Bridging the Scales in Atmospheric Sciences : Local to Global



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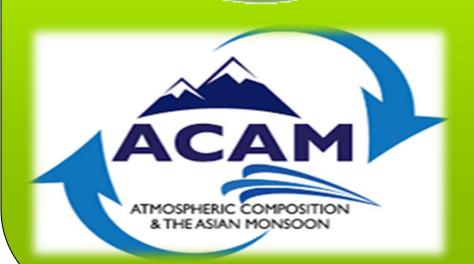
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Performance Evaluation of VAR Model to Forecast Atmospheric Carbon monoxide and Ozone over regions lacking Air quality monitoring networks



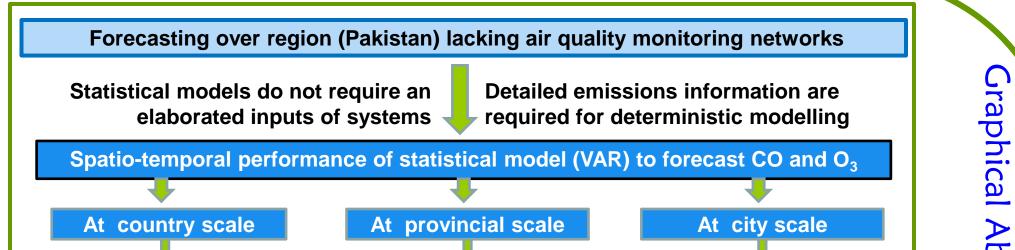
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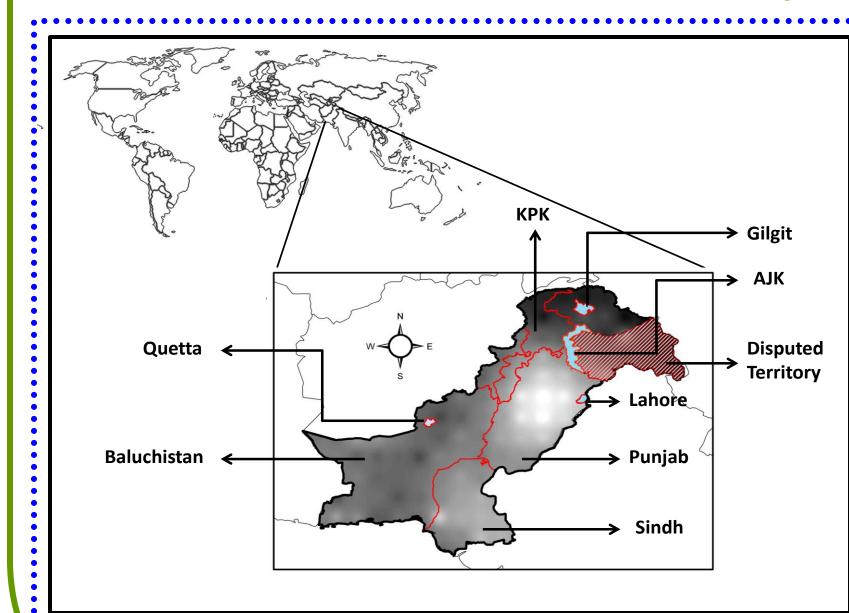


## **Performance of VAR Model over Pakistan**

The VAR model is developed to forecast the concentrations of CO and  $O_3$  over Pakistan from year 2013 to 2025. The monthly mean levels from year 2005 to 2012 are used as input to forecast for the year 2013 to 2025. The predicted (forecasts by VAR model) concentrations are compared with observed (actual/satellite observations) concentrations from year 2013 to 2017 to validate the forecasting ability of the employed model. Spatially, the model is tested over various spatial scales:



the whole country, provinces and the selected cities. Furthermore, to test the interdependency of CO and  $O_3$ , the precursors (NO<sub>2</sub> and HCHO) are also taken as endogenous variables at each study scale to forecast the concentrations of CO and  $O_3$ .



