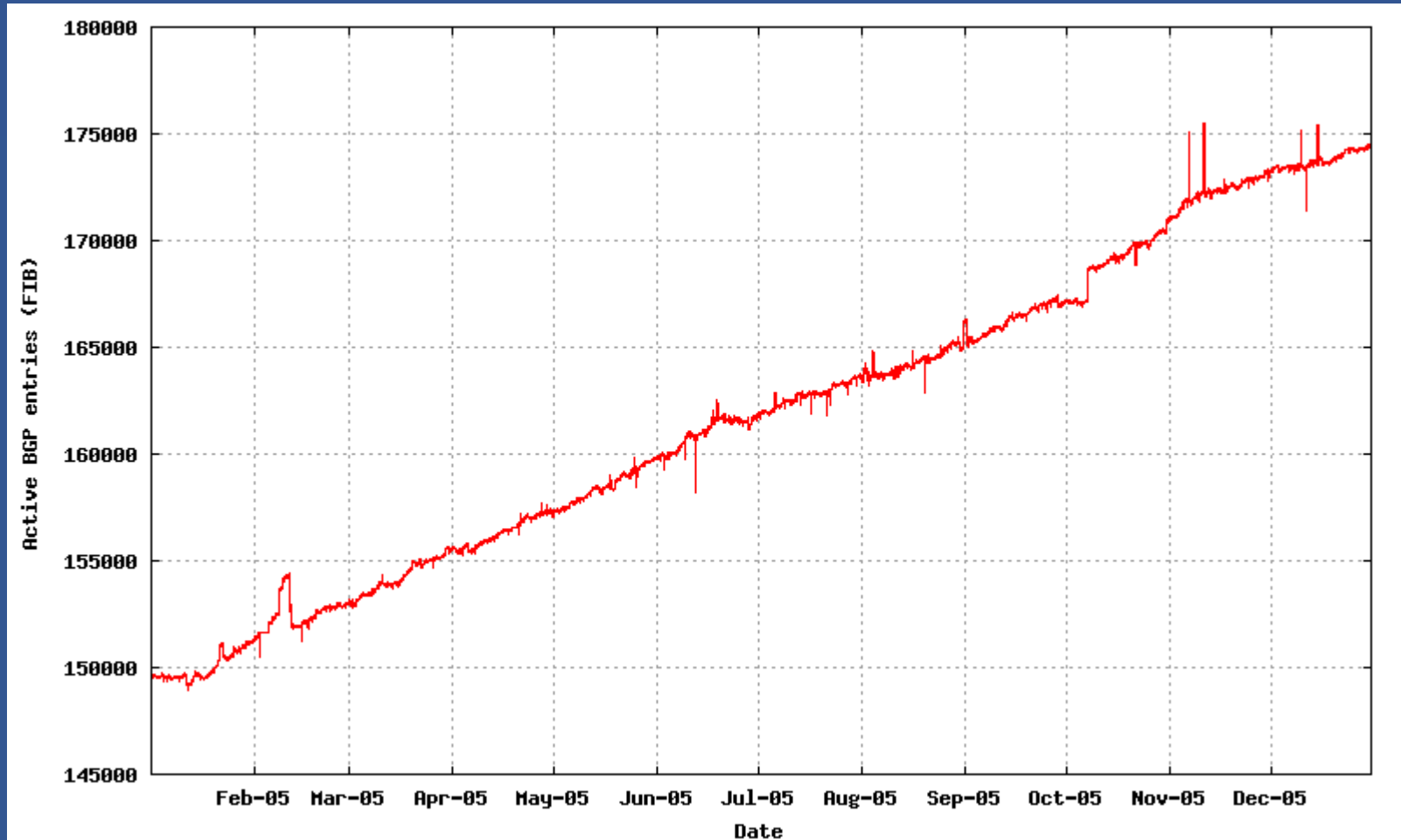# 2005 – A BGP Year in Review

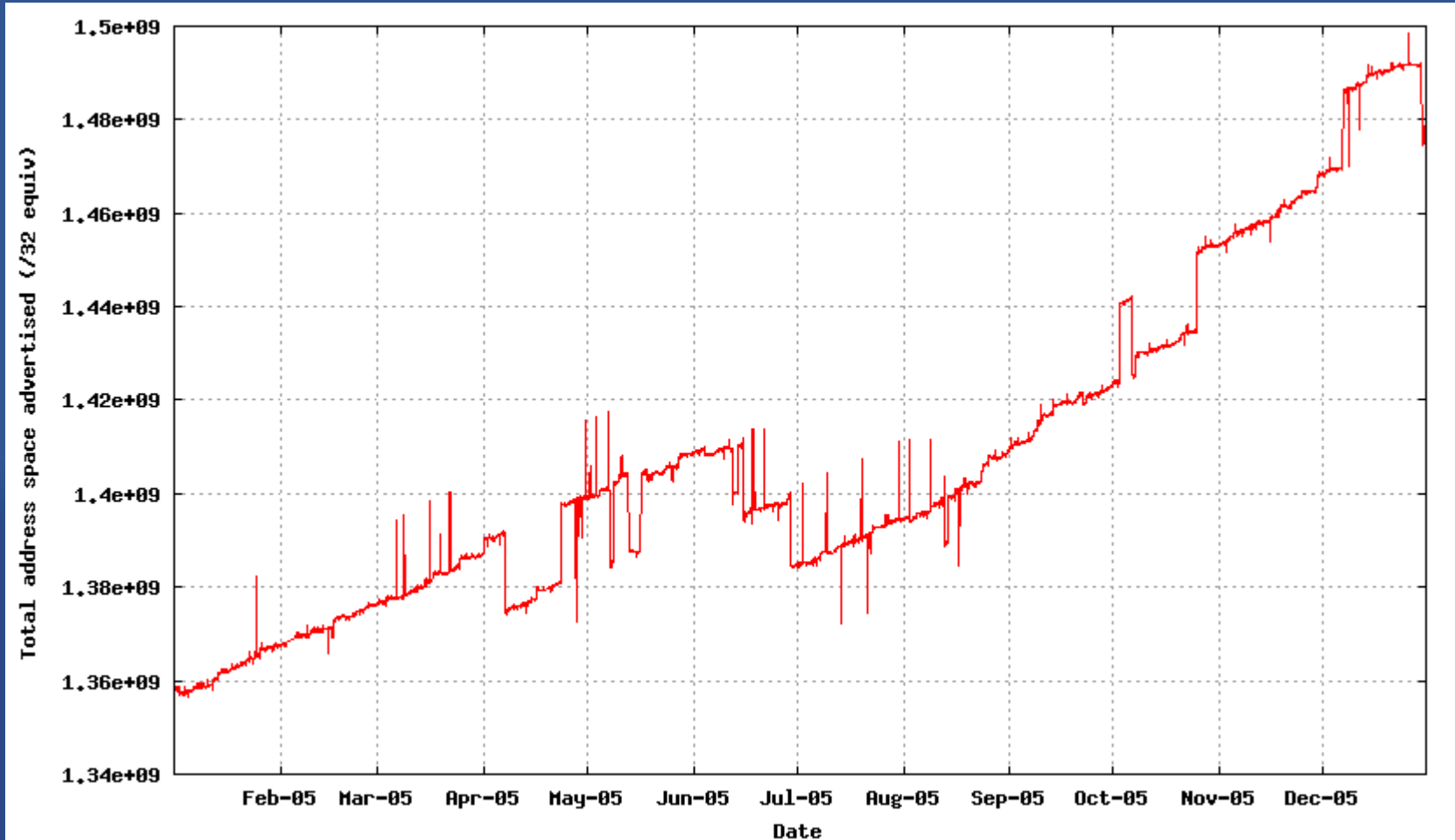March 2006

Geoff Huston
Research Scientist
APNIC

IPv4 in 2005
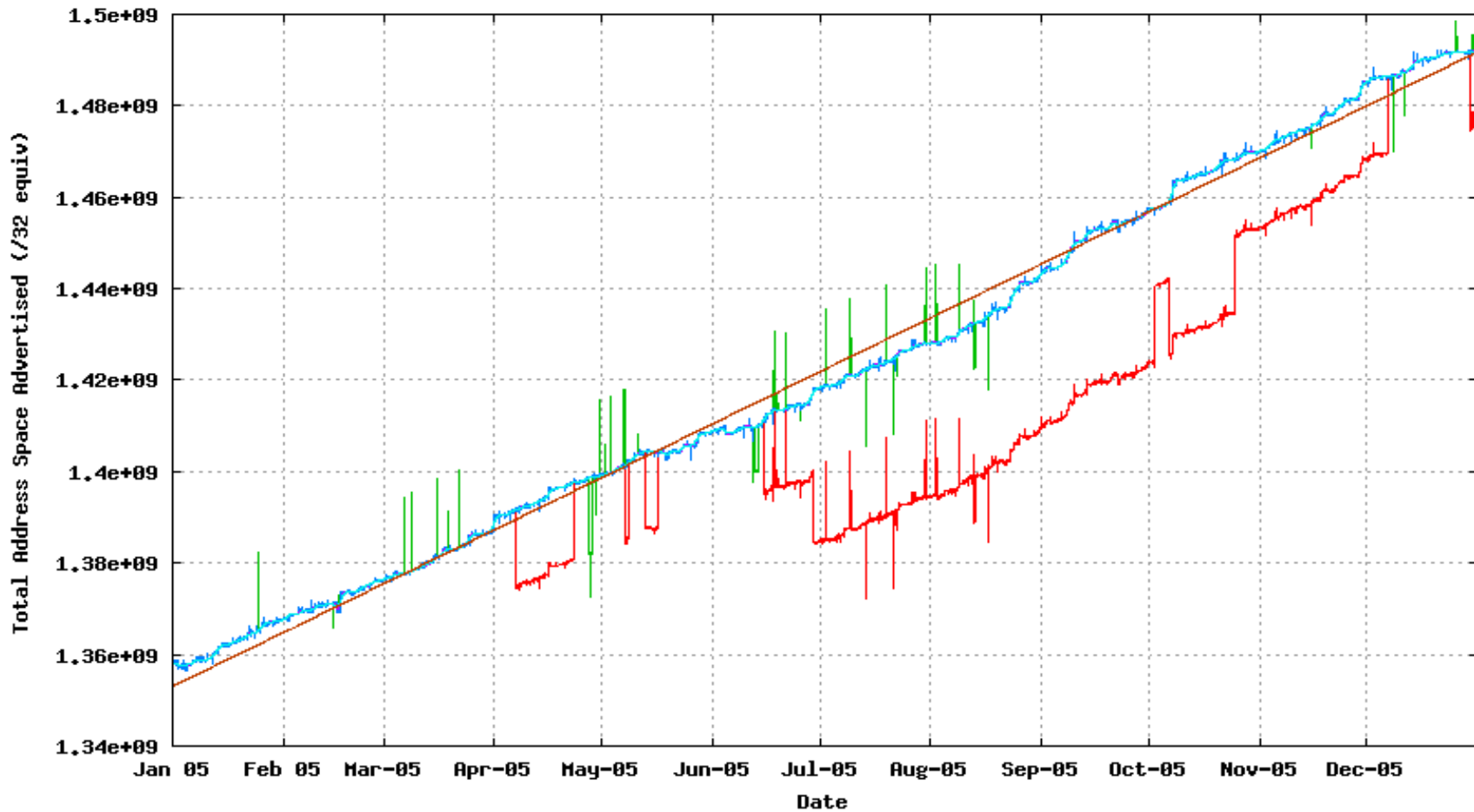# Total Advertised BGP Prefixes

IPv4 in 2005
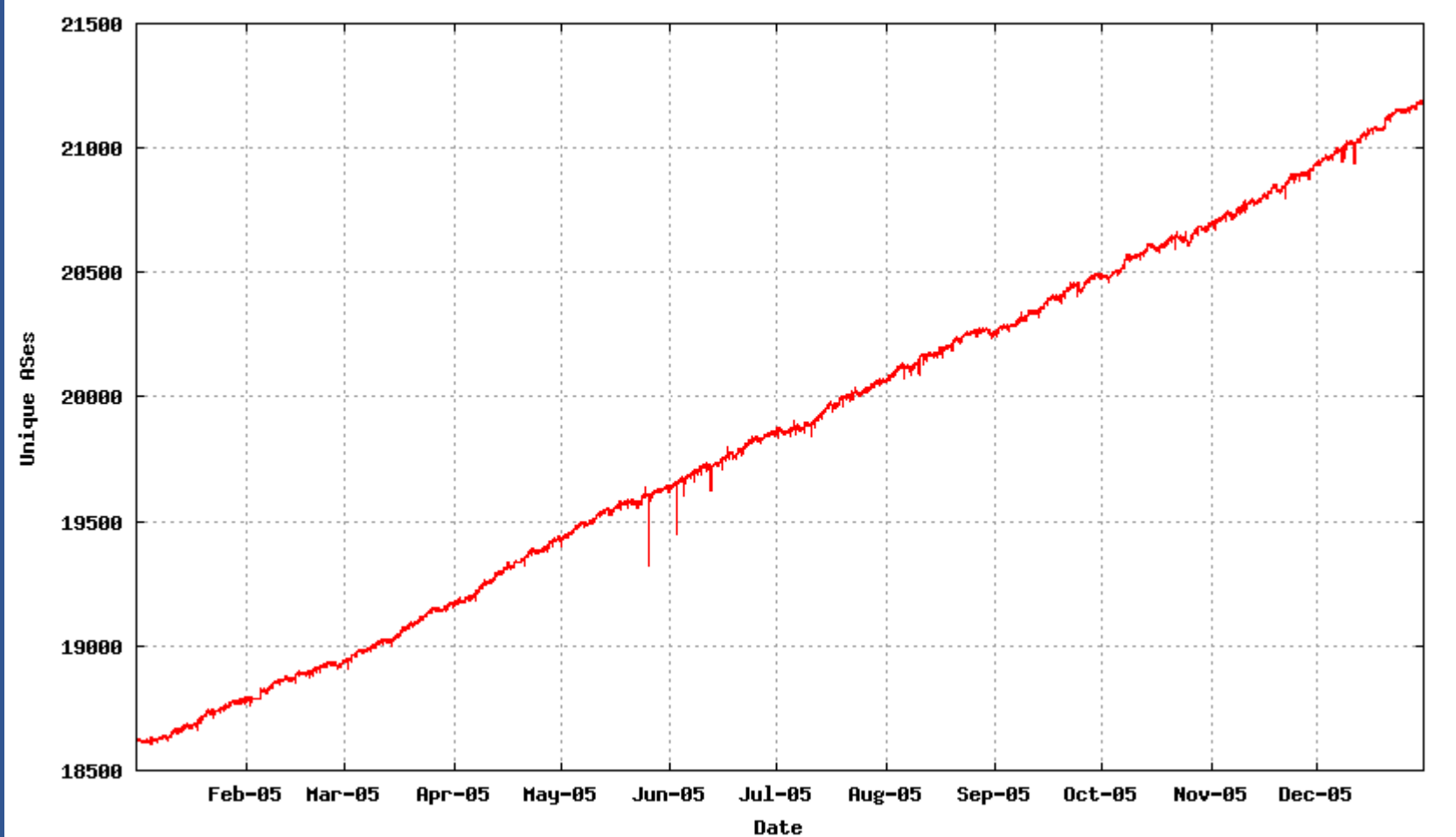# Total Advertised Address Span

IPv4 in 2005
Total Advertised Address Span

IPv4 in 2005
Total Advertised AS Numbers

IPv4 – Vital Statistics for 2005

|			
Prefixes	148,500 – 175,400	+18%	26,900
Roots	72,600 – 85,500	+18%	12,900
Specifics	77,200 – 88,900	+18%	14,000
Addresses	80.6 – 88.9 (/8)	+10%	8.3 /8s
ASNs	18,600 – 21,300	+14%	2,600

Average advertisement size is getting <u>smaller</u>

Average address origination per AS is getting <u>smaller</u>

Average AS Path length <u>steady</u> at 3.5

AS interconnection degree <u>up</u>

The IPv4 network continues to get denser, with finer levels of advertisement granularity.

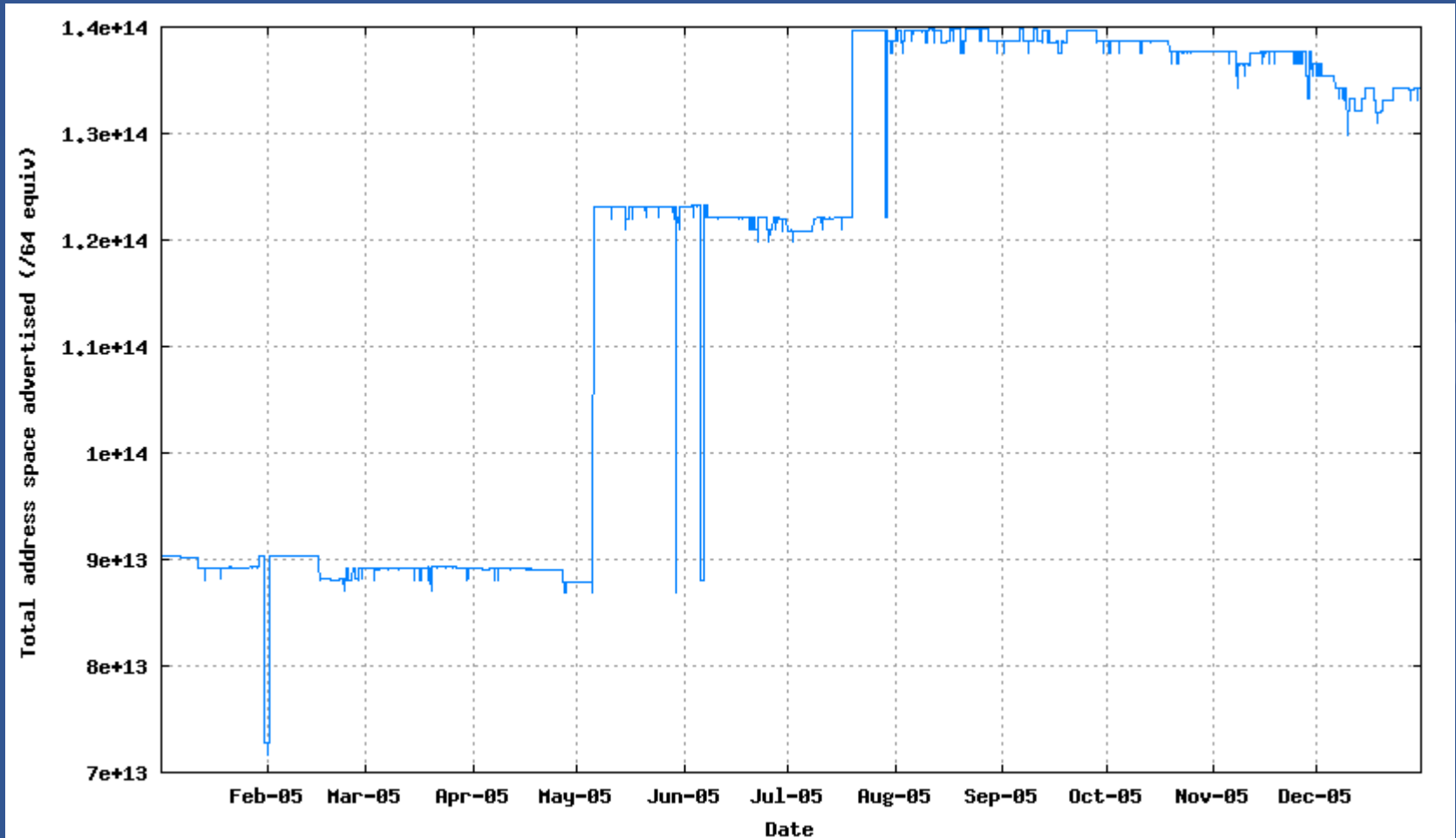More interconnections, more specific advertisements

