National Aeronautics and Space Administration

Headquarters
Washington,. DC 20546-0001

Reply to Attn of: 06-221

April 12,2007

Mr. Mitchell Anderson
P.O. Box 4551
Station Main
Vancouver, British Columbia
V6B 4A1
Canada

Dear Mr. Anderson:

This is in response to your request received on May 18,2006, pursuant to the Freedom of Information Act (FOIA). On or about June 7,2006, you spoke with Ms. Kellie N. Robinson, Headquarters FOIA Public Liaison Officer. You agreed to narrow the scope of your request to *"any documents relating to the decision making process and the final decision to cancel the mission, to include documents regarding any correspondence from the science community."*

The Headquarters Science Mission Directorate conducted a search and from that search provided the enclosed documents responsive to your request. It has been determined that portions of records found responsive to your request contain information which is exempt from disclosure under the deliberative process privilege of Exemption 5. This privilege covers advisory opinions, recommendations, and deliberations, which are part of the government decision-making process.
5 U.S.C.§552(b)(5).

You may appeal this initial determination to the **NASA** Administrator. Your appeal must (1) be addressed to the Administrator, National Aeronautics and Space Administration, Washington, DC 20546, (2) be clearly identified on the envelope and in the letter as an "Appeal under the Freedom of Information Act", **(3)** include a copy of the request for the agency record and a copy of this initial adverse determination, (4) to the extent possible, state the reasons why you believe this initial determination should be reversed, and (5) be sent to the Administrator within thirty (30) calendar days of the receipt of this initial determination.

Sincerely,

Kellie N Robinson

Kellie N. Robinson
FOIA Public Liaison Officer

Enclosures

FILE COPY

Headquarters Action Tracking System (HATS)

Incoming Correspondence Action

A/2005-01311

Title : **Deep Space Climate Observatory (DSCOVR)**

Recipient: **A/Griffin**

Author: **Charlson**

Organization: **Univ. of Washington**

Action Office: **S/Fisher**

Status: **Open** Closed

Date Written: **09/21/2005**

Date Received: *09/29/2005*

Date Concurred:

Date Submitted:

Date Signed: 10/5/05

Date Closed:

>>Current Due Date: **10/14/2005<<**

Original Due Date: 10/14/2005

Signature Office: **S/CLEAVE**

Info Offices:

Abstract:

R. J. Carlson, Prof., forwards response to his 2004 letter to **Sean** O'Keefe from Dr. Asrar. Carlson wants **NASA** to know that his scientific arguments to Mr. O'Keefe are **still** valid.

Comments:

Enclosures: **letter to O'Keefe and response**

Related Records:

Keywords: carlson dscovr deep space climate observatory

File Plan: 1200-2-0321 G 05 Analyst: BFenner

UNIVERSITY OF WASHINGTON

Department of Atmospheric Sciences

28 *January* 2004

Mr. *Sean* O'Keefe, Administrator
NASA Headquarters, *Code* A
300 "E" Street, S.W., Suite 9F44
Washington DC 20546-0001

Dear Mr. O'Keefe,

I am writing to you as an individual scientist to bring to your attention a serious *gap* in the development of an observational basis for quantifying the natural and forced changes in the Earth's climate. Specifically, I want fo urge NASA to move ahead with the deployment of the Deep Space Climate observatory, DSCOVR, as a means to significantly refine the understanding and quantification of the Earth's reflectance *or* albedo.

My own research for the past 14 years has focused on quantification of the effects of anthropogenic aerosols on the Earth's reflection and absorption of solar radiation; indeed, my colleagues and I published the first papers on the complex topic of climate forcing by anthropogenic aerosols *As* a member of the Science Team for the NASA satellite CALIPSO, I am fully aware of the fine opportunities for measurement *that* its laser radar will provide along with the rich data *set* expected from the Aqua-Train. We are confident *that* these new data sources will significantly improve our ability to calculate the climate forcing by aerosols, and it will provide important reductions in *the* dependence upon assumptions regarding aerosol effects in climate models.

But, the larger context of these aerosol effects is the albedo of the planet, which *is* one of *the* least well-quantified factors influencing the *Earth's* energy balance. The global albedo is largely determined by the properties and areal extent of clouds. It is very difficult to model and is measured only with large uncertainties, even by the best radiometers aboard NASA satellites, such as CERES. Among the difficulties with information gained from instruments *in* low Earth orbit is the fact that the satellite *"sees"* only a small portion of the planet at any instant, and polar orbiting platforms are usually sun-syncronous such that they *make* observations at only one time of day and at one or a few angles. The classical technique for determining *the* Earth's albedo is based on observations of the portion *of* the moon illuminated by "Earthlight". This method complements existing satellite observations, and at times *can* "see" nearly the whole sunlit hemisphere, but still has an accuracy of only about 0.006 (in albedo units), which in turn results in an uncertainty in energy balance around 2 Watts per square meter. For reference, the total forcing by greenhouse gases *is* 2.4 Watts per square meter, which has an uncertainty of only about 10%. Thus, the uncertainty in the measurement of albedo and its variations *is* as large or larger *than* the whole man-made *greenhouse* effect. Importantly, much work has been done over the last century on the greenhouse effect but very little has been done about global albedo, largely because clouds are so difficult to model and to measure globally.

In order to obviate this serious problem, radiometers carried aboard DSCOVR could be used to provide much refined data on albedo and its geographical and temporal variability. Its accuracy should be comparable to that of the lunar method. Its high time resolution will undoubtedly

408 Atmospheric Sciences-Geophysics Box 351640 Seattle, Washington 98195-1640
206-543-4250 FAX: 206-543-0308 www.atmos.washington.edu

reveal new aspects of the factors causing albedo fluctuations. It would observe continuously nearly the entire sunlit Side of the Earth from a unique vantage in the vicinity of the L1 point between Earth and the sun. These instruments and the satellite platform for them have been built and are now in storage for want of a launch opportunity.

When launched, DSCOVR will continuously observe the same exact scenes as will be observed by the satellites of the A-Train, providing coincident, multivariate data sets for detailed analysis. Great synergistic value will be added to the A-Train data sets via comparisons and contrasts to the more global data of DSCOVR. Just as albedo is the global context for studying and understanding aerosol effects, the near-hemispheric data of DSCOVR will provide a continuous context for the more detailed measurements made from those platforms in low Earth orbit. Considerable additional value will accrue, far beyond the actual cost of launching and operating DSCOVR.

Recent papers (e.g., J. Geophys. Res. 108(D22) 4709doc:10.1029/2003JD003610,2003; Ibid, 4710doi:10.1029/2003JD003611,22003) including both satellite- and lunar-based observational estimates show that the global albedo is a dynamic quantity with large (many percent) variations that are not captured well in global climate models. However, tests of the internal consistency of these estimates show significant disagreements, even in the nature of the annual variations. DSCOVR will provide an objective means for testing the internal consistency of all of the above as well as the data from the A-Train.

Again, I urge you to press the case for launching and operating DSCOVR so that we in the scientific community can make real progress toward understanding climate and the impacts of human activity upon it. Without it, we will continue to be stuck with excessive uncertainties and dependence upon assumptions instead of data.

sincerely,

R.J Charlson

Robert J. Charlson
Professor
Department of Atmospheric Sciences
TEL (206) 543-2537

cc. Dr. Ghassem Asrar
Prof Daniel Jamb
Dr. Jeffrey Kiehl
Prof. John Seinfeld
Prof. Richard C. J. Somerville
Prof. Francisco P.J.Valero
Dr. David Winker

FILE COPY

Headquarters Action Tracking System (HATS)

Incoming Correspondence Action

A/2006-00540

Title :	**Deep Space Climate Observatory (DSCOVR) Mission**		
Recipient:	**A/Griffin**		
Author:	**Valero**		
Organization:	**Univ. of Calif./San Diego**	**Date Written :**	**03/29/2006**
		Date Received:	03/30/2006
		Date Concurred:	
		Date Submitted:	
		Date Signed:	
Action Office:	**S/Cramer**	**Date Closed:**	**05/05/2006**
		>>Due Date:	**04/28/2006<<**
Status:	**Closed**		

Signature Office: S/CLEAVE

Info Offices:

Abstract:

Francisco P.J. Valero, Dir., Atmospheric Research Lab., requests that the Administrator reconsider his decision to terminate DSCOVR.

Comments:

Enclosures: **Five enclosures (sent to SMD)**

Related Records:

Keywords: dscovr climate observatory
File Plan: 1200-20321G06 Analyst: BFenner

Headquarters Action Tracking System (HATS)

Incoming Correspondence Action

A/2006-00540

Progress Notes:

05/05/2006 11:43AM,	S/CLEAVE:	Scanned copy to Bridget Fenner for closure.gaa
05/01/2006 02:39PM,	S/CLEAVE:	Action Forwarded to S/Cramer

Keywords: dscovr climate observatory

File Plan: 1200-20321G06 Analyst: BFenner

Hammer, Theodore F. (HQ-DK000)

From: Gregory Williams [gregory.j.williams@nasa.gov]
Sent: Thursday, December 01, 2005 1:44 PM
To: Theodore Hammer
CC: Roy Maizel
Subject: Triana in the budget

Ted -

Here are some budget history factoids that may help:

In the FY2002 budget request to Congress (Feb 2001), the official budget justification document said this about the status of Triana:

"Because the launch date for Triana remains uncertain until the Shuttle manifest becomes definitized, Triana will be placed in storage following completion of spacecraft development."

In the FY02 budget request, dollars for Triana were shown as:
FY2001 24.9M
FY2002 0

In the FY2003 budget request to Congress (Feb 2000), the official budget justification document said this about the status of Triana:

"The Triana instruments and spacecraft have completed environmental testing as an observatory and are currently in storage awaiting launch readiness call up."

In the FY03, dollars for Triana were shown as:
FY2001 24.9M
FY2002 1M

In the FY2004 budget documentation, no mention of Triana/DSCVR is made at all, and no funds requested at the level of an ESSP project. By the end of FY2002, all we were paying for were storage costs.

All this happened because of the 2000 Congressionally-imposed standdown on Triana development while the NRC conducted its study of the scientific merits of Triana at the Congress' request. In 2000 and 2001, the Triana schedule and Shuttle flight & manifest schedule where both in flux, and in 2001 the decision was made to pull Triana off the STS-107 manifest due to schedule incompatibility. No future STS opportunity presented itself, and STS-107 [Columbia] was lost in February 2003.

Greg
--
Gregory J. Williams
Senior Policy Analyst
Science Mission Directorate
NASA Headquarters
Washington DC 20546
Office: (202) 358-0241

Hammer, Theodore F. (HQ-DK000)

From: Hooker, Ron (HQ-DE000)
Sent: Tuesday, October 25, 2005 3:37 PM
To: Barber, Patsy (HQ-HA000)
CC: Brown, Faye (HQ-DF000); Hammer, Theodore F. (HQ-DE000)
Subject: DSCOVR Letter
Importance: High
Attachments: DSCOVR Valero letter v0.doc; DSCOVR Valero Exec Summary.doc

Patsy,

Please prepare and route for Dr. Cleave's signature the attached draft letter-regarding the DSCOVR project. Include the Executive Summary (also attached). Additionally, I will provide you with the originating incoming letter to be included as background material along with the Executive Summary.

Let me know if ybu I can be of help.

Thanks Much,
Ron

--
Ron Hooker
Science Mission Directorate, NASA Headquarters
202 358-4508' office, 202 285-5199 cell

Hammer, Theodore F. (HQ-DK000)

From: Mary Cleave [mary.cleave@nasa.gov]
Sent: Thursday, December 01, 2005 8:28 AM
To: Ted
Subject: FW: Triana

****
Mary L. Cleave, Ph.D., P.E.
Associate Administrator for Science
NASA/Headquarters
Washington, DC 20546-0001
Internet: MaG.Cleave@nasa.gov
****

------ Forwarded Message
From: "Maizel, Roy A. (HQ-DB000)" <roy.a.maizel@nasa.gov>
Date: Thu, 1 Dec 2005 08:17:28 -0500
To: "Cleave, Mary (HQ-DA000)" <mary.cleave@nasa.gov>
Conversation: Triana
Subject: Triana

Mary-
2003 was the last year we had any funding on the Triana mission.
Roy

------ End of Forwarded Message

UNIVERSITY OF CALIFORNIA, SAN DIEGO

BERKELEY • DAVIS • IRVINE • LOS ANGELES • RIVERSIDE • SAN DIEGO • SAN FRANCISCO SANTA BARBARA • SANTA CRUZ

FRANCISCO P J VALERO
DISTINGUISHED RESEARCH SCIENTIST
DIRECTOR, ATMOSPHERIC RESEARCH LABORATORY
SCRIPPS INSTITUTION OF OCEANOGRAPHY

9500 GILMAN DRIVE, LA JOLLA,
CALIFORNIA, 920934242

March 29,2006

Honurable Dr. Michael Griffin
Administrator NASA
NASA Headquarters 9F44
300 E Street SW
Washington, DC 20546-0001

Dear Dr. Griffin:

The Deep Space Climate Observatory (DSCOVR) is recognized worldwide as a truly innovative mission that will provide high-priority, ***unique*** scientific information needed36 **help** solve uncertainties in climate, Earth energy balance and global warming research. The international impact of the DSCOVR science objectives is reflected in the composition of the science team that includes co-investigators from France, Germany, Holland, Italy, Japan, Russia and the **USA.** In addition, the DSCOVR solar instruments are capable of meeting the solar weather monitoring needs of our country. On the basis of the above, I am requesting that you kindly re-consider the decision to terminate DSCOVR. It is also most important that **GSFC** be directed **to** preserve the DSCOVR assets in flight condition until a decision is made.

From the budgetary point of view, DSCOVR **is** by far the least expensive method of achieving high **priority,** critical Earth science objectives (e-g. establishing integral constraints for climate observing satellites, unique systematic measurements of climate parameters and consistent calibrations to be provided and shared with radiometric and spectro-radiometric systems in **space** (Atch 1). The synergism to be generated by the "integration" of LEO and GEO Earth observing satellites would be of incalculable value, scientifically and financially.

As an example, major cost savings for the agencies and for the Nation, while conserving intact the scientific and solar monitoring functions **of** DSCOVR, could be possible by implementing either totally or partially *the* suggestions in the following two **paragraphs:**

1) **A** recent NOAA study to assess ?heutilization of the DSCOVR solar weather monitoring instruments to replace the ACE mission currently at L1 provided updated costs to complete the DSCOVR mission. There is now a window of opportunity *to* cost share with NOAA on the completion of the DSCOVR mission to the advantage of both agencies and the American public.

A/2006-00540

2) A ride-share with the Lunar Reconnaissance Orbiter (LRO) is possible utilizing the excess capacity of about 1000 Kg (DSCOVR weights only 570 Kg) of the heavy lift launcher being used by the LRO. The deepspace trajectory for LRO and DSCOVR are compatible and DSCOVR can be ready before the Oct 2008 launch date projected for LRO. NASA ESMD is in the process of selecting payloads fur the utilization of the excess capacity and is willing to contribute towards payload costs, in addition to the launch. DSCOVR's solar weather instruments can provide radiation early warning for the safety of manned and unmanned payloads in lunar exploration, both orbital and surface missions.

Going back to the high standing of DSCOVR's science let me re-iterate that science review panels, including four boards of the National Academy of Sciences (NAS), have repeatedly endorsed the scientific significance of the mission. The NAS report highlights the unique scientific approach and innovation that DSCOVR would bring to the Earth sciences and clearly notes its high priority, ". ...the impact is sufficiently valuable to Earth science that such a mission might have been viewed as an earlier NASA priority had adequate technology been available at reasonable cost", (Atch 2). The reference for the complete NAS report is: National Academy of Sciences, *Space Studies Board Annual Report* 2000 (National Academies Press, Washington, DC, 2001), pp. 93-108.

Recent news articles regarding the termination of DSCOVR have sparked scientific community concern and renewed support for the mission. I am enclosing a reduced sample of the letters that I have received during the last few weeks from prominent scientists in the U.S and abroad (they have agreed that I can share the letters with you). I include in this package letters from US and foreign institutions as well as letters from individuals working in various applicable disciplines (Atch 3).

DSCOVR has unfairly suffered from much political misunderstanding. In reality, DSCOVR is a high-priority, peer-reviewed scientific mission, selected on the basis of its merits, conceived and developed by a team of experts. Possibly, the most reviewed small project ever. I have enclosed my editorial response recently published in *Science* to highlight that Scripps' only motivation in this mission is cutting-edge science **(Atch 4).**

Finally, if DSCOVR remains terminated, the needs that it would serve will not go away. Addressing those needs with a new mission would be far more expensive than completing DSCOVR now. Moreover, the major, non-recoverable, cost of termination will be the sacrifice of the invaluable scientific benefit of synergism and co-observation with existing and soon to be launched satellites, including the A-Train. For example, one of the biggest uncertainties in the whole arena of science of climate change is the albedo of Earth, how it varies naturally and due to exogenous forcing and how it may be involved in climatic feedbacks. DSCOVR would uniquely measure a single vector in the reflectance phase function of Earth from L1, simultaneously observing the entire sunlit disc of the planet *and* simultaneously would act as a comparison/calibration check for all existing LEO and GEO satellites. This is particularly *urgent* now that the global warming/albedo questions require an immediate answer (see for example: Charlson, Valero, Seinfeld, "In Search of Balance", *Science* 6 May 2005 308: 806-807 (Atch 5).

