Paleoceanography and Paleoclimatology

RESEARCH ARTICLE
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^{230}Th Normalization: New Insights on an Essential Tool for Quantifying Sedimentary Fluxes in the Modern and Quaternary Ocean

Kassandra M. Costa[1], Christopher T. Hayes[2], Robert F. Anderson[3,4], Frank J. Pavia[3,4,5], Alexandra Bausch[3,4,6], Feifei Deng[7], Jean-Claude Dutay[8], Walter Geibert[9], Christoph Heinze[10], Gideon Henderson[7], Claude Hillaire-Marcel[11], Sharon Hoffmann[12], Samuel L. Jaccard[13], Allison W. Jacobel[14,15], Stephanie S. Kienast[16], Lauren Kipp[3,16], Paul Lerner[17], Jörg Lippold[18], David Lund[19], Franco Marcantonio[20], David McGee[21], Jerry F. McManus[3,4], Figen Mekik[22], Jennifer L. Middleton[3], Lise Missiaen[23], Christelle Not[24], Sylvain Pichat[25,26], Laura F. Robinson[27], George H. Rowland[27], Matthieu Roy-Barman[8], Alessandro Tagliabue[28], Adi Torfstein[29,30], Gisela Winckler[3,4], and Yuxin Zhou[3,4]

[1]Department of Geology and Geophysics, Woods Hole Oceanographic Institution, Woods Hole, MA, USA, [2]School of Ocean Science and Engineering, University of Southern Mississippi, Stennis Space Center, MS, USA, [3]Lamont-Doherty Earth Observatory, Columbia University, Palisades, NY, USA, [4]Department of Earth and Environmental Sciences, Columbia University, New York, NY, USA, [5]Now at Division of Geological and Planetary Science, California Institute of Technology, Pasadena, CA, USA, [6]Now at Department of Earth System Science, Stanford University, Stanford, CA, USA, [7]Department of Earth Sciences, University of Oxford, Oxford, UK, [8]Université Paris-Saclay, CNRS, CEA, UVSQ, Laboratoire des sciences du climat et de l'environnement, IPSL, Laboratoire CEA, UVSQ, CNRS, Gif sur Yvette, France, [9]Alfred Wegener Institute for Polar and Marine Research, Bremerhaven, Germany, [10]Geophysical Institute and Bjerknes Centre for Climate Research, University of Bergen, Bergen, Norway, [11]GEOTOP, Université du Québec à Montréal, Quebec, Canada, [12]Department of Earth and Ocean Sciences, University of North Carolina Wilmington, Wilmington, NC, USA, [13]Institute of Geological Sciences and Oeschger Center for Climate Change Research, University of Bern, Bern, Switzerland, [14]Department of Earth, Environmental, and Planetary Sciences, Brown University, Providence, RI, USA,

Key Points:

- ^{230}Th normalization is a robust tool for calculating sedimentary mass fluxes
- ^{230}Th may be affected by hydrothermal and boundary scavenging in certain discrete regions
- Generally, ^{230}Th mass fluxes are preferable over age model-based mass accumulation rates

Supporting Information:

- Supporting Information S1
- Table S1

Correspondence to:
K. M. Costa,
kassandracosta@whoi.edu

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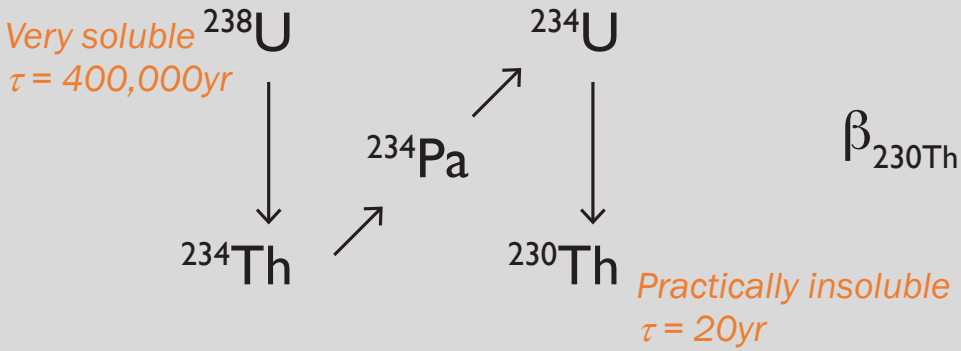
How does ^{230}Th normalization work?

