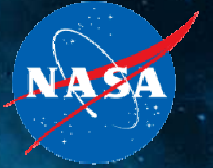


National Aeronautics and
Space Administration



EXPLORE SCIENCE

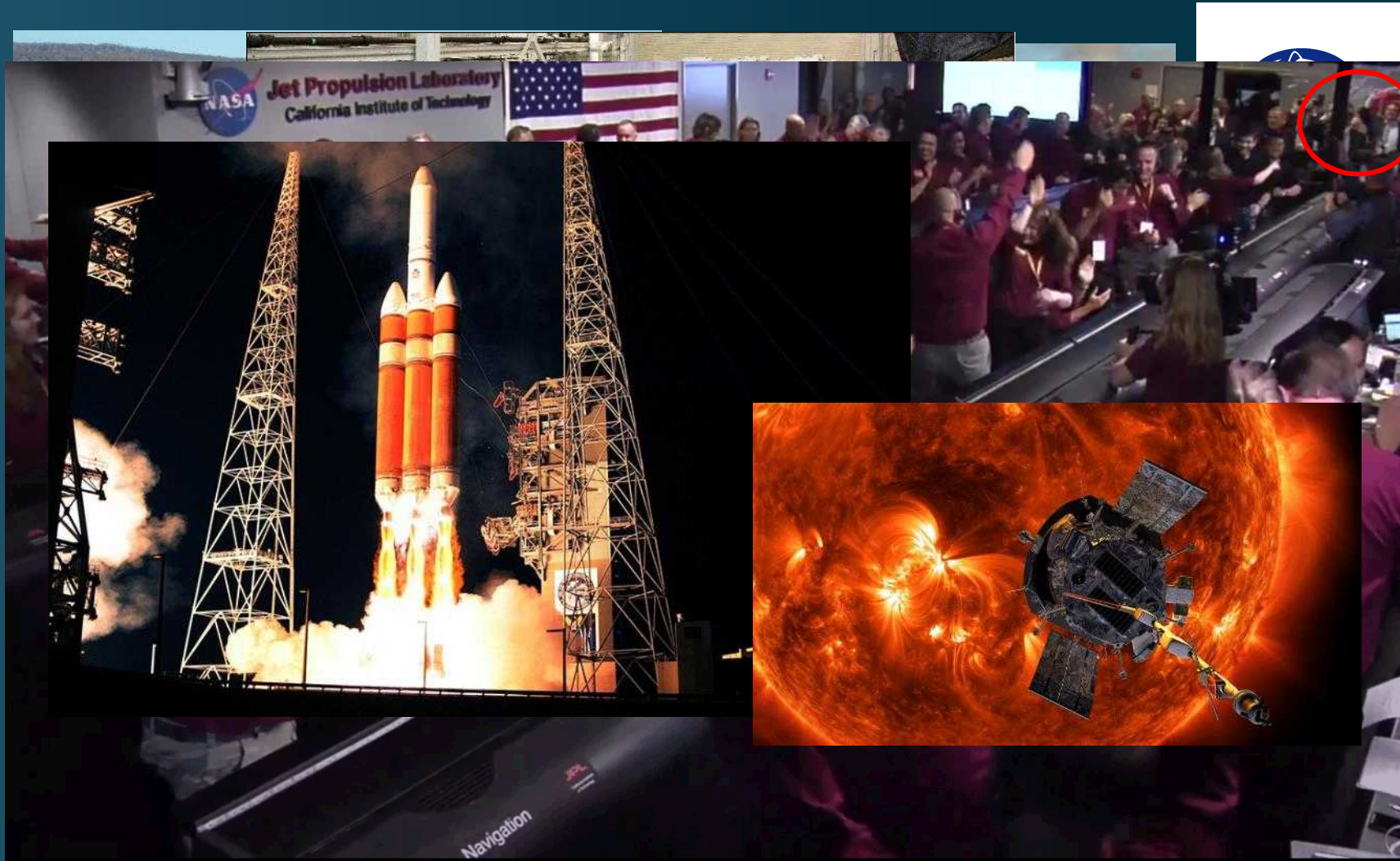
30th Thermal Fluids and Analysis Workshop
Engineering NASA's Science Missions

Joe Gasbarre

Deputy Director for Flight Projects, Science Directorate
NASA Langley Research Center

28 August 2019

First, a little bit about myself...



NASA SCIENCE

AN INTEGRATED PROGRAM

Planetary
Science



Earth
Science



Joint Agency
Satellite Division



Astrophysics

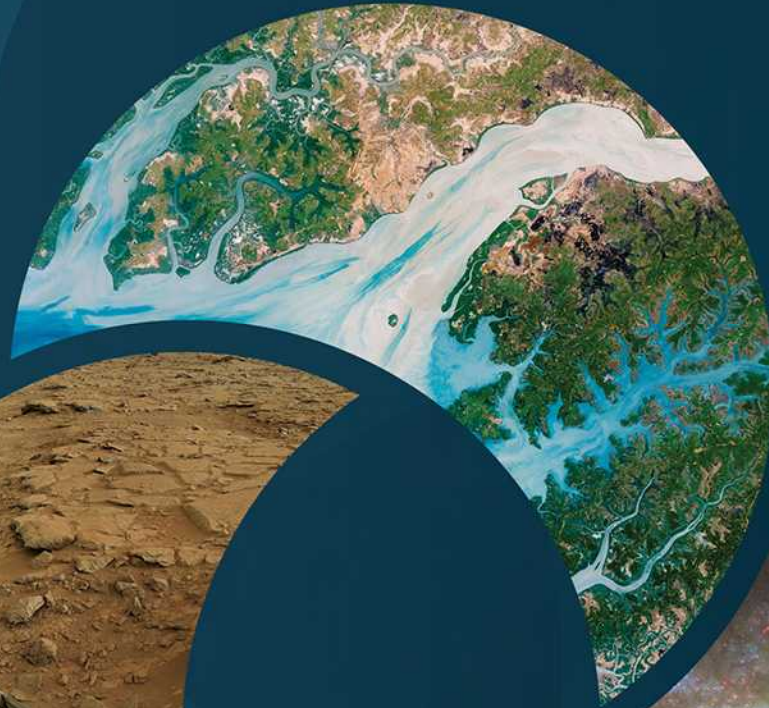


Heliophysics

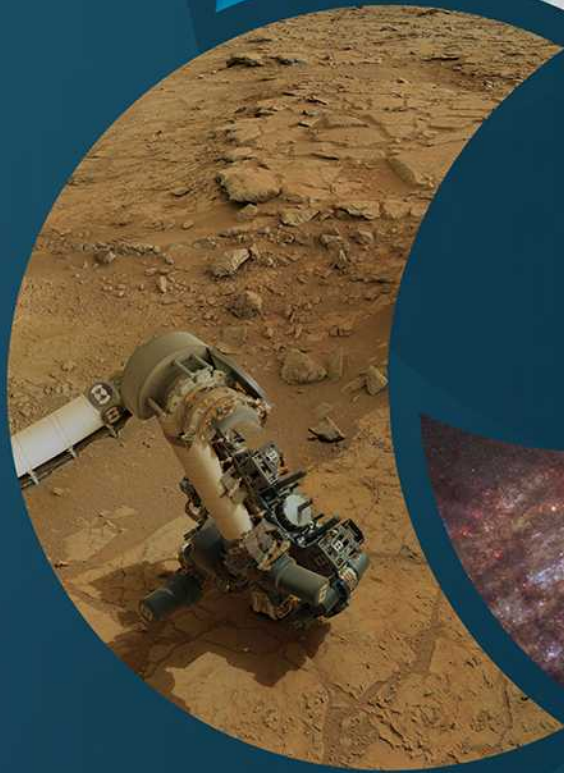


KEY SCIENCE THEMES

Protect & Improve
Life on Earth



Search for
Life Elsewhere



Discover Secrets
of the Universe



RESEARCH

~**10,000** U.S. Scientists Funded
~**3,000** Competitively Selected Awards
~**\$600M** Awarded Annually

