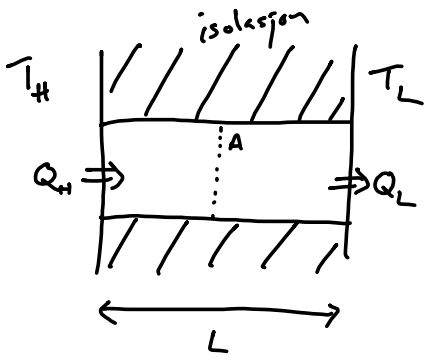
Hvorfor fryser vi?

Varmeledning



$Q_H = Q_L$

Varmestrøm = $\frac{\text{varme}}{\text{tid}}$

$H = \frac{Q}{t} = \lambda A \frac{\Delta T}{L}$ $\quad \Delta T = T_H - T_L$

↑ varmeledningsevnen

$[H] = \frac{J}{s} = W$

$[\lambda] = \frac{W}{mK}$

varmefluks = $\frac{\text{varmestrøm}}{\text{areal}}$

$\phi_q = \lambda \frac{\Delta T}{L}$

Varmeledningsevne for noen stoffer $\frac{\lambda}{W/(Km)}$

Diamant	2000
Kopper	400
Aluminium	240
Rustfritt stål	17
Betong	1,7
Glass	0,80
Vann	0,60
Tre (gran furu)	0,12
Sponplate	0,12
Isopor	0,08
Mineralull	0,036–0,060
Skumplast	0,036–0,060
Luft	0,026

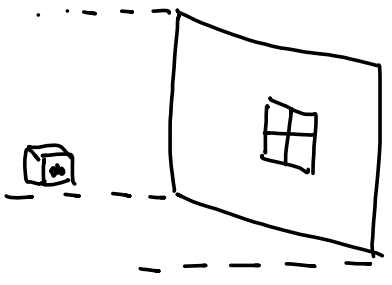
Hva vil du helst sette deg på?

U-verdi

$U = \frac{\lambda}{L}$

$[U] = \frac{W/mK}{m} = \frac{W}{m^2 K}$

$H = UA\Delta T$



vegg: $A = 20\,m^2$, $U = 0{,}60\ W/m^2K$

vindu: $A = 6{,}0\,m^2$, $U = 2{,}5\ W/m^2K$

$T_{inne} = 22°C$

$T_{ute} = 8°C$

$H = ?$

$H_{vegg} = UA\Delta T = 360\,W$

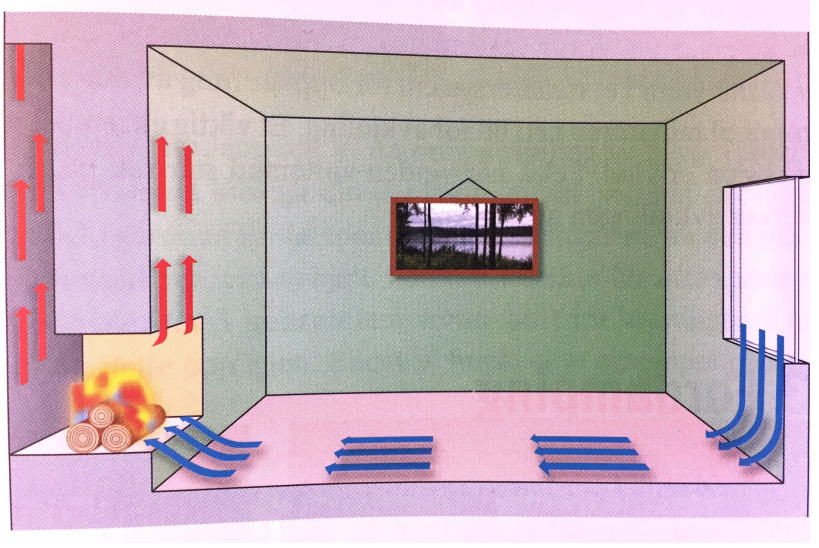
$H_{vindu} = 450\,W$

$Q_{ovn} = H_{vegg} + H_{vindu} = 810\,W$

Konstant T:

$Q_{inn} = Q_{ut}$

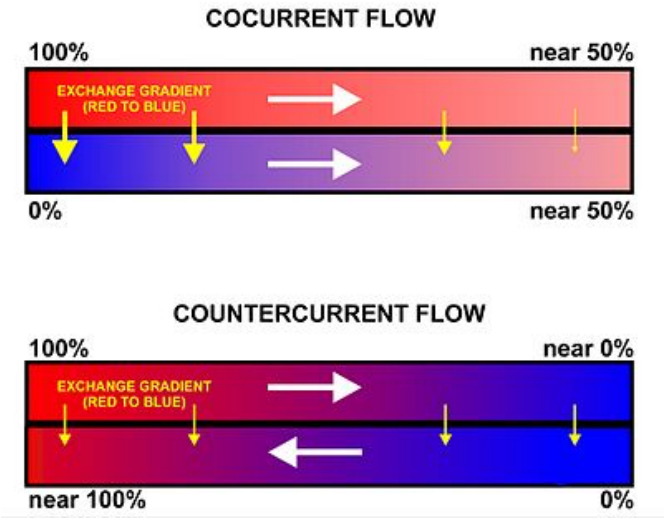
Konveksjon

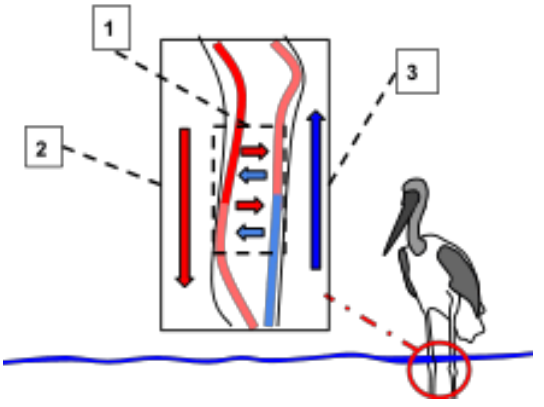


$pV = nRT$

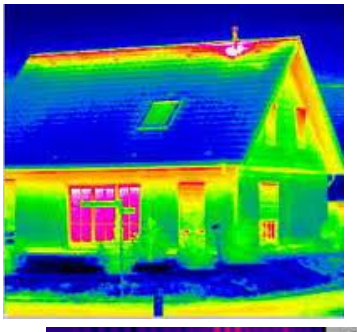
$T\downarrow \Rightarrow V\downarrow$

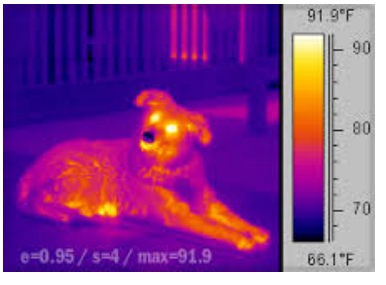
Varmevekslere



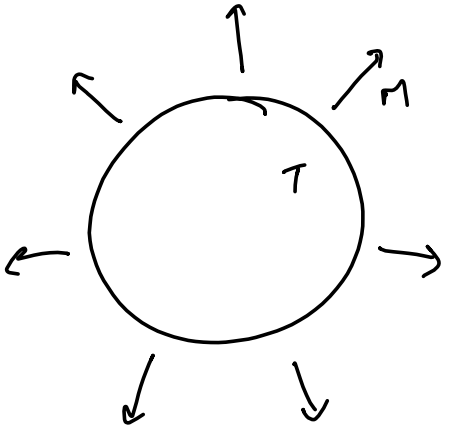


Varmestråling





Strålingstetthet



Utstrålingstetthet

$$M = \frac{P}{A} \qquad [M] = \frac{W}{m^2}$$

Innstrålingstetthet

$$E = \frac{P}{A}$$

Stefan-Boltzmanns lov

$$M = \sigma T^4$$

σ: s-b konstanten

$\sigma = 5{,}67 \cdot 10^{-8}\ W/m^2K^4$

Gjelder svarte legemer

Ikke-svarte legemer:

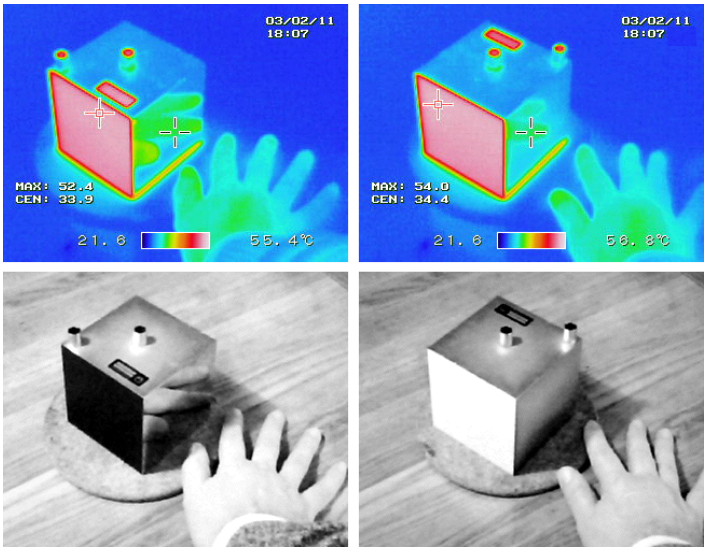
$$M = \sigma \varepsilon T^4$$

ε: emissivitet

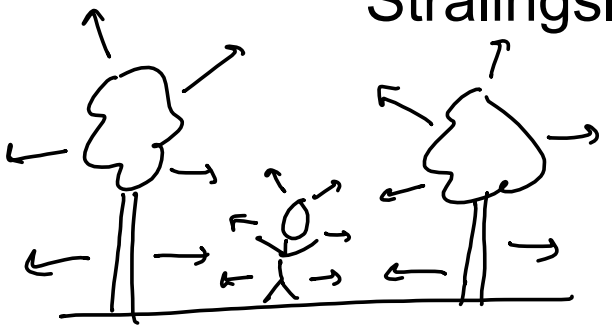
$\varepsilon = 1 \Rightarrow$ svart legeme

$\varepsilon = 0 \Rightarrow$ perfekt speil

Emissivitet



Strålingslikevekt



jeg → omgivelser $P_e = \sigma \varepsilon A T_m^4$

omgivelsene → meg $P_a = \sigma \varepsilon A T_0^4$

$P_{netto} = P_e - P_a = \sigma \varepsilon A (T_m^4 - T_0^4)$

antar:

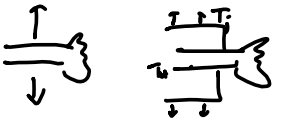
$\varepsilon = 0{,}97$

$A = 2{,}0\,m^2$

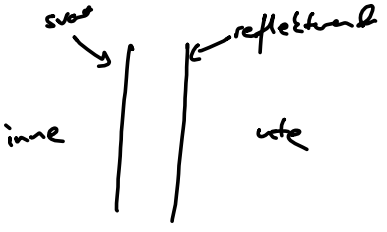
$T_m = 30^\circ C$

$T_0 = 22^\circ C$

$P_{netto} = 94\,W$



Hvorfor bruker vi slike tepper til førstehjelp?



$$P = \sigma \varepsilon A \Delta T$$

$$\varepsilon = 0$$

$$P = 0$$

Faseoverganger

https://en.wikipedia.org/wiki/Perspiration#/media/File:TranspirationPerspirationCommonsFL.jpg

Hvorfor fryser vi?

