Time Estimation on Arctic Methane Catastrophe 2013/5/19, 26, 6/2

The most emergent fatal risk at now world is Methane Catastrophe in Arctic.Unless emergent drastic counter measure,we would have been in desparate hell for decades.This report tryed to reveal the mechanism and the counter measure by easy comprehesional way

[０]：The preliminary.

(1)**MC≡Methane Clathrate**(CH_4　$6.5(H_2O)$)：

Now Arctic sea flor is coarsely estimated to reserve MC about 1000GtC in depth 200m～1200m.Ice formed methane is melted to gas CH4 by heat.CH4 in atmosphere become **G**reen **H**ouse effect **G**as(GHG) of 70 times stronger than CO2. Then Insolation heat becomes to remain on globe .10 GtC of CH4 can heat up globe by RF＝1.5W/m^2.

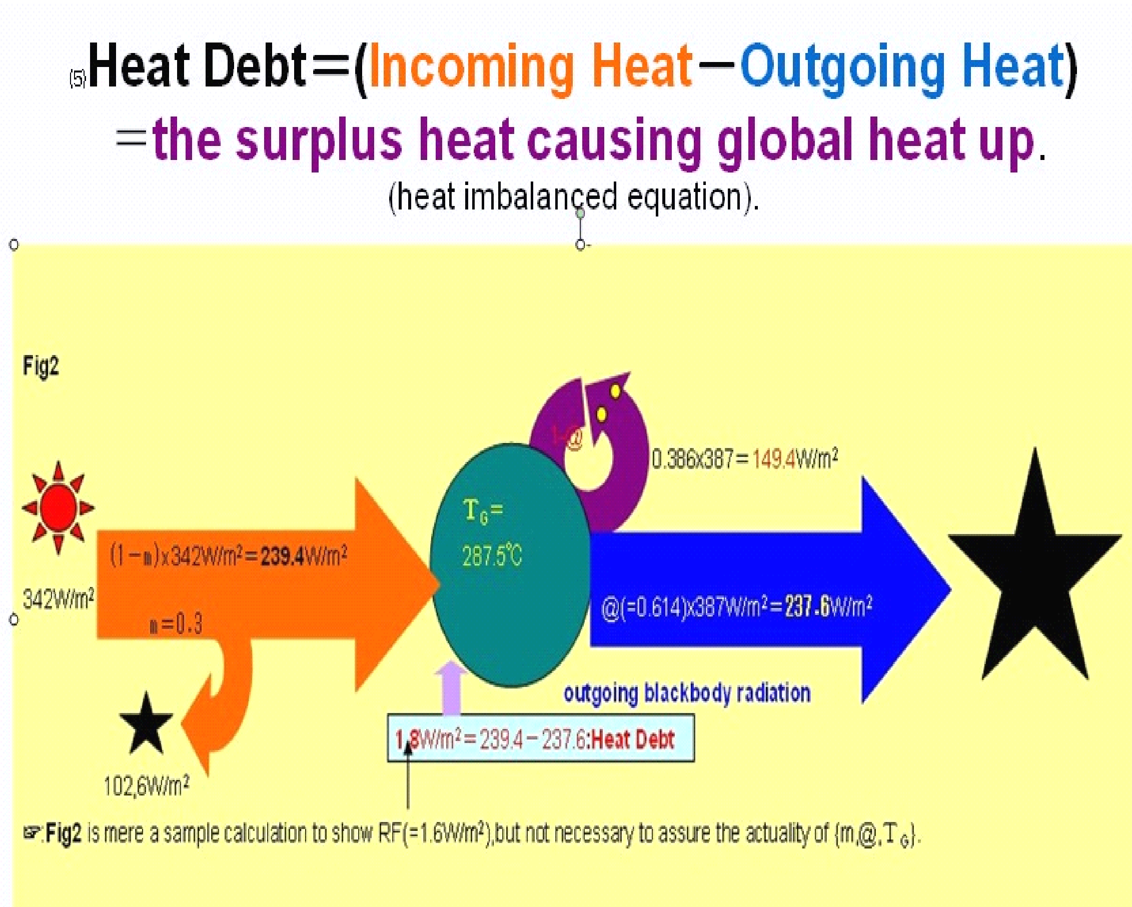
＊Methane Clathrate(CH_4　$6.5(H_2O)$)→10GtC＝10Gt<16＋6.5(18)>/14＝95Gt.

Gt=10^9ton＝10^{12}Kg. GtC＝only carbon counted mass.

(2)**RF≡Radiative Forcing.**

(year global heat/global area×year time＝1.6W/m^2＝heat up globe by≒0.03℃/year)

DEBT HEAT＝{incoming sun heat－outgoing cooling radiation}＝RF.



＊Now RF by CO2 is 1.6W/m^2. So 10GtC release add more debt to (1.6W/m^2＋1.5W/m^2)
to cause temperature rise 0.06℃/year,which is fatal as 0.6℃ rise by 10 years.

http://www.777true.net/0.1C-Temperature-Rise-could-cause-Climate-Wild.pdf

⑶Phse diagram of MC melting at a temperature=T and at apressure＝P.

http://www.killerinourmidst.com/methane%20and%20MHs2.html

Ice of MC could be **depth 200m～1200m** sea flor. MC melt by lower temperature at shallow sea flor. As position is deeper(pressure increasing),melting temperature is to rise.Thereby, stability of MC(the thermal bomb) has been due to **cool temperature with high pressure in Arictic ocean sea flor.**Now outrageous heat invasion to there is just to begin !!!.Then how to stop the heat invasion ?. This the most emergent task of us all in this planet !!!.

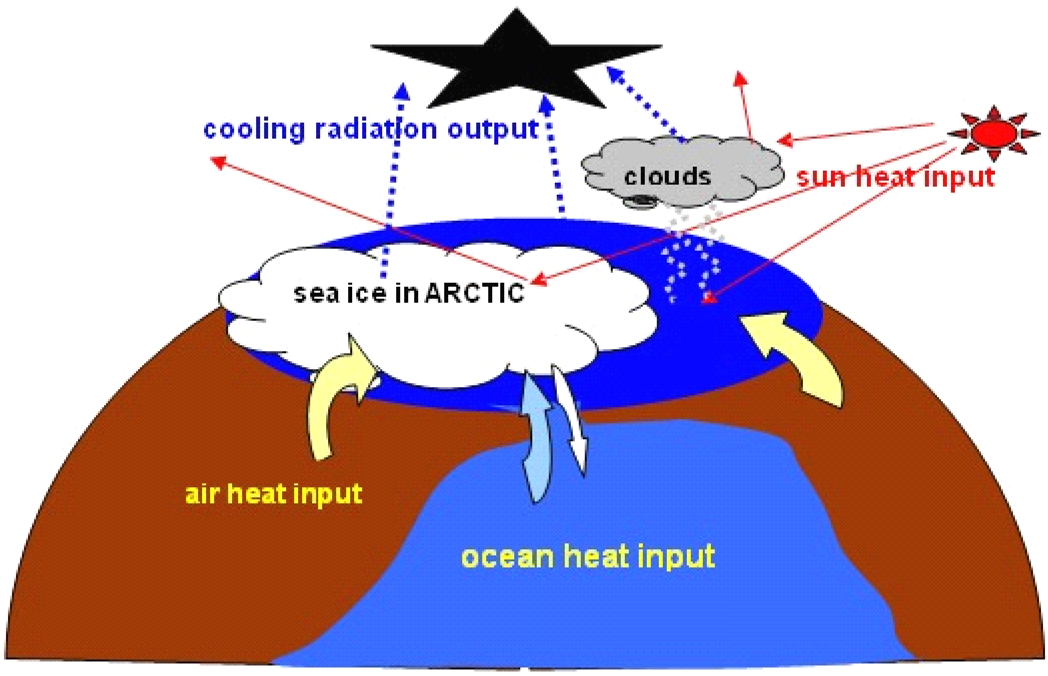
⑷**special thermal physical feature of Arctic ocean with sea ice.**

Temperature of sea water with ice is fundamentaly **zero**℃.Note that special feature of **the heaviest density of water** is at 4℃ temperature where about 350m depth in the phase diagram. Arctic ocean surface warming would make 4℃ sea water,which would go downward to warm around 350m depth.Now methane plume could be seen Arctic coastal line(**E**ast **S**iberian **A**rctic **S**ea),which depth may be around 350m or more shallow.

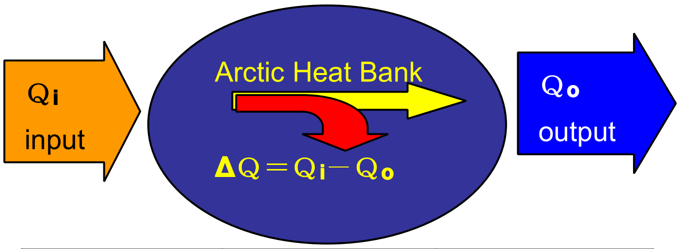
⑸**special feature of super cool sea water in under Arctic ocean sea surface.**

When those become ice,those discharge heat !!!

⑹**Arctic ocean with "3 heat inputs" and "1 output".**



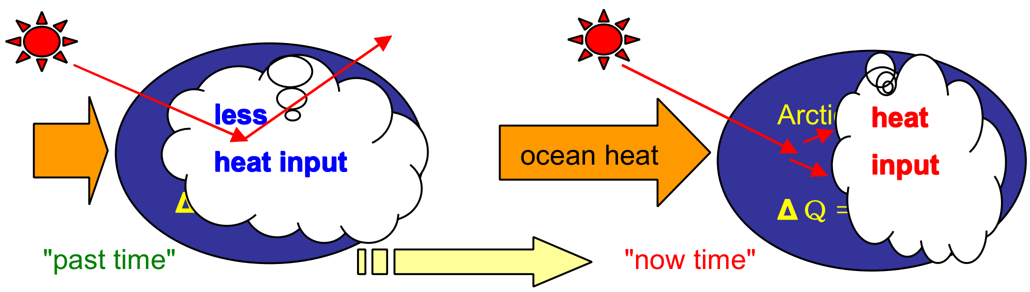
[１]：Heat Budget in Arctic{HEAT DEBT＝incoming heat－outgoing one}.



inputs	output	DEBT
Q_i	Q_o	$\Delta Q = Q_i - Q_o$
Solar heat Input=Q_S	Cooling radiation=Q_R	
Atomosphe-ric flow=Q_A		
Ocean cuurent=Q_C		

(1)Heat is an energy,so the **total amount** never increase or decrease,but is conserved. This fact is entirely analogous to money account(debt＝incoming－outgoing),But note that **heat surplus is bad debt** in heat account.It is *upside down* in heat account.Then debt heat is to trigger fatal MC bomb(bankraptcty)in Arctic ocean sea flor and zundra in land.Now let's begin to survey **the heat account in Arctic**,but which has been rather indefinite in author's survwy.

