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GEOSS, CEOS, and the Future Global Remote Sensing Space System for Societal Benefits

Stephen A. Mango
Stephen P. Sandford
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Editors

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Contents

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Introduction

Significant progress has been made in the world's efforts towards a Global Earth Observing System of Systems [GEOSS] since the GEOSS Conference at the Fifth SPIE Asia Pacific Remote Sensing Symposium in Goa, India in November 2006 and, to be sure, since the GEOSS Conference at the Fourth SPIE Asia Pacific Remote Sensing Symposium in Honolulu, Hawaii in November 2004.

It was realized at the turn of the century that a hallmark of the emerging Twenty-First Century was the emergence of globalization in many areas important to society. An important factor in achieving globalization to improve societal conditions would be the establishment of a global, integrated Earth observing system. In the last five years, many national and international agencies have met and agreed to the development of a cooperative strategy for understanding the Earth's environment and its interactions with the peoples of the Earth. Several high-level activities have culminated in Earth Observation Summits, Group on Earth Observations Plenary Meetings and GEO Ministerial Summits and several Working Groups, Task Forces and Committees.

One of the key foundation stones for a Global Earth Observation System of Systems (GEOSS) and the Group on Earth Observations (GEO) was laid in place at the 2002 World Summit on Sustainable Development in Johannesburg, South Africa. At this Summit the participating countries and organizations "highlighted the *urgent need* for coordinated observations relating to the state of the Earth". In June 2003 in Evian, France the Group of Eight (G8) Summit affirmed the importance of such an urgent need for coordinated observations relating to the state of the Earth. One month later in Washington, DC, July 2003, the first Earth Observation Summit (EOS-I) convened and adopted the Declaration to establish the ad hoc, intergovernmental Group on Earth Observations (GEO) to develop a 10-Year Implementation Plan to build a Global Earth Observation System of Systems (GEOSS) over the next decade. Summit EOS-II occurred in February 2004, in Tokyo, Japan, to adopt the Framework Document which defined the scope and intent of a Global Earth Observation System of Systems (GEOSS). One year later in February 2005 Summit EOS-III convened in Brussels, Belgium to endorse the GEOSS 10-Year Implementation Plan that had been formulated by many of the participating countries and organizations in separate and joint working groups and affirmed and approved in GEO Plenaries.

The formative GEO I Plenary took place May 3–4, 2005 in Geneva, Switzerland. It was at this Plenary that the all important, 10-Year Implementation Plan endorsed by all members at the EOS-III Summit in February 2005, was adopted for execution by the new GEO. As stated by the GEO, the GEOSS vision is embodied in its 10-Year Implementation Plan.

Subsequent GEO Plenaries in the next three and a half years significantly advanced the cooperative process of formulating a realizable GEOSS: GEO II—December 2005, Geneva, Switzerland, GEO III—November 2006, Bonn, Germany, GEO IV—November 28-29, 2007, Cape Town, South, Africa (and a Ministerial Summit, November 30, 2007 also in Cape Town) and the most recent GEO V—November 2008, Bucharest, Romania. GEO V—accepted a 2009–2011 Work Plan that details the actions governments and organizations will take to make the Global Earth Observation System of Systems (GEOSS) a reality. The stated intention is that these activities will build the fundamental infrastructure underpinning GEOSS and establish products and services for decision-makers in the nine Societal Benefit Areas. The next GEO-VI Plenary will be held in Washington, DC in late 2009.

Membership in the GEO and early participation in the planning for a GEOSS has led to a gathering storm of early commitments and activities. The GEO Secretariat clearly indicates that membership in the GEO is open to *all member States of the United Nations*, of which there are presently 192 member States, and to the European Commission, of which there are presently 25 members. As of November 2008 there are 76 countries plus the European Commission for a total of 77 registered as GEO Members (see Table 1).
One of the only conditions of membership is the formal endorsement of the GEOSS 10-Year Implementation Plan.

Participating Organizations are welcome to join the GEO. At present there are 56 such International and National Organizations (see Table 2). New Organizations can be added subject to the approval of the Members meeting in any Plenary. In addition, the GEO may also invite any other relevant entities to participate in its activities as Observers.

The GEO Secretariat is based in Geneva, Switzerland. The GEO Headquarters is at 7 bis, avenue de la Paix, CP 2300; CH-1211 Geneva 2, Switzerland +41 22 730 8505; secretariat@geosec.org; www.earthobservations.org.

The GEOSS implementation plan is a manifestation of the essentially global scientific and political consensus that the complete assessment of the Earth requires continuous and coordinated observation of our planet on many scales. The plan includes the coordination of a wide range of space-based, air-based, and land-based environmental monitoring platforms, resources and networks—presently often operating independently. GEOSS is planned to be a distributed system-of-systems. It will work with and build upon existing national, regional, and international systems in order to provide the comprehensive, coordinated Earth observations distributed over the planet. The present version of the plan keys on tasks for the nine (9) GEOSS "societal benefit areas"—disaster reduction, health, energy resources, water resources, weather, climate, oceans, ecosystems-biodiversity, agriculture, and combating desertification.

In the last few years the Committee on Earth Observations (CEOS) has forged a long-term partnership with the GEO. While the GEO can be considered as a policy group at the governmental and international organization level, the CEOS can be considered as a technical group at the space agency and user organization level. CEOS has at the present time 28 members or space agencies and approximately 20 associates or user organizations (see Table 3). CEOS is recognized as the satellite arm of GEO and is developing a CEOS Implementation Plan for the space-based component of GEOSS. CEOS utilizes a Virtual Constellations concept to organize international collaboration. Currently, there are six Virtual Constellations: 1) AC—Atmospheric Composition (NASA and ESA leads; 2) PC—Precipitation (JAXA and NASA leads); 3) OST—Ocean Surface Topography (NOAA and EUMETSAT leads); 4) LSI—Land Surface Imaging (USGS and ISRO leads); 5.) OCR—Ocean Color Radiometry; and 6.) OSVW—Ocean Surface Vector Winds. Other Constellation teams are also under consideration.

This Conference—GEOSS, CEOS and the Future Global Remote Sensing Space System for Societal Benefits—focused on the future spacebased operational elements of the GEOSS, working in unison with current space-based systems and/or land-, air- or sea-based sensors, missions, and networks in order to make significant contributions to the GEOSS societal benefit areas. The GEOSS is being driven by societal benefits and this conference strived to show linkages between societal needs and the operational and research measurements systems required to meet these needs. Often these benefits require extensive modeling as well as measurements so these linkages are also very important to highlight as well. Key areas highlighted included a potential future operational climate system, disaster monitoring and response system, agriculture, land use and hydrology applications,

This Conference covered some of the CEOS contributions to the GEOSS, partnership models and measures that reflect the payoff of Earth observations and Earth system models, and collaborative mission opportunities among international space agencies to deliver new capabilities and efficiencies at the global system level.

