Estimating Spatial Variability of Ambient Particulate Matter Using Land-use Regression in Tehran, Iran

Hassan Amini, Seyed Mahmood Taghavi Shahri, Sarah B. Henderson, Kazem Naddafi, Ramin Nabizadeh, Masud Yunesian

Kurdistan Environmental Health Research Center, Kurdistan University of Medical Sciences, Sanandaj, Iran

Introduction

- Air pollution and Health in Iran
- Acute or chronic effects?!
- Acute → Time-series studies
- Chronic → Cohort studies

Acute-effect studies of air pollution in Iran

- **Hospitalization due to angina pectoris**

ELSEVIER

Available online at www.sciencedirect.com
SCIENCE DIRECT®

Environmental Research 99 (2005) 126–131

Environmental Research

www.elsevier.com/locate/envres

Air pollution and hospitalization due to angina pectoris in Tehran, Iran: A time-series study ☆

Ahmad Reza Hosseinpoor[a,*], Mohammad Hossein Forouzanfar[a], Masoud Yunesian[b], Fariba Asghari[c], Koroush Holakouie Naieni[a], Dariush Farhood[d]

[a] *Department of Epidemiology and Biostatistics, School of Public Health, Tehran University of Medical Sciences, Poursina Street, Keshavarz Boulevard, P.O. Box 14155-6446, Tehran, Iran*

1 ppm daily CO increment = 1% increase of admissions

Received 29 June 2004; received in revised form 27 November 2004; accepted 6 December 2004
Available online 5 February 2005

Acute-effect studies of air pollution in Iran

- **All causes, cardiovascular and respiratory mortality**

RESEARCH ARTICLE Open Access

Health impact assessment of air pollution in megacity of Tehran, Iran

Kazem Naddafi[1,2], Mohammad Sadegh Hassanvand[1,2*], Masud Yunesian[1,2], Fatemeh Momeniha[1,3], Ramin Nabizadeh[1,2], Sasan Faridi[1] and Akbar Gholampour[1]

All cause mortality

PM10 = 4.6% SO2 = 3.1%

NO2 = 2.2% O3 = 1.7%

Acute-effect studies of air pollution in Iran

- **Hospitalization due to COPD & respiratory diseases**

RESEARCH ARTICLE Open Access

Health impact assessment of air pollution in Shiraz, Iran: a two-part study

Ehsan Gharehchahi[1], Amir Hossein Mahvi[1,2], Hassan Amini[3*], Ramin Nabizadeh[1], Ali Asghar Akhlaghi[4,5], Mansour Shamsipour[4,6] and Masud Yunesian[1,7*]

10 ug/m3 increment PM10 = 0.04% respiratory hospital admissions
10 ug/m3 increment SO2 = 9% COPD hospital admissions

Respiratory admissions in 2008
PM10 = 8.1% SO2 = 30.3% (elderly)

Long-term effect assessment?!

