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

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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**

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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]

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1 ppm daily CO increment = 1% increase of admissions

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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

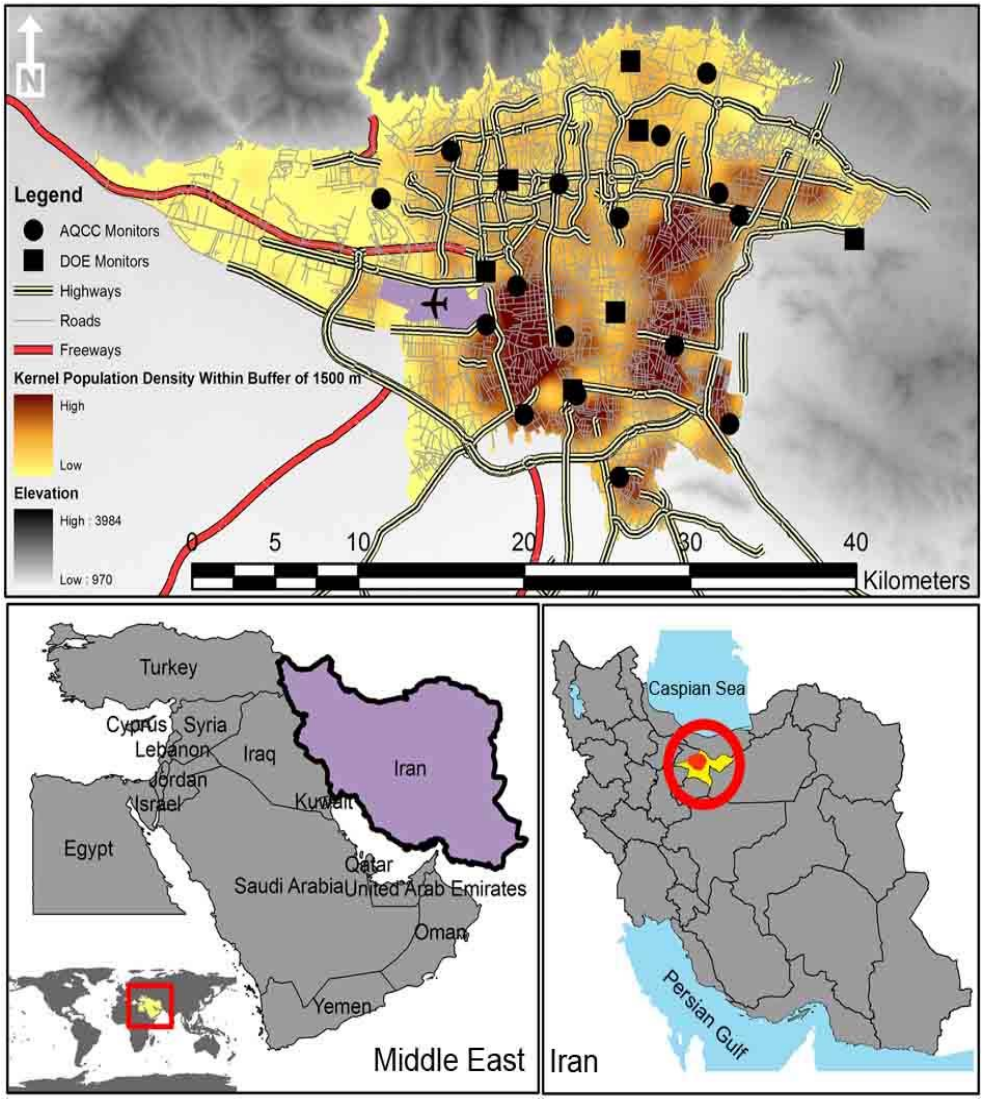
- **LUR in novel context of Tehran, Iran**
- **A novel variable selection method for LUR**
- **Several new predictive variables and variable types**

