Atmospheric Physics Studies in the PdN Region

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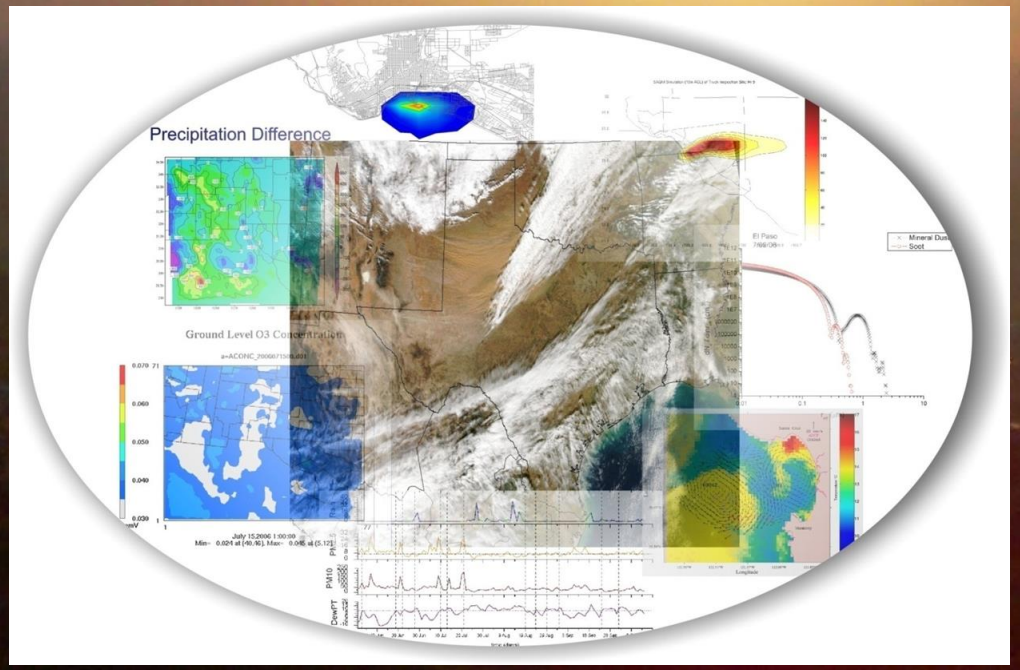
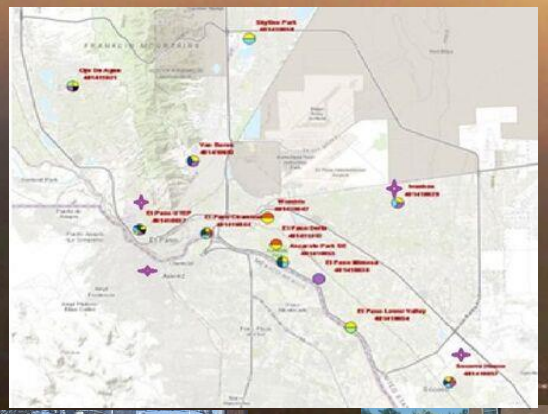
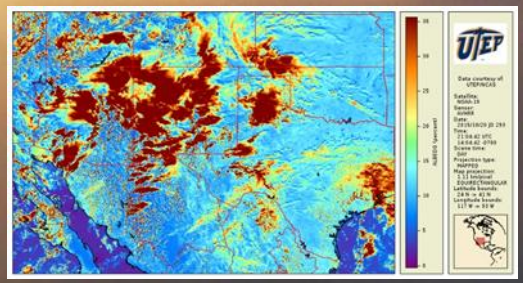
We perform modeling of atmospheric processes, using first principles, mathematical formulations and numerical calculations, to contribute towards a better understanding of atmospheric phenomena.



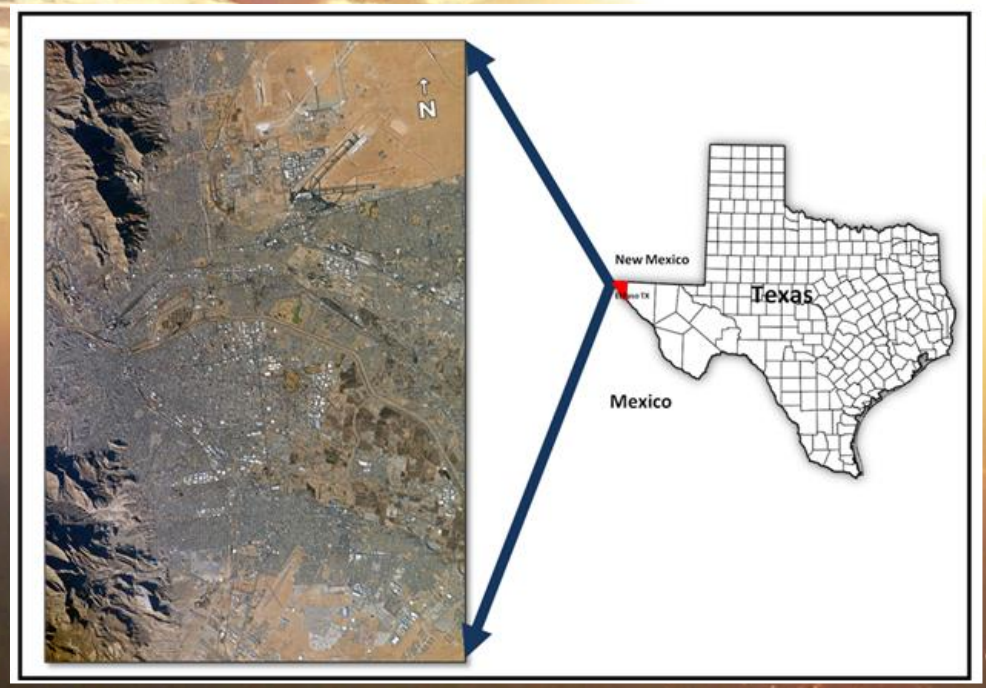
In addition, to monitor pollution we use our own instrumentation, TCEQ CAMS data, NOAA aircraft data and retrieve satellite data using our own antenna and software.





