Transatlantic Earth Observations Collaboration:

Optical Land Imaging Cooperation among the European Commission, U.S. Geological Survey, ESA, and NASA

Briefing to the ESA Living Planet Symposium

International Collaboration in Earth Observation Session
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Why International Collaboration?

Enhance USGS system capabilities and reduce overall costs

Increase quantity and quality of Earth observation (EO) data available to U.S. users

Maximize the utility and interoperability of EO data sets

How Does USGS Engage?

- **Landsat International Cooperator Network and Landsat Ground Network**
- **Bilateral Partnerships**
  - **European Commission/European Space Agency**, Geoscience Australia/Australian Space Agency/Commonwealth Scientific and Research Organisation, German Aerospace Center, Indian Space Research Organization, South African National Space Agency, Japanese Aerospace Exploration Agency, others
- **Multilateral Collaboration**
  - Group on Earth Observations (GEO), Committee on Earth Observation Satellites (CEOS), International Charter for Space and Major Disasters, UN Committee on the Peaceful Uses of Outer Space, UN International Committee on Global Navigation Satellite Systems; Int'l Standards Organization Technical Committee 211 on Geographic Information and Geomatics, others
- **Support to U.S. National and Int'l EO and S&T Policy**
  - U.S. National Space Policy; U.S. National Plan for Civil EO; **State Department Civil Space Dialogues** and international agreement reviews; EO support to USGS International Programs Office

USGS Objectives for Europe-U.S. Land Imaging Collaboration

- Enhanced complementarity of Copernicus/Sentinel-2, Landsat, & related satellite systems
- Consultation/coordination w/NASA, ESA, EC in future mission planning
- Shared vision of full, free, and open data policies
- More comprehensive and timely coverage
- Increased efficiencies and reduced costs
- Enhanced data access, validation, and quality control
- Enhanced instrument inter-calibration and data validation
- Collaboration in the development of improved and hybrid data products

Fundamental Goal:
Better serve U.S., European, and global users

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History and Framework for Collaboration

- Grounded in the close historical relationship between the European Union and the United States
- **U.S.-EU Comprehensive Space Dialogue (CSD)** advances mutual economic, scientific, technological, security, and climate interests
  - Europe-U.S. **Copernicus Coordination Group (CCG)** focused on enhanced Earth Observation collaboration
    - EC, State Department, ESA, NASA, USGS, EUMETSAT, NOAA
    - Common approach to full, free, and open data sharing
- 2016 ESA-USGS Technical Operating Arrangements for the Copernicus Space Component (Sentinel-2 data access and distribution)

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Transatlantic Statement on EU-U.S. Cooperation on Land Imaging and Monitoring

Endorsed at the June 2019 EU-U.S. Space Dialogue

Priority cooperation areas:

- Improve information exchange
- Mission coordination opportunities
  - User requirements sharing
  - Coordination of sensor requirements
  - Sensor development cooperation
  - Orbits planning
  - Launch schedule alignment
- Launch of complementary sensors (e.g., thermal sensors complementing optical sensors)
- Calibration and validation cooperation, including Level-2 product validation
- Ground system development and operations efficiencies
- Product definition and interoperability

Establishment of U.S.-Europe Land Imaging Earth Observation Collaboration working group soon thereafter, focused on detailed aspects of future land-imaging collaboration

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Europe-U.S. Land Imaging Earth Observation Collaboration working group

- Initial meeting held in Brussels, Belgium — 19-20 February 2020
- Conducted 1st status update meeting (virtual) — 20 May 2020
- Briefed Copernicus Coordination Group (virtual) — 2 June 2020
- Conducted 2nd status update meeting (virtual) — 15 October 2020
- Briefed Copernicus Coordination Group (virtual) — 12 November 2020
- Conducted 3rd status update meeting (virtual) — 15 June 2021
- Virtual and in-person coordination prior to EU-US CSD — late June 2022 (tbc)

Technical Collaboration Teams

1 – User Needs and Requirements
2 – Specifications and Future Mission Architectures
3 – Data Acquisition and Initial Processing (through Level-0)
4 – Product Definition and Generation (Level-1 through Level-3, including near-real time
5 – Product Storage, Delivery, and Access Architectures
6 – Calibration and Validation

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Landsat / Copernicus-Sentinel 2 Coordination: Driven by User Needs

