

ECON 109: Economics from Outer Space

Instructor: Megha Patnaik

Summer Quarter 2025-2026

Course Description: The possibilities for economic measurement have been transformed through observation of the earth from satellites. In this course, we will study the array of possibilities in public and commercial imagery, and link up to applications in economic research and industry. The course will start from the physics foundations of how satellites see the earth, examine measurement opportunities at all frequencies, show research and business applications, and carry the students to the point of writing code in Julia for one small problem.

Prerequisites: ECON 1

Course objectives: The objective of the course is to give students a broad base of knowledge of how satellite data can be used to study economic questions and generate working code for one application through the class project that can be used as future resource. A portion of class time will be devoted to group assignments which are to begin in class with your groups (3-4 students in each group) and one submission per group is due by noon on the following week Monday.

Evaluation: In line with the course objectives, students will be evaluated on the basis of class participation (10%), group assignments (30%) group project presentation (30%), and final exam based on main readings (30%).

Logistics: TBA

Course outline:

Introduction to satellite data in economics. The physics of remote sensing: the electromagnetic spectrum, and potential economic applications of different wavelengths. Public sources of satellite data: Landsat, JPSS, and Sentinel. Private satellite data sources. Heights and orbits, geostationary orbits. Introduction to Julia and Raster data structure.

Nighttime lights as a measure of prosperity, sample applications, limitations of the measure. Observing nighttime light radiance: Satellites collecting the data: how to make a map of the world at night. Downloading data from Earth Observation Group, understanding the structure of the data. Working examples in the group assignments that give students code to adapt for the course project.

Illustration of a diverse set of applications of satellite data in economics in: economic growth, economic history, development economics, and climate and political economy. Working examples in the group assignments that give students code to adapt for the course project.

The course will conclude with student presentations using nighttime light data to study an economic question for a region and a time period of their interest. Instructions for the presentation will be provided.

INDIVIDUAL CLASS SCHEDULE

WEEK 1: FOUNDATIONS

Mon June 22: Introduction

Main resource: [Dave Donaldson and Adam Storeygard. The view from above: Applications of satellite data in economics. *Journal of Economic Perspectives*, 2016](#)

Discussion: What are the advantages of remote sensing-based data? We discuss examples where satellite data is able to help us study economic questions based on the high resolution, wide coverage, and availability of data when other sources are unavailable. The Main resource provides an overview of what we will study in the course conceptually.

Wed June 24: A primer on remote sensing

Main resource: [Dave Donaldson and Adam Storeygard. The view from above: Applications of satellite data in economics. *Journal of Economic Perspectives*, 2016](#)

Discussion: We discuss the different divisions of the electromagnetic spectrum and the potential information in each of these available for observation. We see examples of data from satellites such as Landsat, Modis and Sentinel. We learn about sensors used to capture different bands of the electromagnetic spectrum and how this can be used to construct indices. We understand the heights and orbits different satellites operate at, and the resolutions provided by the sensors.

Fri June 26: Introduction to Julia

Main resource: Worksheet provided in class

Discussion: Julia is a high-performance computing language that is particularly helpful for processing large datasets. We will install Julia on our computers and set up our coding environments. You will learn the basic tools needed to start with satellite data. These include writing a for loop, multiplying matrices, and processing images. Please bring your computers as you will work together with your groups in class. We will assist you with the setup and questions during the duration of the class.

WEEK 2: NIGHTTIME LIGHTS DATA

Mon June 29: Nighttime Lights as a measure of prosperity

Main resource: Lecture slides

Advanced resource: [J Vernon Henderson, Adam Storeygard, and David N Weil. Measuring economic growth from outer space. *American Economic Review*, 102\(2\):994–1028, 2012](#)

Other resource: [Vernon Henderson, Adam Storeygard, and David N Weil. A bright idea for measuring economic growth. *American Economic Review*, 2011](#)

Discussion: We discuss how nighttime light activity can proxy for economic prosperity. What are the advantages of this measure and what are the limitations? We look at a few applications together.

