Fundamentals of Communicating Uncertainty and Risk

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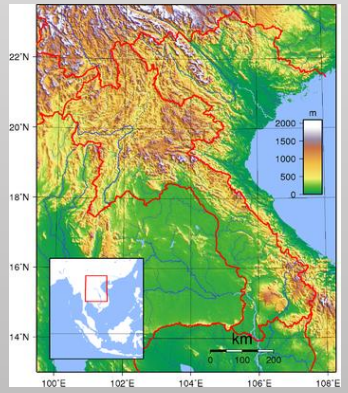
Some Comments on Forecasting

- Forecasting is difficult! It is basically trying to tell the future

- The forecaster needs to stack the odds in his or her favor as much as possible. How can you do that?

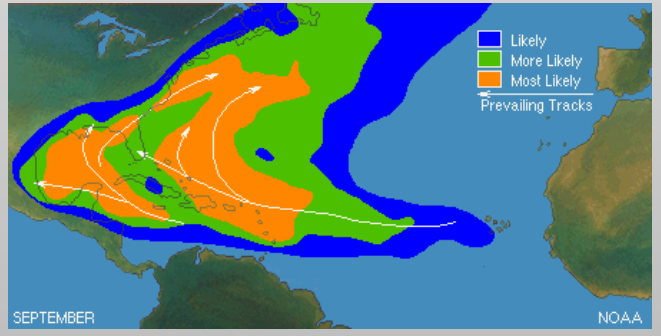
Some Comments on Forecasting

- The forecaster needs to stack the odds in his or her favor as much as possible. How can you do that?
  - Know your geography—it's a constant; it's free knowledge
    - It is important in weather behavior, e.g., orographic lifting
    - It ma be an important source of risk; e.g., a river or dam.
    - It builds credibility with customers; it shows you are aware of and even concerned about **their** location
    - It makes them feel that they are as important as any of your other customers



Some Comments on Forecasting

- The forecaster needs to stack the odds in his or her favor as much as possible. How can you do that?
  - Know your climatology—it's a key reference point; it's also free for the taking
    - Monthly changes are available and contain a lot of valuable information
      - e.g., the mean latitude of the 500 hPa ridge jumps almost 8 degrees latitude between June and July
      - the warm SSTs in the Pacific reach their farthest north latitude in September



Some Comments on Forecasting

- The forecaster needs to stack the odds in his or her favor as much as possible. How can you do that?
  - Know the weather situation
    - If you are on duty, no one should know more about the current weather situation and its uncertainties than you do
      - There are things you know that you know; e.g., accurate location of a typhoon
      - There are things that you know that you don't know; e.g., exact intensity of the typhoon
      - There are things that may be important that you don't know that you don't know; e.g., will a 2° change in temperature in Korea today affect the typhoons motion in 3 days?

Some Comments on Forecasting

- The forecaster needs to stack the odds in his or her favor as much as possible. How can you do that?
  - Know your forecast tools and always look for better ones
    - Know their strengths and weaknesses: the fact that they have weaknesses is a source of uncertainty
    - Know what works best under what conditions
    - Know how to reflect the shortfalls into your forecasts/products

Some Comments on Forecasting

- The forecaster needs to stack the odds in his or her favor as much as possible. How can you do that?
  - Know your customers and their needs
    - This builds credibility
    - This builds team work—getting people to respond the way you want them to will require a team effort to ensure you get across a common message
    - It gives you knowledge about how to formulate words that work for that customer and for other customers
    - It builds mutual understanding of your challenges and their challenges
    - Unless the forecast information is communicated effectively to users, its full value will not be utilized

What People Want

- Most people want perfect or near perfect deterministic forecasts of the event. For tropical cyclones, this means an exact
  - Track and speed (motion vector)
  - Maximum intensity
  - Wind distribution
  - Storm surge height
  - Rainfall amount, intensity and distribution

- Deterministic means: “Just tell me if the typhoon is going to hit me or not and how bad it is going to be”

What People Can Get

- We can give them a deterministic forecast, but it will not usually meet their expectations
  - Confidence in the forecast and your credibility will suffer
  - This will lead to conflicting information instead of a consistent message
- We can give them a purely probabilistic forecast, but most users won't understand it
  - It won't be used or more likely it will be miss-used
- We can give them a disguised deterministic forecast, one that is modified by probabilistic inputs to communicate the inherent uncertainty
  - This is probably what all of us do to one extent or another

Communicating Forecast Uncertainty

- Why communicate forecast uncertainty?
- Sources of forecast uncertainty
- How to communicate forecast uncertainty and risk
- Application of probability forecasts by decision makers

Why Communicate Forecast Uncertainty?

