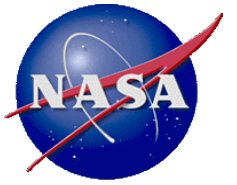
National Aeronautics and Space Administration



Bistatic Optical Photometry of GEO Objects

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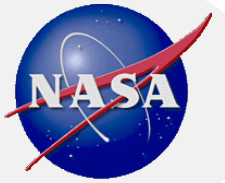
Acknowledgements



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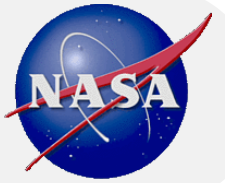
US Naval Observatory Flagstaff Station

Thomas Kelcey

Boeing Corp.

Bistatic Observations of GEO objects



- **Observe same region of GEO space with two widely spaced ground based optical telescopes during same time period.**

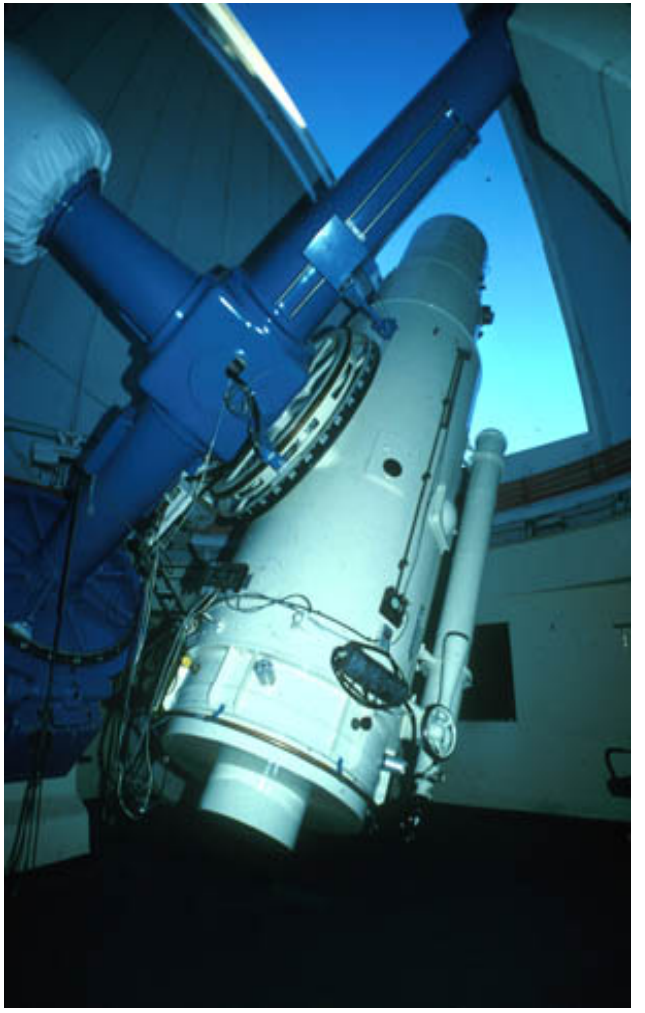
- **Photometry of GEO objects from different topocentric phase angles:**
  - Same incident angle of sunlight.
  - Two different reflection angles.
  - What can be learned about shape, change in attitude, and materials?

North: USNO 1.3-m, Flagstaff, Arizona, USA

W 111.7 N 35.2

South: MODEST 0.6-m, Cerro Tololo, Chile

W 70.8 S 30.2



Summary of Observations

- **4 hours of coordinated observations night of 22 Feb 2014 UT.**

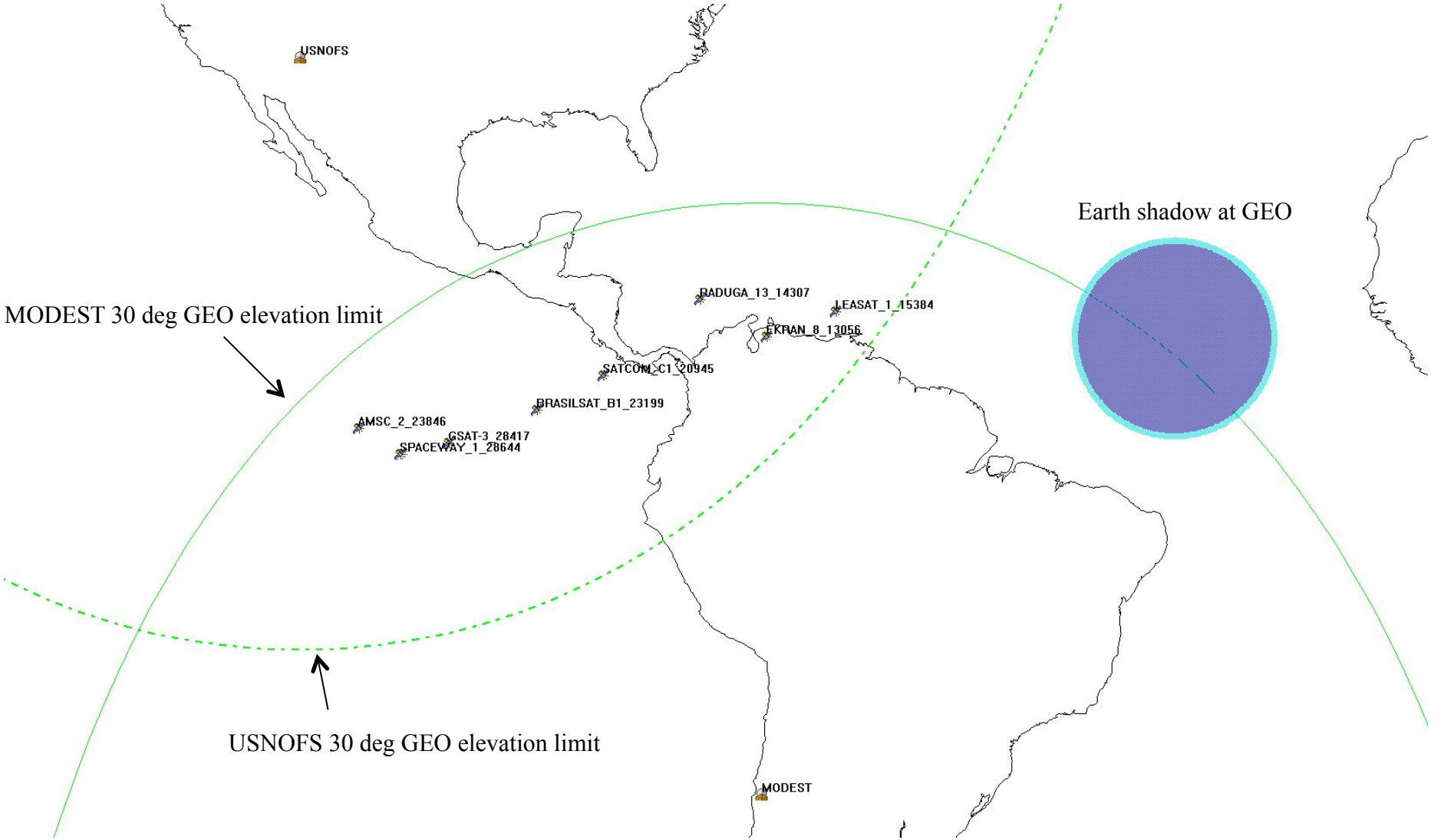
- **USNO 1.3-m in North, MODEST 0.6-m in South**
  - Delta longitude = 40.9 deg.
  - Delta latitude = 65.4 deg
  - GEO Parallax factor > 10 degrees
  - Baseline ~ 7800 km

