A Lunar Eclipse Observed With AMSU-B and its Relevance for Calibration

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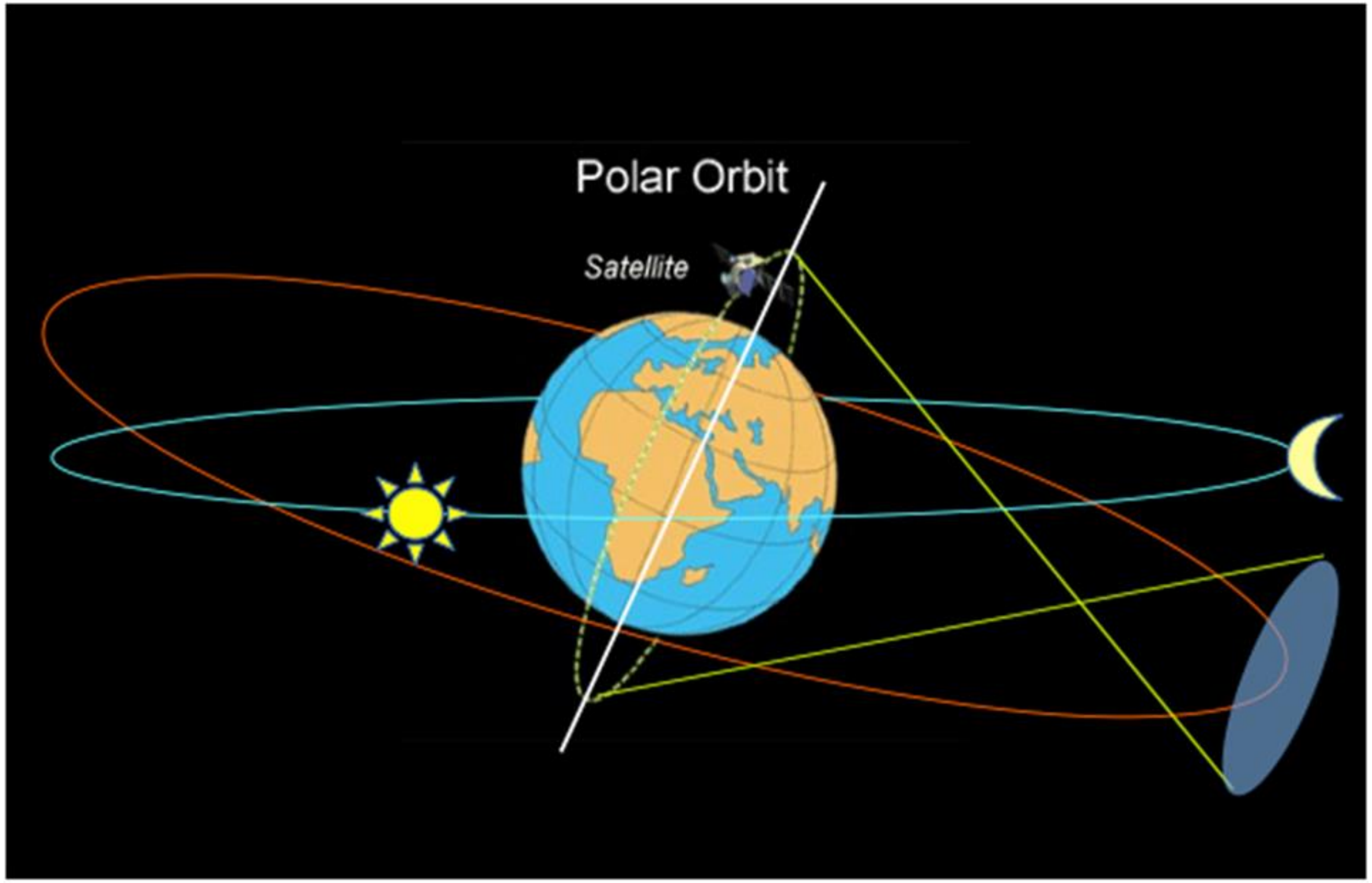
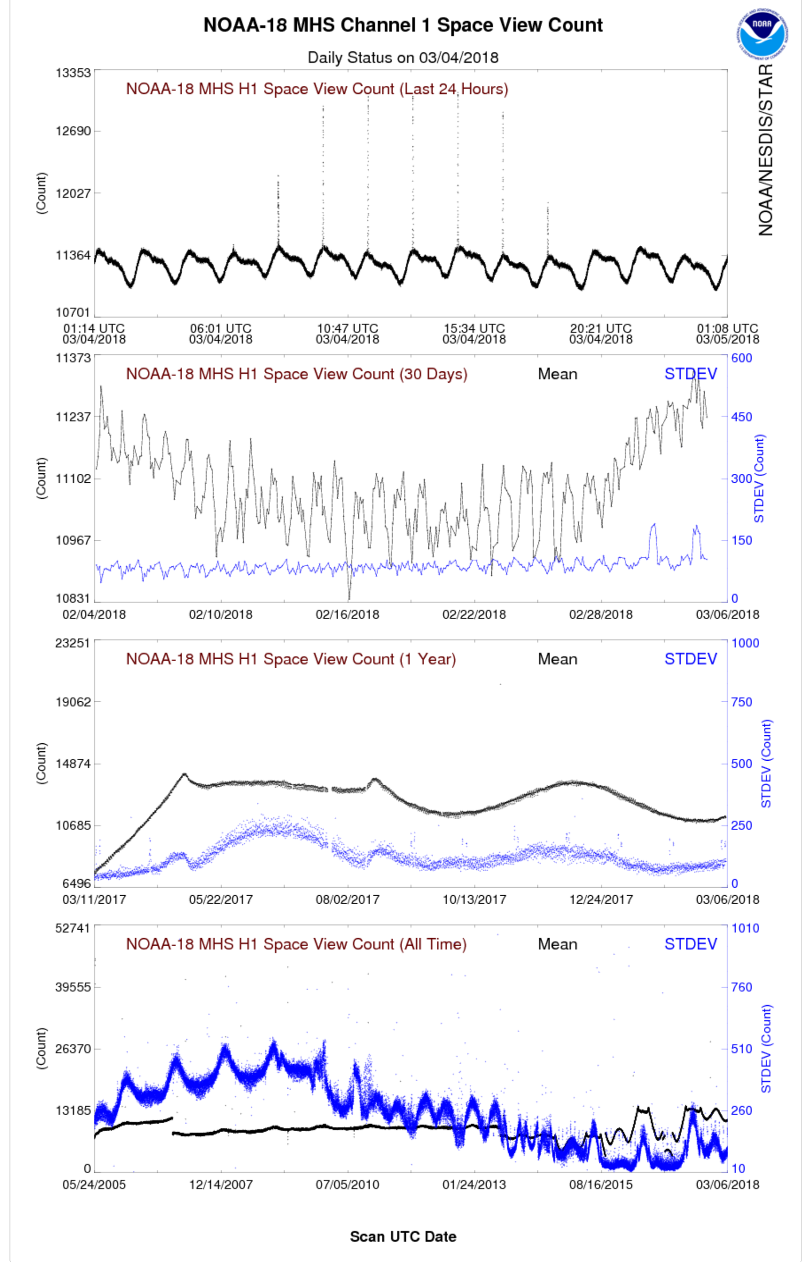
Observing the Moon with the Advanced Microwave Sounding Unit – B on NOAA-15

