Preliminary Analysis of the Absolute Cartographic Accuracy of the Clementine UVVIS Mosaic

A.C. Cook[1], M.S. Robinson[2], B. Semenov[3], and T.R. Watters[4]

[1] School of Computer Science & IT, University of Nottingham, UK (Email: acc@cs.nott.ac.uk)

[2] Department of Geological Sciences, Northwestern University, Evanston, IL, USA (Email: robinson@earth.northwestern.edu)

[3] Jet Propulsion Laboratory, Pasadena, USA (Email: boris.semenov@jpl.nasa.gov)

[4] Center for Earth & Planetary Studies, National Air & Space Museum, Washington D.C., USA (Email: twatters@nasm.si.edu)

Thanks to M. Rosiek and D. Cook USGS Astrogeology

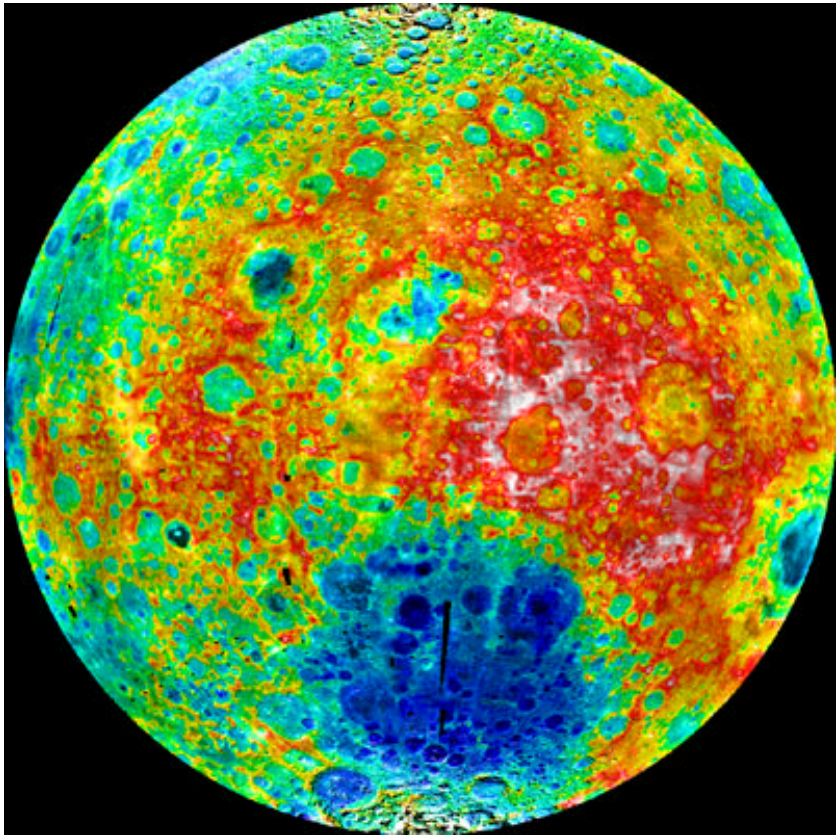
Problem: Evaluating absolute accuracy of Clementine 750 nm basemap

- 43,000 images
- 265,000 match-points
- ground truth from “Apollo zone”, all of farside floats
- no topography used, assumed spherical Moon of 1737.4 km
- spacecraft position
  - doppler tracking
  - gravity models

Validate the Farside?