- **Coordinated observations of same region of GEO during same 30 minute time span - 8 sets of observations. All exposures on both telescopes 3 seconds.**

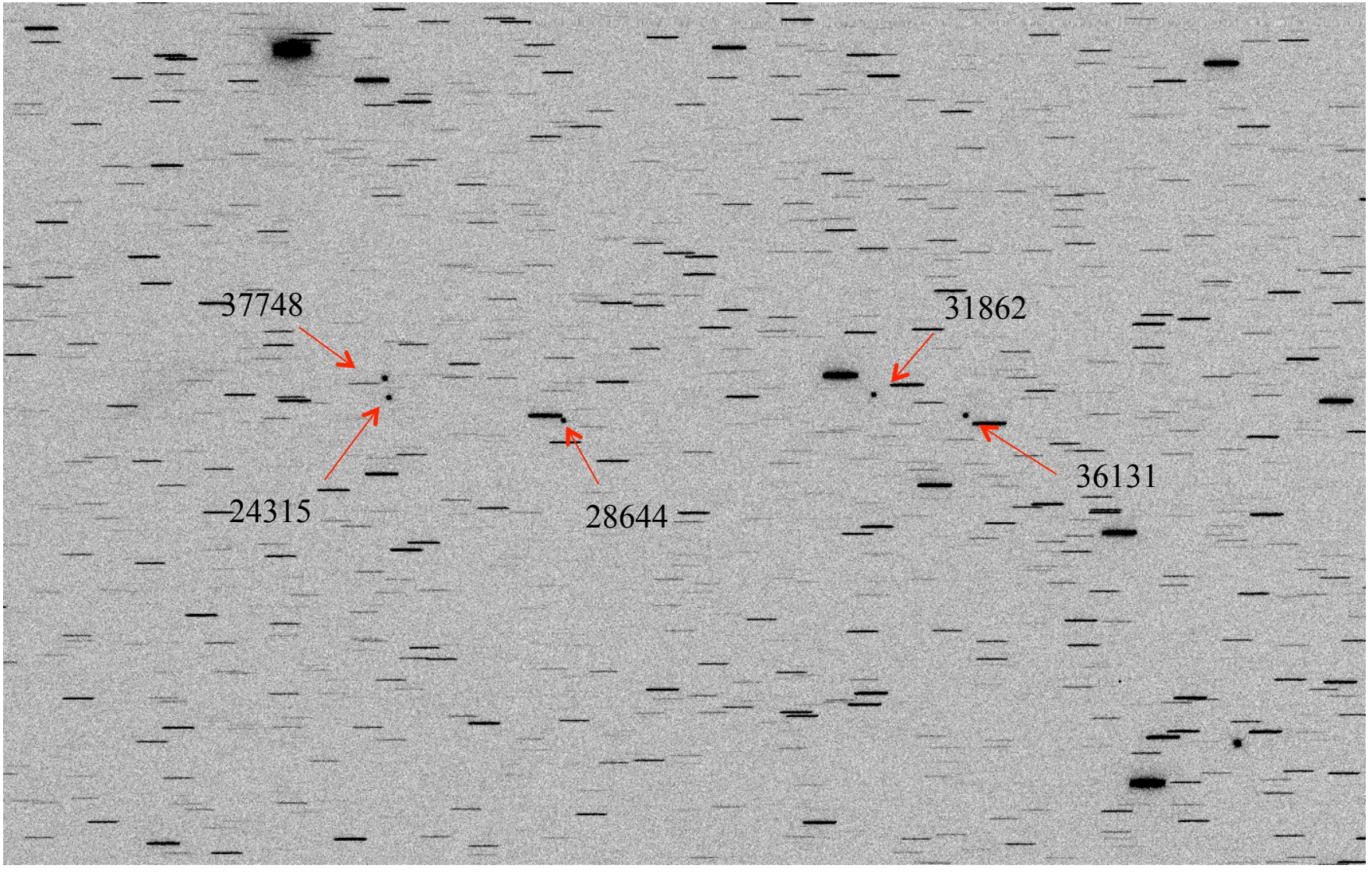
- **Observations with telescope drives off – GEO survey mode. Started with cataloged GEO object in field for test – insure our first observations work!**

