



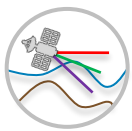
Luce

A Pioneering Lidar Mission for Earth Sciences

Disclaimer: All slides courtesy of the Luce team



A partnership between Italy (led by ASI and Università della Basilicata; includes Leonardo S.p.A.; CNR Institute of Atmospheric Sciences and Climate; CNR- IMAA) and USA (Led by NASA Langley Research Center; includes NASA/GSFC; UW SSEC; Oregon State University; University of Utah)



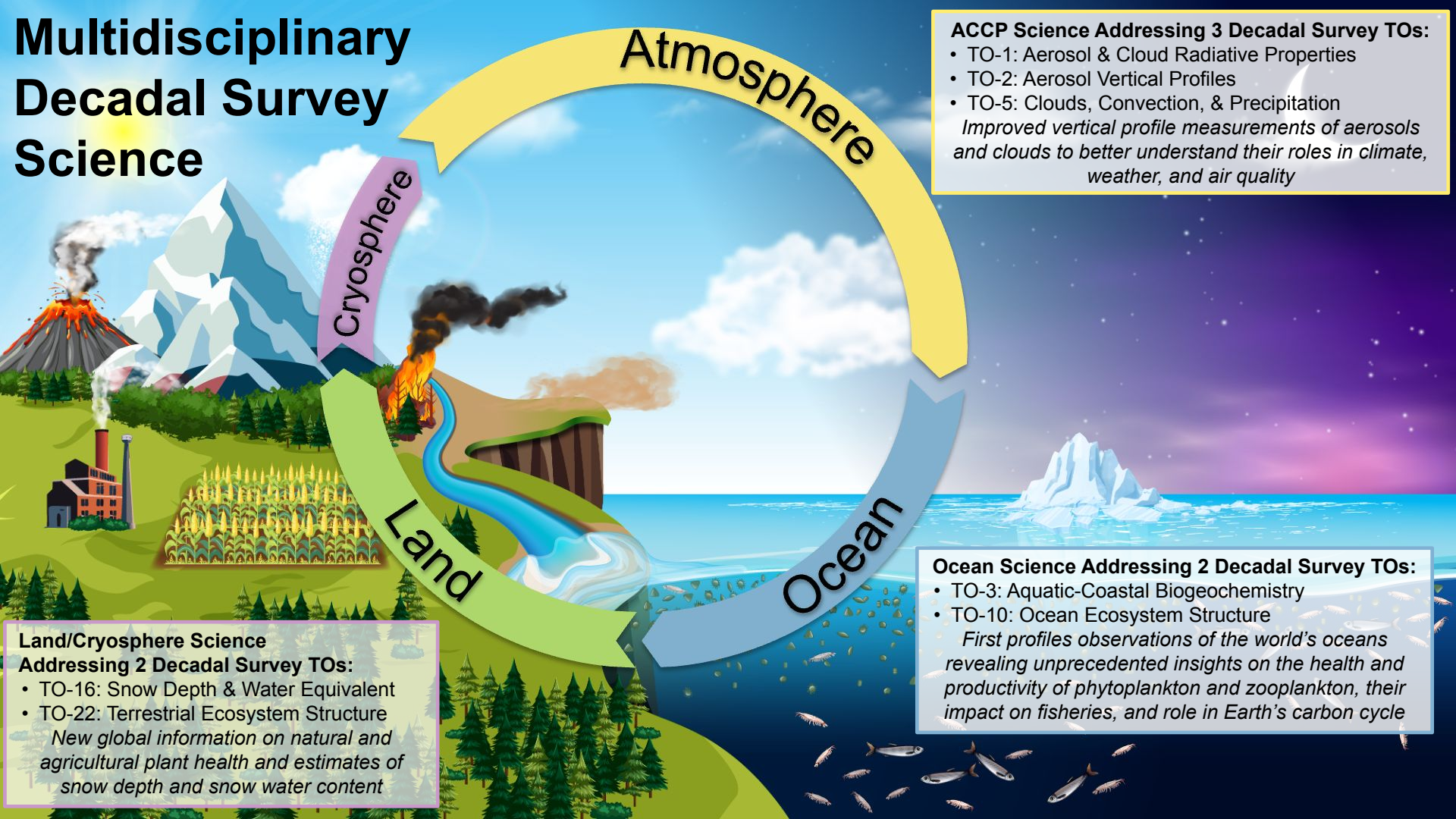
Luce

Advancing Earth System Science

- Luce is an **interdisciplinary Earth Sciences mission** significantly advancing global knowledge on the coupled atmosphere-ocean-land system.
- **First spaceborne Raman-elastic-fluorescence lidar** enabled through a partnership between ASI and NASA.
- Provides **multi-wavelength vertical profile measurements** of atmospheric particles (aerosols) and clouds to better understand their roles in air quality, weather, and climate.
- Provides the **depth-resolved near-surface observations of the world's oceans** revealing unprecedented insights on the health and productivity of phytoplankton and zooplankton, their impact on fisheries, and role in Earth's carbon cycle.
