

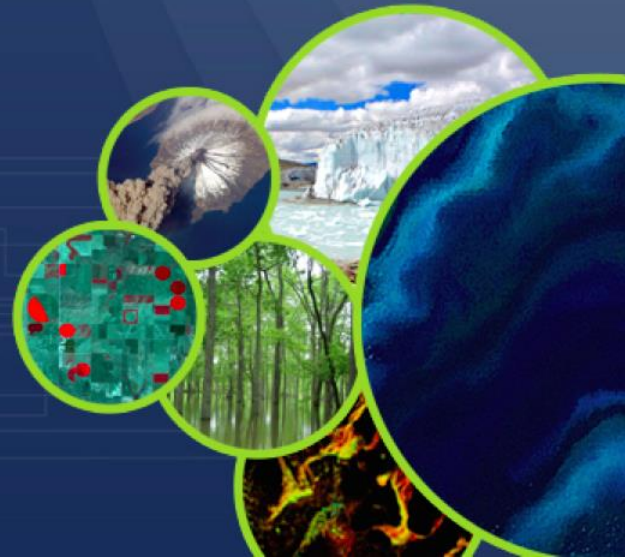


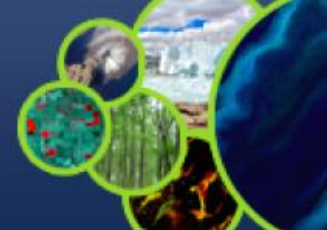
Committee on Earth Observation Satellites

# Analysis Ready Data as addressed by the Committee on Earth Observation Satellites: CARD4L

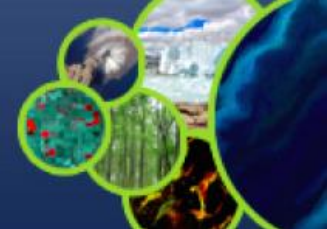
Steven Hosford, Andreia Siqueira, Adam Lewis, Steve Labahn, Zolti Szantoi, Valentina Boccia, Nuno Miranda, Steffen Dransfeld, Ferran Gascon and Pierre Potin

VH Roda, ESA/ESRIN - November 20th, 2019



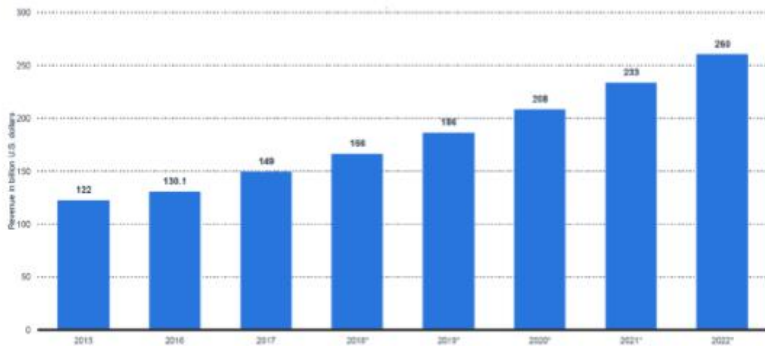


- Context
- What is CARD4L?
- Organisation – product alignment assessment and peer review
- Current Status