TECHNOLOGY DEVELOPMENT

~**\$500M** Invested Annually

EARTH-BASED INVESTIGATIONS

20 Airborne Missions
8 Global Networks

SPACECRAFT

98 Missions
82 Spacecraft

SMALLSATS/ CUBESATS

22 Science Missions
14 Technology Demos

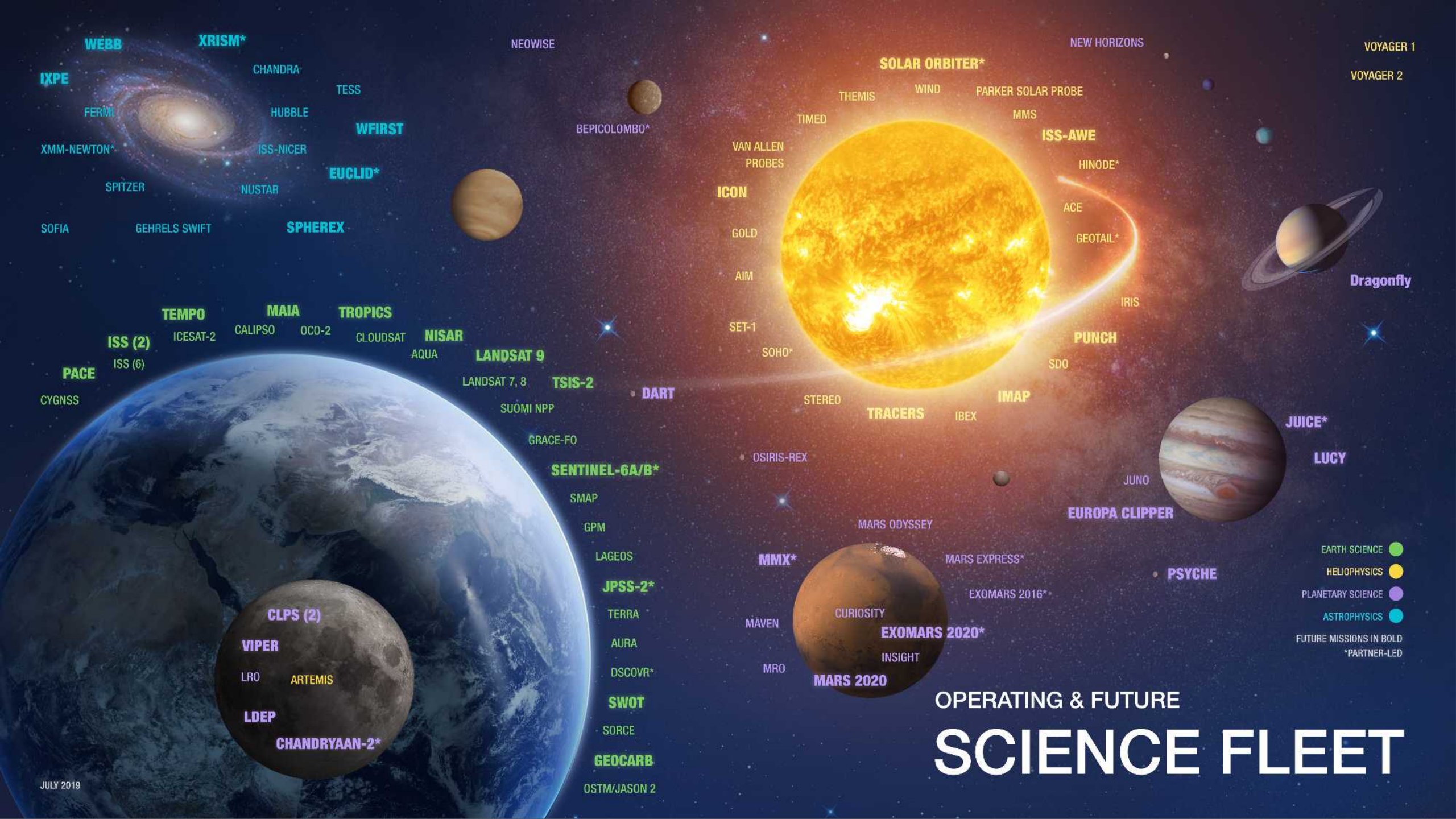
SOUNDING ROCKETS

16 Science Missions
5 Tech/Student Missions

BALLOONS

10 Science Missions
4 Technology/Student

Science by the
NUMBERS



WEBS
XRISM*
IXPE
FERMI
XMM-NEWTON*
SPITZER
SOFIA
CHANDRA
TESS
HUBBLE
ISS-NICER
NUSTAR
WFIRST
EUCLID*
SPHEREX

TEMPO
ISS (2)
ISS (6)
PAGE
ICESAT-2
MAIA
CALIPSO
OCO-2
TROPICS
CLOUDSAT
NISAR
AQUA

CLPS (2)
VIPER
LRO
ARTEMIS
LDEP
CHANDRYAAN-2*

NEOWISE
BEPICOLOMBO*
LANDSAT 9
LANDSAT 7, 8
SUOMI NPP
GRACE-FO
SENTINEL-6A/B*
SMAP
GPM
LAGEOS
JPSS-2*
TERRA
AURA
DSCOVR*
SWOT
SORCE
GEOCARB
OSTM/JASON 2

DART

SOLAR ORBITER*
THEMIS
WIND
PARKER SOLAR PROBE
MMS
ISS-AWE
Hinode*
ACE
GEOTAIL*
IRIS
PUNCH
SDO
STEREO
TRACERS
IBEX
IMAP
SOHO*
SET-1
AIM
GOLD
VAN ALLEN PROBES
TIMED
OSIRIS-REX

