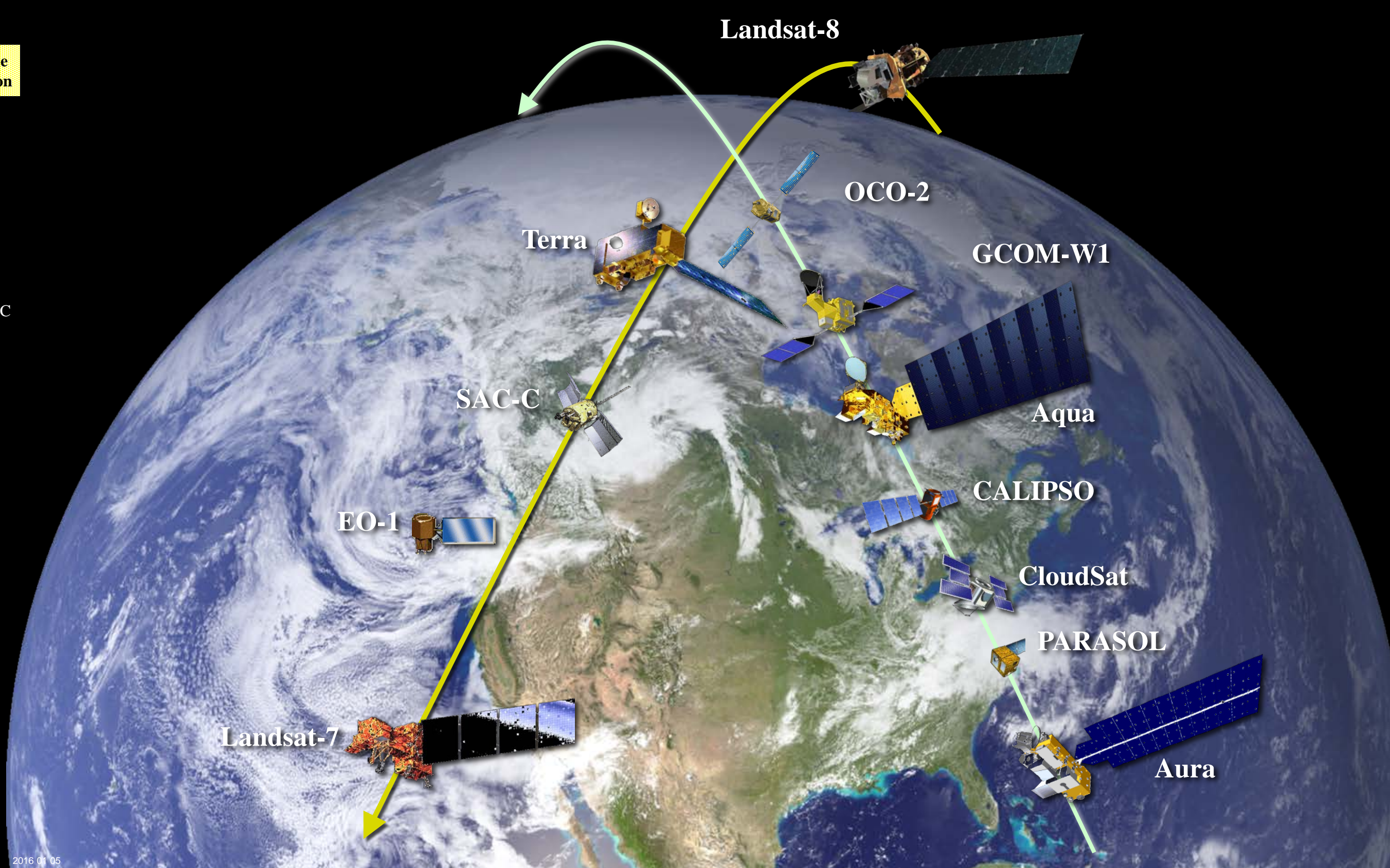


Options for the Continuing Evolution of the Earth Science Constellation

Michael Machado and Bill Guit - NASA/GSFC, Warren Case - ASRC/GSFC

Morning Constellation

Satellite	Summary Of Mission	Instruments	Dates	Responsible Organization
Landsat-7	Provides global coverage, and spectral characteristics to allow comparisons for global and regional change detection and image data to various international users throughout the world during times of sudden global changes (e.g., earthquakes or floods).	ETM+	April 15, 1999	USGS
Terra	Terra is a multi-national, multi-disciplinary mission that will help us to understand how the complex coupled Earth system of air, land, water and life is linked.	MISR CERES MOPITT ASTER MODIS	December 18, 1999	NASA/GSFC
EO-1	Developed and validated a number of instrument and spacecraft bus breakthrough technologies designed to enable the development of future earth imaging observatories that will have a significant increase in performance while also having reduced cost and mass.	ALI Hyperion ALI LEISA LAC and others	November 21, 2000 - March 30, 2017	USGS
SAC-C	Study the structure and dynamics of the Earth's surface, atmosphere, ionosphere and geomagnetic field.	MMRS, HRTC, HSC, Orsted-2/SHM, IST, INES, GOLPE, ICARE, WTE, DCS	November 21, 2000 - August 15, 2013	CONAE
Landsat 8	Provides moderate-resolution measurements of the Earth's terrestrial and polar regions in the visible, near-infrared, short wave infrared, and thermal infrared. Landsat 8 provides continuity with the 40-year Landsat land imaging data set.	OLI TIRS	February 11, 2013	USGS



Afternoon Constellation

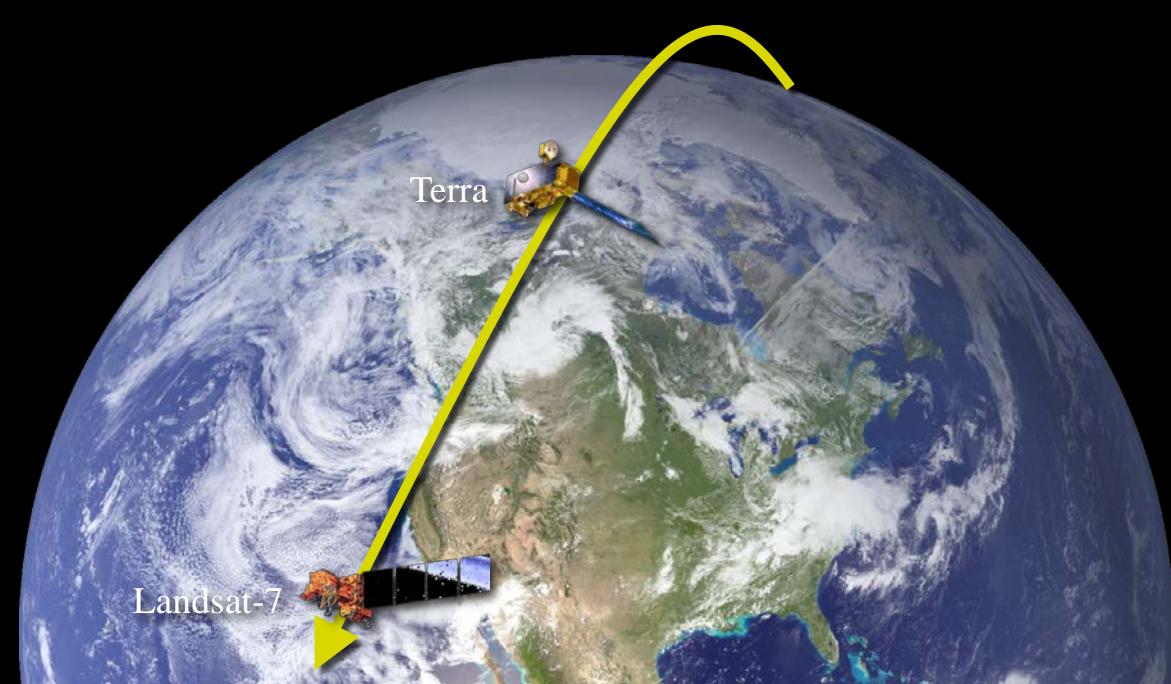
Satellite	Summary Of Mission	Instruments	Dates	Responsible Organization
