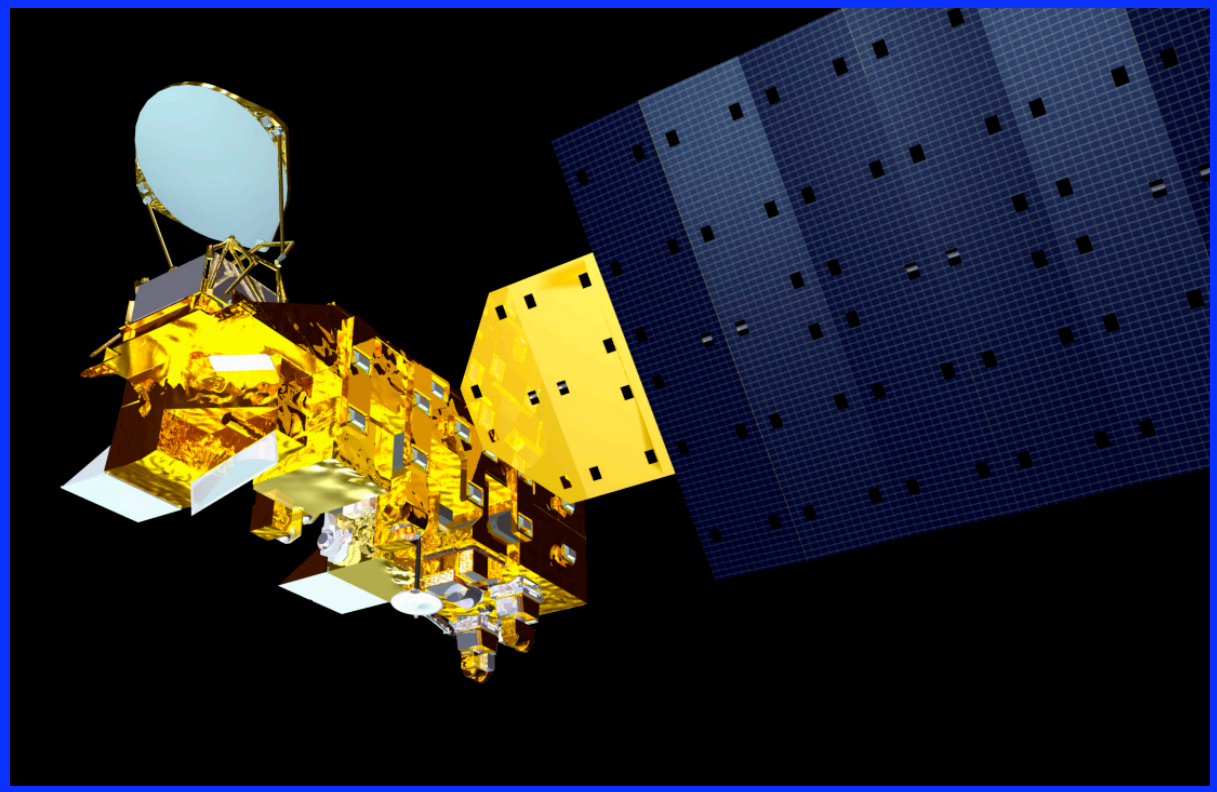
CERES Overview



Norman G. Loeb, NASA LaRC

CERES Science Team Meeting April 28, 2009, Newport News, VA

Clouds and the Earth's Radiant Energy System (CERES) Program

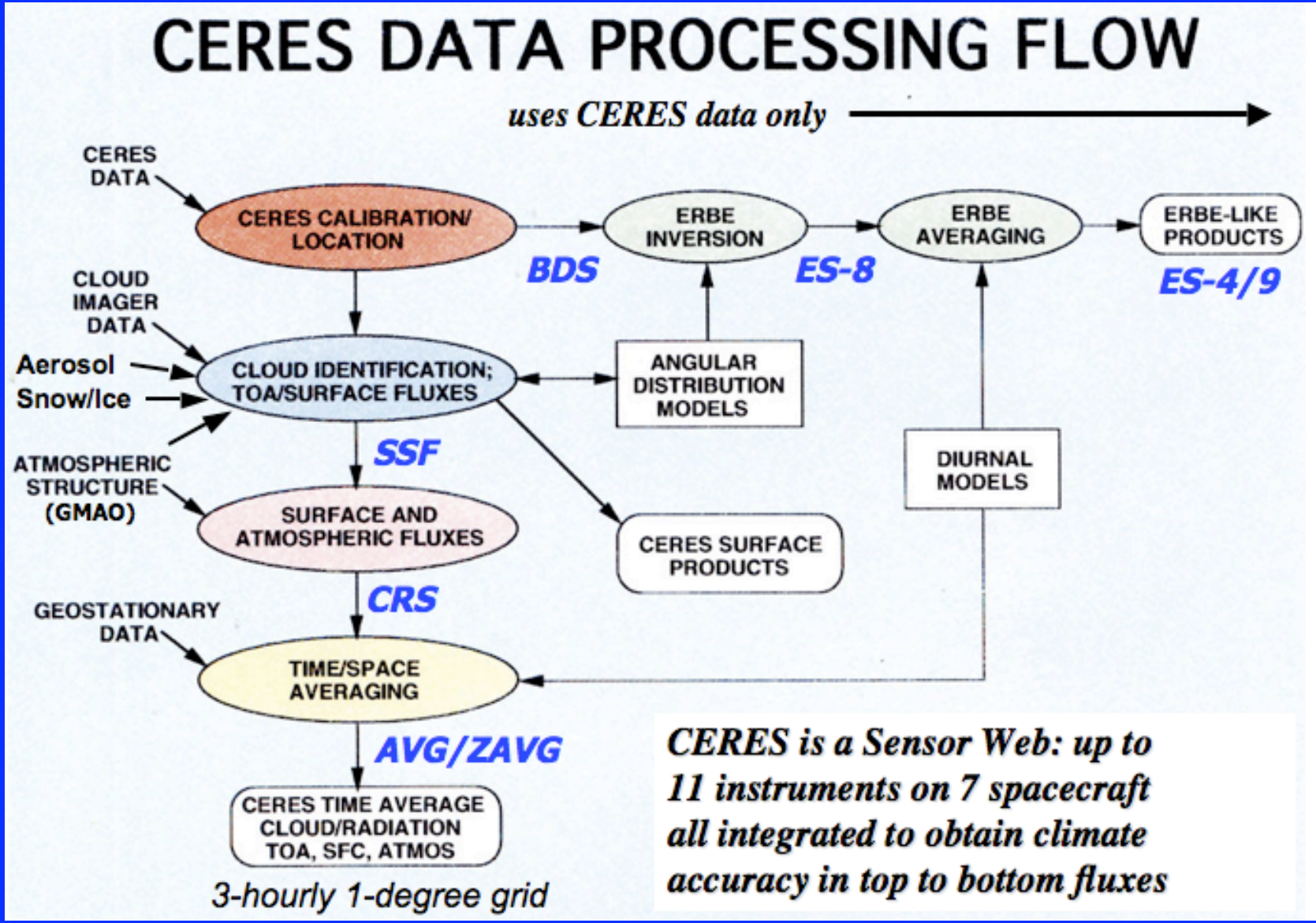
- GOAL:

- Produce long-term climate data records of radiation budget at the top-of-atmosphere (TOA), within the atmosphere and at the surface with consistent cloud and aerosol properties at climate accuracy.

- SCOPE:

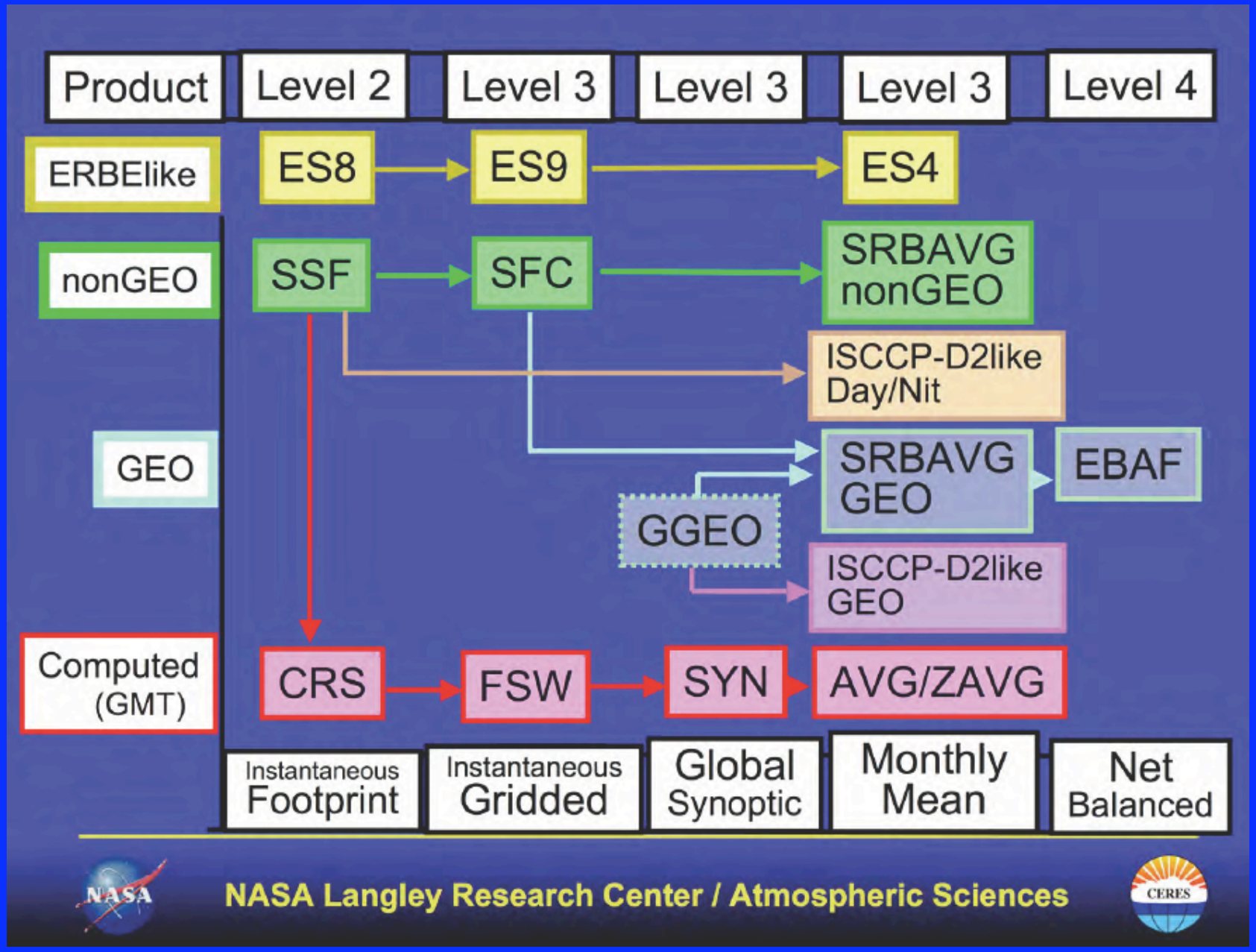
- Integrated instrument-algorithm-validation science team that provides development of higher-level products (Levels 1-3) and investigations.
- High level of data fusion: 11 instruments on 7 spacecraft all integrated to obtain climate accuracy in top to bottom radiative fluxes.
- Approx. 1.7 million lines of QC and validation code, and 0.75 million lines of production code.
- Total of 25 unique input data sources are used to produce 18 CERES data products. Over 90% of the CERES data product volume involves two or more instruments, and individual data products include up to 260 unique parameters.

