

#### **Global Observations**

#### for Climate Prediction and Adaptation

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# Space Agencies' Response to Support GCOS

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### Committee on Earth Observation Satellites (CEOS)



- 28 Member and 20 Associate agencies and organizations
  - Best efforts / voluntary organization
  - Represents international EO satellite community
  - NOAA chairs CEOS Strategic
    Implementation Team
- Space arm of GEOSS
- Virtual Constellations for GEO
- Also pursuing 59 Climate Actions in support of Global Climate Observing System (GCOS) implementation





# CEOS Strategic Implementation Team CE S

#### SIT Objective

To demonstrate real progress and provide tangible results in SIT contributions to GEO and GEOSS, as well as to GCOS in the climate arena

#### 2008 Goals

- Strengthen CEOS linkages to GEO, GEOSS, GCOS
- Advance Constellations
- Align SIT structure to support these efforts





### CEOS Strategic Implementation Team CE®S

- As space arm of GEOSS, CEOS and its Agencies are pursuing "actionable" actions and demonstrated results in addressing GEO Tasks, with a clear set of near-term priorities
- CEOS Space-based Constellations demonstrate the value of collaborative partnerships in addressing key observational gaps. The goal is to:
  - Sustain the routine collection of critical observations
  - Bridge multiple GEO Societal Benefit Areas, including climate
  - Maintain the independence of individual contributions
  - Address data gaps
  - Harmonize and maximize efforts among space agencies to deploy Earth observation missions
  - Avoid overlap among observing systems
  - Make maximum use of existing assets





### **CEOS** Constellations



#### Current Constellations:

- Atmospheric Composition
- Land Surface Imaging
- Ocean Surface Topography
- Precipitation
- Ocean Colour Radiometry
- Ocean Surface Vector Winds





# **SIT Alignment**



- Two highly successful and engaging SIT meetings where Agency Principals confirmed commitment to CEOS actions in support of GEO
  - SIT-21: April in Woods Hole, MA
  - SIT-22: September in Tokyo, Japan
- Monthly tag-ups and progress report to CEOS Chair
- SIT Agency Principal tag-ups in preparation for SIT meetings
  - Spring 2008: Connected with 20 of 31 Agency Principals
  - Summer 2008: Connected with 11 of 13 Principals of Agencies identified as lead for Category 1 actions

#### Creation of the CEOS Societal Benefit Area Coordinators





### **Climate Actions**



- 59 CEOS-GCOS Climate Actions (CEOS response to GCOS IP 107)
- CEOS –GEO actions (identify current or propose new climate actions contributing to climate section of the GEO workplan)





# CEOS 59 "GCOS" Actions in response to GCOS IP



- ensuring continuity of climate-relevant satellite measurements (13 actions);
- 2. taking a systematic approach to generating fundamental climate data records (FCDRs) (11actions);
- 3. preserving climate data records (4 actions);
- 4. ensuring access to climate data products (10 actions);
- 5. coordinating international communities and interaction with users (10 actions); and
- 6. addressing future measurement needs (11 actions).





### **CEOS Climate Action Priorities**



- A first round of climate actions assessment, in coordination with GCOS, led to the identification of:
  - D 22 "Priority 1 actions"
    - Deemed to be progressed immediately
    - Capable of delivering significant outcomes within a 1-2 year timescale.
  - □ 32 "Priority 2 actions"
    - Continuous, on-going, or require additional information from potential contributors in order to be suitably defined
    - will not necessarily deliver significant results in the 1-2 year timescale.
  - **5** "Priority 3 actions"
    - Considered premature at this stage.





## **UNFCCC** Report



 UNFCCC SBSTA invited CEOS to provide an updated progress report at its 29<sup>th</sup> session in December 2008.

 Detailed status of Priority 1 actions and plans for starting new tasks are in the CEOS UNFCCC report.





# **Organization of the Report**



- Purpose
- Background
  - CEOS
  - GCOS IP and ECVs
- Importance of the Satellite Component of GCOS for Climate
- Development of the CEOS Climate Action Plan
- Status of High Priority Actions for Each Domain
- Cross-Cutting Actions
- Summary of Key Accomplishments and Future Plans
- Appendix 1: Overview of CEOS
- Appendix 2: CEOS Actions (separated Priority 1, 2 and 3)





## Initiating remaining actions



- Questionnaires were completed
- Initiate 17 priority-2 actions





= new actions (at least 10, goal of 20)

#### **Atmospheric Domain**



#### = priority 1 actions



<u>Action A-1</u>: In 2007 CEOS agencies will review the capability of passive microwave sensors to make scatterometer-quality measurements and will work to ensure A.M. and P.M. satellite coverage of surface wind speed and direction by 2015.

