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

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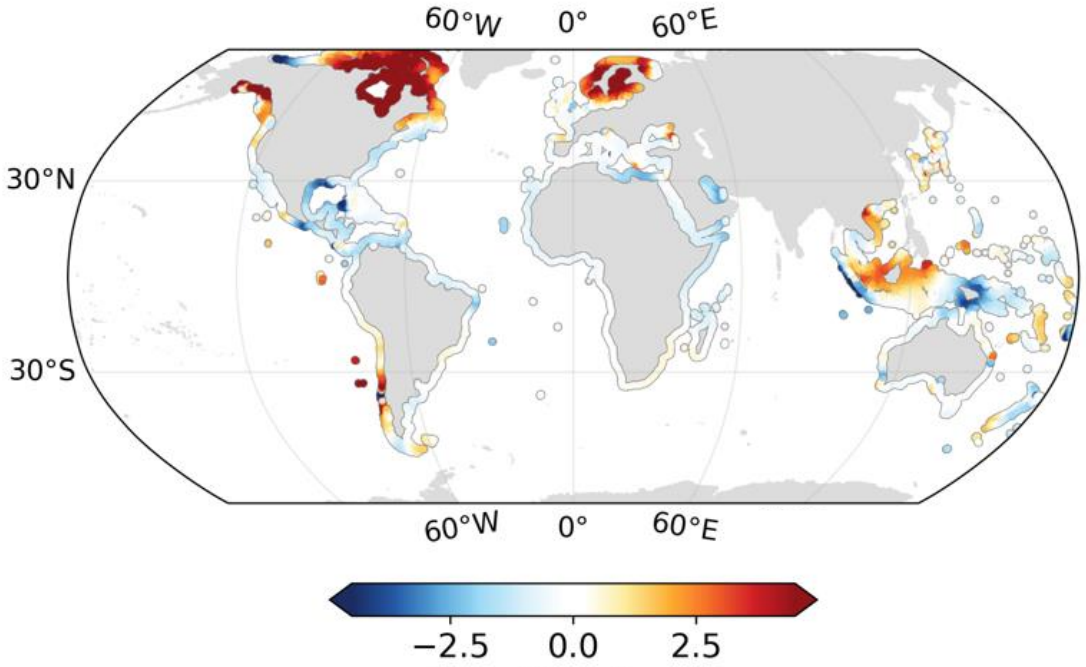

Understanding sea level changes: global to local, from past to future

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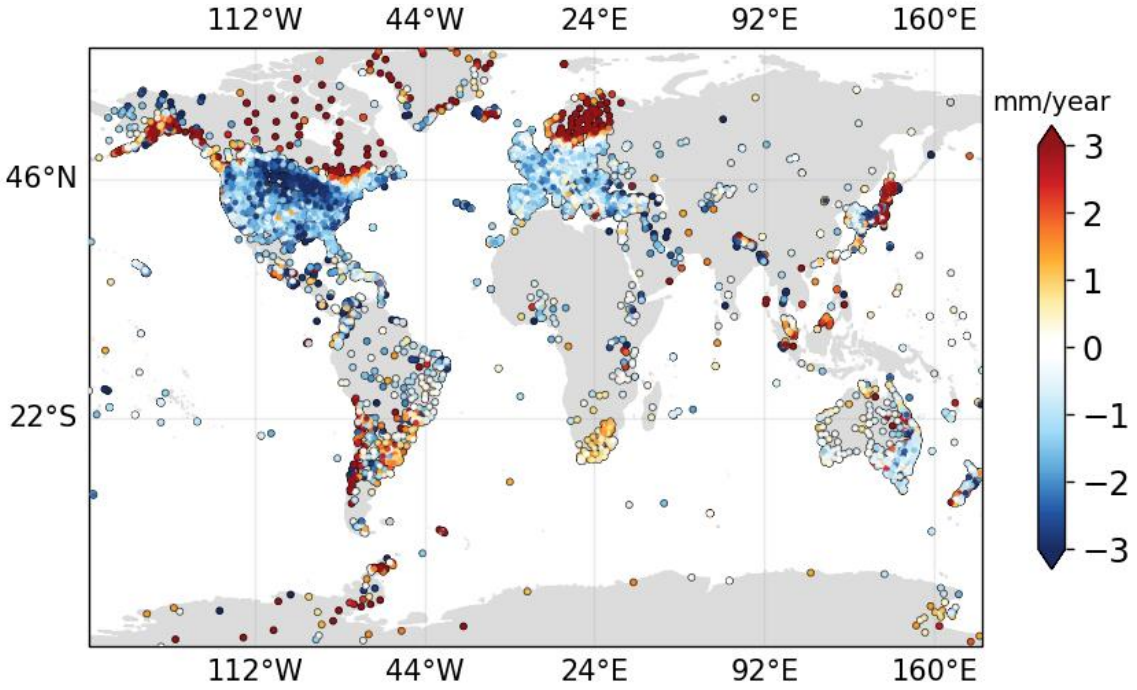
The impact of vertical land motion on relative sea level change

Vertical land motion observations



- 10.957 GNSS time series[1]
- 713 Altimetry minus tide gauge time series[2]
- Period: 1995 - 2020

- 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[3,4,5]
- 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

[1,2] from NGL; Blewitt et al., 2016; CMEMS[refs]; PSMSL[refs]

