Measurements for water

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Waterbalans: Evaporation

Measuring evaporation

Evaporation is …

$$E = E_o + E_t + E_s + E_i$$

E	= total evaporation
E_o	= open water evaporation
E_t	= transpiration
E_s	= soil evaporation
E_i	= interception evaporation

Potential vs Actual

- Potential:
  - No water stress
  - Atmospheric demand for moisture
- Actual:
  - Reality
  - Net result of atmospheric demand for moisture from a surface and the ability of the surface to supply moisture

Evaporation measurements

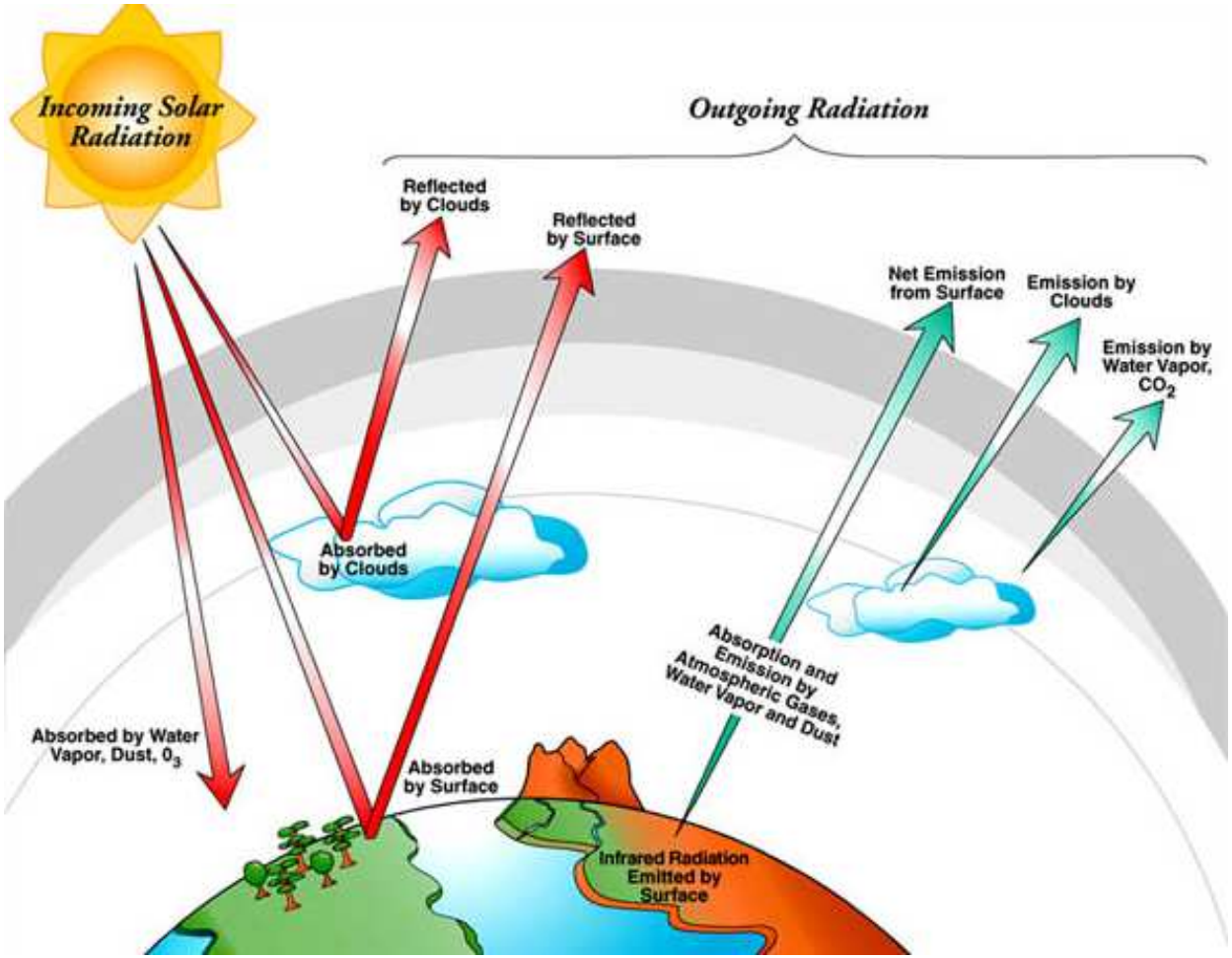
	Measurement	Eo	Et	Es	Ei
Potential	Class A pan	X			
	Penman (-Monteith)	X			
Actual	Lysimeter		X		
	Sapflow		X		
	Bowen ratio	X			
	Eddy correlation	X			
	Scintillometer	X			
	Energy balance	X			

