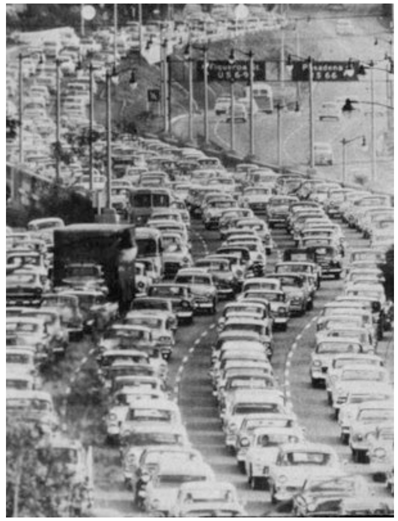
METHANE CLATHRATES

- Weird stuff -ice that burns
- In oceans may melt, lead to warming
- First discuss what, why, where..then
- How can we know more?
- Can we handle problems arising?

CO_2 source



CH_4 source

GREENHOUSE GASES

- Trap heat in the atmosphere
- Most important contain carbon
- CO_2 up from 300 to 400 ppm
- Methane 20x stronger GHG
- Up 1 to 2 ppm

THE HIDDEN METHANE

- Organic goo rains through ocean -dead things and poop
- Turns into methane but traps in shallow, cold sediment
- This means it is mainly an Arctic problem

"Marine Snow"

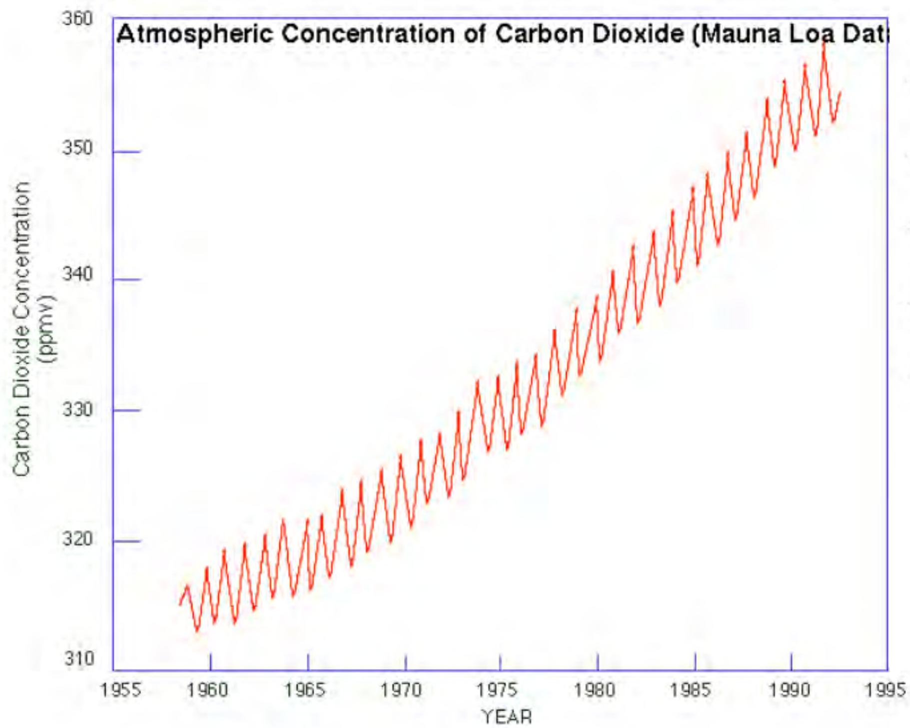
Clathrate portrait

KINKS IN THE GREENHOUSE

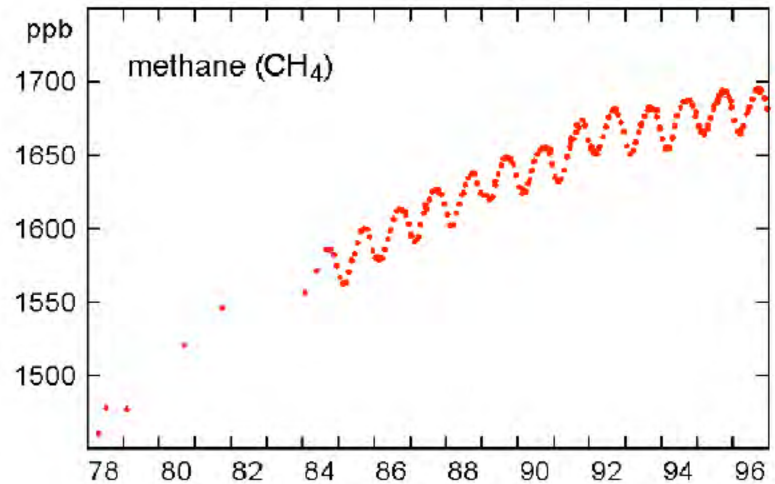
- Clathrate release will bump up methane curve
- But how soon? How much? Will it last?

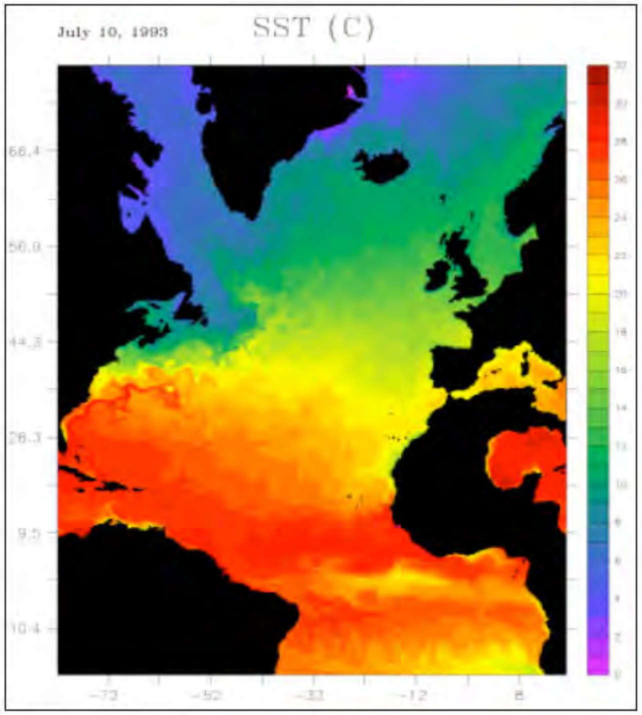
Extra Warming?

