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ASTRONOMICAL PHENOMENA NORTH OF THE ARCTIC CIRCLE… AND HOW PEOPLE RESPOND TO THEM

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ABSTRACT

We first consider how the basic astronomical phenomena of the sun, moon, and stars appear to the north of the Arctic Circle. In general, this is a region of long twilights punctuated by bright sunlight and dark nights. We then discuss two contrasting groups (the Inuit and the Norse) who penetrated some distance into the Arctic and established ways of life there in equilibrium with the climate and landscape. Finally we consider some of the effects on humans of life within the Arctic.

KEYWORDS: Arctic Zone, astronomical phenomena, Inuit, Norse

1. INTRODUCTION

As Homo sapiens spread through the northern hemisphere over many millennia, various groups settled and found sustenance as far north as the Arctic Circle (66° 34′ N), which divides the Temperate from the Arctic Zone. In the Arctic the customary astronomical phenomena of the sun, moon, and stars follow different temporal patterns unique to the north. This paper will discuss those phenomena as well as two contrasting groups, the Inuit and the Norse, that penetrated some distance farther into the Arctic and established ways of life there in equilibrium with the climate and landscape. These people were limited by the Arctic conditions, but were able to use some of them to their advantage.

2. THE TERRAIN AND PHENOMENA

The Arctic Zone (Figure 1) consists principally of the Arctic Ocean, fringed by the Eurasian continent on one side and by the Canadian archipelago and the island of Greenland on the other. Until recently the Arctic Ocean was permanently frozen north of 80° N, and seasonally or intermittently frozen down to the Arctic Circle at 66° 34′ N. Travel through the archipelago and to Greenland thus involved passage over water or ice, while the classic attempts to reach the North Pole ca. 1900 required crossing the frozen ocean from the north of Greenland. The Arctic Circle maps the geographic extent of the Arctic Zone, while the 10° C isotherm marks the climatic extent.

Figure 1. North Polar Map. The Arctic Circle (blue dashed line) defines the Arctic Zone, while the 10° C July Isotherm shows the Arctic Climactic Region. The extent of Intuit and Norse explorations and activities are shown. Map used courtesy of the University of Texas Libraries, The University of Texas at Austin.

There are marked changes in the most obvious astronomical phenomena as the traveler leaves the Temperate Zone, crosses the Arctic Circle, and proceeds further north (Figure 1). (The same changes of course occur when crossing the Antarctic Circle heading south.) Both the Arctic and Antarctic Zones

have the same latitude–dependent seasonal cycles consisting of some days of 24 hour sun, followed by days of partial sun and long twilights, and then some days of 24 hour darkness, with these cycles displaced by six months between the North and South Polar Regions. The "bright nights" around summer solstice when the sun does not set lasts only for days and then weeks with increasing latitude, while the symmetric "total darkness" around winter solstice lasts only for some days or weeks. In between are long sunrises/sets and twilights (Figure 2). Despite this easily verifiable astronomical framework, stories and reports of the Polar Regions sometimes present this annual cycle as consisting of six months of constant sun, followed by six months of constant darkness. For example, a recent National Geographic report on Antarctica includes, "Today, polar summers pound the continent with 24 unforgiving hours of light for about half the year, before polar winters plunge it into complete darkness for the other half." (Zachos, 2018)

