Committee on Earth Observation Satellites

CEOS Analysis-Ready Data for Land (CARD4L) – SAR product specs status update

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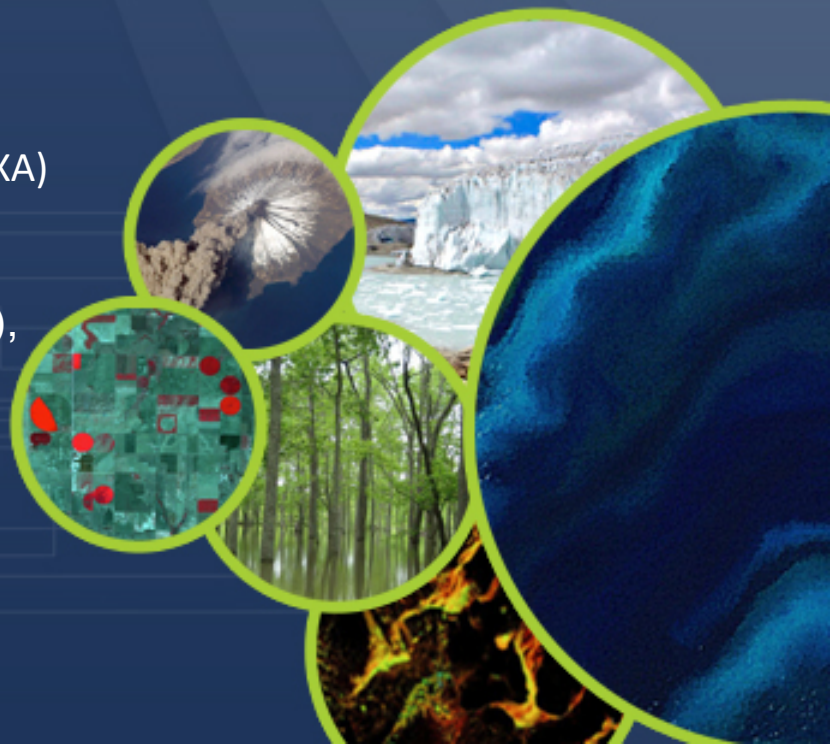
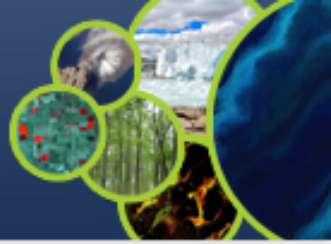
Andreia Siqueira (GA), Medhavy Thankappan (GA),
Marco Lavalle (JPL), Francois Charbonneau (NRCan),
Zheng-Shu Zhou (CSIRO), David Small (UZH)



WGCV SAR ws @ESA/ERSIN 18-22 Nov 2019

Background



Data Heaven around the corner

- The already large data volumes from current EO missions will continue to grow rapidly with the next-generation satellites
- Missions move towards wider swaths, higher spatial resolution, systematic wall-to-wall observation strategies, and in the case for SAR missions, new polarimetric and interferometric options.
- In parallel on the user side, applications are moving towards dense time-series analysis over regional to national to global scales.

→ Users and producers alike, we all risk to drown in Data Heaven!

Background

Analysis-Ready Data

- CARD4L – CEOS Analysis-Ready Data for Land
- A joint effort by CEOS agencies to address this Big Data challenge.
- Effort led by the CEOS Land Surface Imaging Virtual Constellation (LSI-VC) in collaboration with CEOS Working Group for Calibration and Validation (WGCV)
- Objective to streamline data flows and enable new storage and analysis solutions (e.g. data cubes), and to broaden the EO user community by provision of data products that do not require expert knowledge to ingest and analyse (← particularly relevant for radar, where the SAR user community remains small and expert-oriented even after > 25 years of operational SAR missions).

CARD4L Product Family Specifications

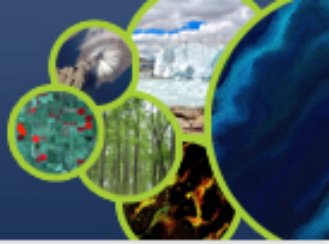
- The Specifications are intended to be flexible, providing requirements but leaving the specific data processing methodology open for data producers to decide.
- Priority to provide users with all of the information needed to understand the provenance and processing steps applied for a given product.
- CARD4L “certification” process
  - Data provider notifies LSI-VC of intention to have a data product certified as CARD4L
  - Data provider undertakes self-assessment of candidate product vs. relevant CARD4L PSF - and if necessary adapts product to meet CRAD4L specs
  - Self-assessment protocol and product sample peer reviewed by CEOS WGCV, in consultation with the LSI-VC
  - --> Approval or request for clarifications/modifications (iterative)

CEOS Analysis Ready Data

CARD4L Product Family Specifications

- The CARD4L specs are referred to as “Product Family Specifications” (PFS)
- PFSs detail 'Threshold' and 'Target' requirements for general metadata, per-pixel metadata, radiometric and geometric corrections.
- Products that meet all **Threshold requirements** should be immediately useful for scientific analysis or decision-making.
- Products that meet one or more **Target requirements** will achieve the same, but also help to further reduce product uncertainties and enhance broad-scale application

