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MEMORANDUM

To: Pete Breitenbach, TCEQ
From: Abby Hoats, Shannon Coulter-Burke, Greg Yarwood, Gerry Mansell
Date: August 13, 2003
Subject: Comparison of GloBEIS results for Dallas Fort Worth Biogenic Emissions Modeling

We are preparing biogenic emission inventories for the Dallas Fort Worth (DFW) modeling domain for the August 13-22, 1999 episode. Previous biogenic emissions modeling for the TCEQ has used GloBEIS version 2.2 (Yarwood et al., 2001a). However, the latest version 3.1 of GloBEIS (Yarwood et al., 2002) includes options to model the effects of drought on biogenic emissions. These options are relevant because the DFW area was experiencing drought conditions in August 1999. Drought influences the biogenic emissions estimated by GloBEIS3.1 in two ways (Guenther et al., 2002): (1) the leaf stomata close tending to decrease isoprene emissions, and; (2) leaf temperatures tend to rise which increases isoprene emissions. This memorandum reports a comparison between results from GloBEIS3.1 with drought and leaf temperature effects and GloBEIS2.2. Detailed below is the process for obtaining the necessary inputs for version 3.1 of GloBEIS, as well as the model settings, post-processing steps and comparison results.

Input Data

GloBEIS2.2 biogenic emissions were calculated using data for land-use/land-cover (LULC), temperature and solar radiation (PAR) developed for the TCEQ by Yarwood et al. (2001b). To calculate biogenic emissions with the leaf temperature and drought index options selected, GloBEIS3.1 requires domain definition, LULC, temperature, PAR, drought index, wind speed, and humidity input files. The domain tested was identical for both GloBEIS runs, so input files for domain definition, LULC, and PAR were the same for both and were from Yarwood et al. (2001b).

It was necessary to update the meteorological data in order to run GloBEIS3.1 because humidity and wind speed are needed in addition to ambient temperature in order to model leaf temperature. It is important for the temperature and humidity data to be internally consistent to obtain a reasonable relative humidity. To promote internal consistency, all of the meteorological data for GloBEIS3.1 came from MM5 results.

Meteorological data, including wind speed, humidity, and MM5 temperature were extracted from CAMx meteorological data files by using a CAMx meteorology data extraction program (camxmet2globeis). For each meteorological variable of interest, a job script was modified to

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specify the appropriate input and output files, data type (wind - uv, temperature - tp, humidity - qa), data dimensions, CAMx run, and the vertical layer of interest. A sample job script is shown in Figure 1. All data for current calculations were taken from the CAMx meteorological input files from MM5 run 3, layer 1 (ENVIRON, 2003).

Figure 1. Sample job script to run camxmet2globeis

```
./camxmet2globeis.lnx << eof
Input file Name      |camx.uv.tceq.04km.990813.run3.bin
Output file Name     |junk ! Not used in camxmet2globeis
Globeis file Name    |camx.uv.dfw.04km.990813.run3.layer1.txt
Meteorology Type     |uv      ! (uv, tp, qa)
NX, NY, NZ           |74, 65, 21
Layer of interest    |1
eof
```

The extraction program outputs the year, Julian day, hour, i and j cell coordinates, and the desired meteorological data in GloBEIS-ready ASCII format with required header. The humidity data required an additional processing step. All values were increased by 2.9 g/kg to account for a known underprediction of water vapor content by MM5 in the run 3 results (ENVIRON, 2003). The magnitude of the adjustment was based on the mean bias of the predicted versus observed humidity data.

The drought index input files were generated from Palmer Drought Index (PDI) data obtained from the National Weather Service Climate Prediction Center. Drought severity is reported weekly for each climate division as defined by the Climate Prediction Center. These data were obtained in ASCII format from the FTP site (<ftp://ftp.ncep.noaa.gov/pub/cpc/htdocs/temp2/>) for the time period of interest. Gridded fields of the PDI were developed for the 12-km DFW modeling grid using the Arc/INFO 7.2x GIS software. Regional climate divisions for Texas were obtained from Harlan Shannon, USDA/OCE/WAOB, in the form of geospatial shapefiles. The PDI data associated a particular value for the PDI for each climate division for each scenario considered. Climate division shapefiles were imported into Arc/INFO as polygon coverages. The PDI data specific to each climate region were then imported as attribute tables and joined with the spatial coverages. The 12-km modeling domain was generated as a polygon coverage and overlaid with the climate division coverages. Based on the coordinates of the centroid of each modeling grid cell, the corresponding climate division within which each grid cell resides was identified. Finally, the 12-km modeling grid cell indices (i,j) and the appropriate value of the PDI was exported as an ASCII text file for input to GloBEIS. Data for the Dallas 4-km modeling domain were windowed out from the 12-km East Texas domain. PDI values for the three different weeks spanned by the modeling period are illustrated in Figures 2, 3 and 4. Drought conditions are mild to moderate (severe drought would have a PDI of less than -4), with increasing severity over the modeling period.