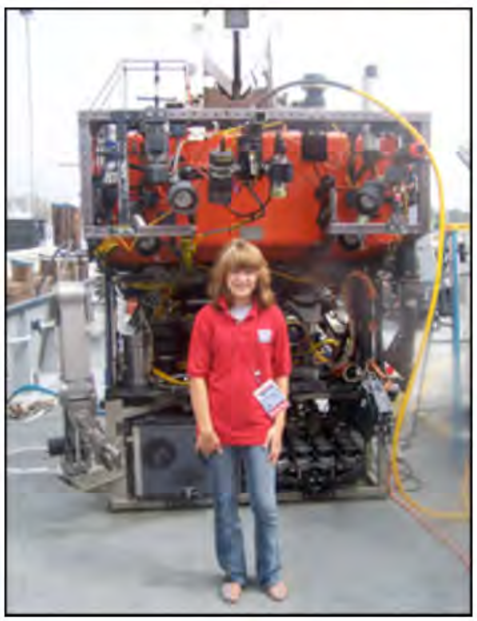
Carbon Dioxide



Methane







WHAT TO DO?

- Hit problem with big machines
- Expensive -should industry help?
- If it's nasty can we fix it?
- Feedbacks and air/water pollution?

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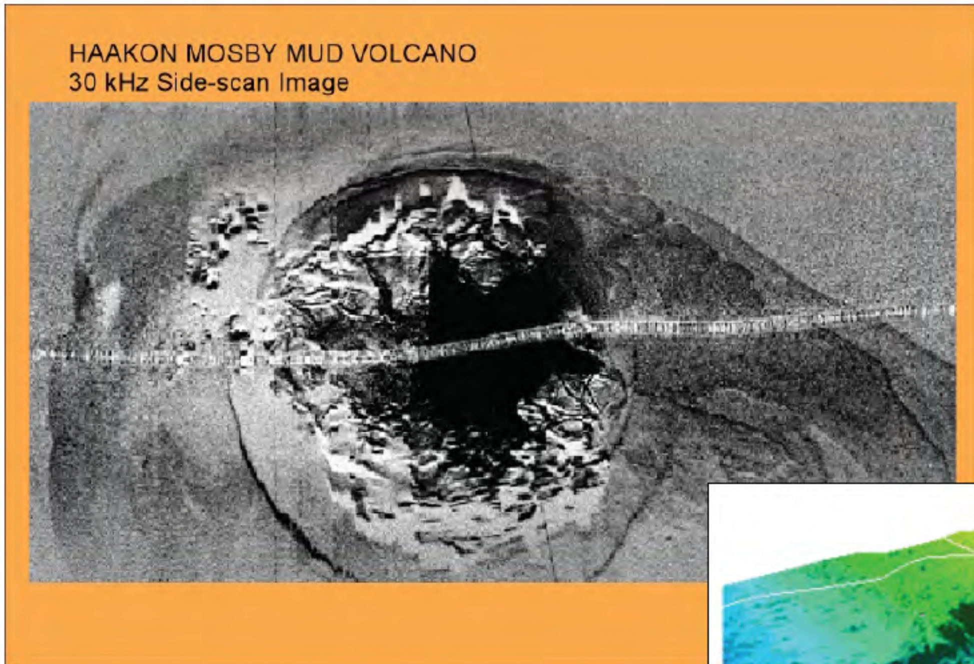