- PRIME USERS: Climate modeling community



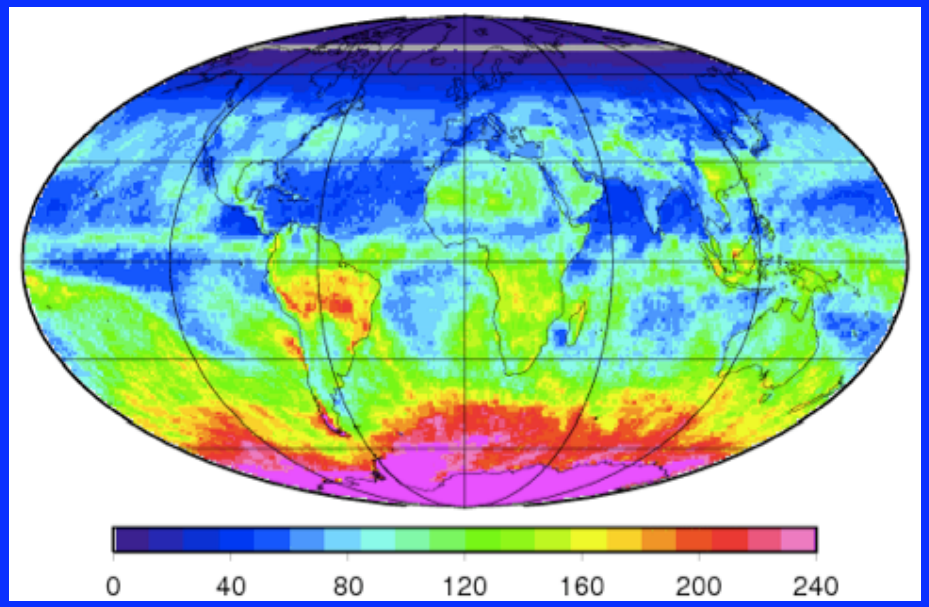
CERES provides cloud-aerosol-radiation data products over several spatial and temporal scales in order to address a wide range of climate science problems.