- Five channels:
  89 GHz
  150 GHz
  183±1 GHz
  183±3 GHz
  183±7 GHz
- Polar orbit has period of 100 min
- DSV close to celestial equator => sometimes ☽ fully included in FOV.



Observations of the Moon With AMSU-B and MHS – Calibration Issues?

- Microwave Humidity Sounder replaced AMSU-B
- Find anomalies in Space View Count with STAR ICVS
- Use Level 1b Data Set
- Remove Count level without Moon in the FOV
- Calculate gain
- Calculate ratio between diameter of Moon and FWHM
- Simplest case: Moon is in center of FOV



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Oct 28, 2004, 4:34, Partial Lunar Eclipse

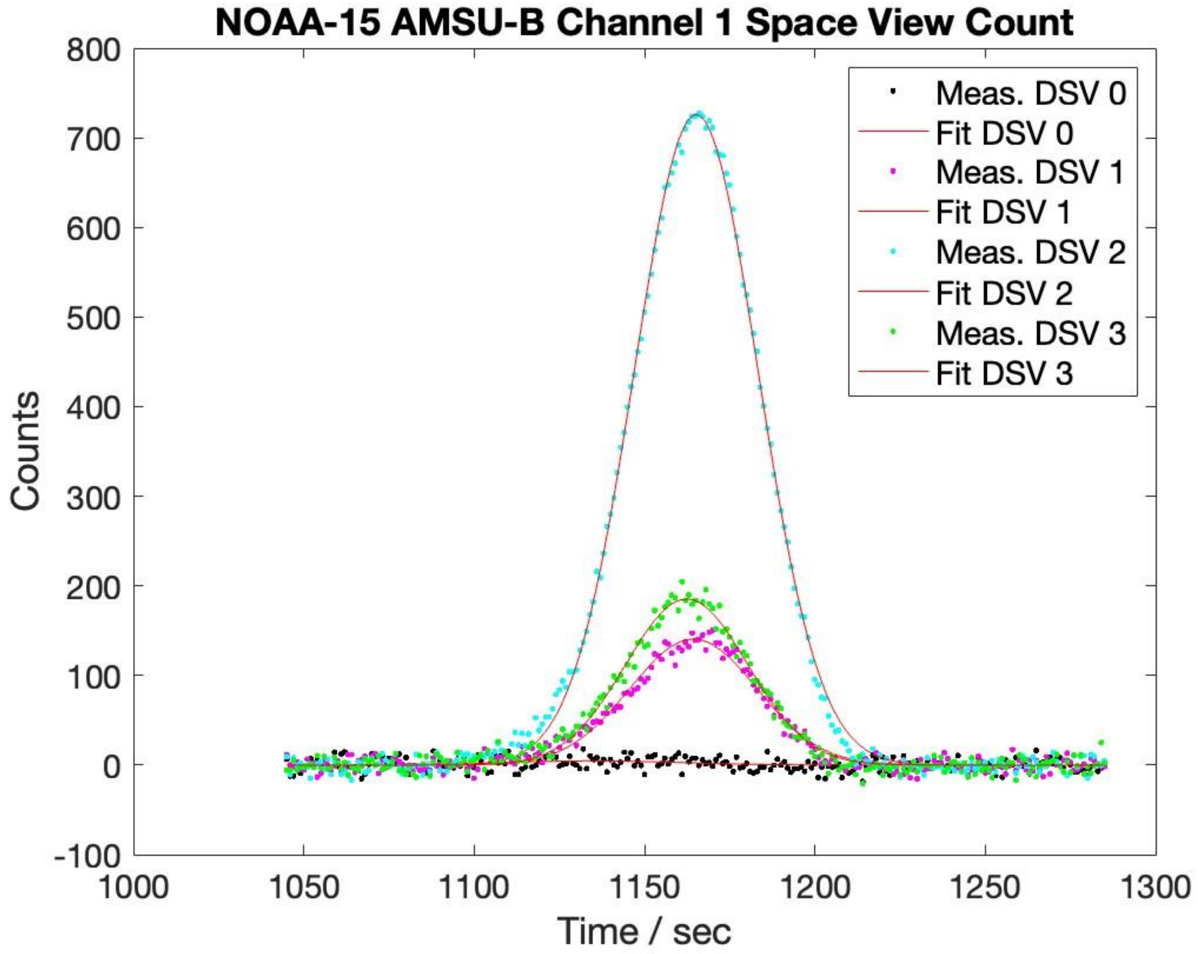
Position of the Moon Relative to Pointing of Deep Space View

