GOES-R

The Nation's Next-Generation Geostationary Weather Satellites

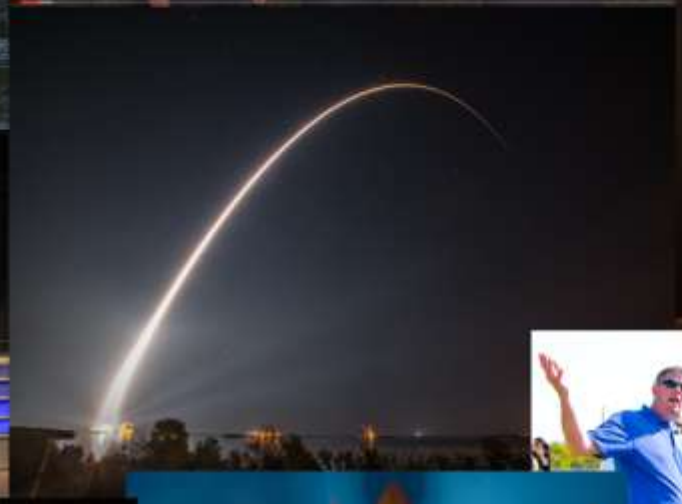
Steve Goodman
GOES-R Program
Senior Scientist

National Academy of Science
Space Studies Board Spring Meeting

Washington, DC
May 4, 2017

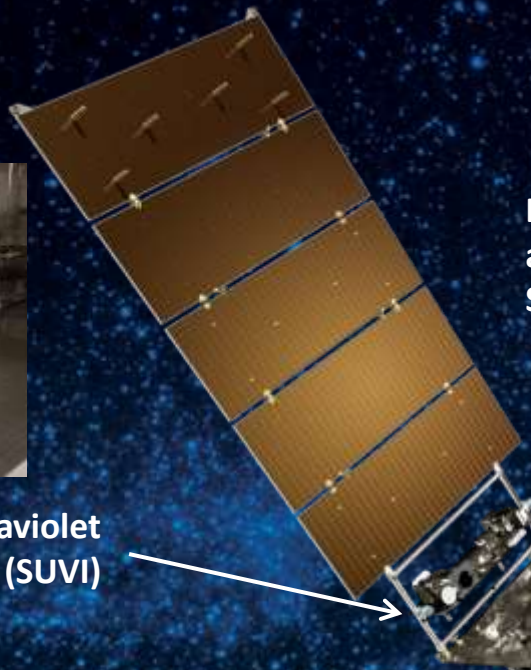

CAPE CANAVERAL, FL


GOES-R




SARSAT

GOES-R Series Spacecraft



Extreme Ultraviolet and X-Ray Irradiance Sensor (EXIS)

Space Environment In Situ Suite (SEISS)

Solar Ultraviolet Imager (SUVI)

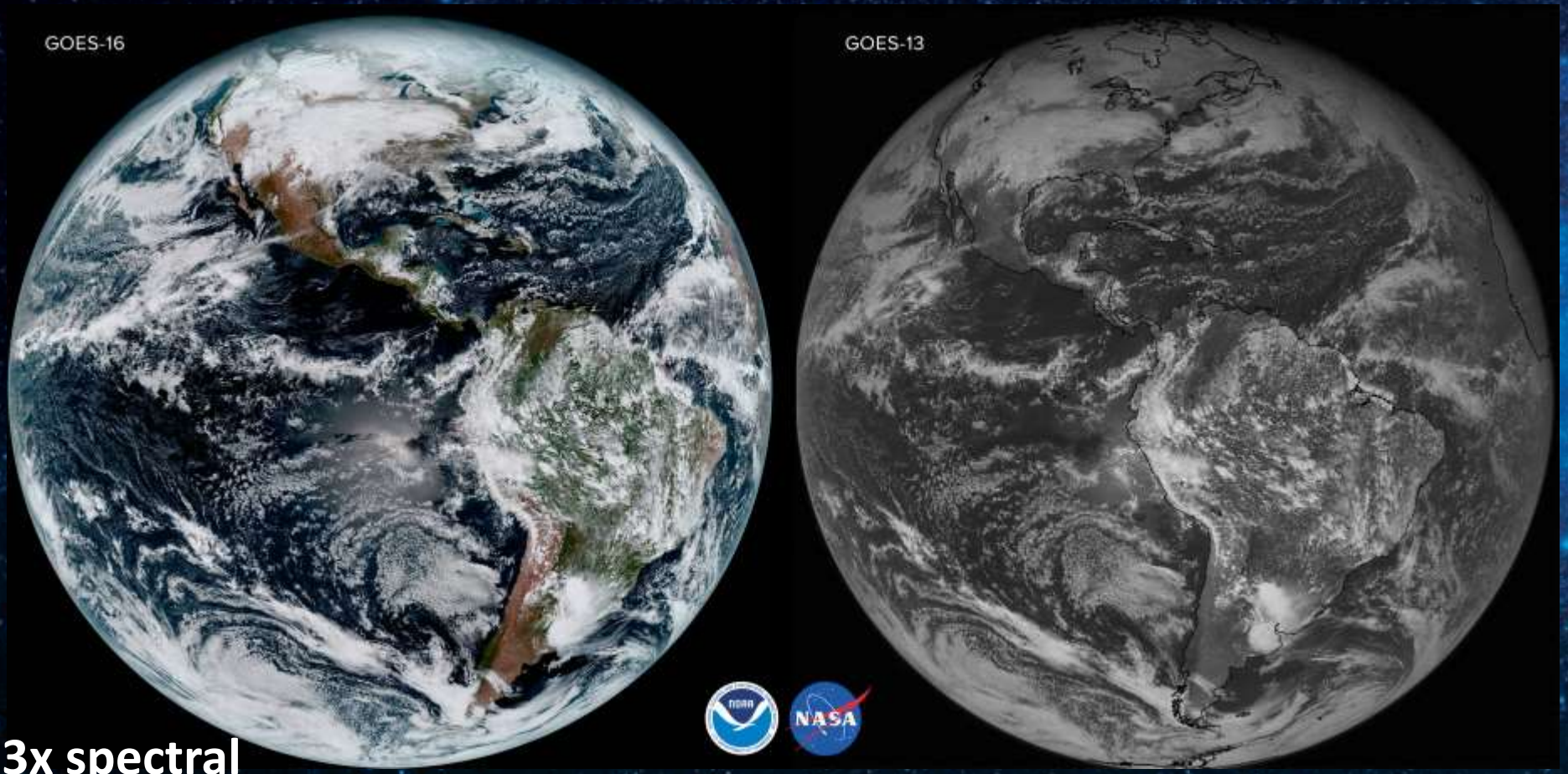
Magnetometer

Geostationary Lightning Mapper (GLM)

Advanced Baseline Imager (ABI)

