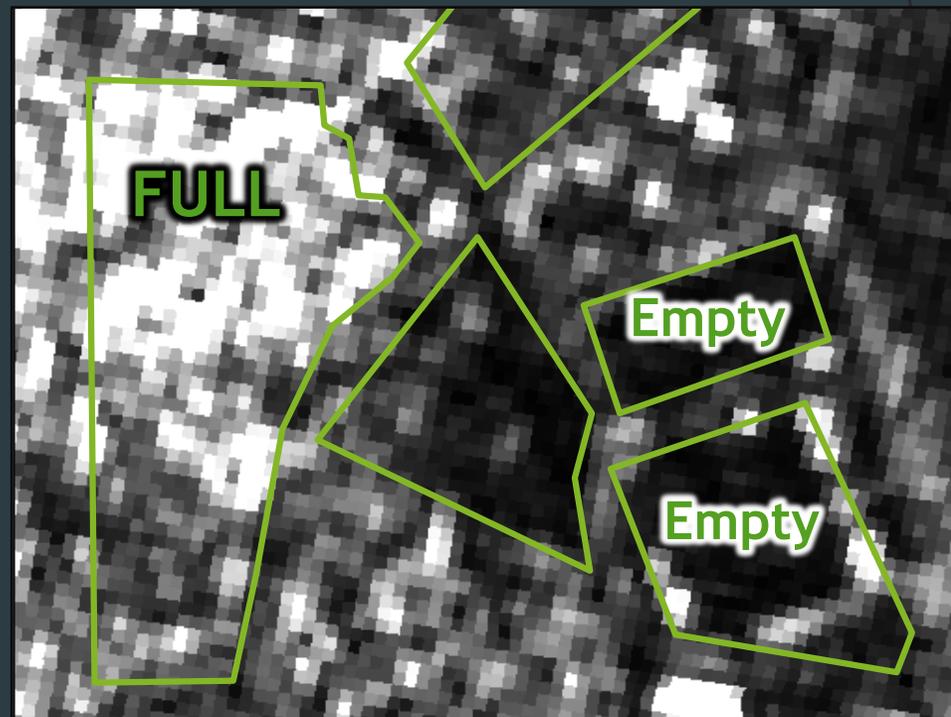


# Sentinel 1 Based Car Park Monitoring

Tracking the economic impacts and recovery from the COVID-19 pandemic

Samuel Barrett, 7/5/2020



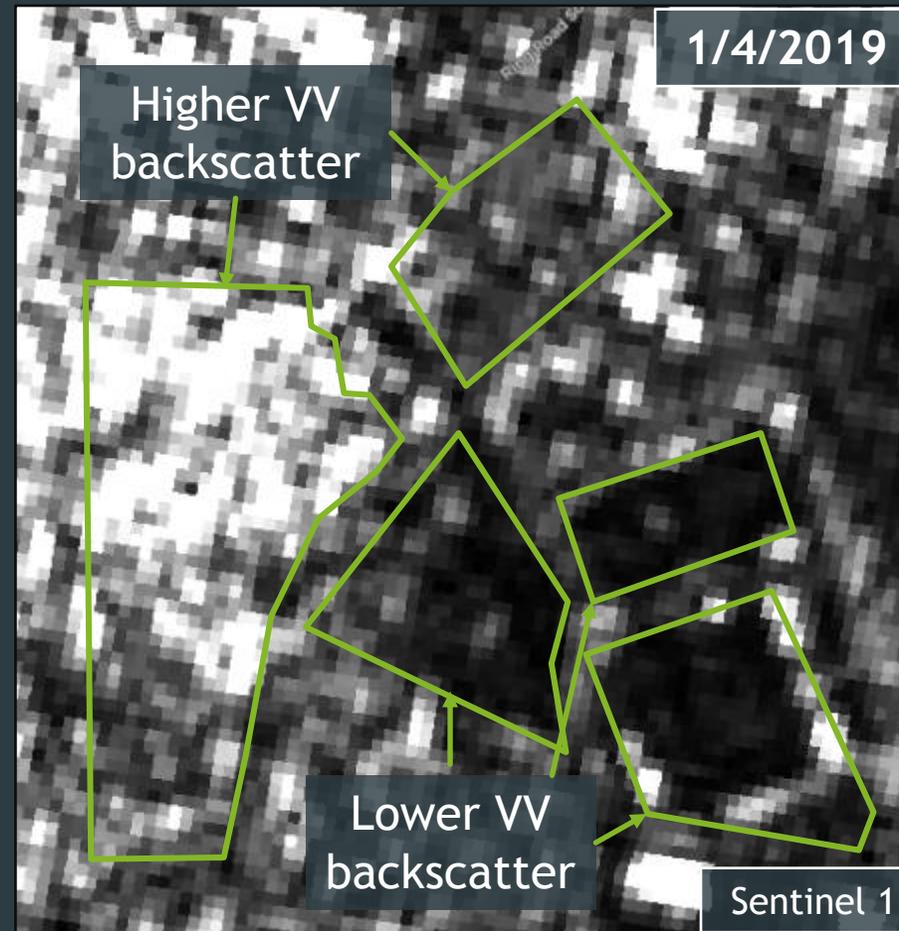
# Background and Research Questions

- ▶ Car park usage can be seen as a proxy for various economic activities.
  - ▶ For example, number of retail customers by supermarket car park usage.
- ▶ Research questions:
  - ▶ Can car park usage be monitored using free, open, frequent and global Sentinel data?
  - ▶ Given the difference in surface geometries of full (“rough” from many parked vehicles) and empty (smooth and reflective paved surface) parking areas, can the usage (full vs empty and intermediate states) be measured using Sentinel 1 SAR backscatter data?