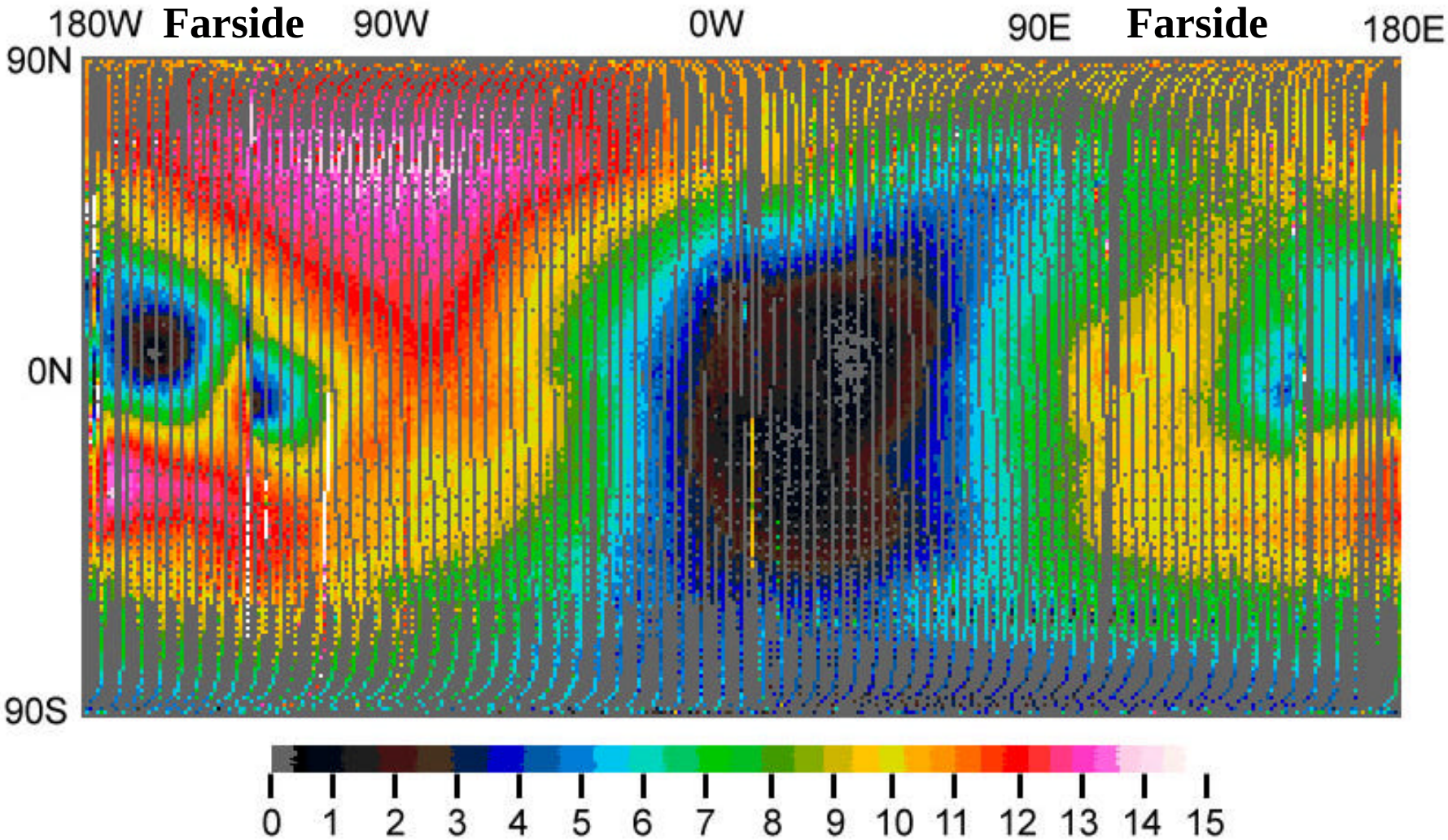
(cartographic sense)

- **Recently completed global stereo based topo map**
- **Used original archived SPICE files (not USGS/Rand control net)**
- **Overlaid the topo with basemap and found large offsets**



Clementine stereo topo on 750 nm basemap

750nm Basemap Geometric Accuracy?

