Superstorm Sandy: Impacts on Global Connectivity

5 February 2013

Superstorm Sandy: Research Opportunity

- The Internet is the planet's most complex manmade system
- What happens if we turn off power to one of the key traffic exchange cities?
- These are experiments we dare not run in real life
- As you listen, think: how could these measurements be made more useful to me, the network operator?

Today's Panelists

- **John Heidemann**, USC/Information Sciences Institute
- **Emile Aben**, RIPE RIS
- **Doug Madory**, Renesys
- **Patrick Gilmore**, Akamai

- Moderator: **Jim Cowie**, Renesys

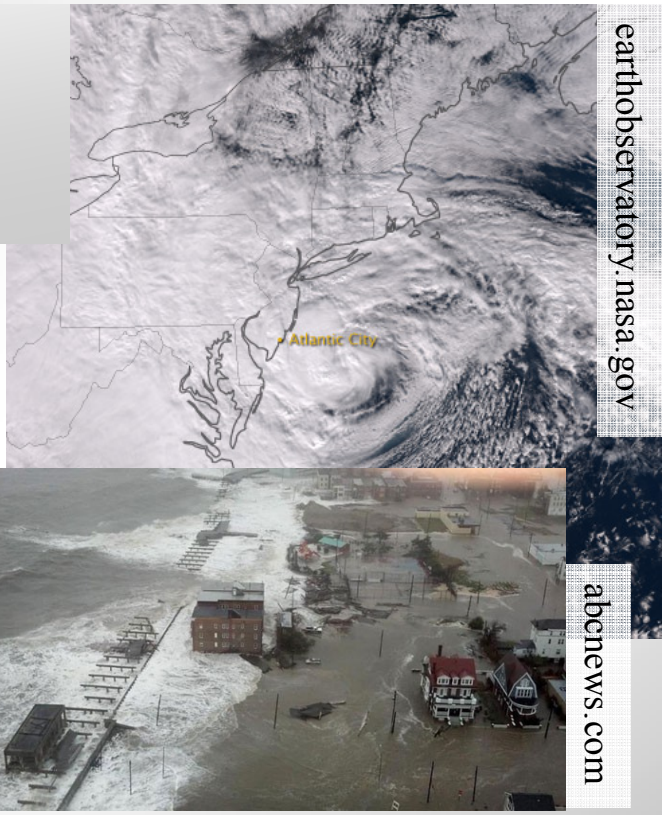
Active Probing of Edge Networks: Outages During Hurricane Sandy

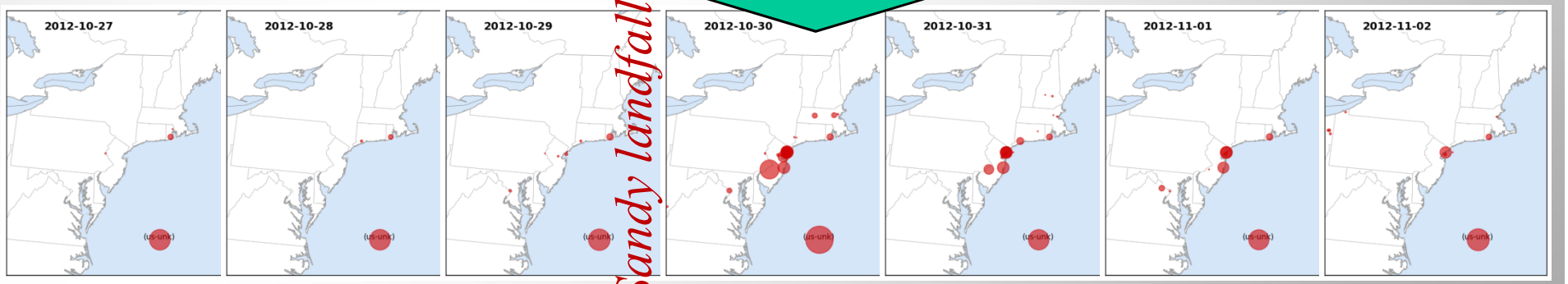
John Heidemann
joint work with Lin Quan and Yuri Pradkin

5 February 2013
NANOG, Orlando, Flordia

Can Pings Measure Hurricane Damage?

```
PING 8.8.8.8 (8.8.8.8) 56(84) bytes of data.
64 bytes from 8.8.8.8: icmp_req=1 ttl=251 time=89.6 ms
64 bytes from 8.8.8.8: icmp_req=2 ttl=251 time=83.6 ms
64 bytes from 8.8.8.8: icmp_req=3 ttl=251 time=86.6
^C
--- 8.8.8.8 ping statistics ---
3 packets transmitted, 3 received, 0% packet loss, time 2001ms
rtt min/avg/max/mdev = 83.602/86.627/89.641/2.465 ms
```





Goal: Tracking Outages in Edge Networks

- quickly know the impact of **natural disasters**
  - Hurricane Sandy, Tōhoku Earthquake 2011, etc.
  - and human ones :-(like Egypt 2011, etc.

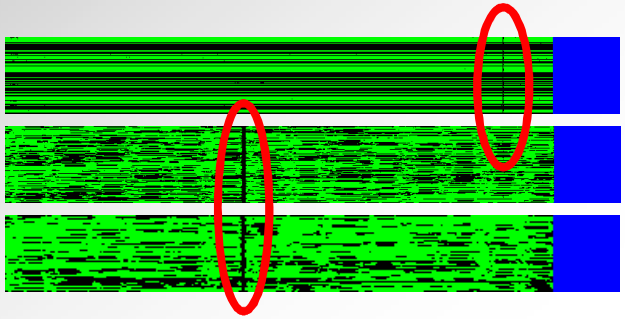
- evaluate ***wide* and *long* outages**
  - many people vs. long duration (vs. both)

- **in *edge networks*: *24s***
  - not just routable prefixes
  - most outages are small, *inside* ISPs, *not* from routing
    - e.g.: [Bush et al, IMC 2007]; us: ~70% smaller than rtg pfx

Approach: Detect Changes in Ping Response

1. probe multiple addresses in each block frequently

green: positive
black: no response
blue: not probed;
each band is a /24 block



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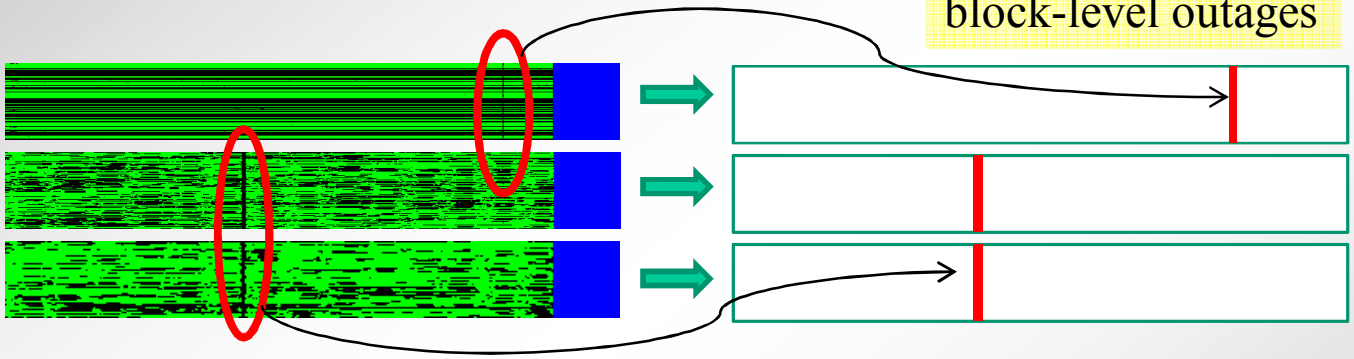

2. gaps indicate block-level outages

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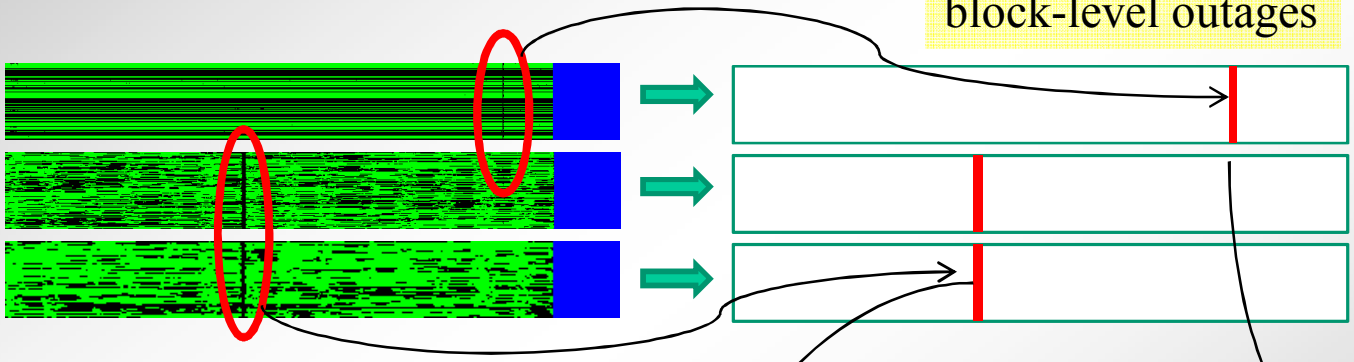
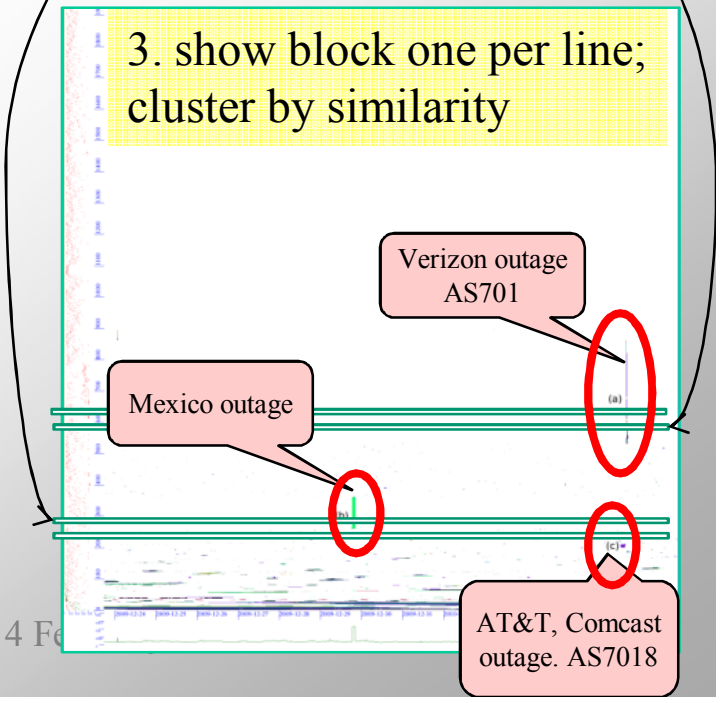


2. gaps indicate block-level outages

3. show block one per line; cluster by similarity



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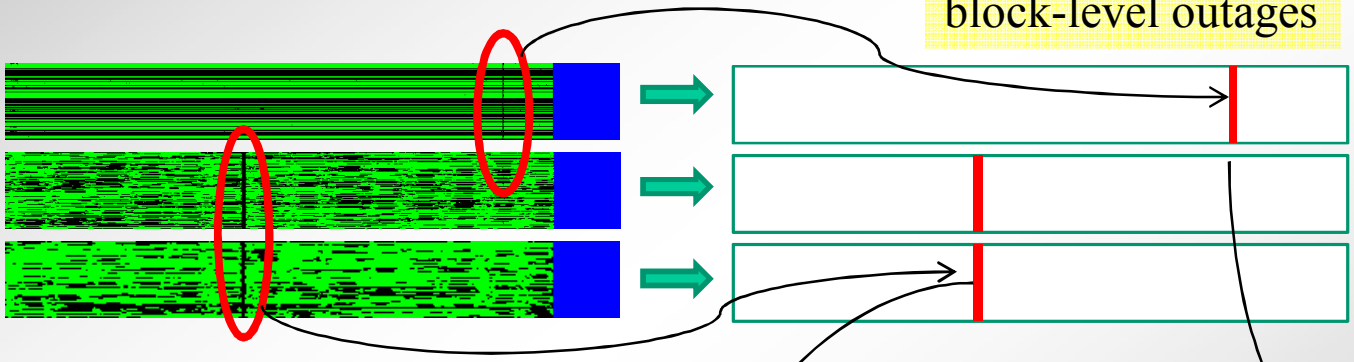

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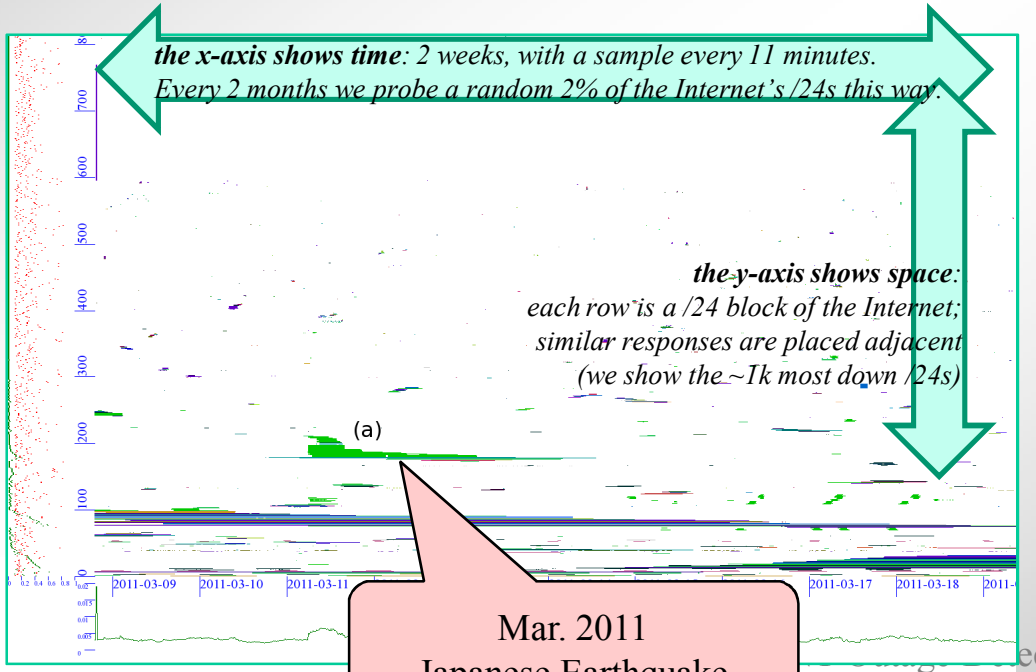

