# Western Region Technical Attachment
## No. 89-12
## April 25, 1989

# POLAR-ORBITING SATELLITE IMAGES AVAILABLE ON SWIS

Satellite imagery is one of the most important tools available to operational weather forecasters. The imagery supplements surface and upper air observations and can provide essential information over data-sparse regions. The geostationary satellites; i.e., GOES, GMS, and Meteosat are especially useful since weather can be monitored as it evolves over one particular area. The Satellite Weather Information System (SWIS) is designed primarily to receive, store, display, and loop GOES imagery. In the Western Region, SWIS receives this imagery from the Satellite Field Services Station (SFSS) in San Francisco (SFO). However, the SFSS in San Francisco also transmits polar-orbiting satellite images which can be received and displayed on SWIS. It is important to be aware of this additional satellite imagery, especially since there is currently only one operational GOES satellite (GOES Central). In the event that GOES Central might become temporarily inoperative, the polar-orbiter images would become extremely valuable.

Currently, there are two basic types of polar-orbiter images: composite images from the NOAA-9 satellite, and single, high resolution images from the Advanced Very High Resolution Radiometer (AVHRR) on the NOAA-10 and NOAA-11 satellites. Though both types have their advantages and disadvantages, neither can compare to the GOES imagery in terms of their practical use as a primary forecasting tool. However, polar-orbiter images could be a valuable supplement to the GOES imagery, depending on the situation, and would be a necessary tool if GOES data were not available. In a 1982 Western Region Technical Attachment (NOAA, 1982), some general information was presented about images available from the only NOAA polar-orbiting satellite in operation at the time, NOAA-7. This paper serves as an update to the 1982 report and, in addition, focuses on the options for viewing the images on SWIS.

## Composites

Composite images are constructed from several successive orbits of the NOAA-9 polar-orbiting satellite over a total period of a few hours (each orbit takes 100 minutes). There are several different types of composite images available from the SFO SFSS throughout each day. Many of these images cover parts of the Earth either unseen by GOES, i.e., Europe and Asia, or covered poorly by GOES (for example, the North Pacific). Some of the composites are polar stereographic projections (generally high latitudes) and some are mercator projections (low latitudes). The composites are either visible images, day infrared (DIR), or night infrared (NIR); there is no difference in the viewing channel between the DIR and

NIR images. Like the GOES images, the composites are gridded with latitude/longitude lines and geographic land/sea boundaries, and an identifying header is included.

There are some significant disadvantages with the polar-orbiter composite images. Since the composites are made up of several images from successive orbits, different parts of the image are valid at different times. Typically, composites cover a four to sever hour time interval. Therefore, a significant portion of each composite image will always be a few hours old, which means it may not be particularly useful in many situations. The resolution of the composites is also quite poor - about 20 miles - which makes it difficult to discern small scale features.

The schedule of composites available from the SFO SFSS is shown in Table 1, which includes a brief description of the image location for each transmission time. All composites are available on dialcode (DC)20 at the listed transmission times. Since switching to a different line would interrupt the transmission of GOES images, the forecaster would need to determine the relative importance of the polar image, given the situation.

Figure 1 is an example of a Northwest Pacific Quad Night-IR composite image (product I.D. PNRD), which is a polar stereographic projection. The Bering Sea is in the lower-right corner of the figure (where the highest latitudes are). This composite covers a period of five hours, from 1400 to 1900 GMT, and is constructed with images from successive NOAA-9 orbits. The poor resolution makes it difficult to interpret, but a synoptic scale low can be seen centered near 45N/172W and there also appears to be a ridge axis around 160 or 165E, evident by the cirrus pattern. The major features are fairly obvious.

Figure 2 is another Night IR composite image. In this case, it is a Mercator projection covering the Eastern Pacific (product I.D. MNRH). Note the Hawaiian Islands near the center of the image at 20N (shown by the white arrow). Even though the resolution is poor, a frontal band/baroclinic zone can be seen in the subtropical clouds northwest of Hawaii with a stratocumulus field well behind it.