<u>Action A-2</u>: CEOS will strive to ensure continuity of GPS RO measurements with, at a minimum, the spatial and temporal coverage established by COSMIC by 2011. CEOS will continue efforts in 2007 to exploit the complementary aspects of radiometric and geometric upper-air determinations of temperature and moisture.

<u>Action A-3</u>: CEOS will support in 2007 investigations of cloud properties and cloud trends from combined satellite imager plus sounder measurements of clouds (with horizontal as well as vertical information) using Cloudsat/CALIPSO for validation.

<u>Action A-4</u>: CEOS agencies will ensure continued improvements to precipitation determinations demonstrated by TRMM and planned by GPM in 2010. The Japan Aerospace Exploration Agency (JAXA) and the National Aeronautics and Space Administration (NASA) will lead a CEOS study team to establish, by 2007, the basis for a future Global Precipitation Constellation.

Action A-5: CEOS will plan by 2011 to make absolute, spectrally resolved measurements of radiance emitted and reflected by the Earth to space for information on variations in both climate forcings and responses.

Action A-6: CEOS agencies will participate in re-planning, by 2007, the Earth Radiation Budget Sensor (ERBS) removed from the planned payload of NPOESS.

Action A-7: CEOS agencies will participate in re-planning, by 2007, the Total Solar Irradiance Sensor (TSIS) removed from the planned payload of NPOESS.

Action A-8: CEOS agencies will participate in re-planning, by 2007, the OMPS limb instrument removed from the planned payload of NPOESS.

# **Atmospheric Domain**









## **Ocean Domain**





<u>Action O-1</u>: CEOS agencies will examine their respective plans to maintain provision of microwave brightness temperatures and visible/infrared radiances for the sea ice ECV.



<u>Action O-2</u>: Relevant CEOS space agencies will consult with the science community on appropriate retrieval algorithms of passive microwave observation for reprocessing sea-ice products. Norway has expressed interest in committing to operational production of a global sea ice ECV (an initiative by the Norwegian Meteorological Institute, and coordinated by the Norwegian Space Center). The European Space Agency (ESA) is currently reprocessing the relevant ERS and Envisat archive to complement Canada's Radarsat in the context of WCRP's Climate and the Cryosphere (CLiC) core project.

**Action O-3**: New space-based measurements and products, including ice thickness and ice drift, will be considered by CEOS agencies as part of their future research missions.



<u>Action O-4</u>: The National Oceanic and Atmospheric Administration (NOAA) and EUMETSAT will lead a CEOS study team to establish, by 2007, the basis for a future Ocean Surface Topography Constellation that satisfies the threshold requirements for the sea level ECV (and those of the sea state ECV). This will include consideration of a future Jason-3 mission and requirements for new altimeter technologies to improve spatial resolution and extend observations in coastal regions (and over lakes and rivers for the lakes ECV).



<u>Action O-5</u>: The Centre National d'Etudes Spatiales (CNES) and the Indian Space Research Organization (ISRO) will cooperate on a new polar-orbiting altimeter aimed at filling a potential data gap beyond 2008. ESA and the European Union (EU) will lead planning for Sentinel-3 carrying an altimeter to complement spatial/temporal coverage of the sea level (and sea state) ECVs (and possibly sea ice extent and thickness, river, and lake level with the altimeter operating in Synthetic Aperture Radar (SAR) mode beyond 2012).

GEO Gros Earth uuse

Action O-6: An ATSR-like instrument is planned on ESA's Sentinel 3, presently scheduled for launch in 2012. JAXA will lead planning for Global Change Observation Mission-Water (GCOM-W) and GCOM-C (Climate) to maintain continuity of the sea surface temperature ECV.



## **Ocean Domain**



<u>Action O-7</u>: CEOS agencies will examine their respective plans to maintain provision of microwave brightness temperatures for the sea surface temperature ECV.

<u>Action O-8</u>: Relevant CEOS agencies will examine their respective plans to maintain continuity of a 10-km-resolution sea surface temperature data sets global product.

<u>Action O-9</u>: CEOS agencies will cooperate to support the combination of all existing sea surface temperature data sets into a global FCDR.

Action O-10: ISRO will lead planning of Oceansat-2, ESA and the EU of Sentinel-3, and JAXA of GCOM-C, which are all new missions planned to carry an ocean colour sensor.

