Interannual sea level reconstruction over 1972-2008 in the Gulf of Mexico derived from altimetry and tide-gauge records

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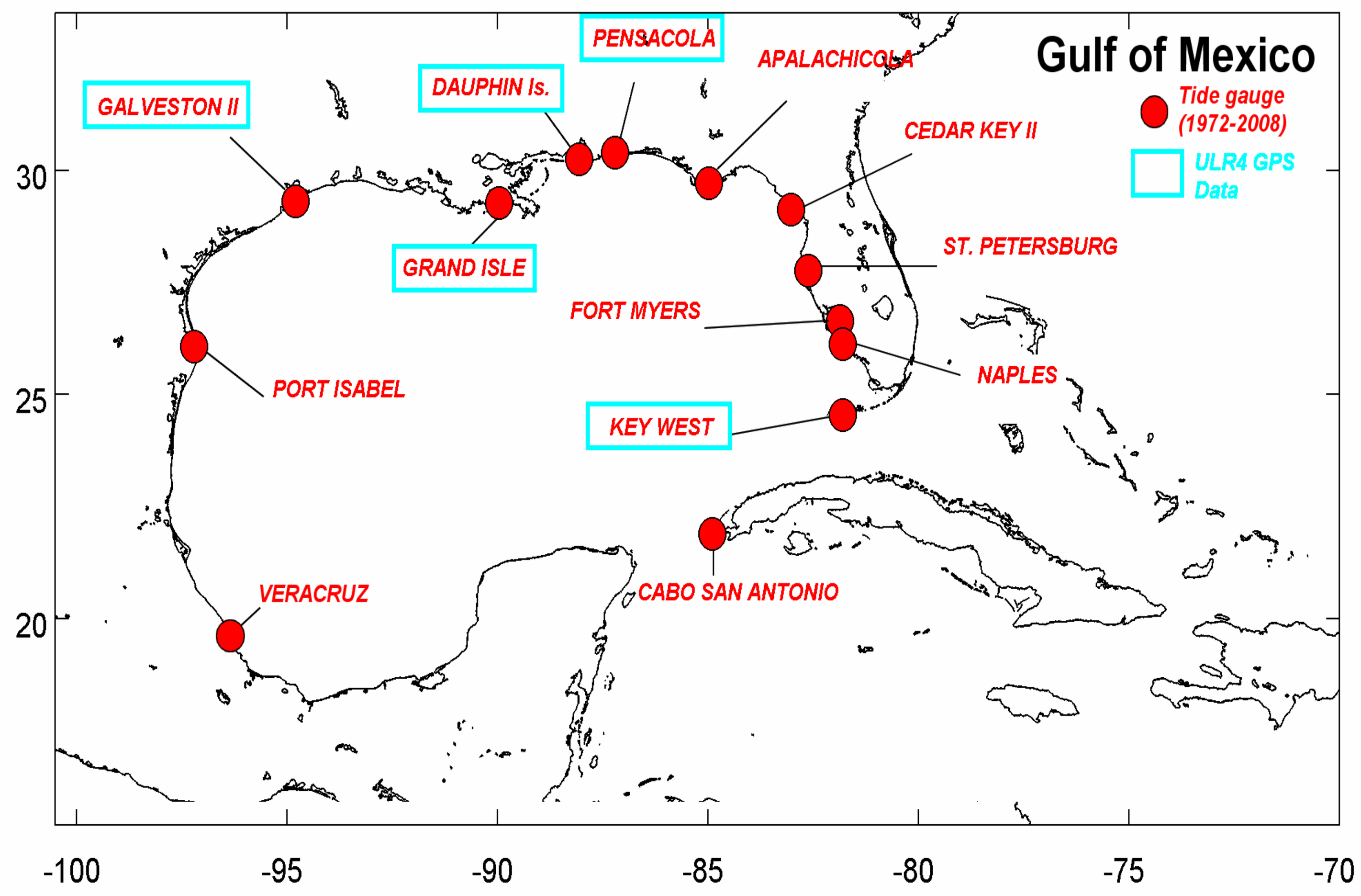
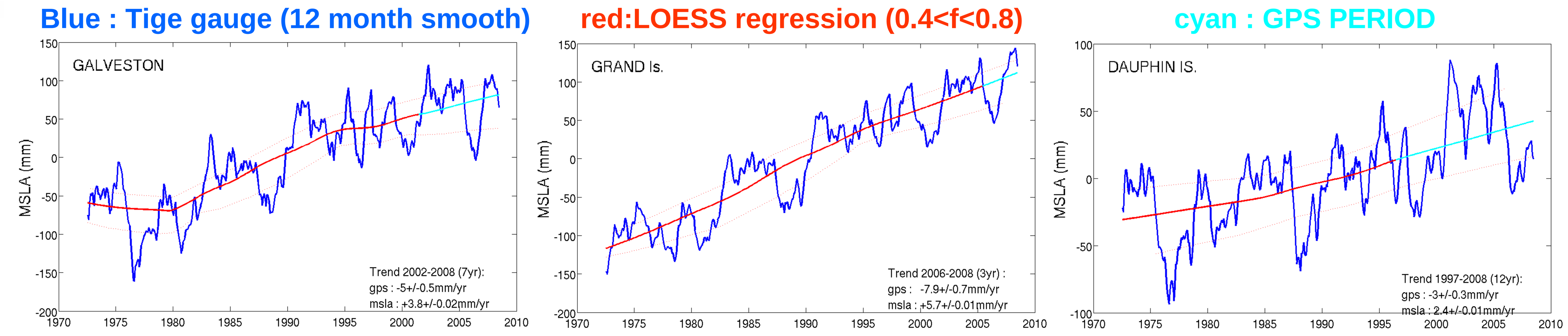
Introduction