## AVHRRs

The high resolution images are obtained from the NOAA-10 and NOAA-11 polar-orbiting satellites. The AVHRR samples five image channels, two in the visible part of the spectrum and three in the IR. Channel 1 is comparable to the GOES visible channel, channel 2 is a near-IR channel good for locating water bodies and vegetation assessment, channel 3 is in the IR and is good for forest-fire monitoring, channel 4 and channel 5 are IR channels used mainly for weather and sea-surface temperatures. If the image is obtained over a region in daylight, then channels 1, 2, and 4 are stored and processed at the SFSS (therefore, visible and IR depictions of the same image are both available). When there is not enough daylight, channels 3, 4, and 5 are stored at the SFSS, but only channel 4 is processed and available for transmission to SWIS. The resolution of all the images is 1 km at nadir, directly beneath the satellite), and slightly larger than 1 km toward the outer edges of the image.

The AVHRR images are only transmitted four times a day, but are relatively current (transmitted 30-90 minutes after the scan begins). The major problem with these images when they are displayed on SWIS is that they lack a header code and a grid overlay. Therefore, the exact time the picture was taken is unknown, and the only way to determine the location of a cloud feature on the image is by identifying nearby land or coastline features. Since there is no header code, these images will be stored in the SWIS message file.

Another problem with the AVHRR images, which limits their application to forecasting, is the schedule. Even though the transmission times are the same every day, the actual time the image was taken and its location change slightly from day to day. The only way to determine the location of an image for a given transmission time before it is received is by using a NOAA polar-orbiting satellite tracking chart (only available at WSFO SFO at the time of this writing), along with an up-to-date transmission schedule for the NOAA-10 and NOAA-11 satellite orbits, which is available on AFOS under the product identifier SFOSODSFO. The transmission schedule is sent out about once a week and covers a one-week period. We hope to make polar-orbiting satellite tracking charts available to the WSFOs in the Western Region before the end of the year.

Figure 3 is a transmission schedule for March 16-22, 1989, and Figures 4a and 4b are examples showing how the tracking chart is used along with the schedule. AVHRR images are transmitted on DC23 at 0429Z, 1129Z, 1659Z, and 2229Z each day. It is important to note that these images are 2650 lines long. Therefore, since SWIS can only display 1365 lines, they are cut off about half way through the image. It is possible, though, to specify a starting line number on SWIS before the image comes in so that the desired portion of the image is displayed. Images are also transmitted on DC24 at 0429Z, 1129Z, and 0129Z. These are special sectors (used by the SFO SFSS) of the full images transmitted on DC23 at 0429, 1129, and 2229Z, respectively. These images are only 1325 lines long and so can be completely displayed on SWIS; however, since they are <u>sectors</u> of the full images, they do not cover any new areas.

The solid circle centered over San Francisco in Figures 4a and 4b is the region within which the signal from the satellite is sufficiently strong at the SFSS so that quality images are received. Each of the two satellites ascends (meaning from south to north) over this region once a day, and descends (north to south) over the region once a day, for a total of four passes per day. The transmission schedule lists the location that each satellite crosses over the equator (from the southern to northern hemisphere) for each transmission time. If the satellite passes northward over the equator in the western hemisphere, then it will be <u>ascending</u> over San Francisco's region, if it crosses northward over the equator in the eastern hemisphere, then it will be <u>descending</u> over the region. Therefore, the image transmitted at 1659Z every day will come from the NOAA-10 polar orbiter as it descends over the region where its signal is clearly received by San Francisco. The transmission schedule shows that the equator crossing, and therefore the exact location of the track, changes slightly every day. The image itself will start at exactly 53N and end at about 27N if the satellite is descending, and will be displayed right side up; if the satellite is ascending then the image will start at exactly 27N and end at about 53N, and will be displayed upside-down.

The example in Figure 4a is the satellite track of NOAA-11 for the transmission time of 1129Z on March 17, 1989 (circled on the transmission schedule in Figure 3 with the letter 'a' next to it). The schedule indicates that the satellite crosses over the equator at 72.5E for this pass. The moveable satellite path on the tracker is rotated so that the ascending side is directly over this longitude (upper-right part of the figure). The line with tick marks represents the track of the satellite while the solid lines on either side of it define the width of the image. Notice that the satellite descends over the western U.S., crossing out over the Pacific at the Baja Peninsula. The area covered by the image is shown roughly by the hatched shading within the dark solid lines.