(2)Conclusionaly to tell, Arctic white ice lid had been intercepting solar heat input into ocean, which had been stabilizing Arctic for long long years. However recent years warmer ocean heat input(from Atrantic and Pacific oceans)had caused those thin to reduce ice extent in Arctic. Once ice extent had reduced,then solar heat inputs to black sea surface more, which turns to accelate more ice lid retreat.This is terrible heat input increasing by so called **"ice albedo(＝sun beam refelctoion rate)decreasing feedback".**



(3)**Once in the past,nothing DEBT**：$\Delta Q = Q_i - Q_o = 0$.But now the situation had turned. Recent remarkable trend is abrupt increasing of Q_S !(solar heat input increasing by ice albedo feedback)!!.While other are rather slow variations.Thereby, the DEBT is to increase monotonously toward fatal bankraptcy.Now let's verify it in the following

[２]：Climatology Components in Arctic.

(1)**Physical constants in climatology.**

(a)bare solar ray input(short wave=SW)：F_0＝1366W/m^2(almost gas burner heat).

(b)global surface average of F_0：$F_0/4$＝342W/m^2.

(c)**cooling radiation(**long wave=LW**)output**：$Q_R = @ \sigma T^4$.

＊Stefan Boltzmann constantσ＝5.67x10^{-8}W/m^{2}K^4.

＊space passing probability of cooling radiation：＠=0.614.?

＊global average surface absolute temperature(Kelvin)：T_G＝273＋15＝288.

(d)sea water mass density＝1020Kg/m^3,sea water specific heat＝4.02KJ/KgK

(e)sea ice mass density＝917Kg/m^3,sea ice specific heat＝2.114KJ/KgK.

sea ice melting heat＝334,7KJ/KgK.

(f)MC melting heat＝440KJ/KgK

(2)**Arctic ocean topographic data:**

http://www.oceansatlas.com/unatlas/about/physicalandchemicalproperties/background/seemore1.html

THE AREAS AND DEPTHS OF OCEANS

Ocean & seas	Area in million km^2	% of the area of the World Ocean	Depth, m mean	Depth, m greatest	Locations of the greatest depths of the Ocean
Pacific	178.8	49.5	3 976	11 022	Marianas Trench
Atlantic	91.7	25.4	3 597	8 742	Puerto Rico Trench
Indian	76.2	21.0	3 711	7 729	Sunda Trench
Arctic	14.7	4.1	1 225	5 608	Greenland Sea (Molloy Deep)
World Ocean	361.3	100.0	3 711	11 022	Marianas Trench

(a) S_A＝**area of arctic ocean**＝14.7x$10^{12}$$m^2$.

＊**Arctic Normalization Coefficient**≡**ANC**≡ S_A×year time(second)

＝ S_A×3600x24x365＝4.64x$10^{20}$$m^2$.s

(b)**Heat Capacity** C≡heat amount for 1℃ rise＝ΔQ/ΔT＝heat amount/temperature rise

C＝mass(kg)Xspecific heat(heat amout for 1℃ rise in unit mass＝1kg).

example)**Arctic ocean total heat capacity＝7.3x10^{22}J/K.**

14.7x$10^{12}$$m^2$×1225m×1020kg/$m^3$×4.02x$10^3$J＝7.38x$10^{22}$J/K.

(c) C_A＝**active heat capacity**(depth＝600m)＝7.38x10^{22}J/K×600/1225＝**3.6x10^{22}J/K.**

＊active heat capacity is one for(annual sea input heat)/(annual sea water temperature rise)

Note that 600m is about sea depth to where heat could reach in a year by sea water turbulence. In generall,wamer water is lighter than colder one except 4℃,so without turbulence(random water stiring),heat never could reach deeper sea.

(d)**Methane Clathrate**(CH4 6.5(H_2O))→10GtC＝10Gt<16＋6.5(18)>/14＝95Gt.

Heat for melting 10GtC Methane Ice＝440KJ/KgK×95x10^9×1000kg＝4.2x10^{19}J.

(e)Melting heat for 2010 **Arcitic maximum ice volume**＝8000Km^3.

http://climateprogress.org/2010/09/09/julienne-stroeve-nsidc-scientist-arctic-sea-ice-melt/

P_{Ice}＝917Kg/m^3×8000x$10^9$$m^3$×334.7x$10^3$J/KgK＝2.46x$10^{21}$J.

(g)"**Comparison" those heat values by Arctic Normalization Coefficient(ANC)**.

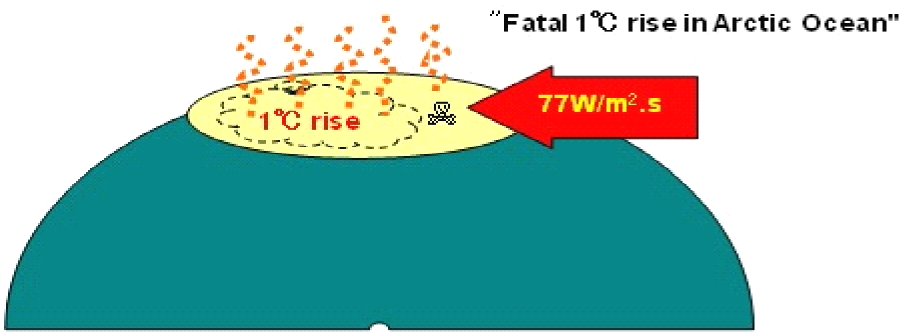
C_A(depth＝600m) ＝**3.6x10^{22}J/K.**	Melting heat for ice 8000Km^3 ＝2.46x10^{21}J.	**melting 10GtC MC** ＝4.2x10^{19}J.
77W/m^2.s＝ C_A/ANC	5.3W/m^2.s	0.1W/m^2.s

Note 77W/m^2s means 1℃ rise/year by heat input 77W/m^2 in a year.

Thereby,*once Arctic ocean temperatuer became 1℃ rise*,all are simuletaneously melted including 10GtC MC or more(bankraptcy)!!!.

Then could such strong heat input 77W/m^2.s realy be realizable ?.

The answer is possible in following paragraphes.



[３]：Insolation Input increasing with albedo decreasing.

"Note Arctic insolation is stronger than that of equator in those max values!!!".

http://www.777true.net/Insolation_Function.pdf

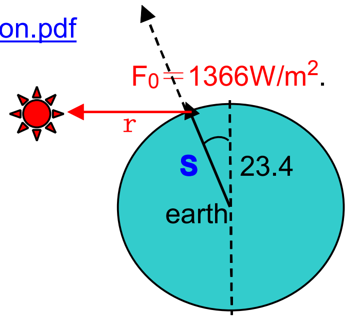
(a)**North Pole**：Θ＝90.

R(t)＝(**r**·**s**)＝cos[90－χ(t)]).

χ＝-Sin^{-1}<sin(23.4)cos(360t/365)＞0.

night sun days(t=0～182.5 日>

0.397(max)≧R(t)≧0.



r：unit vector toward sun

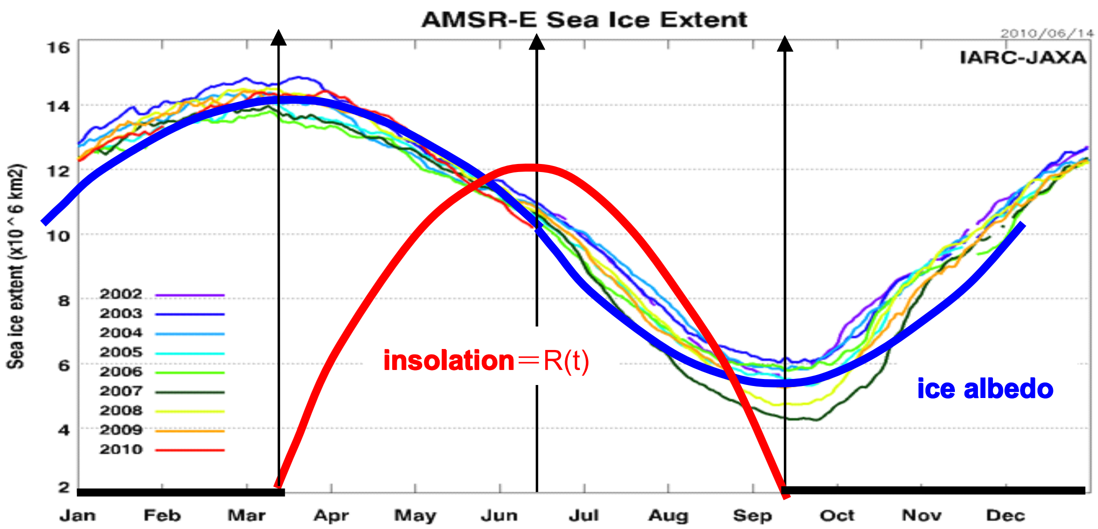
s：unit vector toward position from center. (**r**·**s**) ＝scalar product

☞:surprising for us amateurs:

「**NP is hotter than Euator in midnight sun days in 24hours total**」.

Consequnetly 2/3 of Arctic ice cover extent can be melted in summer season.

http://www.ijis.iarc.uaf.edu/en/home/seaice_extent.htm



(b)Years insolation input into Arctic＝F_0×<R( )=0.397>×<averaged sin(x)/2π>×ANC

＝1366W/m^2×0.397×<2/π>×14.7x10^{12}m^2×3600x24x365/2＝8×10^{22}J.

