

# Satellites Turn "Concrete": Tracking Cement with Satellite Data and Neural Networks - Applications for Emerging Countries

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## *Cement matters...*

2nd most used material in the world after water: 4.6B tons produced in 2015

Used in almost all economic sectors

Key element to monitor the construction industry - and economic activity (Li et al., 2016; Deakshinamurthy, 2017)

## *... and data is not available*

Available stats have 1 to 12 months lags

No uniformity between countries in the origins and calculation method of data

Lack of information for many developing countries

# What is cement ?

Limestone and clay → calcination → clinker → cement

- *Calcination is the key:*

- takes place in huge rotary kilns

- easily identified

- 1400 degrees celsius

- allows for infrared detection!

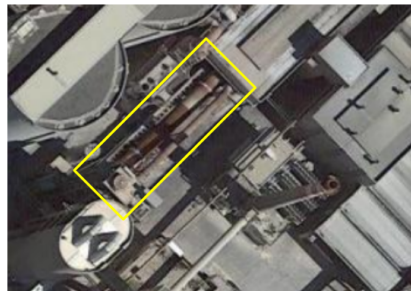


Figure 1: Satellite image of a kiln

# Origin of data

## *Satellite technology:*

Sentinel-2A (2015) Sentinel-2B (2017)

European Space Agency (ESA)

Mean revisit: 3.8 days

Data : <https://scihub.copernicus.eu>



Figure 2: Satellite Sentinel-2

# How does it work? - Fundamentals

**The difference between the bands is the key !**

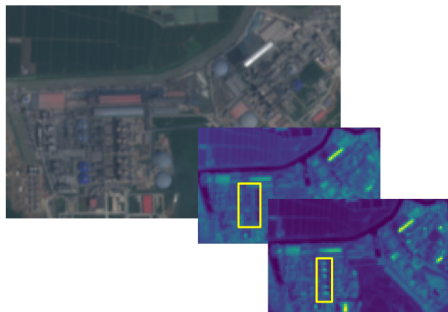
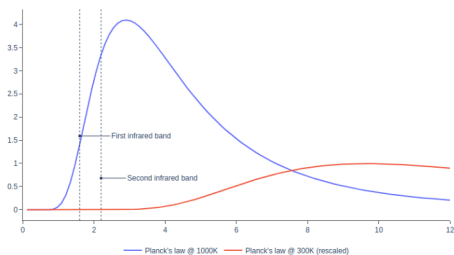


Figure 3: Planck's law and rotary kilns

# How does it work? - Fundamentals

## The problem of clouds

Cloudy images interfere with the heat index...

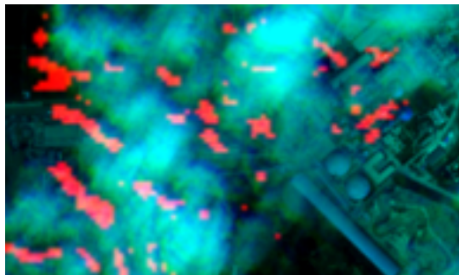


Figure 4: Interference from clouds

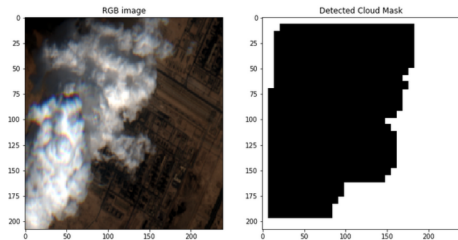


Figure 5: Cloud mask

**AI + Physics are helping us!**

The bands are acquired with a slight offset

AI can detect and tag them

# What do we obtain?



Figure 6: Satellite image of Wuhan cement plant



# What do we obtain?

- Binary index for each kiln and each observation date (0:off; 1:on)
- Aggregate at the country level:



Figure 7: Daily activity index for US cement production

- Refer to [d'Aspremont et al., 2023](#) for more information

# Result at a glance

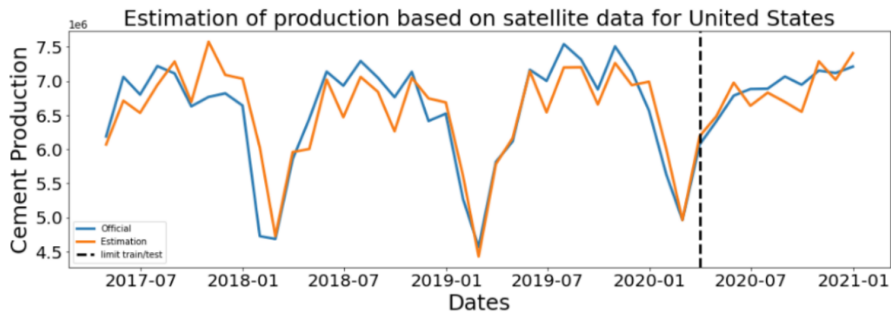


Figure 8: US monthly cement production estimated with satellite data

# Estimation of construction - Out-of-sample RMSE on June 2019-June 2021

**Table 5.** Relative RMSE (out-of-sample)

	Satellite vs. RW	Satellite vs. AR	Satellite vs. PMIs	Satellite vs. GT	Satellite vs. permits
China	-6.3%	-18.6% *	-14.5%	N.A.	N.A.
Euro Area	-39.1% ***	-22.4% *	-1.3%	-20.6% *	N.A.
Spain	-29.8% **	-21.7% **	-11.7%	-19.7% **	-7.7%
Germany	-28.5% **	10.8%	-0.7%	6.0%	6.5%
France	-35.0% **	-18.8% *	3.6%	-9.4%	-17.4% **
Italy	-35.9% **	-15.1%	1.5%	-12.8%	N.A.
United States	0.0%	-2.3%	-24.8% *	-7.5%	N.A.
Brazil	-16.0% *	-10.6%	-11.7%	-8.6%	N.A.
Russia	N.A.	N.A.	N.A.	N.A.	N.A.
Mexico	N.A.	N.A.	N.A.	N.A.	N.A.
United Kingdom	-14.0% *	-34.4% **	6.9%	-31.3% **	N.A.
<b>Average</b>	<b>-22.7%</b>	<b>-14.8%</b>	<b>-5.9%</b>	<b>-13.0%</b>	<b>-6.2%</b>

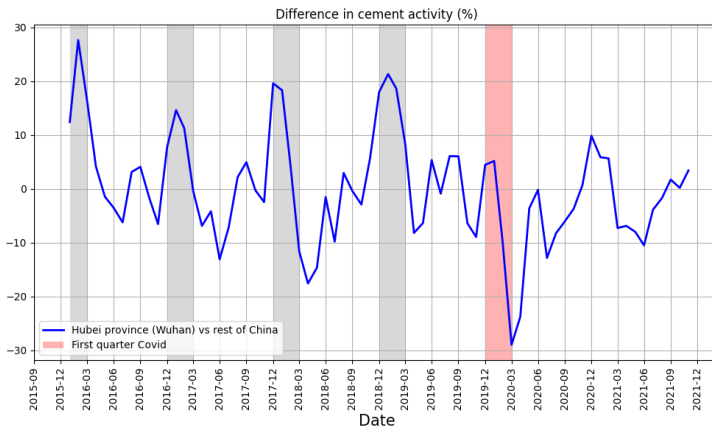
Notes: Period for out-of-sample is June 2019 to June 2021. Results are presented relative to AR and RW models: a negative value indicates over-performance of the OLS model. Coverage ratio is the share of cement plants covered by our technology. \*\*\*, \*\*, and \* indicate that the outperformance in predictive accuracy of the OLS model with satellite-based data is found significant at respectively the 1%, 5%, and 10% levels, based on a one-sided Diebold-Mariano test. Test results are not available for the average.