Method of LUR

- **Land use regression (LUR)**

Methods – Study area

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



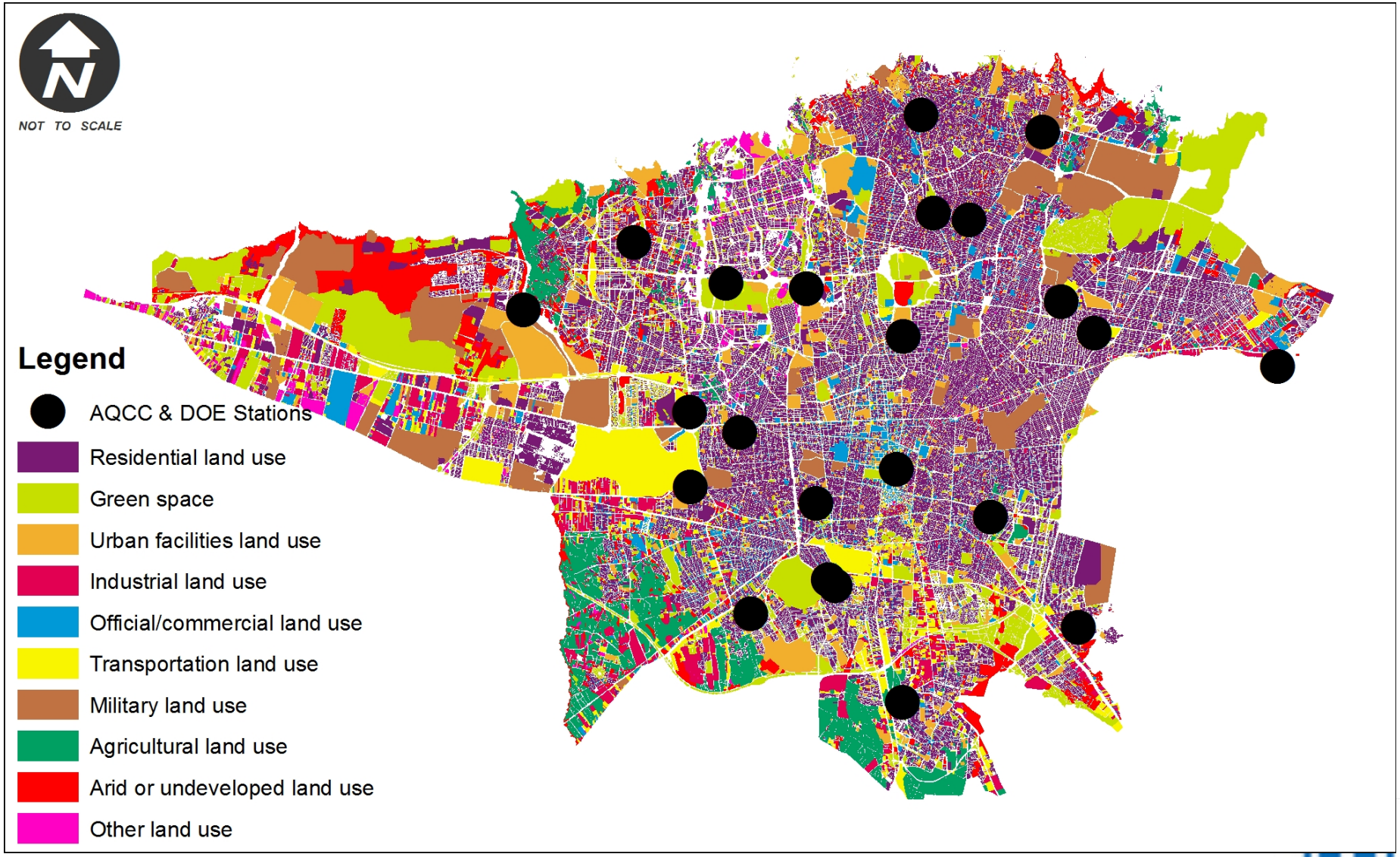
•Annual mean temperature 18.5°C
Highs 40 °C in July
Lows -10°C in January

