How to Make Clouds for intercepting solar heat in Arctic. 2014/6/16,26

Hazardous solar heat input into Arctic can be intercepted by brightening cloud. A cloud is made from massive stray small dust particles(**Cloud Concentration Nuclei**＝**CCN**).Method **sea water spraying**(S.Salter(UK)) into atmosphere may be realizable,effective and relatively cheap.Sea water(**35Kg salt in 965kg water**)tastes very salty,while rain drop from cloud never tastes salty(3.5Kg＞salt?).Author assume 1ton sea water spraying could make cloud of 10ton water.For an example,water mass of **10Kmx10kmx1km cloud** is about 30000 ton. 3000 ton sea water spray could be accomplished in **1hour by 100Kw turbine**. **Cloud Engineering** is unstable due to random wind,however cheap cost could overcome the defect by massive setting the unit.This is the emergent problem of mankind destiny.

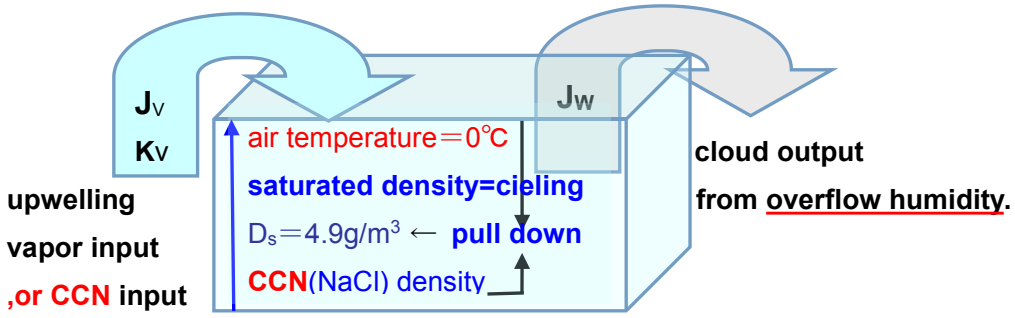
[１] : Cloud is made from overflow humidity in a saturated air volume.

The water circulation budget accounting:

Water flow input＝**water output as cloud(overflow humidity)**

＋**water reserve increase** toward the **density saturation**.

Note that once over the saturation density⑵,which cause **could** from overflow humidity. **Aerosol**⑸such as “NaCl” particles(**cloud condensation nuclei≡CCN**) can **decrease saturation density toward causing cloud from overflow humidity.**



dry air/m^3 is also a finite volume **vessel of humidity**（**saturation density,**D_s＝4.9g/m^3), Then over input of humidity generate cloud,or CCN input cause decrease Ds which also can generate cloud from **overflow humidity**.

⑵**Water Vapor Saturation Density(without CCN)of Air:**

http://ja.wikipedia.org/wiki/%E9%A3%BD%E5%92%8C%E6%B0%B4%E8%92%B8%E6%B0%97%E9%87%8F

-30	-20	-10	**0℃**	5	10	15	20	30
0.45	1.07	2.4	4.9g/m^3	6.8	9.4	12.8	17.3	30.4

⑶**liquid water content in unit volume cloud(LWC) :**

This is the measure of of water mass in a cloud in a unit volume of dry air.

http://en.wikipedia.org/wiki/Liquid_water_content

Cloud Type	LWC (g/m^3)
cirrus	**.03**
fog	**.05**
stratus	**.25-.30**
cumulus	**.25-.30**
stratocumulus	**.45**

Note water output for cloud become less suc as **0.25-0.30**g/m^3.This is about **10%** or less of saturation density.Therefore **CCN inputting** could make cloud for ordinal case.