Class A-pan

Penman (-Monteith)

$$\lambda E = \frac{\Delta\,(R_n - G) + \rho_{air}\, c_p\, vpd\,/\, r_a}{\Delta + \gamma\,(1 + \underbrace{r_s\,/\,r_a}_{= 0 \text{ for Penman (no vegetation)}})}$$

Radiation $R_n = (R_{s,in} - R_{s,out}) - (\text{“}R_{l,in}\text{”} - R_{l,out})$

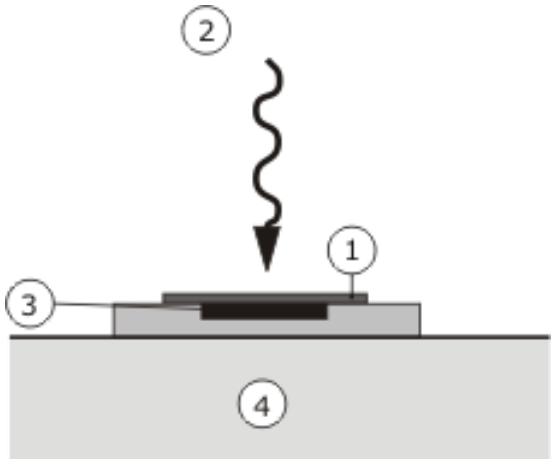


Radiation – Short wave radiation

Hukseflux LP02 (Pyranometer)

LP02 SPECIFICATIONS

ISO classification:	second class
Spectral range:	305 to 2800 nm
Sensitivity (nominal):	15 µV/ Wm^{-2}
Temperature range:	-40 to +80 °C
Range :	0 to 2000 Wm^{-2}
Temperature dependence:	< 0.1%/°C
Calibration traceability:	WRR



The absorber (1) absorbs radiation (2). The radiation is converted into heat. The heat flux to the heat sink (4) is measured by the thermopile (3).

