NASA Fire Products: Current Status and Future Recommendations

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Overview

- Current status of NASA fire products
  - MODIS, VIIRS, Landsat
  - Touch on Sentintel-3 (ESA)
- Assorted recommendations

NASA Active Fire + Burned Area Products

MODIS

MOD14/MYD14 active fire	1-km swath (L2)
MxD14A1, MxD14A2 active fire	1-km gridded daily, 8-day (L3)
Derived GIS products (SCF)	monthly fire locations, 0.25° monthly
MCD64A1 burned area	500-m gridded monthly (L3)
Derived GIS products (SCF)	shapefile, 500-m GeoTIFF, 0.25° monthly

VIIRS

VNP14IMG/VJ114IMG active fire	375-m swath (L2)
VNP14/VJ114IMG active fire	750-m swath (L2)
VNP14A1, etc. active fire	500-m gridded daily (L3)
Derived GIS products (SCF)	monthly fire locations
VNP64A1 burned area	500-m gridded monthly (L3)
Derived GIS products (SCF)	shapefile, 500-m GeoTIFF, 0.25° monthly

Fire Product Status

MODIS

- Collection 6 (C6) production commenced 2015–2016
- Collection 6.1 (C6.1) production commenced 2019 (now complete)
  - L1B polarization correction + minor staging fixes
  - No change in AF product; small differences in BA product
- C6 production to end December 2022
- Collection 7 reprocessing planned for late 2023 *(likely wildly optimistic)*
- MODIS end-of-life plans actively being reconsidered (range 2023-2026)

VIIRS

- Collection 1 (C1) remains current long past its expected lifetime
- Significant improvements made for Collection 2 (C2)
  - NOAA-like SDR → NASA Level 1B transition
  - S-NPP VIIRS - all products; NOAA-20 VIIRS - subset of products
- Collection 2 (C2) Land reprocessing commenced 9 Sep. 2022
  - Public release TBD

VIIRS Active Fire (VNP14/VNP14IMG)

Product Overview

- Level 2 swath + Level 3 gridded
- 375-m product is a significant improvement over MODIS and is widely used
- 750-m produce retained for continuity (more like MODIS)

Limitations and Strengths

- SDR-induced bad scans in C1 product (fixed for C2)
- No morning VIIRS overpass
- Sub-optimal M13 location (tweaked for later VIIRS)
- Responsivity across swath is much more uniform
- Unprecedented sensitivity to small fires

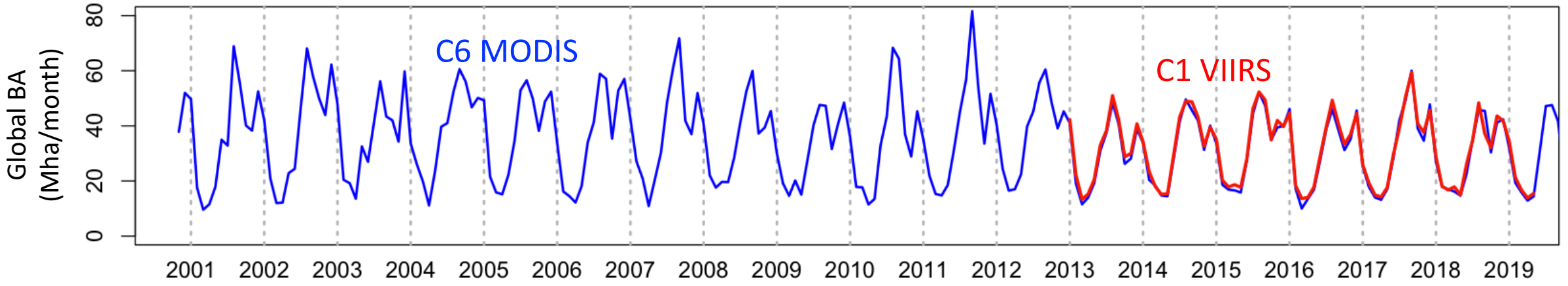
S-NPP VIIRS Burned Area (VNP64A1)

Product Overview

- Monthly global burned area with date of burn mapped to nearest day
- Adapted MODIS MCD64A1 production code to use VIIRS data
- Retained 500-m MODIS grid for compatibility
- Limited C1 release due to artifacts in C1 cloud mask (fixed for C2)

Limitations and Strengths

- No morning VIIRS overpass
- 750-m (vs. 500-m) imagery – I-bands not designed for BA mapping
- Nevertheless, highly consistent with MODIS MCD64A1 product



