Observations and simulations to characterize a changing estuary:

The good, the bad, and the uncertain

António M. Baptista

2018 Columbia River Estuary Conference

Thanks to:

- **Present and past research staff in my group. Currently:**
  - Paul Turner (s. 1988)
  - Michael Wilkin (s. 1996)
  - Charles Seaton (s. 2001)
  - Sarah Riseman (s. 2010)
  - Jo Goodman (s. 2012)
- **Faculty, researchers, managers, staff and students of NSF-STC CMOP (2006-2017) and of the many other collaborative projects that have over time informed and reshaped the SATURN infrastructure**

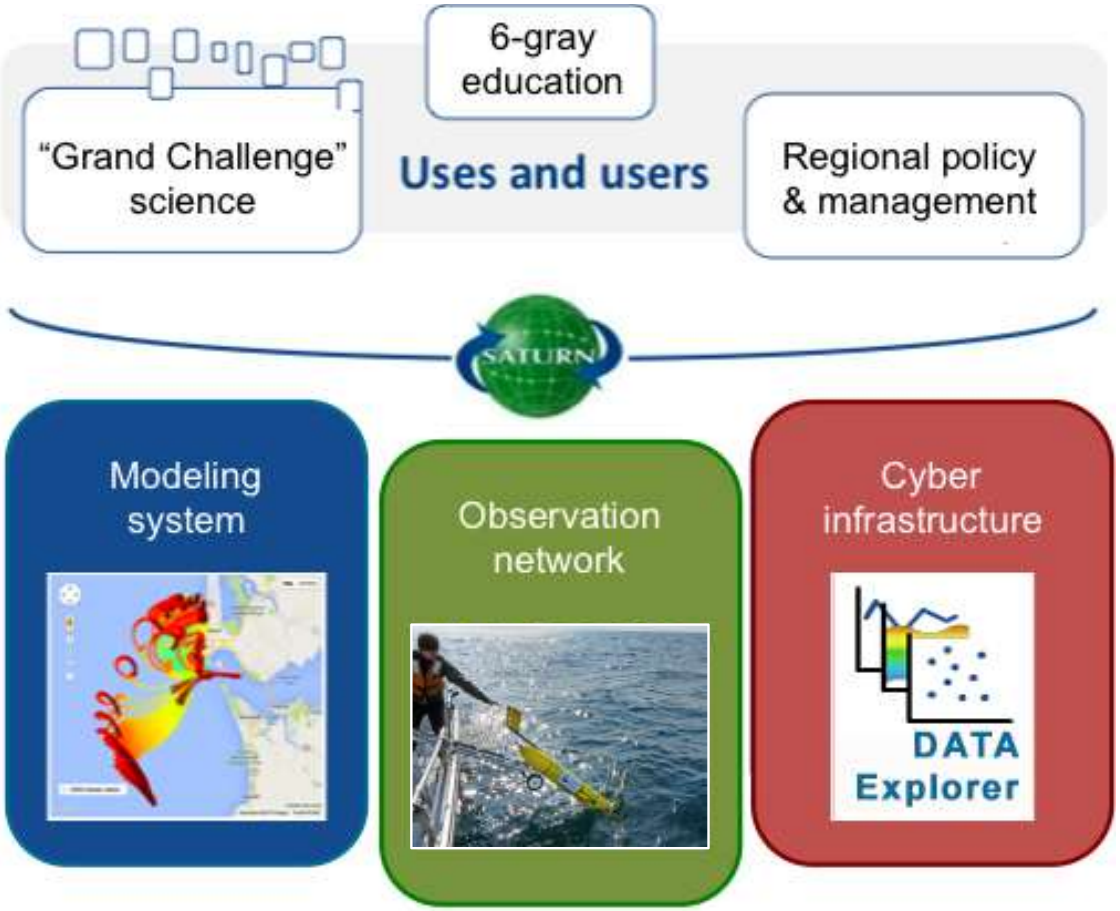
SATURN

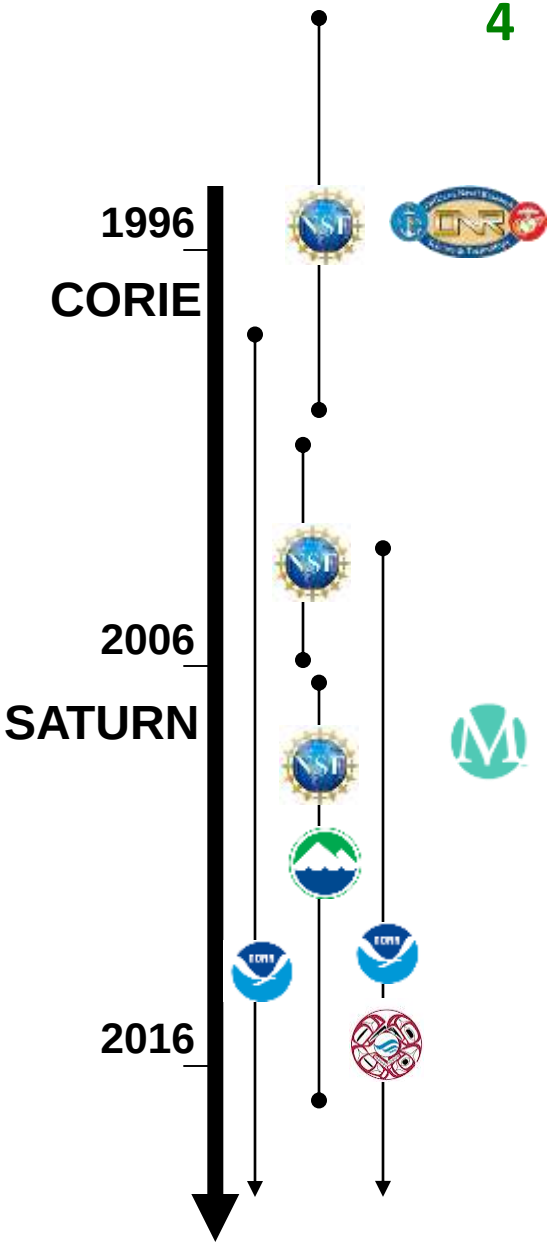
Lynne Krasnow's challenge (slightly rephrased)

Given uncertainties in timing and impact of climate change:

- Does the region need to adjust restoration site designs now or is there time to develop additional measures?
  - **There is likely some time, short of a Cascadia Subduction Zone earthquake – but any estimate (5y? 10y?) is "fuzzy"**
- As an example of the latter, could the region incorporate triggers into its programs and adjust already built projects if/when those are tripped?
  - **Yes. But program-specific triggers need to be identified and monitored, preferably via combined long-term observations and simulations**
  - **SATURN and other long-term CR assets empower (and are essential to) this type of approach**