Radiation – Long wave radiation

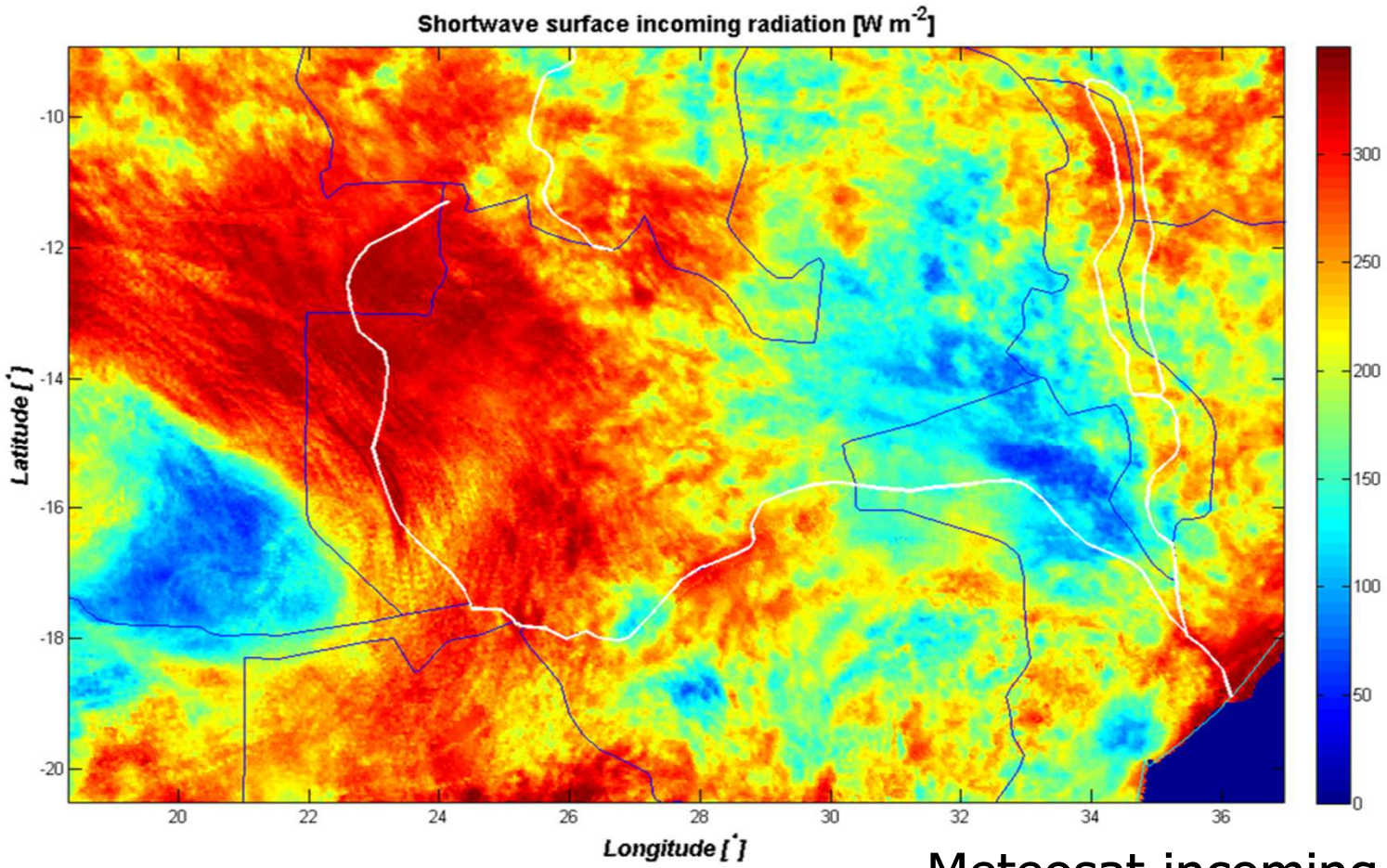
Kipp & Zonen CGR3 Pyrgeometer

Spectral Range	4.5 to 42 µm (50% points)
Sensitivity (nominal)	5 to 7 µV/W/m2
Response time (63 %)	< 6 s
Response Time (99 %)	<18 s
Temperature Dependence of Sensitivity (–20 to +50 ºC)	-10 to +40 ºC ±5 %
Field of View	150°
Irradiance	-250 to +250 W/m2 (net irradiance)
Non stability change / year	< 1%
Temperature sensor	Thermistor (YSI 44031)