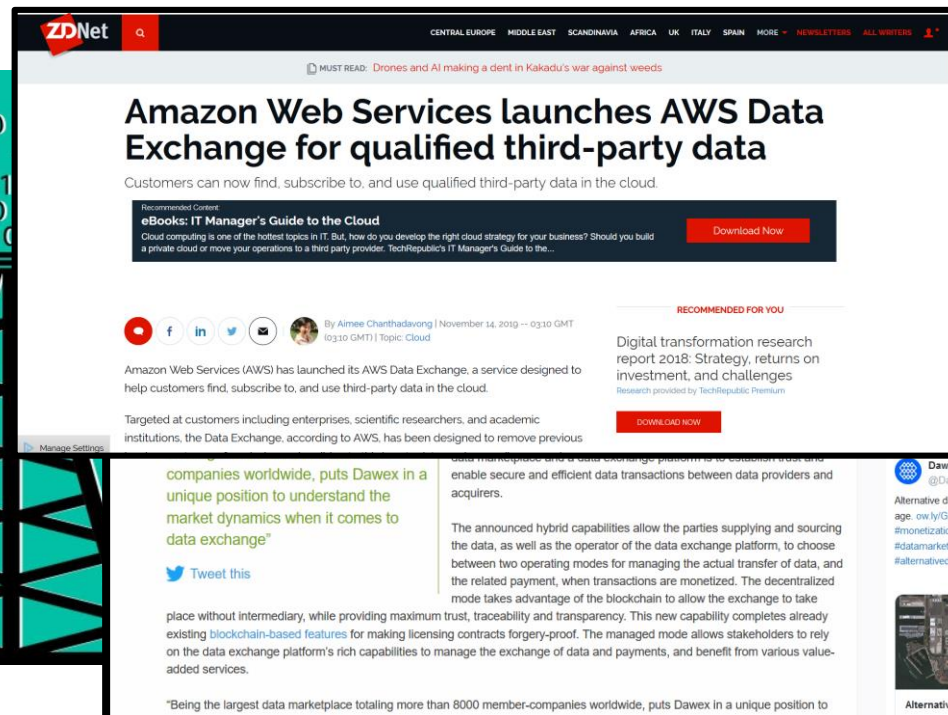
- The big data revolution

Revenue from big data and business analytics worldwide from 2015 to 2022 (in billion U.S. dollars)  
Big data and business analytics revenue worldwide 2015-2022



Note: Worldwide 2015 to 2018  
Further information regarding this statistic can be found on [Statista](#)  
Source(s): IDC, [IDC](#), [IDC](#)

[See also statistics](#)



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## Amazon Web Services launches AWS Data Exchange for qualified third-party data

Customers can now find, subscribe to, and use qualified third-party data in the cloud.

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Cloud computing is one of the hottest topics in IT. But, how do you develop the right cloud strategy for your business? Should you build a private cloud or move your operations to a third party provider. TechRepublic's IT Manager's Guide to the...

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By Aimee Chanthadavong | November 14, 2019 -- 03:10 GMT (03:10 GMT) | Topic: Cloud

Amazon Web Services (AWS) has launched its AWS Data Exchange, a service designed to help customers find, subscribe to, and use third-party data in the cloud.

Targeted at customers including enterprises, scientific researchers, and academic institutions, the Data Exchange, according to AWS, has been designed to remove previous

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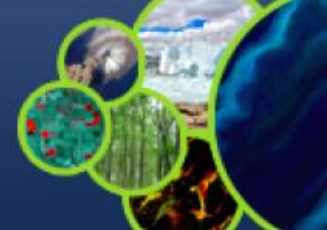
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companies worldwide, puts Dawex in a unique position to understand the market dynamics when it comes to data exchange"

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The announced hybrid capabilities allow the parties supplying and sourcing the data, as well as the operator of the data exchange platform, to choose between two operating modes for managing the actual transfer of data, and the related payment, when transactions are monetized. The decentralized mode takes advantage of the blockchain to allow the exchange to take place without intermediary, while providing maximum trust, traceability and transparency. This new capability completes already existing blockchain-based features for making licensing contracts forgery-proof. The managed mode allows stakeholders to rely on the data exchange platform's rich capabilities to manage the exchange of data and payments, and benefit from various value-added services.

"Being the largest data marketplace totaling more than 8000 member-companies worldwide, puts Dawex in a unique position to



## CEOS Analysis Ready Data

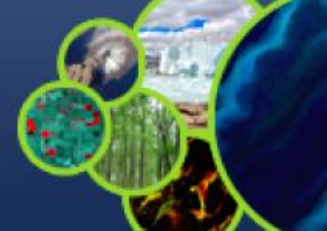
Overview Framework PFS

**CEOS ANALYSIS READY DATA**

CEOS Analysis Ready Data for Land (CARD4L) are 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.