- Benefits of communicating uncertainty
  - Helps users improve decision making
    - If they have options, it helps them choose the best one
      - Can be a simple option like what to wear today
      - Can be complex option like how much area to evacuate
    - Helps them prepare better contingency plans
      - Plans are based on a more quantitative idea of Risk
      - Better thresholds can be established
      - Helps them understand how risk can be low but significant; this is a difficult message to get out and can mislead the public

Why Communicate Forecast Uncertainty?

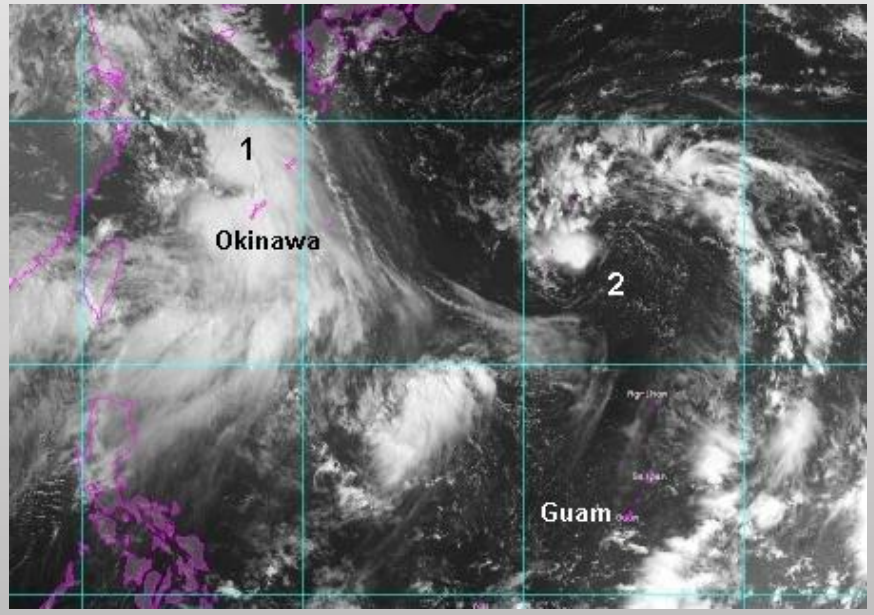
- Benefits of communicating uncertainty
  - Helps manage user expectations:
    - we tend to over-sell our capabilities
    - we are going to have “false alarms”, and they can deteriorate customer confidence and trust
    - we cannot actually give them what they want—a perfect deterministic forecast, but we can help give them what they need—a good probabilistic forecast
    - we have to help the customer understand how useful the product is and in some cases show him/her how to use it

Why Communicate Forecast Uncertainty?

- Benefits of communicating uncertainty
  - Promotes user confidence in the forecast agency through greater consistency of forecasts
    - Consistency is very important and uncertainty gives you some “wiggle room”
    - Changes in uncertainty may give us trends that can allow us to prepare the customer for an up-coming change with minimal loss of credibility
  - Reflects the state of the science
    - Fact: the atmosphere is inherently chaotic; use that knowledge to your advantage
    - Fact: observation coverage is insufficient in time and space; use that to your advantage
    - Fact: much of the data we depend on—radar and satellite—provides us indirect measurements