Stephen A. Mango
Stephen P. Sanford
Haruhisa Shimoda
Ranganath R. Navalgund

Table 1: Group on Earth Observations [GEO] Member Countries (76) Plus European Commission

[Source: Group on Earth Observations - as of November 2008]

1. Algeria
2. Argentina
3. Australia
4. The Bahamas
5. Bahrain
6. Bangladesh
7. Belgium
8. Belize
9. Brazil
10. Cameroon
11. Canada
12. Central African Republic
13. Chile
14. China
15. Congo, Republic of the
16. Costa Rica
17. Croatia
18. Cyprus
19. Czech Republic
20. Denmark
21. Egypt
22. Estonia
23. European Commission
24. Finland
25. France
26. Germany
27. Greece
28. Guinea-Bissau
29. Honduras
30. Hungary
31. Iceland
32. India
33. Indonesia
34. Iran
35. Ireland
36. Israel

38. Italy

38. Japan

39.Kazakhstan

40. Korea, Republic of
41. Latvia
42. Luxembourg
43. Malaysia
44. Mali
45. Mauritius
46. Mexico
47. Moldova
48. Morocco
49. Nepal
50. Netherlands
51. New Zealand
52. Niger
53. Nigeria
54. Norway
55. Pakistan
56. Panama
57. Paraguay
58. Peru
59. Philippines
60. Portugal
61. Romania
62. Russian Federation
63. Slovakia
64. Slovenia
65. South Africa
66. Spain
67. Sudan
68. Sweden
69. Switzerland
70. Thailand
71. Tunisia
72. Turkey
73. Uganda
74. Ukraine
75. United Kingdom
76. United States
77. Uzbekistan

Table 2: Group on Earth Observations [GEO] Member Organizations (56)

[Source: Group on Earth Observations - as of November 2008]

1. AARSE: African Association of Remote Sensing of the Environment
2. ADIE: Association for the Development of Environmental Information
3. APN: Asia-Pacific Network for Global Change Research
4. CATHALAC: Water Center for the Humid Tropics of Latin America and the Caribbean
5. CEOS: Committee on Earth Observation Satellites
6. CGMS: Coordination Group for Meteorological Satellites
7. CMO: Caribbean Meteorological Organization
8. COSPAR: Committee on Space Research
9. DANTE: Delivery of Advanced Network Technology to Europe
10. DIVERSITAS
11. ECMWF: European Centre for Medium-Range Weather Forecasts
12. EEA: European Environmental Agency
13. EIS-AFRICA: Environmental Information Systems - AFRICA
14. ESA: European Space Agency
15. ESEAS: European Sea Level Service
16. EUMETNET: Network of European Meteorological Services/Composite Observing System
17. EUMETSAT: European Organization for the Exploitation of Meteorological Satellites
18. EuroGeoSurveys: The Association of the Geological Surveys of the European Union
19. FAO: Food and Agriculture Organization of the United Nations
20. FDSN: Federation of Digital Broad-Band Seismograph Networks
21. GBIF: Global Biodiversity Information Facility
22. GCOS: Global Climate Observing System
23. GLOBE: Global Learning and Observations to Benefit the Environment
24. GSDI: Global Spatial Data Infrastructure
25. GOOS: Global Ocean Observing System
26. GTOS: Global Terrestrial Observing System
27. IAG: International Association of Geodesy
28. ICIMOD: International Centre for Integrated Mountain Development
29. ICSU: International Council for Science
30. IEEE: Institute of Electrical and Electronics Engineers
31. IGBP: International Geosphere-Biosphere Program
32. IGFA: International Group of Funding Agencies for Global Change Research
33. IHO: International Hydrographic Organization
34. IIASA: International Institute for Applied Systems Analysis
35. IISL: International Institute for Space Law
36. INCOSE: International Council on Systems Engineering
37. IO3C: International Ozone Commission
38. IOC: Intergovernmental Oceanographic Commission
39. ISCGM: International Steering Committee for Global Mapping
40. ISDR: International Strategy for Disaster Reduction
41. ISPRS: International Society for Photogrammetry and Remote Sensing
42. OGC: Open Geospatial Consortium
43. POGO: Partnership for Observation of the Global Ocean
44. SICA/CCAD: Central American Commission for the Environment and Development
45. SOPAC: South Pacific Applied Geoscience Commission
46. UNCBD: United Nations Convention on Biodiversity
47. UNECA: United Nations Economic Commission for Africa
48. UNEP: United Nations Environment Programme
49. UNESCO: United Nations Educational, Scientific and Cultural Organization
50. UNFCCC: United Nations Framework Convention on Climate Change
51. UNITAR: United Nations Institute for Training and Research
52. UNOOSA: United Nations Office for Outer Space Affairs
53. UNU-EHS: United Nations University, Institute for Environment and Human Security
54. WCRP: World Climate Research Programme
55. WFPHA: World Federation of Public Health Associations
56. WMO: World Meteorological Organization

Table 3: Committee on Earth Observing Systems [CEOS] Members and Associates

[Source: Committee on Earth Observing Systems - as of November 2008]

CEOS Members

1. ASI	Agenzia Spaziale Italiana	Italy
2. BNSC	British National Space Centre	United Kingdom
3. CAST	Chinese Academy of Space Technology	China
4. CDTI	Centre for the Development of Industrial Technology	Spain
5. CNES	Centre National d'Etudes Spatiales	France
6. CONAE	Comision Nacional de Actividades Espaciales	Argentina
7. CRESDA	China Centre for Resources Satellite Data and Application	China
8. CSA	Canadian Space Agency	Canada
9. CSIRO	Commonwealth Scientific and Industrial Research Organisation	Australia
10. DLR	Deutsches Zentrum fur KLuft-und Raumfahrt	Germany
11. EC	European Commission	Footnote A
12. ESA	European Space Agency	Footnote B
13. EUMETSAT	European Organisation for the Exploitation of Meteorological Satellites	Footnote C
14. GISTDA	Geo-Informatics and Space Technology Development Agency	Thailand
15. INPE	Instituto Nacional de Pesquisas Espacials	Brazil
16. ISRO	Indian Space Research Organisation	India
17. KARI	Korea Aerospace Research Institute	Korea
18. MEXT/ JAXA	Ministry of Education, Culture, Sports, Science and Technology/Japan Aerospace Agency	Japan
19. NASA	National Aeronautics and Space Administration	United States of America
20. NASARDA	National Space Research and Development Agency	Nigeria
21. NOAA	National Oceanic and Atmospheric Administration	United States of America
22. NRSCC	National Remote Sensing Center of China	China
23. NSAU	National Space Agency of Ukraine	Ukraine
24. ROSHYDROMET	Russian Federal Service for Hydro-meteorology & Environmental Monitoring	Russia
25. ROSCOSMOS	Russian Federal Space Agency	Russia
26. SNSB	Swedish National Space Board	Sweden
27. Tubitak-Uzay	Space Technology Research Institute of Turkey	Turkey
28. USGS	United States Geological Survey	United States of America

