

## INTRODUCTION

This project explores the movements of internally displaced persons (IDP's) in Ukraine as a consequence of the conflict in the Donbas, a region in Eastern Ukraine which comprises parts of the Donetsk and Luhansk oblasts.

The United Nations Refugee Agency (UNHCR) estimated in January 2015 that 943,500 residents of Eastern Ukraine had already been displaced by the conflict, which began in March 2014. Most of these IDP's were relocated to cities in central and Eastern Ukraine.

However, official Ukrainian regional population statistics for 2015 do not show the expected population declines in outlying areas in or near the conflict zone. They also do not show population increases in the areas where UNHCR data indicate that they relocated. Proper measurement of this population shift is essential for understanding the dynamics and effects of the conflict.

This project will analyze nighttime lights data to determine if the official population statistics in conflict years provide an accurate representation of the population distribution, as reflected by nighttime lights data, or if new population estimates would be appropriate in assessing the conflict migration patterns. It will also investigate the structural relationship between nighttime lights and rural and urban populations in Ukraine.

While the larger project will address all conflict years (2015 to 2019), this initial investigation will focus on the first and most intense year of conflict, 2014.

## REVIEW OF LITERATURE AND METHODOLOGY

This project builds on existing literature exploring the applications of nighttime lights data to the study of social statistics, including population, in the context of armed conflict.

A wide body of literature has found that nighttime lights data can be used to model granular population patterns (Mellander et al. 2011, Sutton et al. 2010, Tripathy et al. 2017, Bruederle & Hodler 2018, Bharti et al. 2015, etc.) and to study conflict developments (Agnew et al. 2008, Ahrens 2015, Coscieme et al. 2017, Jiang et al. 2017, Witmer & O'Loughlin 2011). An intensive study by Coscieme et al. (2017) found that in the context of the wars in the Caucasus region, nighttime lights data reflect refugee flight and resettlement, as well as conflict-related fires.

This project attempts to replicate much of that paper's methodology in the context of the war in the Donbas. For the initial examination of data, I use raion-level aggregation rather than city boundaries with a buffer to include populated areas. Because many IDP's relocated from rural to urban areas within the Donbas, it may be necessary to use more granular data to accurately capture the population movement (see Figures 1 and 3).

Studies of applications of nighttime lights data for population measurement have found that light volume is best for predicting population density, but in certain circumstances can be a fair predictor of population count, as well (Mellander et al. 2011).

I generate two linear regression models for predicting 2014 and 2015 population based on nighttime light volume, following Tripathy et al. (2017):  $\log(pop_{year}) = \beta_0 + \beta_1 * \log(DN_{year})$