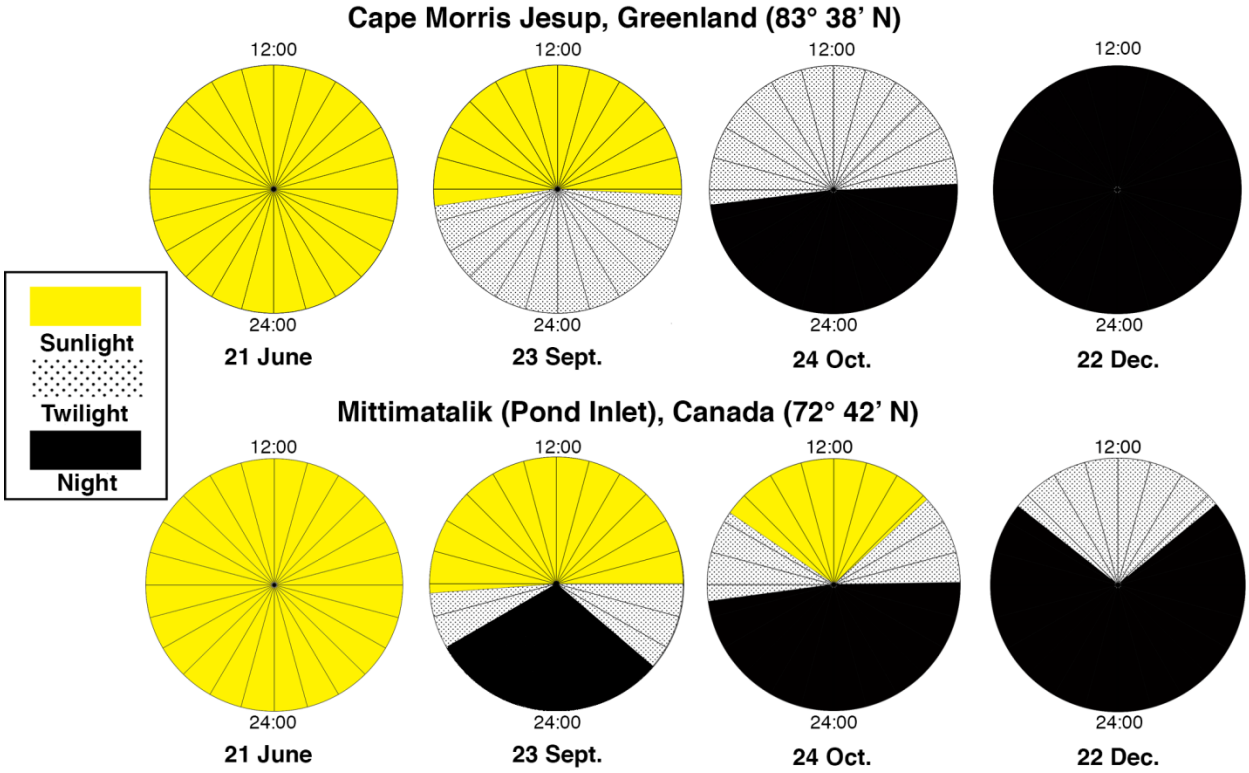

Figure 2. Sunlight, twilight, and night as a function of time during the day at two locations on four days. 12:00 indicates noon each day, and 24:00 midnight.

Figure 2 shows the pattern of *sunlight* (sun above horizon), *twilight*, and *night* sky at two latitudes at four dates (calculations from USNO 2018). Civil twilight and nautical twilight are shown together as "twilight", when outdoor activities can continue, and astronomical twilight and completely dark sky are shown together as "night", when the stars become visible and outdoor activities become difficult or impossible. (These several twilights are defined at USNO 2018.) The dates are chosen to show summer solstice (solar declination δ = 23° 26′), equinox (δ = 0°), October 24 (δ = –11° 39′, a value half way between equinox and winter solstice), and winter solstice (δ = –23° 26′). The two locations chosen are those of a large Inuit settlement Mittimatalik (72° 42′ N) and the farthest north Norse explorations (ca. 73° N), and the most northerly point of Greenland (Cape Morris Jesup, 83° 38′ N) where there is evidence of past Inuit settlements (Figure 1).

We note that at Mittimatalik there is never a time of constant darkness, and even at winter solstice there are some hours of twilight each day. The sun is always below the horizon for only 70 days from November 13 to January 23. At Cape Morris Jesup the period when the sun is always below the horizon is from October 12 to March 2 (140 days), and the period of constant night is from November 14 to January 27 (75 days).

The lunar standstill cycle puts the moon in some years (and for part of some months) higher in the winter sky than the sun reaches in the summer. In the Arctic Zone the moon can thus sometimes be circumpolar and does not set for some days, occasionally providing much–needed light in the winter. Conversely it will sometimes be below the horizon

for some days. So rather than have the moon mimic the sun's motion, as it does in the Temperate Zones, it tends to vary between being a presence and an absence.

In the Arctic the stars and planets are generally visible during the times of "night", and thus for much of the year (day + twilight) they are largely invisible. More constellations are circumpolar than they are farther to the south; conversely, more stars remain invisible below the horizon. Even when the stars are visible they are not as useful as they are in the Temperate Zone, since one prime aid to navigation (Polaris) stays mostly overhead and does not show the compass points as evidently. The maximum height of the sun (when visible) was used as a rough guide to latitude.

The Arctic has its own unique atmospheric phenomena (Greenler, 1980). One phenomenon that can be useful (if sometimes misleading) is the arctic mirage, or hillingar (discussed below), which can make objects below the horizon become visible. Another atmospheric feature that is a hallmark of the Arctic nighttime is the aurora borealis, which can sometimes be bright enough to aid travel.