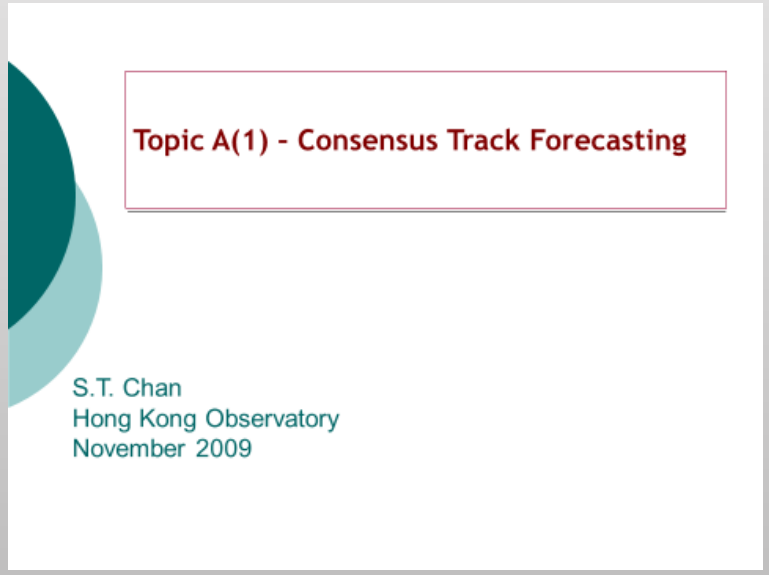
Sources of Forecast Uncertainty

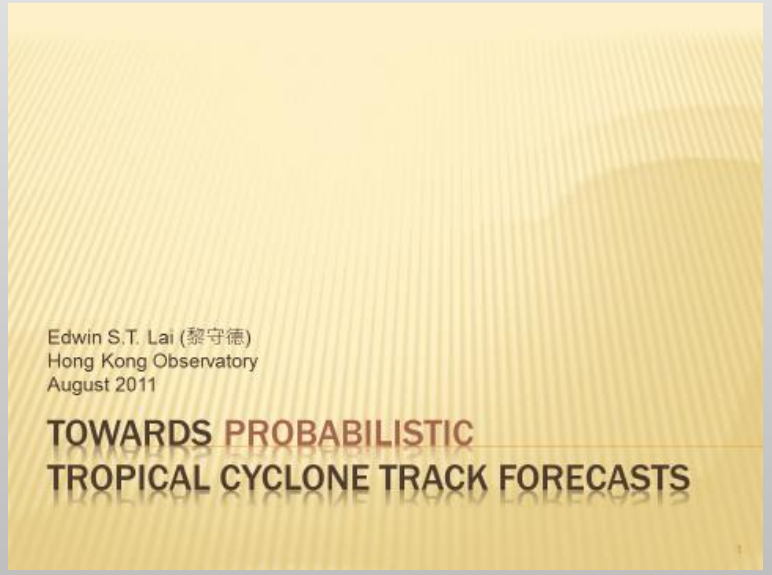
- Inherent atmospheric unpredictability
  - Data sparseness and incomplete initial conditions including uncertain storm data (location, intensity, motion vector, etc.)
  - Atmospheric complexity



Sources of Forecast Uncertainty

- Uncertainty of data interpretation
  - NWP model output interpretation
    - Variations among different models and ensembles
    - Consensus determination
    - Two outstanding Presentations from S. T. Chan & Edwin Lai





Sources of Forecast Uncertainty

- Uncertainty when composing the forecast
  - Model inconsistencies
  - Limitations of terminology and phraseology
- Forecast interpretation
  - Interpretation by the user
  - Misunderstanding of forecast terms by the user and the forecaster (lack of definitions)
  - Misunderstanding due to different languages

How to Communicate Forecast Uncertainty

- Human perceptions of uncertainty information
  - Tendency to apply a higher probability (exaggerate) to a higher magnitude event
  - Users often try to “decode” what the forecaster meant
- User sophistication
  - Users can have different requirements for uncertainty information
  - Users have different levels of understanding of uncertainty and the sources of uncertainty

How to Communicate Forecast Uncertainty

- Examples of uncertainty information
  - Terminology:
    - can be complex or simple
    - vague descriptors—”chance of”, “possible”, “one or two”
    - non-specific descriptors—”later”, “in the area of”, “developing”
    - Alternate scenarios: “This the most likely outcome, but…..”
  - Be careful: You may want to convey this to your emergency managers in a different way than you present it to the general public

How to Communicate Forecast Uncertainty

- Examples of uncertainty information
  - Terminology:
    - Should be unambiguous and consistent
    - Consider language and culture
    - In some languages, words may not exist to describe uncertainty
    - How can we standardize such words of uncertainty?
    - How can we make sure everyone knows the definitions?
    - Example of a Likelihood Scale

Example of a Likelihood Scale

Terminology	Likelihood of the Occurrence/Outcome
Extremely likely	Greater than 99% probability
Very likely	90% to 99% probability
Likely	70% to 89% probability
Probable—more likely than not	55% to 69% probability
Equally likely as not	45% to 54% probability
Possible—less likely than not	30% to 44% probability
Unlikely	10% to 29% probability
Very unlikely	1% to 9% probability
Extremely unlikely	Less than 1% probability

Taken from Table 2, WMO/TD No. 1422 Guidelines on Communicating Forecast Uncertainty

How to Communicate Forecast Uncertainty and Risk

Terminology: How can we make sure everyone knows definitions? We can't educate everyone--prioritize

1. Forecasters (periodic meetings, SOPs, directives)
2. Emergency managers (workshops, SOPs, exercises, visits)
3. Media ("Media Day" workshop, brochures)
4. First Responders (workshops, brochures, exercises)
5. General public (newspapers, outreach, brochures)
6. Eventually into schools (curricula additions); this gets information into the culture