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Figure 2. Dallas 4-km domain shaded by Palmer Drought Index for August 13-14, 1999

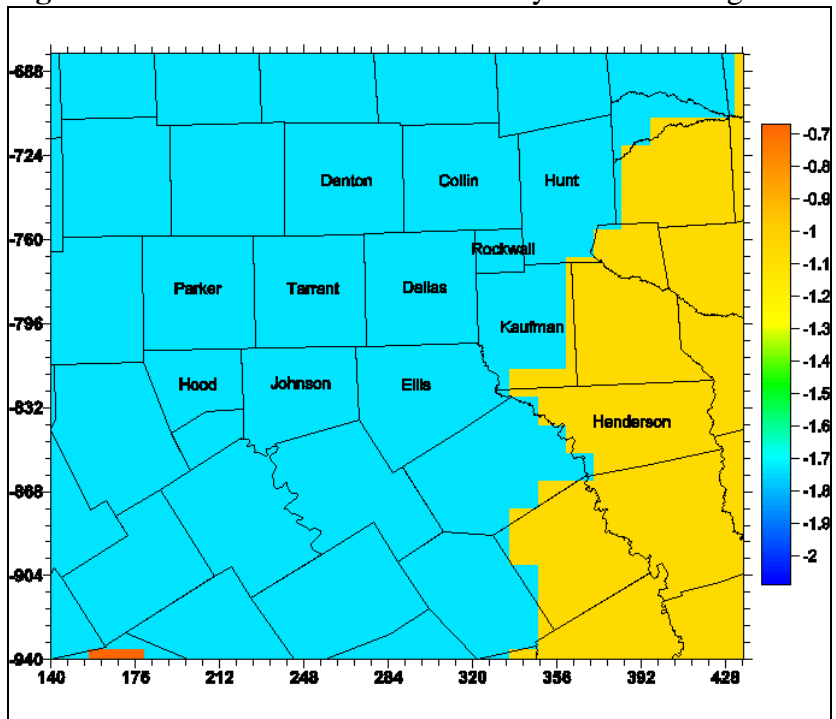
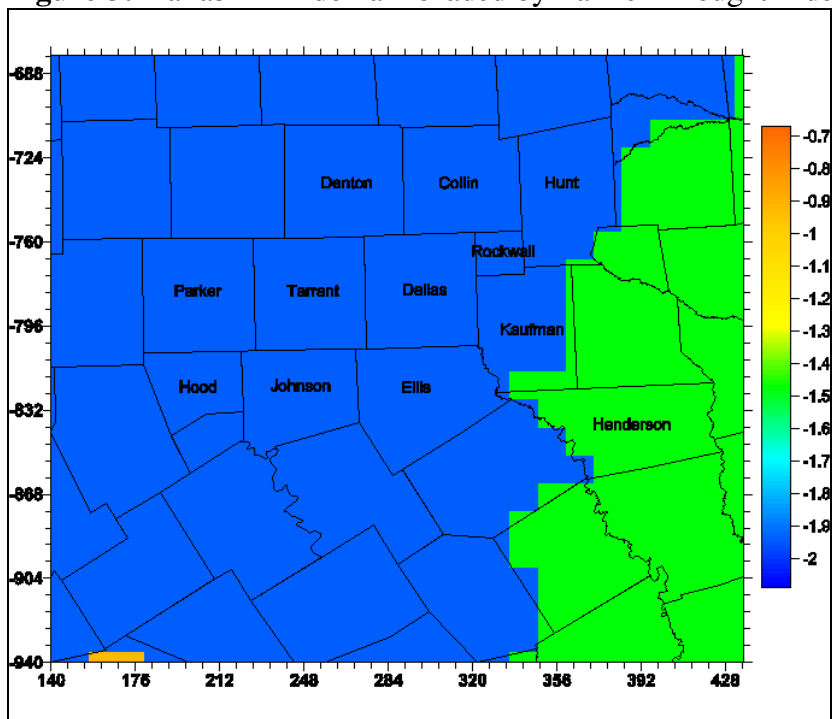


