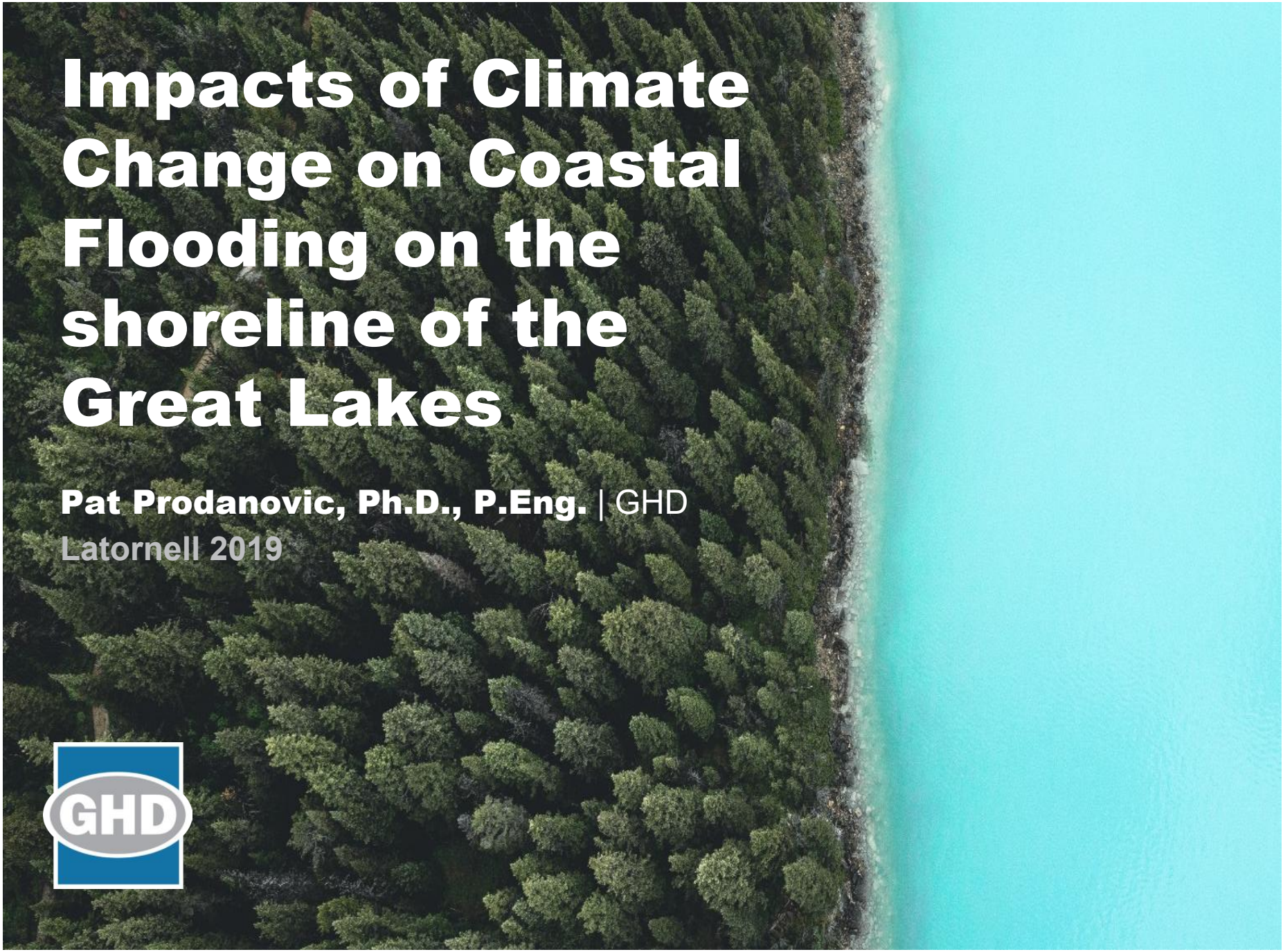

Impacts of Climate Change on Coastal Flooding on the shoreline of the Great Lakes