I am ready and eager to participate, if you find it useful, in any meetings/workshops that may be organized to discuss possible Earth sciences missions.

Looking forward to a favorable decision, please accept my sincere regards,

Francisco P. J. Valero

Francisco P. J. Valero

5 Attachments:

1. "Earth Sciences from a New Perspective, the Deep **Space** Climate Observatory (DSCOVR)"
2. Cover letter/executive *summary* of the **NAS** report on Triana (DSCOVR).
3. Sample of recent letters from the science community. Shared with the author's permission.
4. Valero F.P.J., "Keeping the DSCOVR Mission Alive" *Science* 10 February 2006.311, 775-776.
5. Charlson R., Valero, F.P.J. and Seinfeld J., "In Search of Balance", ***Science 6*** May *2005* 308: 806-807 (in Perspectives).

cc: Dr. Mary Cleave, Associate Administrator, SMD
Dr. Scott Horowitz, Associate Administrator, ESMD
DSCOVR Science Team

Headquarters Action Tracking System (HATS)

Incoming Correspondence Action

A/2006-00540

Title : **Deep Space Climate Observatory (DSCOVR) Mission**

Recipient: A/Griffin

Author: Valero

Organization: Univ. of Calif./San Diego

Date Written: 03/29/2006

Date Received: 03/30/2006

Date Concurred

Date Submitted:

Date Signed:

Action Office: A/Davis, S/CLEAVE

Date Closed:

>>Due Date: 04/28/2006<<

Status: Open

Signature Office: S/CLEAVE

Info Offices: A/Griffin, A/Morrell, AA/Geveden, AD/Dale, B/Sykes, I/O'Brien, T/Horowitz

Abstract:

Francisco P.J. Valero, Dir., **Atmospheric** Research Lab., requests that the Administrator reconsider **his** decision to terminate DSCOVR.

Comments:

Enclosures: Five enclosures (sent to SMD)

Related Records:

Keywords: dscovr climate observatory

File Plan: 1200-20321606 . Analyst: BFenner

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Incoming Correspondence Action

A/2006-00540

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Recipient:	A/Griffin		
Anthor:	**Valero**		
Organization:	**Univ. of Calif./San Diego**	**Date Written:**	**03/29/2006**
		Date **Received**	03130/2006
		Date **Concurred**	
		Date Submitted:	
		Date Signed:	
Action Office:	**A/Davis, S/CLEAVE**	**Date Closed:**	
		>>Due Date:	**04/28/2006<<**
Status:	**Open**		

Signature Office: S/CLEAVE

Info Offices: A/Griffin, A/Morrell, AA/Geveden, AD/Dale, B/Sykes, I/O'Brien, T/Horowitz

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File Plan; 1200-20321606 Analyst: **BFenner**

UNIVERSITY OF CALIFORNIA, SAN DEGO

BERKELEY • DAVIS • IRVINE • LOS ANGELES • RIVERSIDE • SAN DIEGO • SAN FRANCISCO SANTA BARBARA • SANTA CRUZ

FRANCISCO P J. VALERO
DISTINGUISHED RESEARCH SCIENTIST
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SCRIPPS INSTITUTION OF OCEANOGRAPHY

9500 GILMAN DRIVE, LA JOLLA,
CALIFORNIA, 92093-0242

March 29,2006

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Administrator NASA
NASA Headquarters 9F44
300 E Street SW
Washington, DC 20546-0001

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Francisco P. J. Valero

Francisco P. J. **Valero**

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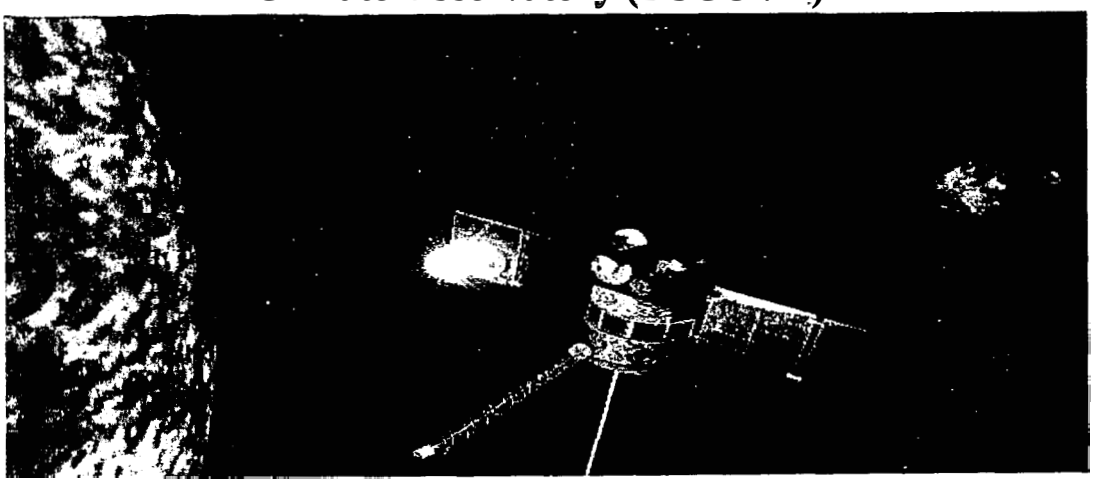
3. **Sample of recent letters** fiom **the science community. Shared** with **the author's permission.**
4. **Valero F.P.J., "Keeping the DSCOVR** Mission **Alive"** ***Science*** **10 February 2006.311, 775-776.**
5. **Charlson R.,** Valero, **F.P.J. and Seinfeld** J., **"In Search of** Balance", ***Science 6*** May 2005 **308: 806-807 (in Perspectives).**

cc: Dr. Mary **Cleave, Associate Administrator, SMD**
Dr. **Scott Horowitz, Associate Administrator, ESMD**
DSCOVR Science Team

Earth Sciences from a New Perspective, the Deep Space Climate Observatory (DSCOVR)



Submitted by Francisco P.J. Valero, DSCOVR Principal Investigator- based on contributions by the DSCOVR Science Team

Scripps Institution of Oceanography, University of California, San Diego

Francisco P. J. Valero, PI
Brett C. Bush
Shelly K. Pope
V. Ramanathan
Dan Lubin
Sally Ride

NASA Goddard Space Flight Center
Jay Herman, *GSFC* Project Scientist
Keith Ogilvie
Warren J. Wiscombe

National Institute of Standards and Technology
Steven Lorentz

NASA Langley Research Center
Patrick Minnis

University of Colorado
Peter Pilewskie

National Center for Atmospheric Research
William D. Collins

University of Texas, Austin
Keith D. Hutchison

Lockheed Martin Missiles and Space
John H. Doolittle

Laboratoire de Meteorologie Dynamique, Ecole Normale Superieure, France
Claude Basdevant
Bernard Legras
Hector Teitelbaum

Virginia Polytechnic Institute
G. Louis Smith

Boston University
Alan Strahler

Istituto di Scienze dell'Atmosfera e del Clima, Bologna, Italy and Italian Space Agency
Claudio Tomasi
Roberto Guzzi

KNMI, The Netherlands
Ankie J.M. Piters

University of Bremen, Germany
John Burrows

St Petersburg University, Russia
Irina Melnikova

Japanese Space Agency (NASDA)
Makoto Suzuki

L l Standards and Technology Corporation
Steven Lorentz

Earth Sciences from the Astronomer's Perspective

1.0 Mission Concept and Purpose

Earth observations from satellites located in deep space offer the exciting opportunity to look at the Earth in a bulk thermodynamic sense, particularly as an open system exchanging radiative energy with the Sun and space, in a way never done before – "the Earth as a whole planet", astronomers would say. This is a fundamental scientific goal with very appealing prospects for climate sciences. Climate research requires stable, accurate, long-term observations made with adequate spatial and temporal resolution in a synoptic context. From deep-space vantage points we can, with a single spacecraft, sample the outgoing energy from virtually an entire hemisphere of Earth at once with high temporal and spatial resolution. At present this is only partially possible by combining data from low Earth orbit (LEO) and geostationary orbit (GEO) satellites into an asynoptic composite of hundreds of thousands of pixels - rather like assembling an enormous jigsaw puzzle. Another advantage of the deep-space perspective is that, because of the integral view of the planet's hemispheres, the observations will simultaneously overlap the observations of every LEO and GEO satellite in existence, making possible a unique synergy with great potential benefits for the Earth sciences.

For example, a satellite placed at the Lagrange 1 (L-1) point between the Sun and the Earth orbits the Sun with the same period as the Earth. (The Lagrange points mark positions where the gravitational pull of the two large masses precisely equals the centripetal force required to rotate with them. The net effect is that a satellite at the solar Lagrange points will orbit the Sun with the same orbital period as the Earth.) Therefore, a satellite placed at one of these Lagrange points would maintain the same relative position to the Sun and the Earth and be able to observe most points on the sunlit planet as the Earth rotates during the diurnal cycle. L-1 and **L-2** are of particular interest because a satellite at either location remains on the Sun-Earth line and views, respectively, the entire daytime hemisphere and the entire nighttime hemisphere. Synoptic, high temporal-resolution observations would be obtained as every point on the planet transits from sunrise to sunset (L-1) or from sunset to sunrise (L-2). **A** pair of deep-space observatories, one at L-1 and one at L-2, could observe almost every point on Earth simultaneously.

The combination of deep-space, LEO, and GEO satellites would certainly provide a powerful observational tool as well as enriched data sets for Earth sciences. Such synergism is greatly enhanced when one considers the potential of utilizing LEO, GEO, and deep-space satellites as an integrated observational system. For example, a satellite at L-1 will view the Earth plus the Moon (see Figure 1) while simultaneously having in its field of view (at one time or another) all Earth-orbiting satellites. This view offers the opportunity to use the Moon as a calibration reference that can in turn be shared with all other Earth observation satellites. In other words, the deep-space observatory can become an important link between LEO and GEO satellites while at the same time providing the data necessary to build an integrated Earth observational system. Such

1. Simulated near R view of u constructed from actual cloud observations seen by the Galileo aft near 1 The fa has b inse from ti of the sunlit d using Clementine t The Moon iew will be s d in-flight calibr io of t EPIC spectra channels

synergism would certainly represent a major advance in Earth sciences and a greatly enhanced return for the nation's investment in space. The unified, synergistic observational system has been the dream of Earth scientists for many years.

The vision of developing an integrated observational system of LEO, GEO and deep-space satellites is very promising for Earth sciences research. The nation would benefit from the advanced and unique studies that would result at minimal additional cost to taxpayers since the LEO and GEO Earth observing satellites are already in place. Only the addition of one or two deep-space platforms will be needed in order to forge observations performed by multiple, mostly independent satellites into a single correlated data set. The benefit for science could be considerable. A synergistic system composed of LEO, GEO, and deep-space platforms is likely the way of the future.

In addition to the unique observations of the Earth system, the Lagrange 1 position offers the opportunity for simultaneous solar observations and monitoring of solar activity and its effect on the upper atmosphere of the Earth that respond to the variations in the solar ultraviolet, visible and particles emissions.

DSCOVR will have a *continuous (from sunrise to sunset)* and *simultaneous* view (see Fig. 2) of the sunlit face of the rotating Earth. This ability alone gives the DSCOVR observations a capability never available from any other spacecraft or Earth observing platform in the past. Additionally, DSCOVR will always observe from the near retro-reflection position, a unique viewing geometry. Spectral images and radiometric measurements will be made to obtain important atmospheric environmental data (e.g., ozone, UV-irradiance at the Earth's surface, water vapor, aerosols, cloud height, etc.) and information related to the Earth's energy balance. DSCOVR measurements will have the advantage of synoptic context, high temporal and spatial resolution, and accurate in-flight lunar calibrations. Except for the period immediately after launch, DSCOVR will observe from near the retro-reflection position and gain a unique piece of the Earth's energy-balance data, along with having increased sensitivity to changes on the Earth's surface.

In this document we describe the questions that can be addressed by the DSCOVR data. We also demonstrate the value of deep-space observatories for acquiring important data not available in other ways. A few key points emphasizing the unique features of the spacecraft's L-1 view of the Earth will be presented here.

2.0 DSCOVR Scientific Goals

2.1 Earth's Atmosphere and Surface with **EPIC**

Using the DSCOVR Earth Polychromatic Imaging Camera (EPIC) instrument, for the first time it will be possible to determine the daily cycles in total ozone, aerosols, and column water vapor at high temporal and spatial resolution. Ten global spectral images of the sunlit side of the Earth will be acquired within 2 minutes with a spatial resolution of **8** km at nadir to 14 km near the Earth's limb.

For example, Ozone anomalies arising from a variety of sources can be tracked with much improved accuracy and related to their meteorological environment. This new knowledge should greatly enhance our basic understanding of ozone processing in the atmosphere and permit more accurate modeling and prediction of ozone variations. The ozone data, in combination with data-assimilation modeling, will also be used to study

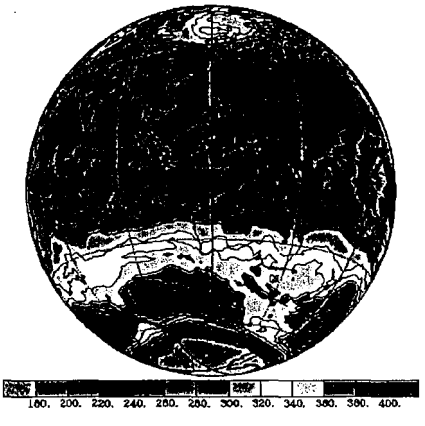


Figure 2. TOMS data was used to simulate the nearly instantaneous global ozone map (in Dobson units) as will be seen from DSCOVR during the southern hemisphere spring. DSCOVR's position on the Lissajous orbit has been optimized for seeing southern polar regions. Actual DSCOVR views will have higher spatial and time resolutions and will not be limited to near local noon. A strong gradient of column ozone is seen at the edge of the polar vortex. The variations in column ozone around the vortex are associated with planetary waves.

wave motions, including gravity waves, in the stratosphere much better than previously possible. Other dynamical processes such as the polar vortex structure, near-tropopause circulations, and jet stream winds can be observed. Arctic ozone depletion events can also be detected to assess their ecological threats through enhanced UV radiation. The DSCOVR ozone, cloud, and aerosol data can be used to compute surface UV irradiance each hour so that exposures and health risks can be more accurately determined.

Aerosols will be monitored hourly during the day using combinations of UV and visible wavelengths. The new combination of wavelengths allows determination of optical depth, single scattering albedo, and particle size. Previous use of visible wavelengths for aerosols has been limited to water or forest backgrounds. This new information, provided at high spatial and temporal resolution, will be extremely useful for understanding and modeling the processes that disperse and deplete aerosols, allowing for

better assessment and prediction of their chemical, cloud, and radiative impacts. Detection of aerosols in the Arctic Basin, where anthropogenic haze (Arctic Haze) is a significant factor, permits a more accurate determination of the aerosol impact in this extremely sensitive part of the world. The ability to detect aerosols each hour at high spatial resolution will be exploited to provide timely warnings of volcanic ash events and visibility anomalies (smoke and dust plumes) to the air transportation industry (through the FAA), the **US** Park Service, and the EPA.

EPIC data will also be used to develop valuable new information about cloud, water vapor, and surface properties. Since LEO/GEO satellites are being used to develop comprehensive climatologies of cloud properties at high spatial and temporal resolution, the unique viewing geometry of EPIC can be exploited in conjunction with these other satellites to determine cloud phase and particle shape. Cloud particle habit (shape) is an assumed parameter in current retrieval methods and in mesoscale models and GCMs. Retrieval of this parameter on a global basis will reduce the uncertainties in cloud and radiation modeling as well as in the retrievals of cloud particle size and ice water path. The atmospheric column water vapor will also be derived from reflected measurements over all surfaces on an hourly basis that will complement similar estimates fiom infiared retrievals of upper tropospheric water vapor column. The near retro-reflection geometry of the EPIC view can also be used to determine anisotropic reflectance properties of various types of vegetation and to improve characterization of canopy structure and plant condition. Diurnal variations of surface spectral albedo will also be derived to provide more accurate models for radiation calculations in GCMs and other atmospheric models.

