CEOS WGCV and CEOS initiatives

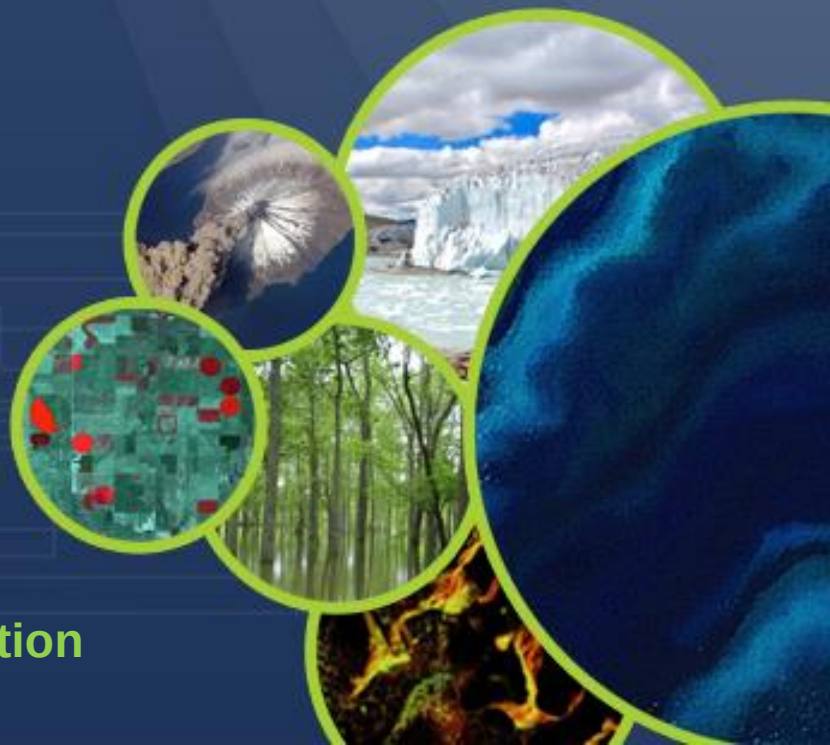
K. Thome

NASA/GSFC

IVOS #29

Tucson, Arizona

March 15, 2017



Working Group on Calibration and Validation

CEOS WGCV and CEOS initiatives

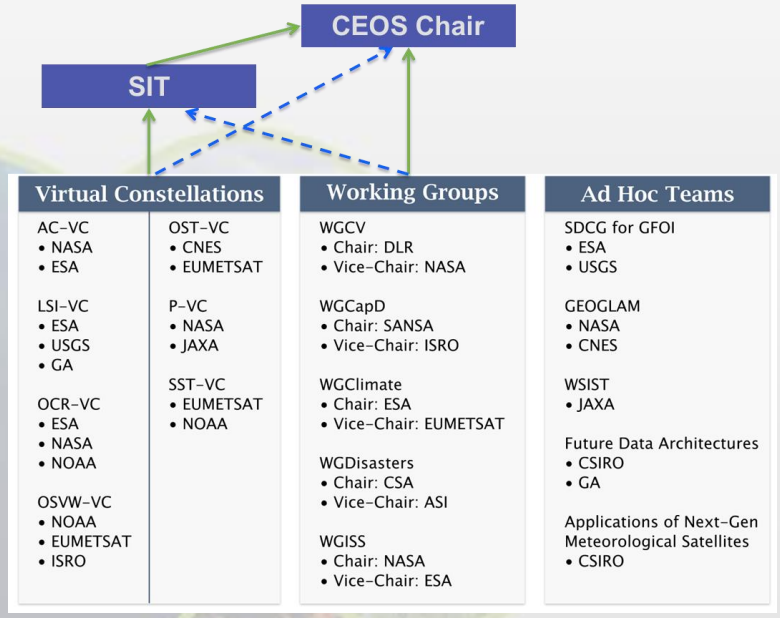
Introduction and discussion on how IVOS can contribute to WGCV and CEOS

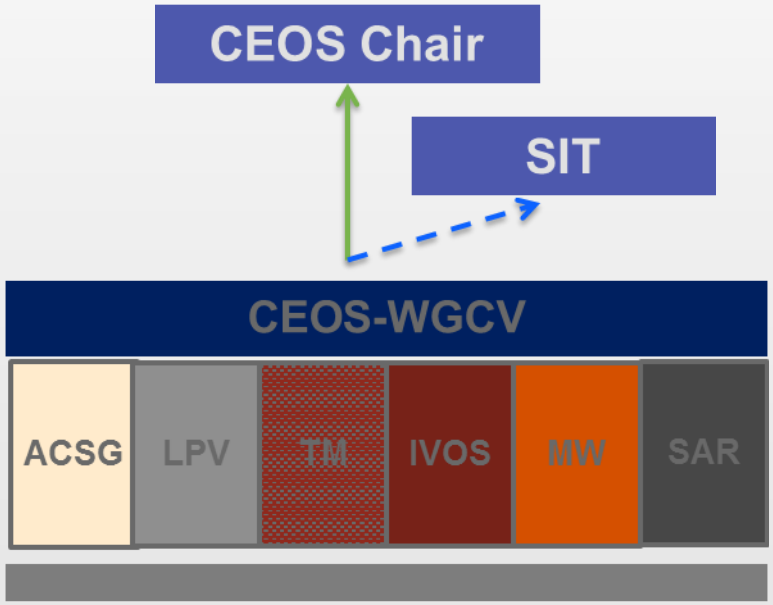
- Review CEOS, WGCV, IVOS organization
- CEOS & CEOS WGCV workplan
- WGCV chair report
- CEOS WGCV activities relevant to IVOS
  - RadCalNet admission of new sites
  - Non-meteorological applications from geo-stationary
  - Analysis Ready Data (ARD)
  - Moderate resolution sensor interoperability (Analysis ready data) initiative
  - Carbon task force actions