CERES Data Products

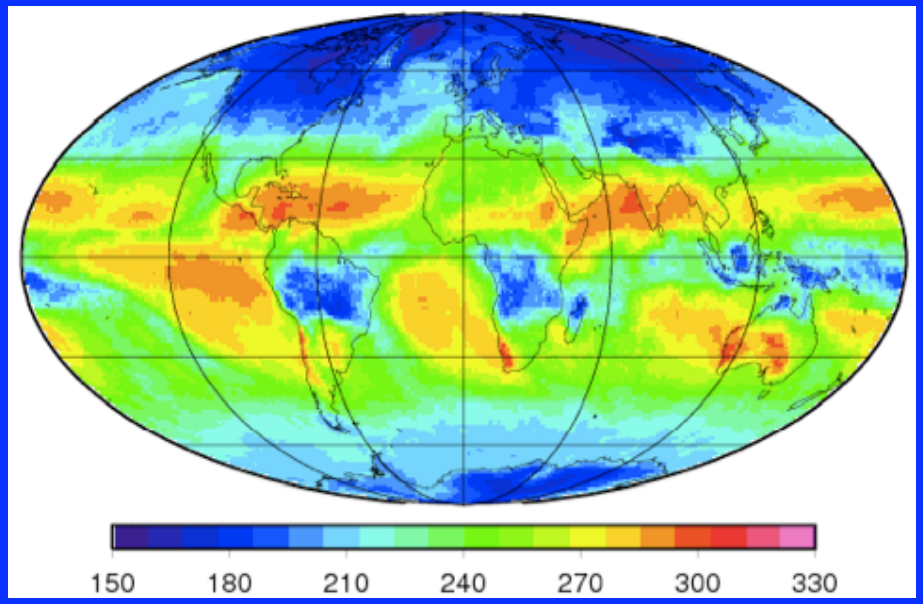


CERES has 0.75M lines of production code; 1.7M lines of validation code

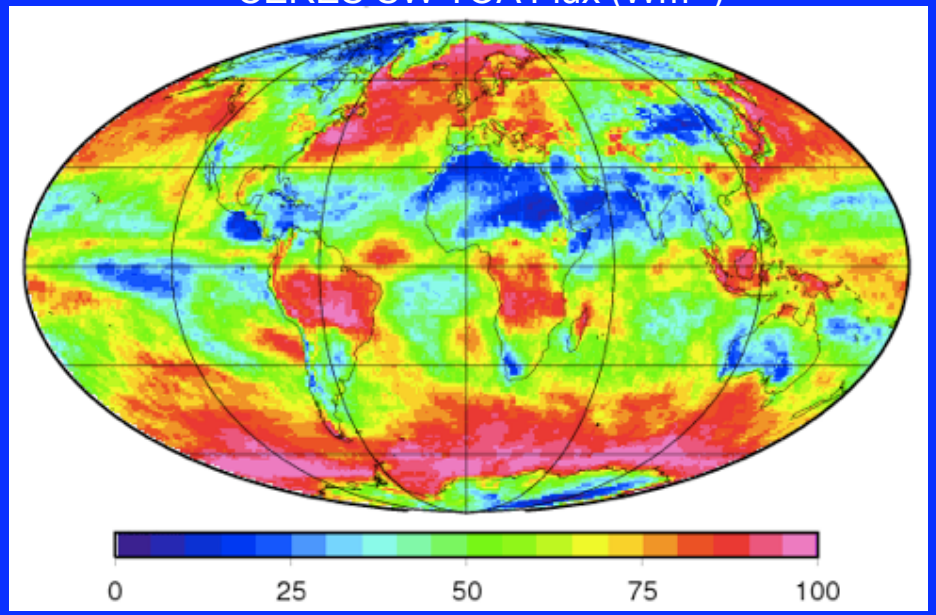
CERES+MODIS+GEO Cloud & Radiation Data (January 2004)



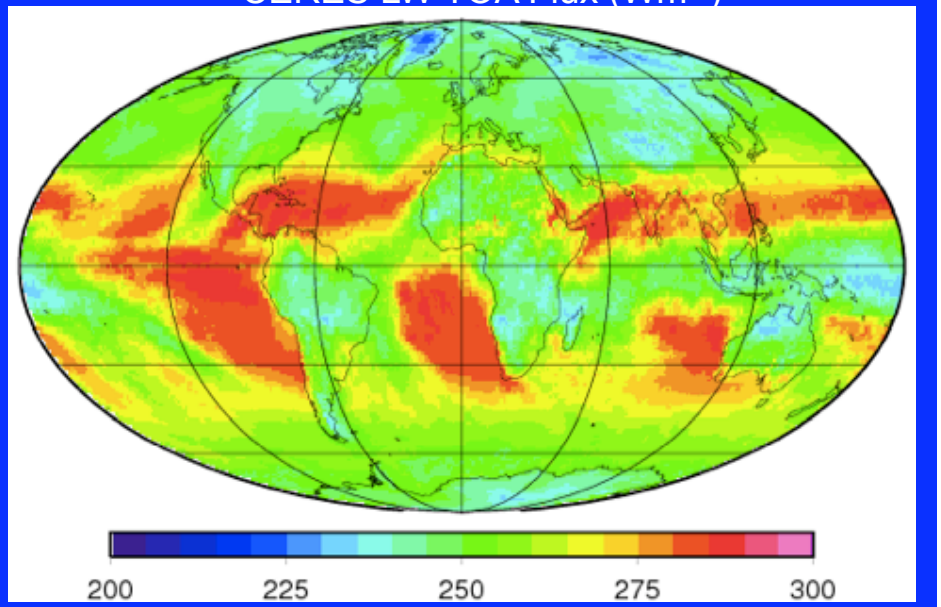
CERES SW TOA Flux (Wm^{-2})



