U.S. DEPARTMENT OF ENERGY

Office of Science

Global Cycles, Polar Interfaces

Scott Elliott of COSIM for:

IARC, other DOE labs, universities, international

Sponsorship:

DOE Science Focus Areas, SciDAC, IMPACTS, external

(NOAA Boulder, June 2012)

OUTLINE

THEMES –Polar filters, surface chemistry

STRUCTURE –Periodic table, oxidation as guides

ELEMENTS –C, N, Mg(*Al, Si*), S, Ca, Fe(*Cu*), Br, I…

STATES –Redox order (VI, V, IV…)

RICHNESS –Omissions, priorities… links

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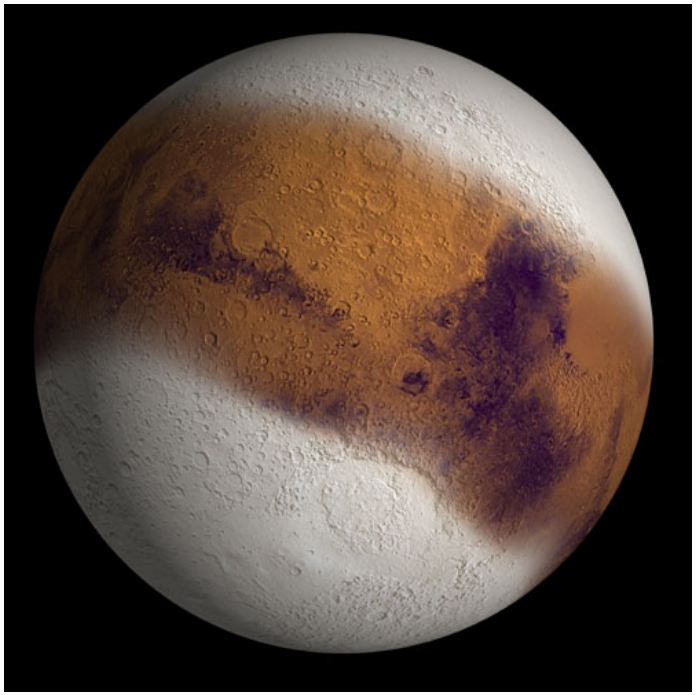
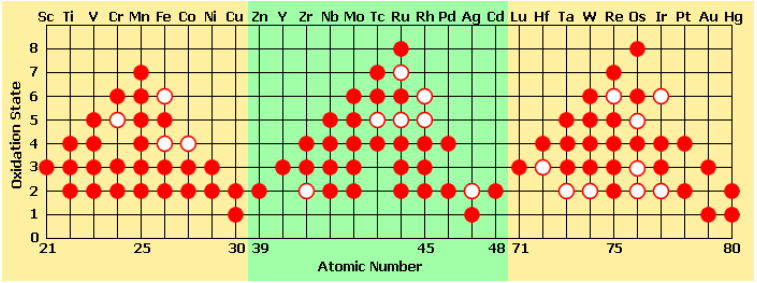
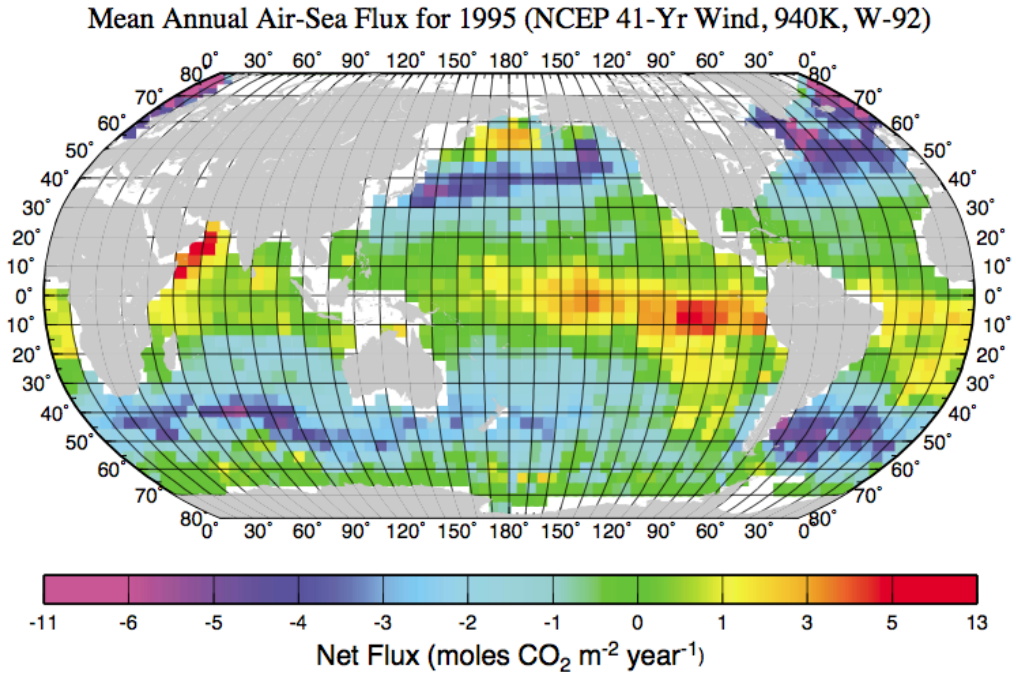
Caution:
SE is a systems modeler,
and tends to go bipolar

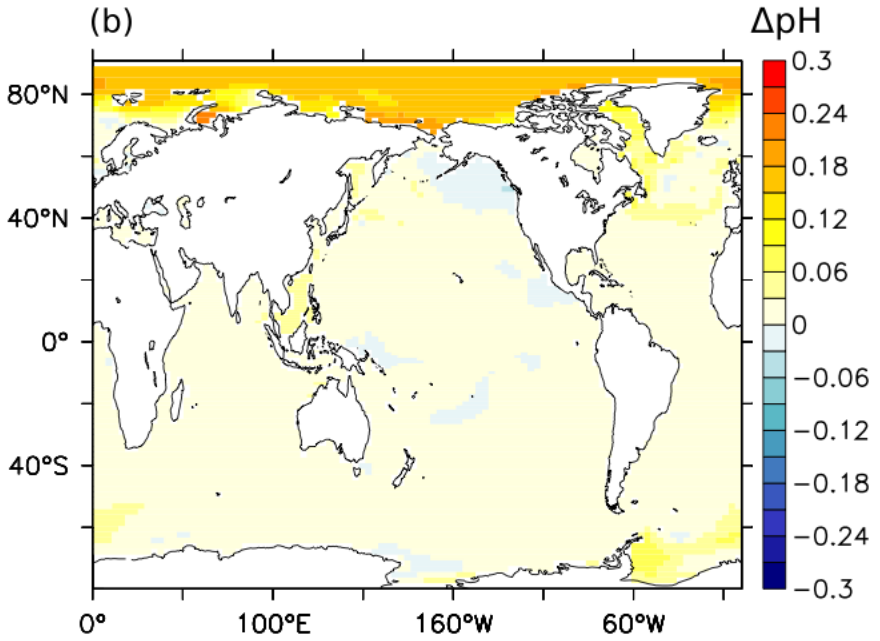


Taz meets Mendeleyev



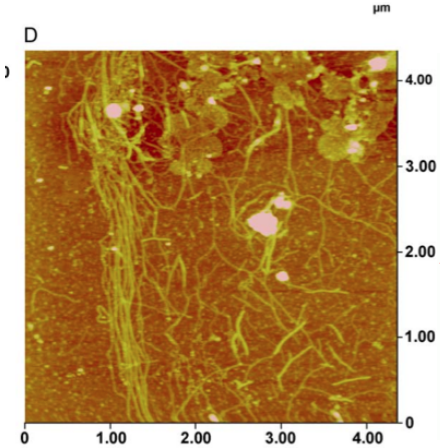
Carbon IV (CO_2)

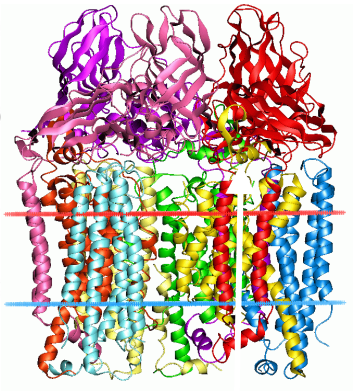


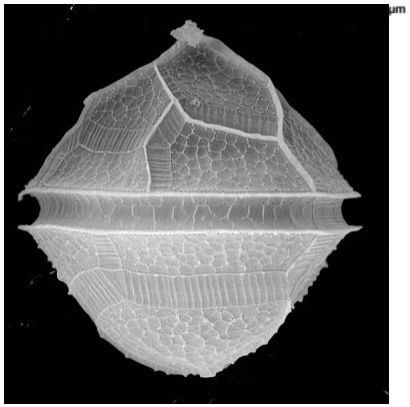


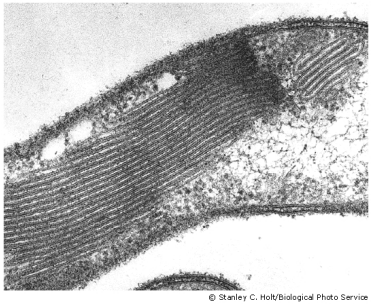
Takahashi 02
Steinacher 10
Shackleton -85

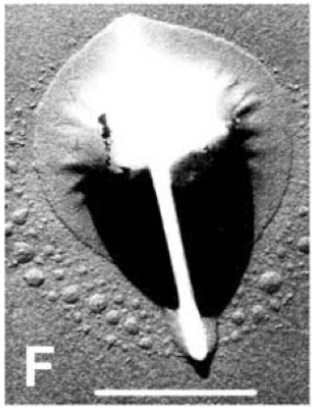
Carbon (0) to -II (Biopolymers)

