

VHRR - A New Environmental Data Source for Alaska

This article has been edited, in part, from reports from the other members of the VHRR Alaska Pilot Project team, viz. Drs. K.O.L.F. Jayaweera and Gerd Wendler of the Geophysical Institute, Dr. Robert Carlson and Mr. Richard Seifert of the Institute of Water Resources, and Dr. Robin Muench and Miss Kristina Ahlms of the Institute of Marine Science, University of Alaska.

The Satellite and the Alaska Pilot Project

The National Oceanic and Atmospheric Administration's NOAA2 satellite, put into orbit in 1972, and NOAA3, orbited in 1973, represent a new concept in the satellites launched by the National Environmental Satellite Service (NESS). The NOAA2/3 has among its sensors the new Very High Resolution Radiometer (VHRR). This instrument scans the earth's surface in both the visible range (0.6 to 0.7 micron) and in the thermal infra-red range (10.5 to 12.5 microns) and has a resolution of one kilometer at the earth's surface directly below the satellite. The satellite is in polar orbit and is sun synchronous, that is, it passes the equator at local noon and local midnight. The satellite is at an altitude of 790 ± 25 nautical miles (1464 ± 46 km) above the earth's surface and circles the earth each 115.14 minutes.

In the United States, the data from the satellite is currently read out only at Wallops Island, Virginia, San Francisco and Gilmore Creek near Fairbanks, Alaska. As there is only a very limited on-board storage capability, the data — for the most part — must be read out close to the region from which it is derived. Thus, for Alaska, the maximum read out capability at Gilmore Creek covers only the region shown in Figure 1. Figure 2 shows an example of the primary (unenlarged) data in the thermal infra-red range for January 17, 1973. One can see

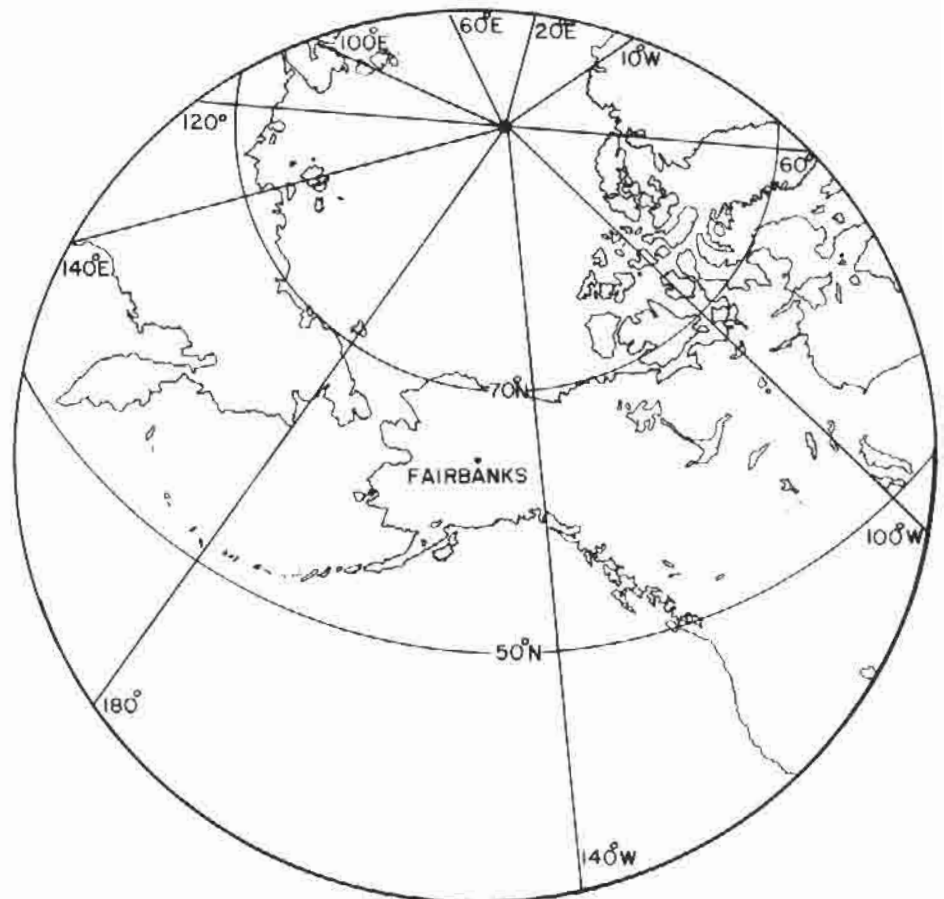


FIGURE 1. Maximum region covered by read-out of VHRR data from the NOAA2 Satellite at Gilmore Creek near Fairbanks.

that the whole state of Alaska is clearly imaged at a time when conventional satellite photography would have been of very poor quality due to the winter darkness.

