PICTURES OF THE MONTH

SMS-1 Nighttime Infrared Imagery of Low-Level Mountain Waves

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ABSTRACT

With the advent of the geostationary satellite SMS-1, it is now possible to continuously observe and record by means of infrared (IR) imagery such small scale weather-effective phenomenon as low-level mountian waves. Continuous (every 30 min) nighttime IR imagery permits the early detection and identification of mountain waves and their growth, propagation and decay.

The inadequacy of present observational methods in satisfactorily delineating the areal extent, intensity and duration of operationally significant turbulence is well known (Musaelyan, 1962). One study reported by Sorenson and Beckwith (1975) showed that mountain waves were responsible for slightly less than 50% of the total number of cases of severe turbulence. Less well known is the contribution of nocturnal low-level

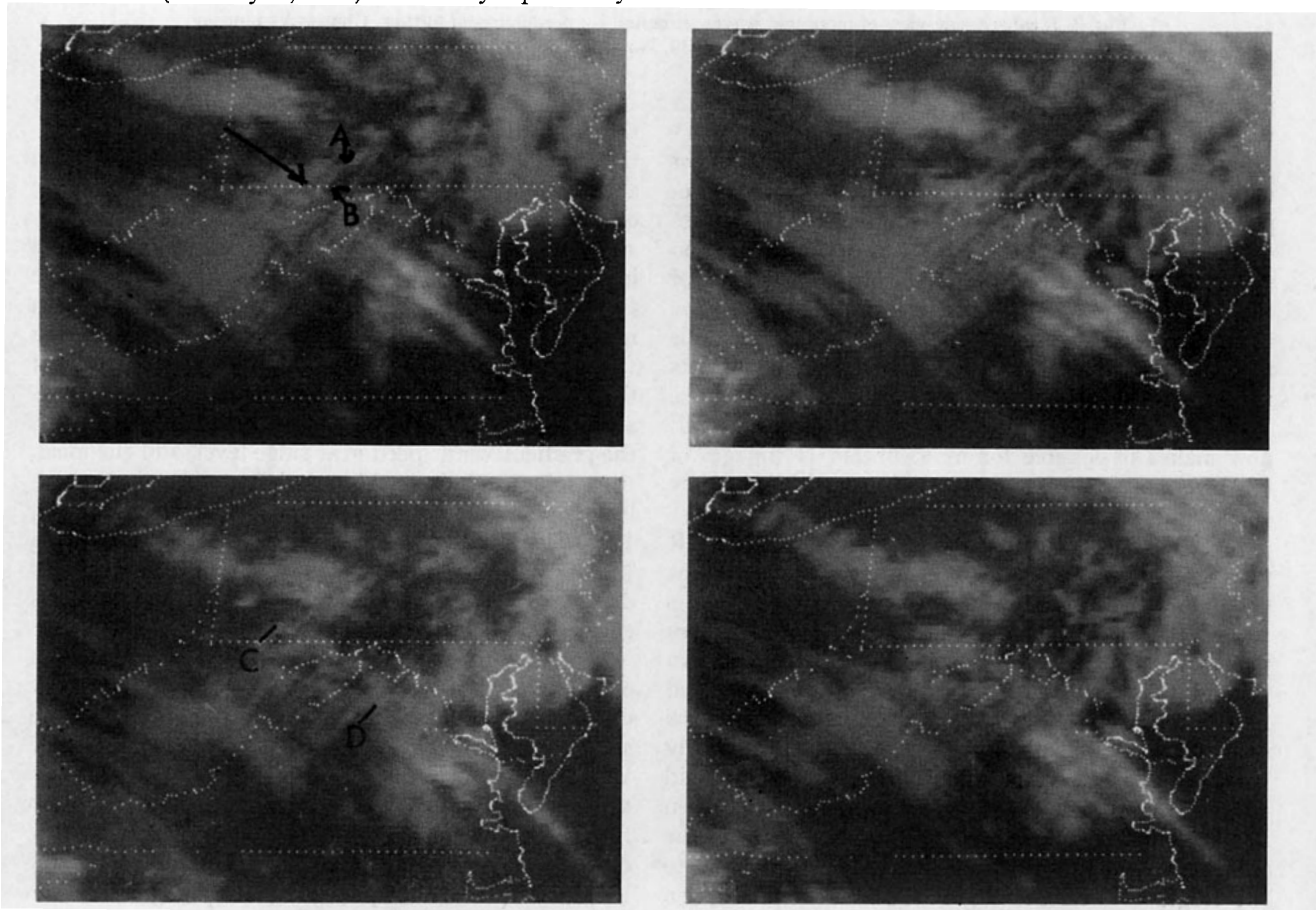

Fig. 1. Portions of SMS-1 infrared images, at half-hour intervals from 0300 GMT through 0430 GMT 17 April 1975 beginning at upper left and moving clockwise. Arrow in Fig. 1a points to low-level mountain waves.

