

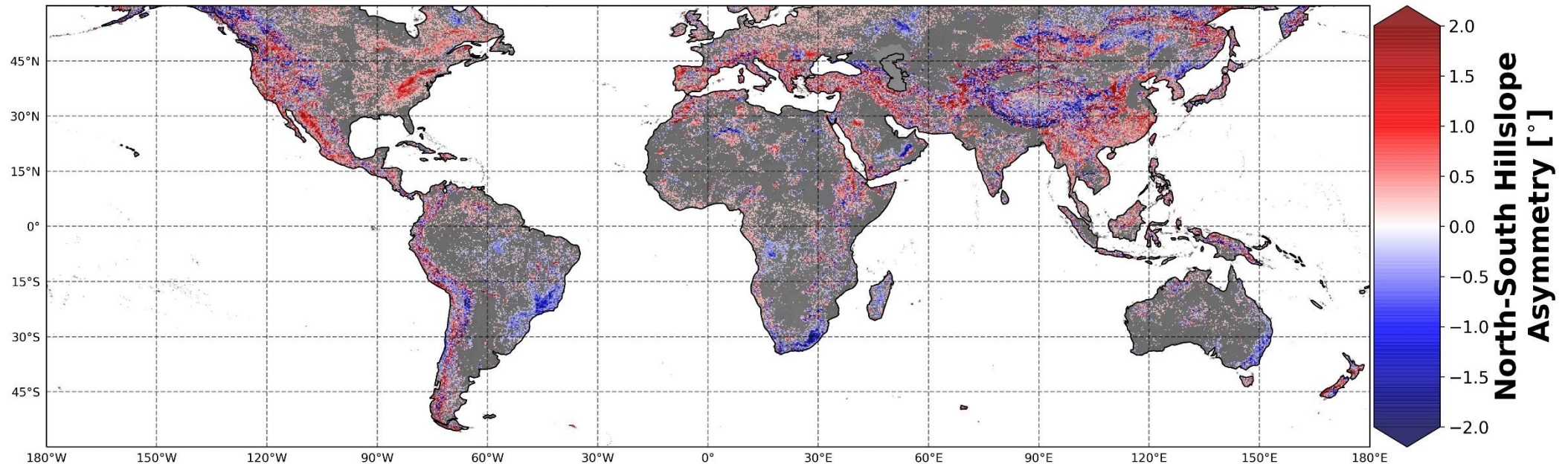
# Shaping Planetary Surfaces: The Impact of Water Mobility on Topography

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TAYLOR SMITH AND BODO BOOKHAGEN