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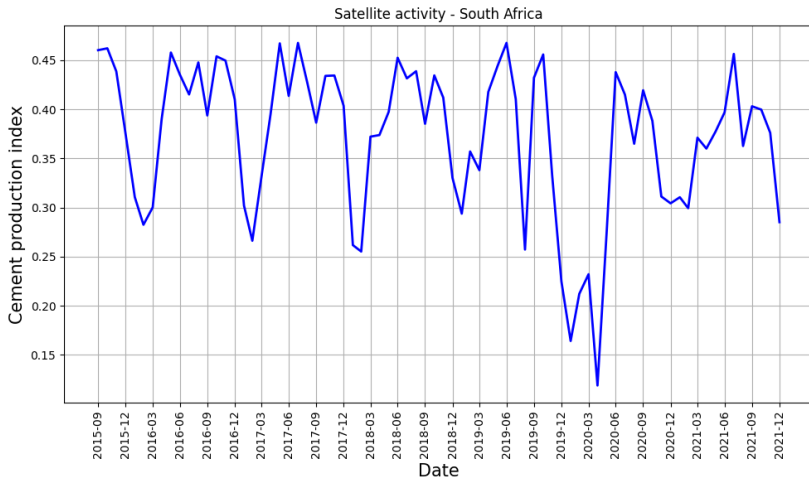
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# Covid-19 in China

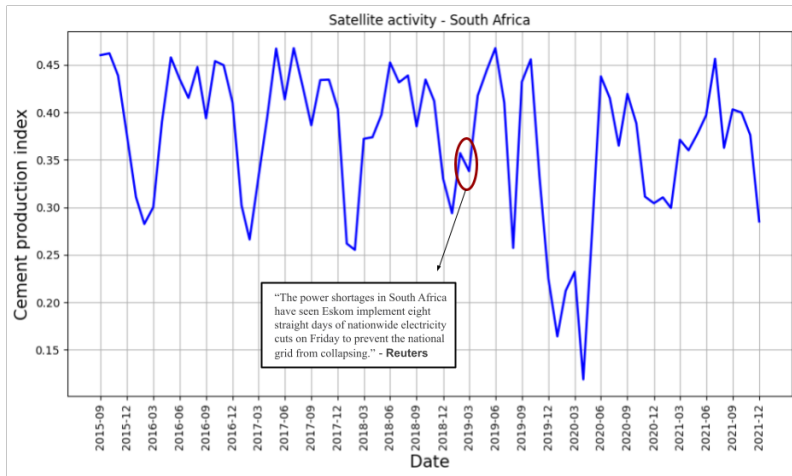
- Satellite activity of Hubei province and rest of China normalised (mean = 100)
- The difference between both series is plotted



