AWS Lunar Pointing Calculation

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AWS Channel Frequency Specification

Table 5 AWS frequency band plan (specification)

Channel	Receiver	RF center [GHz]	IF center [MHz]	Bandwidth [MHz]
AWS-11	54GHz	50.3	2300	180
AWS-12	54GHz	52.8	4800	400
AWS-13	54GHz	53.246	5246	300
AWS-14	54GHz	53.596	5596	370
AWS-15	54GHz	54.4	6400	400
AWS-16	54GHz	54.94	6940	400
AWS-17	54GHz	55.5	7500	330
AWS-18	54GHz	57.290344	9290.344	330
AWS-21	89GHz	89	No IF	4000
AWS-31	183GHz	165.5	2924	2800
AWS-32	183GHz	176.311	13735	2000
AWS-33	183GHz	178.811	16235	2000
AWS-34	183GHz	180.311	17735	1000
AWS-35	183GHz	181.511	18935	1000
AWS-36	183GHz	182.311	19735	500
AWS-41	325GHz	325.15 ± 1.20	1200	800
AWS-42	325GHz	325.15 ± 2.40	2400	1200
AWS-43	325GHz	325.15 ± 4.10	4100	1800
AWS-44	325GHz	325.15 ± 6.60	6600	2800

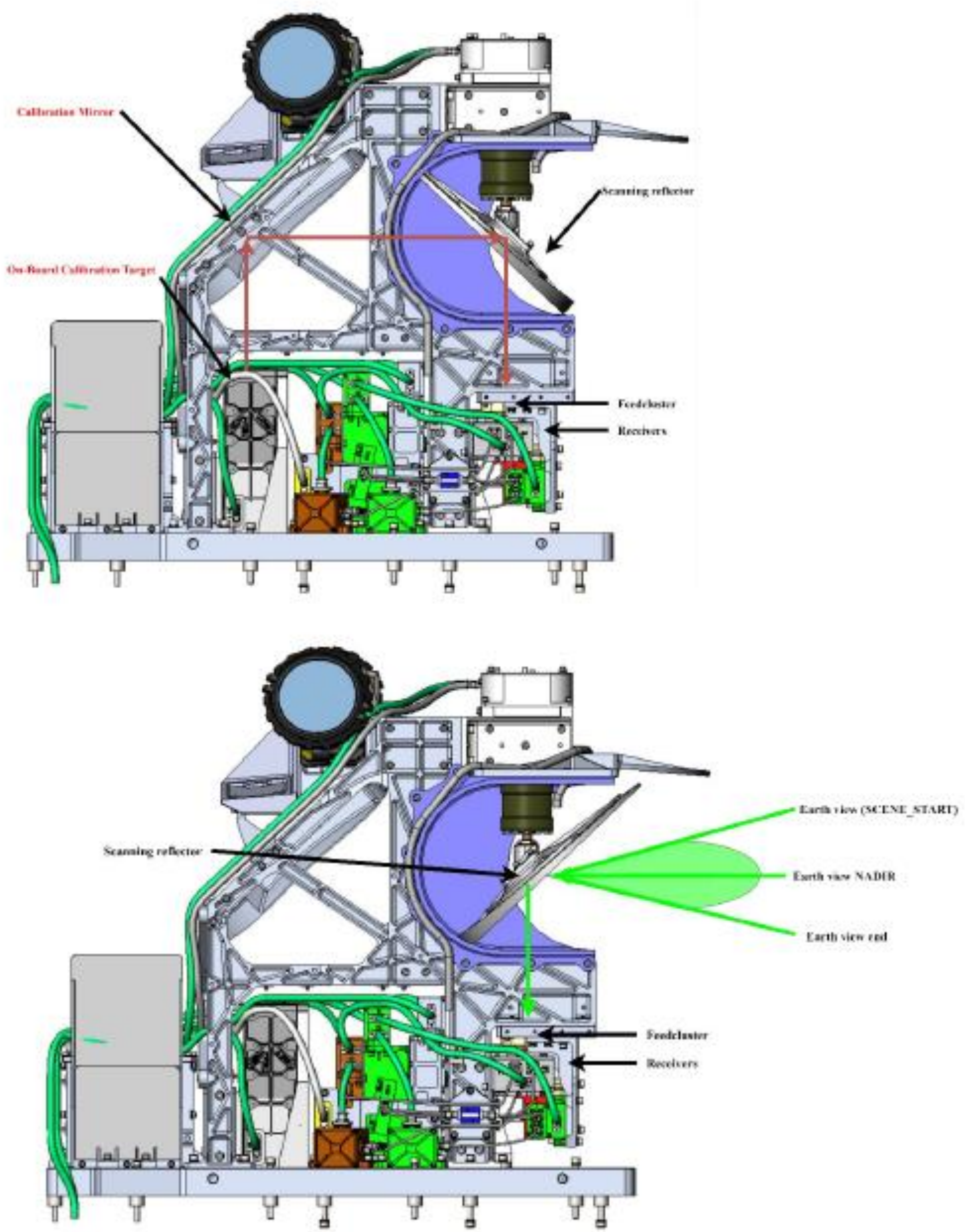


Figure 2 AWS PFM instrument payload overview rendering (Side view). The top image shows the AWS instrument with the rotating reflector oriented to the On-Board Calibration Target, with arrows indicating the beams path in the quasi-optical system. The bottom image shows the instrument with the rotating reflector oriented to the Earth / Scene view

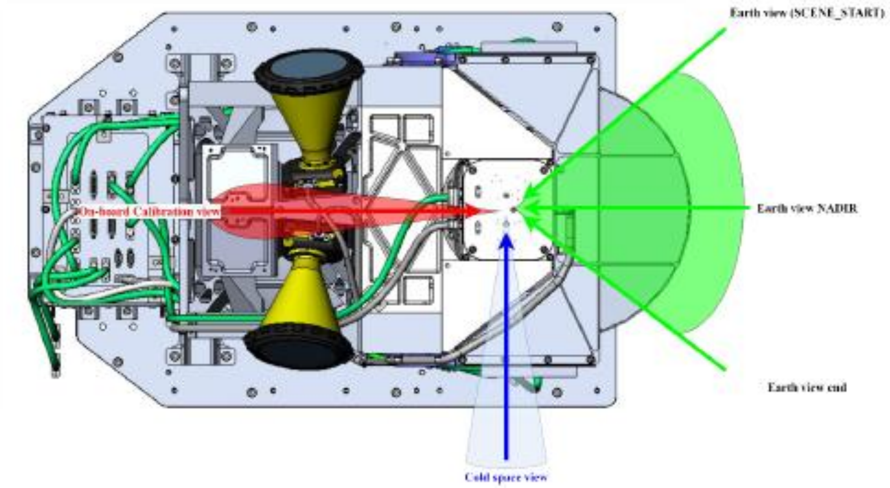


Figure 3 AWS PFM instrument payload overview rendering (Top view)

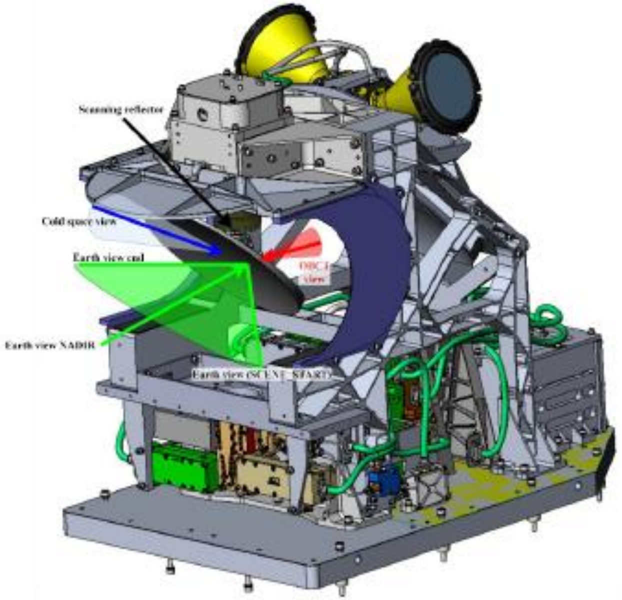


Figure 4 AWS instrument payload overview rendering (Isometric)

