Committee on Earth Observation Satellites (CEOS)

CEOS Systems Engineering Office (SEO) Status Report

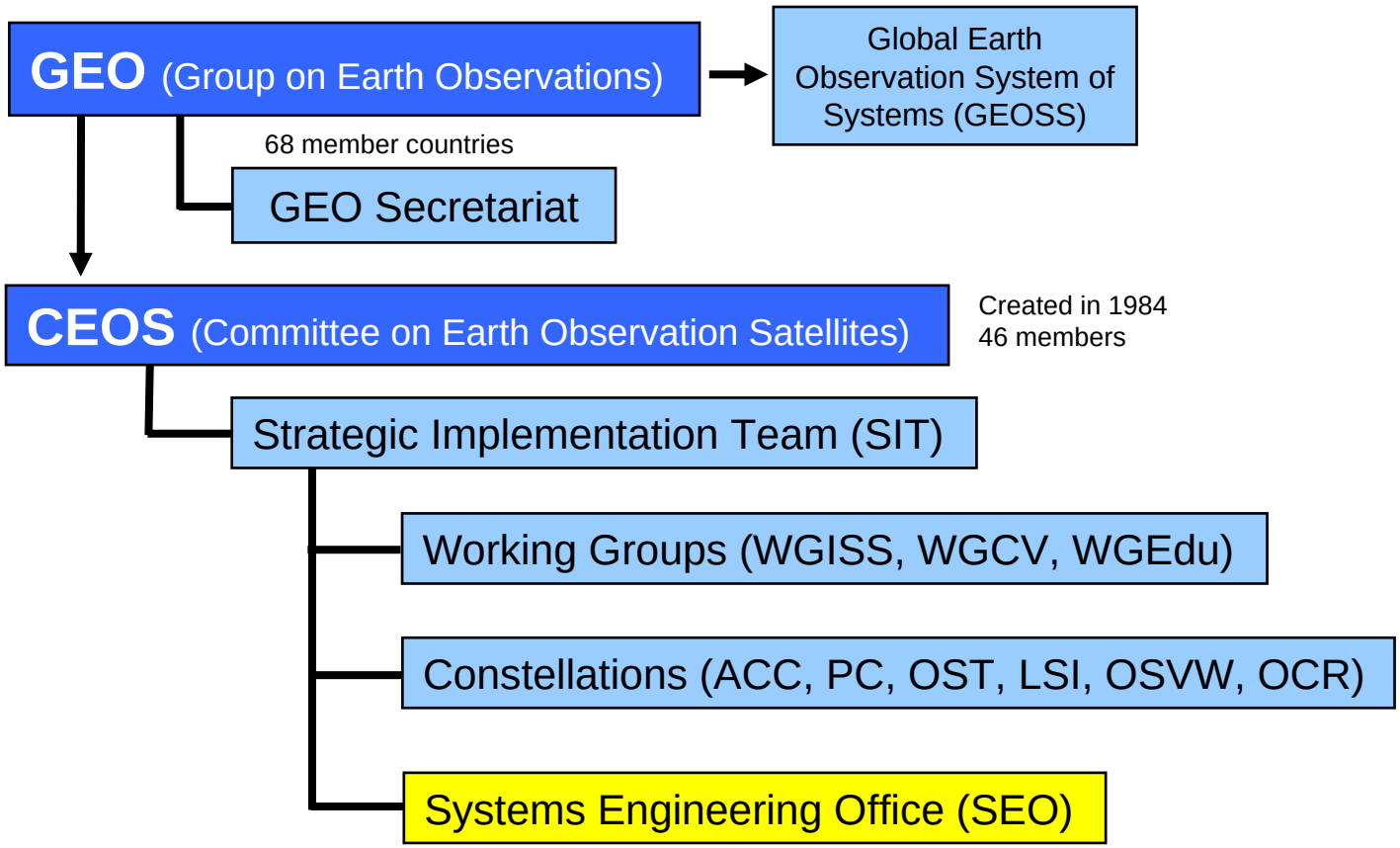
Brian Killough, CEOS SEO

CEOS WGCV Meeting
Avignon, France
October 1, 2008

What is the SEO?