El Paso Del Norte

- Elevation: 3,800 feet (1,140 m) a.s.l.
- Latitude: 31°47’25” N
- Longitude: 106°25’24” W
- Area: 250.5 square miles
- Population: 800,647 (2010 census).



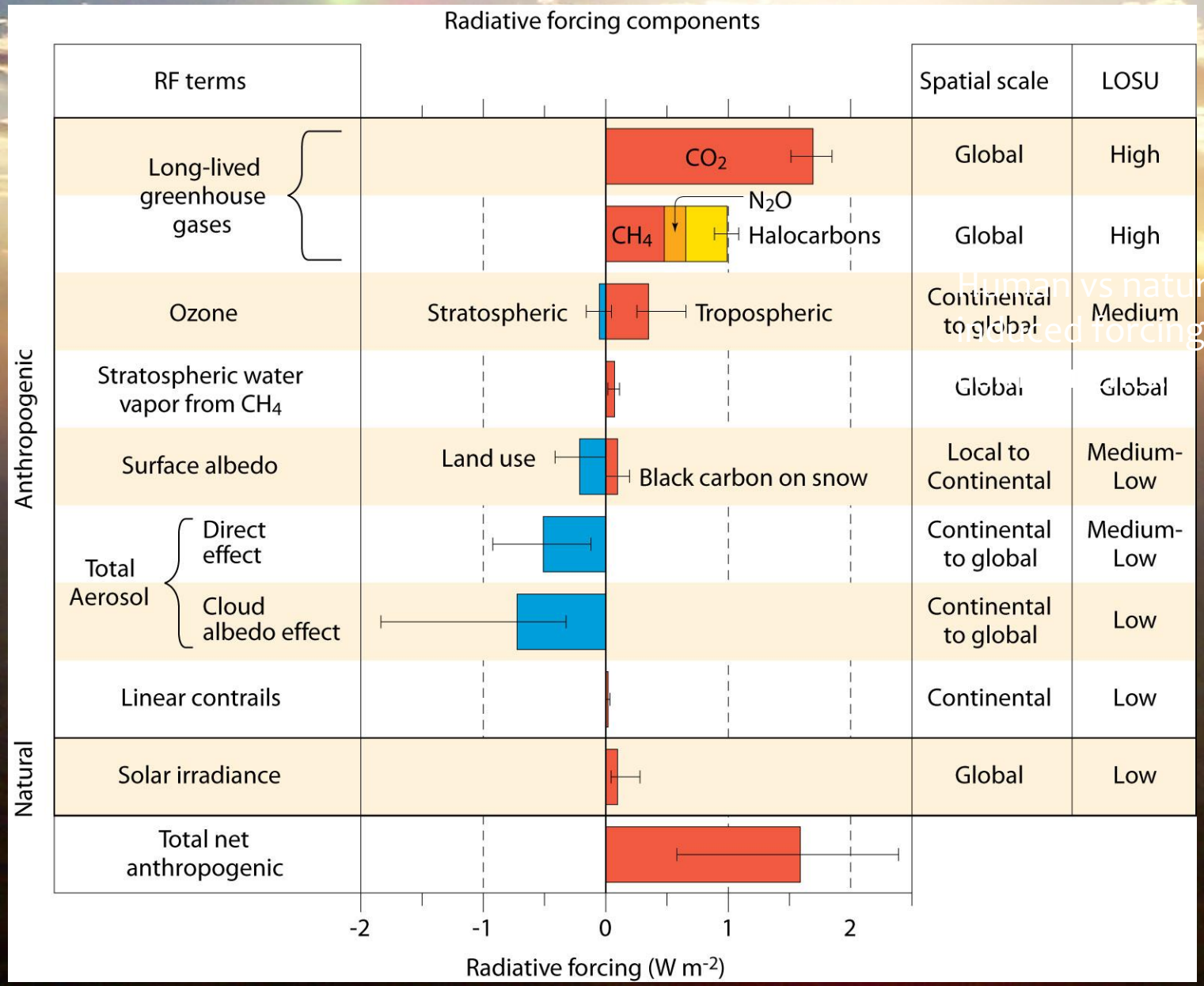
Why are these studies important?