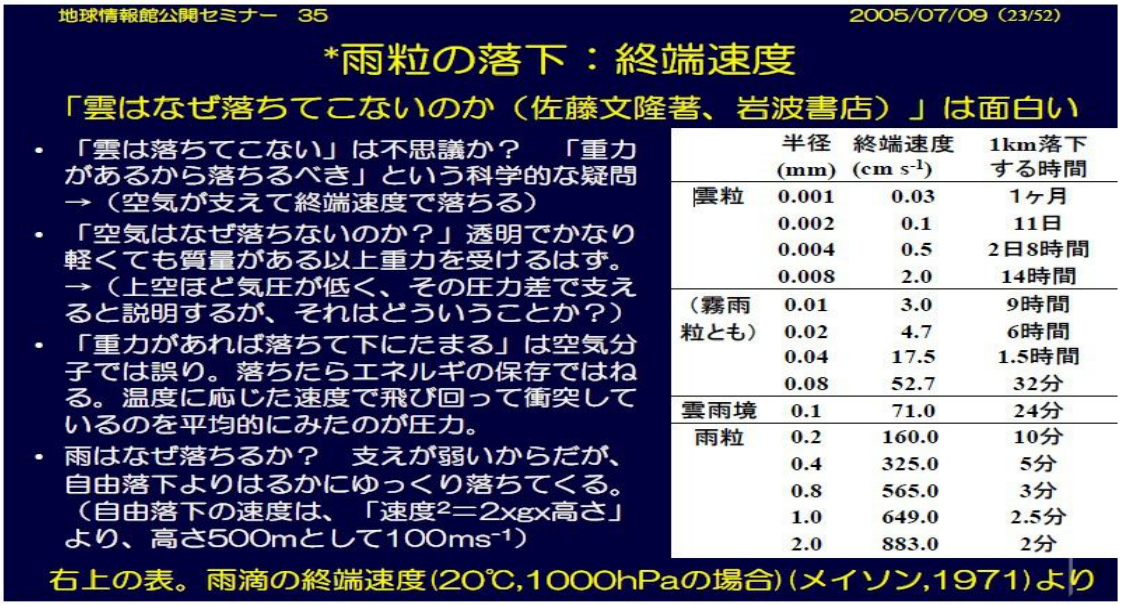
example calculation)

cloud volume V＝10km×10km×1km

water mas M＝V×**LWC**＝3x10^{10}g＝30000 ton

⑷**Droplet size and the life time of cloud ?.**

https://www.jamstec.go.jp/frcgc/jp/sympo/2005/seminar/35/YES_Seminar_Jul09.pdf



For example,we take droplet radius＝0.002mm(0.1cm/s)which take 11days to drop 1km down.By such reason we assume life time of clouds(without becoming rain) is about few days to a week ??.

Reference_1

雲・エアロゾルと気候**<Cloud,aerosol and climate>**

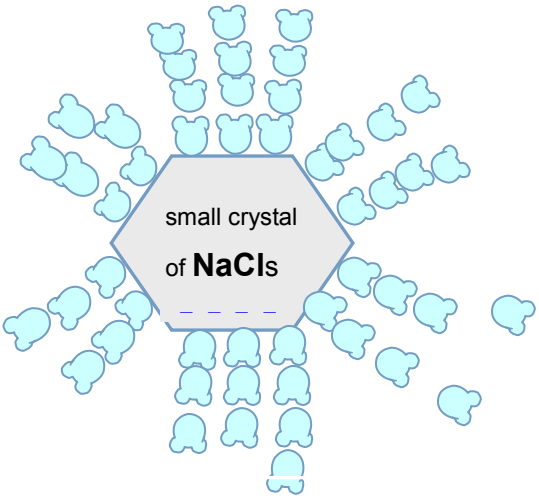
http://www.chart.co.jp/subject/rika/scnet/31/sc31-4.pdf

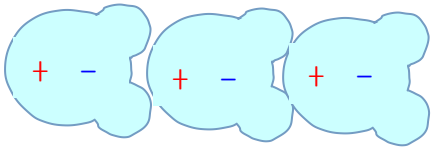
雲とそのモデリング**<Cloud Modeling >** 基本の仕組みから気候モデルでの取り扱いまで

