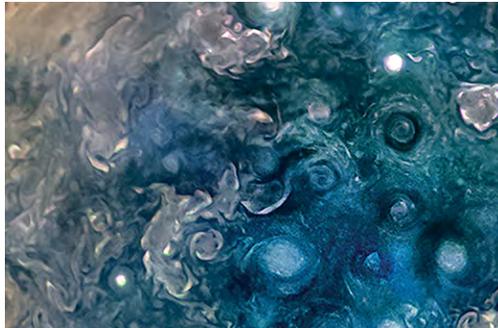


# SCIENCE

National Aeronautics and  
Space Administration



SMALL SATELLITE CONFERENCE

## NASA Science - SmallSat Strategy

Thomas H. Zurbuchen  
Associate Administrator  
Science Mission Directorate, NASA

August 6, 2018

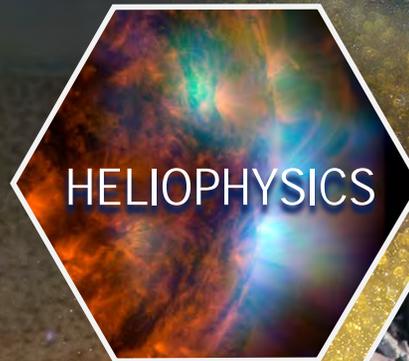
# SmallSats/CubeSats and NASA Science

- Enabling New Science
- Innovation
- Cultivating Mission Success

5 News Stories!

# NASA Science Mission Directorate

An Integrated Program  
Enabling Great Science





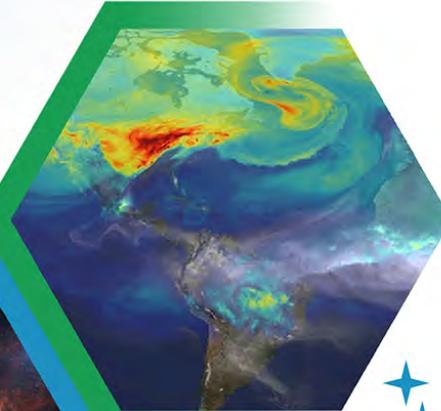


## ~\$100M Yearly Investment for SmallSats/CubeSats

- Nearly \$100M yearly investment for SmallSats/CubeSats
- Manage technology innovation by leveraging partnerships and commercial efforts across disciplines
- Invest in innovative early-stage research and technology to promote economic growth

# Key Science THEMES

Protect & Improve  
Life on Earth



Discover Secrets  
of the Universe

Search for  
Life Elsewhere



Corner of Thermal Blanket

# Mars Cube One (MarCO)

The View from Deep Space (MarCO-B)



High Gain Antenna (HGA)

Discover the Secrets  
of the Universe

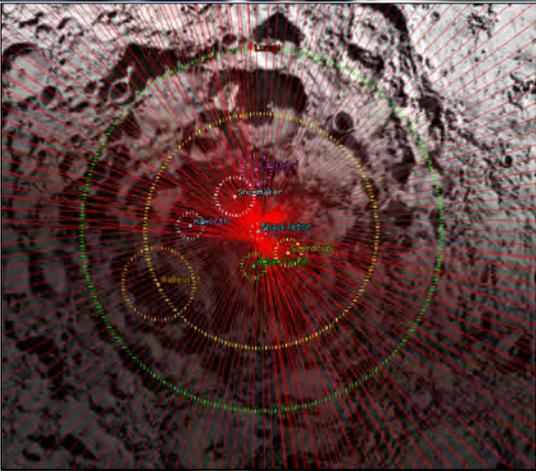
HGA Feed  
(Illuminated from HGA reflection)