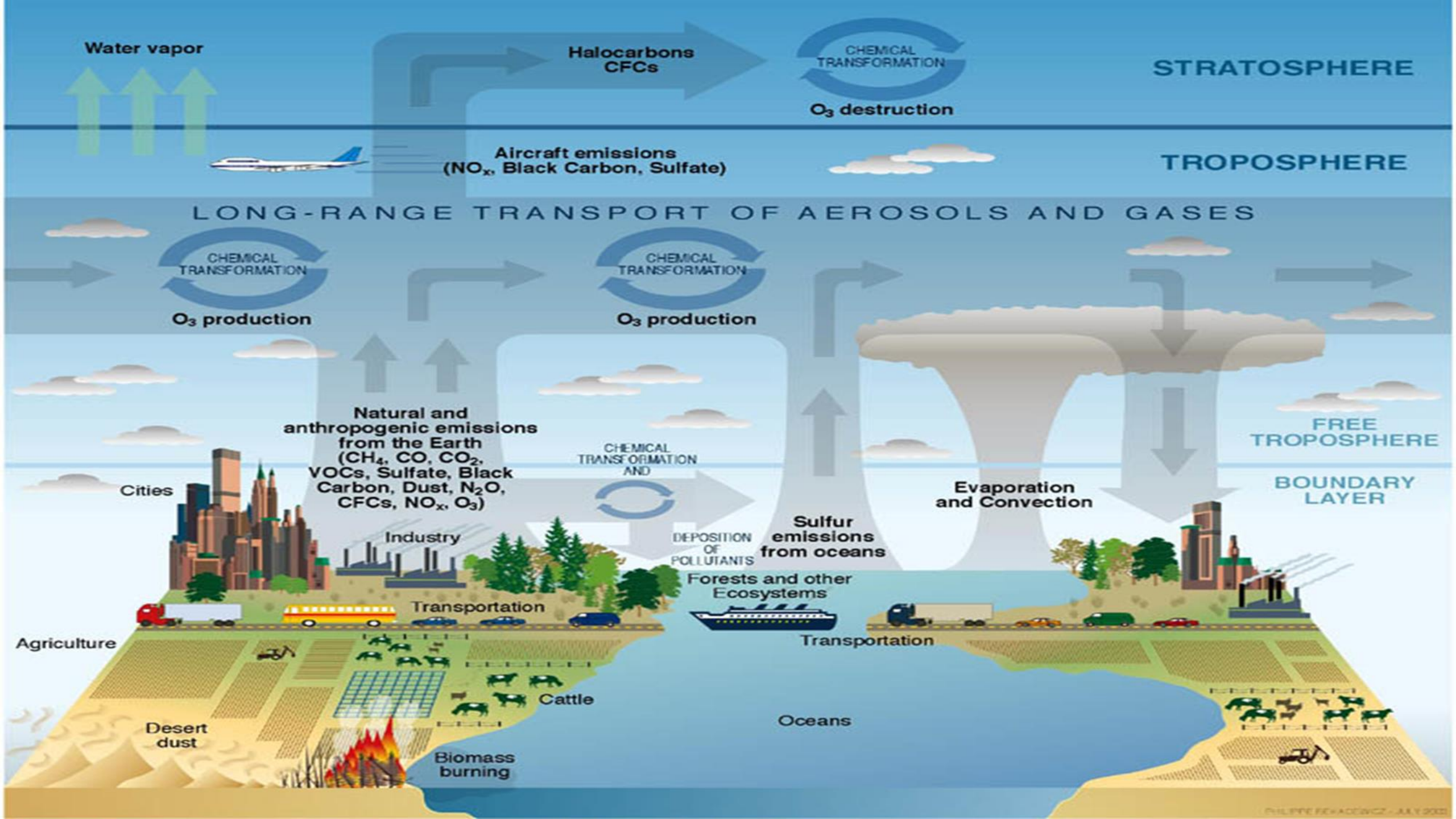
Health Impact:

Health Effects after Exercising in Air Pollution

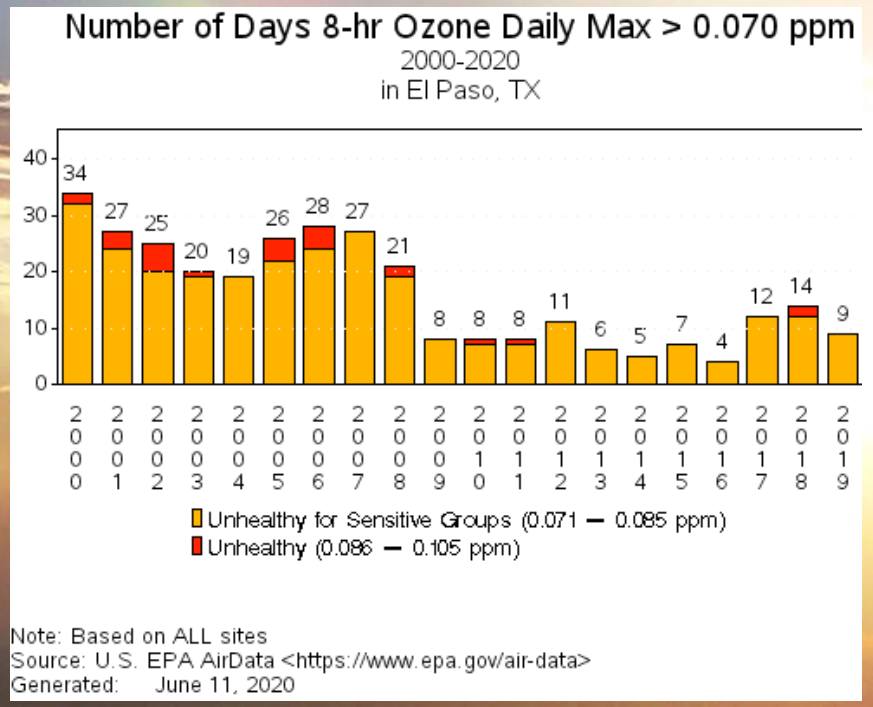
- 4-X ↑ DNA damage after cycling in traffic
- 3-5% ↓ in lung function with ozone exposure while cycling
- 3-X ↓ in ability to deliver oxygen to the heart while exposed to diesel exhaust during exercise
- 3-X ↑ asthma development among children in high ozone areas who played multiple outdoor sports