https://www.jamstec.go.jp/frcgc/jp/sympo/2005/seminar/35/YES_Seminar_Jul09.pdf

(5)**The role of CCN<chemical bonding of generating massive H2Os with a CCN>:**

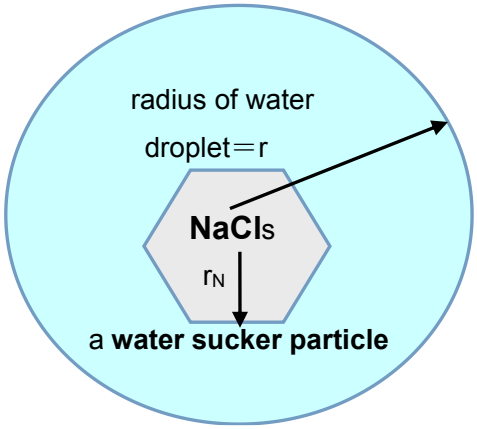
<<water droplet formalization by sucking massive H20s with CCNs>>.



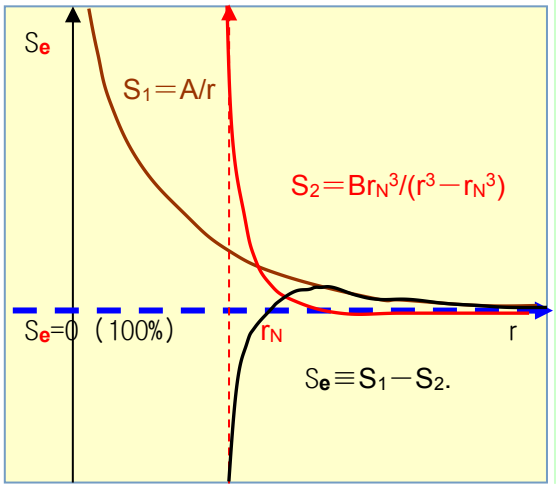


H20 is an **electrical dipole** which reacts with ion of **CCN**(NaCl).NaCl is conductive solid of which surface yields **electrons**(by static induction)to make bonding with +charged H20s.As the consequence,CCNs react to form **water droplet** of visible big size (1～10 μ m)of cloud.

Note these are authors guessing, but not assured by academic.



r～r_N ,so above figure is not actual



CCN can generate cloud under the saturation density of S_e＜0 !!!!!.

How to determine radius=r of droplet.

This is **droplet surface growing equation**.

$(d/dt)<4\pi r^2>=k\{S_e-A/r+Br_N^3/(r^3-r_N^3)$ ¥)

¥)author has not seen the proof,really OK ?!.

S_e≡excess degree of saturation (＝retative humidity－1.0). {A,B;k＞0} are something constant due to CCN property.

$S_e=A/r-Br_N^3/(r^3-r_N^3)$. ←$(d/dt)<4\pi r^2>=0$.

$0=\partial S_e/\partial r=-A/r^2+3r^2Br_N^3/(r^3-r_N^3)^2$,

→→ $r=r(r_N,A,B)$.

http://www.chart.co.jp/subject/rika/scnet/31/sc31-4.pdf

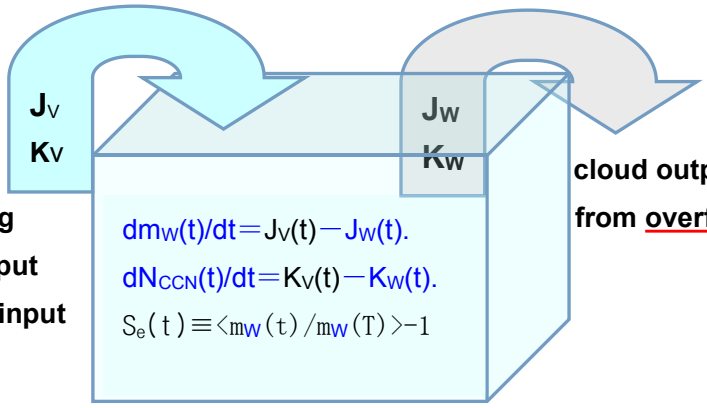
Especiall note that r～r_N where $S_2=Br_N^3/(r^3-r_N^3)=\infty$. That is, cloud can be generatted under the saturation density. !!!

Then S_e is negative(**under saturation**)!!!.