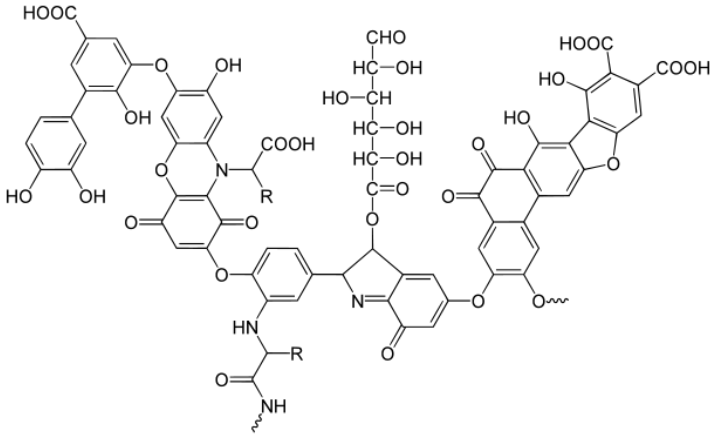












Verdugo 04, Leck 02, ICMS Temple, AAD

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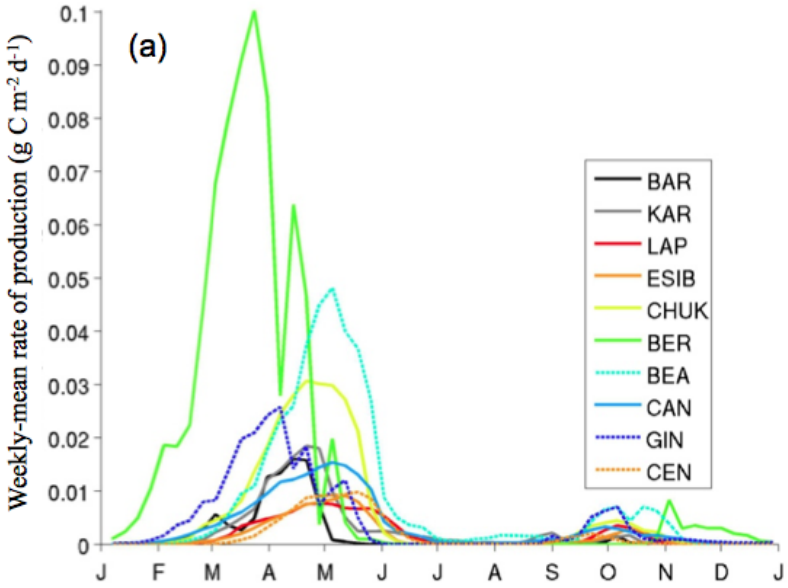
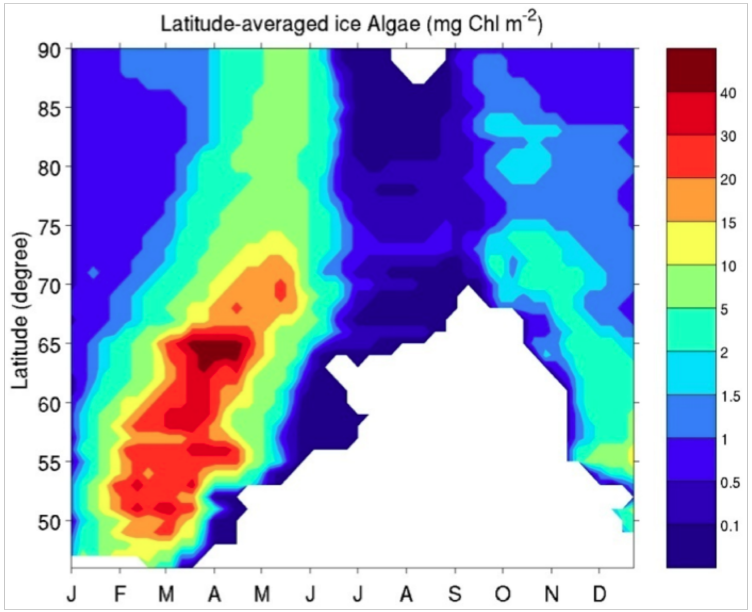
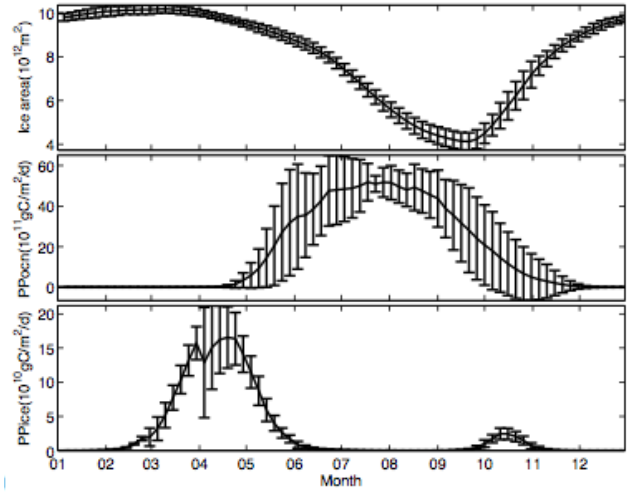
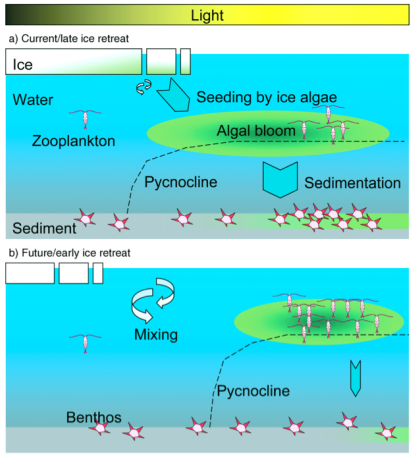
Carbon (0) to –II in CICE





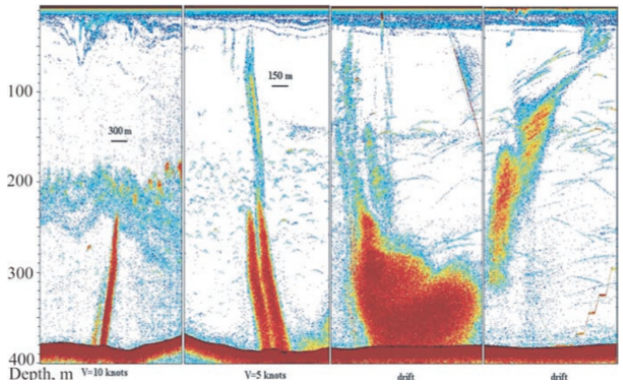


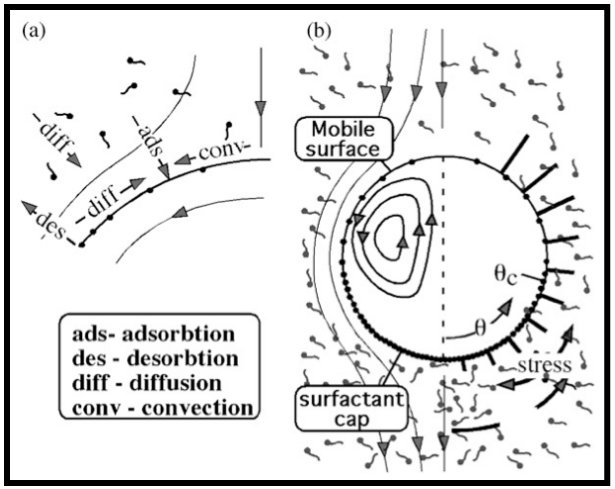


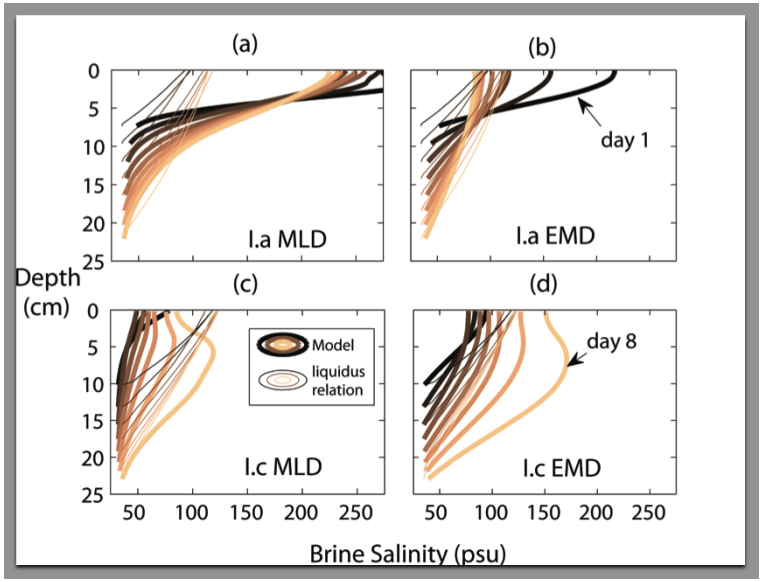
Deal 11, Jin 12

Bluhm & Gradinger 08

Carbon –IV (methane)