Climatology Impact:




Water vapor
Halocarbons
CFCs
CHEMICAL TRANSFORMATION
O_3 destruction
STRATOSPHERE
Aircraft emissions
(NO_x, Black Carbon, Sulfate)
TROPOSPHERE
LONG-RANGE TRANSPORT OF AEROSOLS AND GASES
CHEMICAL TRANSFORMATION
O_3 production
CHEMICAL TRANSFORMATION
O_3 production
Natural and anthropogenic emissions from the Earth (CH_4, CO, CO_2, VOCs, Sulfate, Black Carbon, Dust, N_2O, CFCs, NO_x, O_3)
CHEMICAL TRANSFORMATION AND
FREE TROPOSPHERE
BOUNDARY LAYER
Cities
Industry
DEPOSITION OF POLLUTANTS
Sulfur emissions from oceans
Evaporation and Convection
Forests and other Ecosystems
Transportation
Transportation
Agriculture
Cattle
Oceans
Desert dust
Biomass burning

Ozone and PM


Number of Days 8-hr Ozone Daily Max > 0.070 ppm
2000-2020
in El Paso, TX
40
30
20
10
0
34
27
25
20
19
26
28
27
21
8
8
8
11
6
5
7
4
12
14
9
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
Unhealthy for Sensitive Groups (0.071 – 0.085 ppm)
Unhealthy (0.086 – 0.105 ppm)
Note: Based on ALL sites
Source: U.S. EPA AirData <https://www.epa.gov/air-data>
Generated: June 11, 2020


Dust Storm Approaching El Paso


Dust Storm

Ozone Studies in the PdN Region:

- Performed CMAQ simulations to inter-compare with measurements during the 1996 Paso del Norte Campaign.

D. Lu, R.S. Reddy, R. Fitzgerald, W.R.Stockwell, Q.L. Williams, P.B. Tchounwou, 'Sensitivity Modeling Study for an Ozone Ocurrence during the 1996 Paso del Norte Ozone Campaign', Journal Int.J. Environ. Res Public Health, vol.5, pp 181-203, 2008.

- The differences in the variability of observed and simulated ozone-mixing ratios, using CAMx with Carbon 4 and 5.

W. R. Stockwell, R.M. Fitzgerald, D. Lu, R. Perea, 'Differences in the variability of measured and forecasted Tropospheric ozone mixing ratios over the Paso del Norte Region', Journal of Atmospheric Chemistry, vol. 70, n.1, pp 91-104, 2013.

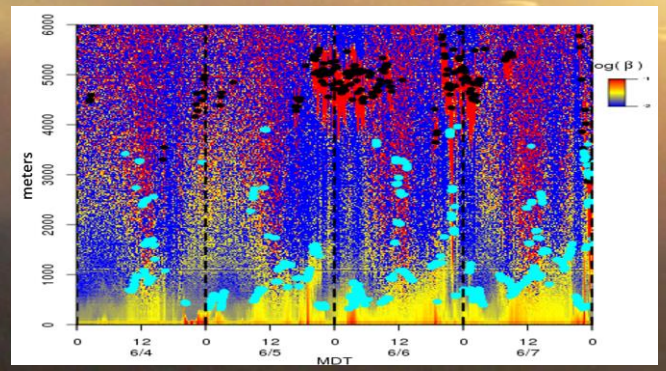
- Performed Ozone Inter-comparisons of model simulations WRF/CAMx, Sondes from 2017, and Satellite Data.

S. Mahmud, N. Karle, R.M. Fitzgerald, D. Lu, N.R. Nalli and W.R. Stockwell, 'Intercomparison of Sonde, WRF/CAMx and Satellite Sounder Profile Data for the Paso del Norte Region', Journal of Aerosol Science and Engineering, vol. 4, pp 277-292, 2020.

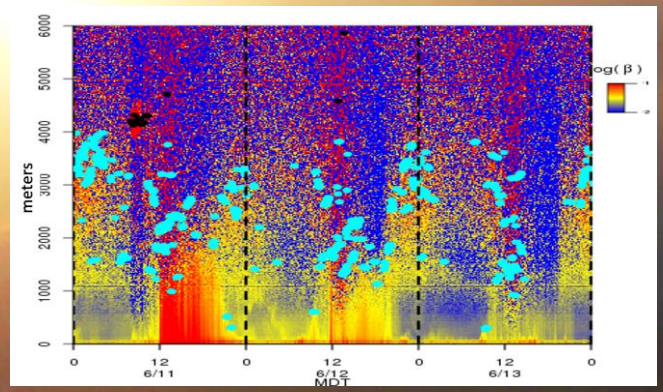
- Studied ozone events and the influence of the PBL, the atmospheric stability, etc.