Moon

Earth

Shadow of HGA Feed

Corner of Thermal Blanket



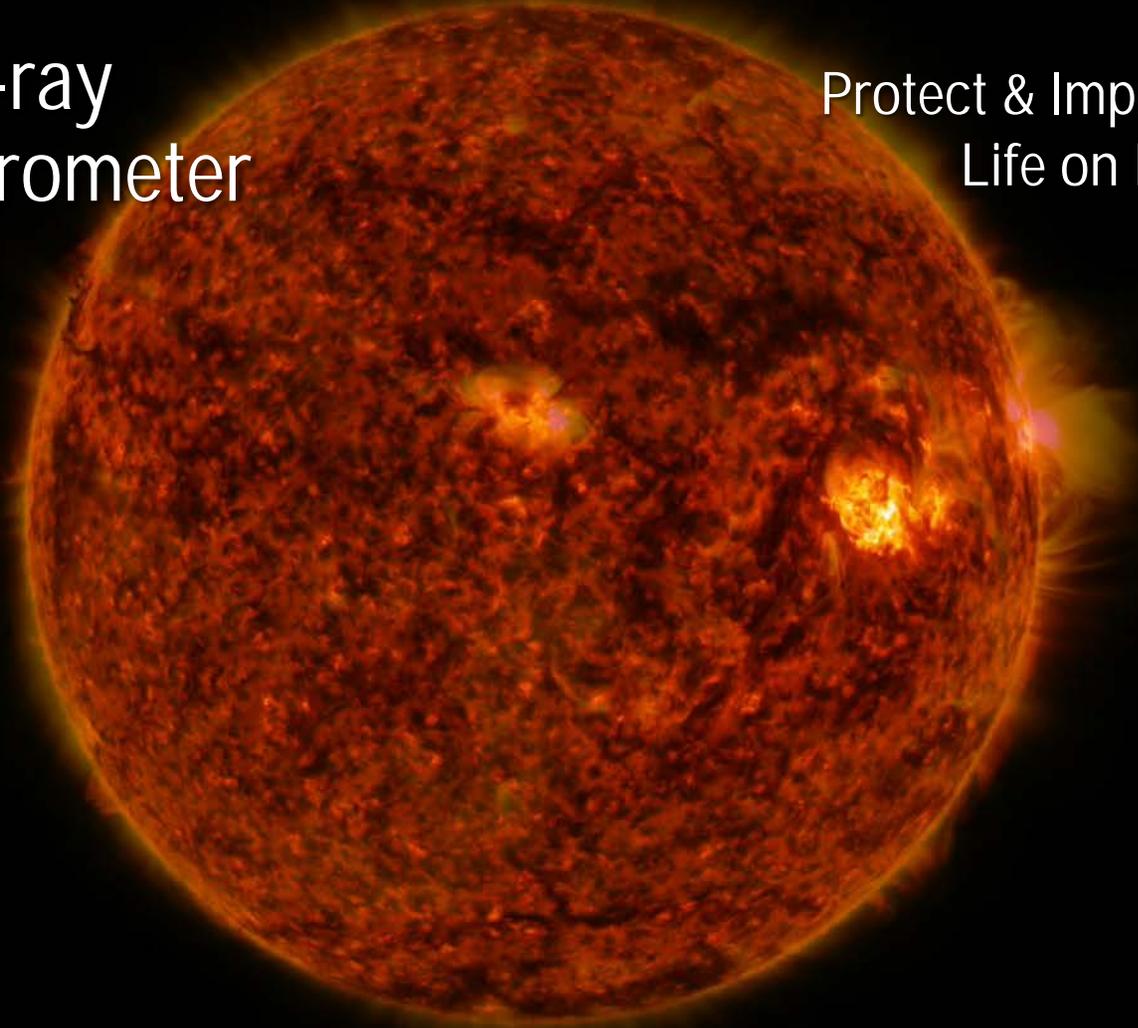
*Orbit ground track for 60 day science phase: 141 passes over target area, Shackleton Crater*

# LunaH-Map

Lunar Polar Hydrogen Mapper

# Miniature X-ray Solar Spectrometer (MinXSS)

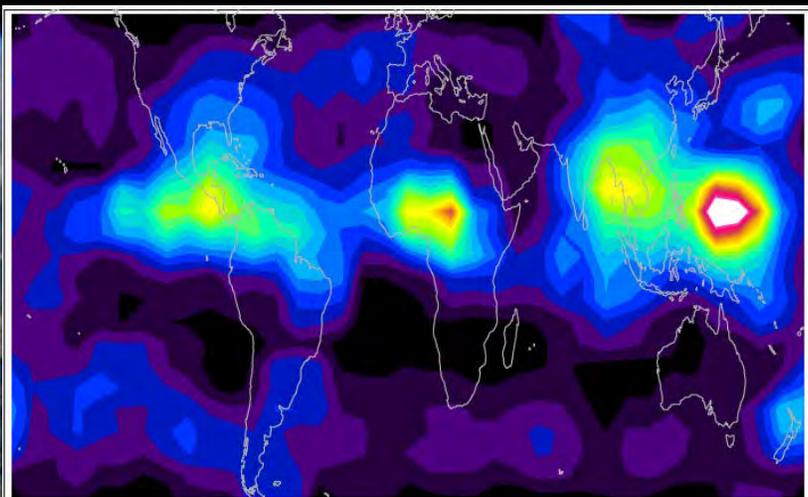
Protect & Improve  
Life on Earth



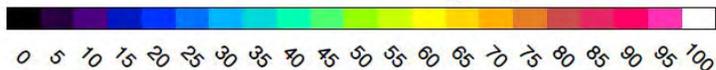
# IceCUBE

## Ice-Cloud Imaging Radiometer

Protect & Improve  
Life on Earth



Ice Water Path (g/m<sup>2</sup>)



First cloud ice map from 883 GHz radiances at 52 deg S - 52 deg N latitude



# BurstCube

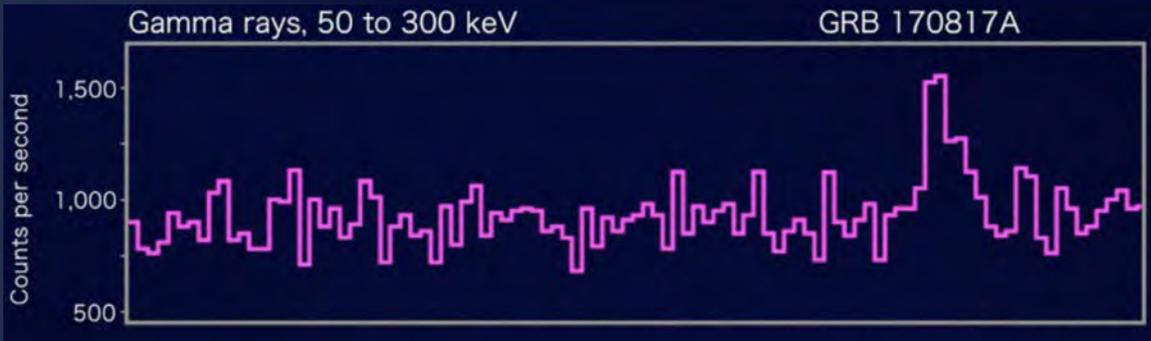
Detect and Localize Gamma-ray Bursts  
as Gravitational Wave Counterparts



