PICTURE OF THE MONTH

From Different Viewpoints: Arc-Line (White Squall) Generation Captured by Simultaneous NOAA-3 and SMS-1 Visible and Infrared Imagery

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Simultaneous photographic imagery from different meteorological satellites is not uncommon. Picture-pair comparisons of imagery in the visible spectrum are frequently made on a non-operational basis between the polar-orbiting satellite series (NOAA-2,-3) and the geostationary Applications Technology Satellite (ATS-3). Fine structure and detail present in the NOAA-2,-3 Very High Resolution Radiometer (VHRR) visible (1-km resolution) imagery are related to and aid in the interpretation of ATS-3 lower (9 km) resolution visible imagery.

With the operational dedication of the Synchronous Meteorological Satellite (SMS-1) at 0000 GMT 27 June 1974 to the Global Atlantic Tropical Experiment (GATE), it has now become possible to compare both near-equivalent visible imagery and infrared (IR) imagery from a geostationary platform to the dual-mode VHRR imagery of the polar-orbiters. Having the capability of user-selectable sector resolutions (1, 2, or 4 km in the visible spectrum, and 8 km in the IR), SMS-1 provided continuous (twice-hourly recycling) real-time coverage 24 hours a day from its station 35 840 km (apogee) above 45°W. Upon completion of National Oceanic and Atmospheric Administration (NOAA) support of GATE in September, SMS-1 was moved to its permanent station at 75°W to provide a perspective view of the Earth disk similar to that available from ATS-3.

The subject of the picture-pair comparison presented here, arc-line generation, has been described in detail by Fujita (1963) and Purdom (1971; 1973a, b). Further discussion of arc-line appearance on the first SMS-1 visible photographs received (1 and 2 km resolution) was described by Ernst and Smith (1974).

Captured in the NOAA-3 VHRR (orbit 2911) visible photograph of 1351 GMT 29 June 1974, the series of arc-lines (A,B) off the east coast of the United States shown in Fig. 1 at 1 km resolution are delineated quite sharply in their typical arcuate configuration. Vigorous in appearance, the parent thunderstorm cells (C,D) loom conspicuously behind the arc-lines, while cirrus

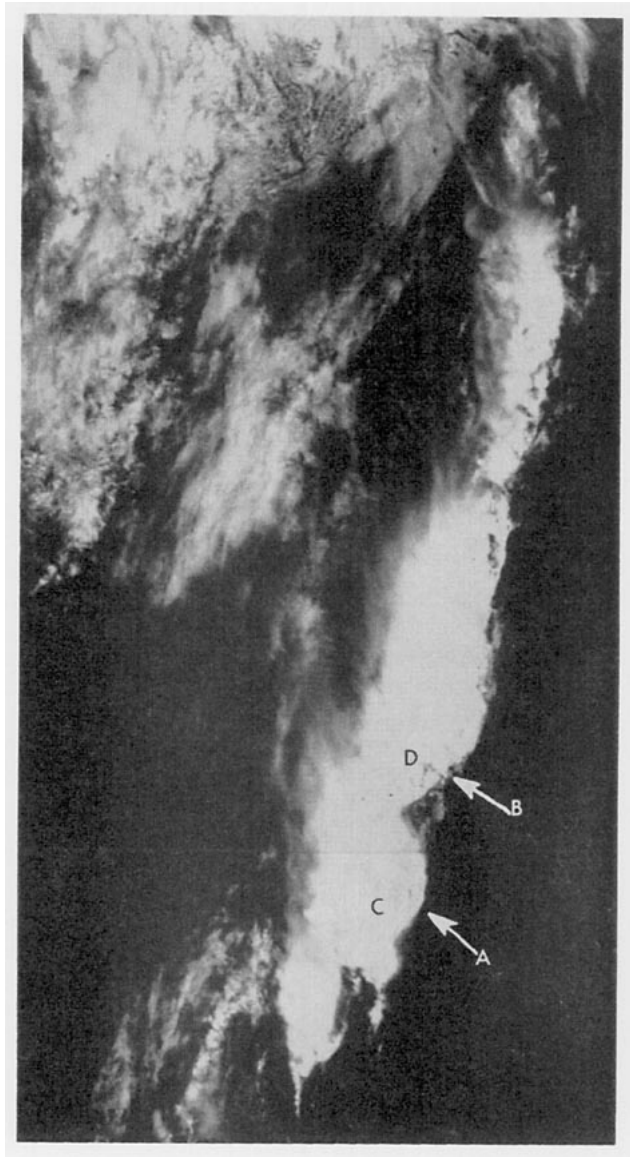


FIG. 1. NOAA-3 VHRR (1 km) visible image, 1351 GMT 29 June 1974.