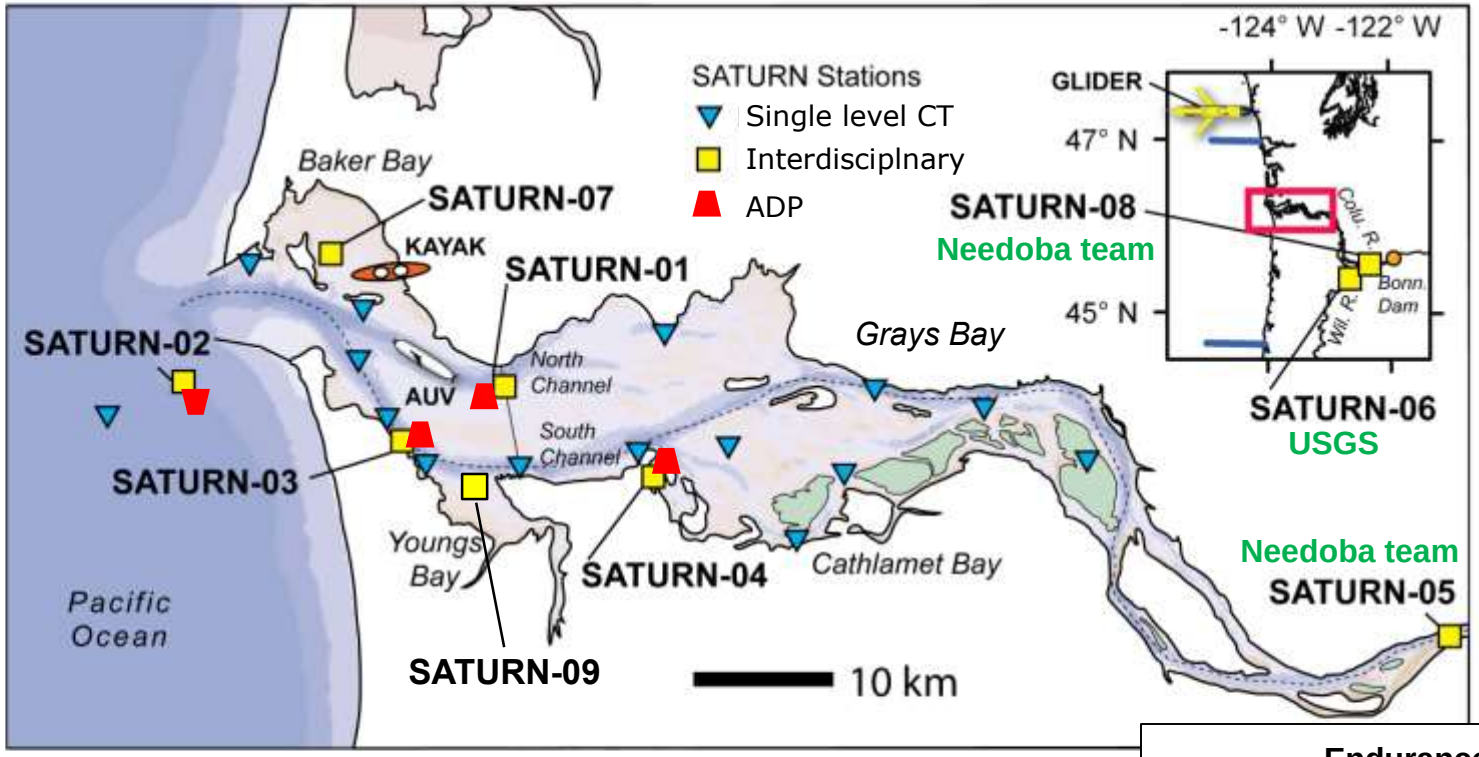
SATURN: Vision and history

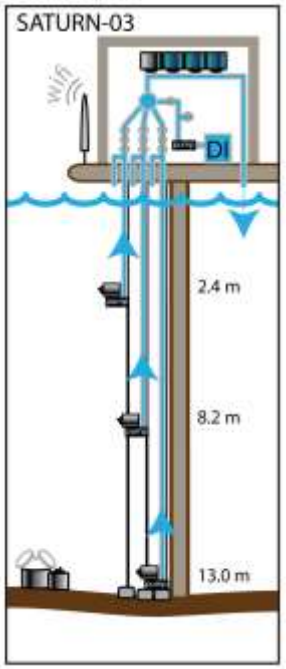




http://www.stccmop.org/saturn

The observation network

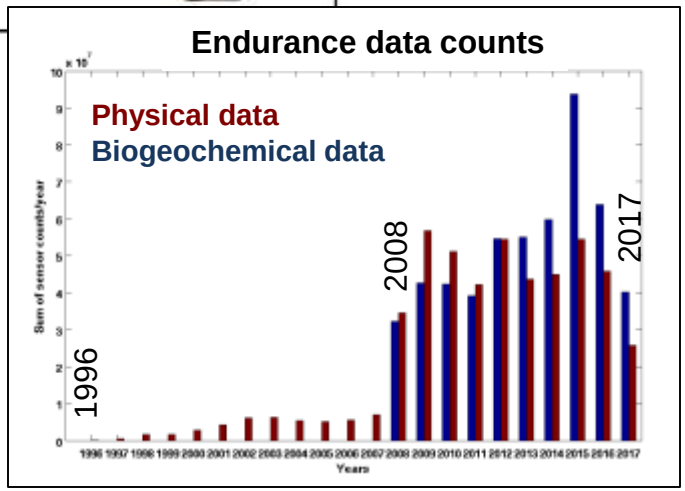




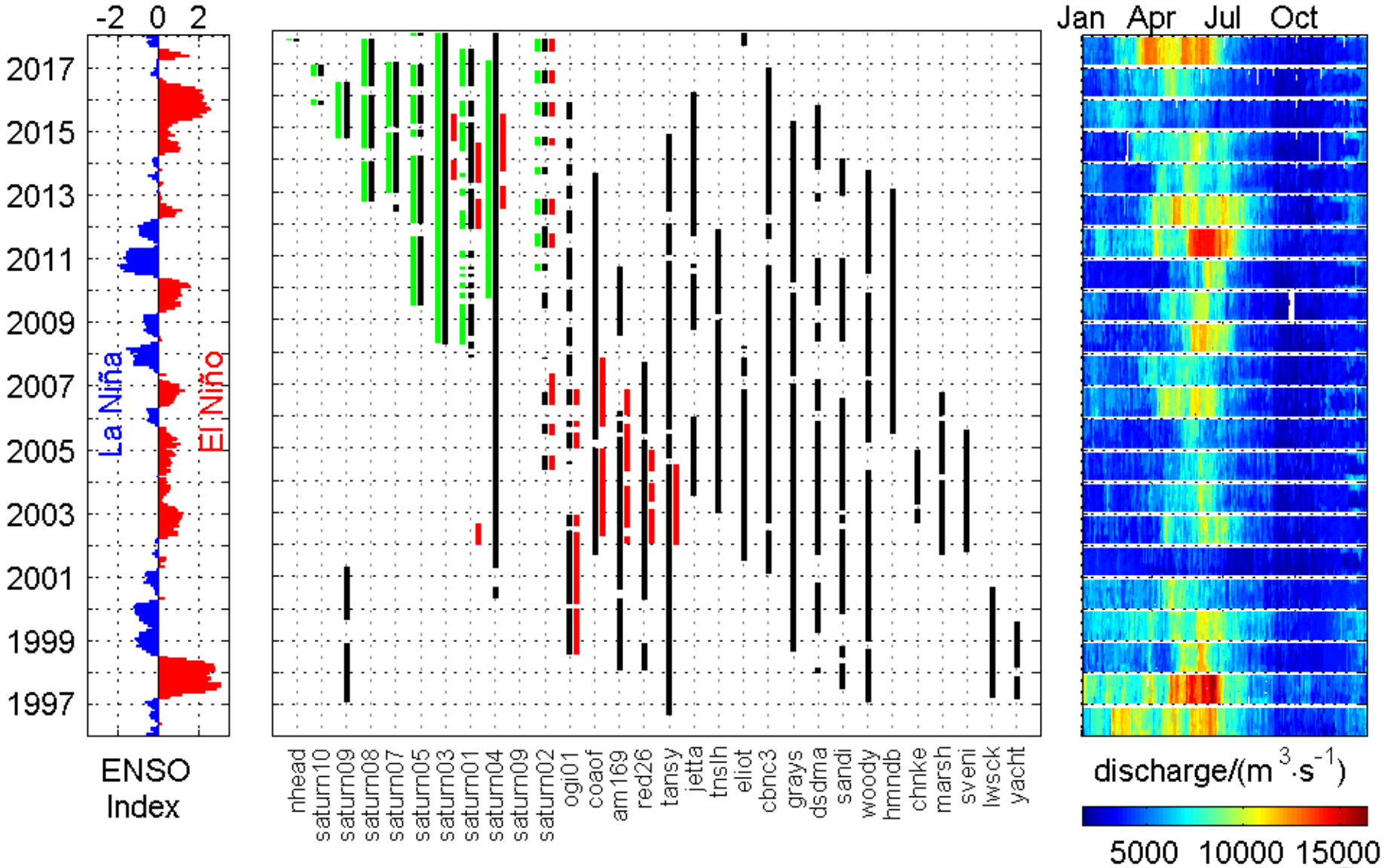
Endurance stations

- Interdisciplinary (01-09)
- Physical

Common variables: Salinity, Temperature, Chlorophyl, Nitrate, Turbidity, CDOM, Dissolved oxygen
Other core variables: pH, Phycoerythrin, PAR

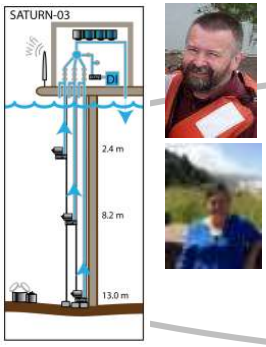


Station history

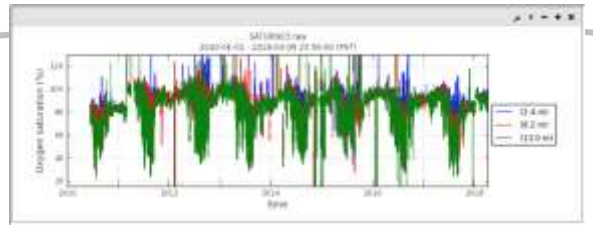


Black: scalar physical stations **Green: interdisciplinary stations** **Red: ADPs**

Process (lower estuary and nearshore stations)

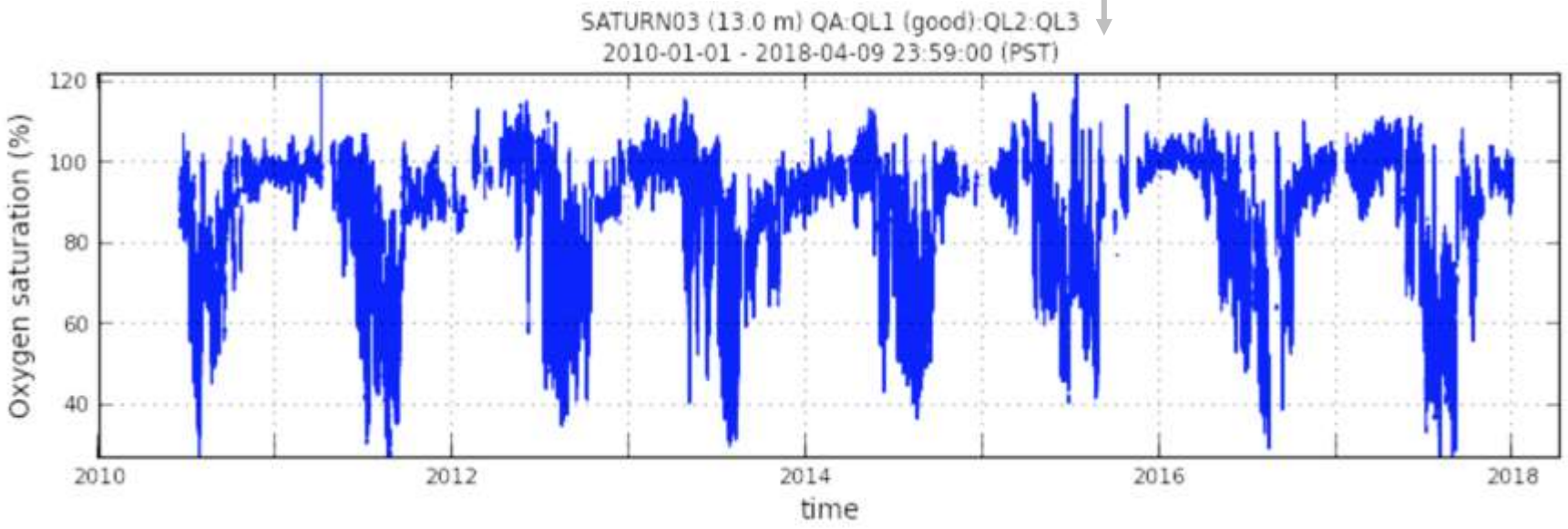


(1) Data collection & local QA/QC



(2) QA/QC (post-processing)

(3) Information flow & visualization



Paul Turner (30y)

