National Atmospheric Deposition Program

2018 Scientific Symposium and Fall Meeting
40 Years of Monitoring Atmospheric Deposition: Historical Legacy and Looking Ahead to the Future.

Background of Atmospheric Deposition in Mexico Studies and Actual Challenges.

Rodolfo Sosa Echeverría*, Ana Luisa Alarcón Jímenez*, Maria del Carmen Torres Barrera*, Pablo Sánchez Alvarez, Elizabeth Vega Rangel, Elías Granados Hernández, Gilberto Fuentes Garcia, Ana Isabel Gonzalez Rivera, Monica del Carmen Jaimes Palomera** and David Gay***

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** Secretaria de Medioambiente, Gobierno de la Ciudad de México.
*** National Atmospheric Deposition Program.

November 5 – 9, 2018, Albany, NY.

Aknowledgements

- **Dr. Humberto Bravo Alvarez†**
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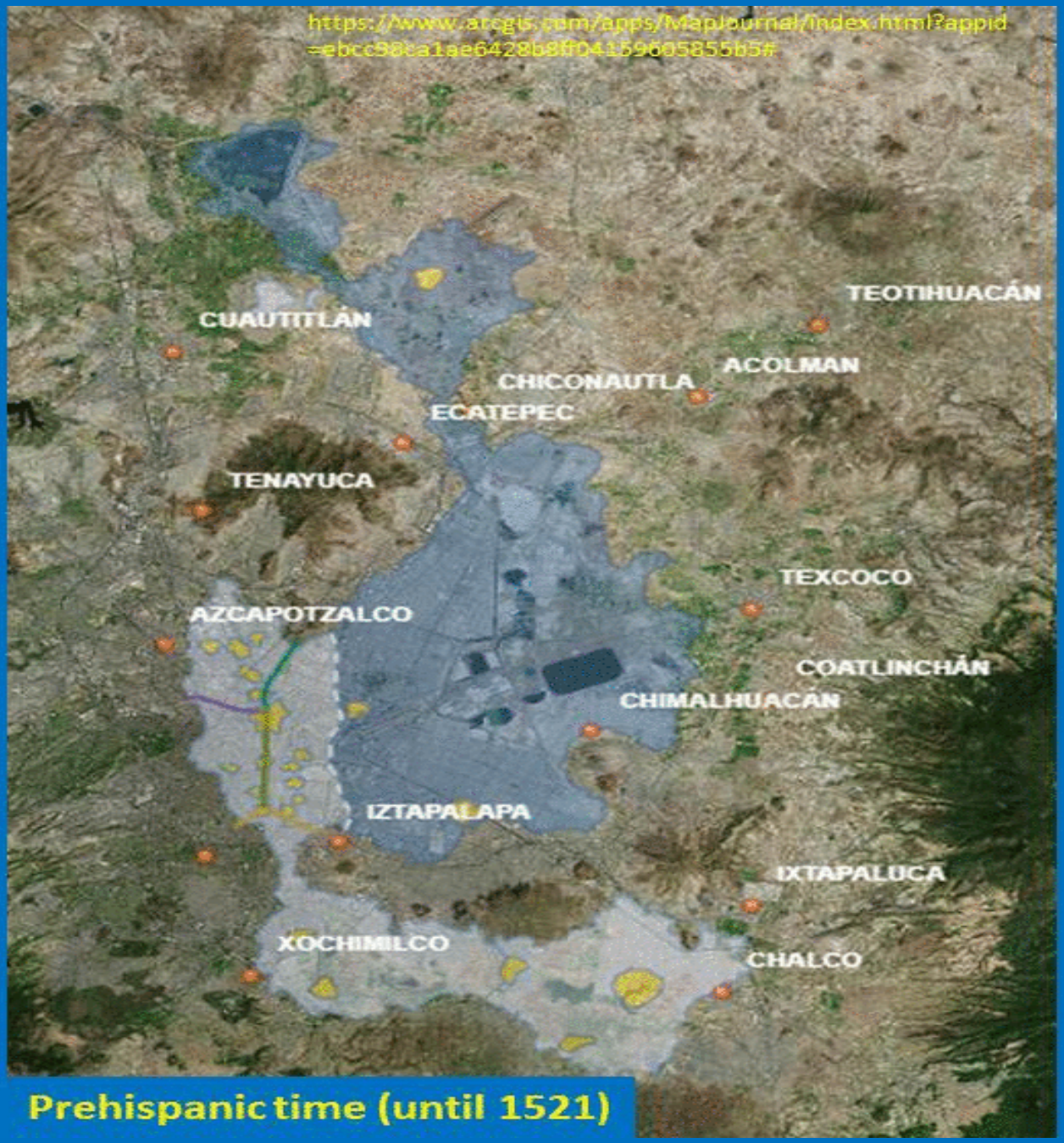
H Bravo A., A.P. Báez and S. Lares. (1960) Study of dust deposition by gravity in México City. Ingeniería Química. June.

Dust storms, Mexico City , 1958.

México, Tenochtitlán

México, Tenochtitlán.

Texcoco Lake Evolution



SEMARNAT
SECRETARÍA DE MEDIO AMBIENTE Y RECURSOS NATURALES

INECC
INSTITUTO NACIONAL DE ECOLOGÍA Y CAMBIO CLIMÁTICO

ANÁLISIS DEL ESTADO DEL ARTE SOBRE EL DEPÓSITO ATMOSFÉRICO EN MÉXICO Y SU RELACIÓN CON EL CAMBIO CLIMÁTICO

INFORME FINAL DEL CONTRATO NO. INECC/RPA1-003/2017

2017

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Preparado para:
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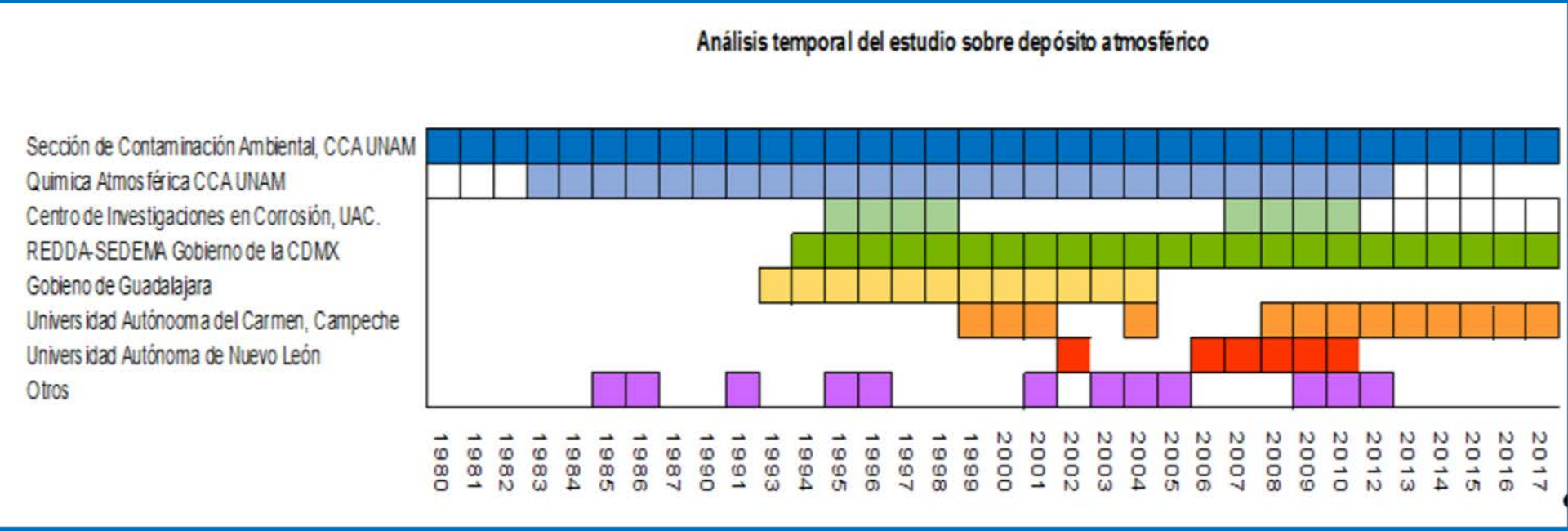
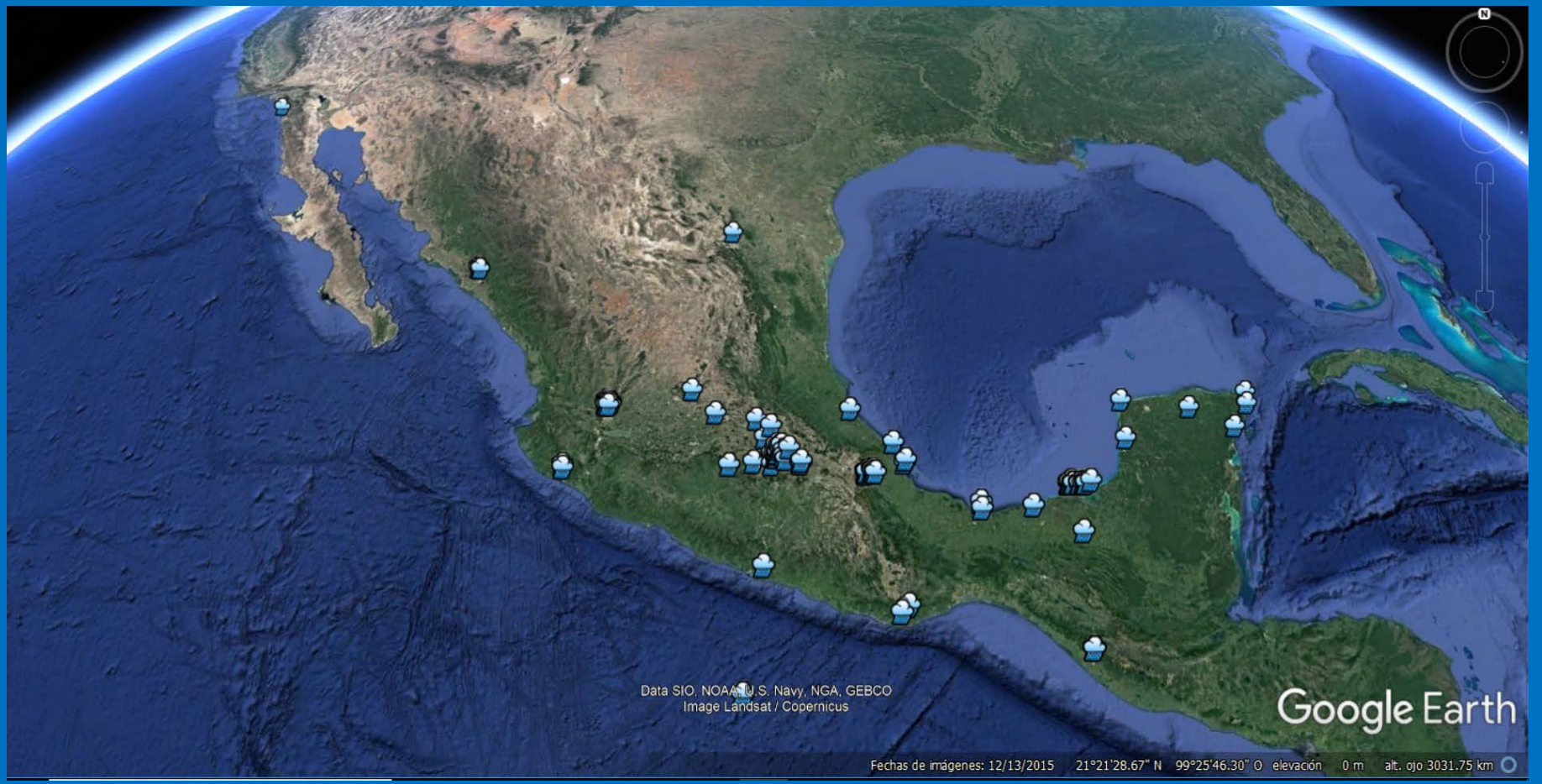
Diciembre de 2017

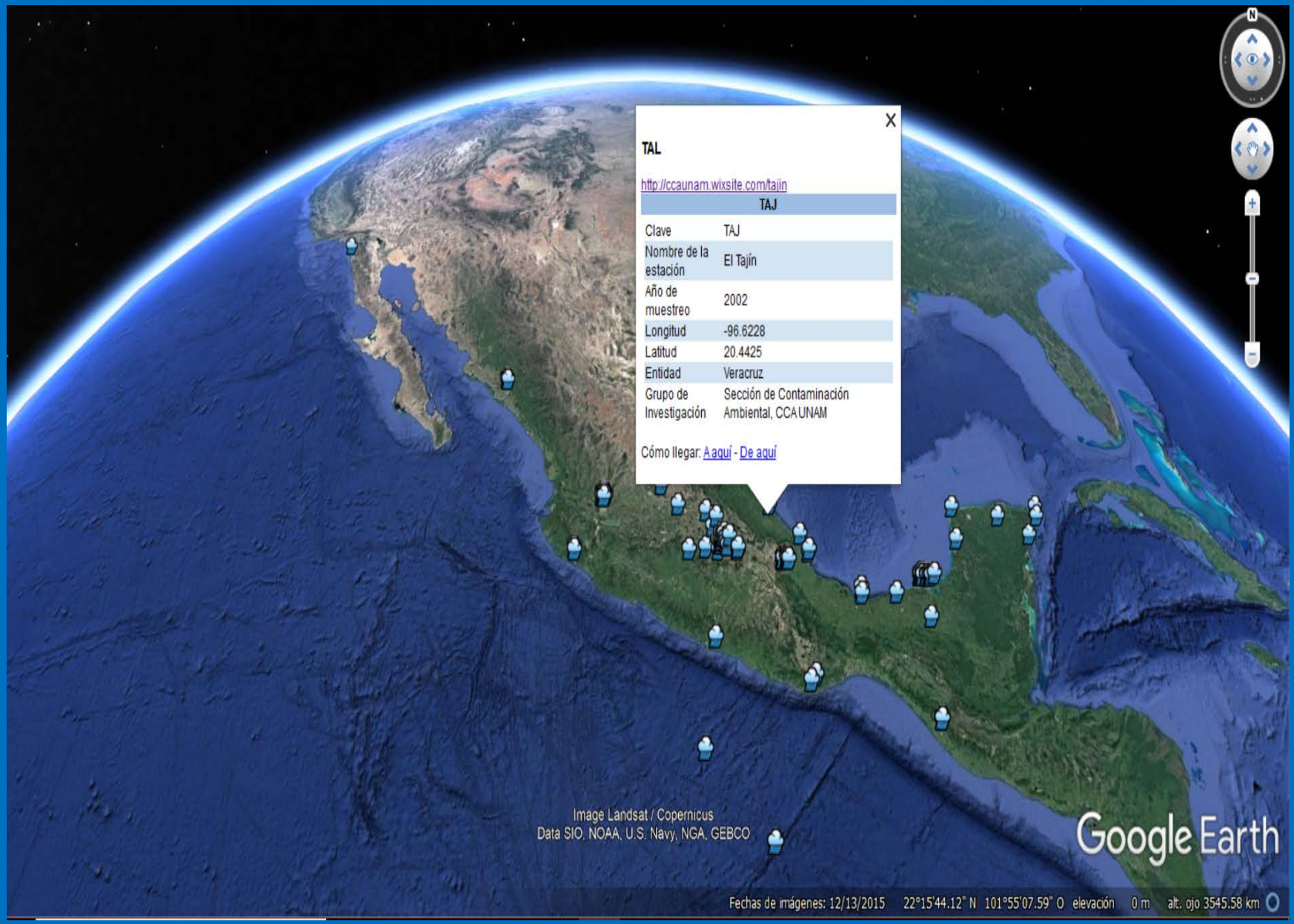
In this research, the background of the studies carried out in Mexico on the subject of atmospheric deposition was integrated. 195 publications were reviewed, including articles, technical reports and theses. The first studies on acid rain in Mexico City began in the 80's between the National Meteorological Service and the National University of Mexico (UNAM).





