The Lockdown Effect: Implications of the COVID-19 Pandemic on Internet Traffic

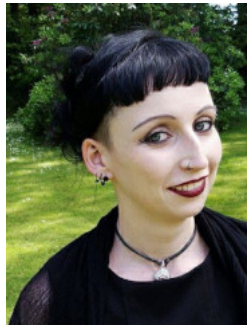
Narseo Vallina-Rodriguez (IMDEA Networks) and **Juan Tapiador** (UC3M)

Jornadas REDIMadrid 2020 | 20 Oct 2020

Lots of data, lots of data crunchers

Anja Feldmann
MPII

Oliver Gasser
MPII



Franziska Lichtblau
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Enric Pujol
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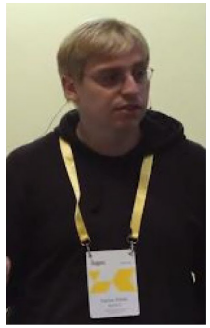

Ingmar Poese
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COVID-19 and the Internet

COVID-19 and the Internet

euronews.

Coronavirus: Half of humanity now on lockdown as 90 countries call for confinement

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The Internet is essential in all these efforts, but how well does it cope?

Goals of this presentation

- Understand the impact of the COVID-19 pandemic on different networks

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- Present our results from a diverse set of vantage points

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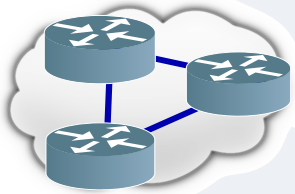
- Understand the impact of the COVID-19 pandemic on different networks
- Present our results from a diverse set of vantage points
- Highlight how a change in user demand affects traffic dynamics

Vantage points

3 IXPs

IXP Central Europe
IXP Southern Europe
IXP US East Coast



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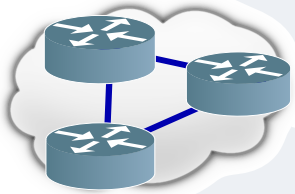

Interconnecting networks

IXPs: Central Europe, Southern Europe, US East Coast

- Central Europe: 900+ members, 8+ Tbps peak traffic
- Southern Europe: 170+ members, 500+ Gbps peak traffic
- US East Coast: 250+ members, 600+ Gbps peak traffic
- IPFIX flows collected at the public peering platforms

Data has been analyzed strictly on premise and results are aggregated.

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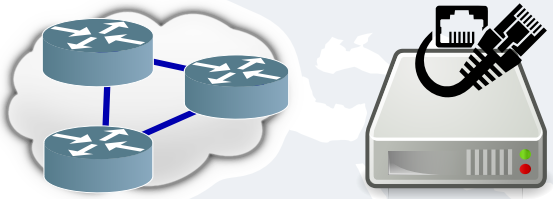
Interconnecting networks



ISP

Central Europe

3 IXPs

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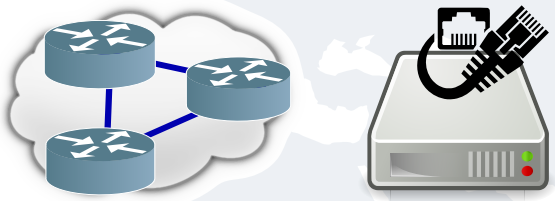
Interconnecting networks



ISP

Central Europe

Residential customers working from home

Large European ISP

- Services ∼15M fixed line subscribers + Tier 1 transit network
- No hosted CDN caches, but a diverse peering infrastructure
- Subscriber view: Netflow captured at the Border Network Gateways (BNGs)
- AS level view: Netflow collected at the border routers

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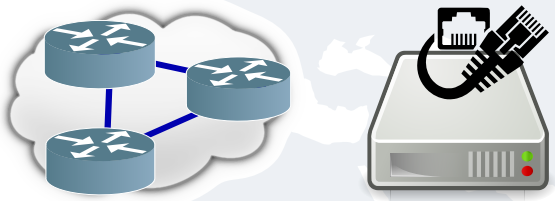
Interconnecting networks



EDU

Madrid region

ISP

Central Europe

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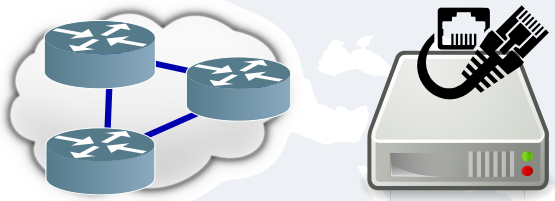

ISP

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EDU

Madrid region

Service network interconnecting universities and research institutions

REDIMadrid university network

- Academic network interconnecting 16 universities and research centers (Madrid region)
- Serves ∼290K users (including WiFi access, student halls, etc)
- NetFlow captured at the border routers

The network operators provided anonymized flow data.

Analyzing the pandemic across time

Our analysis is based on **four weeks** representing the course of the pandemic from **February 2020** to **June 2020**.

Analyzing the pandemic across time

base: February before the lockdown

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Analyzing the pandemic across time

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April: First relaxation of restrictions

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	ISP-CE	IXP-CE	IXP-SE	IXP-US	EDU
base	Feb 20–26	Feb 20–26	Feb 20–26	Feb 20–26	Feb 20–26
March	Mar 19–25	Mar 19–25	Mar 12–18	Mar 19–25	Mar 12–18
April	Apr 09–15	Apr 23–29	Apr 23–29	Apr 23–29	Apr 23–29
June	Jun 18–24	Jun 18–24	Jun 18–24	Jun 18–24	n/a

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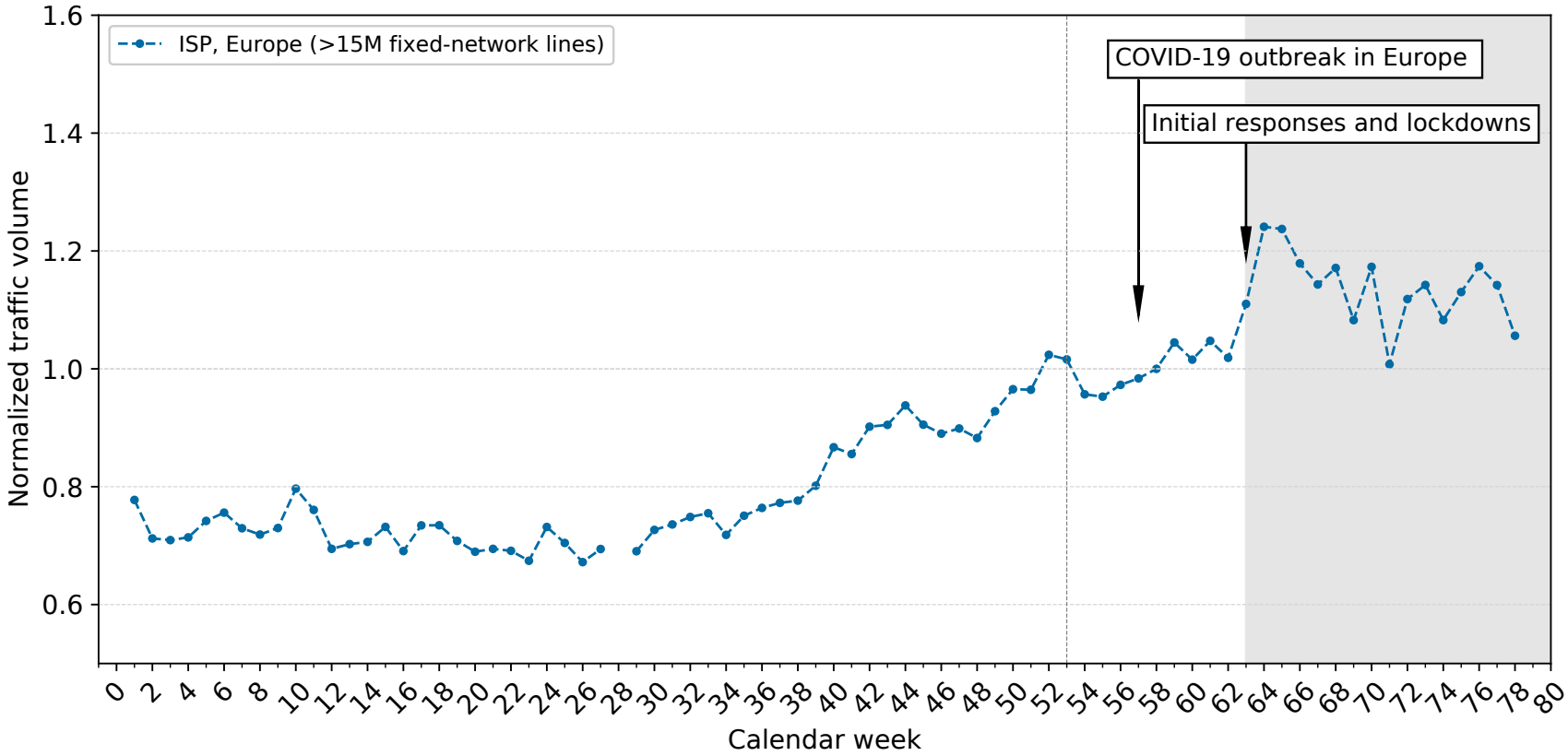
Traffic changes in different networks

Traffic changes January 2019 to June 2020



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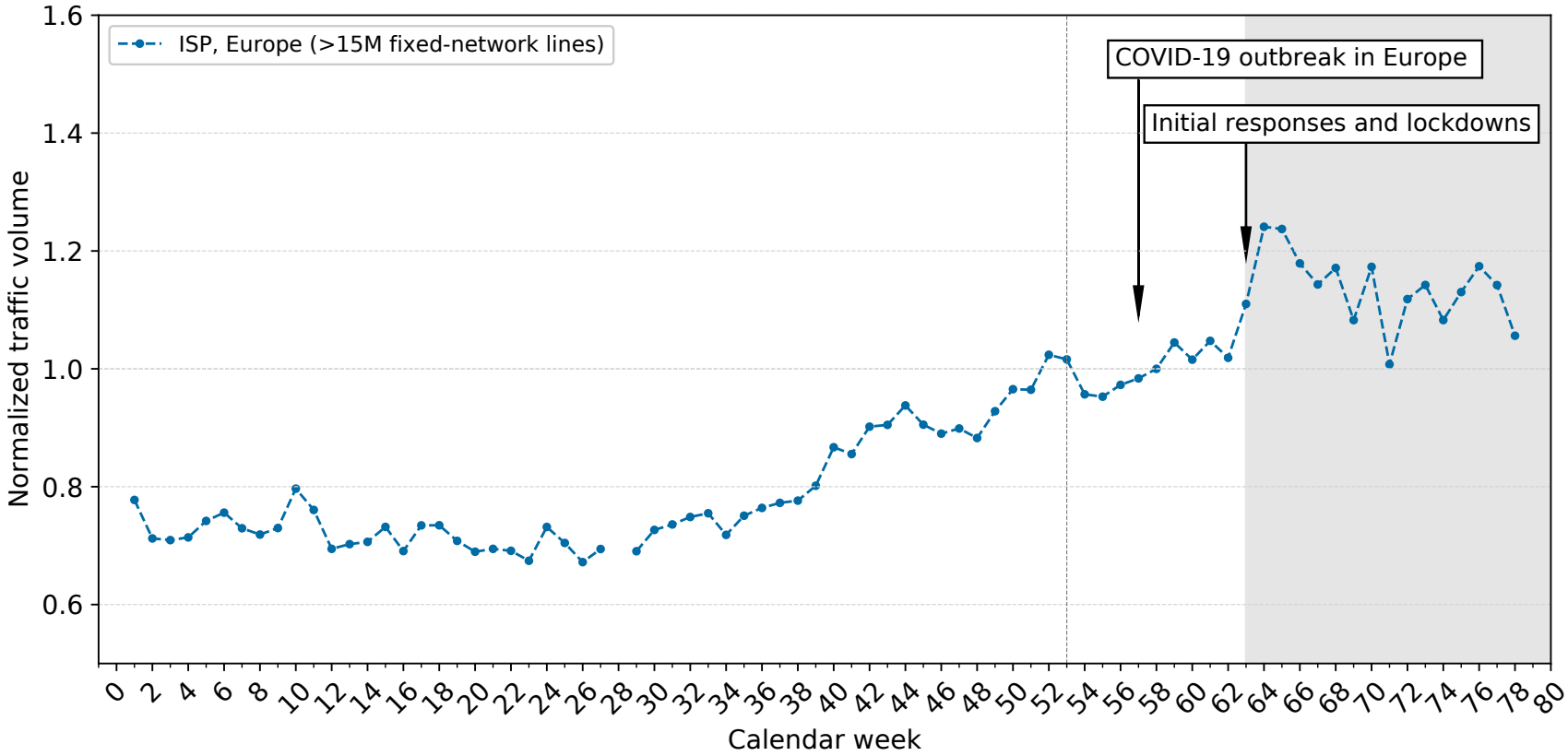

Once the lockdown started the ISP saw an increase in traffic which normally spans over multiple months.

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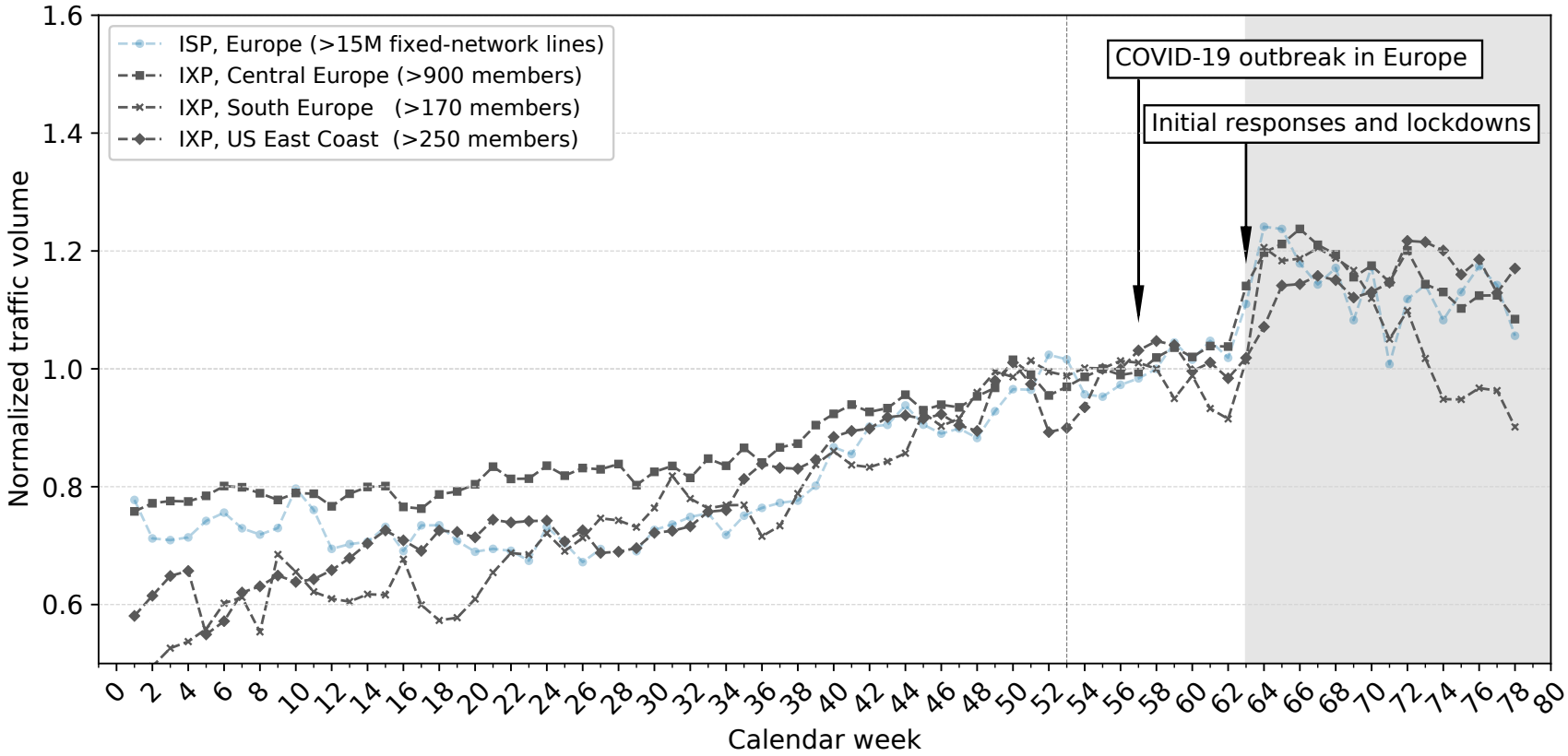

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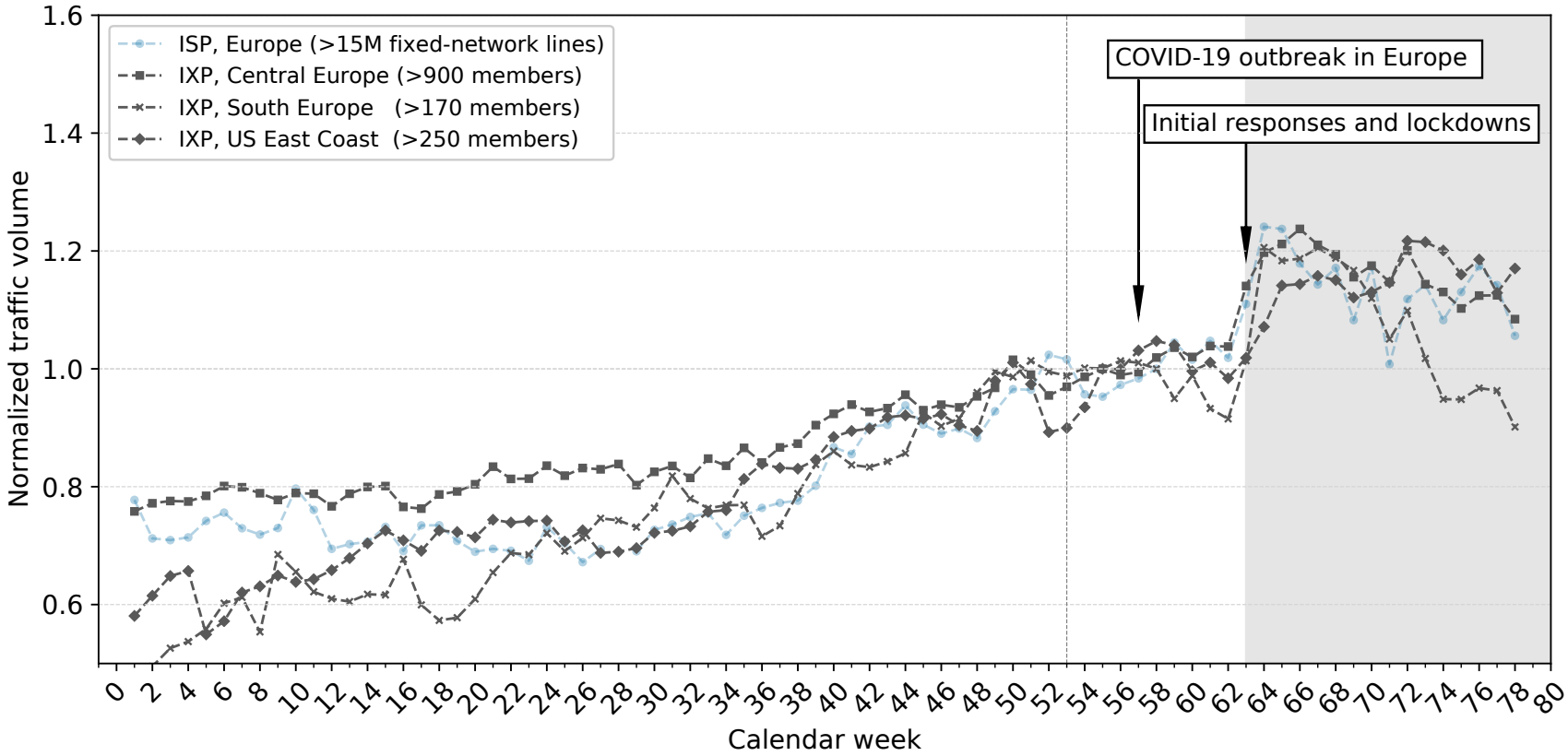
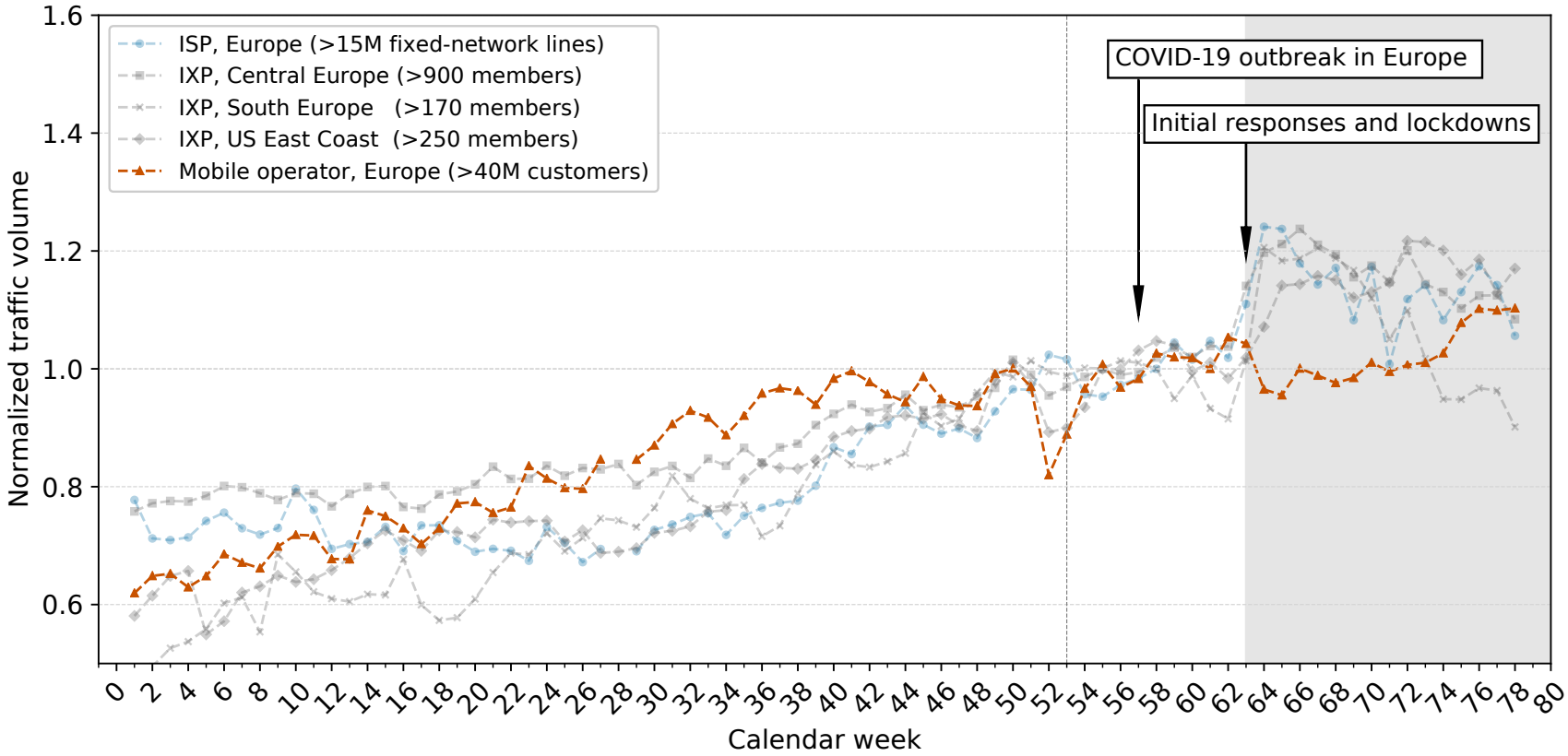


Similar behaviour for the IXPs; for the IXP CE and IXP US the traffic levels keep elevated.

