Sentinel-1 Interferometry from the Cloud to the Scientist

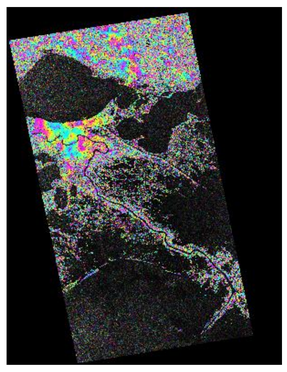
Jessica Garron, Chris Stoner, Andrew Johnston, Scott Arko
Alaska Satellite Facility, 2156 Koyukuk Drive, Fairbanks, AK 99775

G23A-0880

Big data problems and solutions are growing in the technological and scientific sectors daily. Cloud computing is a vertically and horizontally scalable solution available now for archiving and processing large volumes of data quickly, without significant on-site computing hardware costs. Be that as it may, the conversion of scientific data processors to these powerful platforms requires not only the proof of concept, but the demonstration of credibility in an operational setting. The Alaska Satellite Facility (ASF) Distributed Active Archive Center (DAAC), in partnership with NASA's Jet Propulsion Laboratory, is exploring the functional architecture of Amazon Web Services cloud computing environment for the processing, distribution and archival of Synthetic Aperture Radar data in preparation for the NASA-ISRO Synthetic Aperture Radar (NISAR) Mission. Leveraging built-in AWS services for logging, monitoring and dashboarding, the GRFN (Getting Ready for NISAR) team has built a scalable processing, distribution and archival system of Sentinel-1 L2 interferograms produced using the ISCE algorithm. This cloud-based functional prototype provides interferograms over selected global land deformation features (volcanoes, land subsidence, seismic zones) and are accessible to scientists via NASA's EarthData Search client and the ASF DAACs primary SAR interface, Vertex, for direct download. The interferograms are produced using nearest-neighbor logic for identifying pairs of granules for interferometric processing, creating deep stacks of BETA products from almost every satellite orbit for scientists to explore. This presentation highlights the functional lessons learned to date from this exercise, including the cost analysis of various data lifecycle policies as implemented through AWS. While demonstrating the architecture choices in support of efficient big science data management, we invite feedback and questions about the process and products from the InSAR community.

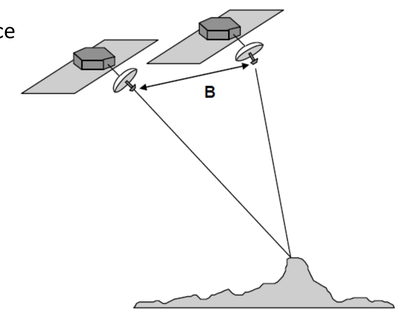
The Project

The Getting Ready for NISAR (GRFN) project is mandated to identify low-cost, prototypical solutions for SAR data management using Amazon Web Services as the computing environment, and Sentinel-1 as the SAR data. The project is a working partnership between the Alaska Satellite Facility (ASF) and the Jet Propulsion Laboratory (JPL), under the direction of NASA ESDIS, wherein JPL operates the ARIA data processor to deliver products to ASF for archival and distribution. A prototypical cloud-processing pipeline has been developed by the Alaska Satellite Facility to determine cost-effective processing solutions for large volumes of SAR data. The system will be used to inform data management decisions for the upcoming joint U.S-India mission NISAR, slated for launch in 2021.

