Experiments in Support of Next Generation Low Earth Orbit Microwave Sounder Formulation at NOAA

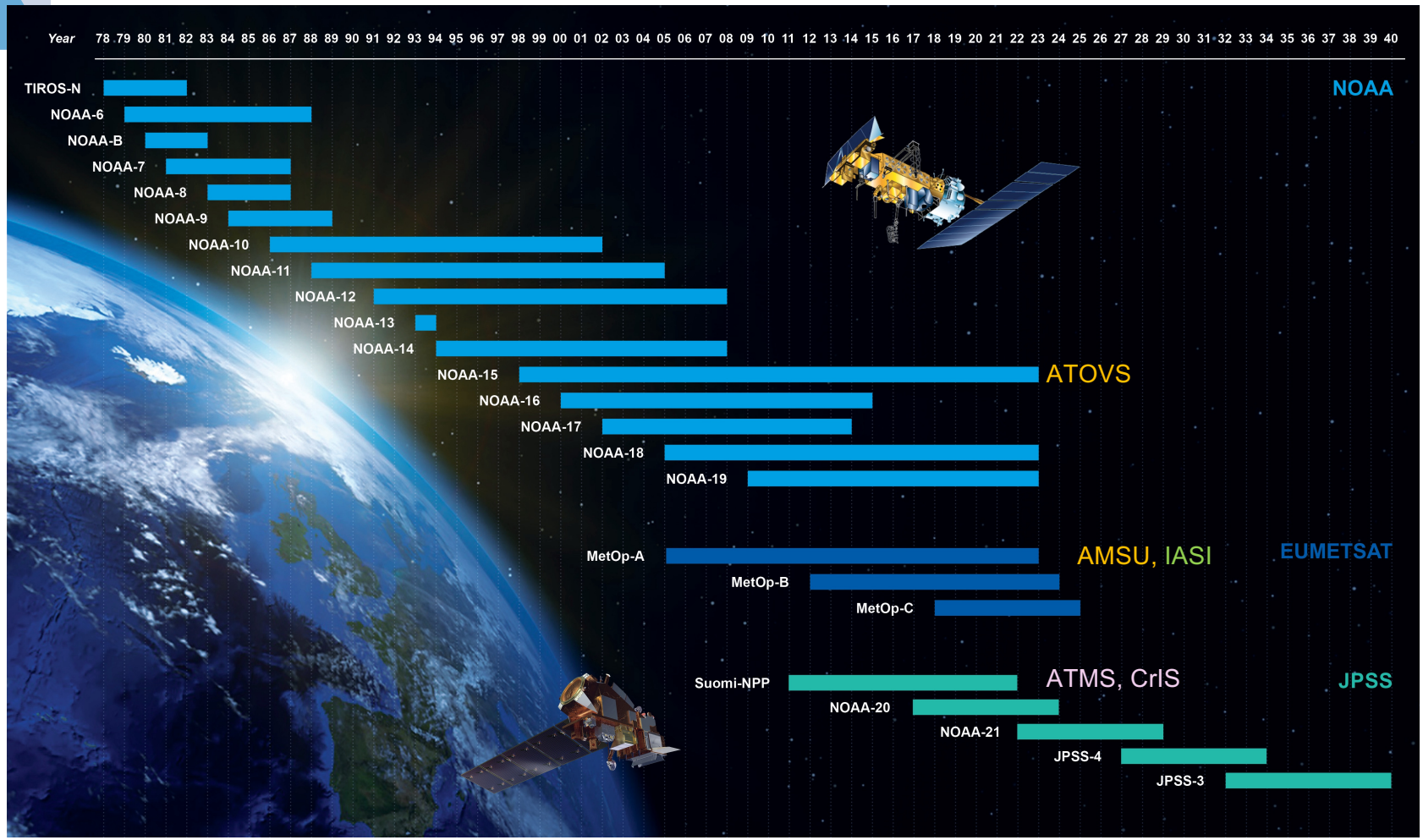
Satya Kalluri, Ph.D.
Senior Scientist
Office of Low Earth Orbit (LEO) Observations
Satya.kalluri@noaa.gov