Traffic changes January 2019 to June 2020



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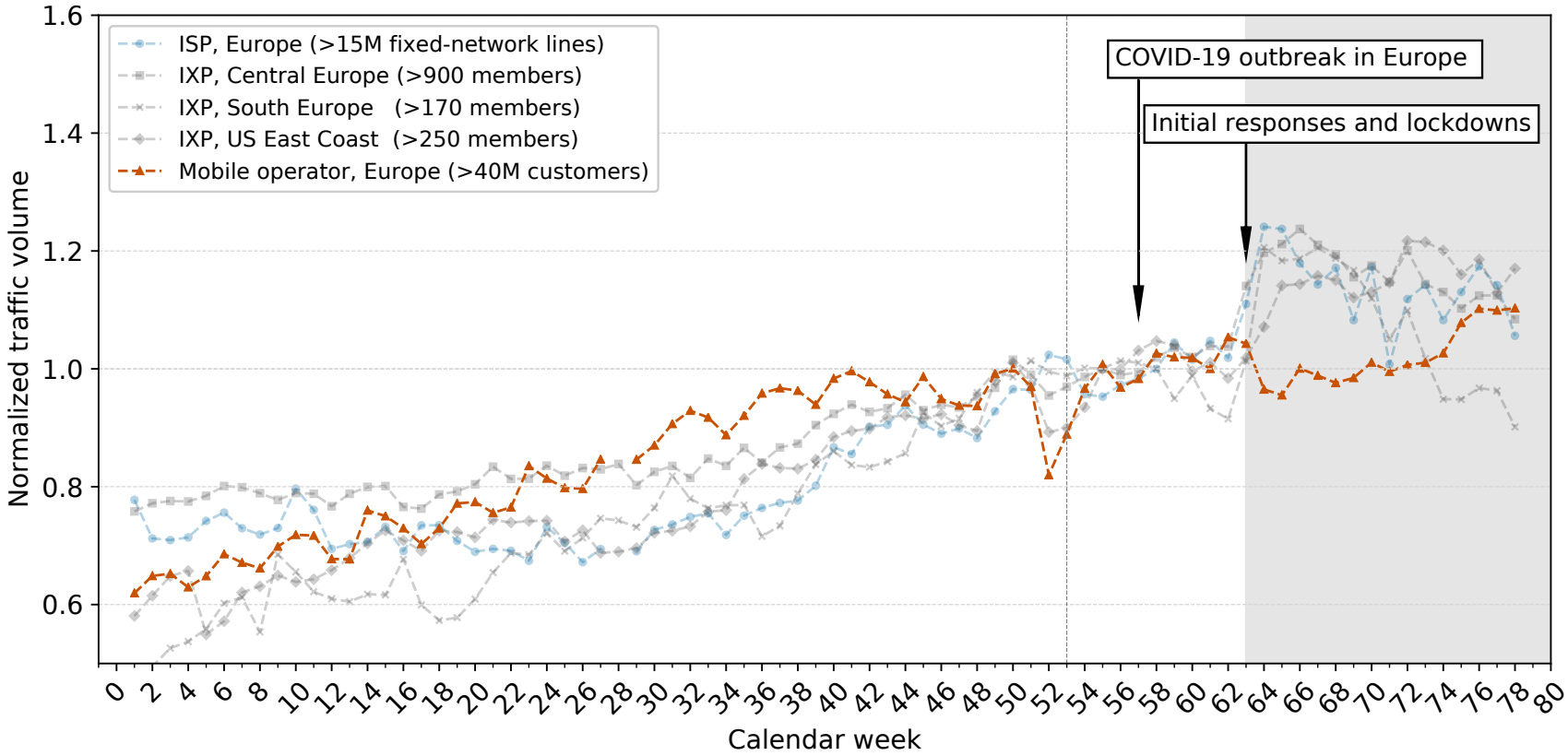
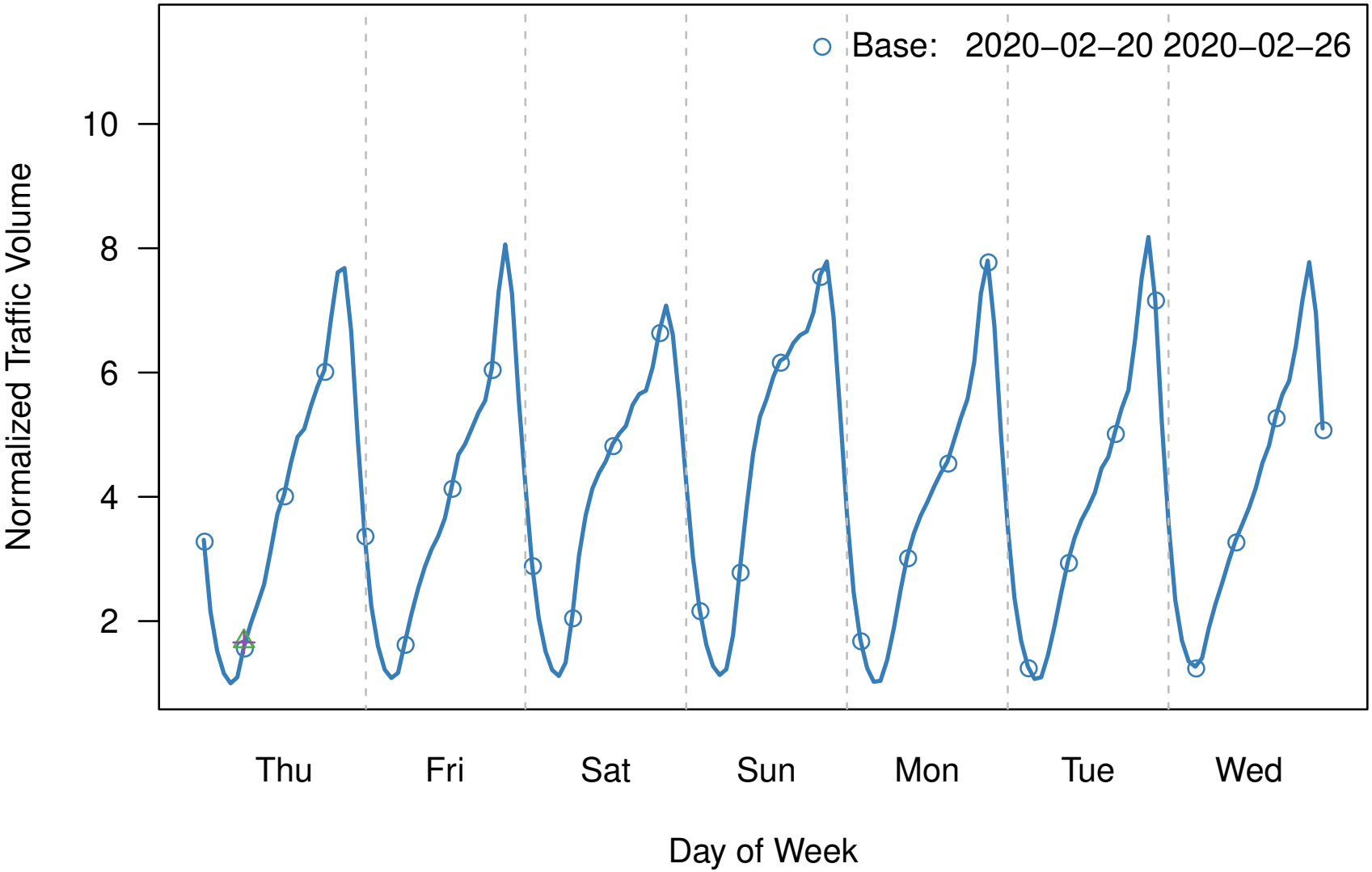


Once the lockdown started mobile traffic decreased measurably and increases with the first relaxations in mid April.

Traffic volumes before and after the lockdown



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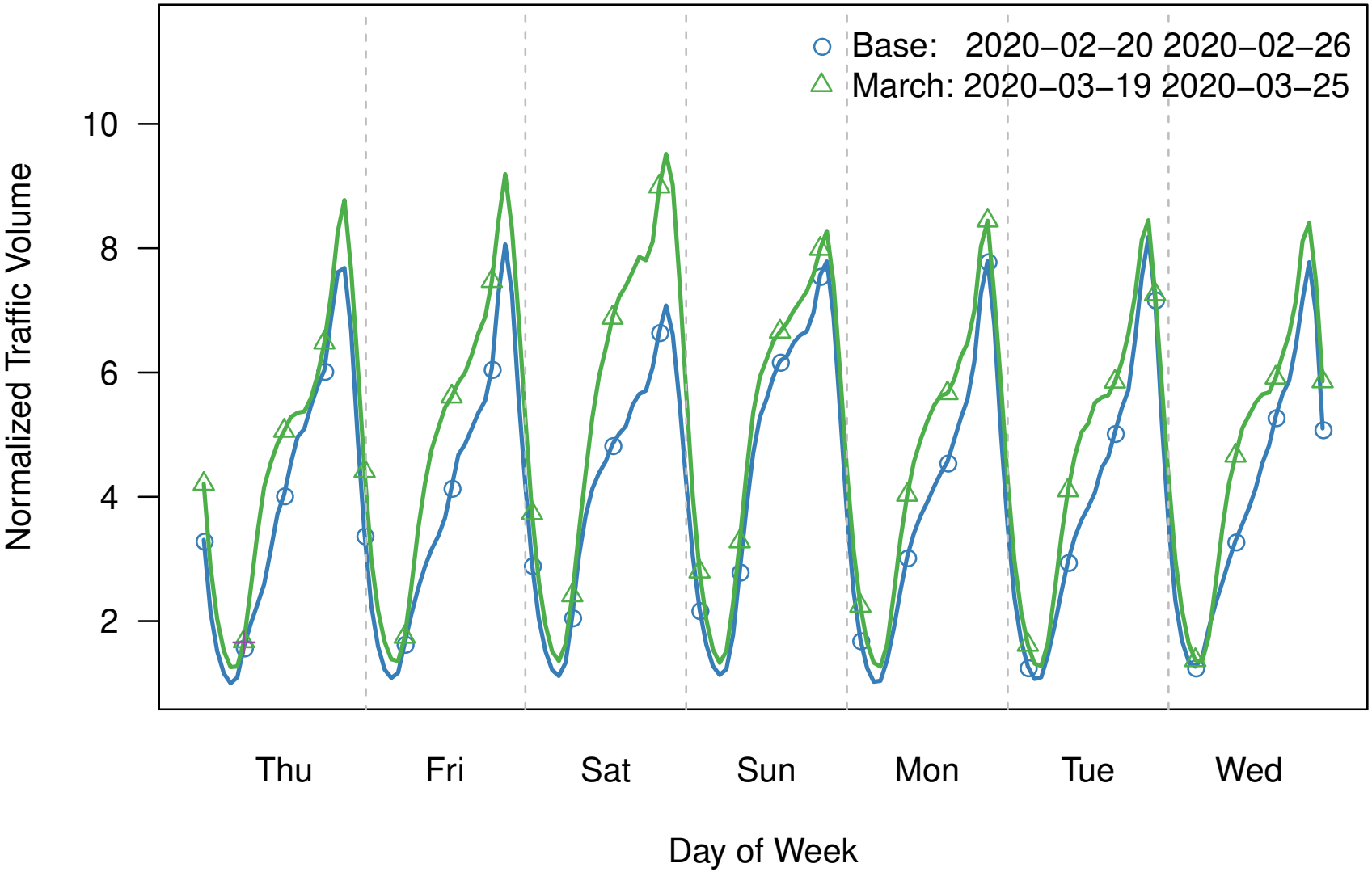

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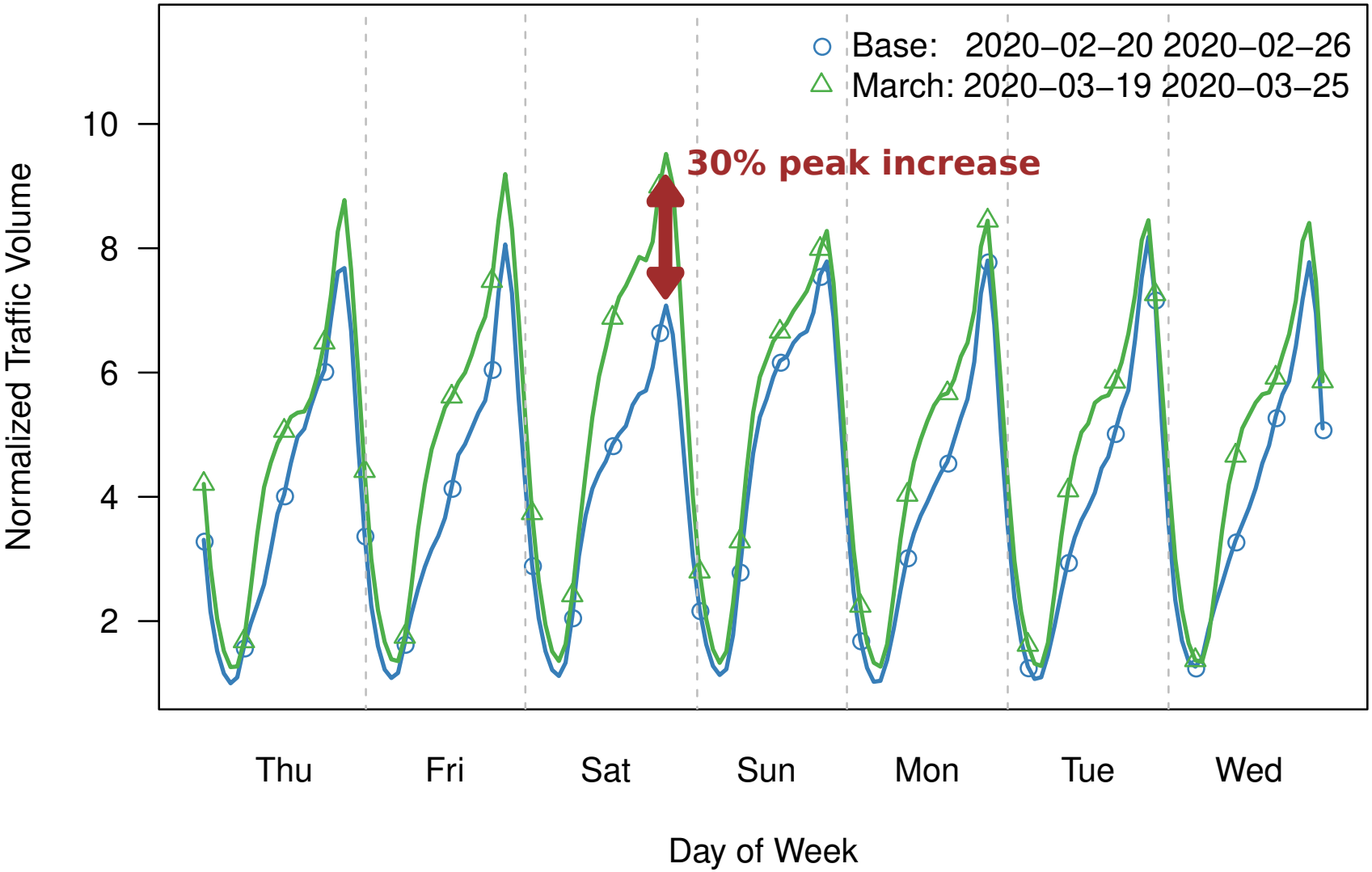

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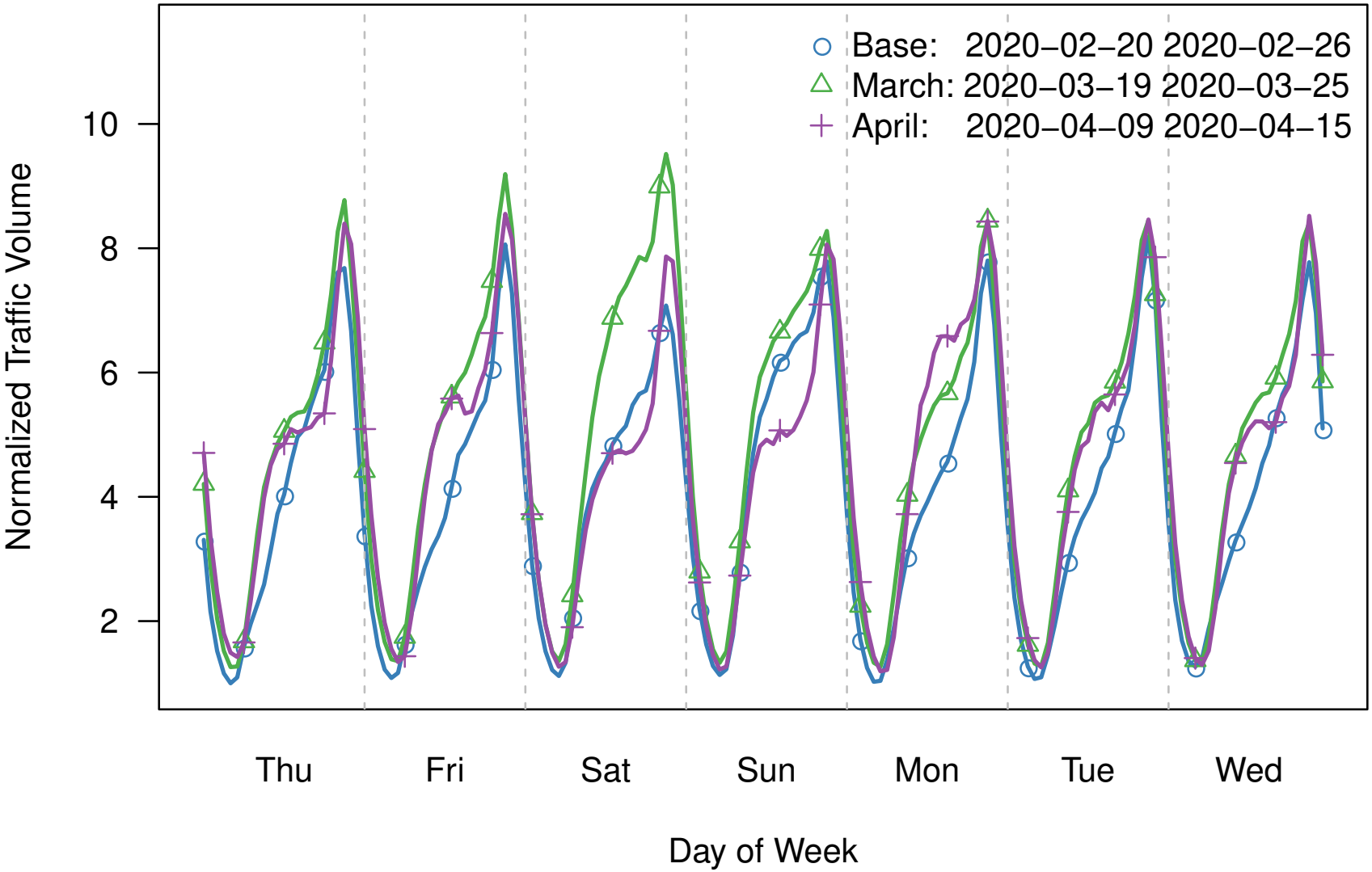

