National Aeronautics and Space Administration

Earth Science

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CEOS Land Surface Imaging Virtual Constellation Meeting
February 22, 2016

Land Imaging Evolution

While recognizing the scientific need for continuity with the 43-year Landsat record, we are seeing new trends & opportunities in land remote sensing

- *Evolving user needs for…*
    - *Improved temporal revisit*
    - *Additional spectral coverage & resolution*
    - *Integration with other modalities (lidar, radar)*
- *Increasing use of "small sat" platforms and distributed architectures*
- *Increasing number of commercial imaging systems*
- *Potential synergy with international systems (e.g. Sentinel-2)*
- *High-performance computing and increased emphasis on information rather than images*

Our challenge is to advance the measurement capability, while preserving continuity and constraining program costs

Sustainable Land Imaging (SLI) in the President's FY17 Budget

A 3-part program for a sustainable and responsible land imaging program through 2035:

1. **Landsat 9** (fully Class-B rebuild of Landsat 8) anticipated to launch in FY 2021
   - Low programmatic risk implementation of a proven system with upgrades to bring the whole system to Class B

2. **Land Imaging Technology and Systems Innovation**
   - Hardware, operations, and data management/processing investments to reduce risk in next generation missions

3. **Landsat 10**, Class B full spectrum, to launch ~2027-2028
   - Mission architecture to be informed by the technology investments (2015-), leading to definition ~2020

SLI: NASA Present Status

Landsat 9 Project initiated with FY15 funds
- Directed to NASA's Goddard Space Flight Center (GSFC)
- Project Office established and substantially staffed
- OLI-2 Instrument and Landsat 9 spacecraft procurement actions in work
- TIRS-2 development in progress
- Launch ASAP, likely NET 12/2020 – there is sufficient funding authority for FY16

Technology studies underway for Landsat 10 definition and long-term technology infusion
- Detector component development
- Overall instrument size reduction using advanced technologies
- ROSES SLI Technology call released (ROSES 2015 A.47 released 23 Dec 2015 with proposals due 30 Mar 2016)

NASA solicited, selected, and initiated science investigations focused on construction of multi-system fusion data sets ("Multi-Source Land Imaging Science")
- "...[W]e solicit for efficient use and seamless combination with Landsat, of satellite sensor data from international Landsat-type moderate resolution (~30 m ground resolution), multispectral sources on continental to global scales. A primary focus is on developing algorithms and prototyping products for combined use of data from Landsat and Sentinel-2 toward global land monitoring. However, we also welcome proposals combining Landsat with other sources of moderate resolution data, such as IRS and/or CBERS..."
- 7 investigations selected, $1.3M/year total, 3-year studies (see later slide)