- The Committee on Earth Observation Satellites (CEOS) **Systems Engineering Office (SEO)** was established in April 2007 to provide system engineering leadership and facilitate the development of CEOS global space constellation plans.
- The SEO **technical tasks** include requirements definition, gap assessments, architecture development and the development of technical decision support tools.
- The SEO **management tasks** include fostering communication among CEOS partners by coordinating and participating in CEOS meetings, developing management tools for more efficient and effective operation (action tracking and enhanced website), and developing visualization products for educating the global Earth Observation community about CEOS.

CEOS Organization Map



2008 Task Summary

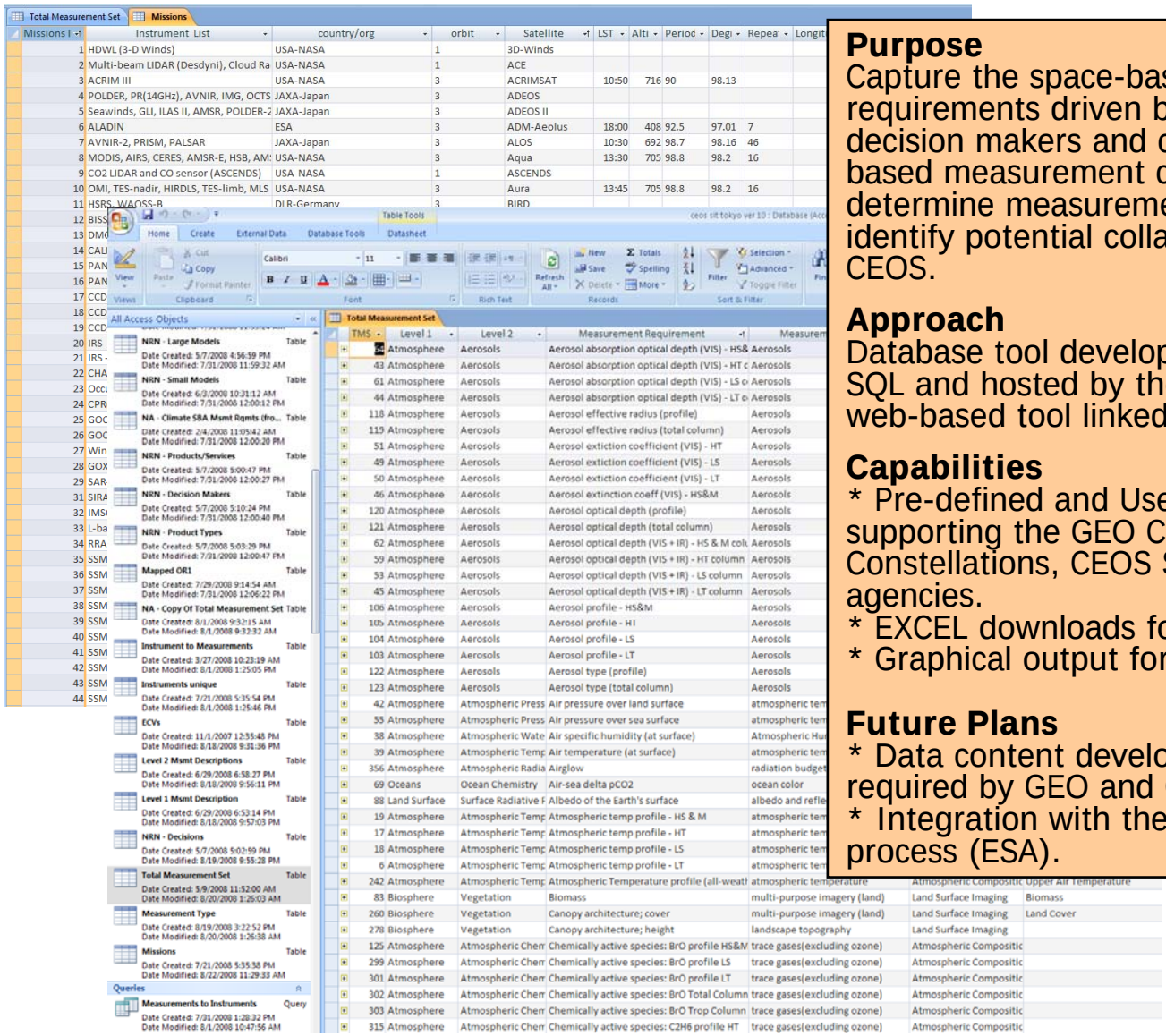
Systems Analysis

- Developed a system requirements database tool for requirement definition, gap assessments, and architecture planning.
- Performed preliminary gap analyses for ACC Constellations, Energy SBA and Climate SBA.
- Managed a subcontract with Rutherford Appleton Lab (RAL) to develop a detailed Atmospheric Composition gap analysis for the CEOS ACC Team.
- Initiated the development of a "Standards Document" for Land Surface Imaging in support of the CEOS LSI Constellation Team.
- Conducting a mid-resolution surface imaging gap analysis to support the LSI Constellation. Expanded effort to consider cloud constraints on measurements.

Enhanced Communications

- Developed a web-based tool for documenting and tracking CEOS actions.
- Led a NASA/NOAA team to revise the CEOS website to include new constellation content and enhanced functionality for users.
- Supporting the planning of the 3rd ACC Workshop at GISS in October 2008.
- Engaged with CEOS Working Groups (WGCV, WGISS, and WGEdu) to develop appropriate tasks and perform analyses in support of CEOS objectives.

Systems Requirements Database



Purpose

Capture the space-based measurement requirements driven by science, applications, and decision makers and compare them with the space-based measurement capabilities of CEOS to determine measurement and time gaps and to identify potential collaborative opportunities for CEOS.

Approach

Database tool developed in MS-ACCESS and MS-SQL and hosted by the SEO. Future migration to a web-based tool linked to the CEOS website.