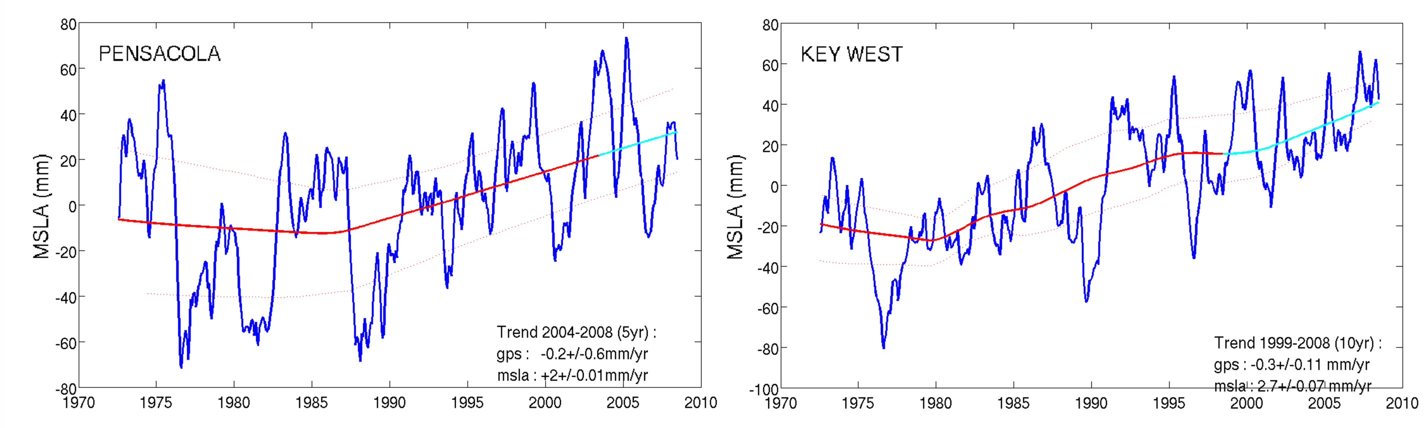
For the past decades, there are no direct basin-scale observations informing on the spatial variability of the sea level in the Gulf of Mexico (GoM). Yet it is important to know the dominant modes of regional variability on interannual/decadal time scale and their driving mechanisms to assess its potential impacts on the region. For that purpose, we have developed a reconstruction method of past GoM sea level (since 1972) that combines long tide gauge (TG) records of limited spatial coverage and 2-D sea level patterns based on the altimetry dataset (since 1993) (Kaplan et al. 2000, Llovel et al. 2009, Meyssignac et al. 2010) . The dominant modes of temporal variability are discussed and sea level hindcasts at tide gauge sites not used in the analysis are compared to the observations. In this region, during the 2 last decades, the dominant contributor to relative sea level rise is the sinking or subsidence of the land whereas global sea level rise can account for only ~2 mm/yr. We use the global positioning system (GPS) results from the latest ULR4 solution (Santamaria et al. 2010) to analyse the ground subsidence along the coast.

Ground subsidence : comparison tide gauge & GPS trend



Blue : Tige gauge (12 month smooth) red:LOESS regression (0.4<f<0.8) cyan : GPS PERIOD





Among the long tide gauge records available on GoM coast, many show strong trends and decadal variability related to anthropogenic forcings (oil and gas pumping, referenced in the literature) which dominate the signal. In these cases, the modern rate of subsidence shown by the GPS receivers can not be extrapolated backward to correct the records from the land motion.

