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SPRING SURFACE REFLECTIVITY AND SURFACE TEMPERATURES IN ALASKA

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A strong association between temperatures and surface albedo is seen in Alaska in spring. This relationship is a partial function of the amount of energy locally available for surface heating, which in spring is principally controlled by the extent of snow cover.

NOAA Very High Resolution Radiometer (VHRR) and Advanced VHRR (.6-.7 microns) imagery of Alaska taken in the springs of 1979-1981 was examined. An image processor was used to measure surface brightnesses of three select regions of the state when skies were clear. Regions include two predominantly forested areas, the Tanana and upper Yukon valleys, and a portion of the tundra-covered North Slope. Brightnesses were converted to estimated surface albedos by linear interpolation between a brightest snow covered surface with a parameterized albedo of 80% and darkest wet snow free land with an albedo of 13%. Regional surface albedos under full snow cover ranged from 35% in the Tanana Valley to 80% on the North Slope. Surface albedo in all regions converges toward a snow free value of 13%. Resultant spring albedo curves for each region were compared with surface temperatures from ground stations within each region.

Figure 1 is an example of the close association between sharply decreasing surface albedo and rapidly rising temperatures seen in all regions in each of the three springs. Note that; 1) all averages remain below 0°C prior to the commencement of melt (decreasing albedo) with the extreme high only reaching 5°C, 2) highs during snow melt average 10°C while lows remain below freezing, and 3) highs average 20°C and lows above 0°C immediately after the melt is completed.

We next investigated the significance of surface albedo as an active factor influencing spring temperatures and snow melt in the three regions. Daily albedos were multiplied by the insolation reaching the top of the atmosphere in the given region and an constant atmospheric screening factor to obtain Q, an index estimating the amount of retained short wave radiation available for surface heating or evaporation on a particular day. Q's were studied in relation to daily high temperatures as shown in figure 2. Results covering all three years show that in most cases three day averaged maximum temperatures remain below 5°C until Q's reach 175 cal/cm^2/day. In all but one case highs are above 5°C in the forested regions once a Q of 175 is reached. This is also the case on the North Slope once Q's reach 225. It was also found that regional surface albedo does not start rapidly decreasing until Q's reach approximately 175. During the melt interval high temperatures remain between 5 and 13°C in the forested regions and 2 and 10°C in the tundra. Q's are above 275 once melt is complete. At this point highs remain above 13°C in the forested regions and 5°C on the North Slope. Thus, it is seen that spring maximum surface air temperatures in parts of Alaska are largely dictated by the attainment of Q thresholds which themselves are functions of insolation and albedo.

Thresholds may be reached on different dates within a region from year to year. The Q threshold of 175 is reached in the Tanana Valley on April 21, 1979, April 12, 1980, and April 18, 1981. Figure 3 shows spring temperatures and albedos for this region during these years and suggests the timing differences are the result of various conditioning factors which affect regional albedo prior to threshold attainment. For instance, advection of warm air into the region early in the spring of 1980 began to slowly melt the snow and decrease the albedo, leading to an early threshold date. In the same sense rain and the lack of a heavy winter snow pack can lead to slightly lower albedos and an early date. None of these factors are sufficient to result in major temperature or albedo changes until rising insolation values combine with the slowly falling albedos to reach a Q of 175. In the opposite sense, a heavy snow pack, as was the case in 1979, or a major spring snow fall, as in 1981, will delay the threshold, even counteracting earlier opposite affects, as in 1981. Threshold timing differences were also found in the tundra, however not in the upper Yukon, where each spring had a deep snow pack and the surrounding mountains appear to prevent warm air or rain from easily entering the region.

In the future we plan to; 1) extend our study into other years and other regions, 2) further analyse changes affecting (conditioning) the snow cover prior to the major melt period, 3) improve albedo estimates with ground truth data and additional brightness measurements, and 4) obtain improved Q's, corrected for real cloud conditions. With this information a more quantitative assessment of the importance of surface albedo on spring temperatures will be obtained.

