The Presiding Officers invite Parliamentarians and Staff to a Science Briefing on

Sea Level Rise and Coastal Inundation

Thursday 11th October, 2012, 1.00pm,
With lunch in the Legislative Council Committee Room

Sea level rise as a consequence of increased anthropogenic greenhouse gases in the atmosphere is one of the more confident predictions arising from climate science. Sea level rise occurs as a result of contributions from a number of sources, including ocean thermal expansion, the addition of melt water from the world's glaciers and the ice sheets of Greenland and Antarctica. Recent progress on understanding the contributions to the observed sea level rise over the twentieth century will help to narrow the uncertainty around future sea level rise projections although significant uncertainties will remain due to uncertainties around the response of the ice sheets to enhanced warming. The magnitude and rate of sea level rise will not be uniform across the globe but will vary due to factors such as changes in large scale ocean and atmospheric conditions and changes in the gravitational fields arising from the melting of land-based ice.

Rising sea level is a significant issue for coastal populations. In Australia, where around 85% of the Australia's population resides, about 6% of Australian addresses are situated below 5 m elevation and within 3 km of the coast. In view of this potential exposure to sea level rise impacts, there has been much effort in recent years to identify particularly exposed areas and quantify the impacts of sea level rise. A consequence of higher global mean sea levels will be an increase in the frequency of extreme coastal high waters that can cause inundation and erosion of coastal land. Extreme coastal high waters arise from a range of processes that include tides and weather-driven storm surges and high waves. Climate change may also bring about changes to the severe weather events that cause hazardous storm surges and waves although these changes will be regionally specific. This talk will present an overview of observed sea level rise and its causes. It will also describe recent efforts to quantify the changes to the risk of extreme sea level inundation from sea level rise and changes in weather conditions.

The speaker will be:

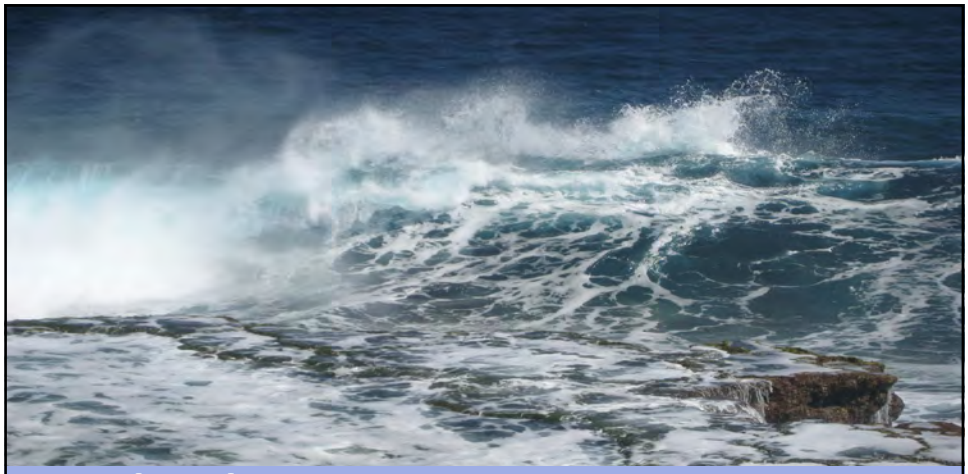
Dr Kathleen McInnes
Leader, Sea Level Rise and Coasts Team
Centre for Australian Climate and Weather Research
CSIRO Division of Marine and Atmospheric Research

The meeting will be chaired by:
Dr Glen Kile FTSE

The Parliamentary science briefings are organised by the Academy of Technological Sciences and Engineering (ATSE) under the auspices of the Presiding Officers and with financial support from the Department of Business and Innovation

Notes on the talks are available on the Parliamentary Intranet.

