High Impact Weather Events
HIWE

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Version 1.20

Basic concepts of high impact

- **High impact weather**
  - *Is a spectrum of events which we will define*
- **Routine weather forecast→**
  - *Studies show that numerical guidance is difficult to beat*
  - Increasingly difficult to add value to NWP beyond 12 h
- **Humans add most value**
  - *Extreme or high impact weather events*
  - *The opportunity to improve upon guidance*
  - *Where humans can assist in decision making*
- **Decision making and high impact weather events**
  - *The Cheney 1% doctrine applied to weather Extreme weather events and climate change*

Basic High Impact weather Events

- Significant weather events which can and do impact human activities. They can disrupt transportation and communication; damage homes and property; have long and enduring economic impacts; and can claim the lives of people.

- MSC definition "*HIW is weather that can result in significant impacts on safety, property and/or socioeconomic activity*" (Sills 2009)

- Spectrum of effects from low to extreme (Sills 2009)
  - Large scale α long predictability horizon
  - mesoscale α short predictability horizon

Spectrum of effects dependent upon

(adapted from Sills 2009)

- **the type, intensity, timing, location, and duration of the weather event**

- **antecedent conditions are critical**
  - *River flooding: High flows and more rain higher flood threat*
  - *Dry conditions higher fire threat*
  - *Warm roads then rain or snow and falling temperatures*
  - *Steep terrain and heavy rain → flash flooding threat*

- **Spectrum relates to predictability**
  - Predictability is a function of the scale
  - Larger scale→ come to you (Big ridge or big cut-off low)
  - Mesoscale→ go to them (may miss you!)

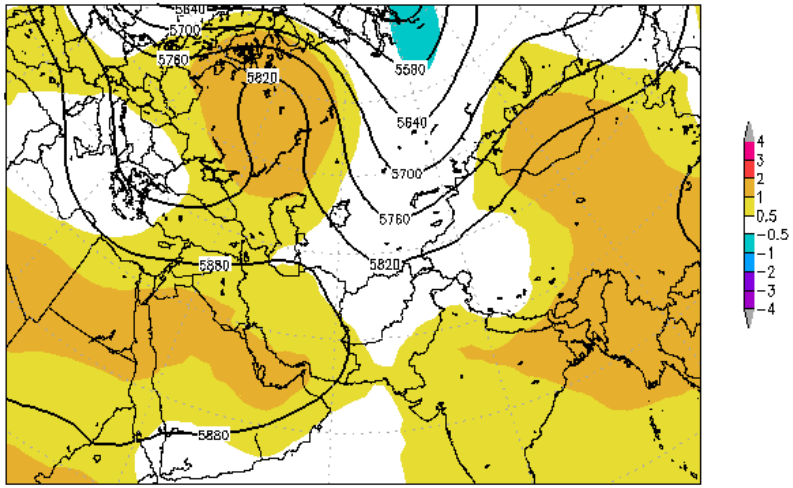
Synoptic or "*come-to-you*" events

- **Events which are synoptic or larger scale in nature**
  - Clear synoptic or large scale pattern
  - Impacts a broad region and can have huge consequences
  - The overall large scale pattern is generally well predicted by models and ensemble predictions systems
  - Have longer predictability horizons (~days)

