Surface Flux Estimates with ASTER Thermal Infrared data

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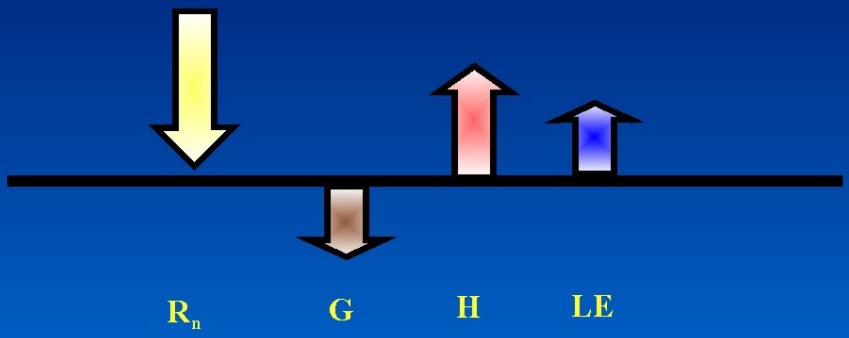
SURFACE ENERGY BALANCE

$$R_n = G + H + LE$$



FLUX EQUATIONS

Resistance formulation

$$F = \frac{c_2 - c_1}{r_{1,2}}$$

Where $c_{1,2}$ are the values of the quantity at the levels $z_{1,2}$ e.g. temperature, vapor pressure, etc. and $r_{1,2}$ is the resistance to flow or transfer coefficient

SENSIBLE HEAT

$$H = \rho c_p \frac{T_{air} - T_{aero}}{r_a} \quad (W/m^2)$$

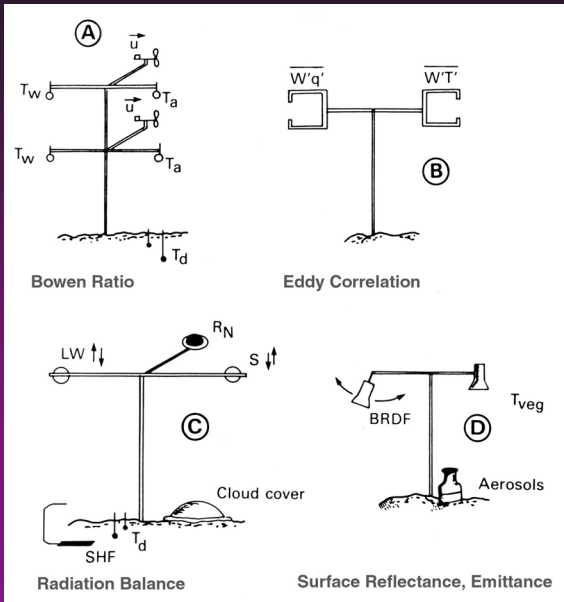
Where ρ is the density of air, c_p is the specific heat, T_{air} is the air temperature above the canopy, T_{aero} is the aerodynamic temperature in the canopy air space, r_a is the aerodynamic resistance.
T_{rad} - T_{aero} = f(Solar radiation, LAI, Soil Moisture, etc)

LATENT HEAT

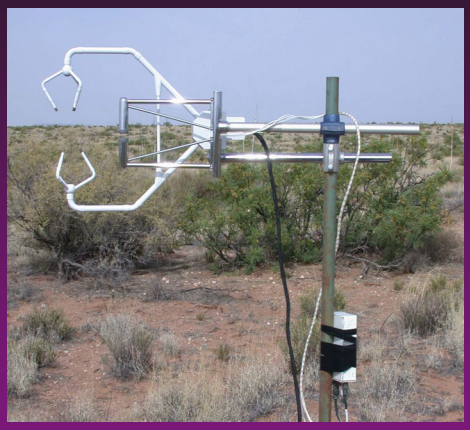
$$LE = \rho c_p \frac{e_{air} - e_s}{\gamma(r_a + r_{stom})} \quad (W/m^2)$$

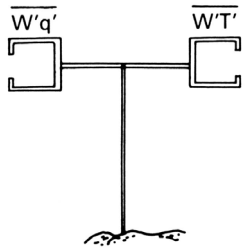
Where γ is the psychrometric constant, ρ is the density of air, c_p is the specific heat, e_{air} is the vapor pressure above the canopy, e_s is the saturation vapor pressure at T_{air}, r_a is the aerodynamic resistance r_{stom} is stomatal resistance.

