Day 1 Afternoon Session
Lecture 4

RS/GIS Awareness Workshop

Observing River Basins from Space: Why is it Important for IWMI
A Remote Sensing and GIS (RS/GIS) Workshop for IWMI by IWMI
June 28th at Board Room of IWMI Headquarters in Sri Lanka

ET Krishna Basin

by

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SEBAL: A technical introduction (da-nitty-gritty)

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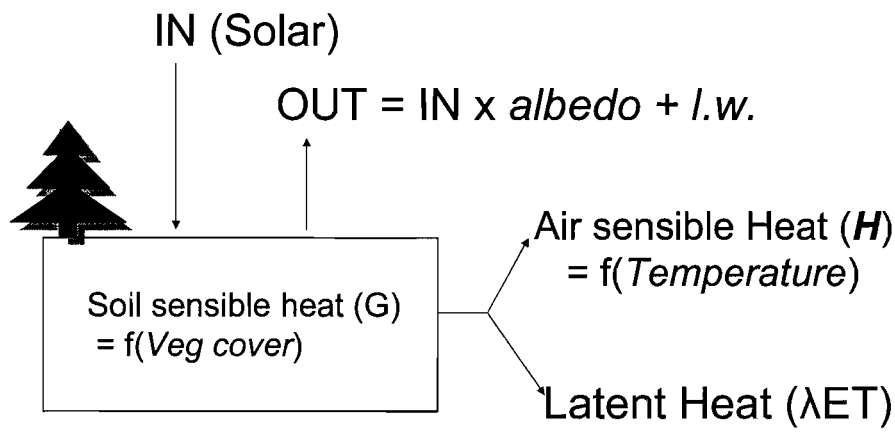
Outline

- Basic assumptions
- What matters?
- Why the over-estimation in Krishna Basin?
- When/where/why to apply?

SEBAL—Surface Energy Balance Algorithm

$$\lambda ET = (IN - OUT - G) - \boldsymbol{H}$$

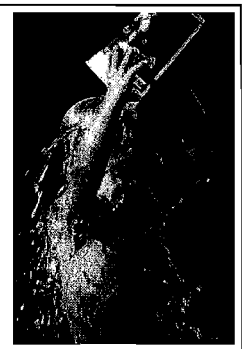


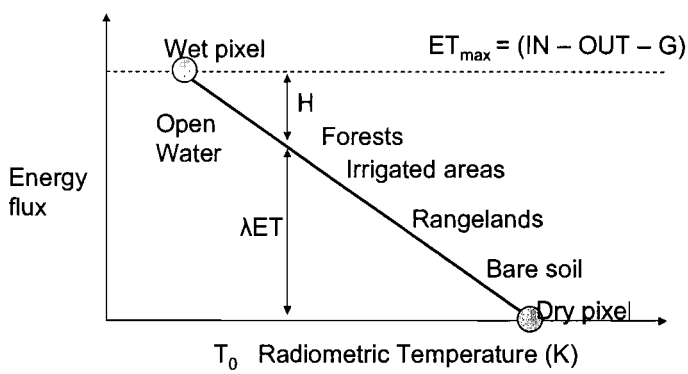
SEBAL's Main Assumption:

$$ET = IN - OUT - G - (a + bT_0)$$

ET = 0 for "dry" pixel

$ET = ET_{max}$ for "wet" pixel





Other Assumptions:

- Uniform wind speed over whole image
- Vertical heat transport only (no horizontal exchange between cells)
- Evaporative fraction remains constant over day, and between images

- These assumptions are difficult to validate…

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List of the variables: Looks complicated! > 20 variables

- Input variables
  - Met station (1 location)
    - Wind speed
    - Air temp
  - Satellite image
    - Visible, NIR bands
    - Cloud-free
    - Center of image (!)