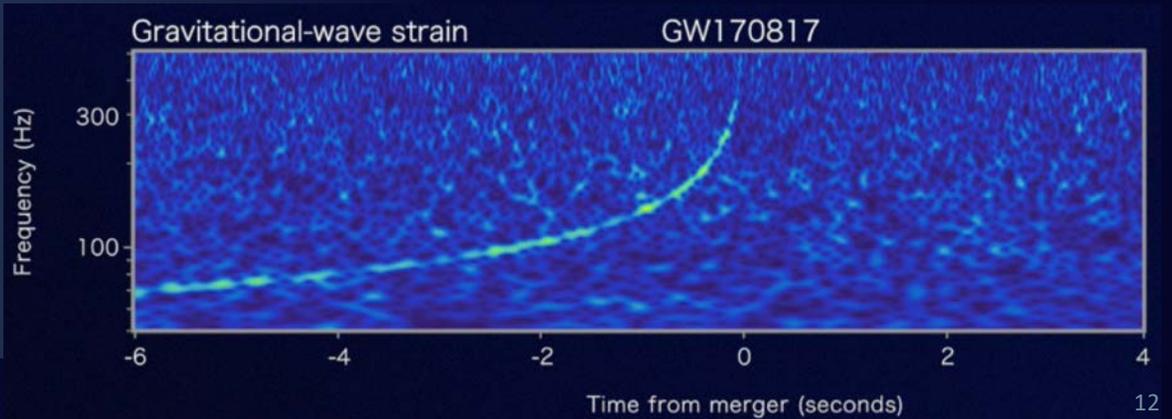
Discover the Secrets  
of the Universe



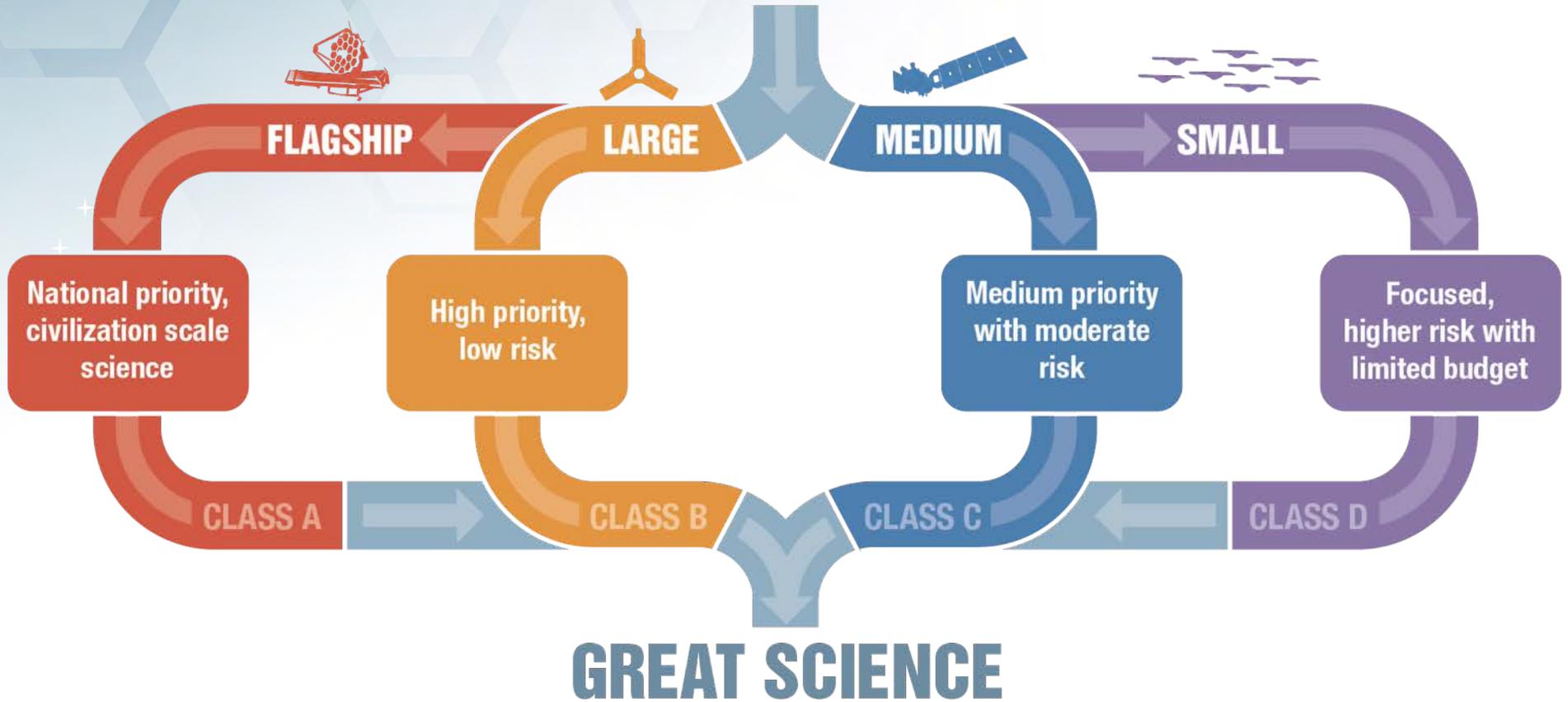
Fermi



LIGO

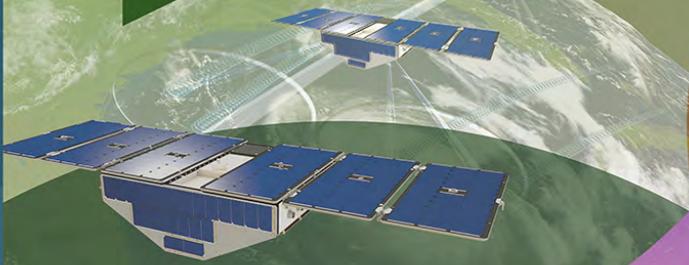


# BALANCED MISSION PORTFOLIO



PROGRAM IMPACT >

**Disruptive Innovation**  
SmallSat Constellations



**Game Changer**  
Deep Space Laser Communication

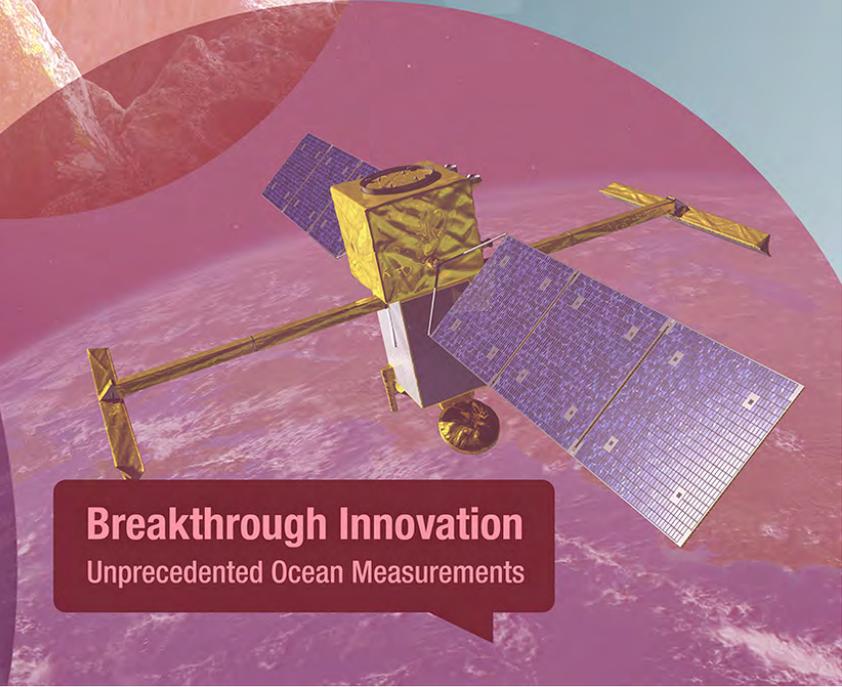