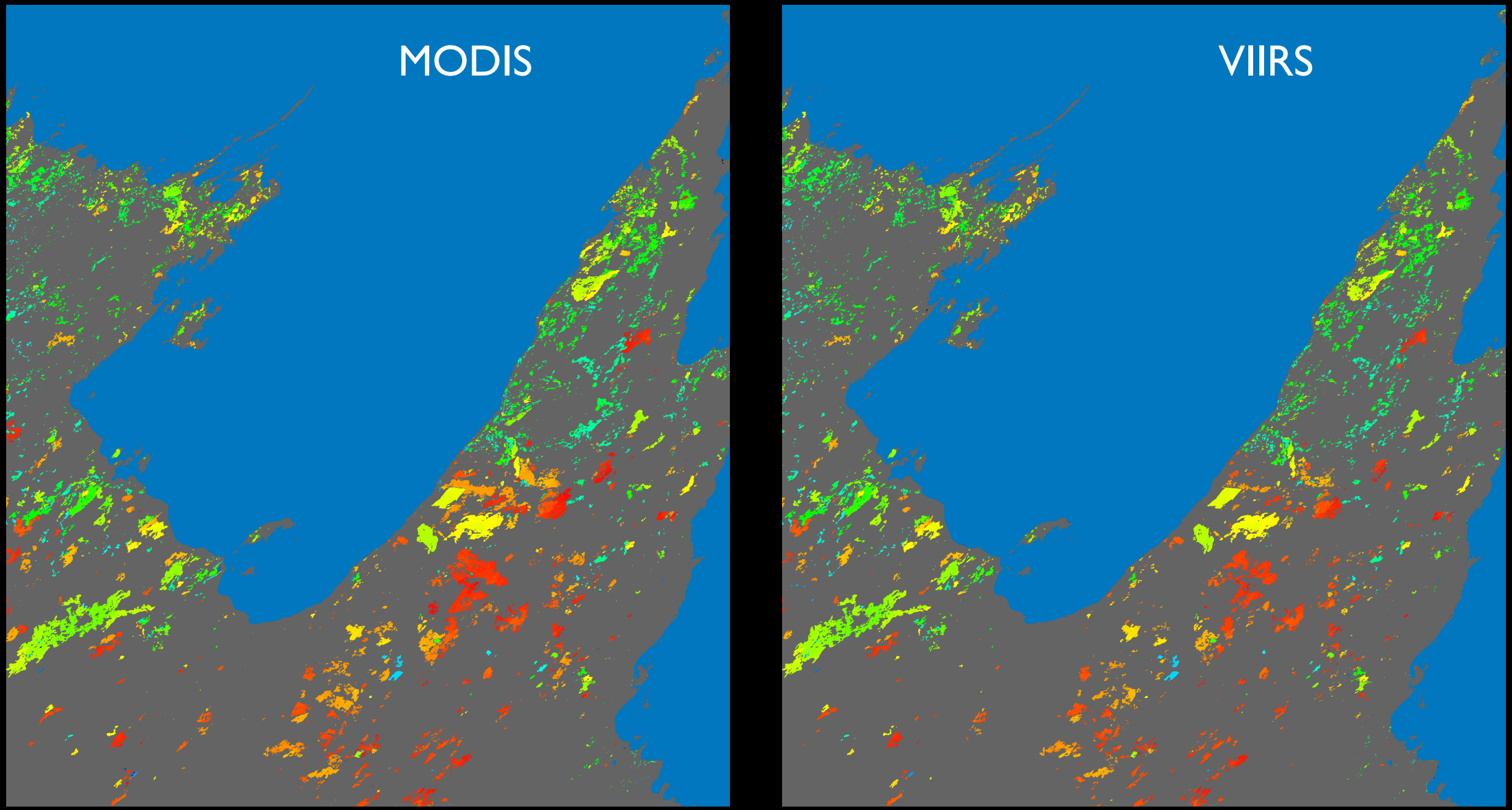
July 2016 h12v03

VIIRS VNP64A0 ΔVI

MODIS MCD64A0 ΔVI

Noise is cumulative result of 5-km × 5-km artifacts in upstream C1 VIIRS cloud mask.

2017 Cumulative Burned Area (Northern Australia)



S-NPP VIIRS Burned Area (VNP64A1)

Distribution Plan

- October 2019: Released sample of C1 VNP64A1
- September 2022: C2 reprocessing
  - Re-tune VNP64A1
- Early 2023 (originally spring 2020!): Release full suite of C2 VNP64A1 products
  - HDF, GeoTIFF, Shapefiles, CMG

C3 Maintenance/Refinement

- Update with “cross-tile” Collection-7 MODIS algorithm
  - Capture smaller burns
  - Modest improvement in cropland burn mapping
  - May implement “backup mode” for extreme smoke conditions (→ no surface reflectance inputs)
- Improve product fidelity by combining S-NPP and NOAA-20 VIIRS observations
  - Multiple VIIRS → Effective resolution of VIIRS burned area product (generated from 750-m VIIRS imagery) much closer to effective resolution of 500-m MODIS burned area product in tropics

MODIS to VIIRS Transition

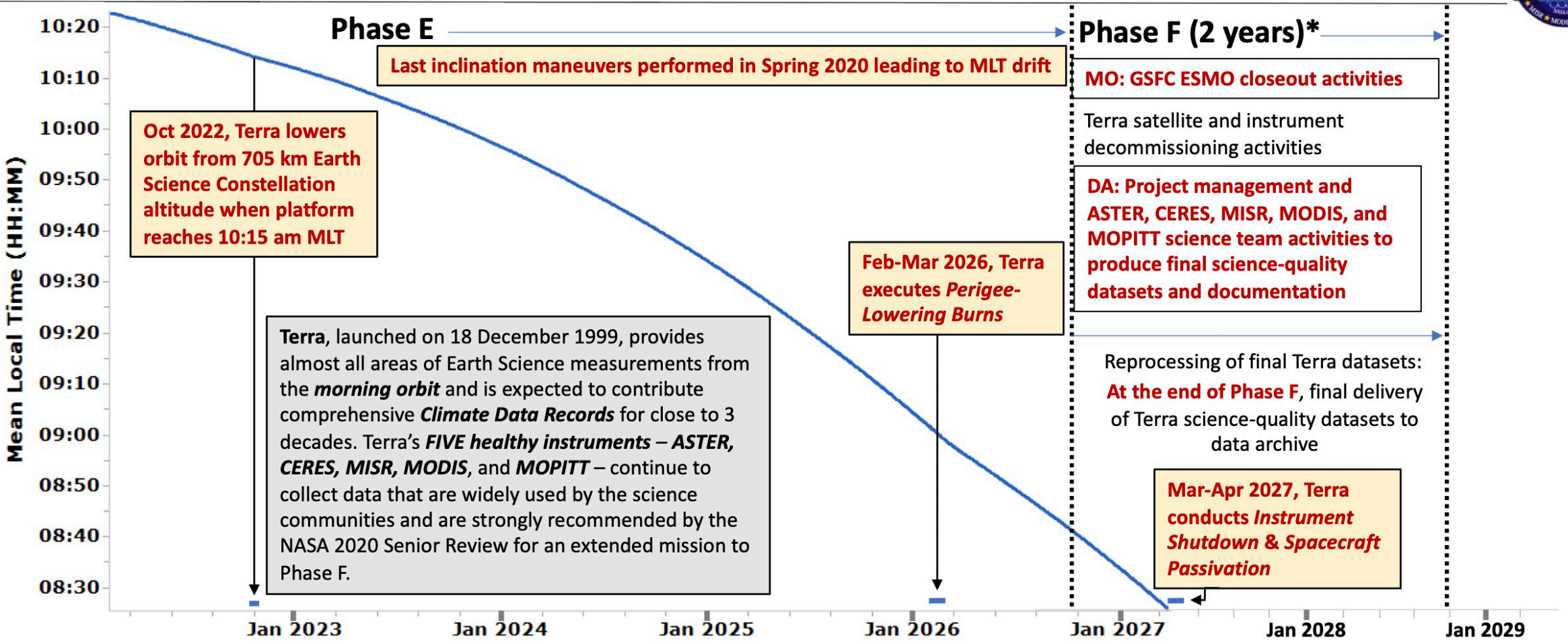
- Active Fire Products
  - 375-m VIIRS active fire product already widely adopted
- Burned Area Product
  - Zero adoption as yet due to C1 problems + C2 reprocessing delays
- Full and/or smooth transition hampered in some cases
  - Shorter VIIRS record (2012 – present versus)
  - Lack of morning overpass VIIRS overpass
- Transition impacted by MODIS end-of-life plans/circumstances and Sentinel-3 possibilities

MODIS End-of-Life Plans

- Initial intent was to maintain Terra and Aqua missions through mid–late 2026 (“Phase F”) as orbits decayed
  - Decommissioning has since been accelerated to late (?) 2023
- NASA *Request for Information for NASA’s Terra, Aqua, and Aura Drifting Orbits Workshop* (NNH22ZDA018L)
  - Science that is uniquely enabled by observations during period of orbital drift
  - Benefits to and impact on current societal applications
  - Closed 10/11/2022 with 112 submissions
- Terra, Aqua, and Aura Drifting Orbits Workshop (virtual)
  - 1—2 Nov. 2022

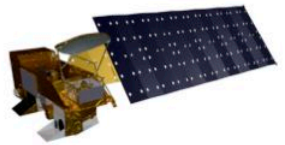
https://science.nasa.gov/earth-science/terra-aqua-and-aura-drifting-orbits-workshop-registration

Terra Timeline if Maximally Extended



NASA HQ

Aqua Timeline if Maximally Extended



Phase E

Phase F (2+ years)

The **Aqua satellite**, launched on May 4, 2002, provides measurements spanning almost all areas of Earth science, from outgoing reflected solar and emitted longwave radiation, to trace gases (including water vapor, carbon dioxide, and methane) and aerosols in the atmosphere, to chlorophyll in the oceans, to fires on land, to the global ice cover, and to atmospheric and ocean temperatures and numerous other geophysical variables. Four of Aqua's instruments – AIRS, AMSU, CERES, and MODIS – continue to collect data that are widely used both by the science community to address key NASA and Decadal Survey objectives and in practical applications ranging from improved weather forecasting to monitoring forest fires, crop yields, volcanic ash plumes, and ice-infested waters.

