



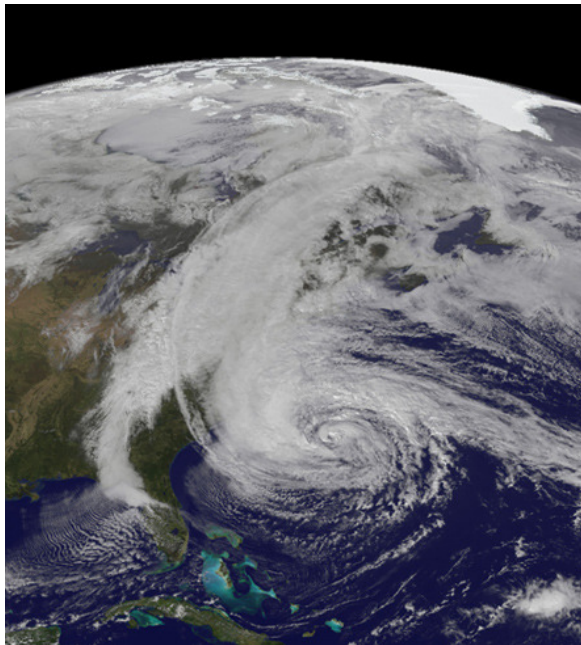
Environment  
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# Superstorm Sandy – An Environment Canada Perspective



NASA Earth Observatory

**Institute for Catastrophic Loss  
Reduction  
Toronto**

**Geoff Coulson  
Warning Preparedness Meteorologist  
January 18 2013**

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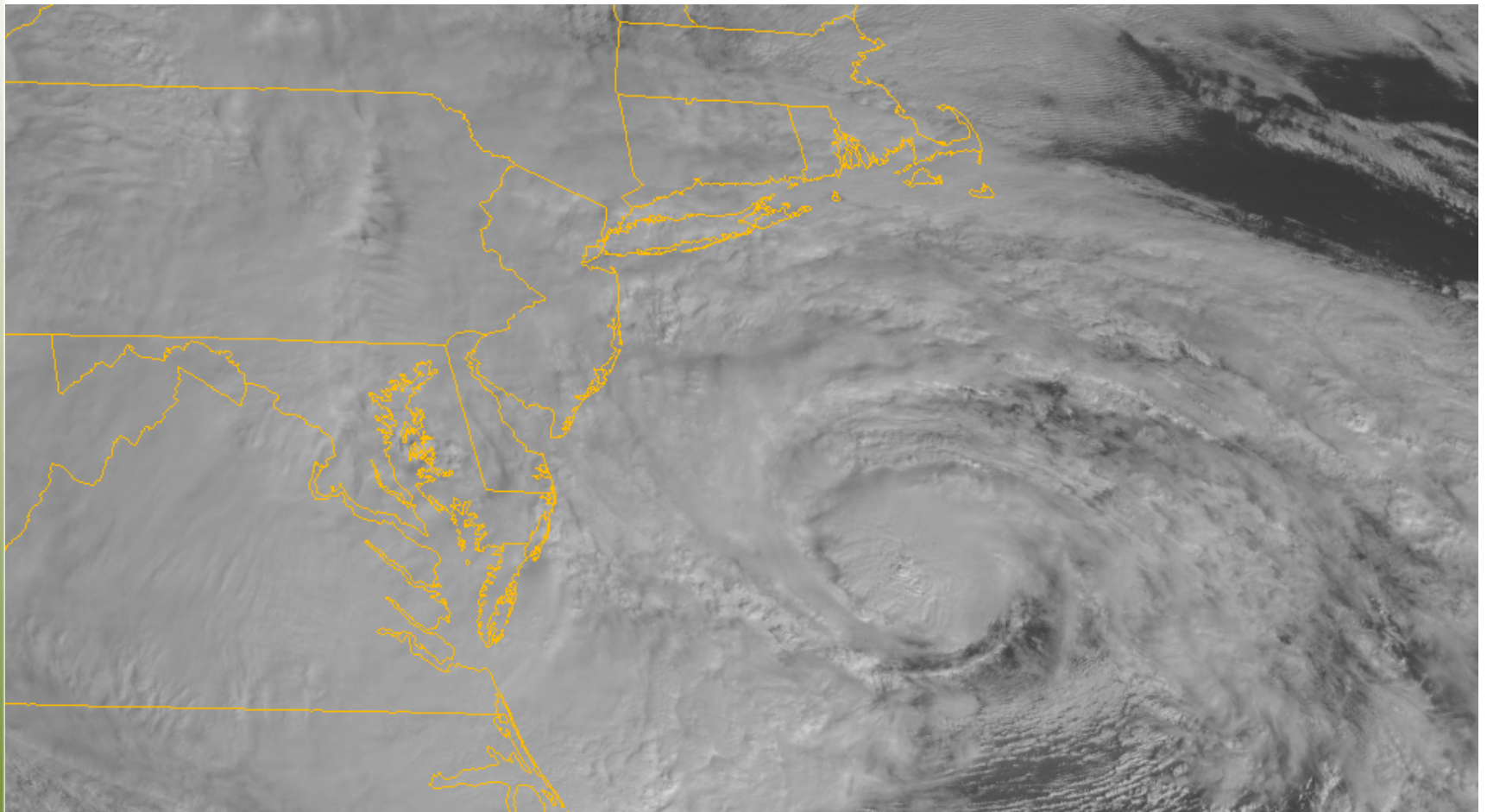
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- Sandy's Nature and Impacts
- Advances in Medium Range (3-10 Day) Forecasts
- EC's Response
  - Inter-regional cooperation
  - Early notification/Risk Communication
- Future of Weather Alerting
  - ECAAlertMe
  - Impact-based, Tiered Warnings



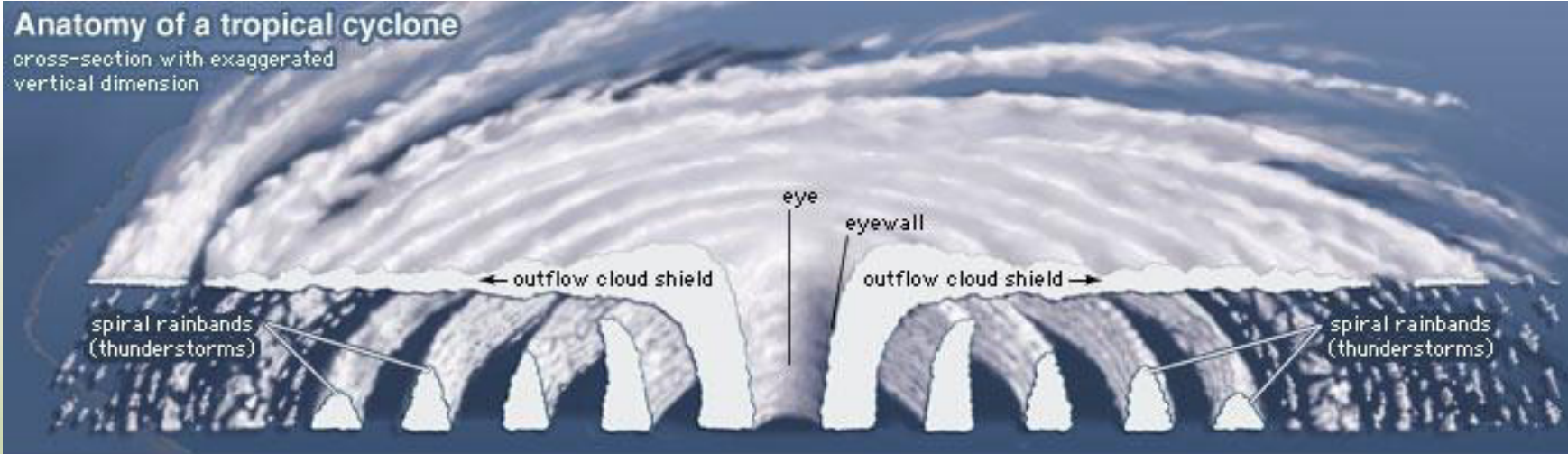
# Sandy's Nature and Impacts

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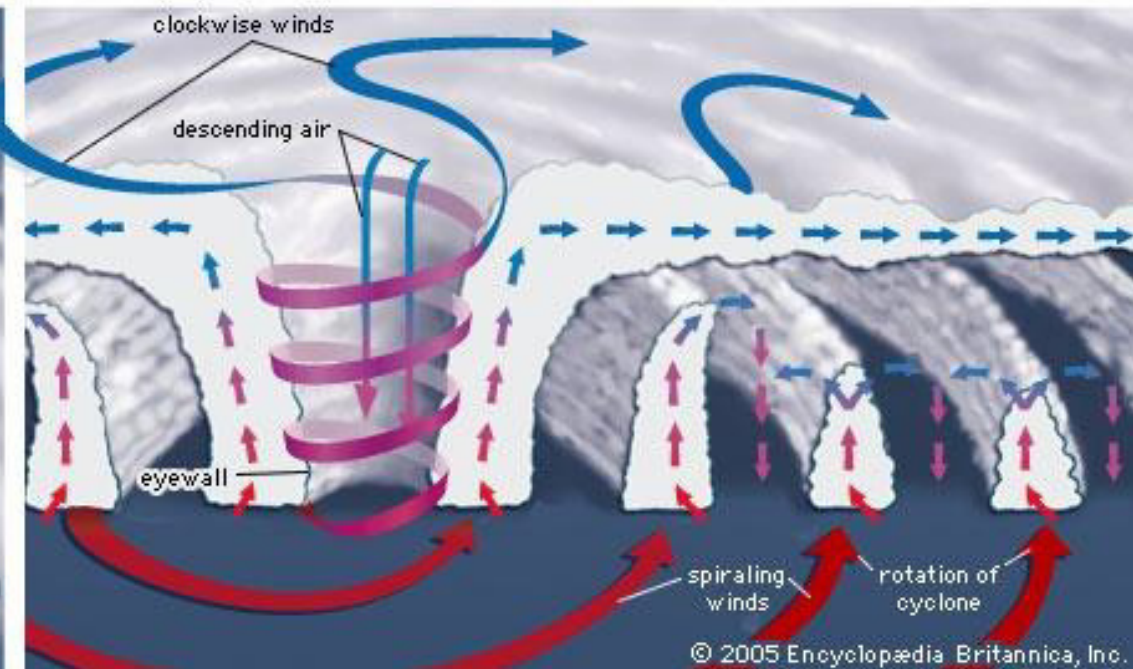