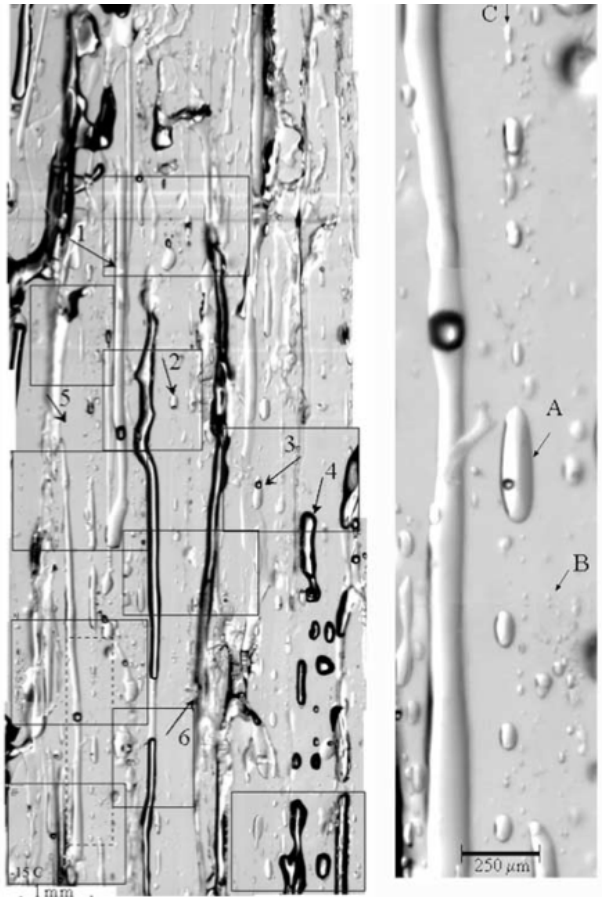


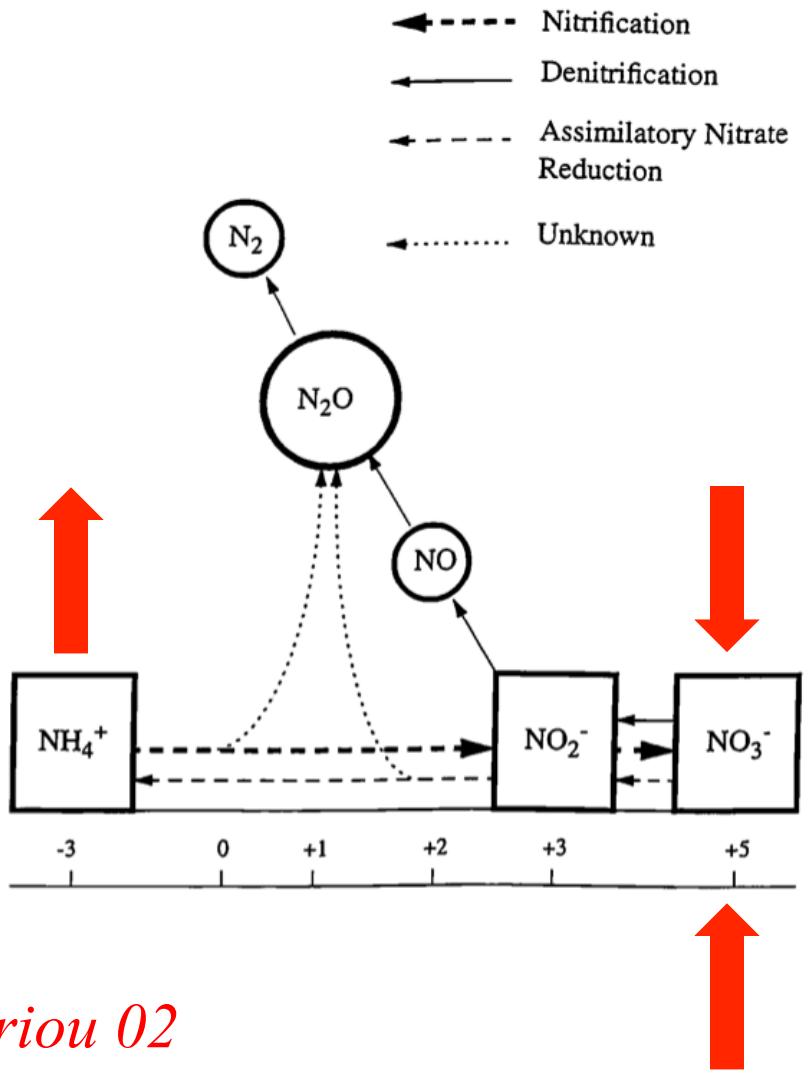




Obzhirov 04, Leifer & Patro 02
Shakhova 09, Jeffery 11

Nitrogen (see scale)

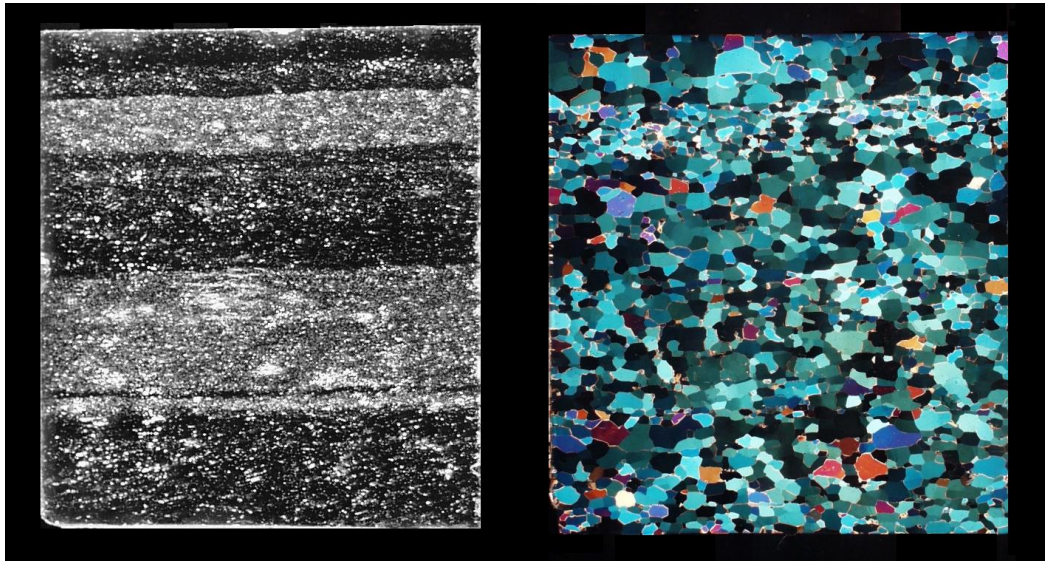


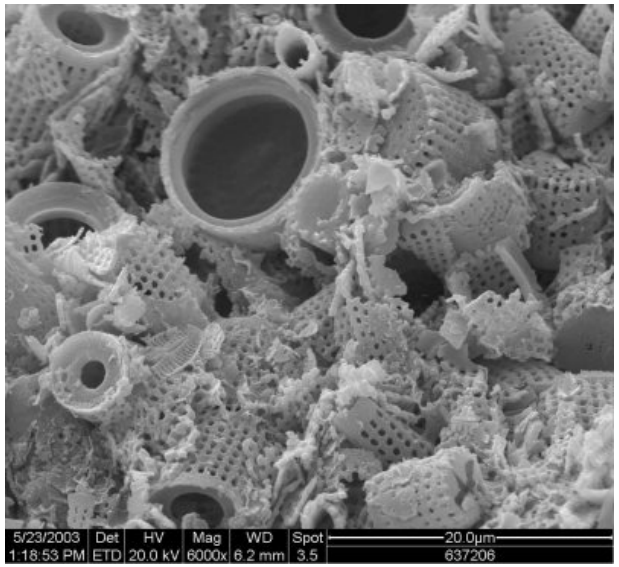


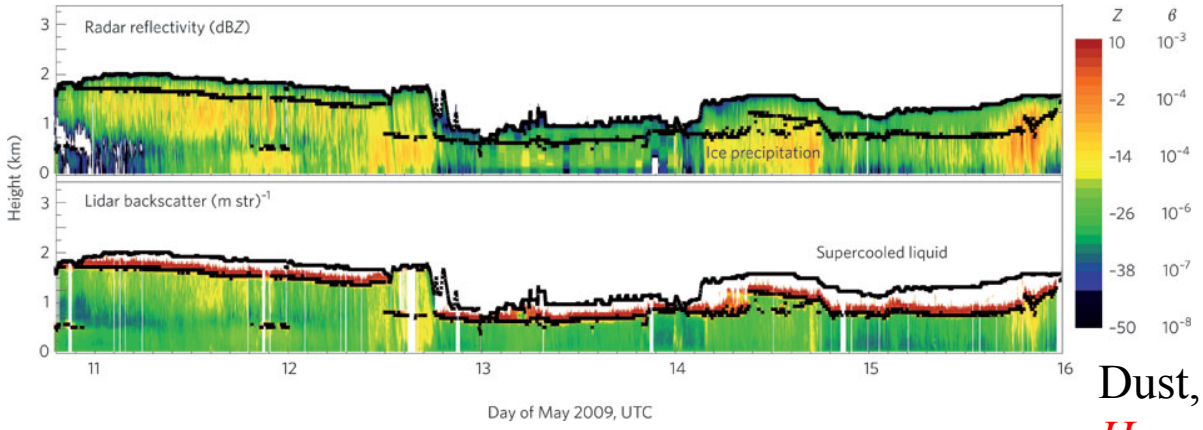
Light 03, Rysgaard 04

Thomas and Papadimitriou 02

Mg, Al, Si (II,III,IV)