CEOS Associates

1. CCRS	Canada Centre for Remote Sensing	Canada
2. CRI	Crown Research Institute	New Zealand
3. ESCAP	Economic and Social Commission of Asia and the Pacific	UN
4. FAO	Food and Agriculture Organization	UN
5. GCOS	Global Climate Observing System	International Programme
6. GOOS	Global Ocean Observing System	International Programme
7. GTOS	Global Terrestrial Observing System	International Programme
8. ICSU	International Council for Science	International Programme
9. IGBP	International Geosphere-Biosphere Programme	International Programme
10. IOC	Intergovernmental Oceanographic Commission	UNESCO
11. IOCCG	International Ocean Colour Coordinating Group	International Programme
12. ISPRS	International Society for Photogrammetry and Remote Sensing	International Programme
13. NSC	Norweigian Space Centre	Norway
14. OSTC	Federal Office for Scientific, Technical & Cultural Affairs	Belgium
15. SAC/CSIR	Satellite Applications Centre/ Council for Scientific and Industrial Research	South Africa
16. UNEP	United Nations Environmental Programme	UN
17. UNESCO	United Nations Educational, Scientific and Cultural Organization	UN
18. UNOOSA	United Nations Office of Outer Space Affairs	UN
19. WCRP	World Climate Research Programme	UN
20. WMO	World Meteorological Organization	UN

Footnote A: European Commission - Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, The Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, United Kingdom

Footnote B: ESA - Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, The Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, and the United Kingdom (Czech Republic, is likely to be a member by the end of 2008; Canada, Hungary, Poland and Romania are Cooperating States)

Footnote C: EUMETSAT - Austria, Belgium, Croatia, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, The Netherlands, Norway, Portugal, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey, United Kingdom (plus 9 Cooperating States: Czech Republic, Iceland, Hungary, Latvia, Lithuania, Poland, Bulgaria, Romania, Estonia)

GCOM-C Ocean-color research

[7151-5]

Hiroshi Murakami, Masahiro Hori, Keiji Imaoka, Keizo Nakagawa, Haruhisa Shimoda
Japan Aerospace Exploration Agency (Japan)

ABSTRACT

JAXA is establishing the Global Change Observation Mission (GCOM) which consists of GCOM-W and GCOM-C satellite series. Target dates of the first satellites are early 2012 and early 2014 respectively. The sensor and products are being designed and investigated for the effective observation of essential climate variables relating to the radiation budget, the carbon cycle, and the water cycle.

Cross-sensor band mapping for developing a consistent climate data record of Earth observations

[7151-8]

Xianjun Hao, John J. Qu
George Mason Univ. (United States)

ABSTRACT

Data continuity and consistency is critical for the synergistic integration of measurements from different satellite remote sensing sensors under the GEOSS framework. Since each sensor has its own spatial and spectral specifications and lifecycle, it is desirable to develop the capability for spatial and spectral mapping between different sensors. Based on our previous work on AIRS/MODIS/VIIRS cross-sensor comparison, band mapping approaches are investigated for enhancing the data integrity, consistency and sustainability of the GEOSS data.

Detection of large scale natural disaster damages by MTSAT

[7151-14]

Takashi Moriyama
Japan Aerospace Exploration Agency (Japan)

ABSTRACT

The ultimate goal of satellite disaster monitoring is 24 hours per day of continuous monitoring by systems such as a geostationary Earth observation satellite with the appropriate high spatial resolution. The technical feasibility study for future GEO-EO satellite system is underway, and in parallel, the possibility of detection of land cover change such as large scale land slide has been studied by using MTSAT (Meteorological Satellite: Visible 1 km resolution). Fortunately, MTSAT observed the large scale land slide over the Leyte mountain Philippine. The image comparison study has been done. The result suggested that a large scale disaster such as a land slide can be detected by using MTSAT, indicating that high ground resolution is not actually needed to detect such a change. This paper describes one of the study results of a change detection of a large scale land slide by 1 km resolution data.

Europe watches the atmosphere

[7151-20]

Philippe L. Keckhut
Ctr. National de la Recherche Scientifique (France))

ABSTRACT

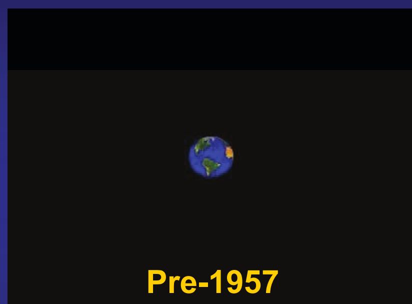
GEOMON (Global Earth Observation and Monitoring of the Atmosphere) is an Integrated Project of the 6th European frame work programme. The overall goal of the GEOMON project is to sustain and analyse European ground-based observations of atmospheric composition, complementary with satellite measurements, in order to quantify and understand the ongoing changes. GEOMON is a first step to build a future integrated pan-European Atmospheric Observing System dealing with systematic observations of long-lived greenhouse gases, reactive gases, aerosols, and stratospheric ozone.

(Invited Paper)

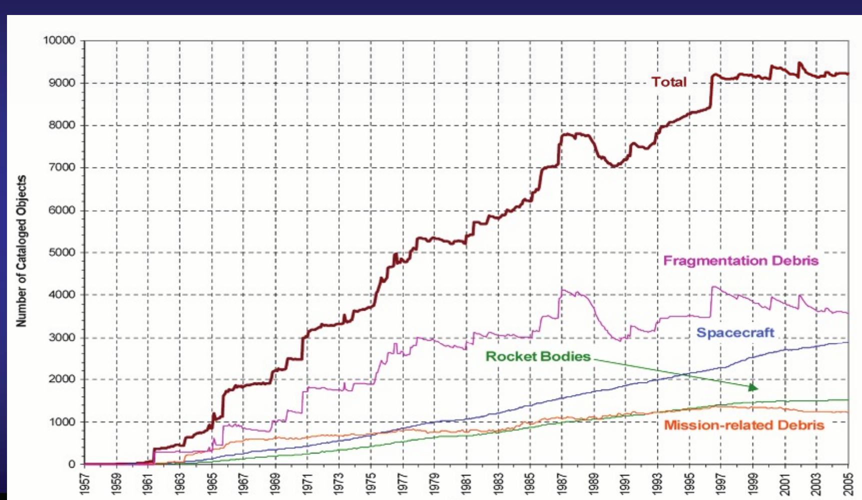
Perspectives on international collaboration in Earth observations: CEOS Contributions to the GEOSS

Barbara J. Ryan, World Meteorological Association

An Historical Comparison



Cataloged Objects in Earth Orbit



Committee on Earth Observation Satellites (CEOS)

- Established in 1984 from the Economic Summit of Industrialized Nations
  - Need to coordinate satellite missions
  - Recognized value of cross-disciplinary efforts
- Outgrowth of two satellite coordinating groups:
  - Coordination on Land Observation Satellites
  - Coordination on Ocean Remote Sensing Satellites
- Best efforts organization – relies on voluntary contributions of members and associates
- 26 Members, 20 Associates

