Response of Regional Air Quality to Severe Drought

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Drought

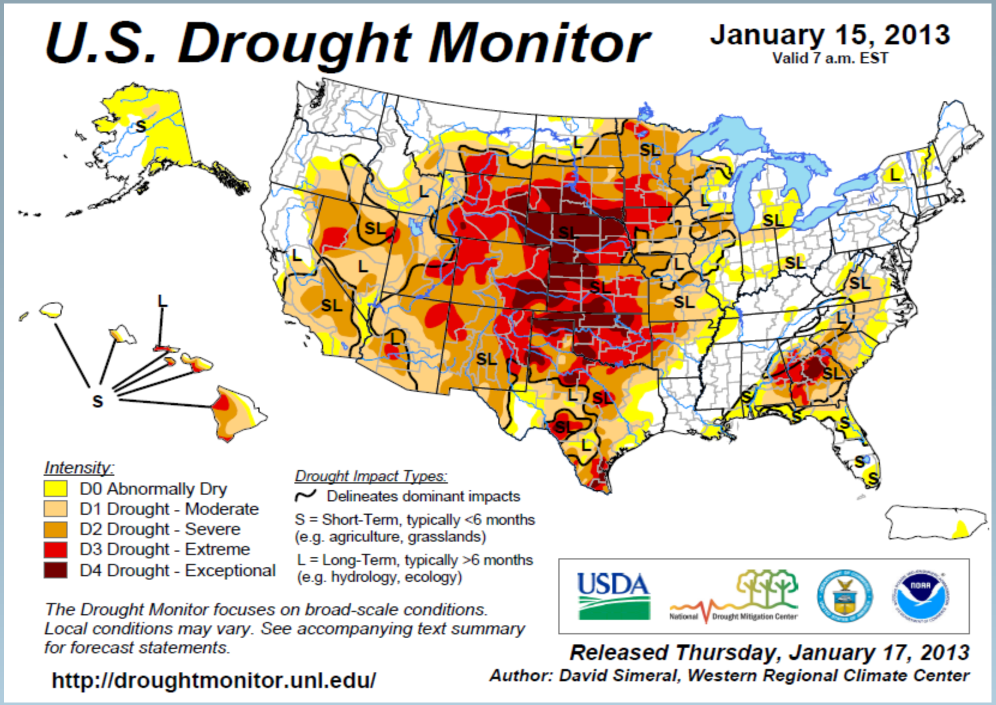
- Broadly recognized as abnormally dry conditions relative to the local normal due to a precipitation deficit over an extended period of time.

- Can occur over most parts of the world and vary substantially in intensity, severity, duration, spatial extent, and frequency.

- Complex and profound social, economic, and environmental effects, e.g., agricultural and livestock losses, wildfire, water supply and quality, food security, economic losses, human migration, disaster relief.

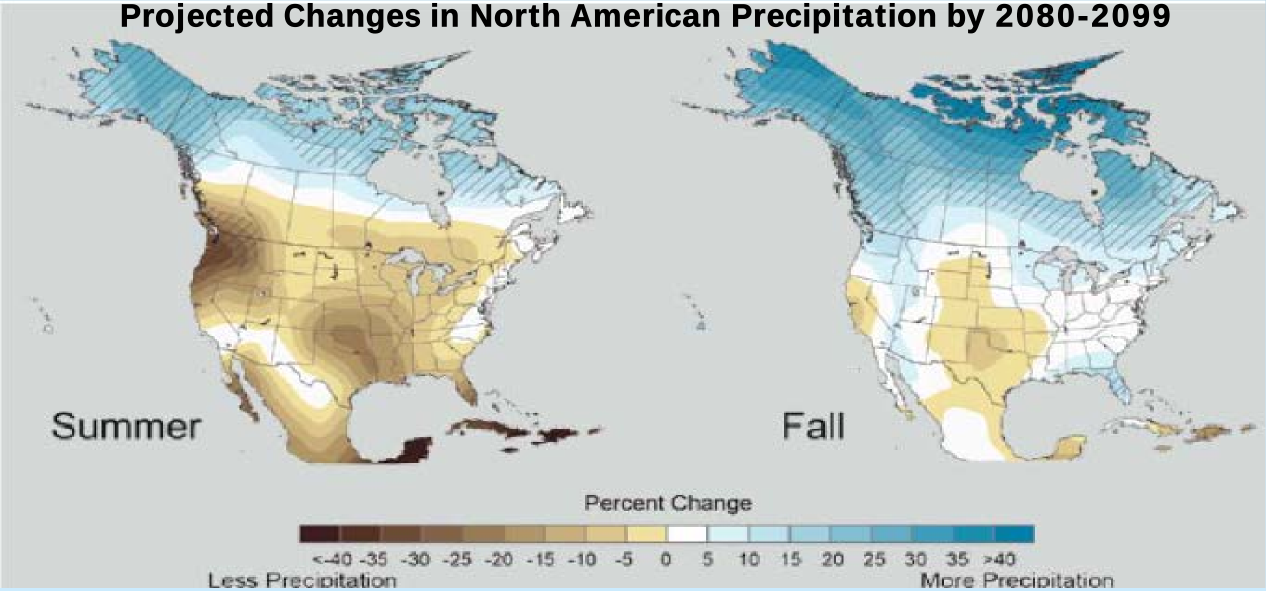
- Effects are highly dependent on the preparedness and coping capabilities of a population.*

*(Wilhite and Knutson 2006).



