A-CCP Aerosols and Clouds-Convection-Precipitation Study

An Overview of the Aerosol and Clouds-Convection-Precipitation Study (A-CCP) and its Relationship to the Geostationary AC-VC

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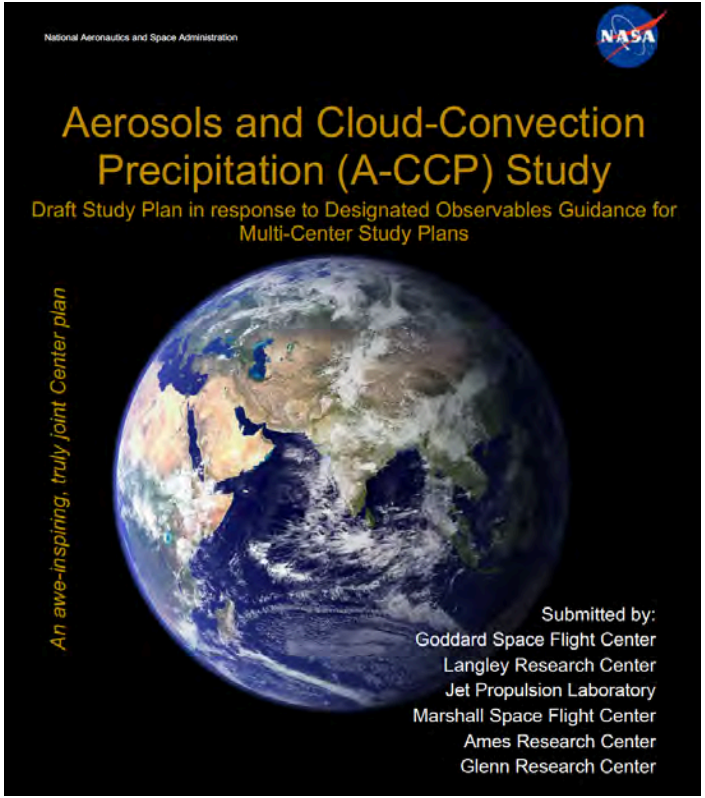
Outline

1. 2017 Decadal Survey Designated Observables
2. The A-CCP Study:
   - Structure and Approach
3. The SATM
   - Overarching Science Goals
   - A-CCP Science objectives
4. Concluding Remarks



Thriving on Our Changing Planet

A Decadal Strategy for Earth Observation from Space

Available from http://sites.nationalacademies.org/DEPS/ESAS2017

Recommended NASA Flight Program Elements

Program of Record. The series of existing or previously planned observations, which **should be completed as planned**. Execution of the ESAS 2017 recommendation requires that the total cost to NASA of the Program of Record *flight missions from FY18-FY27 be capped at $3.6B.*

- ***Designated.*** A new program element for ESAS-designated cost-capped medium- and large-size missions to address ***observables essential to the overall program*** and that are outside the scope of other opportunities in many cases. Can be competed, at NASA discretion.
- ***Earth System Explorer.*** A new program element involving competitive opportunities for medium-size instruments and missions serving specified ESAS-priority observations. ***Promotes competition among priorities.***
- ***Incubation.*** A new program element, focused on investment for priority observation opportunities needing advancement prior to cost-effective implementation, including an Innovation Fund to respond to emerging needs. ***Investment in innovation for the future***.
- ***Venture.*** Earth Venture program element, as recommended in ESAS 2007 with the addition of a new Venture-Continuity component to provide ***opportunity for low-cost sustained observations***.

Designated Observables from 2017 DS

DO	Summary	Candidate Measurement	
Aerosols	**Aerosol properties, aerosol vertical profiles, and cloud properties** to understand their eff…	Backscatter lidar and multi-channel/multi-angle/polarization … together	≤ $800M
Clouds, Convection, and Precipitation	**Couple… dynamics** for monitoring global hydrological cycle and understanding contributing processes including cloud feedback	…uency passive microwave and sub-mm radiometer	≤ $800M
Mass Change	**Large-scale Earth dynamics** measured by the chan… between … ground water, and ice sheets	Spacecraft ranging measurement of	≤ $300M
Surface Biology and Geology	**Earth surface geology and biology,** ground/w… active ge… and algal biomass	Hyperspectral imagery in the visible … multi- or … the thermal IR	≤ $650M
Surface Deformation and Change	**Earth su…** and lands…	…Aperture …pheric correction	≤ $500M

Transition to missions in **2022** Time Frame with a possible second stage in **2024-2027**

