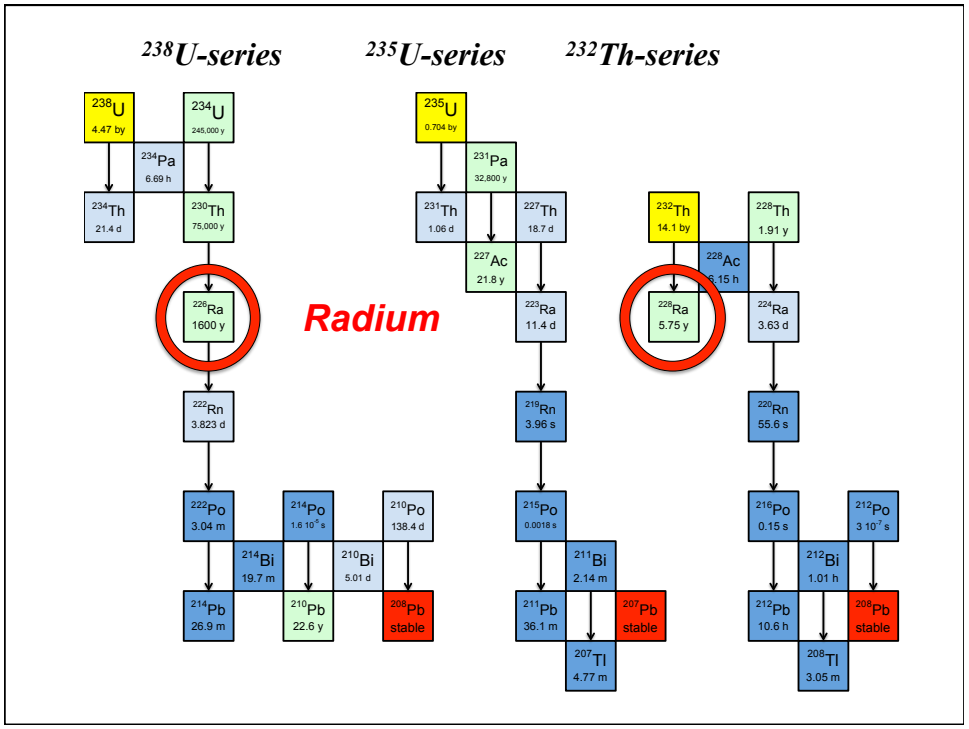
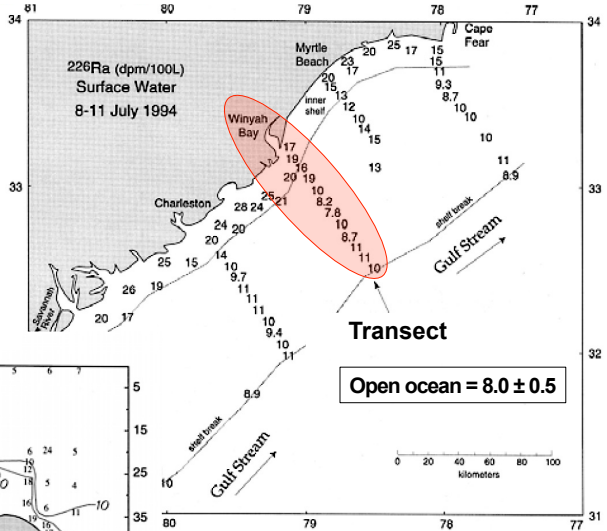


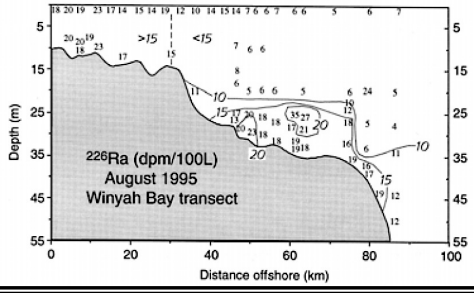
Central Atlantic Bight, Winyah Bay

Detection of ^{226}Ra excesses along the central Atlantic coast

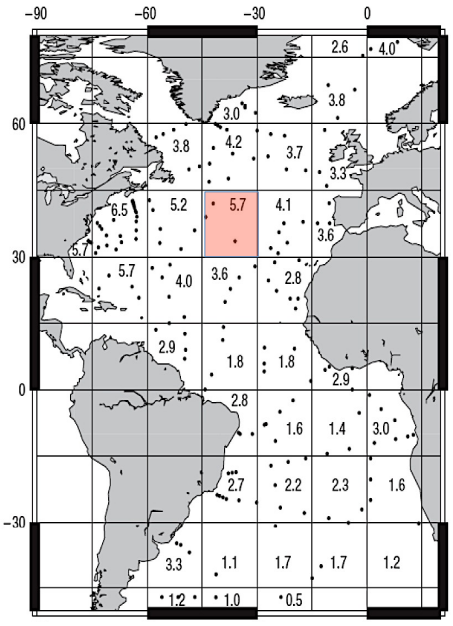
Seepage meters and mass balances:

Flow rates of 2-10 cm day^{-1}





Moore et al., 1996, 1999



Land-Ocean Exchange

^{228}Ra Inventory (I_B) =
Basin Area (A_B) x Average column I
$A = 10^8$ km^2, $I = 3 \times 10^{10}$ atoms m^{-2}
$I_B = 3 \times 10^{24}$ atoms m^{-2}

