# Impacts of drying up of Urmia Lake, the second largest hypersaline lake in the world, on particulate matter concentration in the northwestern Iran

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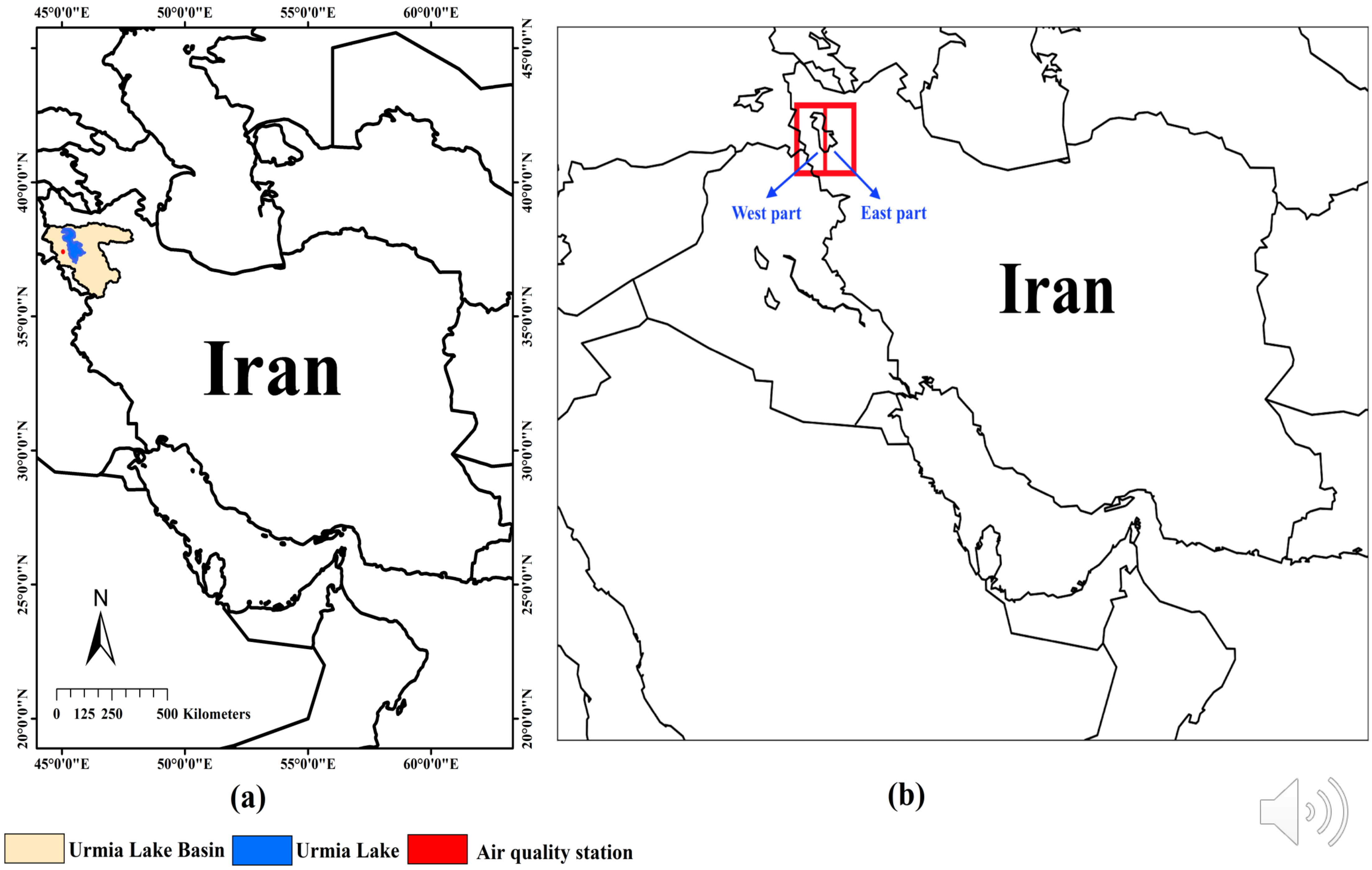


45°0'0"E
50°0'0"E
55°0'0"E
60°0'0"E
45°0'0"N
40°0'0"N
35°0'0"N
30°0'0"N
25°0'0"N
20°0'0"N
Iran
N
0 125 250 500 Kilometers
(a)
West part
East part
Iran
(b)
Urmia Lake Basin
Urmia Lake
Air quality station

Land cover changes in Urmia Lake:

(a) 2005

(b) 2012

(c) 2005

(d) 2010

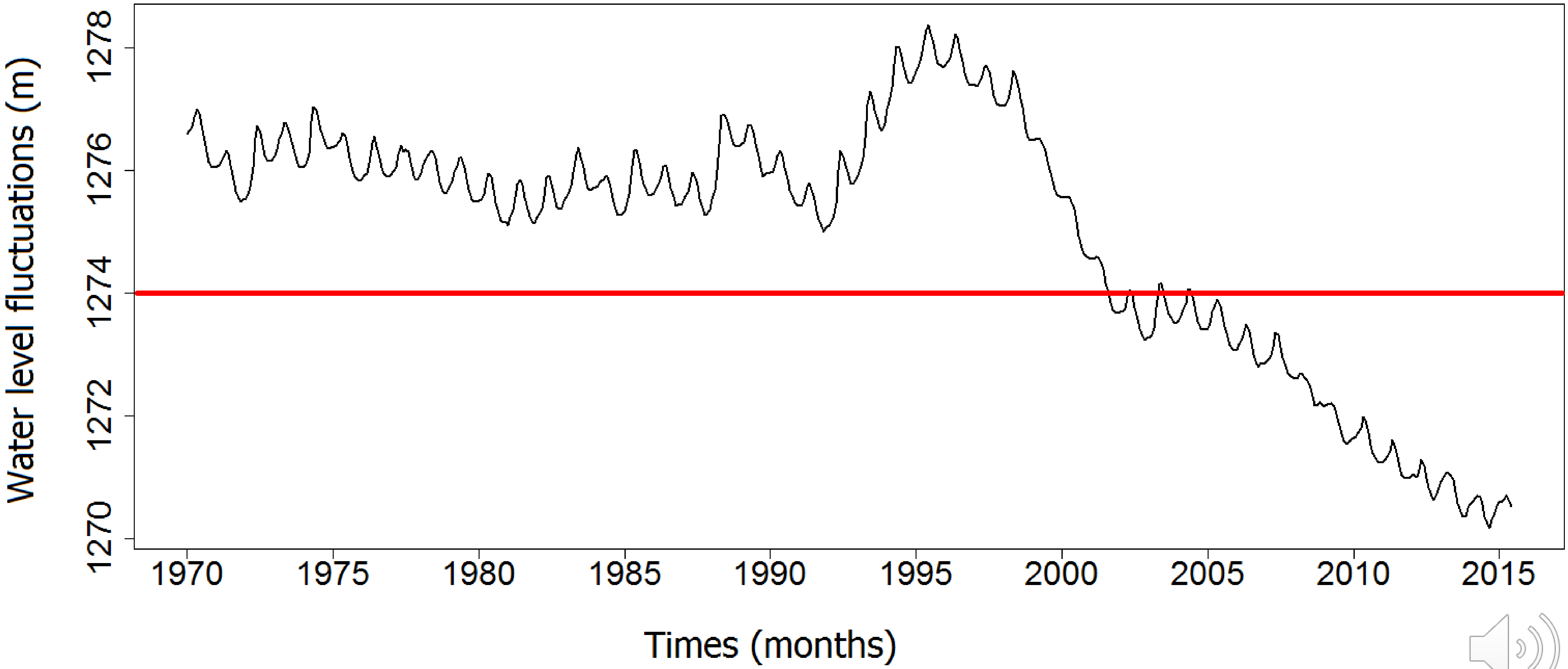

(a)


(b)


(c)


(d)

## Salt playas



Water level fluctuations of Urmia Lake from 1970 to 2016

Land cover changes of Urmia Lake provided by

Yusuf Alizade Govarchin Ghale

**Dust emission**

**and**

**aerosol pollution**

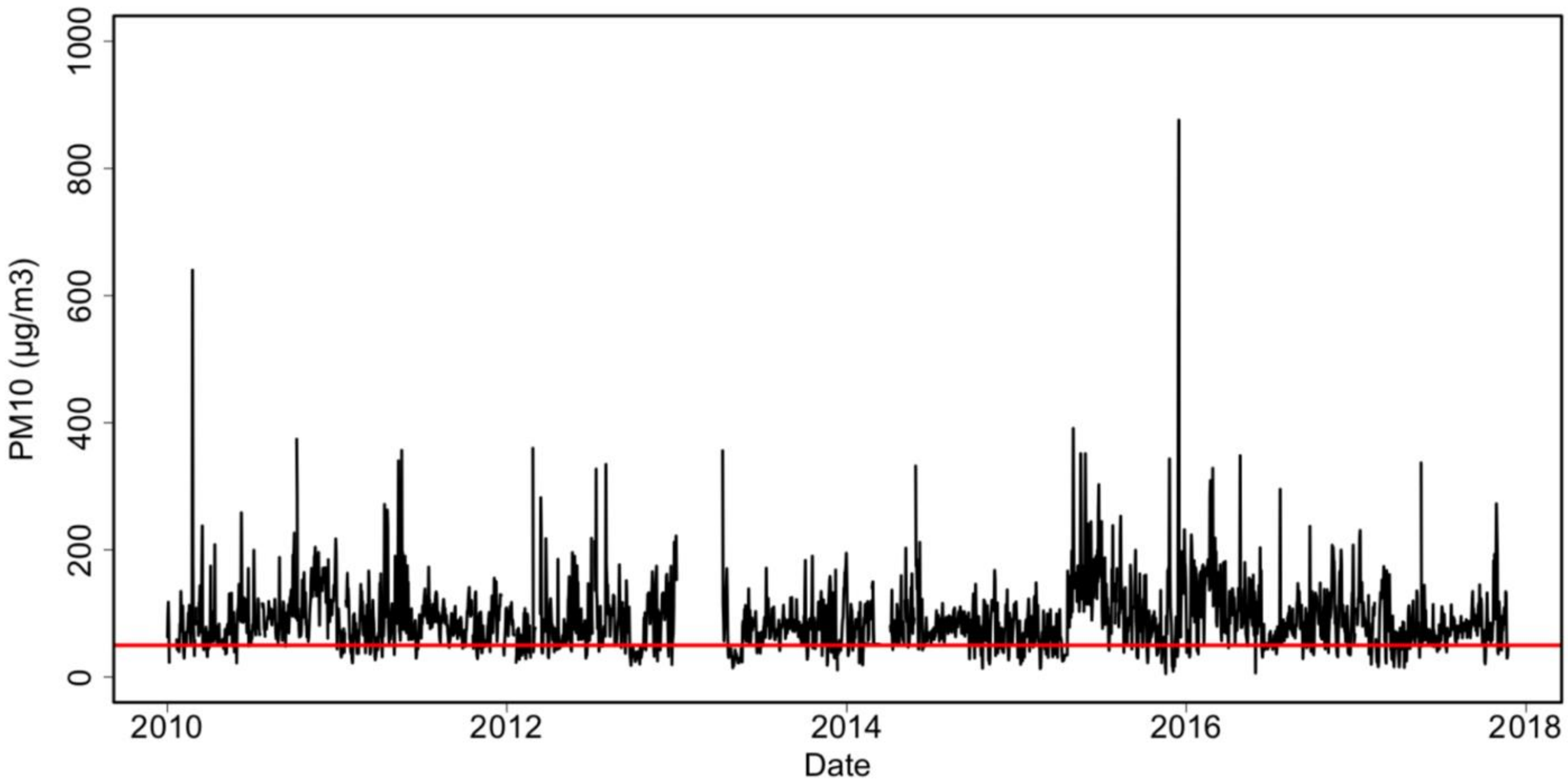
# Consequences and Threats of Urmia lake desiccation

- **Extension of salinization and desertification**

- **The effects of Urmia Lake desiccation on the local and regional air quality**

- Hourly ground-level $PM_{10}$ data of Urmia station in the northwestern Iran conducted by Department of Environment.