IPv6 in 2005
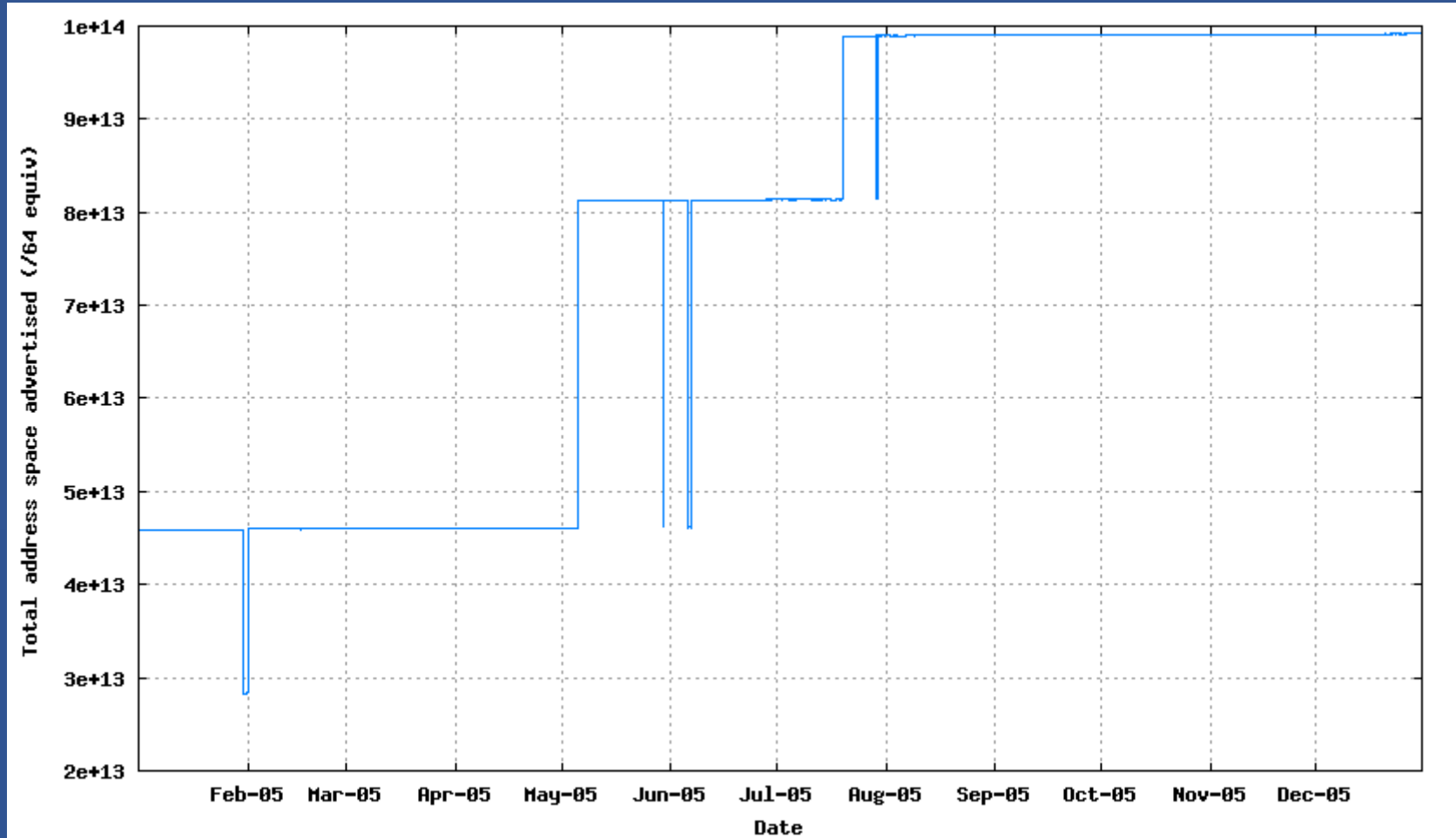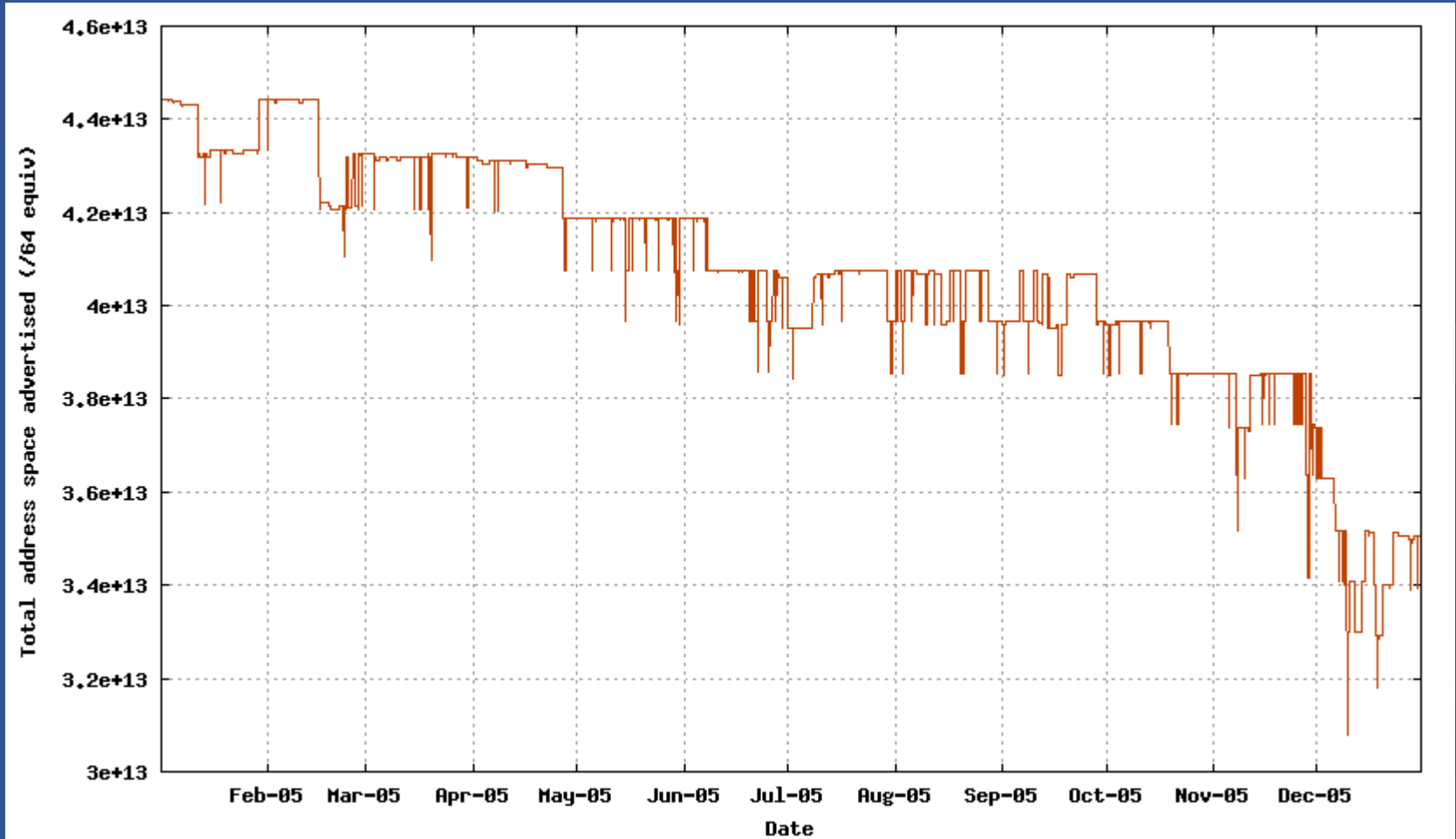# Advertised Prefix Count
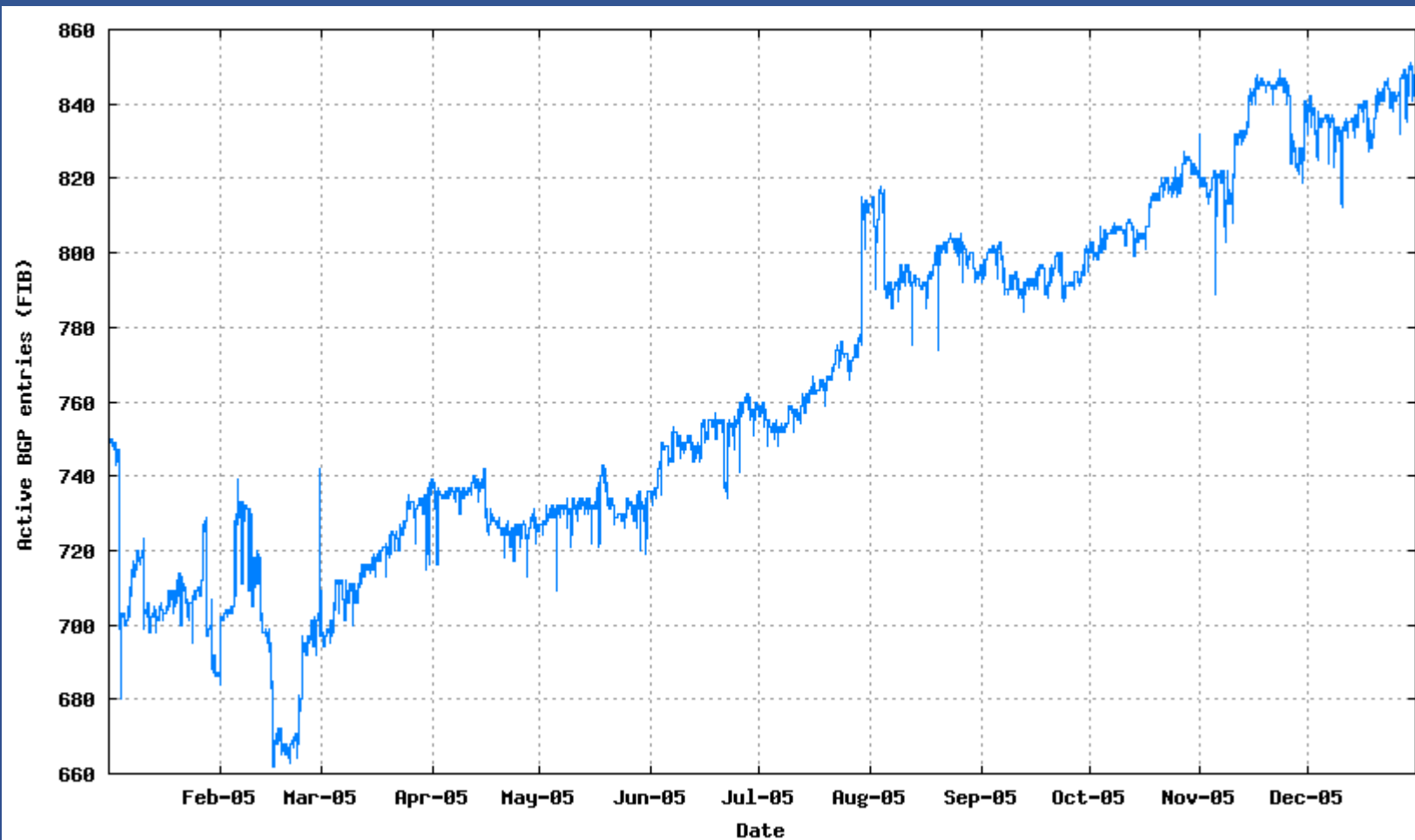
IPv6 in 2005
Advertised Address Span

Advertised Address Span w/o 6Bone

IPv6 in 2005
6Bone Address Span

IPv6 in 2005
Combined View of Address Span

IPv6 Address Space
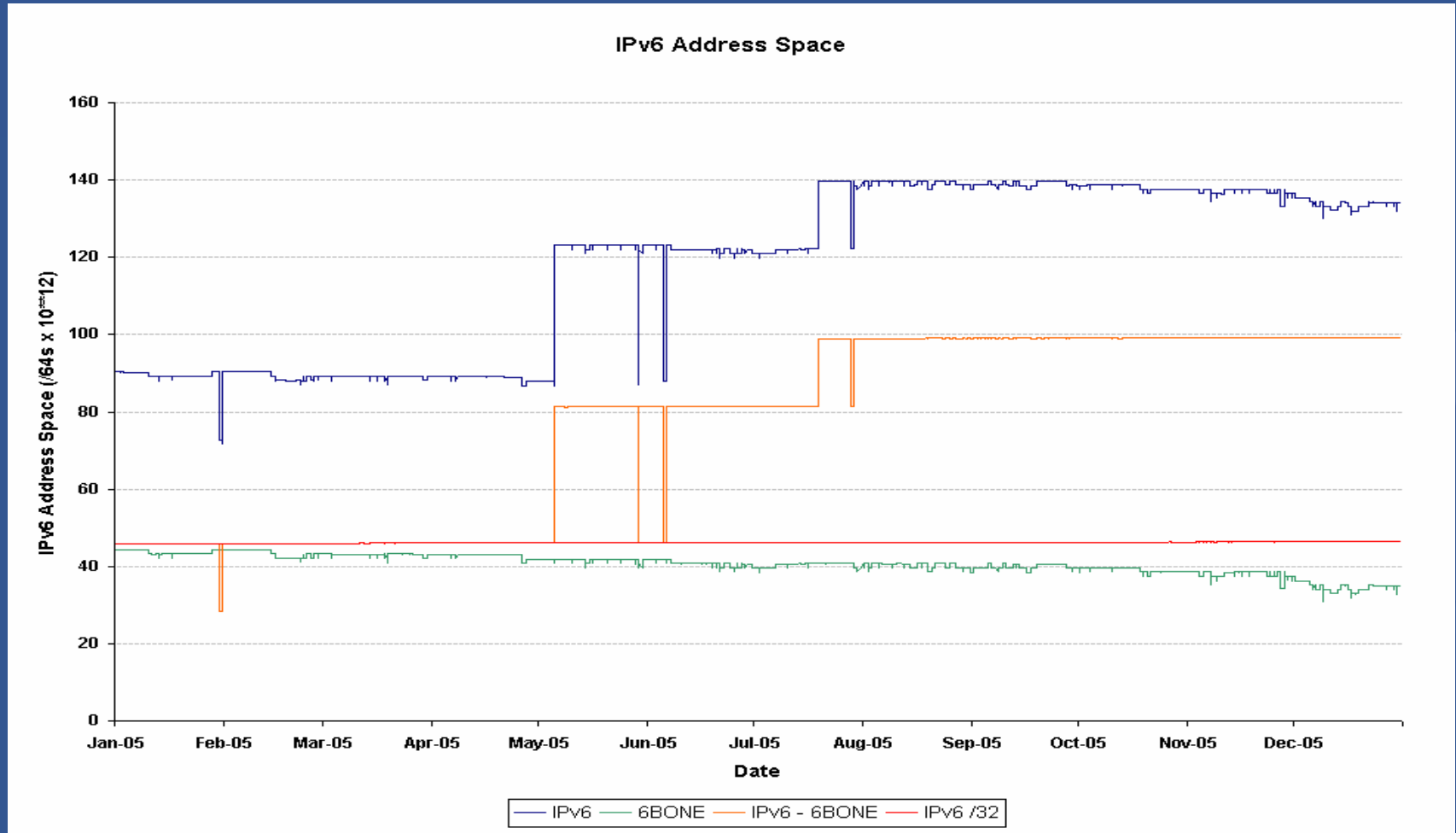
IPv6 in 2005
Total Advertised AS Numbers

IPv6 – Vital Statistics for 2005

Prefixes	700 – 850	+21%
Roots	555 – 640	+15%
Specifics	145 - 210	+51%
Addresses	9 – 13.5 (10**13)	+50%
ASNs	500 – 600	+20%

Average advertisement size is getting <u>larger</u>

Average address origination per AS is getting <u>larger</u>

Average AS Path length variable between <u>3 – 5</u>

AS interconnection degree <u>variable</u>

Through 2005 the IPv6 network remained small and continued to use a very large proportion of overlay tunnels at the edges. Larger scale trends in network characteristics were not readily discernable from 2005 figures

Vince Fuller's question:

If you were buying a large router suitable for use in a "DFZ" with an expected lifetime of 3-5 years, what would you specify as the number of IPv4/IPv6 prefixes it must be able to handle? And how many prefix updates per second?

personal communication, January 2006

BGP Size Predictions - Methodology

- Examine update and withdrawal rates from BGP log records for 2005 from a viewpoint within AS1221
  - Eliminate local effects to filter out non-DFZ BGP updates
  - Look at the relative rate of updates and withdrawals against the table size

- Examine CPU records from a core router in AS1221
  - Again look at the relative processing load against the table size

- Generate a BGP table size predictive model and use this to generate update rate and processing rate predictions

Update Message Rate
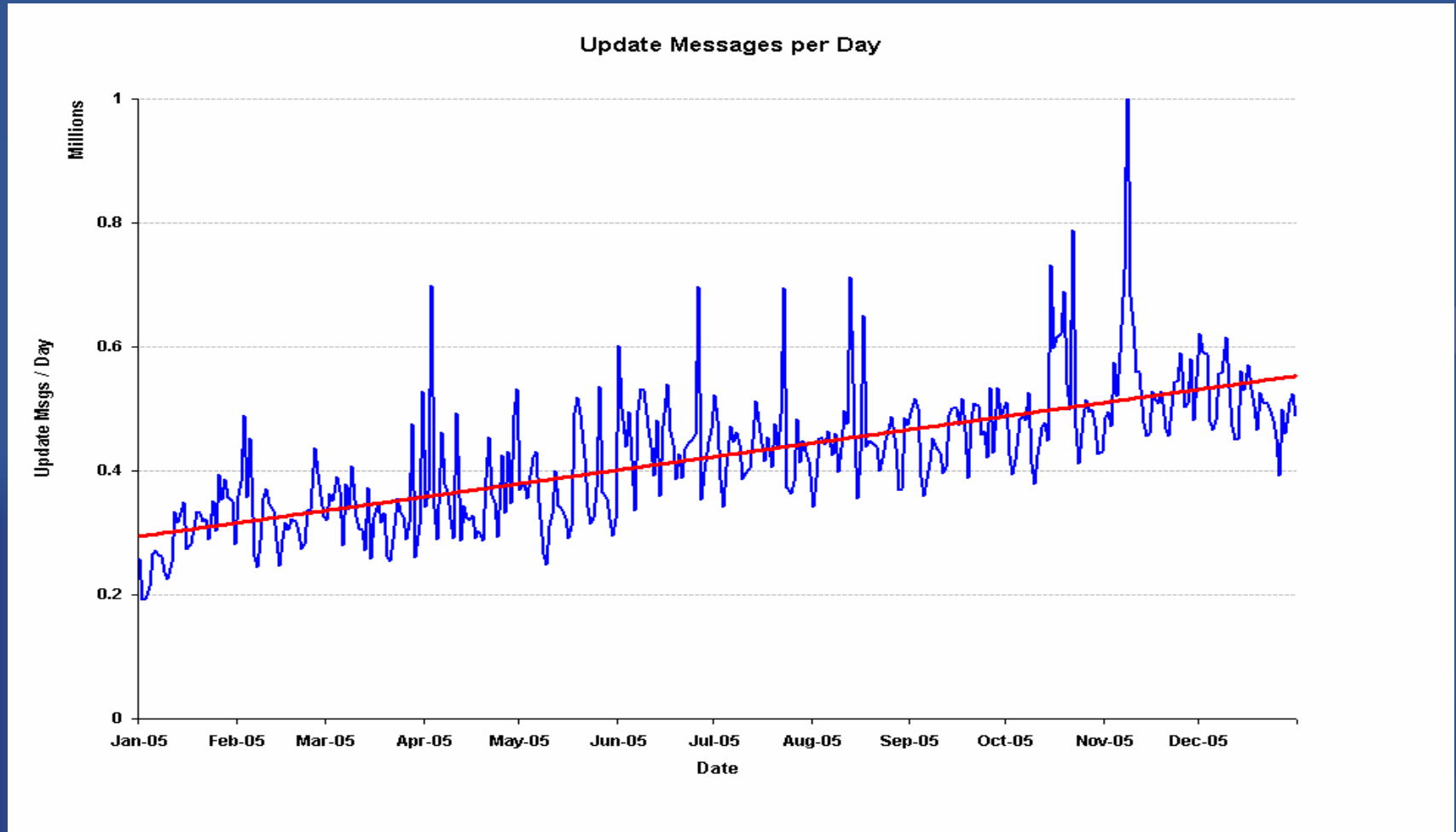
Prefixes per Update Message
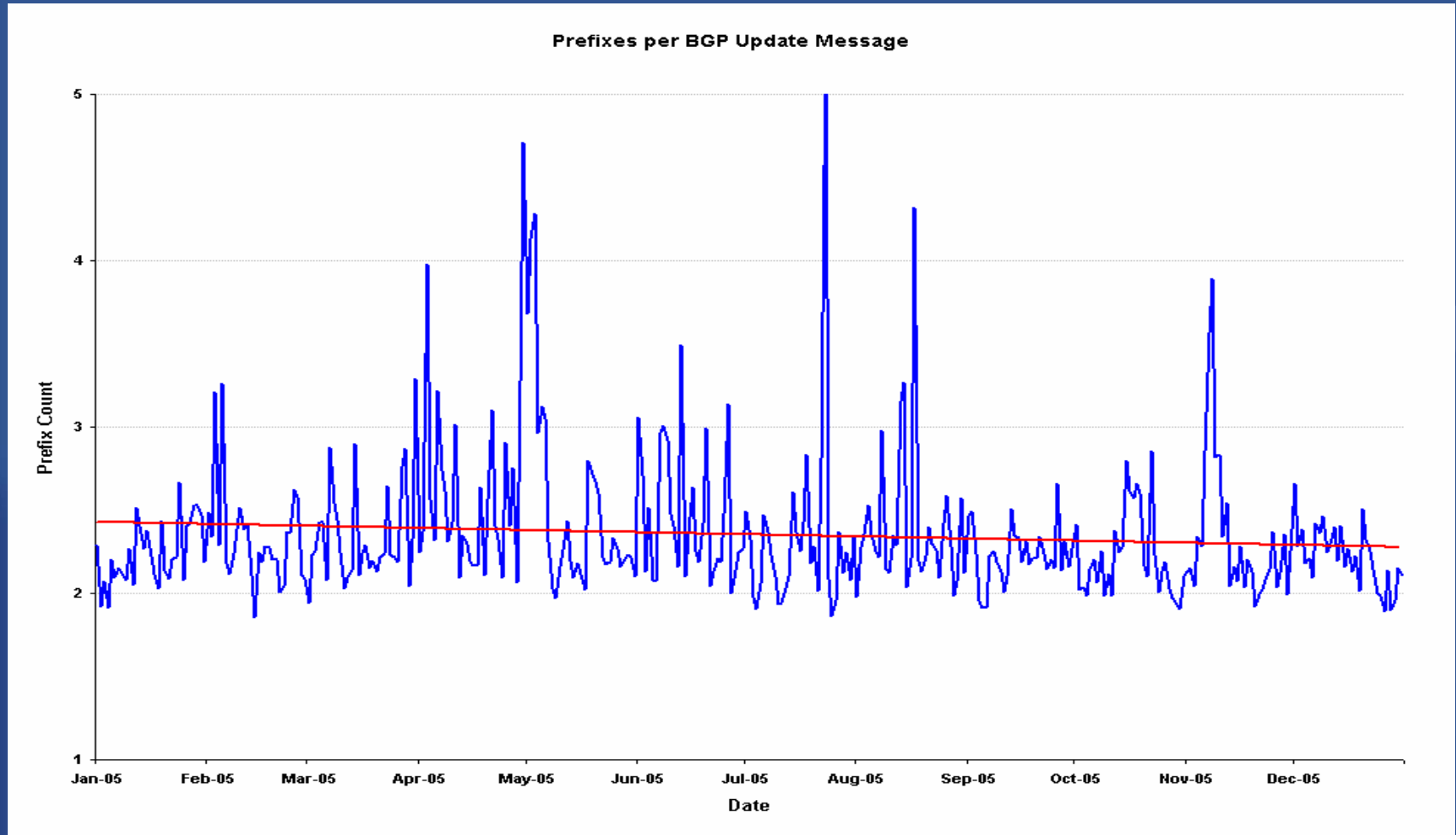
Update Trends across 2005

- Number of update messages per day has doubled across 2005 (Dec 2005 saw approx 550,000 update messages per day)

  Considering the population size the daily rate is highly variable – why?