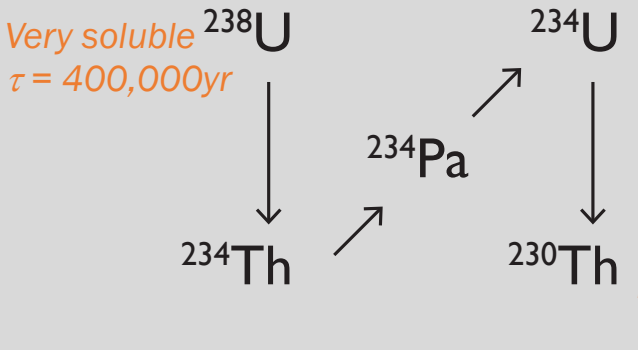
Constant production in the water column:



$$\beta_{230Th} = 2.562^{*}\ 10^{-5}\ dpm/cm^{3}kyr$$

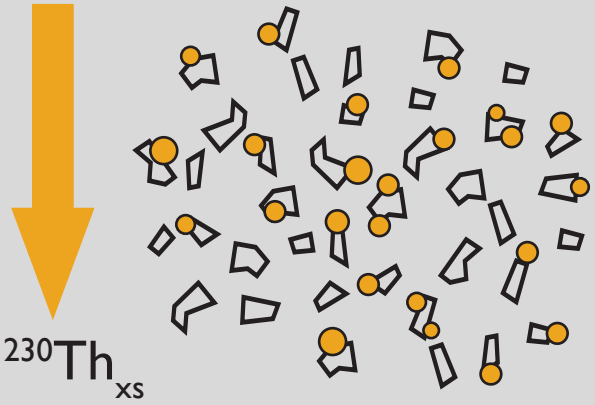
^{230}Th development: Bacon 1984; Suman and Bacon 1989; Francois et al 1990, 2004

Constant production in the water column:



$\beta_{230Th} = 2.562 * 10^{-5}$ dpm/cm^{3}kyr

High Sediment Flux

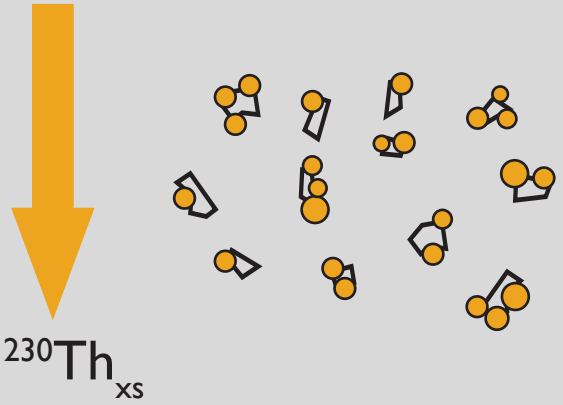


10 dpm

5 g sediment

$^{230}Th_{xs}$ concentration
2 dpm/g

Low Sediment Flux

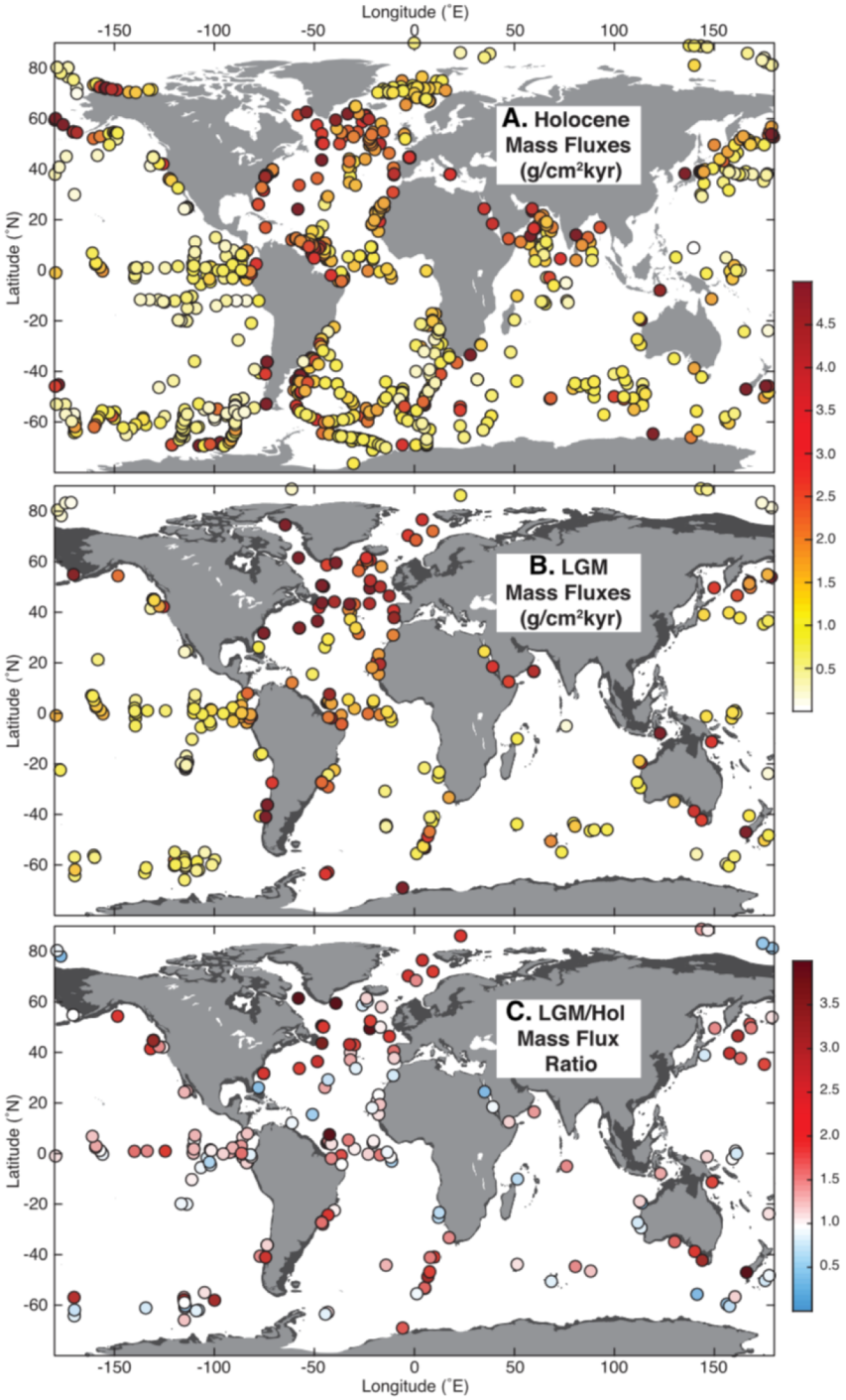


10 dpm

1 g sediment

$^{230}Th_{xs}$ concentration
10 dpm/g

^{230}Th development: Bacon 1984; Suman and Bacon 1989; Francois et al 1990, 2004



^{230}Th Global Database

- Working group in the GeoTRACES program
- Compilation of over 1000 sites!
- Can be combined with measurements of, e.g., $CaCO_3$, Opal, Fe, etc
- Update, synthesis, and outlook for ^{230}Th normalization

^{230}Th assumption

- All the ^{230}Th produced in the water column is scavenged by particles and buried in the underlying sediment

