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SOLAR ALTITUDE EFFECTS ON ICE ALBEDO

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NOTICE

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SOLAR ALTITUDE EFFECTS ON ICE ALBEDO*

S. J. Bolsenga

The albedos of many natural surfaces, such as soils and crops, are known to be affected by solar altitude, but similar processes have not been well documented for ice surfaces. A limited set of ice albedo data shows that the effects of solar altitude are not nearly as pronounced as those attributed to many other natural surfaces. Surface geometry, direct-diffuse radiation balance, and spectral balance all contribute to these differences.

1. INTRODUCTION

In a series of measurements of the total (sun + sky radiation, 300-3000 nm) albedo of ice (Bolsenga, 1977), the influence of solar altitude on ice albedo was apparent in some cases. Graphs of all days of data plotted against true solar time (TST) are shown in figure 1. The data were taken from various types of ice surfaces under different atmospheric conditions. The purpose of this study was to subject the data set to machine computations designed to isolate the effects of solar altitude.

Idso et *al.* (1974, 1975) described the diurnal variation of the albedo of a field of Avondale loam soil and noted three catagories of characteristic daily albedo variations. When the soil is wet, the change in albedo is symmetrical about solar noon, being high early and late in the day and low near noon. The second stage occurs during drying when the albedo rises dramatically. The final stage occurs after drying when the albedo is again symmetrical about solar noon, but with all values higher than the wet soil values. To relate the values solely to soil water content, Idso *et al.* plotted albedo vs. the zenith angle for both wet and dry soils (figure 2).

2. DATA REDUCTION

A computer program was written that (1) computed albedo from the incident and reflected pyranometer readings, (2) computed TST from local standard time (LST), (3) calculated solar altitude (γ), (4) computed zenith angle from solar altitude, and (5) produced graphic plots of albedo vs. zenith angle. A listing of the program is an appendix to this report. TST was calculated by using

$$TST = LST + 4(\lambda_s - \lambda) + E, \qquad (1)$$

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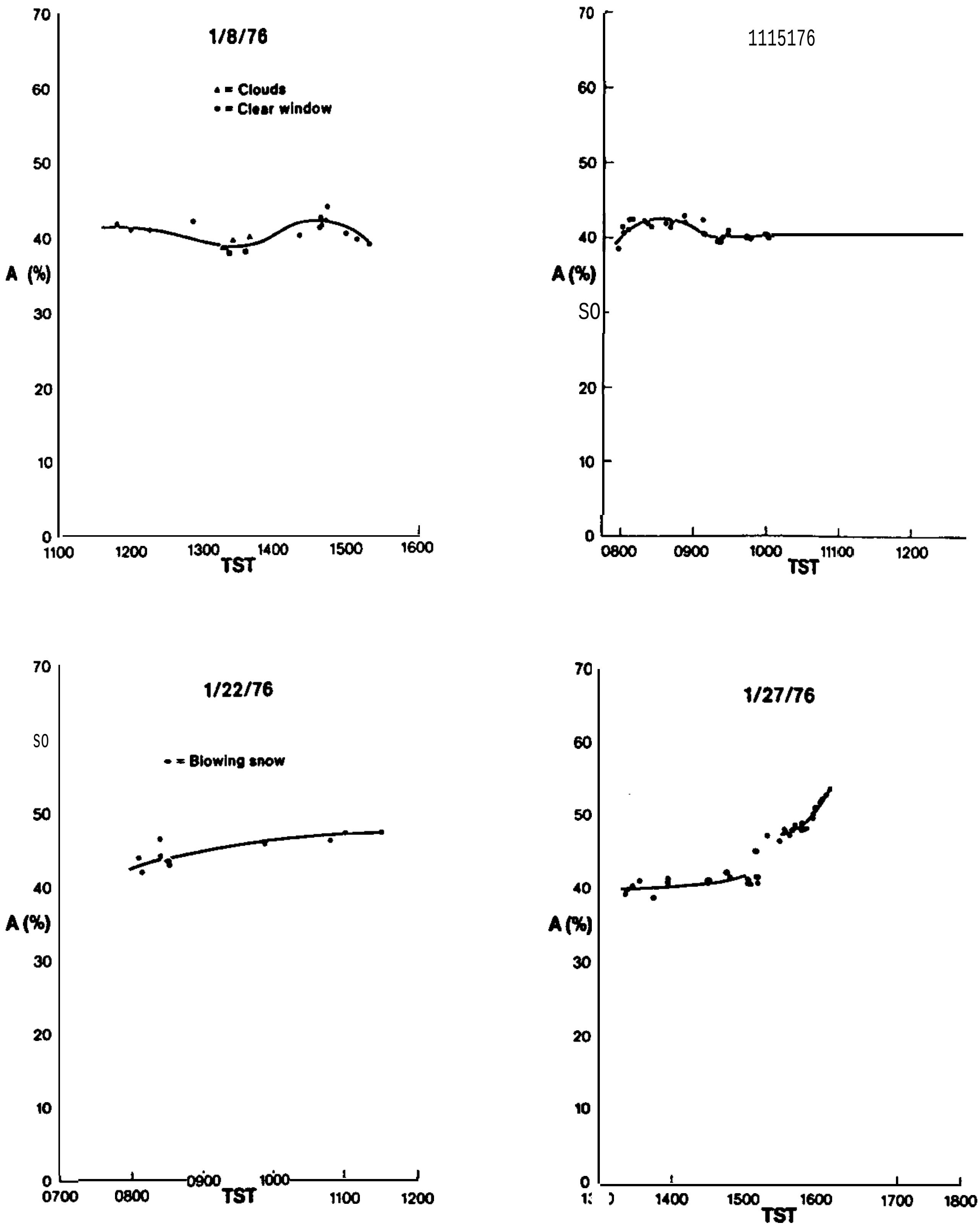
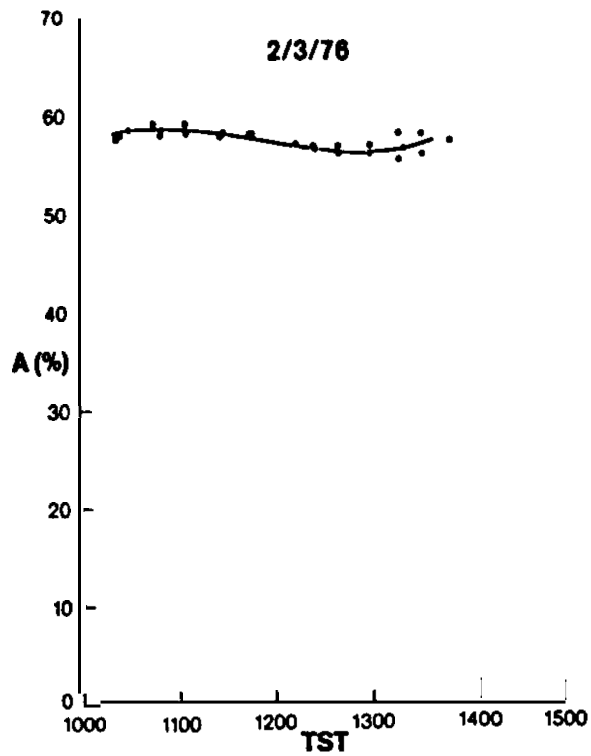


Figure 1.--*Albedo measurements.*



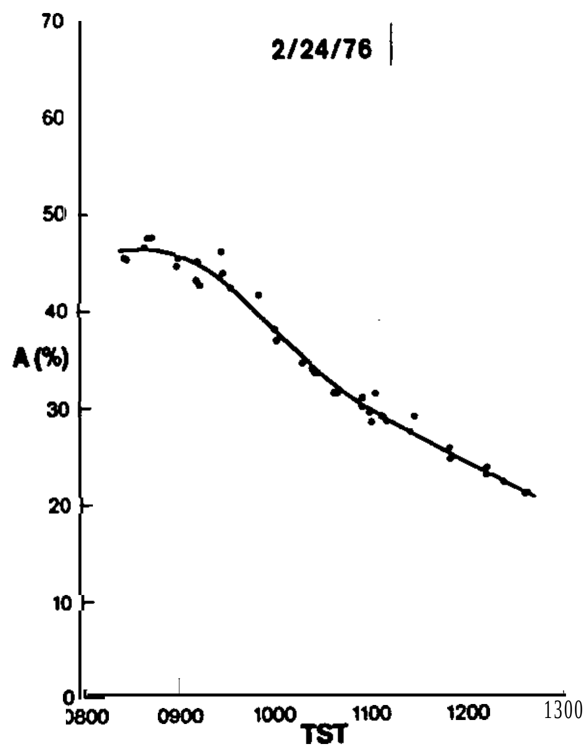


Figure 1.—*Albedo measurements (con.).*

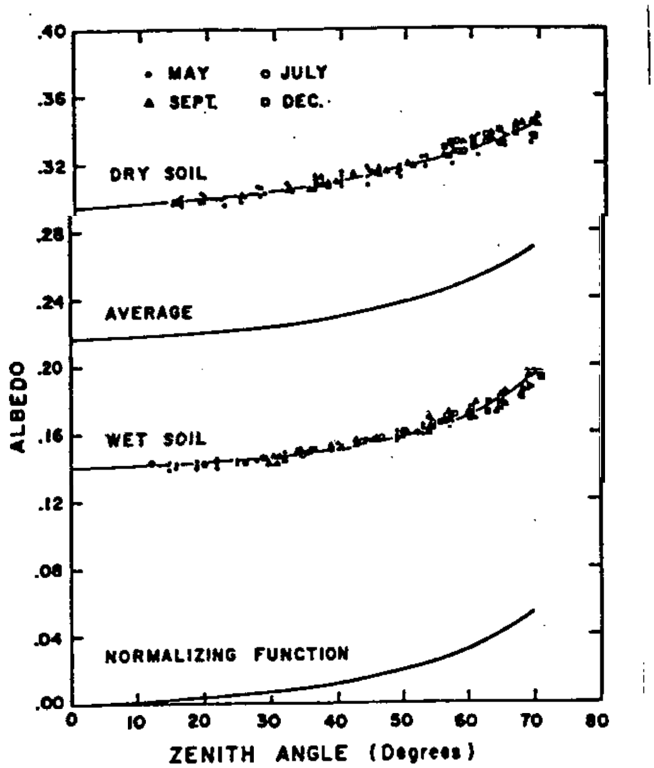


Figure 2.--*Wet and dry soil albedo vs. zenith angle, plus derived normalization function to* remove *zenith angle* effects from *albedo data (from Idso* **et al., *1975*).**

where

λ, λ_s = meridian of the observer and standard meridian, respectively, and

E = equation of time.

The solar altitude, γ, at the time of each observation was determined from

$$\sin \gamma = \sin \phi \sin \delta + \cos \phi \cos \delta \cos h, \tag{2}$$

where

ϕ = latitude,

δ = declination of sun,

h = hour angle, $(TST - 1200) \cdot 15°$.

3. ANALYSIS

In the first group of computer runs, all over-ice radiation data were used, including some at extremely low solar altitudes, where accuracy was questionable because of possible instrument error caused by low light levels. Figures 3-8 are machine generated graphs of all albedo data vs. TST. Data that are obviously in error owing to low light levels are shown near the end of the day on January 27, 1976 (figure 6). Figures 9-15 are computer plots of albedo vs. zenith angle, using the same data. Figure 15 combines all days of data on one graph.

In the next group of computer runs, all data at $\gamma < 10°$ were removed. It is known that a certain amount of good data were removed with the bad, but it was felt that this step would be justified if large amounts of data could be processed from a refined technique. The plots are shown in figures 16-22, with figure 22 representing the combined data set. It is obvious from figure 22 that the data do not separate into the well-defined curves shown in figure 2.

Differences between the ice albedo curves and the soil curves shown in figure 2 could be because the curves in figure 2 do not include data from days when the albedo rises dramatically owing to drying of the soil surface (personal communication, S. B. Idso). To more closely approximate the conditions applied to that data set, we eliminated one measurement day when the average temperature during the ice measurements was above 0°C (February 24, 1976). Above-freezing temperatures prevailed for several days before these measurements. A layer of water formed on the ice during the day, but low nighttime temperatures had solidly frozen this layer by the morning of the measurements. Temperatures were mild during the day, causing the ice surface to partially melt. The albedo decreased rapidly from 48 percent at 0847 TST ($\gamma = 27°1'$) to 21 percent at 1239 TST ($\gamma = 36°52'$) (figure 1). Mean temperatures for all measurement days are shown in table 1. Figure 23 shows all the measurements with low solar altitudes and data from February 24, 1976, deleted.

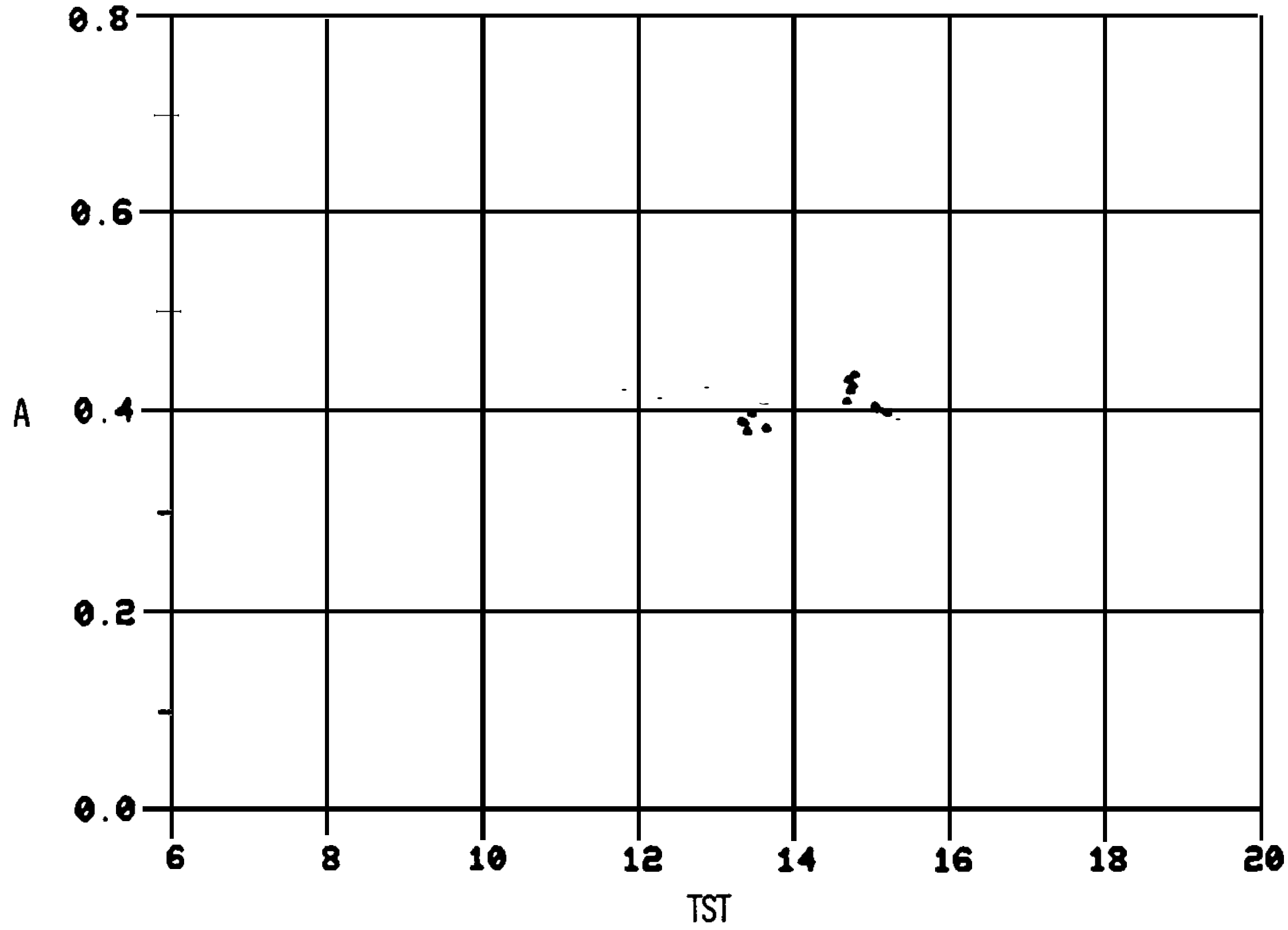


Figure 3.--*Machine plot of albedo (A) vs true solar time (TST) for January 8, 1976*