The example in Figure 4b is the track of NOAA-11 for the 2229Z transmission on March 17. Shown by the circle labeled 'b' in Figure 3, it crosses the equator at 106.2W. Upon rotating the track into position, the satellite would ascend over the Baja Peninsula and then leave the U.S. over eastern Washington State. This image would be displayed upside-down with the top beginning at roughly 27N. The approximate area of the entire image is shown by the hatched region, as in Figure 4a.

Without the tracking chart, determining the location of an image for a given transmission time is very difficult. Until tracking charts are made available to the forecast offices, a forecaster would need to call WSFO SFO/SFSS (the number is listed below the transmission schedule) if he or she wanted to know the coordinates of the image before having it transmitted to their SWIS.

Two examples of AVHRR images are shown in Figures 5 and 6. Figure 5 was transmitted at 2229Z, March 15, 1989 on DC23. Therefore, it was taken by NOAA-11 in its ascending mode as it passed over the western U.S. coast, and was displayed on SWIS upside-down. Since this pass occurs during daylight, a visible image was transmitted as well as an enhanced IR image (IR image not shown). Notice also that the image started at 27N over the Baja Peninsula (bottom of the figure) but cut off around 44N, just north of the Great Salt Lake; the full image would continue up the coast to just north of Vancouver Island. In order to see the north part of the image, the starting line number on SWIS would need to be specified before transmission time.

The clarity of the images is much better on the SWIS screen than Figure 5 suggests; nevertheless, there are several features that show up quite clearly. The white band just east of the Great Salt Lake (upper-right corner) is snow cover along the Wasatch Range in Utah. Another north-south band of snow can be seen along the Sierra-Nevada Range in California. High clouds extend from the southern end of this snow band to the east over Arizona. Bands of low stratus can be seen along the California coast in the San Francisco Bay area. Because of the general lack of cloud cover in Figure 5, it is easy to identify land features and thus determine the locations of clouds. Under different circumstances it might be more difficult.

Figure 6 is an unenhanced IR image transmitted at 1659Z on March 22, 1989 (also on DC23) and is therefore from NOAA-10 in descending mode. A visible image is also available for transmission at this time, although some of the northwest portion of the image may be in darkness (a larger portion in the winter). Because of the extensive low-cloud cover and the fact that the image is in the IR, it is more difficult to find land or coastline features. In this case, it helps to compare the image with GOES images, if possible. The arrow on the bottom, right hand side of the figure points to the central California coast, the dark area just to the right of that is the northern tip of the Sacramento Valley. Mid- to high-level clouds produced by lifting over the Washington Cascades can be seen near the upper right hand portion of the image (marked by the white arrow). A field of stratus and stratocumulus dominates the upper-left third of the image and covers up the northwest U.S. and British Columbia coastline. The pattern in the stratus field shows that there is northwest flow curving cyclonically onto the coast. Although it is hard to tell, the image begins at 53N and cuts off near 40N, again only about half of the full image. As with Figure 5, the image on the SWIS screen was a lot sharper than in this figure. With the satellite tracking chart, it is possible to very closely determine the location of an image, even if cloud cover makes it impossible to find any land or coastline features.

## Summary

Even though the polar-orbiter composite images and the AVHRR images can be valuable supplements to the GOES images, their disadvantages make them far less practical for regular use as a forecasting tool. Neither type of polar-orbiter image can be looped like the GOES images. The poor resolution of the composites makes it difficult to see any detail, and the long delay between the creation of the composite image and its transmission limits their operational use. The absence of a header code and grid overlay on the AVHRR images makes it difficult to pinpoint the time and location, and with only four images per day there are large gaps within which important changes could be taking place, therefore limiting their usefulness as well. The absence of a header code means that the AVHRRs are stored in the SWIS message file, which is not allocated very much space.

On the other hand, the composite images cover some regions where GOES and other geostationary satellites do not "see" as well, and therefore provide information from new areas where significant synoptic developments might be occurring. The AVHRR images provide a detailed look, and from a different angle, of the same areas covered by GOES, and so may reveal small-scale features unnoticed on a GOES image.

The important point is that there *is* other satellite imagery available on SWIS in the Western Region to supplement the GOES and other geostationary satellite images. The polar-orbiting satellite images would be a necessary operational tool for forecasters if the GOES images were ever to become unavailable.

## References

NOAA, 1982: A Review of Polar-Orbiting Satellite Imagery Available from NESS/SFO. Western Region Technical Attachment No. 82-51, Dec. 7, 1982.