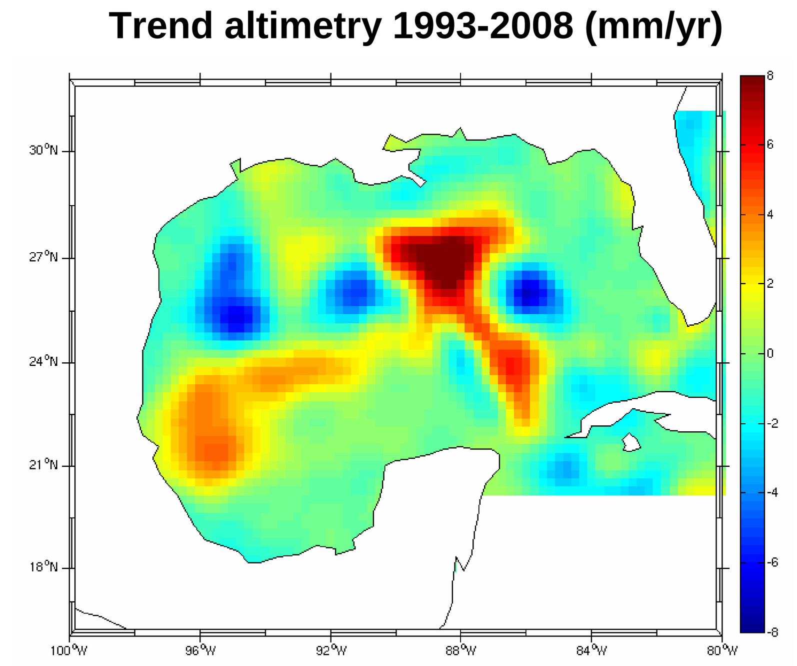
Correlation between tide gauge & Altimetry

Station Name	Best correlation (radius of 1°around the TG) 1993-2008
VERACRUZ	0.8
PORT ISABEL	0.8
GALVESTON	0.9
GRAND ISLE	0.8
DAUPHIN ISLAND	0.5
PENSACOLA	0.8
APALACHICOLA	0.4
CEDAR KEY	0.4
ST. PETERSBURG	0.9
FORT MYERS	0.7
NAPLES	0.9
KEY WEST	0.9
CABO SAN ANTONIO	0.5

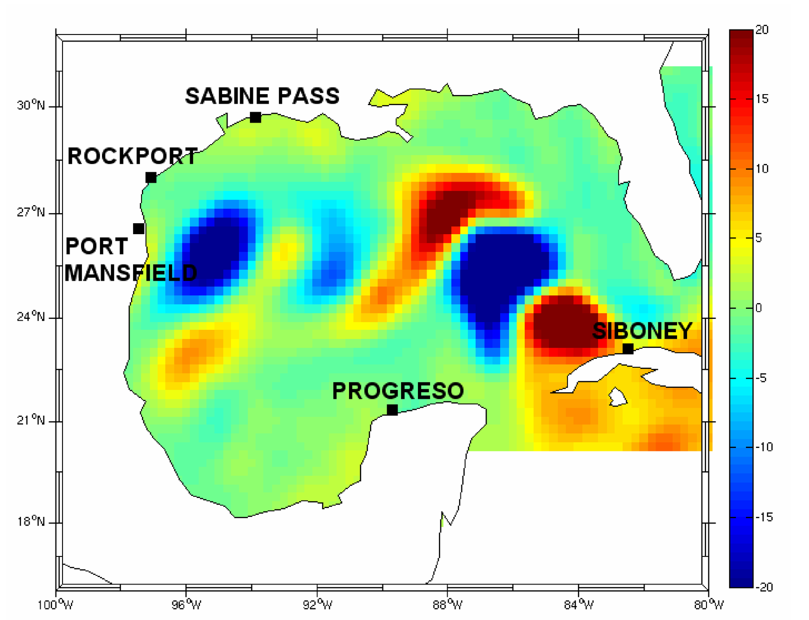
5 of the 13 long tide gauge records available on GoM coast show surprisingly, a low correlation (around 0.4 or 0.5) with the nearby satellite altimetry measurement. For Fort Myers, Apalachicola, Dauphin Island and Cedar Key it appears to be due to local circulation variability that differs significantly from offshore variability (the main factors to drive these differences are local hydrology and coastal circulation). For Cabo San Antonio the difference in the trends between the nearby altimetry measurement (constant trend over 1972-2008) and the tide gauge record which shows 2 different trends over 1972-2008 is the reason of the low correlation. However, the interannual variability is well reproduced. Some land motions at the site of Cabo San Antonio are suspected to introduce spurious signal in the record.