CEOS organization reminder

IVOS is one of six subgroups that are part of WGCV that reports to the Strategic Implementation Team and CEOS Chair

- Interaction with other CEOS bodies (Virtual Constellations, WGs)
- Interaction with other bodies (example: GSICS)
- Topics which are relevant for several subgroups
- General topics (for example: validation metrics, protocols,…)





Interaction with CEOS bodies

"Nature" of CEOS WGCV typically leads to links with other Working Groups and Virtual Constellations

- Other working groups rely on data quality, characterization, metrics
  - WGClimate
  - WGISS (WG Information Systems and Services)
  - WGCapD (WG for Capacity Development)
- Virtual Constellations have direct connections to parts of WGCV through overlap in topics and reliance on data quality
  - Atmospheric Composition (AC-VC)
  - Land Surface Imaging (LSI-VC)
  - Ocean Colour Radiometry (OCR-VC)
  - Sea Surface Temperature (SST-VC)
- Metrics Indicator, Future Data Access, GEO work plan
- Link to GSICS has been established
- Fiducial Reference Measurements and other topics

WGCV chair report

- Sept. 5-7, 2016 WGCV plenary # 41 in Tokyo
- Sept. 7-9, 2016 SAR Sub-group Workshop in Tokyo
- Sept. 12-15, 2016 SIT Workshop in Oxford
- Oct. 31 – Nov. 2 CEOS Plenary in Brisbane
- Monthly SEC telecons
- Finalized WGCV Terms of Reference
- WGCV work plan provided to the CEOS Chair
- ACIX task team continued to make progress – second workshop scheduled for April 11-12 in Frascati

CEOS workplan

A CEOS Workplan is developed each year by the CEOS CE

- Under direction of the CEOS Chair
- Consultation with SIT Chair, SEC, WGs, VCs, Ad Hoc Teams, SEO, CEOS Agencies at large, and external stakeholders
- Near-term objectives and deliverables to achieve goals outlined in *CEOS Strategic Guidance* document
- Current document
  - Description of CEOS activities for 2017 calendar year
  - Summarize anticipated activities for 2018-2019
  - Based on results of discussions from 29th CEOS Plenary Meeting held in Kyoto, Japan in 2015
- Results in actions at the WGCV level that can flow to the subgroups

CEOS workplan activities relevant to IVOS

Learning by doing - through pilot projects

- Future Data Architecture pilot projects to understand how CEOS Agencies can work together on technical activities
- CEOS Data Cube activity supported by LSI-VC
  - Collaboration with WGCV
  - Provide sample ARD for trial implementations of CEOS Data Cube

FDA-7: Product Specifications in accordance with the CARD4L Framework	Q4 2017	CEOS Analysis Ready Data for Land (CARD4L) will be satellite data that have been processed to a minimum set of requirements and organized into a form that allows immediate analysis with a minimum of additional user effort, and, interoperability both through time and with other datasets. LSI-VC will commence development of the first concrete specifications for CARD4L-branded products, with at least two such specification documents presented for endorsement at the 31st CEOS Plenary Meeting. Draft versions of these specifications will be used to inform LSI-VC contributions to FDA-4.	LSI-VC (with WGCV)

CEOS workplan activities relevant to IVOS

Progress implementation of the CEOS Strategy for Carbon Observations from Space

- Targeted initiatives to advance to implementation of the *CEOS Strategy for Carbon Observations from Space*
- CARB objectives/deliverables proposed over the 2017-2018 period

CARB-19: Land products validation listing and framework	Q4 2017	Summarize current list of validated land data products relevant to Carbon Strategy, documenting validation framework and protocols and providing guidance for online platform for intercomparison of terrestrial carbon products.

CEOS & CEOS WGCV workplan

Coordinate the development of suitable methodologies for the on-ground characterization of satellite-based EO sensors, the on-orbit calibration of EO missions, and the validation of satellite-based Level 1 and Level 2 products.

- **2017-2019:** WGCV continue to evaluate and recommend best practices for the characterization/calibration of satellite-based sensors and the validation of satellite-based Earth observation data products
- Tasks are focused sub-groups dealing with specific areas of interest
- WGCV will maintain the CEOS Cal/Val portal including
  - Activities of its sub-groups
  - Information about achievements in calibration and validation
  - Cal/Val supersites
  - Results from recent efforts that impact interoperability

CEOS & CEOS WGCV workplan Relevant to IVOS

Continue cooperation with GEO, Global Space-based Inter-calibration System (GSICS), and WMO and ground-based networks in the provision of high quality EO data products.

- WGCV will strengthen its cooperation with GSICS
  - Sensor calibration to address corrections for sensor differences
  - Traceability to coordinate activities to address interoperability
- WGCV will continue working with the GEO Secretariat
  - Encourage adoption of QA4EO Principles
  - Address needs of users and data providers, by considering the needs of the Atmosphere, Terrestrial, and Ocean communities
  - Develop calibration infrastructure and comparison campaigns to promote QA4EO Principles and best practices
  - Foster cooperation with WMO, ground-based networks, and CEOS WGs and VCs through presence during WGCV meetings

CEOS & CEOS WGCV workplan Relevant to IVOS

Capacity Building, Data Access, Availability and Quality

CB-22: Provide capacity building support to WGCV activities	Q2 2018	Collaborate with WGCV to develop materials to promote e.g., QA4EO, LandNet, optical and SAR calibration/validation. The 2017 meeting of the WGCapD will be a key event in defining specific priorities.	WGCapD with WGCV

CV-1: Update of general WGCV website to enhance better communication across CEOS and users	Q3 2017	Re-organization of WGCV website concept which includes on one side the entry on the CEOS portal, the CEOS CalVal portal, and the different subgroup web-sites in order to achieve a better outreach and communication strategy.	WGCV
CV-3: Workshop on state of the art for pre-flight calibration techniques	Q4 2017	Hold an open-invitation workshop to discuss and promote best practices on pre-flight and onboard calibration of sensors, initially focusing on optical.	WGCV