Source: http://droughtmonitor.unl.edu/

As of mid-January 2013, more than half of U.S. in moderate or worse drought



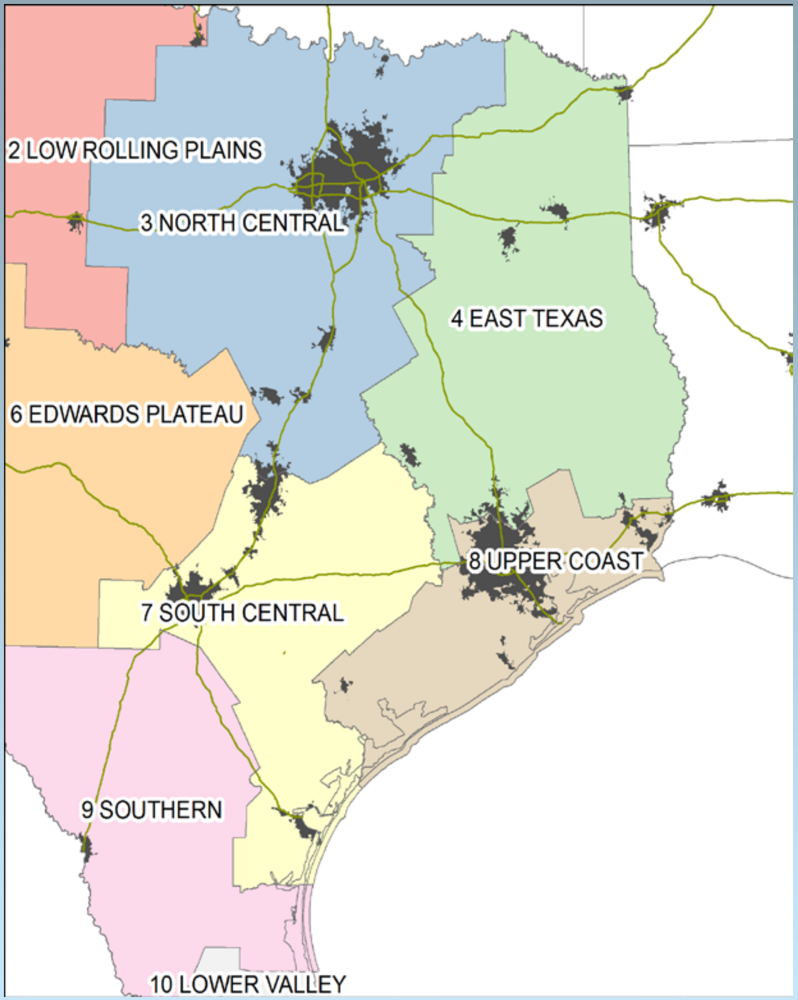
Source: U.S. Global Change Research Report, 2009

Most climate models suggest more severe future droughts

Project Objectives

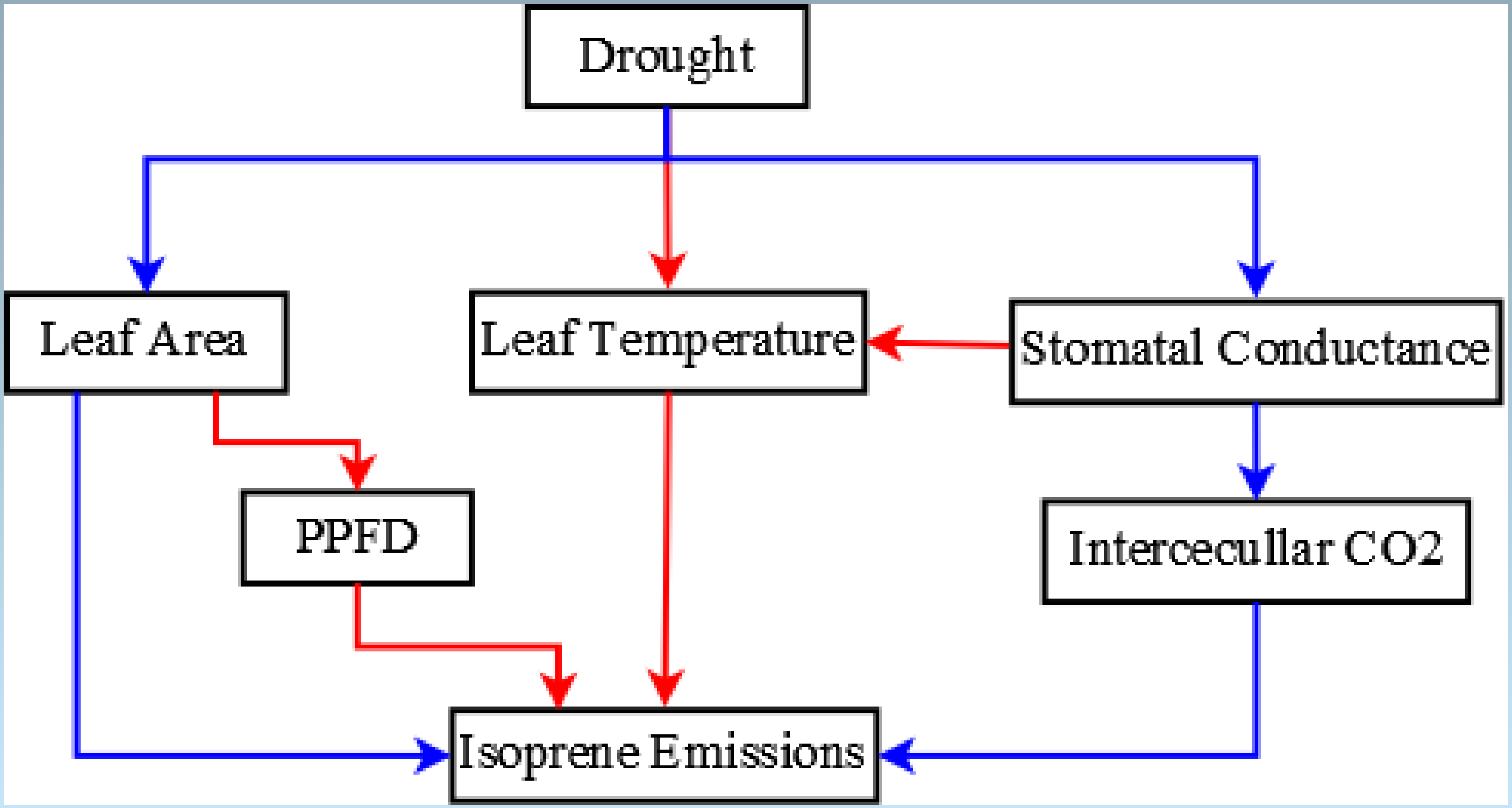
- To model the effects of drought-induced changes in natural systems (biogenic emissions, dry deposition, soil moisture) and agricultural systems and their effects on regional air quality in eastern Texas.

- To understand the direction, magnitude, and synergies between these effects and advance the understanding of how air quality will respond to severe drought.