**SMD**  
ENABLE INNOVATION

**Incremental**  
Discovering More Exoplanets



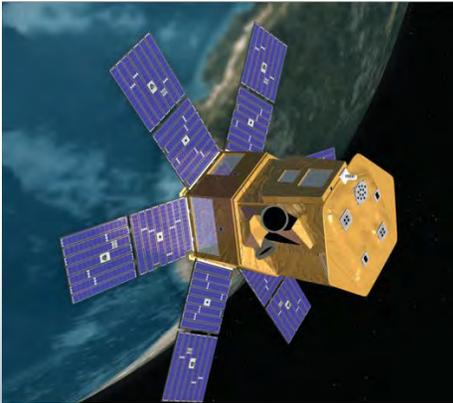
**Breakthrough Innovation**  
Unprecedented Ocean Measurements



TECHNOLOGY >

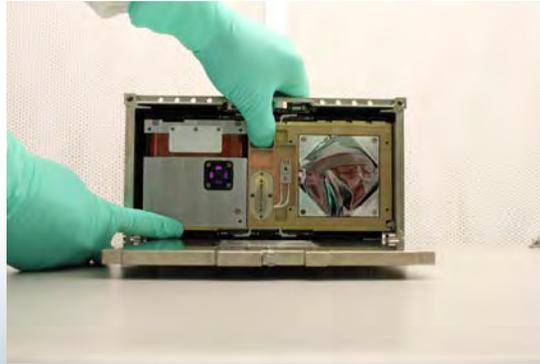
# Enable Innovation – CSIM

## MISSION



SORCE carries four instruments including the Spectral Irradiance Monitor ([SIM](#))