Development of CARD4L Product Family Specifications (PFS)



Optical PFSs:

- Surface Reflectance
- Surface Temperature

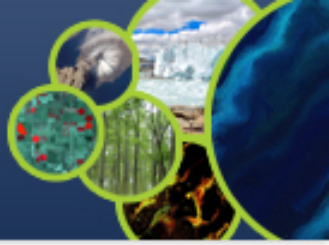
SAR PFSs in the pipeline:

- Normalised Radar Backscatter (v1 endorsed 2019)
- Geocoded SLC
- Polarimetric Radar
- Interferometric Radar

LiDAR PFSs in the pipeline:

- Terrain & Canopy Top Height
- Full Waveform (GEDI, MOLI)
- Photon Count (ICESat-2)

CARD4L
Synthetic Aperture Radar



CARD4L subgroup on SAR

- **Bruce Chapman**, Marco Lavalle (JPL) - NISAR
- **Nuno Miranda** (ESA) – Sentinel-1
- **Takeo Tadono, Ake Rosenqvist** (JAXA) – ALOS/ALOS-2/ALOS-4
- Irena Hajnsek (DLR) – TanDEM-X, Tandem-L
- Zheng-Shu Zhou (CSIRO) – NovaSAR-AU
- Steve Iris, Paul Briand (CSA) – RCM
- Danilo Dadamia (CONAE) – SAOCOM
- Medhavy Thankappan (GA)
- François Charbonneau (NRCan)
- David Small (UZH)
- Andrew Davidson (Ag-Canada)
- Franz Meyer, Kirk Hogenson (ASF)

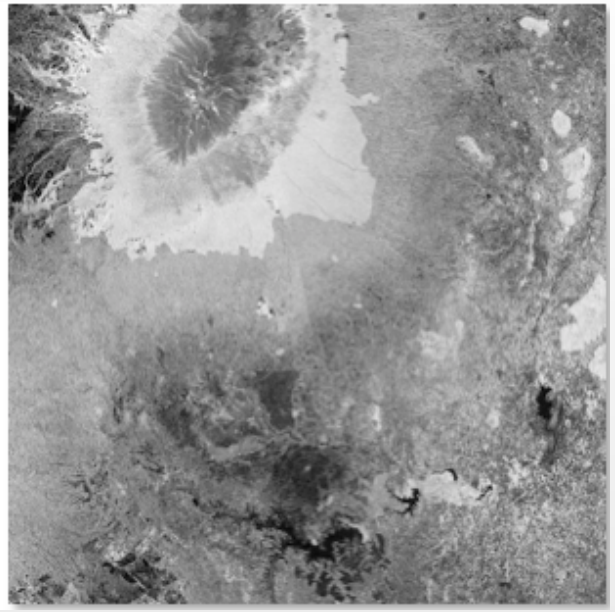
- Good mission representation although participation from ASI would also be desired.

CARD4L
Synthetic Aperture Radar PFSs

Normalised Radar Backscatter (NRB)

- Ortho-rectified
- Radiometrically Terrain Corrected (RTC)
- Illuminated Surface Area Normalisation – Backscatter in γ^0

- Leads/contributors: N. Miranda (ESA), B. Chapman (JPL), D. Small (UZH), A. Siqueira (GA), A. Rosenqvist (JAXA)
- v1.0 endorsed March 2019 (LSI-VC-7)
- v2.0 for endorsement March 2020 (LSI-VC-9)
- Example in presentation by David Small



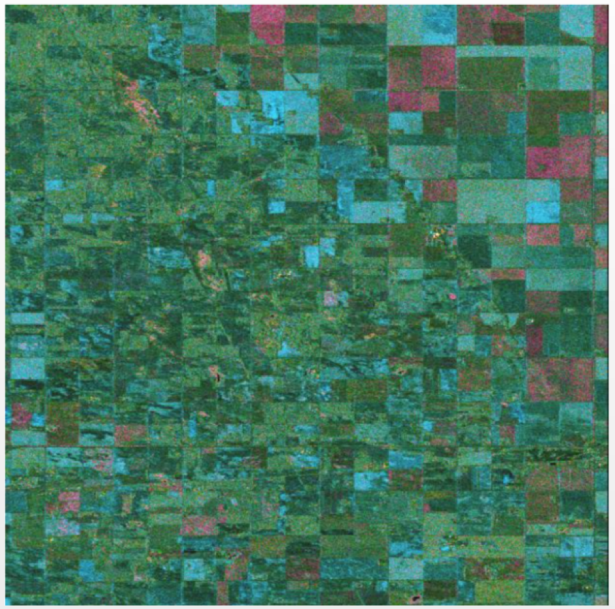
PALSAR-2 mosaic tile
NRB candidate product (JAXA self-assessment ongoing)