- **Long-term exposure assessment**

- **Spatial models → Land-use regression (LUR)**

Key features of our LUR approach

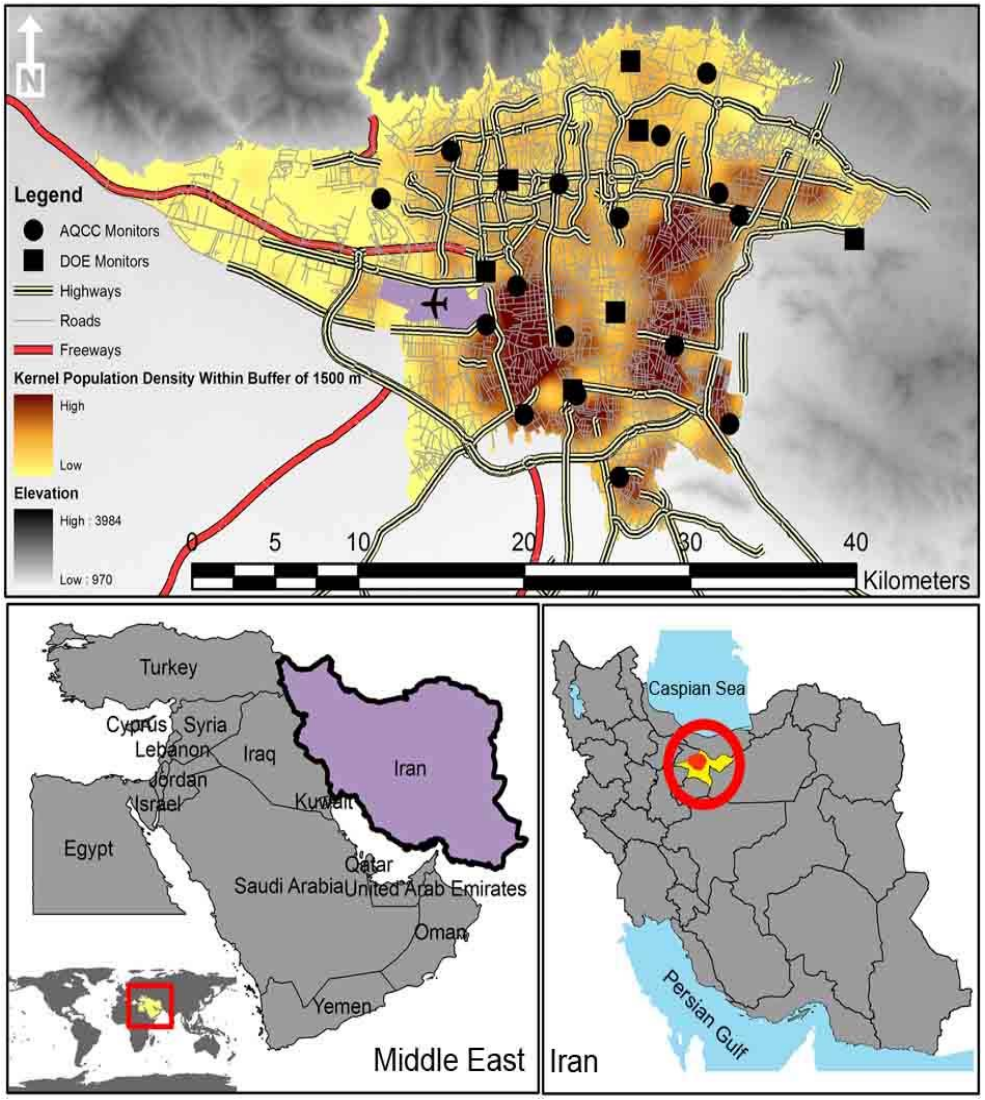
- **LUR in novel context of Tehran, Iran**
- **A novel variable selection method for LUR**
- **Several new predictive variables and variable types**

Method of LUR

- **Land use regression (LUR)**

Methods – Study area

- **Location of Tehran, Iran, Middle East**



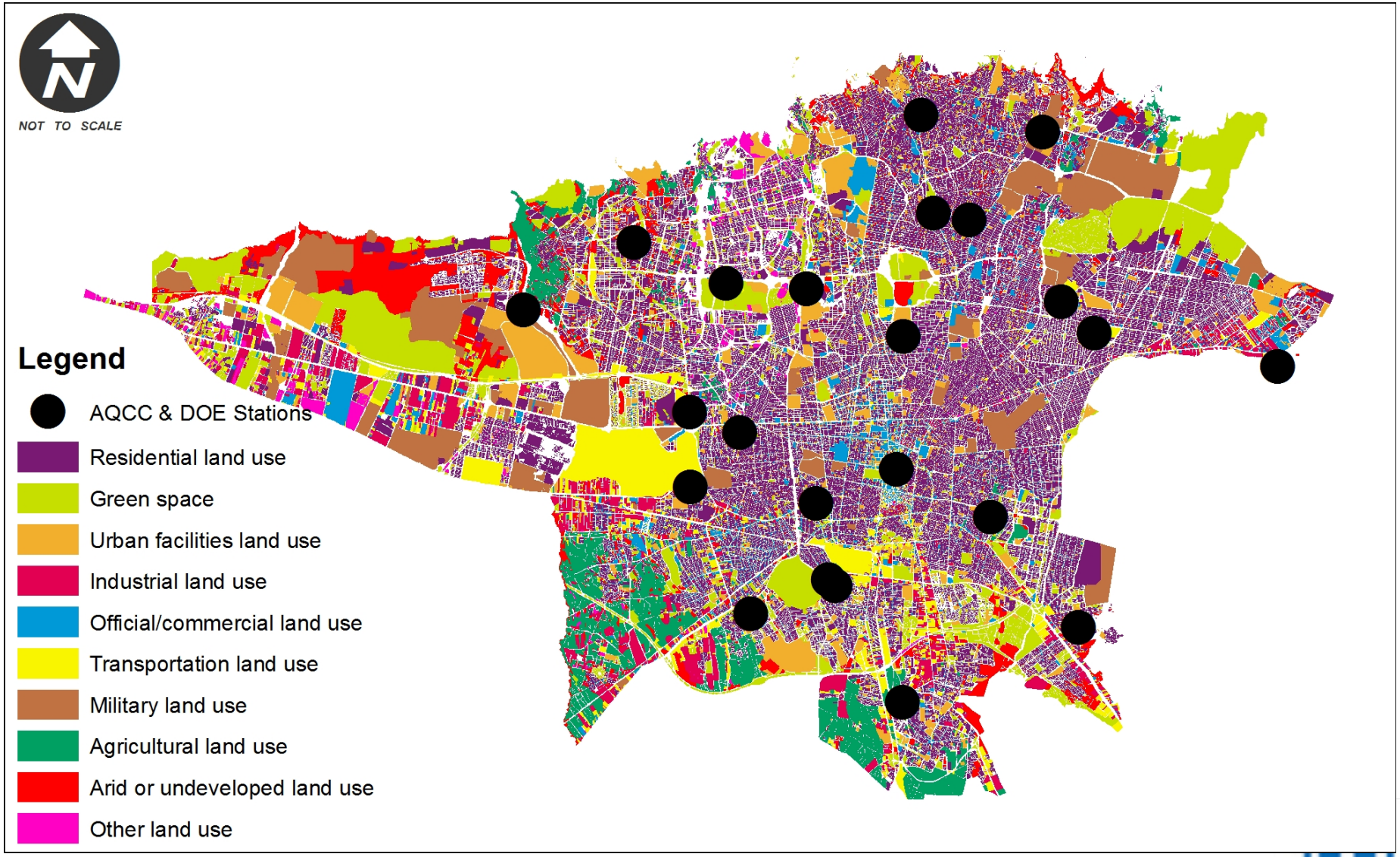
•Annual mean temperature 18.5°C
Highs 40 °C in July
Lows -10°C in January

