

Enhancing Macroeconomic Statistics with Sentinel-1:

Monitoring Automotive Production in Germany for Timely Economic Indicators

Authors

Franziska Kraft¹, Sandro Martinis¹, Simon Plank¹, José Manuel Delgado Blasco²

Affiliations

¹ German Remote Sensing Data Center (DFD), German Aerospace Center (DLR)
² Earth Observation Climate Action, Sustainability and Science Department (EOP-S), European Space Agency (ESA)

Introduction

- Traditional macroeconomic indicators suffer from substantial reporting delays (e.g., German GDP released ~30 days after the end of the quarter)
- Economic crises like COVID-19 exposed the need for near real-time data to support policy decisions
- Earth Observation offers systemic, border-independent observations to complement official statistics
- Automotive industry accounted for ~4% of German GDP in 2021, making it a meaningful proxy for the wider economy

Objective

Developing a Sentinel-1 based indicator tracking production parking lot occupancy as a real-time proxy for automotive production levels (based on a prototype previously implemented as part of the Rapid Action for COVID-19 and Earth Observation initiative of ESA)

Methods

- Site selection:**
- 18 of 24 domestic production sites selected based on suitability of open-air production parking lots
- Sentinel-1 data**
- GRD Level-1, IW mode, VH polarization
 - Observation period from October 2014 to June 2024 with revisit times of 1–12 days
- Processing:**
- Mean σ^0 backscatter per parking lot retrieved via SentinelHub Statistical API → Higher backscatter = more cars present (double bounce effect on metallic vehicle shells)
 - Time series split by orbit, min–max normalized, then recombined
 - Parking lots aggregated by size (weighted average) at site level; simple average at manufacturer and national level
- Validation**
- National level: VDA monthly production figures
 - Manufacturer level: MarkLines monthly data
 - Pearson correlation on min–max normalized time series

Results

- Observed patterns**
- Mean monthly occupancy consistently lower in July–August and December–January across most sites, matching common plant holidays
 - Sharp drops in parking lot occupancy visible at nearly all sites around the first COVID-19 lockdown in March 2020
 - Post-2022 deviations for Ford and Opel, overestimation of production volume potentially linked to logistics bottlenecks

Fig. 1. Overview of domestic automotive production sites by manufacturer in Germany.