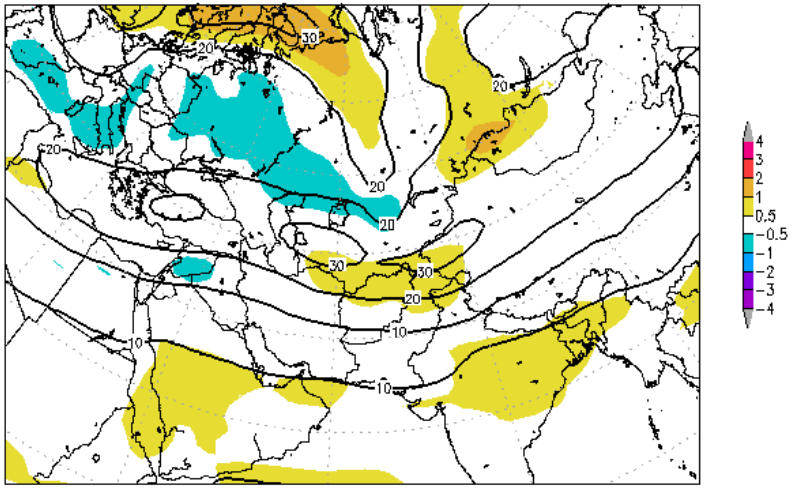
- **Examples**
  - *Heat waves and droughts → Russian Heat and drought 2010*
  - *Large scale flooding events → Pakistani Floods 2010*
  - *Cold episodes*
  - *Snow storms and cut-off lows*
  - *Strongly forced large scale severe weather events*
  - *Larger scale dust storms*

Russian Heat Wave and Pakistani floods clear and distinct large pattern

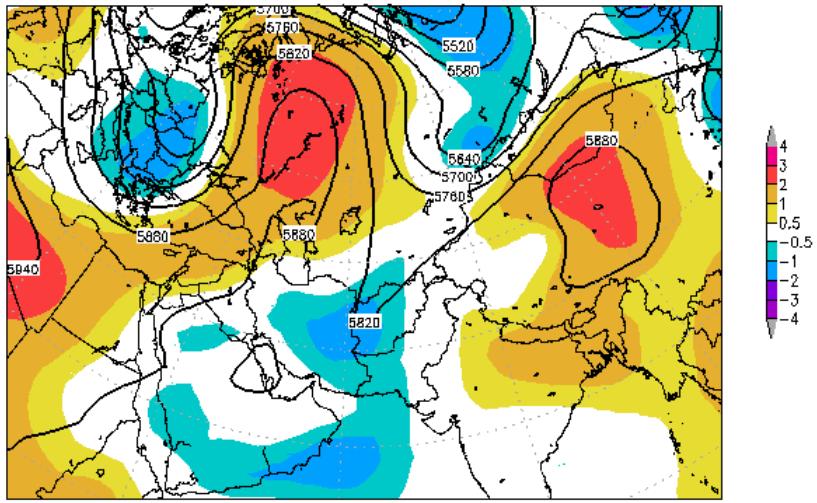
a. Composite 500hPa hgtprs 00Z01JUL2010–00Z01AUG2010



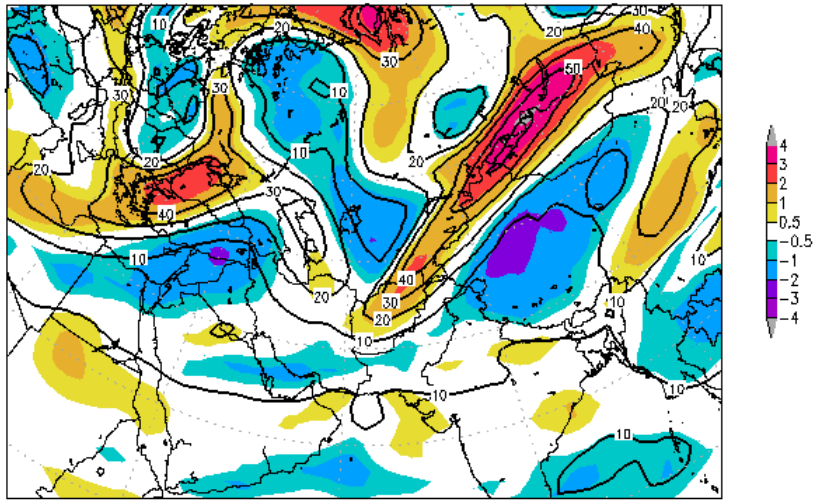
b. Composite 250hPa wind 00Z01JUL2010–00Z01AUG2010



a. Composite 500hPa hgtprs 00Z28JUL2010–00Z29JUL2010



b. Composite 250hPa wind 00Z28JUL2010–00Z29JUL2010



Points about Impacts and consequences for Synoptic events

- Flooding over large region:
  - Crop losses and damage can be in the billions
    - Pakistani Floods 2010 and 2011
    - North Korea August 2007
    - Mississippi Valley May 2010 and April-May 2011
- Heat waves
  - Droughts relate to fires and damaged crops
  - Damage can be in billions
    - Russia Jul-August 2010
    - Southwestern US 2010 and 2011
- Some events have geo-political impacts

