FAO Penman-Monteith Gleichung

$$ET_0 = \frac{0.408 \cdot \Delta \cdot (R_n - G) + \gamma \cdot \frac{900}{T + 273} \cdot u_2 \cdot (e_s - e_a)}{\Delta + \gamma \cdot (1 + 0.34 \cdot u_2)}$$

ET_0	reference evapotranspiration	mm/d
R_n	net radiation at the crop surface	MJ/m²d
G	soil heat flux density	MJ/m²d
T	mean daily air temperature (2 m height)	°C
u_2	wind speed (2 m height)	m/s
e_s	saturation vapour pressure	kPa
e_a	actual vapour pressure	kPa
Δ	slope vapour pressure curve	kPa/°C
γ	psychrometric constant	kPa/°C

FAO IDP 56

Berechnung der Evapotranspiration aus Wetterdaten

Website Agrarmeteorologie Bayern

https://www.wetter-by.de/

Radiation (R_n - G), MJ m^{-2} d^{-1}

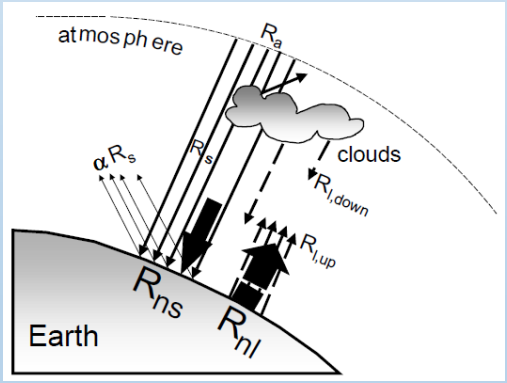
$$R_n = R_{ns} - R_{nl}$$

$$R_{ns} = (1 - \alpha)R_s$$

$$R_{nl} = \sigma\left(\frac{T_{max}^{\ 4} + T_{min}^{\ 4}}{2}\right) \cdot (0.34 - 0.14 \cdot \sqrt{e_a}) \cdot \left(1.35\frac{R_s}{R_{so}} - 0.35\right)$$

$$R_{so} = (0.75 + 2 \cdot 10^{-5} z)R_a$$

G	soil heat flux, ≈ 0
R_n	Nettostrahlung
R_{ns}	Netto kurzwellige Strahlung
R_s	kurzwellige Strahlung
α	Albedo
R_{nl}	Netto langwellige Strahlung
σ	Stefan-Boltzmann-Konst., 4.903 10^9 MJ K^{-4} m^{-2} d^{-1}
e_a	actual vapour pressure, kPa
R_{so}	Strahlung bei klarem Himmel
R_a	extraterrestrische Strahliung
z	elevation above sea level, m



