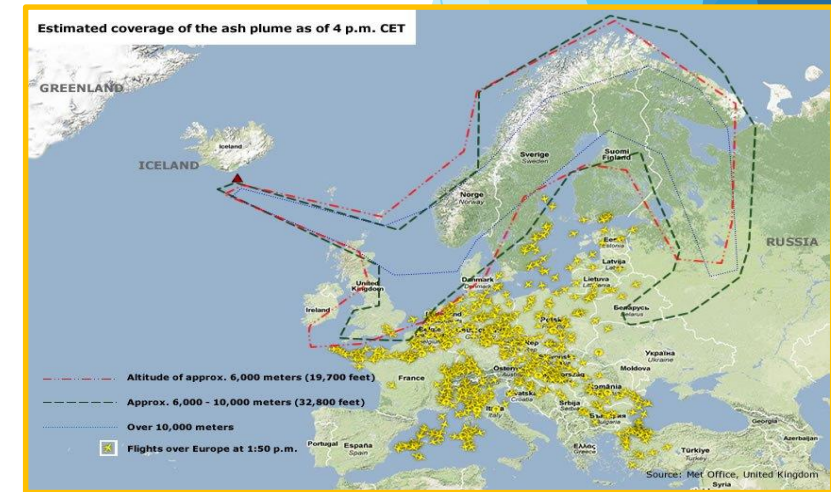




Aviation Security Impacts of Meteorological and Climatic Disruption

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Aviation security is a crossover discipline

- ❖ **Aeronautical Systems Technology & Management:**

aircraft design, flight command, routing

- ❖ **Analysis & Prediction of Operational Factors:**

atmospheric conditions, airfield limitations, costs

- ❖ **Communications and Cyberspace Monitoring:**

two-way voice/data integrity, emergency protocol

- ❖ **Human Behavior and Safety:**

personnel training, passenger/cargo risks

Atypical weather is a risk multiplier

Air transport planning and cost analysis must account for changing conditions --

10 warmest years on climate record (since 1880) have occurred since 1998 ; 2014 was absolute warmest ...

Global warming of air & ocean creates stronger convection, greater water content in clouds, more frequent occurrences of strong pressure gradients & shear producing -- > extreme icing, severe turbulence, deep updrafts

Air France, Air Asia, American Airlines

Airport flooding

Superstorm Sandy 2012 tidal surge and precipitation ; LaGuardia closed for three day; LGA needs \$37.5 million in improvements in flood and storm surge protection

Runway surface impairment

Surface icing , snow and mud inundation

Trend is toward more frequent disruptions

Phoenix dust storms, San Francisco fog/smog, lake-affected areas, ocean coastal facilities



All of New York's airports were flooded during Sandy

Vulnerability to human and natural forces

Drought and other devastations to food supply creates political unrest that triggers airline security threats and airport facilities damage

Severe meteorological events could be used by terrorists to target aircraft or terminals while routine protocol is in chaotic mode, especially for events with extended lead times such as hurricanes

Trends in atmospheric patterns such as diminishing Arctic ice cover, stronger convection and more severe turbulence have impact on route planning and require increased training



Security threats from climate-stressed populations

Aviation business relies on safe and secure transport

The tourism and air cargo industries depend on the policies and stability of governments

Air transport provides approximately 7 million jobs in the global tourism industry

What started on 17 December 2010 with an act of self immolation by Mohammed Bouazizi, a 26-year-old man trying to support his family by selling fruits and vegetables in the central town of Sidi Bouzid in Tunisia, is linked to subsequent political catastrophe in multiple countries

In Libya during 2011, the runway at Benghazi airport was destroyed as a result of continuing clashes between anti-government protesters and security forces.