(c)years insolation input/ANC＝F_0×0.397×<sinx>/2π＝173W/m^2.

＊F_0＝1366W/m^2. ＊global average＝342W/m^2.

(d)**Average Ice Albedo at now**： m_A＝10/14.5.

☞：Note m_A could be varied from 10/14.5 to zero in near future !!!

(e)**effective insolation input** Q_s＝173W/m^2×(1－m_A)×0.9(67°)*)＝49W/m^2.

Arctic total＝Q_s×ANC＝2.3×10^{22}J.

☞：**Note** Q_s could be varied from **49W/m^2** to **156W/m^2** in near future !!!

It is this fact that would cause fatality, unless Arctic cooling !!!.

*)heat incident rate without sea surface reflection＝0.9(incident angle＝67°＝90－23)。

[4]: **Effective Cooling Radiation Output** $Q_R = @\sigma T^4$. <@=0.614, $\sigma = 5.67 \times 10^{-8}$>.

(1)**What is heat transfer ?.**

diffusion and conduction(heat vibration transfer),convection(heat flow with fluids), and Electro-Magnetic radiation,

(2)**What is cooling radiation ?.**

Any matter is composed from molecules with electron clouds around atoms.Then electron clouds become dynamical(becoming radiating antenna) by heat(energy) to radiate electromagnetic wave.This is **cooling radiation** by matter with finite temperature.

(3)$Q_R = @\sigma T^4$:surface radiates energy by proportional to T^4.

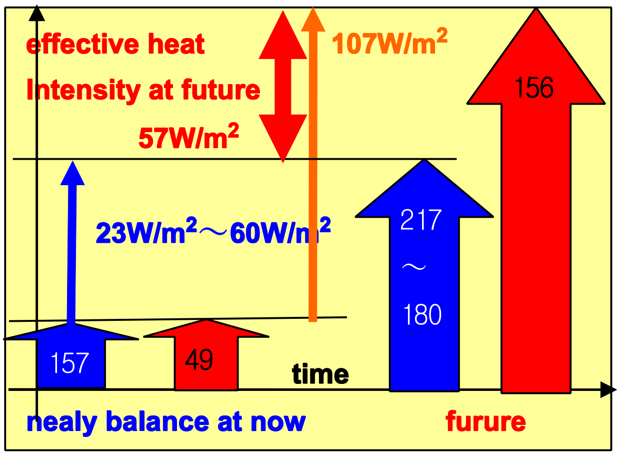
As for σ and @,see [2](1)(c). ***Especially as for Arctic,heat out put is only this.***

Ice flowout from Arctic is equivalent to vanishing ice(heat input).

(4)Following are mrer calculation without observed validity,but with guessing by author.

Summer(mid night sun days)		Winter(all night days)		annual
273(0℃)	193W/m^2	233(-40℃?)	103W/m^2	**148**W/m^2 at now ?.
273(0℃)	193W/m^2	243(-30℃?)	121W/m^2	**157**W/m^2 at now ?.
277(4℃)	205W/m^2	248(-25℃)	132W/m^2	169 **23W/m^2 increasing**
281(8℃)	217W/m^2	253(-20℃)	143W/m^2	180

☞:What author wish tell is that cooling radiation change is smaller than that of insolation heat input by albedo full change(**49W/m^2** to **156W/m^2**). Cooling radiation could not cancell against insolation heat increasing due to albedo decreasing.



$T = 281$(8℃) is outrageous temperature rise in Arctic.Even though cooling radiation rise = **60W/m^2** could not exceed insolation heat.

156W/m^2 — 49W/m^2 = 107W/m^2

57W/m^2 Is outrageous catastrophic heat to warm Arctic ocean **0.7℃ rise/ 1 year** !!!.

Up to here,you could decisively understand **catastrophic heat increasing situation** by some elementary calculation with climatology knowledges.

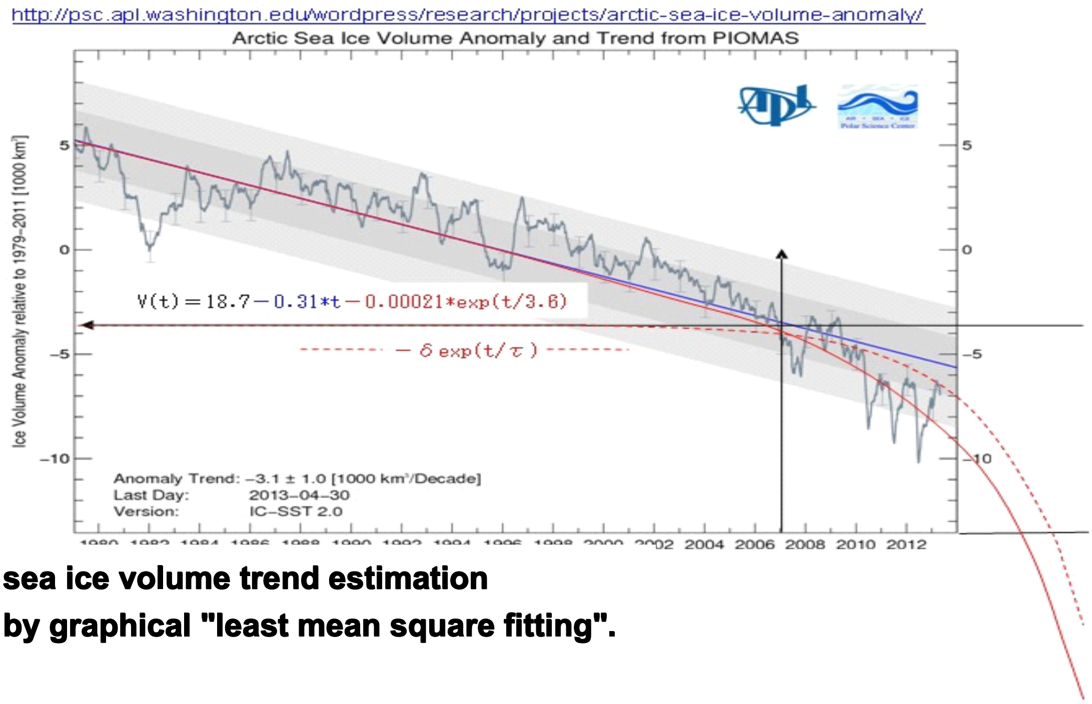
Following becomes rather advanced course in mathematical describtions.

[5]: Coarse Time Estimation(Conclusion):

(1)insolation input increasing is (156-49)＝107W/m^2,while cooling radiation increasing never can exceed 107W/m^2. Even 217(8℃)－157(now)＝60W/m^2 can not exceed insolation heat increasing.Thereby,unless artificial counter measure,Arctic ocean bank is to face heat bankraptcy someday.This is the most emergent risk we mankind has been facing.

(2)**sea ice volume trend estimation by graphical least mean square fitting**

http://psc.apl.washington.edu/wordpress/research/projects/arctic-sea-ice-volume-anomaly/



sea ice volume trend estimation
by graphical "least mean square fitting".

(a)$V(t)=V_0-at-\delta\exp(t/\tau)$ *). fitted function. t≡0<1979>

*) The meaning of "$-\delta\exp(t/\tau)$" could be seen in **APPENDIX_1:**

(b)$a=0.31\pm0.1$<1000km^3/yr>. slope coefficient

(c)$V_0=V(1979)=18.7\mathrm{x}1000\mathrm{km}^3$. Initial value at t≡0<1979>.

(d)$0.5=\delta\exp(2007-1979=28/\tau)$. fitting value due to observed data

(e)$3.5=\delta\exp(2014-1979=35/\tau)$. fitting value due to observed data

(f) (d)/(e)$=1/7=\exp(-7/\tau)$ → $\tau=3.6$yr......... marvelous rapid change !!!!

(g) (e)$=3.5=\delta\exp(35/3.6)$ → $\delta=2.1\mathrm{x}10^{-4}$.

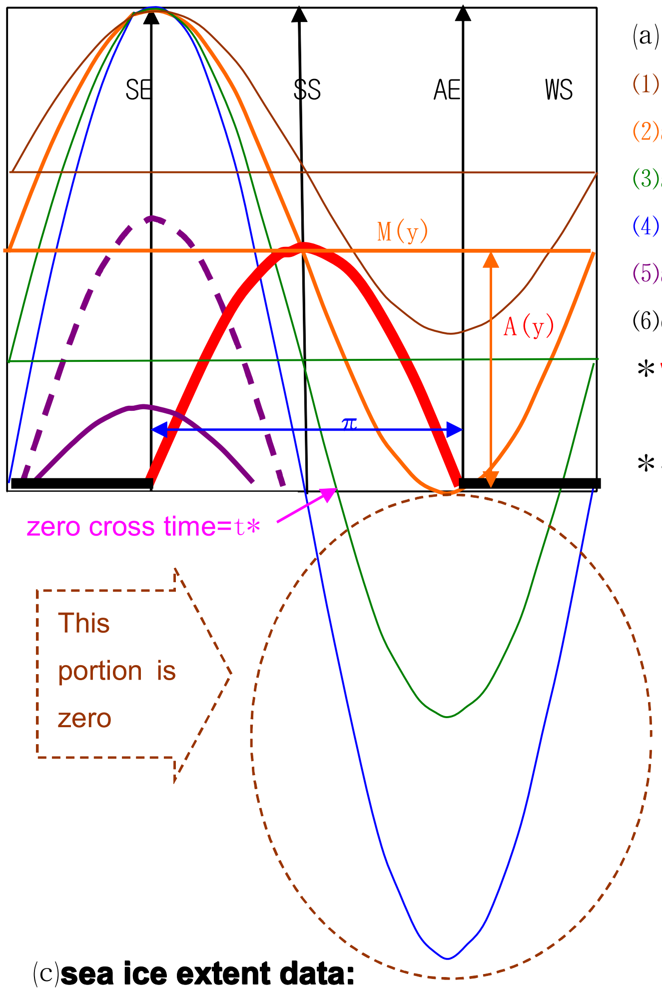
(h)**estimation on ice volume trend by graphical least mean square**

$V(t)=18.7-0.31*t-0.00021*\exp(t/3.6)$.

