LANCE – NASA's Land, Atmosphere Near Real-time Capability for EOS

Jenny Hewson, LANCE Outreach and Implementation Manager (Jennifer.H.Hewson@nasa.gov)
Karen Michael, LANCE Manager (Karen.Michael@nasa.gov)
Diane Davies, LANCE Operations Manager (Diane.K.Davies@nasa.gov)
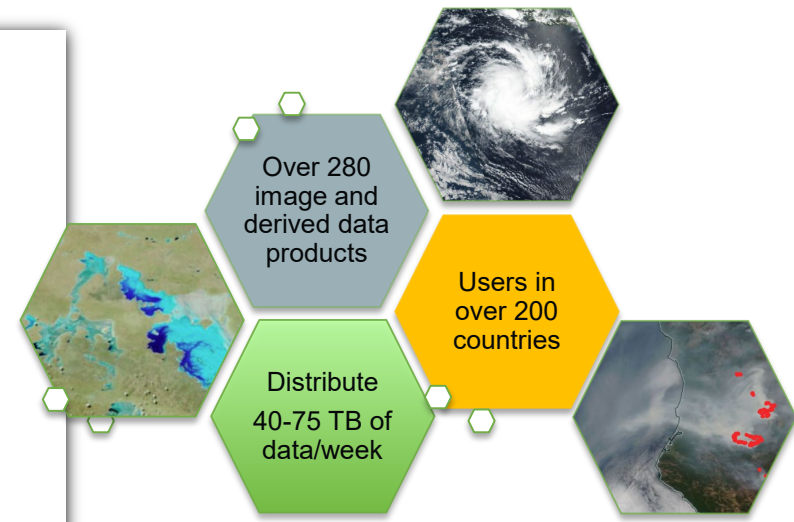
Land, Atmosphere Near Real-time Capability for EOS

- Goal: provide global near real-time (NRT) data products within 3 hours of observation to meet the timely needs of applications users
- Data and imagery from 12 instruments (SMAP coming soon) much quicker than routine processing allows

- **AIRS** - Atmospheric Infrared Sounder
- **AMSR2** - Advanced Microwave Scanning Radiometer 2
- **LIS ISS** - Lightning Imaging Sensor on the International Space Station
- **ICESat-2** - Advanced Topographic Altimeter System (ATLAS) on the Ice, Cloud, and land Elevation Satellite
- **MISR** - Multi-angle Imaging SpectroRadiometer
- **MLS** - Microwave Limb Sounder

- **MODIS** - Moderate Resolution Imaging Spectroradiometer
- **MOPITT** - Measurements of Pollution in the Troposphere
- **OMI** - Ozone Monitoring Instrument
- **OMPS** - Ozone Mapping and Profiler Suite
- **VIIRS-Atmosphere** - Visible Infrared Imaging Radiometer Suite
- **VIIRS-Land** - Visible Infrared Imaging Radiometer Suite

Over 280 image and derived data products

Users in over 200 countries

Distribute 40-75 TB of data/week

- Virtual system: leverages existing Science Processing and Archive Components
- Supports multiple NRT applications

Original Concept of LANCE

1. ## Leverage existing SIPS and DAACs

    a. Initially the SIPS were the preferred distributors for LANCE:

        i.   every "hop" ⮕ impacted the latency (even if 10 min delay)
        ii.   NRT data is not archived ⮕   no need to transfer to DAACs

2. ## Leverage the current science teams for algorithms and QA

    a. Initially all the NRT products had standard products associated with them

    b. Flood Mapping product ⮕   first approved without a standard product/associated science team

3. ## Gather all the NRT (3 hr) data under one umbrella

    a. Easier for users to find the NRT data

    b. Looks like all the data is coming from one location

    c. Uses "umbrella" set of core requirements – consistency, coordination, collaboration

4. ## Establish a User Working Group

    a. Overall guidance for the evolution of LANCE on behalf of **applications user** communities
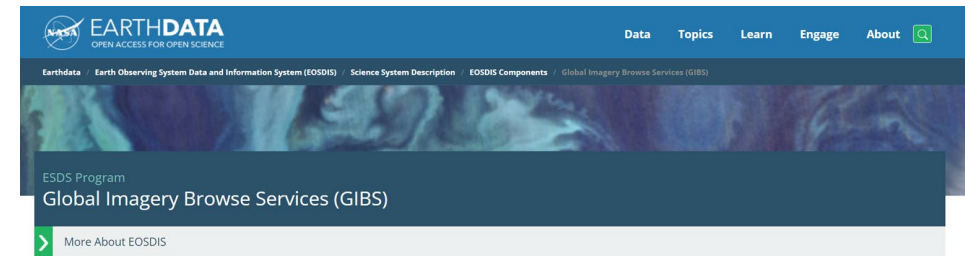
LANCE Continues to Evolve

https://earthdata.nasa.gov/earth-observation-data/near-real-time

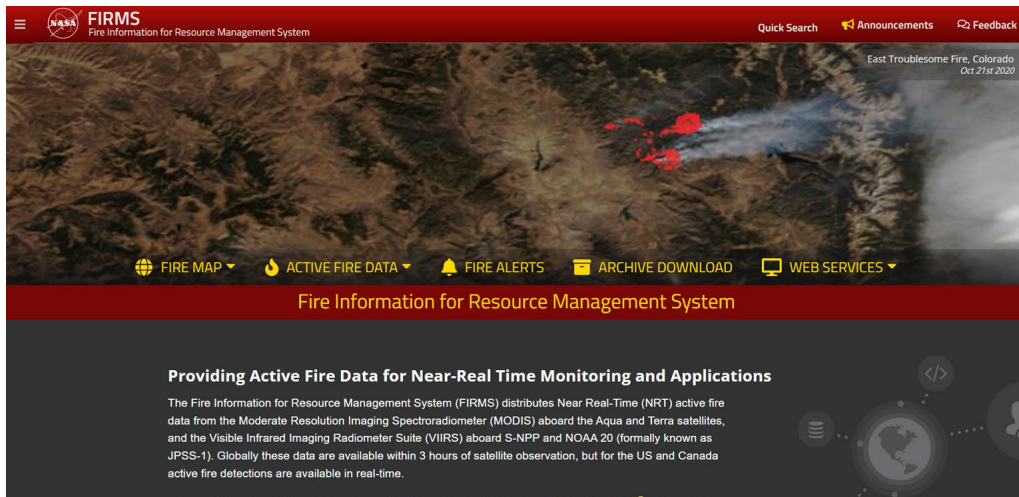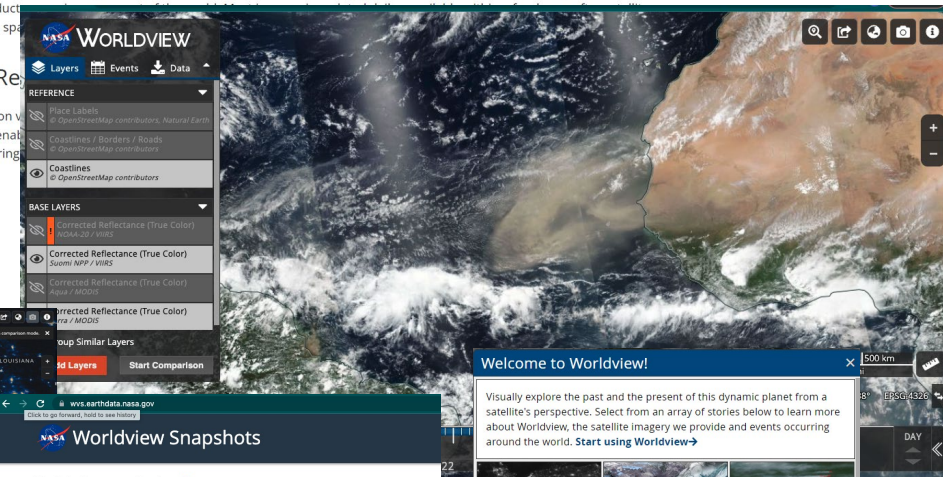- In addition to distributing NRT data
  - Global Imagery Browse Services (GIBS)
  - Worldview (and Worldview Snapshots)
  - Fire Information for Resource Management System (FIRMS)
  - Flood mapping tool was incorporated as a part of LANCE in 2021
    - MODIS NRT flood product (replaces legacy flood product generated since 2012)
  - Most recently Ultra Real Time
  - "Lower" latency
    - ICESat-2 products (added, 2022)
      - Includes: Sea Ice Freeboard product, Atmosphere Cloud Layer Characteristics and 5 other products
      - Added through ⬛ Satellite Needs Working Group process