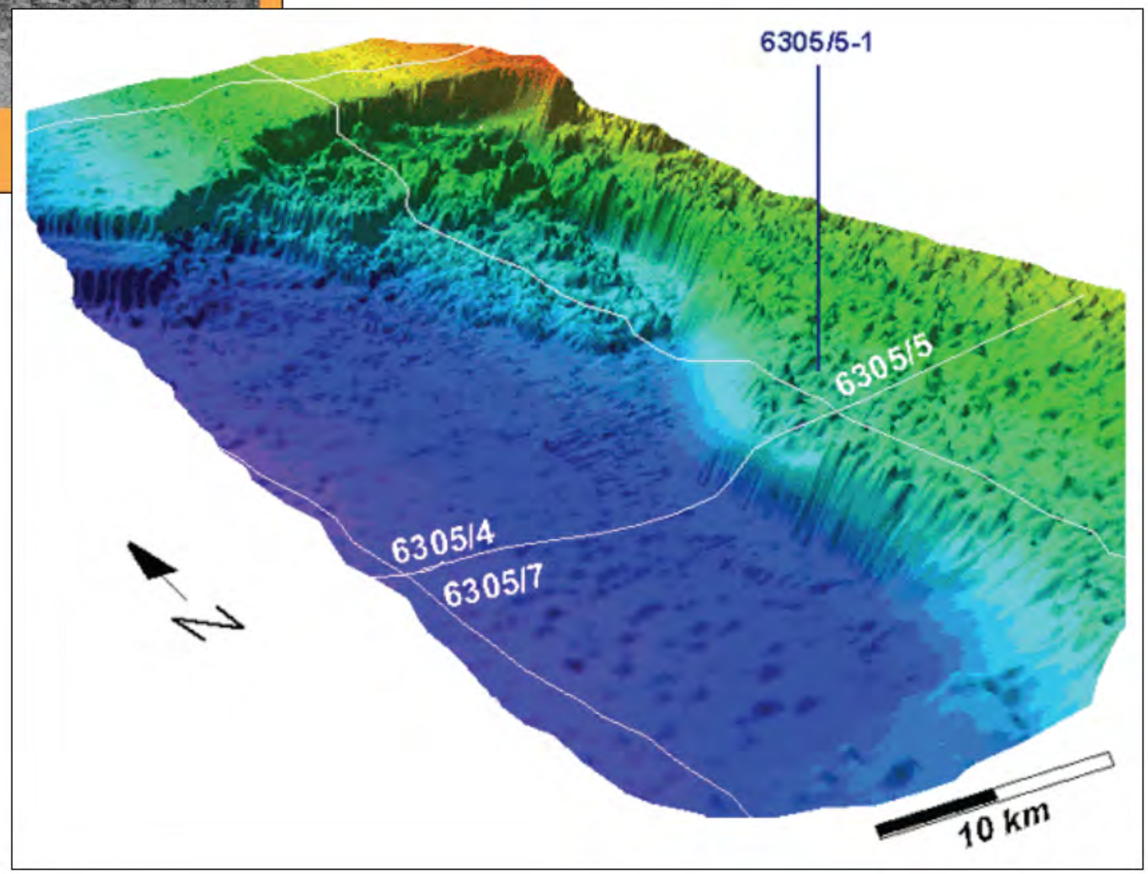

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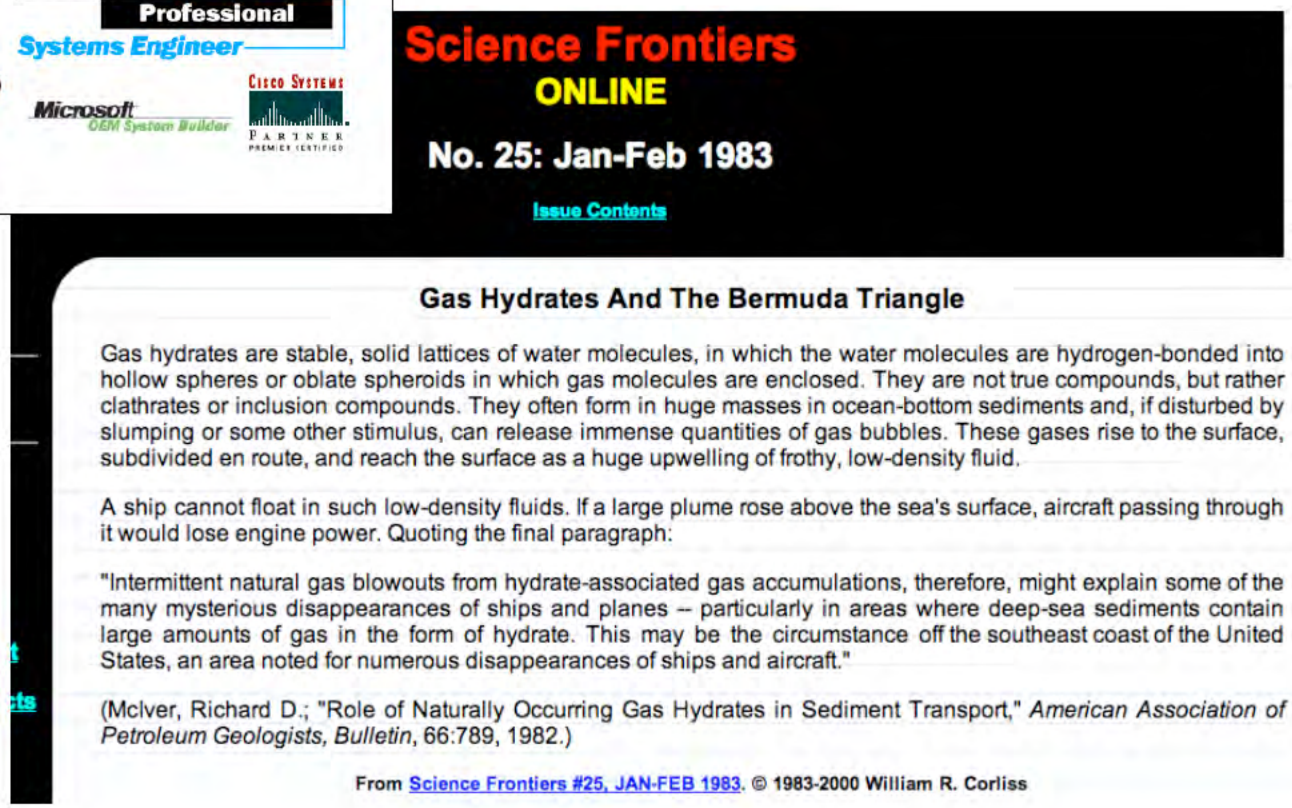

Science Frontiers
ONLINE
No. 25: Jan-Feb 1983
Issue Contents

Gas Hydrates And The Bermuda Triangle

Gas hydrates are stable, solid lattices of water molecules, in which the water molecules are hydrogen-bonded into hollow spheres or oblate spheroids in which gas molecules are enclosed. They are not true compounds, but rather clathrates or inclusion compounds. They often form in huge masses in ocean-bottom sediments and, if disturbed by slumping or some other stimulus, can release immense quantities of gas bubbles. These gases rise to the surface, subdivided en route, and reach the surface as a huge upwelling of frothy, low-density fluid.

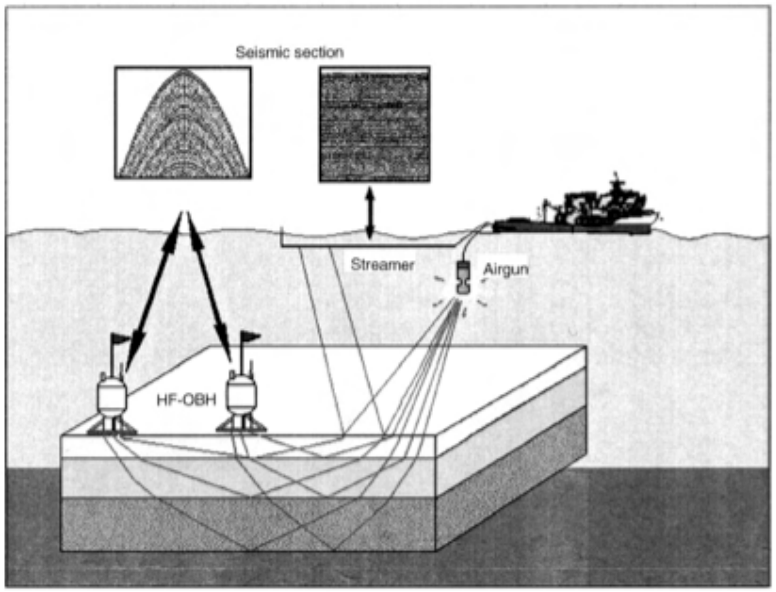
A ship cannot float in such low-density fluids. If a large plume rose above the sea's surface, aircraft passing through it would lose engine power. Quoting the final paragraph:

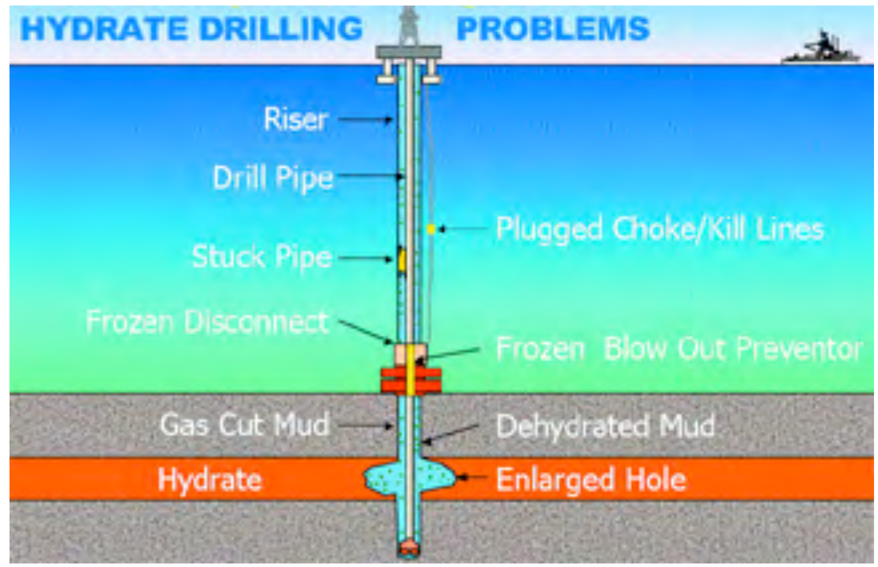
"Intermittent natural gas blowouts from hydrate-associated gas accumulations, therefore, might explain some of the many mysterious disappearances of ships and planes -- particularly in areas where deep-sea sediments contain large amounts of gas in the form of hydrate. This may be the circumstance off the southeast coast of the United States, an area noted for numerous disappearances of ships and aircraft."

(McIver, Richard D.; "Role of Naturally Occurring Gas Hydrates in Sediment Transport," *American Association of Petroleum Geologists, Bulletin*, 66:789, 1982.)