DSCOVR is a valuable platform for half of a multi-angle remote sensing program because its EPIC images can be collocated with those from any other satellite with close temporal and spatial tolerances. Although only one multi-angle application has been noted, it is expected that the ease of matching EPIC and other satellite data will be an extremely valuable resource for remote sensing and, ultimately, climate modeling, especially in the area of validation. Conversely, other satellite and ground-based measurements taken at sparse temporal or spatial resolution will serve to verify DSCOVR's hourly retrievals.

DSCOVR's use of the "far side" of the Moon as a calibration reference (see Fig 1) can also help to assess the calibration of other satellite sensors through matching of co-angled collocated pixels, It is expected that the data will be used to characterize the spectral response of the lunar surface.

The global, high-resolution monitoring of the Earth with EPIC's unique spectral complement will also be valuable for scientific field missions. Phenomena such as aerosol plumes that were only detectable with once-per-day satellite observations can be compared in the field each hour. Mission guidance can be provided for aircraft observations of aerosol plumes or ozone changes. Thus, large-scale context can be characterized more accurately and more information can be provided to mission planners.

2.2 Earth's Radiation and Climate with NISTAR

The National Institute of Standards and Technology Active-cavity Radiometer (NISTAR) instrument will allow the first synoptic study the earth's radiative balance utilizing the unique view of the integrated sunlit Hemisphere of the Earth system. Such synoptic and high-time resolution (a few minutes) view will provide much needed data with different scattering geometry, absolute calibration accuracy and spectral, space and time resolution.

NISTAR is a 4 channels absolute cavity radiometer that includes:

1) **A** UV to far infrared (0.2 to 100 pm) channel to measure total radiant power in the UV, visible, and infrared wavelengths
2) A solar (0.2 to **4** μm) channel to measure reflected solar radiance in the UV, visible, and near infrared wavelengths
3) A near infrared (0.7 to 4 pm) channel to measure reflected IR solar radiance
4) A non-absolutely calibrated photodiode (0.3 to 1 pm) channel for calibration reference for the spectroradiometer.

The absolute accuracy of the NISTAR is 0.1 to 0.2 % as tested after calibrations at the National Institute of standards and in its present condition. It is at the level of accuracy sufficient for climate studies and represents the most advanced absolute radiometry technology not employing cryogenic detectors.

The climate of Earth and its global mean surface temperature are the consequence of a balance between the amount of solar radiation absorbed by Earth's surface and atmosphere and the amount of outgoing longwave radiation emitted by the system. The former is governed by the albedo (reflectivity) of the system, whereas the latter depends strongly on the atmospheric content of gases and particles (such as clouds and dust). While the theory of absorption of infrared radiation in the atmosphere [Arrhenius, 1896] is well accepted and embodied in climate models, the observational and theoretical treatments of albedo, aerosols and clouds (in particular radiative effects) and their interactions are still under development.

The buildup of CO_2 (5), **CH4** and other greenhouse gases during the past century leads to an increased absorption of infrared radiation in the atmosphere (enhanced greenhouse effect) and a consequent warming ("positive forcing") of the climate. But, human-made changes in aerosols and clouds can cause enhanced albedo and hence cooling ("negative forcing"), and they may already have offset a substantial part of the enhanced greenhouse effect. Present trends suggest that by 2050, the magnitude of enhanced greenhouse effect will be so large that the net anthropogenic forcing will be unequivocally positive and substantial in magnitude [Anderson et al., 20031.

Changes in energy balance affect a host of climatic factors, such as temperature, sea level, meteorological patterns, and precipitation. To understand and quantify these effects, the enhanced greenhouse effect and all other forcings must be known accurately. To complicate matters further, the enhanced greenhouse effect is suspected of causing

changes in clouds and hence albedo, resulting in feedbacks on both incoming and outgoing radiation [Sun and Cess, 20041.

Increased albedo could counteract the enhanced greenhouse effect on a global scale. However, the spatial and temporal characteristics of aerosols, clouds, and greenhouse gases differ widely. Clouds change rapidly, and atmospheric residence times for aerosols are short compared to those for the key greenhouse gases (which remain in the atmosphere for centuries). Albedo therefore changes rapidly, whereas the enhanced greenhouse effect simply increases as a result of the slow accumulation of greenhouse gases. Local and regional changes in energy balance would occur even if the albedo change could offset the enhanced greenhouse effect globally. Light-absorbing aerosols further complicate the picture by cooling Earth's surface, heating the atmosphere, and making clouds more absorbing; they may even reduce cloud cover, thereby decreasing albedo further.

These considerations underscore the importance of understanding the natural and anthropogenic changes in Earth's albedo and the need for sustained, direct, and simultaneous observations of albedo with all methods that are currently available. Albedo changes may be as important as changes in greenhouse gases for determining changes in global climate [Charlson et al., 20051.

Many methods have been used to estimate albedo, which cannot be measured directly. These methods differ in their scattering geometries, calibration accuracy, and in spectral, space, and time coverage. The different modes of observation include measurements of earthshine reflected from the Moon [Palle et al., 2004; Palle et al., 20031, broadband radiometer data from low orbits around Earth [Wielicki et al., 20051, geostationary cloud-cover observations [Zhang et al., 20041, deep space radiometry [NAS, Space Studies Board, 2001] and surface radiometry [Pinker ***et al.,*** 2005; Wild ***et al.,*** 2005]. All these methods require a theoretical model for relating the measured parameters to albedo, and they all rely on different assumptions. It is critical to compare the results from different approaches to test the consistency among them. DSCOVR's deep space radiometry [NAS, Space Studies Board, 2001] would provide a crucial component to such studies by providing an alternative, different approach to global albedo determination.

When combined with the EPIC imagery and retrievals of cloud properties, the NISTAR shortwave radiances will produce estimates of the global albedo. The derived albedo values, or the original radiance data, can serve to evaluate the radiation calculations in GCMs. The NISTAR shortwave and longwave radiances will also be used to estimate errors in the albedos and longwave fluxes derived from interpolations of sparsely sampled LEO data, the more conventional technique for measuring the Earth radiation balance.

Because the near-infrared channel is sensitive to vegetation and snow/ice cover in addition to clouds, the NIR/VIS ratio is an attractively simple and fundamental analysis tool for studying global change, and DSCOVR is the perfect vantage point to begin using that tool. (No current or planned LEO or GEO Earth radiation budget satellites have a broadband near-infrared channel, although CERES is apparently planning to add one in the post-2003 timeframe, which should serve as a nice complement to that on DSCOVR.)

A modeling infrastructure will be developed based upon existing efforts at NCAR, participating **NASA** laboratories, and other institutions. This modeling infrastructure will be used to simulate the NISTAR signals and EPIC spectral imagery. Because of DSCOVR's simple viewing geometry and relatively simple data processing requirements compared to LEO satellites, scientists and students would be able to study a wide variety of phenomena without many of the complexities usually associated with remote sensing. Because of the lunar calibration for EPIC and absolute calibration for **NISTAR,** the scientific community would be able to focus on geophysical applications of a stable, high-accurate data set. This could have important repercussions both for remote sensing and climate.

2.3 Solar Wind and Space Weather with Plasma-Mag

The Plasma-Mag instruments will contribute to both the source and structure of the slow solar wind and the heating of the corona. The mechanisms for heating the solar corona to temperatures that are much hotter than the photosphere are not well understood. Waves in the solar wind almost certainly undergo a turbulent cascade to heat the wind at small scales, but our current descriptions of this are mostly phenomenological. More generally, the coupling between magnetic and electric fluctuations and particle distribution functions is a fundamental plasma interaction, important in a wide variety of contexts, but difficult to study directly. The improved time resolution of DSCOVR/Plasma-Mag provides an opportunity to determine the mechanism by which small-scale fluctuations dissipate in plasmas. **A** time resolution of less than 1s will provide information to determine how the plasma responds to the simultaneously measured magnetic fields.

DSCOVR would also provide a monitor of the solar wind in addition to any other spacecraft that may still be available at the time of its launch. This would allow the detailed study of the non-radial correlation with solar wind fluctuations. This study was begun with earlier spacecraft such as the Explorers, IMP, and ISEE, but new opportunities would now be available. For example, if WIND or a STEREO spacecraft were measuring the solar wind at a variety of positions away from L-1, this would provide correlation at multiple baselines. These measurements would help to determine the symmetry of the fluctuations in the wind that in turn determine the way in which energetic particles propagate in the heliosphere. This basic understanding is also central to determining how, for example, solar events affect the Earth and its near-space environment, and thus is important for determining the effects of solar activity on spacecraft and manned space flights.

The Plasma-Mag instruments will measure the magnetic field and the velocity distribution functions of the electron, proton, and alpha components of the solar wind with higher time resolution than existing spacecraft.

The three Plasma-Mag instruments (Faraday cup, magnetometer, and electron spectrometer) will obtain 3-dimensional measurements of the velocity distribution functions of protons, helium ions, and electrons, and the interplanetary magnetic field. The data can be collected with high temporal resolution because DSCOVR is a fixed

orientation spacecraft that permits the solar wind ions and electrons to strike the Faraday cup continuously. The data collected by Plasma-Mag will provide early warning of solar events that may cause damage to power generation, communications, and other satellites. Together, the Plasma-Mag suite of instruments will provide a 1-hour warning to the appropriate agencies that safeguard electrical equipment on Earth and satellites in Earth orbit. Present plans include routinely providing the data to NOAA with typically only a 5-minute data processing delay from detection of an event at the DSCOVR spacecraft position to the time that it is delivered. Monitoring of the solar weather has become a mandatory function of government due to the growth of civilian and military satellite communications. Plasma-Mag will add to, or replace, the first generation space-weather monitors, such as WIND, IMP-8, and ACE.

2.4 Possible Science Enhancements to the DSCOVR Mission

A. The Sun-Earth Coupling.

A major enhancement to the DSCOVR existing scientific objectives would be to include solar activity forecasts and the Earth's response into climate forecasts. To achieve such an objective it is necessary to characterize the coupling between the solar and Earth systems.

The original DSCOVR mission includes the "Plasma-Mag" instruments but we suggest taking further advantage of the L-1 location in space to enhance solar scientific observations by adding capabilities that will provide data directed to the above enhanced scientific objective. The selection of proper instrumentation, spectral coverage and accuracy is critical to achieve these objectives. Additional instrumentation should provide the following data (not a complete list):

1) spatial imaging of bolometric flux of solar photosphere,

2) rapid (–lmin) global imaging spectroscopy of solar UV, EUV and soft X-rays at moderate resolution plus

3) imaging solar magnetograph. Such enhanced capabilities would allow the coupling of the Earth's atmosphere to solar activity.

B. Second Focal Plane for the EPIC

A second focal plane together with an appropriate detector array would allow the extension of the EPIC's wavelength coverage to the middle infrared. This improvement to the EPIC would extend the utility of the instrument in for example, the study of clouds and greenhouse gases. The infrared focal plane for the EPIC was considered originally, engineering studies were completed, but it was necessary to drop this option for financial and schedule reasons.

3.0 Existing Science Payload and Retrieved Quantities

The scientific (built, tested and integrated on the spacecraft, see Fig 3) payload for DSCOVR **is** composed of the following instruments:

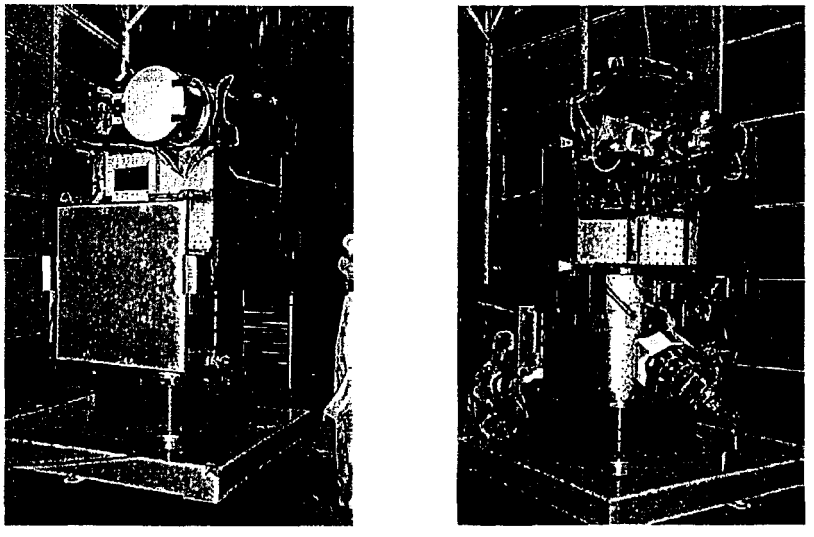


Fig 3. Earth Side and Sun Side Photographs of DSCOVR Spacecraft with Integrated Science Instruments

Scripps-EPIC is a 10-channel spectroradiometer (ultraviolet, visible, and near infrared) that uses a 30 cm telescope and a state of the art detector array (near infrared, visible, and ultraviolet sensitive **2048x2048** CCD) to achieve high sensitivity and spatial resolution.

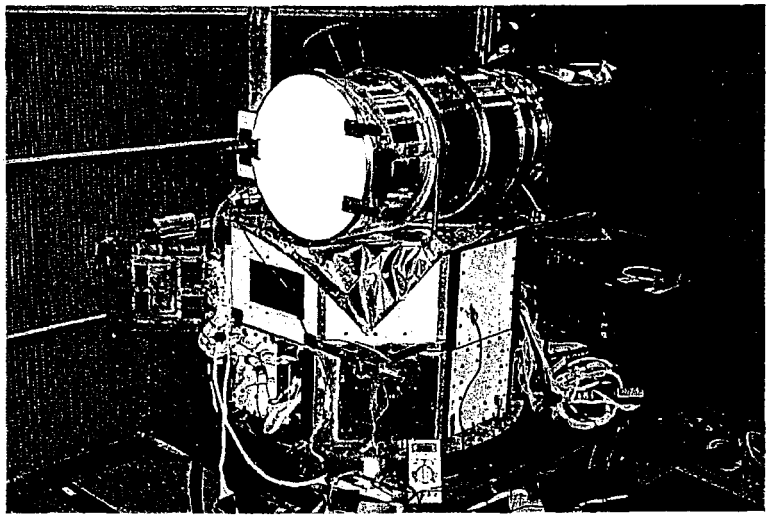


Fig. 4. Scripps-EPIC on the DSCOVR Spacecraft

EPIC will send back Earth-reflected radiances that will be transformed into data products (e.g., ozone; aerosols; cloud fraction, thickness, optical depth, and height; sulfur

dioxide; precipitable water vapor; volcanic ash; and UV irradiance) every hour for the entire globe at **8-14** km surface resolution. EPIC will provide hourly observations from sunrise to sunset for the entire globe, instead of just once per day (as with TOMS, MODIS, SeaWifs, etc.), and will collect monthly measurements and images of the lunar surface in 10 wavelengths (317.5 to 905 nm) for calibration.

Scripps-NISTAR is a greatly improved, advanced technology version of the radiometer systems currently used to monitor total solar irradiance and the radiation reflected and emitted by the Earth. It consists of **4** radiometric channels **(3** highly accurate and sensitive self-calibrating absolute cavities and 1 photo-diode) that will continuously measure the total UV, visible, and IR radiances (0.2 to 100 μm) reflected or emitted from the sunlit face of the Earth. DSCOVR's location at the L-1 observing position, rather than in Earth orbit, will permit long integration times, since no scanning will be required. A radiometric accuracy of 0.1-0.2% is expected, a 10-fold improvement in accuracy over current Earth-orbiting satellite data. These will be the only measurements of the entire Earth's reflected and emitted radiation at the retro reflection angle. **As** such, NISTAR will provide important missing data not obtainable by any Earth-orbiting satellite.

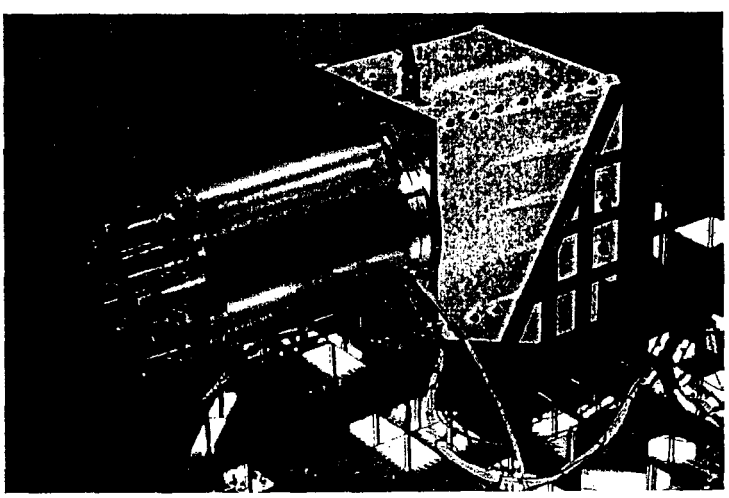


Fig. 5. Scripps NISTAR on the DSCOVR Spacecraft

NISTAR radiances will be used for: *a)* estimating the albedo for the Earth-atmosphere system, ***b)*** evaluating estimates of the Earth radiation budget (ERB) from other monitoring systems like CERES, *c)* validating the mean radiance fields that can be directly computed from GCMs, *d)* evaluating the theoretical ratios of near-infrared to total reflectance, which are of intrinsic interest to the vegetation, cloud and snow/ice communities, and e) attempting to use the thermal infrared as integrative measures of global change.