Reconstruction of MSL over 1972-2008 from 8 tide gauges and altimetry patterns

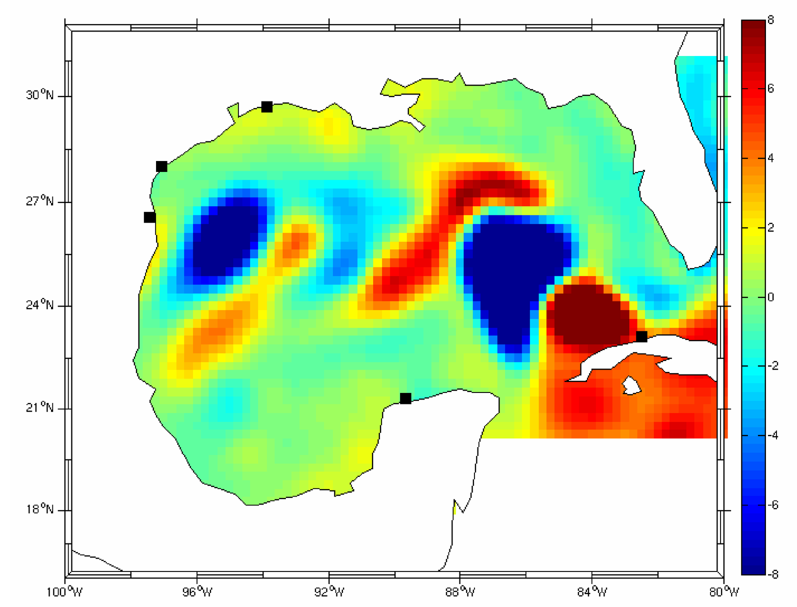
Trend altimetry 1993-2008 (mm/yr)



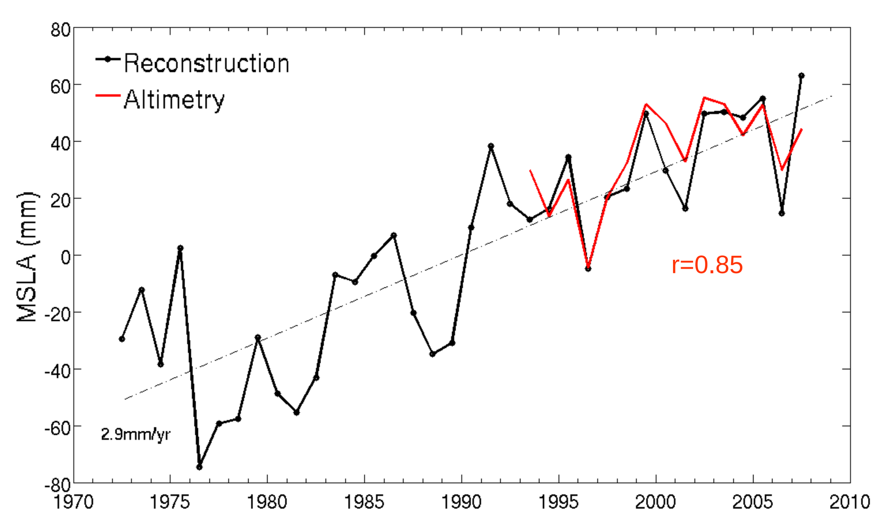
Trend reconstruction 1972-2008 (mm/yr)