NOAA
National Environmental Satellite, Data, and Information Service

5th International TOVS Study Conference (ITSC-25)
8-14 May, Goa, India

Outline

- A brief history of NOAA LEO soundings
- OSSEs in support of future NOAA LEO sounders
- Future plans for microwave and IR sounders in LEO orbit by NOAA
- Summary and Outlook


Year
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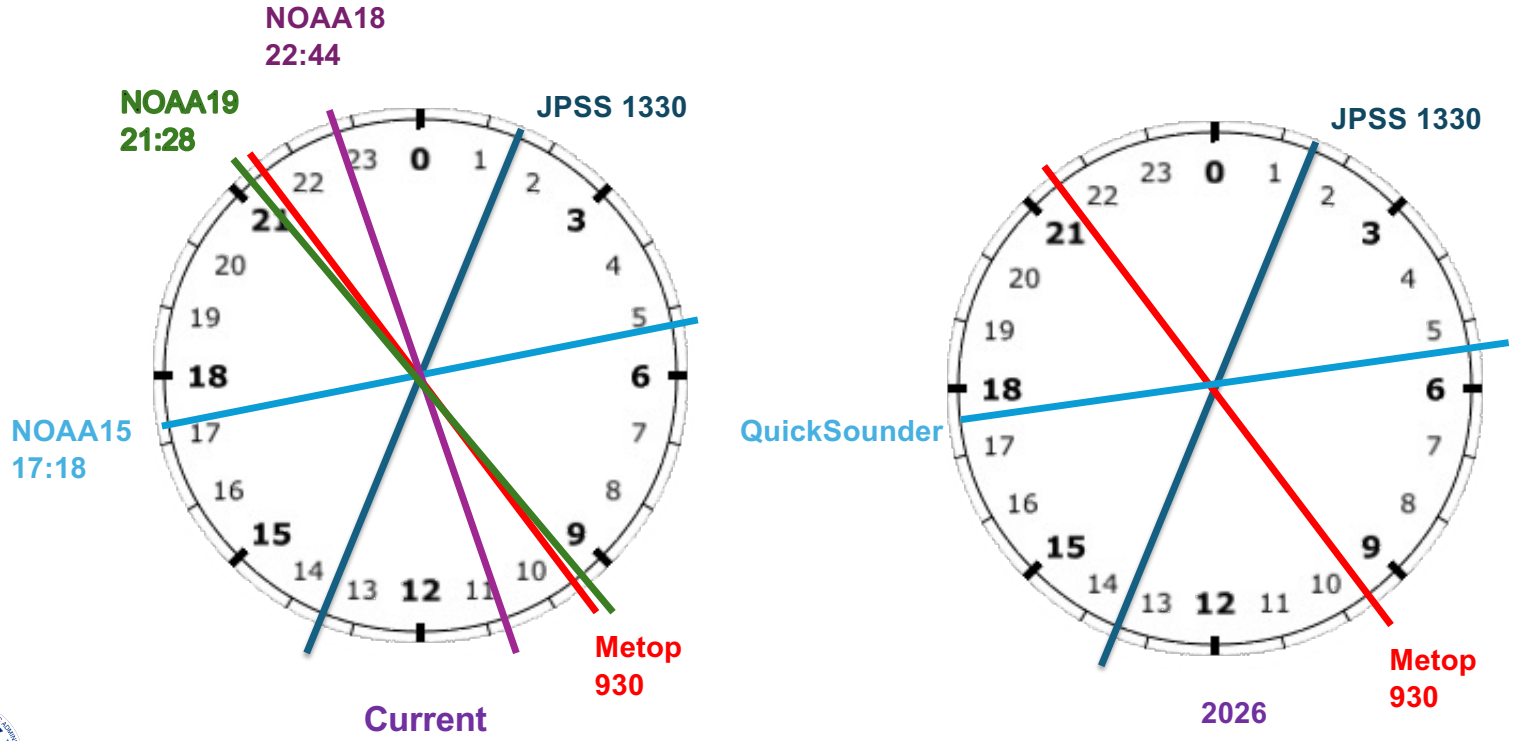
NOAA
ATOVS
MetOp-A
MetOp-B
MetOp-C
AMSU, IASI
EUMETSAT
Suomi-NPP
NOAA-20
NOAA-21
JPSS-4
JPSS-3
ATMS, CrIS
JPSS