Decay = $I_B \lambda_{228Ra}$
$= 3.5 \pm 0.7 \times 10^{23}$ atoms yr^{-1}

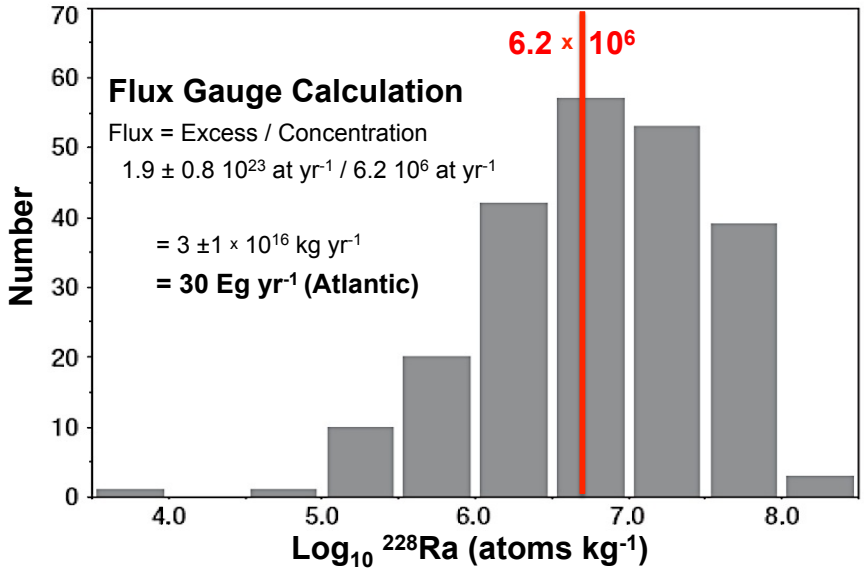
^{228}Ra sources (J_B): 1.6 ± 0.5 atoms yr^{-1}
Sediments: $1.3 \pm 0.5 \times 10^{23}$ atoms yr^{-1}
Rivers: $0.3 \pm 0.1 \times 10^{23}$ atoms yr^{-1}
Eolian: $0.03 \pm 0.02 \times 10^{23}$ atoms yr^{-1}

Difference: $J_B - (I_B \lambda_{228Ra})$ = 1.9 ± 0.8 atoms yr^{-1}

^{228}Ra inventory (top 1000 m, units 10^{10} atoms m^{-2}

Moore et al., 2008

Missing Source – Groundwater (SGD)



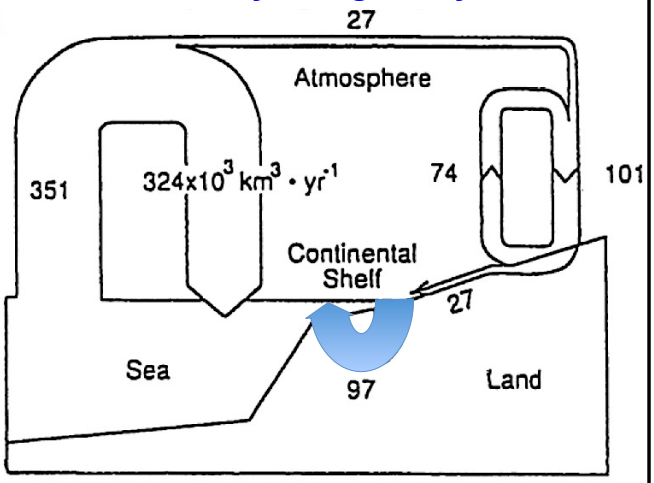
A total of 226 Groundwater ^{228}Ra concentrations measurements

Moore et al., 2008

Subterranean Estuaries (SGD)

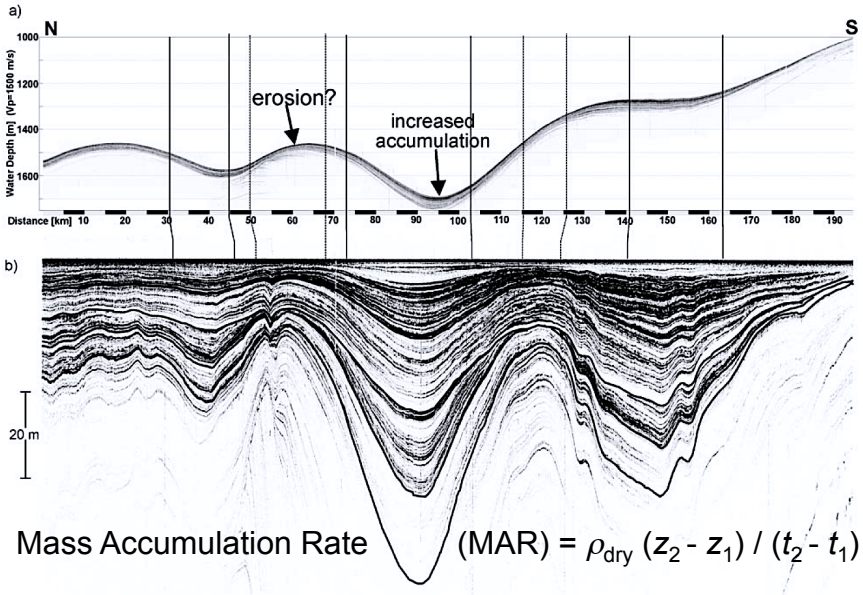
- Analogous to an estuary
- Large volume exchange fluxes
- Intense reaction zones

The Global Hydrological Cycle



Water fluxes in Exa (E=10^{18}) gram yr^{-1} (=10^3 km^3 yr^{-1})

