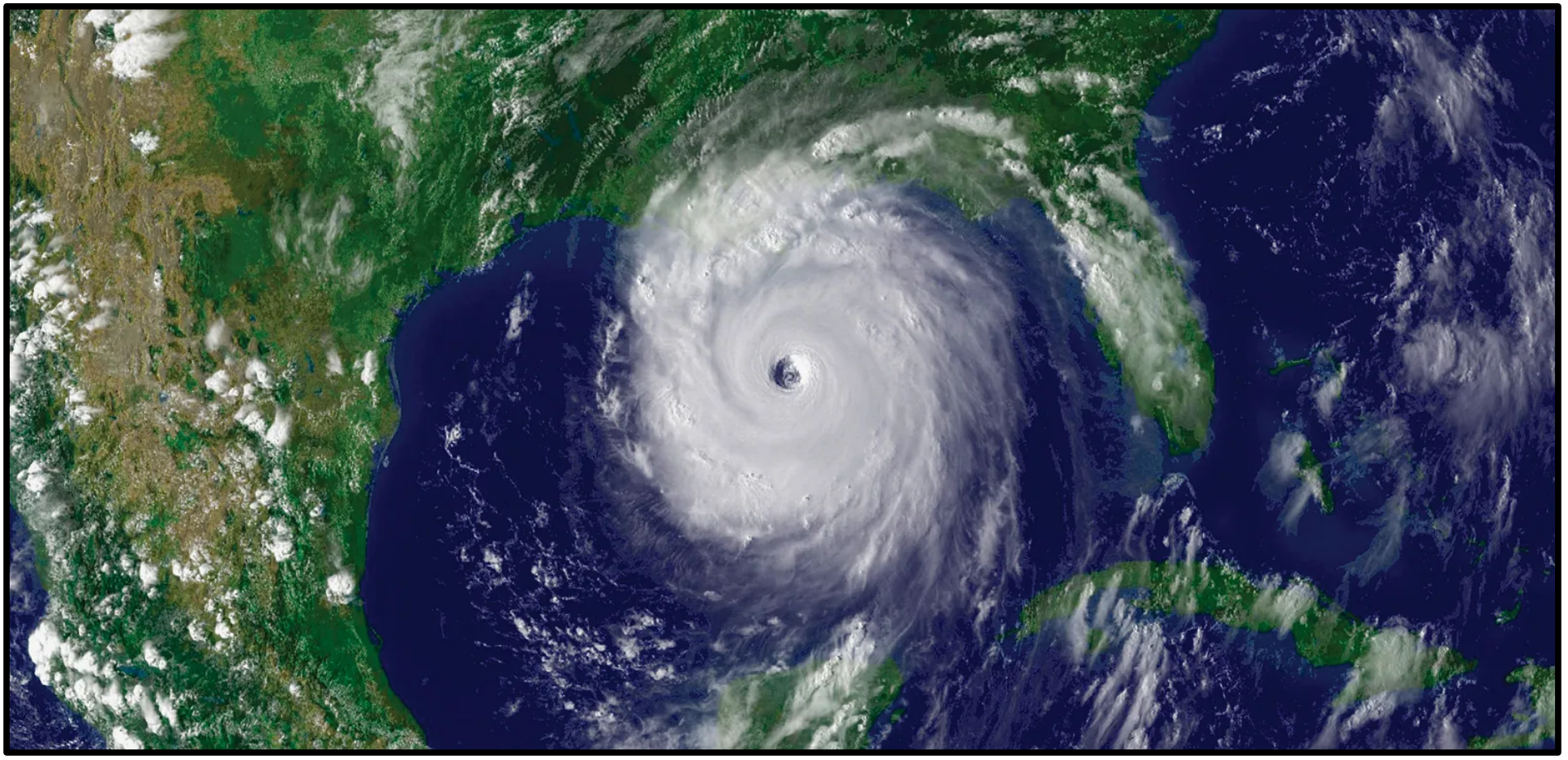
# Hurricane Modification



NOAA satellite image of Hurricane Katrina, taken on August 28, 2005

# Hurricane Formation

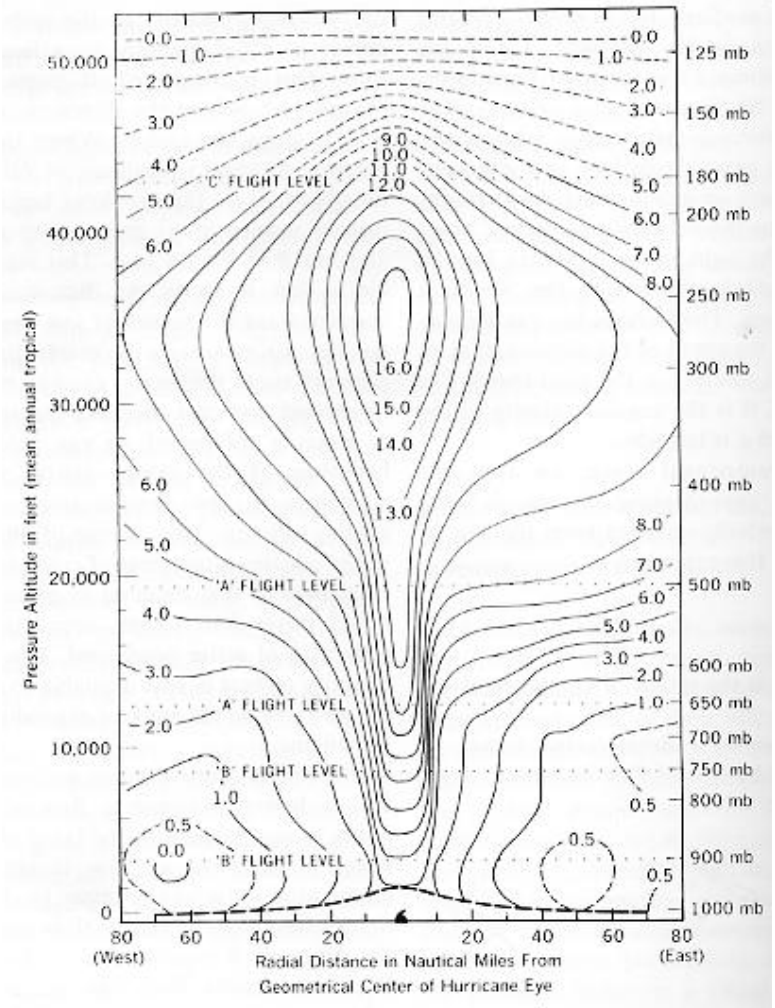
- Hurricanes (called typhoons in the eastern Pacific) form from tropical waves.
- These storms require warm ocean waters.
- Storm energy comes from latent heat of condensation.
- Hurricanes are warm core systems.