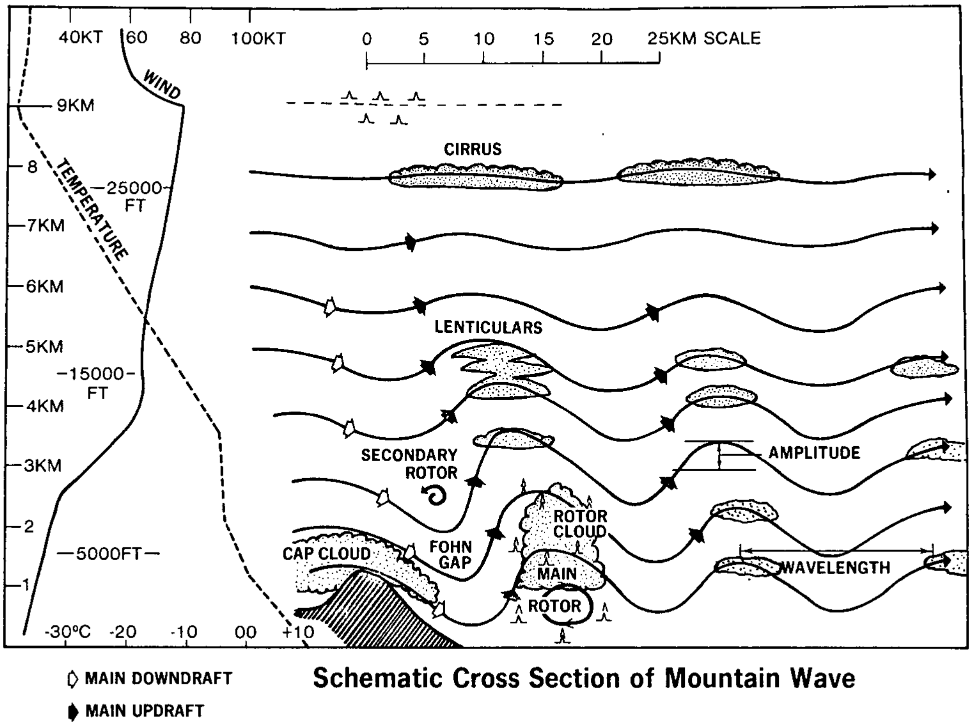

FIG. 2. Idealized side view of mountain waves. Adapted by permission of author, Charles V. Lindsey, from *Soaring*, **39**, No. 4, 1975, p. 42.

mountain waves to aircraft-reported encounters with turbulence of moderate or greater intensity.

One factor that must be considered is the scarcity of nighttime reports. In general, the number of pilot reports of turbulence generated by mountain waves declines sharply after sunset. This decline is by no means a true measure of the frequency of occurrence of this phenomenon. The scarcity of reports can be attributed to the normal decrease in nighttime air traffic. A source of information other than pilot reports is infrared (IR) imagery from meteorological satellites.

The Synchronous Meteorological Satellite, SMS-1, now makes it possible for us to obtain IR images of low-level mountain waves every 30 min whether they occur by day or by night.

Fig. 1 shows portions of SMS-1 nighttime IR photographs taken at 30 min intervals starting at 0300 GMT 17 April 1975. The arrow in Fig. 1a points to an area of relatively low-level clouds in a pattern indicative of the presence of mountain waves. (In general, the darker the grey shade the lower the cloud in IR imagery.) As seen from the perspective of the satellite, wave clouds appear as successive, nearly parallel bands (wave crest, A) alternating with cloud voids (wave trough, B). The parallel cloud bands seen in the IR imagery have a NE–SW orientation over the Allegheny Mountains from central Pennsylvania to the ridges of western Virginia. (In the reproduction process, some detail may unavoidably be lost.) Fig. 2 is an idealized side view of mountain waves as seen from the ground.

Continuous nighttime radiometric observation from the satellite permits the early detection and identification of mountain waves and their growth, propagation and decay. Dissemination of such information can be of extreme importance to aviation interests. Additionally, this information on diurnal variations and changes in wave amplitude (grey shade color changes in the IR reflect temperature changes which may in turn relate to height changes) and in measured wavelengths (average distance between successive wave crests) of these clouds can furnish trend indications not otherwise available (Wallington, 1961). Changes in mean stability, the gradient wind speed near ridge level, and the mean tropospheric wind speed have all been related to wavelengths measured by use of satellite imagery (Fritz, 1965). Using the photograph of Fig. 1d, a wavelength (λ) of 12 km was obtained by dividing the measured distance s (between points C and D) by the number of enclosed wave crests (n).

It is also necessary to interpret the significance of obtained results in terms of IR sensor limitations. The detection of mountain waves in the IR (10.5 to 12.5 μm spectral interval) is dependent upon several factors. When moisture is not present through a sufficiently thick atmospheric depth, clouds will not form even though the wind flow forms standing waves. The difference between the cloud top temperature and the background scene temperature must be greater than 0.5 K, the temperature difference sensitivity of the sensor. Unless this temperature difference is present, clouds will be invisible. Cloud patterns (e.g., wave-form periodicity) of areal extent greater than the sensor's minimum spatial resolution capability (8 km) must be present.

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