Estimation of Regional Surface Resistance to Evapotranspiration from NDVI and Thermal-IR AVHRR Data

Nemani, RR and SW Running. 1989. Journal of Applied Meteorology. 28 (4): 276- 284

Review

- Evapotranspiration (ET) is integral to they hydrologic cycle but it is difficult to measure on large scales
- Potential Evapotranspiration (PET) can be easily estimated but it doesn't take in to account the peculiarities of different plants.
- The Monteith-Penman Equation can be used to determine ET from PET

Review

- Prior to the article some models for remote sensing had been created but they were specific to certain vegetation types and/or required knowledge of the study environment that might not be easily measurable

- Ideally, models with a broad application should be created

Goal of the study

- Validation of a remote sensing technique
- Does remotely sensed data for seasonal trends between vegetation density and surface temperature match relationships known to be true
- Because regional canopy resistance is hard to measure another model (FOREST-BGC) will be used to represent this variable
  - Model is proven to be accurate for the forest in the study
  - Results are context specific

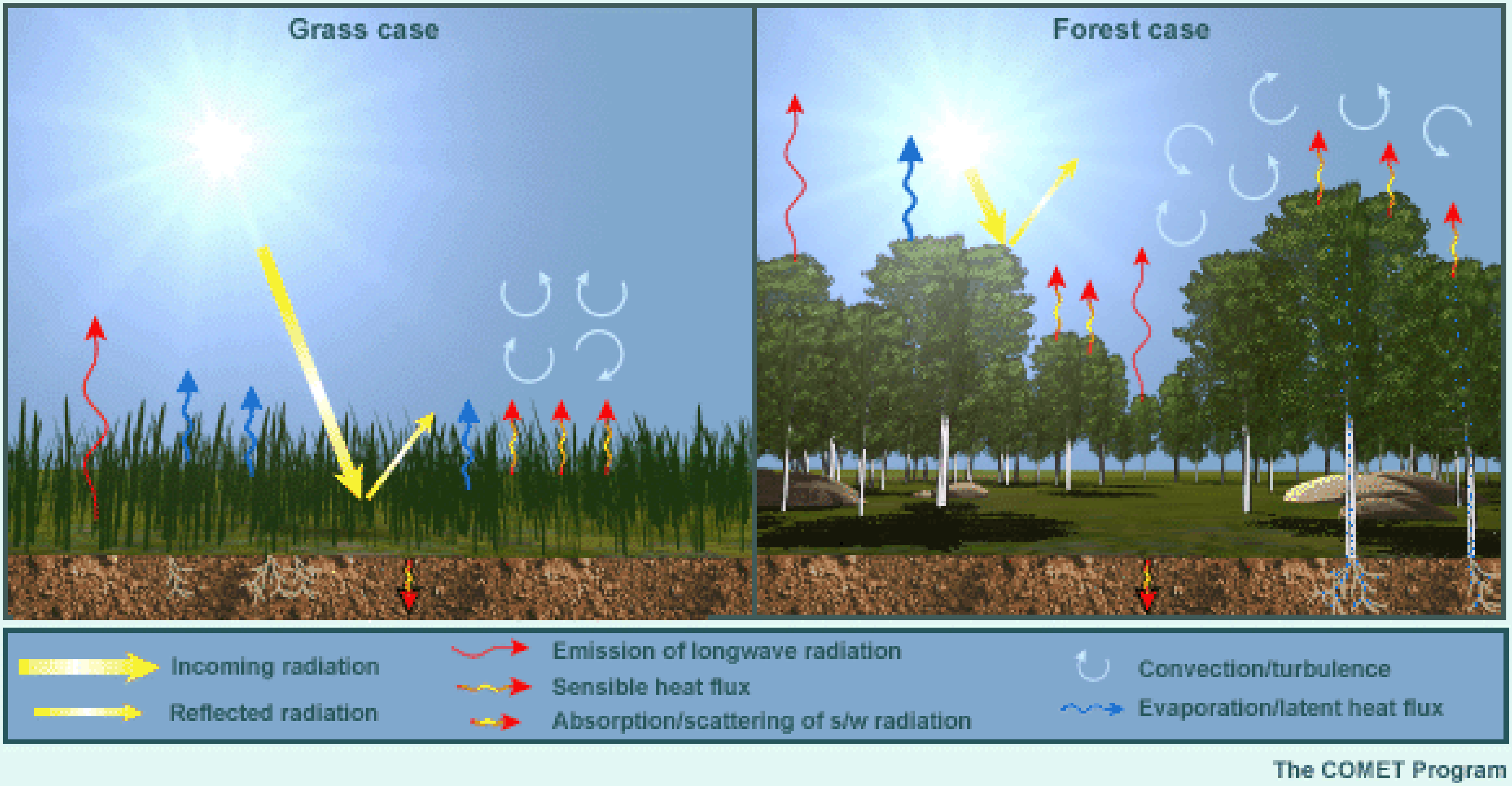
Theory

$$\mathrm{LE} = \frac{sR_n + \rho_{c_p}(\mathrm{VPD}/R_a)}{s + \gamma(1 + (R_c/R_a))}$$