July 2014: 90% of commercial aircraft destroyed in attack on Tripoli airport



Facilities and routes are concentrated at coastlines

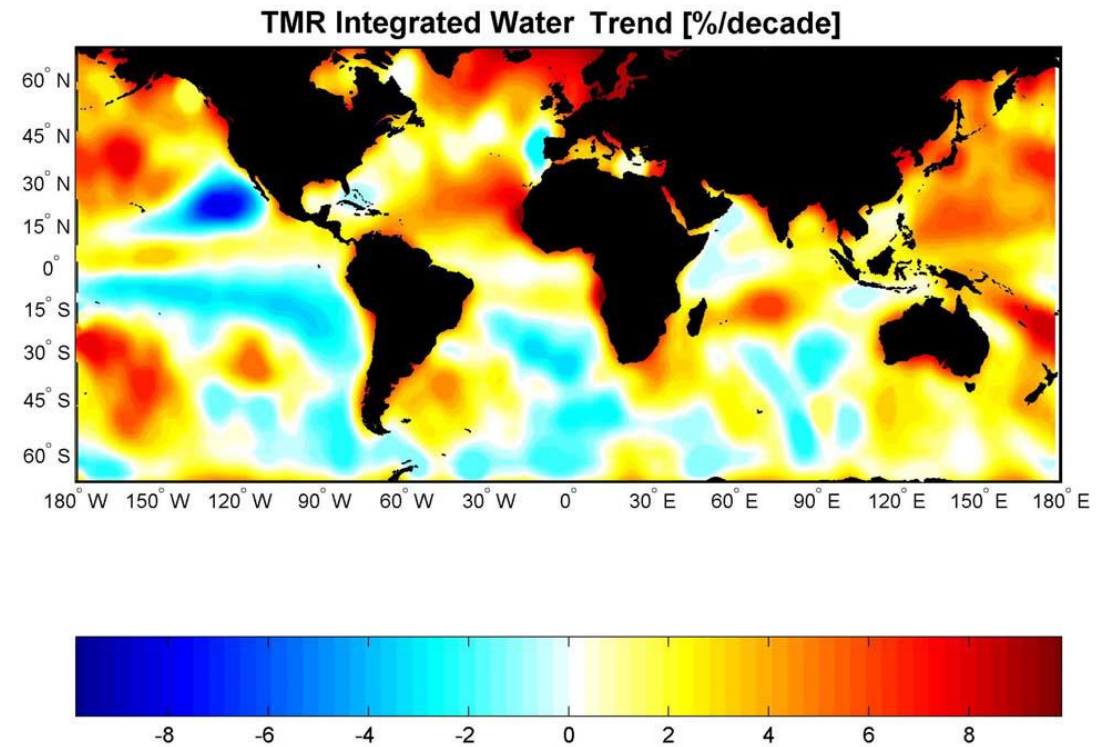
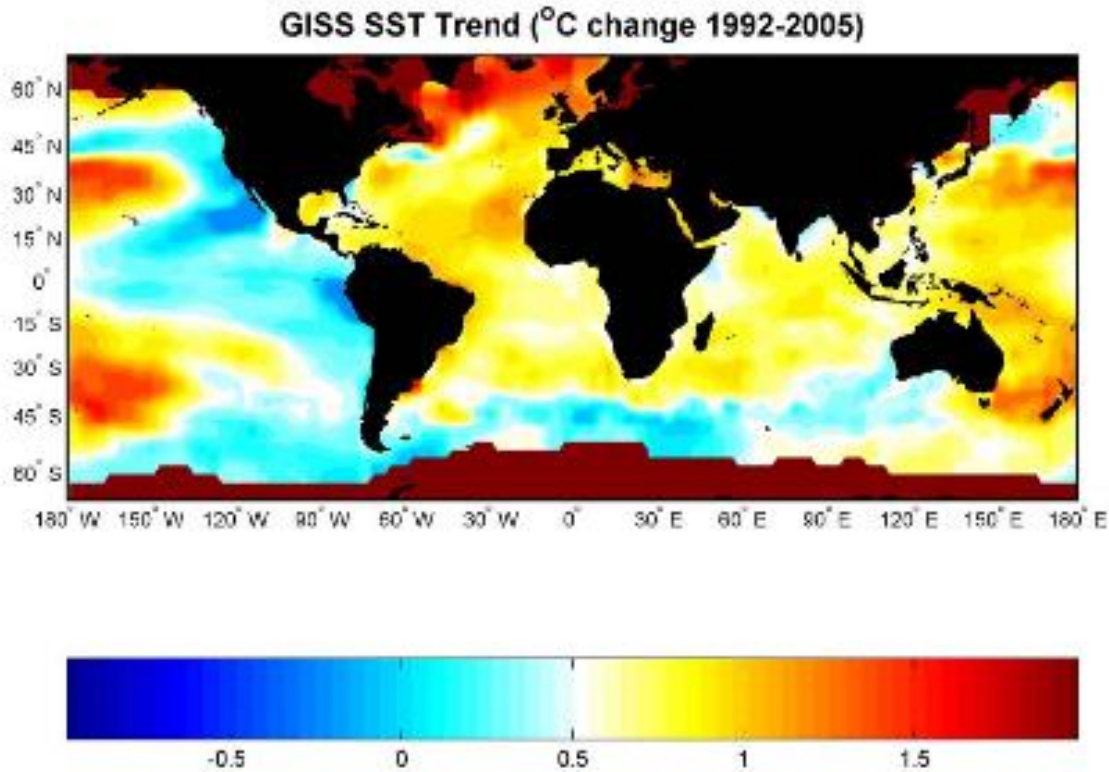
U.S. airports are vulnerable to sea level rise, due to low coastal elevation, storm surges during strong cyclones and sub-surface incursion to the water table that will increase the frequency of airport disruptions and need for re-engineering or facility relocation