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Latornell 2019

Presentation Outline

- Coastal flooding in Canada under Climate Change (CC)
- PPS 2014
- Assessment of CC impacts
  - Stormwater drainage systems
  - Inland rivers and streams
  - Coasts of the Great Lakes
- Standards for flooding under CC not yet available
- Proposed methodology
  - How to assess impacts of CC on coastal flooding in the Great Lakes
- Future work

Coastal Flooding in Canada

- **British Columbia (2011, 2017)**
  - Add freeboard of 0.6 m
  - SLR 1 m by 2050, 2 m by 2100
- **Nova Scotia (2019)**
  - SLR from RCP8.5 scenario (worst case scenario, ~1 m +/-)
  - Add 0.65 m for melting of ice sheet
- **Ontario (2001)**
  - Flood hazard line: 100-yr inst. WL + Wave effects
  - Floodproofing EL: 100-yr mean monthly WL + 100 yr Storm Surge + Wave effects
  - No CC component

Recent
Dated

Ontario's Provincial Policy Statement (PPS)

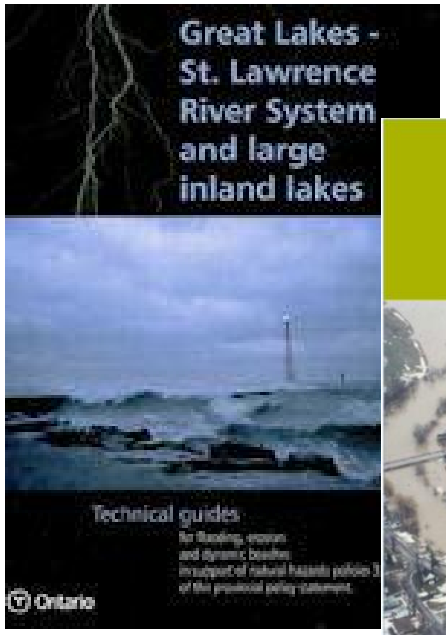
- Section 3.1.3 of the PPS (2014) reads:

- "Planning authorities shall consider the potential impacts of climate change that may increase the risk associated with natural hazards".

- Proposed PPS (July 2019), start of Section 3.0 reads:

- "(Note: policies in this section related to natural hazards are subject to ongoing review by the Province's Special Advisor on flooding. Further changes may be considered as a result of this review)".

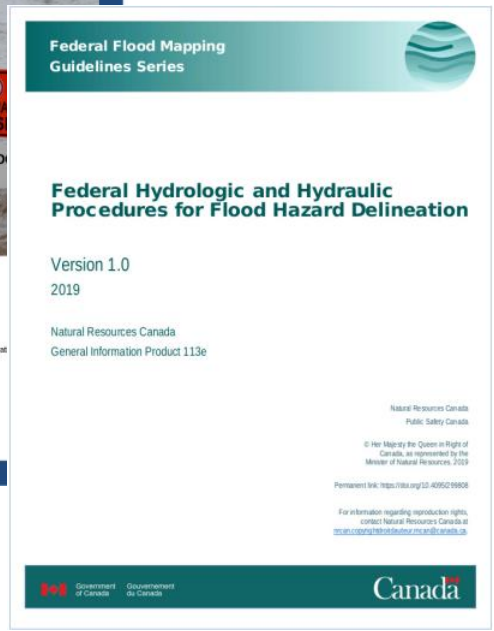
Flooding related guidelines in Ontario



MNR, 2001

MNR, 2002

EWRG, 2017



NRC, 2019

Guidelines for impacts of CC on flooding

- Urban (and Municipal) systems
  - Municipalities leading the charge
  - Governments have started drafting guidelines
- Rivers and Streams systems
  - Assessments completed for some larger watersheds
  - No consistent methodology yet
- Coastal flooding
  - Ocean coasts focusing on sea level rise / land subsidance
  - Nothing yet established for Great Lakes

Climate Change Considerations from NRC, 2019

Number	Climate Change Consideration Practices
H.1	Involve the advice of a qualified professional when selecting, analyzing and using climate information for flood mapping.
H.2	Freeboard may be used as a qualitative method for accounting for climate change uncertainty.
H.3	Conduct downscaling for cases in which this approach will reduce the uncertainty associated with using a Global Climate Model.
H.4	Consider changes in sea level as well as hydrologic processes, climate processes, tides, and storm effects when analysing coastal flooding.
H.5	Update climate change projections as regularly as is reasonable and incorporate recent scientific developments.

