Hurricanes in Hawaii

Human Impacts

- Economy - To-date cost of Iniki
  - $2.8 Billion
- FY2005 Estimated General Fund Tax Revenues
  - $3.6 Billion

More Human Impacts

- Personal (My 1992 Christmas Card)
  - Denial
  - Survival (Failure to Evacuate)
  - Dislocation (major population movement)
More Iniki Impacts

- 90% of structures on Kauai affected
- 14,118 damaged or destroyed
- 30% telephone poles down
- 3 years later unemployment 12%
- Social fabric altered-10% move away

REMEMBER: This coincided with the bursting of the Japan Bubble Economy of the late 1980’s.

Typical Questions/Comments

- 1. It never happened before
- 2. Only Kauai gets hit
- 3. It can’t happen again
- 4. Mountains protect us
- 5. There is no Hawaiian word for hurricane

What is a Hurricane?

- Generic term – tropical cyclone
- U.S. Usage
  - Depression: Winds below 39 mph
  - Tropical Storm: Winds greater than 39 mph, less than 75 mph
  - Hurricane: Winds greater than 75 mph

A Question of Scale

1980 Winter Storm vs. Hurricane Iniki
High Resolution Visible Image of Erin

Radar Image of Andrew Eye

Triple Threat in Hawaii

Debris Line from Iniki
General Things Meteorologists Care About

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

Hawaii Hurricane History

- No “Hawaiian Term” actually no surprise terms such as Hurricane and Typhoon arise from local terms for the winds observed.
- David Malo (1843) defined five different Kona Winds.

History Continued

- In 1950 R.H. Simpson then chief meteorologist in Honolulu used the classification Hurricane for Hurricane Hiki which passed North of Kauai and was primarily a rain event.
- He published an article on Hiki that year one of his several significant contributions to Hawaiian Meteorology (others: first publications on Kona Storms, Volcanic Haze, aka VOG and founding of Mauna Loa Observatory).

Hawaii Hurricane Impacts

Tropical Cyclone tracks within 200 miles of the Hawaiian Islands since 1949.
Next major event was Nina 1957
Late November (29-30) event
One of several that year
Occurred during the International Geophysical Year (IGY)
Was during the first well-observed El Nino
Formed south of Hawaii moved north, veered off to the west
Still the record wind at Honolulu Airport (NE)

Star-Bulletin of December 1, 1957:
Headline “Nina Blasts Hurricane Safety Myth”
“We may never see the like of Nina again in 50 years”
“The British Admiralty Weather Glossary says hurricanes do not occur in the eastern North Pacific” (note: Nina was 4th storm of 1957)

1959 August Dot the statehood hurricane
Formed SE of Hawaii (SS Sonoma stumbled upon it)
Peak intensity of 130 knots early in its life
Weakening storm transited Kauai channel
Eye probably east of Lihue
$6 M damages
The Satellite Era

- TIROS 1  April 1, 1960
- The eastern North Pacific rapidly rose in prominence to status of world’s second most active basin (second only to western North Pacific).
- Sadler finds numerous unidentified systems in post season analyses.

History (Looking Back)

- The 1960’s and 1970’s were relatively quiet save for passing storms most notably 1972 and 1976
- 1978 was very active featuring Fico (July) and Susan (October )
- This prompted Samuel Shaw of National Weather Service, Honolulu to undertake a historical study.

Shaw’s study published in 1981 provided a history of central Pacific tropical cyclones from 1832 through 1979
- This was detective work, using old shipping logs, newspaper accounts, etc.
- Problems included
  - Offshore storms may only show as a surf report
  - Ships encountering significant storms may not have survived the encounter
  - No anemometry (no wind speeds known)

Significant Shaw Findings

- A period of significant events in the late 1860’s and early 1870’s. Including the Kohala Cyclone of 1871 (more about it later) BIG ISLAND AND MAUI
- The Mokapu Cyclone of 1938 (tropical storm intensity, arrived unannounced one morning ) AN OAHU STORM
The Kohala Cyclone
August 9, 1871
- Accounts from The Hawaiian Gazette, published in Honolulu by M. Raplee, Director of the Government Press
- August 16 and 23 issues
- Personal accounts:
  - Mr. Baldwin, manager of Kohala plantation
  - "a fearful "tornado" swept through the district spreading desolation and ruin in its track, demolishing Mr. Wright’s mill building and a large portion of the thatched houses in the district, throwing down our flume, uprooting large trees, and prostrating our cane fields"