The U.S. airports most at risk from encroaching oceans serve major metropolitan regions (millions of customers per year) and are critical to international transport

1. *San Francisco International (SFO)*
2. *Oakland International (OAK)*
3. *Honolulu International (HNL)*
4. *New Orleans Louis Armstrong International (MSY)*
5. *Tampa International (TPA)*
6. *Miami International (MIA)*
7. *Ft. Lauderdale International (FLL)*
8. *Ronald Reagan Washington National (DCA)*
9. *Newark Liberty International (EWR)*
10. *LaGuardia (LGA)*
11. *Philadelphia International (PHL)*
12. *John F. Kennedy International (JFK)*

The hydrologic cycle of our atmosphere is always evolving

Global trends in air and ocean temperatures accelerates the evaporation of water from ocean and land surfaces, which can increase the column amount of water vapor and the liquid/ice content of clouds



Brown, S., S. Desai, S. Keihm, W. Lu, and C. Ruf, 2007: Ocean Water Vapor and Cloud Burden Trends Derived from the Topex Microwave Radiometer, *IEEE. Trans. Geosci. Rem. Sens.*, 45

The combination of stronger surface convection and increased atmospheric column amount of water vapor and cloud mass, creates...

- more intense updrafts
- larger droplets
- greater probability of freezing drizzle and rain
- larger region of mixed-phase cloud

- engine ingest of ice and freezing droplets
- structural icing
- stronger turbulence

Air France Flight 447



Airworthiness regulations, engineering and costs depend on risk factors identified by accidents....

