Report on the 'Aha Huliko'a workshop on extreme events

Held 23-26 January 2007, Honolulu, HI

Jeff Yin National Center for Atmospheric Research Extremes Reading Group 23 May 2007

Goals for this report

- Provide some background on this extreme events workshop
- Describe the group assembled for the workshop
- Share some highlights from the workshop
- Summarize the important points of discussion at the workshop
- Give you experience of having been at the workshop without the trouble of spending a week in Hawai'i to attend it

What are 'Aha Huliko'a workshops?

- According to workshop website: " 'Aha Huliko'a is a Hawaiian phrase meaning an assembly that seeks into the depth of a matter."
- Translation deemed reasonable by a couple of friends who study the Hawaiian language
- Workshops held every 1 or 2 years on specific topics in physical oceanography (15 held so far)
- Funded by Office of Naval Research and University of Hawai'i Department of Oceanography

How did this workshop come about?





http://www.math.uio.no/~karstent/waves/index_en.html

- Previous 'Aha Huliko'a workshop on rogue waves
- Defined as 2X significant wave height (4σ)
- Picture: 25 m wave hitting oil freighter in 5-10 m seas
- Figure: Wave height from North Sea (New Year's wave)

Workshop on extreme events

- Organized by Peter Muller (PI) and Chris Garrett
- Focus on statistics, dynamics, and predictability of extreme events
- Statistics:
 - Non-stationarity and regime shifts
 - Going beyond Gaussian, iid random variables
- Dynamics
 - Special physics?
 - Limiting processes?
- Predictability
 - Deterministic vs. statistical predictions

Who attended this extremes workshop?

- Small workshop: 24 scientists in all
- About half oceanographers
 - Mostly physical; 2 with biogeochemical interests
 - Included Jim McWilliams and Carl Wunsch
- A few atmopsheric/climate scientists
 - Kerry Emanuel, Michael McIntyre, Hans von Storch, Tapio Schneider...and me
- A few fluid dynamicists
- 1 statistical physicist
- 2 statisticians: Richard Smith, Jay Kadane
- 1 social scientist: Roger Pielke, Jr.

What was I doing there?

- Claudia Tebaldi was originally scheduled to go, but couldn't make it and offered her spot to me
- She was going to talk about extremes in global climate models (GCMs), so I took that topic and ran with it
- My presentation:
 - I presented some general results on extremes in GCMs, including work by Claudia, Jerry Meehl, et al.
 - I did mention the extremes reading group at NCAR
 - Then I talked about my work on extreme wind events in GCMs
 - My main contributions:
 - Asking when GCMs are appropriate for studying extremes
 - Trying to stop arguments about "What is an extreme event?"

Motivation: Extreme wind events



• Extreme windstorm Kyrill (18-19 January 2007)

- Wind gusts up to 134 mph (216 kph), 85 mph in populated areas
- At least 47 deaths, estimated \$5-10 billion in damage

After lunch on the first day, on sea level extremes:

- Keith Thompson (Dalhousie University, oceanography and statistics):
- Mark Merrifield (University of Hawai'i, oceanography):

After lunch on the first day, on sea level extremes:

- Keith Thompson (Dalhousie University, oceanography and statistics):
 - Introduced Generalized Extreme Value (GEV) approach in studying sea level extremes
 - Divided into dynamical part (tides) and residuals (storm surges)
 - Used GEV approach only to model tidal residuals
 - 2 highest sea levels not from biggest storm surges, but combination of storm surge and high tide; don't need to get that far into tails of residuals to get extremes, need less data
 - Also: Markovian model of residuals (based on previous residual)
 - Dynamical model could account for climate change (global sea level, atmospheric forcing, river runoff, etc.)

After lunch on the first day, on sea level extremes:

- Mark Merrifield (University of Hawai'i, oceanography):
 - Showed news report on extreme sea level in Hawai'i due to combination of high tide, anticyclonic eddy
 - Trend in extreme sea levels in Honolulu: Waikiki Beach will be under water 3-4 months a year by 2100, based on linear trend

The statisticians:

- Jay Kadane (last on first day)
- Richard Smith (first on second day)

The statisticians:

- Jay Kadane (last on first day)
 - Frequentism vs. personalism (Bayesian philosophy!)
 - Can't describe probability of rain tomorrow as a frequentist
 - Prior assumptions in statistical model are often personal choice, and are important for probabilities calculated from data
 - An extreme event is an event in the tail of *my* probability distribution for it; whether it is extreme is a matter of opinion!