CEOS & CEOS WGCV workplan Relevant to IVOS

Capacity Building, Data Access, Availability and Quality

CV-9: Radiometric Calibration Network (RADCALNET)	Q4 2017	Establish an automated network via a multi-agency project, including coordination infrastructure, and land-based test-sites for post-launch traceable calibration of sensor radiometric gain, initially for <50 m resolution sensors. Progress will follow the developed project plan.	WGCV
CV-13: Intercomparison of atmospheric correction models	Q4 2018	The WGCV task team "Atmospheric correction" will carry out several comparison measures between models and report about their findings including recommendations with respect to EO applications.	WGCV

CEOS & CEOS WGCV workplan Relevant to IVOS

Capacity Building, Data Access, Availability and Quality

CV-14: Report on application of approaches for cloud masking	Q4 2018	The WGCV task team “Cloud masking” will research different cloud masking approaches for different sensors and spectral areas in order to deliver a report about their findings including recommendations for the applications of cloud masking in EO applications.	WGCV
CV-15: L1 top-of-atmosphere interoperability	Q4 2017	Develop an initial recommendation of a community reference in collaboration with GSICS.	WGCV
CV-16: Report on outcomes from GSICS/CEOS reference Solar Spectrum evaluation	Q2 2018	Cooperation through a series of Web Meetings to evaluate recent advances to recommend a solar spectra for GSICS and CEOS to ensure interoperability.	WGCV

CEOS & CEOS WGCV workplan Relevant to IVOS

Advancement of the CEOS Virtual Constellations

- Characterize the Virtual Constellations in the context of both the development of the space segment for GEOSS and of the multitude of outcomes and deliverables that CEOS seeks to provide for GEO and other users and framework

VC-27: Develop a roadmap for the routine production of intercomparable CARD4L	Q4 2018	Building on agreed specifications of CARD4L products, LSI-VC will develop a roadmap for how interested CEOS Agency missions and programs can start processing land surface imaging data with geometrically and radiometrically intercomparable surface reflectance, surface temperature, and analogous radar products	LSI-VC with WGCV

CEOS & CEOS WGCV workplan Relevant to IVOS

Advancement of the CEOS Virtual Constellations

VC-29: Framework for moderate resolution land sensor interoperability	Q2 2018	Increasing numbers of users are interested in the development of product pipelines that are not completely dependent on the characteristics of a single sensor, when a number of different sensors may be able to provide data that is fit for purpose. Interoperability, however, is challenging to define in a manner that enables such users to move beyond theory and in to practice. The framework to be developed will be generally applicable and address factors including radiometry, geometry, data formats, browse information, metadata, data access, metrics and reporting.	LSI-VC (with WGCV and WGISS)
VC-30: Interoperability case study for Landsat and Sentinel-2	Q4 2017	The framework for moderate resolution land sensor interoperability (refer VC-29) will be applied to the Landsat and Sentinel-2 missions.	LSI-VC (with WGCV)

Open WGCV Actions relevant to IVOS

#	Action Item	Lead	Due Date
WGCV-38-02	IVOS Chair to setup a doodle poll regarding availability of participants for a follow-up telecon to the October 2013 WebEX session with user community on the development of best practices for use of External Solar Irradiance Spectrum	IVOS chair (N.Fox)	New due date (WGCV 39) is End of September 2016
WGCV-39-02	Propose methodology for updating LandNet list of approved test sites (both removal of non-active sites and inclusion of new sites)	Thome	IVOS-28
WGCV-39-03	Present proposed method for LandNet site update to WGCV plenary	Fox	WGCV 40

Open WGCV Actions relevant to IVOS

#	Action Item	Lead	Due Date
WGCV-39-04	Provide updated information regarding LandNet to the Cal/Val portal	Thome	WGCV 40+ 1 week
WGCV-40-02	An ad-hoc team comprising one member out of the subgroup LPV, IVOS and ACSG and the CEOS WGCV chair shall recap the terminology needed for validation metrics and formulate along the LPV validation metrics a coherent validation metrics for data products applicable in general with the starting point of individual satellite data products. This shall be developed such that the metrics can be extended in a follow-on step to the requirements of time series / climate data records.	CEOS WGCV Chair and subgroup chairs LPV, IVOS, and ACSG	WGCV plenary 41

RadCalNet admission of new sites

RadCalNet developed through IVOS will soon fall under more direct oversight of WGCV

- Approval of new sites (and opening of web site to public)
- Prospective site manager documents that they meet requirements for membership
- Submission of documentation to RadCalNet Admission Review Panel
  - Panel made up of five WGCV members
  - Panel members distributed geographically
- Panel formulates recommendation forwarded to WGCV plenary
  - Recommendation for approval requires concurrence by majority of panel
  - Much of the evaluation process can take place via telecon/email
- WGCV plenary acts on the recommendation

Non-meteorological Applications

Past Plenary Chair's (CSIRO) initiative that is receiving support from the current Plenary Chair (USGS)

- Take advantage of the expected improvement in GEO sensors
  - More spectral bands
  - Better characterized
  - Better spatial resolution
- Meteorological agencies are doing better at providing the data more easily to non-forecast groups (WGISS is helping here)
- GSICS will be active in ensuring the data quality from these sensors
  - Already strong ties between WGCV and GSICS
  - GSICS will need help with the validation aspects of this problem (LPV, IVOS, AC, Microwave)

Analysis Ready Data

Remove barriers preventing new users from making better use of available data assets

- Builds on Geosciences Australia's efforts to provide Landsat data of Australia in easier to use formats already processed to surface reflectance
- Related to the CEOS System Engineering Office (SEO) efforts with data cubes to provide data sets more available to countries with limited computing power and bandwidth
- Strong interest by Plenary Chair (USGS) on this topic
- Portion of the effort is to allow users to seamlessly use multiple sensors
  - Validation efforts for surface reflectance
  - Interoperability between sensors

Committee on Earth Observation Satellites

Moderate Resolution Sensor Interoperability: Framework

WGCV IVOS

Tucson, US

15 March 2017

Charts provided by Gene Fosnight

Working Group on Calibration and Validation

Moderate Resolution Sensor Interoperability (MRI)

- **This initiative addresses the CEOS strategic objective to encourage complementarity and compatibility among the increasing number of Earth observing systems in the moderate resolution class for both optical and SAR sensors and the data received from them.**
- This presentation:
  - Introduces the MRI framework; and
  - Elicits feedback from the WGCV- IVOS team.

