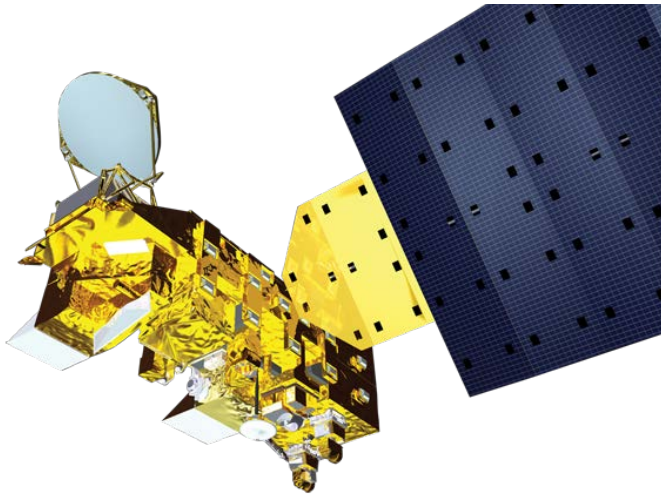


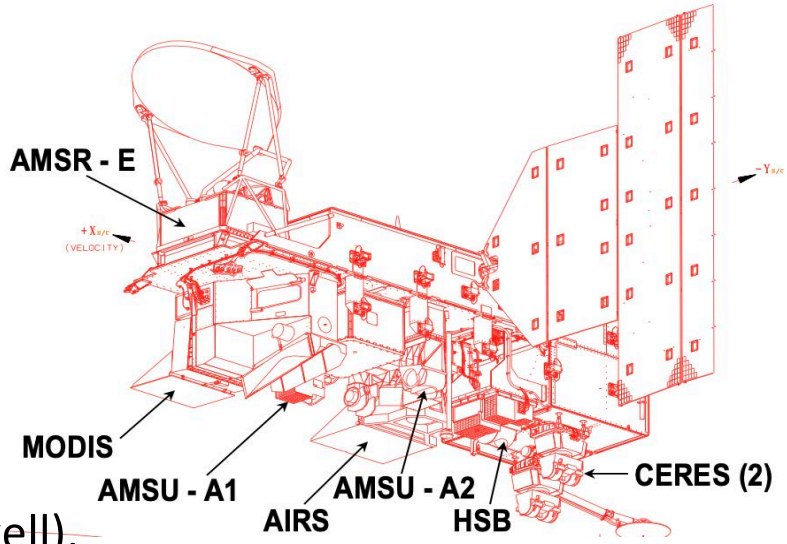
Status of the Aqua Mission

Claire L. Parkinson/Aqua Project Scientist
NASA Goddard Space Flight Center

Presentation at the NASA Sounder Science Team Meeting,

October 2, 2020

Instrument Status



- Atmospheric Infrared Sounder (AIRS)
  - Excellent health.
- Advanced Microwave Sounding Unit (AMSU)
  - Fair health (10 of 15 channels are performing well).
- Humidity Sounder for Brazil (HSB)
  - Provided by Brazil's Instituto Nacional de Pesquisas Espaciais (INPE).
  - Not operating since February 2003.
- Advanced Microwave Scanning Radiometer for EOS (AMSR-E)
  - Provided by the Japan Aerospace Exploration Agency (JAXA).
  - Not operating since March 2016.
- Clouds and the Earth's Radiant Energy System (CERES; 2 copies)
  - Flight Model 3 (FM-3): Excellent health.
  - Flight Model 4 (FM-4): Good health (2 of 3 channels remain operational).
- Moderate Resolution Imaging Spectroradiometer (MODIS)
  - Excellent health.

2020 Aqua Senior Review Process

- Received the Call for Proposals from NASA Headquarters (HQ) on 12/20/19.
- Submitted the 280-page Aqua proposal on 3/2/20.
- Received questions from the Technical Panel on 3/19/20.
- Submitted answers to the Technical Panel on 3/30/20.
- Received questions from the Science Panel (and its National Interests and Cost sub-panels) on 5/27/20.
- Provided answers to the Science Panel in a 70-minute presentation on 7/8/20.
- Received the Senior Review Panel Report on 9/21/20.
- Awaiting NASA HQ decisions.

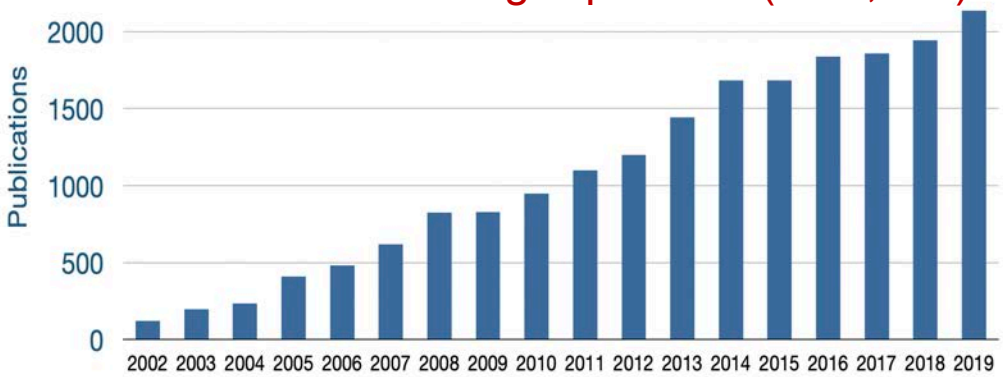
Aqua pre-launch (courtesy of Northrop Grumman)