MO: GSFC ESMO close-out activities

Aqua satellite and instrument decommissioning activities

DA: Project Management and AIRS, MODIS, and CERES science team activities to produce final science-quality datasets and documentation

Reprocessing of final Aqua datasets

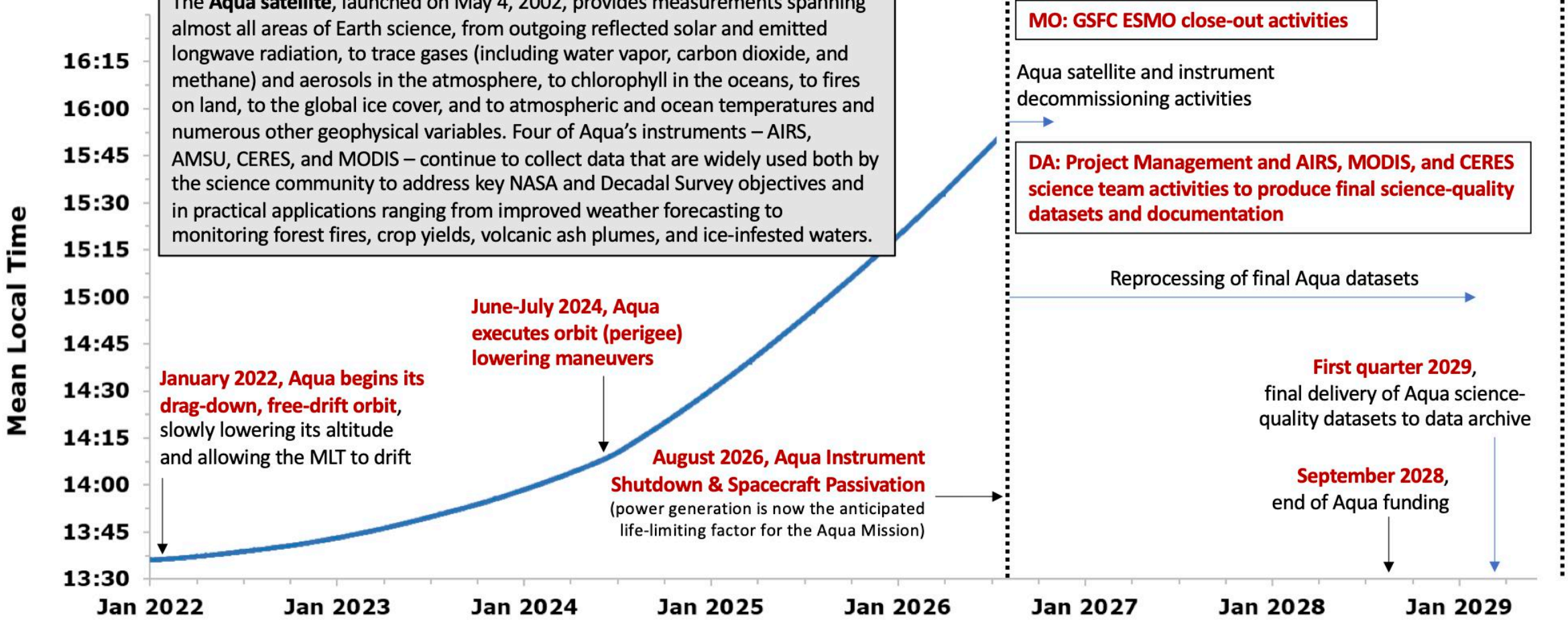
January 2022, Aqua begins its drag-down, free-drift orbit, slowly lowering its altitude and allowing the MLT to drift

June-July 2024, Aqua executes orbit (perigee) lowering maneuvers

August 2026, Aqua Instrument Shutdown & Spacecraft Passivation
(power generation is now the anticipated life-limiting factor for the Aqua Mission)

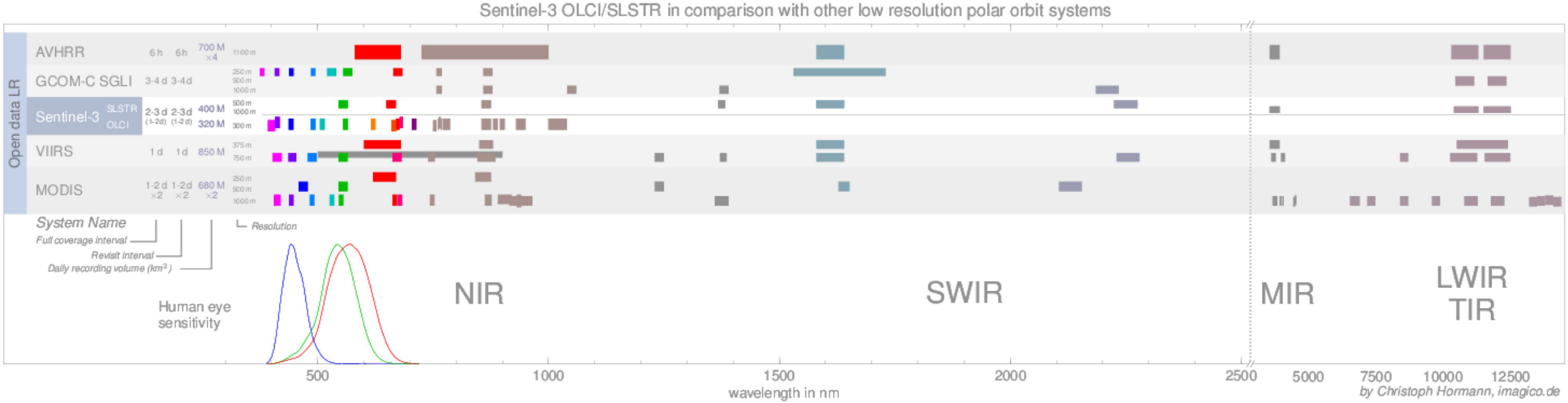
First quarter 2029, final delivery of Aqua science-quality datasets to data archive

September 2028, end of Aqua funding



Sentinel-3A/3B SLSTR

- ESA Sentinel-3A (Feb. 2016 launch) + Sentinel-3B (Apr. 2018 launch)
- 10:00 local crossing time (sun-synchronous orbit)
- Sea and Land Surface Temperature Radiometer (SLSTR)
  - Somewhat less coverage than MODIS
    - 1420-km swath versus 2300-km swath
  - Oblique + nadir views
  - Asymmetric swath avoids sun glint
  - 1-km fire bands
  - Quirks w/ respect to saturation and band-to-band coregistration