Aqua	Aqua (Latin for water) named for the large amount of information that the mission is collecting about the Earth's water cycle, including evaporation from the oceans, water vapor in the atmosphere, clouds, precipitation, soil moisture, sea ice, land ice, and snow cover on the land and ice.	AIRS AMSU-A HSB AMSU-E CERES MODIS	May 4, 2002	NASA/GSFC
Aura	Aura (Latin for air) studies the Earth's ozone, air quality, and climate. It is designed exclusively to conduct research on the composition, chemistry, and dynamics of the Earth's atmosphere. Limb sounding and nadir imaging observations allow studies of the horizontal and vertical distribution of key atmospheric pollutants and greenhouse gases and how these distributions evolve and change with time.	HIRDLS MLS OMI TES	July 15, 2004	NASA/GSFC
PARASOL	Studied the radiative and microphysical properties of clouds and aerosols.	POLDER	Dec. 18, 2004 - Dec. 18, 2013	CNES
CALIPSO	Observations from space-borne lidar, combined with passive imagery, lead to improved understanding of the role aerosols and clouds play in regulating the Earth's climate.	CALIOP IIR WFC	April 28, 2006	NASA/GSFC NASA/LARC CNES
CloudSat	Cloud Profiling Radar allows for the most detailed study of clouds to date and should better characterize the role clouds play in regulating the Earth's climate.	CPR	April 28, 2006	NASA/GSFC NASA/JPL
GCOM-W1	The GCOM-W1 observes integrated water vapor, integrated cloud liquid water, precipitation, sea surface wind speed, sea surface temperature, sea ice concentration, snow water equivalent, and soil moisture.	AMSU-2	May 18, 2012	JAXA
OCO-2	Three grating spectrometers will make global, space-based observations of the column-integrated concentration of carbon dioxide, a critical greenhouse gas.	Three grating Spectrometers	July 2, 2014	NASA/JPL