From Science Frontiers #25, JAN-FEB 1983. © 1983-2000 William R. Corliss

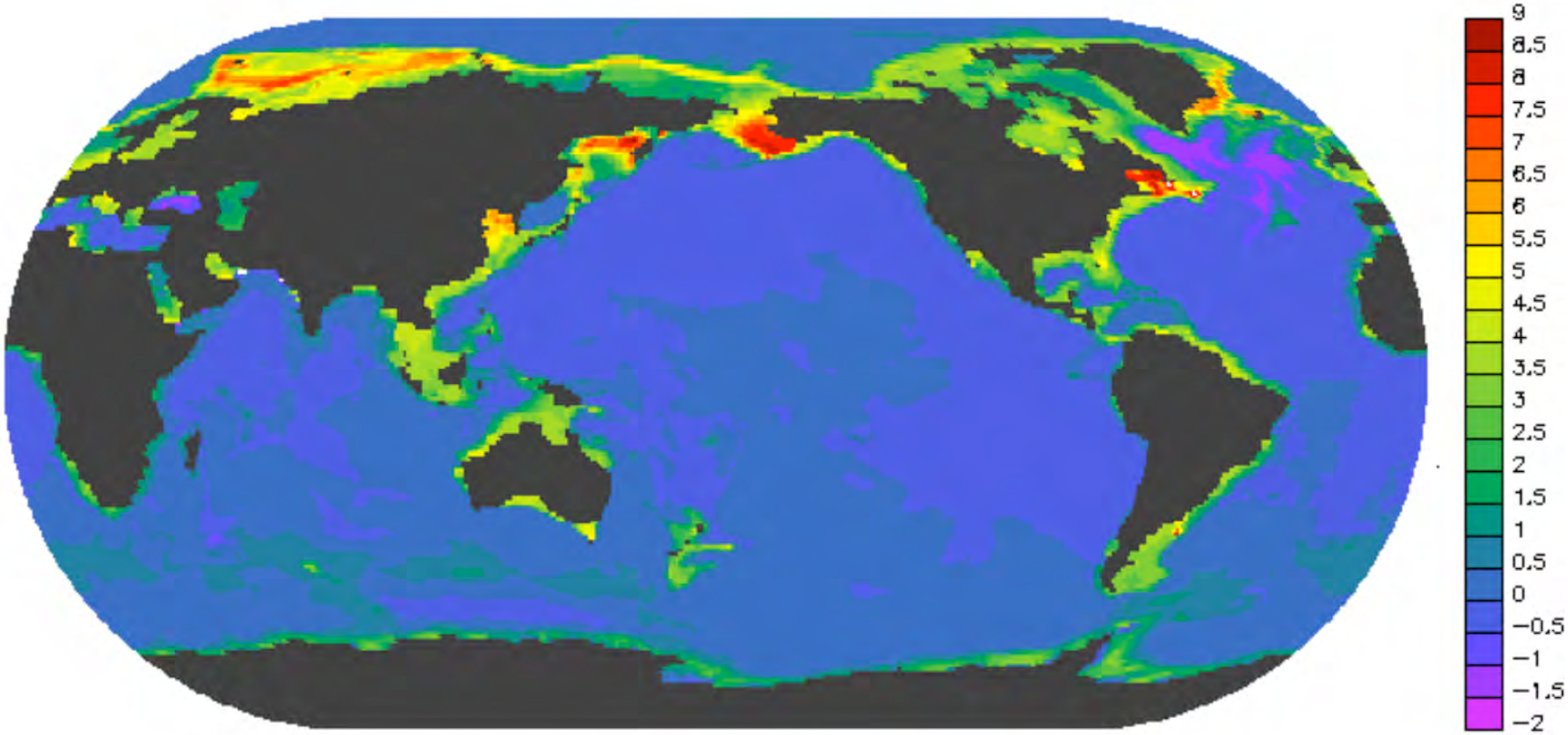
Detection, mining



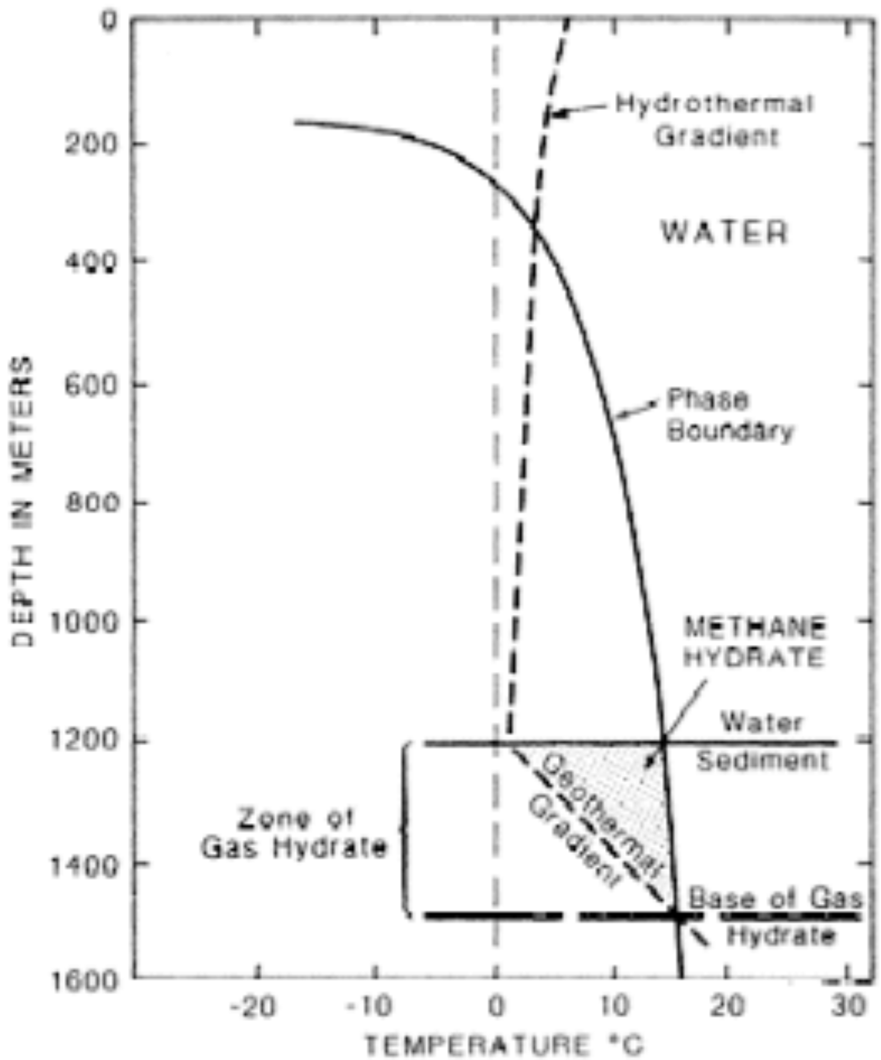


CLATHRATE EXTRAS

1% Carbon dioxide rise, change in bottom T 200 years



GF Classic Diagram



IDEALIZED BARENTS DESTABILIZATION

- Estimate clathrate redistribution for peripheral sea, the Barents
- Enfolds 3 ecoprovinces and is understudied, inherently complex
- Adopt appropriate values from literature for all uncertain parameters
- 70% porosity,10% saturation, 50 degree per kilometer geogradient
- Overall budget is consistent with global values -lies on high side but this is the argument for a remote region with high productivity
- We also differ in applying a detailed, dynamic release model
- For simple T ramp 5º/100y, 0.1 GtC/y on sharply in 1-3 decades, then rises 0.1 GtC per decade with no mass limits
- Reference points - Barents oxygen burden 0.3 GtC equivalents, Arctic tropospheric CH_4 cycles at 0.05GtC/0.3y or 0.15 GtC/y

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Barents Clathrate Budget, Shelf Area 300-500 m ~(1000 km)^2

20 meter contours, T in degrees centigrade, z in meters, C in Gigatons

GF 94 pore 0.7
J96 sed rate
S04 TOC %

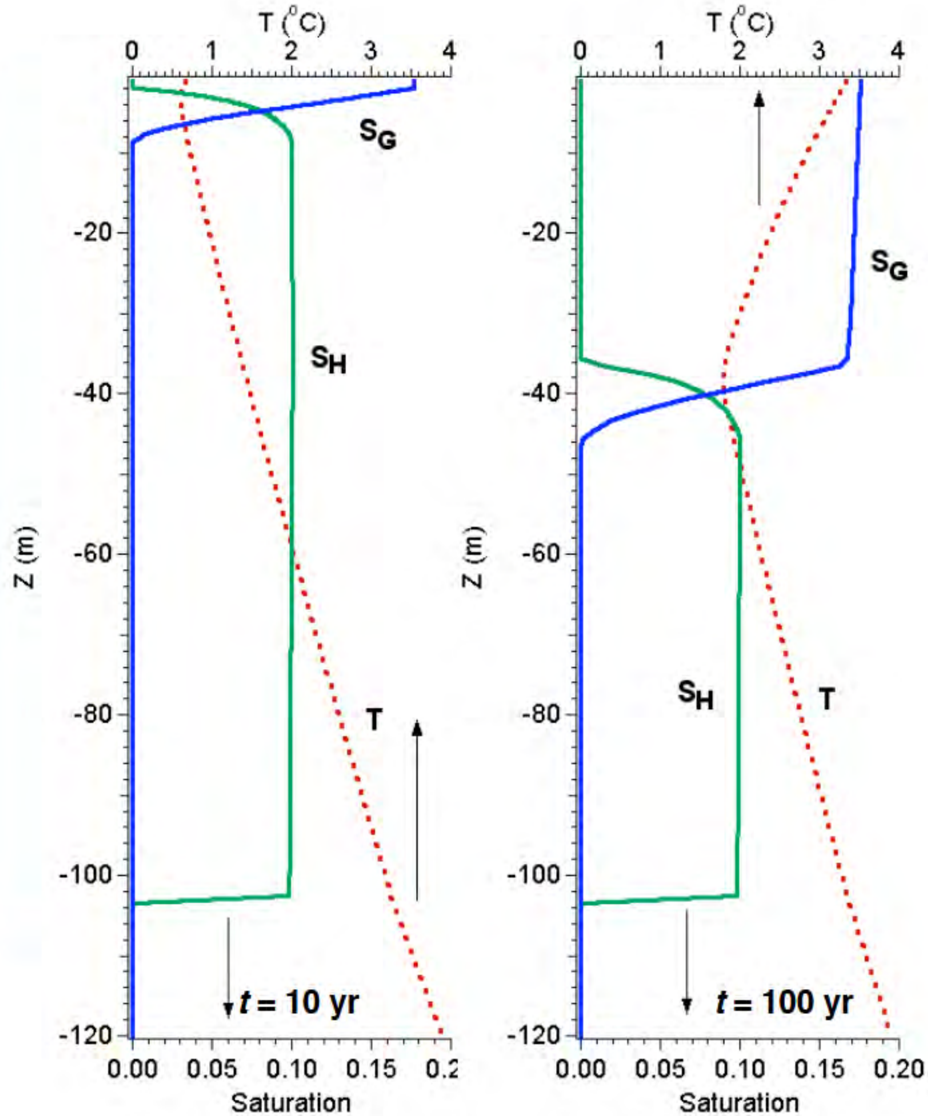
KH83 T_e
M98 T_t

GF94 Arctic geothermal gradient 50 C°/km
(R07 30, A07 70)

