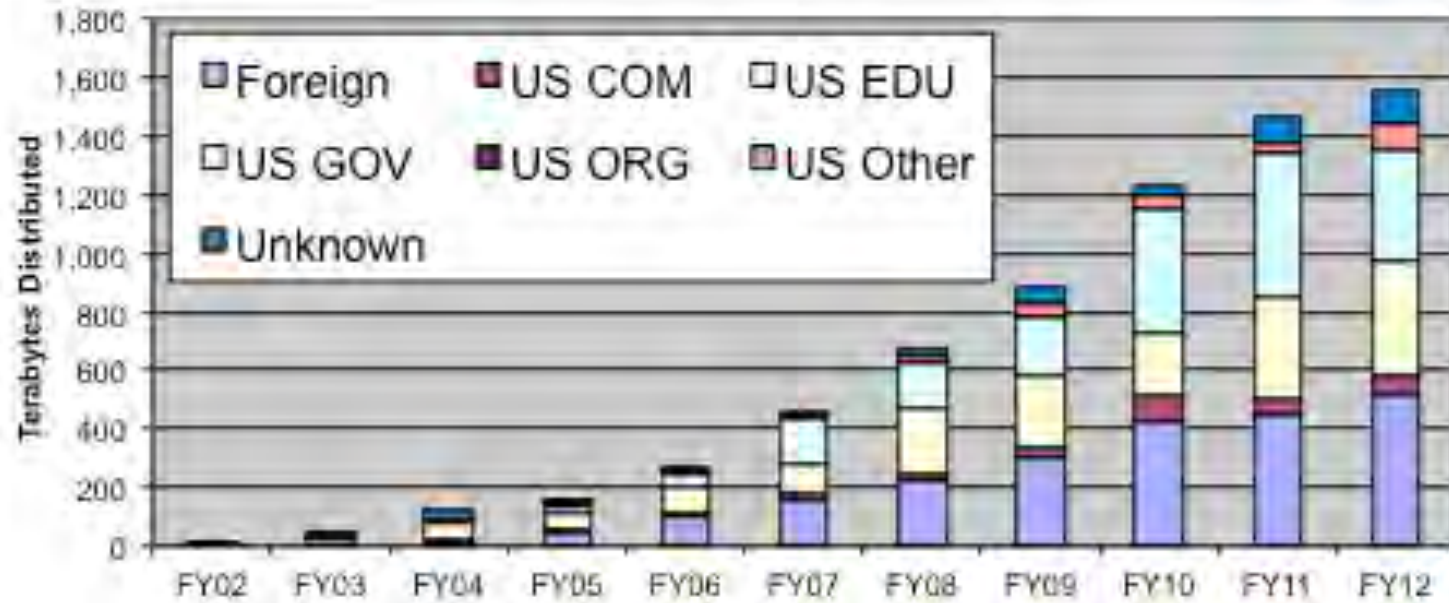


Yearly data in millions of files

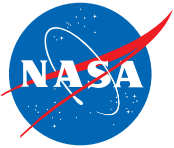
Delivered 116 million Terra data files in 2011 and 155 million in 2012 (95% were MODIS)



