SPATIAL ANALYSIS AND TREATMENT OF TIDE GAUGE RECORDS USING GIS

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Introduction

For most populated regions of the world, sea level is increasing at a rate of a few millimetres per year. There may be an additional component of the rise from vertical land movements. In North America, the modern rate of secular sea level rise recorded by tide gauges, reflect the ongoing influence of Glacial Isostatic Adjustment (GIA) as well as global water rise. We employ monthly mean sea level records obtained from tide gauges to detect GIA. Two questions arise:

1- How can we distinguish between Glacial Isostatic Adjustment (GIA) and other global, regional and local effects in the records?

2- How can we find the spatially optimal network of tide gauges to cancel out some of these effects through differencing?

In order to answer these questions, special attention must be paid to the spatial distribution of physical phenomena responsible for the sea level changes. In this study, We use ArcGIS to visualize the theoretical approaches in answering these questions, and to integrate and analyze different spatially distributed data such as tide gauge records, geological and climate related data.

Preliminary study of sea level records in eastern coast of Canada

Because we employ monthly sea level records from the tide gauges in Canada, high frequency oceanic noise is filtered out. However, there are some other effects such as river discharge and sediment subsidence, which contaminate the records of some of the tide gauges. Therefore, they should be eliminated from the study.

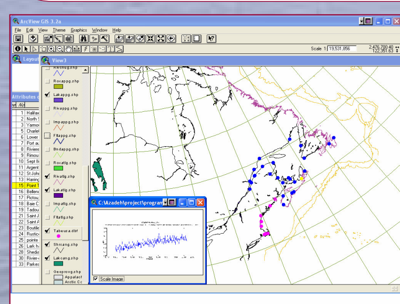

Figure 1: Location of tide gauges from which data are employed in the analysis of secular sea level change from East Coast Canada.

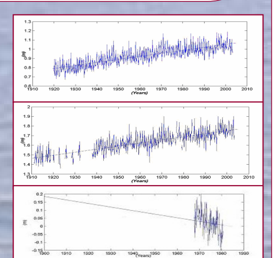

Figure 2: (a) Monthly mean sea level records for Halifax, NS. Present-day linear sea level trend is 3.27 mm/yr obtained from the records of 1920-2003. **(b)** Monthly mean sea level records for Charlettown, PEI. Present-day linear sea level trend is 3.21 mm/yr obtained from the records of 1911-2003.**(c)** Monthly mean sea level records for Riviere du loup, Que. Present-day linear sea level trend is -2.22 mm/yr obtained from the records of 1968-1981.

Application of GIS for impact studies

GIS provides a tool for displaying output that permits users to "see" the geographical distribution of impact from different sources. In this work, the impact study of tide gauge records using GIS is done in 2 steps:

1- Integration of all data.

All available data are integrated with Geological map of Canada in ArcView3.2a and subsequently formatted to meet requirements for the geological map.

2- Spatial analysis of tide gauges

Since all the data are added in different themes, we can select features based on the geographical relationships to other features. In this study, for example, we are interested in finding out which sites are intersecting with rivers. We can perform spatial queries and find the tide gauges affected by river discharge.

Locating the regions where the effect is significant, the affected records are rejected from the database.

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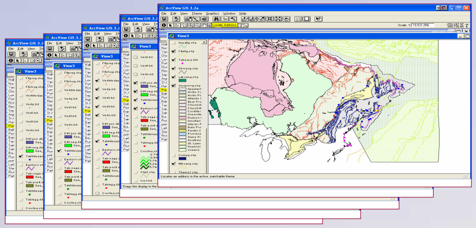
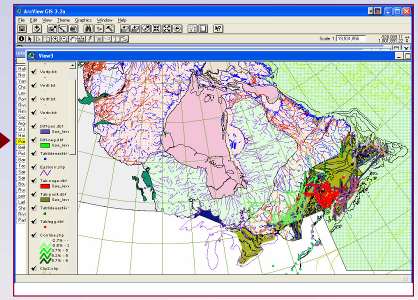
Different themes in Arc View