The results of the investigations carried out in Mexico on wet atmospheric deposition have shown the presence of the acid rain phenomenon at the different studied sites, with the exception of Monterrey, Nuevo León and Calakmul, Campeche, where higher weighted pH values to 5.6 were recorded.

The potential problem of deterioration in sites of natural and cultural interest continues, due to acid pH on the coast of the Gulf of Mexico and in the Southeast of the country.


TAL
http://ccaunam.wixsite.com/tajin
TAJ
Clave TAJ
Nombre de la estación El Tajín
Año de muestreo 2002
Longitud -96.6228
Latitud 20.4425
Entidad Veracruz
Grupo de Investigación Sección de Contaminación Ambiental, CCA UNAM
Cómo llegar: A aquí - De aquí
Image Landsat / Copernicus
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Google Earth
Fechas de imágenes: 12/13/2015 22°15'44.12" N 101°55'07.59" O elevación 0 m alt. ojo 3545.58 km

Sitio de muestreo: El Tajin
Veracruz, México
Depósito atmosférico

Estudios realizados en el sitio de muestreo de El Tajin:

PDF Bravo (2003).pdf

PDF Bravo(2004)CleanAIRuk.pdf

PDF Bravo(2004)AWMA.pdf

PDF Bravo(2005)AWMA.pdf

PDF Bravo (2006).pdf

PDF Bravo(2006).pdf

PDF Kahl(2007).pdf

PDF Kahl(2012).pdf

PDF Sosa(2016)LGM.pdf

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Environmental Pollution 144 (2006) 655–660
ENVIRONMENTAL POLLUTION
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Effect of acid rain on building material of the El Tajín archaeological zone in Veracruz, Mexico

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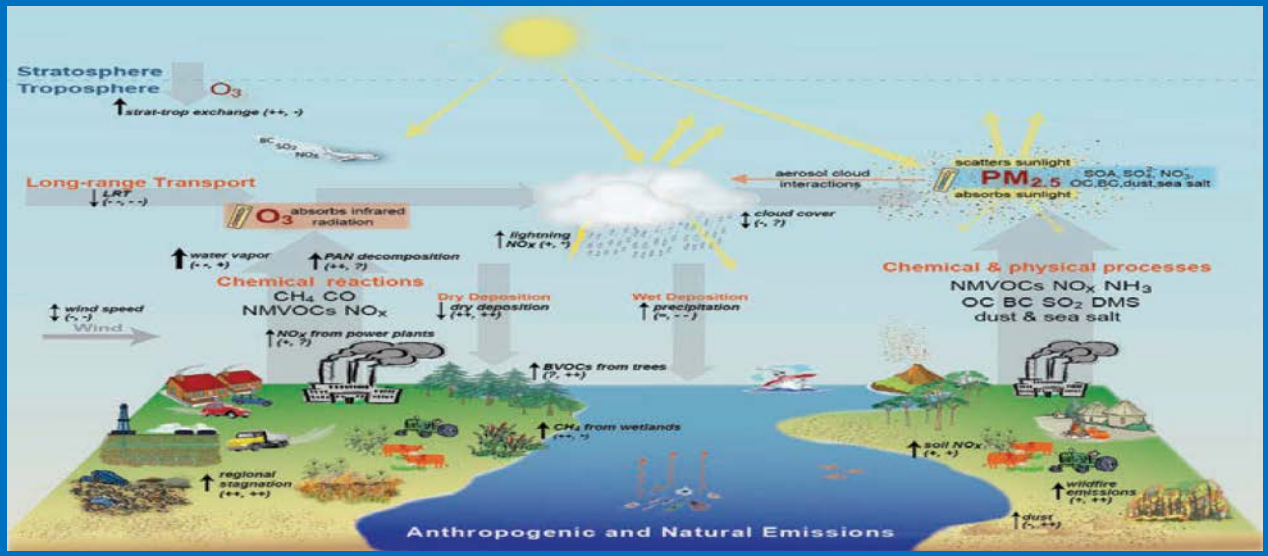
Received 4 December 2004; accepted 29 December 2005

The calcium carbonate content in a limestone sample from the El Tajin archaeological zone was determined, and a dissolution mechanism on this material by acid rain was proposed.

Abstract

Three limestone slabs (approx. 20 cm^2 each) were extracted from the El Tajin archaeological zone in Veracruz, Mexico. X-ray diffraction analysis revealed three components: calcite (81.2%), quartz (17.9%) and feldspar (0.9%). Calcite content by x-ray diffraction analysis was slightly higher than that determined by chemical reaction between the limestone sample and nitric acid. The latter analysis, carried out in triplicate, yielded a calcite content of 77.1%. Mean water absorption, density and porosity of the limestone samples were also determined. Dissolution of limestone samples was investigated using an experimental rainfall simulation chamber, in which the stone samples were irrigated with artificial rain matching the pH and the ionic composition with 40 rainfall samples collected at El Tajin from August 18, 2002, to April 9, 2003. According to calcium and bicarbonate net concentrations found in the effluent of the chamber, a chemical mechanism by which limestone at El Tajin is dissolved by acid rain is proposed. A model used to investigate the air transport pathways corresponding to precipitation events at El Tajin shows that air parcels come mainly from the Gulf of Mexico, although no directional preference is evident for acidic vs. non-acidic events.



Source: Fiore (2015)

An indicator of the reduction of emissions of acid rain precursors is the SO_4^{2-} / NO_3^- ratio, which it was applied during the realization of this study.

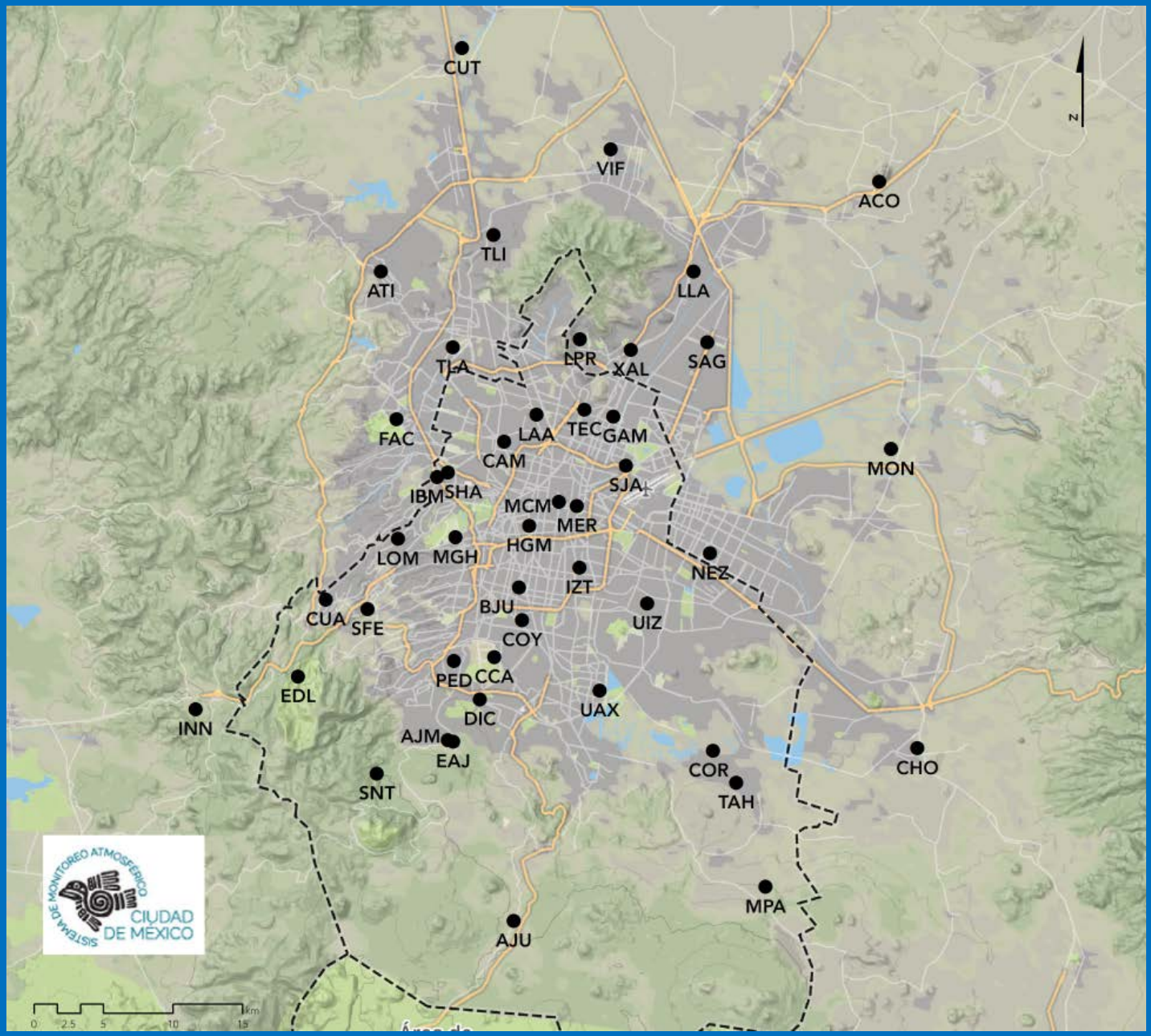
An indicator of the reduction of emissions of acid rain precursors is the SO_4^{2-}/NO_3^- ratio, which it was applied during the realization of this study.

Comparing the chemical composition of rainwater in the Gulf of Mexico region with stations located in the United States from Texas to Florida. The State of Veracruz site reported the high values of the SO_4^{2-}/NO_3^- ratio (a value of 4.9 was registered for 2015), which demonstrates the high contribution of sulfur compounds in the atmospheric deposition and the need to control the emissions of the main sources of SO_2 in Mexico.

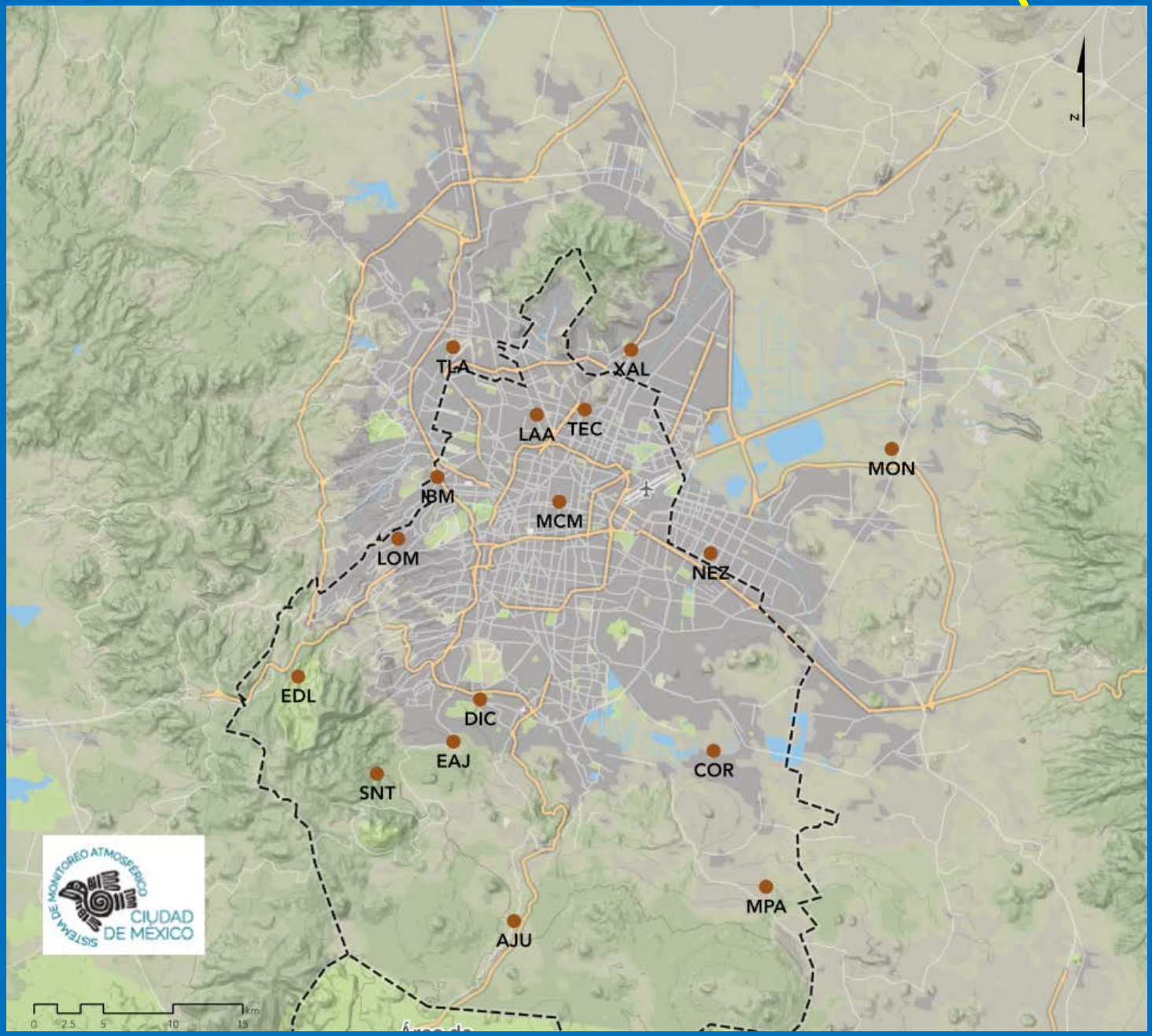
It is necessary to create links with different institutions for jointly and permanently to promote the operation of a National Atmospheric Deposition Network in Mexico, as well as to strengthen collaboration at an international level. In the last years, a collaboration between UNAM and NADP has started and is growing.