More Kohala Cyclone
- Baldwin describes counterclockwise shifting of the winds over a 3 hour period
- Rev. Mr. Bond corroborated the account of Mr. Baldwin and adds details of damage, including mango tree damage which would be equivalent to category 3 Typhoon.
- Similar accounts from Maui including:
  - Captain Makee “It was blowing one of the most fearful hurricanes I ever experienced”
  - Mostly a rain event at Lahaina, though wind “shrieking like 5000 steam whistles”
  - Winds subsided at 5PM

Storm damage estimated up to $10,000 dollars on Hawaii
Reconstructed track has storm hitting Hamakua coast and recurving over Maui and possibly effecting Molokai

The Mokapu Cyclone
August 18-19, 1938
- Broke 50 year record for Honolulu August rain
- Lowest barometer reading since establishment of “Weather Bureau” Office in 1904 (1008 mb)
- “Whole gale” 60 mph at Pan Am Radio Station at Mokapu
- Other than power outages and some vegetation not much damage
Back to the “modern era”

- Nina was one of several 1957 storms near Hawaii
- 1957 was also the year of the International Geophysical Year (IGY)
- 1957 also (coincidentally) was an El Nino year

Back to the “modern era” (cont)

- James Sadler then of the Air Force working with Colin Ramage and the nascent meteorology program at UH began to “connect the dots” on El Nino, large-scale circulation (aka winds) changes and central Pacific tropical cyclones

Some Subsequent Events

- 1972 The El Nino that “killed” the Peruvian anchovy fishery. Hawaii bracketed by Hurricanes Celeste and Diana (Hawaii dodged bullet, Johnston Island was nailed).
- 1976 Moderate El Nino. Hawaii threatened by Kate. Cirrus visible from Hilo
- 1982 Strong El Nino. Iwa forms south of islands (similar to Nina), unlike Nina charges north recurves to NE brushes Kauai, Oahu results $250 M
- 1986 Moderate El Nino. Estelle major event (wave action) for Big Island
And the Beat Goes On

- 1992 Part of a pro-longed (confusing) multi-year event. Iniki
- 1994 Continuation of warm period three category 5 storms south of islands. Emilia the most intense in Central Pacific history with resulting false alarm
- 2002 Pongsana replicates Paka. Disturbance formed in Central Pacific, crossed dateline

General Conclusion

- El Nino years correspond to greater number of tropical cyclones in the Central Pacific.
- Why? The shift of the equatorial wind systems brings the west Pacific genesis region eastward into the Central Pacific.

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

- 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
The Insurance Crisis of 1993

- Pre-Iniki “Hurricane” wind peril coverage was an add-on to fire and theft.
- Iniki wiped out all profits of the homeowners insurance industry in Hawaii since its founding.
- Hawaii is a small revenue source for big firms and provided a disproportionately large loss.
- Iniki occurred within 18 days of Andrew (Miami) and Omar (Guam).
- The global re-insurance industry was reeling.
- In both Florida and Hawaii companies went bankrupt or attempted to withdraw.
- Serious problems for the real estate markets.
Band Aid Solutions

- Florida created a catastrophe fund which is a re-insurer.
- Florida also created a wind pool (insurer of last resort) for high-risk properties (think east of I-95 in Miami).
- Hawaii created the Hawaii Hurricane Relief Fund (sounds like a Red Cross operation), a primary insurer.
- The HHRF filled in until the industry recovered.
- Now in repose, still on the books

Risk Modeling

- Issue: events like Hurricanes are very rare, Iniki is at least a centennial time scale event
- Normal actuarial techniques are not applicable
- In 1985 Karen Clark founded Applied Insurance Research and presented the first Hurricane risk model

Risk Modeling (cont)

- A model consists of
  1. A peril. Here a hurricane
  2. The model simulates a massive number of hurricanes by projecting forward perhaps 100,000 years using statistical approaches.
  3. The model then assesses impacts upon a portfolio of properties (vulnerability).
  4. The model then applies actuarial functions to produce insured losses.
  5. Based upon these projected losses, rates are determined.

Risk Modeling (cont)

- These went over like the proverbial lead balloon.
  1. The methodology is strange to those familiar with traditional insurance practice (think life insurance).
  2. Everybody’s rates were going up.
  3. Insurance companies are evil anyway.
Florida created a Commission on Hurricane Loss Projection Methodology.
Commission reviews models for use in the State of Florida.
Due to Sunshine Laws, modeling companies resist public presentation of trade secrets.
Florida Commission created a professional team to conduct on site audits.