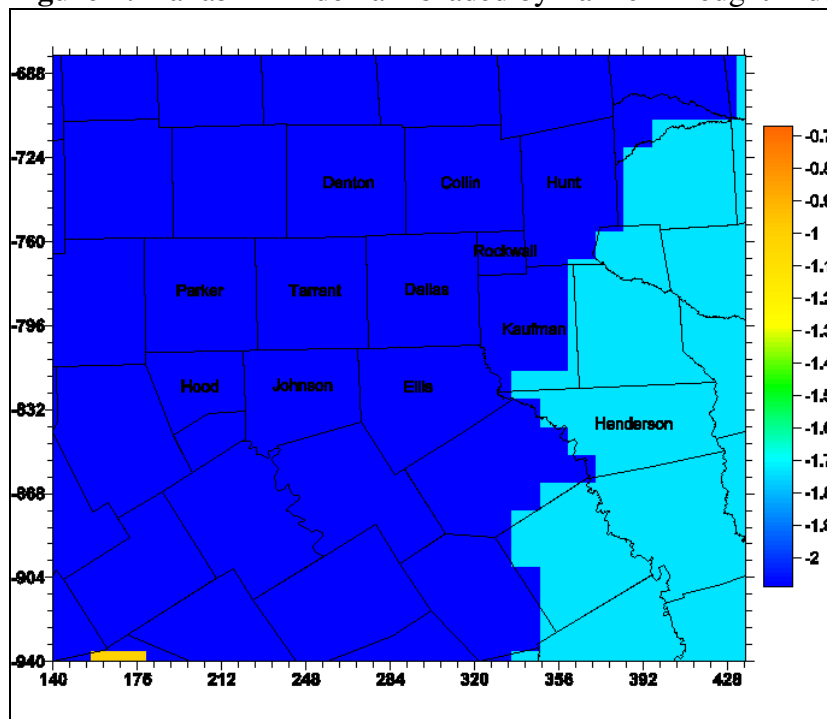
Figure 3. Dallas 4-km domain shaded by Palmer Drought Index for August 15-21, 1999



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Figure 4. Dallas 4-km domain shaded by Palmer Drought Index for August 22, 1999



GloBEIS3.1 and Options

Updated biogenic emissions were prepared using version 3.1 of the GloBEIS model for comparison to the output from version 2.2. Since the previous release of GloBEIS, version 3.1 has incorporated the following improvements:

- Option to run with variable Leaf Area Index values input
- Option to run with variable leaf age input
- Option to run with drought effects from drought index input
- Option to run with leaf temperature effects calculated from humidity and wind speed inputs
- Option to run with antecedent temperature influence
- Added options to speciate VOC emissions as CB4, SAPRC99 or native speciation, rather than just CB4.
- Updated underlying speciation scheme for other VOC (OVC) emissions.
- Simplified option to adjust isoprene emissions by an arbitrary factor via the “model parameters screen,” which replaced two GloBEIS3 parameters (Database Max Iso EF and Revised Max Iso EF) by a single parameter (Adjust Isoprene Emissions) that has a default setting of 1.0.
- Strengthened internal data consistency checks in the QA module.

Figure 5 shows a screen shot with the GloBEIS3.1 model parameters selected. In addition to the inclusion of drought and leaf temperature effects on biogenic emissions, different temperature data were used in current calculations. Previous GloBEIS2.2 biogenic emissions modeling for

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Dallas Fort Worth utilized hourly temperature data from interpolated National Weather Service observations; GloBEIS3.1 biogenic emissions modeling uses MM5 temperature data as described above.