Impacts of CC on flooding in Ontario

- **Stormwater and Municipal Systems**
  - GCM outputs: temperature, precipitation
  - Perturb historic rain based on GCM outputs to get future conditions (IDF-CC)
  - Synthesize into IDF curves, use in design
- **Inland Rivers and Streams**
  - GCM outputs: temperature, precipitation, evapotranspiration, etc.
  - Use as input to local hydrologic models, and generate flows under CC
  - Produce floodlines for existing and future CC conditions
  - Plan for future based on results

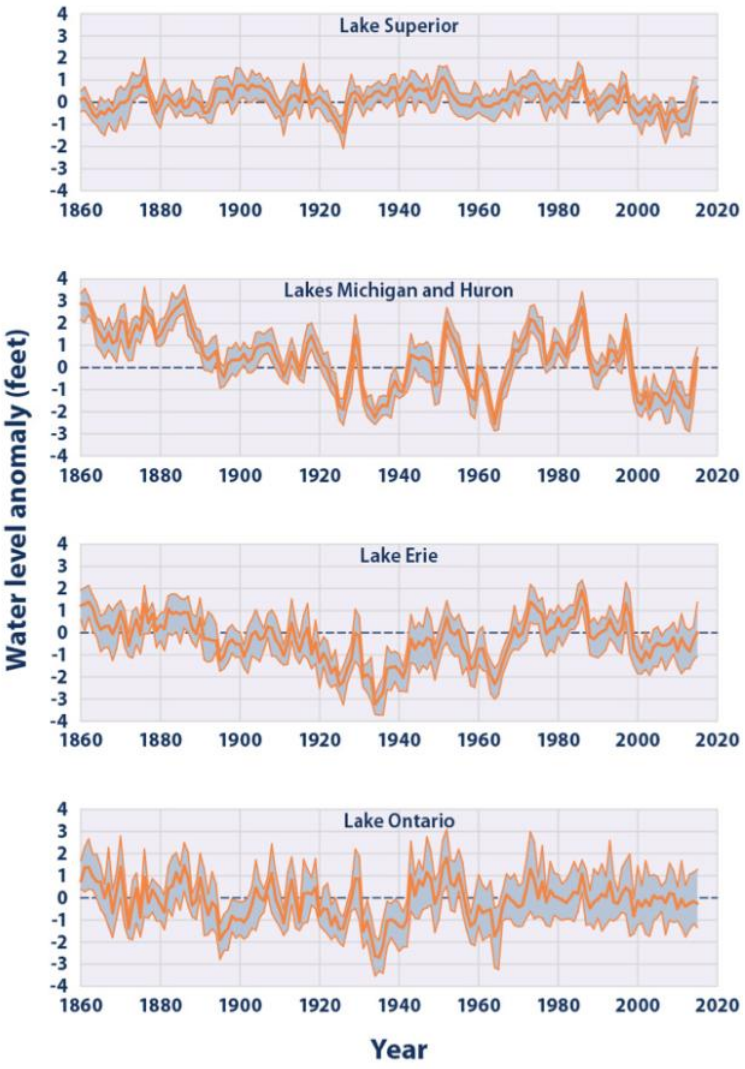
Impacts of CC on flooding in Ontario, cont'd

- **Great Lakes Coasts**
  - GCM outputs: temperature, precipitation, wind
  - Assess Lake Levels under CC (use NOAA's Large Basin Runoff Model, LBRM)
  - Assess Storm Surges under CC (Hydrodynamic modeling)
  - Assess Wave Climate under CC (Wind generated wave modeling)
  - Assess impacts of wave effects (uprush, runup)