Climatological Divisions
in Eastern Texas
Source: NOAA, NCDC;
http://www.ncdc.noaa.gov/temp-and-precip/us-climate-divisions.php

Drought Induced Changes in Biogenic Emissions

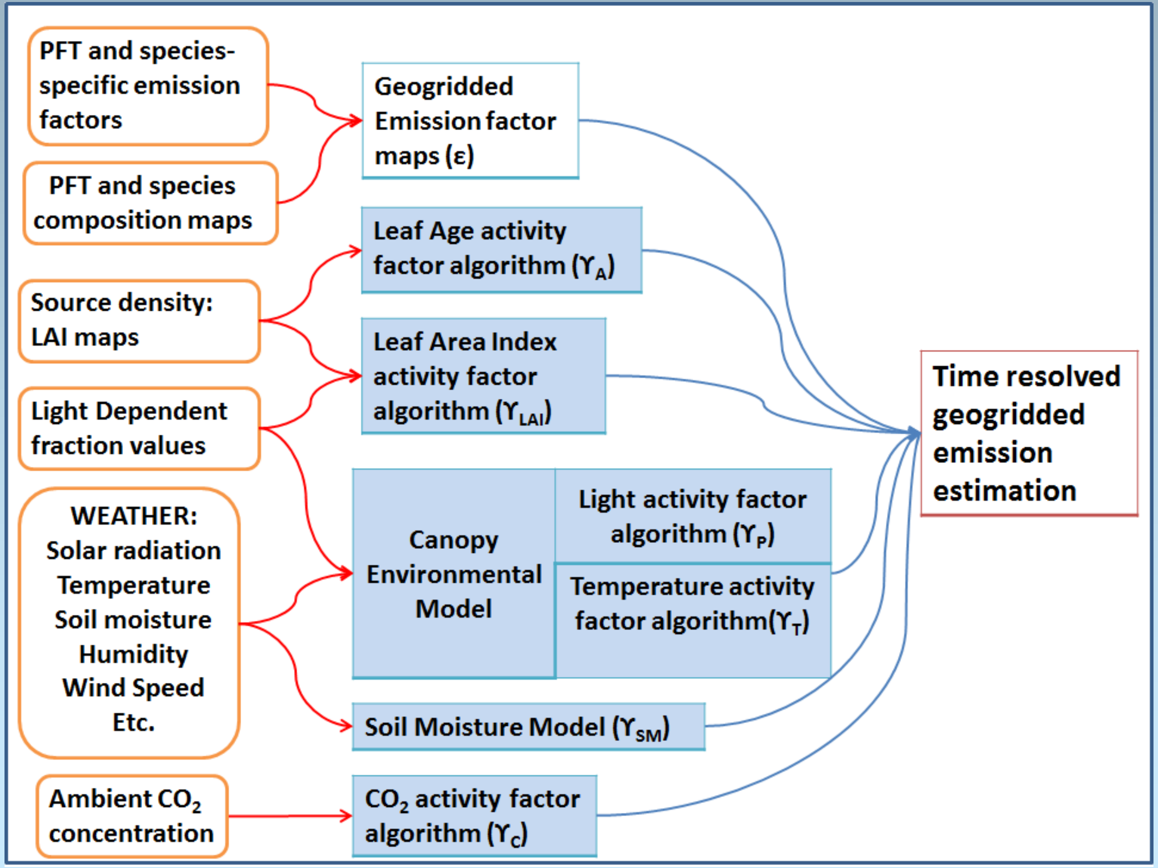


Potential Pathways of Drought Effects on Isoprene Emissions (red: increase; blue: decrease)

Sources: Summarized from Niinemets et al. (2010); Pacifco et al. (2009); Pegoraro et al. (2005); Wilkinson et al. (2009)

Drought Induced Changes in Biogenic Emissions

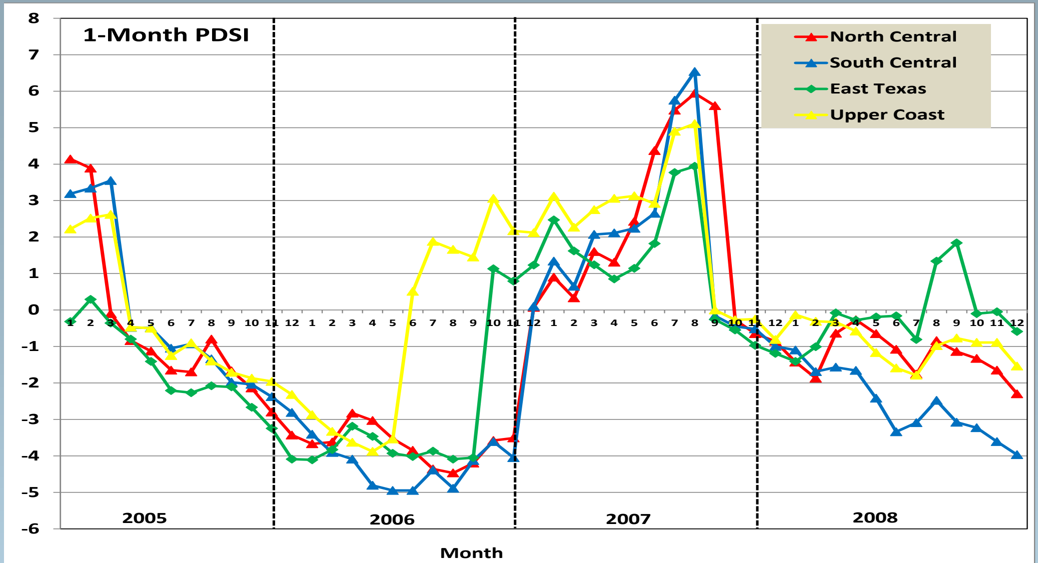
- Model of Emissions of Gases and Aerosols from Nature (MEGAN) used to evaluate the sensitivity of biogenic emissions to changes in leaf area index during 2005-2008 in four climate regions.

