CHANG'E MICROWAVE BRIGHTNESS TEMPERATURE DATA AND LUNAR SURFACE CHARACTERISTICS

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Abstract

On board of each of the recent Chinese lunar orbiters, Chang'E-1 (CE-1) and Chang'E-2 (CE-2), launched on Oct 24, 2007 and Oct 1, 2010 respectively, there was a set of microwave radiometer (MRM) with four frequency channels, 3.0, 7.8, 19.35 and 37GHz. The goal is to measure lunar brightness temperature (TB) from which one can investigate the physical properties of the lunar surface.

With the much improved spatial resolution and full diurnal coverage of CE-2's measurements, we are able to obtain detail local lunar surface and subsurface characteristics in combination with 1D heat conduction and radiation transfer modeling results.

Goal

1. Construct simulation model from physics principles.
2 Compare model results with CE MRM data.
3. Adjust/optimize physical parameters to fit CE MRM data by simulation results.

Contents

- Passive lunar remote sensing - Chang'E microwave radiometer
- Brightness temperature data characteristics
- Simulations: surface thermal environment
  - 1D heat conduction model
  - Multilayer microwave transfer model
    - Ideal homogeneous model
    - Inhomogeneous (random media) model
- Conclusions

Simulation Model

$$\rho(z)C(T)\frac{\partial T}{\partial t}=\frac{\partial}{\partial z}\left[K(z,T)\frac{\partial T}{\partial z}\right]+J(z)$$

$$C=-23.173+2.1270\times T+1.5009\times10^{-2}T^2-7.3699\times10^{-5}T^3+9.6552\times10^{-8}T^4$$

Boundary condition on the surface:

$$F(t)+K(T)\left(\frac{\partial T}{\partial z}\right)_{z=0}-\varepsilon\sigma T_1^4-J_0=0$$

Solar heat flux on the surface

$$F(t)=S(1-A)\cos\alpha\cos(\beta+2\pi t/P)$$

Boundary condition deep down:

$$\left(\frac{\partial T}{\partial z}\right)_{z=d}=-\frac{J_0}{K_d}\approx 0$$

Dielectric constant

$$\epsilon=\epsilon'+i\epsilon''=\epsilon'(1+i\tan\delta)$$

$$k''(x)=2\pi f/c\,[\epsilon'/\cos\delta]^{1/2}\sin(\delta/2)$$

Imaginary part of wave number

$$T_B^p(\theta)=\frac{k_0}{\cos\theta}\sum_{i=1}^{n}\left\{\left(\frac{\varepsilon_{ri}''}{2k_{iz}''}\right)\left|\beta_i^p\right|^2\cdot\left(1-e^{-2k_{iz}''d_i}\right)\cdot\left(1+\left|R_{i,i+1}^p\right|^2e^{-2k_{iz}''d_i}\right)T_i\prod_{j=0}^{i-1}\left(\left|X_{j,j+1}^p\right|^2\cdot e^{-2k_{jz}''d_j}\right)\right\}+\frac{k_0\varepsilon_{r(n+1)}''\left|\beta_{n+1}^p\right|^2}{\cos\theta\cdot2k_{(n+1)z}''}\cdot\prod_{j=0}^{n}\left(\left|X_{j,j+1}^p\right|^2\cdot e^{-2k_{jz}''d_j}\right)T_r$$