- Cross-Referencing European and U.S. user needs
- Adopting common user needs approaches for easier intercomparison
  - User needs levels/satisfaction scale
  - Attributes
  - Geophysical parameters
- Creating a common lexicon of imaging user needs and geophysical parameter terminologies
- Upon lexicon alignment, analyze respective European and U.S. user needs databases to better understand and to refine each database
- Continue to learn more about the future data collection plans and decide how to best synchronize the data collection approach and lexicon
- EC will ensure the consistency of the user requirements data collection through the new Knowledge Center for Earth Observation (KCEO) to feed the process
- Contributing to future mission architectures on both sides of the Atlantic

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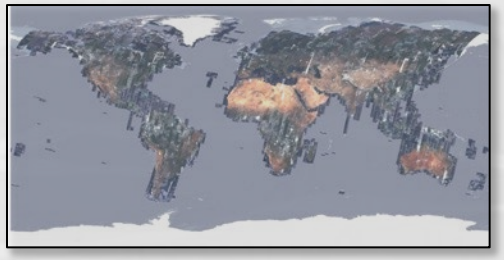
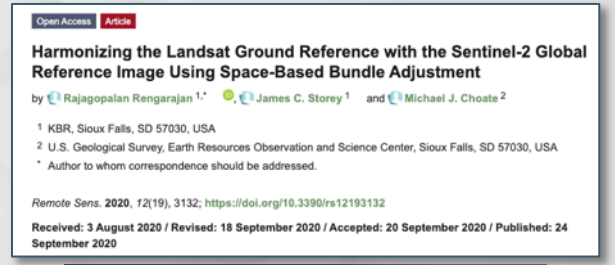
Sentinel-2 & Landsat Interoperability ‡

- ✓ Geometry
- ✓ Level-1 Radiometry
- ✓ Level-2A Radiometry and Cloud Mask
- ✓ Level-2H and Level-2F




Open Access Article

Harmonizing the Landsat Ground Reference with the Sentinel-2 Global Reference Image Using Space-Based Bundle Adjustment

by Rajagopalan Rengarajan [1,*], James C. Storey [1] and Michael J. Choate [2]

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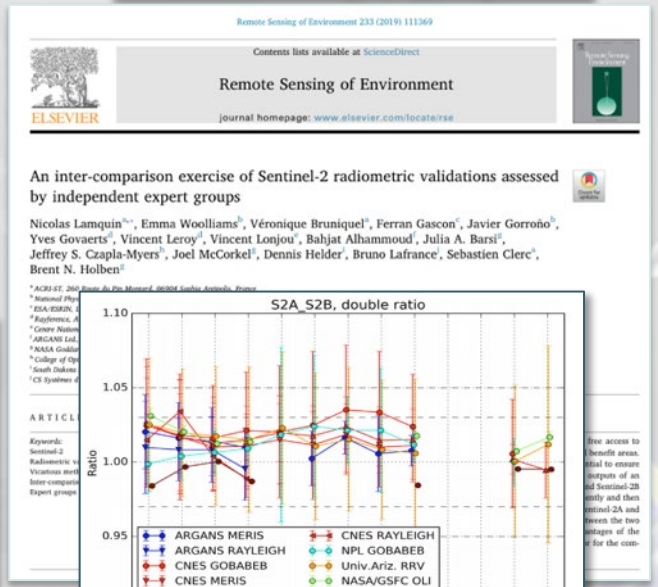
Remote Sensing of Environment 233 (2019) 111369

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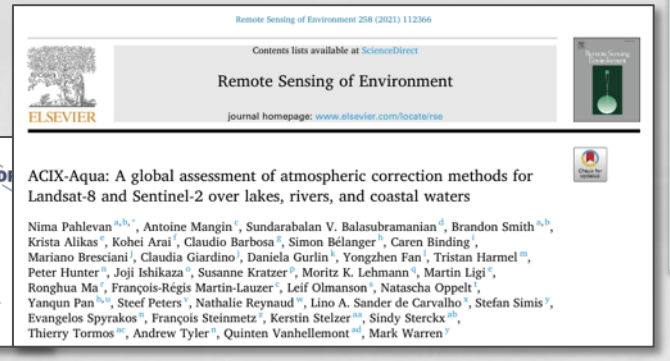
journal homepage: www.elsevier.com/locate/rse

ELSEVIER

An inter-comparison exercise of Sentinel-2 radiometric validations assessed by independent expert groups

Nicolas Lamquin[a,*], Emma Woolliams[b], Véronique Bruniquel[a], Ferran Gascon[c], Javier Gorroño[b], Yves Govaerts[d], Vincent Leroy[d], Vincent Lonjou[e], Bahjat Alhammoud[f], Julia A. Barsi[g], Jeffrey S. Czapla-Myers[h], Joel McCorkel[g], Dennis Helder[i], Bruno Lafrance[c], Sebastien Clerc[a], Brent N. Holben[g]

Fig. 10. Double ratios g(S2A)/g(S2B) for each calibration validation method.