•Annual precipitation 150 mm

•Weather typically sunny
2800 hours bright sunshine

•Mean cloud cover 30%

Methods – Land use in Tehran

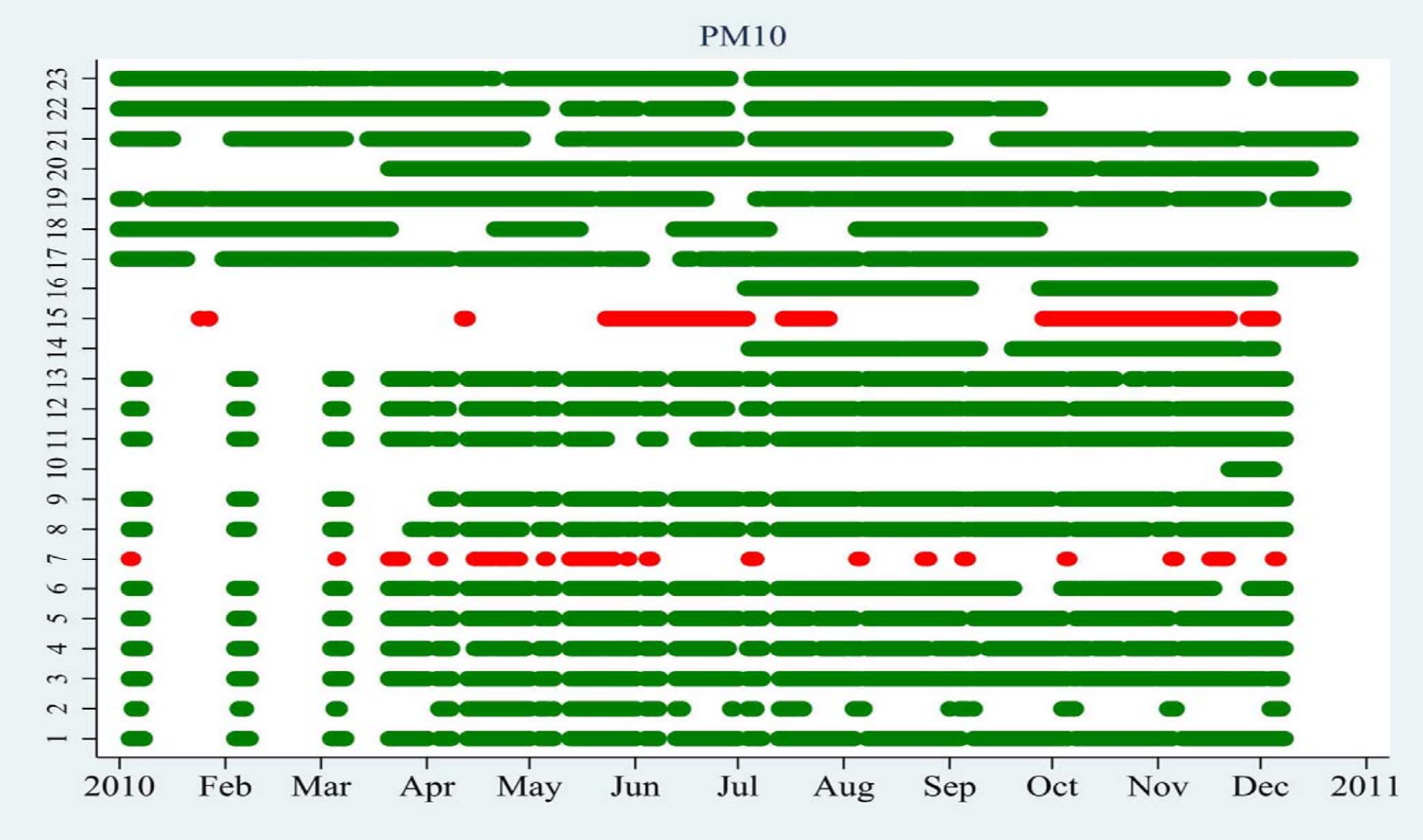


Methods – Air pollution data

- Hourly 2010 PM_{10} concentrations
- **23** air quality monitoring stations
- Quality control → 57% available
- Imputation of missing data

