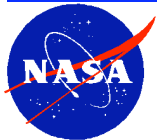


**State of
CCSP/EOS/CERES/NPP/NPOESS/NRC
Decadal Study/A-train/ASIC³**

B. Wielicki and N. Loeb

**10th CERES-II Science Team Meeting
October 27-29, 2008
NASA GISS, New York, NY**



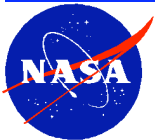
Keeping our eye on the ball...



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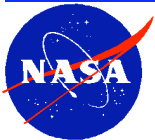
U. S. Climate Change Science Plan (CCSP)

- CCSP Observation Working Group (OWG) was planning a second observation requirements workshop in fall, 2008. Purpose was to evaluate new tools for both science community guidance and for climate model OSSEs. Date now TBD.
- ASIC³ Multi-agency workshop on ways to achieve satellite climate calibration goals: final workshop report released.
- NRC review of CCSP underway: preliminary indications are good science, but poorly funded and space-borne climate observing system is collapsing (e.g. NPOESS climate instruments). At fall 2007 NRC workshop, congressional staffers indicated that congress wants to move out on climate change science but current administration is not interested. Waiting for next administration: Obama, McCain



IPCC Assessment Report 4

- Cloud feedback remains the largest uncertainty in climate sensitivity and low clouds dominate the uncertainty. Feedback that changes planetary albedo.
- Aerosol indirect effect remains largest uncertainty in anthropogenic radiative forcing (changing albedo).
- Decadal changes in cloud/radiation now included in Chapter 3, including ocean heat storage/net radiation consistency.
- Expanded discussion of climate prediction uncertainties including early perturbed physics ensembles.
- Low and High sensitivity climate models show similar global mean temperature increases next several decades: large separations after 2050. Implies we need methods to resolve cloud feedback well before then to constrain climate sensitivity.
- Forcing $0.6 \text{ Wm}^{-2}/\text{decade}$: 25% cloud feedback $0.15 \text{ Wm}^{-2}/\text{decade}$ in cloud radiative forcing: *0.3%/decade in SW channel gain.*



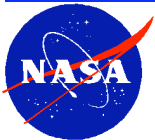
NASA Earth Science

- NASA Administrator is Michael Griffin
 - AA for Space and Earth Science is Ed Weiler.
 - Head of Earth Science is Mike Freilich.
 - Steve Volz is earth science deputy for missions.
 - Don Anderson is Modeling lead and CERES Program scientist
 - Hal Maring is Radiation Sciences program lead
 - NRC Earth Science Decadal Study released Jan 2007. NASA committed to follow this overall guidance.
- FY09 budget likely continuing resolution for extended period.
 - \$78M in FY09 to recover NPOESS lost climate instruments (e.g. CERES on NPP, CERES FM-6A on, or in formation with NPOESS C1
 - Placeholder for FY10 and beyond pending NASA/NOAA plan for recovery of climate observations: still being worked.