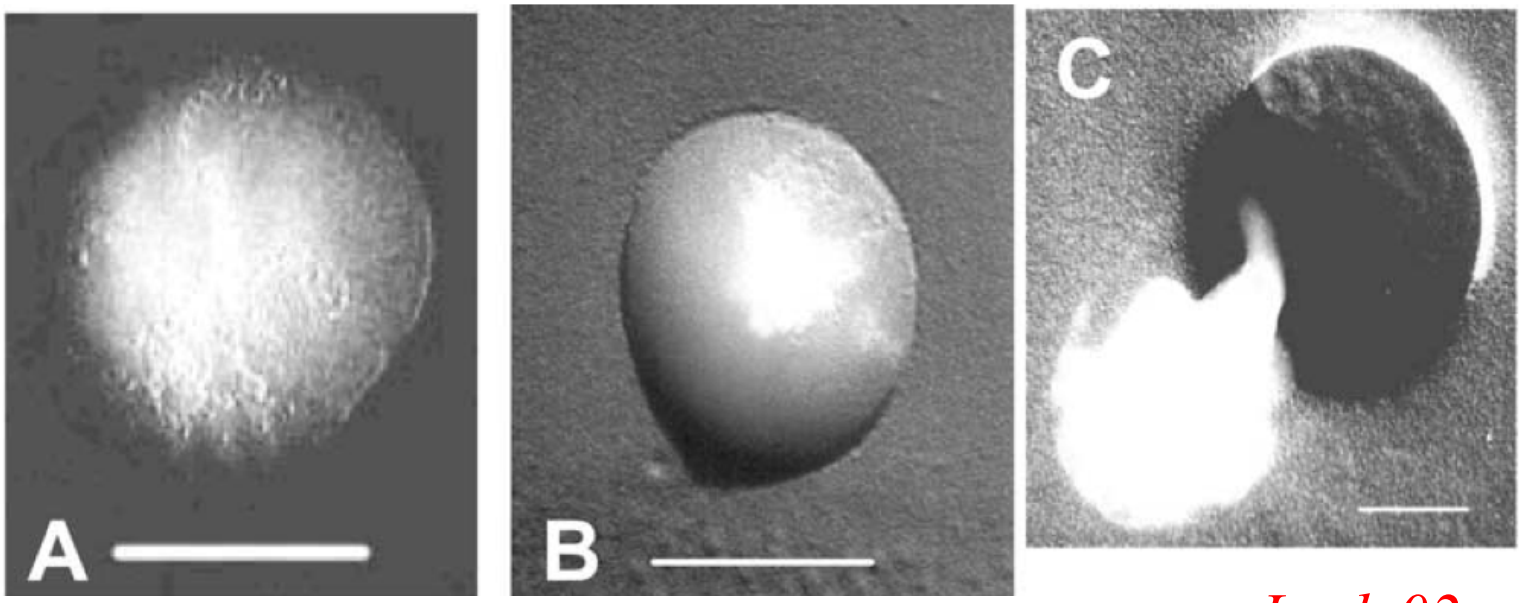
Dust, diatoms, silicate

Hansel 12, Hoose 10

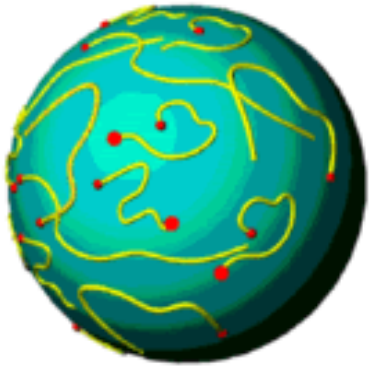
Bohr/Wark Institutes

Gijs and co. Nature 12

Sulfur VI



Leck 02
Ellison 05



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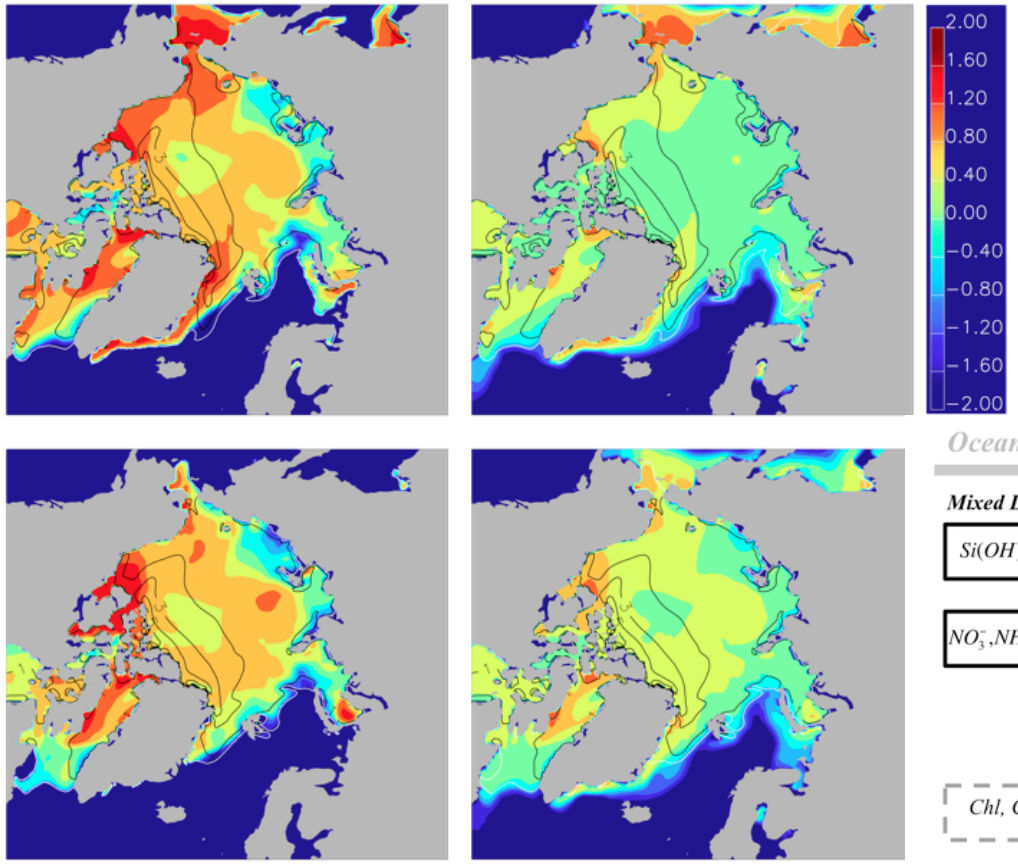
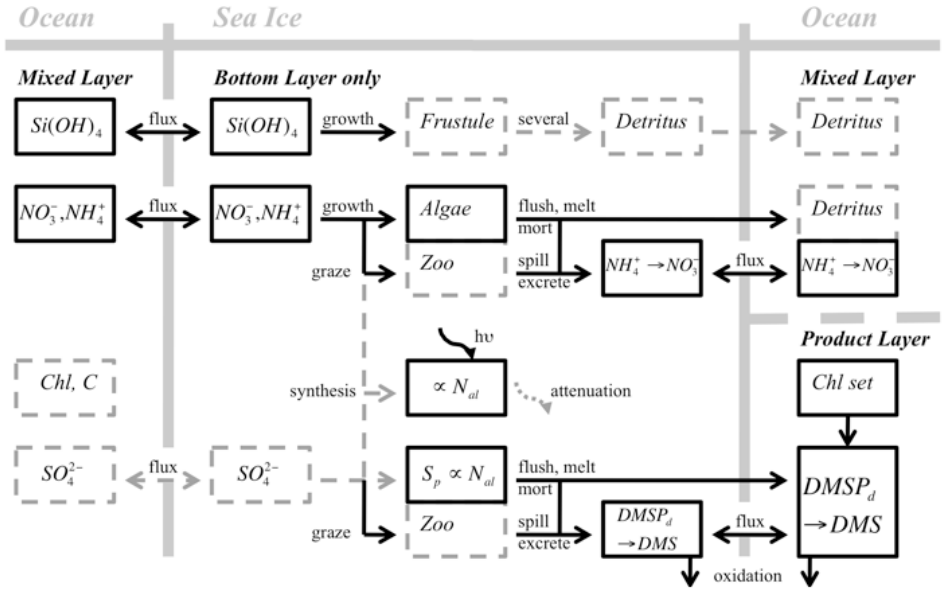
Sulfur -II



Chl (mg/m^2), DMS (nM)

April,
August

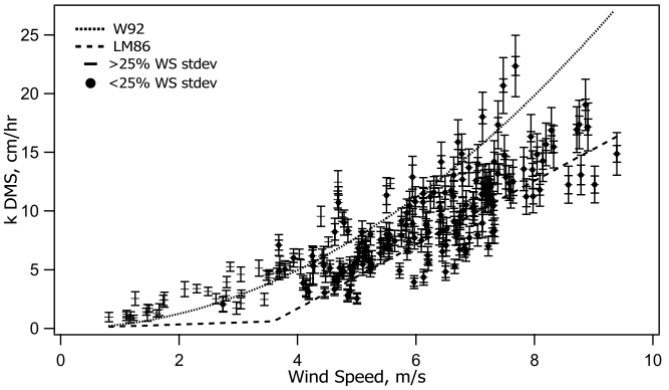


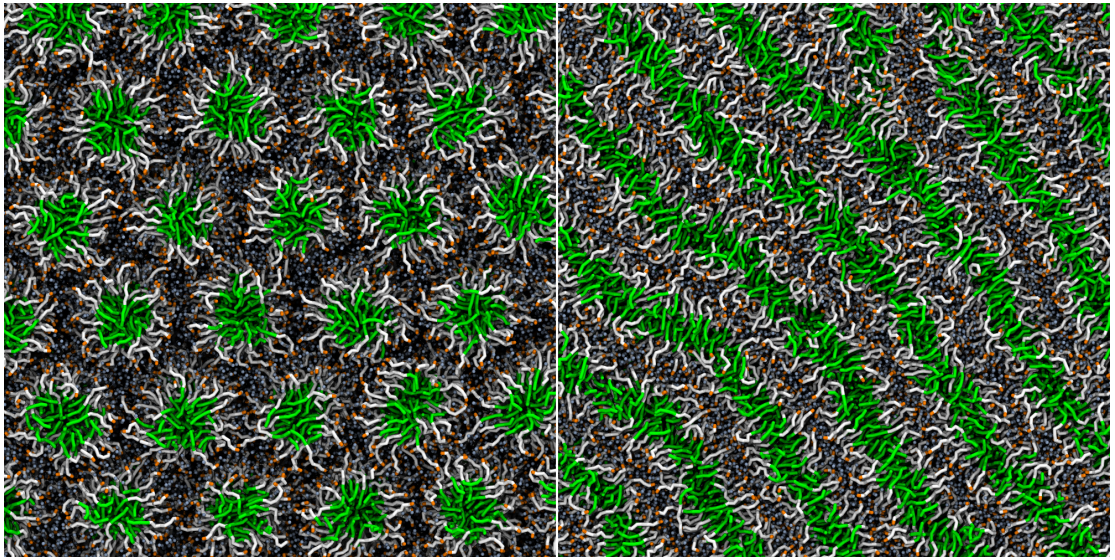
DMS in/from sea ice

Elliott 12, with Deal and Stefels!