- **1 controlled object SSN 28644 plus 7 uncontrolled objects.**

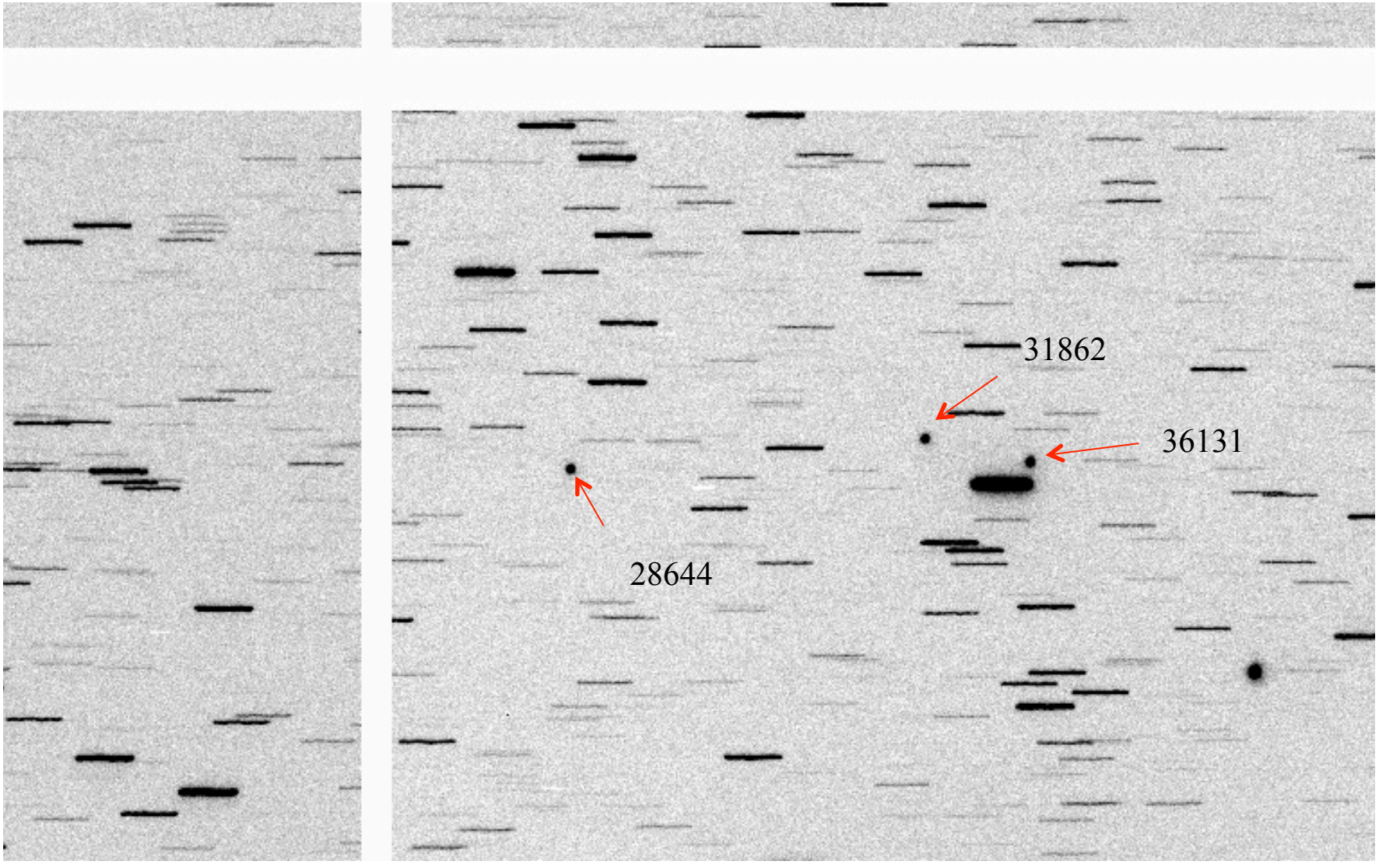
Observing Geometry: 0230 UT 22 Feb 2014



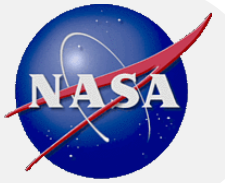
MODEST image 182 at 02:44:54 UT



USNO image 063 at 02:44:30 UT



Photometry from bistatic data



- **Today: calibrated magnitudes for one controlled and 7 uncontrolled objects to Landolt R.**

- **Filters:**
  - MODEST – broad R.
  - USNO – SDSS r.

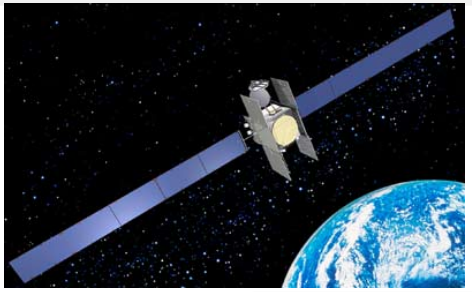
- **No correction for any geometric effects:**
  - No correction to standard range.
  - No correction for phase angle.

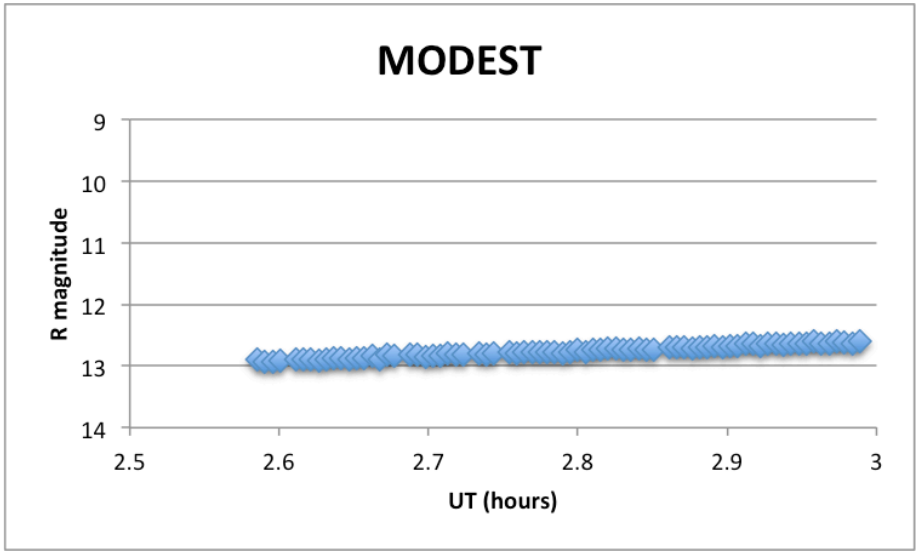
- **Plots show full 30 minute observing window – if less data than this plotted, object went out of field of view before 30 minute window closed.**