- Offers **new land measurement capabilities** on natural and agricultural plant health and refined estimates of snow depth and snow water content.



Multidisciplinary Decadal Survey Science



ACCP Science Addressing 3 Decadal Survey TOs:

- TO-1: Aerosol & Cloud Radiative Properties
 - TO-2: Aerosol Vertical Profiles
 - TO-5: Clouds, Convection, & Precipitation
- Improved vertical profile measurements of aerosols and clouds to better understand their roles in climate, weather, and air quality*

Ocean Science Addressing 2 Decadal Survey TOs:

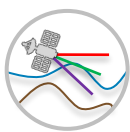
- TO-3: Aquatic-Coastal Biogeochemistry
 - TO-10: Ocean Ecosystem Structure
- First profiles observations of the world's oceans revealing unprecedented insights on the health and productivity of phytoplankton and zooplankton, their impact on fisheries, and role in Earth's carbon cycle*

Land/Cryosphere Science

Addressing 2 Decadal Survey TOs:

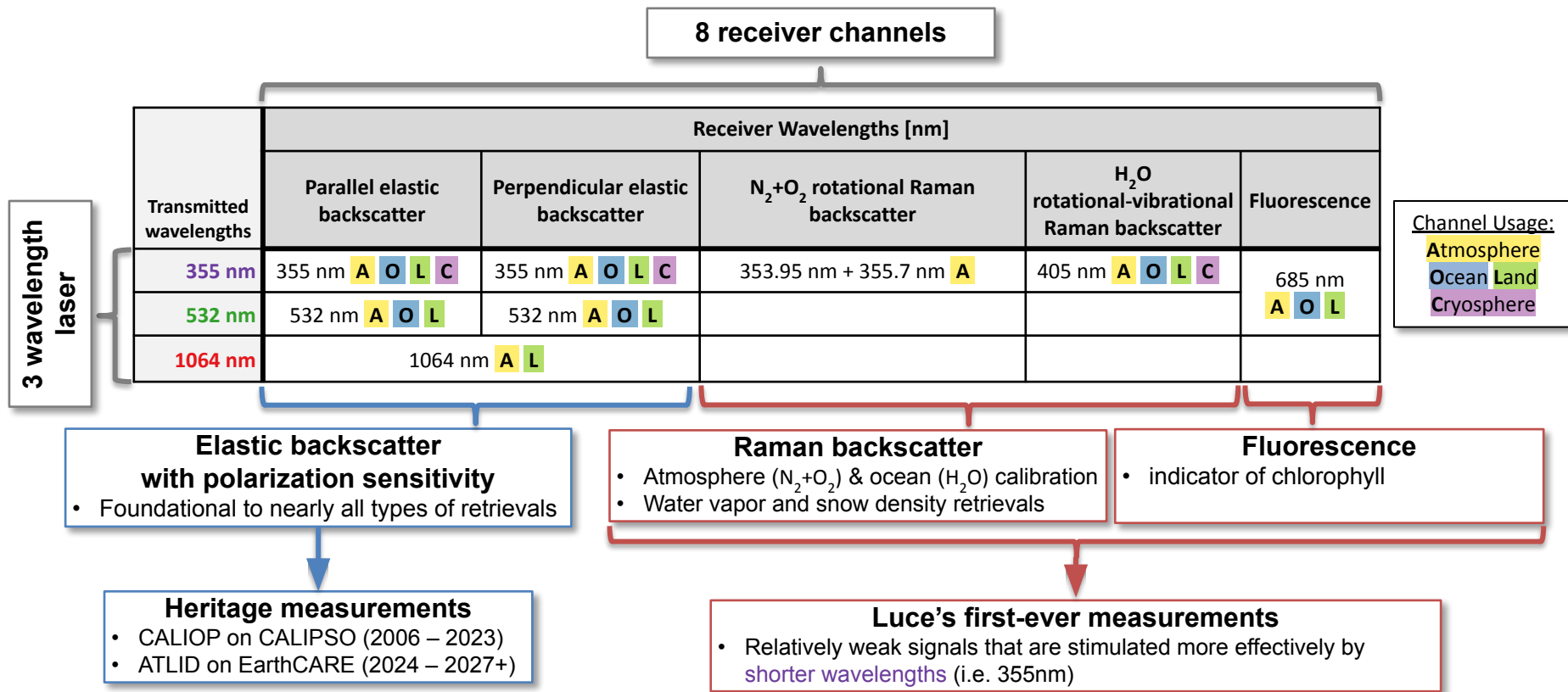
- TO-16: Snow Depth & Water Equivalent
- TO-22: Terrestrial Ecosystem Structure

