West Coast region—carbon budget overview

Authors

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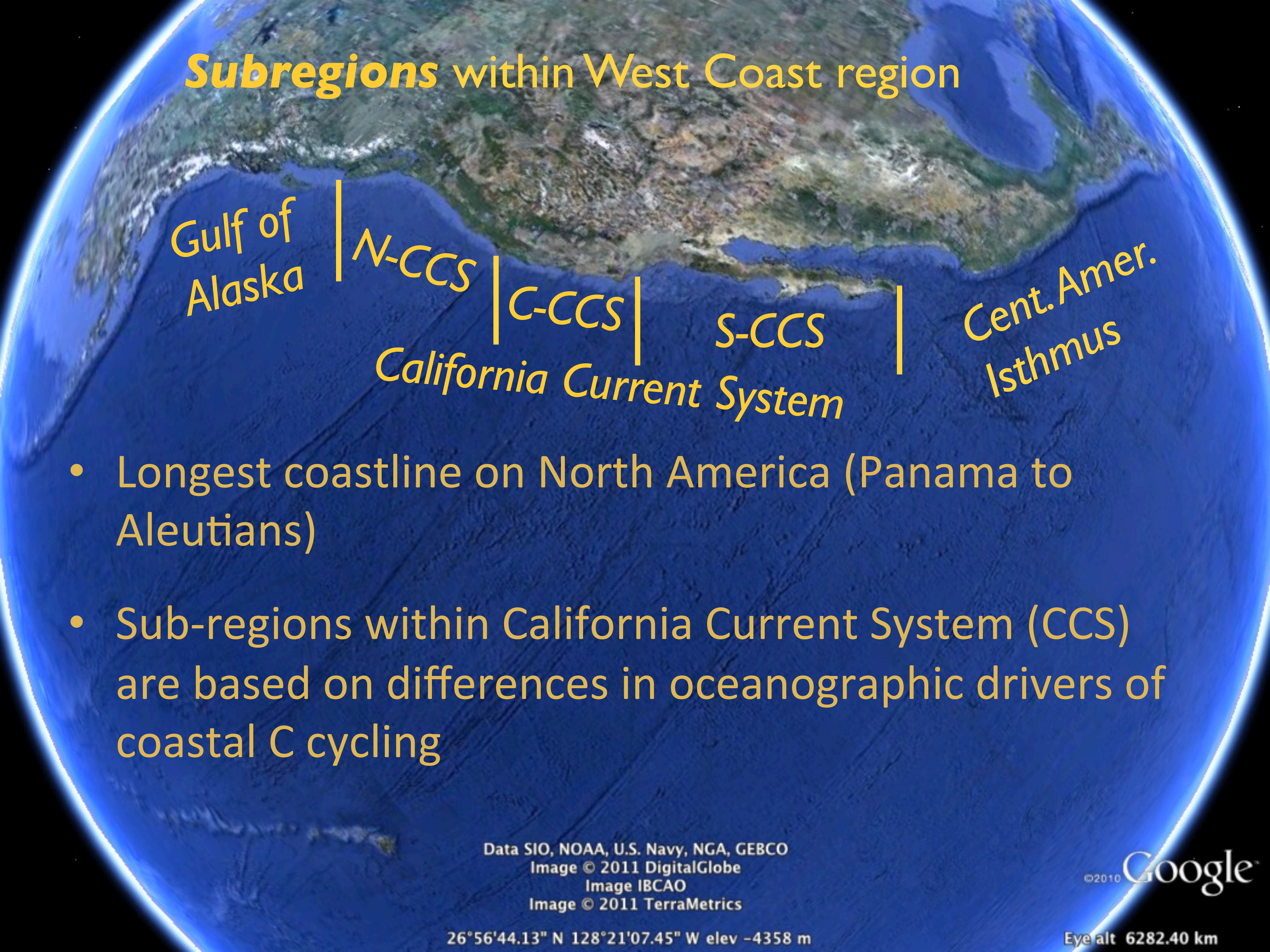
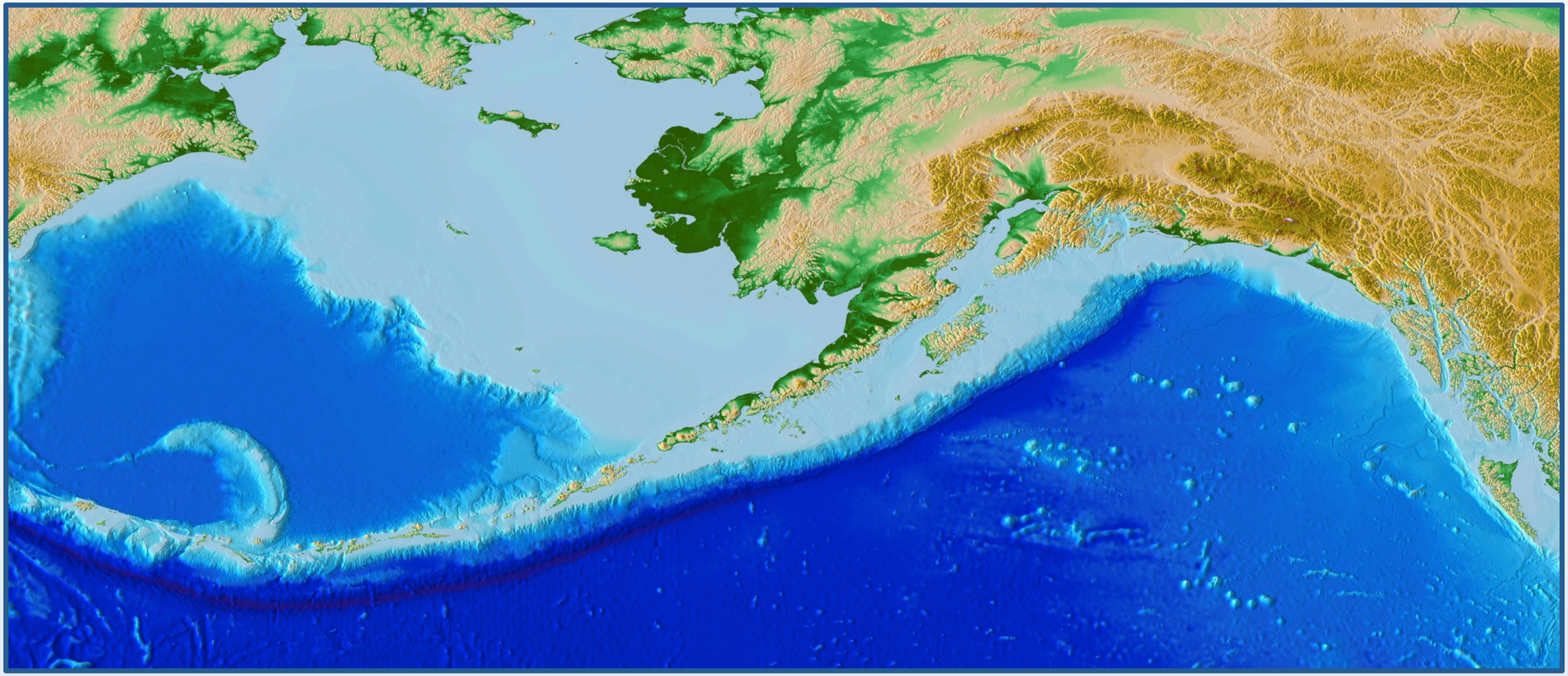
Subregions within West Coast region