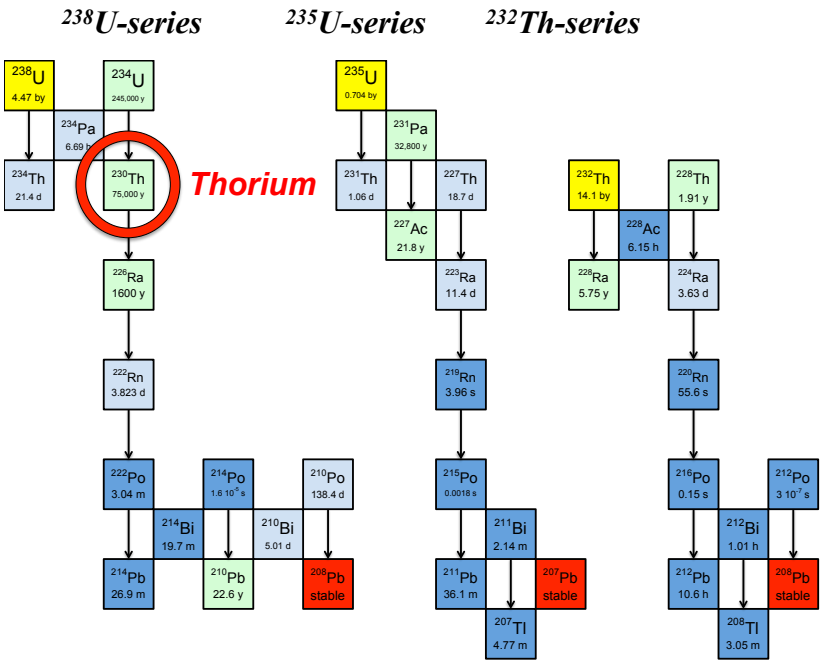
Sedimentation in Space and Time



Mass Accumulation Rate (MAR) = $\rho_{dry}\,(z_2 - z_1) / (t_2 - t_1)$

Echo sounding profiile parallel to the Namibian coast

Mollenhauer et al., 2002



$^{230}Th_x$ Profiling method

Assumption: ^{230}Th rain rate (F_{230}) is the integrated production of ^{230}Th from ^{234}U in the overlying water column.

$$^{230}Th_x = P_{230} / J_m$$

with J_m = dry sediment flux (g cm^{-2} yr^{-1})
and P = integrated production from ^{234}U (dpm cm^{-2} yr^{-1})
with P = βz
with β = production of ^{230}Th from ^{234}U per volume per time (dpm cm^{-3} yr^{-1}), β_{230} (λ_{230} A_{234}) is 0.026 dpm m^{-3} yr^{-1}
and z = water depth above sediment (m)

Rain Rate (F_i)

$$F_i = (c_i\ \beta\ z) / {}^{230}Th_{xo}$$

with c_i = concentration of component (i) in sediment.

$^{230}Th_{xo}$ is determined by correcting for decay since deposition using an independent sediment chronology.

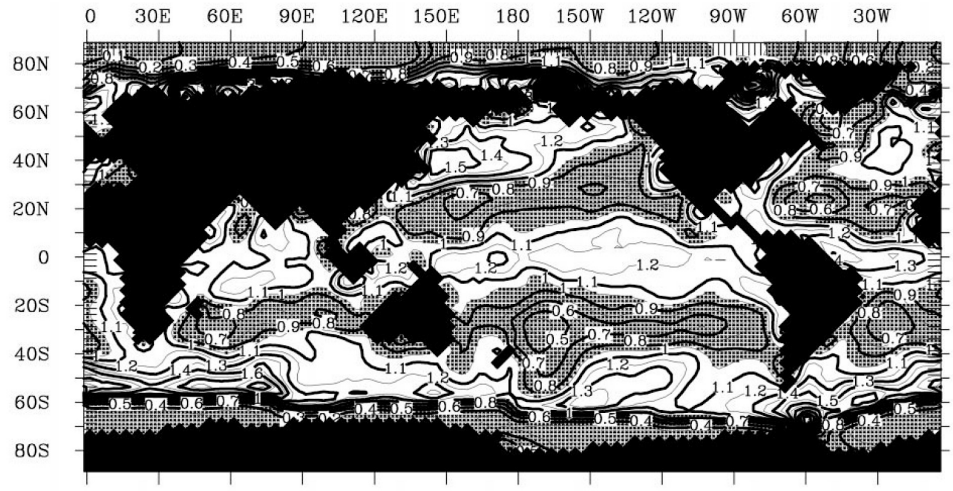
$^{230}Th_x$ Sediment Focusing Factor

Normalize the unsupported ^{230}Th in a sediment column by the integrated production of ^{230}Th from ^{234}U in the overlying water column.

$$\Psi_{230} = \left(\int_{z_1}^{z_2} {}^{230}\mathrm{Th}_{xo}\, \rho_b \, dz \right) / \left(P_{230} [t_1 - t_2] \right)$$

with ρ_b = dry bulk sediment density (kg m^{-3})
and t_i = age at depth z_i (yr)
with P = βz
with β = production per volume per time (dpm m^{-3} yr^{-1})
for ^{230}Th, β is 2.63 dpm m^{-3} yr^{-1}
and z = depth in sediment or water column (m)

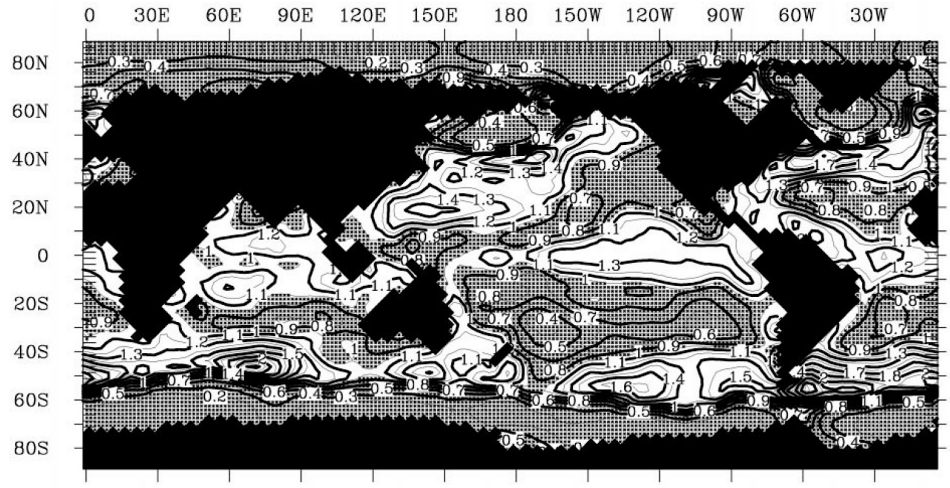
Holocene F_{230} (model-derived), normalized to production in overlying water column