<http://ceos.org/ard/>

# CARD4L Product Family Specifications – Document Overview



## Each PFS document has:

### 1) Description section

### 2) Requirements section:

- General Metadata – lineage, coverage “what is it and where did it come from?”
- Per-pixel Metadata – “is this observation (pixel) suitable to use?”
- Radiometric and atmospheric corrections – “a measurement of the land surface”
- Geometric corrections – “accurately located on the land surface”

### 3) Guidance section:

- Discussion on the difference between **‘threshold’** and **‘target’** levels of processing
- References to example processes that could be used to produce analysis ready data
- Specific examples of data and processing that produces CARD4L

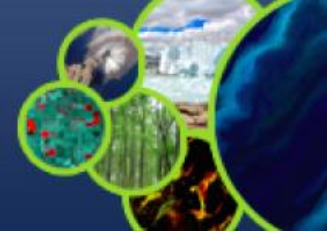
		Description	
		Product family title: Surface Temperature (MODIS 03)	
		<p><b>2. Per-pixel metadata (including, for example, quality flags and data-masks)</b></p> <p>Per-pixel metadata should allow users to <b>discriminate between</b> (checked) observations on the basis of their individual suitability for applications, and include quality flags. The following minimum metadata specifications apply to each pixel. Whether the metadata are provided in a single record relevant to all pixels, or separately for each pixel, is at the discretion of the data provider. Similarly, the metadata or parts of the per-pixel metadata (additional data bands, mask layers, etc.) is open to the provider.</p>	
		<p><b>4. Geometric corrections</b></p> <p>Geometric corrections must place the measurement accurately on the surface of the Earth (that is, <b>georeference</b> the measurement) allowing measurements taken through time to be compared.</p>	
		<p><b>Guidance</b></p> <p>This section aims to provide background and specific information on the processing steps that can be used to address analysis needs. This Guidance material does not replace or over-ride the specifications.</p> <p><b>Introduction to CARD4L</b></p> <p>What is CEOS Analysis Ready Data for Land (CARD4L) product?</p> <p>CARD4L products 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. These products could be re-analyzed into a common geospatial grid for a given product, and would provide baseline data for further interoperability both through time and with other datasets.</p> <p>CARD4L products are intended to be flexible and accessible products suitable for a wide range of users for a wide variety of applications, including particularly time series analysis and multi-sensor application development. They are also intended to support rapid ingestion and exploitation via high-performance computing, cloud computing and other future data architectures. They may not be suitable for all purposes, and are not intended as a requirement for other types of satellite products.</p> <p><b>When can a product be called CARD4L?</b></p> <p>The CARD4L branding is applied to a particular product once:</p> <ul style="list-style-type: none"> <li>• the product has been assessed as meeting CARD4L requirements by the agency responsible for the production and distribution of the product.</li> <li>• that assessment has been peer reviewed by the CEOS Land Surface Imaging Virtual Collaboration in consultation with the CEOS Working Group on Collection and Validation.</li> </ul> <p>Agencies or other entities considering undertaking an assessment process should contact the co-leads of the Land Surface Imaging Virtual Collaboration (Support).</p> <p>A product can continue to use CARD4L branding as long as its generation and distribution remain consistent with the peer-reviewed assessment.</p> <p><b>What is the difference between Threshold and Target?</b></p> <p>Products that meet <b>Threshold</b> requirements should be immediately useful for scientific analysis or decision-making.</p> <p>Products that meet <b>Target</b> requirements will reduce the overall product uncertainties and enhance broad-scale applications. For example, the products may enhance interoperability or provide increased accuracy through additional corrections that are not reasonable at the threshold level.</p>	
<p><b>Requirements</b></p> <p>These are metadata records describing a distributed system or must be contiguous in space and time. The <b>USAGE</b> suitability of the dataset, and must meet the following:</p>		<p><b>1. General Metadata</b></p> <p>These are metadata records describing a distributed system or must be contiguous in space and time. The <b>USAGE</b> suitability of the dataset, and must meet the following:</p>	
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Product Family Specifications do .....

