THE DIFFICULTIES IN USING TIDE GAUGES TO MONITOR LONG-TERM SEA LEVEL CHANGE

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Sciences

Introduction

1. The assessment and interpretation of sea level change is a crucial component, both in detecting climate change and in understanding its impacts.
2. Very long-term sea level change analyses (> 250 yr) rest upon the interpretation of sedimentary and geological data. **Problem: Uncertainty in interpretation.**
3. Shorter term sea level change analyses (from 1770-present) rest upon tide-gauge data. **Problem: Uncertainty in datum.**
4. Very short term analyses (data collected since 1993) rest upon Topex/Poseidon and JASON-1 data. **Problem: Uncertainty with small systematic effects.**

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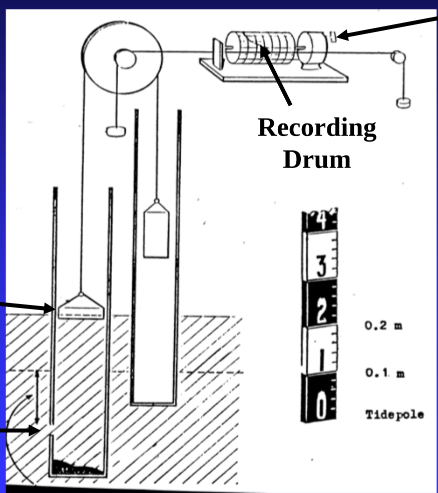
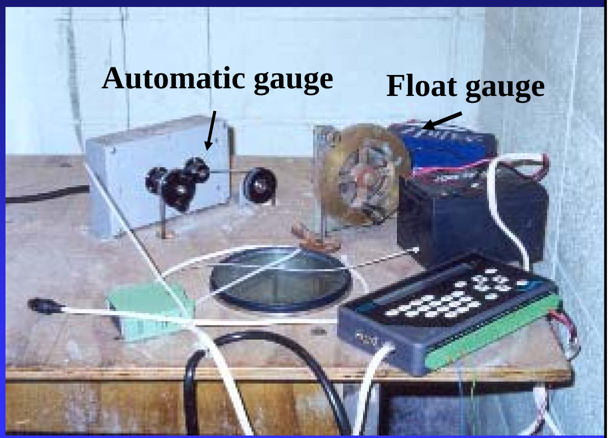
Possible Errors in the Sea Level Analysis Process

1. Tide Gauge Errors
2. Datum Errors
3. Analysis Errors
4. Geophysical effects

The Conventional (Float) Automatic Tide Gauge



Auckland Gauge Site



Tide Gauge Errors

Mechanical Gauges

1. Clock errors - generally negligible impact on monthly means.
2. Height errors in setting the gauge setting (0.02m – 0.08m)
3. Silting of the stilling well → low water curves flatten
4. Friction in the float mechanism → poor tidal curves evident at high and low water.

Electronic Gauges

Produce higher frequency, more precise data BUT regular calibration is essential to avoid drift.

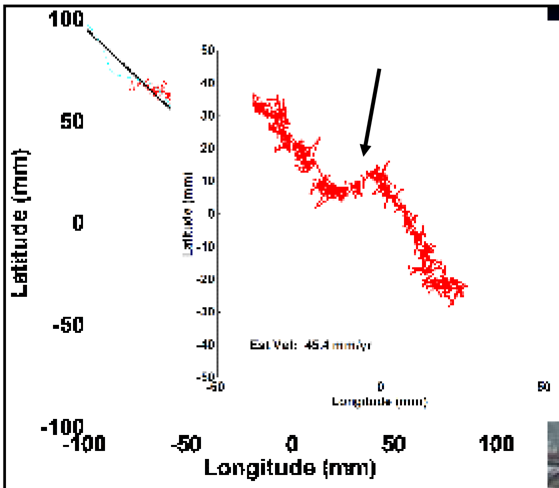
A **well maintained gauge is crucial** to a high quality record!!