This is a chemical reaction forcing to condense water with CCN.

⑹**How much cloud can be generated by the density $N_{CCN}(t)$ of CCN.**

{$m_W(t)$,$N_{CCN}(t)$,$S_e(t)$,r(S_e), , , ,}are unknown variables determined by the equations.



upwelling vapor input ,or CCN input

cloud output from overflow humidity.

Ⅰ：$dm_W(t)/dt＝J_V(t)－J_W(t)$.

water vapor component change/unit time

＝Input humidity mass flow into unit air volume(box)

－output cloud mass flow into unit air volume(box)

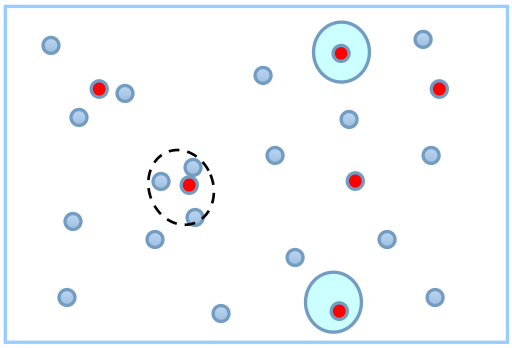
Ⅱ：$dN_{CCN}(t)/dt＝K_V(t)－K_W(t)$

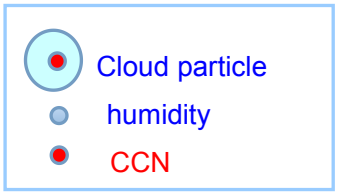
＝external input flow

－internal consuming rate(reaction rate).

＊$K_W(t)$.≡reaction flow density

＝$<m_W(t)/m_W(T)>\times N_{CCN}$. ??





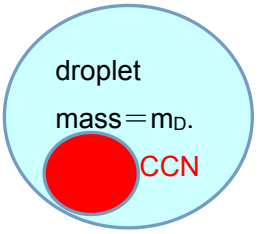
Ⅲ：$S_e(t)≡<m_W(t)/m_W(T)>－1$.

excess saturation density＝relative humidity－1.

$m_W(T)$≡saturation water mass/unit volume at Temperature＝T.

Ⅳ：cloud generating/sec is water mass combined with $K_W(t)$.

$J_W(t)＝m_D(S_e)K_W(t)$.....<m_D＝average droplet water mass>



Ⅴ：vapor amount changed into cloud at S_e/unit CCN.

$m_D(S_e)＝\rho_w 4\pi/3<r(S_e)^3－r_N^3>$.

r_N≡radius of CCN.

r≡radius of water droplet generated at S_e

Ⅵ：$0＝\partial S_e/\partial r＝-A/r^2+3r^2Br_N^3/(r^3－r_N^3)^2 \rightarrow r＝r(r_N,A,B)$.

droplet radius at minimizing S_e at time when droplet growing halt

Ⅶ：$S_e＝A/r－Br_N^3/(r^3－r_N^3)$. ← $r＝r(r_N,A,B)$.these are constant of CCN.