Every Major NWP Centers Around the World Relies on NOAA Data

Centre	AMSU-A												AMSU-B/MHS												ATMS				
	Satellite									Channels			Satellite								Channels				Satellite		Channels		
	N15	N16	N17	N18	N19	AQ	MA	MB	MC	land/sea	sea/ low topo	sea	N15	N16	N17	N18	N19	AQ	MA	MB	MC	land/sea	ea/low topo	sea	NPP	N20	land/sea	sea/low topo	sea
ECCC(Canada)	X			X	X	X	X	X		7-14	6	4-5					X		X	X		3-4		2,5	X	X	9-15	7-8, 20-22	5-6, 17-19
ECMWF(Europe)	X			X	X	X	X	X	X	7-14	5-6						X		X	X	X		3-5		X	X	8-15(3x3 avg.)	-7; 18-22 (3x3 avg)	
MET Norway(Norway)	X	X		X	X		X	X		5-9	5-6	5-9				X	X		X	X		3-5	3-4	3-5					
US-FNMOC/NRL(USA)	X			X	X	X	X	X	X	6-14	6-14	1-14				X	X		X	X	X			3-5	X	X	5-14, 18-22	5-14, 18-22	1-14, 18-22
DWD(Germany)	X				X		X	X	X	9-14		5-14				X	X		X	X	X	3-4		3-5	X	X	-15 (3x3 avg.)20, 22		6-15 (3x3 avg.)18, 20
Met Office(UK)	X			X	X			X	X	4-14							X			X	X	3-5			X	X	7-15, 19-22		6, 18
DMI(Denmark)	X			X	X		X	X		4-10(7)							X		X	X				3-5	X				5-11,19-22 (AAPP preprocessed)
JMA(Japan)	X	X		X	X	X	X	X		8-14	6-7	4-5					X		X	X		3-5			X	X	18-22	AAPP preprocess	APP preprocesse
Meteo France(France)	X			X	X	X	X	X	X	5-13	5-13	5-13					X		X	X	X	3-5	3-5	3-5	X	X	6-14,18-22		
NCEP(USA)	X			X	X	X	X	X	X	1-15						X	G			X	X	1-5			X	X	1-22		
BoM(Australia)	X			X	X		X	X		7-14	6	4-5					X		X	X				3-5	X		8-15	7	6,18-22
CPTEC/INPE(Brazil)	X		X	X	X	X	X	X								X	X		X	X									
OMSZ(Hungary)				X	X		X	X		5-13						X	X		X	X		3-5							
SMHI (Sweden)				x	X		X	x		6-9	6-9	6-9					x		X	x		3-5	3-4	3-5					
ITAF-COMET(Italy)				X	X		X	X	X	7-9	5-6	5-9				X	X		X	X	X		3-4		X	X	6-10, 18-22 (3x3 avg)		
KMA(Korea)	X			X	X		X	X		7-14	6	4-5				X	X		X			3-5			X				
NCMRWF(India)	X			X	X	X	X	X		1-15			X			X	X		X	X		1-5			X	X	6-15, 18-22	X	6, 18-22
NIWA(New Zealand)	X			X	X		X	X		4-14(15)						X	X		X	X				3-5	X		7-15, 22		6, 18-21
CMA(CHINA)	X			X	X		X	X		7-11	6	5-11				X	X		X			3-5			X		6-12, 18-22		
CHMI(Czech Republic)																													

