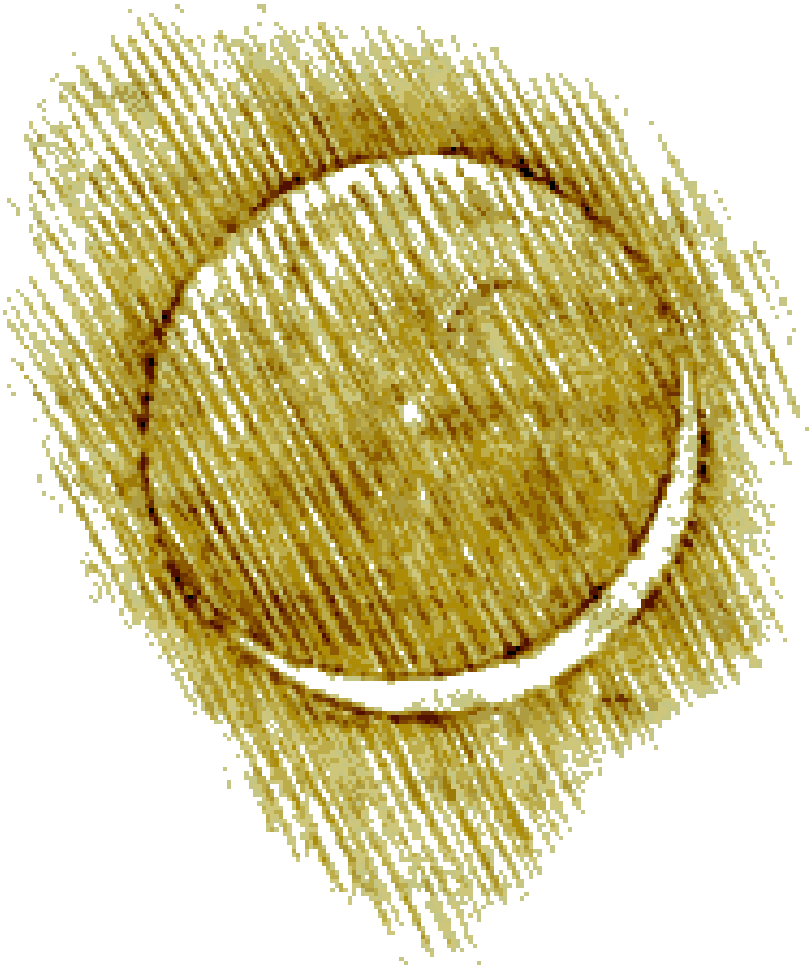
Danish Meteorological Institute
Ministry of Transport

Technical Report 06-04

Lunar observability

Peter Thejll



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Contents

Dansk resumé

Muligheden for at observere Månen fra Polære breddegrader gennemgås med henblik på fordeling af gunstige observationssituationer som funktion af azimuth og altitude. Dette gøres med henblik på IPY i forbindelse med hvilket et automatisk jordskinsteleskop på høje breddegrader blev overvejet.

Det kan ikke påvises at specielle fordele kan opnås fra Polære observatorier under IPY.

Abstract

The possibility to do lunar observations at polar latitudes is reviewed. The distribution of favourable observation opportunities as function of season, azimuth and altitude are derived for various polar-latitude observing stations. This is done in view of the IPY during which the placement of an automatic Earthshine telescope at polar latitudes was considered.

We do not find that placing a telescope at polar latitudes during the IPY will make particularly favourable observing conditions available.

Introduction

Earthshine is the light cast by the Earth onto the Moon. The intensity of this light depends, amongst other things, on the reflectivity of the Earth - the 'albedo'. By carefully observing the Moon it is therefore possible to derive information about the terrestrial albedo. Albedo is a governing factor for the climate energy balance and it is therefore of great interest to observe Earthshine.

Different parts of the Earth reflect light onto the Moon at different parts of the day but the Moon is not continuously observable from a low or middle latitude observatory. The idea to observe the Moon from a location at which the Moon does not set for a long time - i.e a polar site - is at hand.

In this report we review the observability of the Moon from a number of sites that are known to provide the necessary infrastructure in terms of electricity and Internet connections.

Lunar observability

Azimuth of the Moon

It is of interest to find the range and frequency of azimuth of the Moon for a given observatory, because the azimuth gives a first indication of which terrestrial longitudes will be covered by the Moon. Figure 4.1 shows histograms of the lunar azimuth for all suitable observing occasions for the years 2006, 2007, and 2008. The suitability condition is as before: lunar altitude above 11 degrees, solar altitude below -5 degrees, and lunar phase between 20 and 80% of full.

There are evidently times when the Moon is seen due North from tropical latitudes, while the azimuth is restricted between 60 degrees and 300 degrees for all mid-latitudes. For polar latitudes the Moon can be seen at all azimuths, but with best coverage, of course, at the Pole itself. Latitudes above 80 degrees give a fairly complete longitude coverage.

Tropical latitudes tend to have underrepresented longitudes and some bands that are strongly favoured.

Lunar altitude

To evaluate potential observing sites from the viewpoint of lunar altitude we evaluate which ranges of lunar altitude that are attained for the period coinciding with the IPY. We evaluate the altitude using ephemeris functions and pose the requirement that the Sun be at least 5 degrees below the horizon, and the lunar phase between 0.2 and 0.8. We evaluate the maximum altitude attained, and we evaluate the distribution of altitudes and azimuths attained for all altitudes above the horizon as well as for subsets of altitudes above certain limits.

Largest lunar altitude

The maximum lunar altitude that is attained, while the Sun is at least 5 degrees below the horizon, and lunar phase between 0.2 and 0.8, at several sites, is shown in Table 4.1, for the duration of the IPY (January 1 2007 to April 1 2009).

Distribution of lunar altitude and azimuth

Inspecting the figures we conclude that, as expected, the covered azimuth depends strongly on observatory latitude. In Table 4.2 we give the details. Briefly, we see that for a telescope at Thule we can achieve almost full circle coverage, while the Summit station gives coverage from 45 to 315

Table 4.1: Maximum altitude of Moon, with Sun at least 5 degrees below horizon, during IPY at selected sites.

Site	Site latitude	maximum altitude
CPH	55	63.57
Sdr. Strømfjord	67	51.62
Sodankylä	67	51.56
Summit	72	46.61
Thule	76	42.12
North Pole	90	28.63

Table 4.2: Azimuth ranges for various observing sites, for the requirements that the Sun be below the horizon by at least 5 degrees, that the lunar phase is between 0.2 and 0.8 and that the lunar altitude is 15 and 30 degrees respectively.