There is a SO_4^{2-}/NO_3^- ratio of 1.5 at Mexico City, at almost all the stations. However, it is interesting to mention that at the beginning of the 80's s this ratio was four, coinciding with the value currently registered actually in the Gulf of Mexico region.

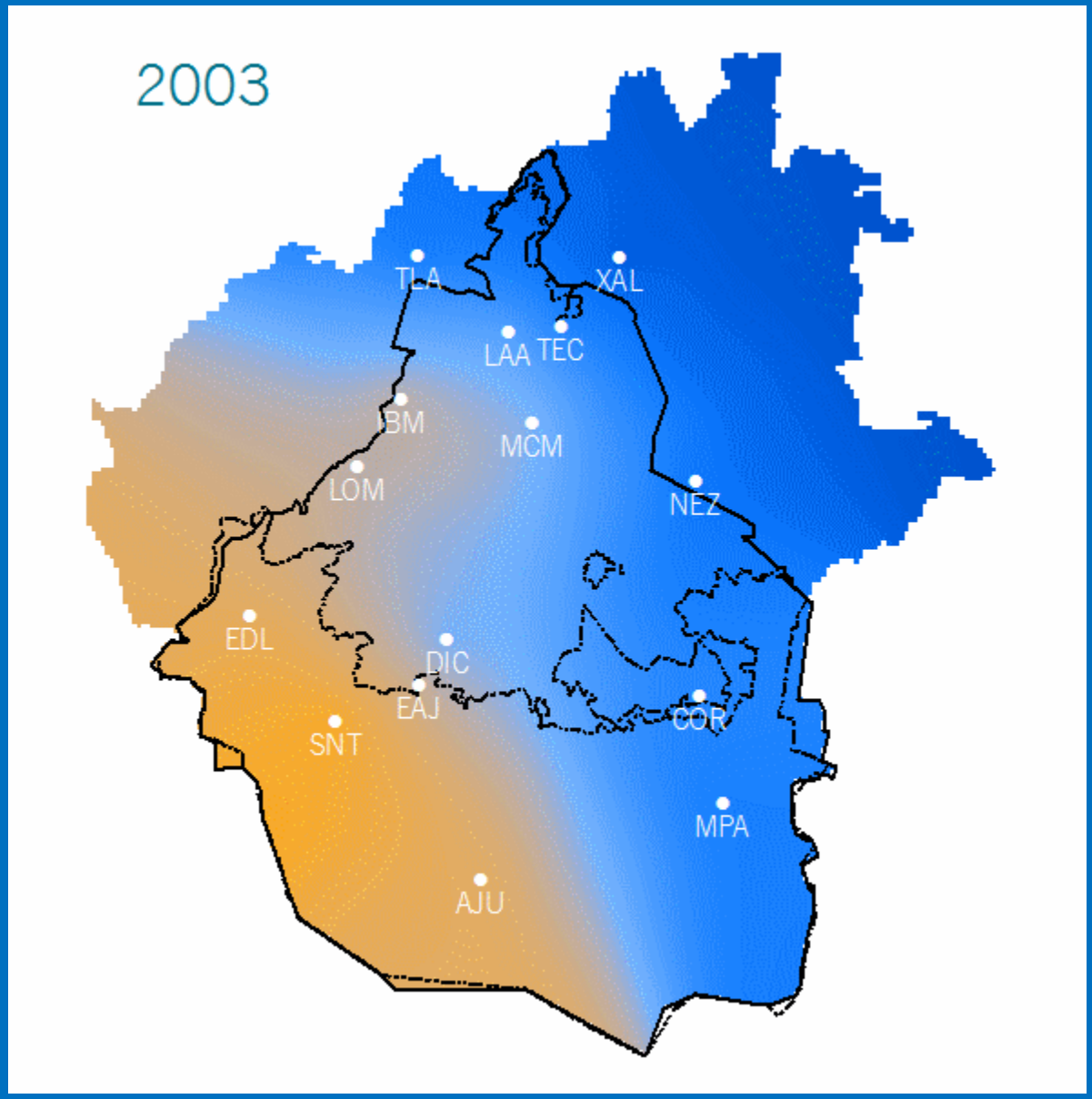
AUTOMATIC MONITORING AIR QUALITY NETWORK



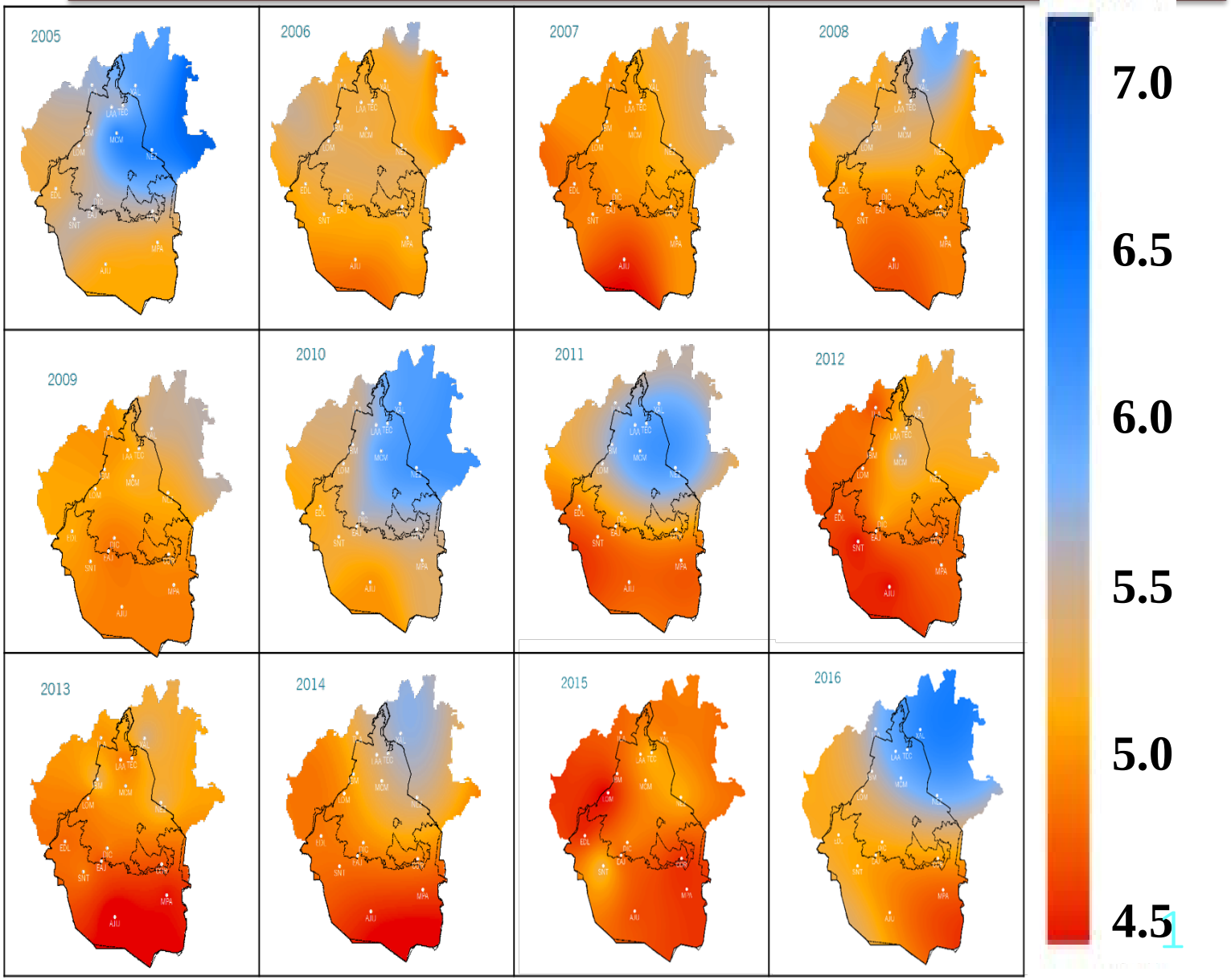
ATMOSPHERIC DEPOSITION NETWORK (REDDA).



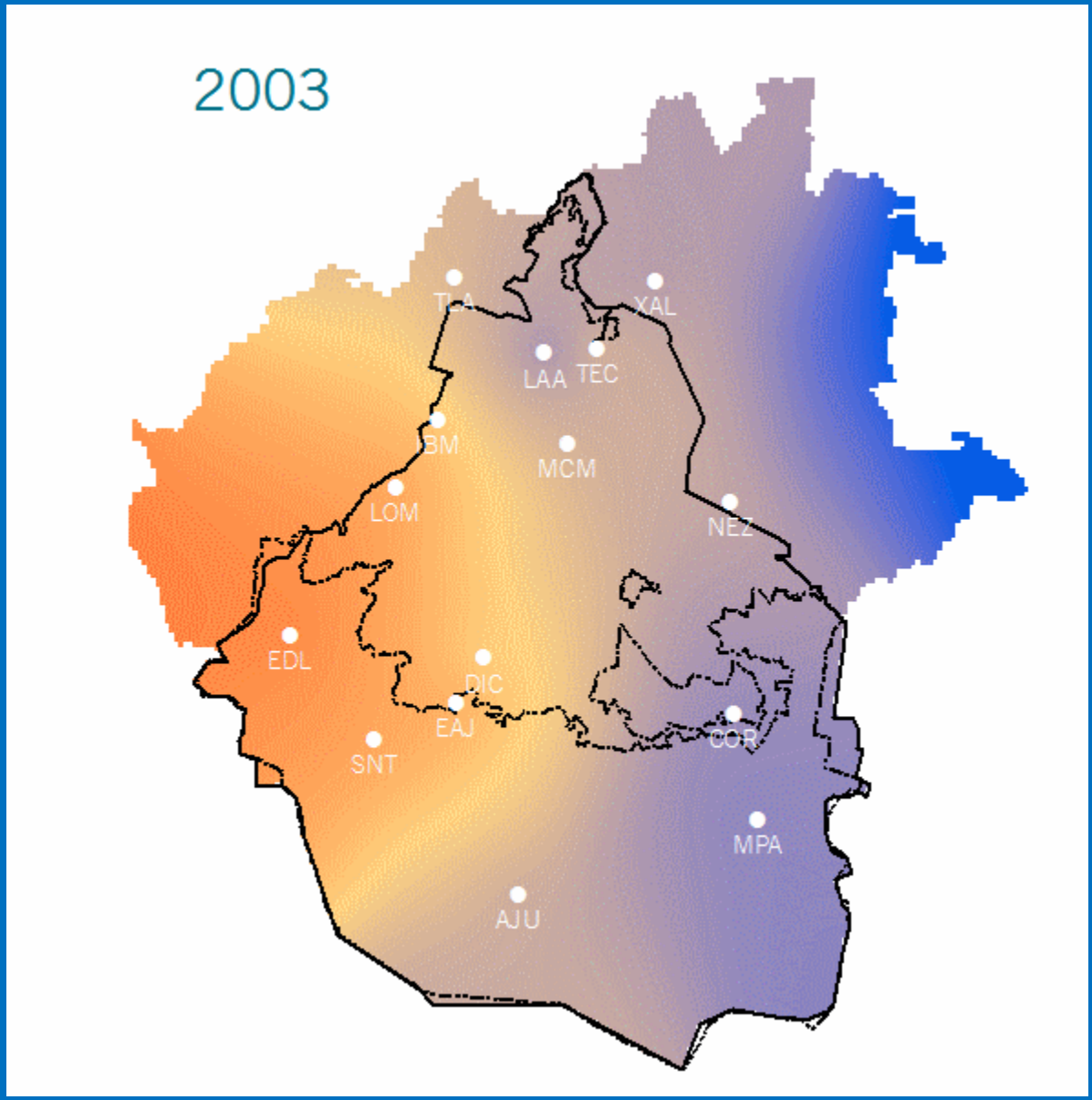
pH


2003
TLA
XAL
LAA
TEC
BM
MCM
LOM
NEZ
EDL
DIC
EAJ
COR
SNT
MPA
AJU
Monitoring station
Federal District
Conservation land
pH
7.0
6.5
6.0
5.5
5.0
4.5