Copernicus data access agreements with EU signed (including all Sentinel-2 data)
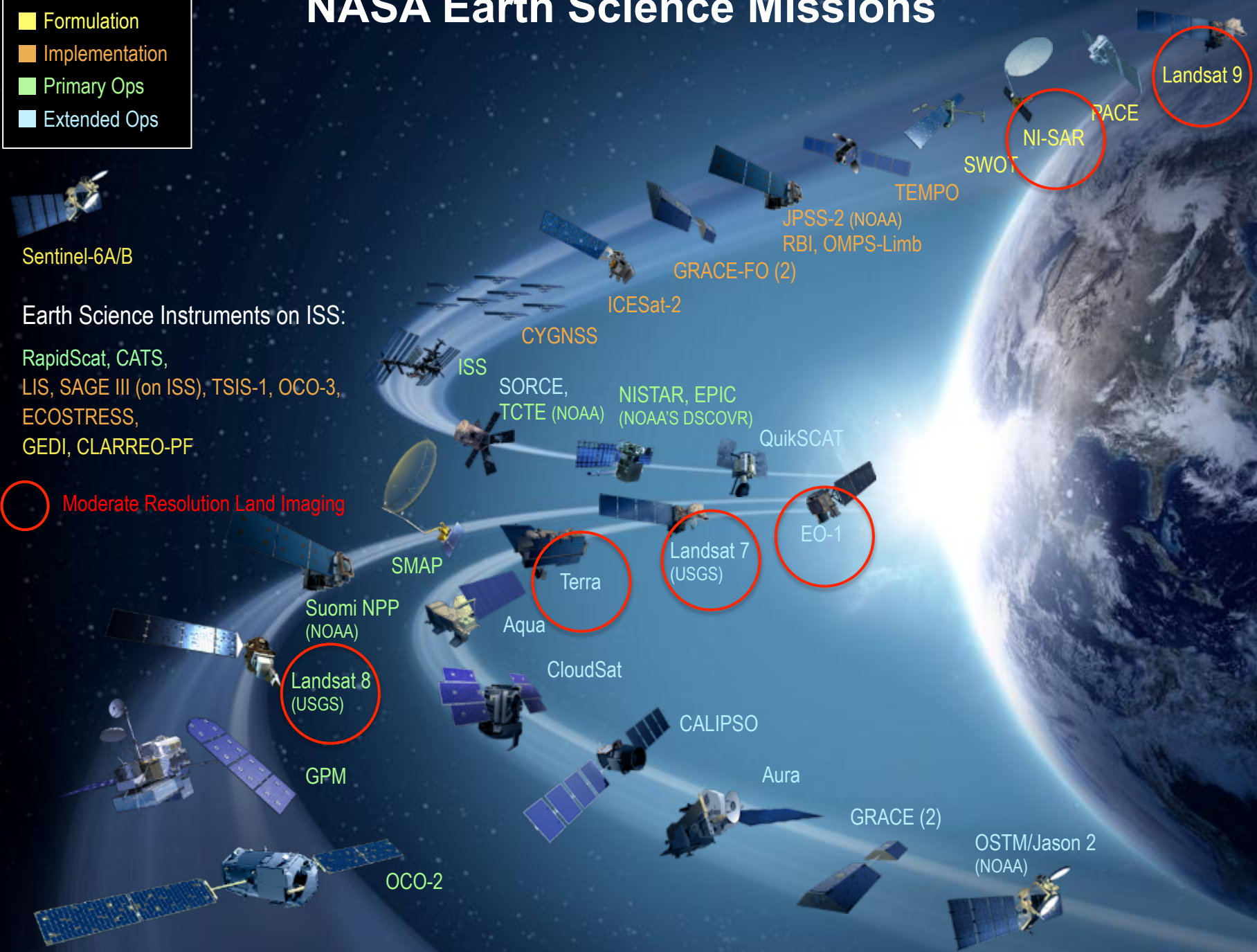
NASA Earth Science Missions

NASA Science Activities Relevant to LSI-VC

NASA is investing in synergistic use of international data sources to improve land monitoring

- Multi-Source Land Imaging Science (MuSLI) Team
  - Solicited through the Land Cover / Land Use Change (LCLCU) research program
  - 3-year activity to prototype land products from fusion of international systems, with focus on Sentinel-1,2 and Landsat (see next slide)
  - Coordinated with ESA SEOM (Scientific Exploitation of Operational Mission) Program

- Harmonized Landsat / Sentinel-2 (HLS) Reflectance Products
  - Goal: seamless, near-daily 30m surface reflectance record from Landsat-8 and Sentinel-2a,b
  - Includes common atmospheric correction, spectral & BRDF adjustment, resampling to common grid & frame ("data cube" concept)
  - Collaboration among NASA GSFC, ARC, and UMD
  - Implemented on NASA Earth Exchange (NEX) – initially as a series of test sites.