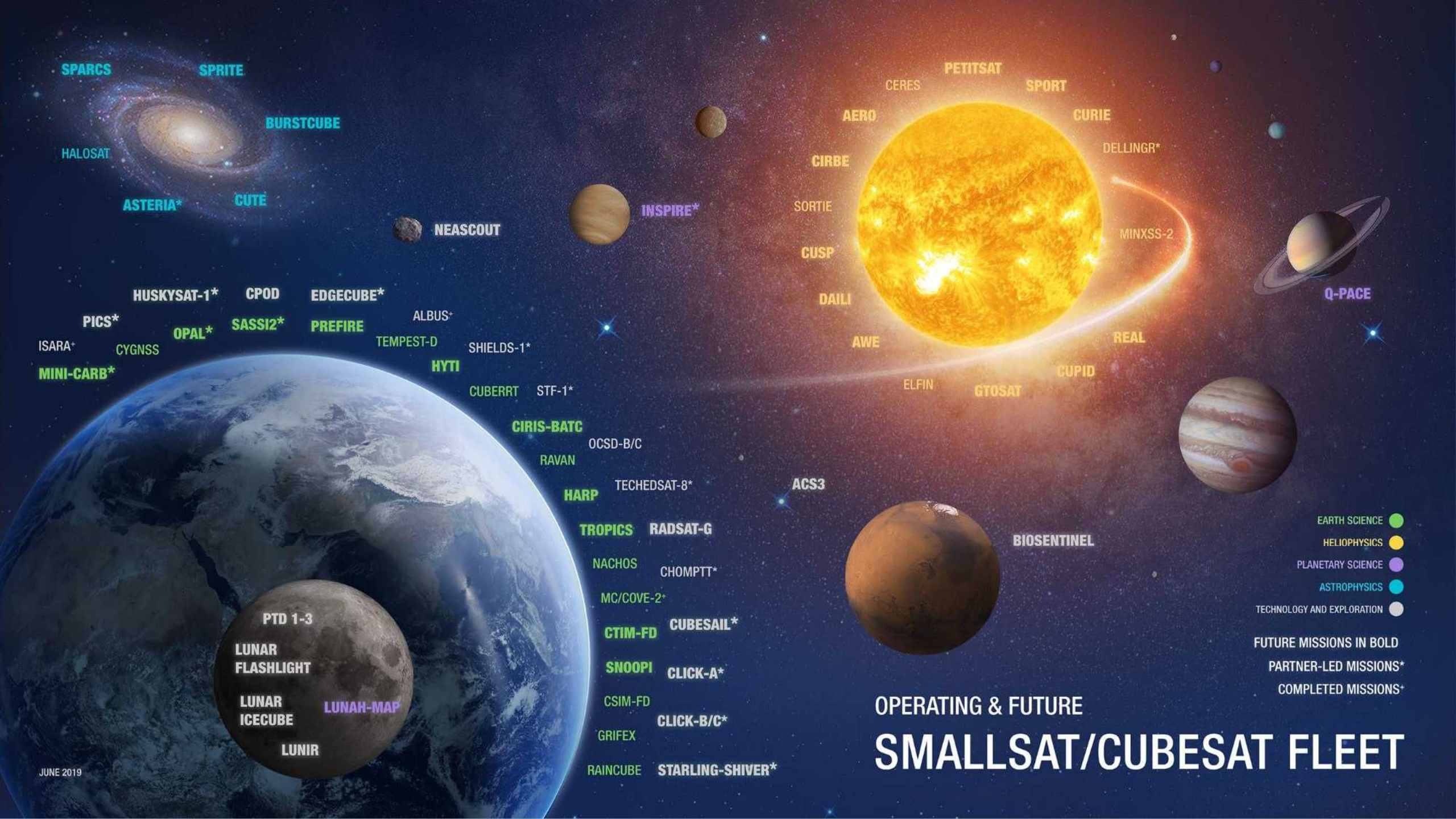
NEW HORIZONS
VOYAGER 1
VOYAGER 2

Dragonfly
JUICE*
LUCY
JUNO
EUROPA CLIPPER
PSYCHE

MARS ODYSSEY
MARS EXPRESS*
EXOMARS 2016*
EXOMARS 2020*
INSIGHT
MARS 2020
MMX*
MARS 2020
MAVEN
MRO

OPERATING & FUTURE SCIENCE FLEET





SPARCS
SPRITE
BURSTCUBE
HALOSAT
ASTERIA*
CUTE

NEASCOUT

INSPIRE*

CERES
PETITSAT
SPORT
AERO
CURIE
CIRBE
DELLINGR*
SORTIE
MINXSS-2
CUSP
DAILI
AWE
REAL
ELFIN
GTOSAT
CUPID

Q-PACE

HUSKYSAT-1*
CPOD
EDGE CUBE*
PICS*
OPAL*
SASSI2*
PREFIRE
ALBUS+
TEMPEST-D
SHIELDS-1*
ISARA+
CYGNSS
MINI-CARB*
HYTI
CUBERRT
STF-1*

CIRIS-BATC
OCS-D-B/C
RAVAN

HARP
TECHSAT-8*

ACS3

TROPICS
RADSAT-G

NACHOS
CHOMPTT*
MC/COVE-2*

CTIM-FD
CUBESAIL*

SNOOPI
CLICK-A*

CSIM-FD
CLICK-B/C*

GRIFEX

RAIN CUBE
STARLING-SHIVER*

BIOSENTINEL

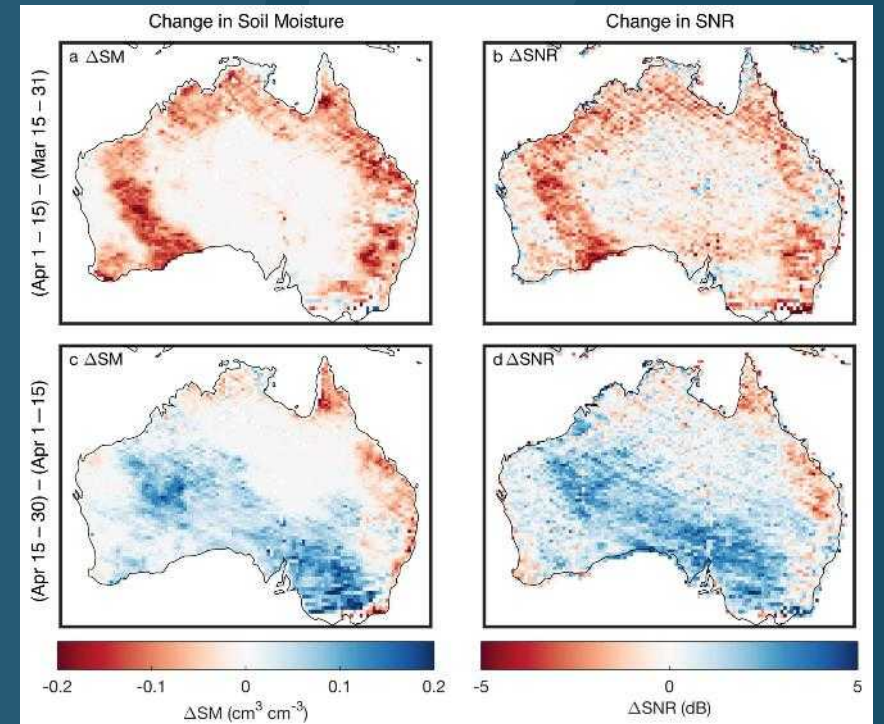
PTD 1-3
LUNAR FLASHLIGHT
LUNAR ICECUBE
LUNAH-MAP
LUNIR

- EARTH SCIENCE ●
- HELIOPHYSICS ●
- PLANETARY SCIENCE ●
- ASTROPHYSICS ●
- TECHNOLOGY AND EXPLORATION ●

FUTURE MISSIONS IN BOLD
PARTNER-LED MISSIONS*
COMPLETED MISSIONS*

OPERATING & FUTURE SMALLSAT/CUBESAT FLEET

CYGNSS



Nature Scientific Reports: Change in mean SMAP soil moisture compared to change in CYGNSS SNR