CARD4L
Synthetic Aperture Radar PFSs

Polarimetric Radar (PD)

- Polarimetric Covariance Matrix
- Polarimetric Decomposition
  (e.g. to be provided on user demand from a list of pre-defined decompositions defined by the data provider)

- Leads: F. Charbonneau (NRCan), M. Lavalle (JPL) & Z-S Zhou (CSIRO)
- In process. Target for endorsement March 2020 (LSI-VC-9)
- Details in presentation by Marco Lavalle



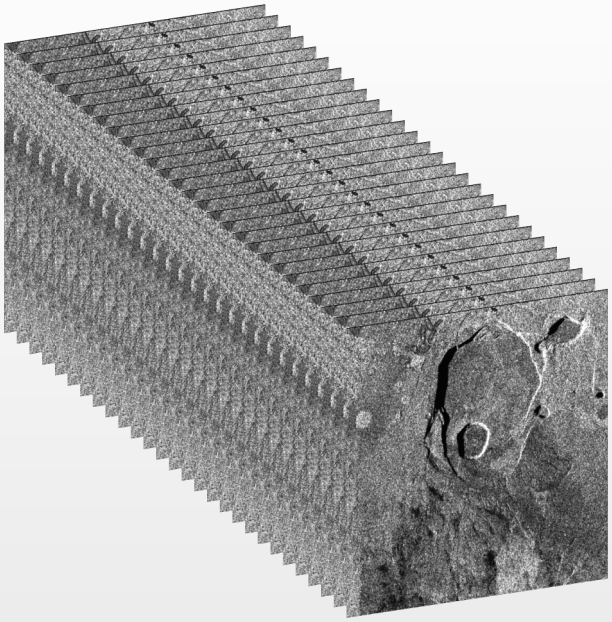
m-χ decomposition
(CARD4L-SAR CoVar, 2018)

CARD4L
Synthetic Aperture Radar PFSs

Geocoded Single-Look Complex (GSLC)

- Geocoding SAR data already at SLC level simplifies generation of interferograms.
- Zero Draft based on NISAR NASA SDS Product Description Doc and SDS Algorithm Theoretical Basis Doc.

- Lead: B. Chapman (JPL) with input from H. Zebker (Stanford U)
- Details in presentation by Bruce Chapman



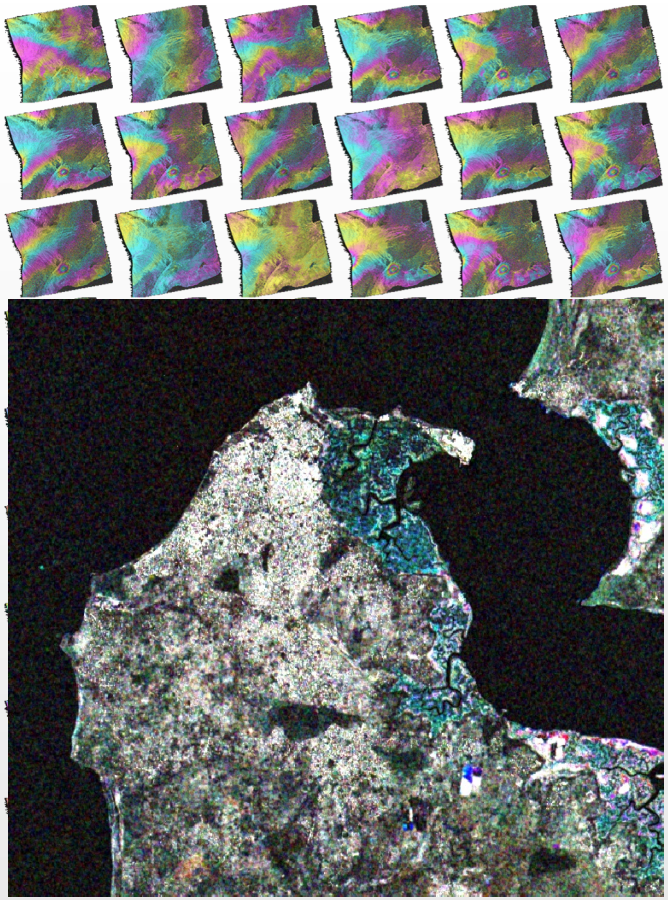
Zebker et al, 2018

CARD4L
Synthetic Aperture Radar PFSs

Interferometric SAR Products

- A suite of InSAR products :
  - Wrapped interferograms
  - Unwrapped interferograms
  - Interferometric coherence

- Lead: M. Thankappan & Geoscience Australia team
- Details in presentation by Medhavy Thankappan



Top: Geocoded (wrapped) interferograms
(Zebker et al, 2018)
Bottom: S1 InSAR Coherence
(J. Wheeler, 2019)