Surface Measurements



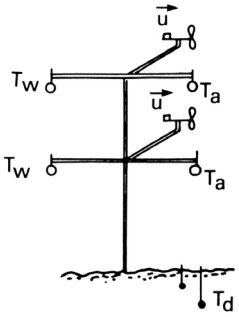
Eddy Correlation





Eddy Correlation

Bowen Ratio: B = H/LE



Bowen Ratio

Using Remote Sensing Data from ASTER

Surface fluxes estimation using

Remote sensing data

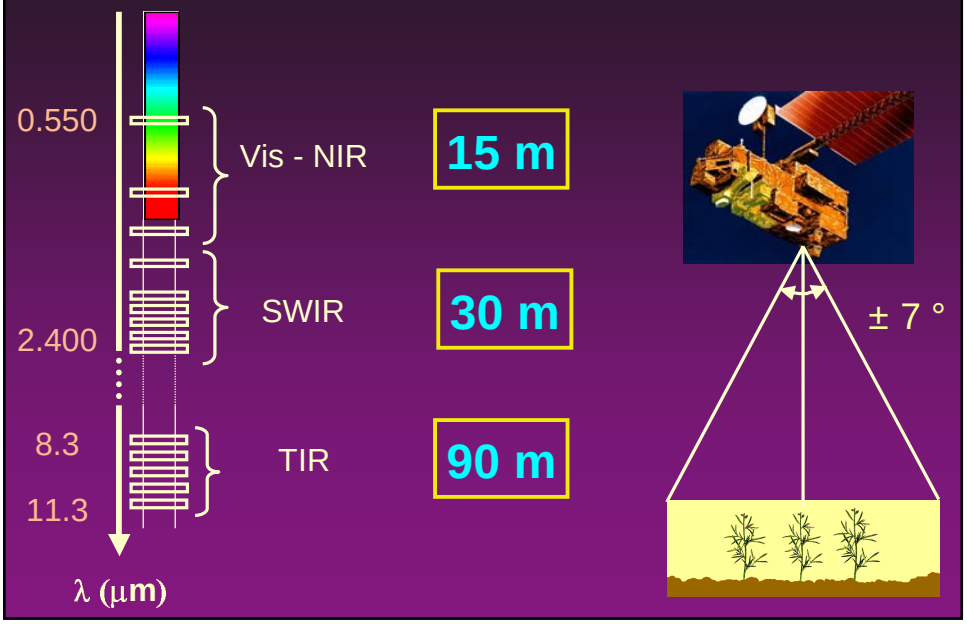
ASTER sensor
90 m imagery

Energy balance model

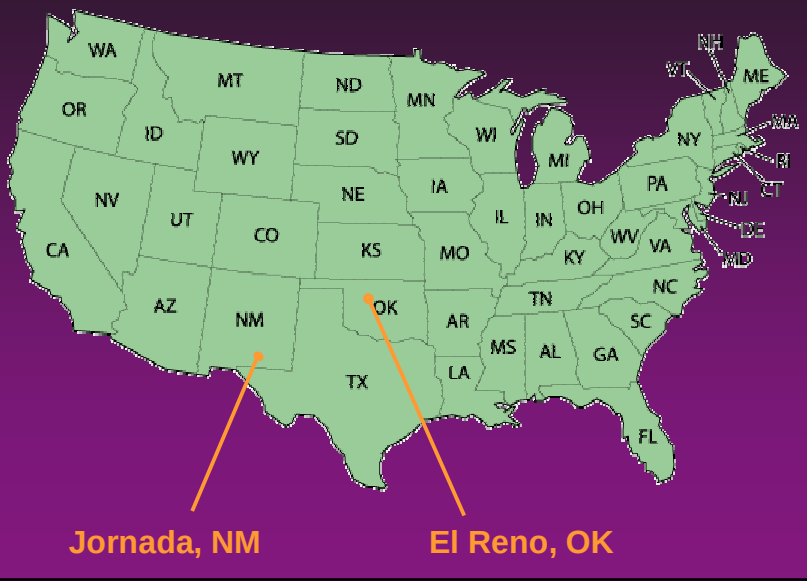
One source (SEBAL) and
two source (TSEB) approaches