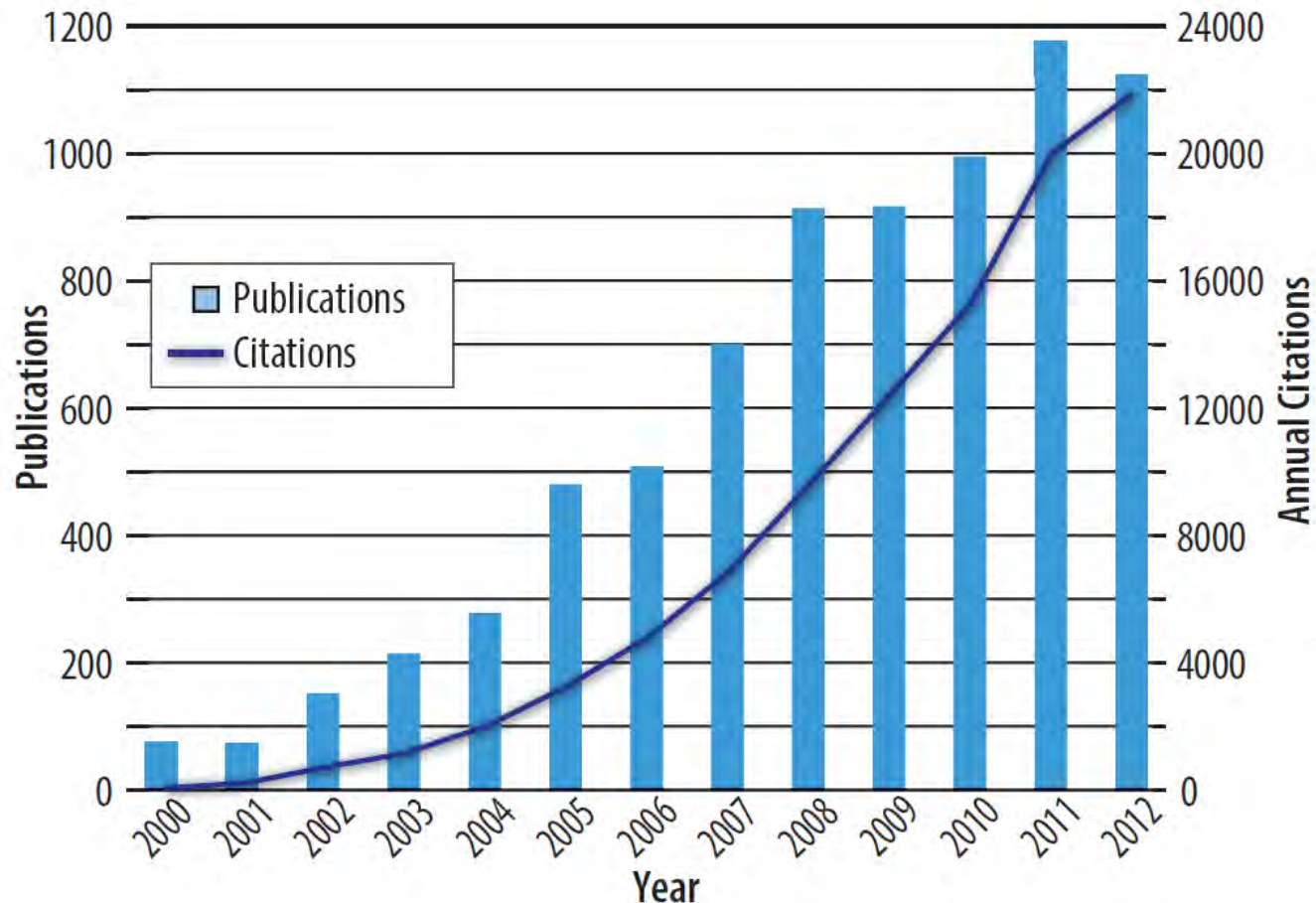
Aqua - Data Distribution



Yearly data in terabytes

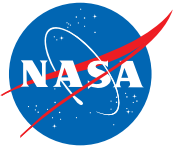


Terra - Publications

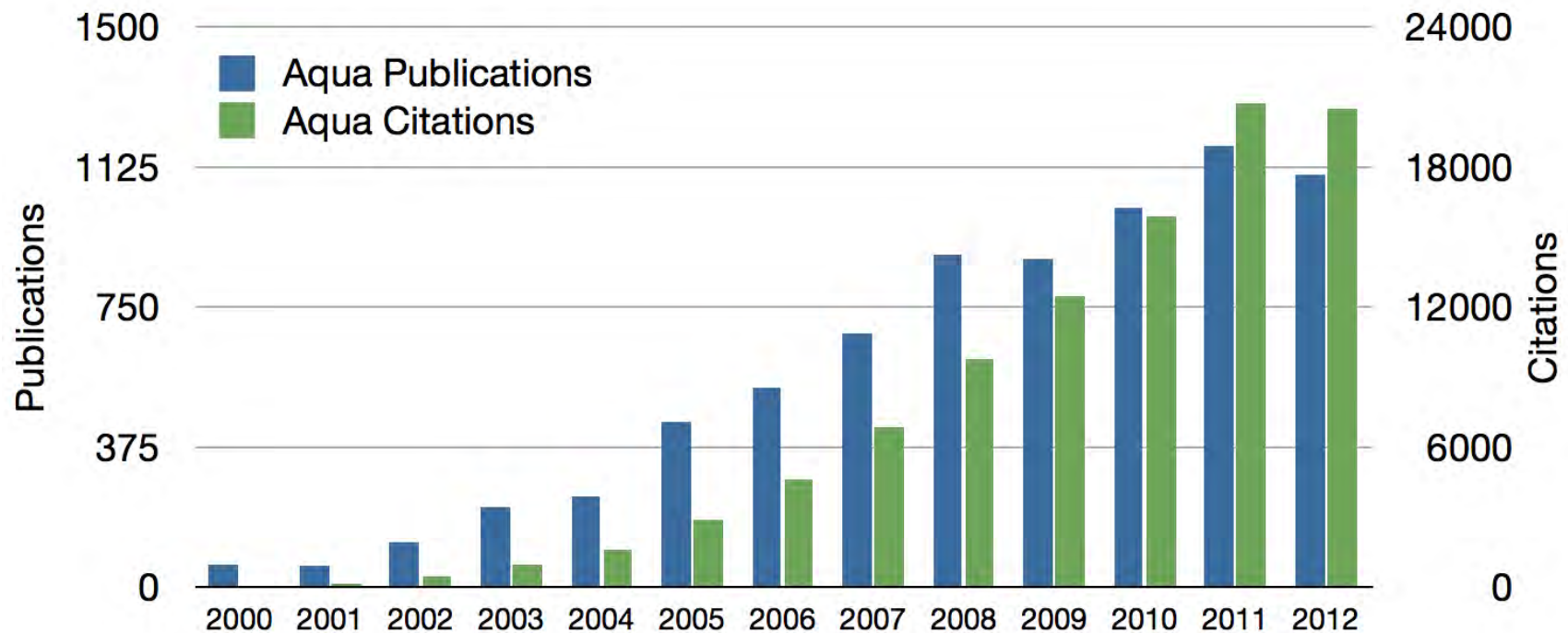


Peer-reviewed publications and annual citations per year (75% are MODIS)

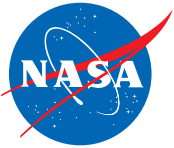
Total of more than 7600 peer-reviewed publications from 2000 to 2012