GSFC PlasMag instrument suite is a comprehensive science and space-weather package that includes a fluxgate vector magnetometer, not present on SOHO, a Faraday Cup solar wind positive ion detector and a top-hat electron electrostatic analyzer. This instrument cluster provides high time resolution measurements in real time and represents

the next generation of upstream solar wind monitors intended to provide continuity of measurements started by IMP 8, WIND, SOHO and ACE.

The PlasMag Faraday Cup will provide very high time resolution (0.5 second) solar wind bulk properties in three dimensions, which coupled with magnetic field data (20 vectors/second), will allow the investigation of solar wind waves and turbulence at unprecedented time resolution. This, in turn, will allow new insights into the basic plasma properties: the process of turbulent cascade and the rate of reconnection. Both topics are critical in understanding the nature of coronal heating.

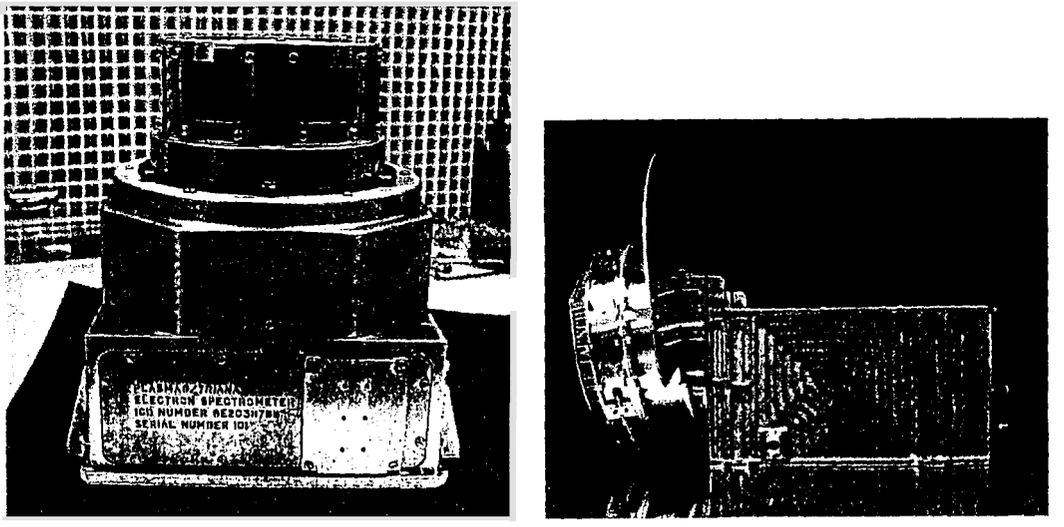


Fig 6. PlasMag Electron Electrostatic Analyzer and PlasMag Faraday Cup

The electron electrostatic analyzer will allow the continual observation of the 3D-electron distribution function for various solar wind conditions. Special attention will be given to the supra-thermal component or "strahl" that follows the interplanetary field lines very closely and provides the closest link to the formation of the solar wind in the upper corona. It provides a way of identifying large magnetic loops that are still connected at both ends to the solar corona.

Since the departure of WIND from L1, ACE is currently the only satellite providing upstream magnetic field measurements. Since ACE is well past the fifth year of operations in its five-year design life, it is important that DSCOVR be at L-1 before the ACE mission ends, to allow for cross calibration of the solar instruments, to augment solar wind early warning, and to eventually replace ACE. The DSCOVR PlasMag fluxgate magnetometer will provide crucial continuity of observation of this important interplanetary solar wind parameter. The magnetic field measurements will allow, among other things, the connection of the photospheric magnetic sector structure to 1 **AU** heliospheric current sheet observations.

All DSCOVR PlasMag observations will be part of a coordinated effort, involving multiple satellites, to investigate the large-scale structure of such transients as CMEs/Magnetic Clouds, interplanetary shocks and discontinuities and high-speed stream interfaces. Specifically, the likely operational time period of DSCOVR will enable the PlasMag observations to provide 1 **AU** measurements connecting the "Living with a Star" solar and heliospheric elements to the geospace components, hence providing a crucial link in the chain of events connecting solar activity to geomagnetic disturbances. The DSCOVR PlasMag data set will also form part of the ISTP database.

4.0 Other Considerations

4.1 Complements other Observational Systems

A very significant contribution of DSCOVR to an Earth integrated observation system would result form its ability to view Earth scenes simultaneously with every other satellite in existence. When this ability is added to DSCOVR's planned use of views of the "back" side of the Moon for calibration comparison and "flatfielding" of its detector arrays, a major synergism becomes apparent as discussed in section 1.0.

Another important example of complementarily (synergism) in the area of climate/radiative balance results from global albedo determinations from the integrated, synoptic and high time resolution observations from L-1. These observations with a different scattering geometry would provide an important component in helping understand the large discrepancies between albedo measurements utilizing different approaches (earthshine, LEO, surface).

Correlation of data from the PlasMag with that from other spacecraft near L-1 would allow the detailed study of the non-radial solar wind fluctuations. This study was begun with earlier spacecraft such as the Explorers, **IMP,** and ISEE, but with DSCOVR, new opportunities would become available. PlasMag solar wind measurements could be correlated with those from other spacecraft at a variety of positions away from L-1, providing multiple baselines. These measurements would help to determine the symmetry of the fluctuations in the wind that in turn determine the way in which energetic particles propagate in the heliosphere. This basic understanding is central to determining how solar events affect the Earth and its near-space environment, and thus is important for determining the effects of solar activity on spacecraft and manned space flights.

4.2 Cost/Benefit

Co-observation with other Earth science satellites and maintenance of a high standard of on-orbit recalibration will allow DSCOVR to test the concept of sharing calibrations with LEO and GEO Earth observation satellites. This has great potential for cost savings within the various Earth observational systems. This can allow the other systems to spend less time and money on obtaining and maintaining a climate level calibration for each instrument. DSCOVR can also provide a means to share calibrations between following generations of an Earth observing satellite system.

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THE NATIONAL ACADEMIES
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Space Studies Board
Commission on Physical Sciences, Mathematics and Applications

March 3, 2000

Dr. Ghassem R. Asrar
Associate Administrator for Earth Science
Code Y
NASA Headquarters
Washington, D.C. 20546

Dear Dr. Asrar:

At your request the National Research Council established a task group to evaluate the scientific aspects of the Triana mission. The charge to the Task Group on the Review of Scientific Aspects of the NASA Triana Mission was to review (1) the extent to which the mission's goals and objectives are consonant with published science strategies and priorities, (2) the likelihood that the planned measurements can contribute to achieving the stated goals and objectives, and (3) the extent to which the mission can enhance or complement other missions now in operation or in development.

Triana is a mission designed to be deployed into a stable orbit, at roughly a million miles from Earth in the direction of the Sun. An orbit at this location, known as Lagrangian point 1 (L1), is stable in the sense that the satellite remains on the Sun-Earth line and views the full sunlit disk of Earth continuously. From L1 Triana will observe Earth with two instruments, and a third will monitor the space environment in the direction of the Sun. Observed data are expected to be delivered in near real time to ground stations.

As proposed, Triana is an exploratory mission to investigate the scientific and technical advantages of L1 for Earth observations. The continuous view of the full sunlit disk of Earth will complement and extend observations from low Earth orbit (LEO) or geostationary Earth orbit (GEO) satellites. Triana will provide a global synoptic view (a continuous, fiom Sunrise to sunset, simultaneous view of the sunlit side) of Earth in a range of wavelengths including ultraviolet, visible, and infrared to observe variations in ozone, aerosols, clouds, and surface ultraviolet radiation and vegetation. Triana is a flight opportunity to extend and improve observation of the solar wind and space weather at a most meaningful site, supplementing the data fiom the Advanced Composition Explorer satellite.

A detailed analysis of instrumentation, data collection and reduction, systems operation, and management was beyond the scope of the task group's effort and was precluded by the time and budgetary constraints placed on the preparation of this report. Nevertheless, the task group agreed on a number of general issues related to the likely scientific success of the mission based on its review of relevant documents and reports and briefings by NASA's Triana science team. In its evaluation, the task group relied heavily on presentations from NASA and members of the Triana science team, and on detailed questioning of the presenters.

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Office Address: Milton Harris Building, Room 584, 2001 Wisconsin Avenue, N.W., Washington, DC 20007

In the attached more detailed technical assessment, the task group relates Triana's scientific objectives and deliverable data products to the research strategies and priorities proposed in earlier National Research Council and government reports. The task group found that the scientific goals and objectives of the Triana mission are consonant with published science strategies and priorities for collection of climate data sets and the need for development of new technologies. However, as an exploratory mission, Triana's focus is *the* development of new observing techniques, rather *than* a specific scientific investigation. The apparent spaceflight heritage of some of the Triana technology and the applicable legacy of the data reduction algorithms should contribute to the achievement of the mission's objectives. The task group concluded that the planned measurements, if successfully implemented, will likely contribute to Triana's stated goals and objectives. It did not attempt to evaluate the applicability of this heritage for a mission at L1.

The task group also found that the Triana mission will complement and enhance data from other missions because of the unique character of the measurements obtainable at the L1 point in space, which allows continuous imaging of *the* full sunlit disk of Earth and monitoring of the space environment upstream from Earth. Furthermore, the full-disk Earth observations provide a unique perspective from which to develop new databases and validate and augment existing and planned global databases. As an exploratory mission, Triana may well open up the use of deep-space observation points such as L1 for Earth science. The task group believes that the potential impact is sufficiently valuable to Earth science that such a mission might have been viewed as an earlier NASA priority had adequate technology been available at reasonable *cost.* The task group is concerned, however, that because of the compressed schedule there may not be adequate time for instrument testing and calibration prior to launch.

The task group is also concerned that significant development, testing, and validation of the operational algorithms are needed, and it recommends that this work *start* immediately. The scientific success of the Triana mission will be judged, in large part, on the quality of the initial data delivered to the scientific community. The task group therefore recommends that NASA seriously consider increasing the level of effort invested in development and testing of data reduction algorithms for *the core* Earth data products as soon as possible. In addition, it is concerned that there may be insufficient funding for scientific analysis of the data If Triana lasts longer than its nominal 2 years, it will be important for NASA to support the data processing activities for the mission's useful duration.

The task group lacked the proper expertise, resources, and time to conduct a credible cost *or* cost-benefit analysis (such an effort might *take* many months and much detailed analysis) or an analysis of the mission goals and objectives within the context *of* a limited NASA budget or relative to other Earth Science Enterprise missions. However, based on the available information, the task group found that (1) the *cost of* Triana is not out of line for a relatively small mission that explores a new Earth observing perspective and provides unique data; (2) since a significant fraction of the Triana funds (according to NASA and the Triana principal investigator, SO percent of total funding and 90 percent of instrument development money) have already been expended, weighing cost issues would lead to only limited opportunities *to* save or transfer funds to other projects. In addition, the task group endorses the statement by

Congress that the delay in the mission mandated to produce this report may mean additional costs.

The task group emphasizes that the attached discussion of the ability of Triana to achieve the mission's stated goals and objectives is predicated on the assumption that the instruments and satellite have been, and will continue to be, subject to all necessary and appropriate exploratory-mission technical and quality control reviews. ***Under no circumstances should this report or the statements contained in it be used as a replacement for these technical evaluations.***

Sincerely,

James J. Duderstadt
Chair, Task Group on the Review of Scientific Aspects of the NASA Triana Mission

Mark Abbott
Acting Chair, Space Studies Board

Eric J. Barron
Chair, Board on Atmospheric Sciences and Climate

Raymond Jeanloz
Chair, Board on Earth Sciences and Resources

Division of Engineering and Applied Science
Department of Earth and Planetary Science
Harvard University, 29 Oxford St., Cambridge, MA **02138**

Steven C. Wofsy
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02 February 2006

Dr. Francisco Valero
Scripps Institution of Oceanography
University of California
San Diego, **CA** 92093

Dear Francisco:

Regarding input to the Decadal Review for Earth Sciences, I would like to express my dismay upon hearing of the cancellation of DISCOVR. The US needs a serious program of climate observations, as distinct from weather observations, in order to be able to formulate wise policies regarding climate change. The President and many other policy makers have clearly expressed this need.

I view DISCOVR as the first true climate observing platform, with its whole-disk view and program of observing climate drivers systematically in a way not possible by ordinary orbiting satellites. I certainly hope to see it reinstated. The program promises to restore the US reputation for scientific leadership in the world, and **NASA's** reputation for innovation and expertise, at a time when both could benefit from a boost.

Sincerely,

Steven C. Wofsy

Steven C. Wofsy

Max Planck Institute for Chemistry
Otto Hahn Institute

MPI for Chemistry. P O Box 3060 • D-55020 Mainz, Germany

MAX-PLANCK-GESELLSCHAFT

Managing Director
Prof Dr J Lelieveld
Atmospheric Chemistry

Prof. Dr. Francisco Valero
Scripps Institution of Oceanography, UCSD
9500 Gilman Drive
La Jolla **CA, 92093-0242**
U.S.A.

Re: DSCOVR decommissioning

Mainz, 12 January 2006

Dear Francisco,

To my great surprise and disappointment the last issue of Science Magazine announced the likely decommissioning of DSCOVR. I wonder why such a great idea, using the L1 point, is given up before putting it to the test.

I would like to contribute to an appeal from the scientific community to help rescue this unique mission. The synoptic view of the Earth by DSCOVR, together with those by the available low earth orbit and geostationary satellites will generate exceptional data to study atmospheric radiation and climate, especially on the Earth's response to changes in the solar radiation energy taken **up** within the climate system. The anticipated improved accuracy of cloud, aerosol and ozone measurements will substantially reduce uncertainties associated with climate change assessments. Therefore, **I** hope that **NASA** can be convinced to reconsider the decision on DSCOVR.

I wish you much success.
Best regards,

Jos Lelieveld

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Joh -J -Becherweg 27
55128 Mainz, Germany

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January 13,2006

Francisco P. J. Valero
Director Atmospheric Research Laboratory
Scripps Institution of Oceanography
University of **California,** San Diego
9500 Gilman Drive, MC 0242
La Jolla, **CA** 92093-0242

Dear Francisco;

I was disturbed to read in Science that **NASA** has elected to not launch DSCOVR as planned. The title of the Science article hints of politically driven consideration and I can only hope **that** this **is** not the case. However, regardless of the considerations **that** went into this decision **by** NASA, I feel that if there is any chance of saving the DSCOVR mission, it should be pursued. **The** unique capabilities to study the **earth** afforded by the L1 vantage point are self-**evident** and will inevitably lead to a niission like DSCOVR. I oppose delaying the **launch of** this mission given some of the compelling global environmental issues DSCOVR can **address** [radiative balance, global albedo, cloud forcing, cloud-aerosol interactions, bio-sphere vegetative response, global event driven interactions (fires, dust plunics, pollution, dynamics etc.)].

A particular advantage of DSCOVR is the opportunity for global study of the coupled **and** integrated atmosphere-biosphere response to both **natural** and anthropogenic activities. Although **many** of these opportunities are identified in the mission plan, I suspect **that** their potential is underestimated. The DSCOVR mission and data resource is likely **to** prompt active use **by** the extended science **community. As** in earlier visionary missions, **I expect** that diverse creative minds will apply this resource to global issues in ways **we** have not yet imagined.

Please feel free to add my name to the list of those who strongly support this mission and the milestone it may become in our understanding of important global processes.

Sincerely yours,

Antony Clarke
Research Professor in Oceanography

Date: Mon, 9 Jan 2006 08:48:59 -0800
To: "Francisco P.J. Valero" <fvalero@ucsd.edu>
From: Jost Heintzenberg <jost@tropos.de> (by way of Robert Charlson)
Subject: DISCOVR (for what it is worth)
Cc: Tad Anderson <tadand@u.washington.edu>
X-grey listing: NO DELAY (Relay+Sender autoqualified);
processed by UCSD_GL-v2.1 on mailbox10.ucsd.edu;
Mon, 09 January 2006 20:41:29 -0800 (PST)
X-Spam-Level: Level
X-Spamscanner: mailbox1O.ucsd.edu (v1.6 Aug 4 2005 15:27:38, 0.1/5.0 3.0.4)
X-MailScanner: PASSED (v1.2.8 32786 k0A4dU6q0432 12 mailbox10.ucsd.edu)
X-NAS-Language: English
X-NAS-Bayes: #0: 0; #1: 1
X-NAS-Classification: 0
X-NAS-MessageID: 3731
X-NAS-Validation: {123A4A81-2EBA-4D62-901A-197AAD9B2A10}

Hola Francisco!

