TROPICS Limb Adjustments

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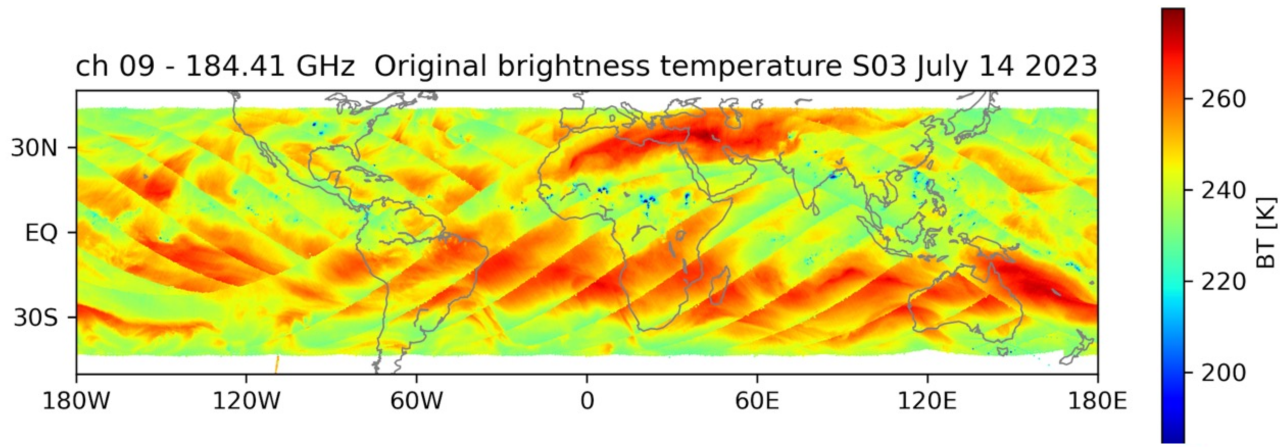
Report to the TROPICS Application Science Team

Why Limb Adjust?

- Imagery, especially water vapor imagery are used routinely by weather forecasters to track the flow and transport of moisture, helping them understand and predict the development of weather systems, and storm intensity
- Microwave water vapor channels have the advantage of much less cloud contamination, however normally the temporal refresh is rather poor which limits it use.
- A constellation of very affordable CubeSats is now feasible (demonstrated by TROPICS) and would provide higher temporal refresh.
- However the instrument is a cross track scanner which has a limb effect that must be adjusted to nadir.
- Limb adjustment efficiently mitigates instrument artifacts.
- A TROPICS Limb Adjustment has been developed based on Goldberg, M.D., D.S. Crosby, and L. Zhou, 2001: The limb adjustment of AMSU-A observations: methodology and validation , Journal Appl. Meteor, 40, 70-83.


ch 09 - 184.41 GHz Original brightness temperature S03 July 14 2023
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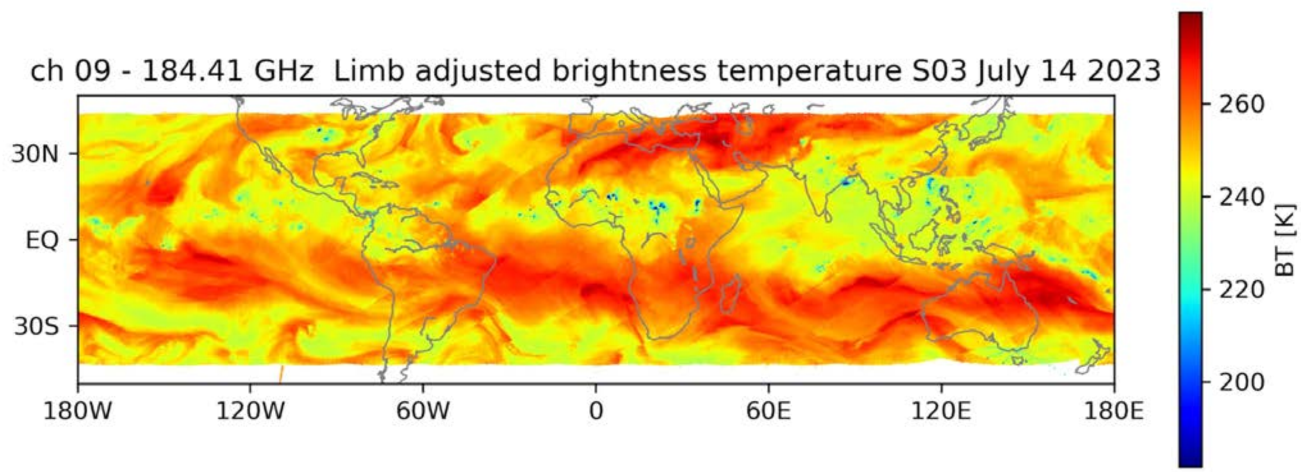
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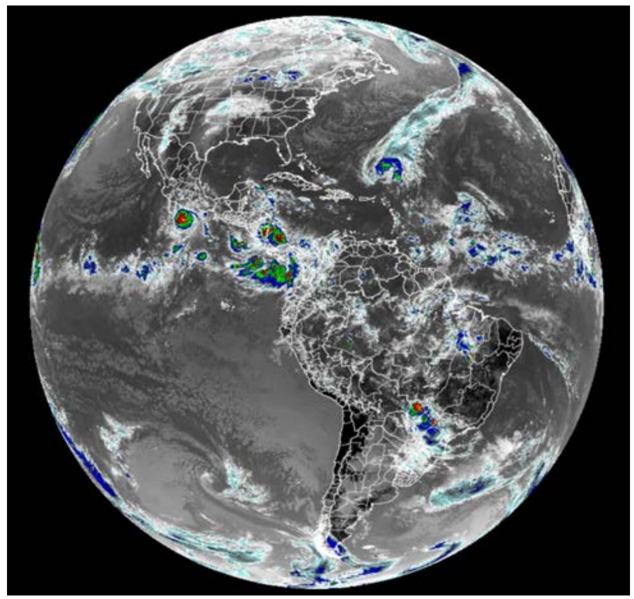

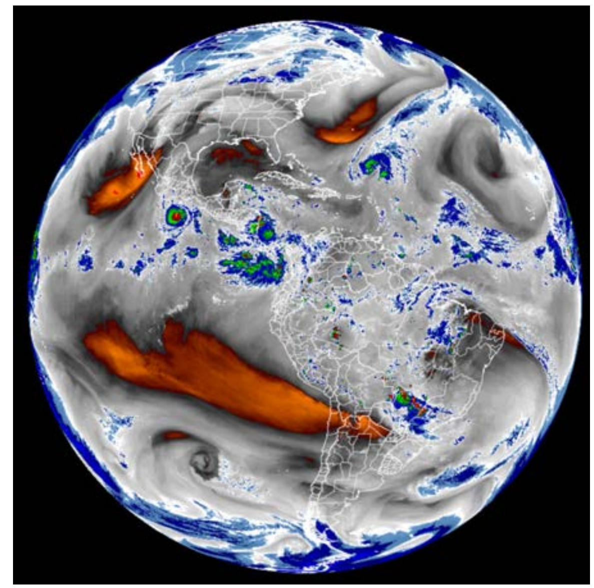

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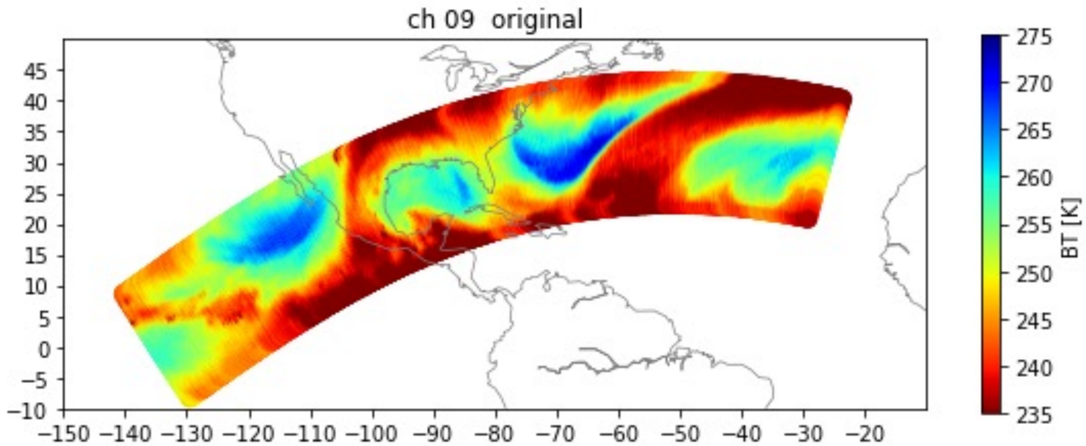

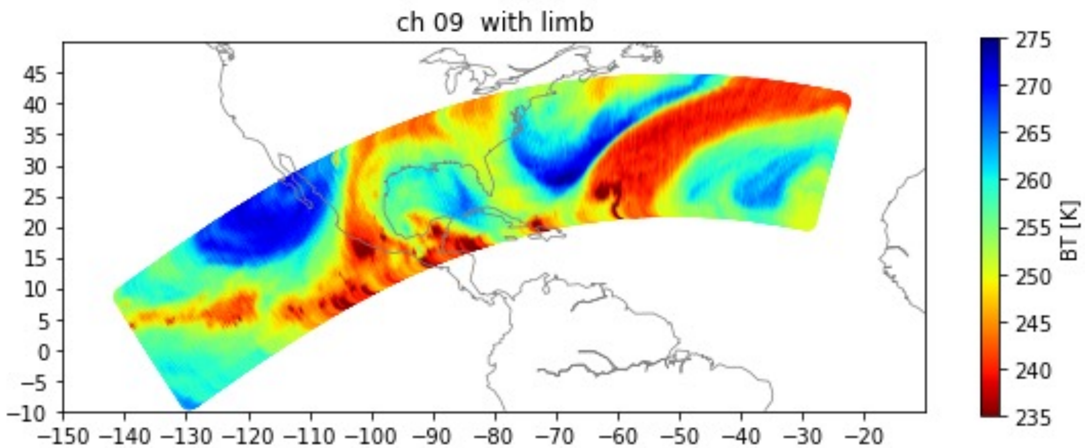

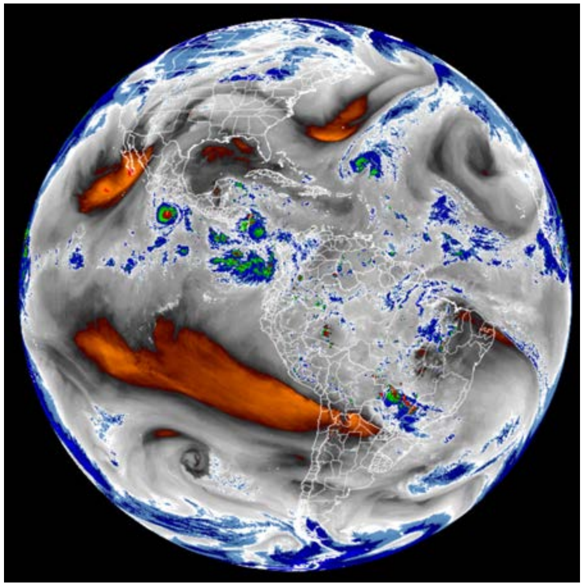

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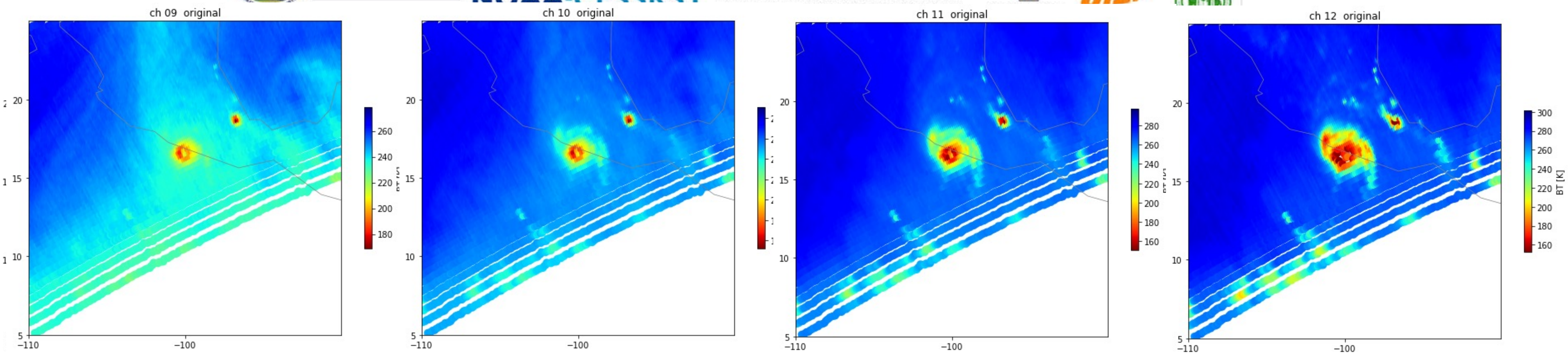
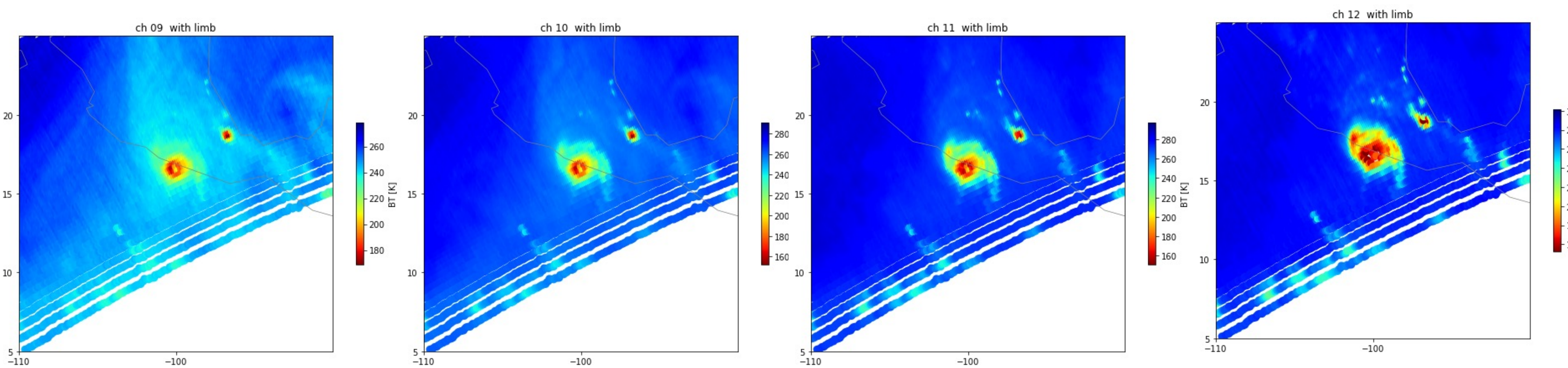


Hurricane OTIS



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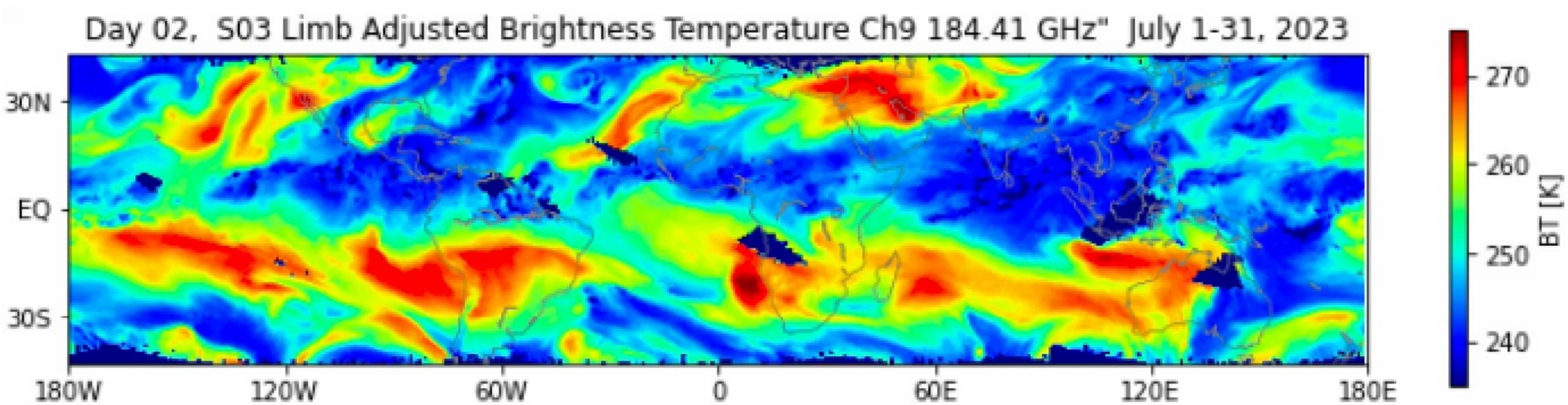


Imagine a constellation of 20 TROPICS-like cubesats

Findings

- Limb adjustment works very well for the water vapor channels!!
- Not so well for the atmospheric temperature channels
- Relatively good for the 89Ghz (channel 1), channels 2 – 3.
- Limb adjustment is an effective way to treat satellite to satellite differences, especially important for a large constellation.

Tropics Weighting Functions

(Temperature Channels (left), Water Vapor Channels (right))

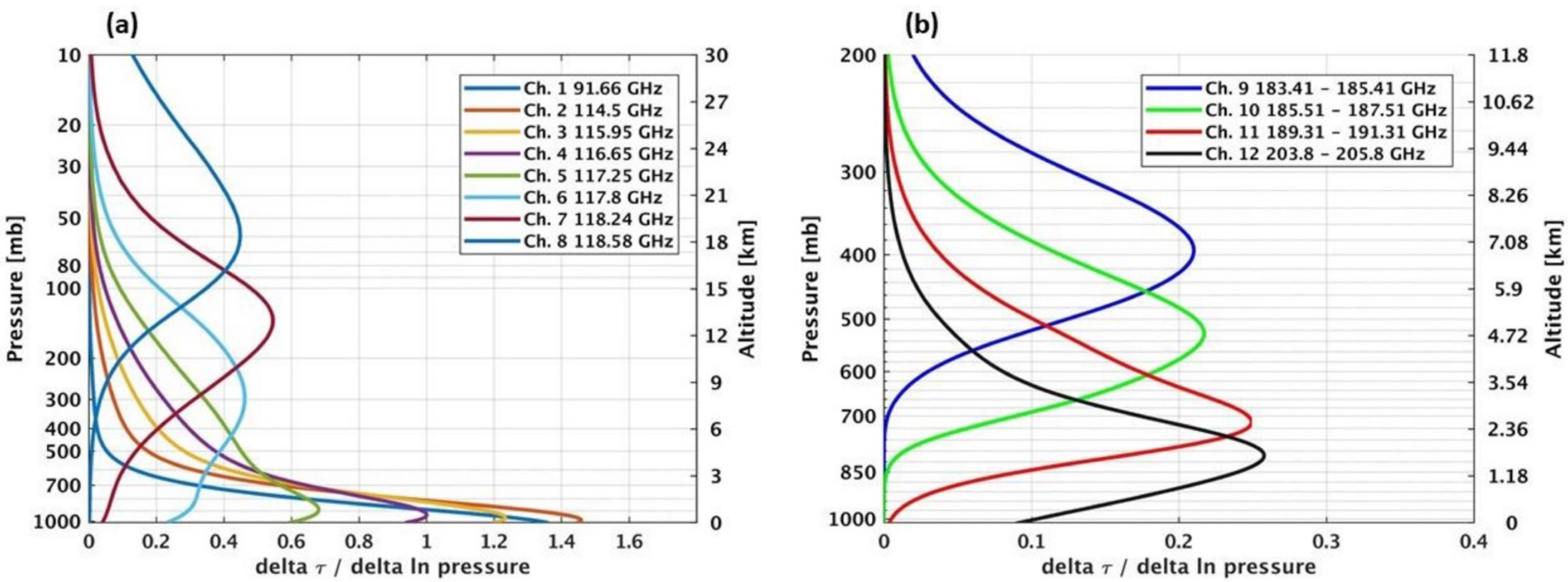
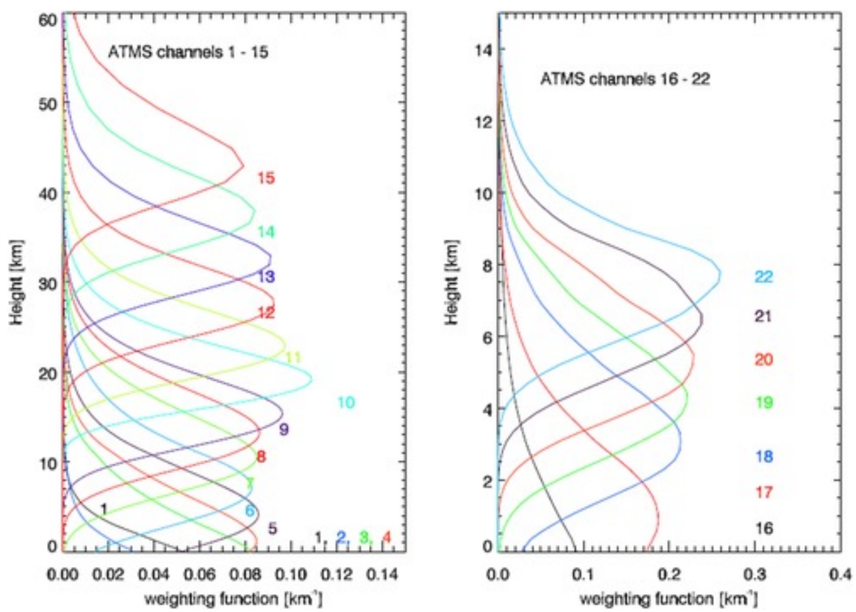


Figure 5. Weighting functions calculated at nadir incidence over a perfectly emissive surface for a standard tropical atmosphere for both a) temperature/imaging and b) water vapor/imaging channels.