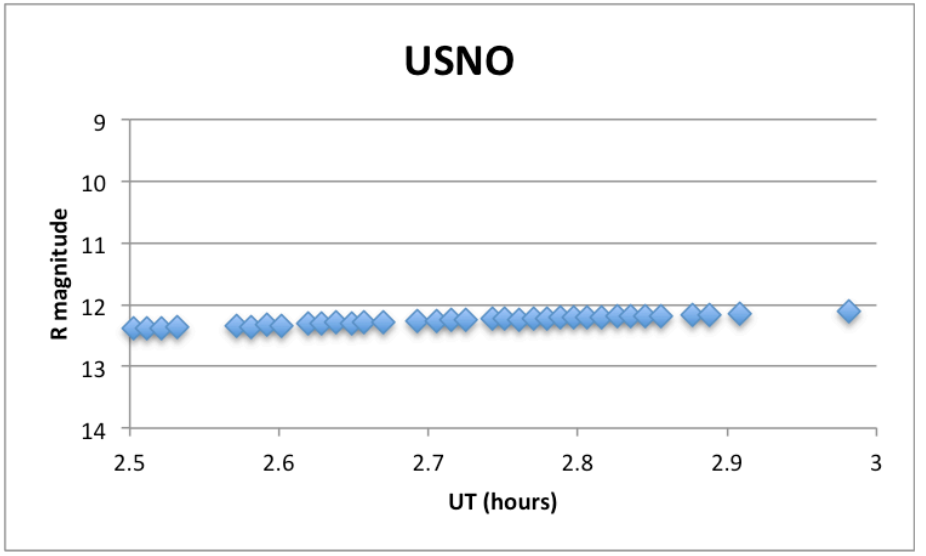
- **Errors are size of the points – typically 0.05 or less.**

- **Only measurements not confused with star trails plotted.**

SSN28644 SPACEWAY 1 (incl = 0.03 deg)

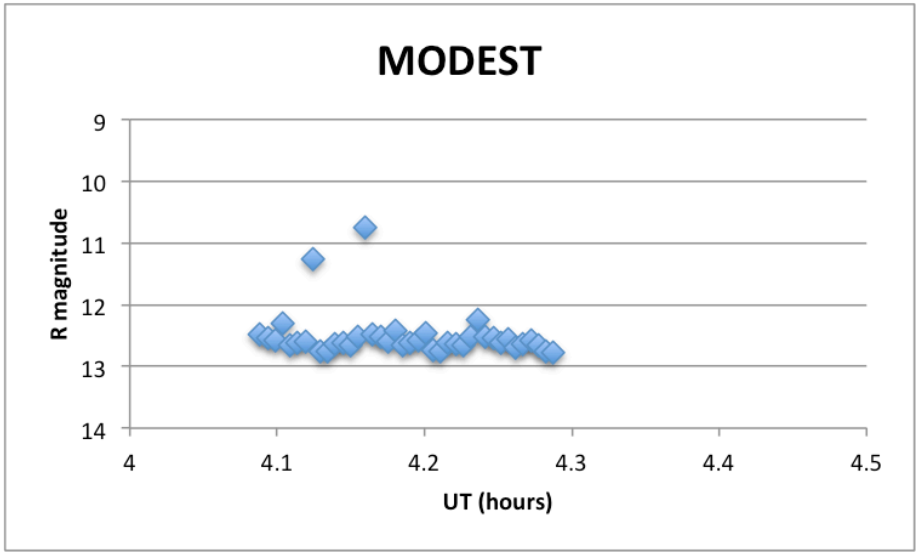


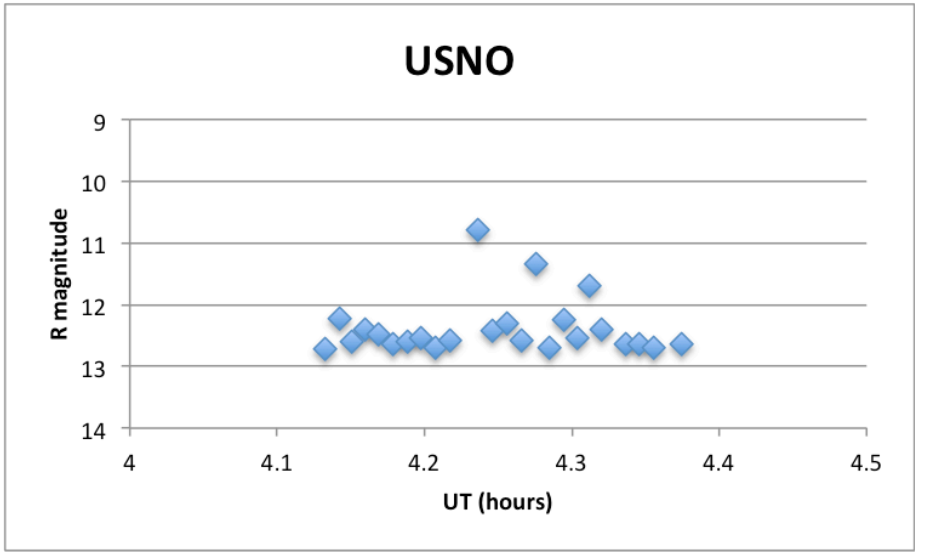




Colocated 31862 (Direct TV 10) and 36131 (Direct TV 12) show similar light curves.

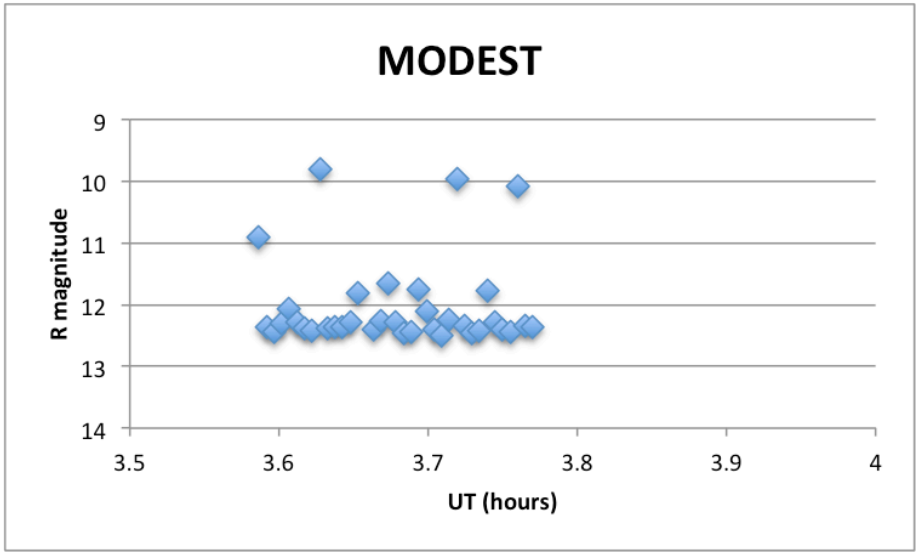
SSN14307 RADUGA 13 (incl = 15.6 deg)