N. Karle, S. Mahmud, R. K. Sakai, R.M. Fitzgerald, V. Morris and W.R. Stockwell, 'Investigation of the Successive Ozone Episodes in the El Paso-Juarez Region in the Summer of 2017', Journal of Atmosphere, vol.11, pp. 532-556, 2020.

Ozone and PBL

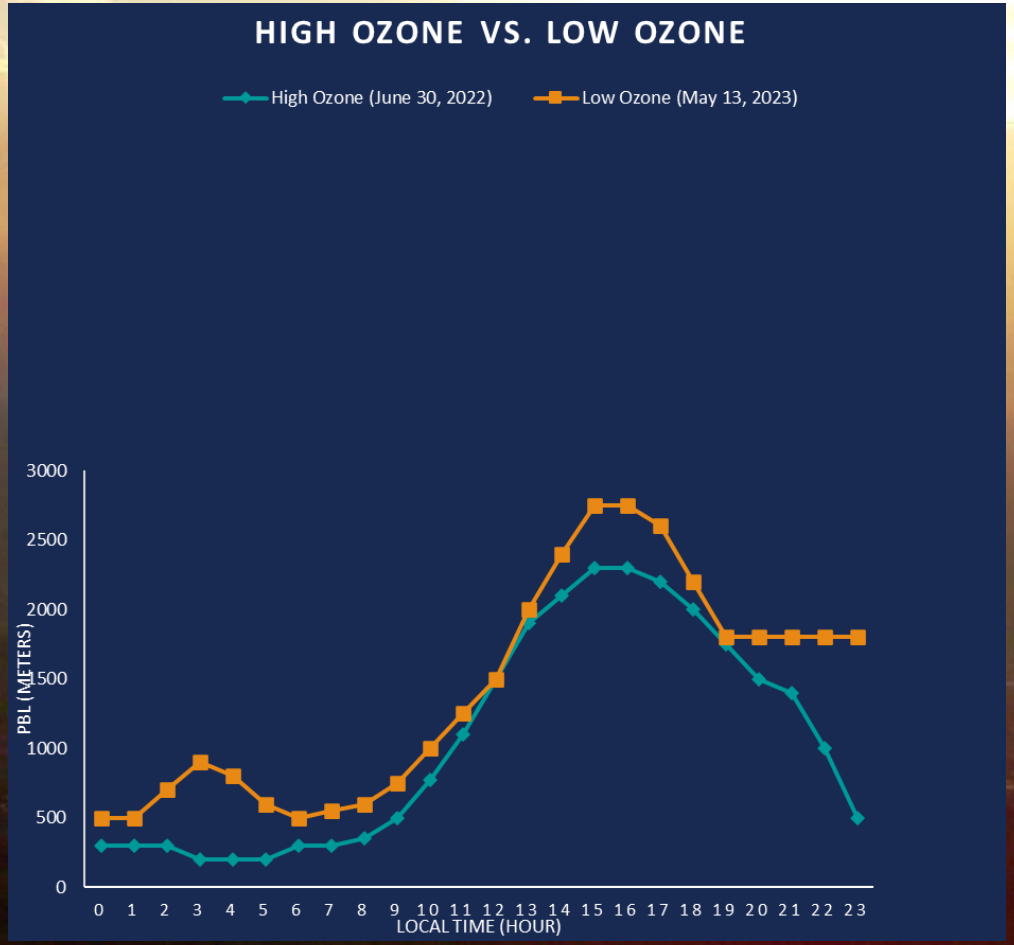


Aerosol backscatter plot for all four high ozone days showing the shallow aerosol layer, June 4-7, 2017.



Aerosol backscatter during all three low ozone days showing the deep aerosol layer, June 11-13, 2017

A PBL Inter-comparison for 2 Different years:



PM Studies in the PdN Region:

- We have performed Dust Studies.

N.Rivera, T. E. Gill, K.A. Gebhart, J.L. Hand, M.P. Bleiweiss, R.M. Fitzgerald, 'Wind Modeling of Chihuahuan Desert Dust Outbreaks', vol. 43, n.2, pp 347-354, 2009.

- We developed our own windblown dust model into an air quality model to improve its PM10 and PM2.5 forecasting capabilities.