(i)linear estimation on ice vanishing year: 18.7/0.31＝60Y, 60＋1979＝2039 !!!.

Exponential albedo feedback predicts neary 2015 for "annual ice volume" vanishing.

(3)**Ice extent(m=Arctic ice albedo) decreasing process toward full vanishing.**



(a)**ice vanishing process imagined.**

(1)Now state m＝2/3

(2)**average albedo m＝1/2**(2015?!)

(3)average albedo＜1/3

(4)less than (3)

(5)**approaching to nearly zero**

(6)completely zero＝ice full vanishing.

＊**wide red is insolation** and

black line is nothing insolation.

＊SE＝spring equinox,

(b)Note above fig is mere author's guessing,but might be not reality. **Albedo decreasing**(heat absorbtion increasing)is to accelate heat store in the ocean,which intecepts ice freezing in autumn and causes ice more thin.Which turn to early ice melting in spring.Thereby these process is to continue untill full ice vanising in all Arctic season at last.

(c)**sea ice extent data:**

http://www.ijis.iarc.uaf.edu/en/home/seaice_extent.htm

(4)**Estimation on Ice extent(=Arctic ice albedo)trend＝absorbtion trend estimation:**

In［5］(2), also author concluded **annual average ice volume** vanishing by about 2015. However certain degress of ice extent could survive **in seasonal**.This process could be Imagined by［5］(3). Ice extent full vanishing would take few decades.

Also in this case,author assumed **exponential increasing of absobtion** by albedo feedback process mentioned in **Appendix_1**.and **Appendix_2.**

＊$\hat{m}(t)=\hat{m}(0)\exp(t/\tau)$.

,where $\hat{m}(0)$ and τ should be determine by (estimated)**observed values** on {$\hat{m}(0)$, τ}.

Following are coarse semi-numerical experiments,but not exact analysis.Then author estimate as follows.

Estimation are $16y < \tau < 26y$, $19y <$ T (time for full vanishing) $< 29y$.

year	anti-albedo=m^(t)=1-m(t)	time constant= τ.
2007	0.3=m^(0)	
2015	0.5=0.3exp(8/τ).	τ=15.7yr
2026	1.0=0.3exp(T/15.7)	T=19yr

year	anti-albedo=m^(t)=1-m(t)	time constant= τ.
2007	0.33=m^(0)	
2015	0.5=0.33exp(8/τ).	τ=19yr
2028	1.0=0.33exp(T/19)	T=21yr

year	anti-albedo=m^(t)=1-m(t)	time constant= τ.
2007	0.36=m^(0)	
2015	0.5=0.36exp(8/τ).	τ=24yr
2032	1.0=0.36exp(T/15.7)	T=25yr

year	anti-albedo=m^(t)=1-m(t)	time constant= τ.
2007	0.33=m^(0)	
2015	0.45=0.33exp(8/τ).	τ=26yr
2036	1.0=0.33exp(T/26)	T=29yr

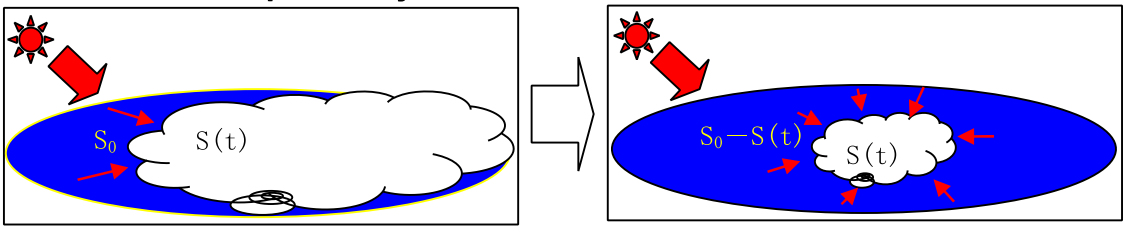
year	anti-albedo=m^(t)=1-m(t)	time constant= τ.
2007	0.3=m^(0)	
2015	0.45=0.3exp(8/τ).	τ=20yr
2031	1.0=0.3exp(T/20)	T=24yr

year	anti-albedo=m^(t)=1-m(t)	time constant= τ.
2010	0.33=m^(0)	
2015	0.45=0.33exp(5/τ).	τ=16yr
2028	1.0=0.33exp(T/16)	T=18yr

year	anti-albedo=m^(t)=1-m(t)	time constant= τ.
2007	0.165=m^(0)	
2015	0.25=0.165exp(8/ τ).	τ =19yr
2028	max0.50=0.165exp(T/19)	T =21yr

APPENDIX_1:The Cause of Rapid Melt by Ice Albedo Feedback.

(1):**The Cause of Rapid Melt by Ice Albedo Feedback.**



<u>This model analysis is on coarse averaged annual one,but not on precise seasonal one.</u>

Ice lid melt amount(area)/year(dS(t)/dt) is proportional to heat input into ice/year, which may be also very coarsely proportional to solar input to opened mouse sea area $=(S_0-S(t))$. Hence we derive,

$*\ (dS(t)/dt)=-k(S_0-S(t))\equiv-(S_0-S(t))/\tau$.

$\rightarrow\ dS/dt-kS=-kS_0. \rightarrow\ d(S.\exp(-kt)]/dt=-kS_0\exp(-kt)$.

$S(t)=-kS_0\exp(kt)\int_0^t du\langle\exp(-ku)\rangle+C\exp(kt)$.

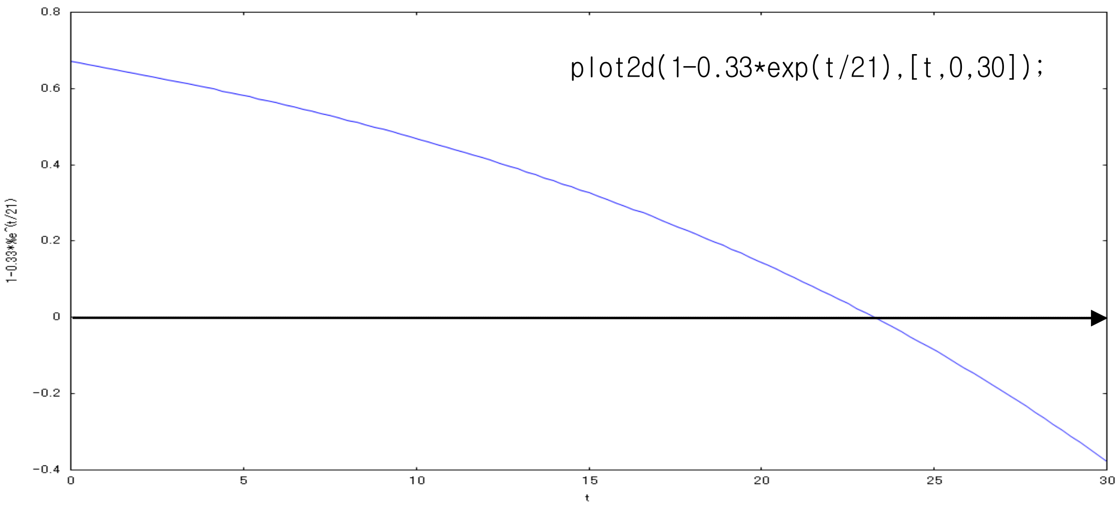
$=S_0\exp(kt)[\exp(-ku)]_0^t+C\exp(kt)=S_0+(C-S_0)\exp(kt)$.

$\rightarrow\ S(t=0)=S_0+(C-S_0). \rightarrow\ C\equiv S_0-\delta. \rightarrow\ \delta$ is something small constant.

> $*S(t)=S_0-\delta\exp(kt)$
>
> $\equiv S_0-S(tm)\exp(\langle t-tm\rangle/\tau)$。 $\langle S(tm)\equiv\delta\exp(ktm)\rangle$

*verification: $dS/dt=-\delta'\exp(kt)-k\delta\exp(kt)=-k\delta\exp(kt)=k(S(t)-S_0)$.

(2)an example curve of $S(t)=1-0.33*\exp(t/21).\langle t=30year\rangle$

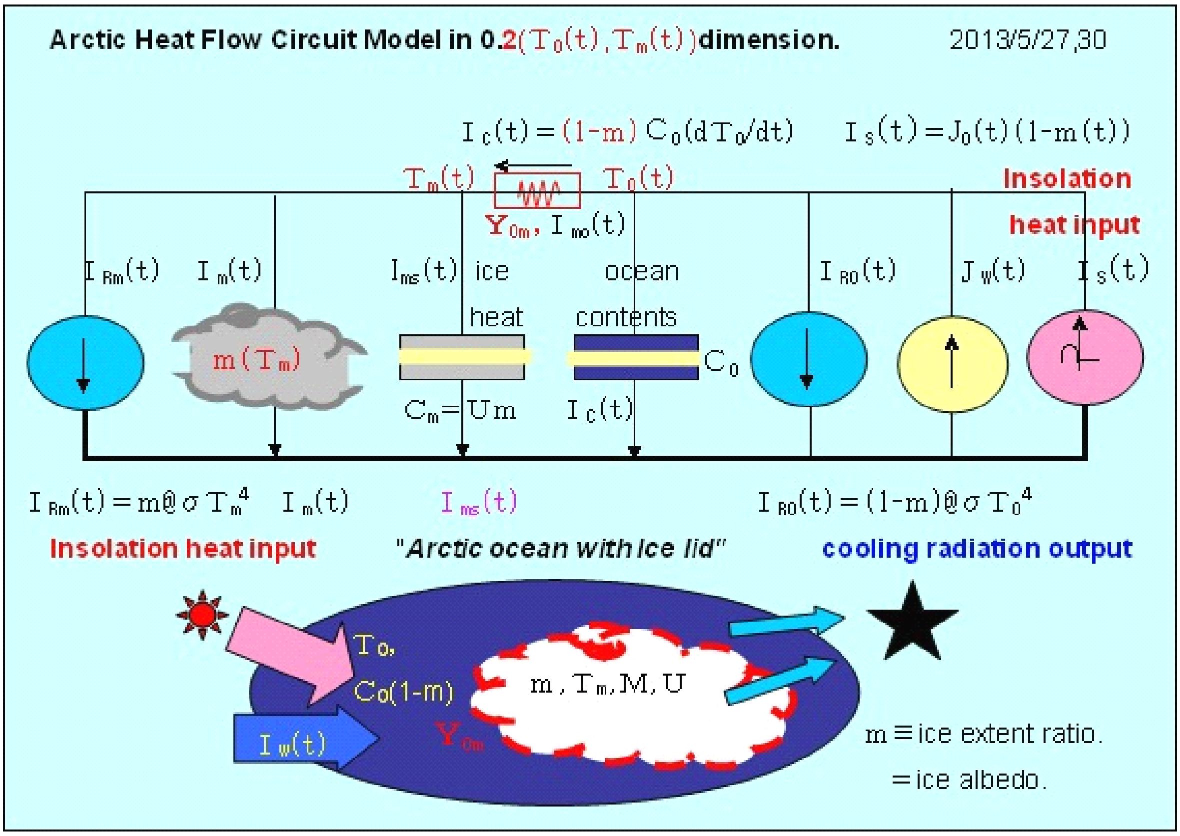


(3):**insolation absorbtion coefficient**$\equiv\hat{m}(t)$.