F = 1.0 means rain rate equals production in overlying water column

Henderson et al., 1999

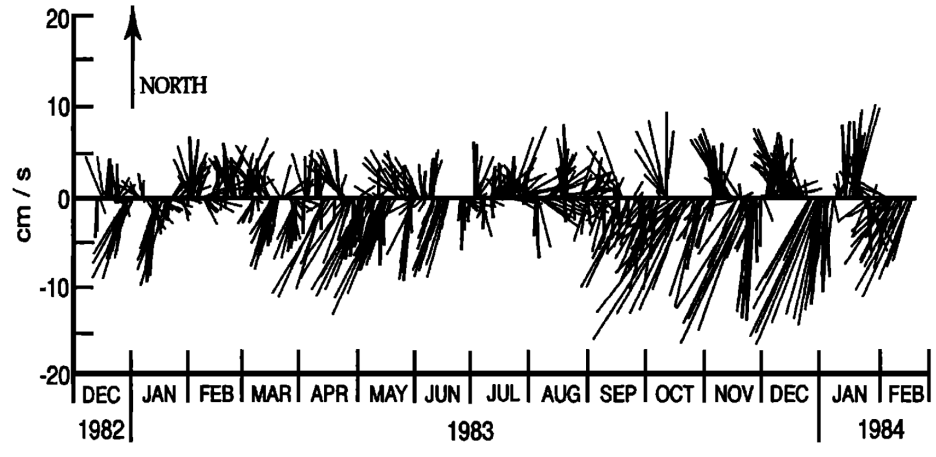
LGM F_{230} (model-derived), normalized to production in overlying water column



F = 1.0 means rain rate equals production in overlying water column

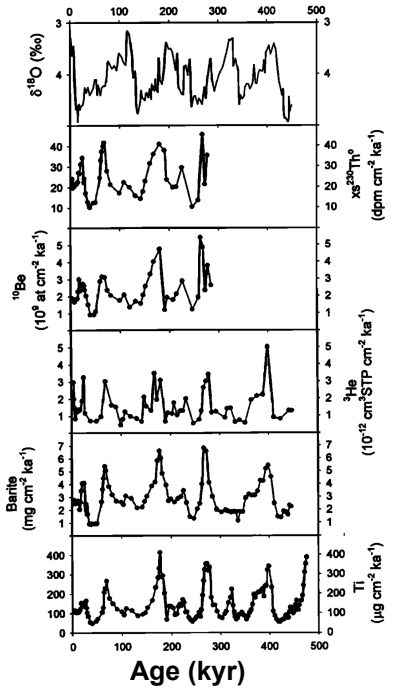
Henderson et al., 1999

Bottom current velocities in the eastern Pacific



Manganese Nodule Project (MANOP), Site C (from Dymond and Collier, OSU)

Marcantonio et al., 2001



Multi-proxy sediment record (PC 72)

