# Application of Satellite Remote Sensing Data for Biogeninc Volatile Organic Chemical Emission Estimates

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## Summary

- Examine the sensitivity of biogenic emission estimates and air quality model predictions to land use/land cover (LULC) data derived from contemporaneous satellite imagery and contrast these results with those obtained with the base case LULC database currently in use by the State of Texas.
- Estimates of biogenic emissions and modeled ozone concentrations were examined using the Global Biosphere Emissions and Interactions System (GloBEIS) version 3.1 and the Comprehensive Air Quality Model with extensions (CAMx) during an August 22-September 6, 2000 episode in the Houston/Galveston area.
- Biogenic emissions estimated from the new LULC dataset showed good general spatial agreement with those from the current LULC dataset but significantly lower emissions (~40% in total hourly emissions).
- Predicted ozone concentrations using the biogenic emissions produced from the new LULC dataset are as much as 25 ppb lower in some areas on some days. The magnitude of the difference showed a high dependence on meteorological conditions.

## Introduction

- Biogenic hydrocarbons, including isoprene, monoterpenes, and oxygenated compounds are emitted in substantial quantities by vegetation and dominate the overall volatile organic compound emission inventory in eastern Texas.
- Spatial distributions of biogenic emissions in Texas are heterogeneous, and biogenic emission processes are affected by the characterization of land cover (vegetation type and biomass density), leaf area index, drought stress, and surface temperatures.
- In a recent collaboration sponsored by the Texas Commission on Environmental Quality (TCEQ), the University of Texas at Austin initiated a study to examine the sensitivity of biogenic emission estimates, dry deposition velocities, and air quality model predictions to LULC characterizations derived from contemporaneous satellite imagery and to contrast these results with those obtained with the LULC databases currently in use by the State of Texas.
- The objectives are to assess the overall sensitivity of model predictions to land cover data and to provide recommendations to the State of Texas regarding the frequency and methodology for future updates.
- The Houston/Galveston area is classified as a moderate nonattainment area with the National Ambient Air Quality Standards (NAAQS) for ozone concentrations averaged over 8-hours.

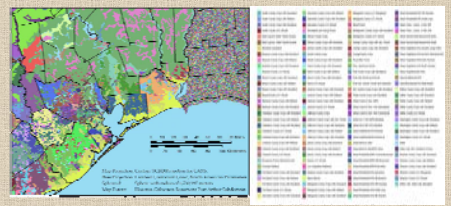
## CAMx/GloBEIS modeling domains

- GloBEIS used to estimate biogenic emissions for the Houston-Galveston-Beaumont-Port Arthur (HGBPA) domain during Aug. 22 – Sept. 6, 2000 episode
- Use interpolated temperature from TCEQ ambient monitoring network and photosynthetically–active solar radiation (PAR) from MM5 for GloBEIS
- CAMx run for episode using each biogenic emission inventory

## Wied-LULC Dataset for HGBPA

- The current database, developed by Wiedinmyer et. al (2001), (WIED-LULC) uses a number of sources, including data from USGS LULC, Texas Parks and Wildlife Department, the USDA Natural Resources Inventory, USDA National Agricultural Statistics Service, and the Texas Agricultural Statistics Service.
- The LULC dataset includes over 600 land cover classes for Texas at a resolution of approximately 1km.
- Field surveys completed to identify species and estimate biomass densities for key land cover types

## Wied-LULC Dataset



Wied-LULC legend for Houston metropolitan area

## CSR-LULC Dataset for HGBPA

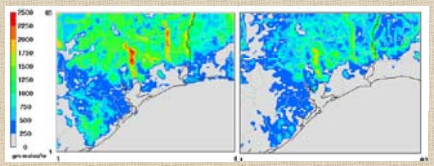
- Source imagery obtained from the USGS, collected between 1999 and 2003 by the Landsat 7 Enhanced Thematic Mapper-Plus sensor supplemented with Landsat 5 Thematic Mapper data as needed. Includes image data for three time periods: n Spring (Jan. – Mar.), Leaf-on (Apr. – Aug.), and Leaf-off (Sep. – Dec.).
- 30 meter nominal ground cell resolution in six spectral channels (visible, near infrared and middle infrared)
- Field data collected by the Texas Forest Service in 2000 and 2001 were used to improve classification, identify species and estimate biomass density. Ecoregion boundaries and field data availability determined the final LCLU class assignment and distribution
- Specie specific leaf mass densities were assigned for each LCLU class. The LCLU classes and the leaf mass density for each vegetation type in that class were input into the GloBEIS lookup table. Areal fractions of each LCLU class present in each grid cell were applied as input into GloBEIS..

