URBAN AEROSOL CONCENTRATIONS FROM MERIS/AATSR SYNERGY: A PREPARATORY STUDY FOR SENTINEL 3

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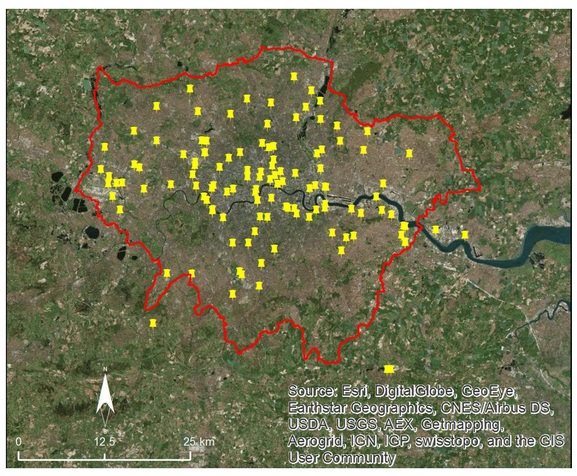
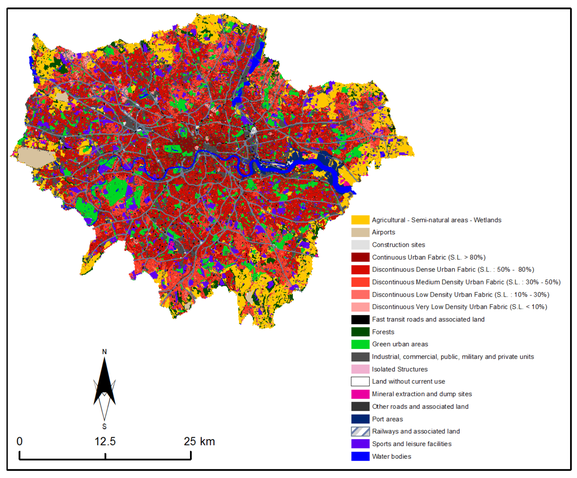
ABSTRACT

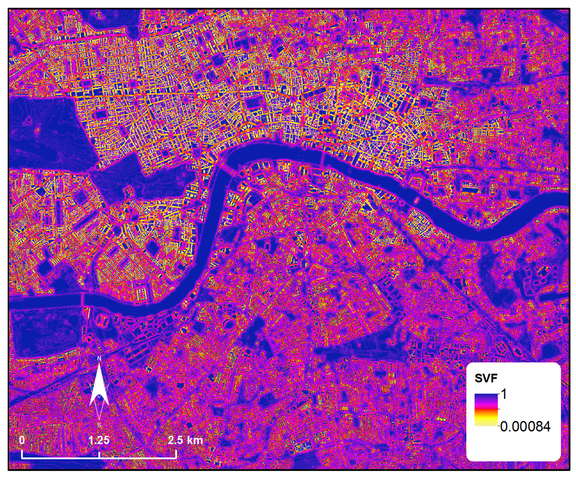
Particulate Matter (PM) concentration is used as an **air quality indicator in urban areas;** it is highly important for **urban planning** and **epidemiological** studies. This reason has prompted an ongoing effort for PM estimation using satellite observations. The present study evaluates alternative spatio-temporal approaches for quantitative estimation of **Daily Mean** PM concentrations. Both fine (**PM2.5**) and coarse (**PM10**) concentrations were estimated over the area of London (UK) for the 2002-2012 time period, using Aerosol Optical Thickness (AOT) derived from MERIS (Medium Resolution Imaging Spectrometer) / AATSR (Advanced Along-Track Scanning Radiometer) **synergy** at 1 km x 1 km spatial resolution. **Local scale** (100 m) **urban surface cover** and **morphology** datasets were incorporated in the analysis in order to capture the effects of fine-scale emissions and sequestration. The **statistical models** produced in this study are expected to contribute to the development of an **operational** tool capable of producing high-resolution PM concentration maps using **Sentinel-3** observations. The **synergistic use** of the Sea and Land Surface Temperature Radiometer (SLSTR) and the Ocean and Land Color Instrument (OLCI), onboard Sentinel-3, will be **exploited** by the developed models to support **local scale** studies on **urban planning** and **public health.**

STUDY AREA AND DATA





Urban Atlas Land Use/Cover (**LUC**)



Sky View Factor (**SVF**)

Satellite Data Products

- **MERIS/AATSR AOT – 1×1 km** (MERIS/AATSR Synergy Algorithm)
- **Surface Temperature** (STMP)
- **Surface Relative Humidity** (RHUM)
- **K-Index** (KIND) – estimator of atmospheric instability