Site	azimuth at 15	azimuth at 30
Canary Islands	65-290	70-280
Copenhagen	65-290	85-275
Oulu	60-295	95-270
Sodankylä	55-305	90-270
Sdr. Strmfj.	55-305	90-270
Summit	45-315	95-265
Thule	20-340	100-265

degrees azimuth, both for an elevation of 15 degrees. If we require that no observations are performed below 30 degrees elevation even Thule does not offer good observing opportunities outside the 100 to 265 degree range in azimuth.

We also estimate the duration of the intervals when the moon is favourable in the sky, and plot the results as histograms in Figures 4.11- 4.19. For locations north of Thule it is possible to have favourable durations exceeding one day, and at the North pole durations may surpass 5 days, but the Moon is rarely also high enough in the sky to enable quality photometric observations.

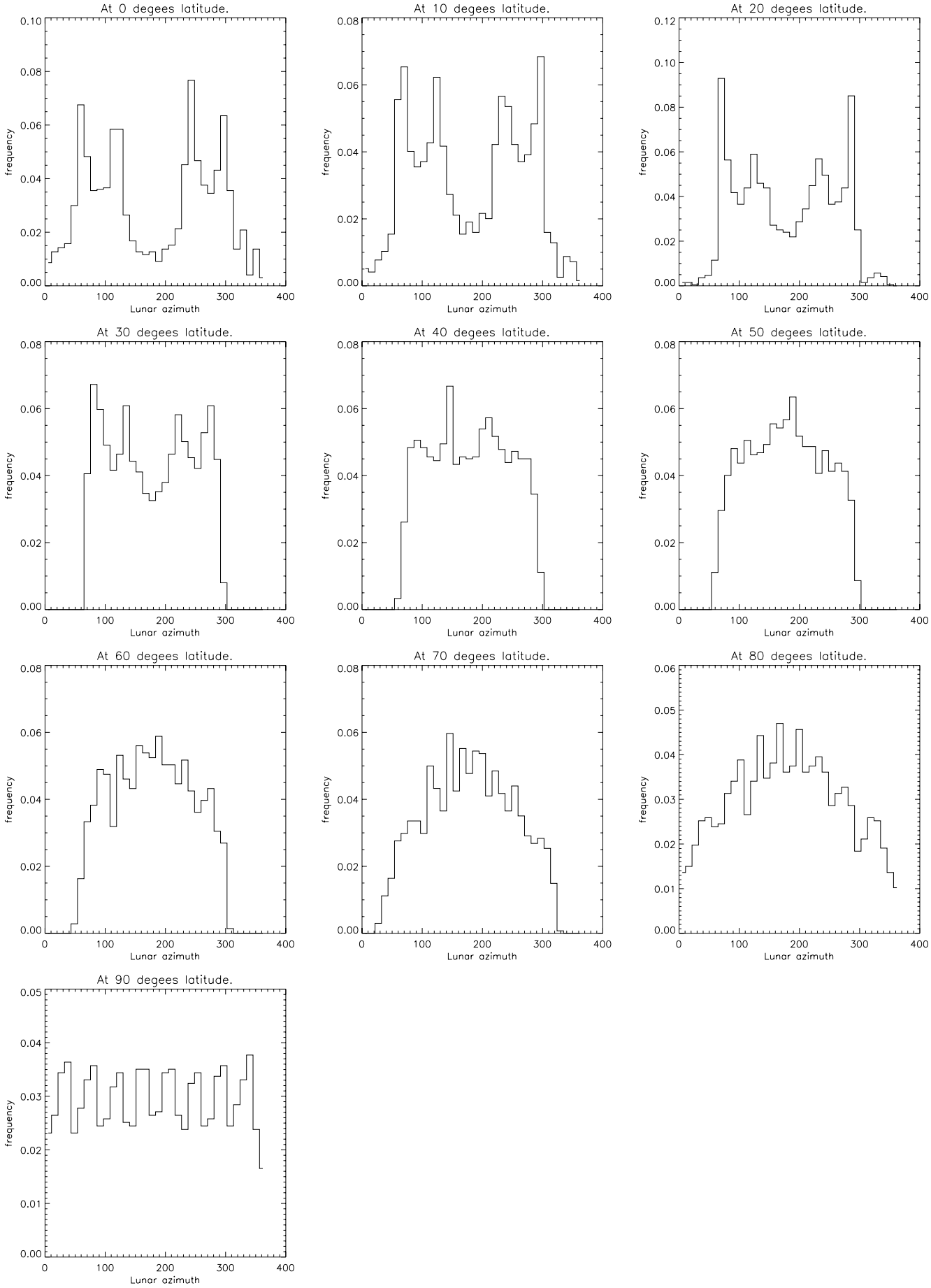

Figure 4.1: The azimuth of the Moon at various latitudes..

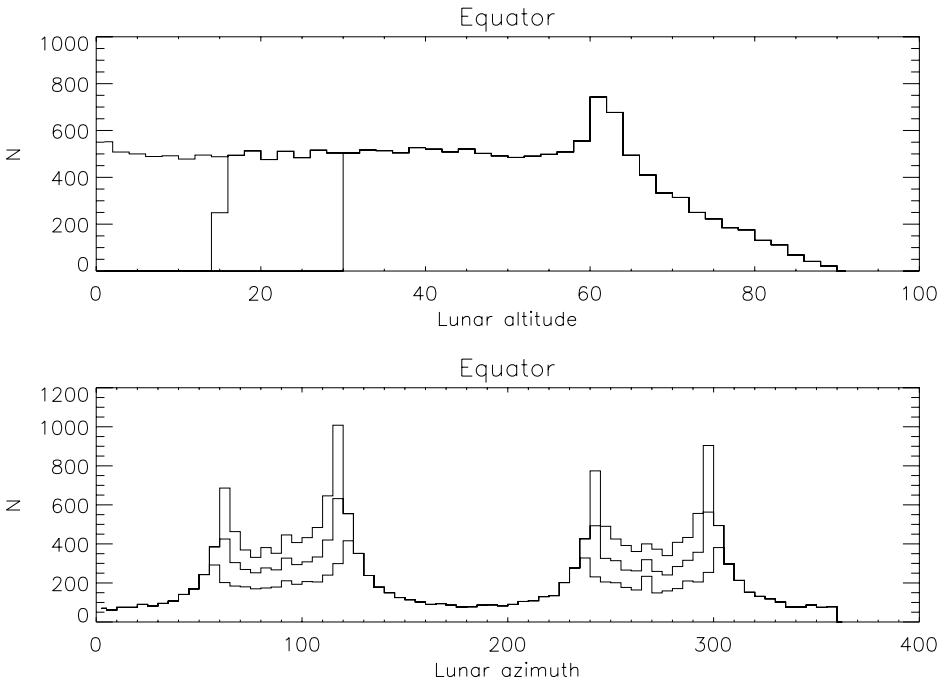

Figure 4.2: Like Figure 4.5, but for the Equator.