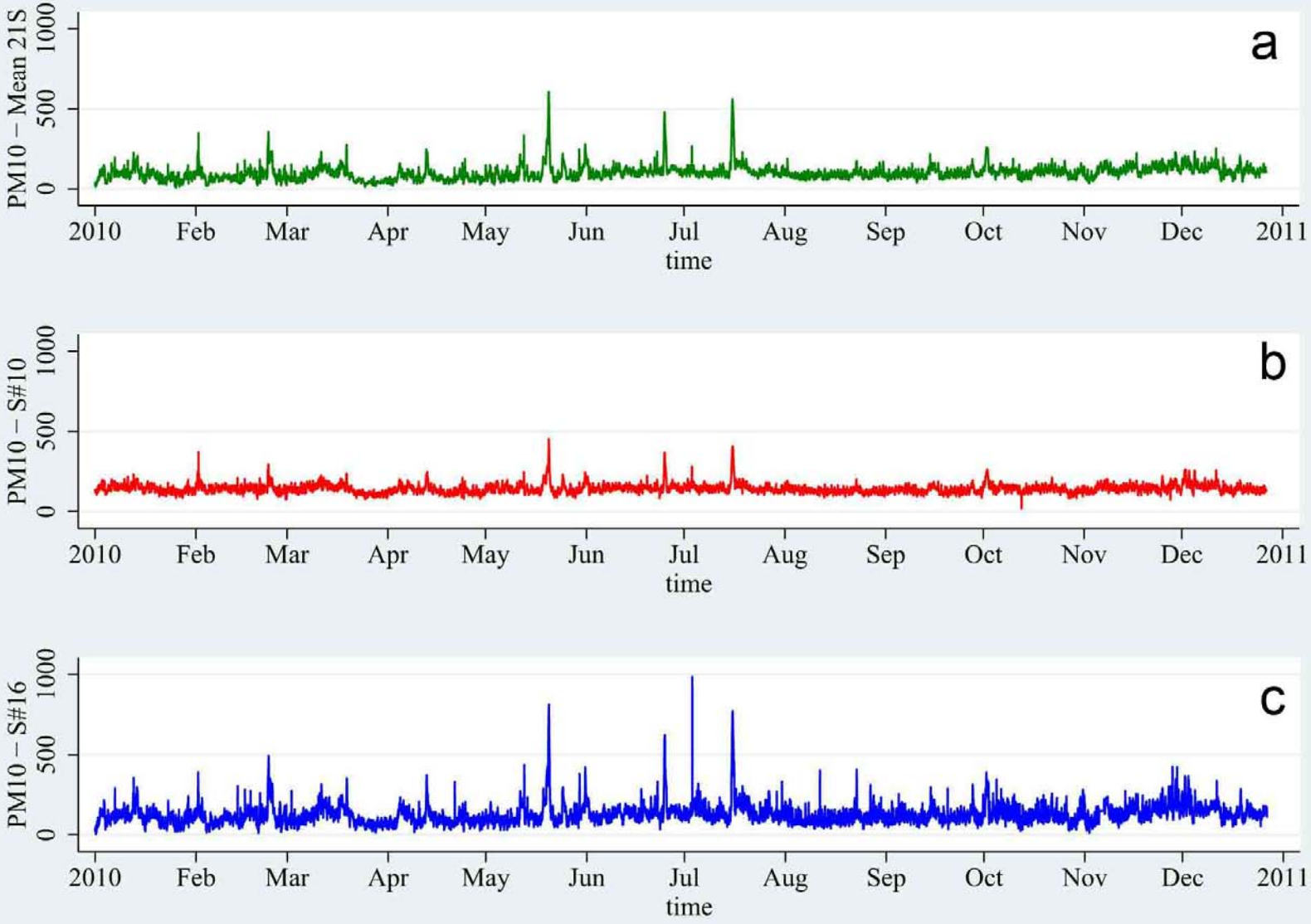
Methods – Air pollution data

- **The missing data at each site**



- **The Amelia program**

Methods – Air pollution data



Methods – Air pollution data

- Annual mean = January 1st, 2010 through January 1st, 2011
- Cooler season mean = October through March
- Warmer season mean = April through September