# Anatomy of a tropical cyclone

cross-section with exaggerated vertical dimension



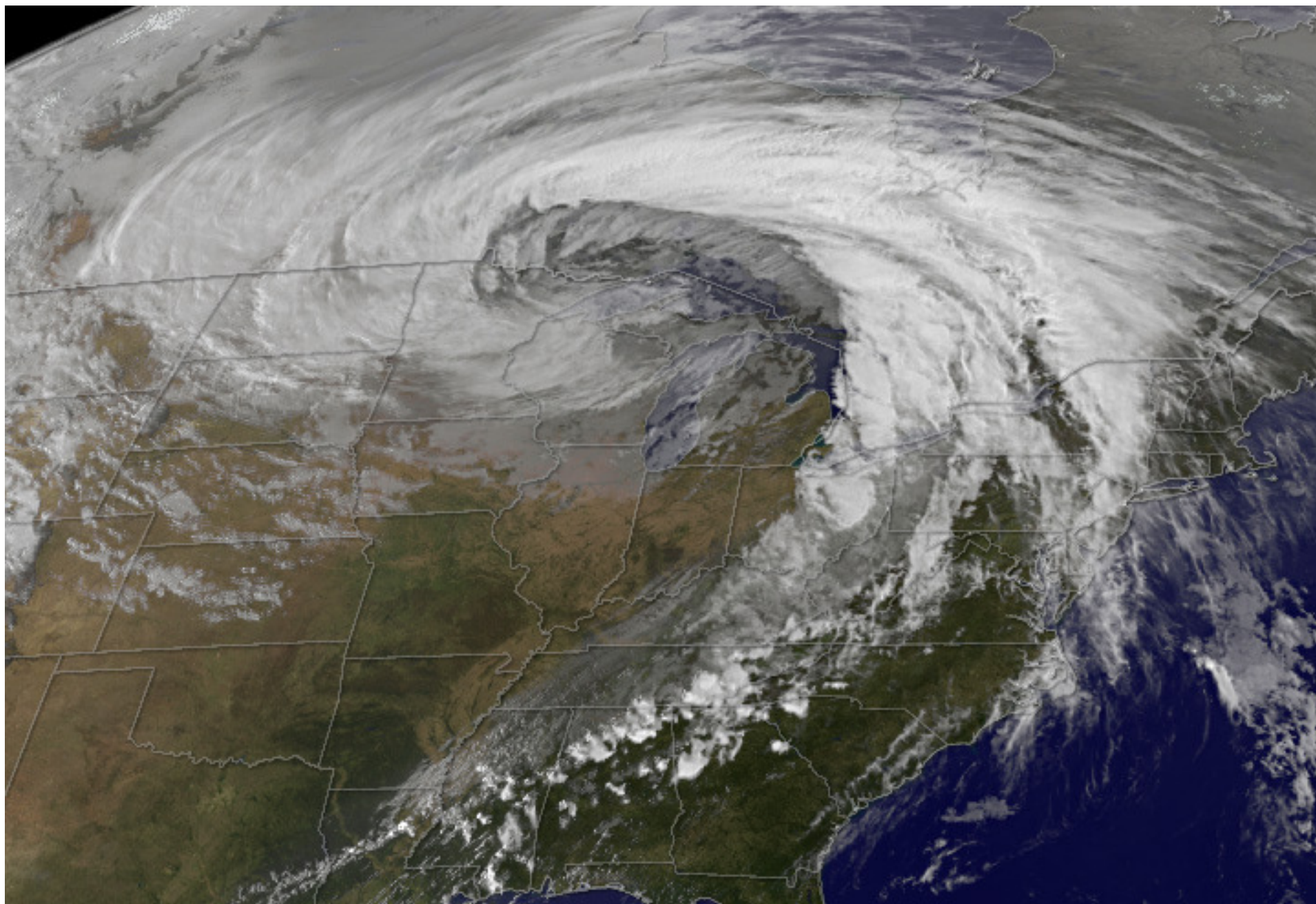
top view



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# NASA Earth Observatory



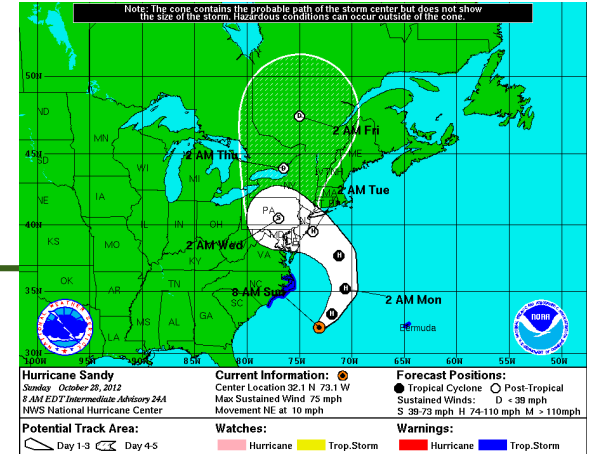
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NWS Jetstream Weather School

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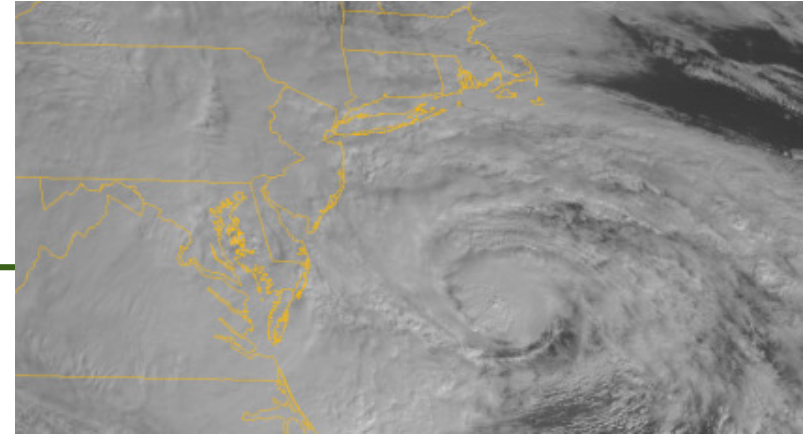
# Extratropical Transition



- Interaction between a tropical cyclone and other non-tropical weather systems
- In many cases, results in a new weather system that is a combination of a tropical cyclone and an extratropical cyclone
- Even after a long period of time, the new weather system can retain some tropical traits
- Many of the tropical cyclones that impact Canada are in some stage of extratropical transition