CERES LW TOA Flux (Wm^{-2})



MODIS Cloud fraction (%)



MODIS Cloud-Top Temperature (K)

CERES Project Structure

Science

- Derives & refines algorithms
- Validates algorithms, ancillary input data & CERES data products
- Writes Data Quality Summaries
- Presents results at science team meetings & conferences
- Organized into Working Groups:
  - Instrument
  - Clouds
  - TOA Flux
  - SFC & ATM Flux
  - Time-Space Average

Data Management Team

- Implements algorithms
- Maintains software
- Verifies data
- Assists in validation
- Provides CM and documentation support
- Sub-Team organization mirrors Science Working Group structure

Atmospheric Sciences Data Center

- Ingests data
- Places operational software in production
- Produces data sets
- Distributes data sets
- Archives data
- Provides User Services

Algorithm development, refinement and validation

Algorithm implementation, validation

Data production

CERES Team Leads

- Instrument: Kory Priestley
- ERBElike: Takmeng Wong
- Clouds: Pat Minnis
- Inversion: Norman Loeb
- SOFA: David Kratz
- SARB: Tom Charlock
- TISA: David Doelling
- FLASHFlux: Paul Stackhouse & David Kratz
- Data Management: Erika Geier
- ASDC: John Kusterer & Mike Little

CERES Meeting Objectives

- Status of CERES/NASA/EOS/Senior Reviews and CERES on NPP and NPOESS.
- Terra and Aqua SW/LW/TOTAL channel calibration: **Extending Edition2 through end of 2008**; **Progress on Edition 3 work**; CERES FM5, FM6 Update.
- **Edition 3 cloud algorithm development and validation**.
- SOFA status.
- CRS Edition 2 Validation.
- Update on SYN/AVG/ZAVG: the Level 3 Gridded Version of Computed TOA/ATM/SFC fluxes
- **Extending SRBAVG, ISCCP-like-GEO and SYN/AVG/ZAVG to August 2007: Overcoming MTSAT Calibration Challenges**.
- ISCCP-like MODIS & GEO Data Products
- Data Management Team Update: Terra/Aqua/NPP
- Atmospheric Sciences Data Center (ASDC) Update
- Overview of the NPP Science Data Segment
- S'COOL Update & S'COOL Rover observations.
- G5 CERES Update
- Invited and co-I presentations.

State of CERES/NASA/EOS/Senior Reviews/ CERES on NPP and NPOESS/Decadal Survey Missions

Norman G. Loeb, NASA LaRC

CERES Science Team Meeting April 28, 2009, Newport News, VA

NASA Earth Science

- NASA Acting Administrator is Chris Scolese.
- AA for Space and Earth Science is Ed Weiler.
- Head of Earth Science is Mike Freilich.
- Jack Kaye is Associate Director for R&A.
- Steve Volz is the Earth Science Deputy for Missions.
- Richard Slonaker is new Program Executive, NASA-HQ.
- Don Anderson retired from NASA and is now at JHU APL until June at which point he starts an IPA at NOAA Climate Program Office. New role will be to bring together Climate Research and Modeling across NOAA and in collaboration with outside community.
- David Considine replaces Don as NASA HQ Modeling lead and CERES Program Scientist.
- Hal Maring remains Radiation Sciences program lead.
- NRC Earth Science Decadal Study released Jan 2007. NASA still committed to follow this overall guidance.

NASA Funding Update

- **Omnibus Appropriations Bill**
  - NASA's overall budget increases 3.5% over FY 2008 to $17.8 billion. The Science Mission Directorate receives $4.5 Billion, a 4.3% decrease over FY 2008. However, the Earth Science portion increases 10.7% to $1.4 billion in 2009.
  - $150M Decadal Survey missions; $9M for DSCOVER, $10M to fly the Thermal Infrared Sensor (TIRS) on Landsat Data Continuity Mission (LDCM); and $10M for Applied Science ROSES.
  - -$7.4 Planetary R&A, -$14M Astrophysics Exploration.
  - Relaxation of $5M NASA conference travel restrictions.
- **Stimulus Package: $389M for NASA Earth Science Directorate.**
  - 80% applied to defining a robust and executable flight program that covers the precursor and Tier I Decadal Survey missions and begins Venture Class.
  - 20% applied to R&A, Technology and Applications, including support for DS Tier II.
  - In reality: Much of the stimulus funding has been spent on existing liens on missions such as NPP, Glory, GPM, LDCM, etc. Some of the new money used for SMAP and ICESAT2 DS missions.
- **President's FY10 Budget.**
  - Total budget $18.7 billion. Continued support of DS missions.