https://imagico.de/blog/en/sentinel-3-a-first-look-at-the-data-part-1/

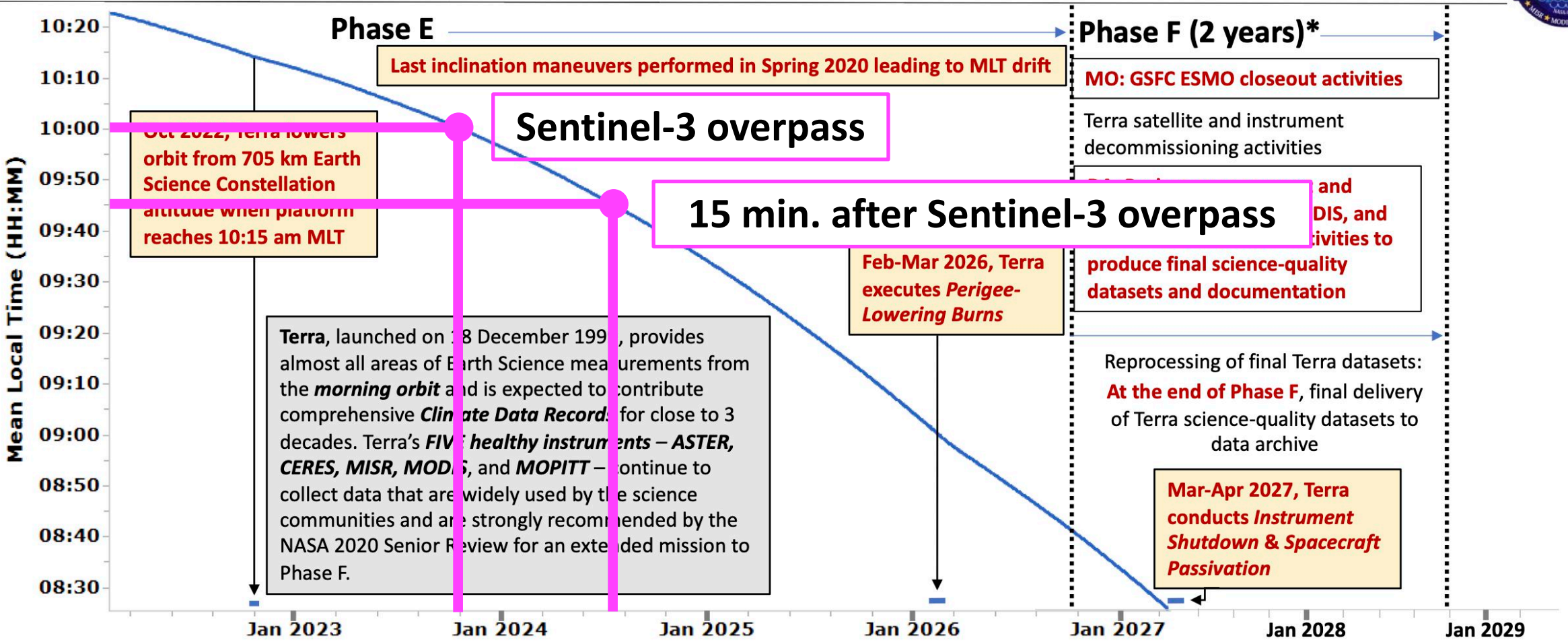
Sentinel-3 SLSTR Active Fire Product

- Sentinel-3A (“S3A_SL_2_FRP”) + Sentinel-3B (“S3B_SL_2_FRP”)
- Two versions
  - Near-real time (NRT) version from EUMETSAT
  - Non-time critical (NTC) version from ESA
- Level 2 (swath)
  - 3-minute granules→484 files/day/sensor
  - 30 GB/day/sensor versus 0.1 GB/day/sensor for MODIS swath product
- Multiple algorithms/layers
  - MWIR (general purpose) + SWIR (high temperature targets)

SLSTR Active Fire Product: NASA Plans

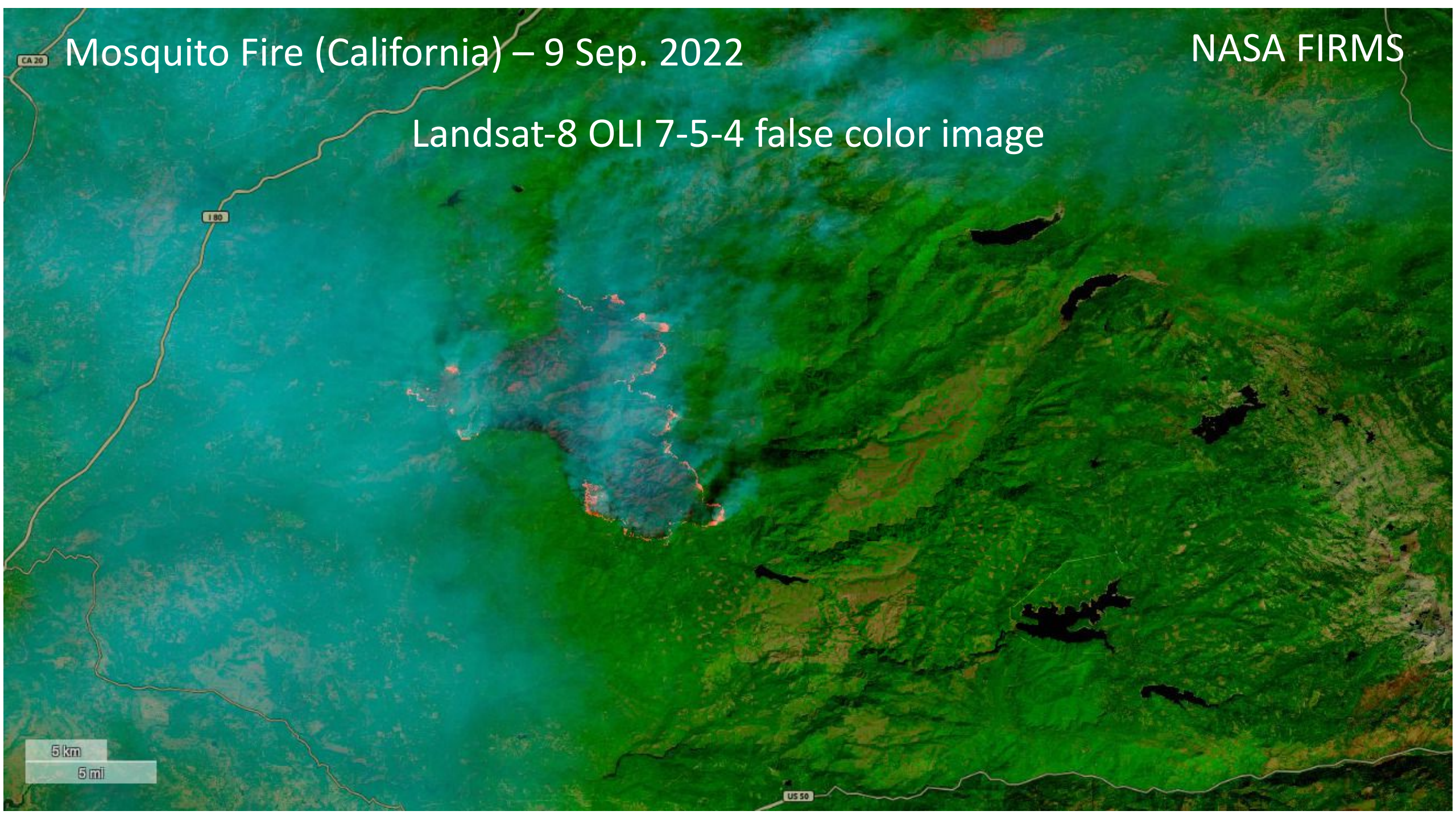
- NASA Terra MODIS continuity prototype underway
  - Adapting MODIS/VIIRS QA codes to handle S3 product
  - Formulating approach to manage unexpectedly large volume of data
  - Evaluation initially focused on NRT version for inclusion into NASA’S FIRMS
  - Evaluation being coordinated with algorithm PI (M. Wooster) and EUMETSAT