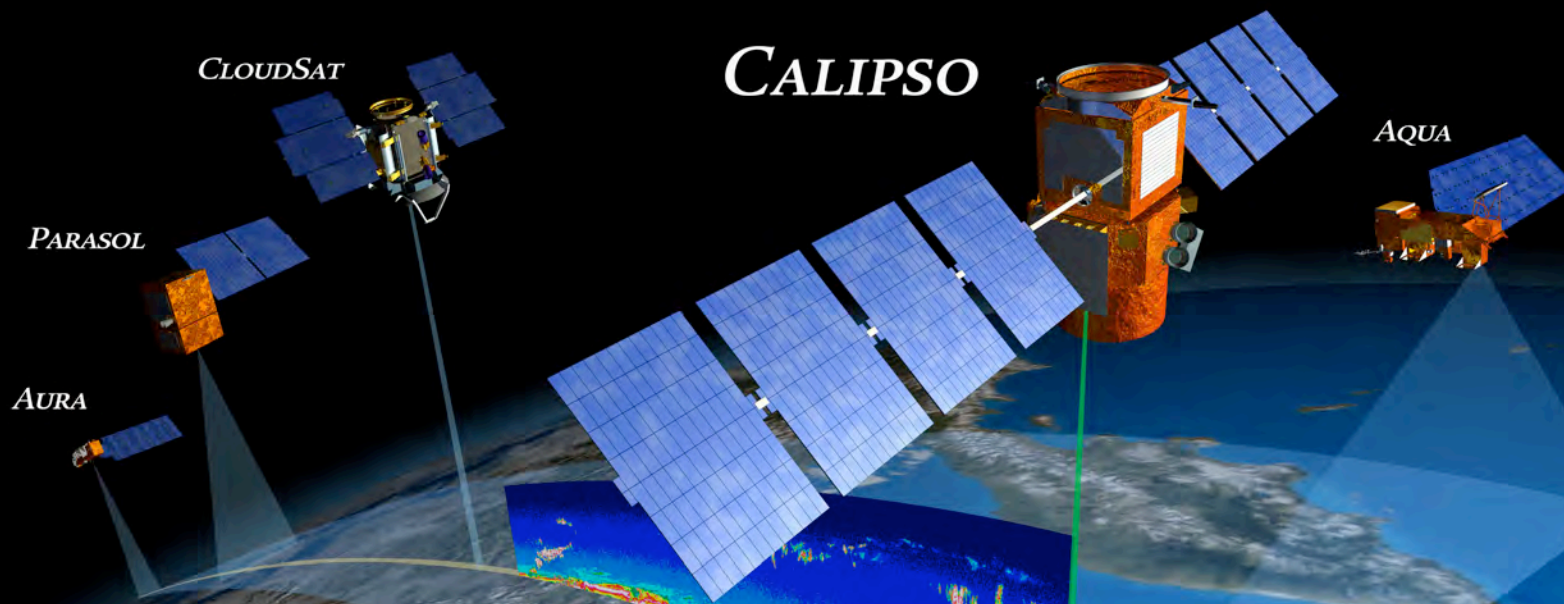


CERES Program

- Terra and Aqua Senior Review (2007) went very well. Aqua End of Prime Mission Review December, 2008. Next Senior Review 2009: proposals due March, review panels meet April, funding decisions Sept.
- NASA Energy and Water System (NEWS) science group
 - global water and energy data sets, including A-train: subsets of CERES, MODIS, CALIPSO, Cloudsat along the lidar/radar ground track (64km swath).
 - Seiji Kato leading merged product development: recently added CALIPSO aerosol and cloud extinction profiles. RAID disk failure has slowed progress
- New budget requirements for obligation, commitment, and costing metrics.
 - Congress took back NASA funding in FY08 because too much of one fiscal year funding was being spent in the following year.
 - New metric is costing funds by 3 months after end of the fiscal year (i.e. bills have come in and been paid out)
 - CERES has worked this way in the past, but startup of NPP and CLARREO related work is bad timing for this limitation.



A-train is on track and doing well. CALIPSO lidar not showing any of the GLAS lifetime issues: 6 yrs looks reasonable, CloudSat radar also doing well...



CALIPSO

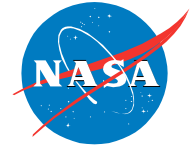
Probing Earth's atmosphere to unravel the mysteries of climate change.