Figure 5. GloBEIS3.1 Model Parameters for biogenic emissions modeling

The screenshot shows the 'Model Parameters' dialog box for GloBEIS3.1. The 'Model Parameters' tab is selected. The 'Output Emissions Speciation' section has 'CB4' selected. The '# of Canopy Layers' is 5, 'Time Zone' is 6, and 'Isoprene EF Adjustment' is 1. In the 'Model Selection' section, 'GloBEIS3' is checked. Under the 'GloBEIS3' options, 'Drought Index' and 'Leaf temperature' are checked. In the 'Antecedent Temperature' section, '24, 48, and 360' is checked. 'Input PAR' is checked, and 'Input Cloud Cover' is unchecked. The 'Select hours to run' section shows 'Start Hour' 0, 'End Hour' 23, 'Start Day' 229, 'End Day' 229, and 'Model Year' 1999. A 'Reset to Defaults' button is present. The dialog is overlaid on a purple background with a sidebar on the left showing '1 hr', '2 hr', '3 hr', and '4 hr' options.

Post-Processing

To summarize the grid cell-based biogenic emissions from GloBEIS for twelve counties of interest in the 4-km domain, a post-processor (emscorn) was used. Sample emscorn output for the August 13, 1999 Collin county GloBEIS3.1 results can be seen in Figure 6. The first number appearing in each row is the domain-wide total, while the second is the total for the specified area. The CB4-speciated output from emscorn for each county and state was converted to tons per day of CO, NO_x and VOC according to equations in Figure 7. These equations are simply a way of back-calculating the tons of VOC, NO_x and CO emissions knowing the factors used by GloBEIS to convert tons of emissions to moles of CB4 species.

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Figure 6. Sample emscorn output for the August 13, 1999 Collin county GloBEIS3.1 results

```

Total emissions of NO   is 3.1268575E+06 2.2682902E+05 moles/day
Total emissions of NH3  is 0.0000000E+00 0.0000000E+00 moles/day
Total emissions of CO   is 1.1485046E+07 6.1888973E+04 moles/day
Total emissions of ISOP is 4.6764705E+07 2.3709855E+05 moles/day
Total emissions of OLE  is 3.0730490E+06 2.5218438E+04 moles/day
Total emissions of PAR  is 1.9442870E+07 1.6701020E+05 moles/day
Total emissions of XYL  is 7.3503648E+04 7.8100104E+02 moles/day
Total emissions of FORM is 7.6582300E+05 4.1267573E+03 moles/day
Total emissions of ALD2 is 2.6602760E+06 2.1583184E+04 moles/day
Total emissions of ETH  is 9.5693431E+05 5.1565894E+03 moles/day
Total emissions of MEOH is 1.9141904E+07 1.0314913E+05 moles/day
Total emissions of ETOH is 1.1485044E+06 6.1888975E+03 moles/day
Total emissions of NR   is 1.2850596E+06 7.2886016E+03 moles/day

```

Figure 7. Factors for calculating CO, NOx and VOC emissions from CB4 species**For GloBEIS2.2:**

```

CO (tpd) = 28 * CO (mol/d) / 907184
NOx (tpd) = 46 * NO (mol/d) / 907184
VOC (tpd) = 68.12 * ISOP (mol/d) / 907184
           + [1.132/0.329*XYL(mol/d) + 1.149/45*MEOH(mol/d)] / 907.184

```

For GloBEIS3.1:

```

CO (tpd) = 28 * CO (mol/d) / 907184
NOx (tpd) = 46 * NO (mol/d) / 907184
VOC (tpd) = 68.12 * ISOP (mol/d) / 907184
           + [1.134/0.329*XYL(mol/d) + 1.774/41.667*MEOH(mol/d)] / 907.184

```

Results

Tables 1, 2, 3 and 4 show the percent change in biogenic emissions of NOx, CO, Isoprene and VOC by county in the 4-km domain for calculations done with GloBEIS3.1 relative to those done with GloBEIS2.2. Overall, emissions of all three pollutants calculated by GloBEIS3.1 were less than those from GloBEIS2.2. All twelve counties experienced similar effects. Averaged over all days of the modeling period and all counties, NOx emissions decreased by about 4%. CO, Isoprene and VOC emissions decreased by about 12%, 10% and 4%, respectively, when averaged over all days and counties.