Fig. 2. SMS-1 B4 sector (2 km) visible image, 1400 GMT 29 June 1974.

debris streams to the northeast in the upper air flow pattern.

Figure 2, a B4 SMS-1 sector of 2 km resolution at 1400 GMT 29 June 1974, shows the same mesoscale phenomena as viewed from the geostationary perspective. At this slightly lower resolution it is still possible to identify the individual arc-lines and parent thunderstorm cells responsible for the arc-line generation.

The complementary nature of visible and IR imagery enables the satellite meteorologist to differentiate between low, middle, and high level cloud layers. Figure 3, a 1 km resolution VHRR IR photograph, shows the arc-lines to be composed primarily of low clouds. In comparison, the 8 km resolution SMS-1 IR photograph (Fig. 4) presents an adequate depiction of the low clouds characteristic of arc-lines. However, some degree of detail is lacking in the lower resolution imagery. Increased experience in the interpretation of 8 km, 24 h IR imagery, as well as application of image comparison techniques, will produce a significant increase in the understanding of those processes, whose complete life cycle it was not heretofore possible to observe continuously by a radiometric sensor.

Over coastal waters, arc-lines or "white squalls" present a particularly dangerous hazard to shipping and low-flying aircraft. In contrast to a typical "black squall," which is accompanied by dark clouds and heavy rain, the innocuous appearing white squall does not present the usual visual indicators of an immediate threat. Similar in appearance to a developed cumulus cloud line or street, white squalls move rapidly (10 to 20 $m \cdot s^{-1}$), are accompanied by whitecaps or broken

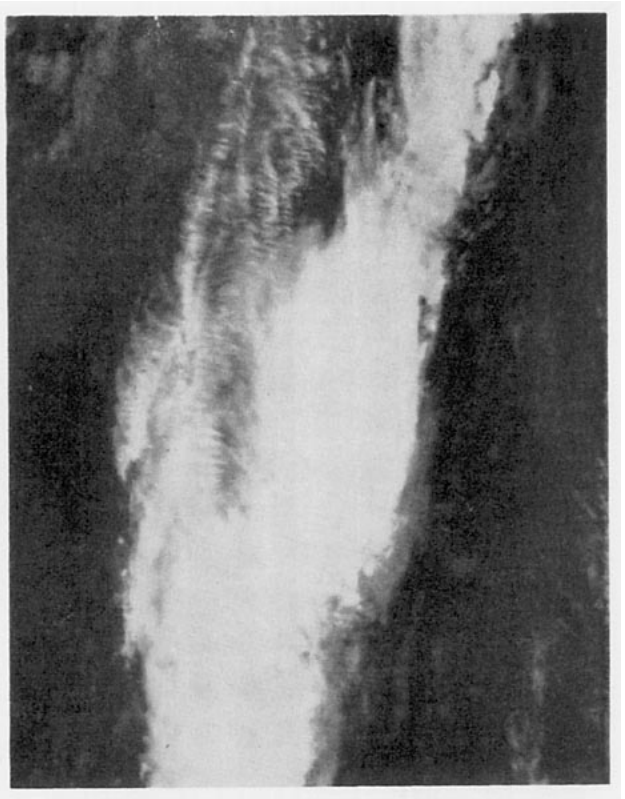


Fig. 3. NOAA-3 VHRR (1 km) IR image, 1351 GMT 29 June 1974.

water, and are followed by a strong, sudden wind shift and perhaps a brief rainshower.