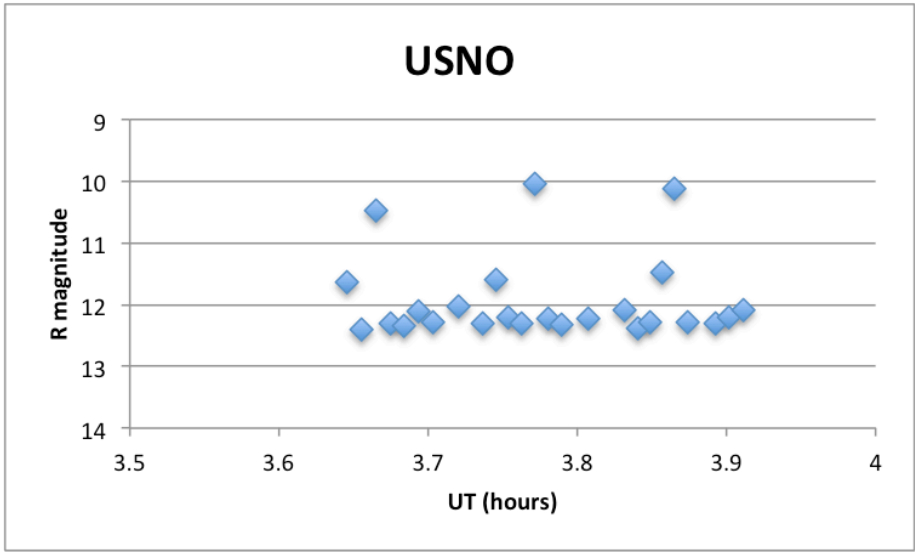




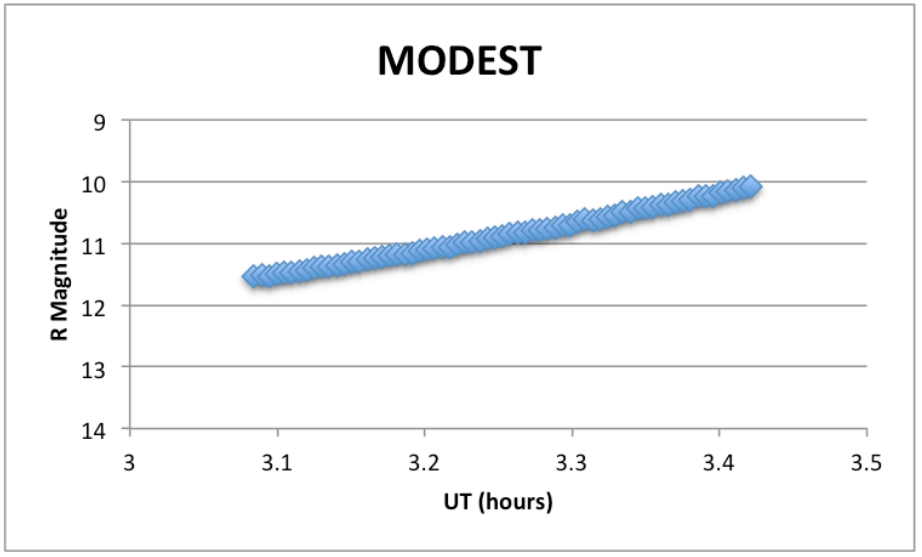
Increases in brightness at different times!

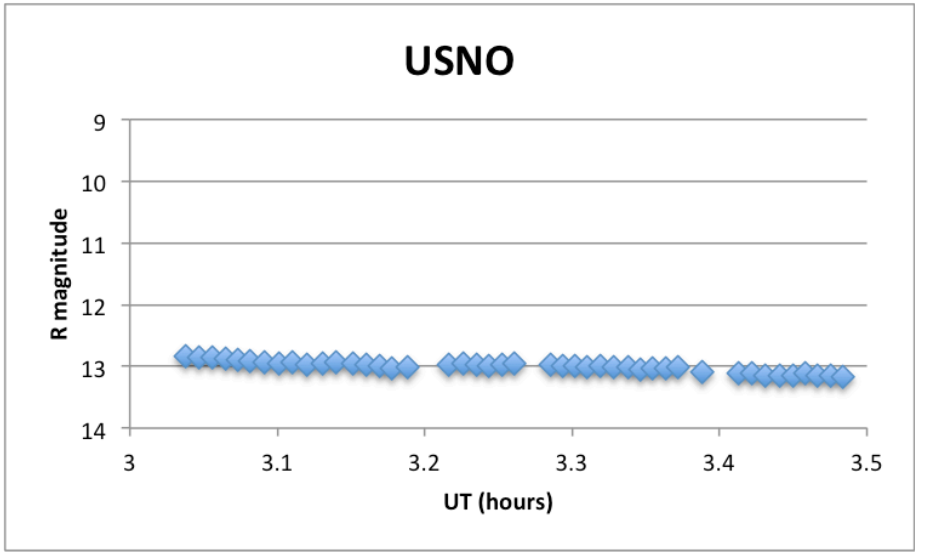
SSN13056 EKRAN 8 (incl = 14.7 deg)





