265°, moreover, reflect the relative trends of the radar data.

The following tentative conclusions are submitted subject to later revisions:

1) The match between the data that I obtained and those of Belton and Hunten (*4*), working as independent teams, demonstrates a consistency in the measurements and in the successful performance of their instrument.

2) Syrtis Major is a rather broad high area which slopes off fairly steeply on both sides—in one case into a relatively high bright desert, Aeria, and in the other into a basin near Isidis Regio.

3) A larger depressed basin is located partly in Aethiopis and Syrtis Minor (the smaller gulf near longitude 260°)–Mare Tyrrhenum.

4) The Mare Cimmerium–Hesperia region appears to be a very broad high area.

5) Two other depressed basins are located in Amazonis near 170° longitude and in Memnonia–Mare Sirenum.

6) The spectroscopic data are in good agreement with the previous range-gated radar data along +21°N.

7) Both the desert regions and dark maria appear to be situated at high, medium, and low levels, though basin-type features tend to show a proclivity for the deserts.

8) The fact that there is no apparent correlation between albedo and height and that the topography on a macroscopic scale appears to be rougher than previously supposed could indicate that the darkness of the features of the maria is due to differences in chemical composition between the dark areas and the brighter deserts rather than to physical differences. Such an interpretation neglects, of course, the added effect of microstructure, which can be considerable.

9) Finally, for scale comparisons, the basin in Isidis is about twice the size of the Aral sea; the Aethiopis basin is about 1.5 times larger than the Gulf of Mexico; the Amazonis basin is about the size of the Mediterranean Sea; and the Memnonia-Sirenum basin is about the size of the Caribbean Sea. The high broad areas in Cimmerium and Syrtis Major are almost the size of Australia. When the sizes of these areas are compared to the size of the earth and Mars, respectively, the similarity in the presence of continental and ocean basin features on Mars is striking indeed!

On the basis of presently available information, it appears that the equatorial structure of Mars is comprised of protocontinental blocks whereas the high and low areas of the northern deserts resemble ocean basins. A high structural feature is also indicated for the stretch of dusky areas in the northern hemisphere: Panchaia-Cebrenia-Utopia-Boreosyrtis-Cecropia-Dioscuria.

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Terrestrial Microclimate: Amelioration at High Latitudes

Abstract. *At latitudes north of the Arctic Circle the diel range of sun altitude declines progressively, reducing the frequency of temperature inversions over level, unshaded ground in summer and extending the frost-free season. North of about 70° north, the potential number of inversion-free days increases rapidly with latitude; this ameliorates the microclimate close to the ground—the zone to which terrestrial organisms are increasingly restricted in higher latitudes. The relation between screen and ground-surface temperatures differs north and south of about 70° north; north of that latitude there are progressively more frost-free days than would be inferred from screen temperatures, were no allowance made for this latitude-dependent change.*

Terrestrial climates are generally assumed to become less suitable for the survival and growth of organisms as latitude increases because the July mean of screen temperature declines steadily toward higher latitudes (*1*). Observations of the climate and of the fauna and flora have shown that relatively benign conditions exist in certain high-arctic localities, for example, Peary Land in northeast Greenland (*2*) and Lake Hazen in northeast Ellesmere Island (*3*, *4*). The rich biota of these sites is seen as a consequence of their relatively warm summer, since it is believed that terrestrial organisms, once safely frozen, are little affected by the extreme cold of winter (*5*). The warm summer (as judged by screen temperature) has in turn been attributed to the fact that these places are inland and therefore free from the moderating influence of the Arctic Ocean and that they are located favorably with regard to such features as aspect, inclination of slope, and proximity of katabatic winds (*3*) which, reflecting local topography, are likely to ameliorate summer climate at any latitude, temperate or arctic.

A fact not generally recognized is that there is an improvement in the "plant climate" (*6*)—air within 10 cm of the ground—toward the highest latitudes which is not evident from measurements of "human climate" obtained at the height of the meteorological screen (1.5 to 2.0 m). The improvement results from the progressive, latitude-dependent reduction of the diel (24-hourly) fluctuation of sun altitude. Thus, the period centered on the summer solstice each year during which the sun remains continuously above the horizon increases from about 48 hours at the Arctic Circle to about 6 months at the North Pole; correspondingly, the diel difference between the sun altitude at solar noon and at "midnight" declines from 45 degrees (altitude) to virtually 0 degrees (*7*).