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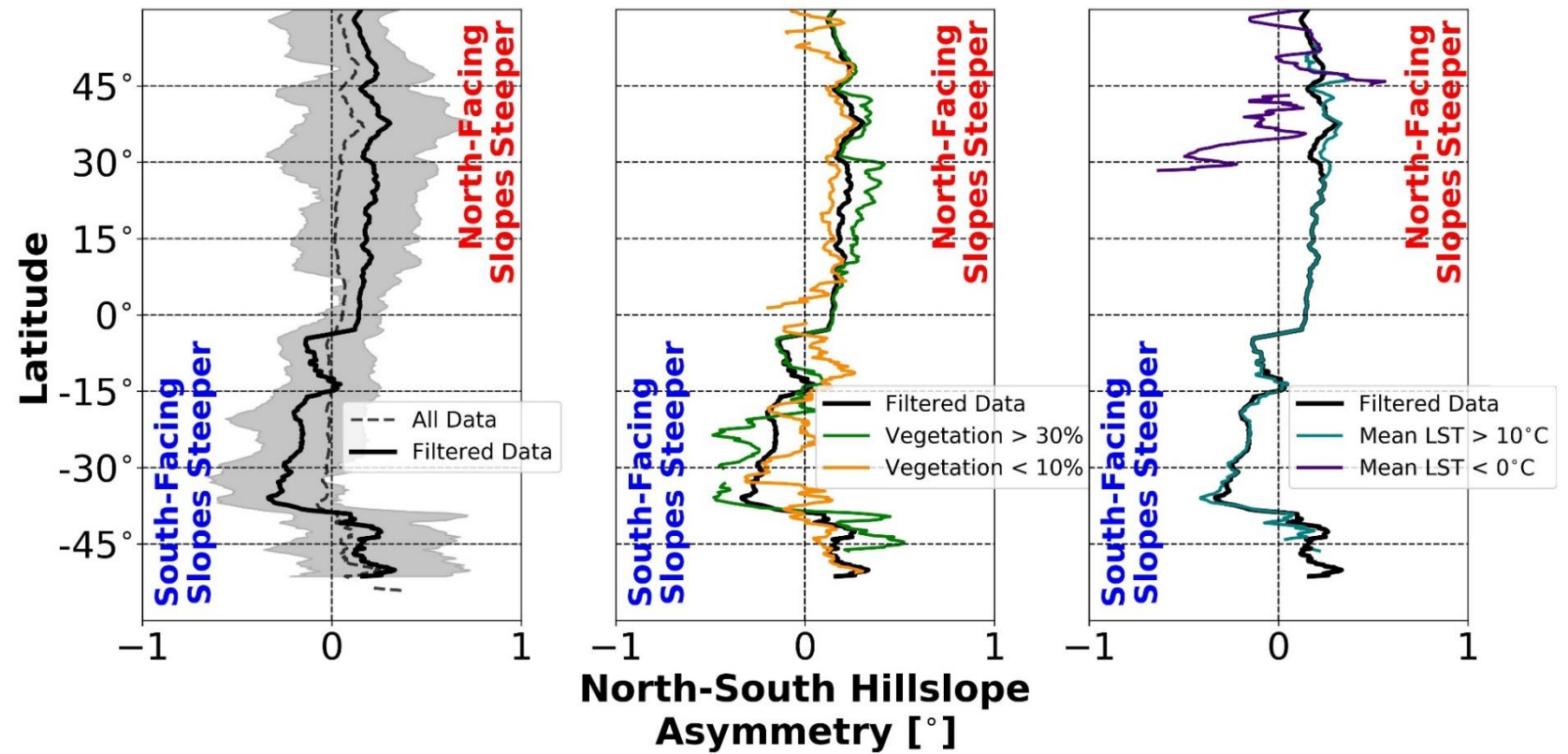
# Motivation: Hillslope Asymmetry



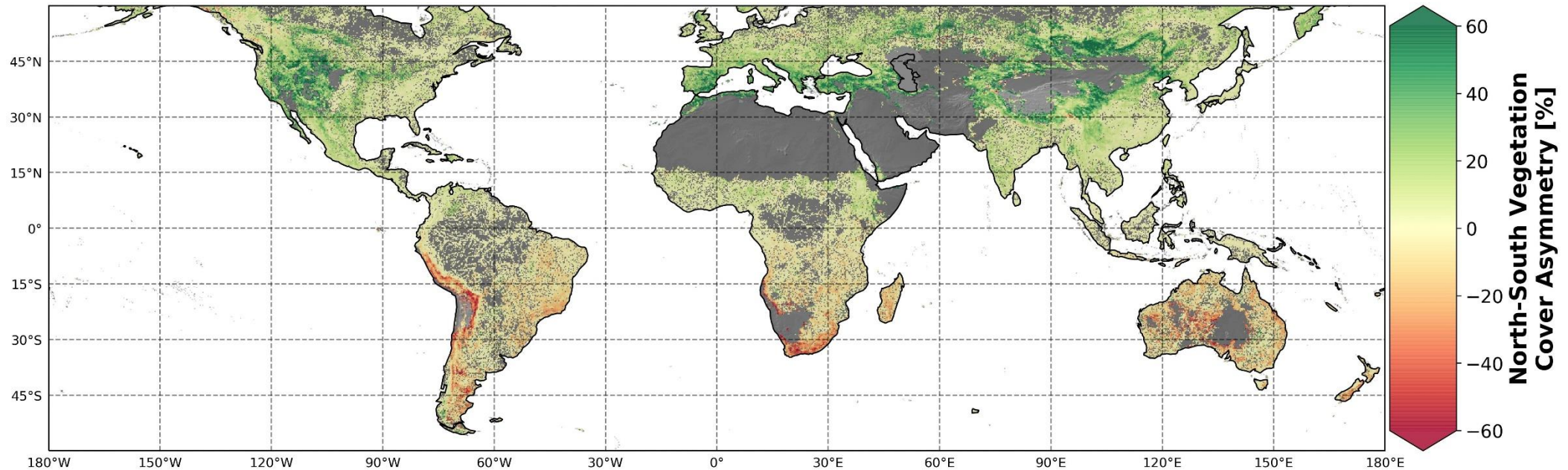
- Many researchers have observed hillslope asymmetry (HA) – the difference in slope between opposing hillslopes – globally
- We confirm these results with 30m SRTM data, processed in 0.25dd boxes across the entire earth
- There are distinct spatial patterns in North-South HA controlled by latitude, climate, and tectonics