# Case Studies

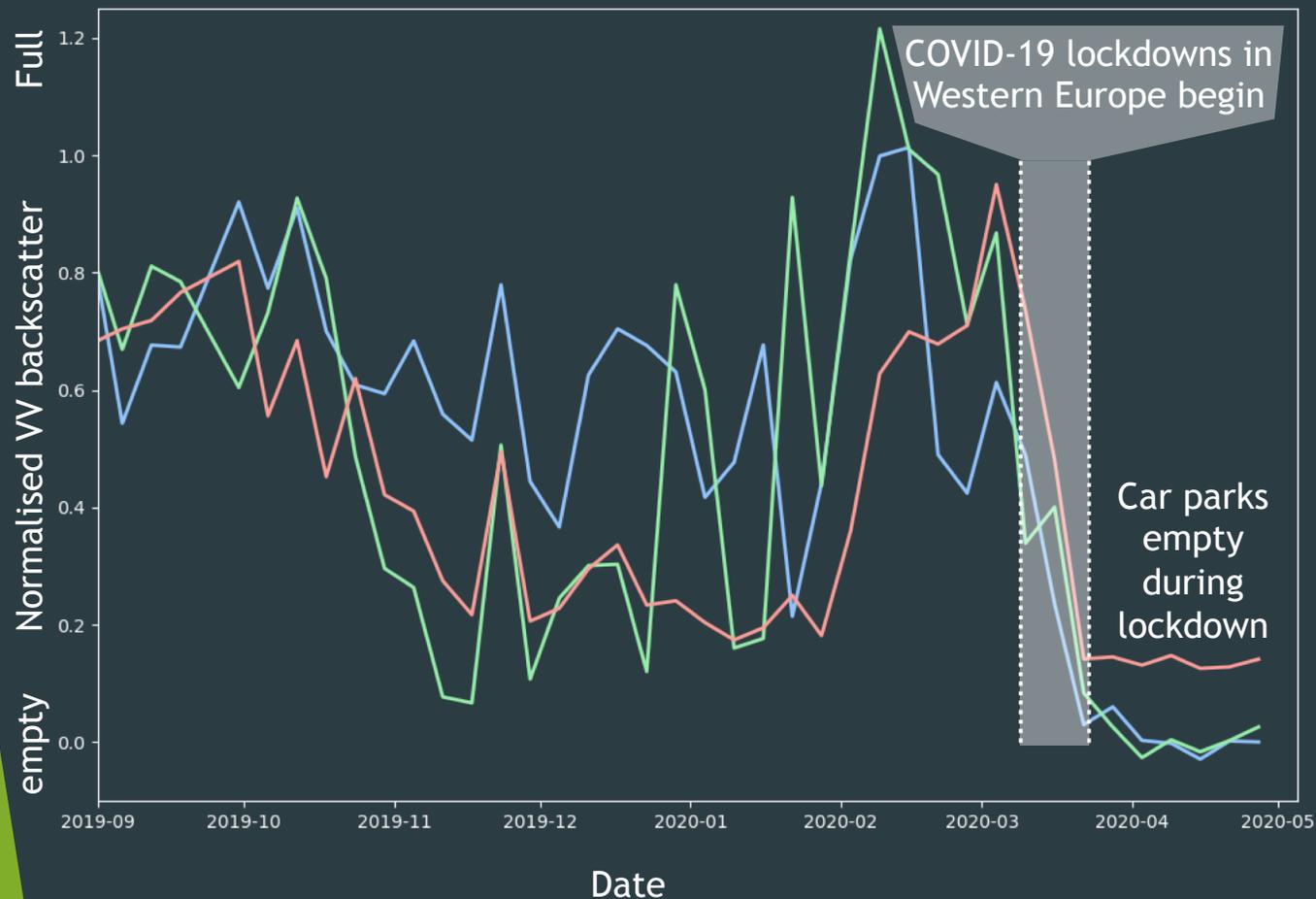
- ▶ The following case studies are presented to address the research questions in different contexts and for different economic proxies:
  - ▶ 1. London Gatwick airport (UK) long stay parking areas
    - ▶ Expect to be relatively stable between days of week and between close observations. Trends over weeks to months.
    - ▶ Proxy for (international) passenger air travel.
  - ▶ 2. Zaragoza (Spain) shopping complex parking areas
    - ▶ Expect significant variation by day of week as well as on longer periods.
    - ▶ Proxy for non-essential retail activity.
  - ▶ 3. Dagenham (UK) supermarket parking areas
    - ▶ Expect significant variation by day of week as well as on longer periods.
    - ▶ Proxy for essential retail activity.