Weather Impacts on Society

First ABI Imagery
January 23

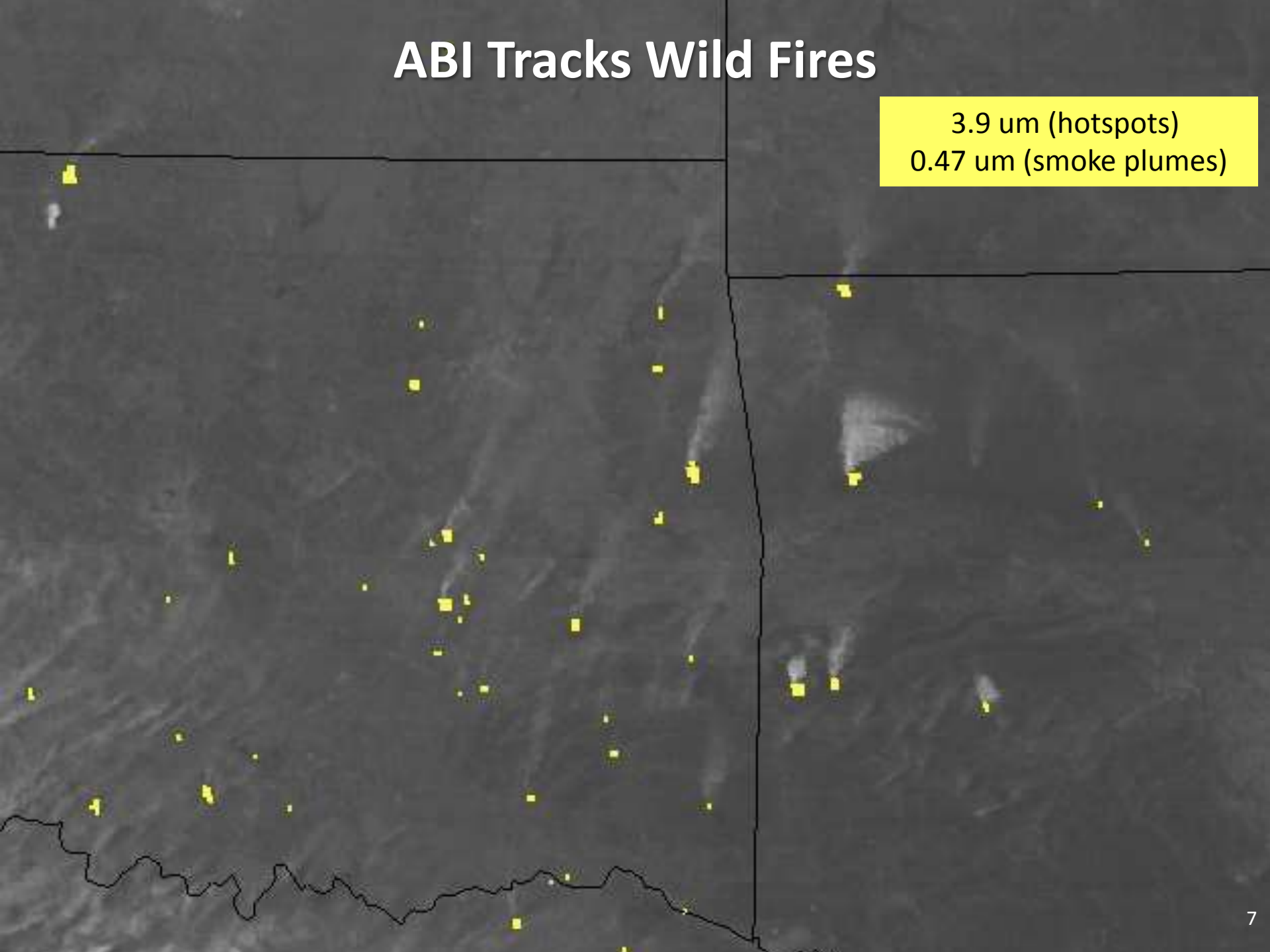


3x spectral
4x spatial
5x temporal

GOES-16 vs GOES-13 on January 15, 2017

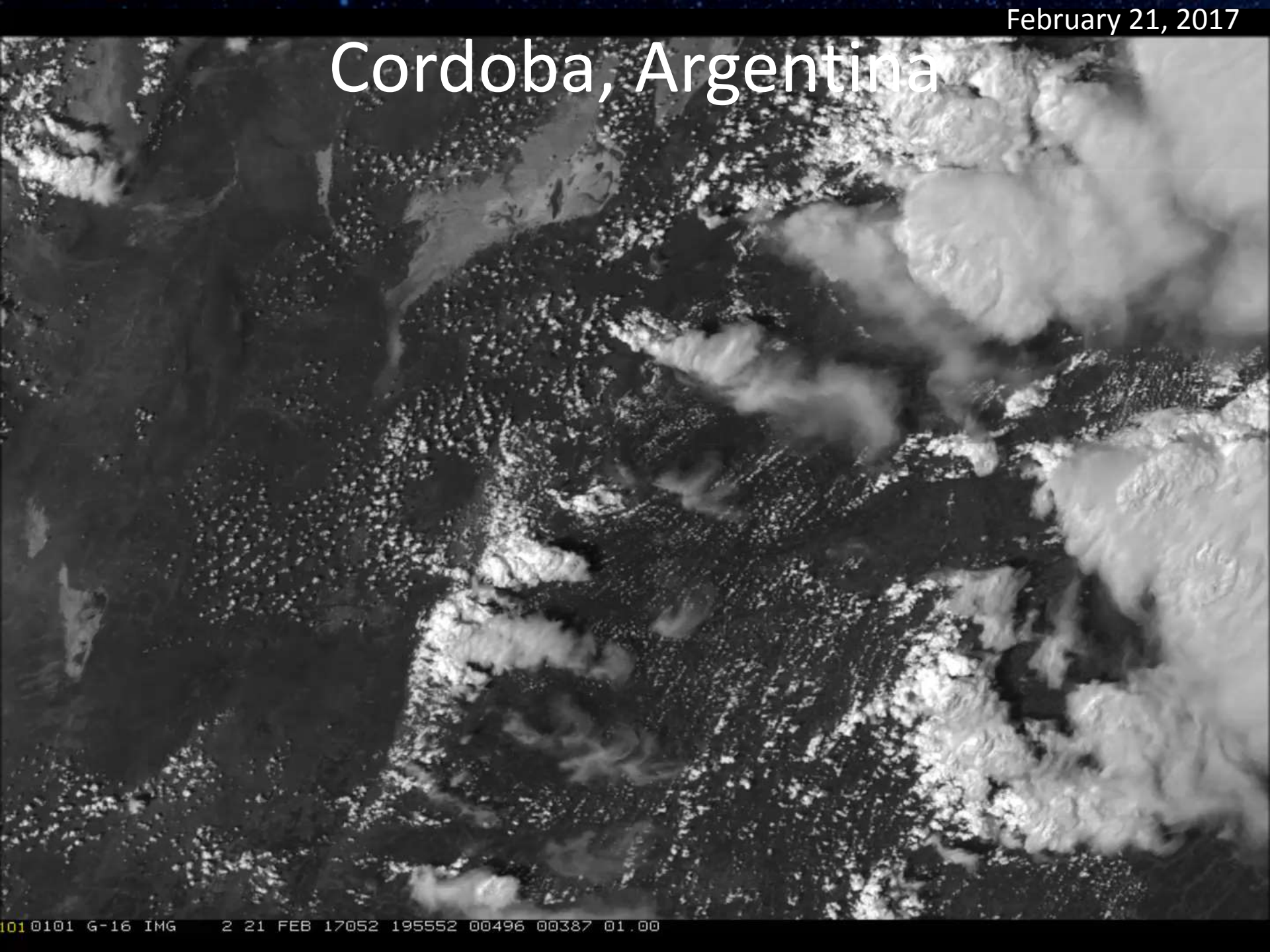
ABI Sees the Moon

ABI Tracks Wild Fires

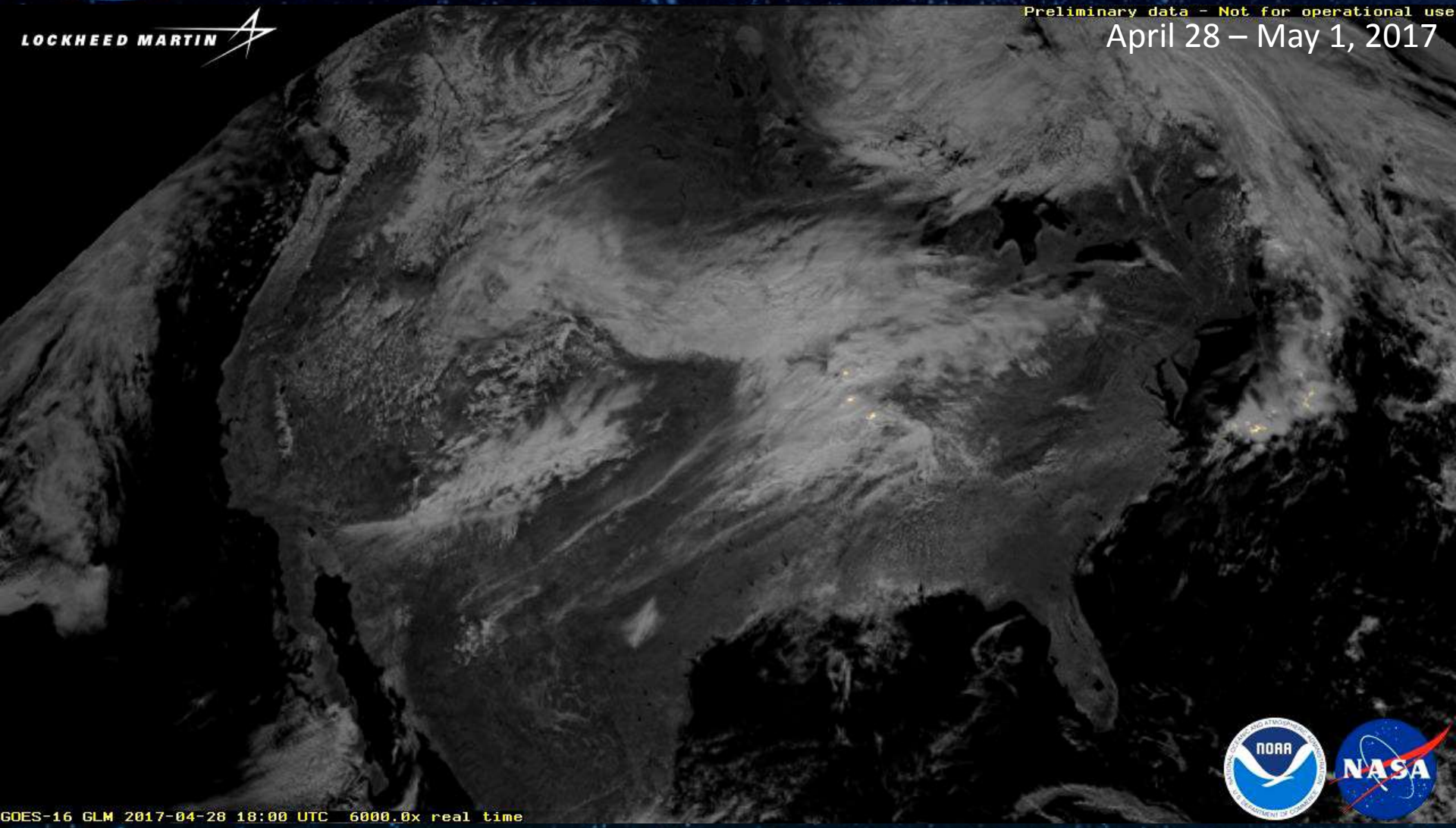


February 21, 2017

Cordoba, Argentina



GLM Tracks Storms

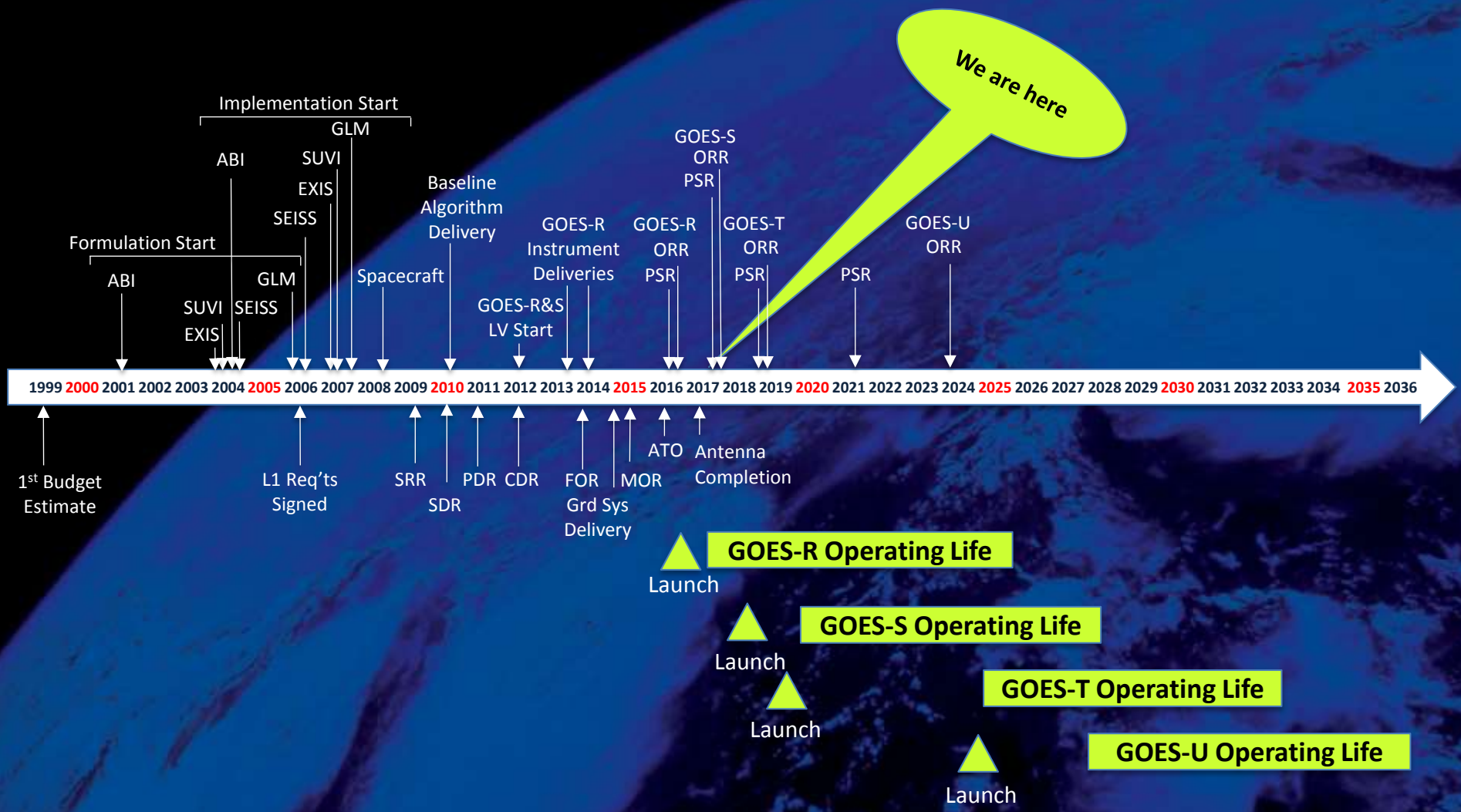


GLM lightning superimposed on GLM background

First SUVI Imagery
February 27

GOES-16 SUVI 94Å

GOES-R Timeline



GOES-16 Science Products Validation Status

ABI L1b Product
Radiances

ABI L2+ Products
Cloud and Moisture Imagery (CMI) and Sectorized CMI (KPP)
Aerosol Detection (Smoke & Dust)
Aerosol Optical Depth (AOD)
Clear Sky Mask
Cloud Particle Size Distribution
Cloud Top Height
Cloud Top Phase
Cloud Top Pressure
Cloud Top Temperature
Derived Motion Winds
Derived Stability Indices

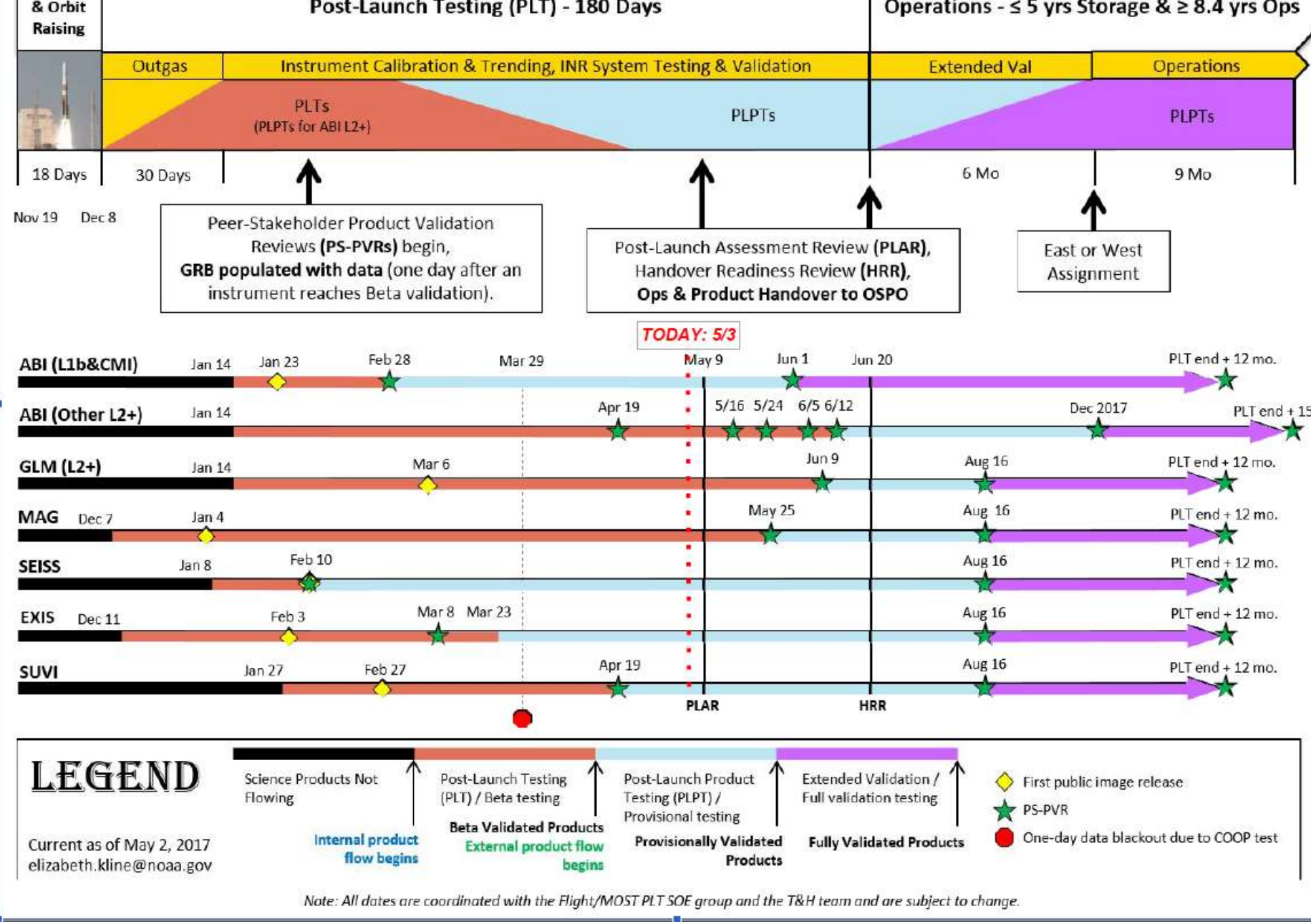
ABI L2+ Products (con't)
Downward S/W Radiation: Surface
Fire/Hot Spot Characterization
Hurricane Intensity Estimation
Land Surface Temperature
Legacy Vertical Moisture Profile
Legacy Vertical Temperature Profile
Rainfall Rate/QPE
Reflected S/W Radiation: TOA
Sea Surface Temperature
Snow Cover
Total Perceptible Water
Volcanic Ash: Detection and Height

GLM L2 Product
Lightning: Events, Groups, Flashes
SEISS L1b Products
Energetic Heavy Ions
Magnetospheric e^-/p^+: Low Energy
Magnetospheric e^-/p^+: High Energy
Solar & Galactic Protons
EXIS L1b Product
Solar Flux: EUV
Solar Flux: X-ray Irradiance
SUVI L1b Product
Solar EUV Imagery
MAG L1b Product
Geomagnetic Field

Validation Maturity Levels:

Continuous Availability (v/s intermittent tests e.g. HRIT/EMWIN, GNC-A):

Not Validated	Beta Maturity	Provisional Maturity	Full Maturity