Sørensen (*8*) remarked that, because the diel range of air temperature in east Greenland was less at 74° 10′N than at 72° 50′N, conditions for plant development (on level ground) were more favorable at the former latitude because temperatures there stayed closer to the daily mean, and therefore above the growth threshold, for longer

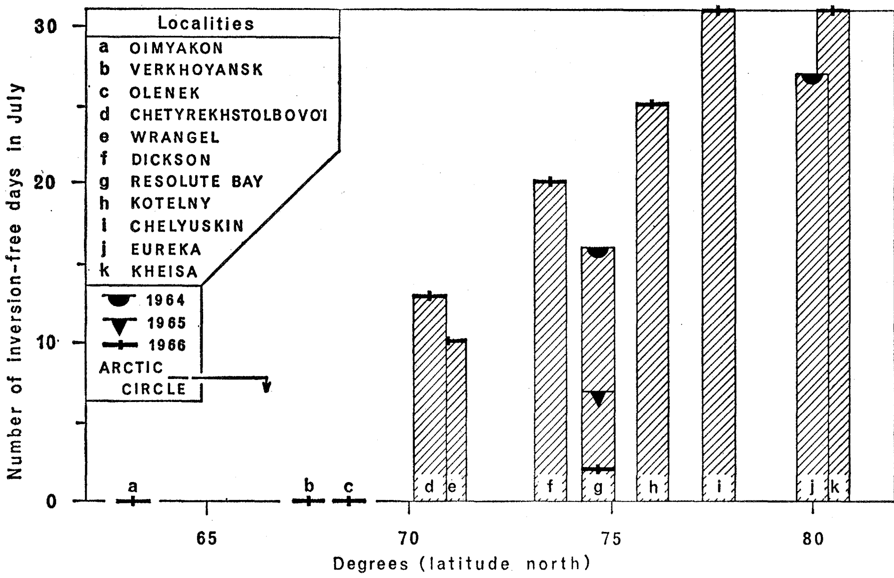

Fig. 1. Latitude-dependent change in the number of July days without an inversion (that is, all hours have a positive radiation balance). Except for Eureka (1964) and Resolute Bay (1964 to 1966), data are for 1966.

each day. Sørensen considered that this resolved the apparent paradox offered by his observation that certain spring plants flower earlier at 74° 10′N than at 72° 50′N. This decline of diel temperature fluctuation with latitude may be illustrated by screen temperatures at three Canadian localities. At Ottawa, Ontario (inland, 45°N) the average diel range and mean during July 1962 and 1963 were approximately 8° and 20°C; at Lake Hazen, Northwest Territories (inland, 81° 49′N) these values were approximately 3° and 7°C; and at Alert, Northwest Territories (coastal, 82° 30′N) they were approximately 1° and 4°C (*9*). One consequence of this progression is that, at the highest latitudes, there will be fewest "frost-changes" (*10*) at the ground surface during summer (*11*) and therefore a longer "frost-free season" (*9*). This progression also has the consequence that nocturnal temperature inversions near the ground become progressively less frequent north of the Arctic Circle.

Although its existence can be inferred a priori, this latitude-dependent change in inversion frequency is evident from two kinds of measurement: hourly temperature profiles near the ground surface, and hourly values for radiation balance. On the Arctic slope of Alaska (69° to 70°N), just north of the Arctic Circle, inversions are usual (*12*) and can last 8 hours or more in June and July (*13*); at Resolute Bay, Northwest Territories (74°43′N), an inversion lasting several hours can be detected in late July (*14*); and at Lake Hazen, Northwest Territories (81° 49′ N) no inversion develops for at least the whole growing season (early June to mid-August) (*15*). Although Antarctica cannot offer an analogous series of records, the expected progression evidently exists there: from extensive observations made between 76° and 78°S, Janetschek (*16*) concludes that at these latitudes inversions occur only exceptionally on exposed ground. He notes also that with increasing latitude cloudiness decreases, a circumstance that would enhance the amelioration resulting directly from sun altitude.

Records for long-wave plus short-wave radiation balance (*17*) reveal the progression clearly (*18*). These data can be analyzed to show the number of inversion-free days at various northern stations during July, the warmest month (Fig. 1). Beyond about 70°N, this number is likely to increase rapidly until, between 75° and 80°N, the whole month may be inversion-free. A similar regression on latitude (with lower absolute values) is found in June and August.

Thus, at the most northerly latitudes microclimates inhabited by terrestrial plants and animals are ameliorated during the biologically active season in two ways, both of which are consequences of the latitude-dependent decline in diel fluctuation of sun altitude. First, temperatures remain relatively stable, producing a long frost-free season; and second, "nocturnal" inversions (over level, unshaded ground) are rare or absent. Being dependent on latitude, these ameliorating influences will always have been effective in high-arctic localities suitably placed topographically; accordingly, their effect should be noted by biogeographers who postulate the existence of far-northern, ice-free refugia in which indigenous plants and animals could have survived the Wisconsin glaciation (*19*). The phenomenon described here also has implications of concern to meteorologists. The relation between screen and ground-surface temperature will be different north and south of about 70°N; north of 70°N there will be progressively more frost-free days than would have been inferred from screen temperatures by using criteria valid south of this latitude.

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