- You can modify the Montheith- Penman Equation (above) to focus on the most important parameters for the environment you are studying

$$\mathrm{LE} = \frac{sR_n}{s + \gamma(1 + (R_c/R_a))} + \frac{\rho_{c_p}(\mathrm{VPD}/R_a)}{s + \gamma(1 + (R_c/R_a))} \quad (3)$$

- In this case split up the energy and aerodynamic components
- For tall vegetation aerodynamics are more important


Grass case
Forest case
Incoming radiation
Reflected radiation
Emission of longwave radiation
Sensible heat flux
Absorption/scattering of s/w radiation
Convection/turbulence
Evaporation/latent heat flux
The COMET Program

Theory

- You can again simplify within the aerodynamic components

$$\frac{\rho c_p(\mathrm{VPD}/R_a)}{s + \gamma(1 + (R_c/R_a))}$$

- Rough surfaces have more turbulance and aerodynamic Resistance (R_a) is low enough to be ignored leaving you with

$$\mathrm{LE} = \frac{\rho c_p}{s + \gamma} \frac{\mathrm{VPD}}{R_c}$$

- R_c is complex but you should be able to use Canopy Temperature /NDVI as a proxy

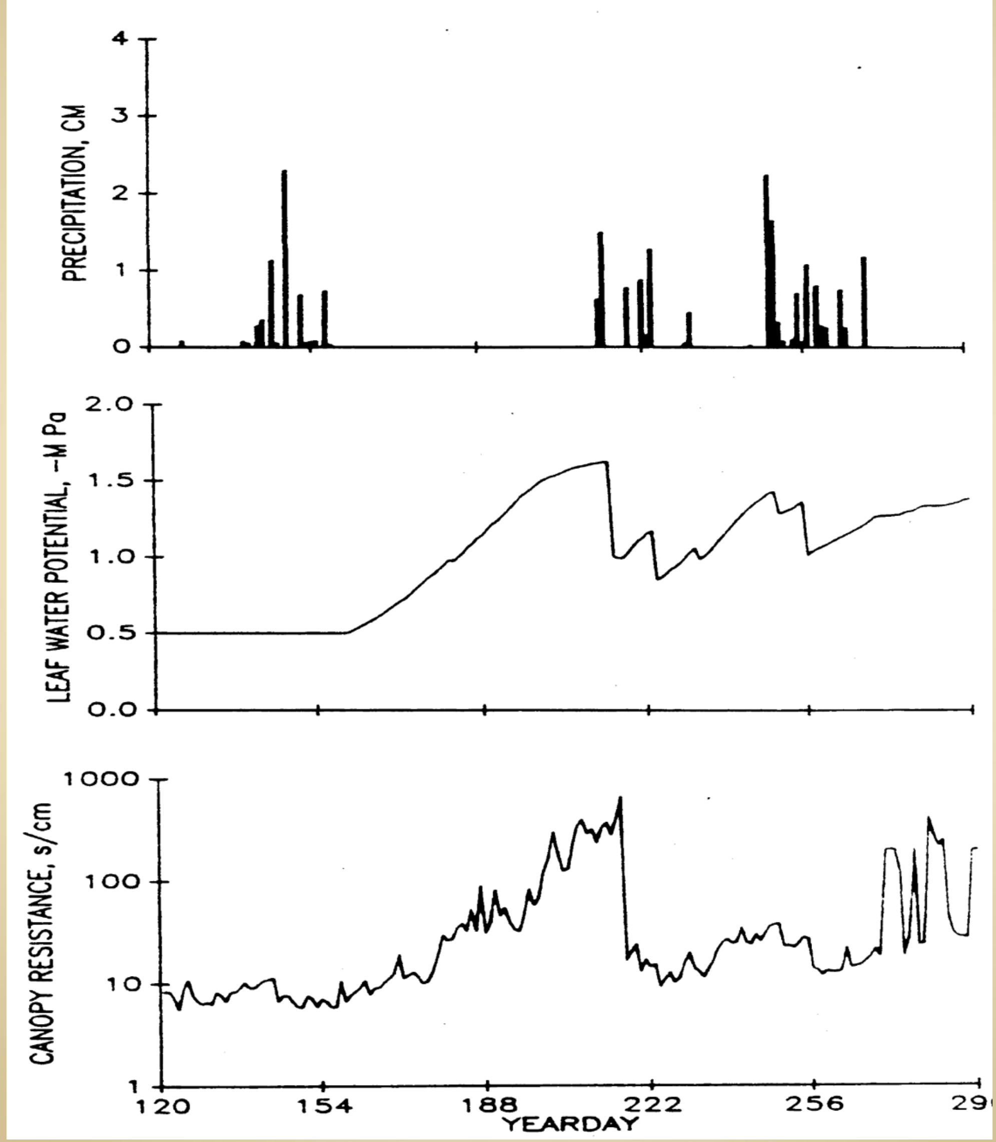
Methods

- Used 20x25 km area in Monta
  - Very vegetated (90% conifers)
  - Mountainous
  - Well studied
- Data from NOAA-9/AVHRR 14
  overpass
- 8 summer days were chosen

Methods

- Used FOREST-BGC to determine water stress
- FOREST-BGC calculates multiple outputs (ET, photosynthesis, etc.) with minimal inputs (air temp, dew point etc.)
- For this study canopy resistance, ET, hydrologic balance and canopy water stress were used
- Model was run for whole year then 8 days were selected for hourly averages of canopy conductance at the time of the overpass

Estimates from FOREST-BGC

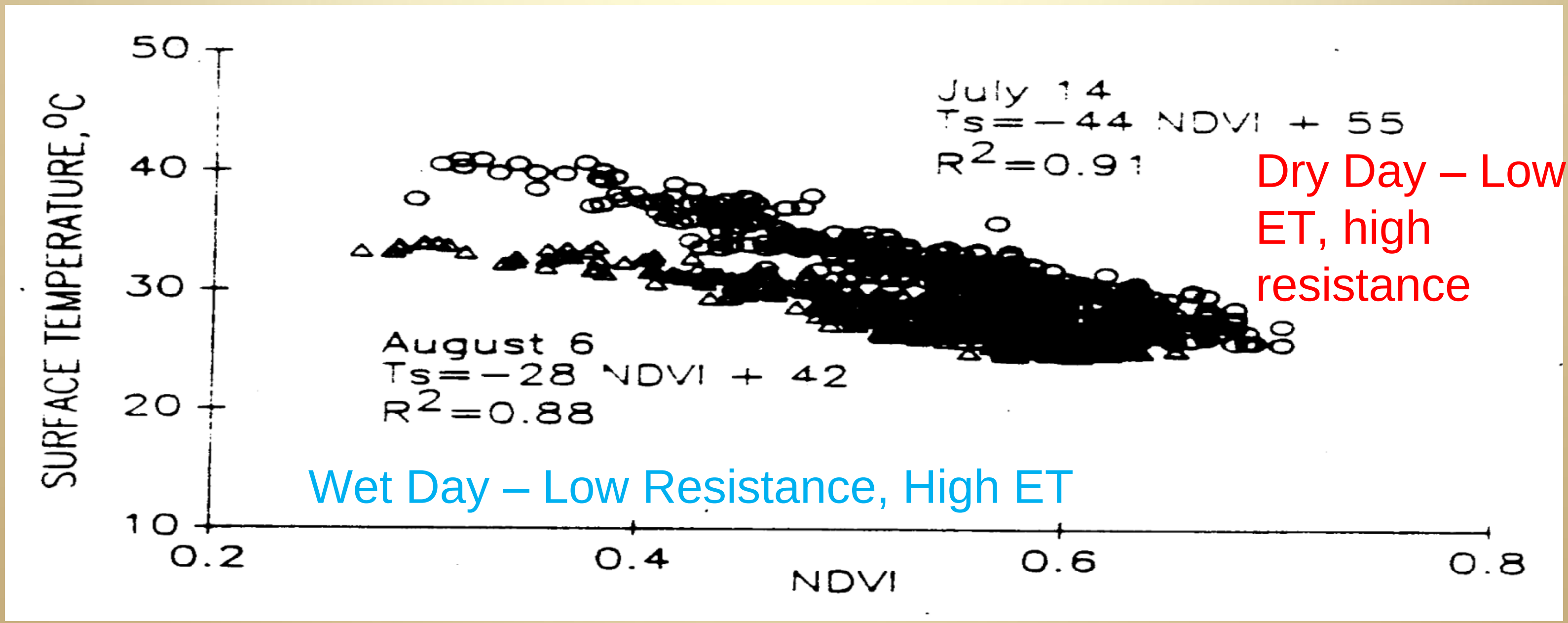


Methods

- Determined NDVI $$NDVI = \frac{NIR - RED}{RED + NIR}$$
- Determined Surface Temperature (Ts)

