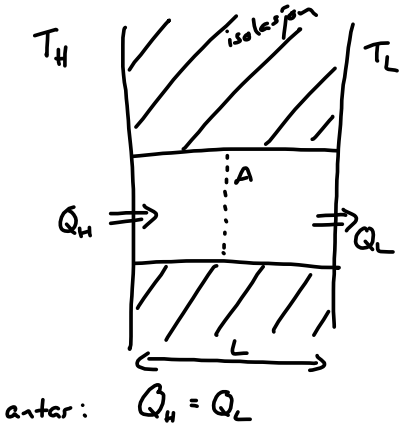
Hvorfor fryser vi?

Varmeledning



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

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

λ: varmeledningsevnen

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

Samsnakk: Du skal ta med deg en kopp varm kaffe, og har valget mellom en kopp av papp og en av isopor. Hvilken velger du? Bruk fysikk til å forklare hvorfor.

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

Du ønsker å bruke mindre energi til oppvarming. Hva er best å gjøre:

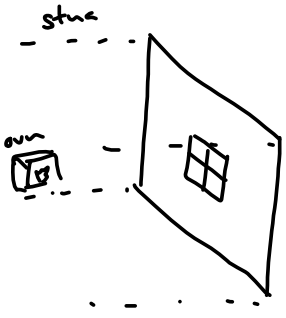
- Bytte vinduer?

- Etterisolere ytterveggene?

U-verdi og energibalanse i bygninger

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

$H = UA\Delta T$



Konstant T

$Q_{inn} = Q_{ut}$

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

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

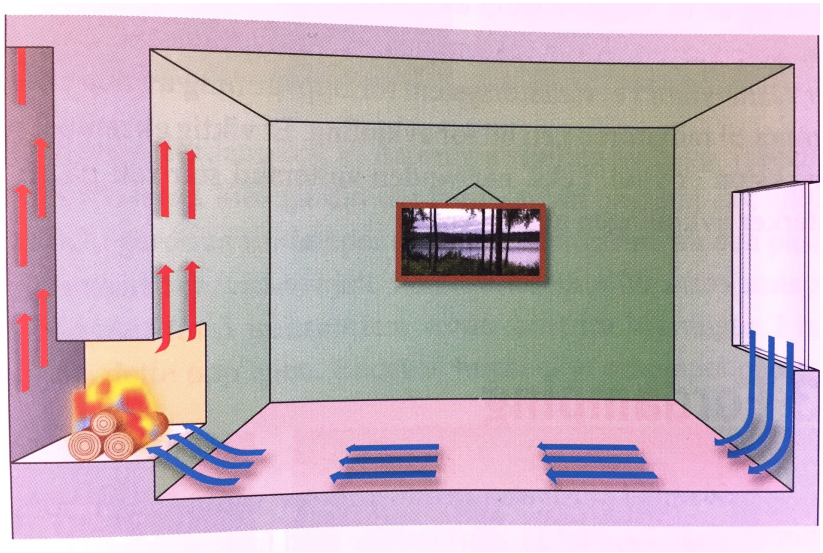
$T_{inne} = 22°C$, $T_{ute} = 8°C \Rightarrow \Delta T = 14K$