Oxygen

$^{230}Thorium_x$

^{10}Be

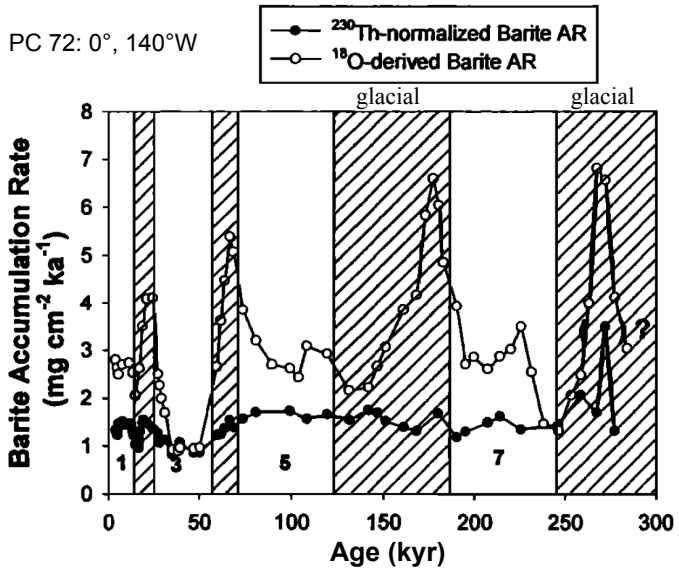
^{3}He

Barite

Titanium

Marcantonio et al., 2001

Barite Accumulation Rates as Proxy for Productivity

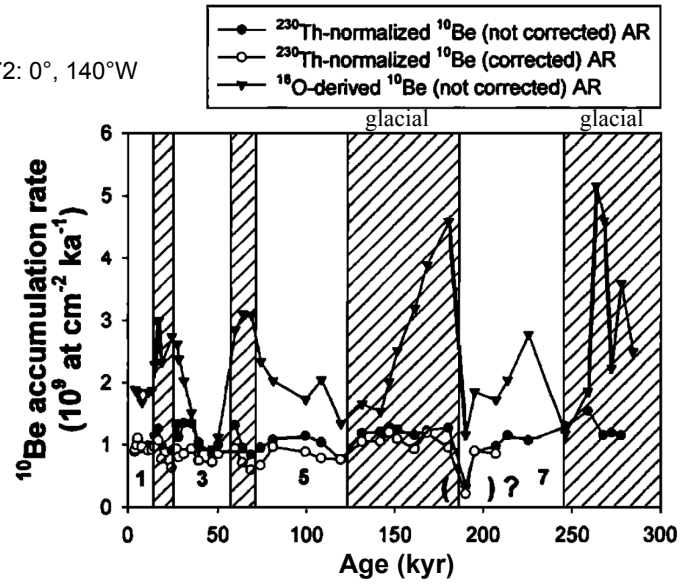


Barite data from Paytan, 1995

Marcantonio et al., 2001

Cosmogenic ^{10}Be Accumulation Rates

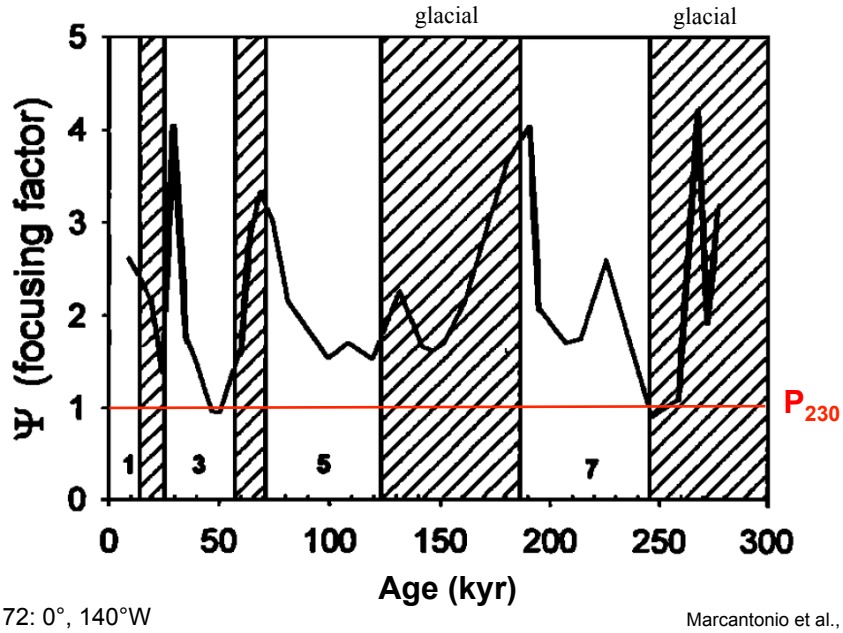
PC 72: 0°, 140°W



Correction for production according to Frank et al., 1997

Marcantonio et al., 2001

Focusing Factors



PC 72: 0°, 140°W

Marcantonio et al., 2001

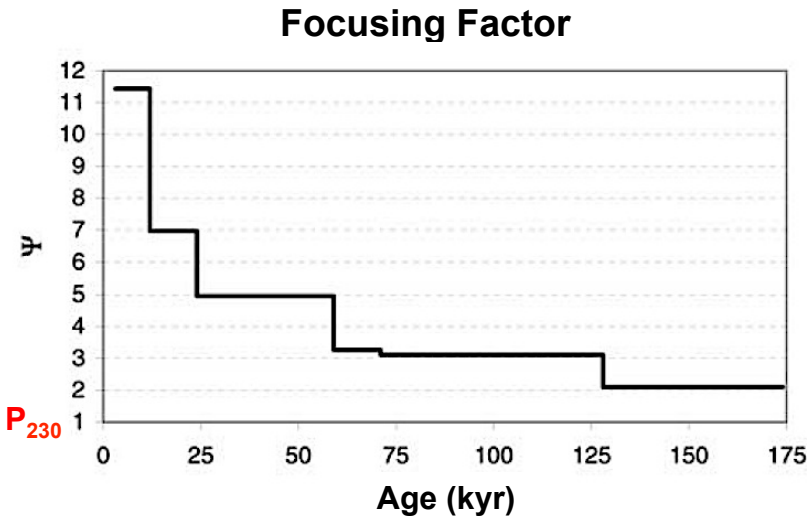
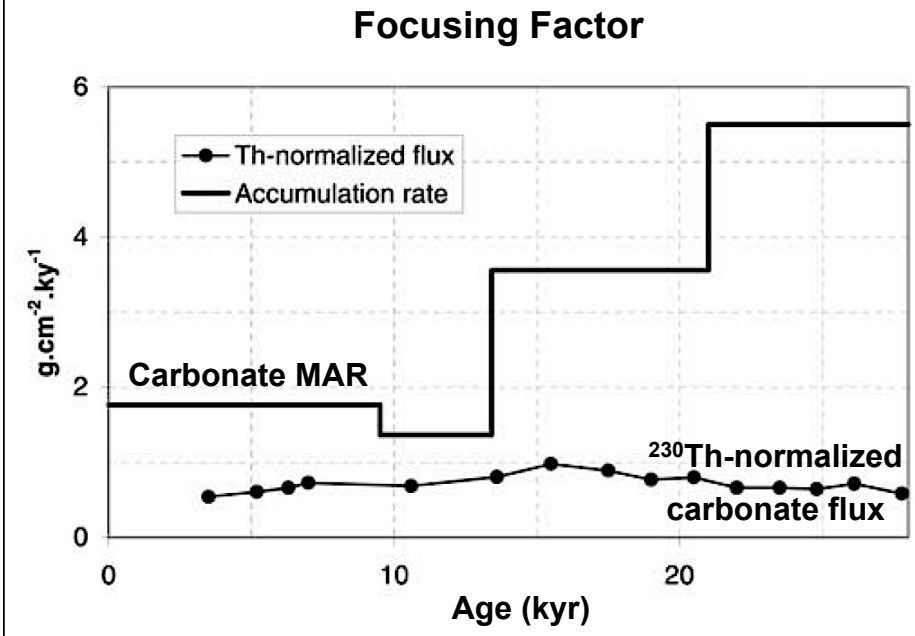


Figure 2. Focusing factor (Ψ) calculated for a core from the southern Scotia Sea (PS2319; 59°47′S; 42°41′W; 4320 m).