Legend
Previously studied by others
Not yet available in literature

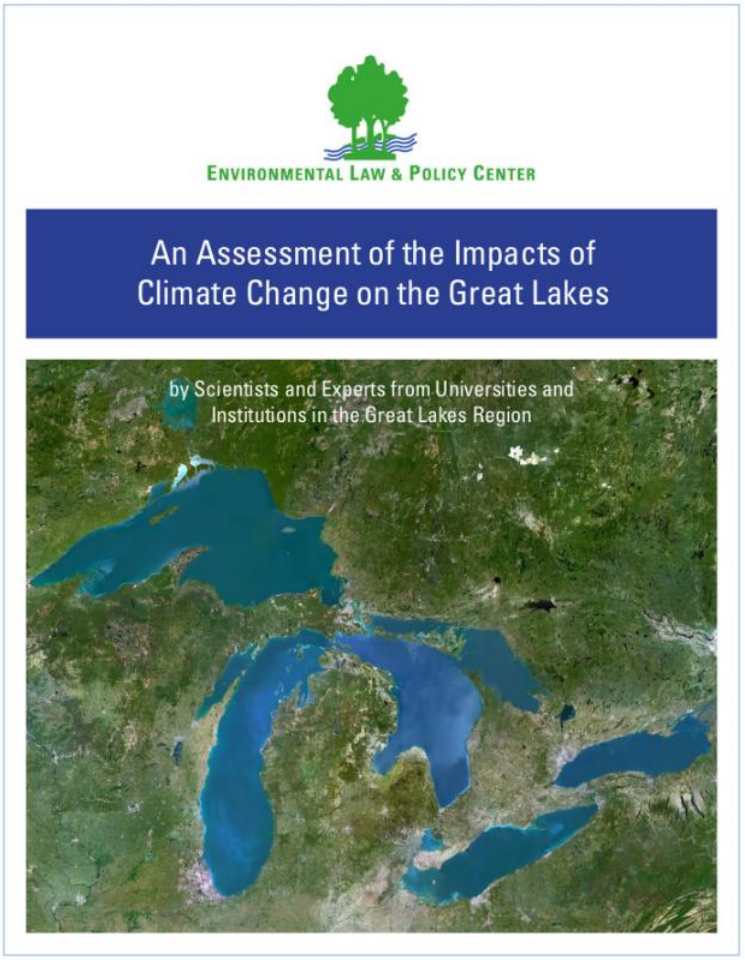
Proposed methodology

- **Part 1: Water levels & ice under CC**
  - Get NOAA's LBRM, or equivalent
  - Get GCM output for alternate climate scenarios (Precipitation, Temperature, Evapotranspiration, etc),
  - Get daily fluctuations in water levels under altered climate
  - Develop long term representative scenarios of daily water levels for all Great Lakes
  - Estimate ice cover under future climates (reduction over time)