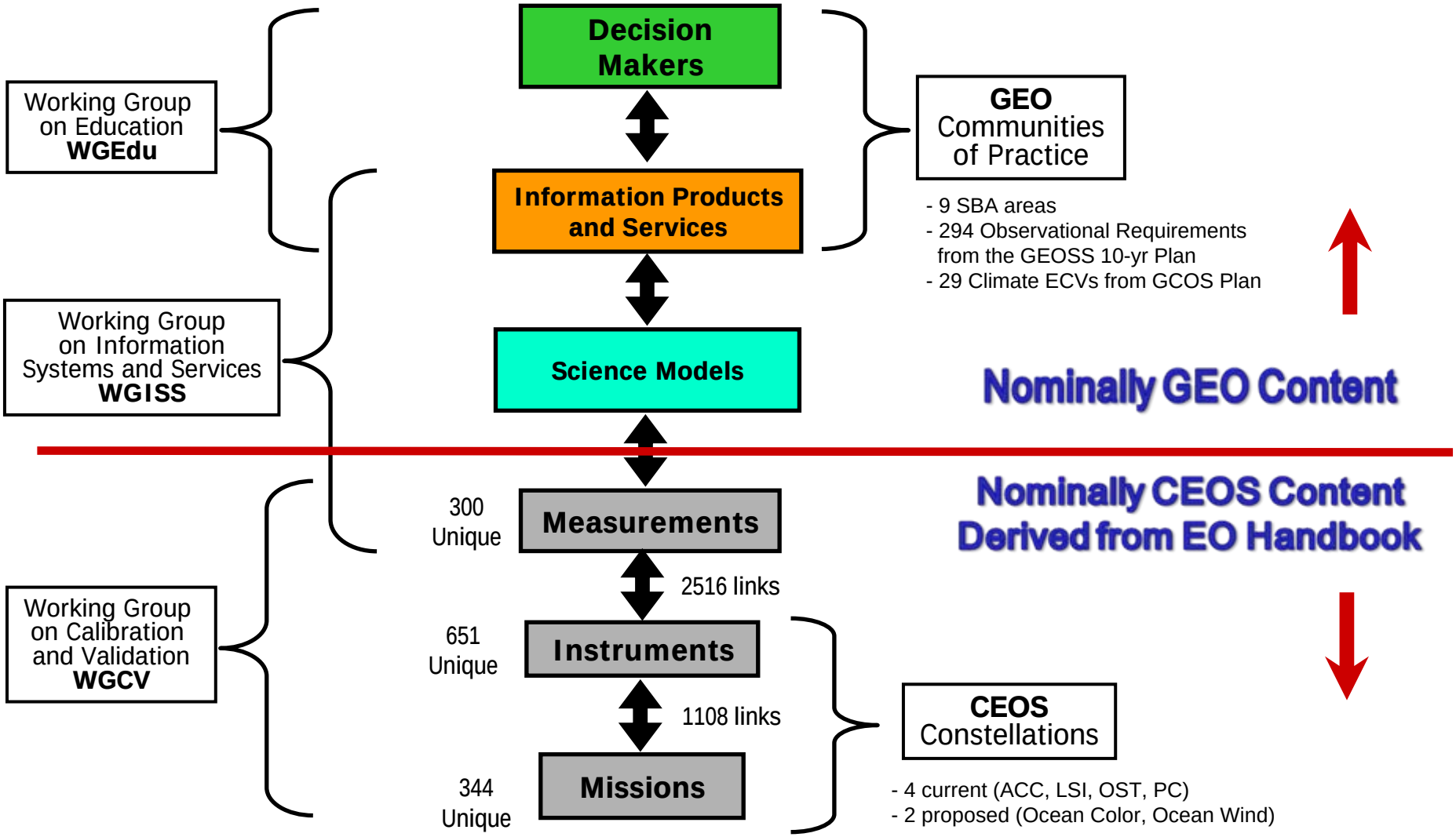
Capabilities

* Pre-defined and User-defined queries and reports supporting the GEO Communities of Practice, CEOS Constellations, CEOS SIT leadership, and CEOS agencies.
* EXCEL downloads for user analyses.
* Graphical output for viewing reports.

Future Plans

* Data content development and authentication required by GEO and CEOS.
* Integration with the EO Handbook update process (ESA).