For information or comments on future briefings contact Professor Kerry Pratt on 0407 513 553 or kerry.pratt@monash.edu



Sea level rise, storm surges, waves and coastal impacts

Centre for Australian Climate and Weather Research
www.csiro.au

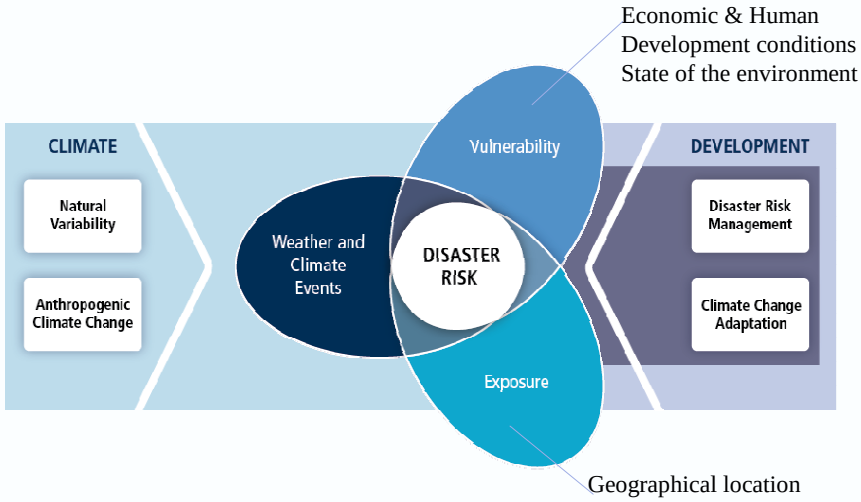
Kathleen L. McInnes

11 Oct 2012

Outline

1. Background
2. Global and regional sea levels
3. Extreme sea levels
4. Coastal inundation
5. Coastal waves and erosion
6. Adaptation options

Factors Influencing Disaster Risk

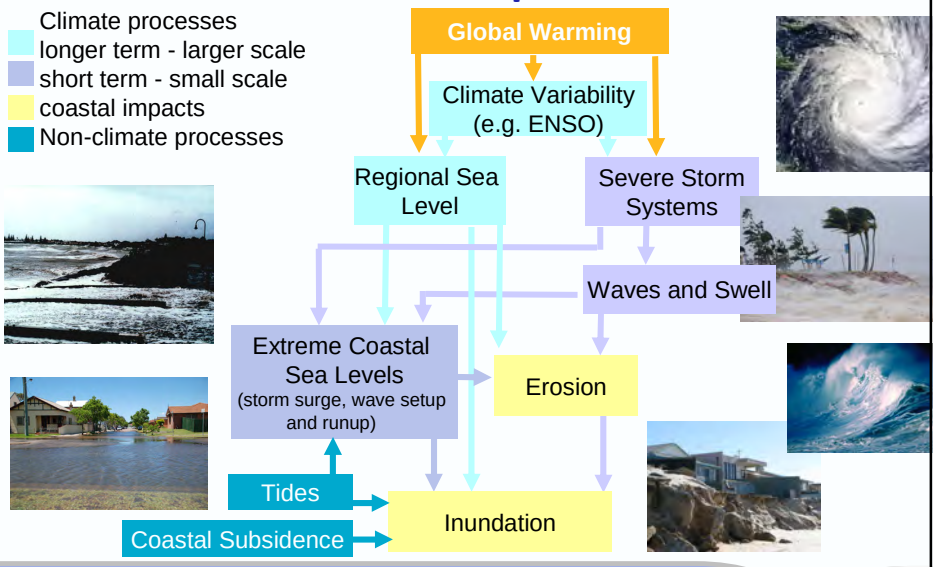


Source: IPCC Special Report on Extremes

Global exposure to sea level

Population exposure to inundation for 1-in-100-year extreme storm for different scenarios of sea level rise. (source IPCC Special Report on Extremes chapter 4)