- In the cross-scan direction: From max of “light” curve
- In scan direction: From Gaussian fit to different DSVs
- Distance between DSVs

AMSU-B: 0.89°/1.02°/1.04°

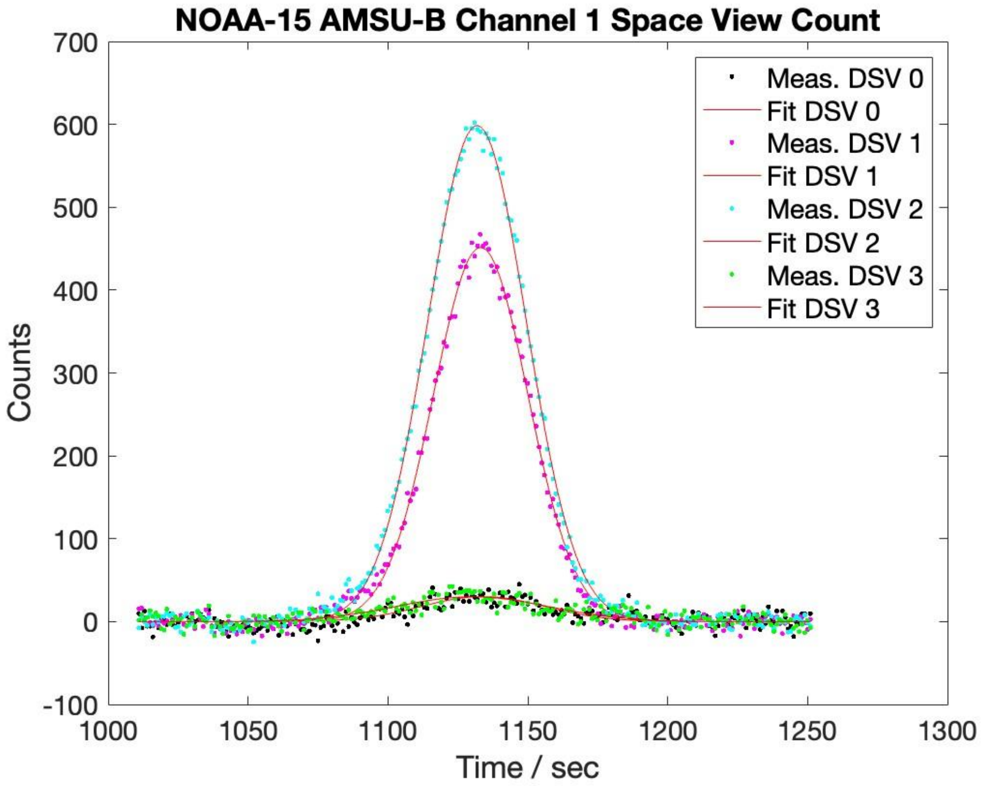
MHS: 1.02°/1.09°/1.11°

- Beamwidth and pointing offsets different in flight
- 95% confidence bounds of counts: 1.2% (89 GHz) and 1.8% (183 GHz)