Senior Review Proposal

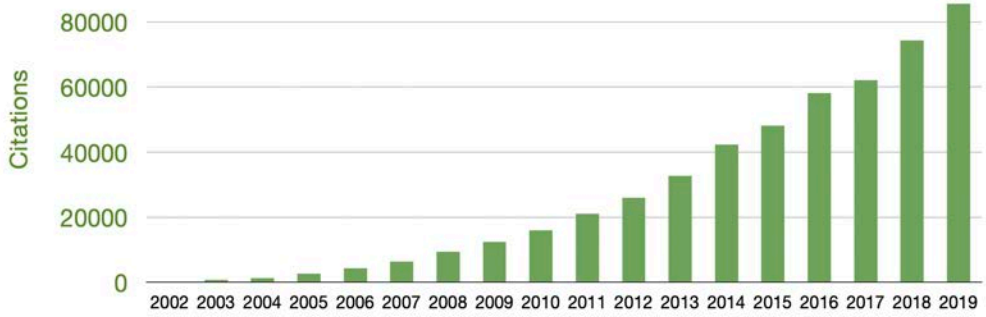
- 280 pages.
- Summarizes the mission.
  - Instrumentation.
  - Science.
  - Applications.
  - Algorithm maintenance.
  - Technical status.
  - Future plans.
  - Budget.
- Advocates for mission continuation.
- Provides in-guide and over-guide budget options.
  - In-guide: Data collection ends April 2023.
  - Over-guide: Data collection ends September 2025.

Science Productivity

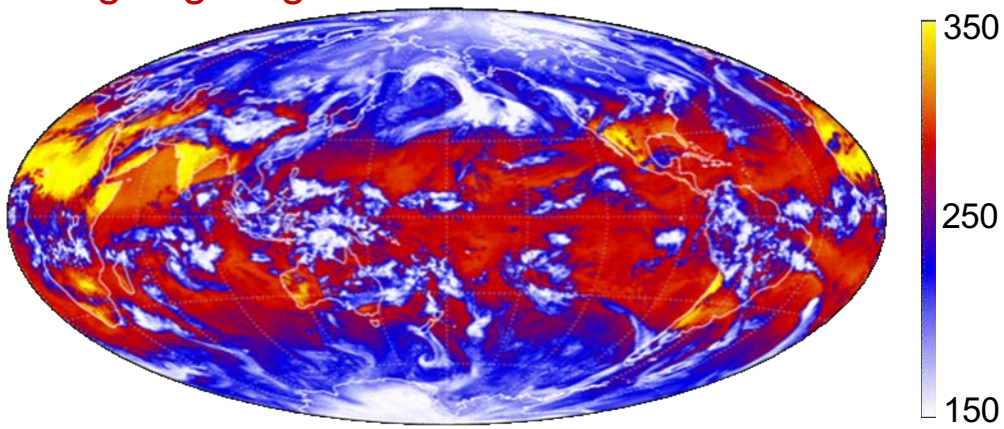
Publications including Aqua data (> 19,000)



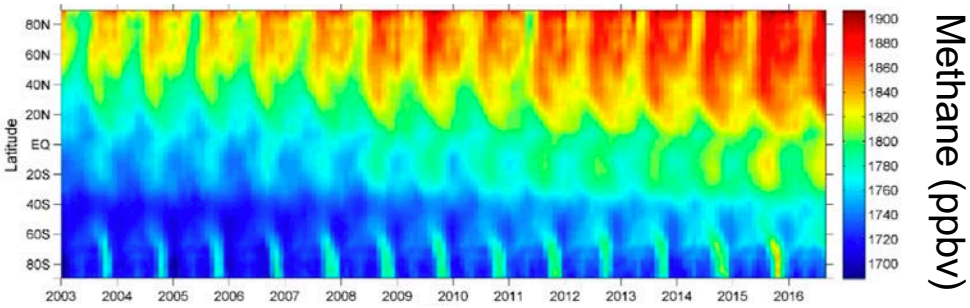
Citations to Aqua publications (> 498,000)



