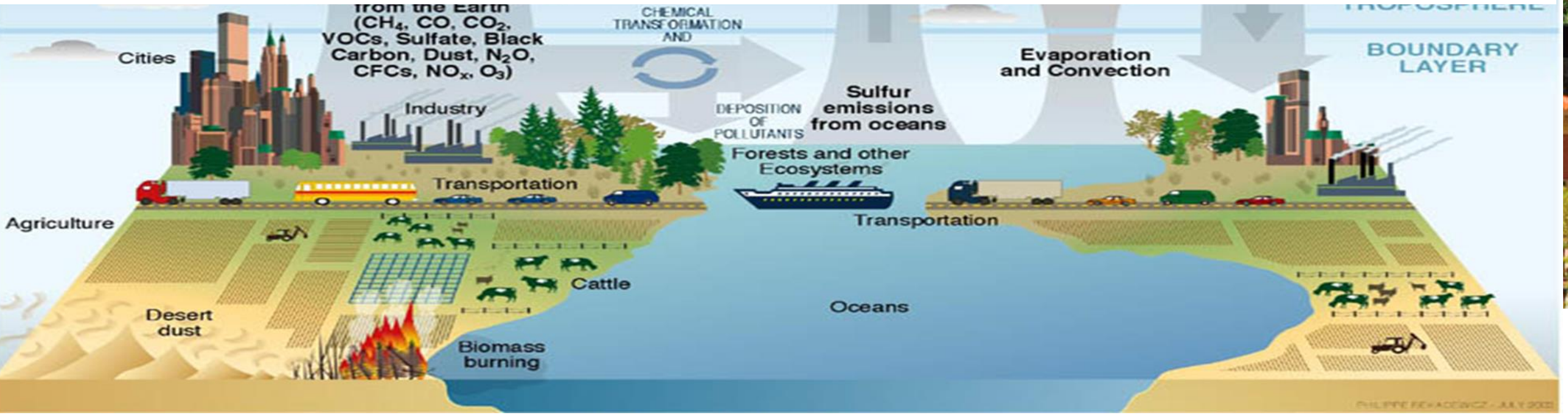
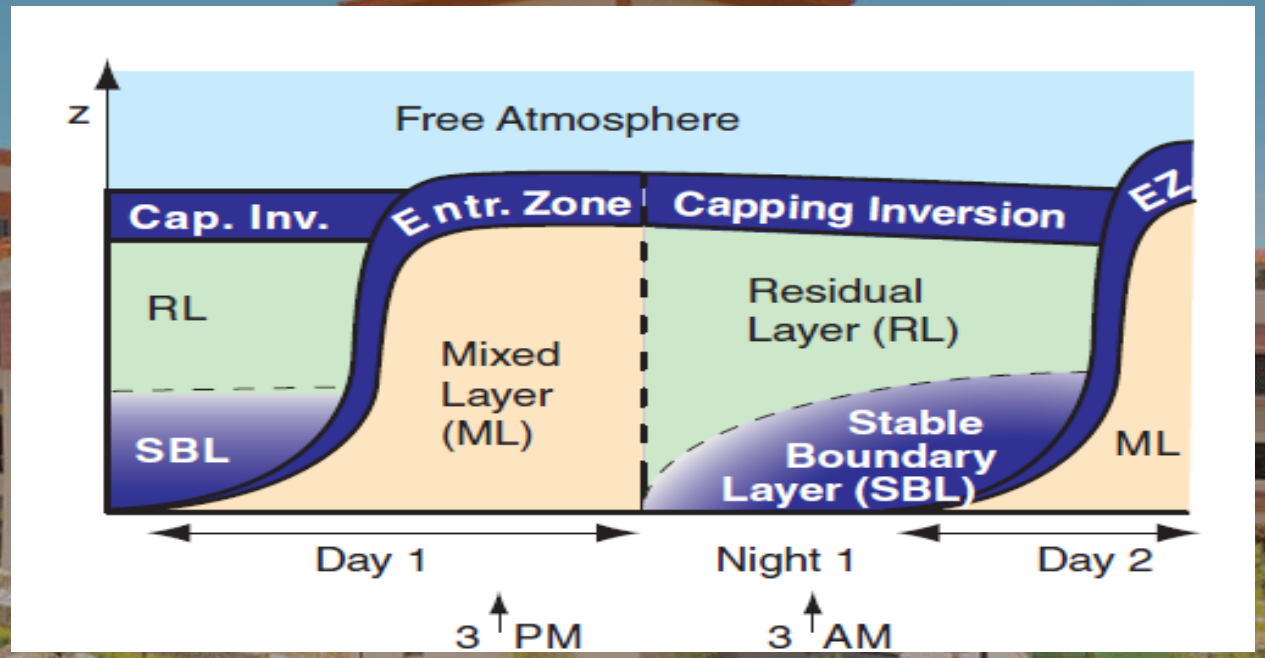
PBL Studies in the El Paso-Juarez Airshed

Rosa Fitzgerald, Nakul Karle, Suhail Mahmud, William Stockwell

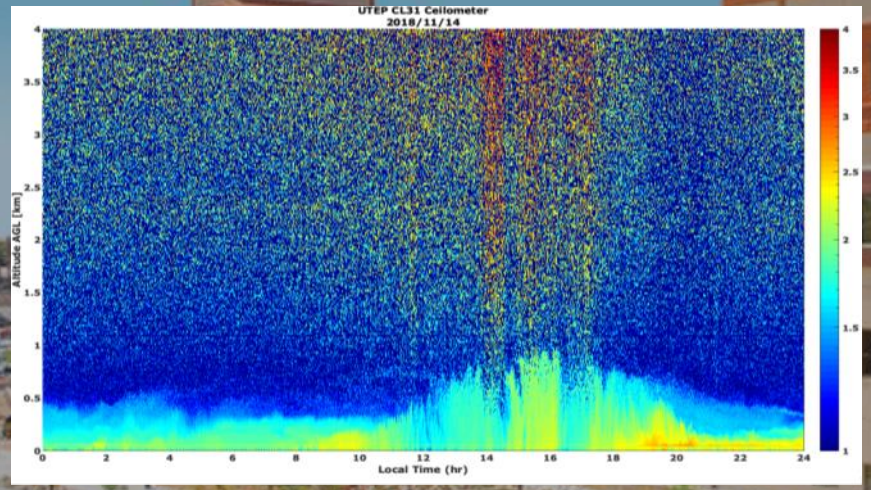
"The Planetary Boundary Layer (PBL) is that part of the troposphere that is directly influenced by the presence of the Earth's surface, and responds to surface forcings with a timescale of about an hour or so."



