NASA CAMEX-4 DROPSONDE

The Precision Dropsonde Instrument

The dropsonde is a small, lightweight (less than 1 lb) cylindrical instrument that falls freely through the atmosphere, slowed somewhat by a small inflatable parachute (**FIGURE 1**). The instrument is ejected from a tube in the underside of weather research aircraft, and as it descends it radios back information on the structure of temperature, moisture, pressure and winds. The computer system on board the aircraft, operated and monitored by a human operator, can track up to four dropsondes simultaneously. The dropsonde is capable of operations in both fair weather and cloud disturbances such as thunderstorms and hurricanes. Sensitive atmospheric sensors and computer electronics inside the dropsonde (**FIGURE 1**) can measure changes in temperature to within 0.2 deg C, 2% variations in moisture, and wind speeds to within 0.5 m/s. The winds are computed using the Global Positioning System (GPS) and thus the dropsonde also contains a special antenna to track the progress of these satellites. The dropsonde is designed and manufactured through a partnership between the National Center for Atmospheric Research (NCAR) and Vaisala, Inc.

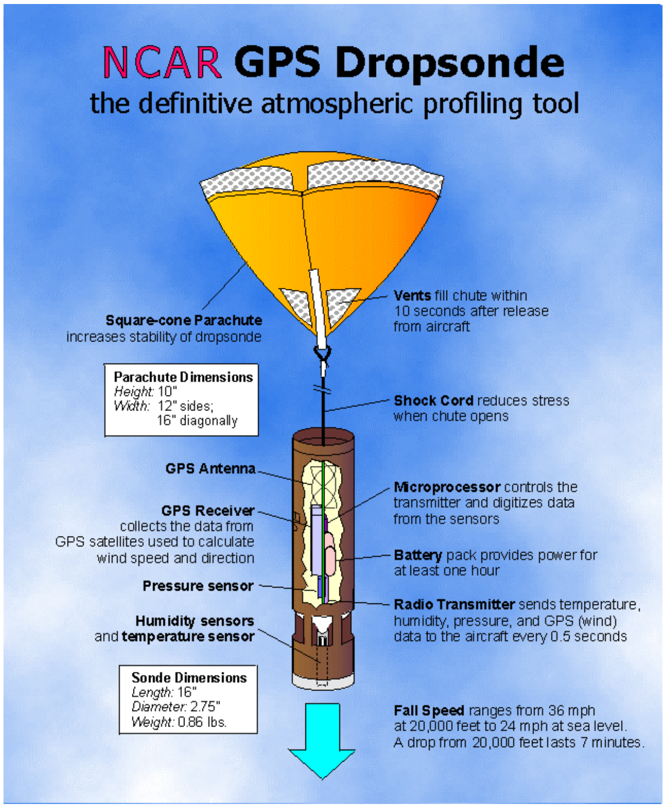


Figure 1: Schematic of the NCAR/Vaisala dropsonde showing internal components

During CAMEX-4, up to 150 dropsondes will be released from both the NASA DC-8 and ER-2 aircraft. The flight altitude of the DC-8 is approximately 40,000 feet, so dropsondes provide invaluable information about winds in the mid-level hurricane vortex and also the vertical temperature distribution within the eye. For the first time ever, the dropsonde technology described above is being adapted to the high flying NASA ER-2, which cruises at nearly 65,000 feet. This is within the stratosphere and thus well above most of the clouds associated with the hurricane. The high altitude dropsonde thus provides an unprecedented opportunity to collect complete observations on the hurricane from the highest cloud turrets down to the sea surface. The ER-2 dropsonde system is designed such that it functions in an autonomous manner, requiring only minimal operator (pilot) intervention. A computer controls the release of dropsondes from a special pressurized instrument pod located beneath the belly of the ER-2 (**FIGURE 2, FIGURE 3**).