Fire Information for Resource Management System (FIRMS)

Originally developed at the University of Maryland. It was funded by NASA's Applied Sciences and the United Nations (UN) Food and Agriculture Organization (FAO) using data from MODIS Rapid Response

FIRMS became part of LANCE in 2012
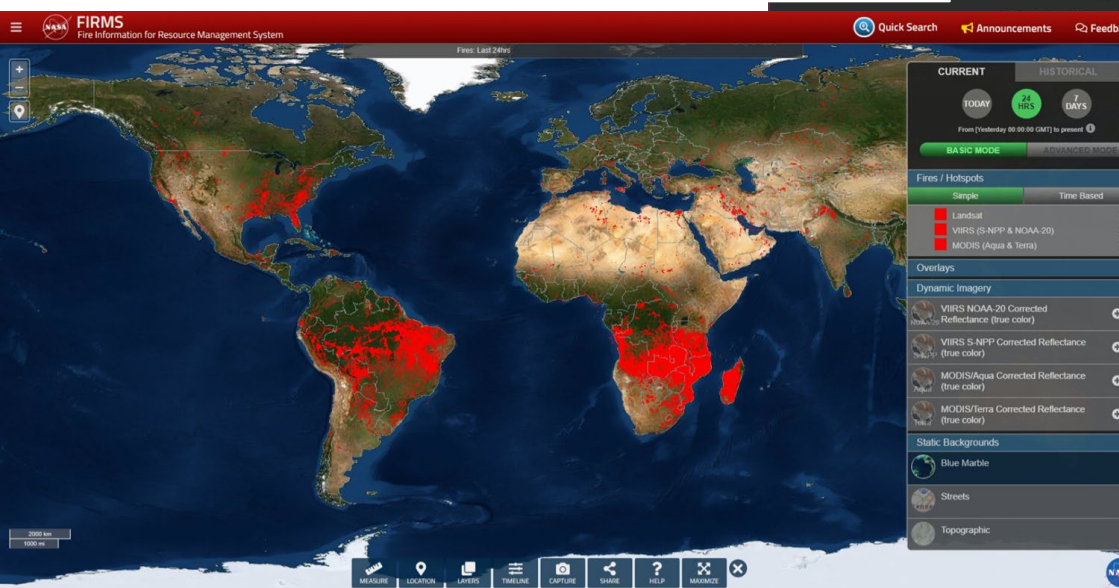
FIRMS US/Canada

- Beta version – released 2021

- Modernizes/optimizes the legacy USFS Active Fire Mapping Program

- Builds on the global Fire Information for Resource Management (FIRMS) capabilities

- Uses NRT/RT remote sensing science data/products for the US/Canada

- Supports the USFS/interagency fire management and general public data needs

- https://firms.modaps.eosdis.nasa.gov/usfs/

https://earthdata.nasa.gov//firms   https://firms.modaps.eosdis.nasa.gov/   - https://firms.modaps.eosdis.nasa.gov/usfs

