Analysis of Equatorial Mount or Platform Star Drift Due to Polar Alignment Error

Website: skyhoundobservatory.com
Author: Thomas Beck
Date: February 21, 2018

Introduction

Equatorial mount telescopes are ideally suited for astrophotography but get very expensive and cumbersome for large apertures. Equatorial platforms provide a way to use large aperture altitude/azimuth mount telescopes like popular Dobsonian telescopes for astrophotography. As with any telescope mount, equatorial axis polar alignment is critical to successful imaging using prolonged exposures. The purpose of this paper is to document a spreadsheet used to calculate star drift due to equatorial mount or platform polar alignment errors for a full variety of celestial object right ascension and declination parameters at a selectable observation site and date/time.

Operation

Equatorial mount telescopes are inherently capable of finding celestial objects from any starting position and can track most objects for unlimited durations of time. Telescopes mounted on equatorial platforms require special initial conditions to locate objects and are limited in duration of a single tracking session.

Swing of a typical equatorial platform is 20 degrees which gives 80 minutes of operation before it needs to be reset to its starting position. Since the initial starting position is 10 degrees from horizontal, the time or location must be offset in the telescope control to be able to automatically seek out objects of interest.

Initial platform tilt when looking east has the telescope pointing lower than its level position placing stars higher than normal in the sky. The tilt effect can be neutralized by adding 40 minutes to the telescope control time setting or moving the longitude setting 10 degrees to the east. Once the desired object is located using the telescope automation, the control tracking is turned off and platform tracking is turn on.

Equatorial mount or platform axis of rotation needs to be aligned to that of the earth for successful imaging of faint celestial objects that require long exposures. The center of rotation of the earth is closely aligned to Polaris. Precise alignment to this polar axis is achieved using star drift observed in south and east or west directions.

Analysis

The spreadsheet includes typical observation site and date/time input parameters. Initial object (actual) and telescope (observed) local hour, altitude, and azimuth angles are calculated for a full rang e of celestial object right ascension and declination parameters using well understood formulas. The equatorial mount or platform pointing error effects on observed object position are calculated using selectable east/west longitude and north/south latitude shifts in telescope location.

Initial and final actual and observed positions after a selectable time are used to compute changes in altitude and azimuth due to rotation of the earth and mount or platform equatorial axis rotation. In addition to selectable pointing errors, there is provision to inject tracking rate error into the star drift analysis. Charts of object altitude, object azimuth, altitude drift, and azimuth drift are included for numerous object declinations and full range of object right ascensions.

Results

Figure 1 shows spreadsheet setup parameters and a summary of star drift expected observations. Figures 2 and 5 show the effects of pointing errors of one degree east and one degree north for six object declinations from -20 to +80 degrees over the full range of object right ascensions.

The standard polar alignment method uses declination drift of stars near the meridian in the south to correct for east and west of the pole pointing errors. If star drift is up the mount or platform equatorial axis is pointing to the east of the pole and west if star drift is down. The east/west pointing position is adjusted to eliminate as much star drift as possible.

Figure 3 shows enlarged 0 degrees declination chart for the east of the pole pointing error since that would be used for stars near the meridian. That chart shows upward drift for an azimuth range of 90 to 240 degrees. Rather than using the standard equatorial mount method of stars due south at 180 degrees azimuth, alignment could be improved using stars at 150 degrees where star drift peaks. Figure 4 for a pointing error of one degree to the west shows an inverted drift chart.

The standard polar alignment method uses declination drift of stars near the horizon in the east or west to correct for above and below the pole pointing errors. If drift is up for a star in the east the mount or platform equatorial axis is pointing below the pole and above if drift is down. The above/below pointing position is adjusted to eliminate as much star drift as possible.

Figure 6 shows enlarged 20 degrees declination chart for the below the pole pointing error since that would be used for stars near the horizon. That chart shows upward drift for nearly all azimuth angles in the east. Rather than using the standard equatorial mount method of stars due east at 90 degrees azimuth, alignment could be improved using stars at 120 degrees where star drift peaks. Figure 7 for a pointing error of one degree above the pole shows an inverted drift chart.

Stars drift in both altitude and azimuth with the greatest deviations being for objects with declinations below 60 degrees. Drift gets much smaller for objects with high declinations. Imaging of high declination objects near Polaris would require much less precise polar alignment than objects near the celestial equator. While it is desirable to image objects at near their meridian transit high point, the charts can be used to select somewhat lower altitude with much reduced star drift.

Figures 8 and 9 show effects of positive and negative 2% errors in the tracking rate. Those errors make the drift alignment less reliable for some combinations of pointing error and object position. Large shifts in azimuth can be used to adjust tracking rate before starting the polar alignment process. East/west and north/south alignment steps may need to be repeated several times to achieve precise polar alignment.