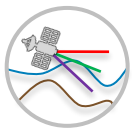
New global information on natural and agricultural plant health and estimates of snow depth and snow water content



Luce

A multi-wavelength elastic-Raman-fluorescence backscatter lidar





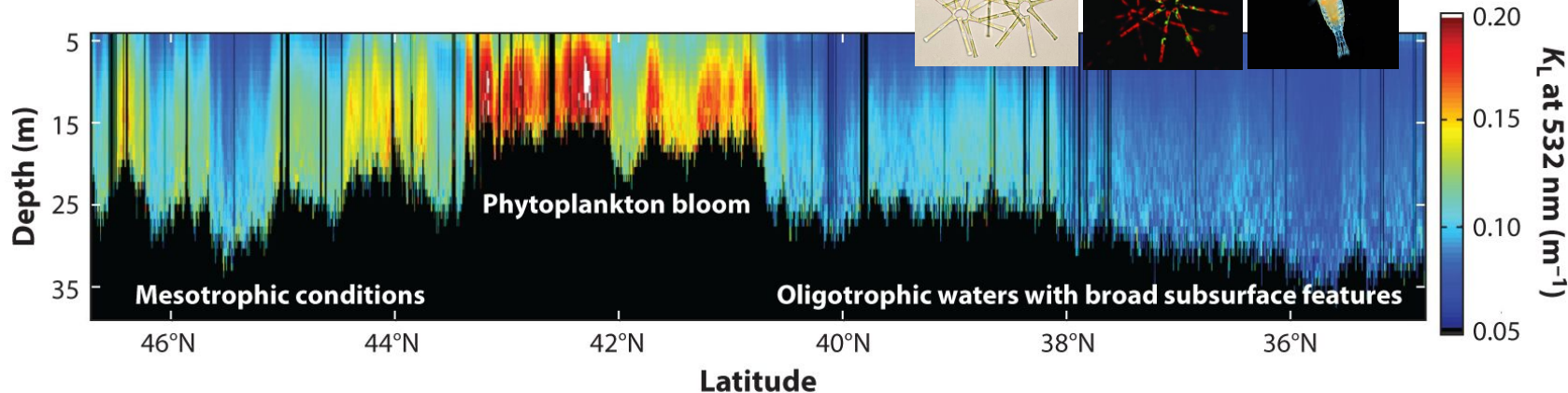
Beyond the Atmosphere: Ocean

Vertically-resolved ocean retrievals highlighting plankton distributions

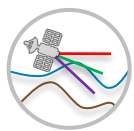
- Dominant source of uncertainty in current estimates of ocean primary production & carbon cycling
- Improved characterization of diel vertical migration – detecting significantly larger portion of migration

