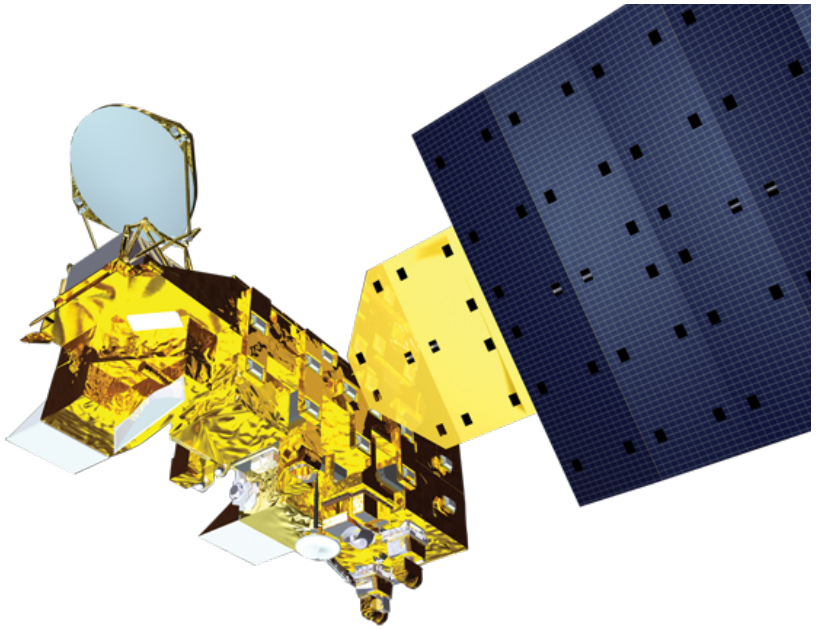
Aqua Status



Lazaros Oreopoulos, Deputy Project Scientist

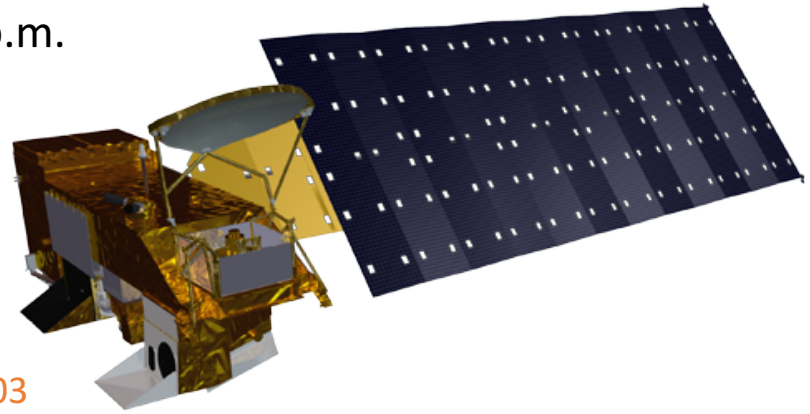
and

Claire Parkinson, Project Scientist

NASA Sounder Science
Team Meeting Fall 2017

Overview of Aqua Mission Instruments and Measurements

Mission basics: Aqua was launched on May 4, 2002 and is in a sun-synchronous orbit at an altitude of 705 km, orbiting the Earth every 98.8 minutes and crossing the equator south to north at ~1:30 p.m.



The Aqua Earth-observing instruments

- Atmospheric Infrared Sounder (AIRS)
  - In excellent health
- Humidity Sounder for Brazil (HSB)
  - Provided by Brazil; failed as of February 2003
- Advanced Microwave Sounding Unit (AMSU)
  - In fair health
- Advanced Microwave Scanning Radiometer for the Earth Observing System (AMSR-E)
  - Provided by JAXA; excellent record until October 2011; turned off March 2016
- Clouds and the Earth's Radiant Energy System (CERES)
  - Two copies, one in excellent health (FM-3) and the other in good health (FM-4), with two of the three channels operational
- Moderate Resolution Imaging Spectroradiometer (MODIS)
  - In excellent health

Aqua Measurements

Aqua measures, among others:

- Radiative energy fluxes
- Atmospheric moisture profiles
- Atmospheric temperature profiles
- Atmospheric gases
- Cloud fraction
- Cloud properties
- Aerosol properties
- Precipitation
- Sea surface wind speed
- Sea surface temperature
- Chlorophyll-*a* concentration
- Ocean particulate organic carbon
- Ocean particulate inorganic carbon
- Fluorescence line height
- Sea ice concentration and temperature
- Snow coverage and depth
- Evaporation/evapotranspiration
- Land surface temperature
- Land vegetation indices
- Land cover classification
- Gross and net primary productivity
- Fires and biomass burning
- Surface reflectance/albedo
- Photosynthetically available radiation

AIRS Instrument Status

https://aqua.nasa.gov/sites/default/files/AquaStatus_September2017.pdf

All voltages, currents, and temperatures are as expected.

- Includes scanner currents, cooler drive levels and heater currents
- On September 25, 2016, Cooler-A experienced a shut down anomaly. Anomaly recovery occurred two days later and also cleared a condition that had disabled Cooler-A telemetry since an earlier Cooler-A anomaly in March 2014.

