

SDT Meeting Intro/Goals

Climate Absolute Radiance & Refractivity Observatory

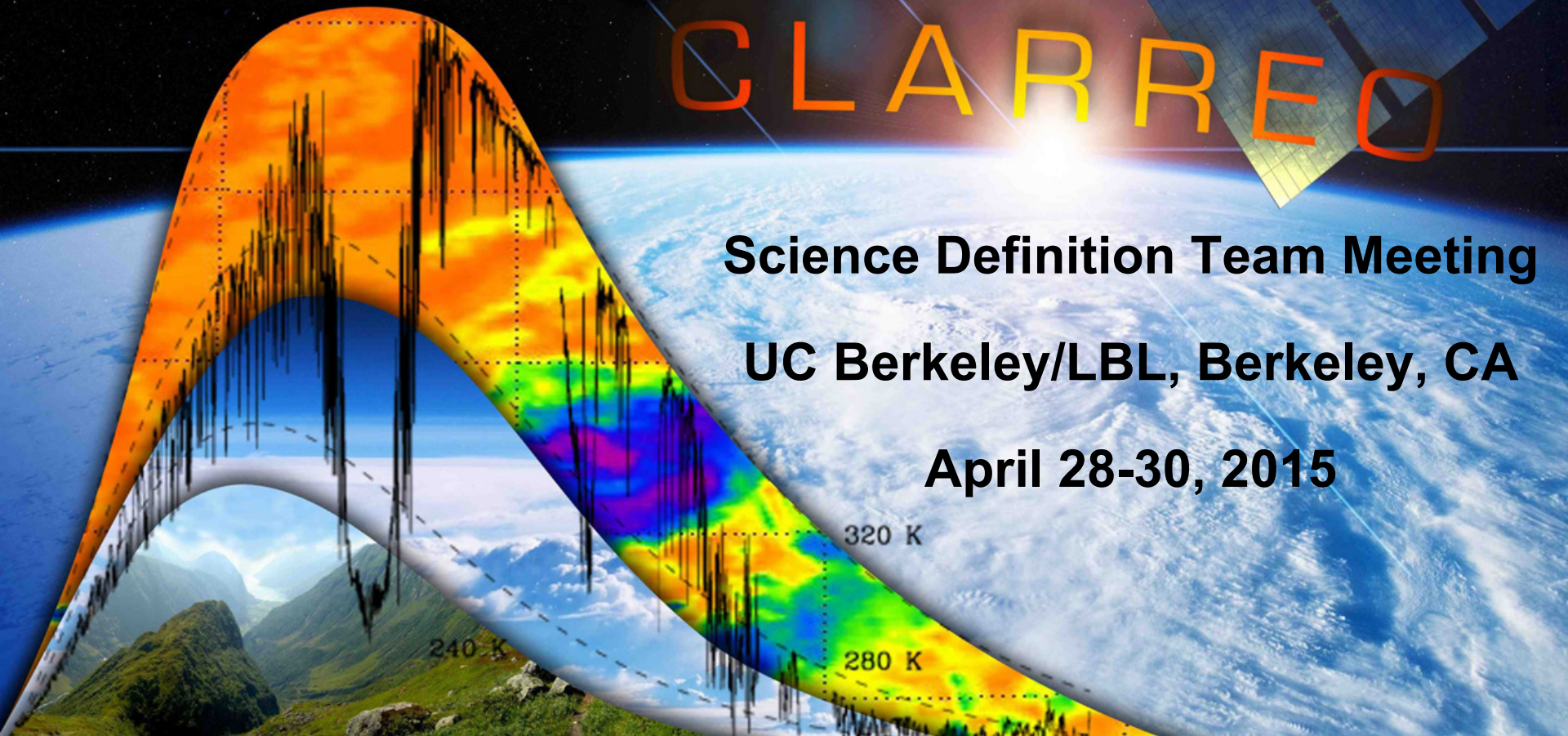
Bruce Wielicki and Rosemary Baize

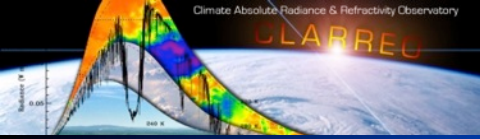
CLARREO

Science Definition Team Meeting

UC Berkeley/LBL, Berkeley, CA

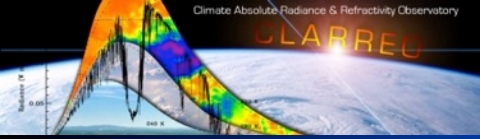
April 28-30, 2015





CLARREO Mission Status

- Passed Mission Concept Review Nov 2010
- Science Definition Team selected in Jan 2011
- NASA Earth Science budget reduction in Feb 2011 has caused a delay.
- Remains in pre-phase A studies, launch no earlier than 2023
- 2 RS and 2 IR instrument calibration demonstration systems underway (CU-LASP/GSFC for RS, UW/LaRC for IR)
- Climate Model OSSEs and Intercalibration simulation studies
- Alternative less costly mission studies: ISS best option to date
- International collaboration options with UK, Italy, India in study
- *No climate observing system: factor of 3 to 4 underfunded*
- *Return on Investment in a climate observing system is ~ 40:1*



2014 Progress: Journals

- 26 journal papers published/in press in 2014
- 10 papers submitted/in review
- 8 papers in preparation
- 26 journal papers were published in 2013
- 105 total journal papers to date
- This SDT meeting will give us a fresh view of science study progress and directions