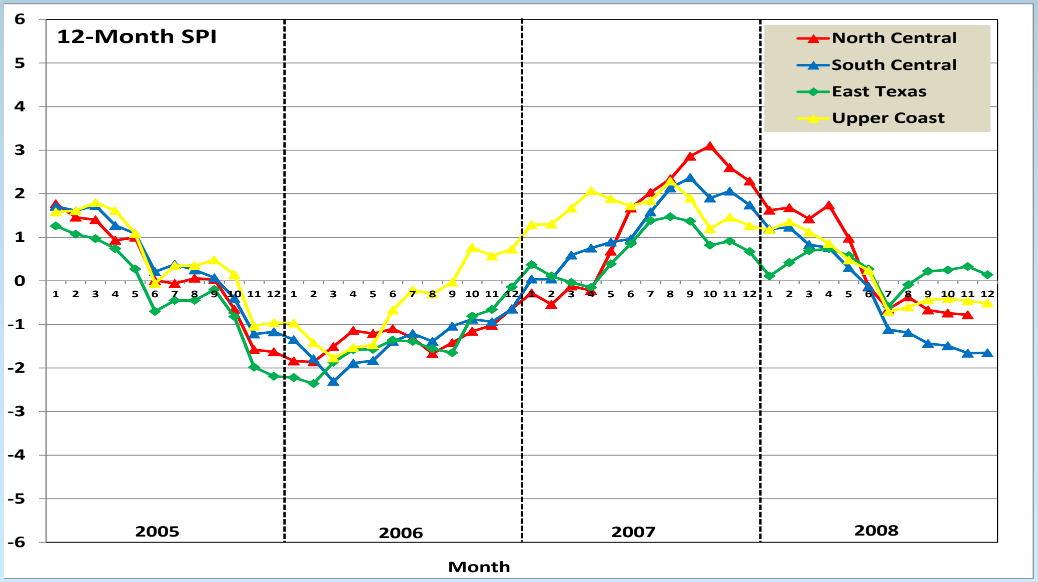


MEGAN2.1 Model Components and Driving Variables

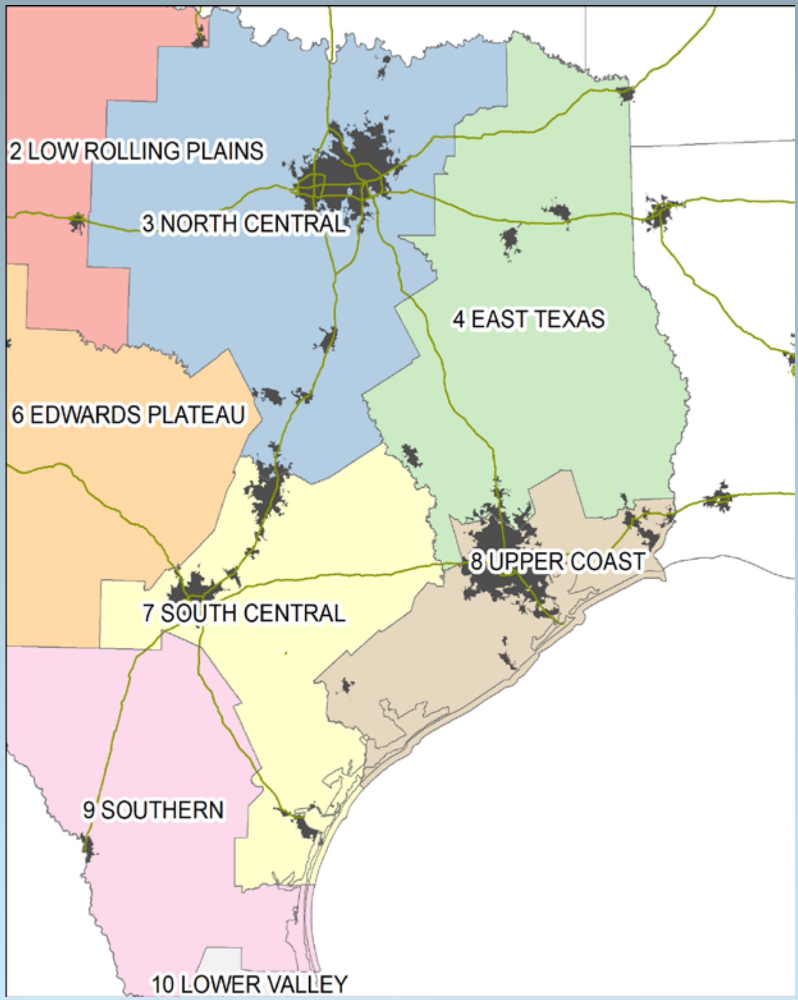
(Source: modified from Figure 1 in Guenther *et al.*, 2012).

Climatology: 2005-2008





1-month PDSI (top) and 12-month SPI (bottom) for four Eastern Texas Climatatological Divisions



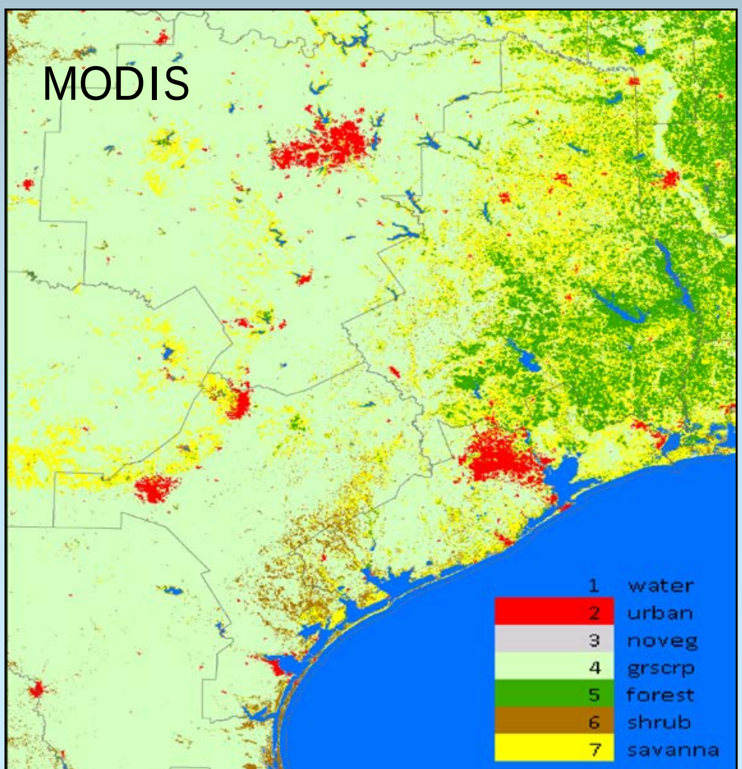
Climatological Divisions in Eastern Texas