- There are no disturbing trends in any engineering parameter.
- Design has considerable spectral redundancy and channels have a pair of detectors whose outputs are combined onboard allowing for correction if only one detector is degraded.
- Approximately 200 of 2378 infrared channels are degraded, primarily due to radiation.
  - Symptoms: increase in Gaussian and non-Gaussian noise
  - These channels are degraded; however, they are still useful for climate studies where averages over many data samples are taken.
  - Uploaded gain change to correct degraded channels for non-Gaussian Noise. Usually a degraded channel has had only one of the two detectors affected.
    - Corrected 106 Channels on January 21, 2012
    - Corrected 10 Channels on June 10, 2013
    - Corrected 91 Channels on March 23, 2015
    - Additional channels can be corrected depending on science team request
  - Increased solar activity may increase degradation rate since the channels are susceptible to radiation.

AIRS is in Excellent Health

AMSU-A Instrument Status

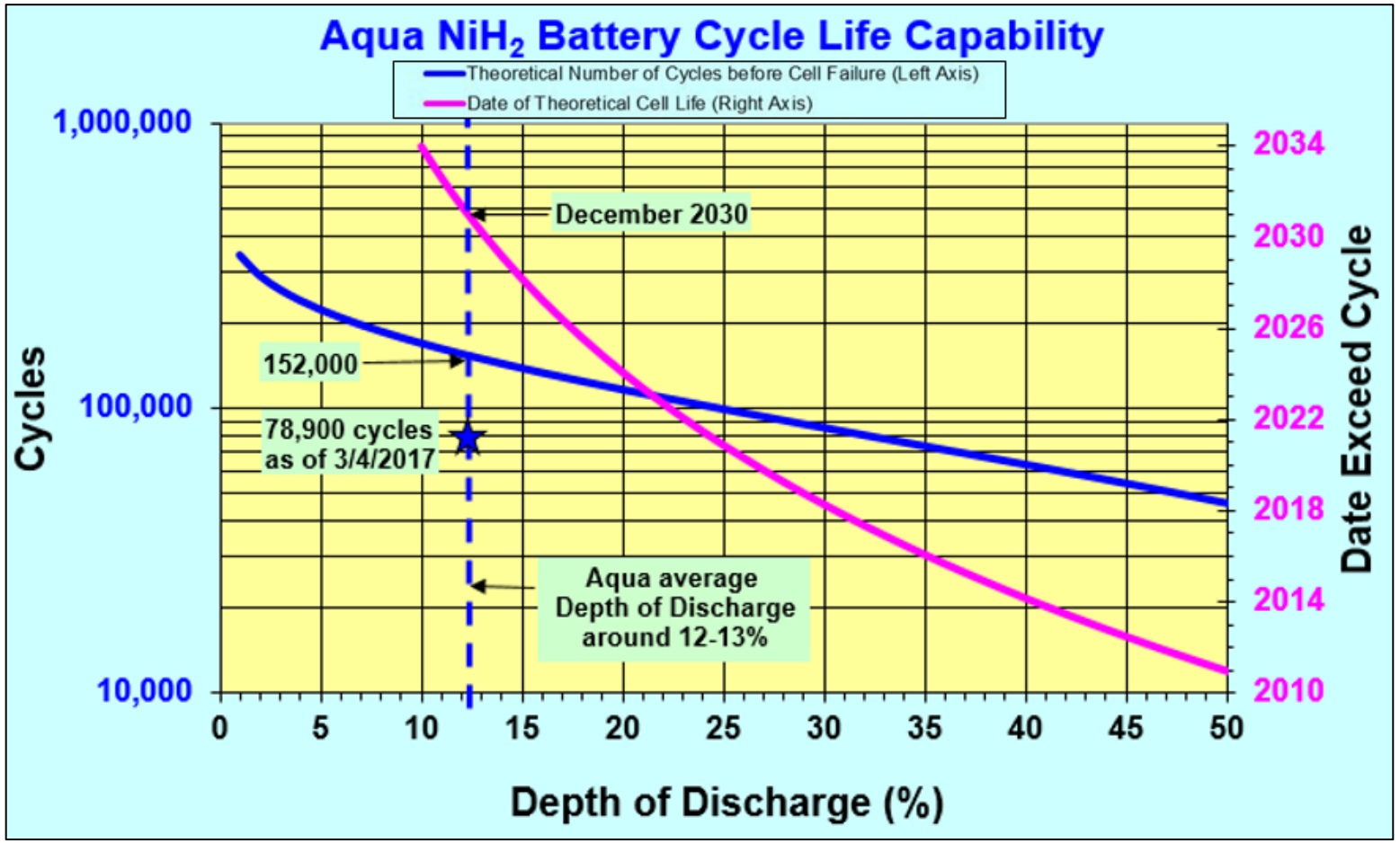
https://aqua.nasa.gov/sites/default/files/AquaStatus_September2017.pdf