Polymer Chemistry of Sea-Air Transfer

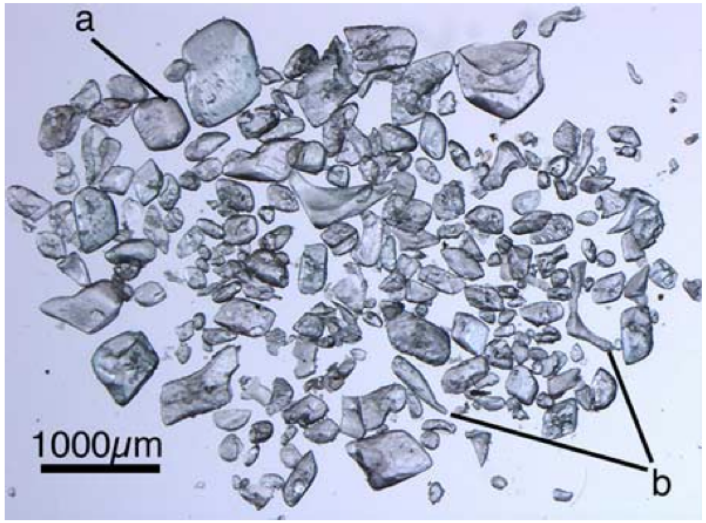
Junger 97
Huebert 04 and 10

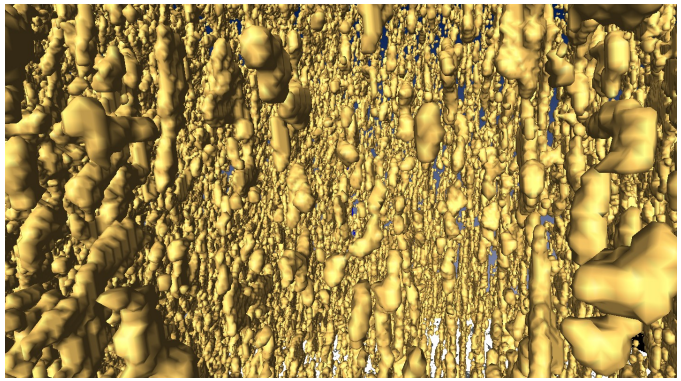


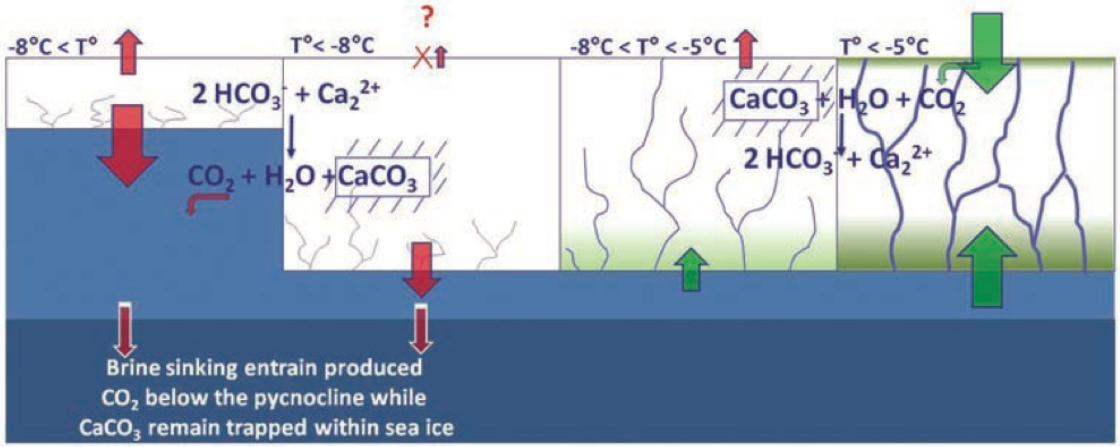


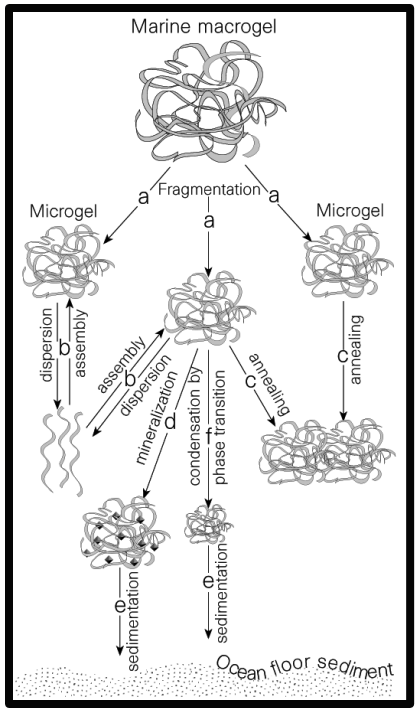
Dieckmann 08
Golden 07
Delille 10
Chin 98

Calcium II

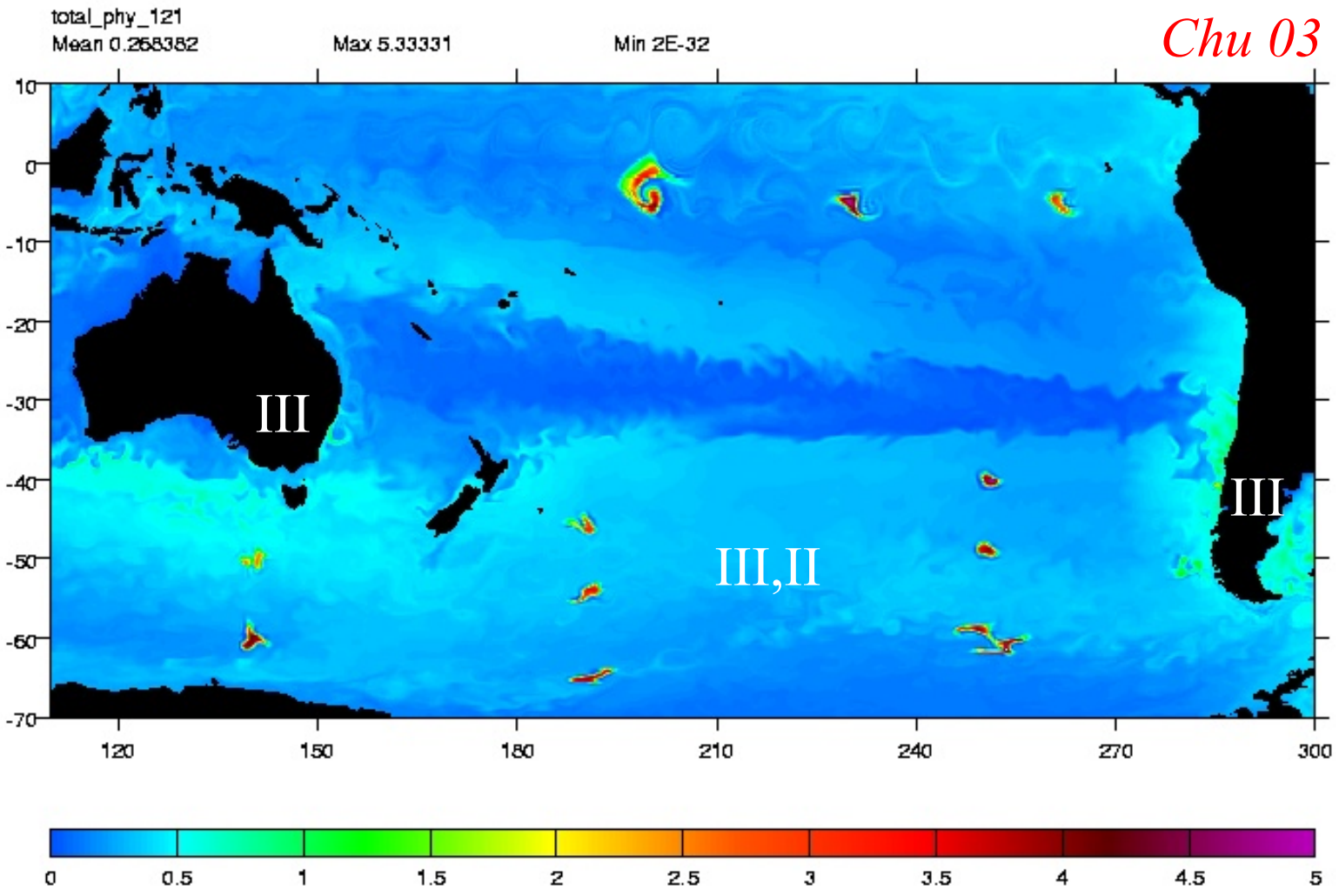








Austral Iron Cycle…III & II



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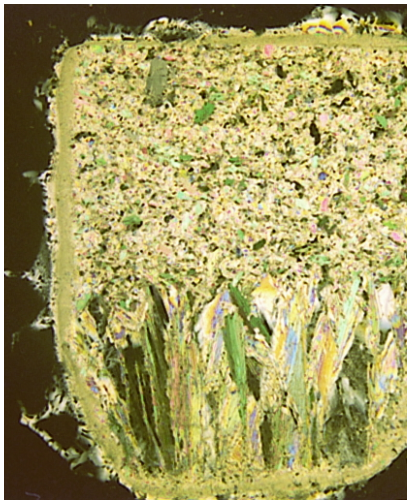
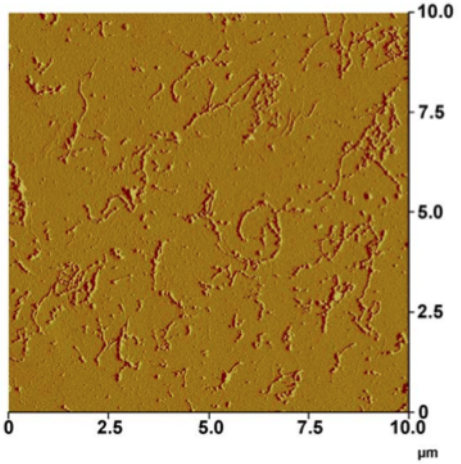
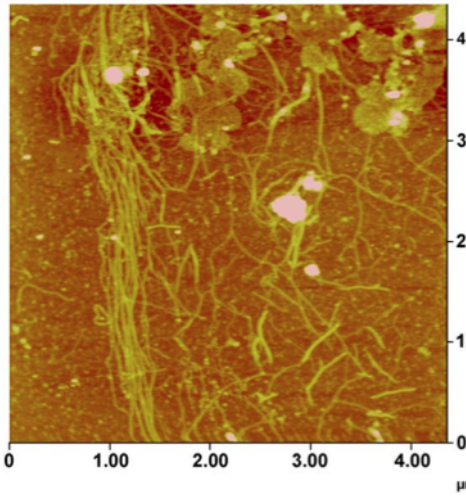
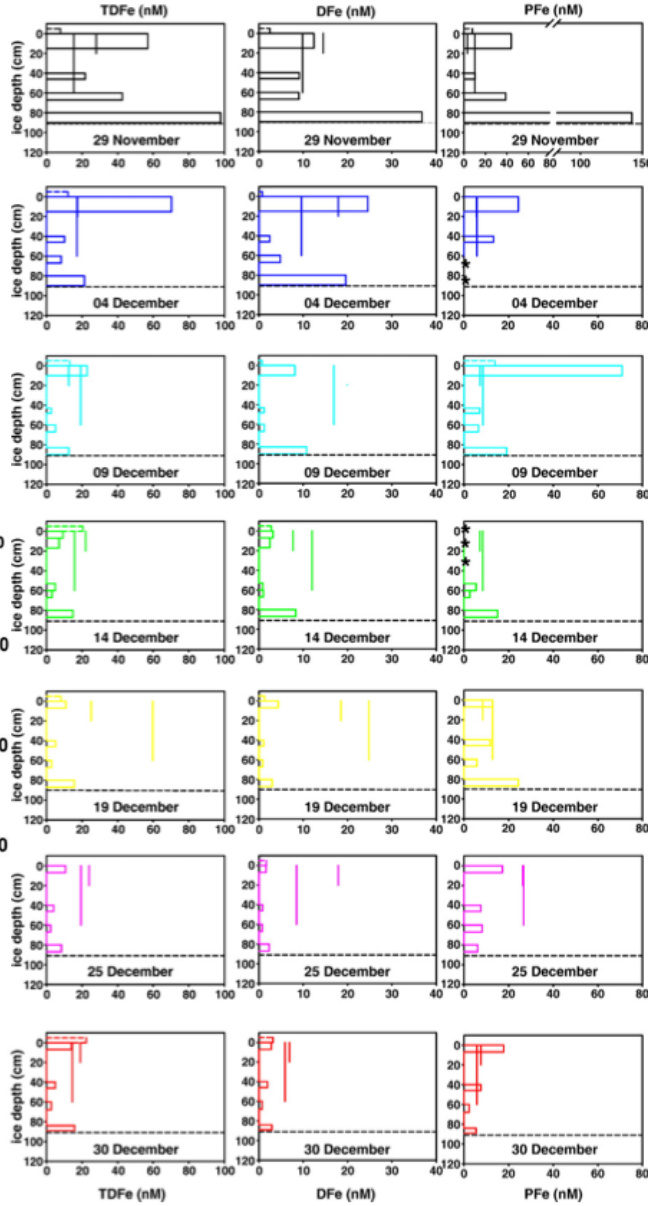
Trace Metal Chromatography (Fe, Cu?)





