GSICS-MW Lunar Calibration Working Group Outlook

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Working Scope of the Group

- **Microwave lunar RTM model development**
  - ✦ Theoretical model development and inter comparison
  - ✦ RTM model validation with satellite observations
- **Lunar radiance measurements based on the satellite observations**
  - ✦ Lunar satellite observation calibration
  - ✦ Sensor related uncertainty in Lunar radiance measurements
- **Lunar observation applications**
  - ✦ Antenna beam pointing/Geolocation accuracy evaluation
  - ✦ Instrument long-term gain stability evaluation
  - ✦ Inter-satellite calibration

Theoretical Model for Microwave Emission of the Moon

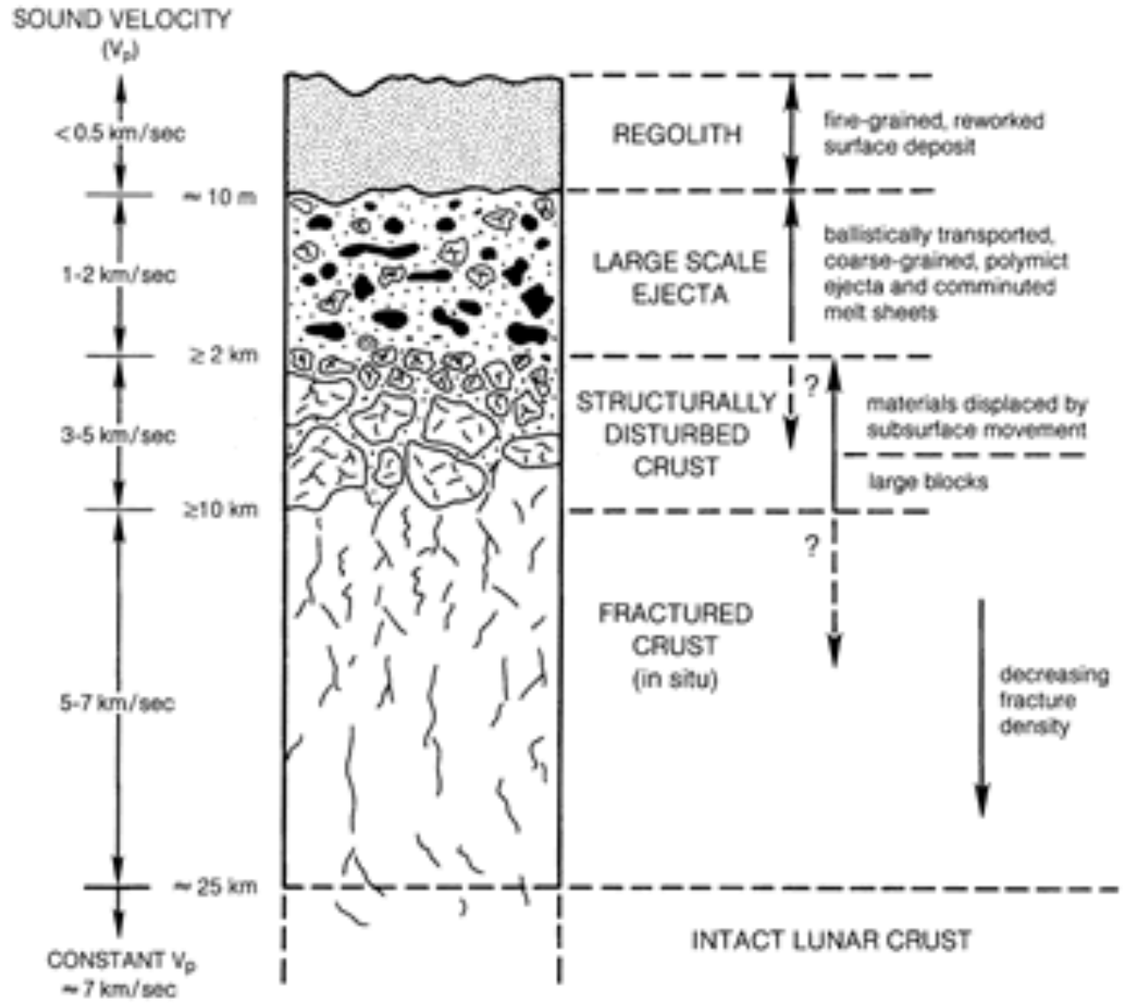
(Stephen Keihm, ICARUS 60, 1984)