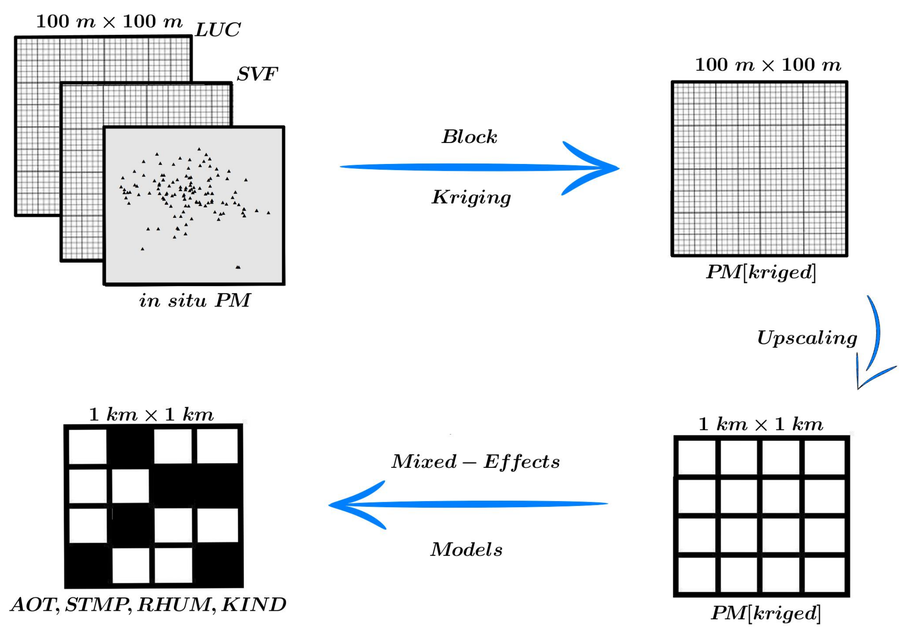
STMP, RHUM and KIND derived from **MODIS Level 2** Atmospheric Profile Products

METHODOLOGY

- ✓ Pairwise comparison of **PM** concentration means for distinct **LUC** classes
- ✓ Adjusted to **PM** spatial variability post-classification of **LUC** product
- ✓ **2D** and **3D** residual kriging at **100m** incorporating **LUC** and **SVF** data:

$$\log(PM_{ij}) = a_0 \cdot SVF_i + \sum_{k=1}^{6} a_k \cdot \mathbf{1}(LUC_i = k) + \varepsilon_{ij}$$

- ✓ Leave-one-station-out cross-validation
- ✓ Block kriging to address the **Change of Support Problem**
- ✓ Upscaling to **1x1 km** by computing averages



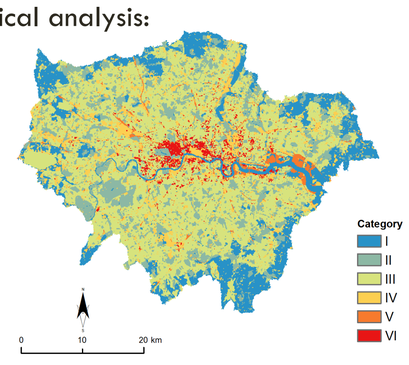
- ✓ Estimation of annual profiles in **AOT, STPM, RHUM** and **KIND** covariates by fitting a sinusoid to the time series
- ✓ Use of deviations from seasonal profiles
- ✓ Linear mixed-effects models with:
  - day-specific (**LMM1**)
  - site-specific (**LMM2**)

  random intercepts and random slopes
- ✓ 5-fold cross-validation
- ✓ For **LMM2** the **PM** concentrations are estimated based solely on satellite-derived products

RESULTS

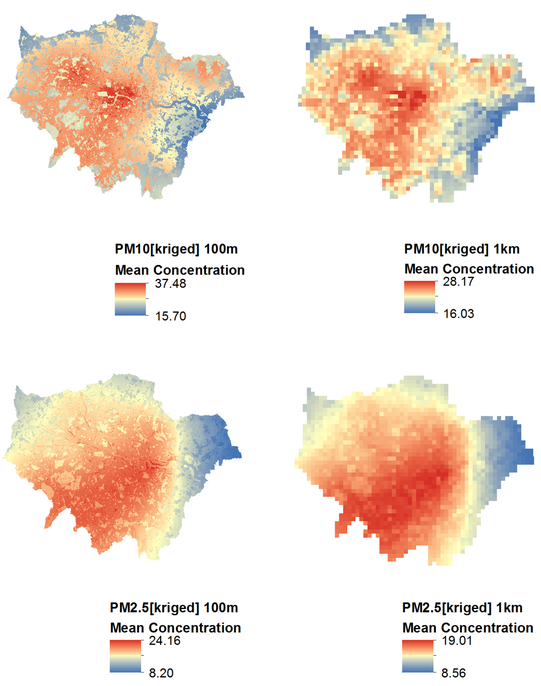
LUC class – PM10	Estimate
1. Agricultural - Semi-natural areas - Wetlands	21.01
2. Sports and leisure facilities	22.25
3. Green urban areas	23.00
4. Airports	26.31
5. Discontinuous Medium D. Urban Fabric	26.88
6. Discontinuous Dense Urban Fabric	26.96
7. Industrial, comm., public, military and private units	27.38
8. Port areas	28.09
9. Other roads and associated land	28.48
10. Continuous Urban Fabric	29.74