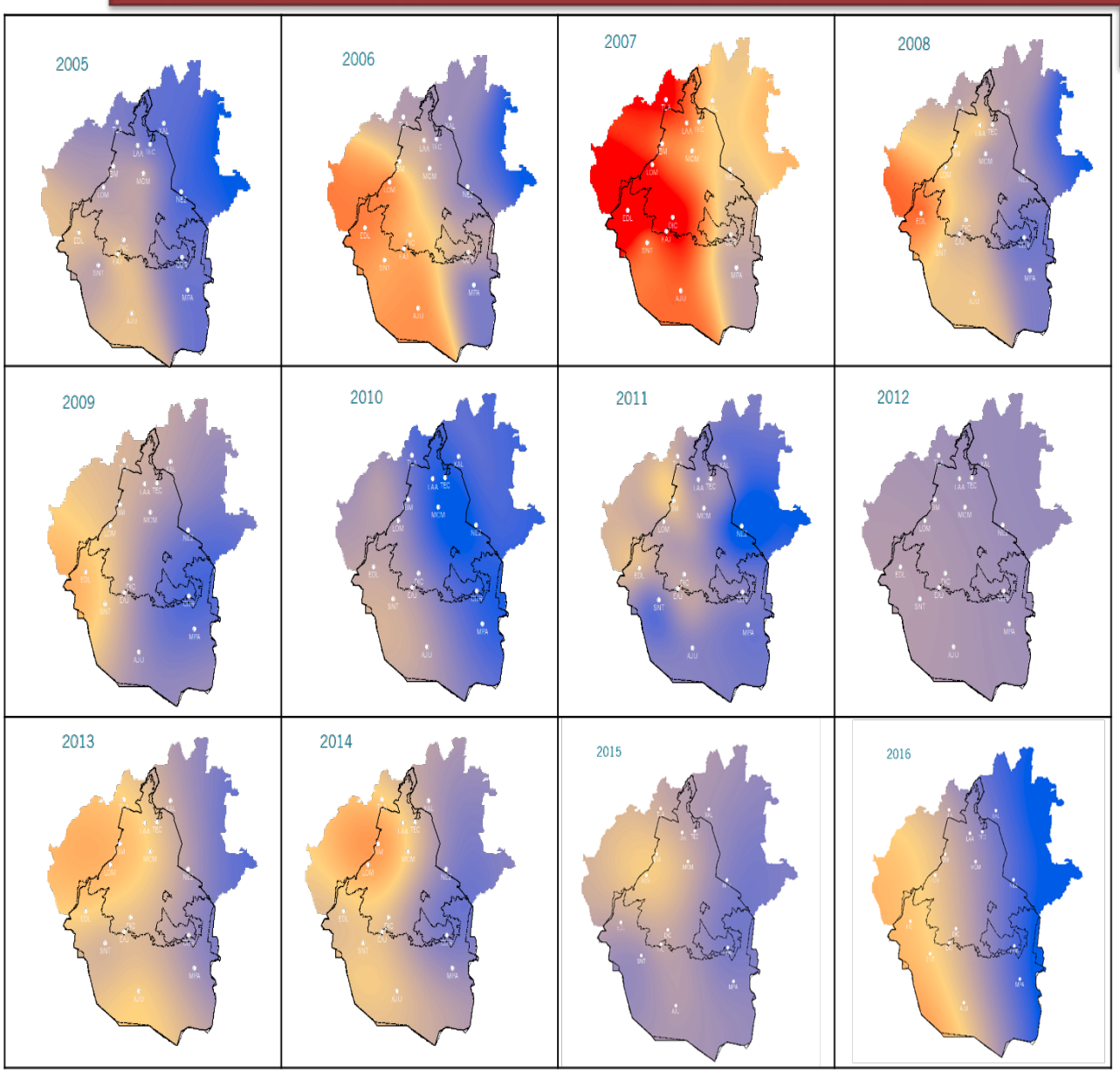
Spatial and temporal variation of pH at the MCMZ



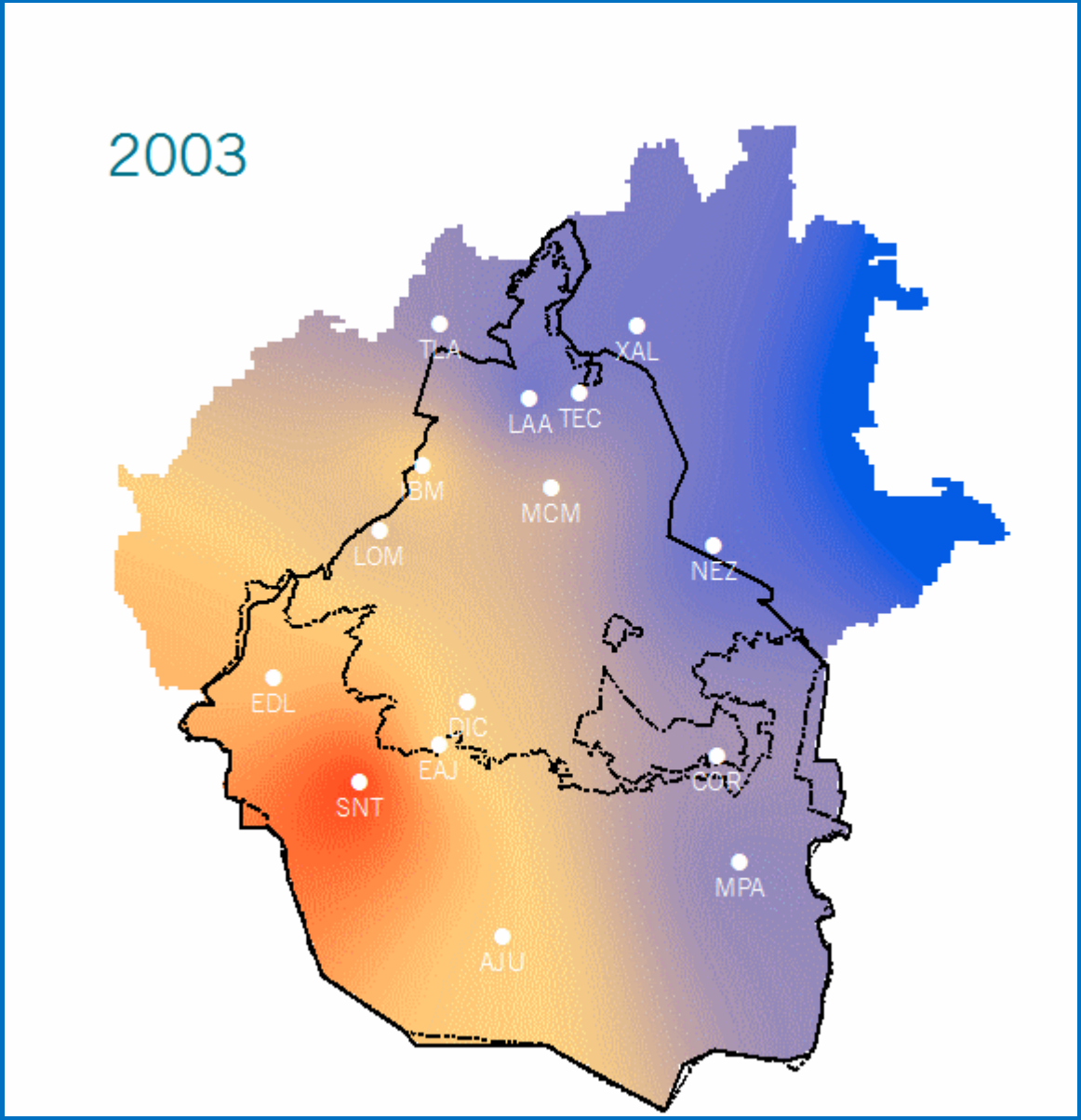
SO_4^{2-}


2003
TLA
XAL
LAA
TEC
BM
MCM
LOM
NEZ
EDL
DIC
EAJ
COR
SNT
MPA
AJU
Monitoring station
Federal District
Conservation land
Sulfate as SO_4^{2-} (kg/ha)
> 40
30
20
10
< 5

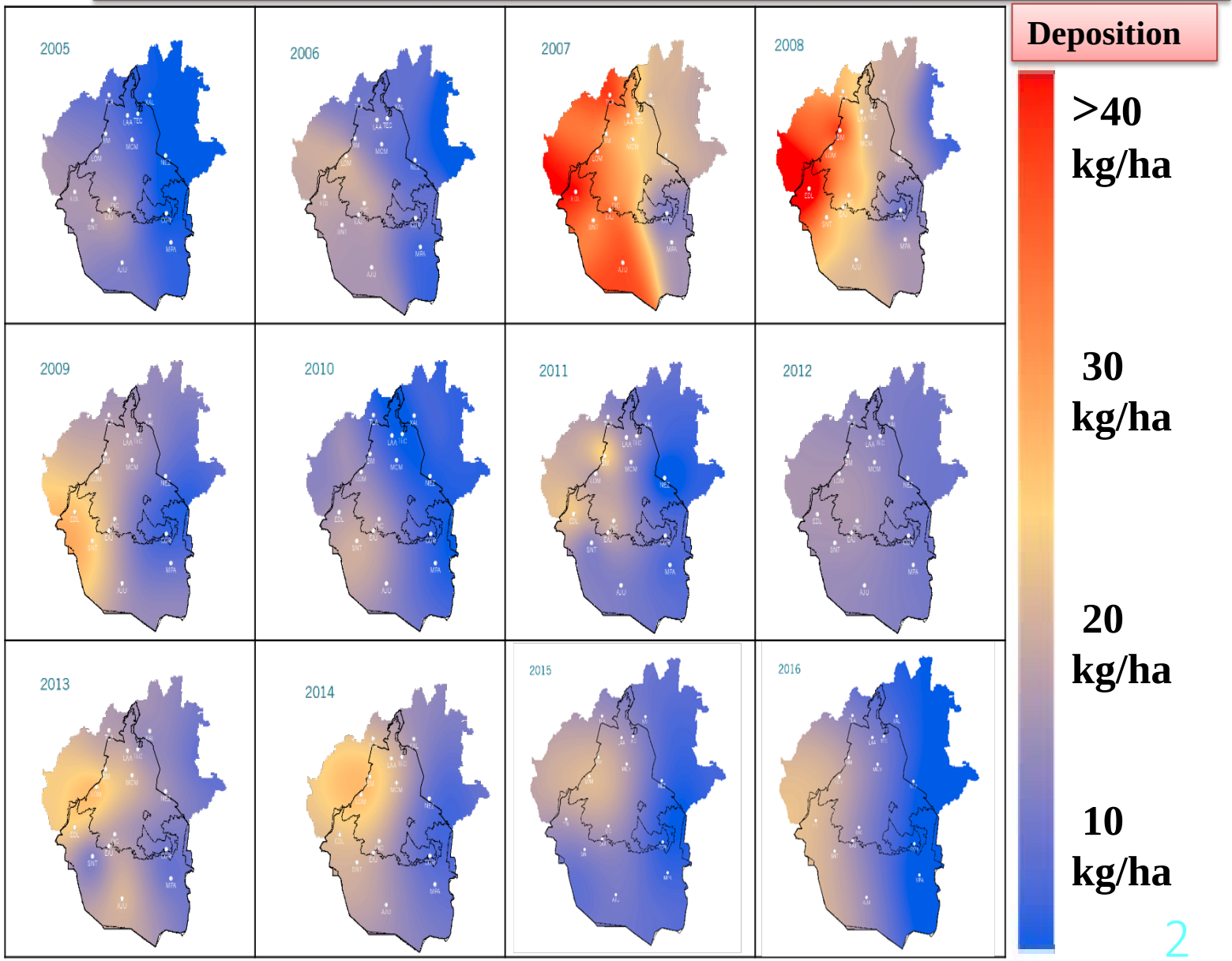
Spatial and temporal variation of SO_4^{2-} in wet deposition at the MCMZ



NO_3^-

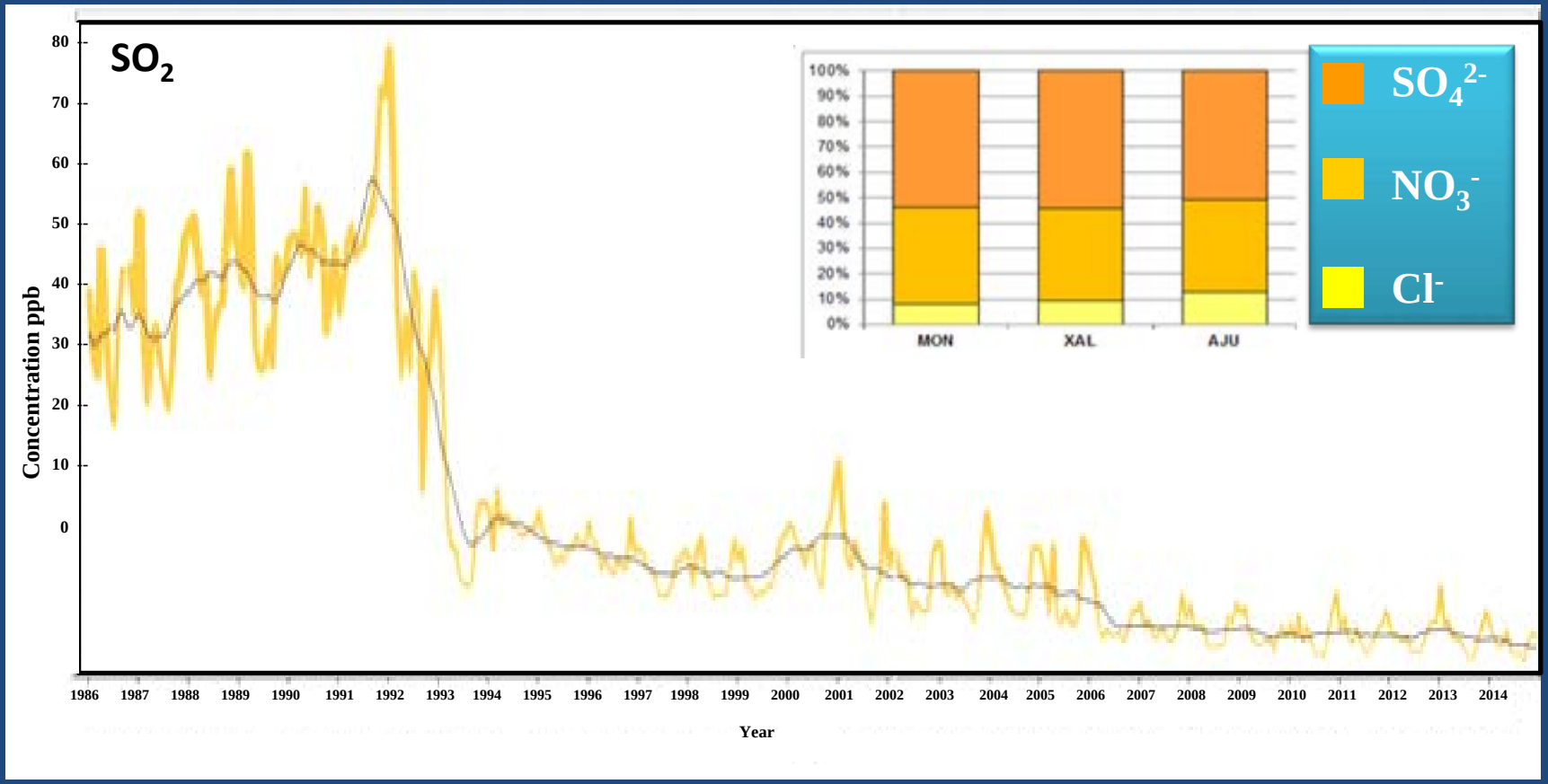

2003
TLA
XAL
LAA
TEC
BM
MCM
LOM
NEZ
EDL
DIC
EAJ
SNT
CUE
MPA
AJU
Monitoring station
Federal District
Conservation land
Nitrate as NO_3^- (kg/ha)
> 40
30
20
10
< 5