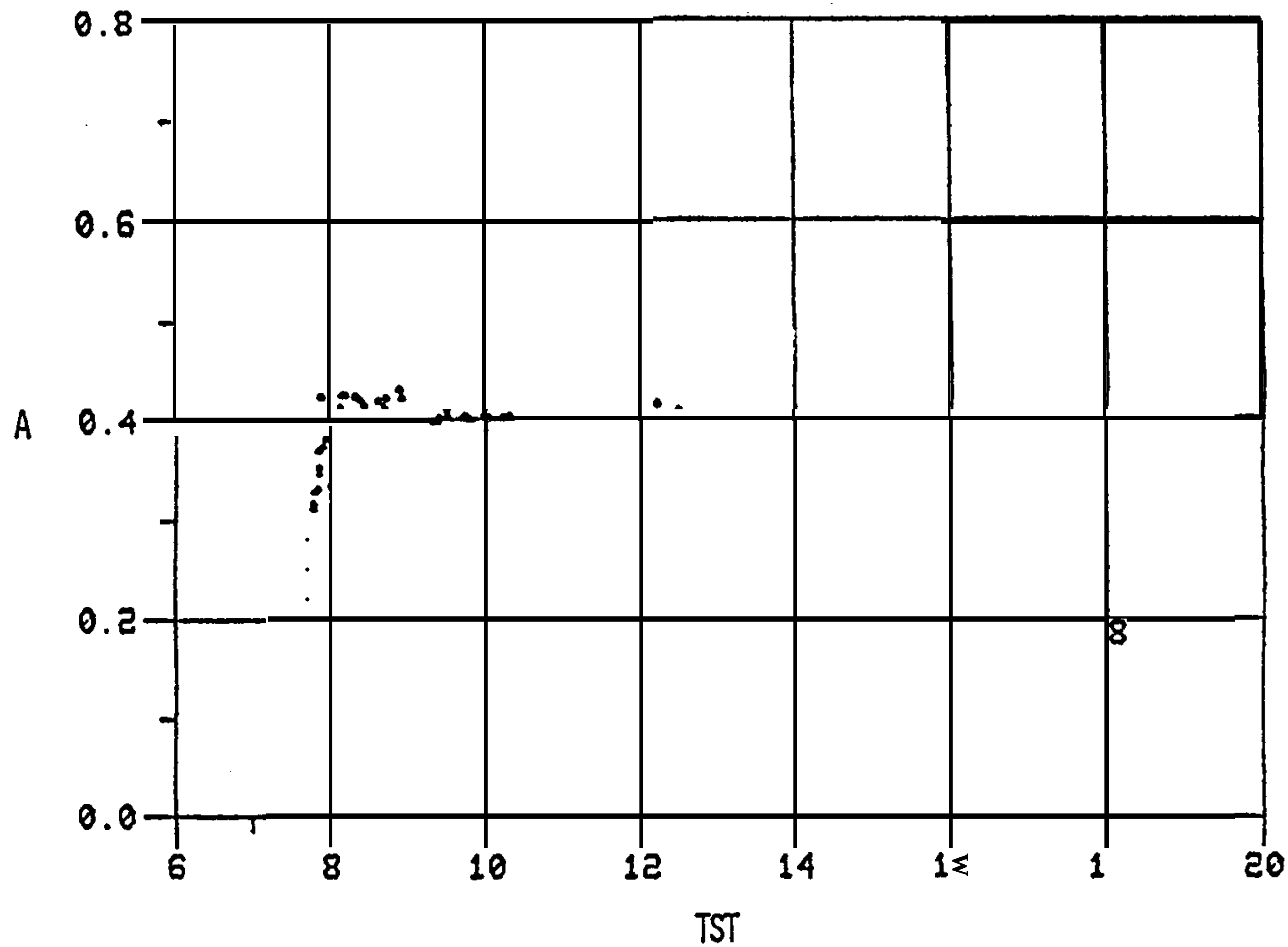


Figure 4 - *Machine plot of albedo (A) vs true solar time TST) for January 15, 1976*

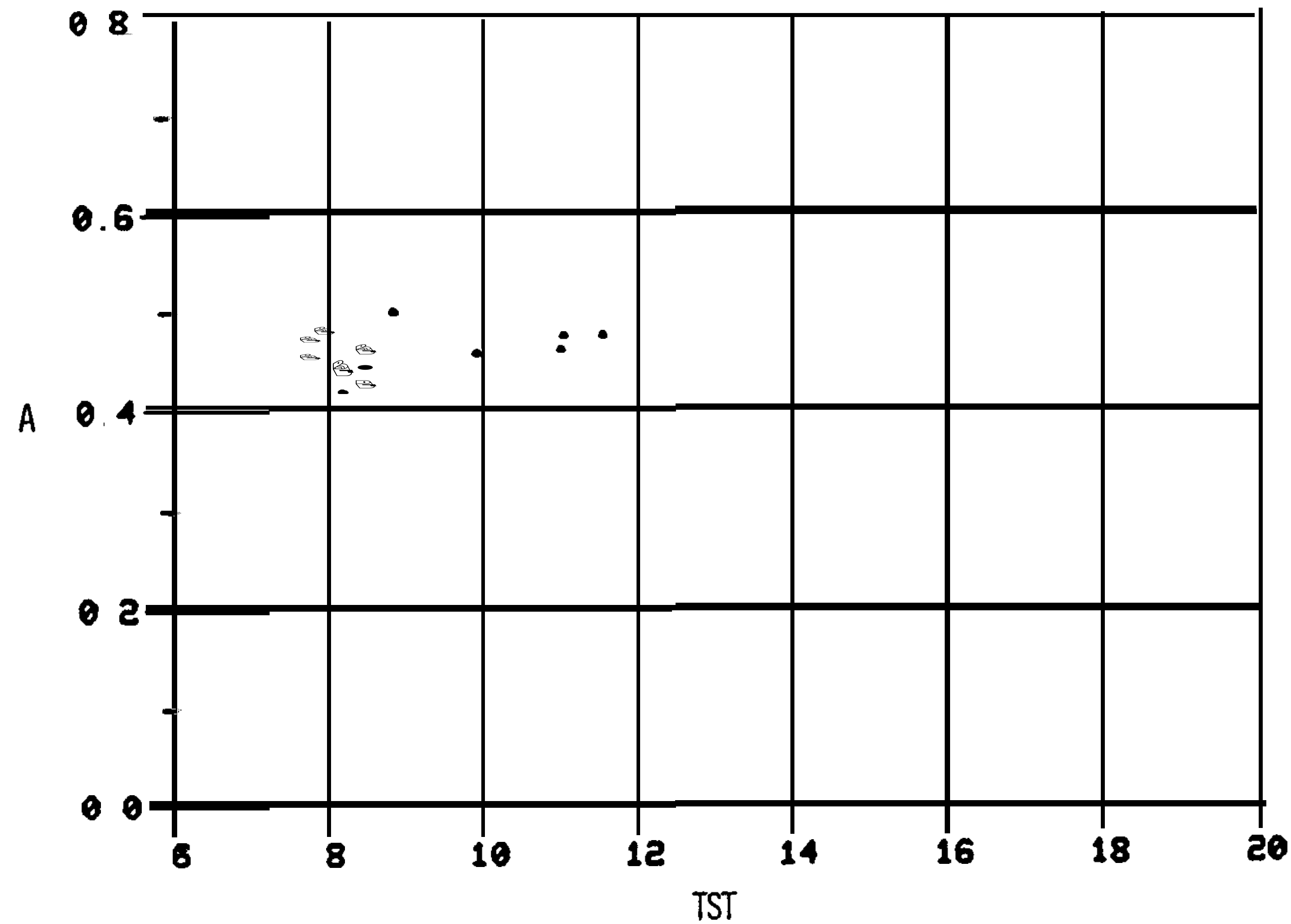


Figure 5.—*Machine plot of albedo A) vs true solar time (TST) for January 22. 1976*

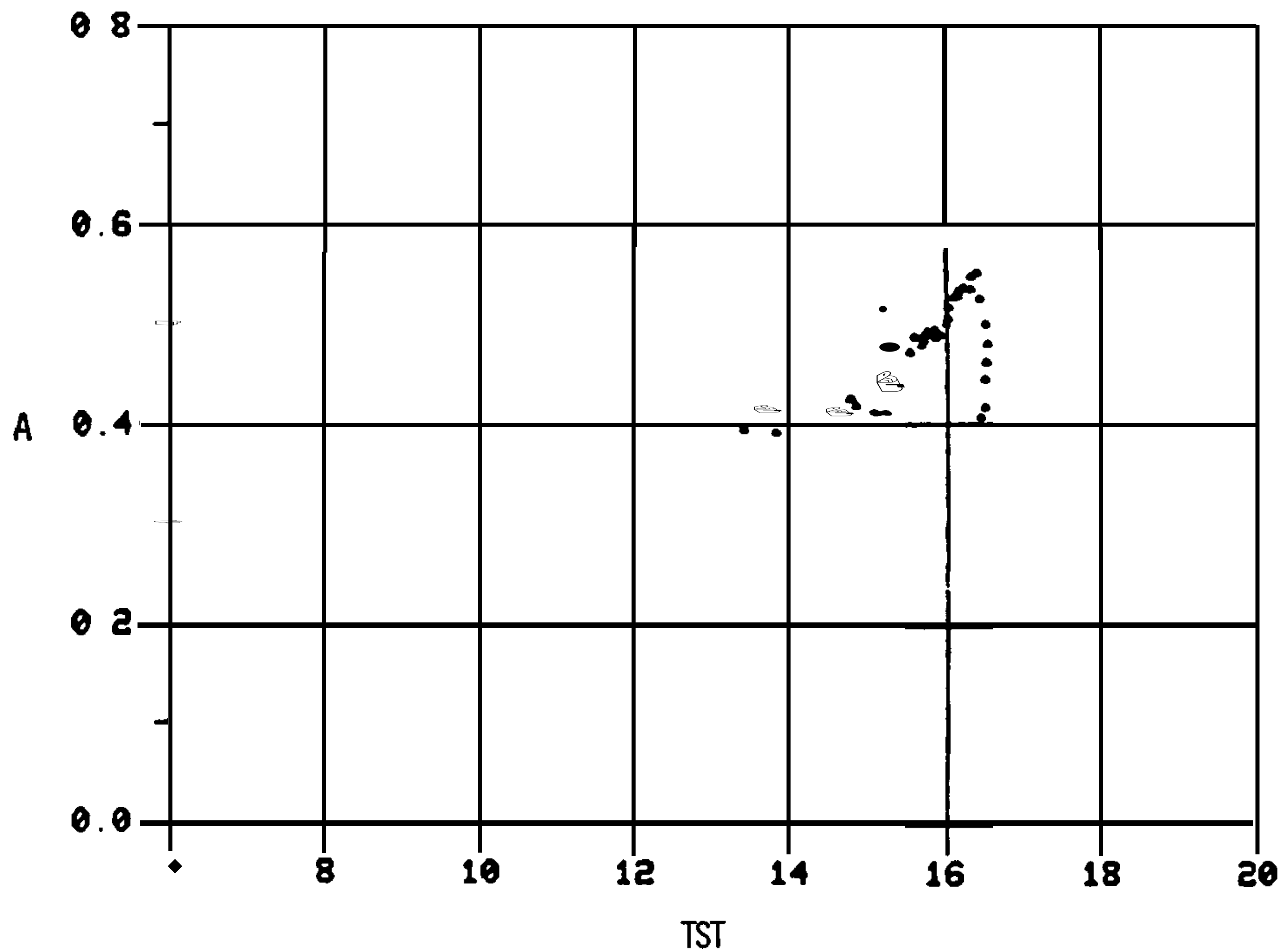


Figure 6.—*Machine plot of albedo (A vs true solar time TST) for January 27, 1976*

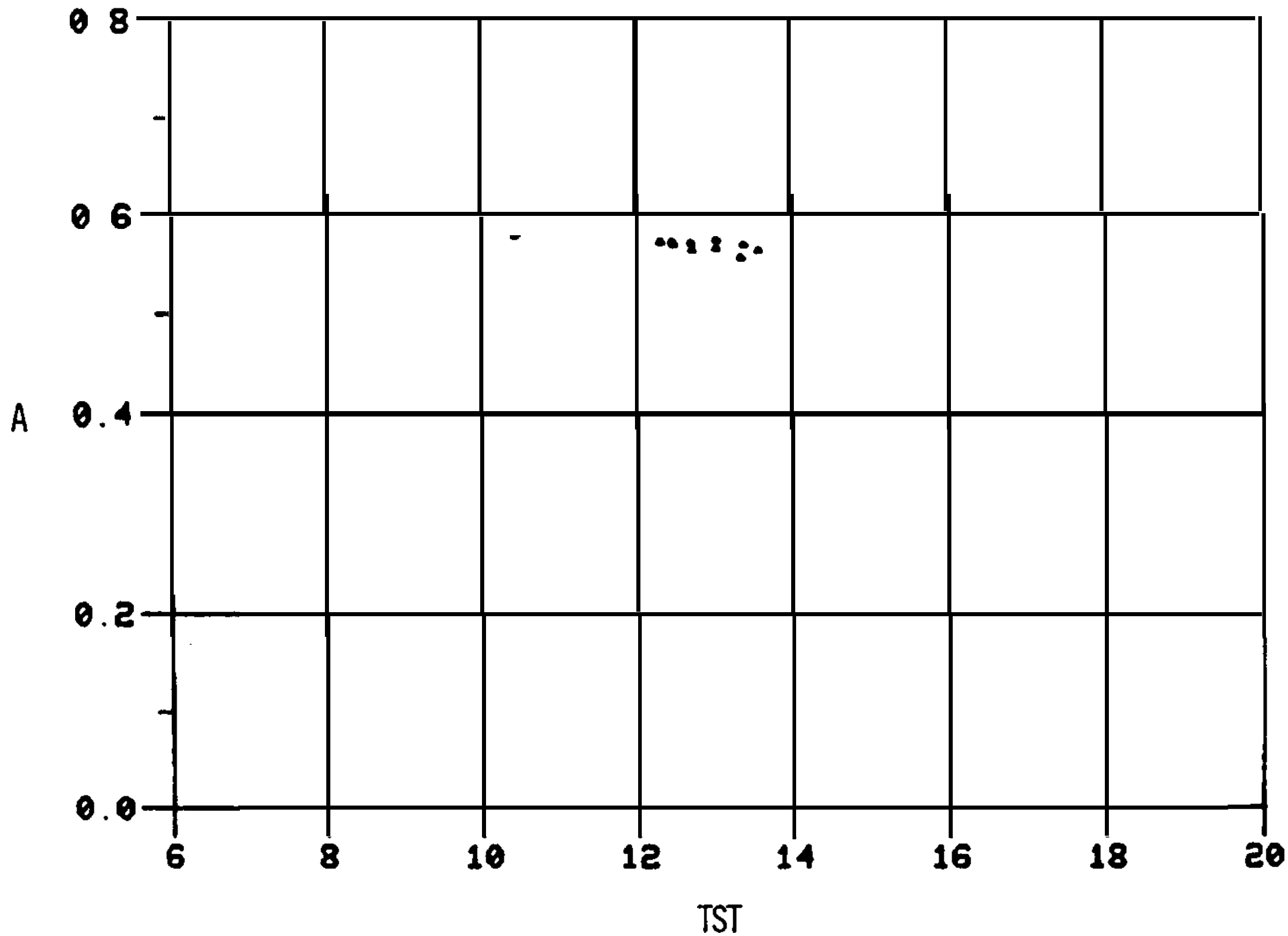


Figure 7. *Machine plot of albedo (A vs true solar time TST) for February 3, 1976*