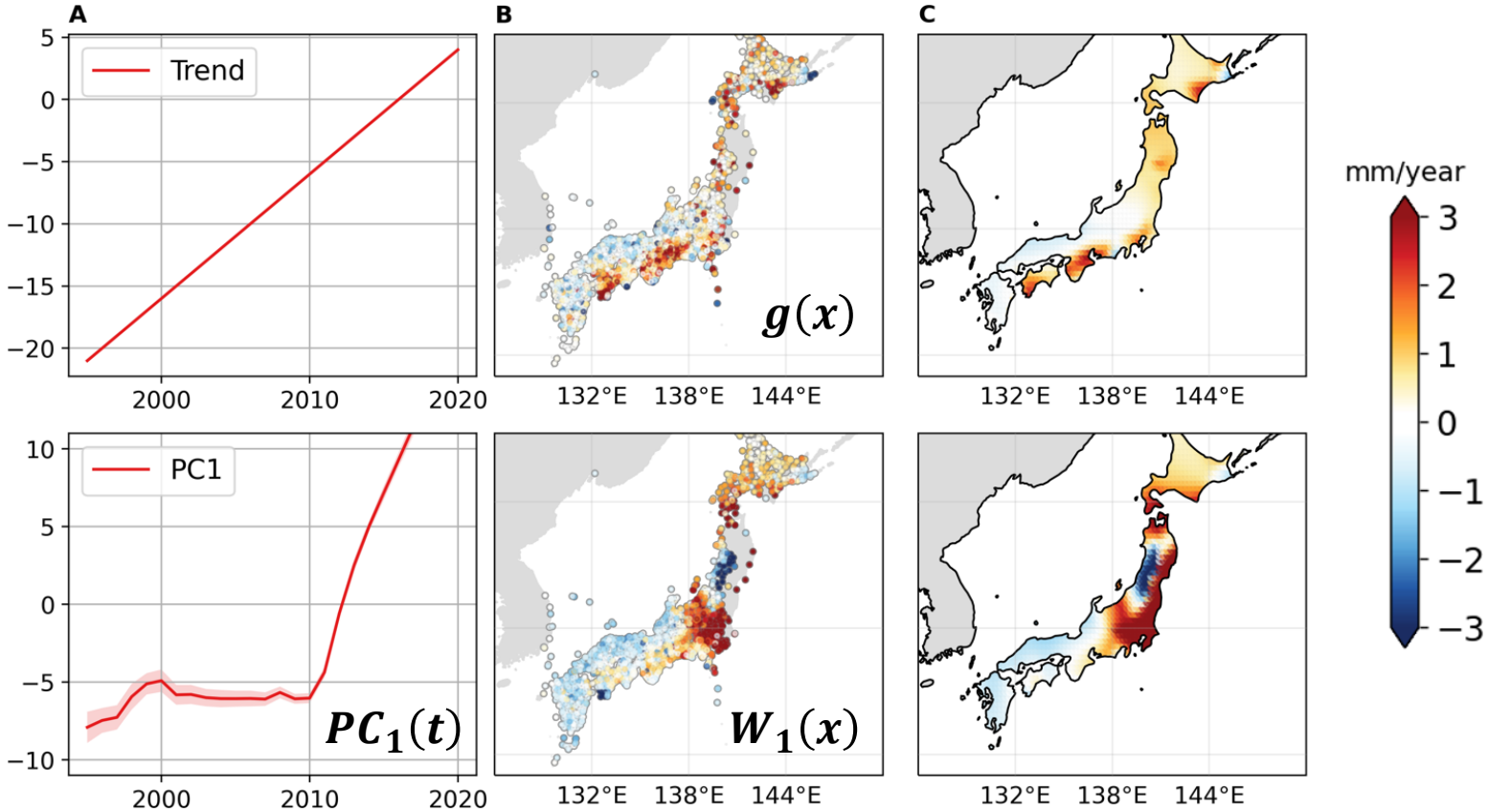
[3,4,5] Church et al., 2013, Dangendorf et al., 2019, IPPC AR6[refs]

Reconstructing time- and space-resolving vertical land motion

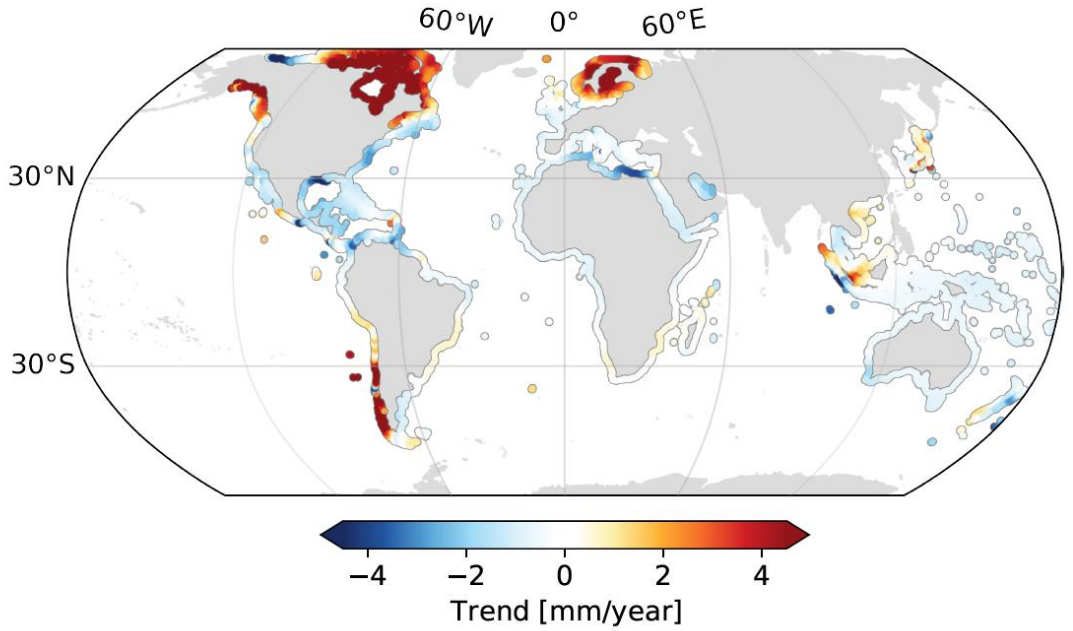
- Bayesian Principal Component Analysis + transdimensional regression

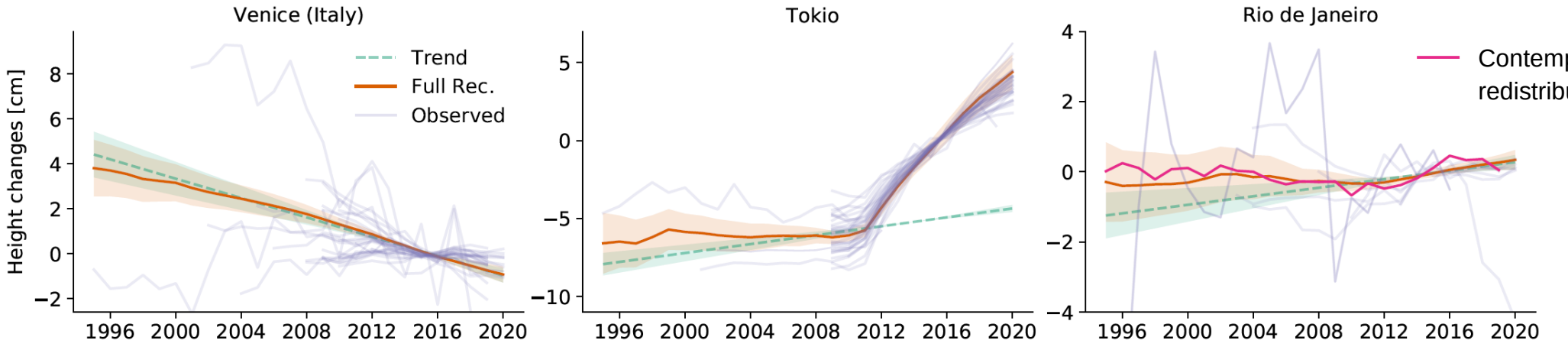
$$U(x,t) = g(x)t + \sum_{k=1}^{n} PC_k(t)W_k(x) + \epsilon(x)$$