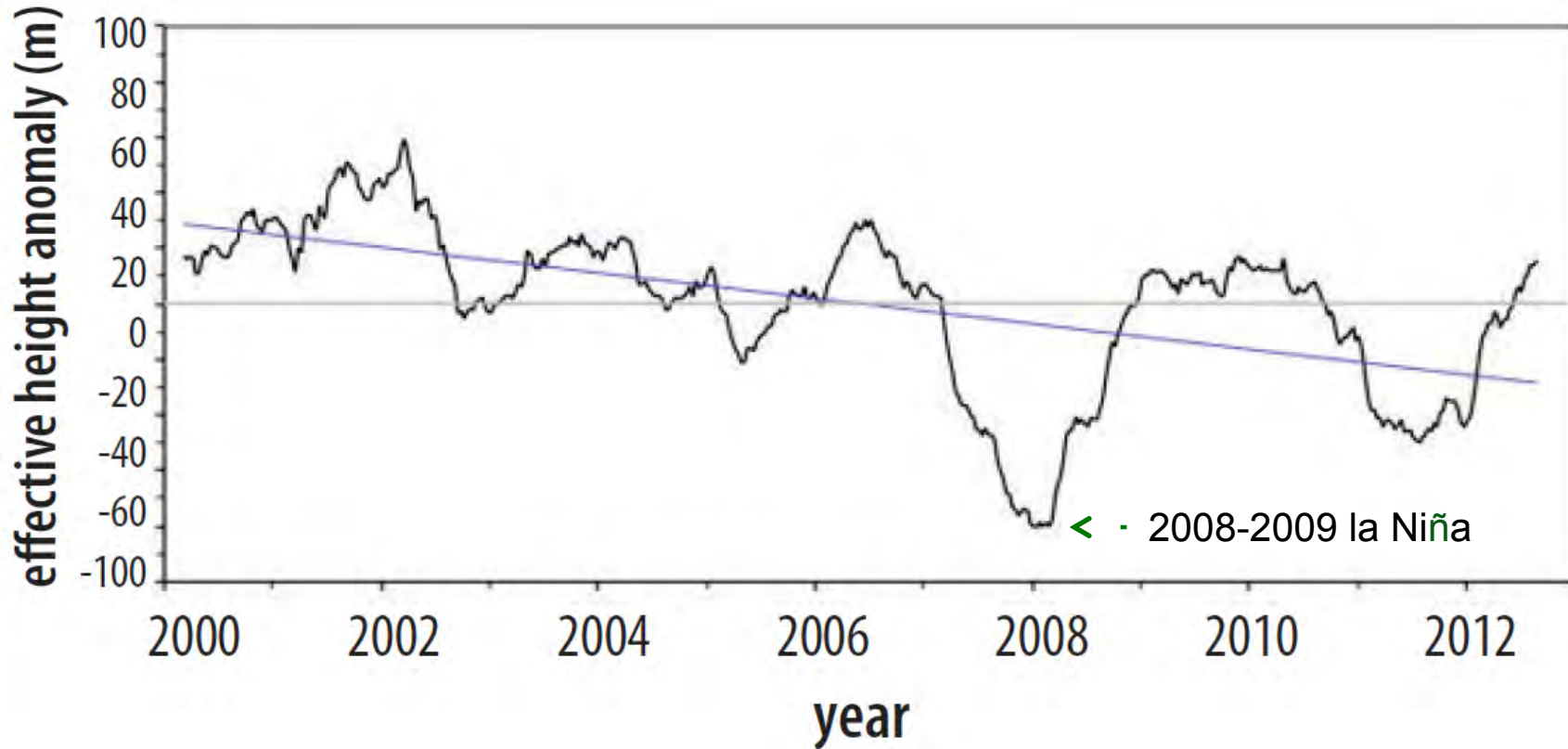
Aqua - Publications



Peer-reviewed publications and annual citations per year (79% are MODIS)

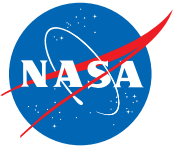


MISR - Climate Variability and Change

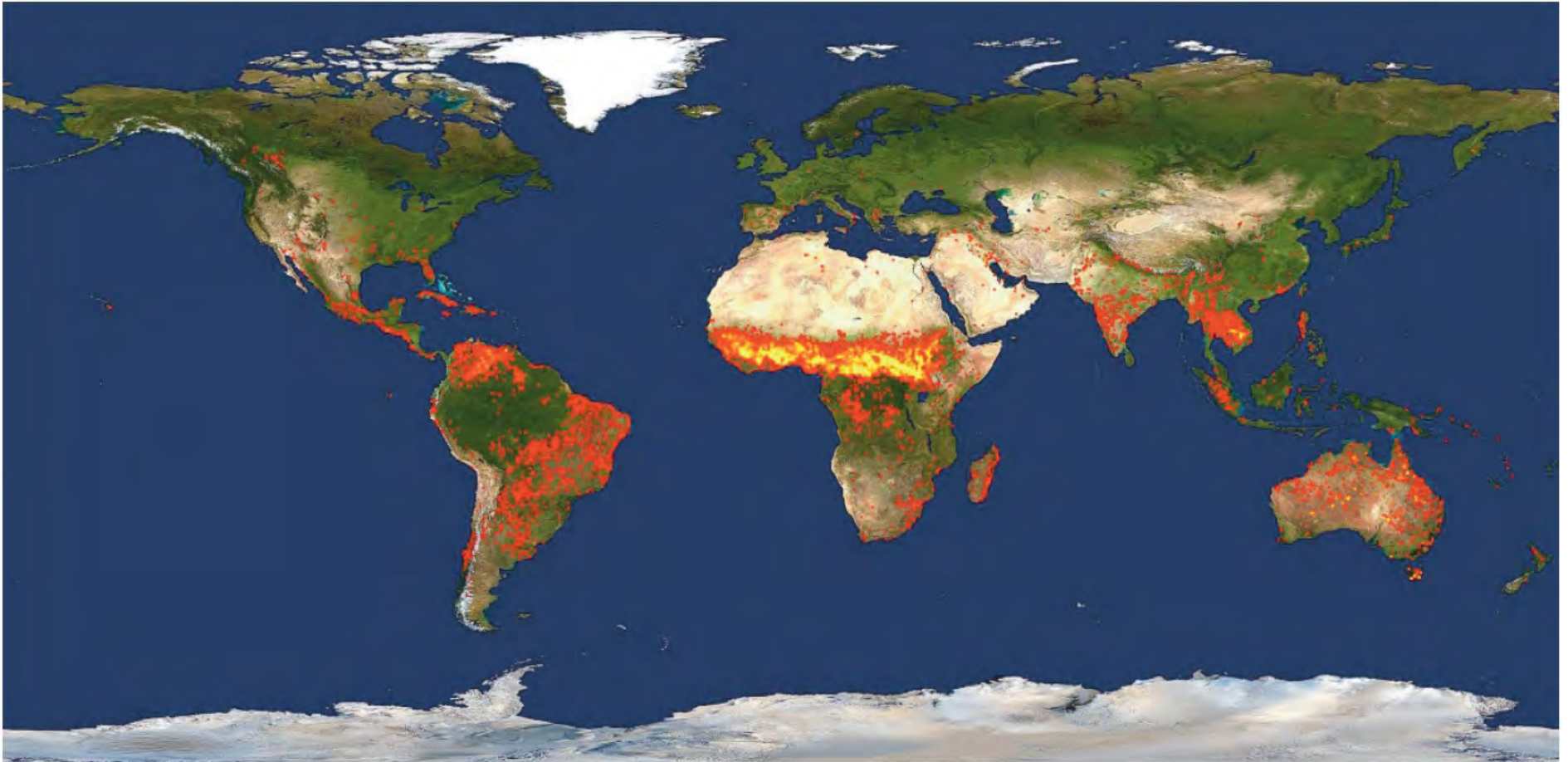


Deseasonalized anomalies in MISR stereo Cloud Top Height (CTH) during the Terra mission.