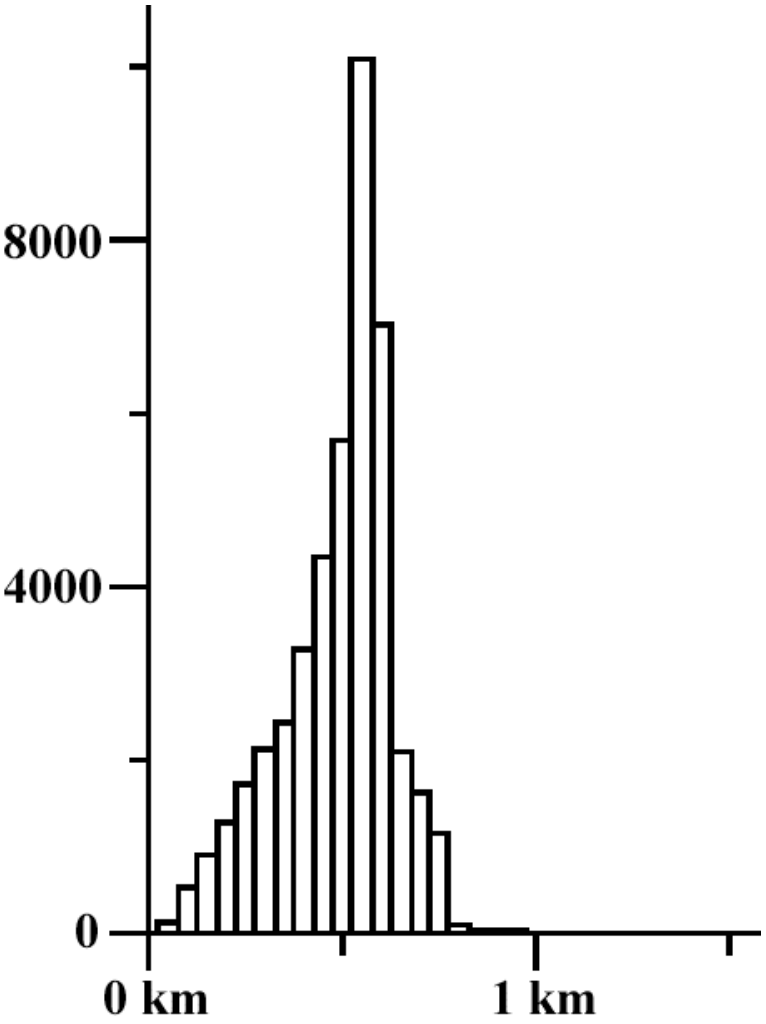


Offset Map: Is this a map of absolute accuracy (lat/lon)?

Spacecraft Position (SPK)

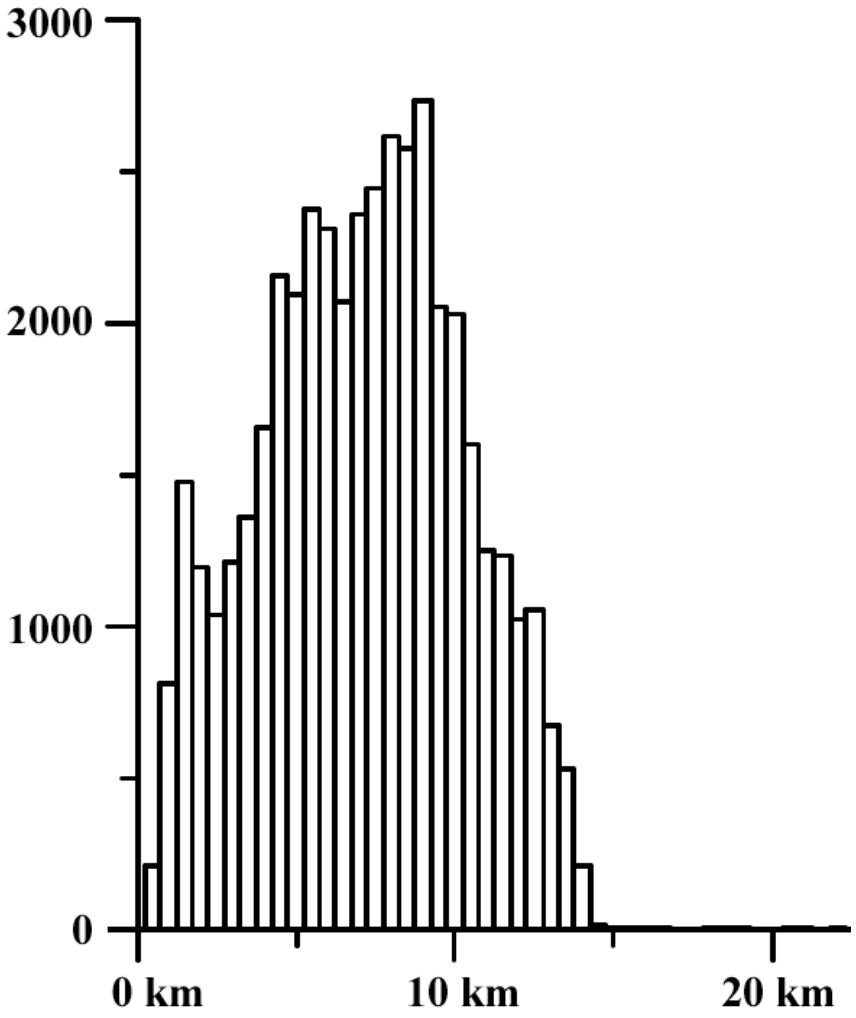
- Small difference in SPK files
- Polar tilt constant differs by 0.022°
- Histogram of sub-spacecraft point differences (max 1 km)