Figure 2: Underside of the ER-2 & approximate location of dropsonde release

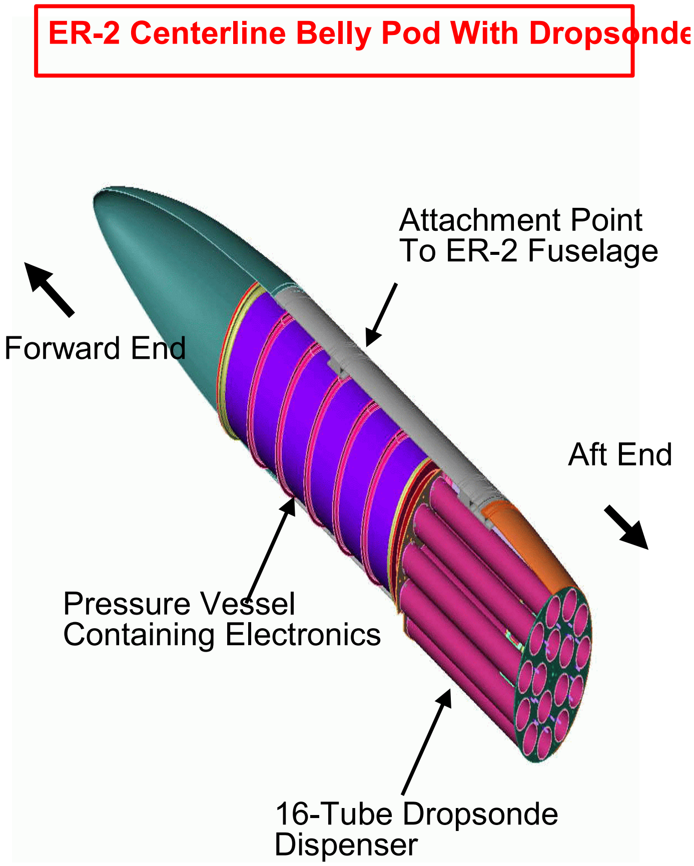


Figure 3: Schematic of the dropsonde system contained within the ER-2 belly pod

Advancing Hurricane Science with Dropsondes

Dropsondes deployed from the high altitude ER-2 will reveal new insights into the upper level structure and dynamics of the hurricane. Very little data have historically been collected from the region of hurricanes above 40,000 feet. However, several important processes related to the storm wind and energy production occur within this high altitude regime. For instance, the cyclonically rotating inner vortex switches direction to become the anticyclonically rotating outflow vortex, where all of the air rising up from lower levels spreads away from the storm. Also, the warmest air contained within the hurricane eye typically occurs in the upper troposphere, and may in some occasions extend into the lower stratosphere (**FIGURE 4**).

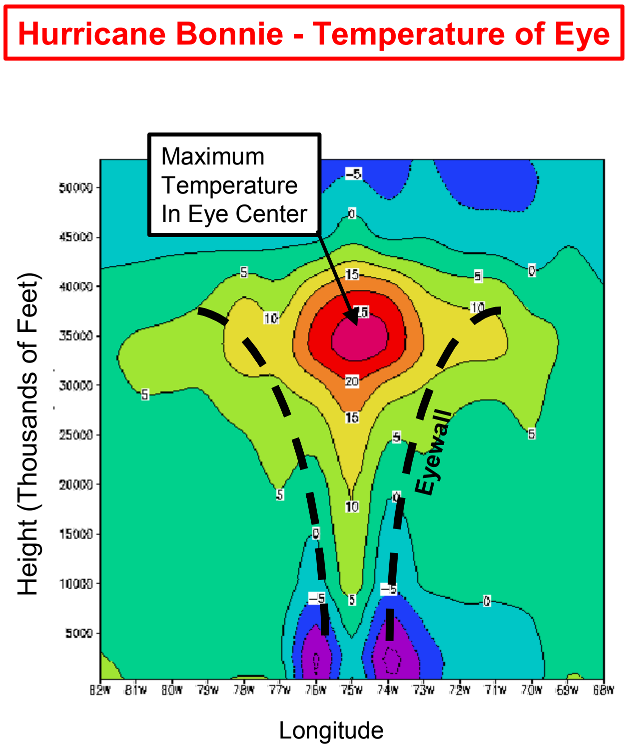


Image taken using NOAA AMSU
Courtesy of C. Velden, U. Wisconsin

Figure 4: Cross section through hurricane eye showing warm air in the upper troposphere (obtained by the NOAA AMSU satellite)