Current LANCE Facilities

Map legend:
- Data Center
- SIPS, SCF, SDS

Map labels:
- **JPL** — MLS SIPS, SMAP SDS, AIRS SCF, MISR SCF
- **NCAR** — MOPITT SIPS
- **NSIDC DAAC** — SMAP, ICESat-2
- **SSEC UW-Madison Atmosphere SIPS** — VIIRS (S-NPP)
- **GES DISC** — AIRS &MLS
- **GSFC** — OMI SIPS
- **GSFC** — ICESat-2 SIPS
- **MODAPS/Land SIPS** — MODIS (Terra & Aqua) & VIIRS (S-NPP)
- **ASDC** — MISR
- **GHRC** — AMSR SIPS, LIS (ISS)
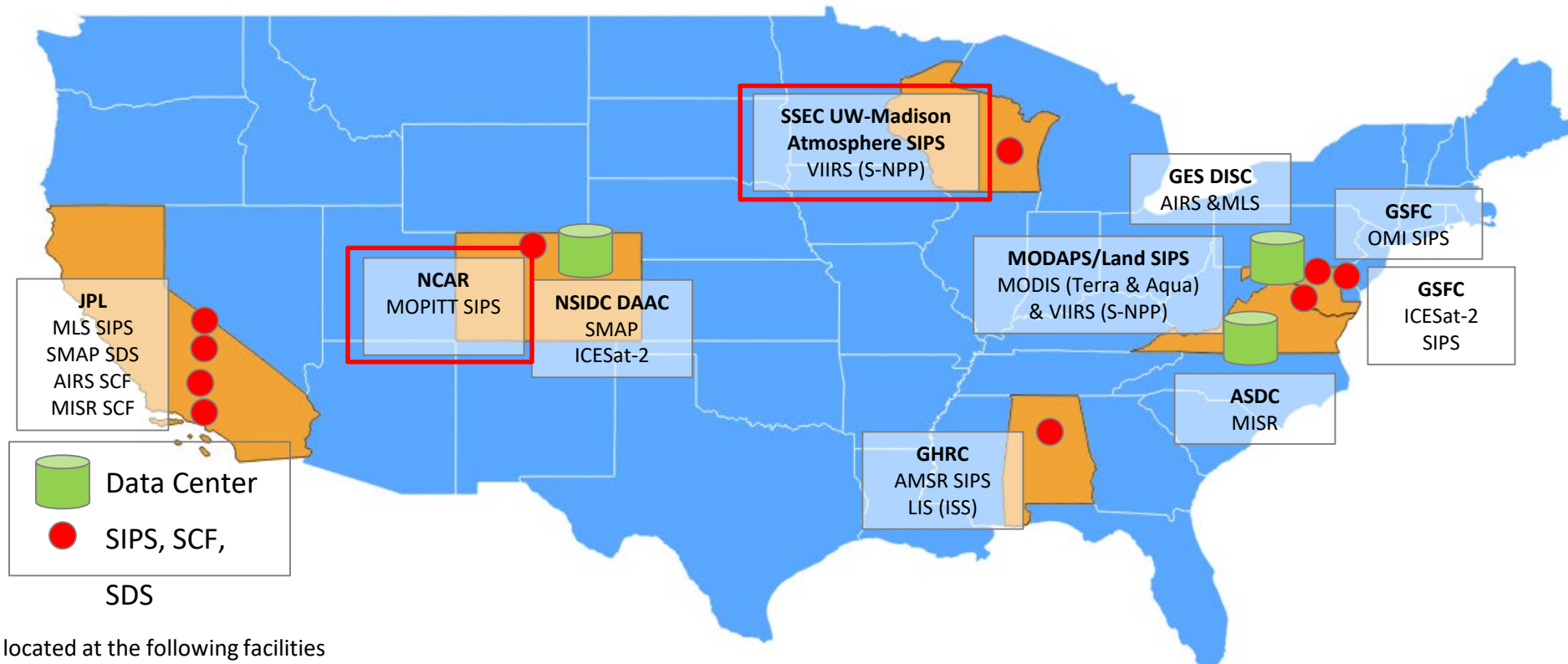
The LANCE elements are located at the following facilities
- **GSFC Earth Sciences Data and Information Services Center (GES DISC)** is providing AIRS with support from the AIRS Science Computing Facility (SCF) at JPL , and MLS data via the MLS SIPS at JPL
- **Atmospheric Science Data Center (ASDC)** is providing MISR data with support from the MISR SCF at JPL
- **AMSR Science Investigator-led Processing System (SIPS)** is providing AMSR2 and LIS data
- **MODIS Adaptive Processing System (MODAPS) and Land SIPS** are providing MODIS and VIIRS Land data
- **OMI Science Investigator-led Processing System (SIPS)** is providing OMI and OMPS data
- **MOPITT SIPS (National Center for Atmospheric Research (NCAR))** is providing MOPITT data
- **Atmosphere SIPS (Space Science and Engineering Center (SSEC) University of Wisconsin)** is providing VIIRS Atmosphere data
- **The Jet Propulsion Lab (JPL) Science Data System (SDS)** is providing SMAP data for distribution by the National Snow and Ice Data Center (NSIDC)
- **The Ice, Cloud and land Elevation Satellite-2 SIPS** is providing the ICESat-2 data for distribution by the National Snow and Ice Data Center (NSIDC)
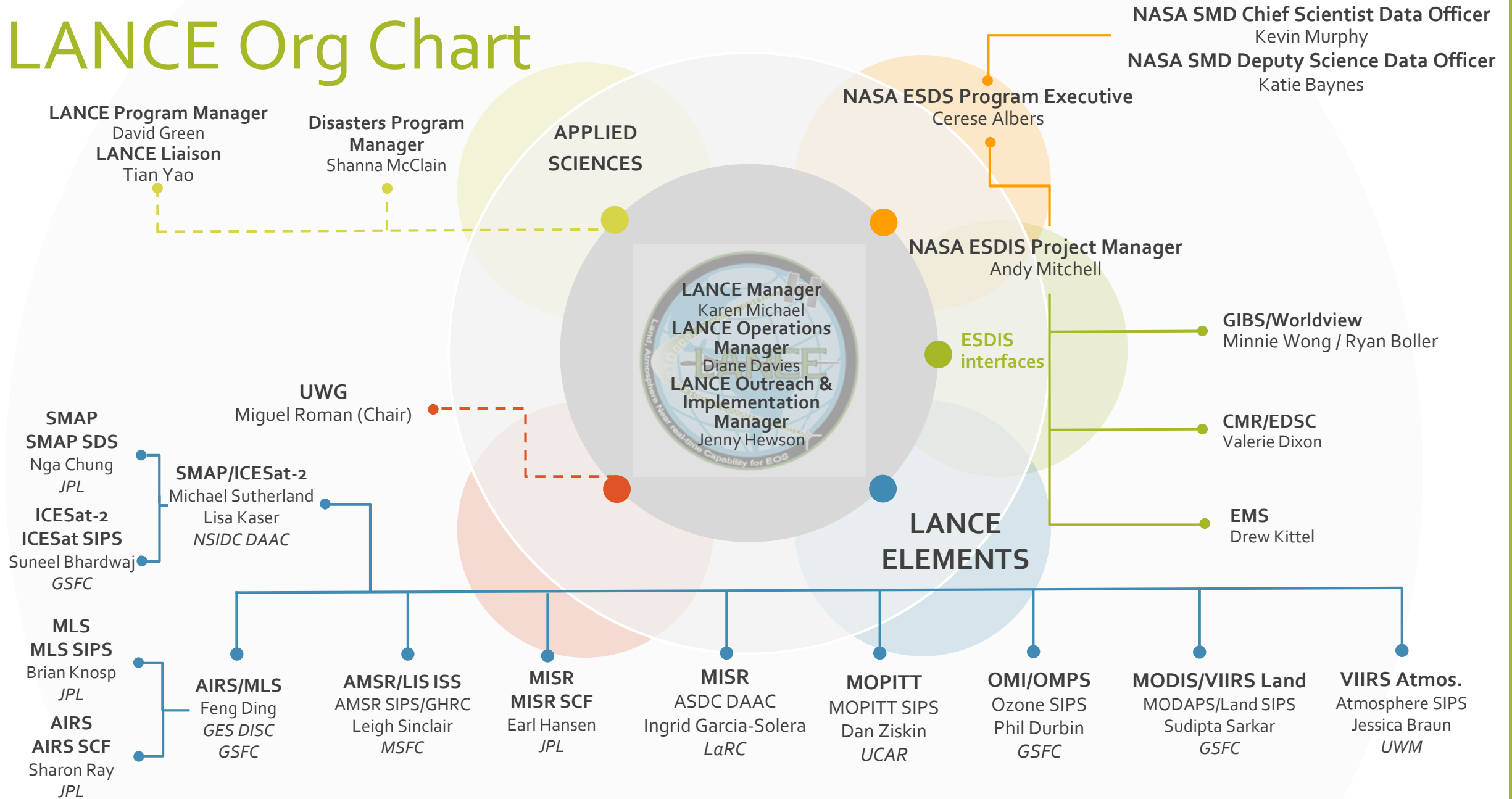
LANCE UWG Members 2022

Name	Affiliation
Miguel Roman/Chair	Leidos Senior Director and Chief Scientist of Climate and Environment
Robert Brakenridge	Colorado/Dartmouth Flood Observatory
Arlindo da Silva	NASA/Goddard
Vanessa Escobar	NOAA/NESDIS
Mike Fromm	NRL/Washington DC
Sean Helfrich	NOAA/NESDIS/OSPO
Steve Miller	Colorado State University
Maggi Glasscoe	UAH/MSFC
Brad Quayle	USFS
Josh Cossuth	NRL/Monterey/Washington DC
Mark Trice	MD DNR
Mike Budde	USGS
Patrick Duran	NASA/MSFC/SPoRT
Lori Schultz	NASA/MSFC/Disasters
Fred Stolle	WRI

LANCE Architecture

Data Acquisition | Data Capture & Processing | Data to SIPS | Science Data Processing & Distribution | Distribution & Access
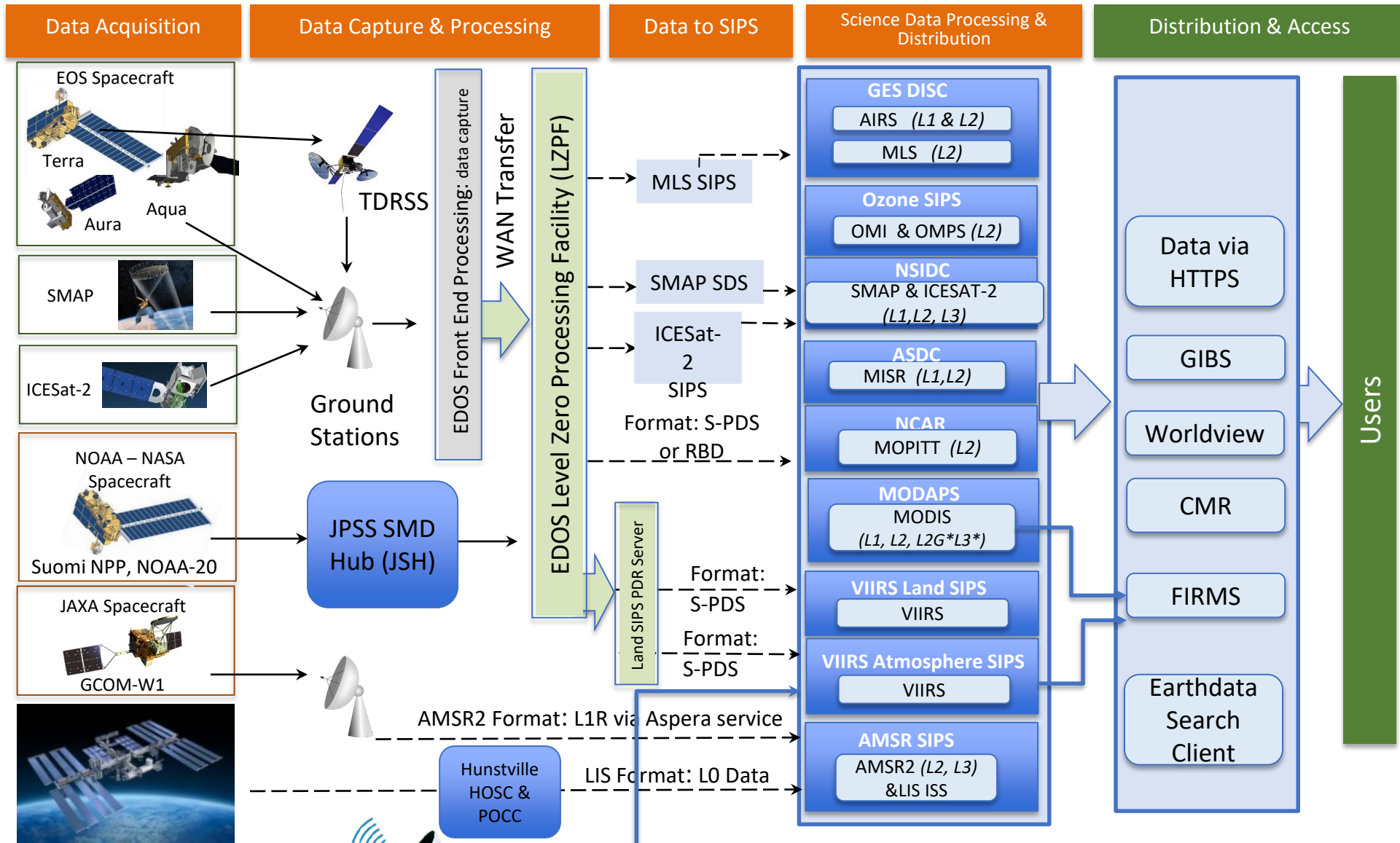
RBD: Rate Buffered Data, S-PDS: Session Based Production Data Set
*MODIS & VIIRS L2G and L3 products are 27 – 48 hours, ICESat-2 L3 has a latency of 3 days
SIPS: Science Investigator-led Processing Systems, TDRSS: Tracking and Data Relay Satellite System, SDS: Science Data System