- Number of prefixes per update message is falling from an average of 2.4 to 2.3 prefixes per update

  Is this attributable to ncreased use of public ASs and eBGP at the edge of the network? (Multi-homing?)

- Is the prefix update rate increasing at a greater rate than the number of prefixes in the routing table?

  – Is there some multiplicative factor at play here?

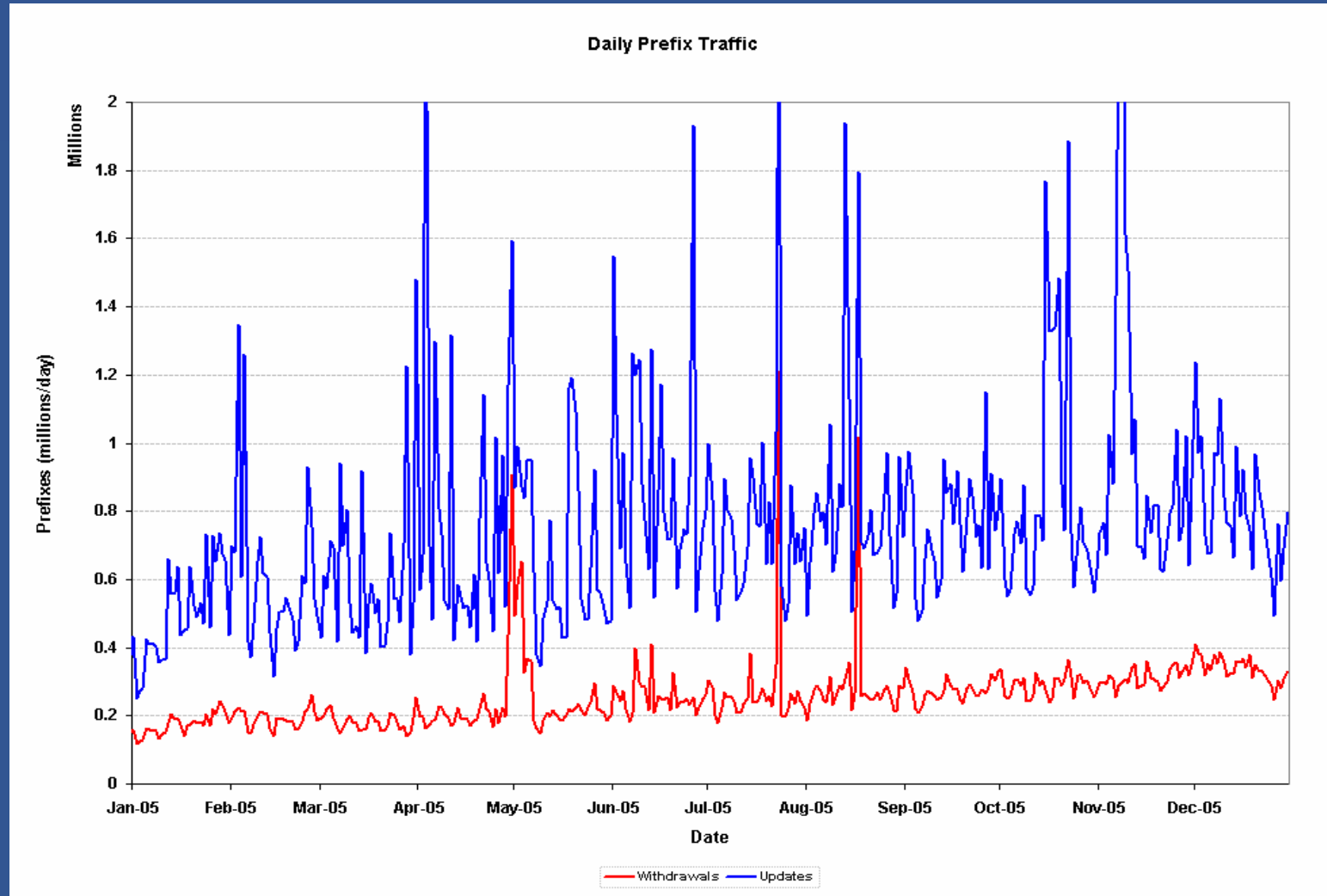 – Why is instability increasing faster than the network size?
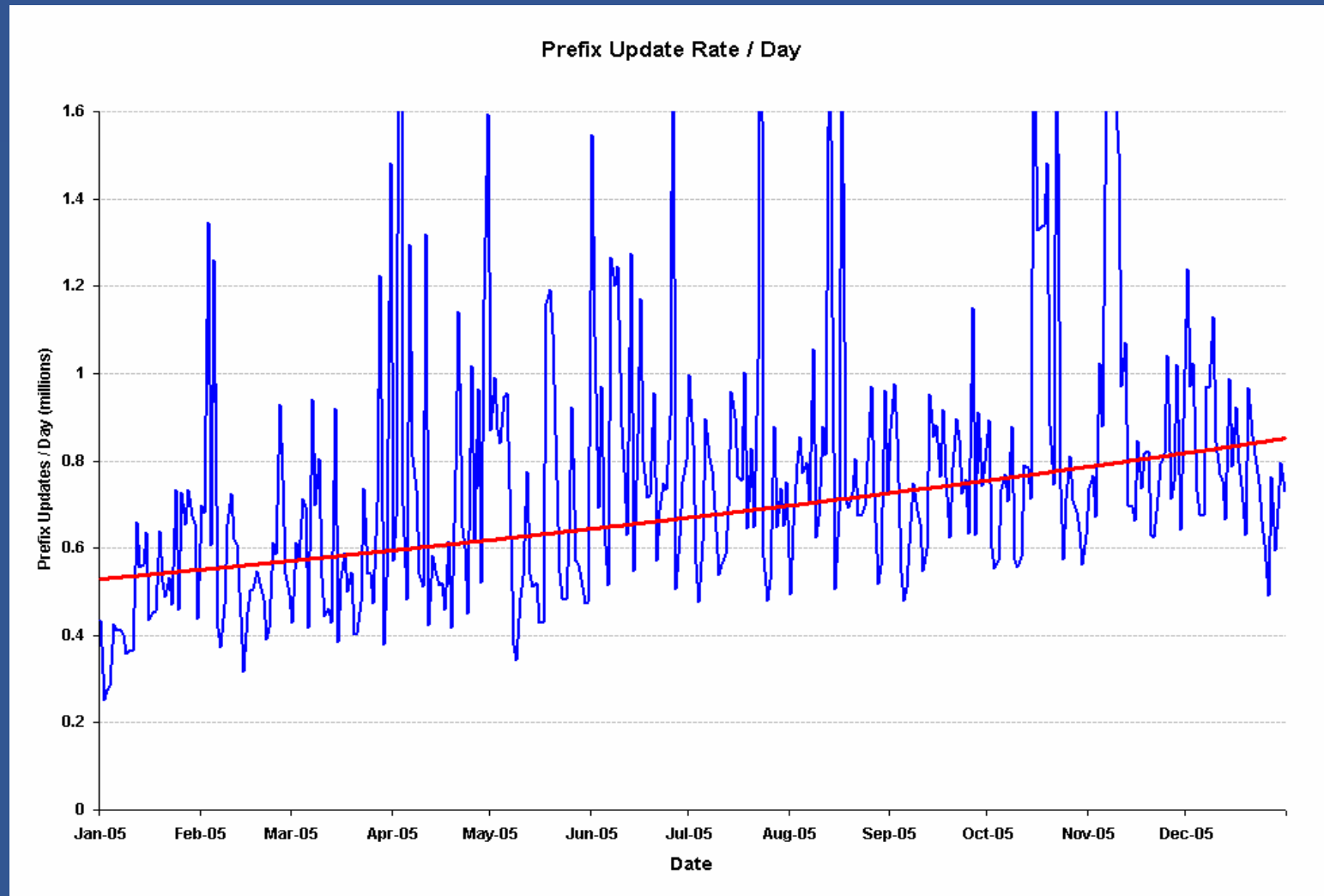
Prefixes vs Updates

- Look at the number of prefixes that are the subject of update messages
- What are the trends of prefix update behaviour?
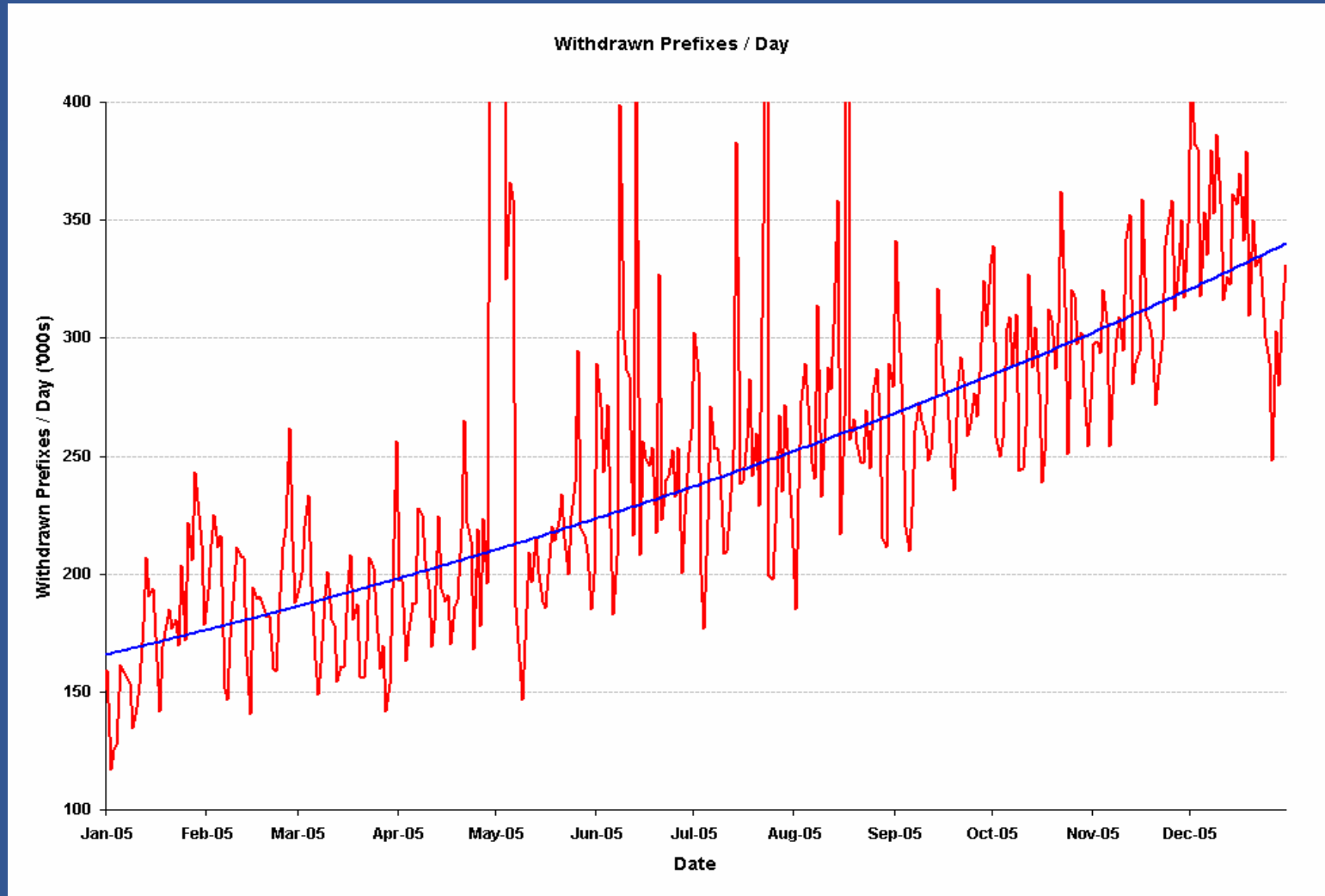
Prefix Update and Withdrawal Rates

Prefix Update Rates

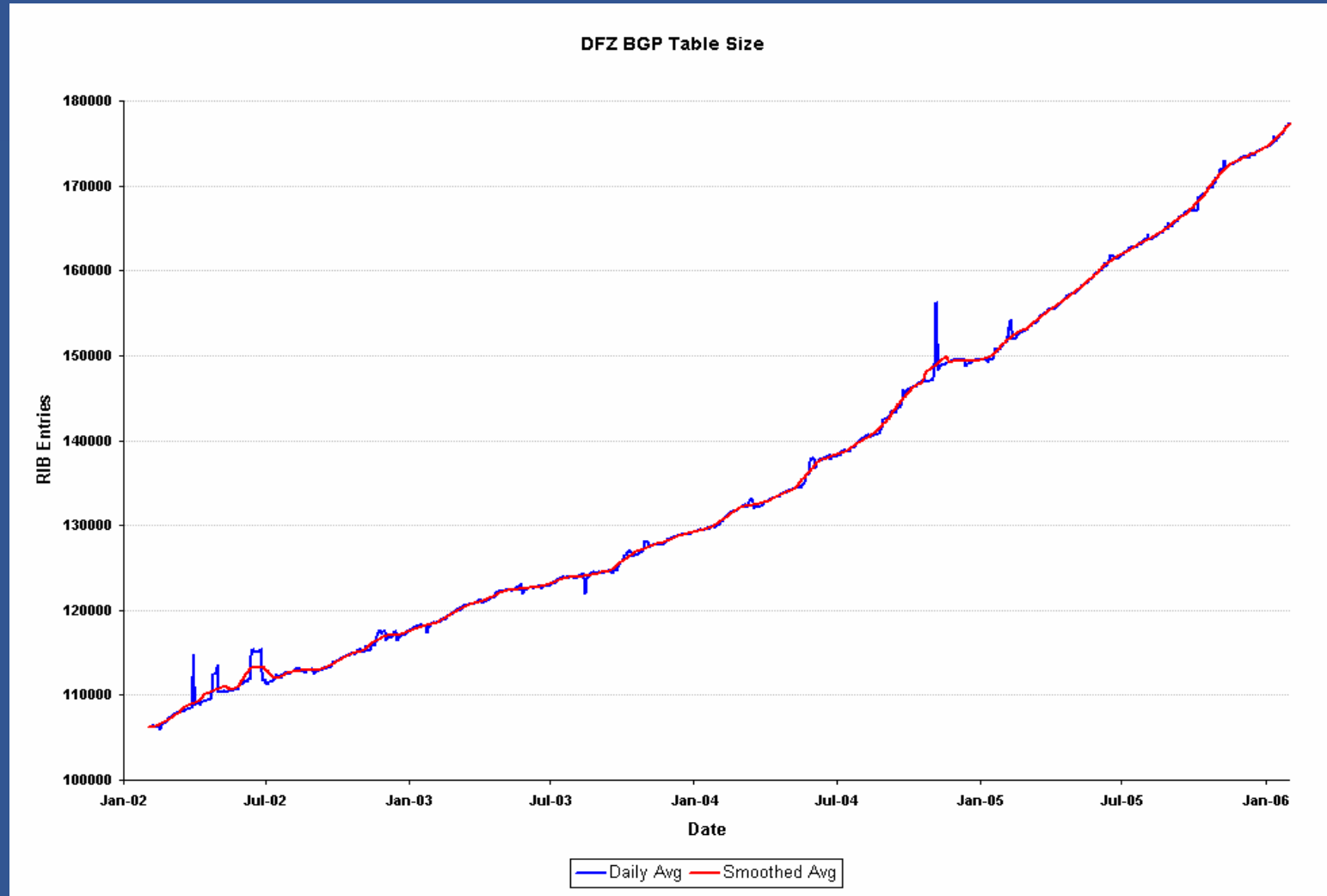Prefix Update Rate / Day
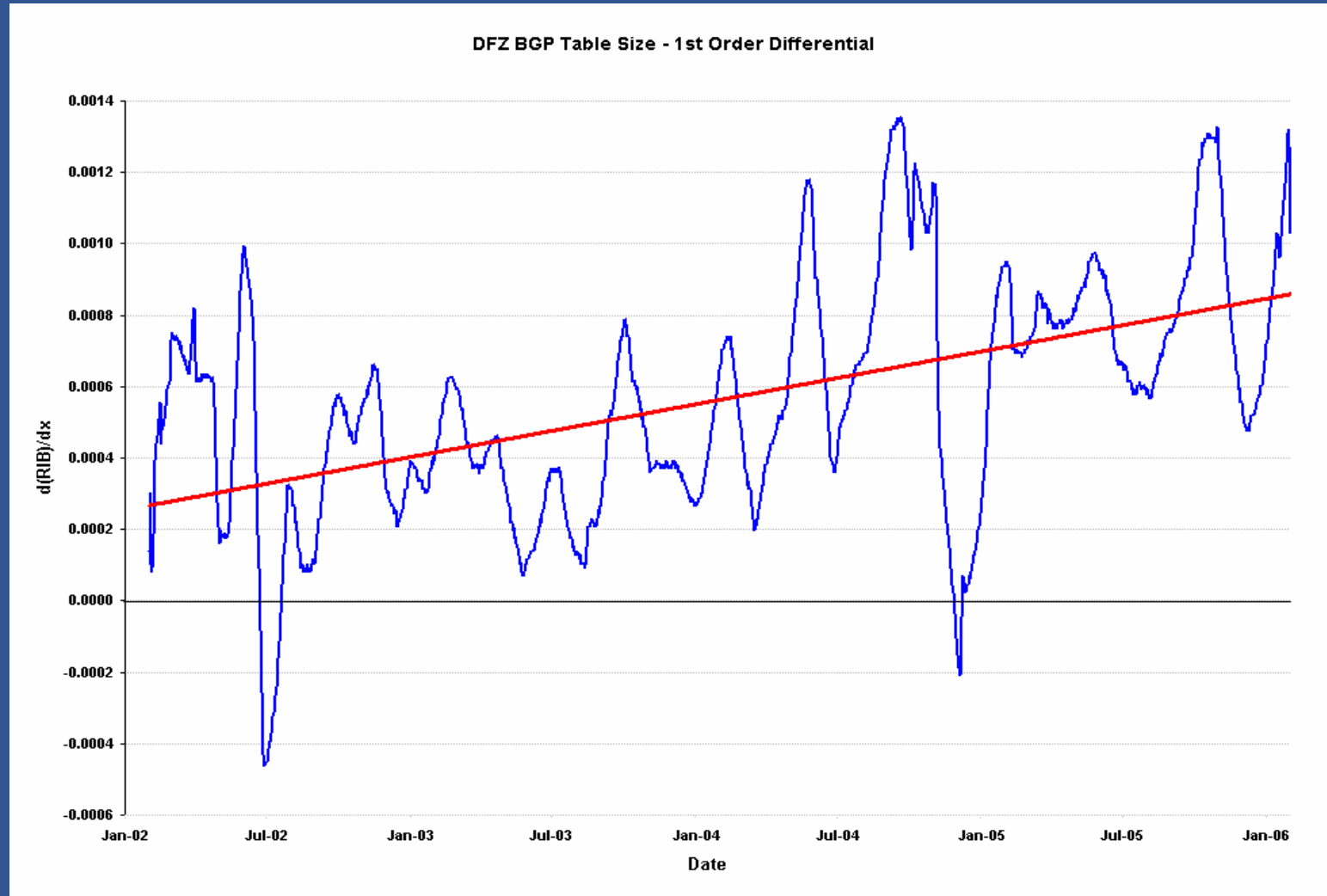
Withdrawal Rates