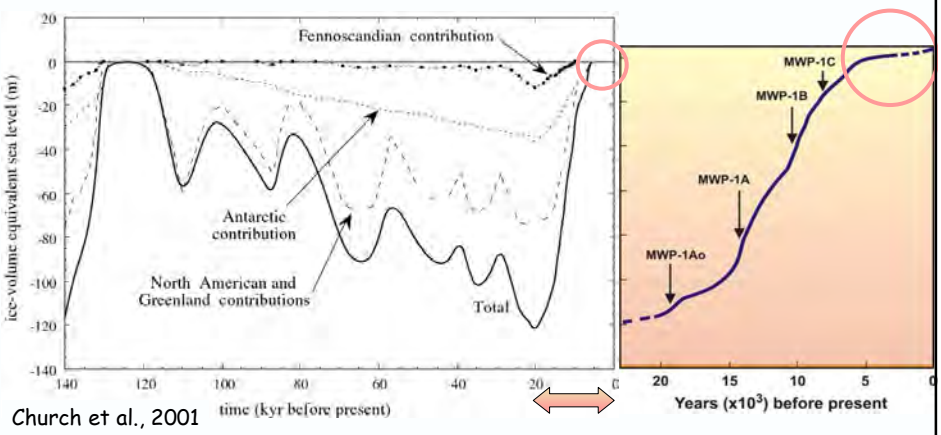
Coastal Processes and Impacts



2. Global and regional sea levels

- The state of the earth's climate system (e.g. atmosphere, cryosphere, terrestrial biosphere and oceans) is reflected in the level of the global oceans.
- Ocean's store 90% of the excess energy in the climate system.

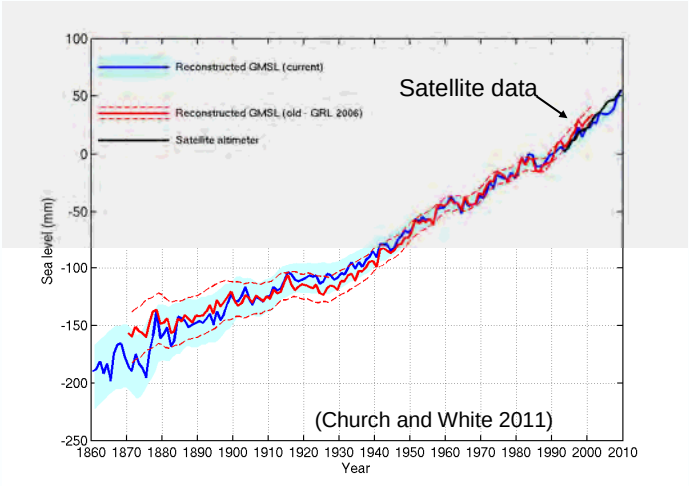
Sea levels have risen by more than 120 m since the last glacial maximum but have been stable over the period of human settlement of coastal regions



Church et al., 2001

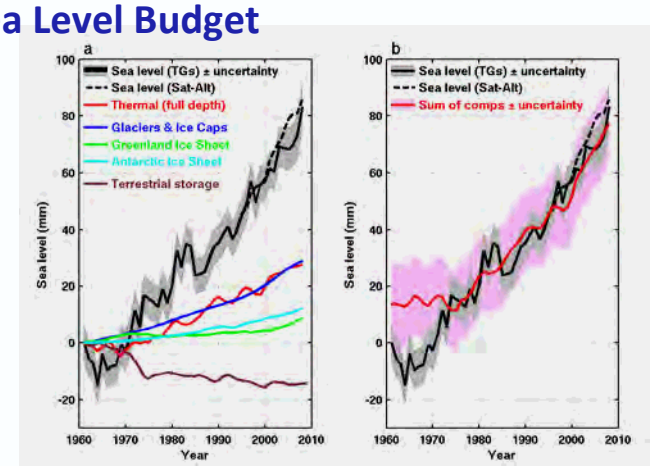
around 10% of worlds population lives in the 2% of land that is below 10m elevation