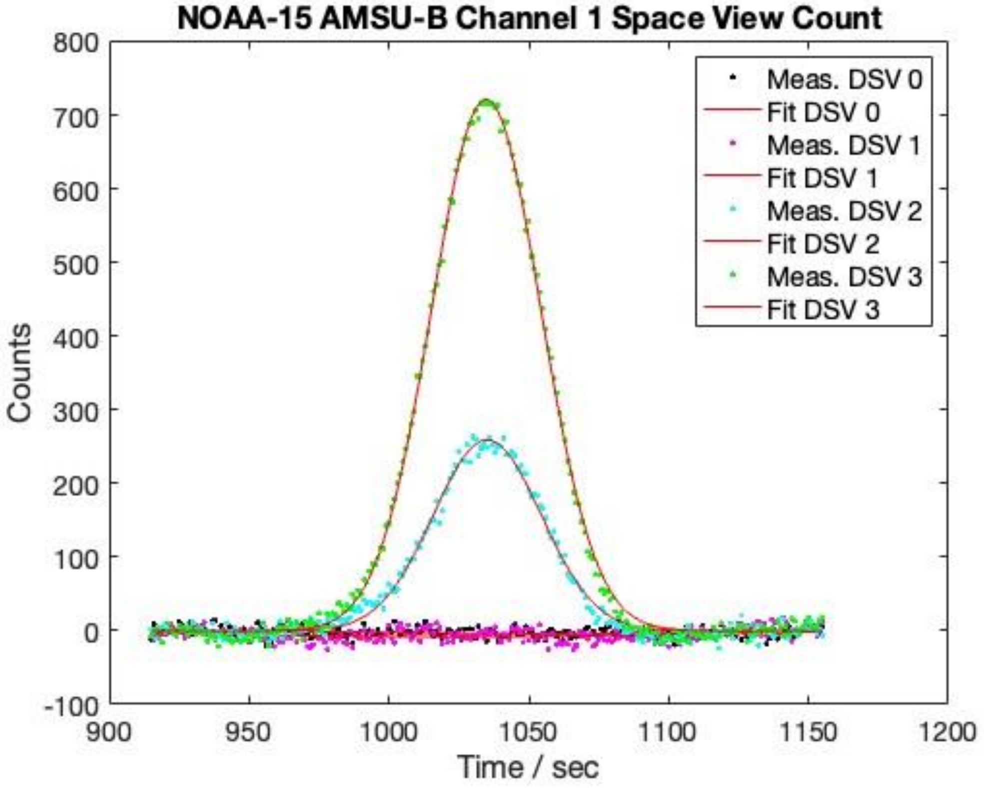


Observing Simultaneously With Four DSVs

Oct 28, 2004, 2:41 (Full Lunar Eclipse)