The Earth Science Constellation comprises the Morning Constellation and the Afternoon Constellations (A-Train)

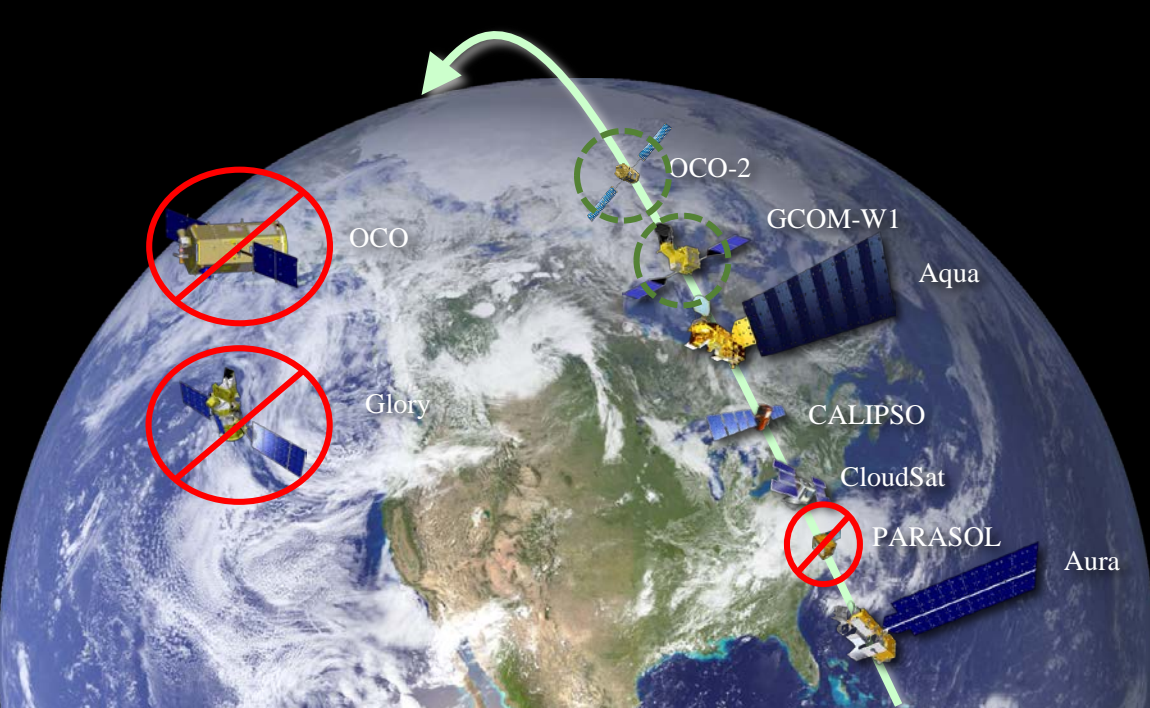
- **International in scope:** Member satellites/instruments from the U.S., France, Japan, Argentina, Canada, Brazil, Netherlands, Finland and the U.K.
- **Multiple U.S. Government Agencies:** Several NASA Centers, the United States Air Force (USAF), and the United States Geological Survey (USGS)