Decadal decrease in effective height of 42 ± 18 m implies a -0.35 ± 0.12 K change in equilibrium surface temperature larger than the $+0.09$ K change implied by the increase in CO_2 concentration over this period

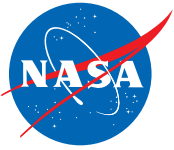


MODIS - Carbon Cycle and Ecosystems

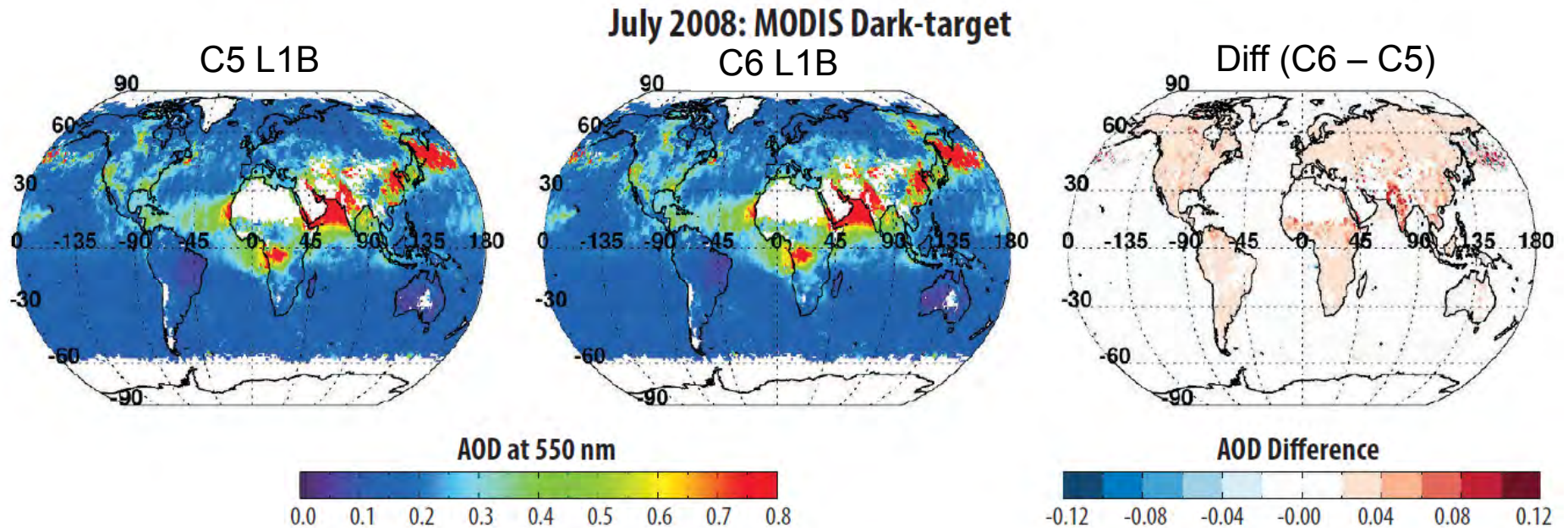


MODIS Fire map 8-day composite for Jan. 1-8, 2013

New Fire Information for Resource Management System (FIRMS) providing near real-time fire alerts builds on MODIS Active Fire and Burned Area Products

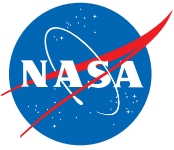


MODIS - Atmospheric Composition

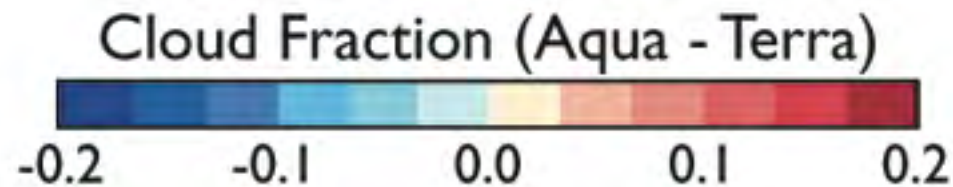
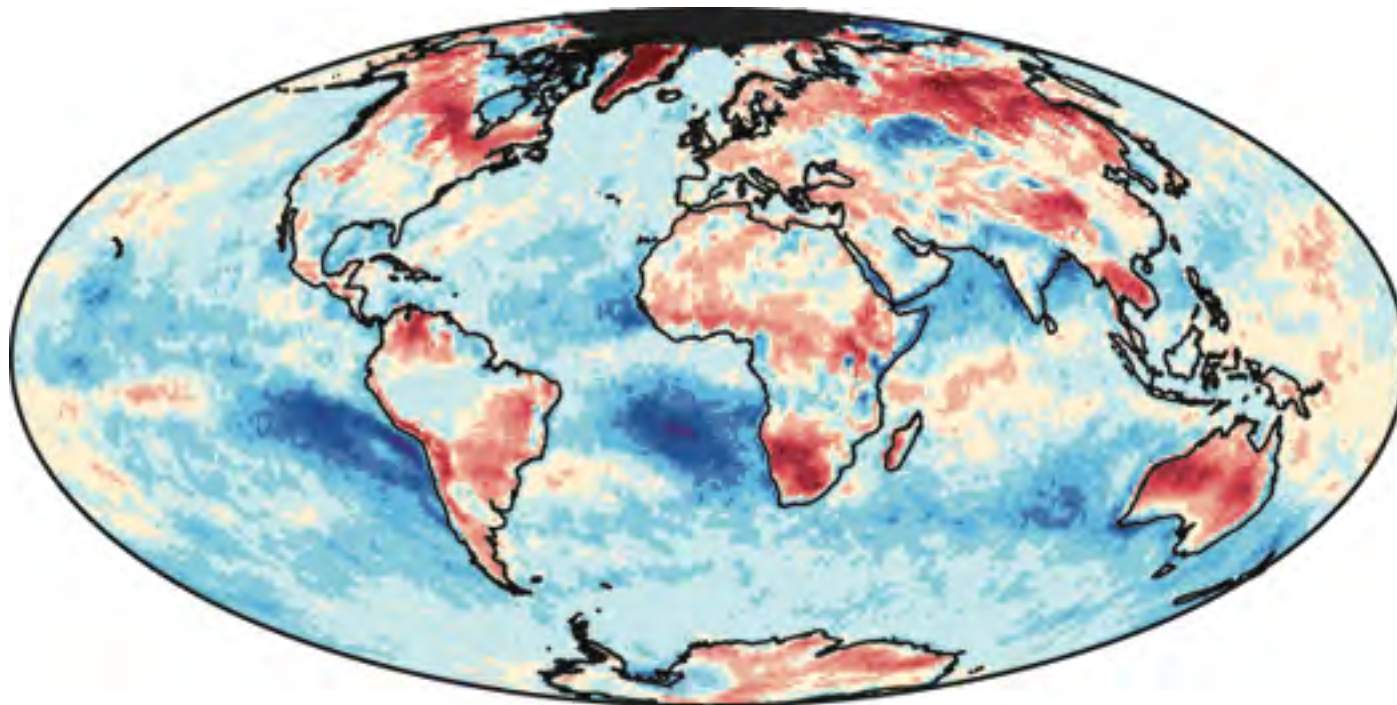