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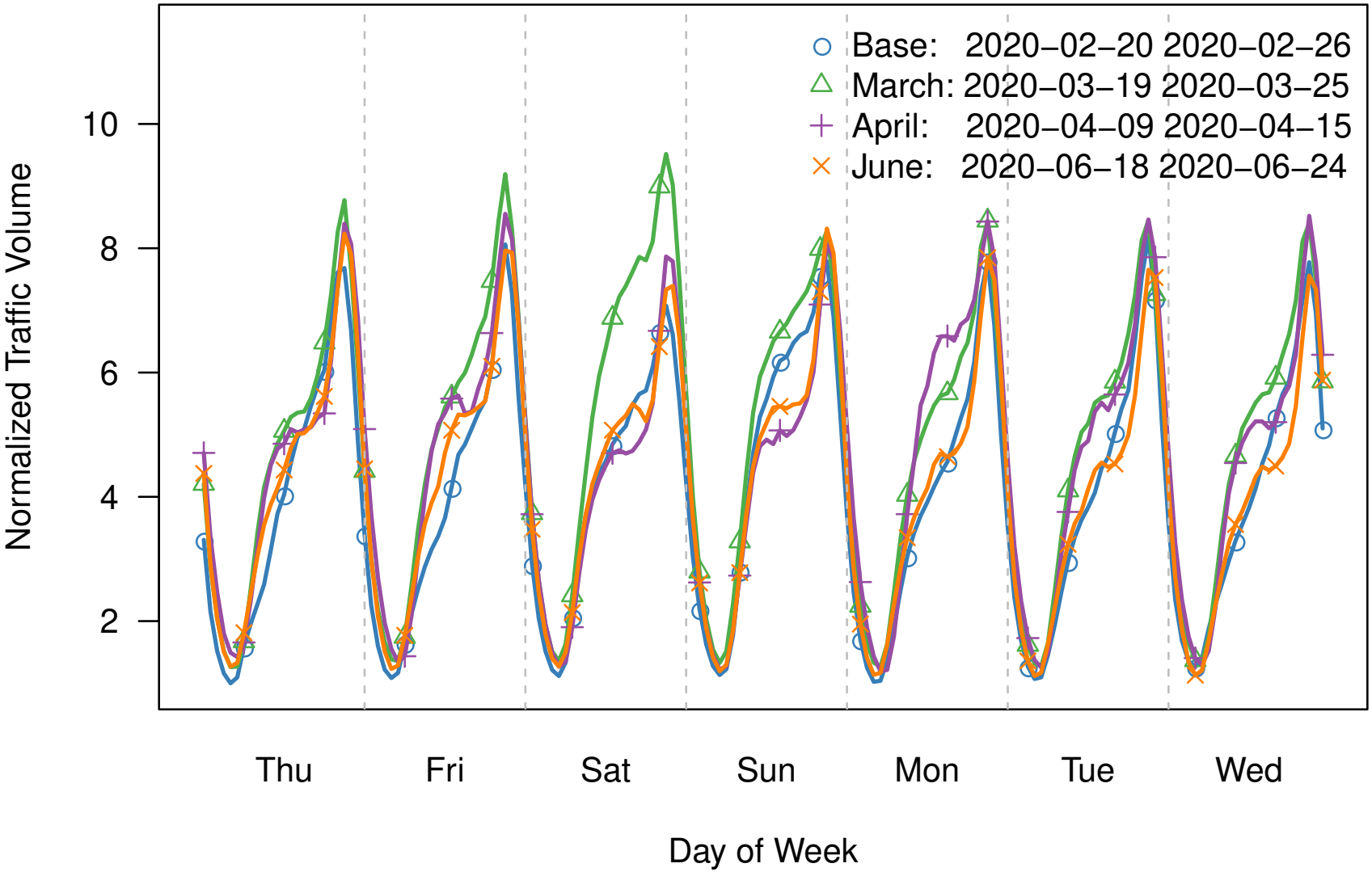
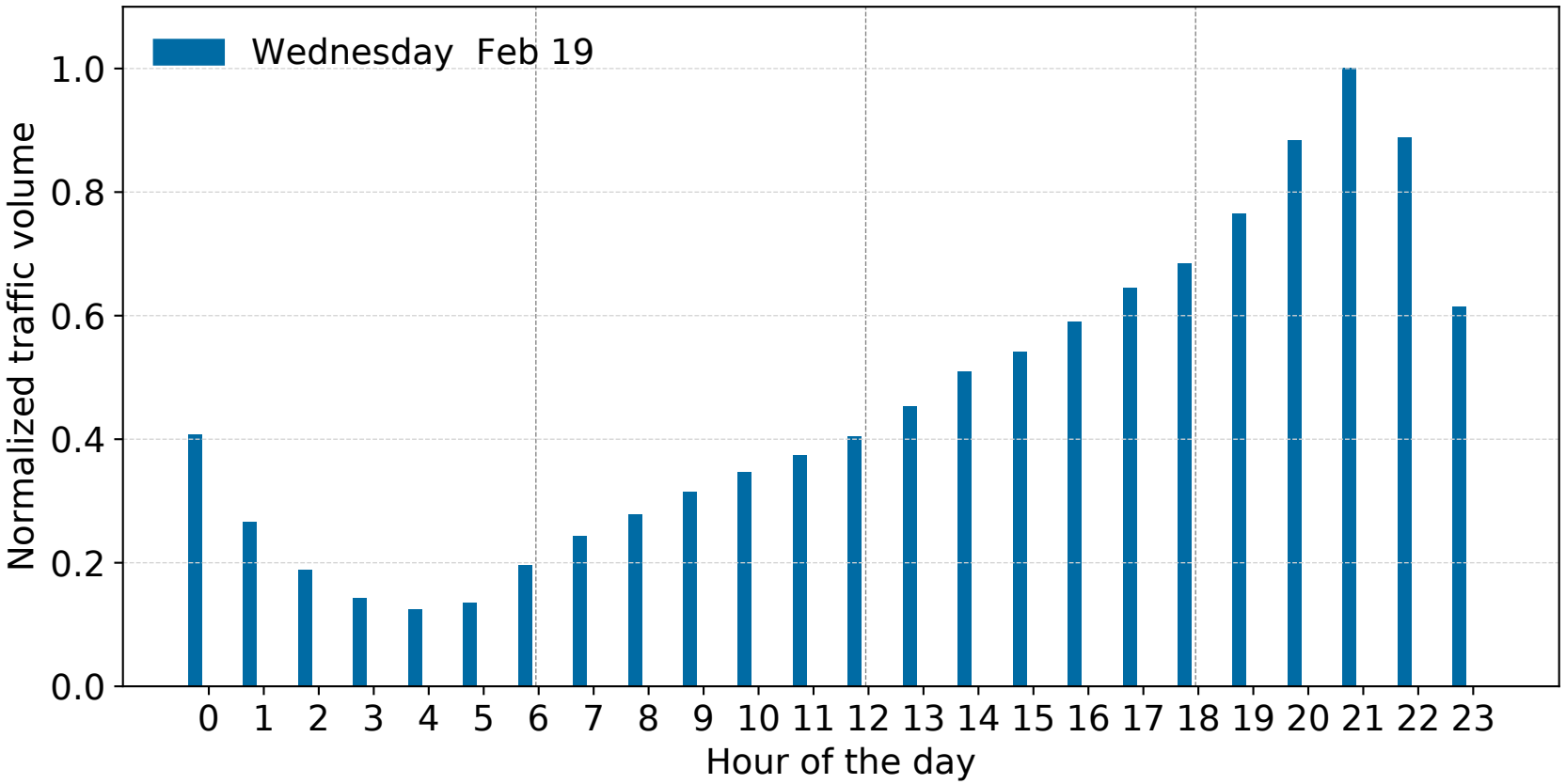


Lockdown: Change in workday vs. weekend pattern (ISP)



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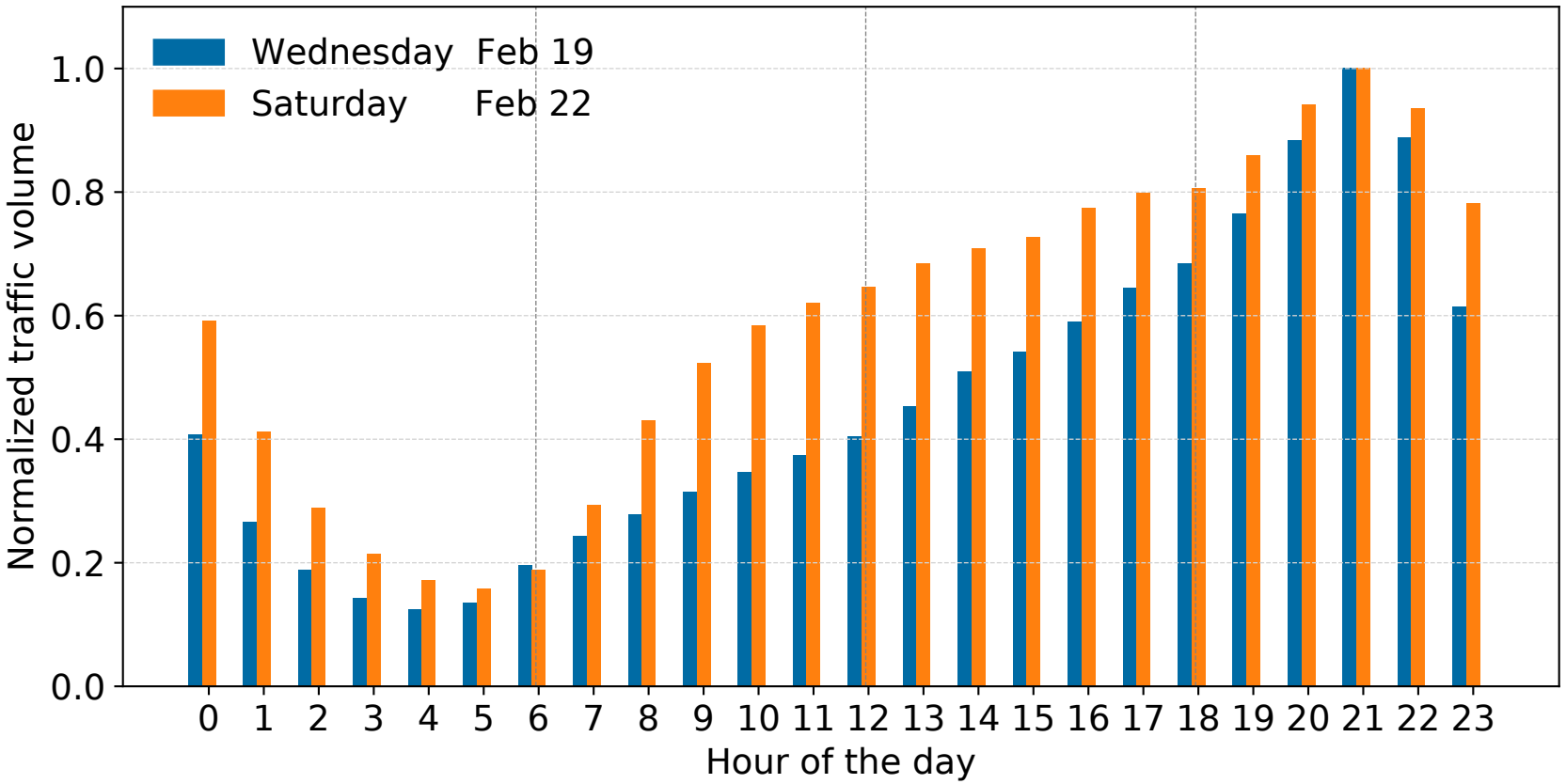

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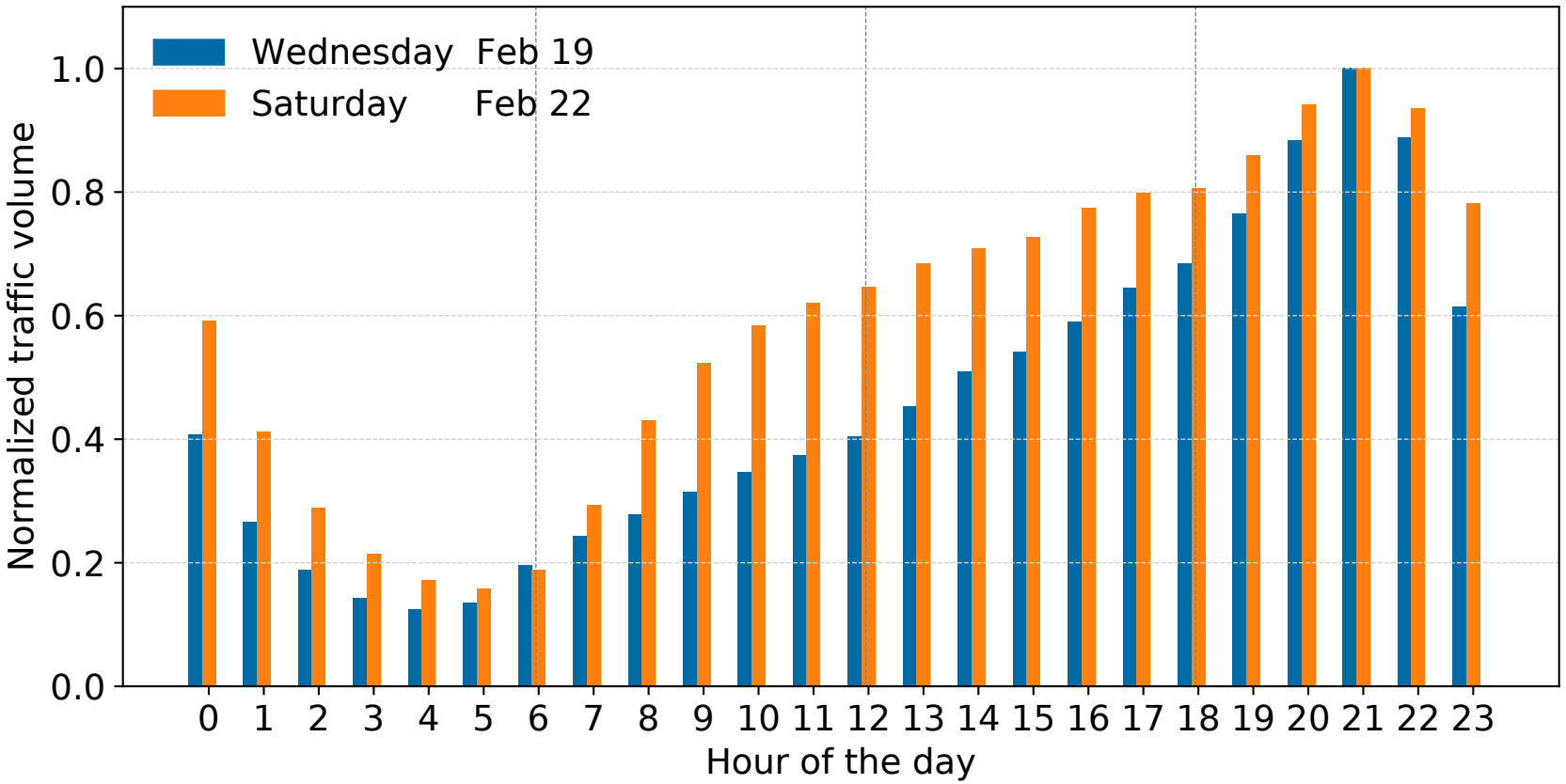
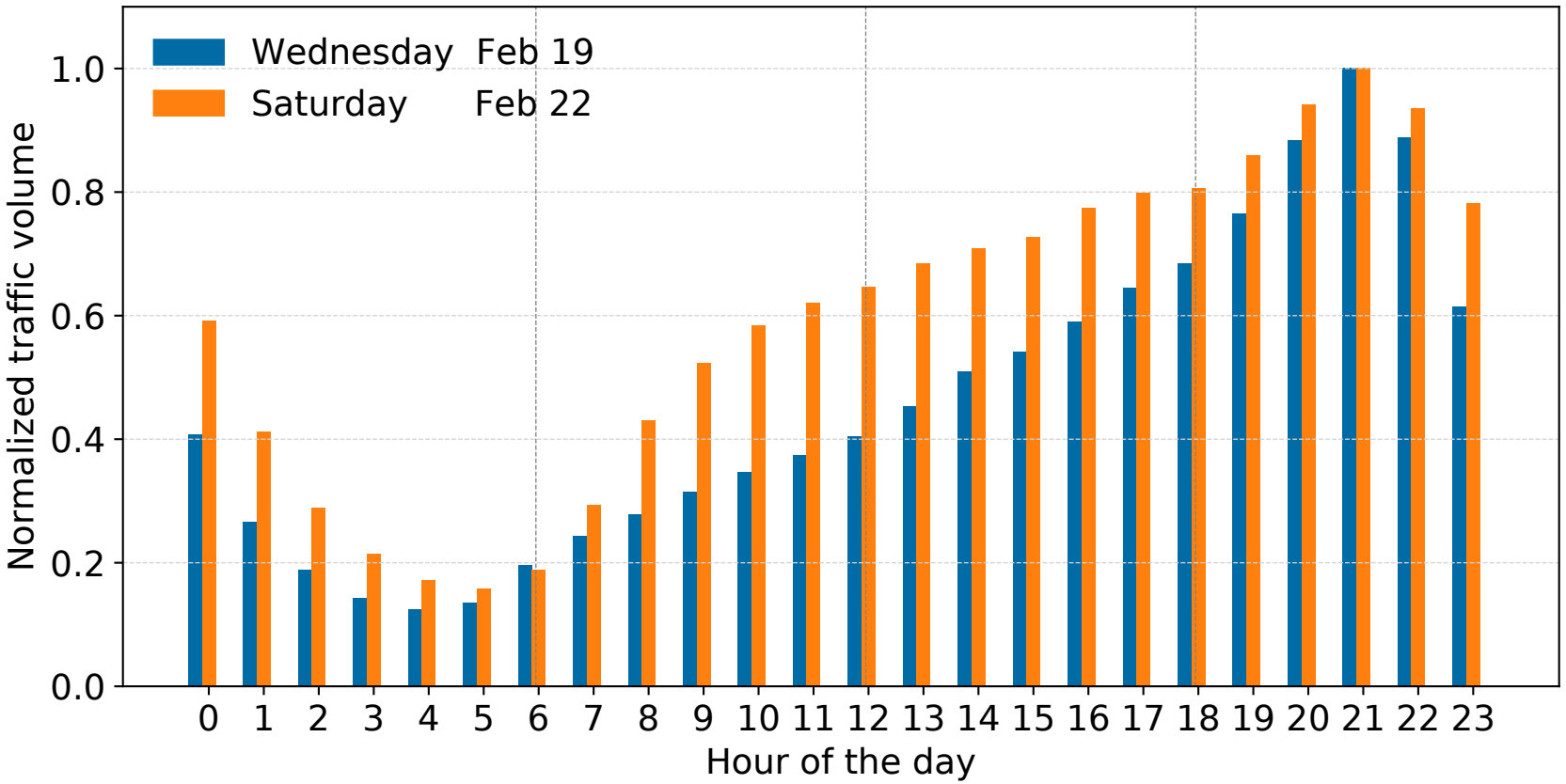