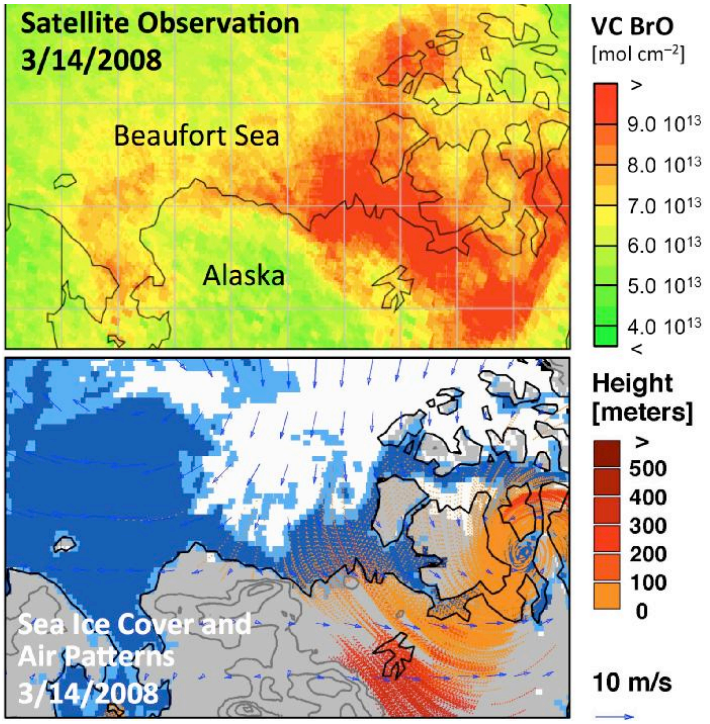
D

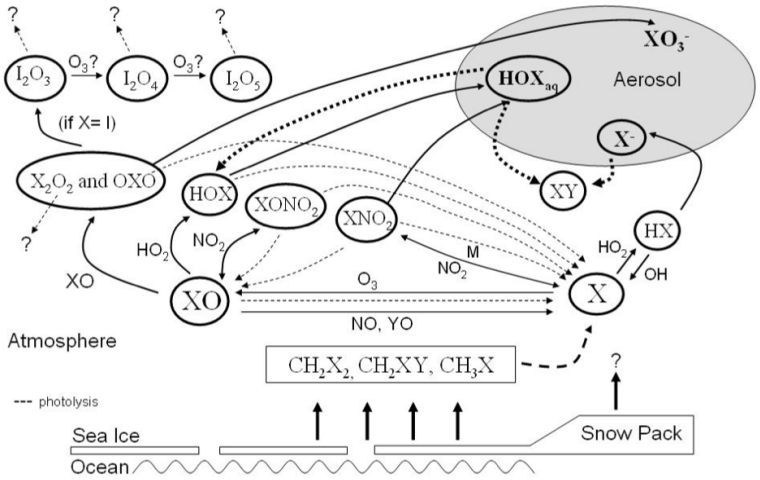




NSIDC, UNIS Svalbard
Verdugo 04, Lannuzel 09

Bromine, Iodine (-I and up)





Nghiem 11
Saiz-Lopez 08

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SUMMARY

THEMES	–Polar filters, surface chemistry
STRUCTURE	–Periodic table, oxidation as guides
ELEMENTS	–C, N, Mg(*Al, Si*), S, Ca, Fe(*Cu*), Br, I…
STATES	–Redox order (VI, V, IV…)
RICHNESS	–Omissions, priorities… links

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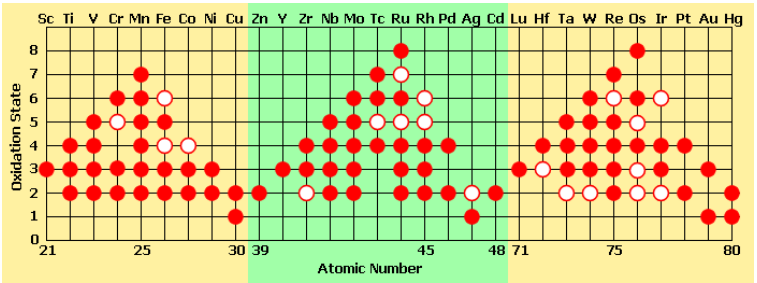
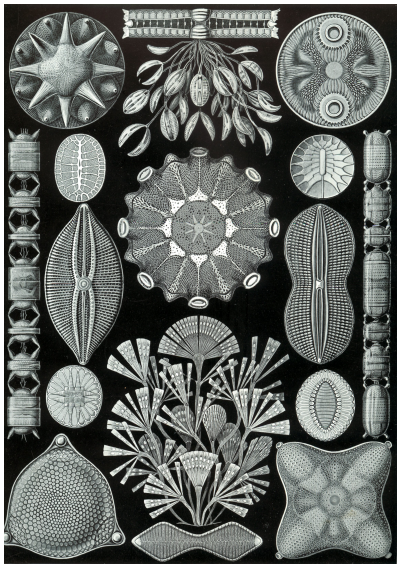
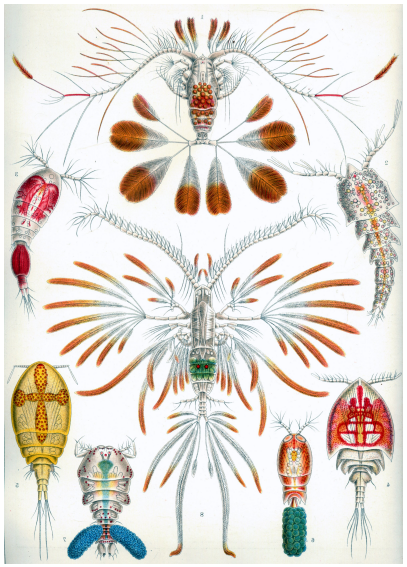
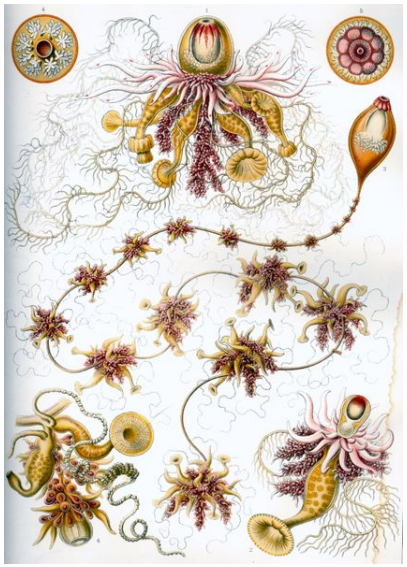
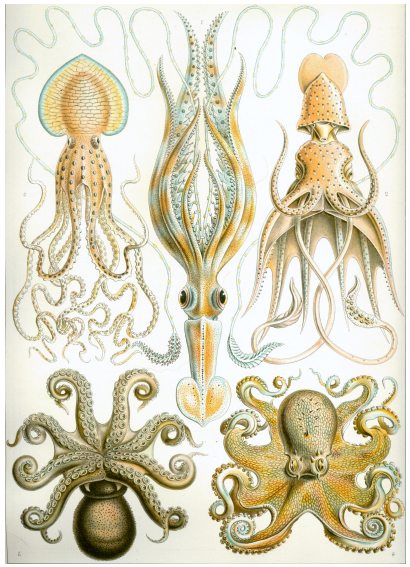
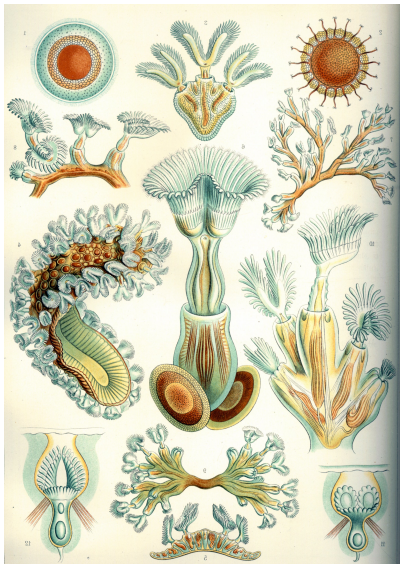
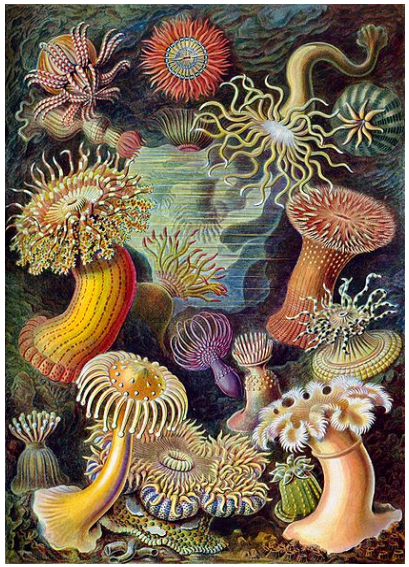
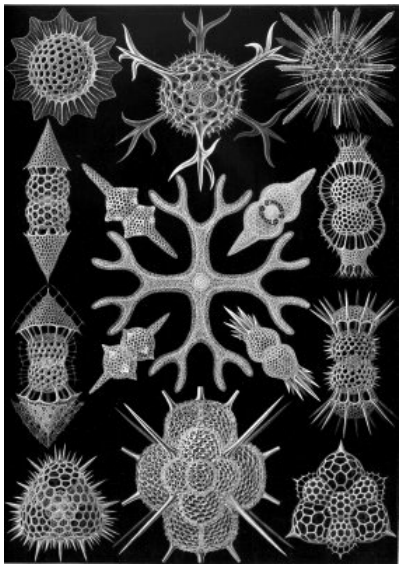
Chemistry Surfing