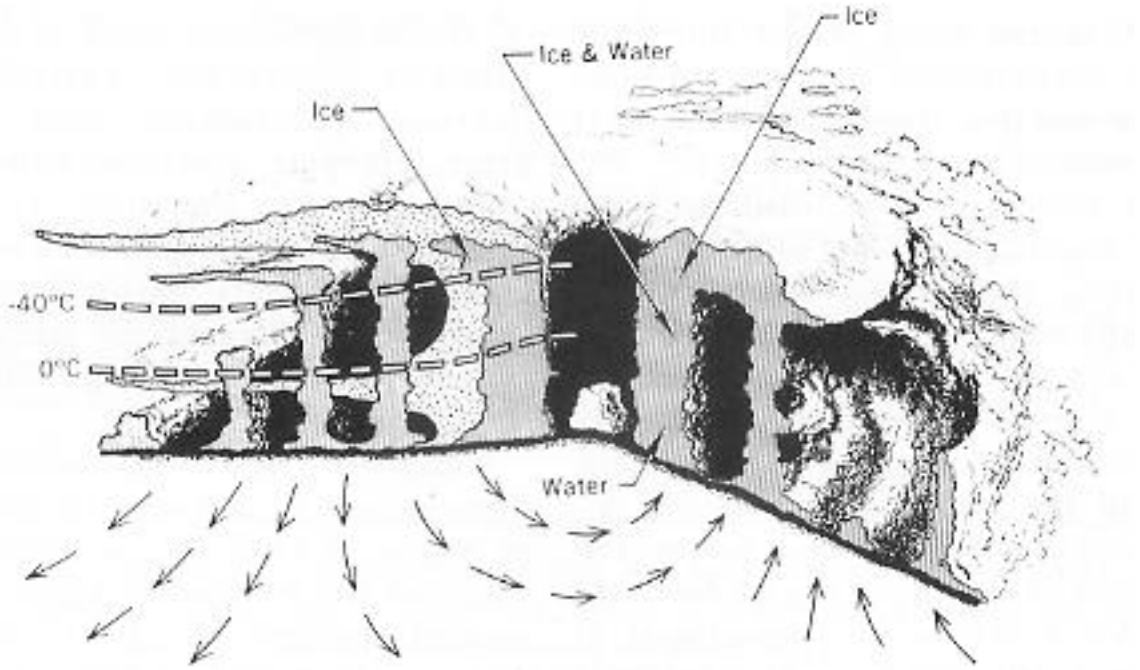
NASA – Hurricane Dorian

# Conditions for Hurricane Formation

- Ocean waters above 26 °C (79 °F).
- Close to the equator.
  - Spin Earth → Coriolis Force
- Saturated lapse rate gradient near the rotation center of the storm.
  - Latent heat will be released at a maximum rate.
- Low vertical wind shear, especially in the upper level.
  - Strong upper level winds destroy the storms structure.
- High relative humidity in the lower part of the atmosphere.
  - Dry mid level air impedes hurricane development.
- A tropical wave.
  - Thunderstorm complex that moves off Africa coast.