Radiation – Net radiation

Figuur 7.6 - Radiometer

Radiation – Remote sensing

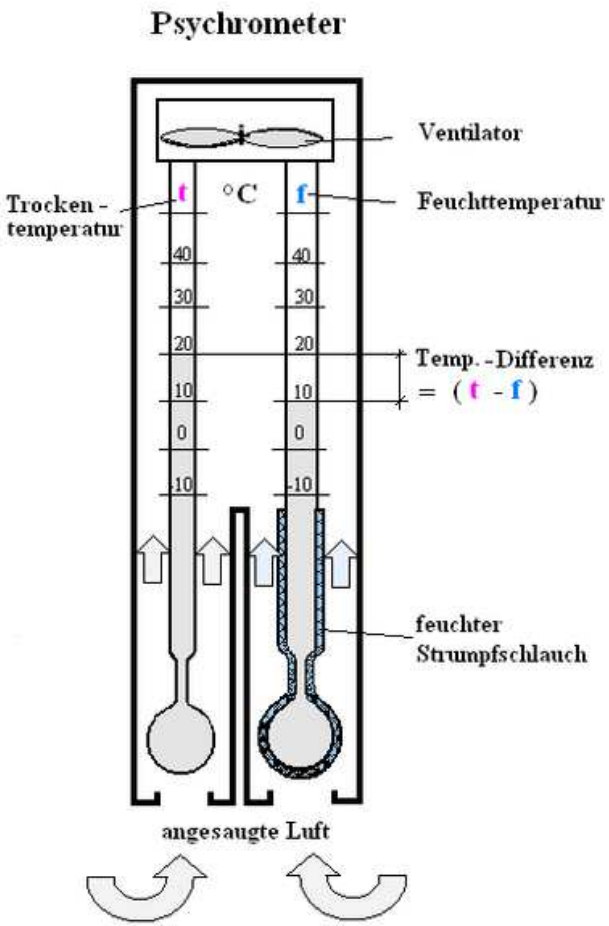


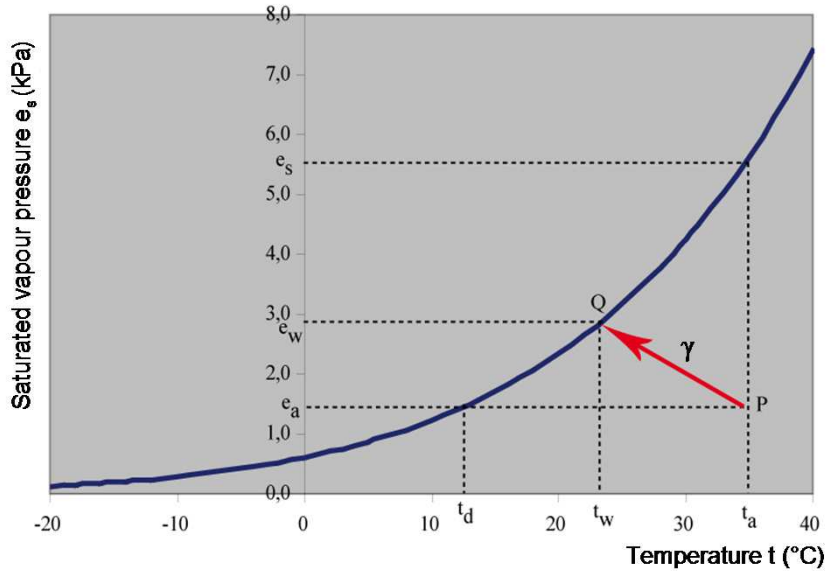
Meteosat incoming radiation

Soil heat flux

$$G = K \frac{dT}{dz}$$

VPD= Vapor Pressure Deficit (e_s-e_a)





$$e_s(t) = 0.61\exp\left(\frac{17.3t}{237+t}\right)$$

$$e_a(t_a) = e_s(t_w) - \gamma(t_a - t_w)$$

Vapor Pressure Deficit (e_s-e_a)

$$e_s(t) = 0.61\exp\left(\frac{17.3t}{237+t}\right)$$

$$h = \frac{e_a(t)}{e_s(t)}$$

Aerodynamic resistance

$$r_a = \frac{245}{\left(0.54u_2 + 0.5\right)} * \frac{1}{86400}$$

Summary Penman

- Net radiation
- Ground heat flux (G=0 on daily time scale)
- Temperature
- Humidity
- Wind