Inspection of the NOx data alone reveals the effect of using MM5 temperatures instead of interpolated hourly National Weather Service observations, because the GloBEIS NOx emissions are simply a function of the ambient temperature and LULC data. The CO respond to the drought conditions as well as the switch to MM5 temperatures because GloBEIS estimates CO as a fraction of other VOC emissions. For CO, drought conditions decreased emissions more than the temperature changes would have alone. The isoprene emissions also respond to the temperature change and drought, but the drought effects are more complex for isoprene than for other VOC and CO. Guenther, et al. (2002) reported that mild drought (PDI = -0.5 to -2) can slightly increase isoprene emissions, while moderate drought (PDI = -2.5 to -4) tends to decrease emissions. Given the varying mild to moderate drought conditions that existed during the modeling period, the isoprene emissions have a different pattern of changes by day and by county than the CO and NOx data. The changes in total VOC emissions trends are the most complex because they combine the effects for isoprene, other VOCs and monoterpenes. The

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decrease in total VOC is smaller than for isoprene or other VOC (as shown by CO) because the monoterpene emissions are not changed by drought.

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Table 1. Changes in emissions of NOx for twelve counties in the Dallas 4km domain for GloBEIS 3.1 compared to GloBEIS 2.2

County	FIPS	13-Aug	14-Aug	15-Aug	16-Aug	17-Aug	18-Aug	19-Aug	20-Aug	21-Aug	22-Aug	Period Avg.
Collin	48085	-5%	-6%	-7%	-4%	0%	-1%	0%	-5%	-2%	-7%	-4%
Dallas	48113	-8%	-8%	-6%	-3%	0%	-1%	3%	-2%	-1%	-6%	-3%
Denton	48121	-5%	-6%	-6%	-3%	1%	0%	4%	-3%	-2%	-5%	-2%
Ellis	48139	-8%	-8%	-6%	-3%	-1%	-1%	2%	-2%	-4%	-5%	-4%
Henderson	48213	-8%	-6%	-4%	0%	1%	0%	2%	-4%	0%	-3%	-2%
Hood	48221	-7%	-10%	-8%	-6%	-3%	-3%	5%	2%	-2%	-4%	-4%
Hunt	48231	-6%	-6%	-8%	-4%	0%	-2%	1%	-5%	-2%	-6%	-4%
Johnson	48251	-8%	-10%	-7%	-5%	-3%	-3%	3%	0%	-3%	-6%	-4%
Kaufman	48257	-11%	-9%	-8%	-4%	-1%	-2%	1%	-5%	-2%	-6%	-5%
Parker	48367	-6%	-9%	-9%	-7%	-3%	-3%	5%	0%	-2%	-7%	-4%
Rockwall	48397	-8%	-9%	-8%	-5%	-1%	-3%	1%	-4%	-3%	-7%	-5%
Tarrant	48439	-6%	-7%	-6%	-3%	0%	-1%	6%	0%	-1%	-4%	-2%

Table 2. Changes in emissions of CO for twelve counties in the Dallas 4km domain for GloBEIS 3.1 compared to GloBEIS 2.2

County	FIPS	13-Aug	14-Aug	15-Aug	16-Aug	17-Aug	18-Aug	19-Aug	20-Aug	21-Aug	22-Aug	Period Avg.
Collin	48085	-13%	-13%	-14%	-11%	-7%	-10%	-8%	-13%	-9%	-17%	-11%
Dallas	48113	-14%	-15%	-12%	-10%	-7%	-8%	-4%	-9%	-8%	-16%	-10%
Denton	48121	-12%	-13%	-13%	-10%	-6%	-8%	-3%	-9%	-8%	-13%	-10%
Ellis	48139	-16%	-17%	-12%	-9%	-8%	-8%	-5%	-11%	-10%	-14%	-11%
Henderson	48213	-14%	-14%	-10%	-5%	-7%	-9%	-8%	-14%	-7%	-11%	-10%
Hood	48221	-15%	-19%	-17%	-15%	-11%	-11%	-2%	-6%	-11%	-14%	-12%
Hunt	48231	-14%	-14%	-15%	-10%	-8%	-10%	-7%	-13%	-7%	-17%	-12%
Johnson	48251	-15%	-19%	-17%	-14%	-11%	-12%	-5%	-9%	-13%	-16%	-13%
Kaufman	48257	-19%	-18%	-15%	-11%	-8%	-10%	-7%	-13%	-8%	-15%	-12%
Parker	48367	-17%	-20%	-19%	-17%	-12%	-12%	-2%	-8%	-11%	-18%	-13%
Rockwall	48397	-16%	-17%	-15%	-13%	-9%	-11%	-8%	-13%	-9%	-17%	-13%
Tarrant	48439	-13%	-16%	-13%	-11%	-7%	-9%	0%	-7%	-7%	-14%	-10%