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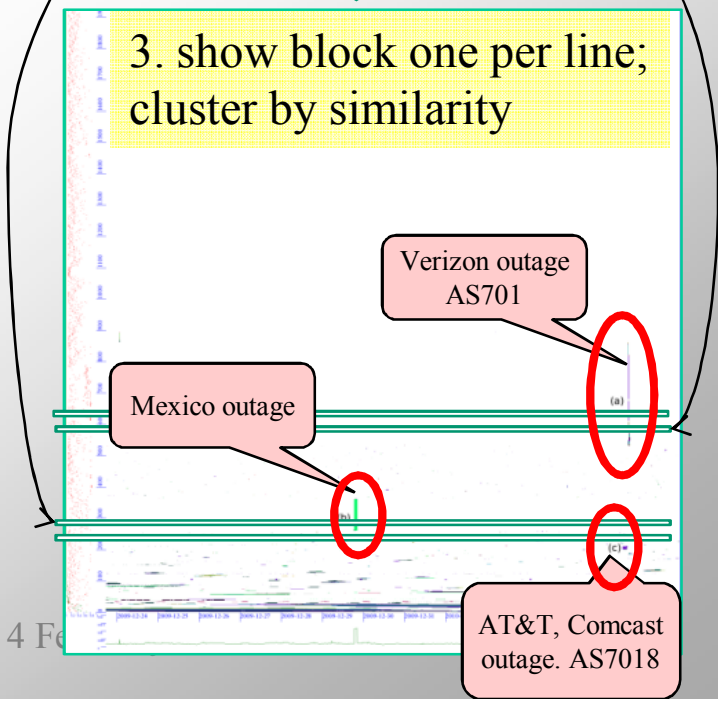
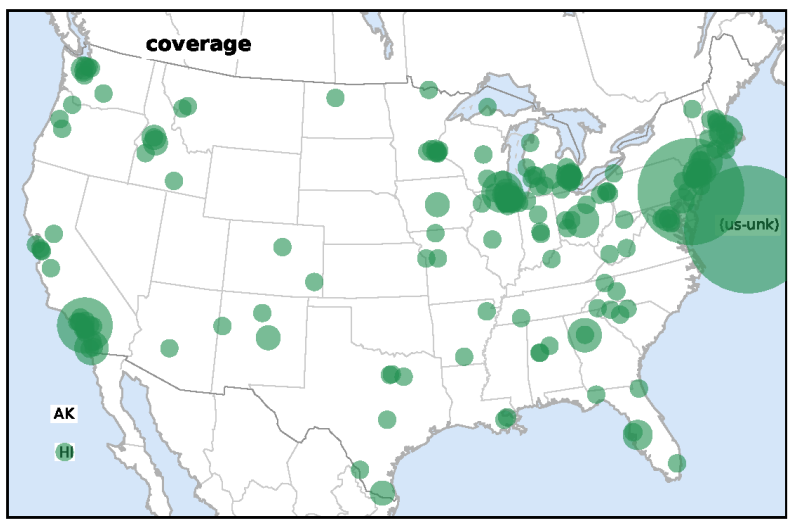


Details: Sandy Analysis

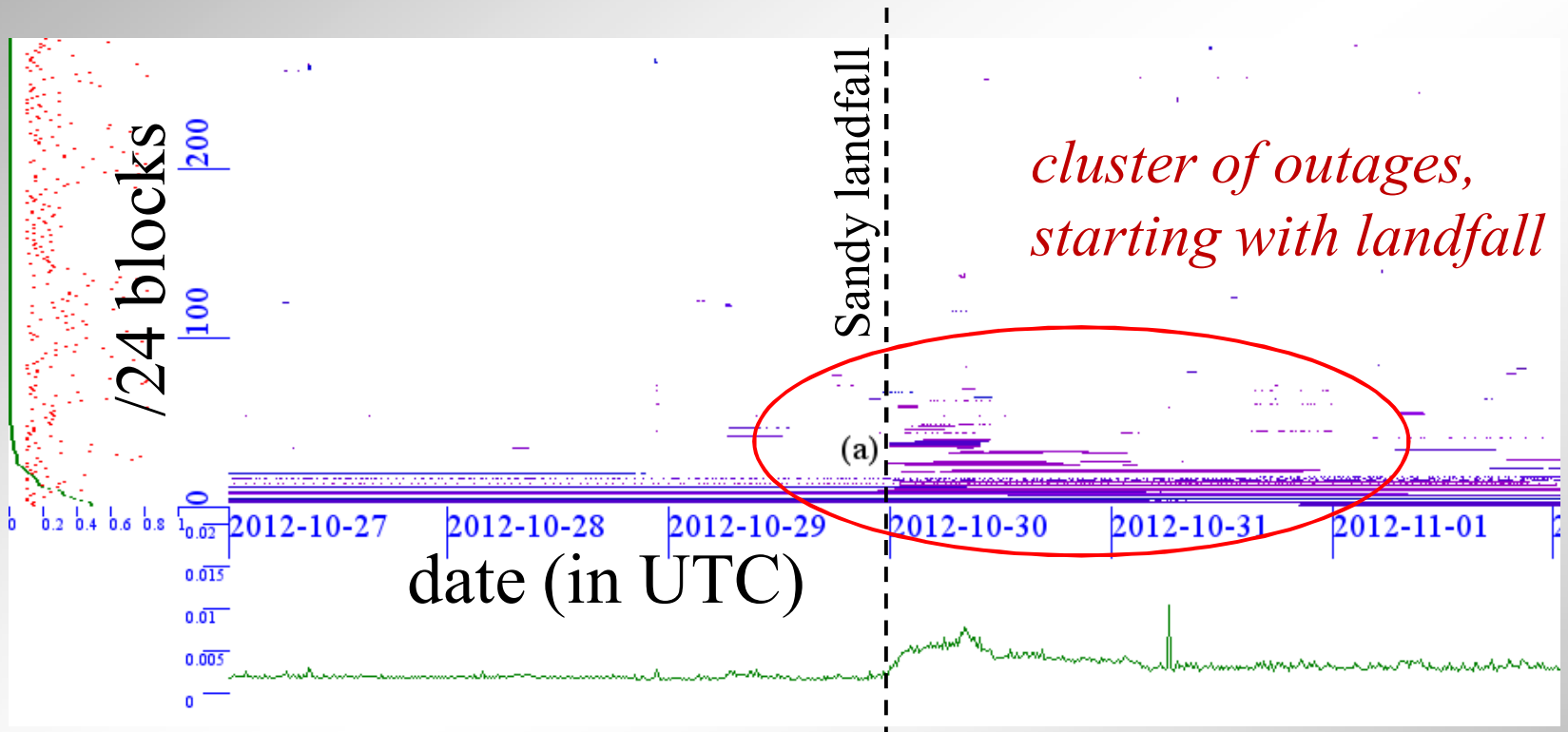
- Sandy-specific methodology
  - re-analyzed existing data
  - moderate traffic: 1400 probes/hour to each /24 block (= 1 probe every 3 s)
  - details in ISI-TR-678b: http://www.isi.edu/~johnh/PAPERS/Quan12a.html
  - data available: http://www.isi.edu/ant/traces/
- work in progress:
  - custom, outage-specific probing
  - expect <15 probes/hour per /24 (~1% above)

Data About Sandy

- look at one dataset:
  internet_address_reprobing_
  it50j-20121027
- 41,582 /24 blocks
- 11,900 geolocate to US
- 4,117 have enough reponse to analyze
  - 60 of these don't have states



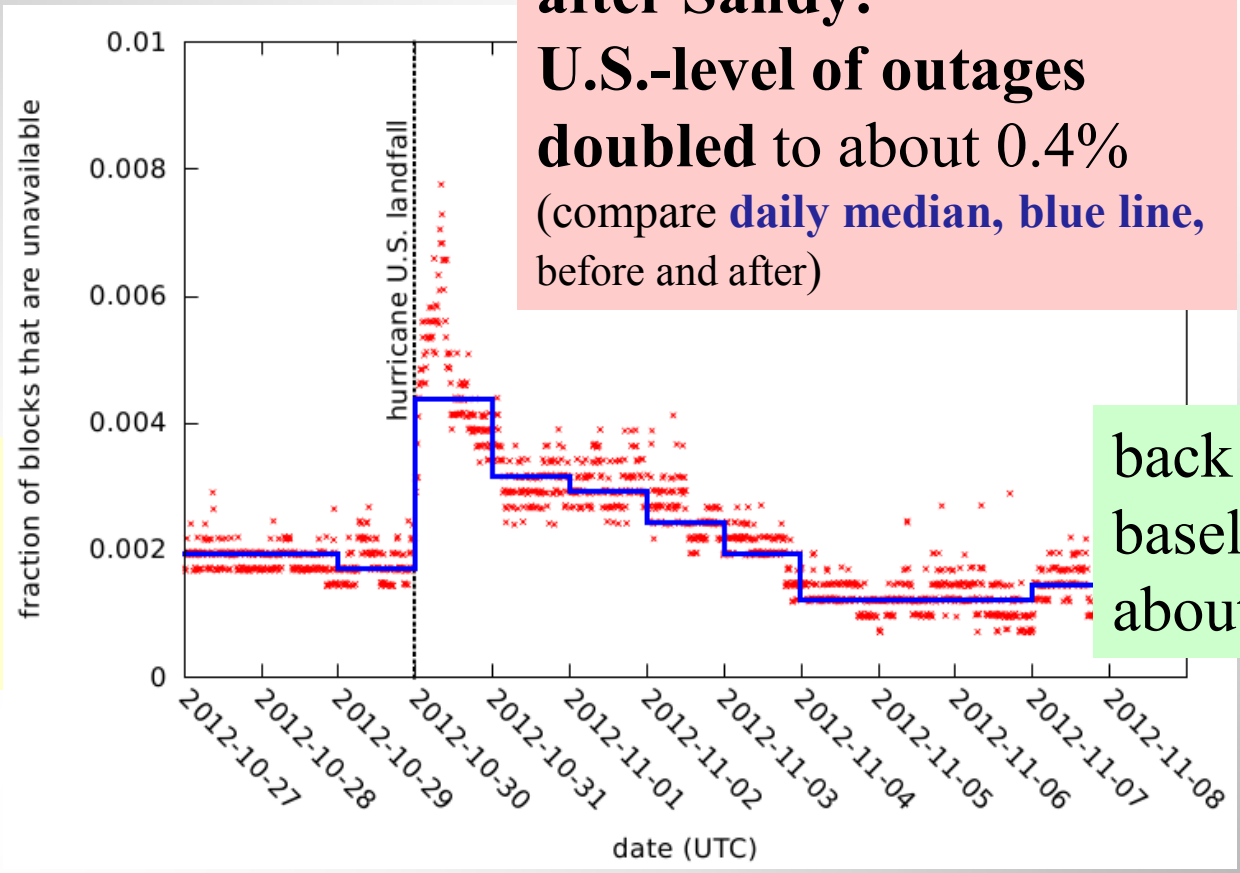
Outages at Sandy Landfall



how many outages? look at marginal distribution

Measuring the Impact

after Sandy:
U.S.-level of outages doubled to about 0.4%
(compare **daily median, blue line,** before and after)

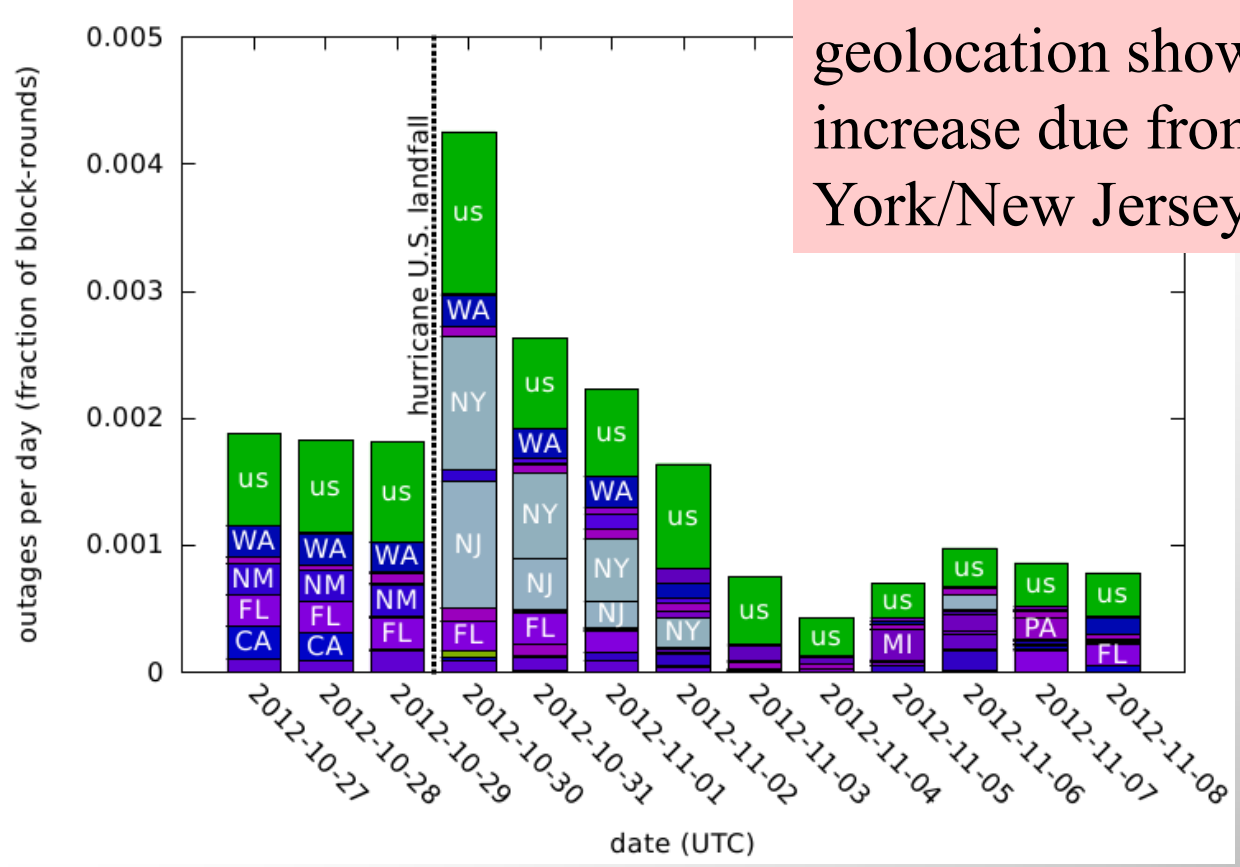


always *some outages* in US about 0.2%

(each red X is amount of U.S. outage for 11 minutes)

back to baseline after about 4 days

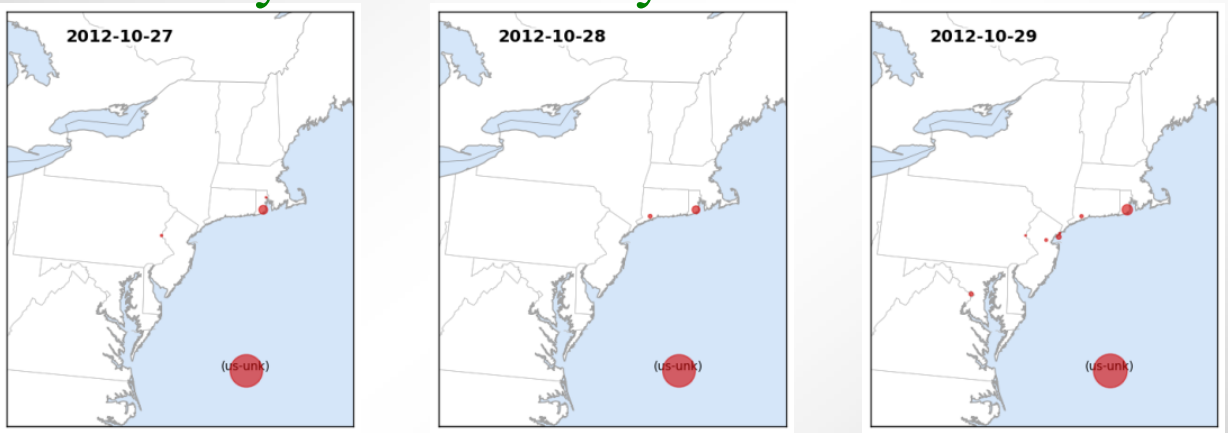
Where Are Outages? NY/NJ



geolocation shows outage increase due from New York/New Jersey area

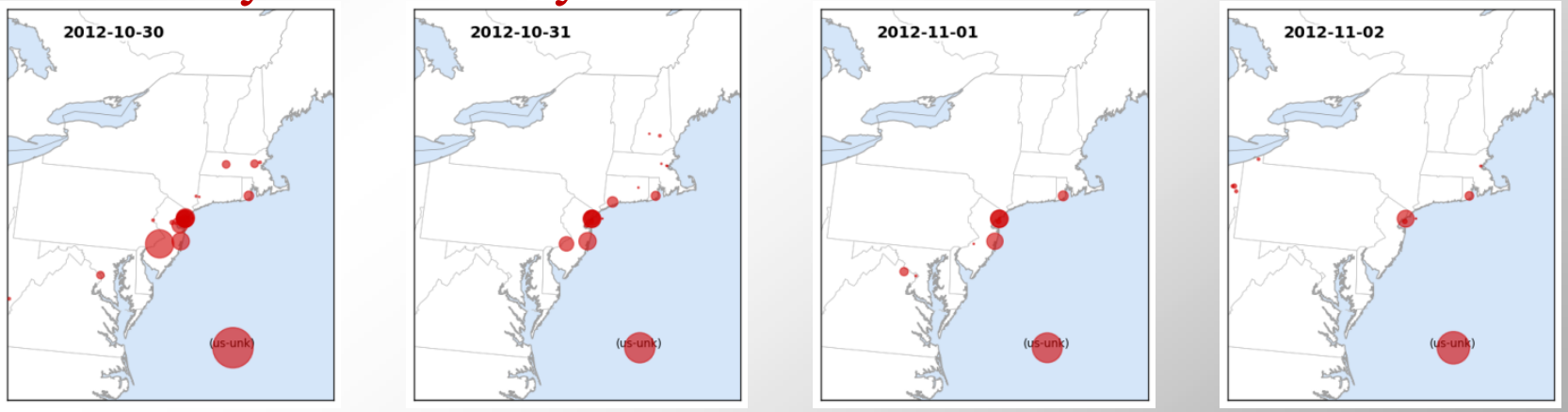
The Northeast, by Day

3 days before Sandy landfall



Sandy landfall

4 days after Sandy landfall



What Next?