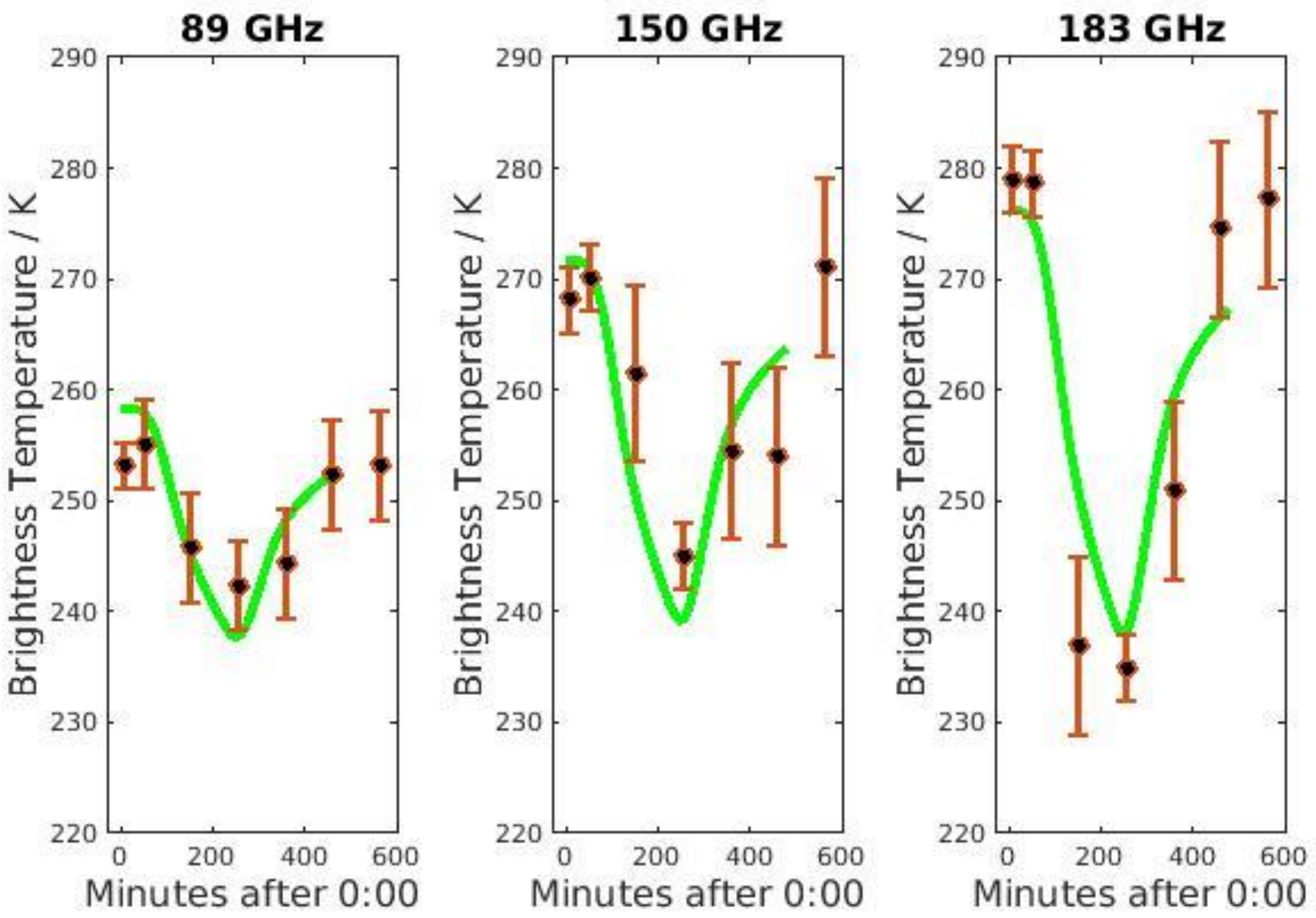


Oct 28, 2004, 6:14, After Lunar Eclipse

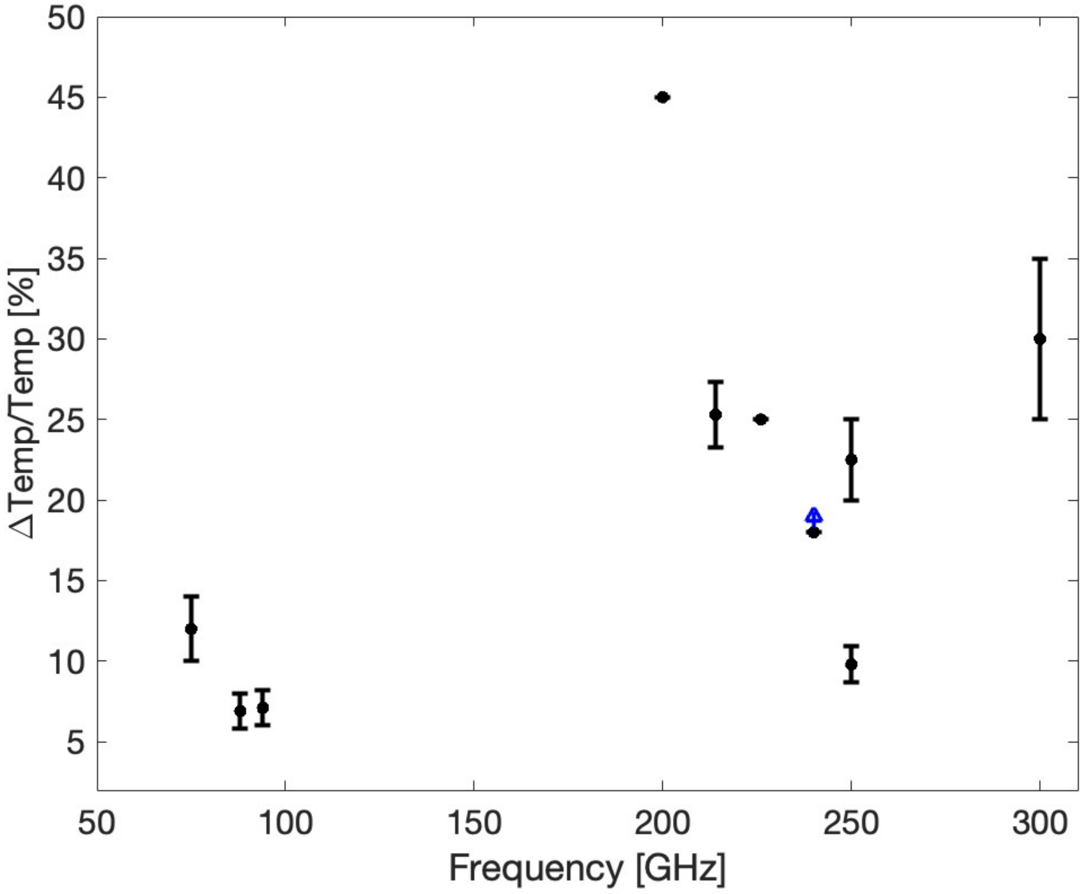


Total Lunar Eclipse on 10/28, 2004, 2:24 – 3:44 (full)

