Introduction to Climatology

GEOGRAPHY 300

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Tropical Storms and Hurricanes

Much of this PPT derived from presentation by Thomas Schroeder

Hurricanes in Hawaii

Hurricane Iniki,
2 PM HST on September 11, 1992

Hurricane Iniki

See Iniki video
Iniki Damage

Hurricane Iniki

Human Impacts
- $2.8 Billion
- Average Annual Net General Fund Revenues for 2002-2004: $3.7 Billion
- 90% of structures on Kauai affected
- 14,118 structures damaged or destroyed
- 30% of utility poles down
- 3 years later unemployment 12%

Hawai‘i Hurricane Myths
- It never happened before
- Only Kauai gets hit
- It can’t happen again
- Mountains protect us
- No Hawaiian word for hurricane

What is a Hurricane
- Tropical Cyclone – generic term
- US definition:
  - Depression: Winds less than 39 mph
  - Tropical Storm: Winds greater than 39 mph and less than 75 mph
  - Hurricane: Winds greater than 75 mph
A Question of Scale

1980 Winter Storm vs. Hurricane Iniki

Triple Threat in Hawaii

High winds
Flying debris
Flash Floods
Storm Surge
Large Surf

Debris Line from Iniki

Hawaii Hurricane Impacts

Tropical Cyclone tracks within 200 miles of the Hawaiian Islands since 1949.
General Things Meteorologists Care About

- When and where will they form? Genesis
- How strong will they be? Intensity
- Which way will they go? Motion

A Brief Discussion of Genesis

- Tropical cyclones are rare
- Roughly 80 per year worldwide
- Assume a one week life span
- Result – 1-2 storms any day in an area half the surface area of the planet
- Reason – you need to bring 6 factors together to produce a storm

Requirements for Genesis

- All must be met
- Warm waters (~ 80 deg F or more)
- Low variation of winds with height (shear)
- Latitude high enough for “spin”
- Deep moist atmospheric layer
- Instability to allow thunderstorms to develop
- A pre-existing disturbance

Tropical Cyclone Structure
Temperature Distribution
Tropical Storms Have Warm Core
Air temperature difference relative to surrounding air at the same level

Pressure Distribution

Circulation

Warm Water Requirement
- Surface air converging toward the storm center
- Air is flowing from high pressure to low pressure
- Pressure decrease causes adiabatic cooling
- Without abundant heat source at surface, cooling air would reduce temperature gradient and weaken the storm
ENSO and Tropical Storms in Hawai‘i

- Nina was one of several 1957 storms near Hawai‘i
- 1957 was also the International Geophysical Year (IGY)
- 1957 was an El Niño year
- 1972 major El Niño that wiped out the Peruvian anchovy fishery
- In 1972 Hawai‘i had 2 near misses, Hurricanes Celeste and Diana
- 1976 Moderate El Niño. Hawai‘i threatened by Hurricane Kate
- 1982 Strong El Niño. Hurricane Iwa formed south of islands, brushes NE Kauai, results in $250 M damage
- 1986 Moderate El Niño. Estelle major event (wave action) for Big Island.

Hurricane Season

- 1992 Part of prolonged El Niño event. Iniki
- 1994 Continuation of warm event. Three category 5 storms south of islands. Emilia was the most intense storm in Central Pacific history
- 1997 Major El Niño. Hawai‘i has no direct hits, but Guam hit by “Paka”, storm formed SW of Hawai‘i. Hits Guam as super typhoon.
ENSO and Tropical Storms in Hawai‘i

• El Niño years correspond to a greater number of tropical cyclones in the Central Pacific
• Reason: The equatorial wind systems shift bringing the west Pacific genesis region eastward into the Central Pacific

Global Warming and Tropical Cyclones

• 2005 Atlantic hurricane season stirred public awareness
• What effects will warming have?
  • More storms?
  • More strong storms?
  • Stronger storms?
  • Larger affected regions?

Global Warming and Tropical Cyclones

• Emanuel (2005): Increased duration of intense TCs in the Atlantic and NW Pacific
• Curry et al. (2005): Increased frequencies in CAT 3-5 storms in all basins globally, correlated with SST rise
• Landsea (2005): Showed some weaknesses in the global claims of Curry et al.
• Debate focuses largely on North Atlantic
Global Warming and Tropical Cyclones

- MPI is a function of temperature of surface inflow air and upper-level outflow air

Global Warming and Tropical Cyclones

- Increased SST (proxy for surface air temperature)
- Decreased lower-stratospheric temperatures
- Increased MPI
- Global Warming scenario produces both results, suggesting increasing MPI

Global Warming and Tropical Cyclones

- MPI Map for NE Australia region—31 January 2011

Global Warming and Tropical Cyclones

**Current Status:**
- Predicted MPI change with double CO2: +5%
- Up to now, the change should be +2%
- Debatable if such a small change would even be detectable