- All voltages, currents, and temperatures are as expected
- There are no disturbing trends in any engineering parameter
- Designed for 3 years (now well beyond design life)
- 9 of 15 Channels show no signs of degradation
- 3 of 15 Channels have degraded and are no longer used for science
  - 05/04/2002: Channel 7 has not met noise specifications since launch (suspect launch related damage) and has never been used
  - 03/05/2008: Channel 4 data removed from level 2 processing; Declared non-operational in November 2007
  - 04/13/2012: Channel 5 data removed from level 2 processing; Declared non-operational in April 2012
- 2 additional channels (#1 and #2) are no longer available as a result of the AMSU-A2 power anomaly on 9/24/2016. Efforts to restore power to the AMSU-A2 module have been unsuccessful. Since the exact cause of the anomaly is unknown, the instrument manufacturer recommends not switching to the A-side to attempt to recover AMSU-A2.
  - 11/29/2016: Anomaly Recovery Team recommended no further commanding
  - 1/31/2017: Anomaly Closeout Review at JPL (Anomaly is considered Closed)
- 1 Channel (#6) is slowly degrading but has many years of useful performance remaining based on current degradation rate
- The scanner and 10 channels appear capable of lasting several more years

AMSU-A is in Fair Health

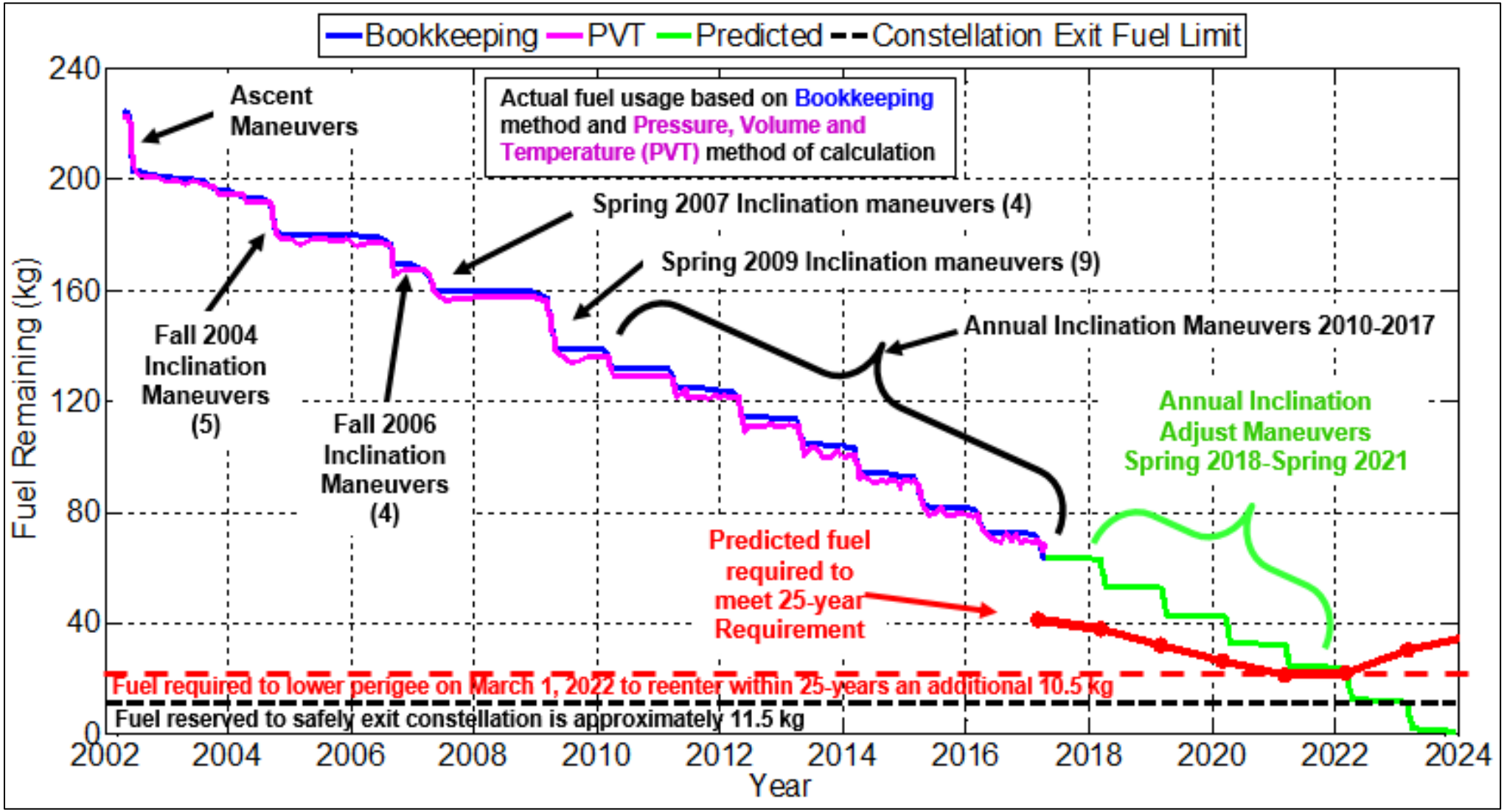
Aqua Battery Life Projection

- Extrapolating the Eagle-Picher NiH_2 Battery Cycle Life Capability data for the typical Aqua Depth-of-Discharge (12-13%) leads to a potential 152,000 cycles from launch that might be achievable with the cells.
- Aqua is projected to reach 152,000 cycles in December 2030.