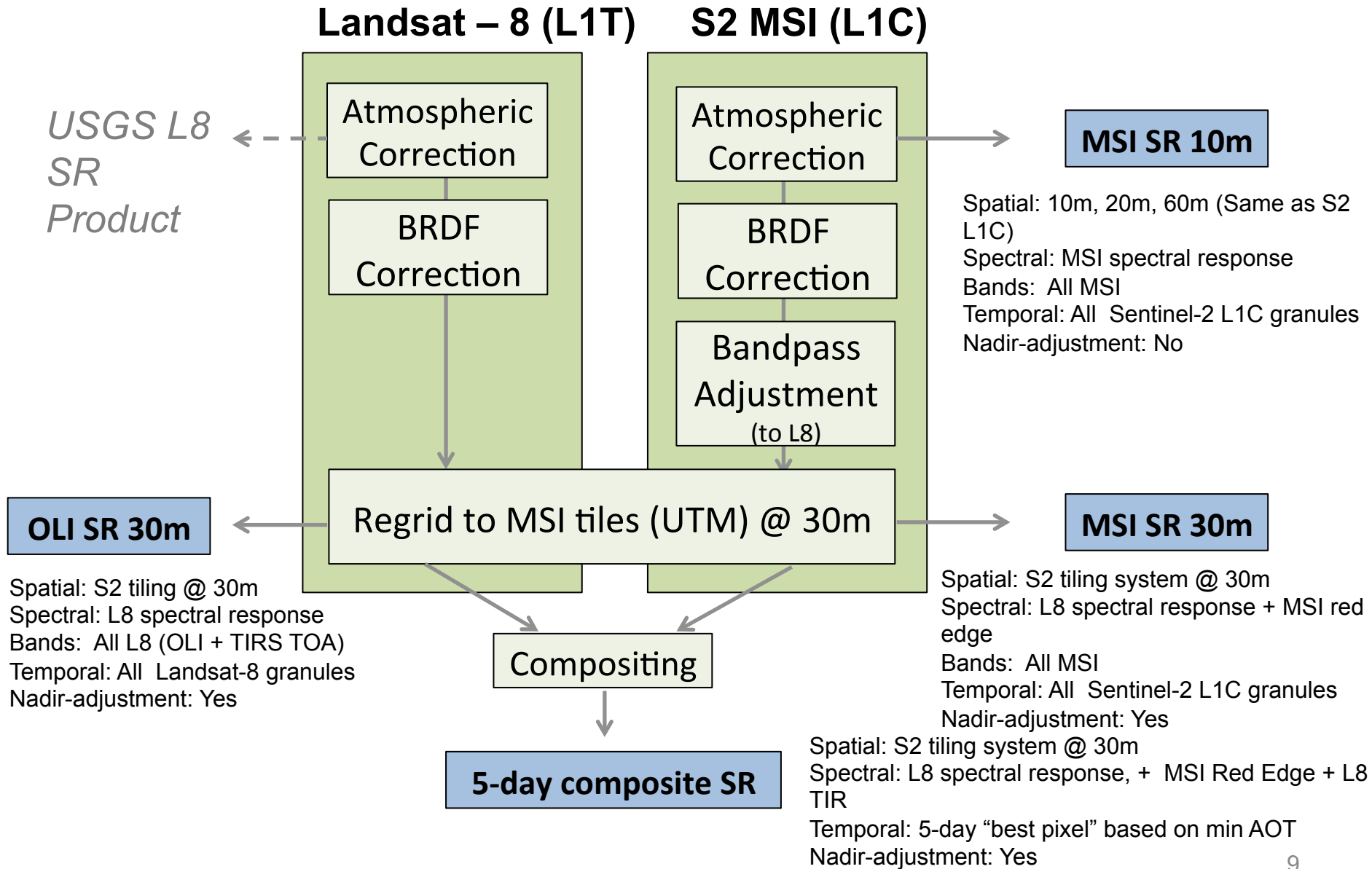# NASA Multi-Source Land Imaging Projects

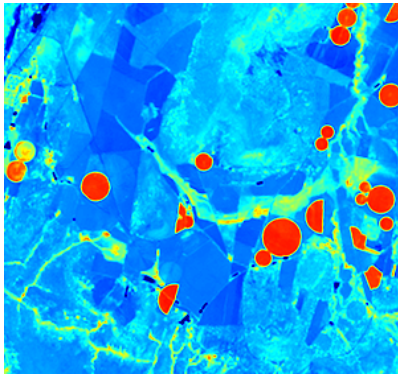| Project Title	PI	International Collaborators
Multisource Imaging of Seasonal Dynamics in Land Surface Phenology	Friedl/Boston U	Eklundh / Lund
Integrating Landsat 7, 8 and Sentinel 2 Data in Improving Crop Type Identification and Area Estimation	Hansen/U. Maryland	Defourny / Louvain
Towards Near Daily Monitoring of Inundated Areas Over North America Through Multi-Source Fusion of Optical and Radar Data	Lang / U. Maryland	Creed / Western
Prototyping a Landsat-8/Sentinel-2 Global Burned Area Product	Roy / SDSU	Chuvieco / Alcala; Tansey / Leicester
Operational Algorithms and Products for Near Real Time Maps of Rice Extent and Rice Crop Growth Stage Using Multi-Source Remote Sensing	Salas / Applied Geosystems	Hoekman / Wageningen; Le Toan / CESBIO
Multi-Source Imaging of Infrastructure and Urban Growth Using Landsat, Sentinel and SRTM	Small / Columbia U	Esch / DLR
Multi-Source Imaging of Time-Serial Tree and Water Cover at Continental to Global Scales	Townshend / U. Maryland	Schmullius /Jena