Present results agree with other researchers who reported a snow-albedo-temperature association (Namias, 1962; McFadden and Ragotzkie, 1967; Weller et al, 1972; and Dewey, 1977) and have found albedo to be a critical factor in the timing of major spring temperature shifts in Alaska.

References

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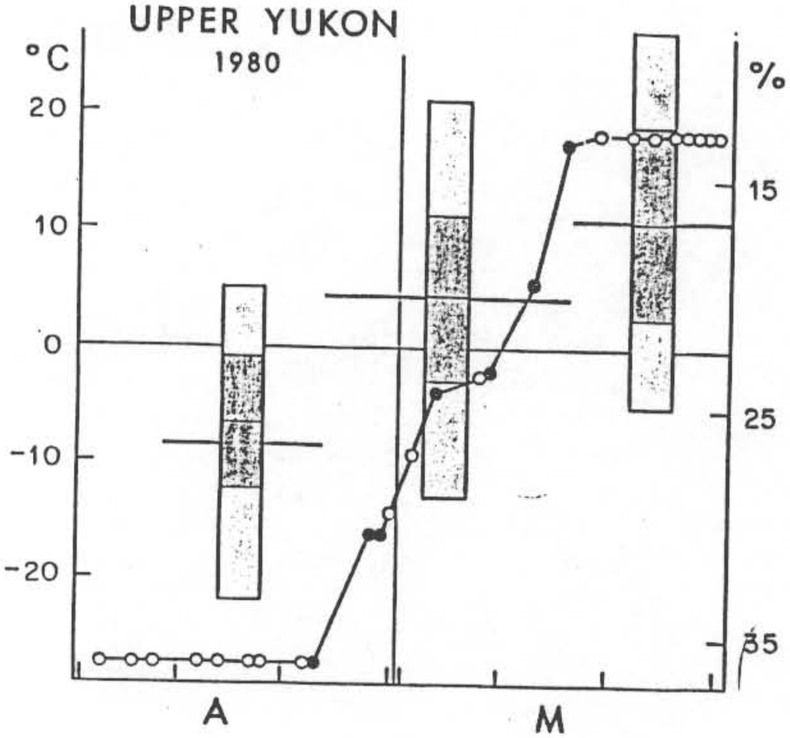

Figure 1. Surface air temperatures and estimated surface albedo in the upper Yukon region of Alaska in the spring of 1980. Albedo (•—o—) from measured brightnesses of selected clear sky AVHRR images •, in addition to scattered measurements on partly cloudy days o. Temperatures cover the 14 days prior to albedo decrease, 21 days during melt, and 14 days following melt and include average highs, means, and lows (heavy stippling) and the extreme high and low recorded at stations in the region during the period in question.