Preliminary Database Architecture



ACC Constellation Gap Analysis

Constellation Measurement / Year	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Chemically active species: BrO profile HS&M	1	1	1	0	0	0	0	0	0	0	0	0	0	0
Chemically active species: BrO profile LS	3	3	2	1	1	1	1	0	0	0	0	0	0	0
Chemically active species: BrO profile LT	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chemically active species: BrO Total Column	4	4	4	3	4	2	2	1	2	2	1	1	1	1
Chemically active species: CH2O total column	1	1	1	1	2	1	2	2	3	3	1	1	1	1
Chemically active species: ClO profile HS&M	1	1	1	0	0	0	0	0	0	0	0	0	0	0
Chemically active species: ClO profile LS	3	3	2	1	1	1	1	0	0	0	0	0	0	0
Chemically active species: ClO Total Column	1	1	1	1	1	1	1	0	0	0	0	0	0	0
Chemically active species: HCl profile HS&M	1	1	1	0	0	0	0	0	0	0	0	0	0	0
Chemically active species: HCl profile LS	1	1	1	0	0	0	0	0	0	0	0	0	0	0
Chemically active species: CO profile HS&M	1	1	1	0	0	0	0	0	0	0	0	0	0	0
Chemically active species: CO profile HT	3	3	3	1	2	2	2	1	1	1	0	0	0	0
Chemically active species: CO profile LS	3	3	2	1	1	1	2	1	1	1	0	0	0	0
Chemically active species: CO profile LT	3	3	3	1	2	2	3	2	2	1	0	0	0	0
Chemically active species: CO Total Column	4	4	4	2	4	3	4	3	4	3	1	1	1	1
Greenhouse gas: CH4 HT	3	4	4	2	2	2	2	0	0	0	0	0	0	0
Greenhouse gas: CH4 LS	6	6	8	7	7	7	6	4	2	1	0	0	0	0
Greenhouse gas: CH4 LT	5	7	7	5	6	5	4	2	2	2	1	1	1	1
Greenhouse gas: CH4 Total column	8	8	10	8	9	8	7	5	4	3	1	1	1	1
Greenhouse gas: CO2 HT	1	3	3	3	2	2	2	0	0	0	0	0	0	0
Greenhouse gas: CO2 LS	5	5	7	7	7	7	6	4	2	1	0	0	0	0
Greenhouse gas: CO2 LT	1	3	3	3	2	2	2	0	0	0	0	0	0	0
Greenhouse gas: CO2 total column	5	6	8	8	7	7	7	5	3	2	0	0	0	0
Chemically active species: HNO3 profile HT	2	2	2	1	1	1	1	0	0	0	0	0	0	0
Chemically active species: HNO3 profile LS	3	3	2	1	1	1	1	0	0	0	0	0	0	0
Chemically active species: NO profile LS	1	1	1	1	1	1	1	0	0	0	0	0	0	0
Chemically active species: NO Total Column	2	2	1	1	1	0	0	0	0	0	0	0	0	0
Greenhouse Gas: N2O HT profile	2	2	2	1	1	1	1	0	0	0	0	0	0	0
Chemically active species: NO2 profile HT	2	2	2	1	1	1	1	0	0	0	0	0	0	0
Chemically active species: NO2 profile LS	3	3	2	1	1	1	1	0	0	0	0	0	0	0
Chemically active species: NO2 profile LT	1	1	1	1	1	1	1	0	0	0	0	0	0	0
Chemically active species: NO2 total column	5	5	4	3	4	2	2	1	2	2	1	1	1	1
Chemically active species: NO2 Trop Column	0	0	0	0	0	0	1	1	1	1	0	0	0	0
Chemically active species: SO2 profile HT	1	1	1	0	0	0	0	0	0	0	0	0	0	0
Chemically active species: SO2 profile LS	1	1	1	0	0	0	0	0	0	0	0	0	0	0
Chemically active species: SO2 Total Column	2	2	2	1	2	1	1	1	2	2	1	1	1	1
Ozone profile HS&M	2	5	5	5	4	3	2	3	3	4	2	2	1	1
Ozone profile HT	4	7	7	7	7	5	4	4	4	5	3	3	2	2
Ozone profile LS	10	12	13	14	13	11	9	9	7	5	2	4	3	4
Ozone profile LT	7	11	10	8	8	6	4	4	4	5	3	3	2	2
Ozone total column	20	21	25	23	23	19	16	18	18	16	13	14	13	13
Specific humdity profile LT (allweather)	0	0	0	1	1	1	0	0	0	1	1	2	2	2
Specific humidity profile LT	31	33	38	35	35	30	30	30	28	25	19	19	16	16
Specific humidity profile HS & M	1	1	1	1	0	0	0	0	0	0	0	0	0	0
Specific humidity profile HT	26	28	33	33	32	28	25	20	17	17	11	12	10	11
Specific humidity profile LS	8	9	11	9	10	9	9	8	8	6	3	4	3	3
Specific humidity profile Total column	25	26	29	26	25	20	17	15	12	10	6	6	7	7
Specific Humidity profile Troposphere column	4	4	4	4	4	4	2	2	1	0	0	0	0	0

Bromine

Chlorine

Carbon Monoxide

Methane

Carbon Dioxide

Nitrogen

Sulfer

Water

Gap Analysis Results

* Mission count summary shows potential gaps in several areas that are consistent with the detailed analysis results in the detailed RAL analysis.