Prefix Rate Trends

- High variability in day-to-day prefix change rates
- Best fit model appears to be exponential – although update and withdrawal rates show different growth rates
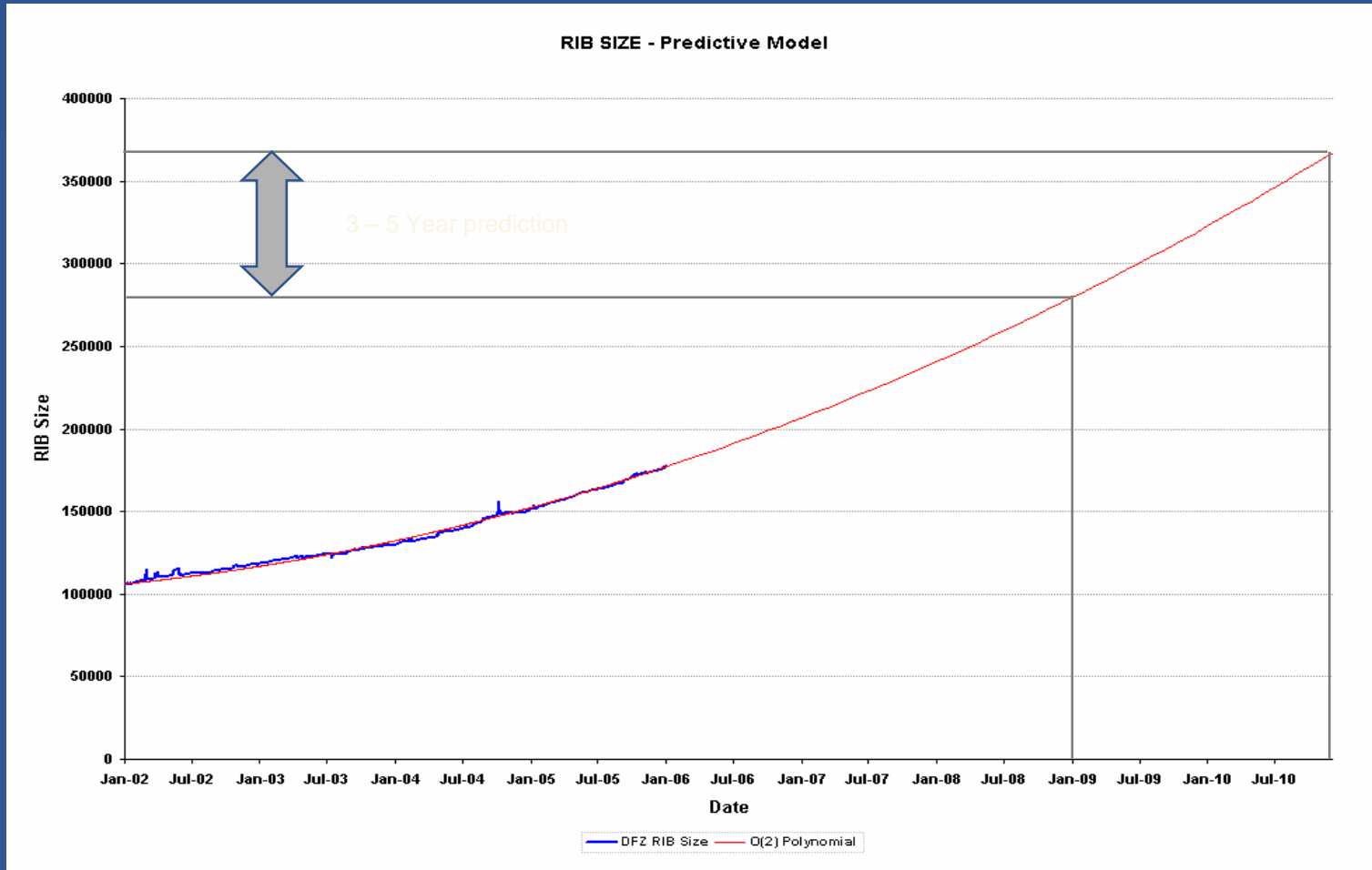
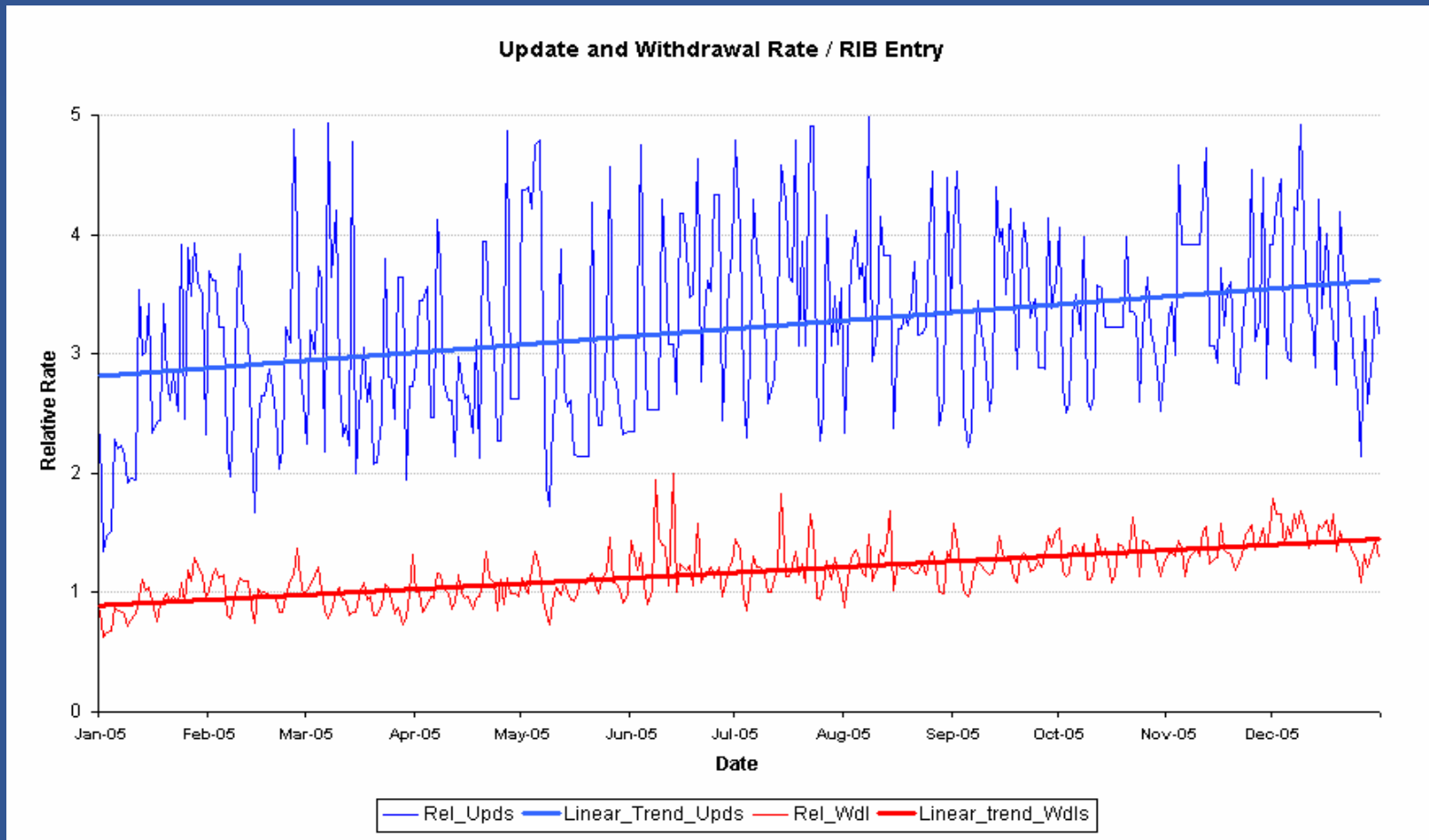# DFZ Prefix Table Size

DFZ BGP Table Size

1st Order Differential
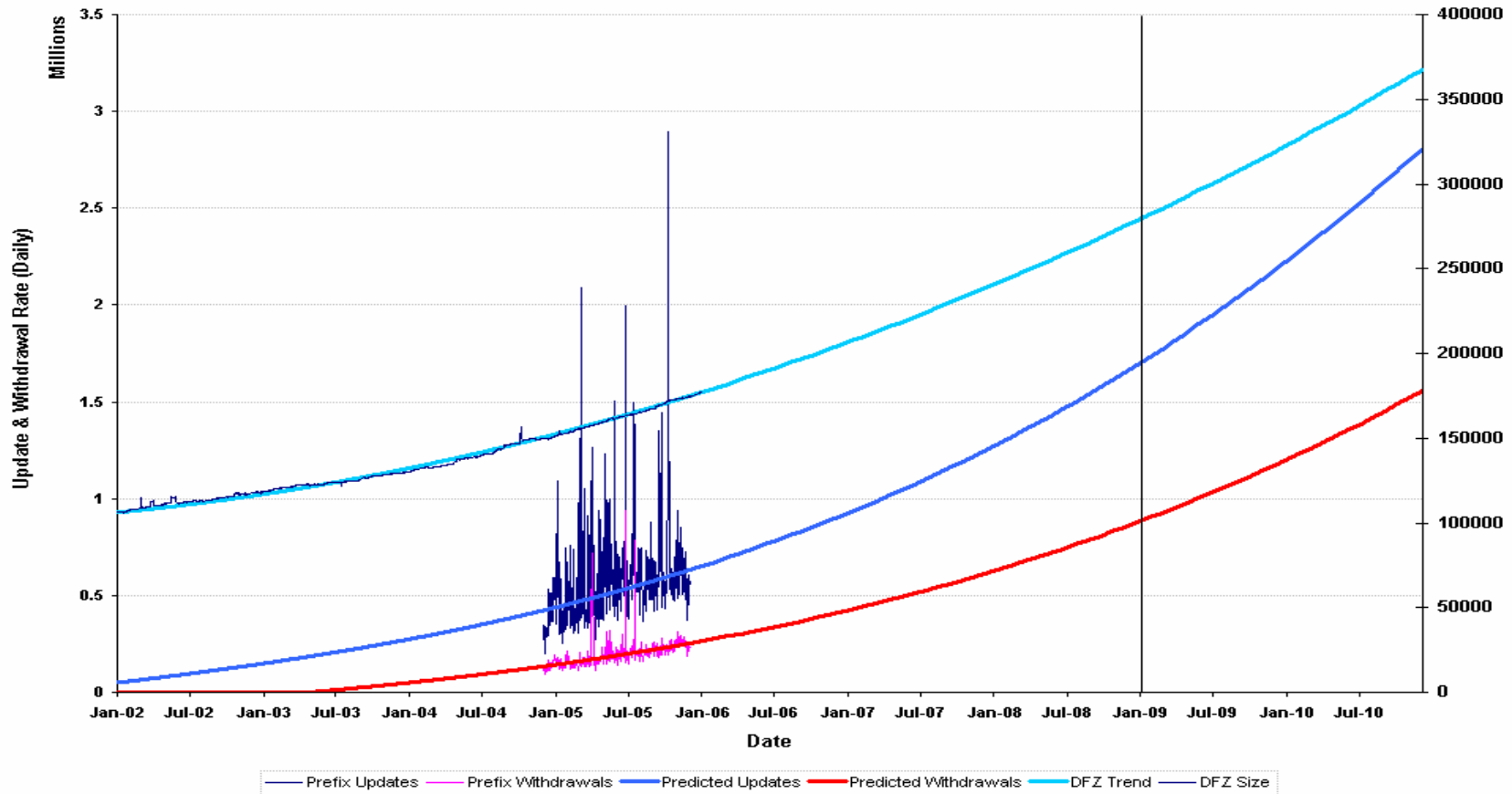
DFZ Model as an O(2) Polynomial
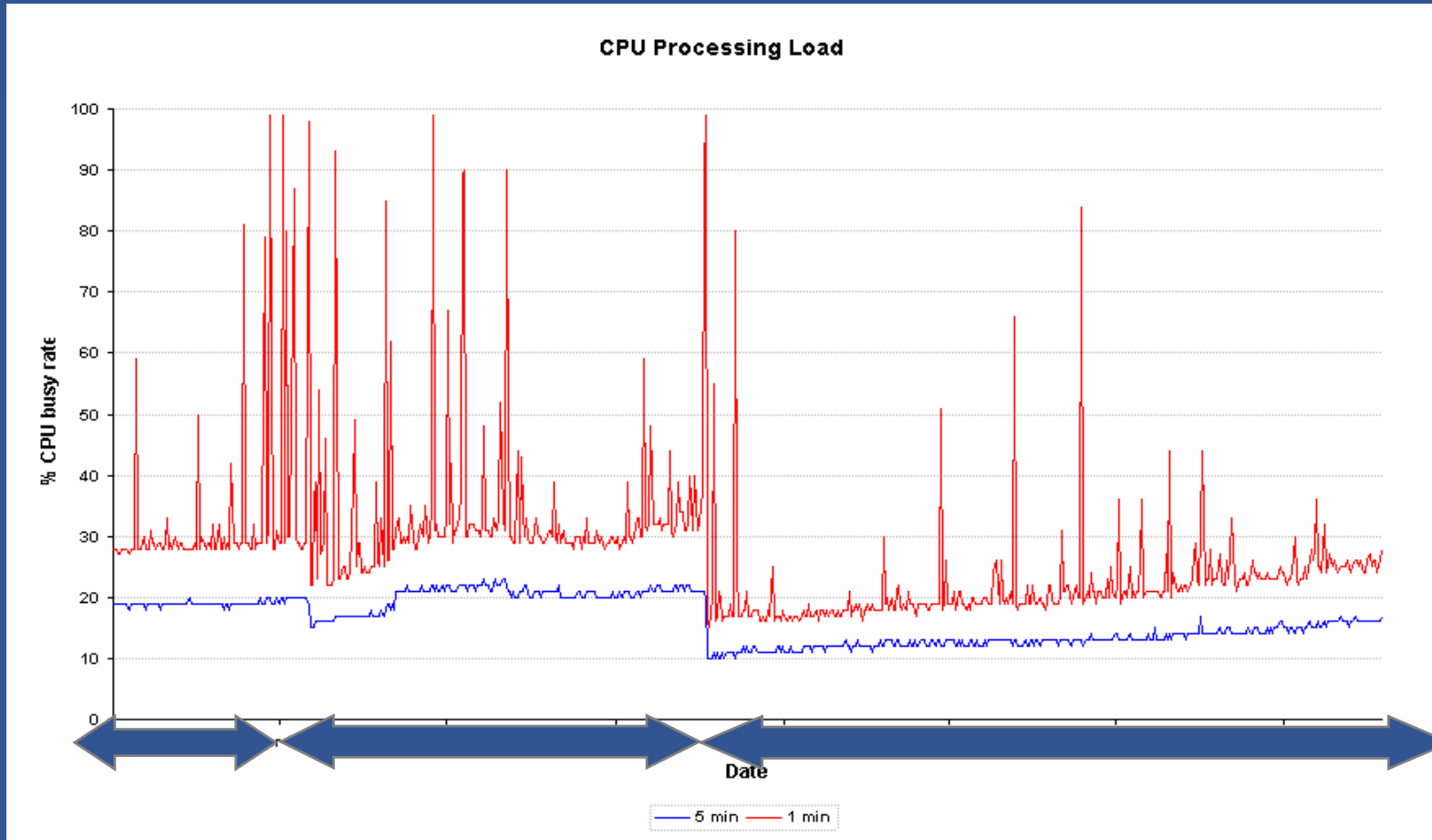
Relative Update / Withdrawal Rates

Update Rate Prediction

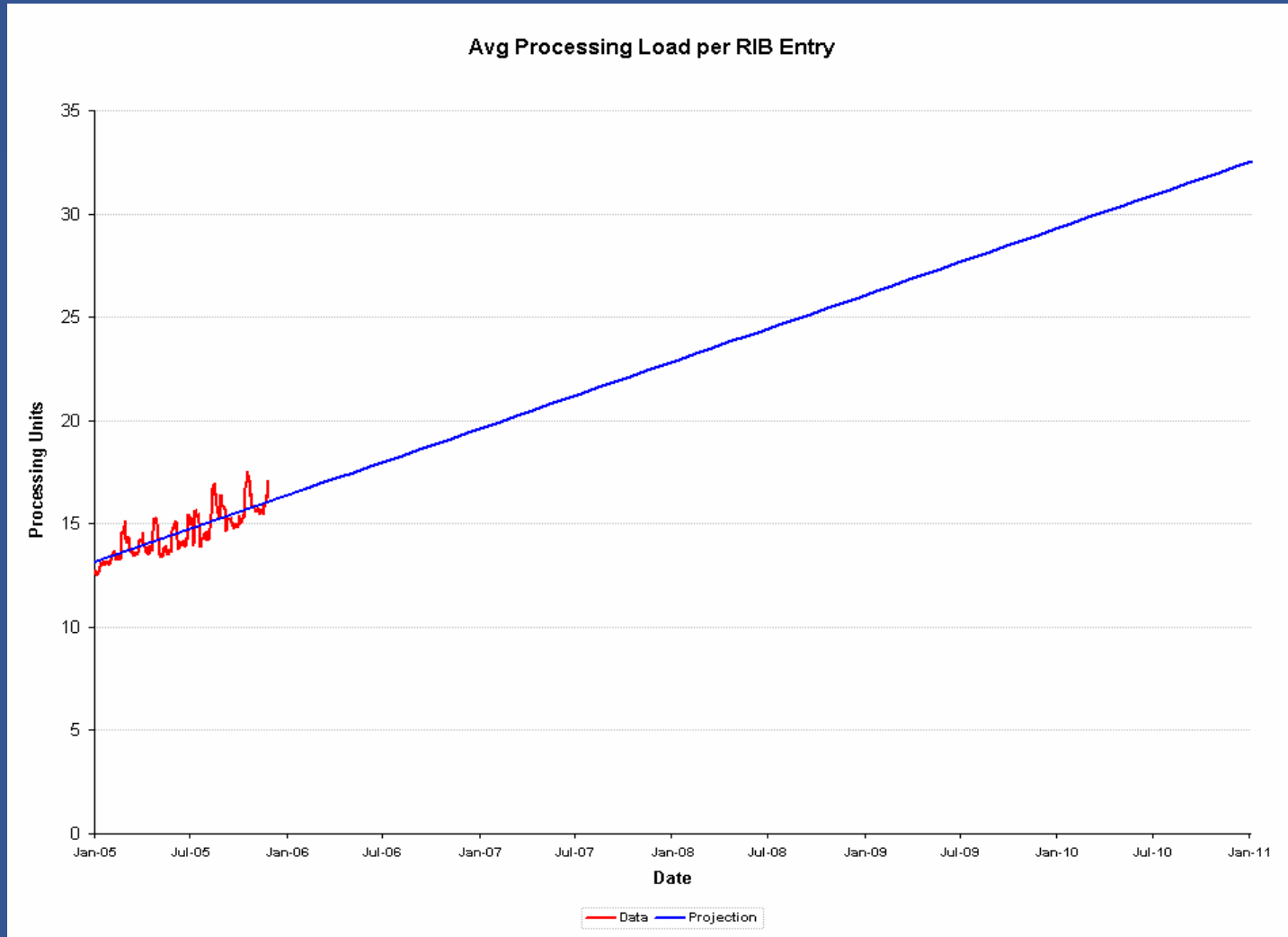Update and Withdrawal Rate Predictive Model

Processing Metrics

Relative Processing Metrics

Avg Processing Load per RIB Entry
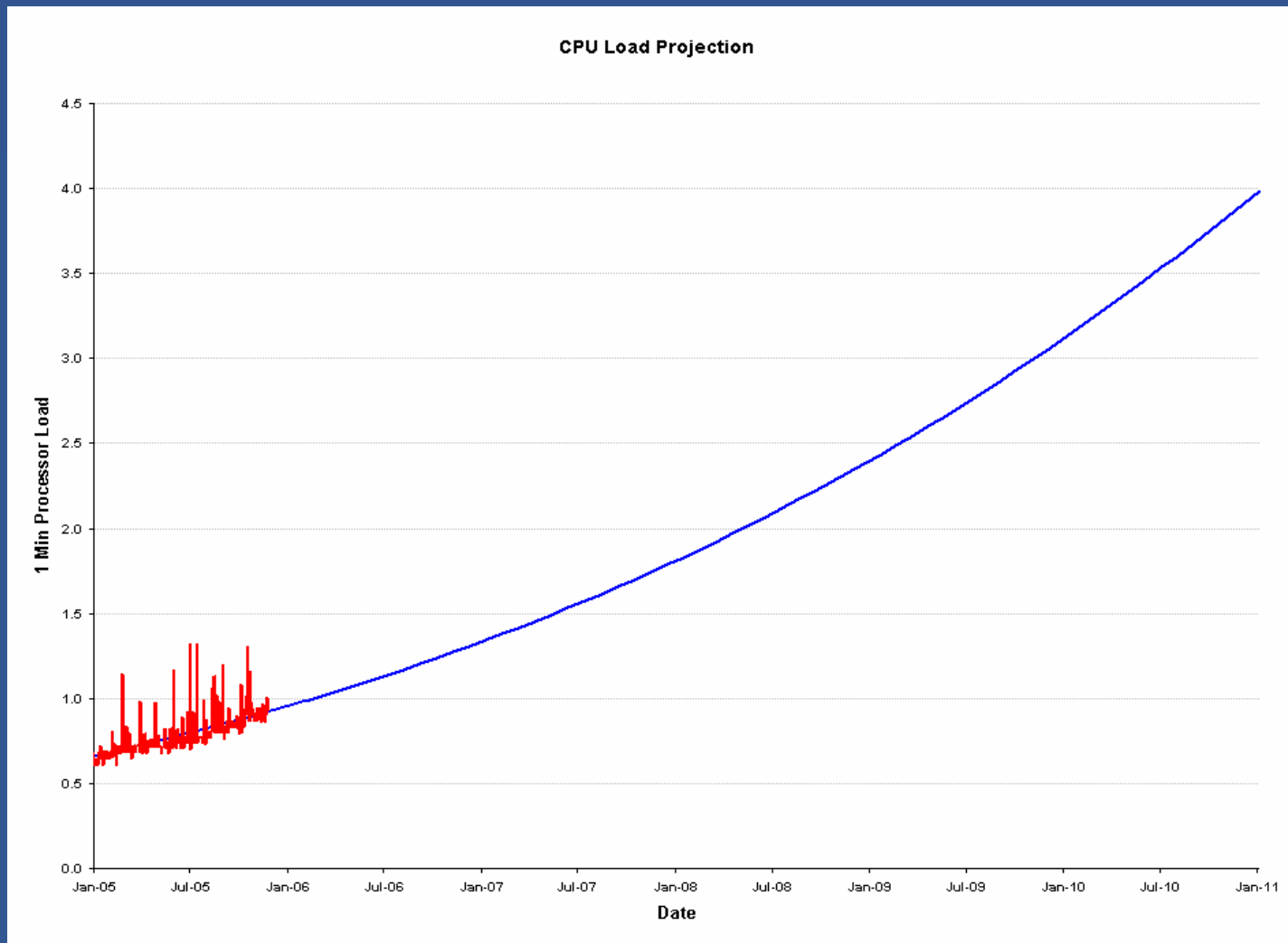
Projected Processing Load

3-5 Year Predictions for the IPv4 DFZ

- Today (1/1/2006)
  - Table Size   **176,000** prefixes
  - Update Rate 0.7M prefix updates / day
  - Withdrawal Rate 0.4M prefix withdrawals per day
  - 250Mbytes memory
  - 30% of a 1.5Ghz processor

- 3 Years (1/1/2009)
  - Table Size   **275,000** prefixes
  - Update Rate 1.7M prefix updates / day
  - Withdrawal Rate 0.9M withdrawals per day
  - 400Mbytes Memory
  - 75% of a 1.5Ghz processor

- 5 Years (1/1/2011)
  - Table Size   **370,000** prefixes
  - Update Rate 2.8M prefix updates / day
  - Withdrawal Rate 1.6M withdrawals per day
  - 550Mbytes Memory
  - 120% of a 1.5Ghz processor

However…

- These are **<u>very</u>** low end predictors
  - The router needs to cope with per second peak update rates, not average loads
  - It's the capability to keep the forwarding fabric in sync with the network topology that is the critical factor – its speed under peak load that counts
  - These projections assume unaltered BGP
    - For example, secure BGP protocol sessions, additional security-related payload factors, incremental workload to validate security payloads, and related aspects are not factored in

- It would be prudent to include a significant additional capability margin for these factors.