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



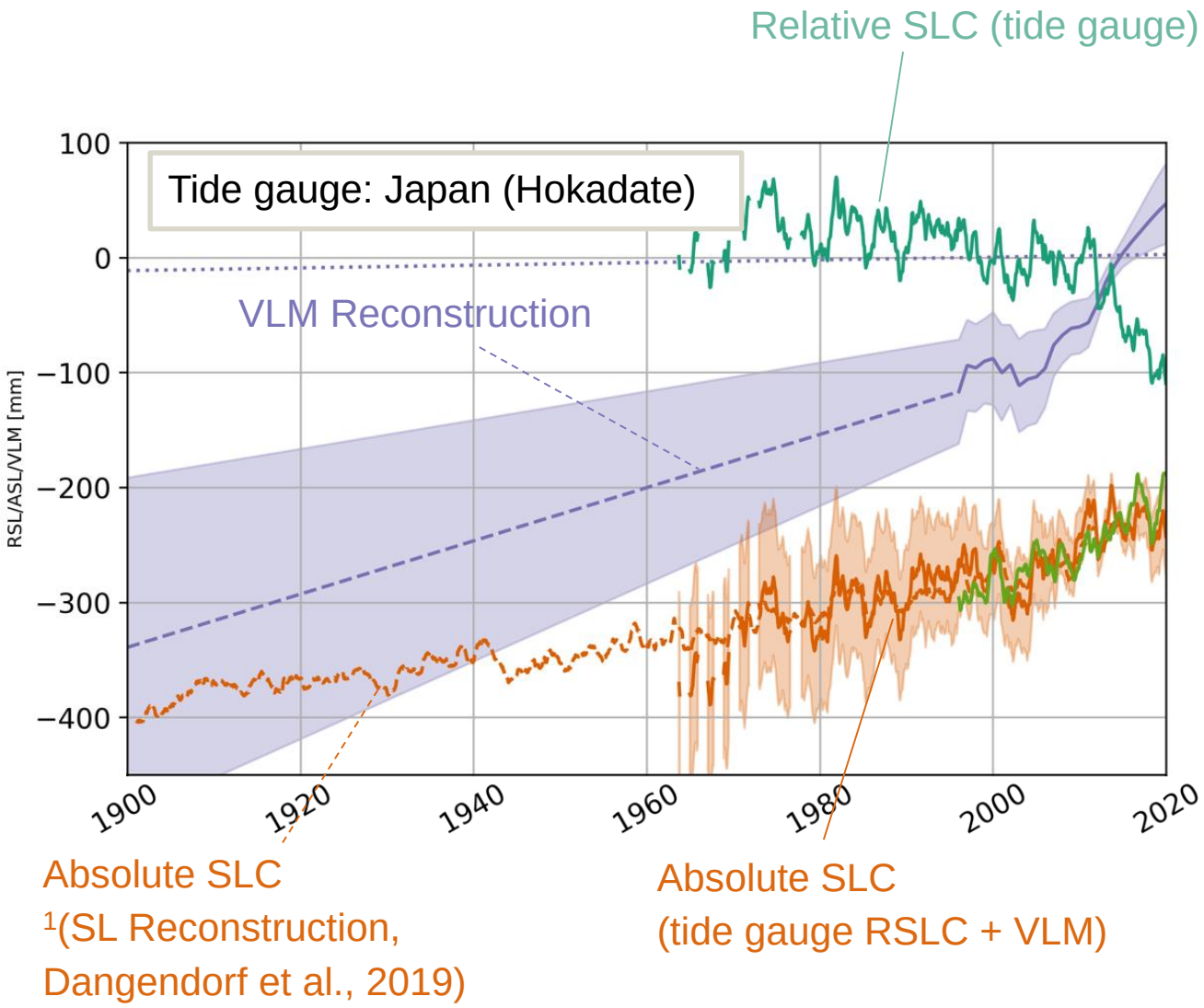
Non-linear VLM along global coastlines



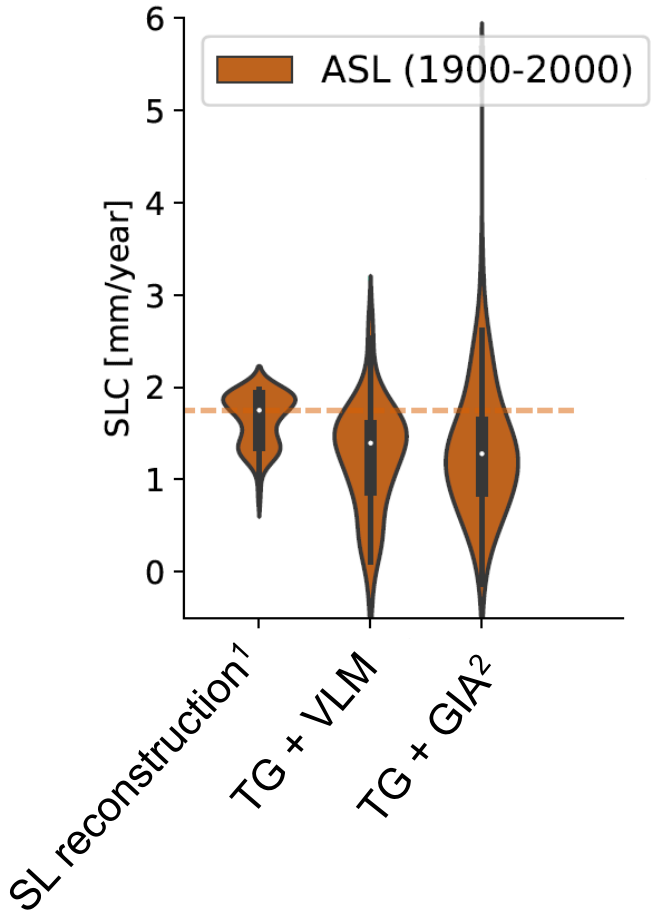


[1]Frederikse et al., 2020

The contribution of VLM to contemporary regional sea level change

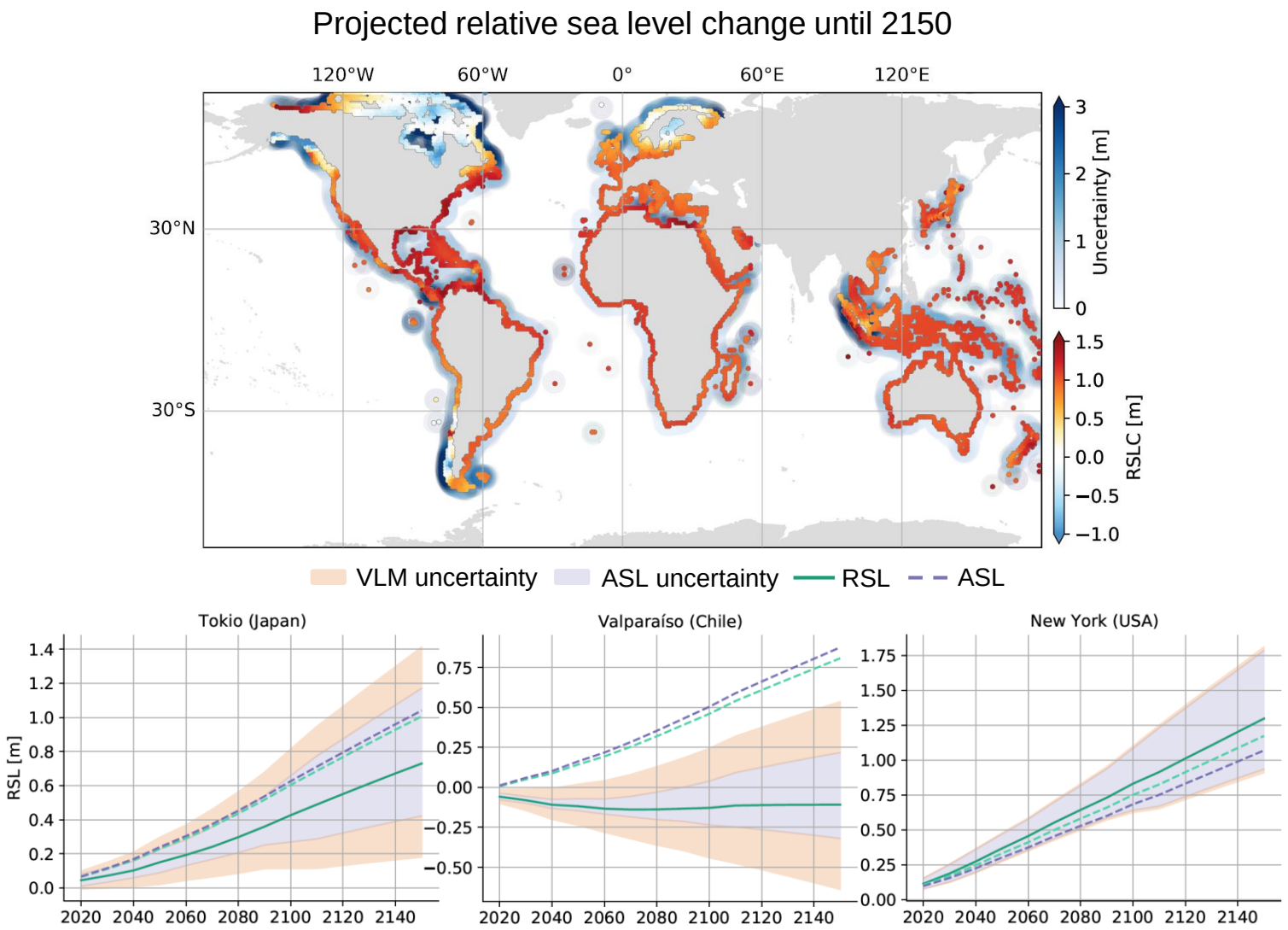


Absolute SLC from a SL reconstruction[1] and VLM corrected tide gauges over 1900-2000



[2] Caron et al., 2020