A fundamental variable of the PBL is its top height (PBLH) that determines many tropospheric processes critical to air pollution, such as aerosol distributions, ozone concentrations, transport, convection activity, cloud and fog formation.

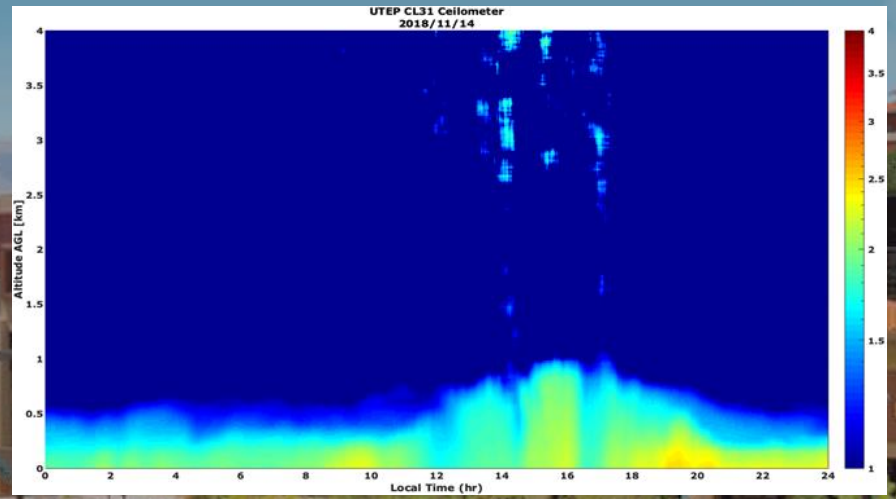


A picture of an industrial city (Shangai, China) illustrating how the PBL traps pollutants below it.

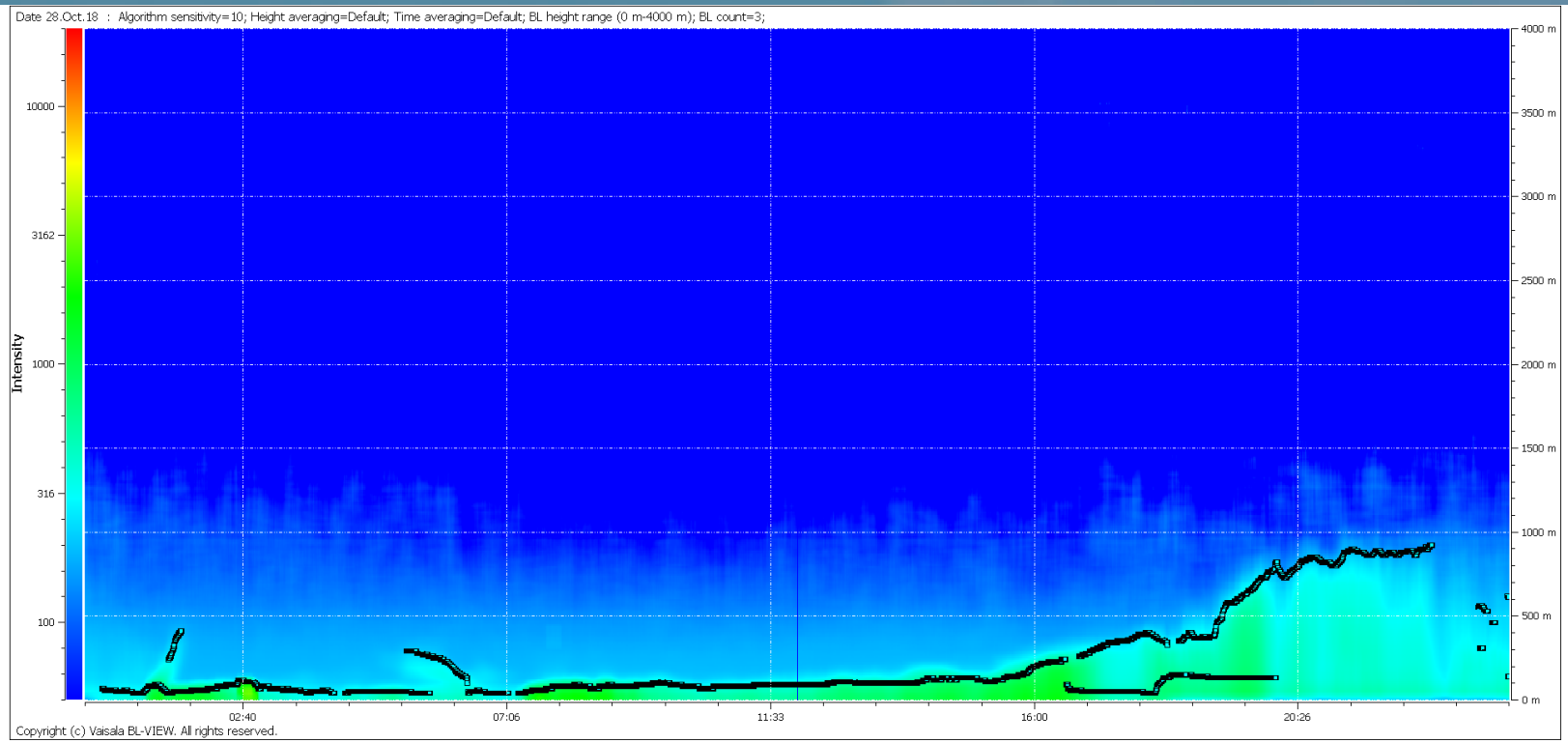


Aerosol backscatter profile of the UTEP raw ceilometer CL31 data, for November 14, 2018.