DFZ router sizing for 3 – 5 years
A more conservative estimate:

- 500,000 entries in the RIB
- Update rate of up to 6M prefix updates /day
- Short term peak update rate 100 x average daily rate (7000 prefix updates /sec)
- 2 Gbytes route processor memory (or more, depending on DFZ peer count)
- 5GHz processor for route processing

+ Security processing overheads

What's the uncertainty factor?

- Are we seeing a uniform distribution of updates across all ASs and all Prefixes?

- Or is this a skewed heavy tail distribution where a small number of prefixes contribute to most of the BGP updates?
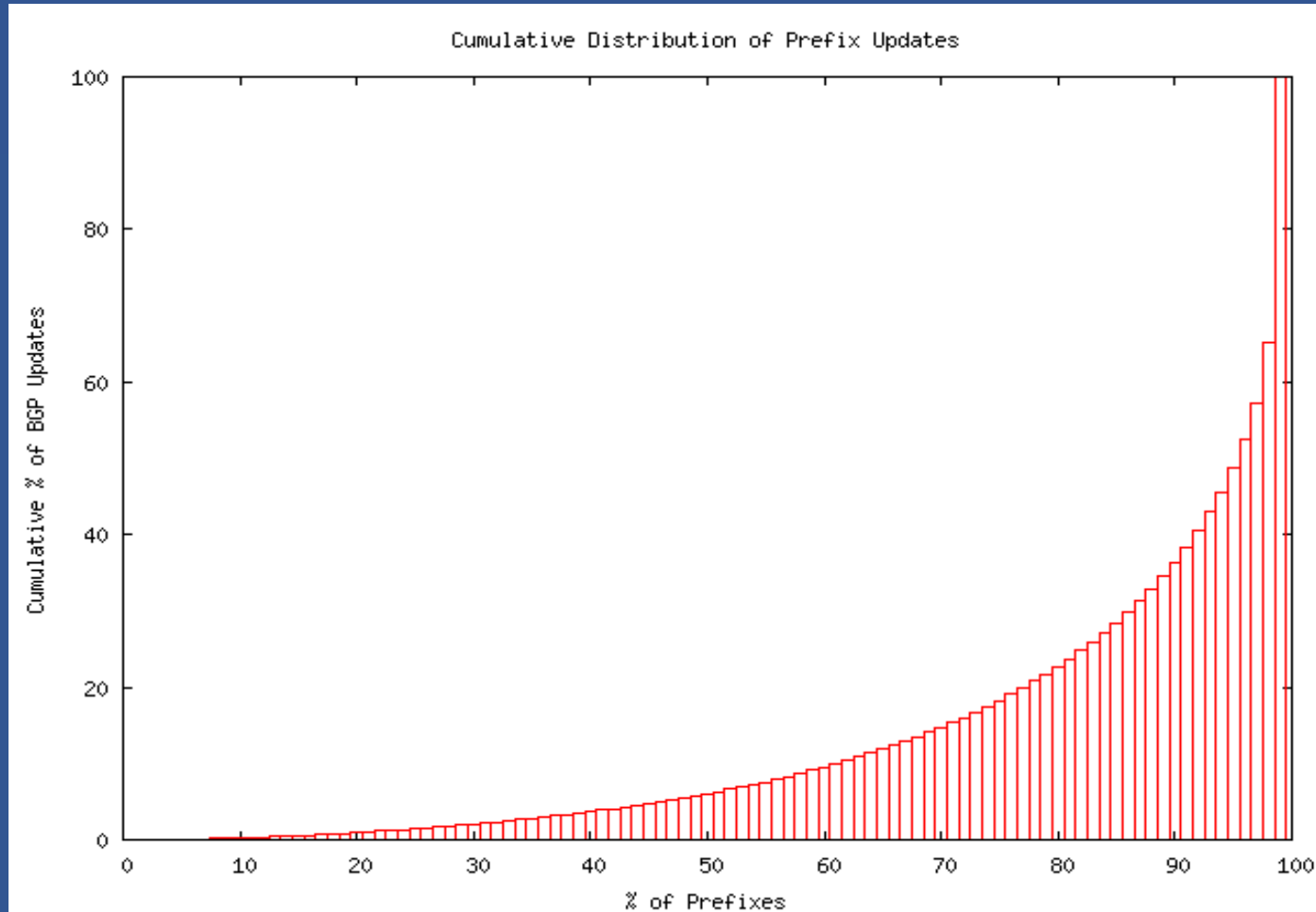
Prefix Stats

- Number of unique prefixes announced: 289,558
- Prefix Updates: 70,761,786
- Stable prefixes: 12,640
- Updated prefixes (year end): 162,039
- Withdrawn prefixes: 127,519
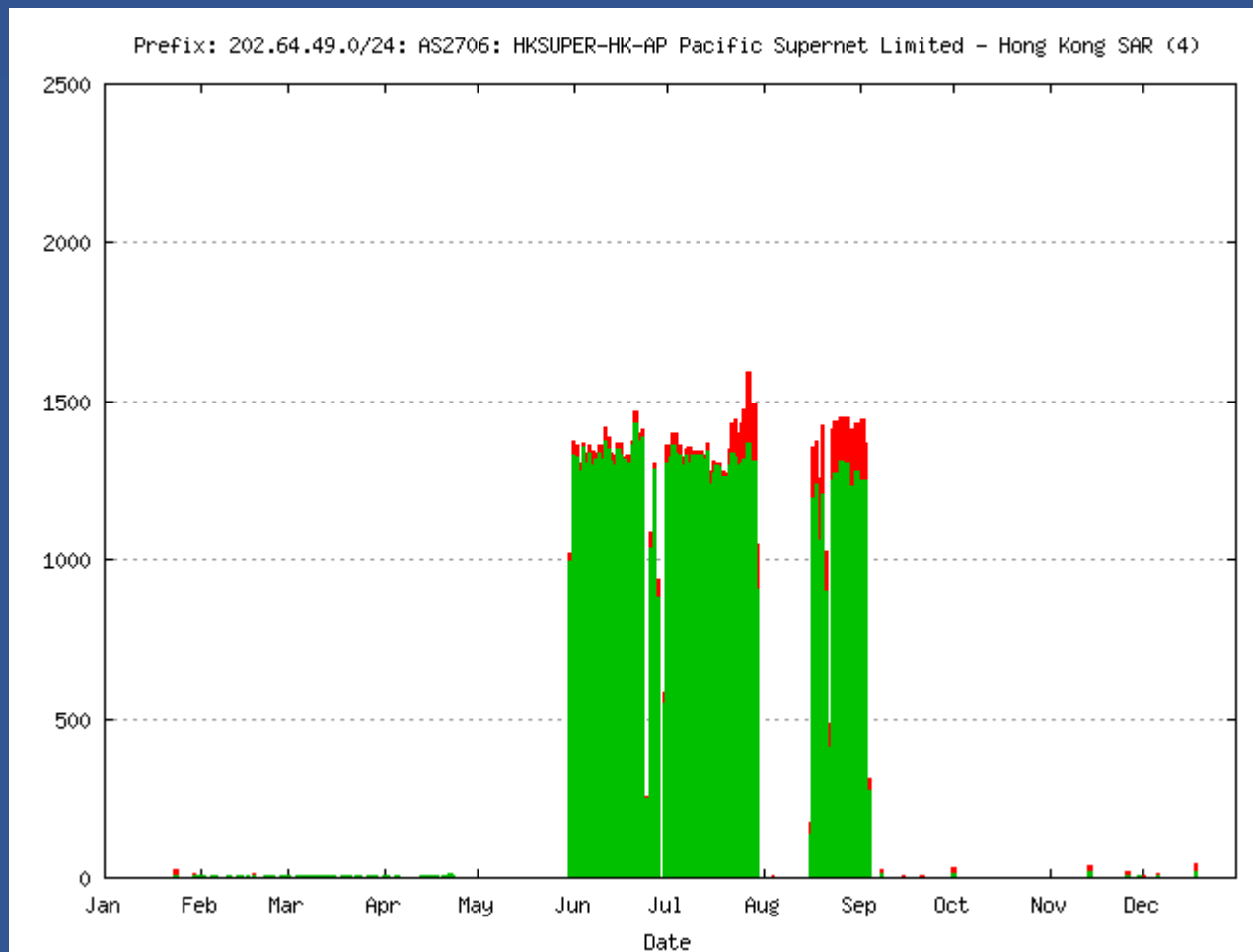
Distribution of Updates by Prefix

Active Prefixes

Top 10 Prefixes

	Prefix	Updates	Flaps	Re-Homes
1.	202.64.49.0/24	198,370	96,330	918
2.	61.4.0.0/19	177,132	83,277	55
3.	202.64.40.0/24	160,127	78,494	1,321
4.	81.212.149.0/24	158,205	61,455	20,031
5.	81.213.47.0/24	138,526	60,885	12,059
6.	209.140.24.0/24	132,676	42,200	0
7.	207.27.155.0/24	103,709	42,292	0
8.	81.212.197.0/24	99,077	37,441	15,248
9.	66.150.140.0/23	84,956	11,109	5,963
10.	207.168.184.0/24	74,679	34,519	0

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1 - 202.64.49.0/24

Prefix: 202.64.49.0/24: AS2706: HKSUPER-HK-AP Pacific Supernet Limited - Hong Kong SAR (4)

2 - 61.4.0.0/19

Prefix: 61.4.0.0/19: AS9899: ICARE-AP iCare.com - Hong Kong SAR (3)

3 - 202.64.40.0/24

Prefix: 202.64.40.0/24: AS2706: HKSUPER-HK-AP Pacific Supernet Limited - Hong Kong SAR (4)

4 - 81.212.149.0/24

Prefix: 81.212.149.0/24: AS9121: TTNET TTnet Autonomous System - Turkey (5)

5 - 81.213.47.0/24

Prefix: 81.213.47.0/24: AS9121: TTNET TTnet Autonomous System - Turkey (5)

6 - 209.140.24.0/24

Prefix: 209.140.24.0/24: AS3043: AMPHIB-AS - Amphibian Media Corporation - USA (1)
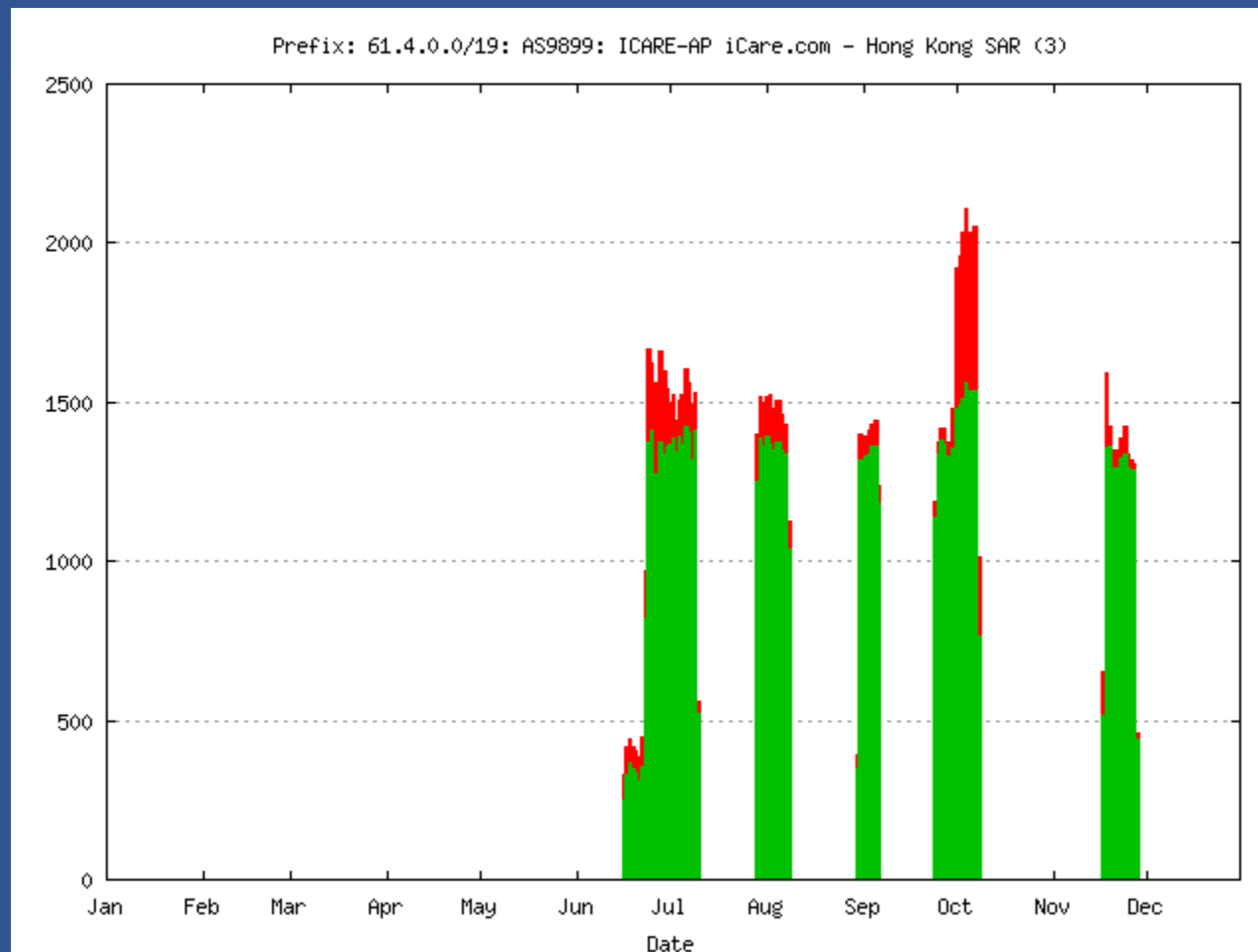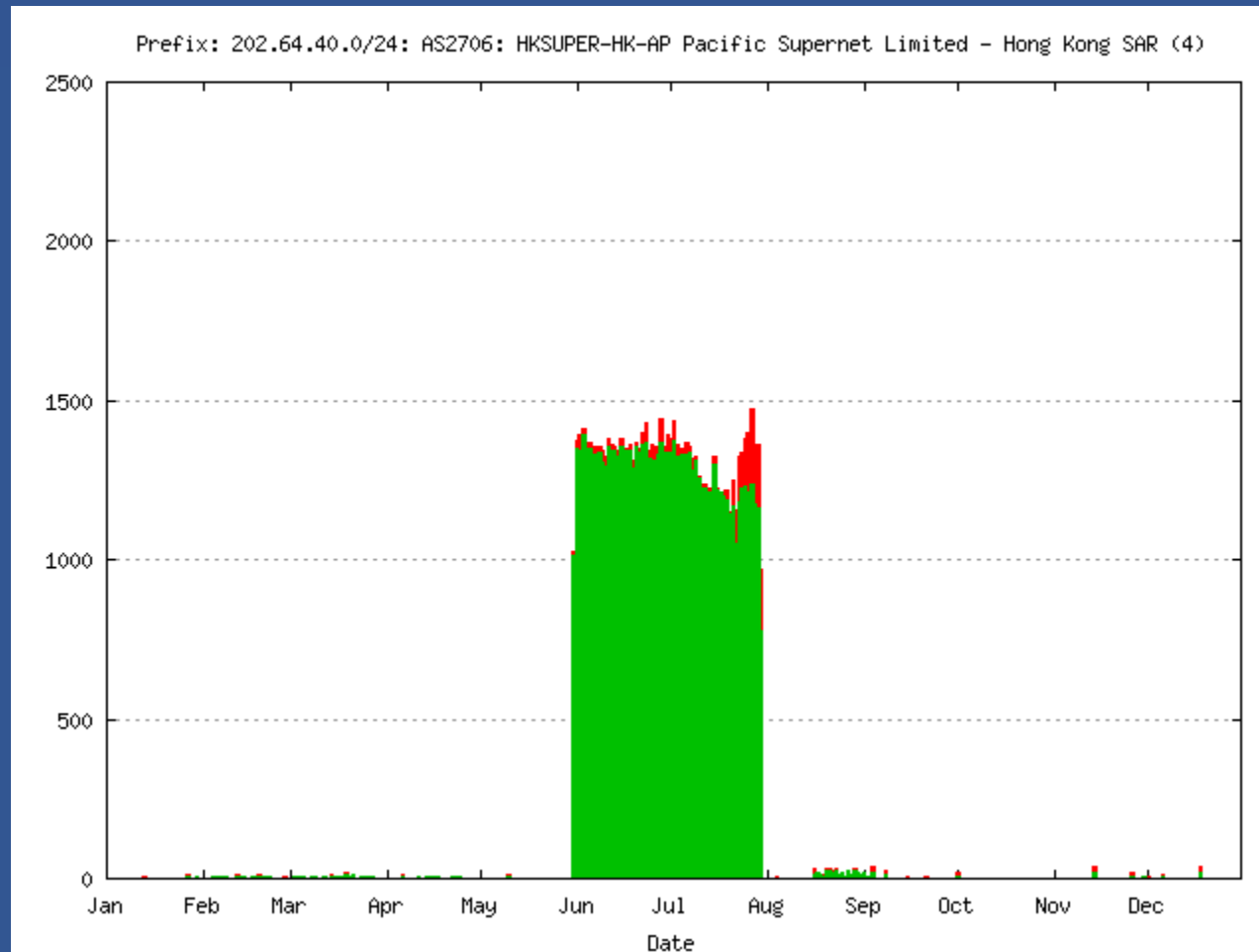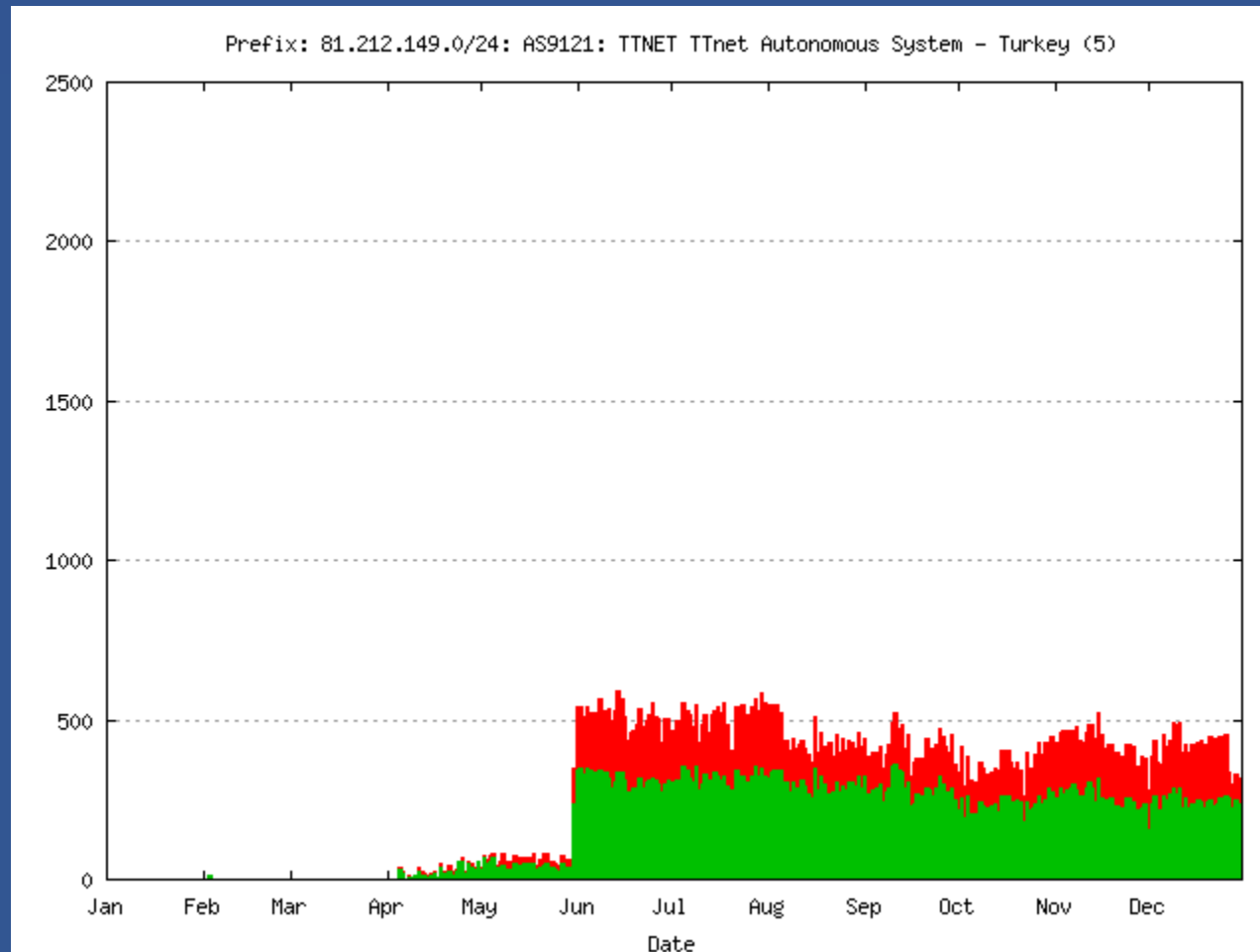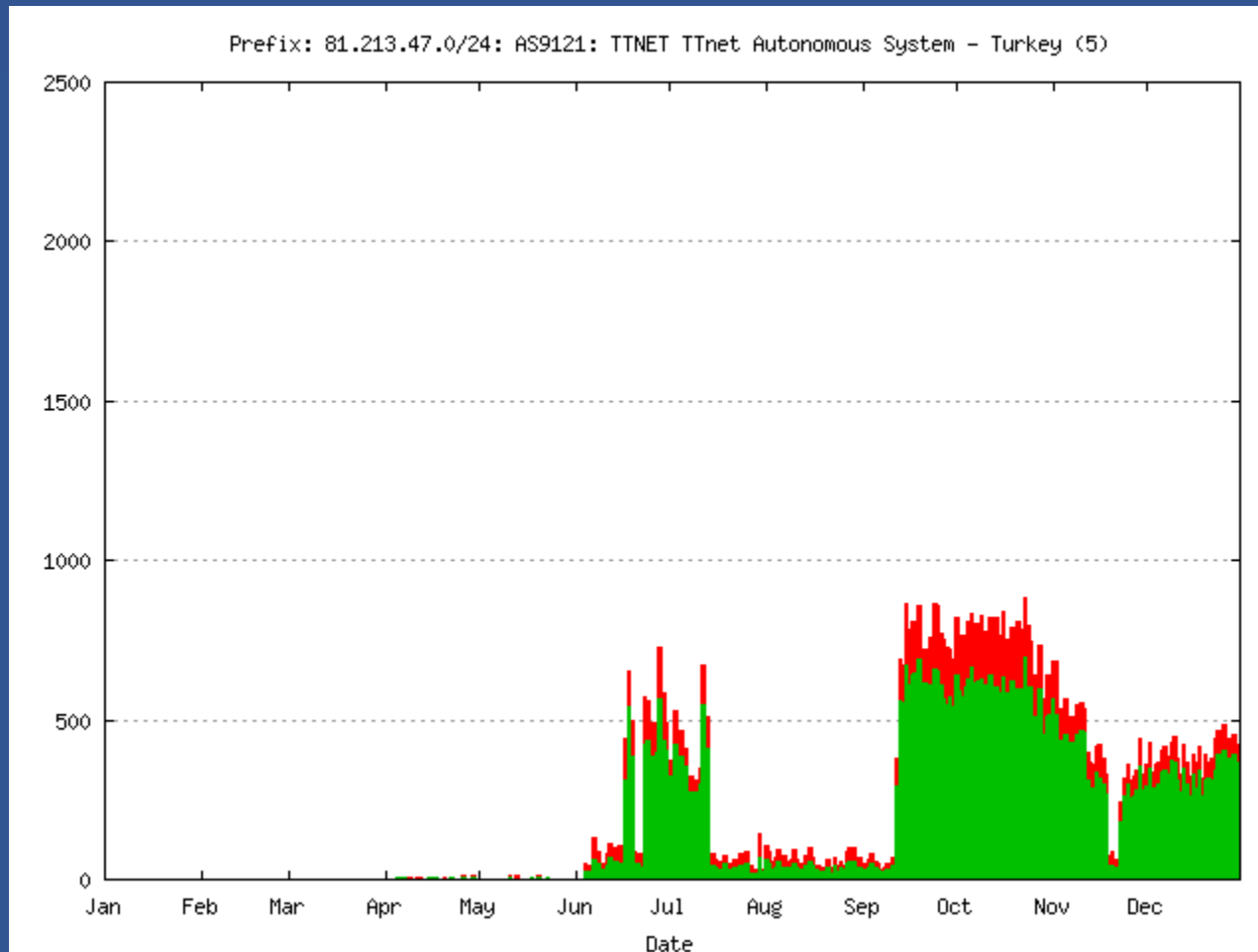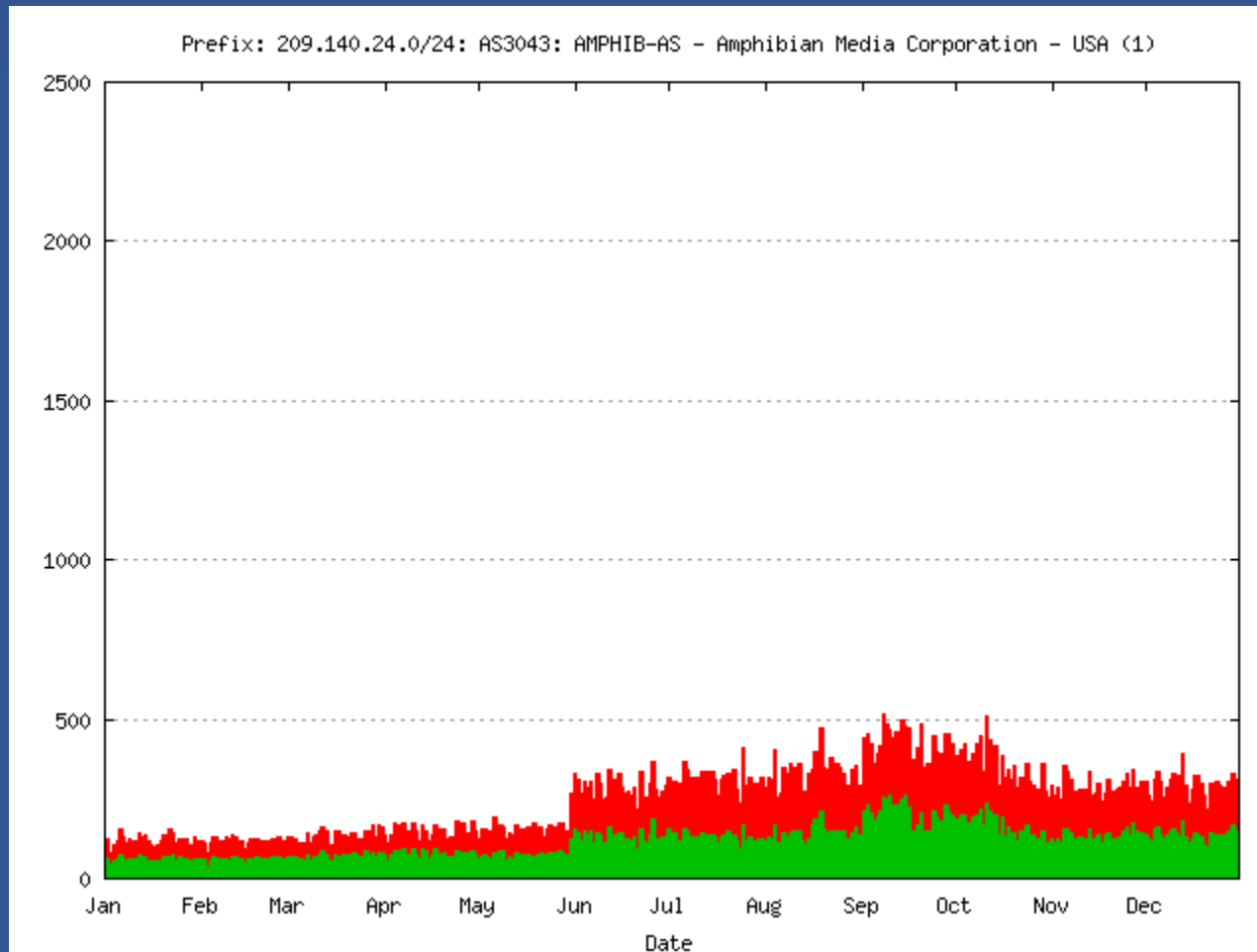
7 - 207.27.155.0/24