  - Flux to Sediment = Production in Water Column
  - F / P = 1

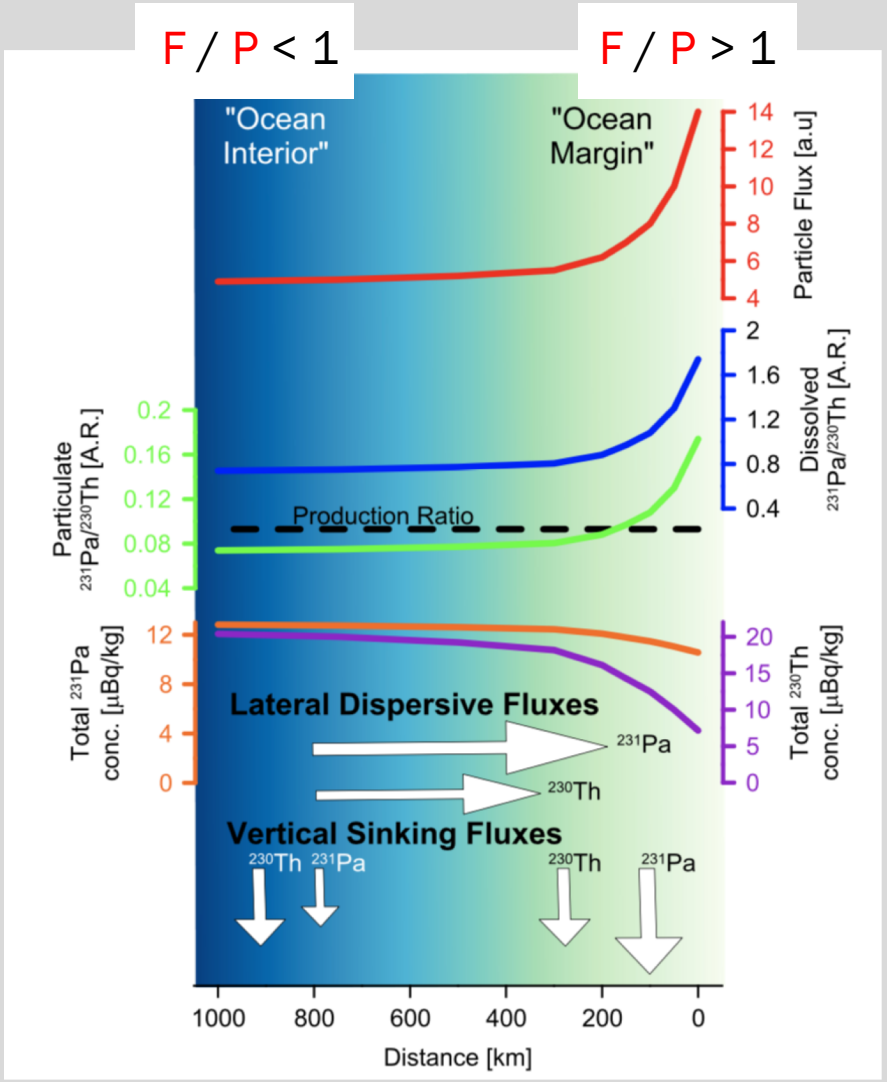
1. Boundary Scavenging

2. Nepheloid Layers

3. Hydrothermal Activity

Boundary Scavenging

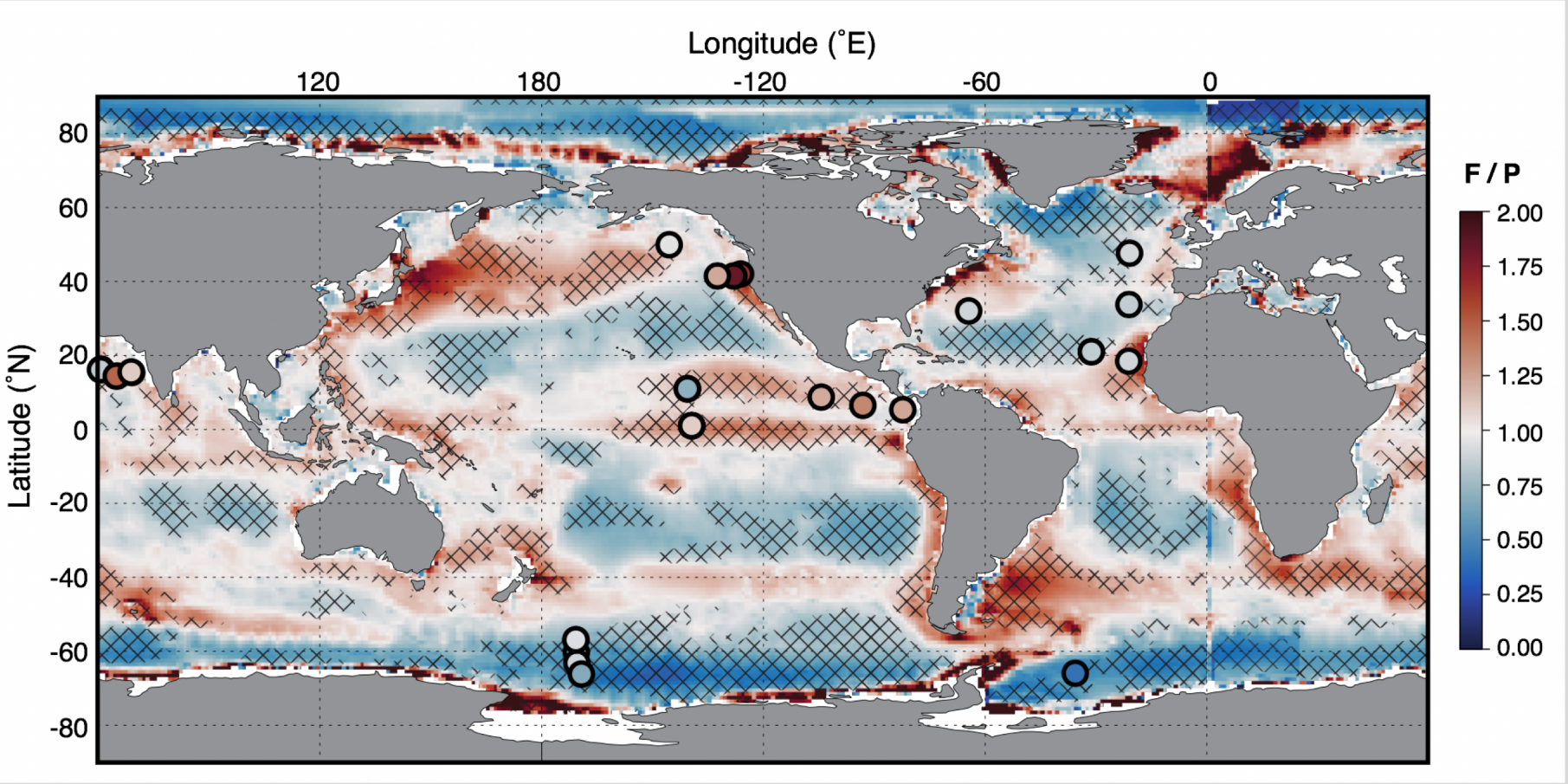
- High particle fluxes near margins rapidly/efficiently strip ^{230}Th out of the water column
- This can create a *concentration gradient* in ^{230}Th in the water column
- ^{230}Th could then follows the concentration gradient towards the boundary