CERES Science Team Update

- Bruce Wielicki is CLARREO Science Team Lead. Dave Young is CLARREO Project Scientist.
- Norman Loeb will become the CERES PI.
- Pat Minnis named AGU Fellow.
- Tom Evert (Northrop Grumman Corp.) received NASA Distinguished Public Service Award. Tom played key role in design/development of CERES FM1-FM6.
- SYN/AVG/ZAVG Edition2 Release!
- Fall 2009 CERES Science Team Meeting: **Nov 3-5**, Fort Collins, CO.
- Updated publication list:

http://science.larc.nasa.gov/ceres/publications/docs/CERES_Pubs_2008-1993.pdf

CERES Publications Statistics

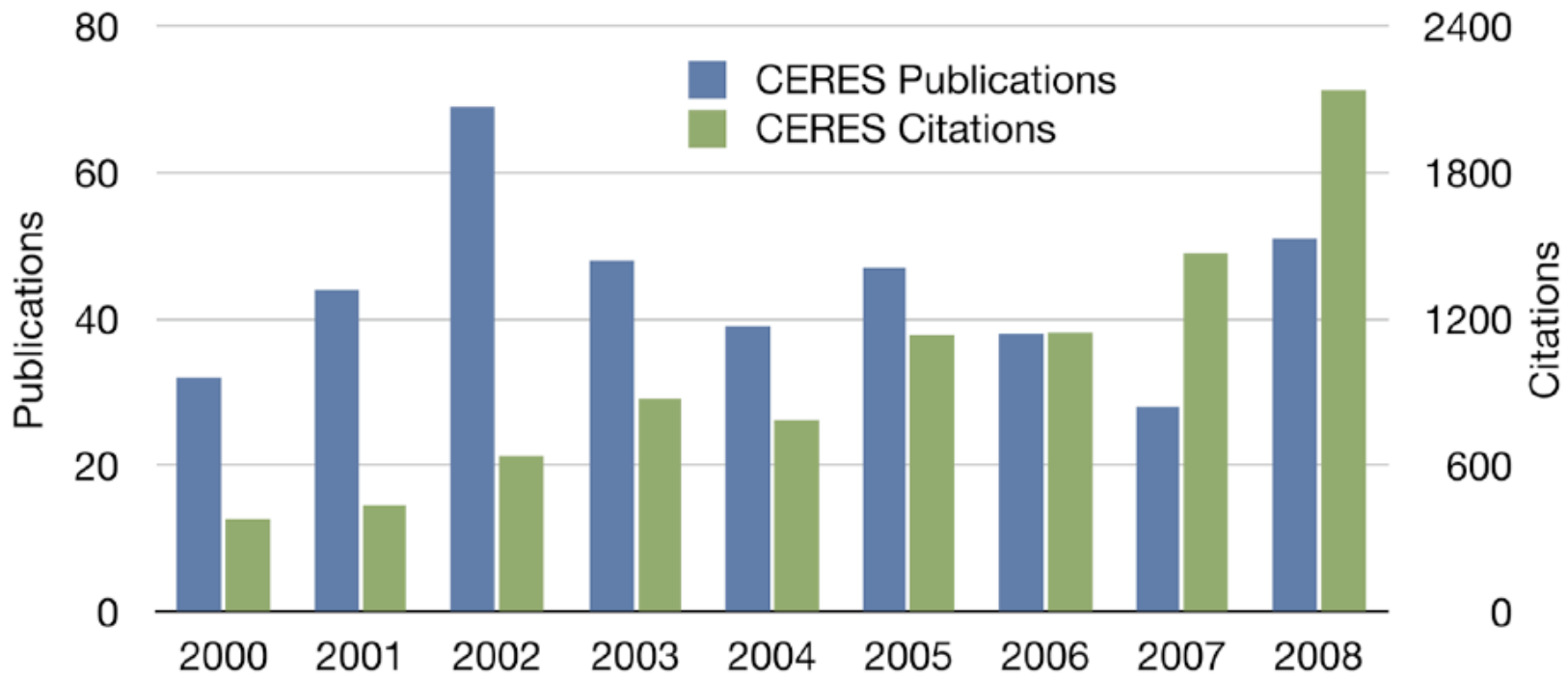


Figure 4. Number of CERES publications in each year 2000-2008 and the annual number of citations to CERES publications, based on numbers provided by the CERES science team. Values include the Terra and TRMM CERES as well as the Aqua CERES.