Current NOAA microwave and IR sounders on legacy POES, JPSS and Metop satellites



Next Generation LEO Sounders

- NOAA will develop future LEO sounders under the the Near Earth Orbit Network (NEON) program

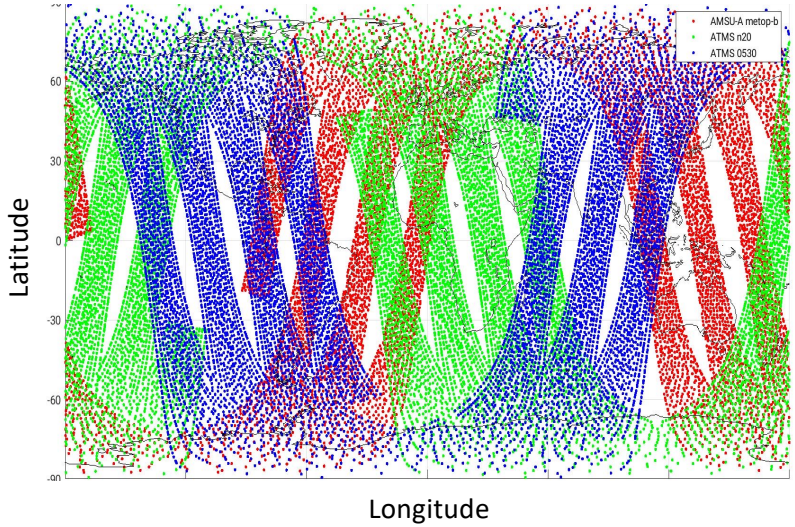
- NEON will support the following needs:
  - Continuity of the product baseline generated from JPSS and current NESDIS partner mission LEO observations
  - Evolution to support new requirements using partnerships, commercial, or NOAA-developed approaches; i.e., buy/partner where we can and build what we must
- Disaggregated architecture: Free flyer missions

GMAO LEO 0530 Orbit OSSE

Evaluate value of MW and IR instruments on an 0530 LTAN platform in a future scenario

- Reduced LEO: MetOp-b and NOAA-20 only
- Hyperspectral IR Geo Ring: 3 platforms
- Add ATMS and CrIS-FSR on 0530 orbit

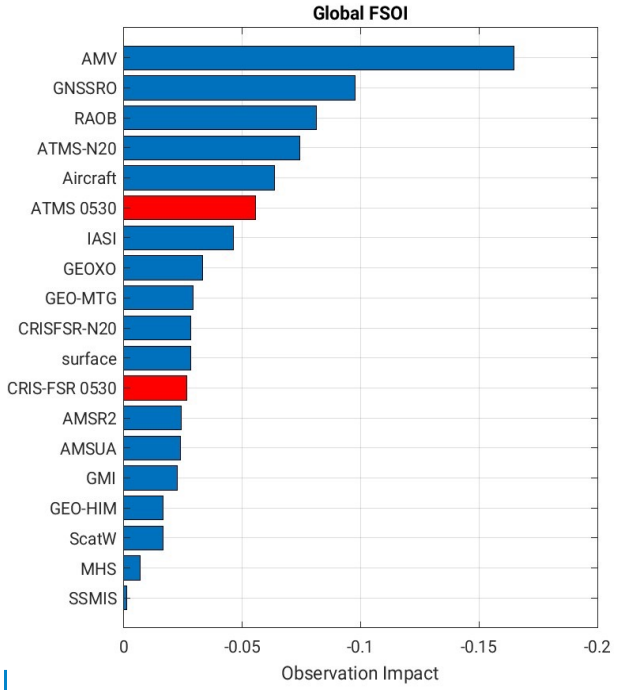
Simulated Orbits: LEO



Results

- Forecast improvements through day 7
- MW has larger impacts than IR on 0530
- CONUS impacts weaker than NOAA-20 due to overpass coincident with RAOBs/aircraft