## TECHNOLOGY



Compact Spectral Irradiance Monitor ([CSIM](#)) Instrument

## IMPLEMENTATION



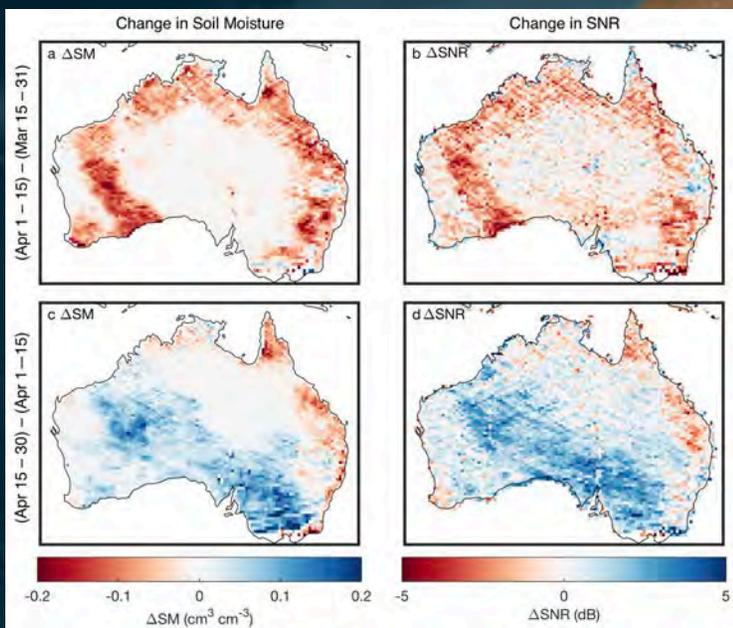
Compact Solar Spectral Irradiance Monitor Flight Demonstration (CSIM-FD)

Enabling Technology  
Result

Single 6U CubeSat at 1/10th mass and 1/20th volume of SORCE SIM instrument  
Rapid deployment validates technology and helps maintain continuity measurement of how solar variability impacts Earth's climate with direct comparison to SORCE (> 15 years on-orbit) and TSIS-1 SIM (< 6 months on-orbit)

# CYGNSS

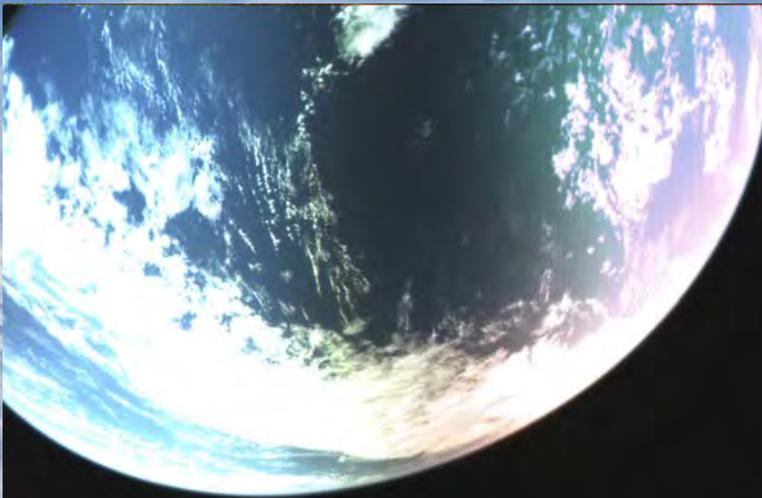
Land Hydrology Opportunistic Measurement  
Near-Surface Soil Moisture



June 8, 2018 *Nature Scientific Reports: Change in mean SMAP soil moisture compared to change in CYGNSS SNR*

# RainCube

CubeSat Ka-band Radar for  
Precipitation Observations



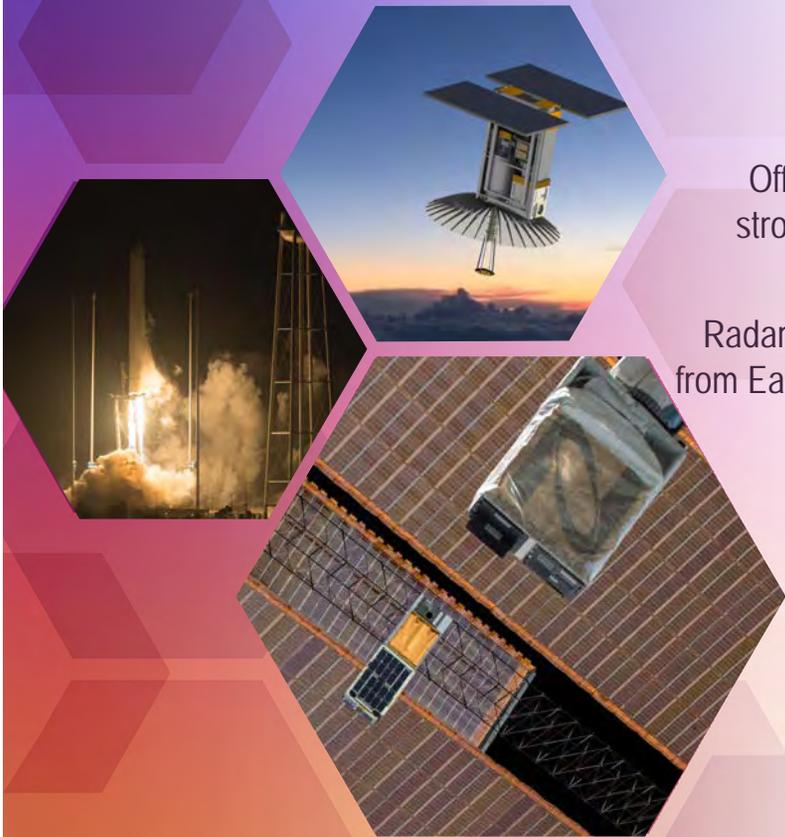
 **Jet Propulsion Laboratory**  
California Institute of Technology

 **Tyvak**  
A Terran Orbital Corporation

July 28, 2018 RainCube antenna deployment (45 times actual speed)