# Transitioning Storms

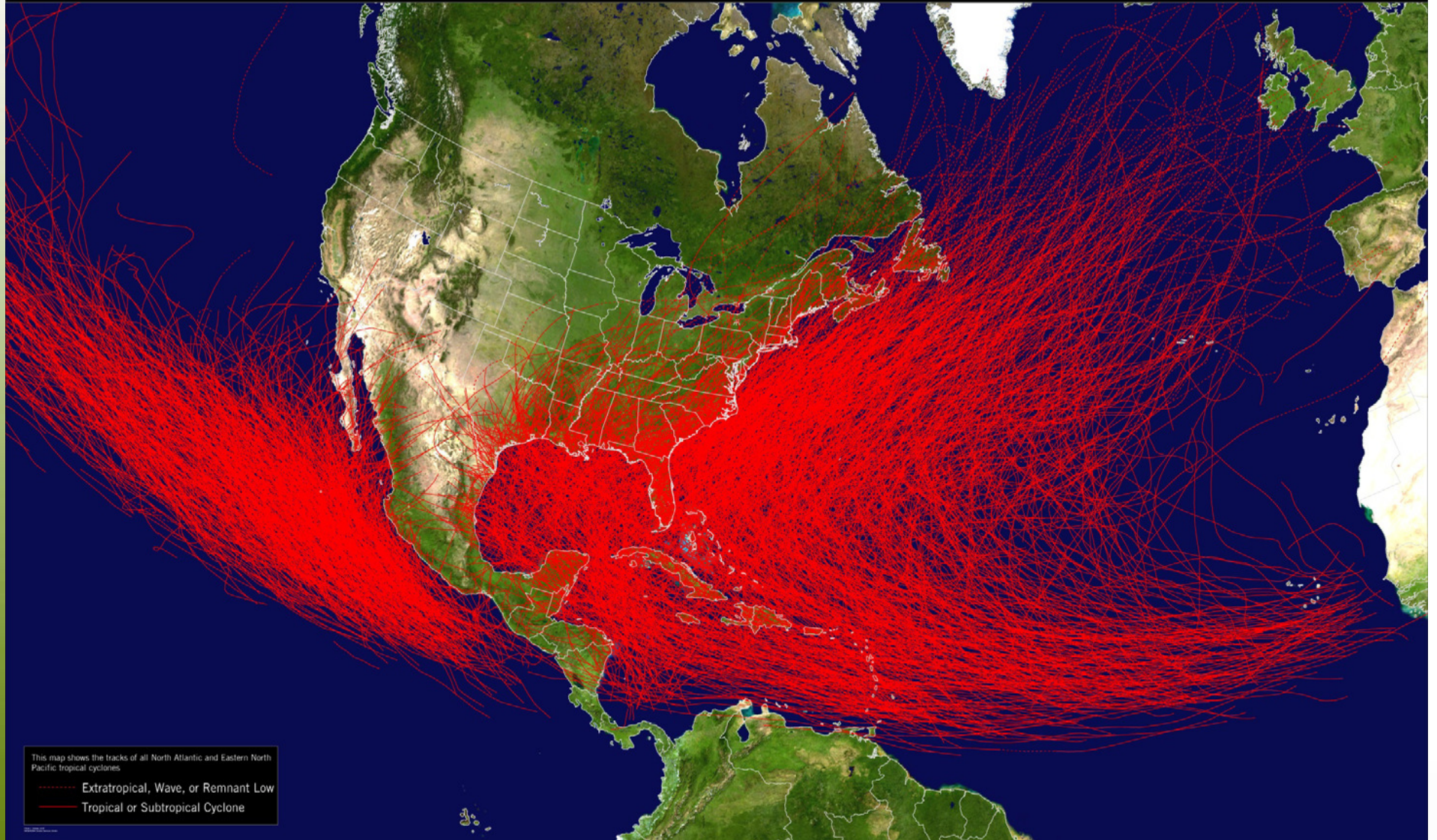
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- Scientists have attempted to categorize storms
- Nature doesn't recognize our categories...a wide spectrum of storms exists that exhibits traits of both tropical and extratropical storms
- Northeastern U.S. most heavily populated area in United States (i.e. 20% of population)
- Implications for impacts from these types of storms in Ontario/Quebec/Atlantic Canada
- Sandy's lasting legacy likely to be more effort put into understanding these types of storms

# Tropical Cyclone History

Data since 1949 in the Pacific, 1851 in the Atlantic



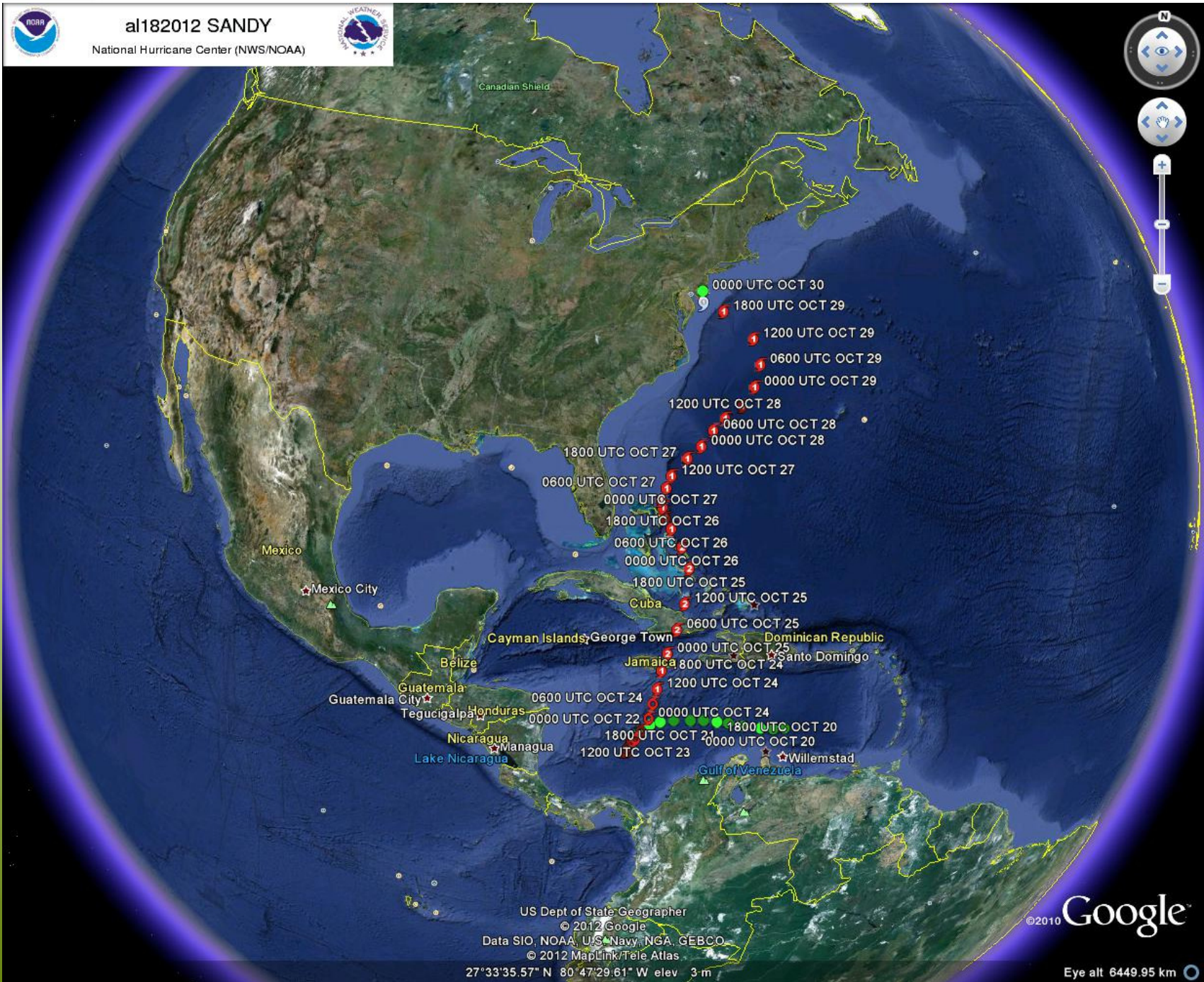
This map shows the tracks of all North Atlantic and Eastern North Pacific tropical cyclones

- Extratropical, Wave, or Remnant Low
- Tropical or Subtropical Cyclone





al182012 SANDY  
National Hurricane Center (NWS/NOAA)

