The Abdus Salam
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Educational, Scientific and
Cultural Organization

IAEA
International Atomic Energy Agency

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College on Soil Physics - 30th Anniversary (1983-2013)

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Reference evapotranspiration

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BELGIUM

Food and Agriculture Organization
Land and Water Division

Reference evapotranspiration

Training module Nr. 2
September 2012, prepared by Dirk Raes

Structure of the presentation

1. **Concept of reference evapotranspiration**
2. **FAO Penman-Monteith method**
3. **ETo calculator**

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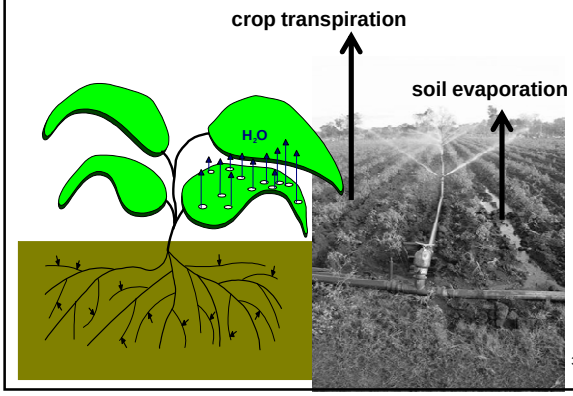
Evapotranspiration (ET)



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Evapotranspiration (ET)

crop transpiration
- weather parameters
- crop characteristics (crop type, development stage, …)
- management and environmental factors (soil fertility, soil water content, …)

soil evaporation
- weather parameters
- environmental factors (soil cover, soil water content, …)

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Evapotranspiration (ET)

	ETo	ETc	ETc_{adj}
▪ weather parameters	~	~	~
▪ crop characteristics	reference	~	~
▪ management and environmental factors	standard non limiting conditions	standard non limiting conditions	~

crop evapotranspiration: standard conditions | non-standard conditions

reference evapotranspiration

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reference evapotranspiration

	ETo	
▪ weather parameters	~	the only factors affecting ETo are weather parameters
▪ crop characteristics	reference	grass reference crop with specific characteristics
▪ management and environmental factors	standard non limiting conditions	no water stress, no fertility stress, no temperature stress, …

ETo is a climatic parameter
it expresses the *evaporating power of the atmosphere*
at a specific location and time of the year
and does not consider crop, soil or management characteristics

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Structure of the presentation

1. Concept of reference evapotranspiration
2. FAO Penman-Monteith method
   ETo computed from meteorological data
   - Penman equation
   - Penman-Monteith equation
   - FAO Penman-Monteith equation

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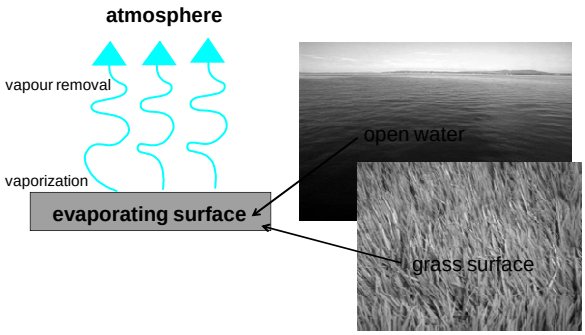
Penman equation

(semi) - empirical equation



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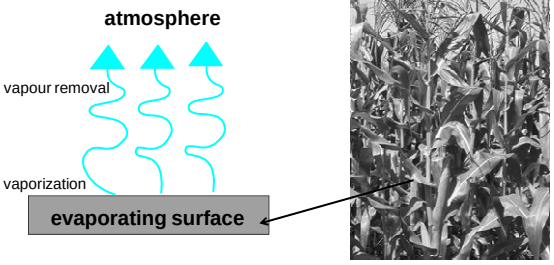
Penman-Monteith equation