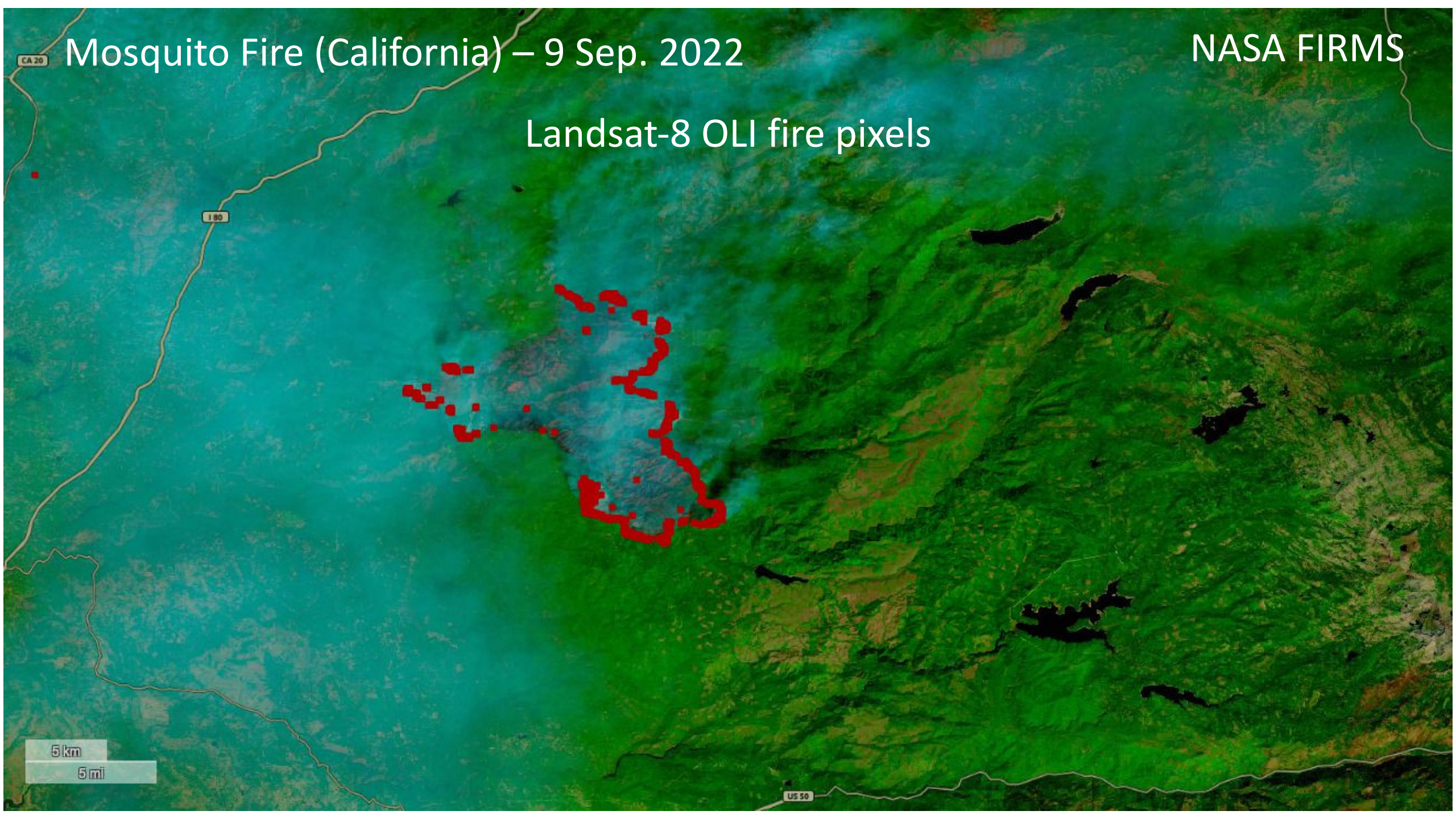
Terra Timeline if Maximally Extended



Landsat OLI/Sentinel-2 MSI Fire Products

- Active Fire
  - NASA/USFS/NOAA-sponsored implementation of modified Schroeder et al. (2016) algorithm running at USGS
  - Fire data will very soon be distributed by NASA FIRMS
- Burned Area
  - Multitudes of small burns are missed completely with coarse resolution sensors (e.g., MODIS)
  - Growing list of demonstration burned area data sets produced using different combinations of Landsat OLI and Sentinel-2 MSI
  - NASA effort is best suited given agency's internal/sponsored experience and record re. sensors, algorithms, production, QA, and validation