Global Mean Sea Levels



The rate of sea level rise increased during the 20th century

Sea Level Budget

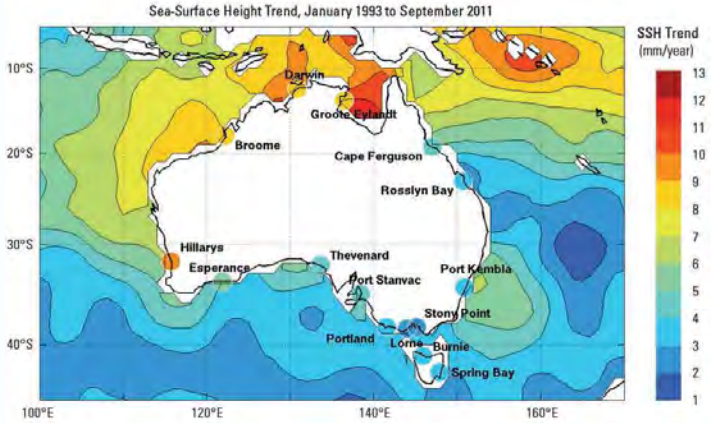


- Observed sea level and the different contributions
- Glaciers and thermal expansion produce the largest contributions
- The sum of the contributions almost equals observed sea level since the early 1970s.
- Closure of budget will allow observations to be used to constrain future projections

Church *et al.* 2011

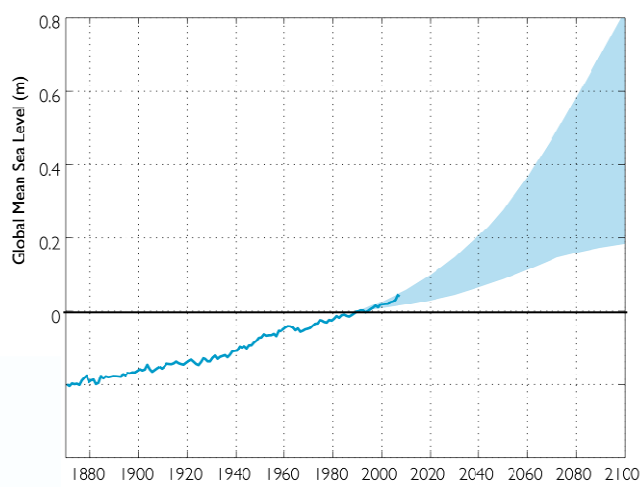
Regional Sea Level Trends

Spatial patterns show large regional departures from global mean sea level rise because of other influences such as El Nino/Southern Oscillation



The rate of sea-level rise from coastal tide-gauges (coloured dots) and satellite observations (coloured contours) from January 1993 to September 2011

Projected sea level rise



IPCC 2007 projections for sea level rise based on Hunter (2009)

SLR ~ 0.2 – 0.8 m by 2100 relative to 1980-2000

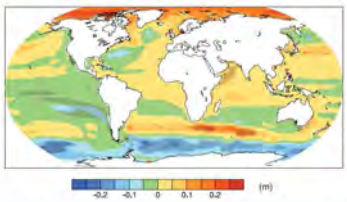
Current rates of sea level rise are consistent with those of the upper IPCC sea level rise estimate.

Regional Sea Level Rise

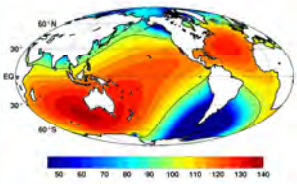
Regional variations in sea level rise occur because of:

(1) temperature and salinity variations in the ocean

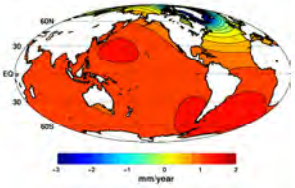
(2) changes in the Earth's gravitation field from ice melt