# Case Study 1 - London (UK) Gatwick Airport Parking - Basic proof of concept

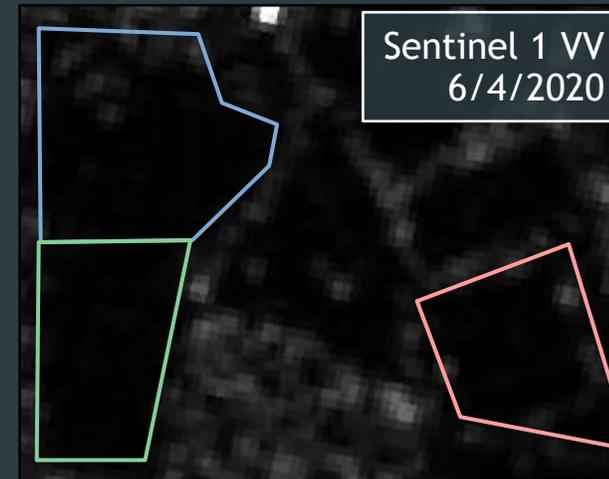


- Sentinel 1 SAR VV backscatter can be used to estimate how full car parks are. Validated by PlanetScope optical imagery.
- Full(er) car parks have high(er) backscatter.
- Empty car parks have very low backscatter.