Wed July 1: Downloading Nighttime Lights data

Main resource: [The NPP Mission Brochure](#) and the [Earth Observation Group website](#) in the class worksheet.

Link for data download: <https://eogdata.mines.edu/products/vn1/>

Discussion: We will be studying the Suomi NPP Satellite which hosts the VIIRS sensor which collects the Day and Night band that we use to measure Nighttime Lights. We will visit the Earth Observation Group website together and navigate to data download. We will understand how a picture of the world at night is constructed. We review the file nomenclature and filesystem structure, and download TILE 1 data as well as a smaller dataset for California. We read these datasets into Julia and familiarize ourselves with rasters objects.

Fri July 3: Independence Day (no class)

WEEK 3: ECONOMIC GROWTH

Mon July 6: Applications: economic growth

Main resource: https://www.youtube.com/watch?v=9nnQq41P_6o

Advanced resource: Danny Quah. The global economy's shifting centre of gravity. *Global Policy*, 2011, Peter Cauwels, Nicola Pestalozzi, and Didier Sornette. Dynamics and spatial distribution of global nighttime lights. *EPJ Data Science*, 2014

Discussion: This week we have our first application of satellite data to an economic question: Has the center of economic activity shifted towards Asia? A question posed as early as 2011 based on GDP estimates is validated using satellite data. How far have we come from these predictions? How much variation is there within countries?

GROUPS FOR GROUP ASSIGNMENTS & FINAL PRESENTATION WILL BE ASSIGNED ON JULY 7.

Wed July 8: Working with shapefiles in Rasters.jl

Main resource: <https://rafaqz.github.io/Rasters.jl/dev/>

Discussion: We understand how spatial data is organized in vector and raster forms. We use the Rasters.jl package to read, write and manipulate rasterized spatial data. We understand the concept of a Raster “stack” for a region of interest. You will learn about shapefiles and how to use them on Nighttime lights data. Please bring your computers as you will work together with your groups in class where we will assist you during the duration of the class.

Fri July 10: ASSIGNMENT 1: Group assignment for using shapefiles in Rasters.jl

The assignments are designed to get you tooled up for the group project. Please bring in computers as you will work together with your groups in class where we will assist you during the duration of the class. You can continue to work on the assignment and submit one assignment per group by the following **Monday July 13** at noon.

WEEK 4: ECONOMIC HISTORY

Mon July 13: Roman Roads

Main resource: [On Roman roads and the sources of persistence and non-persistence in development](#)

Advanced resources: [Carl-Johan Dalgaard, Nicolai Kaarsen, Ola Olsson, and Pablo Selaya. Roman roads to prosperity: Persistence and non-persistence of public goods provision. 2018](#)

Resources for the ORBIS class exercise: [London to Rome on Horseback. The Economist, May 2012.](#) and [ORBIS Route finding tutorial](#)

Discussion: Is economic prosperity persistent? We travel to Ancient Rome to explore areas where there was a high density of infrastructure historically and find that they show high economic activity as measured by nighttime lights in the present time. We will also explore the Roman Road Network with <https://orbis.stanford.edu/>

Wed July 15: Lost Cities

Main resources: (1) [Economists Find Lost Cities Using This Simple Idea, Trade, Merchants, and the Lost Cities of the Bronze Age.](#)

Advanced resources: [Gojko Barjamovic, Thomas Chaney, Kerem Coşar, and Ali Hortaçsu. Trade, merchants, and the lost cities of the bronze age. The Quarterly Journal of Economics, 2019](#)

Discussion: Is economic prosperity persistent? This week we look at two examples where areas where there was a high density of infrastructure historically show high economic activity as measured by nighttime lights in the present time. The second example is on finding lost cities in Assyria.

Fri July 17: Worksheet for sum of light using NighttimeLights.jl

Main resource: Worksheet provided in class.