Site Parameters	Code	Value	Units
Location Time Offset	Tof	-6.00	Hour
Location Latitude	Lat	40.583	Degree
Location Longitude	Lon	111.800	Degree
Location Elevation	Ele	1550	Meter
Observation Year	Year	2017	Year
Observation Month	Mon	4	Month
Observation Day	Day	0	Day
Observation Hour	Hour	0	Hour
Observation Minute	Min	0	Minute
Observation Minute	Sec	0	Second

Scope Parameters	Code	Value	Units
Platform EW Angle	Aew	1.000	Degree
Platform NS Angle	Ans	0.000	Degree
Tracking Time Error	Tte	0.000	Hour
Tracking Time Total	Ttt	1.000	Hour

Output Parameters	Code	Value	Units
Julian Date	JD	2457844	Day
Universal Date	UT	6298.8	Day
Greenwich Time	GMST	18.587	Hour
	π	3.142	

Drift Alignment

Looking	Offset	Pointed	Drift
North	East (+)	East	Down
North	West (-)	West	Up
South	East (+)	East	Up
South	West (-)	West	Down
East	North (+)	Below	Up
East	South (-)	Above	Down
West	North (+)	Below	Down
West	South (-)	Above	Up

Figure 1 Equatorial Platform Drift Analyzer Setup Parameters and Drift Alignment Summary

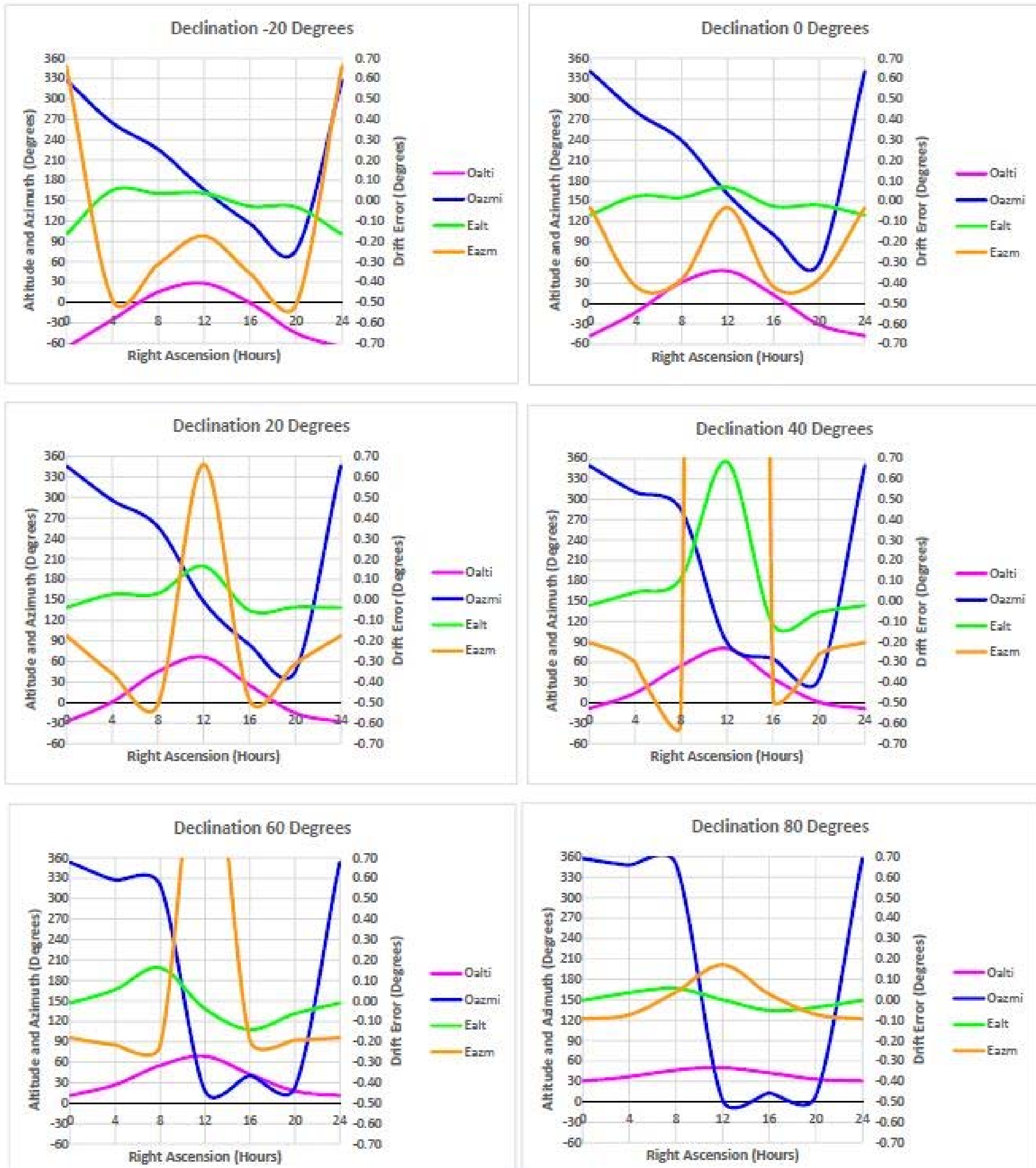

Figure 8 Drift Chart for 1 Degree North Platform Shift and Positive 2% Tracking Error