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

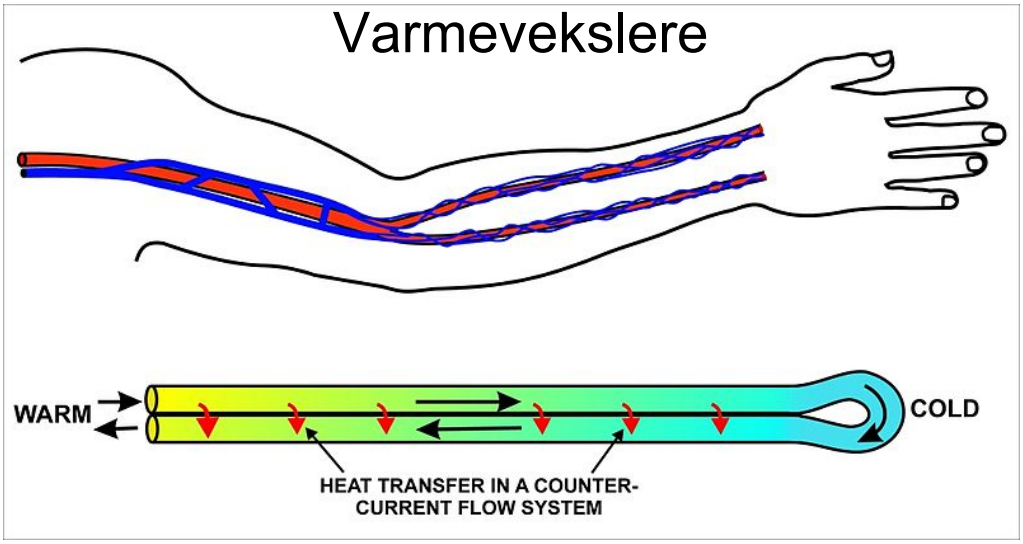
$H_{vindu} = 450\,W$

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

Konveksjon

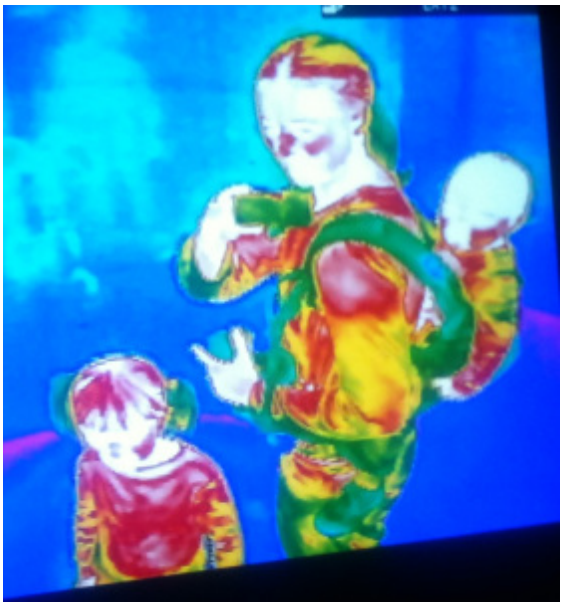


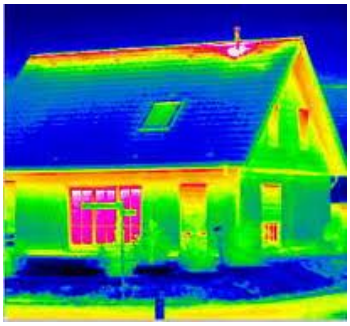
Varmevekslere

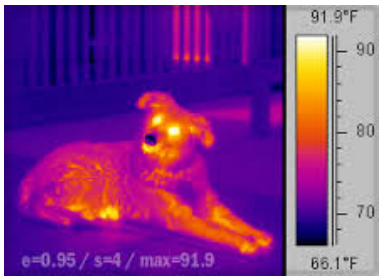


https://commons.wikimedia.org/wiki/File:Arm_counter-current_flow.jpg

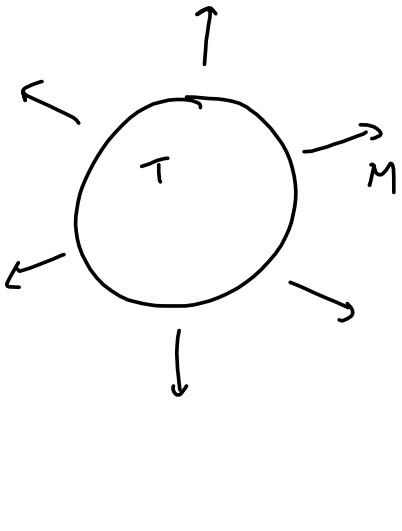
Varmestråling







Strålingstetthet



Utstrålingstetthet

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

Innstrålingstetthet

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

Stefan-Boltzmanns lov

$M = \varepsilon \sigma T^4$

σ: S-B-konstanten