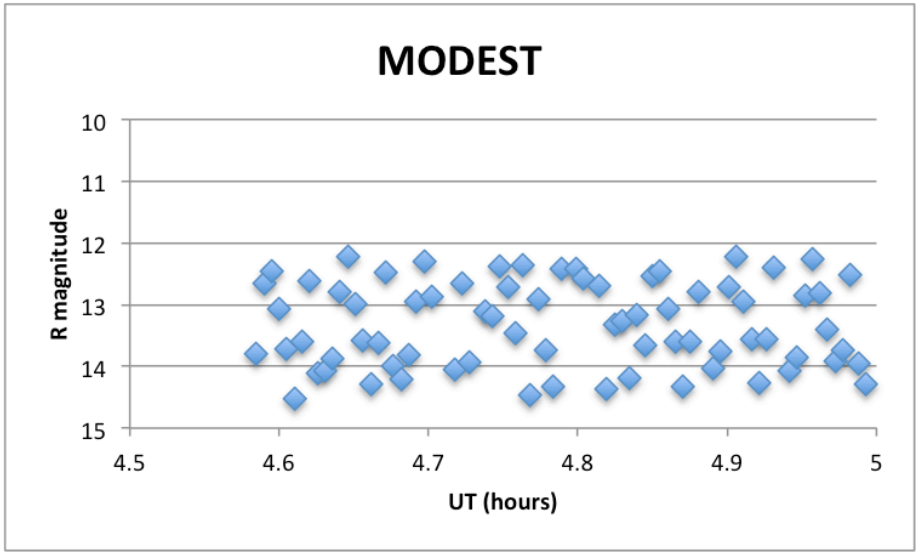
SSN15384 LEASAT 1 (incl = 13.7 deg)

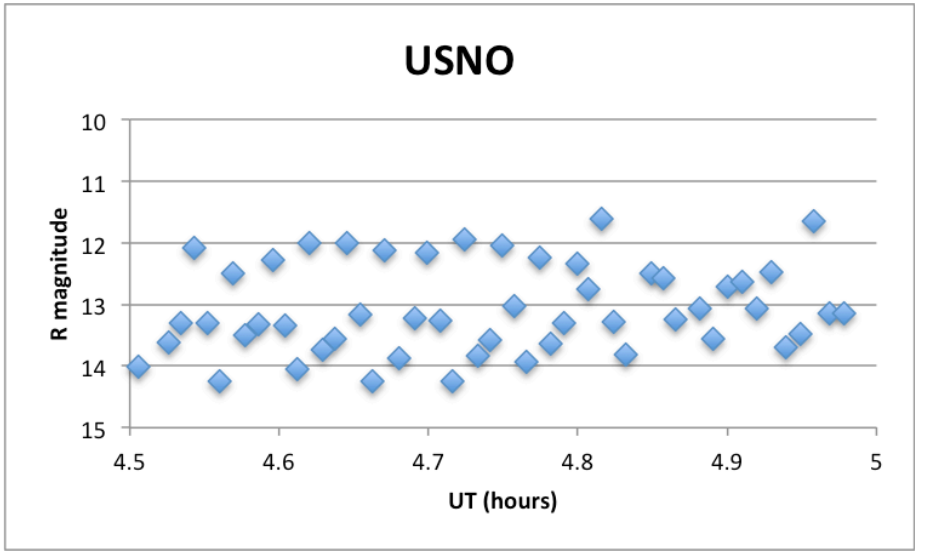




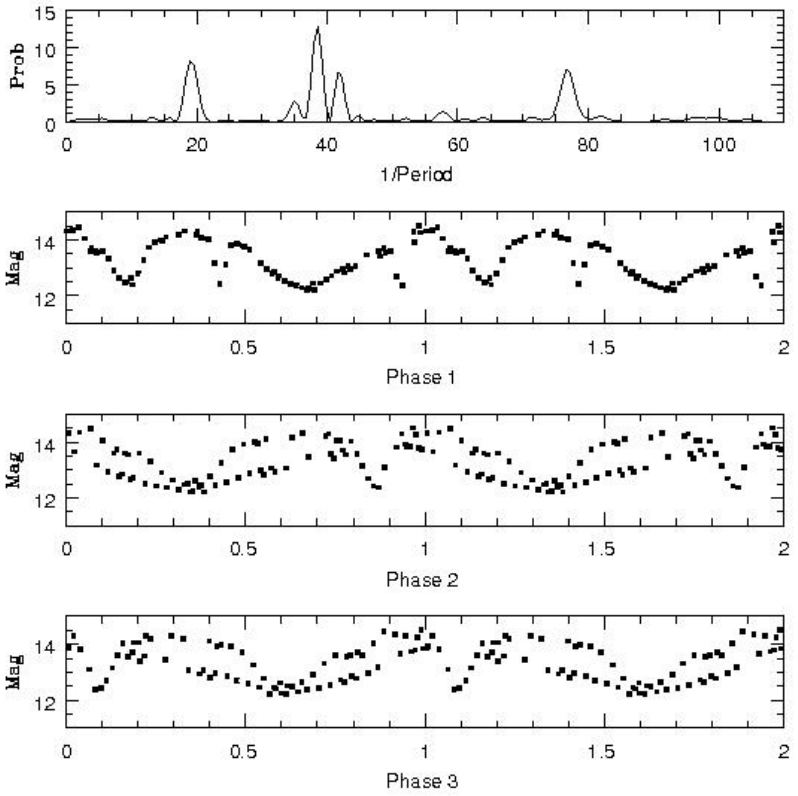
Very different magnitudes and light curves.

SSN20945 SATCOM C1 (incl = 8.9 deg)