•Annual precipitation 150 mm

•Weather typically sunny
2800 hours bright sunshine

•Mean cloud cover 30%

Methods – Land use in Tehran

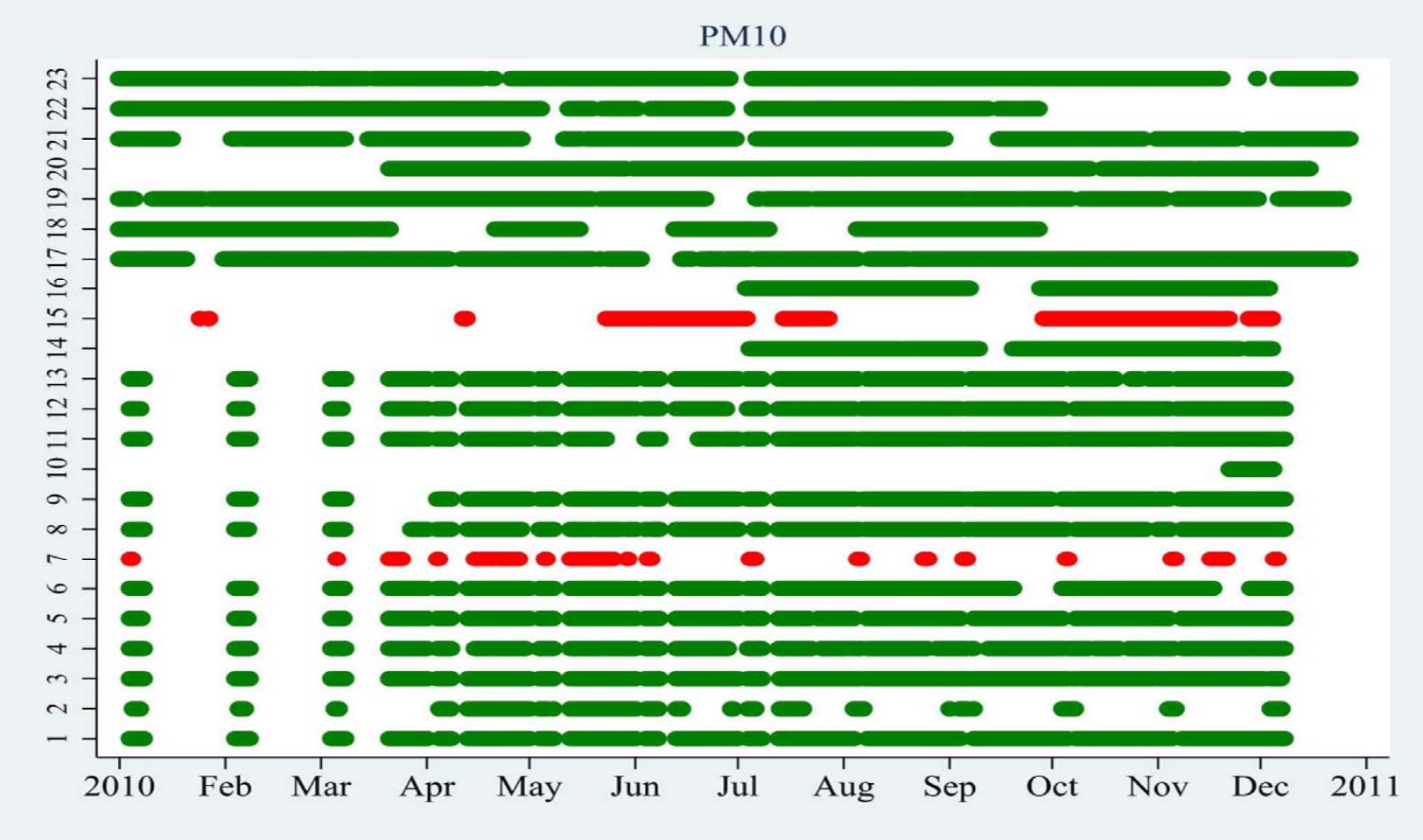


Methods – Air pollution data