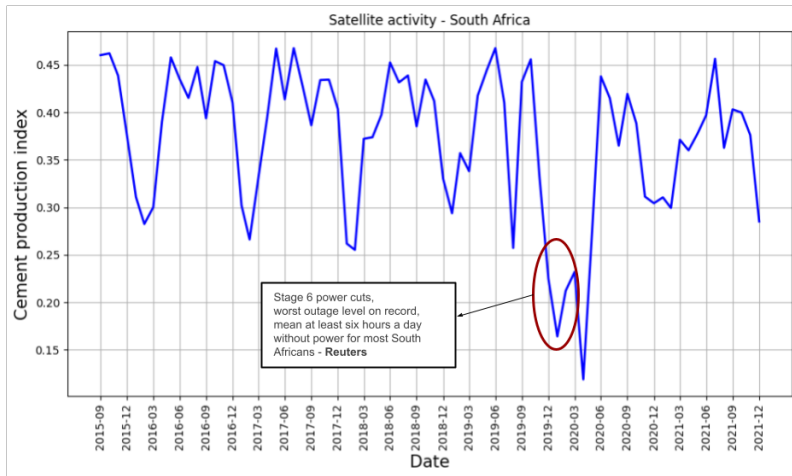
# South Africa



# South Africa

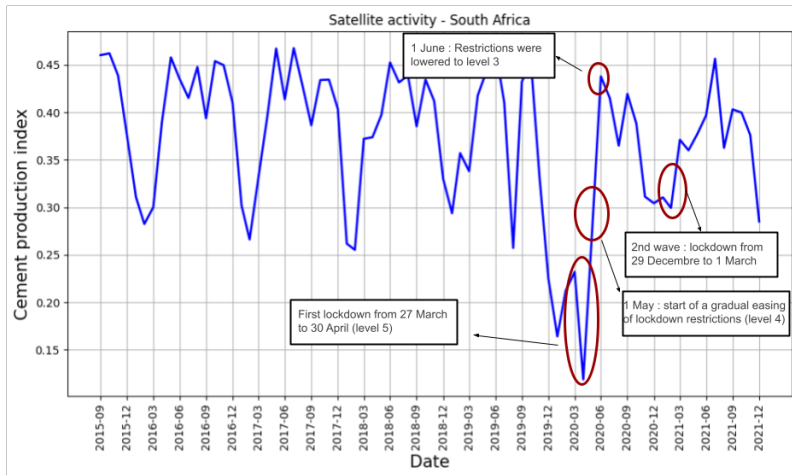


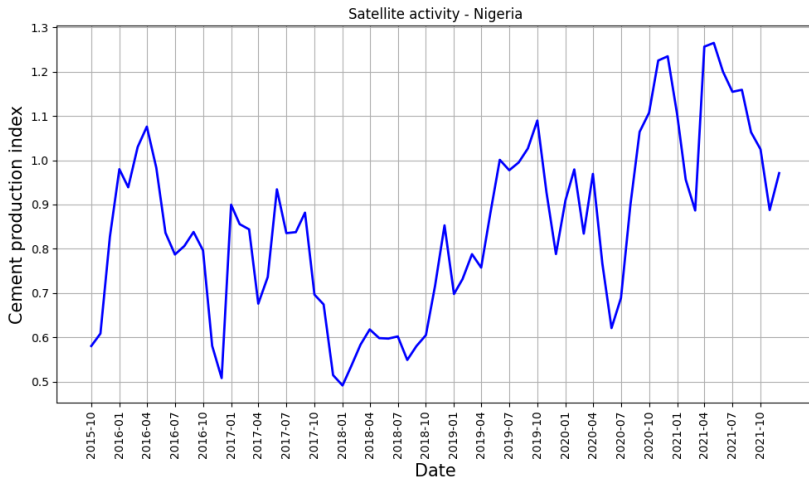
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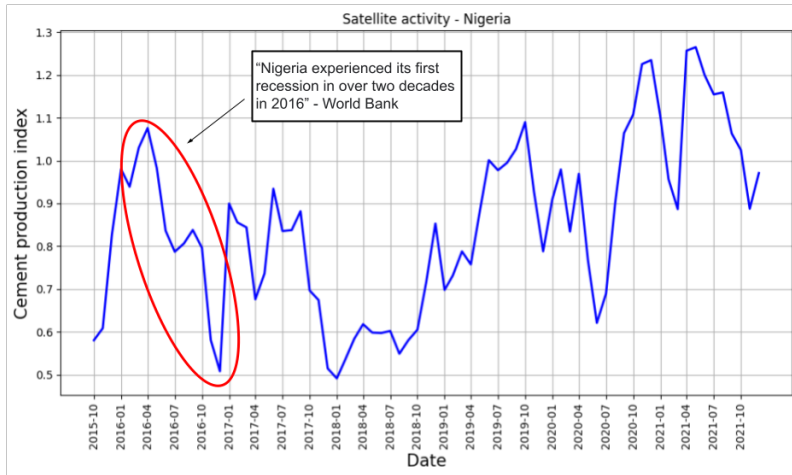