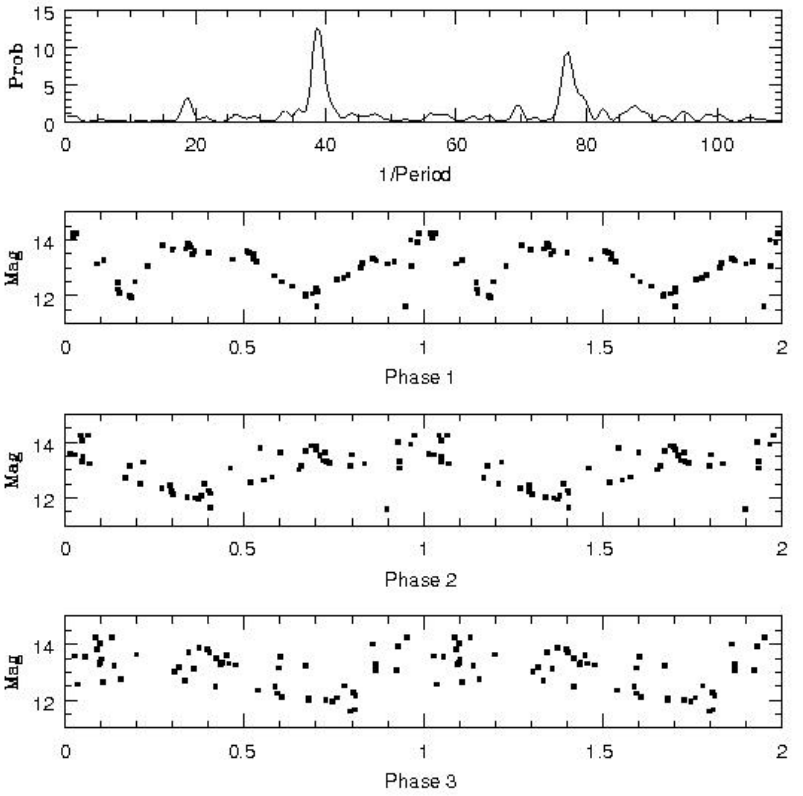




SSN20945 – Periodogram Analysis

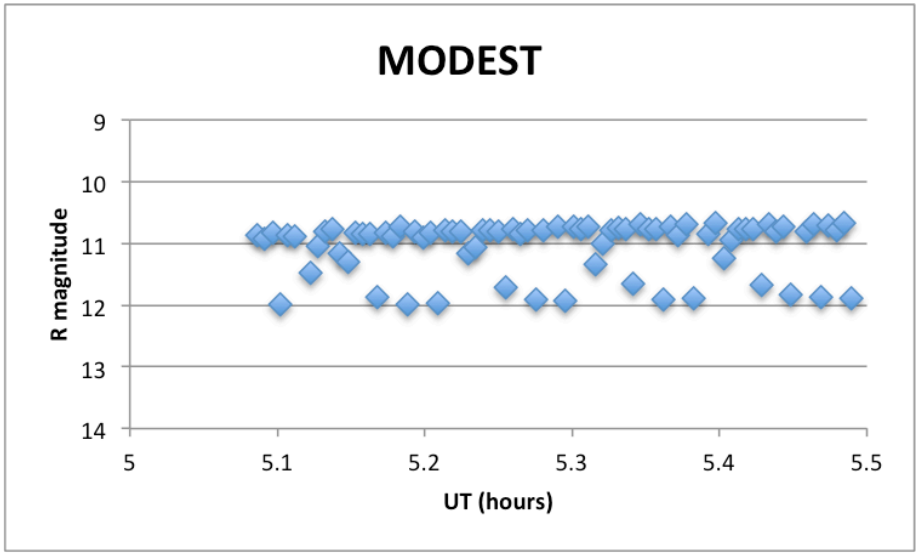


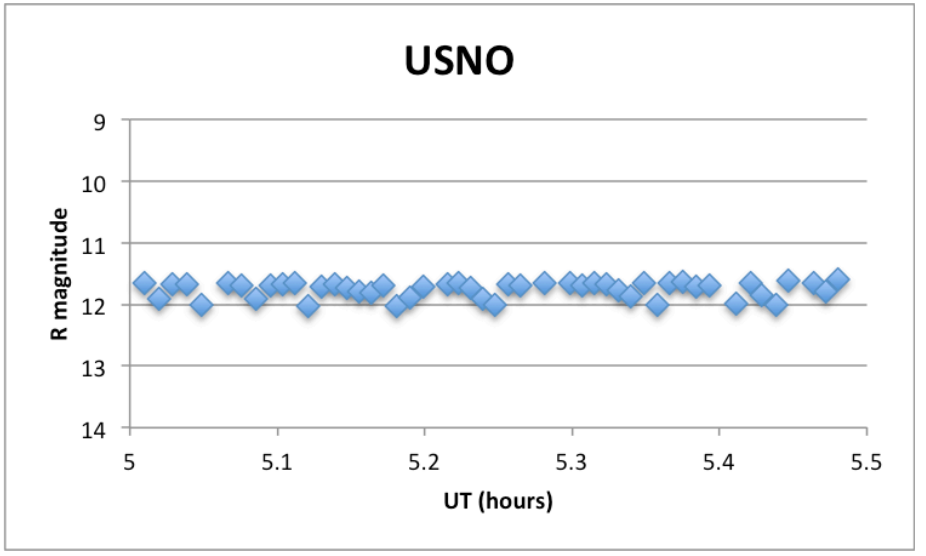
MODEST



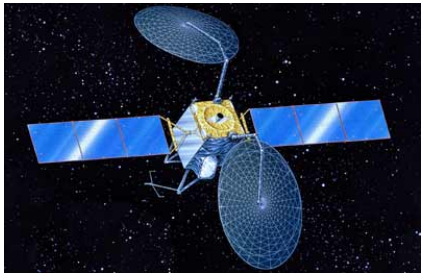
USNO

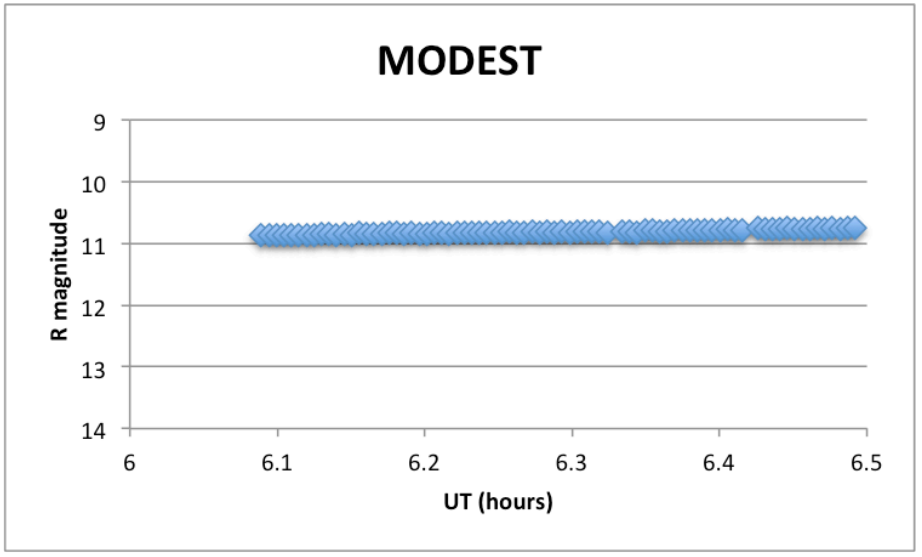
SSN23199 BRAZILSAT B1 (incl = 6.4 deg)