3. THE INUIT

The Inuit were latecomers to the Americas, as part of the last migration from Siberia. Recent work shows strong genetic ties between the Inuit and the Chukchi and other people of the extreme northeast of Siberia (Moreno–Mayar et al., 2018). The traditions and folklore of the Inuit, as well as their cosmological concepts and skylore, have much in common with those of the Chukchi (Bogoras, 1902; Anisimov, 1963).

This last migration first settled along the Alaskan coast and the Aleutian Islands. Then about AD 1000 the Inuit separated and began to enter the Canadian Archipelago. The Inuit traveled throughout the archipelago, reaching Baffin Island about AD 1000, the west of Greenland about AD 1200, and east Greenland a few centuries later, following or replacing earlier Eskimo groups. [Historically the term "Eskimo" has come to refer to several groups from Siberia to Greenland with similar life styles. The Inuit however prefer to be called by their own native name.] After finding the Cape York iron meteorite in northwest Greenland they entered an "iron age", using cold–worked meteoritic iron for harpoon tips and knives (Buchwald et al. 1985).

The Inuit were traditionally nomadic, pursuing seasonal game. The long sunless twilights and darkness do not stop life in the Arctic Ocean, which adjusts to the lunar cycles (Kintisch 2016). After the sun disappears the Inuit continued to travel and hunt, except in total darkness or during the fierce winter storms when they hunkered down in snow shelters.

MacDonald (1998) has made a comprehensive survey that shows a wealth of skylore among the Inuit. The moon is pre–eminent: sometimes fearful, sometimes benevolent. The "circumpolar moon" is welcome. The sun is important, and its annual return anxiously awaited. They formed constellations from the brighter stars and wove them into their legends, and gave the Pleiades special interest. Saladin d'Anglure (1990) has explored their complex cosmic myths and beliefs, particularly those based on the sun and the moon.

Many myths of the Inuit were brought there by the waves of migrants from Asia and have their roots there, or even further back temporally in Africa, whence they were carried by the people who first spread into Eurasia. (Berezkin, 2017; d'Huy, 2016). One study has shown how the world–wide legends based on the Pleiades had a common origin in Africa (d'Huy and Berezkin, 2016–17). These studies of the geographical spread of folklore motifs complement similar studies of genetic and linguistic spread as well as the archaeological record, and in general agree with these other disciplines.

On the practical side the Inuit formed a monthly calendar based on the sun and moon, and on the annual cycles of animals. For navigation in difficult surroundings they used everything at their disposal – the sun and moon, stars, wind and weather, tides, movement of animals (MacDonald, 1998).

In the 20th century as missionaries came to live with them and Canada and Denmark extended their governments to include them, most Inuit settled in government–supplied communities. Thus the site of Mittimatalik was for a long time a place for small seasonal hunting camps, and later became an Inuit settlement because of its proximity to a harbor (Pond Inlet, named after John Pond FRS, the sixth Astronomer Royal). It now has close to 2,000 inhabitants with schools, a community college, churches, government buildings, and an air strip.

The introduction of housing, electricity, schools, and a work economy are changing Inuit life irreversibly. Instead of seasonal igloos the Inuit now live in year–round houses. Electricity and the schedules of school and jobs put them on a 24 hour cycle independent of the season. Only while hunting do they revert to an older style of timekeeping using natural body rhythms (MacDonald, 1998).

The elders have memories and traditions and some parts of their language that the younger have lost. The surveys by MacDonald and Saladin d'Anglure were based on earlier reports and on the present elders and their memories of their elders, and increasingly describe a world that is now past.

4. THE NORSE

Unlike the Inuit expansion, the Norse settlement of the Arctic was a historic event with well–defined dates. The Norse took their seafaring experience in coastal waters and rivers, and developed the navigational skills to extend it to traversing the North Atlantic. They did this with little instrumentation (lacking for example the quadrant and the compass). The sun and stars in the Arctic were of some help in navigation or timekeeping, but they based their seafaring largely on experience and observation of nature and weather (Vilhjálmsson, 2007). So equipped they sailed ever farther west in search of new lands, starting ca. AD 700.