Hayes et al., 2015

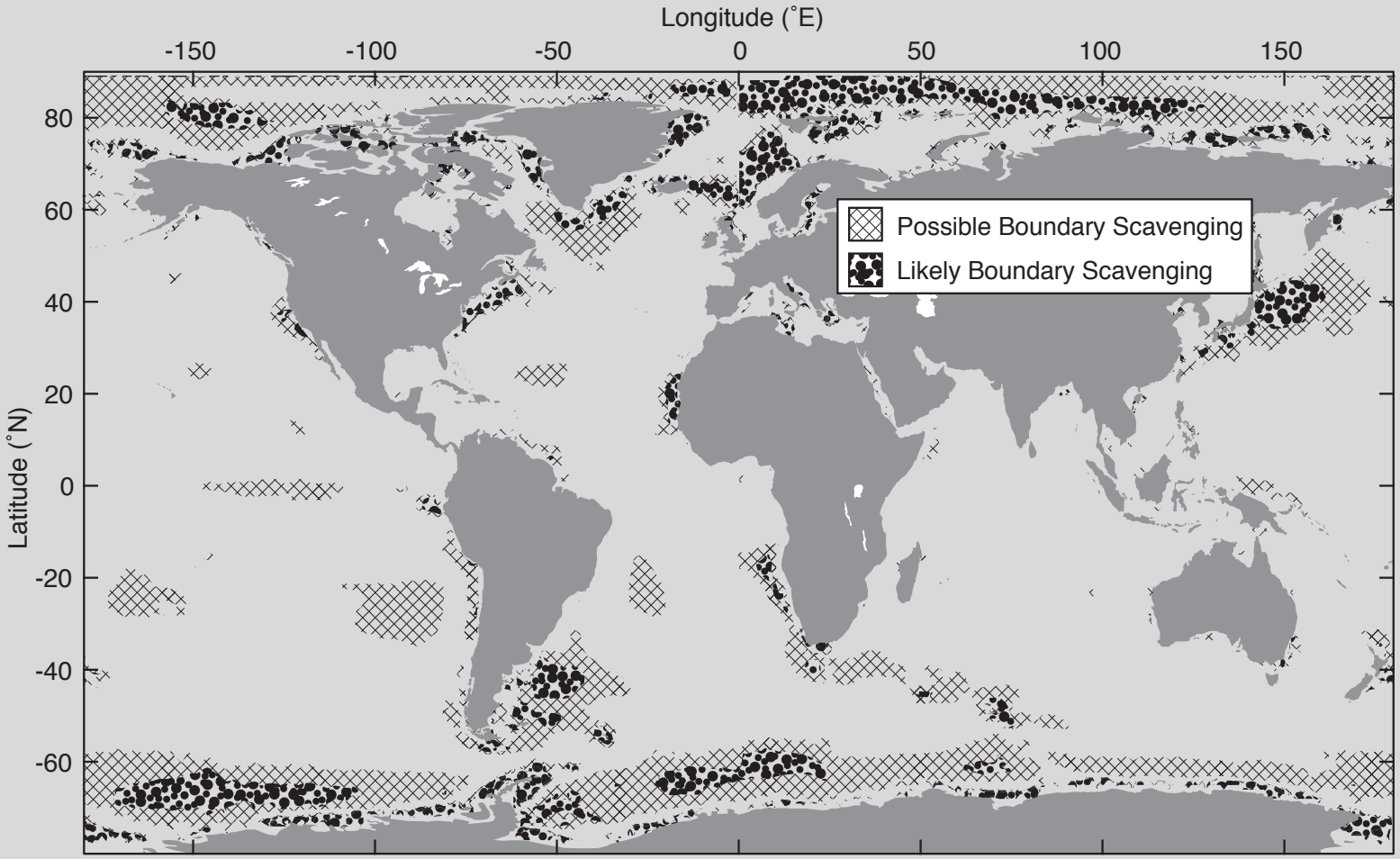
Modelled F/P captures boundary scavenging

73% of the ocean has ^{230}Th flux within 30% of water column production



Background : Composite of iLoveClim, HAMOCC, CESM, and NEMO-PISCES models
Dots : measurements in sediment traps

Boundary scavenging really only an issue in the polar seas and along continental margins



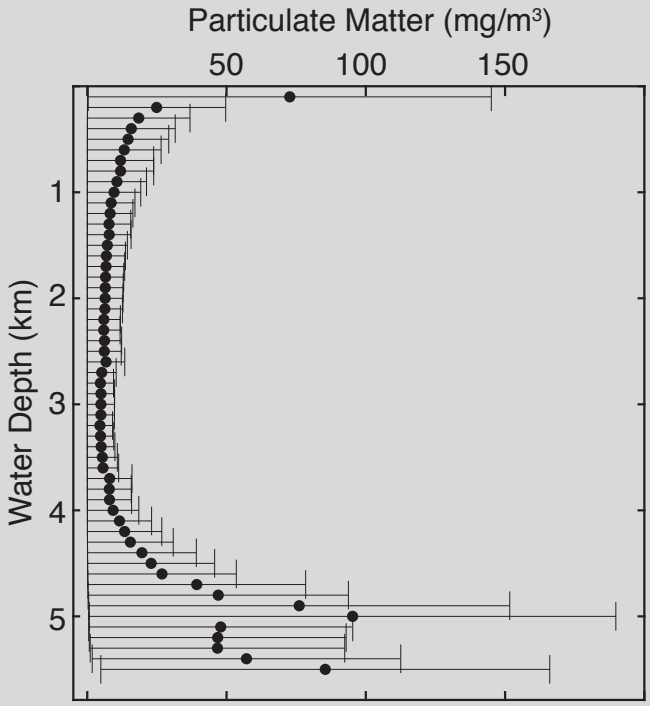
Most of the ocean is doing just fine!!

