Boundary Layer and Air Quality Research at the Center for Analysis and Prediction of Storms

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Introduction

The Center for Analysis and Prediction of Storms (CAPS) at the University of Oklahoma (OU), a former NSF Science and Technology Center and a current University Strategic Organization (USO), has been a leader in storm-scale numerical weather prediction and data assimilation. As an USO, CAPS has been expanding its research breadth, with new projects studying regional climate, boundary layer, air quality and green house gas transport and impacts. This poster highlights some boundary layer related research conducted at CAPS in 5 categories: **Urban meteorology, Air pollution meteorology, WRF/Chem-VPRM CO_2 downscaling, PBL parameterization schemes, and Land surface processes.**

Urban meteorology

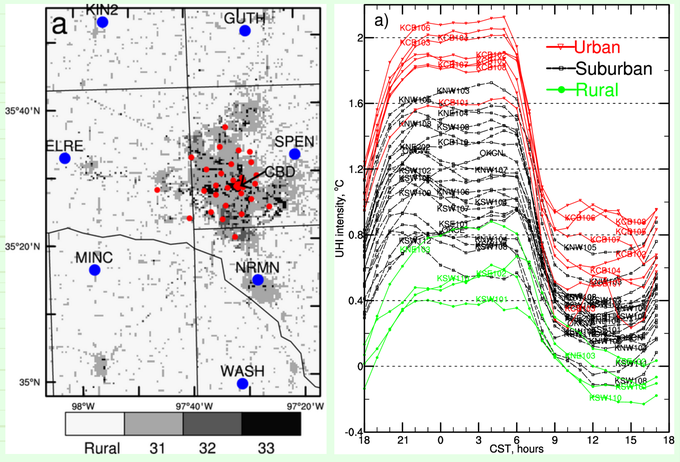
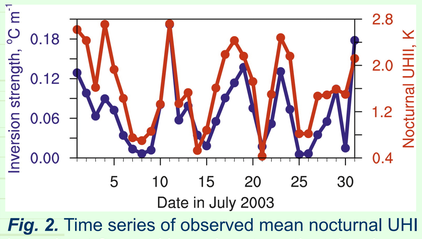


Fig. 1. (left) Location of the OKCNET stations (red dots) and seven surrounding Oklahoma Mesonet sites (blue dots), (right) Mean diurnal variation of UHI intensity at each OKCNET site (classified into three categories, i.e., urban, suburban, and rural) during April 2009–October 2010.

Discussion: The UHI intensity exhibited large spatial variations over OKC. The UHI intensity of OKC increased prominently around the early evening transition and stayed at a fairly constant level throughout the night.



Rural inversion strength shows a high correlation with the nocturnal UHI intensity at OKC, thus it can serve as an indicator for UHI intensity, which highlights that the structure of the nocturnal boundary layer is important for UHI assessments.

Fig. 2. Time series of observed mean nocturnal UHI intensity at 9 m and inversion strength at the six mesonet sites.

Hu, X.-M., P. M. Klein, M. Xue, et al. (2013), Impact of low-level jets on the nocturnal urban heat island intensity in Oklahoma City. *J. Appl. Meteor. Climatol.*, doi:10.1175/JAMC-D-12-0256.1
Hu, X.-M., M. Xue, P. Klein et al. (2016), Analysis of Urban Effects in Oklahoma City using a Dense Surface Observing Network, *J. Appl. Meteor. Climatol.*, doi:10.1175/JAMC-D-15-0206.1
Hu, X.-M., and M. Xue (2016), Influence of synoptic sea breeze fronts on the urban heat island intensity in Dallas-Fort Worth, Texas, *Mon. Wea. Rev.*, doi:10.1175/MWR-D-15-0201.1

Air pollution meteorology

Selected episode

A severe O_3 pollution event occurred in DFW when Hurricane Irene passed by the east coast of US during Aug 25-28, 2011

Discussion: During the O_3 episode on Aug 27, a stationary front maintained in the west of DFW as a result of the passage of Hurricane Irene over the eastern coast. Wind direction experienced a transition from easterly/northeasterly to southwesterly across the front. In the transition zone, the flow was nearly stagnant. The stagnant zone blocked and confined the pollutant plume emanated from DFW, leading to accumulation of primary pollutants and prominent boundary layer O_3 formation. Such a scenario is in contrast to the typical summer days when southerly winds along the western edge of the Bermuda high prevail over the Southern Great Plains and the pollutant plumes from DFW are are advected downwind, thus with lower O_3.