Fiscal and Geopolitical Impacts

- Need to mitigate losses
  - Requires some planning and lead-time
  - Moving and positioning resource
  - Moving and re-positioning of people
    - Think floods in rivers and hurricane landfalls
    - We need to able to this
- Geopolitical consequences
  - Consequences of crop losses→
    - Lost revenues to impacted country
    - Importer loses food supply Egypt 2010 and Russian grain.
  - Money, food supplies, and political capital at stake

Synoptic/Large scale events

- Potentially significant impacts
  - Over larger region and big impacts
  - Require planning to take action
- Forecasting
  - Larger scale events typically more predictable
  - Often can get region of concern correct
    - Some events 3-10 days out (heat events)
    - Some events lower predictability horizons
      - Floods and snows 1-7 days out
- These events we need to provide input to.

The Subtle, mesoscale or "Go-to-them" events

- **More mesoscale in nature**
  - May have a clear signal in broader synoptic pattern
  - Impacts over smaller region → fog or dust
  - Short or very short—predictability horizons (~hours)
  - ***Some events may be predicted by fine resolution models → shorter ranges***
- **Examples**
  - *Smaller scale dust storms, down slope winds, coastal fog*
  - *Many thunderstorms, tornadoes, dust devils*
  - *Locally heavy rain and flash flooding events*

Early morning light snow and icy roads

Denver area 18 November 2010

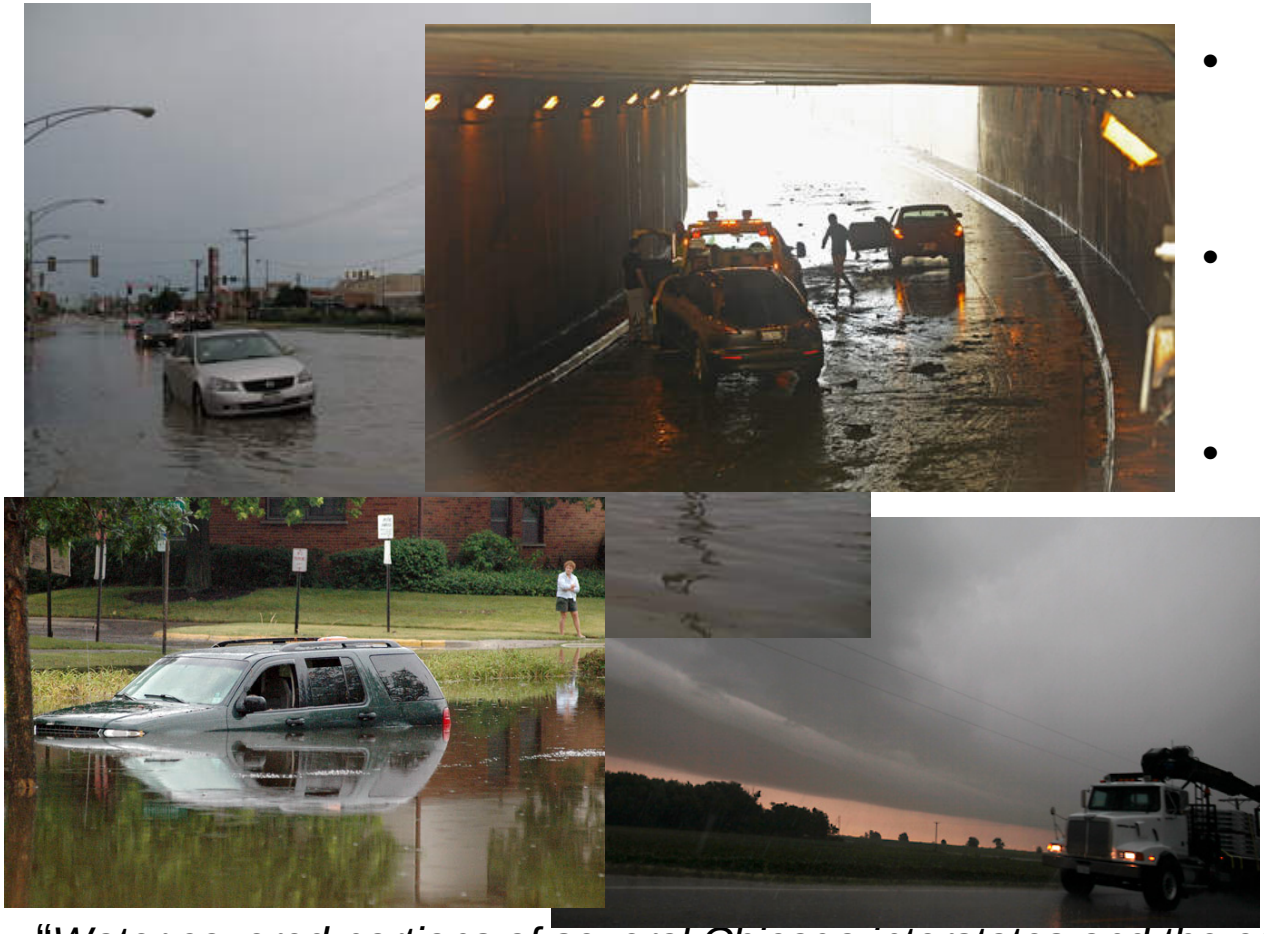
Does not look like a big event…not a lot of snow…but big impact!