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



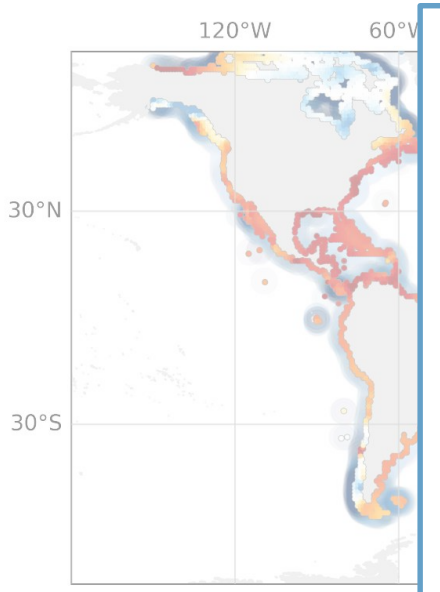
Absolute sea level projections from IPCC AR6/SSP2-45

- 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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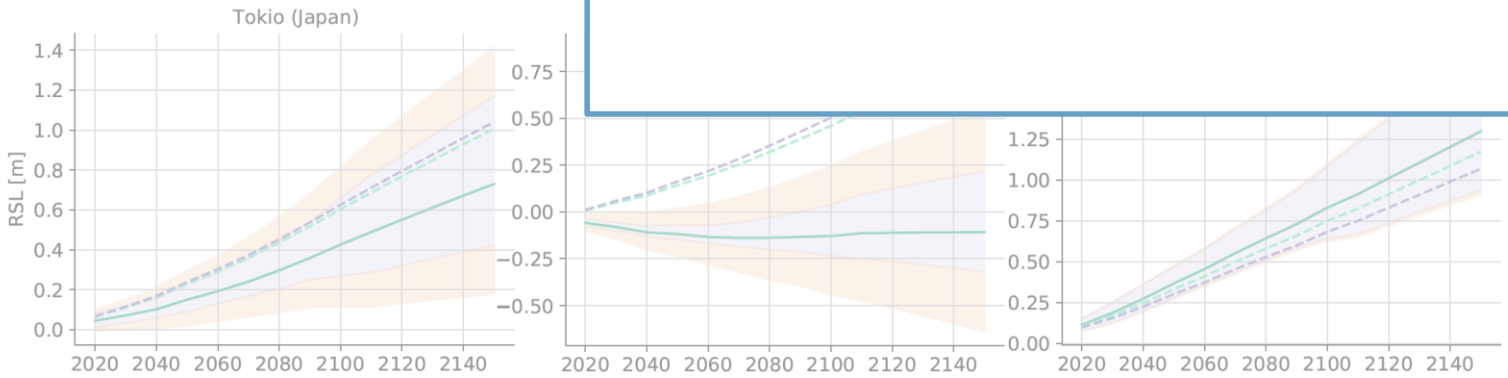

Absolute sea level projections from IPCC AR6/SSP2-45

- VLM reconstruction provides enhanced understanding of non-GIA and non-linear VLM effects on coastal sea level change