The Faroes were found and settled ca. 825, Iceland ca. AD 870, Greenland by AD 985, and Vinland (present–day Newfoundland) ca. AD 1000. The Norse carried a North European culture with them to their island outposts. Unlike the Inuit who lived off the sea, they were basically seafaring farmers who raised domestic animals. This westward progression was likely helped by an atmospheric effect in the Arctic, the arctic mirage (called in Norse the hillingar). This occurs when temperature gradients in the air bend light rays at about the curvature of the Earth, making it possible to detect the presence of "something" (land, mountains, or glaciers) normally invisible below the horizon. Thus Iceland could have been sensed from the Faroes, and Greenland from Iceland, which led to the voyages of exploration by the Norse (Sawatzky and Lehn, 1976).

The two principal Norse settlements were at the southwest corner of Greenland, but the Norse had explored the west Greenland coast at least as far north as 72° 58′ N, the location of the Kingigtorssuaq rune stone carved in the 13th century, and possibly in AD 1244 (Enterline, 2002).

Contact with Europe was vital for the Norse colonies to obtain critical material and equipment, and without that contact they could not survive for long. Maintaining contact between Vinland and Iceland and Europe proved beyond the Norse ability and the Vinland settlement lasted only two years; The Greenland connection proved more durable for four centuries. After the last recorded contact in AD 1408, the onset of the "Little Ice Age" put an end to sailing that far west. When ships from Norway again reached Greenland early in the 18th century, the settlements were in ruins and the Norse vanished. Exchanges between Norway and the Faroes and Iceland continue down to the modern age.

The Norse used the astronomical phenomena of the Arctic as best they could. The Icelanders constructed their own calendar about AD 955 to synchronize events across the island, using the annual motion of the sun on the horizon. It yielded slowly to the Julian calendar that accompanied the Christian conversion of Iceland starting in AD 1000 (Vilhjálmsson 1993). They also used the azimuth of the sun in the summer as a rough clock to divide the days (Vilhjálmsson, 1999).

Trade between the islands and Norway, coupled with religious supervision from Norway, kept the islands a part of the greater Scandinavian world. Their mythology is well covered in the references in Krupp (1991), and their beliefs were strongly affected by their conversion to Christianity.

In the twentieth century improved transportation and technology for living in a cold climate have carried the way of life in the Temperate Zone into the edge of the Arctic. There are now cities there where the residents can live and work on a Temperate Zone schedule throughout the year, insulated from the Arctic's astronomical phenomena. Witness present–day Murmansk and Tromsø (Figure 1), powered by nuclear plants and containing universities and research institutes.

5. THE EFFECT ON HUMANS

Homo sapiens evolved in a tropic/temperate part of the world, with 24–hour solar day/night and monthly quasi–lunar cycles deeply ingrained. Moving into the Arctic creates a new problem: how to maintain the built–in day/night cycle (with night usually the time for sleep) when it is decoupled from the light/dark cycle.

The Arctic forced the Inuit to determine "day" and "night" from circadian body rhythms. For the Inuit there is a continuity between light and dark, not a dichotomy. The Inuit functioned well in "daytime" activities into the twilight and darkness, and feared more the winter storms. Social activities can be in the light or the dark, while the worries and fears of the night, and the need for sleep and suspension of vigilance, that accompany our temperate darkness can be present for the Inuit in light or dark. This has led to an anthropological study of nighttime and its effect on human behavior, and how the day/night cycle continues in the Arctic (Bordin, 2015).

Nineteenth century Europeans in the Arctic reported cases of "Arctic hysteria" (called *Piblokto* by the Inuit), when a native would suddenly run amok. Its cause is not clear but it seems to be related to living in the traditional Inuit life style at high latitudes (Wallace and Ackerman, 1960). Similarly, long exposure to Arctic conditions (sometimes for years) had a profound effect on the physical and mental state of some European explorers of the 18th and 19th centuries while searching for the elusive "Northwest Passage." This was then carried back to feed the imagi-

nation of European society of that time and shape their idea of the Arctic (McCorristine, 2018).

Some of the effects of high latitude can be removed today by artificial lighting in the winter and window blinds in the summer. But there are still residual effects, which are the subject of the International Association of Circumpolar Health.

6. CONCLUSIONS

The Inuit developed a way of life that enabled them largely to reach equilibrium with the climate and seasons. Yet even they had trouble adjusting to the seasonal cycles. The Norse attempted to carry a life style from Europe and needed contact and supplies from there to maintain that style; when those contacts failed, so did their colonies.

An investigation of Arctic astronomical phenomena makes clear that life in the Arctic is more subtle, diverse, and challenging in many ways that are outside our experience in the Temperate Zone. The changes in the astronomical phenomena from circadian to seasonal cycles are at odds with the basic rhythm of human life. It is impressive that people can still adapt so well to living there.

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