# RainCube: First Light Data

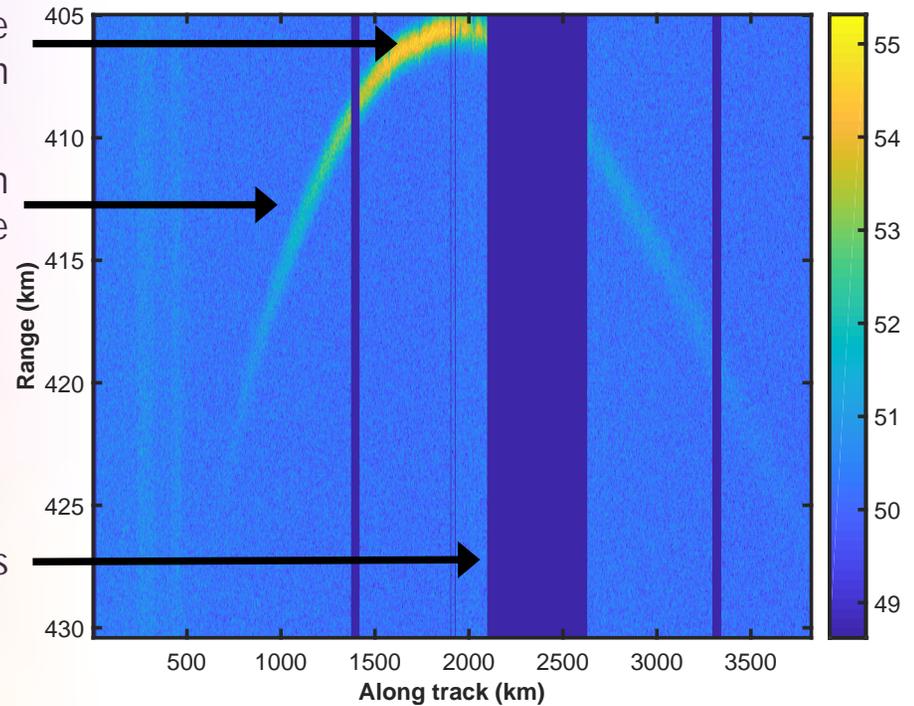
- Radar successfully operated in receive/transmit mode



Off-nadir angle  
strongest return

Radar echo return  
from Earth's surface

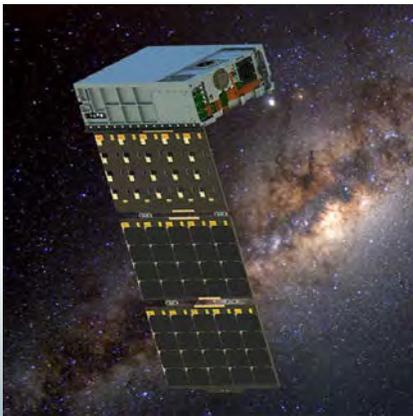
Data gaps



August 5, 2018 Transmit measurement of off nadir echo from the Earth's surface

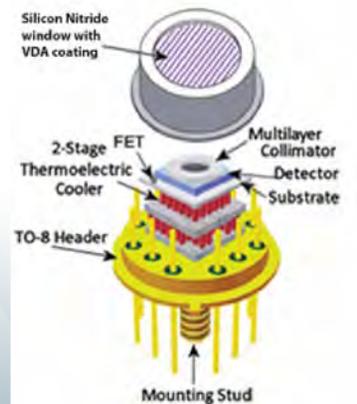
# Enable Innovation – HaloSat

## CONCEPT



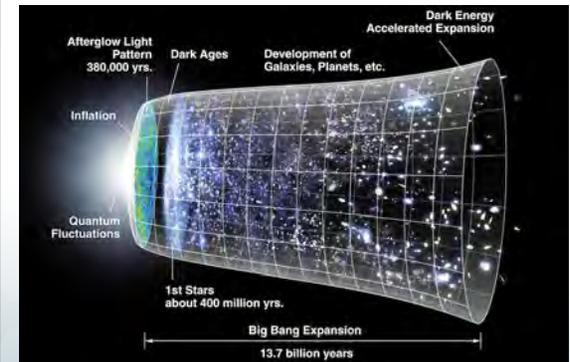
Spacecraft design

## TECHNOLOGY



X-ray detectors from Amptek

## SCIENCE



HaloSat's all-sky survey will constrain the mass and spatial distribution of hot gasses around our galaxy to help address the missing baryon problem

Science Impact

*Examines X-rays hot gas surrounding the Milky Way galaxy to help understand where 1/3 of the matter from early astronomical observations may be found*

Result

*Important science at modest cost and low risk achieved by commercially-available X-ray detectors and bus*

# Small Mission Implementation Strategy

*Accepting higher risk for scientific gain by implementing a tailored, streamlined classification approach*



# Small Satellite Constellation Data Buy Announced

- Pursuing contracts with three companies:
  - Planet – three satellite constellations including 200+ satellites supplying imagery and derived products over the entire Earth
  - DigitalGlobe – operates five satellite constellations that provide very high-resolution (31-50-cm) images
  - Spire – constellation of 48 satellites collecting Radio Occultation soundings and ship reports
- Provides a cost-effective means to augment and complement the suite of Earth Observations
- Acquires data sets, and information products and associated meta-data, through industry partners