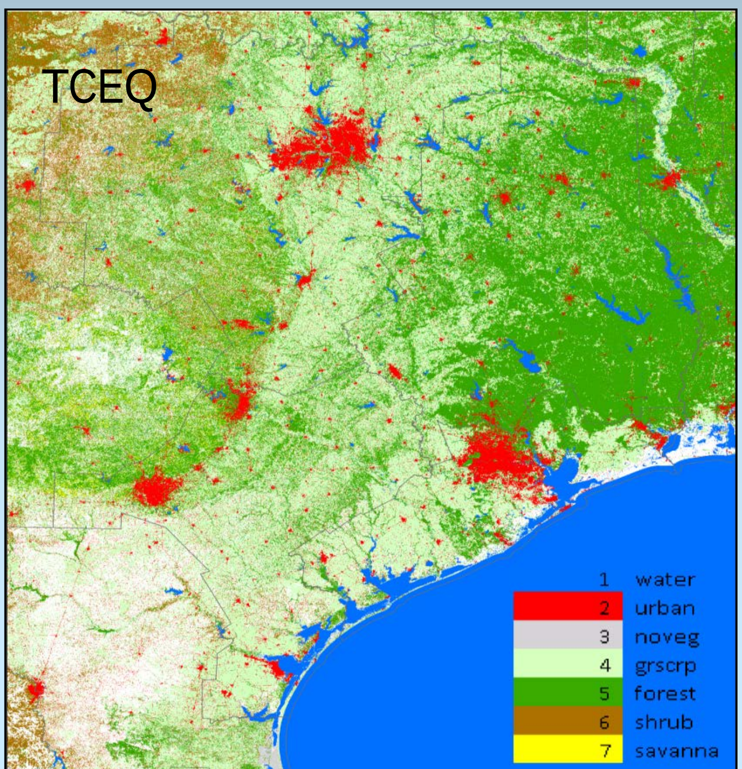
Source: NOAA, NCDC; http://www.ncdc.noaa.gov/temp-and-precip/us-climate-divisions.php

MODIS LAI Product

- Combined Terra and Aqua MODIS 8-day Collection 5, MCD15A2.00; LAI data limited to those denoted as cloud-free.

- MODIS Land Cover Type 3 data (left) compared to regional-scale land cover developed by the State of Texas (right).





Characteristics of MODIS LAI Across Eastern Texas

- All climatological divisions and land cover types had strong seasonal patterns with the lowest LAI in winter and highest during April through September of each year.

- LAI varied substantially between land cover types.
  - e.g., approximate range of spatially-averaged growing season LAI by land cover category for East Texas climatological division:

    2.0 m^2/m^2 for grasses and crops,

    3.0 m^2/m^2 for shrubs,

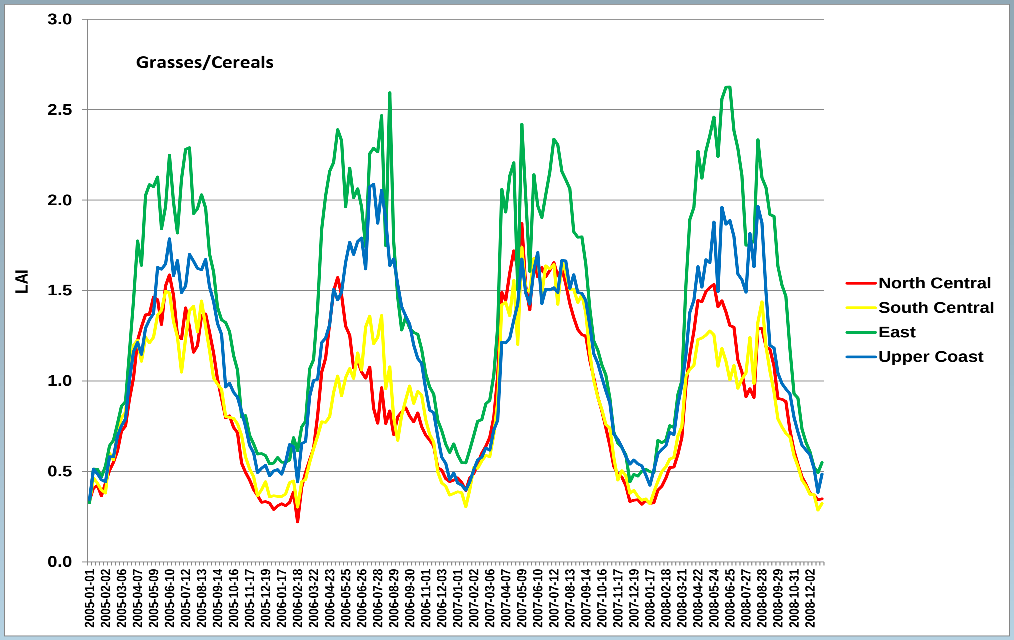
    3.5 m^2/m^2 for savanna

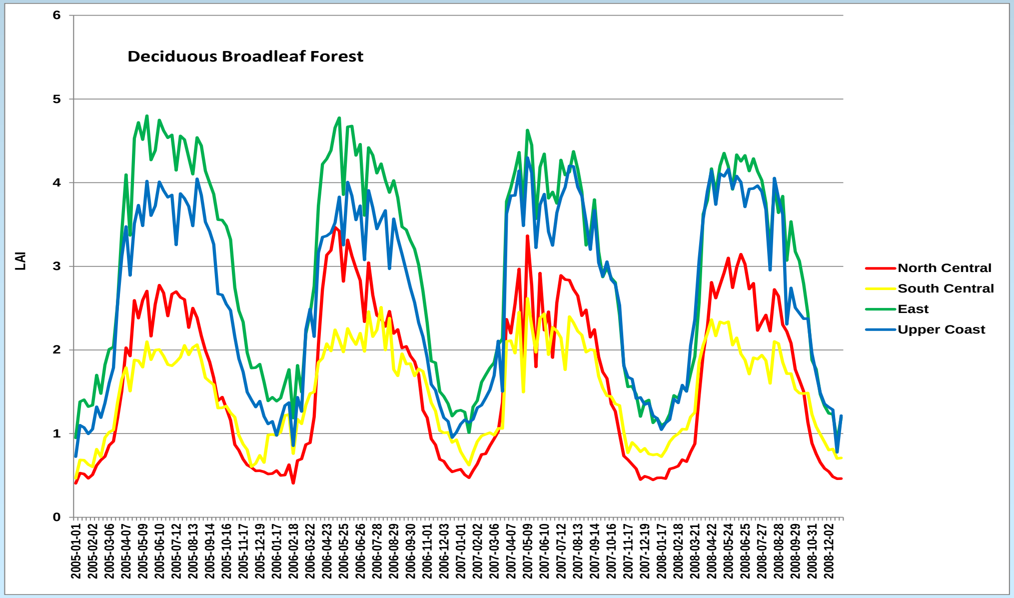
    4.0 m^2/m^2 for evergreen needle-leafed forest and deciduous broad-leafed forest,

    4.5 m^2/m^2 for evergreen broad-leafed forest.