Transition to missions in **2024-2027** time frame

Transition to missions in **2021** time frame

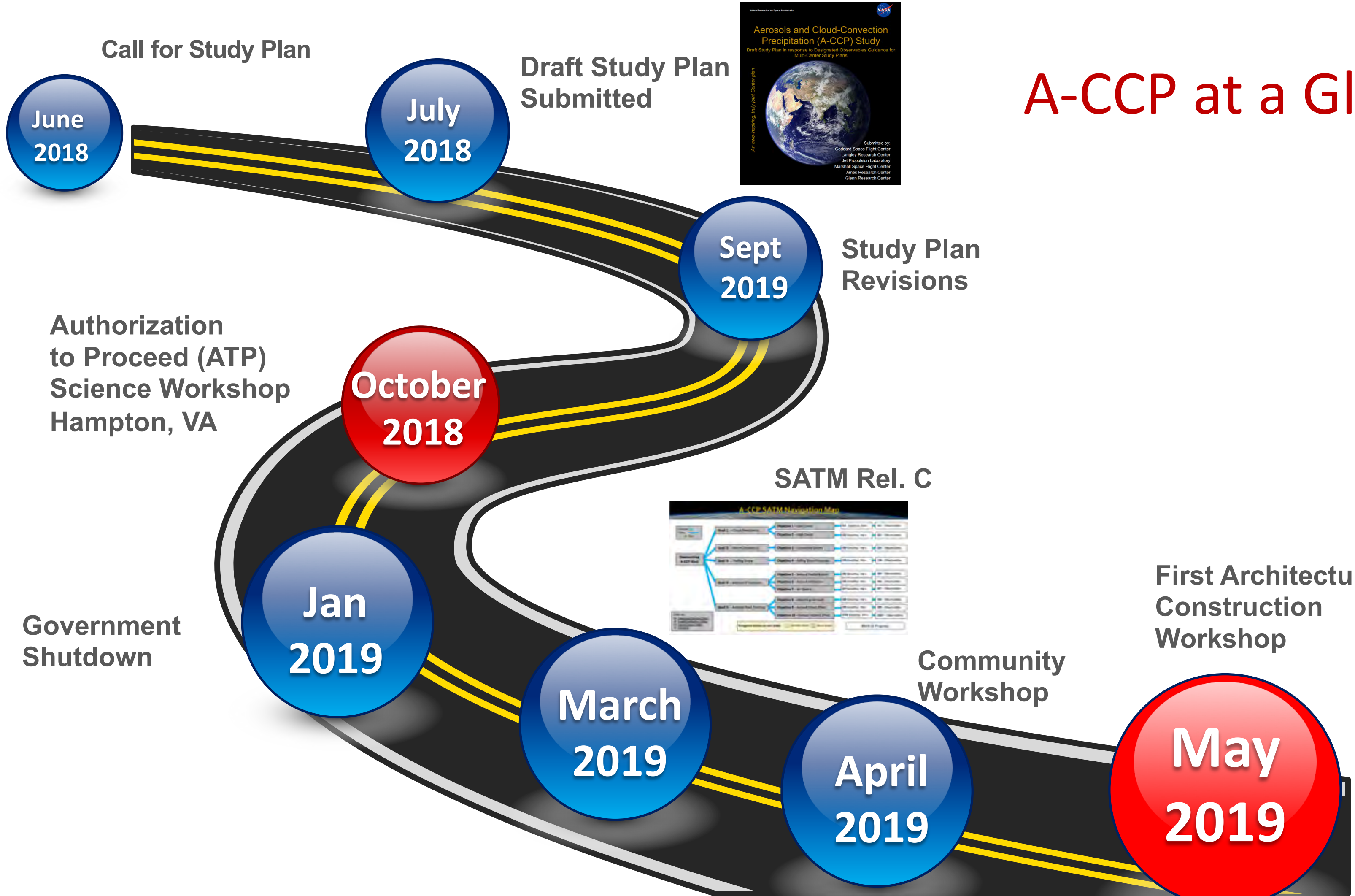
Transition to missions in **2024-2027** time frame

Decadal Survey Aerosol Themes and Objectives

Table 1-1: Most Important (MI) Decadal Survey Science Objectives of relevance to the Aerosol Designated Observable.

Theme	Science Objectives
Climate Variability and Change	• Reduce aerosol radiative forcing uncertainty by a factor of two (C-2h) • Quantify the contribution of the upper troposphere and stratosphere to climate feedbacks and change (C-2g) • Improve estimates of the emissions of natural and anthropogenic aerosols and their precursors via observational constraints (C-5a) • Quantify the effects of aerosols on cloud formation, height, and properties (C-5c) • Reduce uncertainties in low and high cloud feedback by a factor of two (C-2a)
Weather and Air Quality	• Determine the effects of key boundary layer processes on weather, hydrological, and air quality forecasts (W-1a) • Improve the observed and modeled representations of natural, low-frequency modes of weather/climate variability (W-2a) • Improve our understanding of the processes that determine air pollution distributions and reduce uncertainties in PM concentrations (W-5a)