- Longest coastline on North America (Panama to Aleutians)
- Sub-regions within California Current System (CCS) are based on differences in oceanographic drivers of coastal C cycling

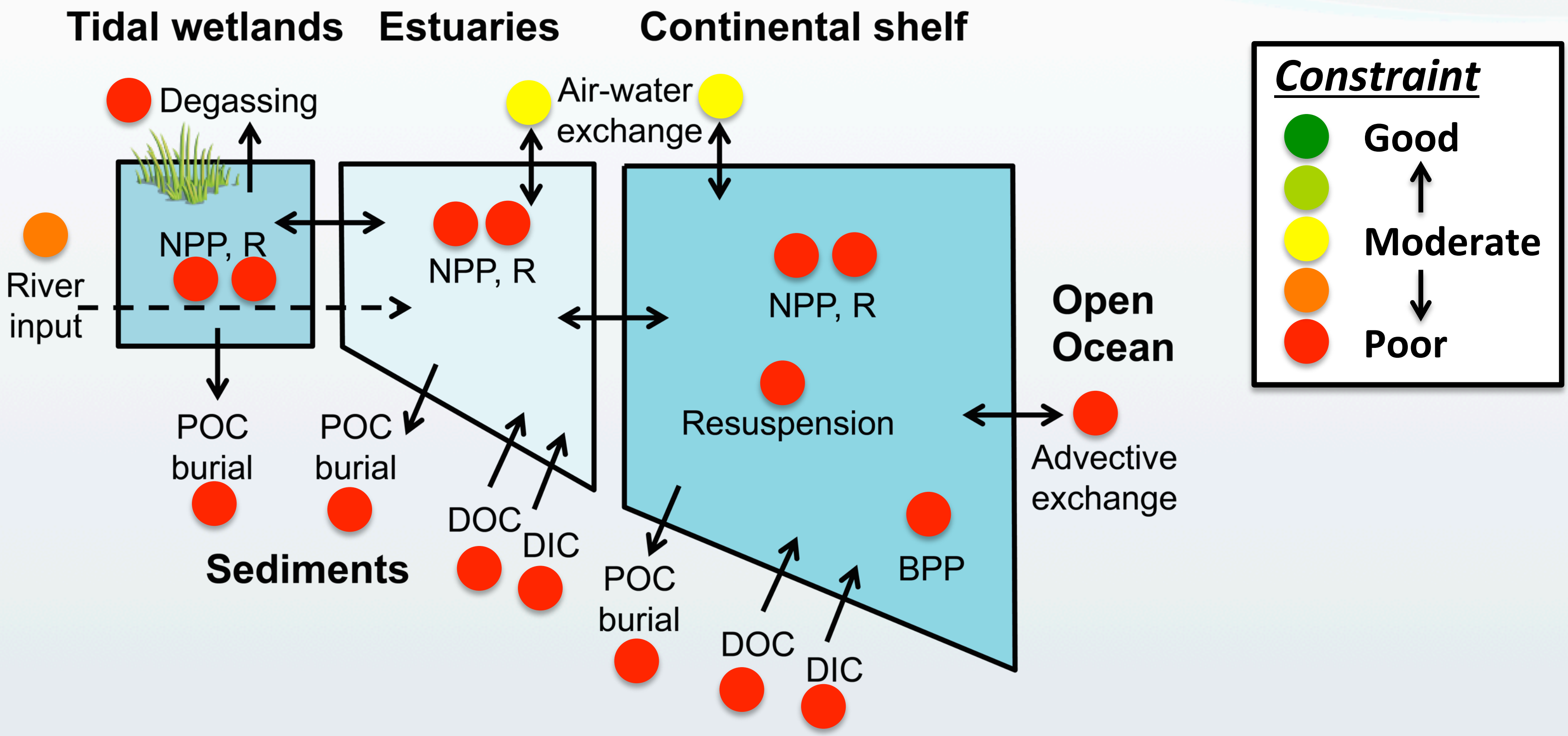
Gulf of Alaska carbon budget



Map: NOAA/NGDC

Coastal carbon cycle drivers—Alaska current system, predominantly downwelling circulation, winter storms, complex coastline, extensive inputs to inland waterway, large freshwater inputs, strong tidal mixing, eddy formation