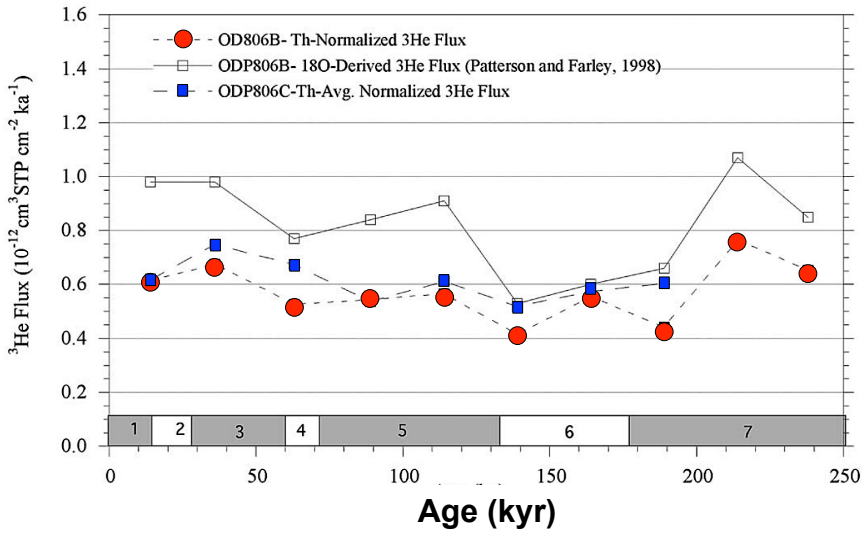
Francois et al., 2004



Eastern Equatorial Pacific, Y69-71, 0.1°N, 86.7°W

Francois et al., 2004

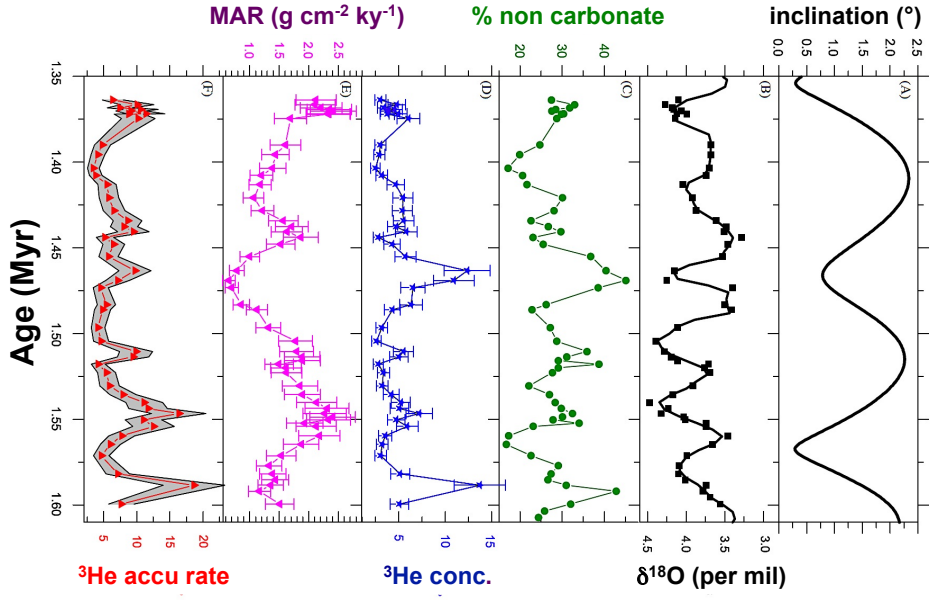
Constant Extraterrestrial ^{3}He Flux?