Timeline

- Kickoff telecon on the 2-3 March 2017
- Presentation of framework for endorsement at LSI-VC-3 on 20 March 2017
- Presentation of work plan with emphasis on metadata at WGISS in April 2017
- Presentation of work plan at SIT-32 in April 2017
- Presentation of work plan with emphasis on data at WGCV in May 2017
- Initial presentation of 2017 results at LSI-VC-4 and SIT TW in September 2017
- Presentation of 2017 results at CEOS Plenary in October 2017

The MRI Team

- Co-leads

Gene Fosnight	USGS	USGS chair team co-lead, Landsat, LSI-VC, SDCG
Cindy Ong	CSIRO	WGCV co-lead, imaging spectroscopy
Richard Moreno	CNES	WGISS co-lead, Copernicus

- Team members

Jeff Masek	NASA	Landsat Sentinel-2 Case study, LSI-VC
Zoltan Szantoi	JRC	Landsat Sentinel-2 Case study, LSI-VC
Adam Lewis	GA	LSI-VC, FDA, CARD4L
Paul Briand	CSA	LSI-VC, GEOGLAM, SAR
Yves Crevier	CSA	SDCG, GEOGLAM, SAR
Brian Killough	NASA	SEO, LSI-VC, SDCG, FDA, CARD4L
Debajyoti Dhar	ISRO	Optical/SAR data fusion
Takeo Tadono	JAXA	LSI-VC, CARD4L, SAR
Amanda Regan	EC	User needs for satellite constellations
Nigel Fox	UKSA	WGCV IVOS
Kurt Thome	NASA	WGCV
Andy Mitchell	NASA	WGISS
Kerry Sawyer	NOAA	Represent SIT vice chair
Kevin Gallo	NOAA	LSI-VC, LPCS data integration
Eric Wood	USGS	Represent USGS Chair Team

Goals

- The goals of MRI are
  - to establish a framework that has traceable links to well-defined case studies that can be used to implement interoperable multi-sensor solutions; and
  - to identify interoperability gaps and suggest case studies needed to support the analysis of deep and dense time series of satellite data.

- The initial case study is the implementation of interoperable Sentinel-2 and Landsat data products and methodologies.

2017 Deliverables

- The **framework** for moderate resolution interoperability addresses components such as radiometry, geolocation, per-pixel metadata, and image metadata needed to support the analysis of science data and the search and discovery of science data.
- Existing **case studies** will be identified, and summarized (and new studies encouraged) to document parameters, thresholds and metadata to support interoperability with an initial emphasis on Landsat and Sentinel-2. Case studies planned and initiated by space agencies to meet their specific agency needs are crucial to the success of the initiative.