Outgoing longwave radiation from CERES

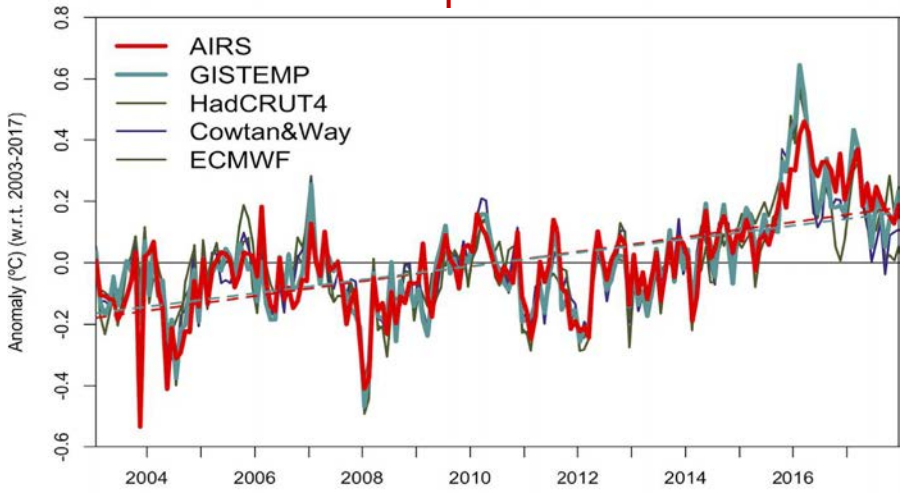


Zonal tropospheric methane from AIRS



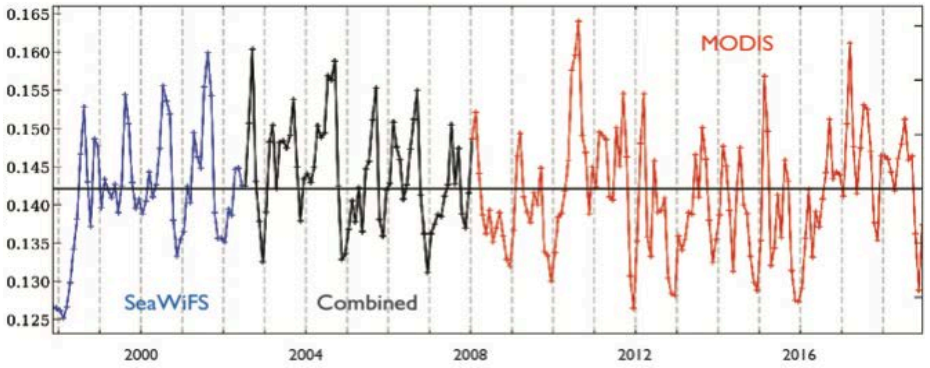
(from Zou *et al*. 2019)

Global surface temperature from AIRS etc.



(from Susskind *et al*. 2019)

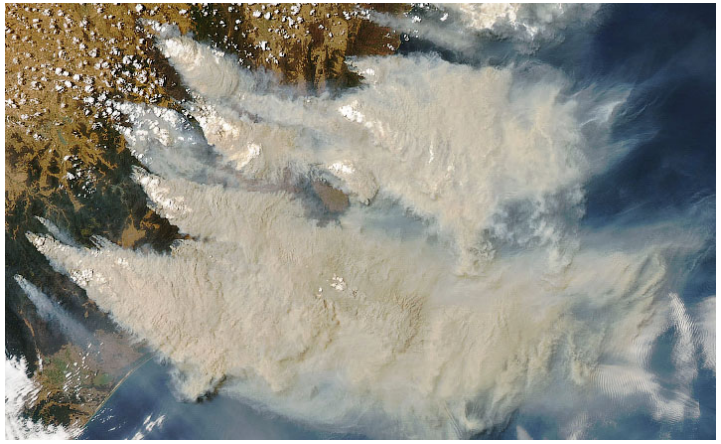
Chlorophyll-*a* concentration, 40°N – 40°S



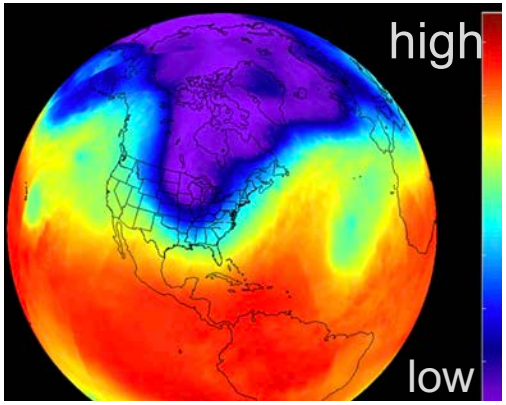
(from Franz *et al*. 2019)

Sample Applied Uses of Aqua Data

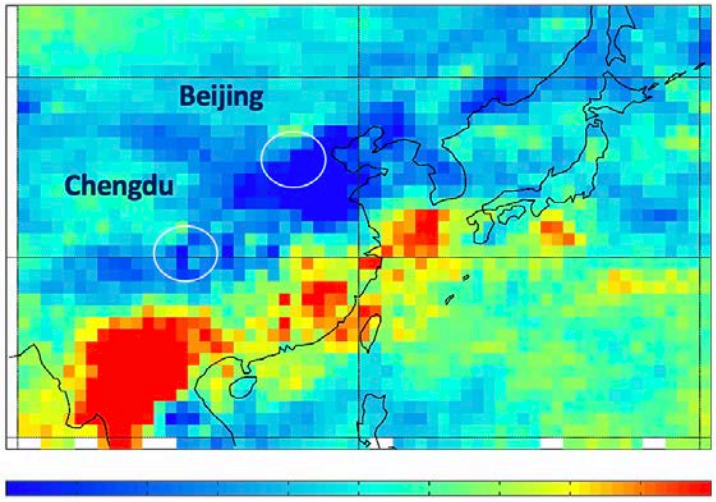
Fires in Australia, 1/4/20, from MODIS



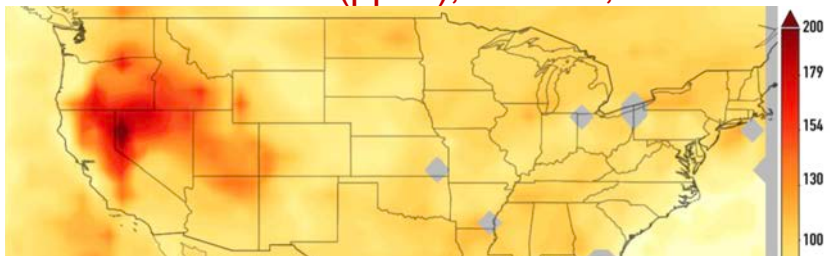
Upper atmospheric temperatures, 1/29/19, from AIRS