Action O-11: Relevant CEOS agencies will examine their respective plans to maintain continuity of the 25-km-resolution ocean colour global product.

Action O-12: CEOS agencies will cooperate to support the combination of all existing ocean colour data sets into a global FCDR.

Action O-13: In consultation with GCOS and the relevant user communities, CEOS agencies will explore the means to secure, by 2011, continuity of the 1-km-resolution global ocean colour product needed to fulfil the target GCOS requirements.

<u>Action O-14</u>: CEOS agencies will cooperate with the user community to support efforts aimed at building on the decade-long satellite sea state records and making a comprehensive use of future altimeter- and SAR-bearing missions.



Action O-15: ESA will fly SMOS in 2007 to demonstrate measurement of the sea surface salinity (and soil moisture) ECV; NASA/CONAE will fly Aquarius/SAC-D in 2009 to demonstrate measurement of the sea surface salinity ECV.

Action O-16: CEOS agencies will cooperate in developing future plans for an Ocean Salinity Constellation.







## **Ocean Domain**



<u>Action O-17</u>: CEOS agencies will undertake planning for reprocessing past data to improve FCDRs and legacy databases (e.g., AVHRR Pathfinder, ATSR, Sea Level Pathfinder, and the sea ice ECV) in close coordination and partnership with existing advisory groups and reanalysis centres. All Level 2 data products for use in reanalysis should be properly accompanied by estimates of their uncertainty.
 <u>Action O-18</u>: CEOS, through its Working Group on Calibration and Validation (WGCV) and in the context of developing standards for on-going missions and for the Constellations, will recommend best practices for pre-launch and onboard calibration of ocean sensors and for validation of spacebased ocean observations with in situ sensors, including the establishment and maintenance of calibration and validation sites and networks. This will facilitate the combination of data from different sources and enable the establishment of global data sets and long-term series.
 <u>Action O-19</u>: CEOS agencies, in cooperation with other partners, will support planning for a follow-on to GODAE by 2007.





# **Terrestrial Domain**





<u>Action T-1</u>: CEOS agencies will determine which alternative approach best fills the current Landsatclass data gap and will explore the potential of integrating high-resolution data from multiple platforms (e.g., China-Brazil Earth Resources Satellite (CBERS), Indian Remote Sensing (IRS) satellite, Landsat, Satellite Pour l'Observation de la Terre (SPOT), and others) based on the results of a CEOS study team led by the United States Geological Survey (USGS) that will establish, by 2007, the basis for a future Land-Surface Imaging Constellation.

<u>Action T-2</u>: CEOS agencies will assess the feasibility of generating global historic and continuing ECVs at fine resolutions for land cover and glacier change.



<u>Action T-3</u>: CEOS (led by USGS and NOAA), in cooperation with relevant stakeholders, will explore the feasibility, by 2007, of retrieving and reprocessing the 1-km AVHRR data record from various centralized archives (NOAA and High Resolution Picture Transmission (HRPT) stations). <u>Action T-4</u>: CEOS will work to enhance the quality of the FCDRs and the ECVs generated from the AVHRR record to meet threshold requirements.

Action T-5: CEOS agencies will undertake research to support satellite technology development, such as lidar or P-band sensors, that are capable of retrieving biomass and LAI globally that meet GCOS requirements. CEOS agencies will also support research to improve algorithms that do not currently meet GCOS threshold requirements. New satellite technology and algorithms should be available by 2015.

<u>Action T-6</u>: CEOS will assess the feasibility of collecting operational multi-angle observations. Research will be carried out by CEOS agencies to improve radiation transfer schemes for albedo and fAPAR, especially under cloudy conditions.





# **Cross Cutting**





<u>Action C-9</u>: CEOS will charge its WGCV to promote existing in situ networks, identify new opportunities for product validation, and support both validation research and operational validation projects at an adequate level.



# **Cross Cutting**





<u>Action C-10</u>: CEOS agencies will coordinate their efforts in designing future data archives and data dissemination systems, ensuring that past data holdings (including associated metadata) are preserved, assessing standards and protocols, and incorporating new information technology (IT) developments as much as possible. Practical actions in response to this cross-cutting need will be developed by CEOS' Working Group on Information Systems and Services (WGISS) in line with the technical solutions adopted by GEO.

<u>Action C-11</u>: CEOS agencies will systematically consult with appropriate scientific and user advisory groups in establishing detailed specifications for each FCDR and derived products, including associated uncertainties.

<u>Action C-12</u>: CEOS agencies will consult on appropriate rules to ensure sustained, open accessibility to FCDRs in order to allow the periodic reprocessing and generation of homogeneous products. <u>Action C-13</u>: CEOS agencies will generate, within available resources, independently processed data sets and products.