Go-them-event as one had to be on the road.

Ice and fog can be like this to the general public…

Fog is aviation hazard….

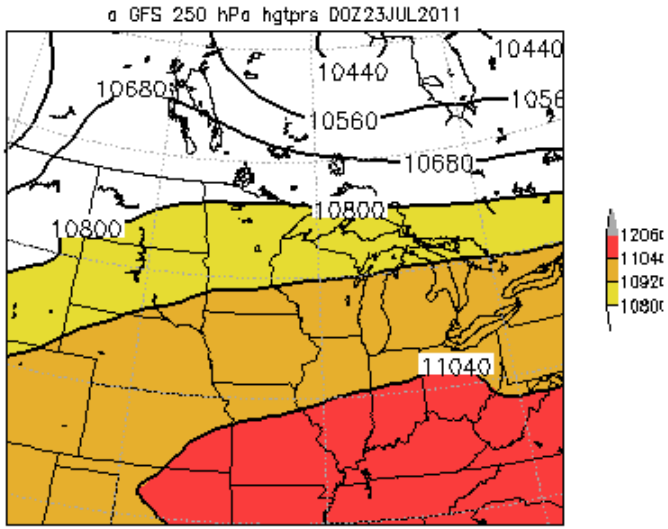
Chicago Floods and record rainfall 6.86 inches 23 July 2011