Jost Heintzenberg just sent me this... Bob

Why the Institute for Tropospheric Research (IFT) needs DISCOVR:
Earth's albedo is one of the key parameters determining the energy balance of our planet and thus our climate. It cannot be measured directly. From space the closest feasible proxie would be the DISCOVR mission. IFT is engaged in an array of ground-based remote and in situ sensing tools that supply input to radiative transfer models yielding Earth's albedo. With highly sophisticated lidar measurements IFT determines similar parameters as DISCOVR would yield. These Lidar-derived albedo-proxies need to be checked against DISCOVR data and the model-derived Earth's albedo need to be constrained with DISCOVR data. That is why IFT needs DISCOVR in order to provide meaningful climate data.
--
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UNIVERSITY OF WASHINGTON
Department of Atmospheric Sciences
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December 20, 2005

Dr. Mary L. Cleave
Associate Administrator for Science Mission Directorate
NASA Headquarters, Mail Suite: 5E39-A
300 "E" Street **S.W.**
Washington, DC 20546-0001

Dear Dr. Cleave,

Thank you for your December 5,2005 response to my letter to Dr. Griffin of September 21,2005. As a Co-Investigator on the CALIPSO satellite, I am deeply concerned that a failure to launch and operate DSCOVR while the A-Train is operational **will** seriously damage the scientific integrity of current research on albedo-related parameters **of** the Earth System.

In your response, you assure me that my "scientific arguments . . . are not forgotten". Yet, in spite of those scientific arguments, you state that "conditions preclude continuation of the (DSCOVR) project". You also mention "significant funding" that would be required to launch DSCOVR but it seems relevant to also consider the much larger, lost-opportunity **cost** of not having the DSCOVR data coincident with the A-Train.

I would appreciate receiving a more complete scientific statement that properly weighs the value *of* the simultaneous DSCOVR and A-Train data. In light of the scientific importance of albedo-related measurements, consideration also should be given to alternate or complementary funding sources such as NOAA.

In closing, I want **to** call your attention to the enclosed reprint of a Perspective in Science that summarizes the scientific importance of the albedo-related measurements.

Sincerely,

R. J. Charlson /s

Robert J. Charlson
Professor of Atmospheric Sciences
and Professor **of** Chemistry
TEL: (206) 543-2537

Enclosure: Perspectives, in Science, Reprint: "In Search **of** Balance", R.J. Charlson. F.P.J. Valero, J.H. Seinfeld, Science, **308,** May 2005, pp. 806-807.

cc: Dr. Michael Griffin
Dr. Patricia Mulligan
Prof. Francisco Valero

agenzia spaziale italiana

Rome, January 17th 2006

OP/OST/2006/002

Dr. Francisco Valero
University of California – Associate
Dir. Center for Atmospheric Sciences
Scripps Institution of Oceanography
0242 – L Jolla – California **92093-0242**

Dear Dr. Valero,

two years ago the Italian Space Agency planned to develop an Earth observation program based on lagrangian missions mainly dedicated to the presence of DSCOVR.
The interest of our Agency was to introduce into the Italian scientific community the concept arising from such missions. Furthermore, during my work as Italian delegate in the GEO project, such lagrangian missions were repeatedly mentioned as a huge improvement for Earth observations from space due to the huge quantity of information we can acquire by looking at the whole Earth as a planet and continuously. I was impressed that such a vision was also present in the DSCOVR mission on which we are working and to which incidentally the Italian Space Agency was contributing with the IRIS launcher.

Now we understand the difficulties to launch DSCOVR.
Without entering into the reasons of such difficulties, I feel that sooner or later a DSCOVR or a DSCOVR-like mission will happen, because it is the true next step in advancing Earth observations from **spate.**

Then we hope the DSCOVR mission flies in the near future so we can continue to support the niission by analysing data and by means of the IRIS launcher. Furtherrnore, we could suggest some actions to be discussed into the **NASA-AS1** joint program.

Hoping in a positive result, I take this opportunity to send you my best regards.

Rodolfo Guzzi
Head of Earth Observations

PRESIDENZA, DIREZIONE GENERALE
AMMINISTRAZIONE E UFFICI
CENTRO DI GEODESIA SPAZIALE "G. COLOMBO"
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INSTITUTE FOR TERRESTRIAL AND PLANETARY ATMOSPHERES

MARINE SCIENCES RESEARCH CENTER

January 30,2006

Dr. Francisco Valero
Director
Atmospheric Research Laboratory
University of California, San Diego
Scripps Institution of Oceanography, 0221
La **Jolla,** California **92093-0221**

Dear Francisco:

I **was** very disturbed to hear that NASA is canceling the DSCOVR (Deep Space Climate Observatory) mission. From my point of view there are two compelling reasons why DSCOVR should proceed **as** originally planned.

The first reason is that this is a scientifically important mission. To give but one example, DSCOVR will allow us to monitor changes in the Earth's and thus better understand cloud/aerosol interactions which so far have proven to be elusive, and for which there currently is contradictory evidence. I will not belabor the importance of the other scientific goals of this mission, since they have already been addressed, in detail, by the report issued by the National Academy of Sciences, a report that strongly endorsed the scientific importance of this mission.

The second compelling reason that DSCOVR should not be cancelled is that the spacecraft and instruments have been built **and** have been tested. If this were not an important scientific mission, then why has it proceeded as **far** as it has?

Given the scientific importance of DSCOVR, I truly hope this mission will be allowed to proceed **as** originally planned.

Sincerely yours,

Bob

Robert D. Cess
Distinguished Professor and Distinguished Service
Professor Emeritus

RDC:sr

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I P S L

CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE

PARIS, 19 JANUARY 2006

PR FRANCESCO VALERO
ATMOSPHERIC RESEARCH LABORATORY
SCRIPPS INSTITUTION OF OCEANOGRAPHY
UNIVERSITY OF CALIFORNIA, SAN DIEGO
95000 GILMAN DRIVE, MC0242
LA JOLLA, CA 92093-0242
USA

Dear Francesco

We have learnt, at LMD, with great disappointment the news that DSCOVR, alias TRIANA, is going to be terminated. This is really bad for science.

Our group has commited itself to work with DSCOVR data because we found that a number of important research applications that cannot be done with the current fleet of operational and research satellites became feasible.

The main interest of DSCOVR is that it provides a global coverage of the Earth complementary to that of geostationary satellites.

ÉCOLE POLYTECHNIQUE

In particular, monitoring the ozone column on a global scale with high spatial and temporal resolution offers unparallel possibility to study and perhaps resolve long standing transport and chemistry issues in the stratosphere. Basically, the DSCOVR images would have there essentially the same impact as water vapor images at lower levels.

Another particularly interesting possibility of DSCOVR is to combine its measurements with geostationary satellites. Our group has been involved in the development of algorithms to retrieve the physical parameters of cirrus clouds. Although DSCOVR cannot claim superiority in terms of accuracy over low altitude platforms carrying dedicated instruments, it would cover a global domain and follow fast temporal variations that escape to low orbit satellites. Under the perspective of generalized assimilation of chemical and physical parameters which is currently under way in most modelling groups, such data will become precious in the near future.

UNIVERSITE PIERRE & MARIE CURIE

The absolute radiative measurements by DSCOVR will pr
povide for the first time unique data at near-retro-reflection angles which will go a long way in improving the quality of albedo determinations so crucially needed in view of the poor present situation with the uncertainties and discrepancies between observations and models of Earth albedo, as Charlson, Valero and Seinfeld descibe in a recent "Perspective" article in Science magazine. The obvious synergism with satellites like Calipso and others will go a long way in the efforts to solve the Earth radiative balance questions. We would strongly encourage you to also pursue the idea of locating another DSCOVR-like satellite in the dark side (at L-2) thus providing complete synoptic coverage of the planet. But obviously big innovations like represented by DSCOVR can only be achieved a step at the time.

DSCOVR has also been exemplary as a space mission in terms of reactivity, technical achievement, cost and good planning thanks to a large part to your efforts. It would really be a shame if all this work is lost due to the unfortunate but temporary situation of launching at NASA and we really hope that reason will prevail and that DSCOVR can be maintained and rescheduled. We will certainly contribute as much as we can in this direction.

With best regards,

ORIGINAL SIGNED BY

Claude Basdevant
Professeur

Bernard Legras
Directeur de Recherche

Hector Teitelbaum
Directeur de Recherche Emérite

François Vial
Directeur de Recherche

UNIVERSITY OF CALIFORNIA, SAN DIEGO UCSD

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SCRIPPS INSTITUTION OF OCEANOGRAPHY
CLIMATE RESEARCH DIVISION

9500 GILMAN DRIVE DEPT. 0224
LA JOLLA, CALIFORNIA 92093-0224

January 31, 2006

Dr. Francisco P. J. Valero
Scripps Institution of Oceanography
University of California, San Diego
9500 Gilman Drive, MC 0242
La Jolla, CA 92093-0242

Dear Dr. Valero:

The DSCOVR project, the first Earth-looking niission from deep space, will make truly pioneering measurements from a million miles **from** Earth (where the Earth's and the sun's gravity approximately balance, at the first Lagrange point or L1). This mission, will make radiometric. chemical and aerosol measurements from space with the full disc in view **for the first** time ever. We have never before had a view **of** the whole planet with all of its synoptic weather patterns from one platform. From this vantage **point,** DSCOVR will also enable calibration of all of the Earth-viewing satellites, including ocean satellites. In short, we should view DSCOVR as starting a new **way** of observing the planet, including the oceans. Every previous satellite measurement of our planet has been from either low-Earth orbit or geostationary orbit. With the DSCOVR project, **we** will have moved out to see our home planet from deep space for the first time.

DSCOVR is the **result** of an intense peer-reviewed **NASA** competition as the most scientifically valuable application for the first Lagrange point spacecraft and additionally has been reviewed and endorsed by a prestigious National Academy of Sciences panel. This group gave a strong endorsement to DSCOVR. The Academy report fully validates the DSCOVR team's vision. **At** present, the DSCOVR spacecraft is ready to fly, but is awaiting launch alternatives **due** to delays with the space shuttle program. The courage and dedication represented by this mission team are recognized throughout the atmospheric and climate science community. It **would** be a tragedy of short-sightedness and misplaced priorities if this pioneering mission were to be sacrificed to budgetary pressures.

Sincerely,

Richard C. J. Somerville

Richard C. J. Somerville
Distinguished Professor

Boston University

Department of Geography
College of Arts and Sciences
675 Commonwealth Avenue
Boston, Massachusetts 02215–1401

Alan H. **Strahler,** Ph.D., **D.S.H.C.**
Professor of Geography
Telephone: (617) 353-5984
Facsimile: (617) 353-8399
Electronic Mail: alan@bu.edu

February 28,2006

Honorable Sherwood L. Boehlert
Chairman, House Science Committee
32320 Rayburn House Office Building
Washington, DC 20515

Dear Chairman Boehlert:

This letter concerns the recent **NASA** decision to cancel the Deep Space Climate Observatory (DSCOVR) mission. **As** you are aware from other documents, the mission includes three elements: **(1)** monitoring of space weather for early warning of solar events with potentially destructive impacts; (2) high precision monitoring of the Earth's reflectance of solar energy back to space; and **(3)** 30-minute imaging of the sunlit side of the Earth for better observation of atmospheric ozone, clouds, coastal waters, and rapidly changing land processes. While the monitoring of space weather is an essential feature of the observatory, I will remark briefly on the scientific significance of the Earth-observing parts of the mission.

How does the Earth as a globe change from minute to minute and hour to hour? The DSCOVR observatory will monitor our constantly changing oceans, atmosphere, and land surface in a way that no other orbiting platform can, because it will ***orbit the Sun, rather than the Earth.*** From the "L-1" point, about ten percent of the way between the Earth and the Sun, the platform will revolve around the Sun in step with the Earth, allowing the platform's two Earth-sensing instruments to continuously observe the sunlit side of our rotating planet.

The NIST high-precision radiometer will measure the flow of solar energy reflected from the Earth back to space with an accuracy that has not yet been attained from an instrument in space. Measuring this flow is significant because it also tells us how much solar energy is absorbed by the Earth, given the total energy output of the Sun. And, it is this absorbed solar energy that powers the circulation of the atmosphere and oceans as well as photosynthesis on the land surface.

The NJST radiometer will not only measure the flow of reflected solar energy with high precision, it will also monitor the flow at 30-minute intervals. This fine time scale will show how the Earth's reflectivity is affected by the constantly changing global pattern of clouds and even by sun glint from ocean surfaces, which depends on wind speed. Over the course of days, the instrument will measure the global effects of snowfalls, which brighten land surfaces, and rainfalls, which darken soils. Over the course of months and years, the instrument will track Earth reflectance to establish a baseline that will measure the natural variability of the solar energy balance in a way that has not been possible heretofore.

The EPIC camera will image every part of the Earth that receives sunlight at 30-minute intervals, allowing (1) observation of the changing patterns of airflows in the at-

mosphere through special ultraviolet imaging bands; (2) viewing of daily cloud patterns and their evolution with time over the sunlit Earth disk; **(3)** monitoring of coastal ocean currents at very fine time scales; and (4) tracking of daily land processes, such as photosynthesis, that are dependent on incoming solar radiation, clouds, and green vegetation cover. This continuous sunlit-side coverage is unique and cannot be accomplished by existing satellite imagers in either geostationary or low-Earth orbit.

The significance of these measurements, of course, lies in their ability to help answer the question, "Is the Earth's Climate Changing?" The DSCOVR mission will measure the natural variability of the Earth's dynamic atmosphere, oceans, and land surfaces in a unique and distinctive way, and thus provide the benchmark data needed to determine how all the elements of the climate system, from ozone to clouds, to snow and ice, and to vegetation growth and development, naturally change with time.

The science content of the DSCOVR mission has been fully vetted by the NAS/NRC and endorsed by NAS boards on space science, atmospheric science and climate, and earth science and resources. NASA's decision to cancel the mission means losing a set of critical observations of great value to scientists as well as decision makers in understanding the variability of our changing planet. I respectfully request that you urge NASA to reconsider its decision and fly the DSCOVR mission at the earliest possible opportunity.

Sincerely yours,

Alan H. Strahler

Alan H. Strahler
Professor of Geography

BROOKHAVEN
NATIONAL LABORATORY

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February 28,2006

Professor Robert J. Charlson
Departments of Atmospheric Sciences and Chemistry
University of Washington
Box 351640
Seattle, Washington 98195-1640

Dear Bob:

I am pleased to respond to your request for my opinion about the scientific merit of the proposed DSCOVR satellite. I do so as a scientist whose research deals with atmospheric radiation and climate. For the record I am Chief Scientist of the Department of Energy's Atmospheric Science Program, but I do not speak for that program, and my views must be considered entirely my own. I attach a brief CV for your reference.

My understanding of this proposed satellite is that the key instrument, a high resolution, high precision radiometer is essentially built and ready for launch. Such an instrument and the proposed positioning of it at the Lagrange point between Sun and Earth would be of enormous value to the atmospheric science community and to the broader community concerned with the issue of Earth's climate and climate change. As such the satellite would have a continuous view of the sunlit side of Earth. It would provide measurements of reflected radiance at high time and space resolution and with high radiometric precision. Such measurement requirements are not met by other platforms and indeed are complementary to other measurements, such as from polar orbiters (Aqua and Terra) and geostationary satellites.

Let me try provide some context to the need for the measurements that would be available from DSCOVR. Earth's climate system is driven by absorbed solar radiation. Solar radiation is incident on the planet at an average intensity of 343 watts per square meter. On average about 70% of this is absorbed and 30% reflected back to space. The fraction reflected (albedo) is highly variable in space and time. Clouds are highly reflective, for example; a 5 % change in cloud cover would result in a change in absorbed solar power of about 2.5 watts per square meter. This might not seem large in the context of incident solar irradiance of 343 watts per square meter, but the important context really is that of climate change; for example the radiative forcing by CO_2 relative to the preindustrial climate, is about 1.8 watt per square meter. For this reason climate models really have to accurately represent cloud influences on radiation. Having measurements such as would be available from DSCOVR would go a long way to providing the information necessary to constrain and improve cloud models. Specifically the continuous temporal coverage, high spatial resolution (of a few kilometers), and high radiometric accuracy of measurements such as those planned for the DSCOVR mission, would be essential in evaluating the performance of climate models in getting clouds right. I hasten to add that so long as models do not get clouds right, they will continue to rest on an unfirm foundation.

I focus on clouds because they are so enormously important in understanding present climate and climate change. However another essential issue is the effect of atmospheric aerosols. Like clouds these aerosols reflect sunlight, and like greenhouse gases, they have been increasing over the industrial period. The most recent (2001) report of the Intergovernmental Panel on Climate Change identified aerosol forcing as the source of greatest uncertainty in climate forcing over the industrial period. The uncertainty associated with estimates of this forcing, which are based

mainly on models, is greater than the total forcing by greenhouse gases over this period. What is essential, therefore, is measurements of these aerosol influences such as have been planned for the DSCOVR mission. These measurements would both give a direct measure of the aerosol influences and could be used to evaluate models that are essential to development of scenarios for future emissions and understanding of the consequences of prior emissions over the industrial period.