Methods – Generation of spatial predictors

- 210 variables in five classes
  - Traffic Surrogates (N = 76)
  - Land Use (N = 50)
  - Distance Variables (N = 60)
  - Population Density (N = 22)
  - and Geographic Location (N = 2)

Methods - Model development

- **A systematic algorithm**

1. Consistency with *a priori* assumptions about the direction of the effect for each variable

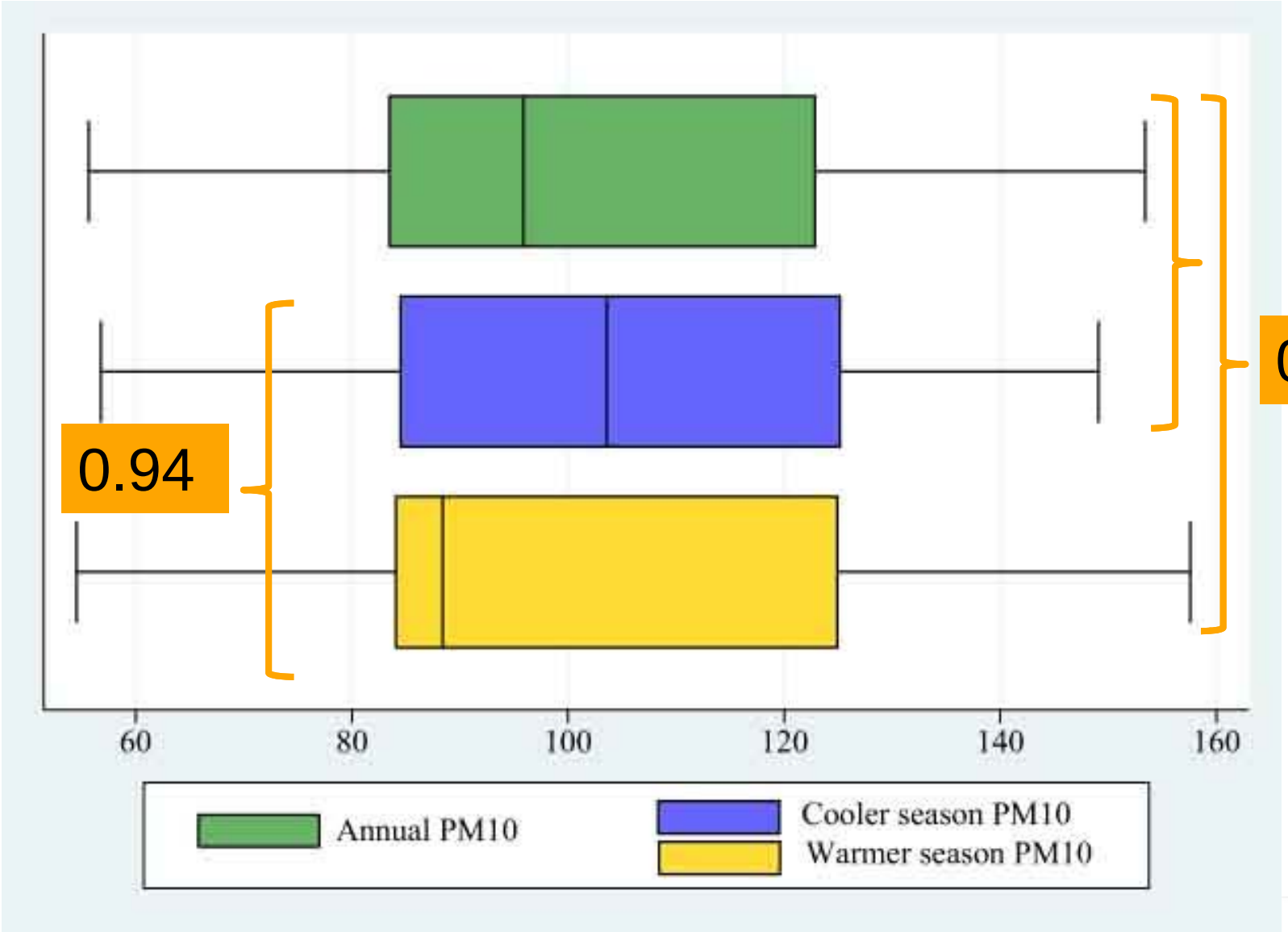
2. A *p*-value of < 0.1 for each predictor