Aqua Battery Life Capability projected through December 2030.

Fuel Usage: Life of the mission (May 2, 2017)



Fuel usage continues to follow prediction.

National Aeronautics and Space Administration

NASA

Aqua

Senior Review Proposal

Submitted to NASA Headquarters
March 1, 2017

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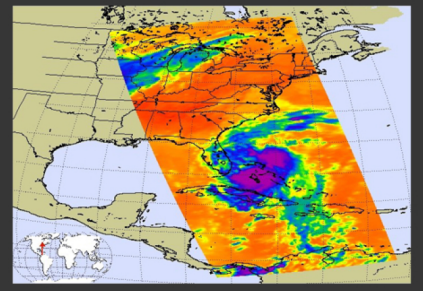


Table of Contents

COVER: Hurricane Matthew as imaged by Aqua's Atmospheric Infrared Sounder (AIRS) on October 16, 2016, 2:23 p.m. eastern daylight time, both in visible light (top image) and in infrared (bottom image). Colors on the infrared image range from brightness temperatures of 210 K for the deepest purple to 300 K for the brightest red, highlighting the cold cloud-top temperatures in the midst of the storm.

What is the Senior Review?

A comparative review of all missions in extended operations, for the purpose of allocating funds for further extension

- NASA Earth Science Division (ESD) is supporting 13 Earth observing missions that are operating beyond their prime mission lifetimes.
  - Each mission has made unique contributions to NASA research objectives.
  - Mission extensions have great potential for advancing NASA ESD science goals.
  - Data from many of these research missions are used routinely by other US agencies and institutions in support of national operational/non-research goals.

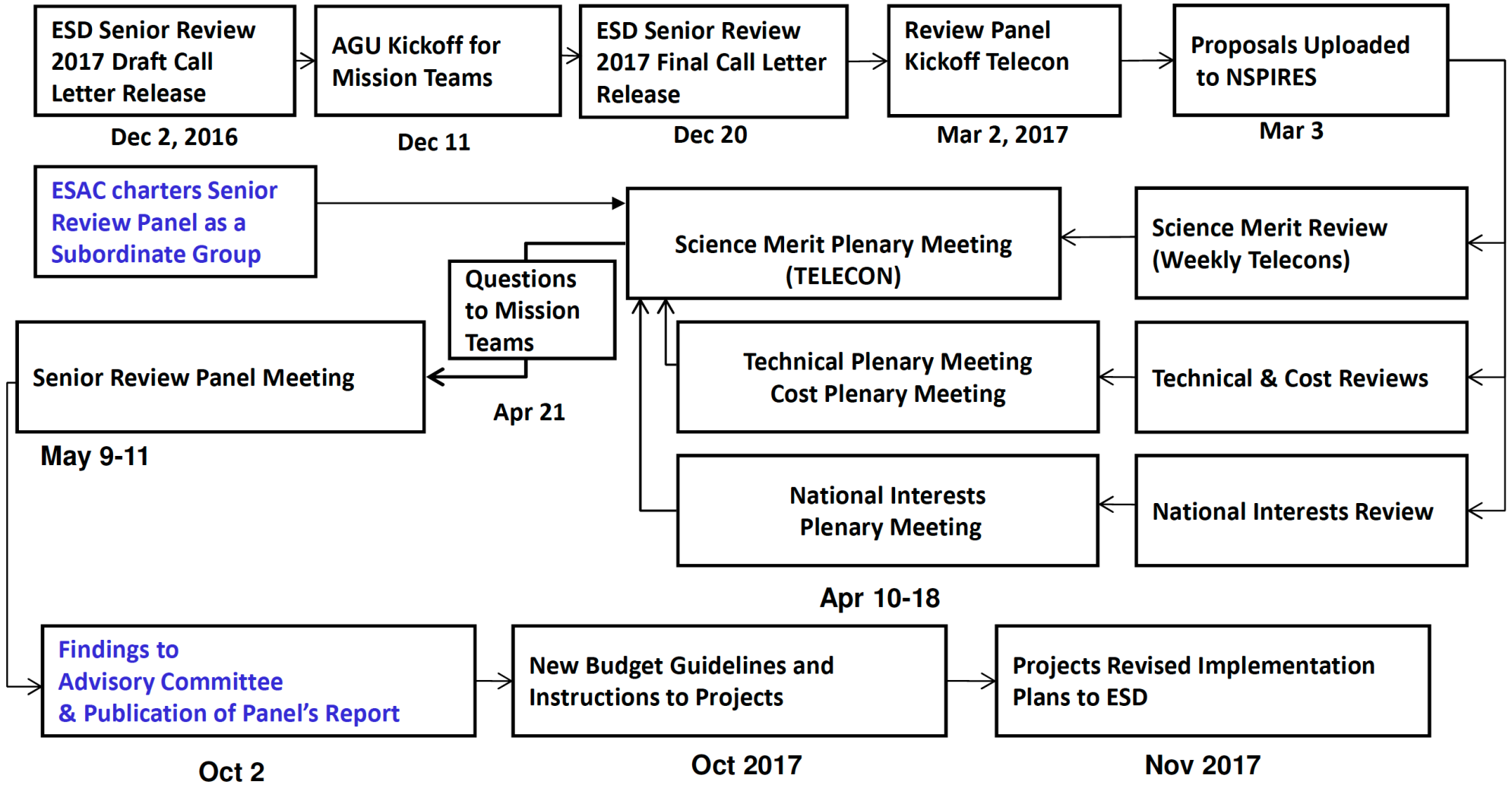
- Extended operations and associated data analysis activities require approximately 8-10% of the annual Earth Science budget (~$157M in FY18)