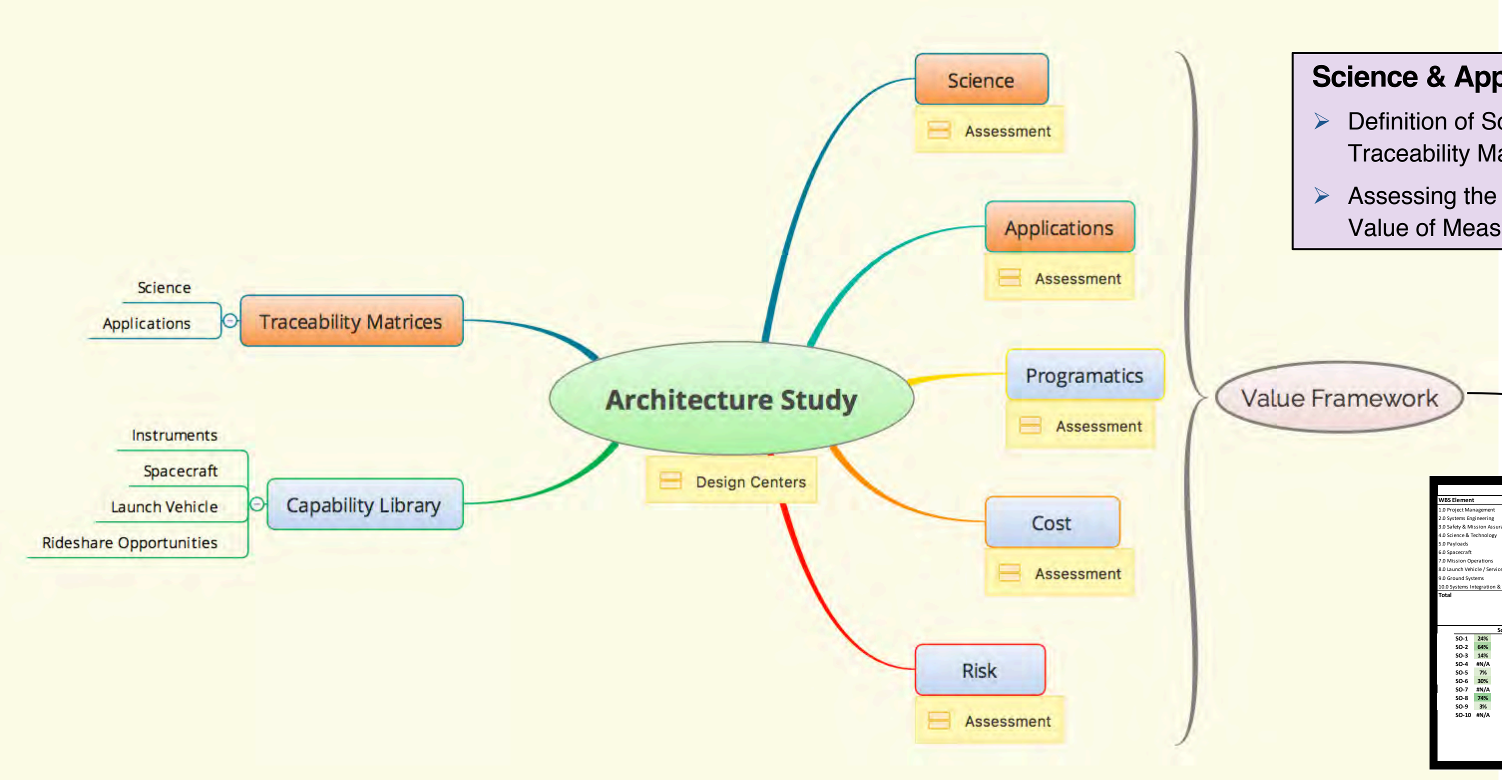
A-CCP at a Glance



Constraints on the A-CCP Study

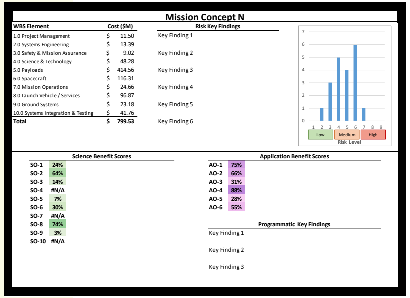
- The *2017 Decadal Survey* (DS) recommended cost-capped missions with specified caps, so challenge for team to envision new science but ensure an implementable observing system
- The DS prioritized science objectives:
  - ➢ most important, very important, and important objectives
- NASA HQ has determined that instruments will be competed rather than designed to SATM (must be TRL-6 by PDR ca. 2023)
  - SATM will define appropriate *desired minimum capabilities* (not requirements)
- Finding an observing system that meets objectives is ultimately dependent on knowledge of available capabilities (Instrument Library)

A-CCP Study: Approach



Science & Applications Activities

- Definition of Science & Applications Traceability Matrices
- Assessing the Science & Applications Value of Measurement Architectures



Mission Concept N

WBS Element		Cost ($M)
1.0 Project Management	$	11.50
2.0 Systems Engineering	$	13.39
3.0 Safety & Mission Assurance	$	9.02
4.0 Science & Technology	$	48.28
5.0 Payloads	$	414.56
6.0 Spacecraft	$	116.31
7.0 Mission Operations	$	24.66
8.0 Launch Vehicle / Services	$	96.87
9.0 Ground Systems	$	23.18
10.0 Systems Integration & Testing	$	41.76
Total	**$**	**799.53**

Risk Key Findings

Key Finding 1
Key Finding 2
Key Finding 3
Key Finding 4
Key Finding 5
Key Finding 6

Science Benefit Scores

SO-1	24%
SO-2	64%
SO-3	14%
SO-4	#N/A
SO-5	7%
SO-6	30%
SO-7	#N/A
SO-8	74%
SO-9	3%
SO-10	#N/A

Application Benefit Scores

AO-1	75%
AO-2	66%
AO-3	31%
AO-4	88%
AO-5	28%
AO-6	55%

Programmatic Key Findings

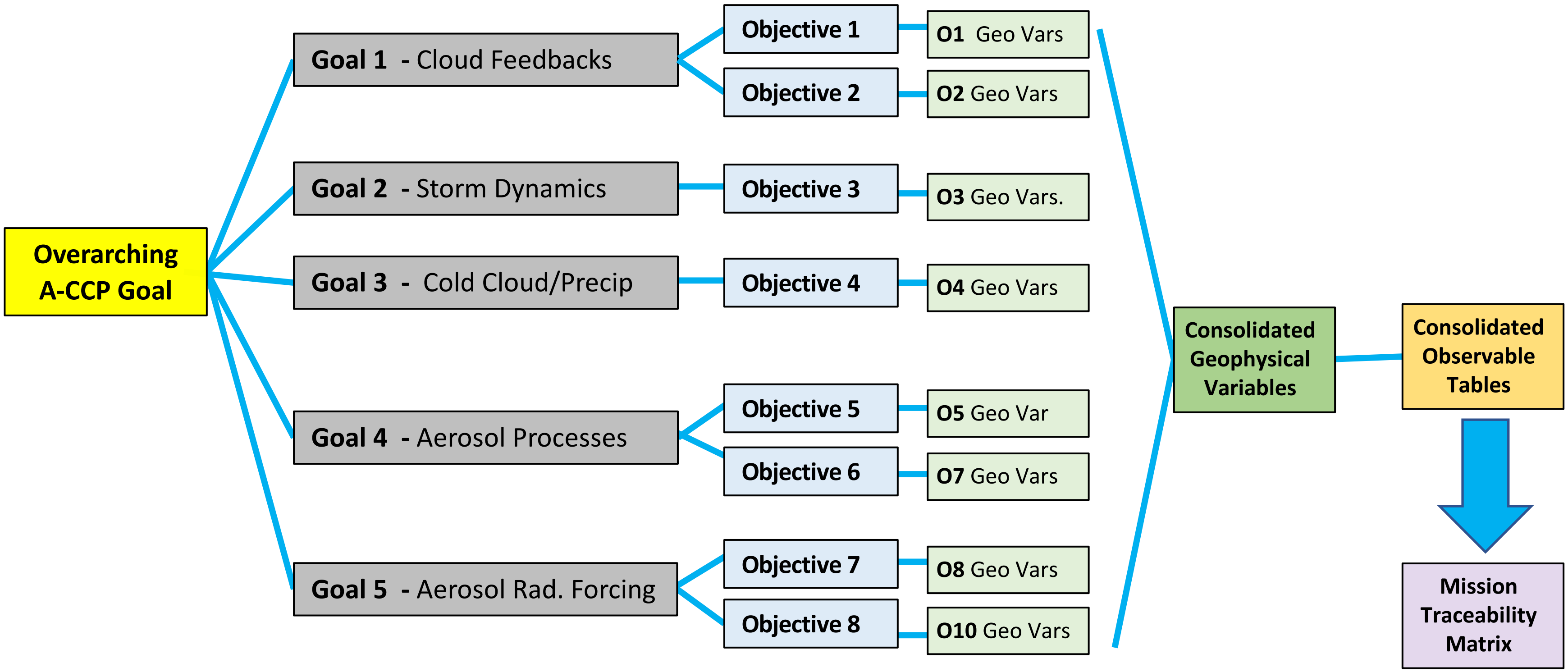
Key Finding 1
Key Finding 2
Key Finding 3

VF Baseball Cards

A-CCP Framing Assumptions

- A-CCP is a combined Aerosols and CCP process-oriented Earth Observing System
- Payload may consist of:
  a) Active sensors (lidars and radars) are the cornerstones of the payload, complemented by
  b) Several passive radiometers (multi-angle, multi/hyper-spectral, with some polarized channels, from UV to sub-mm)
- Being a process oriented mission, some of the instruments may have a narrow swath needed to provide context to the measurements (as opposed to wide swath needed for mapping)
- A-CCP is an Earth Observing System potentially consisting of
  a) A space-based mission (payload, spacecraft, launch vehicle)
  b) A fully integrated, sustained sub-orbital component
  c) Models, data assimilation and synergistic algorithms needed to extract maximum benefits from the A-CCP measurements