CARD4L
Synthetic Aperture Radar

Development of CARD4L sample products – to be publicly available on CEOS ARD www

CARD4L SAR
Sample products

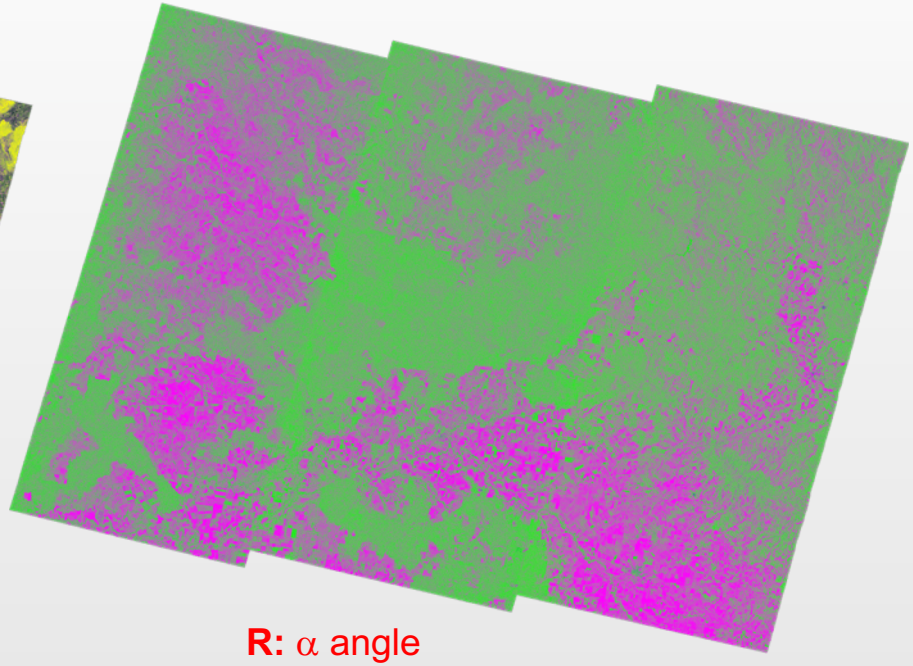
Sentinel-1
Data: ESA
Proc: Z-S Zhou (CSIRO)

NRB & PD

Sentinel-1 Dual-pol
Normalised Radar Backscatter

R: VV
G: VH
B: VV/VH

Sentinel-1 Dual-pol
H-A-α decomposition



R: α angle
G: H – Entrophy (disorder)
B: A - Anisotrophy (directional dependence)

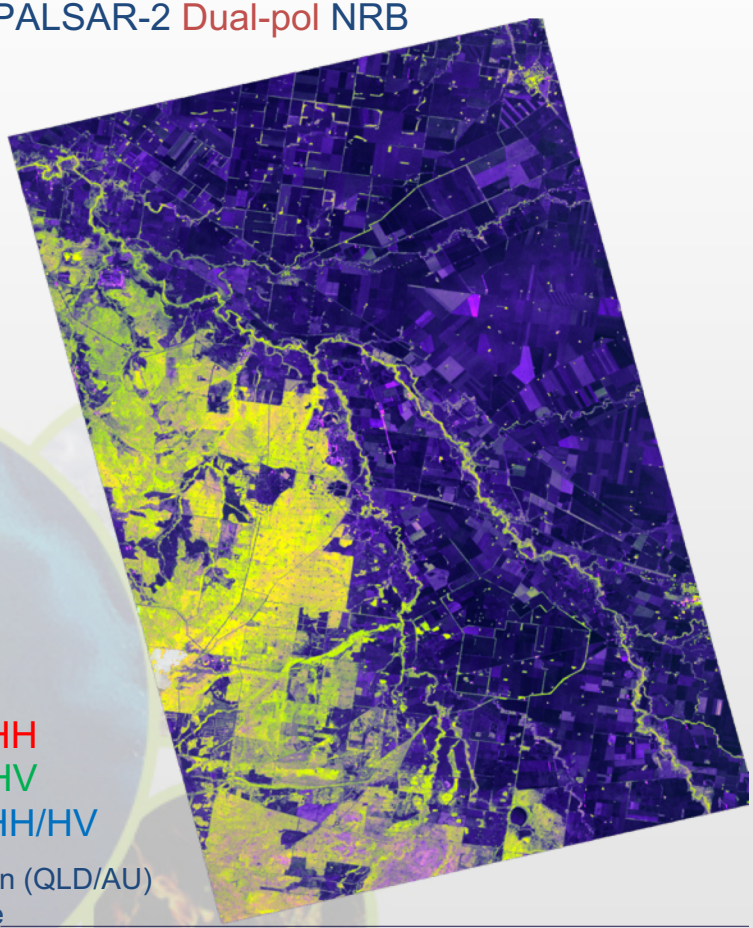
Surat Basin (QLD/AU)
Agriculture

CARD4L SAR
Sample products

ALOS-2 PALSAR-2
Data: JAXA
Proc: Z-S Zhou (CSIRO)