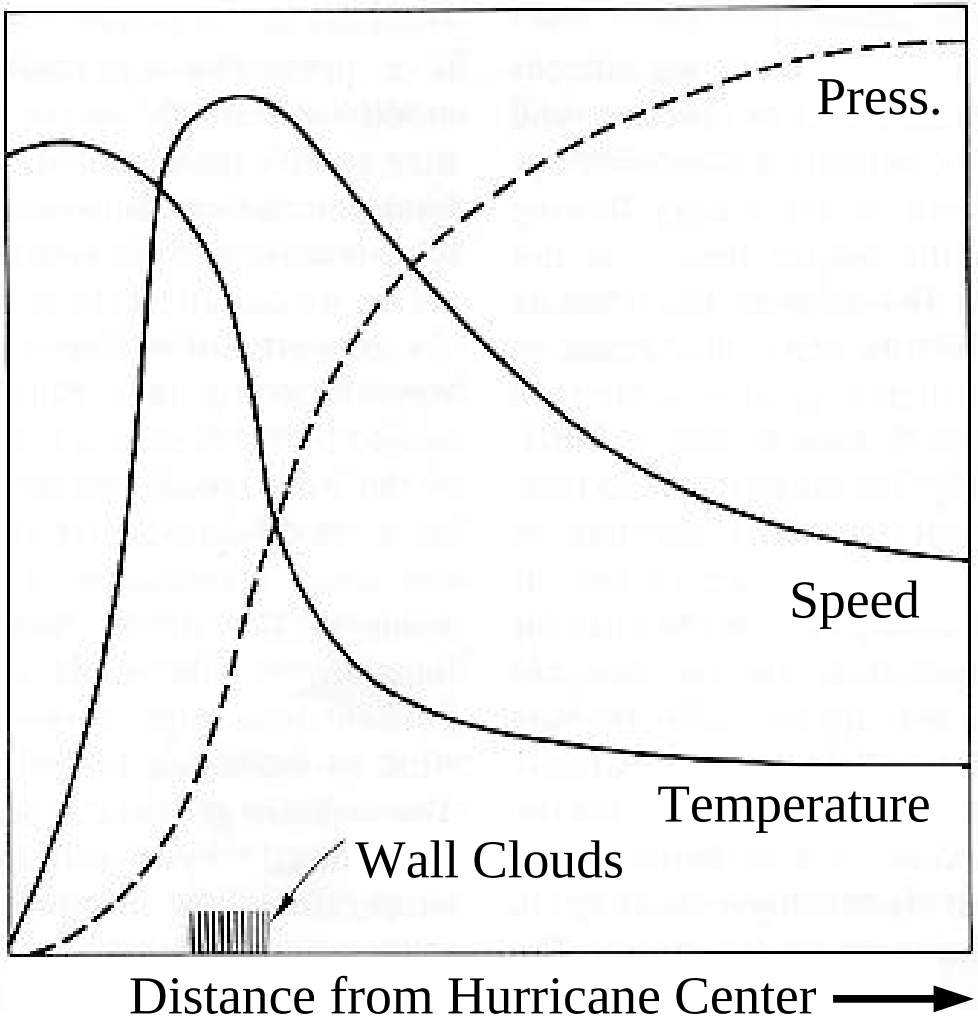
# Temperature and Storm Structure




- Key Features:
  - Eye, Eye Wall, Spiral Bands, and Outflow Cirrus

# Radial Profiles of Temp., Pressure, and Wind



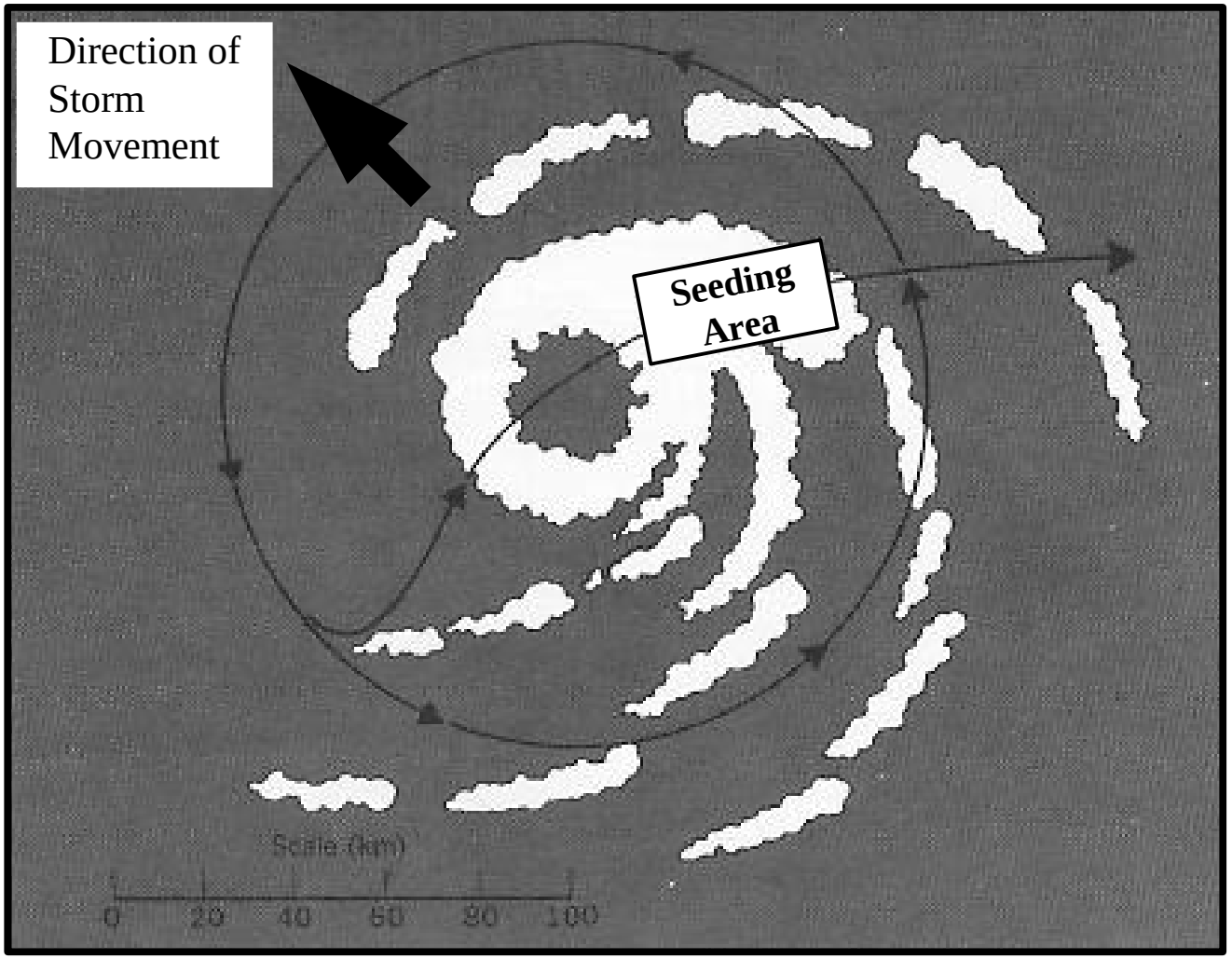