**describe the final dish**





Product Family Specifications do not .....

describe the recipe

#### INGREDIENTI SPAGHETTI CACIO E PEPE PER 4 PERSONE

- 400 grammi di spaghetti
- 200 grammi di pecorino romano grattugiato
- 10 grammi di pepe nero macinato
- Olio extravergine d'oliva
- Sale

#### RICETTA SPAGHETTI CACIO E PEPE ORIGINALE ROMANA

1. Cuocere gli spaghetti in acqua salata e nel frattempo versare in una ciotolina di vetro o di alluminio il pecorino romano e il pepe nero.
2. Alzare la pasta al dente (non scolarla altrimenti perde tutta l'acqua di cottura) calcolando almeno 2 minuti prima della fine cottura, versarla nella ciotola con la miscela di pecorino e condirla per bene aggiungendo due mestoli di acqua di cottura per fare in modo che tutto si amalgami per bene.
3. E' possibile anche mescolare pecorino e pepe nero in una padella grande dove poi saranno scolarli gli spaghetti ricordando però che NON vanno cotti o messi ad amalgamare sul fuoco ma vanno amalgamati "a freddo".
4. Mescolare e servire immediatamente altrimenti la pasta si fredda e il formaggio si raggruma tutto.

#### PREPARAZIONE


COME PREPARARE GLI SPAGHETTI CACIO E PEPE



Per preparare gli spaghetti cacio e pepe, come prima cosa occupatevi di grattugiare 200 g di Pecorino. Proseguite mettendo a bollire l'acqua in un tegame (mettete circa la metà di quanto ne usate di solito per cuocere la pasta, così sarà più ricca di amido) e quando bollerà potete salare a piacere. Una volta salata, potete cuocere gli spaghetti **1**. Nel frattempo, versate i grani di pepe interi su un tagliere **2**, quindi schiacciateli pestando con un pestello per carne o un macinino **3**. In questo modo si sprigionerà maggiormente il profumo pungente del pepe.

#### DOSI & INGREDIENTI

 DOSI PER  
**4 persone**

 DIFFICOLTÀ  
**bassa**

 PREPARAZIONE  
**10 min**

 COTTURA  
**12 min**

 COSTO  
**basso**

 REPERIBILITÀ ALIMENTI  
**molto facile**

- SPAGHETTI 400 gr
- PECORINO ROMANO 200 gr
- PEPE NERO in grani pestato - 2 cucchiaini da tavola
- SALE q.b.

#### ATTREZZATURE

- PENTOLA / ZUPPIERA

#### PREPARAZIONE

- 1** Per preparare una cacio e pepe come Dio comanda dovrete partire dal pepe, che deve essere rigorosamente in grani. Raccogliete i grani di pepe in un mortaio e pestateli con il pestello con energia e con un movimento rotatorio più che verticale.







- LSI-VC
- Define ARD products

## 2015



- Definition
- Framework
- Endorsement

## 2016

- PFSs (SR, LST, NB)
- Engagement
- Feedback
- PFS update

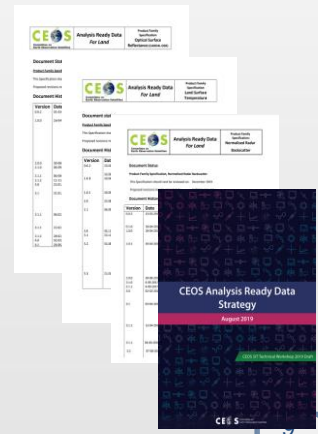
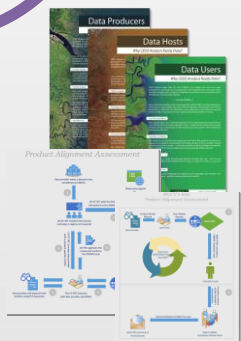
## 2017

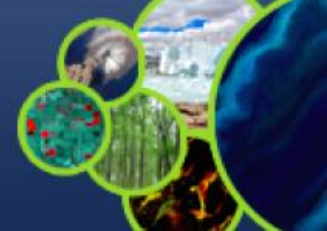
- SAR CARD4L created
- Self-assessment
- PFS review
- Peer-review