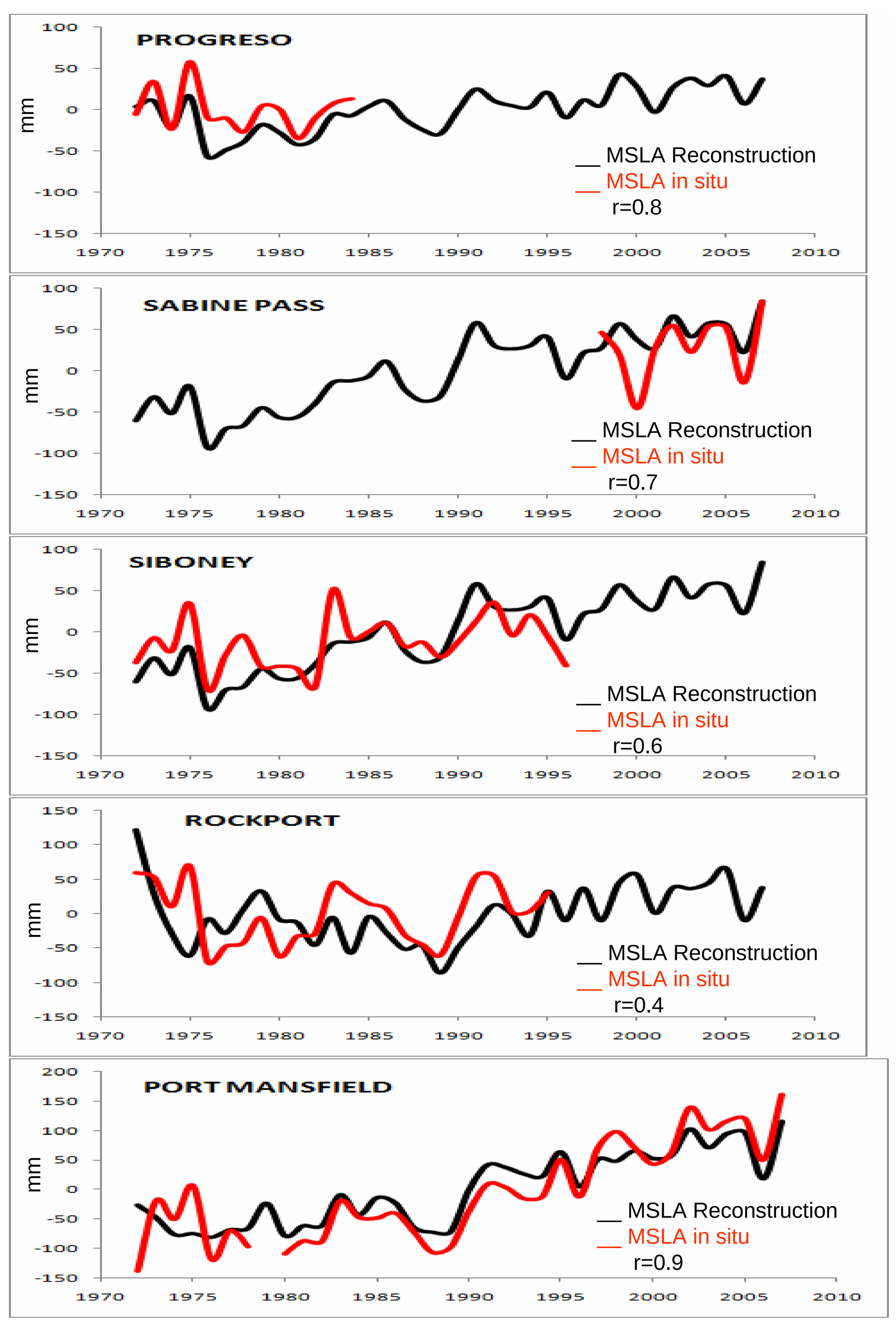


Trend reconstruction 1993-2008 (mm/yr)



Basin-averaged of the MSL reconstruction





The sea level reconstruction method uses the spatial structure (EOFs) of the sea level field obtained from the 2-D well resolved spatial fields of the satellite altimetry measurement to interpolate the historical measurements from the long tide gauge records available on the GoM coast. A global grid that covers the whole GoM over the tide gauge records time span is expected as a result and should give some information on the spatial trend patterns variability in the GoM.

Here we show the trends of the reconstructed field over the whole reconstructed time span (1972-2008). We also show the reconstructed trends over the altimetry period (1993-2008) to validate the reconstruction in comparison with the altimetry trends. Unfortunately, the 2 maps differ significantly, because of the strong spurious signal due to ground subsidence contained in the tide gauge records. The strong mesoscale patterns of sea level in the middle of the GoM appears to play a role as well and make the reconstructed trends definitely not reliable.

Nevertheless, the reconstructed interannual variability gives better results. The figure on the right compares independent tide gauge records (i.e. not used in the reconstruction process) with the local reconstructed field. The interannual variability appears to be well reproduced.

Conclusion

Some tide gauge records among the 13 long ones available on the GoM coast show strong trends and decadal variability due to anthropogenic forcings (gas and oil pumping). The fluctuation with time of these anthropogenic spurious signal does not allow any backward correction on the base of the recent GPS measurement. Unfortunately this feature prevent the reconstruction method from capturing the trends of the GoM past sea level over the period 1972-2008. Nevertheless, comparisons with independent tide gauges around the GoM show that the past interannual sea level variability is well reproduced by the method both at each tide gauge site and on basin average.

References

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