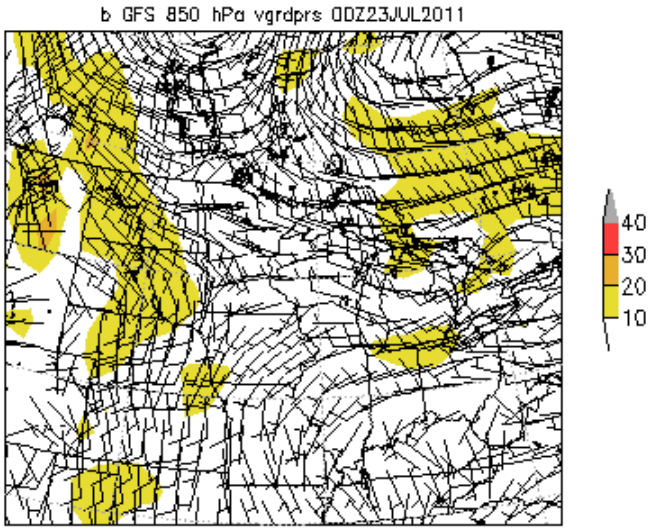


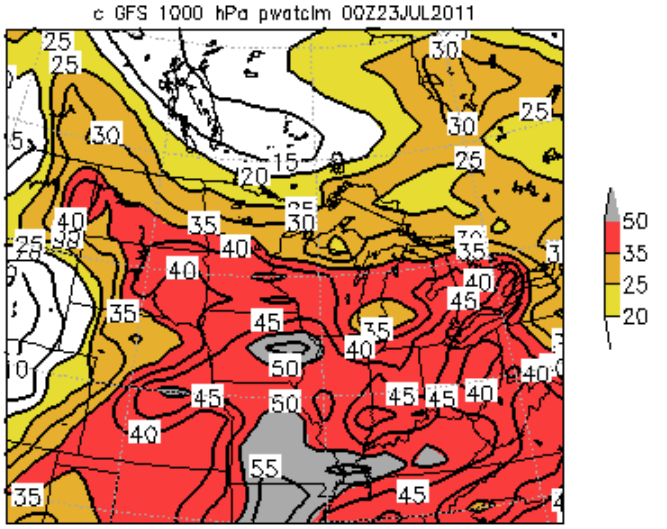
- Most Rain fell in under 3 hours
- Broke record from September 2008 of 6.64
- About a 1% chance event in any given year

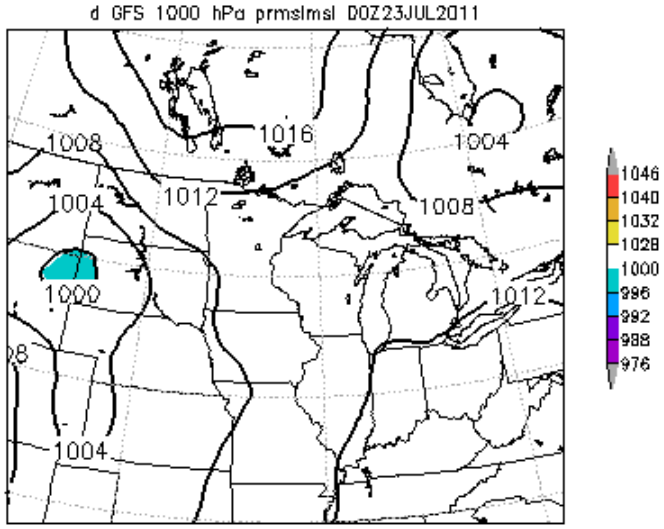
"*Water covered portions of several Chicago interstates and the commuter train tracks that run along them, leading crews to divert traffic and call in bus shuttles. Portions of Interstate 290 west of downtown were closed for several hours.*" Associated Press Story

Good pattern for rainfall Where?