Constellation History and Future Changes

Morning Constellation



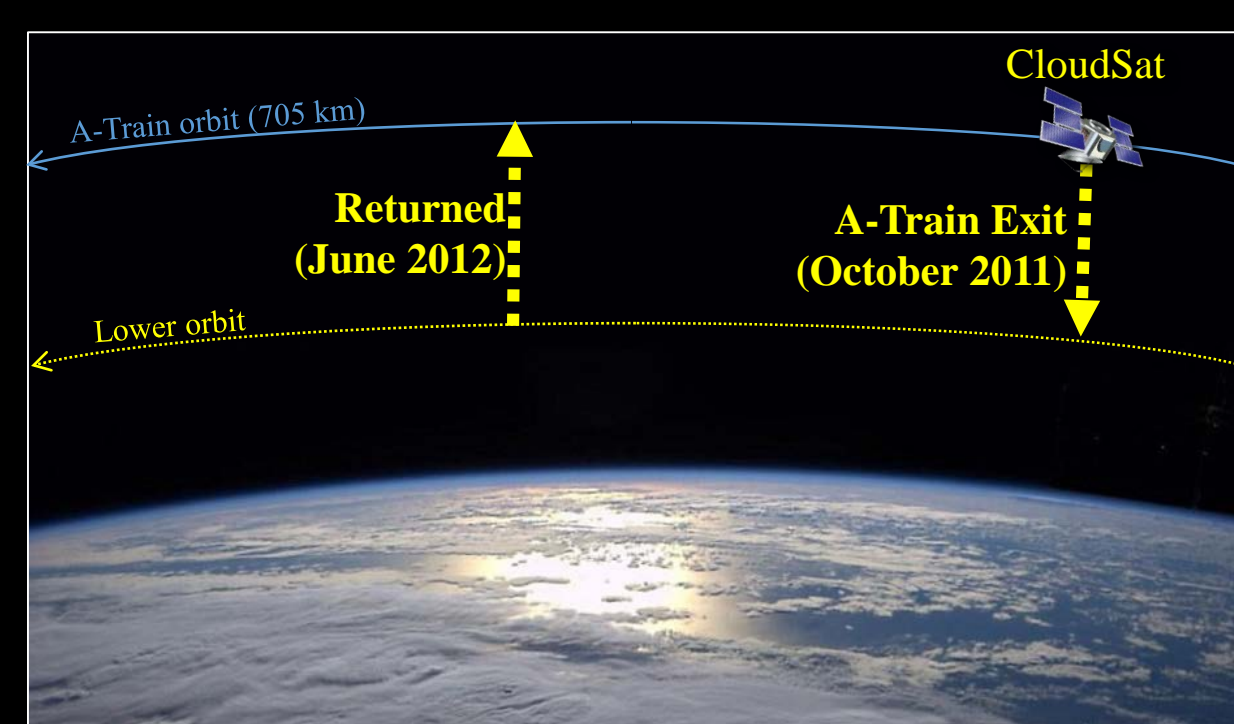
Afternoon Constellation



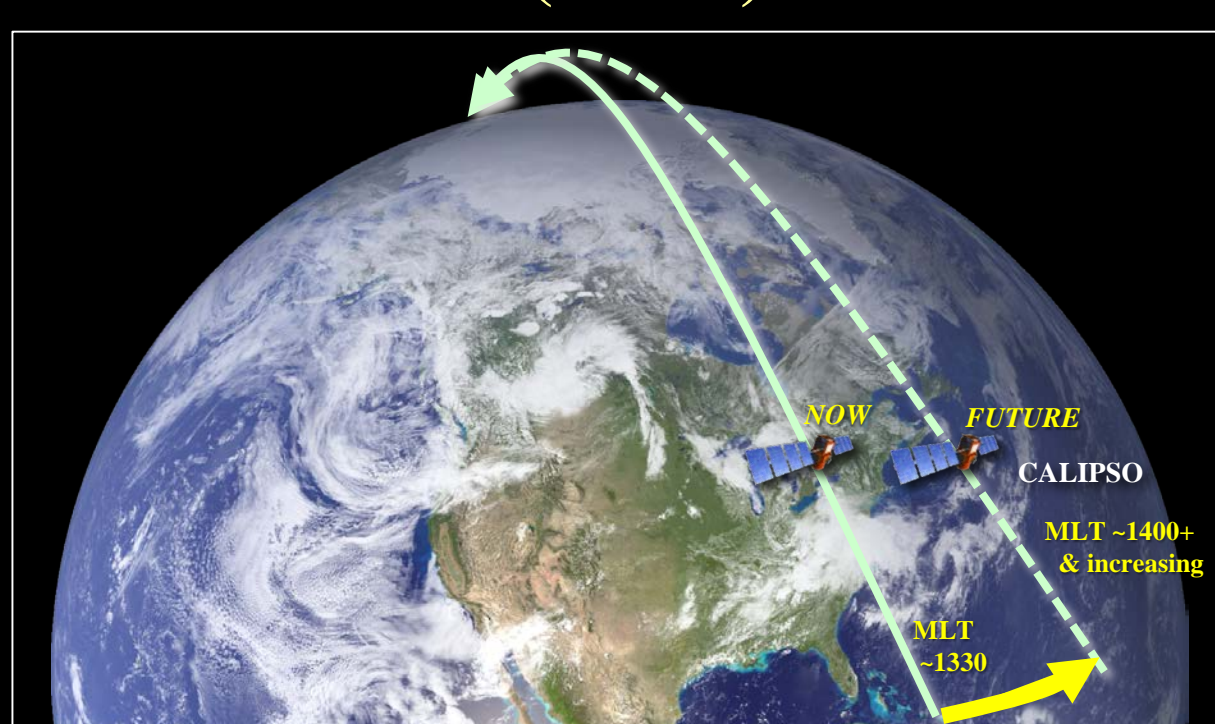
- CloudSat orbit lowered (February 2018).
- Landsat-9 added
- Terra, CALIPSO, Aqua, Aura fuel reserves low - require orbit adjustments.
- Landsat-7 exits Constellation & prepares for Restore-L servicing.