ATMS /AMSU Weighting Functions



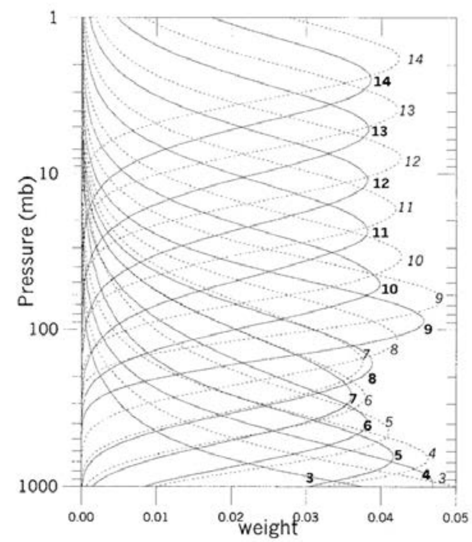


FIG. 3. AMSU-A channels 4–14 weighting functions for two view angles: near-nadir angle of 1.35 (solid curves) and the largest angle of 47.85 (dashed curves).

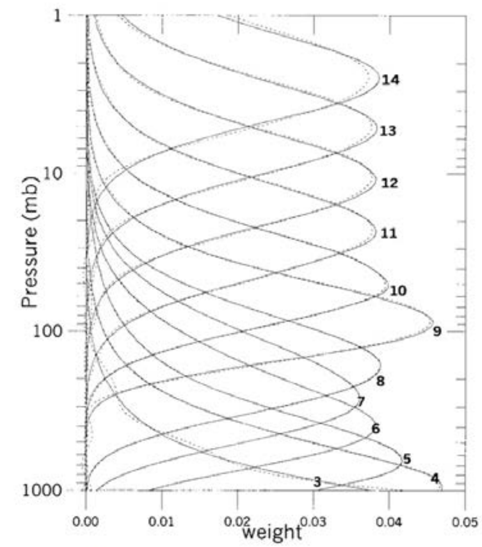


FIG. 7. AMSU-A channels 4–14 weighting functions for near-nadir (solid curves) and physically estimated (dashed curves) weighting functions from the largest off-nadir angle.

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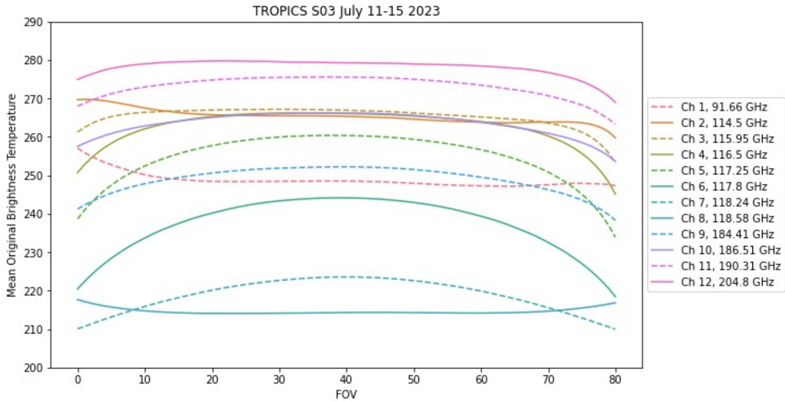
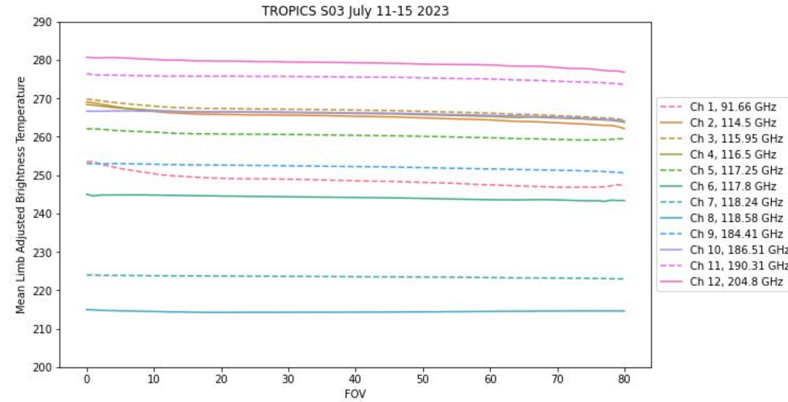
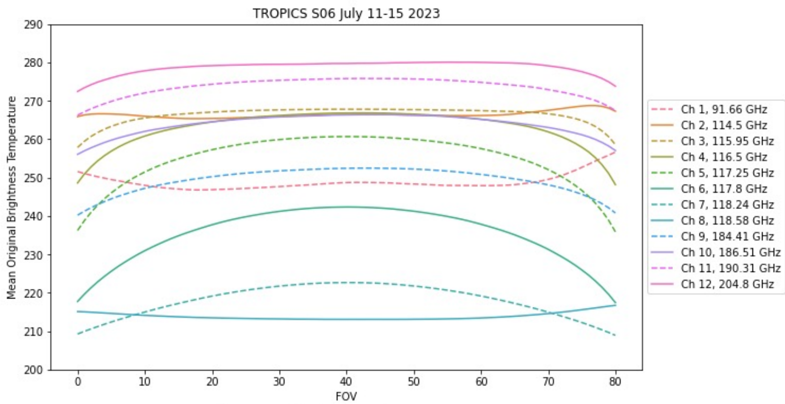
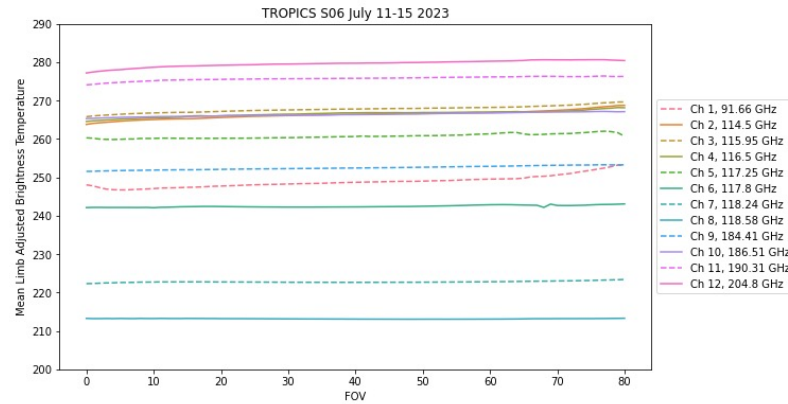
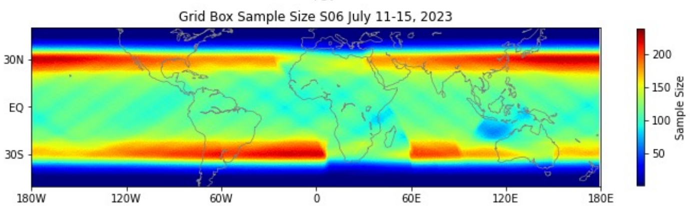
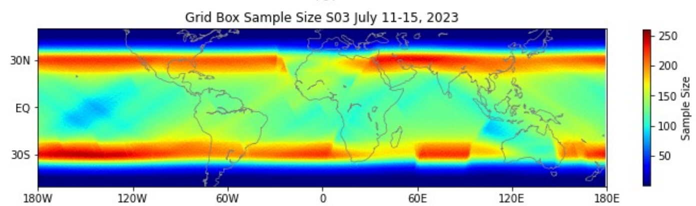




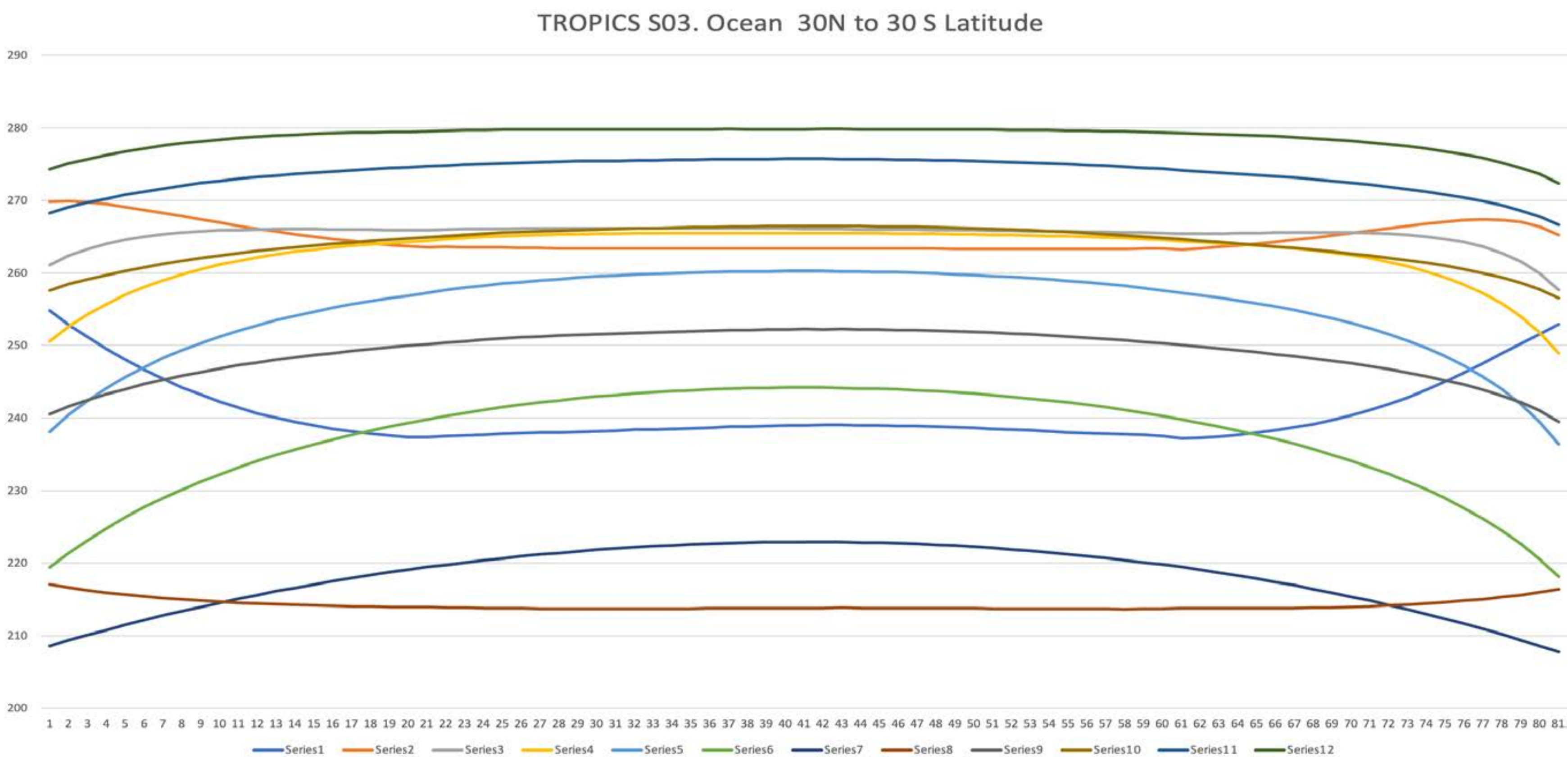








June to October, 2023. = each fov has a sample size ~ 2.5M



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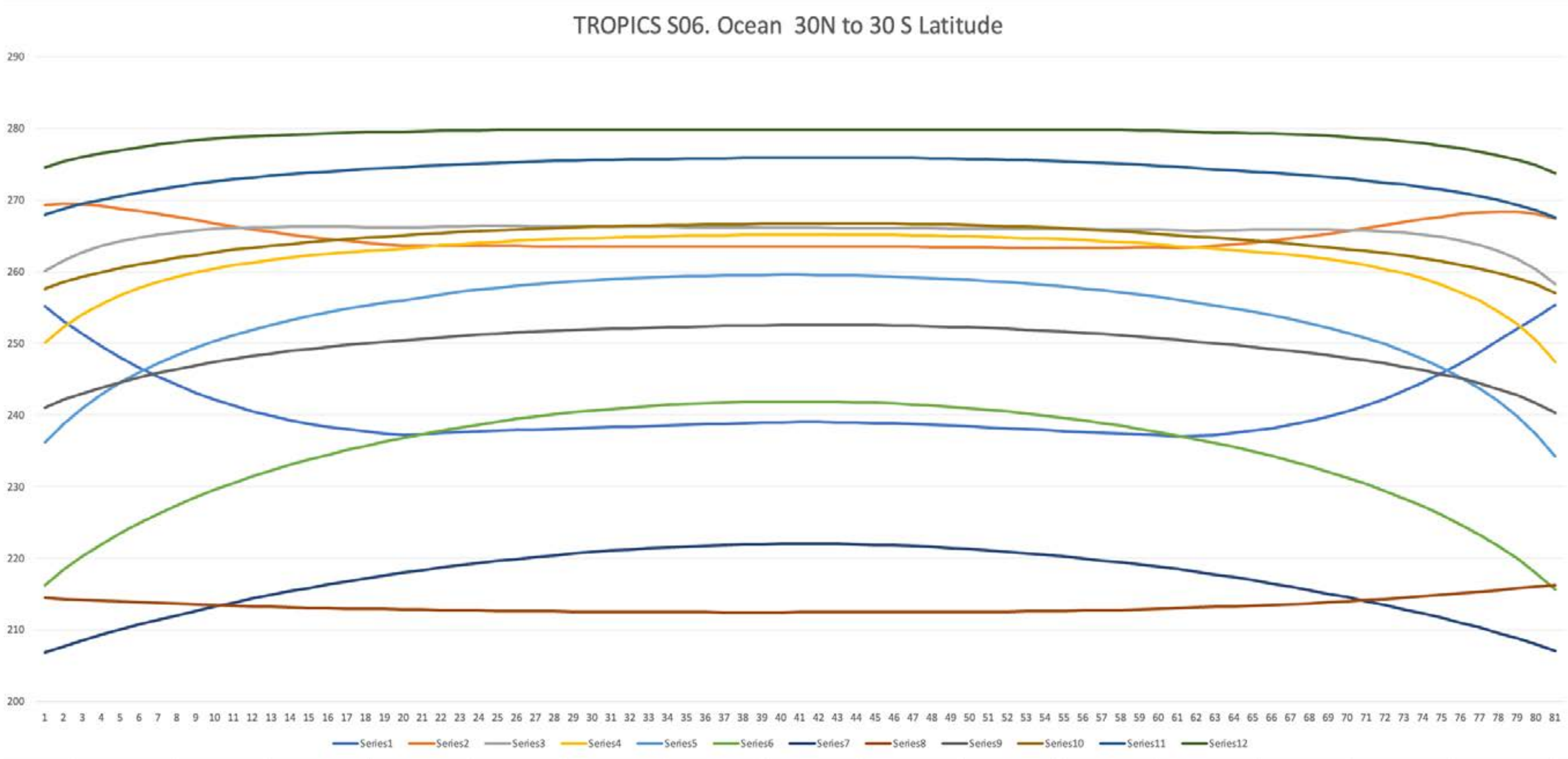

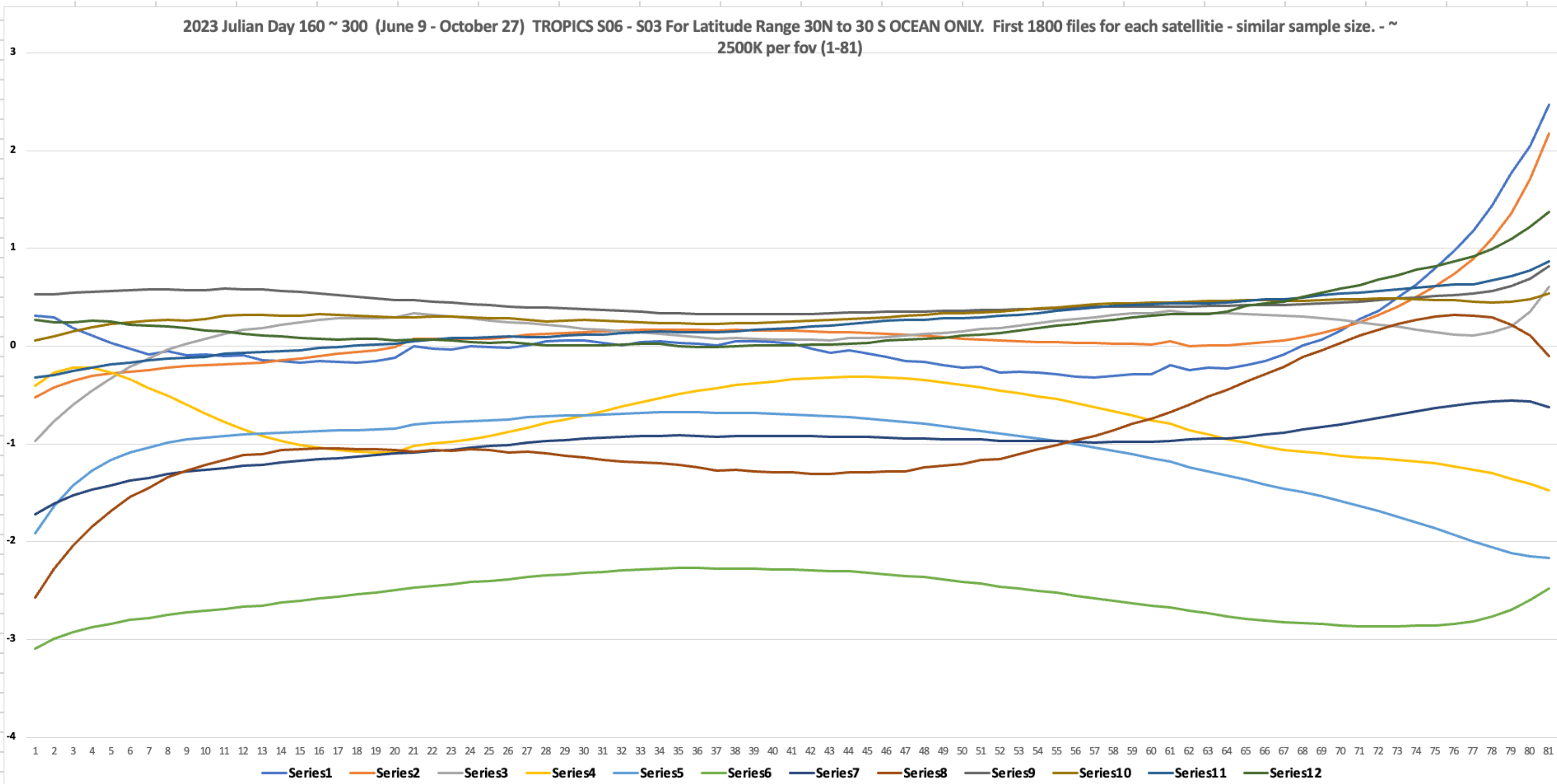
2023 Julian Day 160 ~ 300 (June 9 - October 27) TROPICS S06 - S03 For Latitude Range 30N to 30 S OCEAN ONLY. First 1800 files for each satellitie - similar sample size. - ~ 2500K per fov (1-81)
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Series1 Series2 Series3 Series4 Series5 Series6 Series7 Series8 Series9 Series10 Series11 Series12

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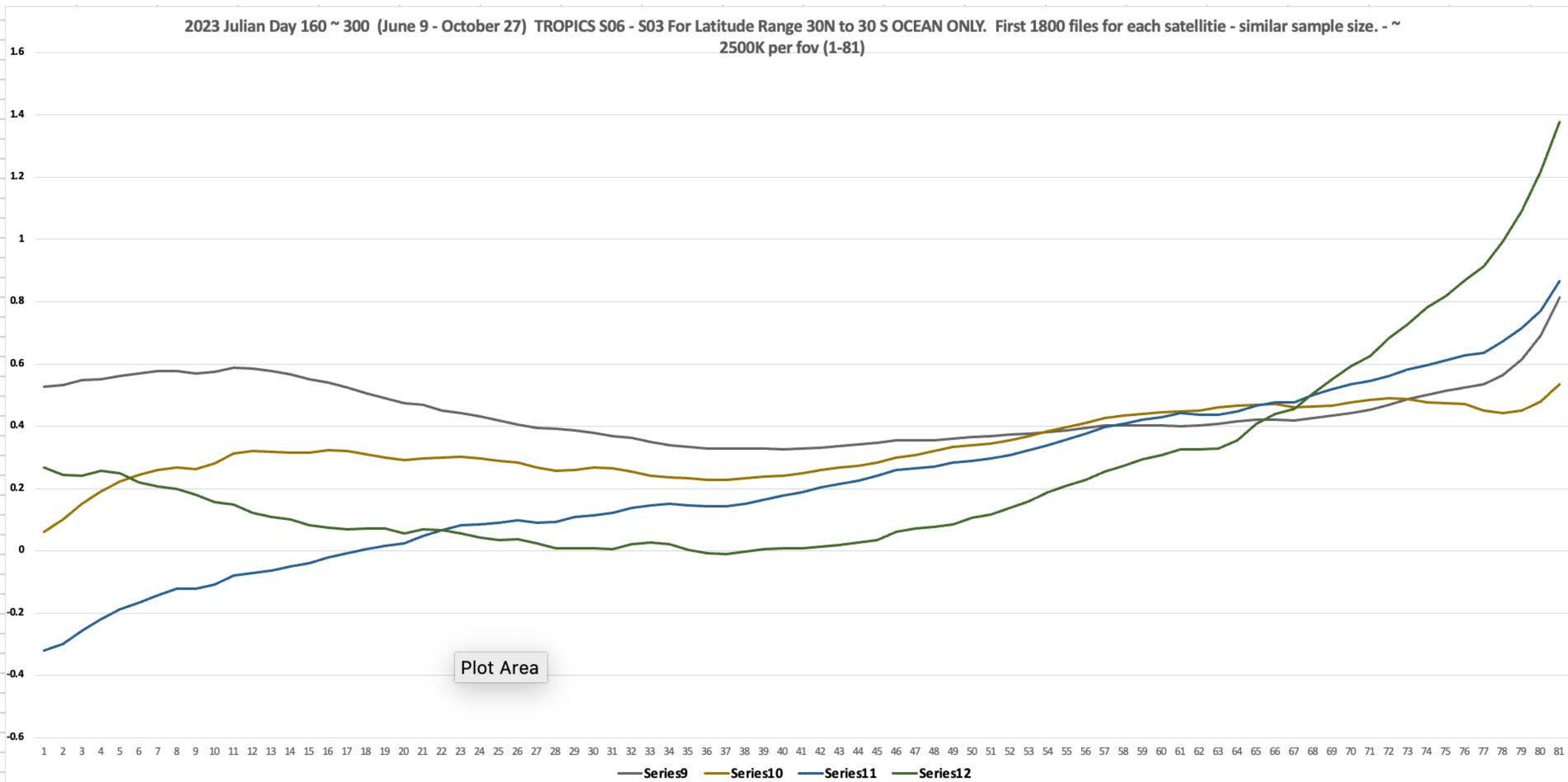