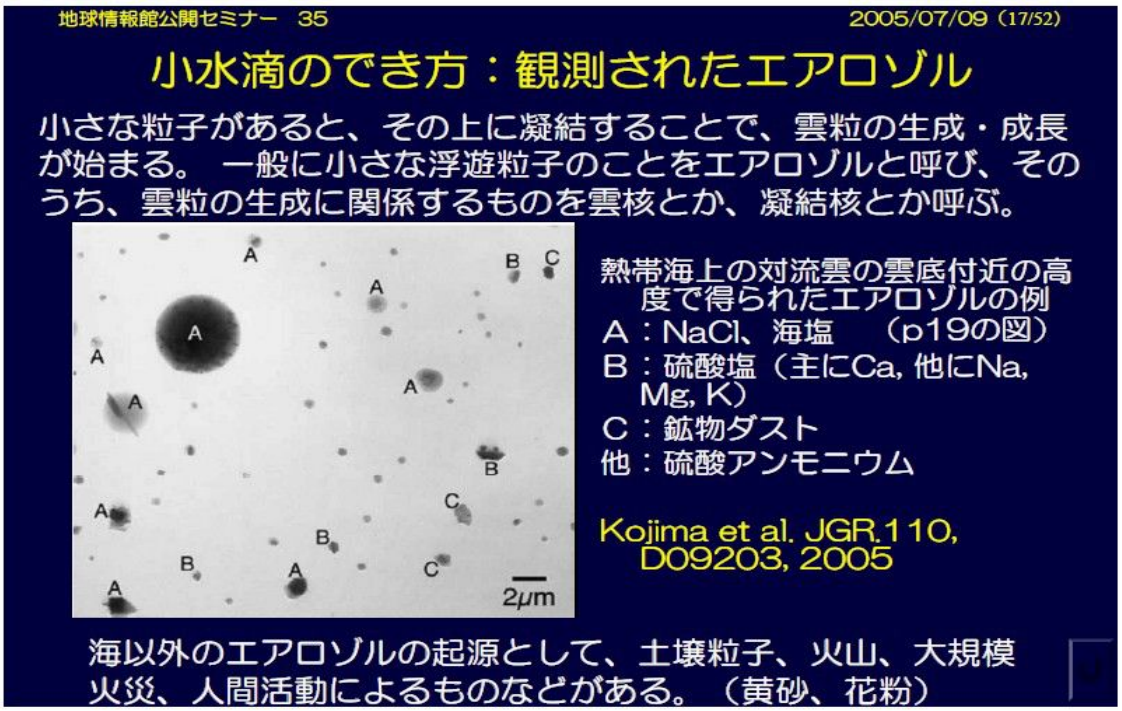
The Stationary solution gives relation as follows. $J_W(t).＝J_V(t)$,,.$K_W(t).＝K_V(t)$

$J_W(t)＝m_D(S_e)K_W(t)＝m_D(S_e)K_V(t)$.

Input amount of CCN/unit time,unit volume determine output cloud density flow. Note ⑹ may be not complete.

In actuality, stationary flow may be nothing. Fulll water absorbtion by CCN would terminate reactions.

(7)Observed aerosol particles.A＝NaCl diameter about＝0.2～4μm.



https://www.jamstec.go.jp/frcgc/jp/sympo/2005/seminar/35/YES_Seminar_Jul09.pdf

(8)**sea water spraying＜10 times gain strategy≡10TGS＞.**

Guessing solution on Ⅳ:$J_W(t)=m_P(S_e)K_W(t)$<how much a CCN can make water of cloud>

As everyone know well,sea water taste too salty,while **rain into sea surface** may be with much CCN of salt,however those tastes little salty.Maybe sea water upwelling into atmosphere Is to return with being more diluted.Therefore sea water spraying in order to make cloud may be **almost CCN(NaCl) spraying**,but that of humidity(water).

＊sea water salt density：salt＝35K g /1000Kg sea water(965Kg pure water)..
＊solid salt density＝2170Kg/m^3.
＊How much weight of 1 μm diameter salt＝1.1×10^{-15}Kg.
＊How much water can 1 μm diameter salt suck ?＝1.1×10^{-15}Kg×(965/35)×10?

In this way author very coarsely guess that **1ton sea water spraying** could generate **cloud of 10 ton water or more**. .....10 times gain strategy≡10TGP.

Then author don't know well about how to lift up sea water humidity into higher sky ??

Another care may be unstable dependency on winds especially in Arctic Ocean.

[２] : Device Design.

The problem is how to design **upwelling input** with **CCN**. **Stephen Salter**(UK) designed **sea water spray turbine** by using energy of wind and wave powers.Now author could not reach the full understanding,so comment here is very coarse calculation.

Reference_2

＊SPRAY TURBINES TO INCREASE RAIN BY ENHANCED EVAPORATION FROM THE SEA、Stephen Salter

http://www.mech.ed.ac.uk/research/wavepower/rain%20making/shs%20rain%20paper%20Feb.pdf

http://en.wikipedia.org/wiki/Cloud_reflectivity_modification

http://rsta.royalsocietypublishing.org/content/366/1882/3989.full

Stephen Slater(UK) is main leader.Power is gained from wind and sea wave.