AWS Scan Geometry and Cold-Space Pointing Vector Calculation

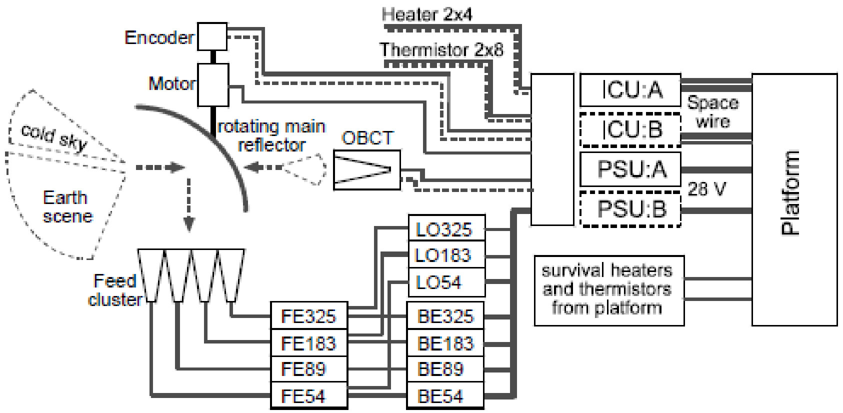


Figure 5 AWS Instrument payload electrical block diagram

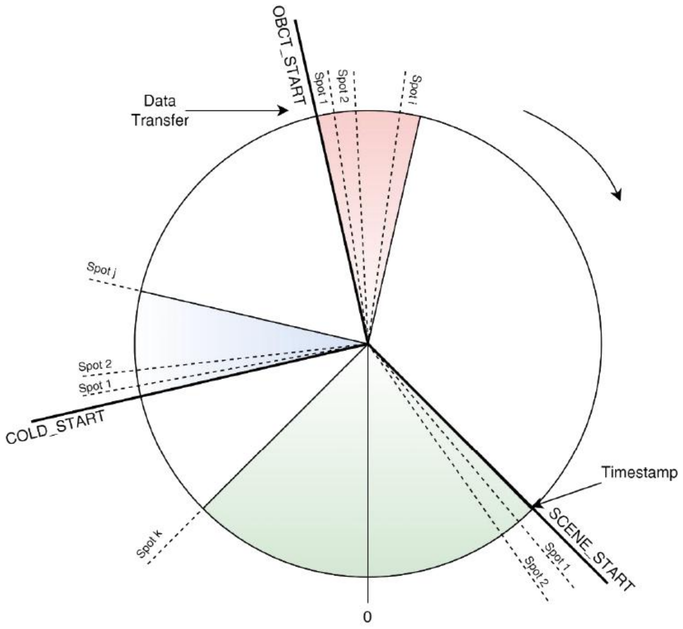


Figure 12 AWS Instrument payload measurement cycle. The instrument measures i samples of the OBCT reference load, j samples of the cold sky reference and k samples of the sky/scene directions

AWS will be a cross-track scanning instrument with channels around 54, 89, 166, 183, and 325 GHz. A high-level description of the cross-track scanning with theta and phi offset angles is found in Figure 30. The cross-track scanning will be performed between about ±57° relative to the nadir direction, and the complete scan duration (360° rotation) will be 1.1906s. The different receivers will point in slightly different directions (~2.6°) at a given moment. The pointing direction of each receiver will rotate around the main scan direction vector along the cross-track scan, with the same angular rate as the main scan angle.

A viewing direction, in the SH reference frame, can be computed from three "scan" angles, and for a given θ, θ_i, and Ø, and this viewing direction can be obtained in the following way:

transform θ_i, and Ø to cartesian coordinates in the scan reference frame,
rotate the obtained vector around the x-axis according to θ

The effective scan pattern on geoid, or the center positions of each sample on the geoid for a complete scan of AWS, is shown in Figure 31. In Figure 31, it can clearly be seen that the relative sample positions from the channels varies across the scan. The theta and phi offsets from the PFM-development are summarized in Table 58. These variables are present in the SCDB under the variable names plcOpticsTheta and plcOpticsPhi.

Table 58 Theta and Phi offsets for the four AWS instrument receivers, taken from RD2

Channel(s)	Theta offset [degrees] (θ_i)	Phi offset [degrees] Ø, (defined at $\theta = 0$ °)
AWS-1x (54 GHz)	6.12	244.04
AWS-2x (89 GHz)	3.04	174.23
AWS-3x (183 GHz)	1.35	45.58
AWS-4x (325 GHz)	2.63	295.96

Calculation of Cold Space Scan Angle

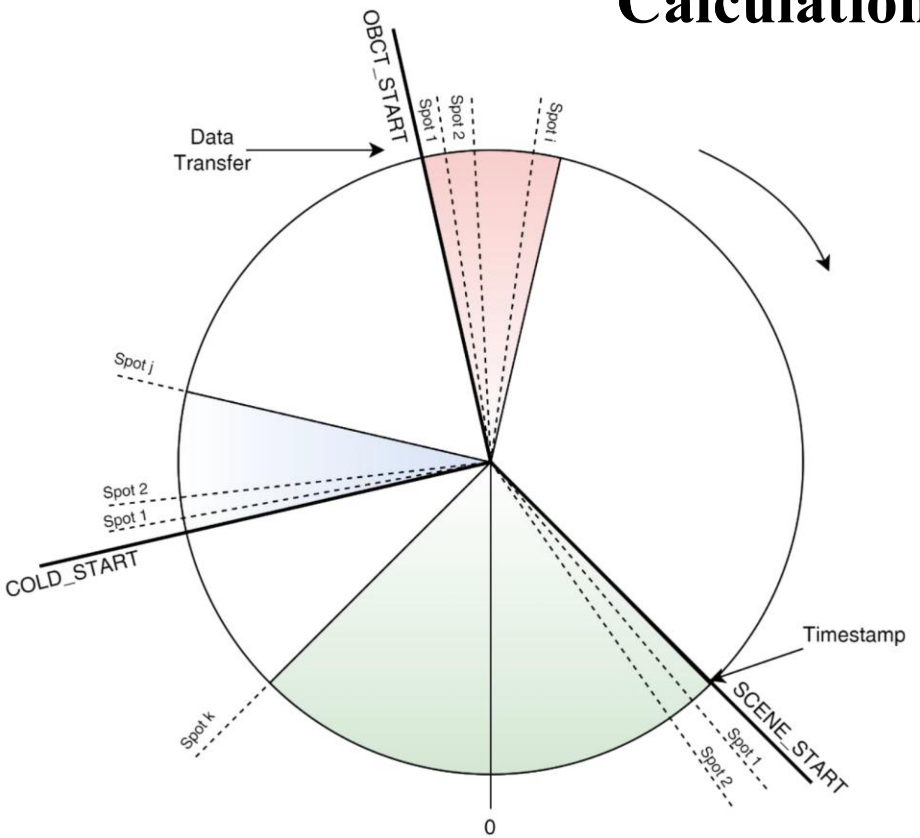


Figure 12 AWS Instrument payload measurement cycle. The instrument measures i samples of the OBCT reference load, j samples of the cold sky reference and k samples of the sky/scene directions

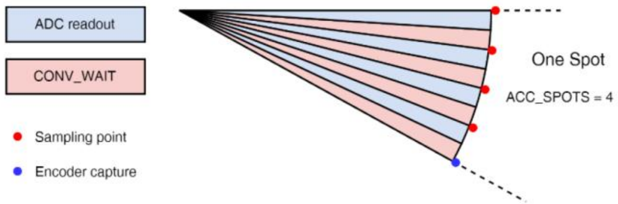


Figure 13 Illustration of AWS Spot acquisition

Angle output format: degrees relative to NADIR.