# CubeSat Launch Initiative Broadens Access to Space



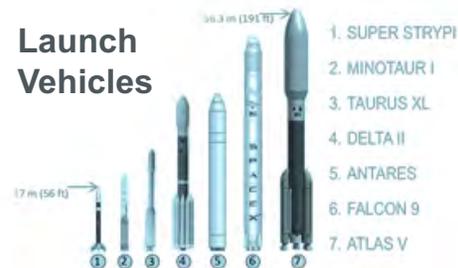
- **PROMOTES** innovative public-private technology partnerships
- **FACILITATES** low-cost technology development
- **STRENGTHENS** NASA and the Nation's future workforce



## Launch Providers

	 A	 B	 C	 D	 E	 F	TOTAL BY STATUS
MANIFESTED	3	0	2	4	18	21	48
LAUNCHED	15	13	13	1	17	0	59
TOTAL BY PROVIDER	18	13	15	5	35	21	107

## Launch Vehicles



**91**  UNIQUE ORGANIZATIONS

 **71** UNIVERSITIES

**155**   
CUBESAT  
MISSIONS  
SELECTED

# Rideshare Opportunities

*What if you could ride along?*

- Last four launches could have included shared payloads
  - GOES – 17
  - InSIGHT
  - Grace – FO
  - TESS
- Fosters partnering on joint international science objectives
- Creates a catalyst for new and innovative measurement techniques

# New ESPA-Class Rideshare Policy

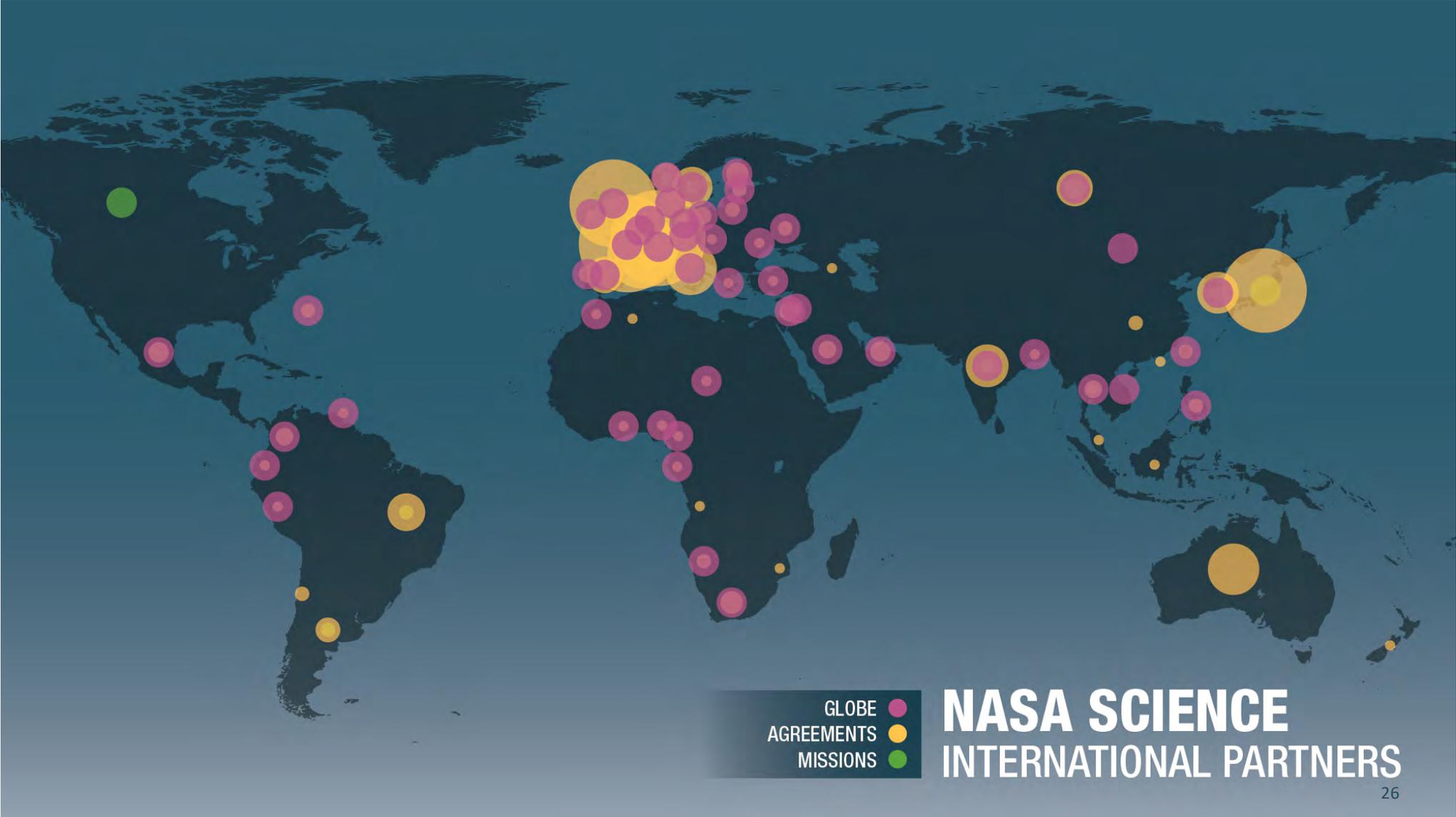
- Actively soliciting ESPA-class rideshare scientific payloads
- Directly supports NASA, government, academic, commercial, and international partnerships
- Recognizes future importance of constellation systems and economies of scale enabled by ESPA-class rideshare