* Similar gaps include: BrO, ClO, HCl, CH4, CO2, N2O, NO2, H2O

"Stop-Light" Chart
RED = 0 missions
YELLOW = 1 to 5 missions
WHITE = > 5 missions

Constellation Measurement / Year	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Aerosol properties - High Trop (HT) column	1	1	1	1	2	1	1	1	2	2	1	1	1	1
Aerosol properties - Low Strat (LS) column	1	1	1	0	0	0	0	0	0	0	0	0	0	0
Aerosol properties - total column	10	10	12	9	11	10	10	11	12	10	6	6	6	7
Aerosol properties profile	1	1	1	1	1	1	1	0	0	0	0	0	0	0
Aerosol properties profile - HT	2	2	3	2	3	4	4	4	4	3	2	2	2	2
Aerosol properties profile LS	5	5	5	3	4	5	4	3	4	2	2	2	2	2
Aerosol properties profile LT	11	15	19	17	20	19	16	12	10	6	3	5	5	6
Cloud cover	27	29	36	34	33	27	25	25	25	20	16	17	17	17
Cloud cover (profile)	0	0	1	1	1	1	2	2	1	1	0	0	0	0
Cloud drop effective radius (top of cloud)	2	2	2	0	0	0	0	0	0	0	0	0	0	0
Cloud ice (profile)	2	2	2	1	1	1	0	0	0	0	0	0	0	0
Cloud ice effective radius (profile)	1	1	1	0	0	0	0	0	0	0	0	0	0	0
Cloud ice effective radius (top of cloud)	3	3	3	1	1	1	0	0	0	0	0	0	0	0
Cloud ice profile Total column	0	0	0	0	0	0	1	1	1	1	1	3	4	5
Cloud imagery	21	21	25	23	23	20	20	18	16	13	11	12	13	13
Cloud optical depth	6	6	6	3	3	4	4	3	3	2	2	4	5	6
Cloud top height	26	29	33	30	29	26	23	23	24	20	17	18	17	17
Cloud top temperature	18	20	23	21	20	16	14	15	12	10	7	6	5	4
Cloud type	30	36	37	33	32	28	24	23	25	22	18	19	18	18
Cloud water profile (<100um) HT	1	1	1	1	1	1	0	0	0	0	0	0	0	0
Cloud water profile (<100um) LT	13	15	17	12	14	13	10	8	7	5	3	3	3	3
Cloud water profile (<100um) Total column	12	14	15	13	11	11	8	8	7	8	5	5	6	6
Cloud water profile (>100um) HT	1	1	1	1	1	1	0	0	0	0	0	0	0	0
Cloud water profile (>100um) LT	1	1	1	1	1	1	0	0	0	0	0	0	0	0
Cloud water profile (>100um) Total column	3	3	4	5	6	6	6	6	7	6	4	4	4	6