SPK: Cannot explain the observed offsets



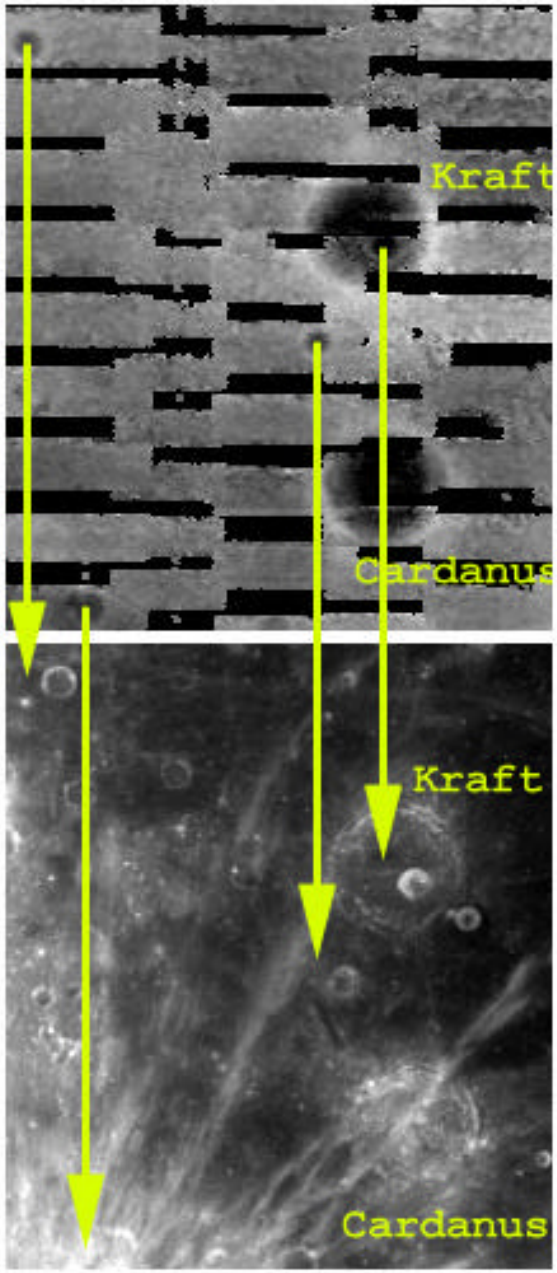
Camera Pointing (CK)

- USGS/Rand control net should be different than the archived CK (that's what was updated)
- And it is! But are these offsets reasonable???
- Histogram shows differences USGS/Rand and archived CK (image center points for all 43,000 images in control net)
- Image strips overlap by 10-20 pixels (1-2 km near eq)