Other considerations for ^{230}Th application

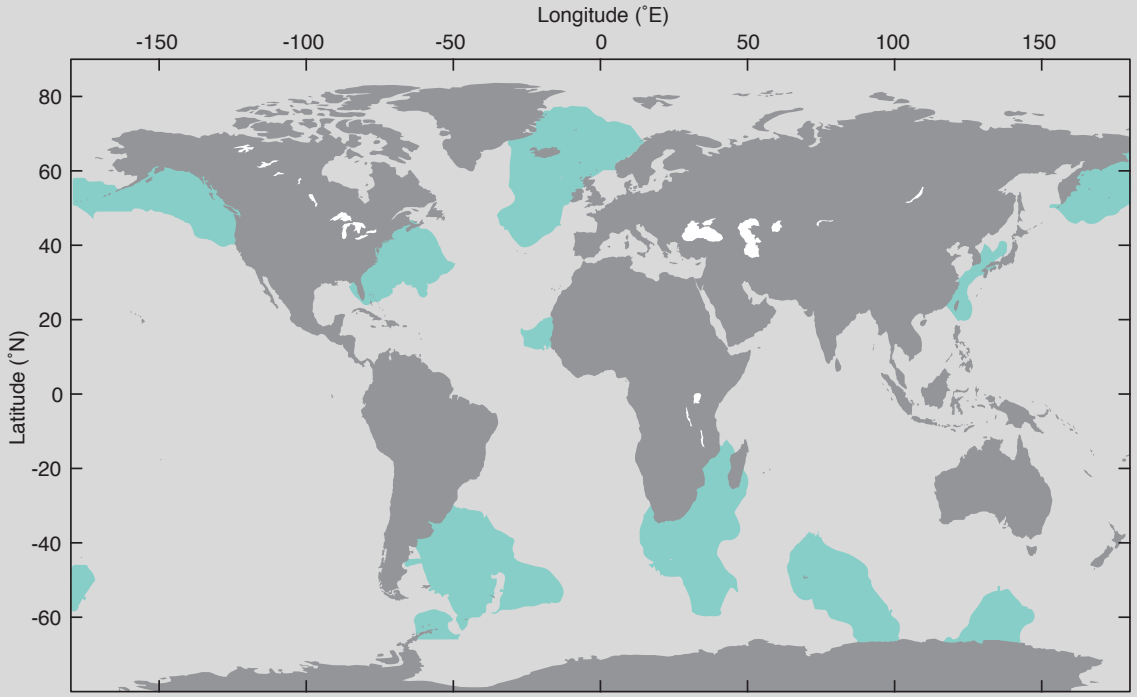
- Discussed next:
  - *Nepheloid layers*
  - *Hydrothermal scavenging*

- Also in the Paper:
  - *Grain sizes and sediment focusing*
  - *Calcium carbonate dissolution*