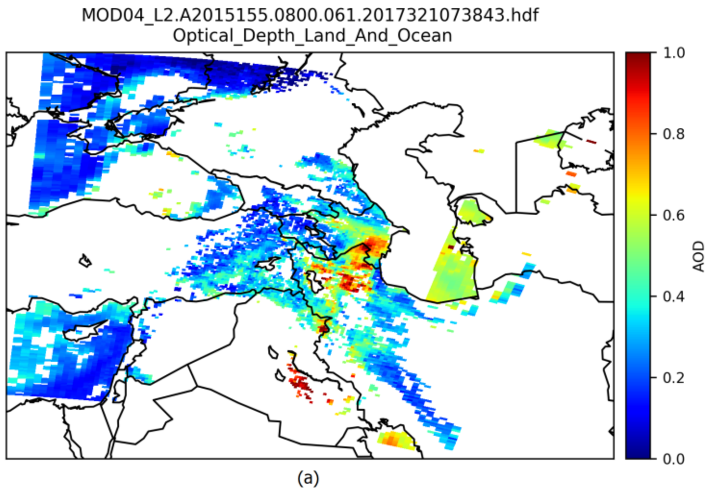
- 9000 daily level 2 Aerosol Optical Depth data (at 550 nm) of Aqua MODIS (MYD04) and Terra MODIS (MOD04), collection 6.1, at 10 *10 km spatial resolution.



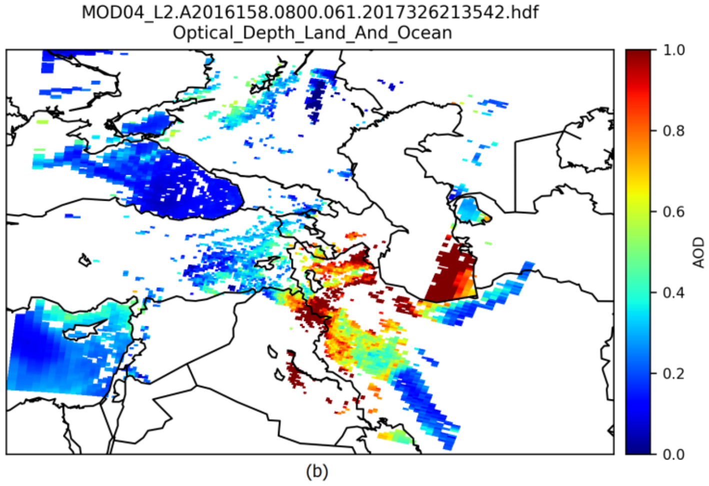

Daily $PM_{10}$ variations of Urmia station located in the northwestern Iran. The red line equals to 50 µg/m3.

AOD map of MODIS aerosol product, when the maximum AOD levels are visible in the southern and northern of Urmia Lake.

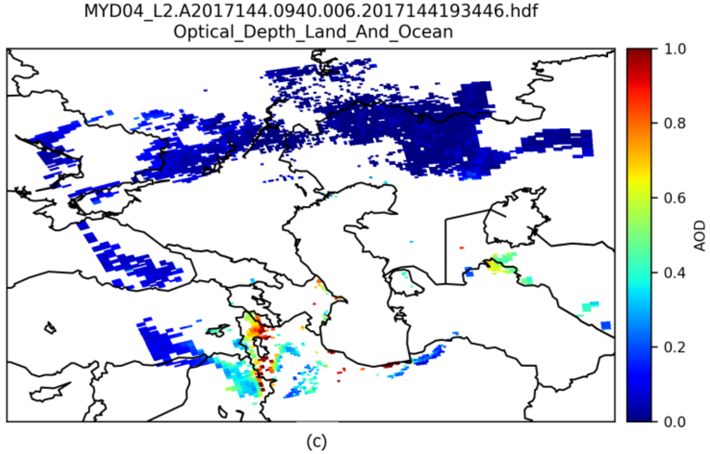
(a) June 04 2015 ($PM_{10}$ = 356 μg/m3)