I might elaborate on the above mission goals as well as enumerate many others, but I think that these two examples serve to demonstrate clearly the importance of measurements such as have been planned for the DSCOVR mission. Given the enormous importance of such measurements, and the relatively low cost associated with this mission, I can only add my strong endorsement of the scientific importance of such a mission.

Sincerely yours,

Stephen E. Schwartz, Ph.D.
Senior Scientist

UNIVERSITY OF WASHINGTON

DEPARTMENT OF ATMOSPHERIC SCIENCES

February 28, 2006

The Honorable Sherwood Boehlert
Chair, Science Committee, U.S. House of Representatives
2320 Rayburn House Office Building
Washington, DC 20515 fax: 202-225-1891

Dear Chairman Boehlert,

While I am a Co-Investigator on the Science Team of the CALIPSO Satellite, I am writing this letter as an individual scientist and professor at the University of Washington. I am not speaking for the CALIPSO Science Team or for NASA.

It is scientifically well accepted that human-induced climate change is real and includes the potential for changes disruptive to the United States and to all of humanity. This potential is sufficient reason for the U.S. to undertake research to provide accurate forecasts of what climate change to expect and to provide guidance on what measures may be necessary in order to avoid and/or adapt to any undesirable consequences.

To that end and in my view, the satellite DSCOVR should be launched as soon as possible in order to obtain data on the Earth's climate system that are coincident with satellite data from NASA's Earth Observing System - in particular, the A-Train and CALIPSO, which will be in orbit until about 2008.

DSCOVR has the unique ability to provide integral constraints on the quantities needed to define the Earth's reflectivity. It will be impossible to improve upon the present, highly uncertain climate forecasts without such data.

Please do not hesitate to contact me if you or your staff requires further information.

Respectfully,

Robert J. Charlson
Professor, Atmospheric Sciences and Chemistry Departments
University of Washington, Seattle WA 98195-1640
phone: 206-543-2537 fax: 206-543-0308 email: bobwhan@comcast.net

cc: Congressman Dave Reichert, Washington State (fax: 202-225-4282)
Congressman Brian Baird, Washington State (fax: 202-225-3478)
Prof. Francisco P.J. Valero, Principle Investigator, DSCOVR Mission

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Dr. Francisco Valero
Distinguished Research Scientist
Director, Atmospheric Research Laboratory
Scripps Institution of Oceanography
University of California, San Diego
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La Jolla, CA 92093-0242

Dear Francisco:

I am writing to indicate my support for the DSCOVR project and to tell you that I was disappointed when I learned that this mission had been cancelled. **As** my personal research concentrates on better understanding the role of clouds in climate feedbacks, I had anticipated that this worthy mission would have provided useful data on the possible causes of changes in the Earth's albedo.

I am hopeful that your efforts will allow this project to be resuscitated as DSCOVR was an innovative approach for making Earth observations from space. I would also be willing to offer any assistance to help with this effort.

Yours sincerely,

ORIGINAL SIGNED BY

Greg McFarquhar
Associate Professor, University of Illinois

LETTERS

edited by Etta Kavanagh

Peer Review and New Investigators

IN HIS LETTER "REVAMPING NIH STUDY SECTIONS" (6 JAN., P. 36), J. LENARD asserts that removal of assistant professors from review panels "to their own great benefit" would "immediately improve" the quality of review and presumably, "correct some of the distortions." The only such distortions specified are "political" and "subculture-sensitive" biases. It is not clear why less experienced scientists would be more biased in this regard; one would imagine that they have much less in the way of entrenched bias. The advantages of young scientists participating on a review panel are obvious. The best way to improve one's success in grant writing is to read many proposals and to experience firsthand the subtle dynamics of the review panel. Balancing these advantages against the time and energy subtracted from the scientist's own research is best left up to the individual.

"The best way to improve one's success in grant writing is to read many proposals and to experience firsthand the subtle dynamics of the review panel."
—Taffe

Regarding "distortions," the average age upon obtaining the first R01/R29 award reached 42 years of age in 2002, up from 37 in 1980 (*1*). The proportion of competing research grants awarded to scientists under 35 was 4% in 2001, down from 23% in 1980 (*2*). Declines for young/new investigator success on these and other measures have been uninterrupted for two decades of increasing NIH funding. Many NIH initiatives such as the R29 program, the "new investigator checkbox." revisions to review criteria/guidance, and the recent launch of a Web page on New Investigators (3) suggest that NIH considers the ongoing declines in young/new investigator success to be a "distortion" of significant importance.

The Center for Scientific Review (CSR) databook (*4*) reports that 26% of standing, and 28.5% of ad-hoc, members of panels were 45 years of age or younger in 2004. The CSR report also confirms that new investigators receive lower median priority scores than experienced investigators and are less likely to submit A1 and A2 revisions, as well as testifying to the substantially improved cumulative funding probability with successive revisions. The director of CSR, Toni Scarpa, is to be congratulated in his efforts to revamp peer review, his desire to make revisions based on review data, and his clear focus on the new investigator as a priority ("Peer review at NIH," Policy Forum, 6 Jan., p. 41). I hope that in this process, he considers the role of career rank quite closely.

MICHAEL A. TAFFE

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Keeping the DSCOVR Mission Alive

THE TITLE OF *SCIENCE'S* ARTICLE ABOUT NASA'S decision to cancel the Deep Space Climate Observatory (DSCOVR) satellite mission, "NASA terminates Gore's eye on Earth" (ScienceScope, A. Lawler, 6 Jan., p. 26), was misleading. This title trivializes the real nature of the mission and obscures the fact that DSCOVR is not the same as the Triana mission promoted by then Vice President Gore. The Triana concept was to provide the public (via the Internet) with a continuous, real-time image of the entire, sunlit Earth, essentially a TV camera in space. DSCOVR is a high-priority, peer-reviewed scientific mission, conceived and developed by a team of experts.

In 1998, NASA issued a request for information to the science community regarding utilization of the L-1 Lagrange point between Earth and the Sun, from which the entire sunlit hemisphere of our planet can be continuously observed. Our team responded by recommending broadband and high-resolution, spectroradiometric measurements that would improve understanding of the solar/infrared energy balance (*1*) for the Earth system as well as of atmospheric composition and dynamics. Importantly, these observations would provide calibrations and integral constraints for all satellites in geostationary and low Earth orbit because they all are at times in view from L-1.

Our proposal was selected by NASA after rigorous scientific and technical reviews. Solar activity observations were added at NASA's request to satisfy scientific needs and NOAA's operational requirements for space weather monitoring. DSCOVR is finnly based on the ideas developed by the science team. The transmission of live images of Earth added to the educational outreach component of the mission but was by no means the primary objective.

Many scientists, both in the United States and abroad, view DSCOVR as one of NASA's most important and innovative Earth science missions. The satellite has been built and could still be launched in time to provide synergistic data coincident with current and future orbiting systems. It offers great potential both as a source of fundamental scientific observations and as a pioneering Earth sciences mission from deep space.

FRANCISCO P. J. VALERO

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How to Measure National Stereotypes?

BECAUSE IT IS PARTICULARLY DIFFICULT TO EVALuate the accuracy of national stereotypes, the Report by A. Terracciano *et* a/. ("National character does not reflect mean personality trait levels in 49 cultures:' 7 Oct. 2005, p. 96) examining the relations between ratings of national character and ratings of individuals in 49 different cultures represents quite a technical achievement. Studies of stereotypes usually suggest that stereotypic beliefs contain a kernel of truth: The perceived differences between groups do in fact exist, but they are smaller than the stereotype would suggest (*1*, 2). Terracciano *et al.* instead found that, on average, there was no relation between national stereotypes and self and other descriptions. Some methodological weaknesses of their study must be considered, however.

One issue is their almost exclusive reliance on college student samples. Although there is some evidence that cross-cultural comparisons between college students may generalize to broader populations (*3*), there is also substantial evidence that findings with college students frequently do not so generalize (*4*). These findings do not invalidate college student samples as representations of broader national populations, but neither do they justify assuming college students provide an acceptable proxy for the population as a whole.

A second issue is whether the authors have provided a sufficient evaluation of national character. The authors reduce national character to personality traits. This ignores other potential elements of stereotype, most particularly differences in values, beliefs, or perceptions that are not adequately included in the measures used in this study.

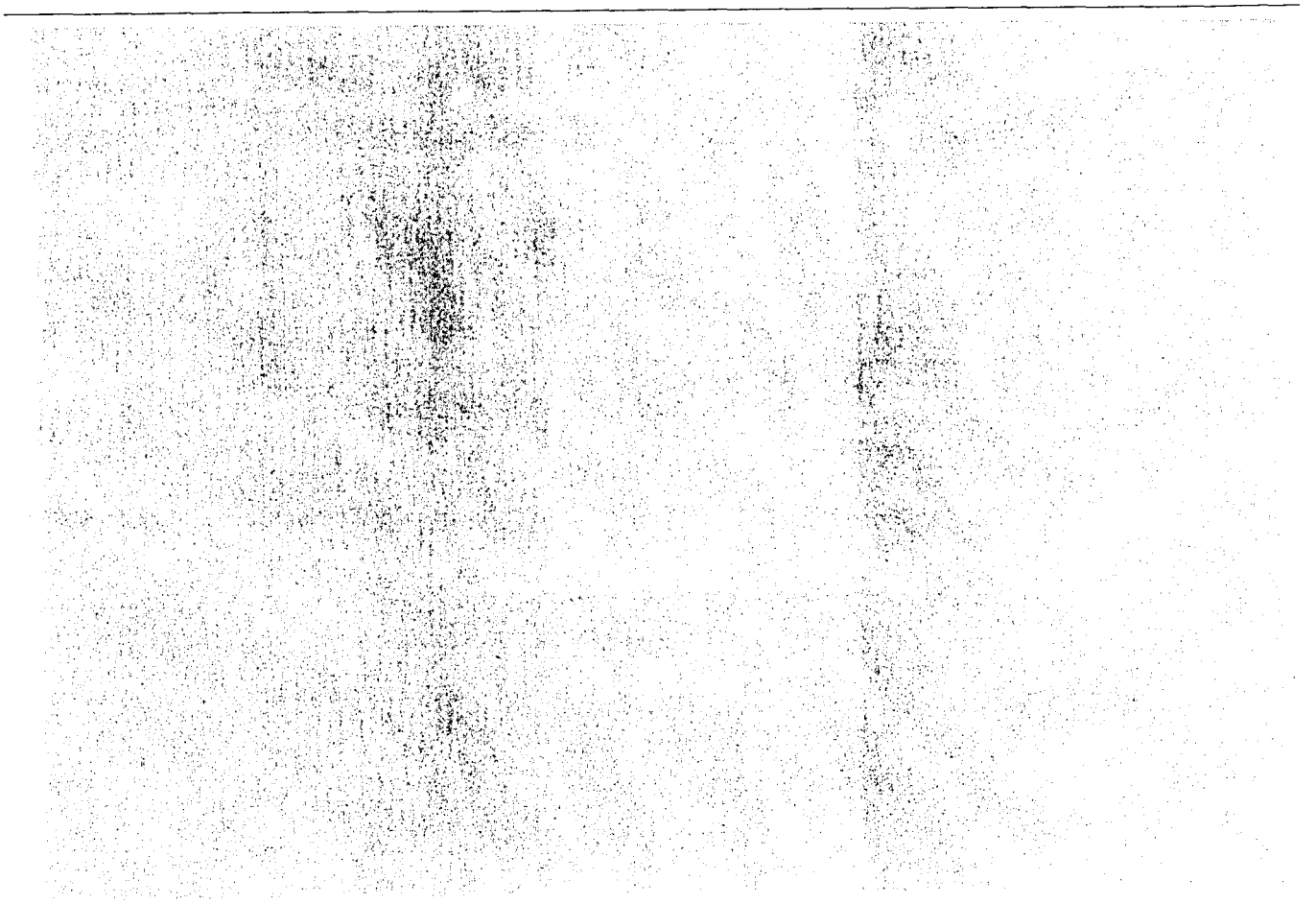
Finally, Terracciano *et al.*'s measures of perceived national character were the mean ratings of the culture by members of that culture. Stereotypes are usually defined in terms of perceptions of the target group by outside observers. Moreover, their measure of actual national character was the mean ratings of oneself or a significant other. In other words, the measurement of national character was based on the ratings of a culture, whereas the measurement of actual character was based on the ratings of a person. The contexts of the two kinds of assessments were quite different and potentially not comparable.

It is increasingly evident that context is an important contributor to outcomes on rating scales (*5*). There is even evidence that cultural differences by themselves can produce differences in the context of the measurement (6). A person familiar to the respondent will likely be evaluated in relation to other individuals familiar to the respondent, while a person asked to rate the culture will rate it in rclatiou to other cultures. It is not surprising then to find that these ratings were on average unrelated to ratings of the country's national character.

It is possible that there really is no relation between national stereotypes and actual behaviors. One must wonder, however, what is the source of the variability in the ratings of cultures. Why, for example, do the German Swiss believe they are so conscientious? Even more curious is why Indonesians and Chileans accept that they are not. It seems likely that when asked to rate themselves on conscien-

Letters to the Editor

Letters (~300 words) discuss material published in *Science* in the previous 6 months or issues of general interest. They can be submitted through the Web (www.submit2science.org) or by regular mail (1200 New York Ave., NW, Washington, DC 20005, USA). Letters are not acknowledged upon receipt, nor are authors generally consulted before publication. Whether published in full or in part, letters are subject to editing for clarity and space.



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*ATMOS*PHERIC SCIENCE

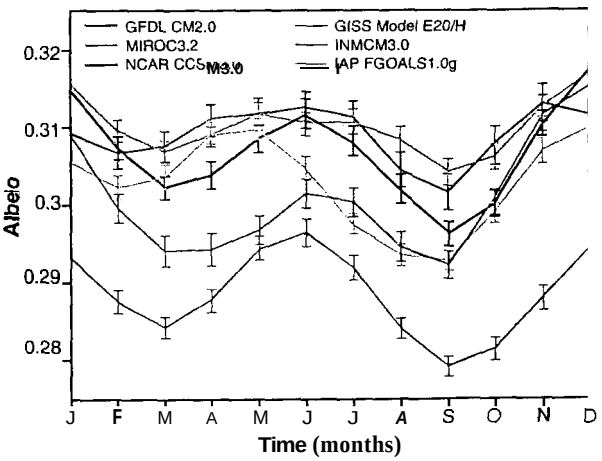
In Search of Balance

Robert J. Charlson, Francisco P. J. Valero, John H. Seinfeld

The climate of Earth and its global mean surface temperature are the consequence of a balance between the amount of solar radiation absorbed by Earth's surface and atmosphere and the amount of outgoing longwave radiation emitted by the system. The former is governed by the albedo (reflectivity) of the system, whereas the latter depends strongly on the atmospheric content of gases and particles (such as clouds and dust). Although the theory of absorption of infrared radiation by gases in the atmosphere (*1*) is well accepted and embodied in climate models, the observational and theoretical treatments of albedo, aerosols, and clouds are still under development. One brevium (2) and two reports (*3*, *4*) in this issue report estimates of Earth's albedo and of solar radiation reaching the surface, but the uncertainties remain large.

The buildup of CO, (*5*), CH_4, and other greenhouse gases during the past century has led to an increased absorption of infrared radiation in the atmosphere (enhanced greenhouse effect) and a consequent warming ("positive forcing") of the climate. But human-made changes in aerosols and clouds can cause enhanced albedo and hence cooling ("negative forcing"), and they may already have offset a substantial part of the enhanced greenhouse effect. Present trends suggest that by 2050, the magnitude of the enhanced greenhouse effect will be so large that the net anthropogenic forcing will be unequivocally positive and substantial in magnitude (6).

Changes in energy balance affect a host of climatic factors, such as temperature, sea level, meteorological patterns, and precipitation. To understand and quantify these effects, the enhanced greenhouse effect and all other forcings must be known accurately. To complicate matters further, the enhanced greenhouse effect is suspected of causing changes in clouds and hence albedo, resulting in feedbacks on both incoming and outgoing radiation **(7).**



Apparent agreement. Monthly mean annual cycle and standard deviation (vertical bars) of albedo from six models (*12*, *15*). These and other models are used by the Intergovernmental Panel on Climate Change (IPCC) for preindustrial control simulations.