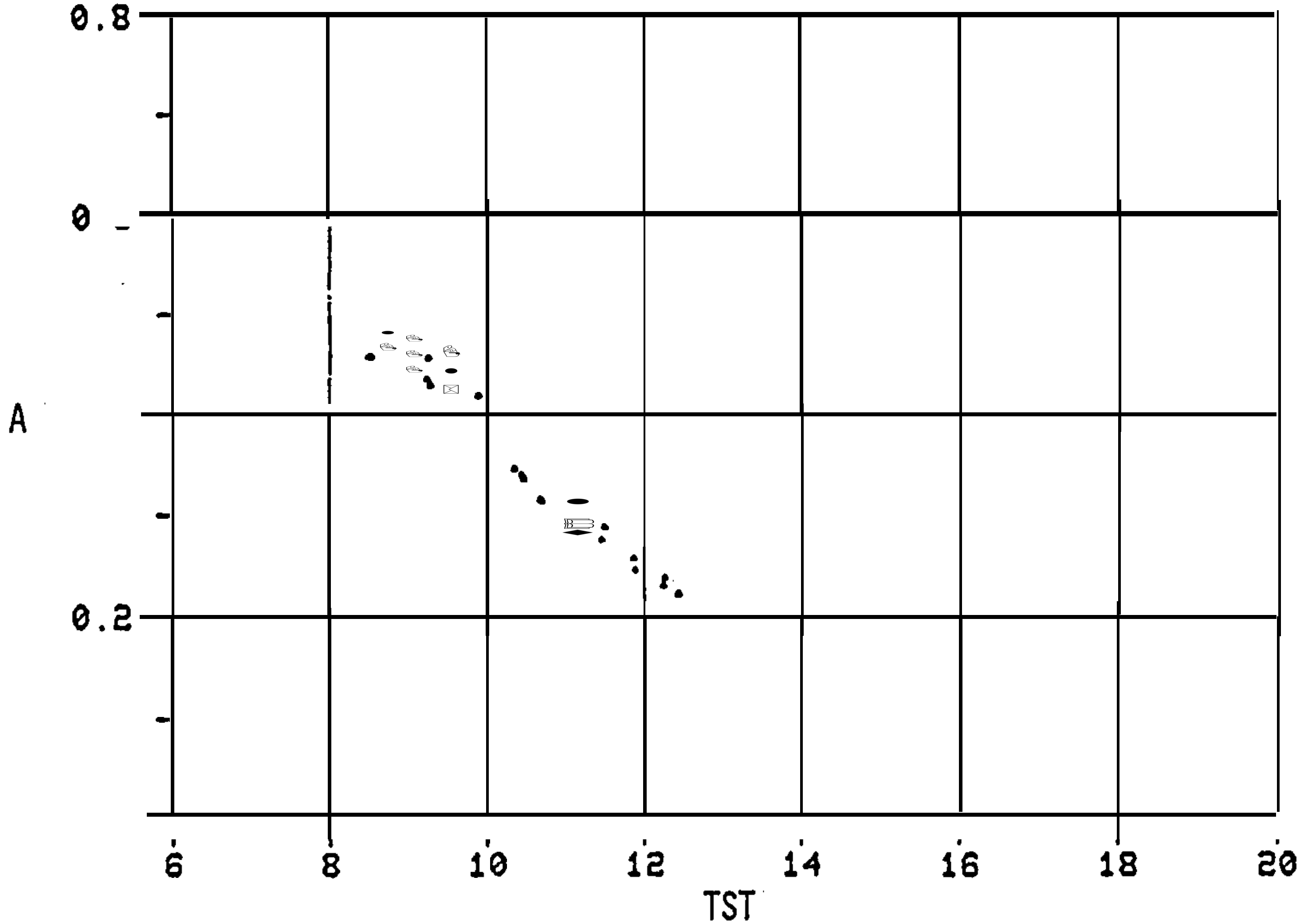


Figure 8.--*Machine plot of albedo (A) vs true solar time TST) for February 24, 1976*

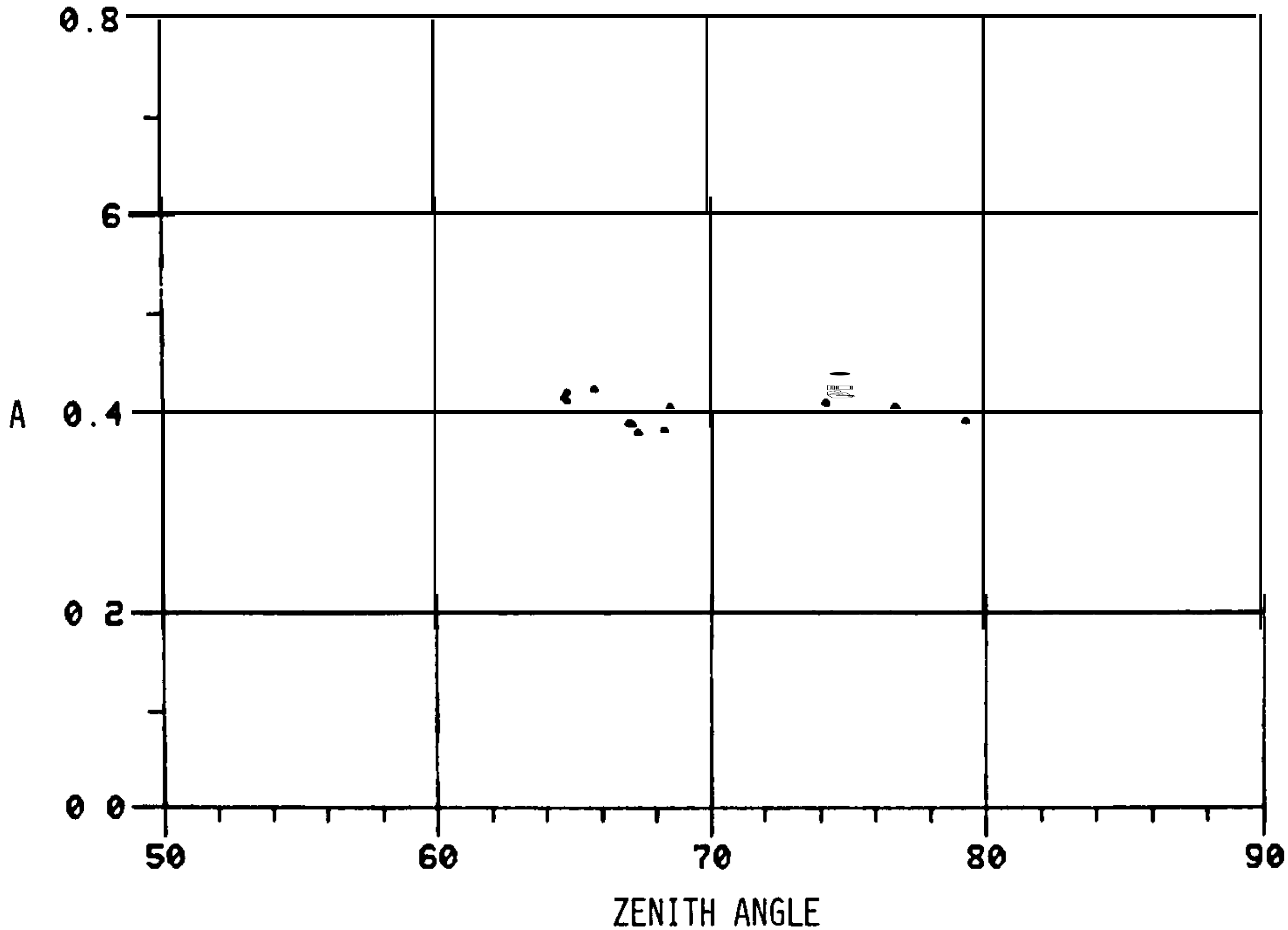


Figure 9. -*Albedo (A) vs zenith angle for January 8, 1976. Data at low solar altitudes included.*

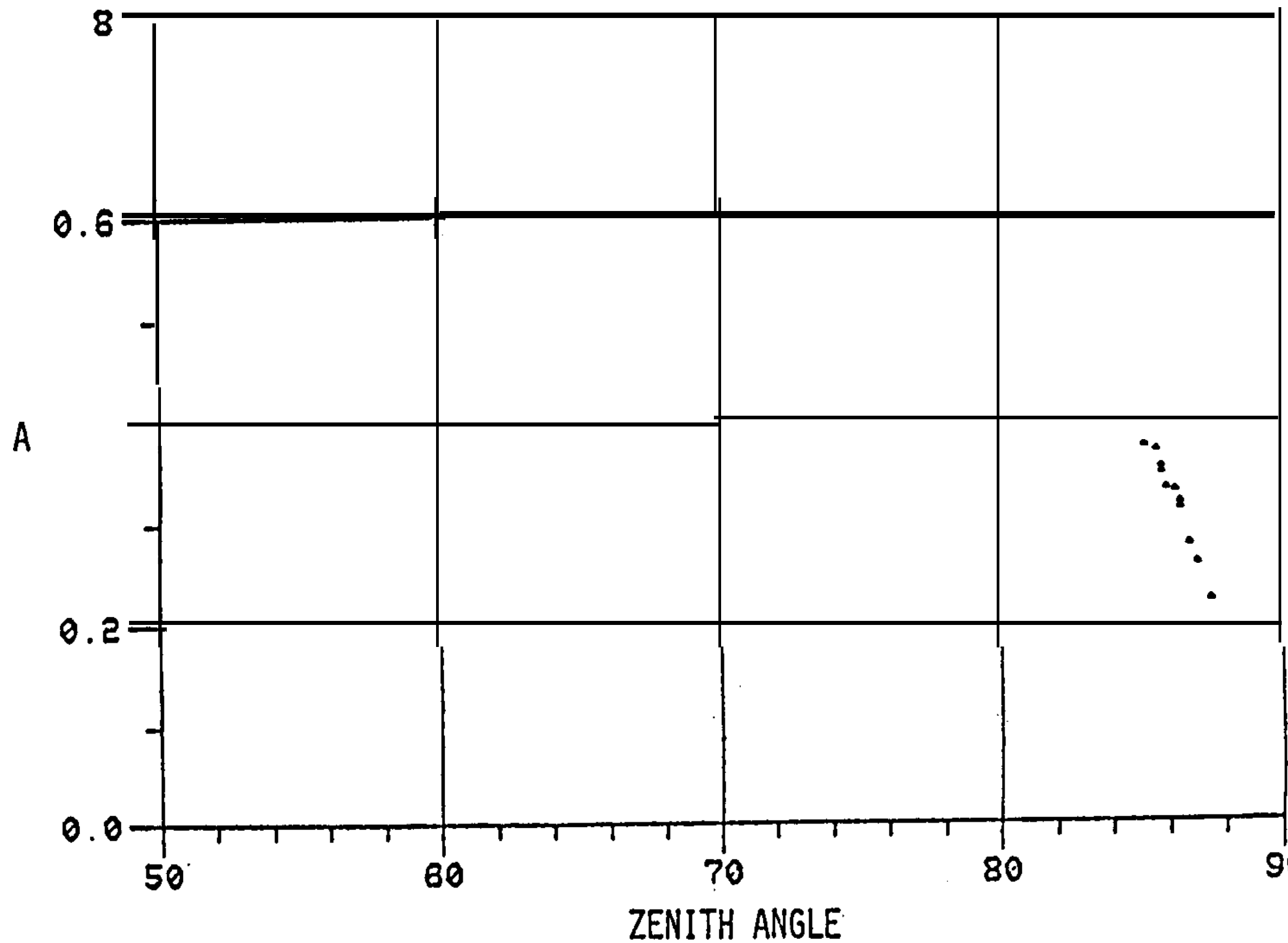


Figure 10 --*Albedo (A) vs zenith angle for January 15, 1976. Data at low solar altitudes included.*

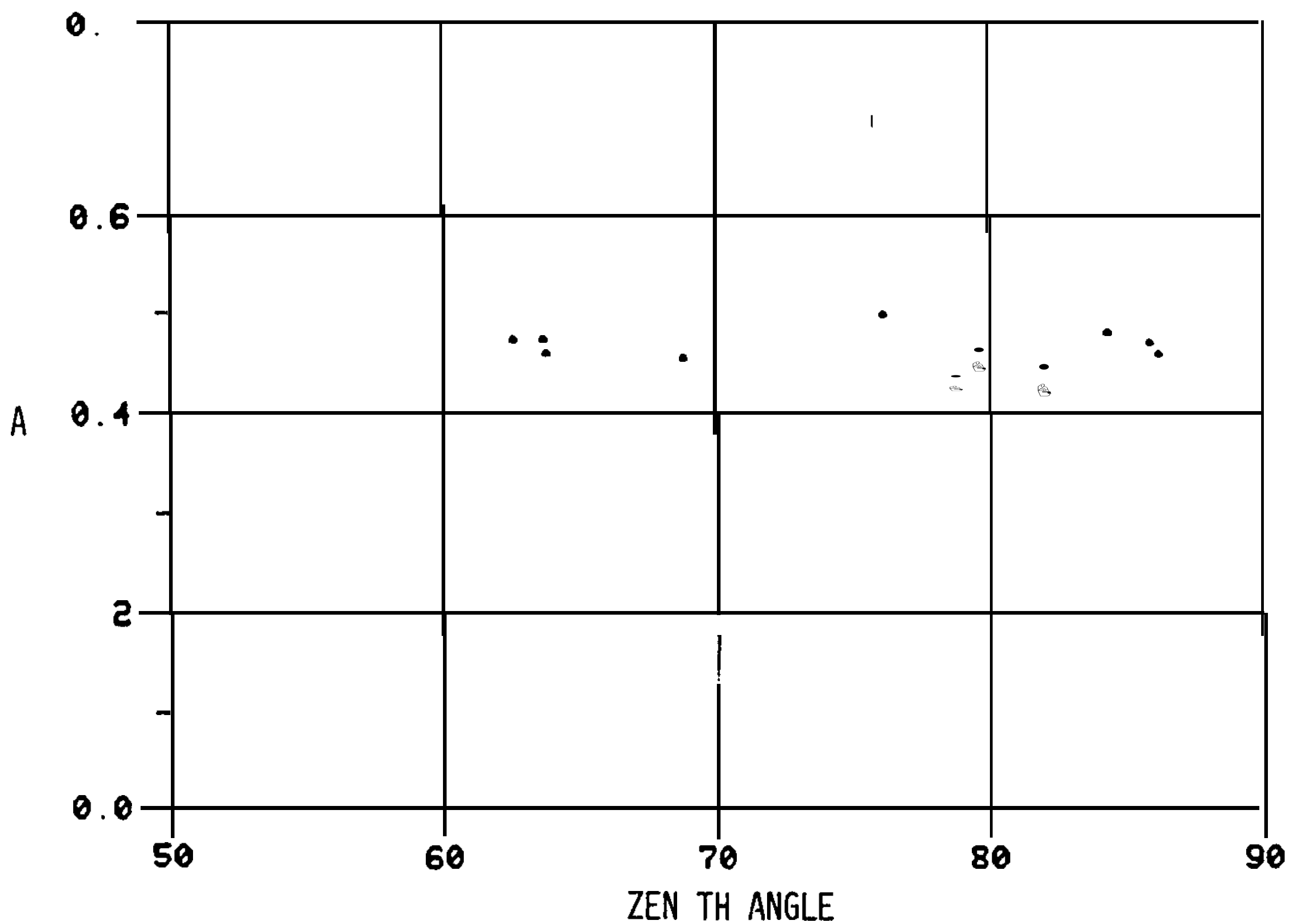


Figure 11 - *Albedo (A) vs zenith angle for January 22, 1976 Data at low solar altitudes included*