Options for Continued Evolution of the Constellation

Exit constellation and return



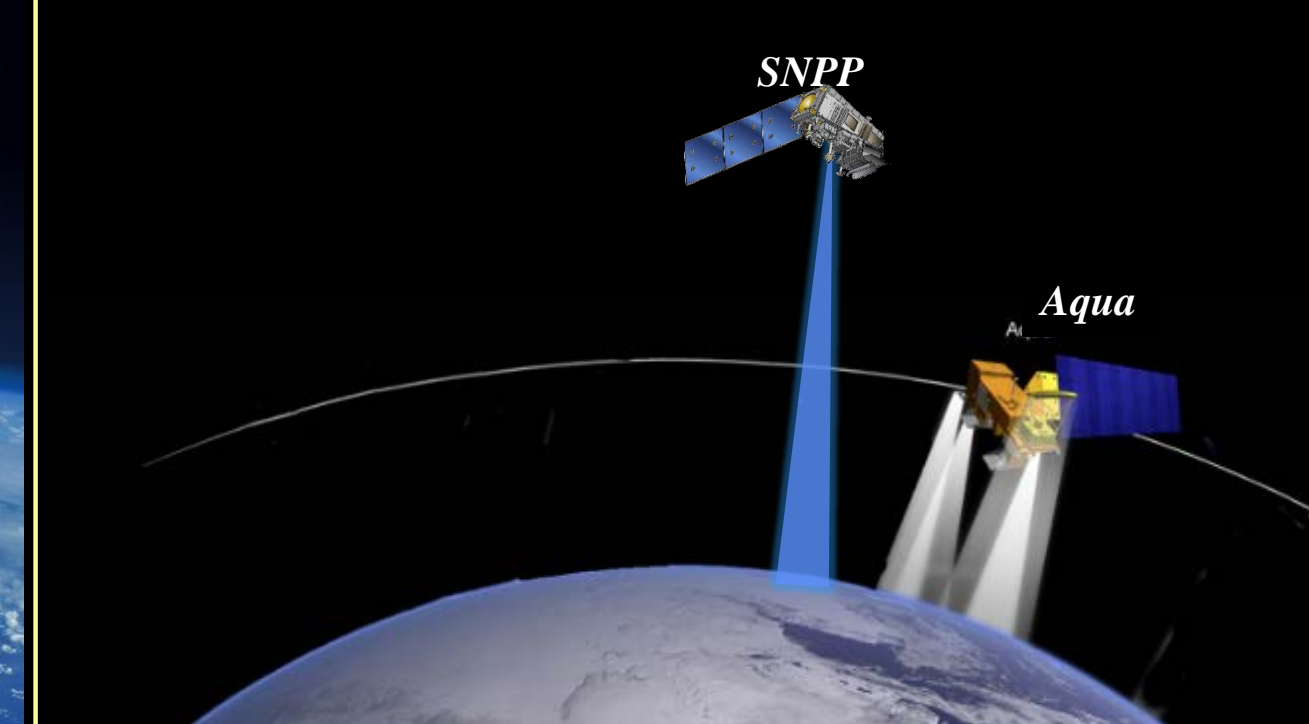
Drift Mean Local Time (MLT)