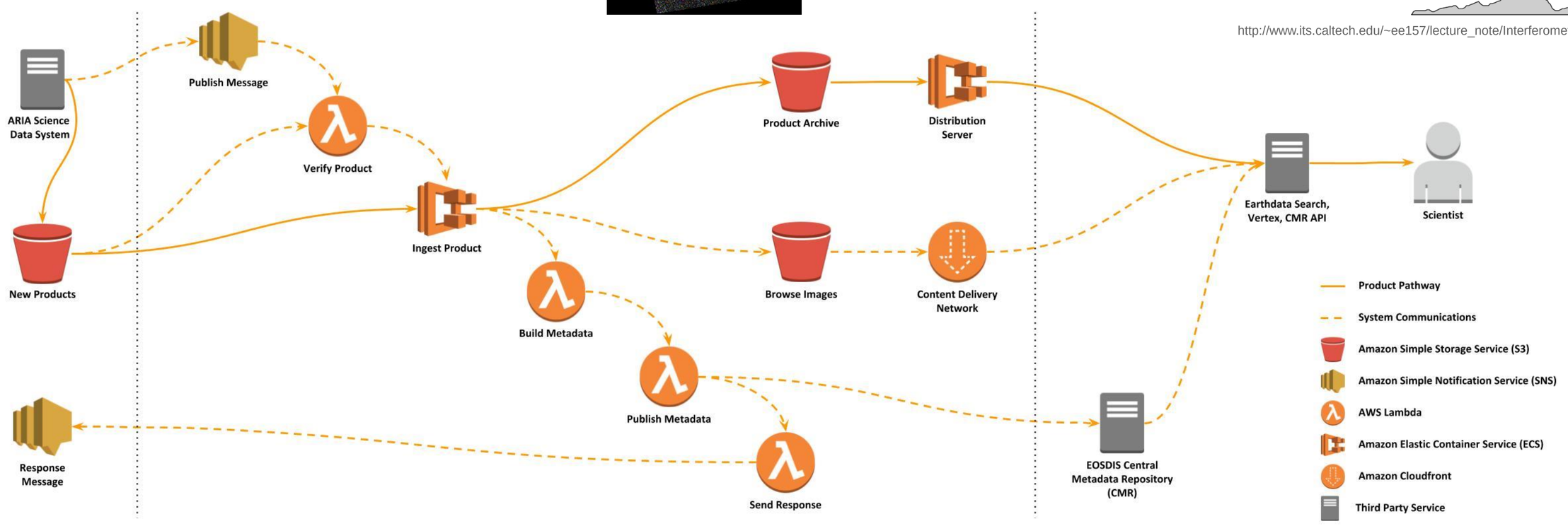


Synthetic Aperture Radar Interferometry

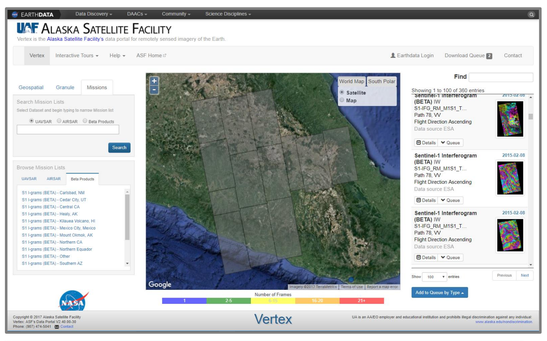
- Two or more SAR images are used to create maps of land deformation changes between the two images over time or space
- Measures signal phase differences among images
- mm to cm scale elevation detection
- Applied monitoring of:
  - Subsidence
  - Ice dynamics
  - Earthquakes
  - Landslides
  - Volcanoes



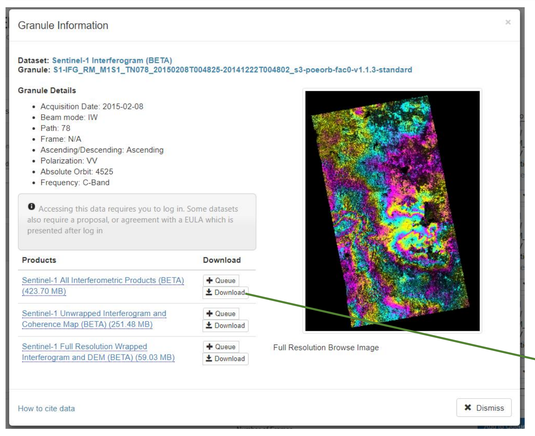
http://www.its.caltech.edu/~ee157/lecture_note/Interferometry.pdf