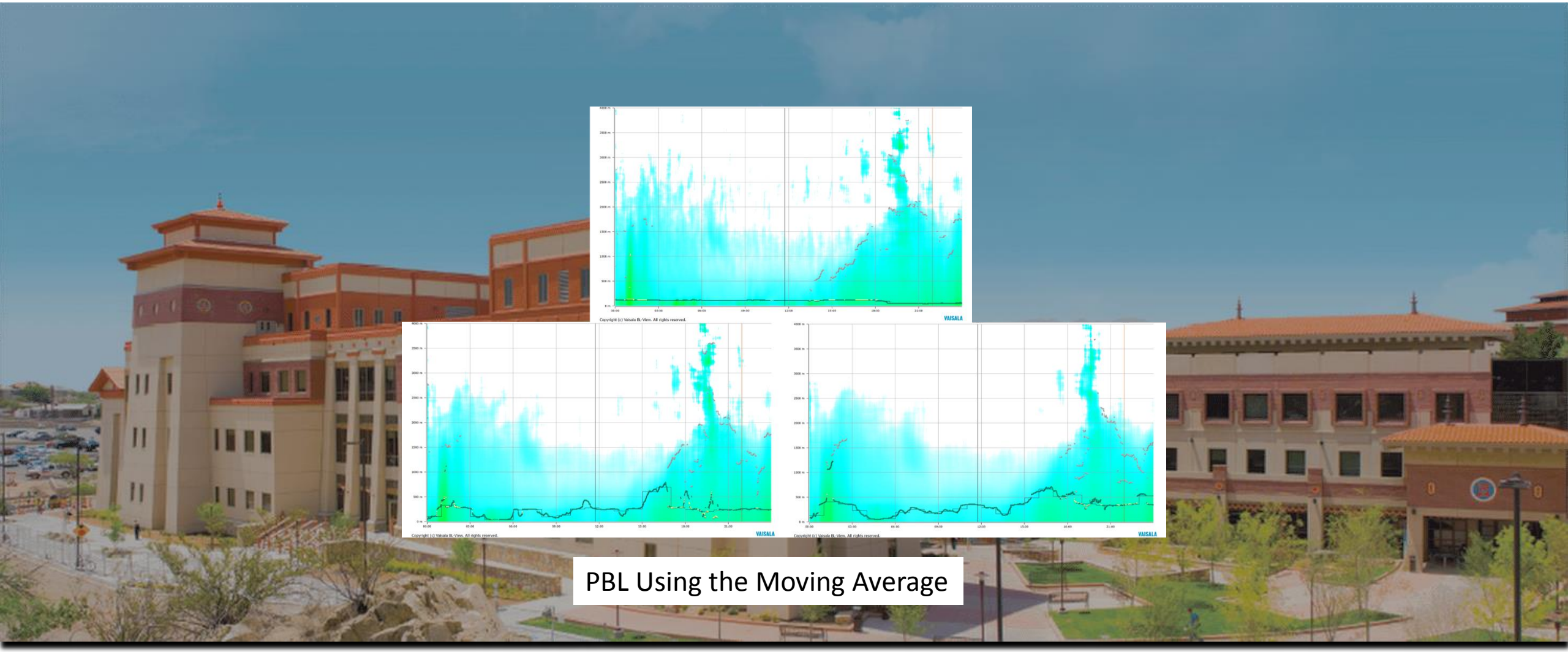
Ceilometer



UTEP CL31 backscatter profile for November 14, 2018, using the moving average.

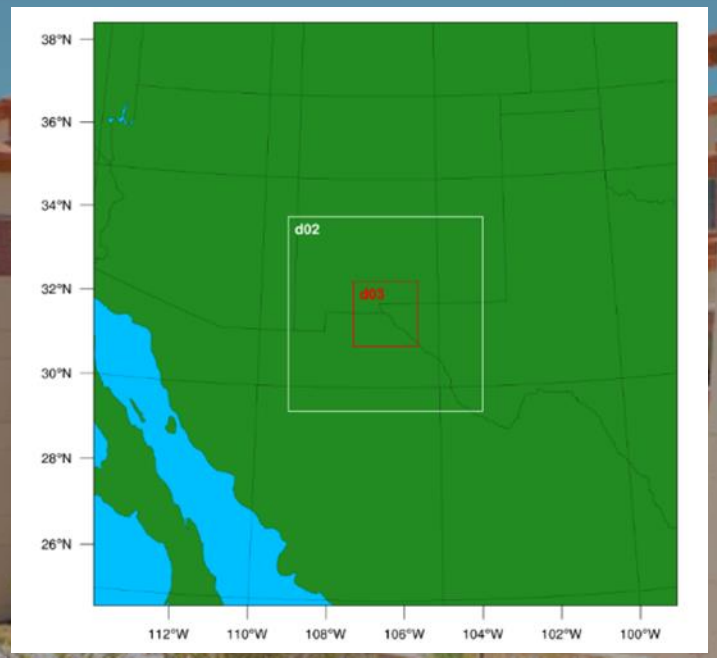


PBL for October 28, 2018, UTEP ceilometer



PBL Using the Moving Average

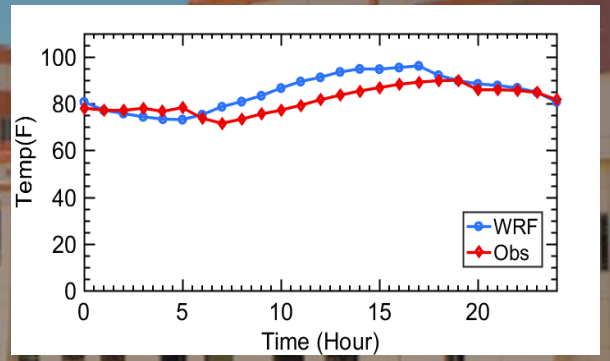
WRF Simulations

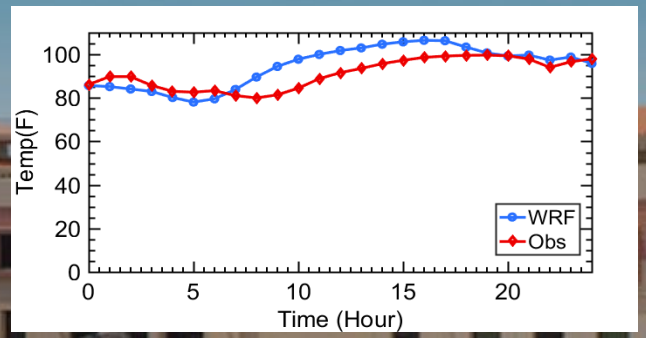


Scheme	WRF Option	Reference
Planetary Boundary Layer (PBL)	First Order Closure YSU	[10]
Microphysics	WRF Single-Moment (WSM)	[11]
Land Surface	Noah Land Surface	[12]
Surface Layer	Monin-Obukhov Similarity	[13]
Cumulus	Kain-Fritsch	[14]