CLARREO Mission BAMS Cover Paper



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BAMS

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POLLUTION FROM WILDFIRES

GLOBAL CLOUD DATASETS

WEATHER DATA FROM CARS

A MEASURE FOR MEASURES



In-Orbit Calibration of
Climate-Change Monitoring

ACHIEVING CLIMATE CHANGE ABSOLUTE ACCURACY IN ORBIT

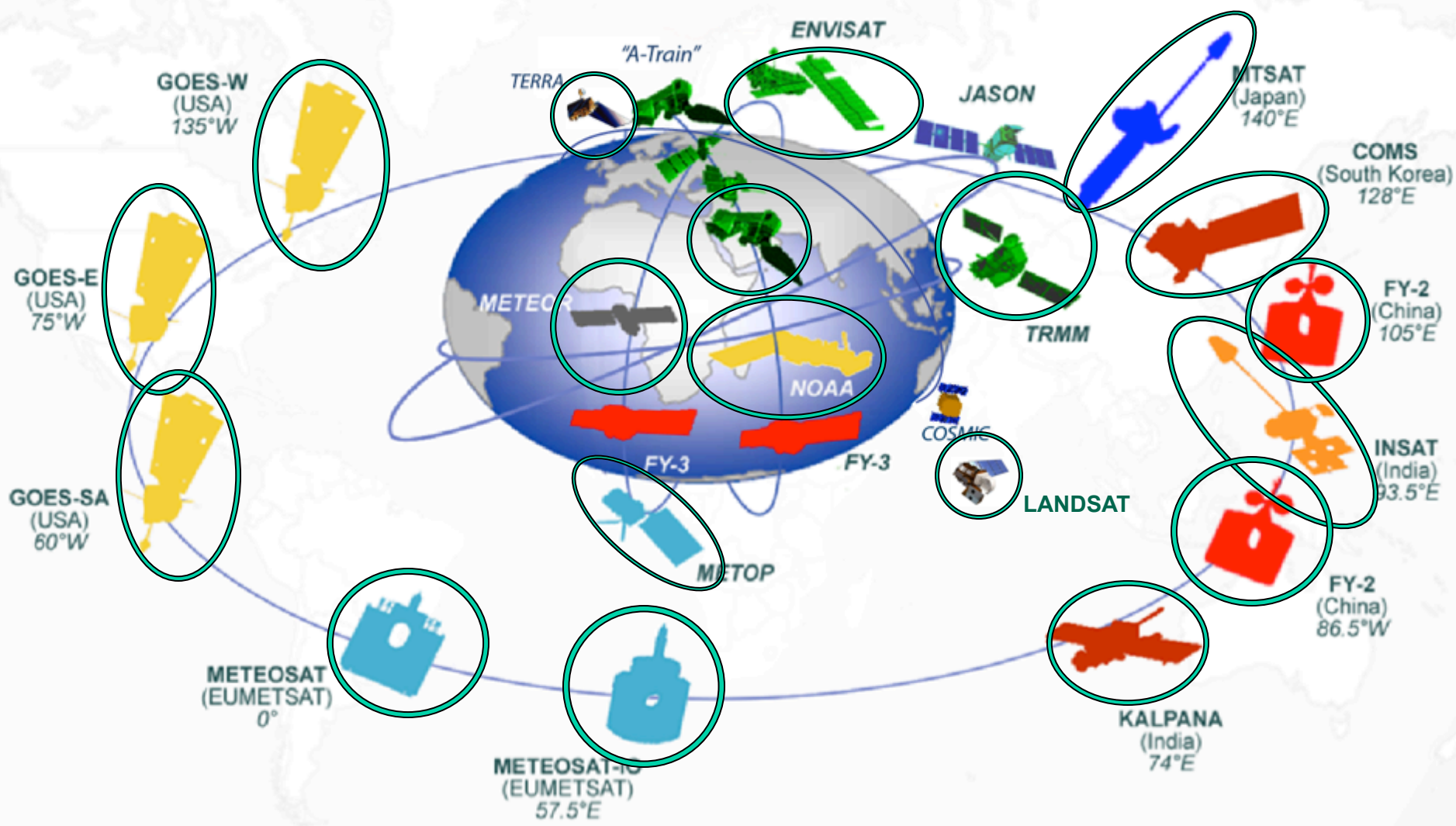
BY BRUCE A. WIELICKI, D. F. YOUNG, M. G. MLYNČZAK, K. J. THOME, S. LEROY, J. CORLISS, J. G. ANDERSON, C. O. AO, R. BANTGES, F. BEST, K. BOWMAN, H. BRINDLEY, J. J. BUTLER, W. COLLINS, J. A. DYKEMA, D. R. DOELLING, D. R. FELDMAN, N. FOX, X. HUANG, R. HOLZ, Y. HUANG, Z. JIN, D. JENNINGS, D. G. JOHNSON, K. JUCKS, S. KATO, D. B. KIRK-DAVIDOFF, R. KNUTSON, G. KOPP, D. P. KRATZ, X. LIU, C. LUKASHIN, A. J. MANNUCCI, N. PHOJANAMONGKOLKIJ, P. PILEVSKIE, V. RAMASWAMI, H. REVERCOMB, J. RICE, Y. ROBERTS, C. M. ROTHMAYR, F. ROSE, S. SANDFORD, E. L. SHIRLEY, W. L. SMITH SR., B. SODEN, P. W. SPETH, W. SUN, P. C. TAYLOR, D. TOBIN, AND X. XIONG

With its unprecedented accuracy, the Climate Absolute Radiance and Refractivity Observatory substantially shortens the time to detect the magnitude of climate change at the high confidence level that decision makers need.

THE CLARREO VISION FROM THE NATIONAL RESEARCH COUNCIL DECADAL SURVEY. A critical issue for climate change observations is that their absolute accuracy is insufficient to confidently observe decadal climate change signals (NRC 2007; Trenberth et al. 2013; Trenberth and Fasullo 2010; Ohring et al. 2005; Ohring 2007). Observing decadal climate change is critical to assessing the accuracy of climate model projections (Solomon et al. 2007; Masson and Knutti 2011; Stott and Kettleborough 2002) as well as to attributing climate change to various sources (Solomon et al. 2007). Sound policymaking requires high confidence in climate predictions verified against decadal change observations with rigorously known accuracy. The need to improve satellite data accuracy has been expressed in ▶

Detail of CLARREO (red orbit track) obtaining matched data to serve as reference intercalibration for instruments on a polar orbiting weather satellite (green track). For more information see Fig. 6.