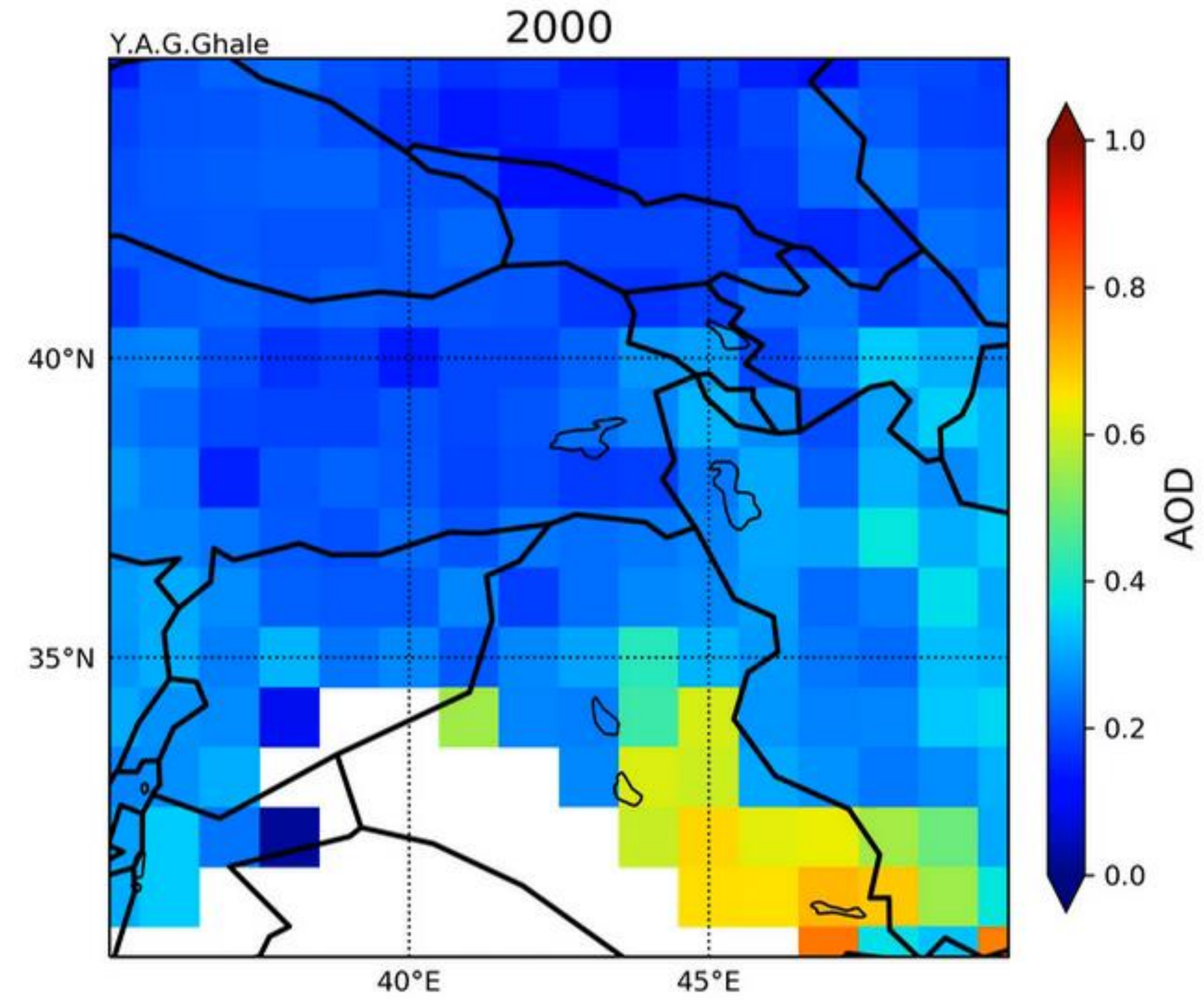



(b) June 06 2016 ($PM_{10}$ = 164 μg/m3)




(c) May 24 2017 ($PM_{10}$ = 240 μg/m3)



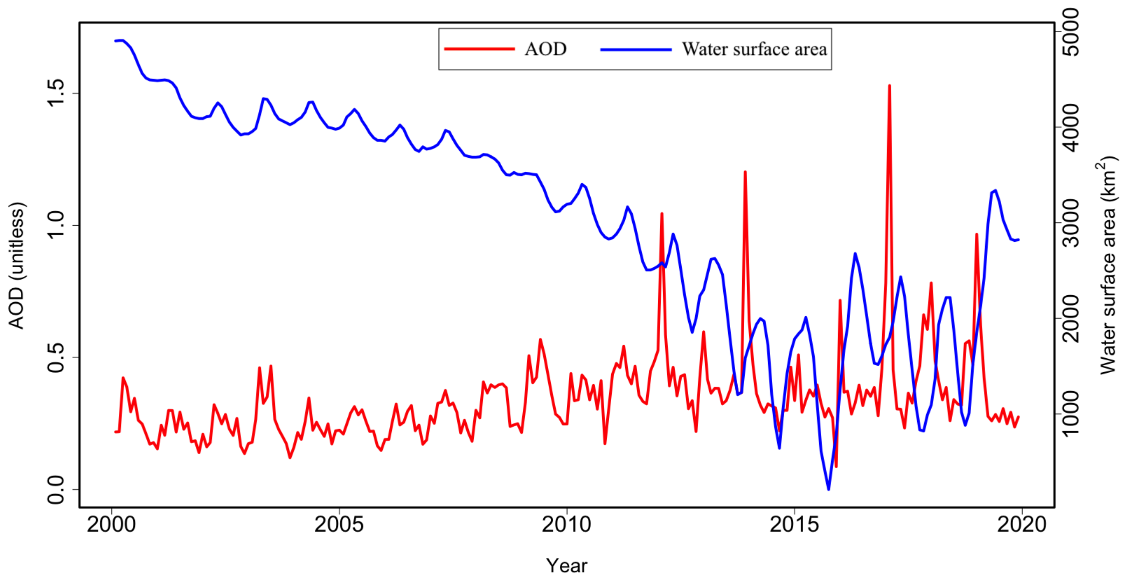

2000
Y.A.G.Ghale
40°N
35°N
40°E
45°E
1.0
0.8
0.6
0.4
0.2
0.0
AOD

- There is an inverse relationship between AOD changes and water surface area changes of Urmia Lake.

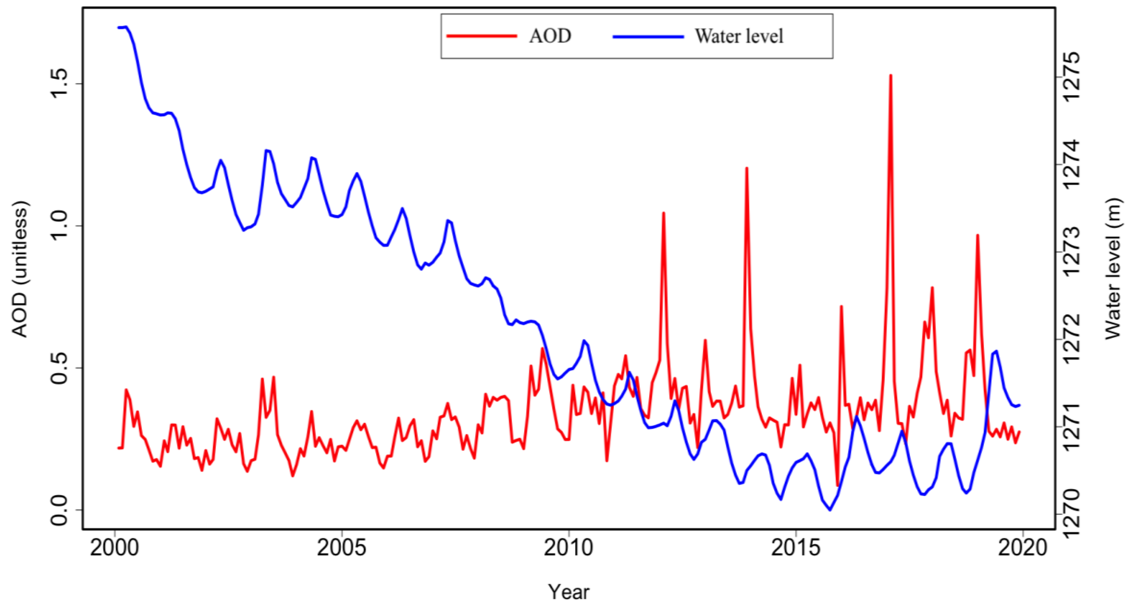
- There is an inverse relationship between AOD changes and water level changes of Urmia Lake.