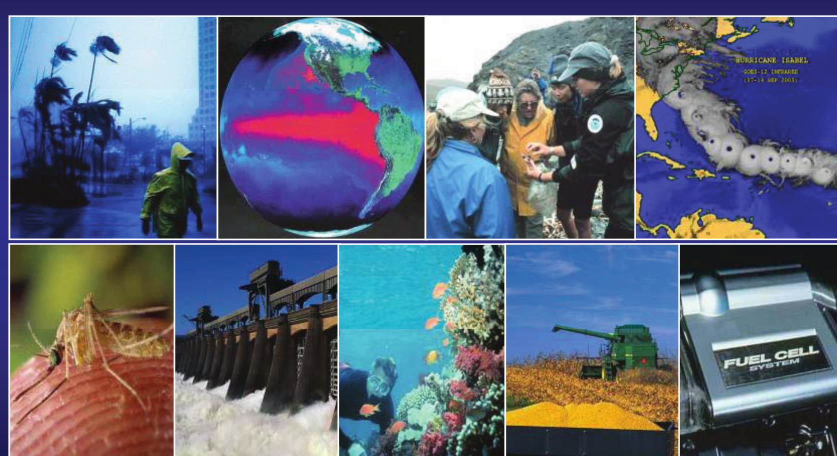
CEOS Members

- Members are national or international governmental agencies and/or organizations that are responsible for:
  - A civil spaceborne Earth observation program;
  - A significant ground-segment activity that supports CEOS objectives; and/or
  - A significant programmatic activity that supports CEOS objectives

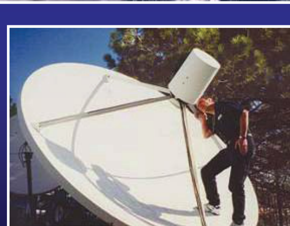
CEOS Objectives

- To optimize benefits of spaceborne Earth observations through cooperation in mission planning and development of compatible data products, formats, services, applications, and policies;
- To serve as a focal point for international coordination of space-related Earth observation activities – the space segment of GEO
- To exchange policy and technical information that promotes complementarity and compatibility among spaceborne Earth observation systems and their data

The Group on Earth Observations (GEO) and Societal Benefits of Improved Earth Observations



Connecting Satellite Observation Systems to GEOSS



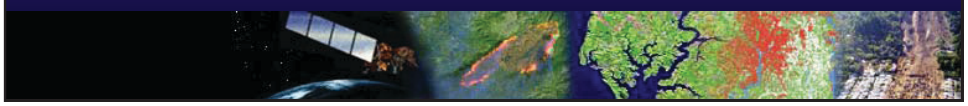
- Integrate observing systems, nationally and internationally, to benefit from the increased number and distribution of observations of any given event
- Identify measures to minimize data gaps – to move toward a comprehensive, coordinated, and sustained Global Earth Observation "System of Systems"

CEOS Role in GEO

- CEOS is a GEO Participating Organization
- Represents international EO satellite community
- Coordinates provision of space segment for GEOSS
- Lead role for CEOS in many GEO Work Plan tasks
- CEOS Members also represented in GEO if their respective countries are GEO Members

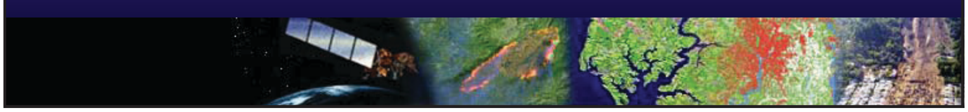
Reinforcing the Linkages to GEO

- Coordinates provision of space segment for GEO
- Represents international EO civil satellite community
- Lead role for many GEO Work Plan tasks
- CEOS is a GEO Participating Organization
- CEOS Members/Agencies also represented in GEO if their respective countries are GEO Members



CEOS Virtual Constellations

- Synergies among national and regional satellite programs and focus dialogue and resources
- [6 Virtual Constellations contemplated so far]
  - Atmospheric composition
  - Global precipitation
  - Land surface imaging
  - Ocean surface topography
  - Ocean color radiometry
  - Ocean surface vector winds
- Common guidelines
- Optimal end-to-end capabilities
- Coordinated user requirements for future systems



Virtual Constellations Objectives

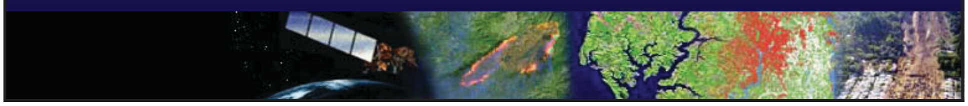
- Focus dialogue from “all topics/all agencies” to smaller, more specialized groups
- Focus resources to demonstrate what may be achieved
- Apply common thresholds/develop framework
  - Participants small and large, established and emerging
  - Understanding common criteria for contributions
  - Provide guidance to aspiring entrants

CEOS Virtual Constellations System Engineering Office

- Dedicated resources from NASA
- Provide Systems Engineering support to each Virtual Constellation Team
  - Requirements taxonomy
  - Mission gap analysis
- Provides cross-Constellation support
  - Communications
  - Consistency
  - Best practices

UN Framework Convention on Climate Change (UNFCCC)

- Actions from COP - 10, 11, and 12
- "Satellite Observation of the Climate System: The CEOS Response to the GCOS Implementation Plan"
- Response covers atmospheric, oceanic and terrestrial domains, as well as cross-cutting issues
- 59 actions identify where additional resources are needed to fill gaps
- Calls for a major, sustained satellite component

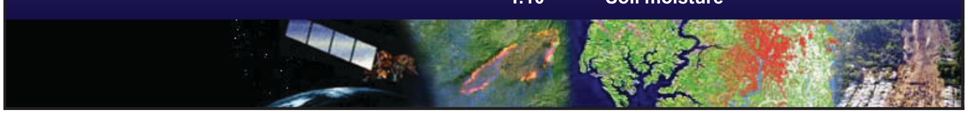


GCOS 26 Essential Climate Variables (ECVs)

A.	Atmosphere
A.1	Surface Wind Speed and Direction
A.2	Upper-air Temperature
A.3	Water A Vapour
A.4	Cloud properties
A.5	Precipitation
A.6	Earth Radiation Budget
A.7	Ozone
A.8	Atmospheric reanalysis (multiple ECVs)
A.9	Aerosols
A.10	Carbon Dioxide, Methane and other Greenhouse Gases
A.11	Upper-air Wind

O.	Oceans
O.1	Sea Ice
O.2	Sea Level
O.3	Sea Surface Temperature
O.4	Ocean Colour
O.5	Sea State
O.6	Ocean Reanalysis
O.7	Ocean Salinity

T.	Terrestrial
T.1	Lakes
T.2	Glaciers and Ice Caps, and Ice Sheets
T.3	Snow Cover
T.4	Albedo
T.5	Land Cover
T.6	fAPAR
T.7	LAI
T.8	Biomass
T.9	Fire Disturbance
T.10	Soil moisture