Lonely Elements

In retrospect-
SE sees that he left out

H, B, O, F, Na, P, Cl, Zn, Hg… and others

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Matrix Elements

The threads start to come together…
SE finds new connections

	C IV	**C** (int)	**C** -IV	**N** +V	**Dust**	**S** -II	**Ca** II	**Fe**Cu	**Br**I
C IV		x					pH		
C (int)	x	x	x		-	x	x	x	=
C -IV		x							
N +V									
Dust		-							
S -II		x						pH	
Ca II	pH	x						pH	pH
FeCu		x				pH	pH		
BrI		=					pH		

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Rank Order Polar Filters

SE priorities courtesy toy climate models-
Uncertainties in overall climate forcing

Start-Finish	POP	CICE	Couple OI	CESM
CO_2	2000-2004			2005-?
DMS	*2002-?*	*2009-?*	*2011-?*	*2010-?*
Ice chlorophyll		*2009-?*	*2010-?*	
CH_4	*2009-?*			*2011-?*
Fe, Cu	*2003-?*			
Polymers (sea-air)				
Polymers (POA)	*2012-?*			
Calcium (ikaite)				
Calcium (TEP)				
Polar halogens	*2000-?*			
N redox	*2000-?*			

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LINKS TO PRESENT COMPANY

CLOUDS	–Aerosol chem dictates structure (MM, JR)
PIGMENTS	–Play into thermo, open or ice? (SA)
RETENTION	–Do ice algae supercede the melt? (CD, JS)
TRANSFER	–Velocities consistent with physics (MM)
LEADS	–Inertial oscillation, aerosol hot spots (AR)

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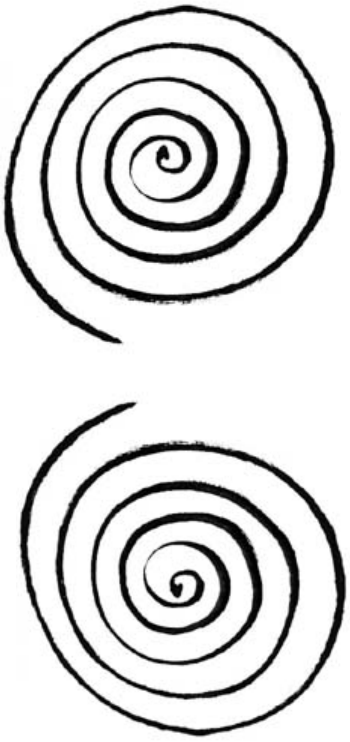
TRACER TABLE?

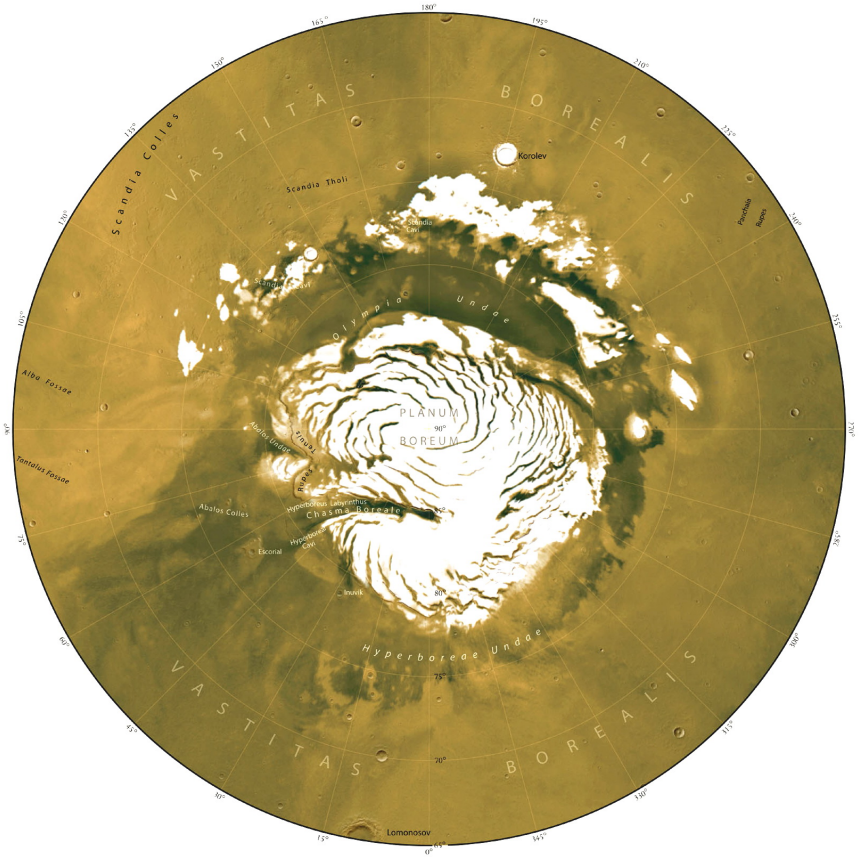


	Ice Domain	Margins	Tracers	Bypasses, Switches
SL, BL	*Atmosphere*	*Atmosphere*	GHG, aerosol, photochemistry	Aerosol, cloud, precipitation
Trapped air	*Snow*		"	Wind pulses
Mushy layer	*Ice*	*Surfactants*	GHG, aerosol, metals	Bubbles, minerals, gels
SL, BL	*Ocean*	*Ocean*	GHG, aerosol, nutrients	Slugs, gels, detritus
(Detail)			CO_2, polymers, CH_4, DMS, Fe, halogens	Sedimentation, storage, CH_4, Ca, CO_2 (DIC), polymers