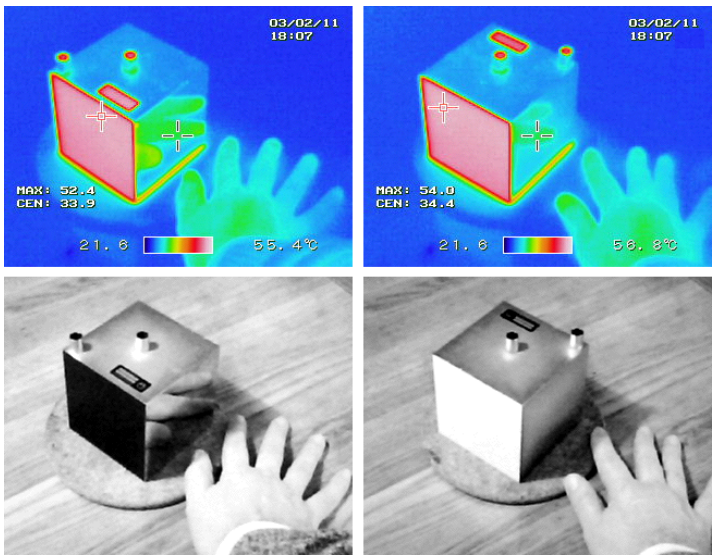
$= 5{,}67 \cdot 10^{-8}\ W/m^2 K^4$

ε: emissivitet

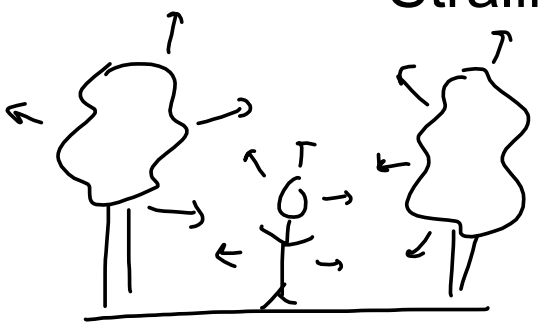
$\varepsilon = 1 \Rightarrow$ svart legeme

$\varepsilon = 0 \Rightarrow$ perfekt speil

Emissivitet



Strålingslikevekt



anta:

$\varepsilon = 0{,}97$

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

$T_j = 30^\circ C$

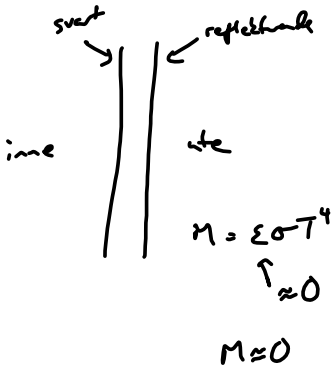
$T_o = 22^\circ C$

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

omgivelser → meg $P_a = EA = \varepsilon\sigma T_o^4 A$

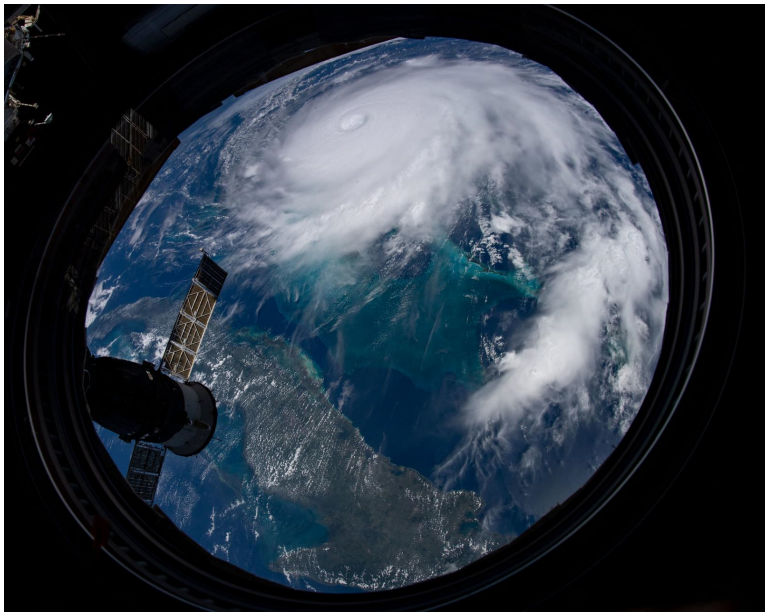
$P_{netto} = P_e - P_a = \varepsilon\sigma A(T_j^4 - T_o^4) = 94\,W$

Hvorfor bruker vi slike tepper til førstehjelp?