# Case Study 1 - London (UK) Gatwick Airport Parking - Time Series



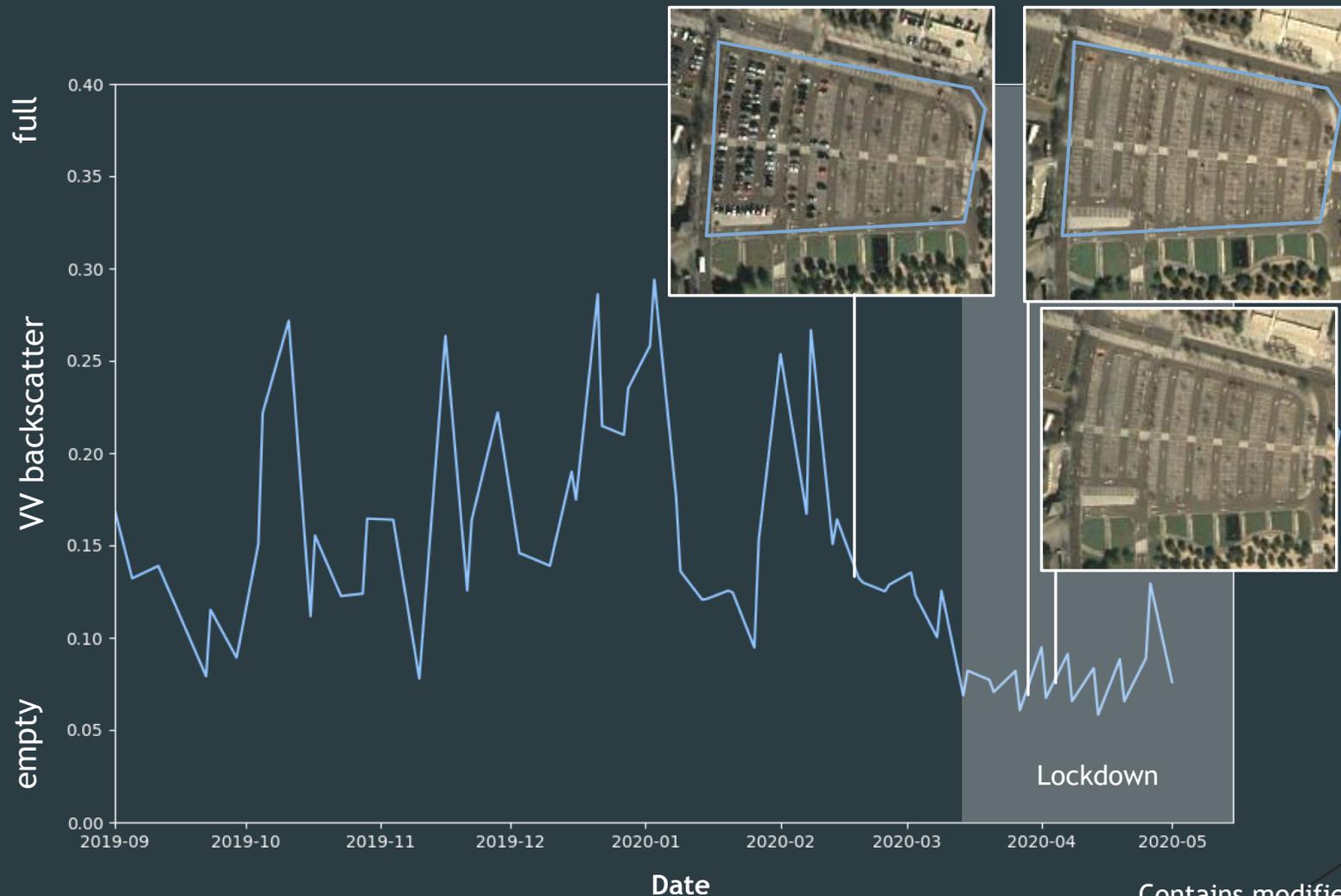
Contains modified Sentinel 2 and PlanetScope data processed by Euro Data Cube



- Long stay parking areas at London Gatwick rapidly empty as the lockdowns begin in Europe.
- Parking areas remain empty until at least early May.
- When will usage/air travel increase again?