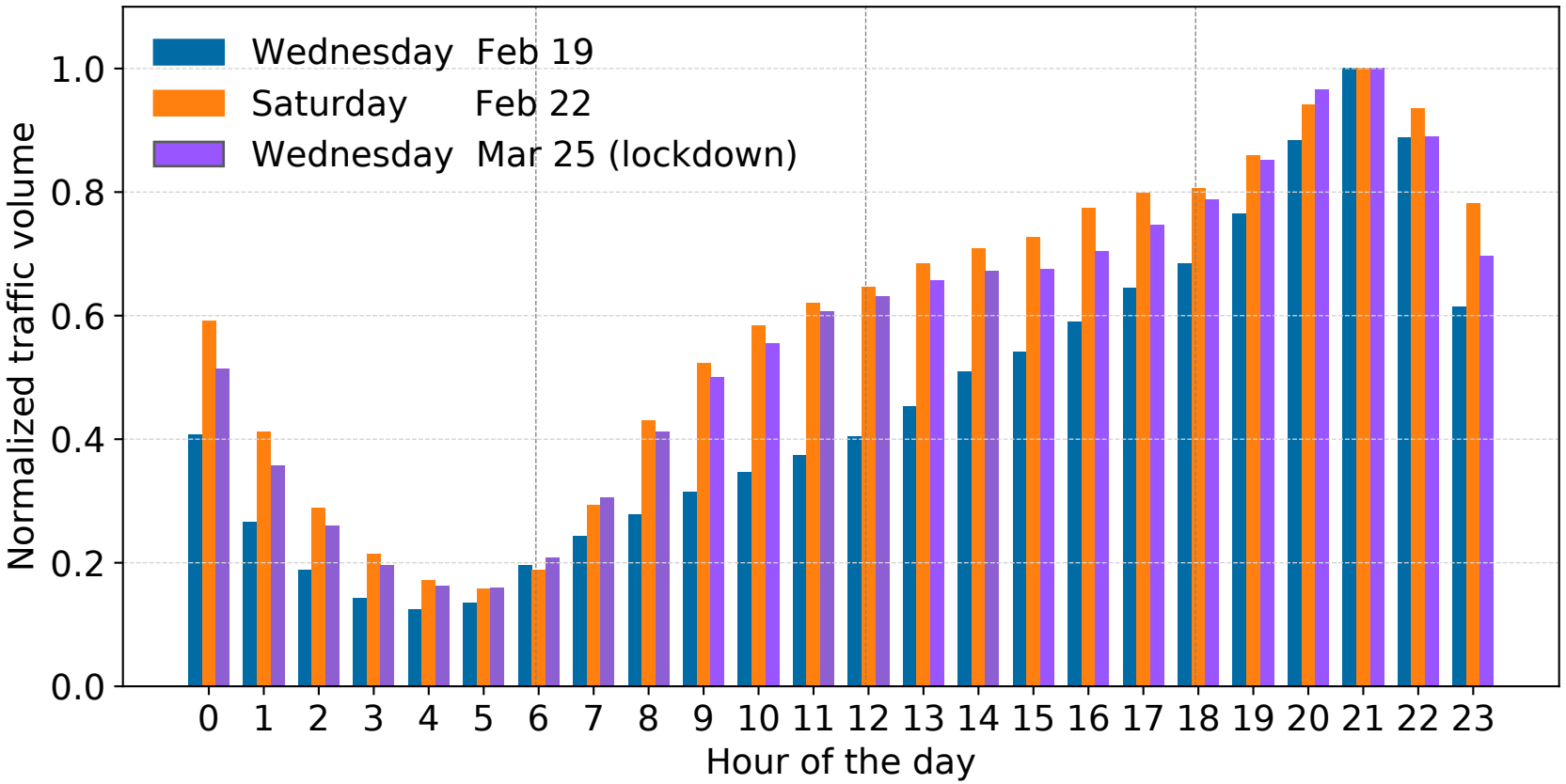
- Regular patterns

Lockdown: Change in workday vs. weekend pattern (ISP)



- Regular patterns
  - Workday: Strong increase in evening hours
  - Weekend: More traffic during daytime

Lockdown: Change in workday vs. weekend pattern (ISP)



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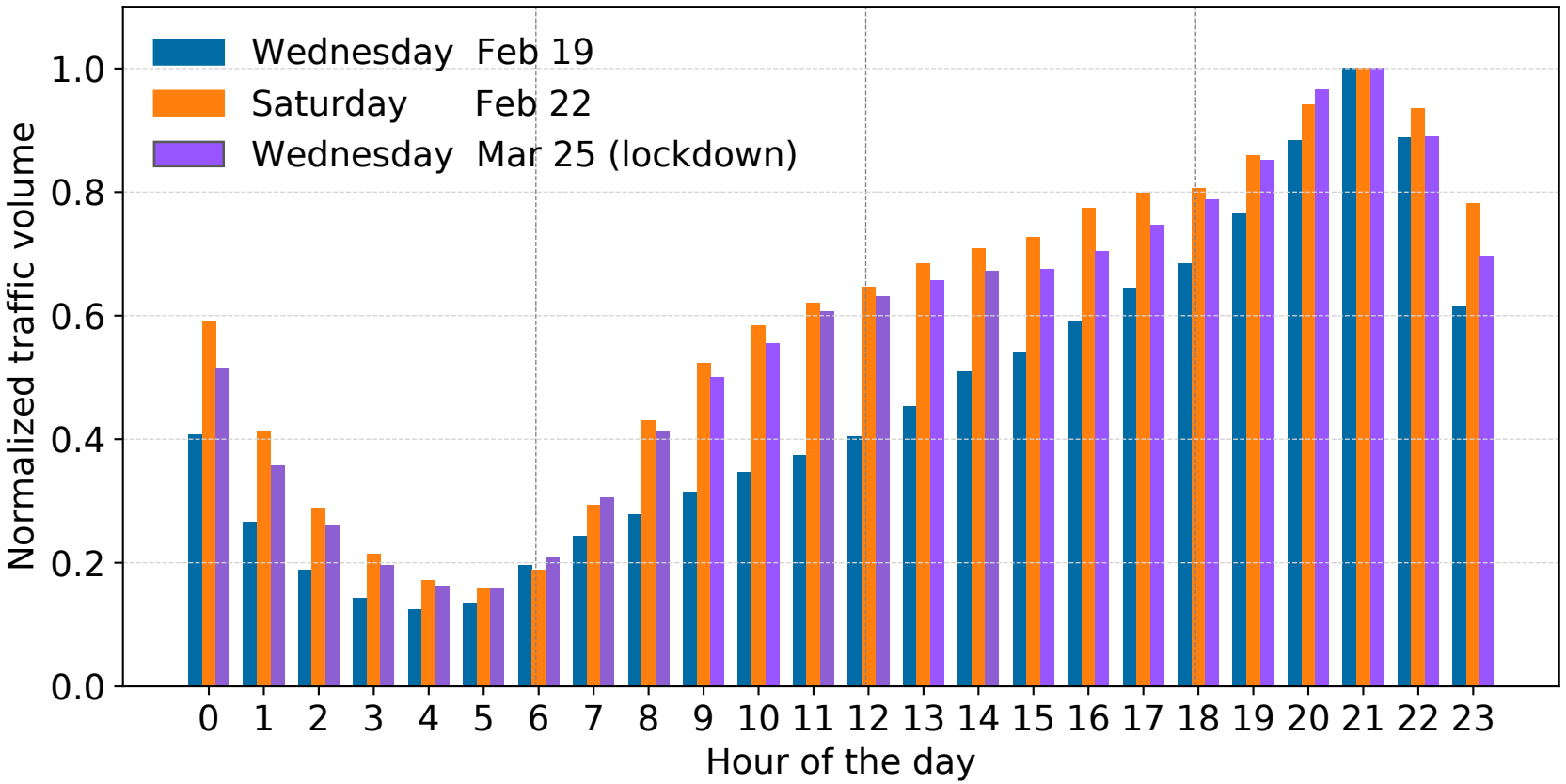
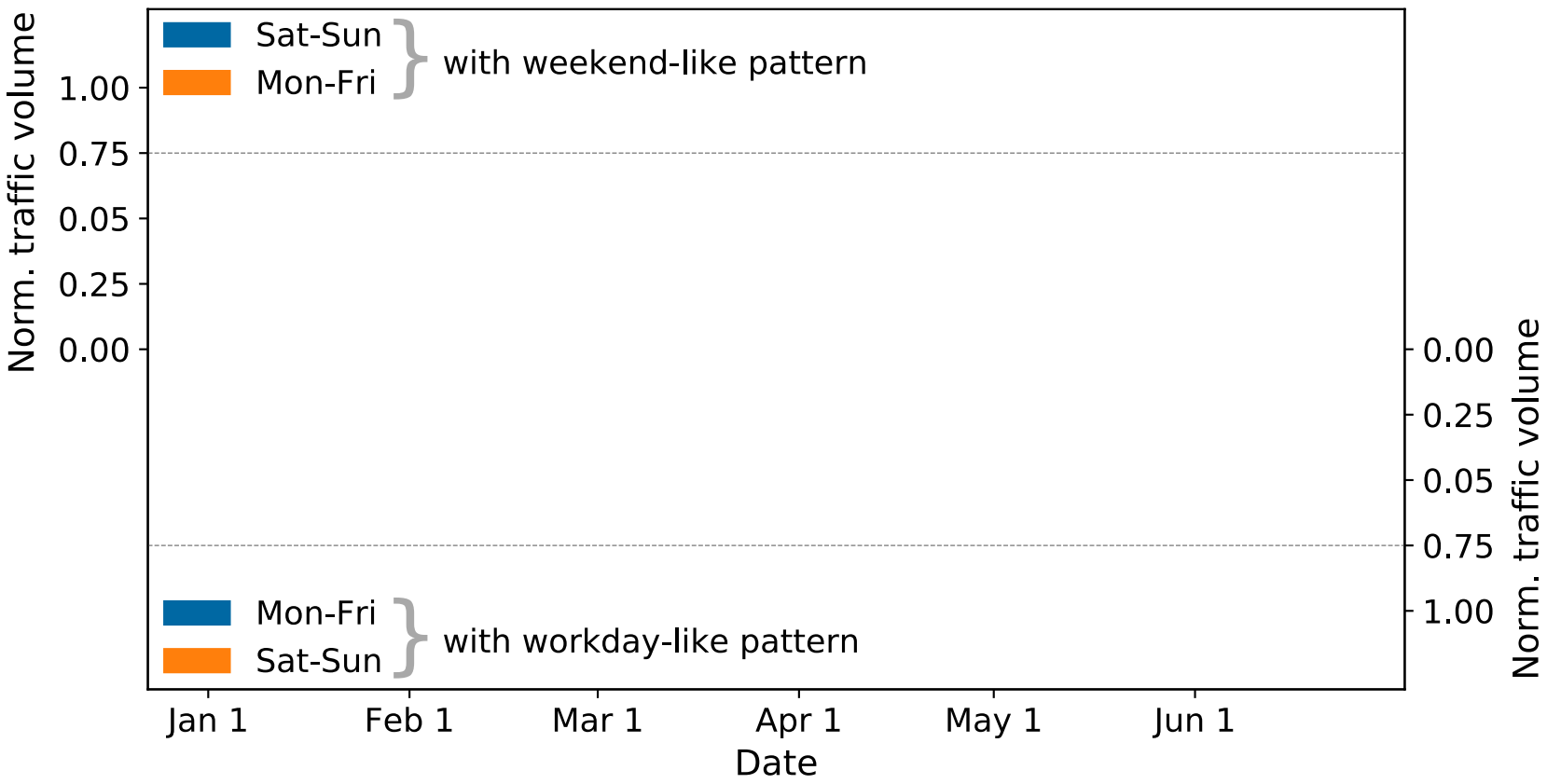


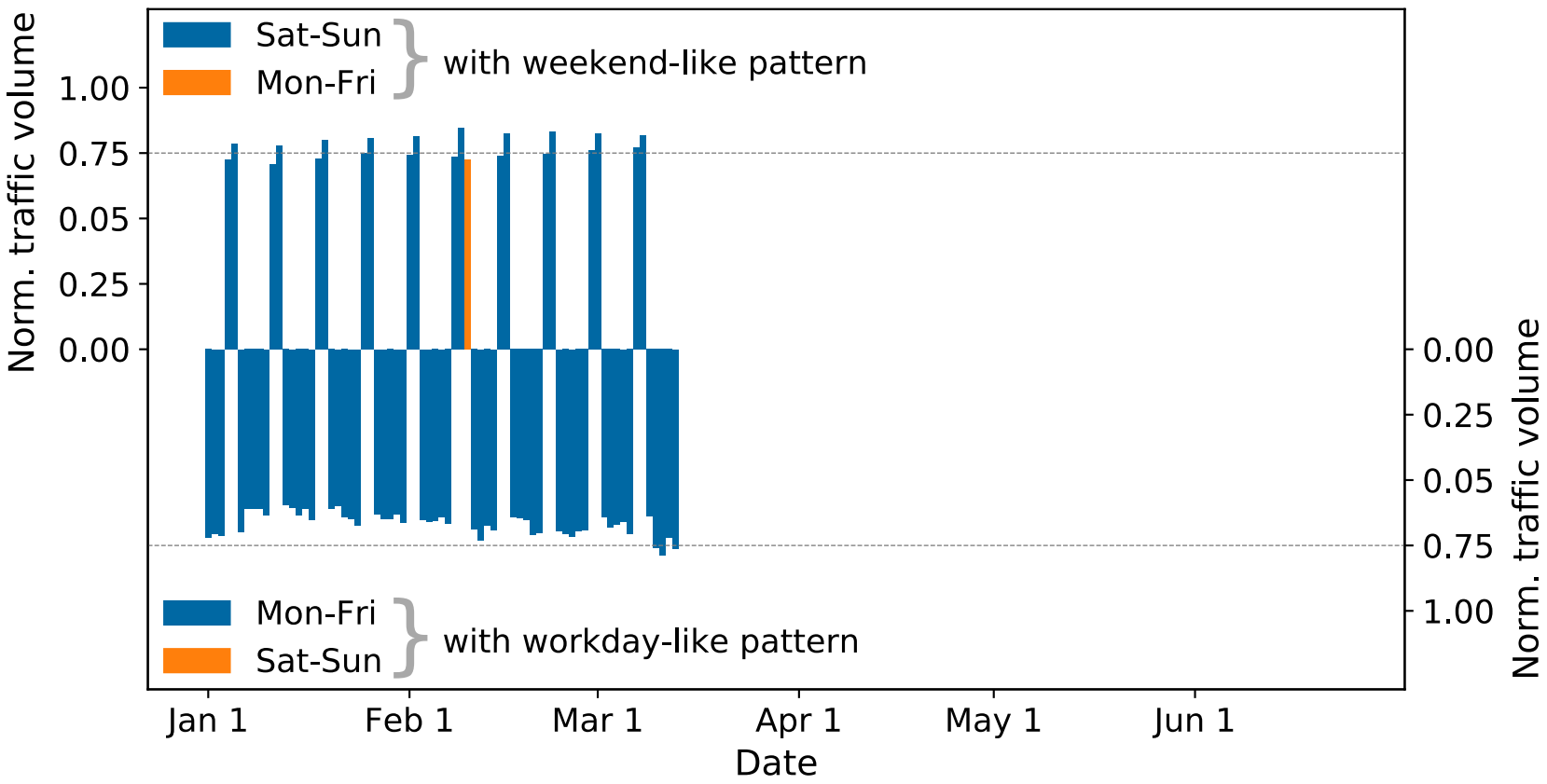
- Regular patterns
  - Workday: Strong increase in evening hours
  - Weekend: More traffic during daytime
- During pandemic: Workdays look more like weekends

Changes in workday vs. weekday patterns at the ISP



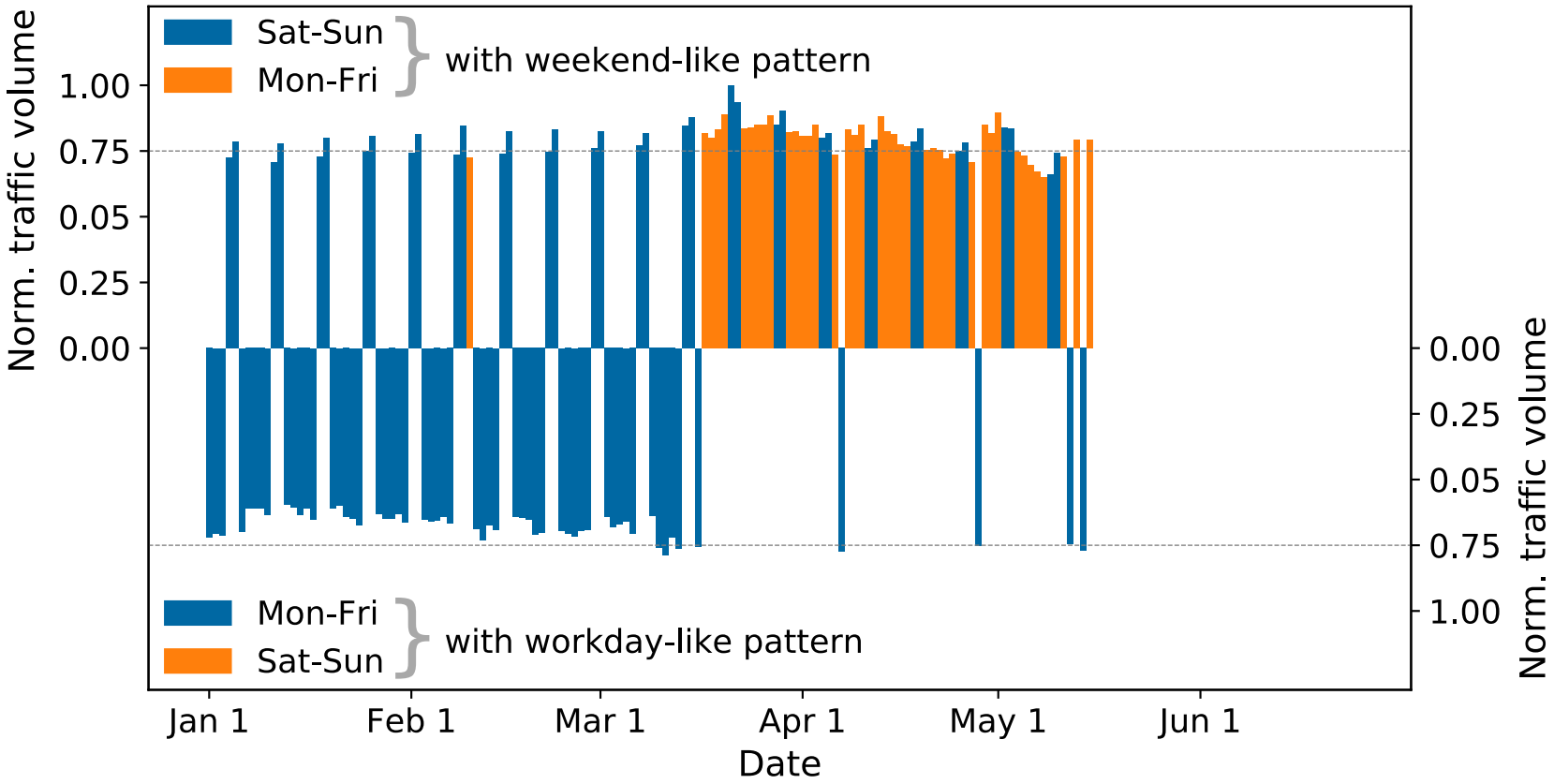
- Classify days into workdays or weekends using traffic patterns

Changes in workday vs. weekday patterns at the ISP



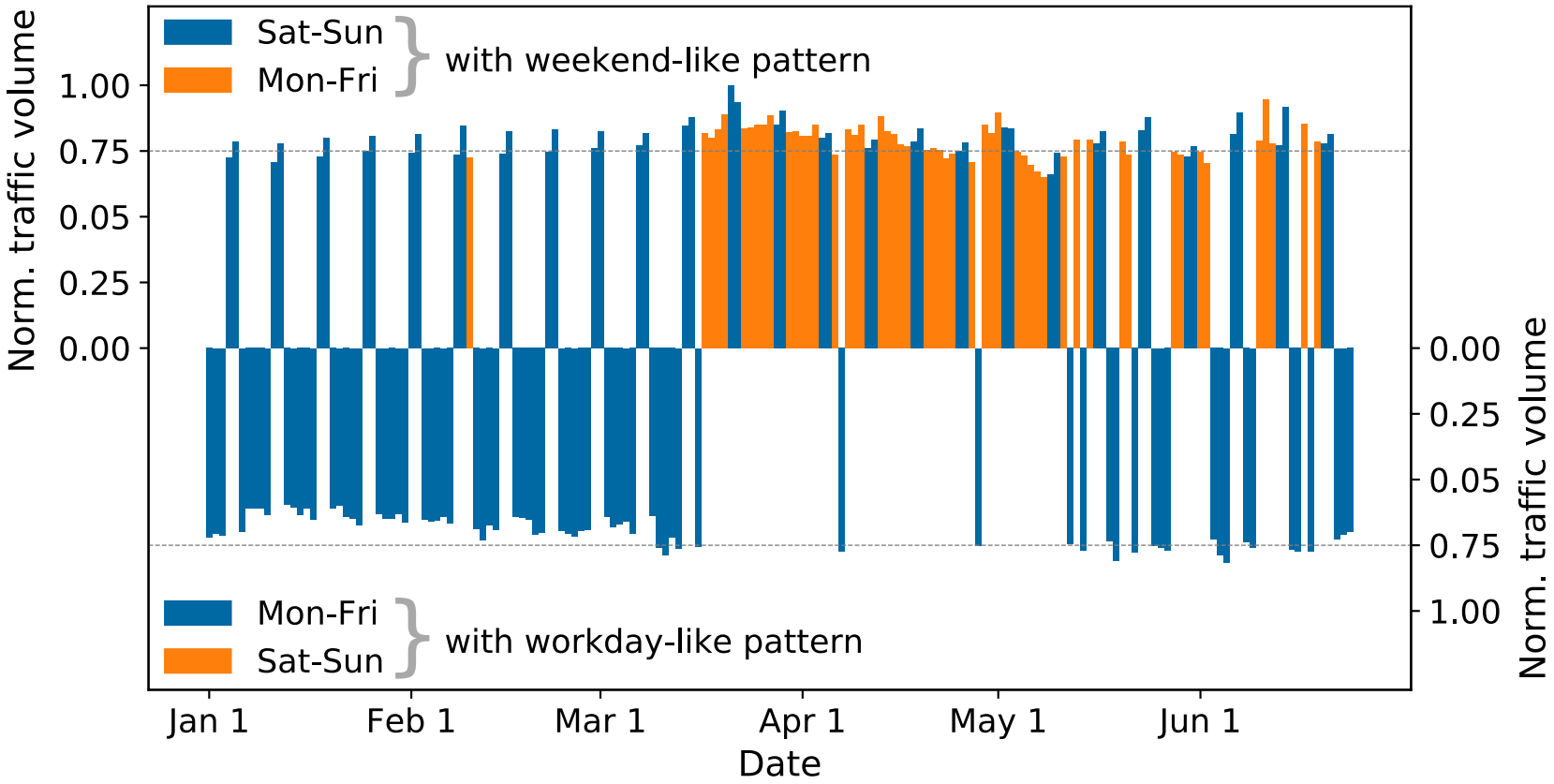
- Classify days into workdays or weekends using traffic patterns
- Pre-lockdown: Most days are classified correctly