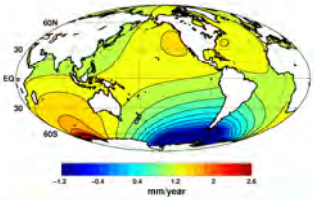
Glacier and ice cap fingerprint



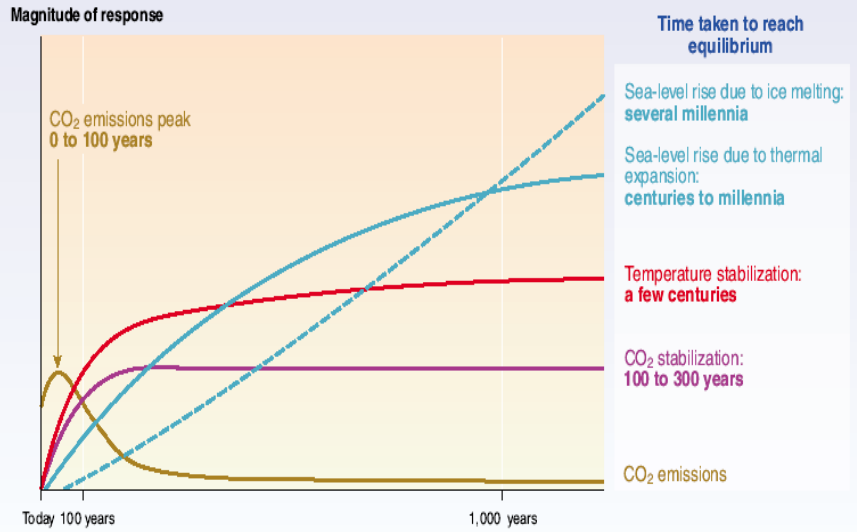
Greenland fingerprint



Antarctic fingerprint



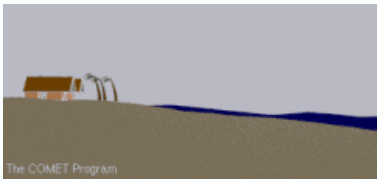
The need for adaptation

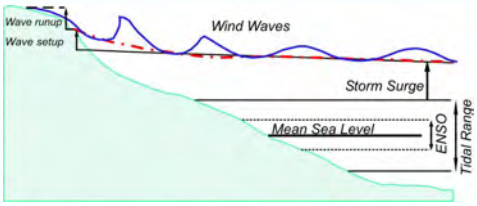


3. Extreme Sea Levels

The effects of changes in mean sea level will be felt most acutely during extreme sea level events such as storm surges due to severe weather events

Extreme Sea Levels

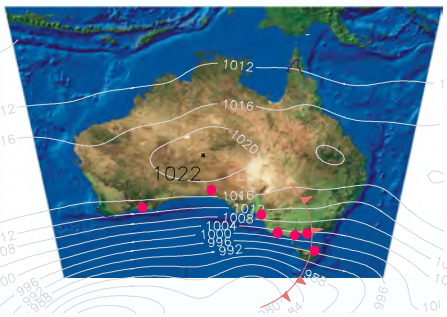




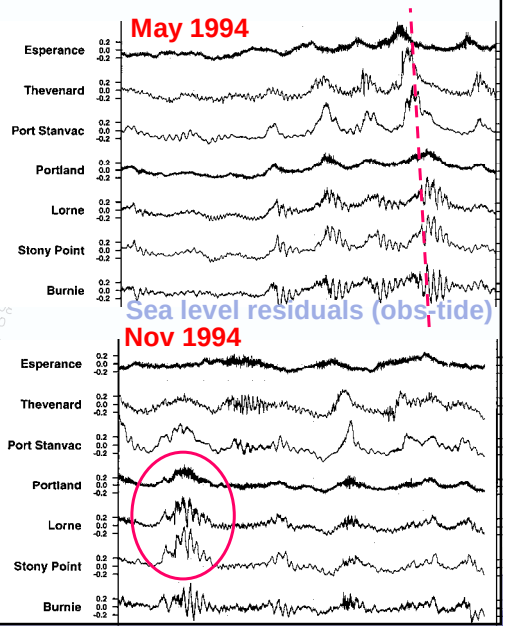
Different models and analysis are needed to understand the contributions to extreme sea levels from:

- Storm surge
- Tides
- Waves
- Climate variability (e.g. ENSO)
- Climate change including:
  - mean sea level rise
  - changes in weather systems
  - => changes in storm surges and waves

Southern Australian storm surges

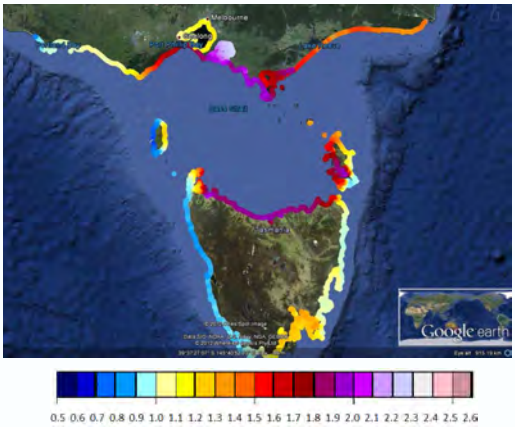


Cold fronts and midlatitude depressions are a major cause of storm surges along Victorian coast

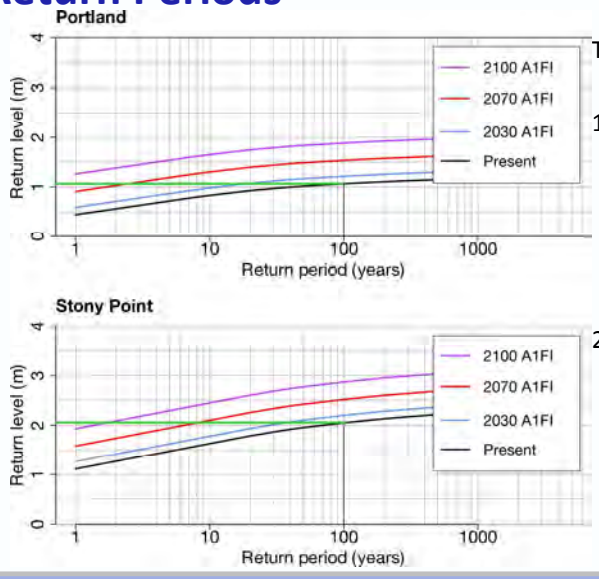


1 in 100 year coastal storm tide values

•Numerical modelling provides a means for estimating areas at risk of inundation due to storm surge plus sea level rise



Return Periods



Two ways to interpret a return period curve

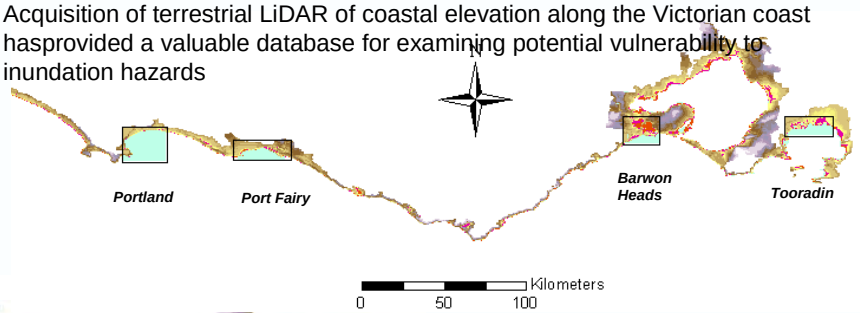
1. The height of a 1 in 100 year sea level event under baseline conditions will be experienced every year under an 80 cm rise in mean sea level
2. A 1 in 100 year level becomes 80 cm higher