Gridded, monthly averaged $1^\circ \times 1^\circ$ AOD (at $0.55 \mu\text{m}$) over land and ocean retrieved from Terra for July 2008. The same Collection 6 (C6) retrieval algorithm is applied to both the C5 and C6 Level1B.

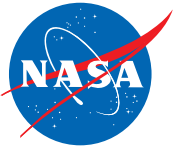
Calibration drift identified in the C5 Terra MODIS shortwave bands affected the Terra AOD trends (compared to Aqua) are fixed in C6



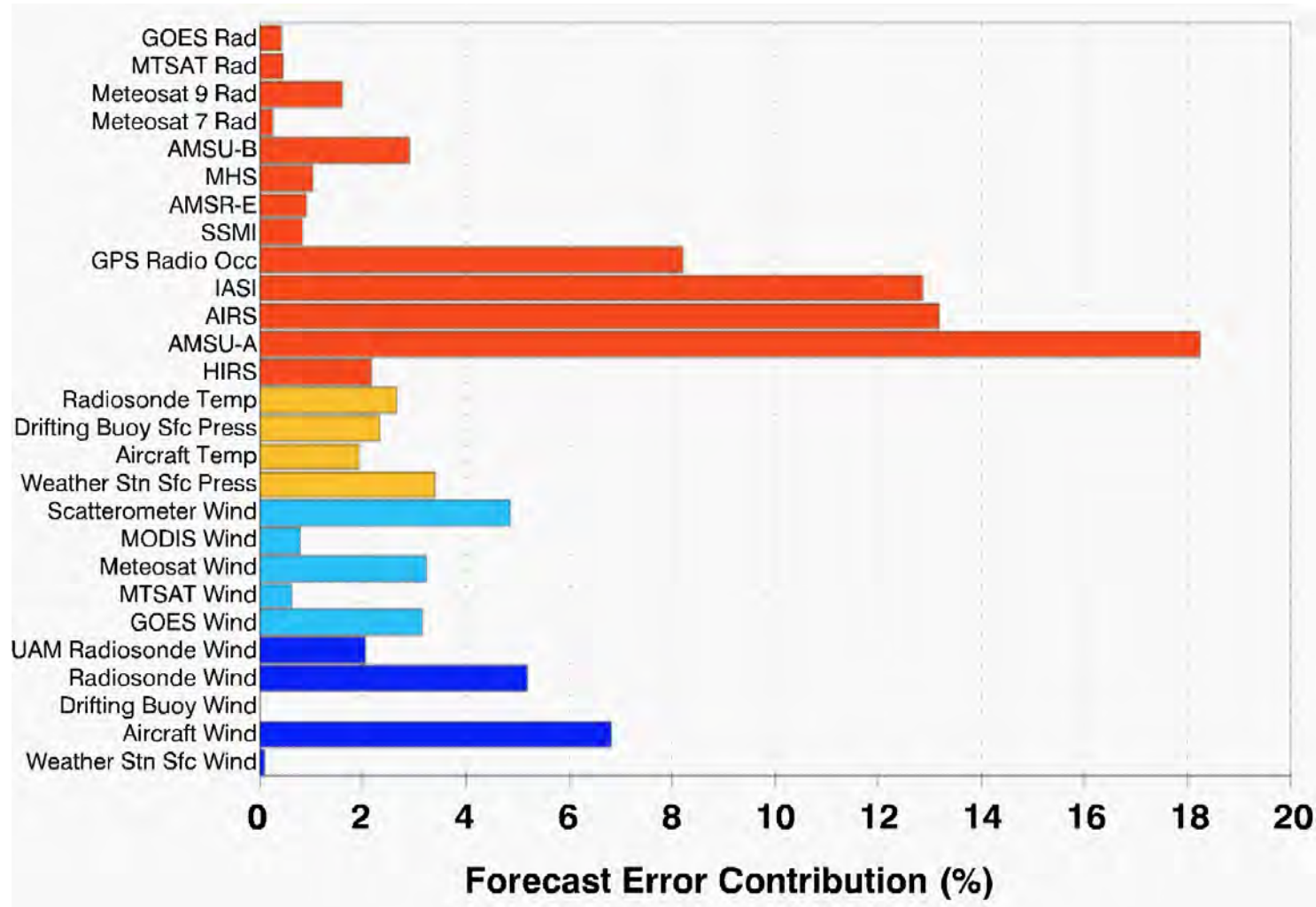
Aqua/Terra Cloud Fraction Difference



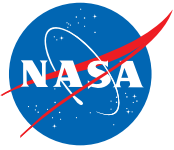
Global map of difference between MODIS Aqua early afternoon and Terra mid-morning Dec/Jan/Feb daytime cloud fraction (based on Dec 2002 to Feb 2011 data)