Floor	T_t	$T_{t,e}$	$\Delta T_{t,e}$	z_t	z_b	Δz	$T_{b,e}$	$\Delta T_{b,t}$	ΔT_b	GtC	GtC
	BPL									BPL	SAR
	SAR										
200	0	neg								0 x5	0 x5
	2	neg									
300	0	2.6	2.6	300	410	110	5.2	5.2	0	110 x5	30 x5
	2	2.6	0.6	300	330	30	3.2	1.2	0		
400	0	5.2	5.2	400	570	170	8.2	8.2	0	170 x5	120 x5
	2	5.2	3.2	400	520	120	7.2	5.2	0		
500	0	7.2	7.2	500	700	200	10.0	10.0	0	200 x0	150 x0
	2	7.2	5.2	500	650	150	9.4	7.4	0		
Total										1500^+	800^+

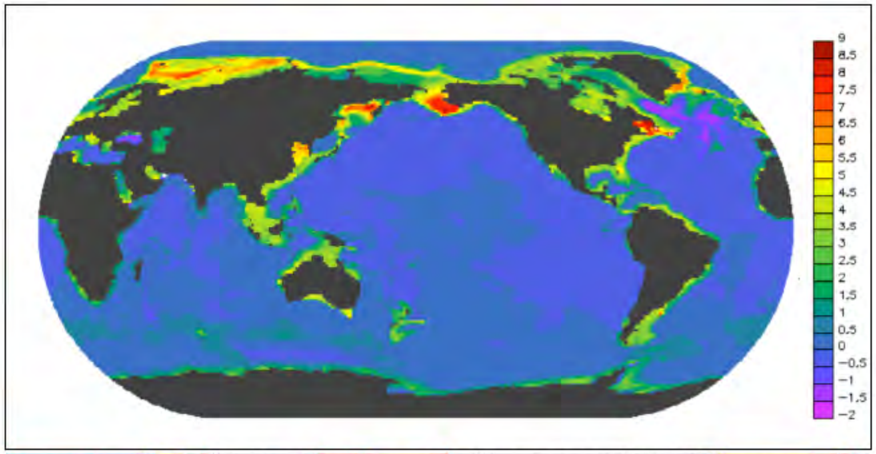
DYNAMIC MELTING

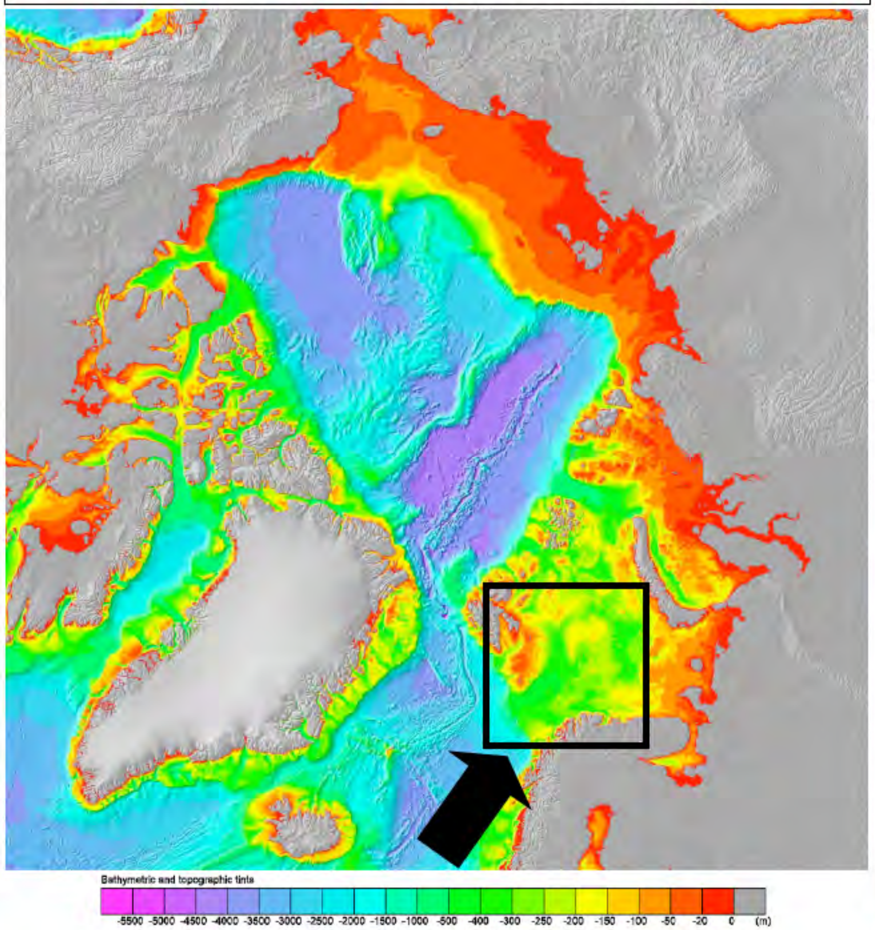
- •LBL develops dynamic models of the destabilization
- •e.g. depth 320 meters, 0.3 pore, 10% saturation, 3°/100y
- •Front is heat of transition limited, proceeds from top
- •We have run Barents cases, obtain order 100 moles/m^{2}y
- •0.1 GtC/y per 20 m contour, or 10% of Barents potential