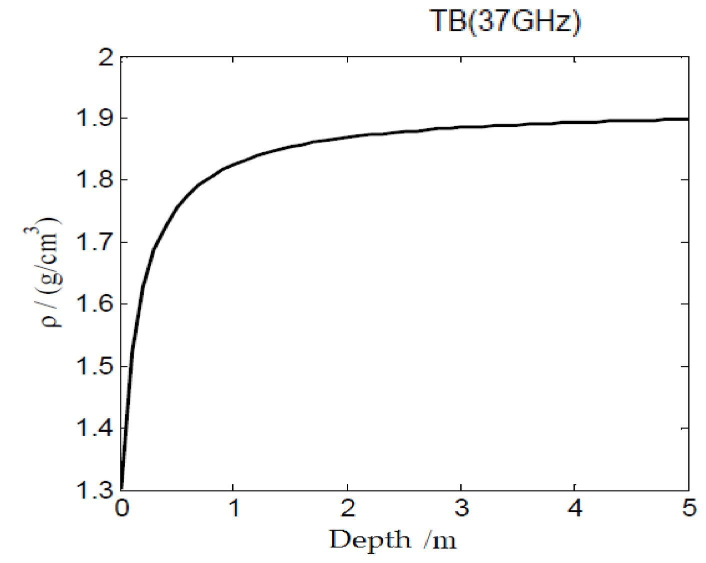
$$\varepsilon_r'=1.919^{\rho}\qquad\varepsilon_r''=\varepsilon_r'\cdot\tan\delta$$

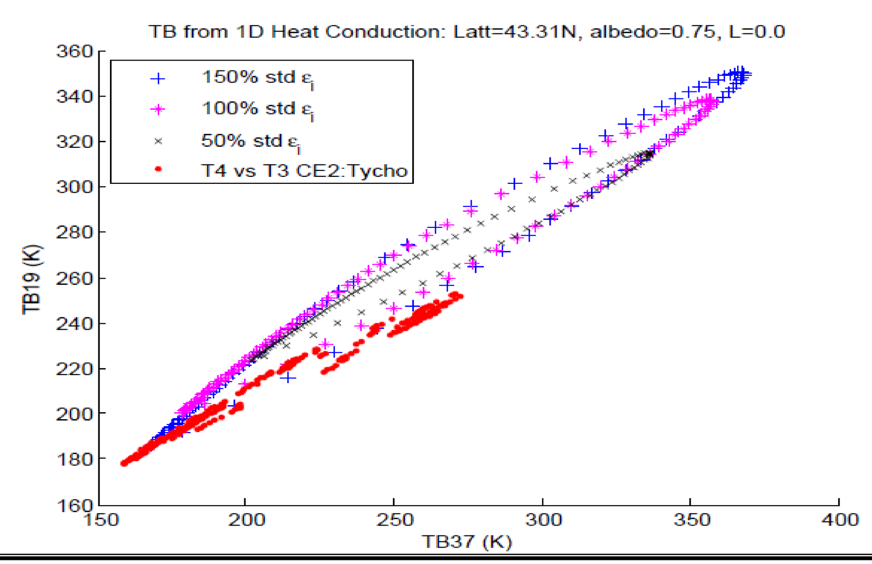
$$\tan\delta=10^{0.440\rho-2.943}$$

$$T_B=k_0\int_0^\infty dx\ \epsilon''\ T(x)\exp\left(-2\int_0^x dx\,k''(x)\right)$$