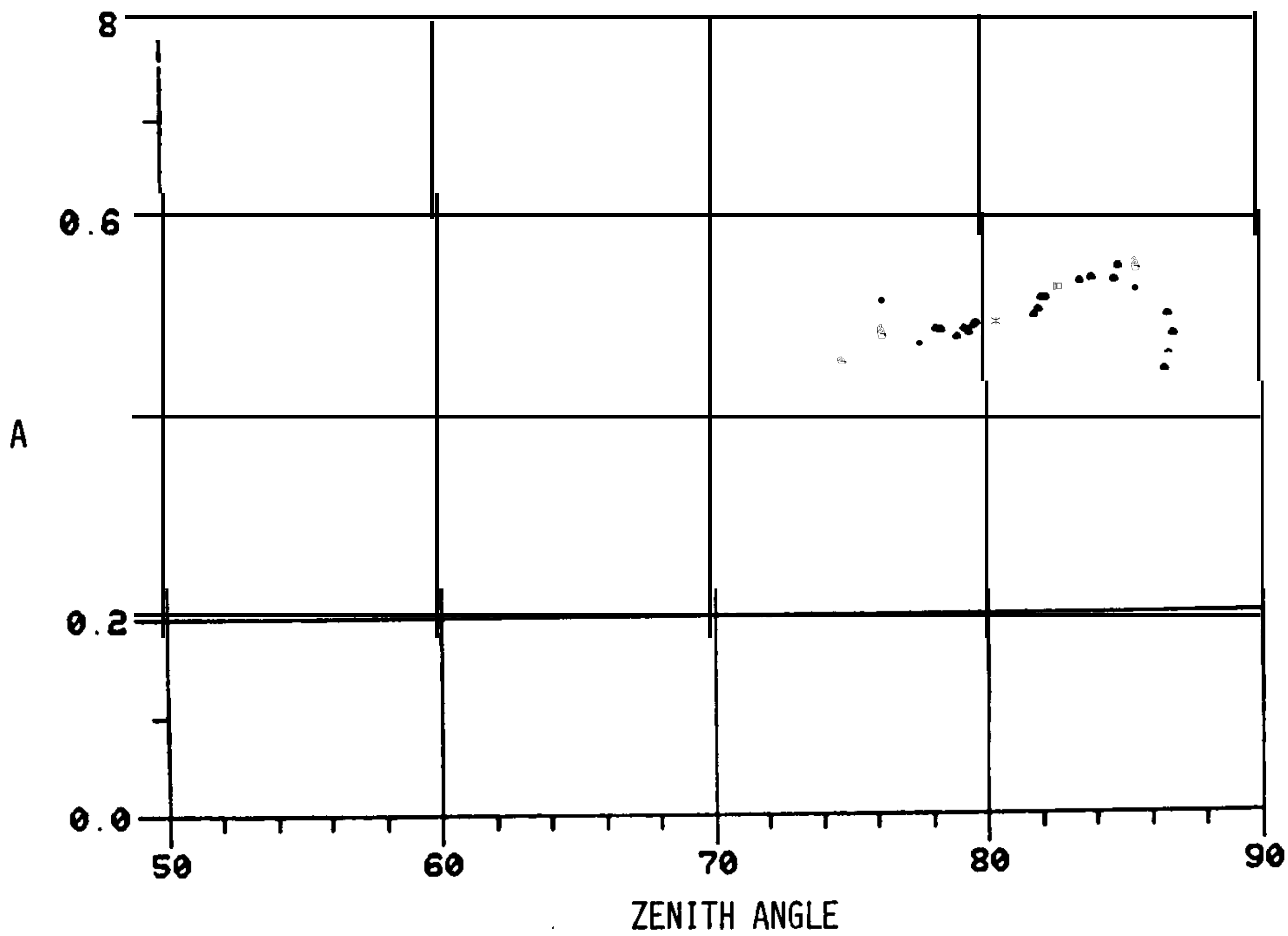


Figure 12.—*Albedo (A) vs. zenith angle for January 27, 1976   Data at low solar altitudes included*

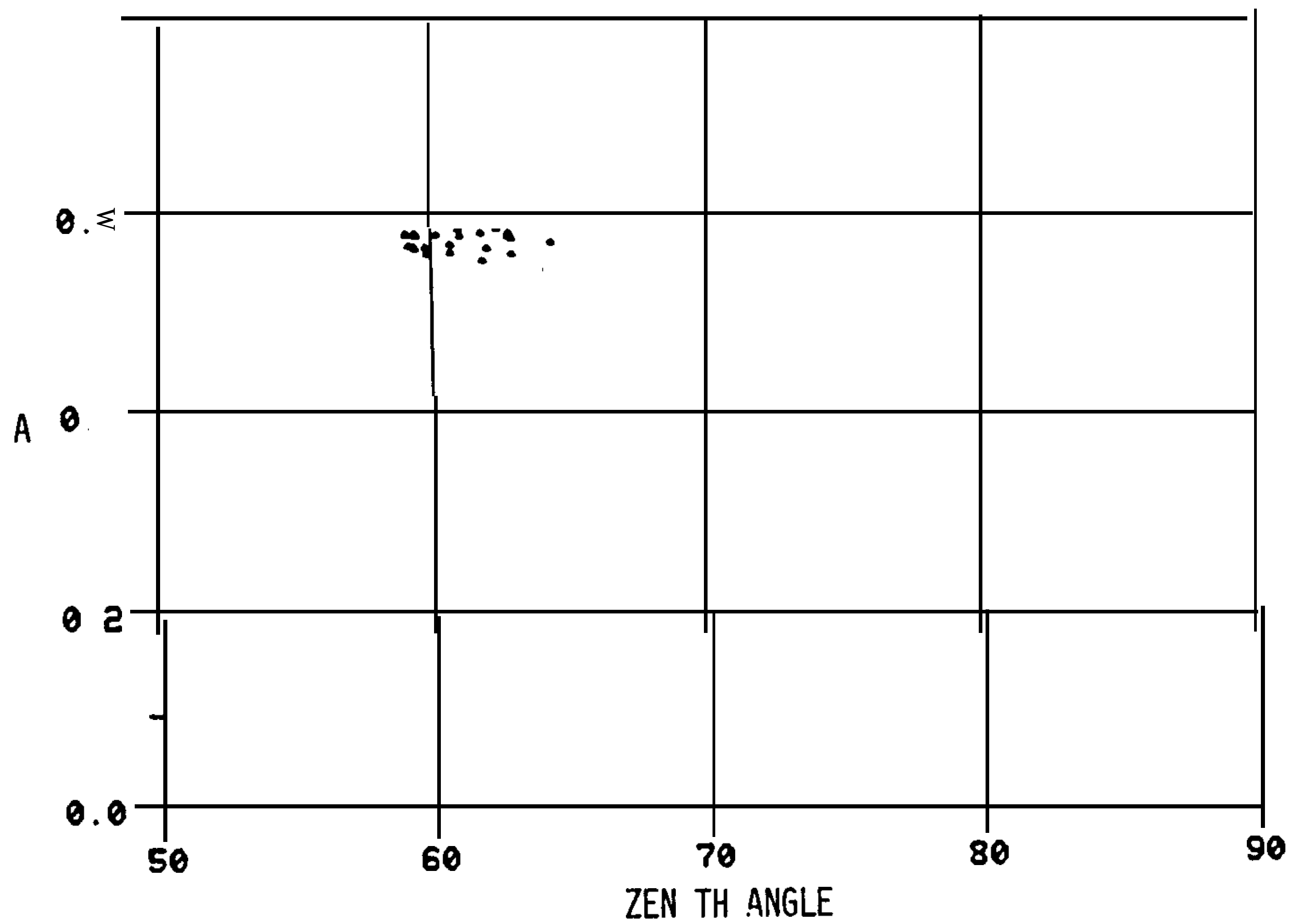


Figure 13—*Albedo (A) vs zenith angle for February 3, 1976 Data at low solar altitudes included.*

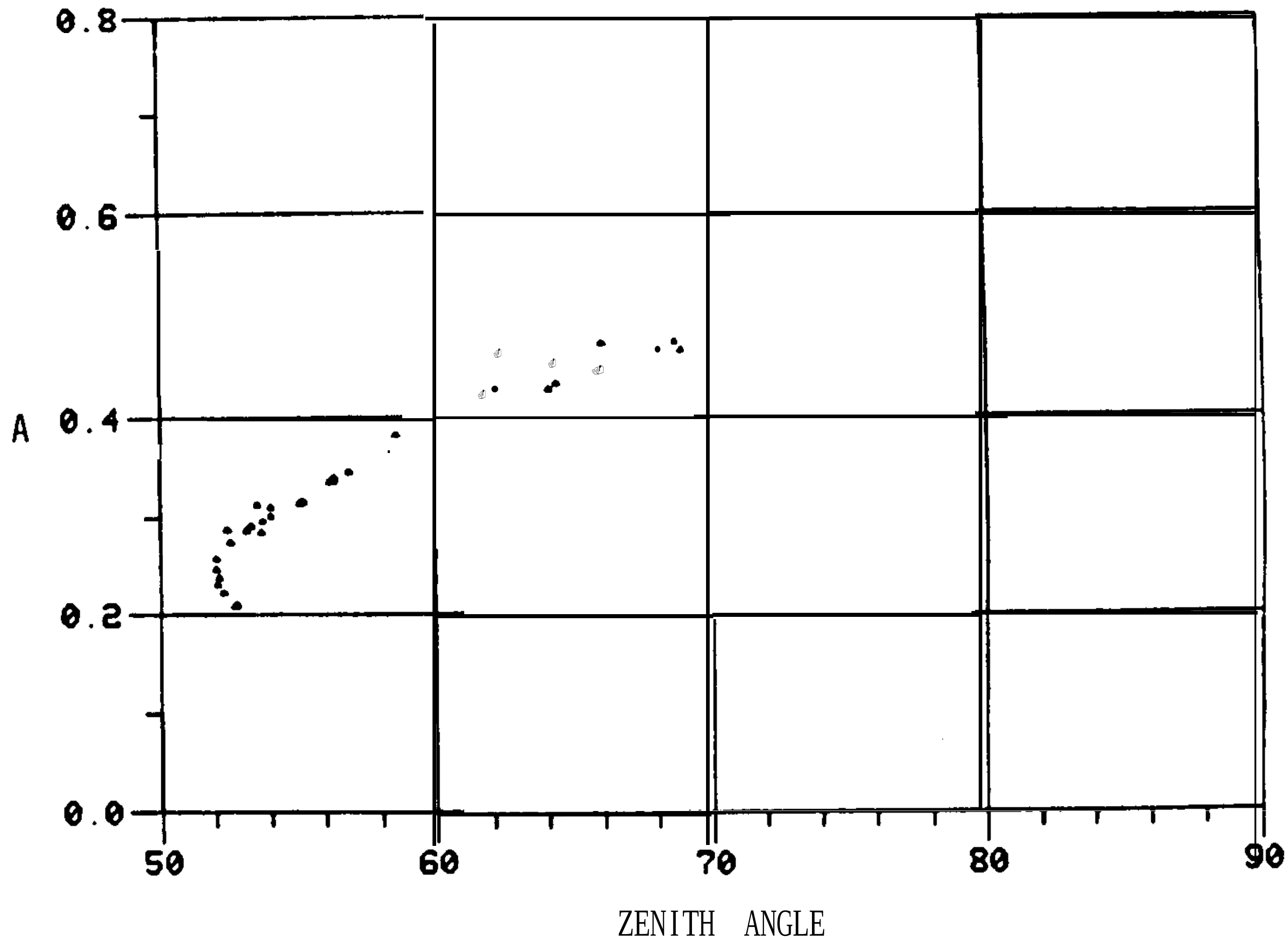


Figure 14.--*Albedo (A) vs. zenith angle for February 24, 1976. Data at low solar altitudes included.*

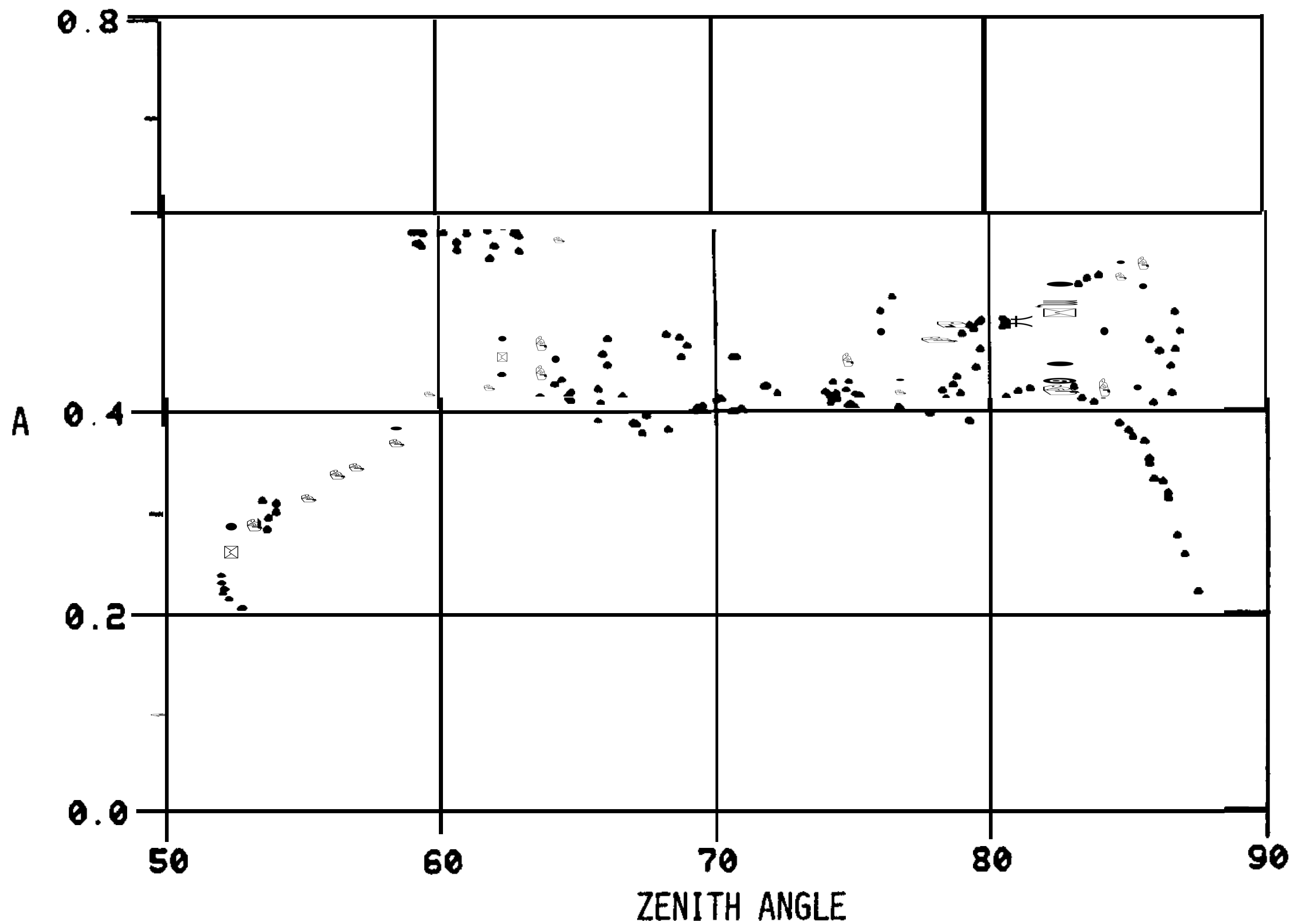


Figure 15.--*Combined plot including all data of albedo (A) vs. zenith angle. Data at low solar altitudes included.*