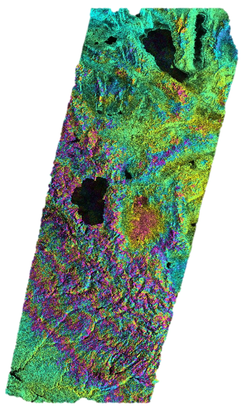


The **GRFN prototypical pipeline** uses exclusively AWS tools and services. Data is produced by ARIA science data system designed and operated by JPL and deposited in the New Product **Simple Storage Serivce** bucket. A **Simple Notification Service** message is generated to kick-off the processing pipeline to retrieve data from the New Product bucket. Data is verified to contain all required products, after which products are ingested by custom software running in an **Elastic Container Service**, to include **Lambda function** driven metadata construction and delivery to EOSDIS metadata repository, which in turn makes the data discoverable through ASF's Vertex and NASA's Earthdata Search. Simultaneously, products are archived using AWS storage policies (S3, S3IA, Glacier), and browse imagery is pushed to **Cloudfront**, a publicly available AWS content delivery network. Users accessing products through Vertex or Earhtdata Search download their products from S3 buckets.



GRFN products are available through ASF's data discovery portal Vertex, and NASA's Earthdata Search portal. Interferograms, their supporting products and metadata are downloaded as one of three different product zip packages from Vertex. Below is an example of an available data package.





GRFN InSAR products are currently available for these geographic regions:

Northern California
Central California
Southern California
Carlsbad, New Mexico
Cedar City, Utah
Healy, Alaska
Mexico City, Mexico
Unimak Island, Alaska
Kilauea Volcano, Hawaii
Mount Okmok, Alaska
Northern Equador
Southern Arizona
Southern Louisiana
Western Colorado
Western Pakistan

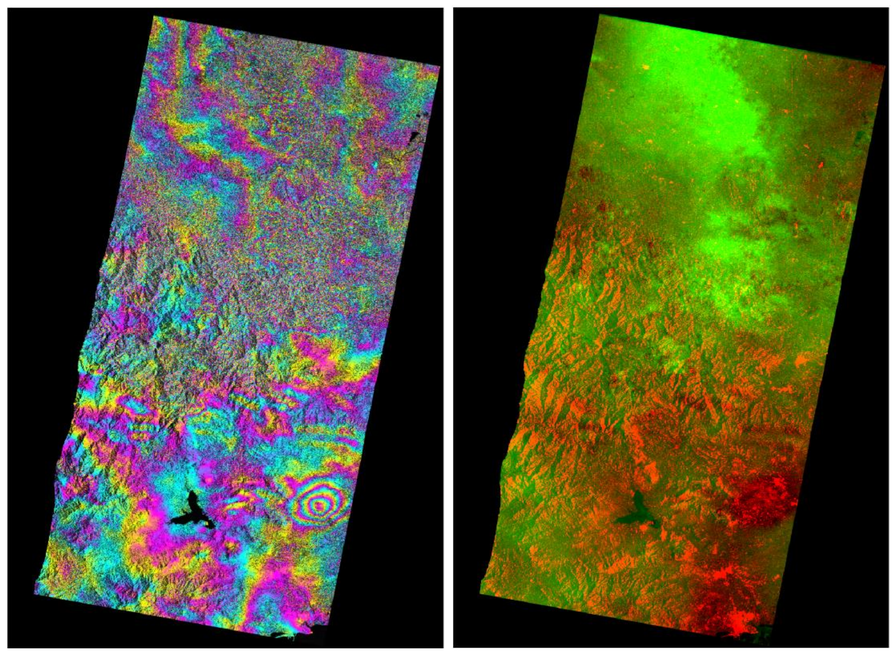
Sentinel-1 All Interferometric Products (BETA)