Faseoverganger

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



Hurricane Dorian sett fra ISS. NASA. https://flickr.com/photos/nasa2explore/48678184092/

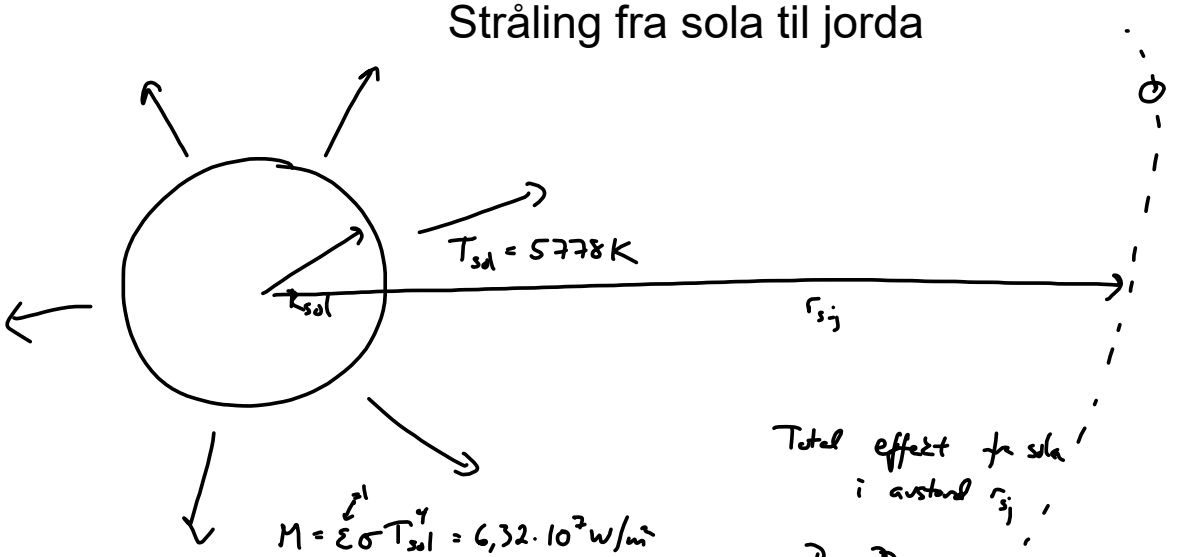
Hvorfor fryser vi?

		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

https://xkcd.com/1732/

https://youtu.be/-yIHxOui9nQ

Stråling fra sola til jorda



$M = \varepsilon \sigma T_{sol}^4 = 6{,}32 \cdot 10^7 W/m^2$ ($\varepsilon = 1$)

Total effekt fra sola

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

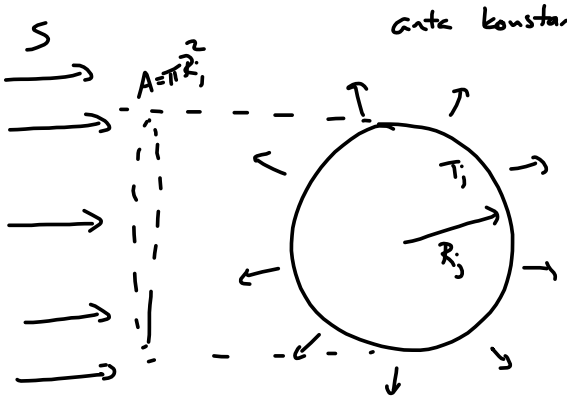
Total effekt fra sola i avstand r_{sj}

$P_{sj} = P_e$

$P_{sj} = S 4\pi r_{sj}^2 = M 4\pi R_{sol}^2$ (S: solarkonstanten)