RainCube/TEMPEST-D Observing Typhoon Trami

Spacecraft constellation separated by 5 minutes revealing 3D storm structure

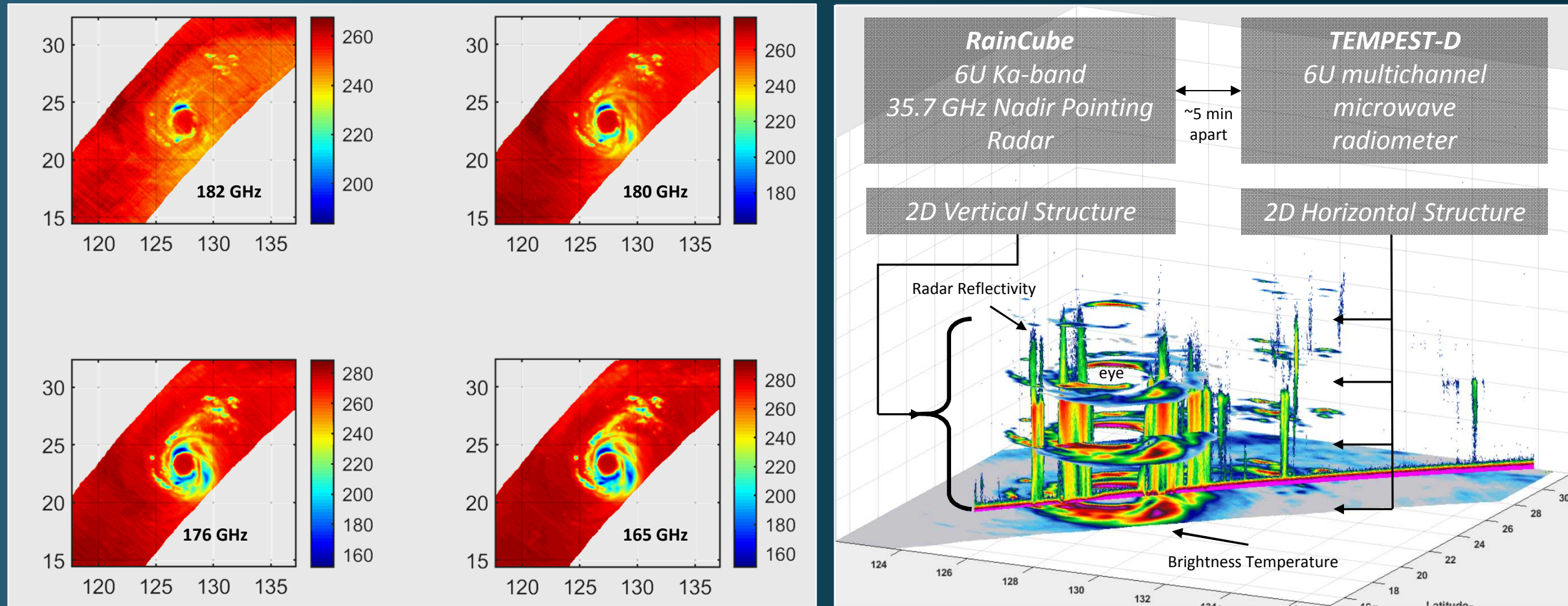


Illustration of complementary nature of these sensors flown in constellation for observing precipitation

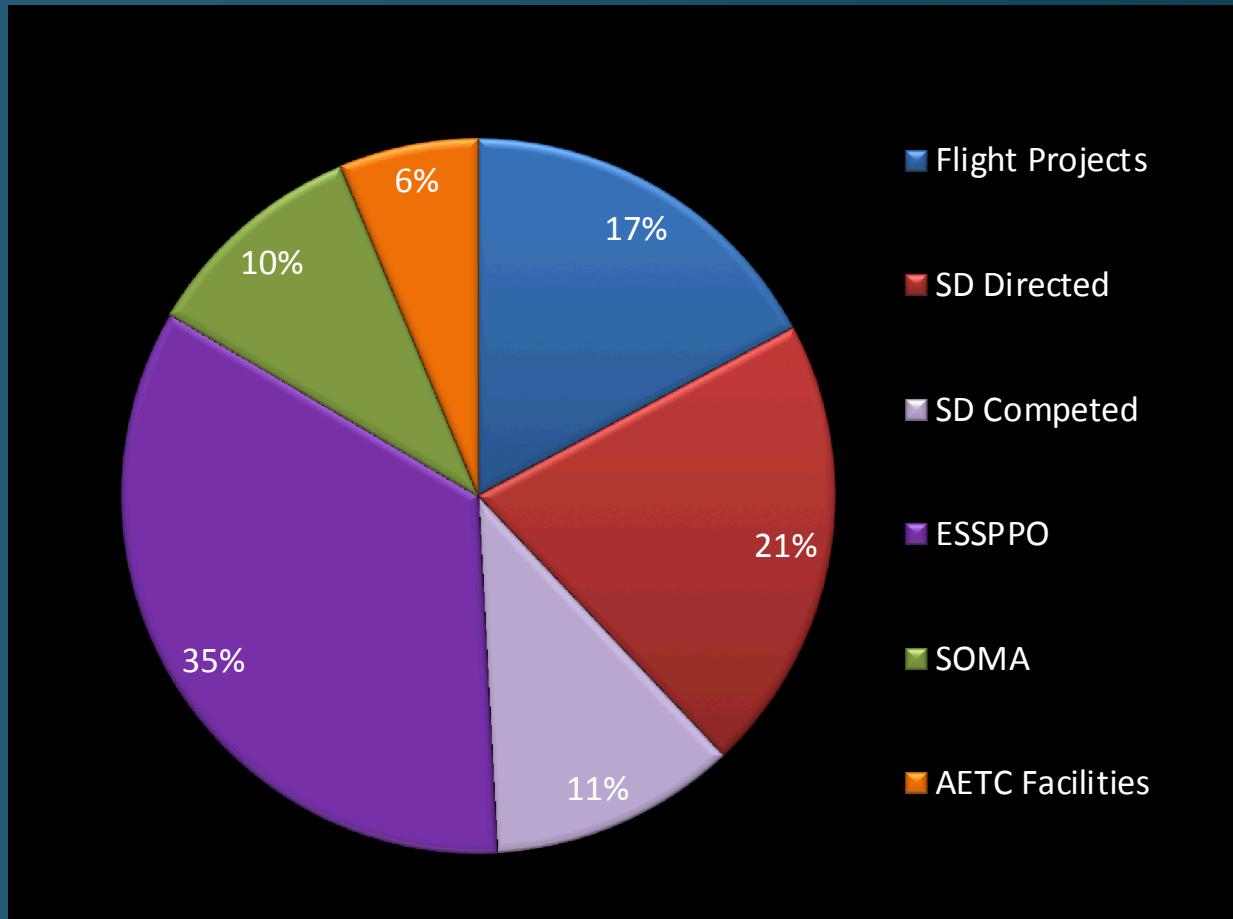
The background of the slide is a composite of two astronomical images. The top half features a dark blue and black space filled with numerous bright blue stars and a large, wispy blue nebula. The bottom half shows a similar scene but with a prominent orange and yellow glow on the left side, transitioning into green and blue on the right, with many bright yellow and white stars.