# Case Study 2 - Zaragoza (Spain)

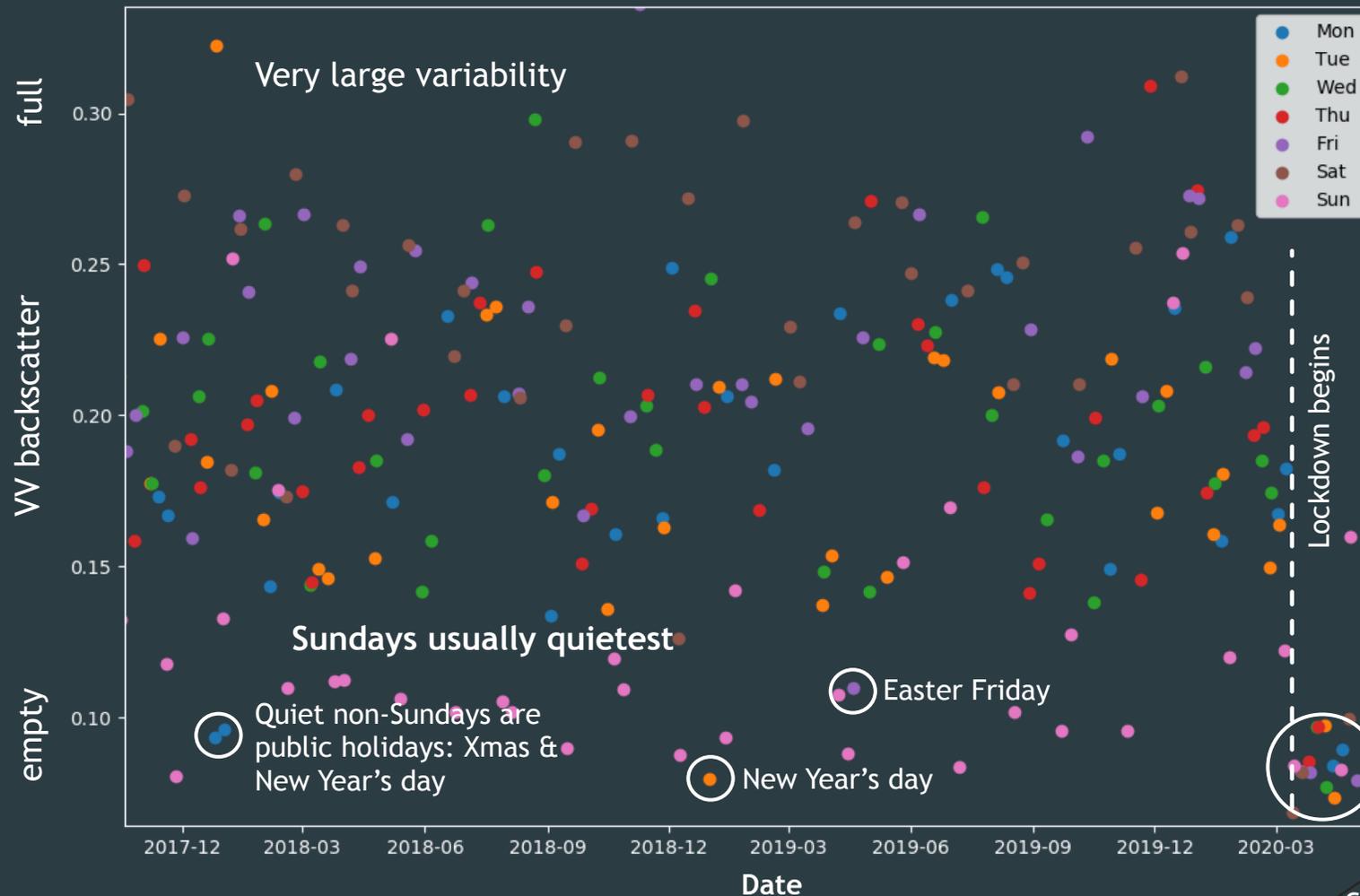
## Shopping Complex Parking - Time Series



- Car park use (proxy for shopping centre customer visits) highly variable in normal circumstances.
- However, consistent low backscatter confirmed by Pleiades optical imagery indicates completely empty car parks during lockdown.
- When and how quickly will customer numbers recover after lockdown ends?

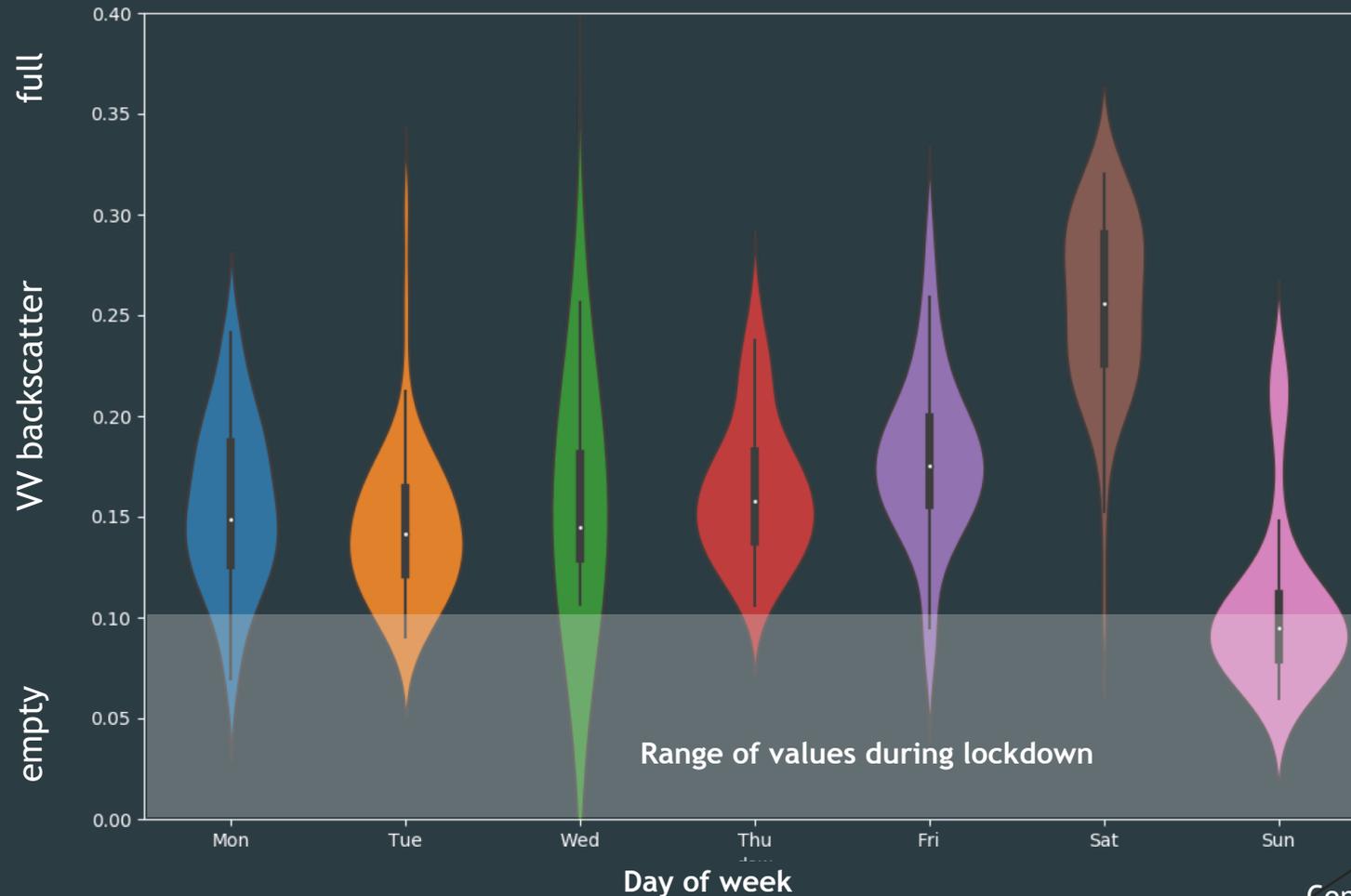
# Case Study 2 - Zaragoza (Spain)