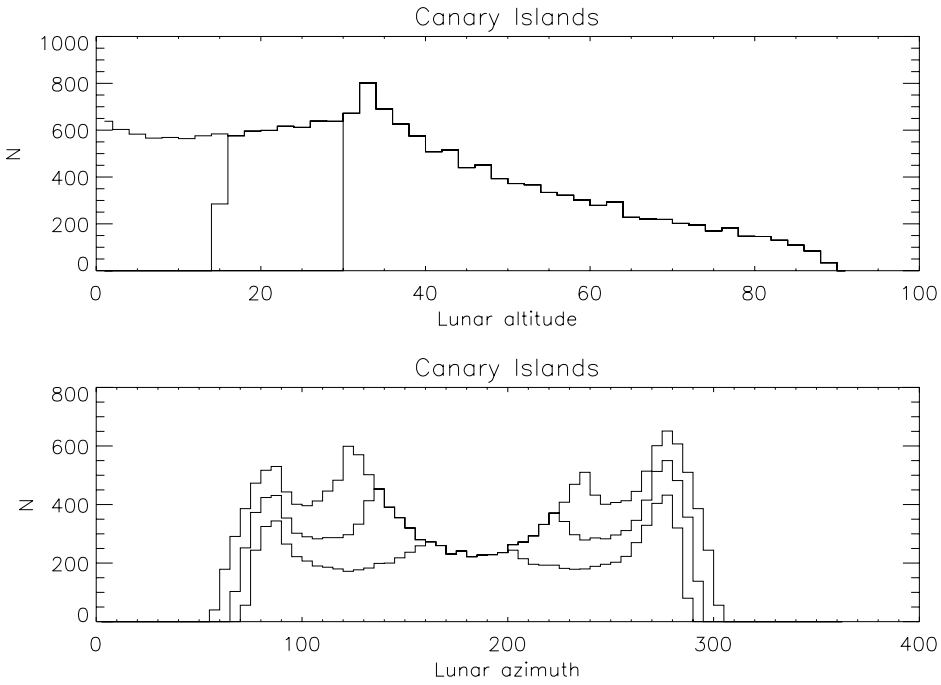

Figure 4.3: Like Figure 4.5, but for the Canary Islands.

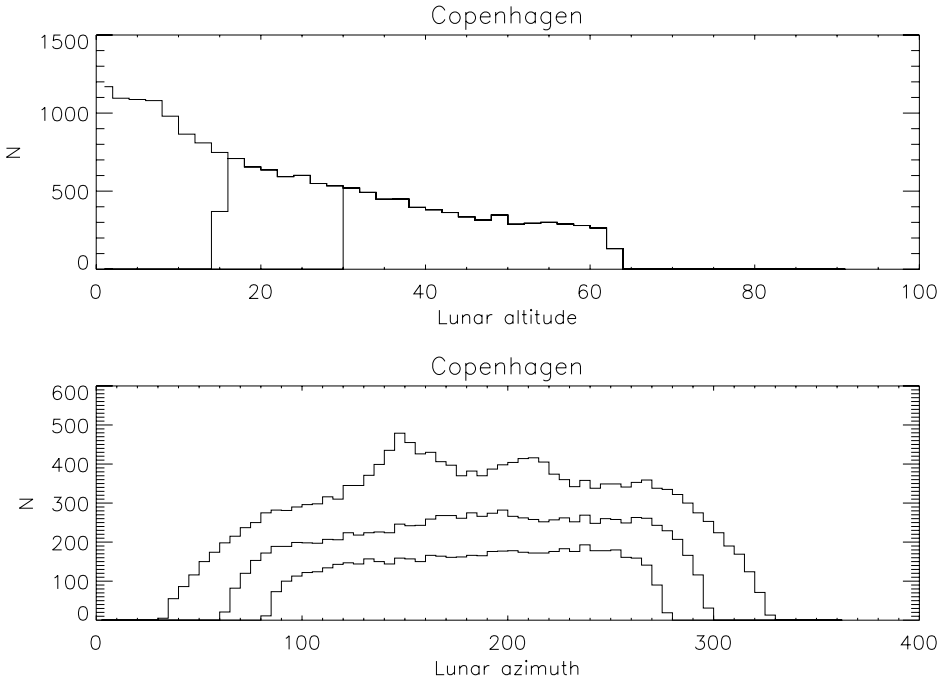

Figure 4.4: Like Figure 4.5, but for Copenhagen.

