Emerging Frontiers in Heliophysics/Space Weather Enabled by AI and Public-Private Partnerships

Today's weather forecast for our star.

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NASA Heliophysics (SCOSTEP Member)





FRONTIER Development LAB

PARTNER





CubeSats					Hosted Payloads	
In Developme	ent			<u>On Orbit</u>	In Development	<u>On Orbit</u>
AEPEX	Dione	CubIXSS	SunCET	CuPID	CODEX	MinXSS-3
AERO / VISTA	GTOSat	petitSat	DYNAGLO	DAILI	LARADO	
CIRBE	ICOVEX	REAL	WindCube		OWLS	
CURIE	LAICE	SPORT			STORIE	
CuSP	LLITED	PADRE			(STRA)	



The Scale of Data

- There is currently over 8.7 PB of compressed AIA images and products.
- Uncompressed this would expand to over 20 PB.
- Optimized SSD reading at 7000MB/s would take over 14 days to read through all AIA files. *Real-world* read/write SSD speeds are closer to 500 MB/s or more than 200 days
- Size isn't the only issue, there are over 230 million AIA images.

Total Data Volume Over Projected Mission Lifetime*

GONG+ (0.61) | SUVI (0.60) | SOLIS (0.49) STEREO (0.08) | IRIS (0.06) HINODE (0.04) | GONG (0.03) RHESSI (0.01) | SOHO (0.01) YOHKOH (0.004) | PSP (0.003) SO (0.003) | TRACE (0.001)

SDO (32.5)

(in petabytes)

DKIST (85)



EVERY 15 SECONDS





Knowing what the Sun is doing matters more than ever.

SPACE TRAFFIC



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- Parks 1 9 1







The Sun Wakes Up: Solar Cycle 25 Is Practically Here

STEREO Ahead COR2

beginning of Solar Cycle 25, and the Sun's activity will once again ramp up until solar maximum, predicted for 2025.

This new solar cycle, and anticipated increase in space weather events, will impact our lives and technology on Earth, as well as astronauts in space.

This is the first solar cycle that many new commercial and government stakeholders will navigate.



SDO/AIA 131 2021-10-09 00:05:32 UT

2021-10-09 03:09:05

Active October 2021 Sun Emits X-class Flare



The New York Times Feb 2022

Elon Musk's Update What Is Starship? Storm Destroys 40 Satellites

Solar Storm Destroys 40 New SpaceX Satellites in Orbit

T+00:15:04

2021-11-16 04:18 UT Speed: 70.30 km/s Distance: 53.76 Rs HAE-LN: 16.00° HAE-LT: -2.95°



SO, HOW TO DELIVER A DAILY **WEATHER FORECAST FOR THE SUN?**



AI CAN HELP











SPACE TRAFFIC



Karman can predict thermospheric changes due to solar EUV, crucial for calculating changes to satellite drag and de-orbiting spacecraft.



POWER GRID INFRASTRUCTURE

D.A.G.G.E.R

DEEP LEARNING GEOMAGNETIC PERTURBATION

Dagger can predict the effects of solar activity on Earth's geomagnetic field, **30 mins in advance**, globally.



COMMUNICATIONS / PNT

auroraML

AuroraML can predict GNSS scintillation crucial for GPS and PNT. (Position, Navigation, Timing





DEEP SPACE EXPLORATION



SPIES can allow us to view the active Sun in EUV, **from any position in the solar system**.





 4π Combines SDO/STEREO A & STEREO B observations into a consistent 4π map of the Sun

It predicts what the Sun's EUV emission images would look like from non-c

NeRFS (Neural Radiance F to Instrument translation) Sun in EUV



WE'RE JUST GETTING STARTED....

CAPABILITIES				
SPACE TRAFFIC	POWER GRID INFRASTRUCTURE	COMMUNICATIONS	DEEP SPACE EXPLORATION	INSTR
KARMAN	D.A.G.G.E.R DEEP LEARNING GEOMAGNETIC PERTURBATION	auroraML	EUV of the full Sun	PRED
Satellite Drag	Geomagnetic Storms	GNSS Scintillation		TEMPE SO

...next time someone asks: "is it a sunny day today?" Al is helping understand and predict what is real happening!



OPEN CHALLENGES

EARLY DETECTION OF FLARES AND CMEs