- pings *can* detect edge-network outages
- we're working to deploy detection
  - lower probe rate: <15 probes/hour per /24
  - grow coverage: 3.4M blocks

- tech report about Sandy: http://www.isi.edu/~johnh/PAPERS/Heidemann12d.html
- datasets: http://www.isi.edu/ant/traces

Hurricane Sandy, as seen by RIPE Atlas

emile.aben@ripe.net

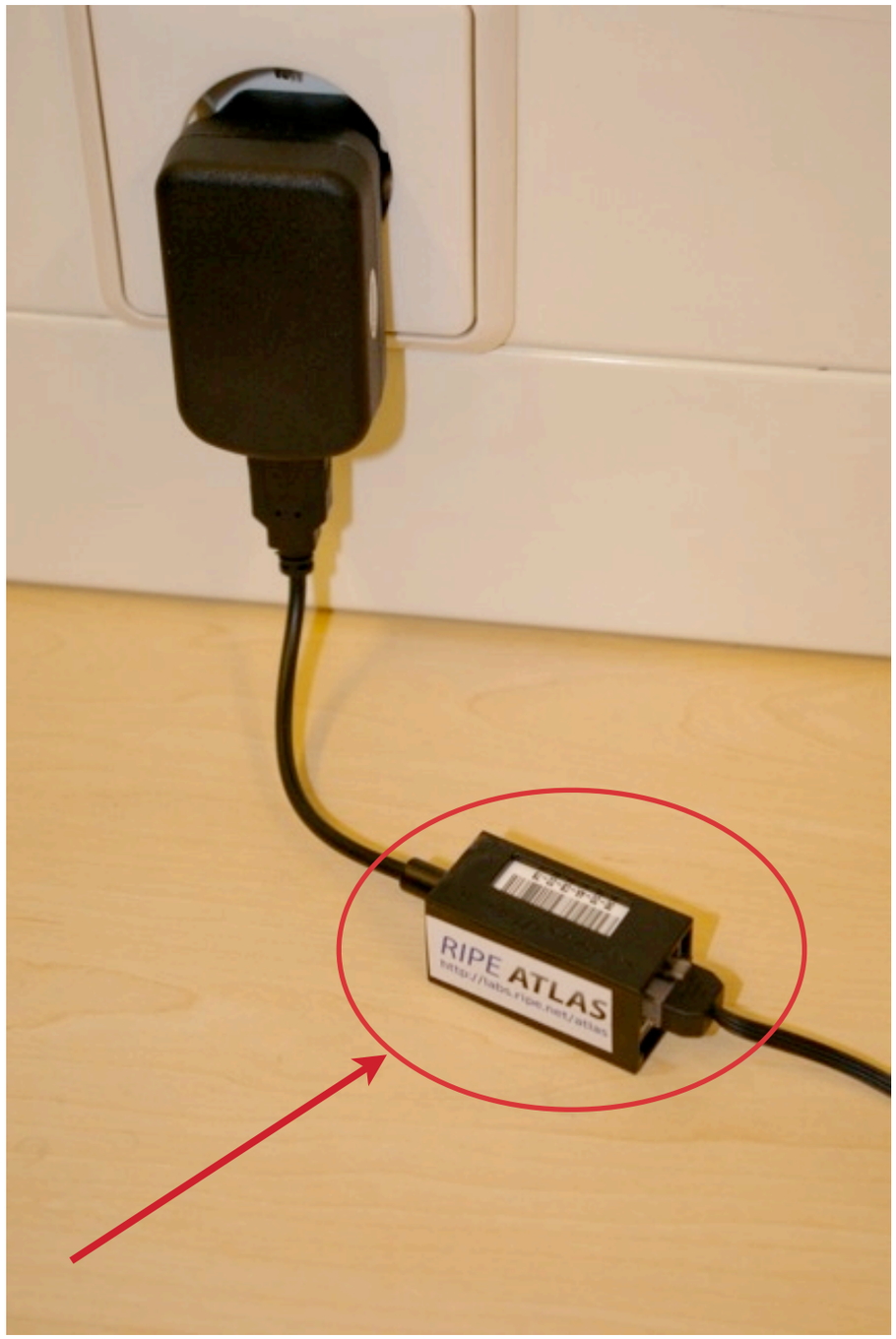
NANOG 57

RIPE Atlas

- Measuring the Internet
  - For the community
  - By the community

- https://atlas.ripe.net/

- https://labs.ripe.net/atlas



2500+ Hardware Probes Deployed

104 countries
1202 v4 ASes (2.8%)
402 v6 ASes (6.1%)

Measurements

- Ping(4/6)
- Traceroute(4/6)
- (DNS/HTTP/SSL)

- Towards “fixed” destinations:
  - DNS root servers + RIPE Atlas infrastructure

- User Defined Measurements

What Do We Want From You?

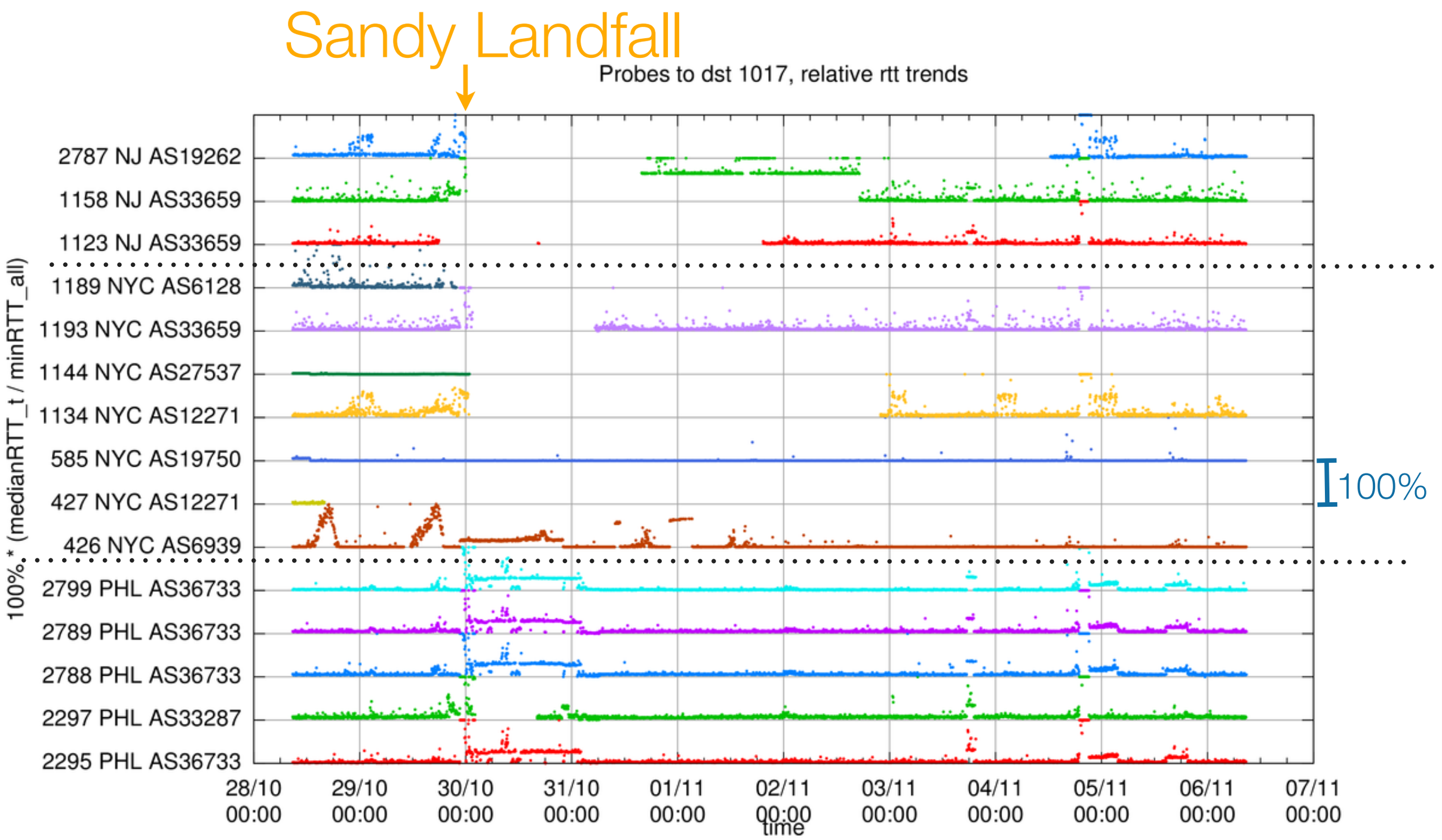
- Use RIPE Atlas!
- Feedback on how to make it (even) better

- Today's presentation: How RIPE Atlas saw Hurricane Sandy
  - https://labs.ripe.net/sandy-2012