Increased albedo could counteract the enhanced greenhouse effect on a global scale. However, the spatial and temporal characteristics of aerosols, clouds, and greenhouse gases differ widely. Clouds change rapidly, and atmospheric residence times for aerosols are short relative to those for the key greenhouse gases (which remain in the atmosphere for centuries). Albedo therefore changes rapidly, whereas the enhanced greenhouse effect simply increases as a result of the slow accumulation of greenhouse gases. Local and regional changes in energy balance would occur even if the albedo change could offset the enhanced greenhouse effect globally. Light-absorbing aerosols further complicate the picture by cooling Earth's surface, heating the atmosphere, and making clouds more absorbing; they may even reduce cloud cover, thereby decreasing albedo further.

These considerations underscore the importance of understanding the natural and anthropogenic changes in Earth's albedo and the need for sustained, direct, and simultaneous observations of albedo with all methods that are currently available. Albedo changes may be as important as changes in greenhouse gases for determining changes in global climate.

Many methods have been used to estimate albedo, which cannot be measured directly. These methods differ in their scattering geometries, calibration accuracy, and in spectral, space, and time coverage. The different modes of observation include measurements of earthshine reflected from the Moon (*8*, *9*), broadband radiometer data from low orbits around Earth [Wielicki *et al.* on page 825 (*2*)], geostationary cloud-cover observations (*10*), deep space radiometry (*11*), and surface radiometry [Pinker *et al.* on page 850(*3*), Wild *et al.* on page 847 (*4*)]. All these methods require a theoretical model for relating the measured parameters to albedo, and they all rely on different assumptions. It is critical to compare the results from different approaches to test the consistency among them.

The scientific community has recognized this essential need for years, but major impediments have developed. For example, the broadband data collected by the ERBS (Earth Radiation Budget Satellite) between 2000 and 2004 are not being analyzed for budgetary reasons. The DSCOVR (Deep Space Climate Observatory) satellite has been built but has since fallen victim to the delayed space shuttle program and is now in storage awaiting a launch opportunity. The CALIPSO (Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation) and CloudSat satellites have been built and have scheduled launches, but recent budget cuts imposed on the Earth sciences in NASA will severely constrain the analysis and interpretation of the data. Inasmuch as

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LARGE INCONSISTENCIES

Climatic observations and forcings	Equivalent change in albedo × 10^3
Enhanced greenhouse effect during industrial era (2.4 ± 0.2 W/m²) (6)	−7 ± 0.6
Anthropogenic aerosol forcing during industrial era (6)	+4 ± 4
Albedo change estimated from earthshine data (2000 to 2004) (2, 8, 9)	+16
Albedo change estimated from low-orbit satellite data (2000 to 2004) (2)	−6
Change in irradiance at Earth's surface measured with satellites (1983 to 2001) (3)	−8
Change in irradiance at Earth's surface measured at the surface (1985 to 2000) [Fig. 1 in (4)]	−13
Change in irradiance at Earth's surface measured at the surface (1950 to 1990) [Fig. 1 in (4)]	+20

the primary objectives of these three satellites include studies of the effects of aerosols and clouds on albedo, what seemed to be real progress could be delayed or thwarted.

Several global climate models appear to calculate nearly the same albedo (see the figure); however, clouds are treated very differently in these models, the seasonal cycles that are prominent in the figure are not apparent in data from the CERES (Clouds and the Earth's Radiant Energy System) experiment or from earthshine data (2, 8, 9, 12), and the global amount of condensed water varies among the models by as much as a factor of 5. Hence, little certainty can be gained from models alone.

To date, the results from different measurement and modeling approaches are inconsistent among themselves and with each other. The magnitudes of the inconsistencies exhibited by both measurements and models of albedo changes and effects are as large as, or larger than, the entire enhanced greenhouse gas effect when compared in terms of the albedo change equivalent of climate forcing (see the table). In fact, the albedo change that is the equivalent of the enhanced greenhouse effect is barely detectable by the available methods for measuring albedo.

To quantify all changes in energy balance, and in view of the discrepancies in magnitude and even sign (see the table and the figure), it will be necessary to develop a strategy to strengthen research efforts on albedo-related quantities, including modeling and analysis of the data from the yet-to-be-launched satellites. To help achieve a balance of effort, care must be exercised in the use of potentially misleading terms like "global warming" (13) and "global dimming" (14). Their use may constitute an obstacle in reaching an understanding of the issues driving the fundamental scientific questions of Earth's energy balance, albedo, greenhouse effect, and interactions of solar and infrared radiation with aerosols and clouds.

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14. Global dimming formally means a decrease in "global radiation" (the sum of direct plus diffuse solar radiation measured at a point on Earths surface), but might seem to imply that the Sun's radiation has dimmed or that the effect is global in extent.
15. GFDL: Geophysical Fluid Dynamics laboratory, USA. NCAR: National Center for Atmospheric Research, USA. GISS: Goddard Institute for Space Studies, USA. INMCM: Institute for Numerical Mathematics, Russia. IAP Institute of Atmospheric Physics, China. Miroc is a medium-resolution model run by the Center for Climate System Research (University of Tokyo), the National Institute for Environmental Studies, and the Frontier Research Center for Global Change of the japan Agency for Marine-Earth Science and Technology.
16. We thank the international modeling groups for providing their data for analysis, the Program for Climate Model Diagnosis and Intercomparison for collecting and archiving the model data, the JSC/CLIVAR Working Group on Coupled Modelling and their Coupled Model Intercomparison Project and Climate Simulation Panel for organizing the model data analysis, and the IPCC Working Group I Technical Support Unit for technical support. The IPCC Data Archive at Lawrence Livermore National Laboratory is supported by the Office of Science, U.S. Department of Energy.

10.1126/science.1108162

GEOCHEMISTRY

The Paradox of Mantle Redox

Catherine McCammon

Redox reactions (those involving reduction or oxidation) occur in many everyday processes, from photosynthesis and metabolism to fuel combustion and household cleaning. They also play a critical role in many geological systems. Processes on Earth's surface are intimately linked to the oxidation state of the mantle through the geochemical cycles of elements such as carbon, sulfur, oxygen, and hydrogen. Recent studies have advanced our understanding of the oxidation state of the mantle, elucidating the redox relations within Earth and their consequences for global processes.

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The term "oxidation state" has caused some confusion in the geological literature, because it has two different meanings in the context of mantle properties. First, it is used to indicate the valence state of elements, for example, divalent iron (Fe^{2+}) and trivalent iron (Fe^{3+}). Second, it is used to indicate the chemical potential of oxygen, more commonly referred to as oxygen fugacity. High oxygen fugacity means oxidizing conditions, whereas low oxygen fugacity implies reducing conditions.

In everyday experience, these two definitions of oxidation state are almost always coupled: Oxidizing conditions favor the formation of Fe^{3+} (for example, rust on a car), whereas reducing conditions favor the formation of Fe^{2+} or even metallic iron (Fe^0). However, paradoxical behaviors can arise when solids are present, because crystal structures impose additional constraints: Some minerals incorporate almost no Fe^{3+} even under oxidizing conditions, whereas others incorporate Fe^{3+} even under reducing conditions. A classic example is iron oxide, Fe_xO, which always contains a measurable amount of Fe^{3+} in its crystal structure, even under reducing conditions where metallic iron is stable.

Studies of mantle rocks show that the oxygen fugacity of the upper mantle is relatively high (1), even though the abundance of oxidized iron (Fe^{3+}) is low (2) (see the figure). How can we reconcile these apparently contradictory observations? The answer lies in the unfavorable energetics of defect incorporation in olivine, the most abundant mineral in the upper mantle. This property leads to an almost negligible Fe^{3+} concentration in olivine even under relatively oxidizing conditions (3). Fe^{3+} is readily incorporated into the minerals spinel and garnet, but because they are at least 1/10th as abundant as olivine, their presence causes only a small increase in Fe^{3+}

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National Aeronautics and
Space Administration

Headquarters
Washington, DC 20546-0001

DEC 5 2005

Reply to Attn of: SMD/Earth-Sun System Division

Professor Robert J. Charlson
Department of Atmospheric Sciences
University of Washington
Seattle, WA 98195-1640

Dear Professor Charlson:

Thank you for your letter of September 21,2005, reiterating your conviction in the science that a mission like Deep Space Climate Observatory (DSCOVR) would offer. First, let me assure you the scientific arguments you have made are not forgotten in the aftermath of the leadership change at NASA. It is widely recognized that the L-1 point offers a compelling vantage point for Earth observation.

Restrictions for the remaining Space Shuttle missions continue to preclude remanifesting DSCOVR for launch, a situation that is not expected to change. Although **NASA** has continued to explore alternative options to launch **this** spacecraft within budget constraints, DSCOVR remains without a specific launch opportunity.

Unfortunately, the significant funding that would be required to ready and launch DSCOVR within the context of competing priorities and the state of the budget for the foreseeable future precludes continuation **of** the project.

Thank you for your interest in the activities of NASA's Earth science mission.

Sincerely,

Mary L. Cleave
Associate Administrator for
Science Mission Directorate

A/2005-0131

cc:
Science Mission Directorate/Dr. Cleave

- Mr. Luther
- Dr. Fisher
- Mr. Gay
- Mr. Hammer
- Dr. Kaye
- Dr. Decola
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September 21,2005

Dr. Michael Griffin
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NASA Headquarters
300 " E Street S.W.
Washington, DC 20546-0001

Dear Dr. Griffin:

Early in 2004, I sent the enclosed letter to Mr. O'Keefe and received the enclosed supportive response from Dr. Asrar. Since this exchange is in support of the Deep Space Climate Observatory, DSCOVR, there have been substantial changes in the leadership in NASA and I want to be sure that the earlier exchange is not forgotten.

The scientific arguments in my letter to Mr. O'Keefe are still valid; indeed radiometric observations from L-1 are the only way to view the entire sunlit side of Earth at the same time.

I also enclose a reprint of a recent "Perspectives" in *Science* that argues for enhanced research on the Earth's albedo, of which DSCOVR is a major part.

Sincereiy,

R. Charlson/sp

R. J. Charlson
Professor

Cc: Dr. Richard R. Fisher
Dr. Mary L. Cleave

A/2005-01311

National Aeronautics and
Space Administration
Headquarters
Washington, DC 20546-0001

MAY 23 2006

Reply to Attn *of:* Science Mission Directorate

Dr. Francisco Valero
Center for Atmospheric Sciences
Scripps Institution of Oceanography
9500 Gilman Drive
La Jolla, CA 92093-0242

Dear Dr. Valero:

Thank you for your letter of March 29, 2006, reiterating the scientific potential offered by the Deep Space Climate Observatory (DSCOVR) mission. As you noted, the value of the science to be gained from the Lagrange-1 (L1) orbit has been well identified by the Earth science community.

As I indicated in my letter to you dated November 18, 2005, continuation of the DSCOVR mission was not practical in the context of competing Earth science priorities. Even though our budgetary situation remains challenging, let me assure you NASA continues to preserve the DSCOVR assets while the results of the NOAA solar wind trade study are assessed for viability.

The recently announced award of d e Lunar CRater Observation and Sensing Satellite (LCROSS) mission to advance the President's Vision for Space Exploration precludes the Lunar Reconnaissance Orbiter (LRO) ride-share to which you referred.

Finally, NASA expects to receive guidance later this year from the National Academies in the form of their decadal survey on Earth science priorities. It is anticipated d e report will aid in setting NASA's mission portfolio strategy, including the role of missions to the L1 orbit.

Thank you for continuing to work within our significant fiscal constraints toward developing the best disposition plan' forthe DSCOVR assets.

Sincerely,

Mary L. Cleave
Associate Administrator
for Science Mission Directorate

A/2006-005540

cc:
Science Mission Directorate/Dr. Hartman

- Mr. Luther
- Dr. Cramer
- Mr. Hooker
- Mr. Hammer

Headquarters Action Tracking System (HATS)

Incoming Correspondence Action

A/2005-01311

Title : **Deep Space Climate Observatory (DSCOVR)**

Recipient:	**A/Griffin**		
Author:	**Charlson**		
Organization:	**Univ. of Washington**	**Date Written:**	**09/21/2005**
		Date Received:	09/29/2005
		Date Concurred:	
		Date Submitted:	
		Date Signed:	12/05/2005
Action Office:	**SMD/Cleave**	**Date Closed:**	**12/05/2005**
		>>Current Due Date:	**10/14/2005<<**
Status:	**Closed**		

Signature Office: **SMD/Cleave**

Info Offices: **A/Geveden, A/Griffin, A/Morrell, AD/Gregory**

Abstract:

R. J. Carlson, Prof., forwards response to his 2004 letter to Sean O'Keefe from Dr. Asrar. Carlson wants NASA to know that his scientific arguments to Mr. O'Keefe are still valid.

Comments:

Response signed by Mary Cleave stating that DSCOVR remains without a specific launch opportunity. bf

Enclosures: **letter to O'Keefe and response**

Related Records:

Keywords: carlson dscovr deep space climate observatory

File Plan: 1200-2-0321 G 05 Analyst: BFenner

Headquarters Action Tracking System (HATS)
Incoming Correspondence Action

A/2005-01311

Progress Notes:

12/05/2005 03:03PM,	A/Griffin:	Action Update. Signed on 12/05/2005, Closed on 12/05/2005.
11/18/2005 04:06AM,	A/Griffin:	HATS Message: Action Item A/2005-01311 is 35 days overdue.
09/29/2005 12:48PM,	A/Griffin:	Action Status Open.

Keywords: carlson dscovr deep space climate observatory
File Plan: 1200-2-0321 G 05 Analyst: BFenner

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Robert J. Charlson
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September 21,2005

Dr. Michael Griffin
Office of the Administrator
NASA Headquarters
300 "E" Street S.W.
Washington, DC 20546-0001

Dear Dr. Griffin:

Early in 2004, I sent the enclosed letter to Mr. OKeefe and received the enclosed supportive response from Dr. Asrar. Since this exchange is in support of the Deep Space Climate Observatory, DSCOVR, there have been substantial changes in the leadership in NASA and I want to be sure that the earlier exchange is not forgotten.

The scientific arguments in my letter to Mr. O'Keefe are still valid; indeed radiometric observations from L-1 are the only way to view the entire sunlit side of Earth at the same time.

I also enclose a reprint of a recent "Perspectives" in *Science* that argues for enhanced research on the Earth's albedo, of which DSCOVR is a major part.

Sincerely,

R. Charlson/sp

R. J. Charlson
Professor

Cc: Dr. Richard R. Fisher
Dr. Mary L. Cleave

A/2005-01311

UNIVERSITY OF WASHINGTON

Department of Atmospheric Sciences

28 January 2004

Mr. Sean OXeefe, Administrator
NASA Headquarters, Code A
300 "E" Street, S.W., Suite 9F44
Washington DC 20546-0001

Dear Mr. OXeefe,

I am writing to you as an individual scientist to bring to your attention a serious *gap* in the development of an observational basis for quantifying the natural and forced changes in the Earth's climate. Specifically, I want to urge NASA to move ahead with the deployment of the Deep Space Climate Observatory, DSCOVR, as a means to significantly refine *the* understanding and quantification of the Earth's reflectance or albedo.

My own research for the past 14 years has focused on quantification of the effects *of* anthropogenic aerosols on the Earth's reflection and absorption of solar radiation; indeed, my colleagues and I published the first papers on the complex topic *of* climate forcing by anthropogenic aerosols. As a member of the Science Team for the NASA satellite CALIPSO, I am fully aware of the fine opportunities for measurement that its laser radar will provide along with the rich data *set* expected from the Aqua-Train. We are confident that these new data sources will significantly improve our ability to calculate the climate forcing by aerosols, and it will provide important reductions in the dependence upon assumptions regarding aerosol effects in climate models.

But, the larger context of these aerosol effects is the albedo of the planet, which is one of the least well-quantified factors influencing the Earth's energy balance. The global albedo is largely determined by the properties and areal extent of clouds. It is very difficult to model and is measured only with large uncertainties, even by the best radiometers aboard NASA satellites, such as CERES. Among the difficulties with information gained from instruments in low Earth orbit is the fact that the satellite "sees" only a small portion of the planet at any instant, and polar orbiting platforms are usually sun-syncronous such that they *make* observations at only one time of day and at one or a few angles. The classical technique for determining the Earth's albedo is based on observations of the portion of the moon illuminated by "Earthlight". This method complements existing satellite observations, and at times can "see" nearly the whole sunlit hemisphere, but still has an accuracy of only about 0.006 (in albedo units), which in turn results in an uncertainty in energy balance around 2 Watts per square meter. For reference, the total forcing by greenhouse gases is 2.4 Watts per square meter, which has *an* uncertainty of only about 10%. Thus, the uncertainty in *the* measurement of albedo and its variations is as large or larger *than* the whole man-made greenhouse effect. Importantly, much work has been done over the last century on the greenhouse effect but very little has been done about global albedo, largely because clouds are so difficult to model and *to* measure globally.