Future: CERES, NPP and NPOESS

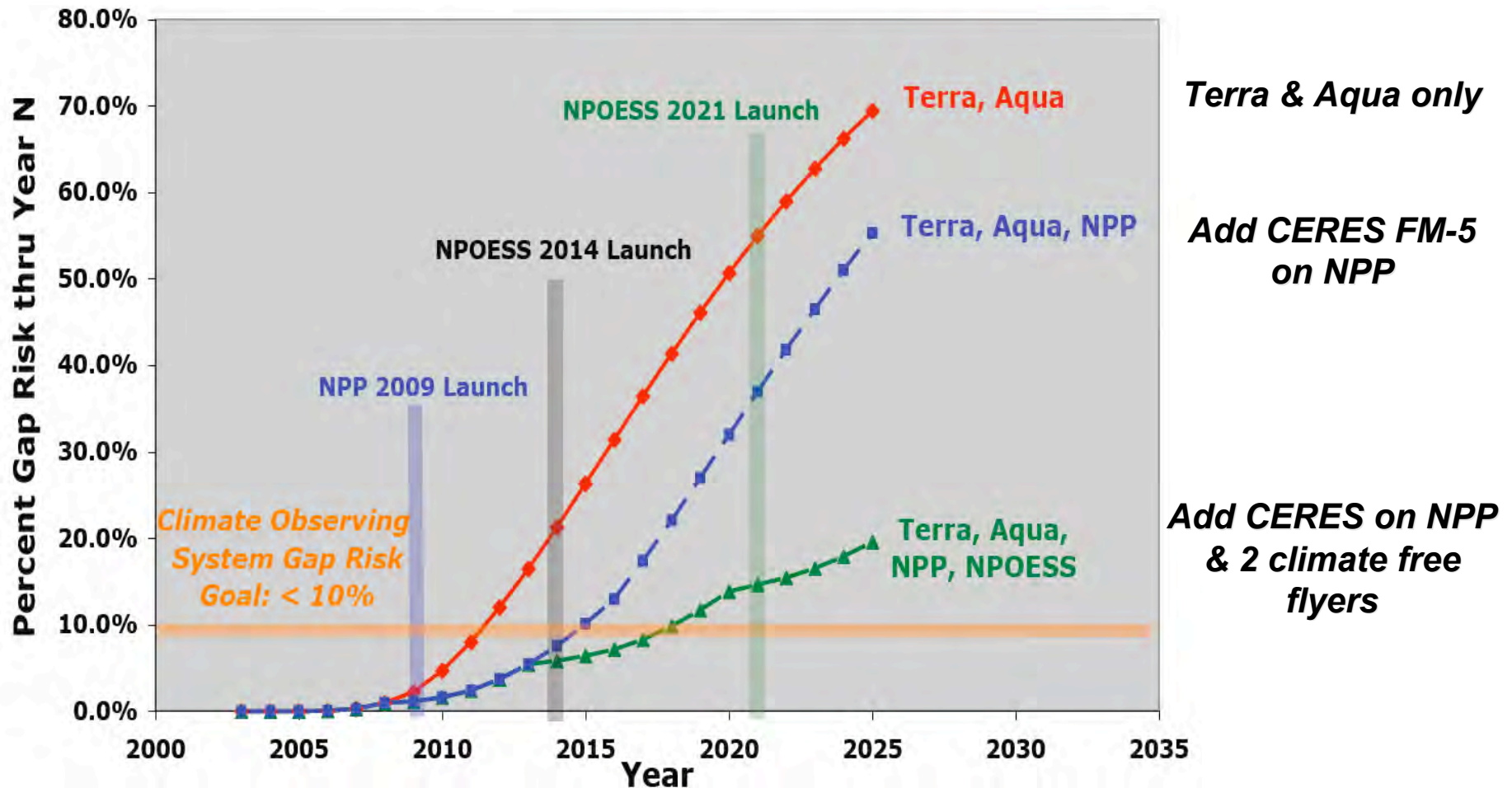
- CERES FM-5 is back on NPP!
 - Decision finally approved late January, 2008
 - NPP GSFC team, NGST (instrument), and Ball (spacecraft) all working very well together to modify/calibrate/integrate the CERES instruments
 - Instrument delivery to S/C Nov 2009: Launch no earlier than June 2010, but with continued VIIRS problems (cooler) likely delay to mid/late 2011. CrIS now OK.
 - Greatly reduces radiation budget gap risk (~ factor of 3 in the near term)
 - Working with NPP is, however, much more complex than even EOS: in essence it includes all of EOS NASA interfaces and adds NPOESS/DoD/NOAA interfaces
 - CERES NPP data products will be produced as CERES CDRs, at LaRC ASDC using the CERES algorithms, validation, quality control methodologies
 - VIIRS NPP imager replaces MODIS
 - Similar spectral bands, spatial resolution
 - Optical crosstalk will be an issue for low reflectance scenes (aerosol/ocean color)
 - CERES/MODIS/VIIRS calibration teams collaborating on VIIRS analysis
 - CERES will build preprocessor codes to convert NPP data to Terra/Aqua-like formats
 - FM-5, Ephemeris, Attitude, VIIRS, aerosol data for NPP will come from GSFC NPP Land PEATE data system to LaRC ASDC.
 - Data flow: NPP => ground station => NPOESS IDPS => NOAA CLASS archive => GSFC SDS => GSFC PEATE => LaRC ASDC => CERES team.





What is the Radiation Budget Gap Risk?

3 future scenarios: NPP and Climate Free-flyers



Gaps start the climate data record back at zero.

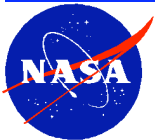
NPP and NPOESS, con't

- CERES after NPP
 - CERES FM-6 will be a modestly improved (calibration) version of CERES and will be constructed primarily from CERES spare parts to save time/cost
 - Planned launch is on NPOESS C1 (2013/2014) in the same 130LT orbit as Aqua and NPP. Option is flying on a small-sat in formation with C1 (within 3-6 minutes of the C1 platform with VIIRS imager, CrIS interferometer, and microwave imager).
 - CERES Follow On would be the next generation CERES instrument and would go beyond FM-6 in calibration improvements.
 - CERES II would also be designed to assure its ability to intercalibrate with future CLARREO missions.
 - CLARREO provides an independent calibration check of CERES
 - CLARREO mission studies will examine its ability to detect and correct for issues similar to the in-orbit contaminants on optics, gain change, offsets, etc.
 - These CLARREO inter-calibration simulations are using the SCHIAMACHY high spectral resolution data for simulations.