$$\theta[i] = 360\frac{MOD(ENC[i] - plcEncoderOffset, plcEncoderMax)}{plcEncoderMax}$$

Equation 3-37

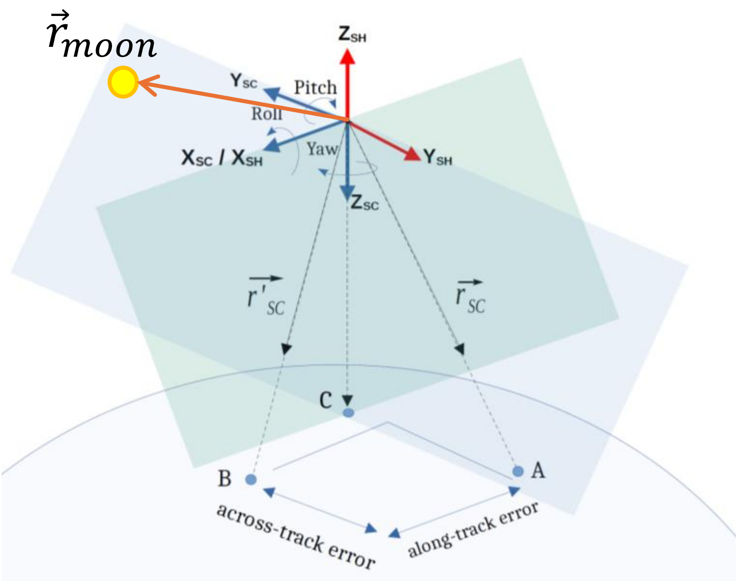
Since the angle sensor is captured at the end of each SPOT as illustrated in Figure 13, half the spot arc has to be subtracted from Equation 3-37 for the output to be aligned with the center of the spot (with a special case for the first spot which begins at SCENE_START).

$$\Delta\theta[0] = 360\frac{ENC[0] - SCENE\_START}{plcEncoderMax}$$

$$\Delta\theta[i] = 360\frac{ENC[i] - ENC[i-1]}{plcEncoderMax}$$

Equation 3-38

Calculation of Moon Angle



$$\theta_{moon} = \arccos(\vec{r}_{moon}^{\,orb} \cdot \vec{r}_{sat}^{\,orb})$$

$$G_{moon} = e^{-\frac{(\theta_{moon} - \alpha_{moon})^2}{2(0.5 * \frac{\theta_{bw}}{\sqrt{2 \ln 2}})^2}}$$

Space View Vector Calculation

$$\vec{r}_{sat}^{\,orb} = R_{sc2orb} \cdot R_{b2SH} \cdot \overrightarrow{r_b}$$

$$\vec{r}_{B,i}(t) = [\sin(\theta_i) \cdot \cos(\emptyset_i(t)) \quad sin(\theta_i) \cdot \sin(\emptyset_i(t)) \quad cos(\theta_i)]^T$$

$$\vec{r}_{SH,i}(t) = R_{SH/B}(t) \cdot \vec{r}_{B,i}(t) = R_x(-\theta(t)) \cdot \vec{r}_{B,i}(t)$$

$$R_{Orb/SC}(t) = R_z(\alpha) \cdot R_y(\beta) \cdot R_x(\gamma)$$

Moon Vector Calculation

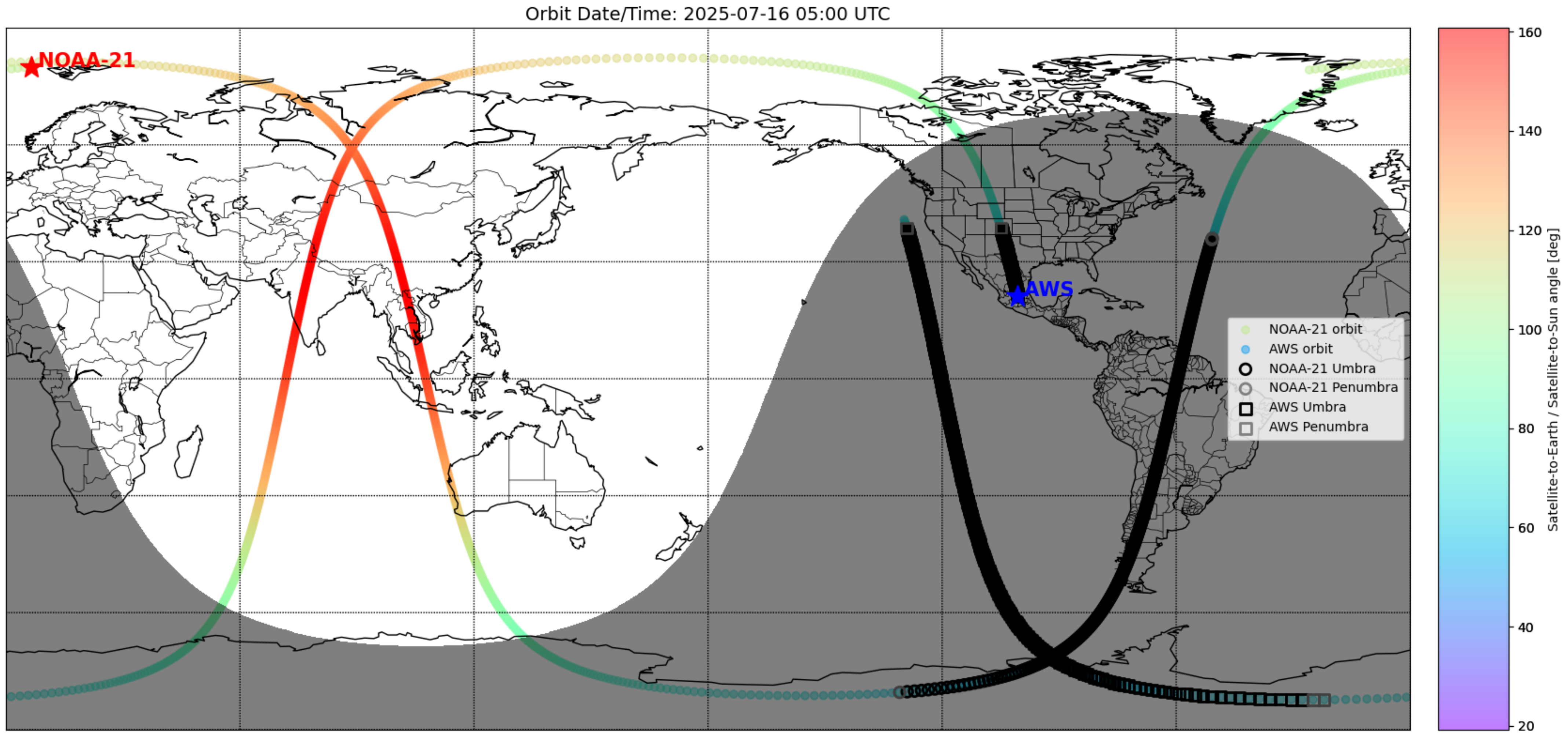
$$\vec{r}_{moon}^{\,orb} = R_{eci2orb} \times \vec{r}_{moon}^{\,eci}$$