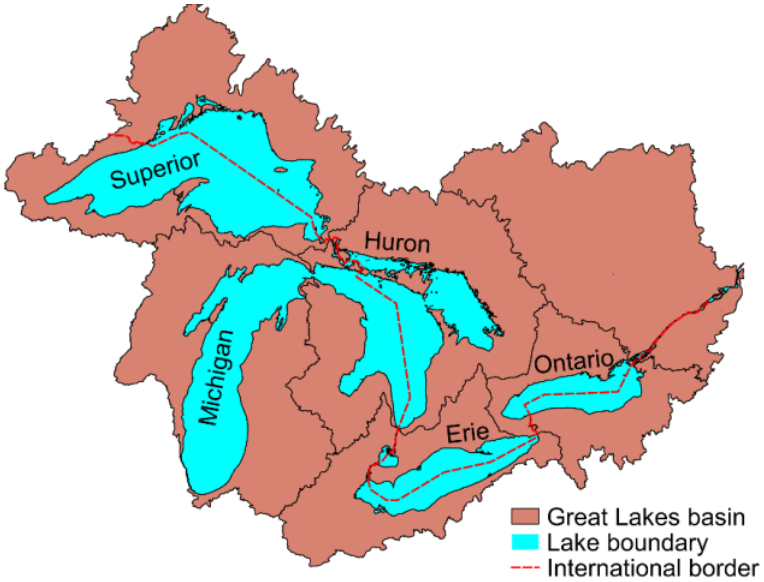
Great Lakes water levels under CC

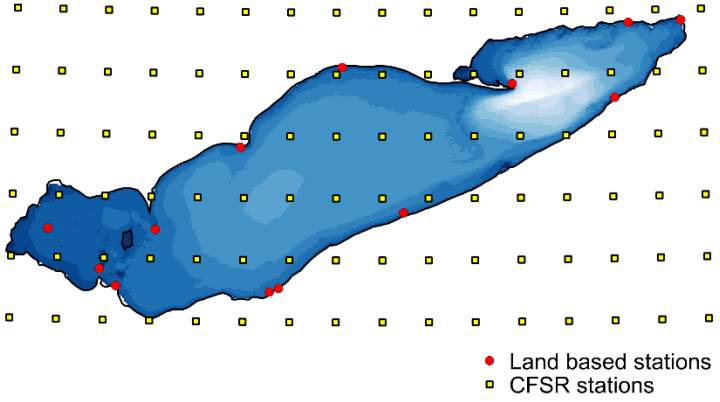
"Newer model-based projections of lake level (since 2011) foresee a ***central tendency toward small drops in lake levels*** to the end of the 21st century, ***with appreciable probability of small rises in lake levels***, in contrast to the large drops projected using the older, now-defunct methodology."



Proposed methodology, con'd

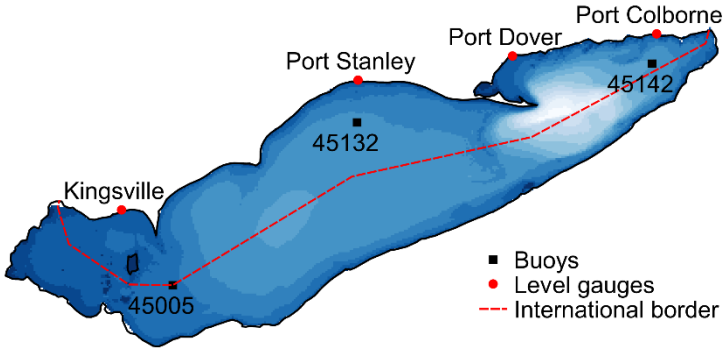
- **Part 2: Wind fields under CC**
  - Get historic NCEP CFSR and CFSv2 reanalysis data (gridded winds at hourly time step, ~50 yrs)
  - Get GCM wind data for various scenarios (at daily time step)
  - Derive change fields for winds
  - Apply change fields to gridded historic data
  - Establish wind fields (50 yr record, hourly data) for future climates