DISTINCTIONS, EFFECTS, UNCERTAINTIES

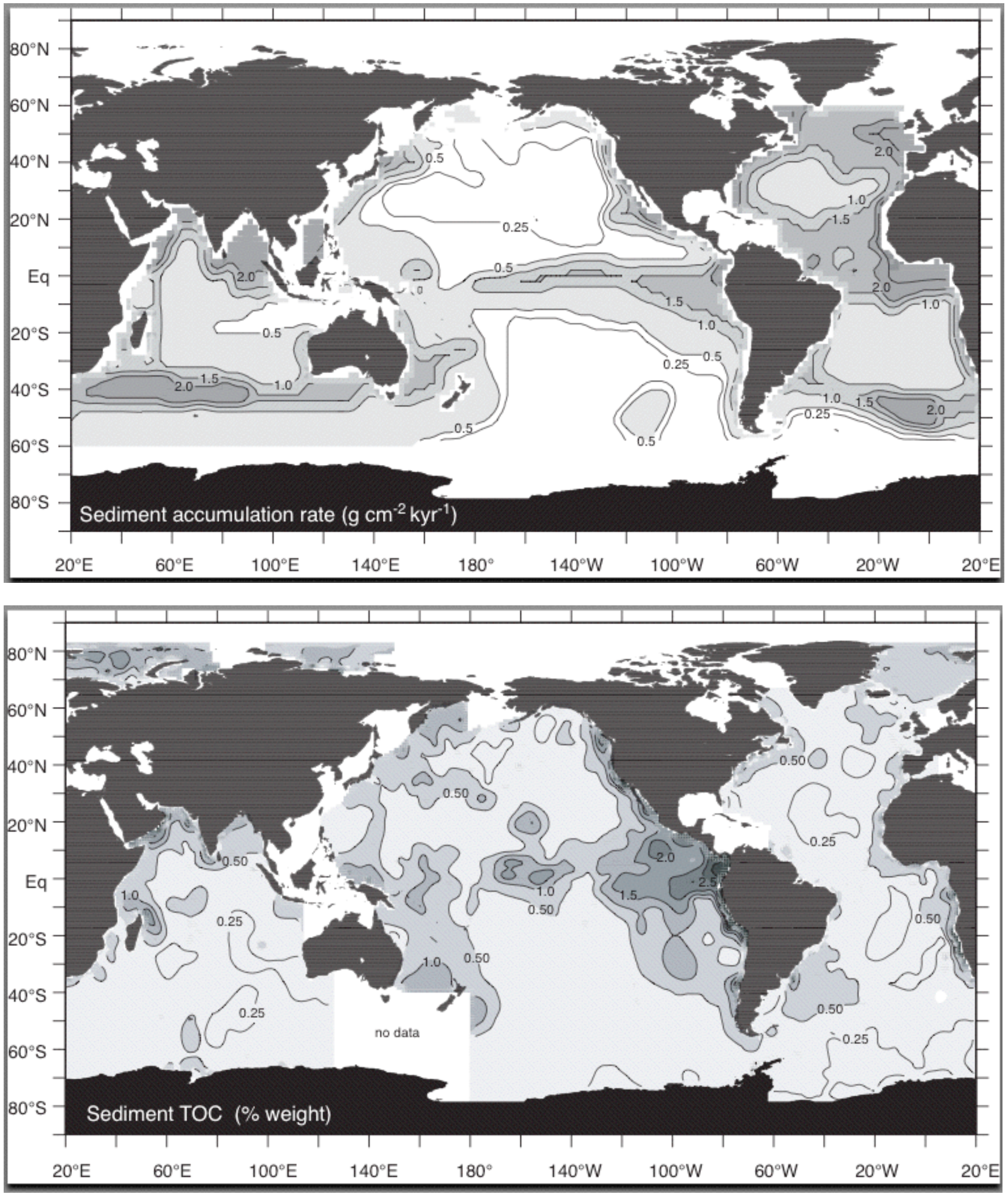
- Arctic warming is accelerated even at depth, sediment systems there are productive but understudied
- Archer review and others point out that there may already be Siberian leakage and more is coming on decadal scale
- Identify fast potential sources of basin scale hypoxia or Δphotochem, bubble rise and column biorates determine which
- Downward uncertainties huge -saturation, porosity, distribution in z
- But also upward -downstream waters including the extra-Arctic, permeability, decadal temperature variability, current shifts
- Polar onset sudden, but rises are then gradual to GtC/y at 30-100y -global photochemistry and the greenhouse both susceptible
- Arctic clathrates deserve focused model and measurement attention





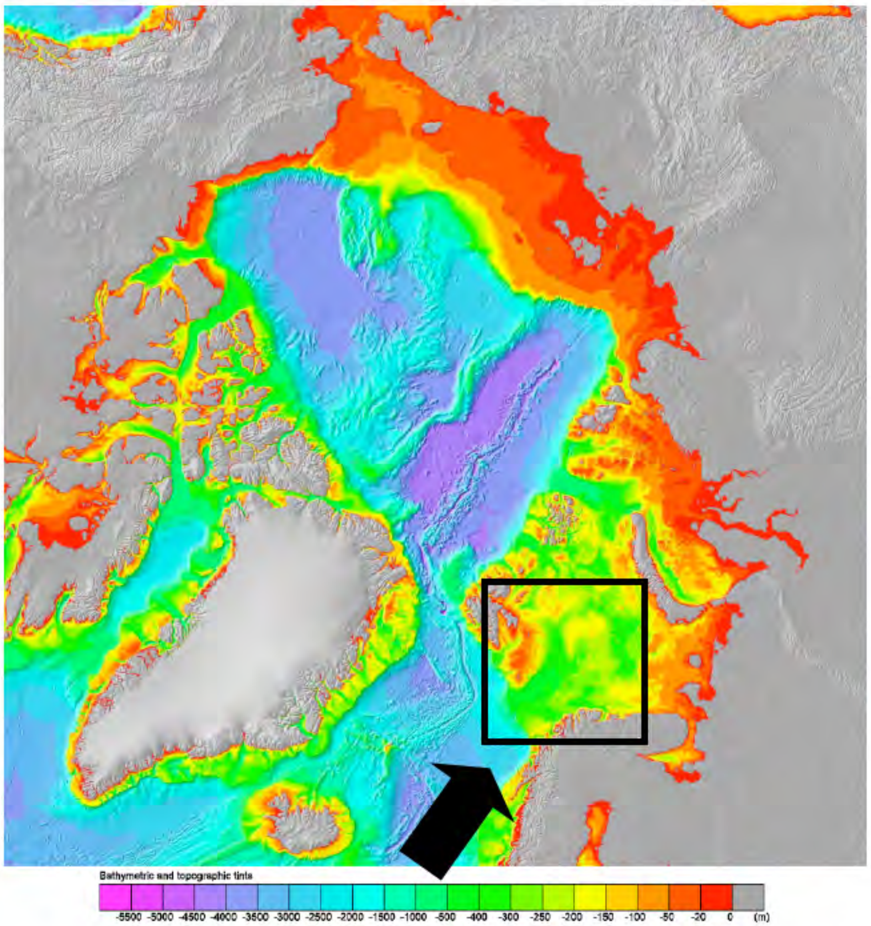
CLATHRATE SUMMARY

- Archer and others note that Arctic hydrates destabilize in decades
- Entry waters may rise 5° per century (200 y CCSM ocean bottom shown)
- Barents Sea in direct line, with 10^6 km^2 clathrate-potential shelf >300 m
- For standard parameters choices total stock is many hundreds of GtC
- Preliminary thermo indicates 100 GtC 3° from transition, 10's within 1°
- Dynamic simulations step fast to 0.1 GtC/y, within decades then ramping
- Triggers basin hypoxia, plus Arctic troposphere cycle is 0.05 GtC/season