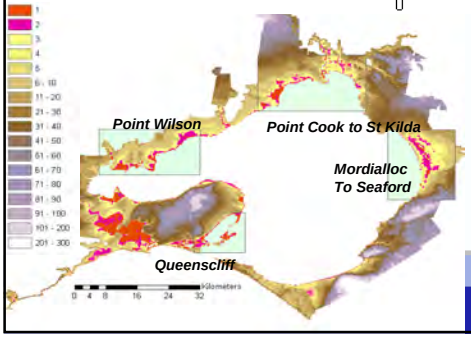
4. Coastal Inundation

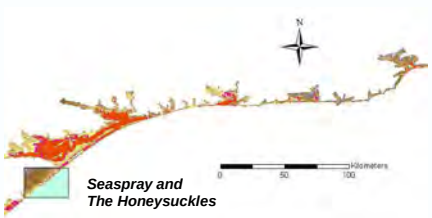
Better understanding of current climate risk of extreme sea levels provides a basis for understanding future vulnerability to inundation

Inundation analysis

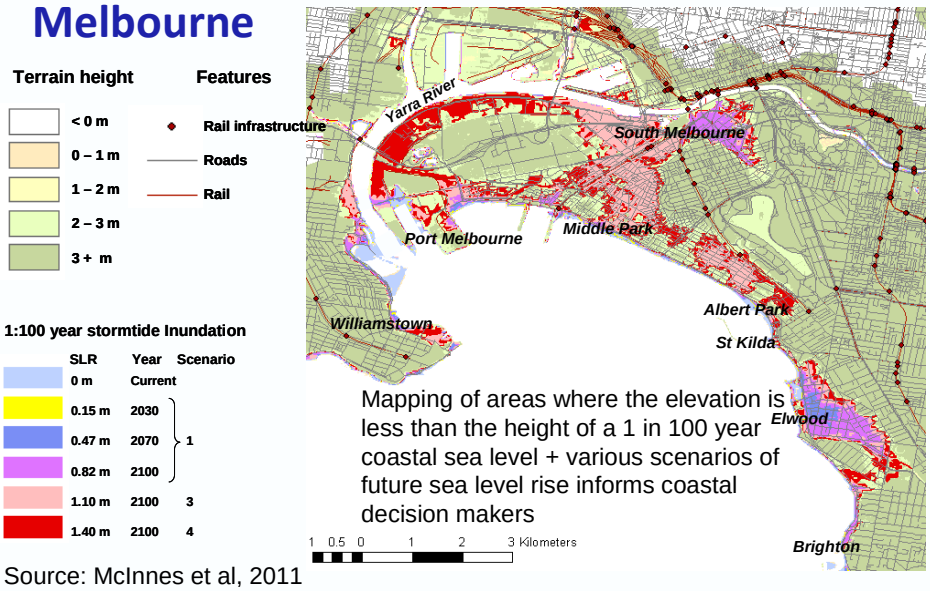
Acquisition of terrestrial LiDAR of coastal elevation along the Victorian coast hasprovided a valuable database for examining potential vulnerability to inundation hazards







Melbourne



Mapping of areas where the elevation is less than the height of a 1 in 100 year coastal sea level + various scenarios of future sea level rise informs coastal decision makers