Gulf of Alaska carbon budget



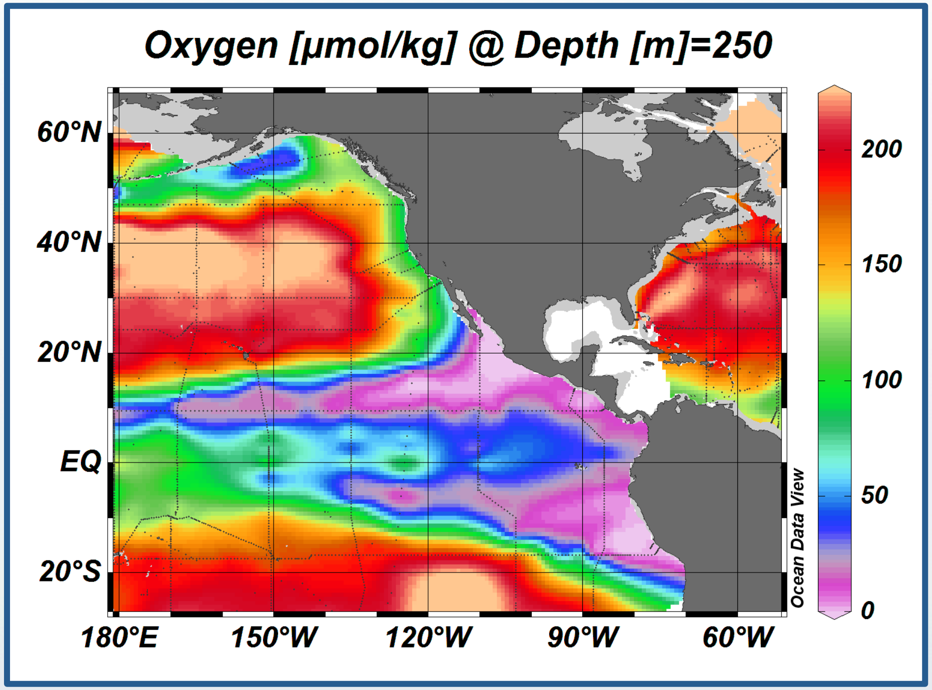
What we know—Better constraint on magnitude of air-sea CO_2 uptake. Terrestrial inputs estimated from GLOBAL-NEWS model.

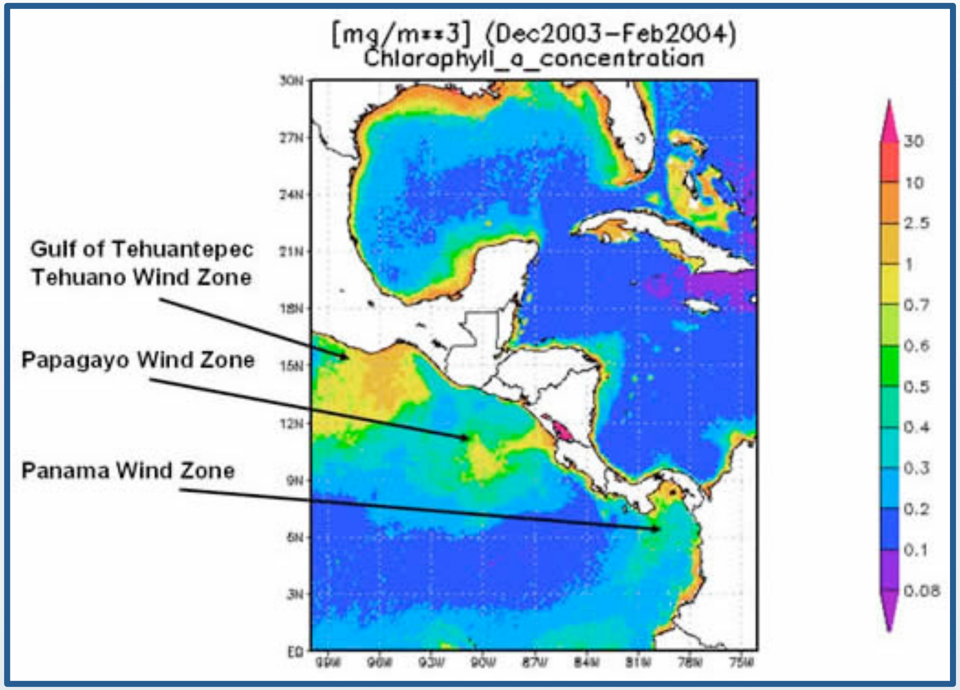
Remaining challenges—No other observations or model estimates found.

Observations, scaling up, and modeling challenging within dissected coastline.

Gaps in spatial and temporal gaps in air-sea flux observations remain.