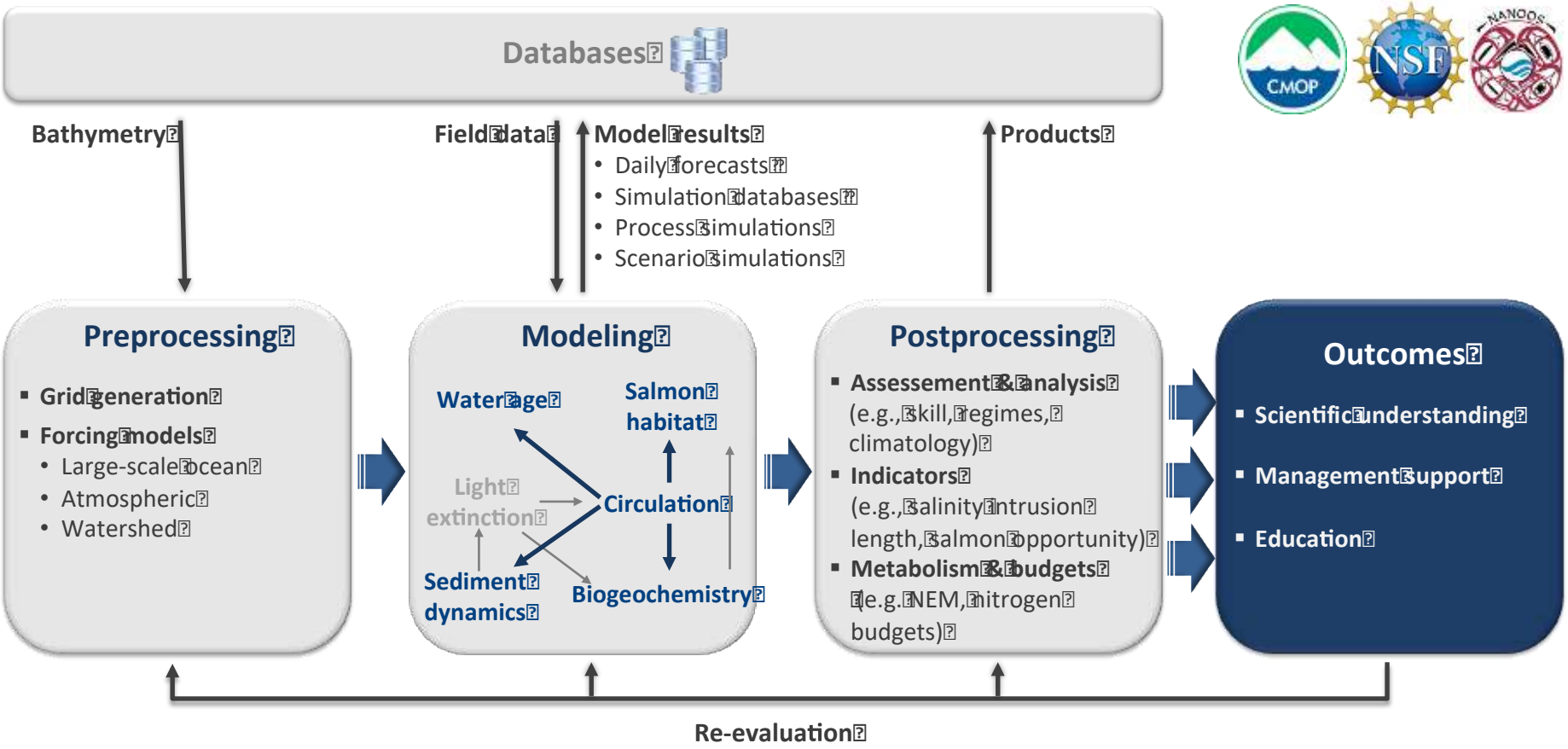
Michael Wilkin (22y)

Charles Seaton (17y)

Sarah Riseman (8y)

Jo Goodman (6y)

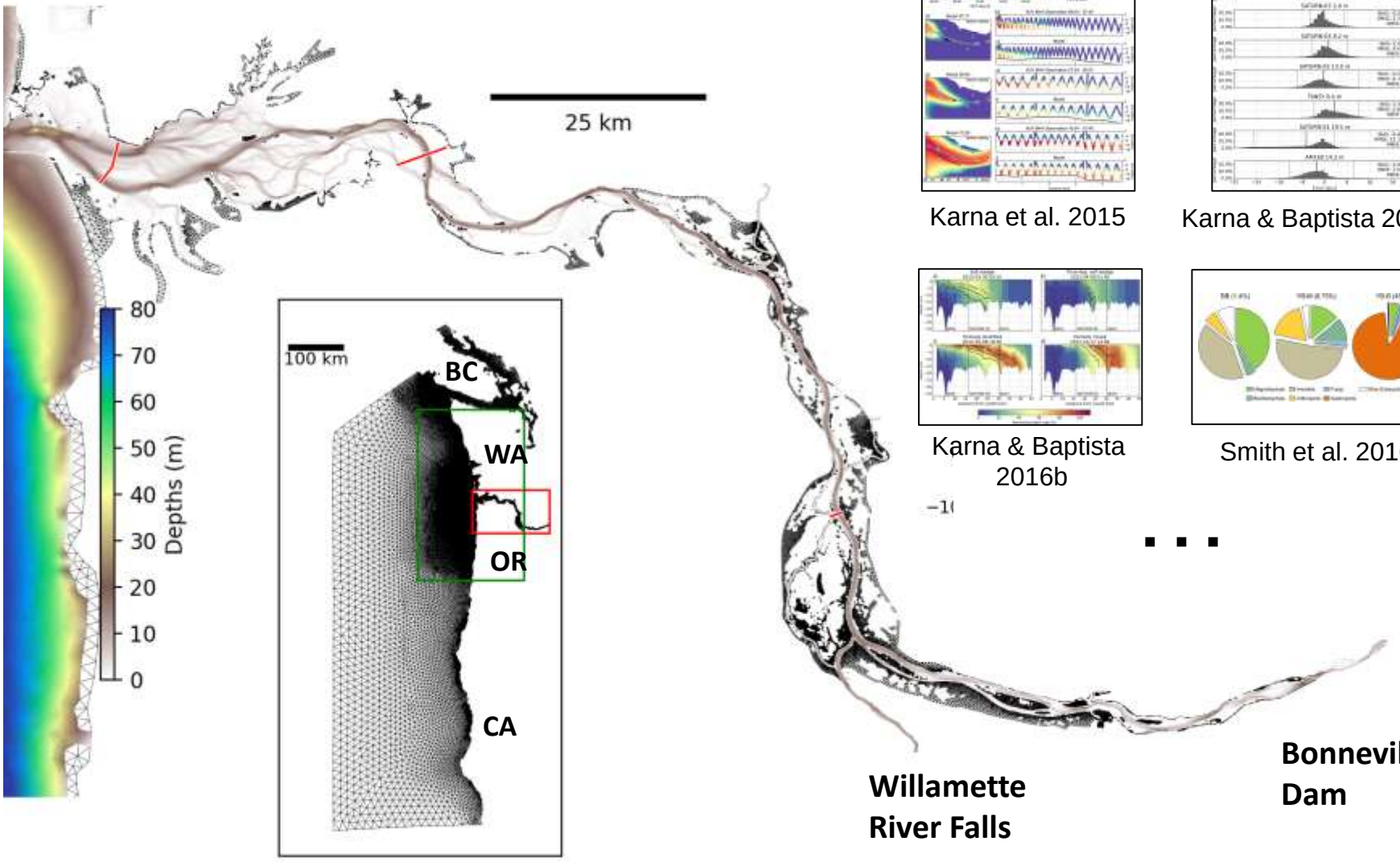
The Virtual Columbia River

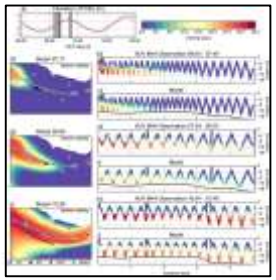


Current modeling engine: SELFE (3D baroclinic circulation model)

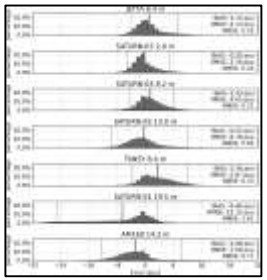
- Uses unstructured grids
- Semi-implicit formulation, with Eulerian-Lagrangian momentum
- Low order (thus diffusive). Robust and “computationally efficient.”

Circulation modeling



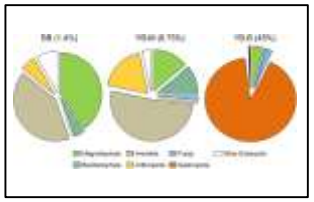


Karna et al. 2015



Karna & Baptista 2016a

Karna & Baptista 2016b



Smith et al. 2016

. . .

See also posters presented by C. Seaton and K. Morrice

What do we expect sea level rise (SLR) impacts on the estuary to look like in the future?

- Part of a complex set of changes
- Significant on their own. Leading to:
  - Increased ocean influences into the estuary (deeper penetration of waters with high salinity, low DO, low pH, high carbon dioxide). [C >> V]
  - Spatially and temporally modified shallow water habitat (changes will be spatially and temporally complex, and non-monotonic with increasing SLR). [C>V]
  - Slightly larger freshwater plumes [C<<V]