SATM Development Process



Public Releases of the SATM

- Available from:
  - https://science.nasa.gov/earth-science/decadal-surveys/
- Distributed to:
  - ➢ National and International invitees of Community Workshop
  - ➢ Members of Science Community Cohort (SCC)
  - ➢ Other center senior scientists not directly involved in A-CCP
- Feedback collected by
  - ➢ Google forms
  - ➢ Email: a-ccp-comments@lists.nasa.gov
  - ➢ Written comments compiled SCC co-chairs (who are embedded in the SALT)
  - ➢ Listening sessions with senior scientists not involved at A-CCP (GSFC & GISS)

Overarching A-CCP Goal	A+CCP	A	CCP	2017 DS Most Important Very Important	Goals
Understand the processing of water and aerosol through the atmosphere and develop the societal applications enabled from this understanding.				C-2a, C-2g, W-1a, W-2a	**G1** Cloud Feedbacks Reduce the uncertainty in low- and high-cloud climate feedbacks by advancing our ability to predict the properties of low and high clouds.
				C-2g, C-5c, H-1b, W-1a, W-2a, W-4a	**G2** Storm Dynamics Improve our physical understanding and model representations of cloud, precipitation *and dynamical* processes within deep convective storms.
				H-1b, W-1a, W-3a, S-4a	**G3** Cold Cloud and Precipitation Improve understanding of cold (supercooled liquid, ice, and mixed phase) cloud processes and associated precipitation and their coupling to the surface at mid to high latitudes and to the cryosphere.
				W-1a, W-5a, C-5a	**G4** Aerosol Processes Reduce uncertainty in key processes that link aerosols to weather, climate and air quality related impacts.
		D I		C-2h, C-5c	**G5** Aerosol Impacts on Radiation Reduce the uncertainty in Direct (D) and Indirect (I) aerosol-related radiative forcing of the climate system.

Goal only fully realizable via combined mission.

A or CCP makes meaningful contribution to goal

A+CCP	A	CCP	Goal	Example Science Questions	Objectives
			G4 Aerosol Processes *Reduce uncertainty in key processes that link aerosols to weather, climate and air quality related impacts.*	*1) What are the major anthropogenic and natural sources of aerosol and how do they vary spatially and temporally?* *2) What are the factors that relate aerosol microphysical and optical properties to surface PM concentrations?* *3) To what extent does long-range transport of smoke, dust, and other particulates impact regional near-surface air quality?*	**O5** Aerosol Attribution and Air-Quality **Minimum:** Quantify optical and microphysical aerosol properties in the PBL and free troposphere to improve process understanding, estimates of aerosol emissions, speciation, and predictions of near-surface particulate concentrations. **Enhanced:** Characterize variations in vertical profiles of optical and microphysical properties over space and time in terms of 3D transport, spatially resolved emission sources and residual production and loss terms.
					O6 Aerosol Redistribution **Minimum:** Characterize the processing, removal and redistribution of aerosols by clouds and light precipitation (<2 mm/hr). **Enhanced:** Characterize the processing, removal and redistribution of aerosols by clouds and heavy precipitation (> 2 mm/hr).

Relevant PoR for A-CCP Objectives 5 & 6

Geostationary Orbit

Mission Family	Agency	Relevant Instruments	Ops Period	Notes
GOES 15-19	NOAA	Multi-purpose Imaging rad (VIS/IR), Lightning imager	2010 - 2040	North and South America sector
Meteosat (MTG 11-14)	EUMETSAT, ESA	Multi-purpose Imaging rad (VIS/IR), Lightning imager	2021 - >2040	Europe and Africa sector
Himawari 8-9	JMA, JAXA	Multi-purpose Imaging rad (VIS/IR)	2014 - 2031	Western Pacific Ocean sector
GEO-KOMPSAT 2A	KARI, KORI, NIER	Multi-purpose Imaging rad (VIS/IR)	2019 - 2029	Western Pacific Ocean sector
GEO-KOMPSAT 2B: ○ AMI ○ GEMS/GOCI	KARI, KORI, NIER	○ Multi purpose Imaging Rad (VIS/IR) ○ Nadir-scanning UV-VIS spectrometer	2019-	○ Full disk ○ NE Asia ○ Korean Peninsula
TEMPO	NASA	Nadir-scanning UV-VIS spectrometer	TBD	CONUS sector only
Sentinel 4 A-B	ESA, COM	Scanning Spectrometer (UV/VIs)	2023 - 2039	Europe and Africa sector

Relevant PoR for A-CCP Objectives 5 & 6

Low Earth Orbit

Mission Family	Agency	Relevant Instruments	Ops Period	Notes
JPSS 2-4	NOAA	Imager (Vis/IR), IR Spec, MW Rad, Broadband Rad	2022 - 2040	Eq crossing: ~02:30 pm
Metop (SG A1/A2)	EUMETSAT, ESA, DLR, CNES, COM	Imager (Vis/IR), IR Spec, MW Rad, Broadband Rad, Polarimeter (3MI: VNIR,SWIR)	2021 - >2040	Eq crossing: ~10:30 am
Sentinel 2 B-C	ESA, COM	Imager (Vis/IR)	2017 - 2029	Eq crossing: ~10:30 am
Sentinel 3 B-C	ESA, EUMETSAT, COM	Spectro-Rad,	2018 - 2029	Eq crossing: ~ 10 am
Sentinel 5 A-B	ESA, COM	Scanning Spectrometer (UV/VIS)	2021 - 2030	Eq crossing: ~9:30 am
PACE OCI	NASA	Ocean Color Radiometer (UV,VIS,SWIR)		Eq crossing: ~1 pm

A+CCP	A	CCP	Objectives
			O5 Aerosol Attribution and Air Quality **Minimum:** Quantify optical and microphysical aerosol properties in the PBL and free troposphere to improve process understanding, estimates of speciation, aerosol emissions and predictions of near-surface particulate concentrations. **Enhanced:** Characterize changes in vertical profiles of optical and microphysical properties over space and time in terms of 3D transport, spatially resolved emission sources and residual production and loss terms.