Location of Pakistan showing study area

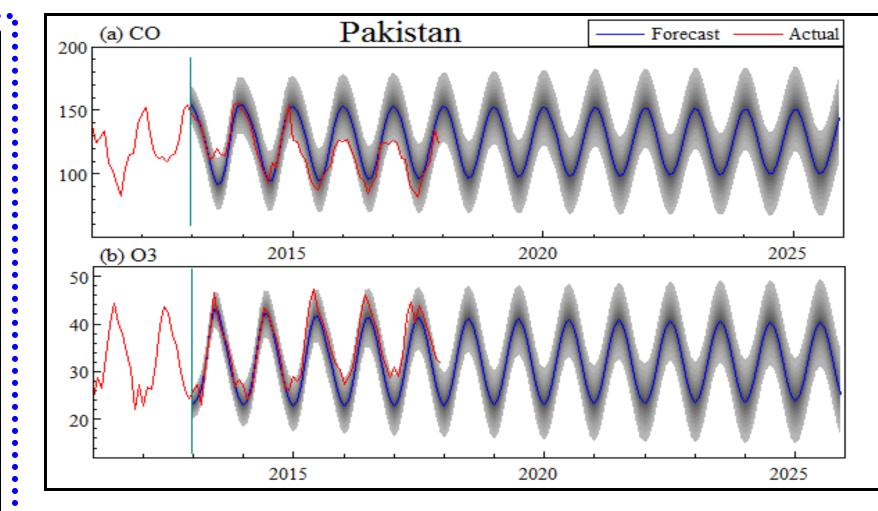
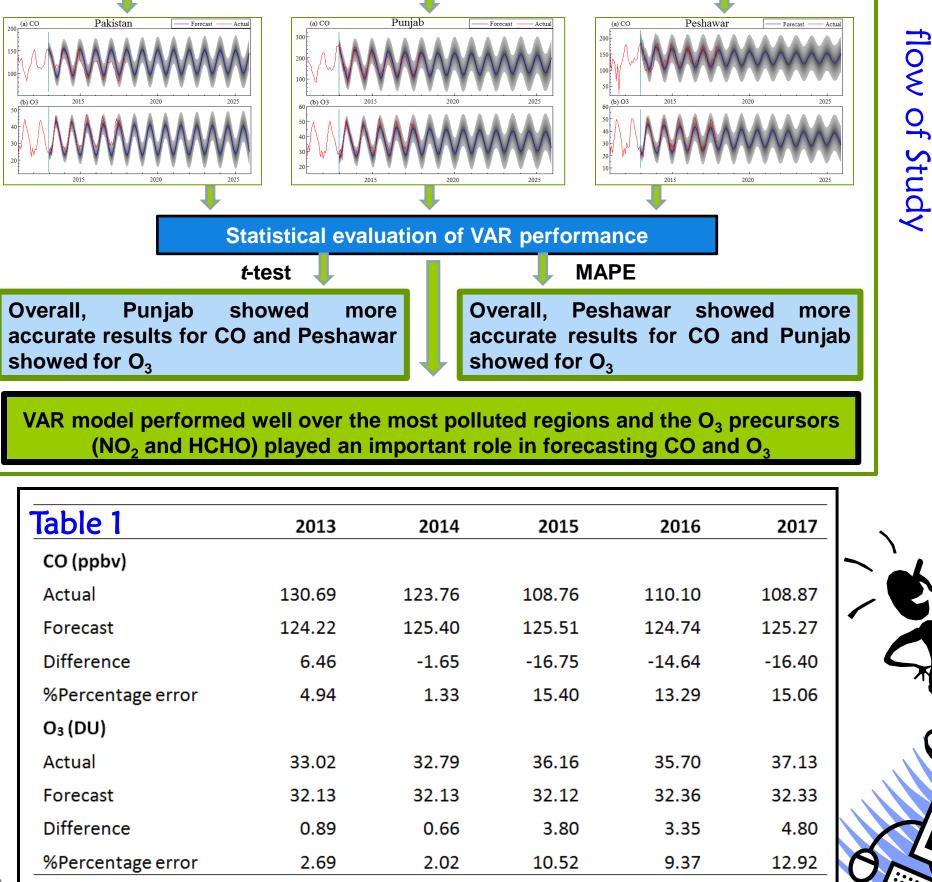


Figure 1: The actual (observed) and forecasted (predicted) concentrations of (a) CO and (b)  $O_3$  over Pakistan by using VAR model

