Bayesian Nonparametric Ensemble (BNE) algorithm for predictions of high spatiotemporal $PM_{2.5}$ concentrations

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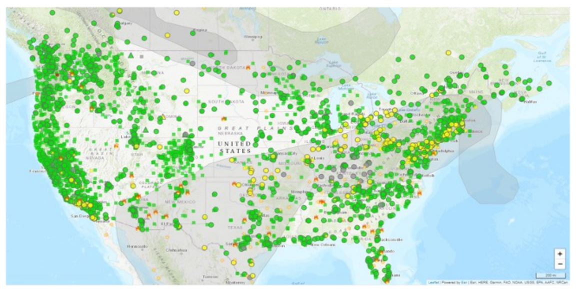
Background and Methods

Motivating Problem:

- Air pollution associated with several adverse health outcomes [1]
- Scarcity of ground level monitors means we must model exposure
- Satellite data essential in filling gaps, but requires translation from column to surface measurements
- Current health studies use predictions from a single dataset
- We present a novel ensembling method to incorporate several different exposure datasets (with various methodologies) and provide uncertainty

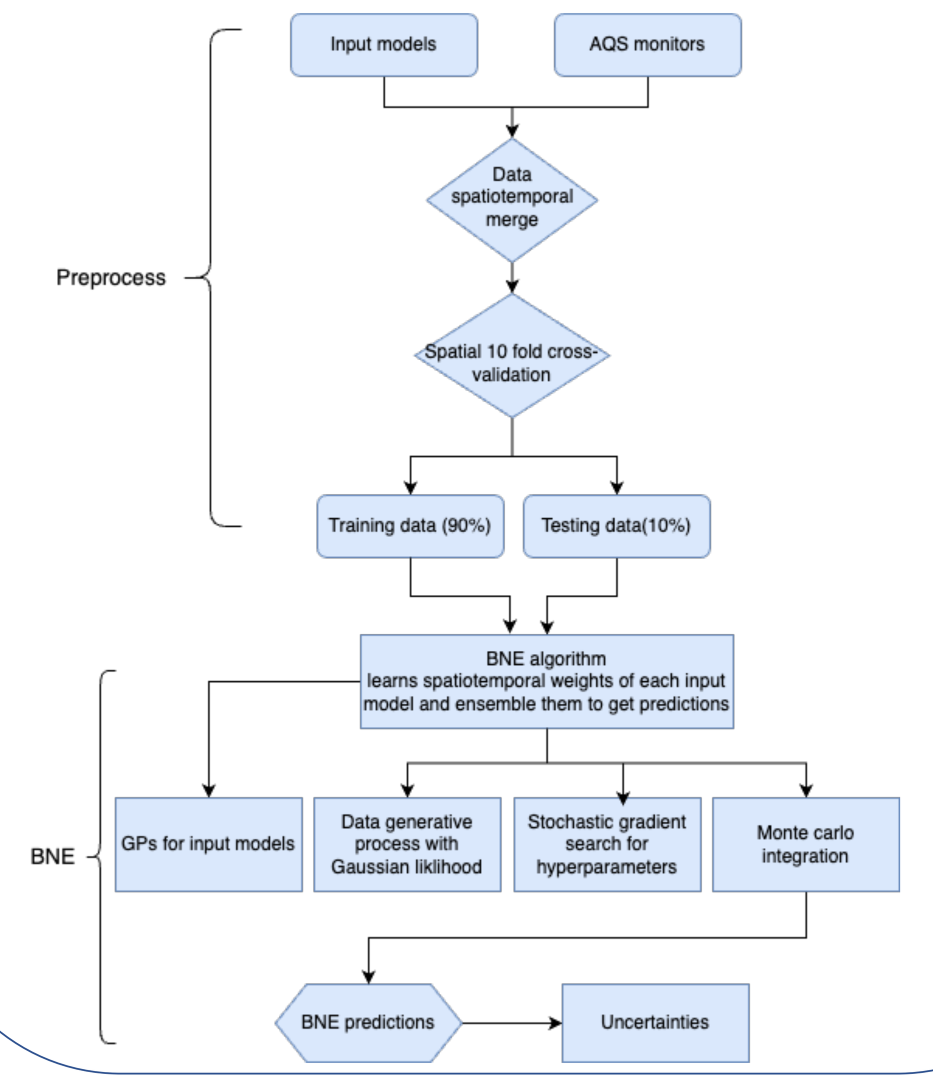


Environmental Protection Agency monitoring network

Bayesian Nonparametric Ensemble (BNE) algorithm

- Integrate information across existing spatiotemporal prediction models
- Weights each model by its spatiotemporal predictive accuracy
  - I.e., spatiotemporal weights
- Provide spatiotemporal uncertainty of predictions
  - Including due to existing model disagreement