Mosquito Fire (California) – 9 Sep. 2022
NASA FIRMS
Landsat-8 OLI 7-5-4 false color image
CA 20
I 80
US 50
5 km
5 mi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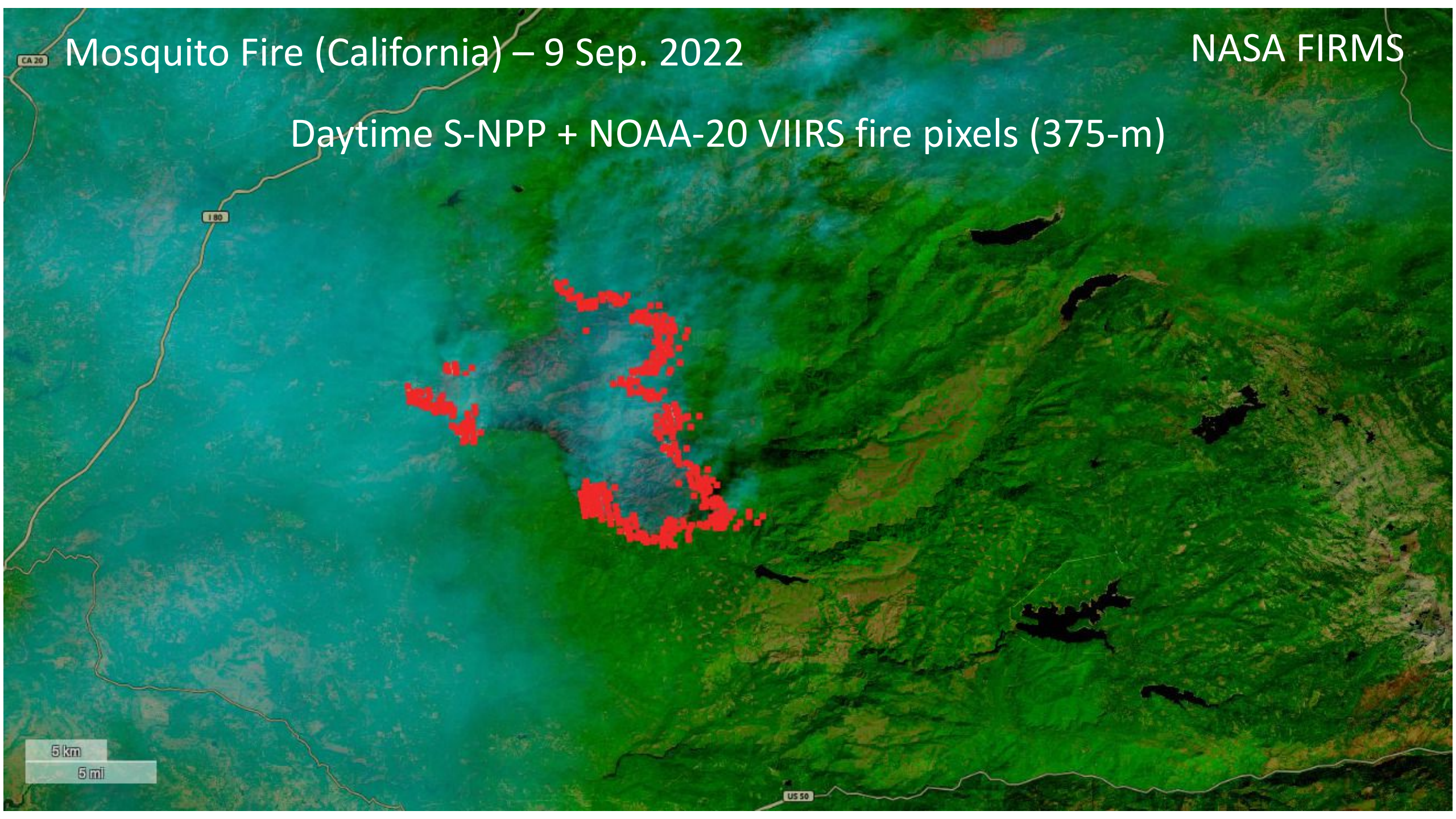
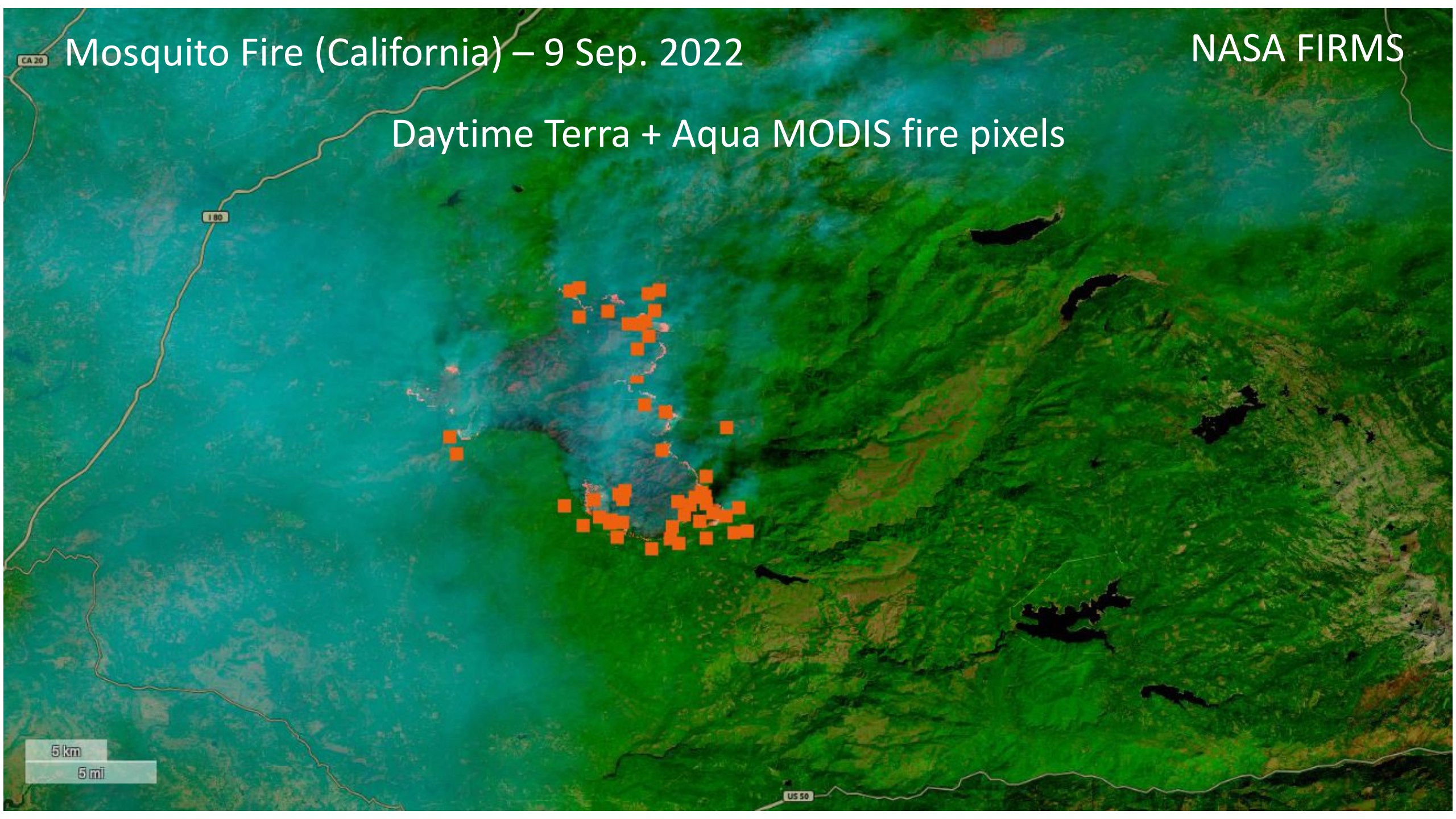

Mosquito Fire (California) – 9 Sep. 2022
NASA FIRMS
Daytime S-NPP + NOAA-20 VIIRS fire pixels (375-m)
CA 20
I 80
US 50
5 km
5 mi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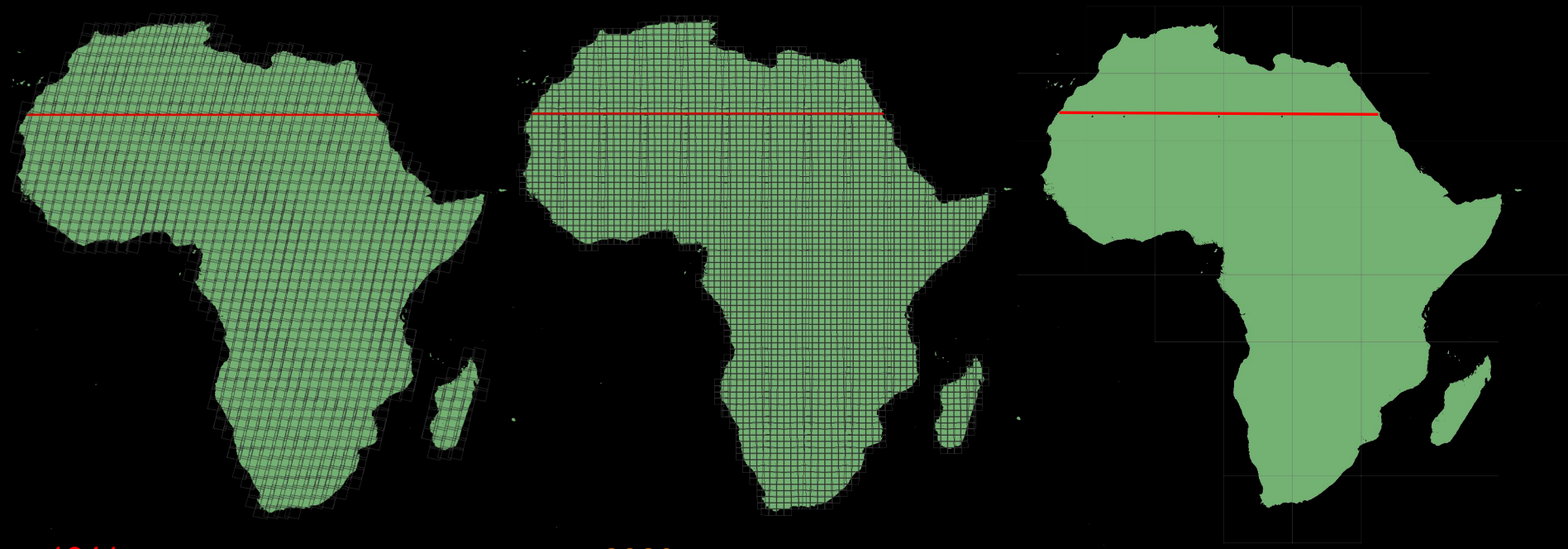
NASA LCLUC Multi-Source Land Imaging (MuSLI)