Source: McInnes et al, 2011

5. Coastal Waves and Erosion

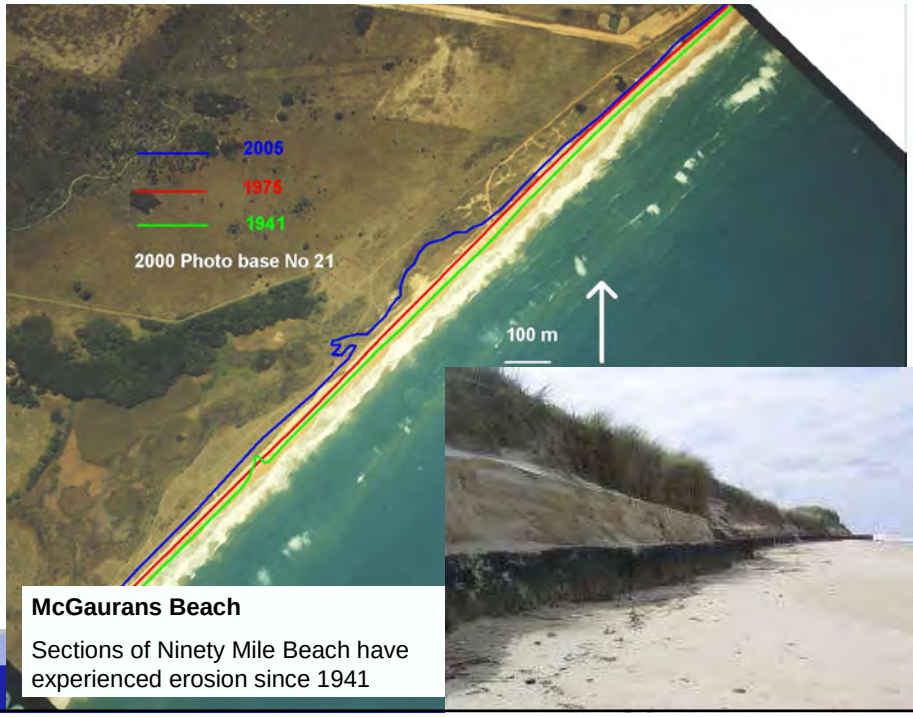
Ocean waves transfer energy to the shoreline

Seasonal cycles in weather and storms contribute to erosion and accretion

Rising sea levels allow the erosive qualities of waves to reach further onshore

Simple empirical rules (e.g. Bruun rule) suggest the 1 unit of vertical rise in sea level will lead to 50-100 units of horizontal erosion

Other factors such as sediment supply, wave climate change and storm frequency are also important



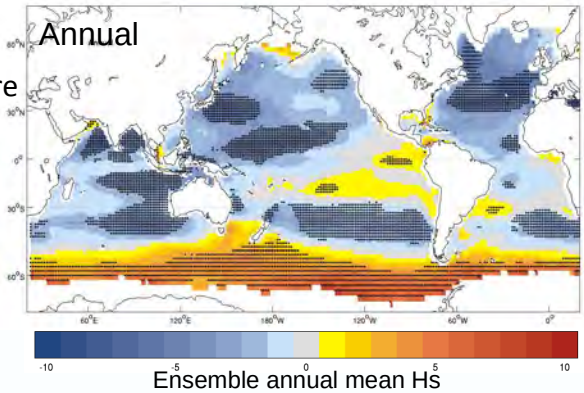
McGaurans Beach

Sections of Ninety Mile Beach have experienced erosion since 1941

The influence of changing weather patterns on waves

Observations indicate that the height of waves in the southern ocean are increasing

Modelling of wave conditions under future climate conditions indicate that wave heights will continue to rise



Ensemble annual mean Hs
(Future – Present) (% change)

Results show average change for (2081-2100) compared to (1981-2000) based on results from 20 climate models

6. Adaptation options

Adaption to climate change requires a risk management approach

Options for adaptation to coastal flooding include retrofitting existing developed areas or building

beach defences, changing building codes, planning and design standards to accommodate extreme and unpredictable conditions,

converting current land uses to those less sensitive to flooding,

Encouraging house insurance rates that send a clear signal about the advisability of living in flood-prone areas,

developing effective early warning systems and evacuation pathways for extreme events.

Source: (2011) http://www.csiro.au/climate-change-book

Summary

(1) Global sea levels are continuing to rise. Rates of rise over past 20 years are higher than the 20th Century average rate of rise

(2) Most of the 20th Century rise is due to thermal expansion and melting glaciers. However, the contribution of Greenland and Antarctic ice sheets will increase over this century

(3) Impacts of sea level rise will be felt most acutely during extreme sea level events. Extreme sea levels vary spatially and interannually due to influences of tides, weather and climate variability

(4) Sea level rise will lead to a marked increase the frequency of inundation events

(5) Rising sea levels, storm and wave climate changes influence erosion although our understanding of this effect is low

(6) There are synergies between adaptation to climate change and disaster risk reduction

Thank you

Centre for Australian Climate and Weather Research

Kathleen McInnes

11 October 2012