Datum Errors

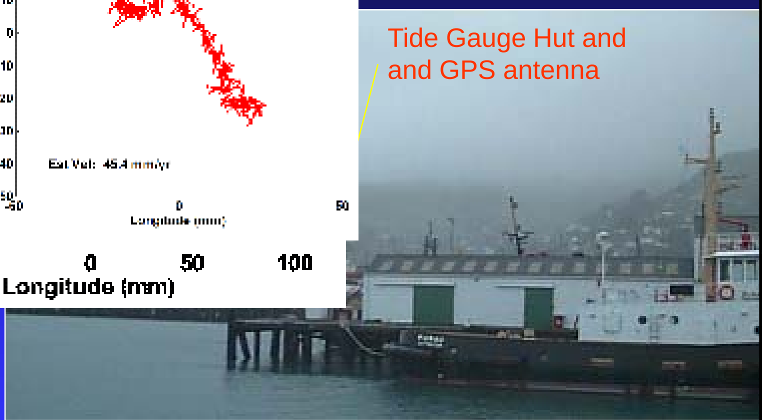
(The single greatest problem to resolve)

- Movement of the tide board (pole)
  - boats/ships collide with wharf pile
  - worn fittings
  - incorrect replacement
- Movement of the tide gauge to a new location
- Movement in the tide gauge benchmarks
- Changes in the setting of the datum.

Errors characterized by a sudden offset in the tidal record.



Lyttelton Tide Gauge Site



Lyttelton.

Dunedin Tide Pole/Gauge

Tide pole bolted to wharf structure

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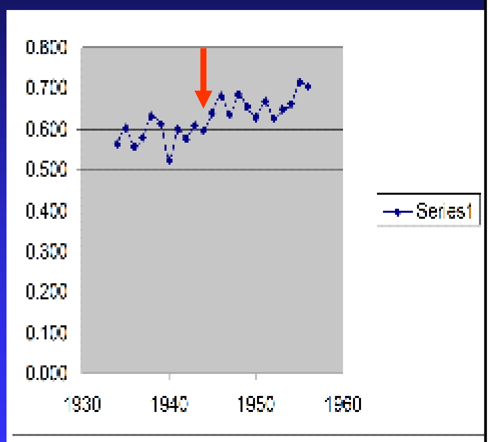
Wellington Data

- 1937 0.579
- 1938 0.631
- 1939 0.613
- 1940 0.522
- 1941 0.598
- 1942 0.577
- 1943 0.610
- 1944 0.595
- 1945 0.640
- 1946 0.683
- 1947 0.636
- 1948 0.684
- 1949 0.654
- 1950 0.630
- 1951 0.669
- 1952 0.625

New Gauge Installed



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Analysis Errors

1. Undetected gauge subsidence → must connect regularly to stable benchmarks. 0.2mm/yr at Wellington since 1946 – only detected in 2001.
2. Insufficient data. 60 yr of data recommended to eliminate the effects of interdecadal variability *(Douglas 1991,1992)*

3. Unmodeled hydrological effects such as river flows, e.g., Newcastle gauge. Model (or ignore the data)

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Geophysical Effects

A. Plate Motion

Central South Island experiences oblique continental collision at about 40 mm/yr

Shortening component normal to Alpine fault is about 10 mm/yr

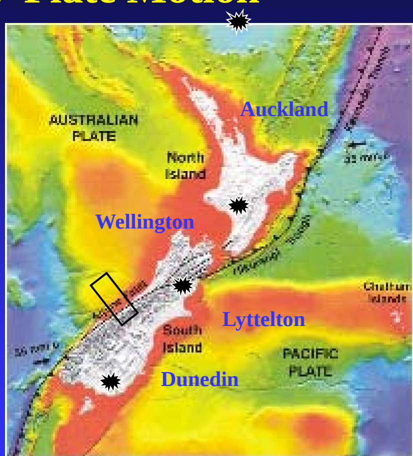

Image from the National Institute of Water and Atmospheric Research

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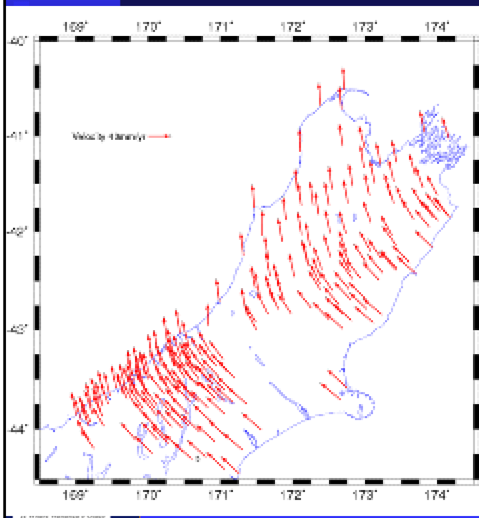
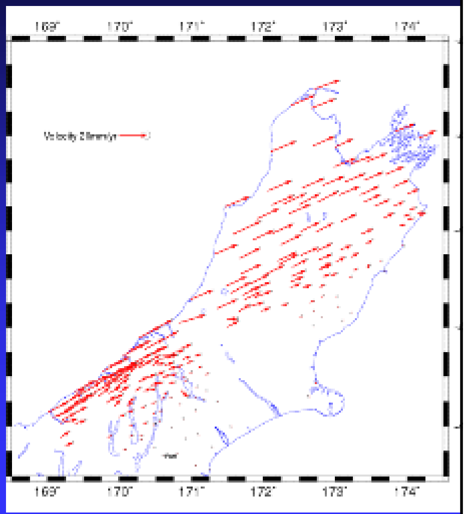
Absolute Velocities