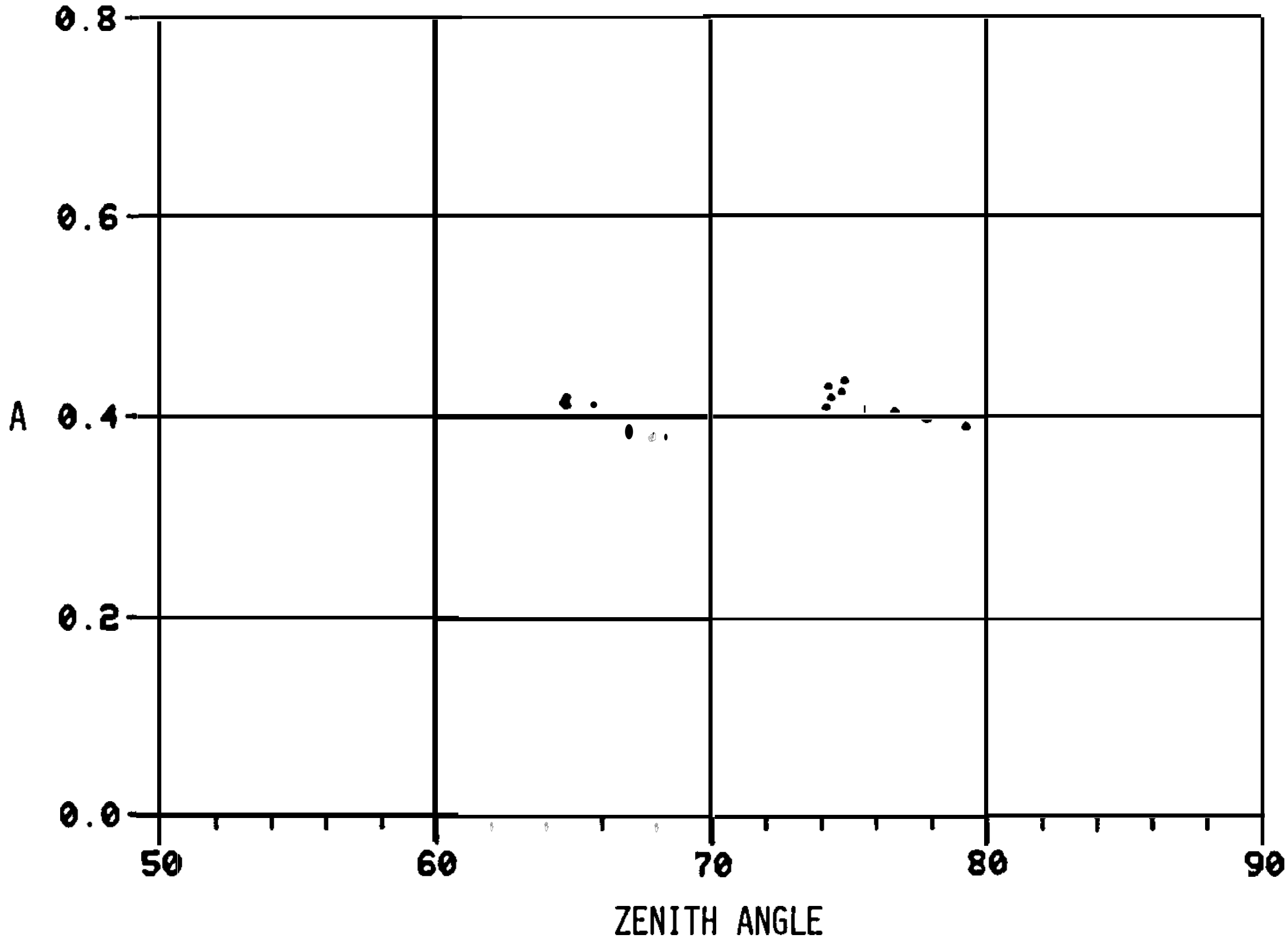


Figure 16.--*Albedo (A) vs. zenith angle* for *January 8, 1976. Data at low solar altitudes not included.*

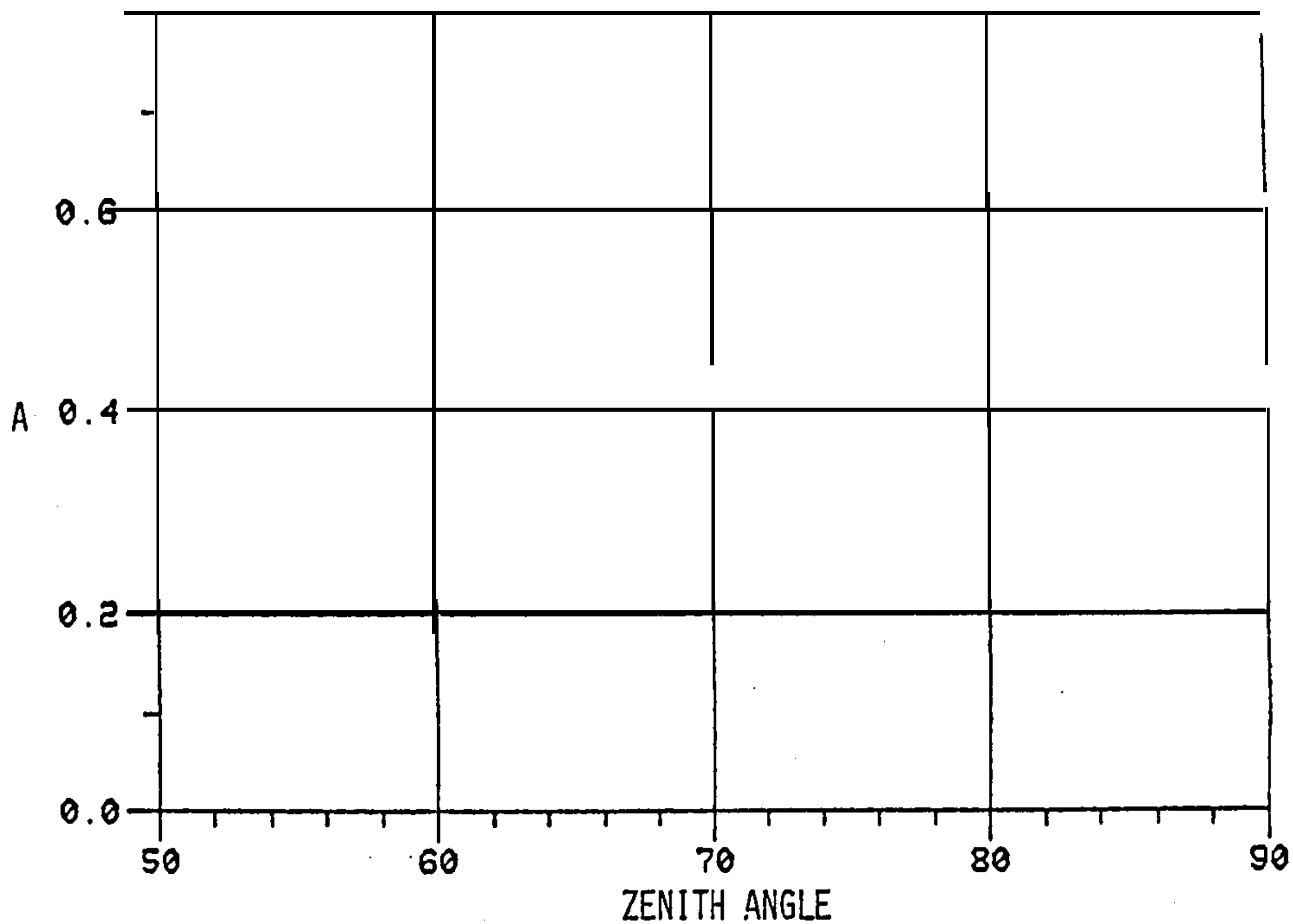


Figure 17 *-Albedo (A) vs zenith angle for January 15, 1976. Data at low solar altitudes not included*

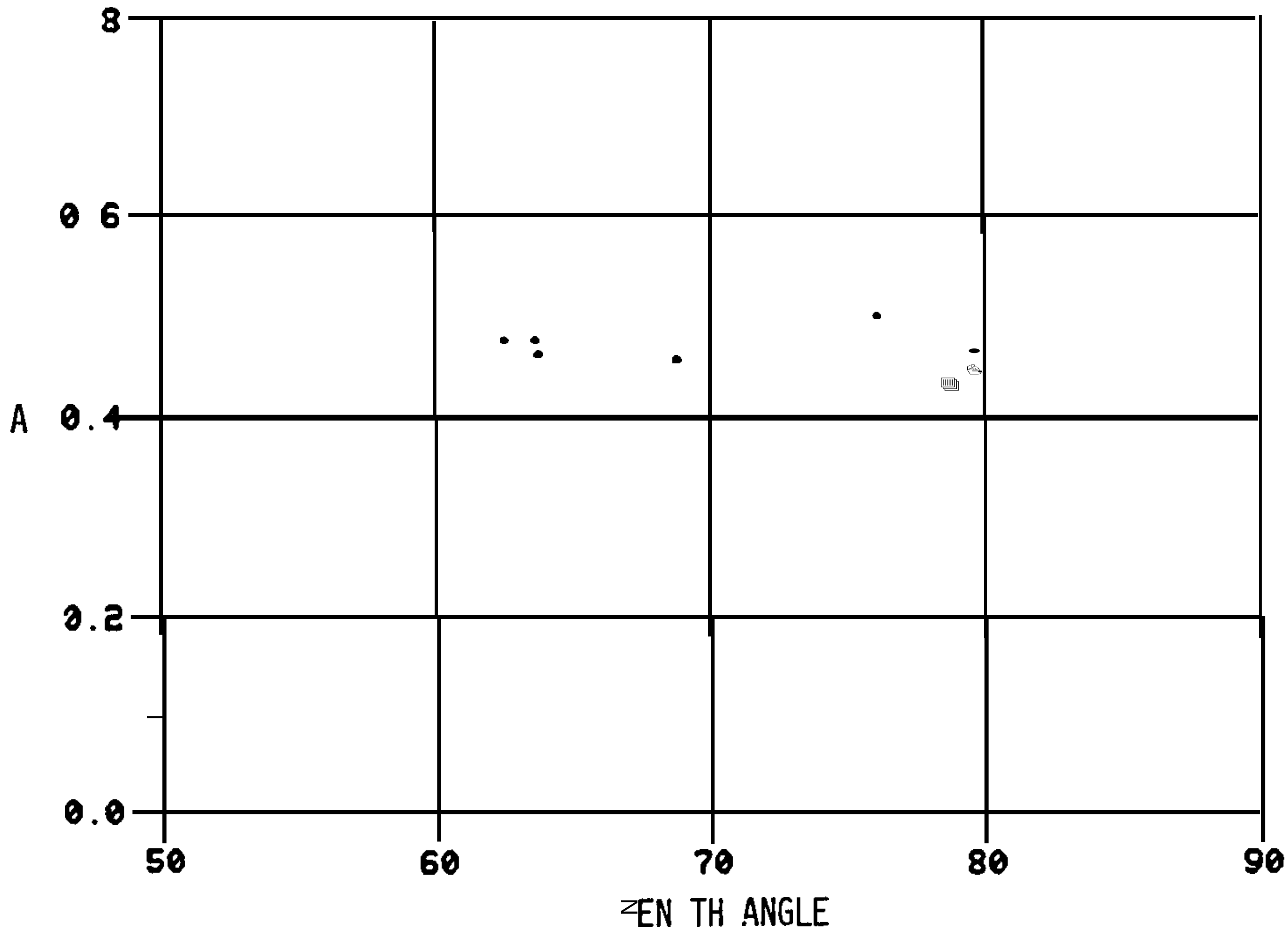


Figure 18.--*Albedo (A) vs zenith angle for January 22, 1976 Data at low solar altitudes included*

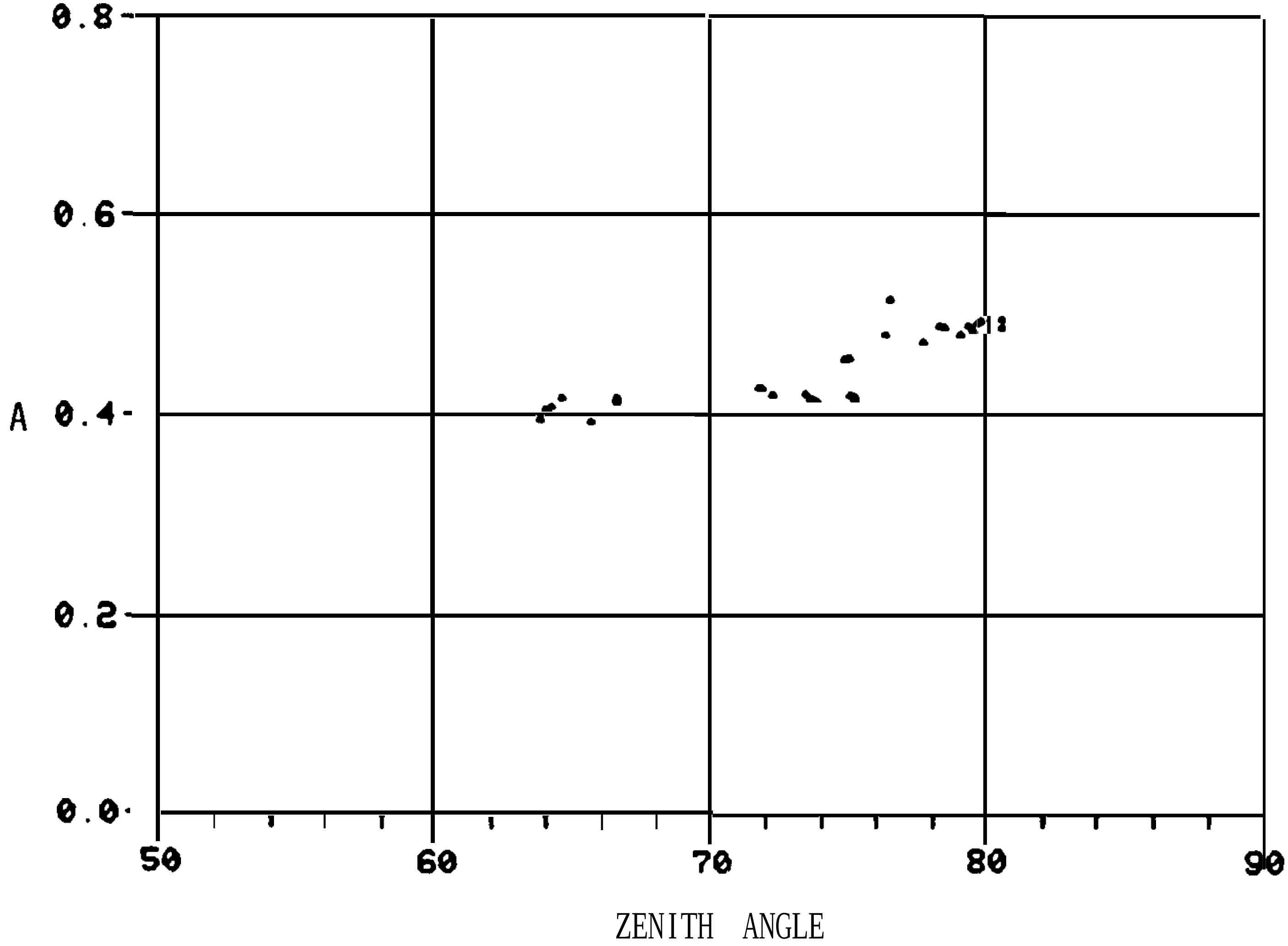


Figure 19.--*Albedo (A) vs. zenith angle for January 27, 1976. Data at low solar altitudes not included.*