Spatial and temporal variation of NO_3^- in wet deposition at the MCMZ



CONCLUSIONS

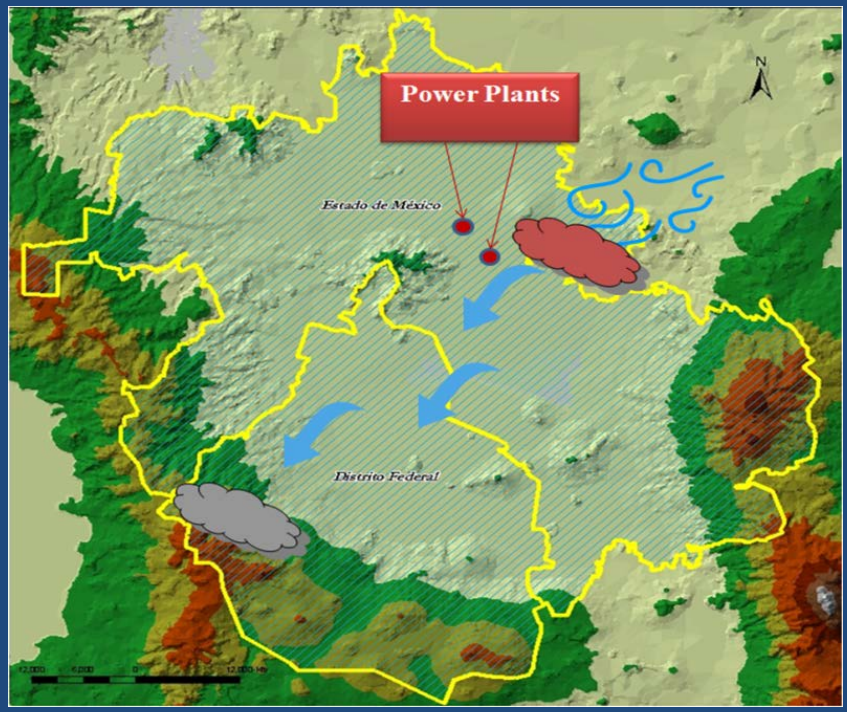
In all wet deposition samples, the SO_4^{2-} presents a higher percentage (60%) with respect to NO_3^- and Cl^-, indicating that the main precursor of acid rain is SO_2, although it levels have been declining at Metropolitan Zone, reinforcing the conclusion that significant emission sources are outside (upwind) of the MCMZ.



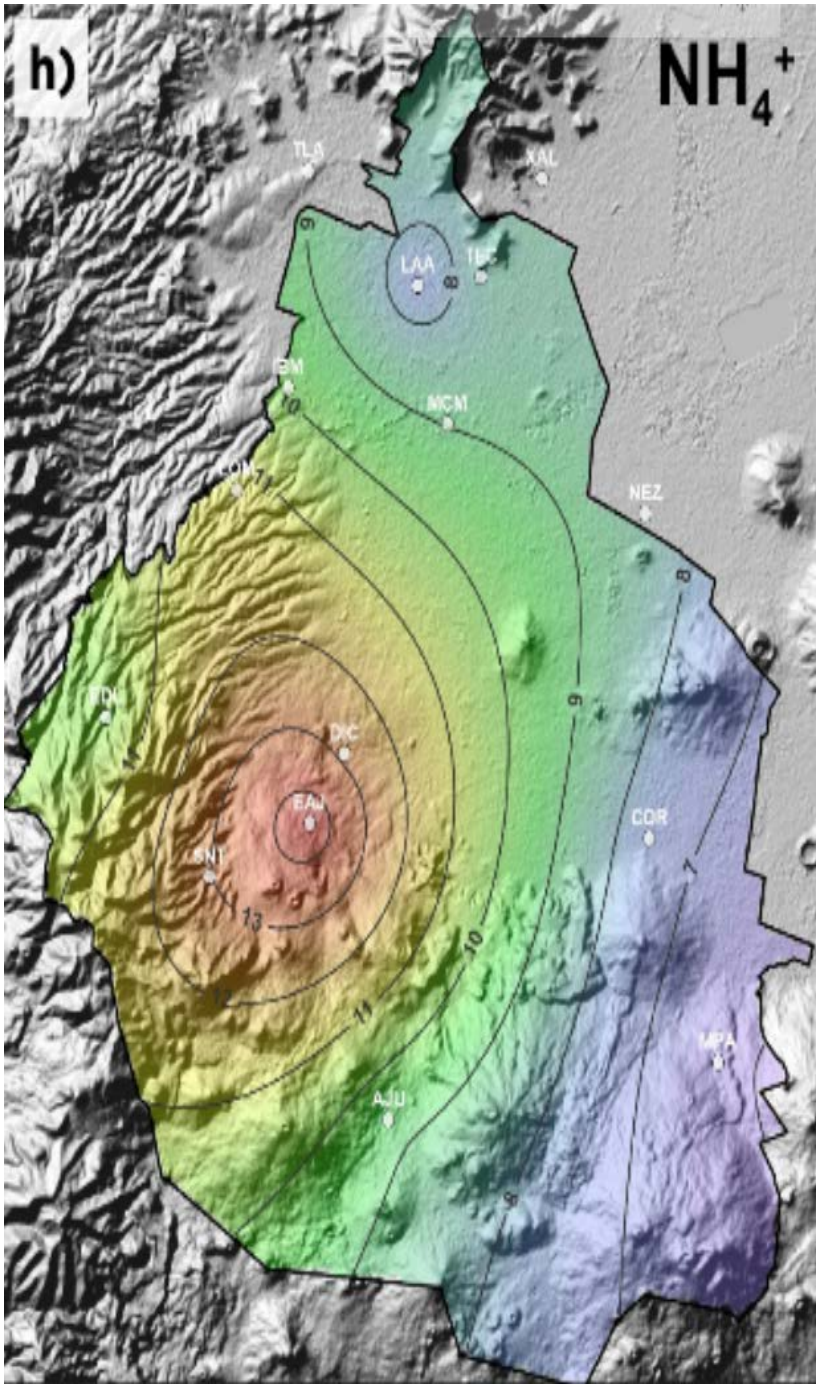
RECOMMENDATIONS

To establish strategies for the reduction of precursor's emissions of acid rain in external sources to North of the MCMZ, such as use of fuels with low - sulphur or substitution of fuel oil by natural gas. A reduction of more than 99% of SO_2 is expected by this change.

The change from fuel oil to natural gas should be seen in emission sources, such as the used of the Best Available Control Technology for the NO_x control, consisting of low NO_x burners.



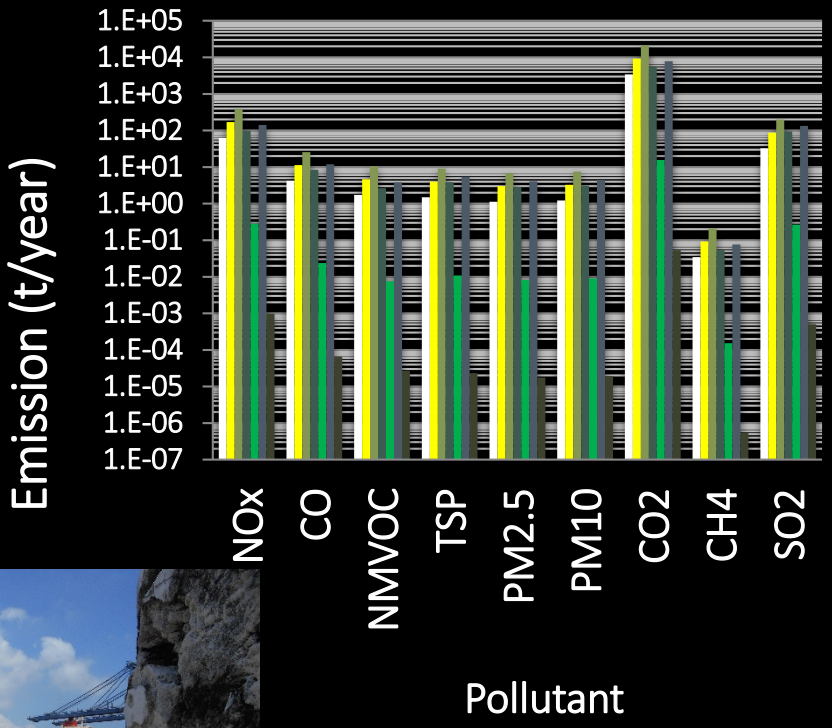
Sitio	NH_4^+ Kg/Ha
AJU	12.1
COR	9.2
DIC	13.6
EAJ	14.9
EDL	11.9
IBM	9.9
LAA	7.5
LOM	11.3
MCM	10.4
MON	6.6
MPA	6.6
NEZ	8.6
SNT	13.0
TEC	8.4
TLA	9.1
XAL	8.7



The evaluation of atmospheric deposition at regional scales requires international collaboration to adequately characterize the occurrence of potential impacts and establish measures to mitigate them.

The Gulf of Mexico Region has important sources of acid rain precursors, both on land and at sea, located in countries bordering the region, such as the USA, Mexico and Cuba. It is very important to study the chemical composition of atmospheric wet deposition through international cooperation.

EMMISSION INVENTORY PORT OF VERACRUZ



Acid rain studies at the Gulf of Mexico

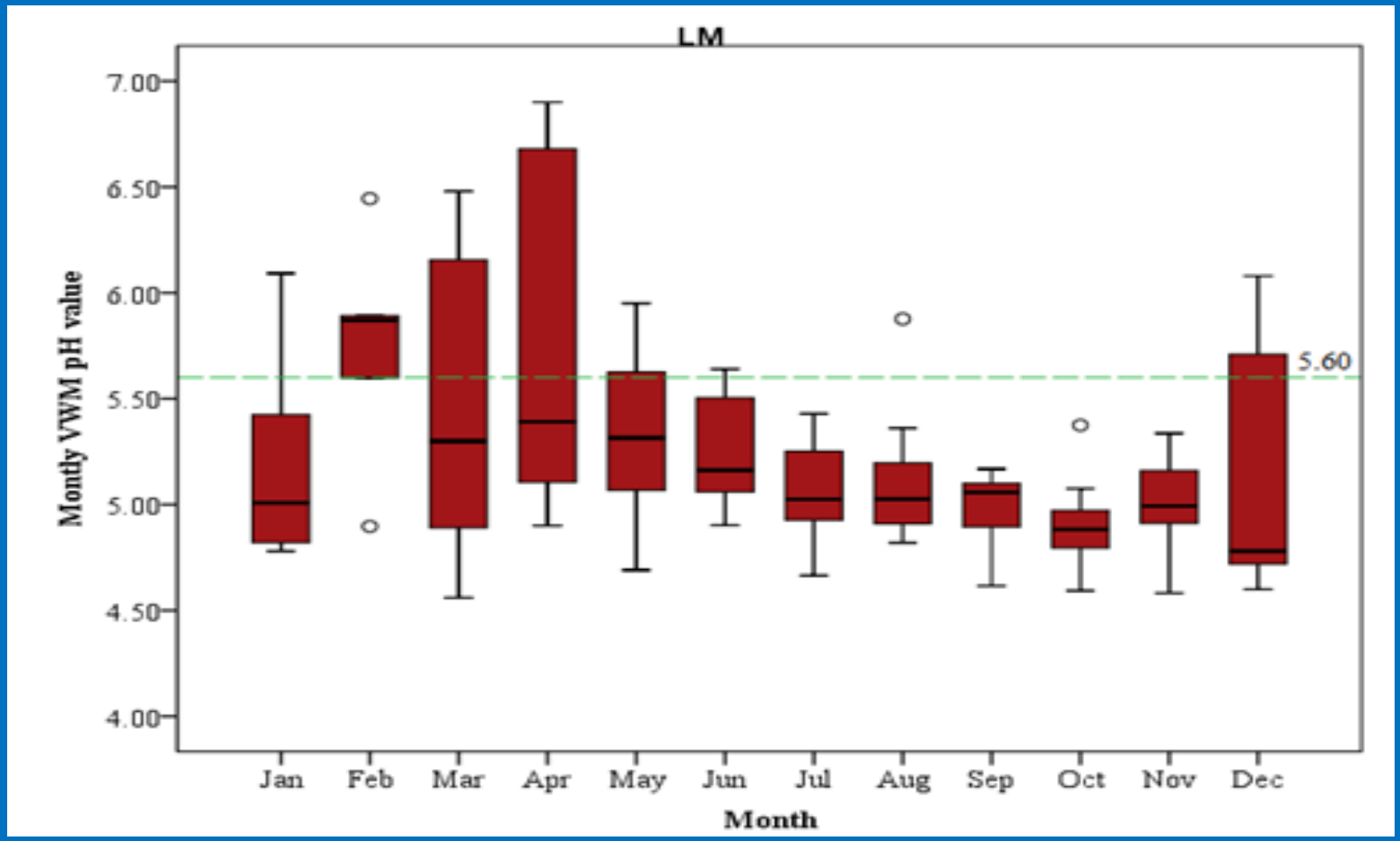
- Studies on the Mexican coast have identified the presence of acid rain since 2003.