Relative Velocities (East Coast Fixed)





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Geophysical Effects

B. Glacial Isostatic Adjustment

Note: Units in mm/yr

Earth Model	Auckland	Wellington	Lyttelton	Dunedin
ICE4G (VM2)	0.103	0.218	0.285	0.314
JM120, 1,10	0.338	0.291	0.234	0.135
JM120, 1,3	0.548	0.549	0.500	0.398

The above numbers calculated by C.K Shum – The Ohio State University

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Results from the New 2008 Analysis

Relative Sea level rise trends			Glacial Isostatic Adjustment
Auckland	1.48	(± 0.09) mm/yr	+ 0.33 mm/yr
New Plymouth	1.24	(± 0.32 mm/yr	
Wellington	2.00	(± 0.17) mm/yr	+ 0.35 mm/yr
Lyttelton	1.90	(± 0.10) mm/yr	+ 0.34 mm/yr
Dunedin	1.28	(± 0.09) mm/yr	+ 0.28 mm/yr

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Future Directions

- Better (electronic) open coast tide gauges → better records.
- GPS + tide gauge → better knowledge of local and regional vertical movements.
- Improved GIA estimates
- Topex/Poseidon → improved open ocean estimates of sea level change.

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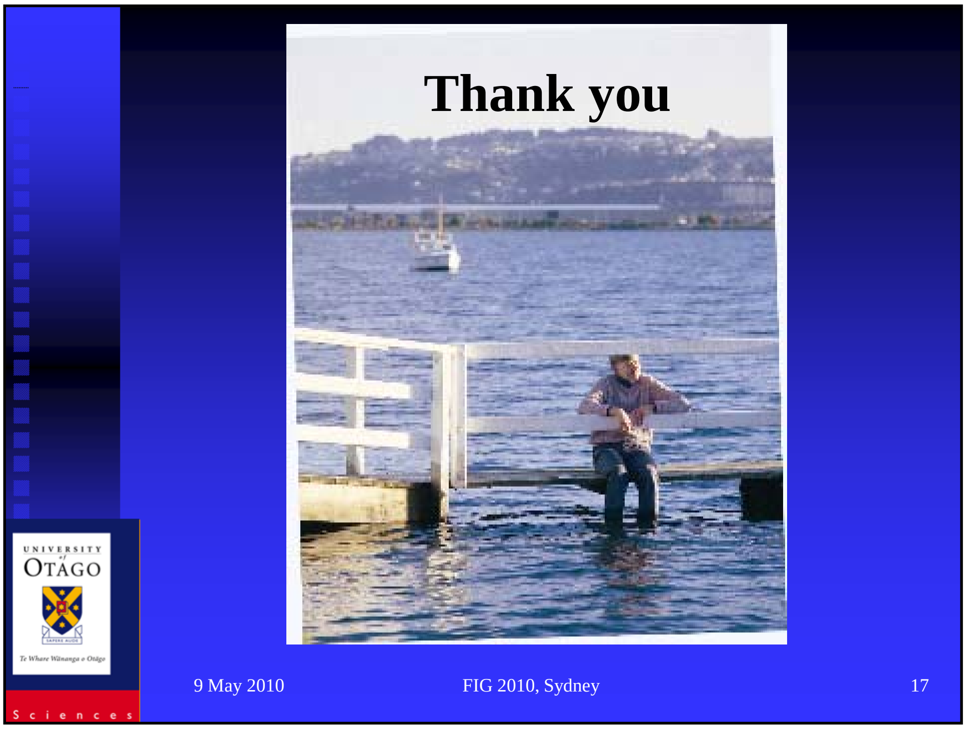
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