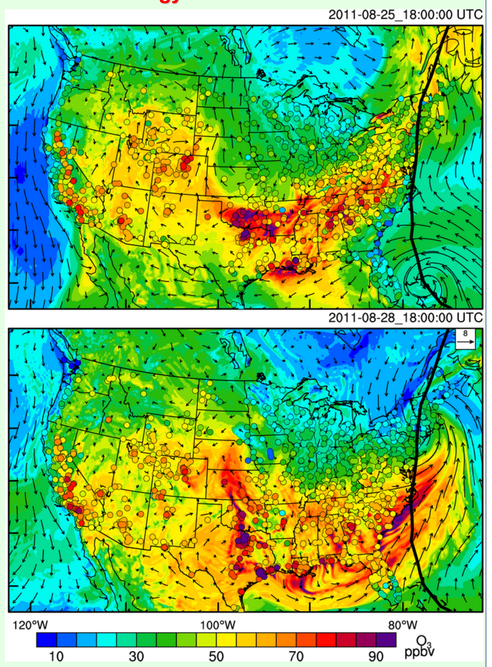


Fig. 3. Simulated O_3 overlaid with observed O_3 (shaded circles). The official track of Hurricane Irene on the eastern coast of USA is marked.

WRF/Chem-VPRM CO_2 downscaling

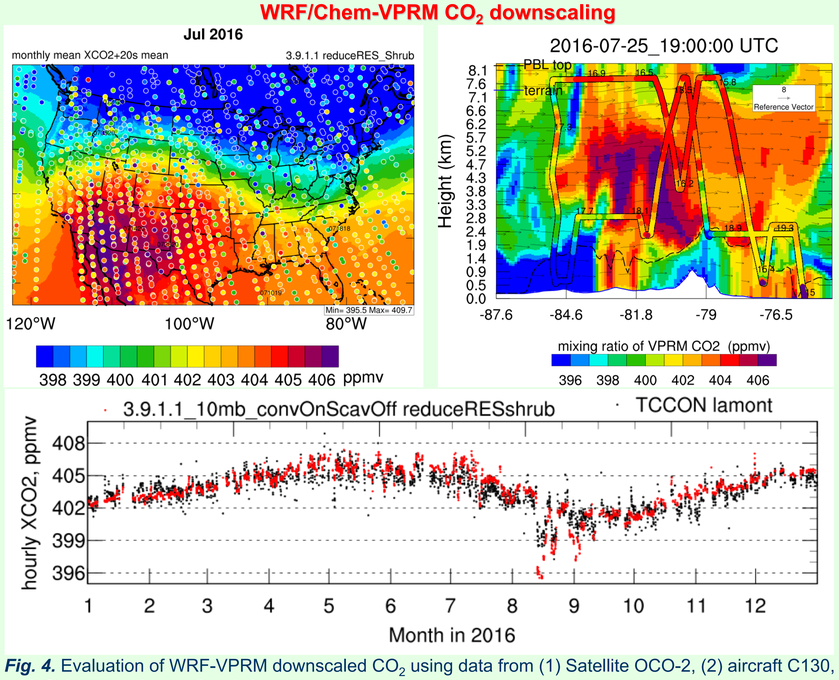


Fig. 4. Evaluation of WRF-VPRM downscaled CO_2 using data from (1) Satellite OCO-2, (2) aircraft C130, and (3) Lamont observational site.

Discussion: CAPS is collaborating with a biology group at OU to improve the WRF-VPRM model for regional CO_2 simulation. The model outputs are evaluated with satellite, aircraft and station data. The model is verified to capture CO_2 spatial distribution over US, variation in the lower troposphere, and monthly variation at TCCON sites (e.g., Lamont).