Chlorophyll fluorescence

- Metric of phytoplankton physiology ('health') will improve estimates of global primary production
- Diagnostic of iron stress

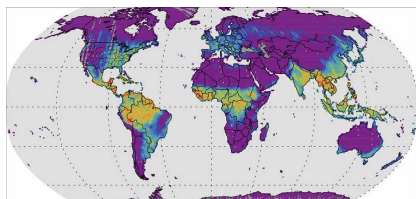


Airborne HSRL Observations from Hostetler et al. (2018) *Annu. Rev. Mar. Sci.*



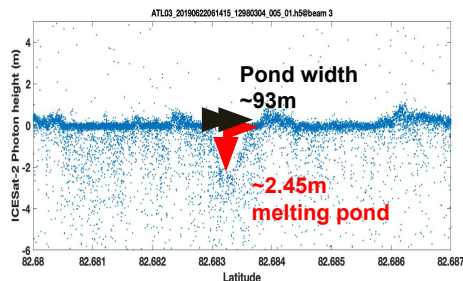
Beyond the Atmosphere: Land/Cryosphere

Solar+laser induced fluorescence and vegetation stress

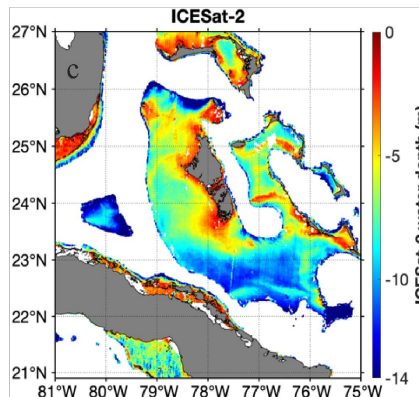


Observations from OCO-2

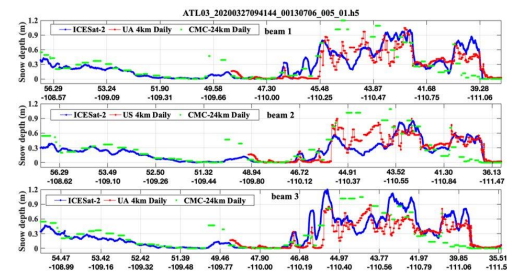
Arctic melt ponds



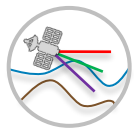
Near shore bathymetry



Snow depth, density and water equivalent

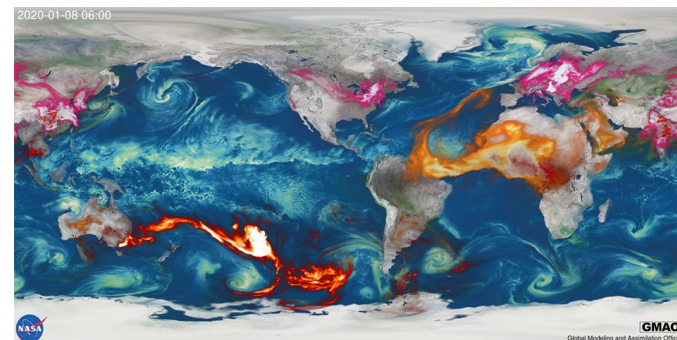


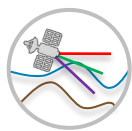
ICESat-2 examples from
X. Lu, et. al., 2022, *Frontiers Remote Sens.*, 3
X. Lu, et. al., 2022, *Opt. Express* 30(20)