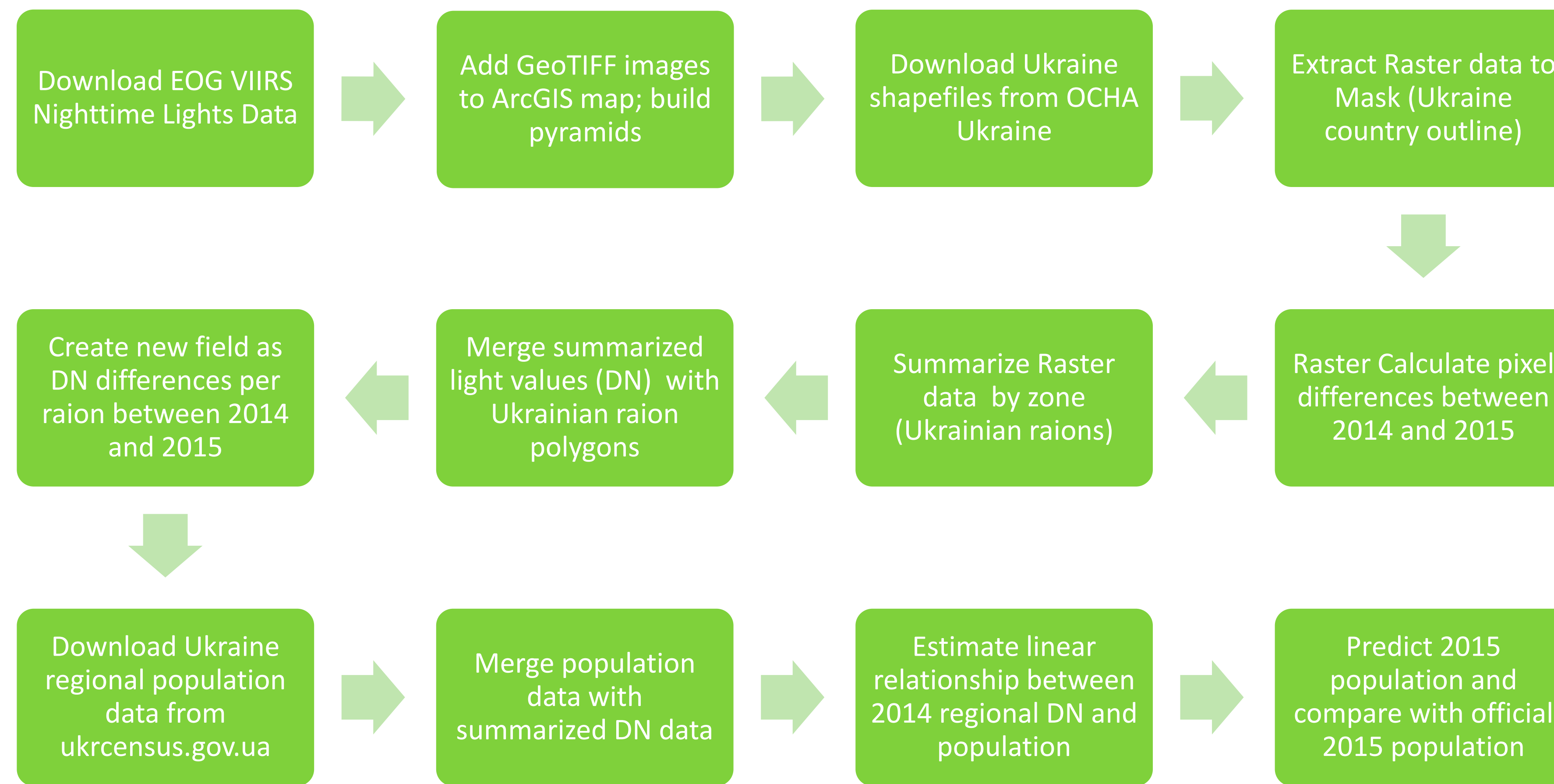
	$\hat{\beta}_0$	$\hat{\beta}_1$	$R^2$
2014	6.31	0.52	0.29
2015	7.84	0.31	0.07

Because the  $R^2$  for the 2015 model is so small, for the purposes of comparison with the official 2015 population statistics, I calculate predicted 2015 population using coefficients from the 2014 model:

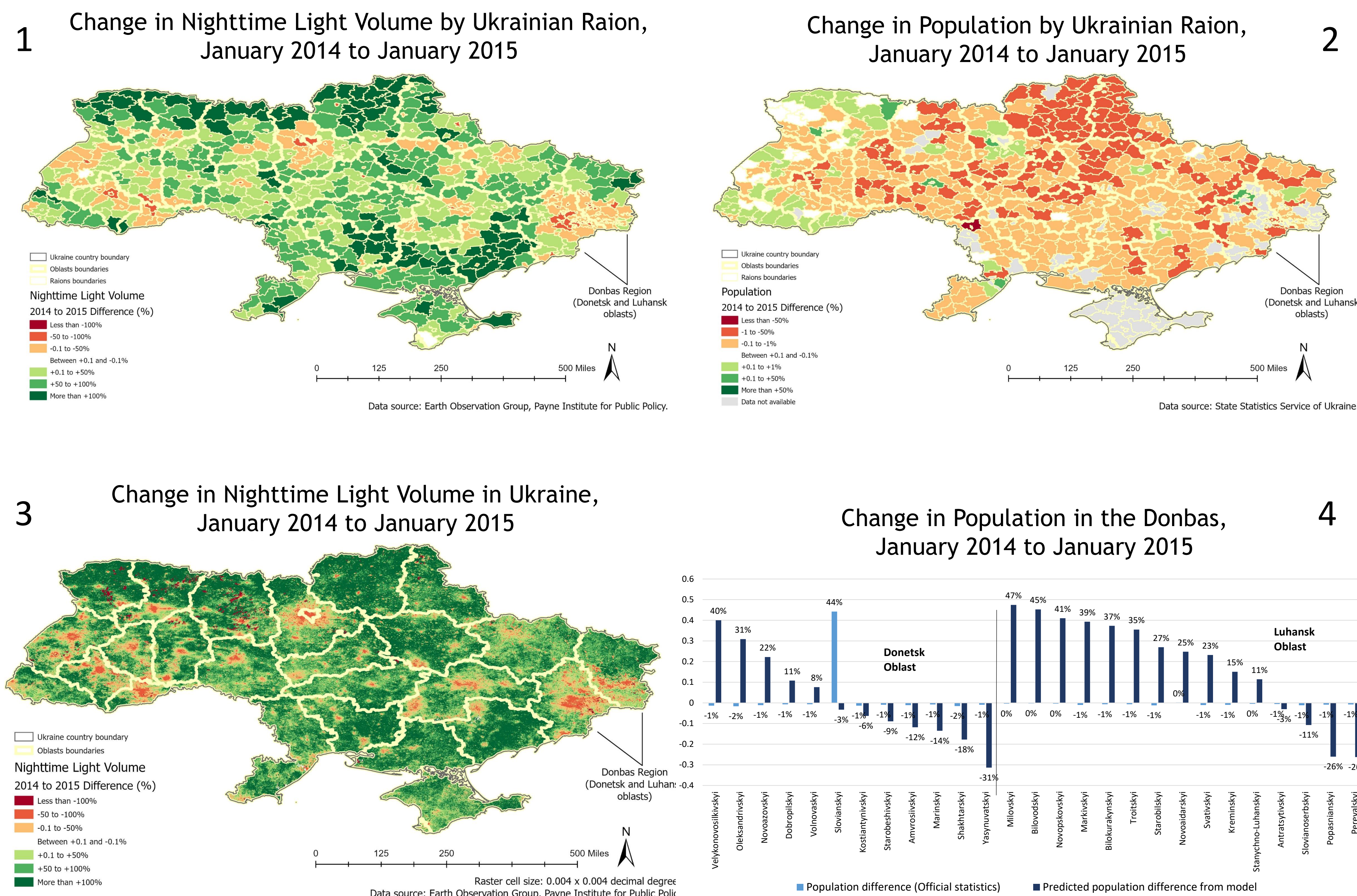
$$\hat{pop}_{2015} = \exp(6.31 + 0.52 * \log(DN_{2015}))$$

The differences between the population differences predicted by this model and those given by official statistics can be found in Figure 4.

## PROCESS FLOW



## RESULTS



## CONCLUSIONS

There is an obvious discrepancy between changes in population given by official statistics (Figure 2) and nighttime light volume (Figure 1), which roughly matches with the IDP migration patterns reported by human rights organizations such as the UNHCR. This mismatch is particularly clear in the Donbas, where the population of most raions was approximately unchanged between January 2014 and January 2015, and in Sloviansk actually increased 44%. Nighttime lights tell a different story: substantial increases in some raions and substantial decreases in others, which fits with the narrative of internal resettlement within the Donbas.

- To fully understand this data, however, a few changes will be necessary, in keeping with the literature:
- 1) The analysis will be repeated using city-level population data and light volume aggregated at the city level, with a buffer.
  - 2) The model will also try to predict population density as well as urban population counts.
  - 3) Findings on presumed IDP resettlement will be compared with qualitative reporting from the UNHCR and other organizations.
  - 4) Economic data will be considered, especially as it might explain apparent emigration from Western Ukraine.
  - 5) The model will be respecified to consider time series dynamics and possible categorical effects of city size.
  - 6) Census methodology will be consulted for official classification of IDP residence.

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