Derived variables

R_n	10 variables Albedo Tau (atmos transmiss) Longwave radiation
G	6 variables NDVI, albedo, T_o
H	16 variables Thermal emissivity Aerodynamic properties zom zoh

Details: Important and not-so-much (IN-OUT-G)

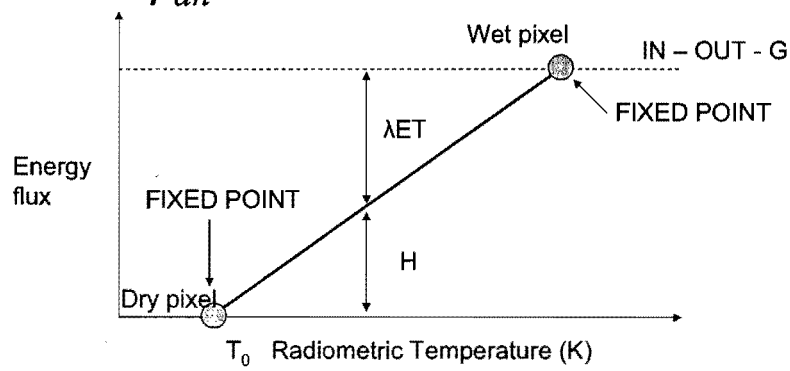
- ***Tau*** (atmospheric transmissivity) – determines IN (SWAT assumes 0.8, measured values ~0.69)
- ***Albedo*** -- determines OUT
- Wet and dry pixel selection
- *Assumption that λET=(IN-OUT-G) wet, and ET=0 dry*
- Calculation of G—especially over water bodies

- Unimportant: Most of the H details
  - Wind speed—other variables (rah, a, b) adjust to fit the assumed H vs T curve
  - Absolute value of surface temperature—only relative values important

Why wind speed, r_{ah} irrelevant?

$$\lambda ET = (IN - OUT - G) - \mathbf{H}$$

$$H = \frac{\rho C_p dT}{r_{ah}} \qquad H = \frac{\rho C_p (a + bT_0)}{r_{ah}}$$



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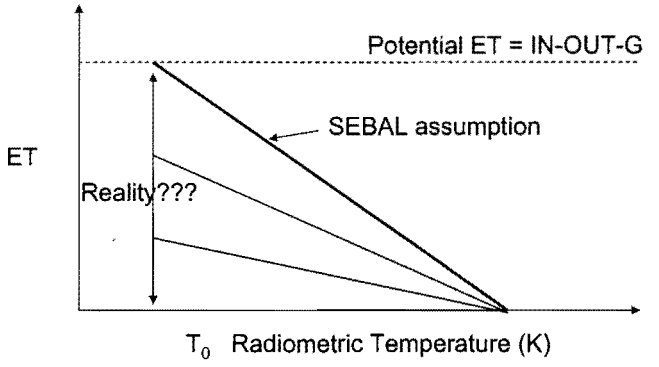
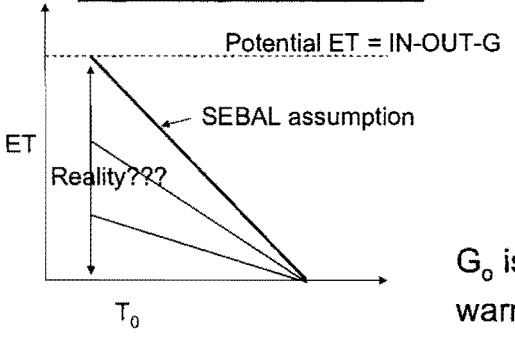
Why the ET overestimation?
1. Too high ET from "Wet" pixel

(...but gives deceptively reasonable results, since ET is forced to scale between 0 and potential ET)



"Soil" heat balance for reservoirs

≠



SEBAL assumes:

G_0 ~ 8-13% of IN-OUT

G_{24} ~ 0

** Both too low. **

G_0 is up to 60% of Rn during lake warming (in the temperate zone)