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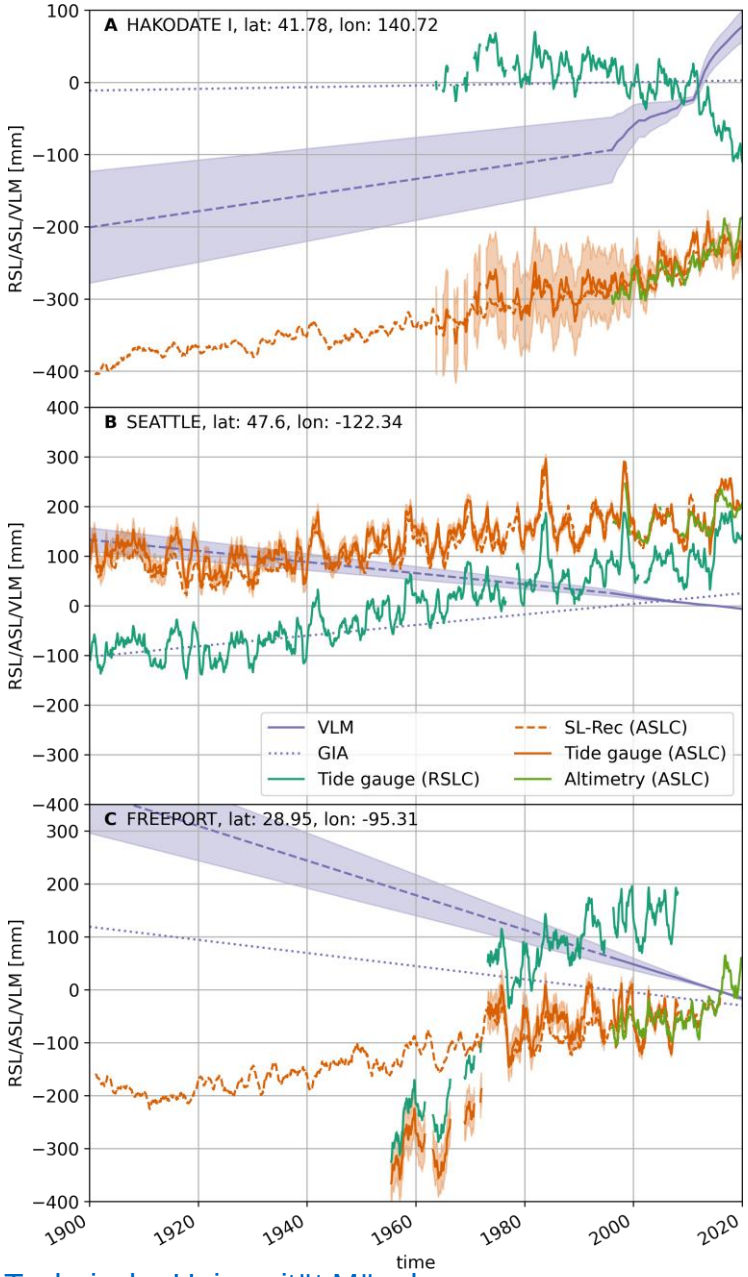
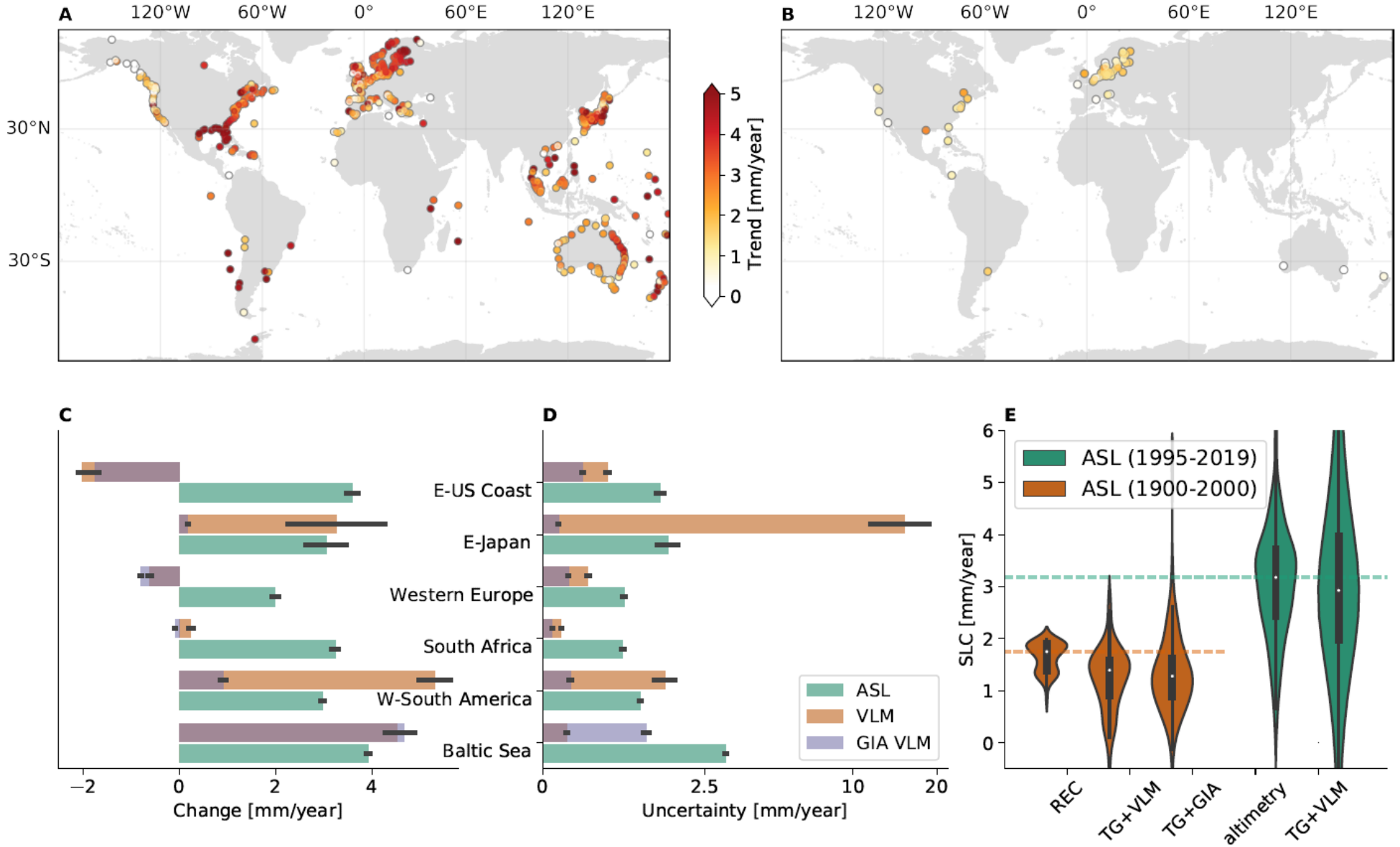
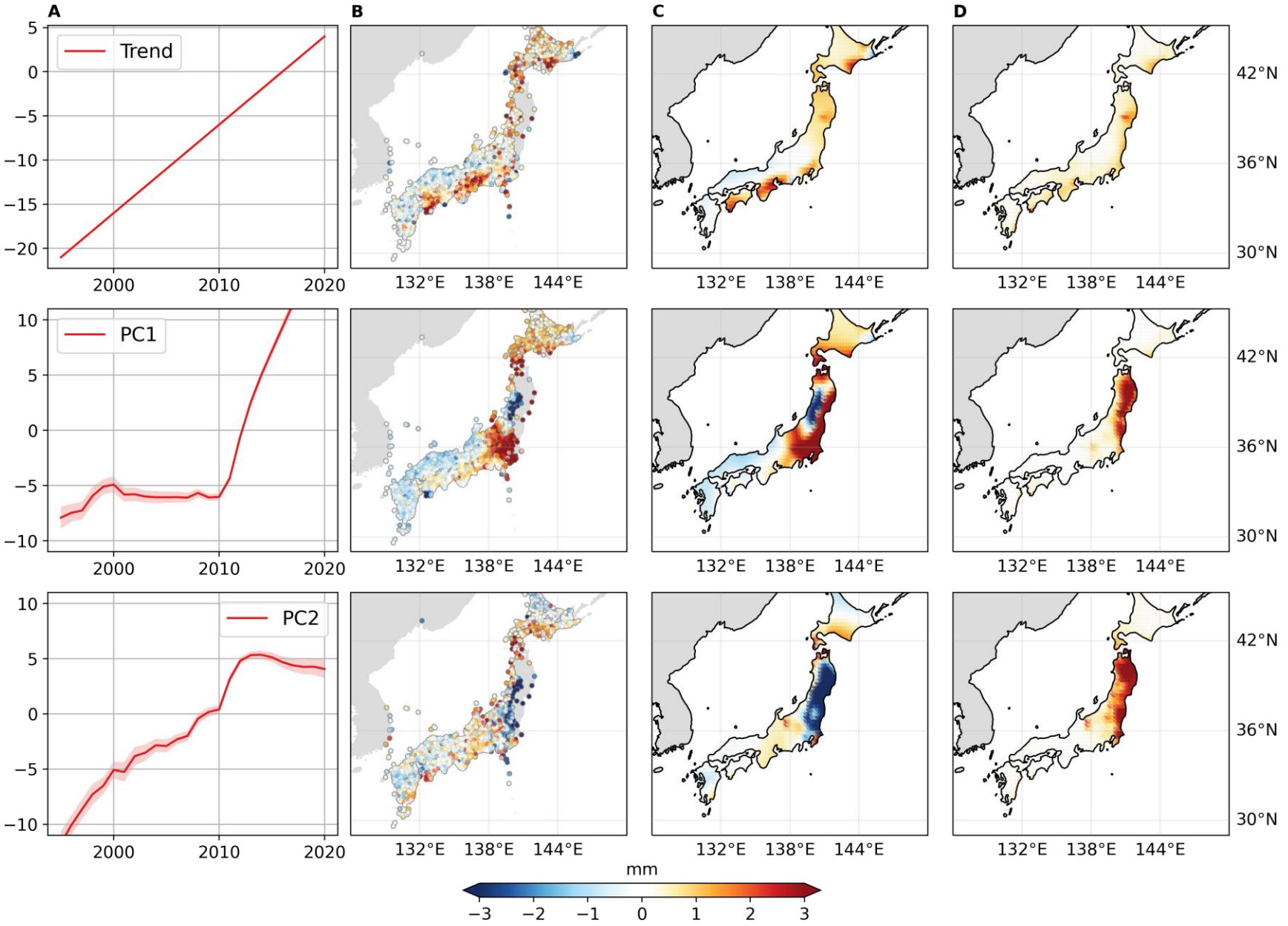
Appendix