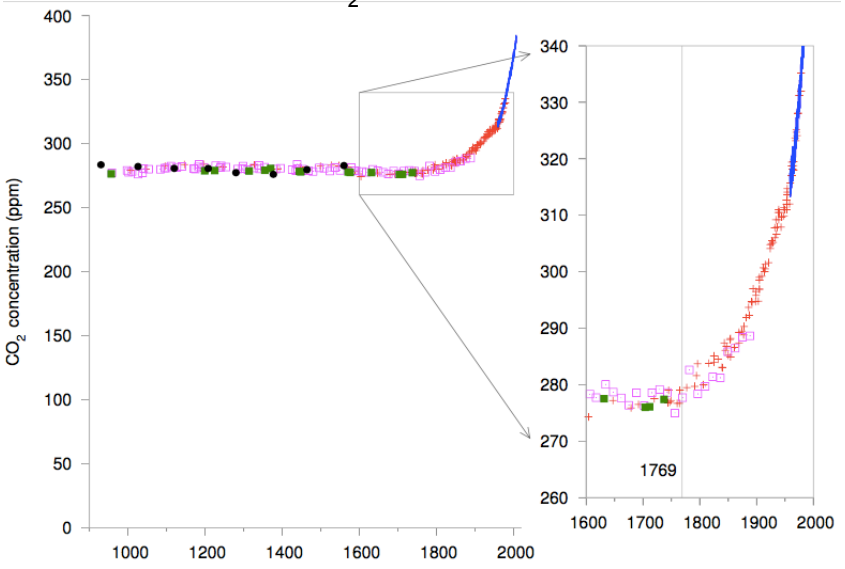
		Lufttemperatur										
		5°	0°	-5°	-10°	-15°	-20°	-25°	-30°	-35°	-40°	-45°	-50°
Vindstyrke (m/s)		**Indeks**											
Svak vind	**1,5**	4	-2	-7	-13	-19	-24	-30	-36	-41	-47	-53	-58
	3	3	-3	-9	-15	-21	-27	-33	-39	-45	-51	-57	-63
Lett bris	**4,5**	2	-4	-11	-17	-23	-29	-35	-41	-48	-54	-60	-66
	6	1	-5	-12	-18	-24	-31	-37	-43	-49	-56	-62	-68
Laber bris	**7,5**	1	-6	-12	-19	-25	-32	-38	-45	-51	-57	-64	-70
	9	0	-7	-13	-20	-26	-33	-39	-46	-52	-59	-65	-72
Frisk bris	**10,5**	0	-7	-14	-20	-27	-33	-40	-47	-53	-60	-66	-73
Liten kuling	**12**	-1	-7	-14	-21	-27	-34	-41	-48	-54	-61	-68	-74
	13,5	-1	-8	-15	-21	-28	-35	-42	-48	-55	-62	-69	-75
Stiv kuling	**15**	-1	-8	-15	-22	-29	-35	-42	-49	-56	-63	-70	-76
	16,5	-2	-9	-15	-22	-29	-36	-43	-50	-57	-63	-70	-77
Sterk kuling	**18**	-2	-9	-16	-23	-30	-37	-43	-50	-57	-64	-71	-78
	19,5	-2	-9	-16	-23	-30	-37	-44	-51	-58	-65	-72	-79
	21	-2	-9	-16	-23	-30	-37	-44	-51	-59	-66	-73	-80
Liten storm	**22,5**	-3	-10	-17	-24	-31	-38	-45	-52	-59	-66	-73	-80
	24	-3	-10	-17	-24	-31	-38	-45	-52	-60	-67	-74	-81

Hva bestemmer temperaturen på jorda?