Back-up

HLS Processing & Products

Landsat – 8 (L1T)   **S2 MSI (L1C)**

USGS L8 SR Product

Landsat – 8 (L1T)
- Atmospheric Correction
- BRDF Correction

S2 MSI (L1C)
- Atmospheric Correction
- BRDF Correction
- Bandpass Adjustment (to L8)

MSI SR 10m

Spatial: 10m, 20m, 60m (Same as S2 L1C)
Spectral: MSI spectral response
Bands: All MSI
Temporal: All Sentinel-2 L1C granules
Nadir-adjustment: No

Regrid to MSI tiles (UTM) @ 30m

OLI SR 30m

Spatial: S2 tiling @ 30m
Spectral: L8 spectral response
Bands: All L8 (OLI + TIRS TOA)
Temporal: All Landsat-8 granules
Nadir-adjustment: Yes

MSI SR 30m

Spatial: S2 tiling system @ 30m
Spectral: L8 spectral response + MSI red edge
Bands: All MSI
Temporal: All Sentinel-2 L1C granules
Nadir-adjustment: Yes

Compositing

5-day composite SR

Spatial: S2 tiling system @ 30m
Spectral: L8 spectral response, + MSI Red Edge + L8 TIR
Temporal: 5-day "best pixel" based on min AOT
Nadir-adjustment: Yes

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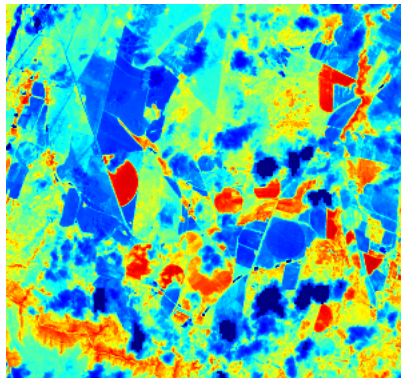# Initial HLS NDVI Time Series (Lydenburg, South Africa)
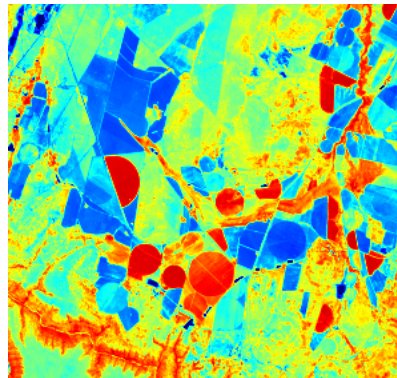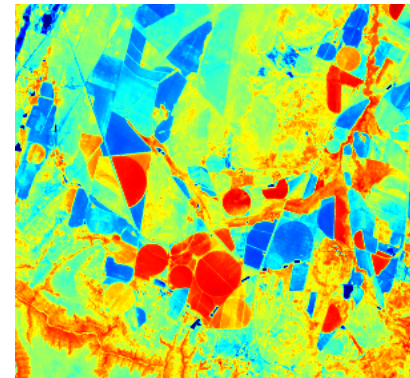
11 Oct