A HAKODATE I, lat: 41.78, lon: 140.72
B SEATTLE, lat: 47.6, lon: -122.34
C FREEPORT, lat: 28.95, lon: -95.31
RSL/ASL/VLM [mm]
time
VLM
GIA
Tide gauge (RSLC)
SL-Rec (ASLC)
Tide gauge (ASLC)
Altimetry (ASLC)

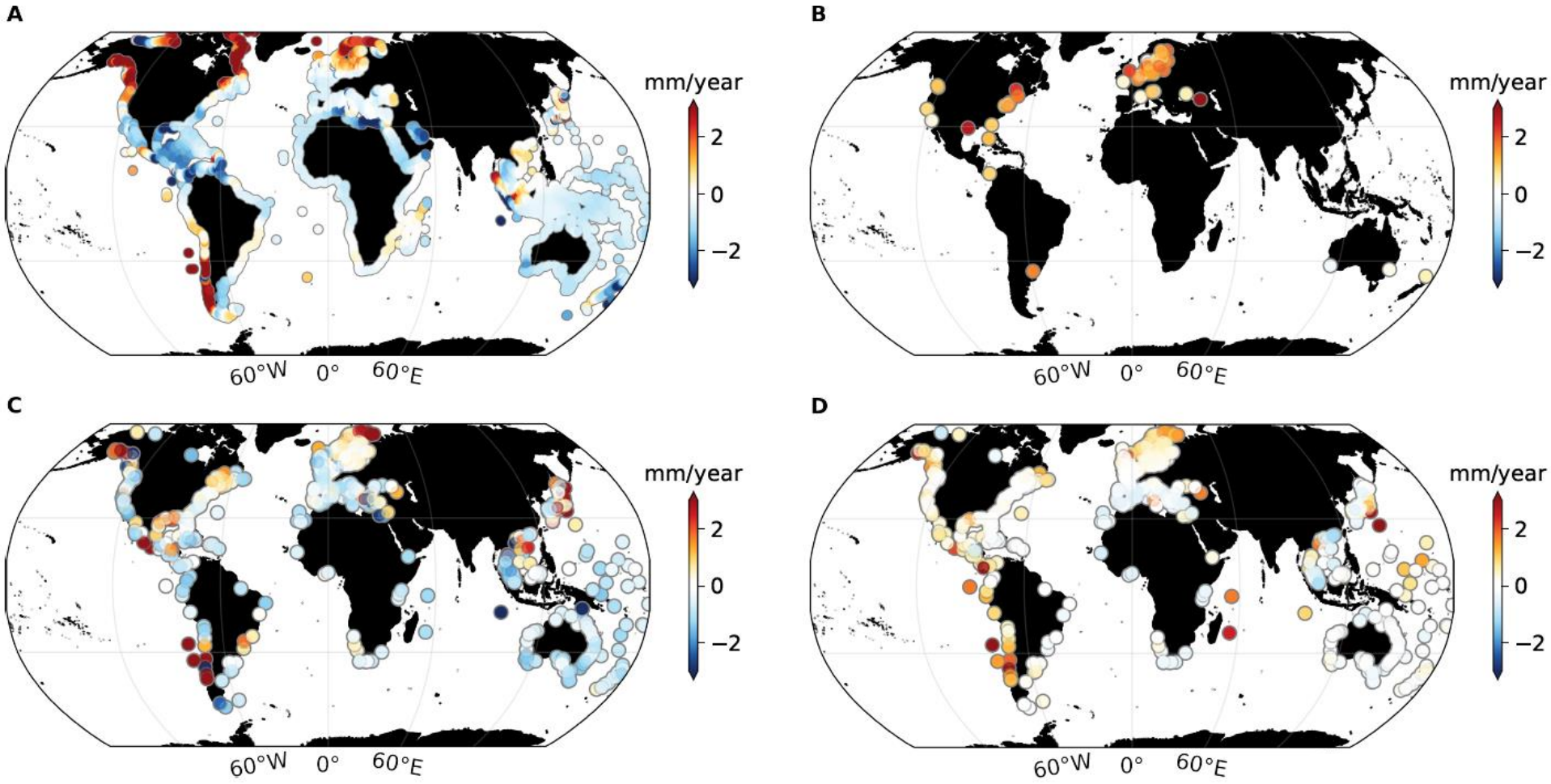
Appendix


A
120°W
60°W
0°
60°E
120°E
30°N
30°S
Trend [mm/year]
5
4
3
2
1
0
B
C
Change [mm/year]
−2
0
2
4
D
E-US Coast
E-Japan
Western Europe
South Africa
W-South America
Baltic Sea
