Outflow from convective storm, Mauritania and adjacent Atlantic Ocean (13 August 2006)

by Martin Setvak (CHMI), Jochen Kerkmann, Alexander Jacob, HansPeter Roesli (EUMETSAT), Stefano Gallino (ARPAL) and Daniel Lindsey (CIRA)

Jump to images

Every convective storm cell is composed of two main vertical currents: updraft and downdraft. While updraft is the main mechanism which creates the visible cumulonimbus cloud, and also most of the storm top features observed by satellites (see also the cases of 25 June 2006 and 13 October 2006), observing downdrafts by satellite is not that common and straightforward. One possible manifestation of strong storm downdrafts can be pools of cold air, spreading outwards from underneath storms, into their surroundings. These low level outflows can be marked by a ring of low clouds or a roll cloud, which can be seen in satellite imagery. Such outflow boundaries may travel tens to hundreds of kilometers from their place of origin and last for many hours.

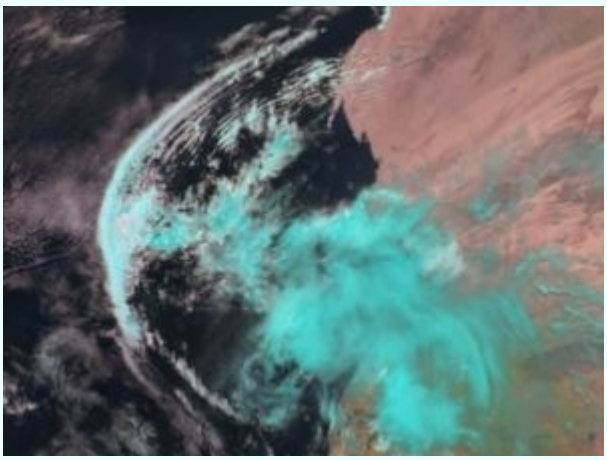
Storm-generated cold pools of air were first documented and explained by Fujita (on the basis of meso-meteorological studies) in 1963 (Fujita, T. T., 1963: Analytical mesometeorology: A review. Meteor. Monogr., 27, 77-128), and in satellite images first described by Purdom in 1973 (PDF, 2585 KB, based on ATS-3 satellite) and 1976 (PDF, 1637 KB, based on GOES-1 satellite). Since then, outflow boundaries have been documented in satellite imagery on many occasions, day and night. The outflow boundaries are also frequently identified as gust fronts (leading edge of gusty winds, associated with the outflow), or as an arc cloud. When two such outflow boundaries meet new storm cells are likely to develop at the point of their intersection.

The case shown here started shortly after midnight when a new, long-lived convective storm developed inland of Mauritania. During nighttime, the lowest cloud top temperatures were within the range -85 to -87°C, and shortly after sunrise the visible imagery revealed features like an above-anvil plume and cloud-top gravity waves (see RGB NIR1.6-VIS0.8-VIS0.6 from 07:00 UTC, JPG, 157 KB). However, at this stage the cloud top temperatures began to increase rapidly, indicating a decay of the storm. Almost exactly at sunrise, an arc-shaped feature began to spread westward from the storm. Initially, as long as the arc-shaped feature moved over land, it marked the leading edge of an outflow boundary, but when the outflow boundary (or gravity current) moved over the Ocean (where it encountered strong stratification near the ground) it transformed into an undular bore (the difference between a gravity current (or outflow boundary) and an undular bore is explained in the paper from Wakimoto and Kingsmill, 1995, PDF, 2702 KB). This can be deduced from the the high speed of the arc-shaped cloud over the Ocean and the "ripples" of clouds behind the leading edge of it (see Terra MODIS RGB composite image, JPG, 512 KB, source: NASA). The undular bore could be traced till sunset, propagating over the Atlantic Ocean, at a speed of about 95 km/h (this speed was estimated on the basis of displacement of the arc-shaped cloud; see also RGB NIR1.6-VIS0.8-VIS0.6 from 18:00 UTC, PNG, 869 KB).

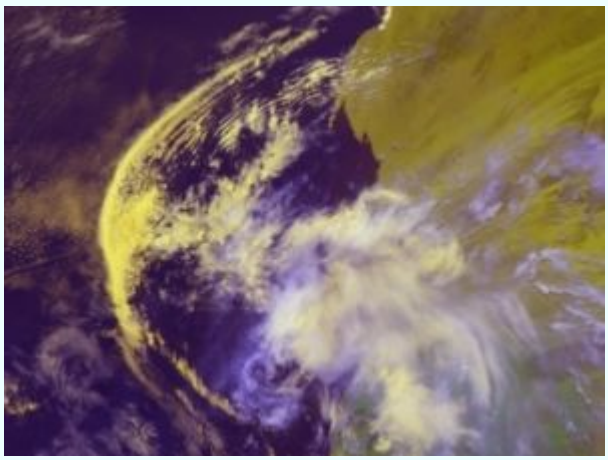
The following loop (01:00-21:00 UTC, MPG, 2011 KB) of Meteosat-8 images is a combination of nighttime infrared imagery (before sunrise) and visible imagery (after sunrise), with a transition period between sunrise and about 10:00 UTC (using Photoshop and the layers transparency function, decreasing gradually the opacity of layers with the IR file). In the IR imagery, the blue color indicates an isotherm of -33°C (240 K), while the darkest brown colors represent temperatures of -80°C and lower. The propagation of the outflow boundary/undular bore can be well observed in the daylight RGB composites of

MSG-SEVIRI bands 1, 2 and 9 (06:00-18:00 UTC, AVI, 4231 KB), and bands 3, 2 and 1 (06:00-18:00 UTC, AVI, 4243 KB).

Meteosat-8 Images



Met-8, 13 August 2006, 12:00 UTC
RGB Composite NIR1.6, VIS0.8, VIS0.6
Large Area (JPG, 607 KB)
Animation (06:00-18:00 UTC, AVI, 4243 KB)



Met-8, 13 August 2006, 12:00 UTC
RGB Composite VIS0.6, VIS0.8, IR10.8i
Large Area (JPG, 606 KB)
Animation (06:00-18:00 UTC, AVI, 4231 KB)