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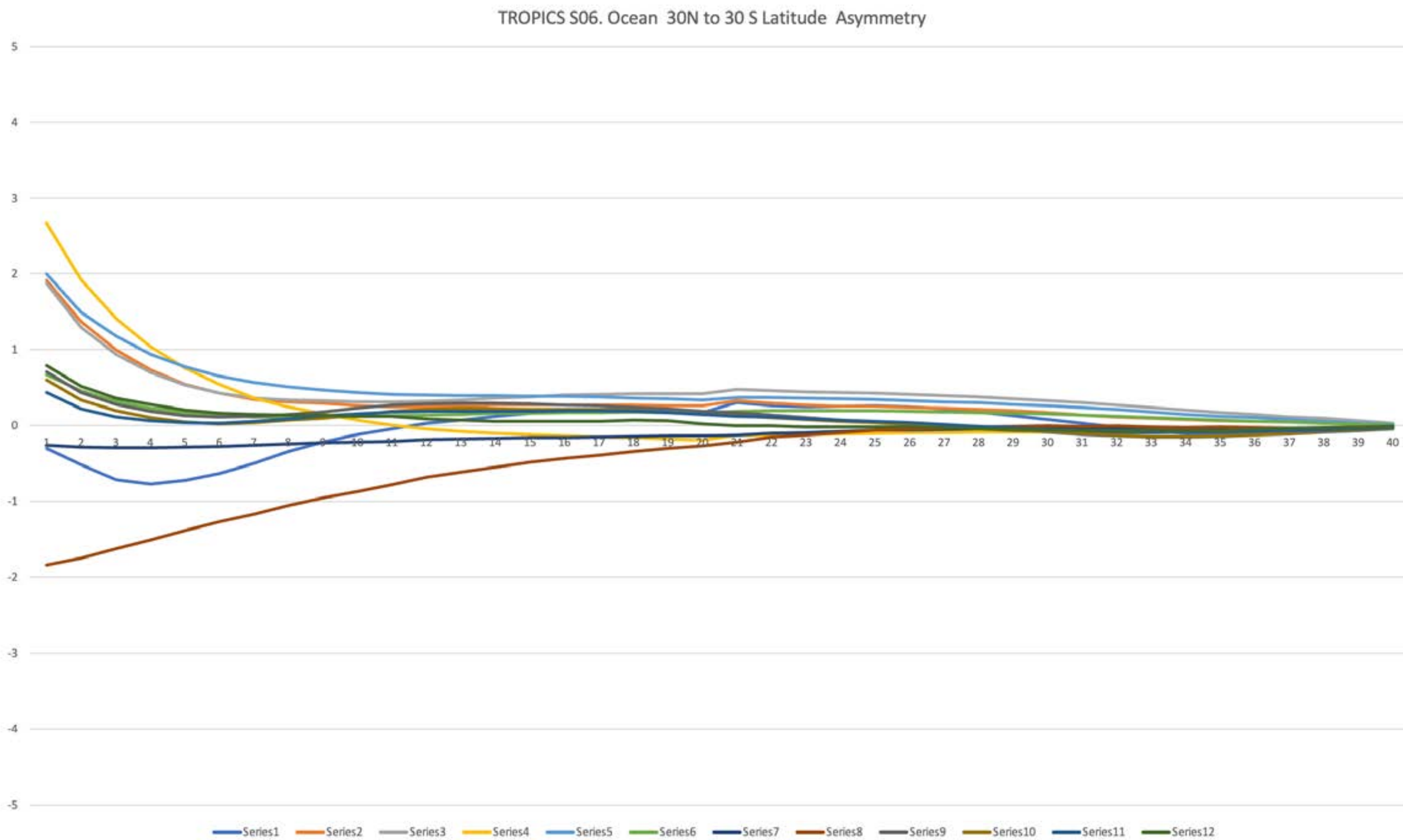

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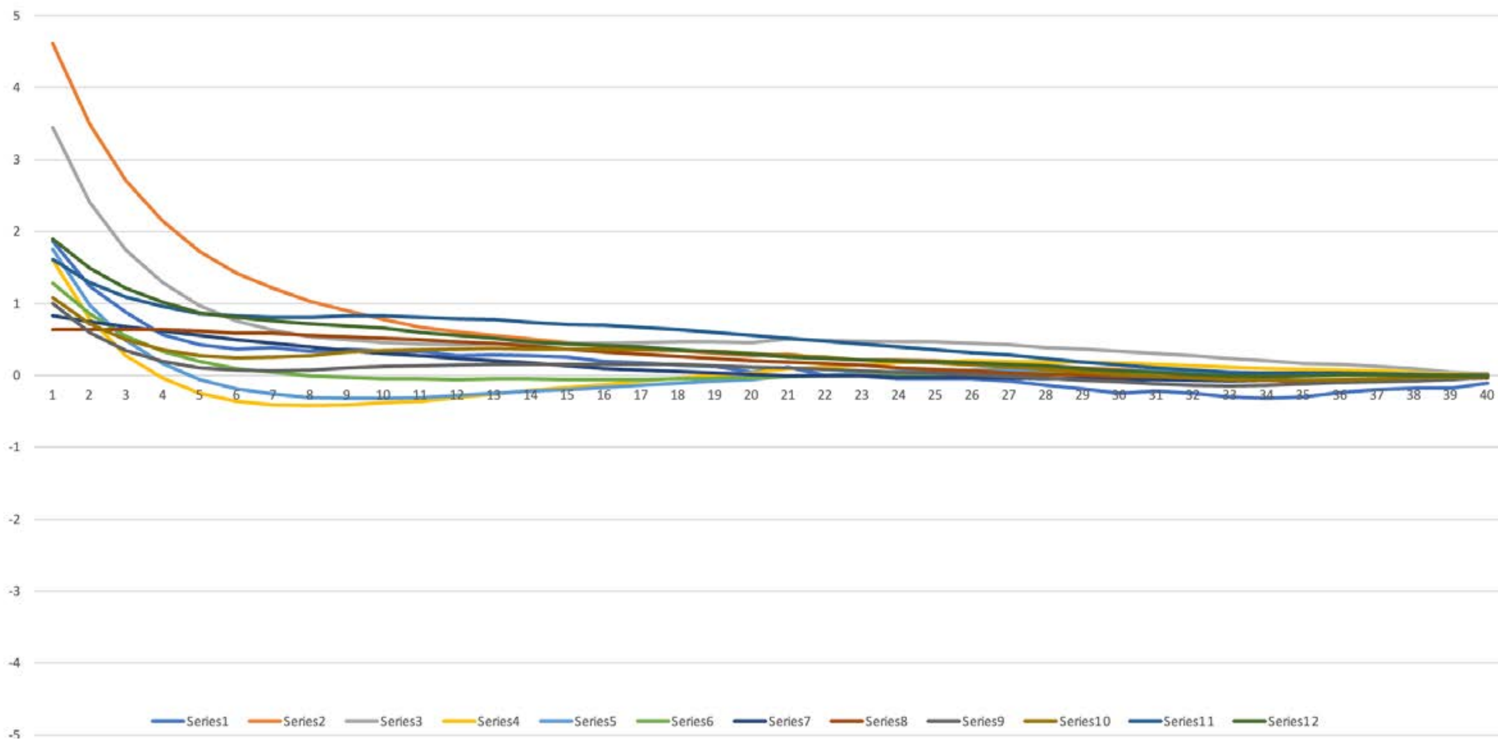
TROPICS S03. Ocean 30N to 30 S Latitude Asymmetry



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Example of N20 minus SNPP ATMS difference before and after final antenna temperature corrections

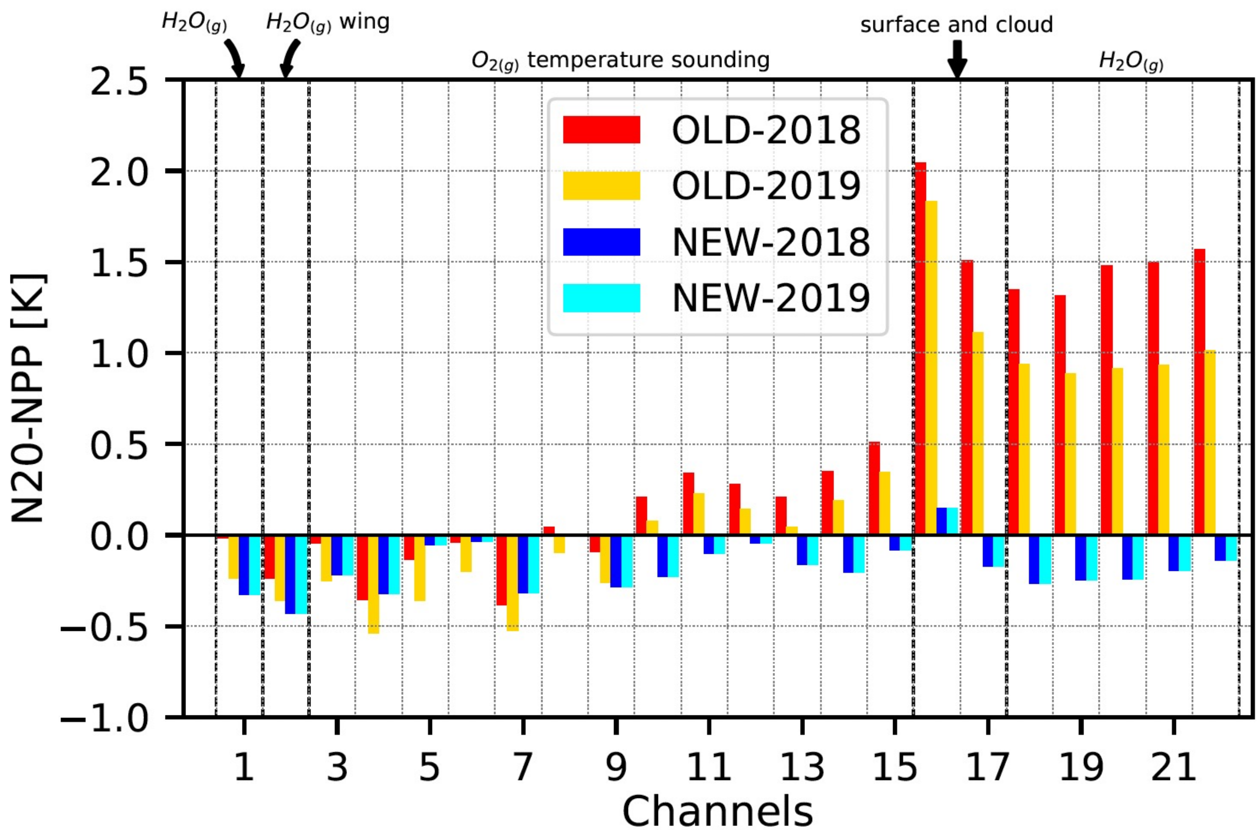
JGR Atmospheres

Research Article | Free Access

Performance of Radiative Transfer Models in the Microwave Region

Isaac Moradi, Mitchell Goldberg, Manfred Brath, Ralph Ferraro, Stefan A. Buehler, Roger Saunders, Ninghai Sun

First published: 06 March 2020 | https://doi.org/10.1029/2019JD031831 | Citations: 5



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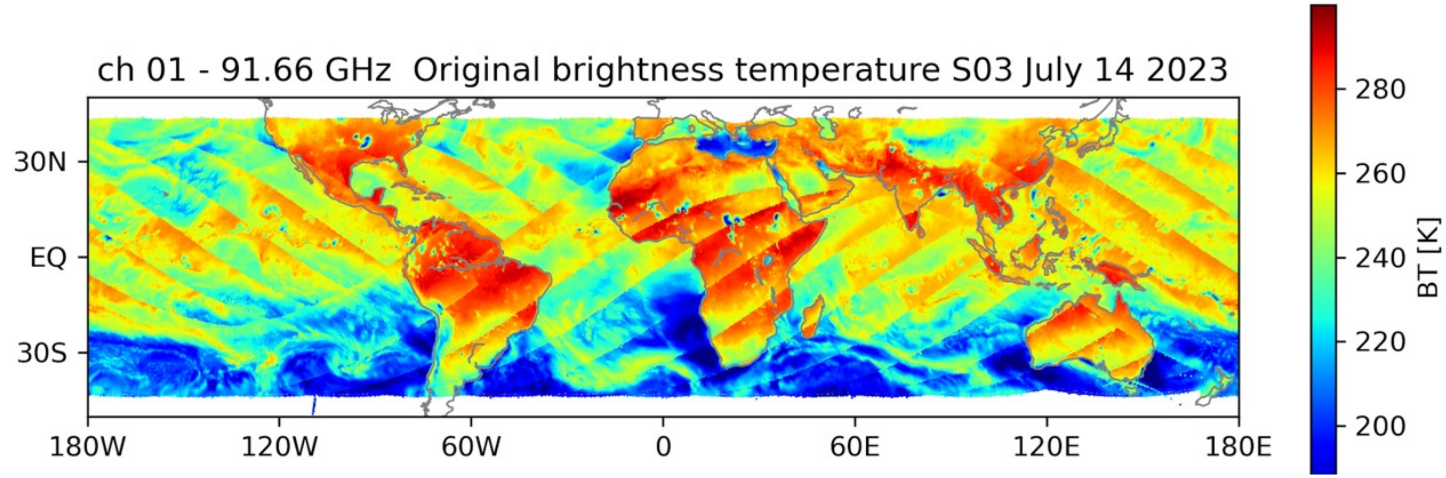
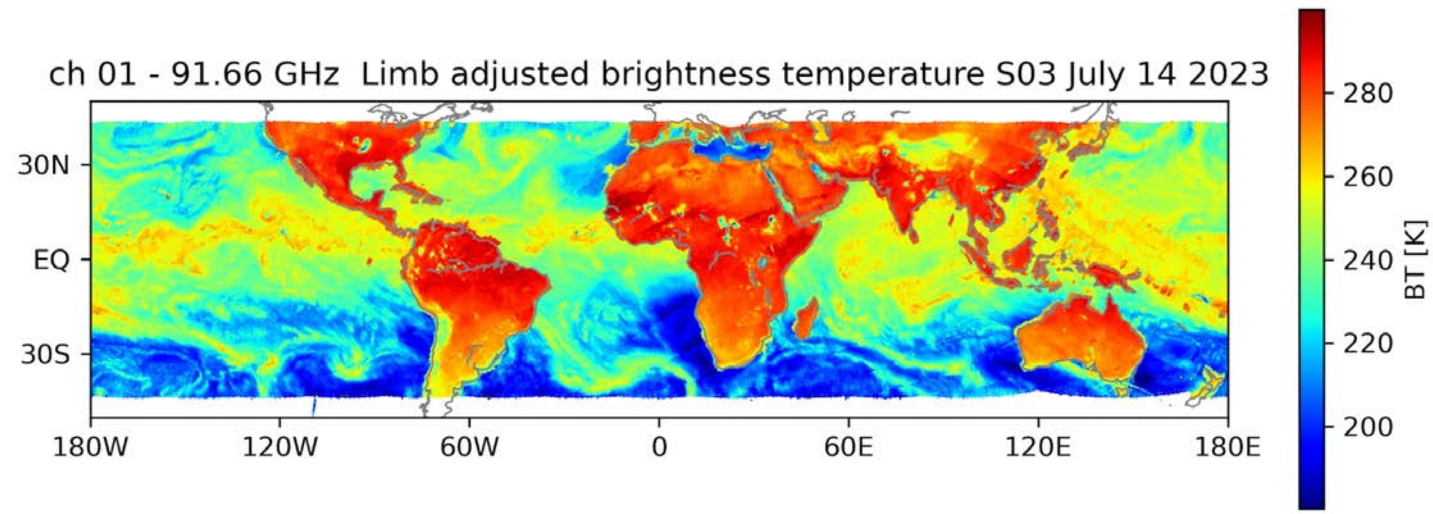
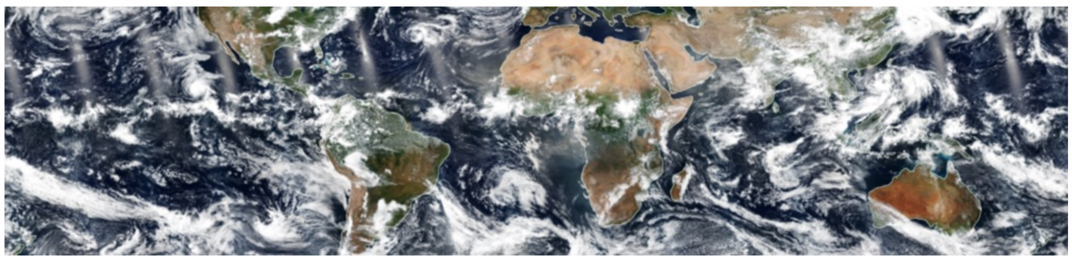
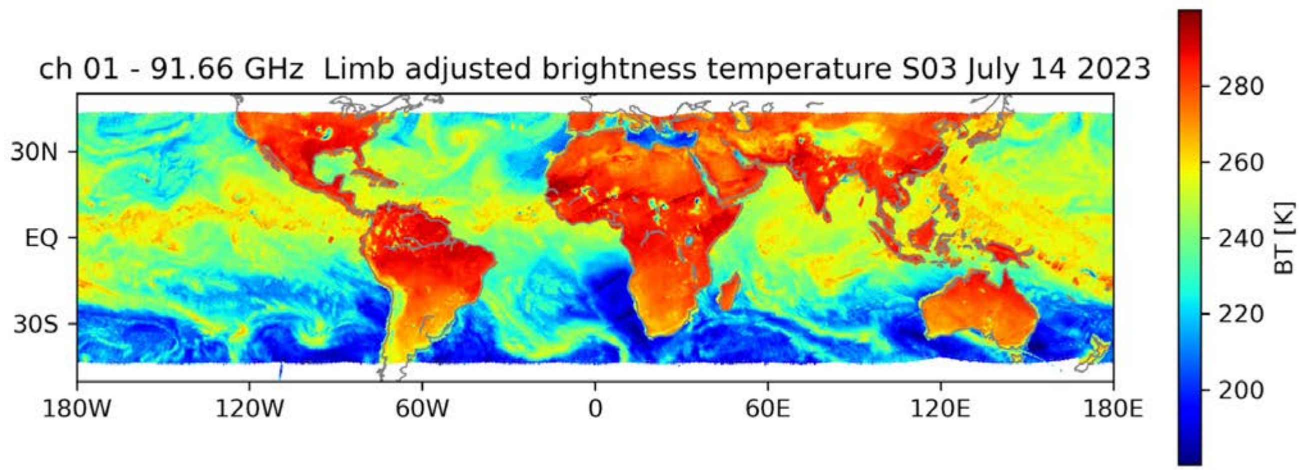




SNPP VIIRS July 14, 2020





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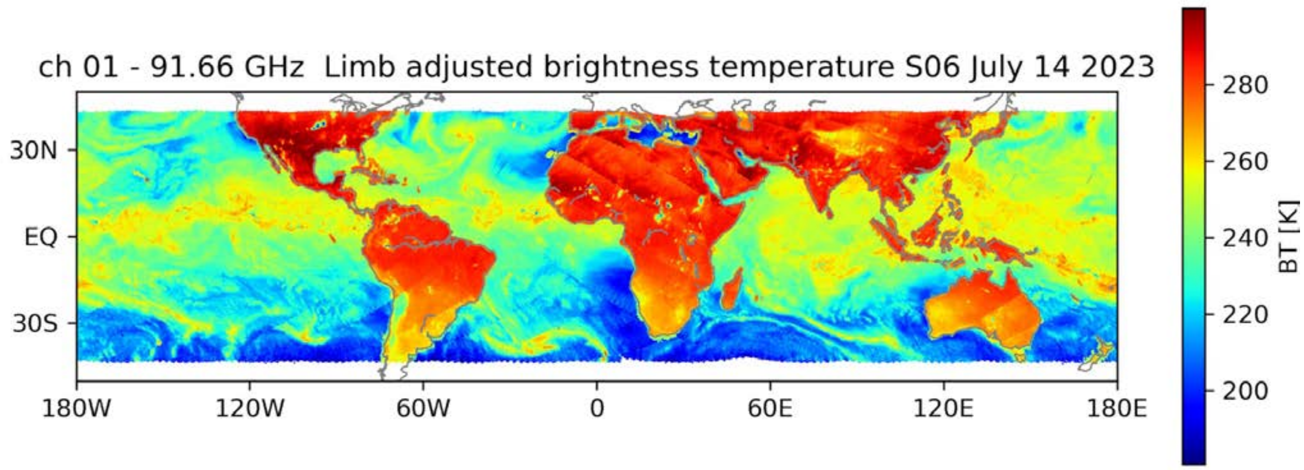
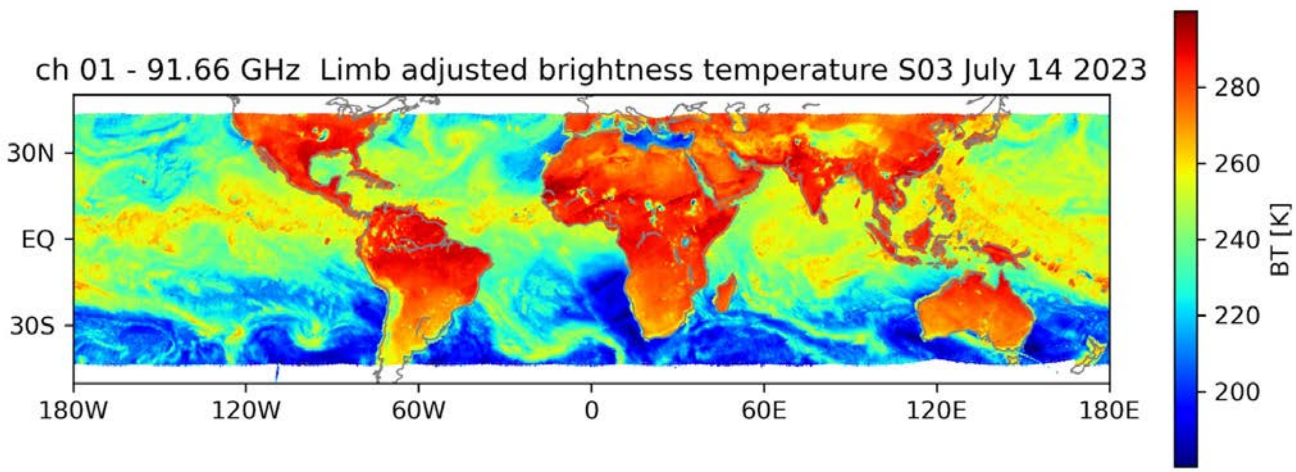
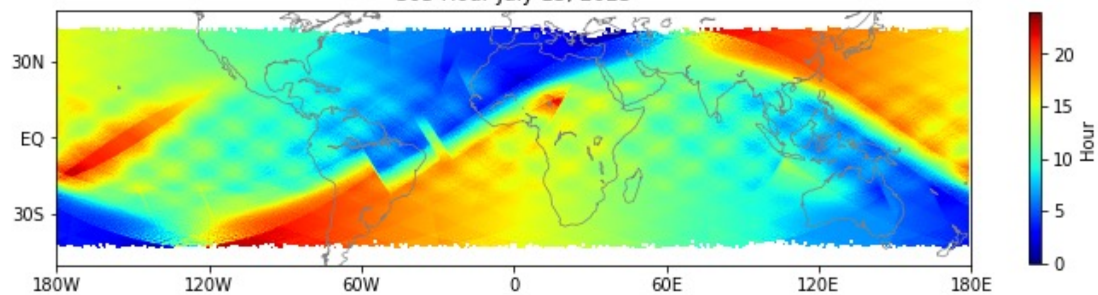
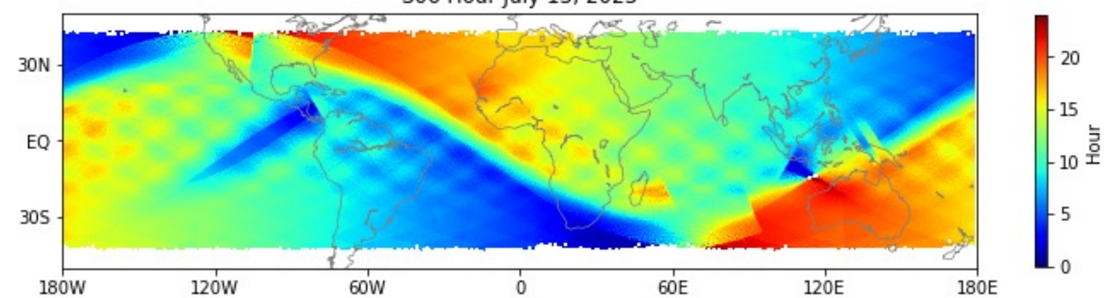