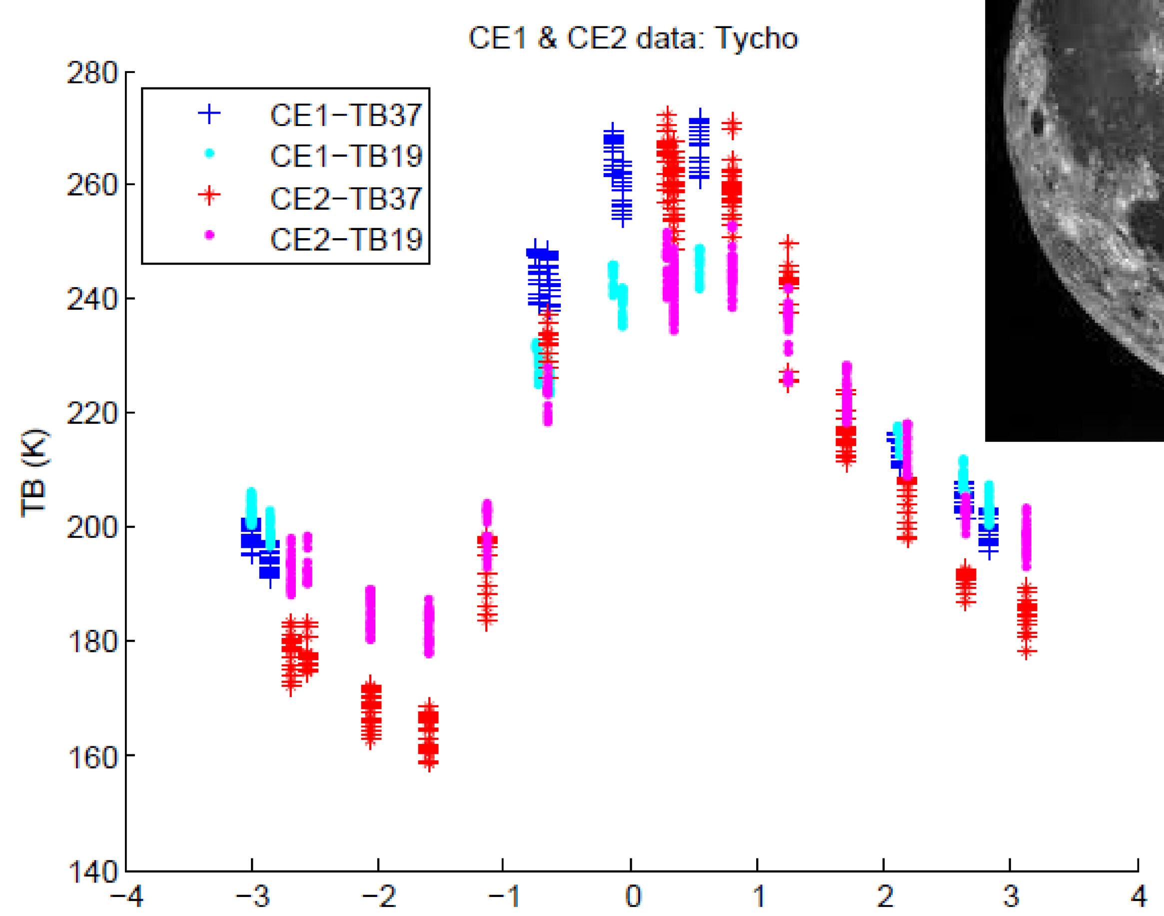
(1-L)

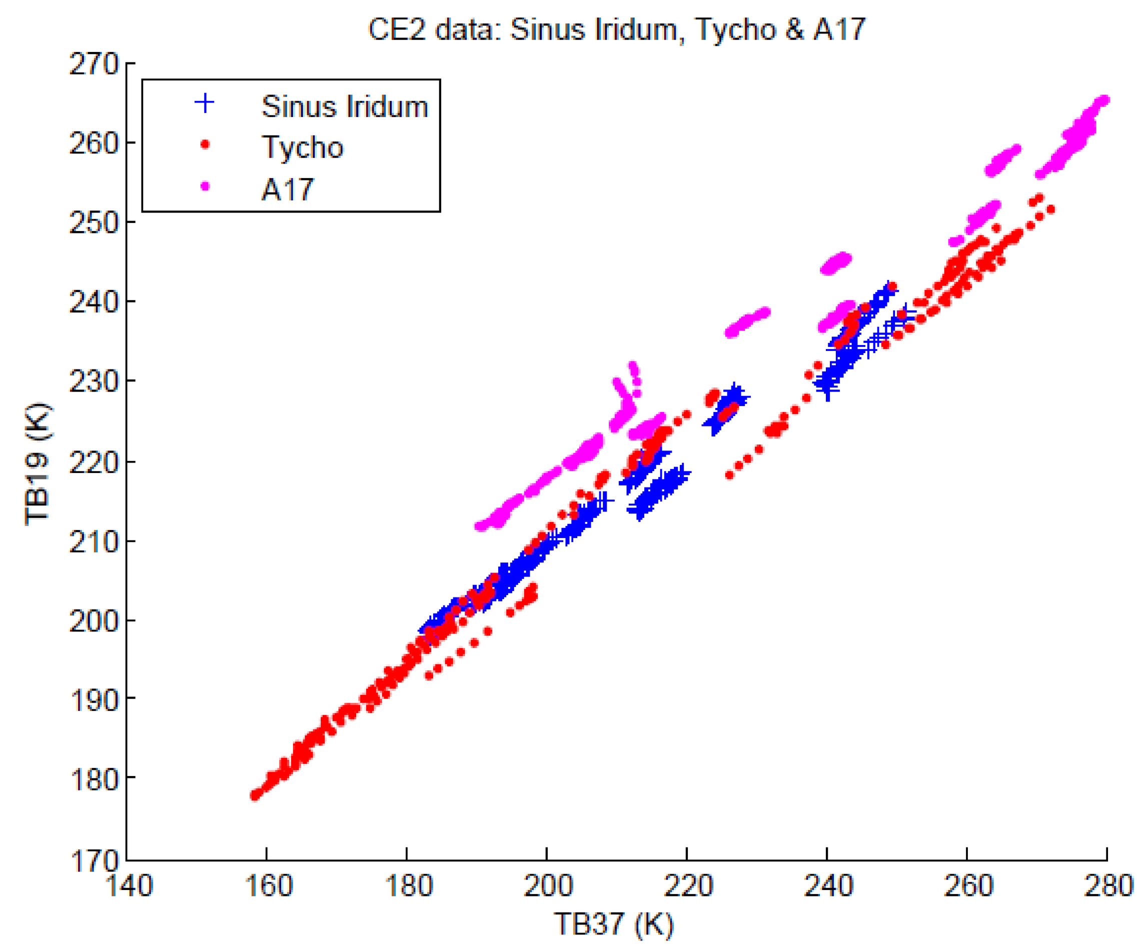
where L is the percentage loss due to the random medium.