This warm air causes the air column in the center of the storm to expand vertically, lowering the surface pressure, which in turns drives the intense spiral inrush of hurricane force winds. Furthermore, the most energetic storm clouds contained within the hurricane eyewall, called **chimney clouds**, often tower to heights greater than 60,000 feet (**FIGURE 5**).

Chimney Cloud Within Hurricane Bonnie - Imaging by

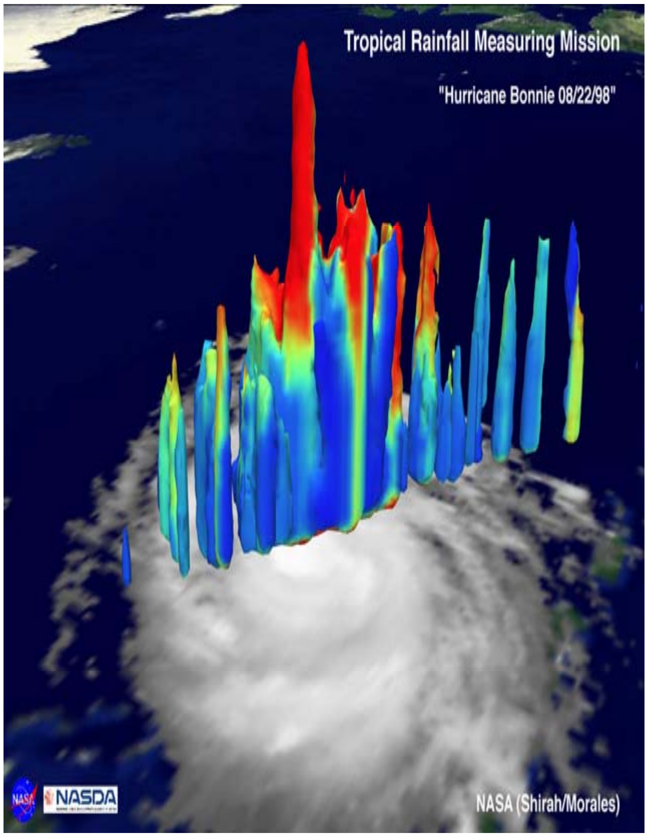


Figure 5: 3D visualization of a chimney cloud in Hurricane Bonnie (1998) obtained from the NASA Tropical Rainfall Measuring Mission satellite

These intense thunderstorms, which are part of larger super-clusters of energetic clouds called **convective bursts** (**FIGURE 6, FIGURE 7**) may rapidly inject large amounts of energy into the storm's inner core and lead to rapid intensification (**FIGURE 8**). For the first time, the structure of the temperature and winds as it relates to the upper level hurricane eye, vortex and convective bursts will be in reach of the CAMEX-4 investigators by using the specially designed ER-2 dropsonde.