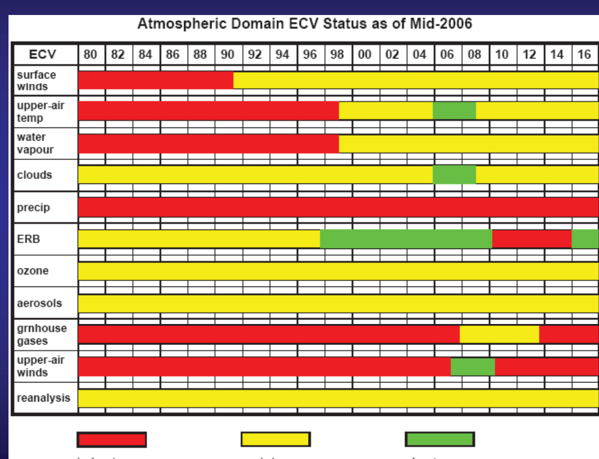


ACC Traceability to GCOS ECVs

[Atmospheric Composition Constellation]

Essential Climate Variable	Characteristic	Action required
Ozone mapping	Profiles, columns	– Reprocessing to remove biases and gaps, improved algorithms, integrated product
Aerosol characteristics	Profiles, columns	
Water vapor content	Profiles, columns	– Employ Data Assimilation for data homogeneity and integration
Greenhouse gases	Sources and Sinks	
Cloud characteristics	Profiles	– Research observations enhanced and standardized for upcoming operational missions (R2O)

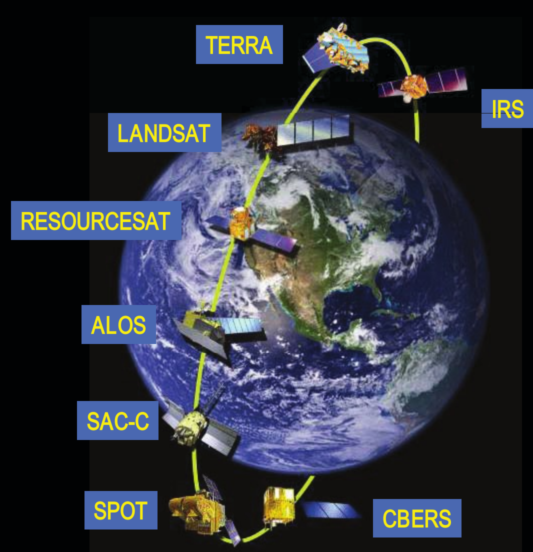
Satellite Observations for Climate – Example of Domain ECV Status

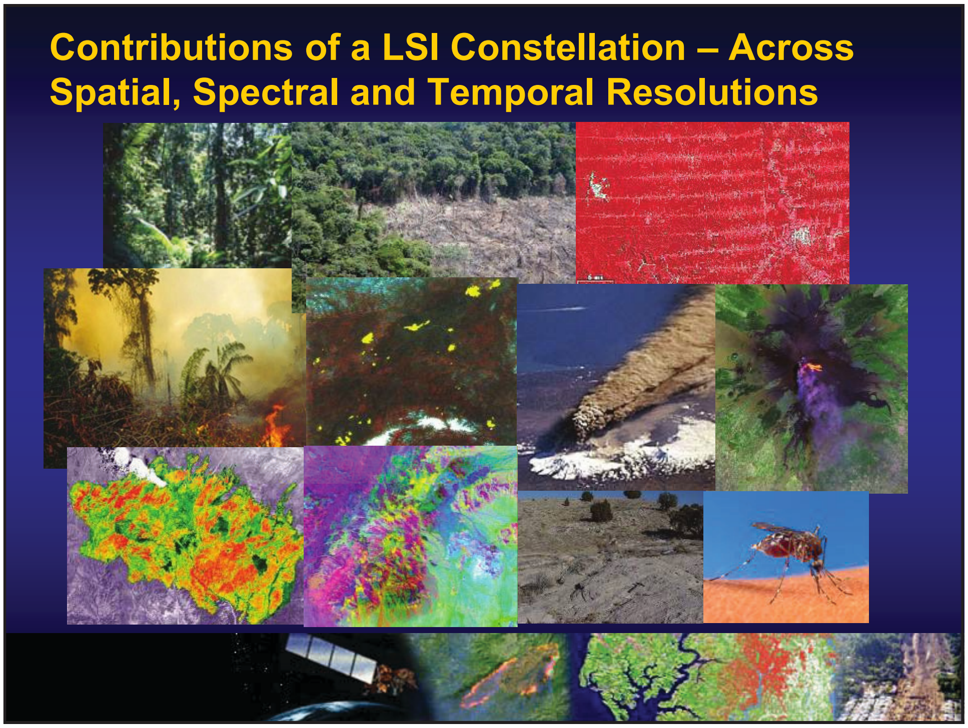


ACC Traceability to GEO SBA's

SBA	Science and Measurements	GEO 2007-2009 Work Plan	GOESS 2-year Plan	GEOSS 6-year Plan	GEOSS 10-year Plan
Disaster	**Fires**: smoke and ash **Seismicity:** volcanic ash aerosols, SO_2 **Pollution events:** emissions, mapping	**DI-06-07:** Multi-hazard zonation and maps **DI-06-09:** Use of Satellites for Risk Management **DI-06-13:** Implementation of a Fire Warning System a a Global Level	Strengthening the International Charter on Space and Major Disasters and similar supporting activities. Production of an inventory of hazards zonation maps.	Facilitating real-time monitoring of volcanic activities. Expansion of the production of an inventory of hazards zonation maps.	Hyper-spectral capability for monitoring smoke and pollution plumes.
Climate	**Atmospheric Composition:** CO_2, CH_4, Trop O_3, other GHG, and Aerosol Properties **Long term measurements:** IGOS and GCOS connections	**CL-06-02:** Key Climate Data from Satellite Systems **CL-07-01:** Seamless Weather and Climate Prediction System	Adhere to the GCOS Climate Monitoring Principles and commit to the suite of instrument, supporting research program to support development of observational capabilities for ECV's.	Development and operation of new instruments. Establishment of data archive centers for all ECVs, institutional commitment to provide integrated global analysis of all ECVs, data integration facilities for exchanging data, products and information between climate sectors and socio-economic benefit areas need to be coordinated.	New and extended re-analysis programs for atmospheric domains and implementation of an integrated observing system for atmospheric composition monitoring in support of climate policy through an optimal combination of ground-based networks, LEO and GEO satellites and models are ultimate goals.
Health	**Air Quality:** ozone precursors, particulates, SO_2, allergens **Stratospheric:** ozone and UV radiation	**HE-06-03:** Forecast Health Hazards **HE-07-01:** Strengthen Observation and Information Systems for Health **HE-07-02:** Environment and Health Monitoring and Modeling **HE-07-03:** Integrated Atmospheric Pollution Monitoring, Modeling and Forecasting	New, high-resolution Earth observations relevant to health needs are advocated. Facilitating development of products and systems that integrate the Earth science database with health information	Monitoring methods and systems to detect health-related change	Early detection and control of environmental risks to human health through improvements in the sharing and integration of Earth observations, and early warning systems are required.
Energy	**Chemical forecasting:** aerosols, GHGs **Climate statistics:** aerosols, GHGs, radiation	**EN-06-04:** Using New Observation Systems for Energy **EN-07-01:** Management of Energy Sources **EN-07-02:** Energy Environmental Impact Monitoring **EN-07-03:** Energy Policy Planning	New generation of operational observing systems.	An evaluation of the observing system progress and its revision.	Implementation of operational observing systems and provision of timely data in support of energy operations.
Ecosystem	**Carbon fluxes/exchange:** CO, CO_2, CH_4 **Solar radiation**: UV radiation	**EC-06-01:** Integrated Global Carbon Observation (IGCO) **EC-07-01:** Global Ecosystem Observation and Monitoring Network	Facilitating full implementation of the IGOS-P Carbon (IGCO) Theme report. Facilitating a globally agreed classification scheme.	Implementation of a global nitrogen observing system.	Facilitating globally agreed spatial-resolved information on ecosystem change.