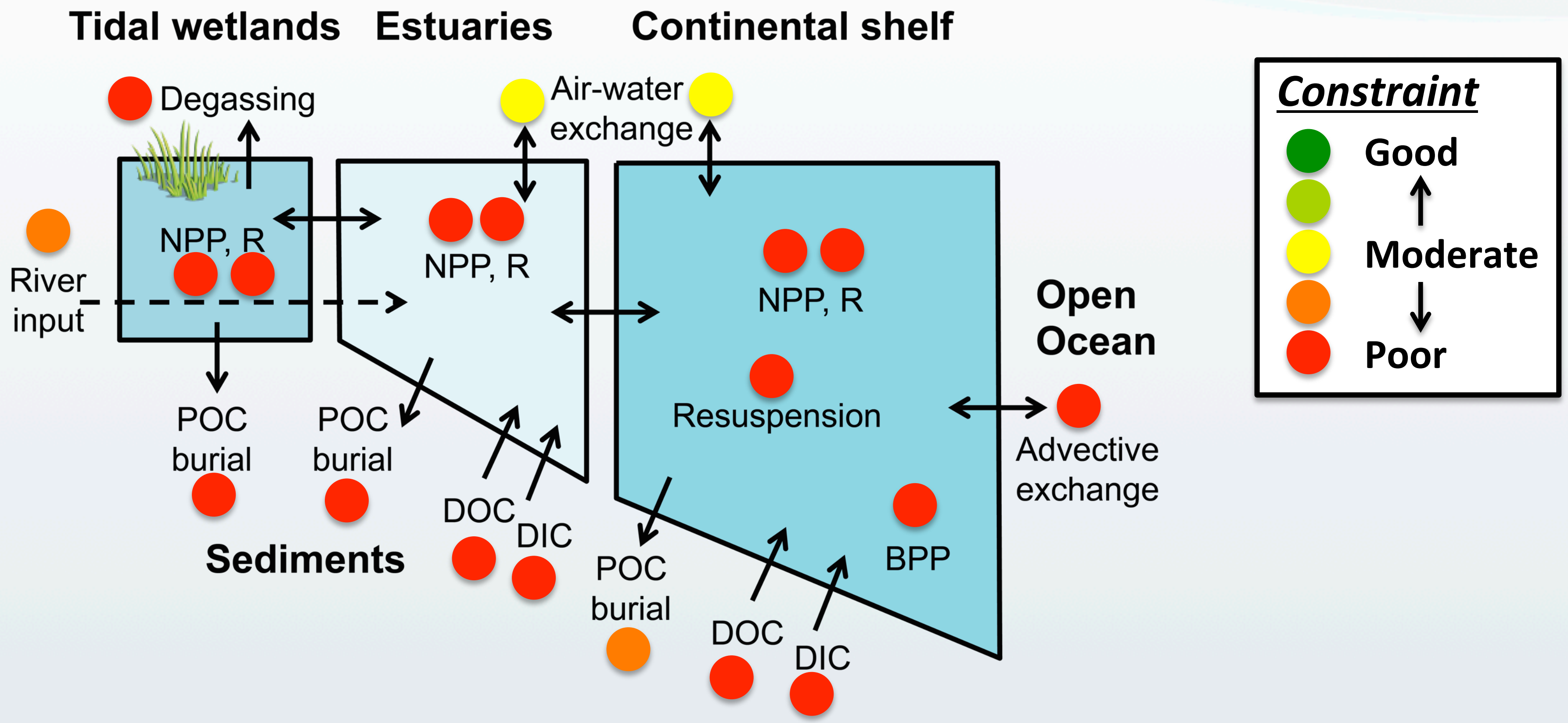
Central American Isthmus carbon budget





Coastal carbon cycle drivers—Equatorial Countercurrent, strong tropical influence, importance of mountain gap wind jets in creating biogeochemical hotspots

Central American Isthmus carbon budget



What we know—Reasonable constraint on magnitude of air-sea CO_2 uptake. Terrestrial inputs estimated from GLOBAL-NEWS model. A few OC burial rates.

Remaining challenges—Few other observations or model estimates found.

Gaps in spatial and temporal gaps in air-sea flux observations remain.

CCS carbon cycle influences by sub-region

- Upwelling important throughout, seasonality and strength vary
- Upwelling is most continuous in C-CCS
- Freshwater input increases to north
- Shelf width increases to north
- Eddy development increases to south
- Shoreline complexity lowest in C-CCS

These factors make it hard to extrapolate well-known fluxes across sub-regions, as these processes should result in strong gradients in C fluxes as well.

CCS carbon budgets by sub-region:

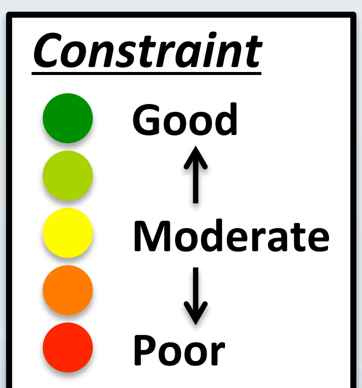
Observations + models

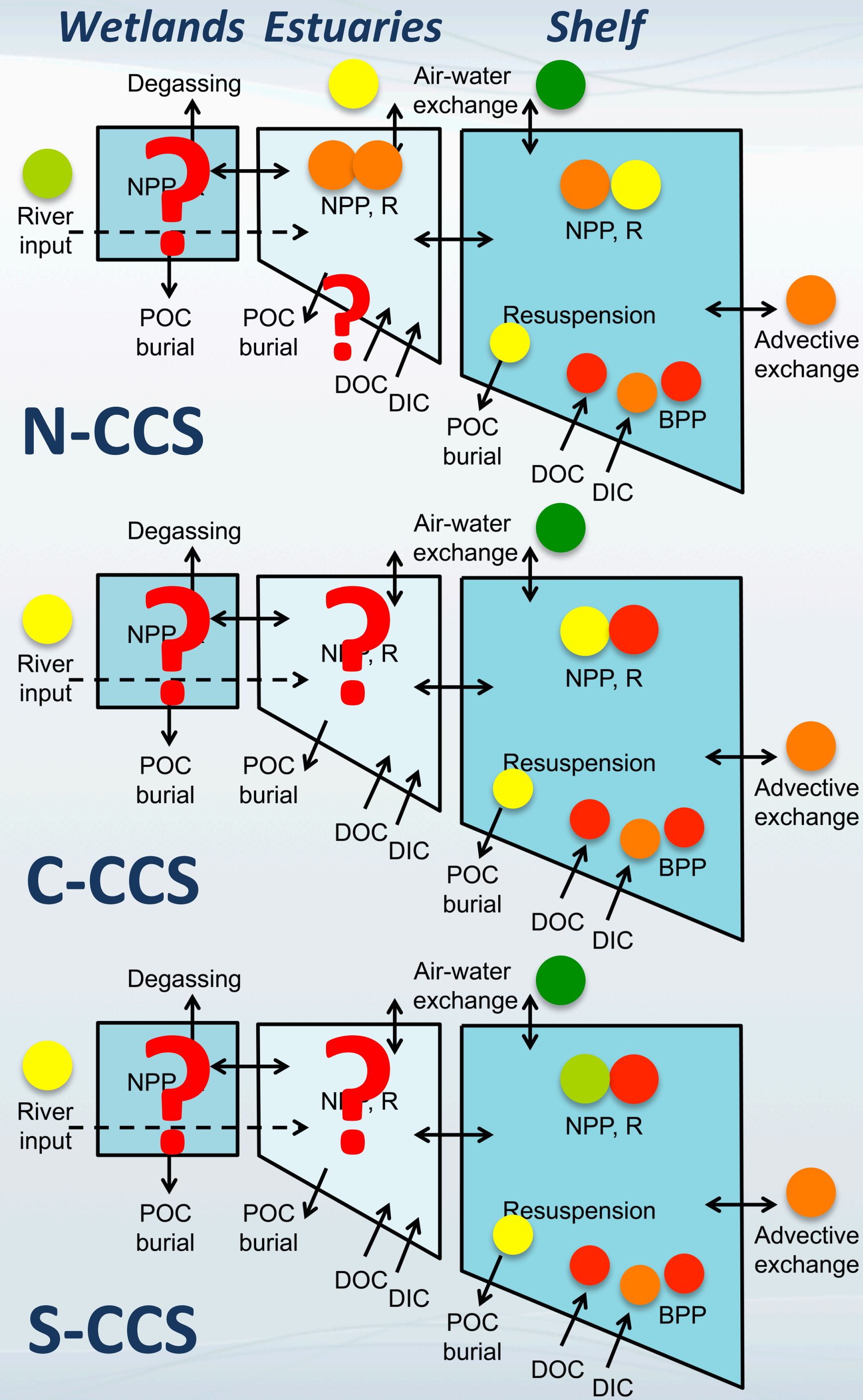
What we know—

- Good agreement on air-sea CO_2 fluxes between models and data.
- Terrestrial inputs estimated from GLOBAL-NEWS model and observations.
- Some OC burial rate measurements.
- Great improvements in coastal C cycle models.

Remaining gaps—

- Estuarine processing rates
- Tidal wetland fluxes
- Winter observations
- Cannot account for fate of all NCP





West Coast—state of knowledge on terrestrial C inputs

What we know—

- Good to pretty good constraint on organic inputs.
- Models and observations agree within factor of 3, where both exist.
- DOC/POC ratios range from 0.5 to 8.
- Inputs from 1.1–4.3 Tg C/yr for DIC, DOC, POC in N-CCS, GOA, and CAI.