Science at LaRC

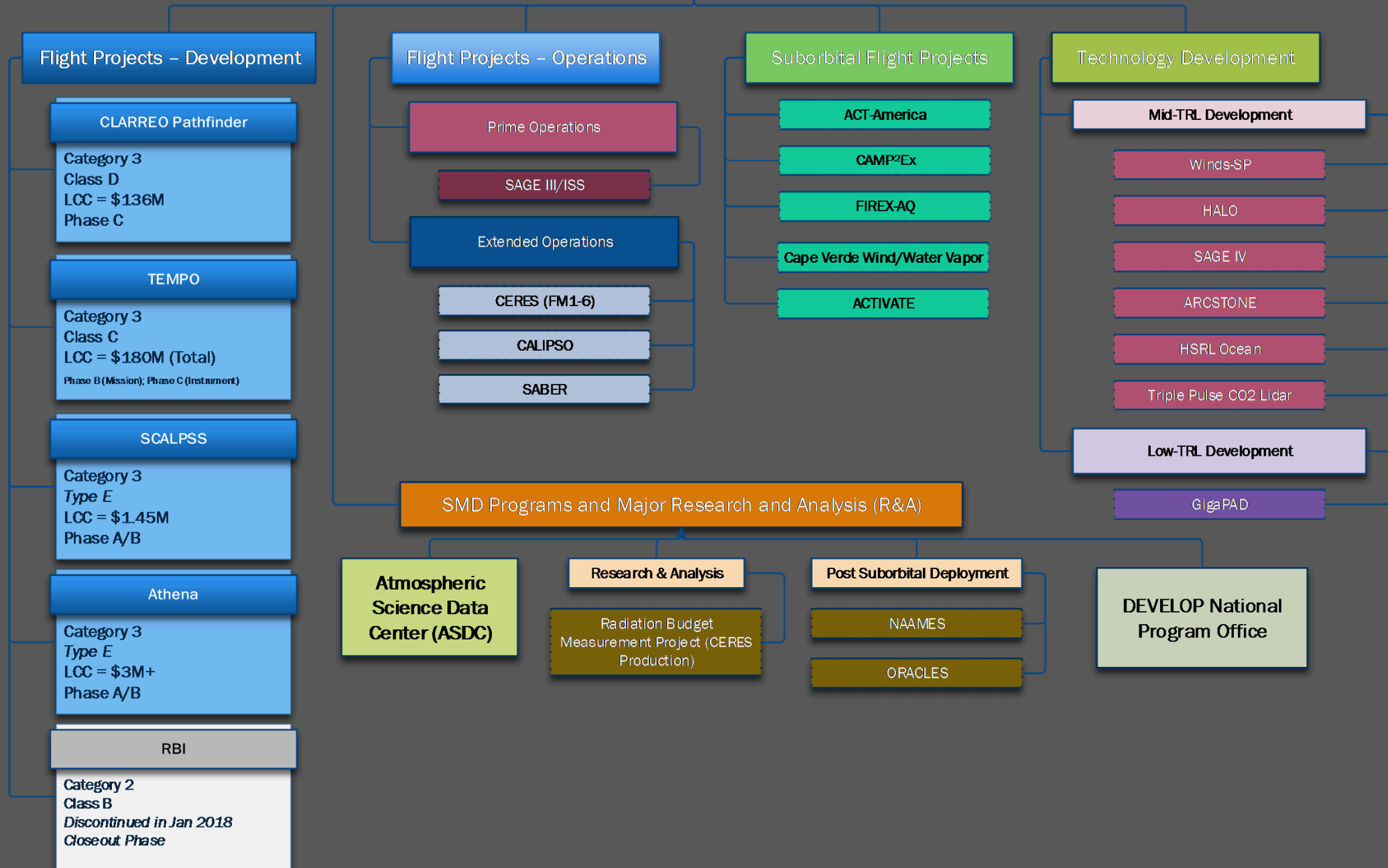
NASA LaRC SMD Budget

SMD funding represents **~30% of Langley's budget in FY19**

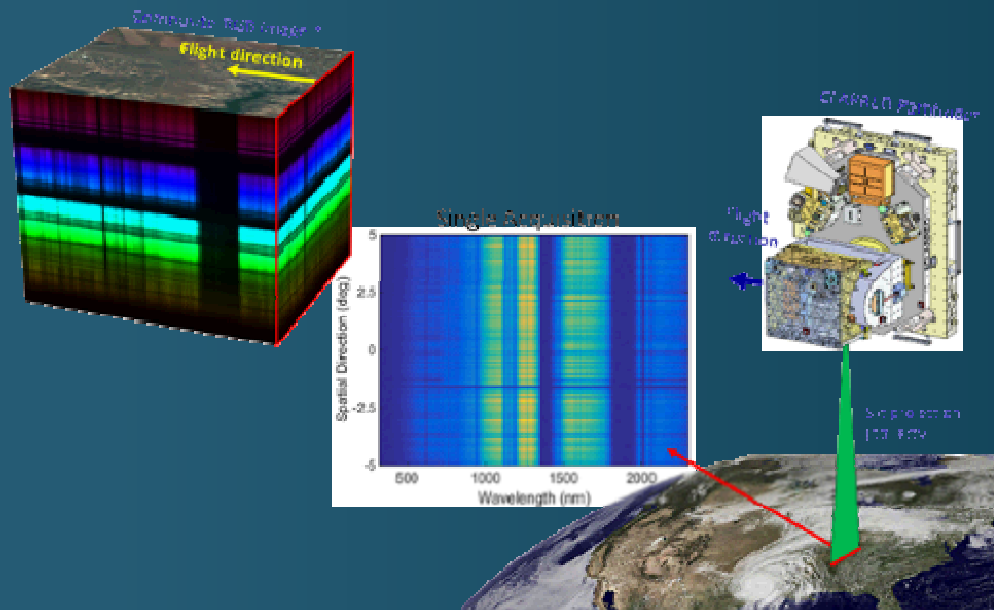
50% of SMD funding at Langley supports Agency functions (SOMA, ESSPPO, and AETC facilities)