CONNECTS TO PRESENT COMPANY

EXTRAS

Mars Map



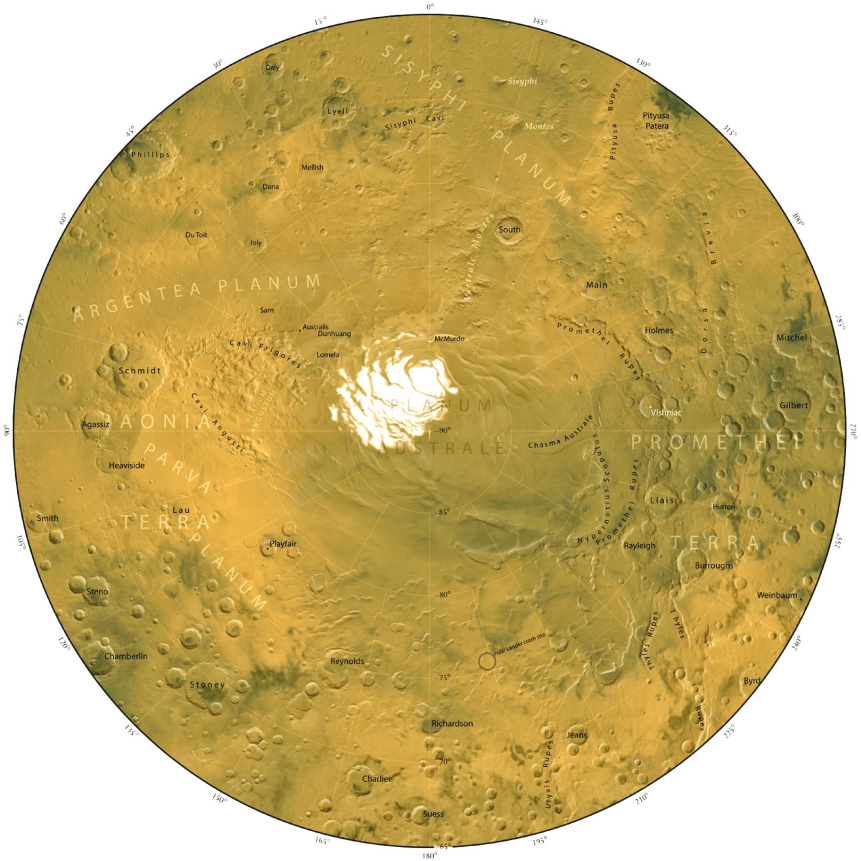
The North Pole Quadrangle of Mars

Shaded Relief with Albedo Color

by

Ralph Aeschliman

Polar Stereographic projection



The Australe Quadrangle of Mars

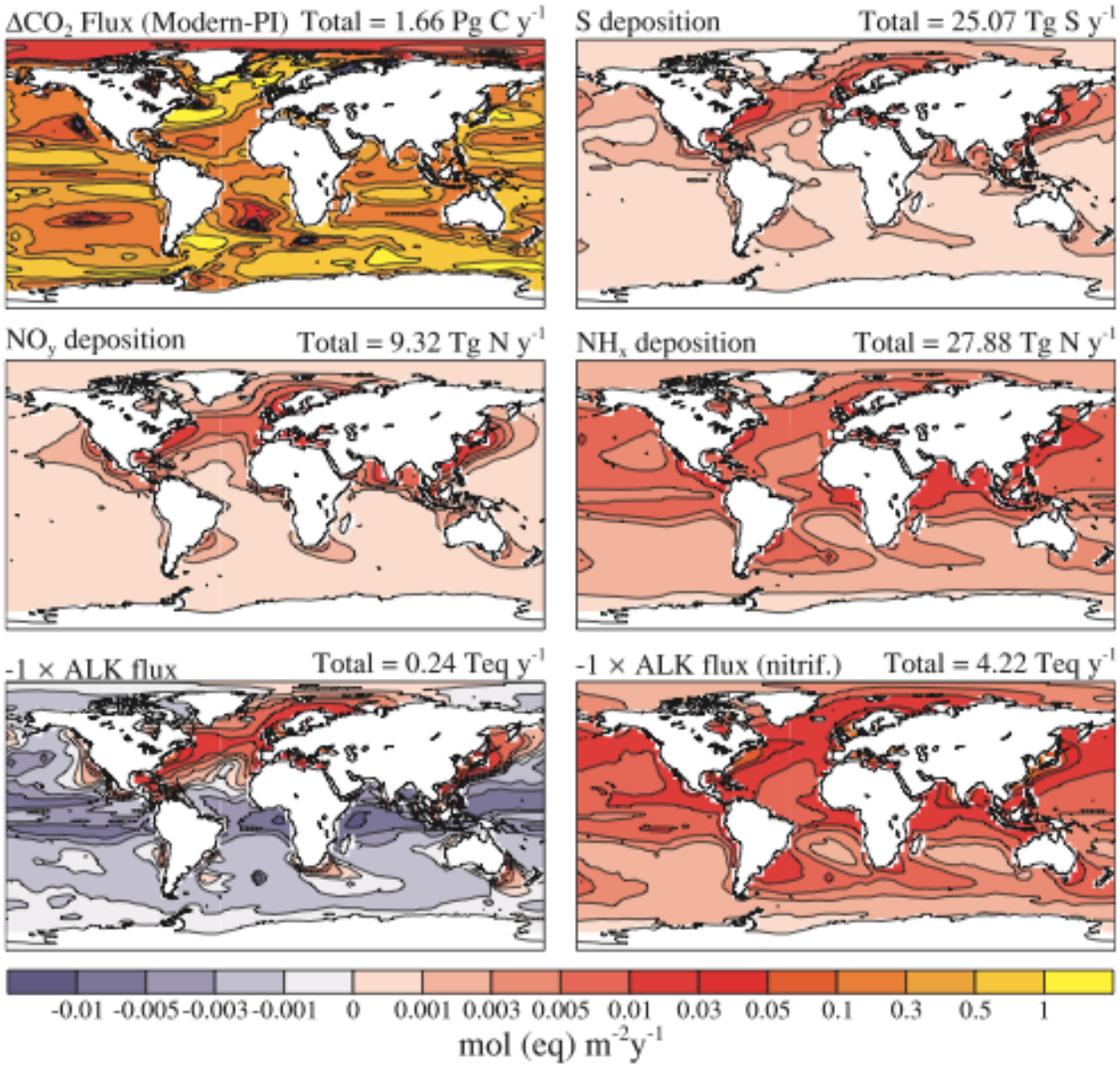
Shaded Relief with Albedo Color

by

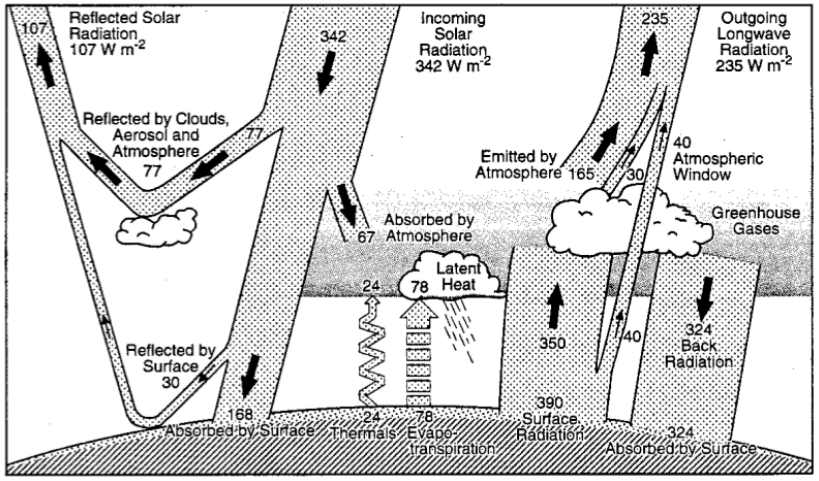
Ralph Aeschliman

Polar Stereographic projection

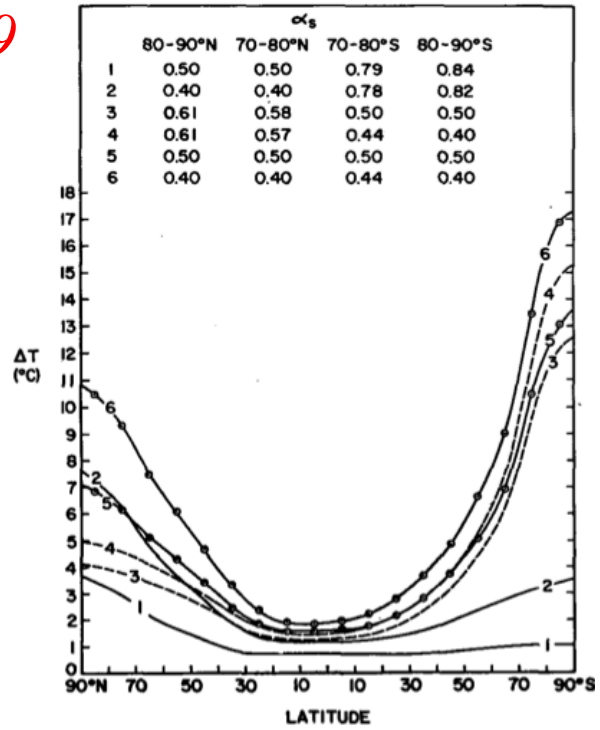
Nitrogen Deposition to the Sea



IT CAME FROM THE SIXTIES…



Sellers 69



Purgatory

The High Latitude Biosphere Responds

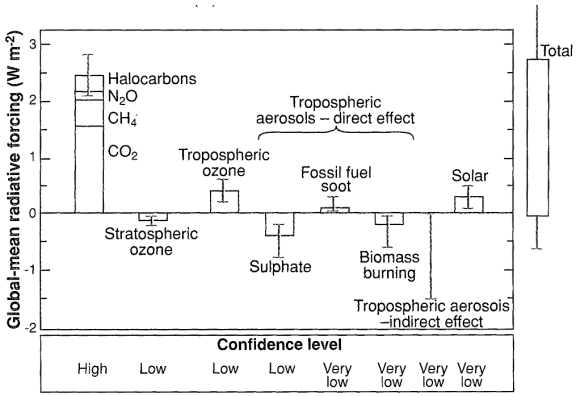
(+3° C)

$GHG+H_2O_{l,c}$

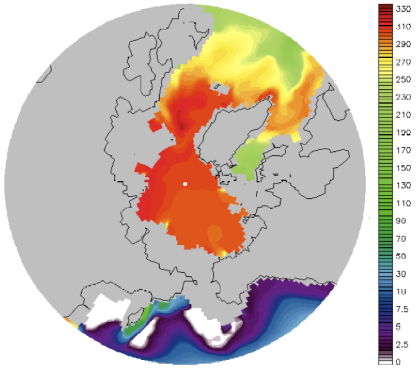
A cozy +1.7°

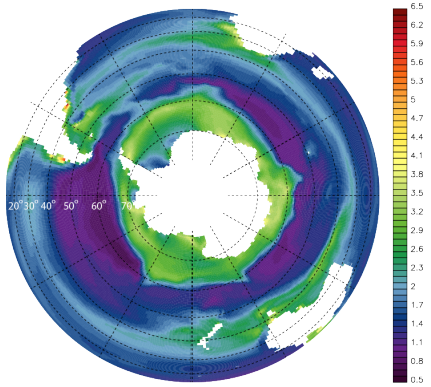
High

Abysmal

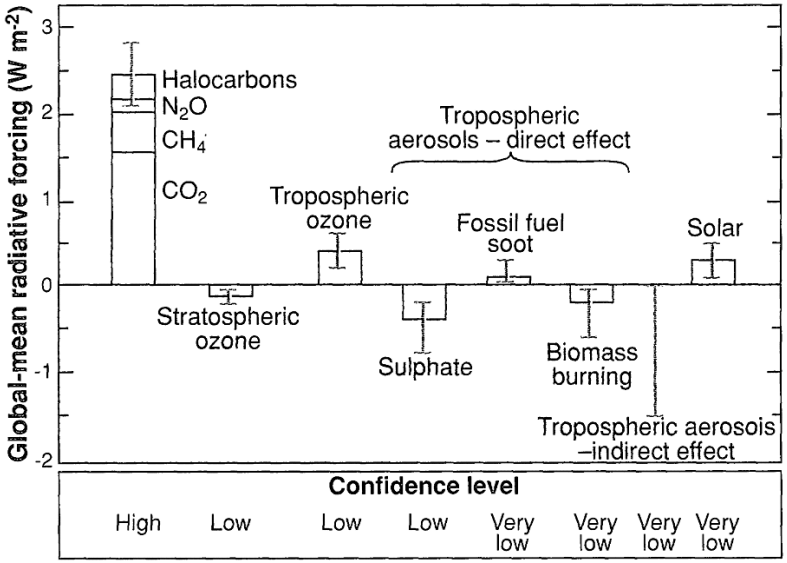


So shouldn't we dig into these issues a bit?





IPCC Logic extends to sea



Preindustrial
290

1750-Present
290.5

$2xCO_2$
291.5

Total

DMS

NH_3

CH_4

Org Aer

Ice

ABYSMAL

(Incidentally:
(The new big dollar sign-
(Ice sheets
(Here is there system forcing

Preindustrial patterns simply amplify so…
Without marine biogeochemistry,
future perhaps completely unknown.
Lovelock is right -bugs rule, people drool

Venus or snowball
Take your pick
or do some real research

The envelope please…

By these criteria, rank order for high latitude cycles:

-Ice chlorophyll (surface darkening)
-DMS
-Organics tweak sea-air transfer
-CH_4
-Organics tweak aerosol
-Seeding tweaks sea-air transfer
-Open, brine, bottom C cycling
-Aerosol/ice iron cycle
-Ice nitrogen ($NH_3/_4^+$, N_2O)
-Halogens and new particles

Note: Order 10^2 characters –IPCC does same job in 10^6