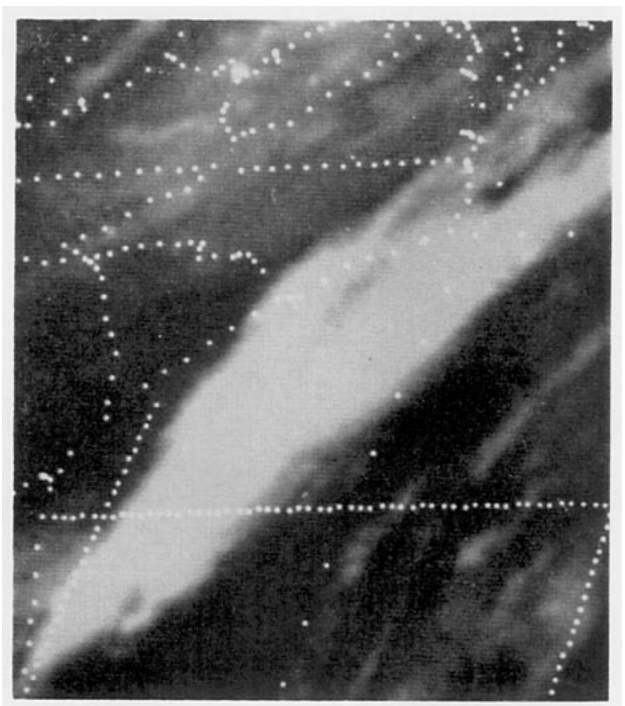
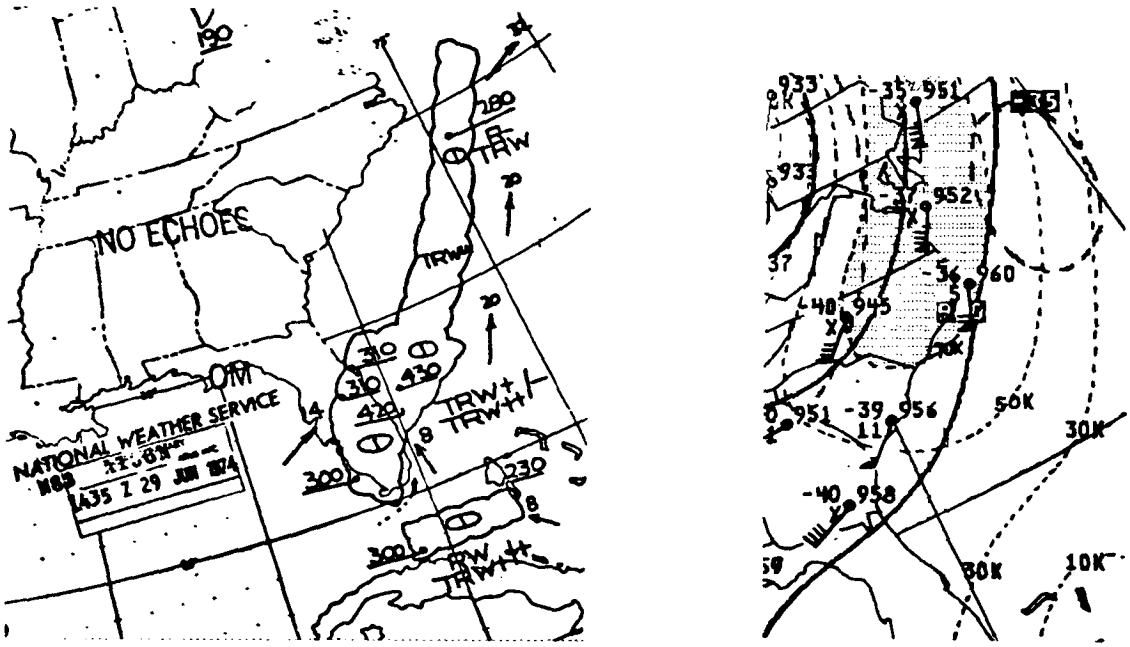


Fig. 4. SMS-1 (8 km) IR image, 1400 GMT 29 June 1974.



(a) (b)

FIG. 5. (a) Radar summary chart, VT 1200 GMT 29 June 1974, and (b) corresponding 300 mb chart.

