Latitudinal and Longitudinal Asymmetries of the Lunar Surface Evolution on Lunar Crater Walls

Kilho Baek[1] (kilho.baek@khu.ac.kr), Sungsoo S. Kim[1], Chae Kyung Sim[2,3]

[1]*Kyung Hee University*, [2]*Korea Astronomy and Space Science Institute*, [3]*Korea National University of Science and Technology*

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INTRODUCTION

- To ensure the statistical significance of Sim et al. (2017), we reproduced their results almost identically by increasing the number of craters. >> [RESULT I]
- We newly discovered a north-south hemispheric asymmetry and a longitudinal offset of optical maturity difference between opposite walls. >> [RESULT II]
- We suggest that the observations can be understood with a simple model integrated with solar wind particles and meteoroids. >> [MODEL]

DATA

➢ Lunar Crater Database

- We adopt the lunar crater database provided by Robbins et al. (2018) to consider more and smaller craters than Sim et al. (2017).

	Sim et al. (2017)	This Study
Database	LPI (2015)	Robbins et al. (2018)
# of craters	1872 (of 8716)	**26,802** (of ~1.3 million)
Diameter	5 ~ 120 km	**2** ~ 120 km

※ Craters smaller than 2 km in diameter cannot be recognized due to spatial resolution (~60 m/pixel) of lunar global map data, even though they are well-preserved.

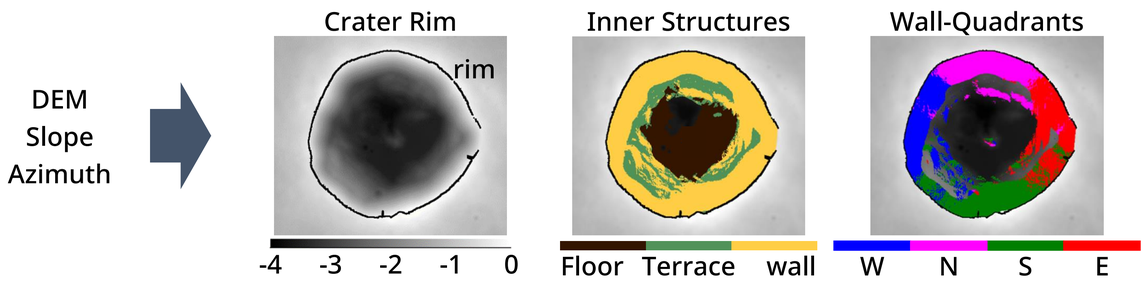
➢ Lunar Global Map

	Digital Elevation Map (DEM)	Reflectance
Mission	LRO + SELENE	SELENE
Instrument	LOLA + Terrain Camera	Multiband Imager
Resolution	~60 m/pixel	

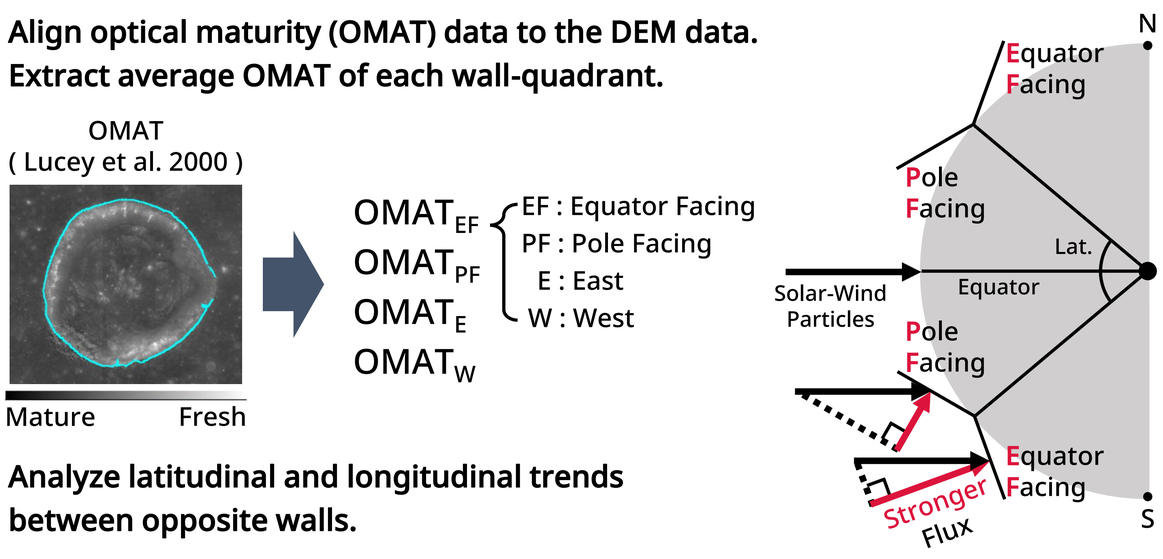
METHODS

We improved the analysis methods of Sim et al. (2017).