AFOS Handbook 2, Operator's Manual, Volume 6, "SWIS Operator's Handbook", Alden Electronics.

NESDIS Programs - NOAA Satellite Operations, National Environmental Satellite, Data, and Information Service, 1985

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Ernest Daghir and Bill Aldridge, WSFO San Francisco/SFSS

WSFO Salt Lake City

# Schedule of NOAA-9 Composites

| Product ID | Time(GMT) | Location | Projection | Image Type |
|---|---|---|---|---|
| MNRI | 0100 | W. Pacific | Merc. | Night IR (NIR) |
| PNRD | 0130 | NW Pacific Quad | P.S. | NIR |
| MVSB | 0200 | Caribbean/Amer. | Merc. | Visible |
| MDRB | 0430 | Carib/Amer | Merc. | Day IR (DIR) |
| MVSC | 0530 | E. Pacific | Merc. | Vis |
| MNRJ | 0630 | Indian Ocean | Merc. | NIR |
| PVSO | 0700 | NE Pacific Quad | P.S. | Vis |
| PNRZ | 1130 | S. Atlantic | P.S. | NIR |
| MVSD | 1330 | W. Pacific | Merc. | Vis |
| PDRP | 1400 | NW Pacific Quad | P.S. | DIR |
| MDRE | 1830 | Indian Ocean | Merc. | DIR |
| MNRG | 1900 | Carib/Amer | Merc. | NIR |
| MNRH | 2130 | E. Pacific | Merc. | NIR |
| MVSA | 2200 | E. Atlantic | Merc. | Vis |
| PNRC | 2230 | NE Pacific Quad | P.S. | NIR |
| PDRR | 2300 | Europe/M.East Quad | P.S. | DIR |

(All available on DC20)

**Table 1**

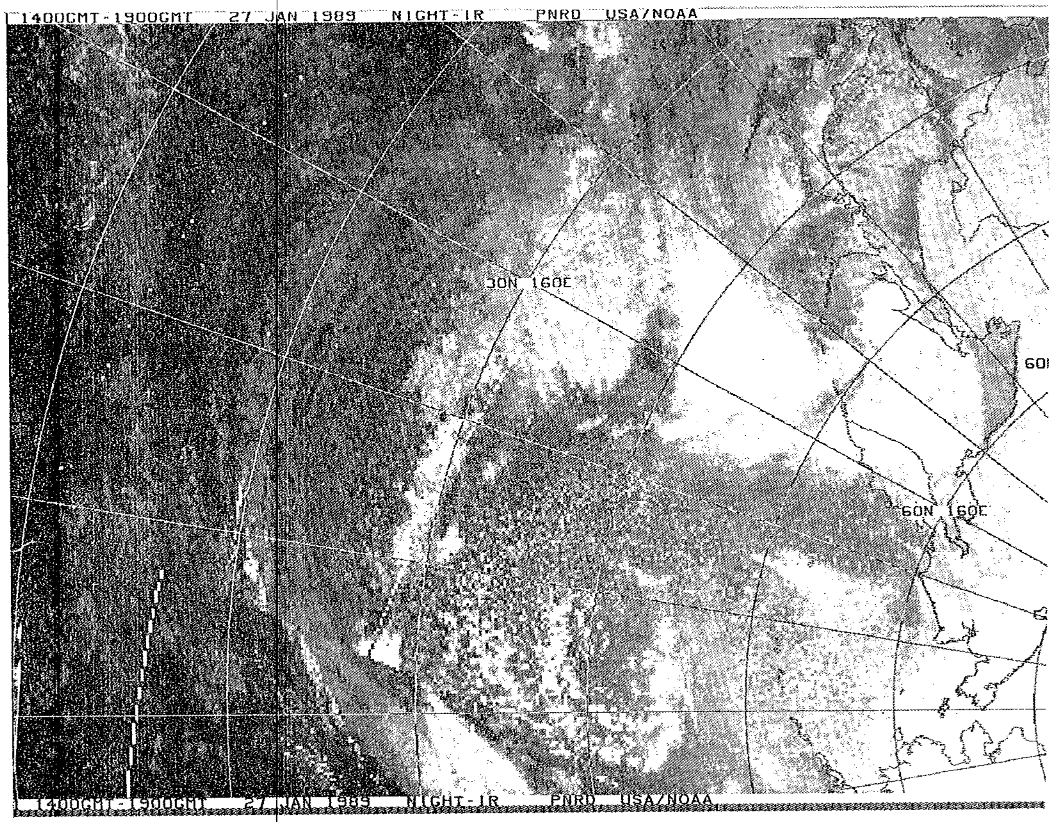


**Figure 1** Night IR composite image of the Northwest Pacific Quad (Polar Stereographic projection). Valid 1400Z - 1900Z, 27 Jan 1989. The Bering Sea is in the lower-right corner.