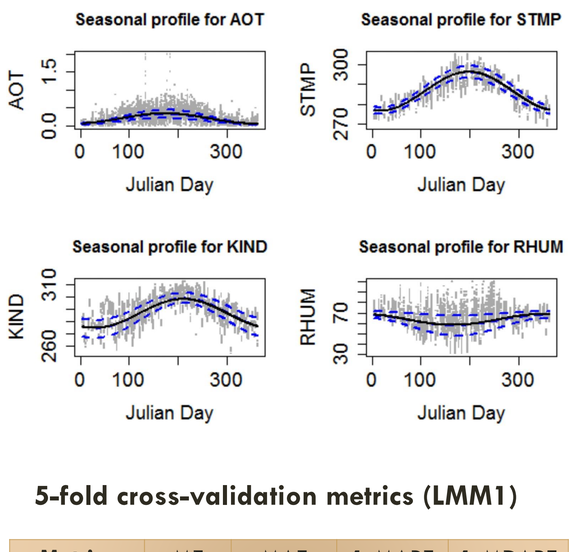
Modified Land Cover map based on Urban Atlas, congaing six meaningful for PM concentration main classes, derived from the above ten classes, as indicated by the statistical analysis:



Cross-validation metrics (3D kriging)

Metrics	RMSE	ME	MAE	R
PM10	9.00	-0.04	5.58	0.78
PM2.5	4.87	-0.05	3.38	0.81



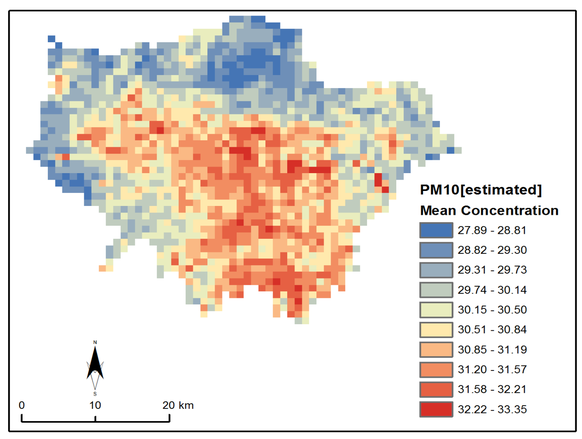


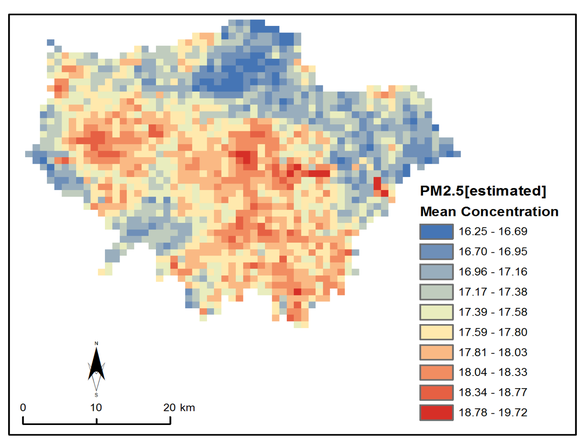
5-fold cross-validation metrics (LMM1)

Metrics	ME	MAE	1-MAPE	1-MDAPE
PM10	0.12	2.14	92.52%	94.15%
PM2.5	0.25	2.24	90.36%	87.79%

5-fold cross-validation metrics (LMM2)

Metrics	ME	MAE	1-MAPE	1-MDAPE
PM10	1.62	7.62	73.28%	78.71%
PM2.5	1.40	5.23	69.88%	76.12%





CONCLUSIONS

- ➢ The methodology developed for London can be transferred to **any urban area** of interest.
- ➢ The simultaneous operation of **Sentinel 3A** and **Sentinel 3B** in the near future is expected to lead to **daily PM** concentration **maps** of **high spatial resolution**, which are necessary in **urban air quality** studies.

REFERENCES

Beloconi, A., Kamarianakis, Y. and Chrysoulakis, N., 2015. Estimating urban PM10 and PM2.5 concentrations, based on synergistic MERIS/AATSR aerosol observations, land cover and morphology data, *Remote Sensing of Environment* (in press)

Benas, N., Beloconi, A. and Chrysoulakis, N., 2013. Estimation of urban PM10 concentration, based on MODIS and MERIS/AATSR synergistic observations, *Atmospheric Environment*, **79**, 448-454