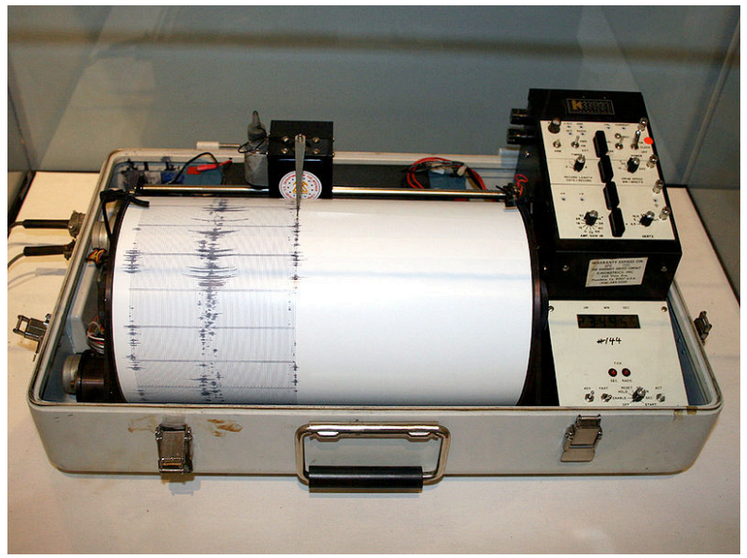
RIPE Atlas Probes in Affected Area

RIPE NCC

Vantage Points in Affected Area

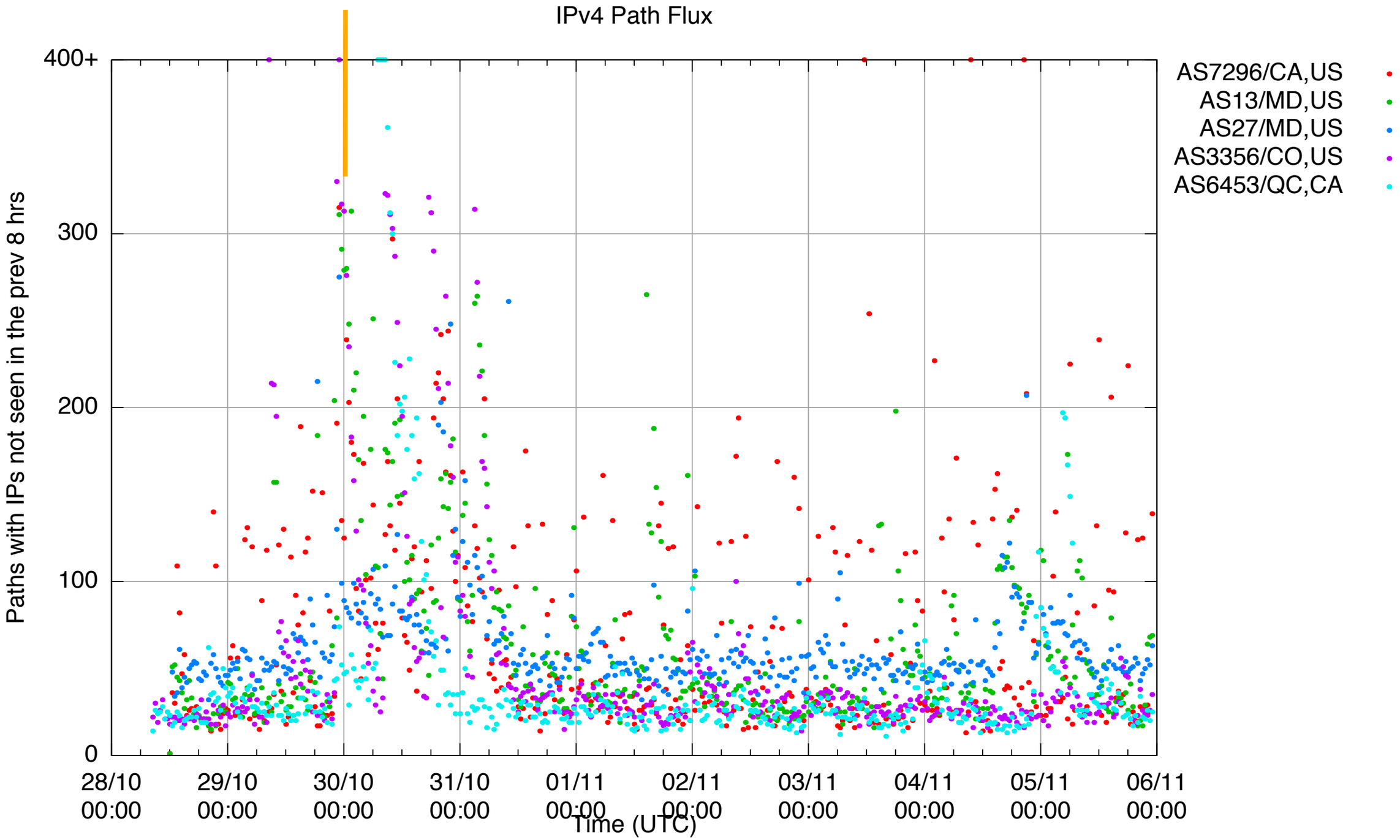


Path Flux

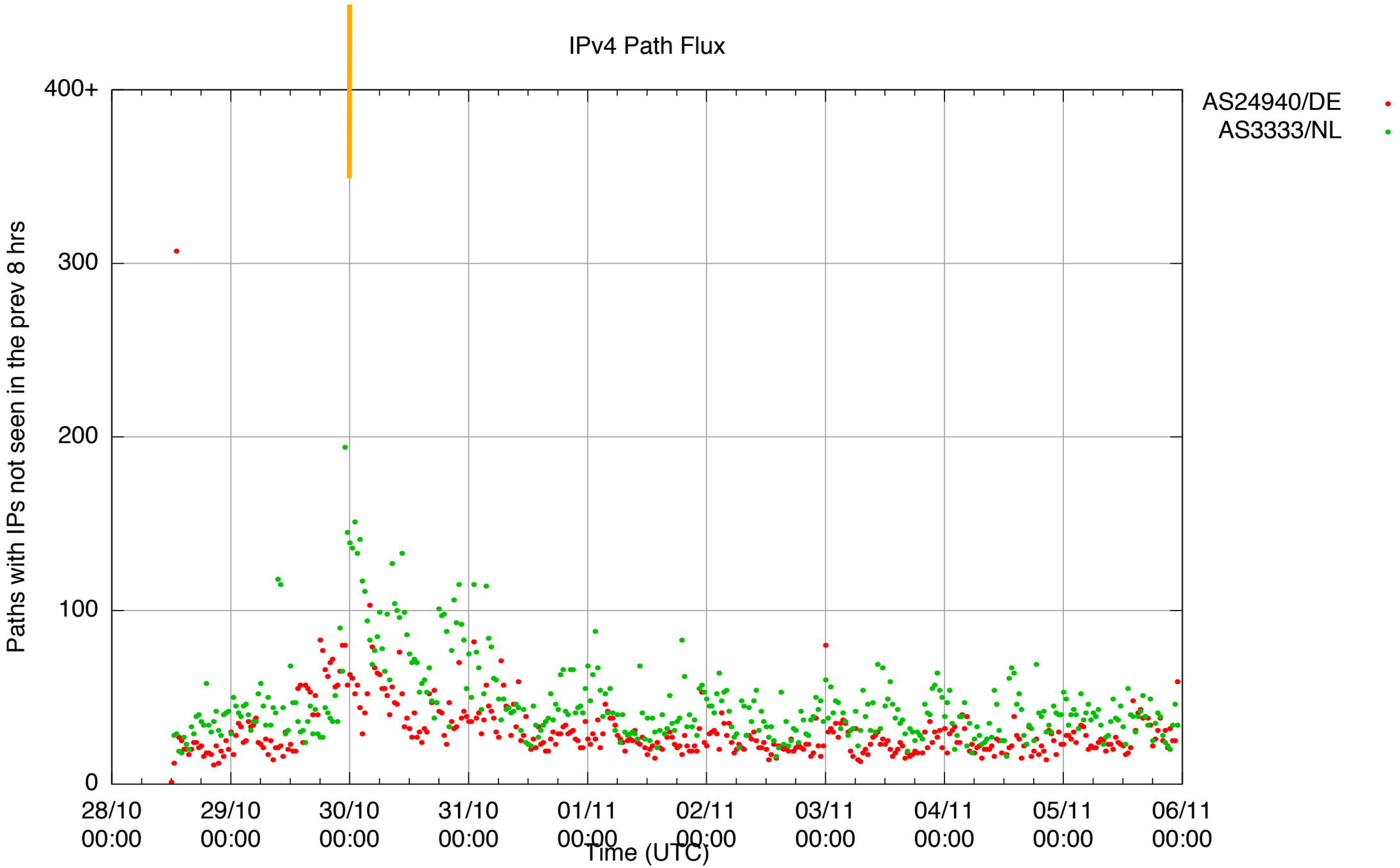


RIPE NCC

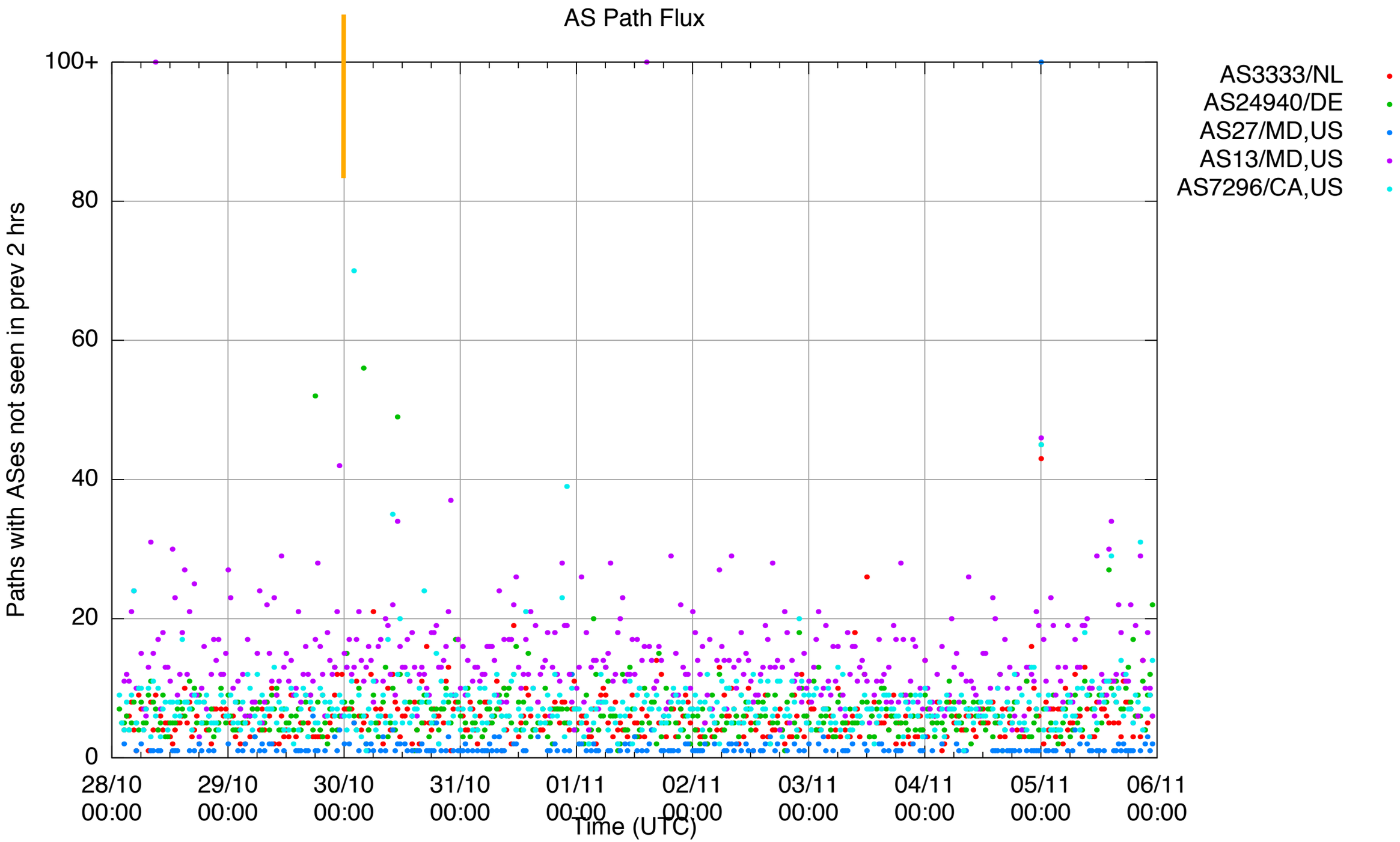
Path Flux towards North American Targets



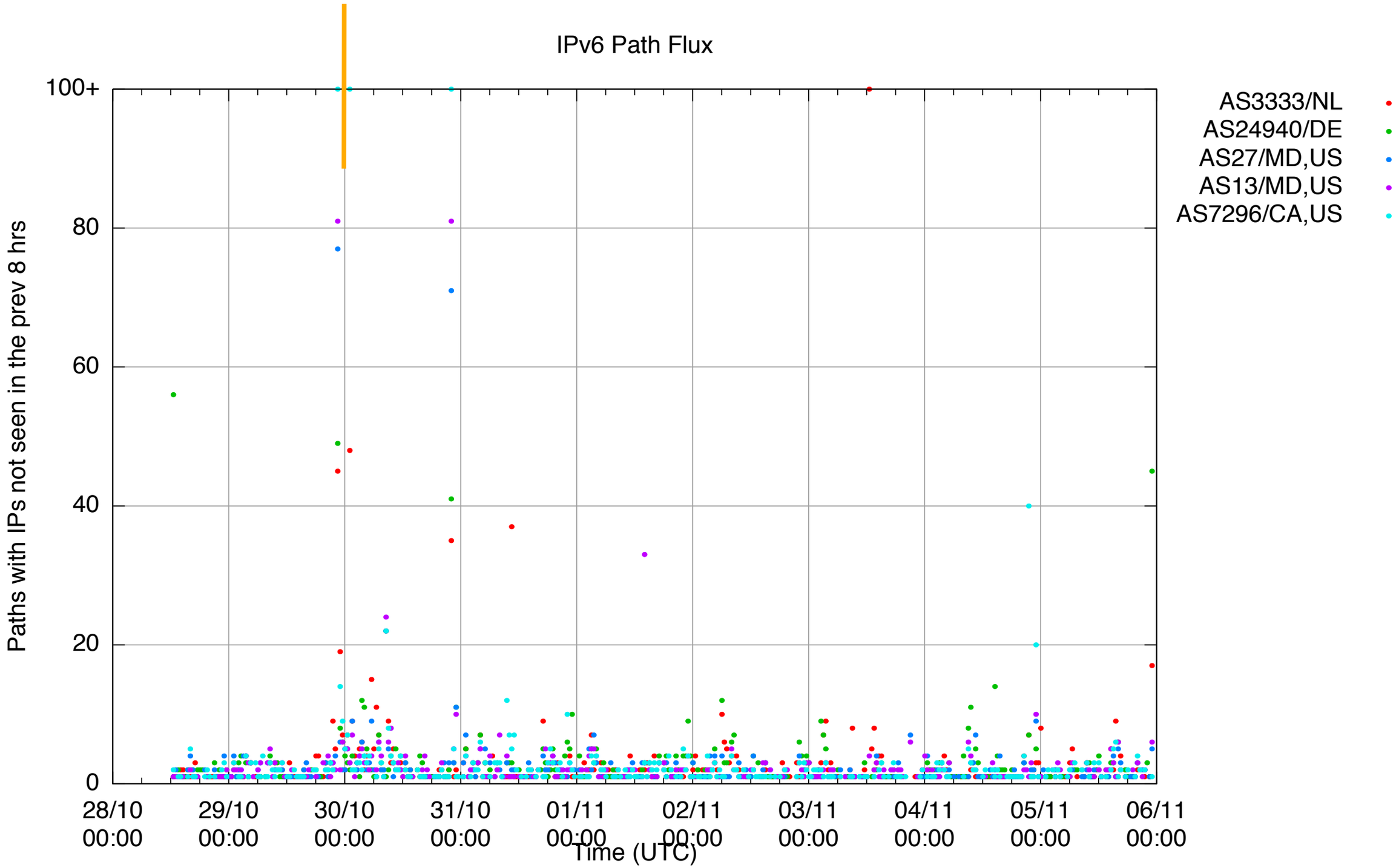
Path Flux towards EU Targets



AS Path Flux (IPv4 paths)



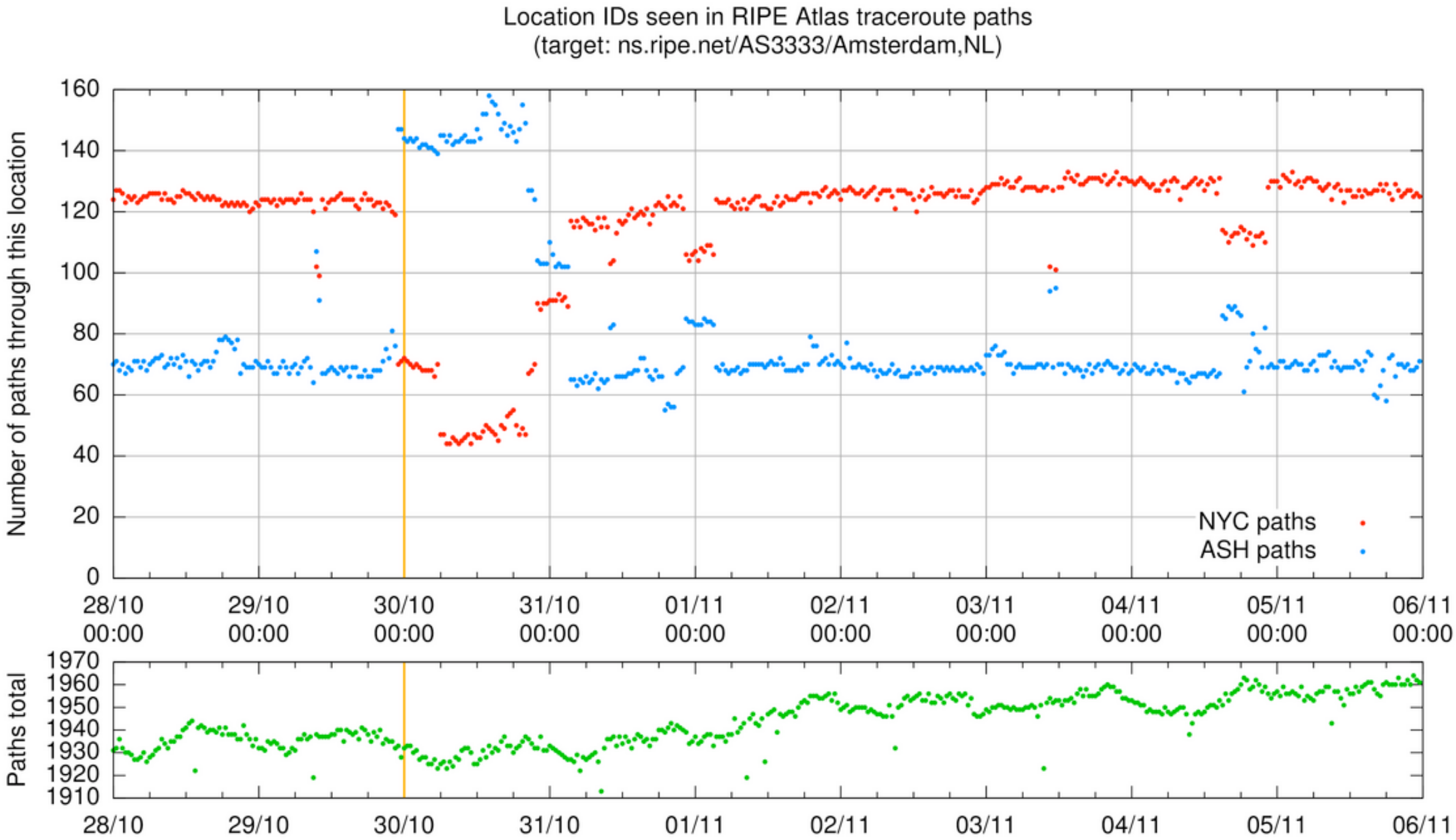
Path Flux (IPv6)