https://xkcd.com/1732/

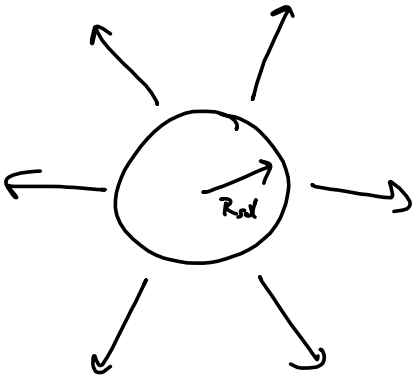
https://youtu.be/-yIHxOui9nQ

CO_2 i atmosfæren



McKay (2009) Sustainable Energy Without the Hot Air

Stråling fra sola til jorda



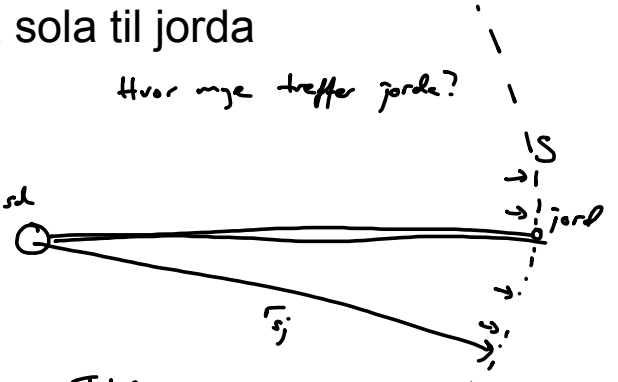
$T_{sol} = 5778\,K$

$M = \sigma T_{sol}^4 = 6{,}32 \cdot 10^7\ W/m^2$

Totalt effekt fra sola

$P_e = MA = M \cdot 4\pi R_{sol}^2$

Hvor mye treffer jorda?



Total effekt i avstand r_{sj}?

$P_{sj} = S \cdot 4\pi r_{sj}^2$ S: solarkonstanten

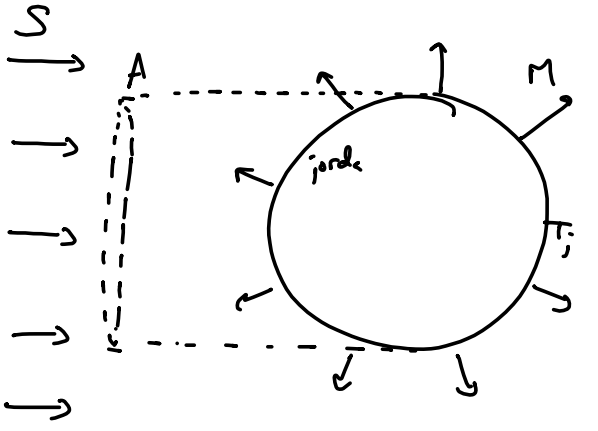
$P_e = P_{sj}$

$M \cdot 4\pi R_{sol}^2 = S \cdot 4\pi r_{sj}^2$

$S = M \frac{R_{sol}^2}{r_{sj}^2}$

$S = 1367\ W/m^2$

Strålingsbalanse og jordas temperatur



varmestråling

$M = \sigma T_j^4$ (anta $\varepsilon = 1$)

$A = \pi R_{jord}^2$

Total effekt inn til sola:

$P_a = S \cdot \pi R_{jord}^2$

total effekt ut fra jorda

$P_e = M \cdot 4\pi R_{jord}^2$

$P_{inn} = P_{ut} \Rightarrow$ konstant T

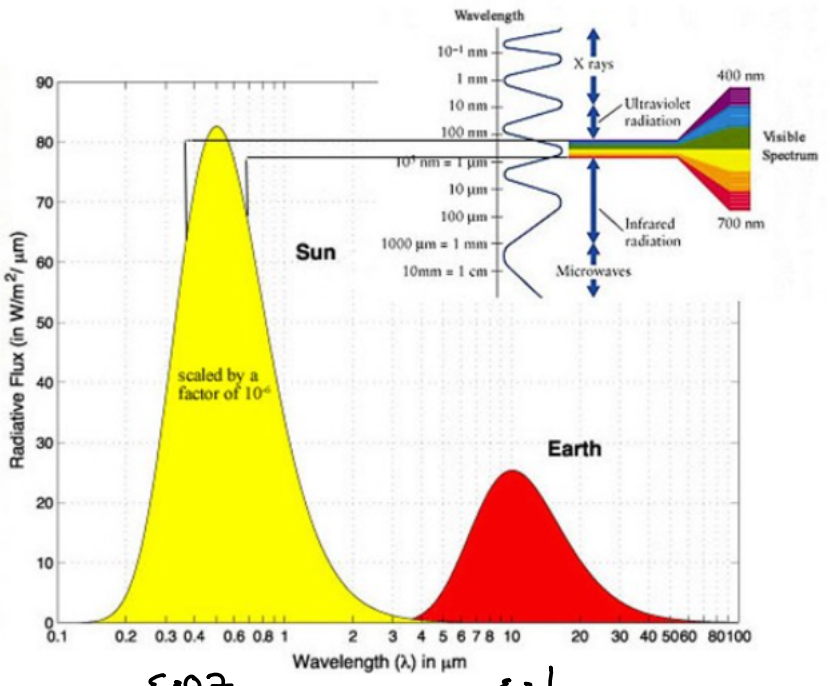
$P_a = P_e$

$S\pi R_{jord}^2 = M 4\pi R_{jord}^2$

$S \cancel{\pi} \cancel{R_{jord}^2} = \sigma T_{jord}^4 4 \cancel{\pi} \cancel{R_{jord}^2}$

$T_{jord}^4 = \frac{S}{4\sigma}$

$T_{jord} = \sqrt[4]{\frac{S}{4\sigma}} = 279\,K = 5^\circ C$



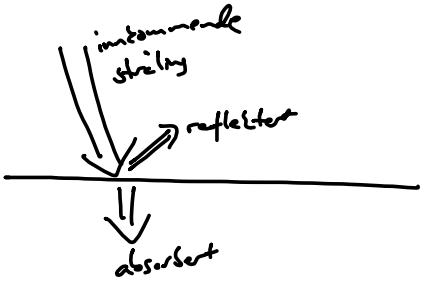
jorda:

ε = 0,7
korte bølgelengde

ε = 1
lange -"-

http://slideplayer.com/slide/5309772/

Albedo A (obs! ikke areal)