Changes in workday vs. weekday patterns at the ISP



- Classify days into workdays or weekends using traffic patterns
- Pre-lockdown: Most days are classified correctly
- During lockdown: Many workdays are classified as weekends

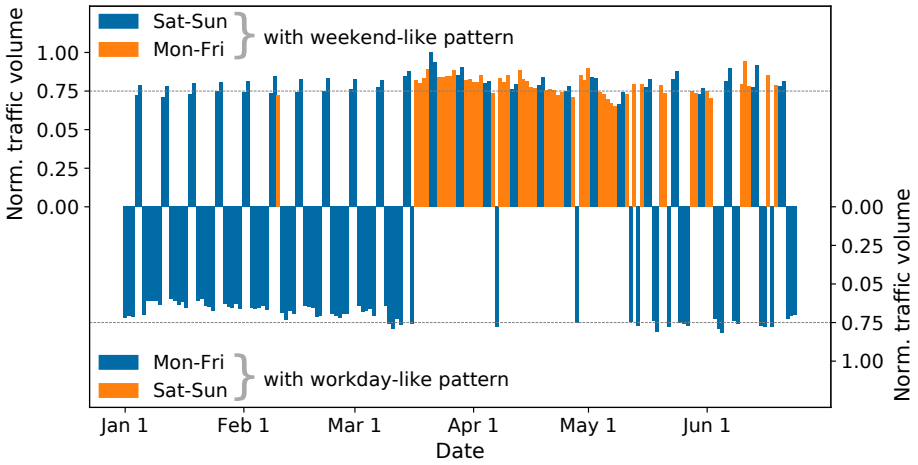
Changes in workday vs. weekday patterns at the ISP



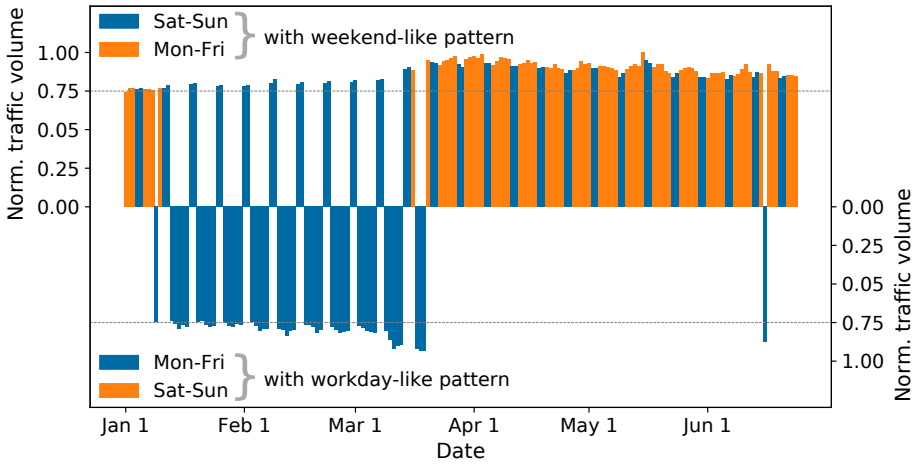
- Classify days into workdays or weekends using traffic patterns
- Pre-lockdown: Most days are classified correctly
- During lockdown: Many workdays are classified as weekends; recovering after mid-May

Changes in workday vs. weekday patterns: ISP vs. IXP

ISP



IXP



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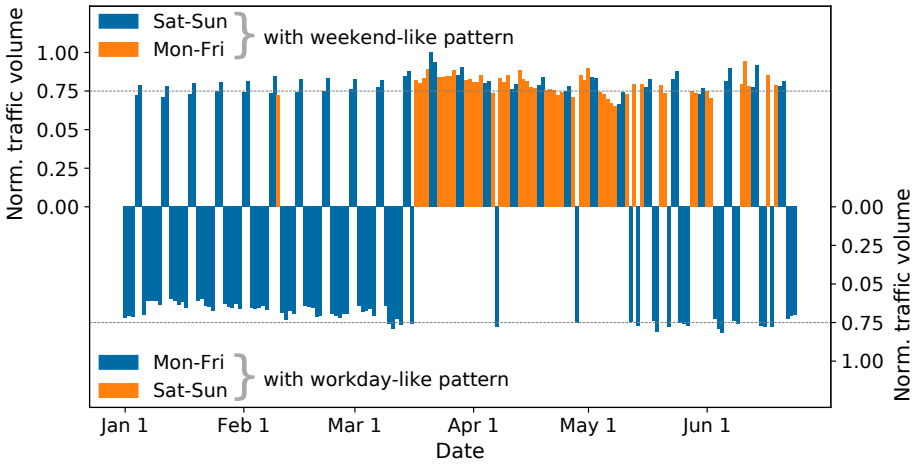
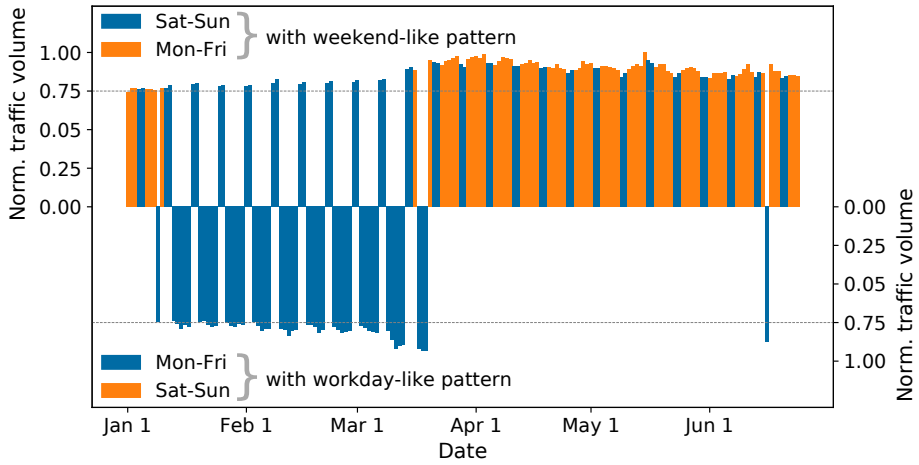


IXP



- Workdays are also mostly classified as weekends at the IXP

Classify traffic by application class

- Classification: transport ports and AS based

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- Normalize traffic to min/max of three weeks

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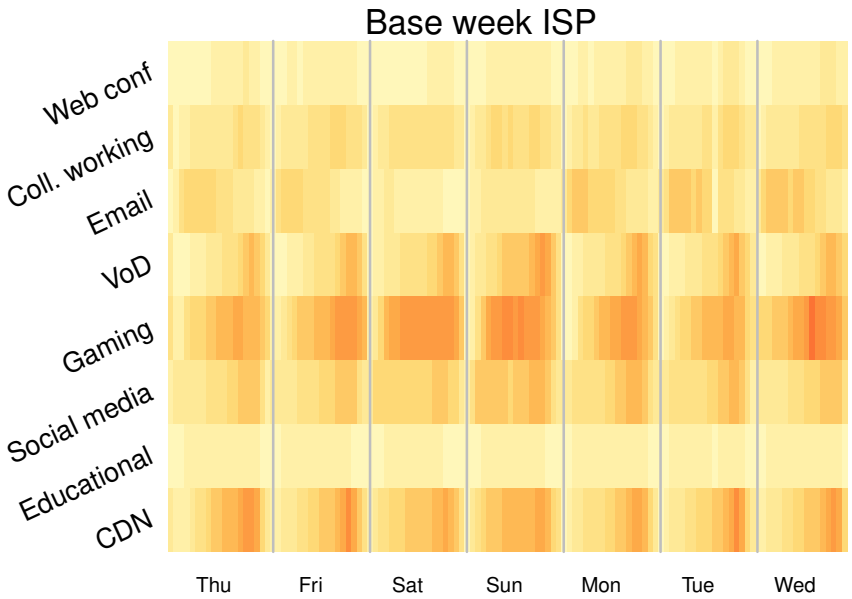

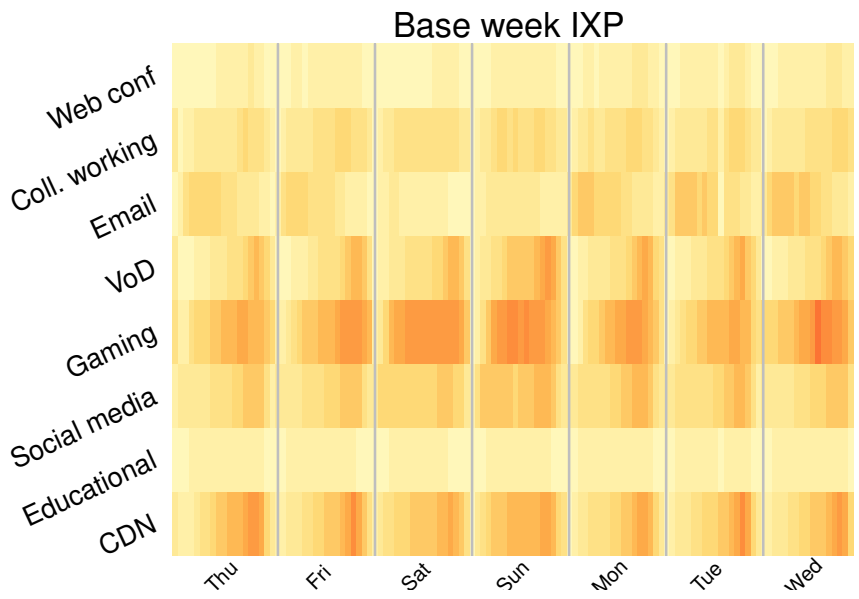

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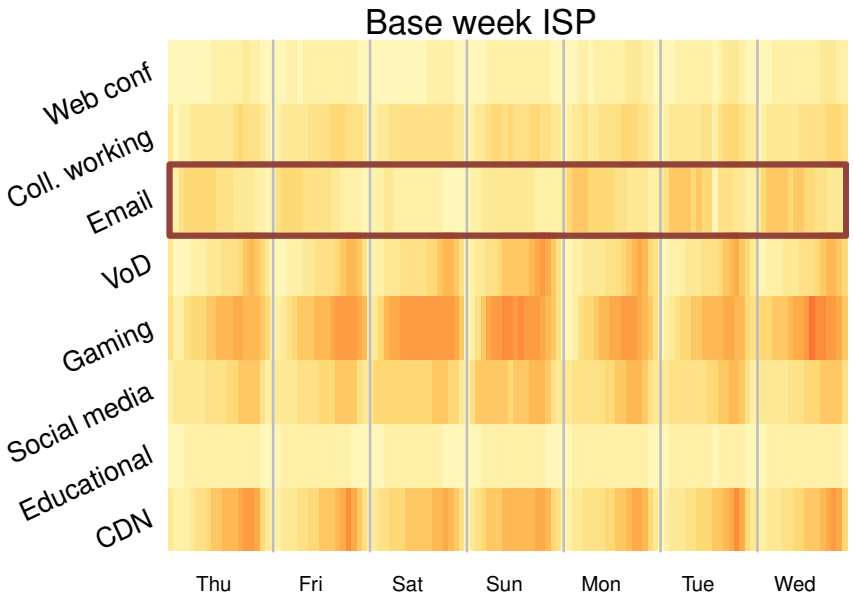

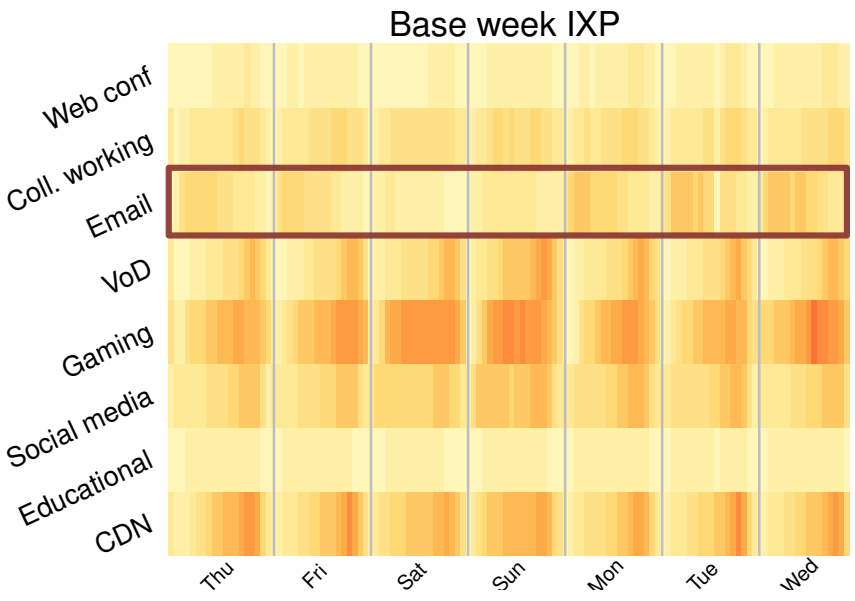

- Email during working hours

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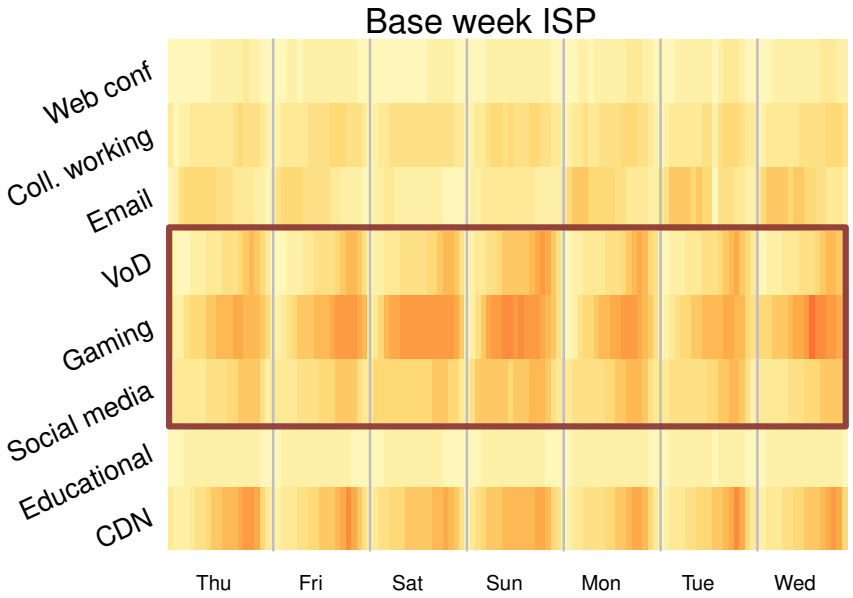

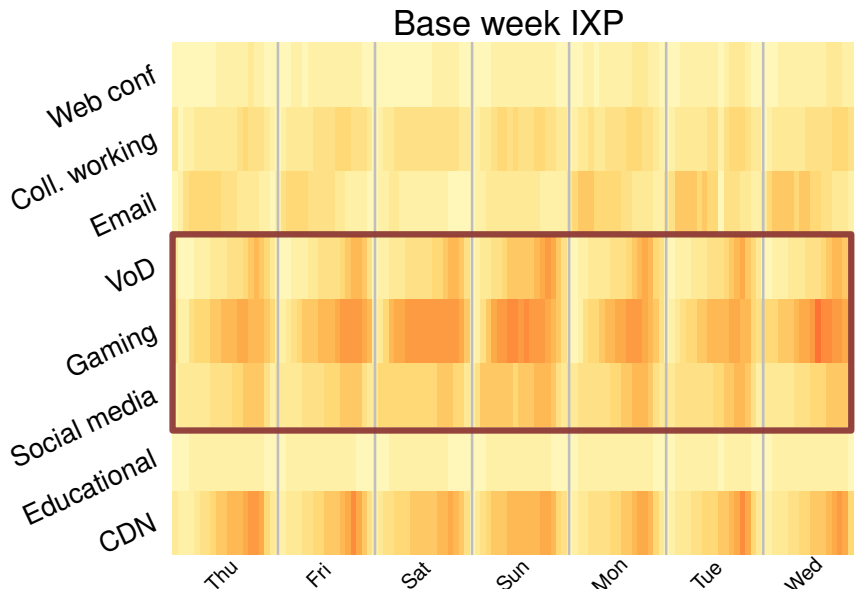

- Email during working hours
- CDN, VoD, gaming and social media during evening hours

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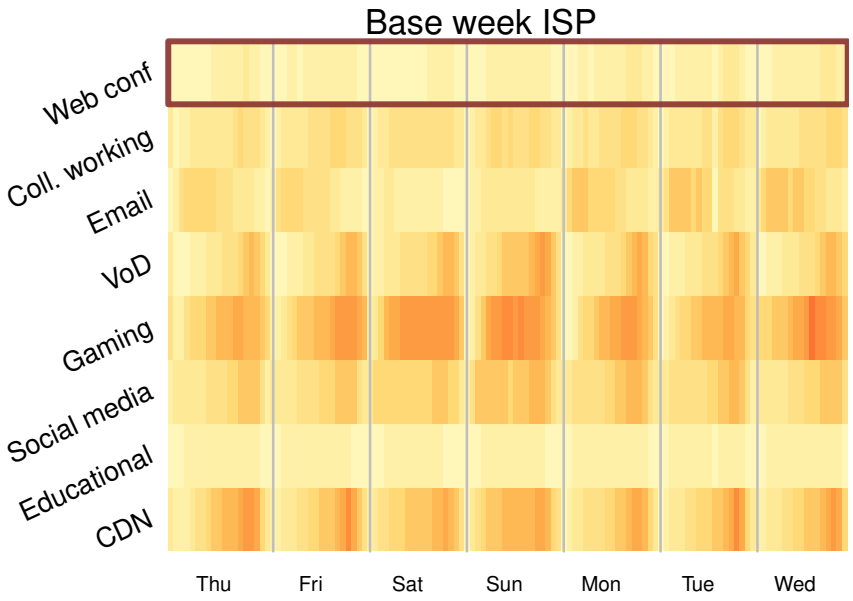
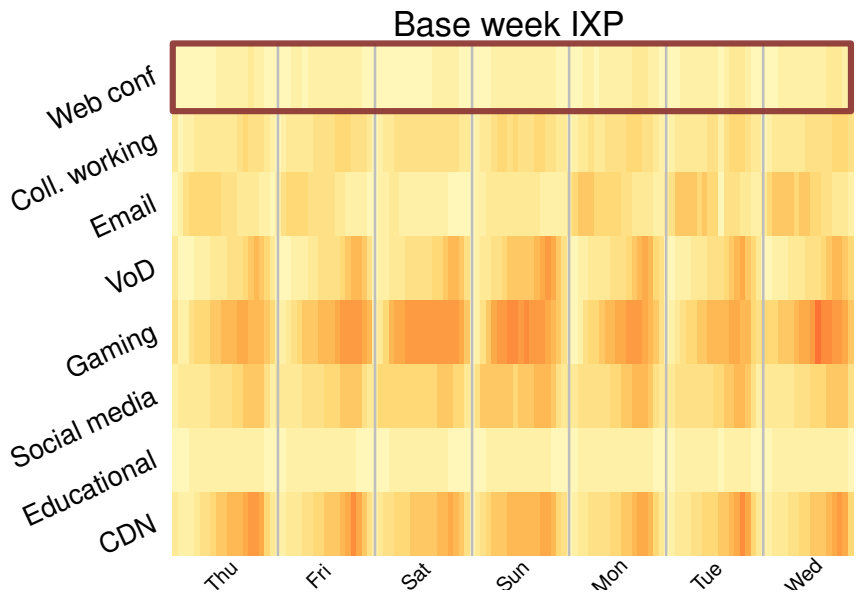
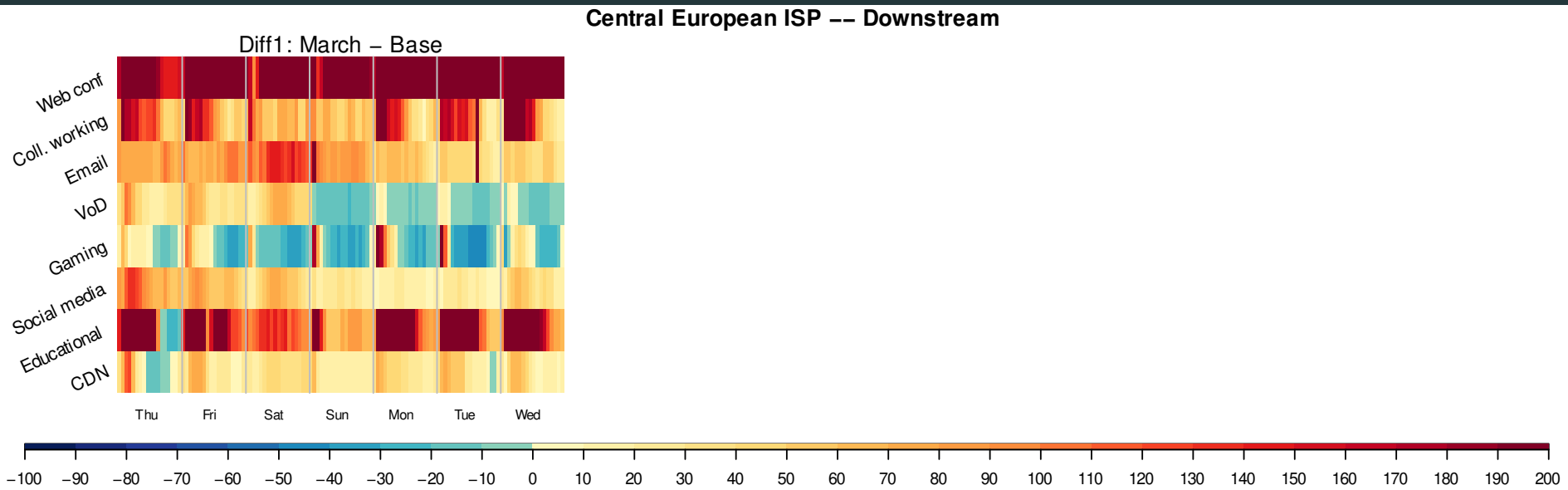
- Normalize traffic to min/max of three weeks
- No change in early morning hours $\rightarrow$ remove