3. Increases in the coefficient of determination (R^2) for a leave-one-out cross-validation (LOOCV)

4. A multicollinearity index called the variance inflation factor (VIF)

5. A grouped (leave-25%-out) cross-validation (GCV) for final model

Results – Air pollution data



Results – Final LUR models, Annual PM10

R^2 = 0.62	LOOCV R^2 = 0.48	GCV R^2 = 0.50	
Predictor	Coefficient	Partial R^2	*P*-value
Intercept	2.37E+02	-	<0.001
log distance to the bus terminal	–1.61E+01	0.40	0.005
distance to airport	–3.64E-03	0.30	0.018
street length in 100 m	1.10E-01	0.27	0.028
Other land use area in 300 m	–2.88E-03	0.20	0.065

LOOCV, Leave-one-out cross validation
GCV, Grouped (leave-25%-out) cross validation

Results – Final LUR models, Cooler season PM10

R^2 = 0.67	LOOCV R^2 = 0.57	GCV R^2 = 0.55	
Predictor	Coefficient	Partial R^2	*P*-value
Intercept	2.39E+02	-	<0.001
log distance to the bus terminal	–1.60E+01	0.44	0.003
distance to airport	–4.10E-03	0.39	0.006
street length in 100 m	1.02E-01	0.27	0.027
Other land use area in 300 m	–3.16E-03	0.26	0.032

LOOCV, Leave-one-out cross validation
GCV, Grouped (leave-25%-out) cross validation

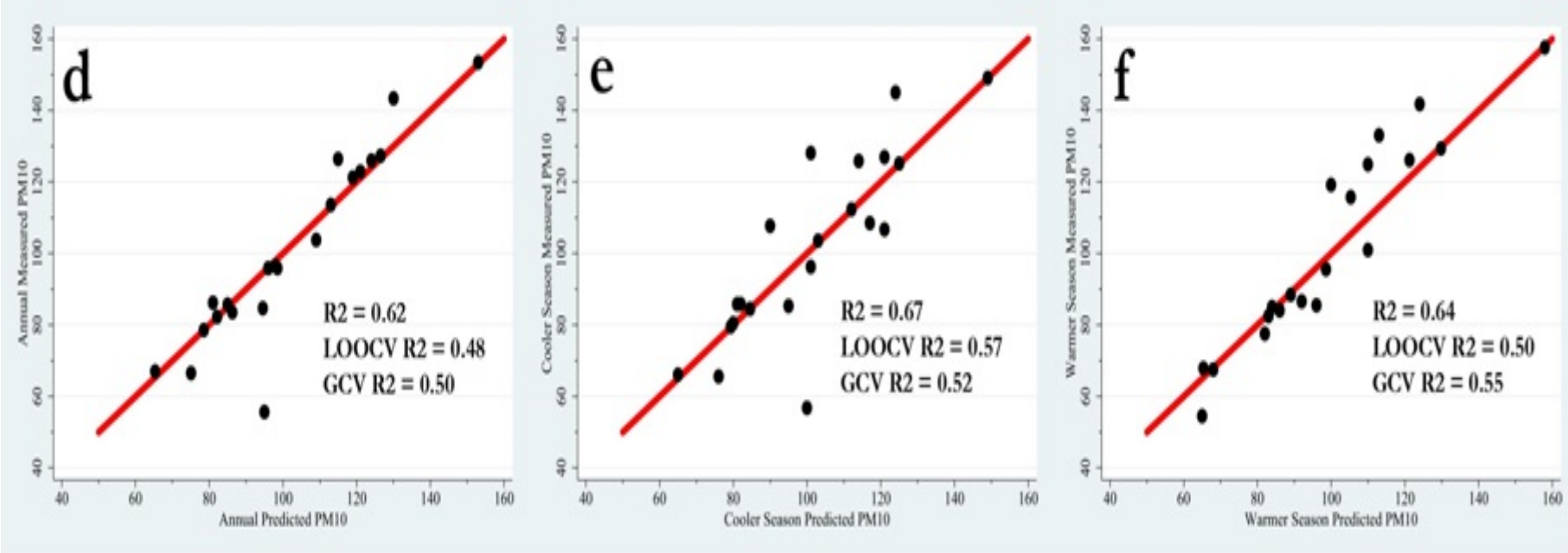
Results – Final LUR models, Warmer season PM10