- The AOD anomalies has increased in recent years as a result of decreasing the water surface area of Urmia Lake.

- The results indicated that dried bottom of Urmia Lake has potential to be known as a new source of aerosol pollution in the northwestern Iran.

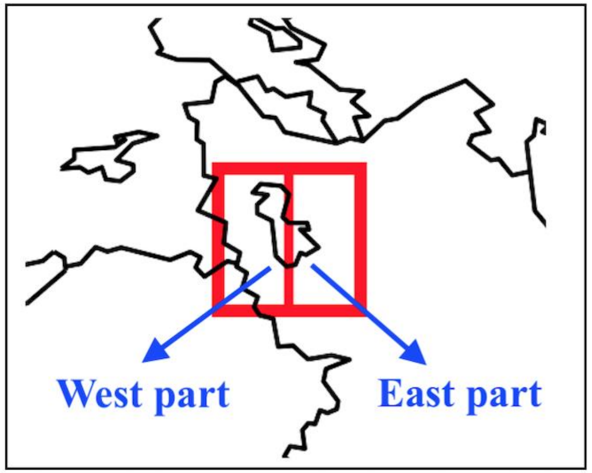


(a)

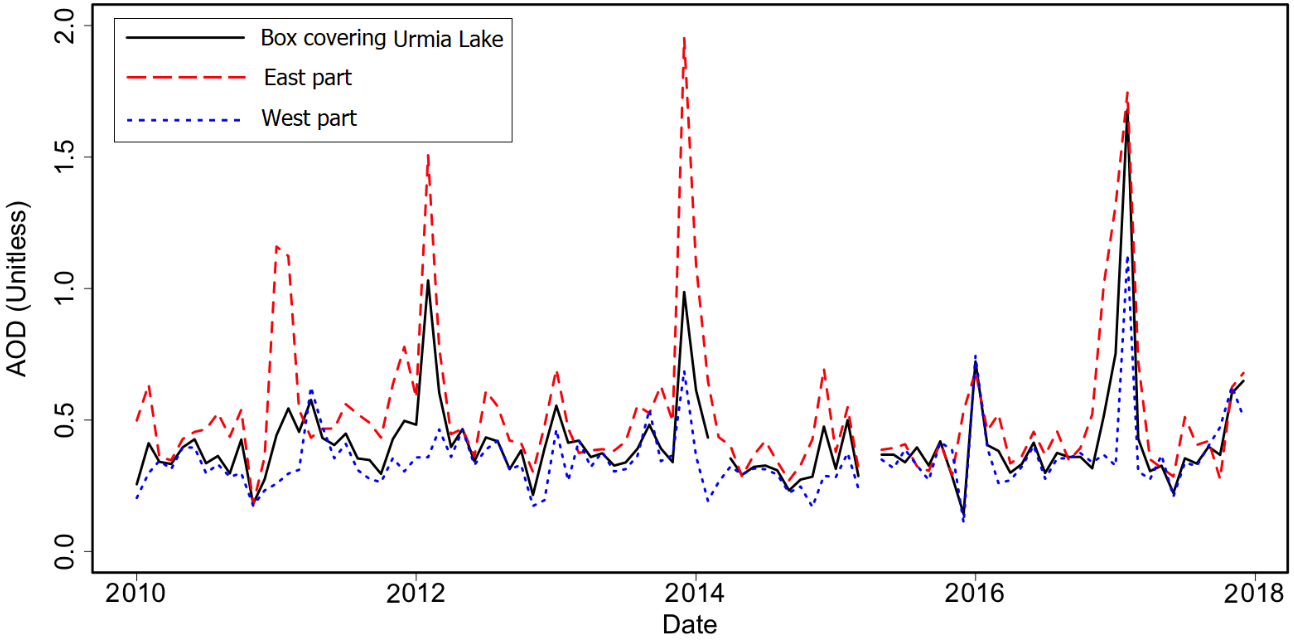


(b)

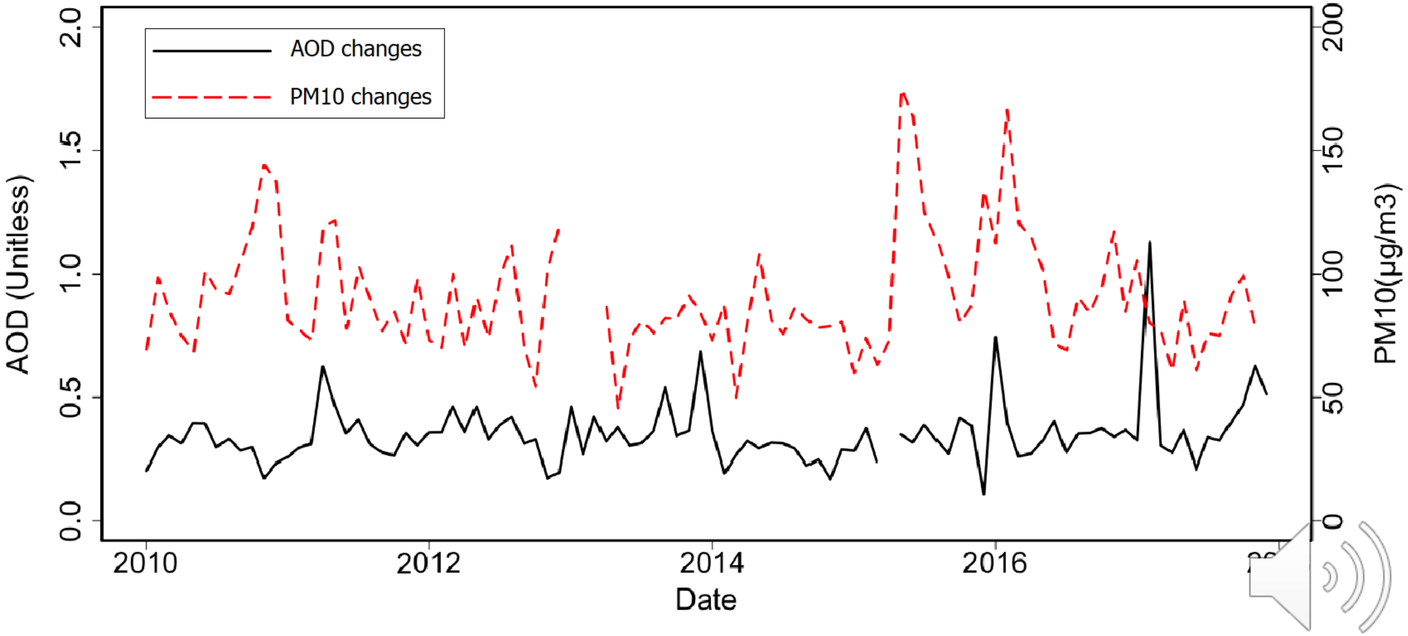
(a) Monthly mean AOD changes in the box covering Urmia Lake (ULB), West Part (WP) and East Part (EP)