LANCE in a Nutshell

GOAL OF LANCE:

Reliable Near Real Time Data < 3 hrs from Observation time Real-time (NRT) data products to meet the timely needs of applications users.

Science Team —Algorithms→ **Development, I&T, Production**

Science Team ←QA→ **Development, I&T, Production**

Input Data —Level Zero→ **Development, I&T, Production**

Input Data —Ancillary→

LANCE Secondary

Development, I&T, Production —Metrics→ **EMS** EOSDIS Metrics System

Development, I&T, Production —Imagery→ **GIBS** Global Imagery Browse Services

GIBS → **FIRMS**

GIBS → **Worldview**

LANCE Primary

Development, I&T, Production —Metadata→ **CMR** Common Metadata Repository

CMR → **Earthdata Search**

Earthdata Login ←Authentication→ **Users**

Archive 7-14 day Rolling ←Product Distribution https,subscription→ **Users**

User Services 8am-5pm weekdays ←Support, Notifications→ **Users**
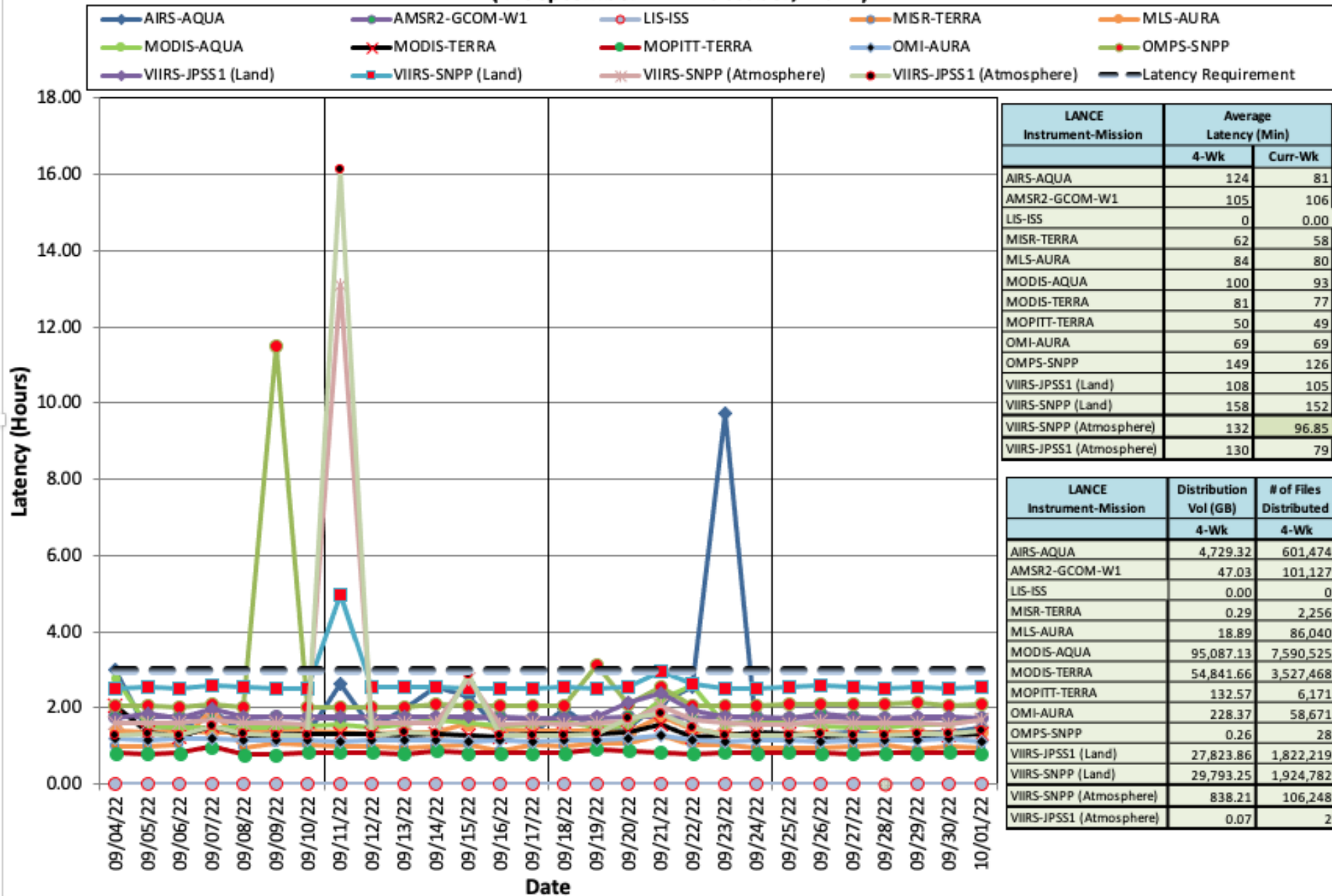
Latency Defined

Data latency is defined here as the elapsed time between satellite observation and the time data are available to the end user. The definitions were adopted by NASA EOSDIS in May 2018.