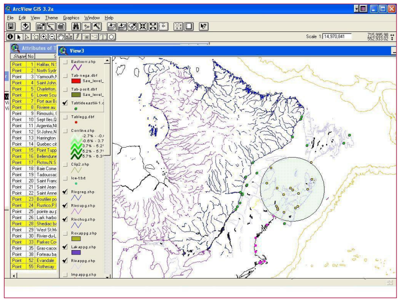


Integration



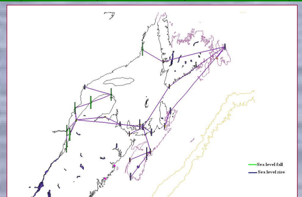
Treatment of sea level

We difference the monthly mean sea-level records to reduce the sea level variations. This method is based on the fact that due to the high degree of coherence between sea level variations at close-by sites, a large portion of these variations disappears when the records are differenced. Using the correlation matrices and their confidence intervals, we define the optimum tree diagram for the differencing. we utilize GIS for selecting the tide gauges using the constructed matrices and the spatial relationships.



Sea level linear trends and their standard deviations in mm/yr of some tide gauges in Atlantic Canada obtained from monthly mean sea level records, along with the isostatic sea level changes from ICE-5G model.

Location	From-To	From Point Velocity*	Propagating Differences*	Isostatic water changes From ICE-3G model (Peltier, 2001)
Halifax, N.S	1919-2003	3.27± 0.05	3.27 ± 0.05	1.07
North Sydney, N.S.	1970-2003	3.07 ± 0.54	3.90 ± 0.37	1.20
Yarmouth, N.S.	1900-2003	2.85 ± 0.15	4.21 ± 0.18	0.67
Charlottetown, PEI	1905-2003	3.21 ± 0.08	3.53 ± 0.09	1.00
Lower Escuminac, Que	1973-2003	1.98 ± 0.66	2.23 ± 0.31	0.57
Port aux Basques, Nfld	1959-2003	2.34 ± 0.24	2.70 ± 0.16	0.53
St John, Nfld	1935-2003	2.11 ± 0.27	3.53 ± 0.35	0.81
Quebec city, Que	1910-2003	-0.52 ± 0.13	2.53 ± 0.21	-1.40
Pictou, N.S.	1957-1996	2.30 ± 0.35	3.95 ± 0.21	1.13
Saint Francois, Que	1962-2003	-0.48 ± 0.91	3.40 ± 0.50	0.26
Shediac bay, N.B	1971-1992	1.23 ± 0.16	2.72 ± 0.14	0.75
Parker's Cove, N.S	1970-1992	0.22 ± 0.15	2.22 ± 0.11	-
St Jean Port Joli, Que	1968-1980	-5.38 ± 2.18	-1.69 ± 1.64	-1.21
Ste Anne des Monts, Que	1967-1997	-0.89 ± 0.44	-0.74 ± 0.49	-0.79
Riviere du loup, Que	1968-1980	-2.22 ± 1.12	-0.40 ± 1.15	-0.99



Topology of tide-gauge differencing in eastern Canada

Results and Conclusions

-Short records display linear trend values which are close to their longer counterparts when the method of propagation of differences is used. The method of propagating differences is working in tide gauges in Eastern Canada, we have reduced the effect of oceanic noises.

-The results showed an average of water rise of approximately 3mm/yr obtained from most tide gauges in Atlantic coast.

-If the global water rise is subtracted from the linear trend of tide gauge records, postglacial signal is inferred which can be compared with GIA models.

-There are some sites with sea level fall, such as St Jean Port Joli in Quebec. These are most likely affected by tectonic effect, which should be considered physically.

-GIS is the solution for making the analysis of tide gauge records a **dynamic proposition**.

Acknowledgement

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