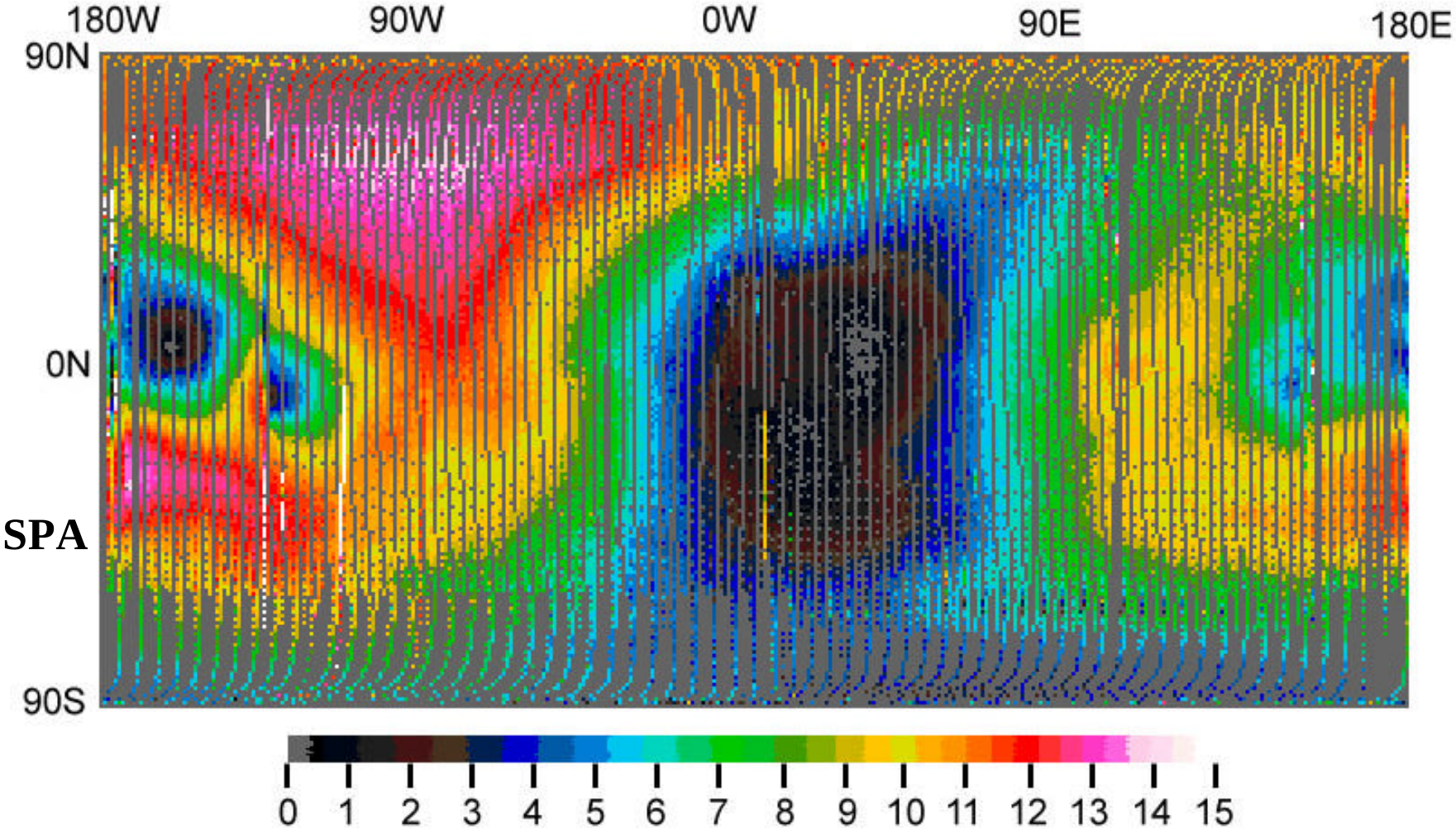


Camera Pointing offsets

- Nearside Apollo zone generally good agreement (<2 km)
- Should be same order for whole Moon otherwise gores between orbits would have occurred
- Outside Apollo zone there were no absolute control points (none exist)
- Control net allowed adjustments up to 10x the accuracy of the spacecraft pointing - is this reasonable?