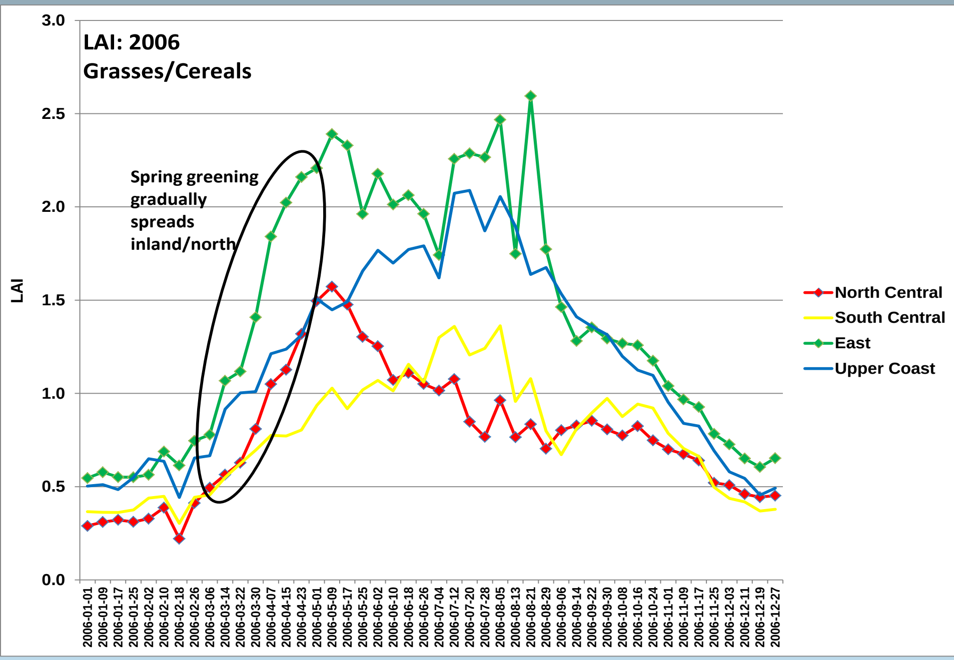
Variations in LAI by Climatological Division

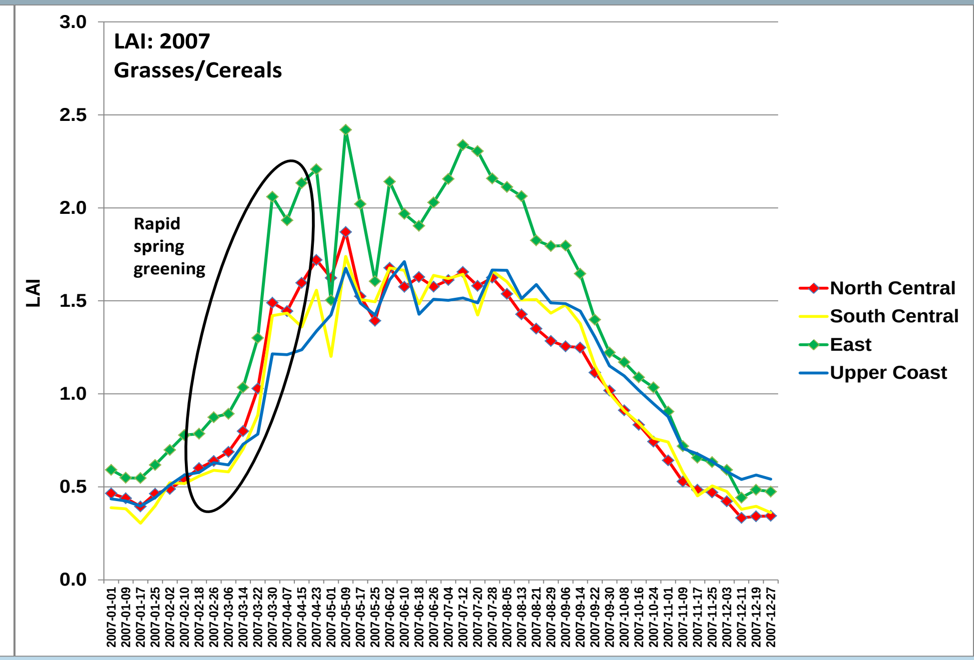
- Mean LAI for given land cover type varied by as much as a factor of two between climate regions.
- LAI values generally highest in East Texas, followed by Upper Coast, and North and South Central Texas, regardless of land cover type.
- Variations in mean LAI were reasonably well correlated between land covers within a climate region.