Nepheloid layers: “Boundary Scavenging” along the seafloor



Lerner et al., submitted

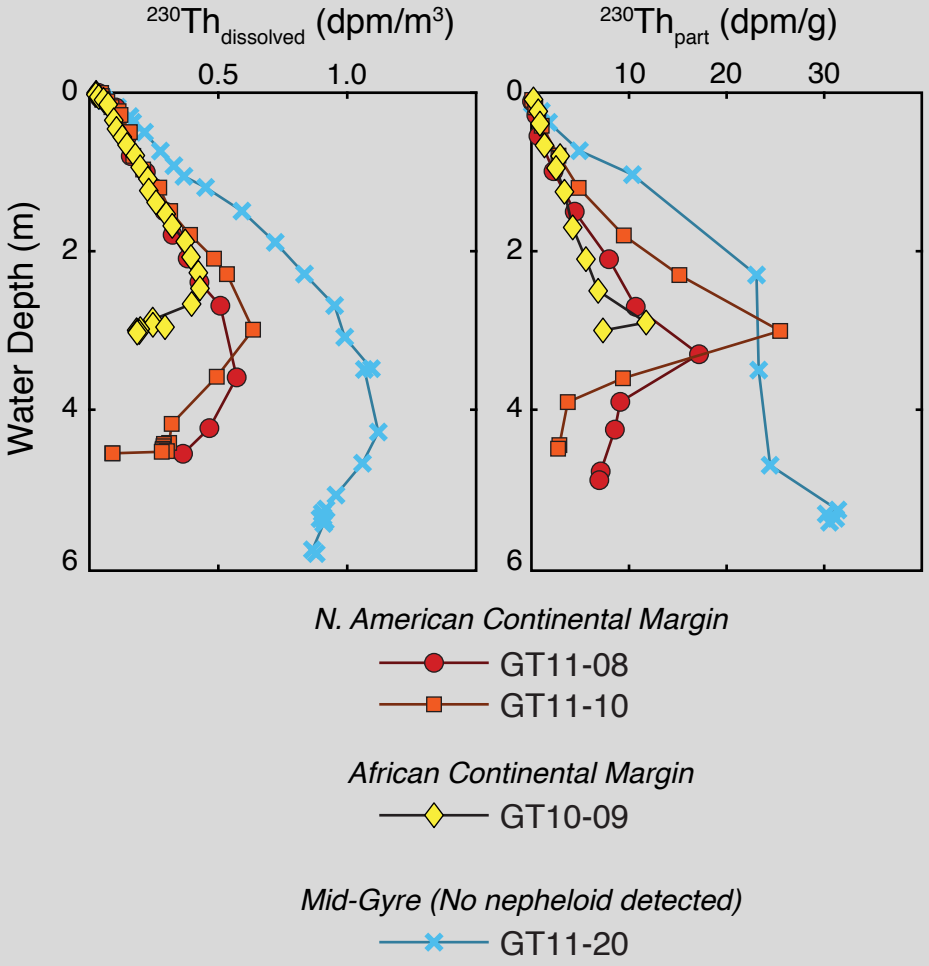


Gardner et al., 2018

- Sediment that gets resuspended due to turbulence along the seafloor

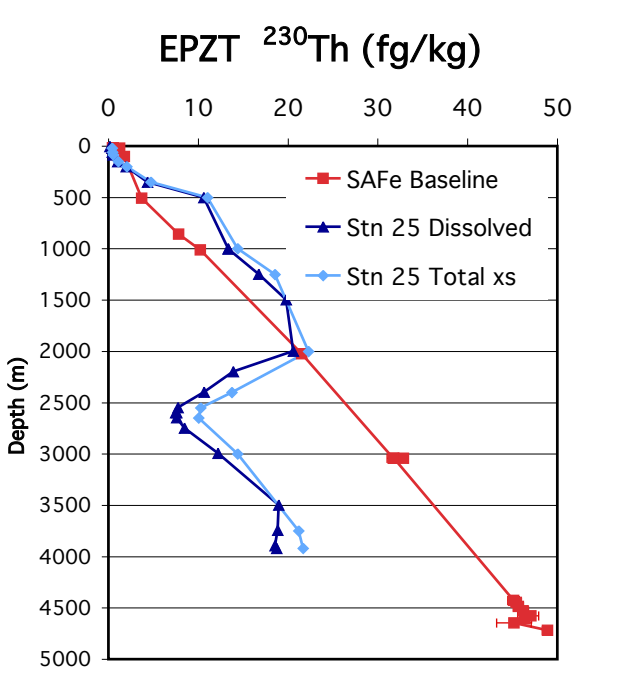
Nepheloid layers do scavenge extra ^{230}Th…

- But the particle concentration is so high…
- That the net ^{230}Th concentration decreases !!
- Could possibly lead to *overestimating* the mass flux
- But need to test this with coretop samples under nepheloid layers



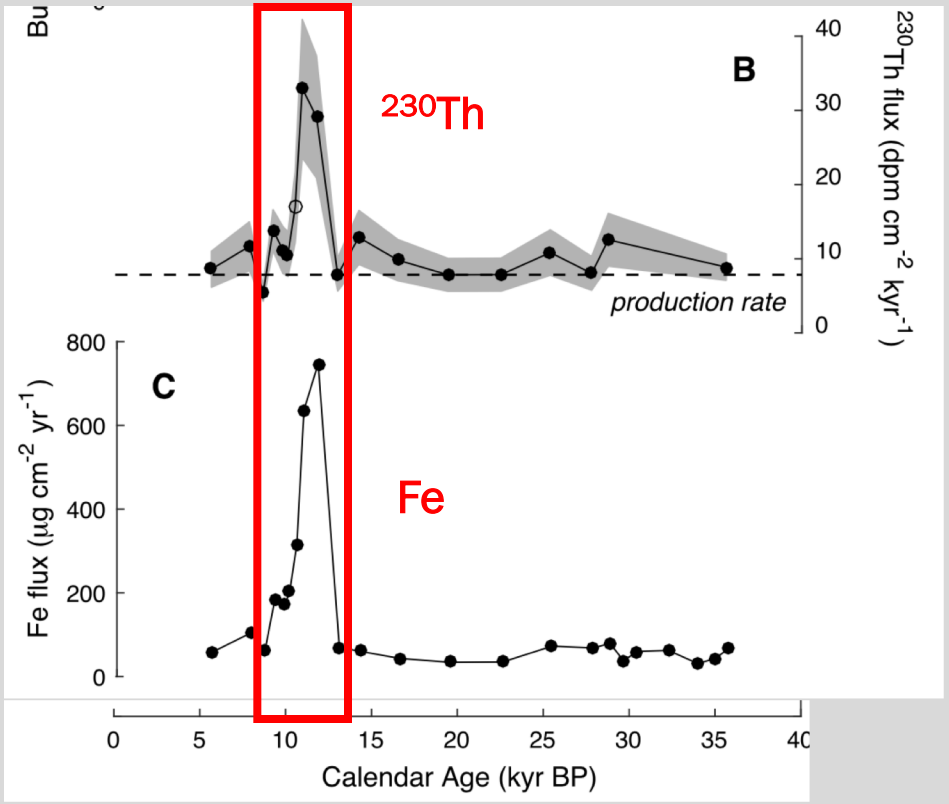
Hayes et al., 2015; Lerner et al., submitted