A	CCP	ODO	POR	Potential Enabled Apps	Geophysical Variables (1 of 2)		Qualifiers
					Minimum	Enhanced	
√				7,8,16,17	Aerosol Extinction Profile		Total + non-spherical
√				5,7,8,15-17	Aerosol Vertical Extent		
√		S	(√)	5,7,8,15-17	Aerosol Optical Depth		PBL and column
√				5,7,8,15-17	Aerosol Absorption Optical Depth		PBL and column
√				5,7,8,16,17	Aerosol Fine Mode Optical Depth		PBL and column
√			(√)	5,7,8,15-17	Aerosol Angstrom Exponent		PBL and column
√			(√)	5,7,8,15-17	Aerosol Real Index of Refraction		PBL and column
√				5,7, 8	Aerosol Non-Spherical AOD Fraction		PBL and column
√					Aerosol Extinction to Backscatter Ratio		PBL and column
√					Aerosol-Cloud Feature Mask		
√			(√)	5,7,8,17	Planetary Boundary Layer Height		
			√		Environmental Temperature Profile		
			√		Environmental Humidity Profile		

Consolidated Observables (3 of 6)		Geophysical Variables	Desired Capabilities						Instrument Class	Desired Mission Capabilities
			Range	Uncertainty	Resolution			Altitude		
					Δx	Δz	Swath			
Minimum / Enhanced	Channels/ Angles	IMPORTANT: Desired Capabilities are preliminary. Click here for additional information.								
TAtbsCo.λz Molecular+Particulate Attenuated Co-polarized Backscatter Profiles (Superseded by HSRL enhanced **RayAtbs.λz, MieAtbsCo.λz** and **MieAtbsCo.λz** measurements when available)	VIS NIR	**AOD.ℓ, AODF.ℓ, AAOD.ℓ,AEXT.z, AABS.z,AEXTF.z,AE.I,AE.z, ACFM.z,ANC.ℓ,AE2BR,AE2BR.ℓ, AEFR.I,AEFR.z,ARIR.ℓ,AIIR.ℓ, ANSPH,ANSPH.z,APM2.5,AVE, BSS,CA,CBH,COD,CTDC,CTDS, CTE,CTH,ICNC,IWP,PANC,PBLH**			100 m	30 m (Minimum) 10 m (Enhanced)	100 m	-2 to 42 km	Backscatter Lidar	Polar Orbit (O1, O4, O7, O9); Note: Δx & swath meant to imply continuous along-track coverage; Swath means receiver footprint diameter View angle: 0.3 to 5 degrees
TAtbsX.λz Molecular+Particulate Attenuated Cross-polarized Backscatter Profiles (Superseded by HSRL enhanced **RayAtbs.λz, MieAtbsCo.λz** and **MieAtbsCo.λz** measurements when available)	VIS NIR	Same as for **TAtbsCo.λz**							Backscatter Lidar	(as above)
Rad.λ Radiances	VIS NIR (Minimum) UV (Enhanced)				100 m	---	100 m	---	Lidar	from lidar background monitor

Consolidated Observables (4 of 6)			Geophysical Variables	Desired Capabilities						Instrument Class	Desired Mission Capabilities
				Range	Uncertainty	Resolution			Altitude		
						Δx	Δz	Swath			
Minimum	Enhanced	Channels/ Angles	**IMPORTANT**: Desired Capabilities are preliminary. Click here for additional information.								
RayAtbs.λz Attenuated Rayleigh Backscatter Profiles		UV VIS	**AOD.ℓ, AODF.ℓ, AAOD.ℓ, AEXT.z, AABS.z, AEXTF.z,AE.ℓ AE.z,ACFM.z,ANC.I,AE2BR, AE2BR.ℓ,AEFR.ℓ,AEFR.z,ARIR.ℓ, AIIR.ℓ,ANSPH,ANSPH.z,APM2.5, AVE,BSS,CA,CBH,COD,CTDC, CTDS,CTE,CTH,ICNC,IWP,PANC, PBLH**			100 m	10 -30 m	100 m	-2 to 42 km	HSRL Lidar	Polar Orbit (O1, O4, O7, O9); Note: Δx & swath meant to imply continuous along-track coverage; Swath means receiver footprint diameter; View angle: 0.3 to 5 degrees
MieAtbsCo.λz Attenuated Mie Co-polarized Backscatter		UV VIS	Same as for **RayAtbs.λz**			100 m	10 – 30 m	100 m	-2 to 42 km	HSRL Lidar	
MieAtbsX.λz Attenuated Mie Cross-polarized Backscatter		UV VIS	Same as for **RayAtbs.λz**			100 m	10 - 30 m	100 m	-2 to 42 km	HSRL Lidar	

Consolidated Observables (5 of 6)			Geophysical Variables	Desired Capabilities						Instrument Class	Desired Mission Capabilities
				Range	Uncertainty	Resolution			Altitude		
						Δx	Δz	Swath			
Minimum	Enhanced	Channels/Angles	**IMPORTANT**: Desired Capabilities are preliminary. Click here for additional information.								
Rad.λ Radiances		**UV:** 400-470nm **VIS:** 635-680nm **SWIR:** 1.6~~-2.2μm~~ # Channels: 5	**Land and Ocean:** AOD.ℓ, APM25, COD, CF **Ocean only:** AODF.ℓ , AE.ℓ		5%	500 m	—	100 km	—	Multispectral Radiometer	
Rad.λα Multi-angle Radiances		**UV:** 400-470 nm **VIS:** 550-870 nm # Channels: 4 # Angles: 5	AOD.ℓ, AODF.ℓ, AAOD.ℓ, AE.ℓ, ASYM, ANSPH, AVE, APM25, CF, CTH			500 m	—	100 km	—	Multi-angle Radiometer	
DOLP.λα*(Rad.λα) Multi-angle Degree of Linear Polarization		**UV:** 350-470 nm **VIS:** 530-870 nm # Channels: 5 # Angles: 5	AOD.ℓ, AODF.ℓ, AAOD.ℓ, AE.ℓ, ASYM, ANSPH, ANC.ℓ, ARIR.ℓ, AIIR.ℓ, AVE, APM25, COD,CTDC,CTDS, CTH		Max(3% Rad, 0.005 DOLP	500 m	—	100 km	—	Multi-angle Polarimeter	