Acid Deposition Events During the Autumn of 2003 in a research cruise over the Gulf of Mexico.

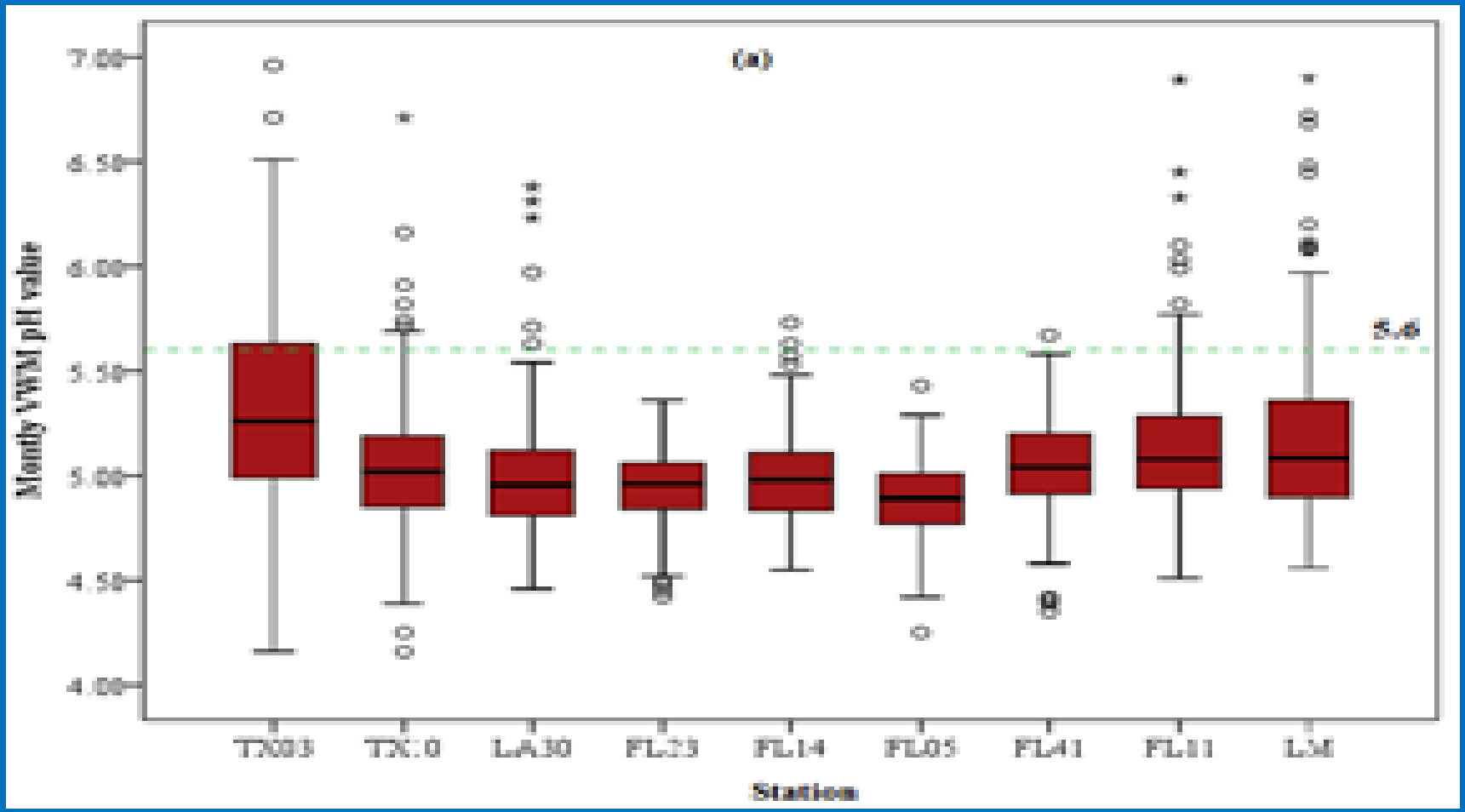
Studies on the Mexican coast have recorded the presence of acid rain since 2003. The aim of this study was to evaluate the major ions (Na^+, NH_4^+, K^+, Mg^{2+}, Ca^{2+}, SO_4^{2-}, NO_3^- and Cl^-), pH and conductivity in atmospheric wet deposition, collected daily from 2003 to 2015 at a sampling site located along the coast of Mexico (La Mancha, Veracruz) and compare the values with the NADP sampling sites located along the Gulf of Mexico coast from Texas to Florida.

pH results

Mexican sampling site “La Mancha”

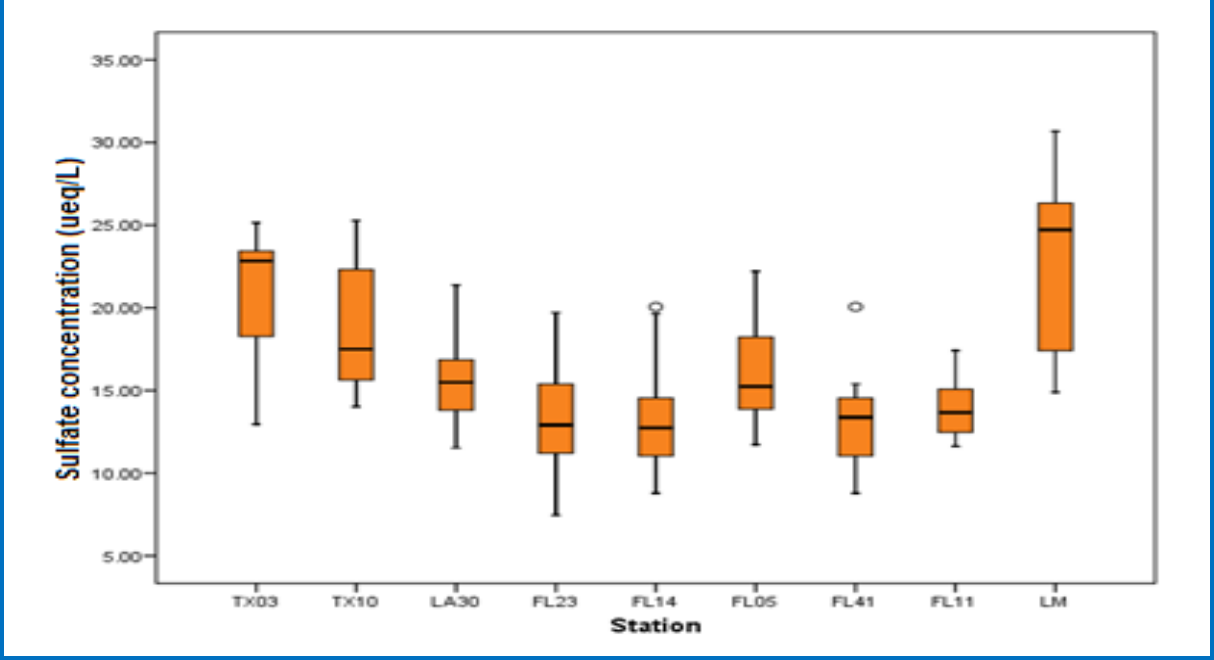


VWM pH values at the coast of the Gulf of Mexico



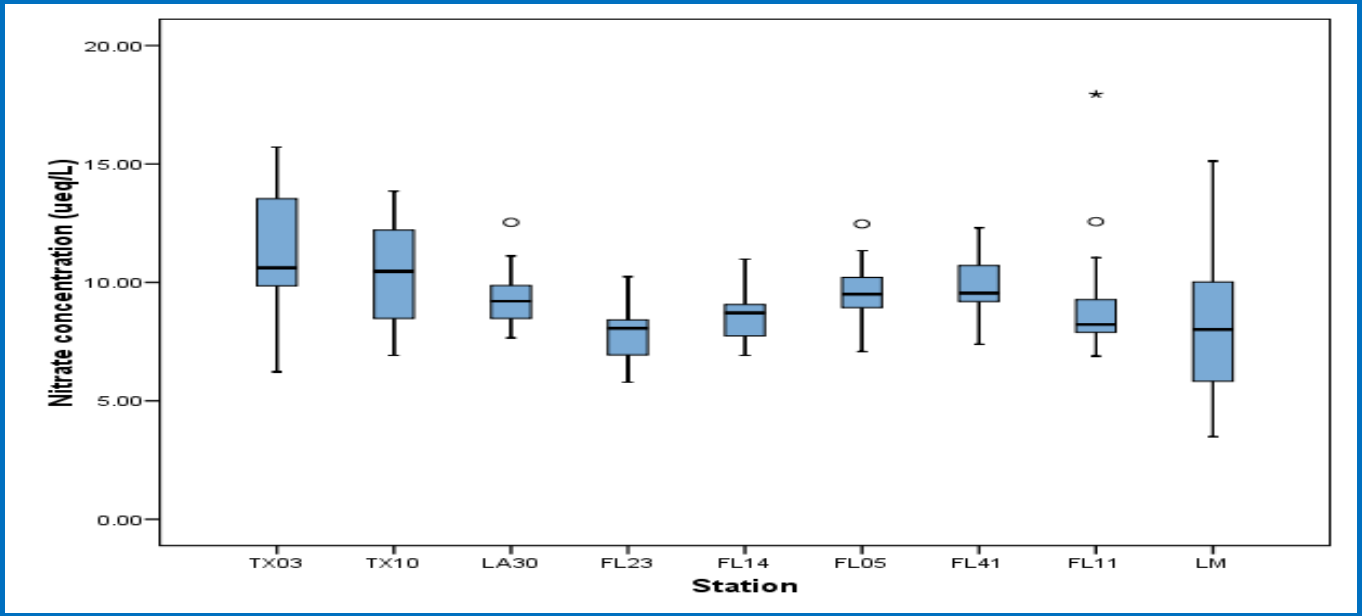
Sulfate

Sulfate			
Site	Min (µeq/L)	Max (µeq/L)	Media (µeq/L)
LM	14.90	30.67	24.72
TX 03	12.96	25.14	22.88
TX 10	14.02	25.27	18.20
LA 30	11.83	21.37	15.56
FL 23	10.12	19.71	13.13
FL 05	12.17	22.21	15.53
FL 14	9.81	19.64	12.71
FL 41	8.79	20.06	13.40
FL 11	11.62	17.41	14.06



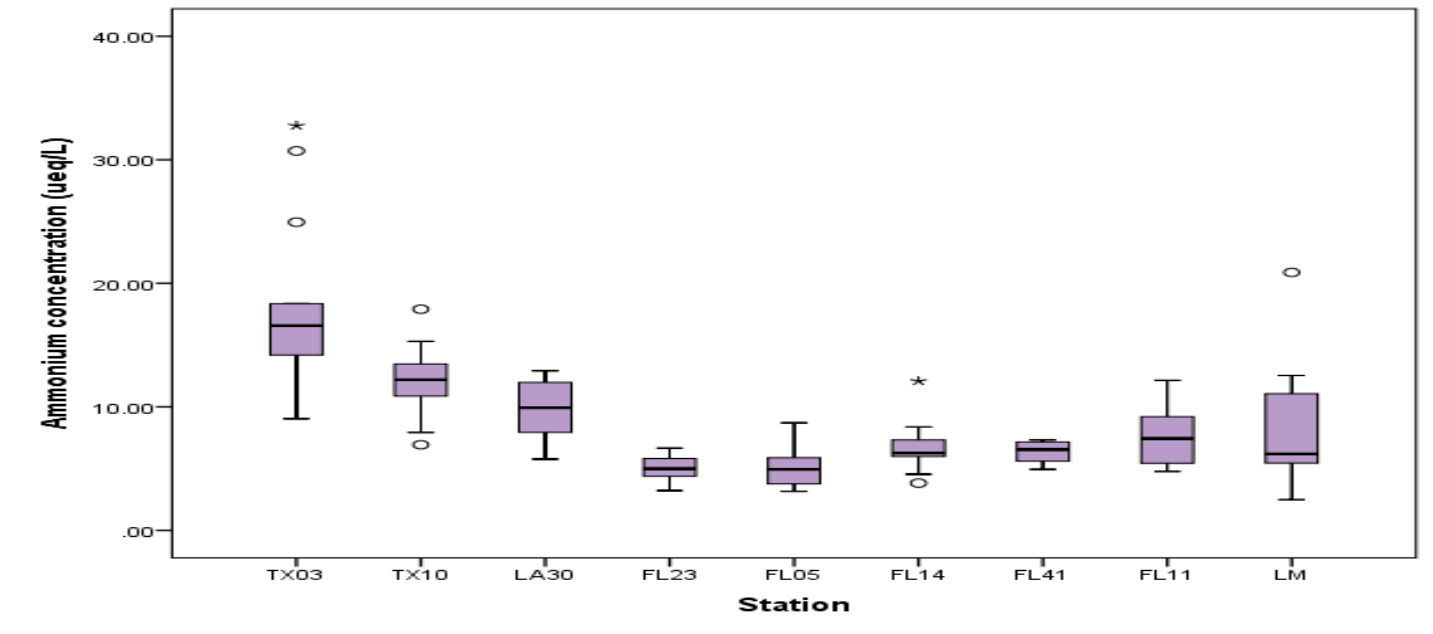
Nitrate

NItrate			
Site	Min (µeq/L)	Max (µeq/L)	Media (µeq/L)
LM	3.49	15.12	8.01
TX 03	6.23	15.71	10.99
TX 10	6.92	13.86	10.61
LA 30	8.02	12.53	9.21
FL 23	6.27	10.24	8.14
FL 05	7.08	12.47	9.37
FL 14	6.92	10.99	8.35
FL 41	7.39	12.31	9.51
FL 11	6.89	12.56	8.11