# Causes of Hurricane Damage Sources

- Wind
- Storm Surge
- Rain
- Tornadoes

# Hurricane Modification Hypothesis

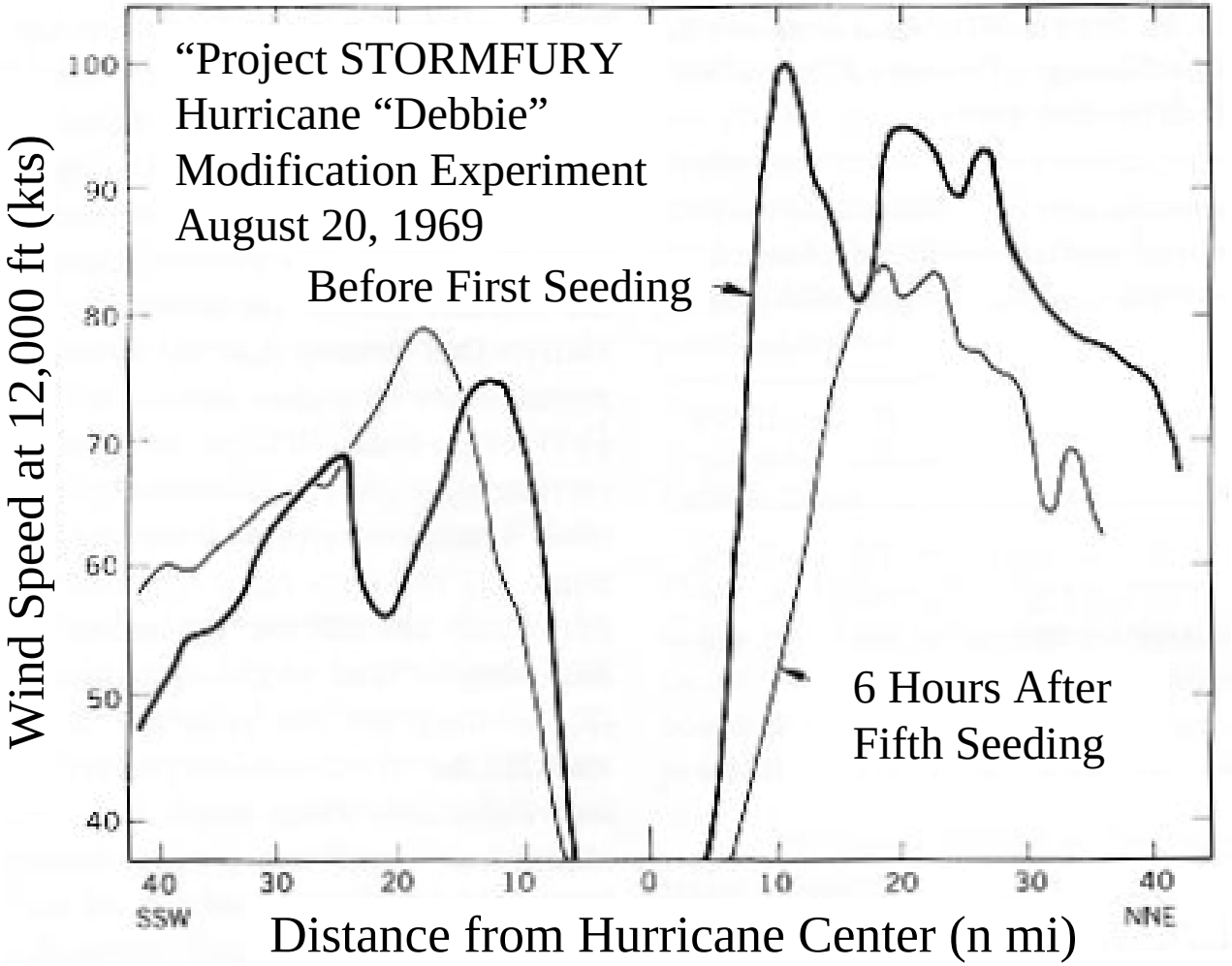
- Primary release of latent heat is in eye wall.
- If energy is released outside of eye less will be available to lower pressure.
- Eye wall will expand and maximum winds will decrease.
- Seed with glaciogenic material in spiral bands, releasing latent heat of fusion.