New York-New York

RIPE NCC

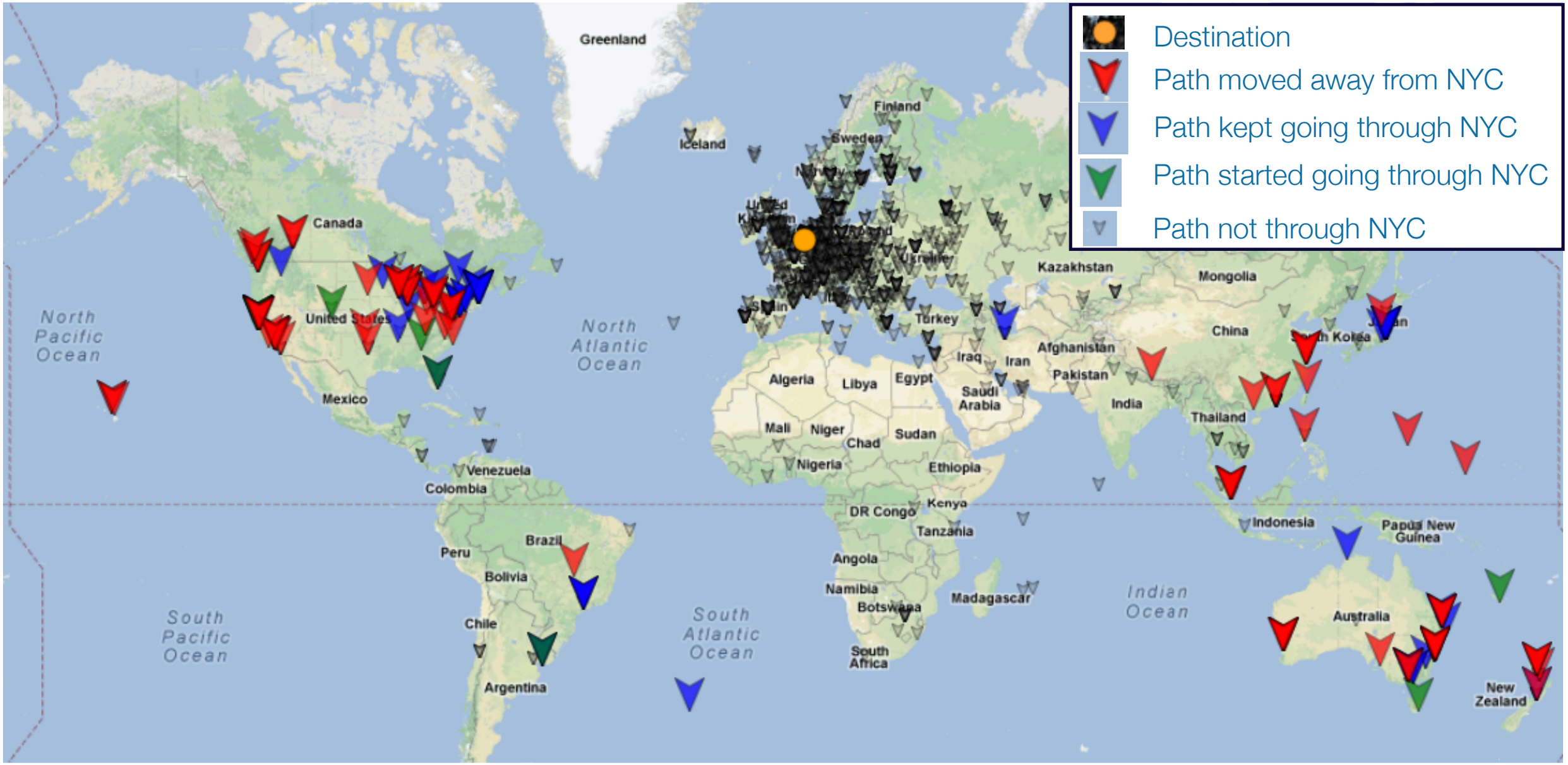
Paths through NYC/ASH to ns.ripe.net



Compare pre/post Sandy Paths

dst: ns.ripe.net / AS3333 / NL

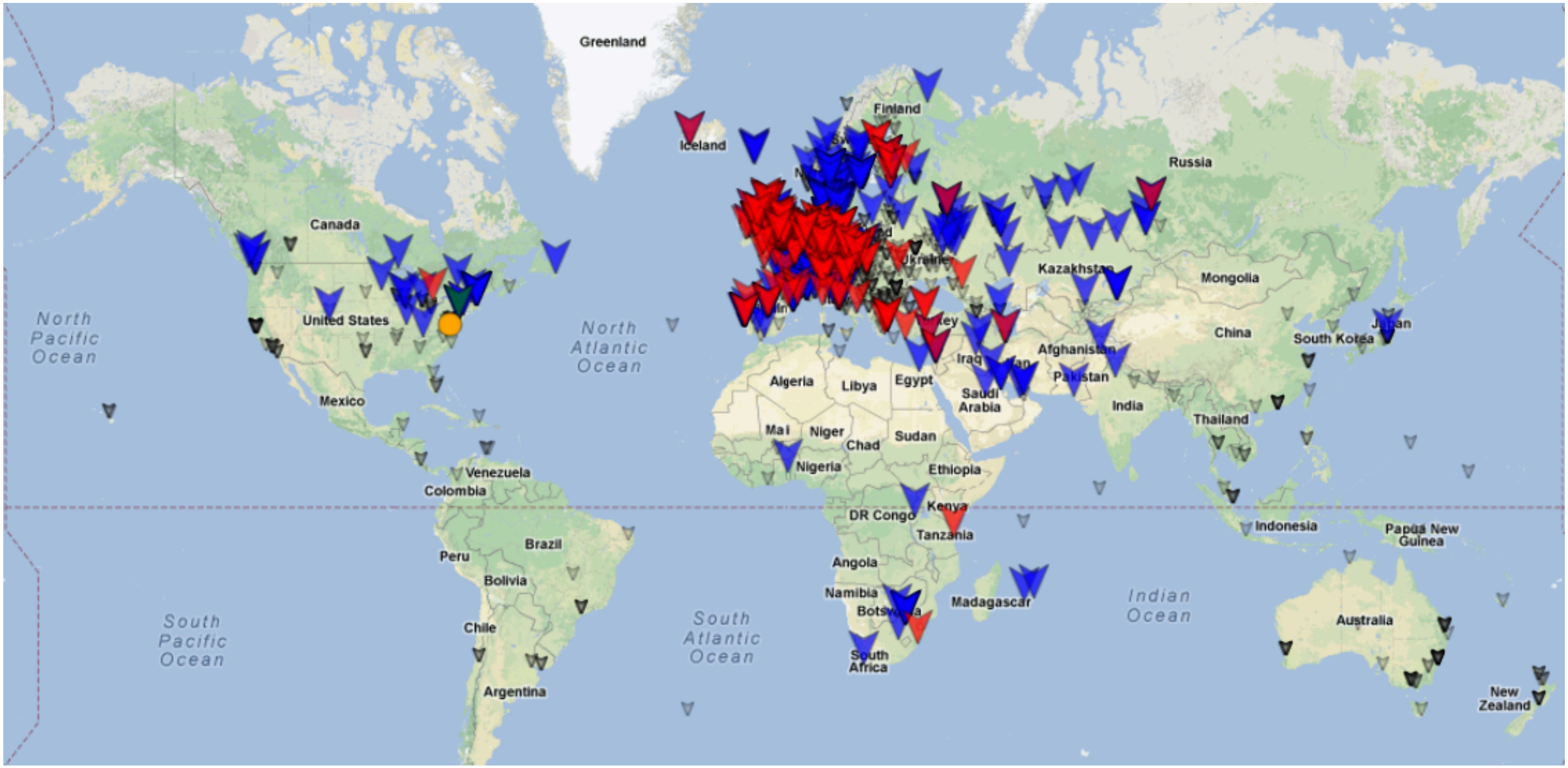
pre: 22:00 UTC vs. post: 09:00 UTC



Compare pre/post Sandy paths

dst: d-root / AS27 / MD,US

pre: 22:00 UTC vs. post: 09:00 UTC



Conclusion

- For the paths that we measured:
  - Paths were noticeably more unstable on 2012-10-30 (UTC)
  - Paths moved away from NYC, but not completely

- There will be a next time (the Mayas were wrong)
  - Next time: ???
- How can RIPE Atlas serve you best?

Questions?

https://labs.ripe.net/sandy-2012

RIPE NCC

renesys

Superstorm Sandy: Impacts on Global Connectivity

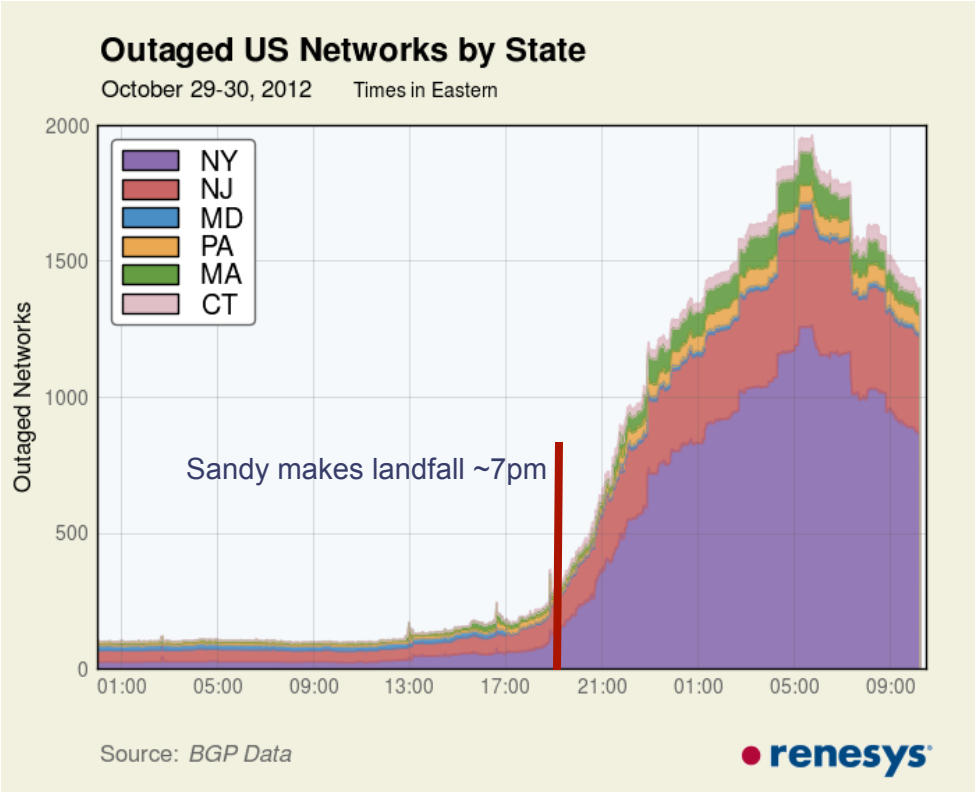
Doug Madory

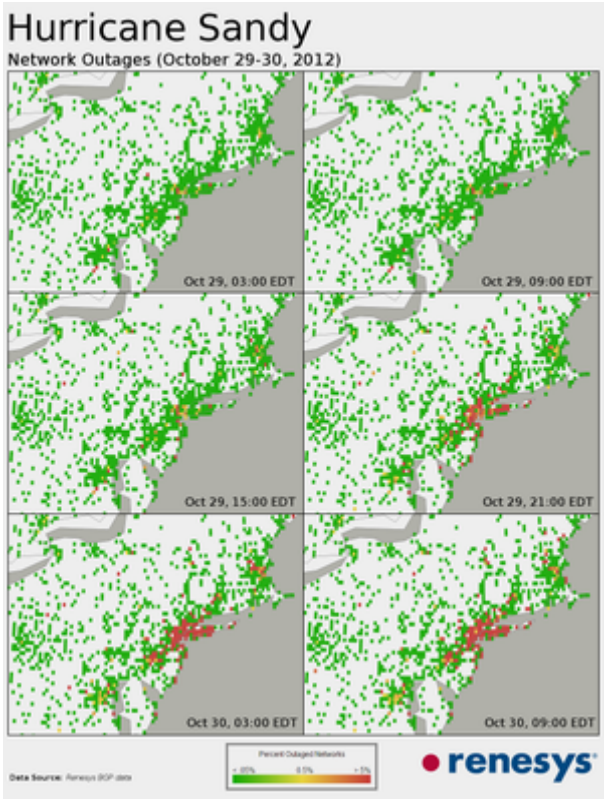
NANOG 57

5 February 2013

Hurricane Sandy – Initial Impacts

- Initial analysis looked at outages by state

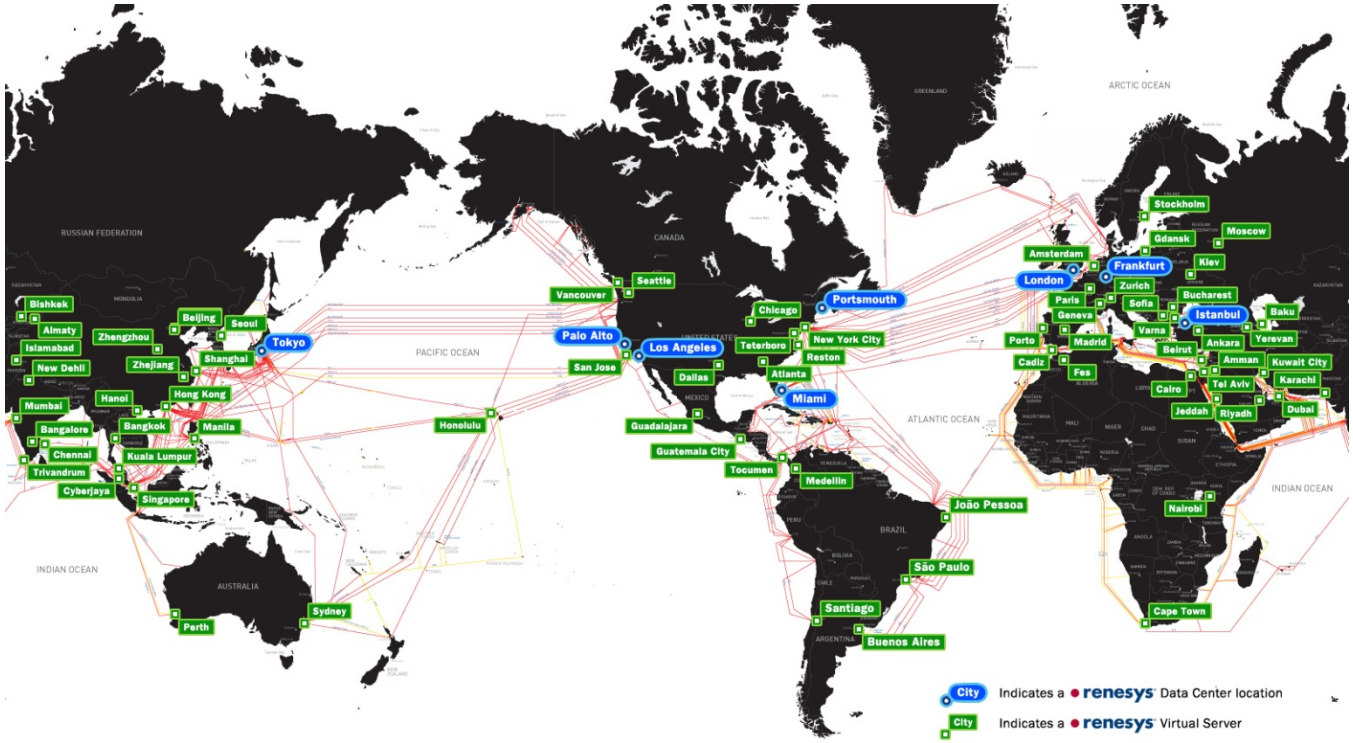




Hurricane Sandy: Initial Impact, Renesys Blog, Oct 30, 2012

Hurricane Sandy – Global Impacts

- For a deeper analysis, we look to our Global Traceroute Infrastructure consisting of 86 cities tracing the entire Internet each day.