# Motivation: Hillslope Asymmetry

- If we sum the HA magnitudes by latitude slices, latitude is clearly a strong control on the direction and magnitude of HA
- Furthermore, that latitudinal pattern is influenced by both vegetation cover and by temperature



# Observation: Vegetation Asymmetry

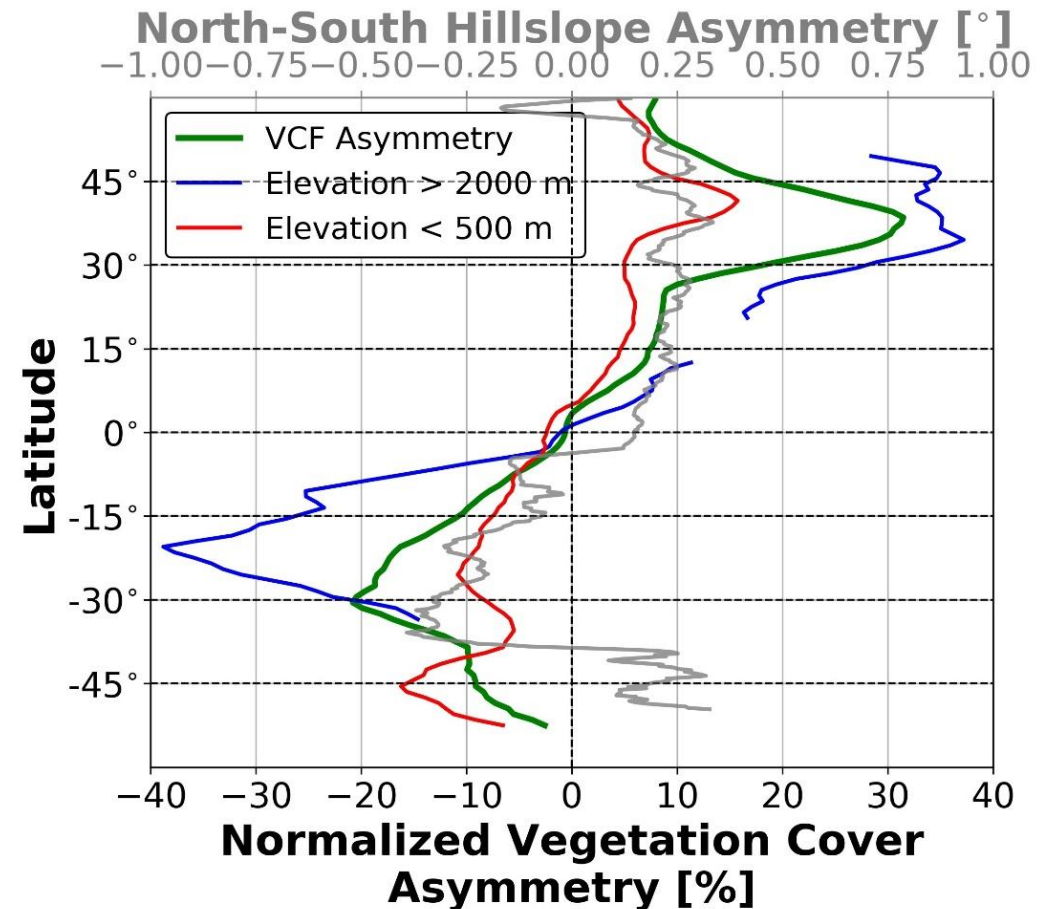


- We also observe vegetation density asymmetries – measured here using 30m Landsat VCF data from the year 2005
- Vegetation cover is distinctly higher on pole-facing slopes – especially in water limited environments