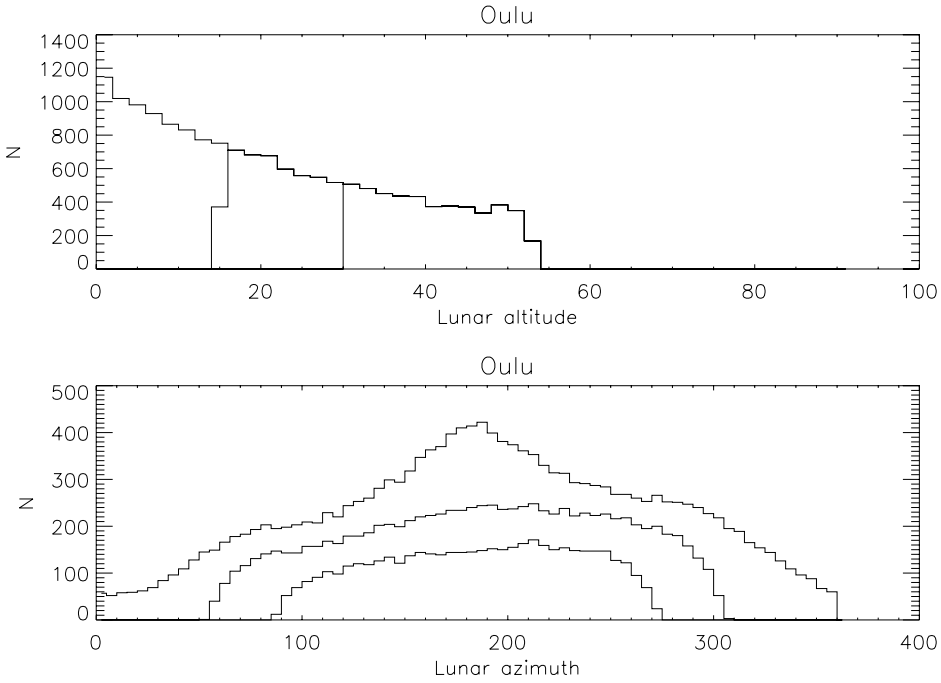

Figure 4.5: Distribution of lunar altitudes and azimuths for all altitudes (full histogram in top panel), and for altitudes above 15 and 30 degrees (middle and lower distributions). The distributions are calculated for Oulu in Finland and for the condition that the Sun is at least 5 degrees below the horizon, and lunar phase between 0.2 and 0.8.

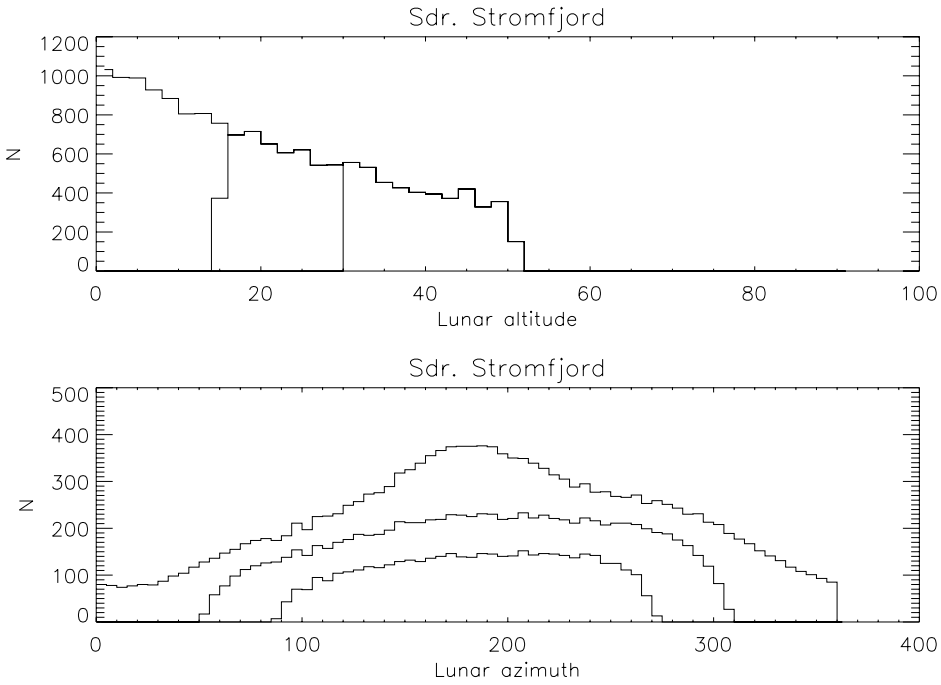

Figure 4.6: Like Figure 4.5, but for Søndre Strømfjord in Greenland.

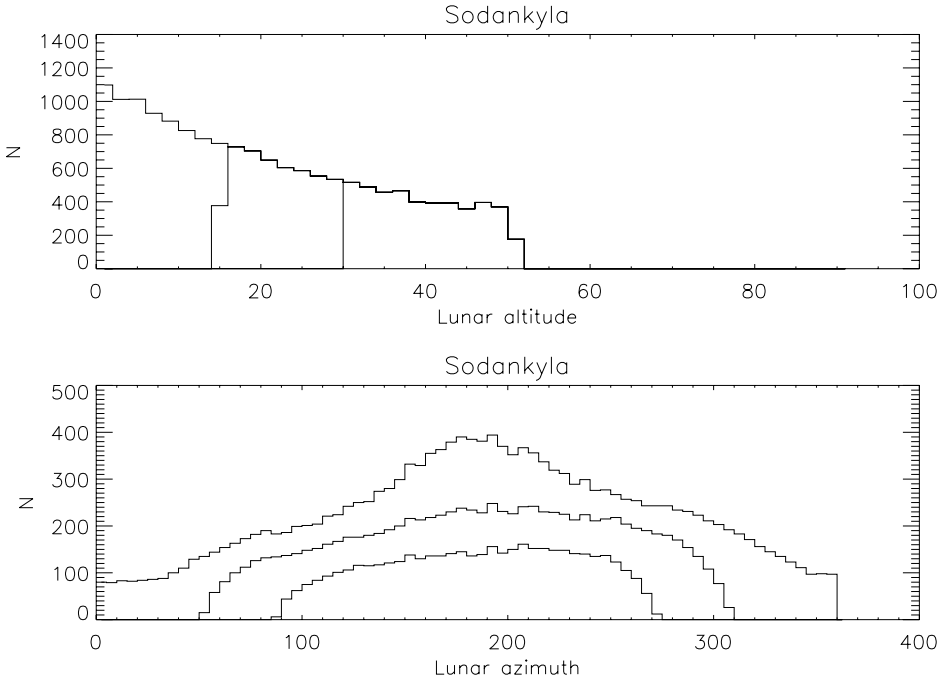

Figure 4.7: Like Figure 4.5, but for Sodankylä, in Finland.