Baseline Availability • CWG (STAR, NCEI-CO, NASA-MSFC) only via PDA, CLASS, LZSS • NWS I&T	Additional Availability • All Receivers via GRB, NWS' SBN • EUMETSAT, CMC, INPE via PDA • DoD's FNMOC, NAVO, 557th via PDA	Additional Availability • All remaining PDA accounts • All receivers via HRIT/EMWIN • All receivers via GNC-A	Additional Availability • No changes


& Orbit Raising
Post-Launch Testing (PLT) - 180 Days
Operations - ≤ 5 yrs Storage & ≥ 8.4 yrs Ops
Outgas
Instrument Calibration & Trending, INR System Testing & Validation
Extended Val
Operations
PLTs
(PLPTs for ABI L2+)
PLPTs
PLPTs
18 Days
30 Days
6 Mo
9 Mo
Nov 19
Dec 8
Peer-Stakeholder Product Validation Reviews (PS-PVRs) begin, GRB populated with data (one day after an instrument reaches Beta validation).
Post-Launch Assessment Review (PLAR), Handover Readiness Review (HRR), Ops & Product Handover to OSPO
East or West Assignment
TODAY: 5/3
ABI (L1b&CMI)
Jan 14
Jan 23
Feb 28
Mar 29
May 9
Jun 1
Jun 20
PLT end + 12 mo.
ABI (Other L2+)
Jan 14
Apr 19
5/16
5/24
6/5
6/12
Dec 2017
PLT end + 15 mo.
GLM (L2+)
Jan 14
Mar 6
Jun 9
Aug 16
PLT end + 12 mo.
MAG
Dec 7
Jan 4
May 25
Aug 16
PLT end + 12 mo.
SEISS
Jan 8
Feb 10
Aug 16
PLT end + 12 mo.
EXIS
Dec 11
Feb 3
Mar 8
Mar 23
Aug 16
PLT end + 12 mo.
SUVI
Jan 27
Feb 27
Apr 19
Aug 16
PLT end + 12 mo.
PLAR
HRR
LEGEND
Science Products Not Flowing
Post-Launch Testing (PLT) / Beta testing
Post-Launch Product Testing (PLPT) / Provisional testing
Extended Validation / Full validation testing
Internal product flow begins
Beta Validated Products
External product flow begins
Provisionally Validated Products
Fully Validated Products
First public image release
PS-PVR
One-day data blackout due to COOP test
Current as of May 2, 2017
elizabeth.kline@noaa.gov
Note: All dates are coordinated with the Flight/MOST PLT SOE group and the T&H team and are subject to change.