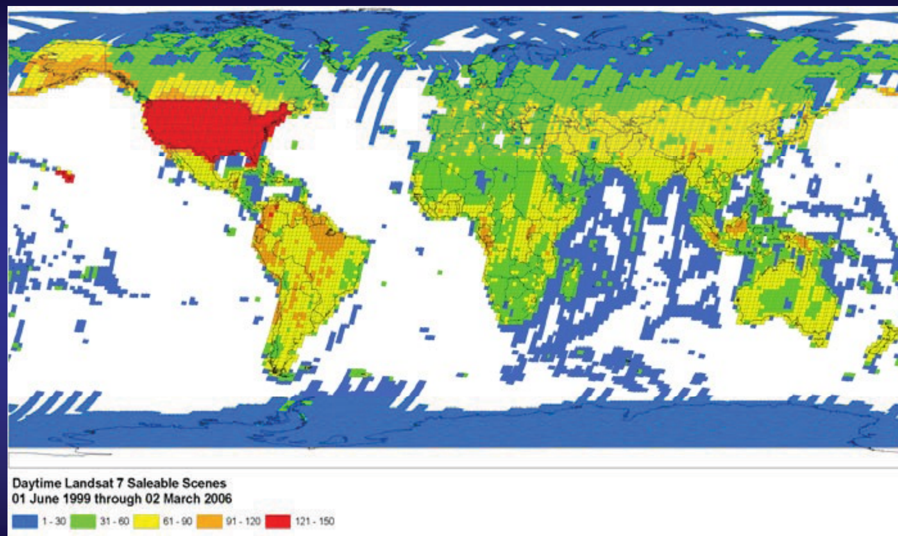
Land Surface Imaging Constellation



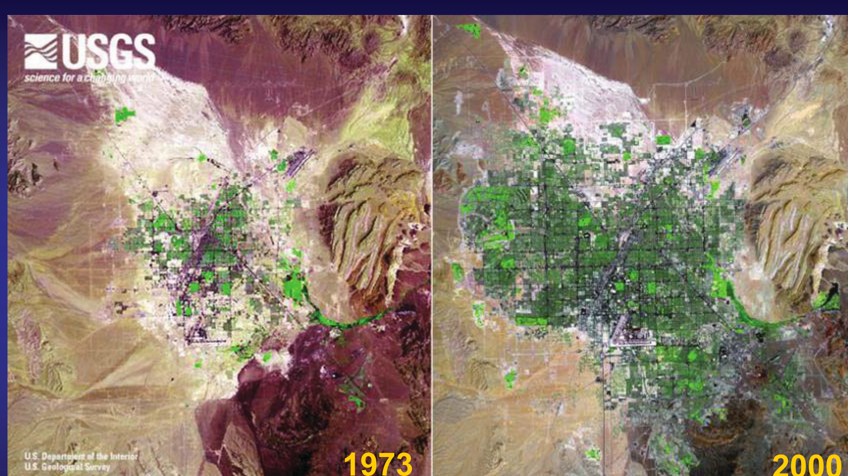

Contributions of a LSI Constellation – Across Spatial, Spectral and Temporal Resolutions


International Partners – A Global Network
PF1
GLC
PAC
GNC
LGS
UPR
CUB
COA
KIS
MTI
JSA
BJC
HIJ
HAJ
BKT
DKI
ASA
HOA
ASA: Alice Springs, Australia (L5/L7)
BJC: Beijing, China (L5)
BKT: Bangkok, Thailand (L5)
COA: Cordoba, Argentina (L5/L7)
CUB: Cuiaba, Brazil (L5)
DKI: Parepare, Indonesia (L7)
GLC: Gilmore Creek (L5)
GNC: Gatineau, Canada (L5)
HAJ: Hatoyama, Japan (L5)
HIJ: Hiroshima, Japan (L7)
HOA: Hobart, Australia (L5/L7)
JSA: Johannesburg, South Africa (L5)
KIS: Kiruna, Sweden (L5)
LGS: Landsat Ground Station (L5/L7)
MTI: Matera, Italy (L5)
PAC: Prince Albert, Canada (L5)
PF1: Gilmore Creek (L5)
UPR: University of Puerto Rico (L7)

Landsat 7 Archive



Urban Growth -- Las Vegas, Nevada



Population: 358,000 1,560,000

UNEP's Atlas of our Changing Environment

"One Planet, Many People"

Everglades Florida

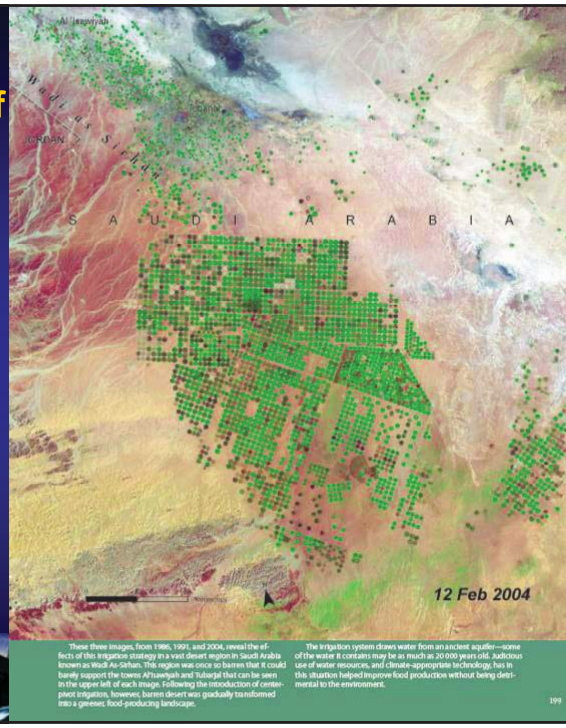
Monitoring Land Management Practices

Targhee National Forest (left) and Yellowstone National Park (right)

UNEP's Atlas of our Changing Environment

"One Planet, Many People"