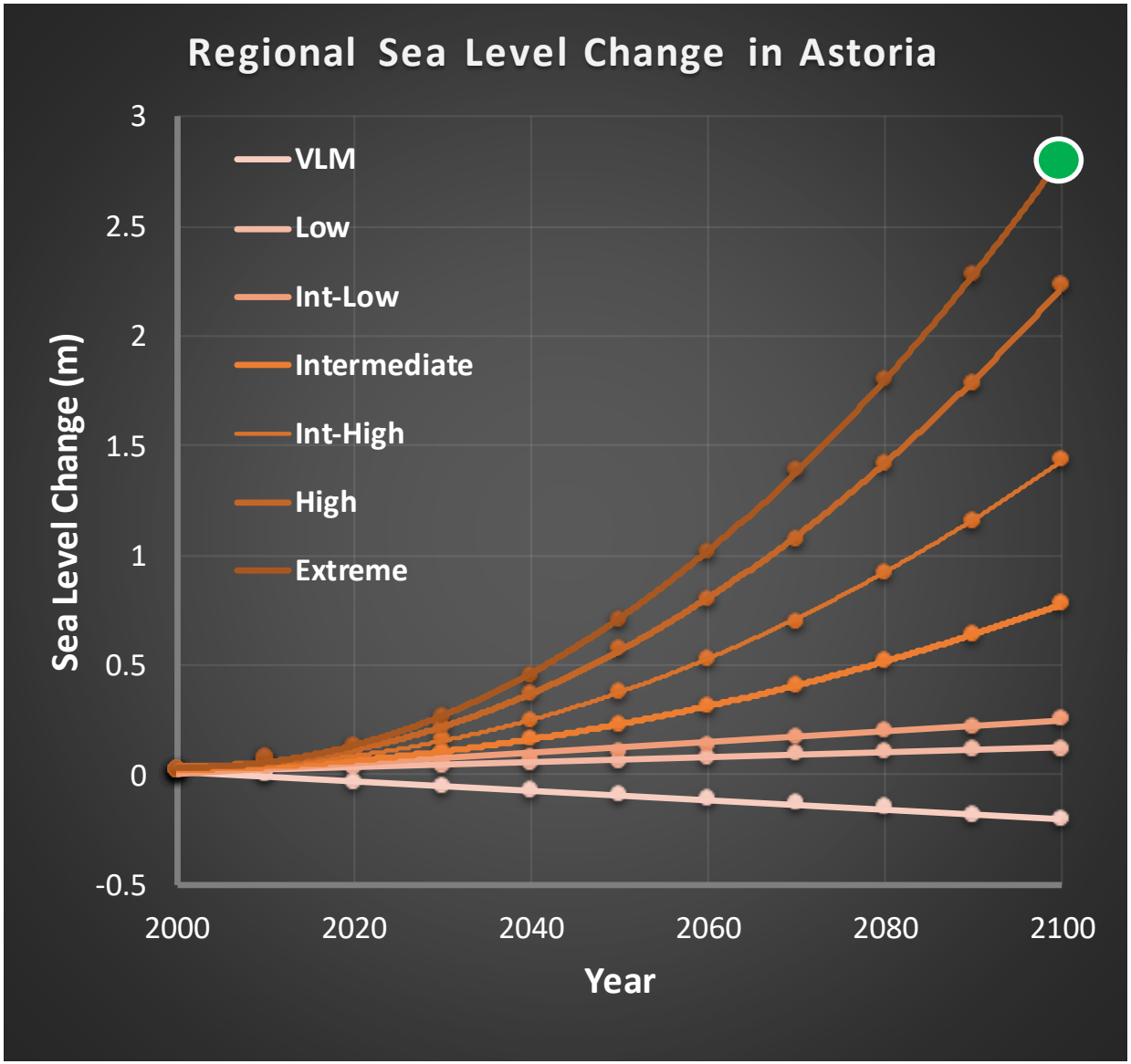
From my concluding CREC 2016 slide

- Uncertainties remain in (especially) the definition and (also) the simulation of scenarios of change
- Results presented today should be further refined:
  - Need to continue to carefully review results, both scientifically and via stakeholder scrutiny
  - Need to be expanded to account for simultaneous change in multiple forcing (SLR, river flows, CSZ, etc.)
  - Need to be placed in site-specific context
- But the results show a potential for drastic change that is too clear to ignore, and that should be incorporated into regional thinking now

Poster presented by C. Seaton

Talk by M. Rostaminia, Otak, Inc

Scenarios



CC (current conditions)
Year 2010

SLR (sea level rise)
0.12m
0.26m
0.78m
1.44m
(1.77m)
2.24m
2.82m ← focus today

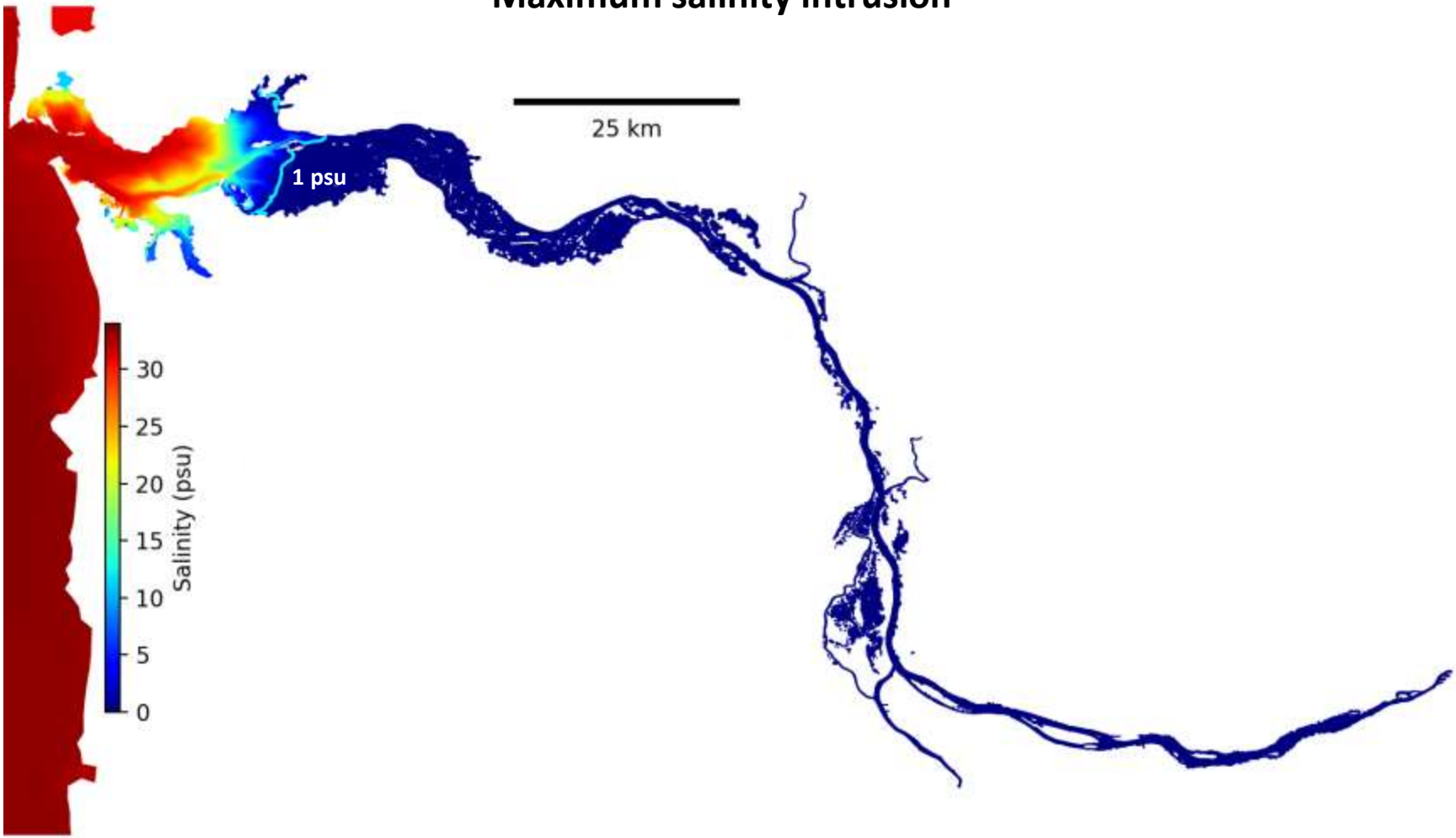
CSZ (subduction)
M_w=9.1

SLR + CSZ
2.82m & M_w=9.1

Scenarios from NOAA 2017

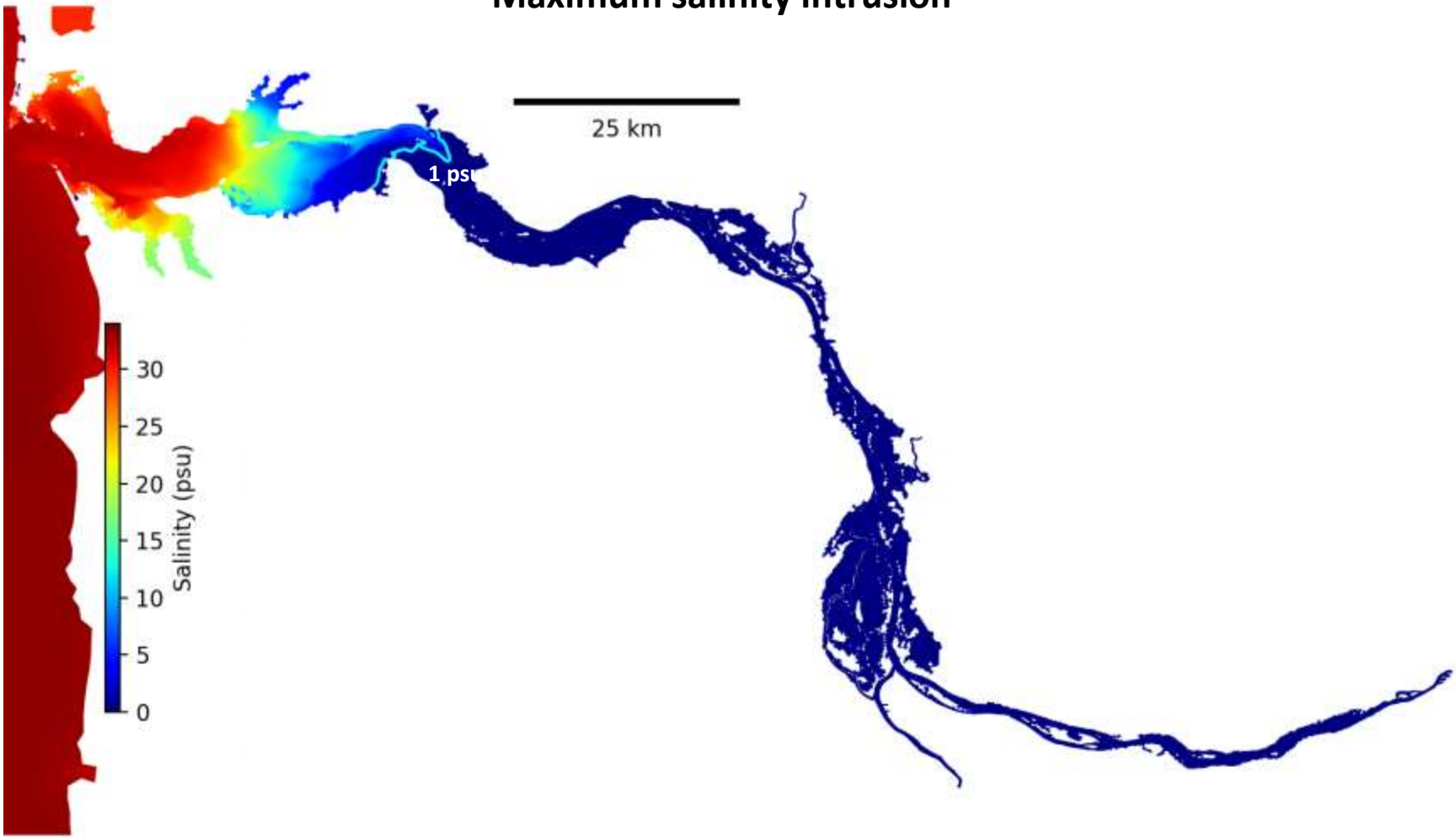
Salinity intrusion (CC, 2010)