The GOES-R PLT Field Campaign

March 21-May 18

Satellite Program Validation Field Campaigns

- Committee on Earth Observation Satellites (CEOS) and WMO GSICS recognized best practice:
  - http://qa4eo.org/docs/QA4EO-WGCV-IVO-CLP-004_vDraft.pdf
- Field campaigns are essential for collecting reference data that can be directly related to satellite observations
  - Reference data:
    - Collected in ideal validation conditions using well calibrated reference sensors
    - Used to validate and characterize post-launch instrument performance
- Field campaigns are implemented on all major satellite programs to ensure post-launch validation of system performance (Ex: MODIS, ASTER, AIRS, S-NPP/CrIS & VIIRS, Landsat, SeaWIFS, OCO-2, GPM, TRMM)
  - Often field campaigns are funded separately at the L1b and individually for select L2+ products
  - The GOES-R field campaign provides a coordinated programmatic approach that consolidates these efforts in support of L1b & L2+ products

Independent Validation of Predicted Performance:

- ABI radiometric accuracy (5 % or 1 K uncertainty)
- GLM flash detection efficiency (70 %) & false alarm rate (5 %)

GOES-R Field Campaign Overview

Goal of the GOES-R field campaign is to support post-launch validation of ABI and GLM L1b & L2+ products:

- ~10 weeks (~100 flight hours)
- March – May 2017
- High-altitude NASA ER-2 platform coordinated with ground based reference data over several Earth targets
- Underflights to be collected, when possible, with low Earth orbit environmental satellites which may include S-NPP, Terra/Aqua, METOP, Landsat, ISS & GPM
- Open access data policy, web portal
- NCEI long-term archive

Two Phased Approach

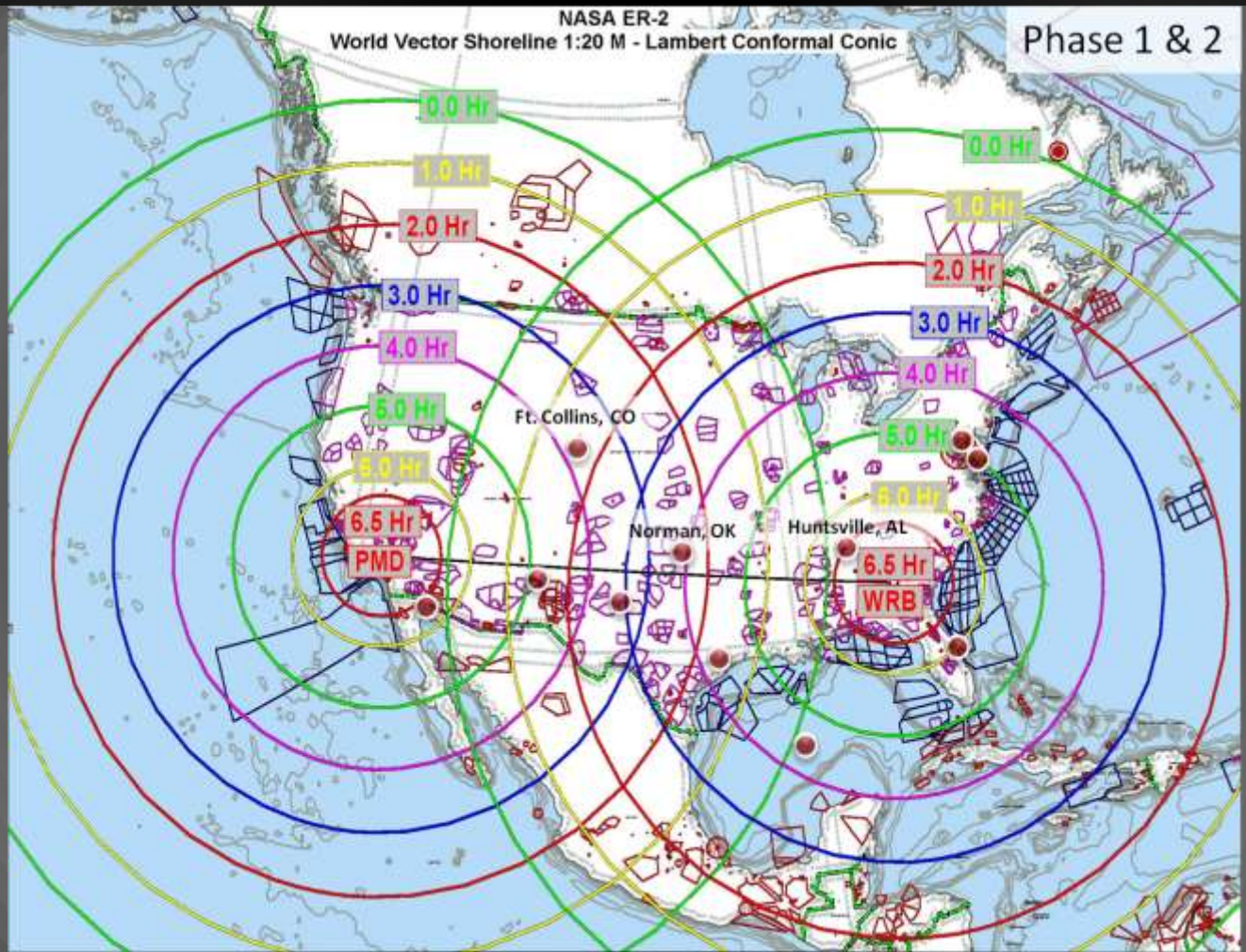
March – May 2017

Phase 1 (2 weeks – U.S. West Coast)

- ER-2 Based at Palmdale, CA
- Flight Window: March 22-31, 2017
- ABI Validation Primary

Phase 2 (4 weeks – U.S. East Coast)

- ER-2 Based at Warner Robins AFB, GA
- Flight Window: April 17 - May 18, 2017
- GLM Validation Primary



GOES-R Field Campaign ER-2 Based Instruments

LIP

FEGS

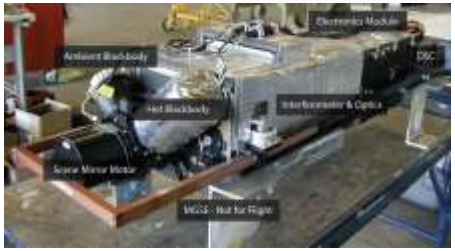
AVIRIS-NG
LIP

INMARSAT

EXRAD

CRS

S-HIS



GCAS

CPL
LIP

Direct Comparison Desert Plan

~7 hr mission

Baseline Mission

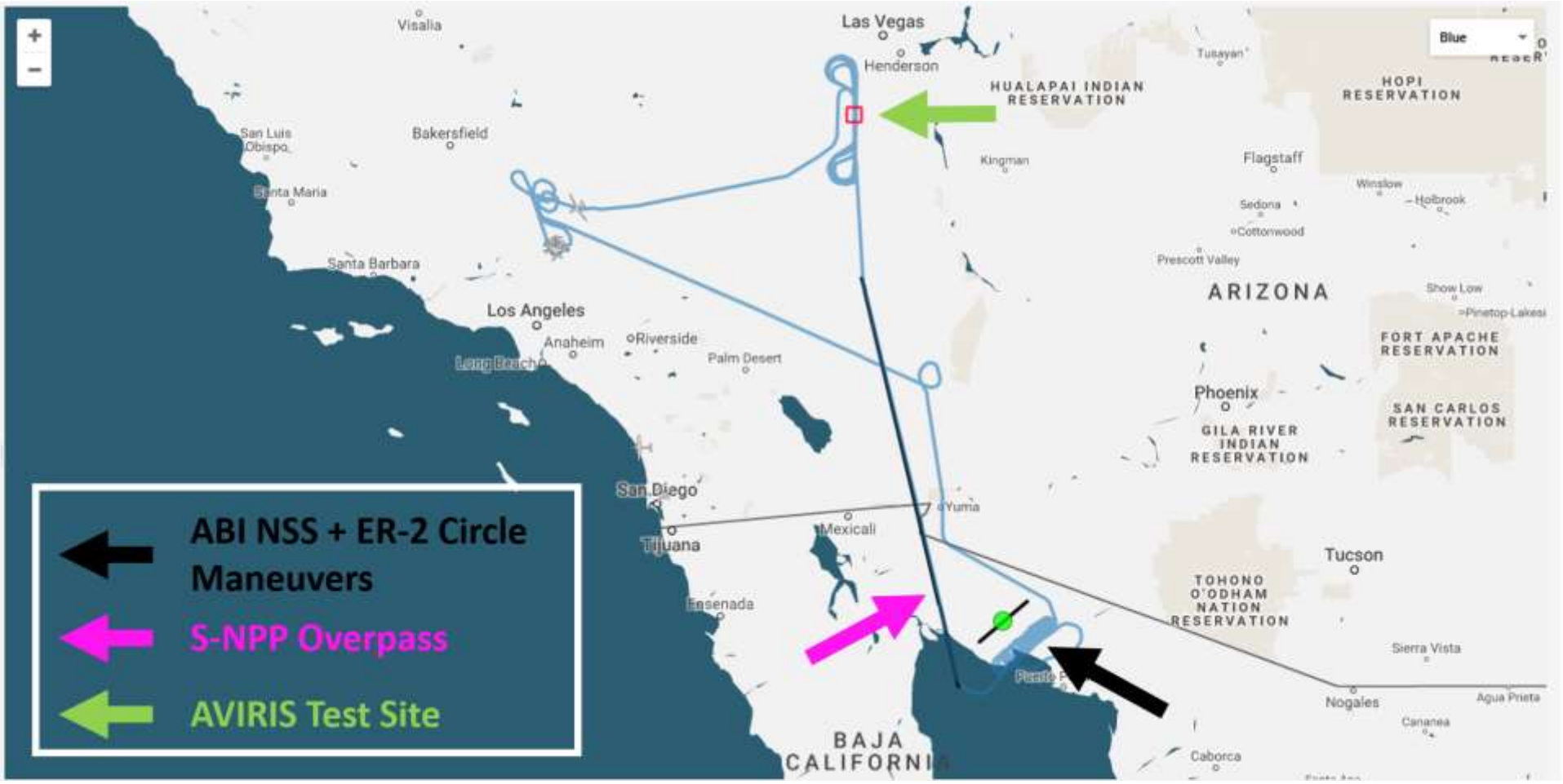
S-NPP Nadir Track

ER-2 Establishing Altitude	ER-2 Relocation	ER-2 Relocation	ER-2 Relocation	ER-2 Relocation
60 min	50 min	10 min	10 min	60 min
	60 min AVIRIS Desert Cal. (1)	90 min ABI NSS: Desert (2)	30 min ABI Mode 3 MESO: S-NPP (3)	60 min AVIRIS Desert Cal.
ER-2: Wheels Up 9:00 am PDT	**10:00 – 11:00 am**	**11:50 – 1:20 pm**	**1:20 – 1:50 pm**	**2:00 – 3:00 pm**
	Satellite Local Time:	1:50 – 3:20 pm	3:20 – 3:50 pm	