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

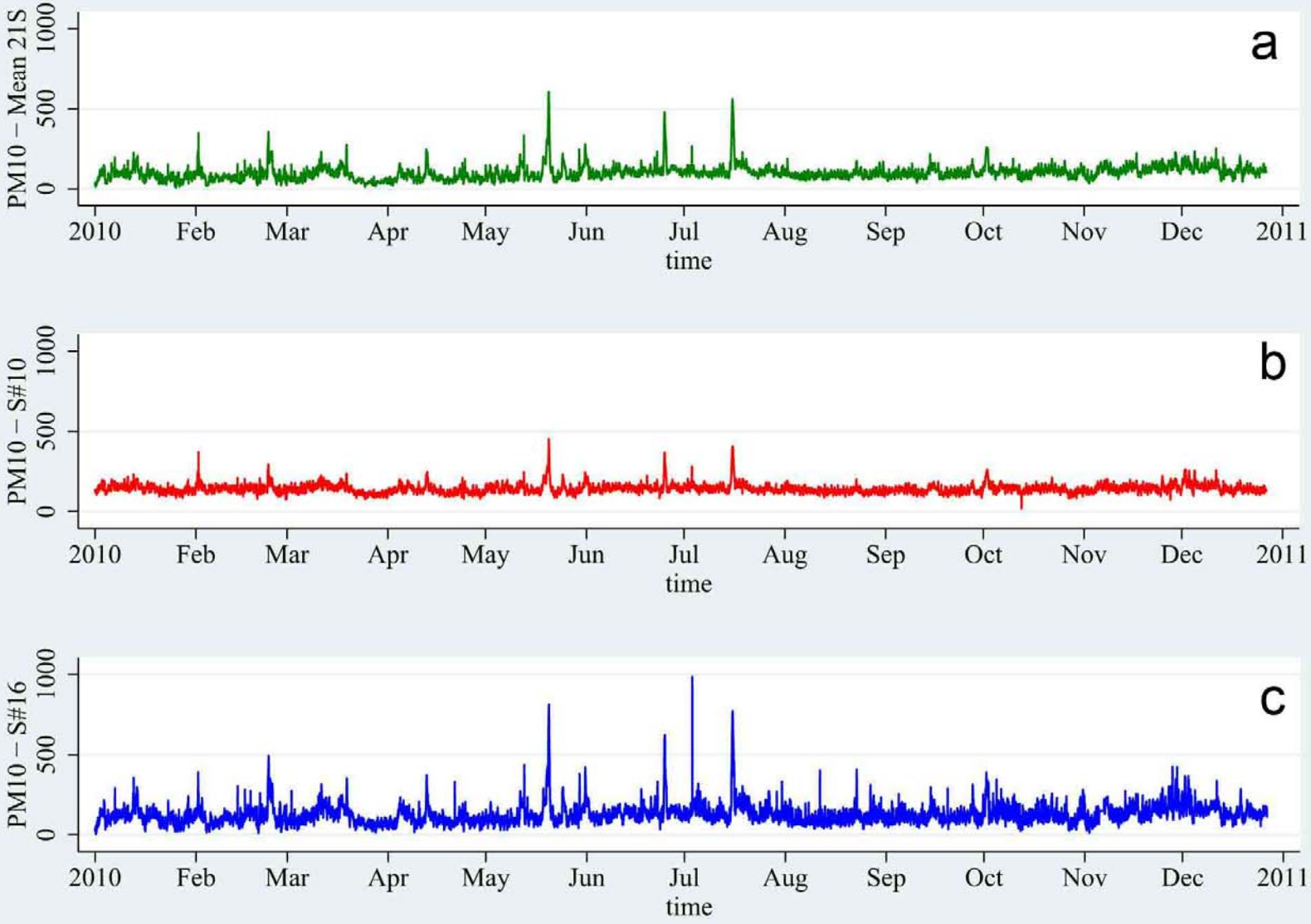
Methods – Air pollution data

- **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

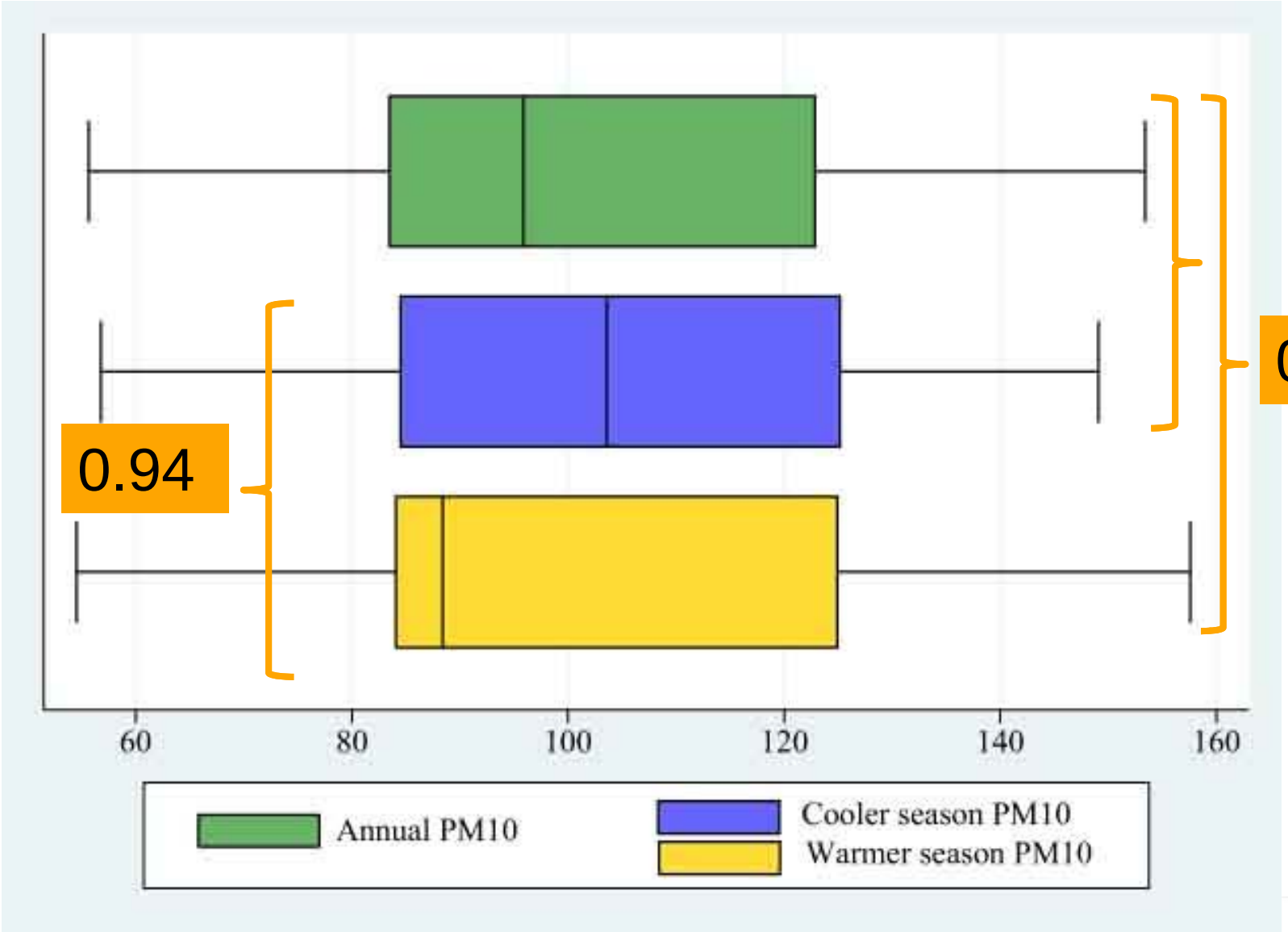