## CSR-LULC Dataset for HGBPA

CSR-LULC classes associated with leaf biomass data

## Isoprene emissions

T= 30 C, PAR = 1500 µmol $m^{-2}$ $s^{-1}$ (326 W $m^{-2}$)



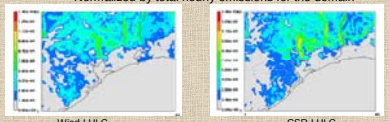
Wied-LULC
Domain total:2.74414E6 gm moles/hr

CSR-LULC
Domain total: 1.65083E6 gm moles/hr

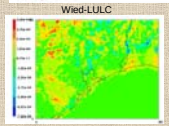
•Hourly isoprene emissions from CSR-LULC are 60% of Wied-LULC emissions
•Comparing the magnitude of biogenic emissions using constant temperature and PAR allows for comparison of biomass densities of the high emitting species, such as *Quercus* (Oak) trees, since emissions from these species dominate the total isoprene emission inventory.

## Normalized Isoprene Emissions

T= 30 C, PAR = 1500 µmol $m^{-2}$ $s^{-1}$ (326 W $m^{-2}$),
Normalized by total hourly emissions for the domain



Wied-LULC CSR-LULC



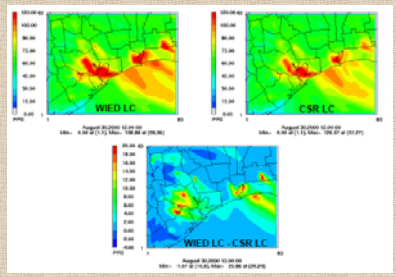
Wied-LULC minus CSR LULC

•Show similar spatial distribution
•CSR-LULC field data is focused on Houston area. The perimeter of the HGBPA region may not fit well within the vegetation types and biomass density assigned to the classification scheme for the entire region
•Considerable uncertainty in vegetation types and biomass densities for Wied-LULC are present due to limited field data and variability of sources, date and scales of data utilized

## Predicted Ozone Concentrations

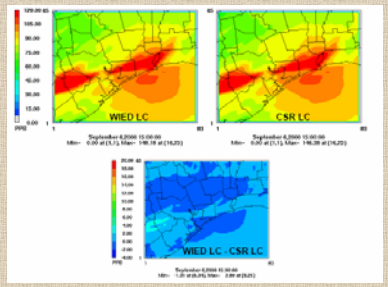
- Analyze the effects of changes in biogenic emissions on ozone concentrations averaged over one-hour on four episode days: August 25, 27, 30, and September 6, 2000. These days have high observed ozone concentrations and distinctive wind patterns.
- Predicted ozone concentrations have the same general spatial distribution, but the magnitude of the predicted ozone was less in the CSR-LULC model results.
- Maximum difference in results occurred in areas with the highest predicted ozone concentrations. Decrease in isoprene results in less ozone generation in areas with elevated NOx concentrations, but the peak ozone concentrations still occur in areas downwind of the urban and industrial NOx sources.
- Large dependence on meteorological conditions.

## Difference in Ozone Concentrations Averaged over 1 hr




8/30/2000: A Flow reversal pattern is observed with winds blowing from the NW and reversing directions in the late afternoon. Under these conditions, chemical production of ozone dominates; advection of ozone into the area from other regions is minimal. Large differences are observed on this day

## Difference in Ozone Concentrations Averaged over 1 hr




9/6/2000. A large air mass from the north east moves through the region, and advection became the dominant factor in ozone concentration. Small differences are observed on this day

## Conclusions

- Isoprene emissions estimated from CSR-LULC dataset are 60% of those estimated from Wied-LULC dataset
- Isoprene emissions have similar spatial distribution
- Predicted ozone concentrations had the same general spatial distribution, but the magnitude of the predicted ozone was less in the CSR-LULC model results.
- The maximum difference in results occurred in areas with the highest predicted ozone concentrations, areas downwind of the urban and industrial NOx sources.
- Large differences are observed on days where chemical production of ozone dominates advection
- Satellite remote sensing data provides adequate data to determine distribution of LULC classes but reliable field data is necessary to link biomass data and species distribution to LULC classes

## References

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2. Texas Forest Service. 2005. Houston's Regional Forest Report: A Report of Structure, Functions, and Values. September 2005. http://files.harc.edu/Sites/HoustonRegionalForest/HoustonRegionalForestReport.pdf
3. Allen, D.T., Feldman, M.S., McDonald-Buller, E., Howard, T., et. al. Satellite Remote Sensing Applications to Improve the Performance of Biogenic Emissions Models for Texas Air Quality Analyses. Submitted to the T CEQ November 2006.

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