Remote Sensing of Environment 258 (2021) 112366

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ELSEVIER

ACIX-Aqua: A global assessment of atmospheric correction methods for Landsat-8 and Sentinel-2 over lakes, rivers, and coastal waters

Nima Pahlevan[a,b,*], Antoine Mangin[c], Sundarabalan V. Balasubramanian[d], Brandon Smith[a,b], Krista Alikas[e], Kohei Arai[f], Claudio Barbosa[g], Simon Bélanger[h], Caren Binding[i], Mariano Bresciani[j], Claudia Giardino[j], Daniela Gurlin[k], Yongzhen Fan[l], Tristan Harmel[m], Peter Hunter[n], Joji Ishikaza[o], Susanne Kratzer[p], Moritz K. Lehmann[q], Martin Ligi[e], Ronghua Ma[r], François-Régis Martin-Lauzer[c], Leif Olmanson[s], Natascha Oppelt[t], Yanqun Pan[b,u], Steef Peters[v], Nathalie Reynaud[w], Lino A. Sander de Carvalho[x], Stefan Simis[y], Evangelos Spyrakos[n], François Steinmetz[z], Kerstin Stelzer[aa], Sindy Sterckx[ab], Thierry Tormos[ac], Andrew Tyler[n], Quinten Vanhellemont[ad], Mark Warren[y]


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Article

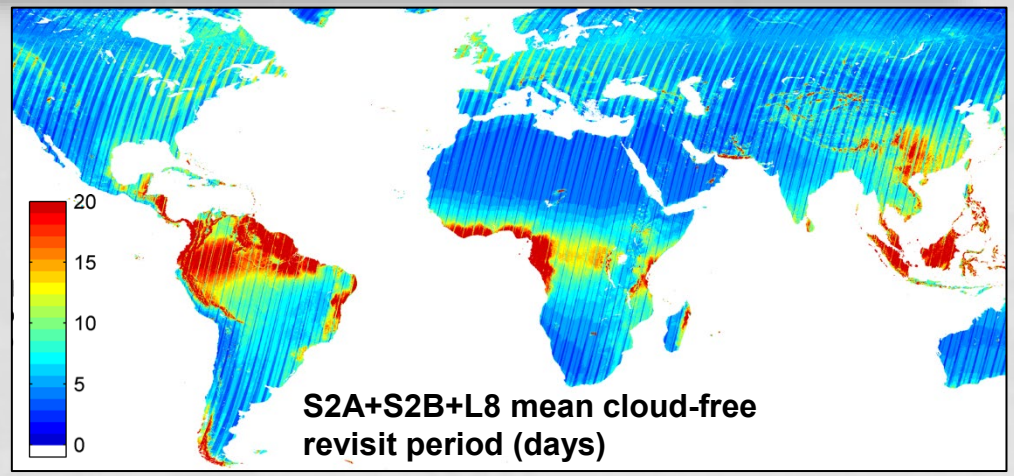
Atmospheric Correction Inter-Comparison Exercise

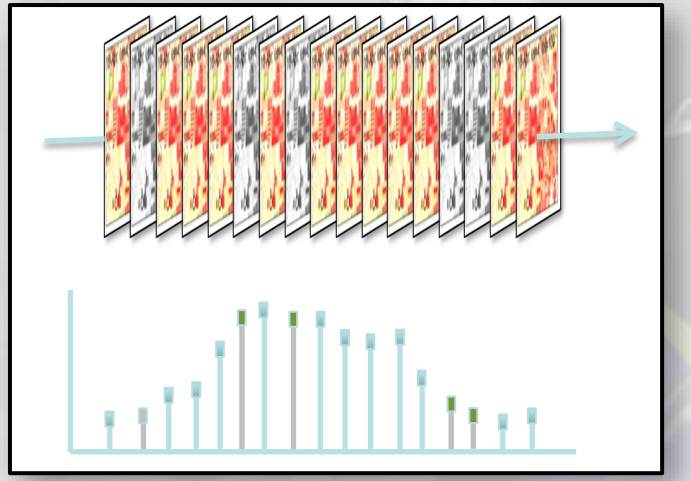
Georgia Doxani [1,*], Eric Vermote [2,*], Jean-Claude Roger [2,3], Ferran Gascon [4], Stefan Adriaensen [5], David Frantz [6,†], Olivier Hagolle [7], André Hollstein [8], Grit Kirches [9], Fuqin Li [10], Jérôme Louis [11], Antoine Mangin [12], Nima Pahlevan [2,13], Bringfried Pflug [14] and Quinten Vanhellemont [15]