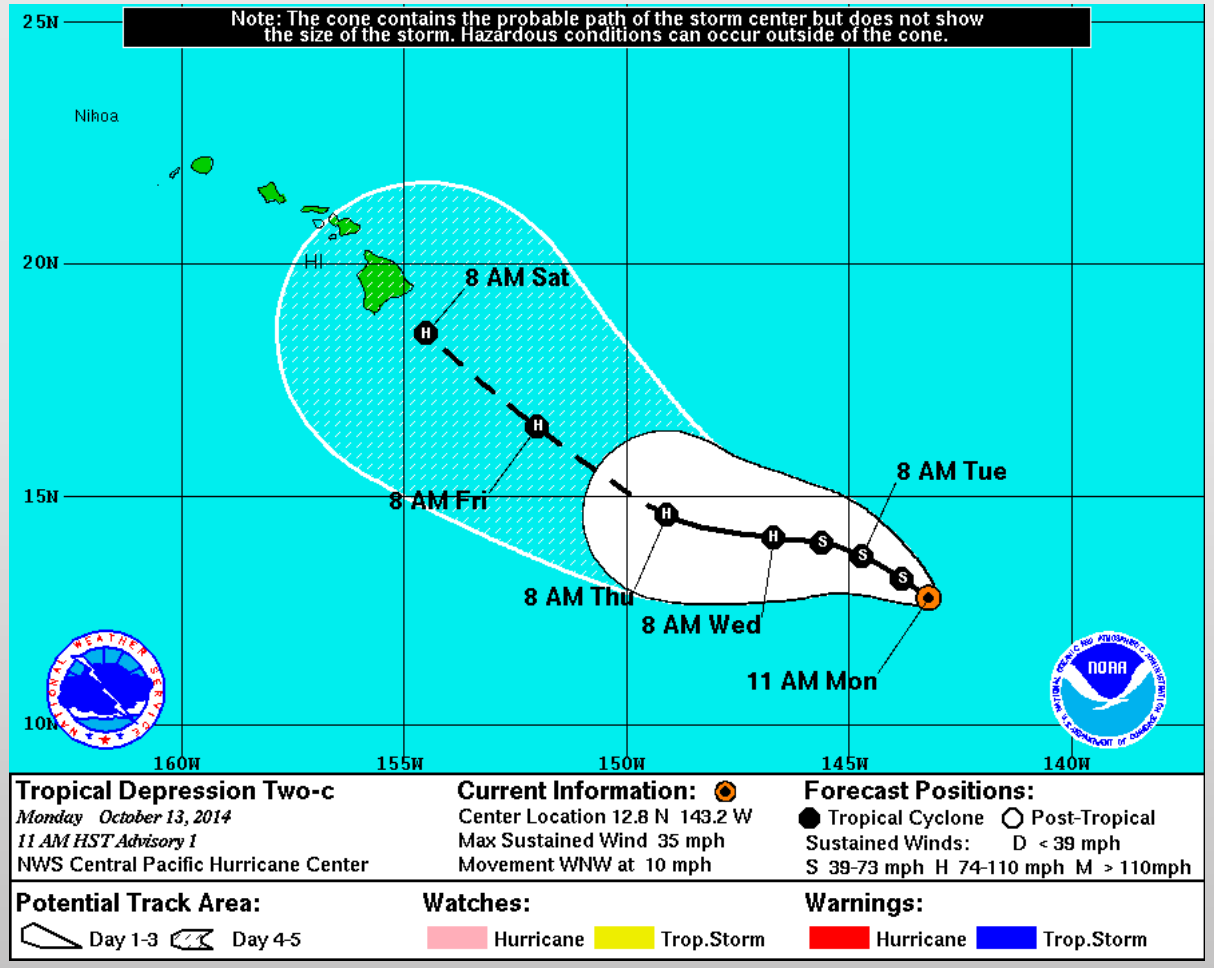
Relationship Between Uncertainty and Risk

- Communicating the risk is both the job of the NMHS and emergency managers. There must be a **consistent message** in the products. It requires a partnership and even a strategy
- In general, the risk increases with the intensity of the event