- Email during working hours
- CDN, VoD, gaming and social media during evening hours
- Hardly any web conferencing

Changes in application classes: Central European ISP



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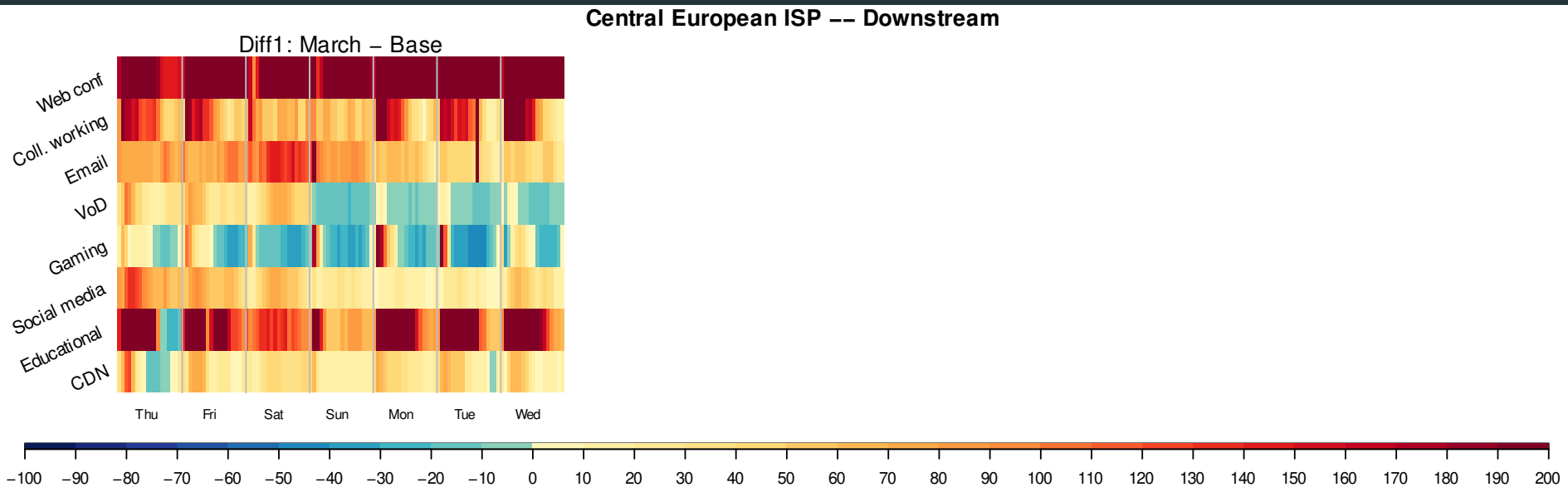

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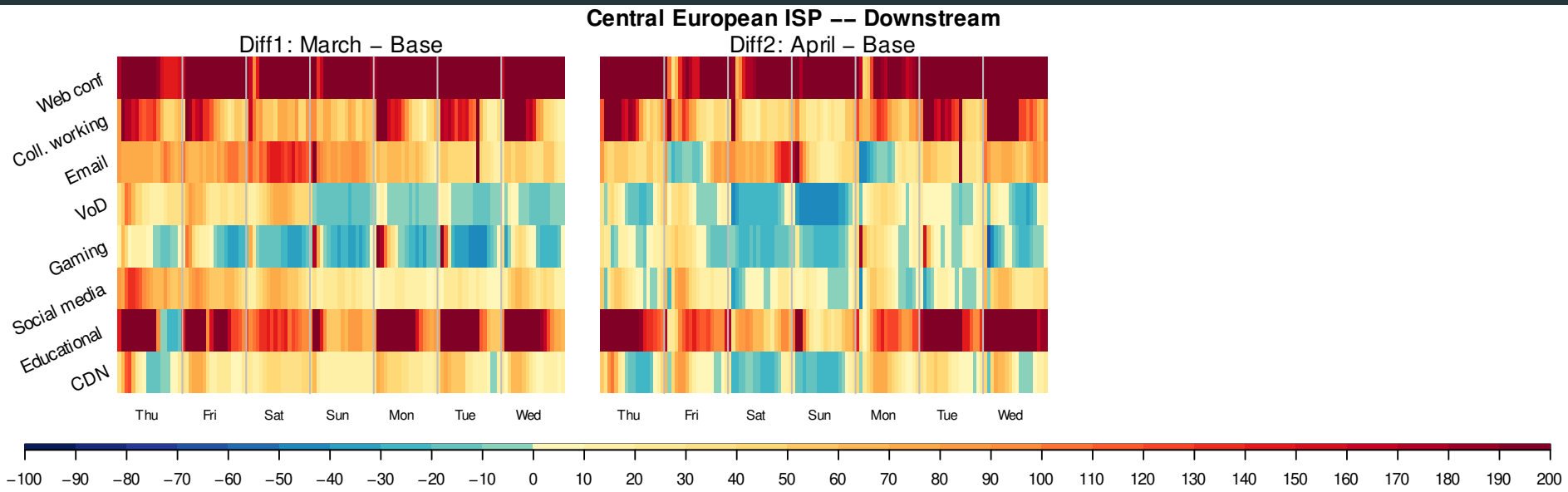

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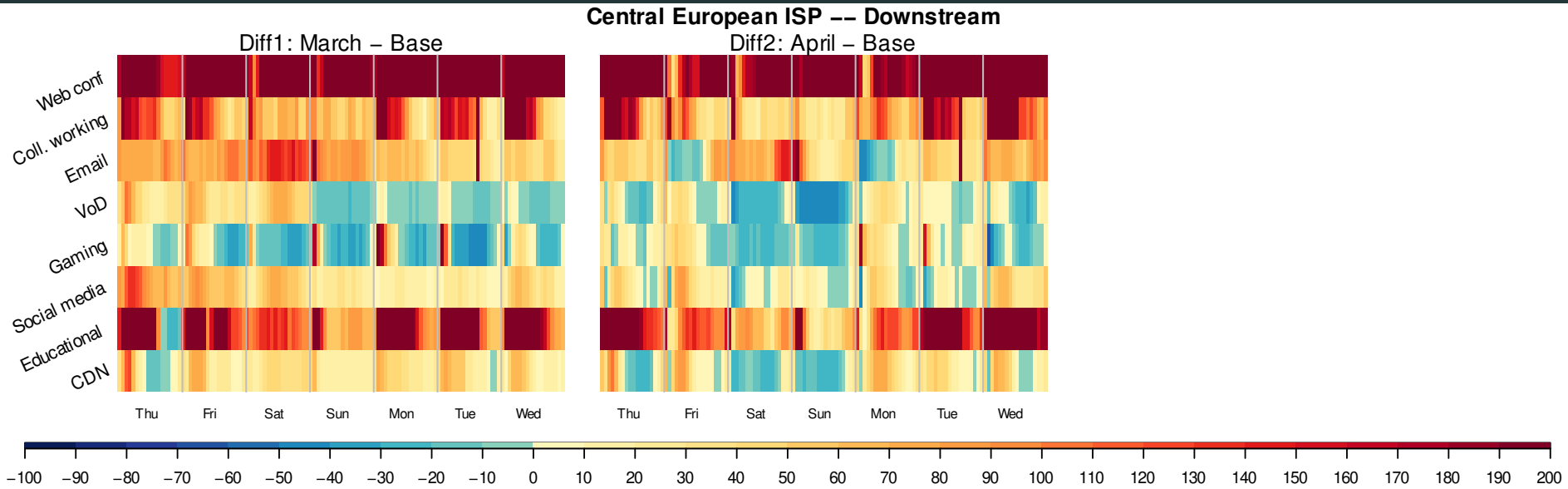

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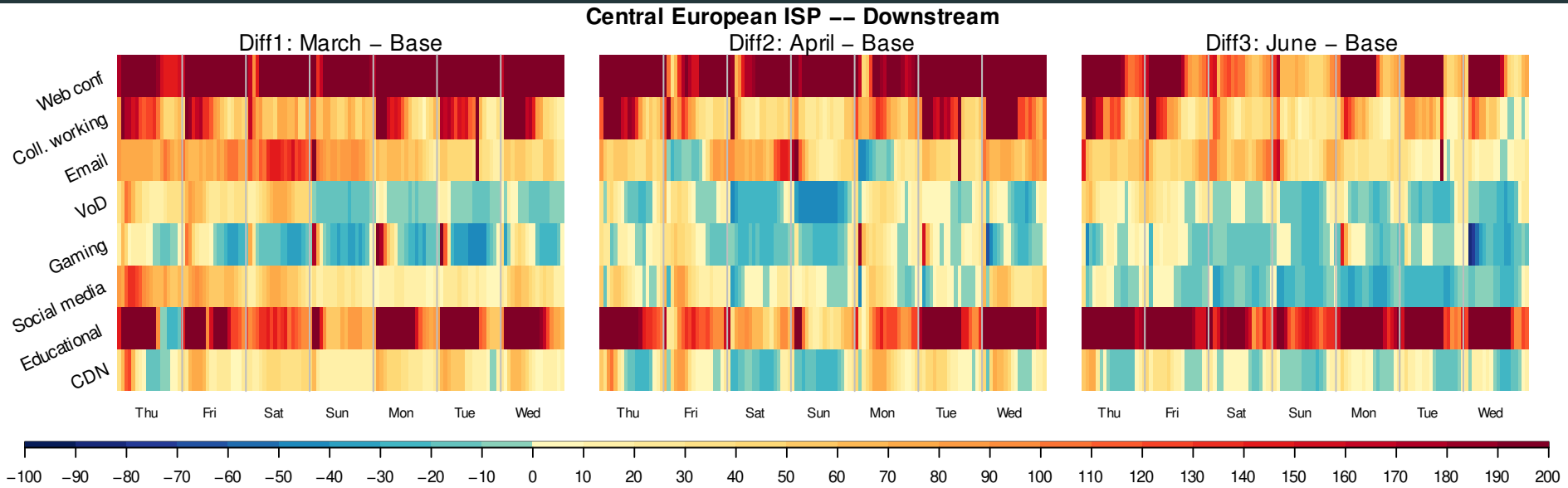

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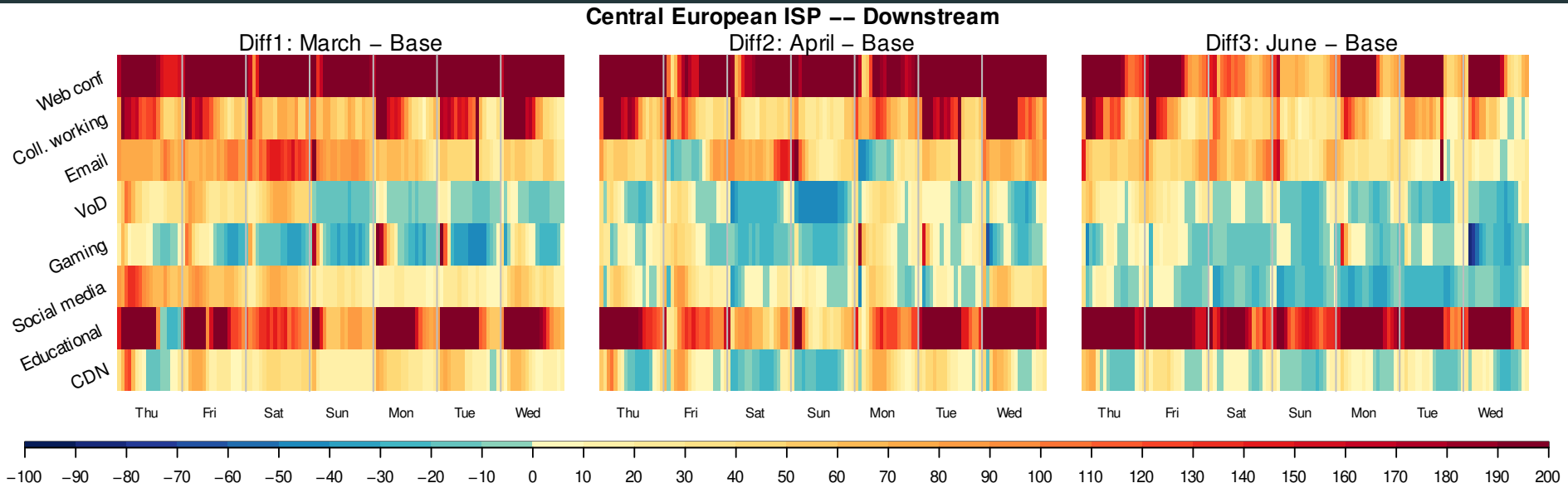

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- Decrease of VoD, gaming and social media

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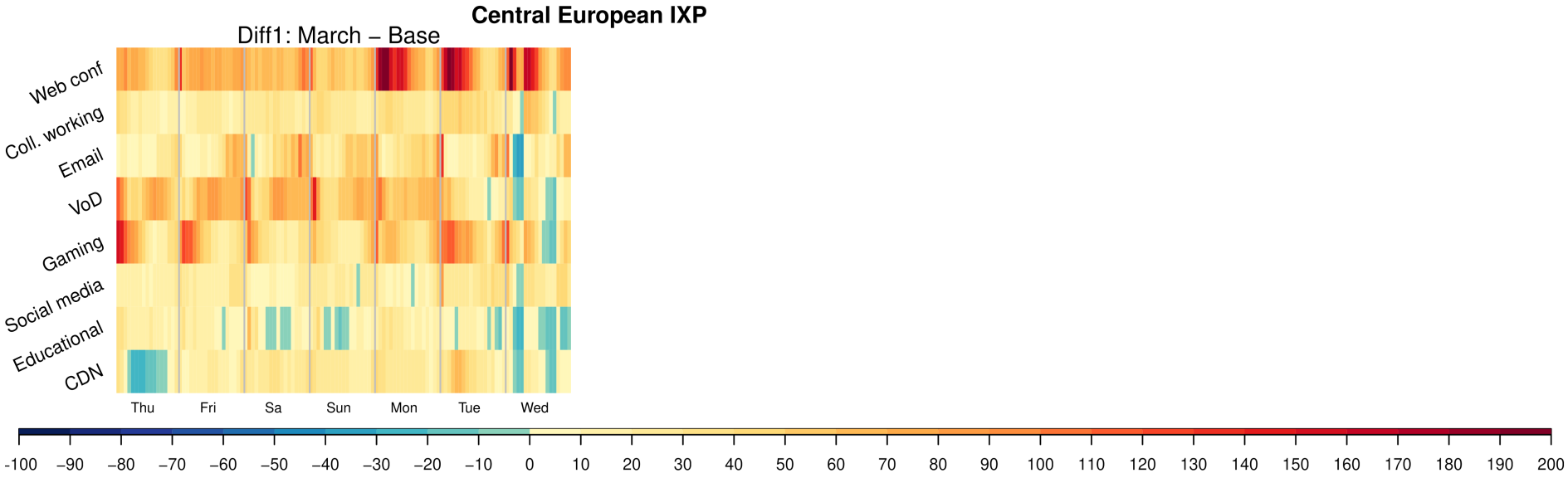

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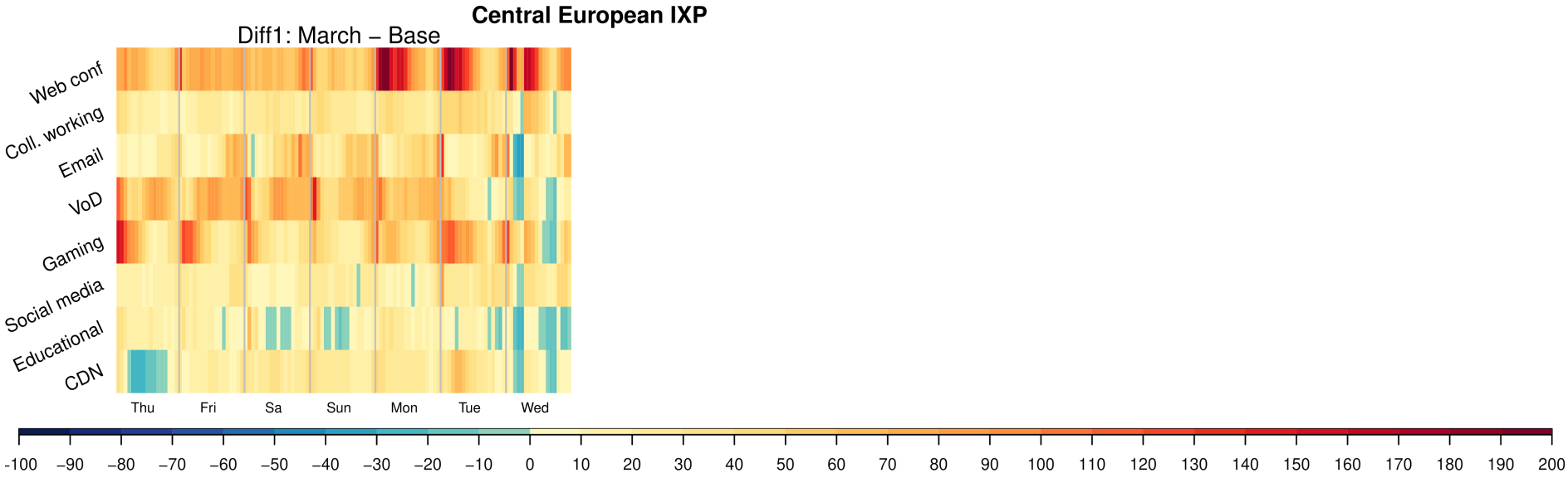

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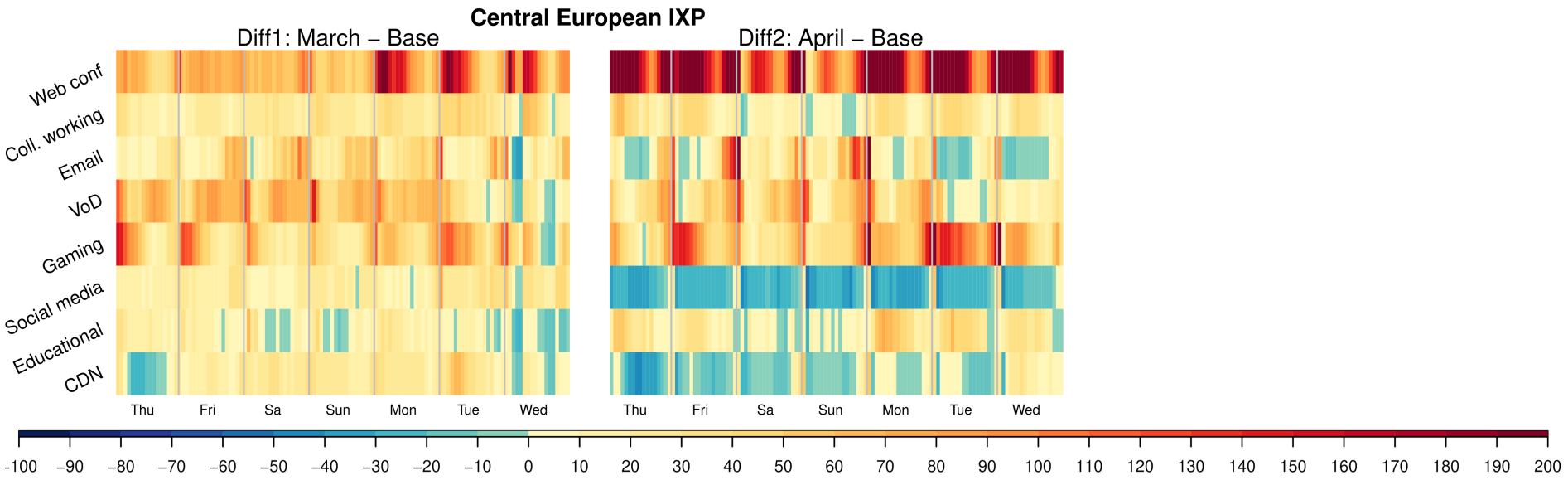