30 m Burned Area Production - all of Africa, including Madagascar, south of the Tropic of Cancer (23.44° N)



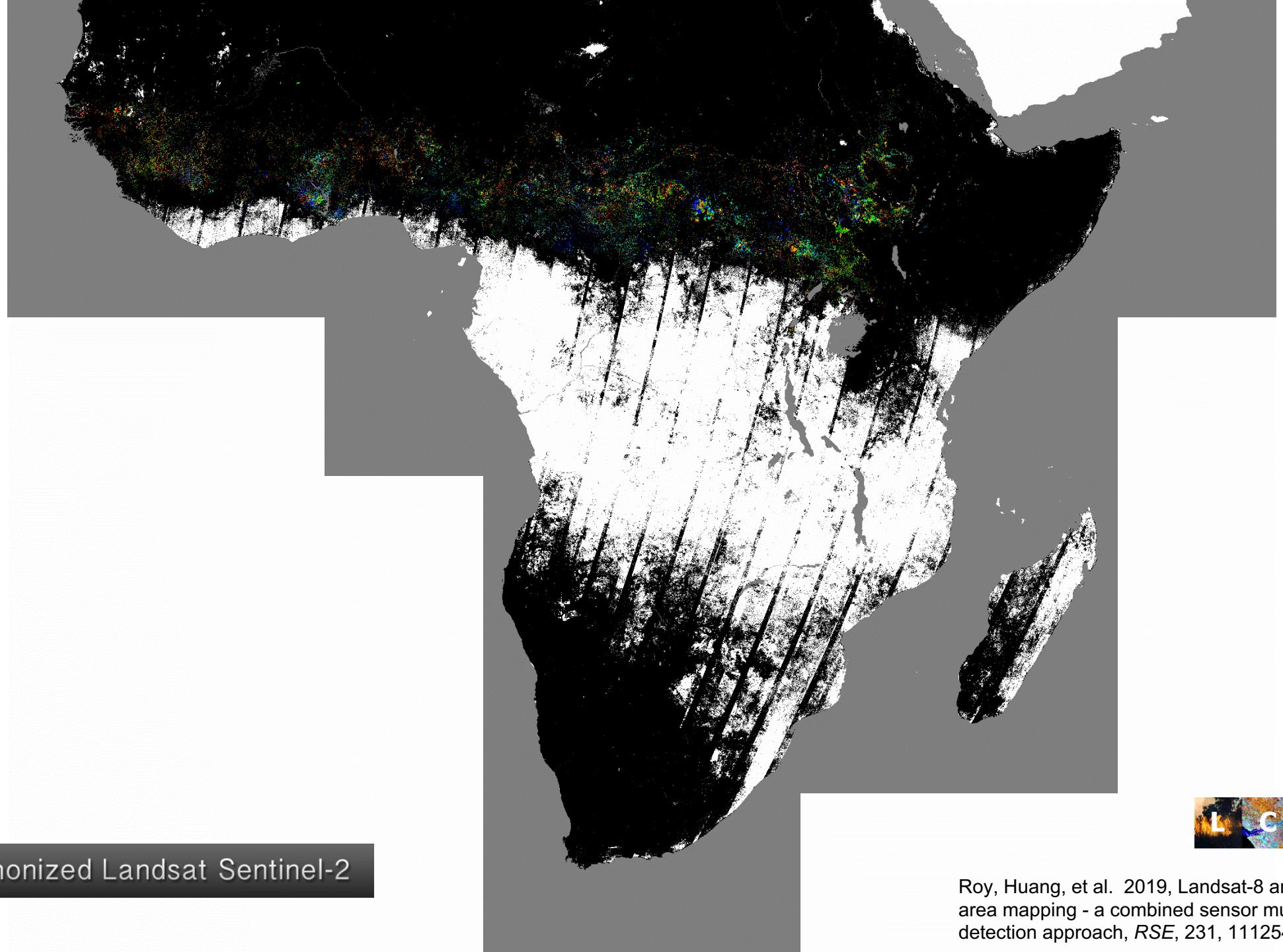
1041
Landsat-8 Collection 1
WRS-2 path/rows (UTM)

2829
Sentinel-2
L1C tiles (UTM)

33
MODIS
Tiles (sinusoidal)

David Roy

Jan 2019



1-2
3-5
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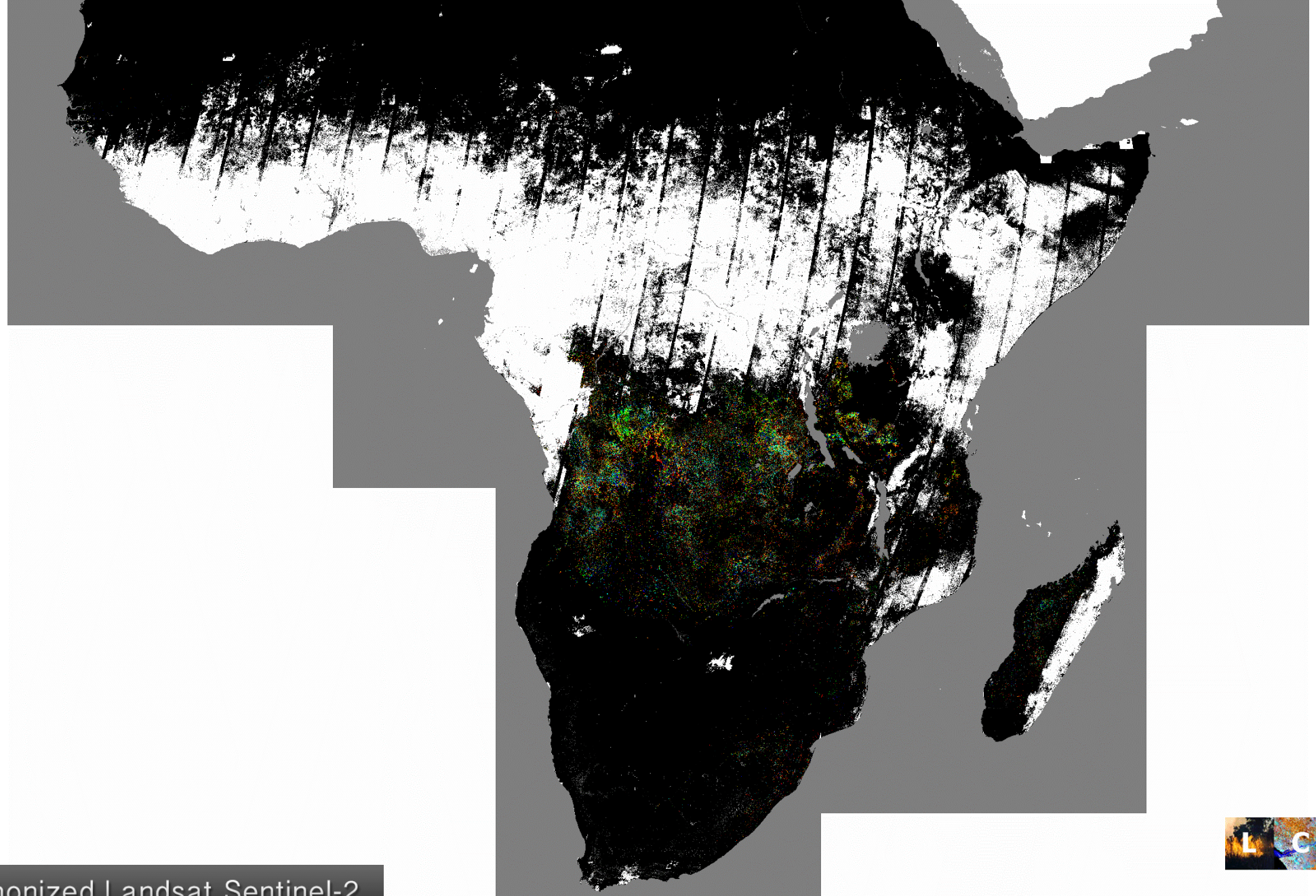
12-14
15-17
18-20
21-23
24-27
28-31
water