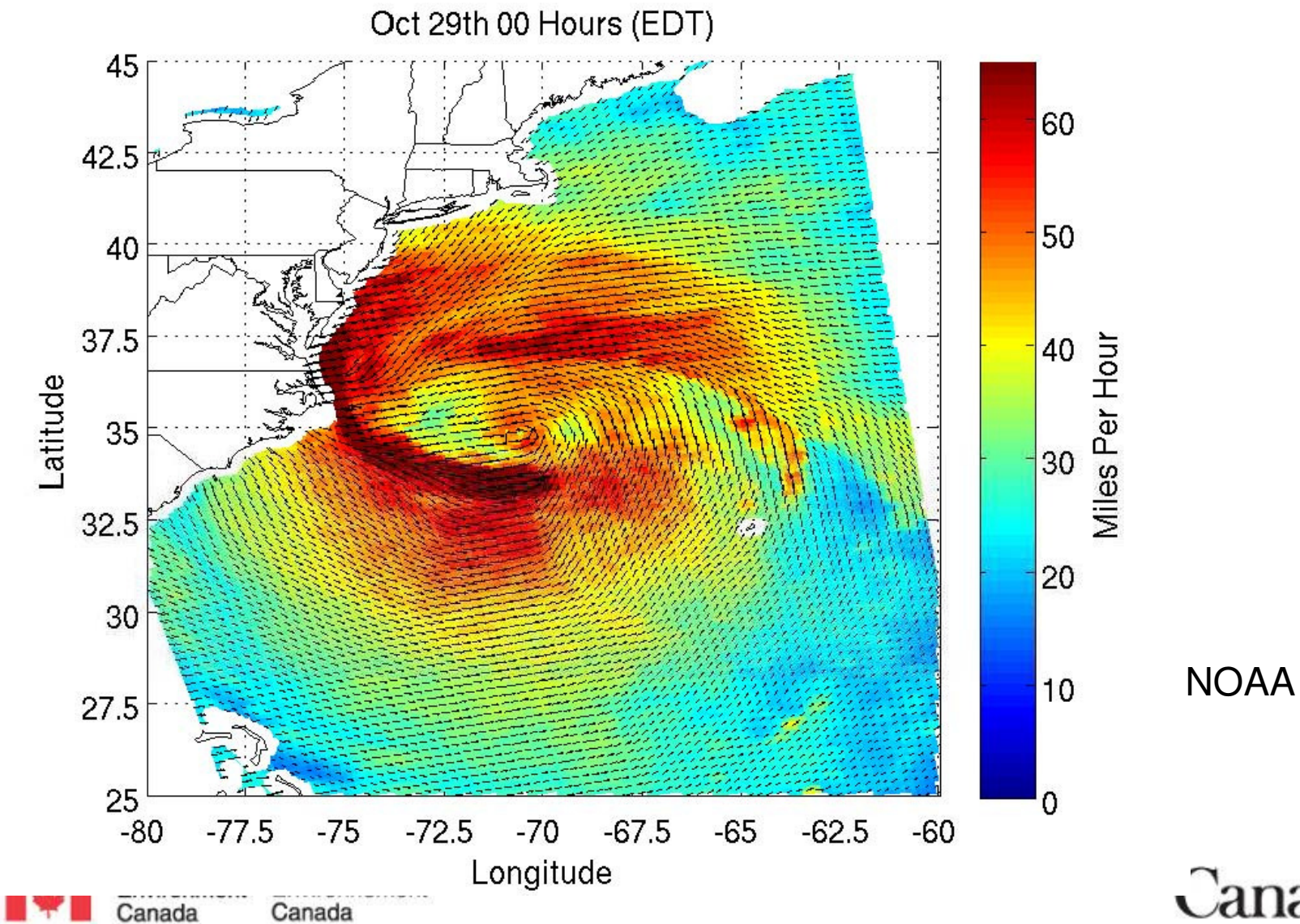


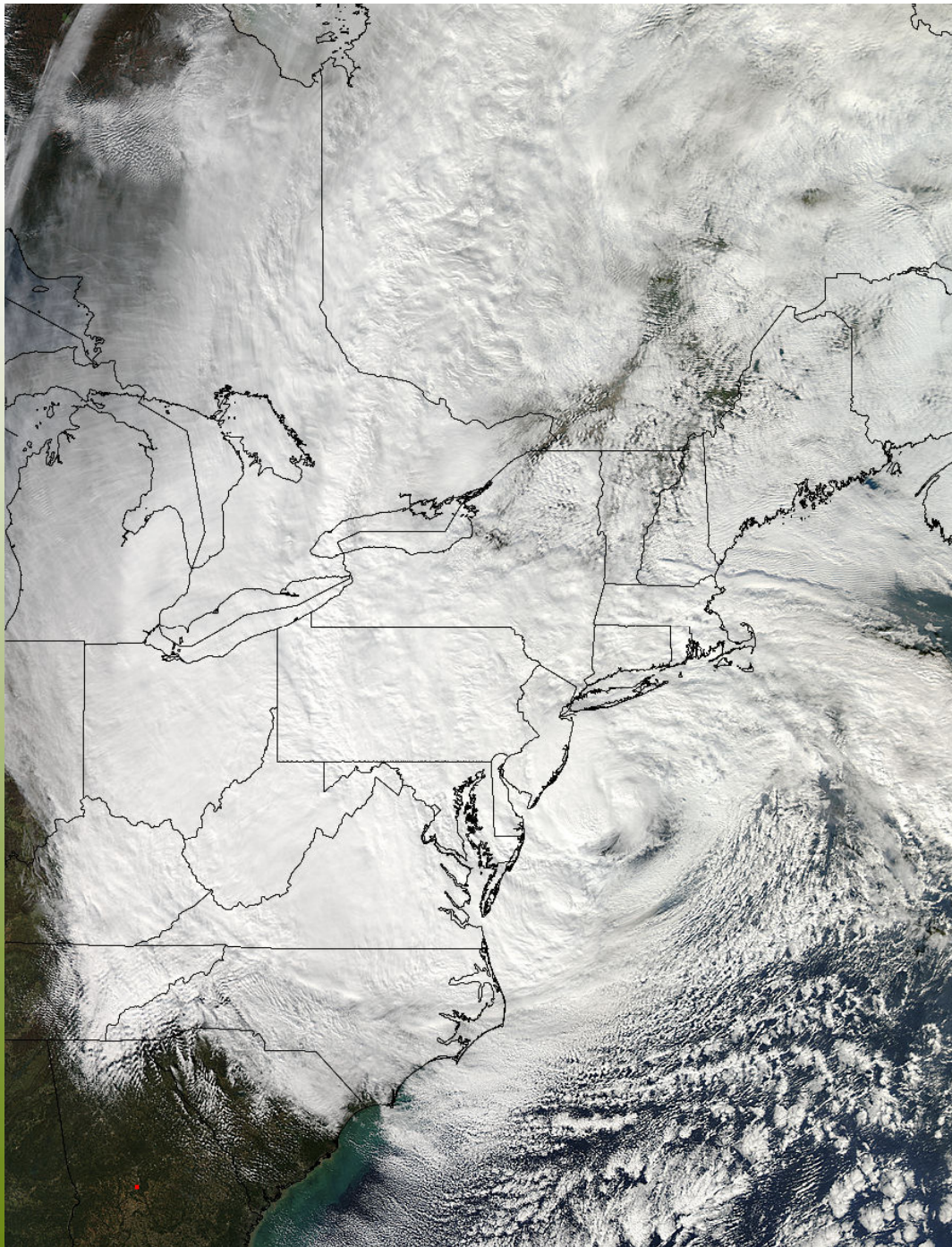
US Dept of State Geographer  
© 2012 Google  
Data SIO, NOAA, U.S. Navy, NGA, GEBCO  
© 2012 MapLink/Tele Atlas  
27°33'35.57" N 80°47'29.61" W elev 3 m

©2010 Google  
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Eye alt 6449.95 km

# Sandy's Wind Field – Midnight Oct 29





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Sandy at 2:20 PM Oct 29

Covers 4.7 Million Square KM

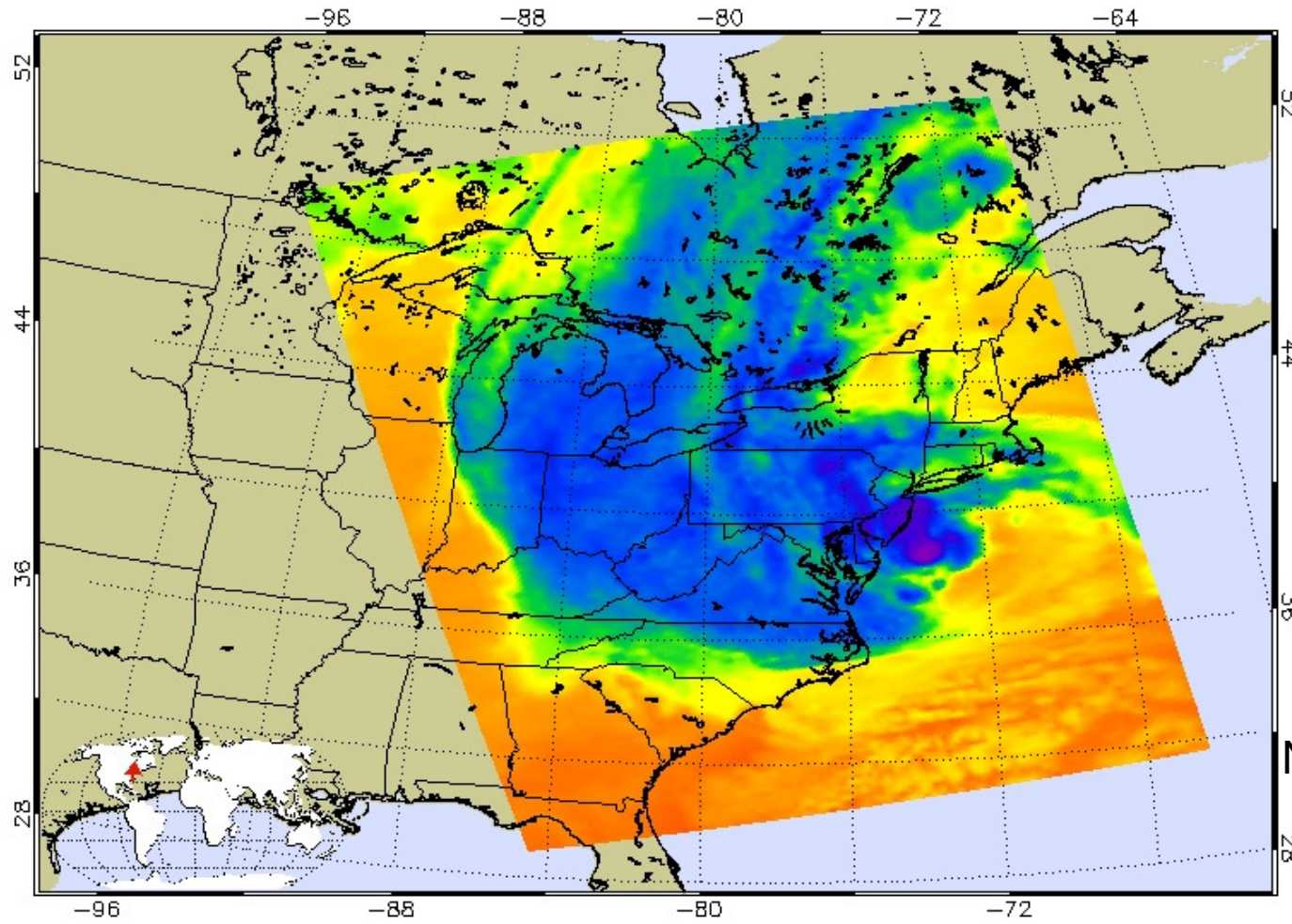
From Northeastern Ontario to  
Ohio Valley to Mid-Atlantic  
States