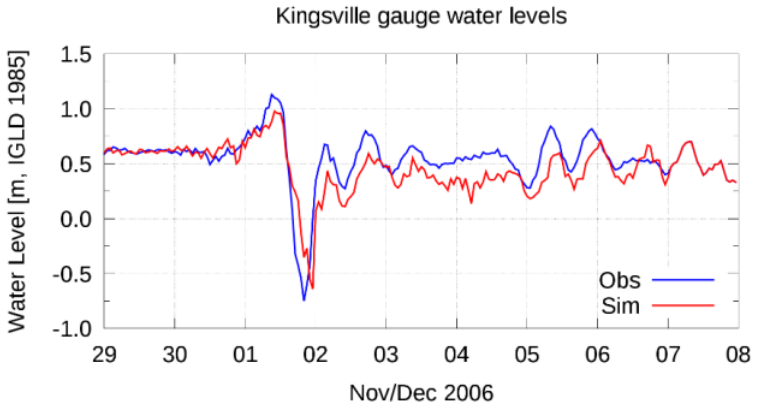


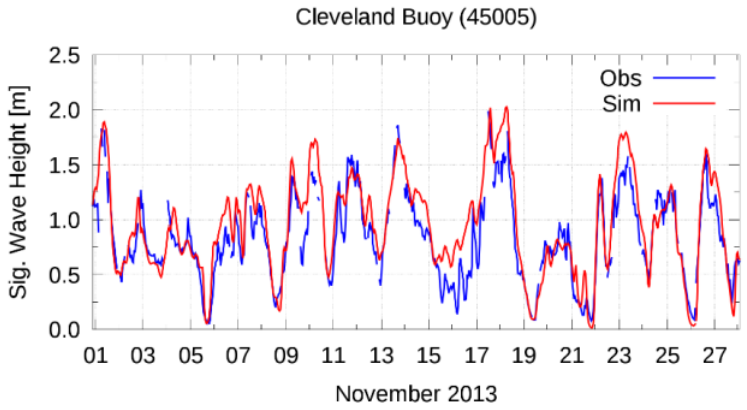
Proposed methodology, con’d

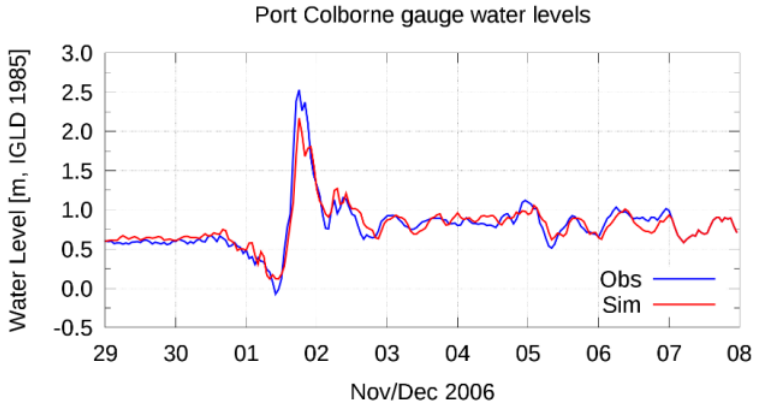
- **Part 3: Storm surges and waves under climate change**
  - Use lake wide numeric models and simulate continuous effect of wind
  - Respect long term fluctuations under climate change (derived earlier)
  - Establish hourly water levels for each of future wind climates considered
  - Establish hourly wave heights, period, direction for future wind climates

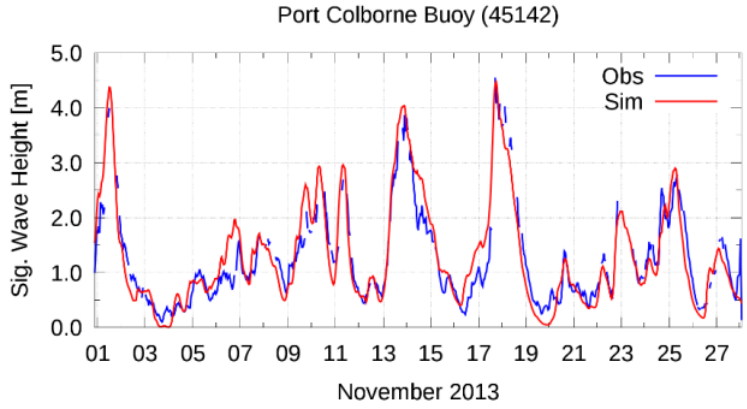


Numeric simulations using open source numerical code TELEMAC at Lake Erie









Proposed methodology, con’d

- **Part 4: End product**
  - Impact of CC on storm surges quantified
  - Impact of CC on wave climate quantified
  - Assess coastal flood hazards, floodproofing elevation in response to CC
  - Assess coastal erosion impacts to CC (driven by wave climate)

Conclusions, and outlook for future

- **Impact of CC on coastal flooding (or erosion) within the Great Lakes is not known**
- Need a coordinated, Province wide, methodology for CC impact assessment
- Existing guidelines need updating
- Need to be consistent with PPS
- Scientific knowledge is never perfect, but is always improving
- Methodology and tools are now available to get started ...


Questions
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