Al'Isawiyah
Saudi Arabia

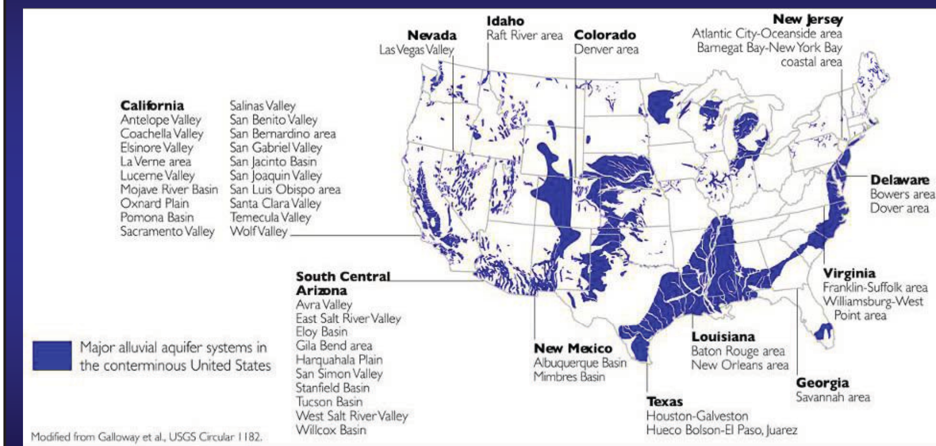


Land Subsidence

- More than 80% of the identified 17,000 square miles of land affected by subsidence in the Nation is a consequence of our exploitation of ground water -- *National Research Council, 1991*
- Most of the ground-water related subsidence is caused by the compaction of susceptible alluvial aquifer systems that typically accompanies overdraft of these systems

California's Central Valley

Major U.S. aquifers and locations where subsidence has been attributed to groundwater pumping



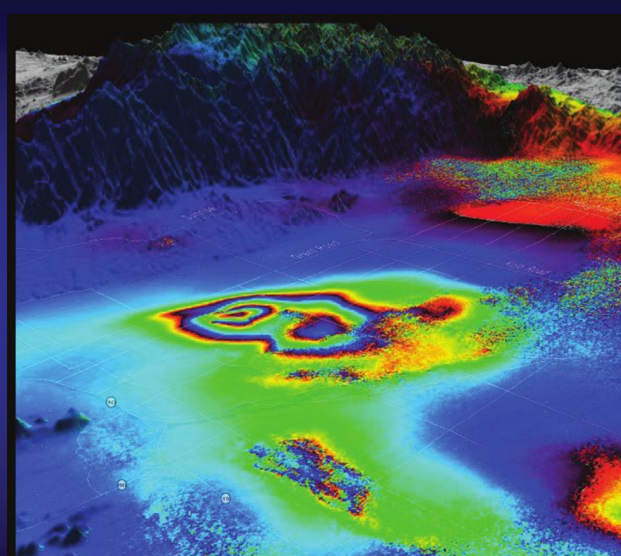
Subsidence due to Ground-Water Withdrawals