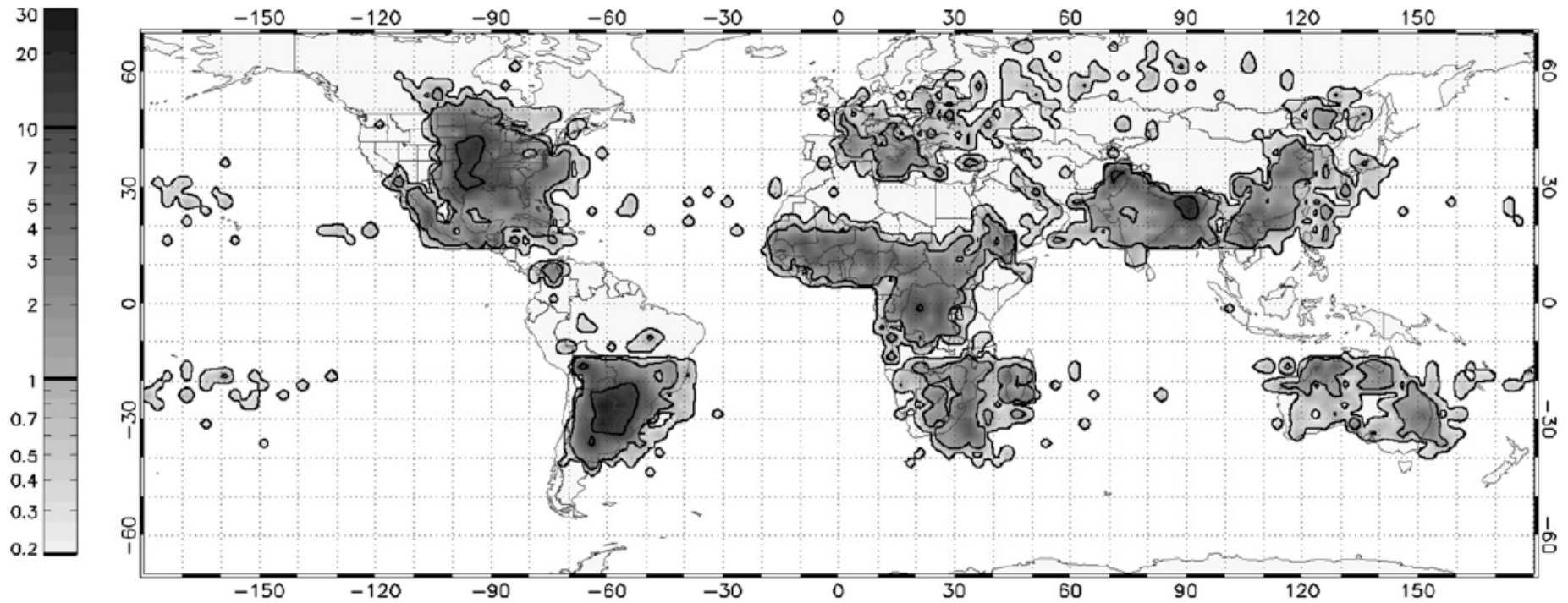
AIRS - Weather Forecasting



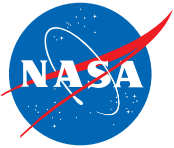
ECMWF Forecast Error Contribution (an estimate of the forecast error due to the absence of a particular system), showing AIRS as the single most important instrument in improving recent weather forecasts