Intercalibration to CLARREO for Climate Change Accuracy



Value of information for climate observing systems

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Abstract

The Interagency Working Group Memo on the social cost of carbon is used to compute the value of information (VOI) of climate observing systems. A generic decision context is posited in which society switches from a business as usual (BAU) emissions path to a reduced emissions path upon achieving sufficient confidence that a trigger variable exceeds a stipulated critical value. Using assessments of natural variability and uncertainty of measuring instruments, it is possible to compute the time at which the required confidence would be reached under the current and under a new observing system, if indeed the critical value is reached. Economic damages (worldwide) from carbon emissions are computed with an integrated assessment model. The more accurate observing system acquires the required confidence earlier and switches sooner to the reduced emissions path, thereby avoiding more damages which would otherwise be incurred by BAU emissions. The difference in expected net present value of averted damages under the two observing systems is the VOI of the new observing system relative to the existing system. As illustration, the VOI for the proposed space-borne CLARREO system relative to current space-borne systems is computed. Depending on details of the decision context, the VOI ranges from 2 to 30 trillion US dollars.

Electronic supplementary material

The online version of this article (doi:10.1007/s10669-013-9451-8) contains supplementary material, which is available to authorized users.

Keywords Value of information – Climate observing system – Social cost of carbon – DICE – CLARREO

Journal of Environment, Systems, and Decisions

Cooke et al., 2013

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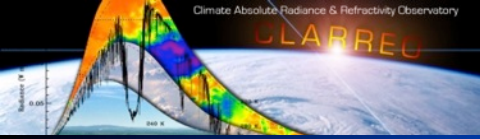
Results and Sensitivity to Assumptions

World Wide Economic Benefits

Parameter Change	CLARREO/Improved Climate Observations VOI (Trillion US 2015 dollars, NPV) 3% discount rate
Baseline*	\$11.7 T
BAU => AER	\$9.8 T
0.3C/decade trigger	\$14.4 T
2030 launch	\$9.1 T

* Baseline uses 0.2C/decade trigger, 95% confidence in trend, BAU => DICE optimal emissions, 2020 launch

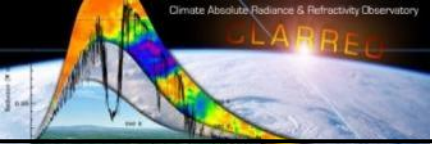
- Delaying launch by 10 years reduces benefit by \$2.6 T



CLARREO Pathfinder

- CLARREO Pathfinder mission included in the Presidents FY16 proposed budget to Congress
- Launch 2019/2020 on ISS
- Includes both RS and IR spectrometers
- Tight Budgets (~\$21M/instrument without cost reserve)
- Depends on Congress passing an increase in NASA Earth Science in FY16: may or may not happen: Congressional arguments underway.
- PPBE budget submitted to NASA HQ and Systematic Missions Program Office April 15, 2015
- More information in a session on Wed Afternoon

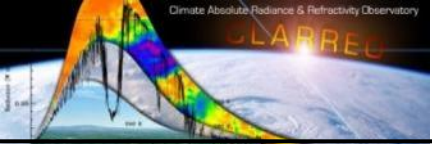




2014 Progress



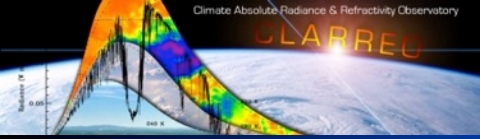
- Held LaRC and GSFC instrument design lab studies for smaller RS and IR instrument concepts: better able to fit in Venture class and lower cost/mass/power requirements, same science.
- Submitted Tech Demo Instrument concepts to NASA HQ in July 2014 and Sept 2014. Freilich reviewing. Volz now head of NOAA weather satellites (NESDIS). (LASP, UW, GSFC).
- Submitted to NASA HQ overguide budget request for Risk Reduction Unit instruments (less expensive EDU or Engineering Design Unit) in Oct 2014. (LaRC, GSFC).
- CLARREO SDT Report (led by Lukashin: ~ 200 pages and 98% complete. Now online on the CLARREO web site. Great resource for Decadal Survey or anyone interested in CLARREO.