Hydrothermal Activity: Fe-Mn rich particles have high affinity for scavenging ^{230}Th



Pavia et al., 2018

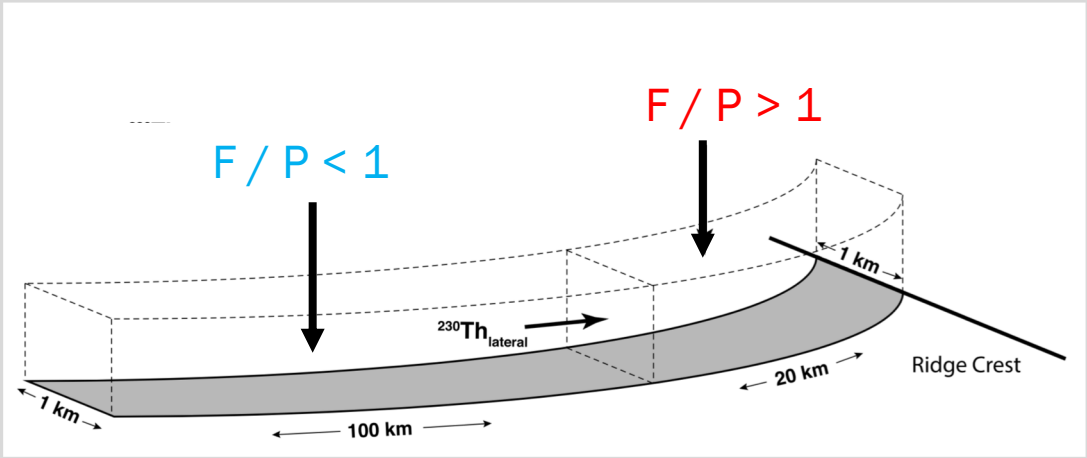
EAST PACIFIC RISE



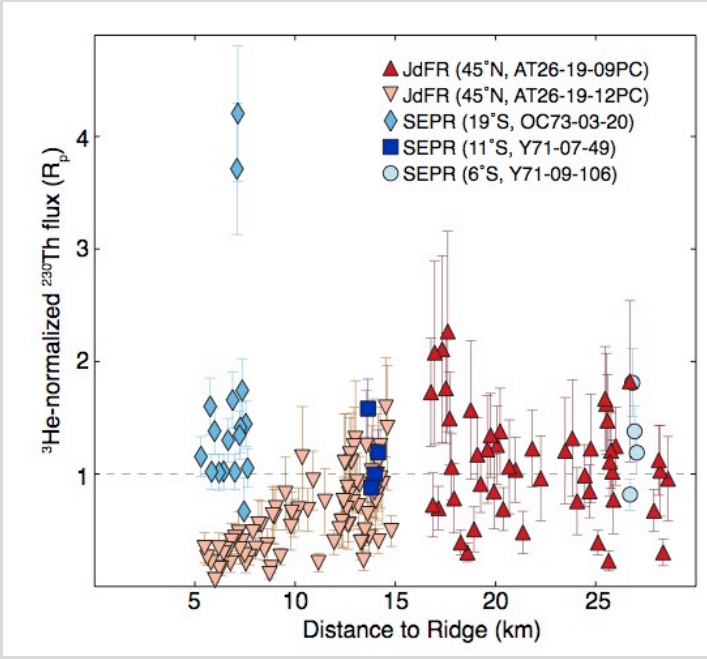
Lund et al., 2019

- Burial rates on mid-ocean ridges may be higher than production (F/P >1)

High ^{230}Th fluxes have to be supplied from somewhere…



Lund et al., 2019



Lund et al., 2019; Middleton et al., in prep

- Excess scavenging at the ridge creates a concentration gradient
- Lateral diffusion supplies more ^{230}Th
- Net effect of hydrothermal scavenging is *difficult to predict*

Summary

- **Where it works:** MOST of the ocean!!
- **Where to use caution:**
  - Continental margins and polar oceans, where boundary scavenging may be high
    - Fluxes biased too LOW
  - Regions with extensive nepheloid layers
    - Fluxes biased too HIGH
  - Mid-ocean ridges with active hydrothermal systems
    - Fluxes could be biased either HIGH or LOW
- **Future directions:**
  - Validate hypotheses with joint ^{3}He-^{230}Th measurements

Questions?

- Please contact me at
  - kassandracosta@whoi.edu

- I look forward to hearing from you!