## Shopping Complex - Week-day Patterns



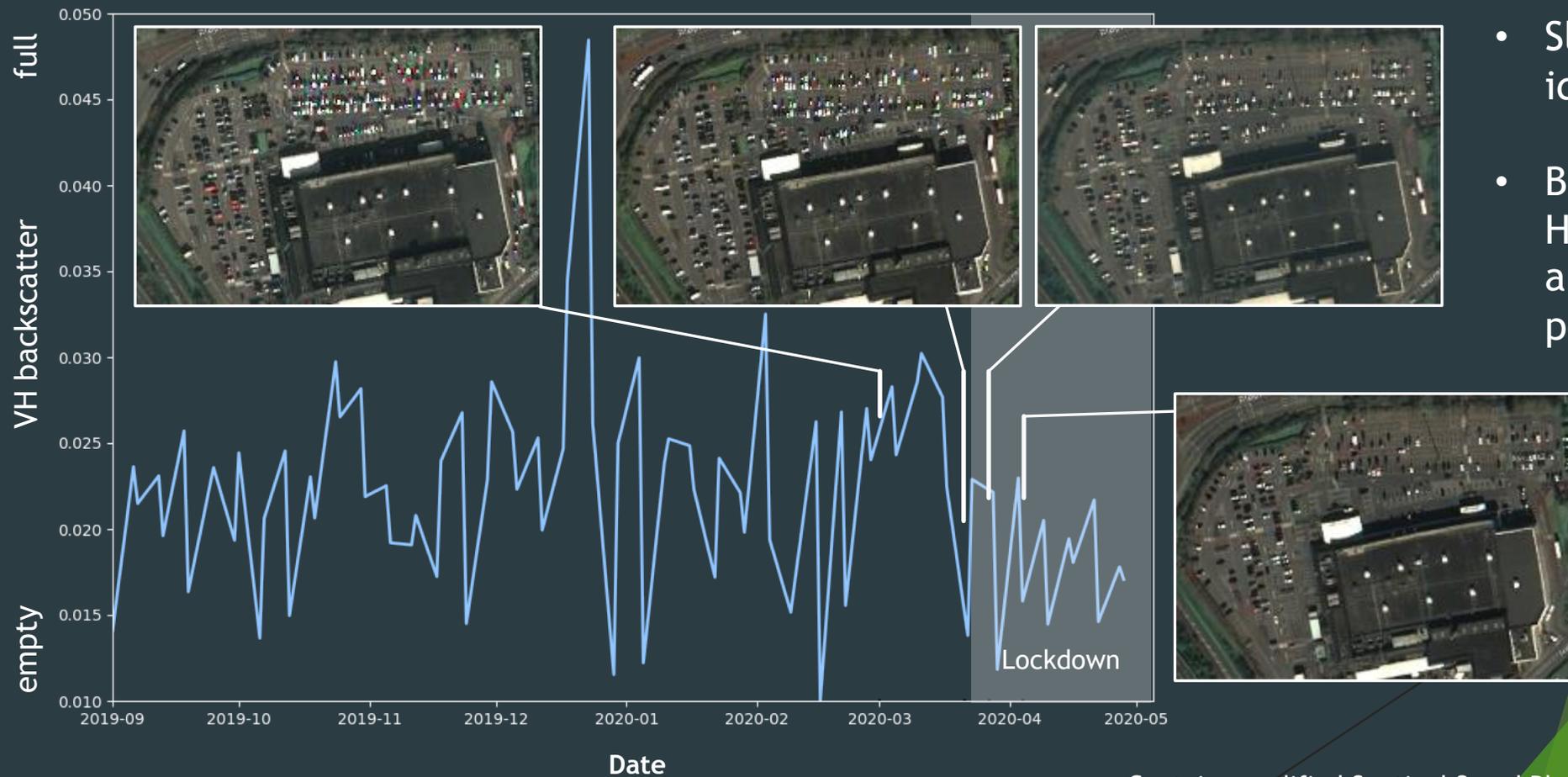
- Very large variability in car park usage by day of week.
- Alternative validation of methodology: Does the parking area usage based on the backscatter follow expected patterns?
- The method correctly identifies:
  - Sundays and public holidays are quietest (shops are closed)
  - Saturdays are mostly busy