$$\varepsilon = \frac{\text{absorbert energi}}{\text{innkommende energi}}$$

$$A = \frac{\text{reflektert energi}}{\text{innkommende energi}}$$ i solspektret

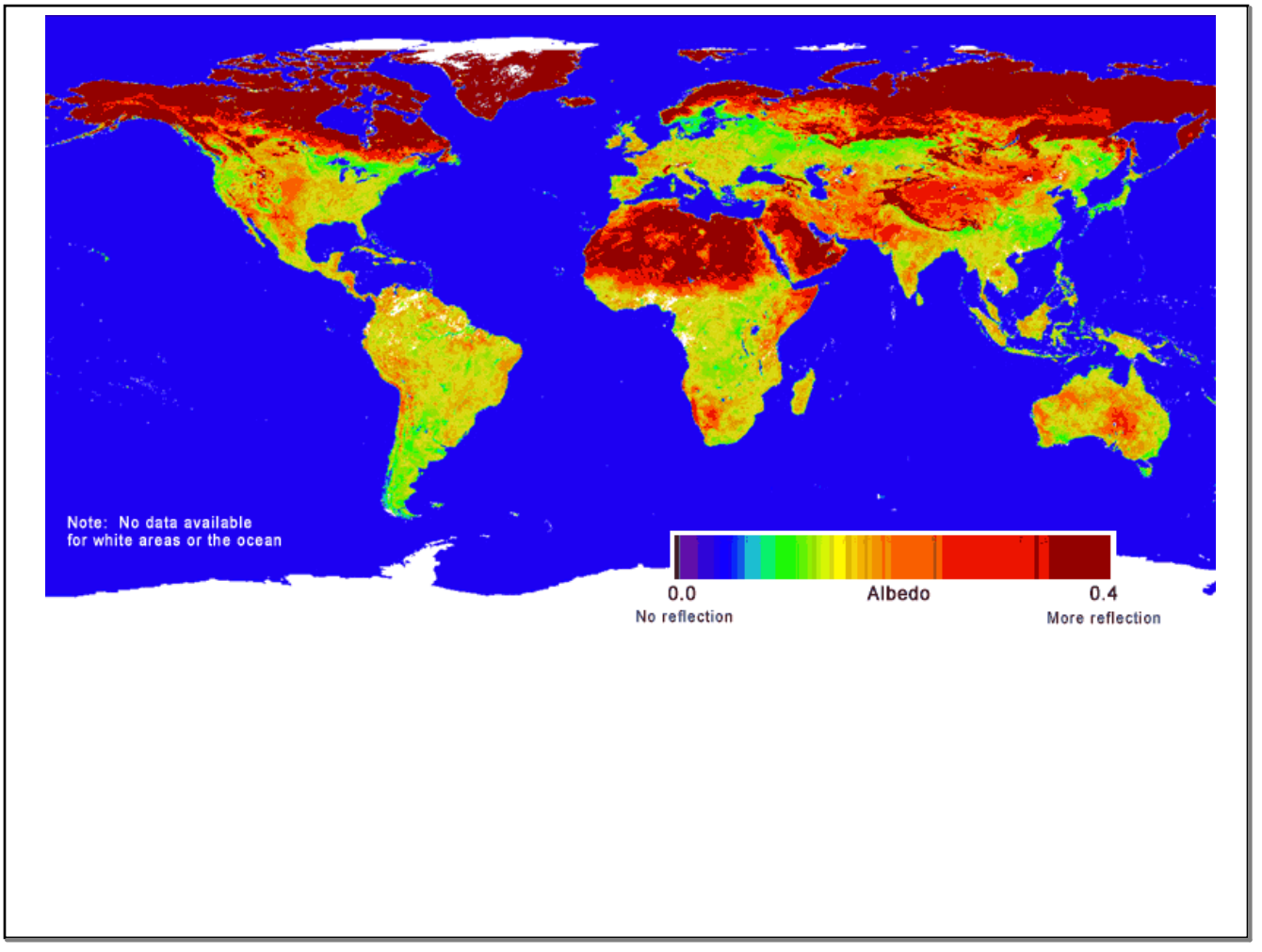
$$A = 1 - \varepsilon$$

$$A_j = 0{,}3$$

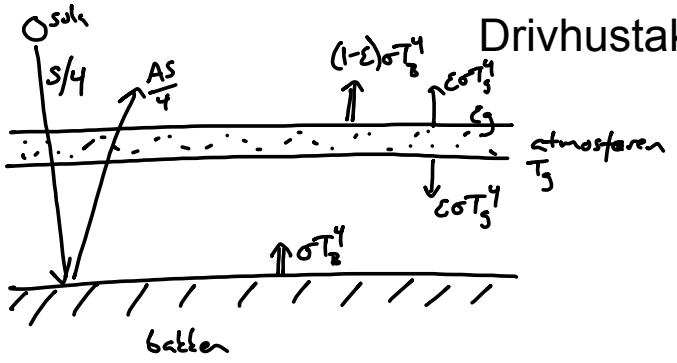
$$T_{jord} = \sqrt[4]{\frac{S(1-A)}{4\sigma}}$$

$$= 255\,K = -18^\circ C$$

March 4, 2019


Note: No data available
for white areas or the ocean
0.0
No reflection
Albedo
0.4
More reflection

Drivhustaket



	solspektret	varmestråling fra jord
bakken	$A = 0{,}3$	$\varepsilon_b = 1$
atmosfæren	gjennomsiktig	$\varepsilon_g < 1$ gjennomsiktig for det som ikke absorberes