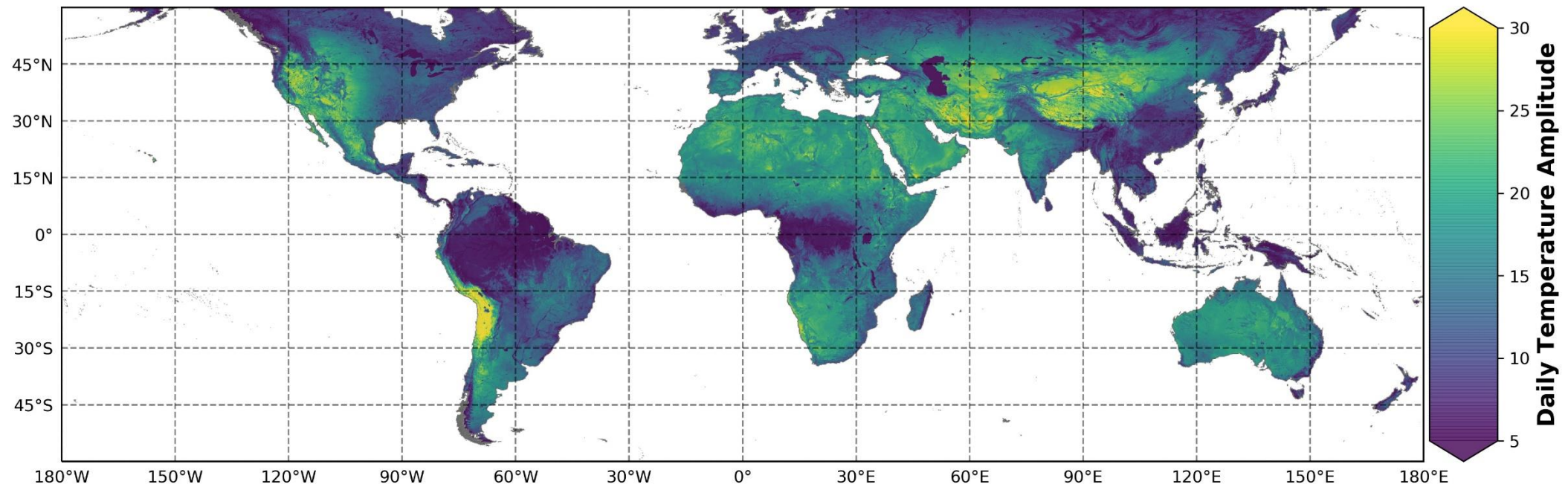


# Observation: Vegetation Asymmetry

- When vegetation asymmetries are also considered by latitude, the spatial pattern mimics that of hillslope asymmetry
- High elevation regions have on average more asymmetric vegetation than low elevation regions