For a *purely absorptive* regolith, the correlation can be expressed simply as an integration of the depth-dependent emission, attenuated by the electrical loss to the surface. For a nadir observation,

$$TB(\lambda) = E_\lambda \int_0^\infty K_\lambda \cdot T(z) \cdot \exp\left[-\int_0^z K_\lambda dz' \right] dz$$

- **Frequency dependent tangent Loss**
- **Thermal conductivity**
- **Density**
- **Specific heat**
- **Solar albedo**
- **IR emissivity**

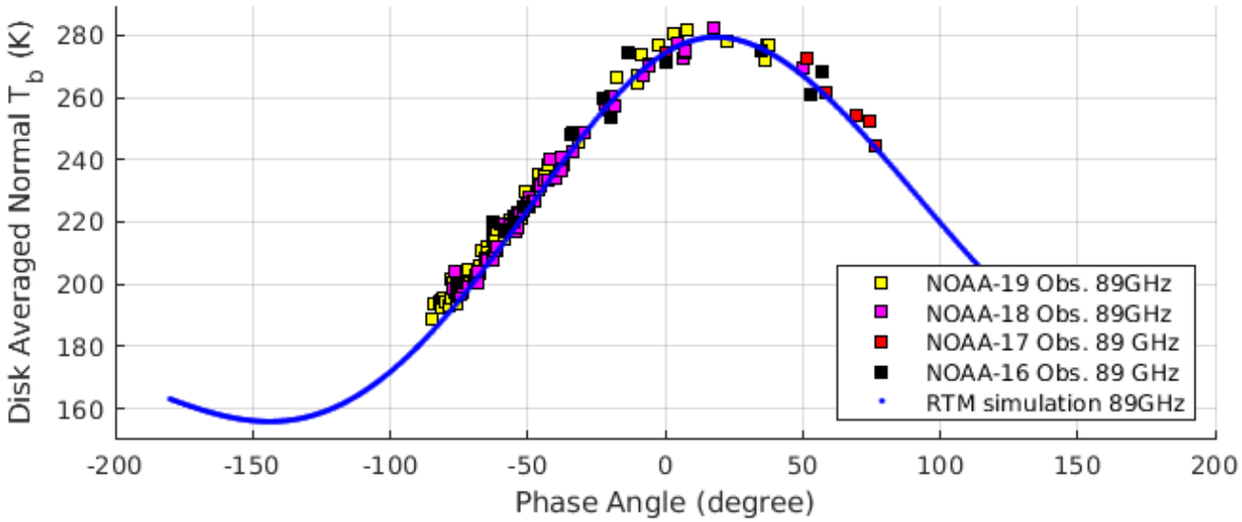
Lunar Surface Structure

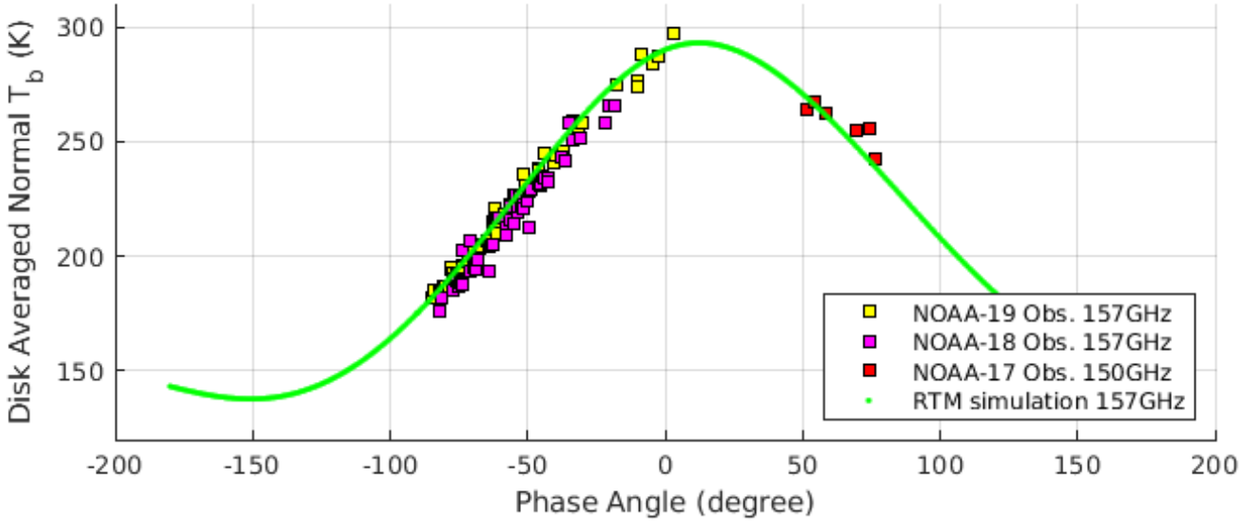


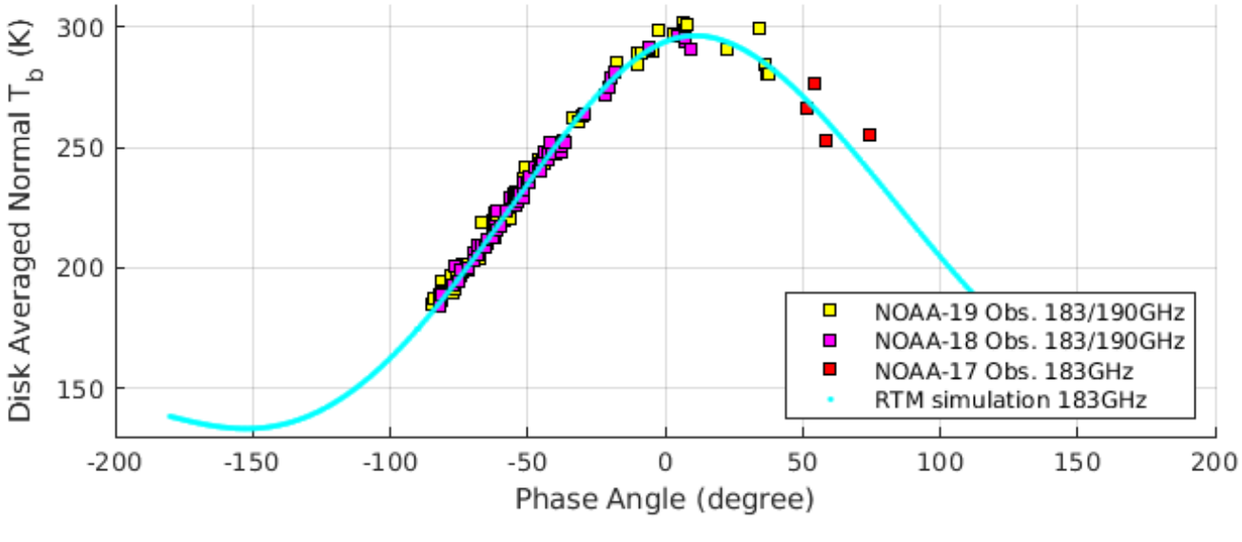
Heiken, G.H., Vaniman, D.T., & French, B.M. eds, **Lunar Sourcebook**, Lunar and Planetary Institute, Houston, 1991.