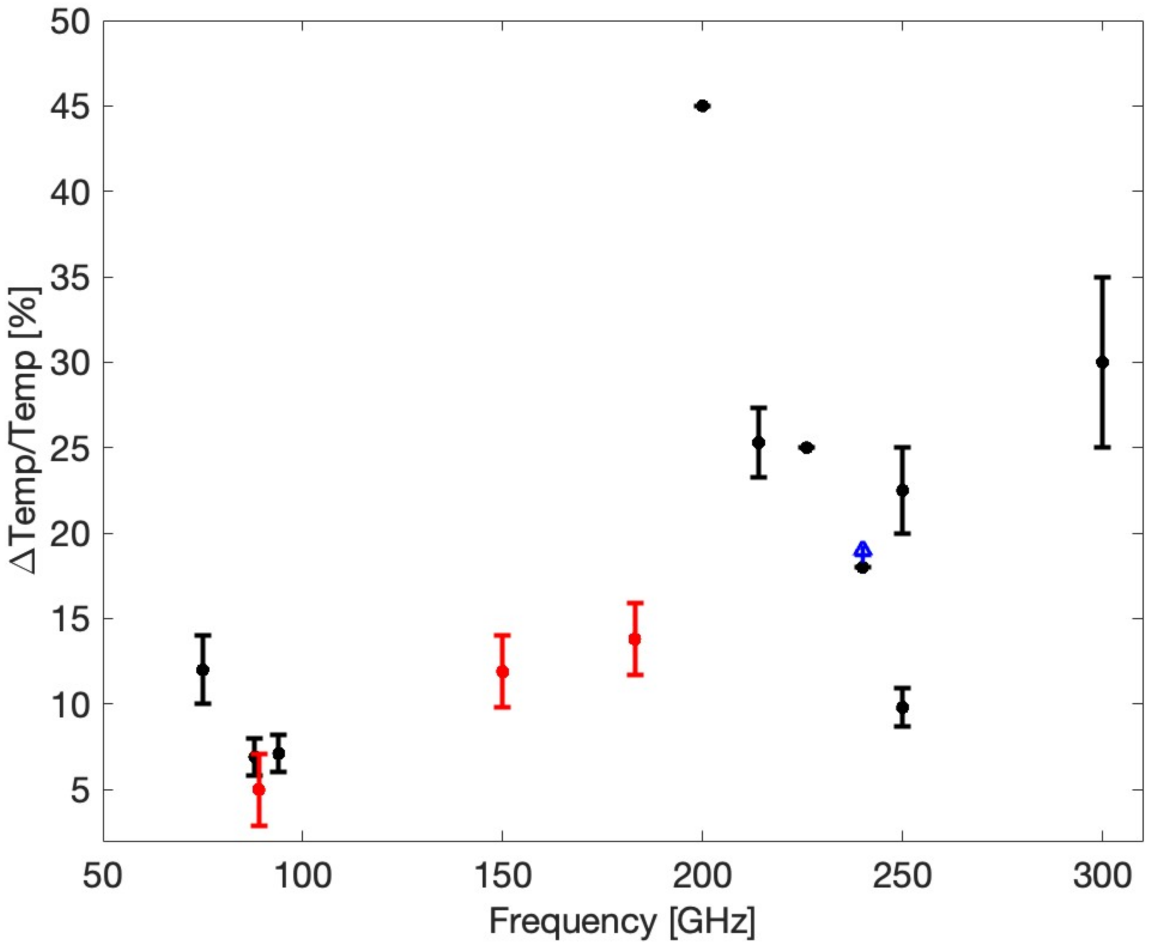
- Light curves from model by Liu & Jin (2019, green) and seven measurements
- Temperature drop increases with frequency.
- Measurements were scaled down by 5 – 9 % to match model.