ASL
VLM
GIA VLM
0
2.5
10
20
Uncertainty [mm/year]
E
ASL (1995-2019)
ASL (1900-2000)
SLC [mm/year]
6
5
4
3
2
1
0
REC
TG+VLM
TG+GIA
altimetry
TG+VLM

Appendix

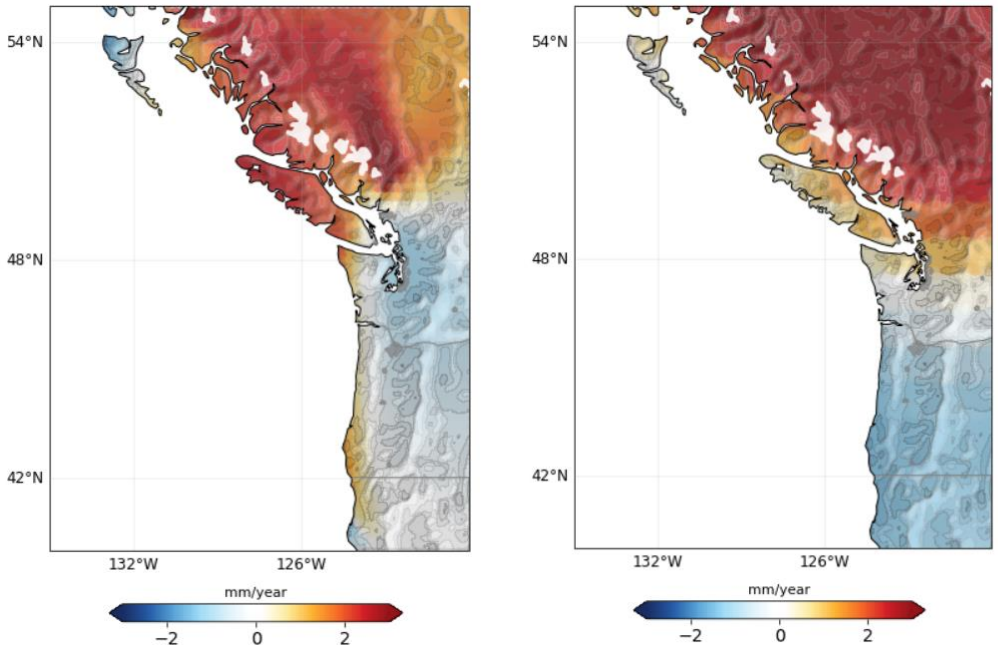

A
B
C
D
Trend
PC1
PC2
2000
2010
2020
132°E
138°E
144°E
42°N
36°N
30°N
mm
−3
−2
−1
0
1
2
3

Appendix



Appendix

VLM-Rec. vs. GIA-VLM



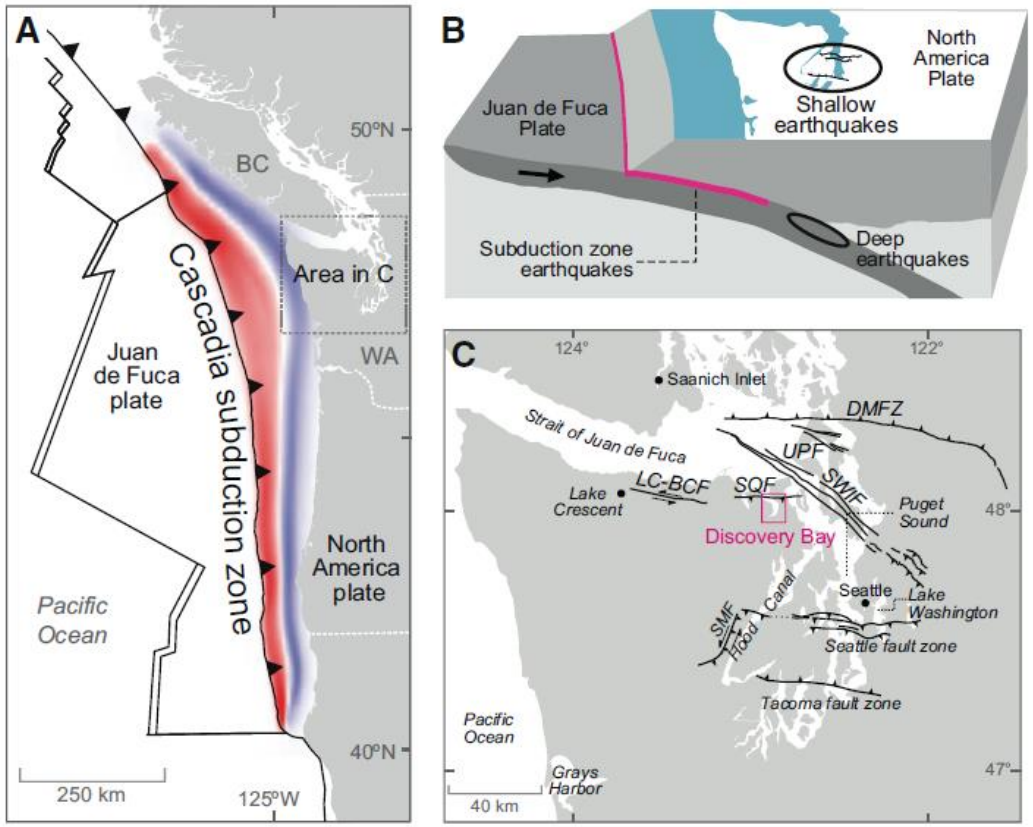
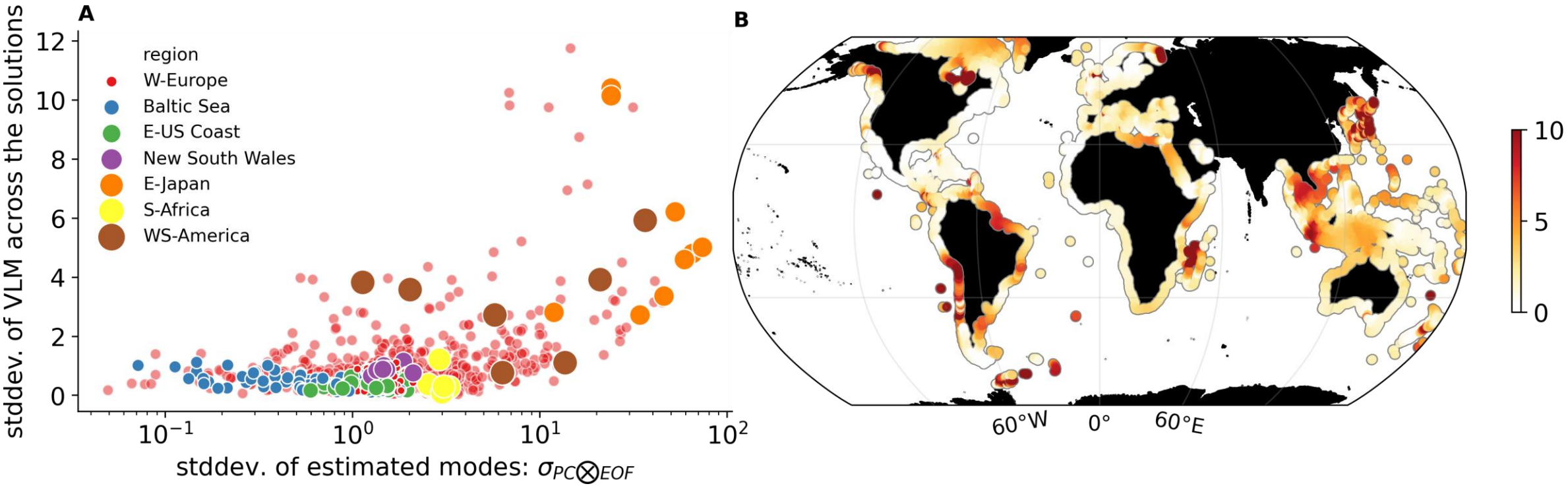