Lysimeters

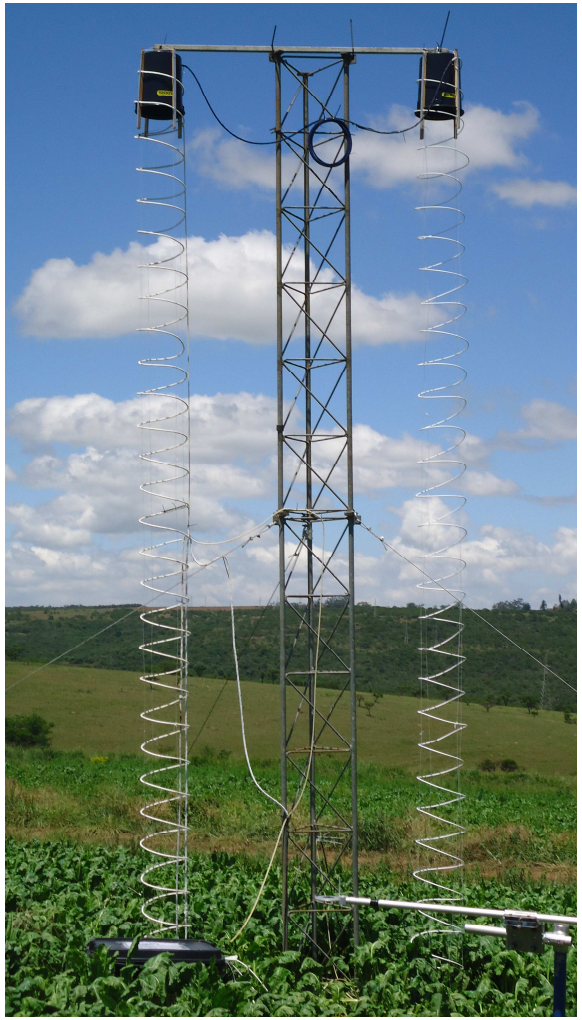
Energy Balance

$$R_n = \rho\lambda E + H + G$$

e.g. Bowen ratio

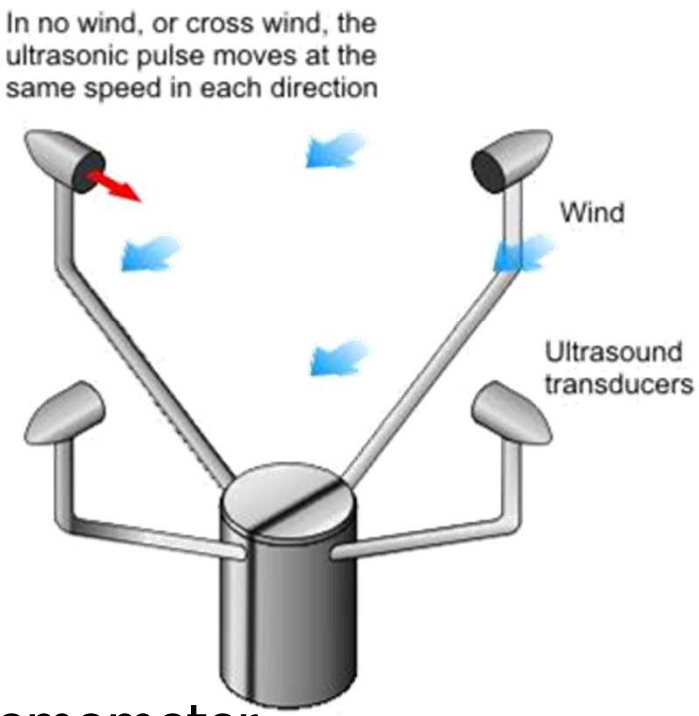
$$\beta = \frac{H}{\rho\lambda E} = \gamma\frac{T2-T1}{e2-e1}$$