## 2018

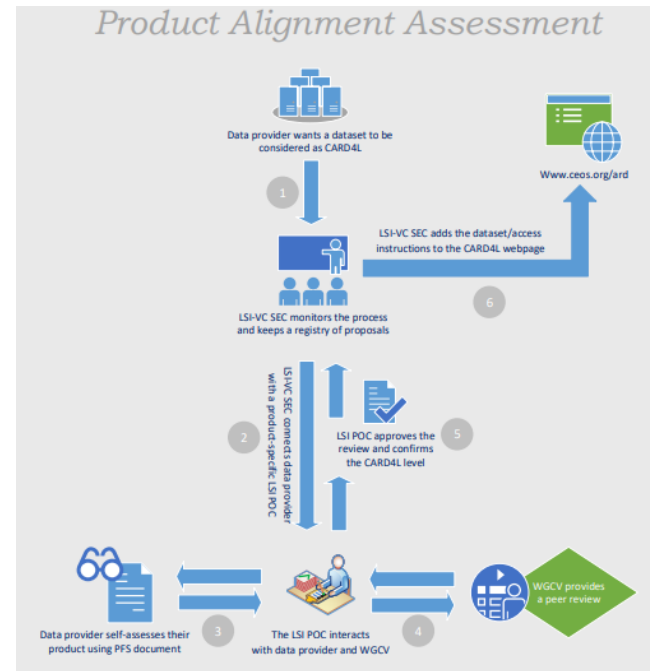
- PFS endorsement
- Self-assess guidelines
- Formal Self-assess
- ARD strategy

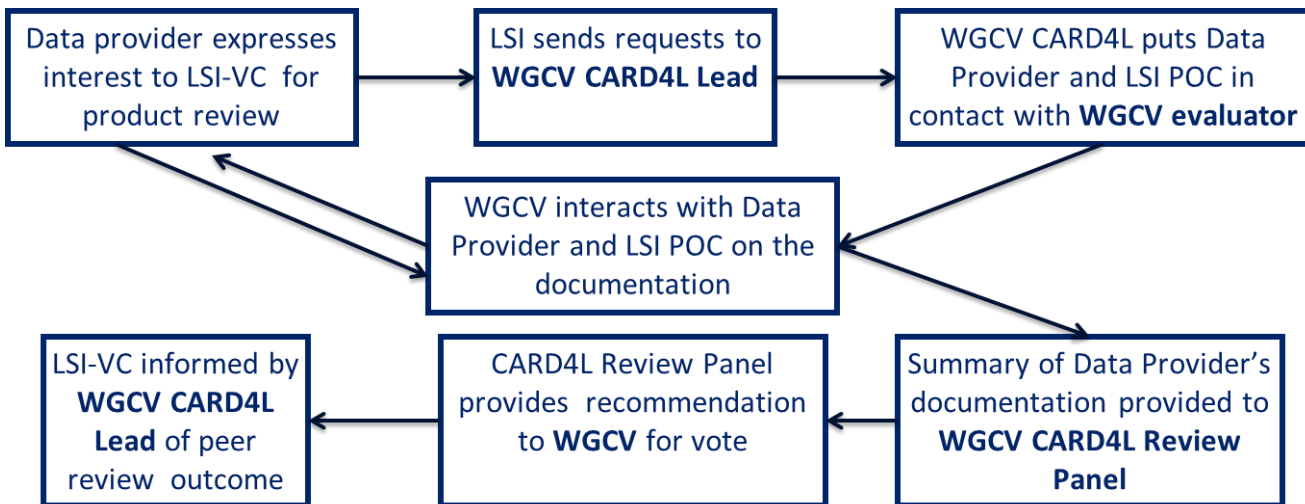
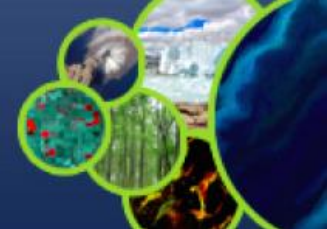
## 2019