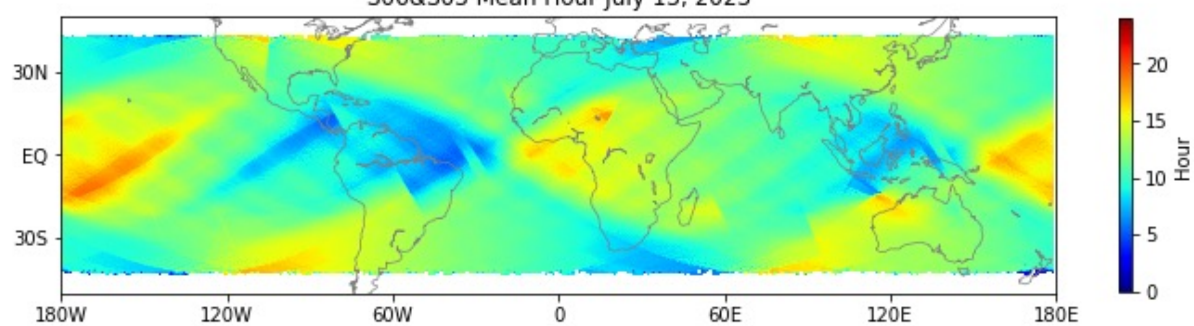
S03 Hour July 13, 2023

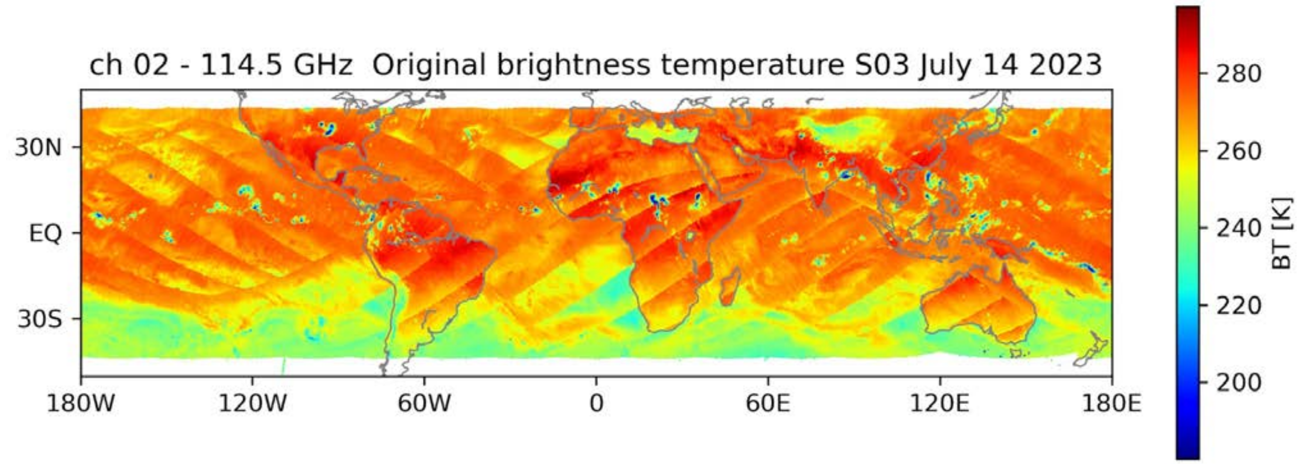


S06 Hour July 13, 2023



S06&S03 Mean Hour July 13, 2023

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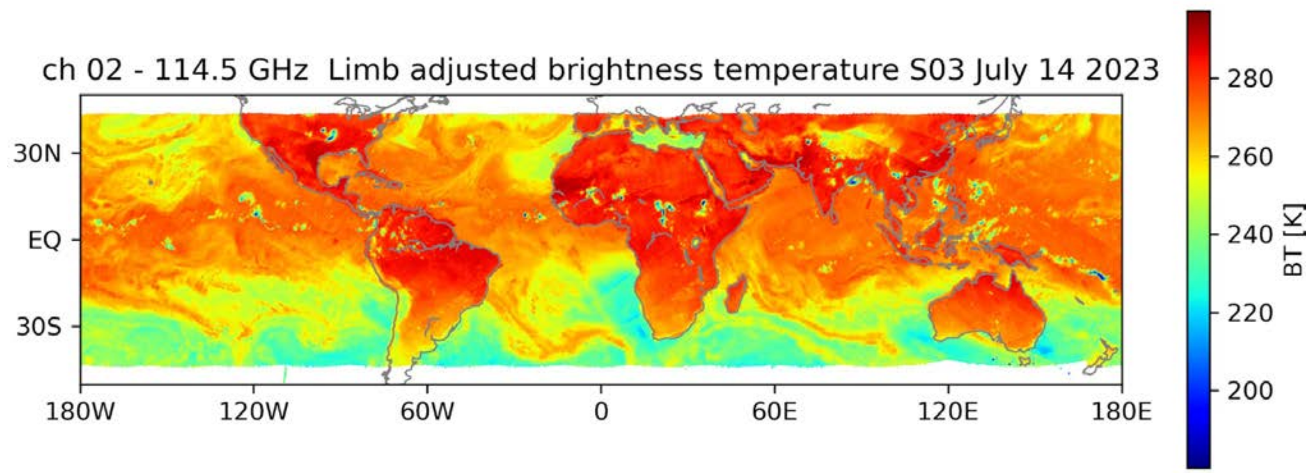
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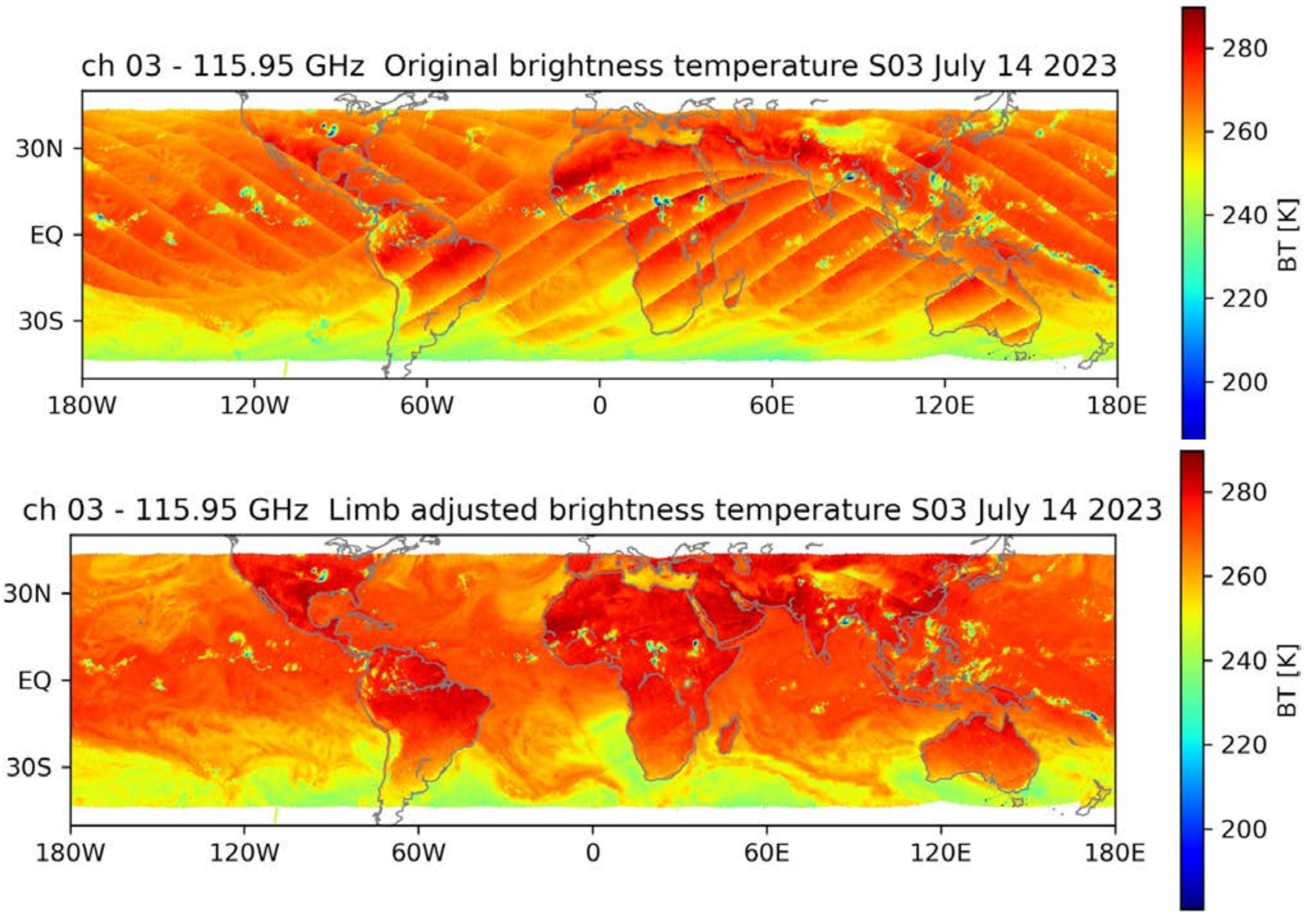
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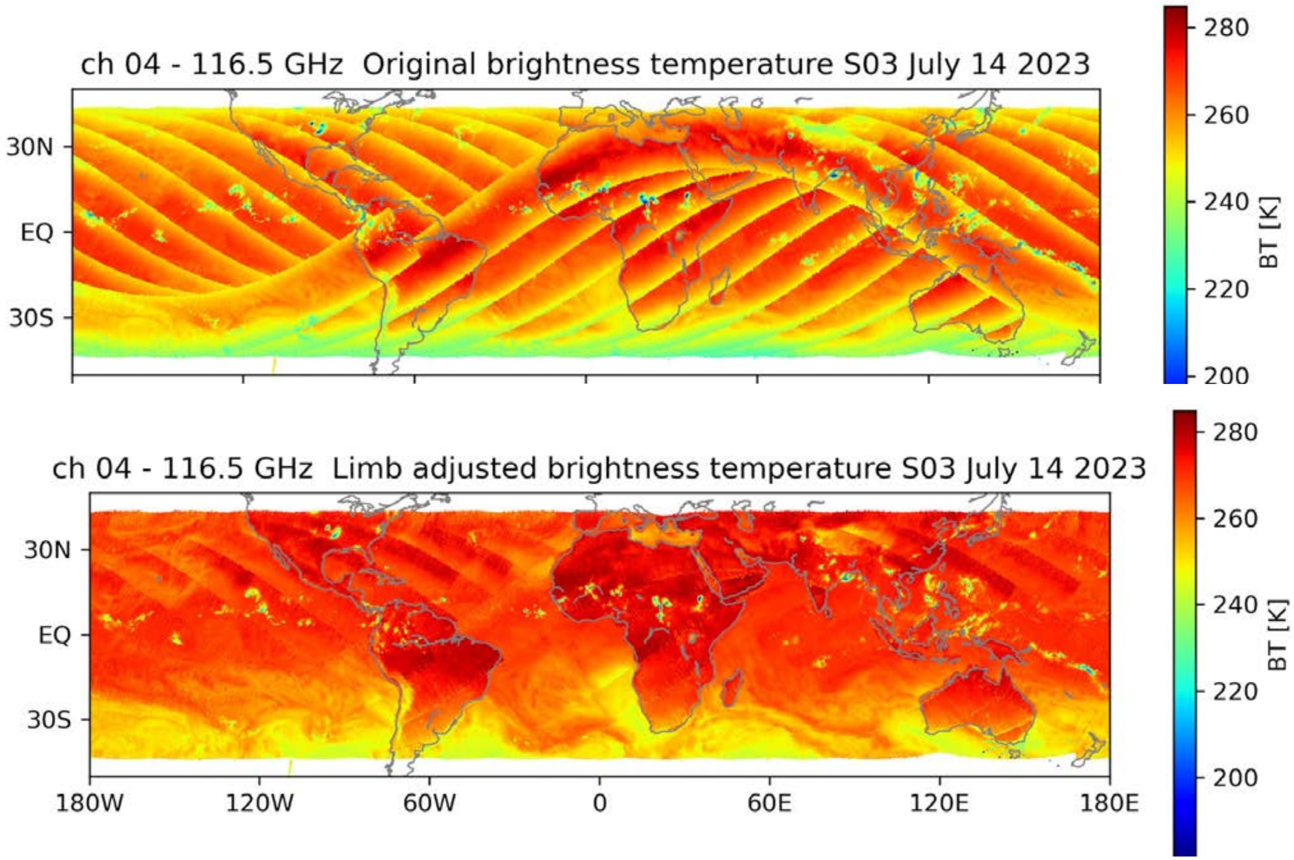

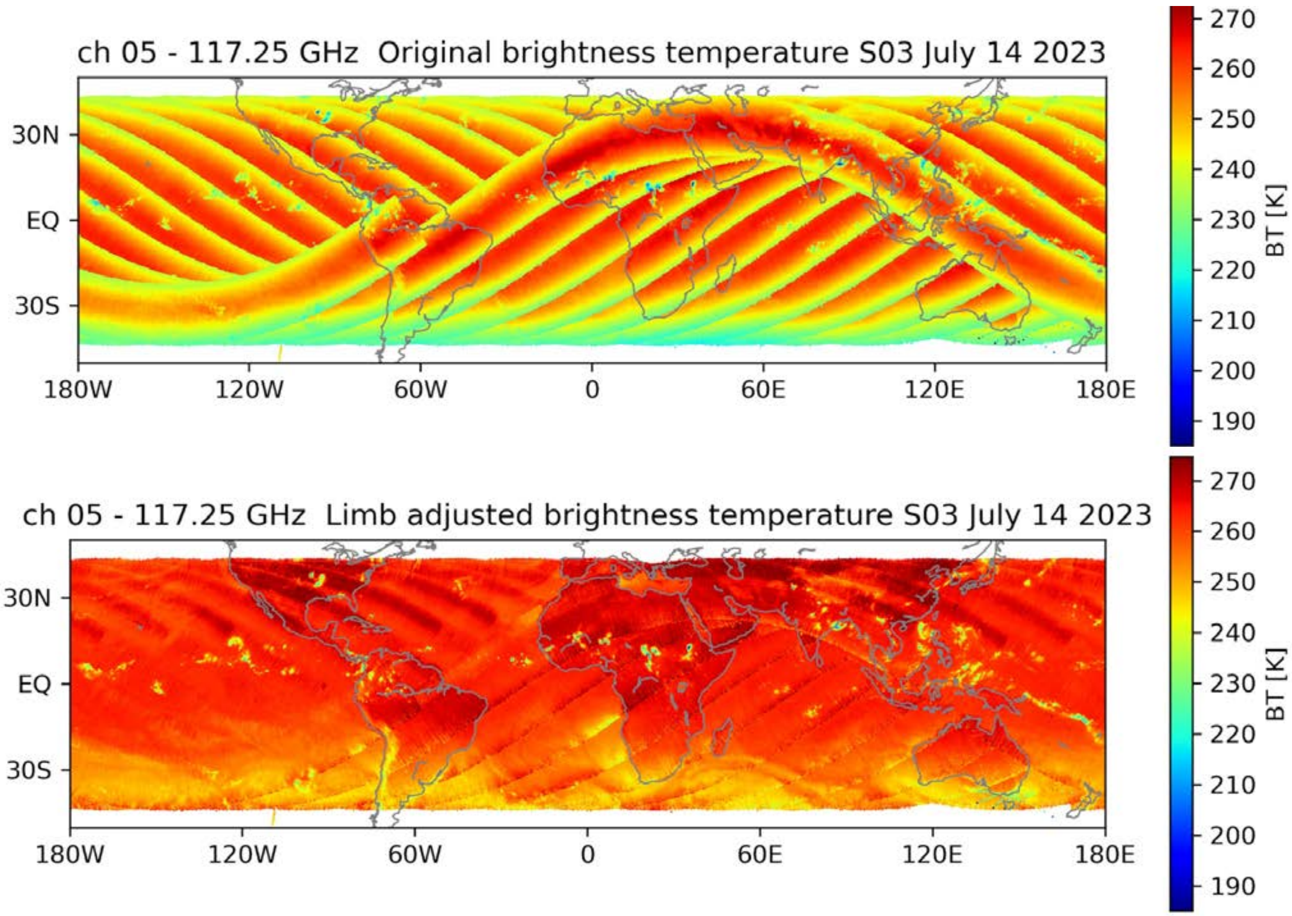
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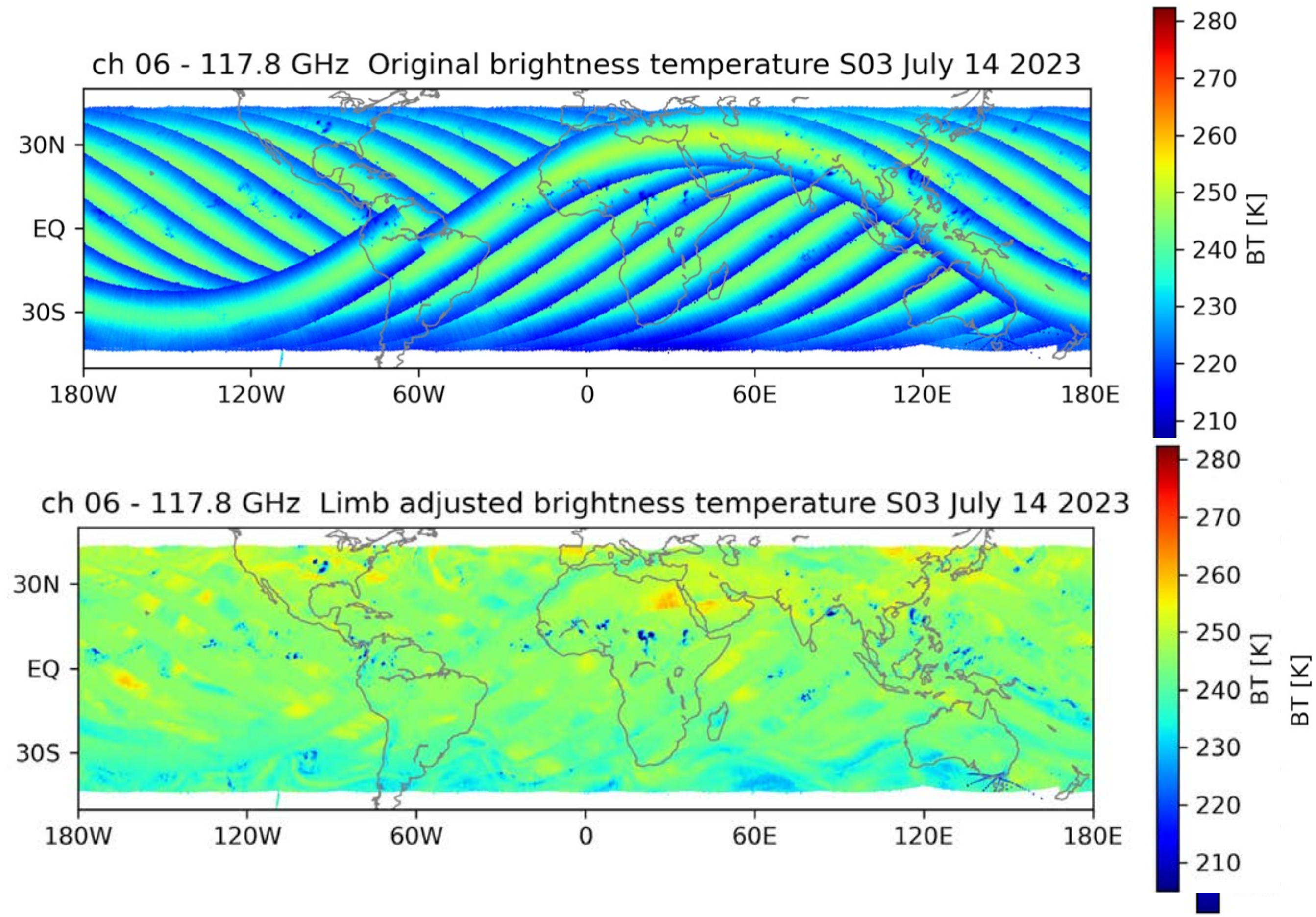