Maximum salinity intrusion



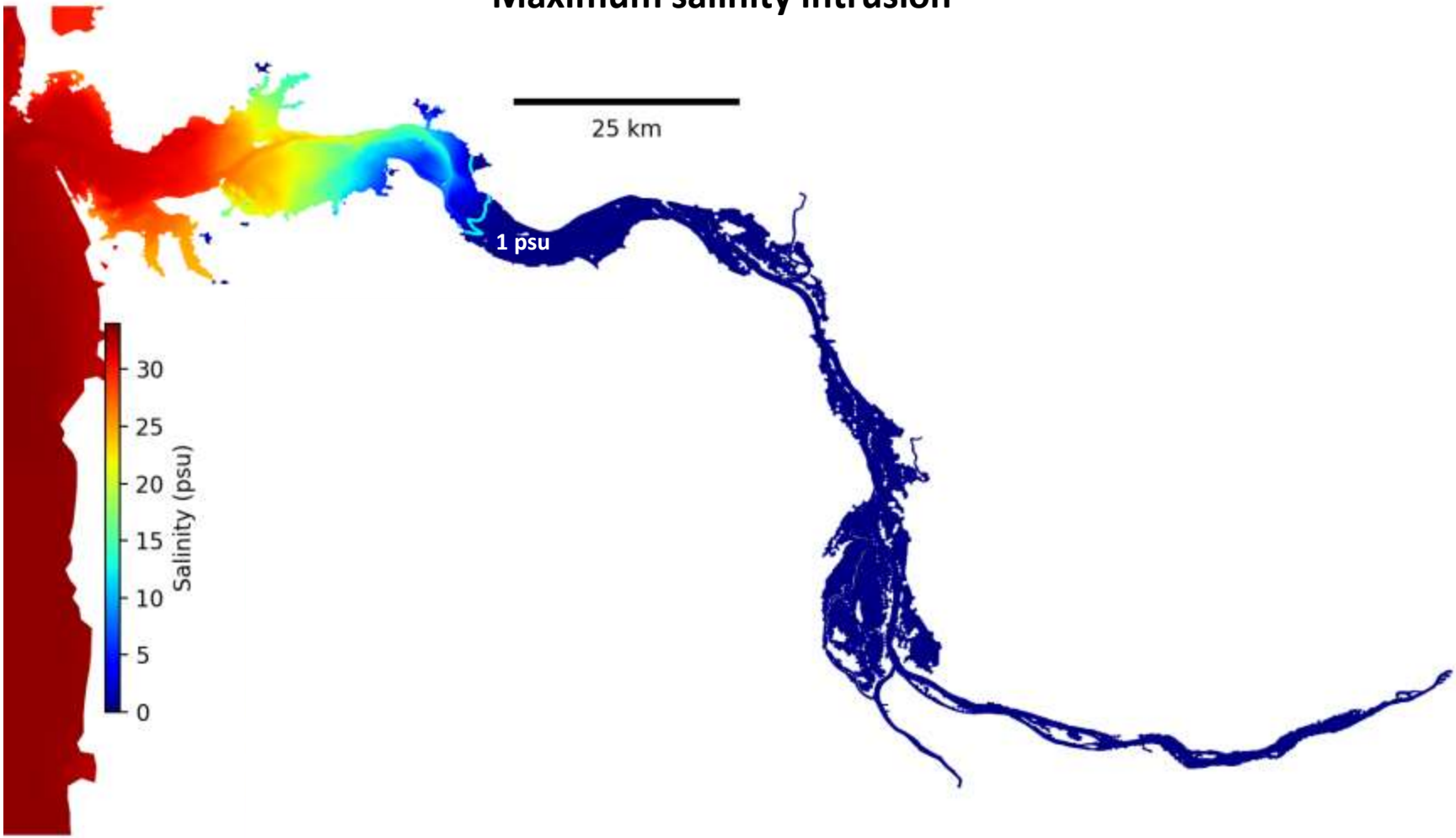
Salinity intrusion (SLR=2.82m)

Maximum salinity intrusion

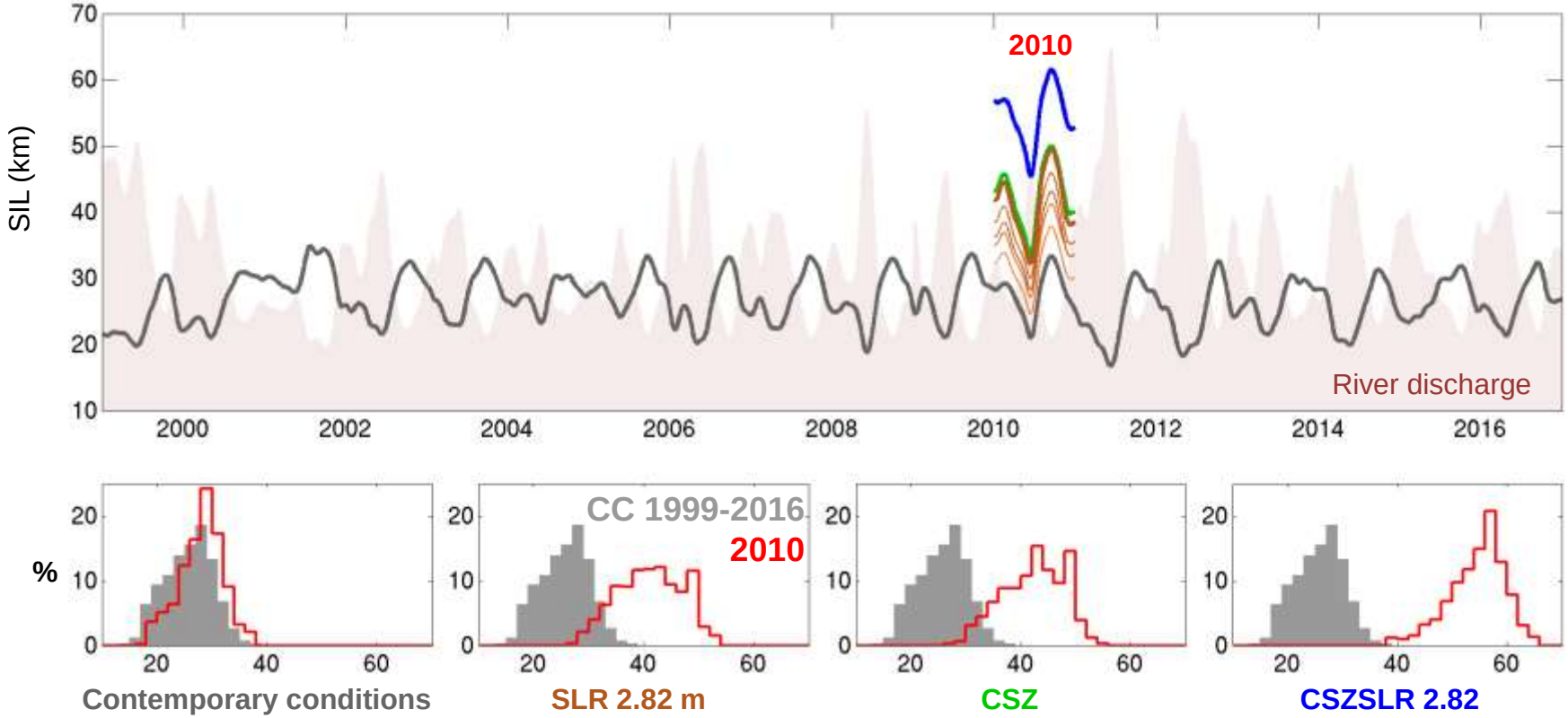


Salinity intrusion (2.82m+CSZ)