any cropped surface

Introduction of resistance factors

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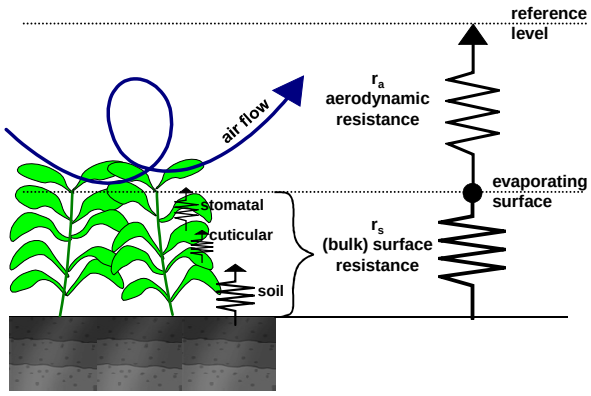
Penman-Monteith equation



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Penman-Monteith equation

$$ET = \frac{1}{\lambda} \frac{\Delta (R_n - G) + \rho_a c_p \frac{(e_s - e_a)}{r_a}}{\Delta + \gamma \left[1 + \frac{r_s}{r_a}\right]}$$

?

local calibration of resistances (r_s and r_a) require demanding and expensive studies

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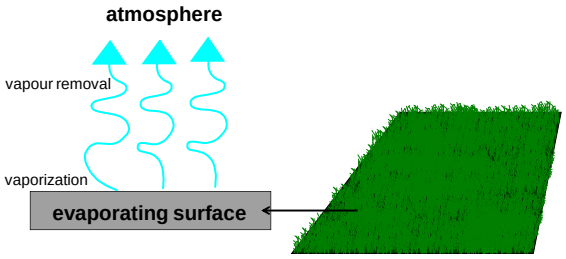
FAO Penman-Monteith equation



hypothetical grass reference with well-defined characteristics

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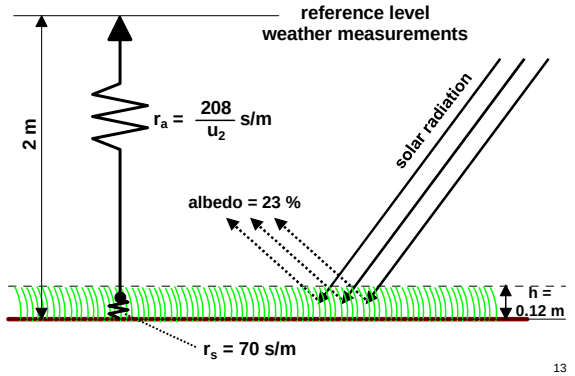
unambiguous defined hypothetical grass surface



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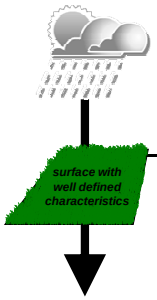
Input is meteorological data recorded in weather station



ETo computed from meteorological data with the FAO Penman-Monteith equation

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

Output:
ETo: evaporating power of the atmosphere

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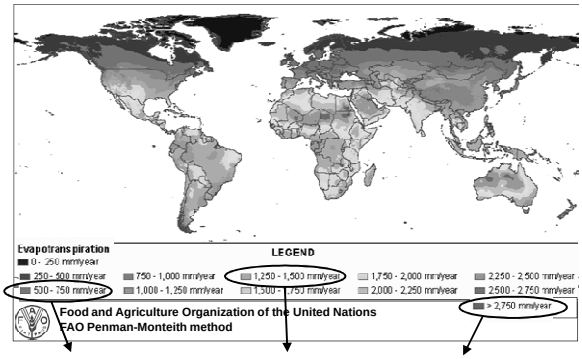
Evaporating power of the atmosphere (ETo) in mm/year



~ 2 mm/day ~ 4 mm/day ~ 8 mm/day

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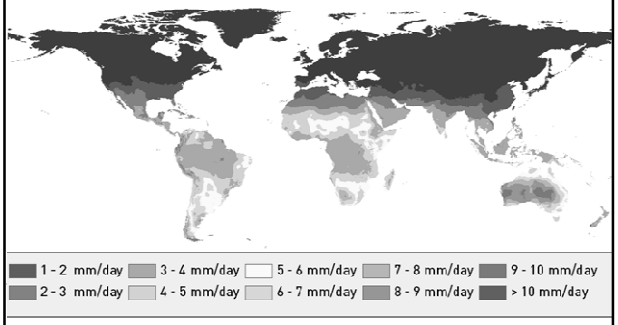
mean monthly reference evapotranspiration (ETo) for January