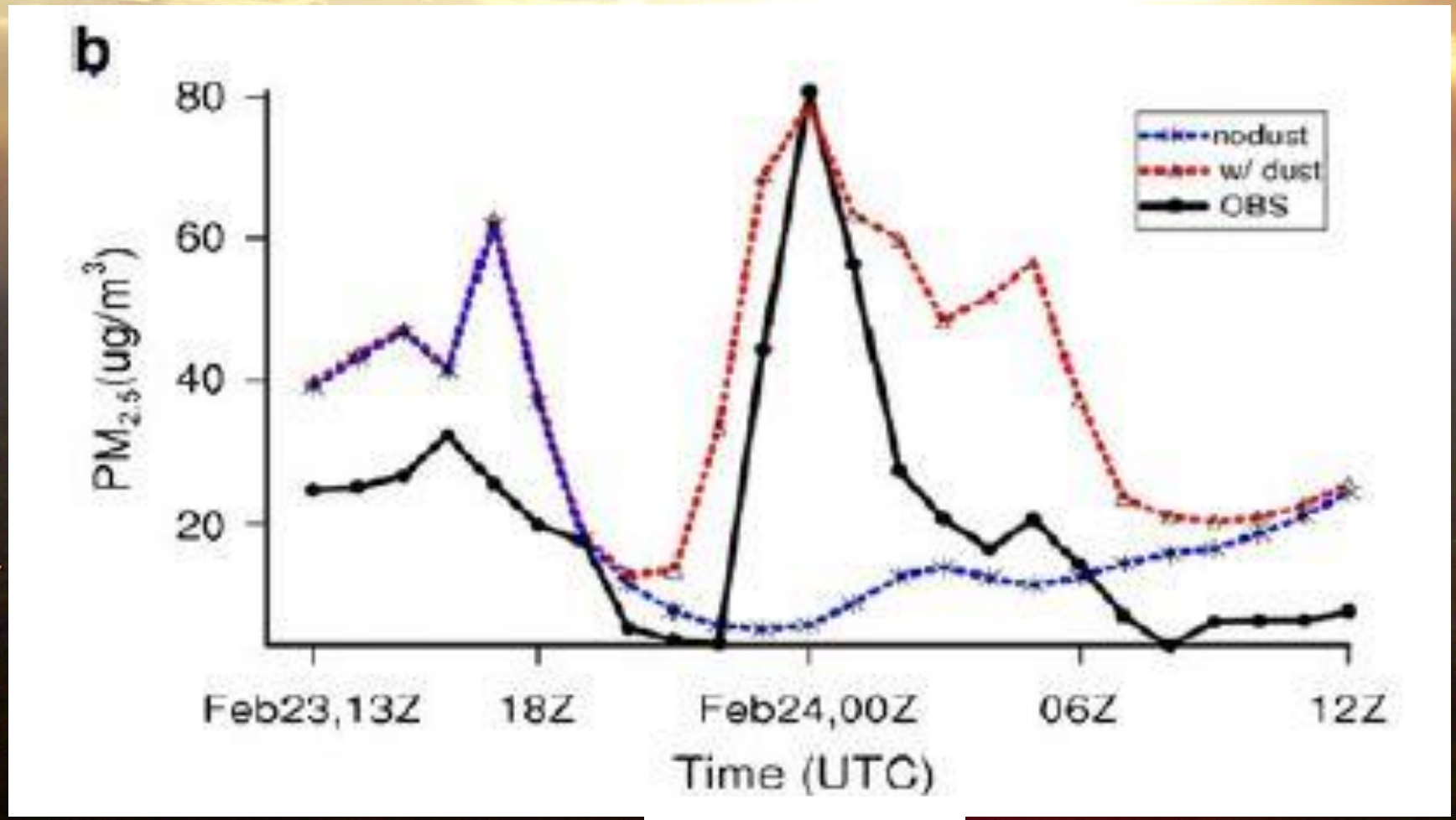
D. Lu, R. Fitzgerald, W.R. Stockwell, R.S. Reddy, L. White, Numerical Simulation for a wind dust event in the US/Mexico border region, Air Quality, Atmospheres and Health, vol. 6, n.2, pp 317-331, 2012.

- Improvement of Air Quality Models.

S. Mahmud, P.Wangchuk, R.M. Fitzgerald, W. R. Stockwell, D. Lu, 'NOAA/EPP/MSI Proceedings, N.Y, 2016.

Development and Enhancement of CMAQ Model's capability

Results:



February, 2007

Aerosol Optical Studies in the PdN Region:

- Developed a model to retrieve aerosol single scattering albedo.

Richard Medina, Rosa M. Fitzgerald and Qilong Min, 'Retrieval of the Single Scattering Albedo in the El Paso-Juarez Airshed using the TUV Model and a UV-MFRSR Radiometer', Atmospheric Environment doi:10.1016/j.atmosenv.2011.09.028, 2011

- Developed an Inverse Reconstruction Model to retrieve Aerosol Size Distribution.

A. E. Esparza, Rosa M. Fitzgerald , Thomas E. Gill and Javier Polanco, 'Use of Light Extinction Method and Inverse Modeling to Study Aerosols in the Paso del Norte Airshed', Atmospheric Environment, 45, 7360-7369, 2011.

- Developed Methodologies to Study Mineral Dust and Soot in the PdN Region.

1. R. Medina, W.R. Stockwell, R.M. Fitzgerald, Optical Characterization of Mineral Dust and Soot Particles in the El Paso-Juarez Airshed, Aerosol Science and Engineering, vol.2, n.1, pp. 11-19, 2018

2. J. Polanco, M. Ramos, R.M. Fitzgerald, W.R. Stockwell, 'An Improved Method for Optical Characterization of Mineral Dust and Soot Particles in the El Paso-Juárez Airshed' Journal Atmosphere, vol. 11, pp. 866-879, 2020.