Relationship Between Frequency and Temperature Drop

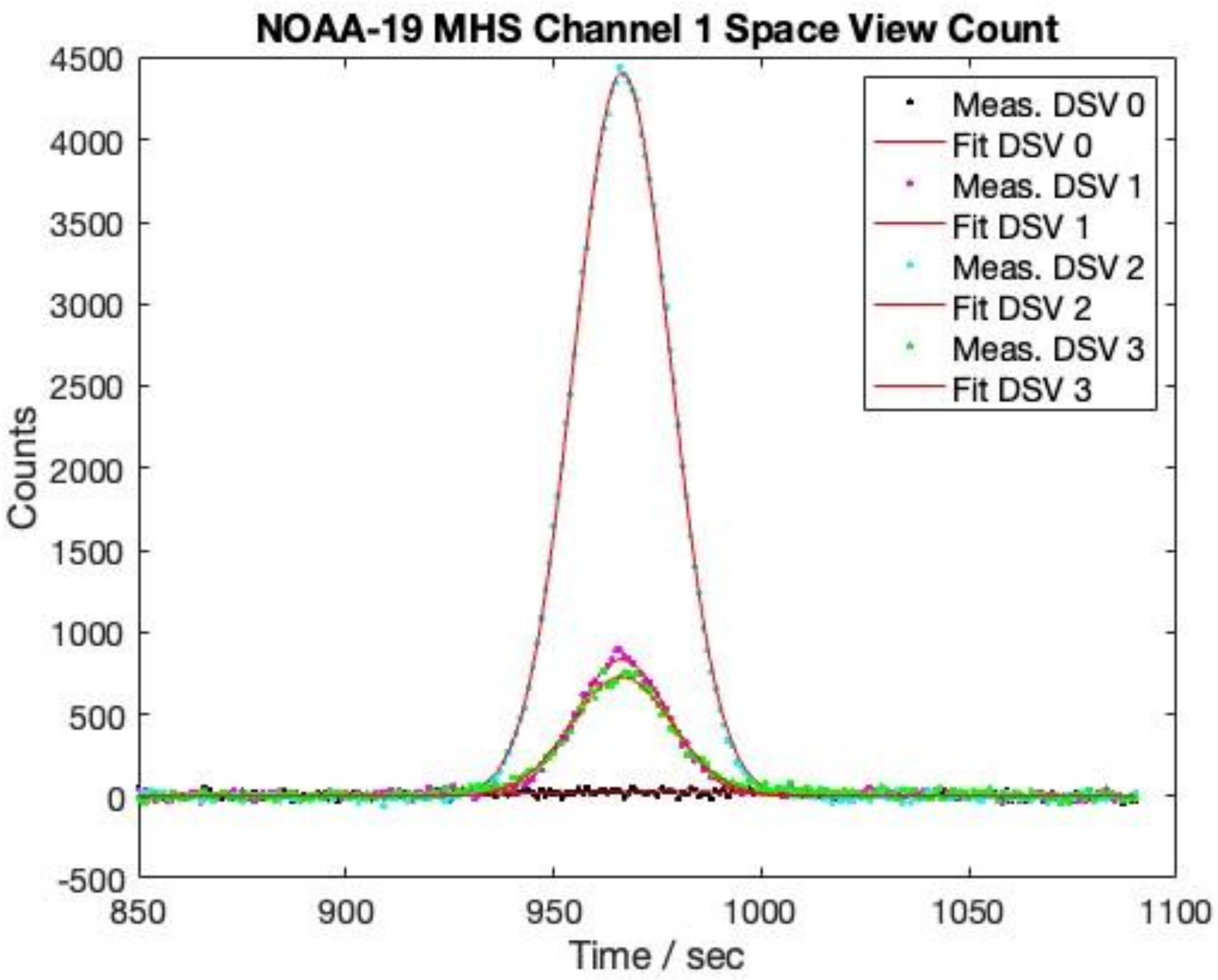


AMSU-B Provides a Clearer Picture



Precision of Measured Radiance of the Moon – AMSU-B/MHS (UTH)

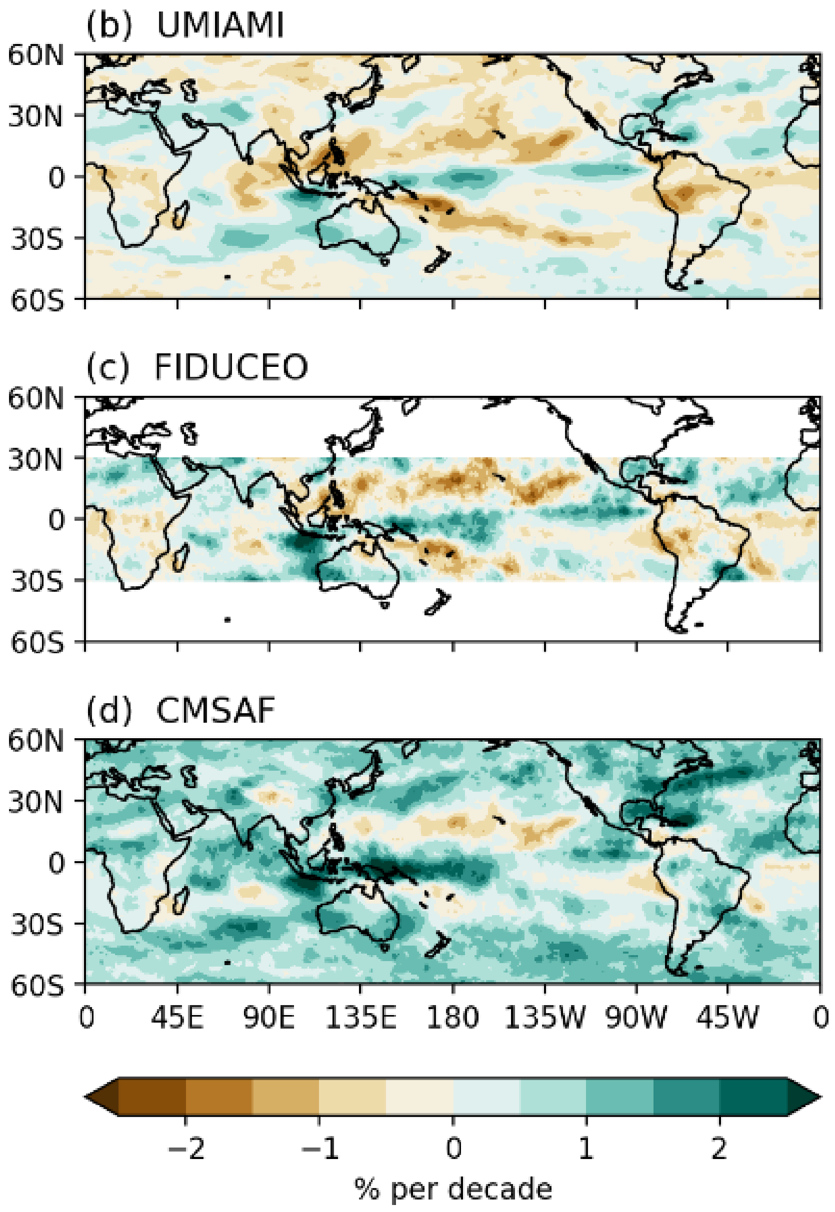
- Amplitude of Gaussian fit
- 95% confidence bounds of counts: 0.5% (89 GHz) and 2.1% (190 GHz)
- $\approx$ 6 orbits when in FoV
- twice in FoV per month
- appears in 6 month/year
- 3 AMSU-B (46 yrs) and 5 MHS (62 yrs)
- $6 \times 2 \times 6 \times 108 \approx 8000$
- Compare to model radiance
- $\Delta m \approx 0.1\text{K/decade}$



Mar 18, 2022

Change rates of UTH datasets 1999 - 2017

- UMIAMI: AMSU-B and MHS (Chung et al., 2013)
- FIDUCEO: SSM/T-2, AMSU-B, MHS, new def. of UTH (Lang et al., 2020)
- CMSAF: AMSU-B and MHS with bias correction (John et al., 2013)
- CMSAF UTH is about 30% and differs by >1.6%/decade
- This corresponds to >0.5K in T_b
- Reason: bias between satellites (Shi et al., 2022)?