Senior Review Schedule

– ESD Approval of Senior Review Scope	Nov 10
– Draft Call Letter to Missions	Dec 2
– Notification to excluded missions	Dec 2
– Mission Scientists Pre-Proposal Briefing @ AGU	Dec 11
– Reclama Due for excluded missions	Dec 19
– Final Call Letter	Dec 20
– Proposals Due	Mar 3
– Science Panel Pre-Panel Tag-Ups	Mar 2, 13, 27, Apr 10
– Science Panel Ethics Briefing	Apr 4, 6
– National Interests Panel &Technical Review Plenary	Apr 10-14
– Science Panel (Telecon)	Apr 18
– Science Panel (Mission Presentations)	May 9-11
– Science Panel Report	June
– PPBE2019/Senior Review Budget Decisions	May – Aug
– Results to ESAC	Oct 2
– ESD Steering Committee Decisions	Oct
– Guidance Letters to Missions	Oct
– Mission Response	Nov

ESD Senior Review 2017 Flow

FACA process applied

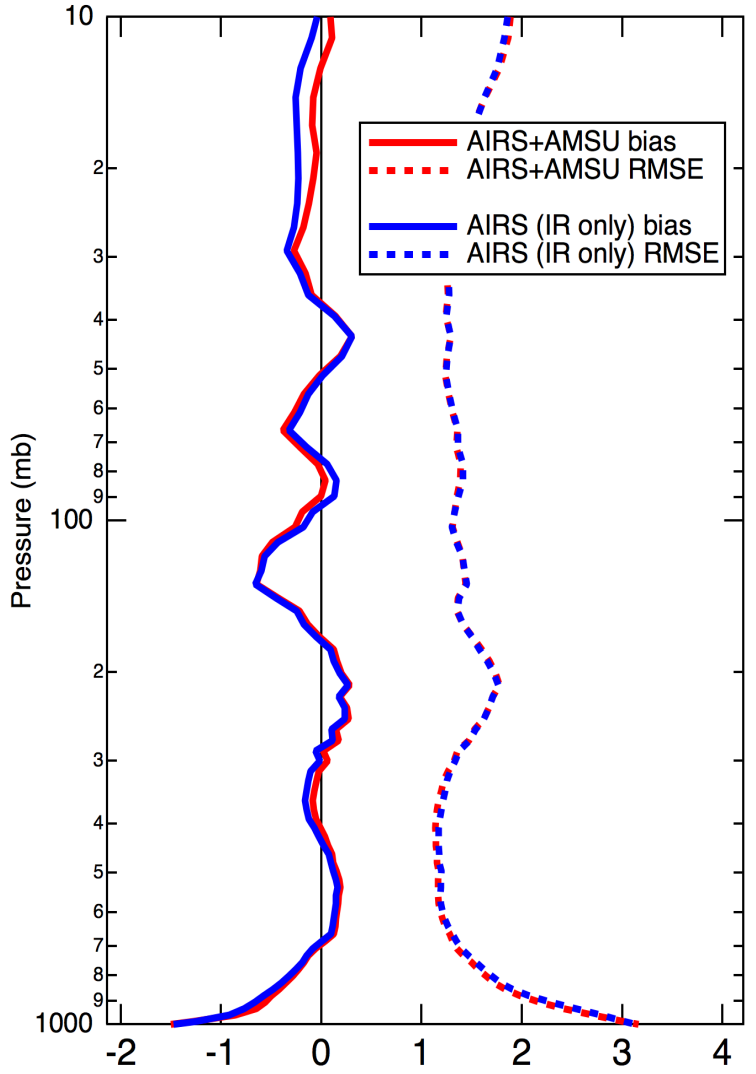


Changes from Previous Senior Review process

- 6 year budgets: 3 “baseline” years (FY18-FY20) and 3 “out” years (FY21-FY23)
- Proposal included 26 algorithm maintenance (“mini”) proposals previously competed in ROSES
  - 22 MODIS (Aqua and Terra) and 4 AIRS/AMSU
- Different formal structure (FACA process)
  - Senior Review Panel (SRP) a Subordinate Group of Earth Science Advisory Committee (ESAC)
  - SRP presents findings of Senior Review to ESAC in a publicly open hearing
  - ESAC issues recommendations to the ESD Division Director