$$R_{eci2orb} = [\vec{x}_{orb} \quad \vec{y}_{orb} \quad \vec{z}_{orb}]$$

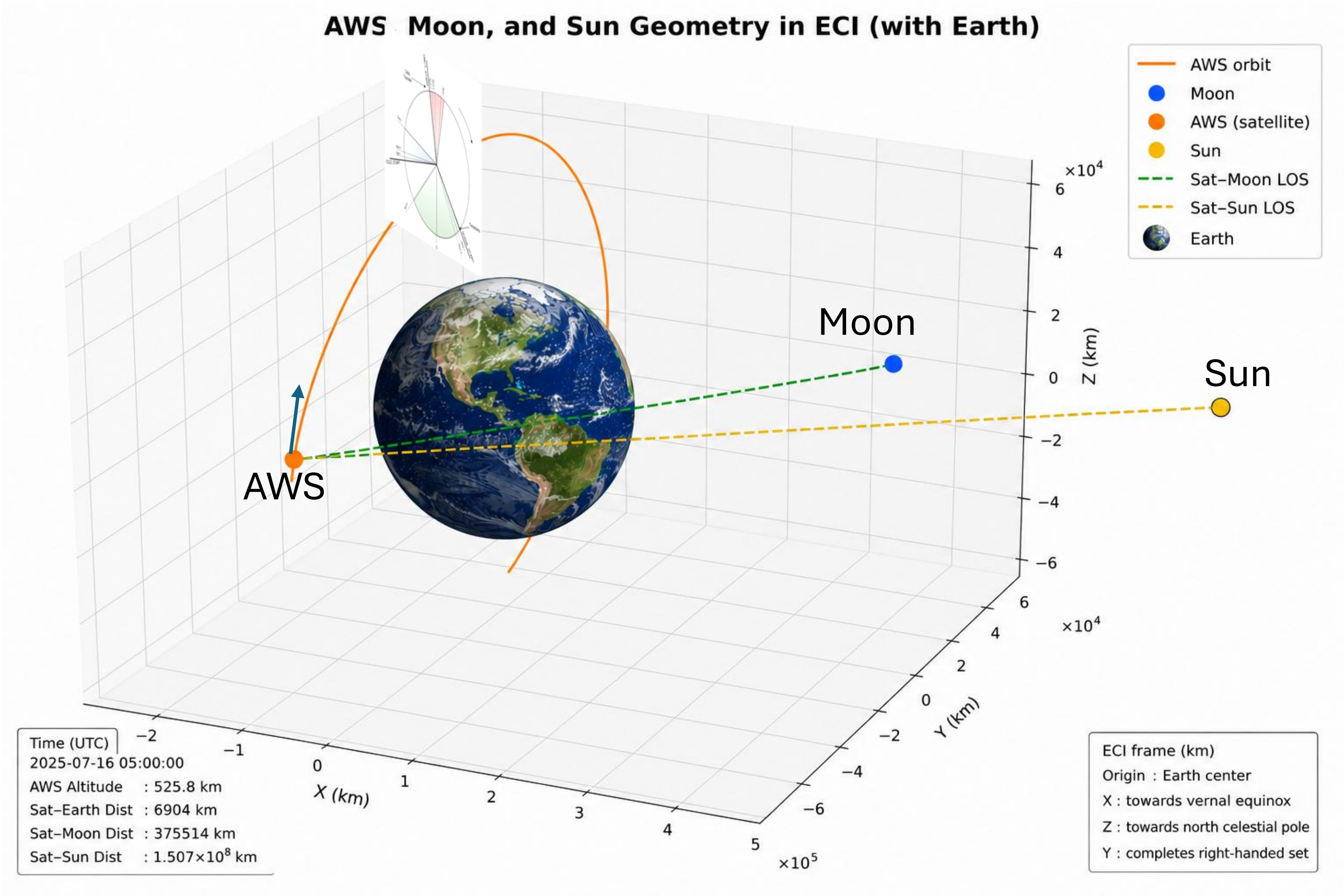
$$\vec{z}_{orb} = \vec{r}_{sat}^{\,eci} / |\vec{r}_{sat}^{\,eci}|$$

$$\vec{y}_{orb} = \frac{\vec{r}_{sat}^{\,eci} \times \vec{v}_{sat}^{\,eci}}{|\vec{y}_{orb}|}$$

$$\vec{x}_{orb} = \frac{\vec{y}_{orb} \times \vec{z}_{orb}}{|\vec{x}_{orb}|}$$

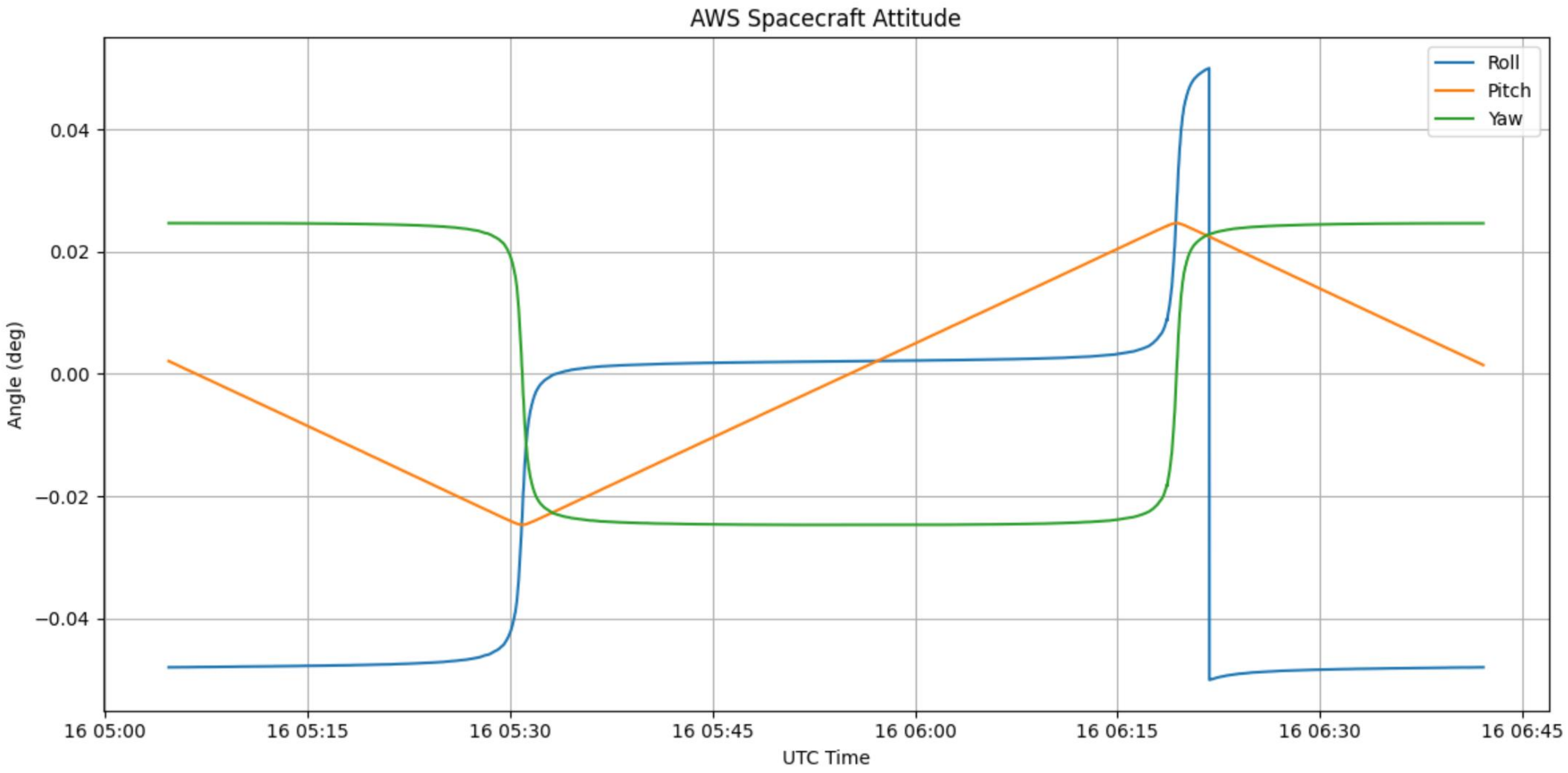

Orbit Date/Time: 2025-07-16 05:00 UTC
NOAA-21
AWS
NOAA-21 orbit
AWS orbit
NOAA-21 Umbra
NOAA-21 Penumbra
AWS Umbra
AWS Penumbra
Satellite-to-Earth / Satellite-to-Sun angle [deg]
160
140
120
100
80
60
40
20