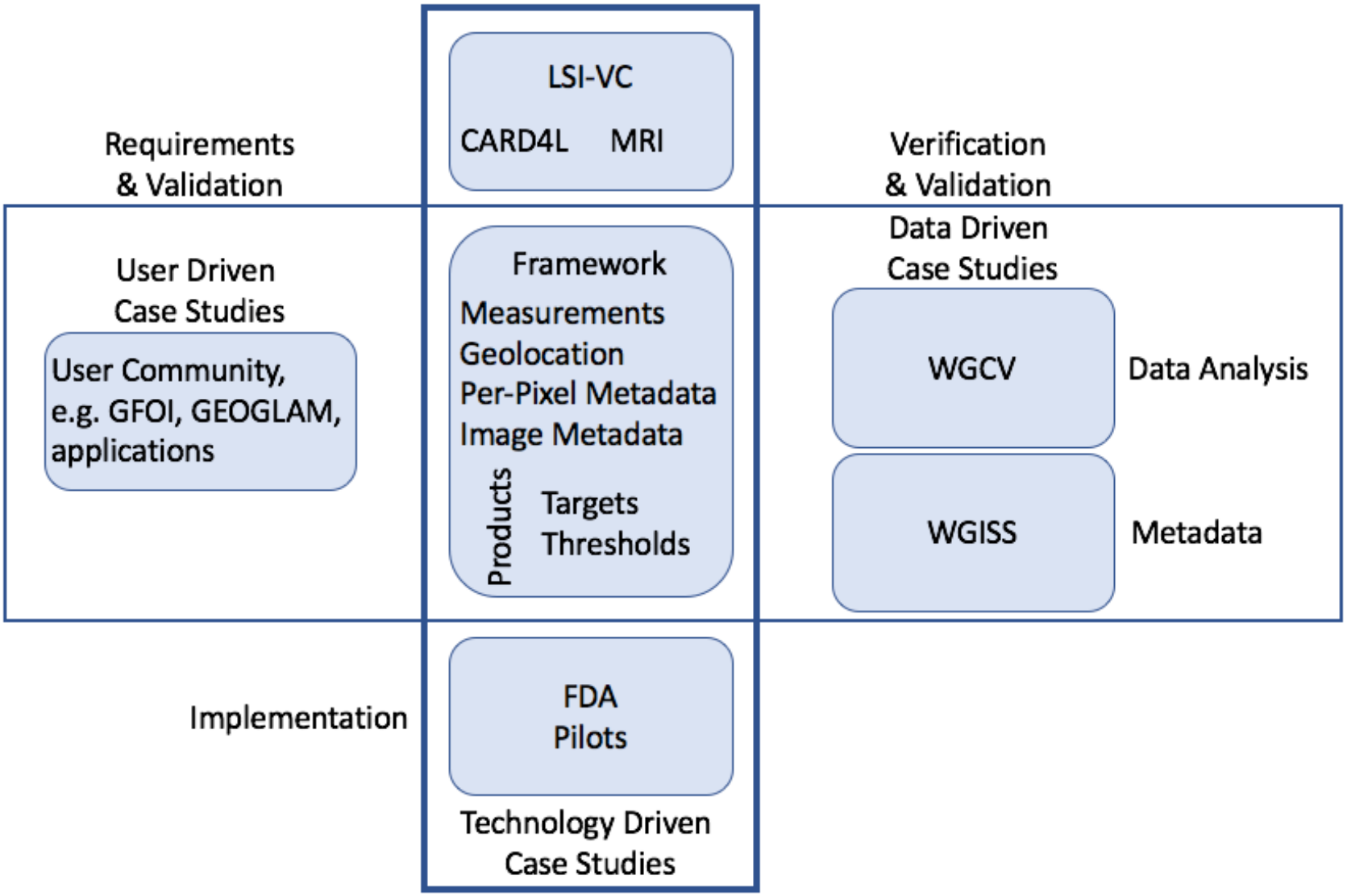
MRI Framework

- The MRI Framework is an LSI-VC (Land Surface Imaging Virtual Constellation) activity closely tied to the CARD4L specification and will evolve in parallel to the CARD4L specification.
  - CARD4L (CEOS Analysis Ready Data for Land) identifies for products
    - threshold information needed to be considered minimally Analysis Ready and
    - target information needed to be fully Analysis Ready
- The MRI team will work closely with WGCV, WGISS and with the thematic communities to identify case studies to advance and implement the CARD4L specification.
- The focus of the MRI framework is on multi-sensor interoperability.
  - The CARD4L specification is necessary, but not sufficient information to meet multi-sensor interoperability requirements

MRI Case Studies

- The **MRI case studies** build on the requirements of **Future Data Architectures**, while continuously advancing products for the **current user** community.
  - The user community is rapidly transitioning to surface reflectance, surface temperature and terrain-flattened gamma naught SAR products.
  - The user community is slowly transitioning to the analysis of deep and dense multi-sensor time series stored as data cubes.
- The 2017 MRI initiative case study deliverable is the results from the **Sentinel-2 Landsat Case Study**

MRI Coordination



LSI-VC, WGCV and WGISS

- Among the challenges of **Future Data Architecture** and **Analysis Ready Data** is the requirement to make **data comparable through time and across sensors**.
- The MRI initiative provides a framework within which interoperable solutions can be identified and documented.
  - The LSI-VC MRI, FDA and CARD4L teams share many members supporting **synergy** across the teams.
  - The **WGCV** is instrumental in coordinating the calibration and validation of sensors
  - The **WGISS** is versed in metadata standards that describe image data for use in analysis and for search and discovery
  - **LSI-VC** agencies work with GEO and other user communities, such as GFOI and GEOGLAM, to evaluate and implement solutions. FDA pilot projects seek to exploit these opportunities.

Framework background: MRI and CARD4L

- CARD4L defines the minimal Thresholds and optimal targets that need to be met before a data product is considered Analysis Ready.
- The MRI Framework extends CARD4L and other definitions to multi-sensor interoperability.
- For example,
  - CARD4L specifies the pixel size and RMSE.
  - MRI describes the consequences of different pixel sizes and RMSE
  - CARD4L specifies the spectral response
  - MRI describes the consequences of different spectral responses

DRAFT!		General metadata		Per pixel metadata		Radiometric measurement corrections		Geolocational correction	
CARD4L Product	Platform-instrument	Threshold	Target	Threshold	Target	Threshold	Target	Threshold	Target
Reflectance at land surface	**Medium resolution optical** -Landsat-TM, ETM, ETM+, OLI -Sentinel 2 MSI -Spot - HRV, HRG **Low resolution optical** -Sentinel 3 OLCI -MODIS - Terra, Aqua	ISO metadata Time of acquisition Sensor spectral characteristics +	SI traceability As per threshold + Processing chain provenance -algorithm (e.g. LPGS version) -ancillary (e.g. aerosol data source) -sensor calibration (e.g. calibration parameter file) -geometric correction source (e.g. GCP chipset)	Per Pixel flags: No data Saturation Cloud/cloud shadow	Per Pixel flags as per threshold + Land/Water Snow-Ice Terrain shadow	Atmospheric Correction	Atmospheric correction - including directional scattering Nadir view angle + solar incident agle correction Terrain illumination correction BRDF correction	sub-pixel correction-relative ground sampling distance - conversion to a uniform ground sampling distance (uniform for sensor-product)	sub-pixel correction-absolute
Reflectance at water surface	**As above**	ISO metadata Time of acquisition Sensor spectral characteristics +	As above -**absolute radiometric accuracy** assessed using in-situ instruments ie Lucinda Jetty	As above	As above + Percent of time water Optically deep/shallow Glint/glint	Atmospheric correction	Atmospheric correction - including directional scattering Adjacency correction Glint correction		
Temperature at land surface	**Landsat-TIRS** **Sentinel 3 - SLSTR** **Himawari 8 - AHI**	ISO metadata Time of acquisition Sensor spectral characteristics +	As above -**absolute radiometric accuracy** assessed using temperature measurements from buoys	No data Saturation Cloud mask	Distance from clouds; uncertainty associated with land target	Brightness temperature without emissivity adjustment	Surface temperature with emissivity adjustment		
C band Gamma 0 backscatter (for each polarisation channel)	**Sentinel 1** **Radarsat - 2**	ISO metadata Time of acquisition +	As above - with ancillaries relevant to SAR radiometric correction -DEM source -water vapour source + -**absolute radiometric accuracy** assessed using corner reflector network	Terrain artefacts + more	?	?	?		
L band Gamma 0 (for each polarisation channel)	**ALOS-1 PALSAR** **ALOS-2 PALSAR**	ISO metadata Time of acquisition +	As above	As above	?	?	?		