CERES Terra/Aqua Update

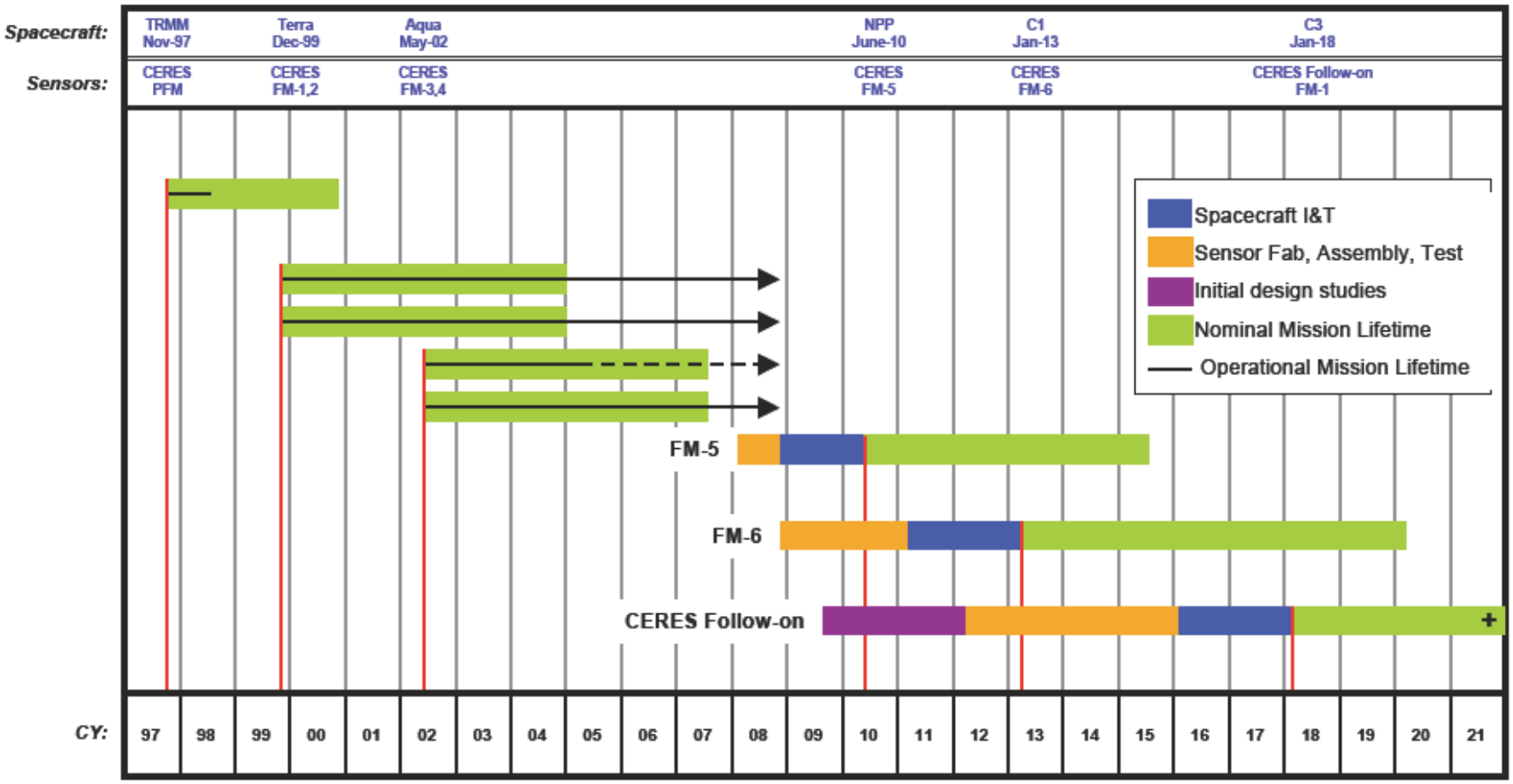
- December 2008: CERES Aqua End-of-Prime Mission Review (Loeb and Priestley presented for CERES).

- March 2009: Terra and Aqua Senior Review Proposal submitted. Special thanks to Dee Poupard, Dave Kratz and Kory Priestley for their help. Thanks to other working group chairs, DMT and ASDC for their contributions.

  - Proposals Submitted: March 23, 2009
  - Senior Review panel meets: May 12-14, 2009
  - Publication of the panel's report: June 2009
  - New budget guidelines and instructions to projects: July 2009
  - Projects revised implementation plans to ESD August 2009

CERES Flight Schedule

Enabling Climate Data Record Continuity



NPOESS Preparatory Project (NPP)

- Comprised of 4 instruments:

Visible/Infrared Imager/Radiometer Suite (VIIRS)

Cross-track Infrared Sounder (CrIS)

Clouds and the Earth's Radiant Energy System (CERES)

Advanced Technology Microwave Sounder (ATMS)

- All of the NASA elements (i.e., launch vehicle, spacecraft, CERES, ATMS) are on schedule.
- Significant delays with the NGST/NPOESS-led procurement of the VIIRS sensor.