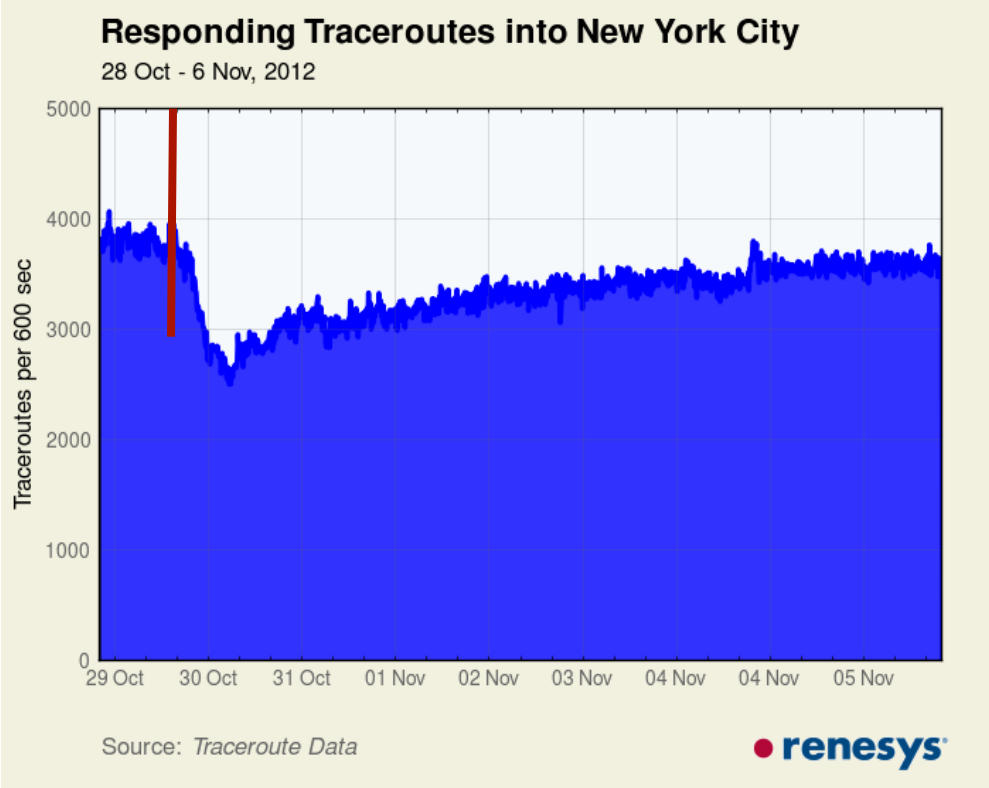


renesys Traceroute Infrastructure - December 2012 (plus Global Submarine Cable Map)

Note: Some cities host multiple collectors. Cable map credit: Telegeography

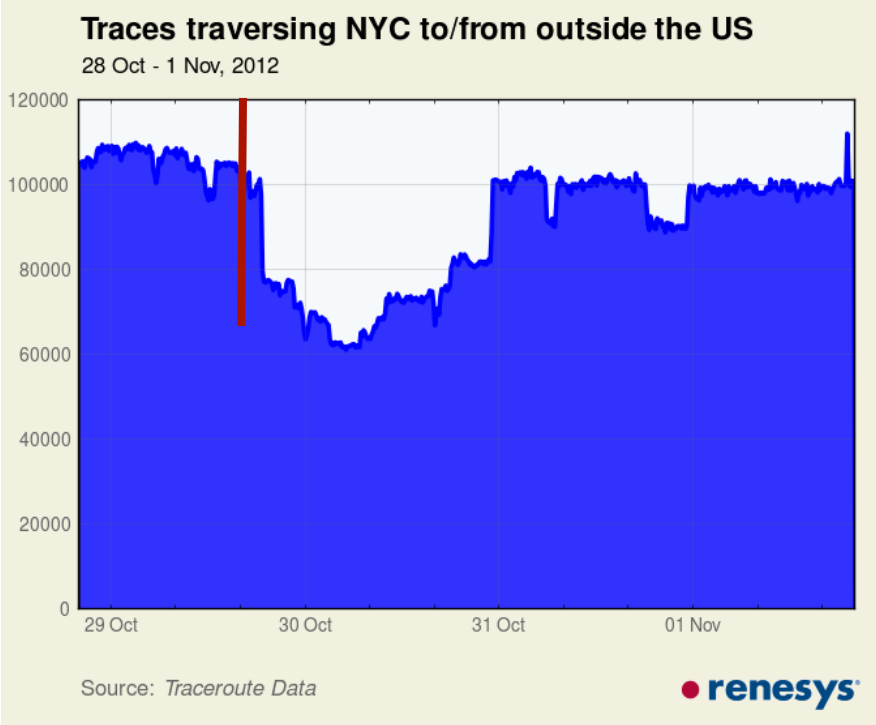
Sandy Impacts – World into New York City

- Consistent with routing, traceroute completions into NYC drop as the Hurricane makes landfall
- Takes 7+ days for traceroute completions to return to normal



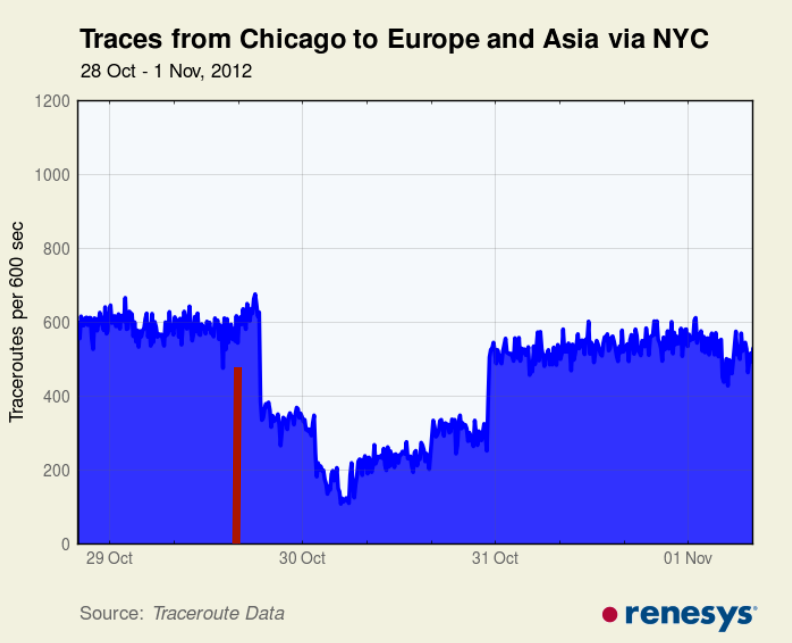
Sandy Impacts – *Non-US* to *Non-US*

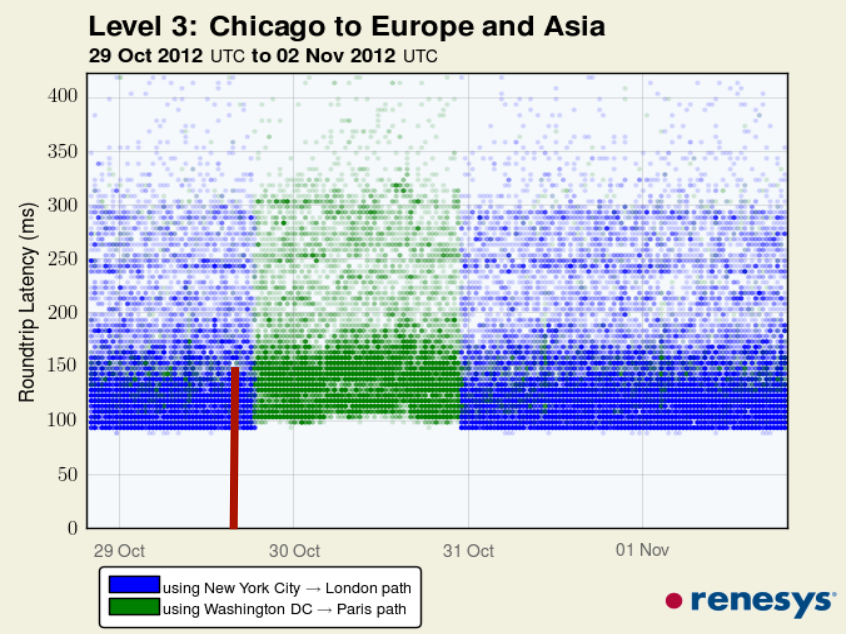
- Of course, pings and traceroutes stop when a network goes out
- More fascinating question: What was the impact on Internet traffic starting and completing outside the US?
- We observed a dip in traceroutes traversing NYC during Sandy



Sandy Impacts – Level 3 Global Traffic

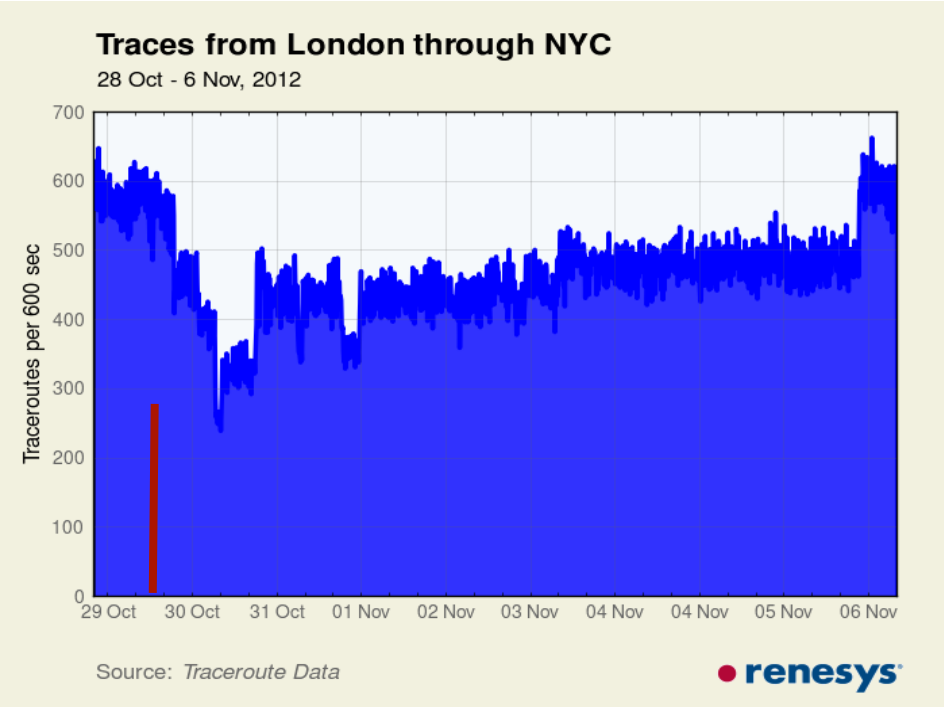
- International traffic shifts away from **NYC** to **DCA** for 24+ hours

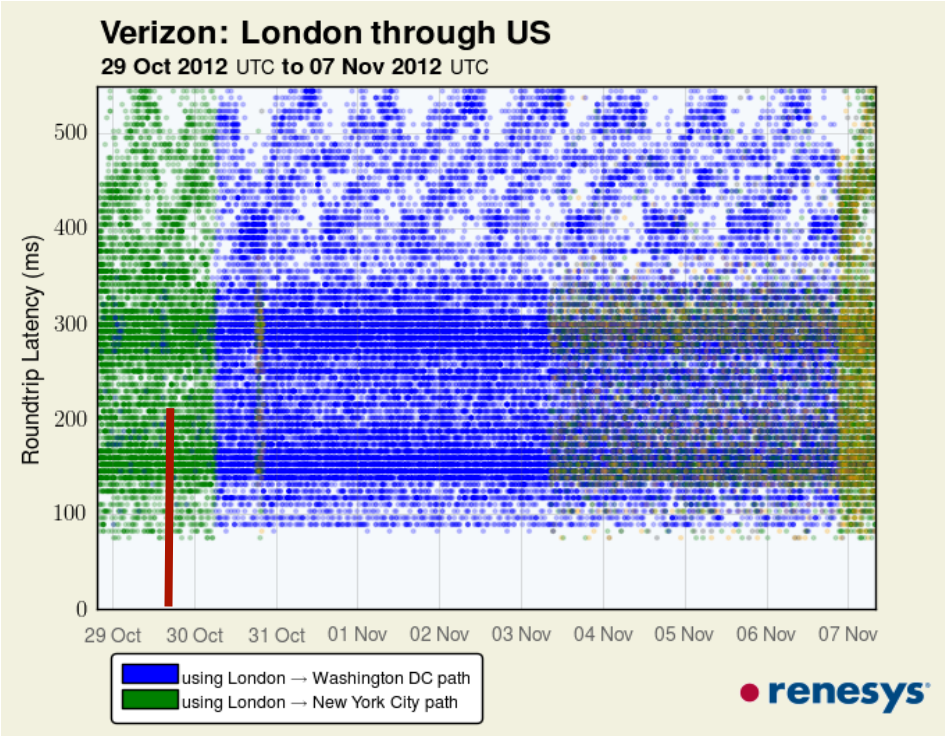




Sandy Impacts – Verizon Global Traffic

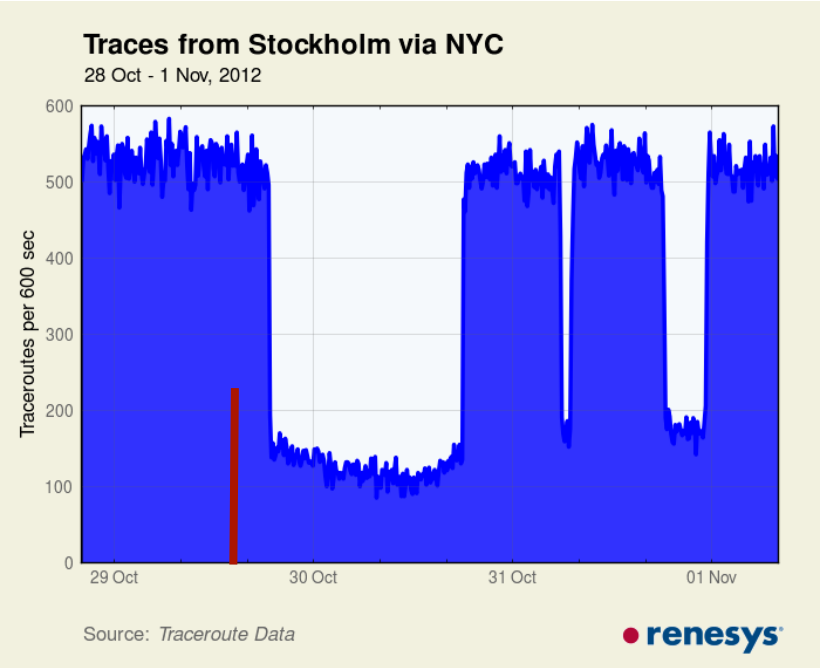
- Verizon shifts to **Washington DC** for several days