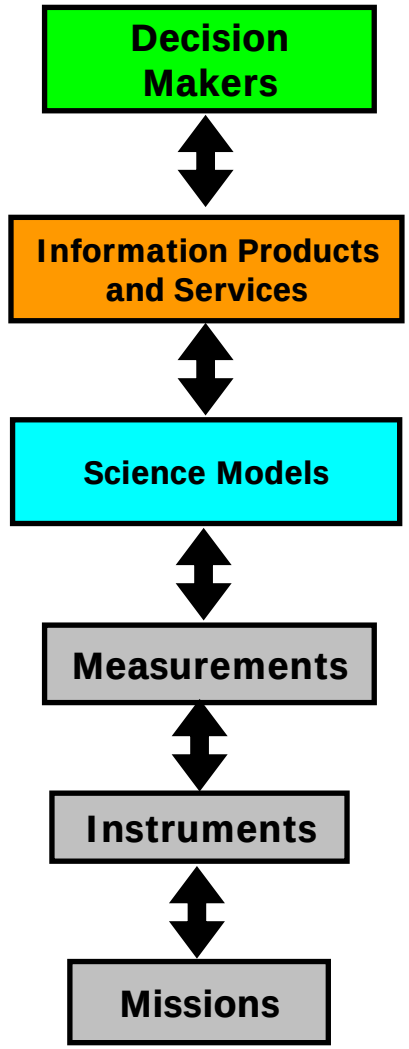
Aerosols

Clouds

Water

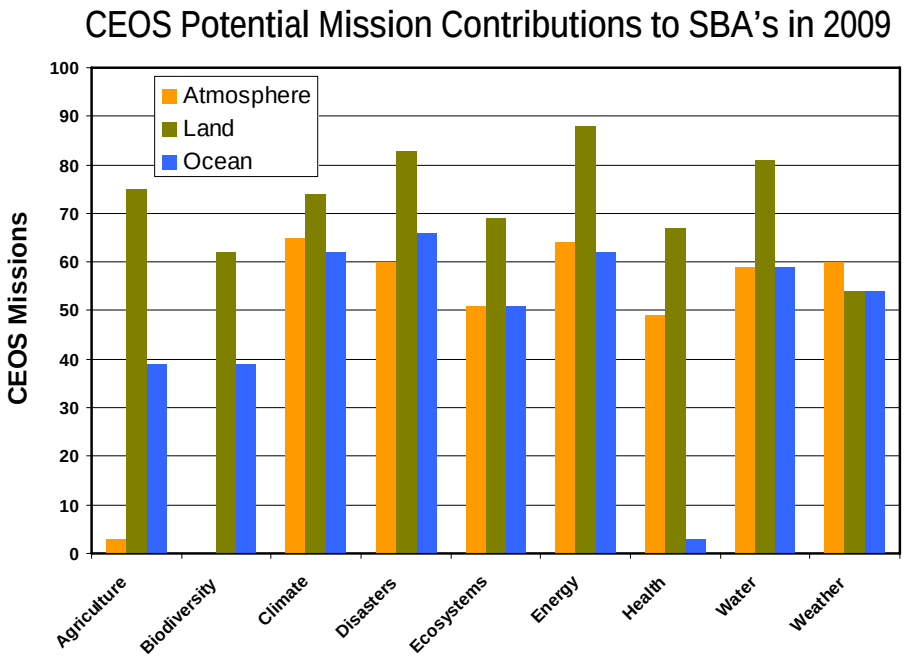
Example: Energy SBA Requirements

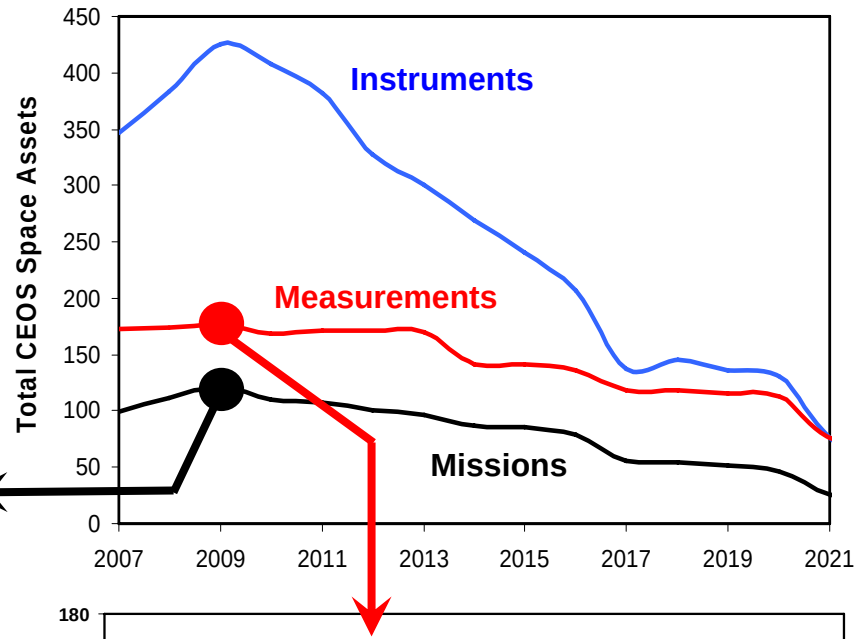
Decisions	Measurements (Types)
Exploration of traditional and renewable energy resources (i.e., solar, wind, geothermal, ocean)	Landscape topography Atmospheric / Ocean Surface Winds Cloud particle properties and profile ★ Liquid water and precipitation rate ★ Radiation budget Aerosols Trace gases ★
Environmental impacts of energy resource exploration, extraction, and exploitation (i.e., air quality, water quality, land resources, ecosystem health)	Aerosols Trace Gases ★
Energy production impact on global climate change (i.e., greenhouse gases)	Radiation budget Atmospheric temperature/humidity Cloud particle properties and profile ★ Cloud type, amount, and cloud top temp Aerosols Trace gases ★