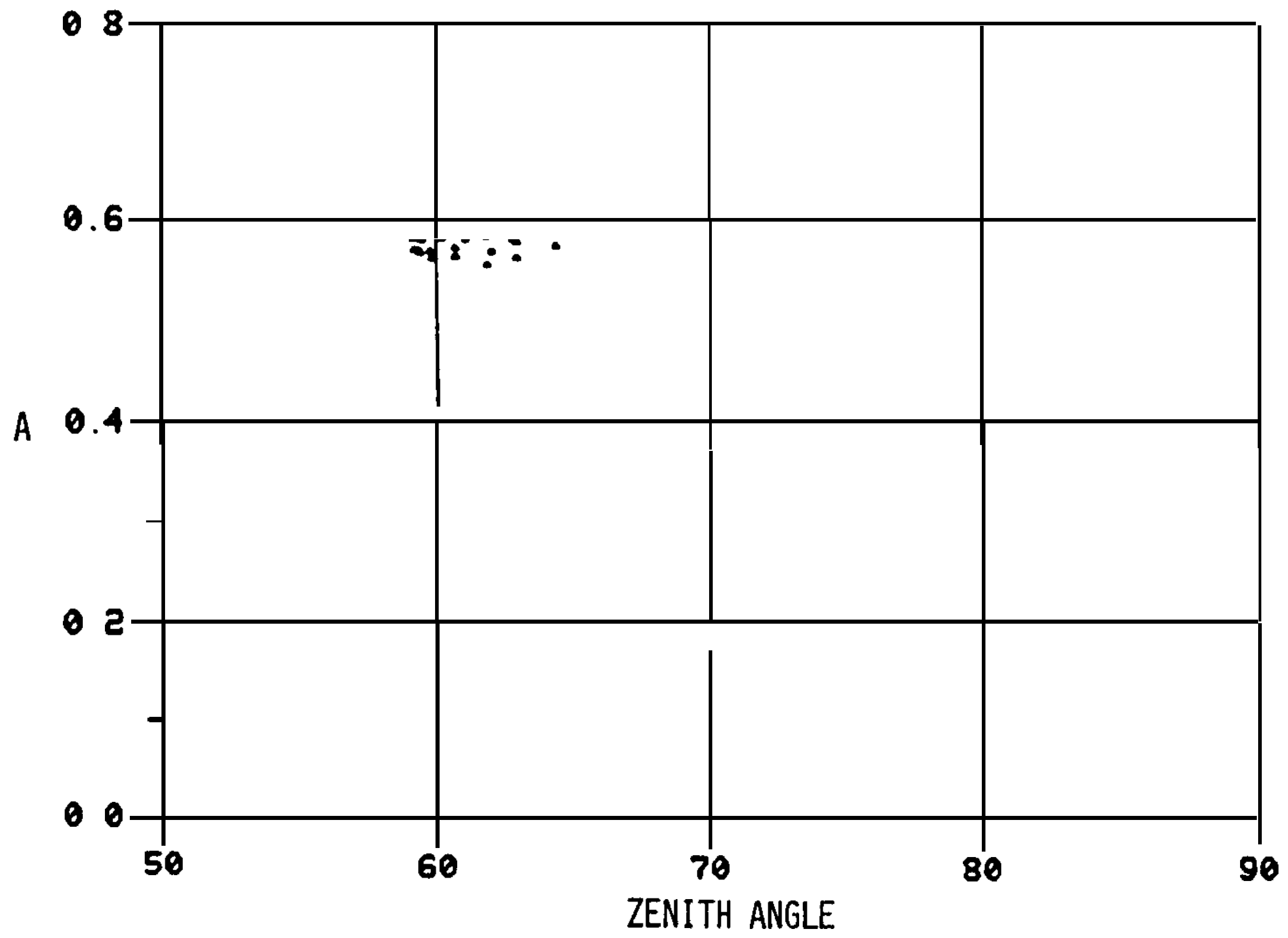


Figure 20.- *Albedo (A) vs zenith angle for February 3, 1976. Data at low solar altitudes not included.*

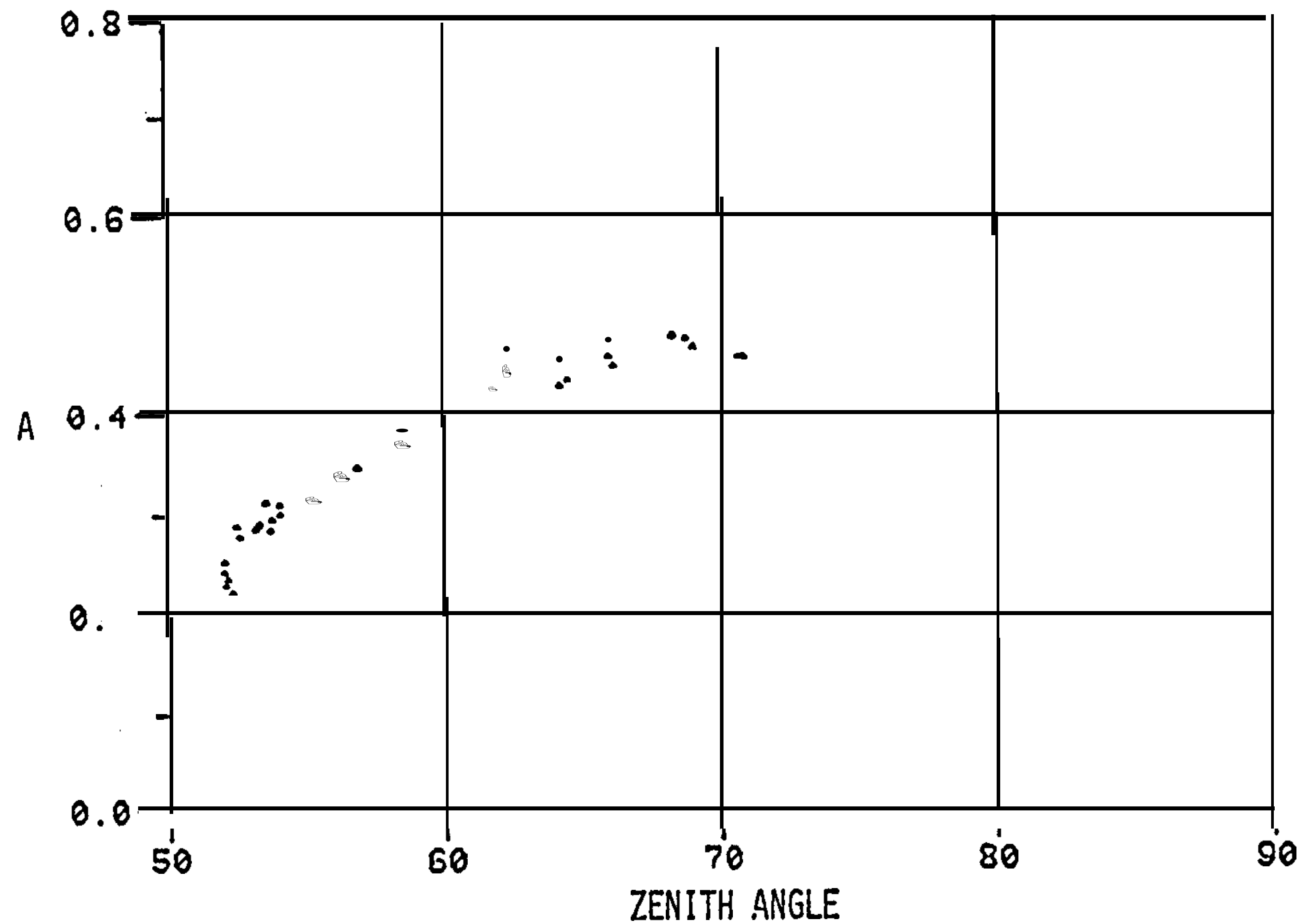


Figure 21 -*Albedo A) vs zenith angle for February 24, 1976 Data at low solar altitudes not included.*

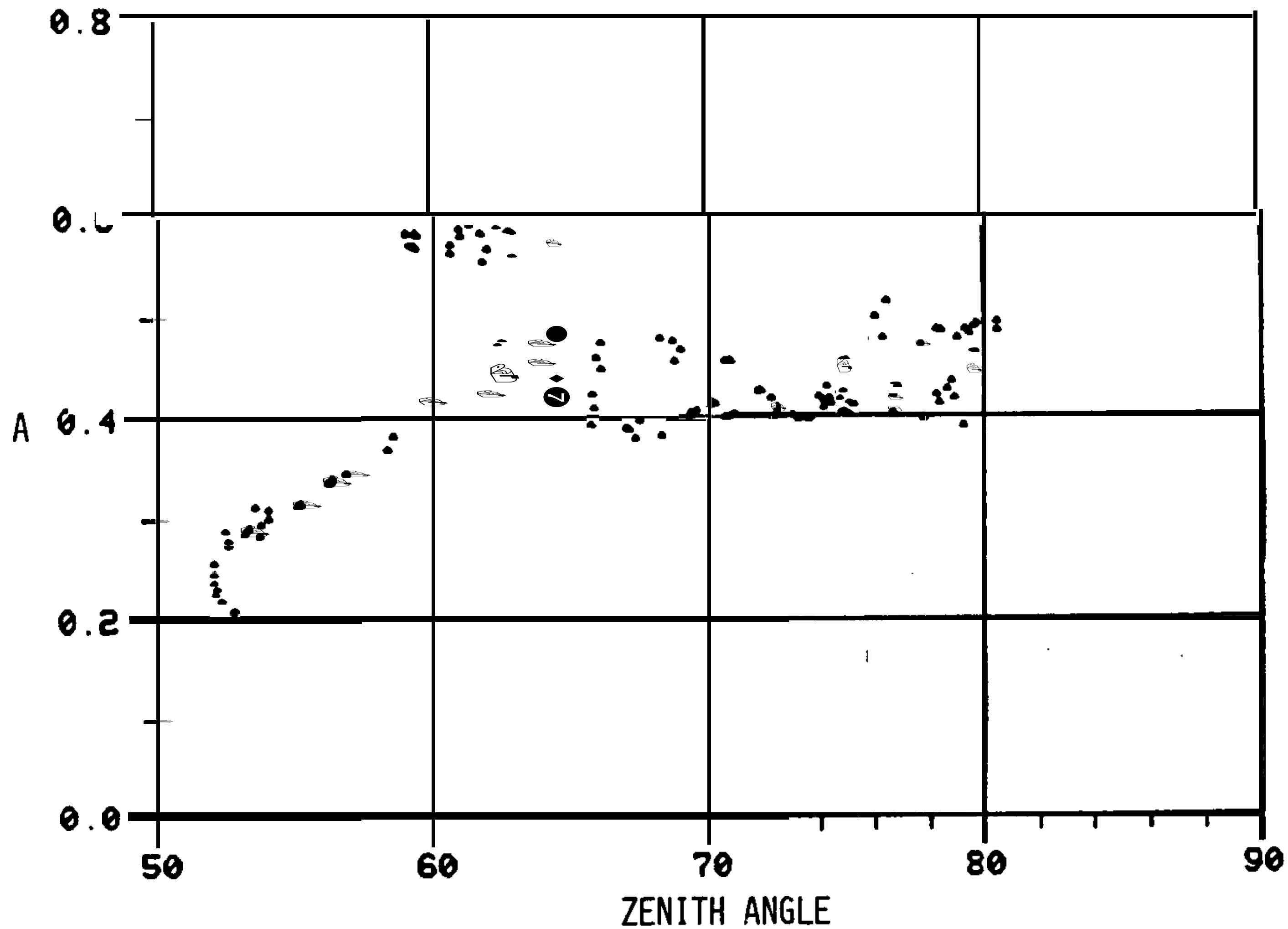


Figure 22.--*Combined plot including all data of albedo (A) vs. zenith angle. Data at low solar altitudes not included.*

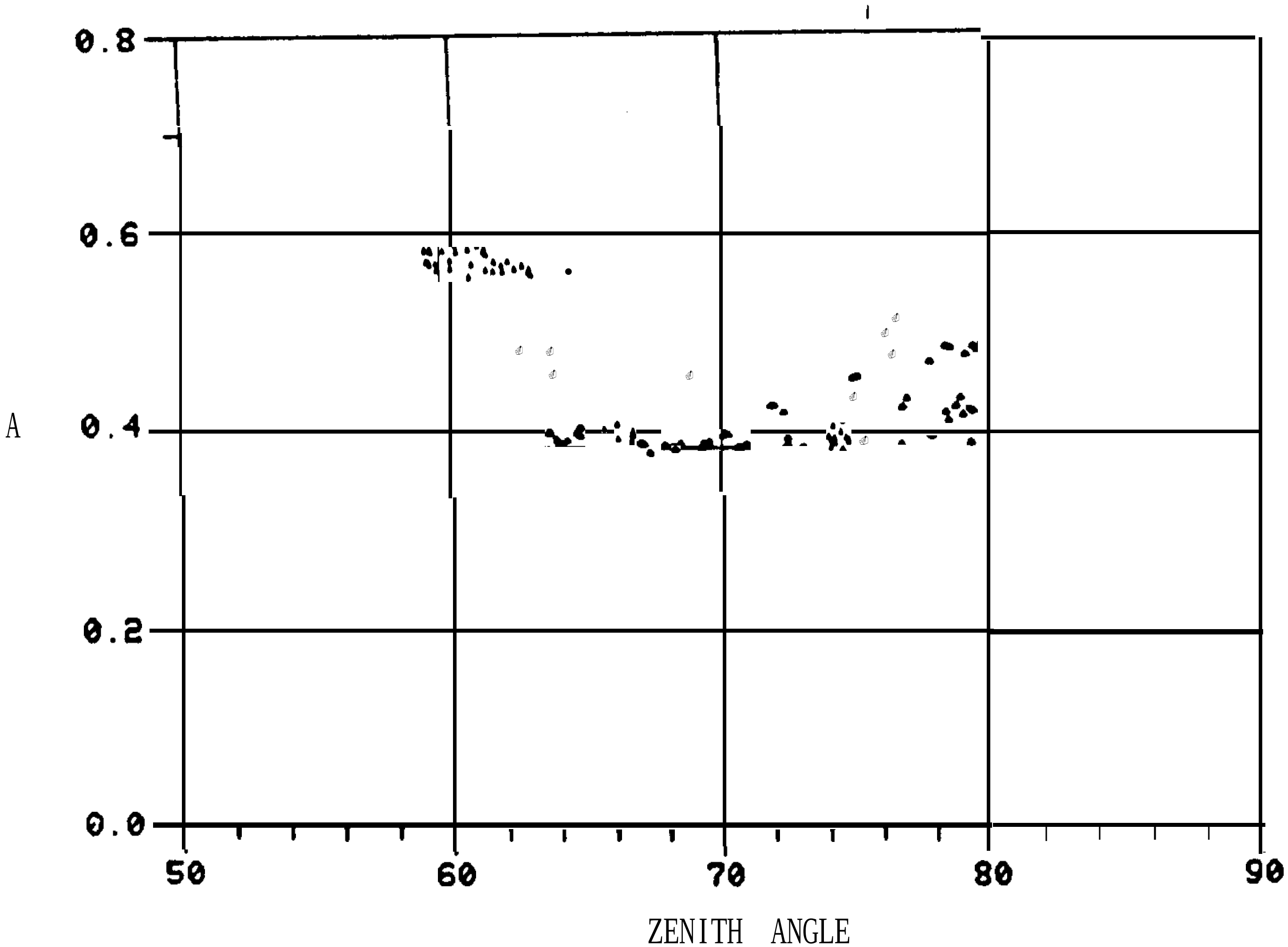


Figure 23.--*Combined plot including all albedo (A) vs. zenith angle data. Day with melting ice (February 24, 1976) and data at low solar altitudes not included.*

Table 1.--Average *temperatures during measurement period by measurement days*

Date	Temperature (°C)
January 8, 1976	-11.8
January 15, 1976	-10.7
January 22, 1976	-10.1
January 27, 1976	-5.6
February 3, 1976	-11.6
February 24, 1976	6.6

The lack of similarity between figures 2 and 23 seems to indicate 'significant differences between this work and the work by Idso *et* al. It is felt that the most basic difference is the nature of the surfaces from which the albedo values were measured.

The soil surface studied by Idso *et al.* was a uniformly plowed field. The individual agglomerates of soil varied widely in size and shape, but they remained in the same position, undisturbed except for irrigation, during the entire study. The surface could, therefore, be classified as a near Lambertian reflector. In contrast, the ice surfaces in this study varied for most of the measurement days. Most of the tine no effort was made to reoccupy a measurement site. The ice surfaces, with one exception (February 3, 1976) could also not be classified as Lambertian. Numerous occasions of specular reflection were noted at low solar altitude (sun glint). For the measurements of February 3, 1976 (figure 1), the ice surface was originally snow-covered, refrozen slush, but when the snow was cleared, a significant amount of granular snow adhered to the ice that could not be removed by sweeping. The remaining snow contributed both to the higher albedo and to the diffuse nature of the reflected radiation. The measurements are clearly different from the others in figure 23 and have been removed in figure 24 to obtain more uniform conditions over all measurement days as with the soil measurements.