$S = M \frac{R_{sol}^2}{r_{sj}^2} = 1367 W/m^2$

Strålingsbalanse og jordas temperatur



$P_{inn} = S\pi R_j^2$

anta konstant T_j $\Rightarrow P_{ut} = P_{inn}$

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

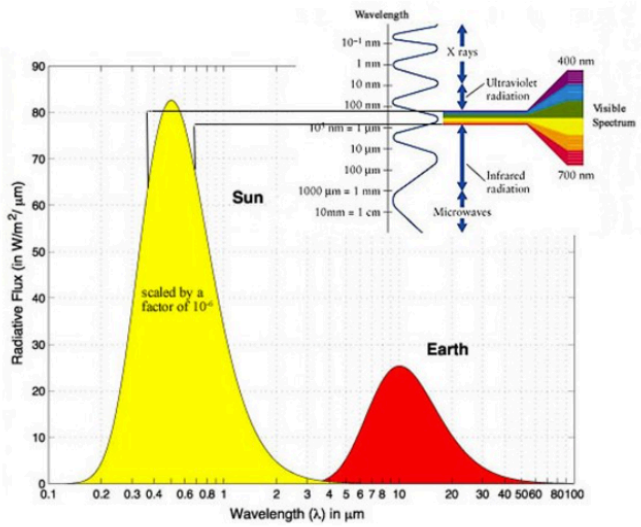
$P_{ut} = M \cdot 4\pi R_j^2$

$M \cdot 4\pi R_j^2 = S\pi R_j^2$

$M = \frac{S}{4} = \sigma T_j^4$

$T_j^4 = \frac{S}{4\sigma}$

$T_j = \sqrt[4]{\frac{S}{4\sigma}} = 279\,K = 5°C$

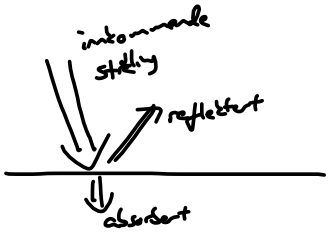


jorda ε = 0,7 ε = 1

solljs vermestiku

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

Albedo



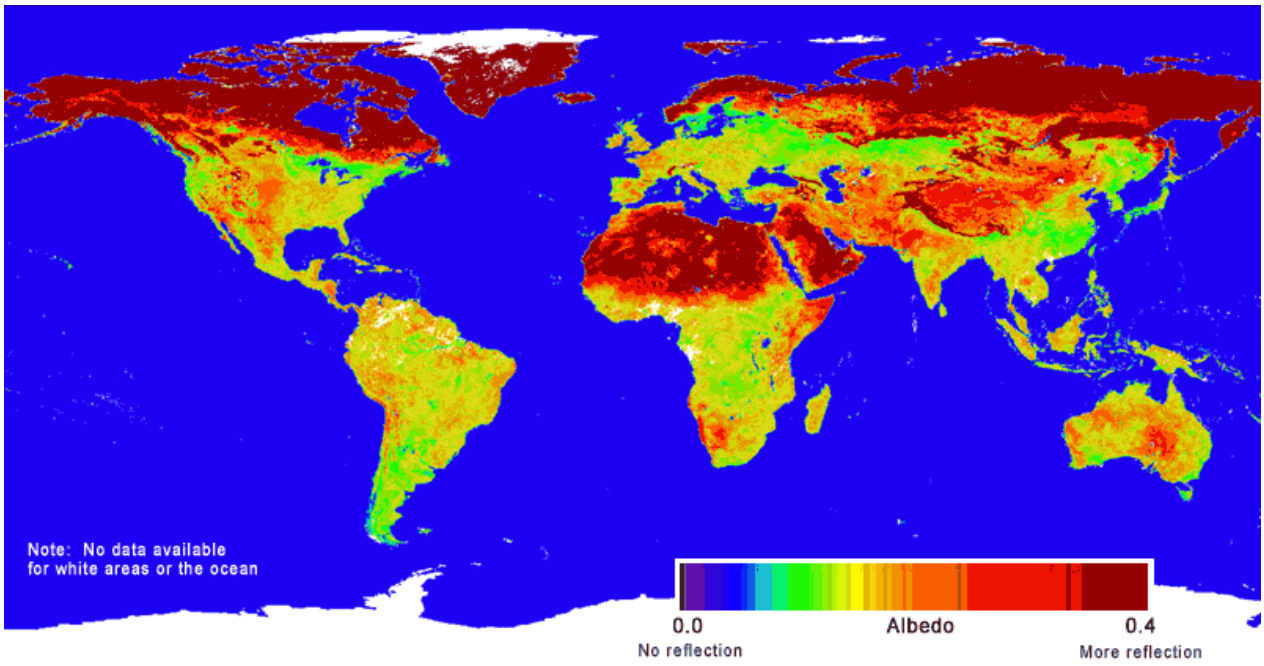
Emissivitet: $\varepsilon = \frac{\text{absorbert}}{\text{innkommende}}$