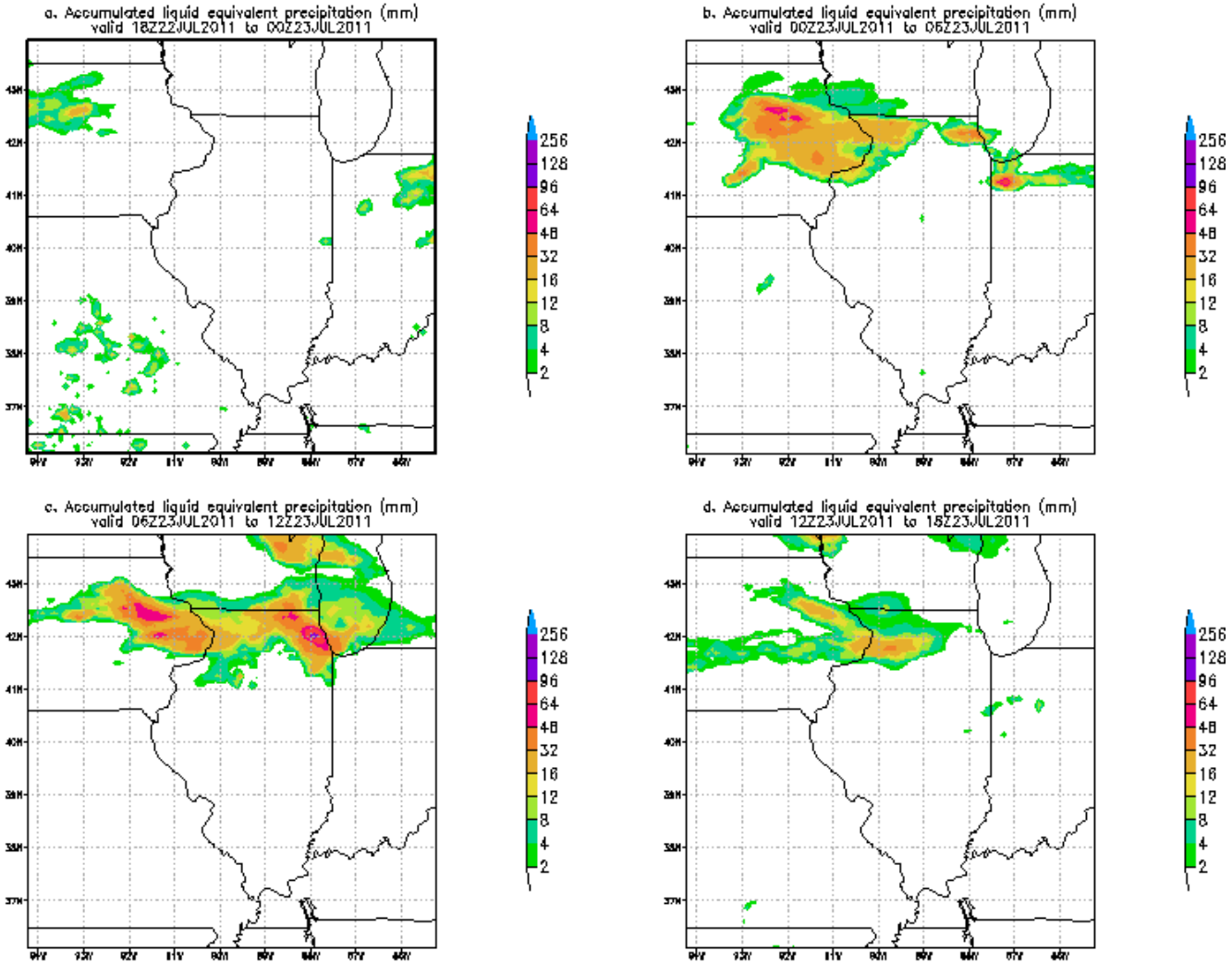






Pattern of Rainfall

Most rain fell 06 to 1200 UTC



Subtle Events

- Regional or local in scale and impact
  - Typically not as expense as larger scale events
  - Locally can tax resources and disrupt human activities

- Smaller scale→
  - Shorter predictability horizons hours to days
  - Need to more pro-active as many have short lead-times
    - Hours
  - We still need to work on improving how we
    - Predict
    - Monitor and advise on these events

Clarifying points
spectrums within spectrums

- **Mesoscale events can actually come to you**
  - But typically a lower probability compared to a synoptic scale event
  - Snow squalls and falling temperatures are of no impact unless one drives into one.
  - Small stream flooding is generally low impact unless you live by one or drive across one.
  - Fog is often localized in valleys, along coastal plain, or water bodies.
    - Affects airports and flight operations
  - Typically have short predictability horizons on the order of hours.
    - Stronger forced perhaps ~day
    - Weakly or locally forced ~hours
- **Go-to-them events are**
  - low probability events in terms of numbers of people and activities affected.
  - They can and often do disrupt local travel activities.
    - Come to your airport!
  - May come-to-you if your in the path, like a tornado or localized floods