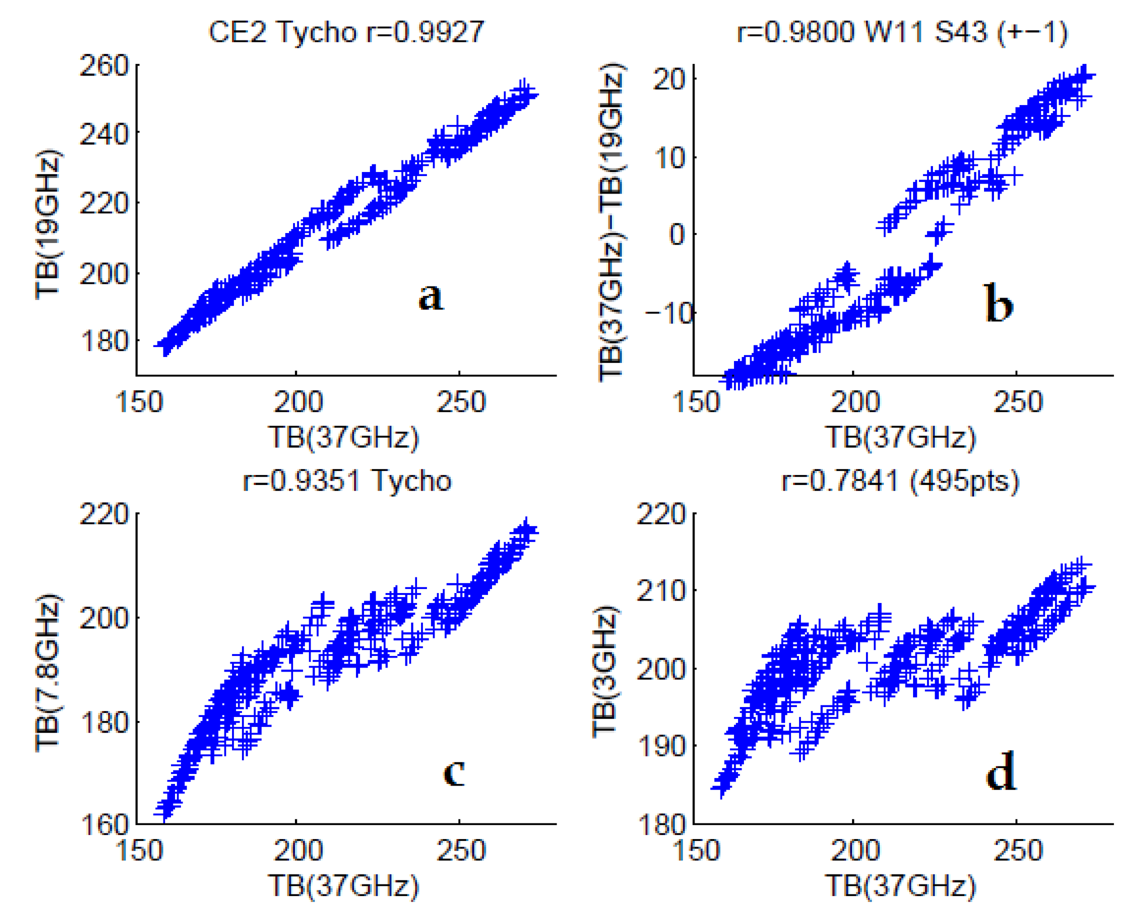


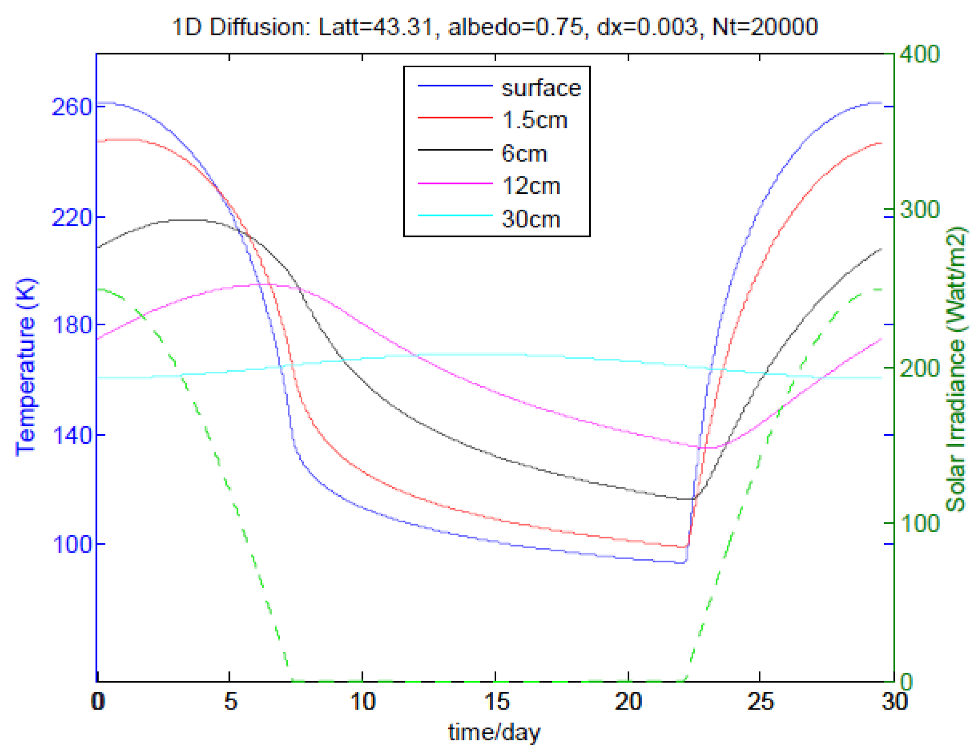


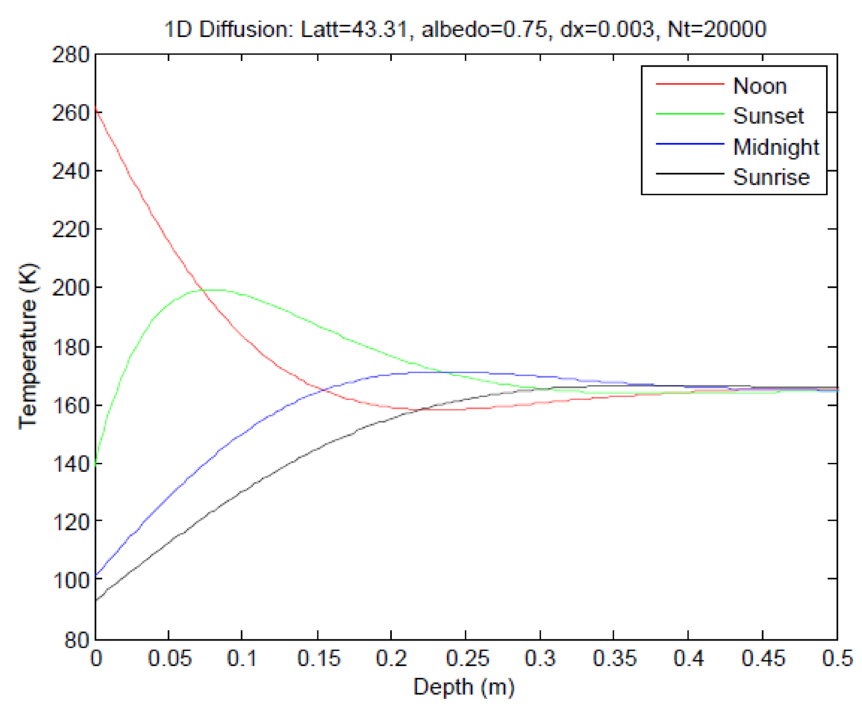
CE MRM data



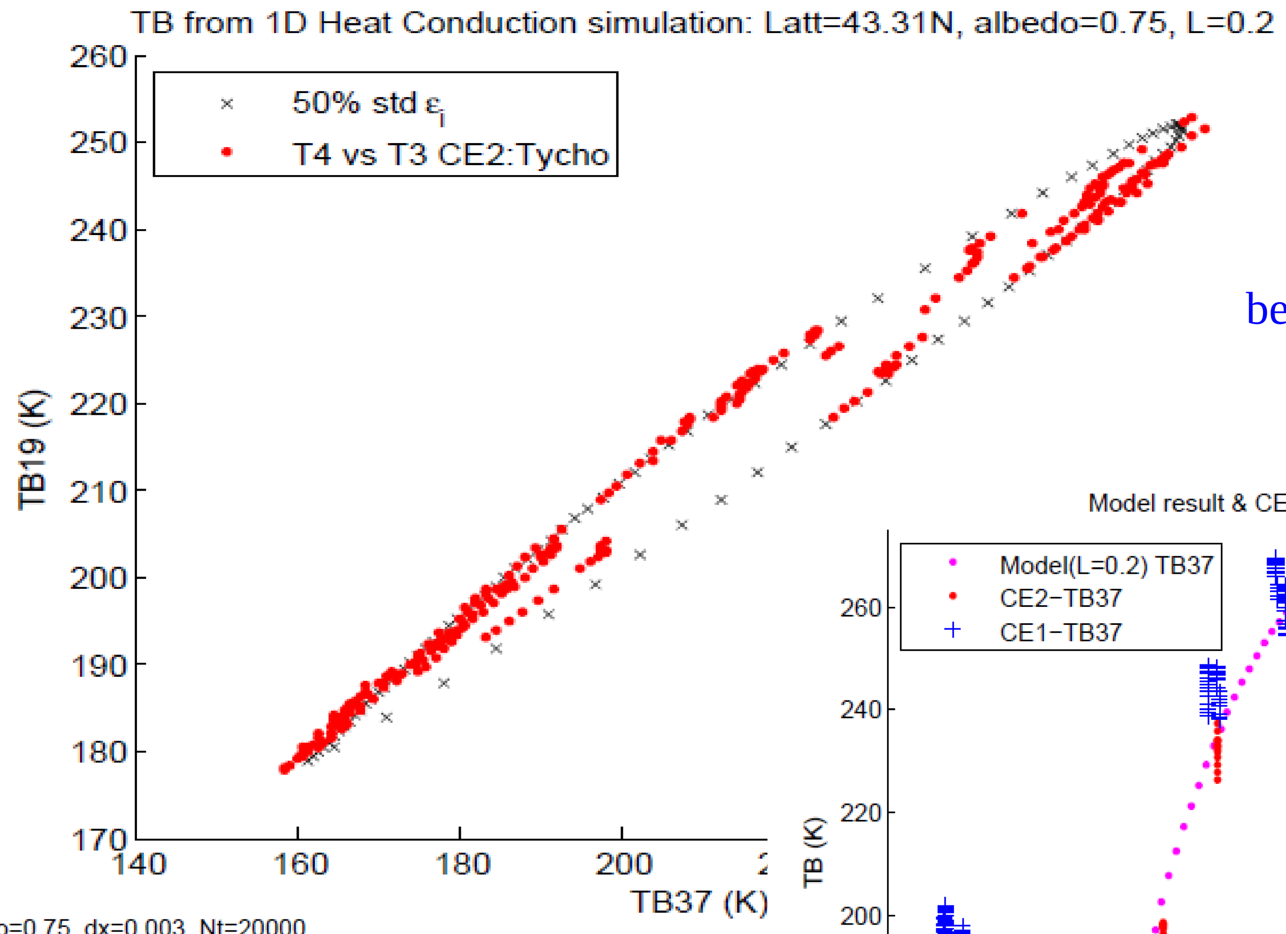




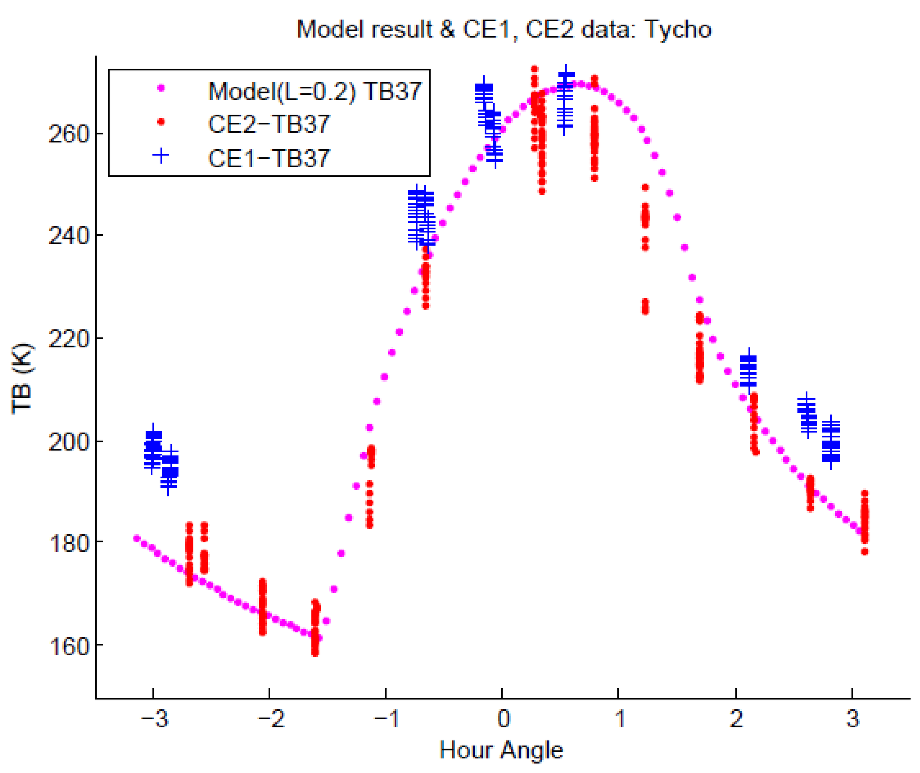




Results



Good agreement between simulation & CE2 data.



Conclusions

- CE2 MRM data are better in quality & quantity compared with CE1 data.
- TB37 & TB19 of the MRM data are particularly interesting because of the higher quality and simplicity they exhibited.
- Local 1D simulations with proper parameters agree with CE2 data well.
- CE MRM data + model can be used to constraint physical lunar regolith parameters (by minimizing sum-square-difference or regression).

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