NOAA2/3 provides both high and low resolution visible and infra-red imagery for purely broad scale meteorological analysis and its improved VHRR resolution permits more detailed examination of meso-scaled meteorological phenomena and earth surface features. In this respect it resembles the Earth Resources Technology Satellite, though ERTS provides multi-spectral data in the visible and near-visible ranges. However, although

NOAA2/3 has a much lower resolution (1 km compared with 100 m for ERTS), it has a much more frequent coverage. At high latitudes, because of the polar orbits and the convergence of longitude lines toward the poles, both ERTS and NOAA2/3 are able to give better coverage over the same region than is obtained from other satellites. However, as NOAA2/3 may include several passes each day over the same area, it is operationally much more useful than ERTS which, after four consecutive days of coverage, may have as many as 14 days with no data.

Under a grant from NESS, an inter-

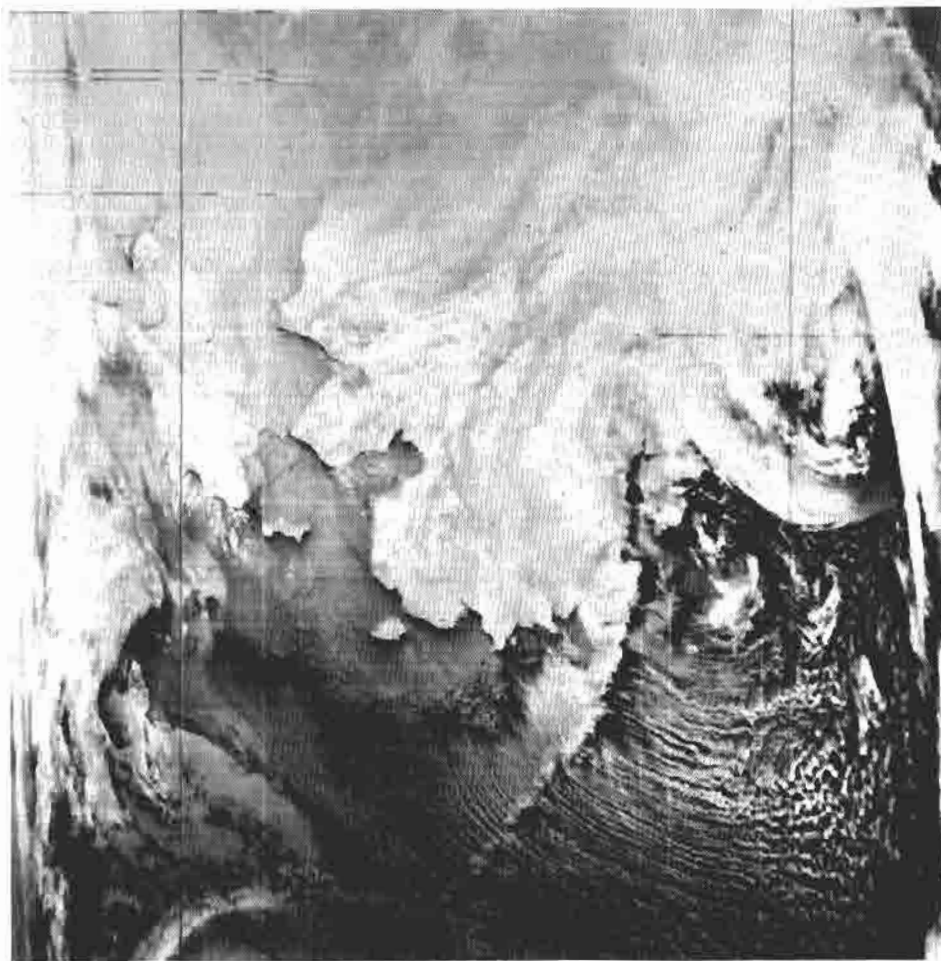


FIGURE 2. Alaska as viewed by the NOAA2 VHRR thermal infra-red radiometer on Jan. 17th 1973. Note the pack ice extent to the south of Nunivak Island and cloud bands extending across the Aleutians forming open cell convective patterns over the North Pacific.

duced forest fires, while the National Oceanic and Atmospheric Administration's Northwest Fisheries Center in Seattle feels the data will be useful in their fisheries research activities in the Gulf of Alaska and the Bering Sea. As the availability of the data becomes better known, the number of users is expected to increase considerably. For example, many of the present ERTS projects may well obtain useful supplementary information from the more frequent NOAA2/3 passes.