Subtle HIWE Events

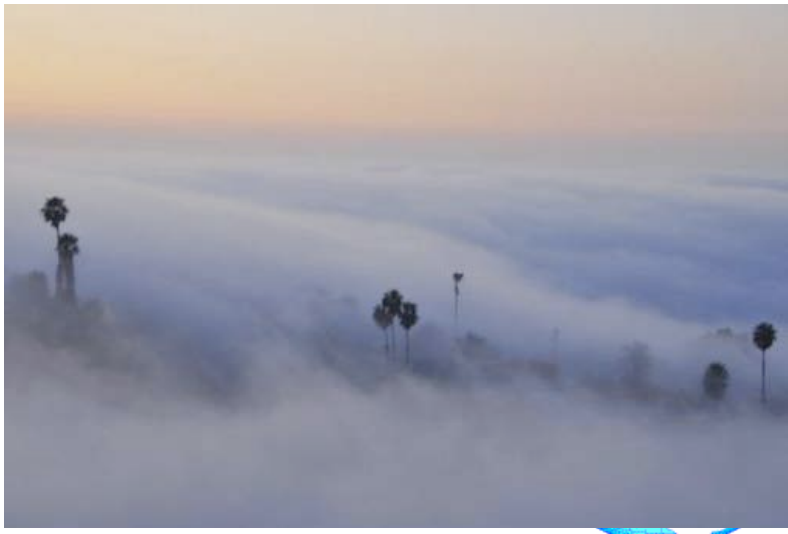
- Often start as modest events
  - Snow showers or light snow; freezing dew; black ice
  - But untreated roads and falling temperatures cause flash freezing
  - Localized fog in a valley, at a terminal or near a coast line
- Can have significant impacts
  - Traffic accidents in above examples
  - Can be regional or localized
- Appear under “normal conditions”
  - Modest forcing no strong signal of a significant event
  - Local meteorological knowledge and very high resolution models can be critical for these events

SHIWE events can be devastating

Winter heat wave leads to thick blanket of fog along coast

Subtle Events and YOU!

- Need to know you local climatology
- Distinguish high impact big events from local events
- Every region has unique problems
  - Coastal fog
  - Winter along coast
  - Warm air over cooler waters
  - Impacts: travel and can close airports!
  - Local flash flooding or lake snows



Key role of human

- **Forecaster uses skills and knowledge**
  - To add value to the forecast
  - Blends patterns and probabilities to assign confidence to forecast and outcome.
  - Match conceptual models to weather events
  - Takes appropriate and effective actions
  - Aids in the decision making
- **Forecaster**
  - Requires skill and knowledge on spectrum of events
  - Life long learning process to keep those skills honed.
  - Intervene and add value at discrete and critical times

Full Spectrum of events

- **Short range Forecaster must add value**
  - For the spectrum of HIWE and SHIWE events at short ranges
  - Must recognized when and how to intervene
  - Constant vigilance or meteorological monitoring required
- **Longer ranges**
  - Typically spectrum of larger scale events
  - Must know when and where to add value
  - Always monitor low probability extreme events as well as the high probability events
- **Forecaster must have**
  - A Constant process to identify HIWE events at all time horizons
  - Be willing and capable of recognizing when to provide input
  - *Be cognizant of low probability of extreme weather events*

Key points

- Patterns and pattern recognition matter
  - Need to recognize patterns
  - Standardized anomalies may aid with pattern and discriminating patterns from typical to atypical event
- Antecedent conditions matter
  - High flows easier to flood again
  - Warm roads can cause flash freezing
- Forecasters add value in HIWE

Classifying Events

- **High impact based on Economic Impact**
  - Synoptic events often bigger $$
  - Compare to say other tragedies→ tsunamis?

- **Impact based on reports**
  - Severe weather tornadoes
  - Points over flood
  - Fog closing roads, airports, or causing accidents
  - Dust storms reducing visibility closing roads.