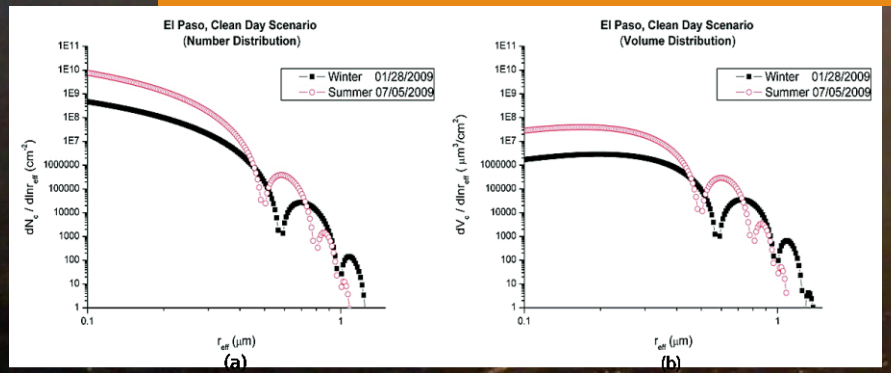
3. R.M. Fitzgerald, N.Karle, P.Lara, J. Polanco, W.R. Stockwell, 'Optical Measurements of Particulate Matter in the El Paso–Juárez Region: Natural Mineral Dust and Soot, E.M, A&WMA, October issue, pp. 24-29, 2021

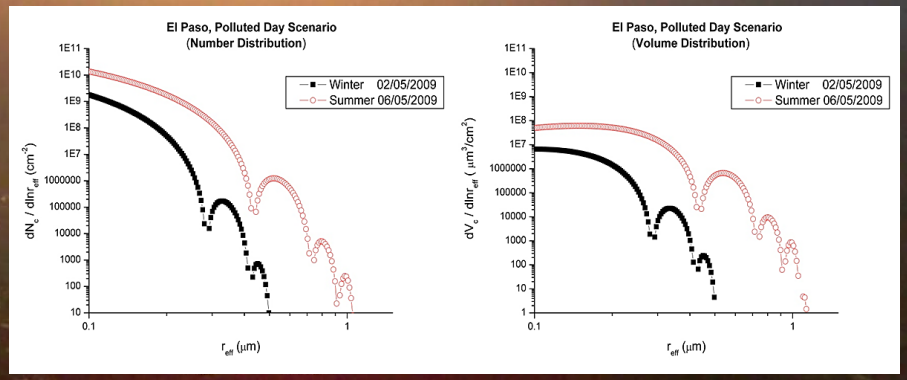
- Developed Methodology to Study Wildfires.

P. Lara, R.M., Fitzgerald, N.Karle, J. Talamantes, M.Miranda, D. Baumgardner, 'Winter and Wildfire Season Optical Characterization of Black and Brown Carbon in the El Paso-Ciudad Juárez Airshed', Journal Atmosphere, vol.13, pp. 1201-1220, 2022.

Optical Studies
Inverse reconstruction model

$$\tau_A(\lambda) = \int_0^{\infty} \int_0^{\infty} C_{ext}(r, \lambda, m) n(r, z) dz dr$$





Publication:
Angel E. Esparza, Rosa M. Fitzgerald , Thomas E. Gill and Javier Polanco, 'Use of Light Extinction Method and Inverse Modeling to Study Aerosols in the Paso del Norte Airshed', Atmospheric Environment, 45, 7360-7369, 2011

The regularized solution is obtained by solving the following equation :

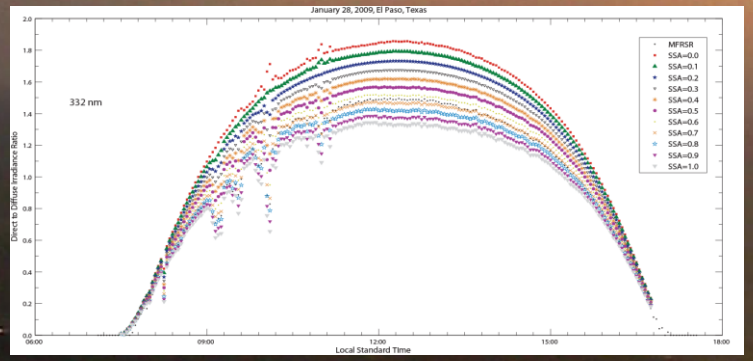
$$f = (A^T A + \gamma H)^{-1} A^T g$$

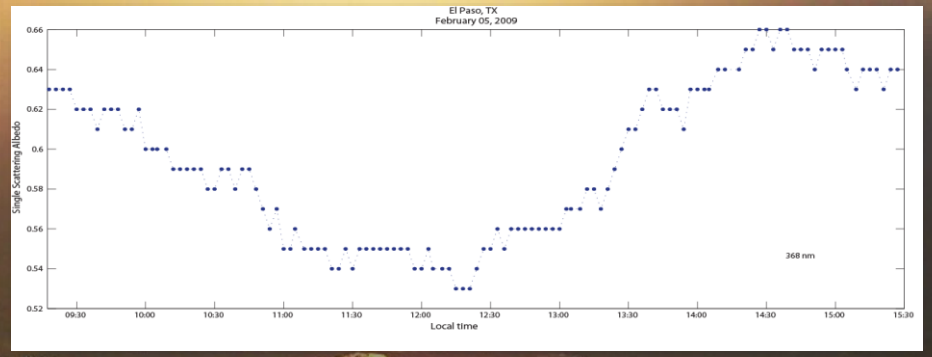
where f is the size distribution array, A is the kernel matrix, γ is the lagrange multiplier, H is the smoothing matrix and *g* is the optical depth data.