AIRS/AMSU Science Team Highest Priority Activities

- Past Year
  - Validated in detail the AIRS (IR only) Level 2 (L2) algorithm (see figure).
  - Performed the initial development, integration, and validation of unified L2 retrieval algorithms for AIRS and the Cross-track Infrared Sounder (CrIS).
  - Developed, integrated, and validated application products using AIRS data, with a focus on drought monitoring.
- Coming Year
  - Finalize Version 7 of the AIRS retrieval algorithm.
  - Continue the development of a unified AIRS/CrIS L2 retrieval algorithm, doing so in the context of the new Version 7 AIRS algorithm.
  - Monitor the behavior of extreme storms/convection as climate changes.
  - Continue the development, integration, and validation of AIRS application products (with a focus on health applications).
  - Support the maintenance of the physical retrieval algorithm, the stand-alone rapid transmittance algorithm (SARTA), the neural network algorithm, and the CO2 retrieval.



Average Temperature Bias vs Sondes (K)

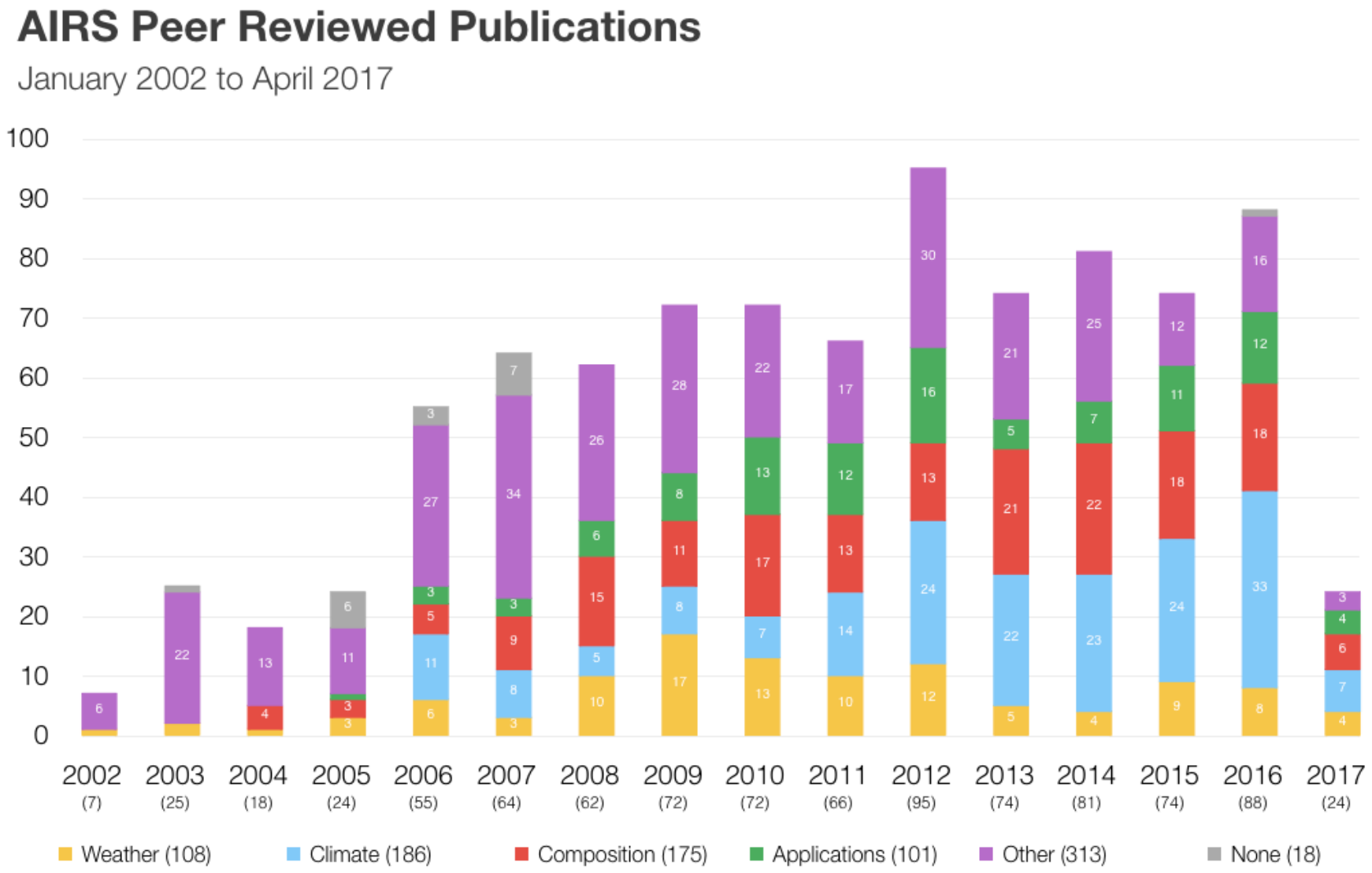
Questions by Senior Review Panel (edited for brevity)
Aqua PS Claire Parkinson presented responses at NASA HQ on May 10