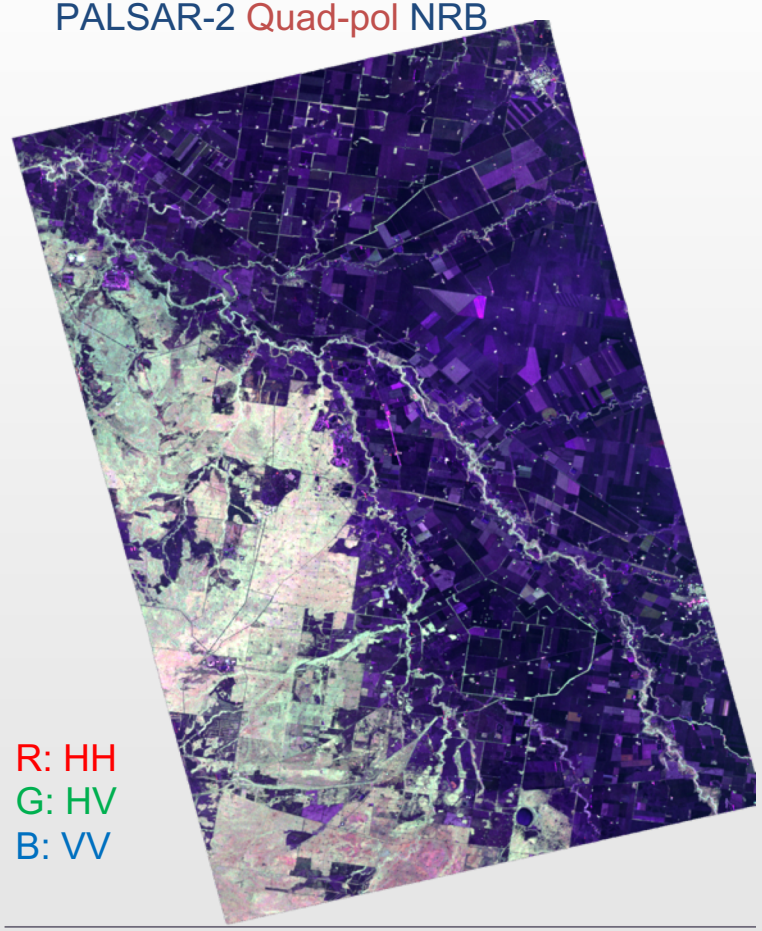
Normalised Radar Backscatter (NRB)

PALSAR-2 Dual-pol NRB



R: HH
G: HV
B: HH/HV

PALSAR-2 Quad-pol NRB



R: HH
G: HV
B: VV

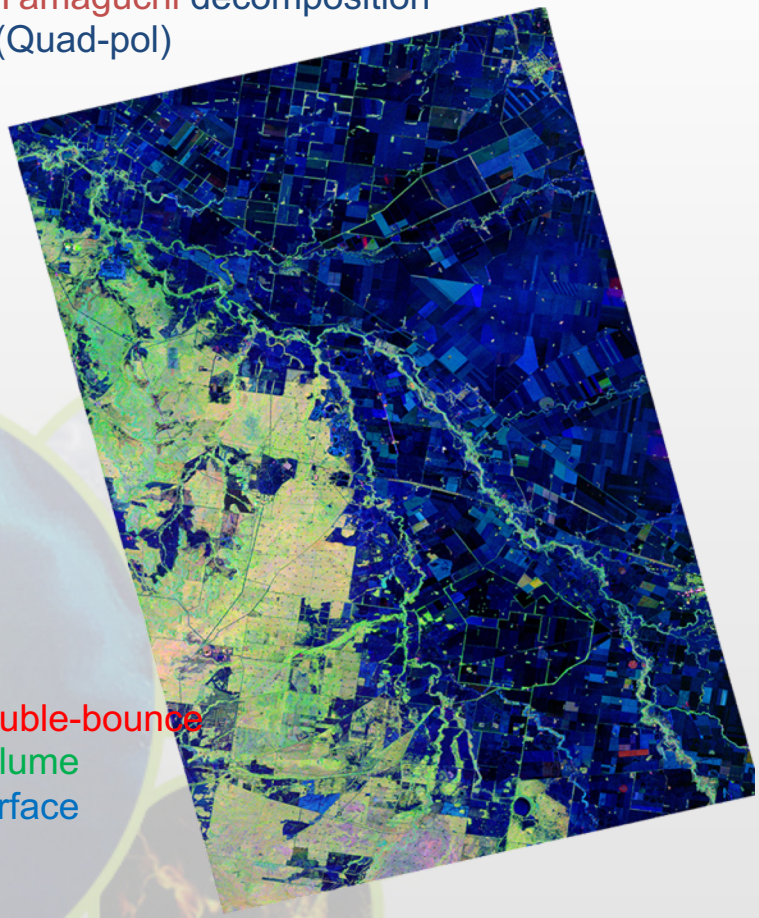
Surat Basin (QLD/AU)
Agriculture

CARD4L SAR
Sample products

ALOS-2 PALSAR-2
Data: JAXA
Proc: Z-S Zhou (CSIRO)