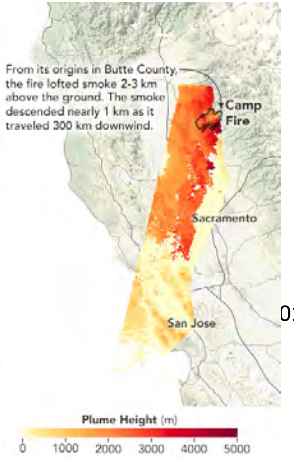
Consolidated Observables (6 of 6)			Geophysical Variables	Desired Capabilities						Instrument Class	Desired Mission Capabilities
				Range	**Total** Uncertainty	Resolution			Altitude		
						Δx	Δz	Swath			
Minimum	**Enhanced**	**Channels/Angles**	**IMPORTANT**: Desired Capabilities are preliminary. Click here for additional information.								
Rad.λ Radiances		**UV:** 355 nm	**AOD.ℓ, AAOD.ℓ, AODF.ℓ, AE.ℓ , APM25, COD, CF**			250 m	—	300 km	---	Multispectral Radiometer	Moderate bandwidth (10-30 nm) channel centered close to wavelength or within given range
Rad.λα Multi-angle Radiances		**SWIR:** ~1680, ~1880, ~2260 nm # Angles: 5.	**AOD.ℓ, AODF.ℓ, AAOD.ℓ, AE.ℓ, ASYM, ANSPH, ANC.ℓ, ARIR.ℓ, AIIR.ℓ, AVE, APM25, COD, CTH**		5%	250 m	—	300 km	---	Multi-angle Radiometer	Moderate bandwidth (10-30 nm) channel centered close to wavelength or within given range
(DOLP.λα)∗(Rad.λα) Multi-angle Degree of Linear Polarization		**SWIR:** ~1680 # Angles: 5.	**AOD.ℓ, AODF.ℓ, AAOD.ℓ, AE.ℓ, ASYM, ANSPH, ANC.ℓ, ARIR.ℓ, AIIR.ℓ, AVE, APM25, COD,CTDC,CTDS, CTH**		5%	250 m	—	300 km	---	Multi-angle Polarimeter	Moderate bandwidth (10-30 nm) channel centered close to wavelength or within given range

Objective 5: Aerosol Attribution/AQ

Potential Enabled Application Example

- **AQ Forecasting & Decision-Making:** Observations of speciated aerosol enable initial conditions, plume tracking (e.g., volcanoes, forest fires), and estimation of emissions for AQ forecasting, as well as, for AQ decision-making, such as State Implementation Plan development and Exceptional Event support.
- **Relevant Geophysical Properties:** AOD, Aerosol Extinction Profiles, Aerosol Speciation, Aerosol layer height
- **Partners**: NOAA, EPA, state AQ agencies, National Forest Service, FAA, VAACs

A+CCP has the potential to provide more and better information to characterize the 3-D structure of speciated aerosols within the boundary layer and to quantify emission sources



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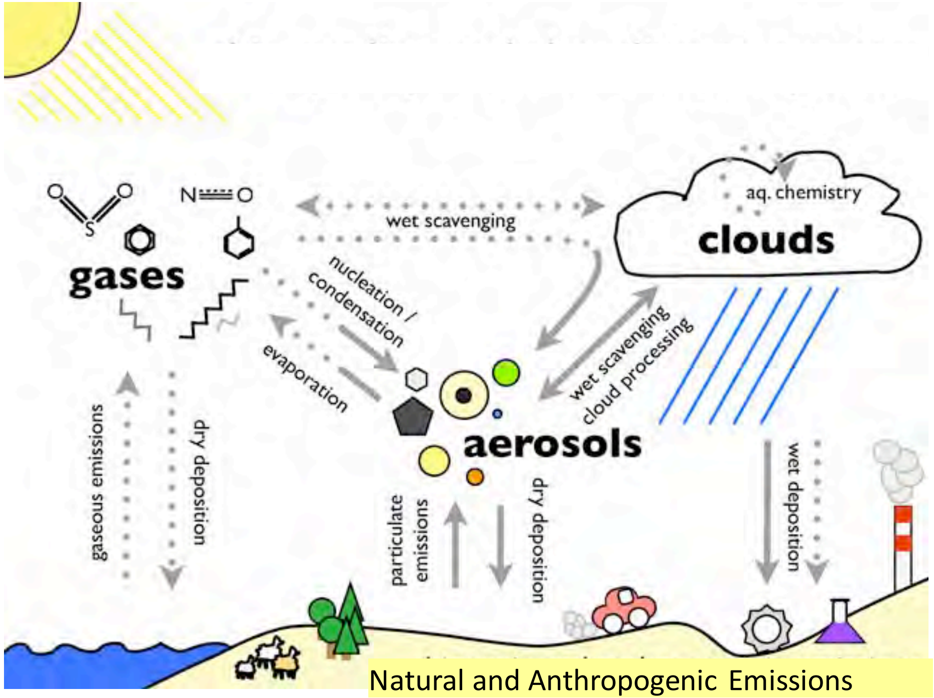
Objective 5: Aerosol Redistribution

Potential Enabled Application Example

- **Operational Air Quality Forecasting**: Aerosol observations are used for operational AQ forecasting (e.g., forecast initialization), tracking dust plumes, and issuing AQ alerts
- **Relevant Geophysical Properties:** Aerosol Optical Depth, Aerosol Extinction Profiles, & Aerosol Speciation
- **Partners**: NOAA, EPA (e.g., AirNOW) and state AQ agencies