Flow-chart

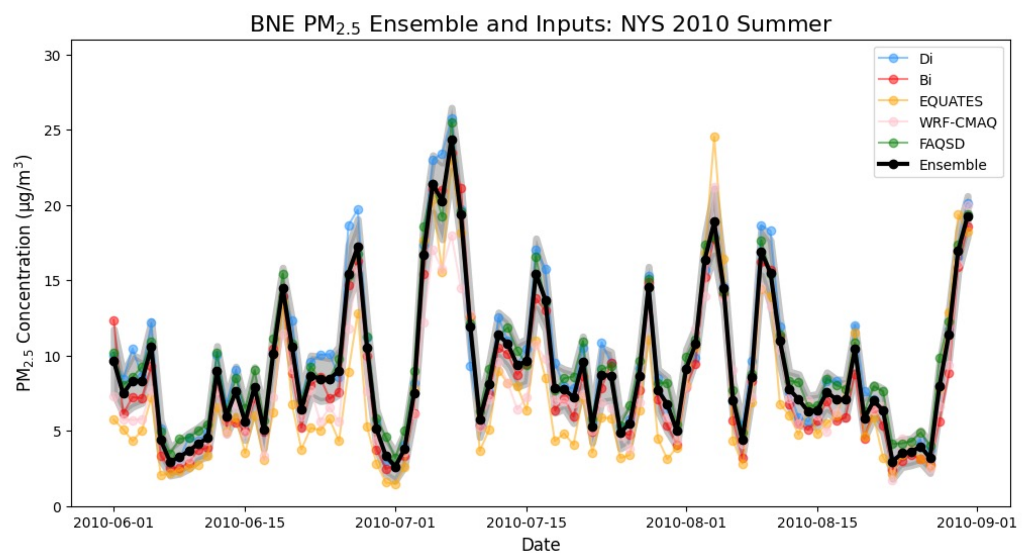


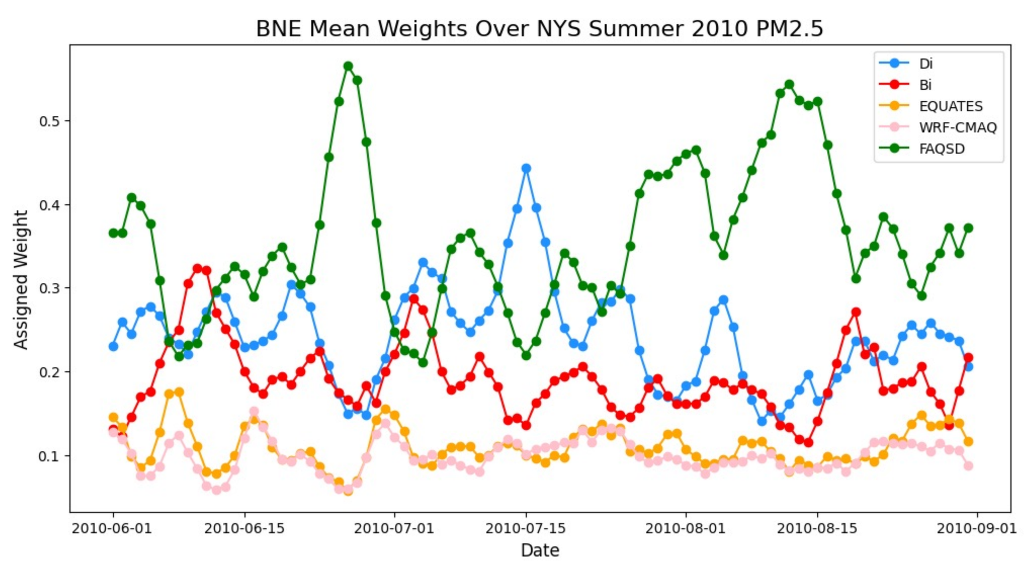
Data and Results

Input Exposure Models:

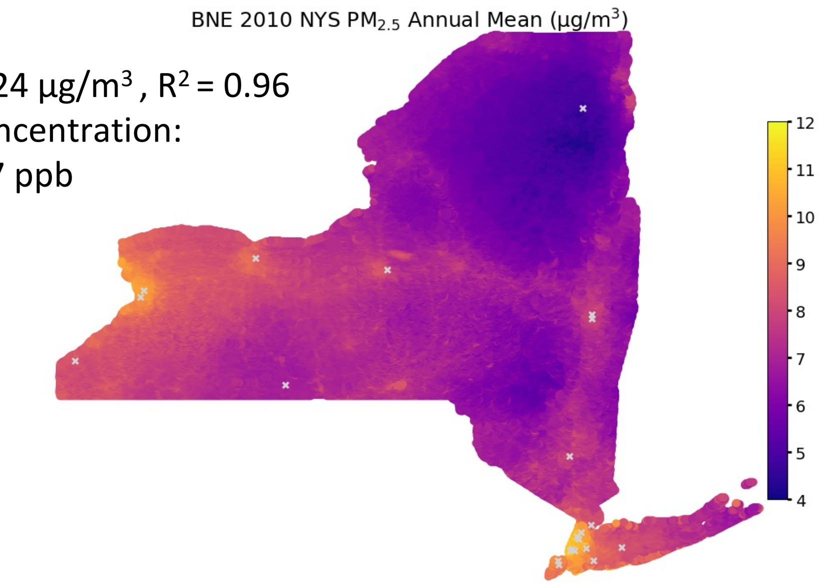
Dataset	Spatial Resolution	Methodology
Bi et. al 2019	1 x 1 km^2	AOD from MODIS, gap filled with random forest approach, incorporating AQS data, land use regression variables, and meteorology from NARR
Di et. al 2021	1 x 1 km^2	Generalized additive model of three ML methods incorporating AQS data, AOD from MODIS, GEOS-CHEM, CMAQ(v5.1), and land use variables
EQUATES (EPA Air QUAlity Time SEries)	12 x 12 km^2	U.S. EPA Air Quality Model: CMAQ (v5.3.2). driven by WRF (v4.1.1) meteorology and the National Emissions Inventory (NEI) for 2017
FAQSD (Fused Air Quality Surface Using Downscaling)	12 x 12 km^2	Fusion of CMAQ (v4.6) chemical transport model (incl. NEI and MM5(v3.6.3) meteorology) with ground level AQS data
WRF-CMAQ with AOD, CO (R. Kumar et. al 2021)	12 x 12 km^2	Reanalysis assimilating AOD retrievals from MODIS and CO retrievals from MOPITT into CMAQ, with WRF providing meteorological input