Instrument Characteristics

- A non exclusive high-level summary of moderate resolution sensors with global observation missions with an emphasis on data with open and free data policies and open access to the image archive.
- Characteristic summaries
  - Band categories
  - Pixel size
  - Mission life
  - Mission documentation

Instrument Characteristics Summarized[1]

	Platform	Instrument	Radiometry	Geometry	Life	References
Optical	Landsat	MSS	Visible, NIR	79 m	1972-2008	[2-4]
		TM, ETM+	Visible, NIR, SWIR, Thermal	30 m	1982-	[5, 6]
		OLI	Visible, NIR, SWIR, Cirrus, Thermal	30m	2013-	[7]
	Sentinel 2	MSI	Visible, NIR, SWIR, Cirrus	20/30 m	2015-	
	Terra	ASTER	Visible, NIR, SWIR, Thermal		1999-	[8]
	SPOT	HRV, HRG	Visible, NIR, SWIR			
	CBERS					
	ResourceSat	AWIFS	Visible, NIR, SWIR			[9]
	EO-1	Hyperion	Visible, NIR, SWIR			[10-12]
SAR	Sentinel 1	C-band				
	Radarsat 2	C-band				
	JERS-1	L-band	HH polarization	25m	1993-1998	[13]
	ALOS-1/2	L-band	HH+HV	25m	2007-	[13]
	TerraSAR-X TanDEM-X	X-band				
	NovaSAR	S-band	Multi polarisations: HH, VV, VH, HV possible Single, dual, tri and quad polar imaging available	6-30 m	2017-	

General Metadata

- Adopt common OGC or ISO metadata standard
- Product-specific metadata are constant for all images in the product line
- Image-specific metadata are specified for each image
- Image-specific metadata are also aggregated from pixel-level data
- General metadata specified within CARD4L are compared between products to establish interoperability using MRI guidelines

General metadata

CARD4L Product	Product-specific metadata	Image-specific metadata	Metadata aggregated from pixel data	references
Reflectance at top of atmosphere	Source pixel size Product pixel size Reference grid reference grid accuracy measurement radiometric accuracy – source radiometric accuracy – resampled Spectral Response curve	grid origin geodetic accuracy number GCPs	Percent cloud cover from cloud mask Percent land from land mask Percent snow/ice from snow/ice mask Percent water from water mask Percent cloud shadow from cloud shadow mask Percent terrain shadow from terrain shadow mask	
Reflectance at land surface	radiometric accuracy	+ Aerosol source uncertainty		
Reflectance at water surface	radiometric accuracy	+ Aerosol source uncertainty		
Temperature at land surface	radiometric accuracy	+ Surface emissivity source uncertainty		
C band Gamma 0 backscatter (for each polarisation channel)				
L band Gamma 0 (for each polarisation channel)				

Per Pixel Metadata

- Interoperability issues include documented algorithms and accuracies for
  - Cloud cover and shadow
  - Land, water and vegetation
  - Terrain shadow
  - Atmospheric model inputs, including aerosols
  - Saturation and other data quality

Per pixel metadata

CARD4L Product	metadata	dependency	References
Reflectance at top of atmosphere	Cloud cover Solar Zenith Angle View Angle Data quality Vegetation Land Water Cloud Shadow Terrain Shadow Saturation DEM Spectral Band Adjustment Factor	Spectral band DEM	[21]
Reflectance at land surface	+ Atmospheric correction - including directional scattering Nadir view angle + solar incident angle correction Terrain illumination correction BRDF correction		
Reflectance at water surface	+ Atmospheric correction - including directional scattering Adjacency correction Glint correction		
Temperature at land surface	+		
C band Gamma 0 backscatter (for each polarisation channel)	DEM Terrain Shadow		
L band Gamma 0 (for each polarisation channel)	DEM Terrain Shadow		

Data Measurements

- Interoperability issues
  - Compensate for available bands
  - Compensate for spectral band differences
  - Share atmospheric correction and compensate for available bands
  - BRDF corrections
    - View angle correction

Radiometric measurement corrections

CARD4L Product	metadata	measurement	References
Reflectance at Top of Atmosphere	Solar Zenith Angle Earth Sun Distance	Surface Reflectance	
Reflectance at land surface	Water Atmospheric Correction	Surface Reflectance	
Reflectance at water surface	Atmospheric correction	Surface Reflectance	
Temperature at land surface	Surface emissivity[25]	Surface temperature	
C band		Gamma 0 backscatter (for each polarisation channel)	
L band		Gamma 0 (for each polarisation channel)	
X band			
S band			

Geolocation

- Interoperability issues
  - Compensate for different pixel size
  - Acknowledge spatial RMSE
  - Share reference grid and acknowledge accuracy
  - Share DEM and acknowledge accuracy

Geolocation

Platform	Instrument	Reference Grid	DEM	Pixel size	RMSE	References
Landsat	MSS	GLS 2000 (25m)	GLS DEM	79 m	134m (95%)	[4]
	TM	GLS 2000 (25m)	GLS DEM	30 m	10.9m (95%)	
	ETM+	GLS 2000 (25m)	GLS DEM	30 m	10.7m (95%)	
	OLI	GLS 2000 (25m)	GLS DEM	30 m	15m (95%)	[26-28]
Sentinel 2	MSI	GRI	PlanetDEM	20/30 m		[28-30]
TERRA	ASTER	GLS 2000 (25m)	?			
SPOT	HRV, HRG					
CBERS						
ResourceSat	AWIFS			56m		[31-35]
EO-1	Hyperion			30 m		[10-12]
Sentinel 1	C-band					
Radarsat 2						
ALOS-1/2	PALSAR L-band					
TerraSAR-X TanDEM-X	X-band					