albedo: $A = \frac{\text{reflektert}}{\text{innkommende}}$

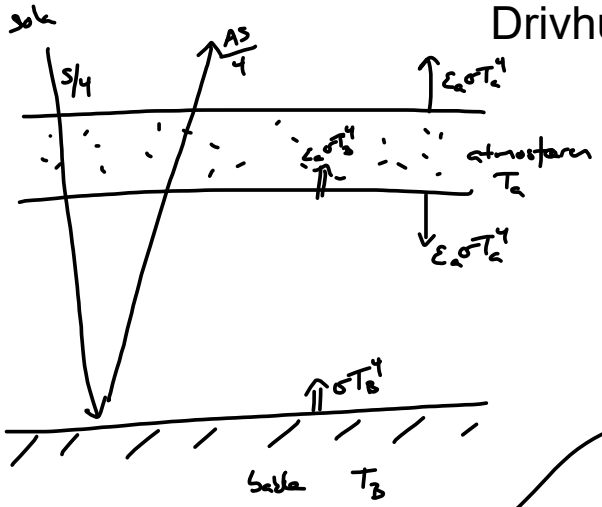
$A = 1 - \varepsilon$
for bølgelengder i solspektret

jorda: $A \approx 0{,}3$

$$T_j = \sqrt[4]{\frac{(1-A)S}{4\sigma}} = 255\ K = -18°C$$


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

Drivhustaket



	solopptak	varmestråling fra jord
Jorden	$A = 0{,}3$	$\varepsilon_j = 1$
atmosfæren	gjennomsiktig	$\varepsilon_a < 1$ (gjennomsiktig for det som ikke absorberes)

Energibalansen for Jorden

inn = ut

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

Energibalanse for atmosfæren

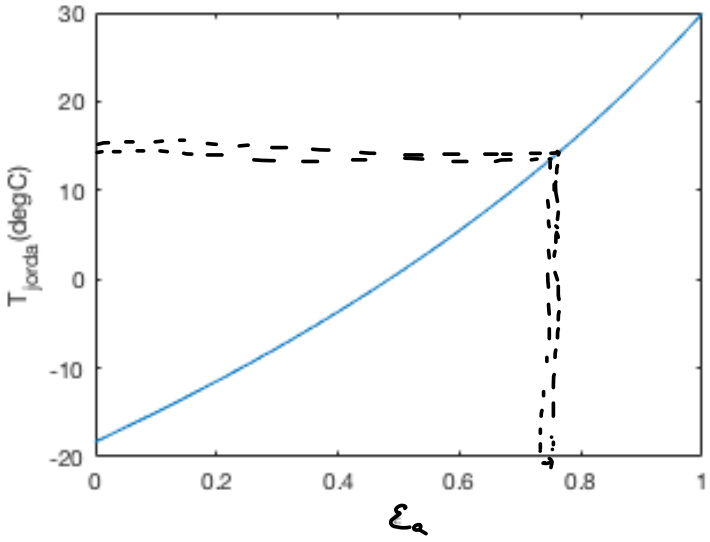
inn = ut

$$\varepsilon_a\sigma T_B^4 = 2\varepsilon_a\sigma T_a^4 \Rightarrow T_a^4 = \frac{1}{2}T_B^4$$

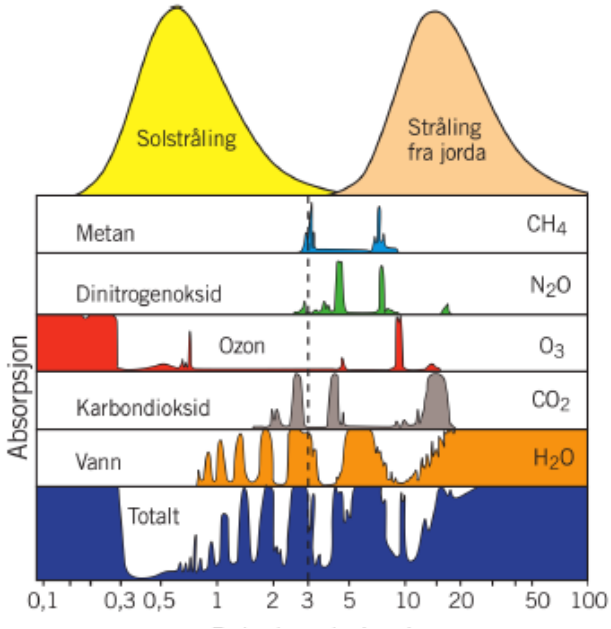
$$\frac{(1-A)S}{4} + \varepsilon_a\sigma\frac{1}{2}T_B^4 = \sigma T_B^4$$

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

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



$A = 0,3$


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