- merged
- PICKLE
- tiles
- amplitude.geo.browse.png
- amplitude.geo.browse_small.png
- filt_topophase.unw.geo.browse.png
- filt_topophase.unw.geo.browse_small.png
- filt_topophase.unw.geo.png
- filt_topophase.unw.geo_5cm.browse.png
- filt_topophase.unw.geo_5cm.browse_sma...
- filt_topophase.unw.geo_20rad.browse.png
- filt_topophase.unw.geo_20rad.browse_s...
- fine_interferogram.xml
- isce.log
- master.xml
- S1-IFG_STCM1S1_TN035_20161208T020...
- S1-IFG_STCM1S1_TN035_20161208T020...
- S1-IFG_STCM1S1_TN035_20161208T020...
- slave.xml
- topophase.cor.geo.browse.png
- topophase.cor.geo.browse_small.png
- topophase_ph_only.cor.geo.browse.png
- topophase_ph_only.cor.geo.browse_small...
- topsApp.xml

The "merged" file contains the functional data files that support the browse imagery of the main directory in four formats; GEO, HDR, VRT, XML. The All Interferometric Products zip contains:

Dem.crop	Los.rdr
filt_topophase.flat	Los.rdr.geo
filt_topophase.flat.geo	Phsig.cor
filt_topophase.unw	Phsig.cor.geo
filt_topophase.unw.geo	Topophase.cor
filt_topophase.unw.conncomp	Topophase.cor.geo
filt_topophase.unw.conncomp.geo	

Cloud Optimized GeoTIFFs (COGs)



GRFN experimental Cloud Optimized GeoTIFFs (COGs). Image on left is an RGB COG of an unwrapped, geocoded interferogram over Mexico City. The image on the right is generated from the same interferometric data, as a power/unwrapped phase image.

A Cloud Optimized GeoTIFF (COG) is a regular GeoTIFF file hosted on a HTTP file server. The GRFN team is experimenting with this new technology to provide users a quickly consumable scientific product.

•Front loaded full resolution metadata, overview metadata and full resolution imagery for quick visualization from the cloud via QGIS – minimal rendering time

•Leverages HTTP GET range requests to ask for just the parts of a file you need (subsetting)

We Need Your Input!

Are these products helpful for your research? Are the formats what you need?

GRFN access through Vertex: https://vertex.daac.asf.alaska.edu/

User feedback survey: http://bit.ly/2hlvLG3

Year 1 Lessons Learned

- AWS services increase developer productivity
  - Eliminates undifferentiated heavy lifting; currently leveraging 19 AWS services
- AWS makes prototyping cheap
- Storage and Compute are bulk of AWS costs for big data issues
  - Storage will be a dominant cost for NISAR
- Delicate balance of user experience and aggressive lifecycle policies for data delivery
- Egress from AWS could get pricey with large volumes of data
  - Reduce Egress costs with smart architecture
  - Co-locate users with archive to reduce Egress costs
  - Experiment with CloudFront for products
- Leveraging existing disciovery systems increase visibility of new products to existing new users

The GRFN Team: A technical team composed of software architects and scientists from the Alaska Satellite Facility and the Jet Propulsion Laboratory.

Alaska Satellite Facility
Scott Arko – Project Manager
Dr. Franz Meyer – Project Scientist
Chris Stoner – Project Advisor
Jessica Garron – Product Owner
Andrew Johnston – Software Engineer/Scrum Master
Ian Dixon – Software Engineer
David Matz – Software Engineer/Systems Engineer

Jet Propulsion Laboratory
Hook Hua – Project Manager
Dr. Susan Owen – Project Scientist
Gerald Manipon – Software Engineer
Lan Dang – Software Engineer
Namrata Malarout – Software Engineer
Justin Linick – Software Engineer
Mohammed Karim – Software Engineer

Learn more about the GRFN project: https://earthdata.nasa.gov/getting-ready-for-nisar

Contact Jessica Garron with questions specific to this poster, to provide GRFN feedback, or to volunteer to test experimental GRFN products at: **jigarron@alaska.edu**