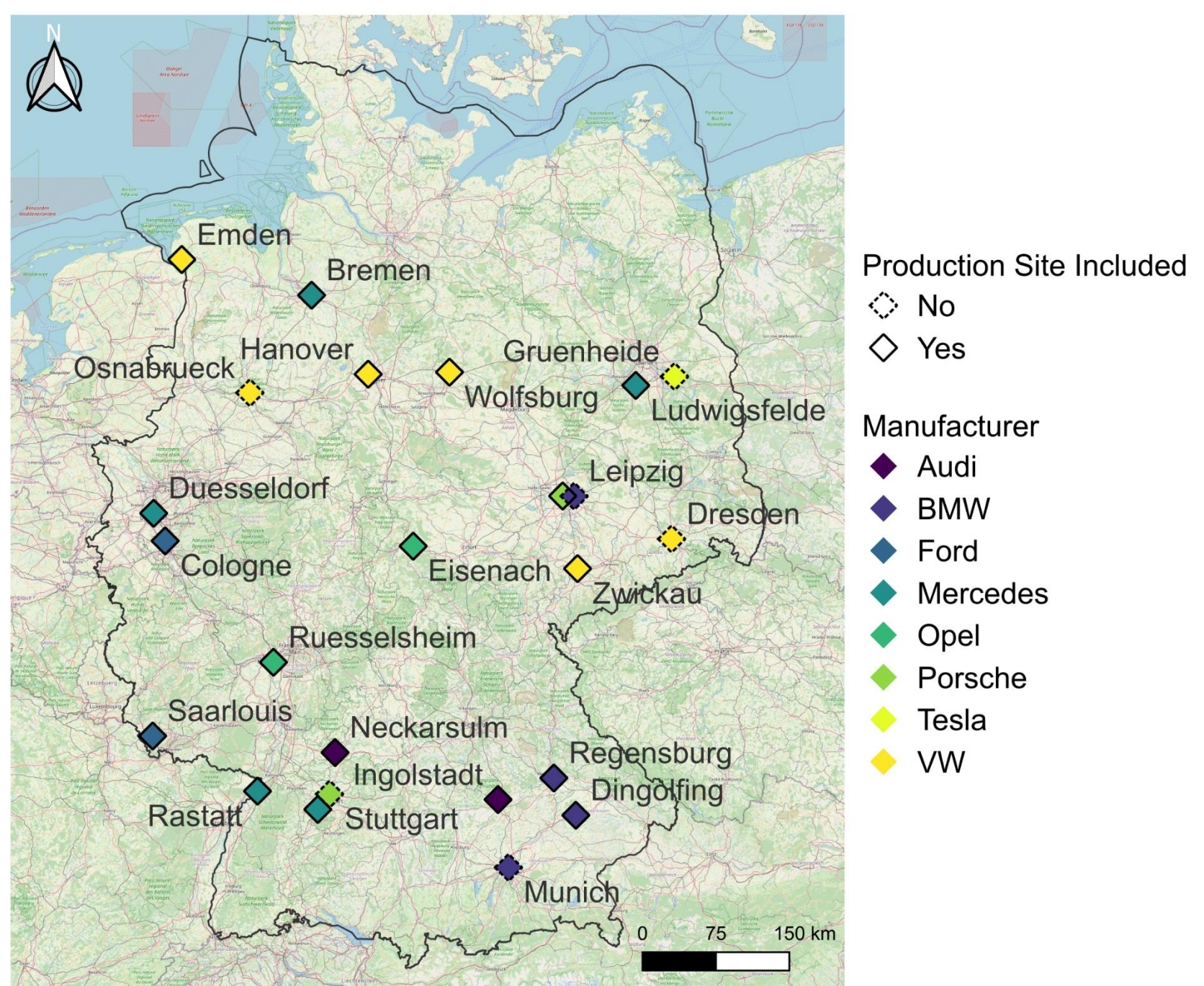
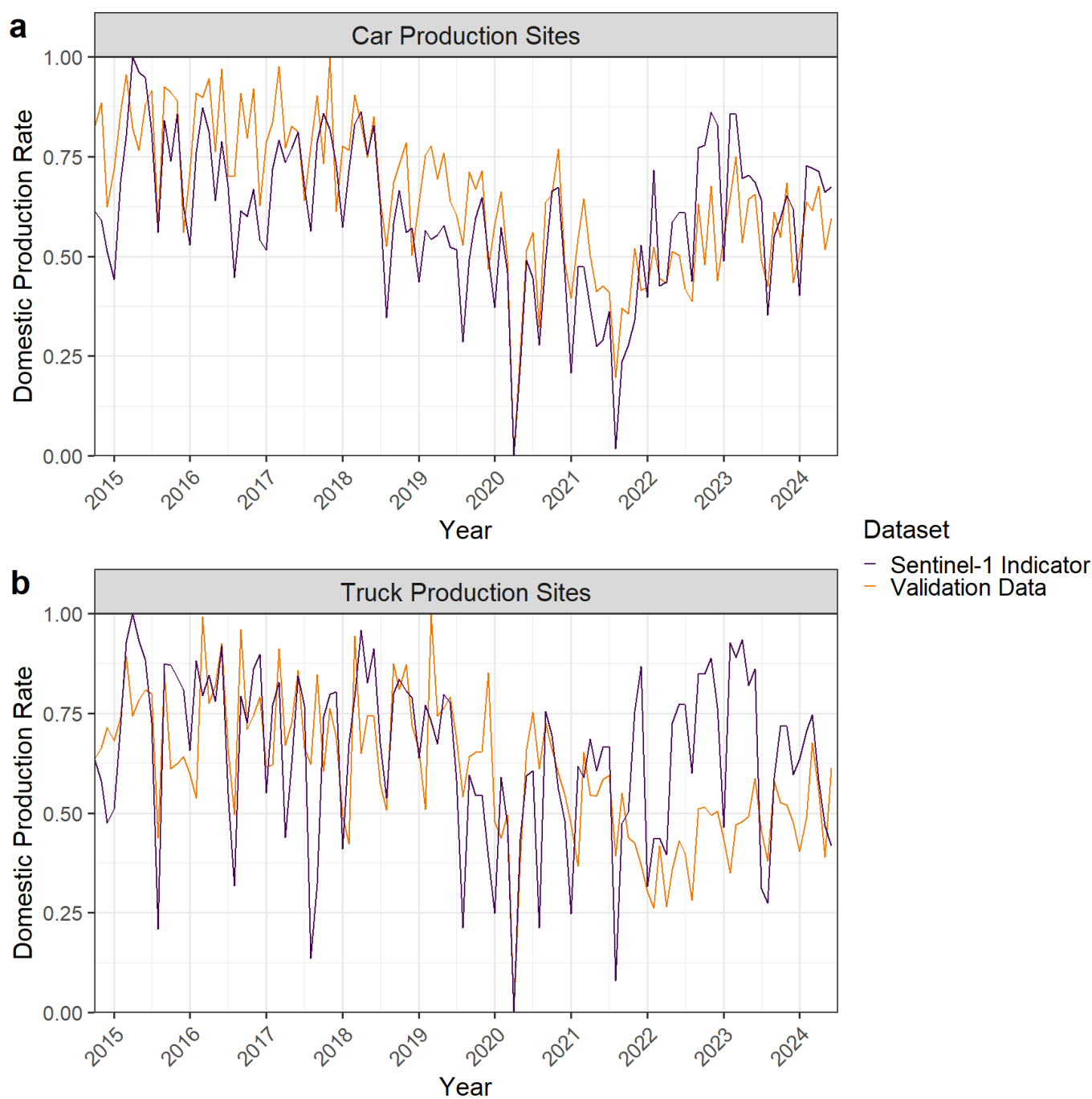