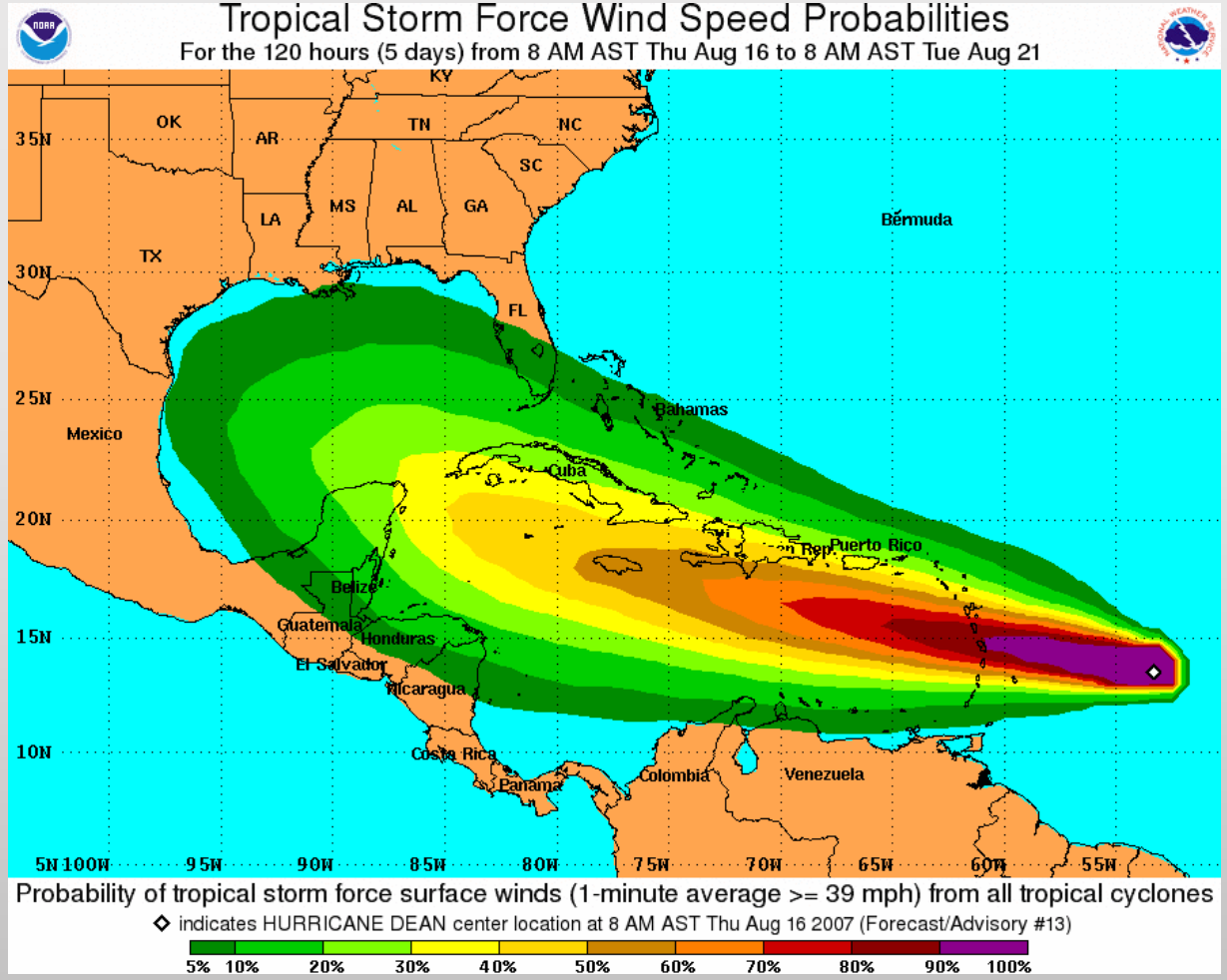
Communicating Uncertainty and Risk

- Communicating the risk is both the job of the NMHS and emergency managers. There must be a **consistent message** in the products. It requires a partnership and even a strategy
- In general, the risk increases with the intensity of the event
- Most warning agencies use a cone to reflect the uncertainty in the path of the storm