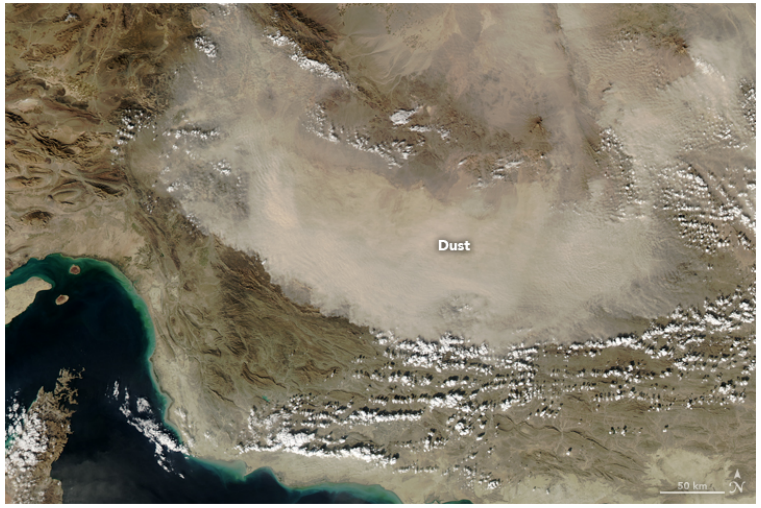
Anomalies in February AIRS CO, 2020 versus 2003-2019