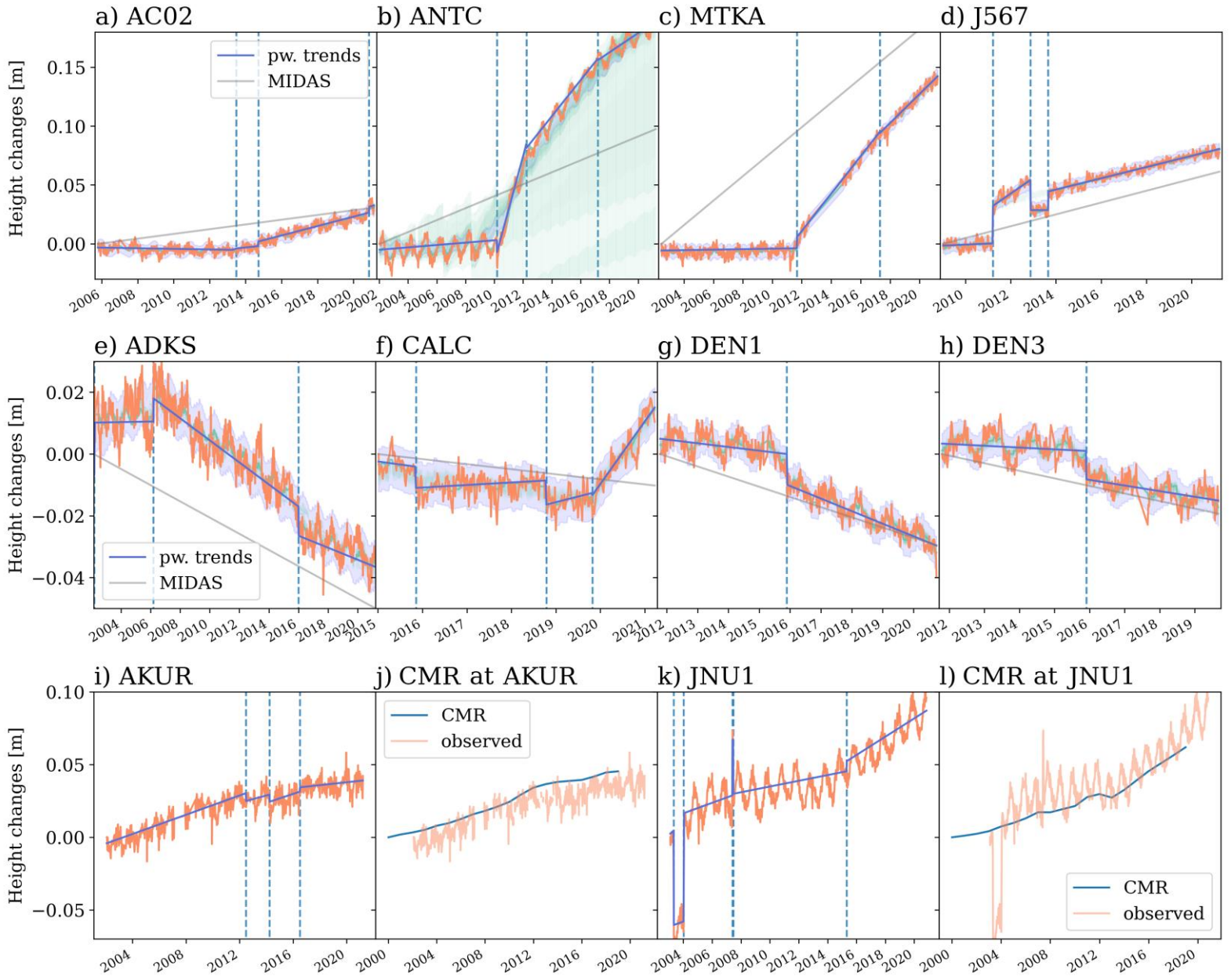
Figure 2.

Garrison-Laney and Miller, 2017

Appendix


A
B
region
W-Europe
Baltic Sea
E-US Coast
New South Wales
E-Japan
S-Africa
WS-America
stddev. of VLM across the solutions
stddev. of estimated modes: $\sigma_{PC \otimes EOF}$
60°W
0°
60°E
10
5
0

Appendix


a) AC02
b) ANTC
c) MTKA
d) J567
e) ADKS
f) CALC
g) DEN1
h) DEN3
i) AKUR
j) CMR at AKUR
k) JNU1
l) CMR at JNU1
pw. trends
MIDAS
CMR
observed
Height changes [m]