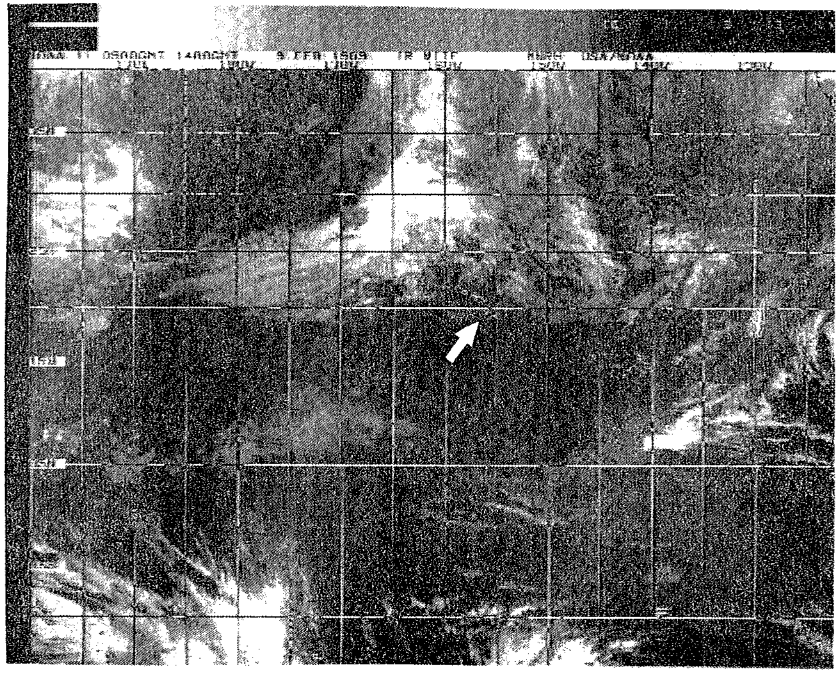
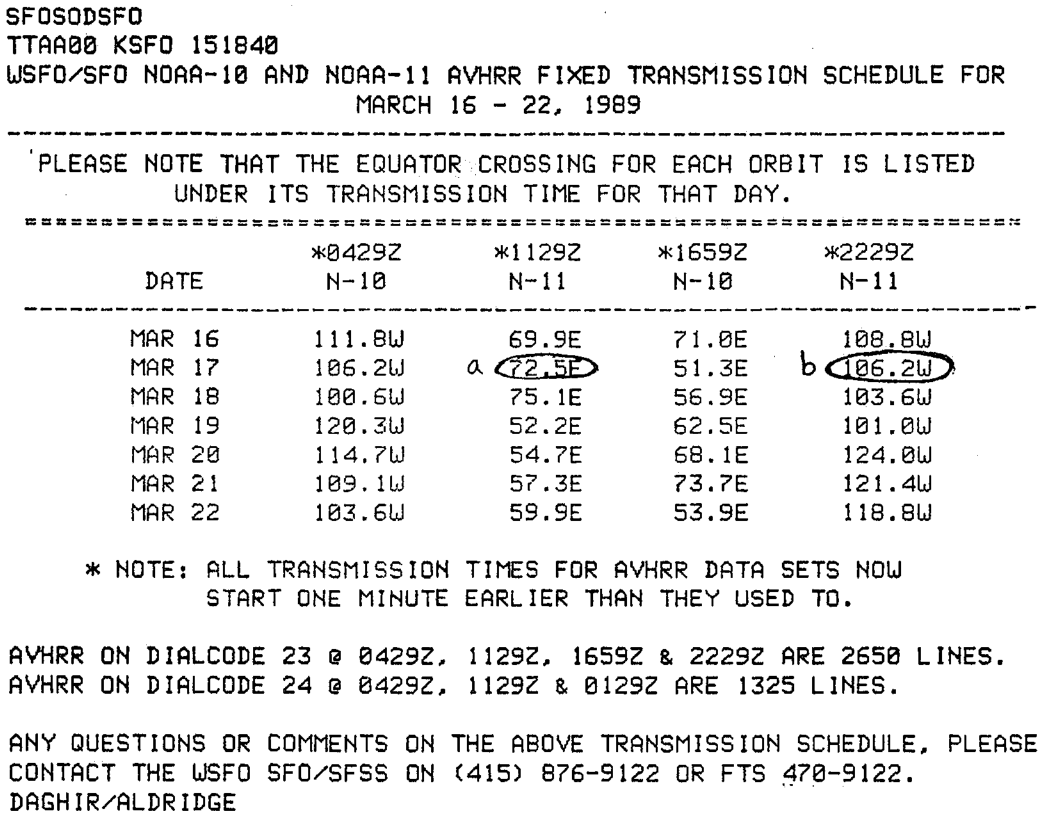