Energibalanse for bakken

inn = ut

$$\frac{(1-A)S}{4} + \varepsilon\sigma T_S^4 = \sigma T_B^4$$

Energibalanse for drivhustaket

inn = ut

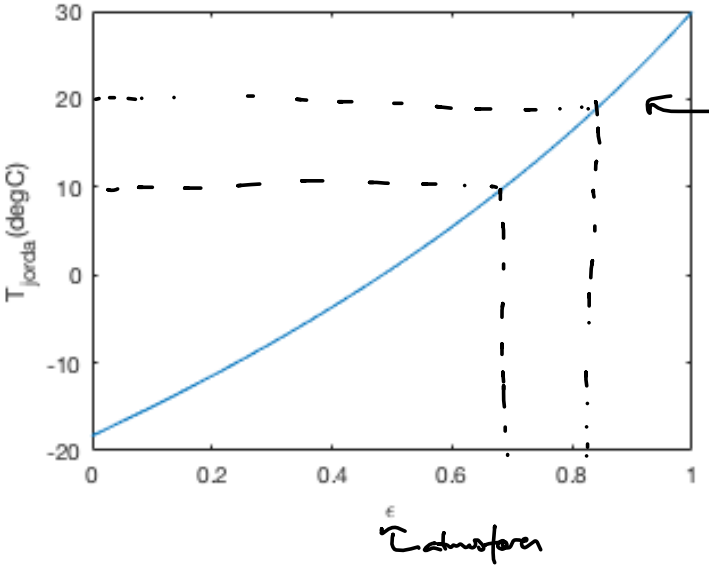
$$\varepsilon\sigma T_B^4 = 2\varepsilon\sigma T_S^4$$

$$T_S^4 = \frac{1}{2} T_B^4$$

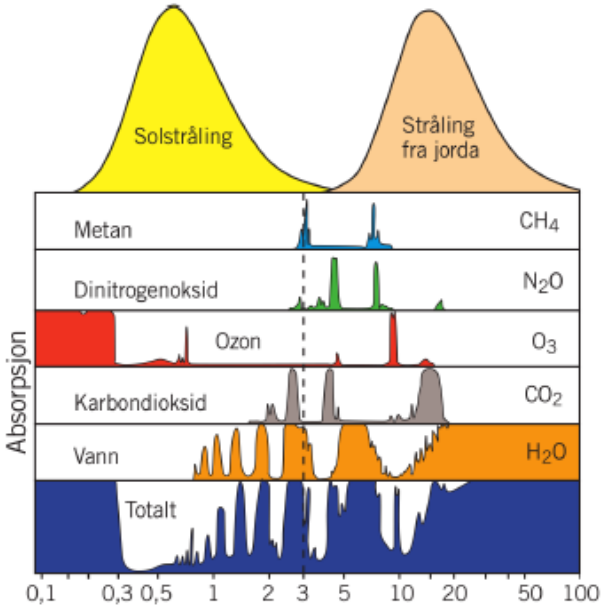
$$\frac{(1-A)S}{4} + \frac{1}{2}\varepsilon\sigma T_B^4 = \sigma T_B^4$$

$$\sigma T_B^4 \left(1 - \frac{\varepsilon}{2}\right) = \frac{(1-A)S}{4}$$

$$T_B = \sqrt[4]{\frac{(1-A)S}{4\sigma(1-\varepsilon/2)}}$$



$$T_s = \sqrt[4]{\frac{(1-A)S}{4\sigma(1-\varepsilon/2)}}$$


Solstråling
Stråling fra jorda
Metan
CH_4
Dinitrogenoksid
N_2O
Ozon
O_3
Karbondioksid
CO_2
Vann
H_2O
Totalt
Absorpsjon
0,1
0,3
0,5
1
2
3
5
10
20
50
100

Jorda - litt mer realistisk