(b) Monthly mean AOD changes and $PM_{10}$ concentration in the WP and Urmia station, respectively.




(a)




(b)

The MLR and multi-variable LME models were used in this study to explore the relationship between $PM_{10}$ and AOD in the northwestern Iran. The daily metrological data of Urmia station and daily average AOD values in the western Urmia Lake (west box) were used to estimate ground-level $PM_{10}$. The Equations of MLR and LME are shown below:

Model-1 (MLR)

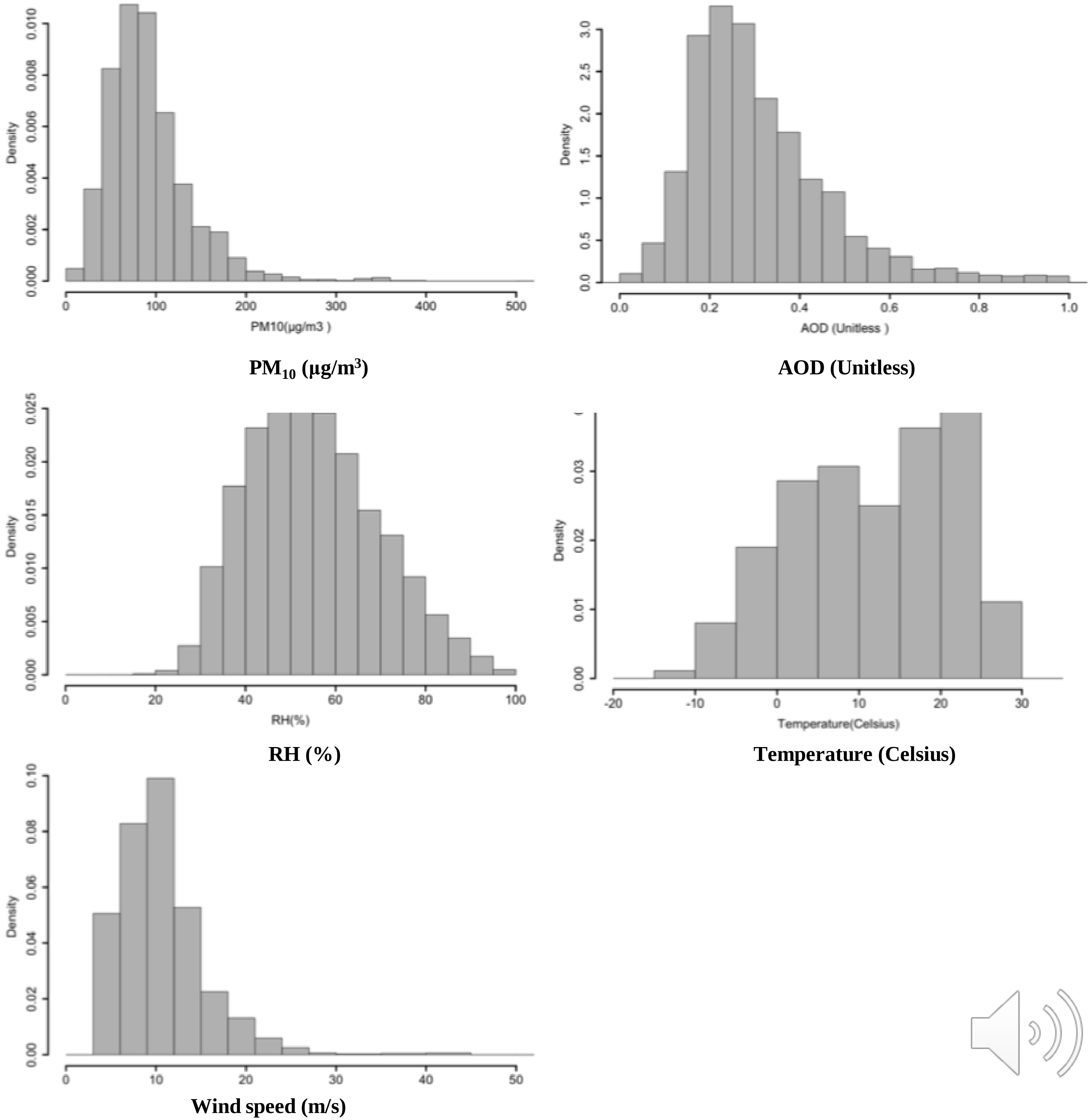
$$PM = a + (b1) \times AOD + (b2) \times Tem + (b3) \times RH + (b4) \times WS + e \quad (1)$$

where, all variables are averaged daily. PM indicates the $PM_{10}$ concentration at Urmia station (dependent variable). AOD, Tem, RH and WS are independent variables, a is intercept, b1, b2, b3 and b4 are regression coefficients and e represents the error term.

Model-2 (LME)

$$PMij = (c + Uj) + (d) \times Temij + (Vj) \times AODij + (Wj) \times RHij + (Zij) \times WSij + eij \quad (2)$$

where, PMij indicates the $PM_{10}$ concentration (dependent variable) at the i-th site (in this study only the data of Urmia station were used because there was no access to the meteorological data of other stations) on the j-th day, c and Uj are the fixed and random intercepts, respectively, d and Vj/ Wj/ Zij are the fixed and random slopes, respectively and eij indicates the error term in i-th site and j-th day. Temij, AODij, RHij and WSij are independent variables in i-th site and j-th day.