**Figure 2** Night IR composite image of the Eastern Pacific (Mercator projection). Valid 0900Z - 1400Z, 9 Feb 1989. The white arrow points to Hawaii.



SFOSODSFO
TTAA00 KSFO 151840
WSFO/SFO NOAA-10 AND NOAA-11 AVHRR FIXED TRANSMISSION SCHEDULE FOR
MARCH 16 - 22, 1989

PLEASE NOTE THAT THE EQUATOR CROSSING FOR EACH ORBIT IS LISTED UNDER ITS TRANSMISSION TIME FOR THAT DAY.

| DATE | *0429Z<br>N-10 | *1129Z<br>N-11 | *1659Z<br>N-10 | *2229Z<br>N-11 |
|---|---|---|---|---|
| MAR 16 | 111.8W | 69.9E | 71.0E | 108.8W |
| MAR 17 | 106.2W | a 72.5E | 51.3E | b 106.2W |
| MAR 18 | 100.6W | 75.1E | 56.9E | 103.6W |
| MAR 19 | 120.3W | 52.2E | 62.5E | 101.0W |
| MAR 20 | 114.7W | 54.7E | 68.1E | 124.0W |
| MAR 21 | 109.1W | 57.3E | 73.7E | 121.4W |
| MAR 22 | 103.6W | 59.9E | 53.9E | 118.8W |

* NOTE: ALL TRANSMISSION TIMES FOR AVHRR DATA SETS NOW START ONE MINUTE EARLIER THAN THEY USED TO.

AVHRR ON DIALCODE 23 @ 0429Z, 1129Z, 1659Z & 2229Z ARE 2650 LINES.
AVHRR ON DIALCODE 24 @ 0429Z, 1129Z & 0129Z ARE 1325 LINES.

ANY QUESTIONS OR COMMENTS ON THE ABOVE TRANSMISSION SCHEDULE, PLEASE CONTACT THE WSFO SFO/SFSS ON (415) 876-9122 OR FTS 470-9122.
DAGHIR/ALDRIDGE

**Figure 3** Transmission schedule for AVHRR images, for the week of Mar. 16-22, 1989. There are two transmissions from the NOAA-10 satellite and two from NOAA-11 per day. The longitude given under each transmission time is the location the satellite crosses the equator moving from south to north. The circled longitudes labeled 'a' and 'b' refer to examples shown in Figs 4a and 4b, respectively.