# Modification Aircraft Operations



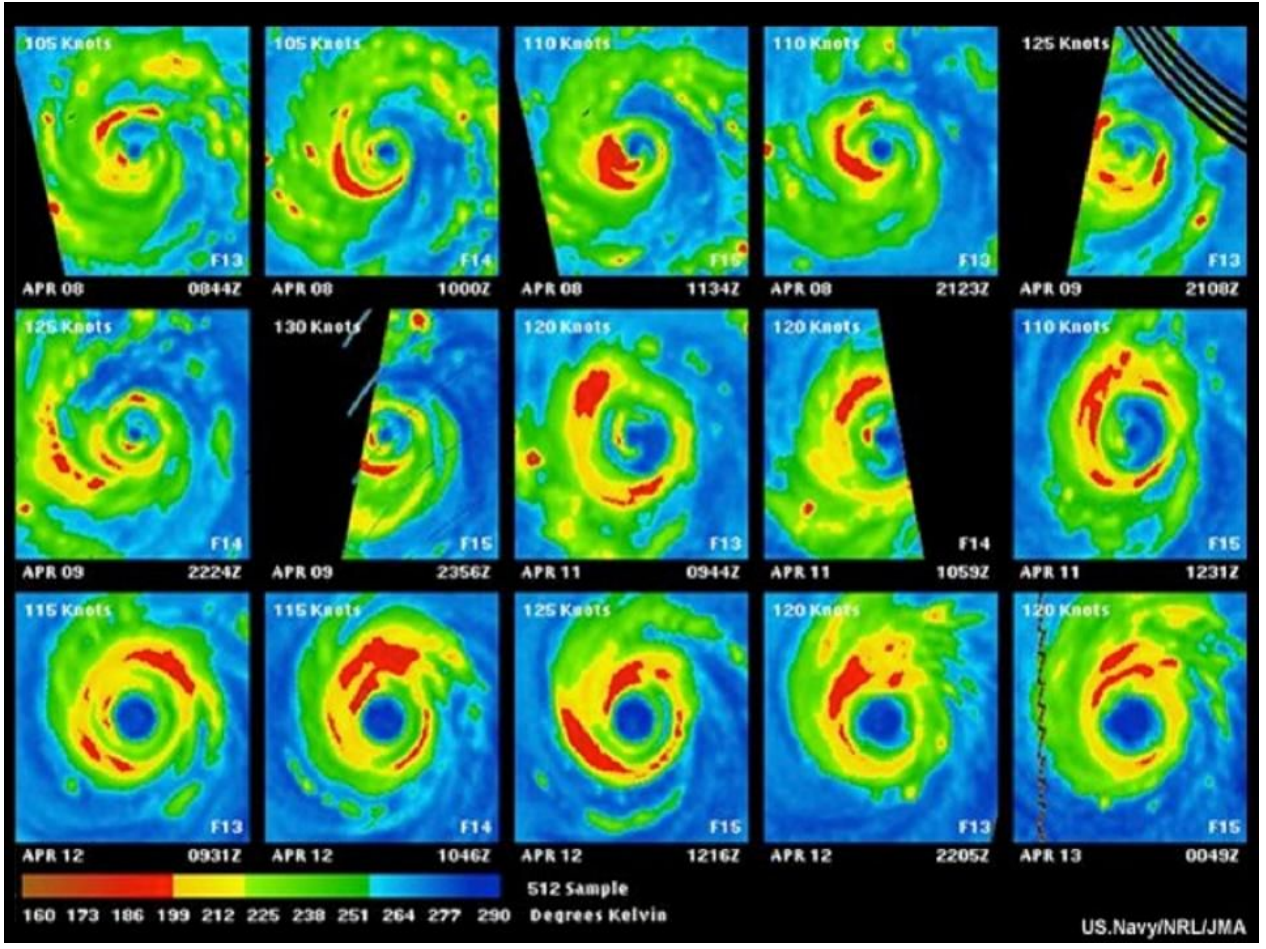
# Weather Modification Project Stormfury