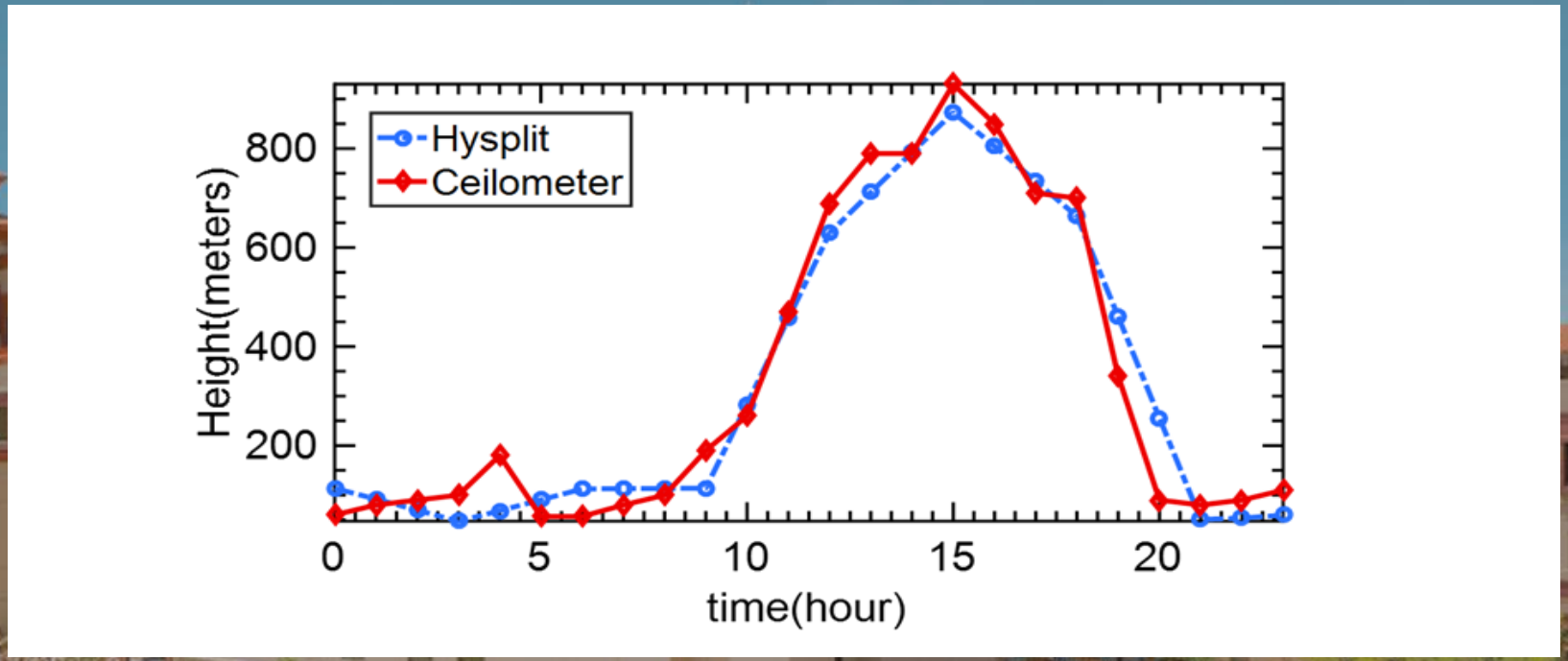
Table: Different popular physics schemes used in WRF

Validation of WRF model for this project



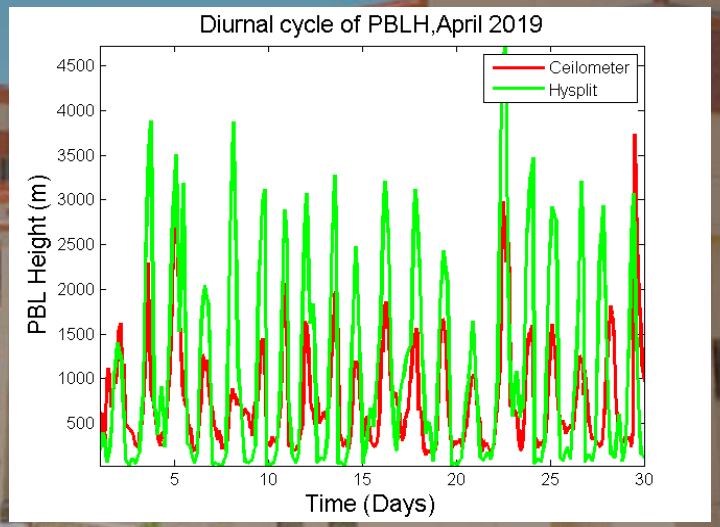


Inter-Comparison of WRF and observational Temperature data for two different days. Left June 05, 2017. Right, May 15, 2017. The monitoring station shown is CAMS 12.



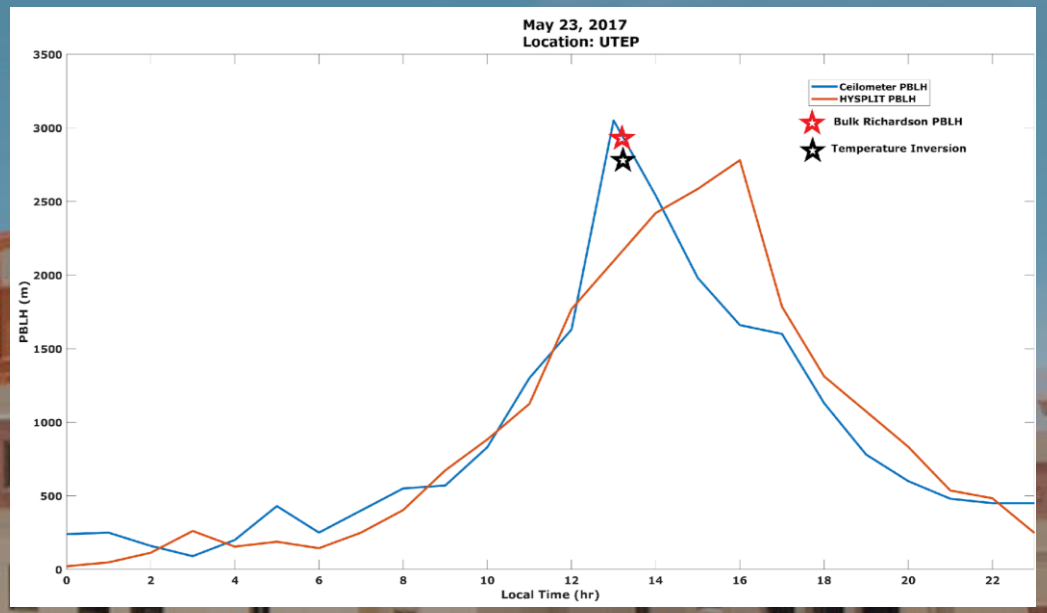
Ceilometer – HYSPLIT PBLH inter-comparison for November 14, 2018