2. A *p*-value of < 0.1 for each predictor

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

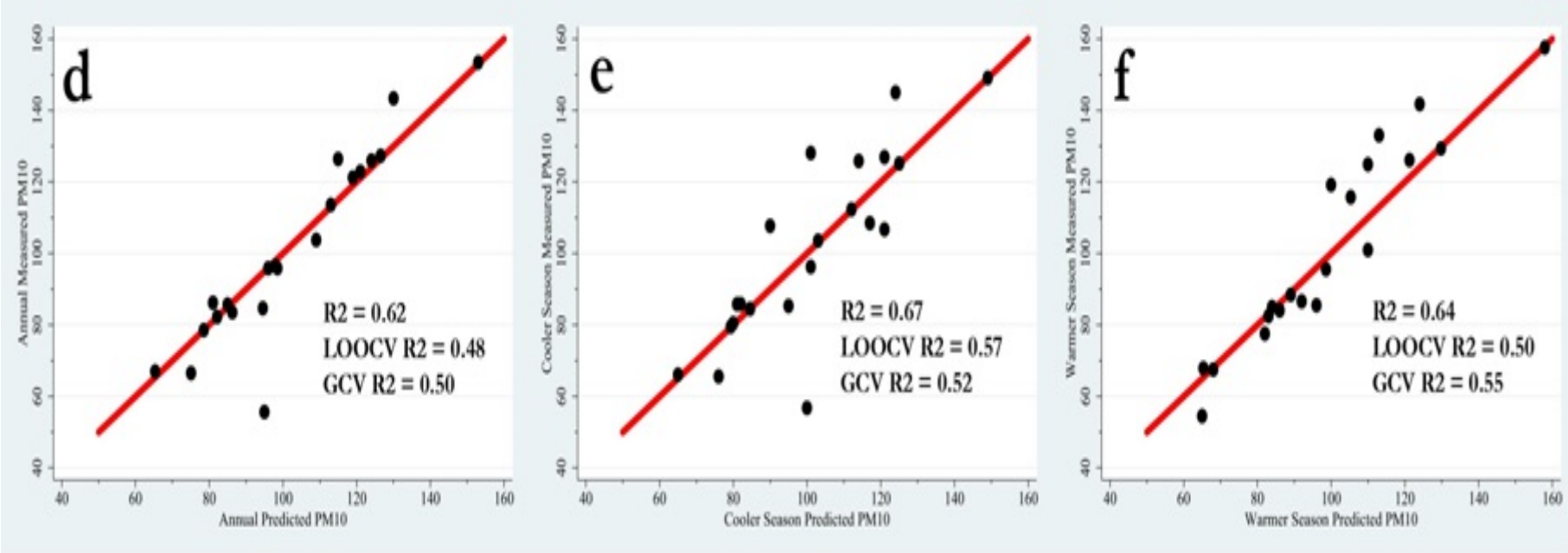
Results – Final LUR models, Warmer season PM10