‡ Courtesy Ferran Gascon, ESA

Harmonized Landsat Sentinel-2 (HLS)

- Merging Sentinel-2 and Landsat 8 data streams can provide **~3-day global coverage**
- Goal is “seamless” near-daily 30m surface reflectance record including atmospheric corrections, spectral and BRDF adjustments, regridding
- Processing migrated to Amazon Web Services (AWS) via NASA Earth Sciences Technology Office (ESTO)
- Landsat-8 data set: 1,100k products From Mar-2013 to Present (135 TB); Sentinel-2 data set: 420k products From Jun-2015 to Present (60 + 274 TB)
- Prototype for a **multi-sensor Analysis Ready Data** product





Credit: Jeff Masek, NASA

Claverie, M, et al. "The Harmonized Landsat and Sentinel-2 surface reflectance data set." *Remote sensing of environment* 219 (2018): 145-161.

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Harmonized Sentinel-2 – Landsat (Sen2Like)

Harmonized Landsat and Sentinel data over the Crau region near Arles, France

Sentinel Data provided courtesy of the EC/ESA

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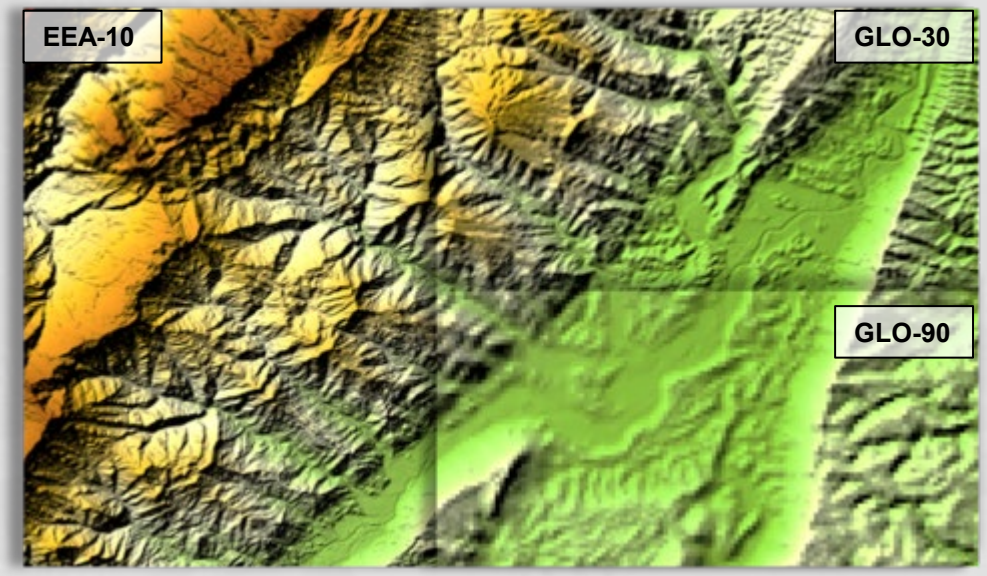
Copernicus DEM

- In 2021, the EC and ESA announced in public availability of their global 30-meter Digital Elevation Model (DEM) GLO-30
  - Decision followed ongoing discussions with USGS
- This global dataset is more consistent and of higher quality than other freely available global DEMs
  - Expected to provide higher confidence in products
  - GLO-30 DEM can also help improve current alignment of Sentinel-2 and Landsat imagery, and improve interoperability



Copernicus DEM Instances EEA-10 (left), GLO-30 (upper right) and GLO-90 (lower right) (Courtesy Copernicus)

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Transatlantic Land-Imaging Accomplishments to Date

- Pre-launch instrument inter-calibration of Landsat 8 and Sentinel-2
- USGS hosting/distribution of Sentinel-2 data
- Landsat Collection 2 reprocessing using the Copernicus Sentinel-2 Ground Reference Image (GRI) to more closely align Landsat and Sentinel-2 data on the ground
- Establishment of EU-U.S. Earth Observation Collaboration Working Group and ongoing supportive technical information exchanges
- Development and release of hybrid data products (HLS and Sen-2Like)
- Public release of Copernicus 30m Global Digital Elevation Model

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Landsat-Sentinel 2 Collaboration – 12 Years and Counting!

Frascati, 2010

Brussels, 2020

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