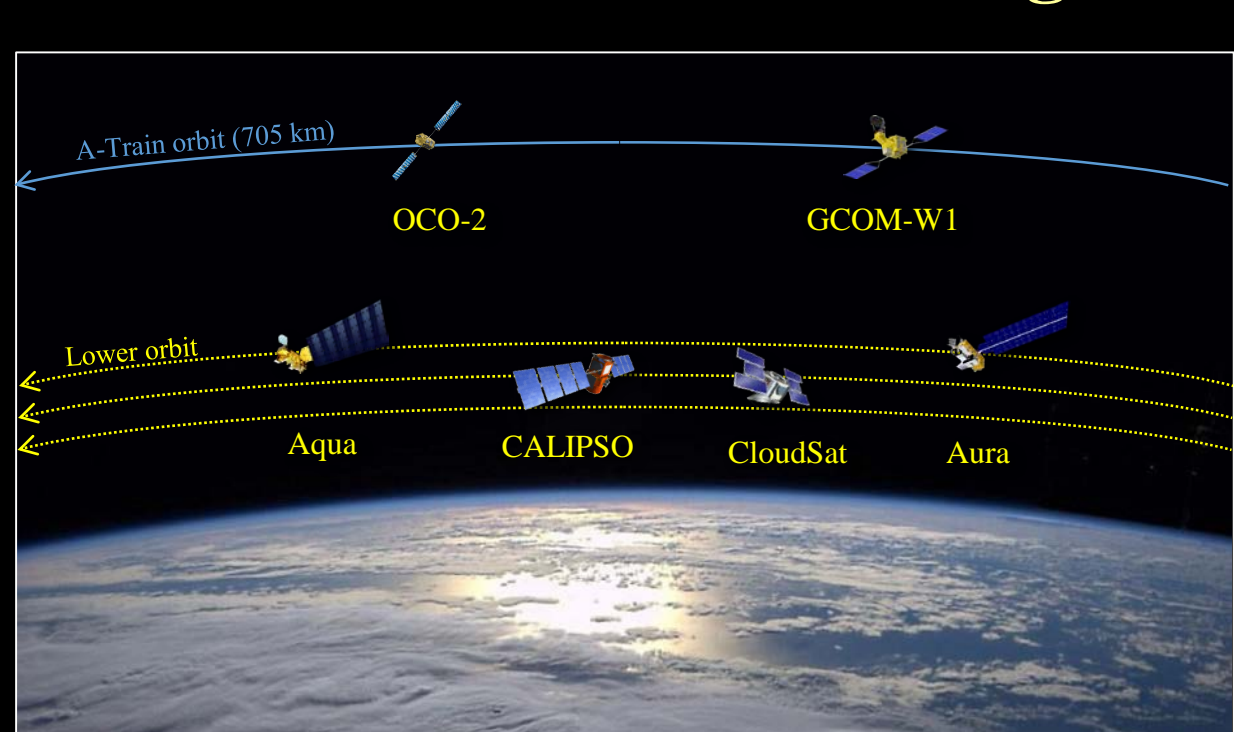
Coincident science after orbit lowering



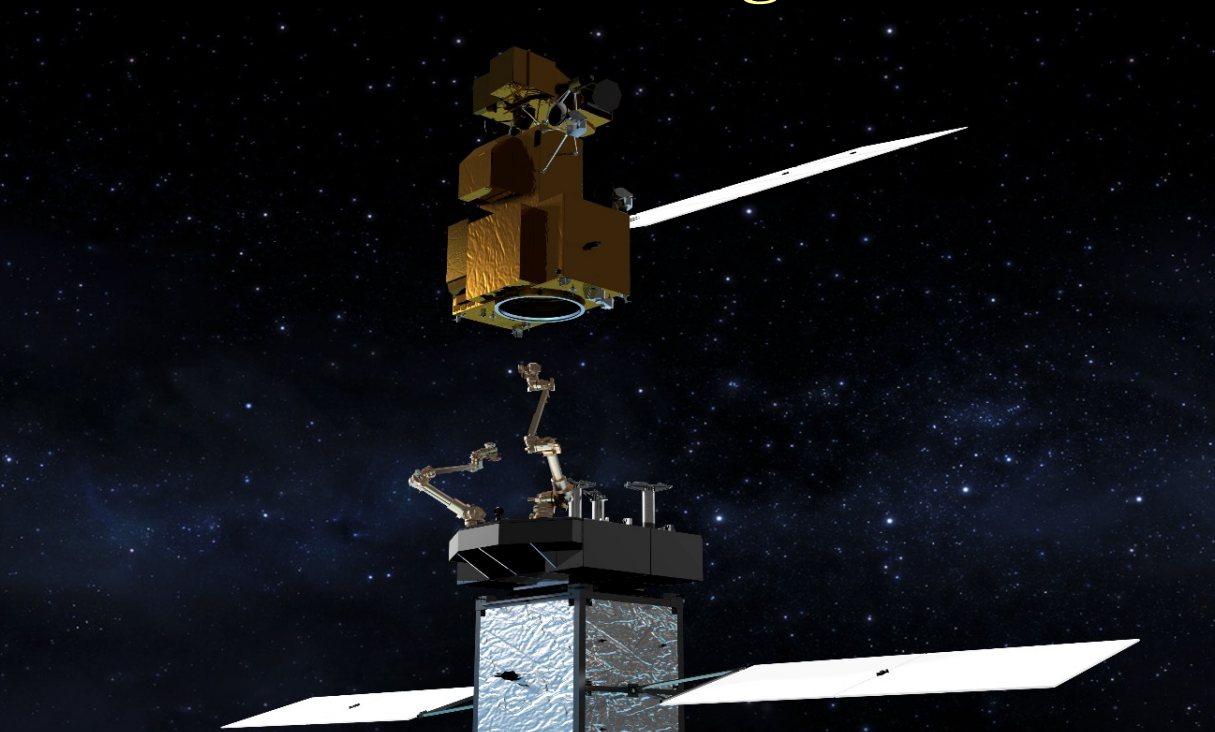
Coincident science with neighbor satellites



Maintain new MLT range



Re-fuel existing missions



Launch new missions



The Future?



Summary

Space agencies face significant challenges in order to extend the current observation capabilities and long-term climate record from the Earth Science Constellation