

# Convergence of Economic Growth and the Great Recession as Seen From a Celestial Observatory

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## Abstract

Macroeconomic theories of growth and wealth distribution have an outsized influence on national and international social and economic policies. Yet, due to a relative lack of reliable, system wide data, many such theories remain, at best, unvalidated and, at worst, misleading. In this paper, we introduce a novel economic observatory and framework enabling high resolution comparisons and assessments of the distributional impact of economic development through the remote sensing of planet Earth's surface. Striking visual and empirical validation is observed for a broad, global macroeconomic  $\sigma$ -convergence in the period immediately following the end of the Cold War. What is more, we observe strong empirical evidence that the mechanisms driving  $\sigma$ -convergence failed immediately after the financial crisis and the start of the Great Recession. Nevertheless, analysis of both cross-country and cross-state samples indicates that, globally, disproportionately high growth levels and excessively high decay levels have become rarer over time.

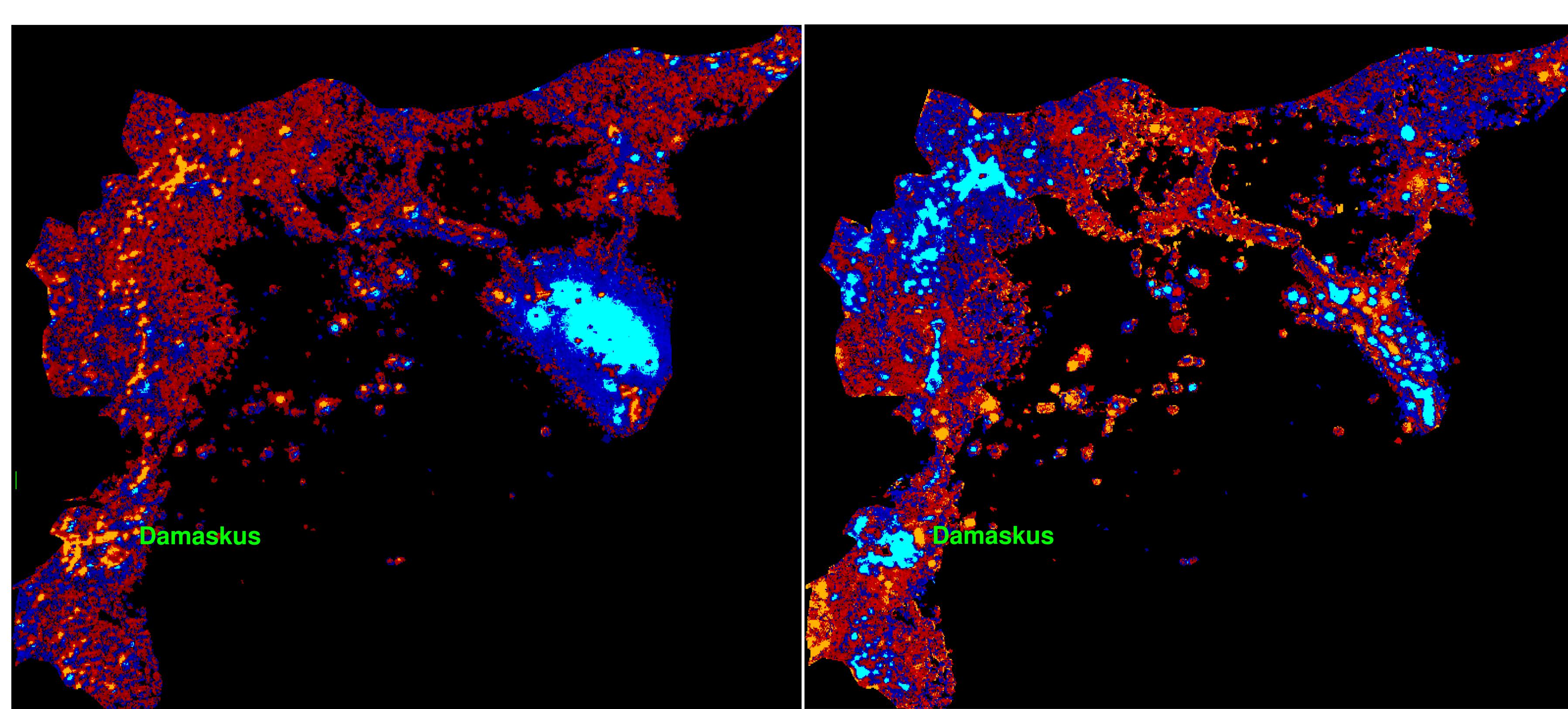
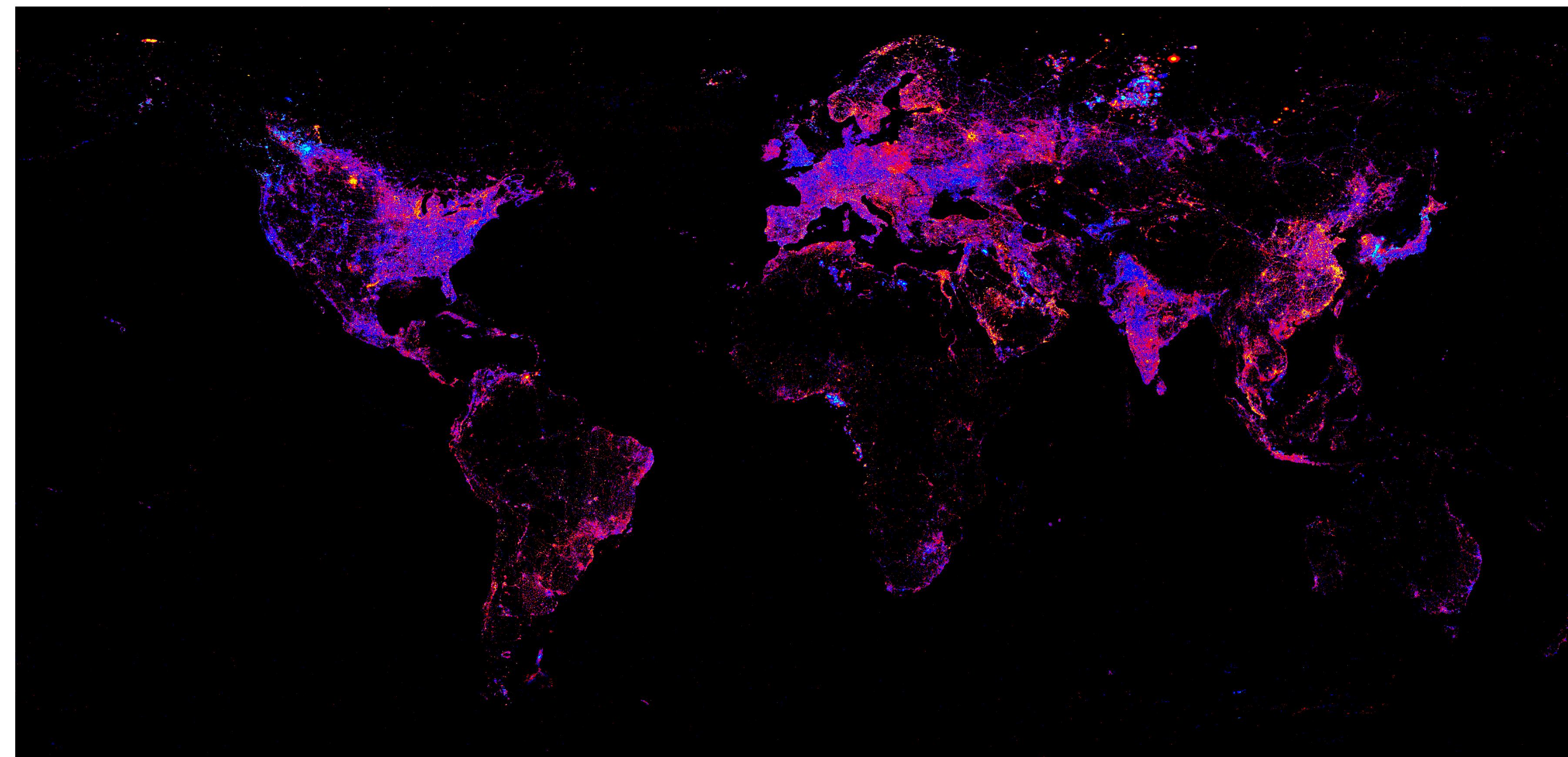
We also see that urban areas, especially concentrated within short distances of major capital cities were more likely than rural or suburban areas to see relatively high growth in the aftermath of the financial crisis. Observed changes in growth polarity can be attributed plausibly to post-crisis government intervention and subsidy policies introduced around the world. Overall, the data and techniques we present here make economic evidence for the rise of China, the decline of U.S. manufacturing, the euro crisis, and the Arab Spring.