$\hat{m}=(S_0-S(t))/S_0=\langle S(tm)/S_0\rangle\exp(\langle t-tm\rangle/\tau)$.

> *__insolation absorbtion coefficient__ : $\hat{m}(t)\equiv\hat{m}(0)\exp(t/\tau)\equiv(1-m(t))$.

APPENDIX_2:Arctic Heat Flow Circuit Model as for albedo＝m(t).



[0]:**The System Components in Heat Current Circuit Model** .<CS≡current source>

(1)insolation heat input(CS) $I_S(t) = I_0(t)(1-m(t))$	(5)Ocean heat current by temeperature change $I_C(t) = (1-m)C_0(dT_0/dt)$. <capacitive>
(2)ocean current heat input(CS) $I_W(t)$	(6)ice freezing and melting heat current $dm/dt = -M I_m(t)$. <quasi-capacitive>
(3)cooling radiation from sea surface(CS) $I_{R0}(t) = (1-m)@\sigma T_0^4$	(7)heat exchange between ice and sea $I_{m0}(t) = \langle T_0(t) - T_m(t)\rangle Y_{0m}$. <conductive>
(4)cooling radiation from ice surface(CS) $I_{Rm}(t) = m@\sigma T_m^4$	(8)ice temperature change heat(neglect at now) $I_{ms}(t) = Um(t)dT_m(t)/dt$. <capacitive>

(8)**circuit action**<The model intend not complete ,but qualitical describtion of albedo>

(a)In summer,heat input into ocean causes $T_0(t)$ rise,which causes increasing of $I_{m0}(t) = \langle T_0(t) - T_m(t)\rangle Y_{0m} > 0$ causes ice melting(m decreasing).

(b)In winter,heat output into spce by $I_{R0}(t)$ causes $T_0(t)$ down,which causes decreasing $I_{m0}(t) = \langle T_0(t) - T_m(t)\rangle Y_{0m} < 0$ causes ice freezing(m increasing).

(c)Once m full vanished in summer,<u>higher capacitive $T_0(t)$ is to delay starting of ice freezing</u>.This action causes albedo(m) collapsing processs by exponential decreasing..

[1] : **The Systeme Components.**

{$T_0(t)$, $T_m(t)$, $m(t)$,,,,,,,,,}.Unknow variables are 3,while independent equations are 3.

All current variables＝ I are defined by{T_0, T_m, m}}and are intermediate ones.

At this time,only m(t) is solved.

(a)$dm/dt = -M I_m(t)$. ......Ice melt&freeze equation

(b)$0 = I_S(t) + J_W(t) - I_C(t) - I_{m0}(t) - I_{R0}(t)$ ......circuit equation

(c)$I_{m0}(t) = \langle T_0(t) - T_m(t)\rangle Y_{0m} = I_m(t) + m@\sigma T_m(t)^4 - I_{ms}(t)$. ..circuit equation

(1)**Heat current conservation low:**

(a) $I_{m0}(t) = I_m(t) + I_{Rm}(t) - I_{ms}(t)$.

(b)$0 = I_S(t) + J_W(t) - I_C(t) - I_{m0}(t)$

$= I_S(t) + J_W(t) - I_C(t) - I_m(t) - I_{R0}(t) - I_{Rm}(t) + I_{ms}(t)$

$= I_S(t) + J_W(t) - I_C(t) - I_m(t) - I_R(t) + I_{ms}(t)$

$= J_0(t)(1-m) + J_W - (1-m) C_0(dT_0/dt) + M^{-1}dm(t)/dt - (1-m)@\sigma T_0^4 - m@\sigma T_m^4 + I_{ms}$.

(c) $I_R(t) \equiv I_{Rm}(t) + I_{R0}(t) = (1-m)@\sigma T_0^4 + m@\sigma T_m^4$.

(2)**Sea temperature**<$T_0(t)$>**change heat flow into and from the ocean.**

$I_C(t) = (1-m(t)) C_0(dT_0/dt)$.

(3)**Ice melting and freezing heat flow.** $m = m(t; T_m \leqq 0)$, M＝melting heat.

＊$dm(t)/dt \equiv -MI_m(t) = -M[I_S(t) + I_W(t) - I_C(t) - I_R(t) + I_{ms}(t)]$.

$I_m(t) = I_S(t) + I_W(t) - I_C(t) - I_R(t) + I_{ms}(t)$.

＊ "m" is ice extent with hidden constant of average thickness.

(4)**Cooling radiation heat flow.**<T_m＝ice lid temperature>

＊ $I_R(t) = I_{Rm}(t) + I_{R0}(t) = (1-m)@\sigma T_0^4 + m@\sigma T_m^4$.

(5)**seasonal insolation change:** $I_S(t) = J_0(t)(1-m(t))$.

(a)$J_0(t) = J_0\sin(t)$. $2n\pi + 0 < t < (2n+1)\pi$; $I_0(t) = 0$. $(2n+1)\pi < t < (2n+2)\pi$.

(b)$J_W(t)$＝heat input by ocean current water(external variable).

(6)$I_{m0}(t) = \langle T_0(t) - T_m(t)\rangle Y_{0m} = I_m(t) + m@\sigma T_m^4 - I_{ms}(t)$.

＊ $I_m(t) = \langle T_0(t) - T_m(t)\rangle Y_{0m} - m@\sigma T_m^4 + I_{ms}(t)$.

(7)$Um(t) dT_m(t)/dt = -I_{ms}(t)$＝heat for ice temperature change.

U is something specific heat of ice. $Um(t) \equiv C_m$ is capacitive.

I_{ms} is neglegible against I_m, ice melt heat＝334.7KJ/Kg, spcific heat＝2.1KJ/KgK.

At this time,thereby, T_m is something formal in algorithm,but not actual.

[2] : **The total account and trend of ice albedo**＝m(t) :

$dm/dt=-M I_m(t)=-M[I_S(t)-I_C(t)-I_R(t)+J_W(t)]$.

(1) $dm/dt=-M[J_0(t)(1-m)-(1-m)C_0(dT_0/dt)-(1-m)@\sigma T_0^4-m@\sigma T_m^4+J_W]$.

Where M is something constant.

$dm/dt=-M[I_0(t)(1-m)-(1-m)C_0(dT_0/dt)-(1-m)@\sigma T_0^4-m@\sigma T_m^4+I_W]$.

$=mM\{I_0(t)-C_0(dT_0/dt)-@\sigma(T_0^4-T_m^4)\}-M\{I_0(t)-C_0(dT_0/dt)-@\sigma T_0^4+I_W\}$

(2) $dm/dt=mM\{I_0(t)-C_0(dT_0/dt)-@\sigma(T_0^4-T_m^4)\}$

$-M\{I_0(t)-C_0(dT_0/dt)-@\sigma(T_0^4-T_m^4)\}-M(I_W-@\sigma T_m^4)$.

(3)**evaluation of the terms**($1\geqq m(t)\geqq 0$).

$dm/dt=-(1-m)M\{I_0(t)-C_0(dT_0/dt)-@\sigma(T_0^4-T_m^4)\}$

$-M\{I_W-@\sigma T_m^4\}$.

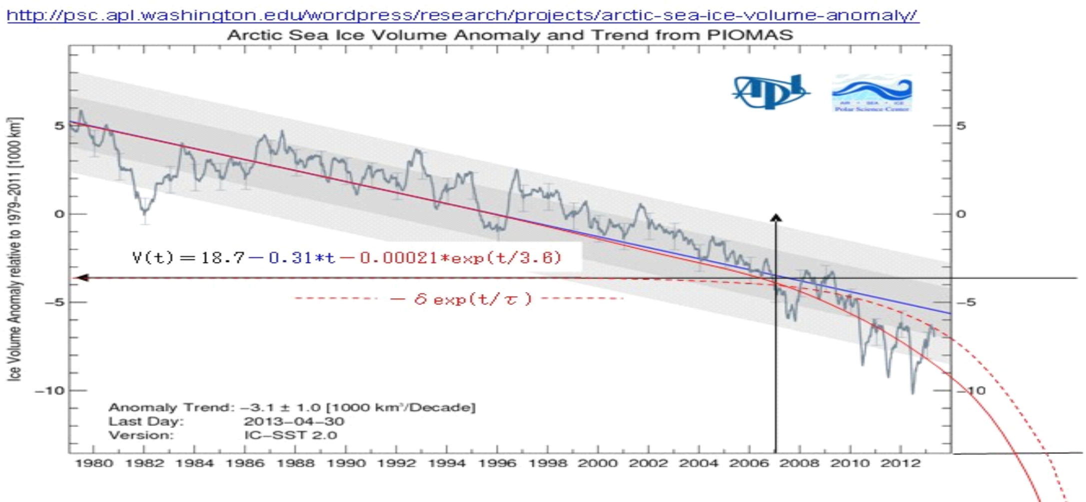
This report will not derive exact and explicit quantitical solution,but give some insight on the coarse qualitical trend on albedo＝m decresing process.In this report,ice extent≡m and ice volume are considered the same.