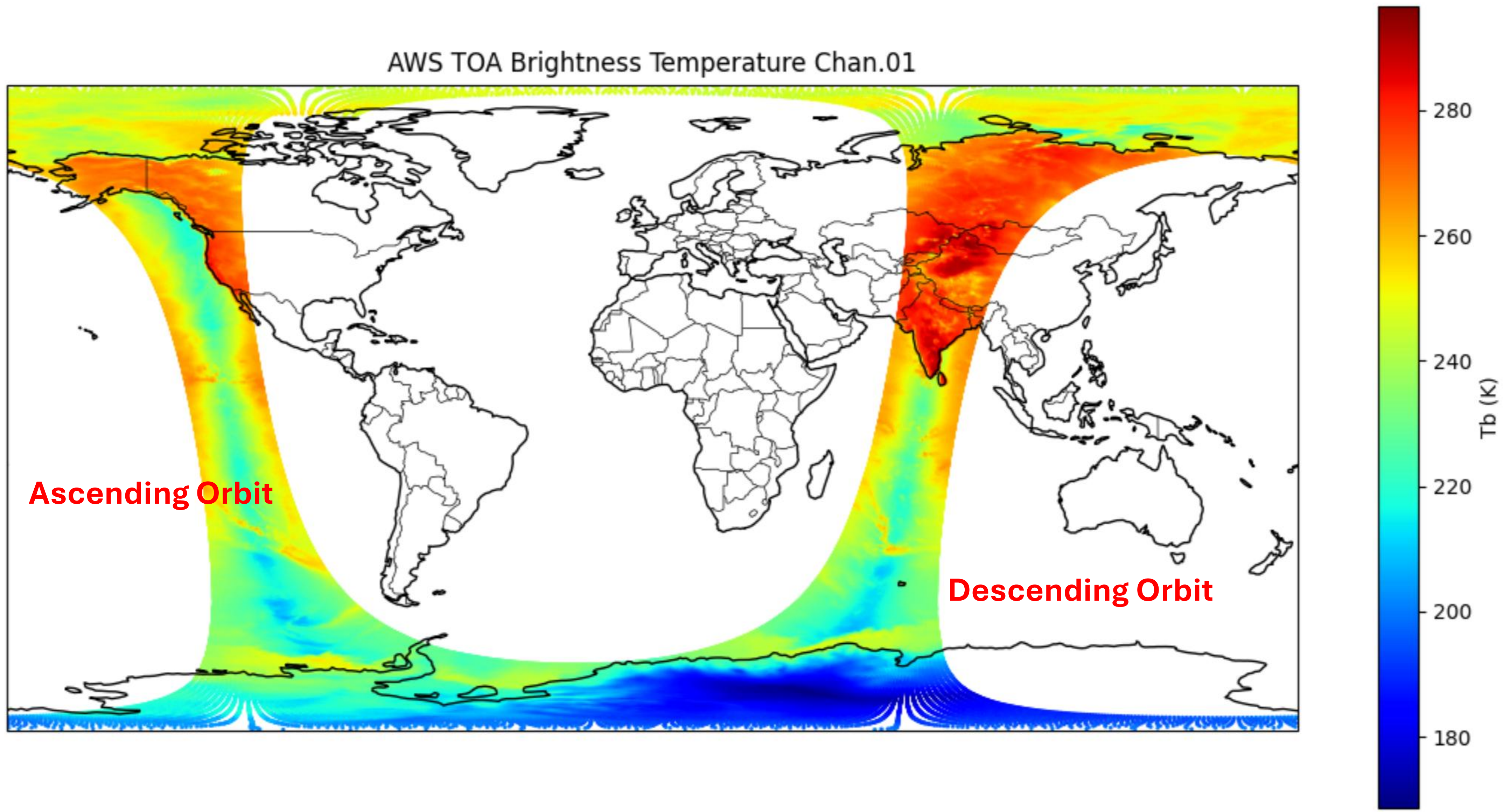
Sanity Check for Lunar Intrusion on 2025-07-16



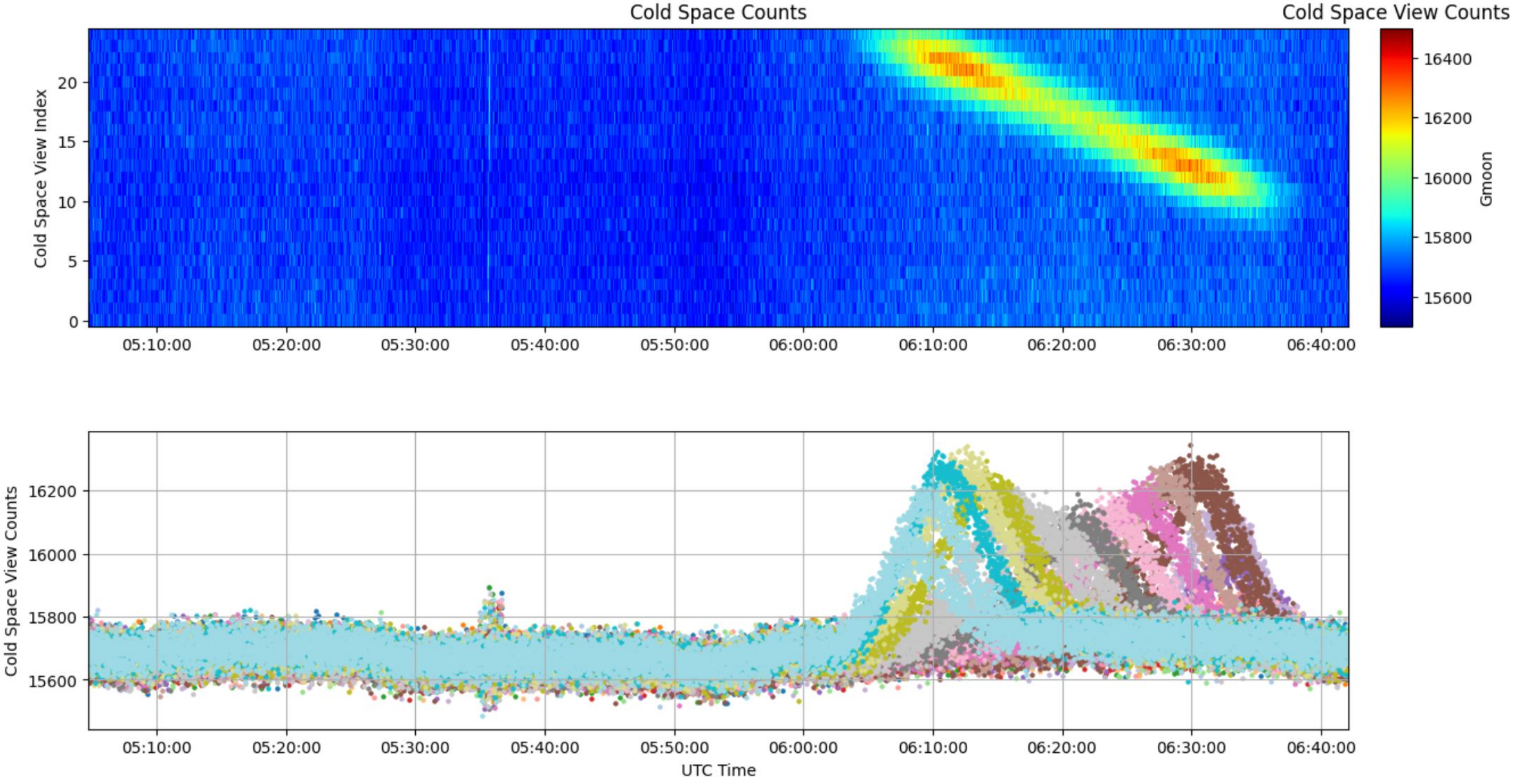
Moon phase angle (deg): 66.20
Illuminated fraction: 0.70