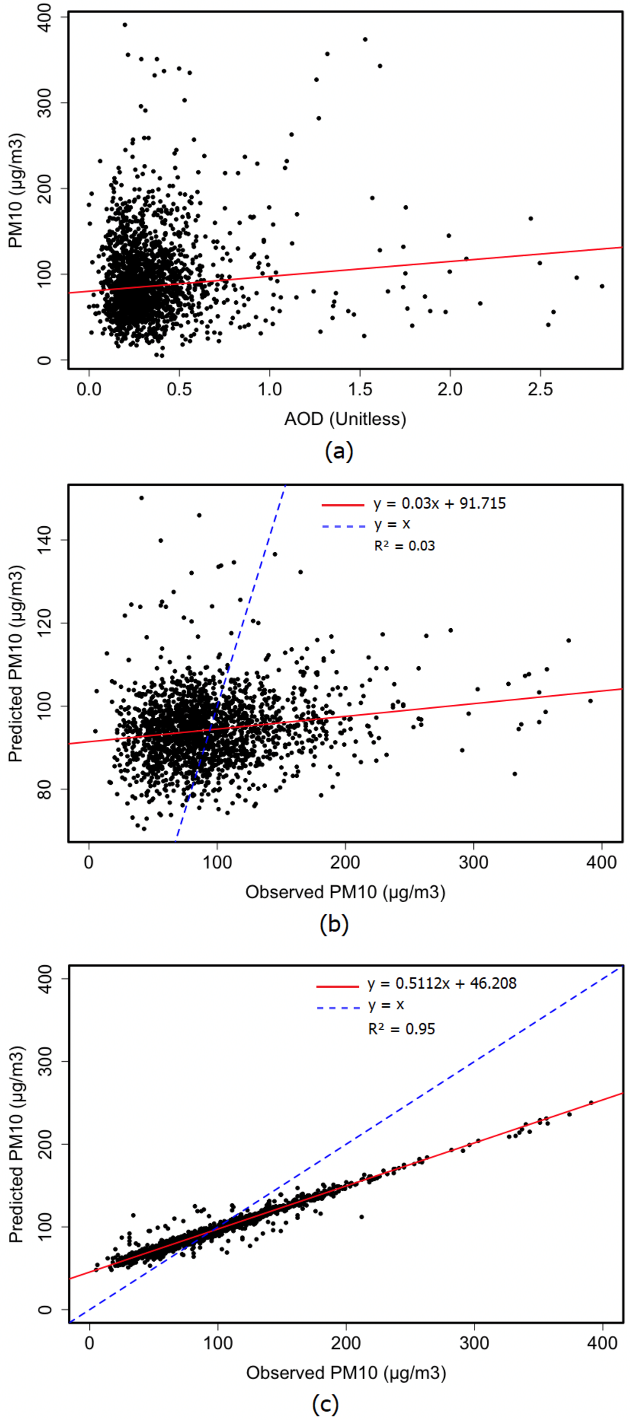


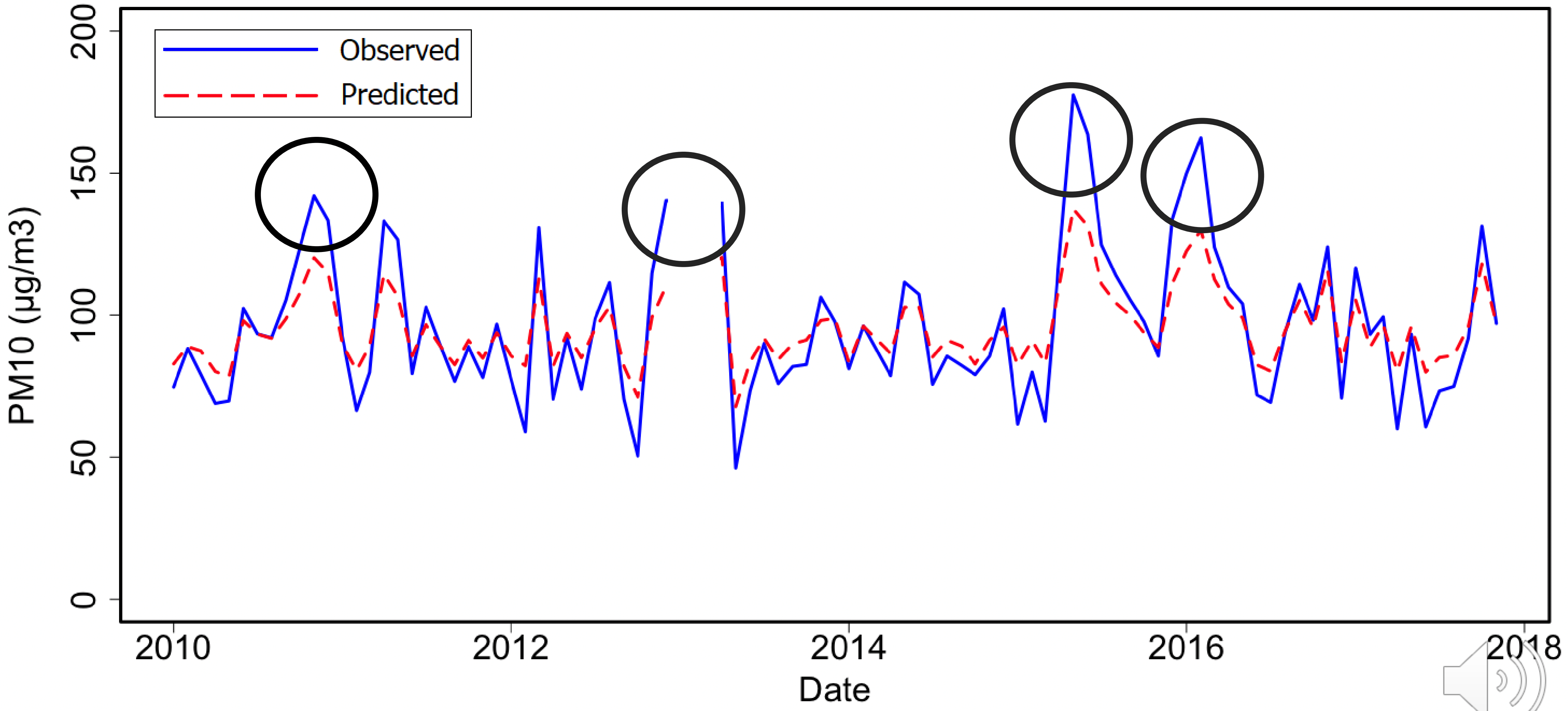

- The histogram graphs indicated normal and log normal like distribution.