- *Recommend these definitions be used in NASA Proposal calls to ensure consistent terms are used*
- *Ultra real-time[1] data added recently*

Term	Latency*	Purpose
Real-time	Less than 1 hour	These terms are often used to refer to data that are made quicker than routine processing allows. They are used for a range of applied sciences, decision and tactical support, monitoring and early warning of events.
Near real-time (NRT)	1-3 hours	
Low latency	3-24 hours	
Expedited	1-4 days	
Standard routine processing	Generally, 8 – 40 hours but up to 2 months for some higher-level products	Standard products provide an internally consistent, well-calibrated record of the Earth's geophysical properties to support science

Earthdata article on latency (https://earthdata.nasa.gov/learn/articles/data-latency)

Four Week LANCE-Wide Latency and Distribution Trend for Level 0, 1, & 2 Products
(4 September - 1 October, 2022)

Legend: AIRS-AQUA, AMSR2-GCOM-W1, LIS-ISS, MISR-TERRA, MLS-AURA, MODIS-AQUA, MODIS-TERRA, MOPITT-TERRA, OMI-AURA, OMPS-SNPP, VIIRS-JPSS1 (Land), VIIRS-SNPP (Land), VIIRS-SNPP (Atmosphere), VIIRS-JPSS1 (Atmosphere), Latency Requirement

LANCE Instrument-Mission	Average Latency (Min)	
	4-Wk	Curr-Wk
AIRS-AQUA	124	81
AMSR2-GCOM-W1	105	106
LIS-ISS	0	0.00
MISR-TERRA	62	58
MLS-AURA	84	80
MODIS-AQUA	100	93
MODIS-TERRA	81	77
MOPITT-TERRA	50	49
OMI-AURA	69	69
OMPS-SNPP	149	126
VIIRS-JPSS1 (Land)	108	105
VIIRS-SNPP (Land)	158	152
VIIRS-SNPP (Atmosphere)	132	96.85
VIIRS-JPSS1 (Atmosphere)	130	79

LANCE Instrument-Mission	Distribution Vol (GB)	# of Files Distributed
	4-Wk	4-Wk
AIRS-AQUA	4,729.32	601,474
AMSR2-GCOM-W1	47.03	101,127
LIS-ISS	0.00	0
MISR-TERRA	0.29	2,256
MLS-AURA	18.89	86,040
MODIS-AQUA	95,087.13	7,590,525
MODIS-TERRA	54,841.66	3,527,468
MOPITT-TERRA	132.57	6,171
OMI-AURA	228.37	58,671
OMPS-SNPP	0.26	28
VIIRS-JPSS1 (Land)	27,823.86	1,822,219
VIIRS-SNPP (Land)	29,793.25	1,924,782
VIIRS-SNPP (Atmosphere)	838.21	106,248
VIIRS-JPSS1 (Atmosphere)	0.07	2

LANCE Users

LANCE products are routinely used by **direct users**, who access data for their own purposes and by **brokers** who add value to the data by combining it with other specialist knowledge and serve it to targeted end users.

Weather / Aerosols

- European Centre for Medium-Range Weather Forecasts
- NASA's Global Modeling and Assimilation Office
- Naval Research Laboratory

Flood

- Federal Emergency Management Agency
- Dartmouth Flood Observatory
- United Nations Satellite Centre

Disasters monitoring

- NASA Disasters Program
- NASA Short-term Prediction Research and Transition Center

Agricultural Monitoring

- USDA /USAID – FEWSNet
- USDA Foreign Agricultural Service

Fires, Smoke and Air Quality

- US Forest Service
- US Climate Resilience Toolkit
- Conservation International
- World Resources Institute
- Governments in India and Thailand
- Greenpeace
- Breezometer

Various News Outlets e.g. The Washington Post, The New York Times, BBC, CNN

Number of NRT Product Files Distributed by LANCE during
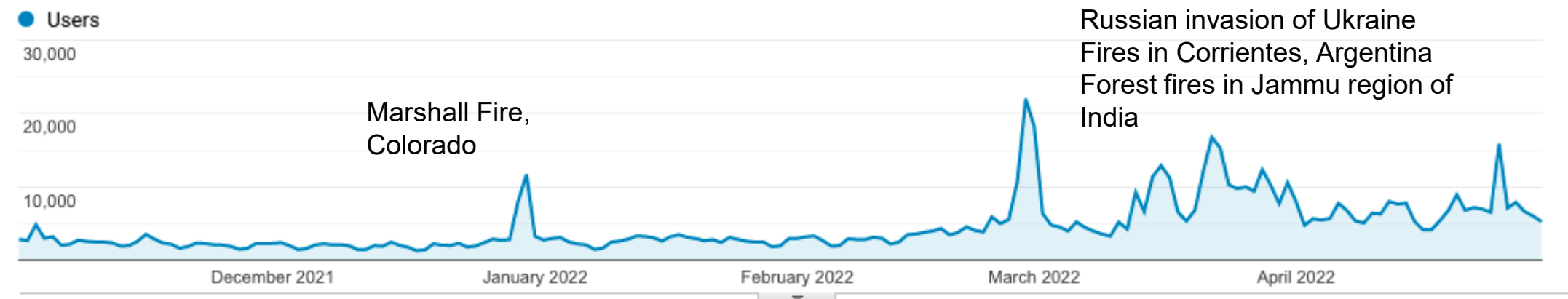(1 April 2021 to 31 March 2022)

May overlay showing where users are from excluding the United States
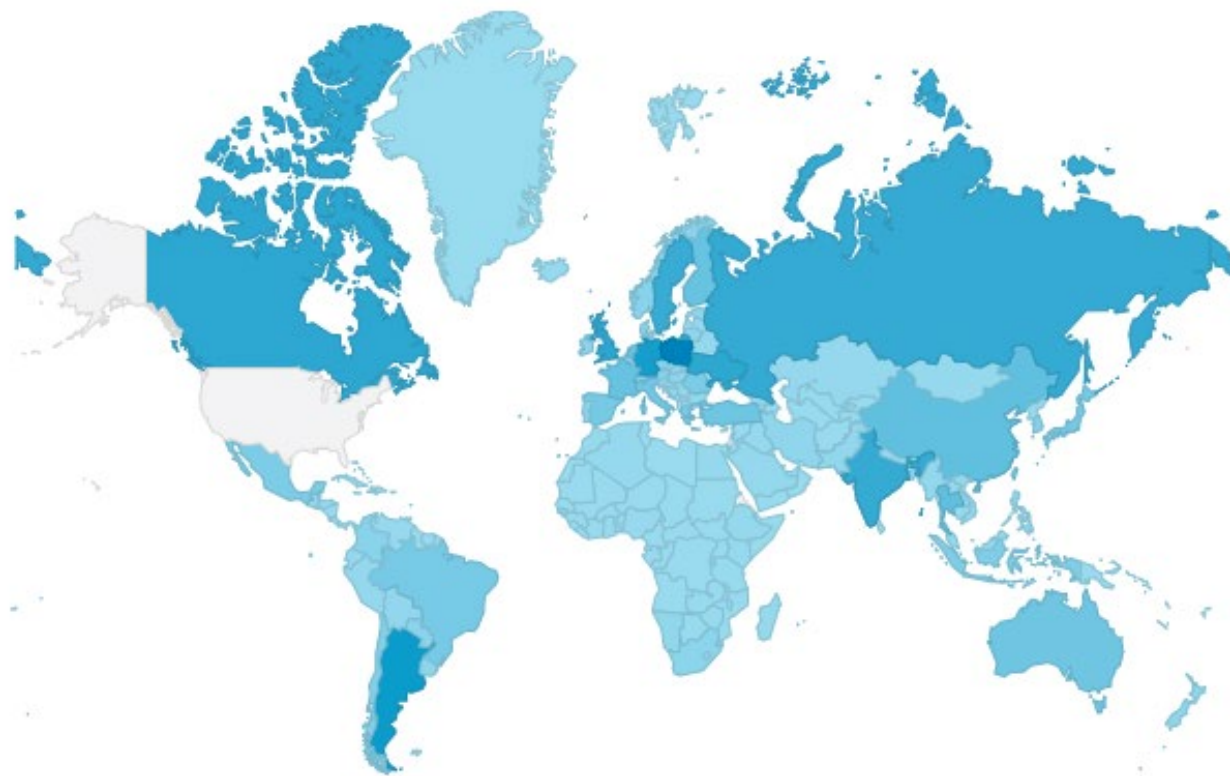
Country	Acquisition	
	Users ↓	New Users
	535,821 % of Total: 100.00% (535,821)	515,787 % of Total: 100.22% (514,653)
1. 🇺🇸 United States	161,734 (30.13%)	160,333 (31.09%)
2. 🇵🇱 Poland	32,597 (6.07%)	32,190 (6.24%)
3. 🇦🇷 Argentina	22,488 (4.19%)	20,764 (4.03%)
4. 🇩🇪 Germany	21,751 (4.05%)	20,541 (3.98%)
5. 🇨🇦 Canada	18,536 (3.45%)	17,740 (3.44%)
6. 🇬🇧 United Kingdom	18,530 (3.45%)	17,795 (3.45%)
7. 🇺🇦 Ukraine	18,330 (3.42%)	18,034 (3.50%)
8. 🇷🇺 Russia	17,324 (3.23%)	16,749 (3.25%)
9. 🇮🇳 India	17,129 (3.19%)	16,050 (3.11%)
10. 🇸🇪 Sweden	16,532 (3.08%)	16,297 (3.16%)