CO from wildfires (ppbv), 7/30/18, from AIRS

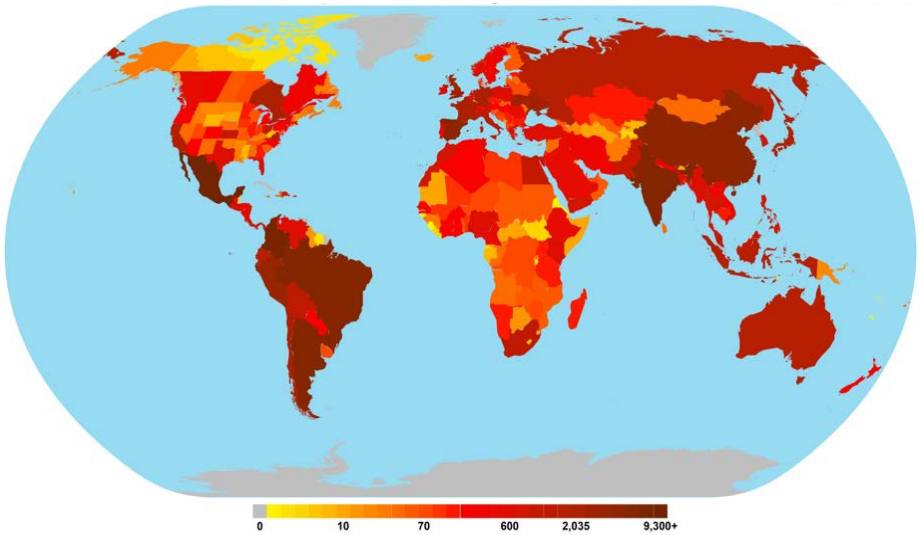


Dust storm in Iran, 12/10/16, from MODIS

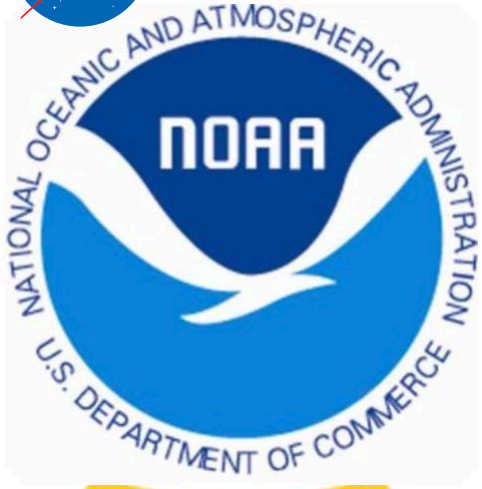


Oil spill, 4/25/10, from MODIS

CERES FLASHFlux users, 5/16/18 - 11/30/19



Federal Government Users of Aqua Data



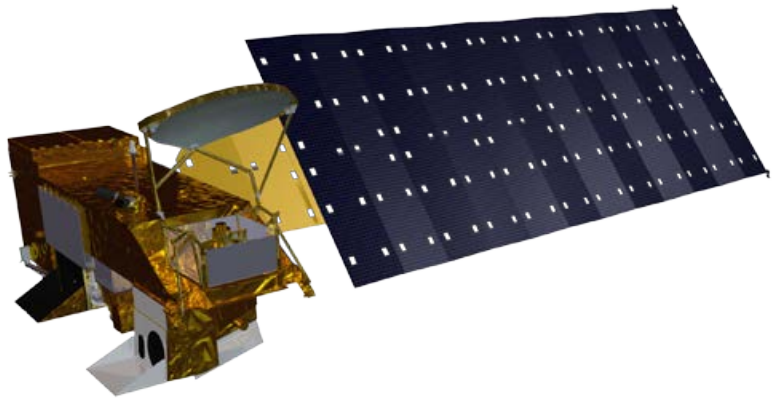
Report of the Senior Review Panel

- Submitted by the Panel to NASA HQ on 8/31/20; provided by NASA HQ to the Aqua mission on 9/21/20.
- 140 pages, covering 13 missions.
- Very favorable toward Aqua.
  - "Excellent" ratings for Science Merit, Relevance, and Data Quality.
  - "Very High" utility rating.
  - Recommendation for the Over-guide budget.
  - Summary statement: "The Senior Review Science Panel unanimously finds there is enormous potential benefit in continuing to receive Aqua data, ... The Senior Review Panel finds in support of Aqua's extension with the over-guide budget for both FY 2021-2023 and FY 2024-2026."
- Should be a factor in funding decisions by NASA HQ.

August 16, 2020 Anomaly

- On 8/16/20, suddenly all the data received from the Aqua solid state recorder (SSR) were corrupted.
- Direct broadcast data were still good.
- Earth Science Mission Operations (ESMO) meticulously sorted through possible causes of the anomaly.
- The problem was determined to be in the Formatter Multiplex Unit (FMU).
- ESMO developed a series of increasingly difficult potential solutions.
- Simulations were done for the simplest potential solution, which would be a reinitialization of the FMU firmware.
- On 9/2/20, the FMU firmware was successfully reinitialized and all the SSR data were back to normal.

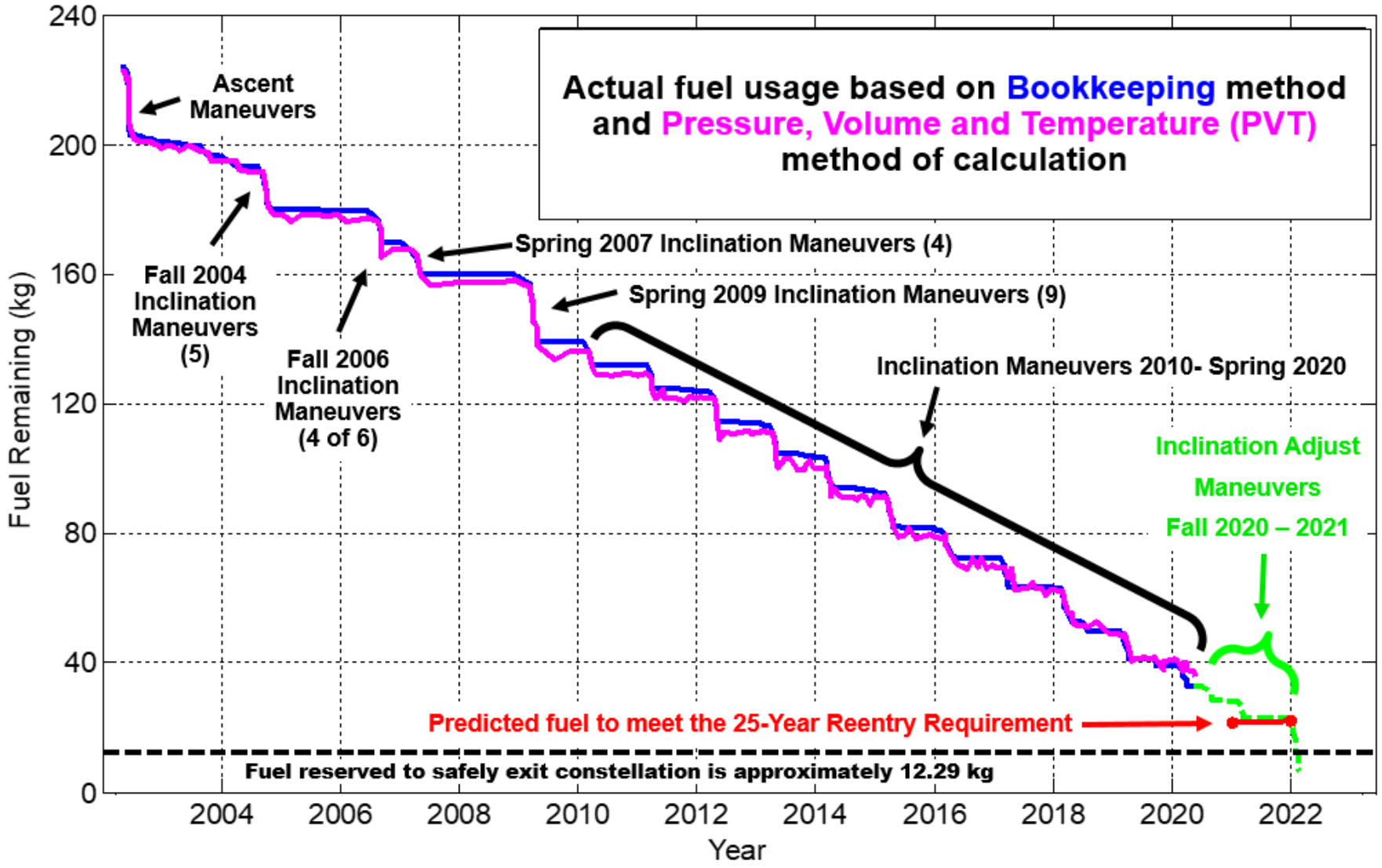
Aqua Going Forward



- Continue in the A-Train until early 2022
  - Continue all science and applications.
  - Exit the A-Train in early 2022 (likely January) due to fuel limitations.
    - Lower the altitude.
    - Allow the mean local time (MLT) of the observations to drift.
- Continue to collect science-quality data after exiting the A-Train
  - Continue most current science and all applications.
  - Perform new science made possible by the shifting MLTs.
  - End data collection in April 2023 if limited to the in-guide budget.
  - Continue data collection until September 2025 if awarded the over-guide budget.
- Meet end-of-mission requirements.