Long-term climate impact on energy resource supply and demand	Radiation budget Atmospheric temperature/humidity Cloud particle properties and profile ★ Cloud type, amount, and cloud top temp Aerosols Trace gases ★
Short- to medium-term weather impact on energy resource supply and demand	Atmospheric temperature/humidity Cloud particle properties and profile ★ Cloud type, amount, and cloud top temp Land surface temperature Soil moisture Snow cover, edge, and depth
Space Weather impacts on energy transmission systems	Space Weather

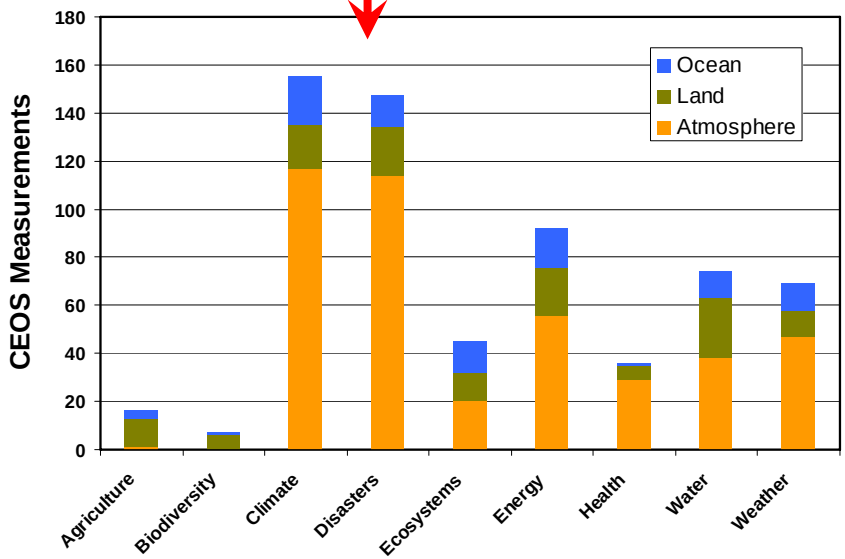


★ Identified in the Energy SBA Gap Analysis as a potential near-term measurement gap.

Example: CEOS Measurement Contributions to all SBA's







Comments:

* 2009 is the peak year for CEOS with 121 missions, flying 425 instruments, making 177 measurements. The total number of planned CEOS missions falls by 50% within 8 years.

* The CEOS space missions have a great potential to contribute to the GEO SBAs across every domain (Atmosphere, Land and Ocean).