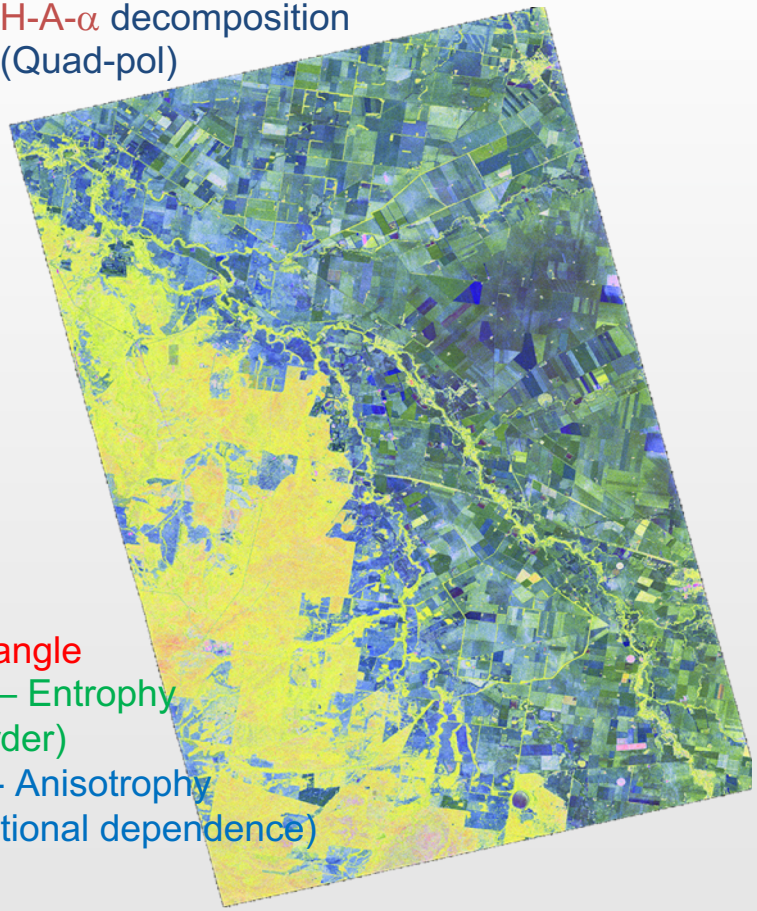
Polarimetric Decomposition (PD)

Yamaguchi decomposition
(Quad-pol)



R: Double-bounce
G: Volume
B: Surface

H-A-α decomposition
(Quad-pol)

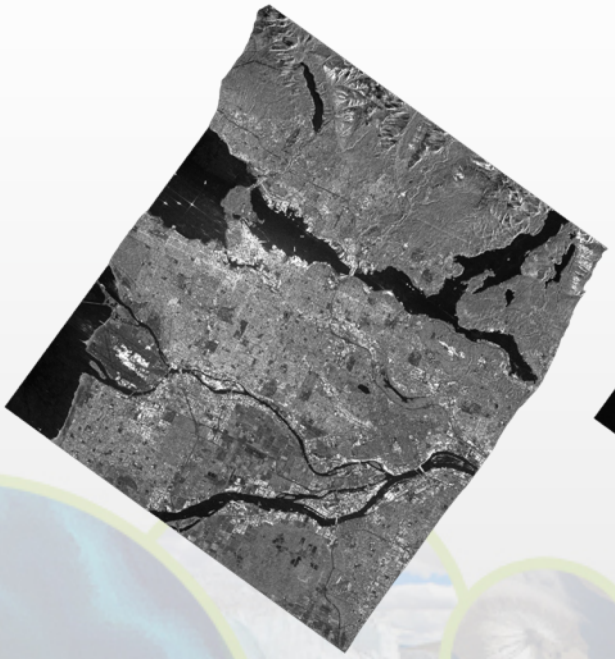


R: α angle
G: H – Entrophy
(disorder)
B: A - Anisotrophy
(directional dependence)

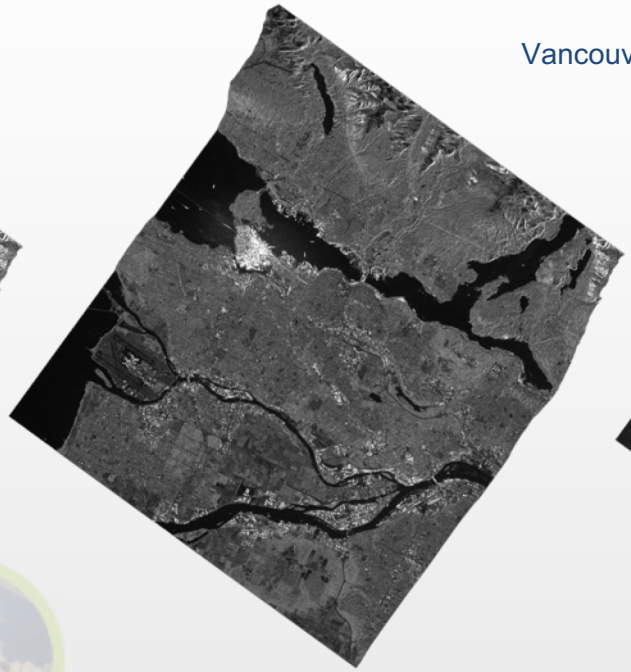
RADARSAT-2
Data: CSA
Proc: F. Charbonneau (NRCan)