Call for Arctic geoengineering as soon as possible ,12 December 2011

http://www.newscientist.com/article/dn21275-call-for-arctic-geoengineering-as-soon-as-possible.html#.U5amc3J_sqM

We must cool the Arctic before it's too late29th April 2014

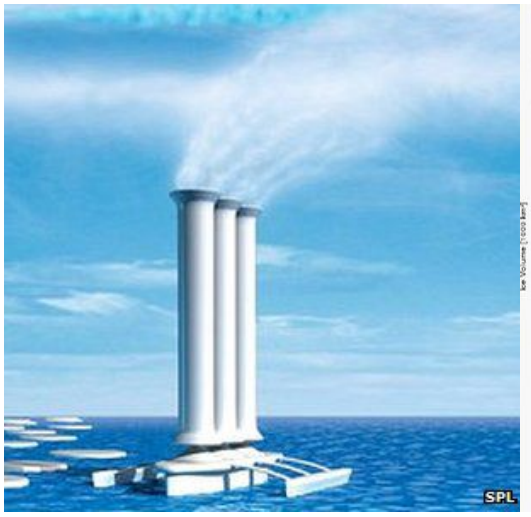
http://www.theecologist.org/blogs_and_comments/commentators/2370255/we_must_cool_the_arctic_before_its_too_late.html

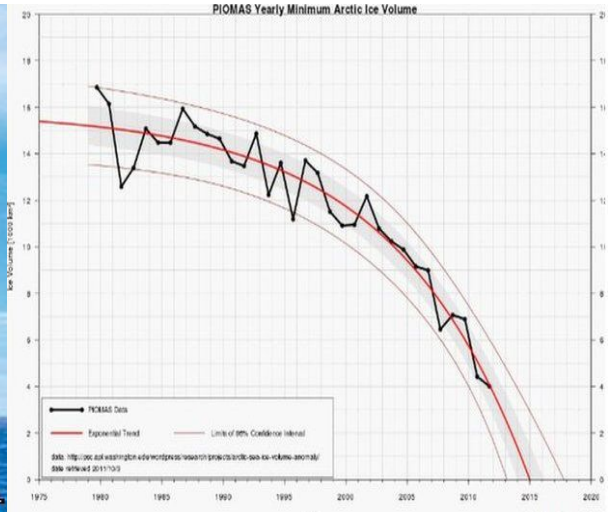
Geoengineering May Be Our Best Chance to Save Sea Ice

http://www.scientificamerican.com/article/geoengineering-last-chance-save-sea-ice/

Climate 'tech fixes' urged for Arctic methane

http://www.bbc.co.uk/news/science-environment-17400804





He has not so far embarked on a full costing of the land-based towers, but suggests £200,000 as a ballpark figure.Depending on the size and location, Prof Salter said that in the order of 100 towers would be needed to counteract Arctic warming.

-A sample coarse calculation of estimating size of engineering scale-

⑴**Power of spray turbine W＝100KW.**

Energy is wind or sea wave one.

⑵**Work for lifting water mass＝m with height＝h (10m)at spraying nozzle.**

W＝mgh。→ m＝W/gh＝1020Kg/s

⑶→**water mass M for cloud generation**＝V×**LWC<[１]**⑸>＝3x10^{10}g＝30000 ton

cloud volume V＝10km×10km×1km.

Now we apply 10 times gain strategy≡10TGP.

Time for 0.1X30000 ton spraying＝3000 ton/1020Kg/s＝2940s＝**0.8**hours.

Cloud area by 1week spraying＝30×7×10km×10km×1km＝21000(Km)^2×1km.

⑷**80° Arctic areas**＝3.9x10^{12}m^2.