# Engaging the Community for Mission Success

- Established Small Spacecraft Coordination Group to advise on agency strategy & policy
- Engaging commercial NewSpace industry to partner on science and technology
- Utilize Small Spacecraft Systems Virtual Institute (S3VI) to support community
- <https://www.nasa.gov/smallsat-institute>

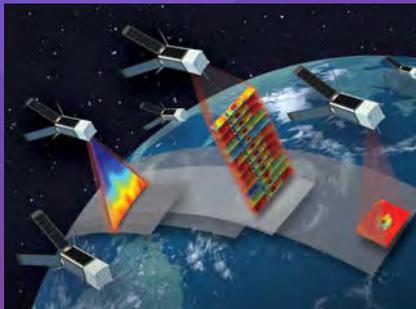




GLOBE ●  
AGREEMENTS ●  
MISSIONS ●

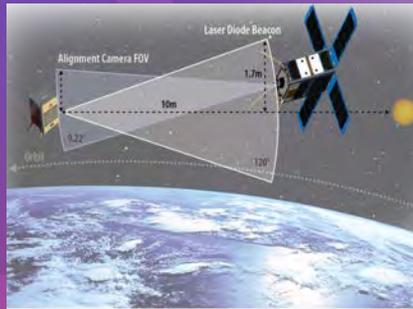
# NASA SCIENCE INTERNATIONAL PARTNERS

# New Program Opportunities Across SMD



Earth Venture Missions (EVM/EVI) and In-Space Validation of Earth Science Technologies (InVEST)

Three InVEST-17 Awards Announced July 20, 2018



Astrophysics Small Explorer (SMEX) and Astrophysics Science SmallSat Studies

First Major Investment in Astro SmallSat Missions



Heliophysics Technology Demonstration Mission of Opportunity

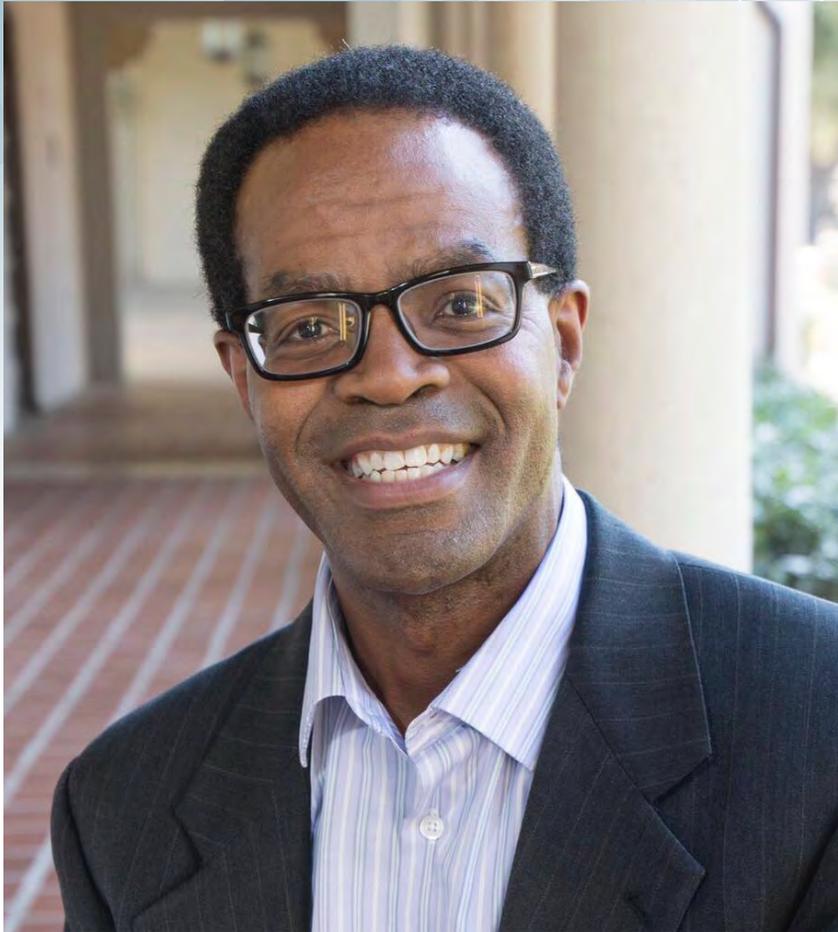
Investing up to \$65M for ESPA-class Payloads



Small Innovative Missions for Planetary Exploration (SIMPLEX)

Investing up to \$55M in Deep Space SmallSat Missions

*SmallSat/CubeSat commercial engagement opportunities are essential to NASA Science's balanced portfolio, achieving distinct science objectives*



## Dr. Charles D. Norton

Assistant Deputy Associate Administrator (AA)  
for Programs, Small Spacecraft Missions

- Advise the SMD Front Office on strategy and development of cross-agency initiatives
- Enable strategic partnerships across the SmallSat/CubeSat community
- Chair of the Small Spacecraft Coordination Group, providing recommendations on strategy and policy to the SMD, STMD, and HEOMD AAs
- Make Contact: [Charles.D.Norton@nasa.gov](mailto:Charles.D.Norton@nasa.gov)

EXPLORE AS  
**ONE**



EXPLORER 1



INSIGHT



PARKER



ICESAT-2



WEBB