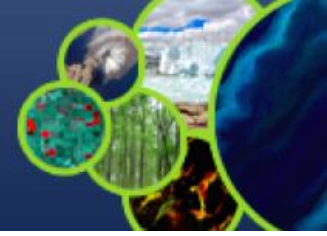




1. Data provider indicates interest to get a dataset assessed through the PAA process
2. The LSI-VC SEC registers the proposal
3. The LSI-VC POC supports the data provider during the self-assessment process
4. The LSI-VC POC interacts with the WGCV POC, to facilitate the peer review assessment
5. Review approved and CARD4L level confirmed (threshold or target level)
6. The LSI-VC SEC publishes the outcome of the review on [ceos.org/ard/](http://ceos.org/ard/)





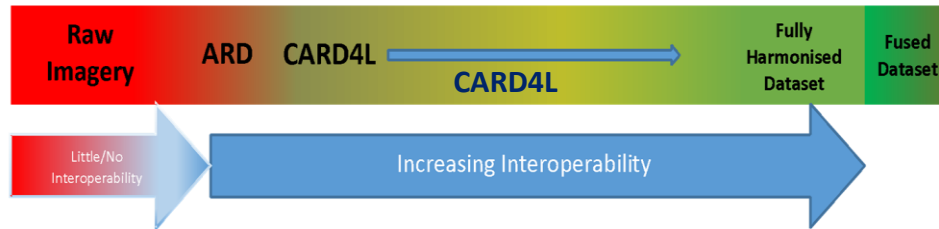


CARD4L Specifications were agreed in February 2019

- Surface Reflectance; Surface Temperature; Normalised Radar Backscatter, endorsed
- Communications materials developed and published on [ceos.org/ard](http://ceos.org/ard)
- Processes to assess datasets against the specifications have been agreed and initiated (self-assessment, independent review process through the WGCV)

Definitions work progressing “the interoperability spectrum”

- This work is capturing what is meant by the term “interoperability”, the different ways in which it can be achieved, and how CARD4L data fits in as a necessary step



# Engaging with Industry



CEOS



CEOS presented at industry-led ARD workshops in August 2018 and July 2019 in California

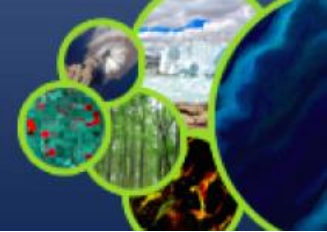
- Industry is applying the same types of corrections (e.g. surface reflectance) to give interoperability between sensors, and through time
- Analysis ready data specifications are a step toward interoperability of commercial satellite data with the 'standards' from ESA, USGS etc.

Industry (and the open source community) are:

- Seeking to warehouse data that is both authoritative and easily used
- Leading the development of catalogs (STAC) and performant data formats (COG, etc)
- Developing tools and workflows to produce ARD

CEOS is looking to increase its engagement with industry on ARD





## Data Producers

### Why CEOS Analysis Ready Data?

CEOS Analysis Ready Data for Land (CARD4L) are 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.

**So why CARD4L?**

Users of EO data typically invest a large proportion of their effort into data preparation. Furthermore, many satellite data users lack the expertise, infrastructure and internet bandwidth to efficiently and effectively access, preprocess, and utilize the growing volume of space-based data for local, regional, and national decision-making.

**Increase Uptake**

Unprecedented availability of computing power and tools are transforming the world. Data analysis, statistics, and machine learning – all are being made easier through the availability of free and open programming modules and tools. Data providers must also take steps to ease the access and use of data, and CARD4L provides a framework.


**Increase Impact**

New and emerging users of satellite data benefit greatly from assistance with pre-processing and data preparation, and who is better placed to provide that than the data producers themselves? Making data easier to access and use will accelerate the growth of this user base and its impact.