2014 Progress

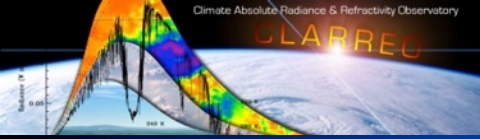


- **Key Invited Talks on CLARREO and VOI:**
 - WCRP Grand Challenge on Climate Sensitivity, March 2014, Germany
 - AMS Radiation Conference, July 2014, Boston, MA
 - AOGS, August 2014, Sapporo, Japan
- Indian Ministry for Earth Science (MoES) annual climate workshop, and Indian Institute for Tropical Meteorology, Sept 2014, India
 - *Indian space program growing*
 - *Great interest in a joint U.S./India CLARREO mission*
 - *Will explore in next few months possible instrument combinations with CLARREO spectrometers (e.g. aerosol or water vapor GPS profiling)*
 - *Might lead to 50% cost reduction for NASA. Freilich aware of interest.*
- Climate Symposium 2014, October 2014, Germany
 - *Overview of satellite climate observing priorities*



2015 Directions

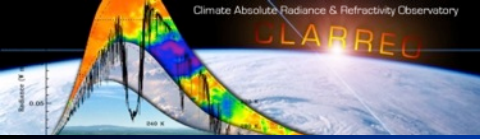
- Extend the science understanding of CLARREO requirements
- Support the next Decadal Survey (e.g. white paper)
- Educate the world on why CLARREO is a critical part of any climate observing system, and its economic value is very high
- Continue to reduce mission costs and risks



2015 Key Tasks

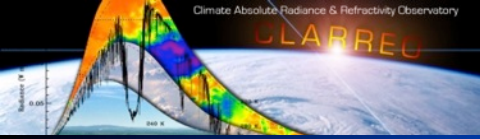
- Key journal papers we still need to publish: IR intercal and orbit sampling for spectral fingerprints. Next VOI paper (submitted Feb 2015), and potentially a paper in Foreign Affairs, Foreign Policy, PNAS, or Science/Nature journals for broad discussion of lack of a climate observing system and VOI of such a system.
- Publish CLARREO requirements as a function of wavelength using new science studies in combination with IIP and CDS instrument calibration studies ($T(z)$, $q(z)$, cloud properties, LW Cloud Radiative Forcing). Paper under development (Yolanda)
- Support studies for CLARREO Pathfinder (e.g. ISS accommodation)
- Continue to improve the SDT Summary Report for the CLARREO web site and for background support of decadal survey white paper
- Decadal Survey schedule and White Paper





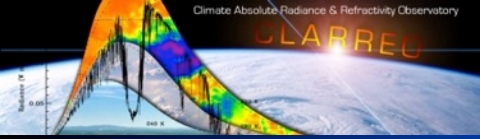
Decadal Survey Schedule

- NASA/NRC terms of reference finally signed by NASA/NOAA/USGS
 - missions as in the last decadal survey? likely NRC preference
 - science topics and priorities? likely NASA preference
 - white paper content may or may not be set in study terms
 - Terms of reference made public after approval at May 12 NRC meeting
- Expected call for White Papers: no earlier than Fall, 2015
- Expected due date for White Papers: early 2016?
- Final report due out in late 2017 or early 2018?



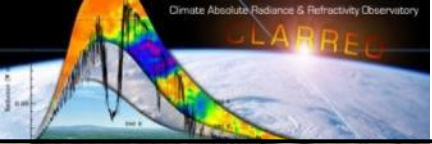
Thursday morning session for discussion of: NRC Continuity Study NRC Decadal Survey





Backup Slides





ISS Mission Concept



- Selected the Japanese Experiment Module Exposed Facility (JEM-EF) for this study
 - L/V, installation and JEM-EF interfaces defined and provided by ISS
 - Other ISS locations viable, but ram-side of JEM-EF is optimal for maximizing viewing opportunities
- Dual-instrument payload approach demonstrated by NRL's HREP