The Florida Professional Team consists of a lead and back-up in the areas of:
- 1. statistics
- 2. meteorology I was lead, now back-up
- 3. structural engineering
- 4. actuarial science
- 5. computer science

The Pro Team signs non-disclosure forms.
We audit against standards developed by the Florida Commission via a public process.
We file reports on our findings.
We attest to our findings in public hearings.
We work with the Commission to develop new, improved standards (raising the bar).

Hawaii uses a simpler process.
Three consultants are retained:
- 1. A meteorologist
- 2. A structural engineer
- 3. An actuary
1 and 3 are both members of the Florida Pro Team.
The consultants review applications of the models to the Hawaii situation.
The first question asked is whether or not the model has been accepted in Florida.
**Global Warming Is Real**

- The devil is in the details of the impacts
- A recent survey reported in the New York Times indicates that the US public (at least those surveyed) identify increased tropical cyclones and associated damages as the number one impact of global warming.

**Key Questions for the Future**

- 1. Will there be “more intense” TC’s
- 2. Will there be more “intense TC’s”
- 3. Will there be more TC’s overall
  (Too date little concern over track??)

**History**

- The storms of 1992 Miami, Hawaii, Guam
- The insurance crisis and the rise of risk modeling
- Climate connection first raised
- 2004 4 Major Hurricanes – Florida
- 2005 Katrina
- Worsening Insurance crisis

**The Scientific Debate**

- 2005 Two key papers in Nature and Science
  - Emanuel: Increased duration of intense TC’s in Atlantic and Northwest Pacific
  - Curry et al: Increased frequencies in CAT 3-5 storms in all basins globally, correlated with SST rise
Subtlety

- Intergovernmental Panel on Climate Change cut-off for recent report was 2005.
  
  No later literature could be used.

Rebuttals

- Some were reasoned, some were nasty and personal
- Landsea (2006) showed some weaknesses in the global claims of Curry et al. Serious debate ensued over quality of global databases.
- Most parties have now focused the debate on trends in the North Atlantic
- STORM WORLD

Intensity/MPI

Emanuel (1986,1988) developed theory of MAXIMUM POTENTIAL INTENSITY or MPI

Basically MPI is function of temperatures of surface inflow air and upper-level outflow air.
MPI (Cont)

- Increased SST (proxy for Surface air) and
- Decreased lower-stratospheric temperatures
- Increase MPI
- Global Warming scenario produces both results thus theory suggests increased MPI

Current Status

- Predicted change in MPI under a CO2 doubling scenario is ~ 5%
- To date should be ~ 2%

PRETTY SMALL NUMBER!!!
Detectable???

MOST TC’s NEVER ACHIEVE MPI

Nature Conspires to repress TC’s

To generate a TC we must pile a lot of warm air in a vertical column
Hydrostatics lead to pressure fall and spin-up.
A number of conditions must be met, no one of which is sufficient

Observational Issues

1. How well do we assess intensity?
2. How have techniques changed?
3. Are the data statistically homogeneous?
4. How long are the time series?

Consensus: Only the North Atlantic data are considered robust. However debate continues even on that one. (3 recent EOS papers).
Political/Observational Issues

The mystery of “existence” of a TC.

Ex. TS Winona (1988)
Ex. Non-event of May 1997
Ex. TD 4C (2006)

Science and Policy

Often science takes longer than policy makers would like.

In the Hurricane case a number of factors are in play already… especially insurance issues. Florida and Hawaii since 1992 but now even Massachusetts. Develop of “short-term” risk models.

The Hawaii Case

Relatively few storms annually and historically.
Serious Infrastructure issues.
How can we project the future:
1. General Circulation Models may or may not simulate “storms”
2. Analysis of GCM outputs for the key genesis factors

Hawaii Case (cont.)

3. No one has considered “track” but GCM’s and regional climate models should be able to produce steering winds.
The capabilities to do the analyses above reside within SOEST, esp. IPRC
SOME CURRENT REALITY

Climate change notwithstanding we have a problem:
1. Coastal populations expanding
2. New Orleans was identified as “at risk” long before any climate change issues

HAWAII REALITY

1. Sea level is rising.
3. We can’t shelter our current population.

IT IS PRUDENT TO ACT TO MITIGATE THE IMPACTS OF CURRENT EVENTS

Conclusions

1. MPI theory is sound, increased MPI a logical future
2. Number changes at best indefinite
3. For Hawaii we really should look at track
4. Many policy responses are prudent even in the absence of climate change
5. If the current furor promotes responsible, necessary societal responses, GOOD!!