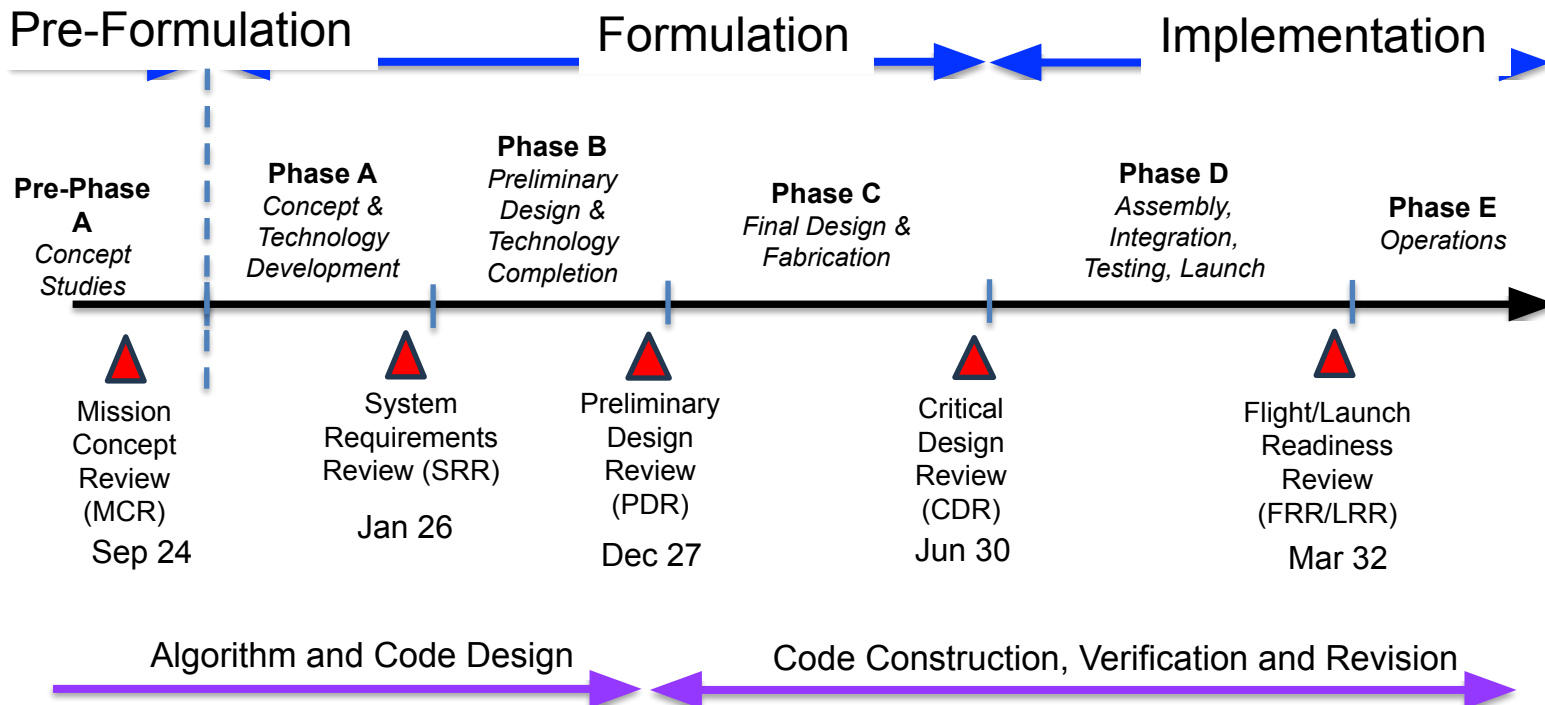
Applications of Science for Societal Benefit

- **Weather Forecasting** by observing cloud distributions & properties to improve retrievals and model assimilation
- **Water Resource Management** by providing satellite-based snow depth/water equivalent estimates in high terrain
- **Earth System Modeling** by providing measurements of aerosol, cloud and biological processes to improve short- and long-term predictions
- **Air Quality** through more precise measurements of aerosols to better forecast impacts on human health
- **Disaster Monitoring** by rapidly conveying observations and predictions of volcanic plumes and wildfire smoke