CURRENT PROJECTS

Sea Ice Mapping and Research

VHRR data promises to provide a primary data source for the production of sea ice maps for the Alaska region and for the study of variations with extent as a function of stresses resulting from wind and current action (Streten 1974). Although frequent cloudy weather in the Bering Sea presents problems, the large number of orbits should enable the compilation of an ice map on an approximately weekly basis by using data carefully plotted for each cloud free orbit. Such maps may be expected to play an increasingly important role in the planning of shipping communications to northern Alaska's oil and mineral rich regions. Also, satellite techniques should enable a reduction in, or better utilization of, air-

disciplinary team at the University of Alaska, representing the Geophysical Institute, the Institute of Marine Science, and the Institute of Water Resources, is currently engaged in a pilot project which will evaluate the extent to which data from NOAA2/3 may be utilized for both research and operational environmental activities in Alaska (McClain, 1973).

Following a period of study of non-real time data during the latter part of 1973, the project became operational in March 1974 when the production of high quality photographic prints became possible at Gilmore Creek tracking station. The data is now examined on a day-to-day basis and information is supplied to user organizations — at present, primarily the National Weather Service for meteorological and hydrological purposes. However, other potential users will also be supplied with data to assist in their operational field programs. The Bureau of Land Management hopes that the data will help in the detection of thunderstorm-pro-

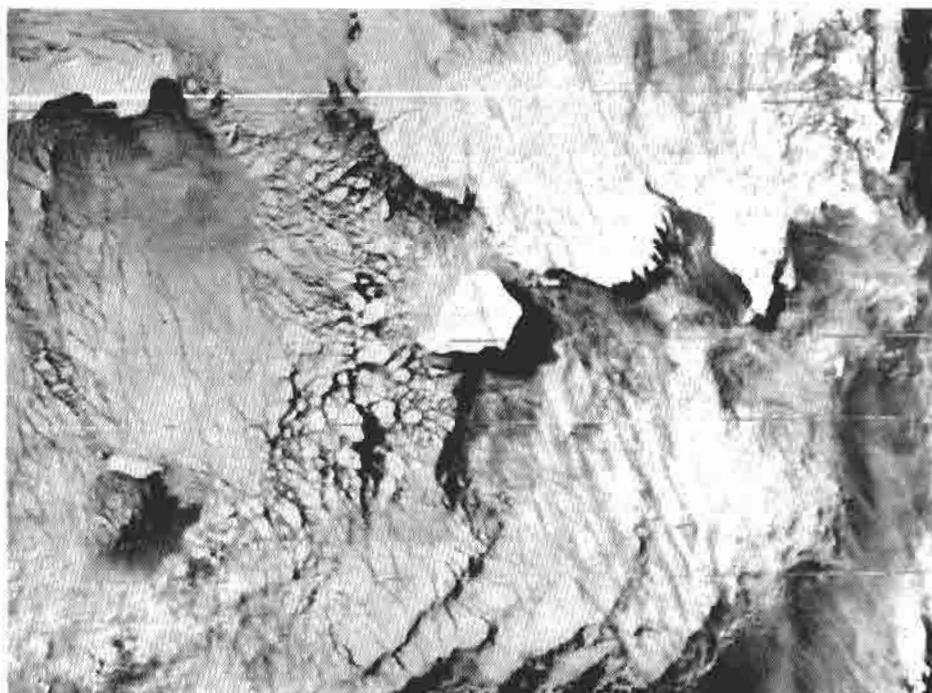


FIGURE 3. Detail of ice features in the Bering Sea as viewed by the NOAA2 VHRR visible range radiometer on Jan. 4th 1973. St. Lawrence, Nunivak and St. Matthew Islands may be recognized and the Yukon delta is visible in the central upper part of the imagery.

craft for arctic ice reconnaissance. Figure 3 shows an indication of such sea ice imagery for the Bering Sea in the visible range. Owing to the large temperature differences that exist between the water and the surface of the floating ice in winter, the thermal infra-red data readily reveal areas of open water within the Arctic Ocean pack ice. The study of the formation, deformation and life history of such leads is an integral part of the Arctic Ice Dynamics Joint Experiment (AIDJEX) which may be expected to materially gain from these data. In a wider contrast, the year-to-year variations in the seasonal extent of open water in the Arctic are believed to have a profound effect on the broad character of the global climate. Thus, the VHRR data will enable the establishment of a more thorough basic mapping program throughout the year and on a continuing basis which will provide valuable source information for numerical climatic simulation studies.