(a)Before 1979, $dm/dt=0$ had been heat balanced state.

(b)Then 2nd term＝ I_W is ocean current heat input between 1979～2007.

Which had been causing linear decline of dm/dt＝3.1±1.0(1000km^3/10yr).

(c)1st term is **albedo feedback**＝(1-m),deceasing "m" is to accelate more decline $dm/dt<0$.,which had become evident nearly about 2007.The trend reveals evident more down turn toward zero..



sea ice volume trend estimation
by graphical "least mean square fitting".

(d) $I_0(t)$ is seasonal insolation change,which is almost constant in annual.

(e)$-C_0(dT_0/dt)$ is seasonaly heat charging in summer and **discharging** in winter.

Then the discharging in early winter phase is to delay ice freezing and to cause ice thin in winter..

(f)$-@\sigma(T_0^4-T_m^4)$ is **cooling radiation to cause ice freezing**,however, the intensity increasing could not become sufficient to weaken ice diminishing.

(g)dm/dt=3.1±1.0(1000km^3/10yr).

I=3.1x1000km^3/10yrx917Kg/m^{3}x334,7KJ/KgK/ANC=2.84x10^{12}kgx334,7KJ/KgK/ANC.

=9.5x10^{20}J/y/4.64x10^{20}m^2.s=2W/m^2.

＊sea ice mass density=917Kg/m^3,

＊sea ice melting heat=334,7KJ/KgK.

＊ANC=S_A×3600x24x365=4.64x10^{20}m^2.s

＊2.84x10^{12}kg=2.84Giga ton.

(5)**analytical solution**:

$* F\equiv\{I_0(t)-C_0(dT_0/dt)-@\sigma(T_0^4-T_m^4)\}.$

$* G\equiv\{I_W-@\sigma T_m^4\}.$

$* dm/dt=-(1-m)F-G. \rightarrow dm/dt-mF=-(F+G).$

$(d/dt)(m\cdot\exp<-\int_0^t du F>)=-(F+G)\exp<-\int_0^t du F>.$

$m(t)\cdot\exp<-\int_0^t du F(u)>-m(0)\cdot\exp<-\int_0^0 du F(u)>$

$=-\int_0^t du(F(u)+G(u))\exp<-\int_0^u dv F(v)>.$

$m(t)-m(0)\exp<\int_0^t du F(u)>$

$=-\exp<\int_0^t du F(u)>\int_0^t du(F(u)+G(u))\exp<-\int_0^u dv F(v)>.$

solution:

$m(t)=m(0)\exp<\int_0^t du F(u)>-\int_0^t du(F(u)+G(u))\exp<\int_u^t dv F(v)>.$

verification)

$m(t)\equiv-\int_0^t du(F(u)+G(u))\exp<K(t)-K(u)>+m(0)\exp<\int_0^t du F(u)>$

$=-\exp<K(t)\int_0^t du(F(u)+G(u))\exp<-K(u)>+m(0)\exp<\int_0^t du F(u)>.$

$dm/dt=-F(t)\exp<K(t)>\int_0^t du\{(F(u)+G(u))\exp<-K(u)>\}$

$-\exp<K(t)(F(t)+G(t))\exp<-K(t)>+F(t)m(0)\exp<\int_0^t du F(u)>$

$=-F(t)\int_0^t du(F(u)+G(u))\exp<\int_u^t dv F(v)>+F(t)m(0)\exp<\int_0^t du F(u)>$

$-(F(t)+G(t)).$

$dm/dt-F(t)\{m(0)\exp<\int_0^t du F(u)-\int_0^t du(F(u)+G(u))\exp<\int_u^t dv F(v)>\}$

$=-(F(t)+G(t)).$ <proof end>.

(6)**interpretation on the solution $m(t)$.**

$m(t)=m(0)\exp\langle\int_0^t du\,F(u)\rangle-\int_0^t du(F(u)+G(u))\exp\langle\int_u^t dv\,F(v)\rangle$

$=\exp\langle\int_0^t du\,F(u)\rangle m(0)-\exp\langle\int_0^t du\,F(u)\rangle\int_0^t du(F(u)+G(u))\exp\langle-\int_0^u dv\,F(v)\rangle.$

$1>m(0)\geqq m(t)=\exp\langle\int_0^t du\,F(u)\rangle\{m(0)-\int_0^t du(F(u)+G(u))/\exp\langle\int_0^u dv\,F(v)\rangle\}\geqq 0.$

Now extremely coarse saying, $(1+G/F-m_0)>0$, F and G are assumed constant .Then the integration could be simply accomplished as follows.

$m=\exp(Ft)(m_0-\int_0^t du(F+G)\exp(-uF))=\exp(Ft)[m_0-(F+G)*(\exp(-tF)-1)/F]$

$=m_0.\exp(Ft)+(1+G/F)*(1-\exp(Ft))=m_0.\exp(Ft)+1-\exp(Ft)+G/F-(G/F)\exp(Ft)$

$m=(1+G/F)-(1+G/F-m_0)\exp(Ft).$

Thereby,"$m(t)$"is unstable to be rapid(exactly how much ?) exponential **deceasing**.

*) $\int_0^t du\,F(u)=t\,F(u*)$. $\langle t\geqq u*\geqq 0\rangle$ is called **integral theorem of middle value.**

$\int_0^t du(F+G)\exp(-uF))=\langle F(v*)+G(v*)\rangle\int_0^t du.\exp(-uF))$. $\langle t\geqq v*\geqq 0\rangle$

APPENDIX_3:General Feedback MODEL

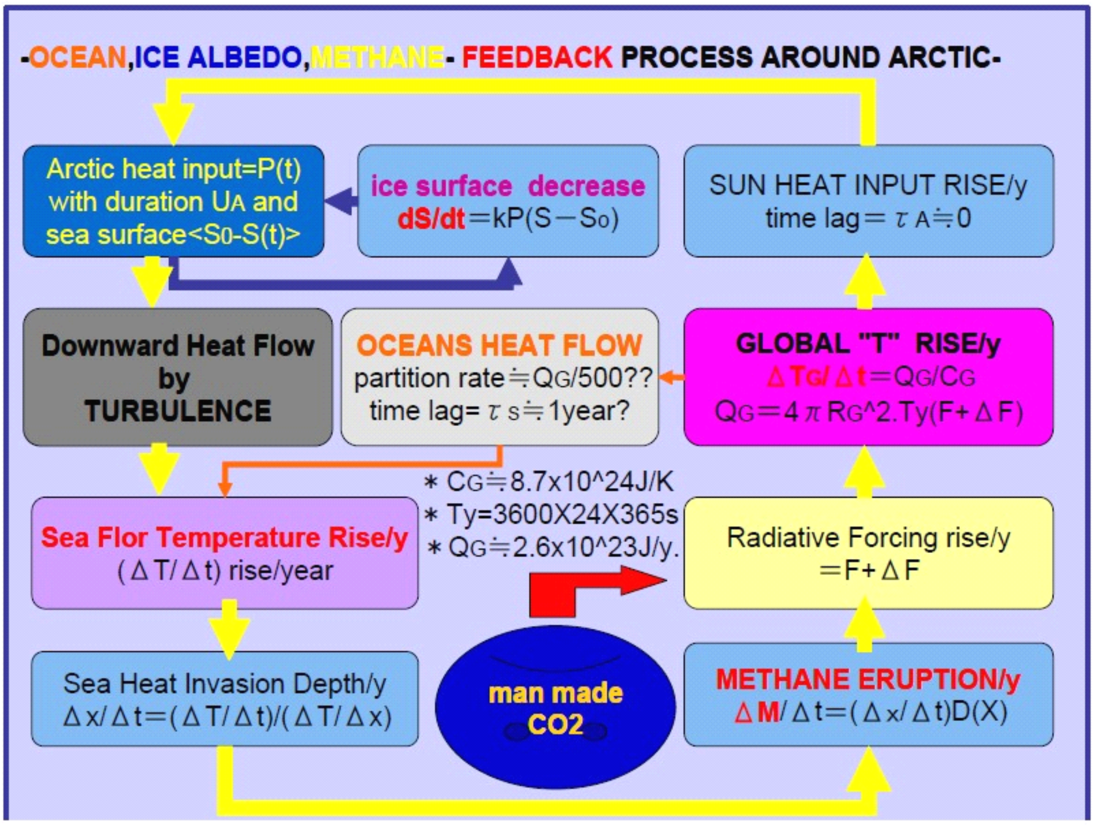
General Feedback MODEL 2013/5/23

"result enhances cause,then the sytem become unstable to monotonously increase or decrease(**positive feedback**)".This common sense could be proved by math in general.

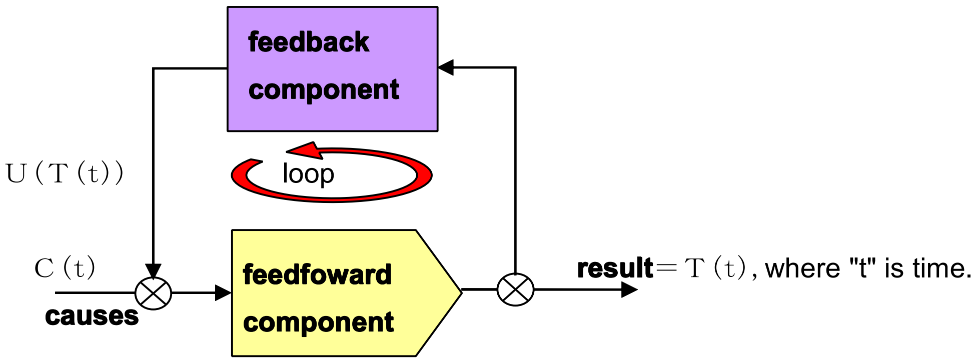
(1)**feedback:**

Generally to tell,**climate system** is composed from many componets such as **heat sources**(sun heat),**heat sinkers**(space,atmosphere with clouds, ocean with ice and evapolating sea surface,sea flor and land, and **chemical components**(matter) and **heat flows**(energy) by ocean current,atmospheric flow,radiation,...}.Those are connecting by matter and heat flows in many componets.Sometimes,those network connections become **loops** which establish so called feedback.