cloudy

30 Dec
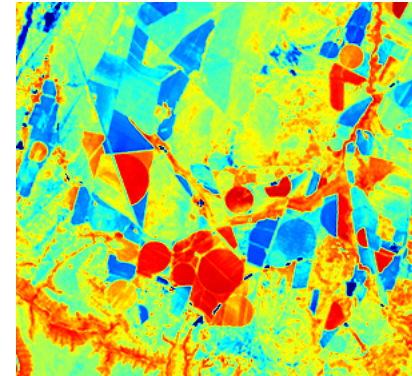
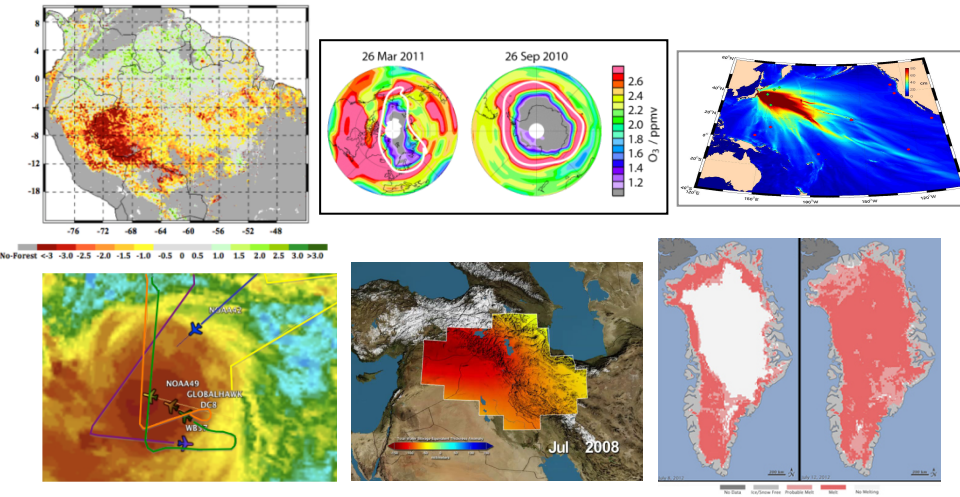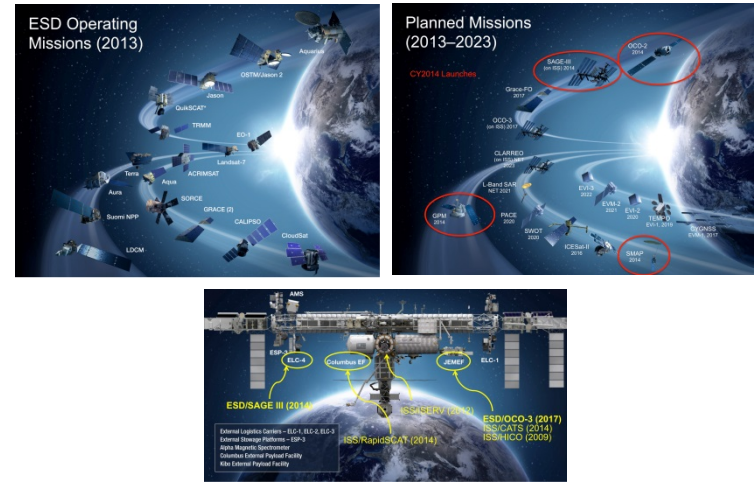L8 OLI

16 Dec

19 Dec
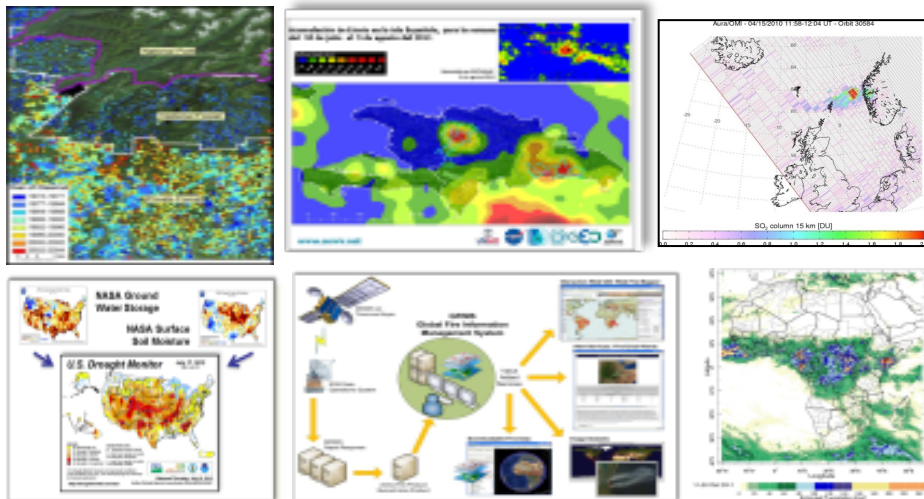

29 Dec

S2a MSI

NASA's Earth Science Division

Research

Flight

Applied Sciences

Technology