Simple Cylindrical Projection of Differences in Image Centers from Archived CK & USGS/RAND Control Network



SPA

Image bore-sight offsets (km)

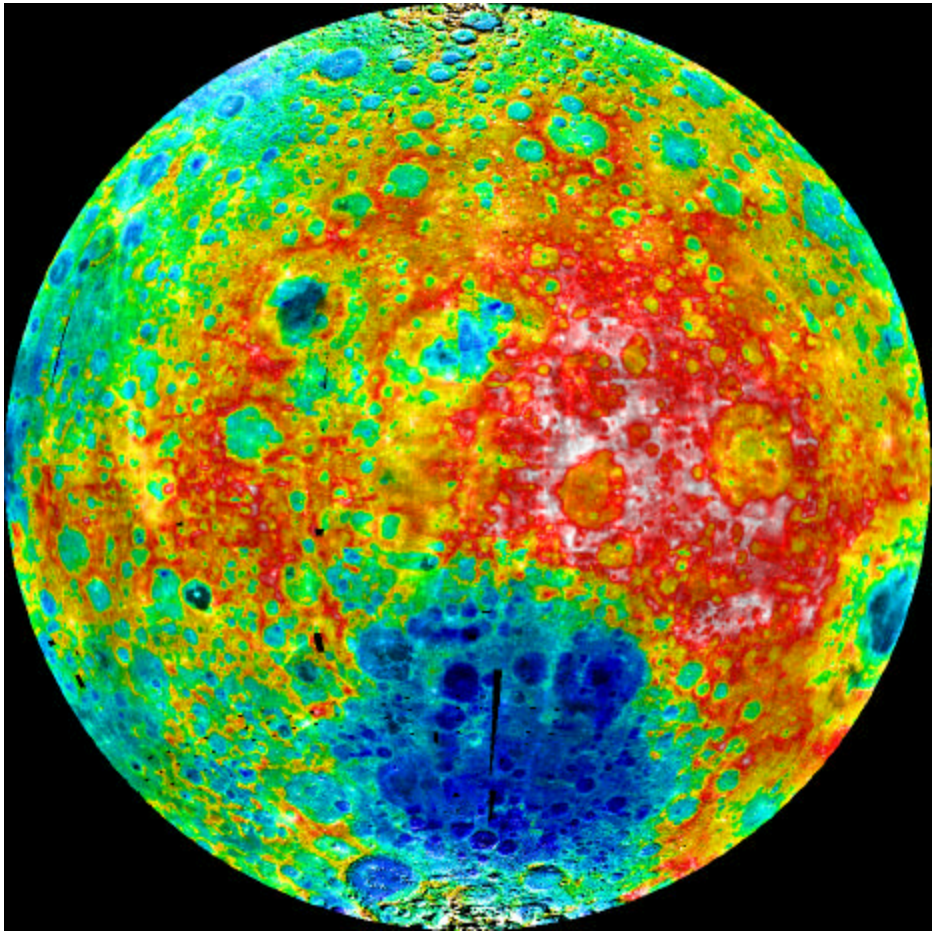
What's Up?

- **No absolute control outside the "Apollo Zone"**
- **Spherical Moon (1737.4km) when in reality there are ± 10 km topographic excursions (SPA and near Korolev crater)**
  - **Clementine periselene ~400 km**
  - **± 10 km translates to ±2.5% error in pixel scale**

- **The lack of control outside Apollo zone results in extrapolation across hundreds of orbits and thousands of images, of these images pixel scale exhibits low frequency error term.**

Where are we?

- We <u>believe</u> that the offset map indicates there is a low-frequency error term in the control network which is not in line with the reported 500m absolute accuracy of the basemap (except in the Apollo zone).
- We <u>believe</u> the offset should be 1-2 km everywhere, in line with the accuracy of spacecraft pointing, perhaps a little larger in areas with no direct radio tracking on the central farside.
- We <u>do not know</u> of an unambiguous way to solve this problem with the existing data. Redoing the control network using the low frequency Clementine LIDAR map may improve the solution somewhat-to-considerably. Still - there is no absolute control for >50% of the Moon.

Summary

- **Mert Davies had for years cobbled together diverse data of the Moon to make best possible effort at creating lunar control network (Telescopic, LO, Mariner 10, Galileo, Clementine)**
- **We <u>desperately</u> need a dedicated geodesy mission**
- **SPA sample return will have to deal with <u>possible</u> positional errors of 10-20 km**