Overestimation: Possibility 2
Heterogeneity and scaling effect

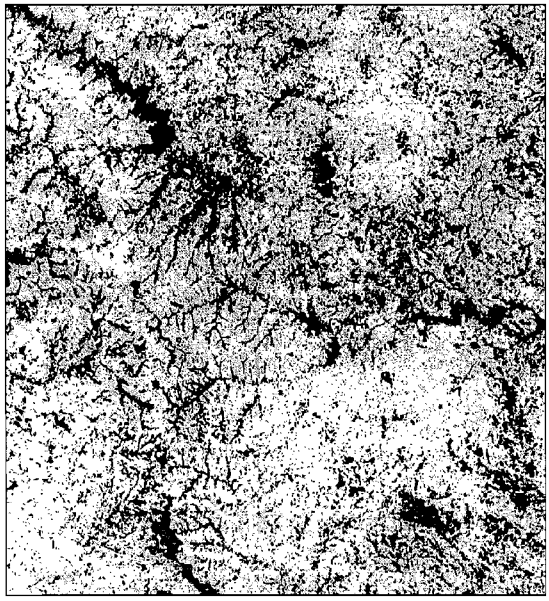
Oasis effect:

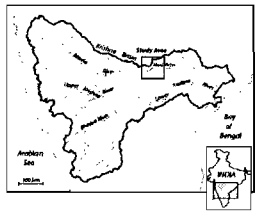
Wind can blow heat from one pixel to the next,
messing up T0 – H relationship

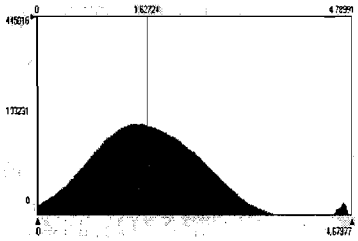
Heterogeneity—

Many studies find average variables work ok....
but more uncertain in highly heterogeneous gwtr irrigated envt

Landsat7 ETM+,
December 2001

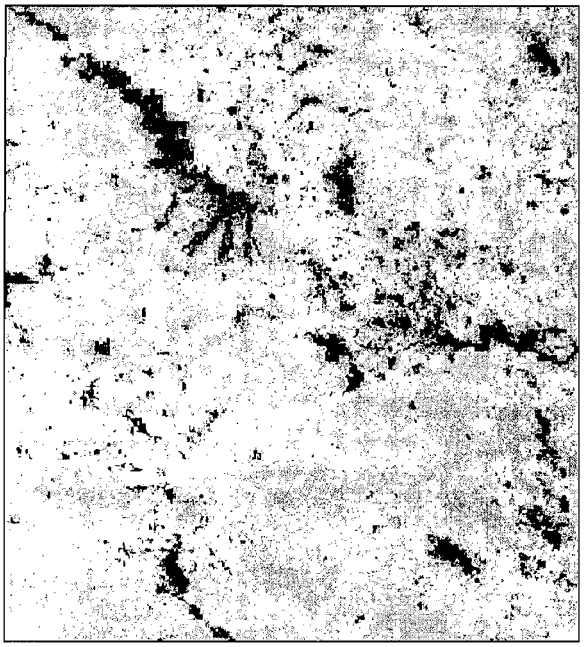






Source: Mobin

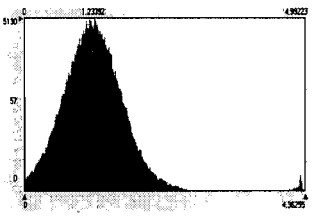
Scale discrepancy: MODIS vs Landsat



Scene Average:

MODIS ET: 1.2 mm
Landsat: 1.6 mm

...but this takes us in the wrong direction!



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Past successful applications

- Rechna Doab—5-20% error in ET
- Sri Lanka – 5% error

Most valid for:

1. Large, homogeneous irrigated areas
2. Crops—aerodynamics better understood and uniform
3. Situations where ET is close to PET for "wet pixels…less likely overestimation

What can we learn? A Hierarchy of certainties

- Spatial patterns in NDVI, albedo
- Spatial patterns in relative ET values
- Snapshot comparisons of relative values
- Dry season trends
- Dry season ET, water productivity
- Annual trends
- Annual water balances
- Inter-annual water balances
- Crop production
- Stream flow prediction/modeling

Certain

Increasing uncertainty

Highly uncertain

Conclusions

- SEBAL most useful for spatial distribution of relative ET
- Not plug-and-play for seasonal ET; other methods (crop growth modeling + Penman-Monteith) might prove more robust
- Fairly easy to learn and apply---~10 hours from beginning to end for 1 image
- Needs refining, but what's the alternative?