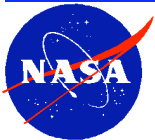
NRC Decadal Survey

- Study Released Feb 2007
- NASA committed to support, the missions are considered "notional"
- NRC Decadal Survey asked to do "Delta" study on loss of NPOESS climate instruments
 - Recommended adding CERES FM-5 to NPP and building next generation copies to fly in formation with NPOESS VIIRS 2014/2020
- CLARREO one of 4 first missions with earliest action (Tier 1)
 - CLARREO funding for pre-phase A mission studies started April, 2008
 - New Benchmark IR and Solar Spectral climate record
 - New ability to act as a Calibration Observatory in orbit to calibrate other solar and infrared wavelength sensors (e.g. CERES, VIIRS, CrIS, etc)
 - Langley assigned as CLARREO mission lead center
 - First CLARREO mission study team meeting April 30-May 2, 2008
 - Second community CLARREO workshop, Oct 21-23, 2008
 - Mission studies to firm up science requirements and be ready for Mission Confirmation Review in early fall, 2009.
 - Three IIP investigations selected in 2008 to support CLARREO.



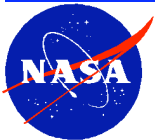
NRC Decadal Survey: CLARREO

- CLARREO Mission Studies over next 18 months
 - Mission Study team: LaRC, GSFC, GISS, JPL, GDFL, U. Wisc., Harvard, U. Md., Berkeley, U. Colo.-LASP, U.K Imp. Coll, NPL
 - Infrared Benchmark Spectrum for Decadal Climate Change
 - Ability to interpret benchmark spectra in clear-sky and all-sky conditions
 - Climate OSSEs (Observing System Simulation Experiments) carried out by major climate modeling groups (Berkeley-NCAR/GFDL/GISS)
 - Use of A-train plus RTM theory to evaluate issues with trade cu, thin cirrus, and boundary layer T,q structure in interpreting benchmark spectra
 - Space/Time Sampling AIRS/IASI studies to define fov/swath/orbits
 - Infrared Benchmark Spectrum to intercalibrate other sensors
 - Space/time/angle matching for MODIS/VIIRS/CrIS/IASI/CERES, etc
 - Ability to detect and correct spectral response errors or changes in filter radiometers like MODIS/VIIRS
 - Ability to detect nonlinearity, orbit thermal issues, etc with sufficient sampling in a short time interval (~ 1 to 3 months) for each intercalibration
 - Spectral coverage, resolution, noise requirements.



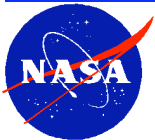
NRC Decadal Survey: CLARREO

- CLARREO mission studies con't
 - Solar benchmark spectrum for decadal climate change
 - Similar to infrared for climate model OSSEs, all-sky vs clear-sky
 - FOV less of a design issue: nominal 0.5 to 1km in 100km swath likely
 - Lunar stability/calibration requires 1km or smaller fov
 - SCHIAMACHY being used for natural variability spectral tests
 - CERES/MODIS/GEOS 4.0.3 plus full spectrum MODTRAN RTM tests for swath and ability to detect trends in key climate variables like cloud, aerosol, water vapor, surface albedo, etc
 - Solar benchmark spectrum for intercalibration of other sensors
 - SCHIAMACHY used as CLARREO simulator to test ability to verify instrument filter or optics changes (CERES, VIIRS, MODIS, SeaWiFS, Landsat, etc), gain, offset, contamination in orbit.
 - Imagers used to define space/time/angle matching needed
 - Orbit sampling tests to sampling vs orbit selection and nadir vs pointing
 - 3 CLARREO Instrument Incubator Proposals Selected: LaRC for detectors, UW/Harvard blackbodies, LASP solar spectrometer.



Next Administration and Climate

- The U.S. public climate epiphany is finally passing the 50% point, and congress passed this point a year ago. All we need to cross the tipping point is an administration that cares: both Obama/McCain do.
- NASA total budget not likely to rise because of deficit/bailout, but balance of exploration/space science/earth science is likely to change.
- Earth Science is currently ~ 7% of NASA's budget, Space Science is ~ 21%, rest is exploration/space station/shuttle
- NRC Decadal Survey asked for 30% increase in earth science and includes little for sustained climate observations: mostly process missions. Must balance the two (both required).
- A true climate observing system would likely require a doubling to tripling of earth science at NASA: say to 20% of NASA budget.
- Is this feasible? Funding within agencies for climate would have to be walled off (e.g. NOAA does surface/in-situ CDRs, NASA does space-based CDRs), or a new agency with climate as its top mission would have to be created. This is a MAJOR challenge coming up.



Next Administration and Climate

- The bank bailout won't help.
- Most funding will go to energy technology development
- But tripling climate science is only additional \$4B/yr: 0.5% of the bailout level and much less than energy technology development
- Climate science remains a high value/cost input for future decisions on economic, political, and social policies relative to climate change.
- Uncertainties remain in climate science, economics, and technology development. Strategies will evolve as things clarify in all three areas. (see book "Shaping the Next 100 Years", Rand/Pardee)
- International collaboration in climate science is likely to increase dramatically in the next administration: especially Obama, but also McCain.
- Bottom line: cautious optimism for serious improvement in climate science efforts.