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

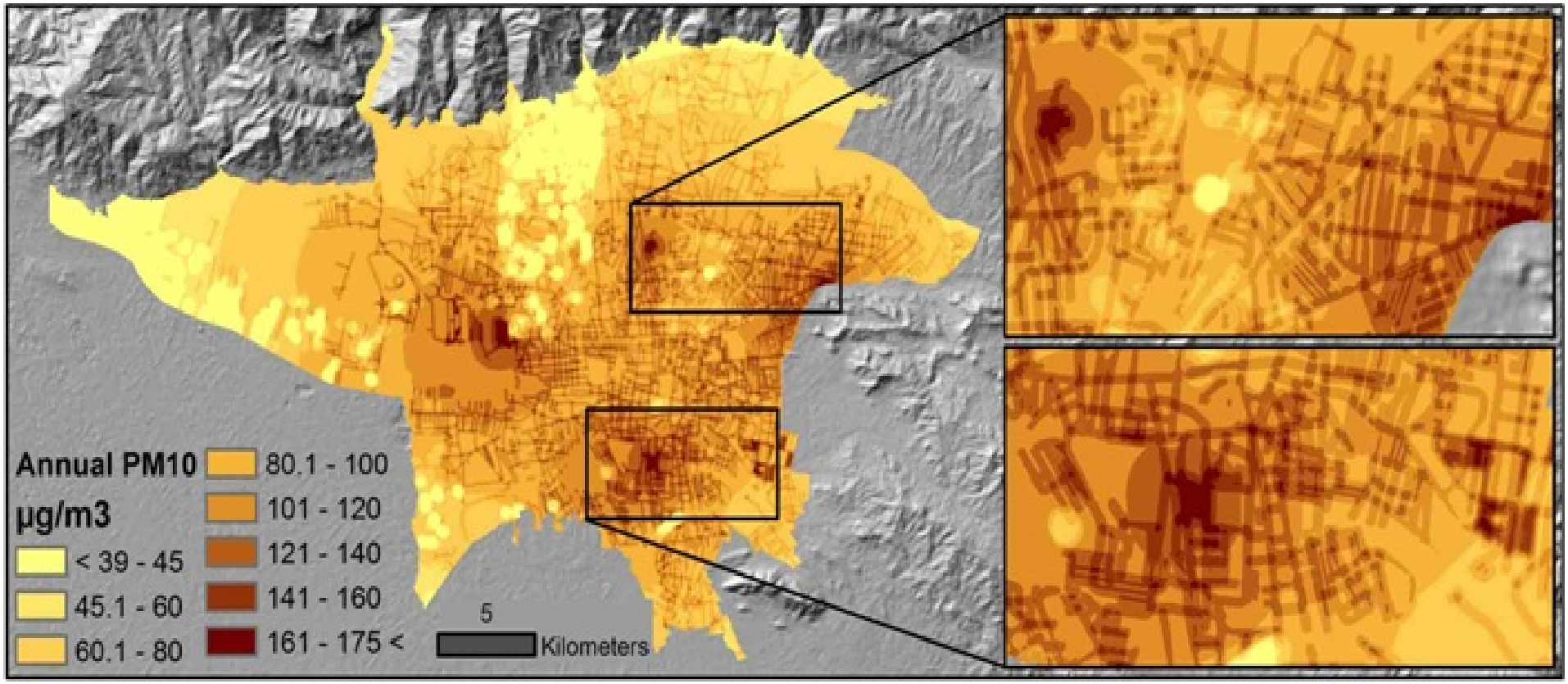
Results – Final LUR models

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



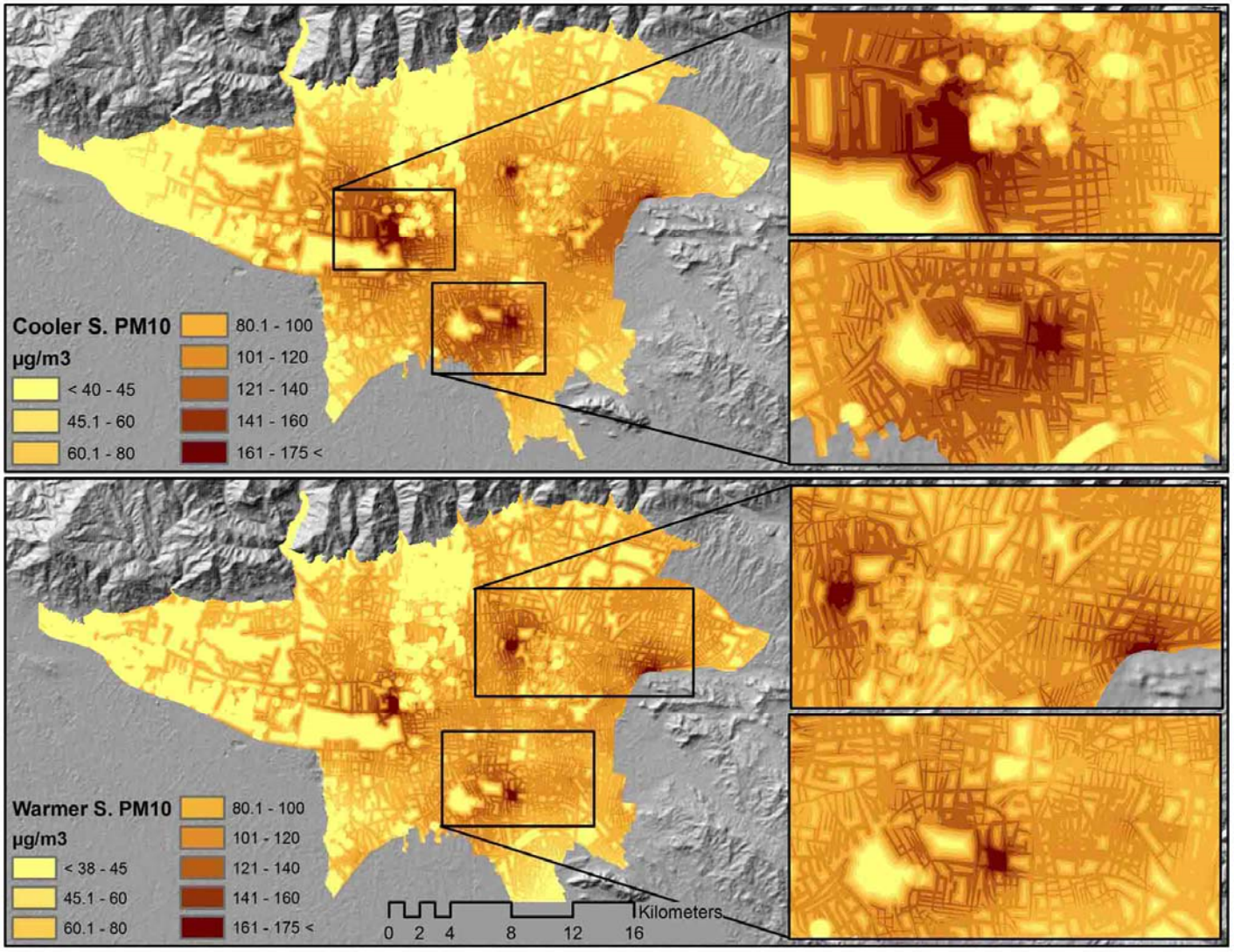
Results – Final LUR maps

- 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

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Special thanks to Swiss TPH colleagues

Thanks for your attention!