Response of LAI to Onset and Persistence of Drought



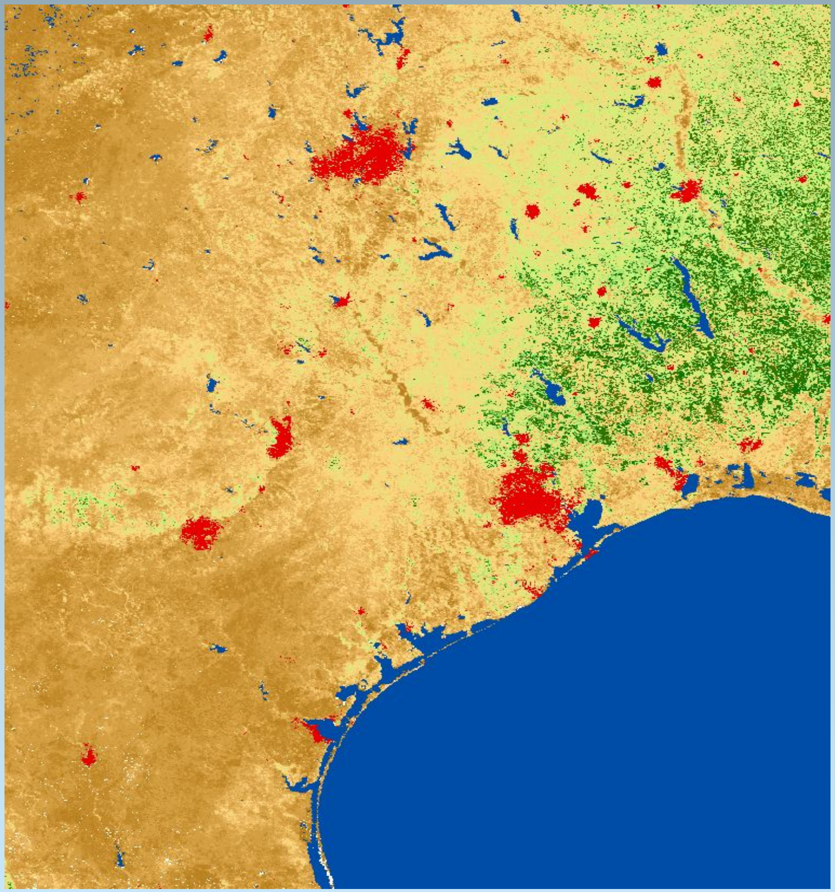


Slower advancement inland and more spatially heterogeneous greening in 2006

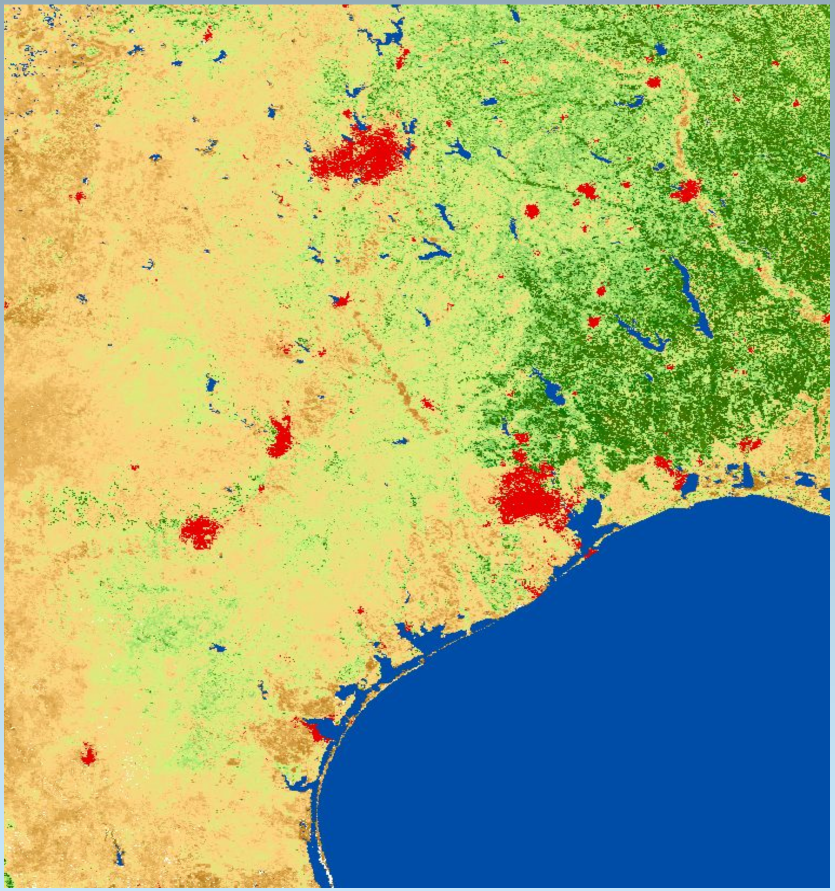
More rapid spring greening across all of eastern Texas during 2007

