Trends in sea-level trend analysis

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- F. Baart, P.H.A.J.M. van Gelder, J. de Ronde, M. van Koningsveld, B. Wouters, *The effect of the 18.6 year lunar nodal cycle on regional sea-level rise estimates*. JCR (2012)
- F. Baart, M. van Koningsveld, M.J.F. Stive, *Trends in sea-level trend analysis*. JCR (2012)

Introduction

Fedor Baart

PhD thesis: Confidence in morpological forecasts

This research

http://citg.tudelft.nl http://www.deltares.nl
http://www.openearth.nl http://www.micore.eu

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Study of the Dutch trend

Nourishment strategy

How much sea-level rise do we expect for the next 5 years?

Figure: Nourishment of the sand engine (src: zandmotor@flickr)

Improving the confidence of the $^{1}/_{10000}$ storm surge estimate

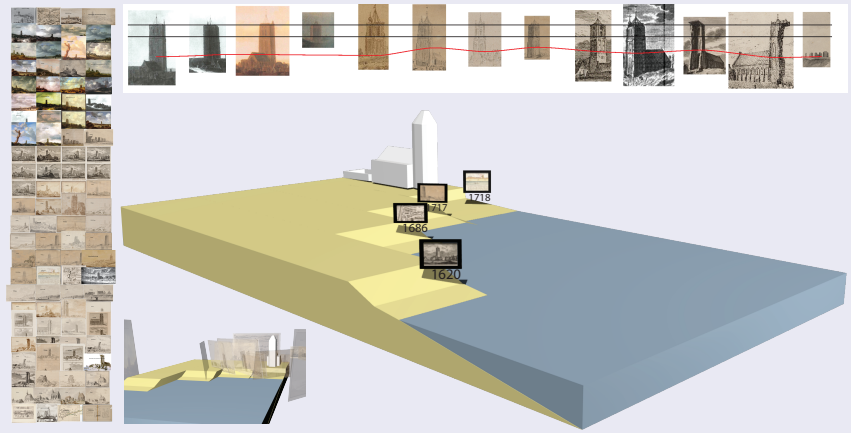

Figure: Using 18th century paintings to reconstruct the storm surge of 1717 at Egmond (NHESS-2011)

Current observed trend (tide gauges)

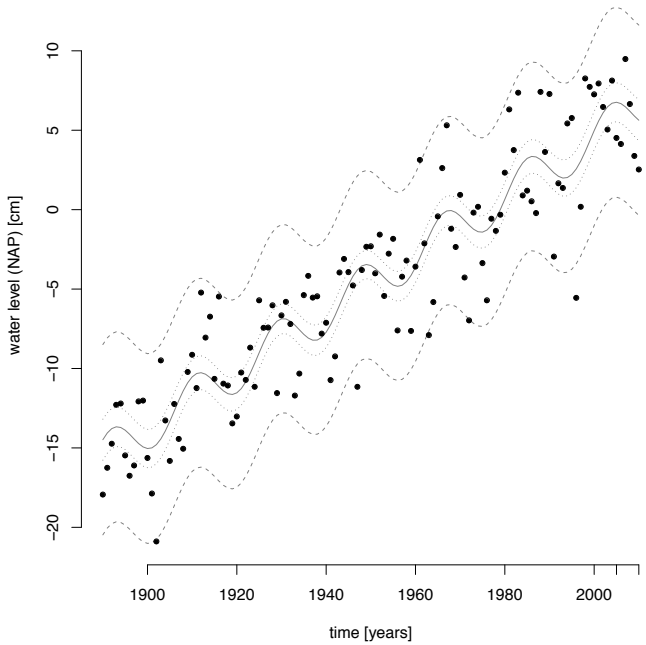

Figure: Relative sea-level at the Dutch coast 19 cm/century ($\pm$ 1.5), no acceleration (JCR-2012)