NASA Goddard MODIS  
Rapid Response Team

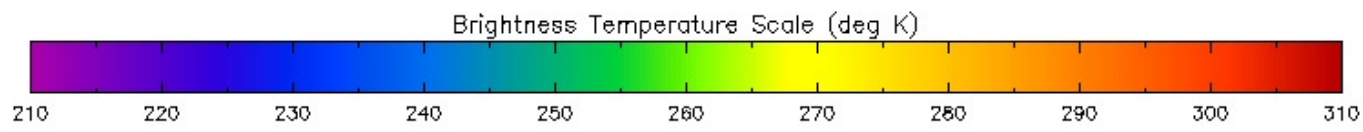
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AIRS Level-1B Quick Browse Image

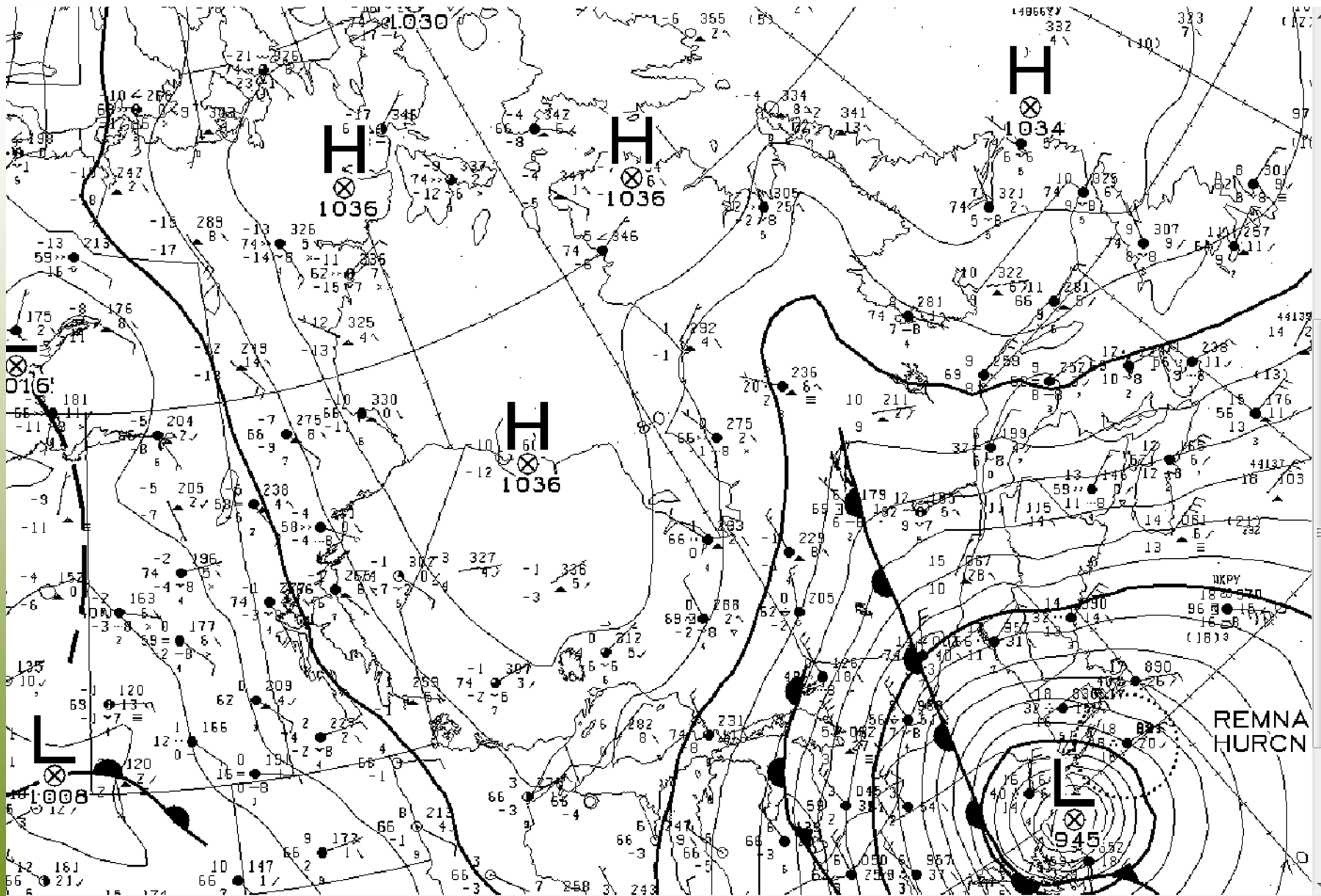
12.047  $\mu\text{m}$  Brightness Temperature Oct 29, 2012 18:17:23 UTC Granule 183



NASA JPL CalTech



Granule Id - AIRS.2012.10.29.183.L1B.AIRS.Rad.v5.0.14.0.R1230315D650.hdf



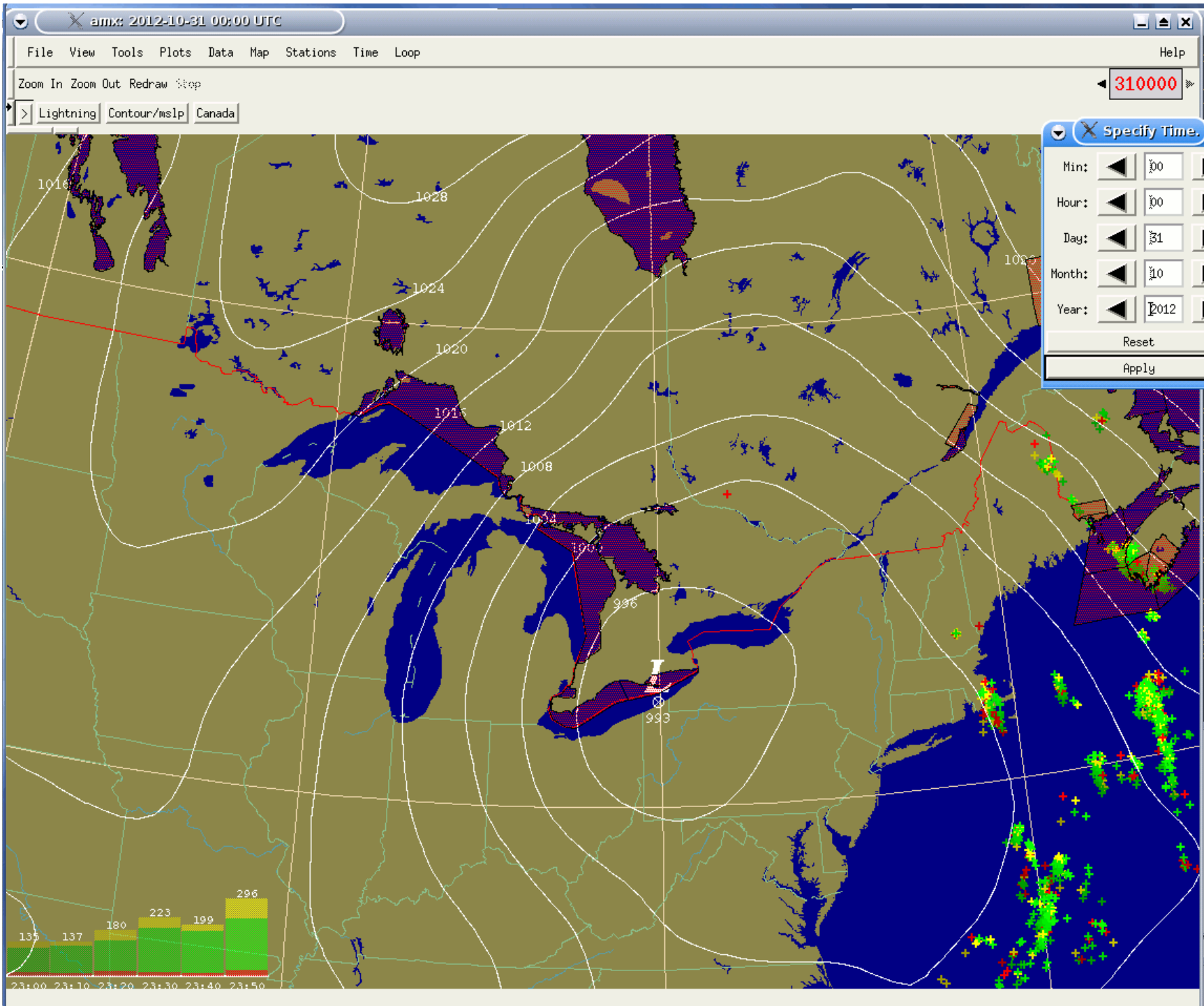
# Superstorm Sandy

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- Lowest central pressure ever recorded for a storm making landfall north of North Carolina (approx. 940 mb)
- Massive size (at one point over 1600 km in diameter)
- Record storm surge for NYC (4.2 metres) coincides with high tide
- 10 metre wave recorded in New York Harbour
- Multiple elements (wind, surge, rain and snow)
- \$50 Billion in losses?