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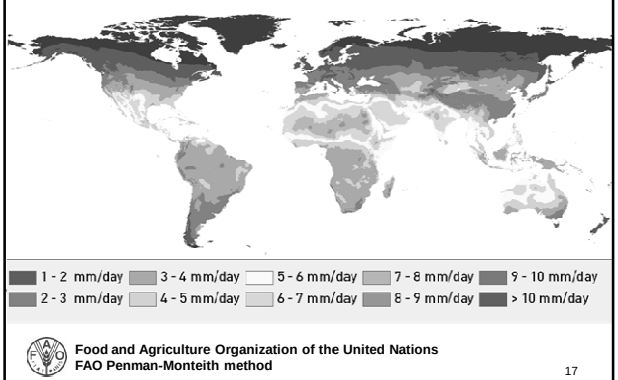
mean monthly reference evapotranspiration (ETo) for April



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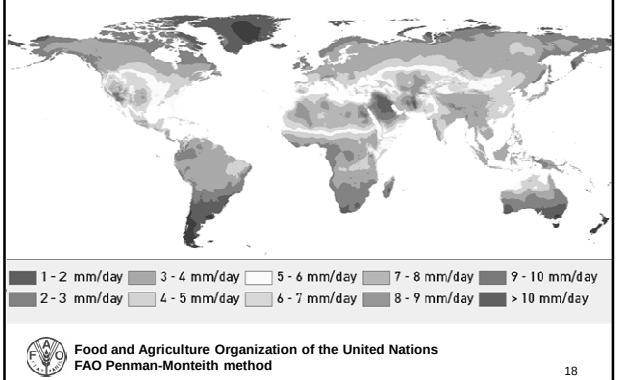
mean monthly reference evapotranspiration (ETo) for July



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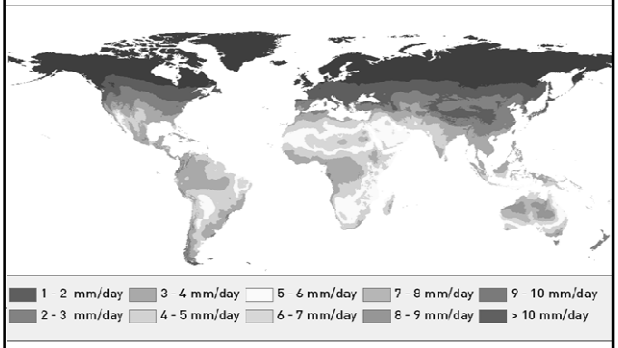
mean monthly reference evapotranspiration (ETo) for October



Food and Agriculture Organization of the United Nations
FAO Penman-Monteith method

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Structure of the presentation

1. Concept of reference evapotranspiration
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   ETo computed from meteorological data
   - Penman equation
   - Penman-Monteith equation
   - FAO Penman-Monteith equation

→ ETo estimated from pan evaporation

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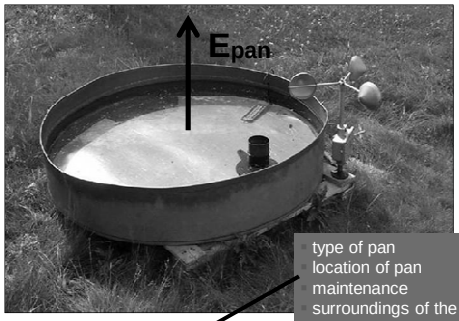
Pan evaporation method



- type of pan
- location of pan
- maintenance
- surroundings of the pan

$ETo = K_{pan} E_{pan}$

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Structure of the presentation

1. Concept of reference evapotranspiration
2. FAO Penman-Monteith method
3. → ETo calculator

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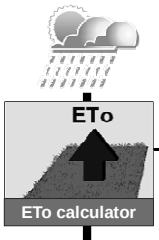

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Output:
ETo: evaporating power of the atmosphere

AQUACROP

AquaCrop

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