The impact of continuous space and time-resolving vertical land motion on relative sea level change

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Understanding sea level changes: global to local, from past to future

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The impact of vertical land motion on relative sea level change

- **Vertical land motion** significantly contributes to regional relative sea level change
- Accurate VLM estimates are required to understand contemporary and future relative sea level change

**Challenges:**
- Previous studies incorporated limited assumptions of VLM processes (i.e., GIA VLM) and limited observational constraints
- Point-wise VLM observations are limited in time and space
- Several processes cause **nonlinear** VLM or regional non-GIA VLM (tectonic activity, mass loading changes, human-induced VLM)

**Reconstruction of time- and space-resolving VLM**

- 10.957 GNSS time series¹
- 713 Altimetry minus tide gauge time series²
- Period: 1995 - 2020

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¹² from NGL; Blewitt et al., 2016; CMEMSrefs; PSMSLrefs

³⁴⁵ Church et al., 2013; Dangendorf et al., 2019, IPPC AR6refs
Reconstructing time- and space-resolving vertical land motion

- Bayesian Principal Component Analysis + transdimensional regression

\[ U(x, t) = g(x)t + \sum_{k=1}^{n} PC_k(t)W_k(x) + \epsilon(x) \]

Height changes = linear trend + present-day variability + noise

A

- Trend

B

- \( g(x) \)

C

- \( PC_1(t) \)

- \( W_1(x) \)
Non-linear VLM along global coastlines

Frederikse et al., 2020

1Frederikse et al., 2020
The contribution of VLM to contemporary regional sea level change

Absolute SLC from a SL reconstruction\(^1\) and VLM corrected tide gauges over 1900-2000

1\(^1\)(SL Reconstruction, Dangendorf et al., 2019)

\(\text{SLC} [\text{mm/year}]\)

\(\text{ASL (1900-2000)}\)

Caron et al., 2020

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Non-linear VLM inflates projected regional coastal sea level change uncertainties

- VLM explains 49% of the regional relative sea level change variance of the deviations from the GMSLC
- Non-linear VLM increases relative sea level change uncertainties (explaining 33% of combined uncertainties)
- Confidence in relative sea level change is reduced in regions with high present-day VLM variability (i.e., due to tectonic activity)

> VLM reconstruction provides enhanced understanding of non-GIA and non-linear VLM effects on coastal sea level change
Non-linear VLM inflates projected regional coastal sea level change uncertainties

Projected relative sea level change until 2150

Thank You!!

paper/data in preparation

https://github.com/oelsmann/discotimes
https://github.com/rhyshawkins/TransTessellate2D
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VLM reconstruction provides enhanced understanding of non-GIA and non-linear VLM effects on coastal sea level change


Appendix
Appendix
Appendix

A

B

C

D

mm/year

mm/year

mm/year

mm/year

60°W 0° 60°E

60°W 0° 60°E

60°W 0° 60°E

60°W 0° 60°E
Appendix

VLM-Rec. vs. GIA-VLM

Garrison-Laney and Miller, 2017
Appendix

A

stddev. of VLM across the solutions

stddev. of estimated modes: $\sigma_{PC\otimes EOF}$

region
- W-Europe
- Baltic Sea
- E-US Coast
- New South Wales
- E-Japan
- S-Africa
- WS-America

B

World map showing distribution and density of estimated modes.

- Color scale indicates values from 0 to 10.

- Regions marked with different colors and symbols.

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