Two days of data (January 8 and 15) collected over the same ice surface are shown in figure 25. No dependence of the albedo on zenith angle is shown. The graph is, in fact, similar to one shown by Coulson and Reynolds (1971) for a blacktop surface (figure 26). They attribute the lack of dependence on "the virtual lack of shadows on the relatively smooth surface of the blacktop." Coulson and Reynolds measured the dependence of the albedo of various surfaces including soils and crops on solar altitude and concluded:

> Surfaces of a complex nature which contain many Interstices within the structure generally show a decrease of reflectance

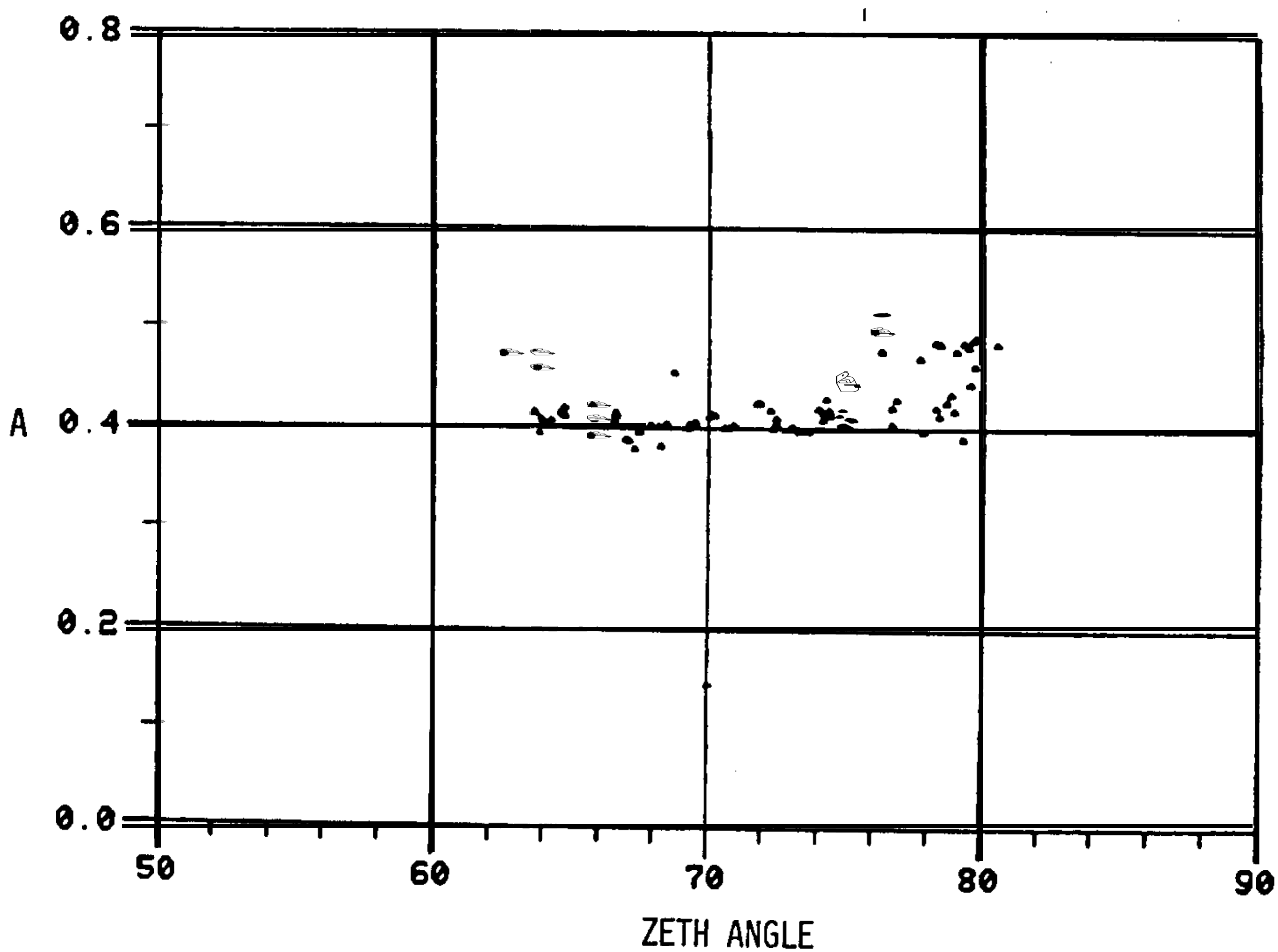


Figure 24.--*Albedo (A) vs. zenith angle for all da tawith days showing high albedo (February 3, 1976), ice melting (February 24, 1976), and low solar altitudes not inc uded.*

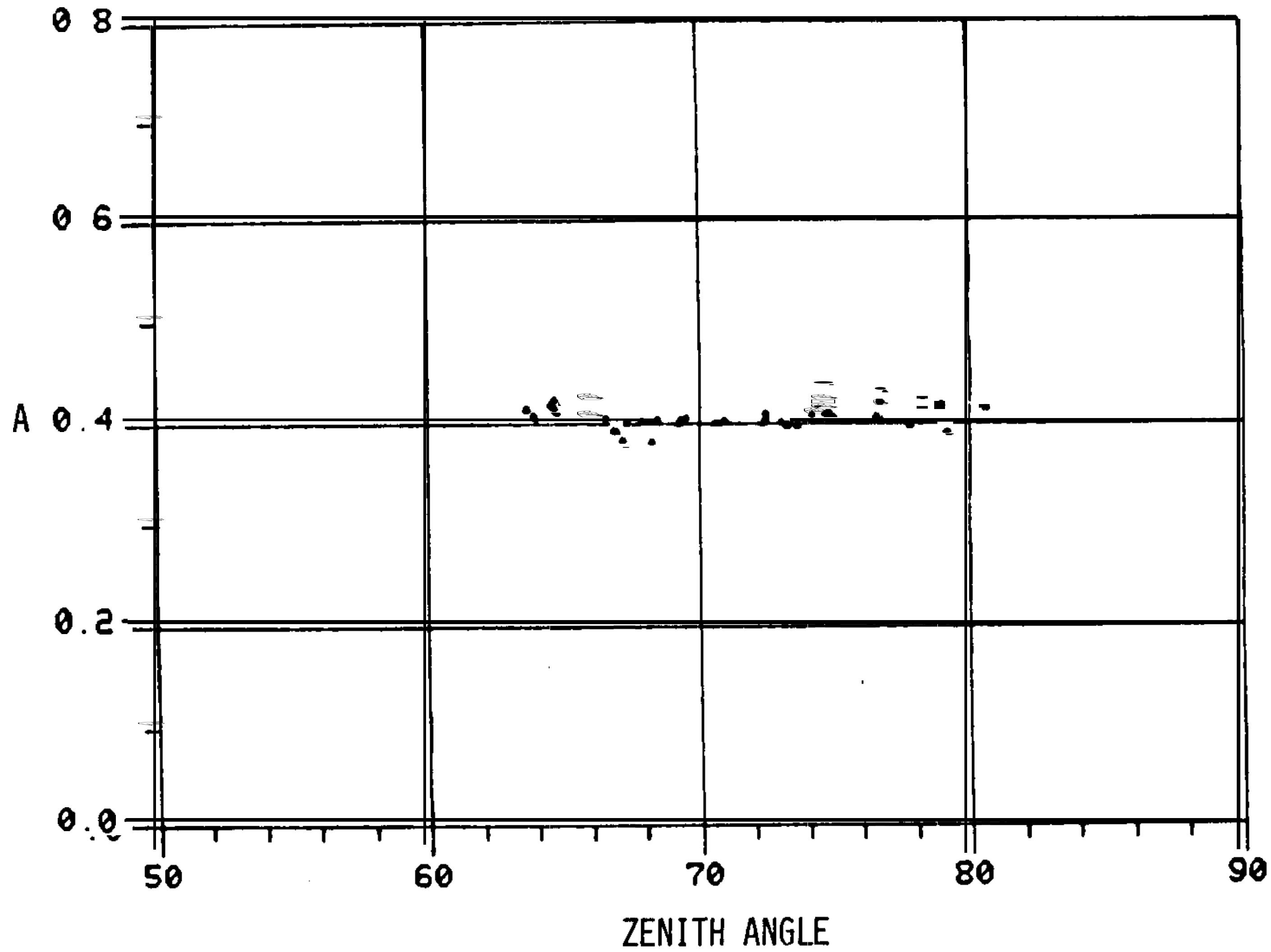
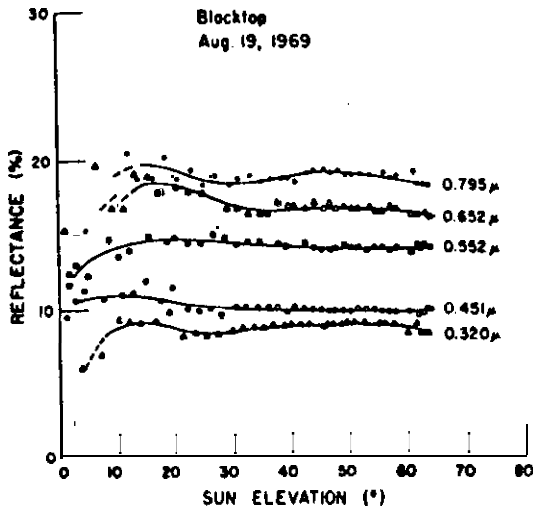


Figure 25.--*Albedo (A) vs. zenith angle for 2 days of data (January 8 and 15, 1976) collected over the same ice surface showing a lack of dependence of albedo on solar altitude.*



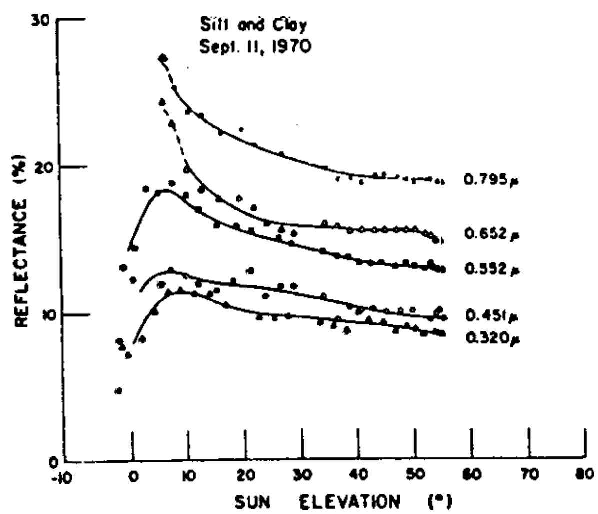


Figure 26.--*Hemispheric reflectance* of *blacktop and silt and clay (shown for comparison purposes) at various wavelengths* (from *Coulson and Reynolds, 1971).*

with increasing sun elevation. It is probable that this feature is caused by a significant part of the incident radiation being trapped within the interstices, in a manner similar to that in other types of optical traps.

It would thus appear that flat ice surfaces show much less albedo variation with changing solar altitude than more complex surfaces. On the other hand, ice surfaces with sufficient relief (brash ice for example) might well exhibit daily variation with solar altitude. The orientation of individual plates of ice in a brash field could, however, cause a lack of symmetry about 1200 TST. A similar lack of symmetry was noted by Diamond and Gerdel (1956) for measurement of snow albedo in northern Greenland. Mean morning and afternoon albedos showed that albedo was higher in the afternoon than in the morning on both clear and cloudy days (table 2). The differences were attributed to etched patterns in the snow due to wind erosion, which exhibited vertical to undercut surfaces. This caused shadows, depending on sun angle.

Table 2.--Mean values of albedo in the morning and afternoon (from Diamond and Gerdel, 1956)

	Solar time 0500-1100	Solar time 1300-1900
Clear day	0.77	0.87
Cloudy day	0.80	0.86
All days of record	0.80	0.85

Many of the measurements were made over ice surfaces cleared of snow. Cleared areas were of sufficient size to eliminate snowbank effects from the ice albedo results. However, on the first morning of the measurements (January 8, 1976) a small ice surface was cleared by shoveling and sweeping. In order to check the effects of the nearby snow cover on the albedo, a larger area was cleared in the afternoon. The albedo dropped significantly, indicating that albedo values from the smaller cleared area were unrepresentative. The morning albedo values are not included in any of the previous plots, but are shown in figure 27. A definite dependence of albedo on zenith angle is apparent. The effect is most likely due to shading of the measurement surface at low sun angle by the banks of snow (about 30 cm high) left after clearing the ice. The albedo variation due to shading might well be similar to that observed for soils and crops.

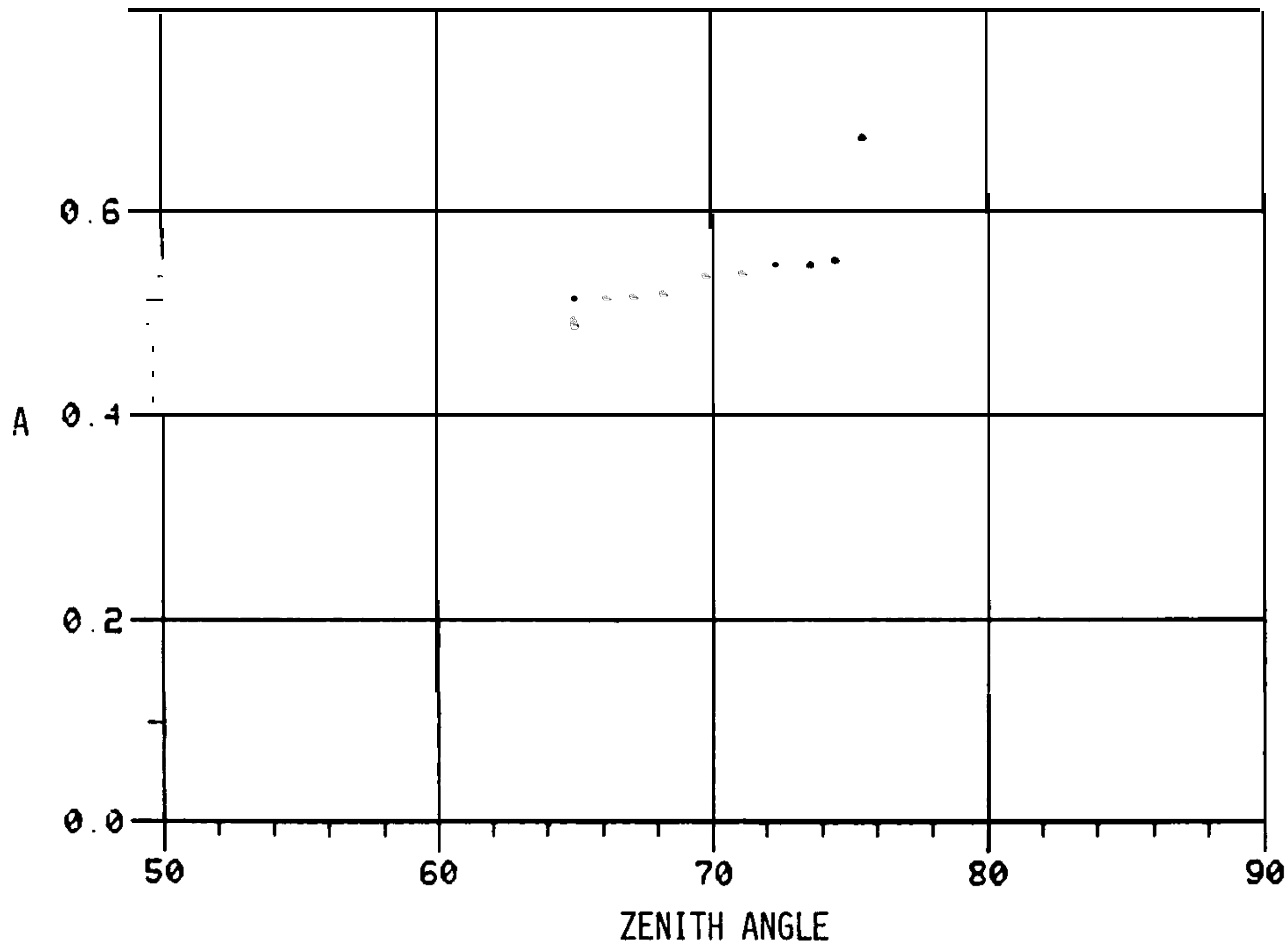


Figure 27.--*Albedo (A) vs zenith angle for January 8, 1976, showing dependence of albedo on solar altitude due to shadowing effects.*

Coulson and Reynolds (1971) found a significant increase in soil albedo at solar altitudes from 10" to 20°; lower albedos were noted at solar altitudes from 0" to 10'. Similar results were also noted in this study as shown by figure 6 (January 27, 1976), where a steady rise in albedo was followed by an abrupt drop. All the lower readings occurred at solar altitudes less than 5°. The Eppley Corporation, manufacturer of the instruments used, has indicated that measurements at solar altitudes of less than 10" could be in error since the capability of the thermopile might be exceeded due to low light levels. It is felt that these measurements are accurate to about 5°-7° owing to special care in measurement technique and measurement of output by a precision portable potentiometer. It is therefore concluded that the abrupt drop in albedo shown in figure 6 and in several figures in Coulson and Reynolds' study was due to instrument error.