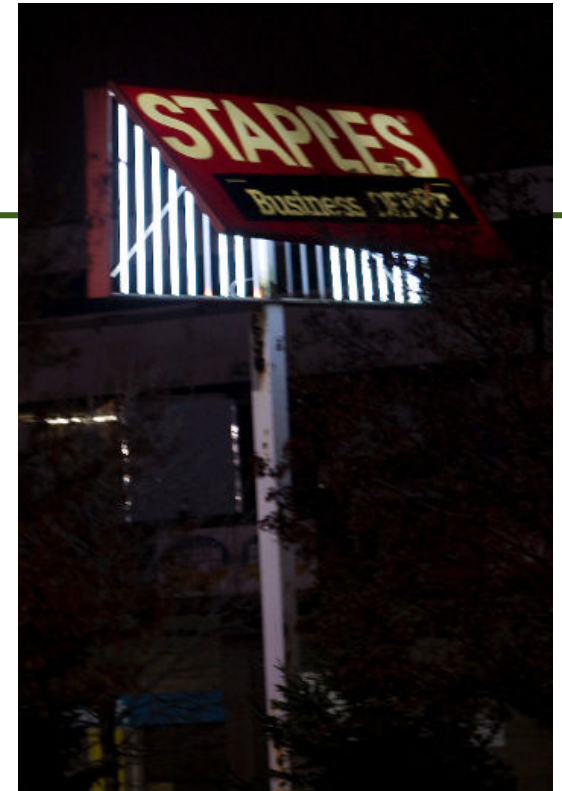


# Sandy's Impacts





# Canadian Impacts



Toronto Sun



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# Superstorm Sandy – Ontario Impacts

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- Strong North winds in Southern Ontario from evening of Monday, Oct. 29 into morning of Tuesday, Oct. 30
- Wind gusts between 80 and 90 km/h...strongest gusts in Sarnia area to 100 km/h
- 2 fatalities – Toronto woman hit by debris, Bluewater Power employee killed repairing downed power lines
- Up to 150,000 without power
- 7 Metre waves at south end of Lake Huron...lakers stuck at west end of Lake Erie



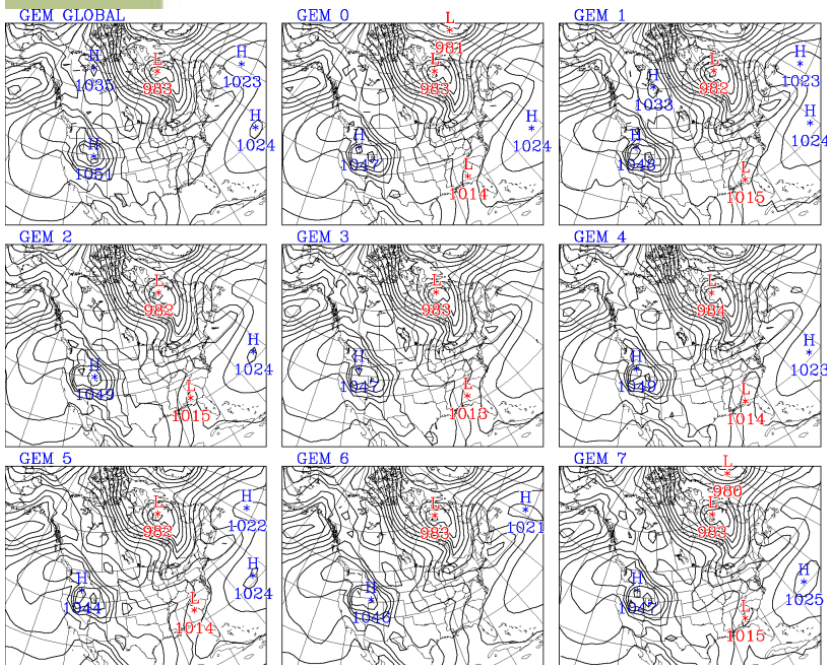
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# Advances in Medium Range (3 to 10 Day) Forecasting

- Supercomputers now capable of up to 70 trillion calculations per second
- Better ability to approximate atmospheric processes
- Ensemble approach makes slight changes in initial conditions and then displays multiple future solutions



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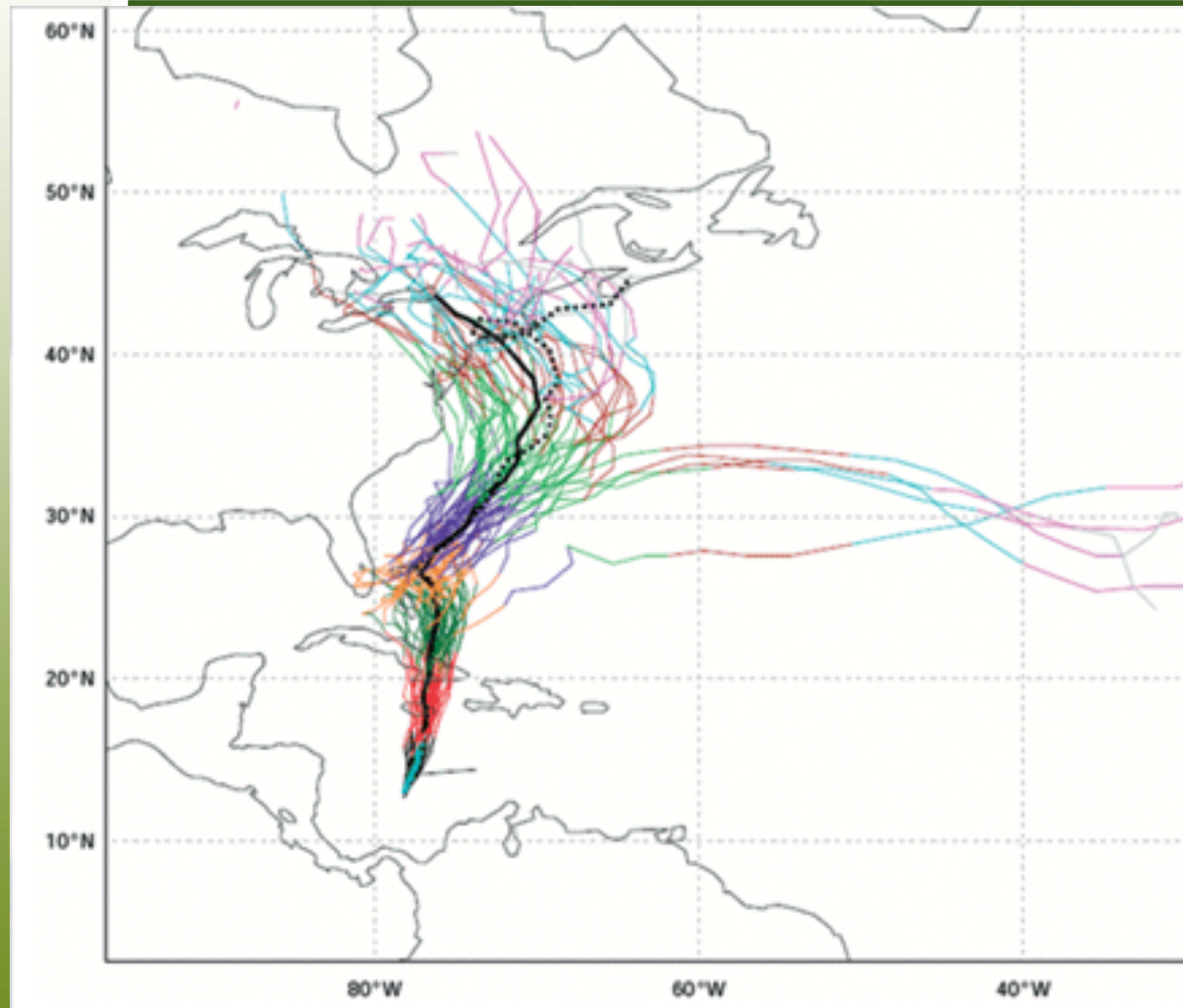
# Advances in Medium Range Forecasting



- Day 2 forecast as accurate as Day 1 forecast in 1988
- Day 7 forecast as accurate as Day 5 forecast in 1988
- Increased safety and economic benefits as longer range forecasts become more accurate
- Aviation, Agriculture, Tourism, Retail, Utilities



# Advances in Medium Range Forecasting



ECMWF (European Centre for Medium Range Weather Forecasts)