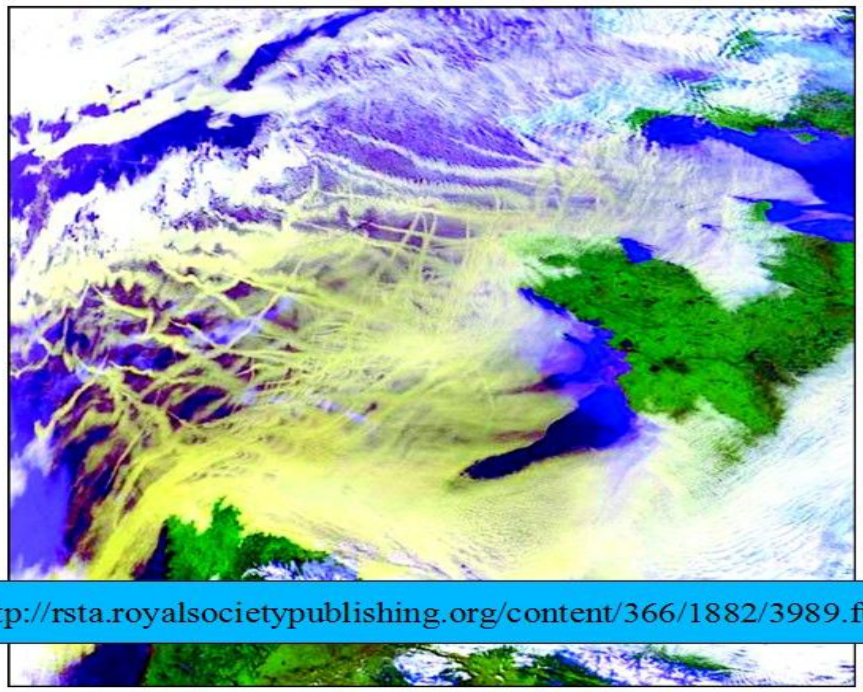
⑸number of spraying unit＝3.9x10^{12}m^2/21000(Km)^2＝190.

⑹unit cost＝200000$？？, total cost＝40 m$.??

＊**supplement:Origin of cloud engineering??!!**

Ships(with chimney emitting soot)trajectory is with that of cloud.Following is the satelite photograph.Sea water spraying could be similar with those.

Demonstration of the Twomey effect.



http://rsta.royalsocietypublishing.org/content/366/1882/3989.full#ref-19

Salter S et al. Phil. Trans. R. Soc. A 2008;366:3989-4006

［3］：**Building Thicker Sea Ice in very cold Arctic Winter Season**(2014/6/26)**.**

This is **primitive and exact method** to **increase sea ice thickness** by sea water spreading in very cold Arctic winter season in order to prevent solar heat input.However covering area is narrow than cloud making method.Thereby the cost would be higher.