AMSR-E - Hailstorm Frequency

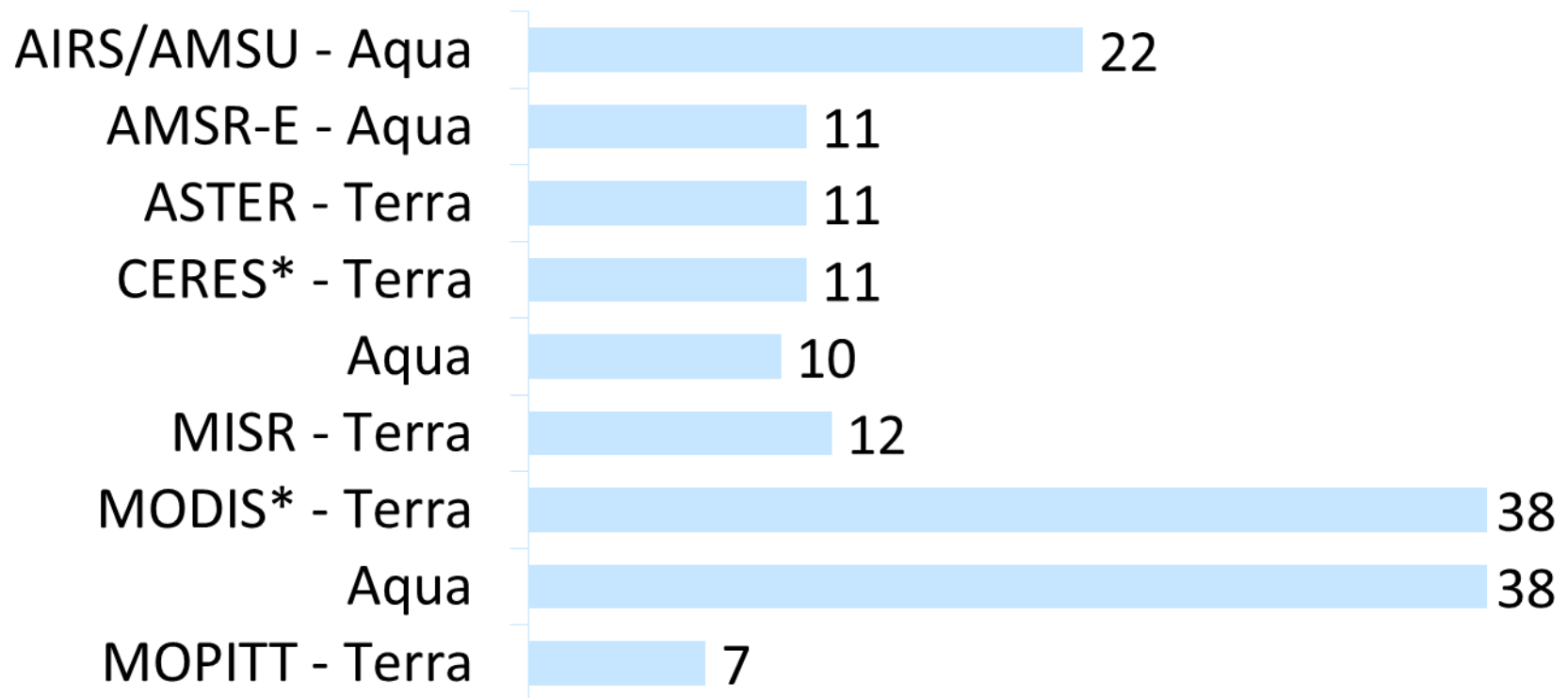


Estimated hailstorm frequency from eight years of AMSR-E 36 GHz data

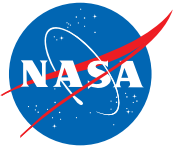


Data Products

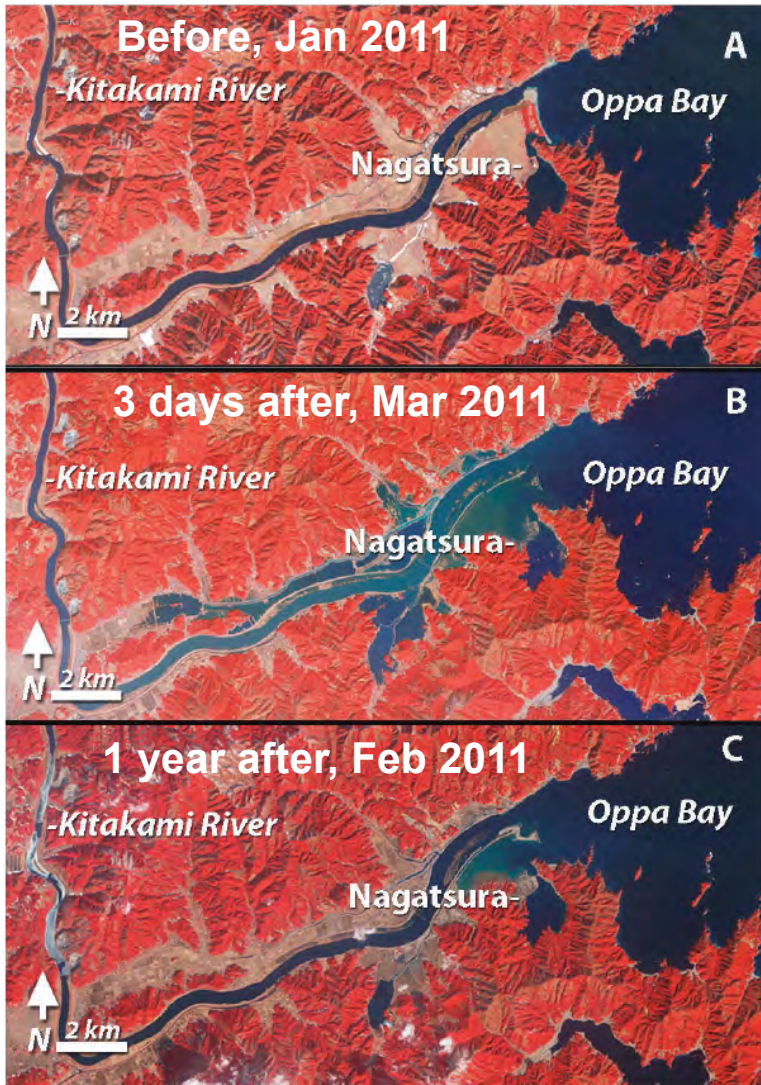
Terra and Aqua provide an unprecedented number of core data products to the worldwide scientific community.



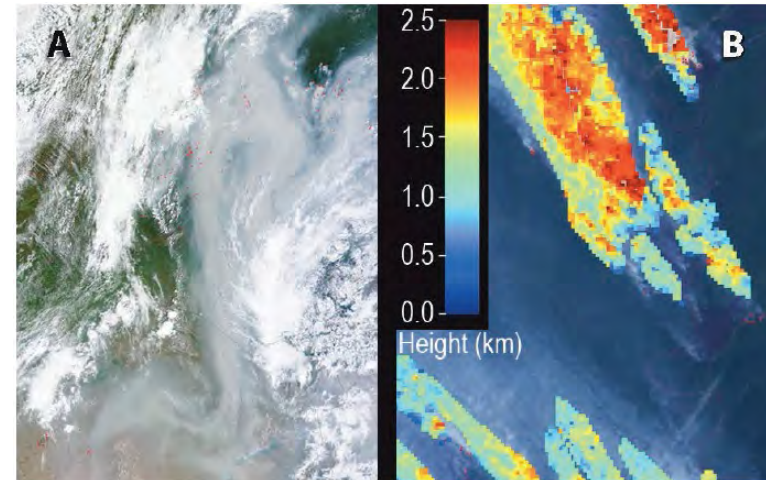
* CERES and MODIS totals include combined (Terra + Aqua) products