PBL parameterization schemes

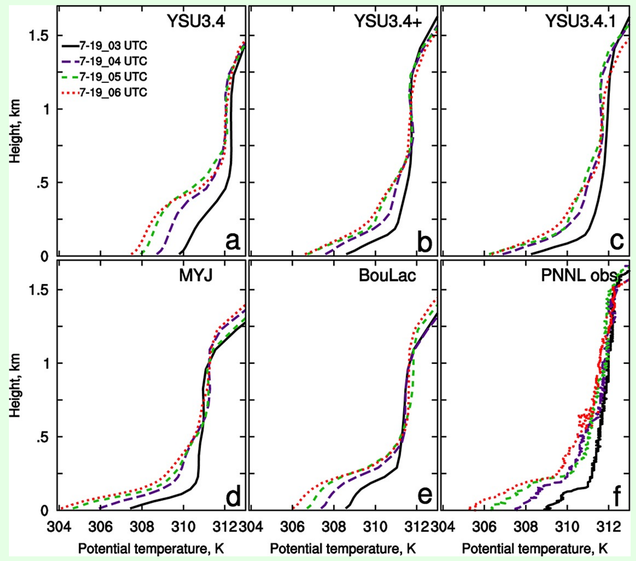


Fig. 5. Profiles of potential temperature over OKC at 0300–0600 UTC on 19 July 2003 simulated by the numerical experiments (a) YSU3.4, (b) YSU3.4+, (c) YSU3.4.1, (d) MYJ, and (e) BouLac, and (f) observed by radiosondes.

Hu, X.-M., P. M. Klein, and M. Xue (2013), Evaluation of the updated YSU Planetary Boundary Layer Scheme within WRF for Wind Resource and Air Quality Assessments, *J. Geophys. Res.*, 118, doi:10.1002/jgrd.50823.

CAPS is currently examining the impact of different PBL schemes (particularly convectional vs. scale-aware schemes) on tornado simulations in a VORTEX-SE project

Land surface processes

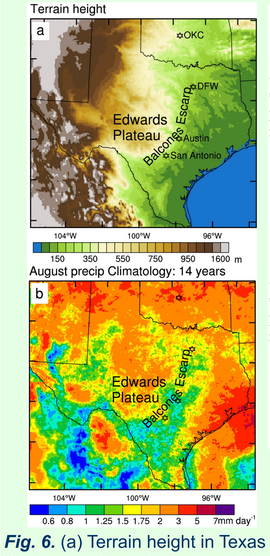


Fig. 6. (a) Terrain height in Texas and (b) August climatological precipitation.

Discussion: The clay-based soil types that dominate the Edwards Plateau have great potential to retain soil moisture and limit latent heat fluxes, consequently leading to higher sensible heat flux than over the plain to the east. As a result, vertical motion is induced, triggering the afternoon moist convection over the Edwards Plateau.

Hu, X.-M., M. Xue, and R. A. McPherson (2017), The Importance of Soil-Type Contrast in Modulating August Precipitation Distribution near the Edwards Plateau and Balcones Escarpment in Texas, *J. Geophys. Res.*, doi:10.1002/2017JD027035

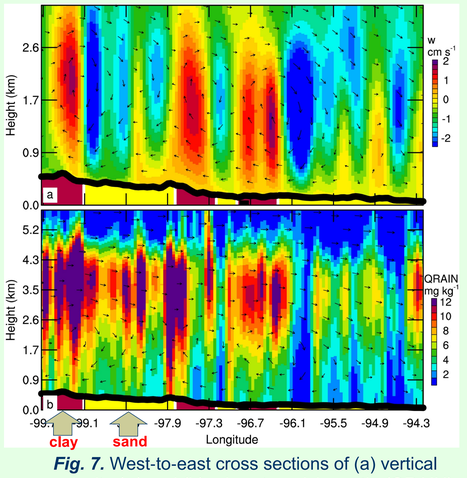


Fig. 7. West-to-east cross sections of (a) vertical velocity (w) and (b) rainwater mixing ratio (QRAIN) through Dallas, Texas, at 1500 CST. The clay-based soil types are shaded in dark red brown; sand-based types are shaded in yellow.