＊note also **economy system** has feedback loop as that income decreasing causes no buying which acclelate economy more downturn to cause more income decreasing.



Then output result $T(t)$-itself is to become cause to dominate trend $= dT/dt$, whic is called **feedback** process.This proces sometime becomes unstable toward catastrophe.



$dT/dt = F(T(t); C(t))$.　　　　″instant response"

dT/dt means T increasing(decreasing) rate/ unit time,whic is a trend indicator, and is dominated by right term = F(cause).If it is positive,the trend increasing,if negative, the trend is decreasing.

$dT/dt = \int_{-\infty}^{t} du\, F(t; T(u); C(u))$.　″historical response = past storage effect"

$d^2T/dt^2 = F(t; T(t); C(t))$.

(2)**general non-linear feedback**:

Taylor expansion of $F(T(t); C(t))$ is as follows.

$$F(T;C) = F(T_0;T_0) + (T-T_0)\,\partial F/\partial T_0 + (C-C_0)\,\partial F/\partial C_0$$
$$+ \tfrac{1}{2}(T-T_0)^2\,\partial^2 F/\partial T_0^2 + \tfrac{1}{2}(C-C_0)^2\,\partial^2 F/\partial C_0^2 + \tfrac{1}{2}(T-T_0)(C-C_0)\langle\partial F/\partial C_0\rangle\langle\partial F/\partial T_0\rangle$$
$$+ \{\text{higher orders}\}.$$

As is seen,right terms become non-linear for $T(t)$,which becomes difficult to treat analytical way.However,employing even only linear term sometime gives useful insight on system.

(3)**linear feedback**:

$$dT/dt = F(T_0;C_0) + (T(t)-T_0)\,\partial F/\partial T_0 + (C(t)-C_0)\,\partial F/\partial C_0$$
$$= \langle\partial F/\partial T_0\rangle T(t) + F(T_0;C_0) + (C(t)-C_0)\,\partial F/\partial C_0 - \langle\partial F/\partial T_0\rangle T_0 \equiv -kT(t) + D(C(t))$$

$dT/dt + k(t)T = D(t)$. ..... ″Trend is dominated by ownself $= T$ and external factor $= D$".

$$d(T\exp(\textstyle\int_{-\infty}^{t} du.\,k))/dt = \exp(\textstyle\int_{-\infty}^{t} duk.)\,D(t).$$
$$T(t) = \exp(-\textstyle\int_{-\infty}^{t} dv.\,k)\textstyle\int_{-\infty}^{t} du.\,\exp(\textstyle\int_{-\infty}^{u} dv.\,k)\,D(u) + A\exp(-\textstyle\int_{-\infty}^{t} duk).$$
$$= \textstyle\int_{-\infty}^{t} du\,\{\exp[-\textstyle\int_{u}^{t} dv.\,k(v)].\,D(u)\} + A\exp(-\textstyle\int_{-\infty}^{t} du.\,k(u)).$$

(a)if $k \geqq 0$, system become stable as $t \to \infty$.

$\exp(-\int_{-\infty}^{t} du.\,k(u)) \to 0$,

long past history of D(u) become no effect for now.

$\exp\langle -\int_{u}^{t} dv.\,k(v) \rangle D(u) \rangle \to 0.$ $T(t) \fallingdotseq \int_{t-(\text{a little time})}^{t} du.\,D(u)$

(b)if $k < 0$, system become unstable as $t \to \infty$.

$\exp(-\int_{-\infty}^{t} du.\,k(u)) \to \infty$ means something catastrophic in general.

(c)$k < 0$ is called positive feedback,which means "*result enhances cause*".

(4)***"result*** T ***enhances cause*** F ***"***.

$k \equiv -\partial F/\partial T_0$ negative measn positive $\partial F/\partial T_0 > 0$

This is nothing,but that *"result* T *enhances cause* F *"*.

(5)As for non-linear terms.

if $\partial^2 F/\partial T_0^2 > 0, T-T_0 > 0$ causes unstable due to $+\frac{1}{2}(T-T_0)^2 \partial^2 F/\partial T_0^2 > 0.$

if $\partial^2 F/\partial T_0^2 > 0, T-T_0 < 0$ causes stable due to $+\frac{1}{2}(T-T_0)^2 \partial^2 F/\partial T_0^2 > 0.$

(6)**saturation point:**

If variable such as T has **finite saturation point**,system unstability would reach there at last. For example,Arctic ice extent is finite,so those must be zero time someday,if we do not Arctic cooling.Then the sea water monotonously would have been being warmed to cause Methane Catastrophe at last.Then the methane amount is also finite to stop temperature rise of fireball earth someday. Uhh,........certainly earth itself would be survive,but almost life on the earth would be wiped out. It is outrageous rebel against God the creator by stupid and arrogant mankind.

APPENDIX_4 Arctic Cooling Geo-engineering.

(1)**How to cool the Arctic** by John Nissen. December 2011.

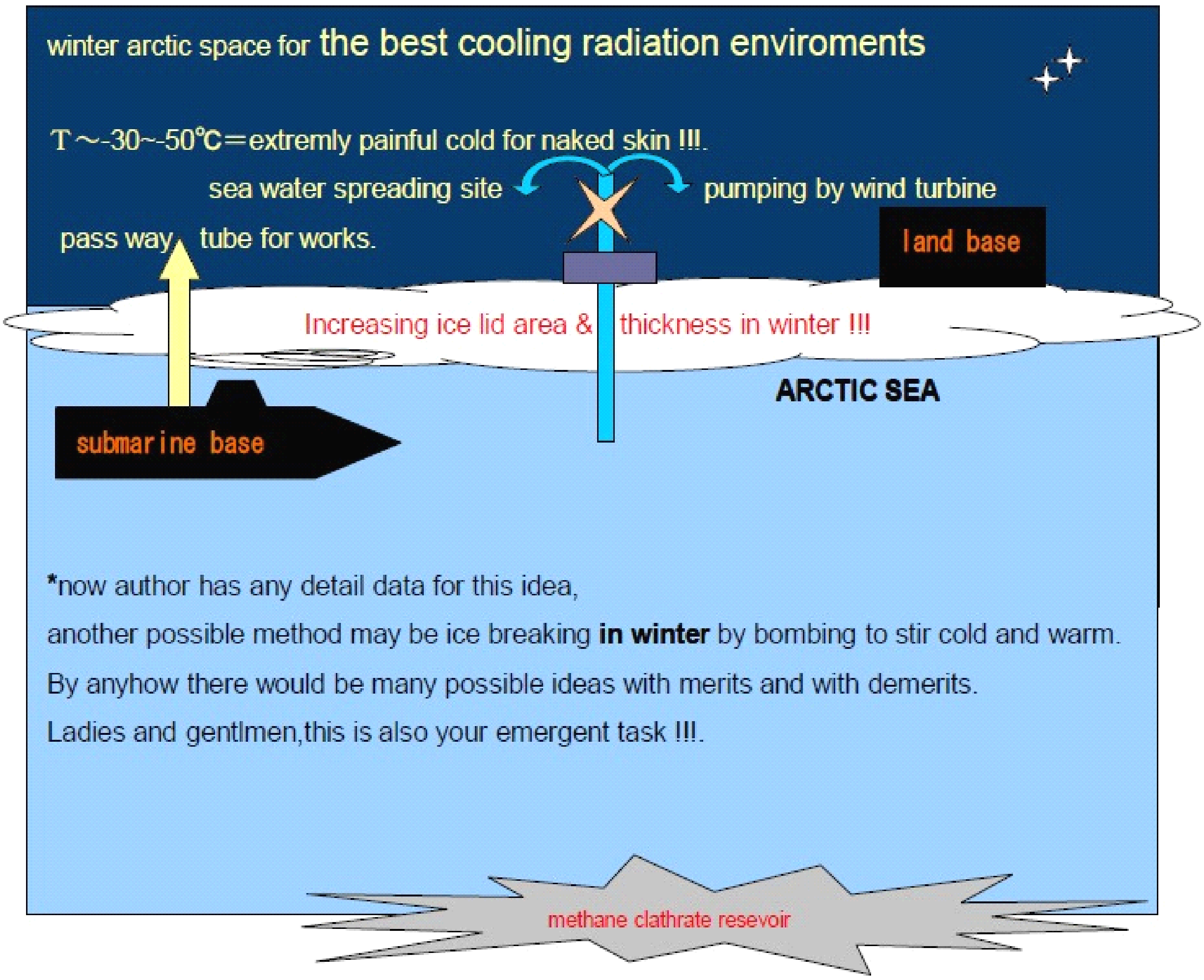
http://arctic-news.blogspot.jp/p/how-to-cool-arctic.html

Which is the most viable method of emergency cooling of the Arctic to prevent runaway global heating? There are several approaches for cooling the Arctic and saving the sea ice, some involving the **reduction of heat flux into the Arctic** and others involving the **increase in heat flux out.**