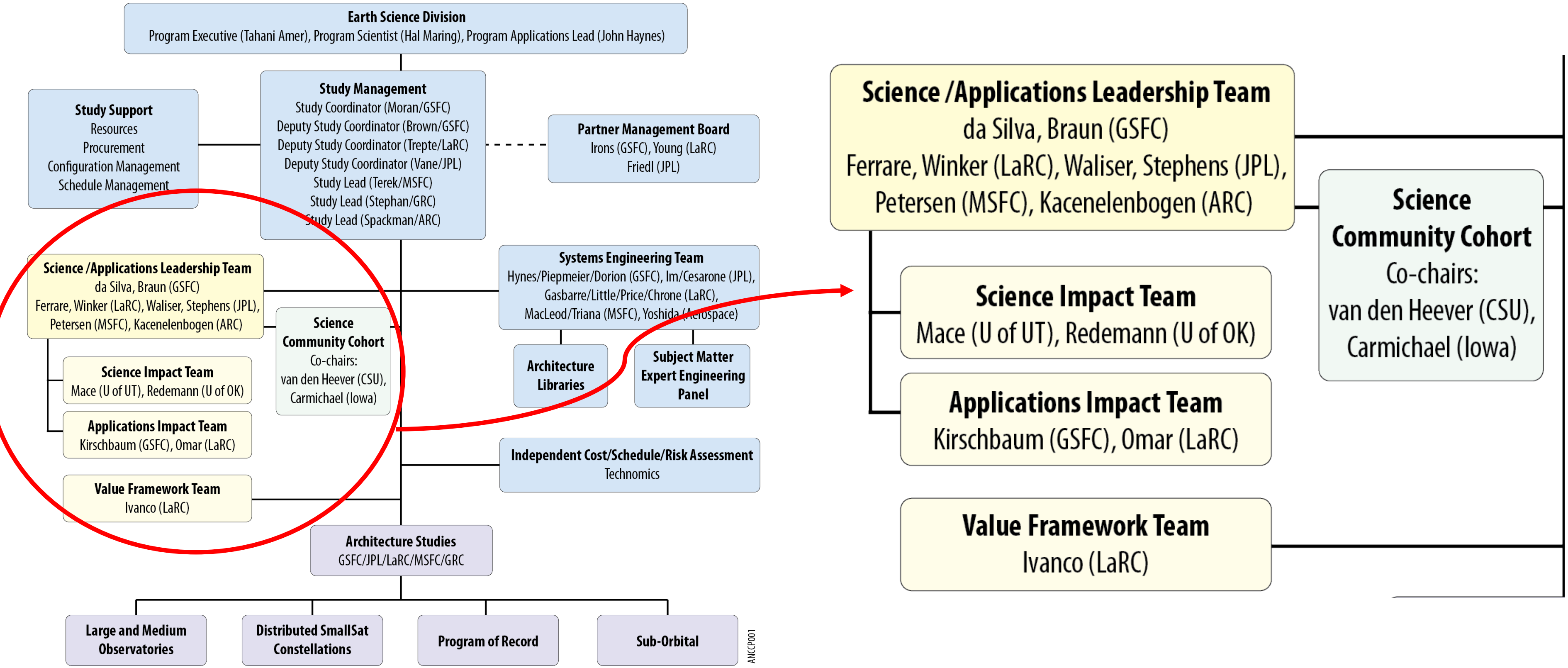
Courtesy of EMPA

Concluding Remarks

- Aerosol speciation is the linchpin for improving aerosol emissions and for gaining insight into aerosol processes such as vertical transport, wet removal and cloud processing
- Objectives 5 and 6 cannot be fully addressed with remotely-sensed observations alone — earth system models play a critical be it in data assimilation/inverse calculations or systematic upscaling from LES to the climate scales.
- Simultaneous observations of the aerosol and clouds/precipitation states are not easily (if at all) realized from space — an integrated space/sub-orbital approach is necessary to fully address many of the A-CCP objectives.
- The Geostationary PoR, in particular the Atmospheric Composition Virtual Constellation, will play a critical role for the process oriented aerosol objectives in A-CCP.

Extra Slides

Science Team Organization

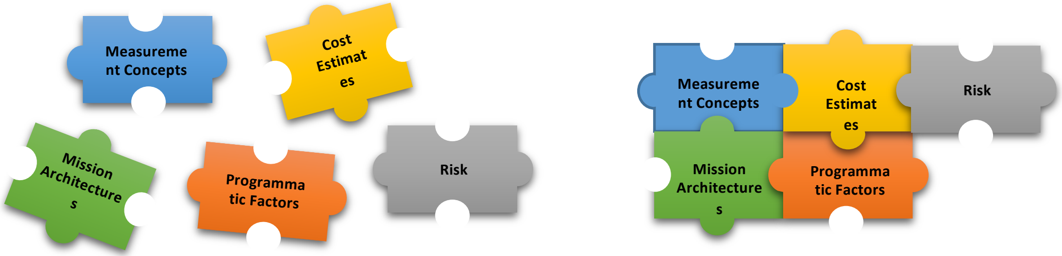


What is a DO Architecture?

- An observing system concept; for example:
  - ✓Dedicated observatory
  - ✓A CubeSat/Small-Sat constellation
  - ✓Hosted on a Commercial Sat
  - ✓Flying in constellation with Agency X's Satellite Z
- Desired Instrument Capabilities (NOT requirements)
  - ✓This may include evaluation of specific instrument types (i.e. spectrometers, lasers, radiometers, etc)
- Other elements of the system:
  - ✓Access to space
  - ✓Ground Systems
  - ✓ Etc.

Value Framework Objective

The function of the Value Framework Team is to **facilitate and document conversations among stakeholders** by providing an objective, structured, and traceable approach. The Value Framework is the set of processes and methods chosen to achieve this objective.



Defining Value

Value = *f*(**Science Benefits**, **Applications Benefits**, **Programmatic Factors**, **Cost**, **Risk**)

Programmatic Factors → e.g. schedule, international partnerships, etc.

Benefits, cost, and risk are intentionally not rolled up into a single value score to avoid:

- **Losing discriminators**
- **Combining uncertainty**
- **Anchoring cognitively on an initial value**

Value Output: Baseball Cards for Concept N

Cost Estimate Summar y

Science Benefit Scores

Risk Estimate Summary

Applications Benefit Scores

Observing System Concept N

WBS Element	Cost ($M)	
1.0 Project Management	$	11.50
2.0 Systems Engineering	$	13.39
3.0 Safety & Mission Assurance	$	9.02
4.0 Science & Technology	$	48.28
5.0 Payloads	$	414.56
6.0 Spacecraft	$	116.31
7.0 Mission Operations	$	24.66
8.0 Launch Vehicle / Services	$	96.87
9.0 Ground Systems	$	23.18
10.0 Systems Integration & Testing	$	41.76
Total	$	799.53

Risk Key Findings

Key Finding 1

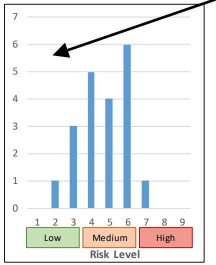
Key Finding 2

Key Finding 3

Key Finding 4

Key Finding 5

Key Finding 6



Science Benefit Scores

O1 Low Clouds	24%
O2 High Clouds	64%
O3 Convective Storms	N/A
O4 Falling Snow	30%
O5 Aerosol Redistrib.	90%
O6 Aerosol Attribution	85%
O7 Air Quality	75%
O8 Absorbing Aerosols	80%
O9 Aerosol Direct Eff.	85%
O10 Aerosol Ind. Eff.	75%