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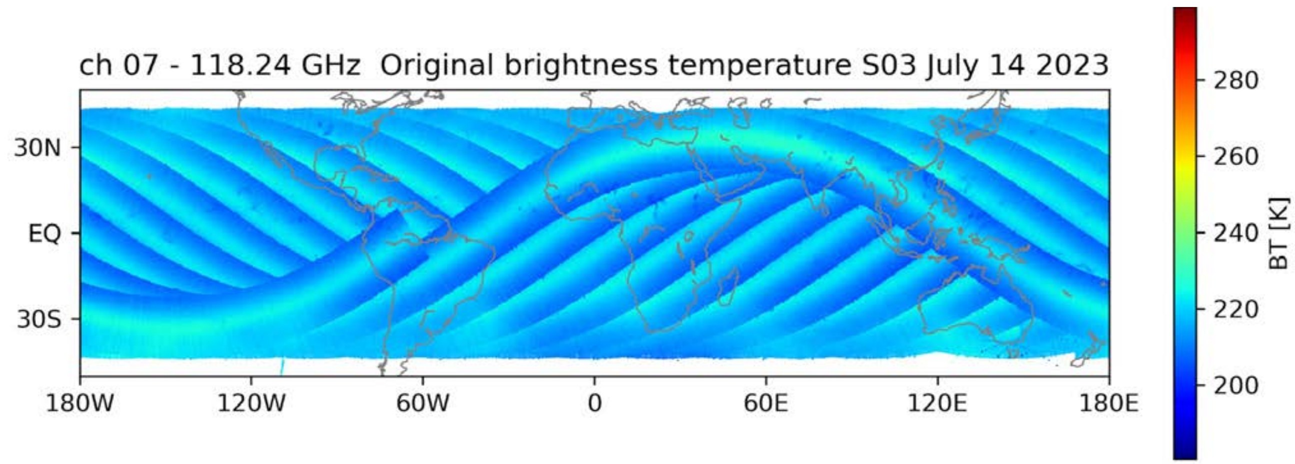

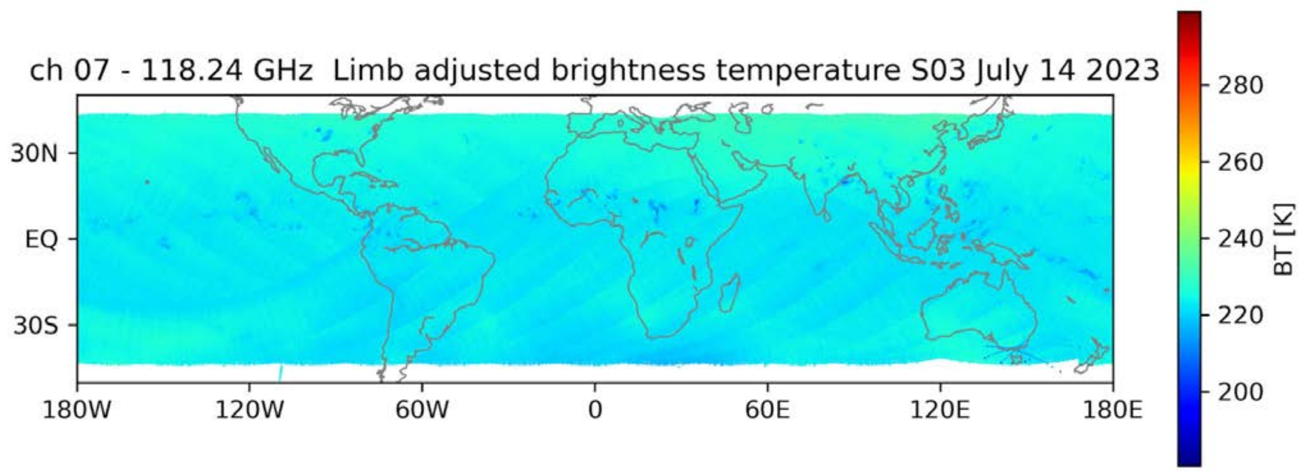

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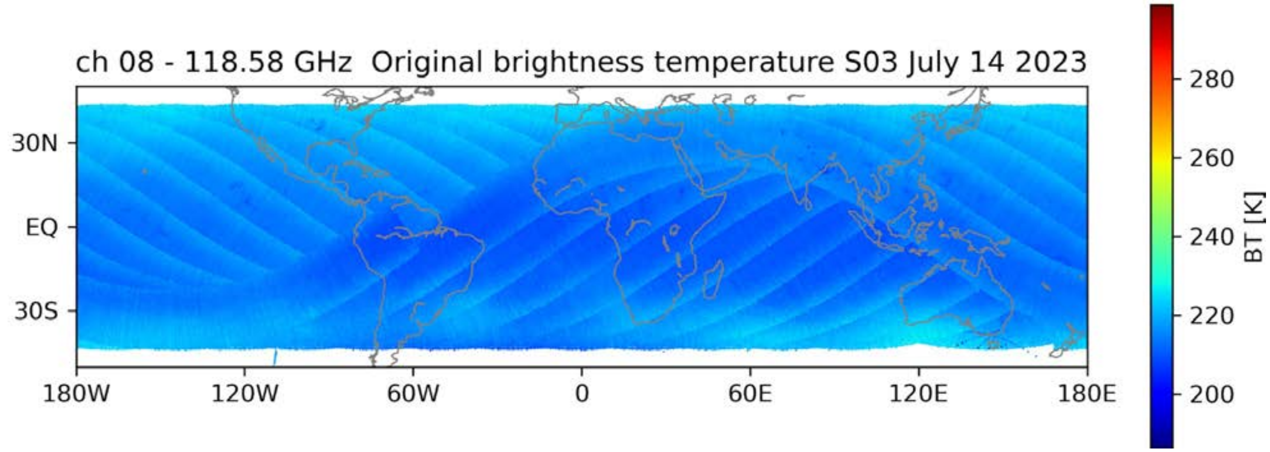

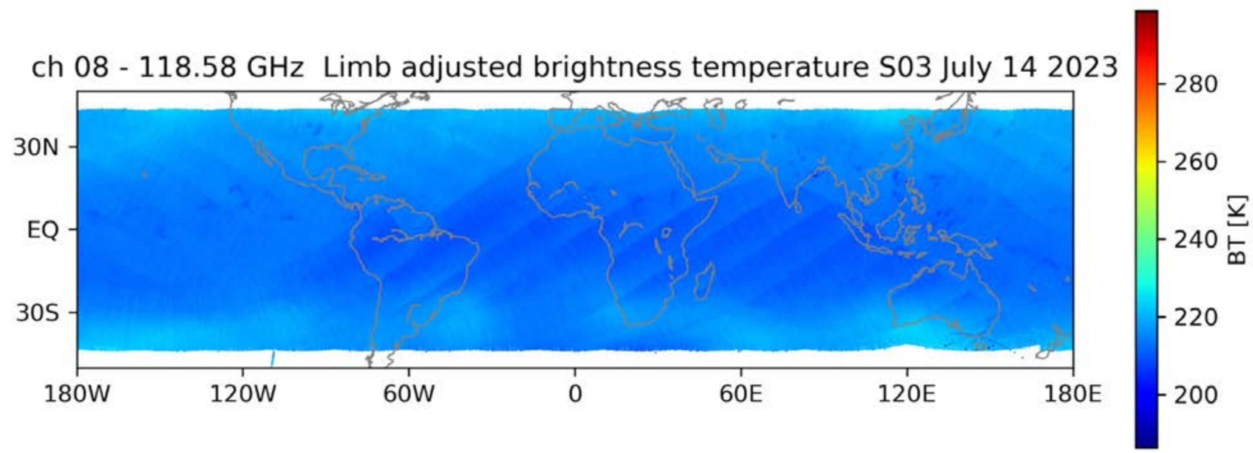

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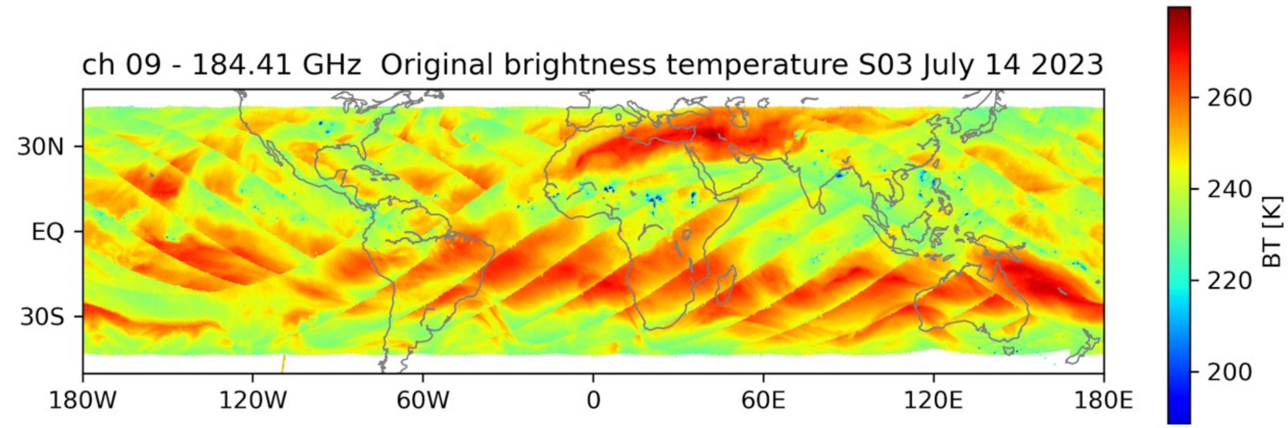

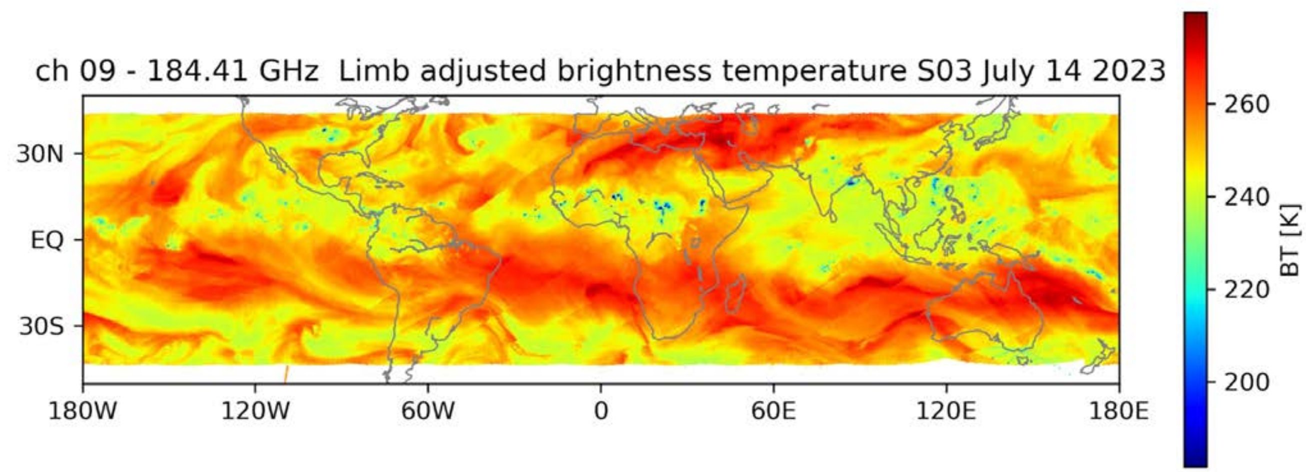

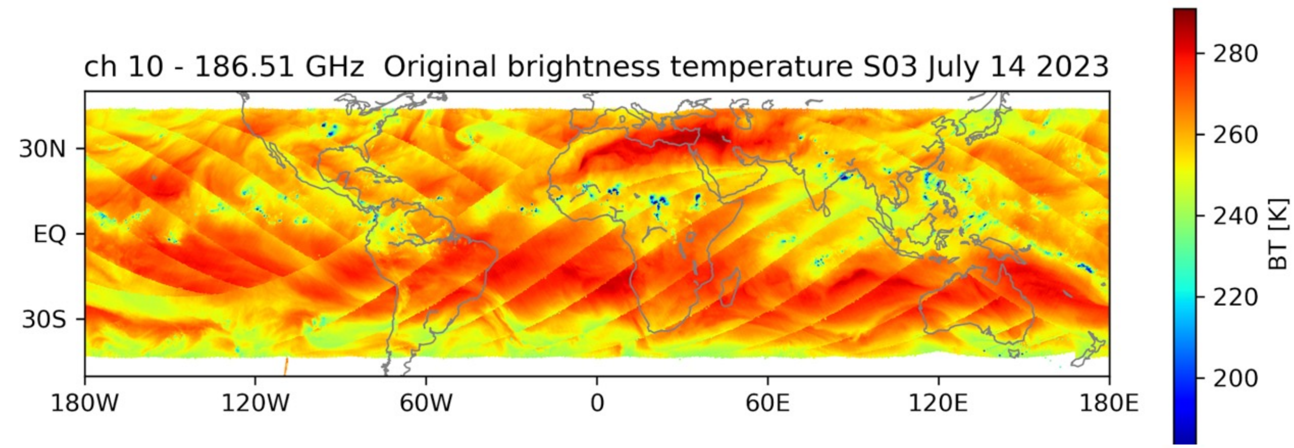
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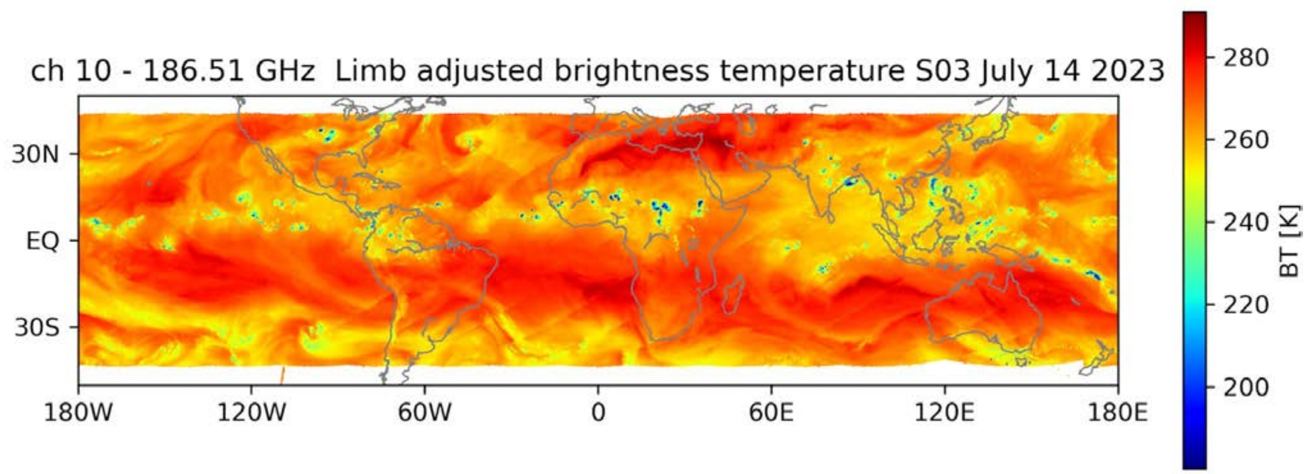
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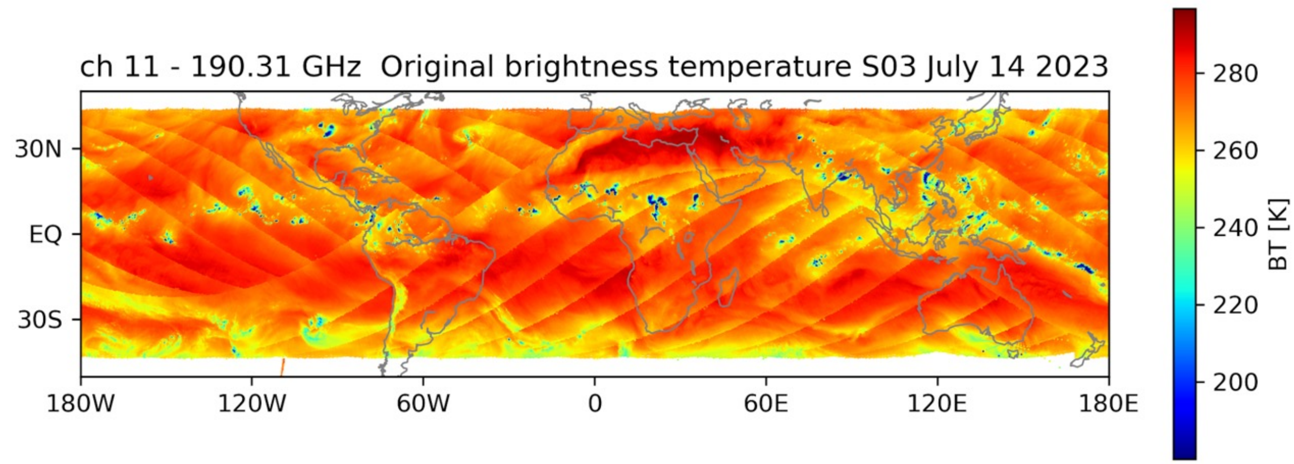
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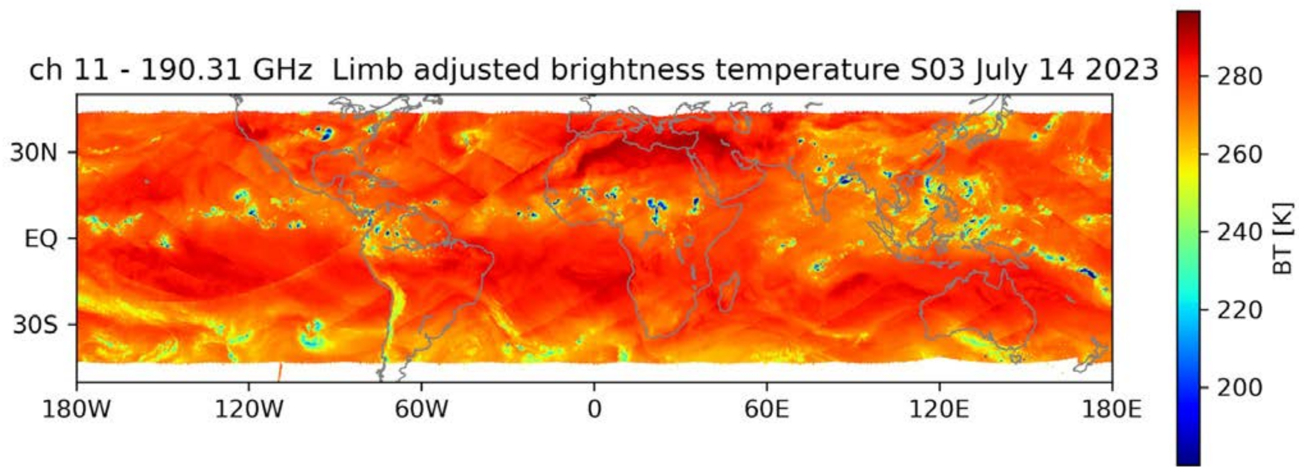
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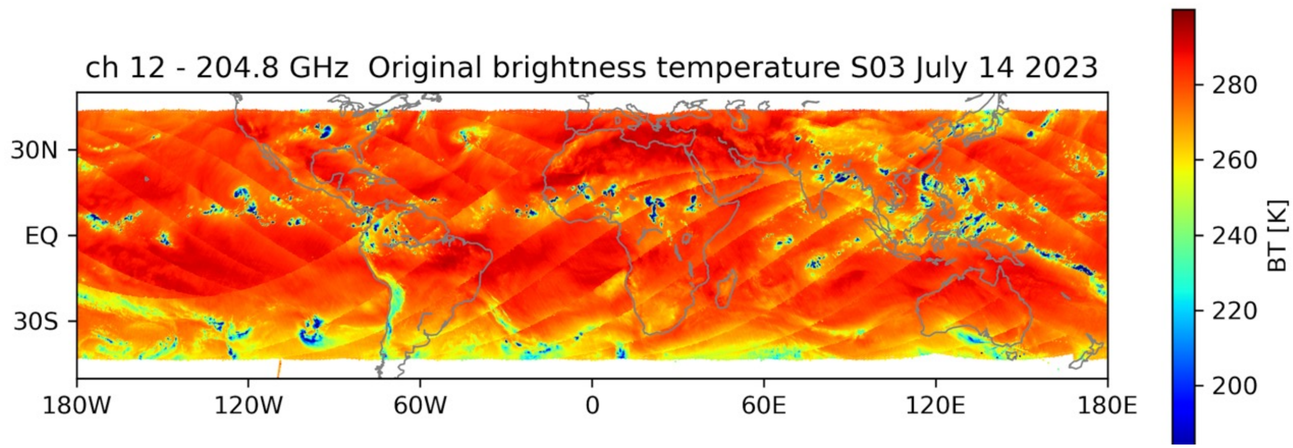
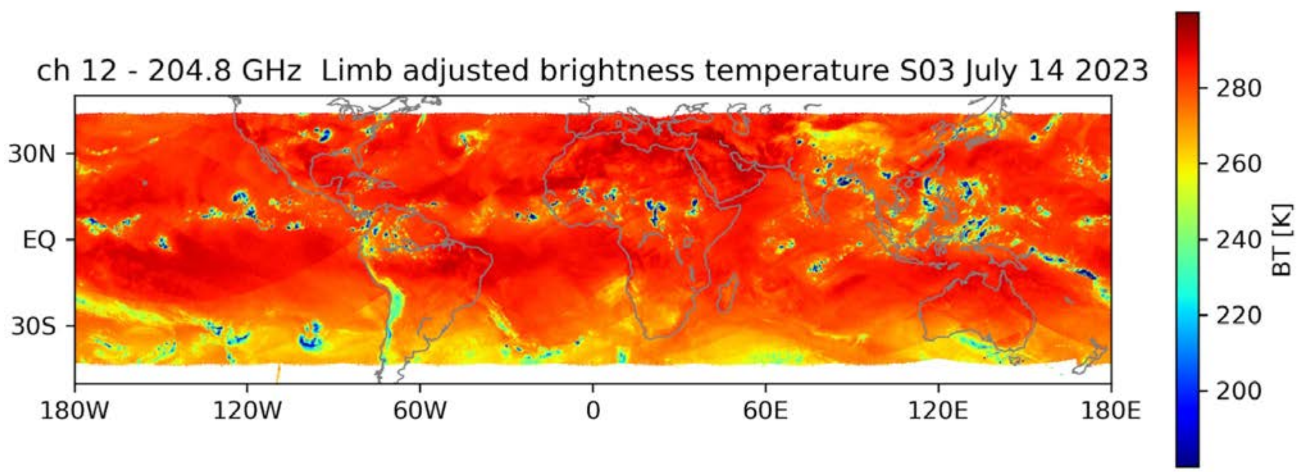
BT [K]


ch 12 - 204.8 GHz Original brightness temperature S03 July 14 2023
30N
EQ
30S
180W
120W
60W
0
60E
120E
180E
280
260
240
220
200
BT [K]


ch 12 - 204.8 GHz Limb adjusted brightness temperature S03 July 14 2023
30N
EQ
30S
180W
120W
60W
0
60E
120E
180E
280
260
240
220
200
BT [K]