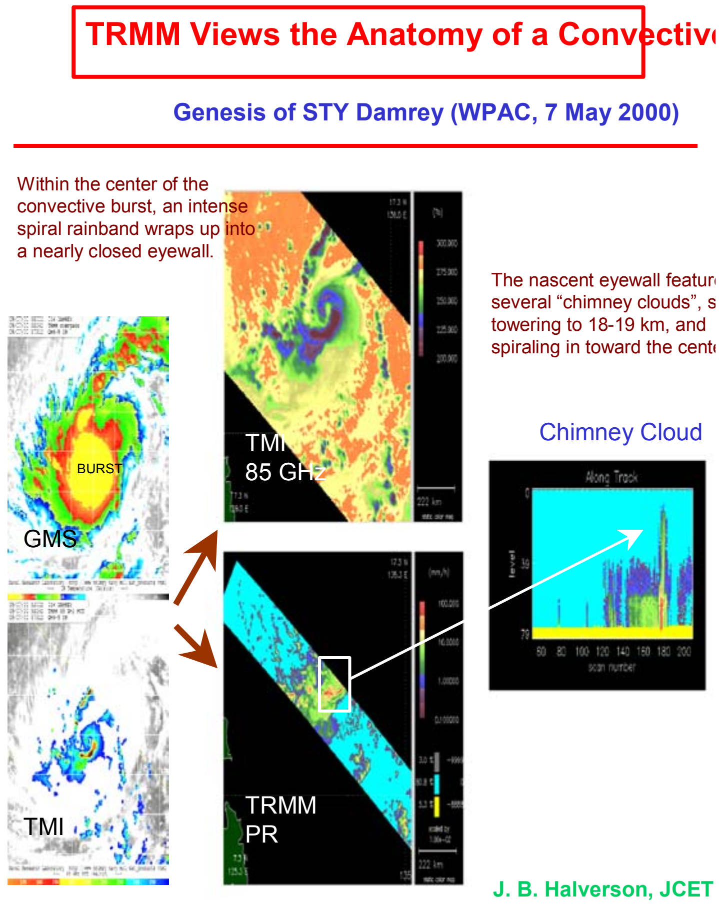
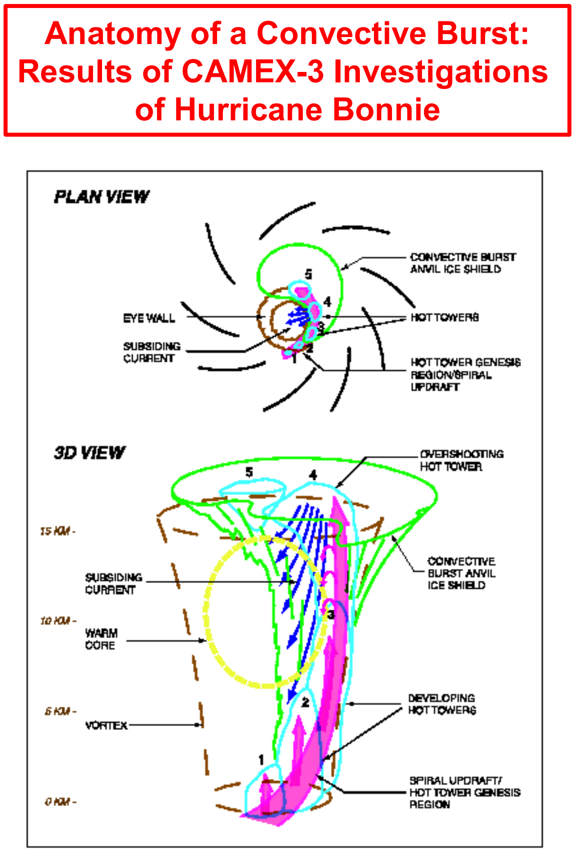


Figure 6: View of a convective burst from satellite images, showing the very cold, deep thunderclouds near the center of intensifying super typhoon Damry (2000), and the rapid formation of an eye inside the burst



From Heymsfield et al. 2001

Figure 7: 3D schematic of the internal air motions and atmospheric processes contained within a convective burst, investigated during CAMEX-3 aircraft flights through Hurricane Bonnie (1998) (From Heymsfield et al., 2001)