R^2 = 0.64	LOOCV R^2 = 0.50	GCV R^2 = 0.52	
Predictor	Coefficient	Partial R^2	*P*-value
Intercept	2.75E+02	-	<0.001
log distance to the bus terminal	-1.83E+01	0.47	0.002
distance to the military land use	-1.13E-02	0.34	0.012
distance to the major roads	-2.22E-01	0.32	0.015
Other land use area in 300 m	-3.81E-03	0.27	0.028

LOOCV, Leave-one-out cross validation
GCV, Grouped (leave-25%-out) cross validation

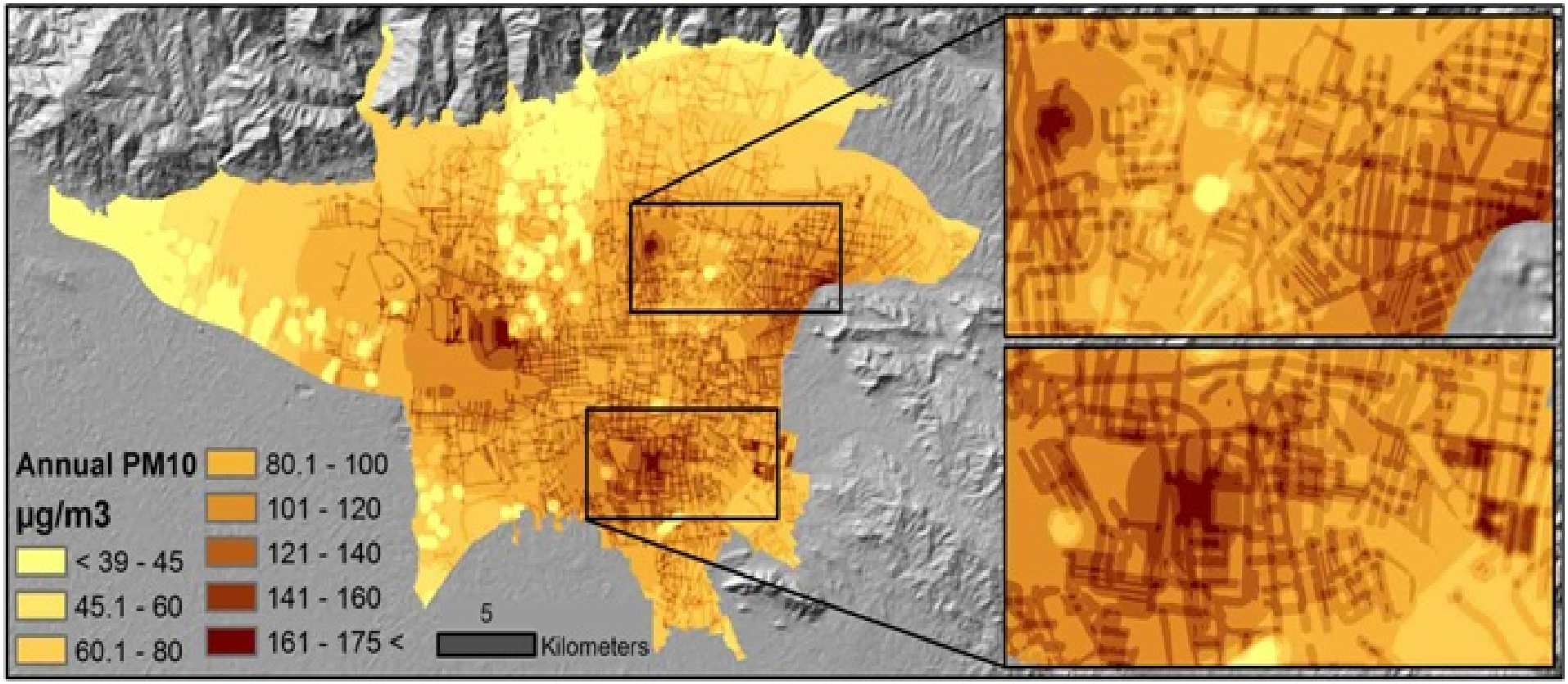
Results – Final LUR models

- Predicted PM_{10} concentrations agree well with measured concentrations



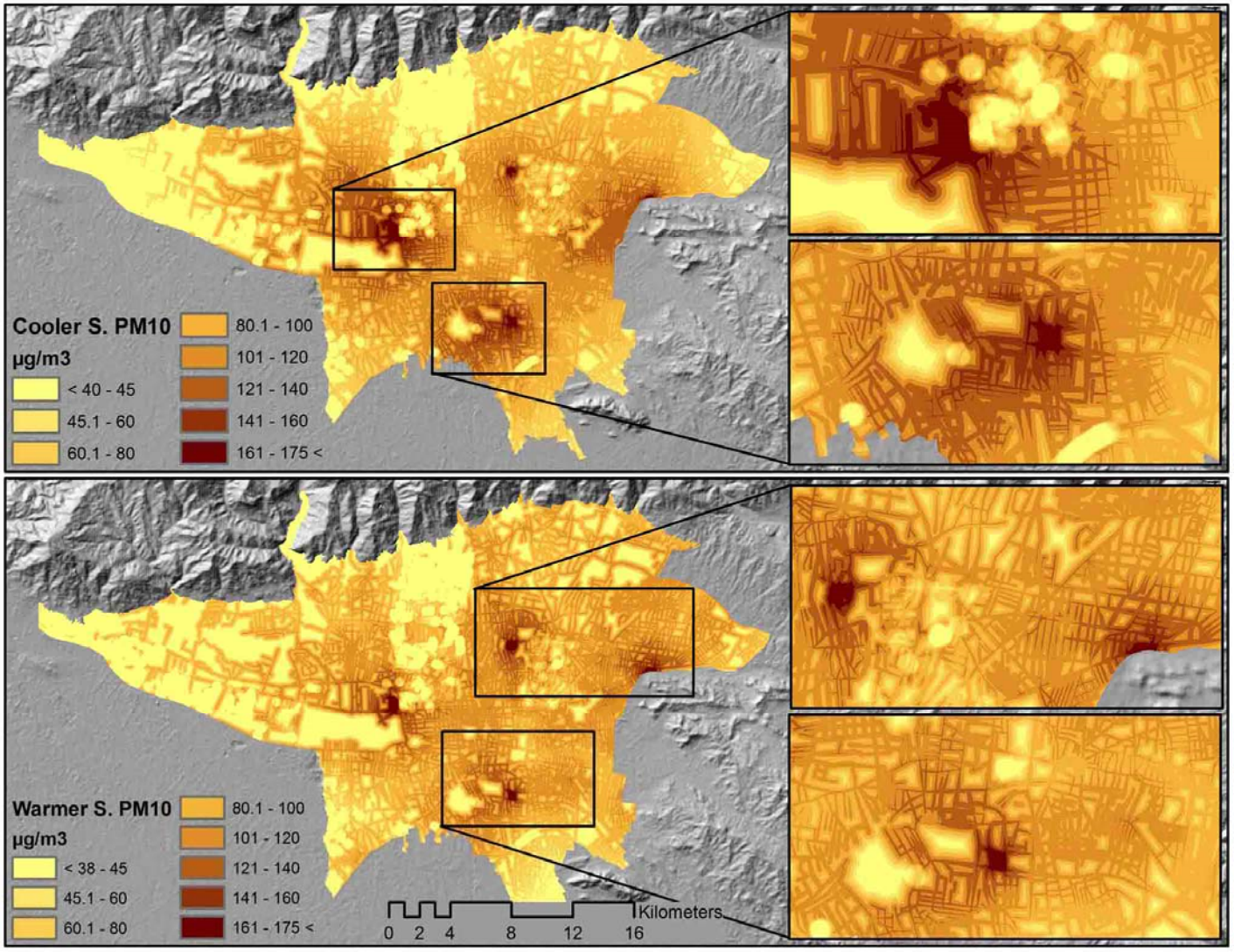
Results – Final LUR maps

- Annual PM_{10} model captures hot-spots well, such as bus terminals



Results – Final LUR maps

- Cooler season and warmer season PM_{10} models are very similar



Results – Application of LUR in population

- All population lived in areas exceeding WHO's Air Quality Guideline (20 µg/m^3) for PM_{10}

- 88% of the general population and 89% of the children under 5 lived in areas exceeding WHO's Interim Target 1 Guideline (70 µg/m^3) for PM_{10}

Conclusions and outlook

- We have generated LUR models for use in upcoming population-based epidemiologic studies

- Strength & limitations to using regulatory network data for LUR modeling needs further investigation

Conclusions and outlook

- In future health studies we need additional pollutants:

Pollutant	Involvement
Nitrogen oxides	Yes
Sulfur dioxide	Yes
PM10	Needs clarification
PM2.5	Needs clarification
PM2.5 - PM10	Needs clarification
Ultrafine particles	Needs clarification
Elemental carbon	Needs clarification
Elemental composition	Needs clarification
PAHs	Needs clarification

Thanks to:

Seyed Mahmood Taghavi Shahri, Sarah B. Henderson, Kazem Naddafi, Ramin Nabizadeh, Masud Yunesian

Gerard Hoek, Michael Brauer, Nino Künzli

Special thanks to Swiss TPH colleagues

Thanks for your attention!

Hassan Amini

amini_h@razi.tums.ac.ir

Additional figures for discussion

▪ Wind rose in Tehran, Iran