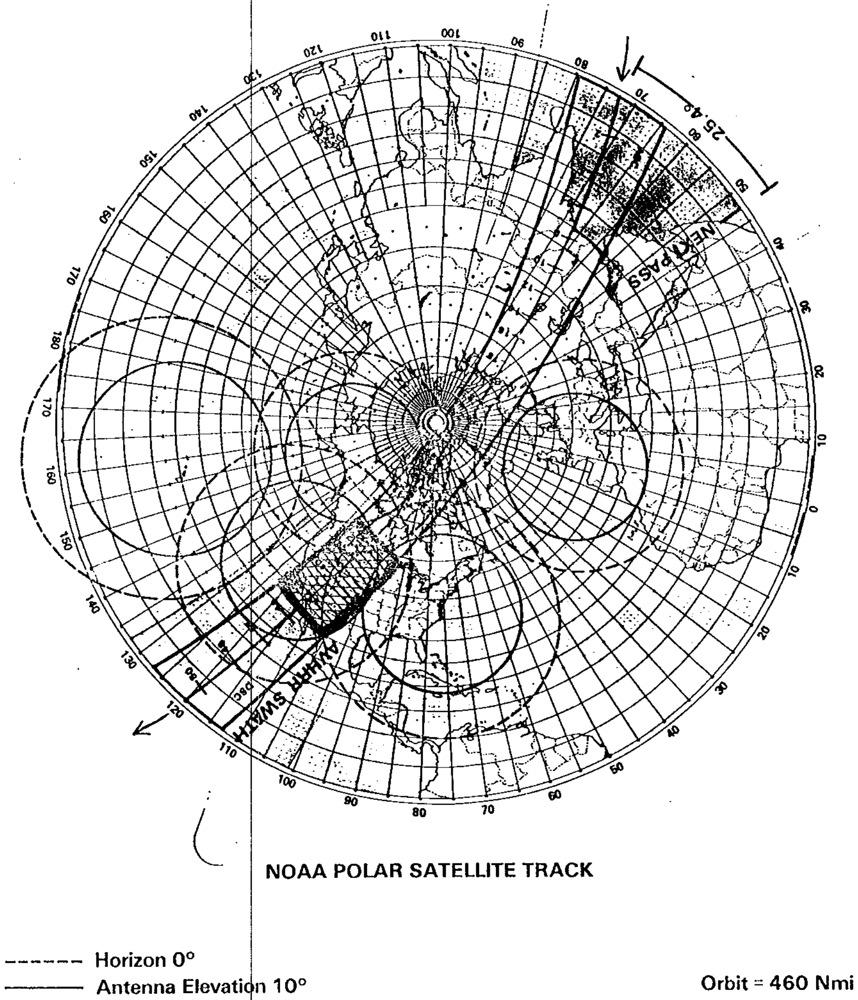


**Figure 4a** Example showing the satellite track of the 1129Z transmission on Mar. 17, 1989 (see Fig. 3). The satellite crosses the equator at 72.5E moving northward, then descends over the Western U.S. where the image is taken. Arrows on either end of the track show the direction of the satellite track, and the dark box with the hatched shading defines the area covered by the full image. The solid circle centered over San Francisco is the region within which the signal from the satellite can be received.