Discussion: We use the Julia package NighttimeLights.jl to extract and analyze data on nighttime light intensity for the US. We use the data in combination with shape files to construct region-level sums of nighttime lights. Please bring in computers as you will work together with your groups in class where we will assist you during the duration of the class.

WEEK 5: CODING WEEK

Mon July 20: ASSIGNMENT 2: Group assignment for sum of light using NighttimeLights.jl

The assignments are designed to get you tooled up for the group project. You will bring in computers and work together with your groups in class where we will assist you during the duration of the class. You can continue to work on the assignment and submit one assignment per group by the following Monday **Jul 27** at noon.

Wed July 22: Worksheet to cut a circle around a coordinate in NighttimeLights.jl

Please bring your computers as you will work together in class. We will assist you with the setup and questions during the duration of the class.

Fri July 24: ASSIGNMENT 3: Group assignment to cut a circle around a coordinate using NighttimeLights.jl

The assignments are designed to get you tooled up for the group project. You will bring in computers and work together with your groups in class where we will assist you during the duration of the class. Please note that the assignment is due **Friday Jul 31**.

DEADLINE FOR PROPOSALS FOR FINAL GROUP PROJECTS IS JULY 24.

WEEK 6 CLIMATE AND POLITICAL ECONOMY

Mon Jul 27: Worksheet for radiance datacube in NighttimeLights.jl

Main resource: Worksheet provided in class.

Discussion: We use the Julia package NighttimeLights.jl to work with datacubes (timeseries of rasters) for nighttime lights data. We learn about annular rings and circles on raster data, summary statistics of light measurements, and time series analysis. Please bring your computers as you will work together with your groups in class where we will assist you during the duration of the class.

Wed Jul 29: Measuring Deforestation using Satellite Data

Main resource: [National Policy Reversals and Deforestation in the Amazon](#)

Other reading: [Rainforests provide a public good. The world should pay to conserve them](#)

Advanced resource: [Robin Burgess and Benjamin A Olken. The power of the state: National borders and the deforestation of the amazon. 2024](#)

Discussion: Satellite data can be used to track changes in forest cover and emissions. This can be used to verify countries are on track for climate commitments. We discuss two applications focusing on deforestation this week.

Fri Jul 31: Deforestation and Political Conflict

Main resource: Lecture slides

Advanced resource: [Mounu Prem, Santiago Saavedra, and Juan F Vargas. End-of-conflict deforestation: Evidence from colombia's peace agreement. World Development, 2020](#)

Discussion: Satellite data can be used to track changes in forest cover and emissions. This can be used to verify countries are on track for climate commitments. We discuss two applications focusing on deforestation this week.

WEEK 7: DEVELOPMENT ECONOMICS

Mon Aug 3: Predicting poverty

Main resource: [Combining satellite imagery and machine learning to predict poverty 1,](#)

Advanced resource: [Combining satellite imagery and machine learning to predict poverty 2](#)

Advanced resource: [Neal Jean, Marshall Burke, Michael Xie, W Matthew Davis, David B Lobell, and Stefano Ermon. Combining satellite imagery and machine learning to predict poverty. Science, pages 790–794, 2016](#)

Wed Aug 5: Urbanization

Main resource: [Mapping urbanization in India with satellite imagery](#)

Advanced resource: Kathryn Baragwanath, Ran Goldblatt, Gordon Hanson, and Amit K Khandelwal. Detecting urban markets with satellite imagery: An application to india. *Journal of Urban Economics*, 2019

Discussion: Developing countries have poor data collection on the ground, and official statistics may reflect actual economic activity poorly relative to developed countries. Satellite data allows supplementing on-the-ground measures with measures that are not affected by the quality of economic institutions.

Fri Aug 7: Discuss solutions for the Mock exam with the TA and review for exam.

WEEK 8 (STUDENT PRESENTATIONS)

Mon Aug 10: Group presentations

Group presentations on a chosen area using nighttime light data on an economic context of interest.

Wed Aug 12: Group presentations

Group presentations on a chosen area using nighttime light data on an economic context of interest.