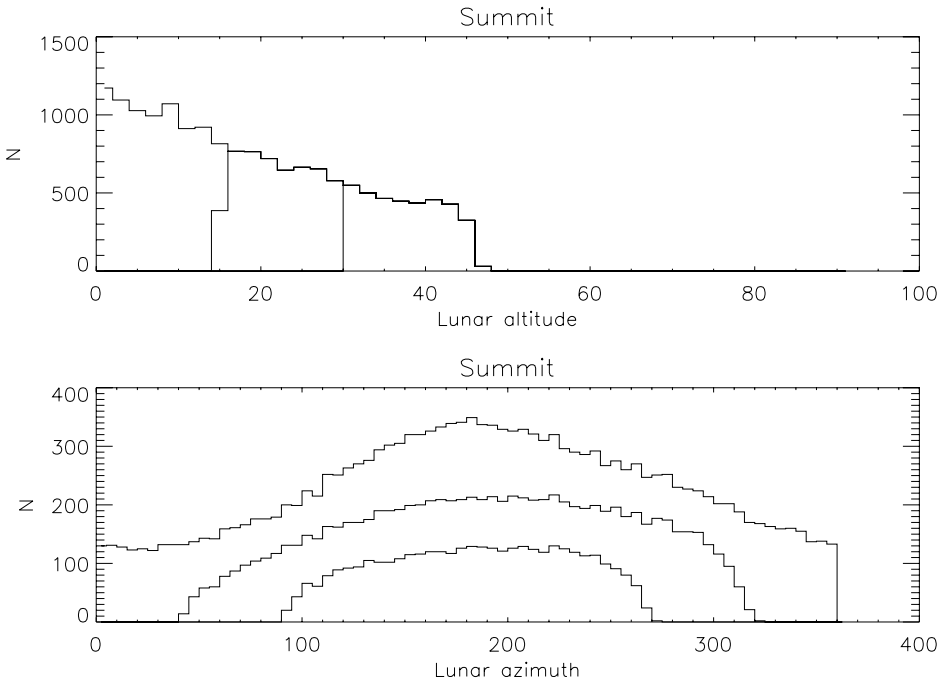

Figure 4.8: Like Figure 4.5, but for Summit base, in Greenland.

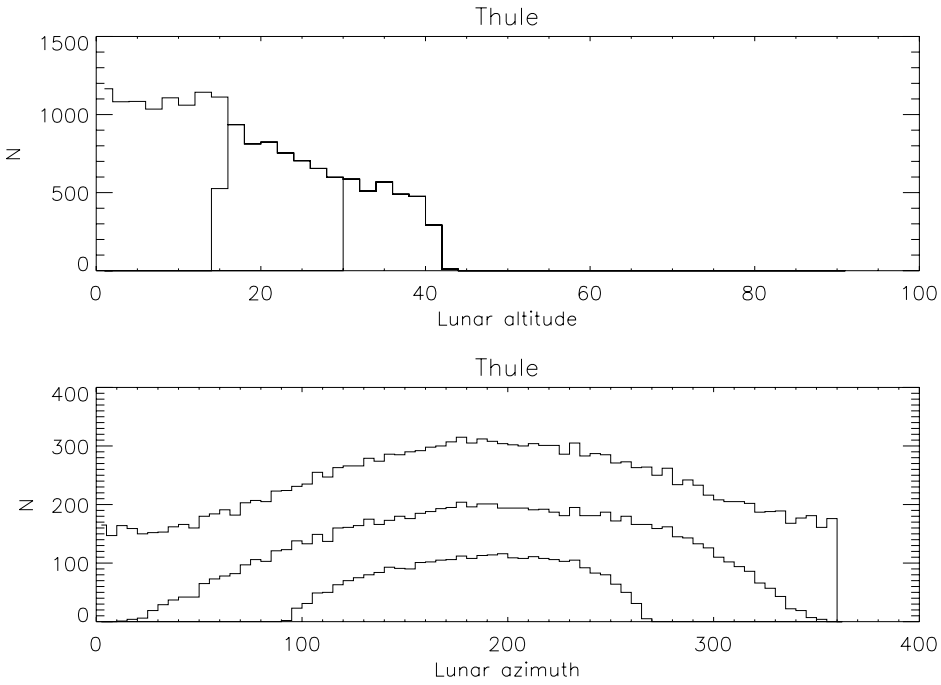

Figure 4.9: Like Figure 4.5, but for Thule, in Greenland.

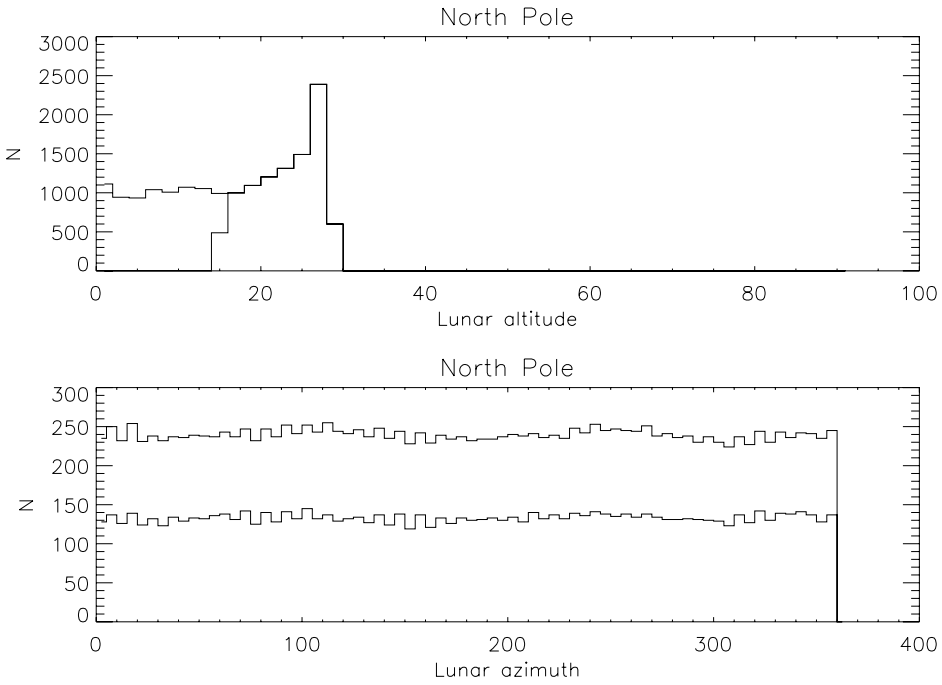

Figure 4.10: Like Figure 4.5, but for the North Pole.