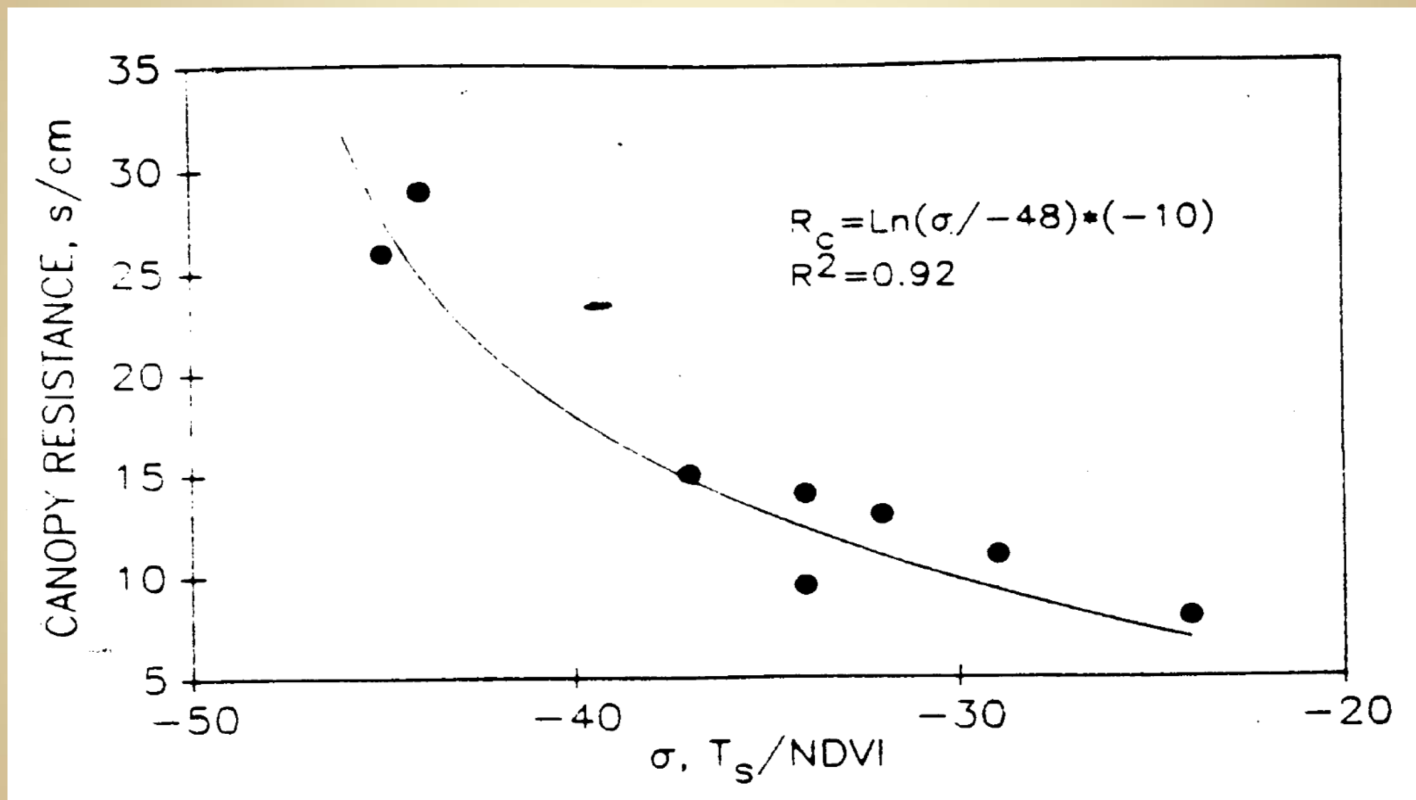
$$T_s = 1.764Tb4 - 0.764Tb5 + 0.78$$

- Plotted Surface Temperature against NDVI



Results

- Surface temperature and NDVI are strongly negatively correlated
  - Differences between the 2 example days are explained by available moisture
- Seasonal trends in canopy resistance had 3 periods
  - Late spring early summer (adequate moisture, low VPD)
  - Midsummer (low moisture, high VPD)
  - Late summer (recovered soil moisture, moderate VPD)
- The relationship between R_c and Canopy Temperature /NDVI is non-linear



35
30
25
20
15
10
5
CANOPY RESISTANCE, s/cm
R_c = Ln(σ/−48)*(−10)
R² = 0.92
−50
−40
−30
−20
σ, T_s/NDVI

Conclusions

- Canopy Surface Temperature/NDVI can be used to show changes in canopy resistance
- May not give accurate estimates
- Will still be useful in other equations
- Can be used to determine air temperatures
- Improved estimated compared to older models