ER-2: Wheels down 4:00 pm PDT

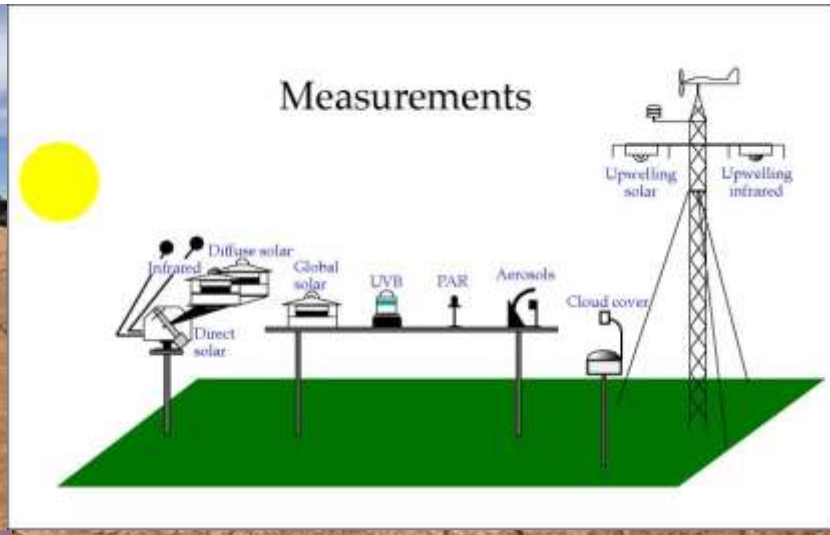
March 23, 2017 – Sonoran Desert Mission

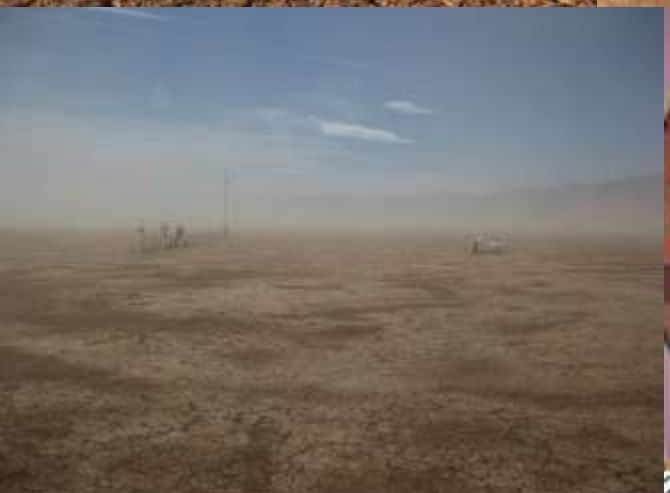
ABI reflective solar band primary validation flight



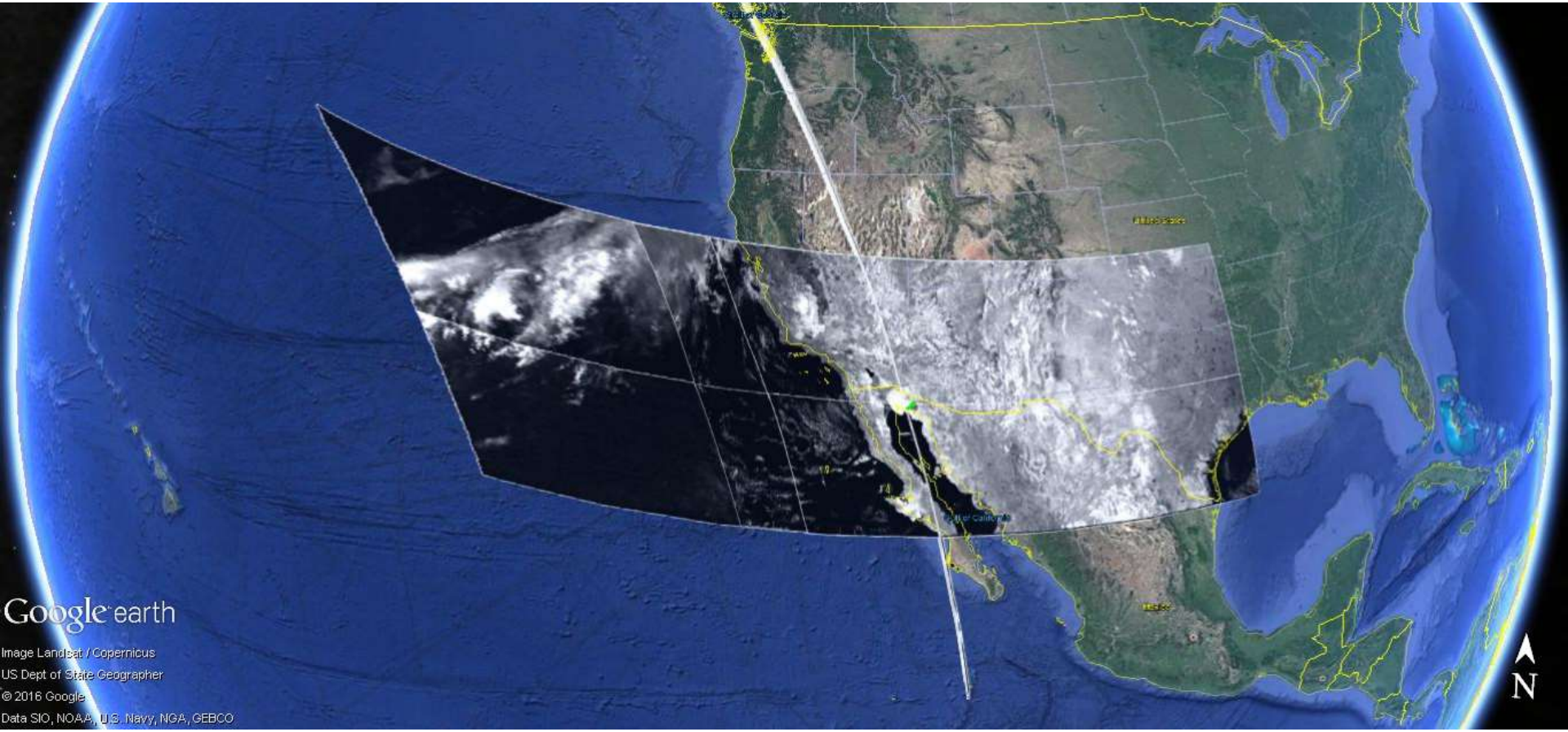
On March 30, 2017 a rapidly moving and severe dust storm came into the area and crossed over the SURFRAD station at Red Lake. Our Total Sky Camera captured the dust storm as well as photos taken from the RV.

There were periods of clear-sky prior and after the dust storm. The MFRSR (Multi-Filter Rotating Shadowband Radiometer) will capture information about the dust including Aerosol Optical Depth and Angstrom Coefficient. The new 1625-nm channel in the MFRSR gives more information on these types of larger particles.