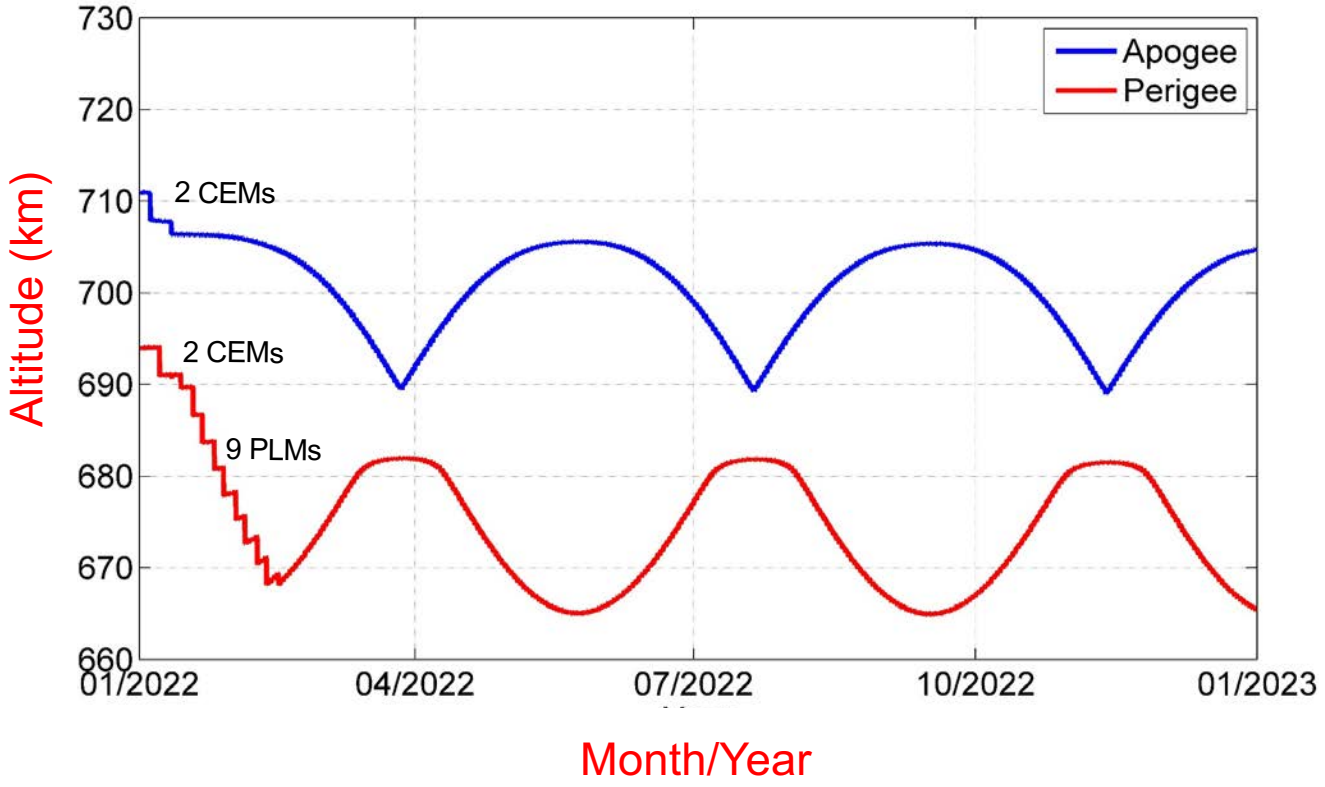
(Aqua visualization by Marit Jentoft-Nilsen)