Validation with Satellite Observations

(Provided by M.Burgdorf)







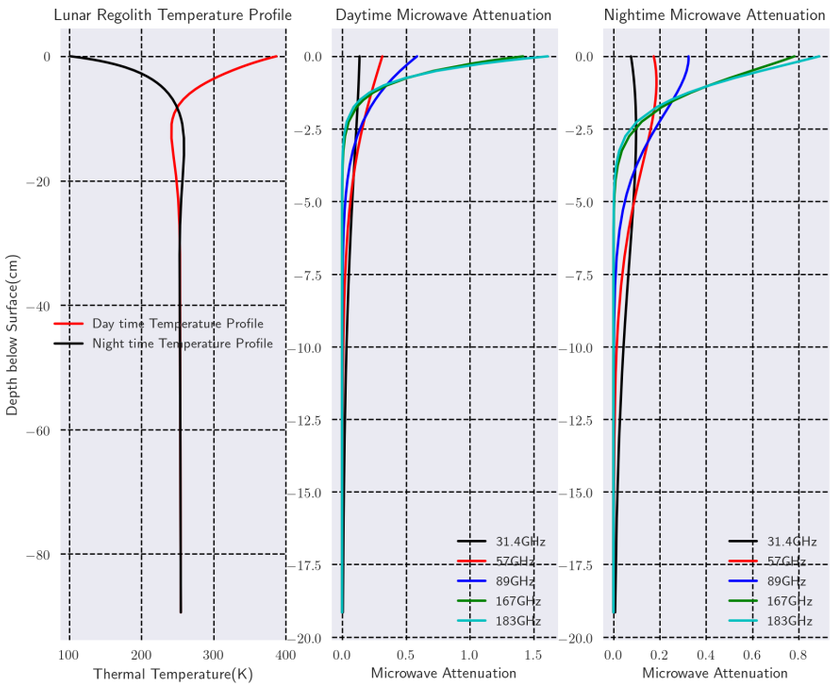
Lunar observation data sources

AMSU/MHS
ATMS
FY3 ?
Tropics ?

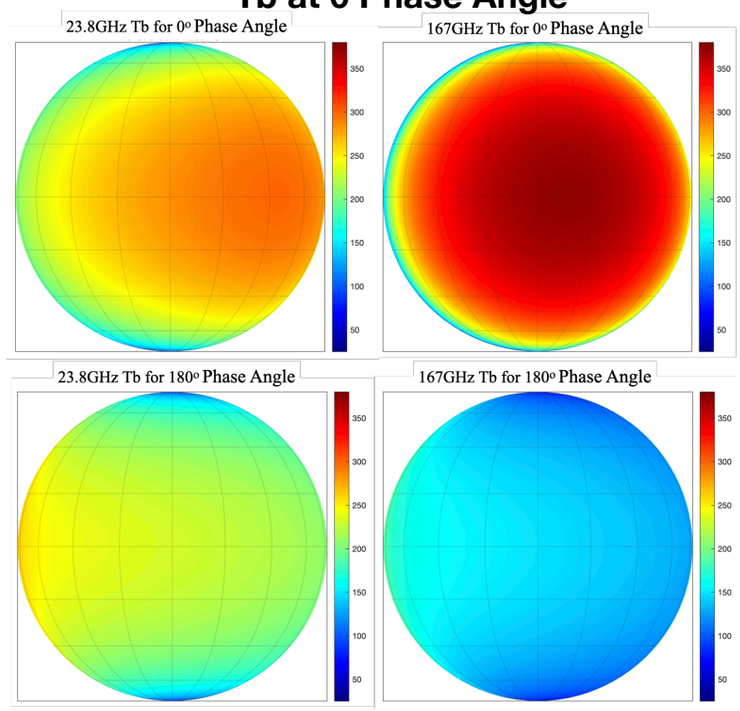
Calibration of the RTM with Satellite Observations

Yang H, Burgdorf M. A Calibrated Lunar Microwave Radiative Transfer Model Based on Satellite Observations. Remote Sensing. 2022; 14(21):5501. https://doi.org/10.3390/rs14215501