The rise in albedo prior to the drop is another matter. Bolsenga (1977) in describing the January 27, 1976, measurements states:

> The increase in albedo near the end of the day with decreasing solar altitude is likely due to the effects of increasing diffuse sky radiation which is relatively rich in visible light (i.e., incident flux component due to direct solar radiation becomes progressively smaller and diffuse component relatively larger). If the ice albedo is high in the visible spectrum, as with snow, the albedo of the ice could be expected to increase at increasingly lower solar altitudes under clear skies (Liljequist, 1956, p. 88). The limited information available indicates that the albedo of ice similar to slush ice and snow ice in the visual spectral range is high but that this would not be the case for clear ice (Sauberer, 1938).

Coulson and Reynolds offer the following explanation for both the increase and the decrease:

> The reflectance of most surfaces appears to reach a maximum at sun elevations of 10-20°. This apparent reflection maximum, while not completely understood, is probably the result of a combination of two effects. First, observations show that most surfaces have a higher reflectance for light incident at a large zenith angle than for that at more nearly normal incidence. This would explain the decrease of reflectance with increasing sun elevation for the portion of the curve subsequent to the maximum. Second, the ratio of direct to diffuse light undergoes a rapid shift at low sun elevations. Obviously, the incident light is entirely diffuse when the sun is below the horizon, and since the major part of the diffuse flux is from zenith angles which are not large, the reflectance of the surface is relatively low at that time. This is shown by the curves. As the sun increases in elevation, the relative

contribution of diffuse light decreases with respect to direct light, and since the direct light is incident at a large angle, it is more strongly reflected than is the diffuse light. This explains the increasing reflectance observed at low sun elevations. Finally, the two opposing effects will just balance each other, thereby producing no change of reflectance, at some elevation of the sun. This point of maximum reflectance is seen by the curves to occur at a sun elevation of 10-20°.

Coulson and Reynolds' interstitial trap, diffuse vs. direct radiation explanation and Bolsenga's diffuse vs. direct radiation, spectral reflectance explanation are only in partial agreement. However, it is fair to speculate that soil and crop surfaces are influenced primarily by interstitial trap effects and secondarily by diffuse-direct and spectral effects. Smooth ice surfaces are influenced primarily by the diffuse-direct balance and spectral effects and only slightly by shading effects due to the lack of relief of such surfaces.

It also appears likely that shading has a greater effect on the albedo of any surface than the diffuse-direct balance and associated spectral effects. This conclusion was derived after examining the apparent conflict between the measurements of January 27 (figure 19), which seemingly show a rather large albedo increase with zenith angle, and all of the other measurements (particularly those of January 8-15). The increase of January 27 is the only case indicated by the measurements that compares favorably with the large soil increases noted by Idso et al. However, an analysis of the cloud patterns prevailing during the period of measurement on January 27 shows that the cloud regime changed from variable cloudy to nearly clear skies at a zenith angle of about 74". The albedo increase of about 6 percent at that time is probably due to the diffuse-direct radiation balance and associated spectral effects as influenced by cloud cover changes. If the albedo changes on January 27 can be considered as two separate regimes, before and after clear skies, one finds no ice albedo changes that can be compared to those noted in soils. The lack of variation in ice albedo might be explained by lack of shadowing. The weak dependence of ice albedo on solar altitude (as compared to the results reported by Idso *et al.*) noted in some data here is probably caused by variation in the spectral reflection as influenced by the diffuse-direct radiation balance. It thus appears that soil and crop albedo are strongly influenced by solar altitude, whereas ice albedo is only weakly influenced by comparison and that the major influence on soils and crops might well be shadowing effects. Clearly, much additional study with a larger data base is warranted.

4. CONCLUSIONS

Six days of albedo data collected from a variety of ice surfaces on an inland lake were processed to determine solar altitude effects on ice albedo. When albedo values were plotted against zenith angle, the data failed to produce the smooth curves presented by Idso *et al.* (1975). The principal reason for the lack of agreement is that measurements for the studies by Idso *et al.* were all taken over one surface where shading effects occurred due to individual agglomerates, whereas these measurements were from various smooth surfaces with little shading effects. If the measurements are taken over the same ice surface, possible variations in the physical properties of the surface from day to day also tend to cloud comparability. The ice measurements showed characteristics more similar to those of blacktop than to those of soils or vegetation as measured by Coulson and Reynolds (1971). The differences are attributed to the flat and impervious nature of the ice as opposed to crops, soils, and undercut snow surfaces. Physical reasons for the soil-crop vs. ice differences in albedo behavior at low solar altitudes include surface geometry, direct-diffuse radiation balance, and spectral balance of the radiation.

Future studies on ice should include a lengthy series of measurements over a single ice surface. However, the results of this study emphasize that each series of measurements would be site specific. Separate curves would be necessary to represent the various ice types, such as pancake ice, ball ice, snow ice, etc. The same situation is likely with different soil and crop surfaces. Certain ice types such as brash ice would closely approximate soil conditions, but would require separate measurements for each individual field because of the orientation of individual ice blocks. Considerable additional work is needed to understand these phenomena.

5. REFERENCES

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APPENDIX

COMPUTER PROGRAM FOR

PROCESSING ALBEDO DATA

```
      PROGRAM ALBEDO(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT,TAPE2)
C     INITILIZATION OF ALL VARIABLES
      INTEGER V,DATE
      DIMENSION SA(1000),TST(1000),AL(1000),H(1000),ZAL(1000),IADE(1000)
     1,R(1000),X(1000),M(1000),V(1000),K(1000),L(1000),RR(1000),RX(1000)
      DIMENSION SSA(6000),ALL(6000)
      REAL LAT,LST,LMT,LON,MIN,NIM
      IZ= 0
      SM=75.
      YM=83.717
      LAT=42.3
      COR=4*(SM-YM)
      COR=COR/60
      DEG=57.29577958
      RAD=.017453293
      LAT=LAT*RAD
      CALL INITT(960)
      READ(5,102) ISWTCH
  102 FORMAT(I5)
      DO 11 II=1,50
      XA = 0.
      RR = 0.
C     READ IN THE DECLINATION(A,B,C),E(F+G),THE TIME CORRECTION
C     FACTOR, AND THE DATE OF THE OBSERVATION.
      READ(5,100)A,B,C,F,G,O,DATE,ZEG,MIN,GED,NIM
      IF(EOF(5))99,1
    1 CONTINUE
C     CONVERT DECLINATION IN DECREES,MIN., AND SEC. TO DECIMAL DEGREES
      AK = 1.
      IF (A.LT.0.)AK=(-1.)
      A = A*AK
      D =A+B/60+C/3600
      D =D*AK
C     SIMILARLY CONVERT THE TIME INTO DECIMAL HOURS.
      LAT = ZEG+MIN/60.
      LON=GED+NIM/60.
      COR = (4.*(SM-LON))/60.
      LAT = LAT*RAD
```

```
      FK = 1.
      IF(F.LT.0.)FK=(-1)
      F=F*FK
      E =F+G/60
      E=E/60.
      E = E*FK
C     CONVERT DECLINATION TO RADIANS
      D = D*RAD
C     OUTPUT HERDERS
      WRITE(6,202) DATE
      WRITE(6,201)
C     READ IN THE DATA
      N=0
      J = 0
      ISTART = 1
      DO 10 KK=1,1000
      J = J+1
      READ(5,101)S,T,R(J),X(J),RA,XA,IDX
C     S = HOURS
C     T = MINUTES
C     R = REFLECTED
C     X = INCIDENT
C     IDX IS AN INDICATOR THAT NO DATA FOLLOWS
    2 IF(IDX.GT.0)CO TO 9
      IF(X(J).EQ.0.)GO TO 20
      GO TO 30
   20 CONTINUE
      IJ = 0
      IC = N-ISTART+1
      XA = XA/IC
      RA = RA/IC
      DO 40 IA=ISTART,N
      IJ =IJ+1
      X(IX) = X(IX)-(IJ*XA)
      R(IX) = R(IX)-(IJ*RA)
      RR(IX) = R(IX)/7.01
      RX(IX) = X(IX)/6.01
      AL(IX) = RR(IX)/RX(IX)
```

```
      ZAL(IX) = AL(IX)
   40 CONTINUE
      ISTART=N+1
      J = J-1
      GO TO 10
   30 CONTINUE
C     COUNT THE NUMBER OF OBSERVATIONS AT THIS STATION
      N=N+1
C     CORRECT THE TIME
      T=T+0
C     CONVERT LOCAL STANDARD TIME TO DECIMAL HOURS
      LST=S+T/60
C     CALCULATE TRUE SOLAR TIME
      TST(J)=LST+COR+E
C     CALCULATE THE HOUR ANGLE OF THE SUN
      H(J) = (TST(J)-12.)*15.*RAD
C     CALCULATE SOLAR ALTITUDE
      SAA=SIN(LAT)*SIN(D)+COS(LAT)*COS(D)*COS(H(J))
      SA(J)=ASIN(SAA)
C     CALCULATE REFLECTED AND INCIDENT RADIATION
      RR(J)=R(J)/7.01
      RX(J)=X(J)/60.
C     CALCULATE ALBEDO
      AL(J) = RR(J)/RX(J)
      ZAL(J)= AL(J)
C     CONVERT LOCAL STANDARD TIME AND TRUE SOLAR TIME TO HOURS & MINUTES
      M(J) = TST(J)
      V(J) = (60*(TST(J)-M(J))+.5)
      K(J) = LST
      L(J)= (60*(LST-K(J))+.5)
C     CONVERT SOLAR ANGLE FROM RADIANS TO DEGREES
      SA(J)=SA(J)*DEG
C     AS WELL AS THE HOUR ANGLE
      H(J) = H(J)*DEG
   10 CONTINUE
C     OUTPUT ALL DATA IN TABULAR FORM
    9 DO 50 IO=1,N
      AL(IO)=ALOG(AL(IO))
      WRITE (6,200) M(IO),V(IO),K(IO),L(IO),R(IO),RR(IO),X(IO),RX(IO),AL
```

```
     1(IO),SA(IO),H(IO)
   50 CONTINUE
C
C      NOW THAT ALL OBSERVATIONS FROM ONE DATE ARE TABULATED, ENTER
C      PLOTTING SECTION OF THE PROGRAM
       DO 300 I=1,N
       IZ = IZ+1
       SSA(IZ) = 90.-SA(I)
  300  ALL(IZ) = AL(I)
       CALL BINITT
C      HEADER LABEL FOR EACH PLOT
       KLM=DATE
       CALL KAM2AS(10,KLM,IADE)
       GO TO (3,0,330,310,305)ISWTCH
  305  CONTINUE
       CALL NOTATE(120,0,10,IADE)
C      CONVERT ARRAYS TO STANDARD FORM FOR THE PLOTTING PACKAGE
       CALL MPTS(AL,N)
       CALL MPTS(TST,N)
C      POINT PLOT
       CALL LINE(-4)
C      TRIANGLES FOR SYMBOLS
       CALL SYMBL(3)
C      AT THREE TENTHS NORMAL SIZE
       CALL SIZES(.3)
C      ESTABLISH THE LIMITS OF THE Y AXIS SO THAT THEY ARE CONSISTENT
       CALL DLIMY(0.,.80)
C      SIMILARLY,THE X AXIS
       CALL DLIMX(6,20)
C      PLOT THE ARRAYS...ALBEDO VS .TRUE SOLAR TIME
       CALL CHECK(TST,AL)
       CALL DSPLAY(TST,AL)
C      GET HARDCOPY
       CALL HDCOPY
C      ERASE THE SCREEN
       CALL NEWPAG
C      PUT ARRAYS BACK INTO THEIR ORIGINAL FORM
       CALL FINITT(0,767)
       CALL UPTS(AL,N)
```

```
      GO TO 330
  310 CONTINUE
      DO 320 I=1,N
  320 SA(I)=90.-SA(I)
C     SORT THE DATA
      CALL BSORT(SA,AL,N)
C     PREPARE FOR THE SECOND PLOT
      CALL BINITT
C     TITLE..
      CALL NOTATE(120,0,10,IADE )
C     ETC.
      CALL LINE(-4)
      CALL SYMBL( 3 )
      CALL SIZES( .3)
      CALL MPTS(SA,N)
      CALL MPTS(AL,N)
      CALL DLIMY(-2.50,-0.20)
      CALL DLIMX(50.,90.)
C     PLOT ALBEDO VS. ZENITH ANGLE
      CALL CHECK(SA,AL)
      CALL DSPLAY(SA,AL)
C          ETC..
      CALL HDCOPY
      CALL NEUPRC
      GO TO 330
      CALL BINITT
      CALL NOTATE( 120,0, 10, IADE )
      CALL LINE(-4)
      CALL SYMBL( 3)
      CALL SIZES( .3)
      CALL MPTS(H,N)
      CALL MPTS(ZAL,N)
      CALL DLIMY(0., .80)
      CALL DLIMX(-90.,90.)
      CALL XWDTH( 3)
      CALL XNEAT( 0)
      CALL XTICS(6)
      CALL CHECK(H ,ZAL)
      CALL DSPLAY(H ,ZAL)
```


A

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      CALL HDCOPY
      ENDFILE 2
      CALL NEWPAG
C     GO BACK UP AND INITIATE THE NEXT DAYS DATA
  330 CONTINUE
   11 CONTINUE
   99 CONTINUE
      GO TO(340,335,335,340),ISWTCH
  335 CONTINUE
      CALL BINITT
      CALL LINE(-4)
      CALL SYMBL(3)
      CALL SIZES(.3)
      CALL BSORT(SSA,ALL,IZ)
      CALL MPTS(SSA,IZ)
      CALL MPTS(ALL,IZ)
      CALL DLIMY(0.,.80)
      CALL DLIMX(50.,90.)
      CALL CHECK(SSA,ALL)
      CALL DSPLAY(SSA,ALL)
      CALL HDCOPY
  340 CONTINUE
      CALL DONEPL
      STOP
  100 FORMAT(3F3.0,F4.0,F5.0,F3.0,7X,A10,1X,4F3.0)
  101 FORMAT(2F2.0,2F6.0,F4.2,1X,F4.2,54X,I1)
  200 FORMAT(2(5X,I2,':',I2),7F14.4)
  201 FORMAT('          TST          LST          RAW REF.     RED. REF.        RAW
     1INC.      RED. INC.          ALBEDO      SOL.ALT.            H',/,118('-
     2'))
  202 FORMAT('1',10X,A10)
      END
```