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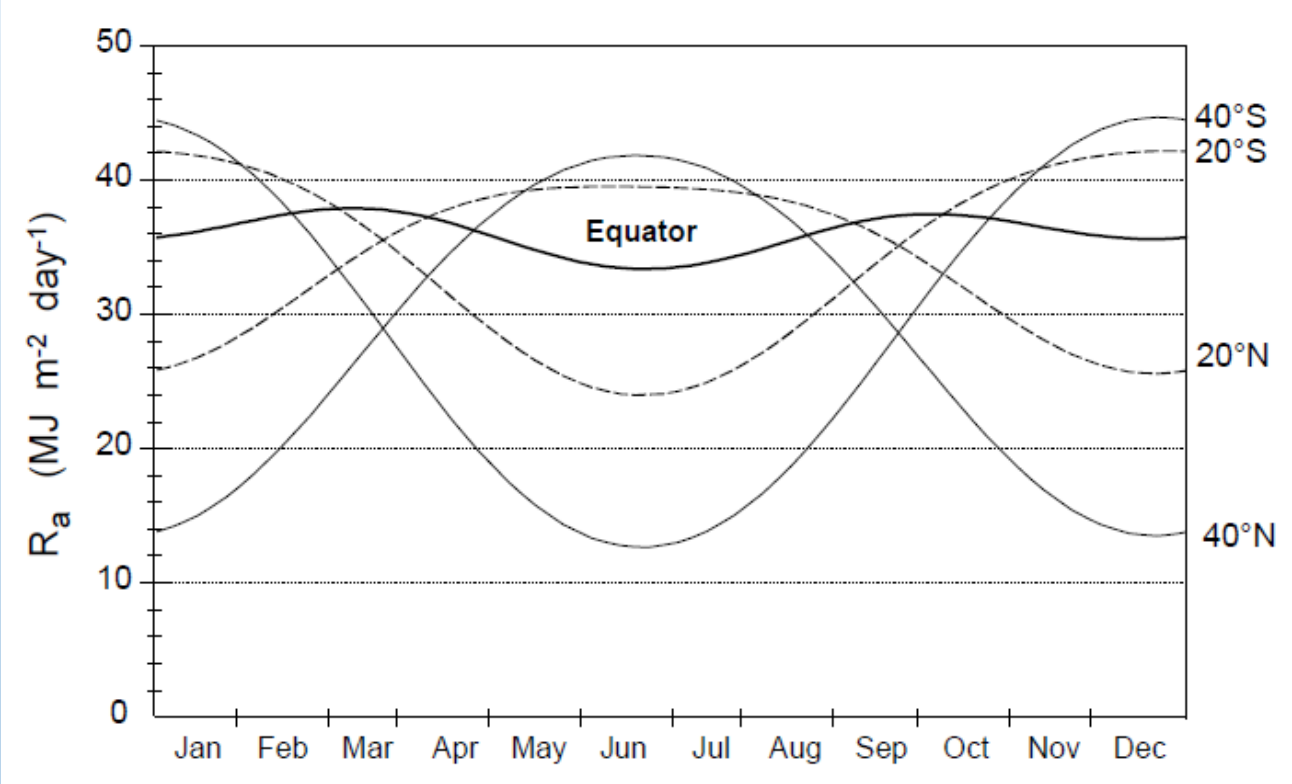
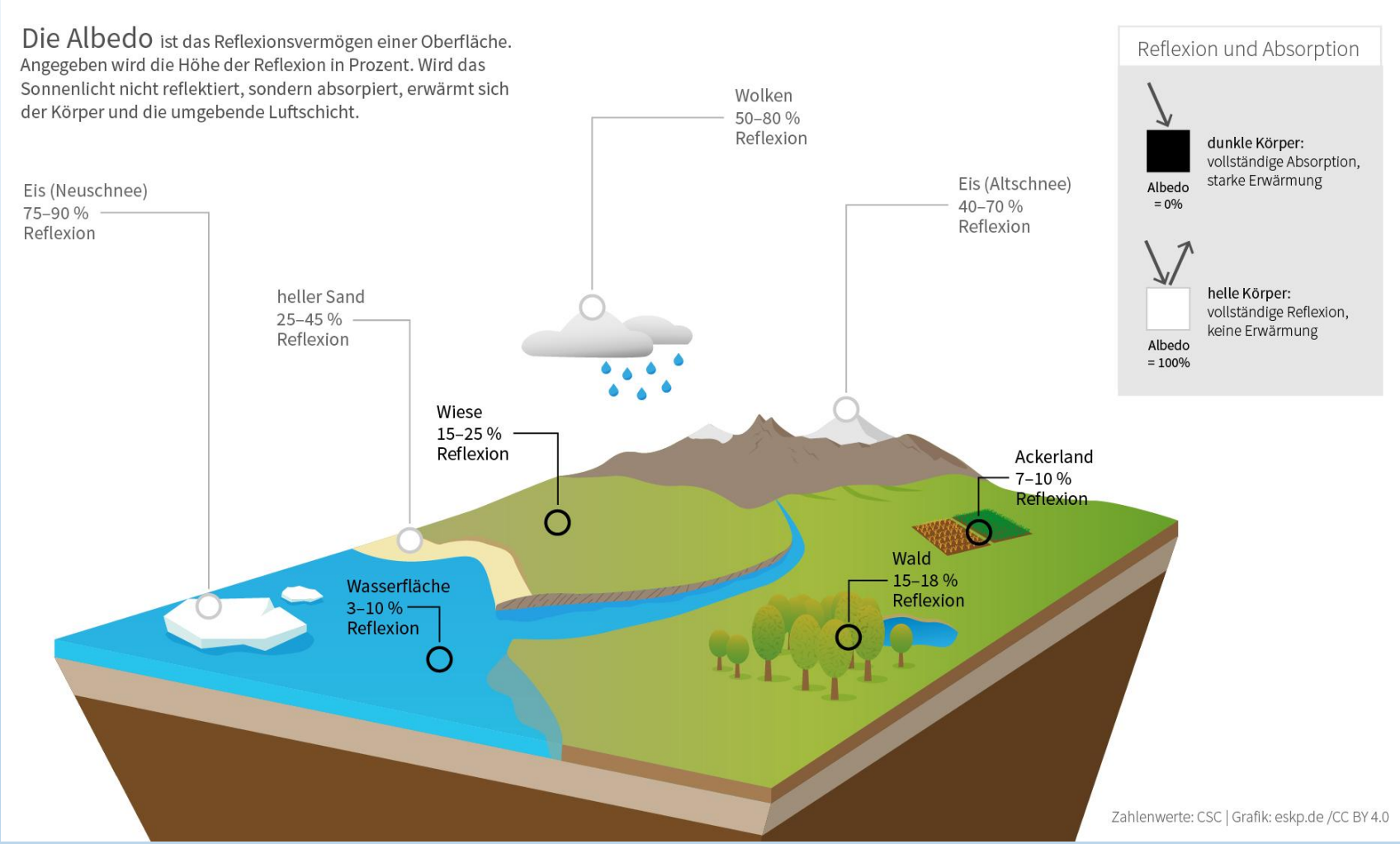
http://www.fao.org/3/X0490E/x0490e00.htm#Contents

