Recent Reduction of Subsidence Rates in the Mississippi River Delta Plain

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Abstract

The Mississippi River delta plain has long been characterized as an area with high rates of relative subsidence. This concept was reinvigorated by integrating National Ocean Service tide-gauge records with National Geodetic Survey benchmarking data and GPS elevations at Continuously Operating Reference Stations (CORS). A new classification scheme identifies that rates of relative sea-level rise (RSLR) are greatest from 1971 to 1984 in the north-central delta plain, from 1966 to 1993 in the south-central delta plain, and from 1947 to 1951 in the western delta plain. The most recent subsidence rates are similar to those measured over geologic time scales (e.g., radiocarbon-dated peats) that are attributed to natural sediment compaction and coastal loading.

Subsidence Measurements

Tide-Gauge Records

Rates of RSLR can be used as a proxy for vertical land motion if the records are long enough that trends can be established. The National Ocean Service tide-gauge rate data (1945 to 2007) for the Mississippi River delta plain shows that the highest historic subsidence rates generally occur over nearby oil-and-gas fields and inferred faults. A lack of reported data since 1993 prevents using this method to determine more recent trends and processes.

Regional Benchmark Survey

Survey data from the Mississippi River benchmarking surveys were used to calculate decadal-scale elevation changes. Although the rates of RSLR increased from about -6.3 mm/yr between 1938 and 1951 to about -10 mm/yr between 1965 and 1993, they then decreased to about 3.4 mm/yr since 1991. The potential effects of interannual and decadal variations in RSLR need further study. Benchmark surveys in Pensacola, Florida, which is the highest tide gauge, is subject to a relatively stable geologic setting. Here, the observed trend is a relatively uniform acceleration of RSLR of about 0.2 mm/yr since 1984. There are no known causes for this trend.

Environmental Change

The Mississippi River Delta Plain is a highly productive and dynamic area, with subsidence rates that are comparable to rates averaged over geological time scales and that are comparable to rates from other coastal plains. However, these processes operate on geologic time scales, making it difficult to explain the observed subsidence rates. The most recent subsidence rates are comparable to rates from other coastal plains.

Subsidence Mechanisms

Compaction of Holocene Sediments

Compaction, or reduction in volume, occurs during interburial and compactional processes. The subsidence rates that were likely induced by deep subsurface hydrocarbon production. The most recent subsidence rates are comparable to rates averaged over geologic time scales and the recent reductions in subsidence rates likely reflect balancing of subsurface stress and a return to near-equilibrium condition. A better understanding of the most recent trends and process causing subsidence needs to be developed to understand small construction efforts and to model expected impacts of increased RSLR in a time of global climate change.

Conclusions and Implications

Integration of rates of RSLR from tide-gauge records, elevation changes from repeating leveling surveys, and subsidence rates from continuous GPS measurements reveal a decadal pattern of shore-normal subsidence that is attributed to formation of a near-equilibrium condition. The observed trend is a relatively uniform acceleration of RSLR at Pensacola, Florida, which is the highest tide gauge, is subject to a relatively stable geologic setting. Here, the observed trend is a relatively uniform acceleration of RSLR of about 0.2 mm/yr since 1984. There are no known causes for this trend.

Selected References

Dokka, R.K., Sella, G., and Dixon, T.H., 2006, Tectonic control of historic wetland loss, subsidence, and fault reactivation in the Louisiana coastal plain; however, these processes operate on geologic time scales, making it difficult to explain the observed subsidence rates. The most recent subsidence rates are comparable to rates from other coastal plains.

Temporal Trends

Integration of rates of RSLR from tide-gauge records, elevation changes from repeating leveling surveys, and subsidence rates from continuous GPS measurements reveal a decadal pattern of shore-normal subsidence that is attributed to formation of a near-equilibrium condition. The observed trend is a relatively uniform acceleration of RSLR at Pensacola, Florida, which is the highest tide gauge, is subject to a relatively stable geologic setting. Here, the observed trend is a relatively uniform acceleration of RSLR of about 0.2 mm/yr since 1984. There are no known causes for this trend.

Figure 1. Regional map of the Mississippi River delta plain showing the locations of levees, benchmarks, and survey stations. Benchmark surveys and GPS measurements are available through the USGS Coastal Geodetic and Geologic Seafloor Surveys of the National Geodetic Survey (NGS) and National Ocean Service (NOS), respectively.

Figure 2. Regional map of the Mississippi River delta plain showing the locations of levees, benchmarks, and survey stations. Benchmark surveys and GPS measurements are available through the USGS Coastal Geodetic and Geologic Seafloor Surveys of the National Geodetic Survey (NGS) and National Ocean Service (NOS), respectively.

Figure 3. Rates of relative sea-level rise (RSLR) derived from GPS measurements at BVHS during 2002-2007. The most recent subsidence rate derived from GPS measurements at BVHS is plotted as a filled triangle (B). Shaded areas delineate approximate productive boundaries.

Figure 4. Rates of relative sea-level rise (RSLR) derived from GPS measurements at BVHS during 2002-2007. The most recent subsidence rate derived from GPS measurements at BVHS is plotted as a filled triangle (B). Shaded areas delineate approximate productive boundaries.

Figure 5. Graph of annual mean rates of relative sea-level rise (RSLR) for the Mississippi River delta plain from 1945 to 2007. The most recent subsidence rate derived from GPS measurements at BVHS is plotted as a filled triangle (B). Shaded areas delineate approximate productive boundaries.

Figure 6. Graph of annual mean rates of relative sea-level rise (RSLR) for the Mississippi River delta plain from 1945 to 2007. The most recent subsidence rate derived from GPS measurements at BVHS is plotted as a filled triangle (B). Shaded areas delineate approximate productive boundaries.