GENESIS AND RAPID INTENSIFICATION PROCESSES (GRIP) EXPERIMENT

WHAT MAKES HURRICANES, HURRICANES?

NASA's Genesis and Rapid Intensification Processes (GRIP) experiment studied the physical and environmental factors that contribute to hurricane formation and intensification. The experiment sought to answer:

- What environmental and inner-core processes determine whether a storm will strengthen into a hurricane?
- To what extent can we predict whether this intensification will occur?

From 15 August through 30 September 2010, NASA flew three aircraft carrying fifteen instruments over the Atlantic Ocean and Gulf of Mexico to measure vertical and horizontal wind speeds, precipitation, pressure, temperature, and humidity in and around tropical cyclones in an attempt to figure out what fuels the powerful storms.

HOW DRY IS TOO DRY?

Data collected during the GRIP campaign revealed new clues into how hurricanes form, strengthen, and eventually disappear. The new data showed:

- **The Saharan air layer (SAL) does not necessarily prevent very intense hurricanes from forming.** Contrary to previous studies, data from GRIP showed that storms are fully capable of intensifying into major hurricanes in the presence of dry air and dust. Previously believed to inhibit storm development, the SAL was observed during the formation and rapid intensification of Hurricane Earl in 2010, which eventually strengthened into a Category 4 storm with peak winds of 145 mph.

- **A "deep wave pouch" of moist air is important, and most likely necessary, for hurricane formation.** Although scientists had previously hypothesized that hurricanes favored warm, moist conditions, data from the GRIP campaign helped solidify this hypothesis. During the campaign, scientists observed that the inner core of developing storms was much warmer and more humid than the surrounding environment. This moist air typically extended from 700 hPa to 400 hPa, creating what some scientists refer to as a protective "pouch" that helps hurricanes form.

- **Further proof was observed that convective bursts are helpful in hurricane formation.** Multiple cycles of deep thunderstorms, or convective bursts, over several days near the center of tropical cyclones are essential for moistening the "wave pouch" and leading to hurricane genesis.

THE IMPORTANCE OF UNDERSTANDING HURRICANE INTENSIFICATION

Over the past several decades, scientists have significantly improved their ability to predict where and when hurricanes will strike. They have not, however, with the same level of accuracy, been able to predict how strong those hurricanes will be.

These data will help scientists get closer to answering lingering questions about hurricanes, including what factors allow some storms to rapidly intensify into major hurricanes, and how necessary it is to account for Saharan dust in hurricane forecast models.

Along with improving understanding of storm behavior, these data are helping scientists improve computer models of storms and predictive capabilities for determining hurricane intensity. This information can ultimately be transitioned from research to operations to help National Hurricane Center and National Weather Service forecasts, and to help emergency managers, businesses, elected officials, and the public anticipate and respond to severe storms.

TRACKING HURRICANES FROM SPACE

WHY NASA?

NASA's Earth Science Division (ESD) sees hurricanes differently—literally. ESD collects data remotely from space using highly advanced instruments mounted on research satellites hundreds of miles away. In order to ensure their satellites are really seeing what they were designed to see, ESD runs airborne field campaigns to validate their results and get a deeper look into how atmospheric processes influence hurricane development.

KEY INSTRUMENTS USED

NASA flew three different aircraft equipped with multiple instruments during the GRIP campaign, including:

- **Global Hawk**: Unmanned aircraft system with a range of 8,500 nautical miles at altitudes up to 63,000 feet for up to 26 hours.
  - **HAMSR**: High Altitude Monolithic Microwave Integrated Circuit (MMIC) Sounding Radiometer, which measures the 3D distribution of temperature, water vapor, and cloud liquid water
  - **HIWRAP**: High Altitude Wind and Rain Airborne Profiler, which measures precipitation, and wind speed and direction
  - **LIP**: Lightning Instrument Package, which measure lightning, electric fields and fluxes, and air conductivity

- **DC-8**: Airborne science laboratory with a range of 5,400 nautical miles at altitudes from 1,000 to 42,000 feet for up to 12 hours.
  - **APR-2**: Airborne Precipitation Radar duel frequency, which measures the vertical structure of precipitation and cross-aircraft-track winds
  - **CAPS, CVI, PIP**: Measure cloud particle size and distribution, precipitation rate, and liquid and ice water content
  - **DAWN**: Doppler Aerosol Wind Lidar, which measures vertical profiles of horizontal winds
  - **LASE**: Lidar Atmospheric Sensing Experiment, which measures water vapor and aerosol profiles, and ice water content
  - **MMS**: Meteorological Measurement System, which measures in-situ pressure, temperature, and 3D wind and turbulence

- **WB-57**: Airborne science laboratory with a range of just over 2,000 nautical miles at altitudes up to 65,000 feet for approximately 6.5 hours.
  - **HIRAD**: Hurricane Imaging Radiometer, which measures surface wind speed over water

FOLLOW-UP MISSIONS

After GRIP concluded, NASA carried out a multi-year airborne campaign to study the lifecycle of hurricanes: the Hurricane and Severe Storm Sentinel (HS3). HS3 flew two Global Hawks during the Atlantic hurricane seasons from 2012 to 2014. The data and observations from HS3 helped scientists further determine that dry air and dust do not necessarily mean a hurricane will not intensify, and that the development of storm symmetry may be a precursor to rapid intensification.

Without GRIP, HS3 would not have had the same amount of technological expertise for operating the Global Hawk over hurricanes, as well as many of the instruments they carried, such as the HIWRAP and AVAPS. Some of these technologies are now being tested for operational use by NOAA to forecast future hurricanes.

NASA will fly another hurricane campaign this summer, the East Pacific Origins and Characteristics of Hurricanes (EPOCH) mission, to continue their work on the processes behind hurricane genesis and intensification.