- The rationale for extending the mission is stated to extend the length of climate quality data and cross calibration with other sensors. Are there any specific science goals for the extended mission?
- Is there a more current list of products available on the web for the user community other than the one in Appendix A?
- *The science results described in the proposal seem biased towards AIRS and atmospheric science.* Please provide some results in other disciplines supported by Aqua (e.g., ocean biology).
- *How do the instrument team's product developers participate with the broader community of developers of related products? What can be done to improve the interactions with the goal of providing more useful comments to the algorithm developers?*
- Please provide an update on the calibration issues with MODIS, particularly the blue channels.
- Please describe the coordination between the Aqua leadership and OBPG.
- What are potential impacts on water-leaving reflectance and other land and atmosphere products of the 412 nm band?
- What is the content of your FY23 budget request considering spacecraft life expectancy?
- Several questions about Algorithm Maintenance mini proposals.
- *Do the Terra and Aqua Projects and/or the relevant DAACs keep any data/statistics on the uses of specific data products and/or track publications in their bibliographies by the specific data products used in the publication?*

AIRS Science Team and the broader community

- The AIRS Project and AIRS Science Team work closely with the sounder science community in general, including within NASA, with NOAA, with U.S. universities, and with European counterparts.
- The AIRS project regularly integrates and validates algorithms developed by the science community in general and by members of the AIRS Science Team.
- The AIRS product developers collaborate closely with the broader community of developers of related products – It is in fact a fairly well integrated sounder community. For example, the AIRS project is working closely with teams at NASA GSFC, NASA JPL, and the University of Maryland Baltimore County (UMBC) towards the development of joint unified retrieval algorithms for AIRS and CrIS.
- Each year, the AIRS Project and Science Team organize and coordinate a springtime AIRS Science Team Meeting and an autumn NASA Sounder Science Team Meeting, where many interactions take place. Additional interactions occur throughout the year in smaller meetings and telecons.

AIRS tracking publications



Aqua Senior Review 2017 findings

Mission	Science Score			Summary Science Score	Adject. Summary Science Score	Natl Int. Utility Score	Technical Risk Rating	Cost Risk Rating
	Sci. Merit	Relev. to NASA E.S.	Data Quality					
Aqua	5.0	5.0	5.0	5.0	Excellent	V. High	Low	Low

Mission	Conclusion		Suggested Change in Scope
	FY18-20	FY21-23	
Aqua	Continue	Continue	

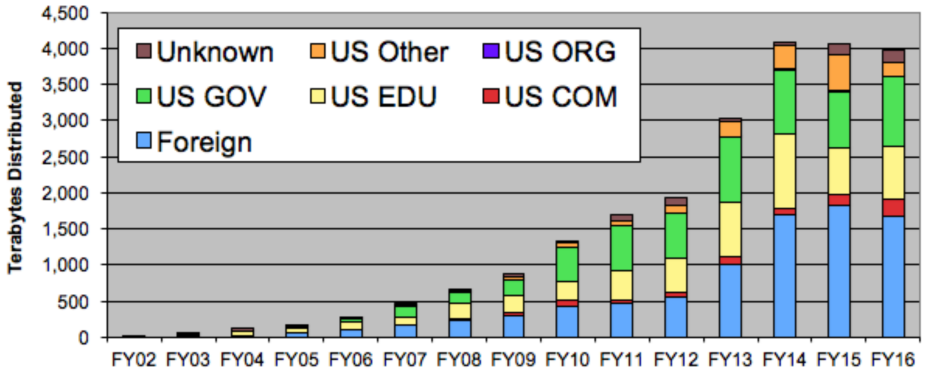
"The fifteen years of Aqua data have provided critical Earth observation capabilities that become even more valuable by extending the mission."

https://science.nasa.gov/earth-science/missions/operating

Summary

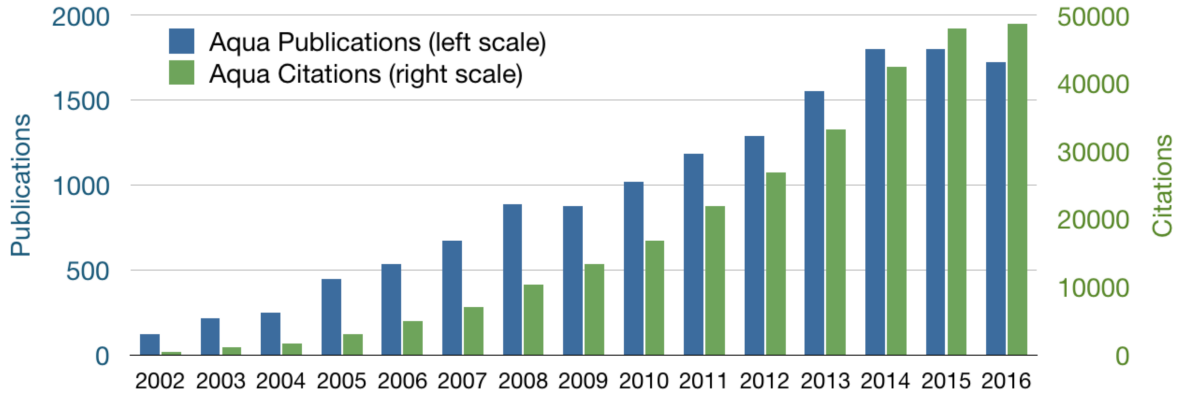
- Aqua is doing well, over 15+ years after launch.
- AIRS/AMSU, CERES, and MODIS continue to transmit high--quality data.
- The mission is expected to continue nominal operations through 2022 (with fuel the likely limiting factor).
- Users have downloaded well over 20 petabytes of Aqua data; and thousands of publications have incorporated Aqua data.
- The 2017 Aqua Senior Review proposal was very favorably reviewed which bodes well for a positive funding outlook for the next three years.