Timeline of Aqua Fuel Levels



Planned Aqua Exit from the A-Train and Subsequent Orbit-Lowering Maneuvers

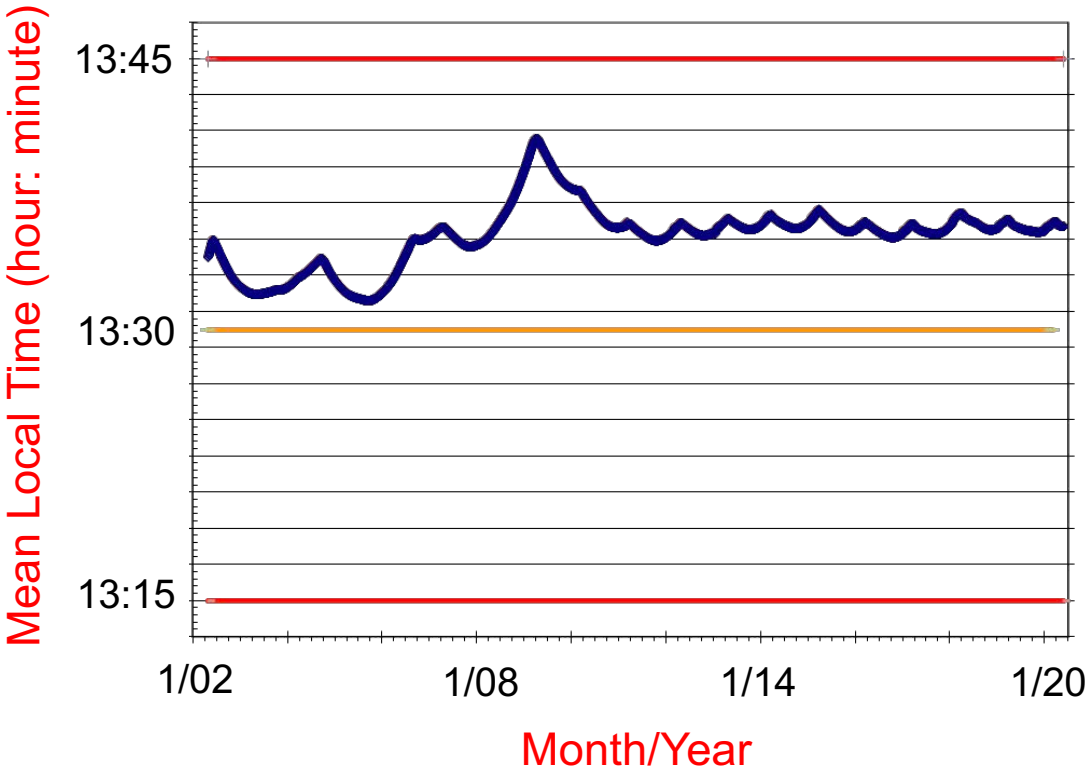
Anticipated Aqua Altitude during 2022



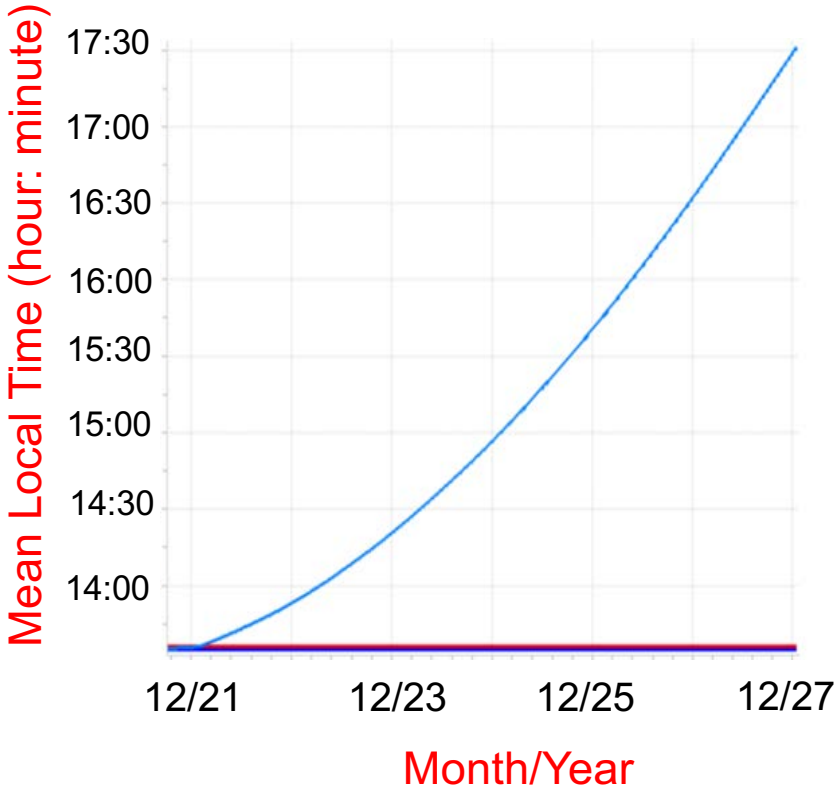
CEM = Constellation Exit Maneuver
PLM = Perigee Lowering Maneuver

Aqua's Mean Local Time (MLT) at the Northward Equatorial Crossing (Ascending Node)