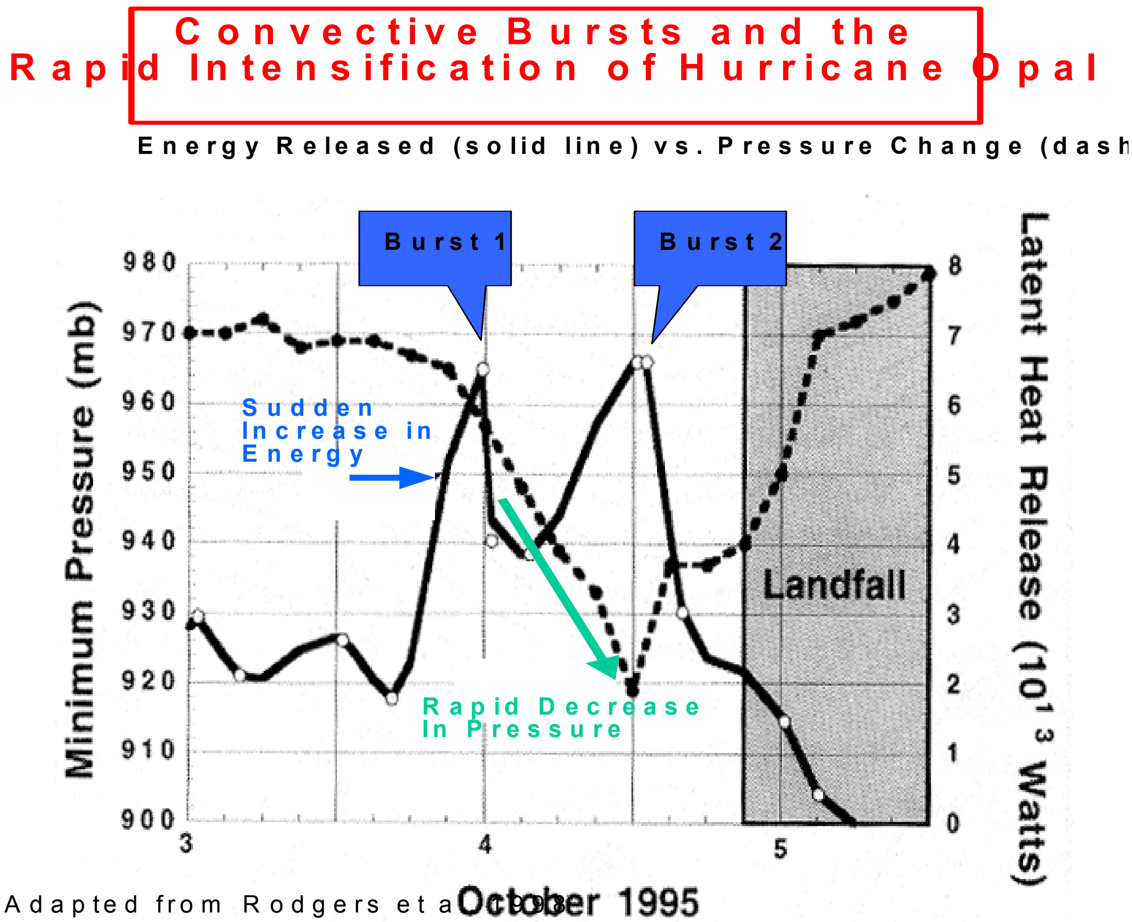


Figure 8: The relationship of convective bursts and cycles of rapid intensification in Hurricane Opal (1995) (From Rodgers et al., 1998)

References

Heymsfield, G.M., J. Halverson, J. Simpson, L. Tian and P. Bui, 2000: ER-2 Doppler Radar (EDOP) investigations of the eyewall of Hurricane Bonnie during CAMEX-3, To Appear in *J. Appl. Meteor*.

Rodgers, E.B., W.S.Olson, V.M. Karyampudi and H.F. Pierce, 1998: Satellite-derived latent heating distribution and environmental influences in Hurricane Opal (1998). *Mon. Wea. Rev.*, **126**, 1229-1247.