⑴**References on Arctic geo-engineering//Building thicker sea ice.**

http://en.wikipedia.org/wiki/Arctic_geoengineering

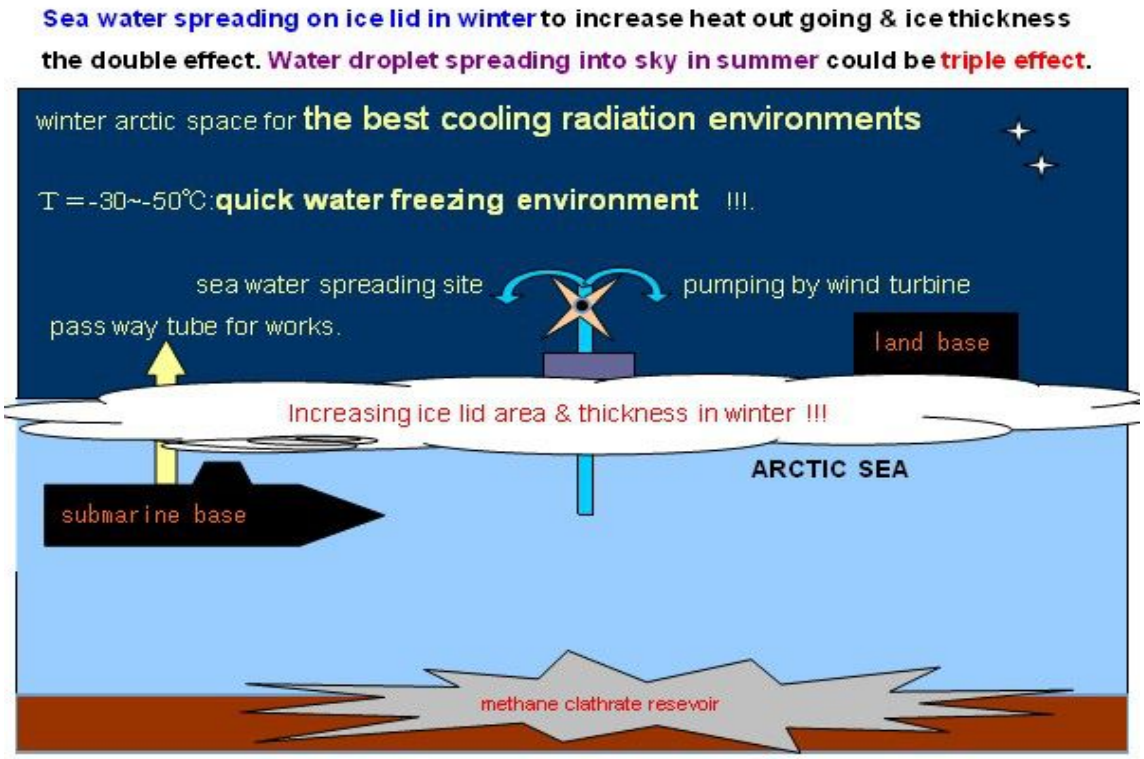
9) Watts, Robert G. (1997). "Cryospheric processes" (Digitized online by Googlebooks). *Engineering Response to Global Climate Change: Planning a Research and Development Agenda*. CRC Press. p. 419. ISBN 978-1-56670-234-8. Retrieved 2009-01-02.

10)**Jump up^** "Duct Tape Methods to Save the Earth: Re-Ice the Arctic". Popular Science. Retrieved 4 March 2009.

Jump up^ S. Zhou and P. C. Flynn (2005). "Geoengineering Downwelling Ocean Currents: A Cost Assessment". *Climatic Change* **71** (1-2): 203–220. doi:10.1007/s10584-005-5933-0.

⑵**How much can we make ice by sea water spreading in winter-.**

Following is primitive estimation by author.



(a)**Recent years trend of Arctic ice volume decline**≒1000Km^3/year

Arctic Sea Ice Volume Anomaly(PIOMAS)

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

Now we must emergently compensate year's loss of **V**≒1000Km^3/year.

If we fail,decline trend become more and more toward increasing difficulty of the operation.

(b)**mass of Arctic ice** with sea ice mass density＝917Kg/m^3,

M＝1000Km^3×917Kg/m^3＝9.2x10^{14}Kg＝9.2x10^{11}ton..

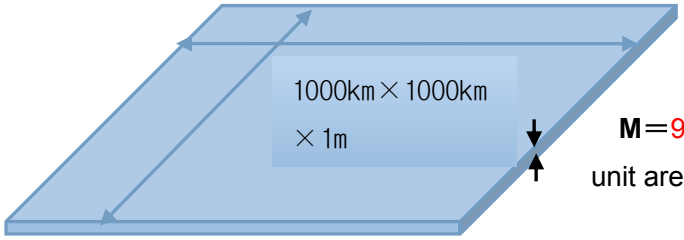
(c)**m**＝total mass by a water pump：100ton/60sec×(3600×24×120<winter days>)

＝1.7x10^{7}ton

＊pumping power＝Mgh/T＝100,000kg×9.8m/s^2×10m/60s＝**160KW**(?2014/6/12 revised).

(d)N(cooler units #)＝M/m＝9.2x10^{11}t/1.7x10^{7}t＝54,000. N＝54,000.

"N" is outrageous scale,however none could tell it impossible.If unit cost of the implementation is 500,000$？,the coarse estimated total cost is about 2.7T$.



M＝9.2x10^{11}ton..

unit area＝(1000km)^2/54000＝20km^2.