Extra-terrestrial radiation R_a , extraterrestrische Strahlung



Albedo α


Die Albedo ist das Reflexionsvermögen einer Oberfläche. Angegeben wird die Höhe der Reflexion in Prozent. Wird das Sonnenlicht nicht reflektiert, sondern absorpiert, erwärmt sich der Körper und die umgebende Luftschicht.
Reflexion und Absorption
dunkle Körper: vollständige Absorption, starke Erwärmung
Albedo = 0%
helle Körper: vollständige Reflexion, keine Erwärmung
Albedo = 100%
Wolken 50–80 % Reflexion
Eis (Neuschnee) 75–90 % Reflexion
Eis (Altschnee) 40–70 % Reflexion
heller Sand 25–45 % Reflexion
Wiese 15–25 % Reflexion
Ackerland 7–10 % Reflexion
Wald 15–18 % Reflexion
Wasserfläche 3–10 % Reflexion
Zahlenwerte: CSC | Grafik: eskp.de /CC BY 4.0

Dampfdruckdefizit (e_s-e_a)

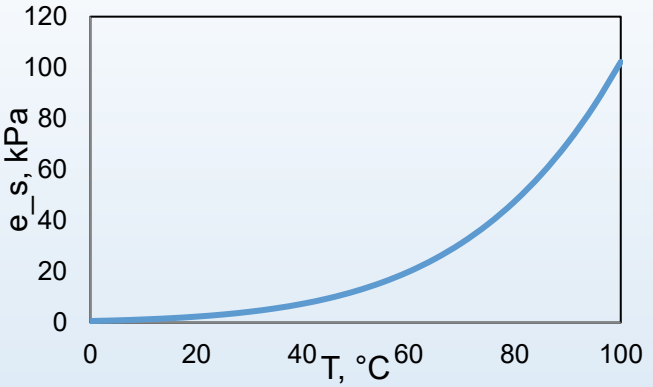
$$e_s(T) = 0.6108 \cdot e^{\left(\frac{17.27 \cdot T}{T+237.3}\right)}$$

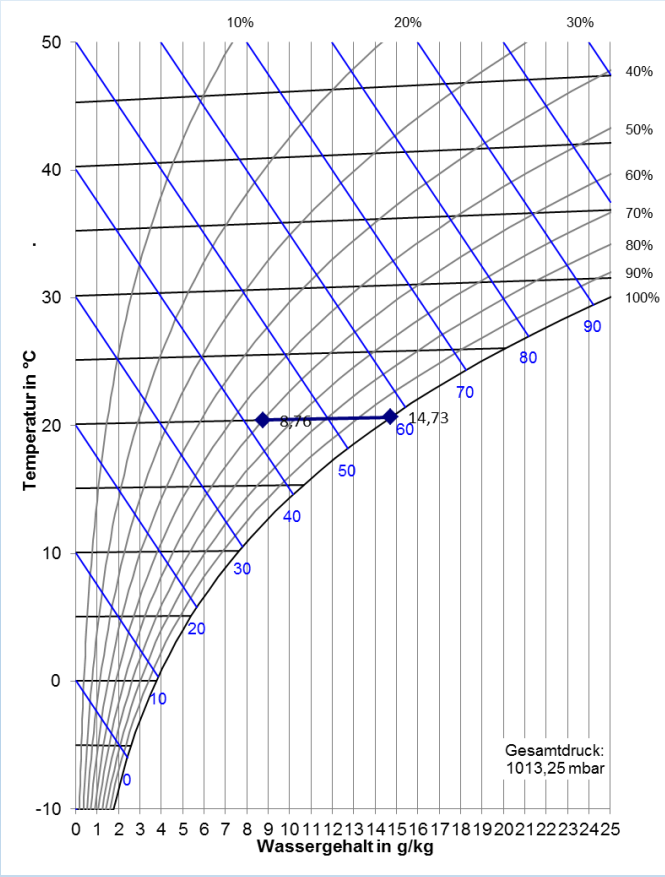
$$\Delta = e_s(T)' = \frac{17.27 \cdot 237.3 \cdot 0.6108 \cdot e^{\left(\frac{17.27 \cdot T}{T+237.3}\right)}}{(T+237.3)^2}$$

$$e_a = \frac{e_s(T_{min}) \cdot \frac{RH_{max}}{100} + e_s(T_{max}) \cdot \frac{RH_{min}}{100}}{2}$$

$$\gamma = 0.665 \cdot 10^{-3} \cdot P$$

e_s	Sättigungsdampfdruck, kPa
e_a	tatsächlicher Dampfdruck, kPa
Δ	Steigung der Dampfdruckkurve, kPa/°C
γ	psychrometrische Konstante, kPa/°C
P	Luftdruck, kPa