In order to obviate this serious problem, radiometers carried aboard DSCOVR could be used to provide much refined data on albedo and its geographical and temporal variability. Its accuracy should be comparable to that of the lunar method. Its high time resolution will undoubtedly

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reveal new aspects of the factors causing albedo fluctuations. It would observe continuously nearly the entire sunlit side of the Earth from a unique vantage in the vicinity of the L1 point between Earth and the sun. These instruments and the satellite platform for them have been built and are now in storage for want of a launch opportunity.

When launched, DSCOVR will continuously observe the same exact scenes as will be observed by the satellites of the A-Train, providing coincident, multivariate data sets for detailed analysis. Great synergistic value will be added to the A-Train data sets via comparisons and contrasts to the more global data of DSCOVR. Just as albedo is the global context for studying and understanding aerosol effects, the near-hemispheric data of DSCOVR will provide a continuous context for the more detailed measurements made from those platforms in low Earth orbit. Considerable additional value will accrue, far beyond the actual cost of launching and operating DSCOVR.

Recent papers (e.g., J. Geophys. Res. 108(D22) 4709doc:10.1029/2003JD003610,2003; Ibid, 471Odoi:10.1029/2003JD003611,2003) including both satellite- and lunar-based observational estimates show that the global albedo is a dynamic quantity with large (many percent) variations that are not captured well in global climate models. However, tests of the internal consistency of these estimates show significant disagreements, even in the nature of the annual variations. DSCOVR will provide an objective means for testing the internal consistency of all of the above as well as the data from the A-Train.

Again, I urge you to press the case for launching and operating DSCOVR so that we in the scientific community can make real progress toward understanding climate and the impacts of human activity upon it. Without it, we will continue to be stuck with excessive uncertainties and dependence upon assumptions instead of data.

Sincerely,

R.J Charlson

Robert J. Charlson
Professor
Department of Atmospheric Sciences
TEL: (206) 543-2537

cc. Dr. Ghassem Asrar
Prof. Daniel Jacob
Dr. Jeffrey Kiehl
Prof. John Seinfeld
Prof. Richard C. J. Somerville
Prof. Francisco P.J.Valero
Dr. David Winker

National Aeronautics and
Space Administration
Headquarters
Washington, DC 20546-0001

February 17, 2004

Reply to Attn of: YF

Professor Robert J. Charlson
Department of Atmospheric Sciences
University of Washington
Seattle, Washington 98195-1640

Dear Professor Charlson:

Thank you for your letter of January 28, 2004, expressing your sincere interest in the Deep Space *Climate* Observatory (DSCOVR) mission. Indeed, your points on the value of developing an improved observational basis for quantitatively characterizing the climate forcing of aerosols are well taken. It is widely recognized that the science offered by DSCOVR would help make possible an integrated self-consistent global database for studying the extent of regional and global change.

Due to Space Shuttle manifesting constraints recently directed by the President the DSCOVR mission is currently without a specific launch opportunity. Presently, the DSCOVR *spacecraft* remains safely in storage at NASA's Goddard Space Flight Center awaiting future identification of a suitable launch. NASA is continuing to explore options to launch this spacecraft as soon as possible.

I share your view of the high priority that needs to be placed on accurate quantification of climate forcing due to aerosols and that, in its unique vantage point at the L1 orbit, DSCOVR would play a valuable role toward our understanding of *those* aerosol effects. Until a new flight opportunity for DSCOVR is identified, NASA will continue to encourage its scientists, led by Dr. Francisco P. J. Valero at the Scripps Institute of Oceanography, to collaborate on this exciting mission via the DSCOVR Science Team.

Thank you for your interest in this important NASA mission.

Cordially,

Ghassem R. Asrar
Associate Administrator for
Earth Science

cc:
A/Mr. O'Keefe
AA/Mr. Schumacher
Y/Mr. Luther
YF/Mr. McCuistion
YF/Mr. Hooker
YS/Dr. Kaye

Science Reprint

In Search of Balance

Robert J. Charlson, Francisco P. J. Valero, John H. Seinfeld

6 May 2005, Volume 308, pp. 806-807

ATMOSPHERIC SCIENCE

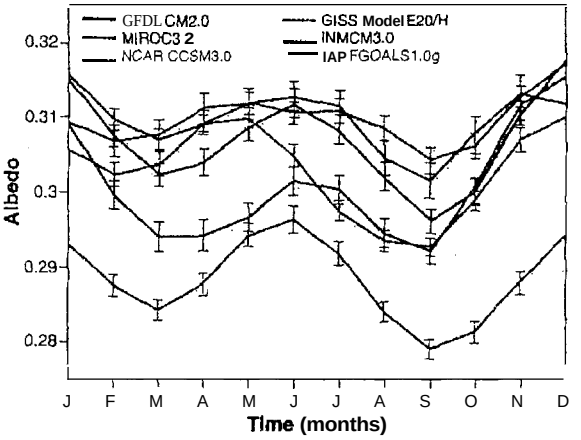
In Search of Balance

Robert J. Charlson, Francisco P. J. Valero, John H. Seinfeld

The climate of Earth and its global mean surface temperature are the consequence of a balance between the amount of solar radiation absorbed by Earth's surface and atmosphere and the amount of outgoing longwave radiation *emitted* by the system. The former is governed by the albedo (reflectivity) of the system, whereas the latter depends strongly on the atmospheric content of gases and particles (such as clouds and dust). Although the theory of absorption of infrared radiation by gases in the atmosphere (*1*) is well accepted and embodied in climate models, the observational and theoretical treatments of albedo, aerosols, and clouds are still under development. One brevium (2) and two reports (*3*, *4*) in this issue report estimates of Earth's albedo and of solar radiation reaching the surface, but the uncertainties remain large.

The buildup of CO_2 (*5*), CH_4, and other greenhouse gases during the past century has led to an increased absorption of infrared radiation in the atmosphere (enhanced greenhouse effect) and a consequent warming ("positive forcing") of the climate. But human-made changes in aerosols and clouds can cause enhanced albedo and hence cooling ("negative forcing"), and they may already have offset a substantial part of the enhanced greenhouse effect. Present trends suggest that by 2050, the magnitude of the enhanced greenhouse effect will be so large that the net anthropogenic forcing will be unequivocally positive and substantial in magnitude (*6*).

Changes in energy balance affect a host of climatic factors, such as temperature, sea level, meteorological patterns, and precipitation. To understand and quantify these effects, the enhanced greenhouse effect and all other forcings must be known accurately. To complicate matters further, the enhanced greenhouse effect is suspected of causing changes in clouds and hence albedo, resulting in feedbacks on both incoming and outgoing radiation (*7*).



Apparent agreement. Monthly mean annual cycle and standard deviation (vertical bars) of albedo from six models (*72*, *75*). These and other models are used by the Intergovernmental Panel on Climate Change (IPCC) for preindustrial control simulations.

Increased albedo could counteract the enhanced greenhouse effect on a *global* scale. However, the spatial and temporal characteristics of aerosols, clouds, and greenhouse gases differ widely. Clouds change rapidly, and atmospheric residence times for aerosols are short relative to those for the key greenhouse gases (which && the atmosphere for centuries). Albedo therefore changes rapidly, whereas the enhanced greenhouse effect simply increases as a result of the slow accumulation of greenhouse gases. Local and regional changes in energy balance would occur even if the albedo change could offset the enhanced greenhouse effect globally. Light-absorbing aerosols further complicate the picture by cooling Earth's surface, heating the atmosphere, and making clouds more absorbing; they may even reduce cloud cover, thereby decreasing albedo further.

These considerations underscore the importance of understanding the natural and anthropogenic changes in Earth's albedo and the need for sustained, direct, and simultaneous observations of albedo with all methods that are currently available. Albedo changes may be as important as changes in greenhouse gases for determining changes in global climate.

Many methods have been used to estimate albedo, which cannot be measured directly. These methods differ in their scattering geometries, calibration accuracy, and in spectral, space, and time coverage. The different modes of observation include measurements of earthshine reflected from the Moon (*8*, *9*), broadband radiometer data from low orbits around Earth [Wielicki *et al.* on page 825 (*2*)], geostationary cloud-cover observations (*10*), deep space radiometry (*11*), and surface radiometry [Pinker *et al.* on page 850 (*3*), Wild *et al.* on page 847 (*4*)]. All these methods require a theoretical model for relating the measured parameters to albedo, and they all rely on different assumptions. It is critical to compare the results from different approaches to test the consistency among them.

The scientific community has recognized this essential need for years, but major impediments have developed. For example, the broadband data collected by the ERBS (Earth Radiation Budget Satellite) between 2000 and 2004 are not being analyzed for budgetary reasons. The DSCOVR (Deep Space Climate Observatory) satellite has been built but has since fallen victim to the delayed space shuttle program and is now in storage awaiting a launch opportunity. The CALIPSO (Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation) and CloudSat satellites have been built and have scheduled launches, but recent budget cuts imposed on the Earth sciences in NASA will severely constrain the analysis and interpretation of the data. Inasmuch as

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LARGE INCONSISTENCIES

Climatic observations and forcings	Equivalent change in albedo × 10^3
Enhanced greenhouse effect during industrial era (2.4 ± 0.2 W/m²) (6)	−7 ± 0.5
Anthropogenic aerosol forcing during industrial era (6)	+4 ± 4
Albedo change estimated from earthshine data (2000 to 2004) (2, 8, 9)	+16
Albedo change estimated from low-orbit satellite data (2000 to 2004) (2)	−6
Change in irradiance at Earth's surface measured with satellites (1983 to 2001) (3)	−8
Change in irradiance at Earth's surface measured at the surface (1985 to 2000) [Fig. 1 in (4)]	−13
Change in irradiance at Earth's surface measured at the surface (1950 to 1990) [Fig. 1 in (4)]	+20

the primary objectives of these three satellites include studies of the effects of aerosols and clouds on albedo, what seemed to be real progress could be delayed or thwarted.

Several global climate models appear to calculate nearly the same albedo (see the figure); however, clouds are treated very differently in these models, the seasonal cycles that are prominent in the figure are not apparent in data from the CERES (Clouds and the Earth's Radiant Energy System) experiment or from earthshine data (2, 8, 9, 12), and the global amount of condensed water varies among the models by as much as a factor of 5. Hence, little certainty can be gained from models alone.

To date, the results from different measurement and modeling approaches are inconsistent among themselves and with each other. The magnitudes of the inconsistencies exhibited by both measurements and models of albedo changes and effects are as large as, or larger than, the entire enhanced greenhouse gas effect when compared in terms of the albedo change equivalent of climate forcing (see the table). In fact, the albedo change that is the equivalent of the enhanced greenhouse effect is barely detectable by the available methods for measuring albedo.

To quantify all changes in energy balance, and in view of the discrepancies in magnitude and even sign (see the table and the figure), it will be necessary to develop a strategy to strengthen research efforts on albedo-related quantities, including modeling and analysis of the data from the yet-to-be-launched satellites. To help achieve a balance of effort, care must be exercised in the use of potentially misleading terms like "global warming" (13) and "global dimming" (14). Their use may constitute an obstacle in reaching an understanding of the issues driving the fundamental scientific questions of Earth's energy balance, albedo, greenhouse effect, and interactions of solar and infrared radiation with aerosols and clouds.

References and Notes

1. S. Arrhenius, *Philos. Mag.* 41,237 (1896).
2. B. A. Wielicki *et al.*, *Science* 308, 825 (2005).
3. R. T. Pinker *et al.*, Science 308, 850 (2005).
4. M. Wild *et al.*, *Science* 308, 847 (2005).
5. C. D. Keeling, *Tellus* 12, 200 (1960).
6. T. L Anderson *et al.*, Science 300.1103 (2003).
7. M. Sun, R. D. Cess, Geophys. *Res.* Lett.31, L12215 (2004).
8. E. Pallé et al. *Science* 304, 1299 (2004).
9. E Pallé *et al., J. Geophys. Res.* 108 (D22), 4710 (2003).
10. Y. Zhang *et al., J.* Geophys. Res. 109, D19105 (2004).
11. National Academy of Sciences, Space *Studies* Board Annual *Report 2000* (National Academies Press. Washington, *OC*, 2001). pp. 93–108.
12. F. Bender, H. Rodhe. R. J. Charlson, Global Albedo in *GCMs—Key* to *Climate Stability?* Poster presented at the IPCC Model Analysis Workshop. Honolulu, 1 to 4 March 2005.
13. Global warming formally means an increase in the mean temperature at Earth's surface, but may seem to imply (incorrectly) that the whole Earth will warm more or less uniformly.
14. Global dimming formally means a decrease in "global radiation" (the sum of direct plus diffuse solar radiation measured at a point on Earth's surface), but might seem to imply that the Sun's radiation has dimmed or that the effect is global in extent.
15. GFDL: Geophysical Fluid Dynamics Laboratory. USA. NCAR: National Center for Atmospheric Research, USA GISS: Coddard Institute for Space Studies. USA. INMCM: Institute for Numerical Mathematics. Russia. IAP institute of Atmospheric Physics, China. Miroc is a *medium-resolution model* run by the Center for Climate System Research (University of Tokyo). the National Institute for Environmental Studies. and the Frontier Research Center for Global Change of the Japan Agency for Marine-Earth Science and Technology.

16. We thank the international modeling groups for providing their data for analysis. the Program for Climate Model Diagnosis and Intercomparison for collecting and archiving the model data, the JSC/CLIVAR Working croup on Coupled Modelling and their Coupled Model Intercomparison Project and *Climate* Simulation Panel for organizing the model data analysis. and the IPCC Working Group I Technical Support Unit for technical support. The IPCC Data Archive at Lawrence Livermore National Laboratory is supported by the Office of Science. U.S. Department of Energy.

10.1126/science.1108162

Headquarters Action Tracking System (HATS)
Correspondence Information Only

A/2006-00021

Title : **Writer Requests More Information from Dr. Mary Cleave**

NASA Recip/Originator: **A/Griffin**

Ext Author/Recip: **Charlson**

Organization: **Univ. of Washington**

Date Written: **12/20/2005**

Date Received: 01/06/2006

Action Office: **SMD/Cleave**

Status: **Closed**

Info Offices: **A/Griffin, A/Morrell, AA/Geveden, AD/Dale**

Abstract:

Administrator Griffin is "cc'd" on a letter to Dr. Mary Cleave from Prof. Charlson. Charlson requests a "more complete scientific statement that properly weighs the value of the simultaneous DSCOVR and A-Train data.

Comments:

Enclosures: **an article**

Related Records: **a/2005-01311**

Keywords: charlson university Washington DSCOVR

File Plan: 1200-2-0900606 Analyst: BFenner

Headquarters Action Tracking System (HATS)

Correspondence Information Only

A/2006-00021

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06/27/2006 11:43AM,	A/Griffin:	Action Update. Closed on 01/09/2006.
06/27/2006 11:43AM,	A/Griffin:	Action Update. Status changed from Closed to Open.
01/09/2006 03:38PM,	A/Griffin:	Action Update. Closed on 01/09/2006.
01/09/2006 03:37PM,	A/Griffin:	Action Update. Status changed from Closed to Open.
01/09/2006 03:37PM,	A/Griffin:	Action Status Closed.

Keywords: charlson university washington DSCOVR
File Plan: 1200-2-0900G06 Analyst: BFenner

UNIVERSITY OF WASHINGTON
Department of Atmospheric Sciences
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December 20,2005

Dr. Mary L. Cleave
Associate Administrator for Science Mission Directorate
NASA Headquarters, Mail Suite: 5E39-A
300 "E" Street S.W.
Washington, DC 20546-0001

Dear Dr. Cleave,

Thank you for your December 5,2005 response to my letter to Dr. Griffin of September 21, 2005. As a Co-Investigator on the CALIPSO satellite, I am deeply concerned that a failure to launch and operate DSCOVR while the A-Train is operational will seriously damage the scientific integrity of current research on albedo-related parameters of the Earth System.

In your response, you assure me that my "scientific arguments . . . are not forgotten". Yet, in spite of those scientific arguments, you state that "conditions preclude continuation of the (DSCOVR) project". You also mention "significant funding" that would be required to launch DSCOVR but it seems relevant to also consider the much larger, lost-opportunity cost of not having the DSCOVR data coincident with the A-Train.

I would appreciate receiving a more complete scientific statement that properly weighs the **value** of the simultaneous DSCOVR and A-Train data. In light of the scientific importance of albedo-related measurements, consideration also should be given to alternate or complementary funding sources such as NOAA.

In closing, I want to call your attention to the enclosed reprint of a Perspective in *Science* that summarizes the scientific importance **of** the albedo-related measurements.

Sincerely,

R. J. Charlson /s

Robert J. Charlson
Professor of Atmospheric Sciences
and Professor of Chemistry
TEL: (206) 543-2537

Enclosure: Perspectives, in *Science,* Reprint: "In Search of Balance", R.J. Charlson, F.P.J. Valero, J.H. Seinfeld, *Science,* **308,** May *2005,* pp. 806-807.

cc: Dr. Michael Griffin
Dr. Patricia Mulligan
Prof. Francisco Valero

A/2006-00021