8 - 81.212.197.0/24

Prefix: 81.212.197.0/24: AS9121: TTNET TTnet Autonomous System - Turkey (5)

9 - 66.150.140.0/23

Prefix: 66.150.140.0/23: AS20183: VERICENTER - VeriCenter, Inc. - USA (2)

10 - 207.168.184.0/24

Prefix: 207.168.184.0/24: AS32832: ESDESIGN-COM - Environmental Systems Design, Inc. - USA (1)
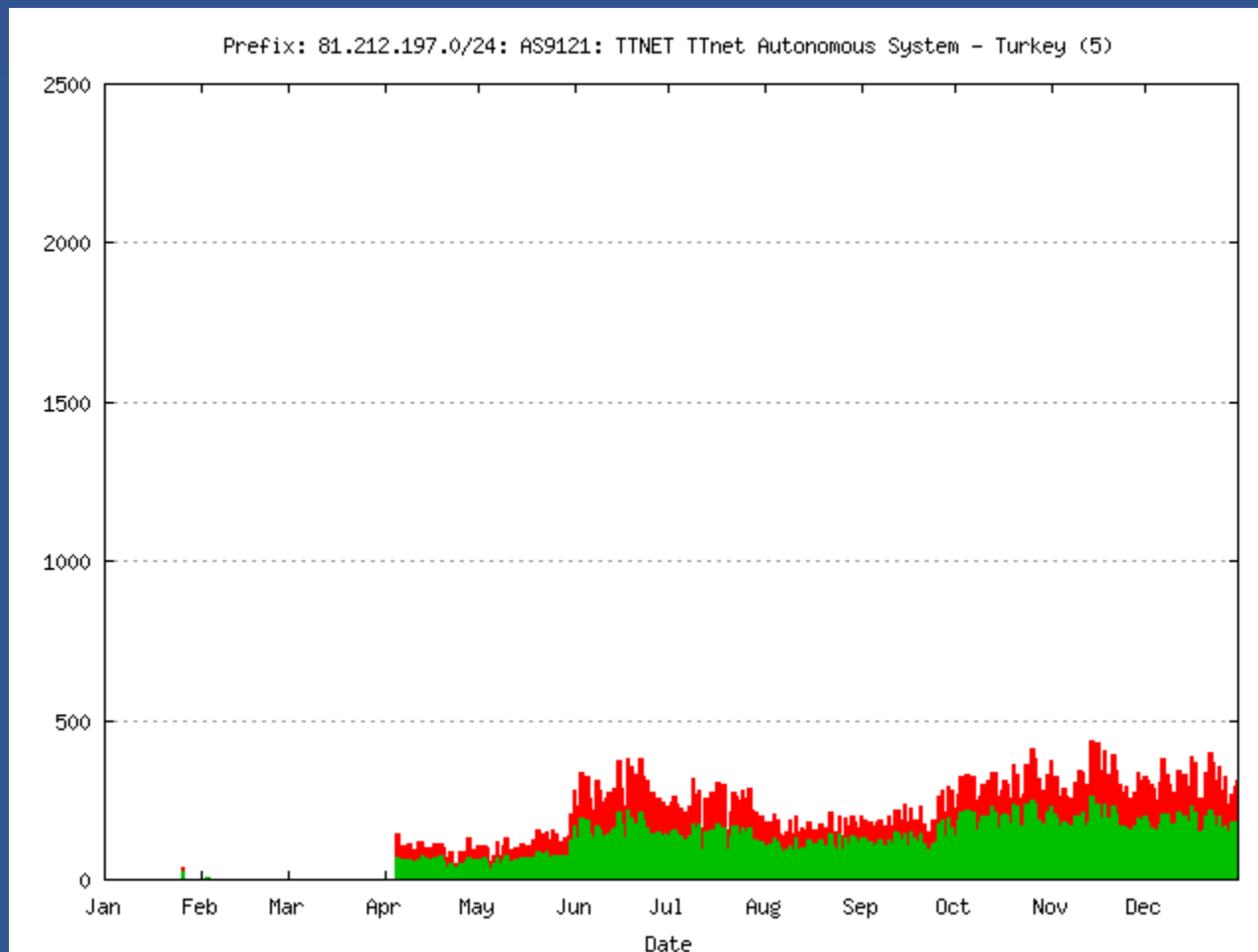
Distribution of Updates by AS
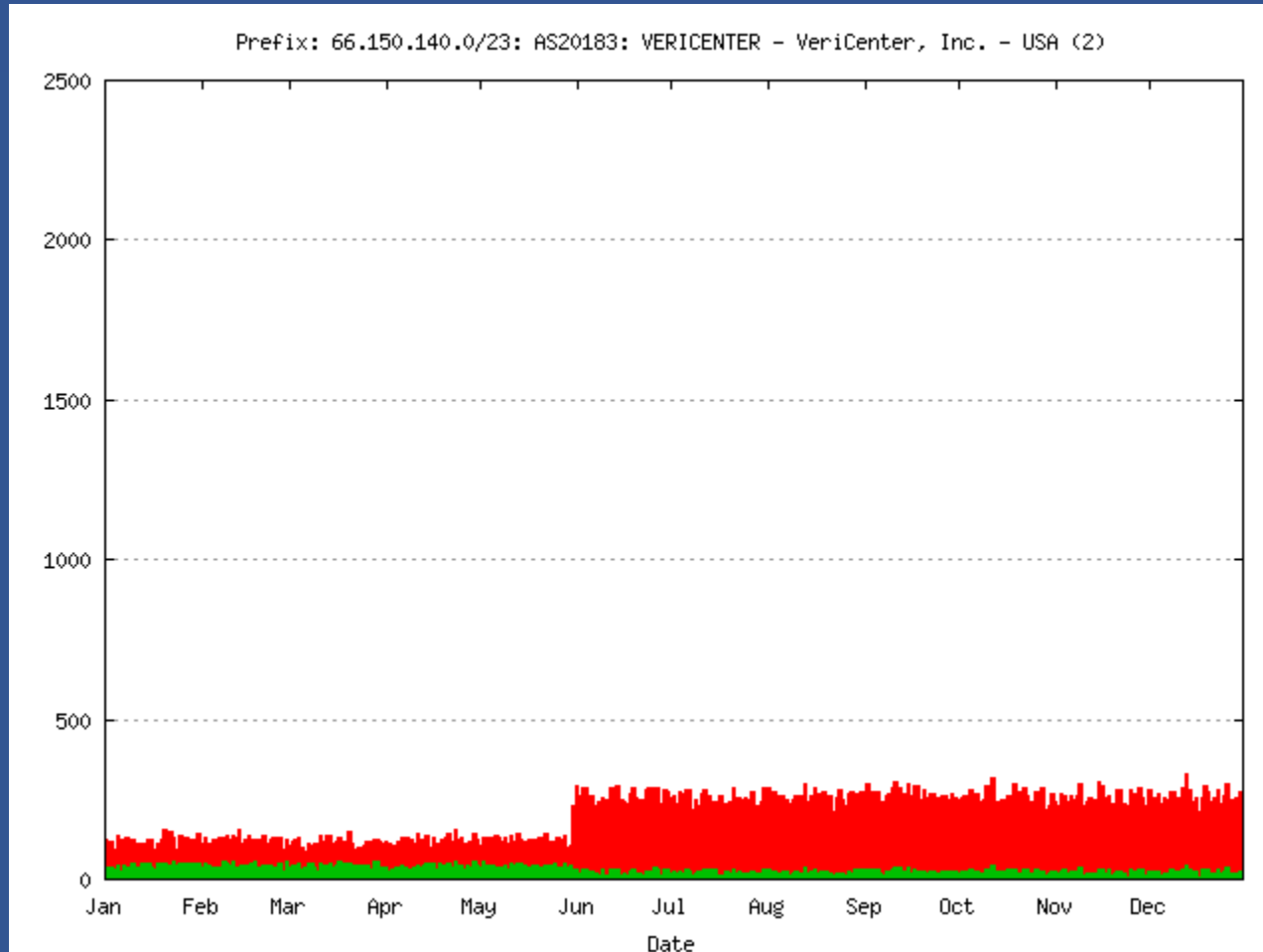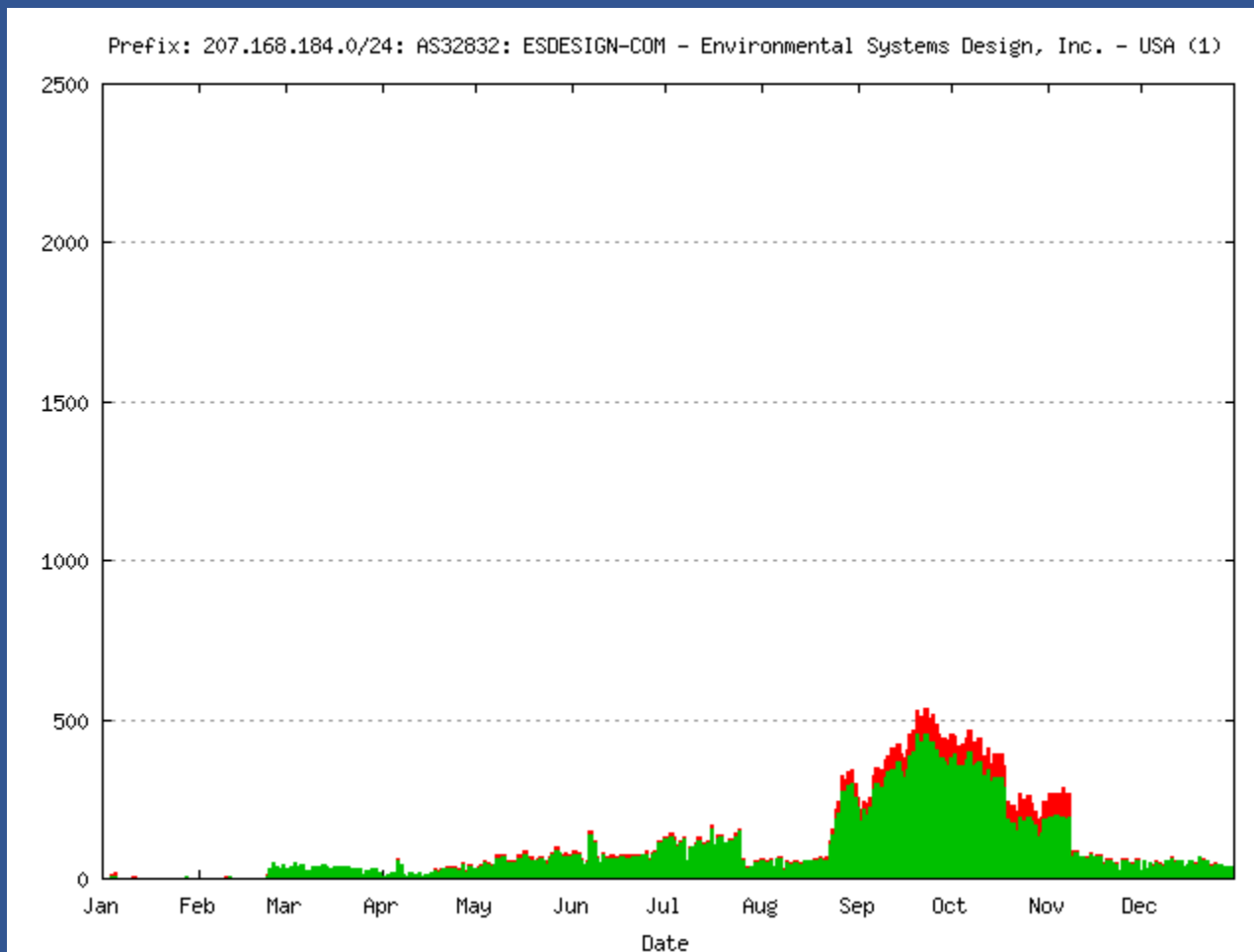
Cumulative Update Distribution across ASNs
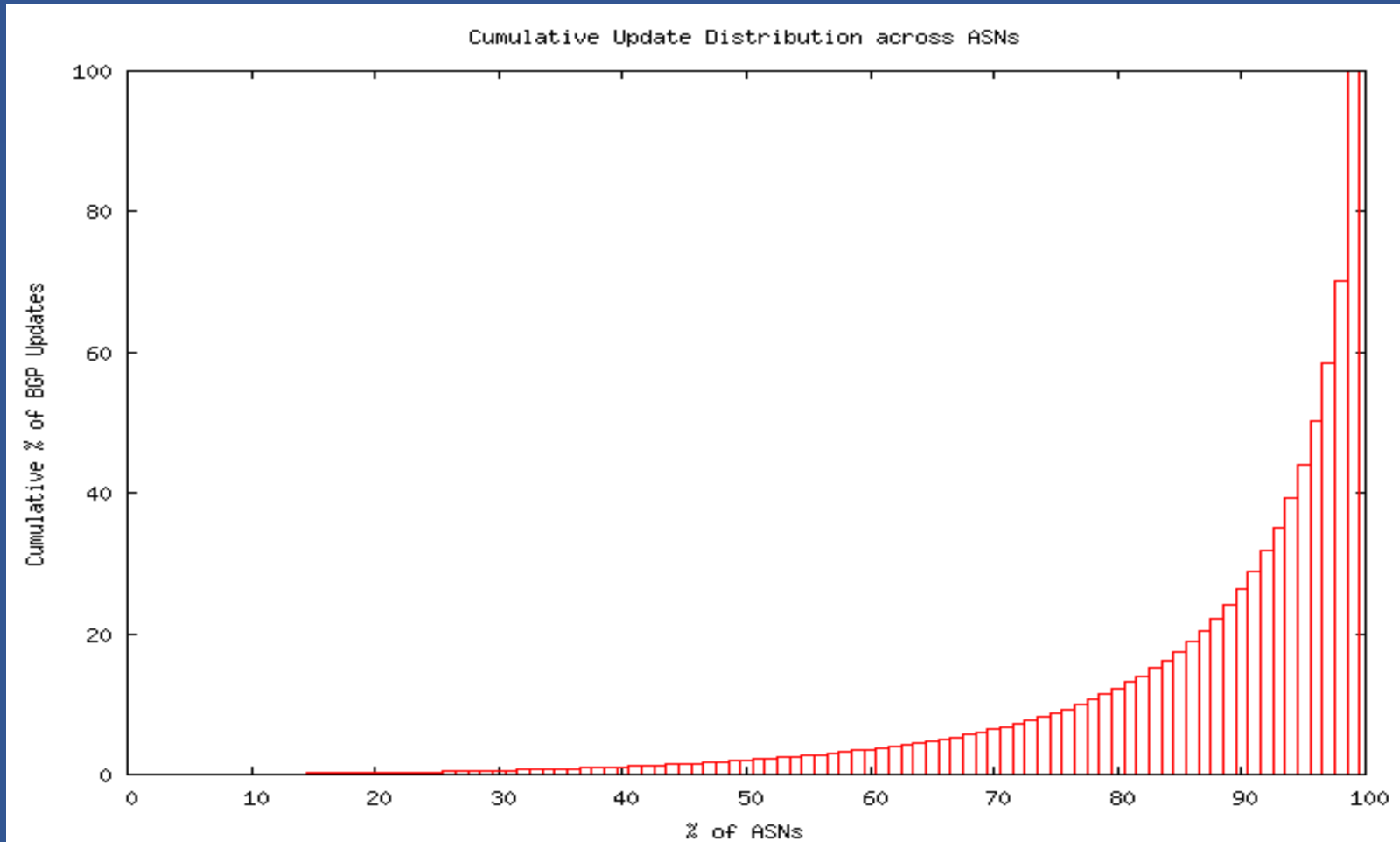
Distribution of Updates
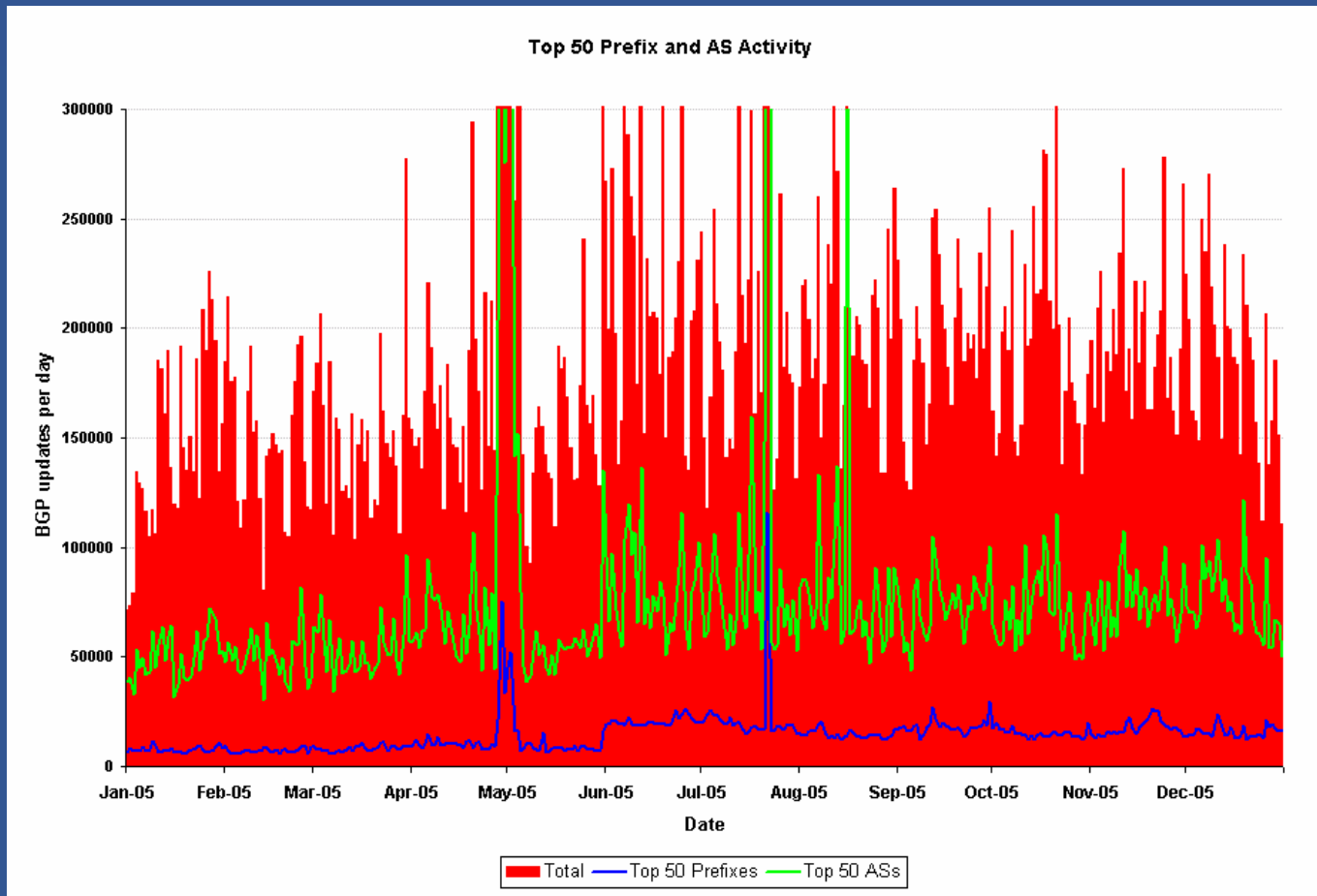
Active ASNs