<http://www.gpo.gov/fdsys/pkg/FR-2014-11-04/pdf/2014-25789.pdf>

Supercedes prior rules ->

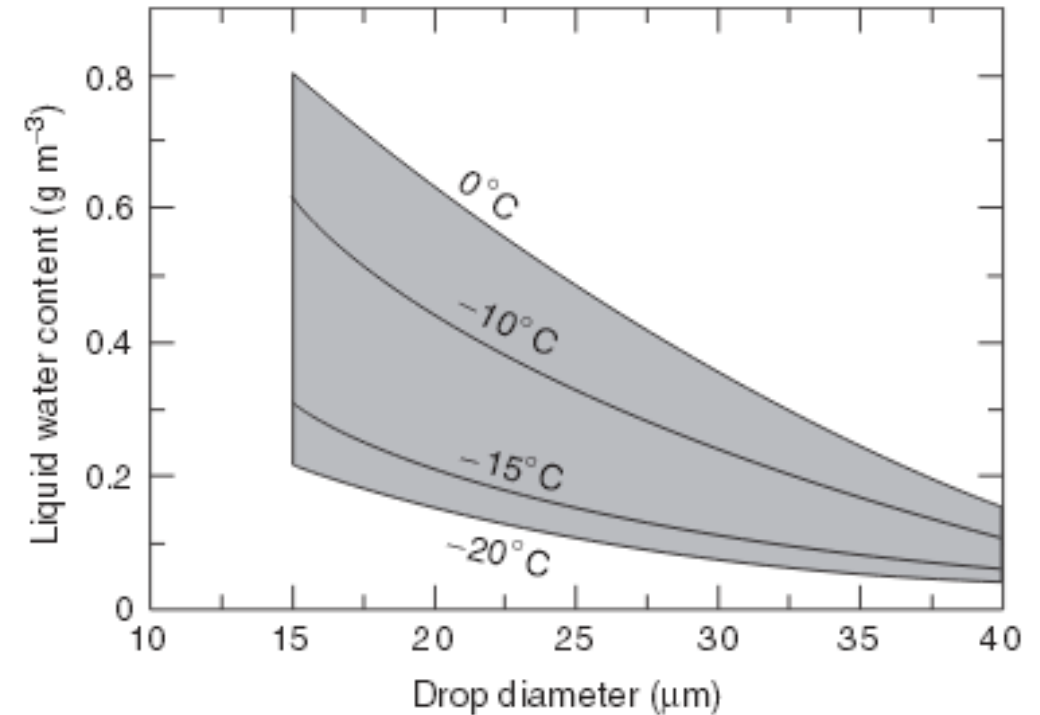


Figure 1 Icing envelopes defined by liquid water content, droplet size, and temperature. The shaded areas denote the limits of these environmental parameters in which aircraft must be able to fly safely to be certified for flight into icing conditions. (From FAA Federal Aviation Regulations Part 25, Appendix C.)

Air commerce is increasingly sensitive to airport closures

Rising temperatures of air and ocean can cause more intense cyclonic storms, larger accumulations of rain/snow, wave-driven coastal surges and dust storms



LaGuardia after Hurricane Andrew

Phoenix dust storm



Airports are critical nodes of collection and distribution (people, cargo, fuel, emergency supplies, diseases)

Many inland airports also are at risk due to flooding of riverways, canyons and connector highways after extended precipitation events (New Year's Flood at Reno-Cannon)

Passengers and pilots are a volatile cargo

Long-duration flights may have more passengers moving around cabin, leaving off seat belts, unaware of flight conditions, flying in regions not well covered by observations, out of range of safe alternate landing locations

Ground delays due to severe weather conditions create passenger confinement

Risk of onboard injury or aircraft accidents is increased by more extreme cloud icing, turbulence, wind shear, fog, dust storms

Climate anomalies (heavy precipitation, high temperatures) initiate disease outbreaks with international consequences