<u>Action C-14</u>: Recognising that space agencies are responsible for only a portion of the value chain involved in the generation of FCDRs, CEOS will explore ways to strengthen linkages to the communities involved in climate product generation and use, e.g., through framework agreements with major reanalysis centres.



<u>Action C-15</u>: CEOS agencies will encourage funding of climate change research at an adequate level for multiple groups to analyze data records, reprocess climate variables, and perform reanalysis. <u>Action C-16</u>: CEOS agencies will consider, in the context of the Constellations, ways and means to support the transfer of demonstrated observations from research satellites into operational capabilities. In particular, CEOS will encourage "convergence" of climate-observing requirements (usually for high-quality data) with operational requirements (usually for rapid and ensured data availability), and support institutional arrangements that would help transfer ECVs from research to





# **Cross Cutting**



<u>Action C-17</u>: CEOS agencies will maintain R&D efforts aimed at confronting the knowledge challenge posed by climate and climate change, and strive to overcome the current scientific and technical limitations of climate-quality measurements.

Action C-18: CEOS agencies will ensure that data acquired through research satellites are fully used for the benefit of creating and/or improving the FCDRs of all ECVs.

Action C-19: CEOS agencies will continue to devote particular efforts to the reprocessing and improvement of these fundamental data sets.



<u>Action C-20</u>: CEOS agencies will endeavour to ensure global, easy, and timely access to climate-related products, including by developing countries.

Action C-21: CEOS will establish a programme in 2007 to document the data archive and access arrangements in place for each of the FCDRs contributed by space agencies. WGISS will lead this effort in order to evaluate practical solutions to current obstacles and issues.



Action C-22: CEOS agencies will continue their efforts, both individually and through the CEOS Working Group on Education and Training (WGEdu), to build capacity.







### **Sample Activities Supporting GCOS**





#### CEOS Action CL-06-01\_2

"Provide a four-year extension of the total ozone and ozone profile Climate Data Records for the SBUV(/2) measurement retrievals."

The SBUV/2 data for NOAA-16 SBUV/2 (2004 to 2007) and NOAA-17 SBUV/2 (2003 to 2007) has been reprocessed with the latest instrument characterization and calibration to extend the previously released Ozone Climate Data Record (1979 to 2003) from SBUV(/2) instruments by four years.

Significance: The SBUV(/2) ozone CDR's are used to determine and monitor atmospheric ozone trends and variations. These are compared to models and other results in creating the international ozone assessments. The latest report is available at:

#### www.esrl.noaa.gov/csd/assessments/2006/





Figure from NOAA's 2007 S.Hemisphere Winter Summary showing total ozone anomalies versus time and latitude. www.cpc.ncep.noaa.gov/products/stratosphere/winter\_bulletins





#### CEOS Action CL-06-02-4 Reprocess SCIAMACHY Products

SCIAMACHY provide products of O3, BrO, HCHO, NO2, SO2, OCIO, H2O, CO, CO2, CH4 and properties of aerosols and clouds

The data has been reprocessed from the start of operations – August, 2002 using the improved calibration and algorithms,

Significance: Provides critical atmospheric chemistry datasets for monitoring



Ozone difference in % between SCIAMACHY and Brewer data from Hohenpeissenberg, Germany





#### CEOS Action, CL-06-05\_1

Generation of real-time and historical satellite products over the Arctic and Antarctic in support of IPY

•Real-time and historical satellite products (1981 to present) from AVHRR are available in support of the International Polar Year (IPY)

•*Real-time* products being generated at direct readout sites in the Arctic and Antarctic include:

•Atmospheric products:

polar winds, cloud fraction, cloud phase, cloud top pressure, cloud optical depth and cloud particle size

#### •Surface products:

ice/snow surface temperature and albedo, snow cover, sea ice cover, concentration, motion, and thickness/age.

Significance: This unique suite of real-time and historical satellite products will provide data for meteorological and climatological studies, and will be part of the IPY legacy.





Left: Real-time winds from direct readout AVHRR data acquired at Barrow, Alaska, Sept 22, 2008.

APP-x cloud phase trend in winter (1982-2000)

Right: Decadal trends in Arctic winter cloud phase (100= ice, 0=liquid) from APP-x 1982 -2000. Trends with confidence levels larger than 95% are indicated with +.