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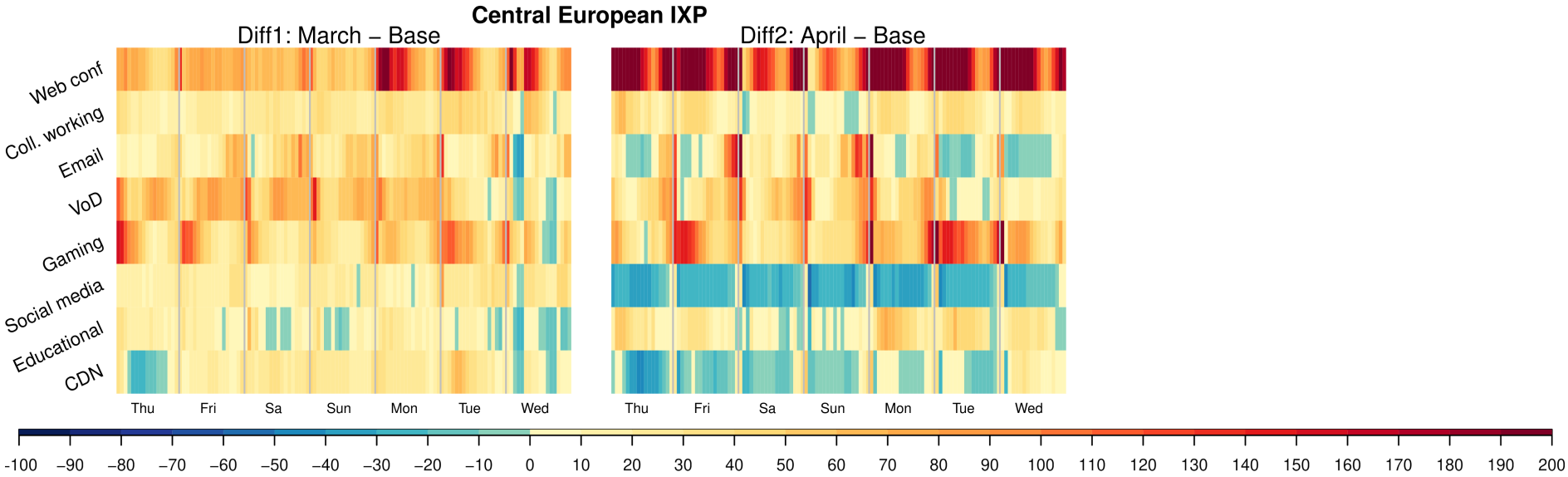

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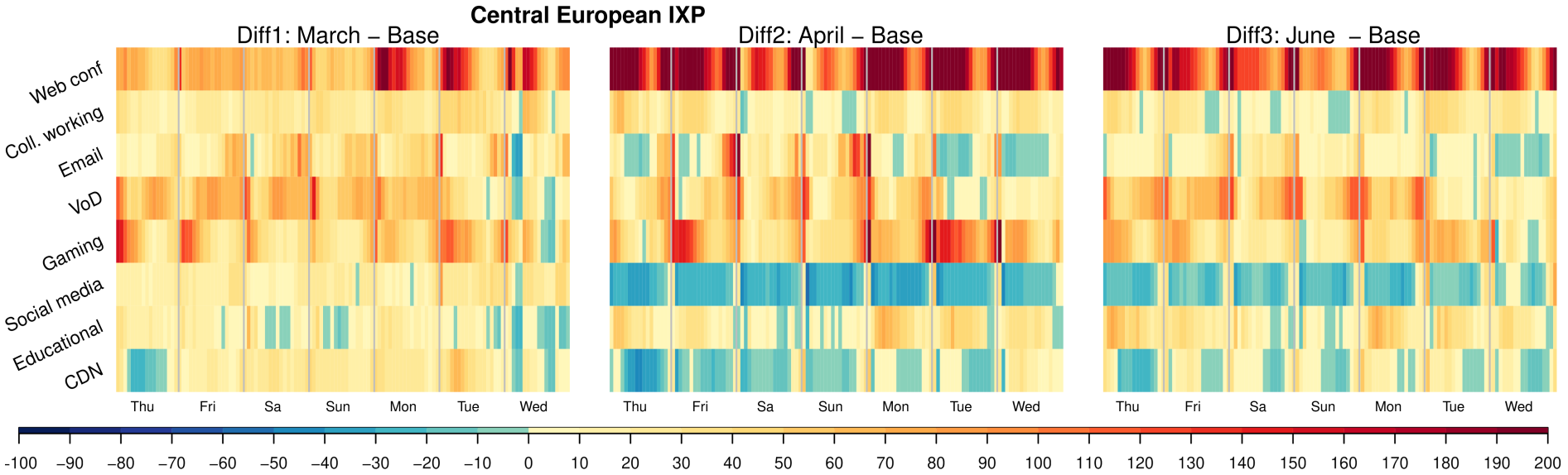

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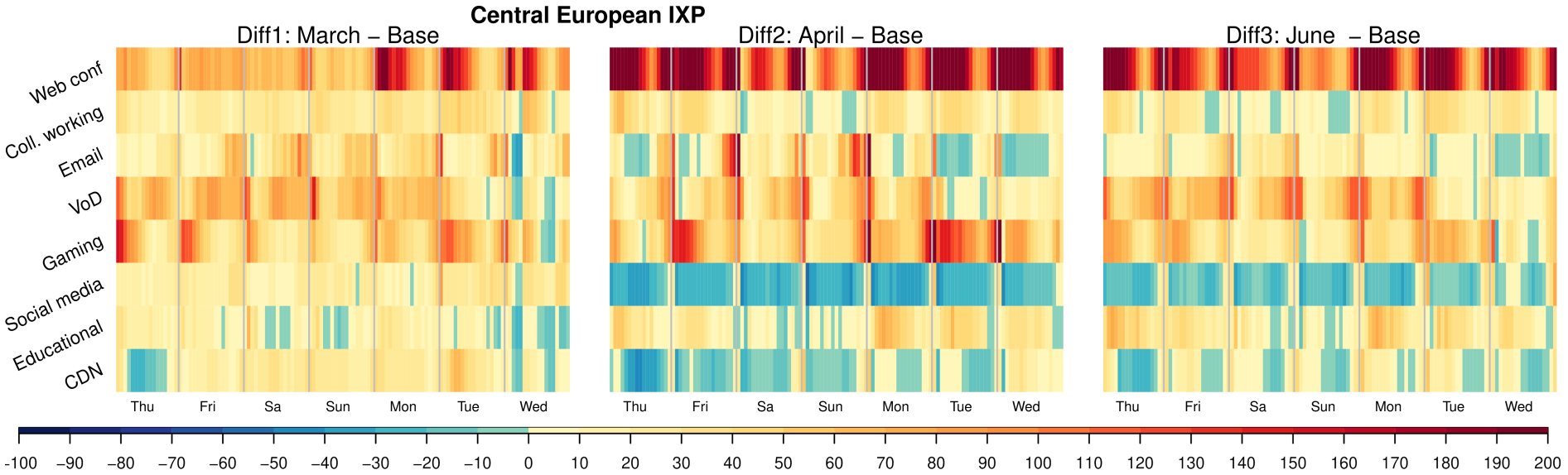

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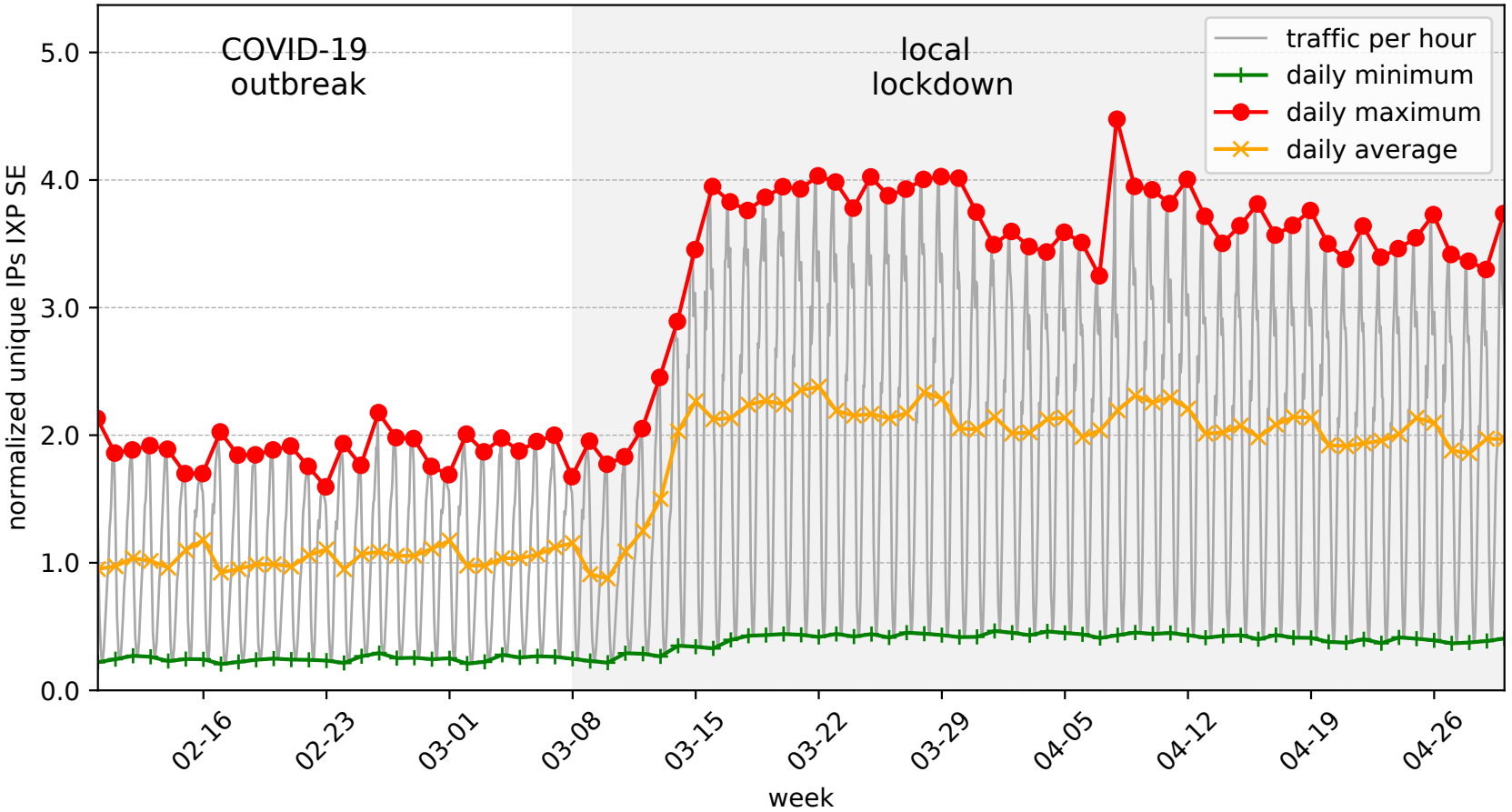
Case Study: Gaming traffic at a Southern European IXP



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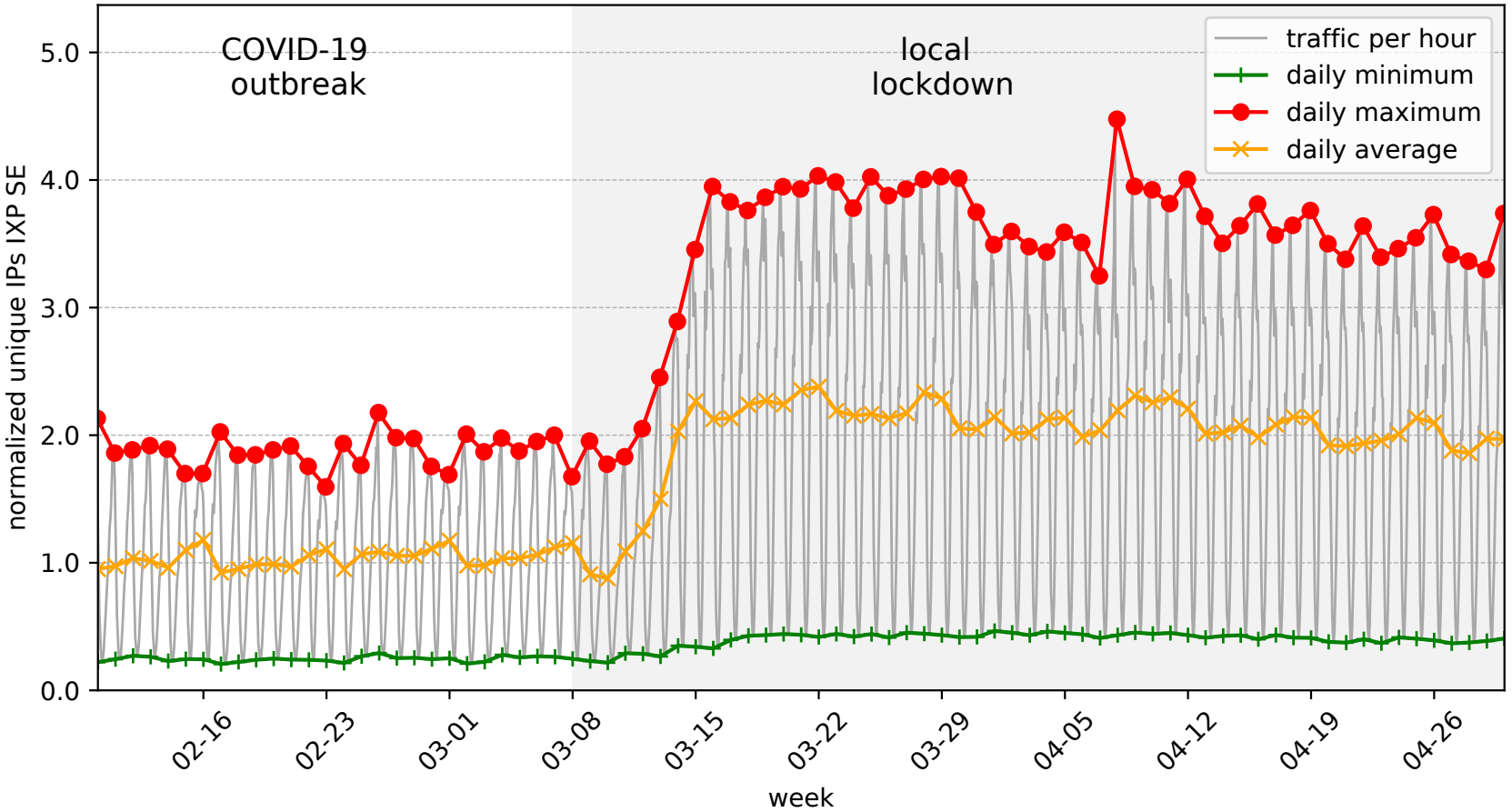

- Gaming: Large increase in number of active IP addresses and traffic volume

VPN traffic: Central European IXP

VPN identification

- Port-based: Well known port/proto combinations exclusively used by VPN services
- DNS-based: For TCP/443 traffic, IPs labeled `*vpn*`, but not `www.`

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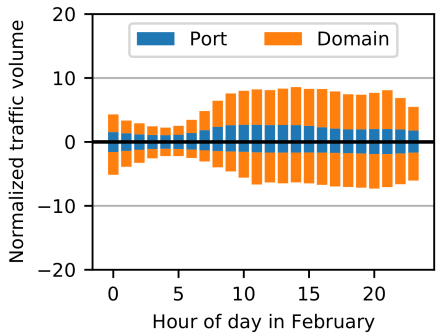

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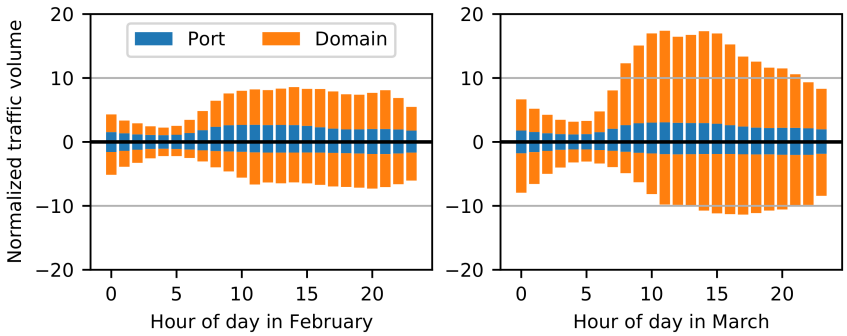

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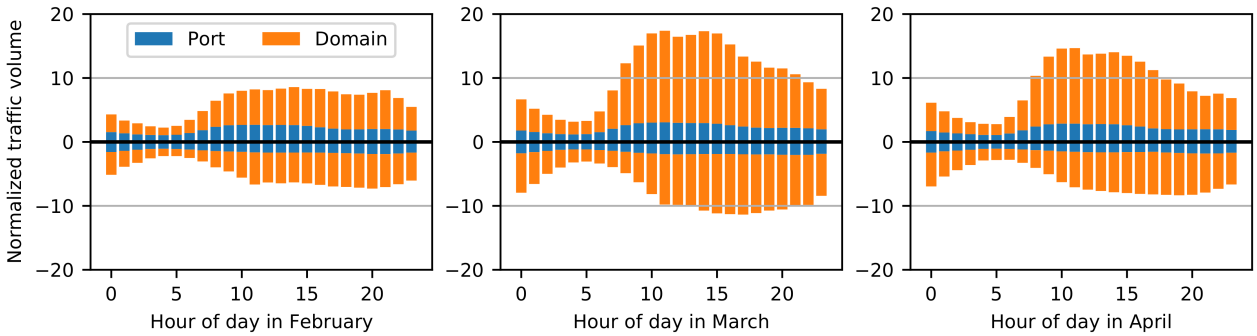

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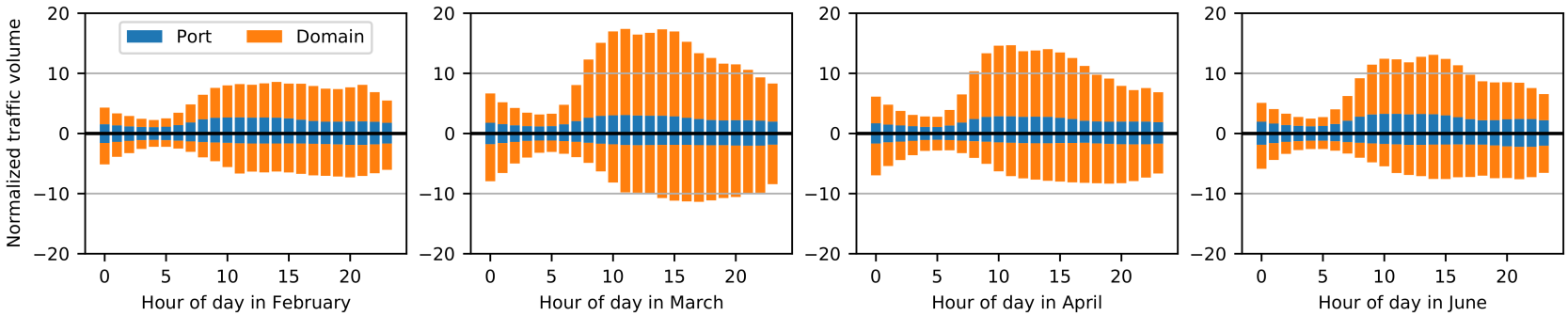

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How did edu traffic change?