- Conducted in 1960s.
- Actually seeded several hurricanes.
- Possible results noted.



# Project Stormfury Problems and Issues

- Hurricanes don’t really contain much supercooled water.
- Hurricanes naturally go through life cycle changes like those observed in seeded storms.



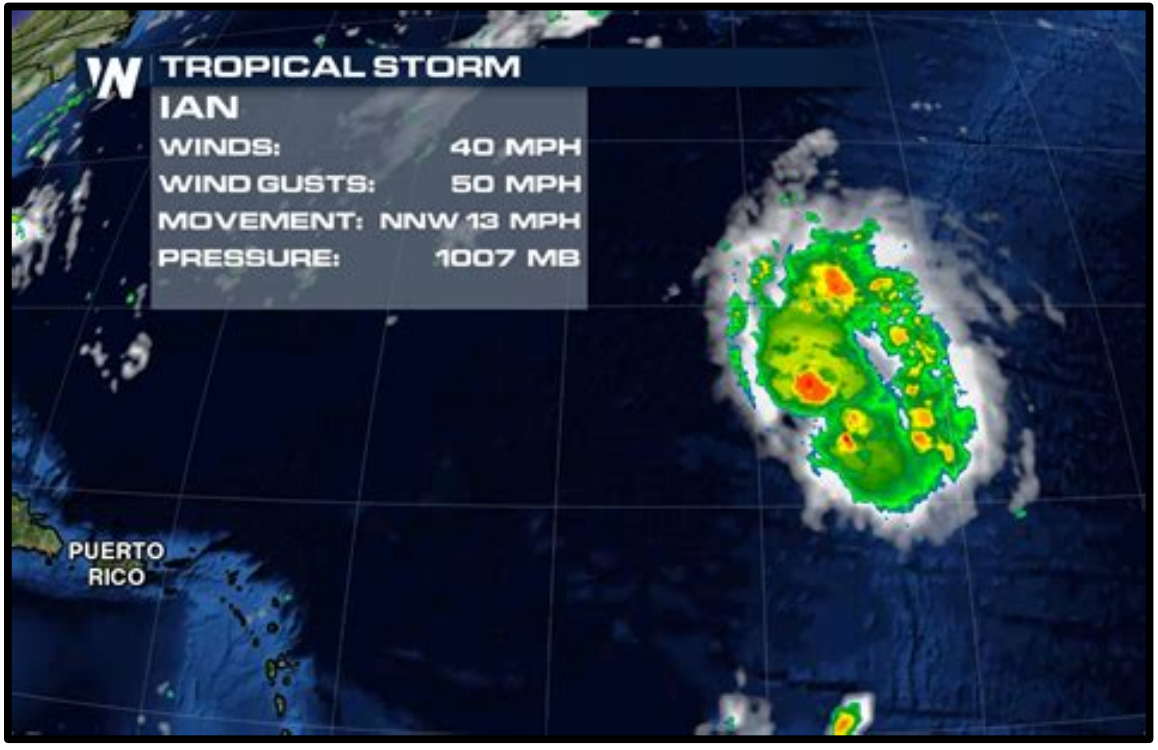

Hurricane Matthew Completing an Eyewall Replacement Cycle.

# Other Hurricane Modification Hypotheses

- Cooling the ocean with cryogenic material or icebergs.
- Retardation of surface evaporation with monomolecular films.
- Changing the radiation balance in the hurricane environment by absorption of sunlight with carbon black.
- Blowing the hurricane apart with hydrogen bombs.
- Releasing huge quantities of moisture-absorbing gel (Dyn-O-Gel) into the storm to remove water.

# Issues with Hurricane Modification

- Delivery of seeding material.
- Storms occur far from land.
- Lots of material required.
- Liability.
- Possible test cases limited.
- Hurricane rains are also beneficial.

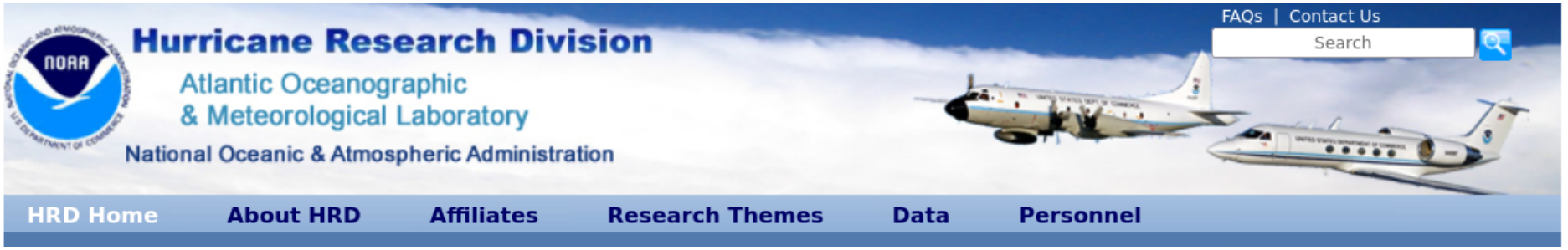



Tropical Storm Ian Forms in Atlantic

# Hurricane Modification and Myths

## NOAA Hurricane Research Division:

## Tropical Cyclone Modification and Myths

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### Frequently Asked Questions

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**version 4.11**
**June 1, 2018**

**C : TROPICAL CYCLONE MODIFICATION AND MYTHS**

Text version of TROPICAL CYCLONE MODIFICATION AND MYTHS

- C1) Doesn't the low pressure in the tropical cyclone center cause the storm surge?

TC FAQ

- Basic Definitions
- Cyclone Names
- Cyclone Myths
- Cyclone Winds
- Cyclone Records
- Cyclone Forecasting
- Cyclone Climatology
- Cyclone Observation
- Real Time Info
- Historical Info
- Cyclone Prep
- Hurr. vs Tornado

# Hurricane Irma (Radar Loop)