- <u>VIIRS Update</u>:
  - Ambient Electro-Magnetic Interference Testing (EMI) Completed (Nov '08)
  - Vibration testing completed (Feb '09)
  - Thermal Vacuum testing starting this month. Completion in August.
- Anticipated NPP launch: Jan 2011

CERES FM5 on NPP

- CERES FM5 is a NASA sensor manufactured by Northrop Grumman (NG), and provided to the NPP by NASA.
- Instrument Operations, Data Processing and Science provided by NASA LaRC.
- Congratulations to FM5 team: January 2008 ATP to November 2008 instrument delivery. On cost and on schedule!
- Center Team Award for CERES FM5.
- CERES data management group also deserves credit for getting code ready (code conversion/VIIRS subsetting); Working in a much more complex environment:
- **Data flow**: NPP => Ground Station => NPOESS IDPS =>
- (i) NOAA CLASS archive; (ii) GSFC SDS => GSFC PEATE => LaRC ASDC => CERES Team

NPOESS Climate Sensors Funding Update

- **The White House Science Office requested NOAA and NASA to provide:**
  - An analysis of possible mitigation options of the climate impacts of the NPOESS Nunn-McCurdy Certification through 2026.
  - An assessment of the potential costs of these options
  - All options contingent upon getting new funding
- **Primary goal: Ensure continuity of long-term climate records**
- **NOAA and NASA analyzed the following options:**
  - Remanifesting the climate sensors on NPOESS spacecraft
  - Placing sensors on currently planned non-NPOESS spacecraft
  - Developing new gap-filling climate satellite missions
  - Partnering opportunities
- **Key results:**
  - NOAA's FY 2009 Passback included $74M to mitigate the loss of climate sensors on NPOESS and to provide long term Climate Data records
    - Specifically targeted for most cost effective options for launching Clouds and Earth's Radiant Energy System (CERES) and Total Solar Irradiance Sensor (TSIS), as well as support for initial work on Climate Data Records.

CERES FM6 on NPOESS

- CERES FM6 is a government-furnished sensor manufactured by Northrop Grumman (NG), and provided to the NPOESS program by NOAA/NASA.
- Instrument Operations, Data Processing and Science historically provided by NASA LaRC (EOS & NPP). Ongoing discussion between NASA and NOAA to determine roles/responsibilities.
- Northrop Grumman Aerospace System (NGAS) working under contract to NASA LaRC.
- Build-to-Print and from spare parts.
- Minor modifications to accommodate NPOESS C1 interface, and improve calibration.
- Tentative Start Date: May 2009; Delivery Date: July/August 2012; Launch in 2014.
- NPOESS Critical Design Review April 20-24, 2009 (last week).

A-Train Update

- OCO launch separation failure
- Glory launch delayed to January 2010
- CALIPSO passed 1000 day-mark in orbit on January 23, 2009. Successfully transitioned to backup laser on March 9, 2009.
- New merged CALIPSO-CloudSat-CERES-MODIS (C3M) dataset to be released soon (see S. Kato Co-I presentation).

Decadal Survey

- NASA still committed to implementing DS. Tier 1 Missions:

  - Climate Absolute Radiance and Refractivity Observatory (CLARREO)
  - Deformation, Ecosystem Structure and Dynamics of Ice (DESDynI)
  - Soil Moisture Active-Passive (SMAP)
  - Ice, Cloud, and Land Elevation Satellite (ICESat-II)

CLARREO (Led by NASA Langley)

- The foundation for CLARREO is on-orbit calibration that is traceable to international standards. This will provide the climate record required for:
  - Long-term climate trend detection
  - Improvement and testing of climate predictions
  - Calibration of operational and research sensors
- Mission Configuration: 2 identical spacecraft; Near-polar orbits; 5-year expendable lifetime; Global sampling for accurate climate means.
- Measurements
  - Spectrally resolved radiance emitted from Earth to space
  - Refractivity of the atmosphere observed by radio occultation
  - Spectrally resolved reflectance of Earth to space

Status

- October 2008 open science workshop on the entire CLARREO mission.
- January 2009 meeting on solar science with special emphasis on polarization and solar spectra, intercalibration approaches: recommended APS-like continuity for aerosol forcing as did NRC Decadal Survey Delta Study in summer 2007, but not on CLARREO itself. NOAA wants to wait to see how well APS works before committing.

- CLARREO is targeting a fall Mission Confirmation Review (MCR).
- Close interaction of science/engineering team in mission formulation phase.
- Infrared Interferometer and Solar Spectrometer had Instrument Design Lab sessions at GSFC in April 2009 to develop point concepts in support of MCR and mission cost/engineering.
- Science team meeting on Level 1 and 2 science requirements May 11-15, 2009.
- Memorandum of agreement with UK on CLARREO is being worked by LaRC, NASA HQ and the UK. Early focus would be on science collaboration with potential for future mission collaboration.
- CLARREO team is still working to meet a 2015 launch.
- CLARREO may get increased funding, but no word yet on stimulus funds or out year funding budgets. This is very likely wrapped up in the new administration sorting out the overall direction it wants NASA to go, who to lead it, and relative priority of manned flight, space science and earth science.