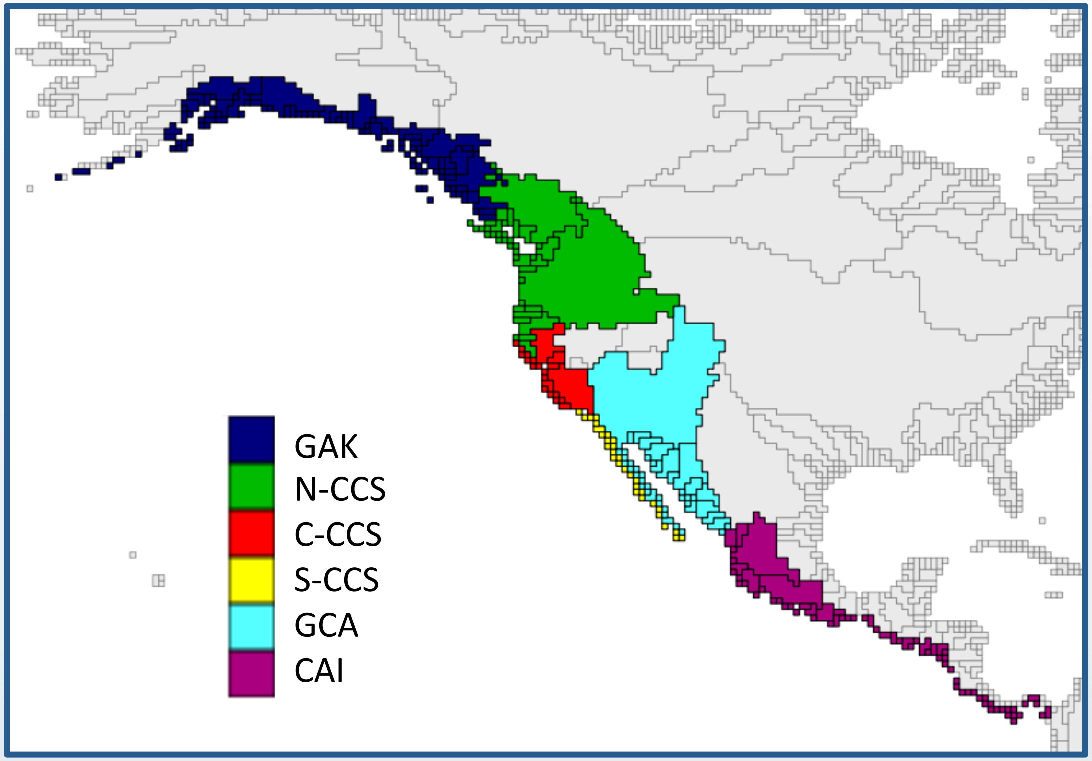


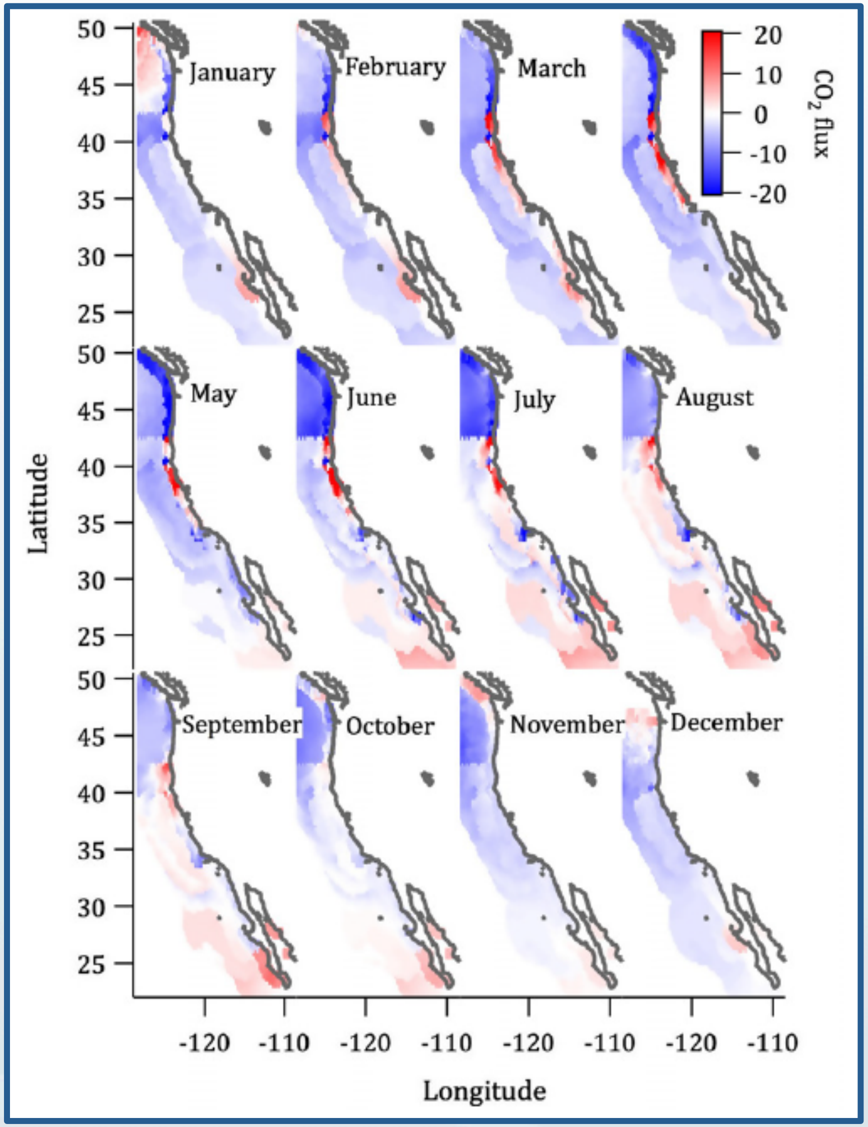
Figure: E. Mayorga

- Order(s) of magnitude lower freshwater and carbon inputs in C-CCS, S-CCS, and Gulf of California.

Remaining challenges—

- DIC inputs less well constrained by observations.

CCS—state of knowledge on air-sea CO_2 flux



Hales et al., Progress in *Oceanography*, 2012

What we know—

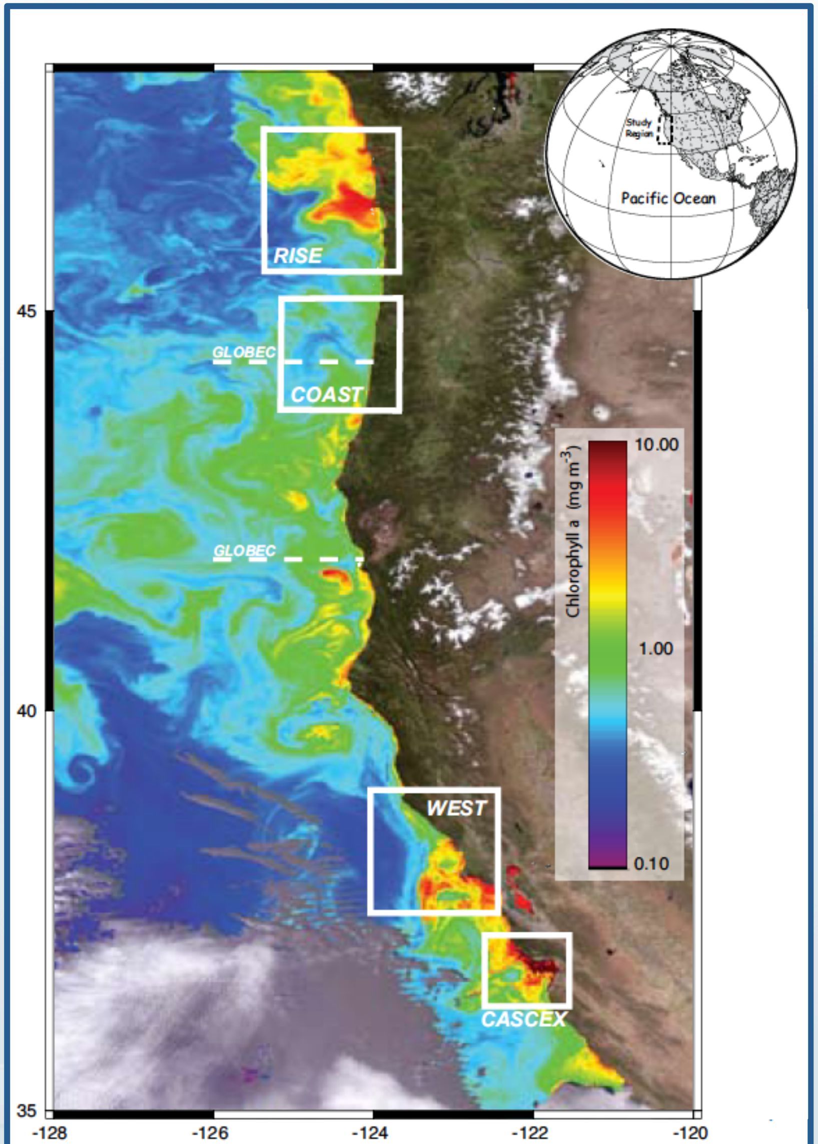
- Model-based and observational studies converging on similar numbers.
- Moderate CO_2 sink further N and weak sink to weak source to S.

Remaining challenges—

- Use of appropriate wind speed products inconsistent (temporal averaging issues).
- Estuarine and tidal wetlands fluxes less well and unconstrained, respectively.

CCS—state of knowledge on water column metabolism

NPP and R estimates



Kudela et al., *Oceanography*, 2008

What we know—

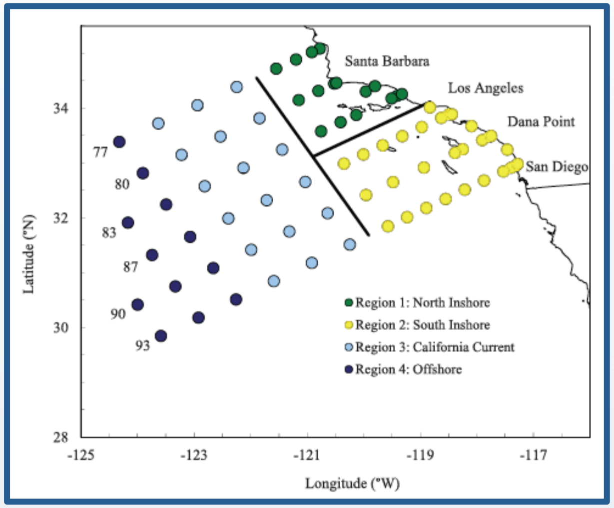
- Most spatial and temporal coverage of NPP measurements in CalCOFI region (U.S. part of S-CCS).
- Some measurements and model estimates of respiration in N-CCS only.