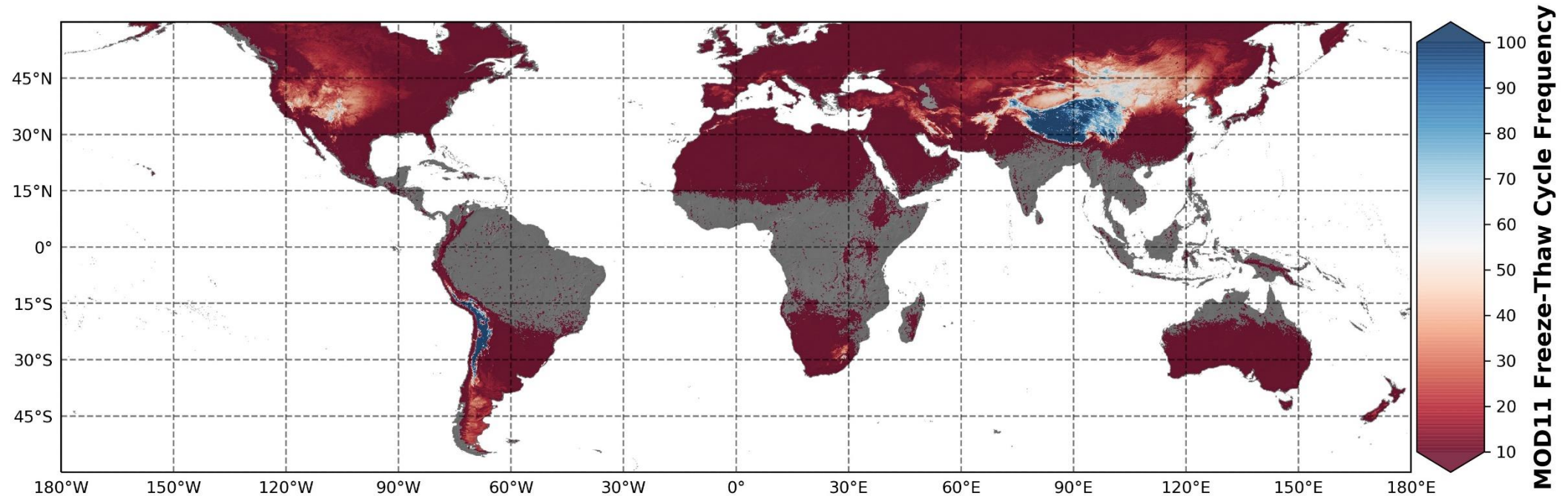


# Observation: Temperature Amplitude



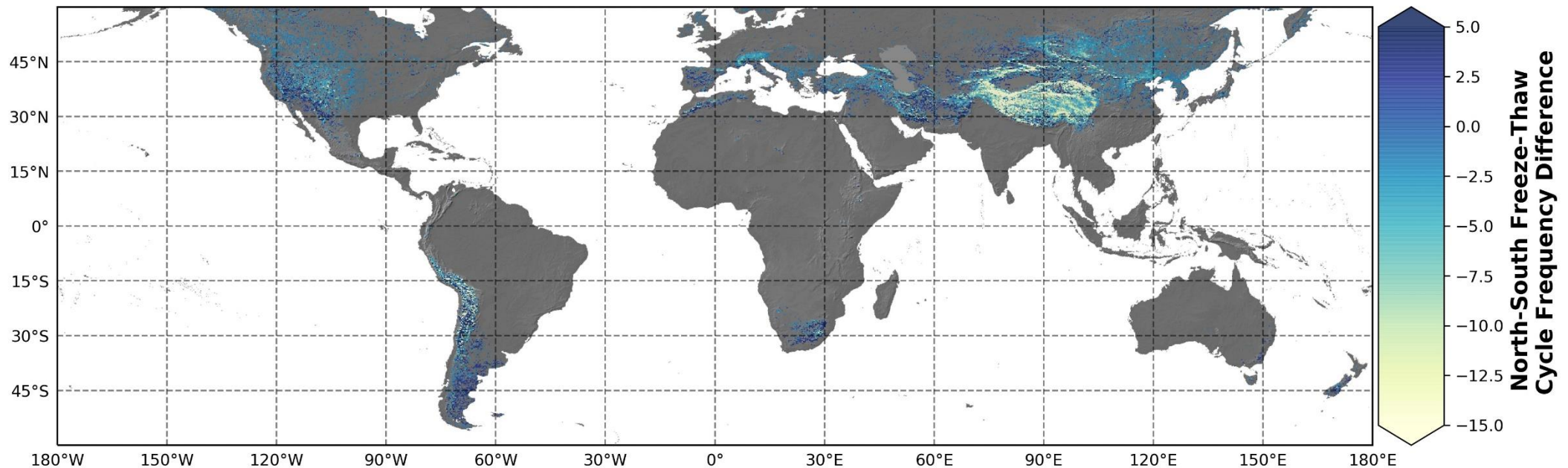
- Previous work has also linked mean annual temperature to the development of hillslope asymmetry
- We, however, posit that the temperature amplitude is more important in driving hillslope asymmetry, as it controls the magnitude and frequency of freeze-thaw cycling

# Observation: Freeze-Thaw Frequency



- Using MODIS MOD11A Land-Surface-Temperature data, we can develop a metric of freeze-thaw cycle frequency
- We count a freeze-thaw cycle when night time temperatures drop below  $-1^{\circ}\text{C}$ , and daytime temperatures rise above  $0^{\circ}\text{C}$