Global Impacts: 24 hr

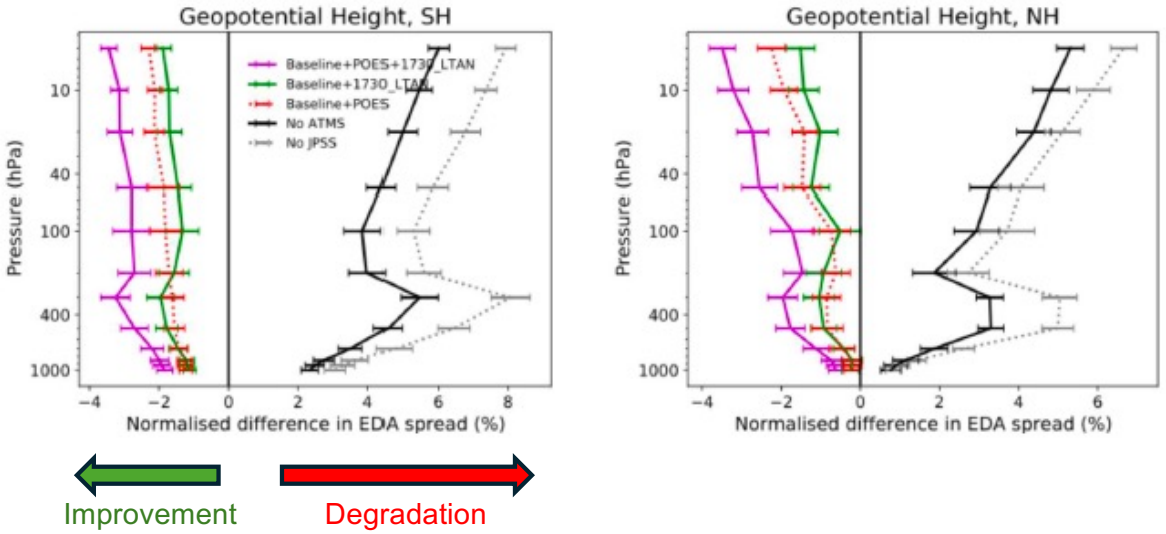


Privé, N.C., Karpowicz, B.M., McGrath-Spangler, E.L. and Kalluri, S. 2024. DOI: 10.16993/tellusa.4080

Vertical Profiles For EDA Spread Changes

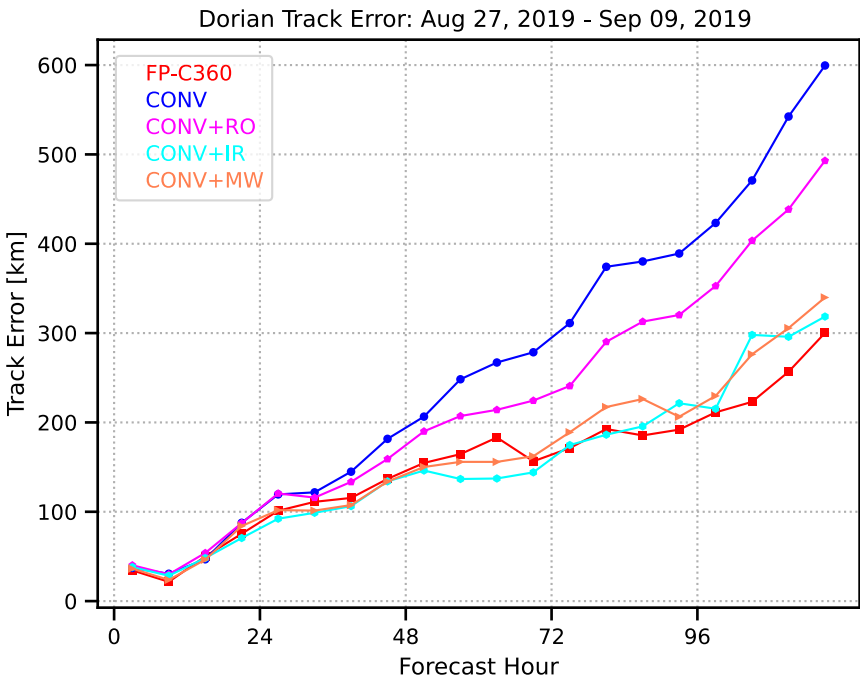
Findings:

- Remove of JPSS orbit results in a large degradation.
- The EDA analysis shows that a 530 LTAN MW sounder significantly impacts a range of atmospheric variables including temperature, geopotential height, relative humidity and wind as evidenced by the EDA spread.
- Largest impact is achieved when a MW sounder in the 530 LTAN and legacy POES are used together. Demonstrates increasing benefit as more MW sounders are assimilated.

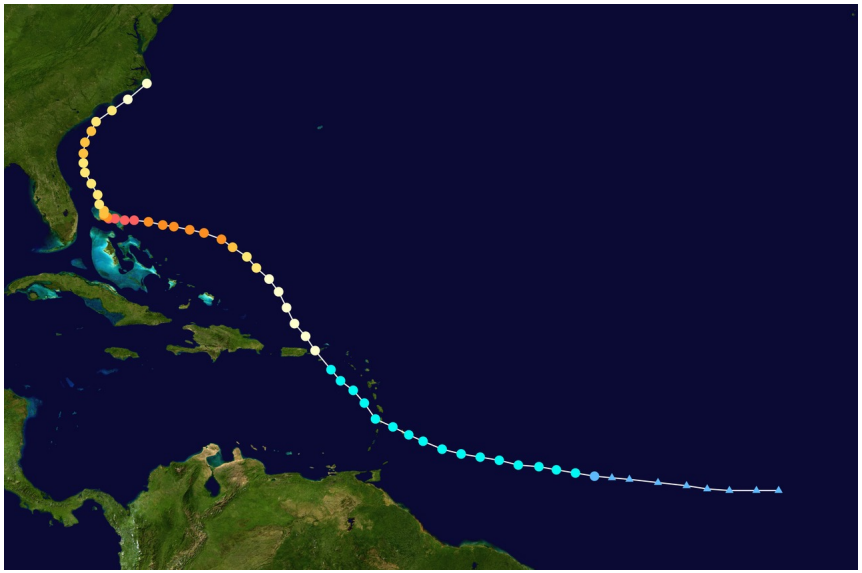


Ma, Z., N. Bormann, K. Lean, D. Duncan, E. Berbery and S. Kalluri, 2024: Forecast impact assessment of a potential ATMS instrument in the early-morning orbit using the EDA method. *ECMWF Technical Memorandum*, 925, https://doi.org/10.21957/59eb3a9b44

Observation Experiments: Impact of Various LEO Satellite Data on Category 5 Hurricanes Dorian



Overall Track of Hurricane Dorian, Aug 24 - Sep 7, 2019



The Impact of Various Observations on Hurricane Dorian's and Lorenzo Track Error in GEOS Forecasts extended up to Five Days. The Track Error is Calculated With Respect to the Hurricane Location in the Hurricane Best Track Dataset at the Time of Forecasts.
FP-360 is the Control Experiment With All the Observations Being Assimilated.