Decommissioning of Terra, Aqua, Aura

- Current plan per the ESMO project:

	Inguide				Overguide		
	Terra	Aqua	Aura		Terra	Aqua	Aura
Constellation Exit	Oct-2022	N/A	Sep-2023		Oct-2022	N/A	Aug-2024
End Science	Dec-2023	Aug-2023	Aug-2023		Mar-2027	Aug-2026	Aug-2025
Passivation	Jan-2024	Jan-2024	Jan-2024		Apr-2027	Sep-2026	Sep-2025

- Decommissioning of Terra, Aqua and Aura 🡪 loss of LANCE data

- **AIRS** - Atmospheric Infrared Sounder
- **AMSR2** - Advanced Microwave Scanning Radiometer 2
- **LIS ISS** - Lightning Imaging Sensor on the International Space Station
- **ICESat-2** - Advanced Topographic Altimeter System (ATLAS) on the Ice, Cloud, and land Elevation Satellite
- **MISR** - Multi-angle Imaging SpectroRadiometer
- **MLS** - Microwave Limb Sounder

- **MODIS** - Moderate Resolution Imaging Spectroradiometer
- **MOPITT** - Measurements of Pollution in the Troposphere
- **OMI** - Ozone Monitoring Instrument
- **OMPS** - Ozone Mapping and Profiler Suite
- **VIIRS-Atmosphere** - Visible Infrared Imaging Radiometer Suite
- **VIIRS-Land** - Visible Infrared Imaging Radiometer Suite

- VIIRS data is available in LANCE for continuity with MODIS (PM)
- OMPS data is available in LANCE for continuity with OMI
- ATMS and CrIS data: available in NRT to a limited customer base from NOAA; would there be value in obtaining permission to re-distribute the NOAA products through LANCE?
- Sentinel 3: some potential for continuity with MODIS (AM); LANCE pilot study underway (Fire product from EUMETSAT for FIRMS; Corrected Reflectance and Land Surface Reflectance for Worldview).

ICAP Relevant Products
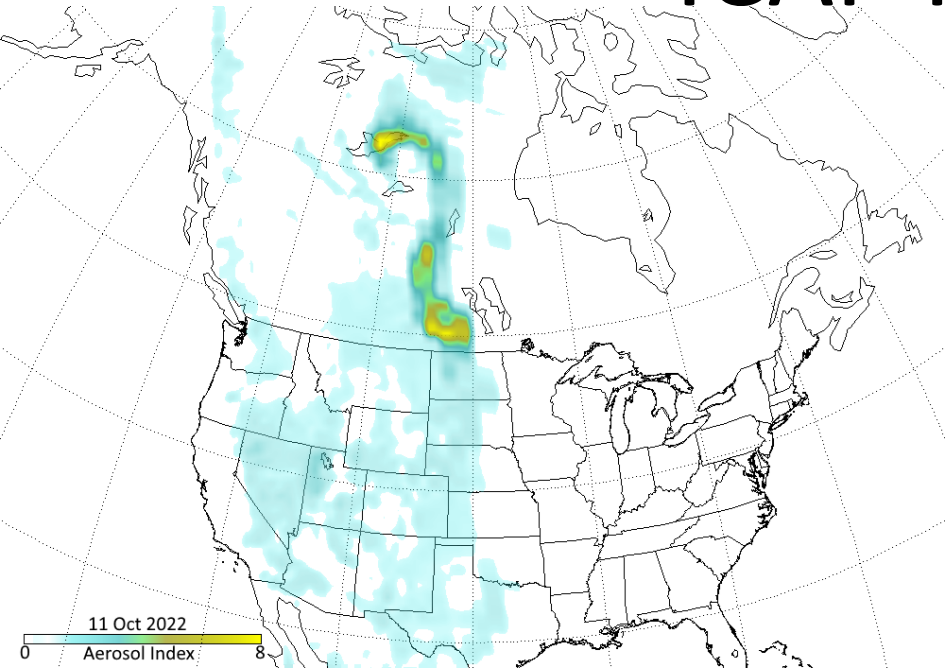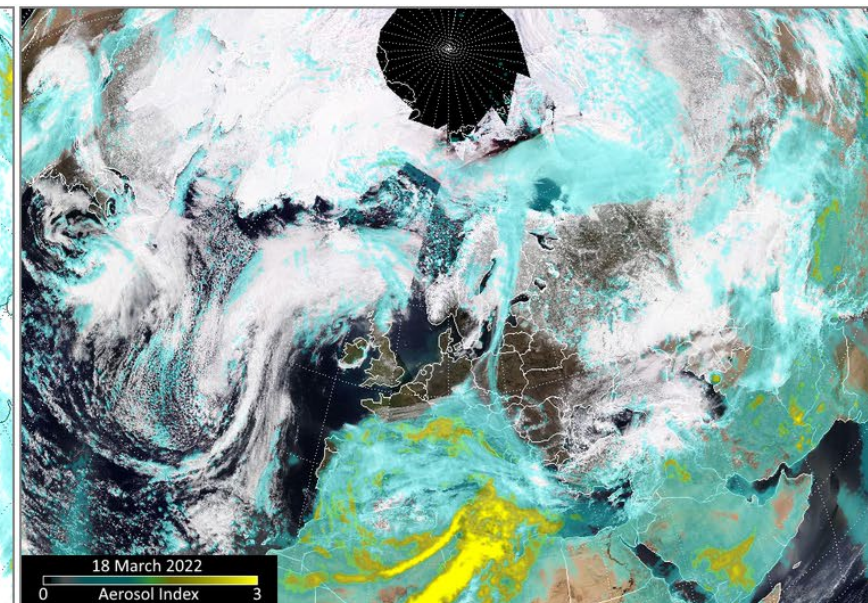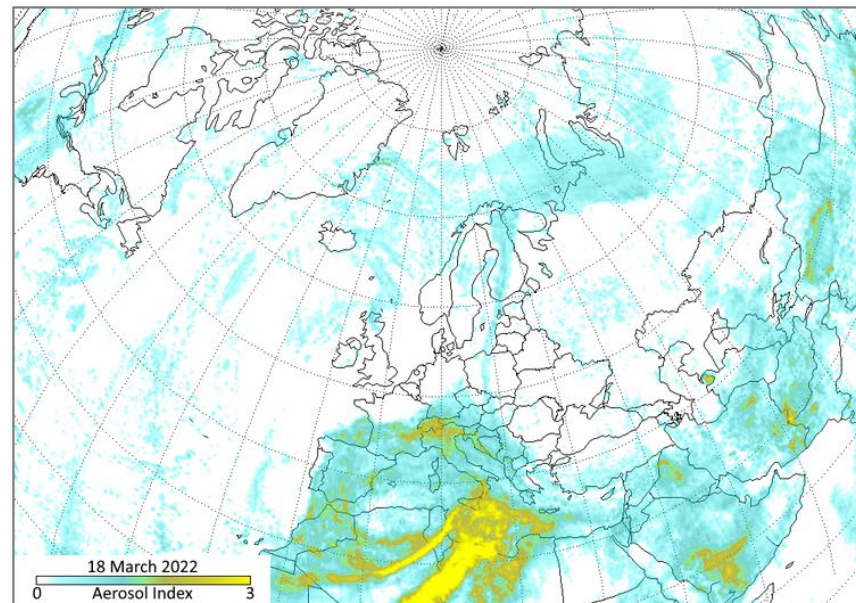

SNPP OMPS AI (11/10/22)