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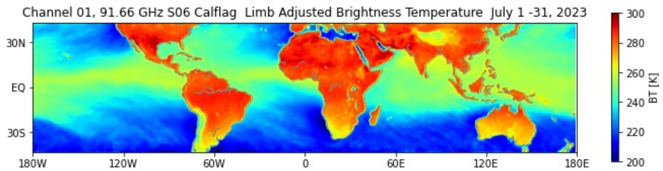

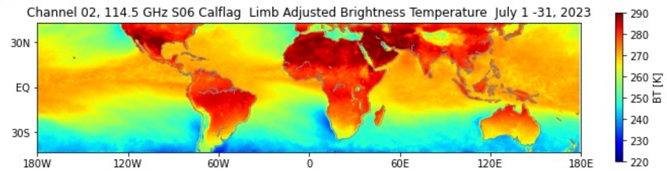

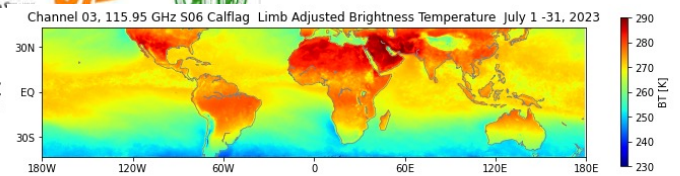

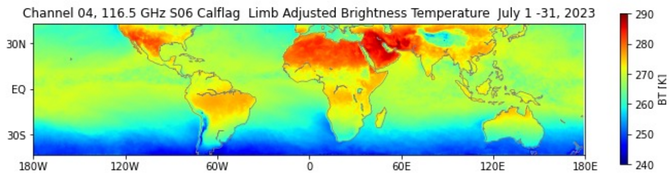

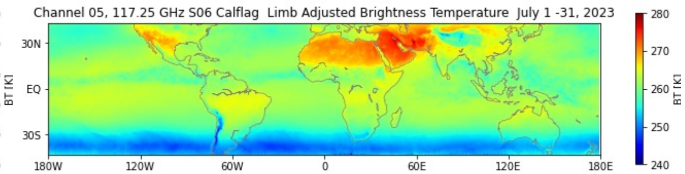

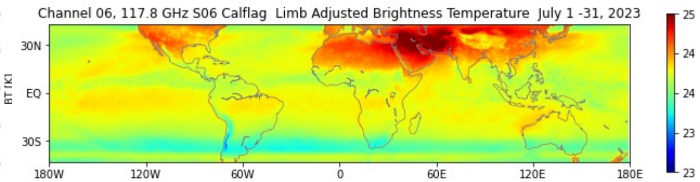

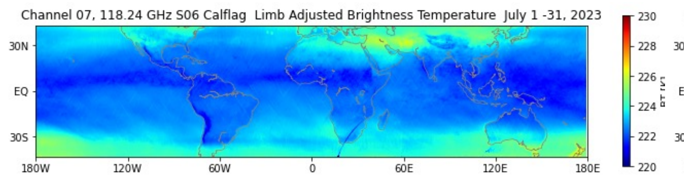

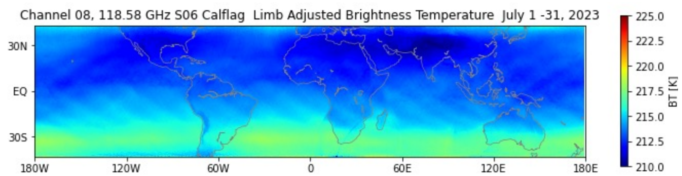

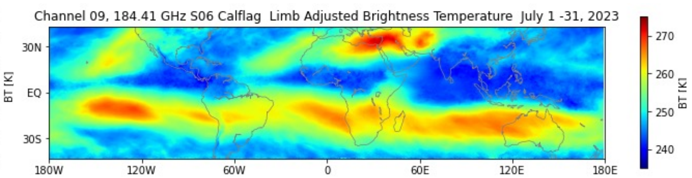

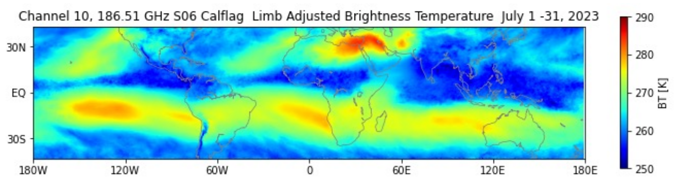

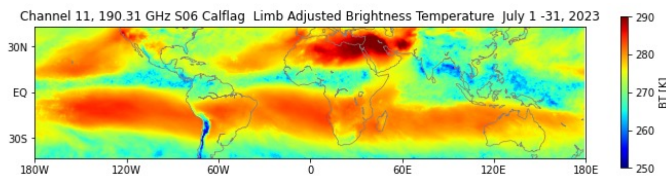

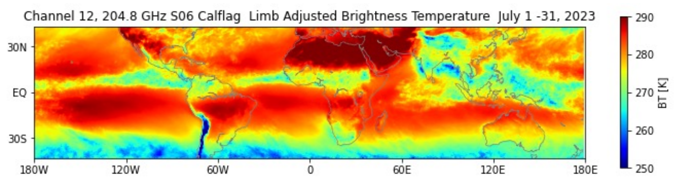

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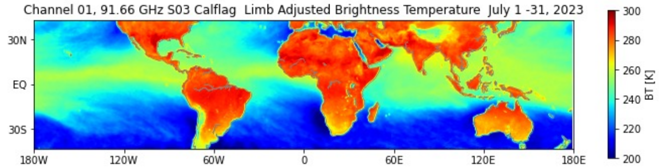
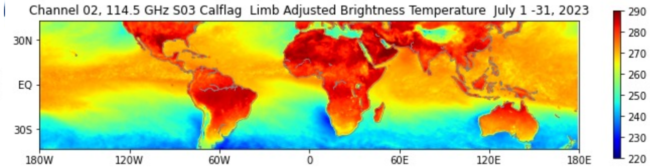
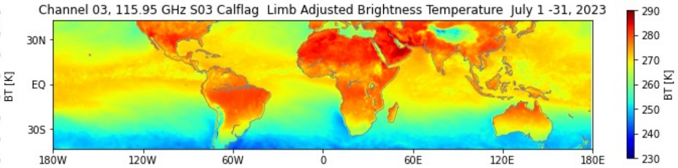
Channel 01, 91.66 GHz S03 Calflag Limb Adjusted Brightness Temperature July 1 -31, 2023



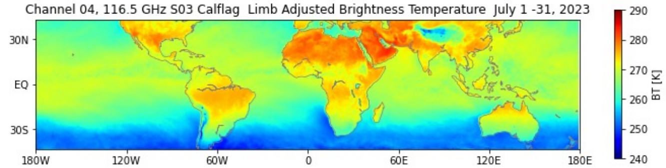
Channel 02, 114.5 GHz S03 Calflag Limb Adjusted Brightness Temperature July 1 -31, 2023



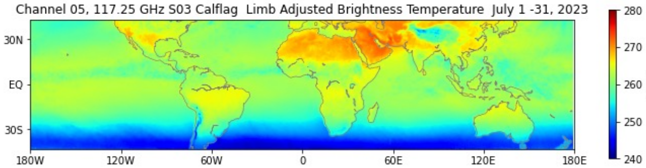
Channel 03, 115.95 GHz S03 Calflag Limb Adjusted Brightness Temperature July 1 -31, 2023



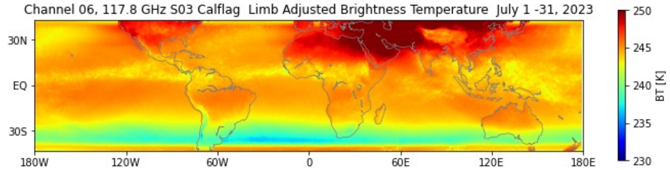
Channel 04, 116.5 GHz S03 Calflag Limb Adjusted Brightness Temperature July 1 -31, 2023



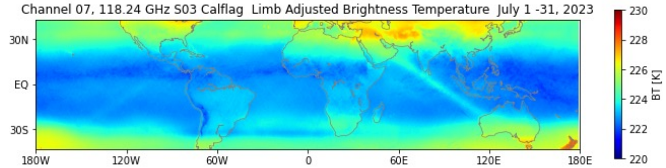
Channel 05, 117.25 GHz S03 Calflag Limb Adjusted Brightness Temperature July 1 -31, 2023



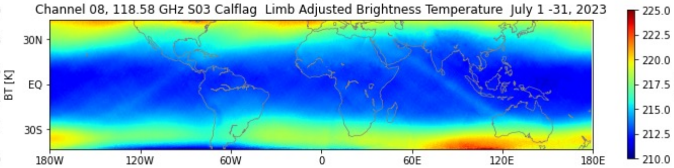
Channel 06, 117.8 GHz S03 Calflag Limb Adjusted Brightness Temperature July 1 -31, 2023



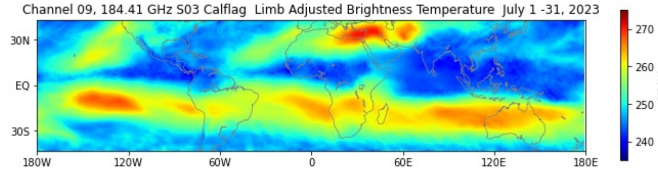
Channel 07, 118.24 GHz S03 Calflag Limb Adjusted Brightness Temperature July 1 -31, 2023



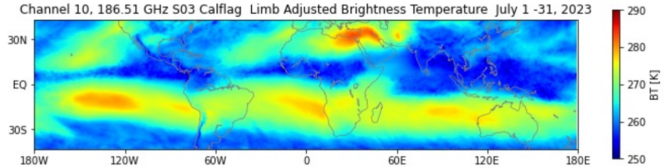
Channel 08, 118.58 GHz S03 Calflag Limb Adjusted Brightness Temperature July 1 -31, 2023



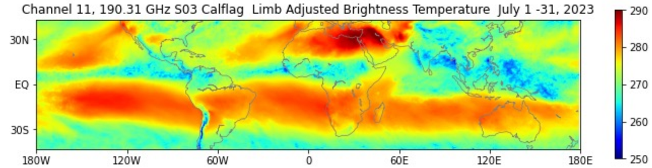
Channel 09, 184.41 GHz S03 Calflag Limb Adjusted Brightness Temperature July 1 -31, 2023



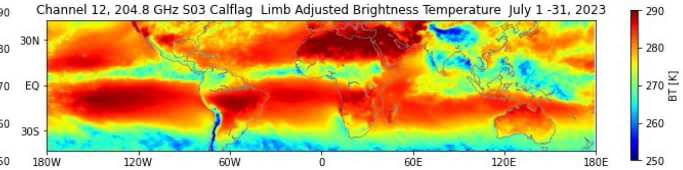
Channel 10, 186.51 GHz S03 Calflag Limb Adjusted Brightness Temperature July 1 -31, 2023



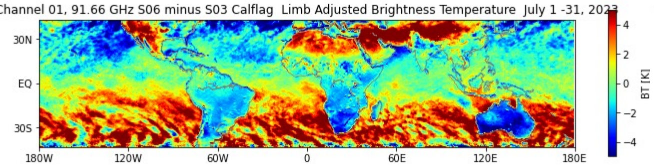
Channel 11, 190.31 GHz S03 Calflag Limb Adjusted Brightness Temperature July 1 -31, 2023



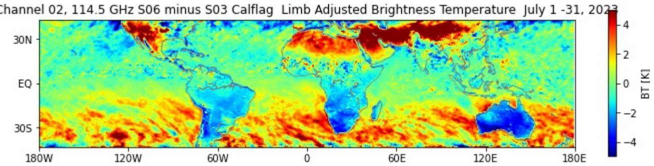
Channel 12, 204.8 GHz S03 Calflag Limb Adjusted Brightness Temperature July 1 -31, 2023



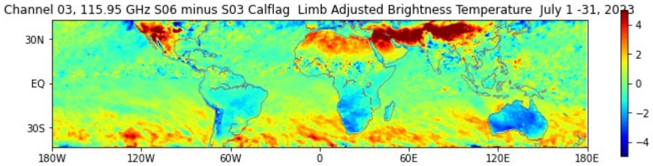
Channel 01, 91.66 GHz S06 minus S03 Calflag Limb Adjusted Brightness Temperature July 1 -31, 2023



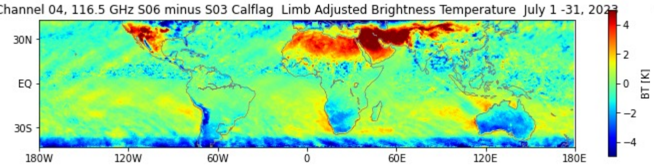
Channel 02, 114.5 GHz S06 minus S03 Calflag Limb Adjusted Brightness Temperature July 1 -31, 2023



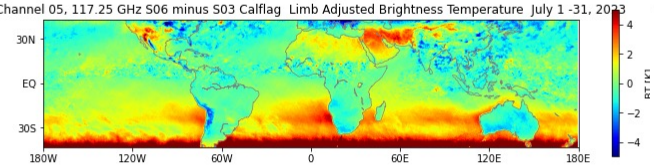
Channel 03, 115.95 GHz S06 minus S03 Calflag Limb Adjusted Brightness Temperature July 1 -31, 2023



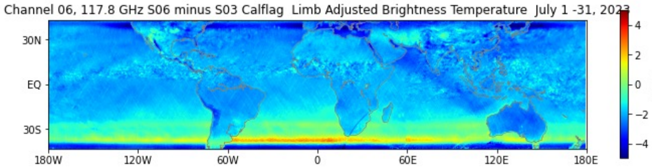
Channel 04, 116.5 GHz S06 minus S03 Calflag Limb Adjusted Brightness Temperature July 1 -31, 2023



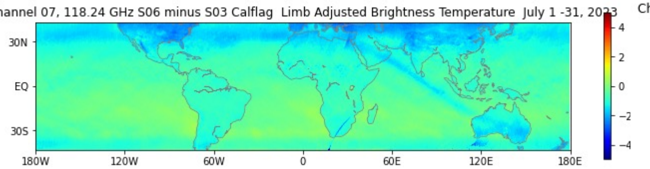
Channel 05, 117.25 GHz S06 minus S03 Calflag Limb Adjusted Brightness Temperature July 1 -31, 2023



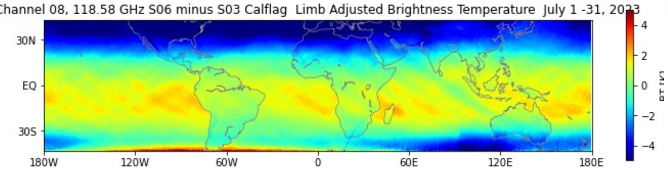
Channel 06, 117.8 GHz S06 minus S03 Calflag Limb Adjusted Brightness Temperature July 1 -31, 2023



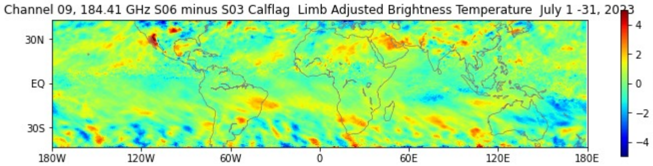
Channel 07, 118.24 GHz S06 minus S03 Calflag Limb Adjusted Brightness Temperature July 1 -31, 2023



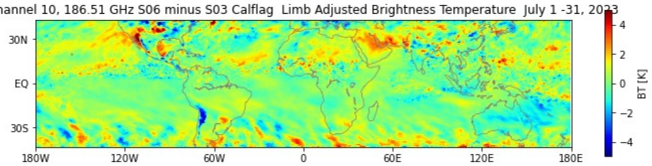
Channel 08, 118.58 GHz S06 minus S03 Calflag Limb Adjusted Brightness Temperature July 1 -31, 2023



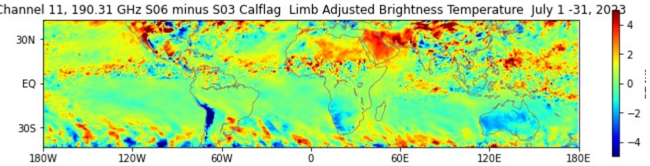
Channel 09, 184.41 GHz S06 minus S03 Calflag Limb Adjusted Brightness Temperature July 1 -31, 2023



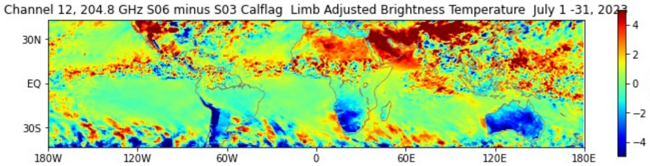
Channel 10, 186.51 GHz S06 minus S03 Calflag Limb Adjusted Brightness Temperature July 1 -31, 2023



Channel 11, 190.31 GHz S06 minus S03 Calflag Limb Adjusted Brightness Temperature July 1 -31, 2023



Channel 12, 204.8 GHz S06 minus S03 Calflag Limb Adjusted Brightness Temperature July 1 -31, 2023



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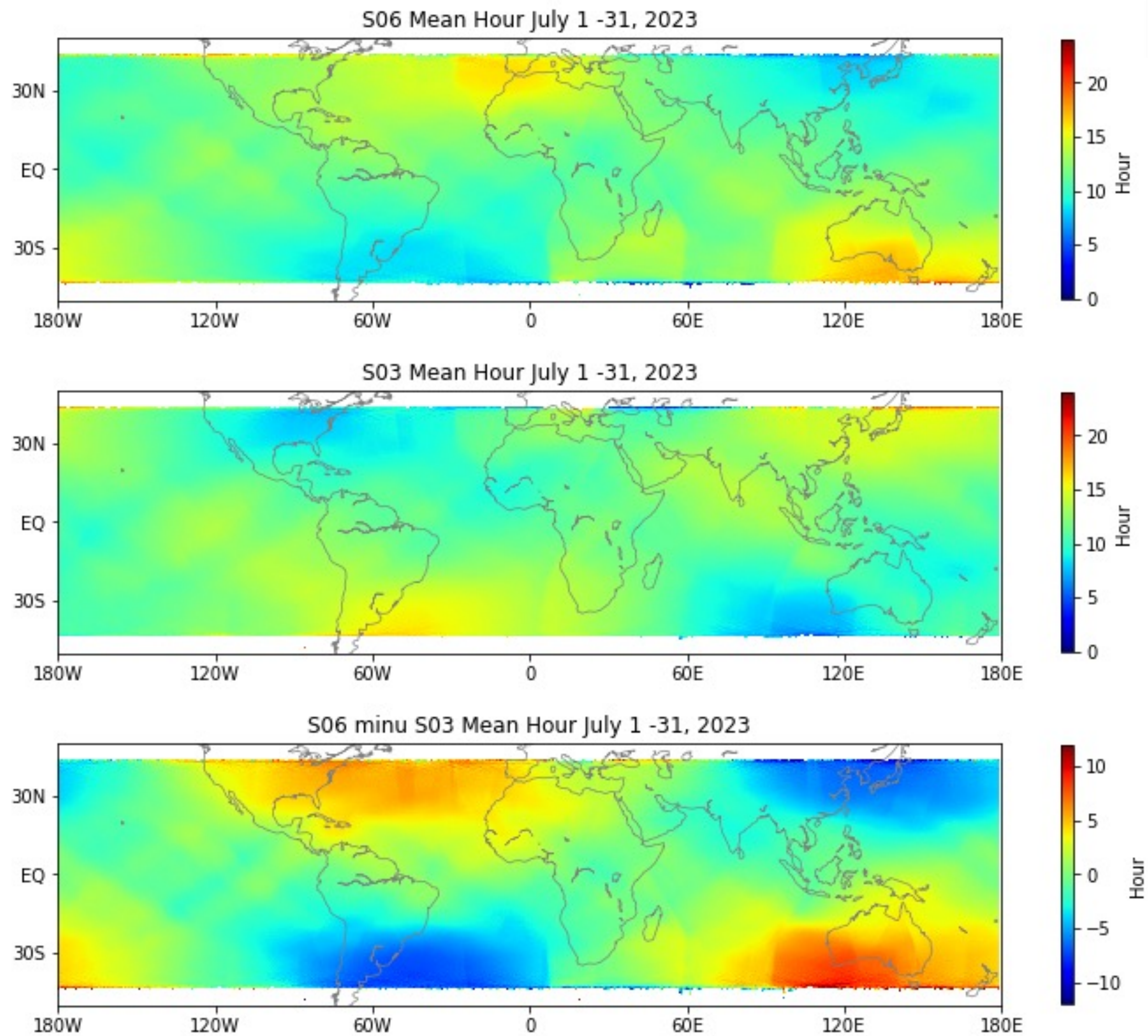