7.5 Days in Advance

Coloured Lines represent Various forecast tracks

Actual Track in Black

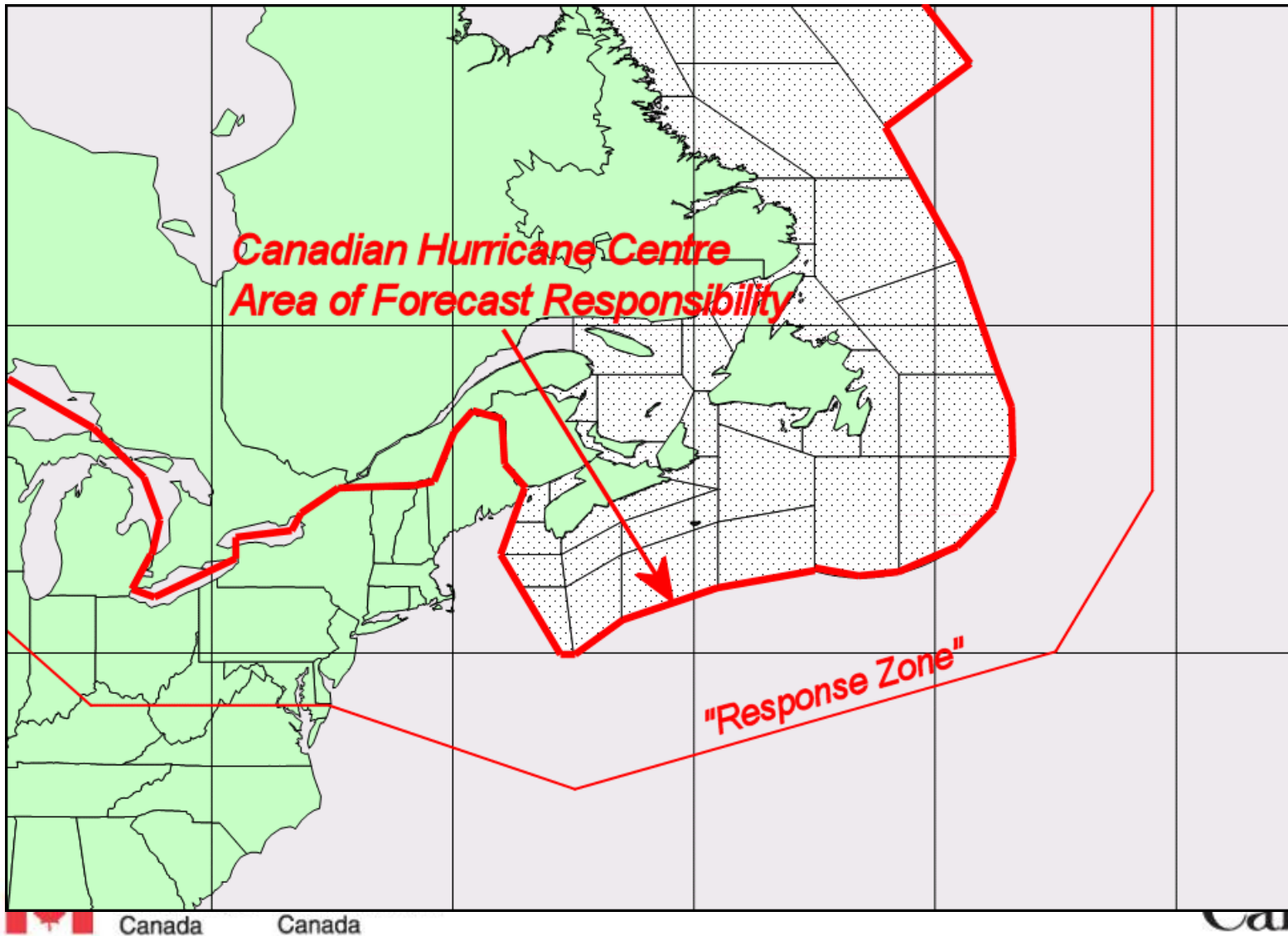


# Advances in Medium Range Forecasting

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- Increased accuracy in longer range forecasts introduces challenge of how to impart this information
- Works best with large, well-defined weather systems
- Smaller scale storms (i.e. individual thunderstorms) still difficult to pinpoint days in advance
- Some situations still low confidence

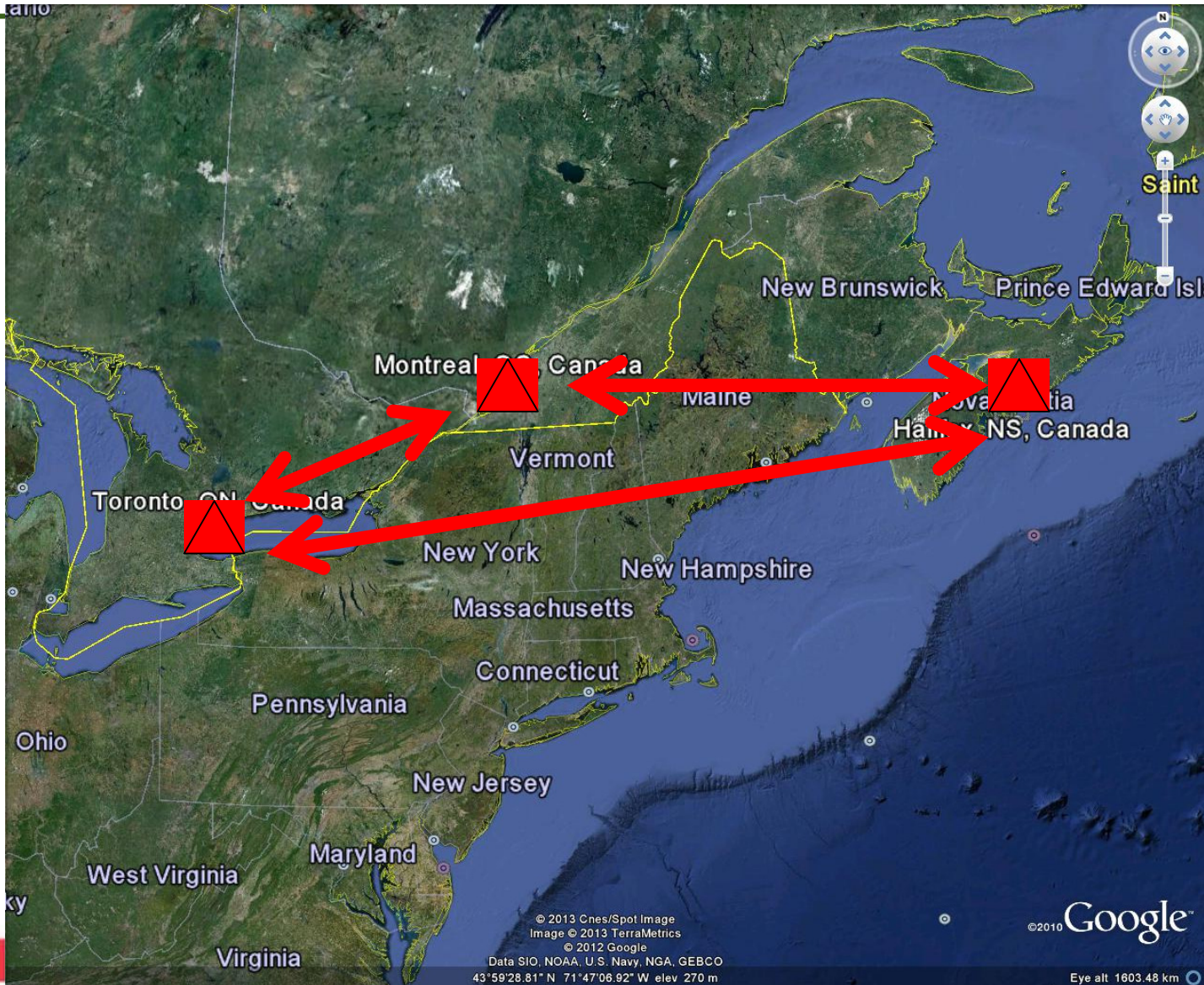
# EC's Response – Inter-regional Cooperation - Canadian Hurricane Centre Response Zone



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# EC's Response – Inter-Regional Cooperation



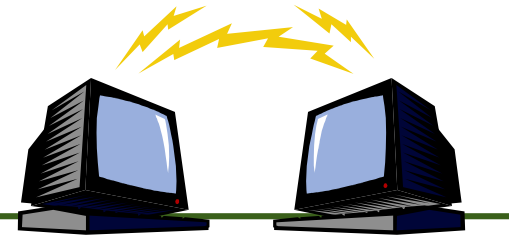
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Data SIO, NOAA, U.S. Navy, NGA, GEBCO  
43°59'28.81" N 71°47'06.92" W elev 270 m

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# Early Notification

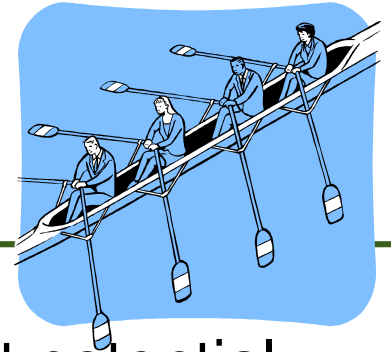


- When, how and who do we tell about approaching large storms?
- How do we express confidence level in longer range forecasts?
- How do we ensure the message and risks are properly understood?