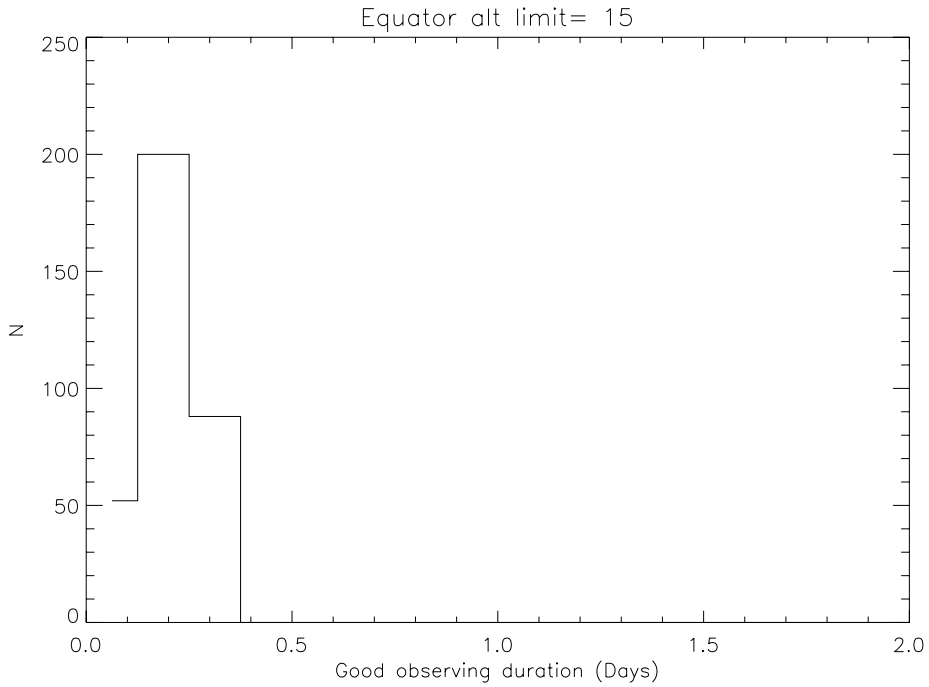

Figure 4.11: Like Figure 4.5, but for the Equator.

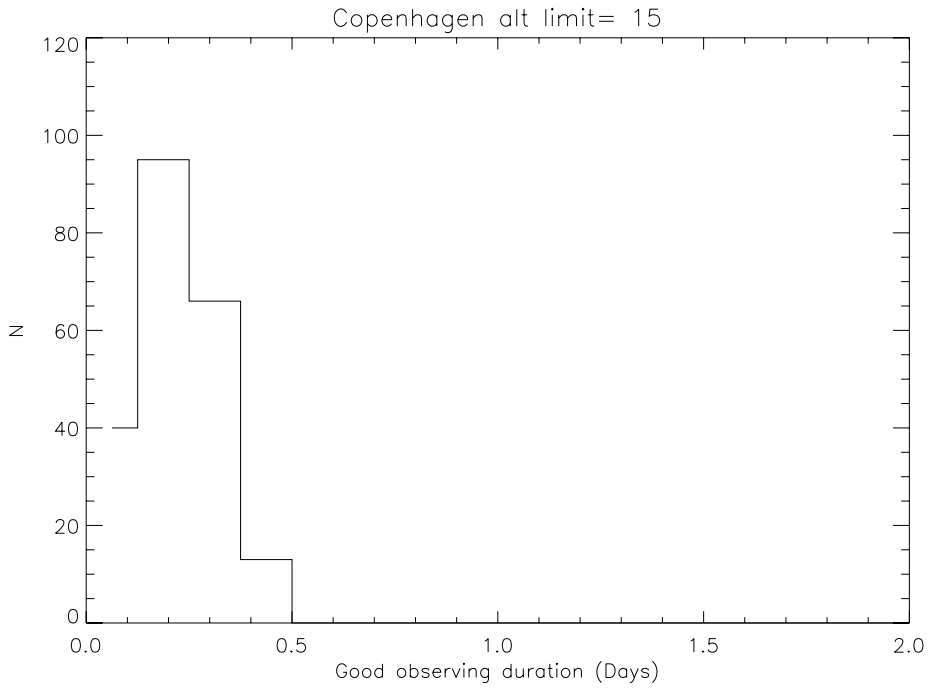

Figure 4.12: Like Figure 4.5, but for the Equator.

Conclusion

None of the polar latitude observing sites considered provide a view of the Moon under good conditions (i.e. high altitude acceptable for photometric purposes) for more than about half a day - it is therefore not worth placing a telescope at these latitudes in order to obtain long uninterrupted observing series.

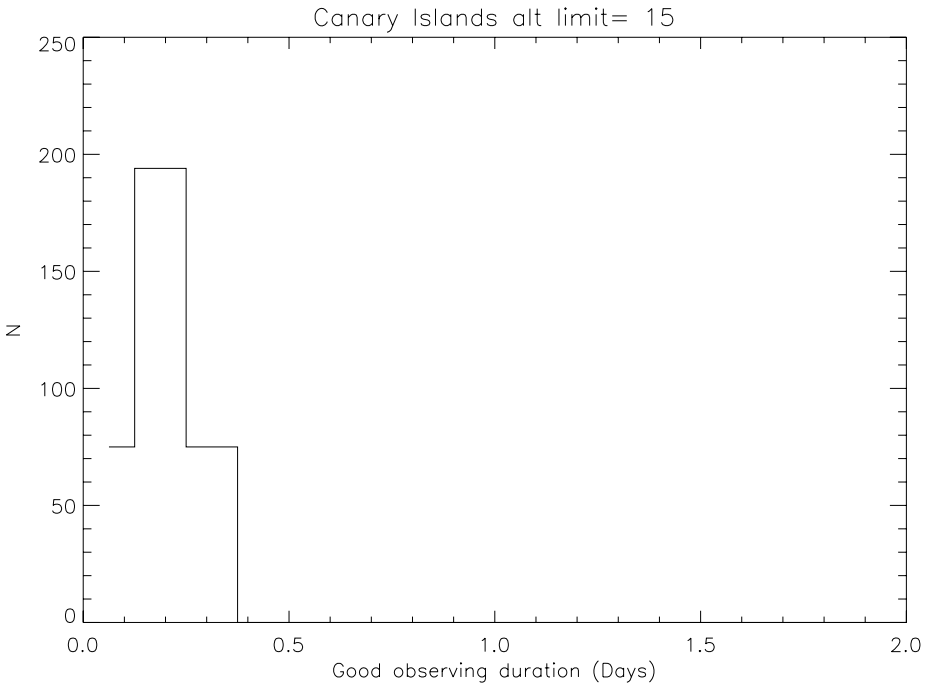

Figure 4.13: Like Figure 4.5, but for the Equator.