Verification & Validation of target parameters, thresholds and metadata

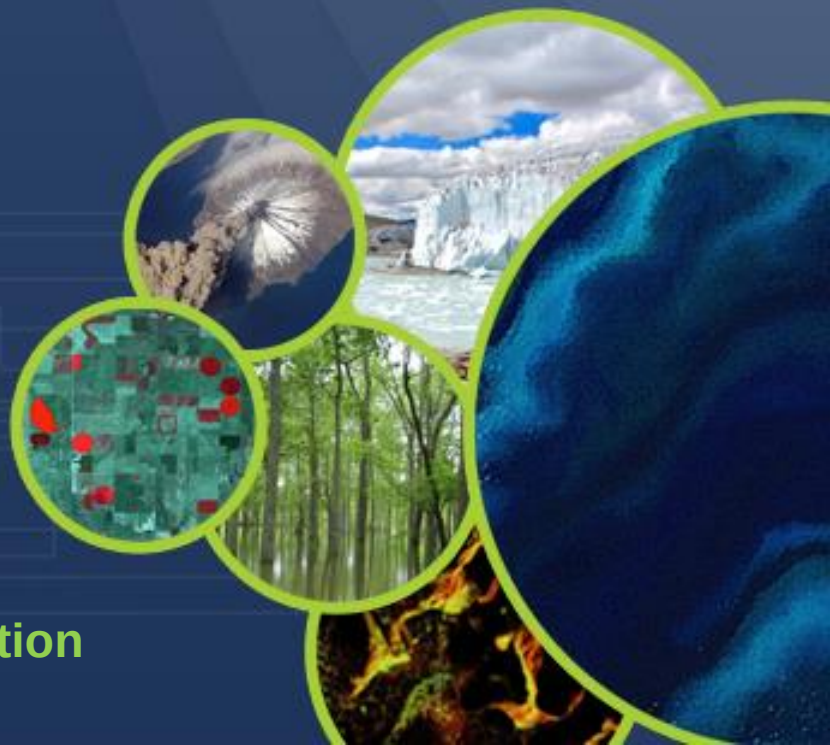
- Case studies are needed to test, evaluate and implement the solutions needed create and advance CARD4L products. Each of the framework components captured in the CARD4L specifications need quantitative analysis leading to implementable solutions.
  - The MRI framework will summarize the results of case studies.
  - Targets identified within CARD4L require definition, verification and validation. The maturity level of the targets are highly variable.
  - Expertise to address these issues reside within agencies associated with WGCV and WGISS. The intent is to leverage existing agency activities.

Multi-sensor implementations

- Cooperation among agencies is needed to support interoperability.
- Adopt Standards
  - OGC/ISO metadata standards
  - Shared reference grids and DEMs
  - Reflectance and atmospheric models
  - Common general and per pixel metadata
- Compensate for differences
  - Pixels sizes
  - Spectral band differences
  - Spectral band availability
- The MRI initiative supports Future Data Architecture studies and studies at agencies evolving implementation strategies. These strategies may be physical higher level products or models designed to use well defined lower level products as inputs. When standards cannot be adopt, compensation for differences is needed.