1. Detect crater structures & Divide wall-quadrants using the topographic data.



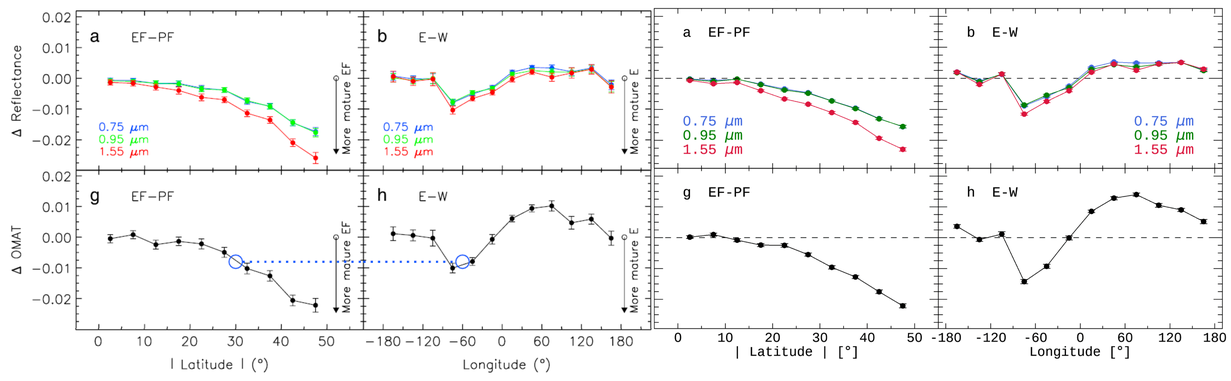
2. Align optical maturity (OMAT) data to the DEM data. Extract average OMAT of each wall-quadrant.



3. Analyze latitudinal and longitudinal trends between opposite walls.

RESULT I (Reproduction for Sim et al. 2017)

Sim et al. (2017): LPI DB > **1,872 craters** **This study** : LPI DB > **3,144 craters**

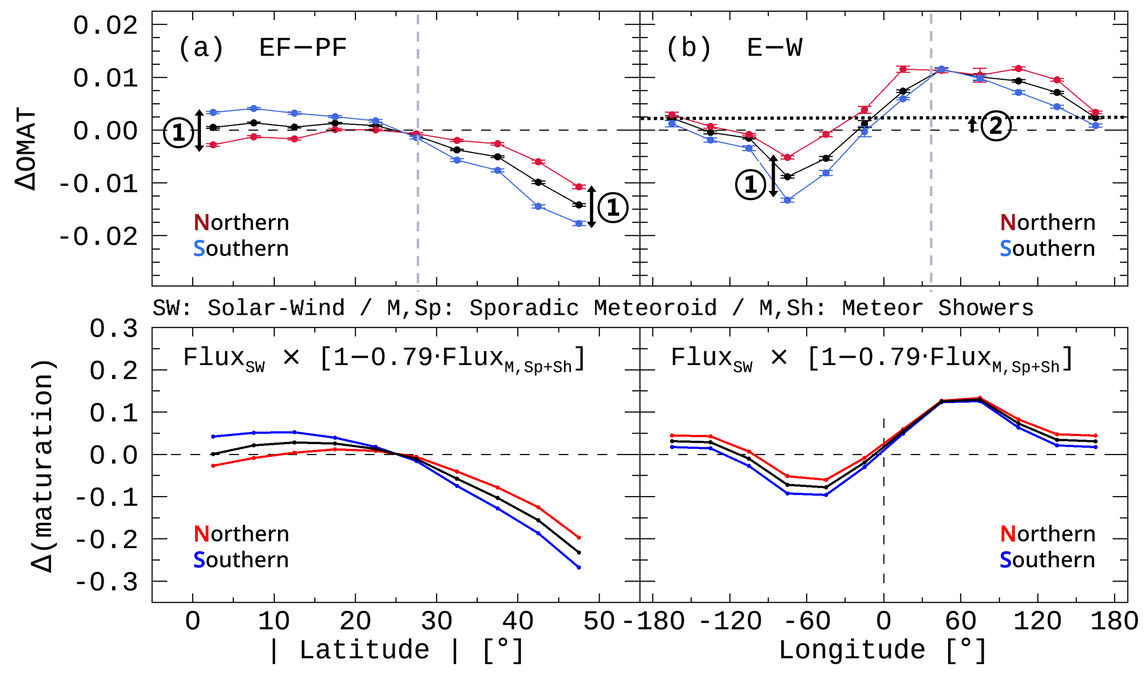


- We reproduced almost the same results of Sim et al. (2017) with more craters selected by the improved methods.