$^{230}Th_{xo}$-normalized ^{3}He fluxes vary much less than the focusing factor

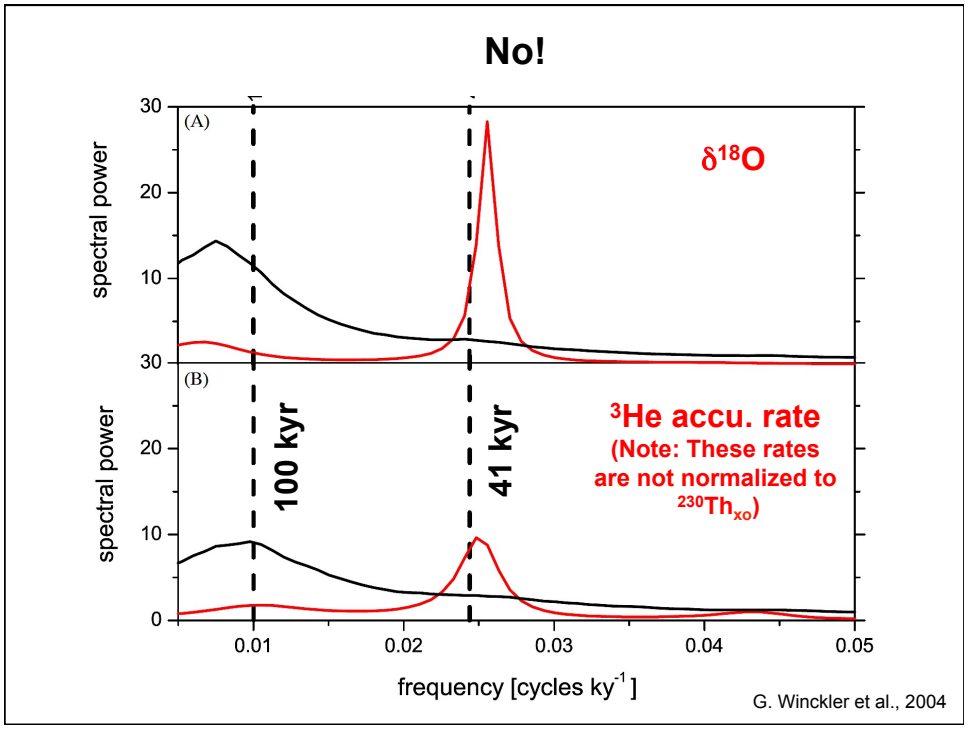
S. Higgins et al., 2002

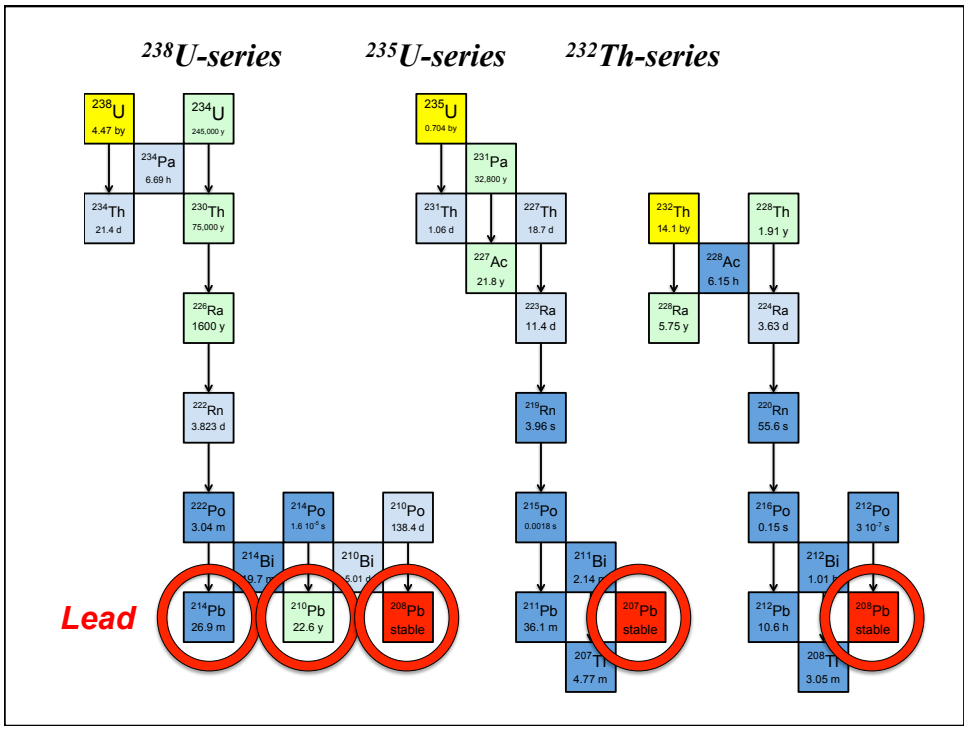
Is there a 100-kyr cycle in ^{3}He accumulation rates?



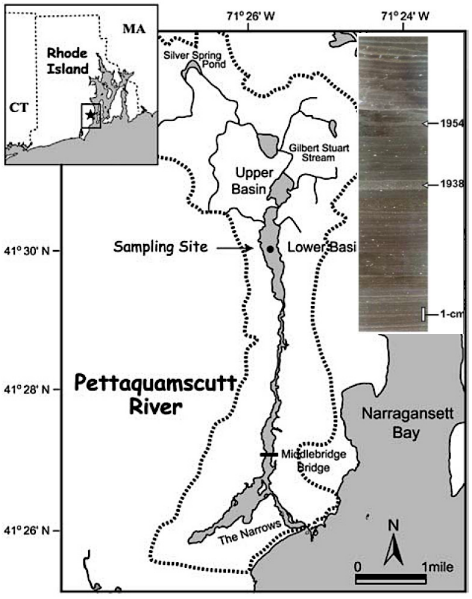
ODP 849, Eastern Equatorial Pacific

G. Winckler et al., 2004


No!
(A)
δ18O
(B)
3He accu. rate
(Note: These rates are not normalized to 230Thxo)
100 kyr
41 kyr
spectral power
spectral power
frequency [cycles ky-1]
G. Winckler et al., 2004


238U-series
235U-series
232Th-series
Lead

Anoxic Sediment Records



Pettaquamscutt River Basin, RI:

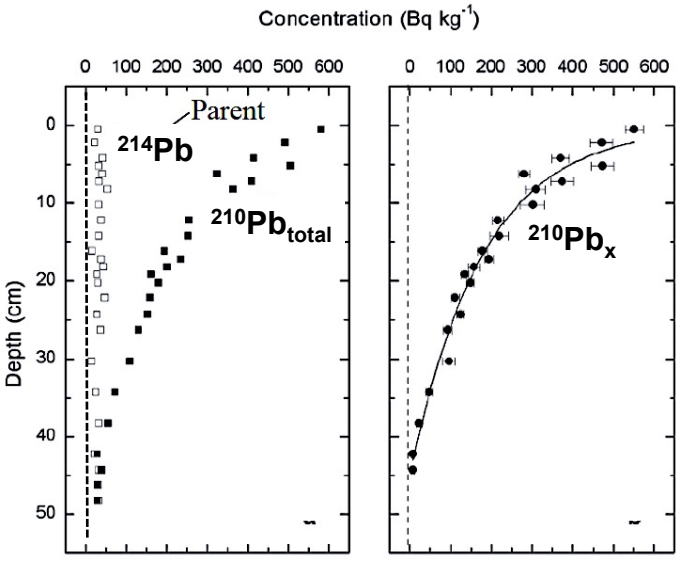
- Permanently anoxic Upper and Lower basins.
- Warved sediments.
- Relatively natural setting.
- Significant eolian deposition.
- Detailed work by WHOI and MIT students, postdocs and faculty.

Lima et al., 2005

Determining Accumulation Rates

^{210}Pb from eolian deposition and in-situ decay. Excess ^{210}Pb ($^{210}Pb_x$) gives time-averaged sedimentation rate:

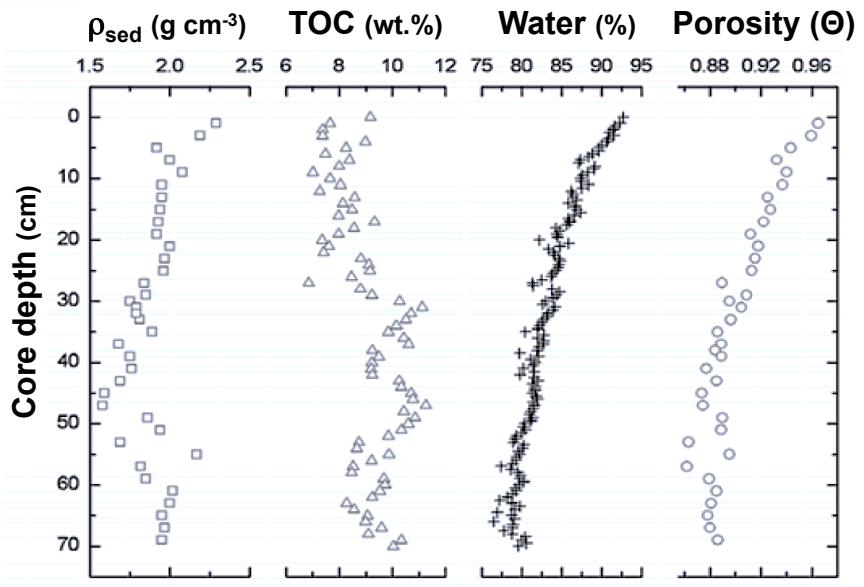
$$\int_0^\infty A\,dz = \frac{s}{\lambda}A_0$$



Lower Pettaquanscutt River Basin, RI

Lima, 2005

Determining Accumulation Rates



Lower Pettaquanscutt River Basin, RI — Lima, 2005

Determining Sediment Accumulation Rates

1) Assume c_0 (t) = const

$$c\,(z) = c_0\,(t)\; e^{-\lambda t}$$

$$t_1 = 1/\lambda\; ln(c_0 / c_z)$$

CIC

2) Assume c_0 (t) r (t) = const,

with r = sediment accumulation rate (g cm^{-2} yr^{-1})

for small Δz

$$dz = r\,(t) / \rho\,(z)\; dt$$

with ρ = dry sediment mass (g cm^{-3})

$$dz / dt = r / \rho$$

CRS

$$A\,(z) = A_0\,(t)\; e^{-\lambda t}$$

with A = Activity

$$t_2 = 1/\lambda\; ln(A_0 / A_z)$$

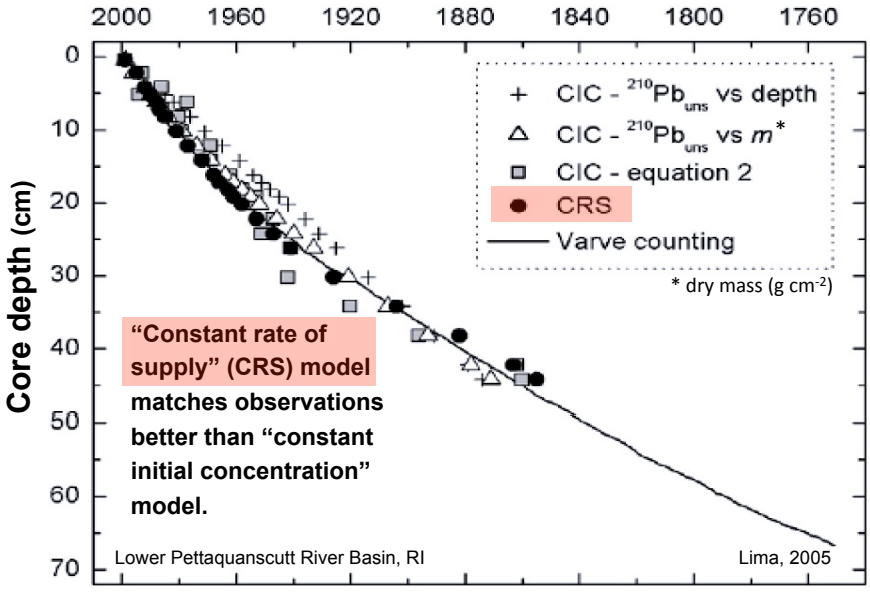
Age difference $\Delta t = t_2 - t_1 = 1/\lambda \ln (A_0\, c_z) / (A_z\, c_0)$

$$= 1/\lambda \ln (r_0 / r_t)$$

with $r = \lambda A / c$ at any give depth

Appleby & Oldfield, 1978

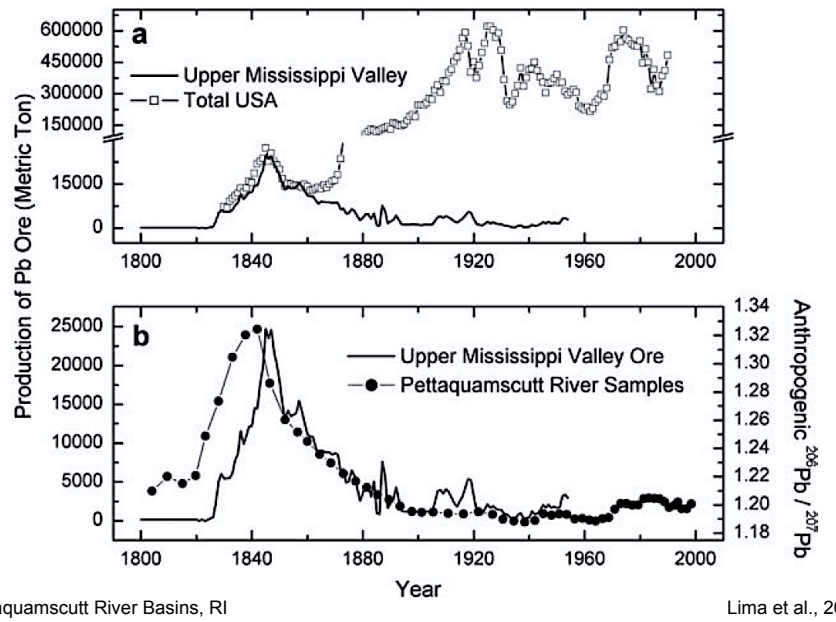
Determining Sediment Accumulation Rates



"Constant rate of supply" (CRS) model matches observations better than "constant initial concentration" model.

Lower Pettaquanscutt River Basin, RI — Lima, 2005

Tracking Eolian Pollution – Anthropogenic Pb



Pettaquamscutt River Basins, RI — Lima et al., 2005