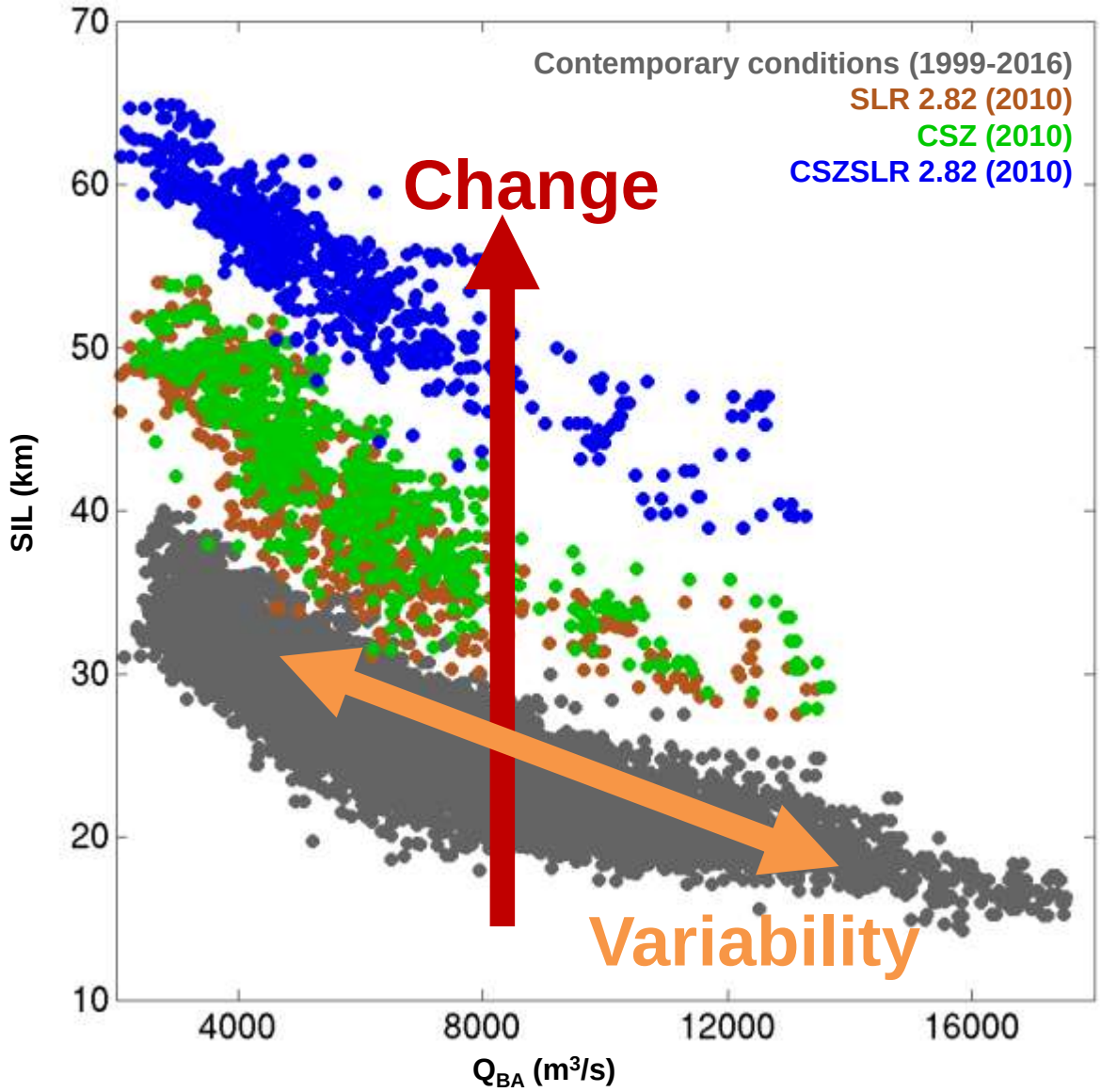
Maximum salinity intrusion



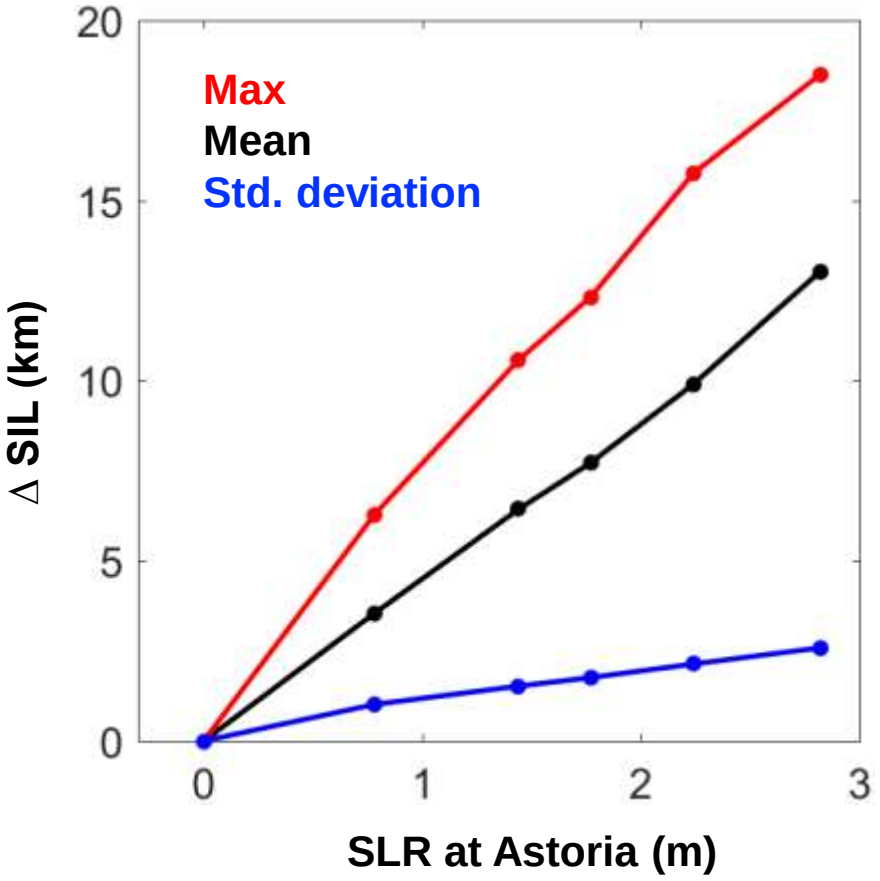
Salinity intrusion length (SIL)

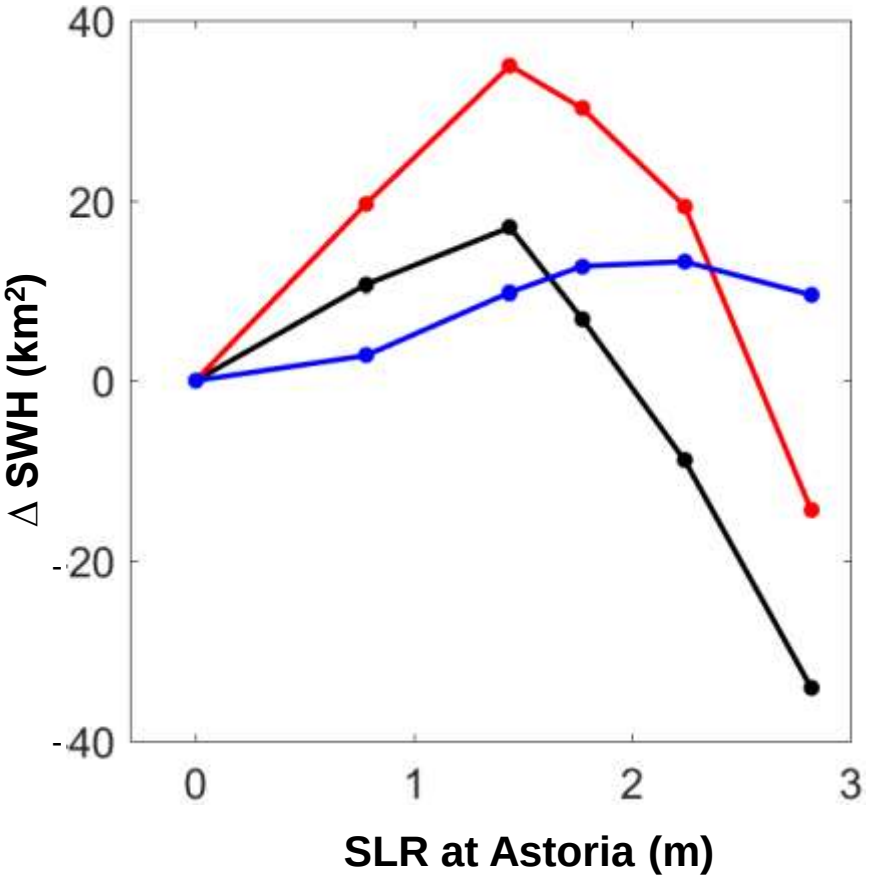


SIL: Variability versus change



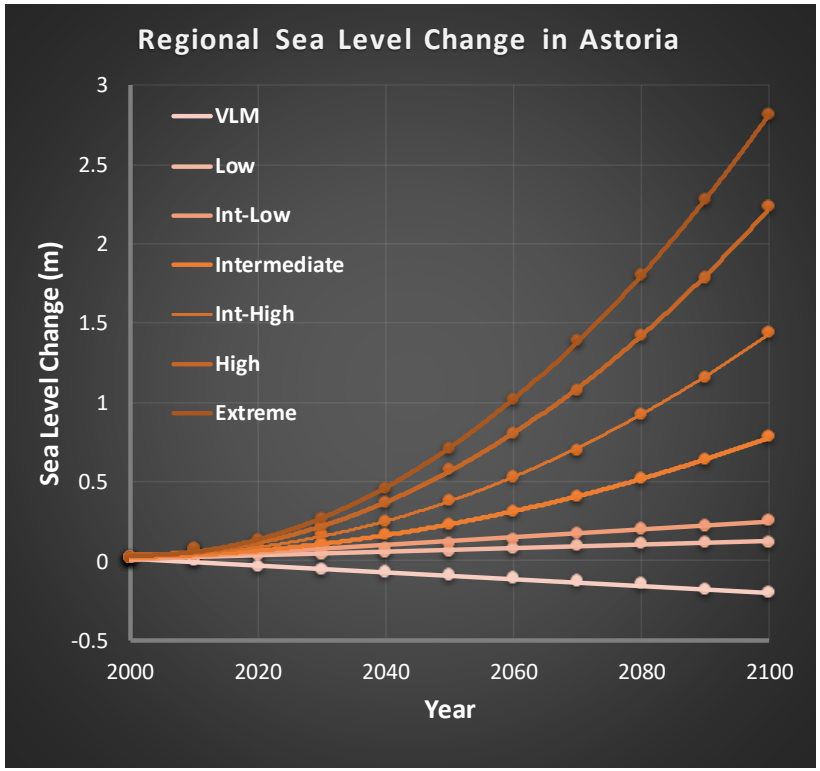
Progression of change (relative to CC)





SLR scenarios considered: 0.78, 1.44, 1.77, 2.24 and 2.82 m
SWH defined as 0.1 m < depth < 2.0 m

Are we seeing supporting evidence of SLR impacts yet?

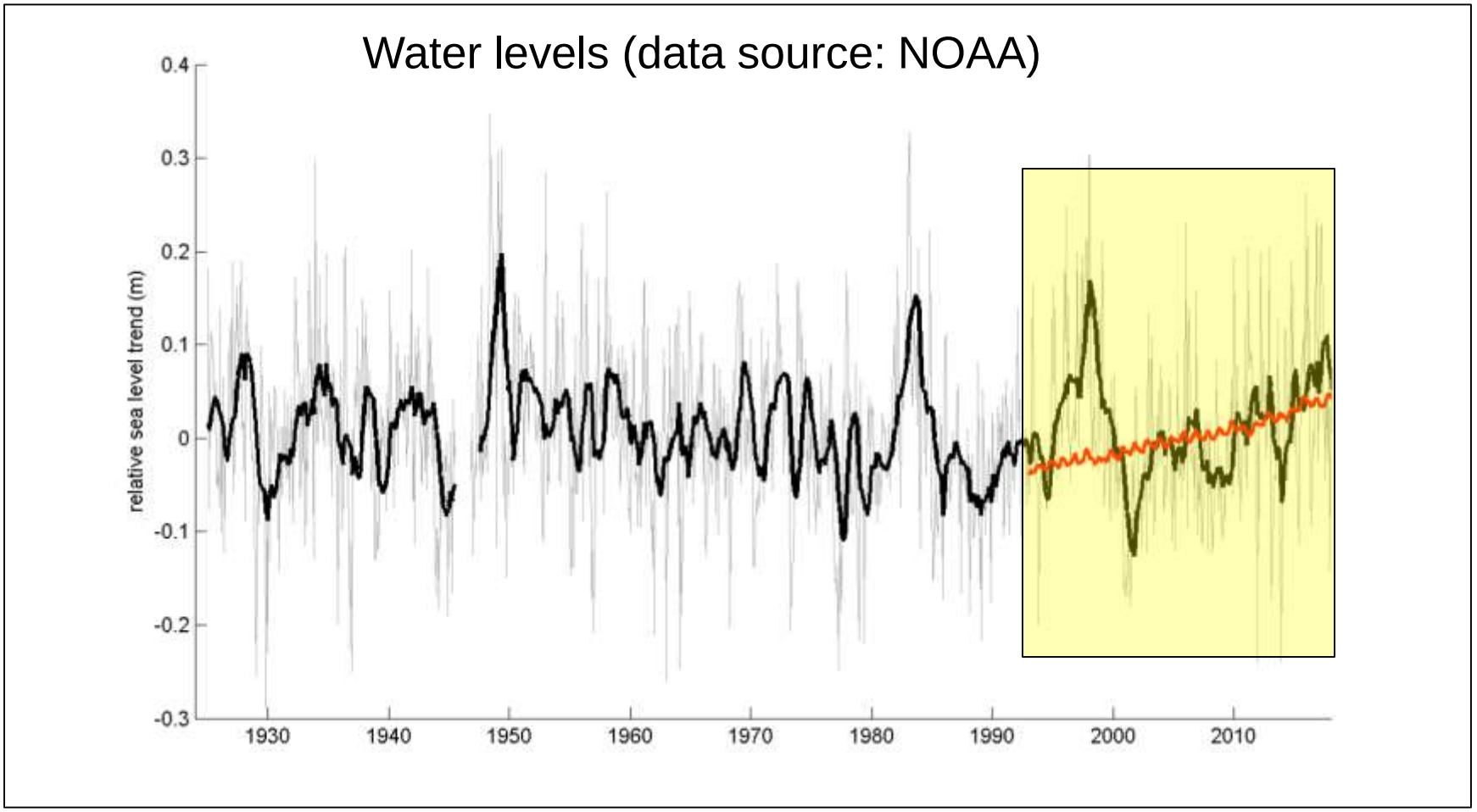


- Perhaps – but neither strongly nor indisputably
- Change & variability have multiple sources, which are confounding
- Observations are still too short, with data gaps and disruptive network configuration changes
- Models are increasingly useful, but have simplifications and uncertainties