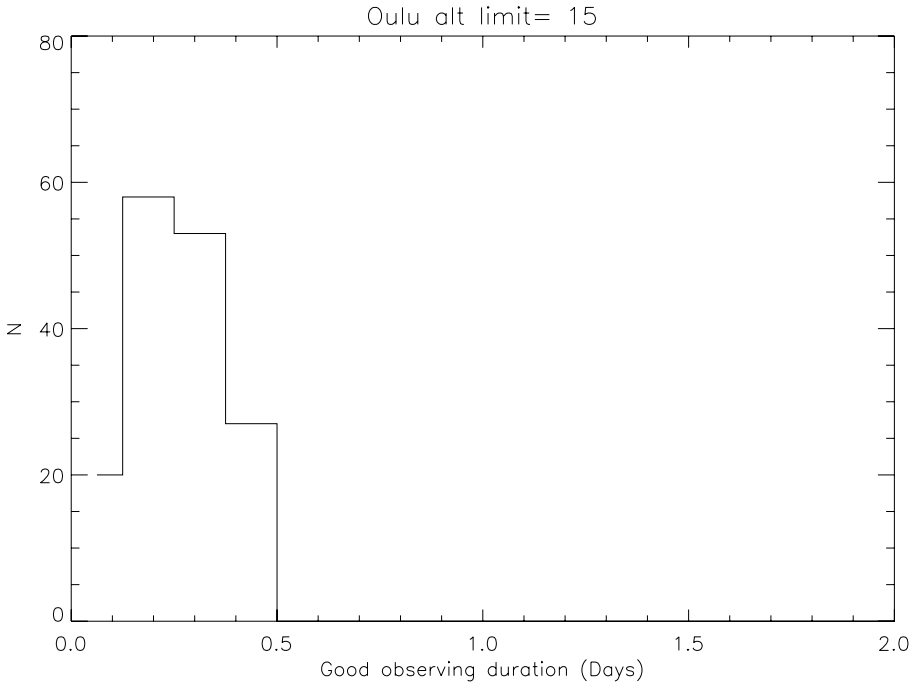

Figure 4.14: Like Figure 4.5, but for the Equator.

This statement may not be correct for an arbitrary year due to the 18-year lunar Saros cycle: other altitudes may become available from a given site under the conditions of observability factored in.

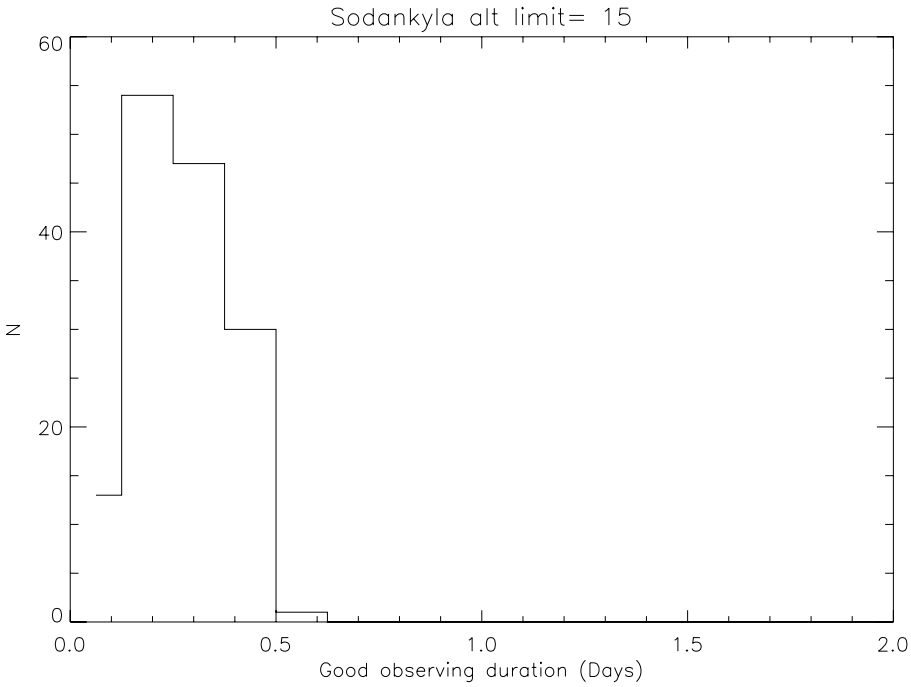

Figure 4.15: Like Figure 4.5, but for the Equator.

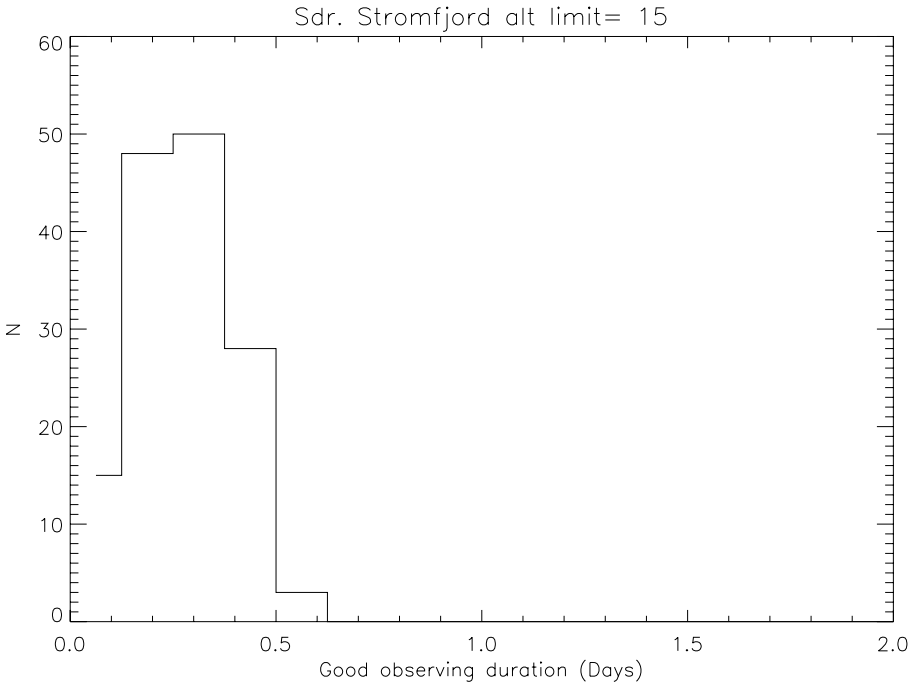

Figure 4.16: Like Figure 4.5, but for the Equator.