- **We need to expand our knowledge of**
  - Event types and impacts

Forecasting Large scale HIWE

- Planning purposes 1-7 days out
  - Ensembles and high resolution global models
  - Some events have long predictability horizons
  - Patterns and persistent patterns can be important
- Short range: 0-1 days out
  - Ensembles, better if regional scale
  - Higher resolution local models
  - Nowcasting

Forecasting meso and local scale HIWE

- **Planning purposes 1-7 days out**
  - Ensembles and high resolution global models
    - May get the pattern
    - But forecasters knowledge of regional and local weather required to anticipate potential
  - Long lead-times may not be practical

- **Short range: 0-1 days out**
  - Pattern recognition and forecaster knowledge helps
  - ***High resolution local models may help***
  - Short-term diagnosis and MET-WATCH may be critical
    - Fog formation conditions and satellite data
    - ***Forecaster knowledge and experience vital.***

The 1% doctrine

- Famous Cheney quote to motivate action for a low probability high impact event from November 2001:
  - *" If there's a 1% chance that Pakistani scientists are helping al-Qaeda build or develop a nuclear weapon, we have to treat it as a certainty in terms of our response. It's not about our analysis … It's about our response."*
  - *Concept: Uncertainty is a reason to act not a reason not to act.*
  - Title of a Ron Suskind book about the Americas Response to terrorism.
- Meteorological and climatological context:
  - We need to be mindful of the low probability of high impact events
  - When faced with a credible threat of a potentially catastrophic event, uncertainty is why you act.
  - This is a paradigm change for many

Climate Change

example from Friedman and Mandelbaum

- Climate is currently warming the trend is real
  - Clean energy and energy efficiencies could mitigate this
  - Short-term worried about potential costs
  - Long-term→ we could get more energy efficient and reduce future intrusions of CO2 into atmosphere
- The 1% doctrine:
  - If above the 1% level we are causing some of the climate change, similar to the terrorism argument we need to act. The results may help mitigate the consequences, make us more efficient and less reliant on foreign energy.
  - Uncertainty is large enough to act!
  - Mitigation may help avoid the unmanageable which could force expensive adaptation

Simple Personal Examples

can you think of examples?

- You buy car insurance
  - to protect your car from the uncertainty of an accident
  - to protect your home from weather, fire, and meteors!
  - Apartment contents from the uncertainty of theft
- It might rain so you (flood, snow, sleet, freezing rain….)
  - Wear Gortex to the football game at 20% or 50% chance
  - Carry an umbrella at 30,40 or 80%?
  - Put up a tent for an outdoor family wedding or re-union
- Loss mitigation to avoid expensive adaptation
  - Buying expensive poncho or umbrella at football stadium
  - Filling a small house with wedding guests, paying for hail damage to your house, or to replace thousands of dollars of items lost through theft

Flood Potential

- Need to think in probabilities
  - We need to know the probabilities at lower ends
  - typically focus on higher end probabilities → paradigm shift
- Begin to alert and gear up at lower probabilities
  - Costly high impact events
  - 5% chance of rains to create severe flooding
  - Critical at longer ranges and high end users need to know of low probability of extreme weather event
- When to act:
  - Action at the 50% level may not be effective
  - Need to know the cost of mitigation verse adapation

Improved forecaster role

leverage knowledge of low probability high impact event

- **Forecaster uses skills and knowledge**
  - To add value to the forecast
  - Blends patterns and probabilities to assign confidence to forecast and outcome.
  - Match conceptual models to weather events
  - Takes appropriate and effective actions by alerting decision makers early for *low probability of a high impact event*
- **Forecaster**
  - Requires skill and knowledge on spectrum of events
  - Life long learning process to keep those skills honed.
  - Intervene and add value at discrete and critical times
    - Especially when have high impact but low probability event

Summary

- **HIWE defined as a spectrum of weather that can result in significant impacts on safety, property and/or socioeconomic activity.**
- **The spectrum spans scales of meteorological phenomena**
  - *Which can limit predictability horizons*
  - *Each scale and event have unique predictability horizons*
- **Critical role of human forecasters is**
  - *Recognize these events*
  - *Provide timely input to mitigate losses*
  - *Consider the lower probability of an extreme events and alert users earlier for low probability of extreme high impact events*

Key references

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