# Case Study 2 - Zaragoza (Spain) Shopping Complex - Week-day Usage Distributions



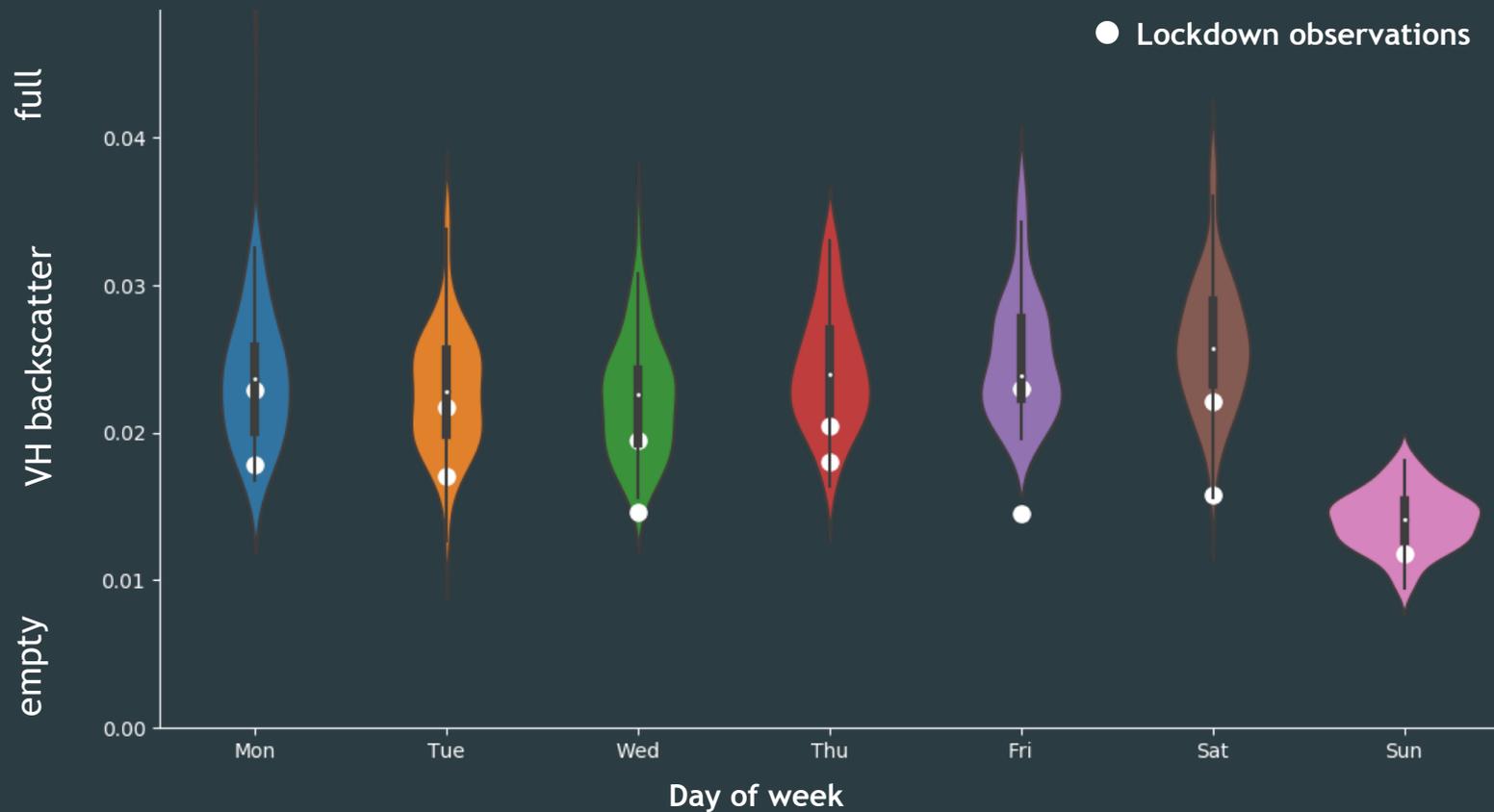
- Analysis of week-day usage distributions in normal circumstances:
  - Saturday busiest
  - Sunday quietest
  - Week days similar
  - Lockdown consistently lower than normal conditions