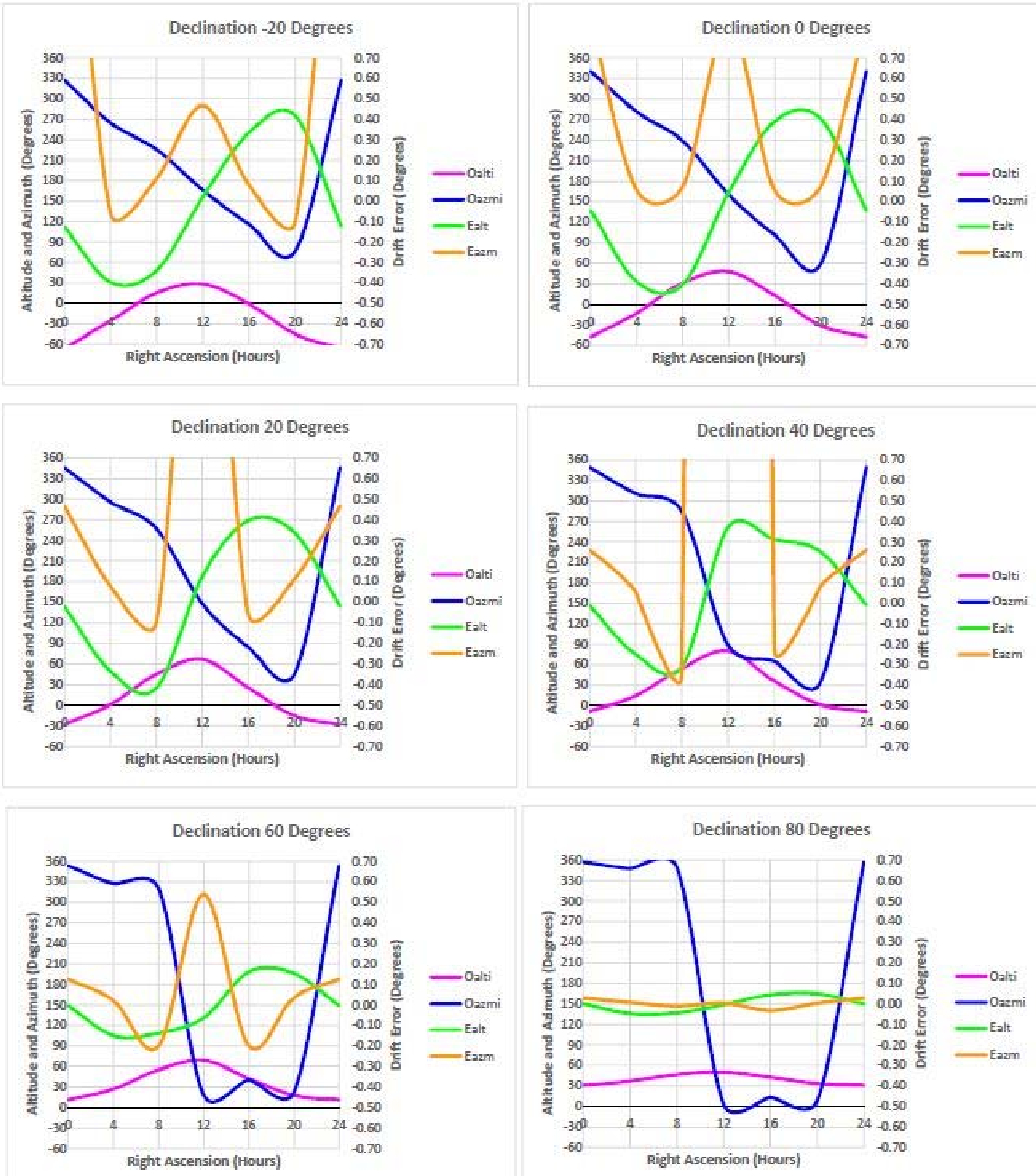

Figure 9 Drift Chart for 1 Degree North Platform Shift and Negative 2% Tracking Error