Top 10 ASns

	AS	Updates	Flaps	Re-Homes
1.	9121	970,782	349,241	206802
2.	7563	869,665	326,707	5
3.	702	605,090	232,876	144523
4.	17557	576,974	178,044	175275
5.	17974	569,806	198,948	310
6.	7545	562,879	200,425	8931
7.	721	498,297	175,623	35866
8.	2706	418,542	196,136	16945
9.	9950	411,617	148,725	6
10.	17832	393,052	143,018	0

1 – AS 9121
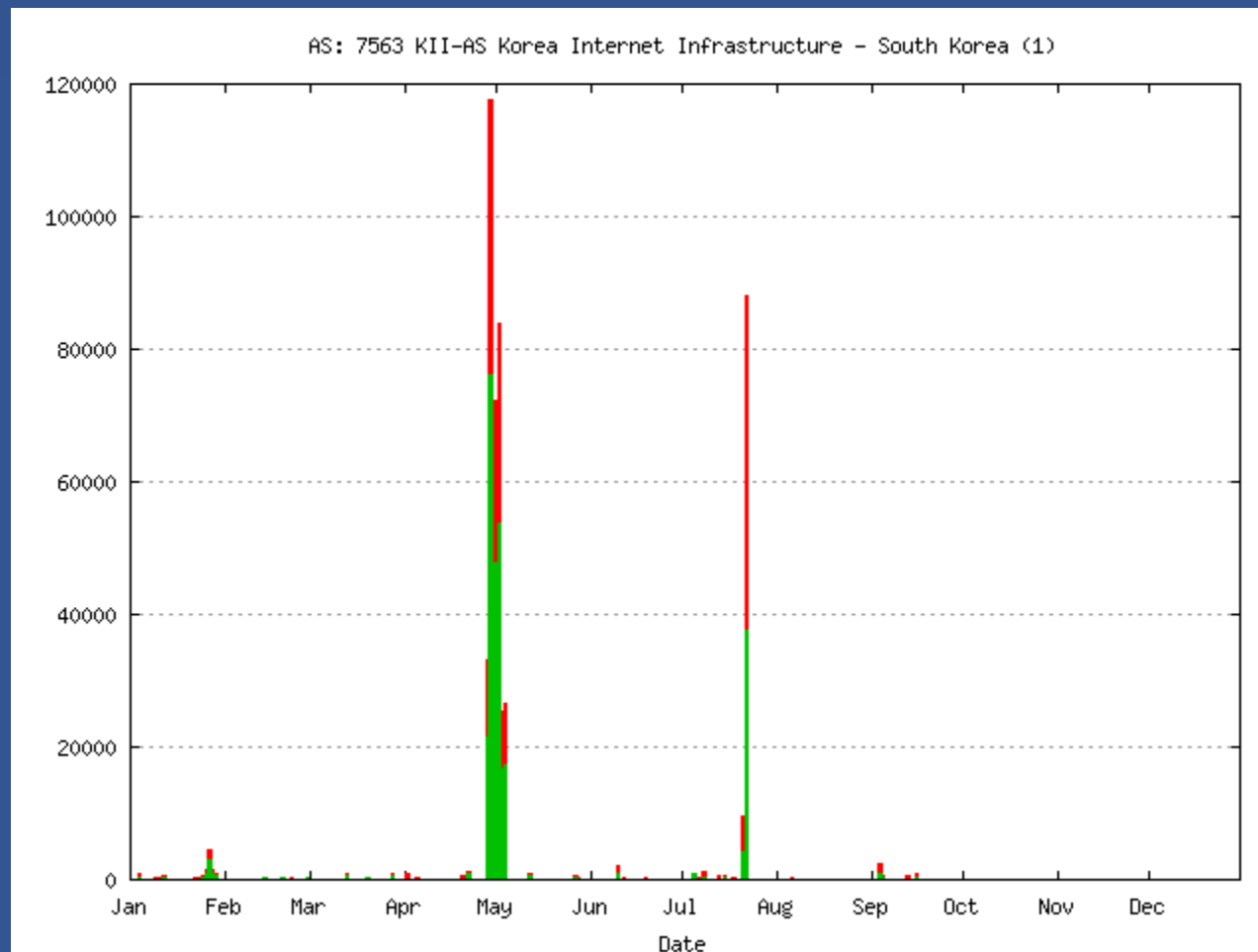

AS: 9121 TTNET TTnet Autonomous System – Turkey (5)
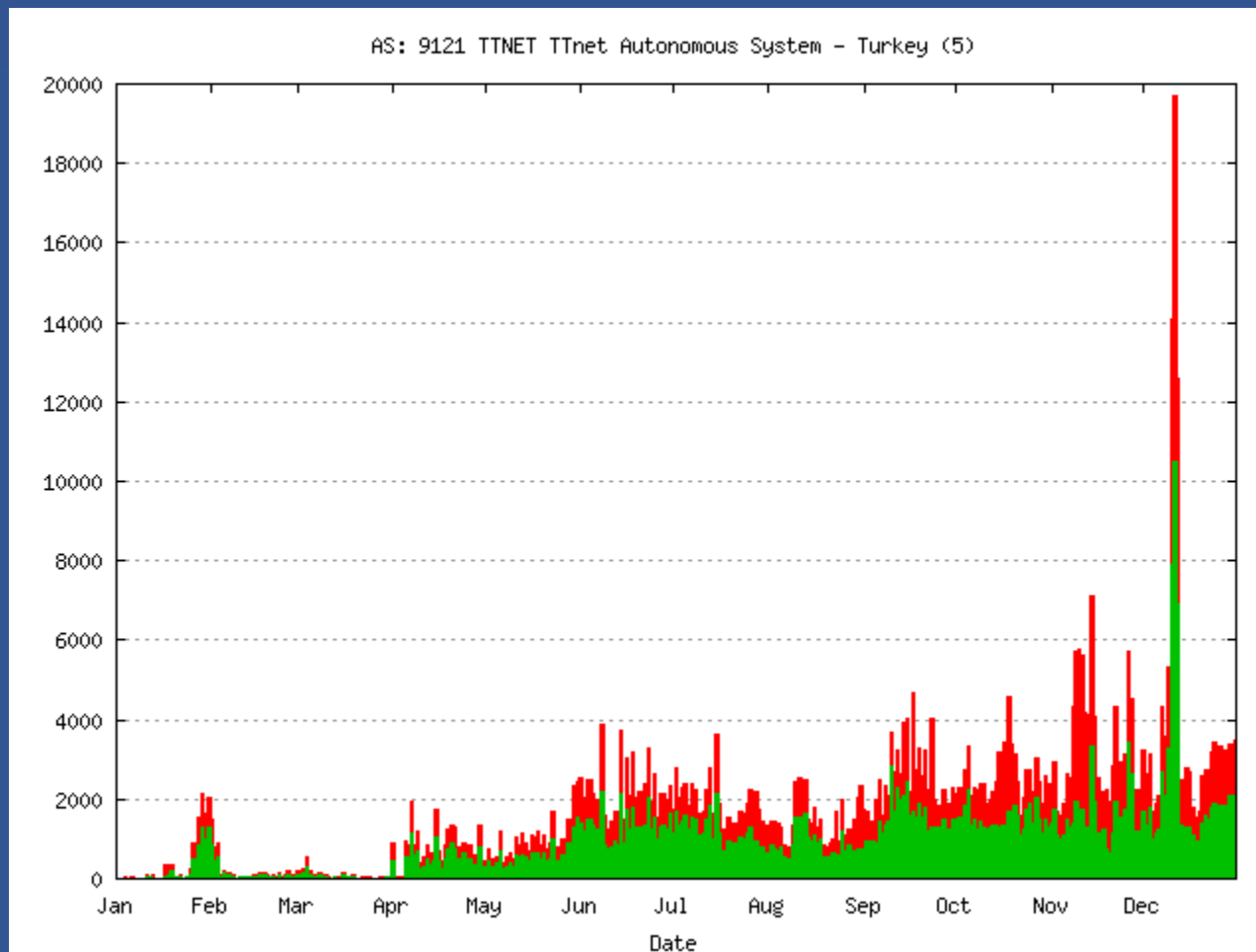
AS9121 Upstreams

- 9121 TTNET TTnet Autonomous System Adjacency: 84 Upstream: 6 Downstream: 78
- Upstream Adjacent AS list

  AS1299 TELIANET TeliaNet Global Network

  AS3257 TISCALI-BACKBONE Tiscali Intl Network

  AS3356 LEVEL3 Level 3 Communications

  AS3549 GBLX Global Crossing Ltd.

  AS13263 METEKSAN-NET Meteksan.NET Autonomous System

  AS6762 SEABONE-NET Telecom Italia Sparkle

2 – AS 7563
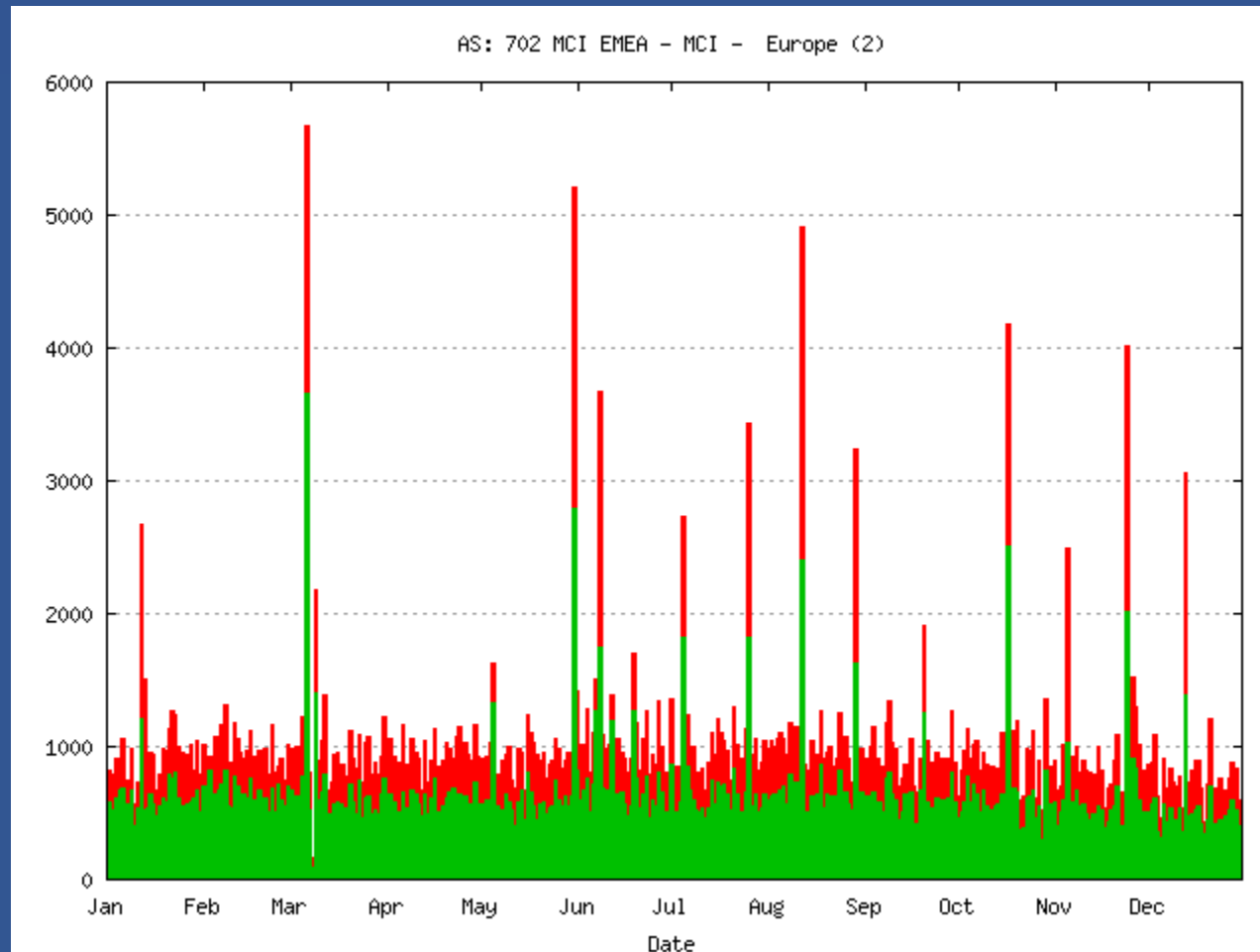

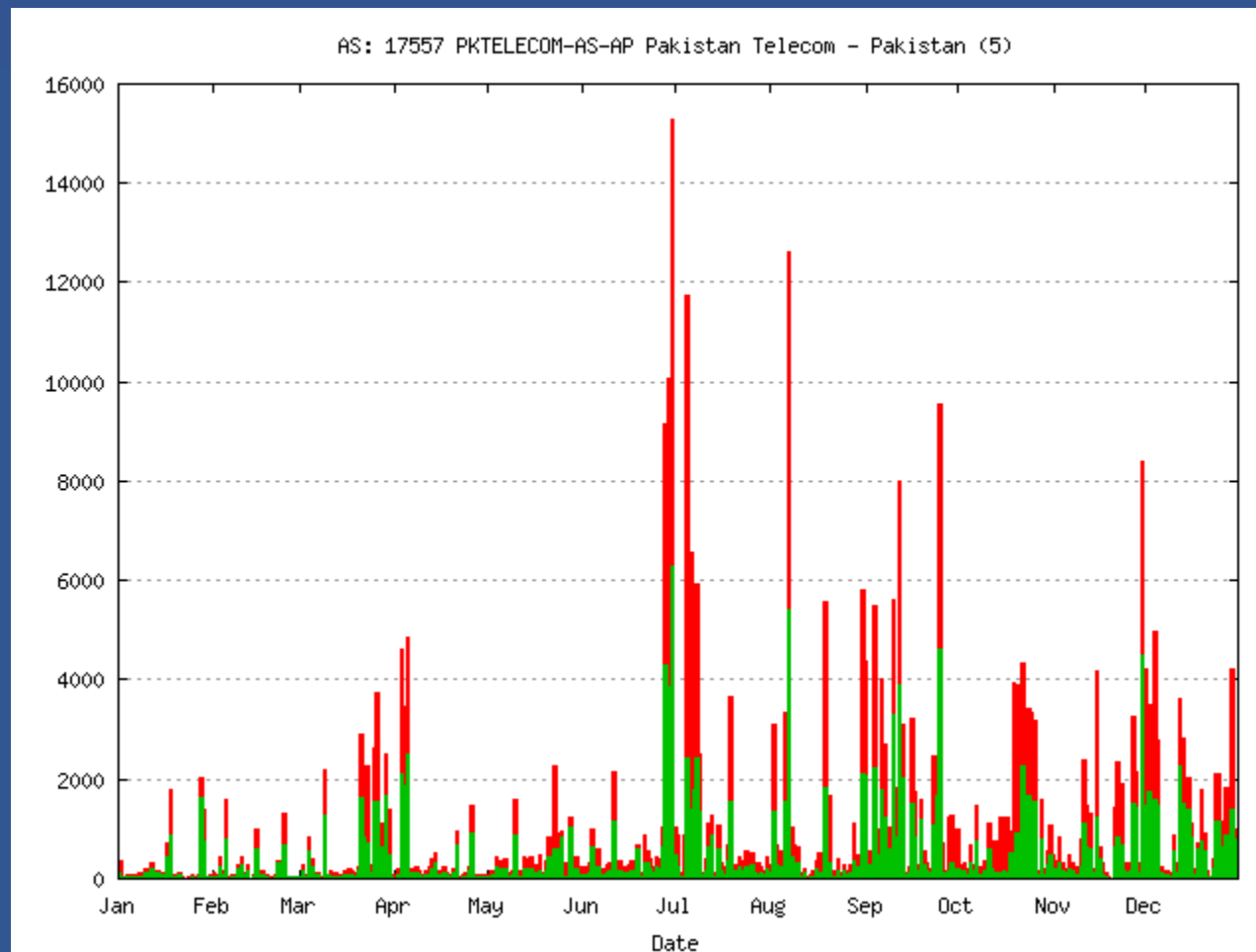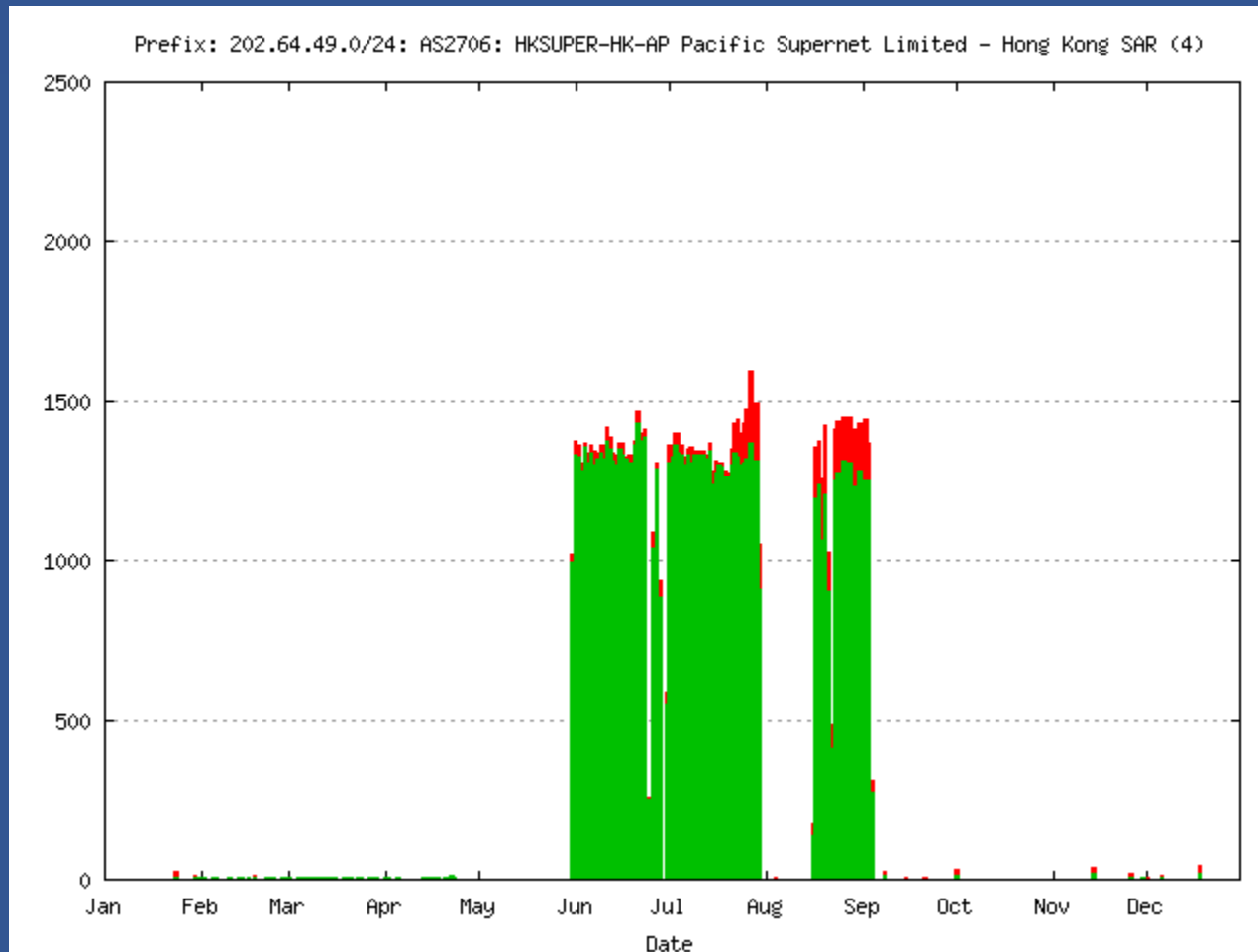AS: 7563 KII-AS Korea Internet Infrastructure – South Korea (1)