## Big Theory needs Big Data

Theoretical models are excellent ways to deal with complexity and to organize data. Yet, *a priori* assumptions can have surprising outcomes and important implications for science and society.

## World Change Detection

Blue-coded areas correspond to net negative dynamics (decay); red-colored areas indicate net positive dynamics (growth)  
Neutral changes are not distinguishable from the black background  
Extreme outliers for negative and positive change are marked with cyan and orange correspondingly



Intensities for nighttime lights are represented by the time-indexed array  $X_t(i, j)$ , where  $t = 1992, \dots, 2013$  and each element contains the intensity of light detected for a pixel with a given longitude  $lon(i)$  and latitude  $lat(j)$ . We perform the following differencing for all pixels to obtain:  $\Delta X_t(i, j) = X_t(i, j) - X_{t-1}(i, j), \forall t \in (1993, 2013)$  We demean our time series:

$$\Delta X'_t(i, j) * \mathbf{1}(\Delta X_t(i, j) \neq 0) = \Delta X_t(i, j) * \mathbf{1}(\Delta X_t(i, j) \neq 0) - \frac{\int_{\text{lon}}^{\overline{\text{lon}}} \int_{\text{lat}}^{\overline{\text{lat}}} \Delta X_t(u, v) dudv}{\int_{\text{lon}}^{\overline{\text{lon}}} \int_{\text{lat}}^{\overline{\text{lat}}} \mathbf{1}(\Delta X_t(u, v) \neq 0) dudv},$$

where  $\mathbf{1}(\Delta X_t(i, j) \neq 0)$  is an indicator function that is zero for all pixels with no change in intensity and one for all pixels that display a change in intensity.

## SIMD vector processing

Instruction-level single processor parallelism is fully exploited.  
Many-core parallelism is handled by the MATLAB parallel toolkit.

## Data: DMSP-OLS Nighttime Lights and NASA/NOAA VIIRS

US Airforce DMSP-OLS Nighttime Lights and NASA/NOAA Visible Infrared Imaging Radiometer Suite (VIIRS) high resolution 2D spatial-temporal satellite data are processed and analyzed: ( $\approx 2-3$  km spatial resolution), 25+ years of annual and monthly spatial data resulting in  $\approx 3$  TB in input data arrays.

Current data for analysis are obtained at higher resolution and frequency.

RCC Midway cluster is used for data storage and processing. Our approach involves statistical analysis with the discrete Fourier transform and a variety of filtering algorithms applied to the observations. High-memory nodes (256GB-1TB) are used for image processing. We filter away both pixels that do not have any signal and pixels that do not show any difference when demeaned.

## References

Convergence of economic growth and the Great Recession as seen from a Celestial Observatory  
by E. Duede and V. Zhorin - EPJ Data Science, 2016  
Economic Development, Flow of Funds and the Equilibrium Interaction of Financial Frictions  
by B. Moll, R. Townsend and V. Zhorin - NBER Working Paper Series, 2017

## Additional imagery

<http://www.victor-z.com/lights.html>

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