The 2030 Agenda for Sustainable Development, Sendai Framework for Disaster Risk Reduction 2015-2030, and Paris Climate Agreement are global challenges that require global data. Satellite data provides a unique perspective for these challenges – one that many new users can be expected to be looking toward for their information needs in these contexts. Increasing data accessibility and usability will increase societal impact on a global scale.

**Stay Relevant**

Users want answers to their questions, and they want them fast. Agile technology places an emphasis on rapid results and iterative improvement. Non-scientific users prioritise availability over perfection, therefore if data is not available for use straight away, it will likely be left behind. For continued relevance, data should be easy to use, access, and fit seamlessly into work flows and future data architectures – all of which are properties of CARD4L.

 [ceos.org/ard](http://ceos.org/ard)

 [ceos.org/ard](http://ceos.org/ard)

**Key messages**

• Users want answers to their questions, and they want them fast. Agile technology places an emphasis on rapid results and iterative improvement. Non-scientific users prioritise availability over perfection, therefore if data is not available for use straight away, it will likely be left behind. For continued relevance, data should be easy to use, access, and fit seamlessly into work flows and future data architectures – all of which are properties of CARD4L.

## Data Hosts

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**Platform Appeal**

Users are increasingly moving their workflows to the cloud. Providing a broad range of analysis-ready data products, ready to use and hosted within the same cloud makes a platform very appealing to customers.


**Host Data, Get Paid**


Who better to pre-process CARD4L data, once they make it available to a large number of users. Minimal costs related to the duplication of data transfer and processing work, and maximise profits with a new service offering or provide value-add appeal to customers. EO data sets are large, very large – and they are only getting bigger as increased coverage and significant data volumes to asymptote. Data analytics and machine learning require readily processing power – providing a great opportunity for those that sell it.

**Consistent Data Sets**

Providing consistent and comparable, ready to use datasets makes life easier for users – encouraging them to investigate additional sources and greatly increasing the amount of analytics that can be performed.

The integration and combination of data provides new avenues for analysis – increasing the amount of processing performed by users, and thus revenue for cloud platform operators.

 [ceos.org/ard](http://ceos.org/ard)

 [ceos.org/ard](http://ceos.org/ard)

**Key messages**

• Users of EO data typically invest a large proportion of their effort into data preparation. Furthermore, many satellite data users lack the expertise, infrastructure and internet bandwidth to efficiently and effectively access, preprocess, and utilize the growing volume of space-based data for local, regional, and national decision-making.

## Data Users

### Why CEOS Analysis Ready Data?

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Users of EO data typically invest a large proportion of their effort into data preparation. Furthermore, many satellite data users lack the expertise, infrastructure and internet bandwidth to efficiently and effectively access, preprocess, and utilize the growing volume of space-based data for local, regional, and national decision-making.

**Save Time and Effort**

Even sophisticated users of EO data typically invest a large proportion (around 80 per cent) of their effort into data preparation. This is a major barrier to full and successful utilization of space-based data. As data volumes grow, this barrier is becoming more significant for all users.

**Capitalise on Experts**


Who better to rely upon for data preparation than those that produce the data? Be it agencies or companies, these groups invest huge amounts of time and effort making sure data is as good as can be – so why not capitalise on this knowledge and expertise for your applications? Ensure quality and accuracy by using CARD4L datasets.

**Minimise Costs**

Data processing is costly. Pre-processed datasets eliminate this cost – and if you're using a cloud platform that already hosts this data, it could even be free to access and transfer.

**Consistent Data Sets**

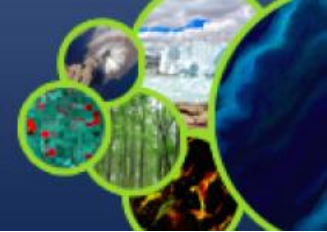
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**Key messages**

• Users of EO data typically invest a large proportion of their effort into data preparation. Furthermore, many satellite data users lack the expertise, infrastructure and internet bandwidth to efficiently and effectively access, preprocess, and utilize the growing volume of space-based data for local, regional, and national decision-making.