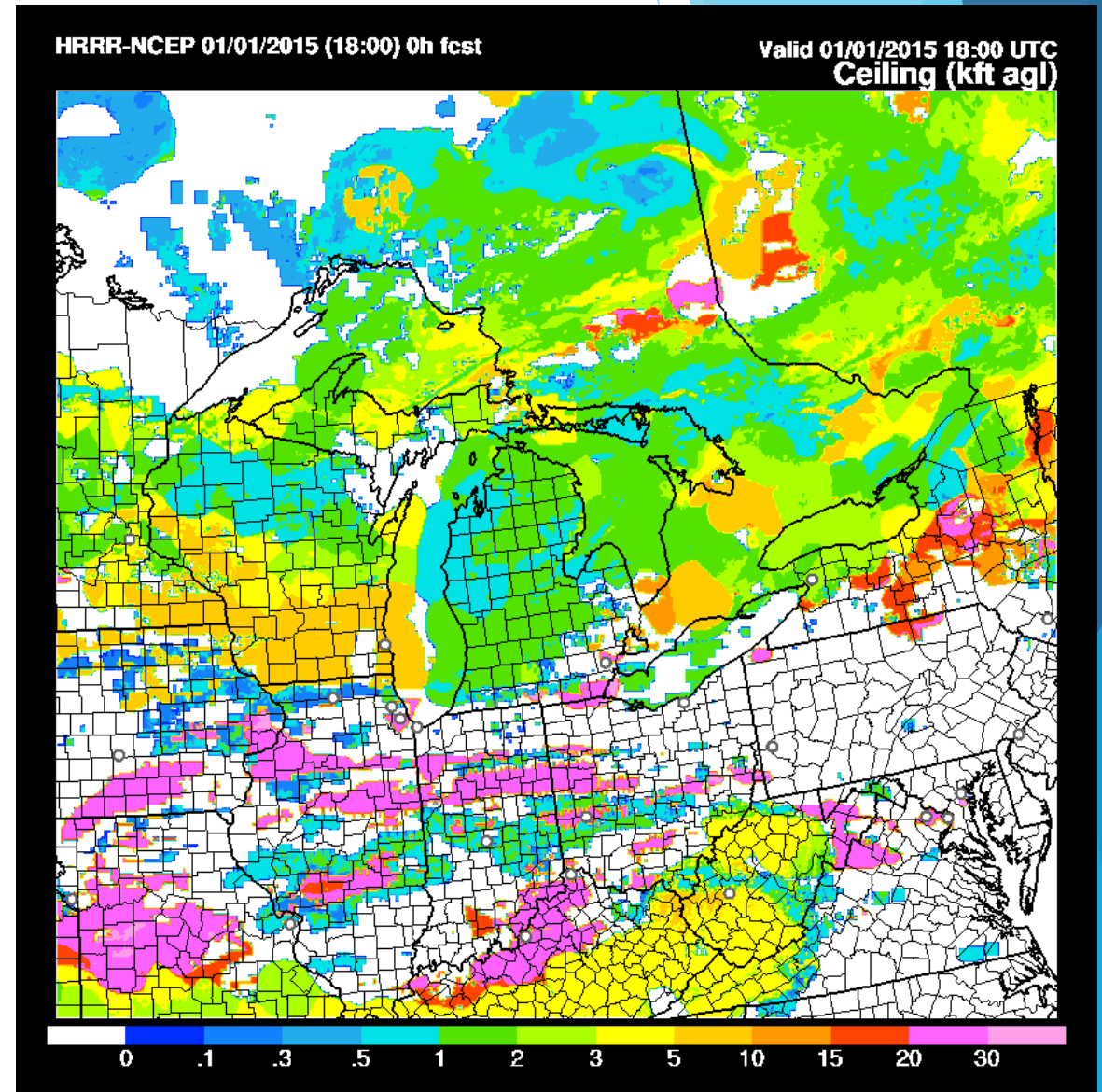
Diseases such as dengue fever, SARS and Ebola can have drastic effects on air travel screening requirements, staff travel restrictions and costs

Human Factors are a benefit:risk trade-off

Will more high-resolution weather data and more direct/selectable air routes cause pilots to “Steer-Near” rather than “Steer-Clear” ?

Recent aviation incidents indicate that aircraft are still not sufficiently instrumented, intelligent or connected to protect the inhabitants from hazard or prevent deadly incidents

Deployment of semi-autonomous fleets requires greater capabilities for detecting proximity conditions for other aircraft and atmospheric hazards



Disruption can create opportunity

Increased need for airborne atmospheric monitoring and post-event assessment will speed the implementation of UAS platforms and other systems integration

Atmospheric variability is increasing the need for research pilots and research-capable instrumented aircraft

Geoengineering schemes to reduce global warming trends are likely to be attempted, and many could pose risk to aviation (dispersion of reflective aerosol, experiments with long-duration balloons, enhancing the persistence of low cloud...)

Integrated training approaches

- 1. Initiate student projects using datasets for real scenarios**
- 2. Examine current impacts using news stories, journal articles, conferences, data mining**
- 3. Assess trends and consequences of air transport security issues**
- 4. Develop a research agenda that involves students**