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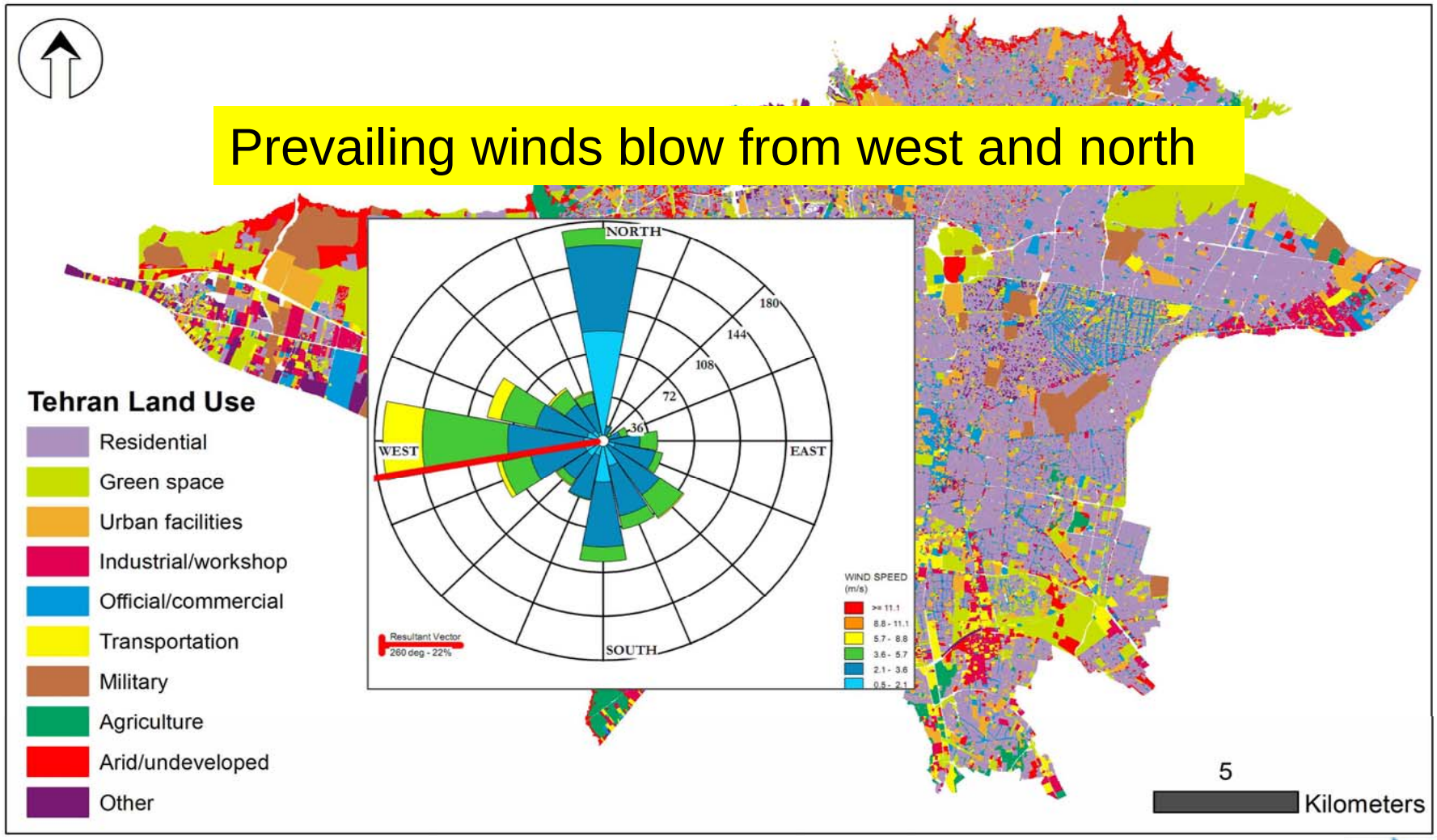
Additional figures for discussion

▪ Wind rose in Tehran, Iran



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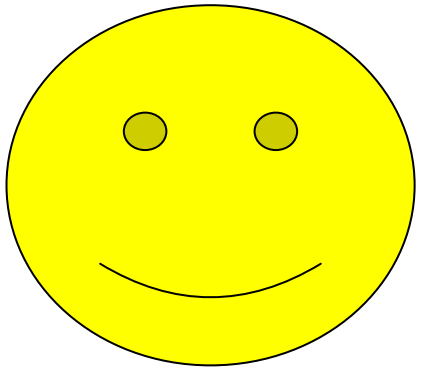

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