Isaac Moradi, UMD

QuickSounder Mission Summary

Mission Description

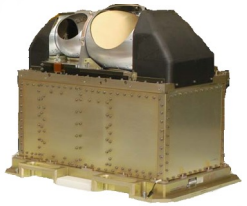
- A small, microwave sounding satellite to demonstrate operational observations can be obtained using “New Space” on a compressed schedule
- Polar-orbit sun-synchronous 17:30 LTAN
- Launch Readiness Date: 2026 (LRD change pending)
- Mission Life: minimum of commissioning + 30 days, 5-year goal, 3-year design life
- Mission Data Processing and Dissemination: based on legacy NOAA systems that are part of the NESDIS enterprise
  - Peraton is performing IDPS development

Peraton

Instrument Complement

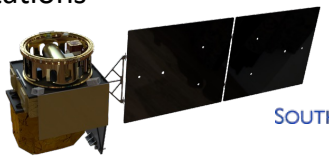
- Refurbished ATMS Engineering Development Unit (NG Azuza)
- Cross-track microwave sounder that provides temperature and moisture observations
  - 22 Channels
  - 23.8 GHz – 183.3 GH
  - Mass: 85 kg
  - Volume: 70cm x 40cm x 60cm

NORTHROP GRUMMAN



Spacecraft and Mission Operations (SMOS)

- Awarded heritage spacecraft from Rapid Spacecraft Development Office (RSDO) catalog to Southwest Research Institute (SwRI) in October 2023
- MOC in Boulder, CO will be operated by SwRI using KSAT and commercial ground stations



SwRI SOUTHWEST RESEARCH INSTITUTE

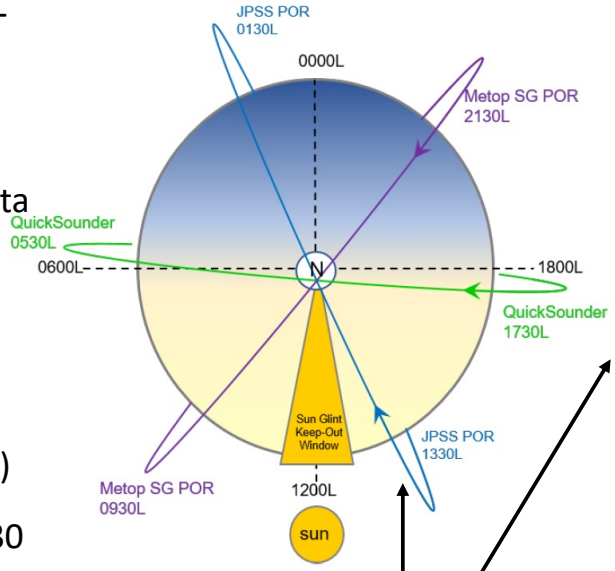
Launch Segment

- KSC/LSP provided Venture Class Launch Vehicle (LV) through Venture-Class Acquisition of Dedicated and Rideshare (VADR) contract
- Awarded to Firefly Aerospace on September 23
  - LV: Firefly Alpha
  - Launch Site: Vandenburg SFB
  - Configuration: Dedicated (no ride share)

FIREFLY AEROSPACE

SMBA Science Overview

- Sounder for Microwave-Based Applications (SMBA) is the next-generation microwave sounder
  - Capabilities address data product needs
  - Performance factors drive key science performance requirements
- Basic features:
  - 5-year lifetime (Class C)
  - 2 backbone polar sun-synch orbits: 1330, 1730 LTAN
  - Daily Global Coverage
- Continuity with heritage sounders



SMBA to populate 2 of 3 backbone orbits

SMBA Performance Factors Drive Performance Requirements That Will Achieve Data Product Needs