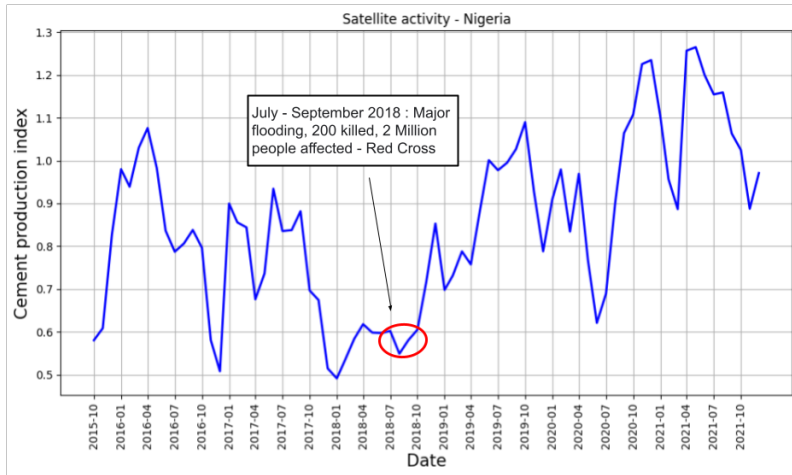
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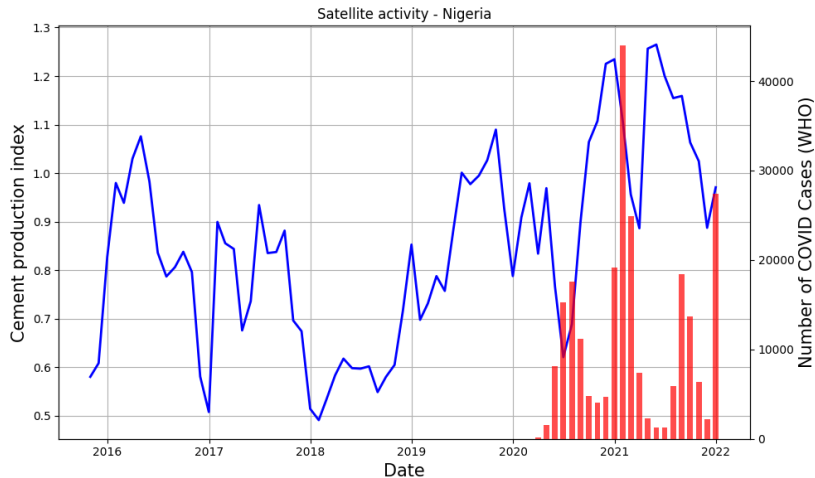


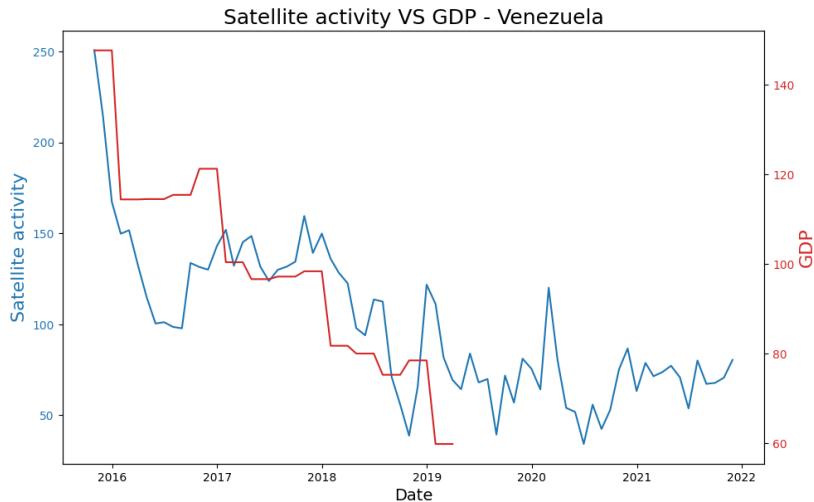


# Nigeria









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- ① Development of a new indicator:
  - In (quasi-)real time
  - Global coverage
  - Homogeneous data
  - Independent from states
- ② For detailed monitoring of activity in the construction industry and economic activity
- ③ Allow for study of regional economics