### **New PFSs**

- 2 further PFS are under development specifically for SAR – 2020 endorsement
- A new working group is being established to develop CARD4L PFS for LIDAR products

### **New CARD4L datasets**

- CEOS Agencies are self-assessing their products against the endorsed specifications and adjusting as necessary
- CEOS WGCV will undertake peer reviews of these self-assessments, when requested
- Following approval, CARD4L datasets will be catalogued for promotion and ease of user access



## Outreach

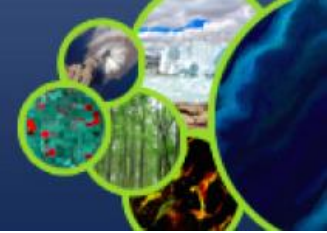
- LSI-VC plans to conduct data supply and user access trials – pushing data to large online storage and analysis hubs to further ease of access and use
- Trials with forest monitoring communities have been identified as a priority in the broader CEOS strategy for ARD (2020-2021).
- Promotion and communication of information on CARD4L products (e.g. conferences, meetings and through the CARD4L webpage).





Questions?

# Example: Threshold for CARD4L- Optical Surface Reflectance



## General metadata

- Traceability (1.1)
- Metadata machine readability (1.2)
- Data Collection Time (1.3)
- Geographical Area (1.4)
- Coordinate Reference System (1.5)
- Map Projection (1.6)
- Geometric Correction Methods (1.7)
- Geometric Accuracy of the Data (1.8)
- Instrument (1.9)
- Spectral Bands (1.10)
- Sensor Calibration (1.11)
- Radiometric Accuracy (1.12)
- Algorithms (1.13)

## CARD4L PRODUCT FAMILY SPECIFICATION

(e.g. Surface Reflectance, Surface Temperature)

### *Threshold and Target:*

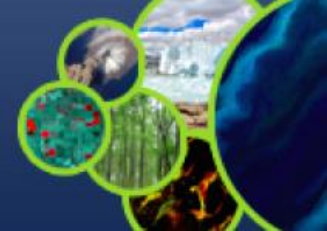
- *General Metadata*
- *Per-pixel Metadata*
- *Radiometric and atmospheric corrections*
- *Geometric corrections*

## Ancillary Data (1.14)

Processing Chain Provenance (1.15)

## Data Access (1.16)

Overall Data Quality (1.17)



## Per Pixel metadata

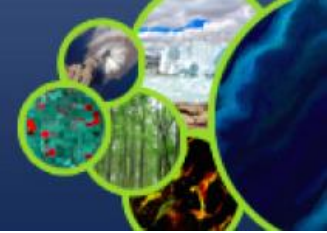
- Metadata machine readability (2.1)
- No Data (2.2)
- Incomplete Testing (2.3)
- Saturation (2.4)
- Cloud (2.5)
- Cloud Shadow (2.6)
- Land/Water Mask (2.7)
- Snow/Ice Mask (2.8)
- Terrain Shadow Mask (2.9)
- Terrain Occlusion (2.10)
- Illumination and Viewing Geometry (2.11)
- Aerosol Optical Depth Parameters (2.12)

### CARD4L PRODUCT FAMILY SPECIFICATION

(e.g. Surface Reflectance, Surface Temperature)

#### *Threshold and Target:*

- *General Metadata*
- *Per-pixel Metadata*
- *Radiometric and atmospheric corrections*
- *Geometric corrections*



## Radiometric and atmospheric corrections

- Measurement (3.1)
- Measurement Uncertainty (3.2)
- Measurement Normalisation (3.3)
- Directional Atmospheric Scattering (3.4)
- Water Vapour Corrections (3.5)
- Ozone Corrections (3.6)

## Geometric corrections

- Geometric Correction (4.1)

Sub-pixel accuracy is achieved in relative geolocation, that is, the pixels from the same instrument and platform are consistently located, and in thus comparable, through time.

### CARD4L PRODUCT FAMILY SPECIFICATION

(e.g. Surface Reflectance, Surface Temperature)

#### *Threshold and Target:*

- *General Metadata*
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- *Geometric corrections*