Application Benefit Scores

AO-1	75%
AO-2	66%
AO-3	31%
AO-4	88%
AO-5	28%
AO-6	55%

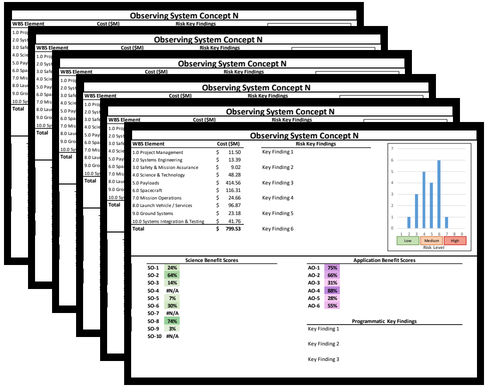
Programmatic Key Findings

Key Finding 1

Key Finding 2

Key Finding 3

Programmatic Factors



The VF Baseball Card allows for simultaneous comparisons across observing system concepts on the basis of cost, risk, science and applications benefits, and programmatic factors.

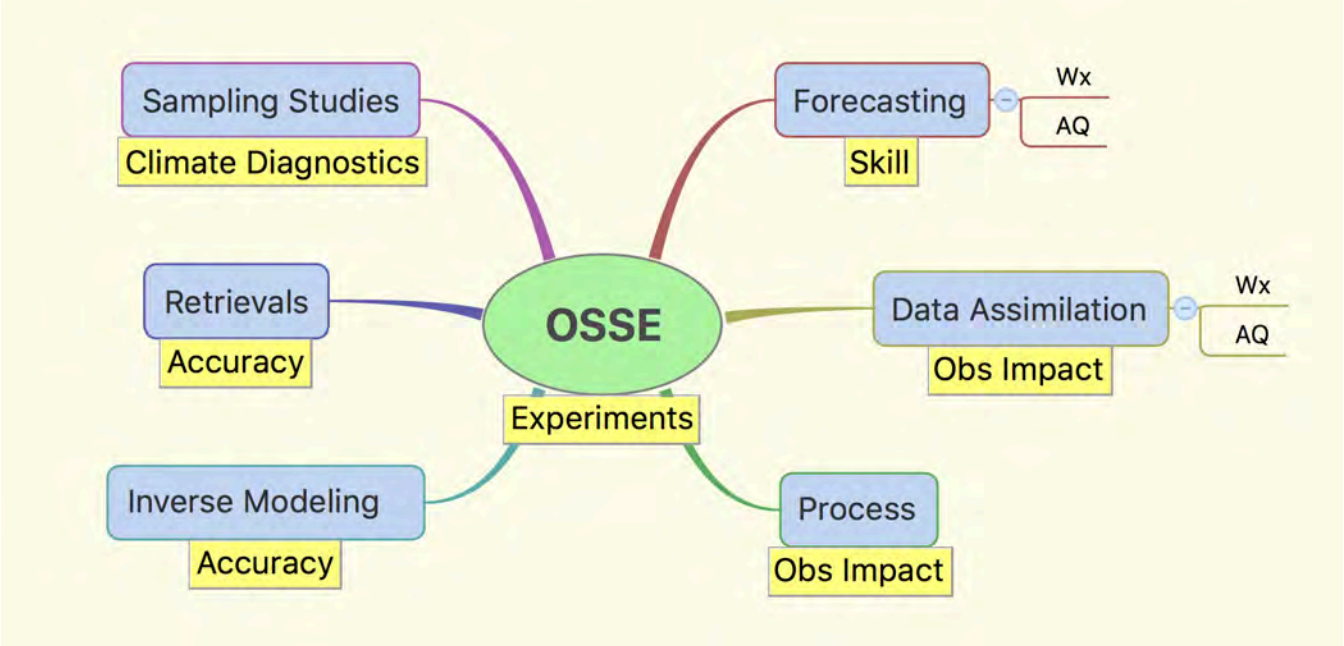
Scoring a Science Objective

$$\textbf{Score of Objective} = \frac{1}{N}\sum_{\text{GVs, Measurements}} \underbrace{\textbf{Utility of GV for Objective}}_{\text{(SALT)}} \times \underbrace{\textbf{Quality of Measurement for GV}}_{\text{(SIT)}}$$

Modeling, OSSEs, and Field Campaign Data Analysis

- Use data from past NASA or other field programs to address the applicability of measurement combinations to constrain geophysical parameters and physical tendencies (processes).
- The SIT will provide information to the Value Framework assessment so that objective decisions regarding mission architecture trades can be made.
- The SIT will also coordinate OSSE activities to assess the ability of specific architectures to address the A-CCP science objectives.

The "E" in OSSE: *A Spectrum of OSSEs*



SCC US Membership				Science Expertise				Application Expertise	
First	Last	Institution	Science Interests	A	Cl	Cv	Pr	A	CCP
Greg	Carmichael	Iowa	Data Assim., GAW perspective	√				√	
Sue	van den Heever	CSU	CCP, aerosols	√	√	√	√		
Tristan	L'Ecuyer	U Wisc	clouds		√	√	√		
Ana	Barros	Duke	CCP/Hydrology			√	√		(√)
Andy	Dessler	Texas A&M							
Graham	Feingold	NOAA	Clouds, aerosols	√	√				
Andrew	Gettleman	NCAR	Climate Modeling	√	√	√	√		
Colette	Heald	MIT	aerosol modeling	√					
Steve	Klein	LLNL	cloud feedbacks	√					
Mark	Kulie	Mich.Tech	CCP(snow, microwave)		√	√	√		
Ruby	Leung	PNNL	precip, convection		√	√	√		
Yang	Liu	Emory	Air Quality	√				√	
Johnny	Luo	CCNY	UTLS						
Allison	McComiskey	DOE/BNL	aerosols, radiation	√					
Steve	Nesbitt	Illinois	CCP			√	√		
Jeff	Reid	NRL	Aerosols, modeling	√				(√)	
Lynn	Russell	Scripps	aerosol chemistry	√					
Courtney	Schumacher	Texas A&M	radar, convection			√	√		
Armin	Sorooshian	U Arizona	aerosols, clouds	√					
Rob	Wood	U Wash	Clouda-erosol interactions	√	√				
Faisal	Hossein	U Wash	hydrology				√		√
James	Nelson	NOAA/NWS/WPC	weather ops, precip, hydrology		√		√		√