Monthly PBL Inter-comparison Between Ceilometer and HYSPLIT Model



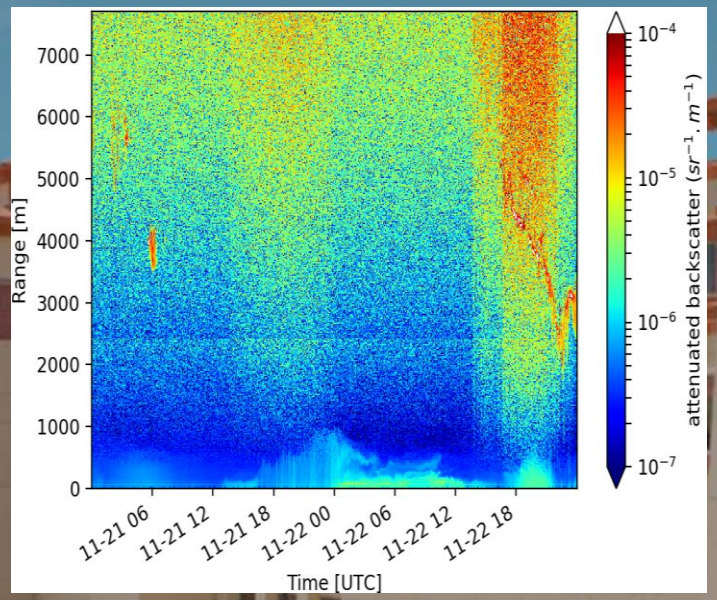
Performance and Error calculation tests for October 2018 using UTEP data

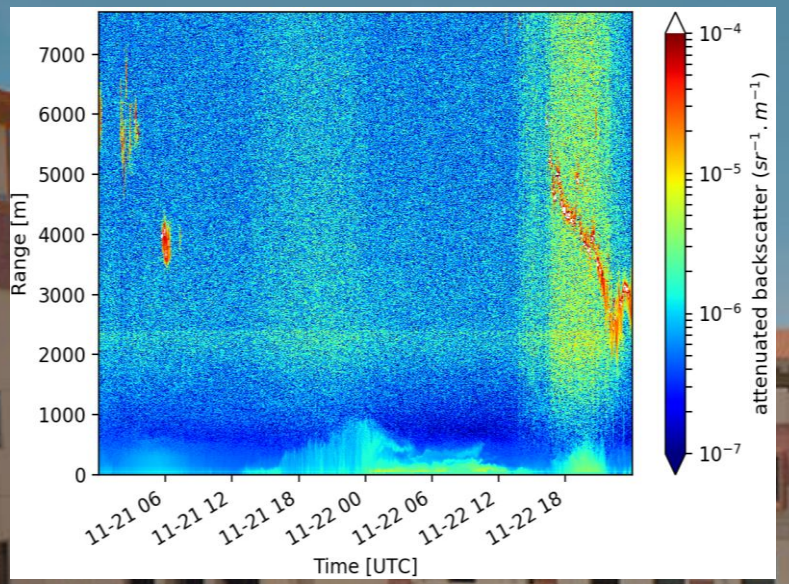
Test	Values
Correlation Coefficient (Pearson)	0.70
Index of Agreement	0.58
Mean Absolute Error	283.91
RMSE	369.05



An inter-comparison of the PBLH from ceilometer, HYSPLIT and radiosonde.
(obtained using the Bulk Richardson and the lapse rate or temperature inversion PBLH detecting algorithm) for May 23, 2017.
The location of the radiosonde launching was at UTEP.