RESULT II (New Findings)

➢ Comparison of Observation (top) and Our Model (bottom)

- The observations are explained very similarly with a model (see below section for details) that considered both solar-wind and meteoroids.
- Model = Solar-wind particles + Earth's magnetosphere + **Earth's orbital motion** + **Meteor showers** + **Sporadic meteoroids**
- New Findings: ① Hemispheric asymmetries & ② Longitudinal offset

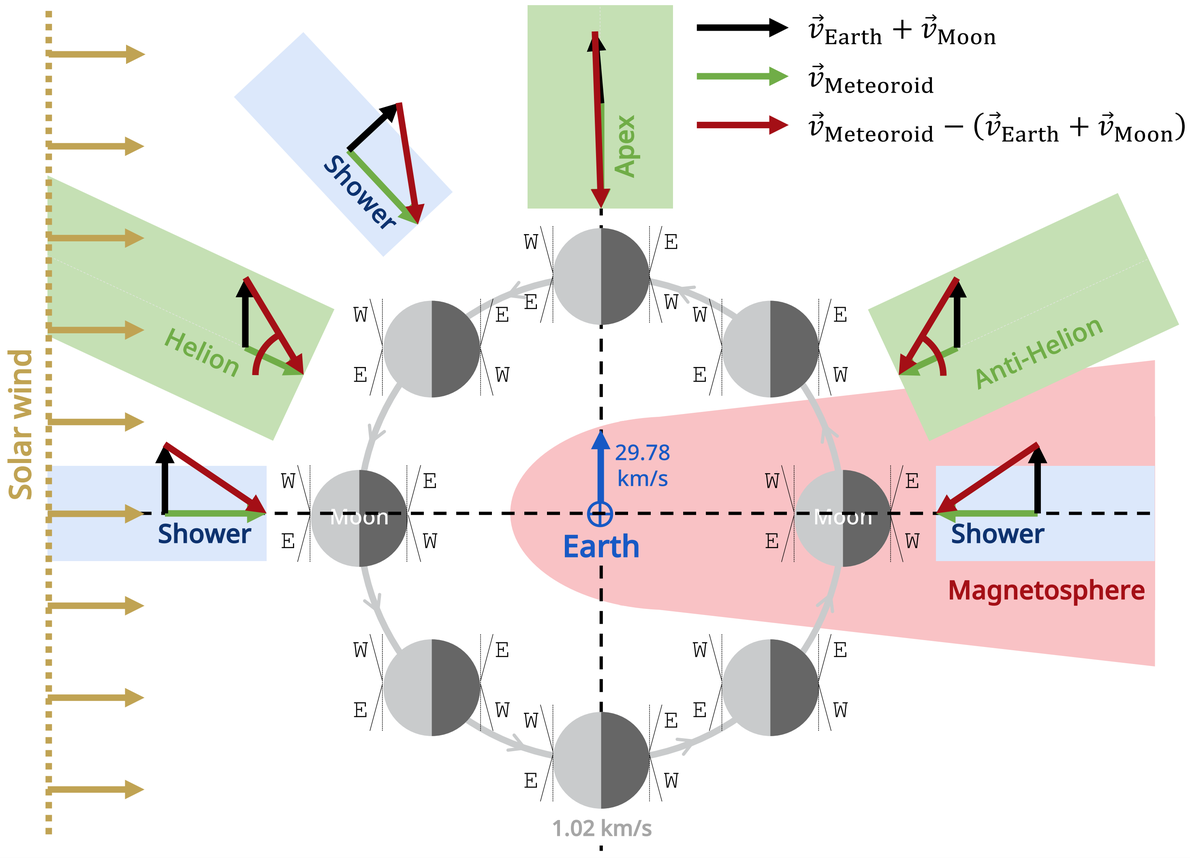


MODEL

➢ Meteoroid Environment

- Meteor shower (Merisio & Topputo, 2023)
  - The top 4 of the most effective showers are incident **from the N-hemisphere**.
  - The number of meteoroids: **Helion > Anti-helion** (for 12 major showers)
- Sporadic Meteoroid (Szalay & Horányi, 2015)
  - It enters along the ecliptic plane.
  - The number of meteoroids: **Helion > Anti-helion**

➢ Integrating Solar Wind and Meteoroid Environment near the Moon



CONCLUSION

➢ New findings: Hemispheric asymmetries & Longitudinal offset

- They are caused by **impact gardening of meteoroids** near the Moon.

➢ Latitudinal Trend

- |Lat.| ~ 0 : **Refreshment** by meteor showers is dominant.
  |Lat.| > 0 : **Maturation** by solar-wind particles becomes more and more dominant toward higher latitudes.

➢ Longitudinal Trend

- The effect blocking **solar-wind particles** by the **Earth's magnetosphere** creates an overall trend like sine function.
- The distribution of **meteoroids** near the Moon and the relative velocity by the **Earth's orbital motion** create a longitude offset.