UTC 2025-07-16T05

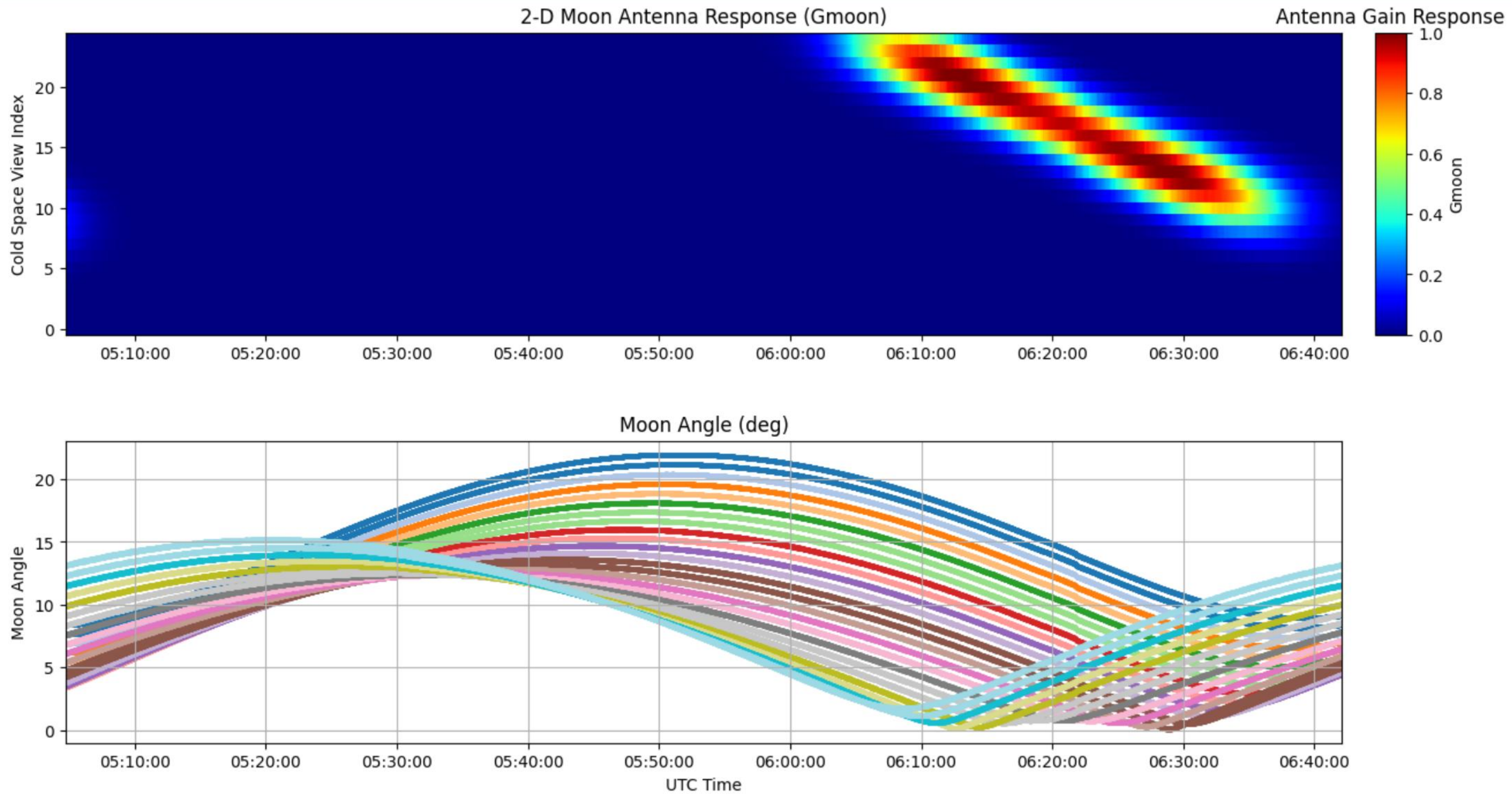



AWS TOA Brightness Temperature Chan.01
Ascending Orbit
Descending Orbit
280
260
240
220
200
180
Tb (K)