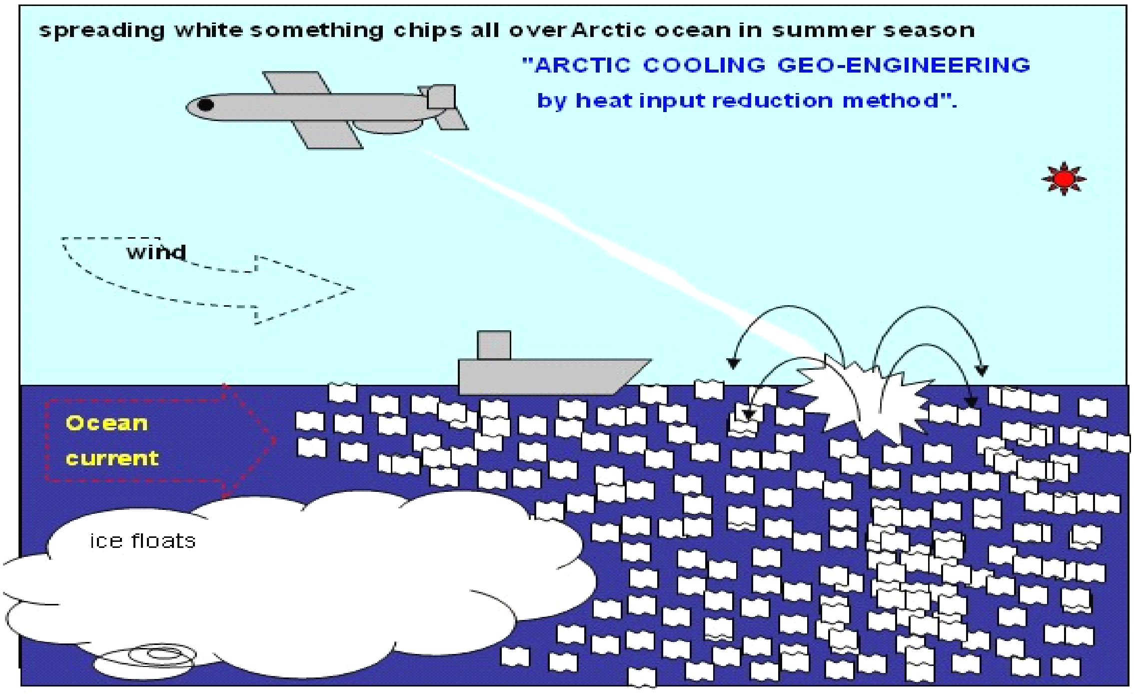
(2)**sea water spreading on ice lid in winter to increase heat outgoing & ice thickness.**

Arctic geoengineering From Wikipedia, the free encyclopedia

(b)Heat input rise by **Arctic ice albedo feedback** become difficult to stop as time goes on. A possible counter measure is massive scale of **man making ice cover** by such sea water spreading over ice surface in cold winter by huge amount pumping sites.



⑶**spreading white something chips all over Arctic ocean in summer season**



white something chips must be very light,durable,not harm, and low cost.,but

⒜highly insolation reflective on sea surface

⒝tendency wide spreading,but not gathering ,overlapping,and not floating(impossible ?).

⒞mass productive,recyling-able ,not harmful,

⒟extensible on sea surface and durable in freezing in winter ice seasons.

⒠massively transportable by spreading plane,or ship.

⒡**Do chemists,or someone know what it is ???.**

⒢The decisive difficulty on the Arctic-Geoengineering is **outrageous covering area extent of** $S_A = 4.7 \times 10^{12} m^2$.The actual dangerous area might be about $S_A/100 = 4.7 \times 10^{10} m^2 = (217 km)^2$. Even though,it is too wide to implement.**But it could be be accomplished by global cooperation with massive nations powers.**

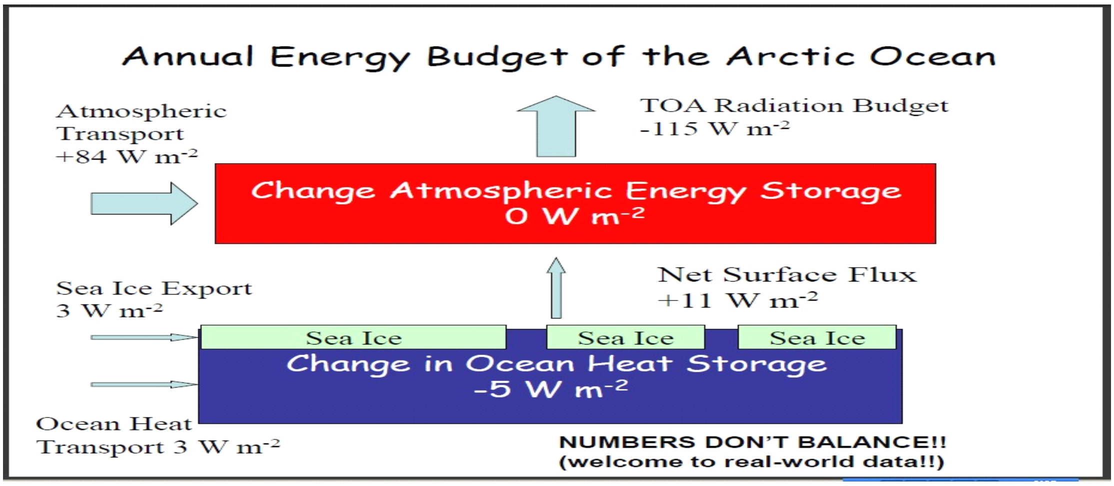
⒣**Thereby,the best strategy is quick starting of the project before full ice vanishing.**

⒤Note also **global cooling engineering** must be pararelly implemented not to input heat into Arctic by anymore .Then **OCEANs COOLING TECHNOLOGY** by stiring surface sea water with deeper cooler sea water is decisive !!......... **OPERATION EXODUS.**

APPENDIX_5:ANNUAL HEAT BUDGET in ARCTIC

(1)**Annual heat budget in Arctic Oceans.**

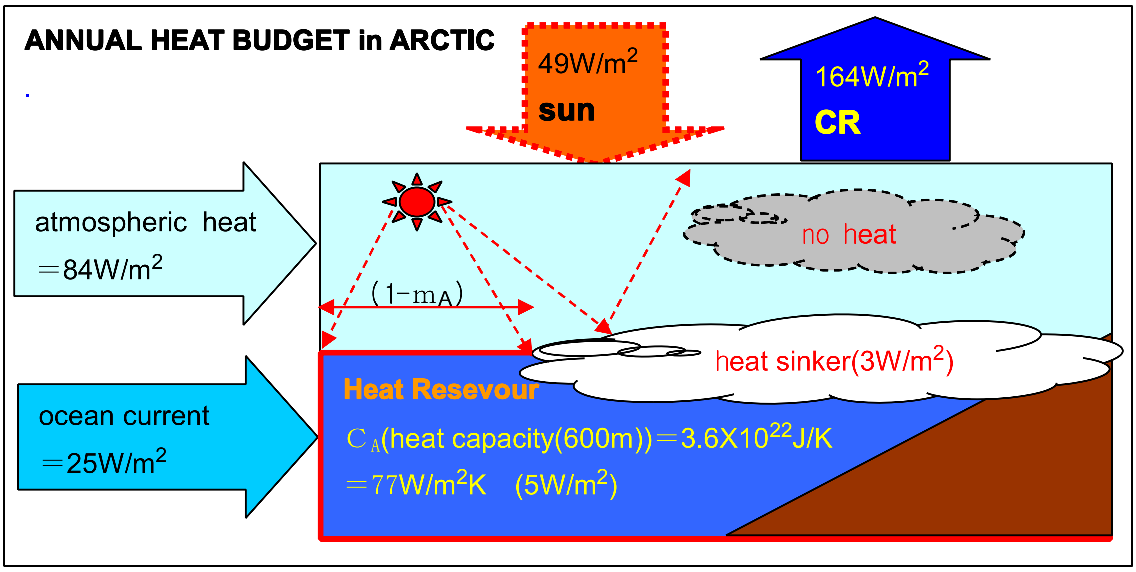
http://www.colorado.edu/geography/class_homepages/geog_4271_f12/lectures/notes_2.pdf



(2)**Atmospheric Heat Input**＝$84W/m^2$. **Ocean Heat Input**＝$37W/m^2$？？.

R(273)＝$193W/m^2$？ summer ;R(245)＝$135W/m^2$? winter

R(annual)＝$115W/m^2$.(P15/35)＝$164W/m^2$－$49W/m^2$



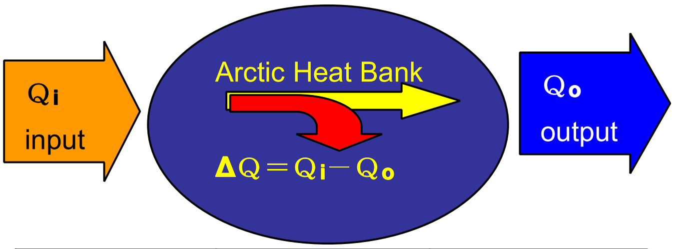
Thermal Irreversible Process in Arctic are follows.

＊sea ice vanishing by melting and export flows＝$3W/m^2$.

＊sea water warming＝$3W/m^2$<nothing validity,but a guessing>.

＊melting zundra and ice methane＝$2W/m^2$<nothing validity,but a guessing>.

Heat Budget in Arctic{HEAT DEBT＝incoming heat－outgoing one}.



inputs	output	DEBT(W/m²)
Q_i ≒172	Q_o ≒164	ΔQ ＝Q_i－Q_o ≒3＋5
Solar heat Input=Q_S ≒49	**Cooling radiation=Q_R** ≒49+115＝164	**3**＝annual ice decreasing,
Atomosphe-ric flow=Q_A ≒84		**5**＝annual heat input into ocean
Ocean current=Q_C ≒39	It 's irresponsible not to disclose the exact data !!!	

⑴Heat is an energy,so the **total amount** never increase or decrease,but is conserved. This fact is entirely analogous to money account(debt＝incoming－outgoing),But note that **heat surplus is bad debt** in heat account.It is *upside down* in heat account.Then debt heat is to trigger fatal MC bomb(bankraptcty)in Arctic ocean sea flor and zundra in land.Now let's begin to survey **the heat account in Arctic**,but which has been rather indefinite in author's survwy.

*__Blue is Colorado data__,while **brown is author's guessing without varidity**.

Now Q_S≒**49**W/m² would go toward 156W/m² with deadly debt heat **Δ**Q＞**57**W/m² <see **[４]** :⑶>,which is fatal,unless emergent **Arctic Cooling Geo-Eingineering !!!**.