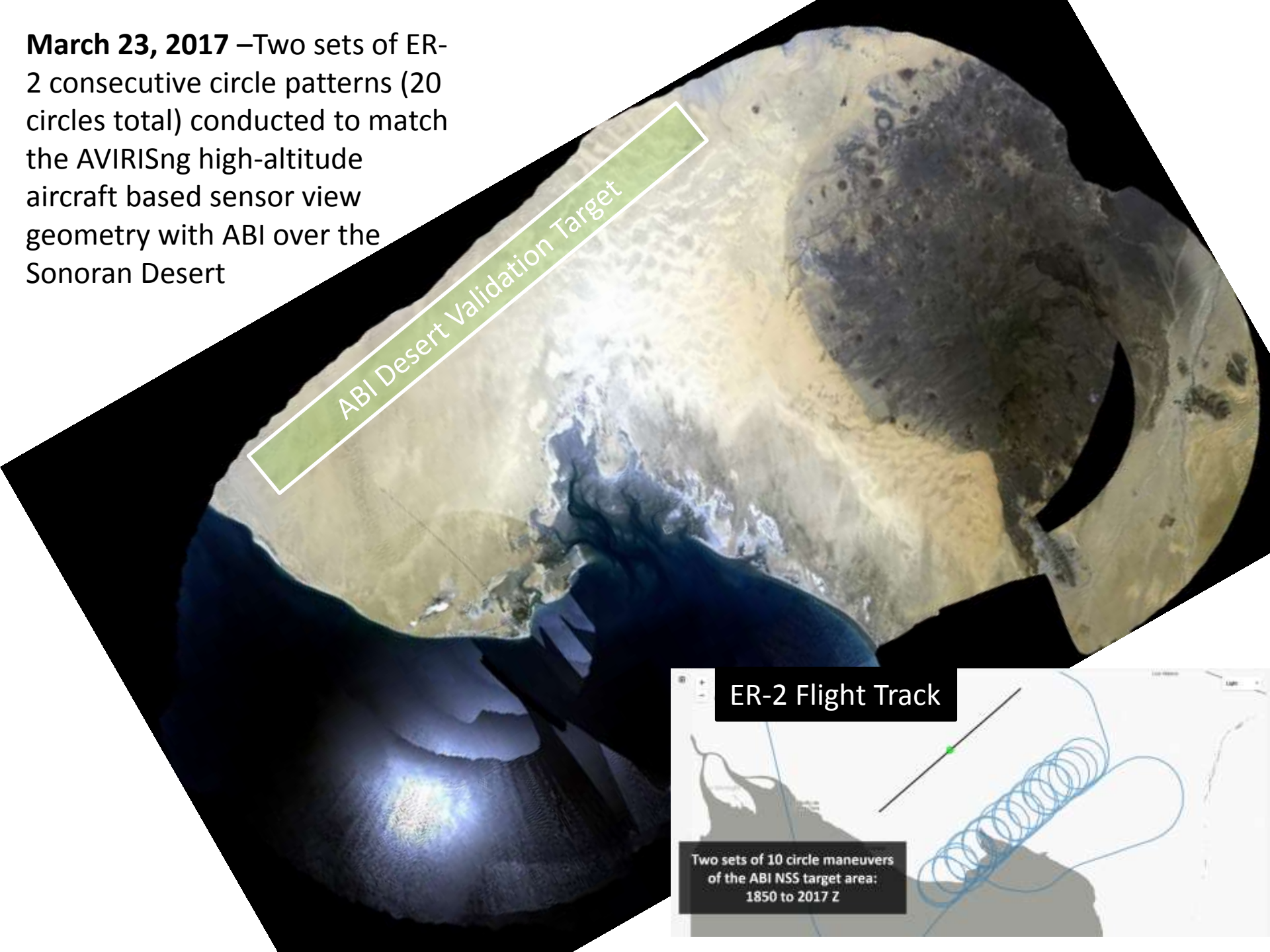


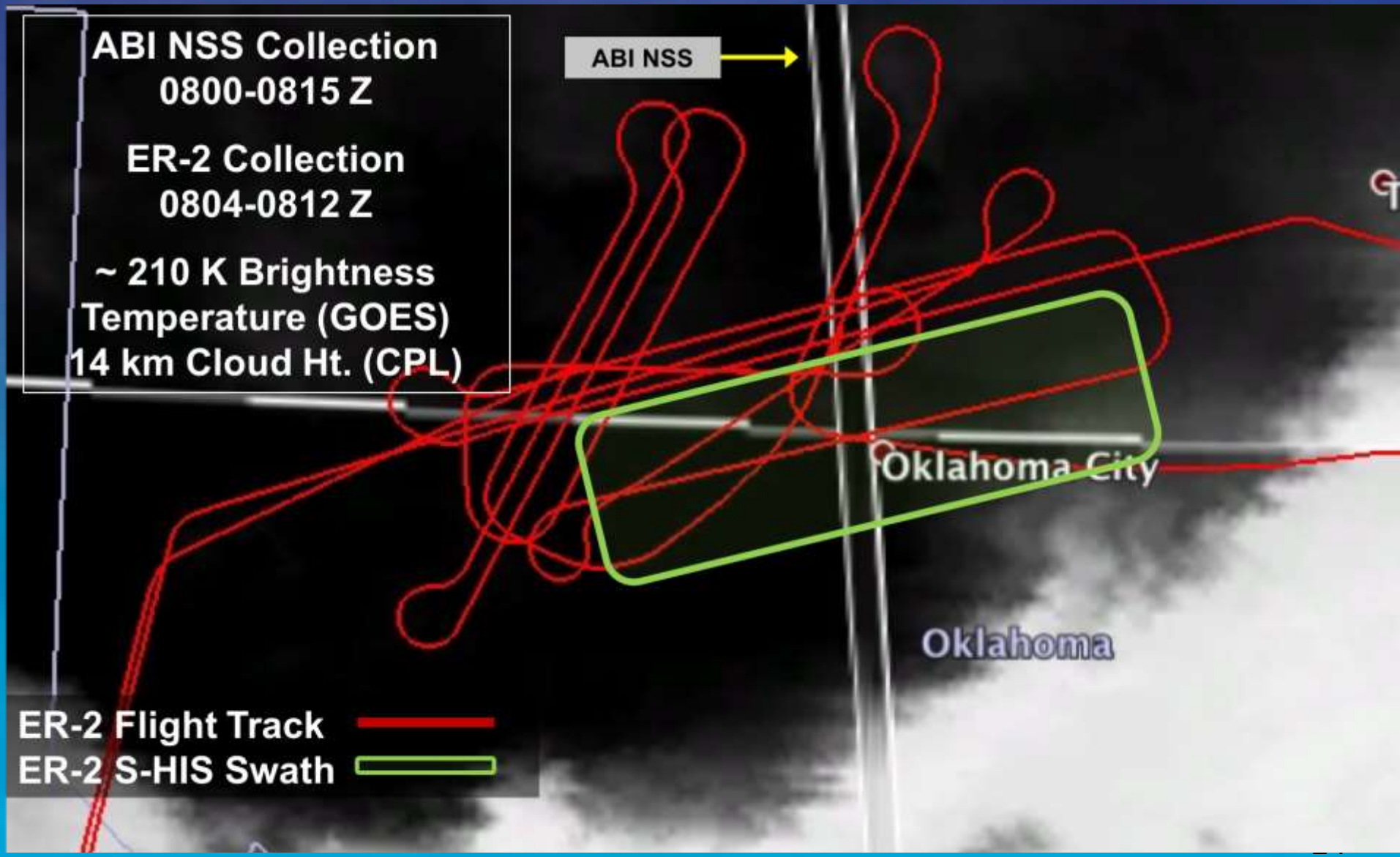
March 23, 2017 – Sonoran Desert Mission



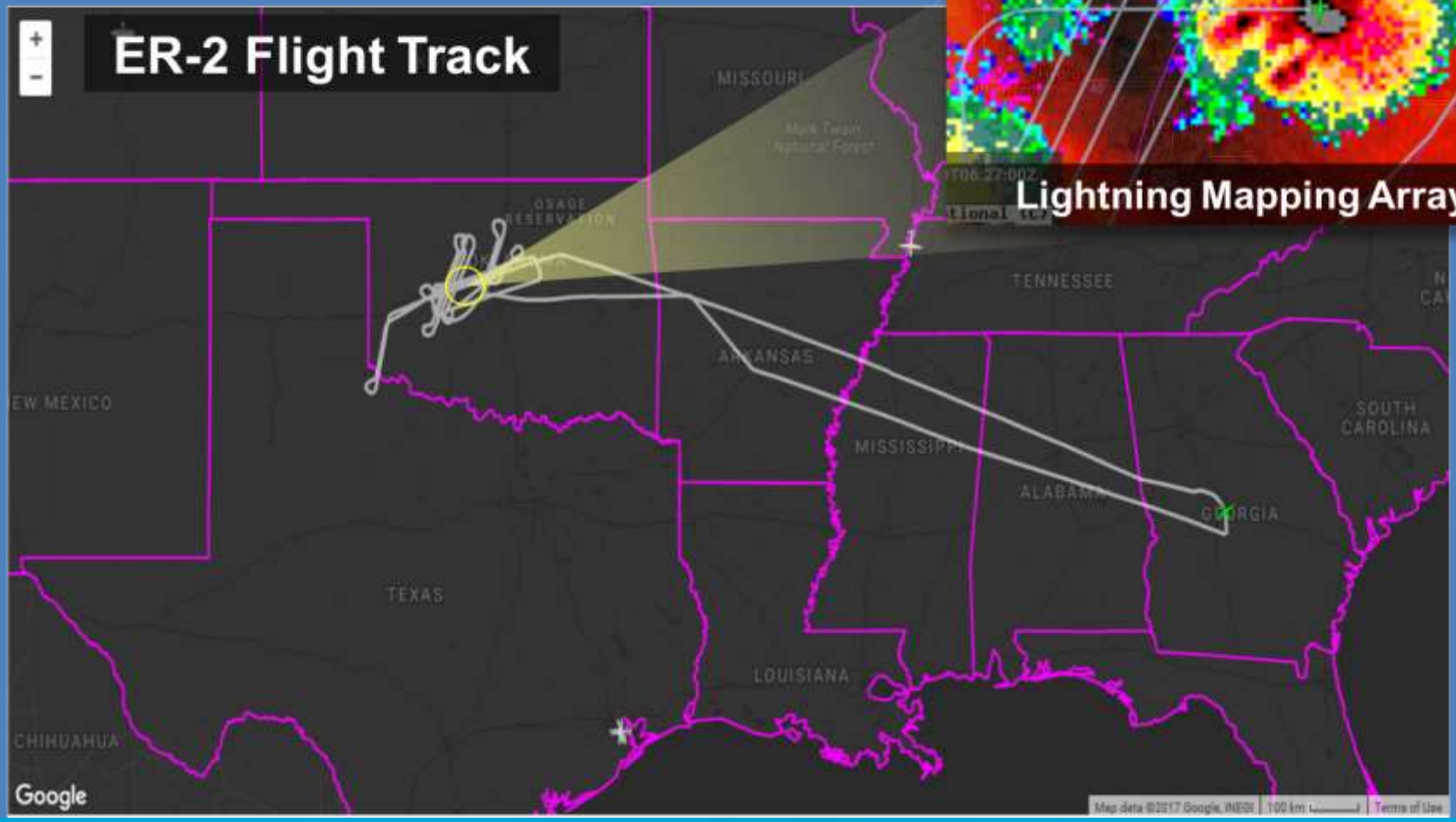
Preliminary analysis confirms ABI NSS coincident & collocated with ER-2 collections (90 min duration) – a subset of an ABI timeline 25 is shown above

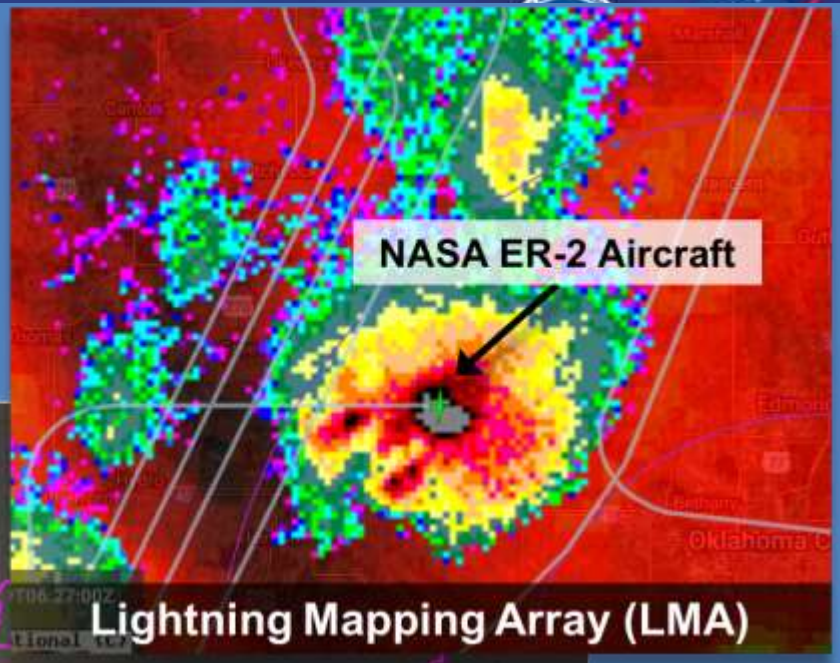
March 23, 2017 –Two sets of ER-2 consecutive circle patterns (20 circles total) conducted to match the AVIRISng high-altitude aircraft based sensor view geometry with ABI over the Sonoran Desert