(a) Scatter plot of AOD-$PM_{10}$ relationship.

(b) Scatter plot of predicted PM10 by Multiple Linear Regression Model versus observed $PM_{10}$ concentrations.

(c) Scatter plot of predicted $PM_{10}$ by Linear Mixed Effect Model versus observed $PM_{10}$ concentrations.



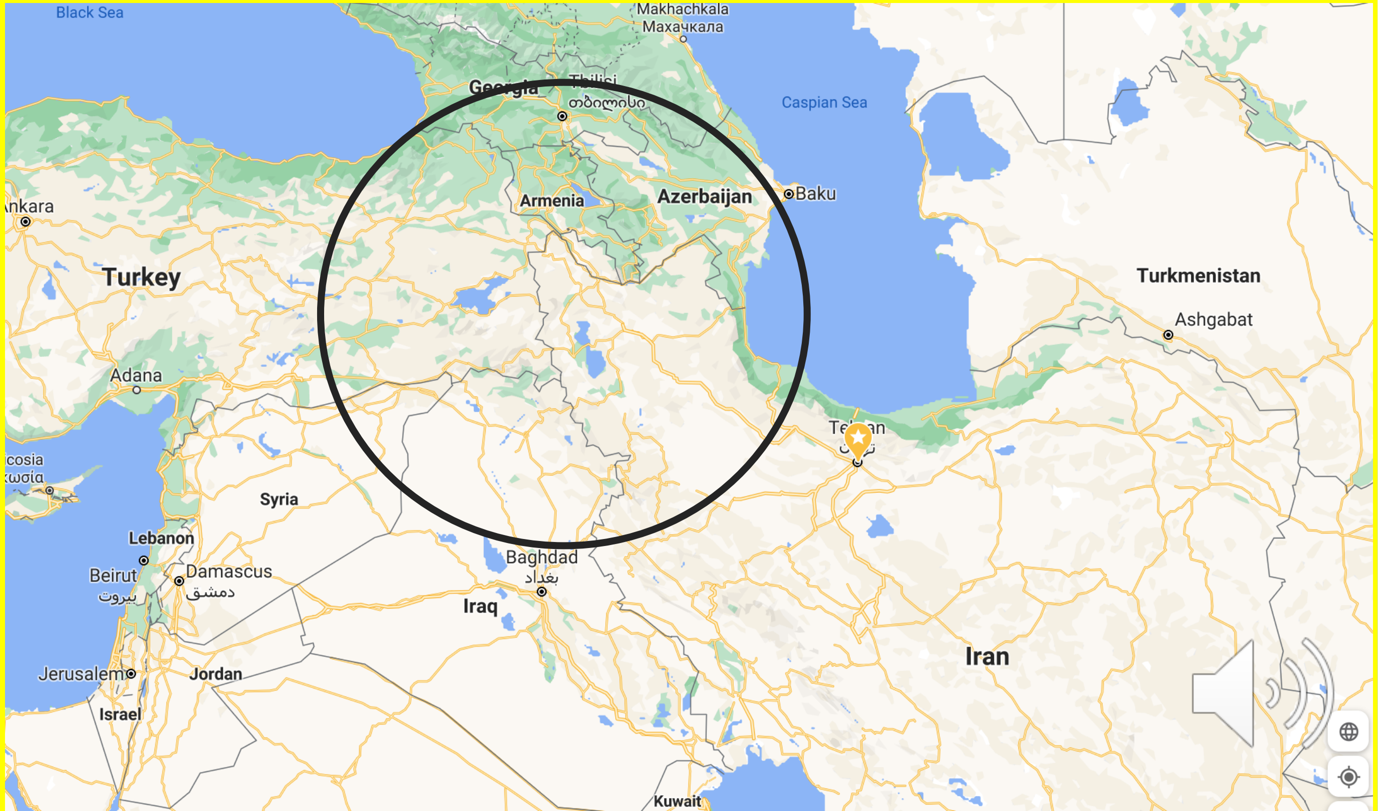



Monthly variations of observed and predicted $PM_{10}$ concentration by Linear Mixed Effect Model

# Future work:

Investigating the use of atmospheric transportation model (CMAQ) to understand the mechanics of dust transportation in the region.

In addition to northwestern Iran, the high levels of $PM_{10}$ values and aerosol concentration were observed in the eastern and southeastern Turkey. We would like to investigate the possible transportation of dust from Urmia Lake to neighbouring regions and countries.



# Conclusion

- The Shrinkage of Urmia Lake has caused many environmental problems in the northwestern Iran such as salinization, desertification and air pollution.
- The daily mean AOD in the west part of the lake and east part of the lake was 0.348 and 0.508, respectively.
- Although, the eastern part of the lake is mostly affected by dust emission, other parts of the lake are also at risk.
- In total, 129 days with mean AOD values more than 1 were observed in box covering all parts of the lake between 2010 and 2017, which indicated the severity of air pollution and dust emission from the dried bottom of the lake.
- Two statistical models including MLR and LME were used for estimation of $PM_{10}$ concentrations in Urmia station. The RMSE and AME values of MLR were 45.60 $\mu g/m^3$ and 33.09 $\mu g/m^3$, respectively, while, the RMSE and AME values of LME were 23.22 $\mu g/m^3$ and 16.59 $\mu g/m^3$, respectively.
- The $R^2$ of LME was 0.95 and this model performed better than MLR model. Moreover, the seasonal analysis of LME indicated that the summer and winter seasons account for higher (0.98) and lower (0.86) values of $R^2$.

# Do you have any question?

Thank you for your attention…