Thunderstorms and Forest Fires

Surveys of Alaskan forest fires during the last two decades have shown that even though the number of lightning-induced fires is only about one-third that of man made fires, the acreage burned by lightning-caused fires is over three times as great (Barney 1969). This imbalance in the burned acreage results from the time interval occurring between the ignition of lightning-induced fires and their detection. The Bureau of Land Management (BLM), which conducts an extensive operational program in the Interior of Alaska, has made significant improvements in developing systems to reduce the time interval between the discovery and control of lightning-caused fires. However, the same cannot be said for the time span between ignition and discovery. A reduction of this discovery time interval is possible only through the development of techniques for the identification of thunderstorms.

Many methods are currently used to identify and locate thunderstorms — aircraft surveillance, radar observations, and forecasts using surface and upper air meteorological observations. However, the most promising technique is the use of high resolution satellite imagery. Prior to the advent of VHRR, the resolution of meteorological satellites was, in general,



FIGURE 4. Extensive thunderstorm cells over central Alaska depicted in the NOAA2 VHRR thermal infra-red imagery for July 3rd 1973. Here, the cold tops of the high cloud cells show brightest with lower cloud, sea ice and land surfaces progressively darker.

too poor to satisfactorily identify isolated thunderstorms or to distinguish them from other clouds. An exception to this was, of course, ERTS. However, this satellite does not scan in the thermal infra-red and thus cannot give approximations to cloud top temperature. Moreover, its coverage of a particular area is too infrequent for operational purposes. Now, however, NOAA2/3 provides a good compromise between suitable resolution and frequent coverage. The ability of this satellite to see thunderstorms is shown in Figure 4. This figure shows a group of large cumulonimbus clouds visible in the infra-red imagery of the Tanana-Delta flats area, and indeed, forest fires were reported in the area on this day and the next.

Summer thunderstorms in Alaska occur mainly through differential heating of air masses and, hence, tend to occur generally on otherwise clear days. This tends to simplify the identification of the thunderstorm cells from satellite imagery. However, because of the availability of both infra-red and visible imagery, we find that thunderstorm location is possible even within cirrus cover.

The analysis of thunderstorms during the summer of 1973 suggests that there are preferred areas in the State of Alaska

for the formation of thunderstorms. One of these regions is the Yukon flats where the highly continental climate and the extensive moisture source may be important factors in producing large cloud buildup.

With the presently available techniques and with those hoped to be further developed using ERTS imagery, it should be possible to provide locations of thunderstorms in real time to BLM. These locations could then be verified using the other techniques that are now being employed such as aircraft surveillance. Ultimately, satellite imagery on a regular basis may well largely replace such costly aircraft operations.

Snow Mapping and Hydrology

In addition to its utility in studies of the atmosphere and ocean surface, frequent imagery of the earth surface under conditions of little or no cloud cover may also be of considerable value. Figure 5 shows such a visible range VHRR image of southcentral Alaska. One of the most significant contributions that can be made by such terrain pictures is in the field of snow hydrology. Thus, VHRR provides an especially valuable observational tool for periods when any rapid changes in the snow cover may be economically important, such as during spring break-up,

Changes in snow cover which can be used to derive estimates of total snowmelt may be correlated with streamflow and such models are now being tested in the present research project for particular river basins. NOAA2/3 VHRR imagery has been used to map watershed snow cover to within five per cent of the accuracy achieved by ERTS pictures. This is accomplished by substantial magnification and optical rectification of the radiometer imagery. Although obscuring of the surface by different types of vegetative cover and terrain shadowing are important problems in the interior regions of Alaska, the snow cover and break-up conditions on Alaska's North Slope provide an ideal situation for the monitoring and study of breakup. Research into these areas is continuing, as well as investigations of the patterns of autumn freeze-up of rivers and lakes.

Operational use of the data is expected to be at a maximum during spring break-up and day-to-day information on snow cover is to be made available to National Weather Service hydrologists in Anchorage who would then be principally concerned with the forecasting of river run-off and flooding. Use of VHRR, at that time, should strongly supplement the present, expensive, program of river surveillance by aircraft.