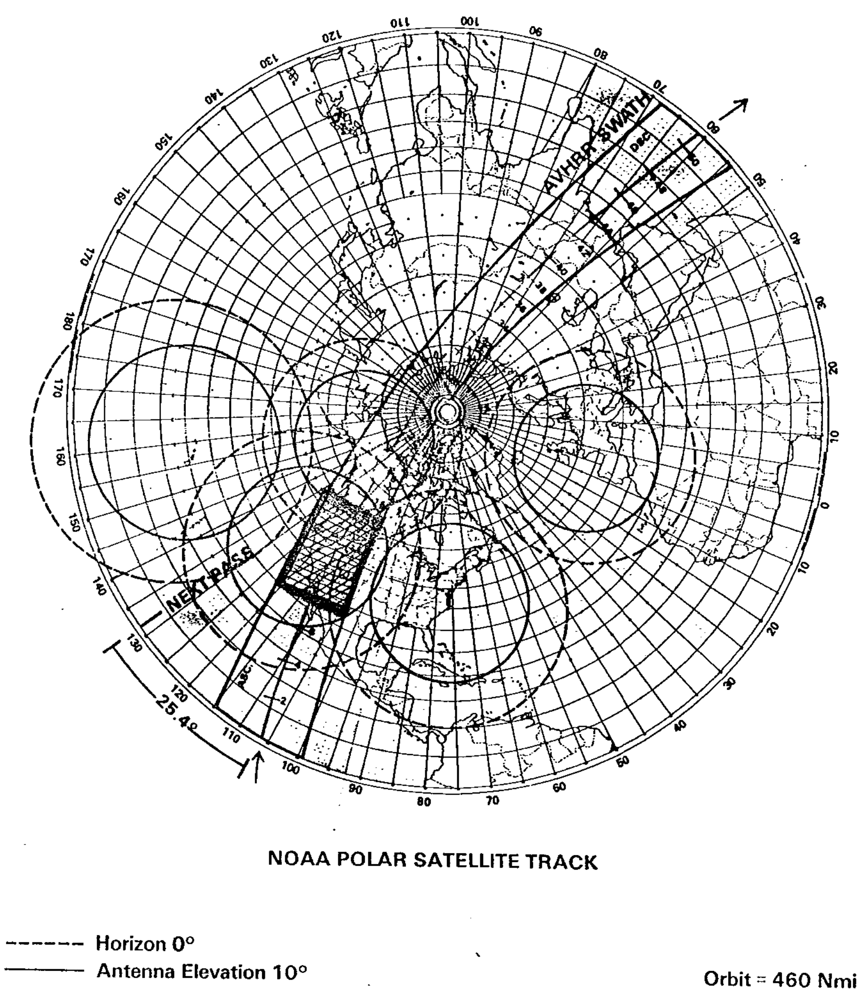


**Figure 4b** Same as Fig. 4b, but for the 2229Z transmission on Mar. 17, 1989 (see Fig. 3). The track crosses the equator at 106.2W and ascends over the Western U.S. (where the image is taken) before descending over Asia. Again, the arrows show the direction of the track, and the dark box shows the full image region.

**Figure 5** AVHRR visible image transmitted at 2229Z on March 15, 1989. The image shown is the portion of the full image displayed on SWIS (only the southern half in this case). The California coastline and the Great Salt Lake are the two most distinct features which help to determine the location and orientation of the image.

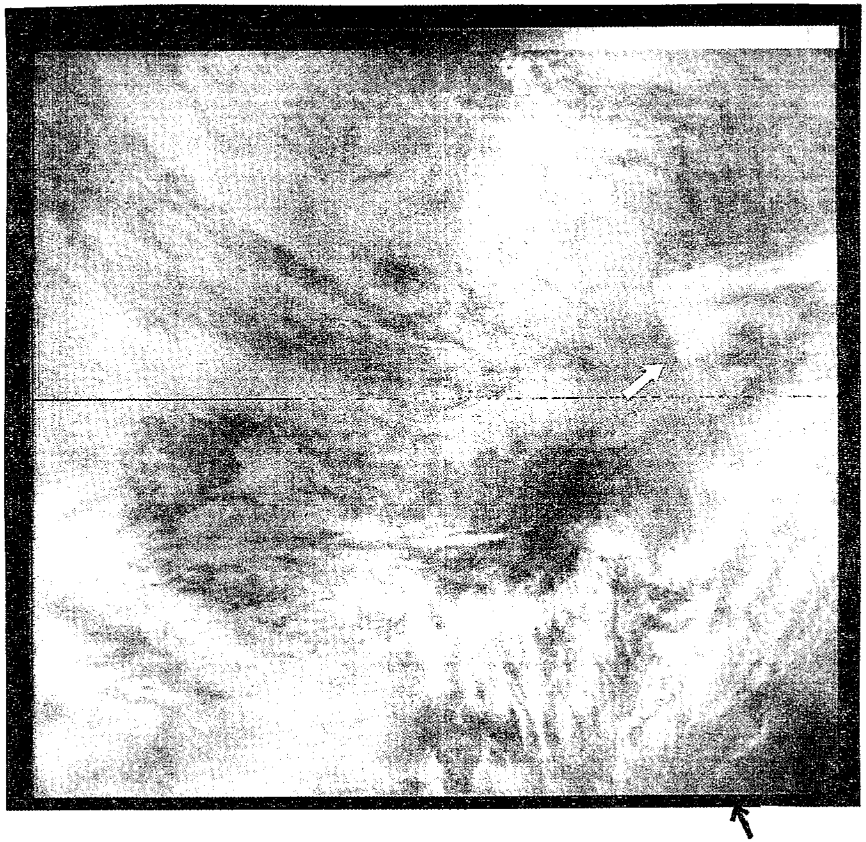


**Figure 6** AVHRR IR image transmitted at 1659Z on March 22, 1989. As in Fig. 5, this is only a portion of the full image (the northern half in this case). The extensive low cloud cover makes it difficult to distinguish any land features. The black arrow points to the north central Calif. coast, and the white arrow points to mid to high-level clouds produced by lifting over the Washington Cascades.