$$E = \frac{R_n}{\rho\lambda(1+\beta)}$$



DTS Flux tower

Eddy covariance



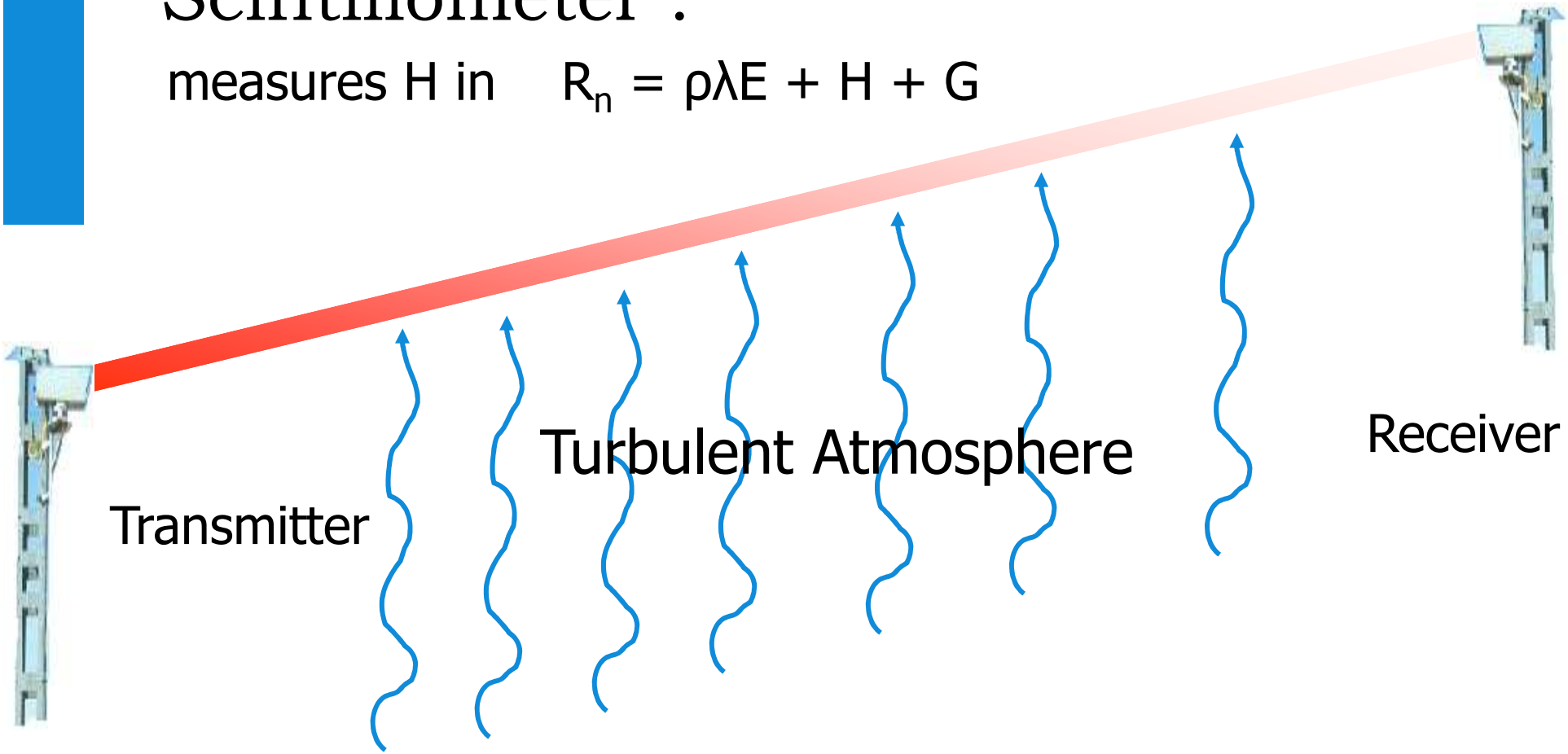
Sonic anemometer

Vertical wind *moisture=>

vertical moisture flux

Scintillometer :

measures H in $R_n = \rho\lambda E + H + G$



Scintillometer