Sea Surface Temperature Analysis

The VHRR thermal infra-red imagery of the sea surface presents the possibility of examining patterns of surface temperature variation in currents and regions of oceanic upwelling. Such areas are of particular economic importance in southern Alaska because of their relation to the fish population. Although the extensive cloudiness over the waters south of Alaska has so far made preliminary analyses difficult, it is expected that, with new techniques and an increasing and regular supply of VHRR imagery, better results may be achieved.

Macro and Meso-Scale Weather Systems

VHRR infra-red data enables the detailed cloud top temperature structure to be observed in active cyclonic depressions and bands of frontal cloud. Such more precise identification of smaller regions of active weather activity within larger scale synoptic circulation systems

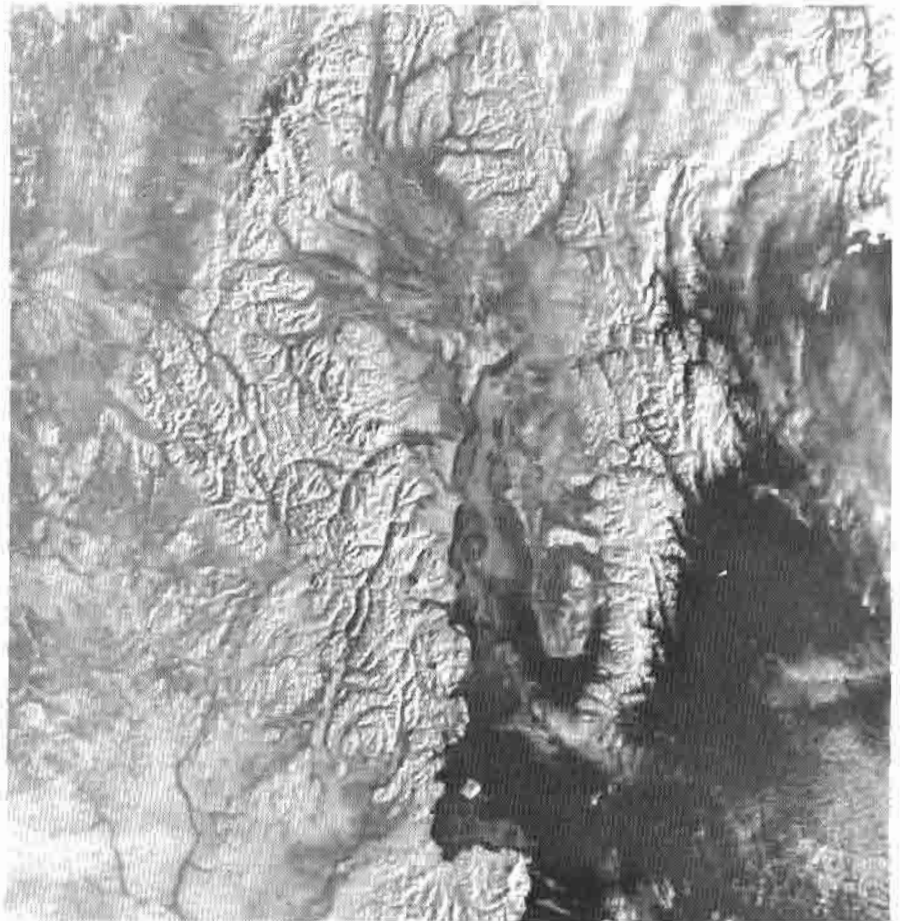


FIGURE 5. Southcentral Alaska terrain viewed by the NOAA2 VHRR visible range imagery for Feb. 28th 1974. The drainage pattern of the Susitna River and Cook Inlet are readily revealed.

is of obvious importance in meteorological analysis and forecasting. This is of particular practical utility at high latitudes where winter darkness and ice cover often severely limit the value of conventional satellite photography (Streten 1974b). Operationally, these data will be used by the National Weather Service Offices in both Fairbanks and Anchorage for aviation and general forecasting.

For meteorological research, the data will enable studies to be made in greater depth of the evolving cloud patterns associated with various development stages of depressions and with the modification of cold air being advected across warmer ocean surfaces.

CONCLUSION

This new and exciting tool for the study of the environmental sciences presents many new opportunities for operational services and research projects in the polar regions and promises to be of particular value in the management and study of Alaskan resources.

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