Table 1. Overview of Validation Results.

Manufacturer	Number of Sites	Vehicle Type	Pearson's Correlation Coefficient			Validation Data Source
			combined orbits	ascending orbit	descending orbit	
Audi	2	Cars	0.35	0.20	0.50	MarkLines
BMW	2	Cars	0.50	0.49	0.50	MarkLines
Ford	2	Cars	0.58	0.56	0.57	MarkLines
Mercedes	3	Cars	0.61	0.62	0.58	MarkLines
	2	Trucks	0.22	0.23	0.21	MarkLines
Opel	2	Cars	0.30	0.23	0.31	MarkLines
Porsche	1	Cars	0.26	0.24	0.25	MarkLines
VW	3	Cars	0.69	0.71	0.66	MarkLines
	1	Trucks	0.57	0.44	0.60	MarkLines
All	15	Cars	0.74	0.72	0.75	VDA
	3	Trucks	0.45	0.44	0.45	VDA

Fig. 2. Comparison of the satellite-based production indicator (purple lines) and the VDA validation data (orange lines) for the (a) car and (b) truck production sites aggregated for the entire domestic production.



Discussion

Strengths

- Weather-independent, openly available, continuous monitoring
- Captures broad production trends and major disruptions
- Despite coarse resolution, mean backscatter is sensitive to sub-pixel occupancy changes

Limitations

- Short-term production halts not always visible (vehicles may remain parked; bundled shipments)
- Indoor storage facilities not captured
- Aggregated validation data limits site-level performance assessment
- Temporal resolution constrains capturing rapid occupancy changes

Conclusion

- Sentinel-1 based production parking lot occupancy is a viable real-time proxy for automotive production in Germany
- Indicator can complement traditional short-term economic statistics with significantly reduced latency
- Future work: methodological refinement, transfer to other sectors (retail, tourism, port logistics)

Acknowledgments

Funded by the European Union under the programme "SMP-ESS-2022-GEOS-REGIO-IBA" (Grant 101113054) as part of the project "Satellite-based economic flash estimates".

Full Paper

Kraft, F., Martinis, S., Krullikowski, C., Plank, S., Anghilea, A., Delgado Blasco, J. M., Schönenberger, K., Köhlmann, M., & Brauchler, M. (2025). Satellite Data for Economic Insights: Towards Tracking Automotive Production in Germany With Sentinel-1 for Economic Nowcasting. *IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing*, 18, 23505–23514. <https://doi.org/10.1109/JSTARS.2025.3601351>