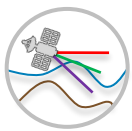


Overview of Mission Lifecycle



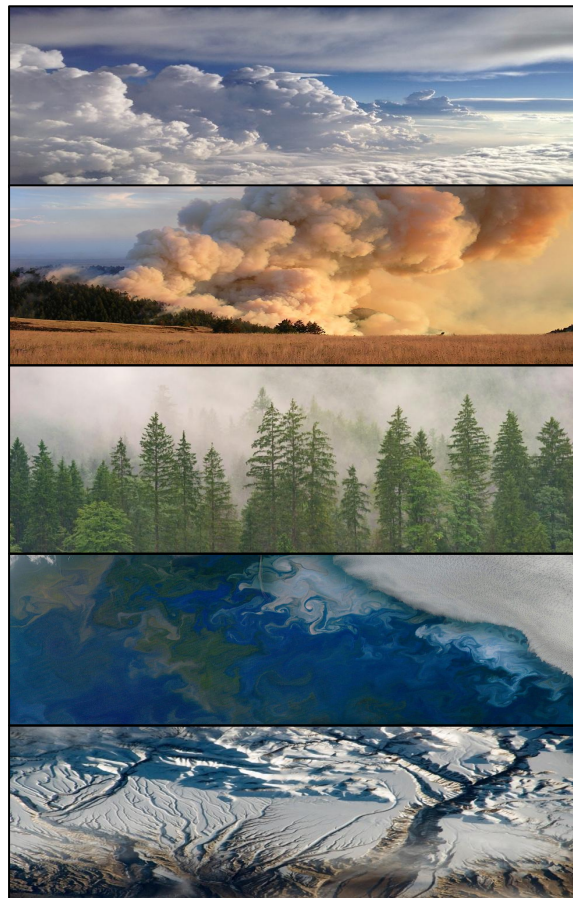
Note: Instrument and platform schedules have different milestone schedules

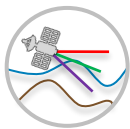




Preliminary Lidar Characteristics

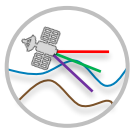
- Transmitted wavelengths: 355, 532, 1064 nm
- Pulse energy: 157, 47, 144 mJ
- Pulse repetition rate: 51 Hz, ~140 m between shots
- Vertical sampling: 1.25 m, native (on-board vertical averaging)
- 8 detector channels Raman, elastic and fluorescence
- Telescope diameter: 1 m
- Field of view: 30 μ rad, ~14 m at surface
- Off-nadir pointing angle: ~10 deg
- Mean orbit altitude: ~450-500 km (trade study)
- Equatorial crossing time: 13:30 (descending node)
- Data volume ~4 Tbits/day
- Data access NASA and ASI data facilities
- Launch 2032





Data Downlink Vertical Resolution

Reference	Range (km)		Description	Vertical resolution (in air) [m]					
	Upper	Lower		Para-Perp 355nm	Para-Perp 532nm	Total 1064nm	Rotational Raman	Water Raman	Fluorescence
MSL	90	45	Stratosphere & mesosphere	360					
	45	32	Calibration	180	180		180		
	32	20	Stratosphere	90	90	90	90	360	
	20	8	Troposphere	30	30	30	30	120	120
	8	5	Liquid clouds, coarse resolution	7.5	30	30	30	120	120
	5	0.20	Liquid clouds, fine resolution	3.75	30	30	30	120	120
	0.20	-0.25	Ocean & ocean surface	1.25	1.25	30	1.25	1.25	1.25
	-0.25	-0.50	Atmosphere below MSL	30	30	30	30	120	120
AGL	0.20	-0.05	Snow & vegetation (land-only)	1.25	1.25			1.25	1.25



Summary

- **Luce**: multi-functional Raman/elastic/fluorescence lidar mission seeks to provide profile measurements on **aerosols**, **clouds**, **marine biology** as well as new information on **vegetation stress** and **snowpack** needed to advance an understanding of the **coupled Earth System**.
- Luce is a **partnership** between **Agenzia Spaziale Italiana (ASI)** and **NASA**.
 - **ASI**: spacecraft, launch vehicle, laser, optics, ground segment, and science
 - **NASA**: detector system, downlink support, science
- Luce is being developed independent from but closely coupled with NASA's Atmosphere Observing System (AOS) mission elements (AOS-Sky and AOS-Cloud) and is expected to fly in formation with a cloud radar and polarimeter
- Just entered NASA Phase A, expected to launch in 2032