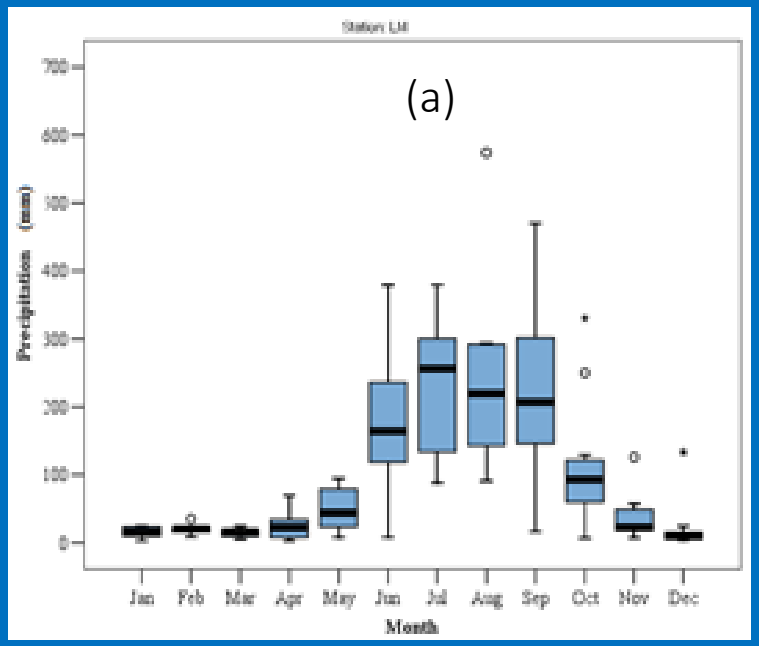


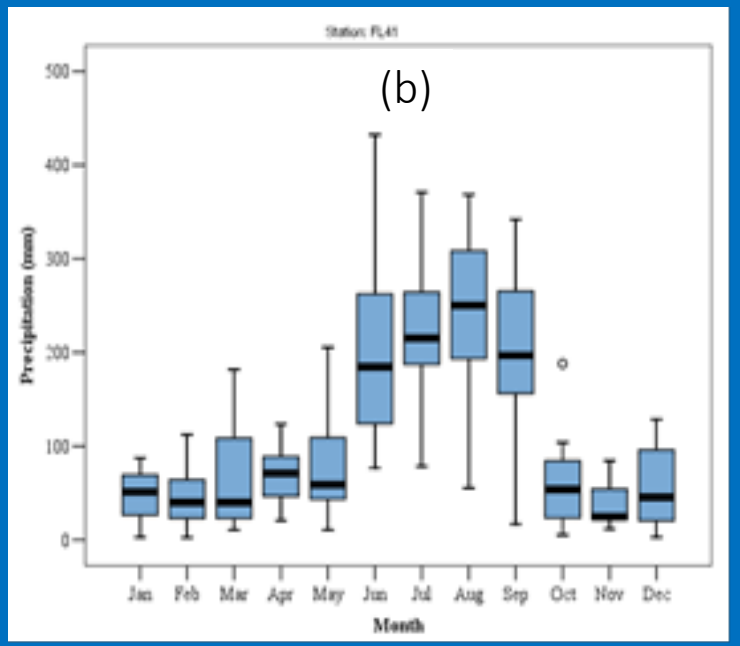
Ammonium

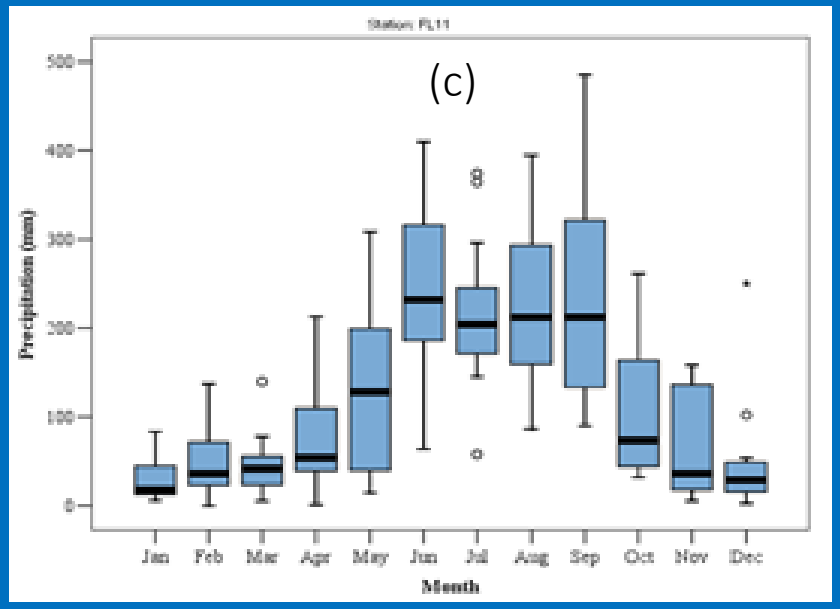
Concentration (µeq/L)			
Site	Min	Max	Media
TX03	9.04	32.77	16.57
TX10	6.93	17.91	12.19
LA30	5.77	12.92	9.92
FL23	3.22	6.65	4.99
FL05	3.16	8.70	4.93
FL14	3.83	12.09	6.26
FL41	4.93	7.32	6.54
FL11	4.77	12.14	7.42
LM	2.48	20.88	6.18



Precipitation. La Mancha (a), FL 41 (b) y FL 11 (c).

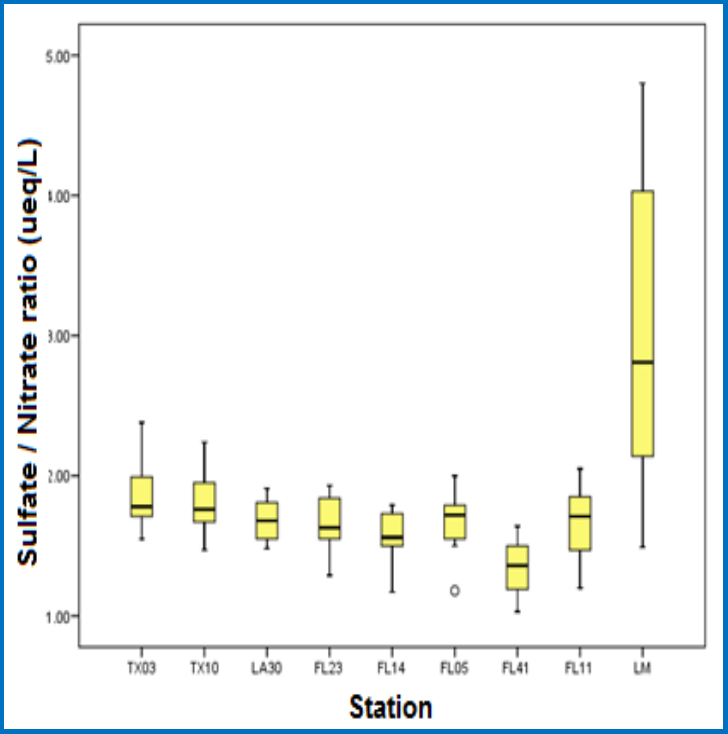






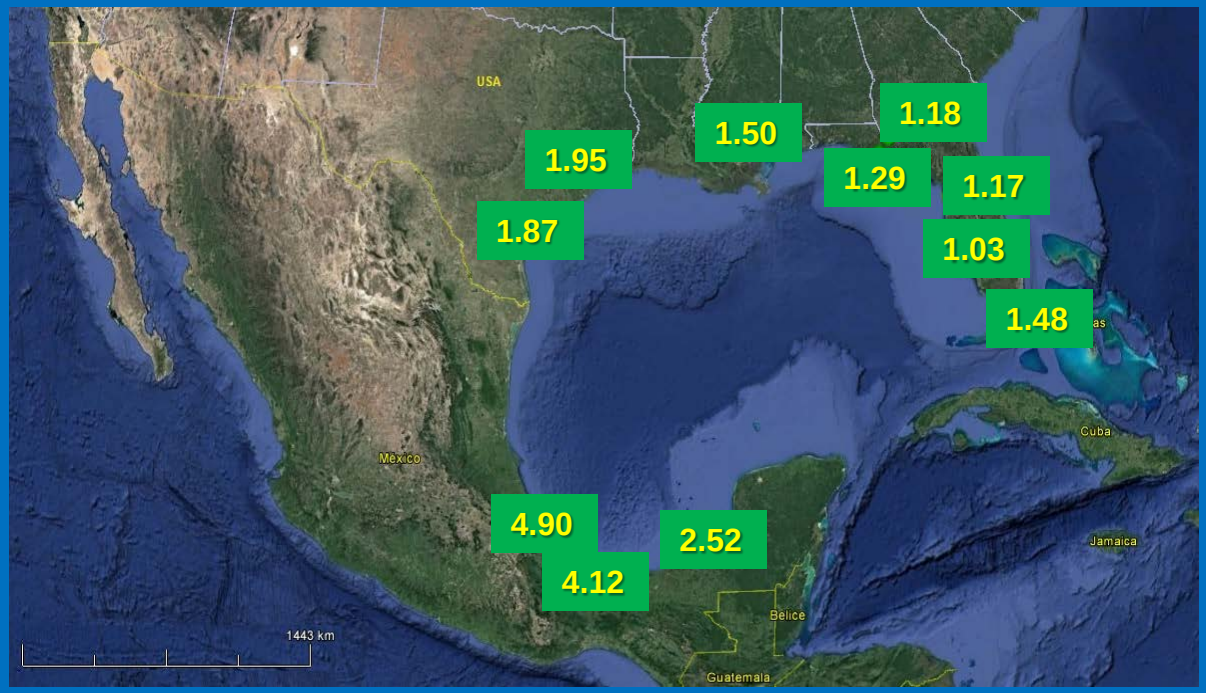
SO_4^{2-}/NO_3^- ratio at the coast of the Gulf of Mexico.

Year	Sampling site								
	TX03	TX10	LA31	FL23	FL14	FL05	FL41	FL11	LM
2003	1.71	1.67	1.83	1.79	2.00	1.56	1.58	1.92	1.52
2004	2.02	1.76	1.68	1.84	1.79	1.54	1.50	2.05	2.86
2005	1.78	1.76	1.90	1.83	1.78	1.73	1.64	1.85	2.24
2006	1.82	2.06	1.71	1.92	1.90	1.79	1.42	1.20	2.19
2007	1.78	1.67	1.68	1.87	1.79	1.59	1.63	1.72	1.67
2008	1.99	2.08	1.91	1.93	1.66	1.74	1.36	1.94	2.13
2009	2.38	1.83	1.81	1.60	1.50	1.75	1.25	1.40	3.55
2010	2.08	1.68	1.50	1.63	1.72	1.50	1.45	1.62	2.29
2011	1.71	1.77	1.63	1.53	1.56	1.59	1.19	1.47	4.12
2012	1.75	1.47	1.48	1.36	1.75	1.36	1.24	1.69	4.70
2013	1.55	2.24	1.64	1.55	1.51	1.51	1.12	1.71	3.45
2014	1.60	1.63	1.55	1.61	1.55	1.30	1.14	1.31	4.46
2015	1.87	1.95	1.50	1.29	1.18	1.17	1.03	1.48	4.90



Besides, sampling site at “La Mancha”, two new sampling sites have been included. Campeche City and Veracruz Port.

- **The ratio of SO_4^{2-} to NO_3^- has been used as indicator of the effectiveness of SO_2 and NOx emissions reductions in the USA. The SO_4^{2-}/NO_3^- ratio found for "La Mancha" in 2015 was 4.9, the highest value when compared to other sites in the Gulf of Mexico, which had ratios between 1.03 and 1.95. Due to the high levels of SO_4^{2-} and the ratio SO_4^{2-}/NO_3^- found at "La Mancha," it is important to monitor the sulfur dioxide emission sources in Mexico.**

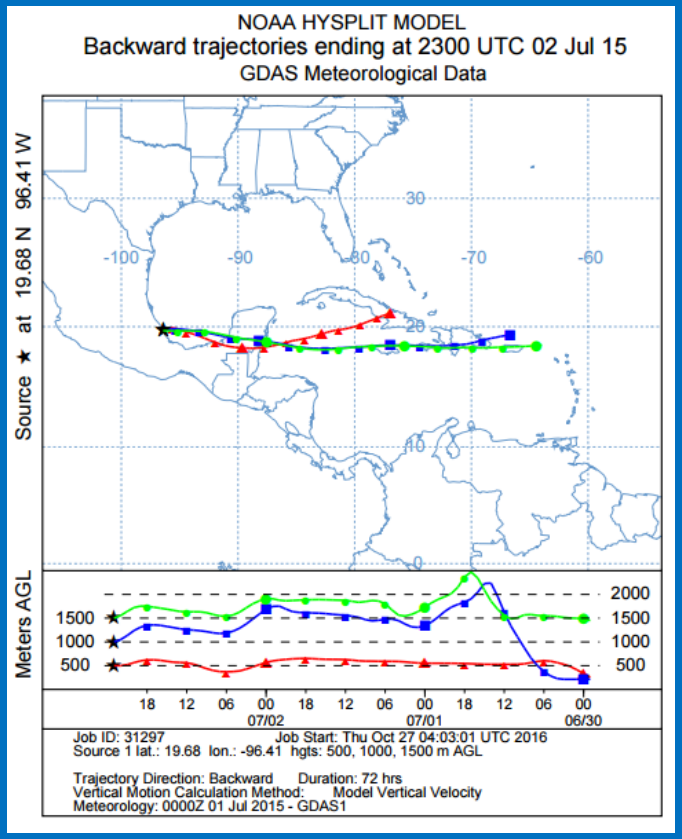


Sulfate / Nitrate ratio by 2015

http://nadp.sws.uiuc.edu/data/sites/map/?net=NTN

Conclusions and recommendations

The establishment of the international network for the evaluation of atmospheric deposition in the Gulf of Mexico represents a great opportunity for international collaboration. NADP protocols for sampling and analysis will be adopted, including quality-assurance and quality-control protocols, to ensure that information generated is comparable between current participating countries, USA and México and possibly Cuba.