ABI NSS Collection
0800-0815 Z
ER-2 Collection
0804-0812 Z
~ 210 K Brightness Temperature (GOES)
14 km Cloud Ht. (CPL)
ABI NSS
Oklahoma City
Oklahoma
ER-2 Flight Track
ER-2 S-HIS Swath

GOES-R Field Campaign Phase 2 Operations
Date: April 29, 2017
Mission Objective: GLM Primary Validation - Norman, OK Supersite (Night)
Takeoff: 0300 Z
Landing: 1054 Z
Flight Duration: 7.9 hrs

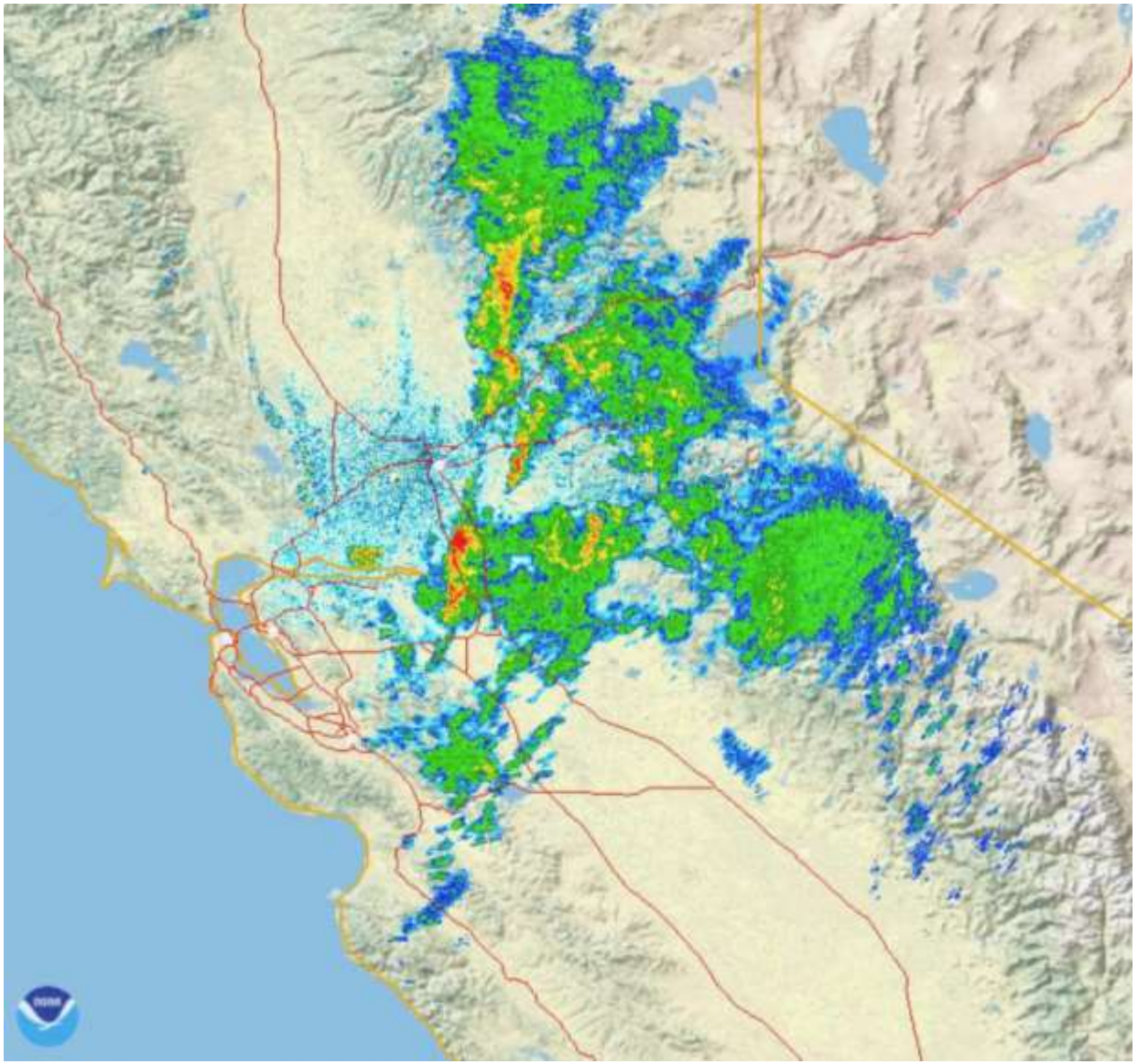


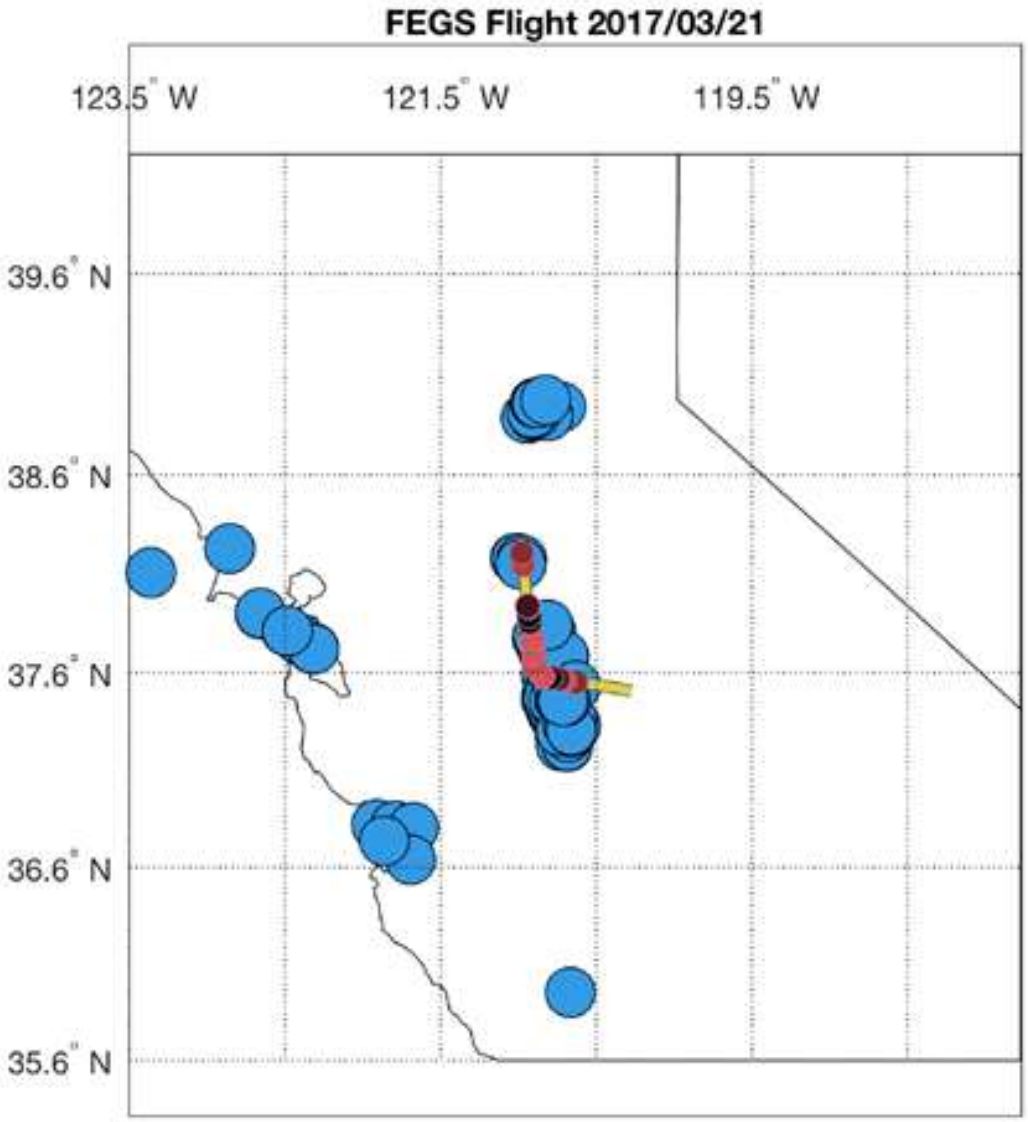


ER2 Test Flight & GLM Validation Mission

March 21, 2017 – Test Flight & GLM Validation Mission

- The observation target was a weather system in the Sacramento and San Joaquin River Valley. This system on the windward (western) side of the Cascade and Sierra Nevada Mountain Ranges produced frequent lightning and wind damage.