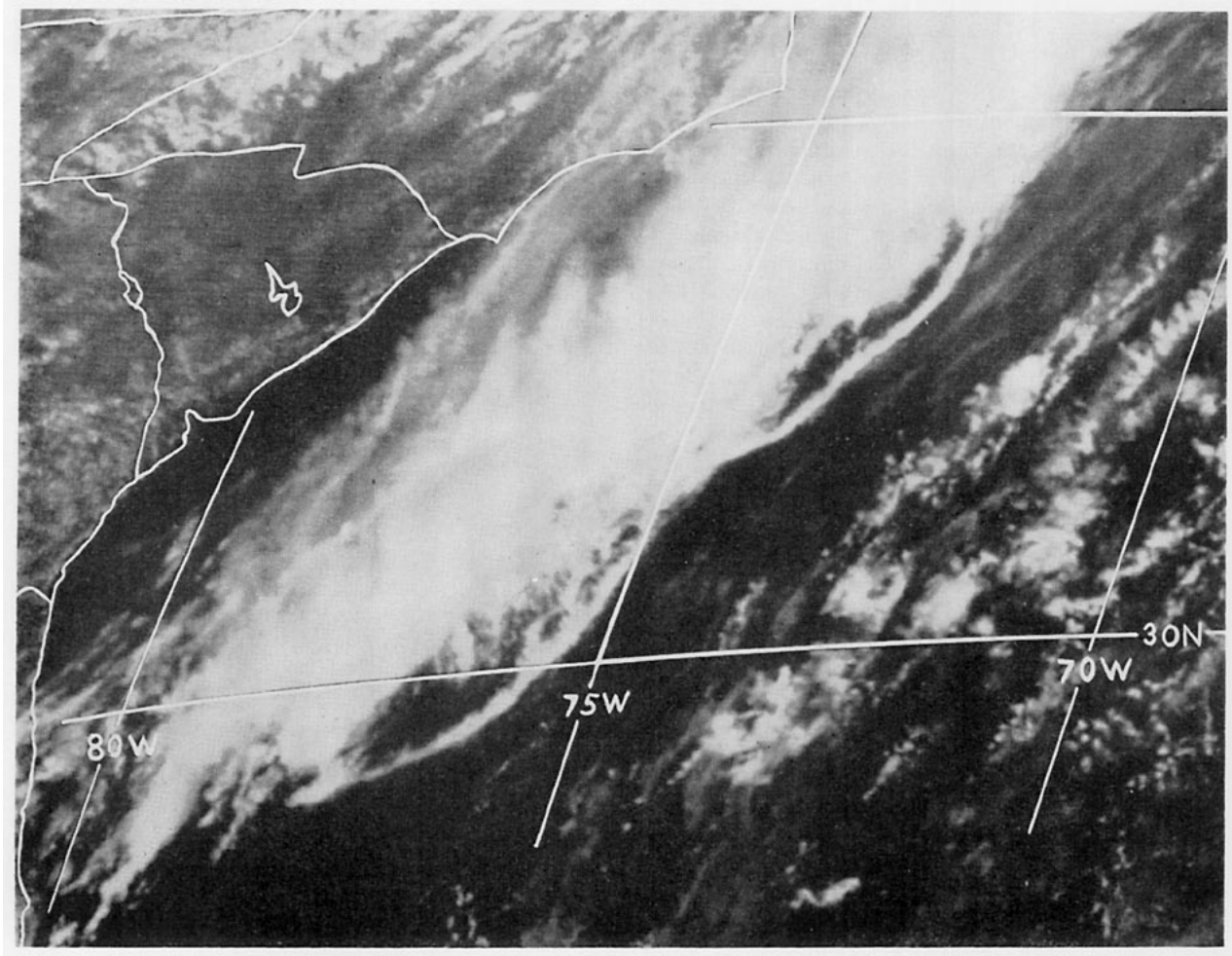


FIG. 6. SMS-1 A5 Sector (1 km) visible image, 1700 GMT 29 June 1974.

Figures 5a and b show one situation that explains why white squalls are deceptive. For other than right-moving severe thunderstorms, cell movement usually is in general agreement with the upper-air flow pattern. The radar summary chart of 1435 GMT (Fig. 5a) shows movement to the northeast at 10 $m \cdot s^{-1}$ (20 kt), which is in good agreement with the direction of the jet axis at 300 mb (Fig. 5b). Thunderheads caught in such upper-air flow patterns seemingly present no clear danger in their southeast quadrants. It is the white squall spawned from the parent thunderstorm cell that does the damage. A series analysis of twice-hourly consecutive 1 km resolution visible photographs (Fig. 6) showed movement of the white squall to the southeast at an average speed of 15 $m \cdot s^{-1}$ (30 kt).

For operational utility, meteorologists must have rapid access to near real-time data. With full implementation of the GOES Central Data Distribution System at National Weather Service Forecast Offices (WSFO), SMS-1 imagery will provide an early warning of such hazardous mesoscale phenomena as white squalls.

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