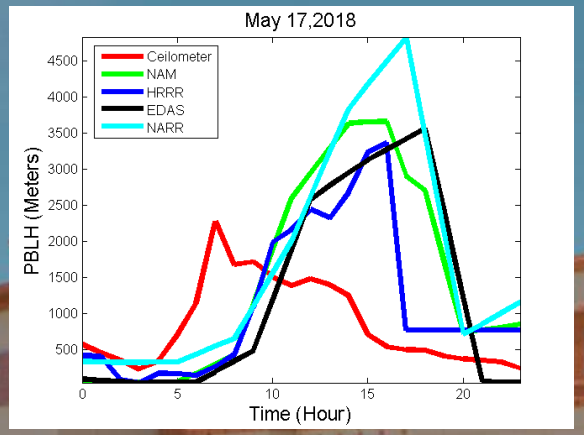
UTEP-Socorro Ceilometers

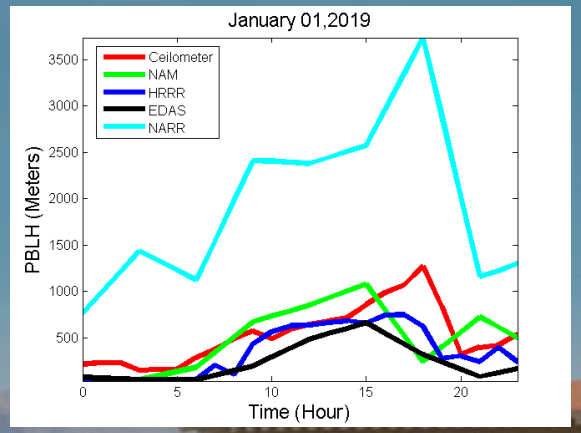


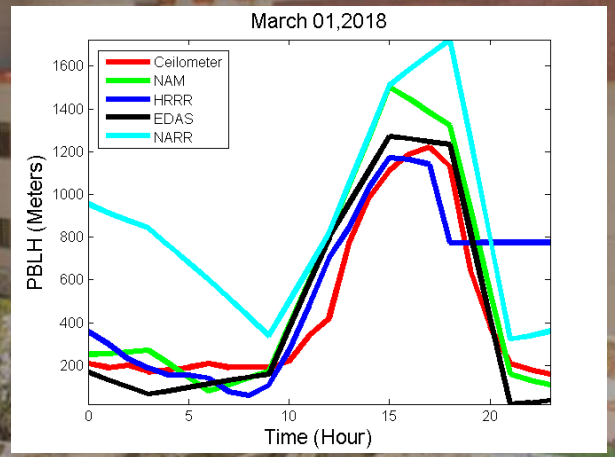


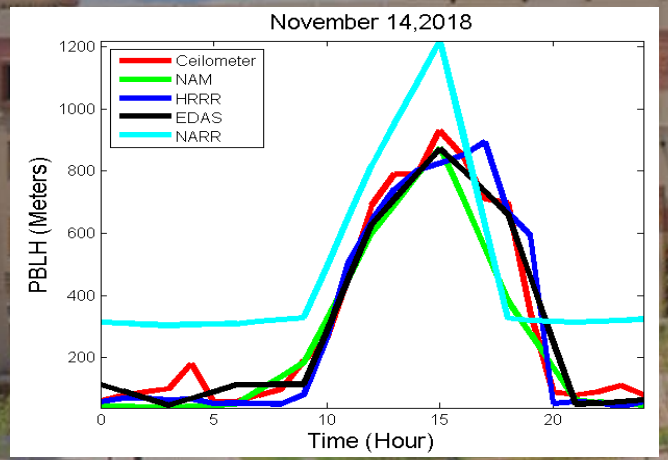
Backscattering profiles for November 21, 2018, from ceilometers (left CL-UTEP and right CL-Soc)

HYSPLIT with Different Met Datasets

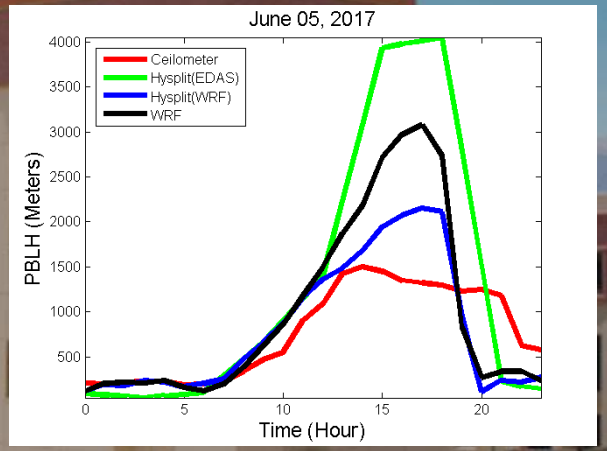




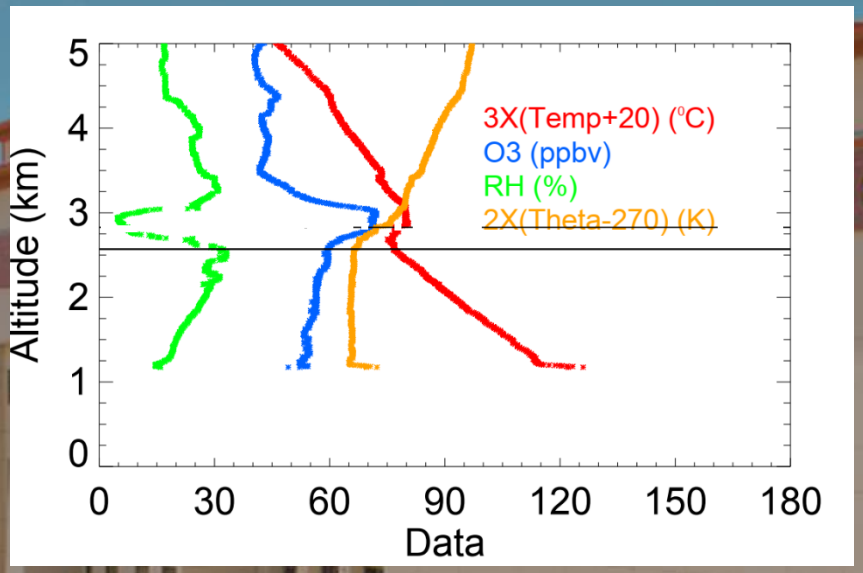




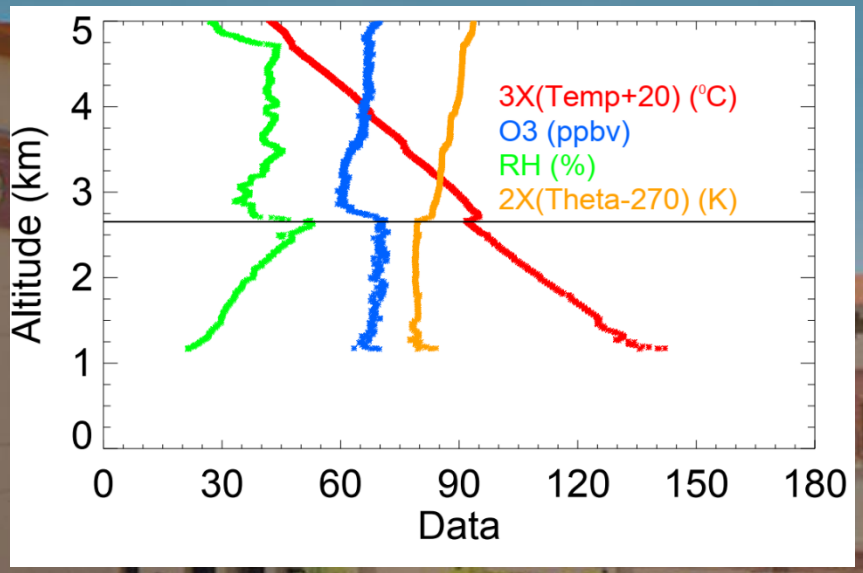
PBLH Intercomparison Using Different Methods