**CAUTION**

# Early Notification – Sandy



- Internal discussion held Tuesday, Oct 23 about potential Sandy Impacts in Canada on Oct 29
- Email sent to key emergency management clients on October 23 providing initial concerns about potential Sandy impacts for Oct 29 (i.e. rain and wind)
- Additional Email sent Oct 24 to an expanded list of key clients
- First public notification – Evening of October 25 – Tropical Cyclone Statement from Canadian Hurricane Centre



# Early Notification - Sandy

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- Oct 26 – Conference calls between regions
- Oct 26 PM – Special Weather Statement for Southern Ontario (i.e. rain and wind) for Mon Oct 29
- Special Media and Emergency Manager conference calls Oct 27, 28 ,29
- Extra staffing in Weather Centres and for media spokespeople Sat Oct 27 and Sun Oct 28
- Continued coordination of messaging between regions
- Coordination with Conservation Authorities



# Early Notification - Sandy

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- 4:50 AM Mon Oct 29 – Wind Warning for Southern Ontario (rain no longer expected to be significant)
- Emergency Management Ontario (EMO) coordinates conference call with other Provincial Ministries...Environment Canada provides briefing
- EMO in concert with Ministry of Transportation changes messaging on 400 series highway signs to mention Wind Warning
- Approx 8 PM Mon Oct 29 – north winds strengthen over Southern Ontario

# Some Ontario Media and Public Reaction

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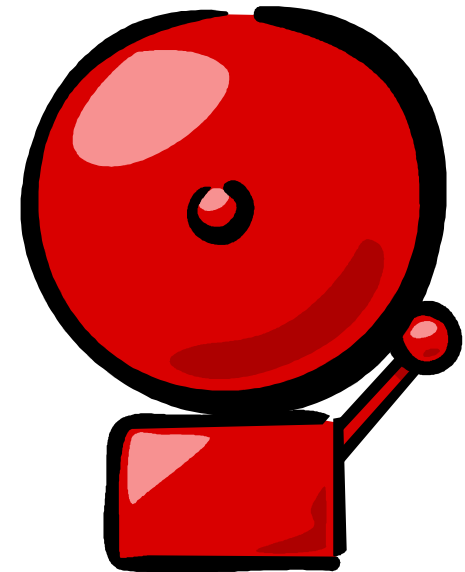
- Didn't seem so bad...
- Didn't you overdo it?
- Mixing of American messaging/warnings with Canadian messaging
- Impacts in U.S. much larger than in Canada
- However Canadian Warnings not overdone (i.e. we got pretty much what we said we'd get)...Americans as well...
- Traditional Media...Social Media...Media-on-demand from many sources...blurs geography...blurs the message...



# Future of Weather Alerting/Notification

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- ECAAlertMe – Email/Text Message
- Tiered/Impact-based Warnings
- When to alert media/public (i.e. especially when confidence low)?
- How to alert?





# Rainfall warning ISSUED for [Geoff1](#) Issued on Tue Sep 4, 2012 18:42 UTC [View More](#)



e

Severe thunderstorms are imminent or occurring in the area. These storms may produce large hail, damaging winds or heavy rainfall. Remember that some severe thunderstorms can also produce tornadoes.

Emergency management Ontario recommends taking cover immediately when threatening weather approaches.

[More details on the alert are available here.](#)

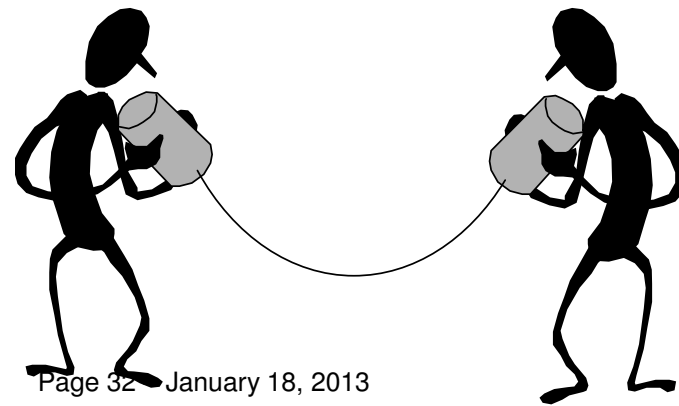
Replies to this message will not be read or responded to.

Latest information is always available here: [http://weatheroffice.gc.ca/warnings/warnings\\_e.html](http://weatheroffice.gc.ca/warnings/warnings_e.html).

- Snow Squall
- Tornado
- Weather
- Watches (4)
  - Snow Squall
  - Winter Storm
- Severe Thunderstorm
- Wind Chill
- Winter Storm
- Severe Thunderstorm
- Storm Surge
- Wind
- Wreckhouse Wind
- Tornado



# Risk Communication – Impact-based Warnings



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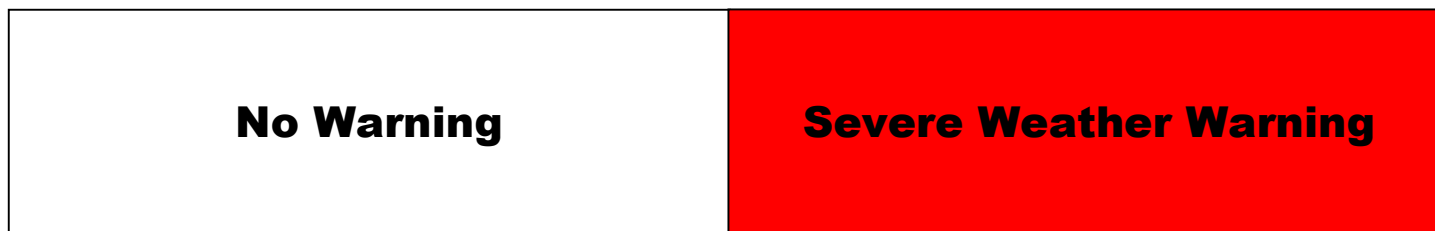
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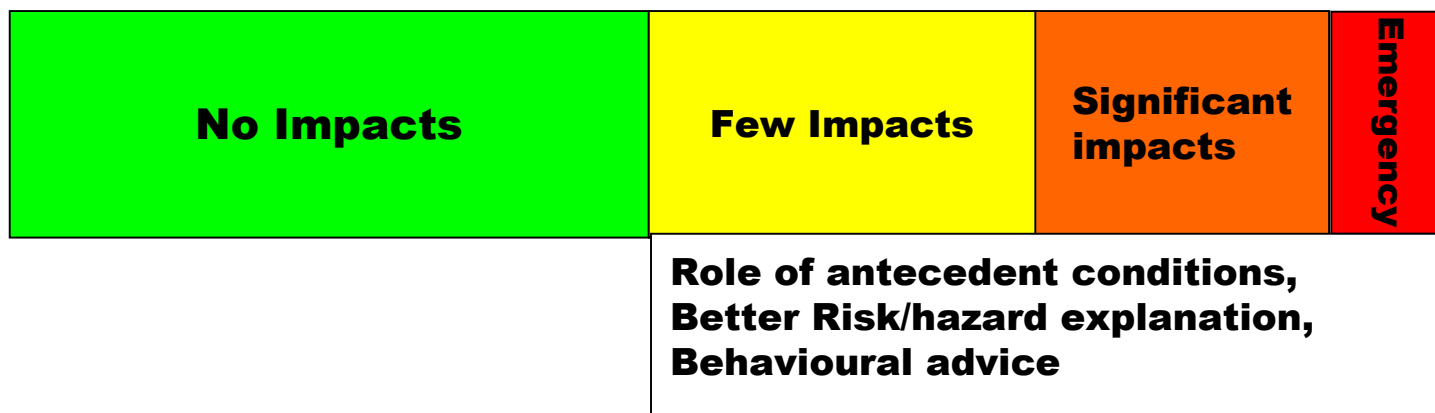


# Risk Communication – Impact-based Warnings

## Current warning system



## Proposed alternative: Impact Based



# Levels of Warning

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- Green – OK
- Yellow – Current Warning Criteria
- Orange – Significant Warning (once a season type of event)
- Red – Rare, Particularly Dangerous situation (once in a decade kind of storm)



# Warning Impact Statements

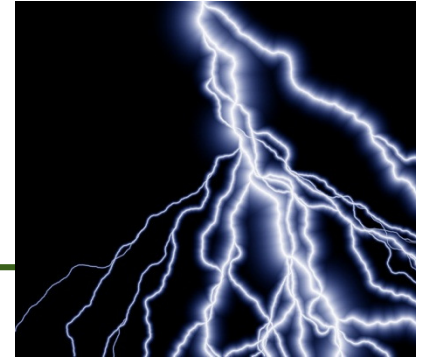
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- Link impact statements to level of message
- Strong tornadoes could cause serious injury or death
- Intense snow squalls causing zero visibilities and extremely dangerous driving conditions
- Freezing Rain/High Winds resulting in widespread power failures



# Summer 2013

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- Changes begin with Severe Thunderstorm, Tornado Warnings
- More specific impact messages (i.e. wind, hail, rain, tornado)
- More specific geographic area (i.e. attempt to better focus on the areas of immediate risk)
- Fall – Winter 2013 – process begins for winter storms
- Continue to assess/fine-tune based on client feedback





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# Thank you!



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