Communicating Uncertainty and Risk



Communicating Uncertainty and Risk



Communicating Uncertainty and Risk

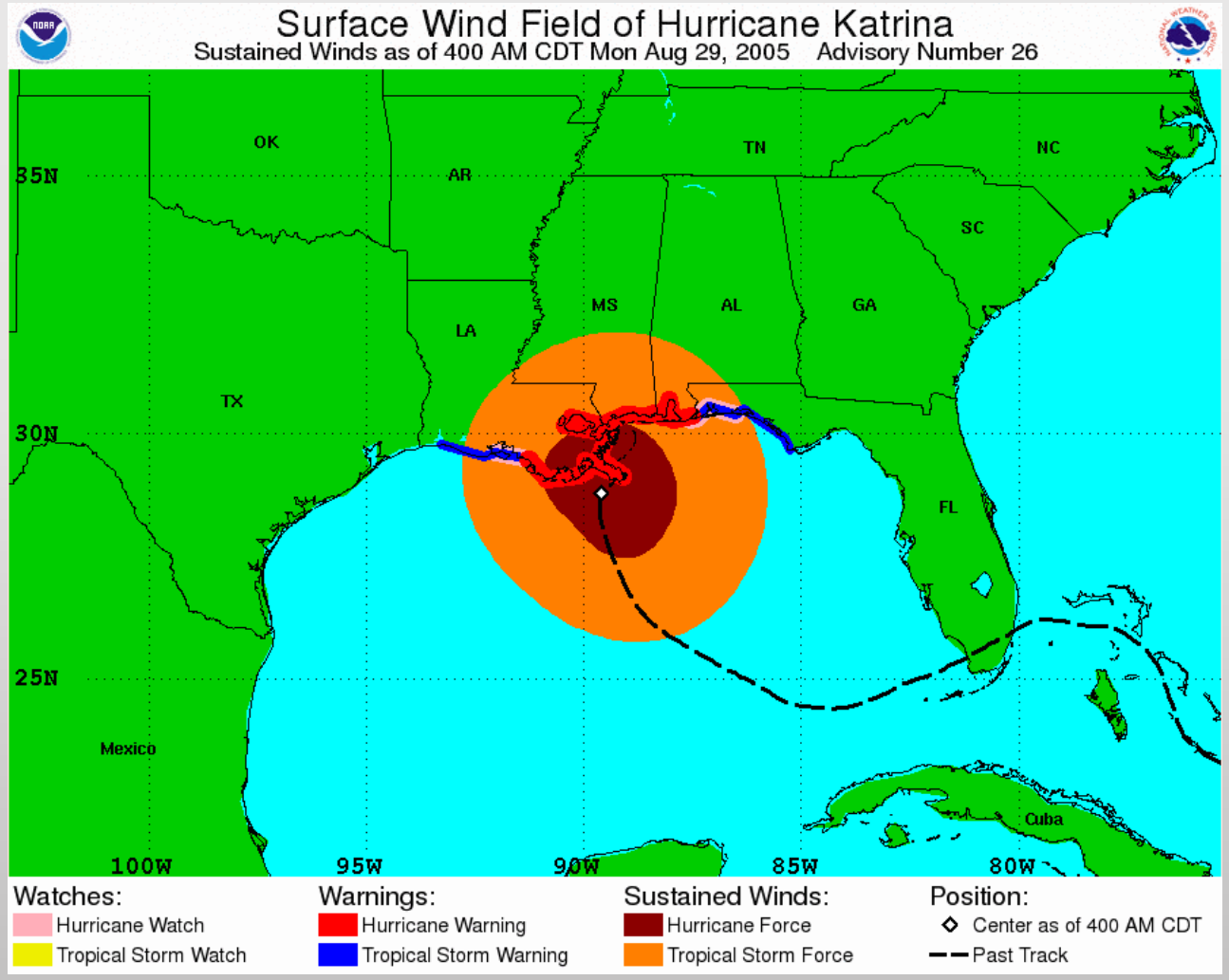
- How do we compensate for the uncertainty?

- With respect to the wind and storm surge: we tell the emergency managers to plan for one Storm Category higher than forecast
- With respect to storm surge: we tell the emergency managers to always plan for high tide
- Because rainfall can be highly variable and can begin well before and last well after other storm effects with respect to a tropical cyclone, we issue separate flood products and then associate them with the tropical cyclone

Scales of Uncertainty

- Back to user sophistication: Some ways to satisfy user's needs
  - Use a Watch-Warning concept where
    - inexpensive decisions and actions are made during a WATCH phase (perhaps 48 hours before arrival) where track forecast error are larger
    - more expensive decisions and actions are made during the WARNING phase (perhaps 24 hours before arrival) where forecast errors are smaller
  - Provide face-to-face briefings to key users

Communicating Uncertainty and Risk



Examples of Uncertainty Information

- Scales of uncertainty
  - Probabilities
    - Perhaps the most common way to express uncertainty
    - Should be defined carefully and explained to users
    - The first decision is to choose what quantity the probability will refer to
    - Frequently it is the value of a weather parameter exceeding a defined threshold value; e.g., above or below normal rainfall