Vertical Profiles of Ozone, Relative Humidity, Temperature, Potential Temperature Using Radiosondes, Showing PBLH in solid black line

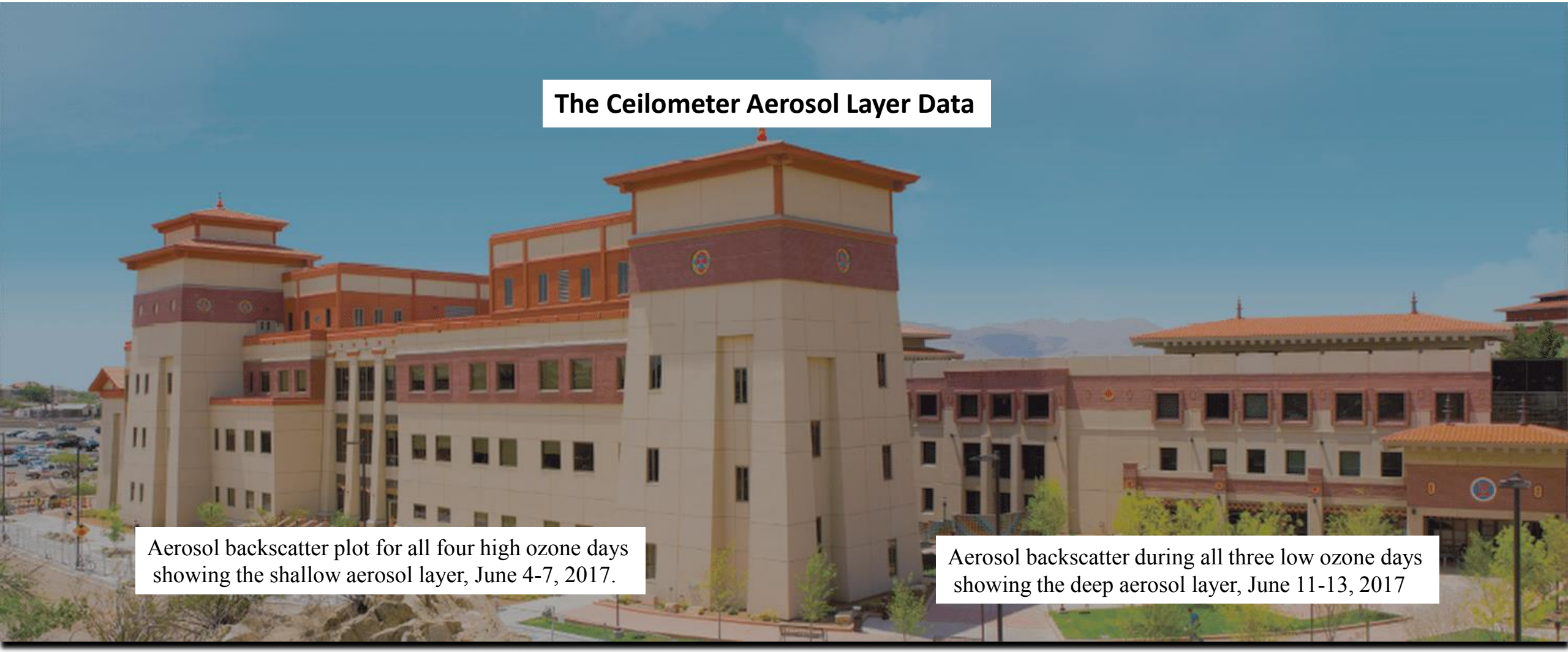


May 17, 2017



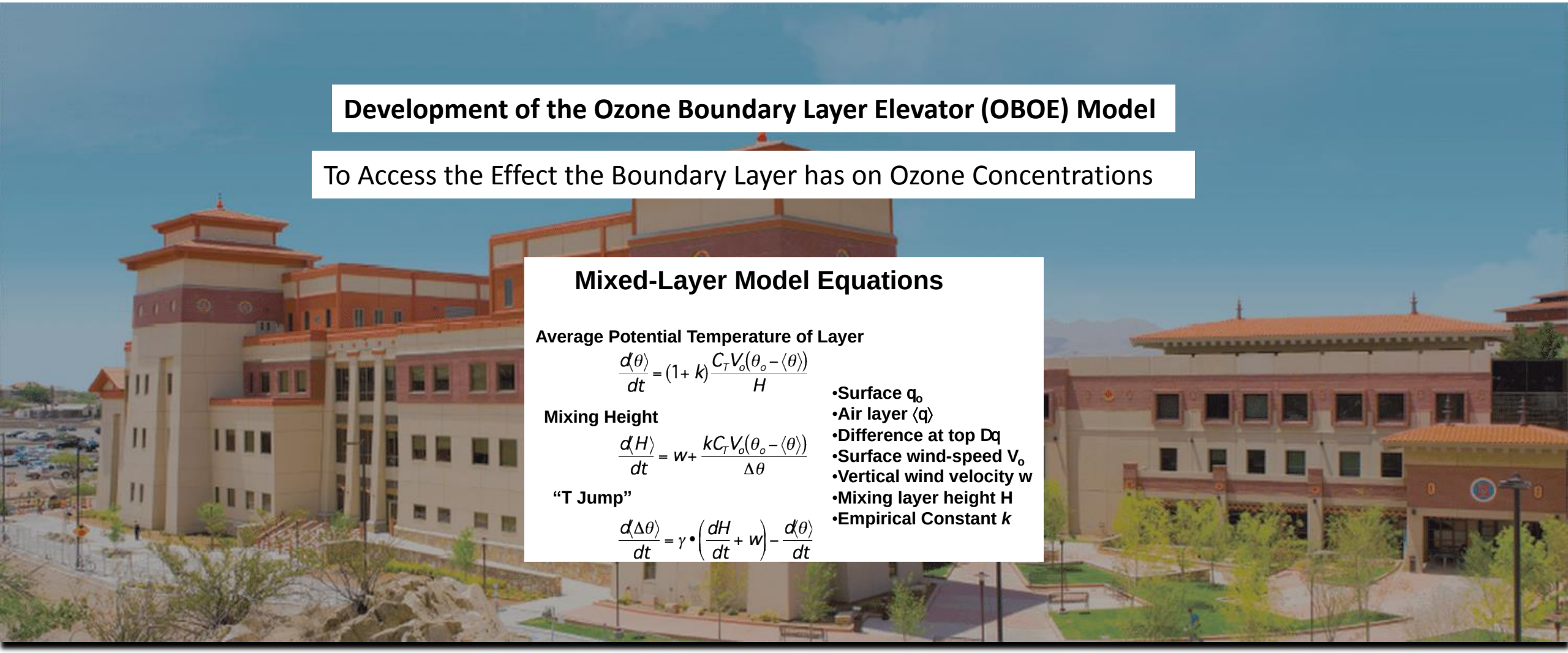
May 30, 2017

The Ceilometer Aerosol Layer Data



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



Development of the Ozone Boundary Layer Elevator (OBOE) Model

To Access the Effect the Boundary Layer has on Ozone Concentrations

Mixed-Layer Model Equations

Average Potential Temperature of Layer

$$\frac{d\langle\theta\rangle}{dt} = (1+k)\frac{C_T V_o(\theta_o - \langle\theta\rangle)}{H}$$

Mixing Height

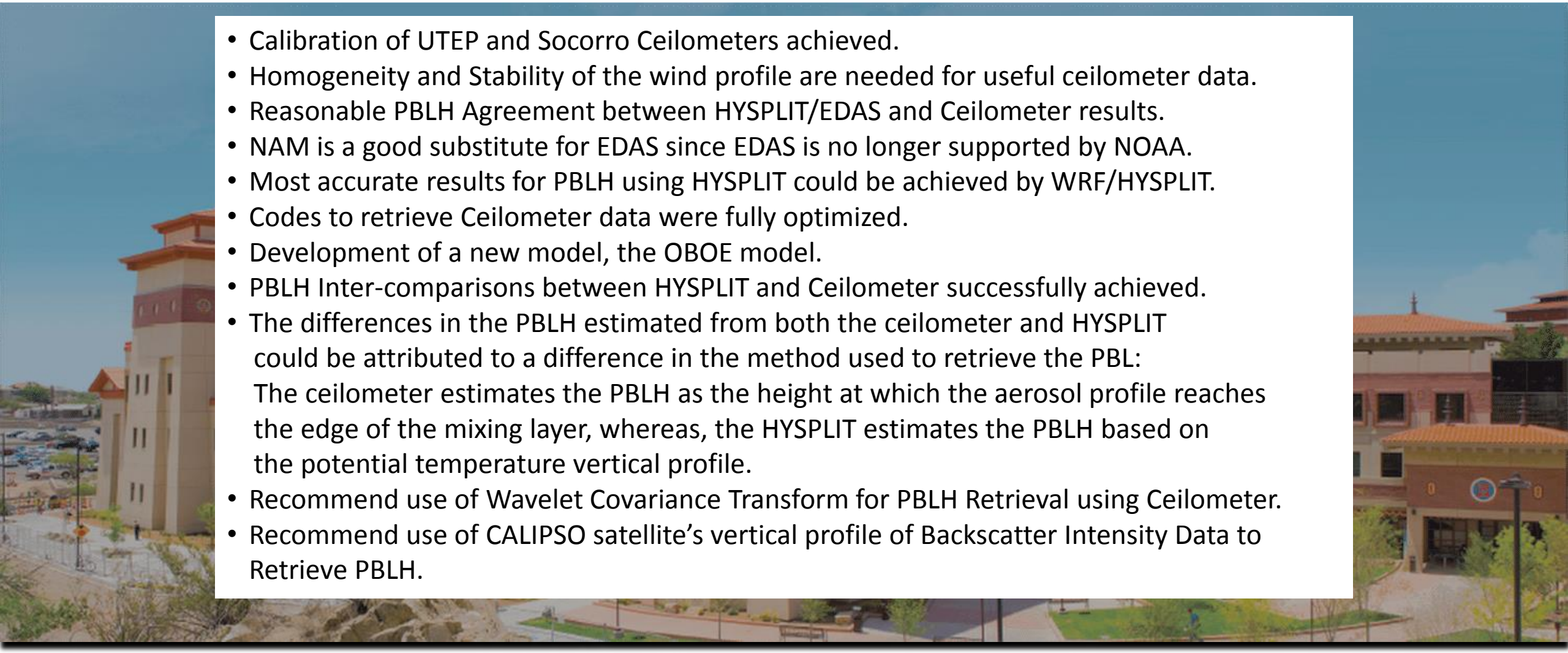
$$\frac{d\langle H\rangle}{dt} = w + \frac{kC_T V_o(\theta_o - \langle\theta\rangle)}{\Delta\theta}$$

"T Jump"

$$\frac{d\langle\Delta\theta\rangle}{dt} = \gamma \bullet \left(\frac{dH}{dt} + w\right) - \frac{d\langle\theta\rangle}{dt}$$

- **Surface q_o**
- **Air layer $\langle q\rangle$**
- **Difference at top Dq**
- **Surface wind-speed V_o**
- **Vertical wind velocity w**
- **Mixing layer height H**
- **Empirical Constant *k***

Conclusions



- Calibration of UTEP and Socorro Ceilometers achieved.
- Homogeneity and Stability of the wind profile are needed for useful ceilometer data.
- Reasonable PBLH Agreement between HYSPLIT/EDAS and Ceilometer results.
- NAM is a good substitute for EDAS since EDAS is no longer supported by NOAA.
- Most accurate results for PBLH using HYSPLIT could be achieved by WRF/HYSPLIT.
- Codes to retrieve Ceilometer data were fully optimized.
- Development of a new model, the OBOE model.
- PBLH Inter-comparisons between HYSPLIT and Ceilometer successfully achieved.
- The differences in the PBLH estimated from both the ceilometer and HYSPLIT could be attributed to a difference in the method used to retrieve the PBL: The ceilometer estimates the PBLH as the height at which the aerosol profile reaches the edge of the mixing layer, whereas, the HYSPLIT estimates the PBLH based on the potential temperature vertical profile.
- Recommend use of Wavelet Covariance Transform for PBLH Retrieval using Ceilometer.
- Recommend use of CALIPSO satellite's vertical profile of Backscatter Intensity Data to Retrieve PBLH.

Acknowledgments

Authors will like to thank TCEQ for their intellectual and financial support for this project.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