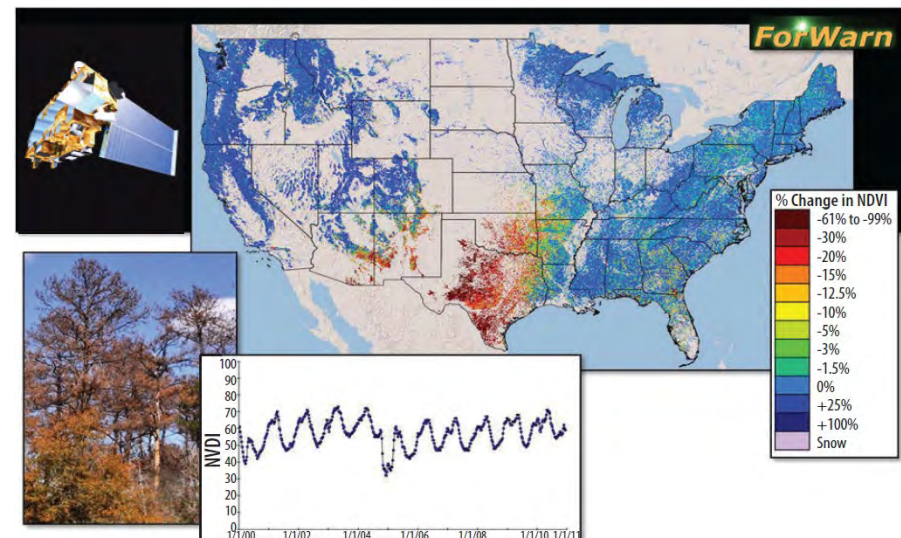
Terra - Applied and Operational Uses



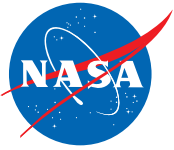
Monitoring Tohoku tsunami damage in Japan with ASTER



2012 Siberian forest fires: A) MODIS image of heavy smoke near the Tomsk region; B) MISR smoke plume heights

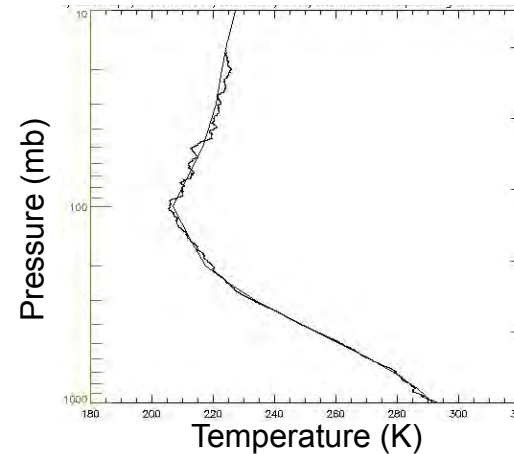


ForWarn forest change recognition and tracking system uses MODIS data to provide near real-time forest change maps showing effects of disturbances

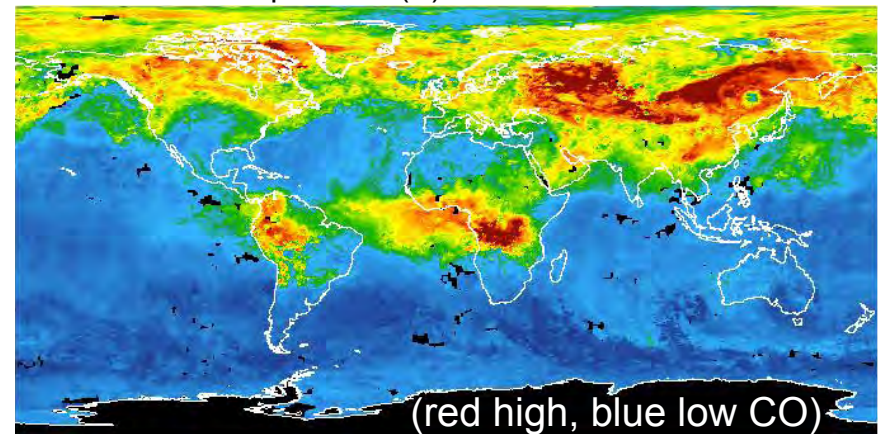


Practical Applications of Aqua

- Weather forecasting
- Monitoring of forest fires (for firefighters)
- Monitoring of volcanic emissions (for airplane pilots)
- Monitoring of sea ice (for ships in polar waters)
- Monitoring of sea surface temperature and ocean color (for the fishing industry)
- Monitoring CO and aerosols (for air quality analyses)
- Monitoring of floods, oil spills, dust storms, etc.



AIRS and radiosonde temperature profiles over Chesapeake Bay, 9/13/2002 (from McMillan and AIRS Science Team)



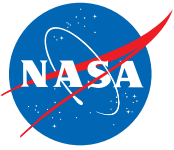
Global CO (Aug. 9-11, 2010) from AIRS/AMSU



Deepwater Horizon oil spill, Gulf of Mexico (4/25/2010) from MODIS

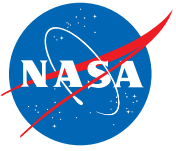


Hyde Park Fire near Fort Collins, Colorado (6/9/12) from MODIS



Summary

- The Terra spacecraft and all the 5 instruments performed in an exemplary fashion since last Senior Review (SR).
- The Aqua spacecraft and 4 of its instruments also performed in an exemplary fashion since the last SR, but unfortunately, the AMSR-E instrument ceased science operations as of Oct 2011. AMSR-E is back in operating mode as of Dec 2012, although at a slow rotation rate that allows calibration with the AMSR2 instrument but not high-quality science data.
- The Terra and Aqua projects produced 79 and 81 calibrated and validated core data products, respectively, for Land, Ocean and Atmosphere.
- Both Terra and Aqua are capable of supporting full science operations through 2020, with the primary known limitations on mission lifetime being the availability of fuel and the battery life.
- Aqua and Terra have been two of the more highly ranked missions in past SRs and this is a direct result of the efforts of the science teams (including MODIS).



Questions?