Smoke plume from PyroCumulus event over NW territories
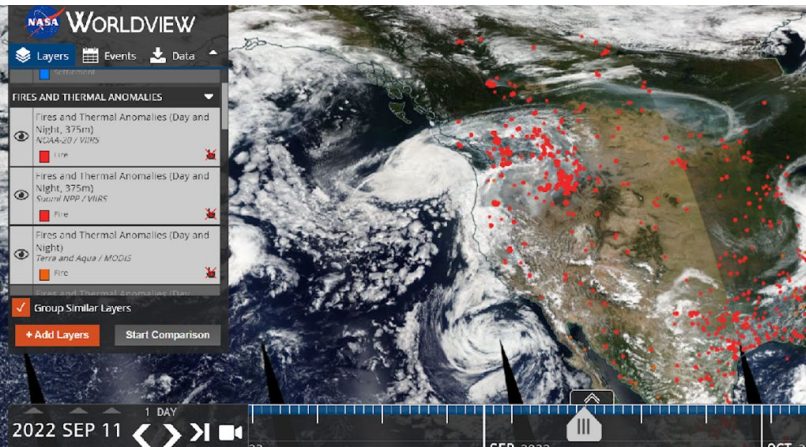
Provided by C. Seftor

NOAA-20 OMPS AI (03/18/22)

Dust-Infused Baroclinic storm transporting dust over Europe and Artic Ocean
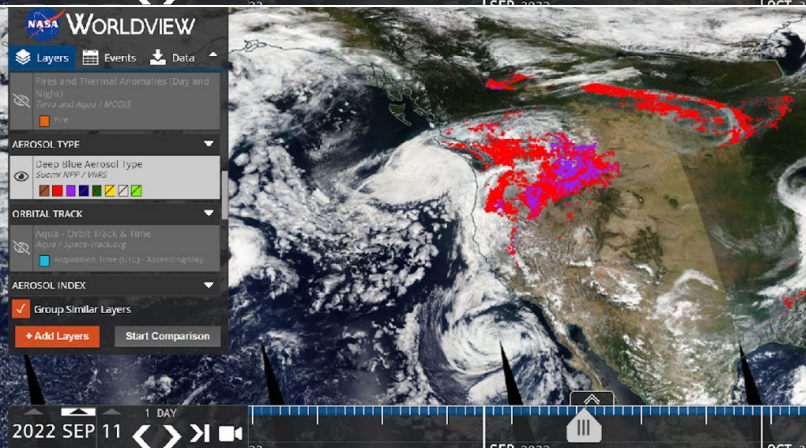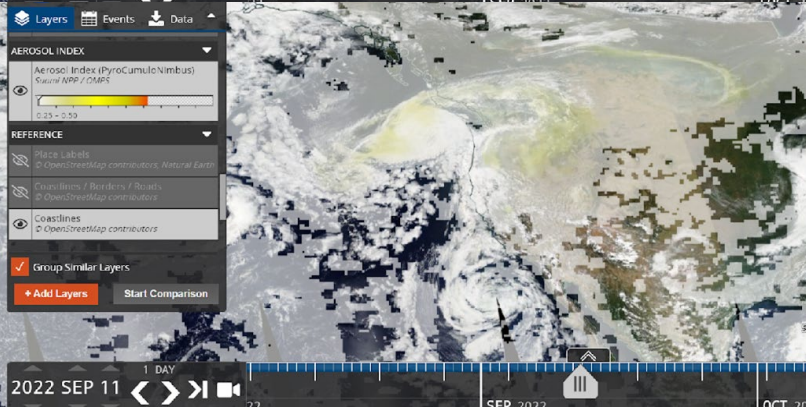
Provided by C. Seftor

ICAP Relevant Products

NOAA-20 VIIRS; SNPP VIIRS, A/T MODIS (09/11/22)