Polarimetric Covariance Matrix

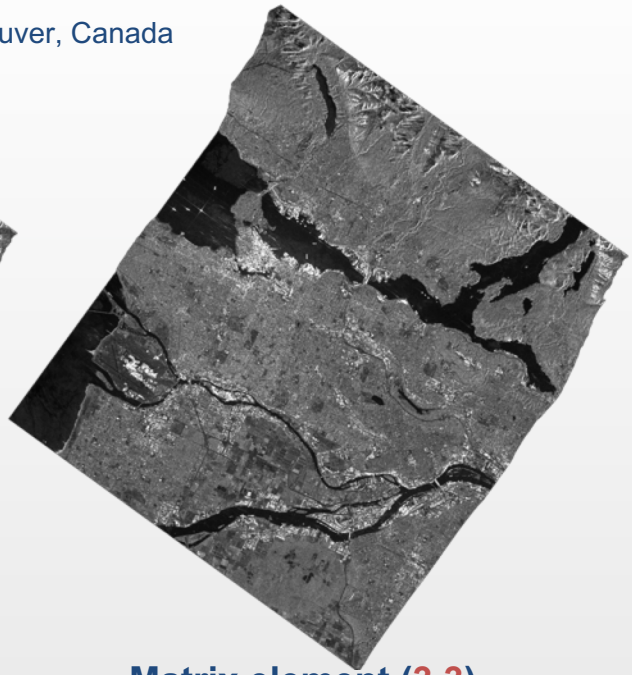
Vancouver, Canada



Matrix element (1,1)
REAL
HH amplitude



Matrix element (2,2)
REAL
HV amplitude



Matrix element (3,3)
REAL
VV amplitude

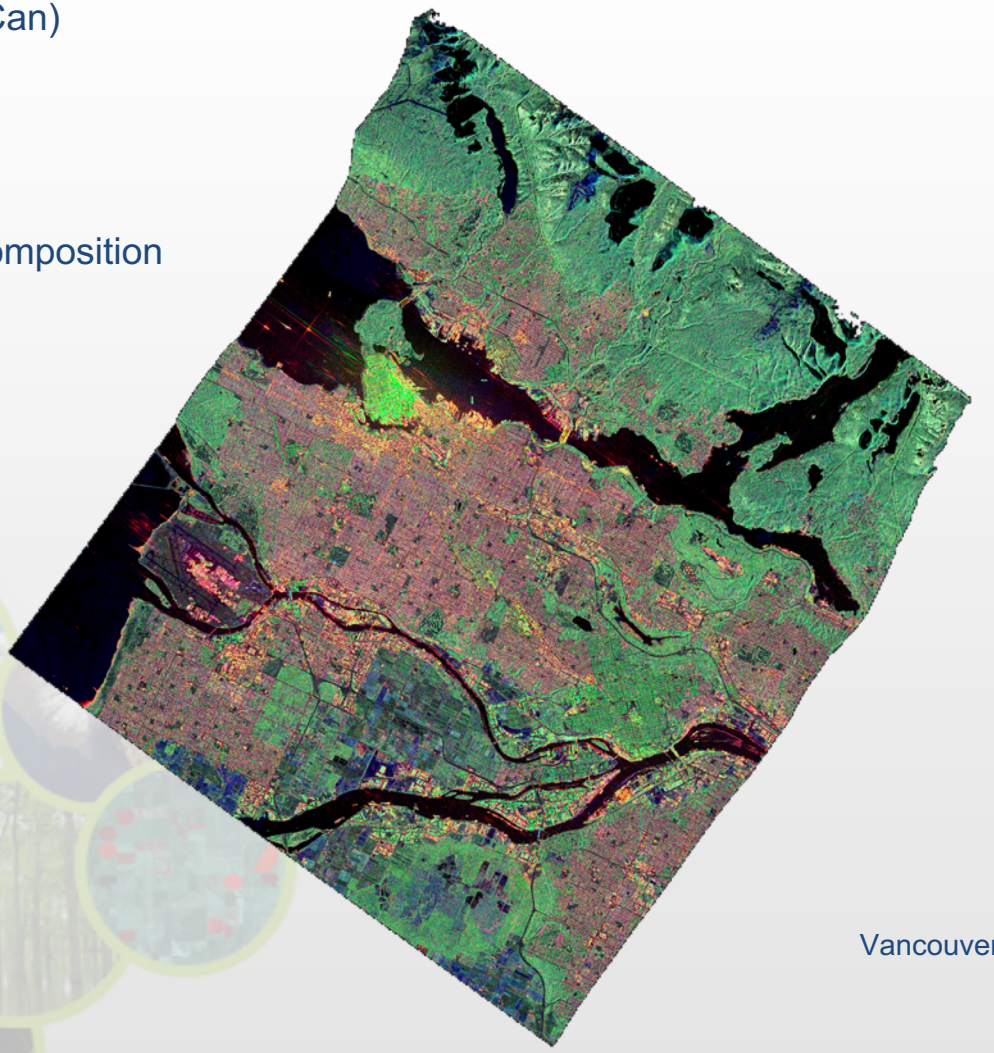
Matrix elements (1,2) (1,3) & (2,3):
COMPLEX (Im + Re)
Polarimetric phase