Terabytes of Aqua Data Distributed to Users



[ORG, GOV, EDU, and COM signify the internet addresses .org, .gov, .edu, and .com]

Number of Aqua Publications and Citations

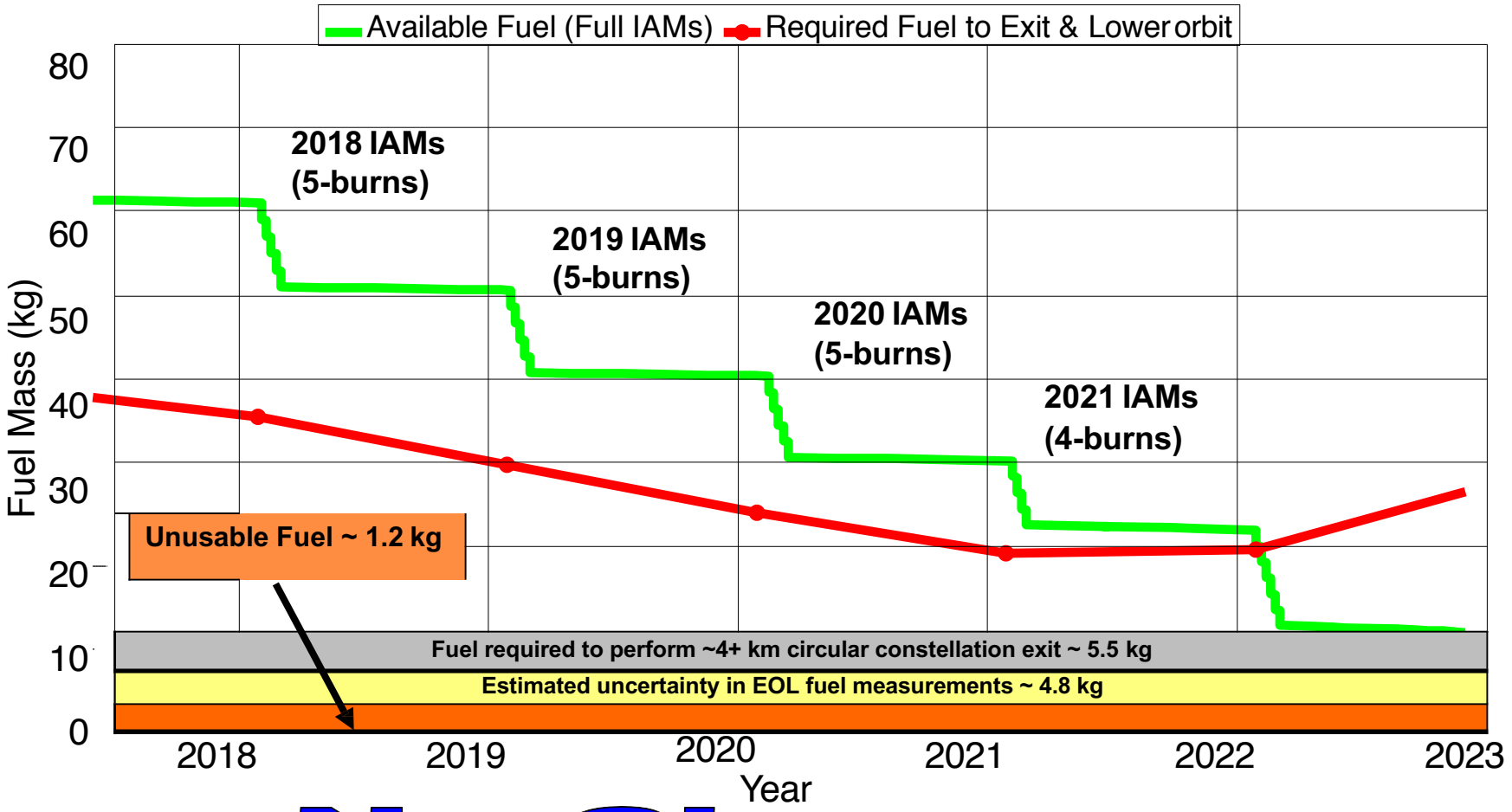


[Publication data are from the Web of Science and include Terra CERES and MODIS data as well as Aqua data]

(plots from the 2017 Aqua Senior Review proposal)

Additional Slides

Fuel Usage:
Predicted Available & Required
(May 2, 2017)



No Changes