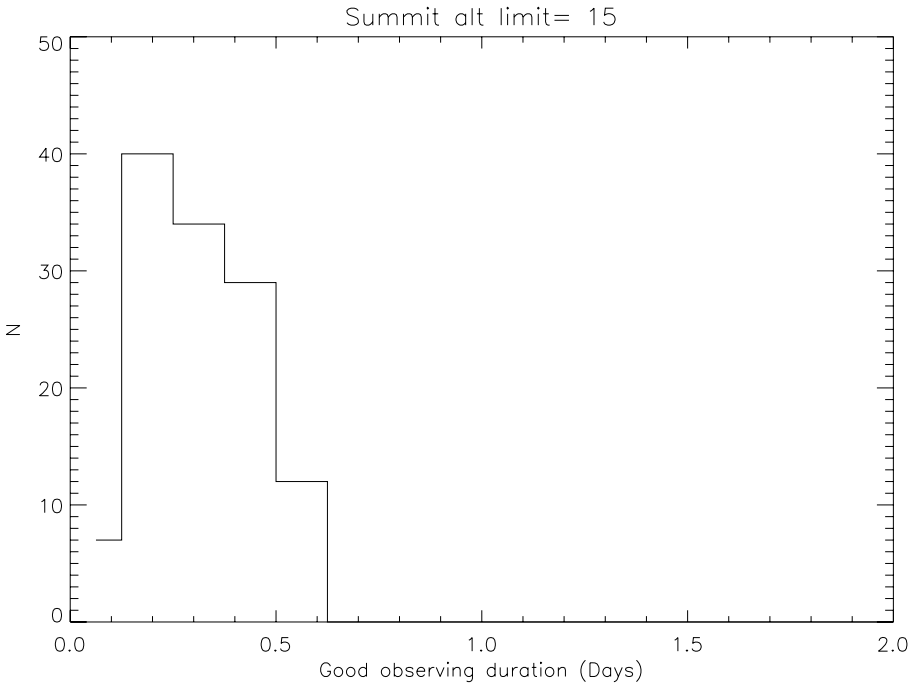

Figure 4.17: Like Figure 4.5, but for the Equator.

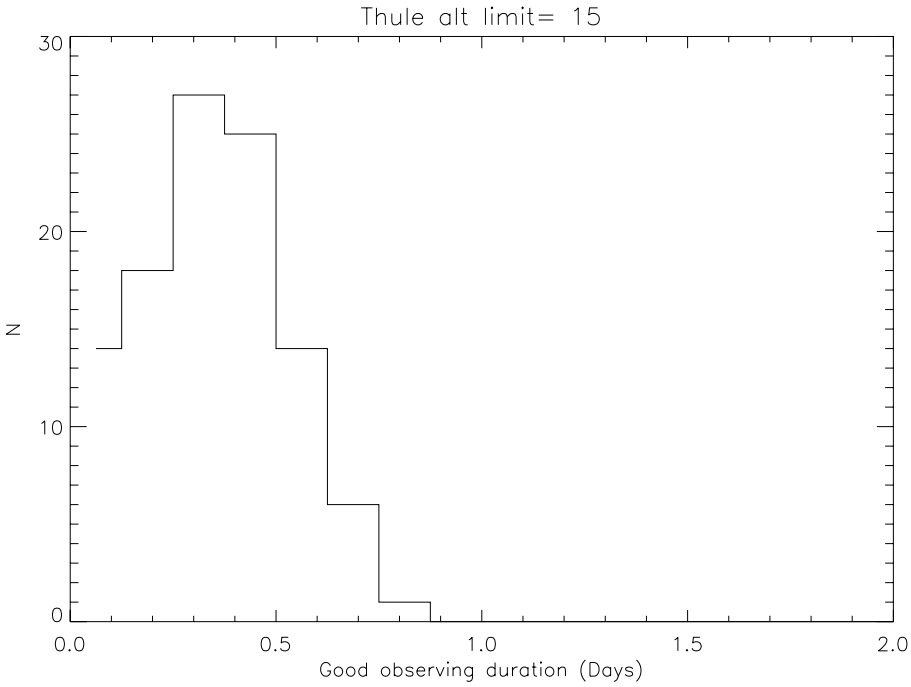

Figure 4.18: Like Figure 4.5, but for the Equator.

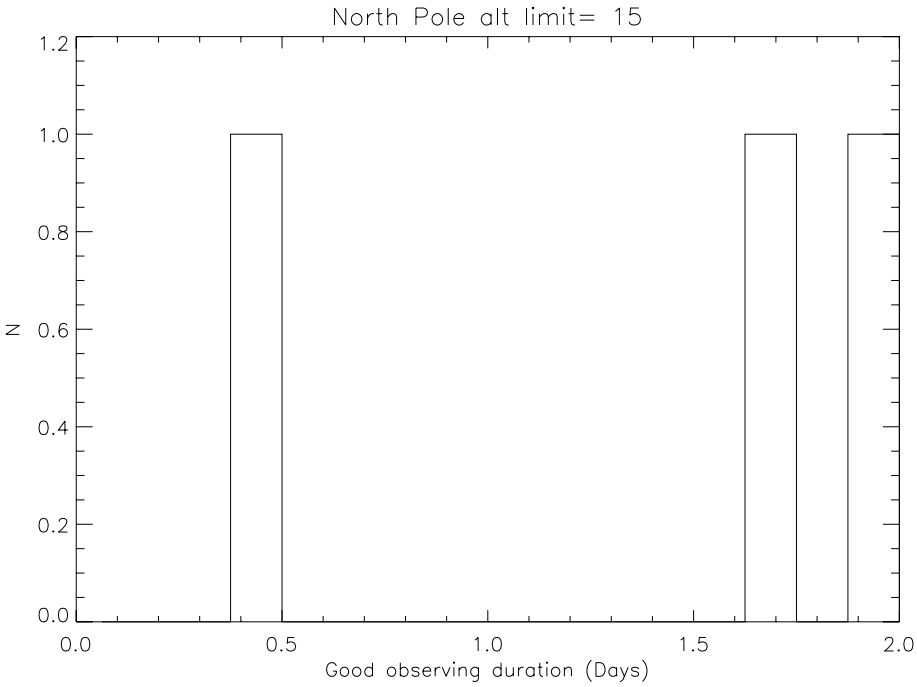

Figure 4.19: Like Figure 4.5, but for the Equator.

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