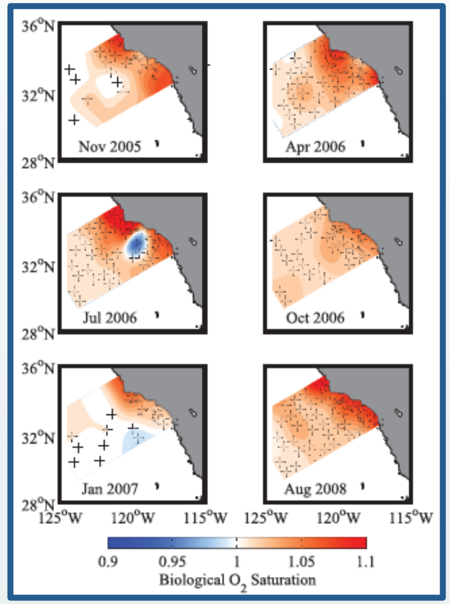
Remaining challenges—

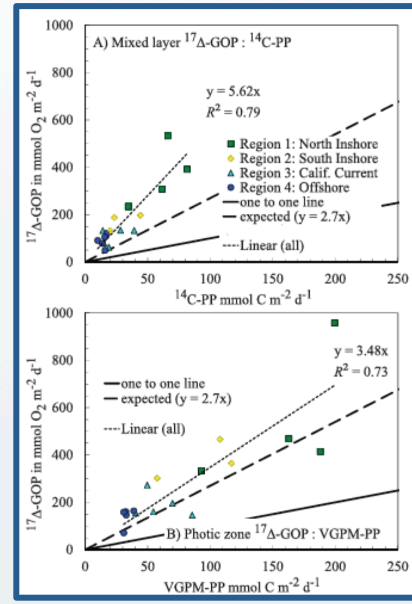
- Wide variety of methods used to measure NPP present inconsistent biases.
- Different boxes in space and time for different studies – how to best generate regional estimates?
- Strong inter-annual and decadal variability (ENSO, PDO, NPGO, etc.).

CCS—state of knowledge on water column metabolism

NCP and other export production estimates







Munro et al., *Limnology & Oceanography*, 2013

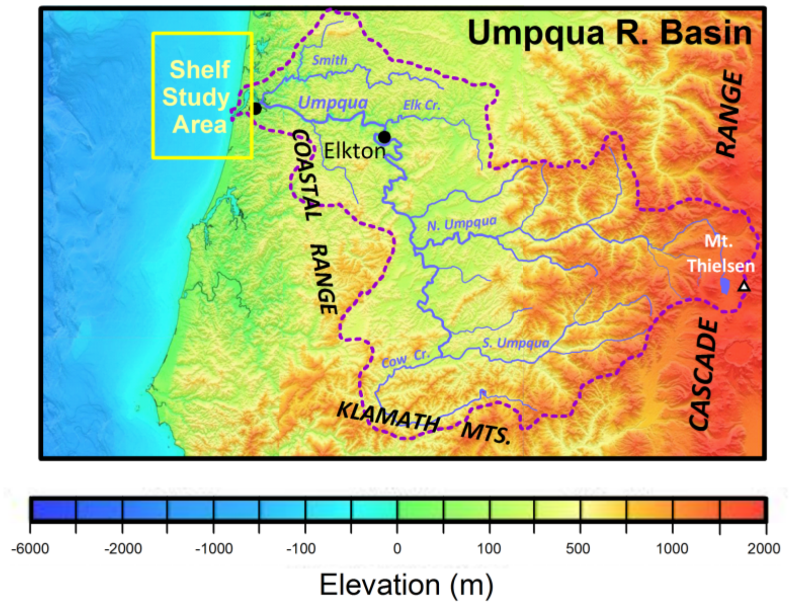
What we know—Best observational constraint on NCP and other estimates of export production in CalCOFI region.

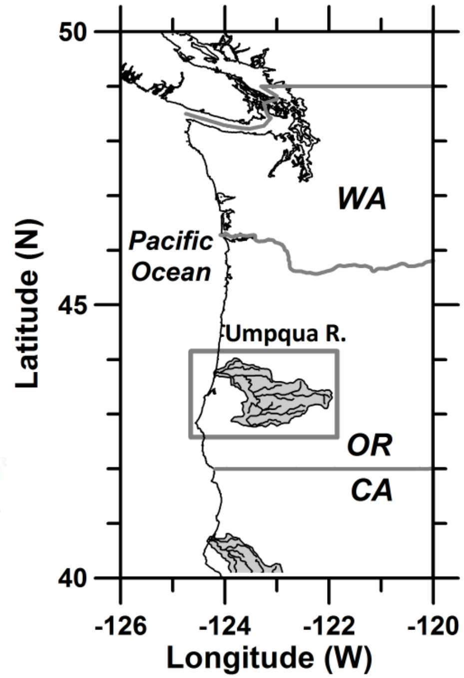
Remaining challenges—

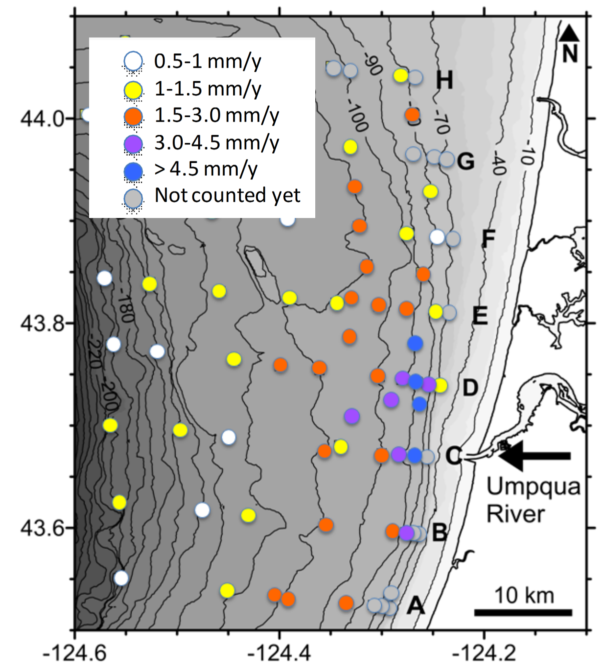
- Strong spatial and temporal heterogeneity make upscaling estimates to annual regional fluxes very challenging even for S-CCS.
- Essentially no estimates for N-CCS and C-CCS where we know controls are very different on these processes.
- “Missing NCP” – not balanced by other observed losses.
- How to deal with R beneath mixed layer.