3 – AS 702

4 – AS 17557

AS: 17557 PKTELECOM-AS-AP Pakistan Telecom - Pakistan (5)

5 – AS17974

Prefix: 202.64.49.0/24: AS2706: HKSUPER-HK-AP Pacific Supernet Limited - Hong Kong SAR (4)

6 – AS 7545

AS: 7545 TPG-INTERNET-AP TPG Internet Pty Ltd – Australia (4)

7 – AS721

8 – AS2706

AS: 2706 HKSUPER-HK-AP Pacific Supernet Limited – Hong Kong SAR (4)

9 – AS9950

AS: 9950 PUBNETPLUS2-AS-KR DACOM - Korea (1)

10 – AS17832

AS: 17832 SIXNGIX-AS-KR National Computeriztion Agency - Korea (1)
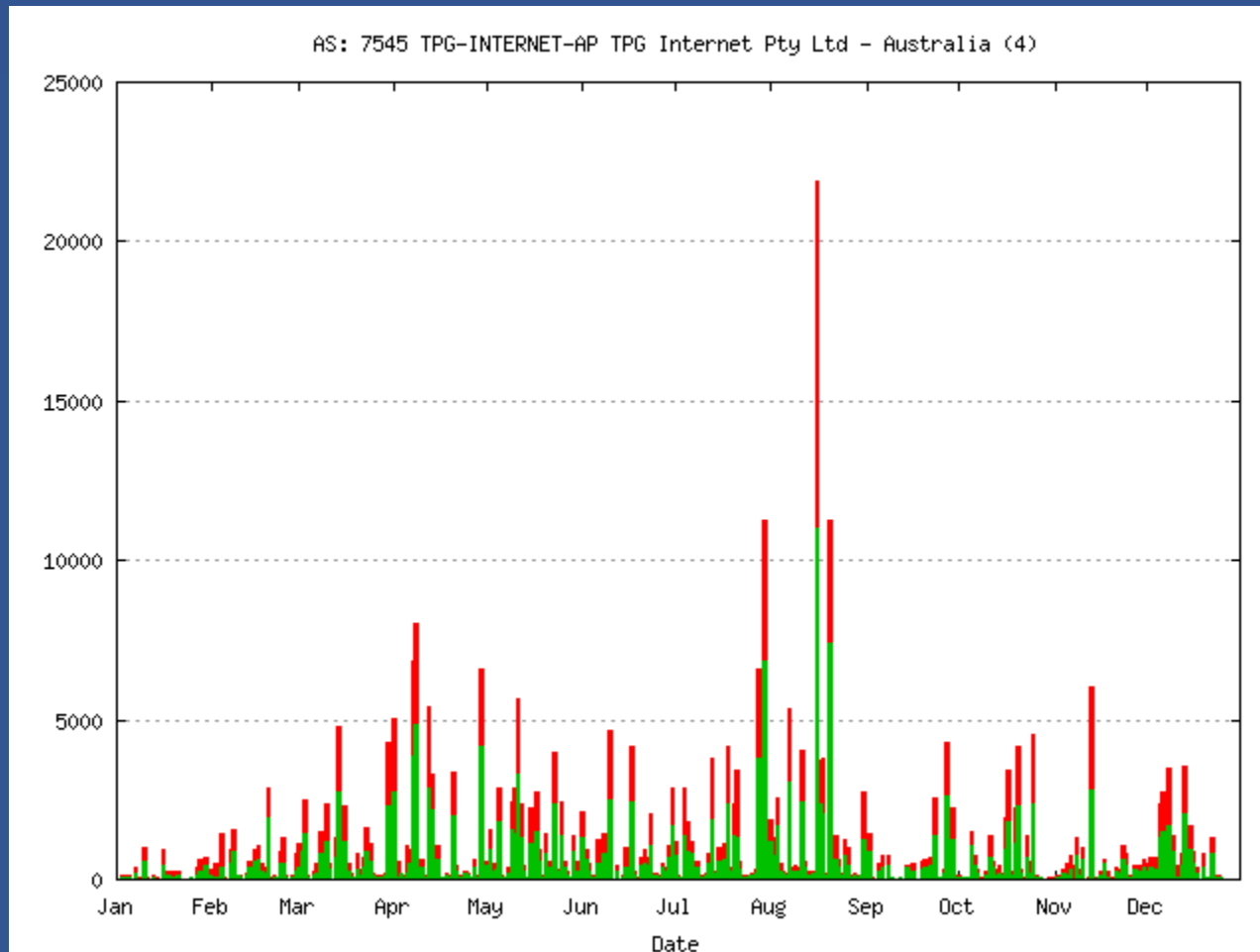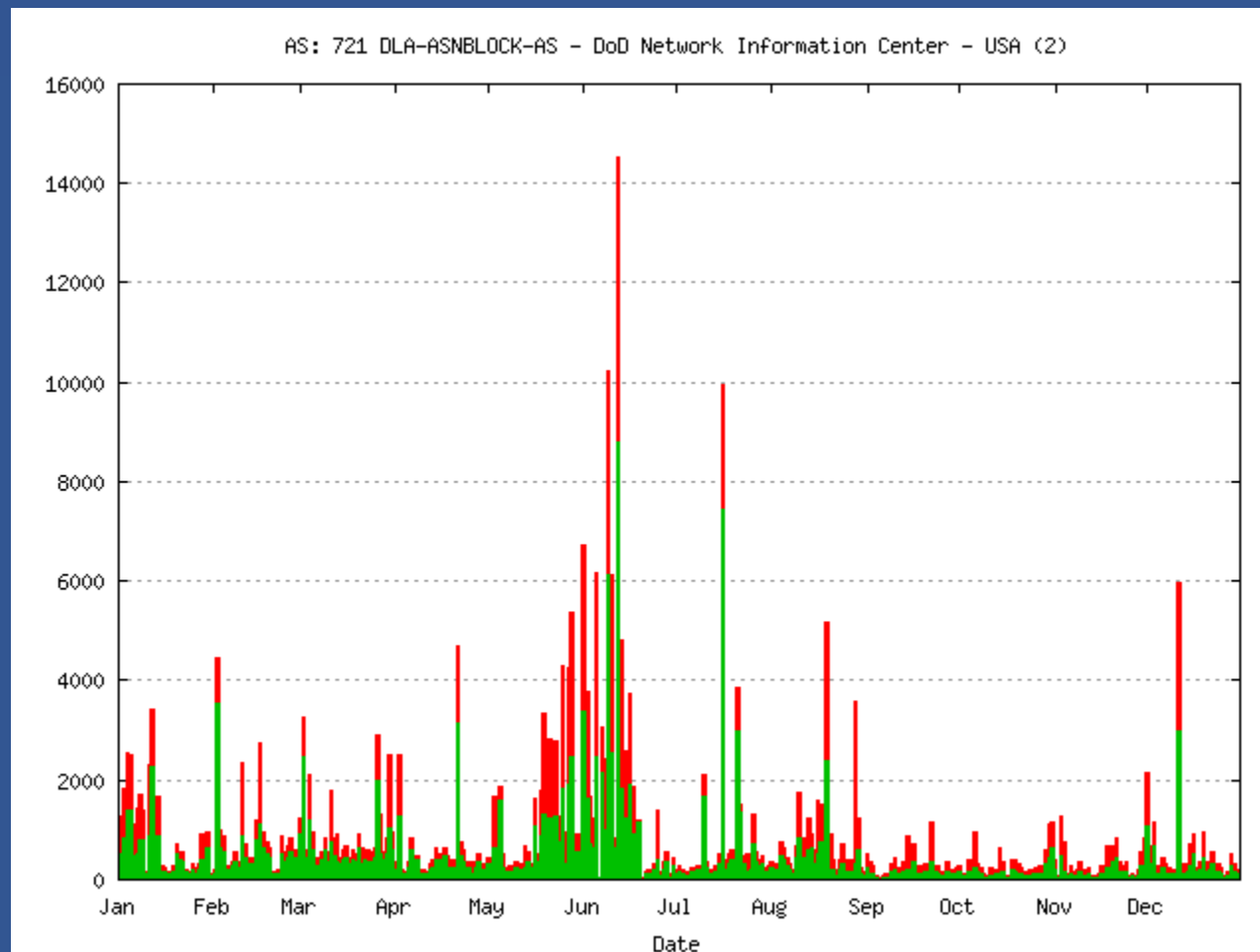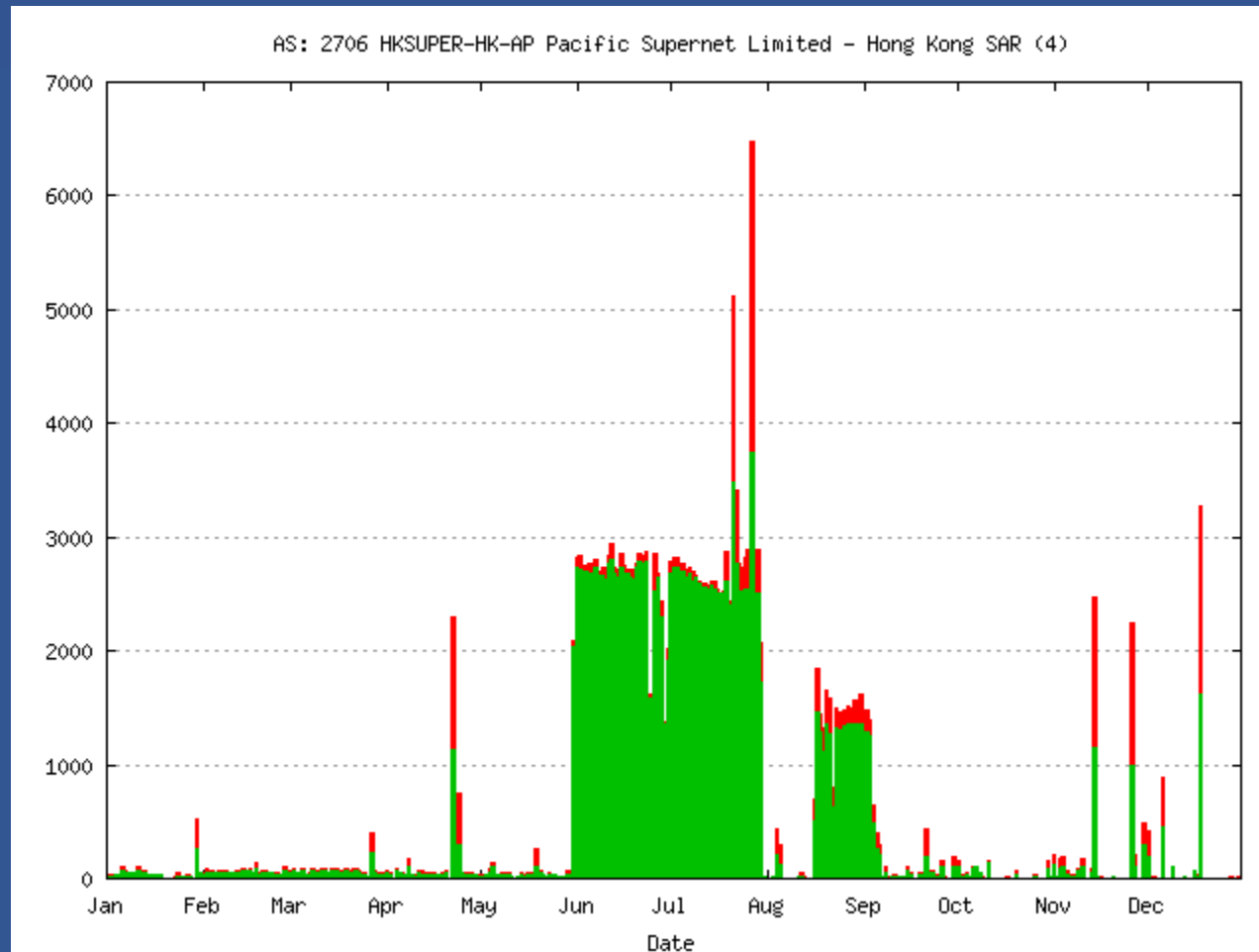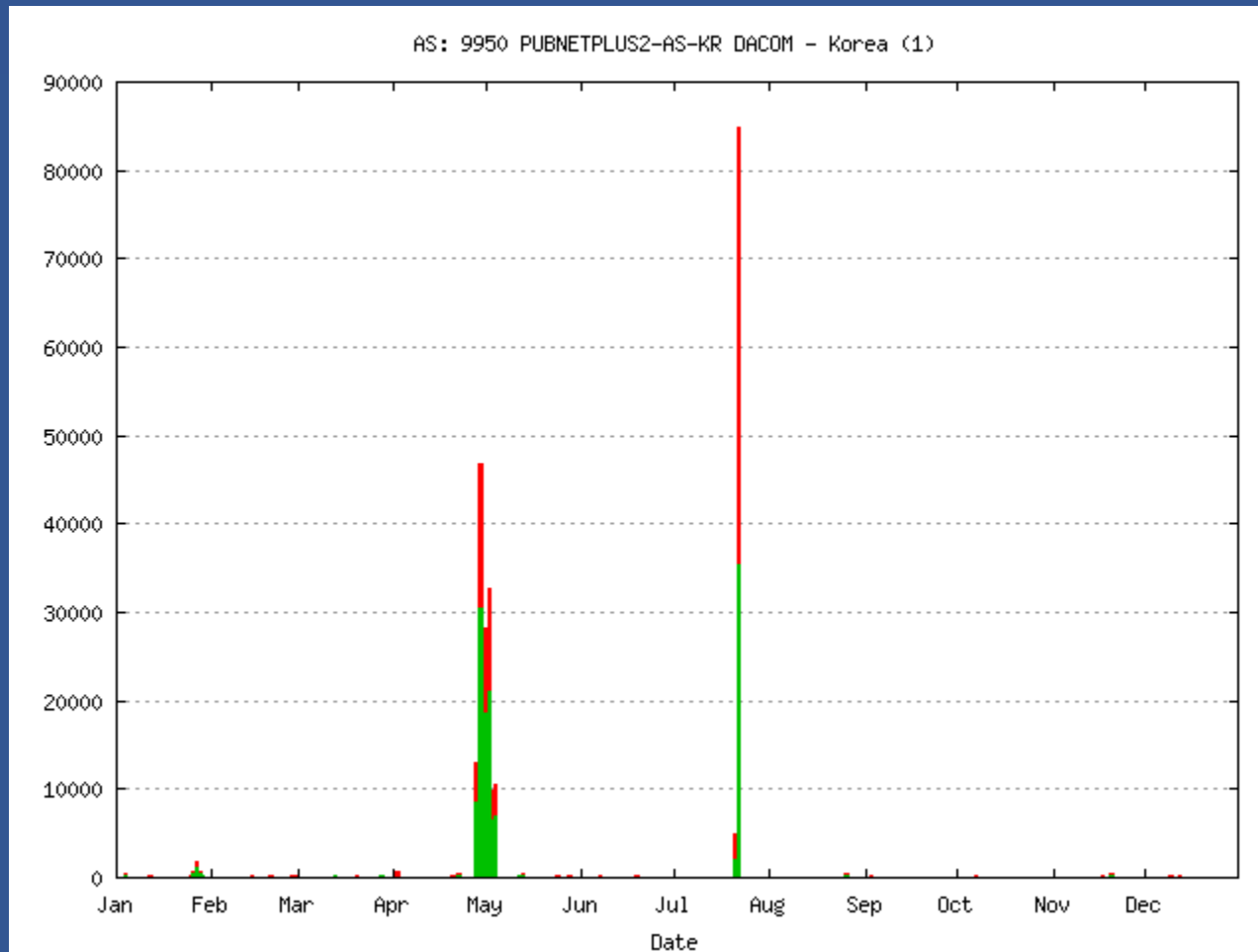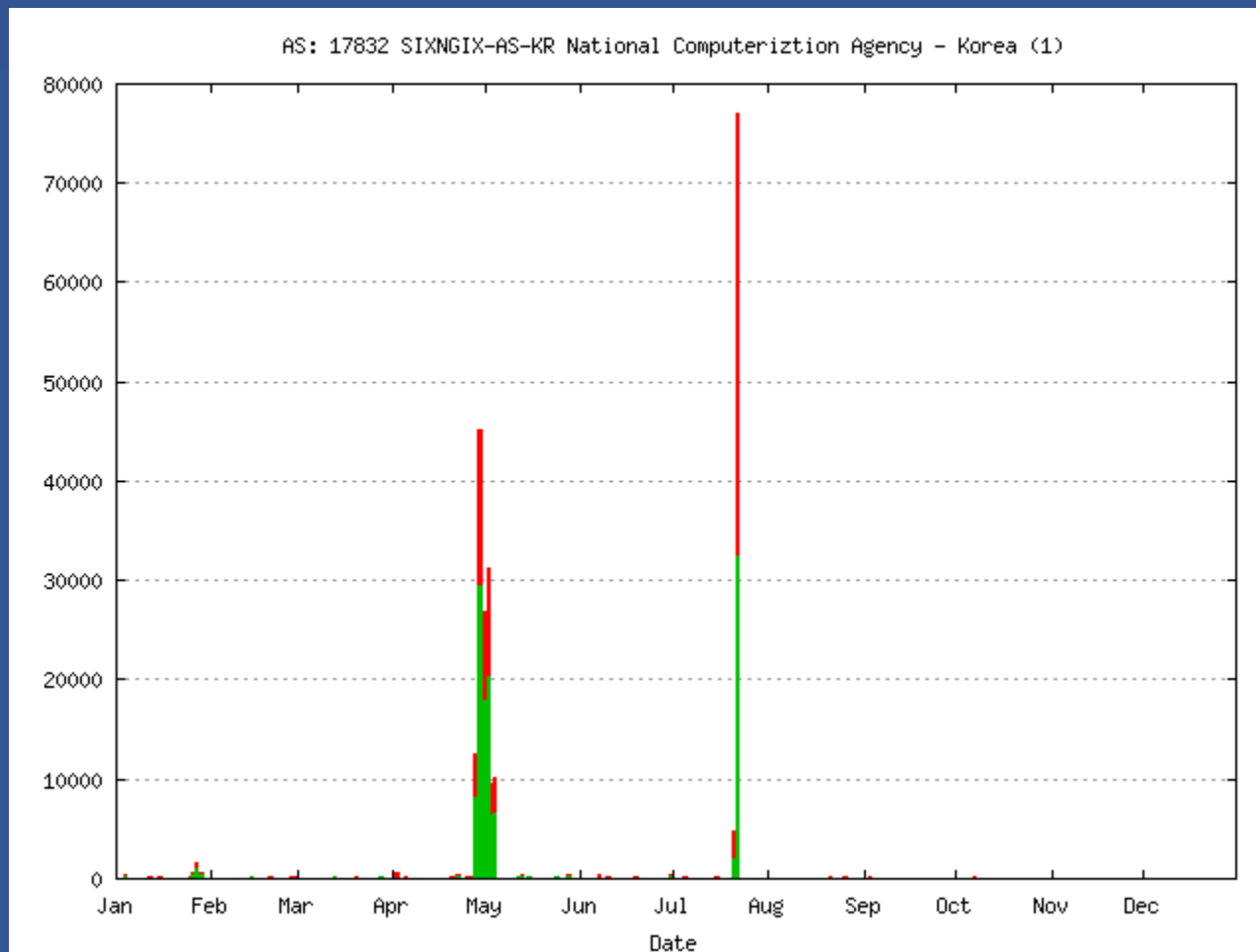
So what's going on?

- It would appear that the BGP update rate is being strongly biased by a small number of origins with two forms of behaviour:
  - Traffic Engineering - consistent update rates sustained over weeks / months with a strong component of first hop change and persistent announce and withdrawal of more specifics
  - Unstable configuration states – a configuration which cannot stabilise and for a period of hours or days the update rate is extremely intense

The Uncertainty Factor

- Given that the overwhelming majority of updates are being generated by a very small number of sources, the level of uncertainty in extrapolation of trend models of BGP update rates is extremely high
- This implies that the predictions of router capabilities in a 3 – 5 year interval is also extremely uncertain

APNIC

Thank You