Committee on Earth Observation Satellites

Carbon Actions

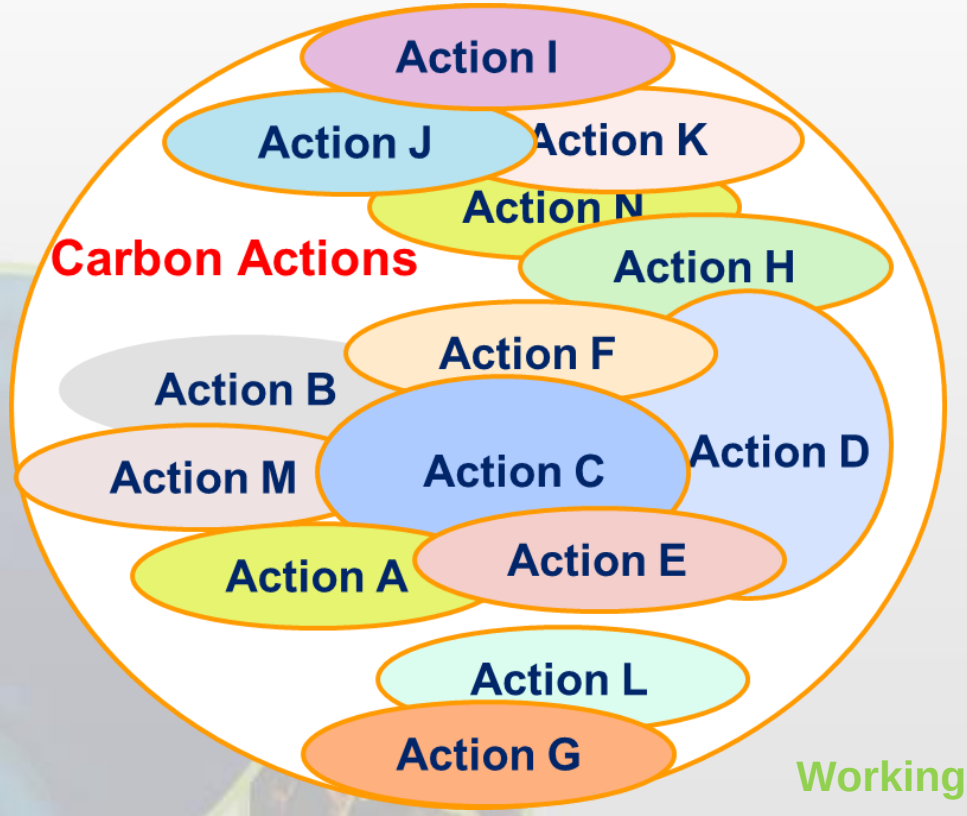


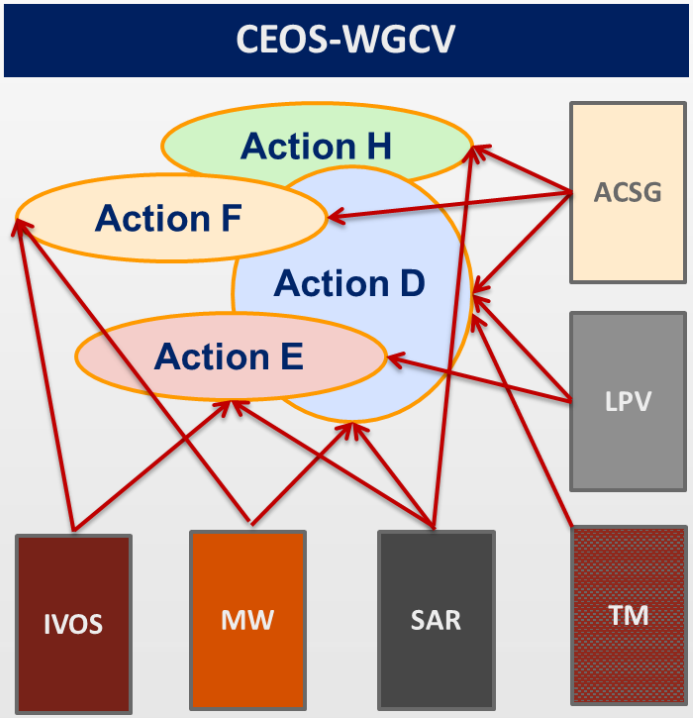
Working Group on Calibration and Validation

Ad-Hoc Carbon Strategy assigned 14 actions to WGCV

Work done within WGCV to understand how best to optimize our effort to address the actions

- Treating actions as a discrete set not efficient due to overlap in some of the actions
- Identify where actions fit within Subgroups





A set of WGCV Carbon Actions have been developed

Total of 30 action items that when completed should allow closing all 14 Carbon Actions assigned to WGCV

- Distilled WGCV CAs to remove overlap
- Identified Carbon Strategy Actions covered
- List will be sent to WGCV plenary before March 31
  - Determined relevant subgroups
  - Assign responsible parties
  - LPV subgroup will likely bear the burden of most activities
- Prioritized several actions to allow closing them in the short term
  - Demonstrate progress for the CEOS SIT meeting the end of April
  - Selected three actions that fall under the LPV group (LPV chair is Miguel Roman of NASA/GSFC)

LPV's actions beginning the effort

WGCV-CA-22	Summarize the current list of WGCV-LPV validated land data products and those to be validated via WGCV-LPV identifying any gaps between LPV and Carbon Task Force report.	CARB-08 CARB-34
WGCV-CA-18	Document WGCV LPV LAI validation framework and protocols as it would relate to Carbon products and provide to SIT as a broader example of validation methodologies and protocols. Documentation will include listing requirements for data quality (or maturity matrix) as a starting point for developing similar requirements for Carbon products as well as guidance for design of an online platform for intercomparison of terrestrial carbon products. Specific emphasis is also placed on new focus areas for land data products to be included in WGCV.	CARB-08 CARB-09 CARB-26 CARB-31 CARB-32 CARB-34
WGCV-CA-02	Work with CEOS SEO to develop an online platform to make available WGCV results of intercomparison of carbon products while ensuring a common set of reference data, methods and output reporting, and allowing data product subsets to be automatically pushed from data catalogues to inventory results of validation/database input against requirements and suggested maturity of products.	CARB-27 CARB-32 CARB-34 CARB-35

Likely IVOS-related actions

WGCV-CA-10	Determine appropriate methodology for treating validation of ocean-carbon relevant products within WGCV organizational framework.	CARB-14
WGCV-CA-01	Develop list of completed and planned intercomparison excercises relevant to Carbon Plan	CARB-27
WGCV-CA-08	Develop draft recommendation of terminology related to uncertainty measures (e.g. temporal and spatial characterization of uncertainty measures)	CARB-22
WGCV-CA-09	Recommend approach for coordinating inputs from multiple organizations to develop definitions for products, validation success, etc. that are suitable across the range of WGs and VCs based on the process developed for LAI, where a common definition was accepted by GCOS, GTOS and CEOS.	CARB-14 CARB-22

Likely IVOS-related actions

WGCV-CA-17	Develop an inventory of existing protocols and definitions for products, validation, and intercomparisons and collate those publications from WGCV members documenting the traceability and protocols of satellite data uncertainty assessment.	CARB-26 CARB-27
WGCV-CA-19	Develop protocols for selecting variable-specific validation sites and validation super sites	CARB-38
WGCV-CA-20	Develop protocols for intercomparison of a selected carbon time series data product produced from multiple sensors as a test bed for protocol development for broader range of data products including backward compatibility of reference data	CARB-05
WGCV-CA-23	Identify a list of candidate products to be used for development of protocols/benchmarks for maturity matrix.	CARB-32
WGCV-CA-25	Validate a selected time series product using protocols developed for intercomparison of the product produced from multiple sensors	CARB-05

Summary

IVOS will continue to play an active role in achieving the goals of WGCV

- WGCV subgroups are still the best opportunity for those not part of a CEOS Space Agency to impact CEOS
- Subgroups are an excellent means to improve international collaborations on an array of topics
  - Some of these topics can have relevance only to the subgroup
  - Some must still have relevance to WGCV and at some point an impact on CEOS itself (RadCalNet is a good example)
- Interoperability and Carbon Actions are two near-term activities requiring help from IVOS members
- Not discussed today were the WGCV Task Groups that address shorter term issues crossing multiple subgroups that benefit from subgroup members help
- Continue to do the work that is of interest to IVOS while periodically considering how the activity can help the broader CEOS community