SMBA Performance Factors

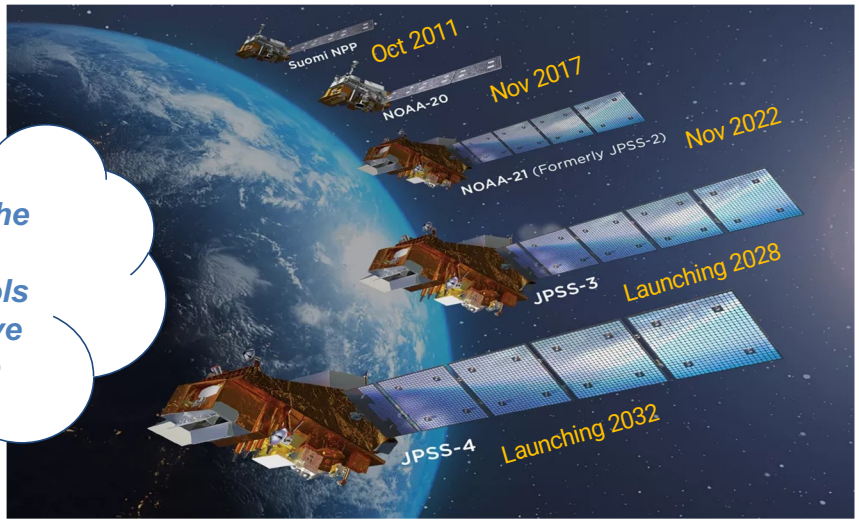
Performance Factor	Performance Target
Channels for direct Temperature Sounding	≥ 20 channels around 50-60 GHz and ≥ 10 channels around 118 GHz
Channels for direct Moisture sounding	≥ 10 Channels or more around 183 GHz
Window channels; channels for cloud, precipitation, ice detection for direct all-sky assimilation and NWP QC	Channels at 23.8, 31.4, 88.2, 165.5, and 229 GHz
Spatial coverage (daily global)	95% Global Coverage
Noise Level (NEDT) for Temperature sounding channels	At least as good as ATMS
Noise level (NEDT) for Moisture sounding channels	At least as good as ATMS
Spatial horizontal resolution (at nadir)	32 km (T) 16 km (q)
Spatial sampling	Contiguous footprints (or better)
Scan geometry	Cross track
Polarization	Single linear polarization
ATMS Channels Continuity	Yes, for similar channels
Calibration accuracy	At least as good as ATMS

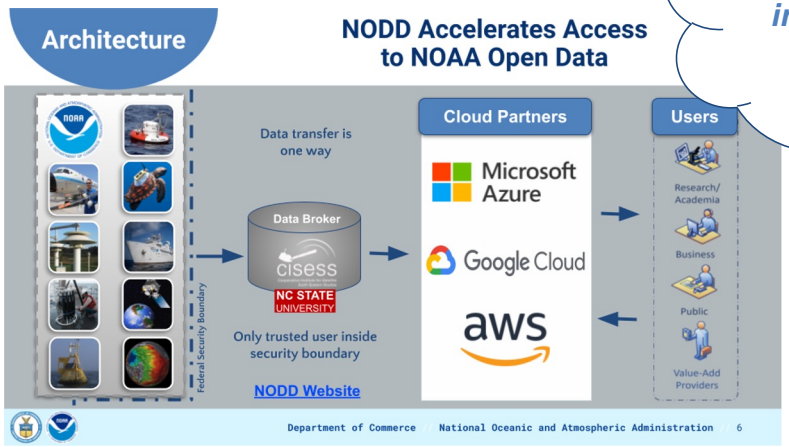
Near Real-Time JPSS Data via NOAA Open Data Dissemination (NODD)

In progress

- AWS - Registry of Open Data
- Google Cloud - Marketplace
- Microsoft - Planetary Computer

NODD leverages the CSPs' expertise, platforms, and tools in order to improve public access to NOAA data





NODD@NOAA.GOV

FROM THE NOAA NESDIS OFFICE OF LOW EARTH ORBIT (LEO) OBSERVATIONS

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LEO DIGEST

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Summary

- LEO soundings data are key to global NWP as demonstrated through several impact studies.
- The contribution of different observations (microwave, IR, RO) is incremental and additive to NWP.
- OSSEs demonstrate the value of a 3-orbit backbone.
- NOAA is formulating the next generation microwave sounder missions and is schedule to launch an ATMS in 1730 LTAN in 2026 (Quicksounder).
- Formulation and acquisition of next generation NOAA LEO microwave sounder (SMBA) is underway.

Thank you!
Namaste!