Lunar Regolith Temperature Profile and MW Thermal Emission Weighting Function



Calculated Moon Surface(Earth Side) Microwave Tb at 0 Phase Angle

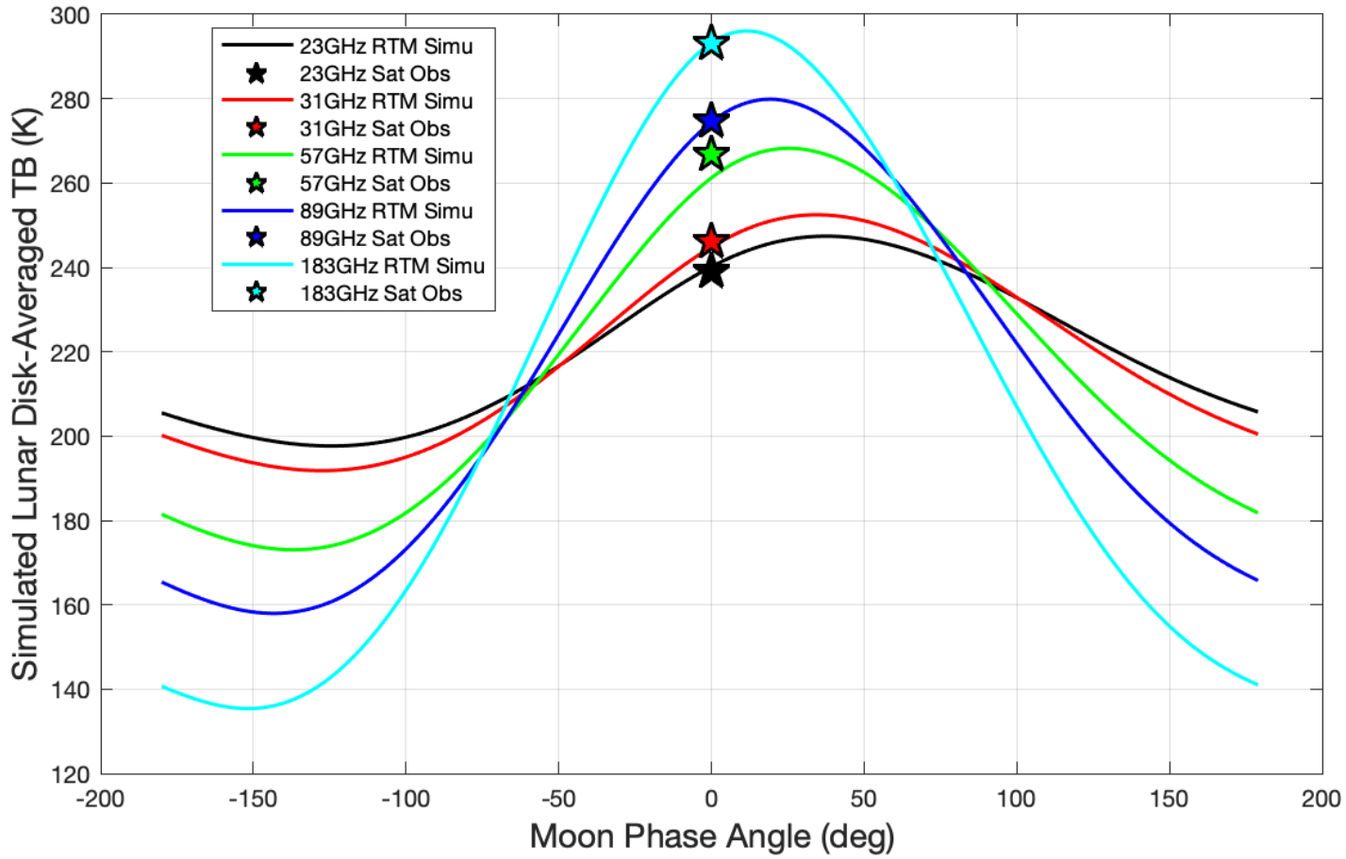


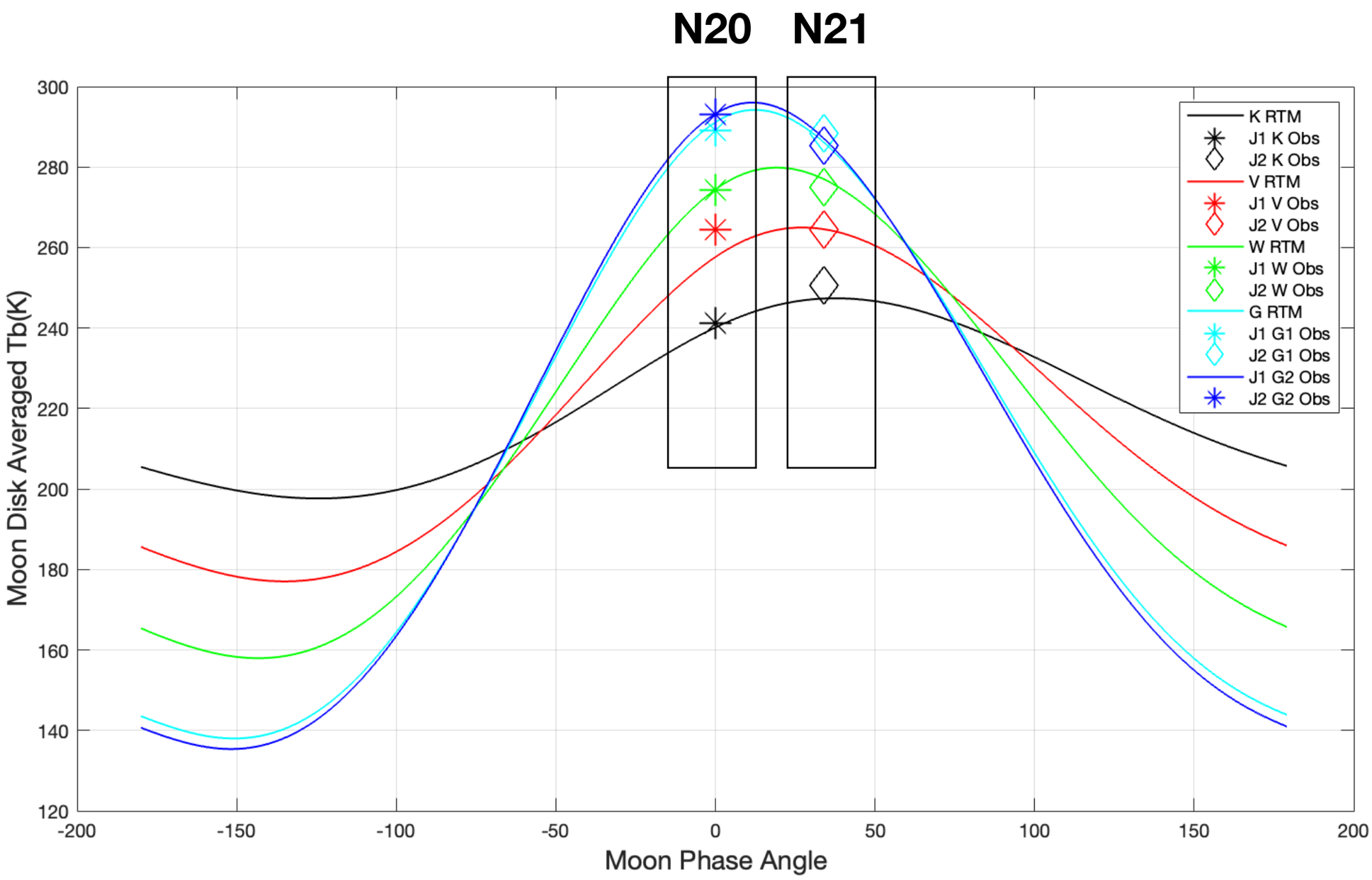
Calculation of Disk-averaged Lunar Tb

- No diurnal variation in deep layer
- More contribution from deeper layer in lower frequency band
- More contribution from deep layer during night time
- Magnitude of Phase-Lag decrease with the increase of frequency

$$T_B(\lambda) = E_\lambda \int_0^\infty \kappa_\lambda \sec(\theta_i) \cdot T(z) \cdot e^{-\int_0^z \kappa_\lambda(z)\sec(\theta_i)dz} dz$$