#### CEOS Action, CL-06-01\_3: Extend SSM/I total precipitable water, rain rates and snow cover products to June 2008

•The Special Sensor Microwave/Imager (SSM/I) monthly products was extended to twenty-one years (July 1987 – June 2008)

•Products include rainfall rate, snow cover, and total precipitable water. Data is available from NCDC.

•Rainfall rates are used by the international Global Precipitation Climatology Project (GPCP).

•Future work includes reprocessing entire record using improved satellite intercalibration.

Significance: The extended time series of SSMI products allows us to more accurately monitor and detect change in the amount and pattern of climatically important surface and atmospheric processes such as rainfall.



#### CEOS Action, CL-06-01\_7 Reanalyzed global sea ice (1987 – 2005)

Reprocessing of daily ice concentration products from SSMI for 1987 – 2007 using latest algorithms and most current ECMWF reanalysis for atmospheric corrections.

Reprocessing is on-going and is expected to be completed in December 08, using SMMR data (1978 – 1987)

http://sat.met.no in NETCDF

Ocean pice: aggregate ice concentration

Significance: Provides critical ice cover datasets for monitoring sea ice and for use in models.







#### CEOS Action, CL-06-01\_3: Extend long-term time series of AVHRR (clouds, aerosol, surface temperature, vegetation index) to June 2008

•AVHRR data from 2006 – July 2008 was reprocessed

•This extends the AVHRR Pathfinder Atmospheres Extended (PATMOS-x) datarecord from September 1981 – July 2008.

•Products include clouds, land and sea surface temperatures, aerosols and vegetation index.

Cloud anomaly over Brazil in 2007

Climatogically significant low cloud amounts may be due to excessive agricultural burnings in response to higher demands of biofuels



2007 Total Cloud Amount Anomaly [%]

Significance: Provides the longest satellite record of clouds, aerosols and surface temperatures for climate studies.

#### Example AVHRR false-color image from NOAA-18



#### Corresponding derived Cloud+SST image



#### CEOS Action, CL-06-02-4 Global datasets & accessibility from GlobCarbon and GlobColour,

GlobColour: Ten year dataset (1997 – 2007) derived from MODIS, MERIS, SeaWifs can be accessed at www.globcolour.info

**GlobCarbon:** 9 years available derived from SPOT-4, SPOT-5, ATSR-2, AATSR and MERIS : consists of land products such as Burn Scar, Leaf Area Index, fraction of absorbed photosynthetically active radiation (fAPAR), and vegetation growth cycle.

http://dup.esrin.esa.int/ionia/glo Concarbon/products.asp Project Lead: Einar-Arn Herland



Significance: Provides essential datasets for carbon surface/air exchange studies and carbon modeling.

#### CEOS Action, CL-06-01-4 Reprocessed altimetry (Radar Altimeter 2) and atmospheric chemistry products (SCIAMACHY, GOMOS and MIPAS) from ENVISAT

**ALTIMETRY**: Proposal for the development of the "ERS Altimetry reprocessing chain" has been received and is under review. The Envisat IPF (version 6.0) has been validated. **Reprocessing will start soon**.

**GOMOS:** The new baseline for IPF version 6.0x is currently under verification testing by the ESL and selected validation teams. A full mission reprocessing will be done with the corresponding IPF 6.0x. **Reprocessing will start soon.** 

**MIPAS:** Processor baseline is under IPF implementation by industry. Due to significant problems encountered, the IPF delivery is not expected before October 2008. As with all other atmospheric chemistry instruments a validation exercise will be organised using the TASTE and EQUAL\* collocated measurements before the reprocessing. **Reprocessing will start soon.** 

**SCIAMACHY: second reprocessing cycle completed** : period August 2002 – September 2007. The complete Level 1b and Level 2 dataset is available at D-PAC by FTP. Currently, the next processor version for Level 1b and Level 2 are under implementation, with an anticipated start of the third full mission reprocessing in Q1/2009.



Significance: reprocessing of historical datasets to obtain consistent long-time series of satellite records



# Coordinate with other programs to generate climate data records



#### GSICS (Sensor Intercalibration)

- With CEOS Working Group on Calibration and Validation
- RSSC CM (Climate Data Records)
  - With CEOS Working Group on Information Systems and Services
- GEWEX project (ISSCP, GPCP, GACP)









- CEOS Actions supports GCOS Essential Climate Variables requirements
- Start 17 more CEOS "GCOS" actions to be started in 2009
- CEOS "GEO" Actions complements the 59 CEOS-GCOS actions. Will continue in 2009.
- Atmospheric Domain strong GSICS/RSSC-CM role for developing climate data records
- Developing climate teams for key Climate Data Records