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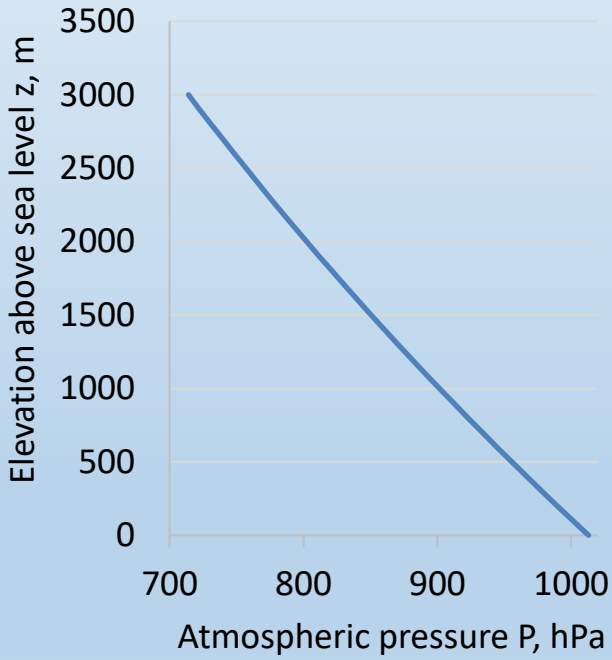
Atmospheric pressure P, Luftdruck

$$P = P_0 \cdot e^{-\left(\frac{g \cdot M}{R \cdot T} \cdot z\right)}$$

P	atmospheric pressure, kPa
P_0	pressure at sea level, kPa
g	gravitational acceleration, 9.807 m/s²
M	molar mass of air: 0.02896 kg/mol
R	universal gas constant: 8.314 J/mol/K
T	temperature, K
z	elevation above sea level, m



PC-Übung Sensibilität T, RH, u, R

Change, %		0 *Erhöhung in %*			100				
		Default	R_s	T_mean	RH_mean	u	α (albed	P_0	z
R_a	MJ/m^2/d	41.8	41.8	41.8	41.8	41.8	41.8	41.8	41.8
R_s	MJ/m^2/d	19.8	19.8	19.8	19.8	19.8	19.8	19.8	19.8
α (albedo)		0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
G	MJ/m^2/d	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
T_mean	°C	17.3	17.3	17.3	17.3	17.3	17.3	17.3	17.3
RH_mean	%	74.6	74.6	74.6	74.6	74.6	74.6	74.6	74.6
u	m/s	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
P_0	kPa	101.4	101.4	101.4	101.4	101.4	101.4	101.4	101.4
z	m	440.0	440	440	440	440	440	440	440
g	m/s^2	9.81	9.81	9.81	9.81	9.81	9.81	9.81	9.81
M	kg/mol	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
R	J/mol/K	8.31	8.31	8.31	8.31	8.31	8.31	8.31	8.31
σ (Bolzmann)	MJ/K^4/m^2/c	4.903E-09	4.9E-09	4.9E-09	4.9E-09	4.9E-09	5E-09	4.9E-09	4.9E-09
R_n	MJ/m^2/d	12.9	12.9	12.9	12.9	12.9	12.9	12.9	12.9
R_ns	MJ/m^2/d	15.8	15.8	15.8	15.8	15.8	15.8	15.8	15.8
R_nl	MJ/m^2/d	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9
e_a	kPa	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
e_s Tmean	kPa	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
R_s0	MJ/m^2/d	31.7	31.7	31.7	31.7	31.7	31.7	31.7	31.7
Δ (slope e_s)	kPa/K	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125
γ (psychr const)	kPa/K	0.064	0.064	0.064	0.064	0.064	0.064	0.064	0.064
P_z	kPa	96.3	96.3	96.3	96.3	96.3	96.3	96.3	96.3
ET_0_day	mm/d	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7
Change ET_0	%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

$$ET_0 = \frac{0.408 \cdot \Delta \cdot (R_n - G) + \gamma \cdot \frac{900}{T + 273} \cdot u_2 \cdot (e_s - e_a)}{\Delta + \gamma \cdot (1 + 0.34 \cdot u_2)}$$