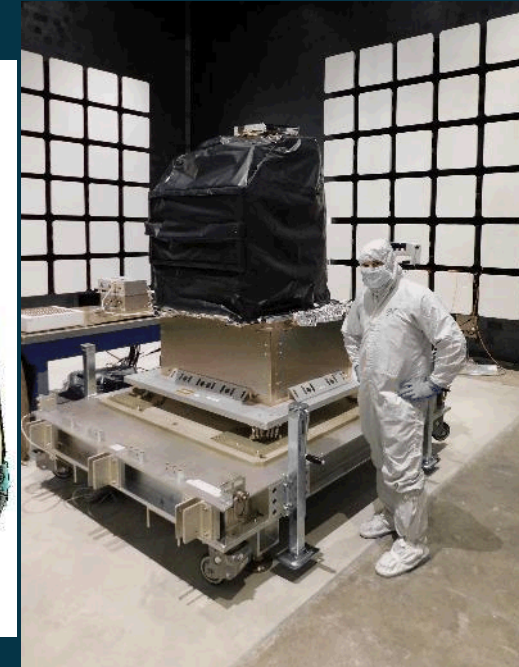
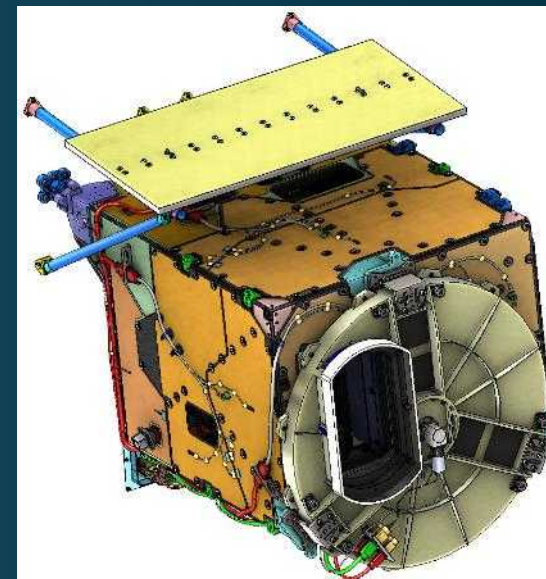
Science Directorate



LaRC Science Missions in Development



Climate Absolute Radiance and Refractivity Observatory (CLARREO) Pathfinder

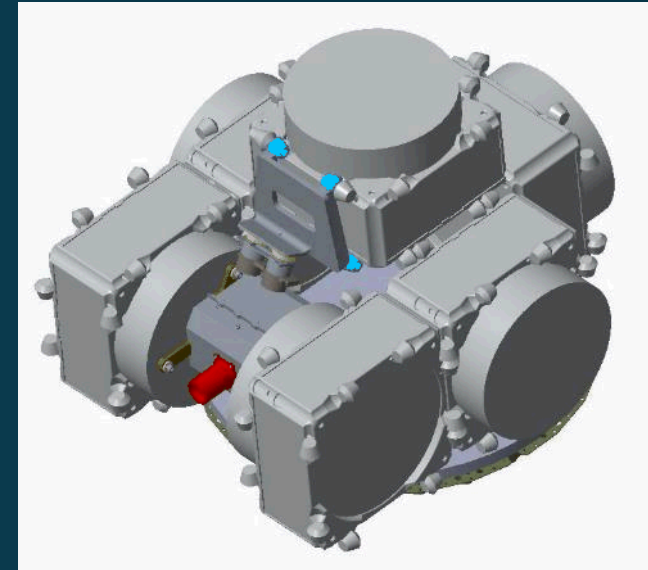


Tropospheric Emissions: Monitoring of Pollution (TEMPO)

LaRC Science Missions in Development



**Stereo CAmeras for
Lunar Plume-Surface
Studies (SCALPSS)**

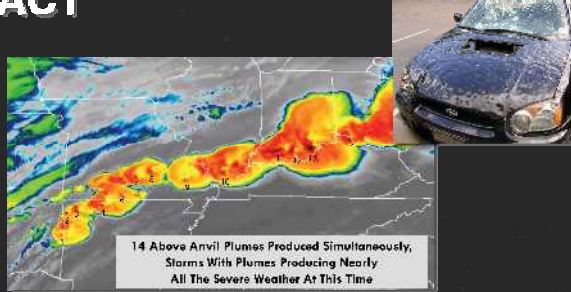


Athena

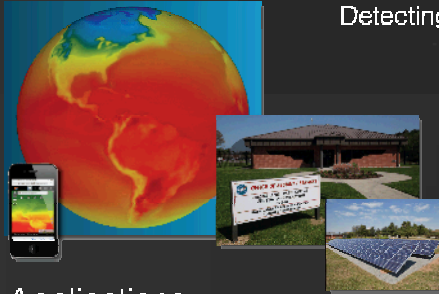
EXPLORE LANGLEY - *Earth Energy Budget*

We provide precise, accurate, consistent and continual monitoring, measuring and archiving of data to detect and understand climate change.

SOCIETAL IMPACT



Detecting Severe Weather



Applications:

- Agroclimatology (Nutella)
- Sustainable Building (3M & UMich)
- Renewable Energy

CERES FM 6 | on JPSS-1
Clouds and the Earth's Radiant Energy System Flight Model 6



EXPLORE LANGLEY - *Upper Atmosphere Composition*

We study Earth's stratosphere and upper atmosphere (aeronomy), as well as space weather in the context of sun-Earth connection.

- Flight instruments: [SAGE](#), [LIMS](#), [HALOE](#), and [SABER](#)
- Technology Development: [SAGE IV](#)
- Research & Analysis



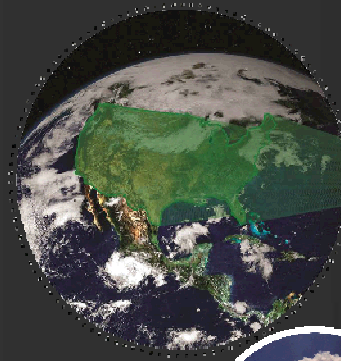
SAGE III | on ISS
Stratospheric Aerosol and Gas Experiment III



EXPLORE LANGLEY - *Air Quality*

We study changes in the atmosphere's chemistry and what those changes mean for the environment and public health