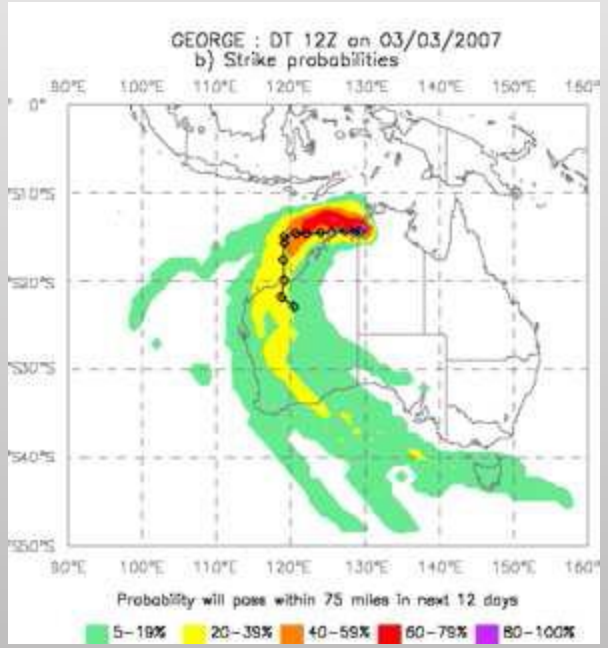
Challenges with Understanding Probabilities

- Most users want a deterministic forecast—they want to know “will something happen or not”
- Must educate people why meteorology is not an exact science
- Need to understand what the “probability of occurrence” actually refers to
- A good test of a definition is to ask: “Could I objectively verify the forecast?” If not, refine the definition
- The 50% probability problem: Users consider this as a “sitting on the fence” forecast. To some, it may be looked at as the highest measure of uncertainty since it is often viewed as “that even the forecaster is uncertain”

Challenges with understanding probabilities

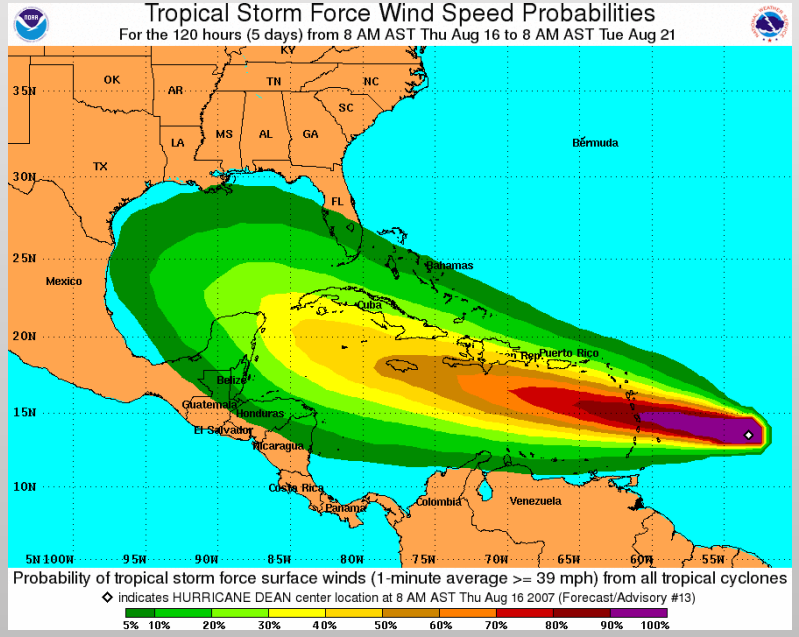
Examples of Probability Information

- Probabilities
  - For typhoons: the probability that a tropical cyclone will pass within a certain distance (e.g., 100 km) of a location



Examples of Probability Information

- Probabilities
  - For typhoons: the probability that a tropical cyclone will produce tropical storm force winds within a certain period of time