CCS—state of knowledge on sediment respiration & burial

Open-shelf and small mountainous river (SMR) burial







Hastings et al., 2012; Wheatcroft et al., 2013

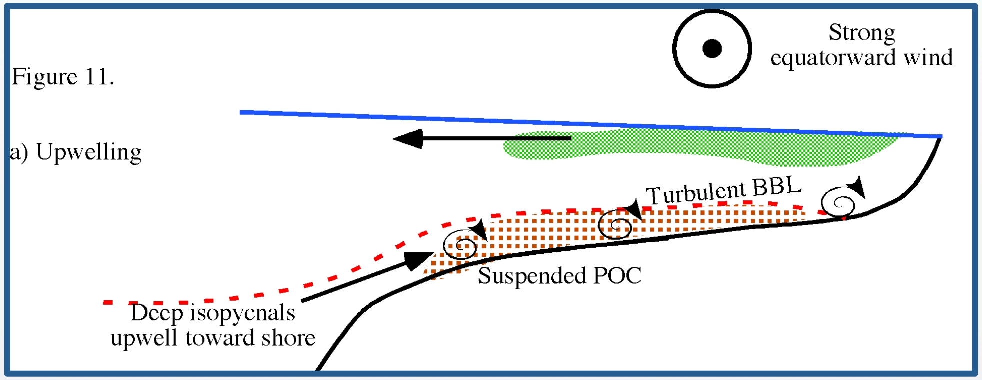
What we know—We have some sediment remineralization and burial estimates from observations and models from all regions except Gulf of Alaska.

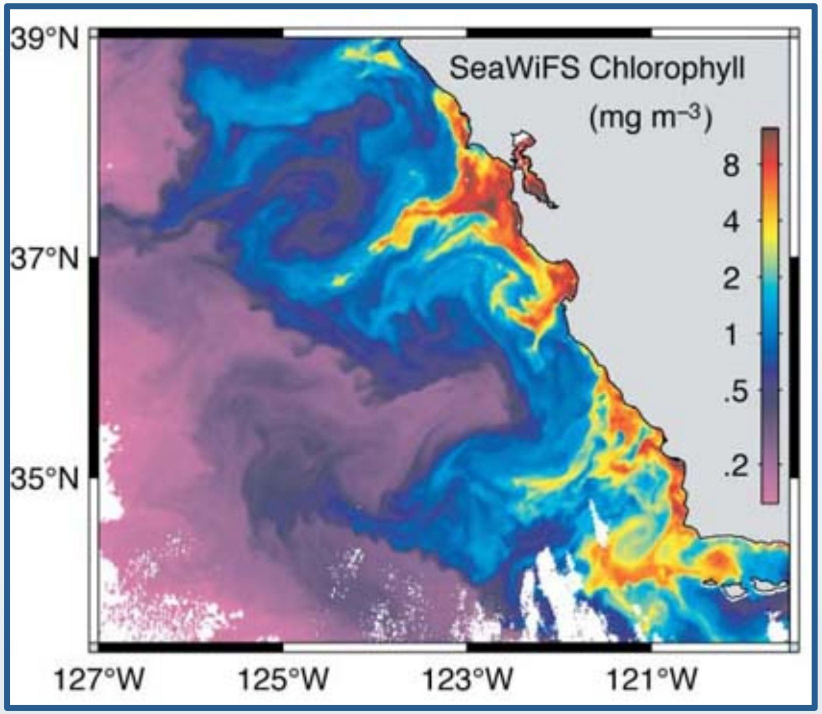
Remaining challenges—Spatial and temporal resolution of estimates are insufficient for robust upscaling of estimates.

Inherent time-averaging of burial measurements relative to other rates.

CCS—state of knowledge on carbon transport

Alongshore and offshore





What we know—Steady upwelling leads to net consumption of DIC much larger than cross-shelf export of OC (both POC and DOC)

Remaining challenges—Need better constraint on cross-shelf transport of organic constituents (not as altered from source water characteristics as inorganic constituents).

Along-shore transport more difficult to constrain with observations. Need detailed ship-based surveys or perhaps gliders to get required spatial and temporal resolution. Role for models?

West Coast region—achievements and gaps

Key achievements since NACM report:

- Air-sea flux estimates from models and observations are converging, suggesting we are in the right ballpark.
- Coastal C cycle models are sophisticated enough to start directly comparing with observations.
- We are starting to have enough observations in the CCS for robust syntheses of spatial and seasonal to inter-annual variability.

Key remaining gaps:

- Estuarine processing—how much of what comes into the estuary enters the coastal ocean?
- Winter observations—not a lot of them.
- Missing net community production—where does it end up?
- Most C cycle terms in the Gulf of Alaska and Central American Isthmus sub-regions are poorly constrained.

West Coast region—recommendations

Selected priorities as we move into the future:

- More mining and synthesis of long-term data sets (CalCOFI, IMECOCAL)
- More cross-platform data synthesis
- More model-data and model-model (inter)comparisons
- Prioritize modeling and observational efforts needed to close C budgets (e.g. winter, estuaries, missing NCP)
- Improve understanding of how coastal C budgets are affecting ocean interior
- Time-series observations with water column profiles
- Understanding how coastal C cycles will change in the future—will require models to make predictions and process studies to test hypotheses generated by them