What is needed:

- A focused collaborative regional effort
- Long term (multi-decadal) time series of observations and simulations (most powerful when combined and cross-disciplinnary)

Astoria water levels, in global context



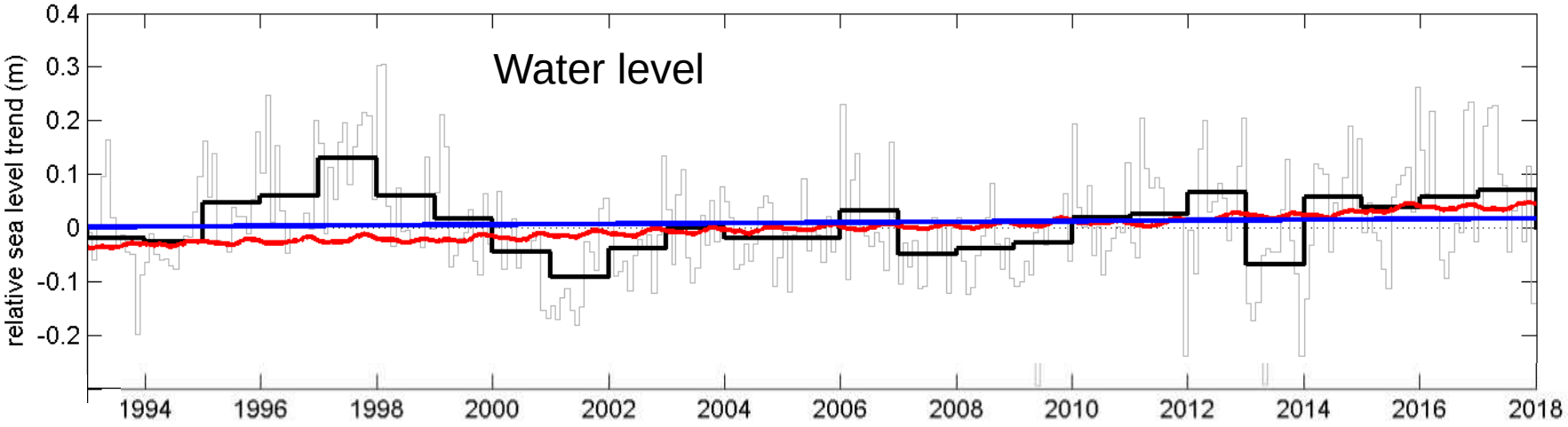
Gray: Astoria data, de-tided and de-seasoned

Black: Astoria data, further filter (12 month moving average)

Red: Global MSL data

Recent trends

Gray: Local data, de-tided and de-seasoned
Black: Local data, further annually averaged
Blue: Local data (linear regression)
Red: Global MSL data



Recent trends

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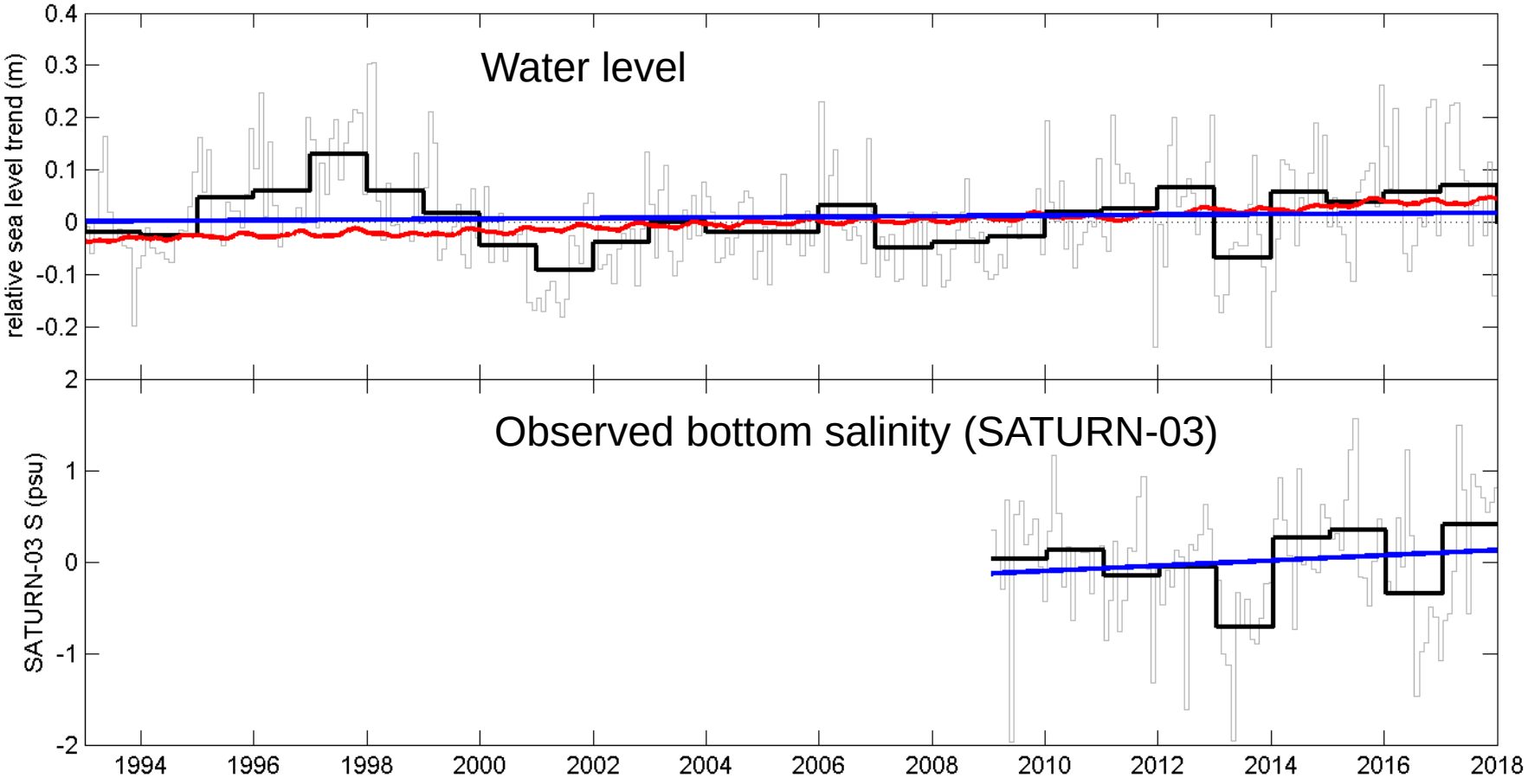

- Non-robust (too short a period; single station data) suggestion of a trend of recent salinity change, based on SATURN-03 observations

Recent trends

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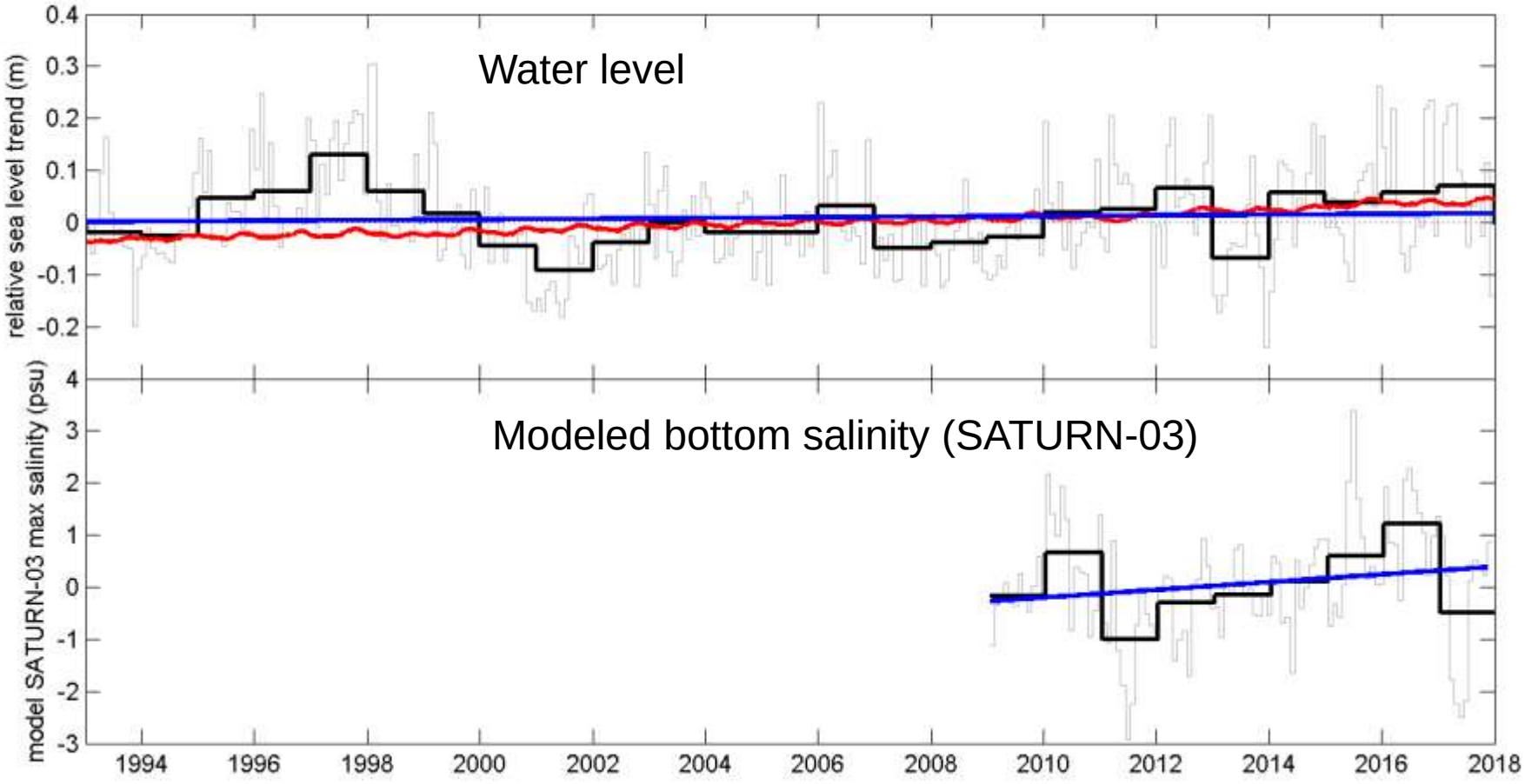