# Case Study 3 - Dagenham (UK) Supermarket - Time Series



- Slightly reduced usage identified in Pleiades
- Backscatter method: Highly variable normally and in lockdown but possible slight reduction?

# Case Study 3 - Dagenham (UK) Supermarket - Week-day Distributions



- Comparison of typical usage distributions and usage on particular days in lock down.
- Lockdown usage observations consistently below average, but not exceptionally low - i.e. not empty.

# Summary of Results - Methodology

- ▶ Direct visual comparison of S1 backscatter with PlanetScope and Pleiades VHR optical imagery confirms the basic methodology:
  - ▶ S1 backscatter can be used as a measure of parking area usage.
- ▶ Analysis of broader parking area usage patterns further validates the methodology, e.g. for retail:
  - ▶ relative usage by day of week
  - ▶ lack of usage on public holidays
- ▶ Major changes such as full to empty parking areas are clearly distinguishable, and more subtle changes can be identified statistically when the day-of-week variability is considered.

# Summary of Results - Impacts of COVID-19

- ▶ The significant reduction in air travel is expressed by the emptying of the long-stay parking areas at London Gatwick airport.
  - ▶ The pattern began rapidly over the period when Western European nations were beginning their lockdowns.
  - ▶ As of early May, the parking areas remain empty, reflecting the continued low levels of passenger air travel.
- ▶ Complete absence of customers visiting Zaragoza shopping centre expressed by the emptiness of the customer car parks.
  - ▶ Pattern began at the start of lockdown in March and continues in early May.
  - ▶ Future question: when and how quickly will customer numbers recover?
- ▶ Slight reduction in customers visiting Dagenham supermarket expressed as slight reduction in usage of car park.
  - ▶ Pattern is subtle but occurs around start of lockdown.
  - ▶ Future question: when and how quickly will customer numbers recover?

# Potential applications

- ▶ Measurement of car park usage with free and open, frequent and global Sentinel 1 SAR data can be used as a proxy for many economic activities.
- ▶ Proxies demonstrated here:
  - ▶ International (or domestic) passenger air travel volumes by airport long-stay parking area monitoring.
  - ▶ Essential retail (food etc.) activity by supermarket parking area monitoring.
  - ▶ Non-essential retail activity by shopping centre parking area monitoring.
- ▶ Possible additional proxies:
  - ▶ Industrial activity by factory and warehouse parking area monitoring.
  - ▶ Logistics/freight transport activity by logistic hub (e.g. airport freight facilities) parking area monitoring.
  - ▶ Car manufacturing output/surplus and distribution by car factory and distribution centre parking and storage area monitoring.
  - ▶ Large city commuting and visitor numbers by park and ride parking area monitoring.
- ▶ Besides these economic aspects, parking area monitoring may also help to indicate the patterns of movement and concentration of people to assist policy makers in coordinating post-lockdown pandemic suppression measures.