CARD4L SAR
Sample products

RADARSAT-2
Data: CSA
Proc: F. Charbonneau (NRCan)

Polarimetric Decomposition

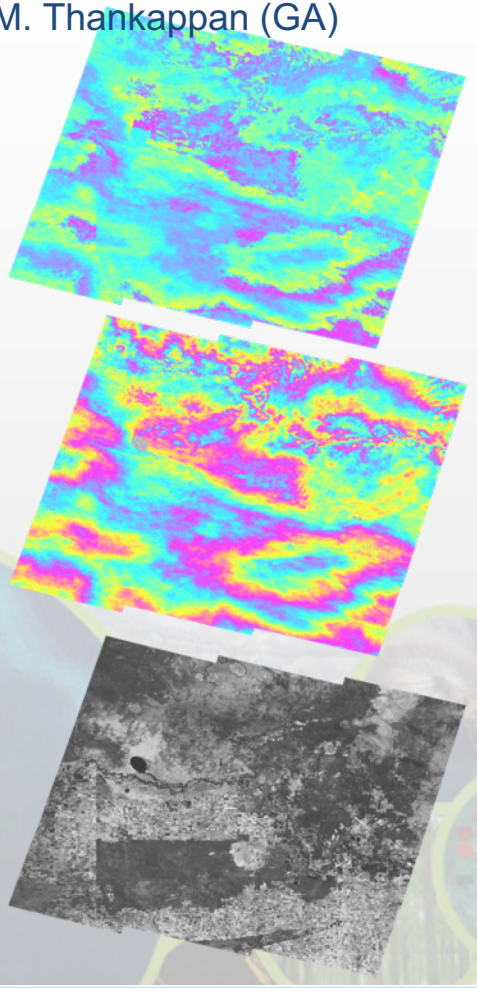
Yamaguchi decomposition
(Quad-pol)



Vancouver, Canada

Discussion topics

Sentinel-1
Data: ESA
Proc: M. Thankappan (GA)



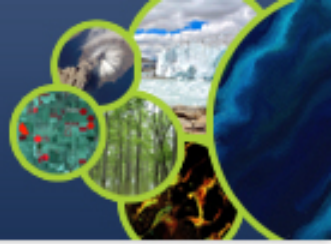
Interferometric SAR products

- Wrapped interferograms
- Studying large deformation events e.g. earthquakes
- Time series analysis, using Persistent Scatterer algorithms

- Unwrapped interferograms
- Time series analysis, using DInSAR-SBAS algorithms

- Interferometric coherence
- Change detection, land-cover applications

CEOS Analysis Ready Data



Voluntary efforts

- CARD4L implementation is voluntary, and for every data provider to decide which product(s) to implement
- Can be generated as standard for all products, or on demand by user
- It is recognised that “expert users” may find CARD4L products too simplified and prefer to continue using current lower level data (e.g. SLC)
- There is no requirement/recommendation that CARD4L products should replace existing product levels, but can be generated in addition.
- CARD4L process open – anybody interested to contribute very welcome

CEOS Analysis Ready Data

ceos.org/ard/

Search

CEOS Analysis Ready Data

Overview Framework Specifications Resources Information for: Data Producers Data Distributors Data Users

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.

CARD4L
LiDAR

LiDAR – measurements of vegetation canopy structure and height. GEDI and ICESat-2 launched in 2018 + MOLI targeted for 2022. Proposal to develop CARD4L for LiDAR well received by mission teams.

Oct 2019: Launching new CARD4L subgroup on LiDAR

- Group members representing 3 spaceborne LiDAR missions + science users
  - John Armston, Laura Duncanson (UMD/NASA GSFC) – GEDI
  - Amy Neuenschwander (U Texas) – ICESat-2
  - Rei Mitsuhashi, Tadashi Imai, Takeo Tadono (JAXA) - MOLI
  - Peter Scarth (U Queensland) – advanced science user
  - Paul Montesano (NASA GSFC) – advanced science user
  - Richard Lucas (U Aberystwyth) – advanced science user
  - Greg Stensaas, Jeff Daniels (USGS) – advanced science users
  - Ake Rosenqvist (soloEO) – coordinator & layman user guinea pig