Retrieval of the Single Scattering Albedo: ω

$$\mu \frac{\partial I}{\partial \tau}(\tau, \mu, \phi) = I(\tau, \mu, \phi) - J(\tau, \mu, \phi)$$

$$\omega = \frac{C_{sca}}{C_{ext}} = \frac{C_{sca}}{C_{abs} + C_{sca}}$$

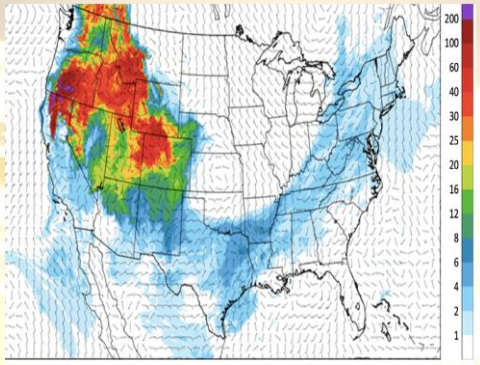




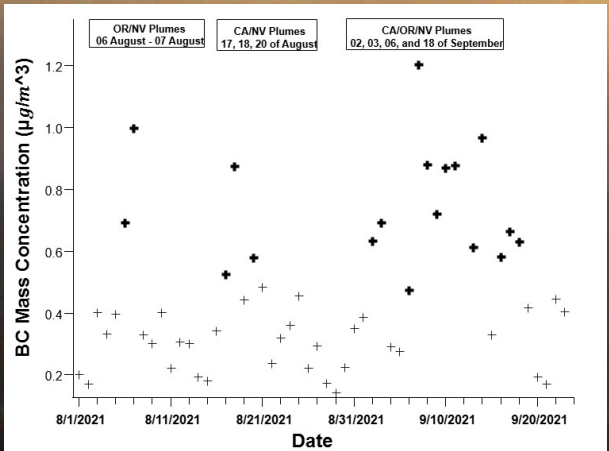
Publication:

Richard Medina, Rosa M. Fitzgerald and Qilong Min, 'Retrieval of the Single Scattering Albedo in the El Paso-Juarez Airshed using the TUV Model and a UV-MFRSR Radiometer', Atmospheric Environment doi:10.1016/j.atmosenv.2011.09.028, 2011

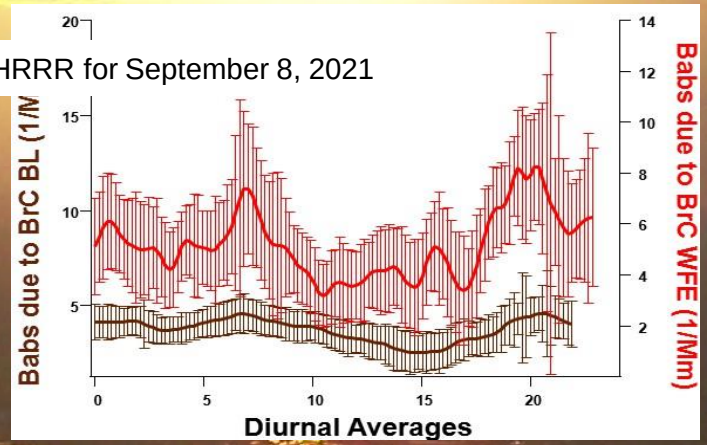
Wildfire Studies



HRRR
Wildfire Smoke Maps



Black Carbon Mass Concentration
Bold marking represent the 18 days when the wildfire plumes reached our instruments



Inferred BrC Babs for the diurnal averages of August 1 through September 23, 2021

Publication:
Lara, Pamela & Fitzgerald, Rosa & Karle, Nakul & Talamantes, Jose & Miranda, Miranda & Baumgardner, Darrel & Stockwell, William. (2022). Winter and Wildfire Season Optical Characterization of Black and Brown Carbon in the El Paso-Ciudad Juárez Airshed. Atmosphere**,** 13. 10.3390/atmos13081201.

Conclusions

- The University of Texas at El Paso (UTEP) has a strong research and education thrust in Atmospheric and Environmental Physics.
- We make state-of-the-science meteorological measurements at UTEP sites to characterize planetary layer boundary height using ceilometers, atmospheric circulation patterns, temperature, relative humidity, atmospheric stability and solar actinic flux.
- We apply optical methods, such as Multi-filter Rotating Shadowband Radiometers, photoacoustic extinctiometers and laser particle counters to measure atmospheric particulate matter, especially black and brown carbon. We have begun to use the particulate matter measurement to estimate the particulate emissions from wildfires that are increasing due to climate change..
- Data analysis and modeling include atmospheric wind trajectory models, meteorological models, air quality, health impact models; the models may include the Weather Research and Forecasting Model (WRF), CMAQ, CAMx, WRF with Chemistry (WRF-Chem), HYSPLIT, HYSPLIT/FENGSHA, health effects models (Environmental Benefits Mapping and Analysis Program, BENMAP).

Acknowledgements


THANK YOU