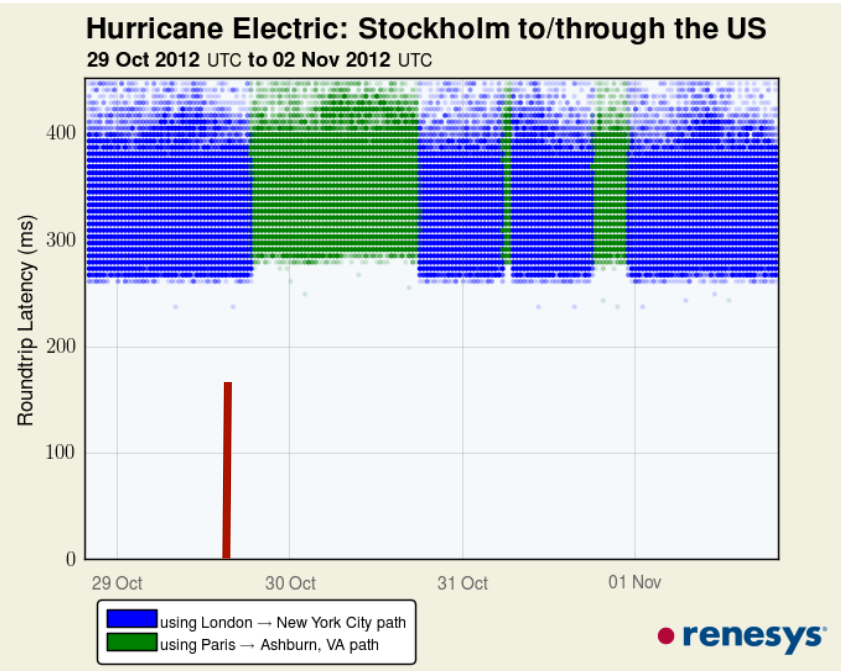




Sandy Impacts – Hurricane Electric

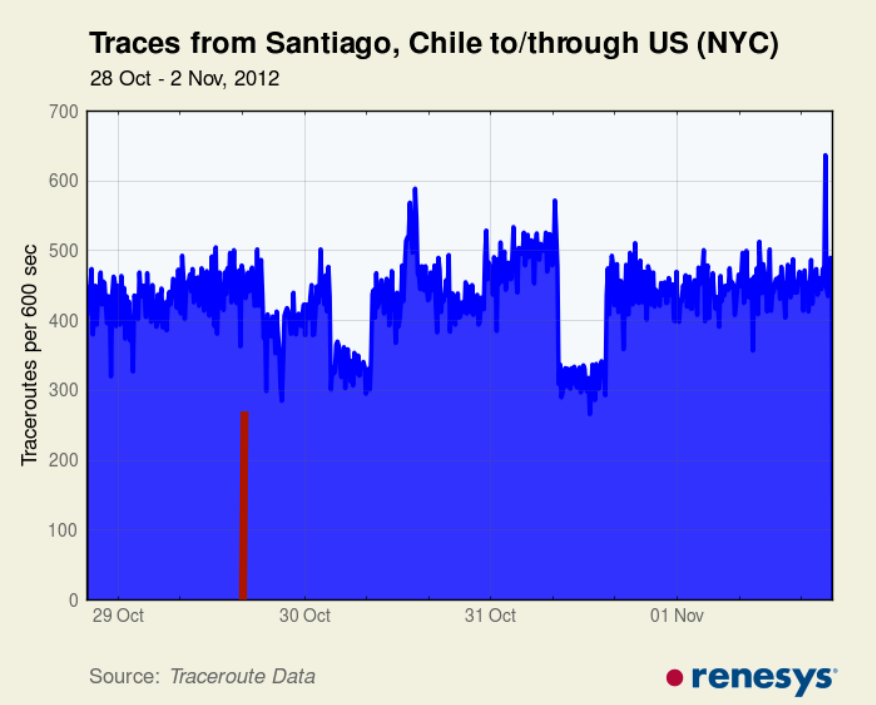
- Hurricane Electric shifts traffic away from **NYC** several times

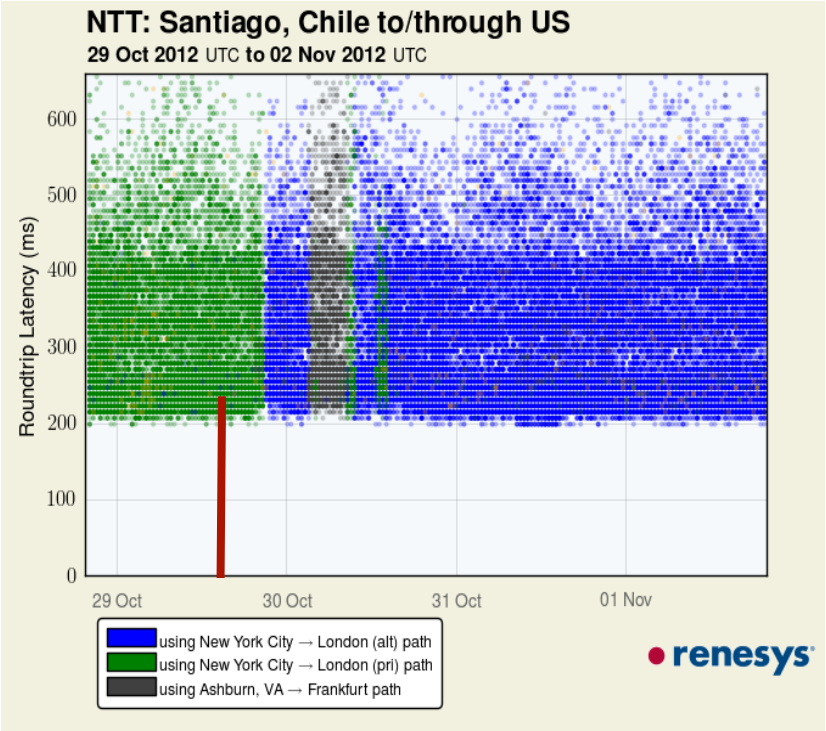




Sandy Impacts – NTT Global Traffic

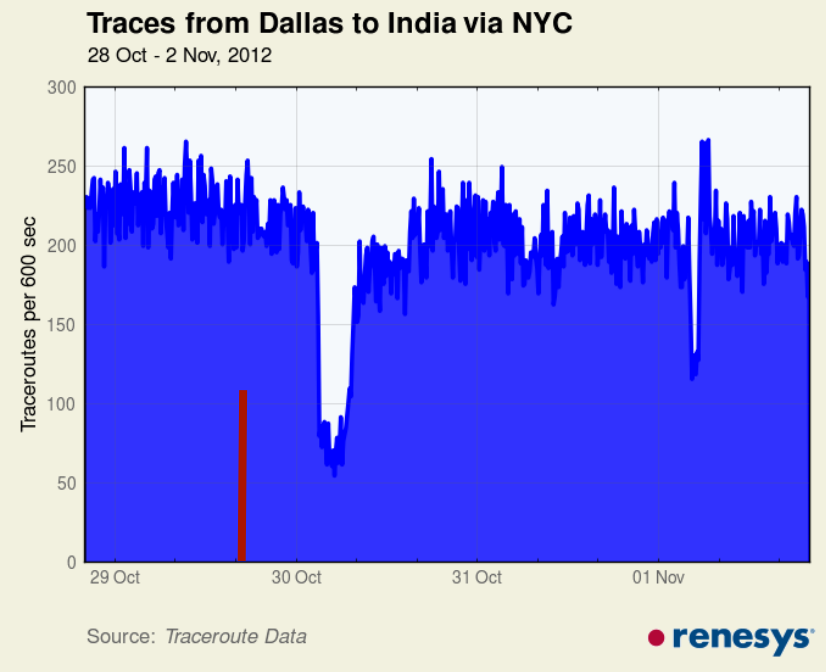
- NTT moves traffic to **Ashburn** and **secondary NYC** route

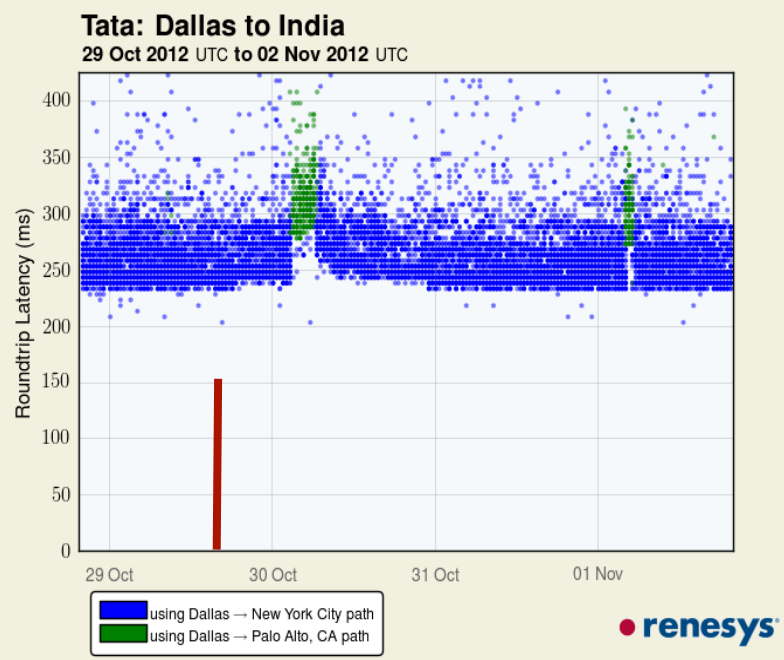




Sandy Impacts – Tata Global Traffic

- Tata briefly shifts traffic from **NYC** on two occasions





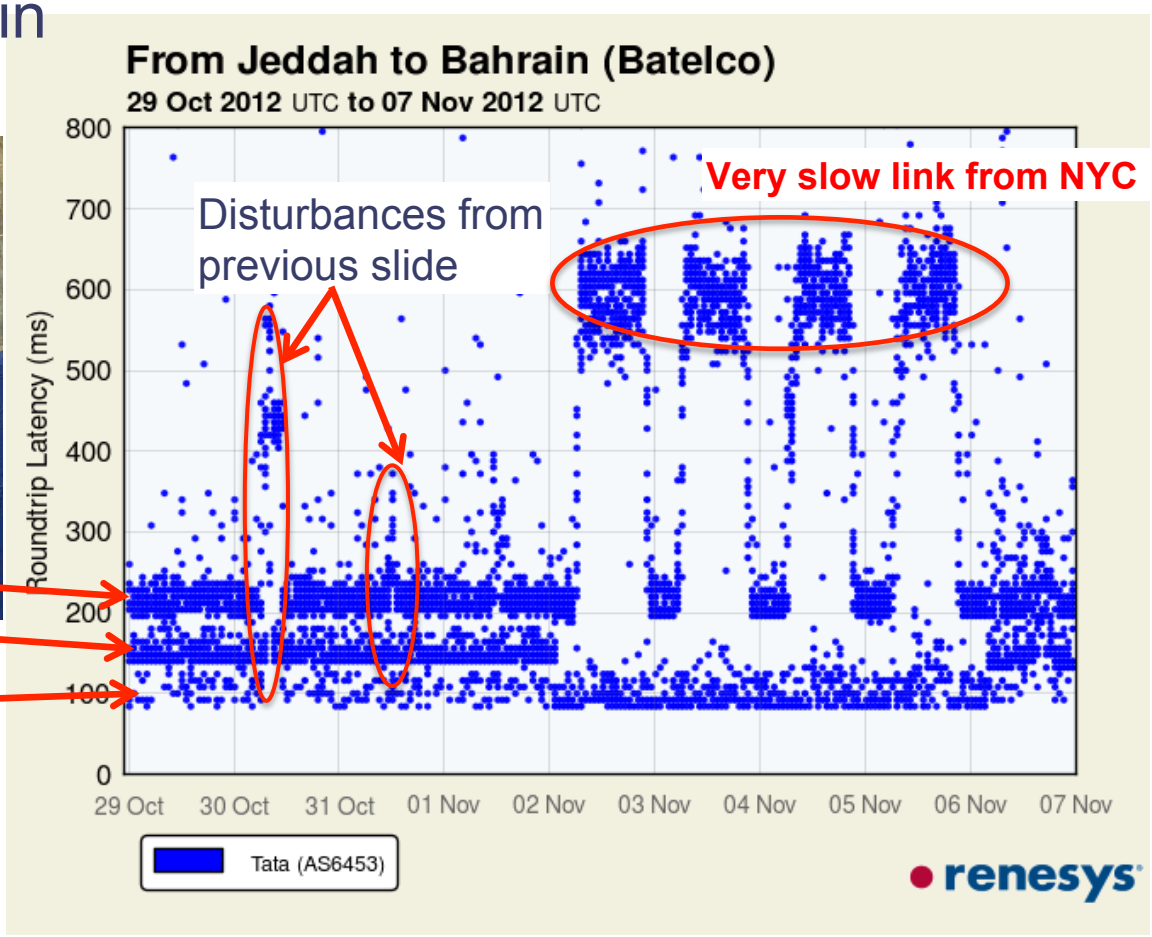
Sandy makes weird routing *even weirder*

- Saudi Arabia to Bahrain

via NYC

via London

via Marseille



Sandy Impacts – Conclusions

- New York City a critical node of the Internet
- In the face of outages, global providers routed around failures
- Events like this reveal a lot about how providers handle challenges

Impacts of Super Storm Sandy

Patrick W. Gilmore

February 5, 2013

What were the effects of Sandy

It is hard to say exactly what the effects were, as the storm was not an atomic event like a fiber cut

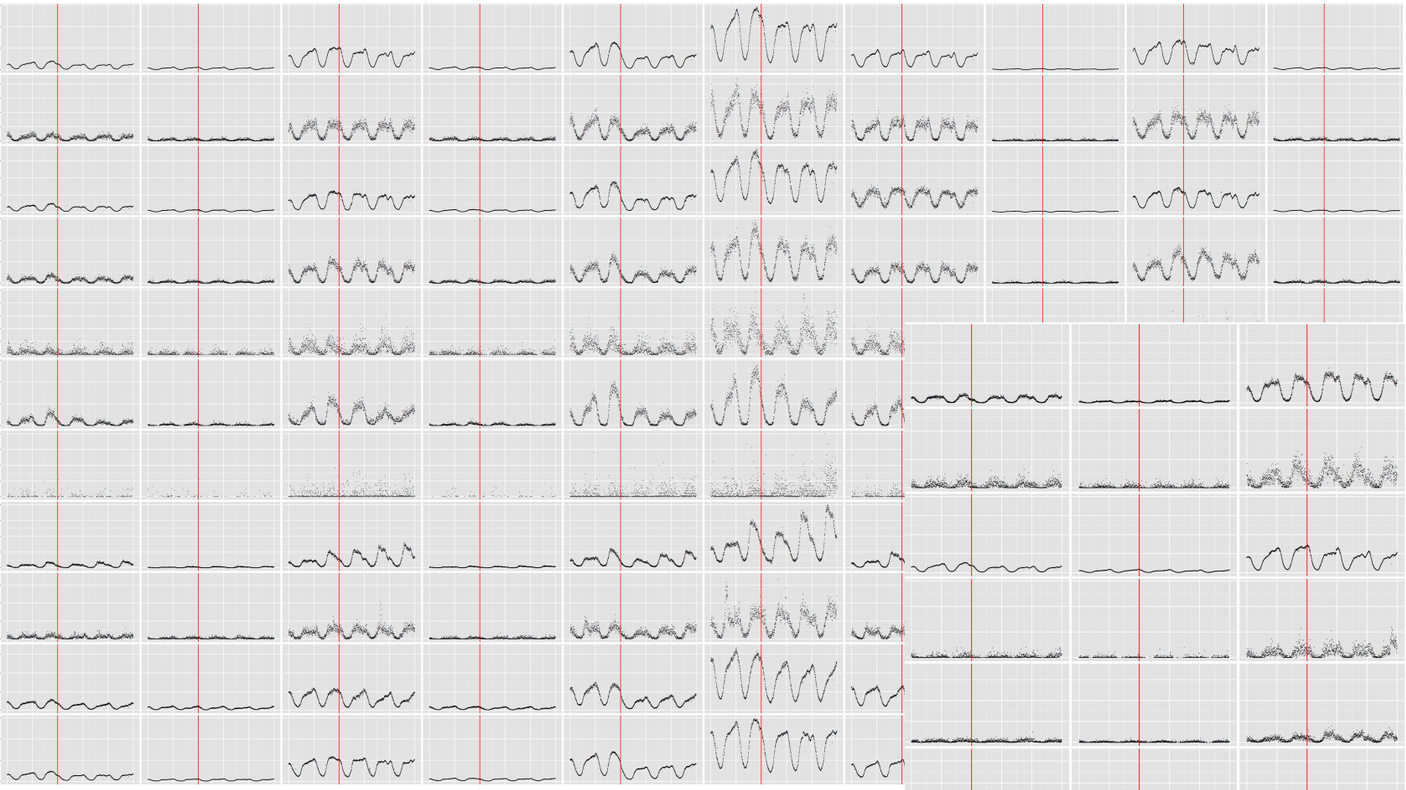
To help see the problem, the following graphs show 5 days