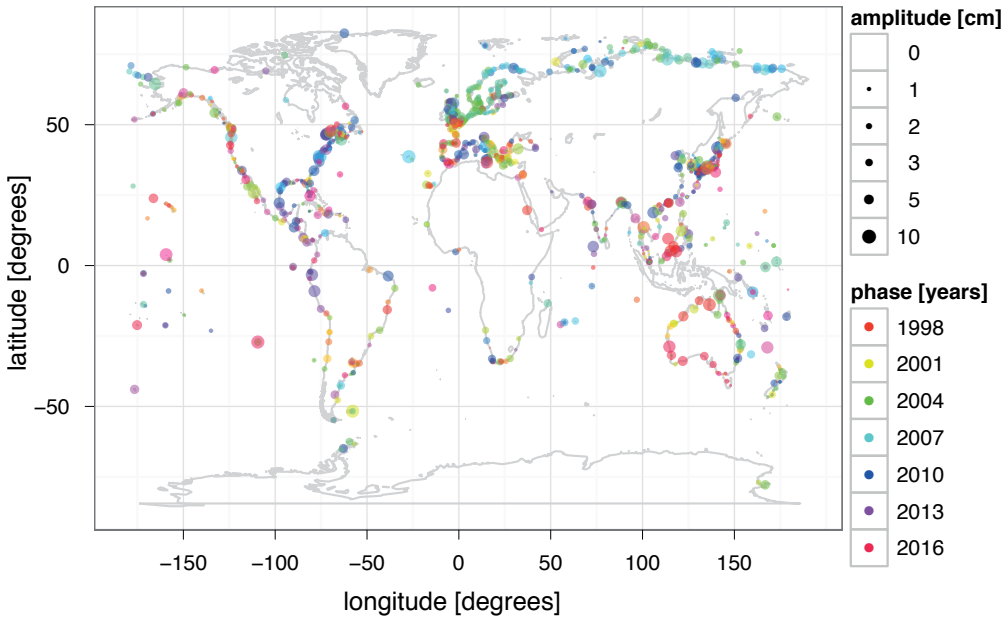

Figure: Nodal cycle variation in tidal gauges (JCR-2012)

Deceleration versus acceleration

Figure 3. Locations of 57 tide gauges.

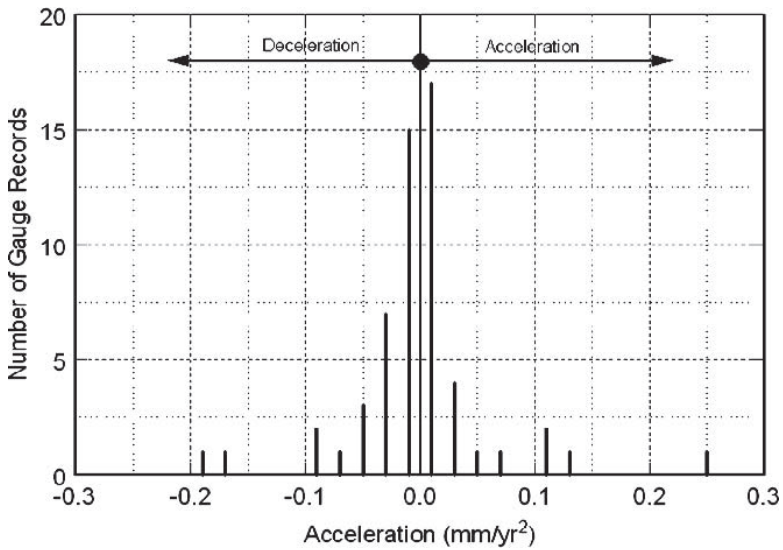

Figure 4. Number of gauge records in bins of acceleration, a_2, in mm/y ^{2}.

Figure: Significant deceleration in US and deceleration World tide gauges (1930-2010) (Houston & Dean JCR-2011)

Deceleration versus acceleration

Observations

Constant rise

Forecasts

Accelerated rise

Dutch forecasts

van Dantzig, 1956

Observed	20cm per century
Forecast	70cm per century

KNMI, 2006

Observed	20cm per century
Forecast	35 to 85 cm (1990–2100)

Forecasts

Are we structurally overestimating?

When should acceleration occur/have occured?

1700–1800

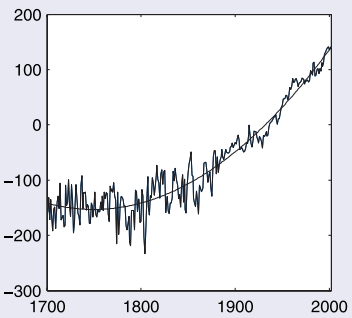

Figure 1. Sea level reconstruction since 1700, the shadow represents the errors of the reconstruction. The fitted curve is a second order polynomial fit.

Figure: Jevrejeva 2008

1993-2010

Donoghue (JCR-2011): 17 cm/century for past century versus 30 cm/century since 1993 (comparing tide gauges with altimetry satellites).

tomorrow

Rahmstorf (JCR-2011): Why would tide gauge data of the twentieth century show the acceleration expected in the twenty-first century?

Fitting methods

Regression (OLS)

Assumes uncorrelated errors.

Generalizable?

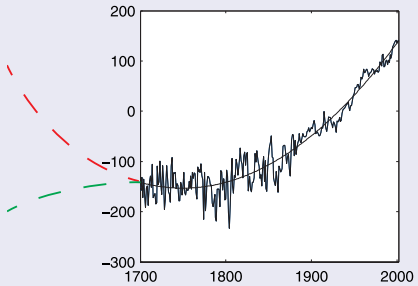

Figure 1. Sea level reconstruction since 1700, the shadow represents the errors of the reconstruction. The fitted curve is a second order polynomial fit.