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Table 3. Changes in emissions of isoprene for twelve counties in the Dallas 4km domain for GloBEIS 3.1 compared to GloBEIS 2.2

County	FIPS	13-Aug	14-Aug	15-Aug	16-Aug	17-Aug	18-Aug	19-Aug	20-Aug	21-Aug	22-Aug	Period Avg.
Collin	48085	-1%	-9%	-9%	-9%	-10%	-12%	-10%	-11%	-5%	-15%	-9%
Dallas	48113	1%	-13%	-3%	-7%	-6%	-7%	-6%	-7%	-5%	-11%	-6%
Denton	48121	-1%	-11%	-9%	-10%	-9%	-12%	-9%	-10%	-7%	-13%	-9%
Ellis	48139	-1%	-17%	-5%	-8%	-7%	-5%	-6%	-9%	-10%	-10%	-8%
Henderson	48213	-5%	-20%	-8%	-13%	-12%	-11%	-10%	-12%	-10%	-10%	-11%
Hood	48221	-1%	-19%	-11%	-11%	-9%	-11%	-9%	-7%	-11%	-16%	-11%
Hunt	48231	-6%	-12%	-10%	-11%	-11%	-11%	-9%	-12%	-4%	-13%	-10%
Johnson	48251	1%	-20%	-9%	-10%	-7%	-9%	-8%	-9%	-12%	-14%	-10%
Kaufman	48257	-8%	-18%	-8%	-12%	-11%	-9%	-9%	-12%	-7%	-11%	-11%
Parker	48367	-4%	-15%	-14%	-12%	-11%	-13%	-10%	-10%	-10%	-17%	-12%
Rockwall	48397	-7%	-17%	-11%	-14%	-13%	-12%	-12%	-12%	-7%	-15%	-12%
Tarrant	48439	3%	-14%	-7%	-8%	-6%	-10%	-7%	-8%	-6%	-12%	-7%

Table 4. Changes in emissions of VOC for twelve counties in the Dallas 4km domain for GloBEIS 3.1 compared to GloBEIS 2.2

County	FIPS	13-Aug	14-Aug	15-Aug	16-Aug	17-Aug	18-Aug	19-Aug	20-Aug	21-Aug	22-Aug	Period Avg.
Collin	48085	3%	-4%	-4%	-4%	-3%	-5%	-3%	-6%	0%	-10%	-4%
Dallas	48113	5%	-7%	1%	-2%	0%	-1%	1%	-2%	1%	-6%	-1%
Denton	48121	2%	-7%	-6%	-6%	-5%	-8%	-4%	-6%	-3%	-9%	-5%
Ellis	48139	2%	-11%	0%	-3%	-1%	1%	0%	-3%	-4%	-5%	-2%
Henderson	48213	-2%	-14%	-3%	-7%	-6%	-5%	-5%	-7%	-4%	-5%	-6%
Hood	48221	8%	-7%	-1%	0%	3%	2%	8%	7%	2%	-2%	2%
Hunt	48231	-2%	-7%	-6%	-6%	-6%	-6%	-4%	-7%	1%	-9%	-5%
Johnson	48251	4%	-15%	-5%	-6%	-3%	-5%	-3%	-4%	-8%	-9%	-5%
Kaufman	48257	-5%	-14%	-5%	-8%	-6%	-5%	-5%	-8%	-3%	-7%	-7%
Parker	48367	1%	-10%	-8%	-6%	-5%	-6%	-2%	-3%	-4%	-11%	-5%
Rockwall	48397	-3%	-11%	-6%	-7%	-6%	-5%	-4%	-6%	-1%	-9%	-6%
Tarrant	48439	6%	-9%	-3%	-4%	-1%	-4%	0%	-3%	-1%	-7%	-3%

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