Shi et al. (2022)

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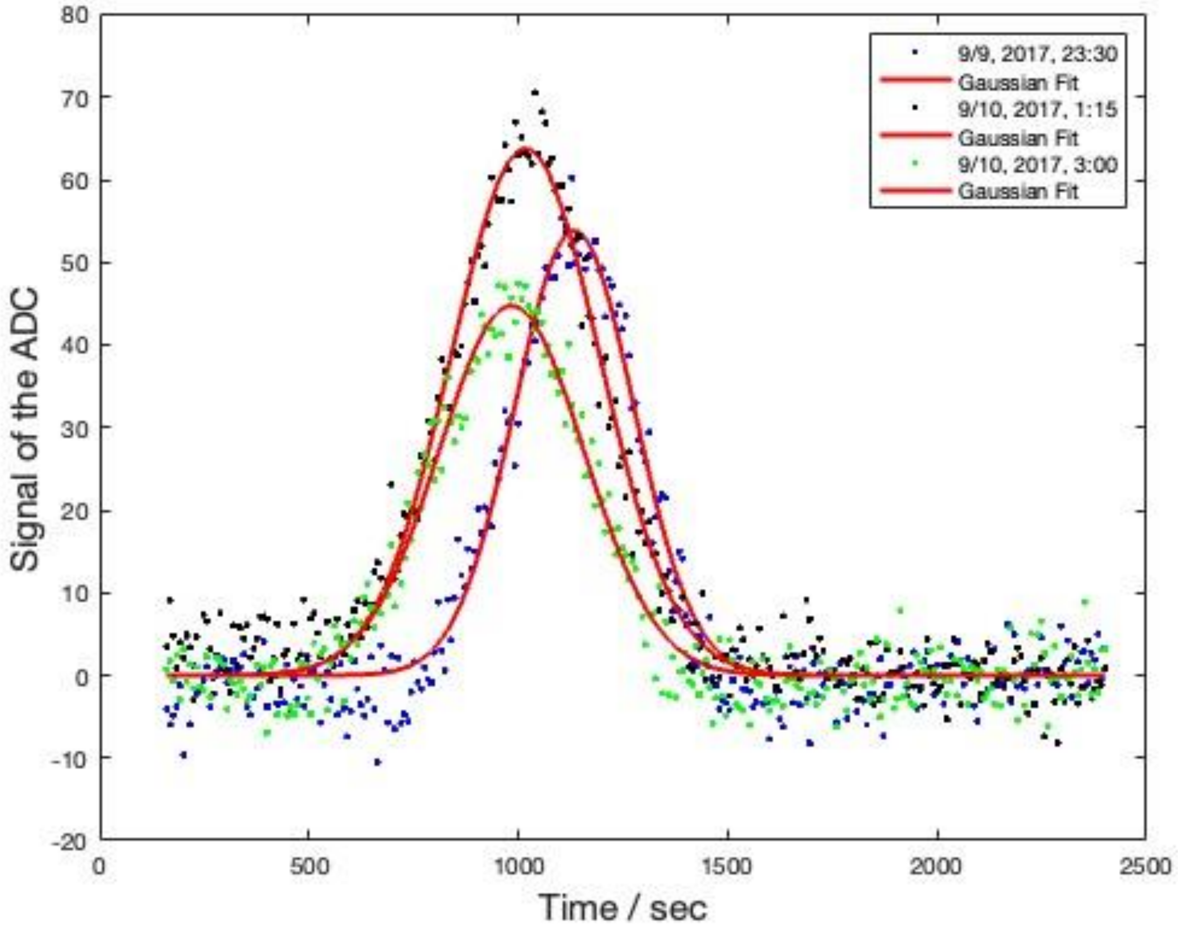
Precision of Measured Radiance of the Moon – AMSU-A (Troposph. Temp.)

- AMSU-A(B) has 1(4) DSVs
- AMSU-A(B) FOV has 3°(1.1°)
- AMSU-A(B) scan is 8(8/3)sec
- AMSU-A(B) DSV is 83.3° (77.5° – 80.5°) away from nadir
- stays 20× longer in FOV
- 9 AMSU-A (>130 yrs)
- Moon scene radiance low ⟹

Offset change has large impact on calculated radiance

- Offset changes are present (Zou & Wang, 2011)

The Moon on Sep 10, 2017, with AMSU-A at 31.4 GHz



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Summary

- Need accurate model *and* precise measurements of lunar radiance
- Precision of radiance of the Moon: 0.5% (MHS) – 1% (AMSU-B), 95% confidence bounds (worse for channel H2/17)
- Comparable to accuracy achieved with astronomical radio telescopes
- Essential: exact distance between DSV and Moon position, get it from light curve and different DSVs/observing times
- Characteristics from ground tests unreliable $\Longrightarrow$ determine diameter(FOV), pointing accuracy, etc. in flight (with Moon)
- Good agreement between measurements and model radiances suggests: Moon is a suitable calibration standard