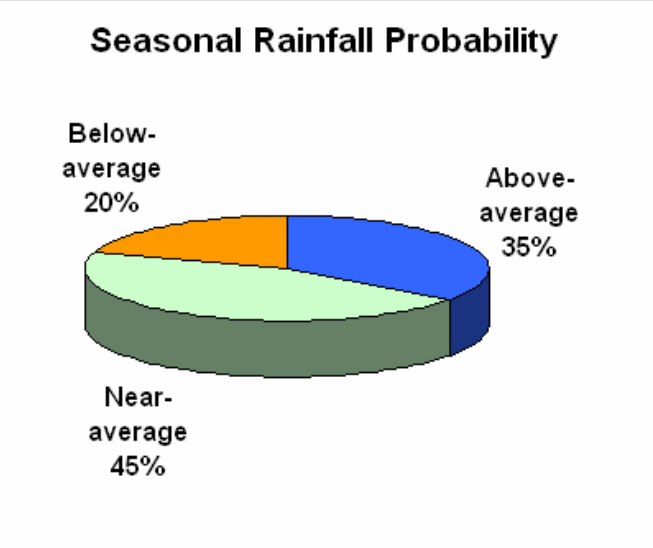


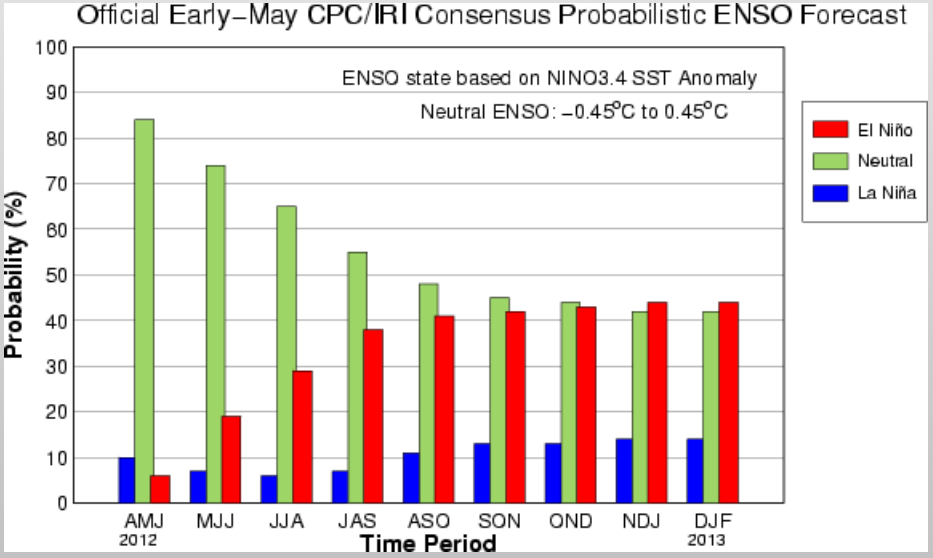
Examples of Uncertainty Information

- Worded categories (See the Likelihood Scale)
- Tropical Cyclone Intensity Category Scales
  - Saffir-Simpson Hurricane Scale (without storm surge)
  - Saffir-Simpson Tropical Cyclone Scale (with storm surge)
  - Australian Scale
  - Amadore Scale in the Philippines

Examples of Uncertainty Information

- Graphs
  - Can show all possibilities at once
  - Can show most likely outcomes and alternatives





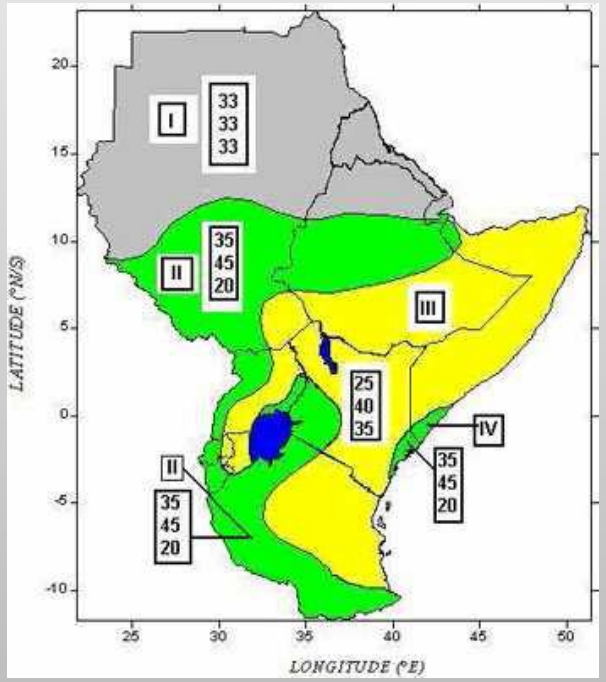
Examples of Uncertainty Information

- Icons
  - Can apply the uncertainty value on the icon
  - Simple words can be used to clarify the icon

Showers

Examples of Uncertainty Information

- Charts and maps
  - Uncertainty information is depicted well spatially
  - Can show both the forecast and the uncertainty



Examples of Uncertainty Information

- Confidence indices
  - Must avoid over simplification
  - Dangerous to use a single index for a total forecast
  - Values are generally high at short forecast periods and lower at longer forecast periods

Examples of Uncertainty Information

- Weather indices
  - Good for single parameters such as Air Quality, Ultraviolet radiation, Fire Index
  - Not so good for typhoons or events that have multiple hazards
  - Does anyone here know of such an index for typhoons?