Air quality and atmospheric deposition station in the Port of Veracruz (UNAM).

Air quality, atmospheric deposition and Meteorological station in Veracruz Port (UNAM).

Extension works in the Port of Veracruz.

San Juan de Ulúa (SJU) Fortress in the Port of Veracruz.

Superficial recession

micrometers/year

- Tulúm: 4.41 (R. Soto)

- El Tajín: 4.15 (J. Ruiz)

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Effect of acid rain on building material of the El Tajín archaeological zone in Veracruz, Mexico

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Received 4 December 2004; accepted 29 December 2005

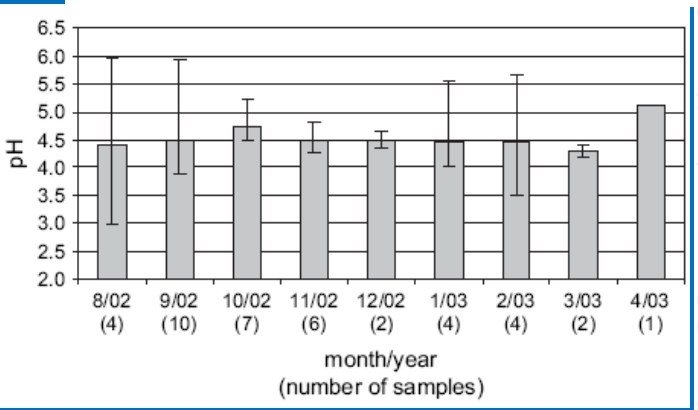
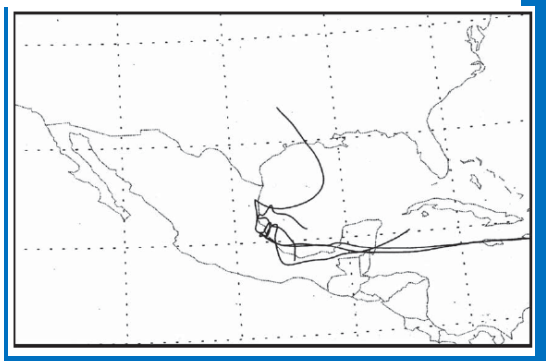
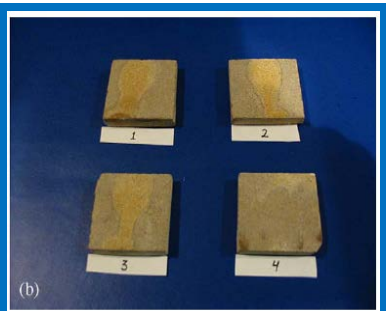


Table 4
Precipitation-weighted concentrations (ppm) of major cations and anions in rain samples collected at El Tajin from August 18, 2002 to April 9, 2003

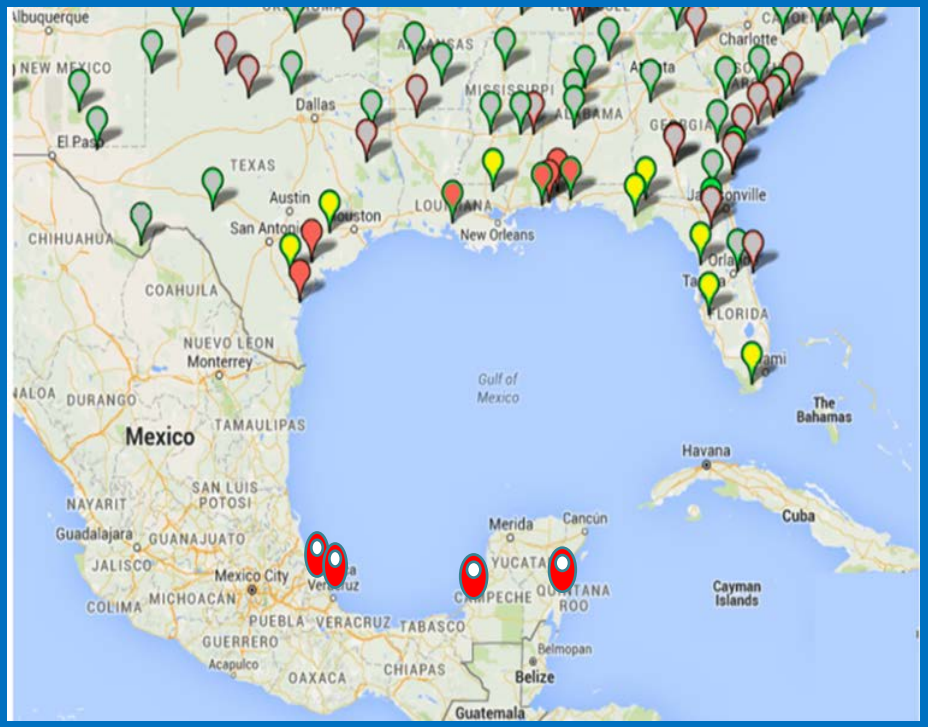
Ion	Concentration (ppm)
Na^+	0.28
K^+	0.12
NH_4^+	0.30
Mg^{2+}	9.6×10^{-4}
Ca^{2+}	0.24
Cl^-	0.49
NO_3^-	0.72
SO_4^{2-}	0.66





Superficial recession
4.15 µm/año
Experimental rainfall simulation chamber

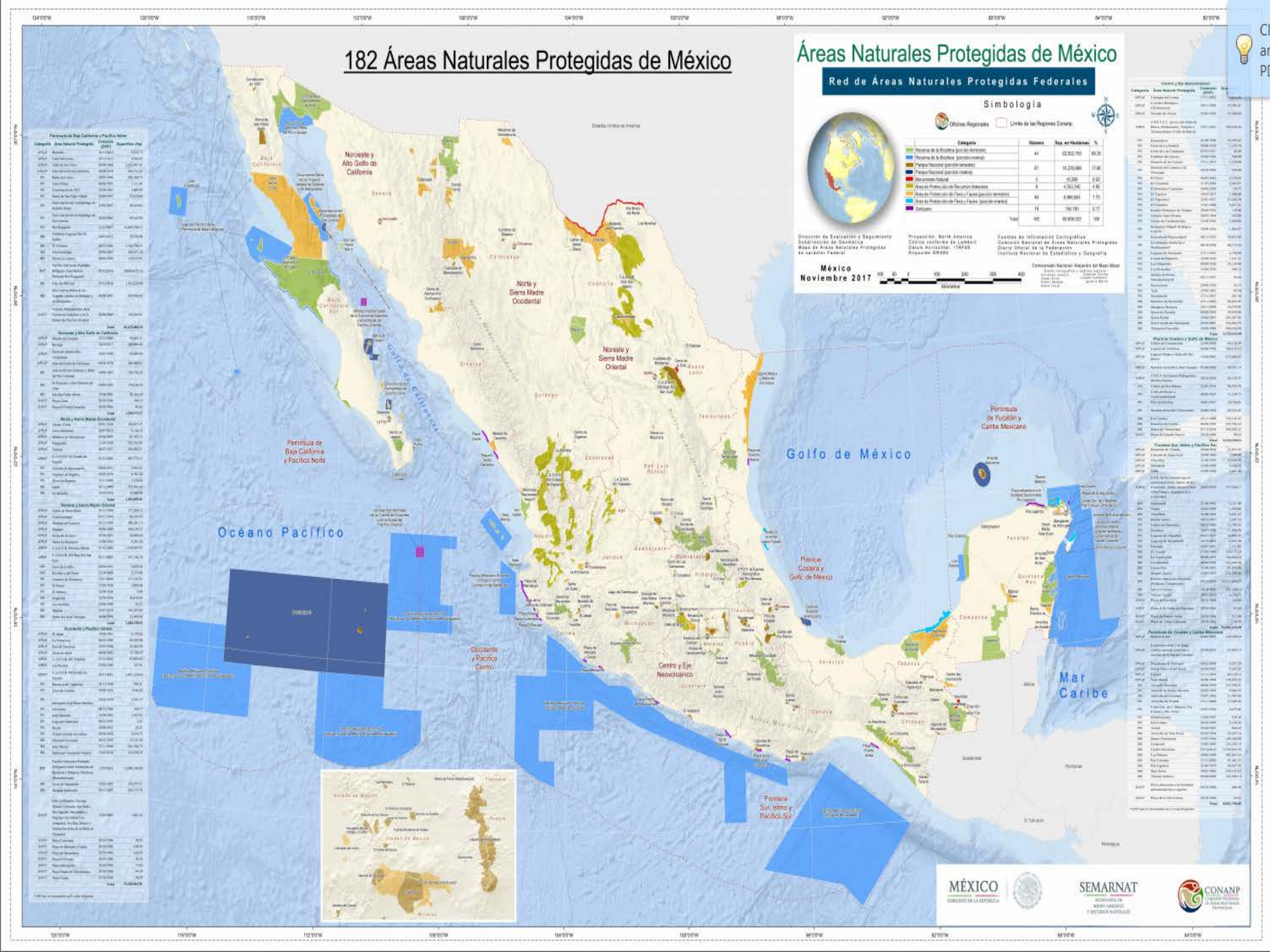
What will we do?

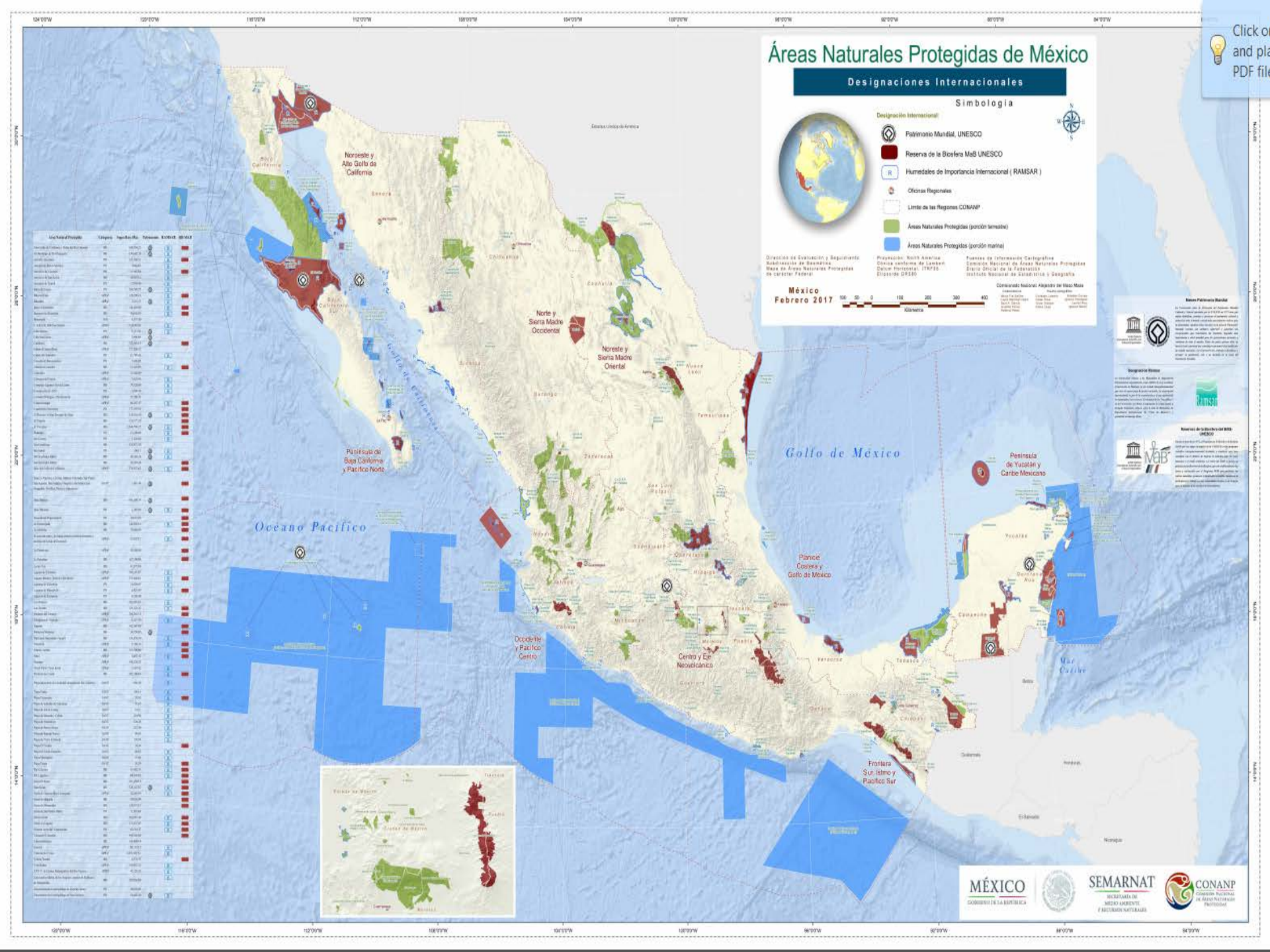


National Atmospheric Deposition Network for Natural and Cultural Heritage Conservation.

RED DE CIENCIAS APLICADAS A LA INVESTIGACIÓN Y CONSERVACIÓN DEL PATRIMONIO CULTURAL

182 Áreas Naturales Protegidas de México

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Designación Internacional
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(UNESCO) Cultural and Natural Heritage (México).

1987 - **Centro Histórico de la Ciudad de México y Xochimilco - Bien Cultural**
Criterio ii-iii-iv-v

1992 - **Ciudad Prehispánica de El Tajin - Bien Cultural**
Criterio iii-iv

2002 - **Antigua Ciudad Maya de Calakmul, Campeche - Bien Cultural**
Criterio i-ii-iii-iv

2007 - **Campus Central de la ciudad universitaria de la Universidad Nacional Autónoma de México - Bien Cultural**
Criterio i-ii-iv

2008 - **Reserva de la Biosfera de la Mariposa Monarca - Bien Natural**
Criterio vii

National Atmospheric Deposition Program

2018 Scientific Symposium and Fall Meeting
40 Years of Monitoring Atmospheric Deposition: Historical Legacy and Looking Ahead to the Future.