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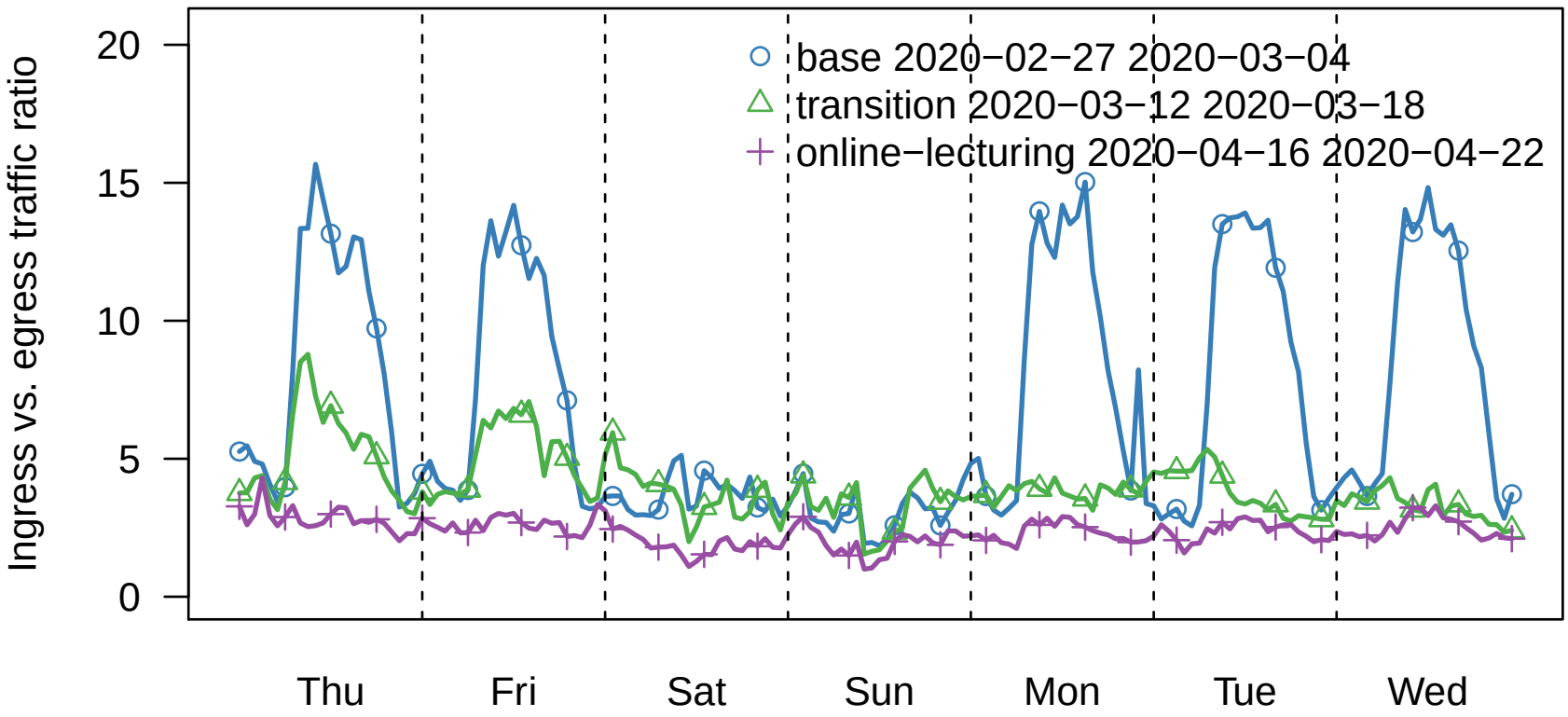

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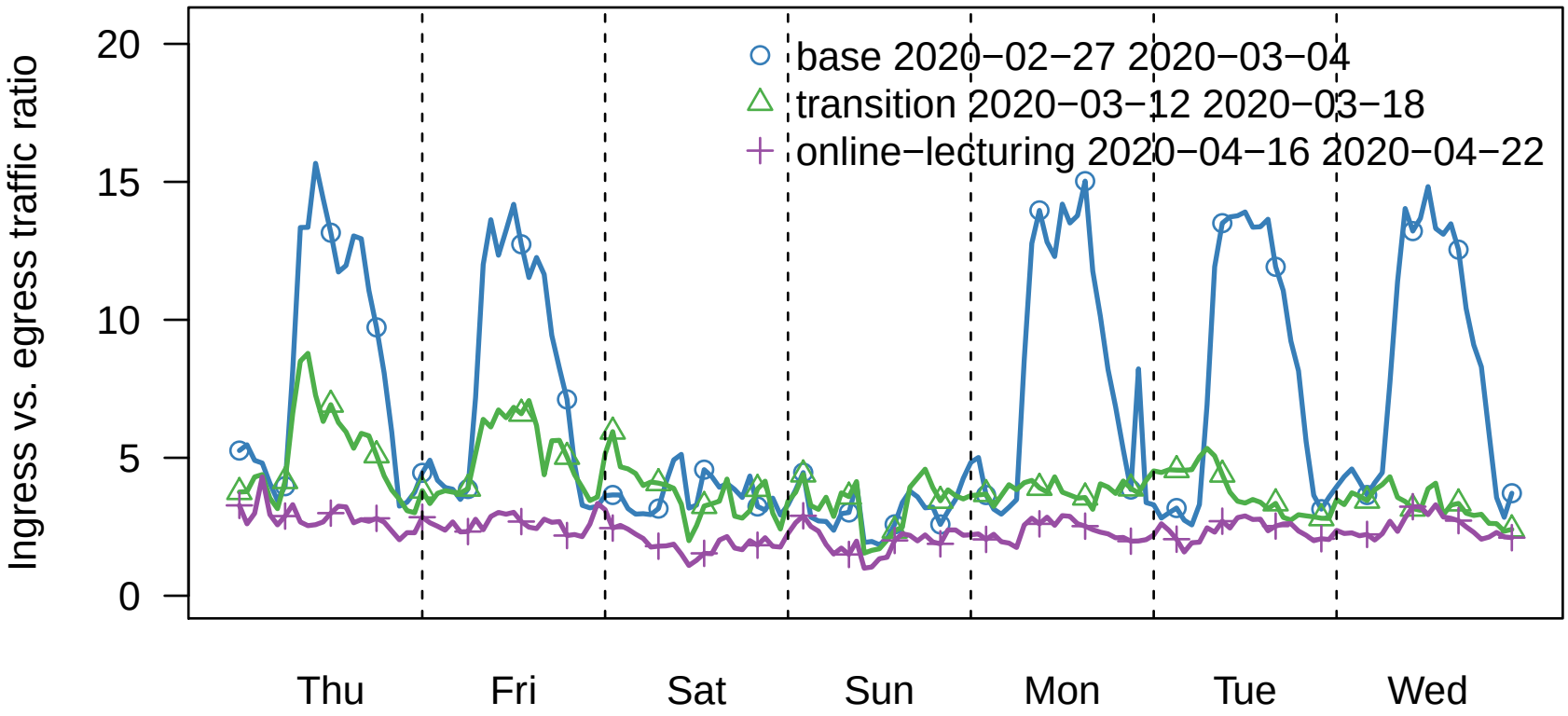

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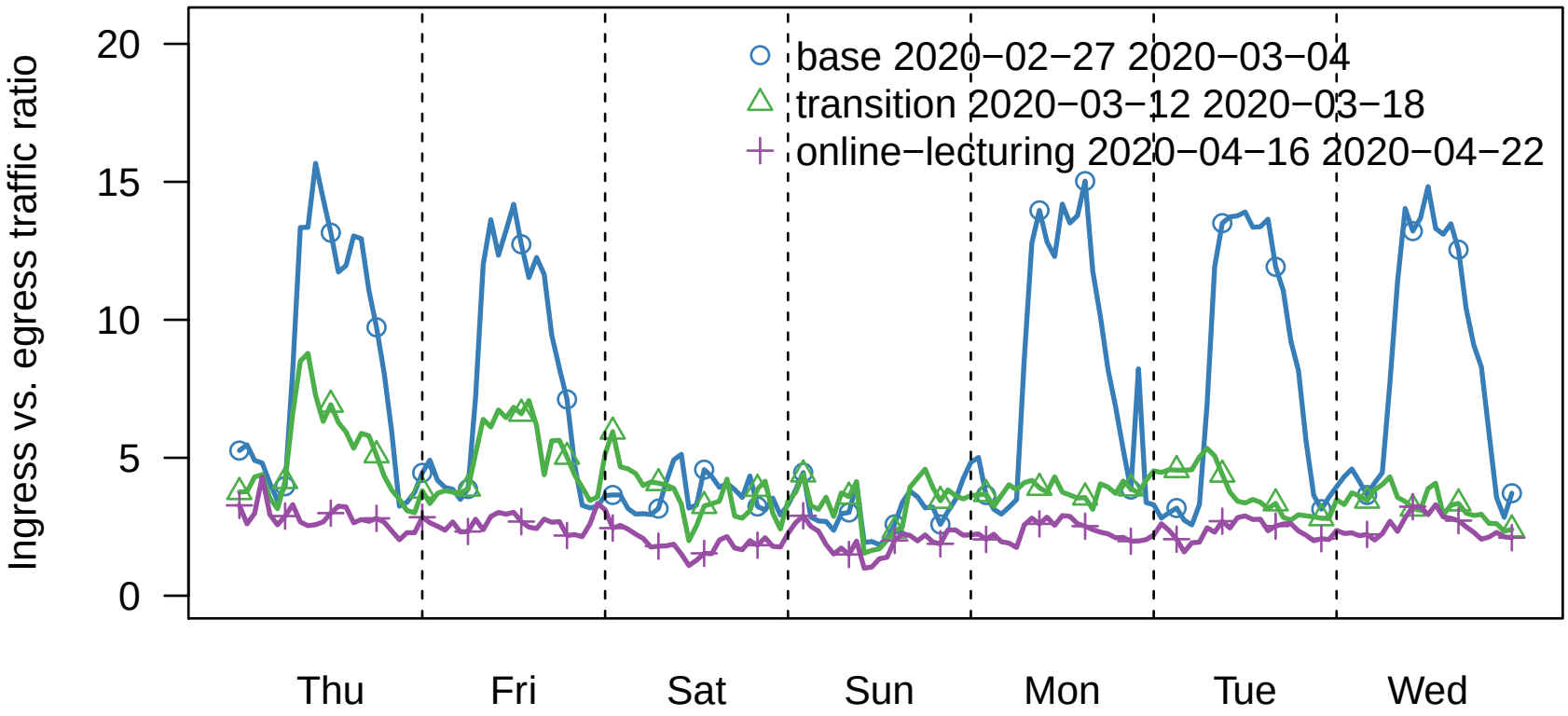
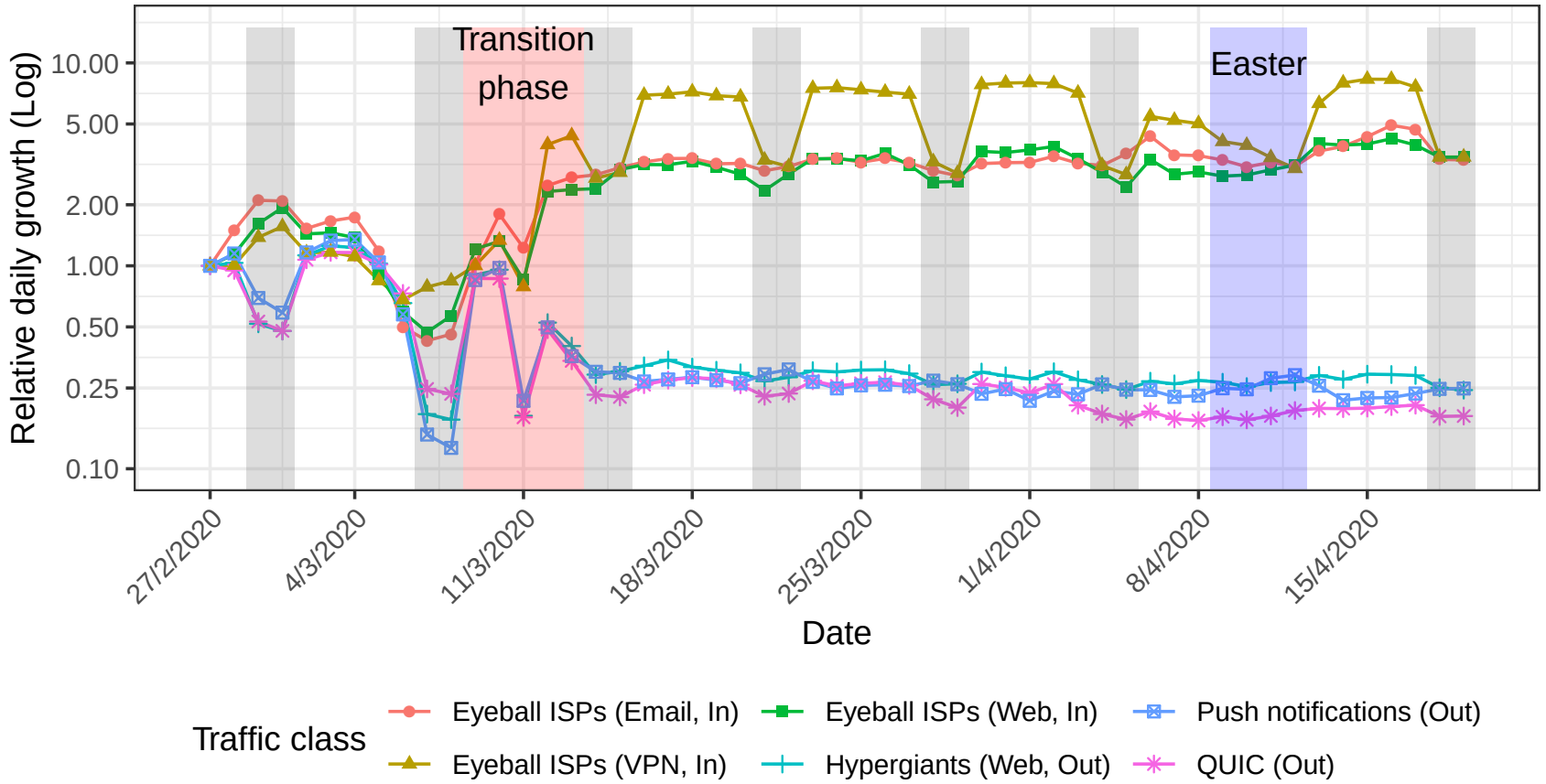


- Large decrease in traffic and number of connections
- Traffic ratio significantly decreased from 15:1 to 4:1

Protocol changes: REDIMadrid



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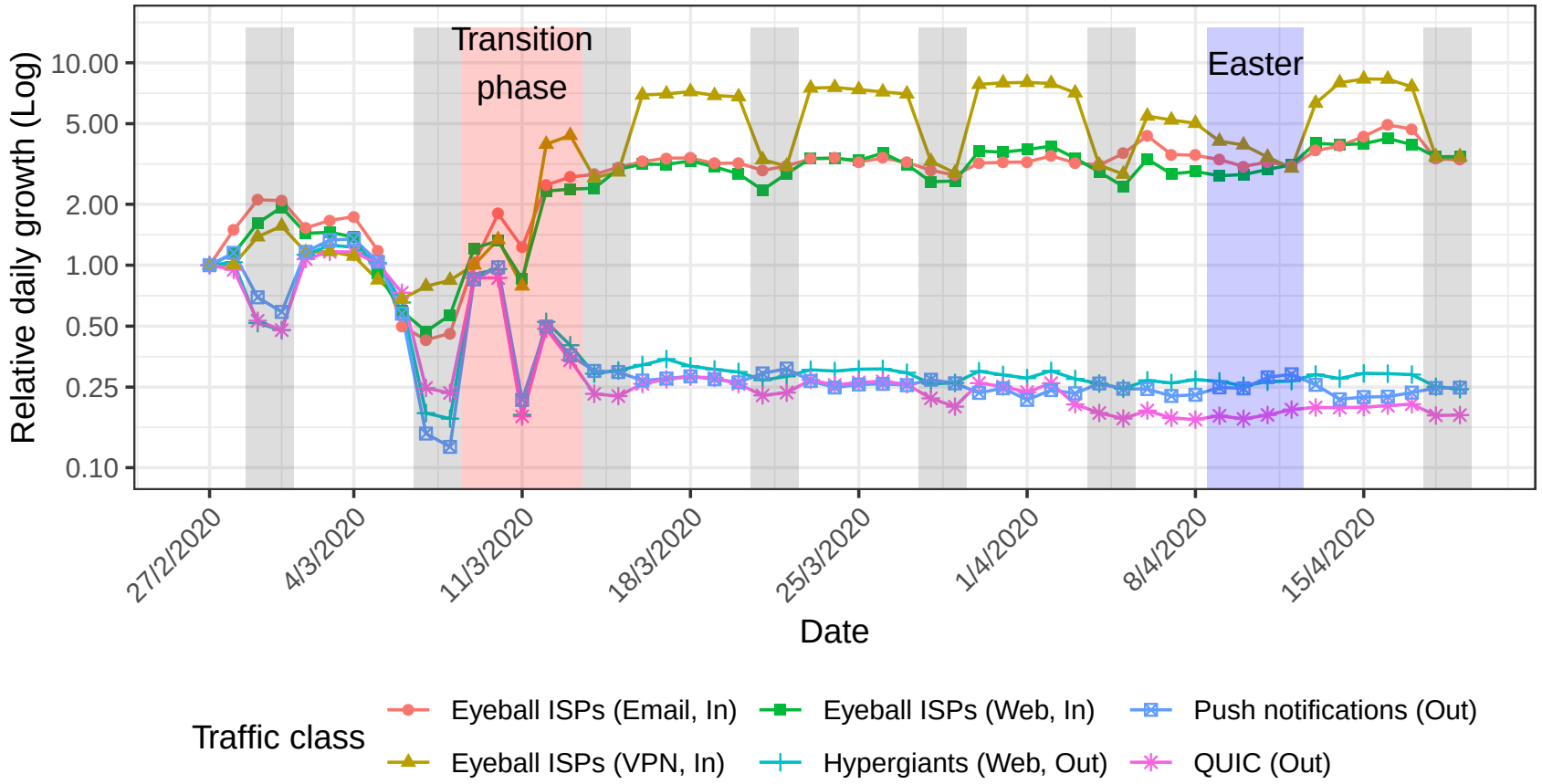

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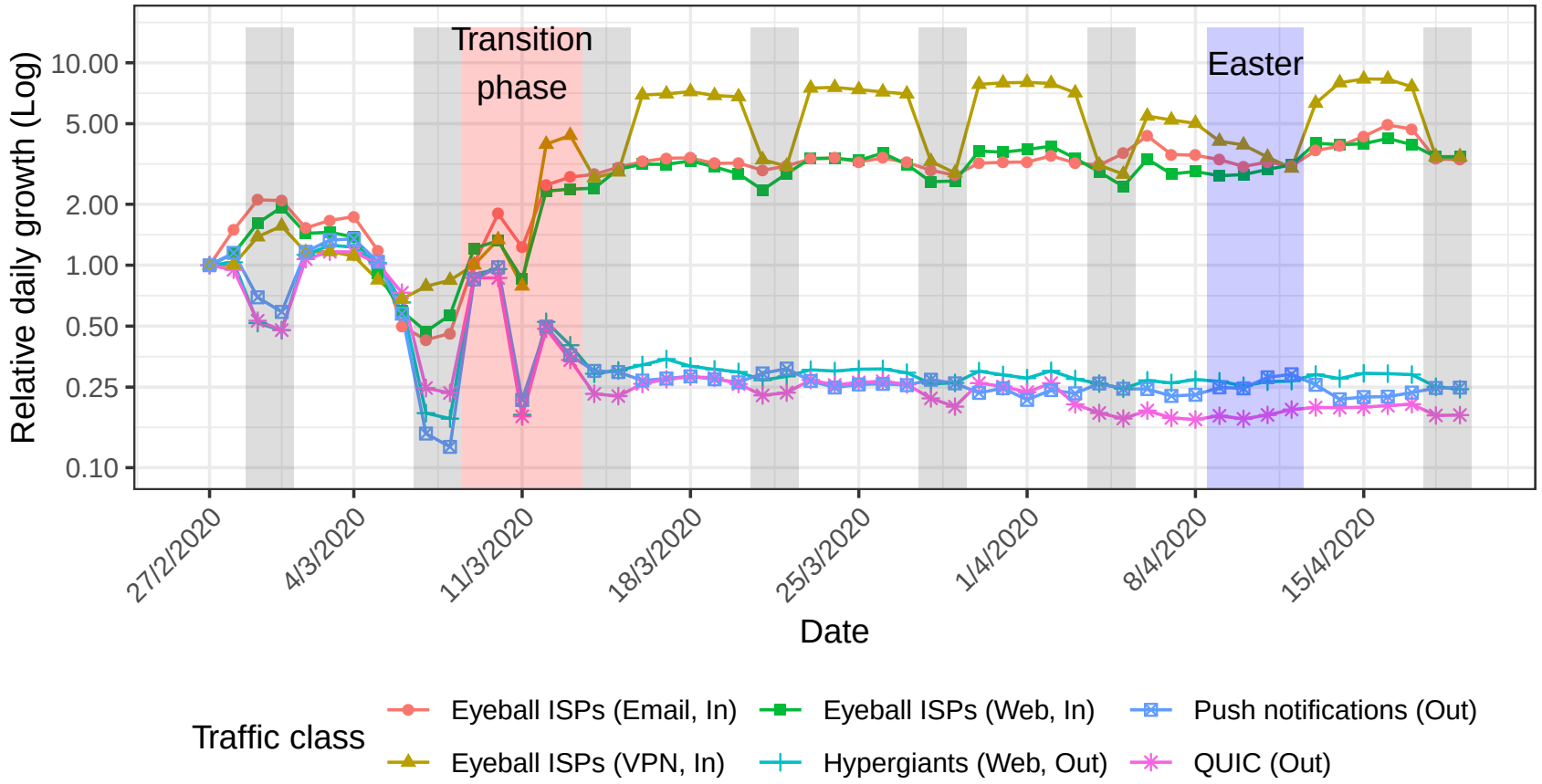

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What we found

People change $\rightarrow$ traffic changes

- Changes in people's lives lead to new traffic patterns

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Our vantage points reveal that the impact of the COVID-19 panedmic is directly reflected in changes to Internet traffic patterns.

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Contact emails: narseo.vallina@imdea.org jestevez@inf.uc3m.es

Paper link: arXiv:2008.10959