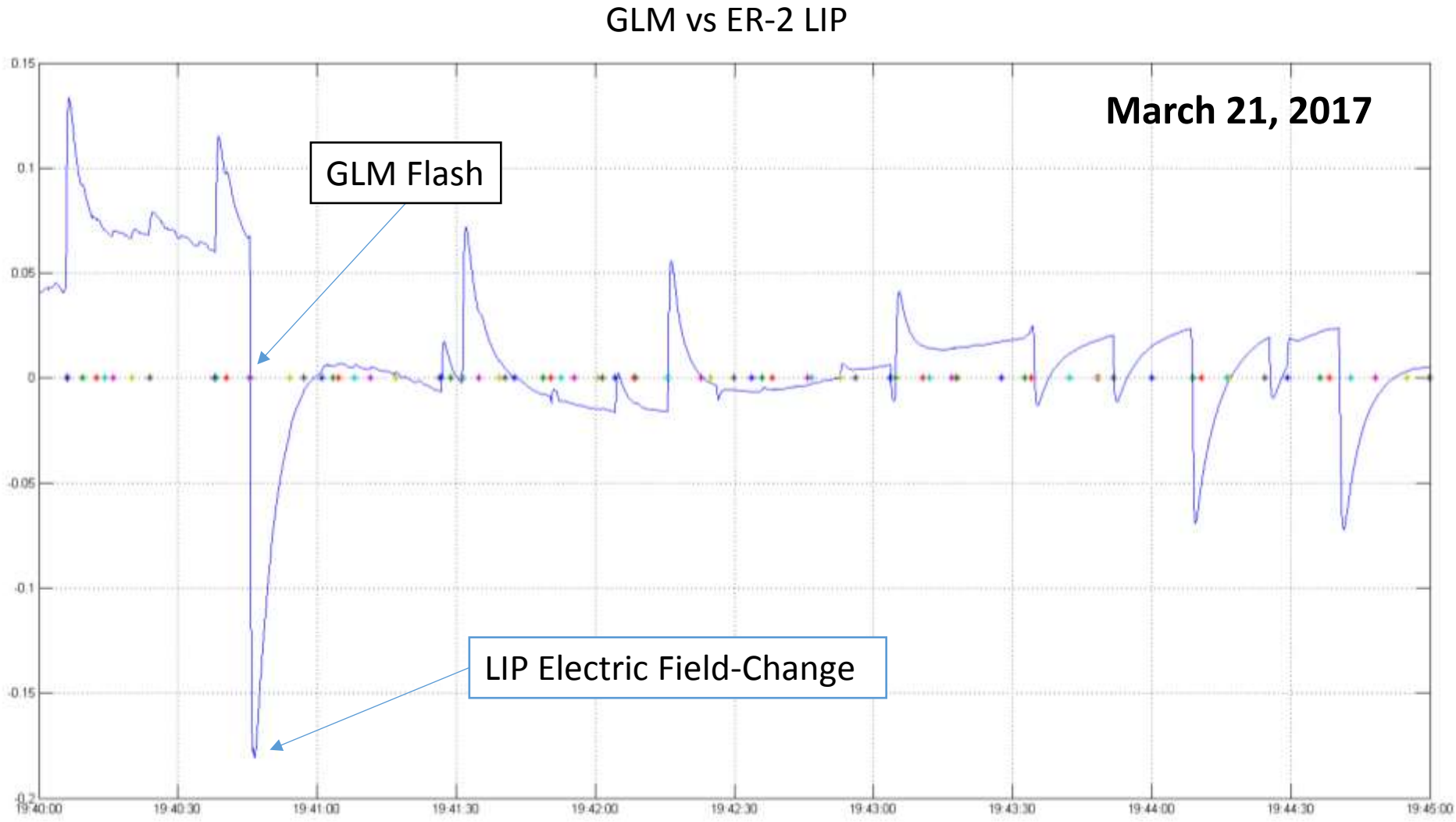




A 10 minute period with 300 GLM events (**BLUE**)

FEGS events (**RED**) along the flight path

Test Flight & GLM Validation Mission



Weather Quicklook

Navigation

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- Image Gallery
- Related Links
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  - ABI Workspace
  - Quicklooks
  - File Naming Convention
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  - Daily Meeting Information
  - ER-2 Operations Schedule
- Mission Reports
  - Plan of the Day
  - Weather Forecast
  - ER-2 Flight Reports
  - Mission Scientist Reports
  - Instrument Status Reports
- Lightning
  - NLDN in Last 5 Minutes
  - NLDN in Last 10 Minutes

Plan Of The Day: April 11, 2017

Submitted by fpadula on Tue, 04/11/2017 - 17:46

KML Files

04_11_17_POD.kmz

Date: Tue, 04/11/2017 - 17:41

Day 0: 11 April 2017 (Tues)
Transit flight from PMD to WRB
ER-2 Aircraft - ~5 hr flight: 1600 to 2100 z

Day 1: 12 April 2017 (Wed)
ABI Mission - Night Flight
Weather – Clear sky possible over Gulf of Mexico validation target
ER-2 Aircraft - ~5.5 hr flight: 0455 to 1030 Z

Day 2: 13 April 2017 (Thurs)
ABI Mission - Night Flight (Back-Up)
Weather – Clear sky possible over Gulf of Mexico validation target
ER-2 Aircraft - ~5.5 hr flight: 0455 to 1030 Z

Day 3: 14 April 2017 (Fri)
TBD

Day 4: 15 April 2017 (Sat)
TBD

LMA Coverage Map

Latest map time: Apr 11 09:50

Latest Instrument Reports

Aircraft: ER-2

Instrument	Status	Date
S-HIS	Green	04/12/2017
FEGS	Green	04/12/2017
EXRAD	Green	04/11/2017
CRS	Green	04/11/2017
AVIRISc	Green	04/06/2017
GCAS	Green	03/28/2017

Summary

- GOES-16 launch 19 November, currently in post-launch testing at 89.5 W for 1-year, ABI imagery via GRB after March 1
- ER2 airborne 10-week field campaign March 21-May 18 concurrent measurements with other satellites and ground-based reference sites to calibrate and validate ABI and GLM performance and L2 products.
- Planned announcement in May-June for the GOES-16 operational location beginning November 2017.

Thank you

For more information visit www.goes-r.gov

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Back-Up

Phase 1 Data Collection

Phase I: Successful GOES-R Post Launch Airborne Science Calibration / Validation Field Campaign operations (17.5 flight hours) from Palmdale, CA (March 12-29, 2017):

- Successful completion of a Combined System Test (CST) - Monday March 20, 2017
- Successful completion of a 6.6 hr test flight on March 21, 2017:
  - Calibration maneuvers conducted for instrument checkout
  - GLM validation mission was also conducted resulting in the continuous observation of an active line of thunderstorms (NWS severe thunderstorm warnings issued with damaging surface winds reported) east of San Francisco
  - This first flight provided critical data towards GLM validation
- Completed ABI primary Reflective Solar Band (RSB) validation objectives -- 2 sorties (March 23, 2017 & March 28, 2017) -- the fully coordinated validation mission set required a diplomatic flight clearance with the Mexican Government, aircraft special maneuvers, ABI special scans, and coordinated ground validation teams.
  - These two collections and data sets are unprecedented in geostationary Earth observation and are a major achievement towards the post-validation of the next generation of GOES imagers
  - Sonoran Desert provided an ideal calibration target due to its large size and spatial uniformity

Phase 2: Transit Flight from Palmdale, CA to Warner Robins, GA on April 10 with GulfMex ocean night flight April 12 (concurrent with S-NPP overpass and ABI NSS)

Phase 2 Data Collection

Phase 2: (27 flight hours) from Warner Robins, GA (April 16-29, 2017):

- Completed 6 sorties to date towards GLM primary validation objectives
- Each sortie was tailored to satisfy GLM primary field campaign validation objectives.
- All missions conducted with ABI 30-second imagery coincident and collocated with the ER-2 aircraft:
    - April 16, 2017 (7.8 hr mission) - Targeted a large Mesoscale Convective System (MCS) during the transition from late night into daylight hours that produced near continuous lightning over the northern range of the Norman, OK total lightning supersite.
    - April 18, 2017 (6.2 hr mission) - Collected nearly 2 hours of compact low flash rate lightning over the Northern Alabama total lightning supersite and Atlanta, GA LMA during daylight hours. This sortie also provided ~2 hrs of convective initiation collection for ABI L2+ product validation.
    - April 20, 2017 (7 hr mission) - Targeted northern latitude lightning over the Toronto LMA from a line of organized storms that produced horizontally extensive and high flash rate lightning observed during the transition from twilight to night conditions.
    - April 22, 2017 (5.9 hr mission)- Collected data over afternoon severe storms in northwest Alabama and southern Tennessee with reports of golf ball size hail and concurrent with tornadoes on the ground, all within range of the North Alabama Supersite. In addition the NOAA P3 and UAH mobile research radars, profilers, and lightning detectors were in place throughout the severe storms.
    - April 27, 2017 (5.3 hr mission) - 2.5 hours of horizontally extensive low-flash-rate thunderstorm data collected over the northern Alabama supersite. ER-2 flew over a large active fire along the FL/GA border for ABI validation.
    - April 29, (7.9 hr mission) - 4 hours of nighttime data of high-flash-rate supercellular thunderstorms coincident with the Norman, OK supersite. ER-2 overflight of deep convective clouds with GOES-16 ABI NSS.

Mission Flight Hours Accounting

Flight	Location	Objectives	Planned Flight [hrs]	**Actual [hrs]**	Dependencies	Total Hours
1	PMD	Test Flight/GLM Lightning Flight	3 (+4)	6.6		Phase I 25 hours
2	PMD	Aircraft - Direct Validation (RSB - Day)	7	5.7	ABI special collection & S-NPP overpass	
3	PMD	Aircraft - Direct Validation (RSB - Day)	7	6.5	ABI special collection & S-NPP overpass	
4	PMD	Transit to WRB	5.5	4.8	DOE ARM + Special Sounding	
5	WRB	Aircraft - Direct Validation (TEB - Night)	5.2	3.9	ABI special collection & S-NPP overpass	Phase II 75 hours (External Funds 12 hrs)
6	WRB	GLM Supersite (Night/Twi.)	8	7.8		
7	WRB	GLM Supersite (Day)	8	6.2		
8	WRB	GLM Supersite (Twi/Night)	8	7		
9	WRB	GLM Supersite (Day/Twi.)	6.8	5.9		
10	WRB	GLM Supersite (Night)	8	5.3		
11	WRB	GLM Supersite (Night)	8	7.9		
12	WRB	GLM Supersite (Day)	8			
13	WRB	Ocean, LMA, other (Day)	6			
14	WRB	Colorado Supersite (Day/Night)	9		Transfer to WRB	
			Total	60.4 (1.3)		

Collection Matrices: ABI & GLM

ABI Collection Matrix [Times Observed]

	ABI Primary Validation: Sonoran Desert	ABI Primary Validation: Central Gulf of Mexico	Clouds					Active Fire	SURFRAD Sites
			Low Light	Clouds Over Snow	Pre-Storm Environment	Convective Events	Post-Storm Environment		
Total Collects	2	1	4	1	3	7	1	1	3

GLM Collection Matrix [hours of lightning observed]

Location	Day Operations (Total: 9 hrs)				Night Operations (Total: 12 hrs)				Twilight Operations (Total: 3 hrs)			
	Compact	Horizontally Extensive	Flash Rate Low	Flash Rate High	Compact	Horizontally Extensive	Flash Rate Low	Flash Rate High	Compact	Horizontally Extensive	Flash Rate Low	Flash Rate High
Northern, AL	4.5		1	3.5		2.5	2.5		1.5			1.5
Norman, OK		0.5		0.5		6.5	1	5.5		1	0.5	0.5
Lubbock, TX												
KSC, FL												
Wallops/DC												
Ft. Collins, CO												
Socorro, NM												
Atlanta, GA	1		1									
Houston, TX												
Toronto, Ca.						3	1.5	1.5		0.5		0.5
Land		3		3								
Ocean												
ISS Overpass												