Response of LAI to Onset and Persistence of Drought

MODIS LAI



03/30/2006



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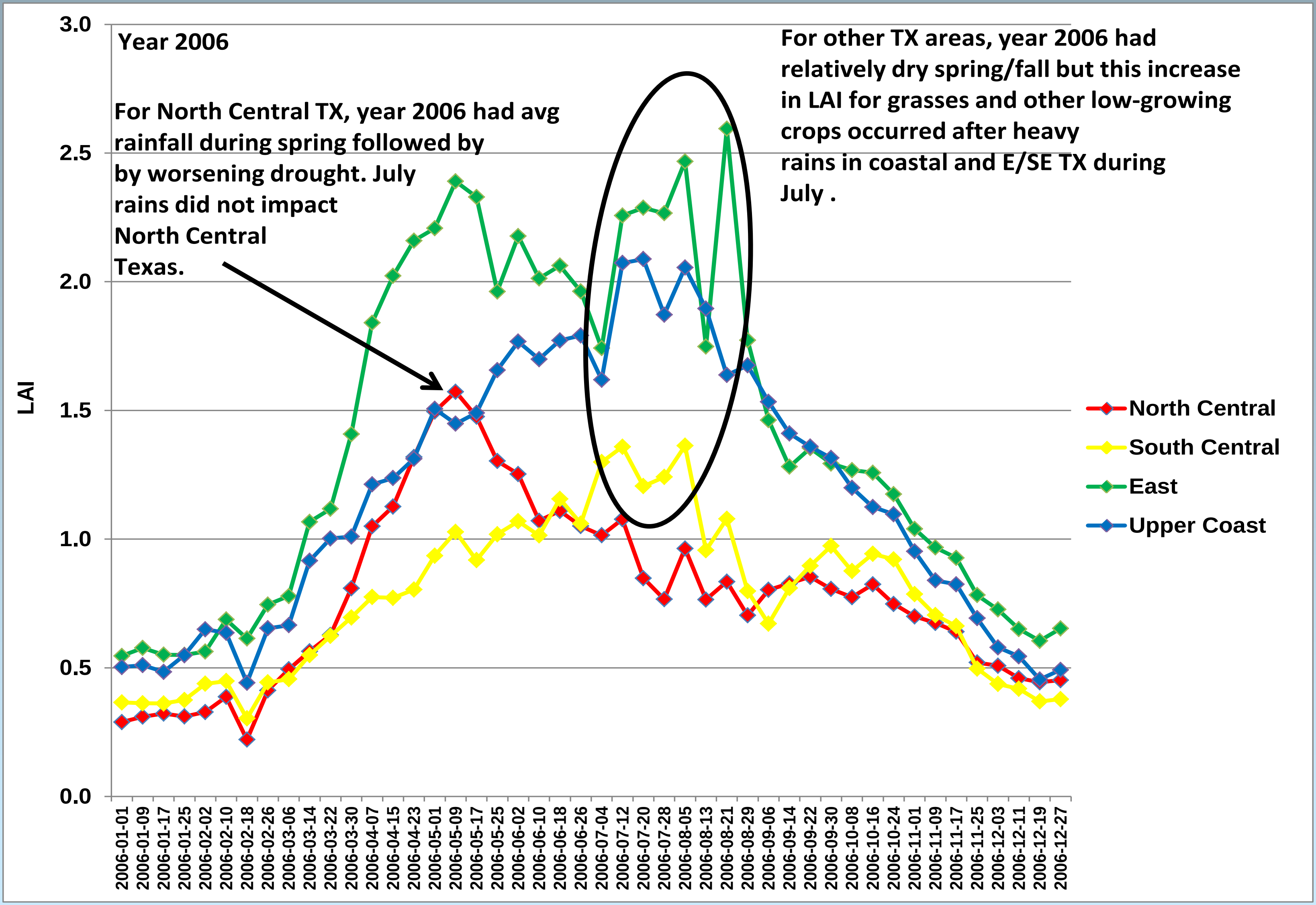
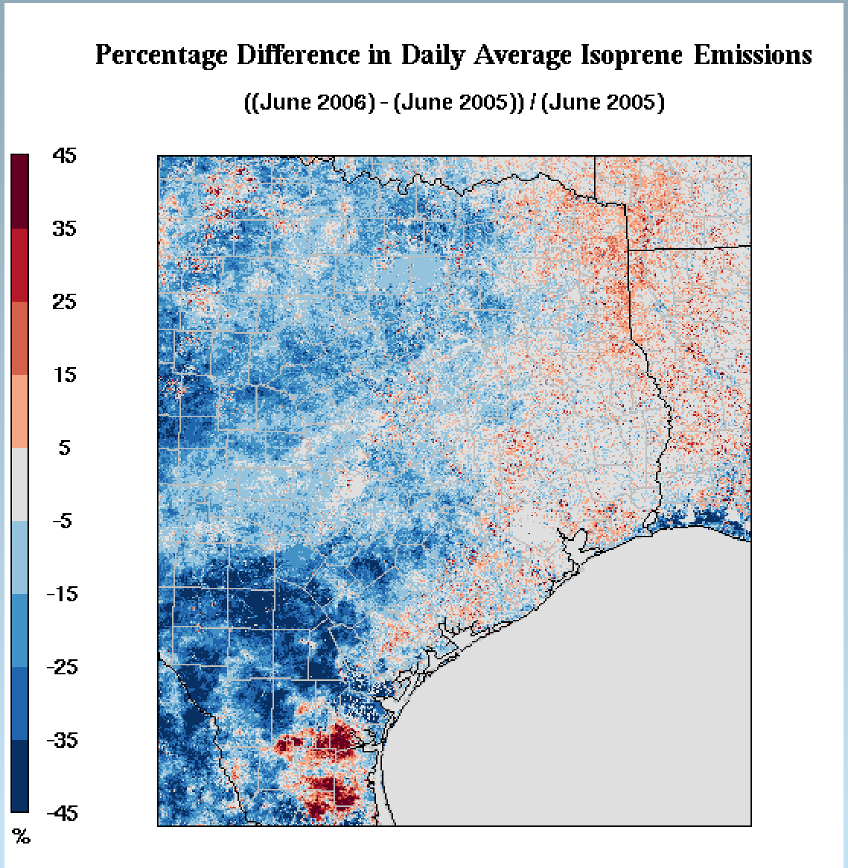
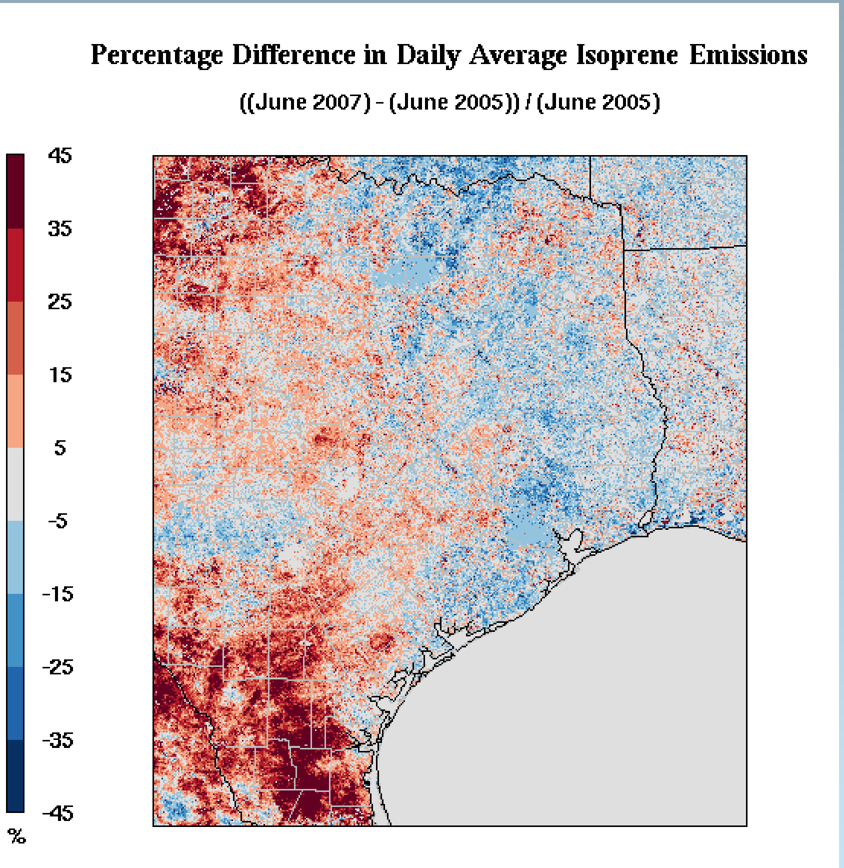
Response of LAI to Onset and Persistence of Drought



Sensitivity of MEGAN Predictions of Isoprene Emissions to Inter-Annual Variability in LAI





- Differences up to 15% in predicted isoprene emissions between 2006/2007 and 2005 base year.
- Spatial heterogeneity in response across eastern Texas.

Next Steps

- Examine MODIS LAI and conduct MEGAN simulations for 2009 - 2012, which includes periods of extreme drought.
- Compare MODIS and SPOT-VEGETATION LAI products.
- Investigate availability of BVOC observations during dry and wet years.
- Investigate effects of soil moisture, temperature, and solar radiation on MEGAN predictions during dry and wet years.
- Conduct CAMx simulations to examine sensitivity of predicted ozone and fine particulate matter concentrations to changes in biogenic VOC emissions during dry and wet years.
- Examine Zhang dry deposition algorithm in CAMx during dry and wet years.

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