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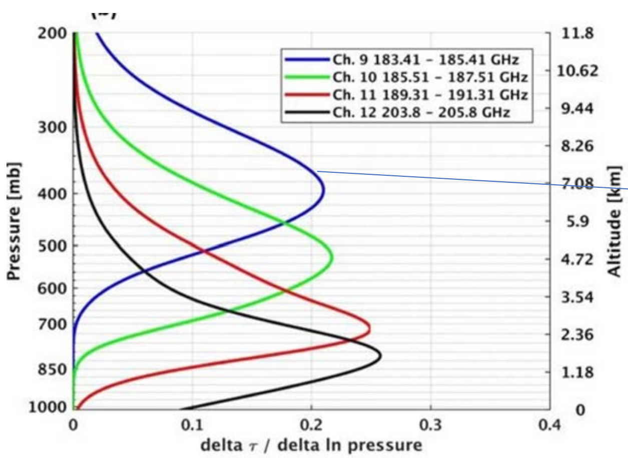
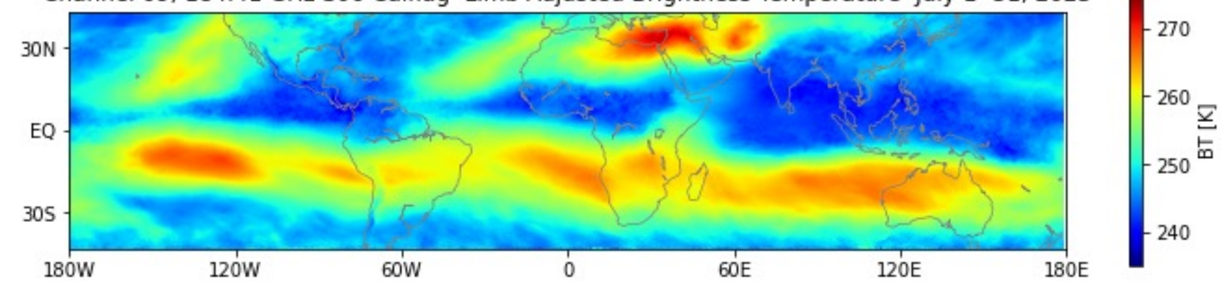
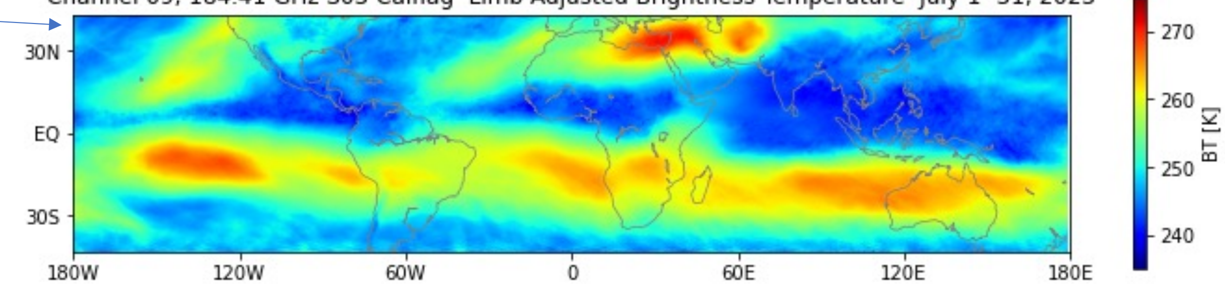


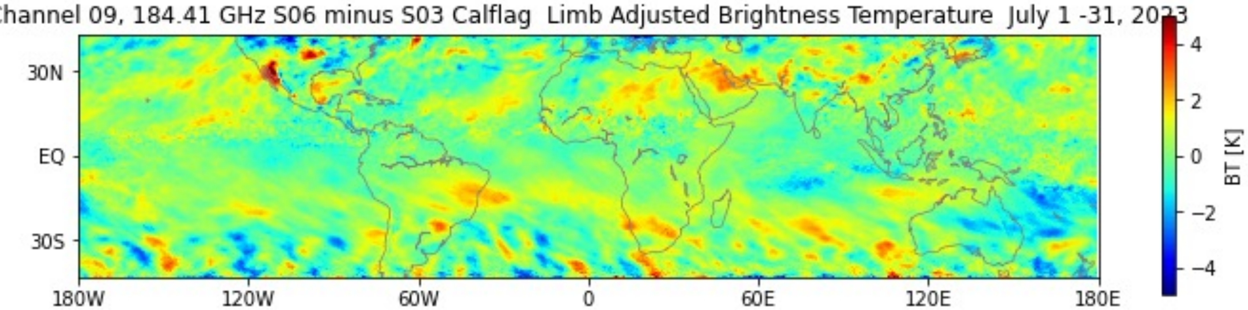
Channel 09, 184.41 GHz S06 Calflag Limb Adjusted Brightness Temperature July 1 -31, 2023



Channel 09, 184.41 GHz S03 Calflag Limb Adjusted Brightness Temperature July 1 -31, 2023



Channel 09, 184.41 GHz S06 minus S03 Calflag Limb Adjusted Brightness Temperature July 1 -31, 2023



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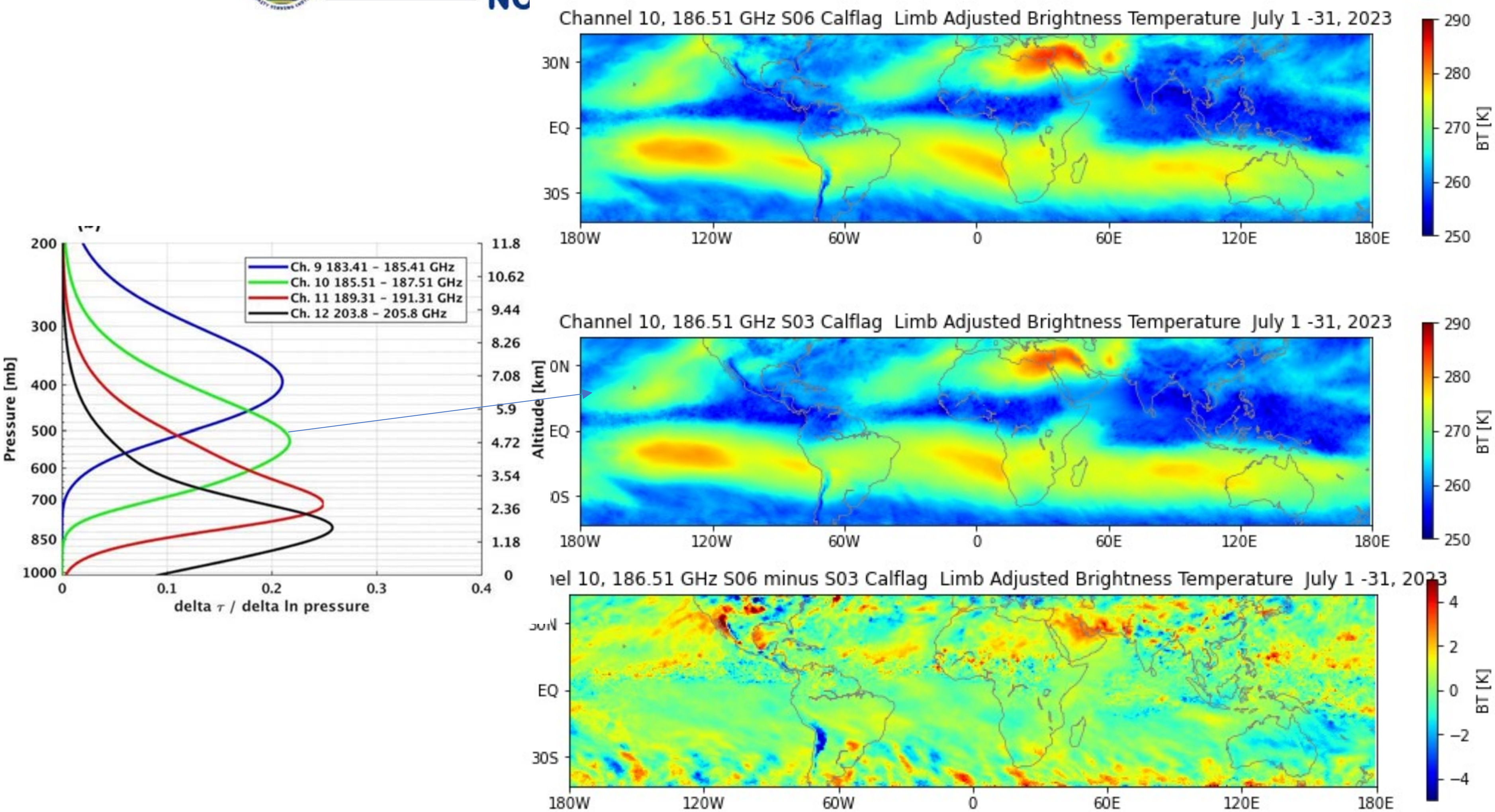

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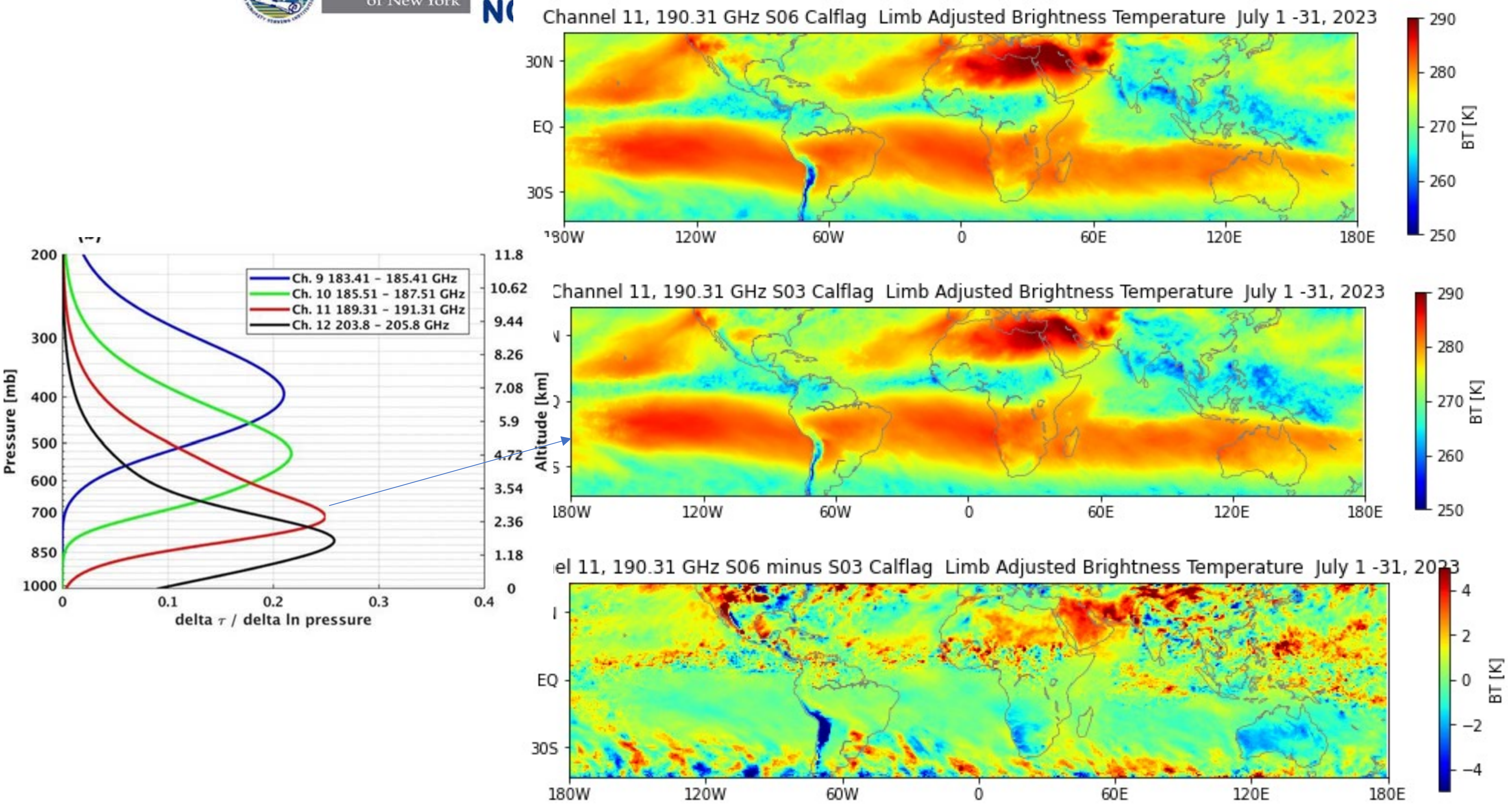
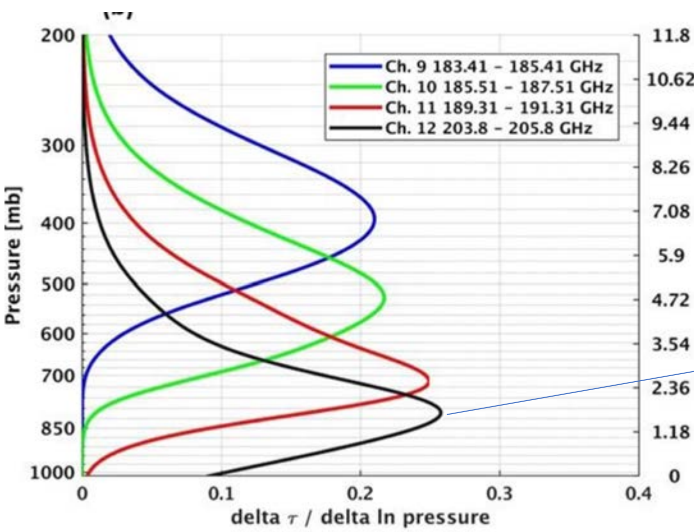
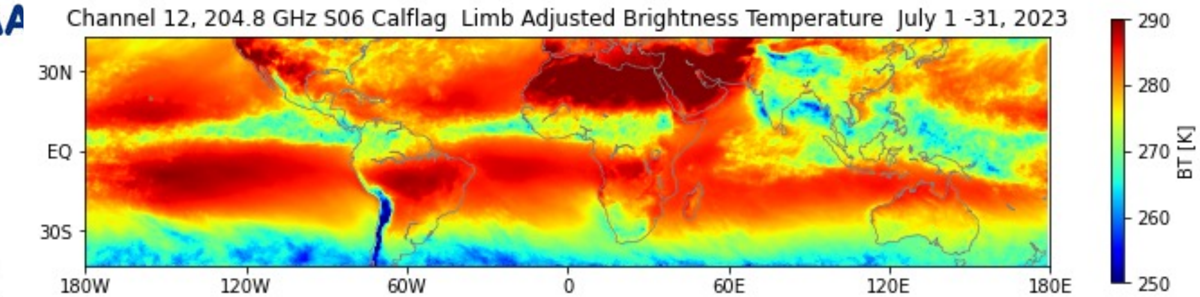
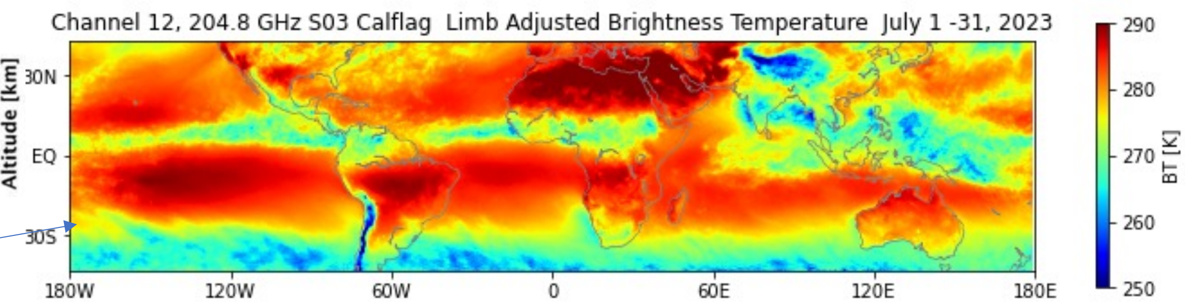



Ch. 9 183.41 – 185.41 GHz
Ch. 10 185.51 – 187.51 GHz
Ch. 11 189.31 – 191.31 GHz
Ch. 12 203.8 – 205.8 GHz
Pressure [mb]
Altitude [km]
delta τ / delta ln pressure


Channel 12, 204.8 GHz S06 Calflag Limb Adjusted Brightness Temperature July 1 -31, 2023
BT [K]


Channel 12, 204.8 GHz S03 Calflag Limb Adjusted Brightness Temperature July 1 -31, 2023
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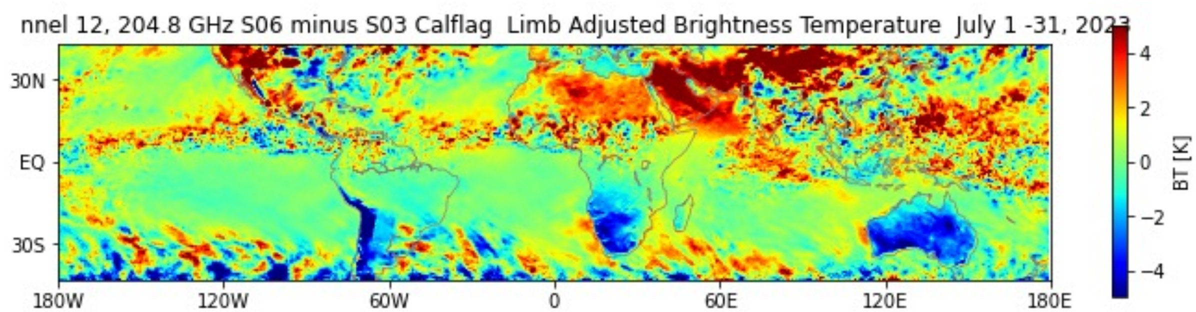
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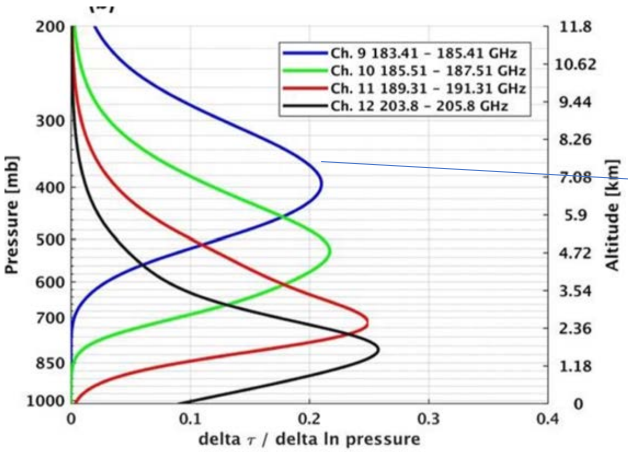
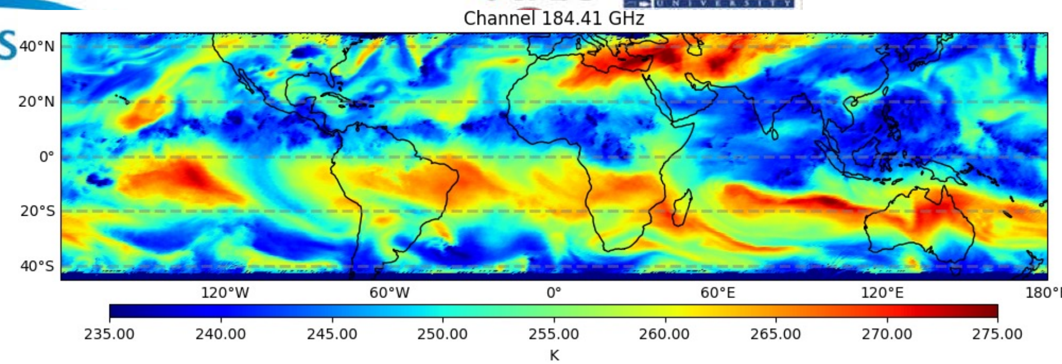
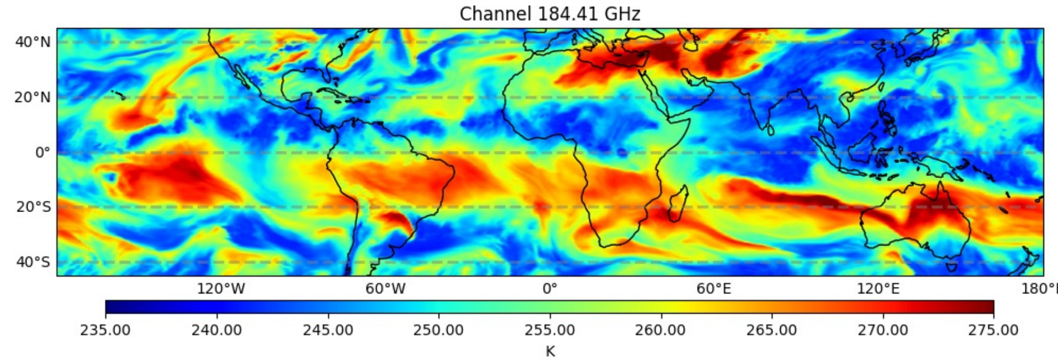
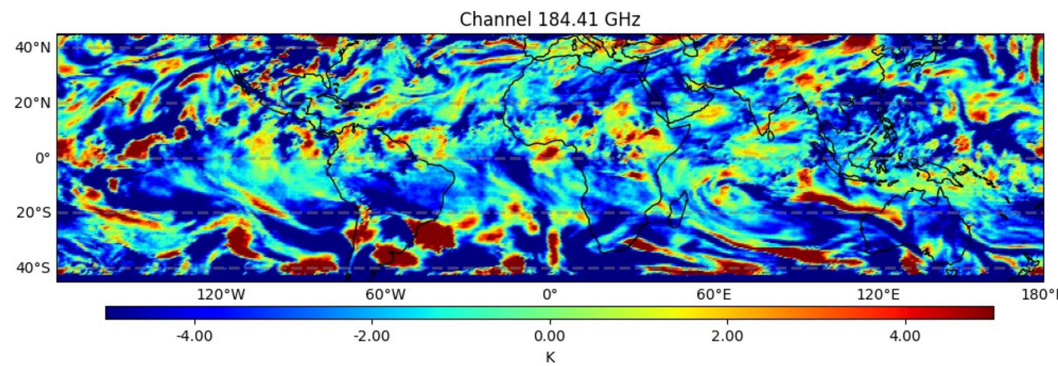