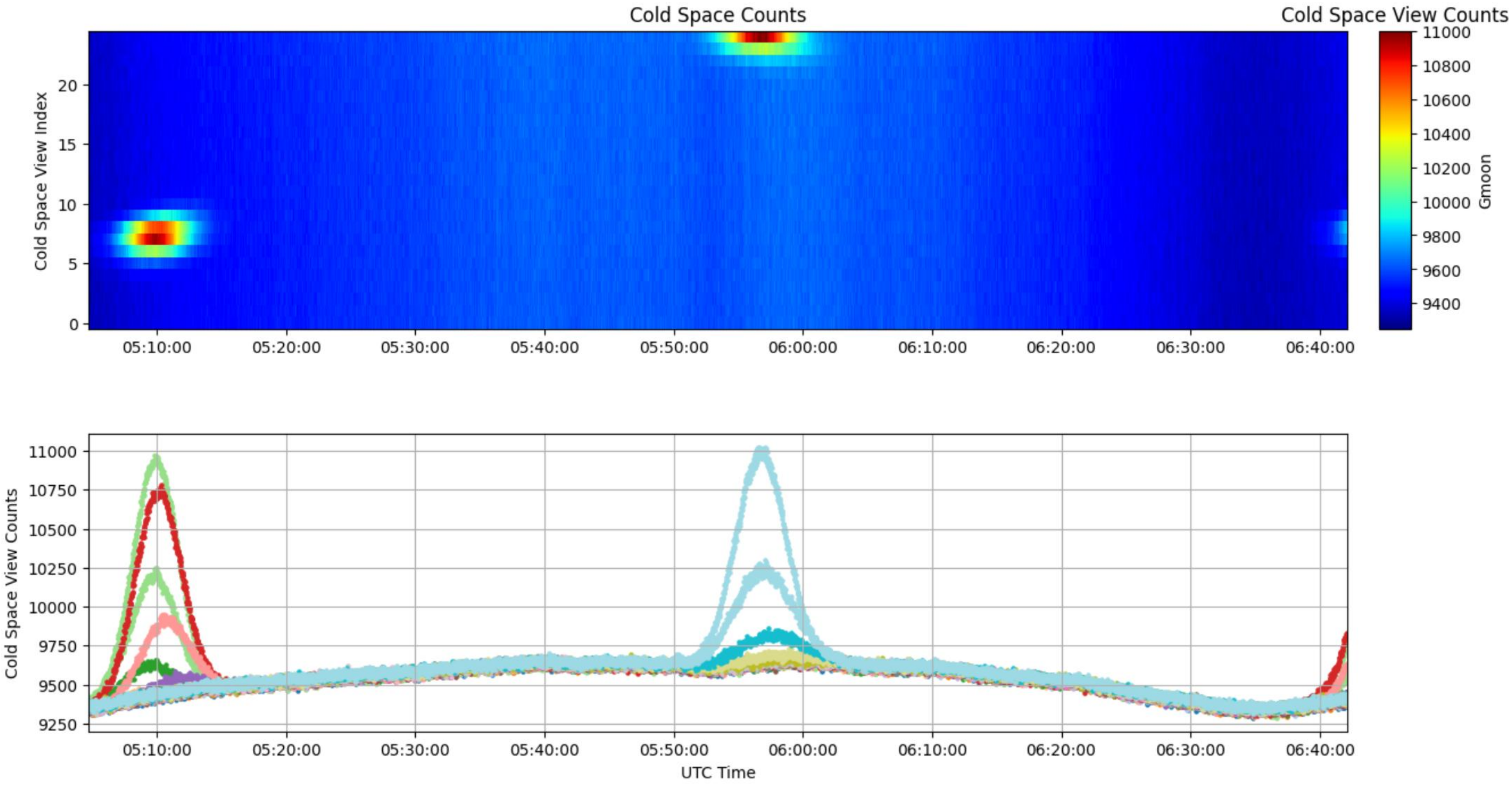
AWS Chan.01, Band 01



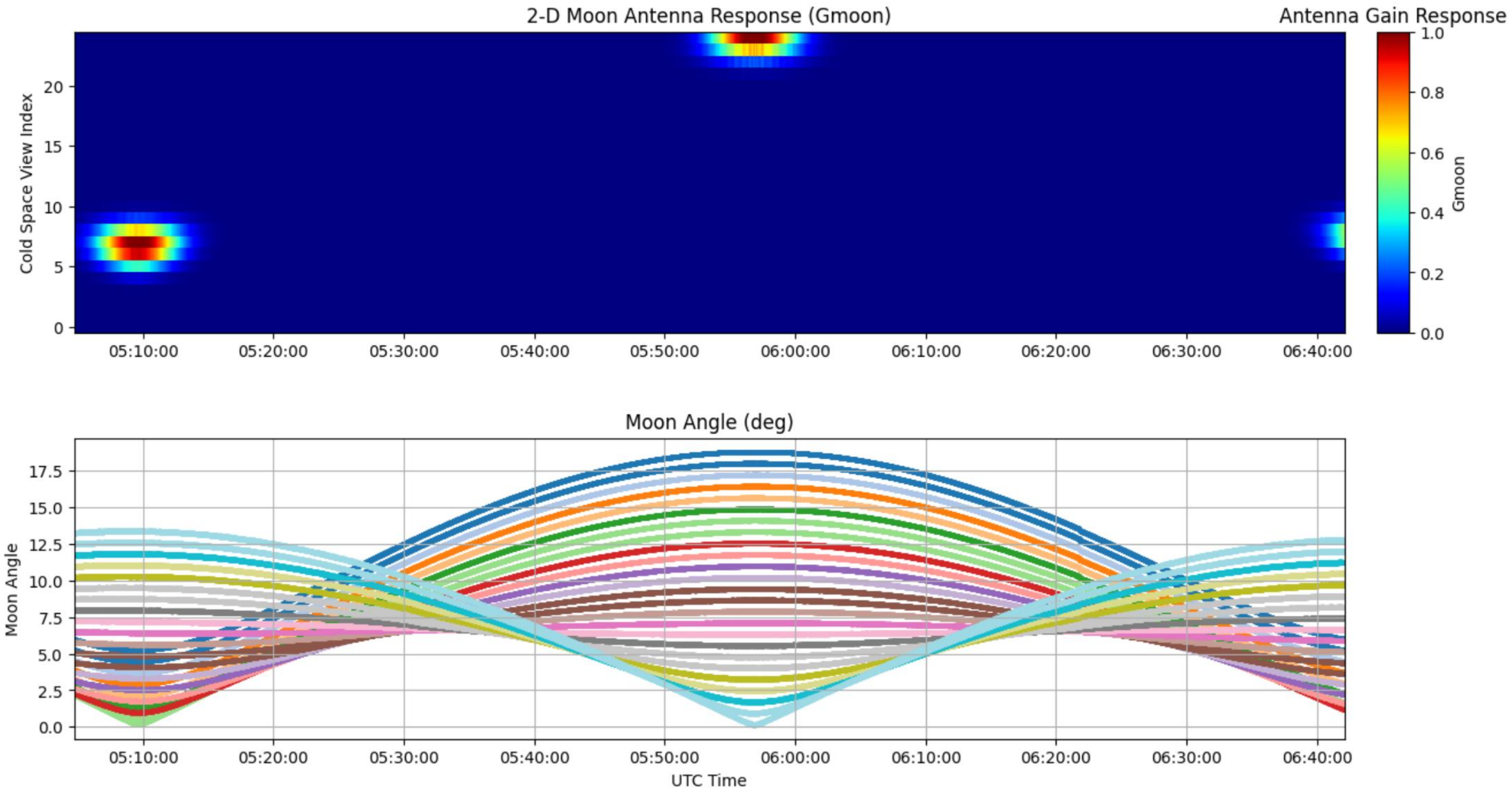
AWS Chan.01, Band 01



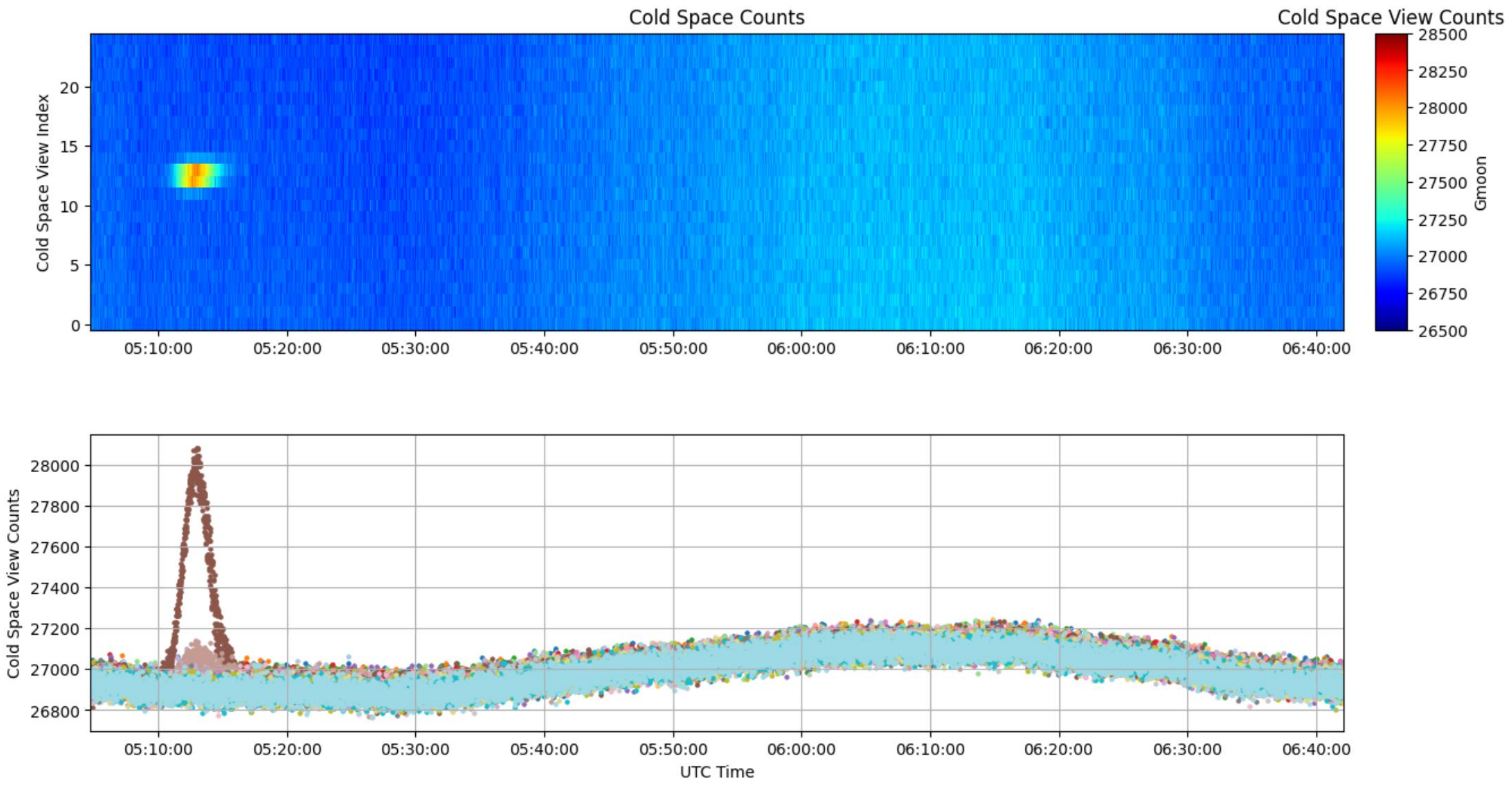
AWS Chan.08, Band 02