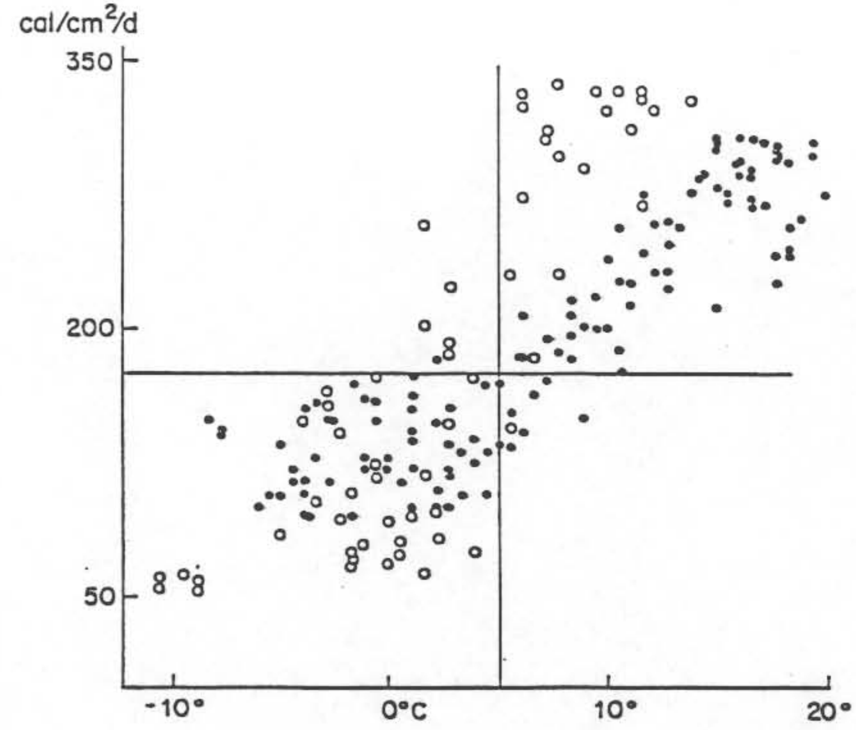

Figure 2. Relationship of temperature to Q in all study regions during the springs of 1979-1981. Each point represents a 3 day average of daily maximum temperatures versus the average Q during the same period. Three day intervals are between March 20 and May 21 in the two forested regions (•) and April 20 to June 21 in the North Slope region (X).

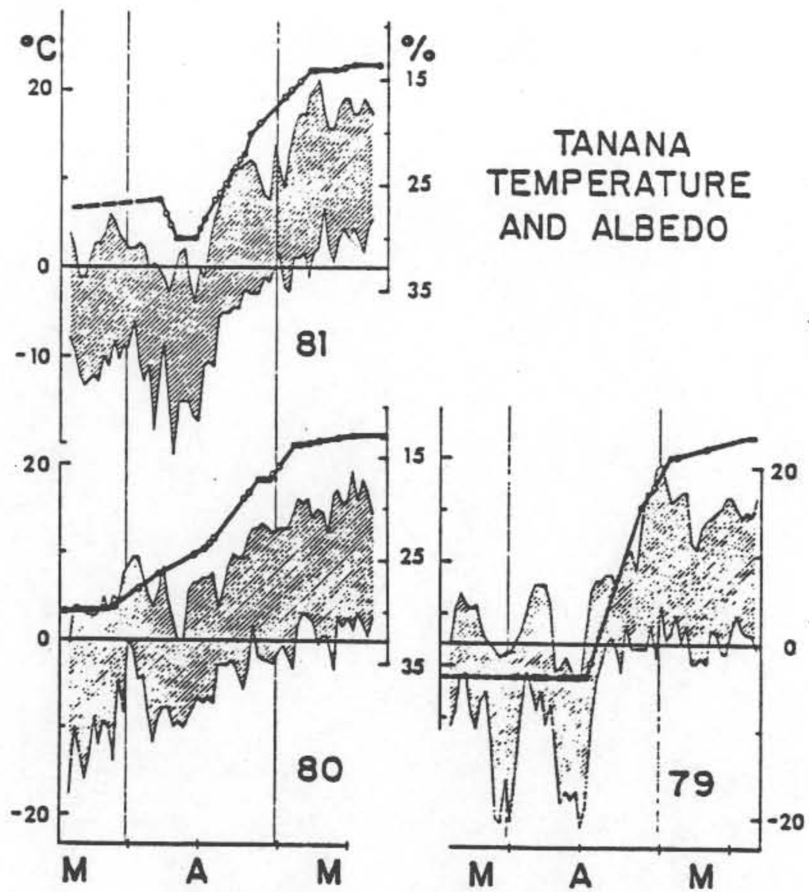

Figure 3. Surface air temperatures and estimated surface albedo in the Tanana Valley in the springs of 1979-1981. Albedo same as in figure 1. Daily highs and lows averaged from 5 stations within the region separated by hatching.