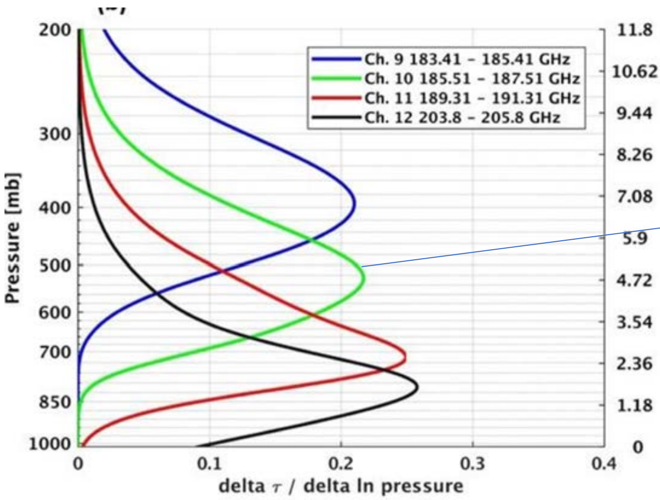


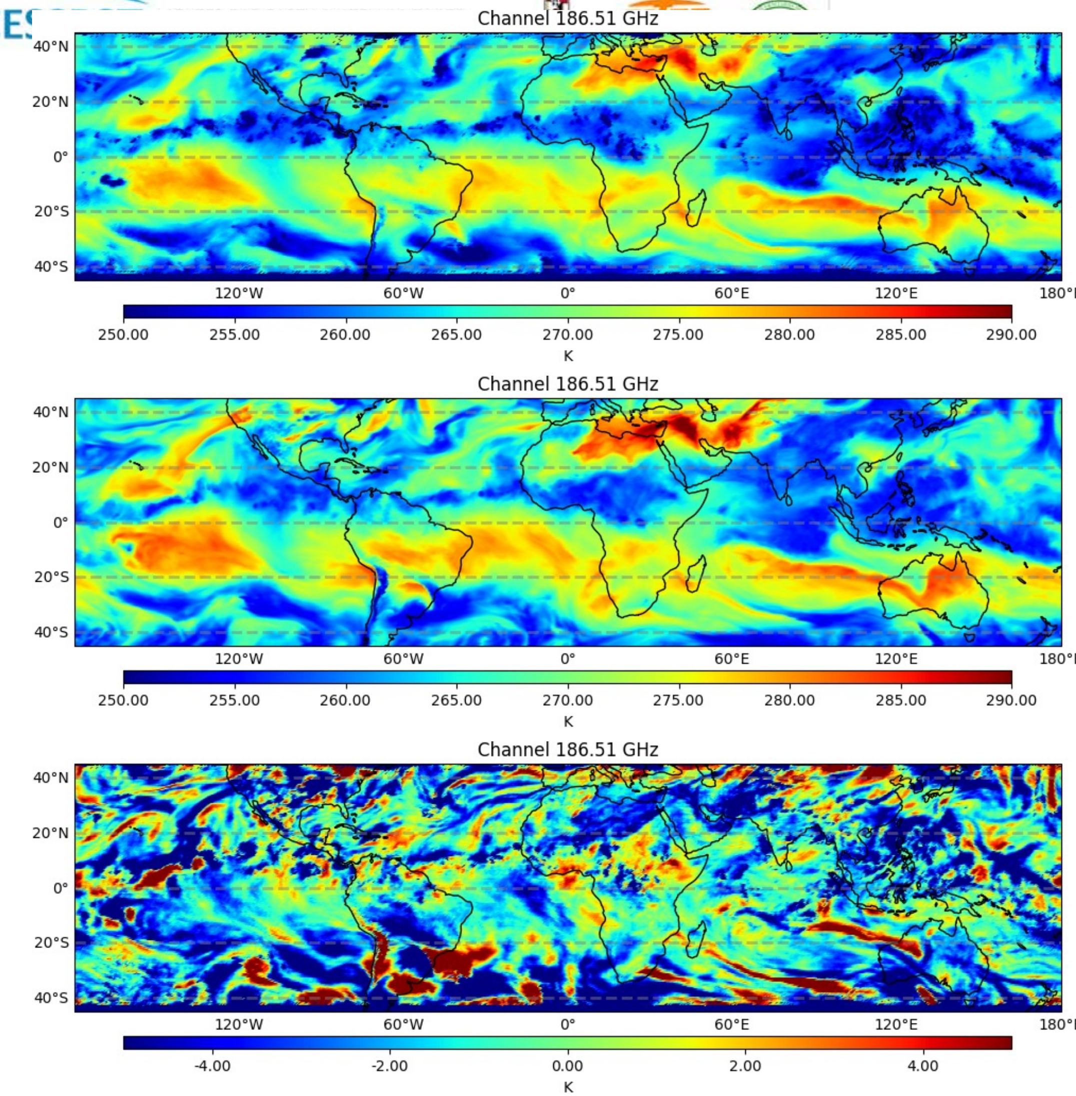


Observed minus calculated ERA5
July 13, 2023

TROPICS full day vs ERA5@ 3 UTC







Observed minus calculated ERA5
July 13, 2023

TROPICS full day vs ERA5@ 3 UTC

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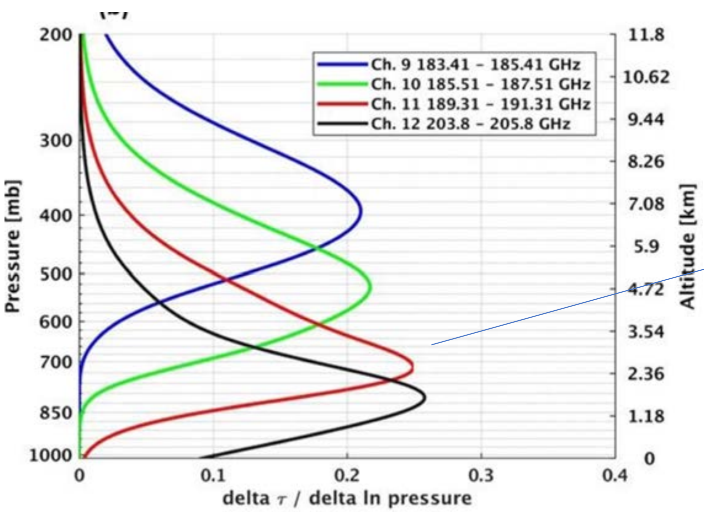
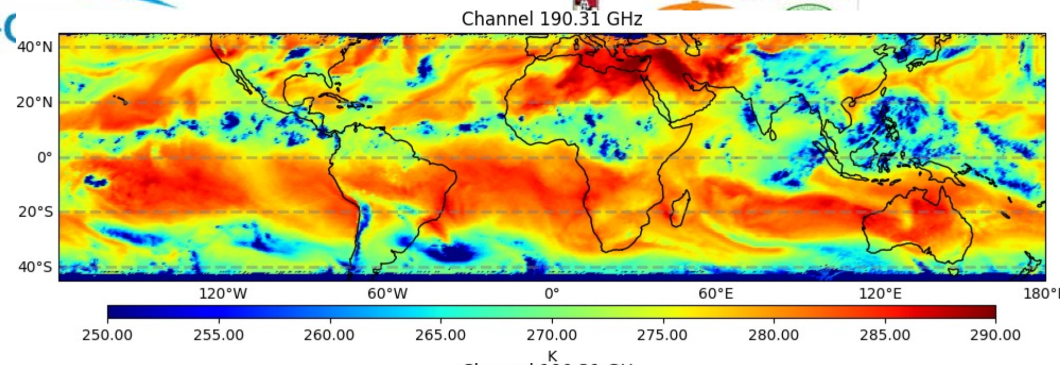
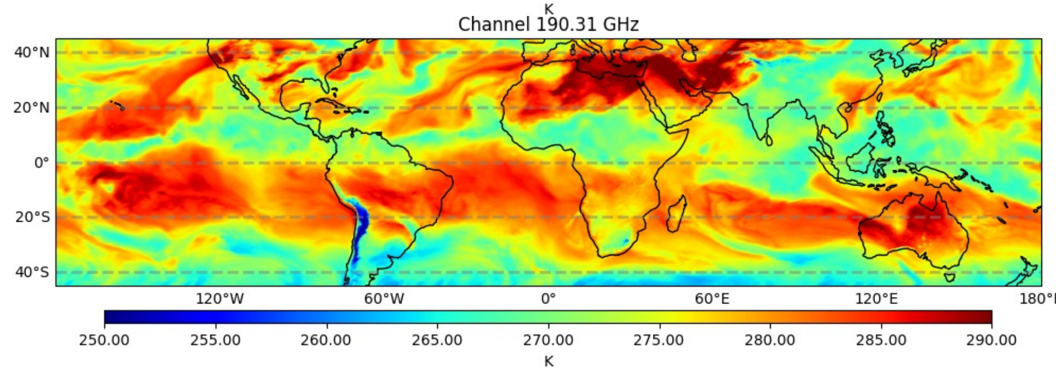
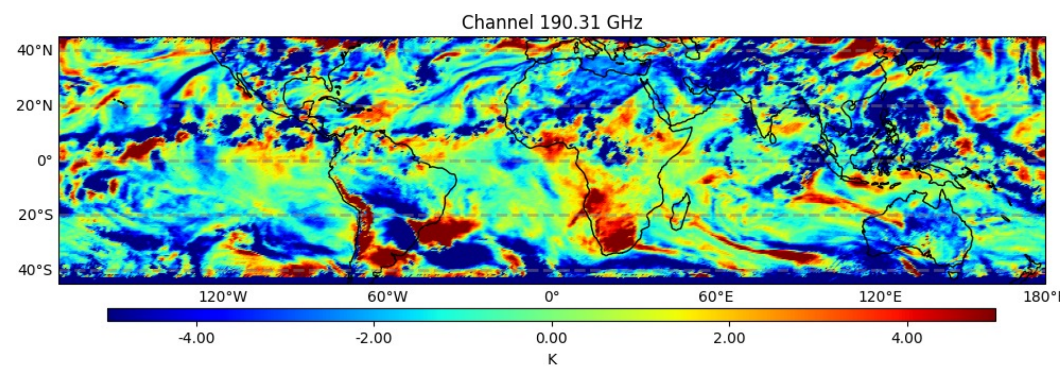


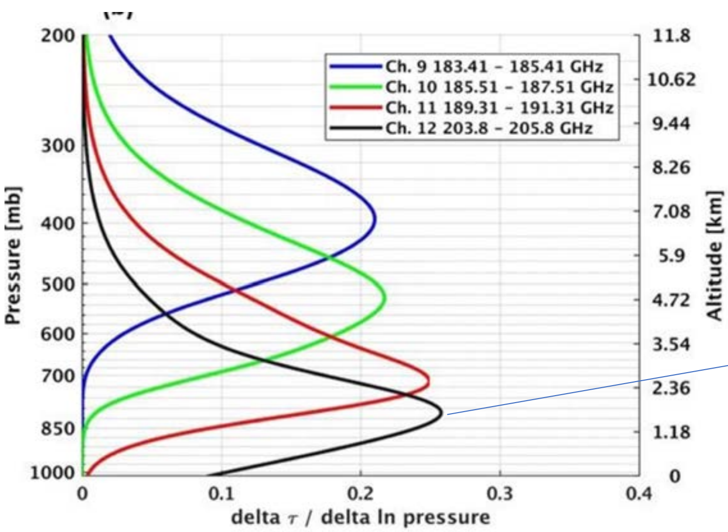


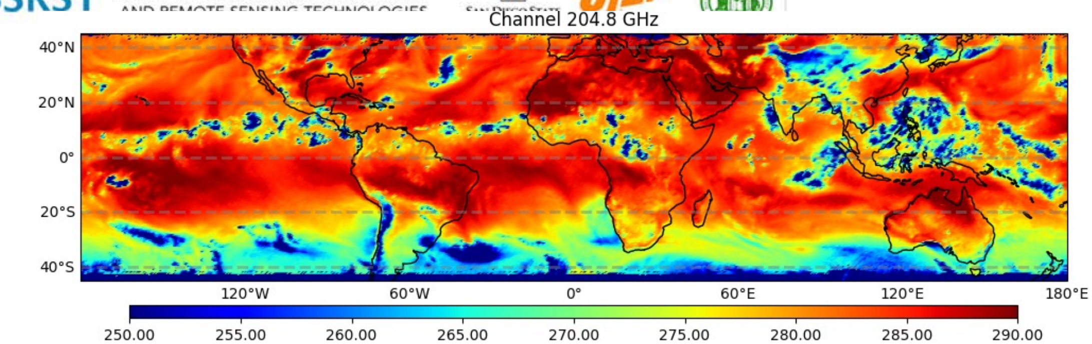


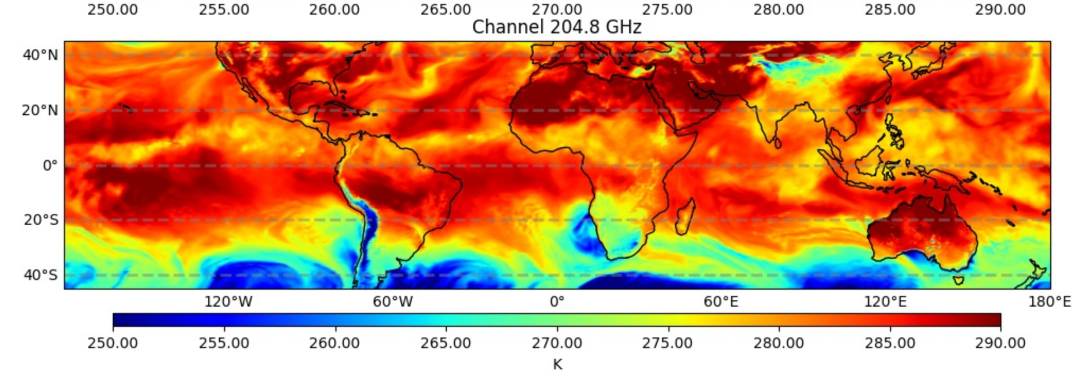
Observed minus calculated ERA5
July 13, 2023

TROPICS full day vs ERA5@ 3 UTC



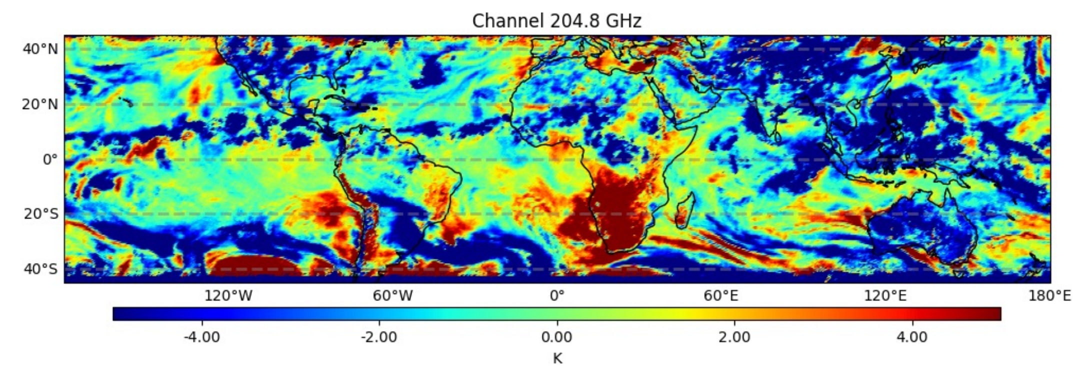






Observed minus calculated ERA5
July 13, 2023

TROPICS full day vs ERA5@ 3 UTC



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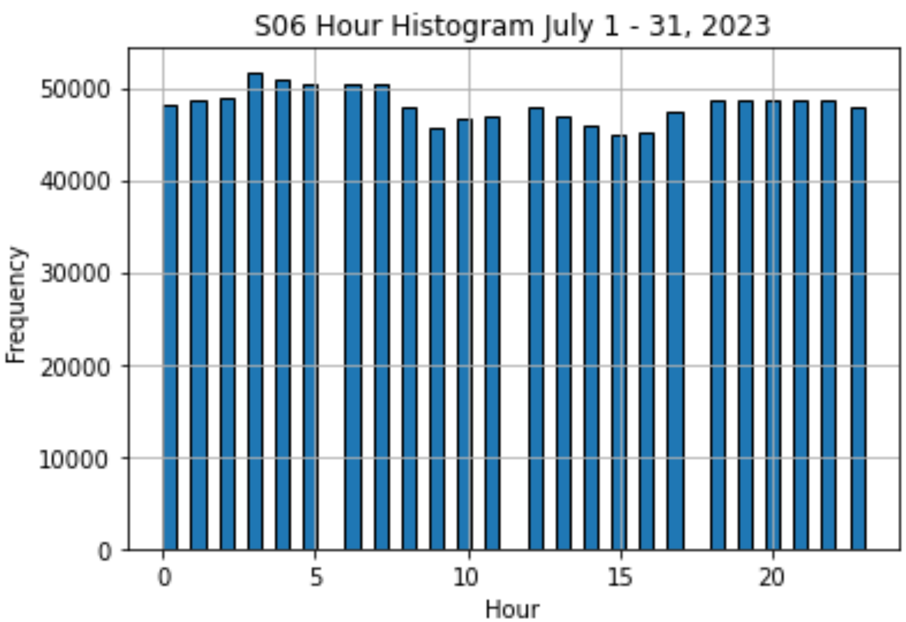

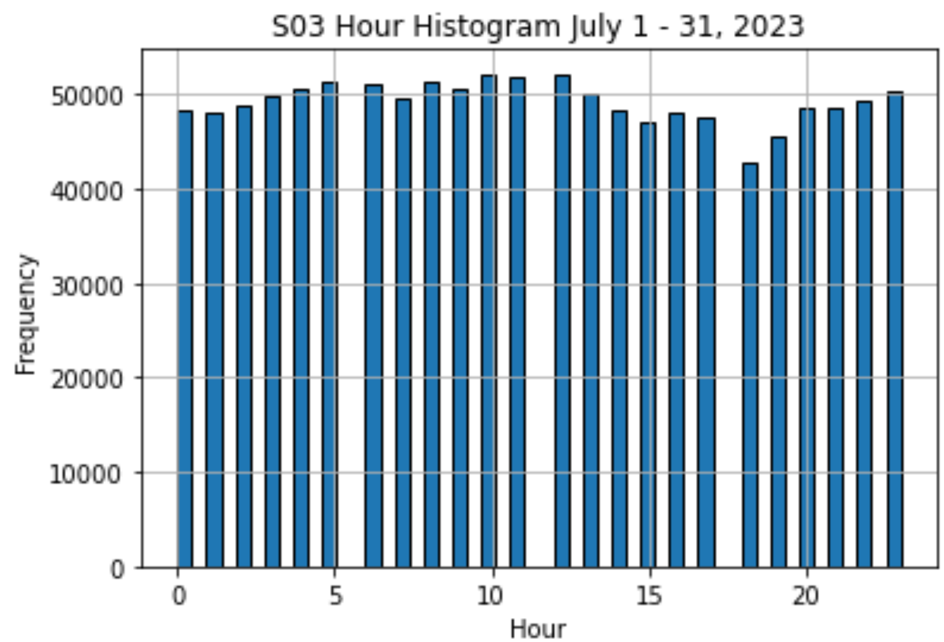

The City College of New York

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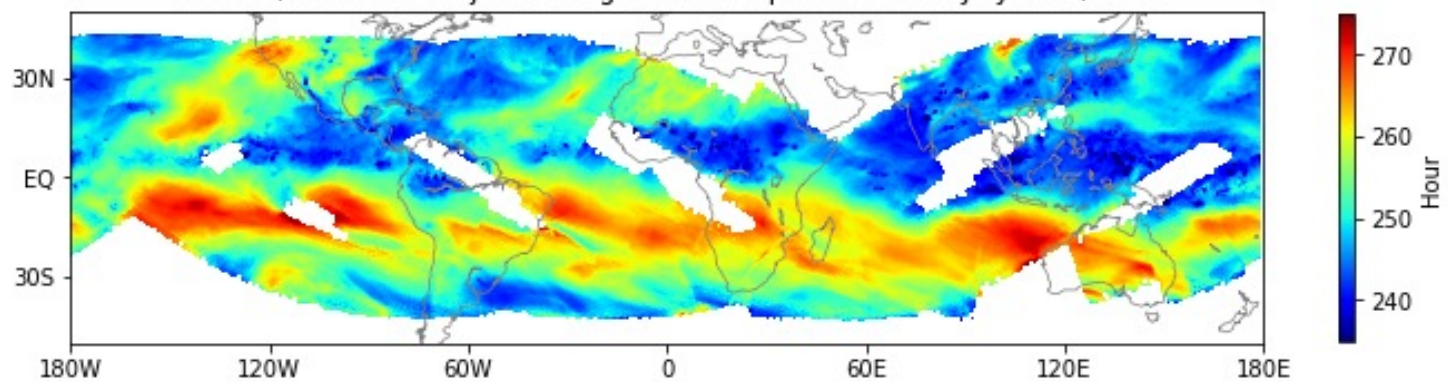
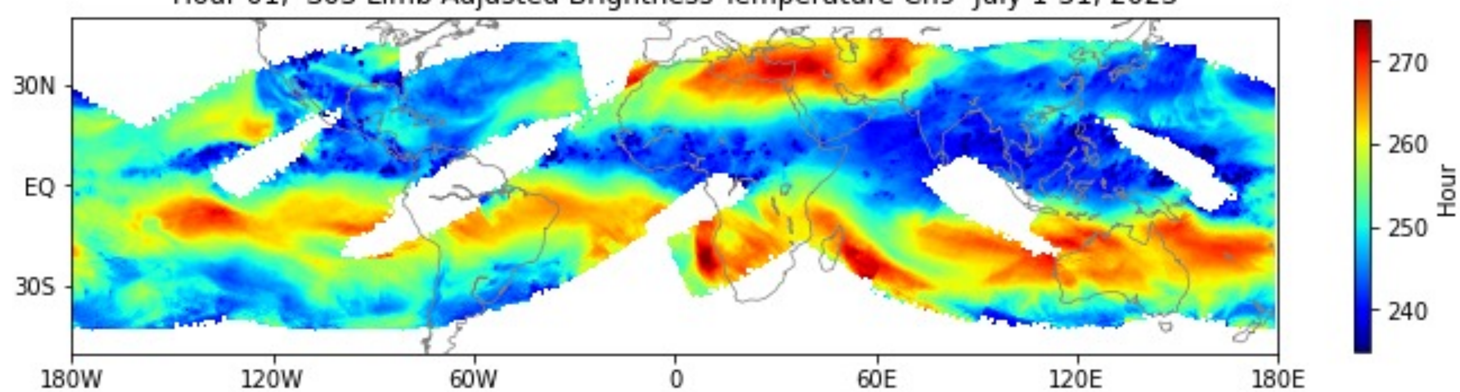
HAMPTON

Hour 01, S06 Limb Adjusted Brightness Temperature Ch9 July 1-31, 2023



Hour 01, S03 Limb Adjusted Brightness Temperature Ch9 July 1-31, 2023



Summary

- TROPICS data looks promising
- Water vapor channels. – satellite to satellite differences are smaller than satellite to ECMWF simulated (esp. upper tropospheric)
- However we need to account for satellite to satellite differences, limb adjustment is one approach - looks very promising for the water vapor channels. Also we should look at observed minus analysis calculated - especially for the temperature channels.
- Collaborate to get feedback from NWS forecasters
- How do we maximize the utilization of the water vapor channels?
  - For both weather and climate applications.
  - We should keep the water vapor bias corrections free of NWP.
- Limb adjustment coefficients are available.
- More comparison with ECMWF ERA5 and with ATMS
- Limb adjusted imagery should be considered as a ”EDR” imagery product.