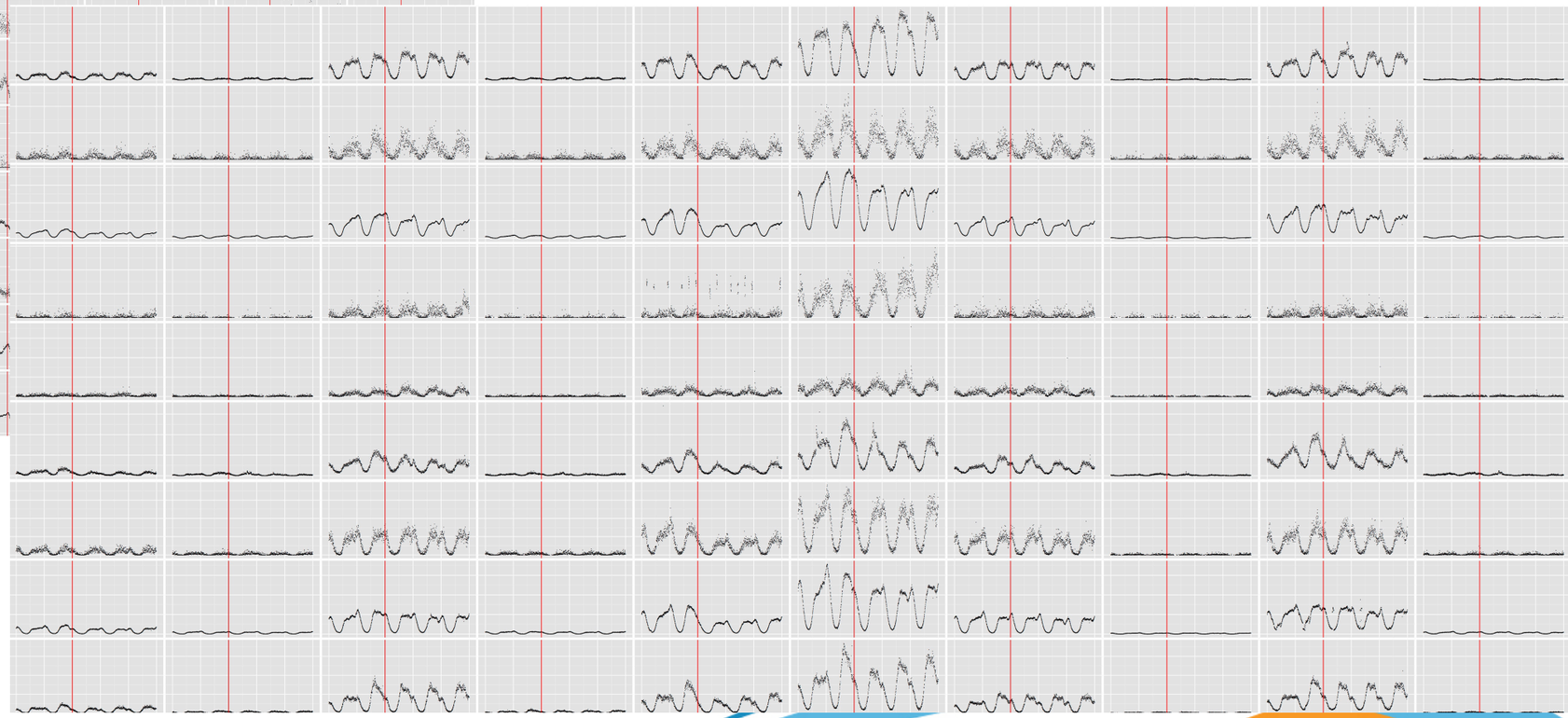
Each graph has a red vertical line at midnight local time (EST / UTC-0500)

Details of graphs

- Information presented is geography (US state level) cross customer segment (Finance, Gaming, Education, etc.)
- Graphs have no Y axis to protect the guilty, but side-by-side graphs have the same Y axis units
- Geography is determined by end user IP address, not server location

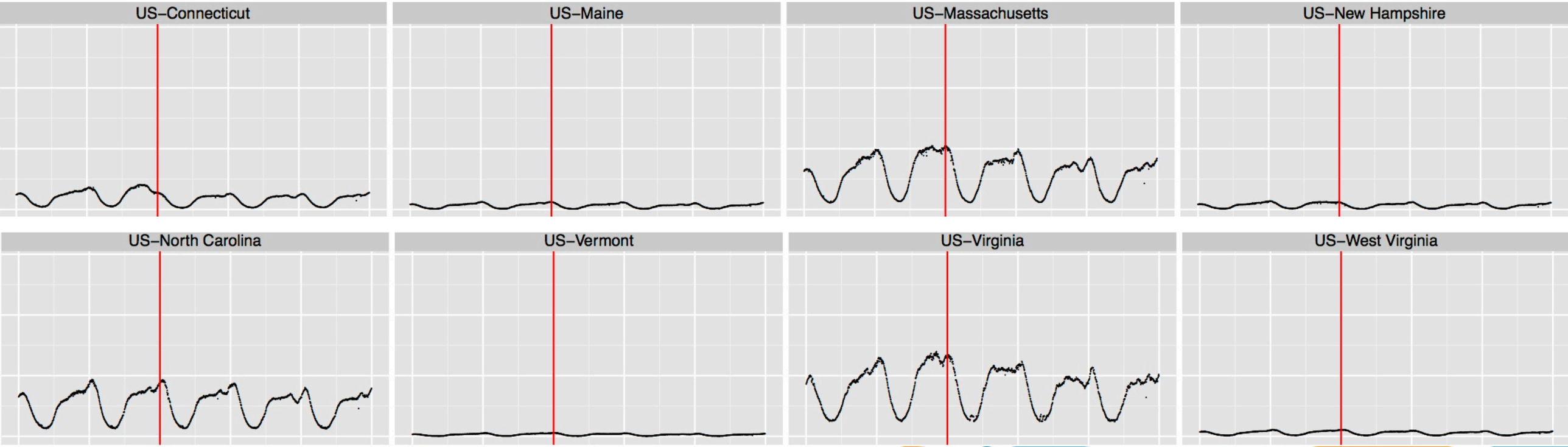
Summary of effects





Total Effects by state

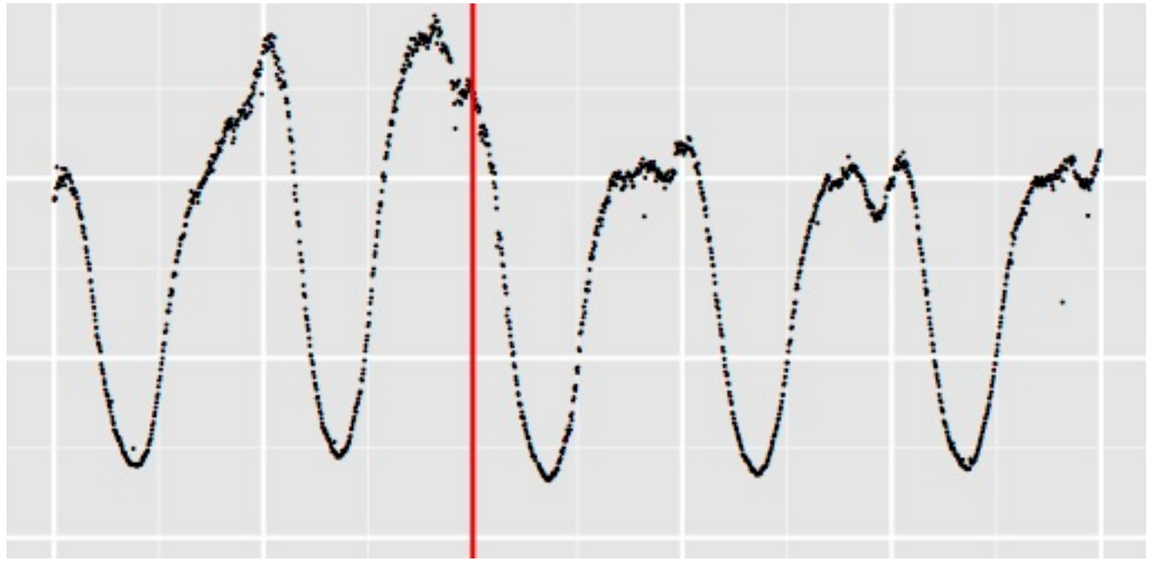
Pulling out eight states along the east coast, there is no clear effect when Sandy hit

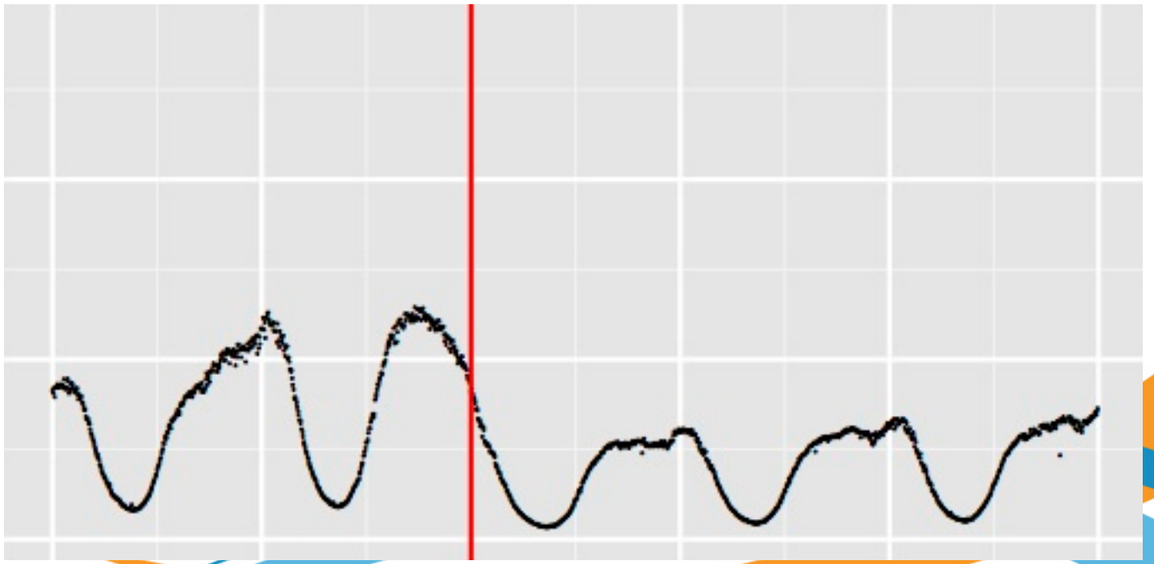


Drilling Down – New York & New Jersey

Story changes when you drill down to New York (left) and New Jersey (right)

Traffic dropped by nearly 1/3

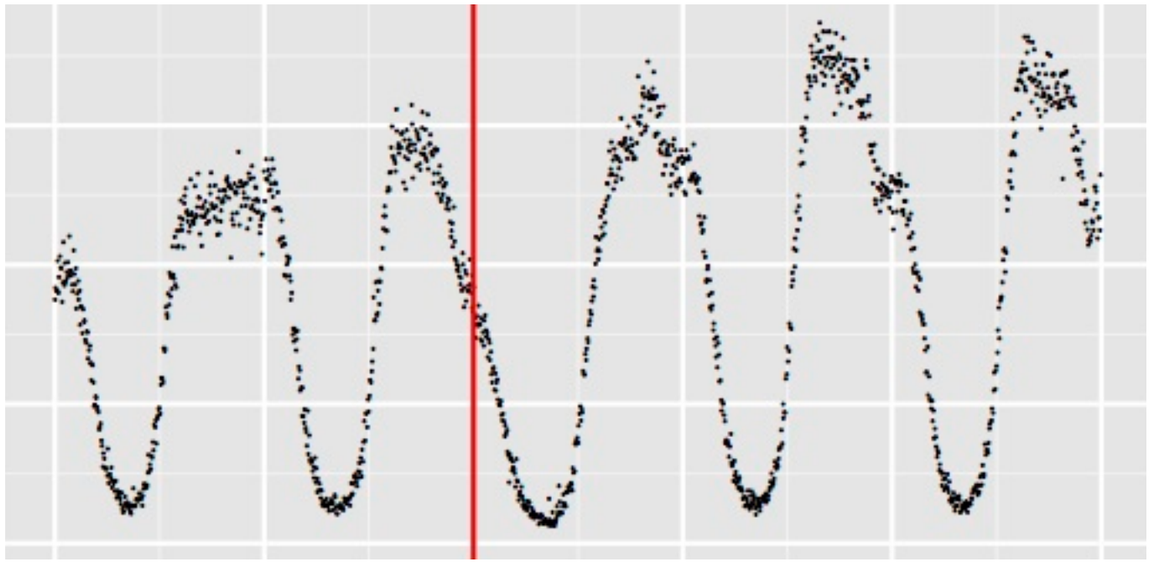


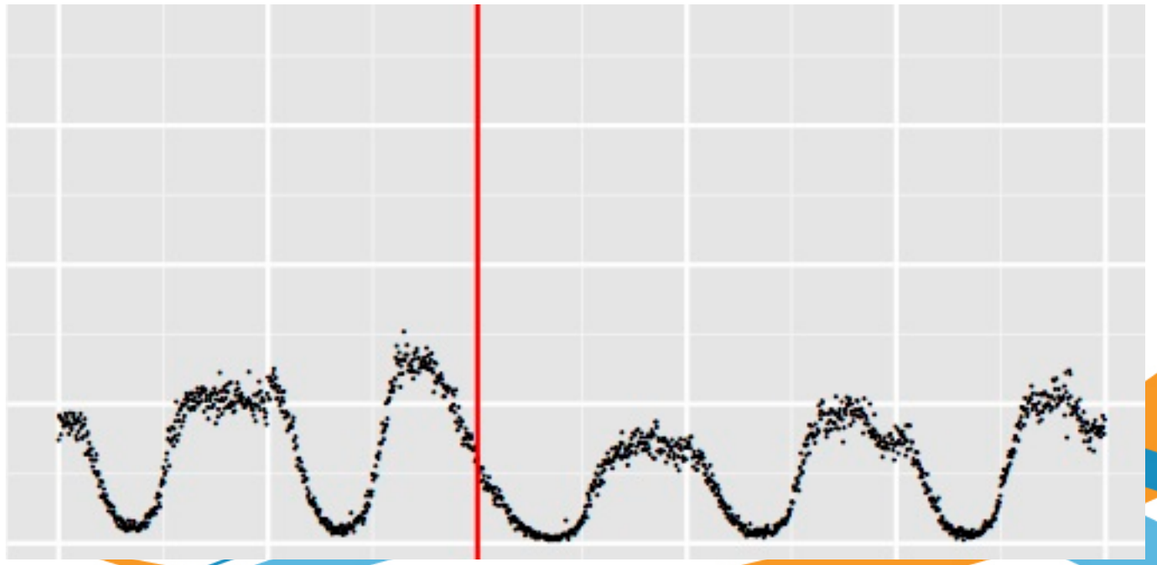


Some segments increased traffic

One of the few customer segments that increased traffic was financial services

Well, at least in New York





Some segments increased traffic

Customer segments which increased traffic over this time period:

- **Financial Services**
  Somewhat understandable
- **Travel - Hotel**
  Duh
- **Energy - Utilities**
  Double Duh
- **Miscellaneous**
  Order of magnitude less traffic than others

All other customer segments were down

Every other segment was down

Let me repeat that: Every other customer segment was down in New York and New Jersey

Some were down slightly, some were down more, but nothing else gained traffic, or was even just flat

Conclusions

There was definitely an effect, as seen across all segments

Nearly 1/3 of all traffic disappeared at least for a few days

But there was a lot of connectivity, and “The Tubes” helped real people get answers they needed

Which makes me feel all warm & fuzzy inside

Questions?

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Today's Panelists

- **John Heidemann**, USC/Information Sciences Institute
- **Emile Aben**, RIPE RIS
- **Doug Madory**, Renesys
- **Patrick Gilmore**, Akamai

- Moderator: **Jim Cowie**, Renesys

Superstorm Sandy: Impacts on Global Connectivity

5 February 2013