Historical MLT



Predicted MLT

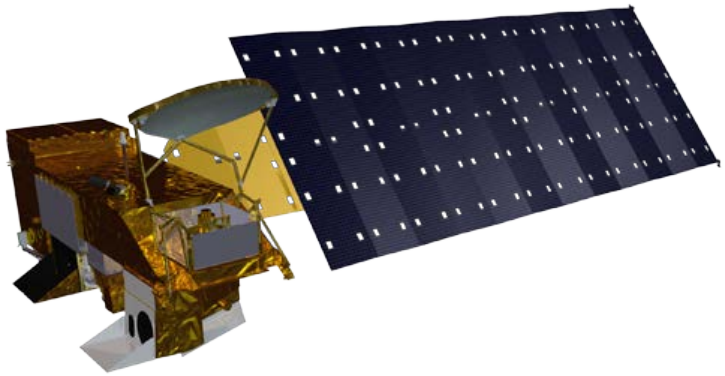


Red lines bound the mission MLT requirements: 13:30 ± 15 minutes

After-the-A-Train Opportunities

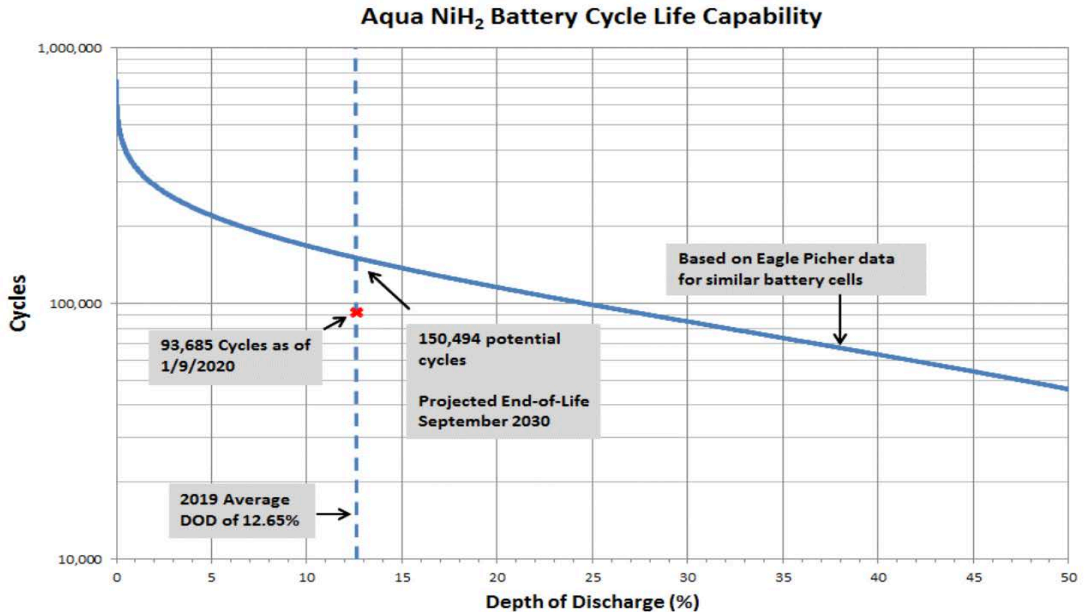
- AIRS opportunities
  - Will allow weather prediction centers to assess the impact of infrared (IR) sounders on forecast quality at local times different from current operational IR sounders.
  - Will provide time-of-day information of value in designing new missions.
  - Will result in Aqua measurements in many locations being much closer to the peak time of convection and severe storms, likely improving thunderstorm forecasts and helping to answer key science questions related to convection and storms.
  - Will enhance understanding of diurnal cycles of atmospheric and surface phenomena.
  - Will allow weather and climate model evaluations at different times of day.
- CERES opportunities
  - Will enable continued intercalibration of Aqua, Suomi NPP, and NOAA-20 CERES data, as well as possible overlap with CLARREO.
  - Will enable, when combined with Suomi NPP and NOAA-20 data, highly accurate corrections for orbital drift in the historical record dating back 40 years.
  - Will provide an opportunity to evaluate the diurnal cycle of surface fluxes currently estimated using geostationary imagers.
- MODIS opportunities
  - Will enable examination of: (1) diurnal variations in land surface temperature; (2) fire occurrence and burn scars in mid and late afternoon; (3) solar zenith angle impacts on land and ocean data products.

Status of the Spacecraft Bus, Solar Array, and Battery



- Aqua Bus
  - Overall status – Excellent.
  - All components remain on primary hardware.
  - One of four thrusters has degraded performance.
- Aqua Solar Array
  - 113 of the 132 strings of solar cells continue to operate.
  - The solar array could likely operate at least until early 2028 if Aqua were to remain in its A-Train orbit.
  - Aqua's anticipated exit from the A-Train in early 2022 will likely bring the effective performance of the solar array to an end in September 2025.
- Aqua Battery
  - All 24 cells of the main Aqua battery remain fully operational.
  - The battery could potentially last 150,494 (or more) Earth orbits, until September 2030.

(plot based on data from Eagle Picher, the battery's manufacturer)



Concluding Summary

- Aqua continues to collect valuable data from AIRS, AMSU, MODIS, and CERES.
- Thousands of people directly use the Aqua data, and millions benefit from the data.
- Fuel limitations will likely lead to Aqua's exiting the A-Train in early 2022.
- After its A-Train exit, Aqua could continue to collect valuable science data, at a lower altitude, drifting with later equatorial crossing times, for several additional years.
- The spacecraft will be passivated when the data are no longer valuable, likely in late 2025, unless budget, fuel, or technical considerations lead to earlier passivation.

Aqua pre-launch (courtesy of Northrop Grumman)

References

- Franz, B. A., I. Cetinic, E. M. Karaköylü, D.A. Siegel, and T. K. Westberry, 2019: Global ocean phytoplankton, *Bulletin of the American Meteorological Society*, 100, S92-S93.
- Susskind, J., G. A. Schmidt, J. N. Lee, and L. Iredell, 2019: Recent global warming as confirmed by AIRS, *Environmental Research Letters*, 14 (4), 044030, https://doi.org/10.1088/1748-9326/aafd4e.
- Zou, M., X. Xiong, Z. Wu, S. Li, Y. Zhang, and L. Chen, 2019: Increase of atmospheric methane observed from space-borne and ground-based measurements, *Remote Sensing*, 11, 964, doi:10.3390/rs11080964.