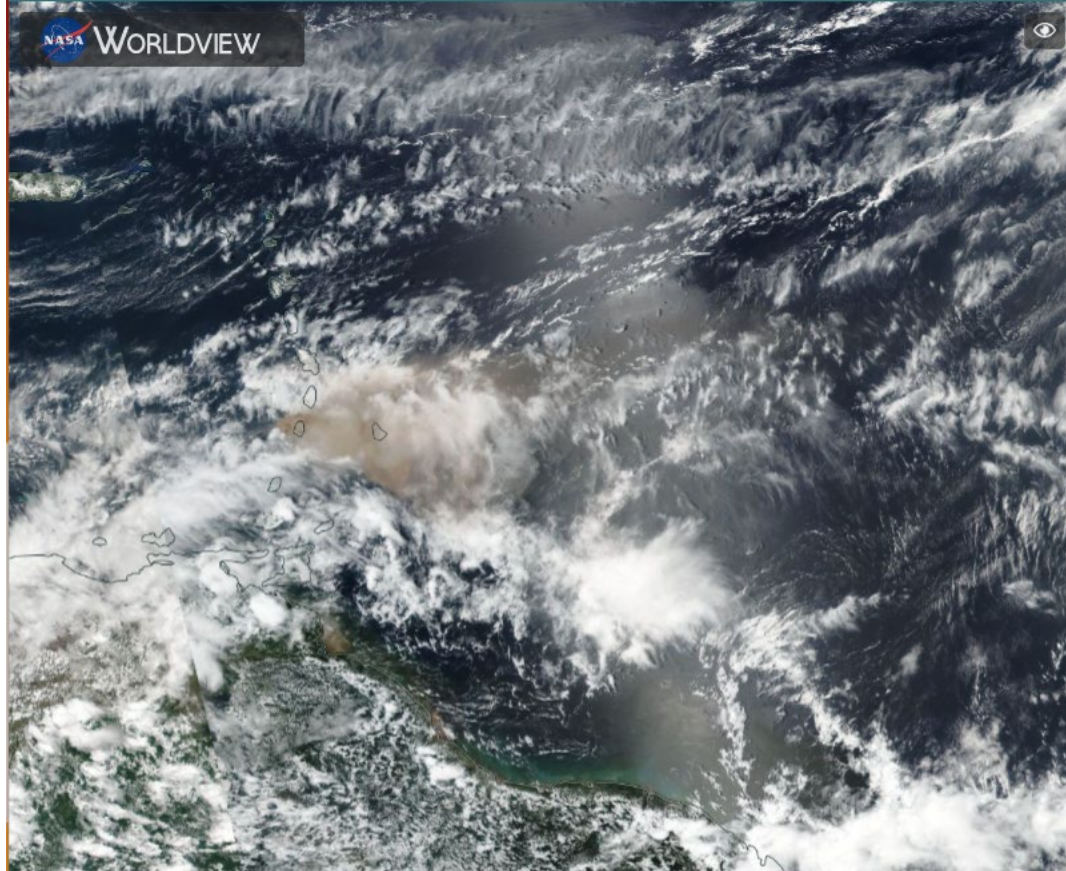Fires and Thermal Anomalies - Idaho

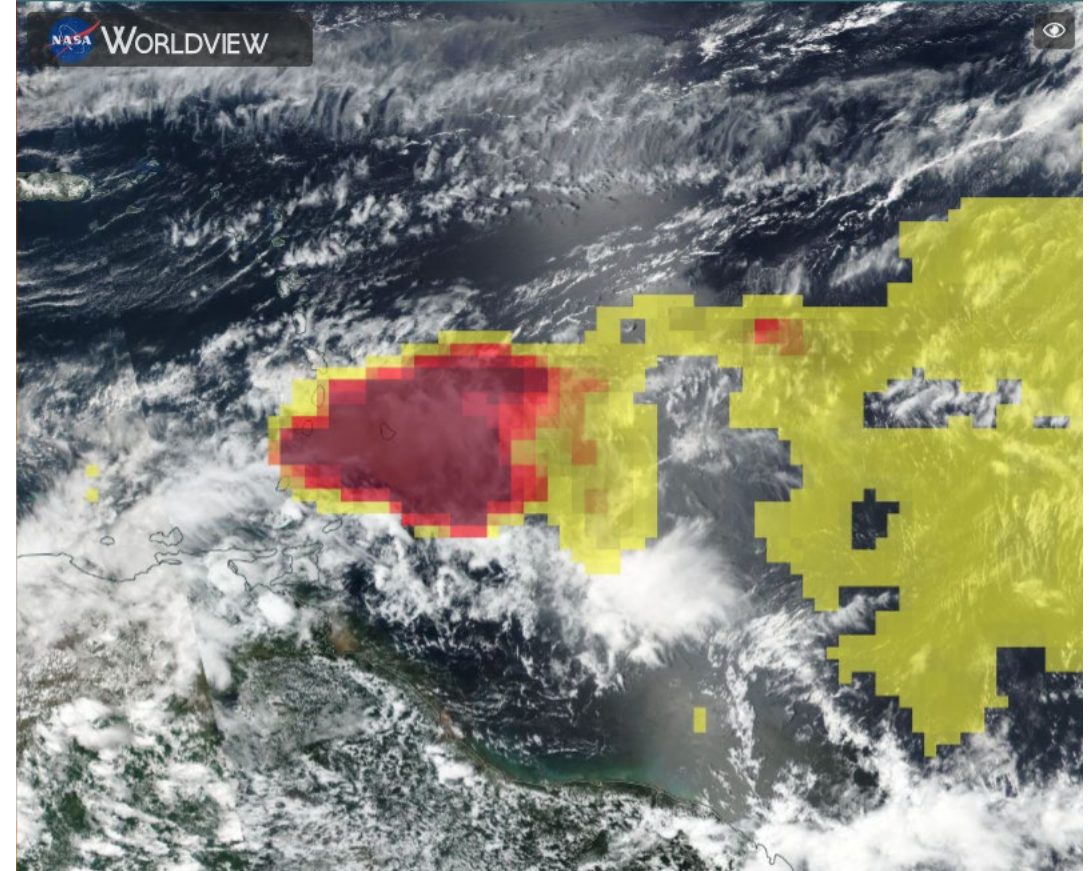SNPP VIIRS Aerosol Type (09/11/22)

Smoke and high-altitude smoke

SNPP OMPS AI (09/11/22)

PyroCumuloNimbus layer

ICAP Relevant Products

SNPP VIIRS Corrected Reflectance (04/10/21)
Soufrière St Vincent Volcano Eruption

SNPP OMPS AI (04/10/21)
Soufrière St. Vincent Volcano Eruption

Other Potential LANCE Products

- TROPICS (Time-Resolved Observations of Precipitation structure and storm Intensity with a Constellation of Smallsats) Constellation-cost capped mission
  - Pathfinder launched June 30th 2021; Production at UWM and archive at the GES DISC
  - Three more launches in the near future which will introduce 6 more CubeSat's (3 pairs)**
  - NOAA funded a Pathfinder latency demonstration to reduce latency from 12 hrs to 1-2 hrs
- TEMPO (Tropospheric Emissions: Monitoring of Pollution) Mission-cost capped mission
  - NRT products have been requested through the SNWG to assist in forecasting and modeling efforts. Air quality products identified were NO_2, HCHO,SO_2 as well as adapting OMI algorithms for some additional trace gas products
  - Ways to reduce the latency and funding are being explored by NASA and NOAA
- SNWG (Satellite Needs Working Group) Products
  - Many additional products will be coming through the SNWG and some will not be NRT but may still serve the LANCE user community well e.g. ICESat-2 lower latency freeboard & ice thickness (>45 days to 3-5 days)
  - SNWG products will be considered for inclusion into LANCE on a case-by-case basis

Other Potential LANCE Products (part 2)

- AOS (Atmospheric Observing System)
  - NRT needs have been identified by the AOS application's team for weather forecasting and time critical decisions
    - Current AOS latency requirements:
      - 75% of radiometer data downlinked in <3 hours
      - 85% available in <4 hours
      - 95%-100% available in <5-6 hours

- SBG (Surface Biology and Geology)
  - The SBG application team indicated that latency less than 24 hrs would be sufficient for most applications although lower latency would add substantial benefit for some applications
  - Considering having a NRT processing stream in addition to the standard processing stream
    - Current SBG latency requirements:
      - <24 hours from collection through processing L2+ products
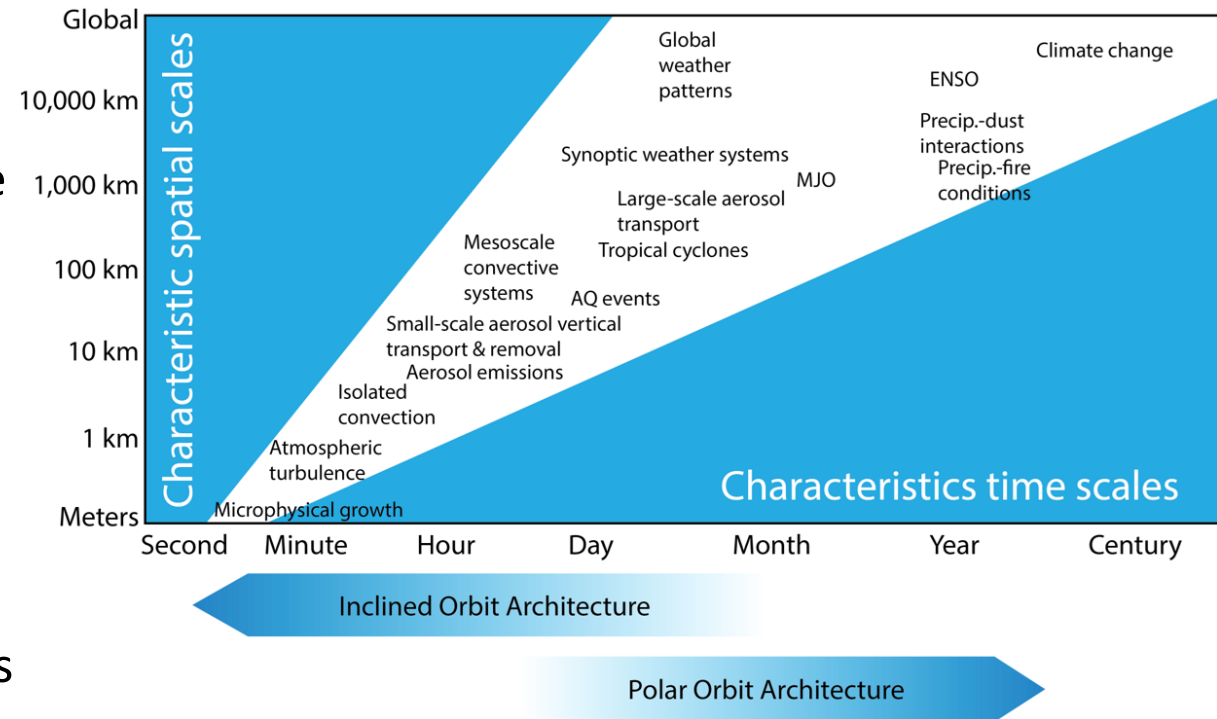
ICAP Recommendations?

- Are there any NRT products that you would like to see in LANCE?
  - For example: would ICAP members like to see the NRT NOAA produced ATMS and CrIS NRT products available in LANCE to replace AIRS when decommissioned?

- What is the process for requesting new products in LANCE?
  - A LANCE Enhancement request needs to be filled out and provided to the LANCE Manager
    - The enhancement request includes information about the product, why it is needed, who at HQ endorses the effort, the level of support needed for implementation, and letters of endorsement from the community
  - The request is reviewed by ESDIS, HQ and the LANCE UWG
    - If approved and funding is secured, implementation proceeds

LANCE Related URL's

- LANCE: https://earthdata.nasa.gov/LANCE
- FIRMS: https://firms.modaps.eosdis.nasa.gov/map
- FIRMS US/Canada: https://firms.modaps.eosdis.nasa.gov/usfs/map/
- Flood Mapping: https://www.earthdata.nasa.gov/learn/find-data/near-real-time/modis-nrt-global-flood-product
- Worldview: https://worldview.earthdata.nasa.gov/