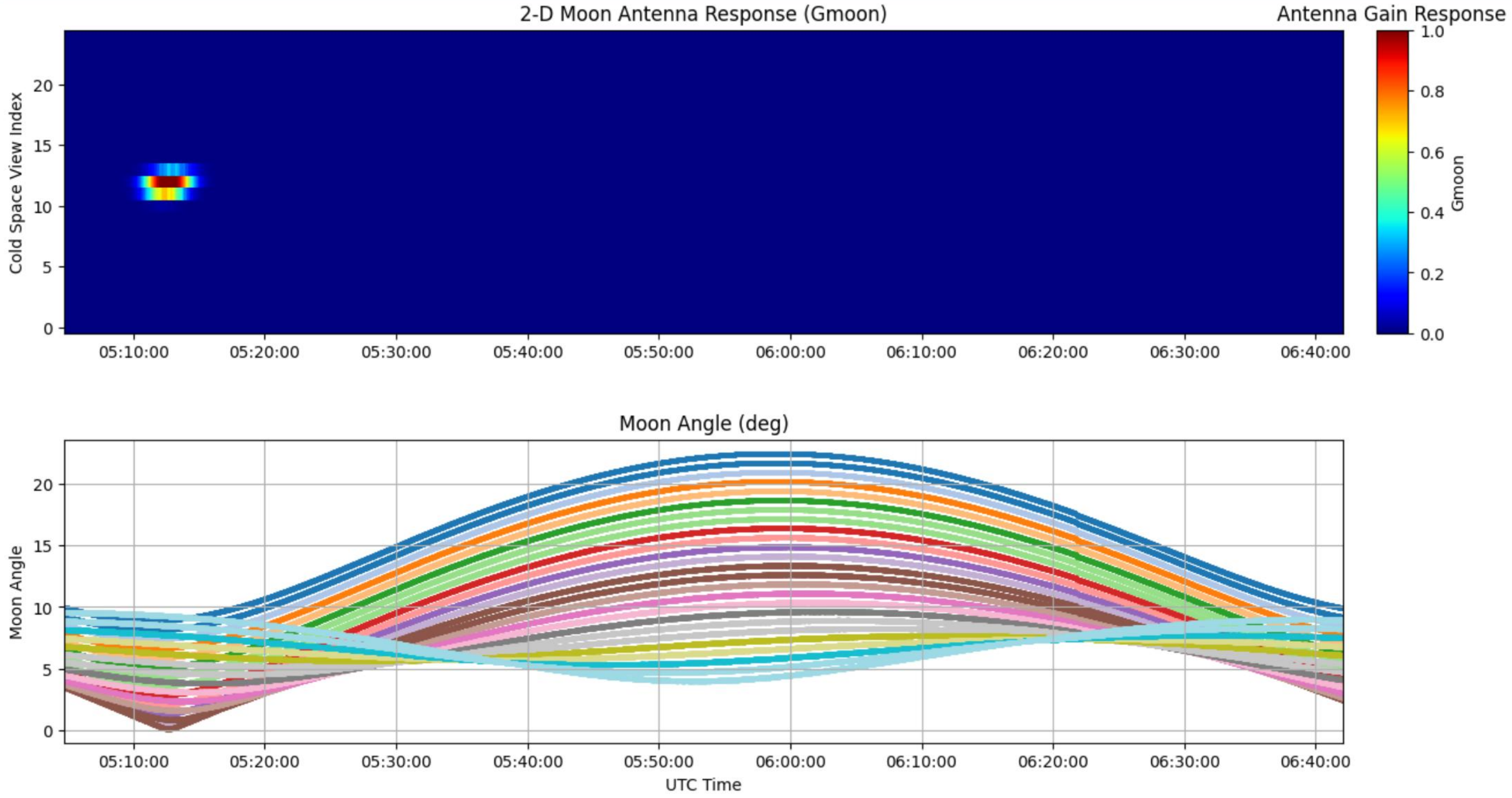
AWS Chan.08, Band 02



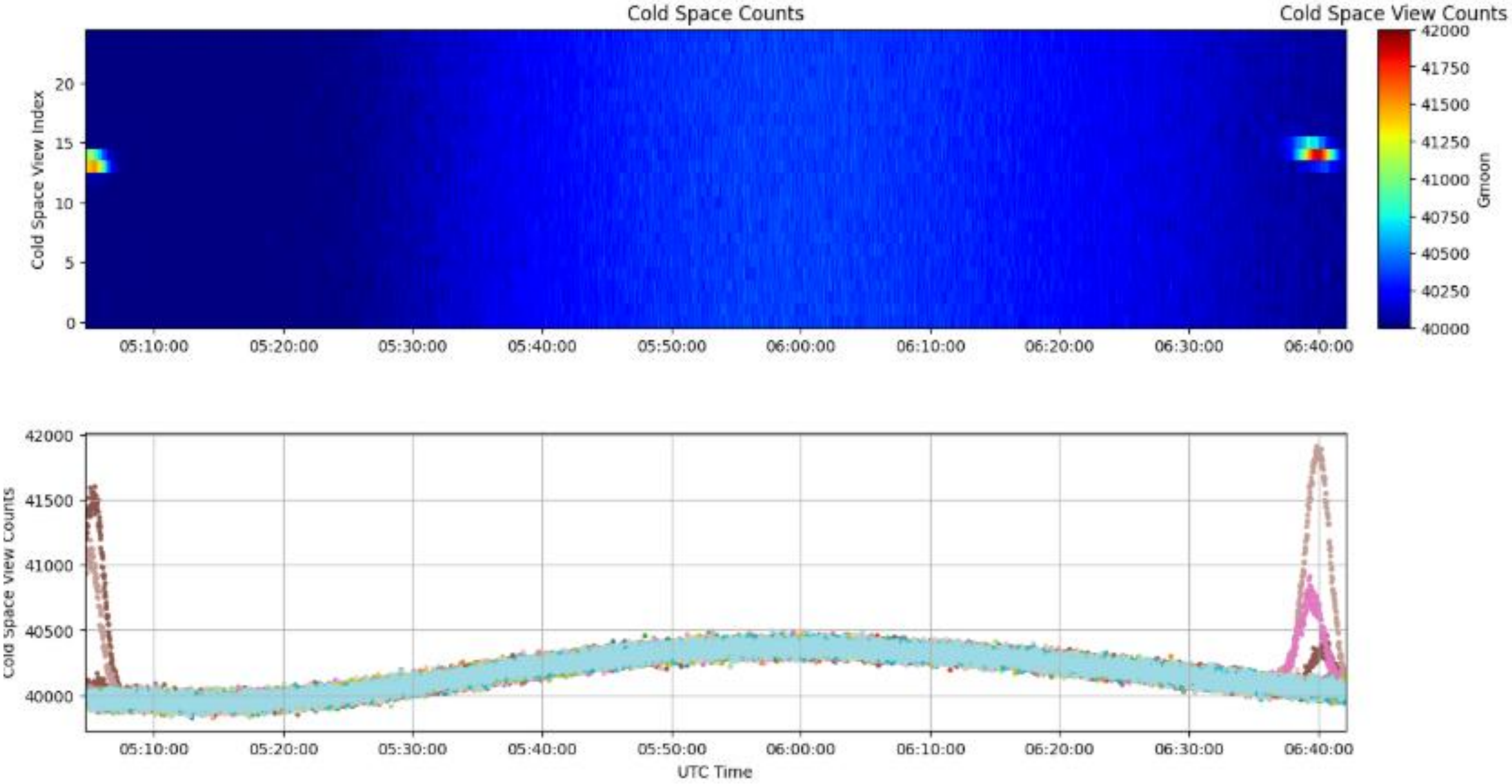
AWS Chan.15, Band 03



AWS Chan.14, Band 03



AWS Chan.19, Band 04



AWS Chan.18, Band 04