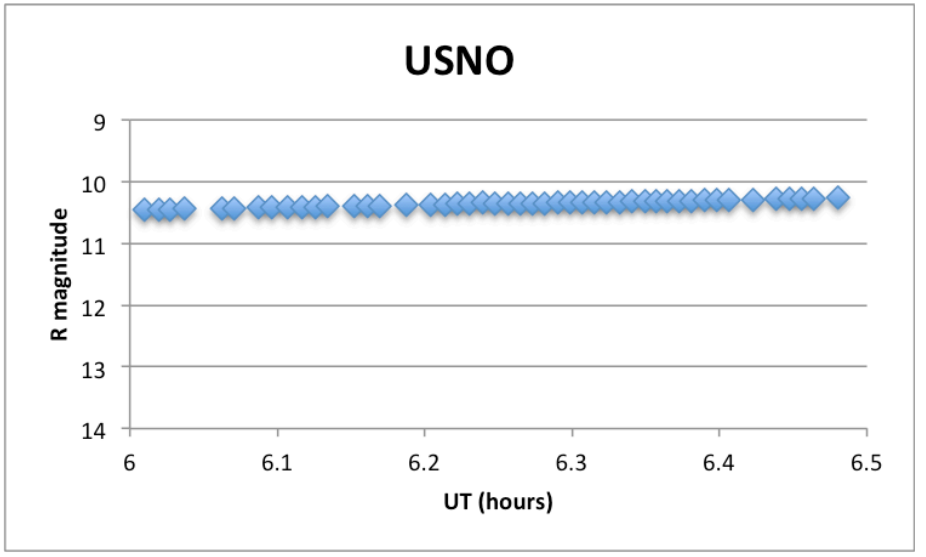




SSN23846 MSAT M1 (incl = 6.1 deg)

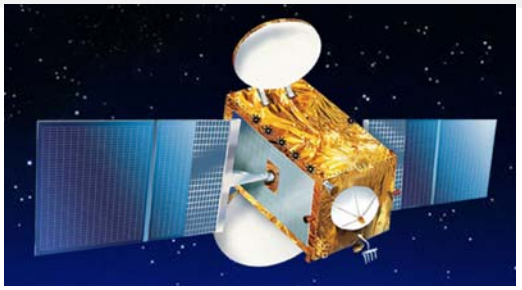


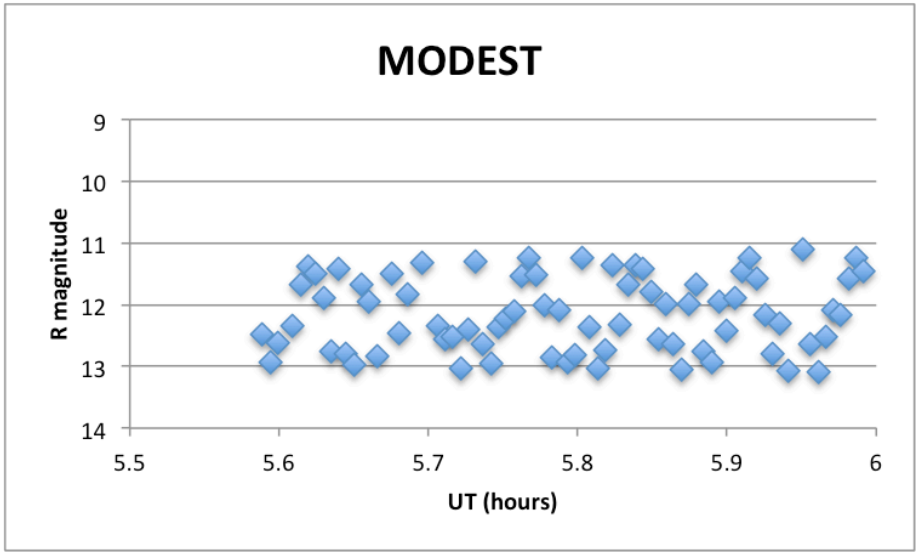


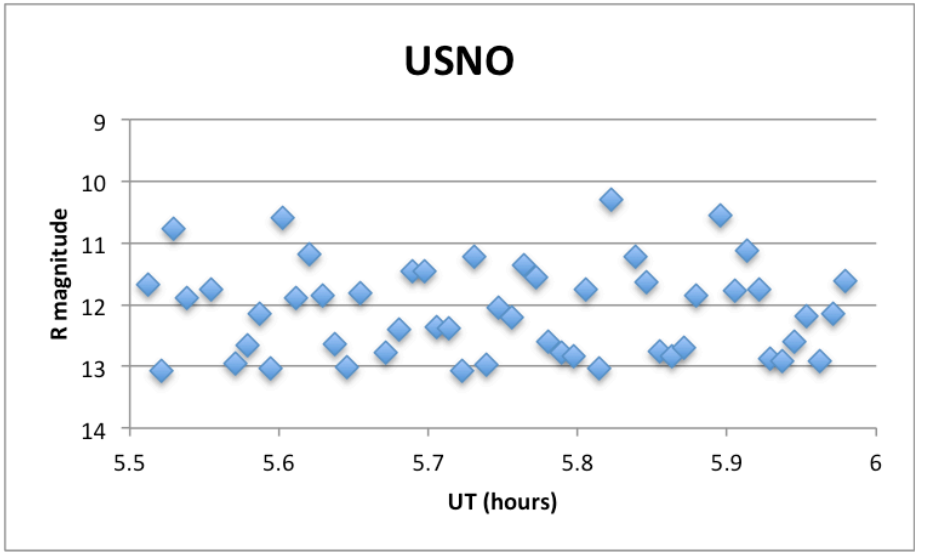


Well behaved!

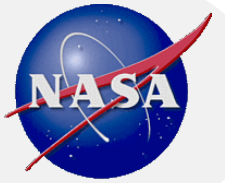
SSN28417 GSAT 3 (incl = 3.2 deg)







Summary



- **Proof of concept observations on known objects to judge advantages of doing bistatic GEO observations.**

- **Photometry:**
  - Observed optical brightness depends on time ***and*** location.
  - Very different light curves depending on object.
  - Light curve for any one object qualitatively similar as observed at two sites, but amplitude and timing can be quite different.