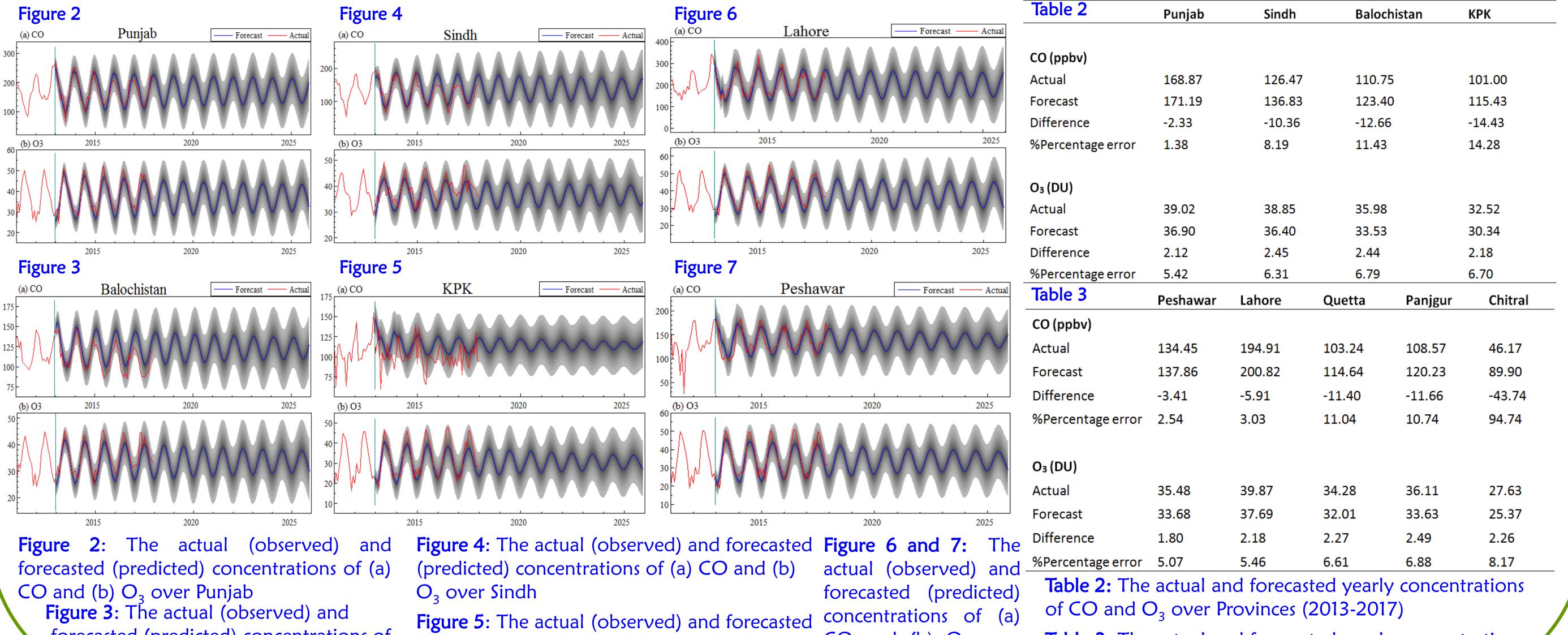
 
 Table 1: The observed and predicted yearly
 concentrations of CO and  $O_3$  over Pakistan (2013-2017)



## **Performance of VAR Model over Provinces and Cities**

Better performance of VAR model over Punjab is observed as compared to other provinces irrespective of spatio-temporal scale. This could be related to high concentrations of other endogenous variables (NO<sub>2</sub> and HCHO) employed by model over Punjab. As O<sub>3</sub> and its precursors (NO<sub>2</sub> and HCHO) are taken as endogenous variables in the VAR model to forecast CO whereas, O<sub>3</sub> precursors (NO<sub>2</sub> and HCHO) and CO are taken as endogenous variables in the VAR model to forecast O<sub>3</sub>. According to WHO report (2016), the cities of Peshawar and Lahore are among the most polluted cities in the world, are selected to test the

performance of VAR model. Peshawar and Lahore being the most polluted cities with greater anthropogenic activities showed relatively better results for CO forecasts with an error of 2.54% and 3.03% respectively (Figure 6 and 7; Table 3). However, model showed poor performance over the city of Gilgit.



fore	casted (predicted) concentrations of	(r
	(a)CO and (b) $O_3$ over Balochistan	

CO and (b)  $O_3$  over predicted) concentrations of (a) CO and (b) Lahore and Peshawar O<sub>3</sub> over KPK

 
 Table 3: The actual and forecasted yearly concentrations
 of CO and O<sub>3</sub> over Cities (2013-2017)

	CO	Оз	Conclusions and Recommendations	Acknowledgments
	MAPE (%)	MAPE (%)	<ul> <li>•The VAR model provided successful results at both spatial and temporal scales.</li> <li>•Comparatively, its performance is better over regions with more anthropogenic activities as</li> </ul>	Authors gratefully acknowledge NASA Data
Pakistan	11.00	9.44	• Finer results of VAR model are observed over the province of Punjab and the city of Lahore	Team for data products. Big thanks to ACAN Organizers and IGAC for providing travel grant
Punjab	10.50	7.25	and Peshawar (relatively more polluted)	Organizers and tone for providing traver grant
Sindh	12.59	7.72	•The model is not recommended for non-polluted sites as it failed to forecast over Gilgit	to attend 4 <sup>th</sup> ACAM Workshop
Baloch	13.17	9.03		
КРК	18.78	10.50	(relatively cleaner city). It is observed that $O_3$ precursors (NO <sub>2</sub> and HCHO) played an important role in forecasting CO and $O_3$ over study region. Furthermore, VAR Model has	
Peshawar	10.00	9.78	shown more promising results for $O_3$ forecasts as compared to CO forecasts.	e-mail: naila.zeb@iese.nust.edu.pk
Lahore	11.24	7.48	• The VAR model used in this study has prognostic capabilities to forecast atmospheric pollutants	
Quetta	12.50	8.69		Phone: +923136764760
Panjgur	15.41	7.34	over region with least data inputs to compensate for deterministic modelling.	INTIONAL CONTRACTOR OF A CONTR
Chitral	19.65	17.75	• It can be further tested for daily forecasts to provide early warnings in areas with limited	
Table 4 Statistical estimation to determine the			•Future scenarios with high and low concentrations of CO and O <sub>3</sub> precursors can be created	ACAM (GAC) NASA

accuracy of VAR model using MAPE

using VAR model to explore the role of precursors in forecasting.