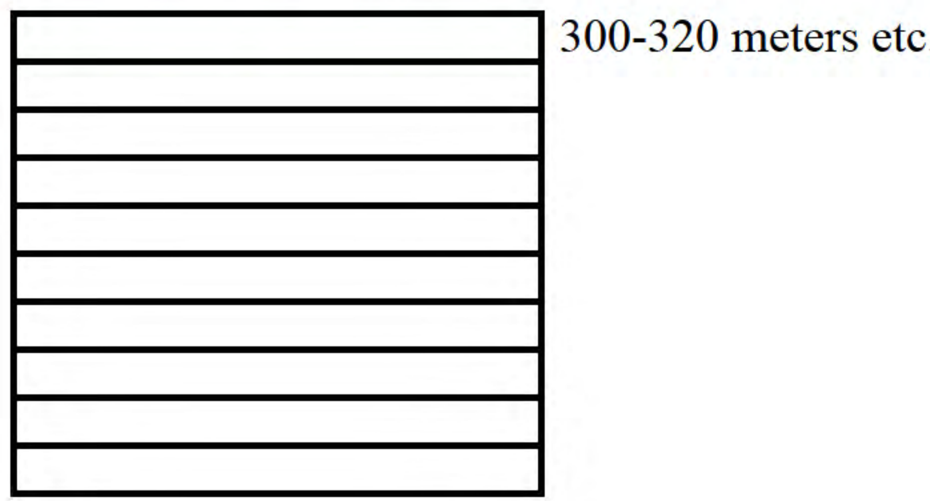


Global compilations of sediment accumulation rate and weight fraction organic carbon show that critical areas of the arctic are likely to hold clathrate extremes but simultaneously are understudied

NUTS AND BOLTS



- Assumed 100 kilometer wide strips each spanning 20 meter contours
- From 300 to 500 meters, clathrate and Barents provide practical limits
- Clearly detailed ocean models can do much better
- Real bathymetery, temperatures, advection, bubble rise, air transfer



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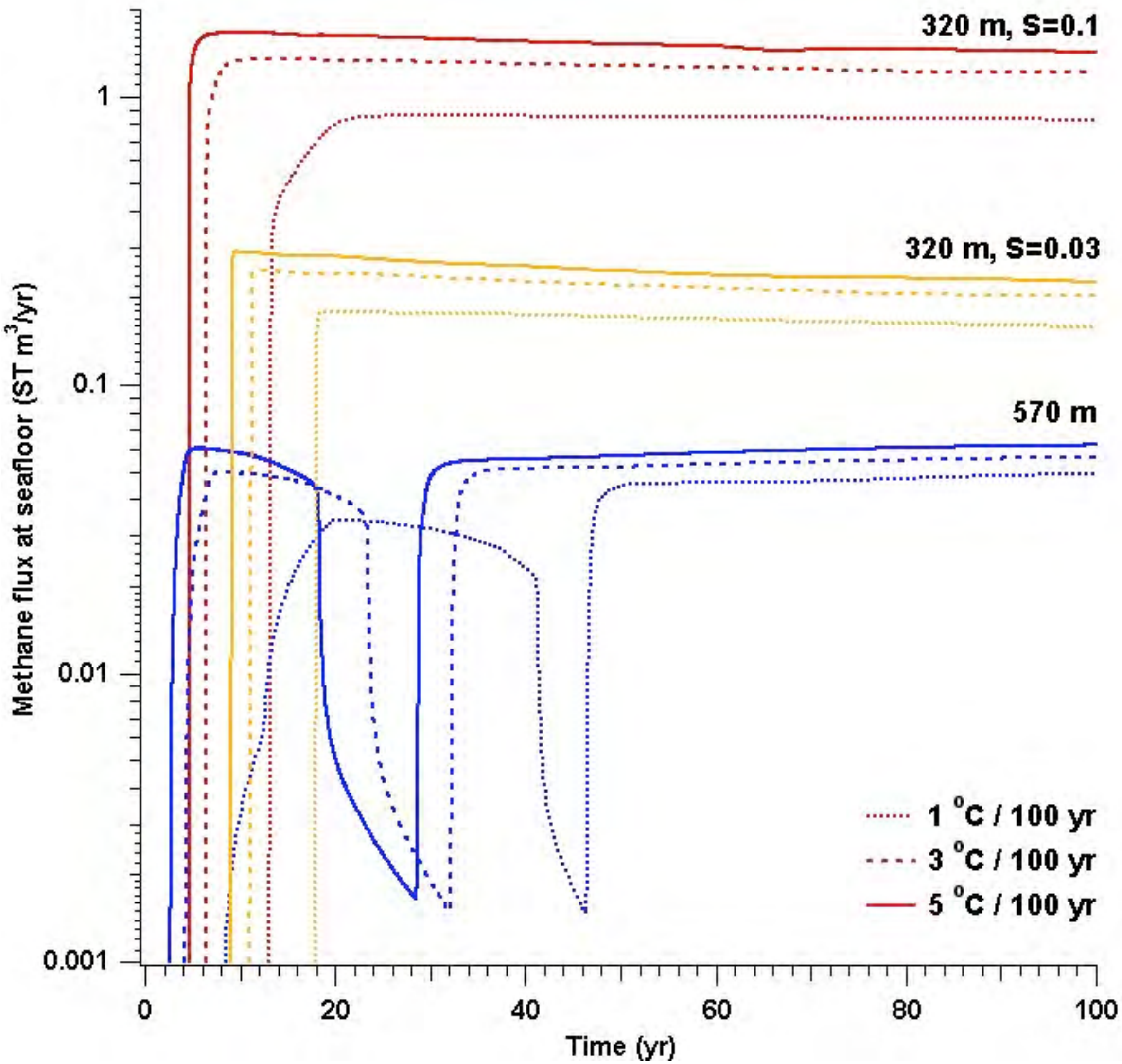
	2	7.2	5.2	500	650	150	9.4	7.4	0		
Total										2400	1500

Results: Release Rates



Q_{CH4} = 0.86 - 1.3 ST m³/yr/m²

= 38 - 58 mol/yr/m²

Q_{CH4} = 0.16 - 0.23 ST m³/yr/m²

= 7.1 - 10 mol/yr/m²

Q_{CH4} = 0.049 - 0.062 ST m³/yr/m²

= 2.2 - 2.8 mol/yr/m²