# Observation: Freeze-Thaw Asymmetry

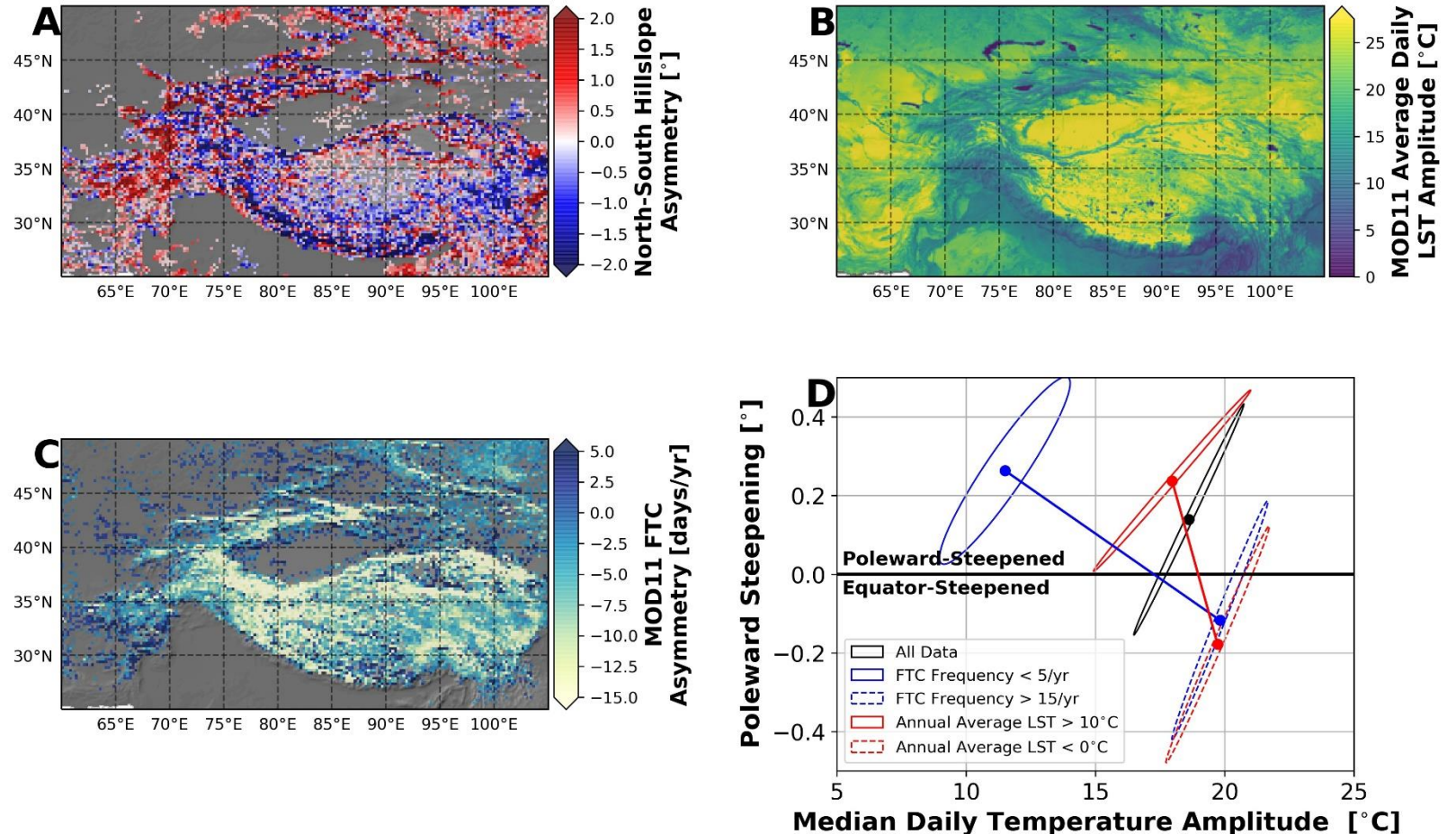


- Using the 1km SRTM DEM, we can calculate the average aspect of each MODIS pixel
- By again grouping our data into 0.25 dd boxes, we can calculate the North-South difference in freeze-thaw cycle frequency
- The largest asymmetries are found in high-elevation and mountainous environments



# Observation: Freeze-Thaw Asymmetry

- For example, High Mountain Asia has very high freeze-thaw asymmetries
- HMA also has very equator-steepened terrain, in opposition to the global average of poleward steepened terrain
- If we divide the HMA region into cold and temperate (or low and high freeze-thaw cycle) regions, only cold regions are steepened towards the equator



# Conclusions

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- Hillslope asymmetry is encouraged by solar radiation differences on opposing hillslopes
- Differences in soil-water availability and retention drive asymmetric soil formation rates
- In warm environments, pole-facing slopes will have thicker soil mantles due to vegetation cover differences
- In cold environments, equator-facing slopes will have thicker soil mantles due to freeze-thaw cycle magnitude and frequency differences
- Gravity-driven hillslope diffusion processes will lead to higher erosion rates on slopes with thicker soil mantles – over much of the earth this is pole-facing slopes

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