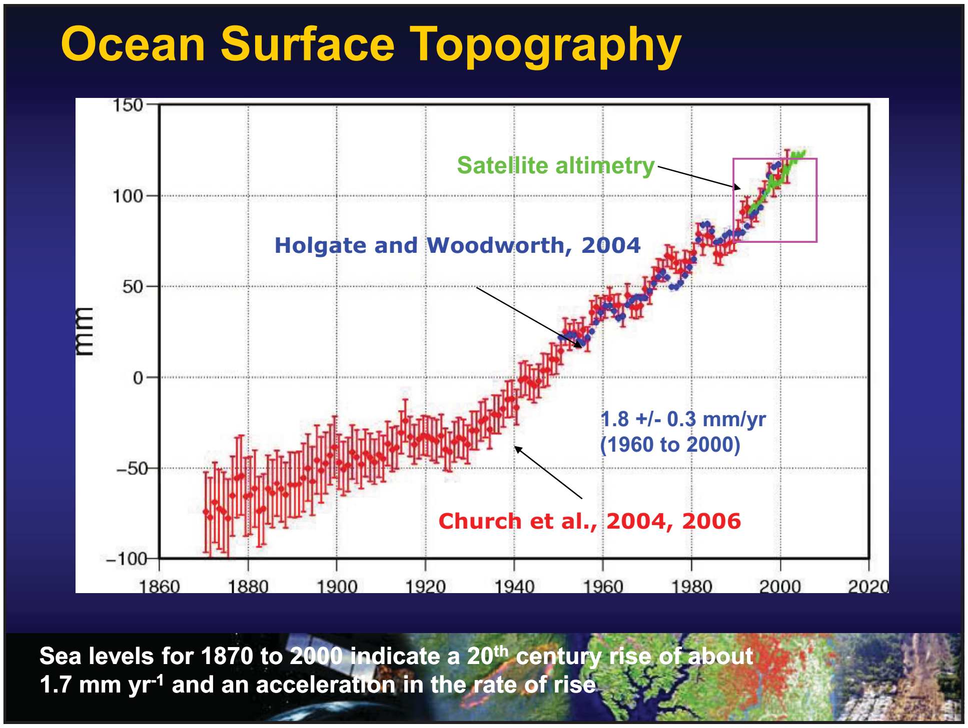
90 mm
Subsidence

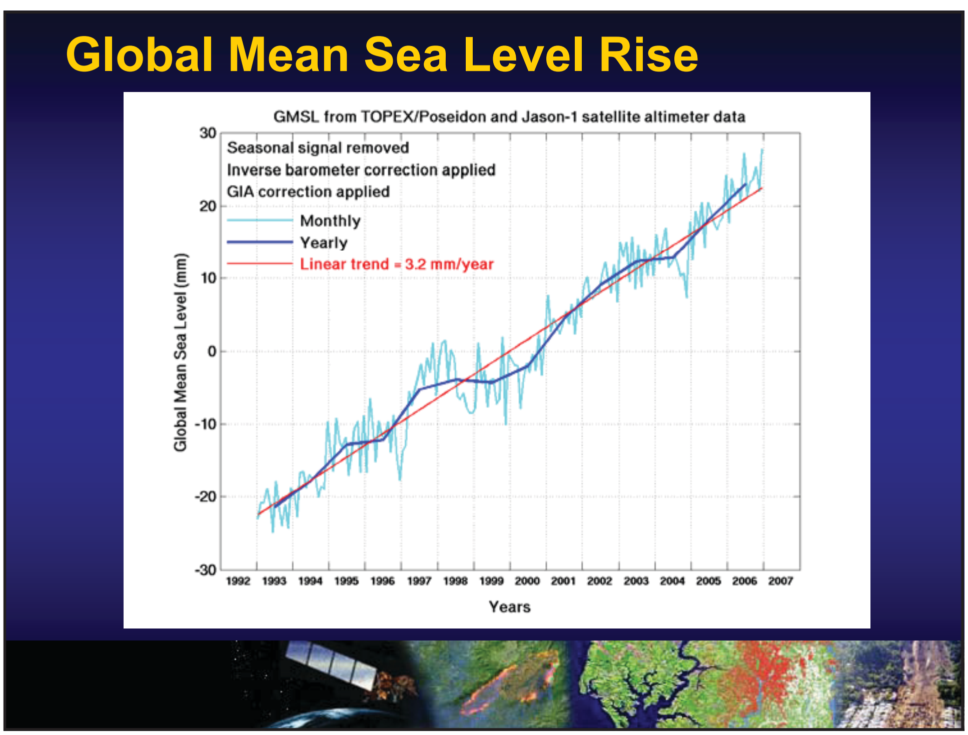
Tucson
Arizona

November
1992 to
January 1997

InSAR data from
Envisat



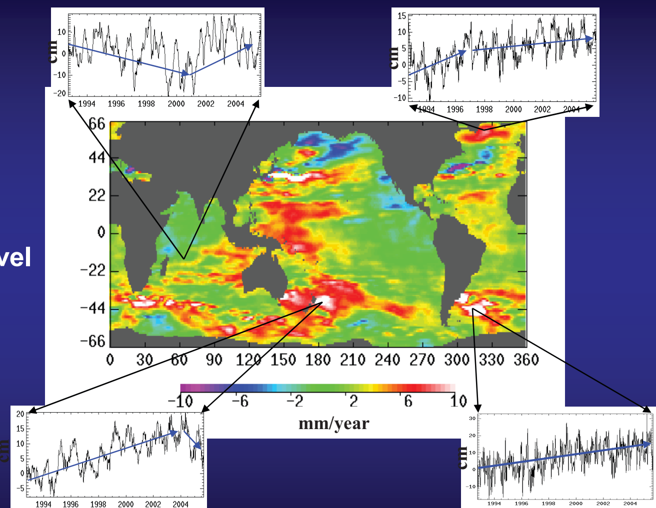

Ocean Surface Topography
Satellite altimetry
Holgate and Woodworth, 2004
1.8 +/- 0.3 mm/yr
(1960 to 2000)
Church et al., 2004, 2006
mm
150
100
50
0
−50
−100
1860
1880
1900
1920
1940
1960
1980
2000
2020
Sea levels for 1870 to 2000 indicate a 20th century rise of about
1.7 mm yr-1 and an acceleration in the rate of rise

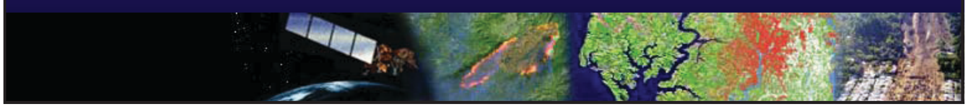

Global Mean Sea Level Rise
GMSL from TOPEX/Poseidon and Jason-1 satellite altimeter data
Seasonal signal removed
Inverse barometer correction applied
GIA correction applied
Monthly
Yearly
Linear trend = 3.2 mm/year
Global Mean Sea Level (mm)
30
20
10
0
-10
-20
-30
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
Years

Global Sea Level Rise

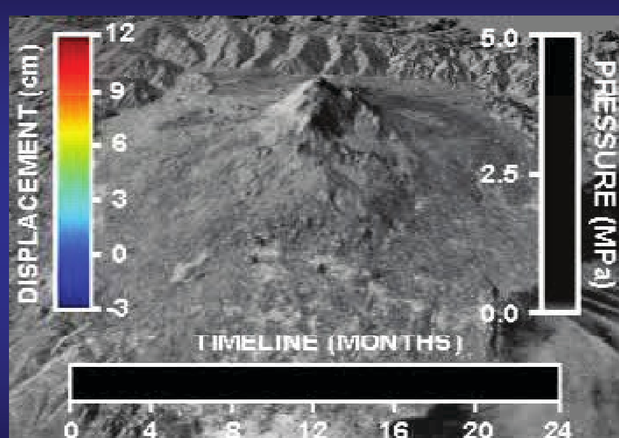
Satellite Altimetry

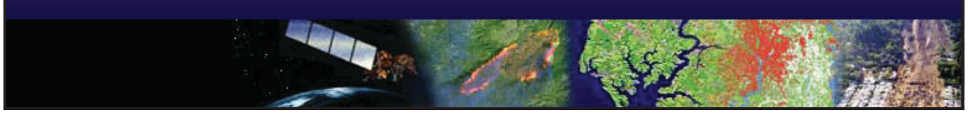
- Unique system to observe global variations in sea level rise



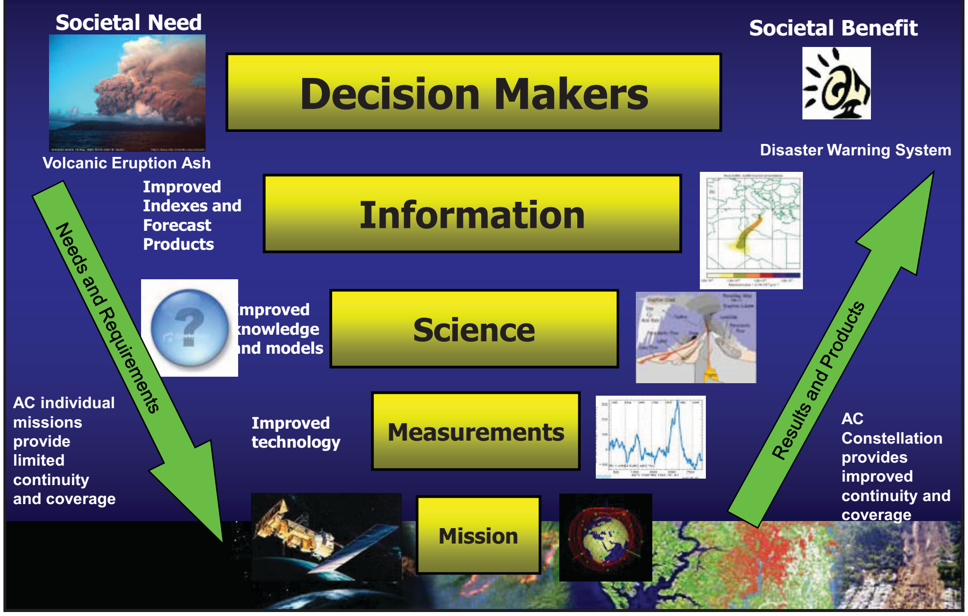


Working across the Constellations -- Mt. Etna InSAR

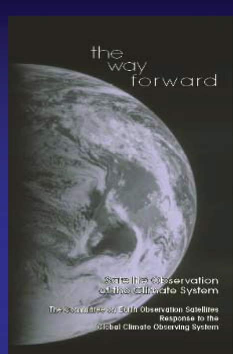




Virtual Constellation (ACC) Example of Value Chain



The Way Forward



www.ceos.org

In conclusion, CEOS recognizes that both satellite and *in situ* data are required to better monitor, characterize, and predict changes in the Earth system. While *in situ* measurements will remain essential and largely measure what cannot be measured from satellites, Earth-observation satellites are the only realistic means to obtain the necessary global coverage, and with well-calibrated measurements will become the single most important contribution to global observations for climate.

The Way Forward – Working together with academia, industry, and policy makers