Table: Daily $PM_{2.5}$ base models

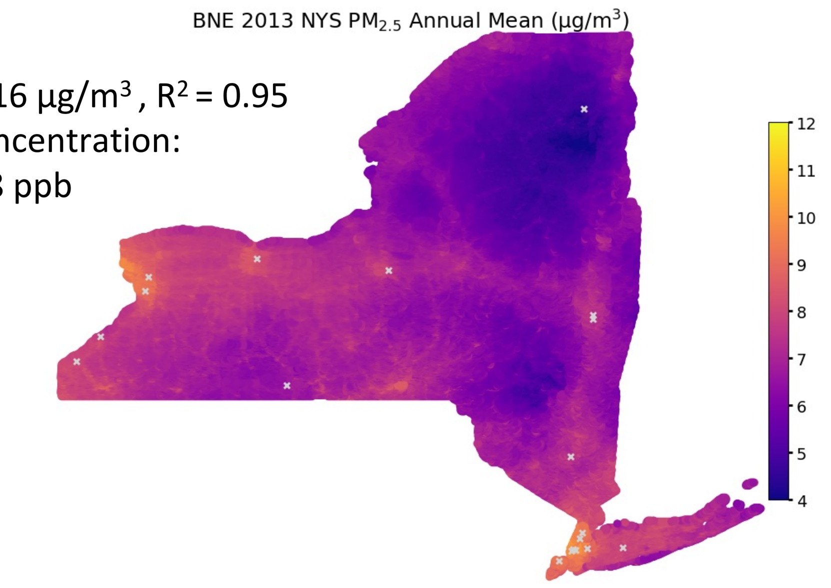




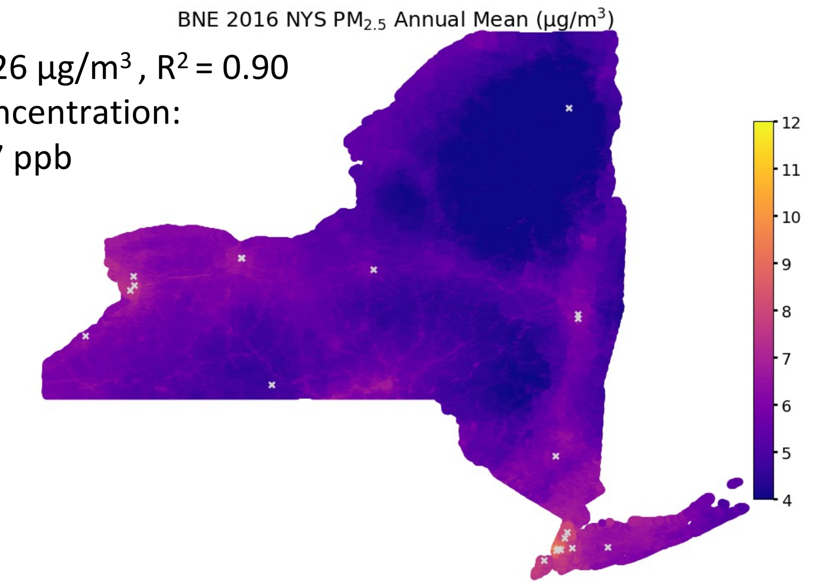
Results



RMSE=1.24 µg/m^3 , R^2 = 0.96
Mean Concentration:
6.84 ± 0.7 ppb



RMSE=1.16 µg/m^3 , R^2 = 0.95
Mean Concentration:
6.53 ± 0.8 ppb



RMSE=1.26 µg/m^3 , R^2 = 0.90
Mean Concentration:
5.03 ± 0.7 ppb

Completed 2010-2016; more years, pollutants coming!

References

- Fuller R. et. al, Pollution and health: a progress update. Lancet Planet Health. 2022 Jun;6(6):e535-e547
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