- Suggestion that observed and simulated trends are self-reinforcing (if not exactly the same) for the period

Recent trends

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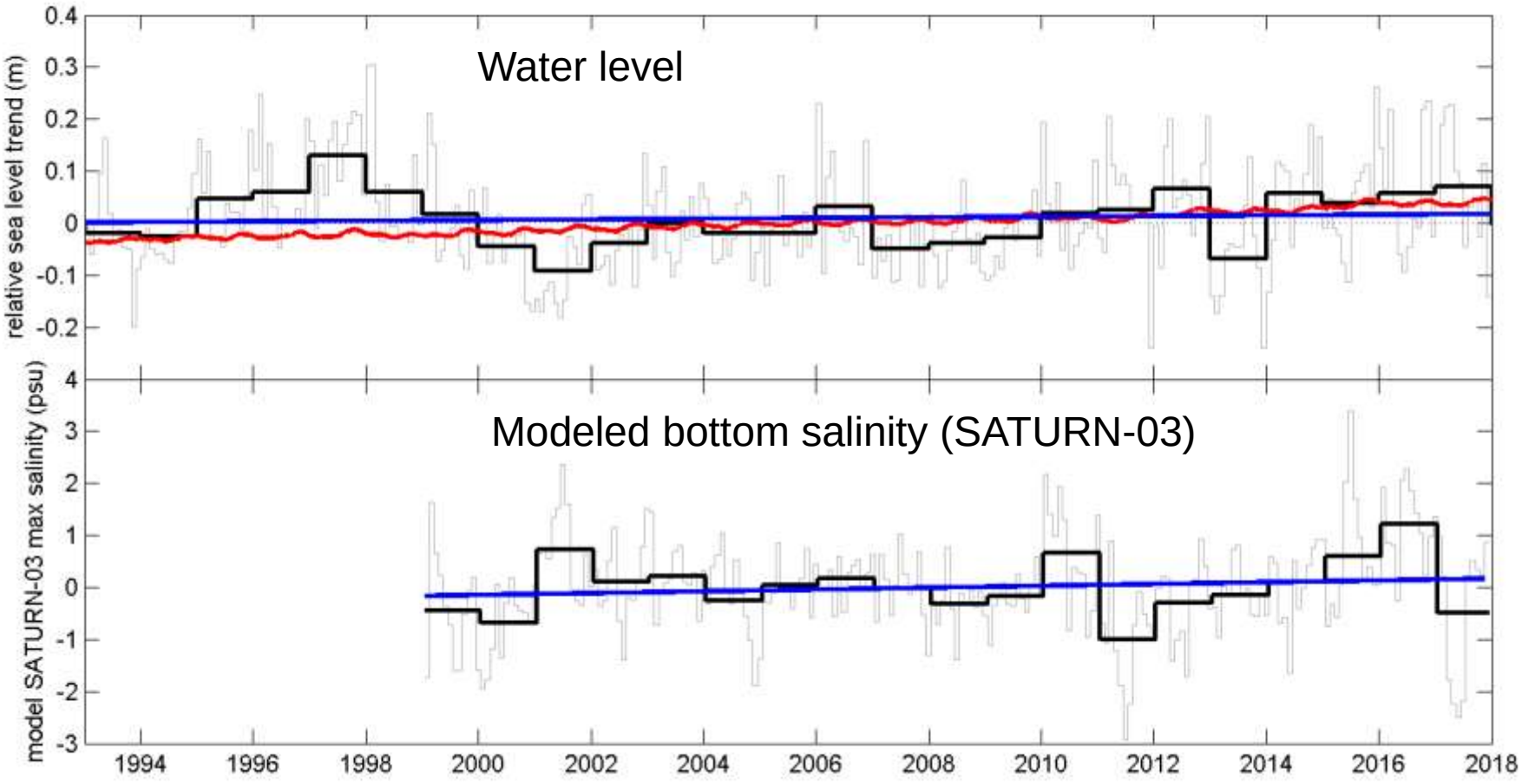
Blue: Local data (linear regression)
Red: Global MSL data



- Suggestion (based on simulations) that observation period is indeed too short

Recent trends

Gray: Local data, de-tided and de-seasoned
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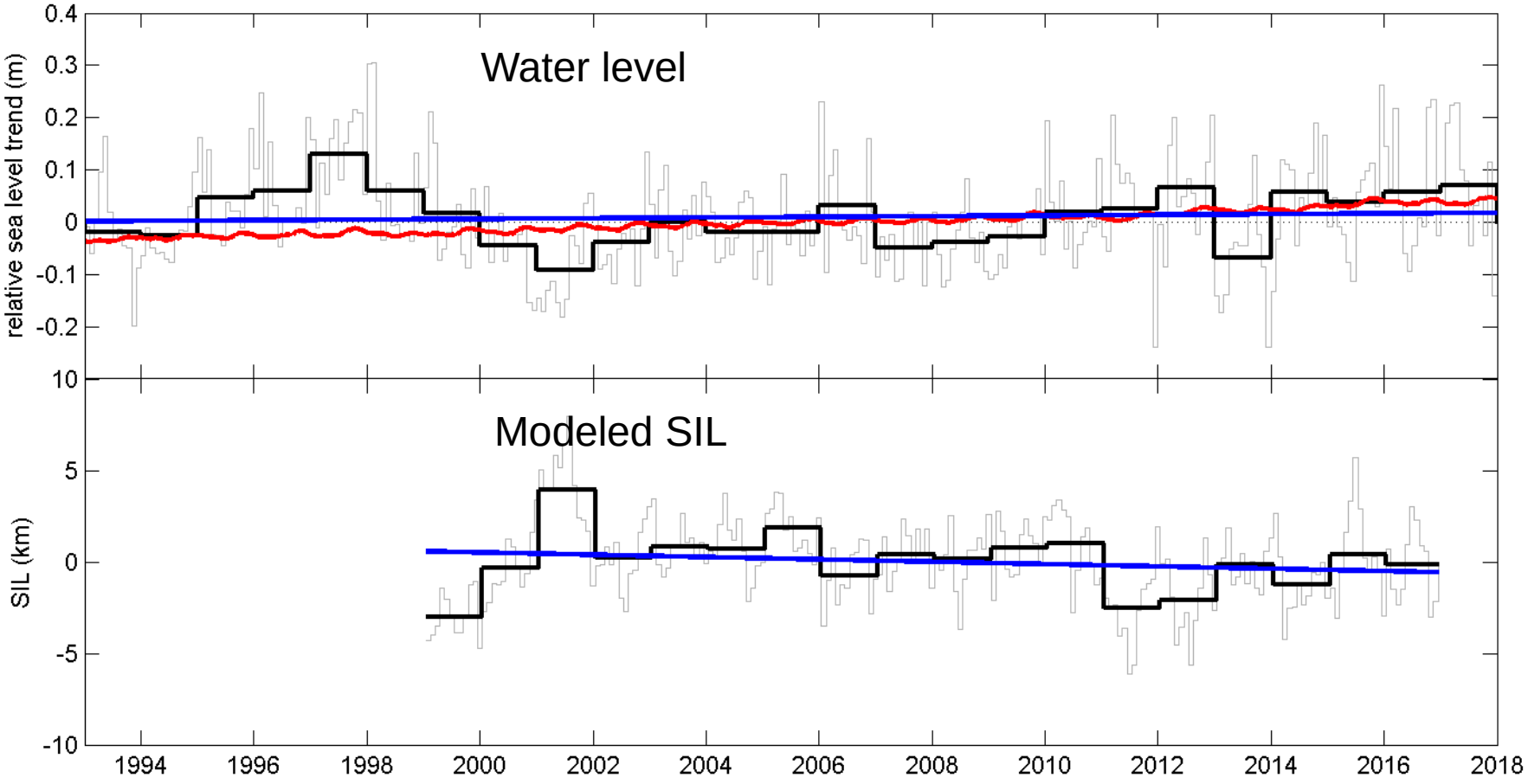
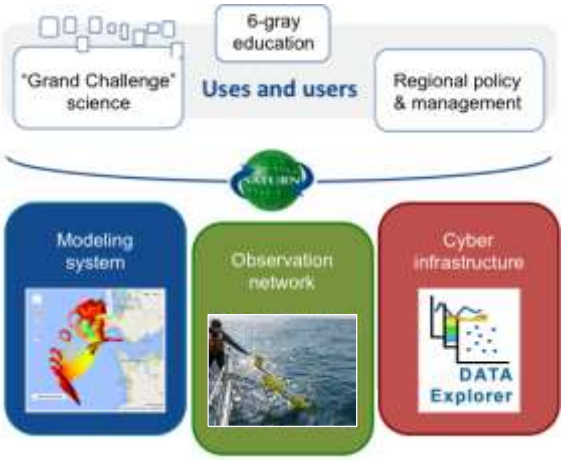
Blue: Local data (linear regression)
Red: Global MSL data



- Evidence (based on simulations) that other factors of variability or change outweigh the impact of SLR, even for the longer period

SATURN: What future?



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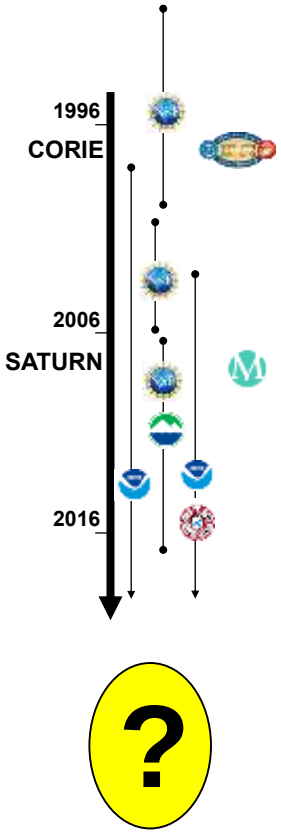

Ongoing dialogue towards:

- Enhanced ability to anticipate and monitor change
- Long-term sustainability (data, know-how, funding)
- Institutional or regional ownership