Calibrated RTM Simulation for the Moon Disk-Averaged Tb

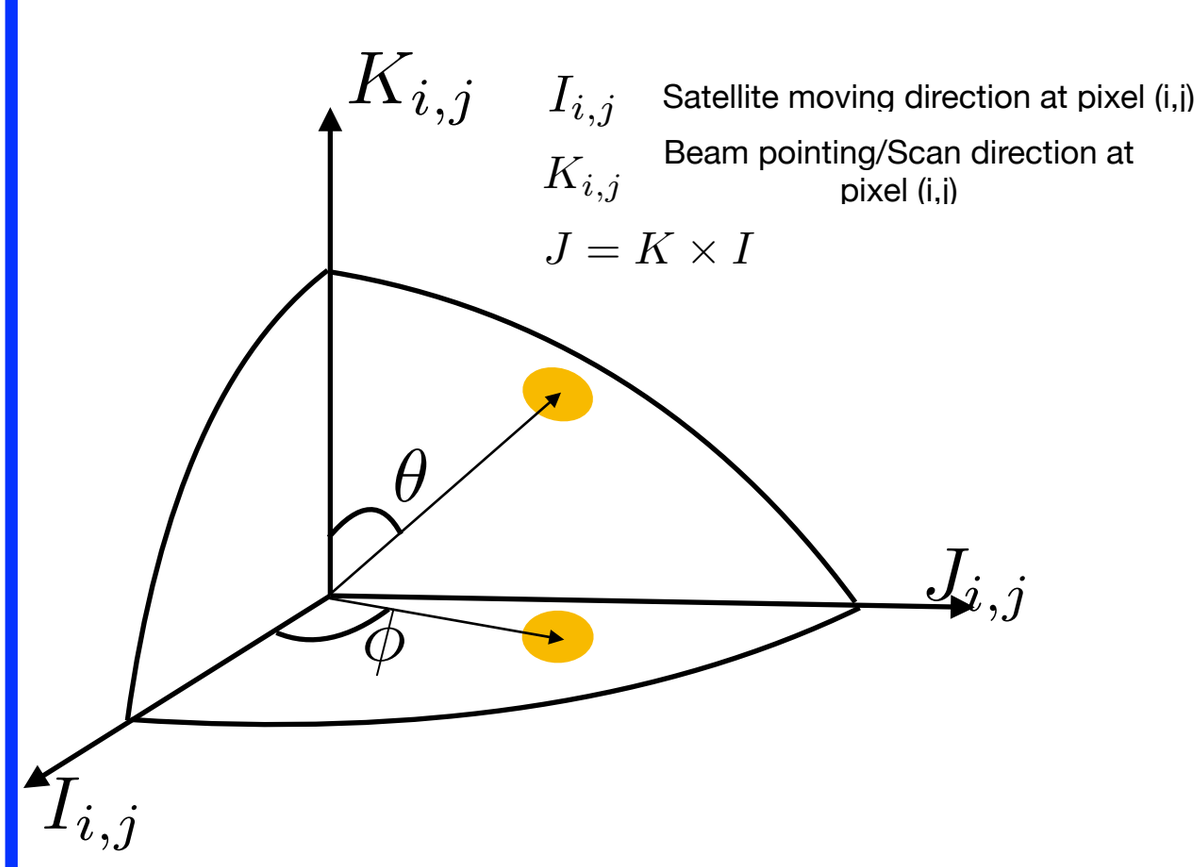



N20
N21
Moon Disk Averaged Tb(K)
Moon Phase Angle
300
280
260
240
220
200
180
160
140
120
-200
-150
-100
-50
0
50
100
150
200
K RTM
J1 K Obs
J2 K Obs
V RTM
J1 V Obs
J2 V Obs
W RTM
J1 W Obs
J2 W Obs
G RTM
J1 G1 Obs
J2 G1 Obs
J1 G2 Obs
J2 G2 Obs

Model for Satellite Lunar Observations

$$Ta_{Moon} = \frac{\Omega_{Moon}}{\Omega_{ant}} \cdot TB_{moon}^{RTM}$$

- 2D Gaussian function to calculate the antenna gain
- Calibrated RTM model to calculate the Moon-disk averaged Tb, with consideration for phase shift in microwave band



Sensor Related Parameters:

- **Antenna solid angle**
- **Oversampling**
- **beam pointing**

Expected Outcomes from the Group

- A validated Lunar RTM for microwave sounding instruments calibration
- General algorithm for on-orbit lunar intrusion correction
- Website for lunar data and code exchange within GSICS working group