Figure: Fitted trend from Jevrejeva 2008 extrapolated to < 1700

Water level

Correlated errors

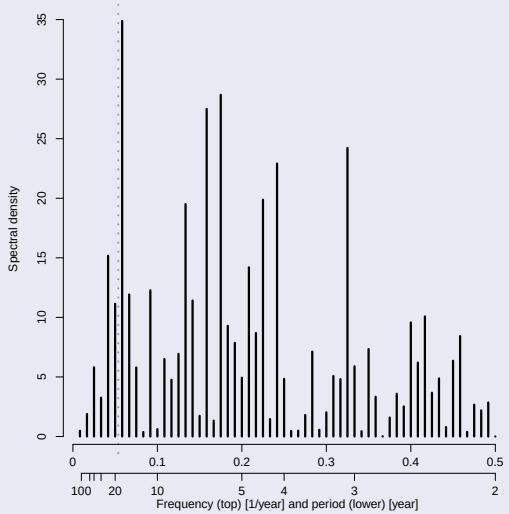

Figure: Multiy year spectrum of relative sea level along Dutch coast

Physicalness

Empirical

$$h(t) = \beta_0 t + \beta_1 t^2 + c$$

Semi-empirical

$$h(t) = \beta_n (T_t - T_{t-n}) + h(t-1)$$

Numerical

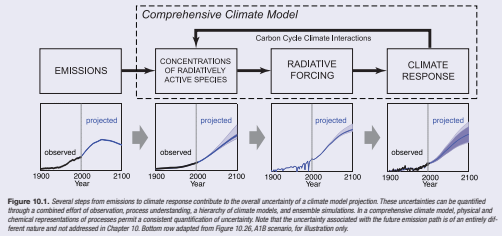

Figure 10.1. *Several steps from emissions to climate response contribute to the overall uncertainty of a climate model projection. These uncertainties can be quantified through a combined effort of observation, process understanding, a hierarchy of climate models, and ensemble simulations. In a comprehensive climate model, physical and chemical representations of processes permit a consistent quantification of uncertainty. Note that the uncertainty associated with the future emission path is of an entirely different nature and not addressed in Chapter 10. Bottom row adapted from Figure 10.26, A1B scenario, for illustration only.*

Independent variables?

Time versus temperature versus emission.

Best practices

Falsifiability Use well defined periods. Predict the trend evolution.

Reproducibility Make all data (station selections), models, and tools available.

Perspectives Include opposing perspectives. Use the whole modeling toolbox.

Statistical Report the whole model (not just 1 parameter). Use the linear model as a reference forecast.

Skill Compare old forecasts (1980s) to observed data to test our skill. Use longer verification periods for new forecasts (30+ years).

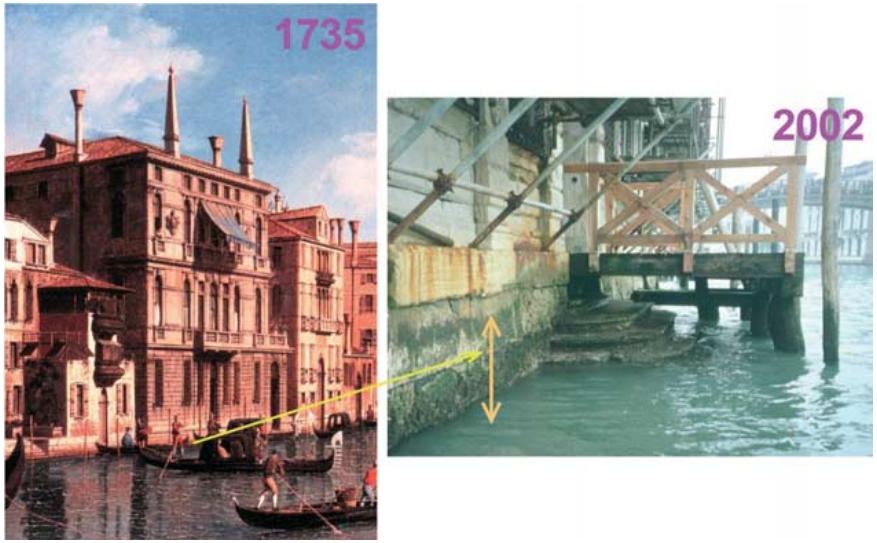

Figure 3. A view of Palace Giustinian-Lolin painted by Bellotto in 1735 (left), and a detail of the main entrance today (right). The algae shift is 66 ± 10 cm. The main staircase is now submersed and a new wooden wharf was necessary to enter.

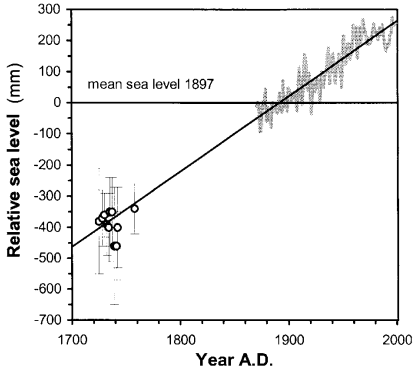

Figure 5. Relative sea level (RSL) at Venice from tide gauges (continuous grey line, period 1872–2000) and from Canaletto's and Bellotto's paintings (white dots with error bars, period 1727–1758). RSL from paintings was estimated from the difference in level of the algae belt as it was in the paintings and as it is today.

Figure: Canaletto's Paintings used to study relative sea-level rise in Venice (Camuffo 2003)