SOCIETAL IMPACT

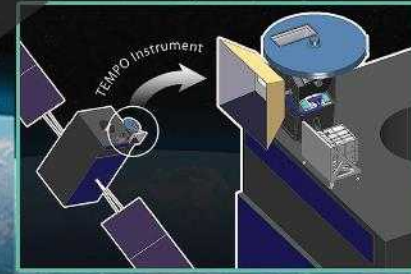


morning commute



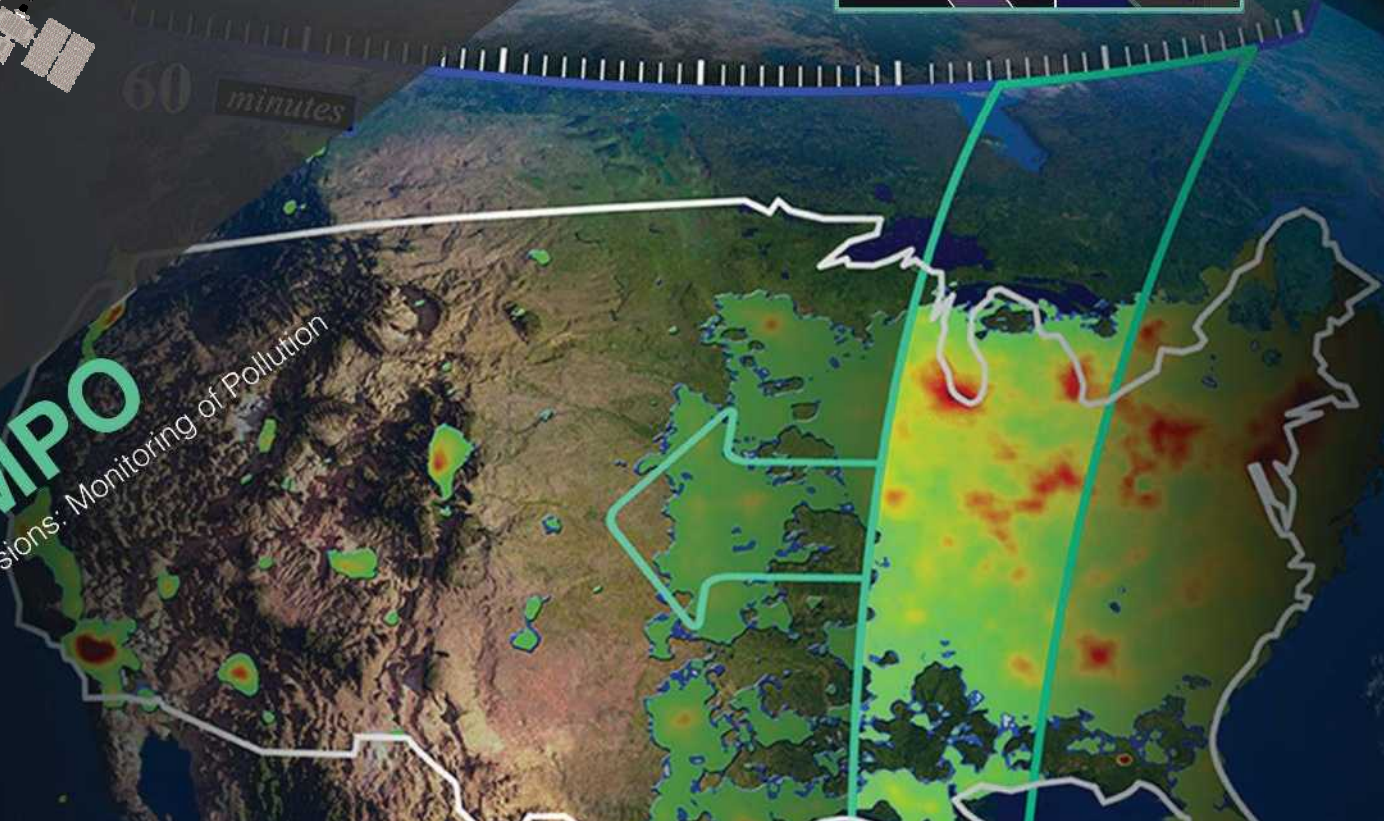
intercontinental pollution

hosted payload



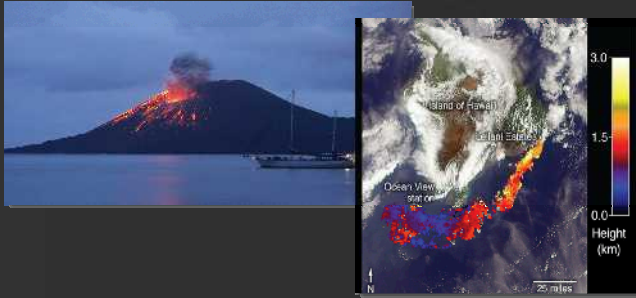
TEMPO
Tropospheric Emissions: Monitoring of Pollution

60 minutes

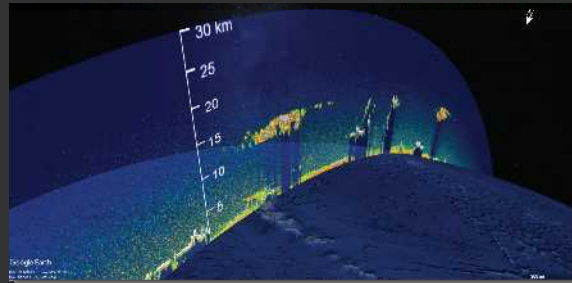


EXPLORE LANGLEY - Lidar Remote Sensing

SOCIETAL IMPACT



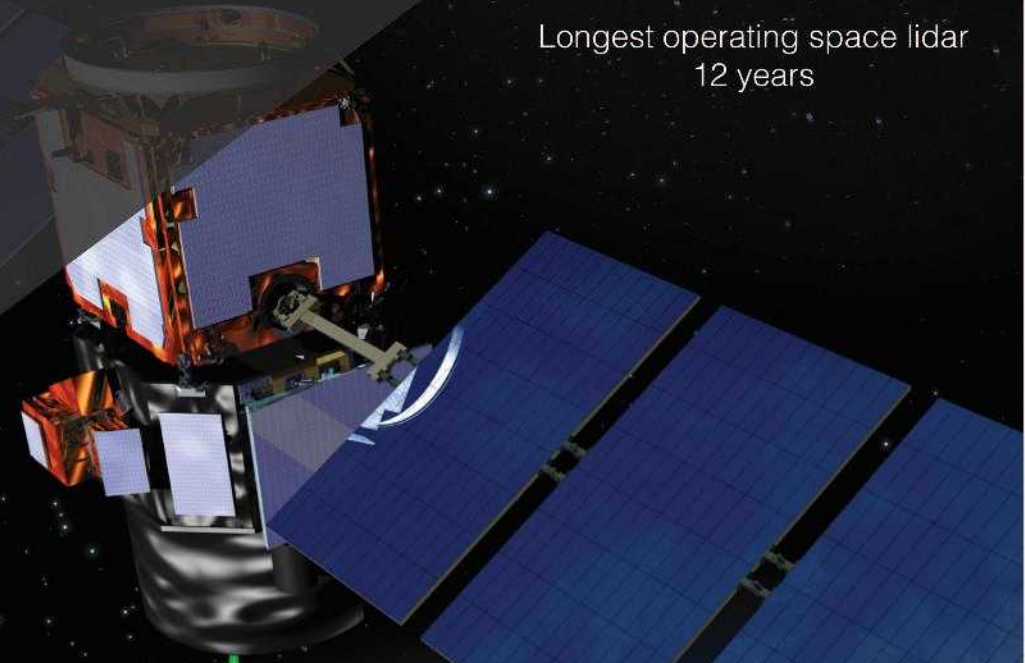
NASA data captures Kilauea volcano eruption in Hawaii