Harmonized Landsat Sentinel-2

David Roy

Roy, Huang, et al. 2019, Landsat-8 and Sentinel-2 burned area mapping - a combined sensor multi-temporal change detection approach, *RSE*, 231, 111254.

Jun 2019



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Harmonized Landsat Sentinel-2

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Recommendations: Preface

- Variously directed toward:
  - broader science community
  - remote sensing community
  - NASA and other agencies
  - product developers
- Some recommendations are my take
  - Views/priorities not necessarily shared by others

Recommendations (1 of 5)

- Restore/retain original “extended” Terra/Aqua end-of-life mission
- Landsat/Sentinel-2 global burned area mapping
  - Reinforce established and well characterized Roy et al. (2019) approach with global production
- Renewed consideration of long-term data/monitoring capability
  - MODIS was major improvement over the AVHRR
  - Followed by VIIRS (2012) and SLSTR (2016)
    - Less than stellar spectral, spatial, and temporal consistency across sensors and orbits

Recommendations (2 of 5)

- Shift S-NPP to morning overpass?
  - JPSS-2 launch 1 Nov. 2022
  - Interest within NASA + NOAA
  - Northrup Grumman Mission Extension Vehicle (MEV) + Pods (MEP)
    - Used with Intelsat GEO satellites in 2020 and 2021
  - On-orbit Servicing, Assembly, and Manufacturing 1 (OSAM-1) mission
    - Test with Landsat 7 (≥ 2025)

https://nexis.gsfc.nasa.gov/osam-1.html

Recommendations (3 of 5)

- Support for long-term fire data assessment and harmonization
  - L. Boschetti: *Disentangling decadal trends, inter-annual fire variability and product uncertainties, through harmonization of the NASA MODIS and VIIRS fire product record*
- CEOS Land Product Validation (LPV): Fire Disturbance
  - Active fire detection, fire radiative power, and burned area
  - Update/draft best practices guides – progressing slowly

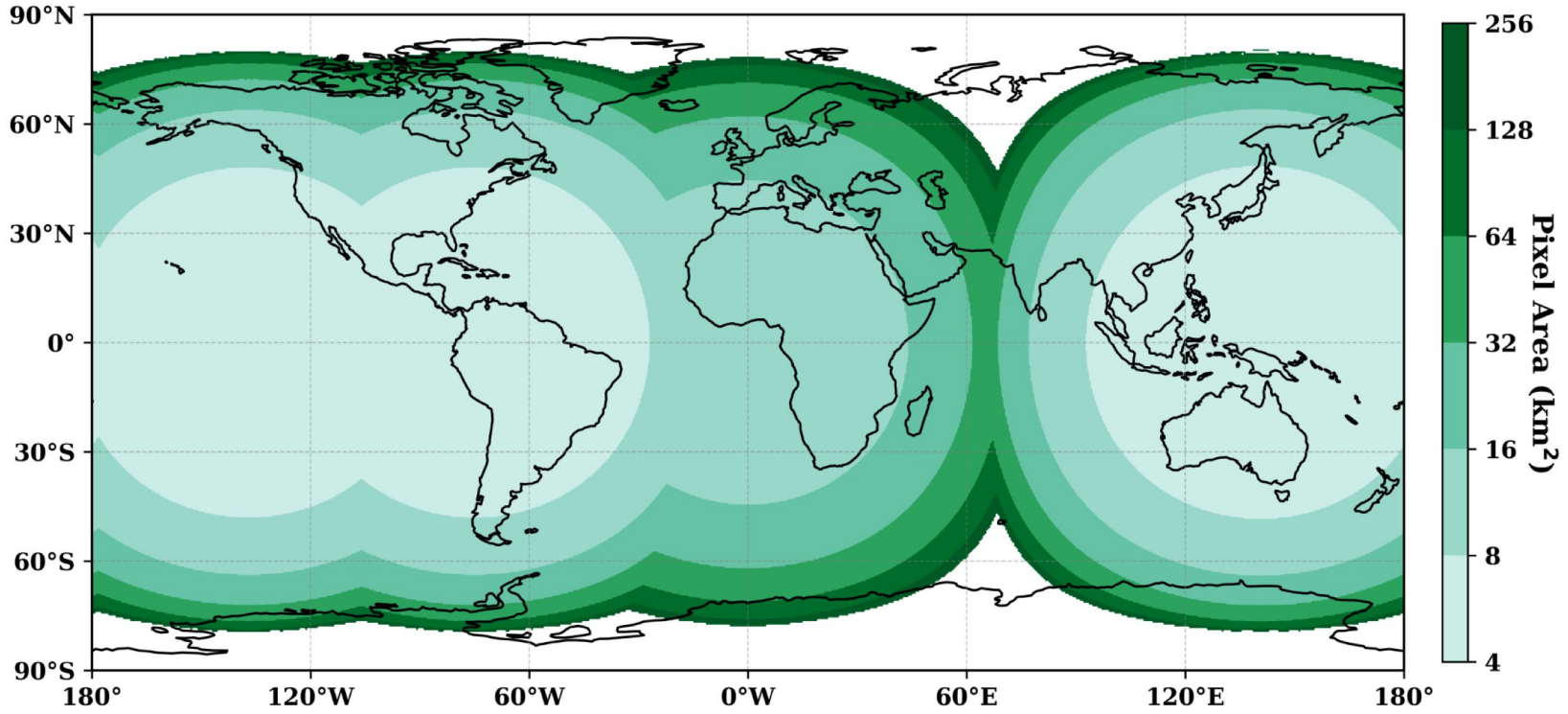
Recommendations (4 of 5)

- Coordinate/reconsider LEO fire-monitoring satellite constellations
  - Goal is early detection → tens to hundreds of satellites
  - Vicariously calibrated visible/NIR, MWIR , thermal bands
  - Redundant development efforts
  - Funded: WildFireSat (2028 launch)
    - CSA system w/ opportunities for institutional buy-in

Recommendations (5 of 5)

- Geostationary satellite fire monitoring network
  - NOAA not geared for reprocessing
  - Potentially include polar orbiters

GOES-17, GOES-16, MSG, Himawari



Joanne Hall