The statisticians:

- Richard Smith (first on second day)
 - Presented work on precipitation extremes from rain gauge data and CCSM (NCAR climate model)
 - Provided group with second exposure to GEV approach
 - They were starting to buy it, and realize the value of being able to include covariates in the GEV approach (season, ENSO, etc.)

Before lunch on second day (right after me)

- Hans von Storch
- Roger Pielke, Jr.

Before lunch on second day (right after me)

- Hans von Storch
 - Caution on use of statistics in climate science (like Wunsch)
 - Stated that no serious science backs up claims about stronger storms (in Europe) due to a warming climate so far, but expects to see stronger storms by 2100
 - Most exciting part: Commentary on the social rewards of *Nature* and *Science* publications, and attention for taking exciting results to the media
 - Said science will correct itself in time, but errors now immediately go into the media

Before lunch on second day (right after me)

- Roger Pielke, Jr.
 - Made case that increases in hurricane damage are due more to societal changes (greater wealth, more building on coast) than climate changes
 - "Basing public policy on return periods is absurd"
 - Surveyed hurricane experts (on period 2050-2100):
 - Change in hurricane frequency: -20% to +20%
 - Change in hurricane intensity: 0 to +18%
 - Said scientists can make more of a difference by coming up with new policy options, rather than arguing for one existing policy option over another

Before lunch on third day:

- Kerry Emanuel
- Michael McIntyre

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- Kerry Emanuel
 - Theoretical upper bound on hurricane maximum wind speed based on SST (enthalpy difference between SST and air above)
 - 10% increase in hurricane potential intensity \rightarrow 65% change in power dissipation index, due to greater strength and duration
 - Predicted that stronger future hurricanes would increase thermohaline circulation via increased subtropical mixing
 - Perhaps this made the poles much warmer during the Eocene (supported by GCM experiment with state-dependent mixing)
 - And the effect of hurricanes on ocean heat transport (or on anything else) is not in current climate models!

Before lunch on third day:

- Michael McIntyre
 - Was scheduled to speak on "The dynamical constraints on extreme events", but opted for a more philosophical talk on "Science and scientific uncertainty"
 - Fitting models in our minds is unconscious (see below)
 - From a Bayesian perspective: Unconscious priors
 - Our brains are interested in patterns where some things change while others stay the same ("organic change principle")

Themes for final day of discussion

- What is an extreme event?
- Extra physics
- Stationarity vs. regime shifts
- Impacts/predictability

What is an extreme event?

- This was a long discussion! (I tried to make it shorter)
- We had a tough time coming up with a definition
- Sarewitz and Pielke, Jr., (2001) definition:
 - "We define extreme events as occurrences that, relative to some class of related occurrences, are either notable, rare, unique, profound, or otherwise significant in terms of their impacts, effects, or outcomes."
- No universal statements about extremes could be made
- Consensus: Extreme events are context-dependent
- Agreed to create matrix: examples of extreme events vs. characteristics that some of these events had in common

Extra physics

- Large deviation theory (Oliver Buhler)
 - Evolution of extreme event looks like autocorrelation function
 - Applies to system that is Gaussian and random
- Does physics limit the size of extreme events?
 - Not in general, and might not be seen in reality
- There are phenomena (i.e., hurricanes) for which not getting the extremes means you can't get the mean

Stationarity vs. regime shifts

- To test for non-stationarity, need to agree on:
 - A prior
 - A statistical model
 - What data to use
- Test must be of a particular kind of non-stationarity
- Regime shift:
 - Could mean a change between two stationary states
 - Could mean a move to a different part of phase space
 - Could construct a statistical model where regime is a parameter
- Example: Climate change detection
 - Requires prior assumption about natural variability

Impacts and predictability

- Daily weather events can have impact
 - 13,000 annual excess deaths due to cold more than in Katrina
- How important are extremes for the mean state?
 - In distribution with long tail, extremes can dominate mean
 - Extremes in one variable (waves) may determine mean in another (coastal erosion)
- Predictability vs. robustness
 - Are you robust to all possible outcomes?
 - Need to say where uncertainties are, so they can be planned for
 - Distinguish uncertainty from ignorance
- Useful plot: Probability vs. impact
 - Important events are high impact but not too rare

...and then it was time for drinks!



The view from the Outrigger Canoe Club