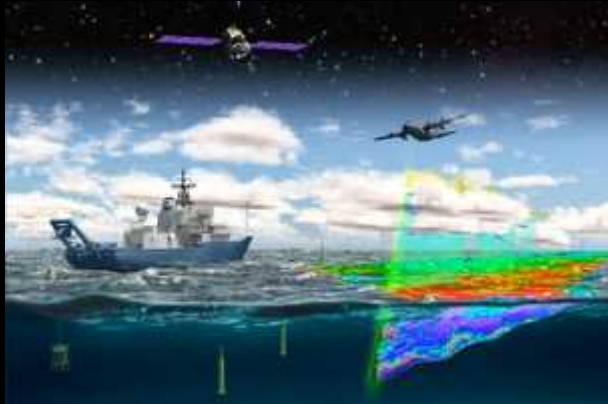
Global 3-D "CAT scan"

CALIPSO
Cloud-Aerosol Lidar and Infrared Pathfinder
Satellite Observation

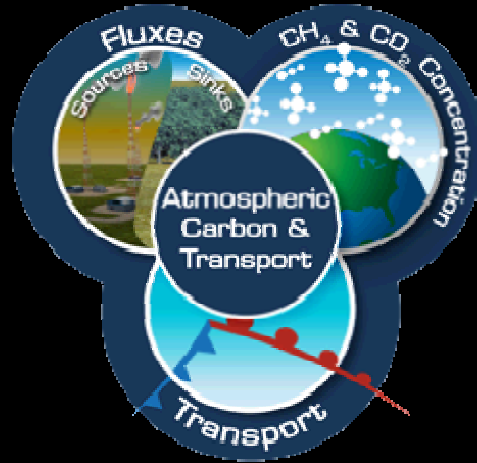
Longest operating space lidar
12 years



Langley Airborne Science



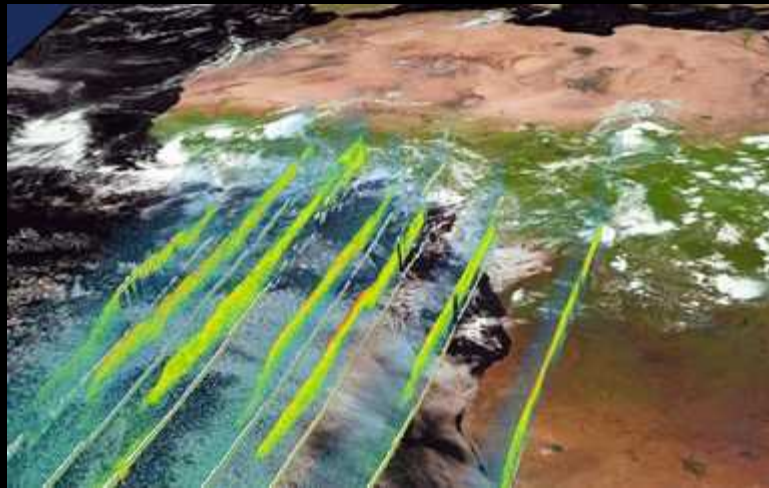
NAAMES



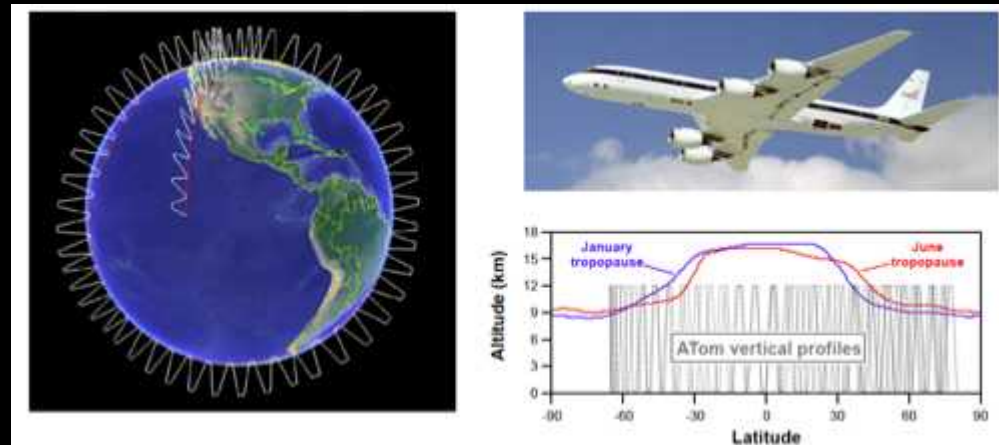
ACT-AMERICA



KORUS-AQ



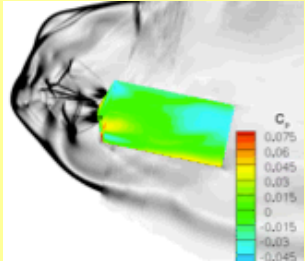
ORACLES



ATOM

Langley Delivers Technology That Enables Planetary Science

Technology Advancement,
Systems Analysis,
Concept Development
Through Flight Operations



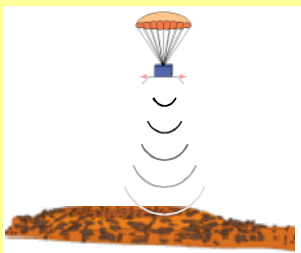
HPC CFD



Integrated composites



Aerocapture Systems Analysis



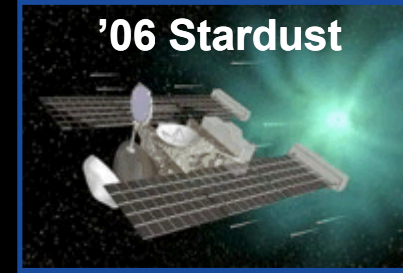
Flight Mechanics



'97 Mars Pathfinder



'01 Odyssey



'06 Stardust



'20 2020/MEDLI2



'97 MGS



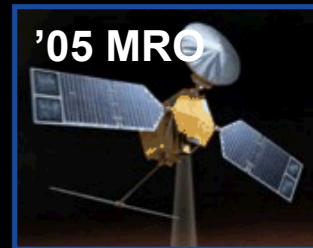
'07 Phoenix



'18 InSight



'23 OSIRIS-REx



'05 MRO



'09 IRVE-II



'14-19 MAVEN



'26 Dragonfly



'04 Genesis



'03 MER



'11 MSL/MEDLI



'31 MSR-EEV



Some Closing Thoughts...

- NASA Science continues to be a growing area of the Agency's portfolio and provides information the public craves and policy makers leverage
- Thermal and fluids engineering is key to NASA's Science Missions – from detector stability to reentry thermal protection to cooling systems for RTGs, we can't do it without you!
- These disciplines are a great way to bridge into flight systems engineering and project management because you are involved in all phases of a mission and many times your designs and analyses touch every part of the system



EXPLORE
with us