Validating and comparing
TSEB and SEBAL over Jornada, NM & El Reno, OK

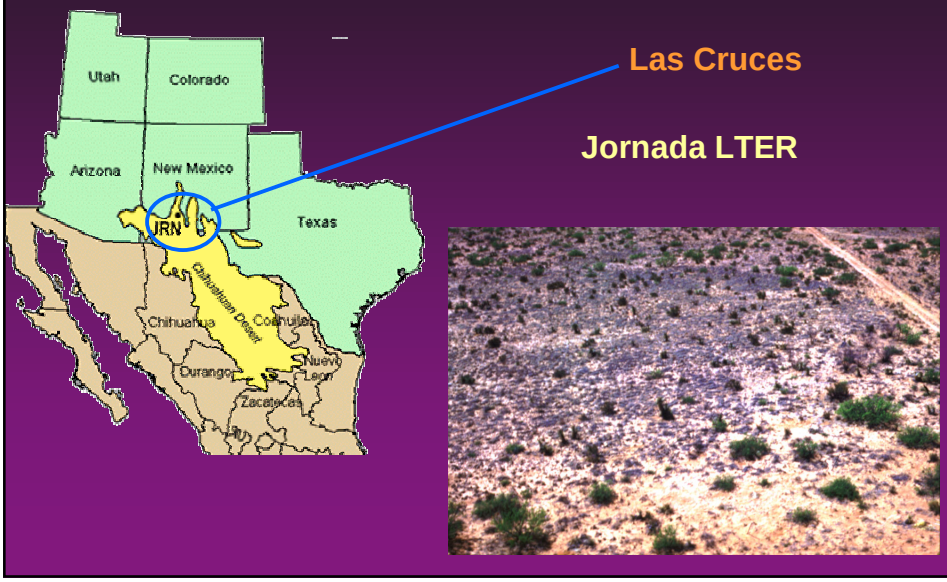
ASTER sensor



Study areas



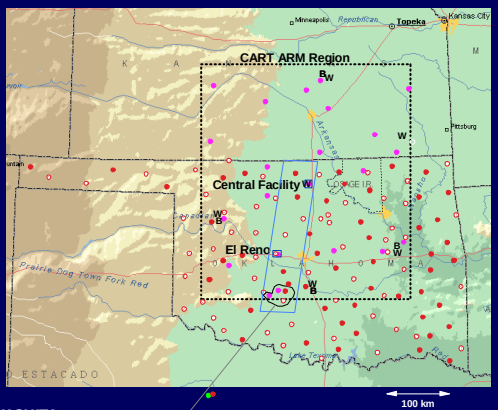
Jornada, NM Site



El Reno, OK Site

SGP97

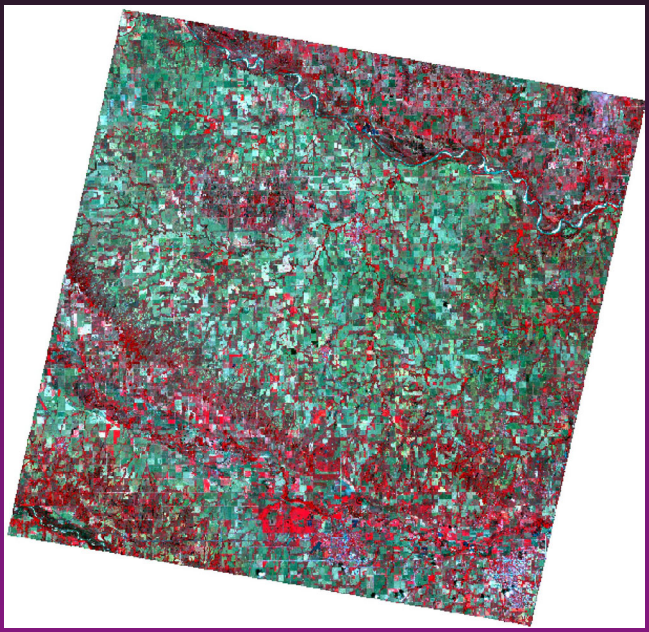
- Testbed
  - 10,000 km^2
  - 1 month



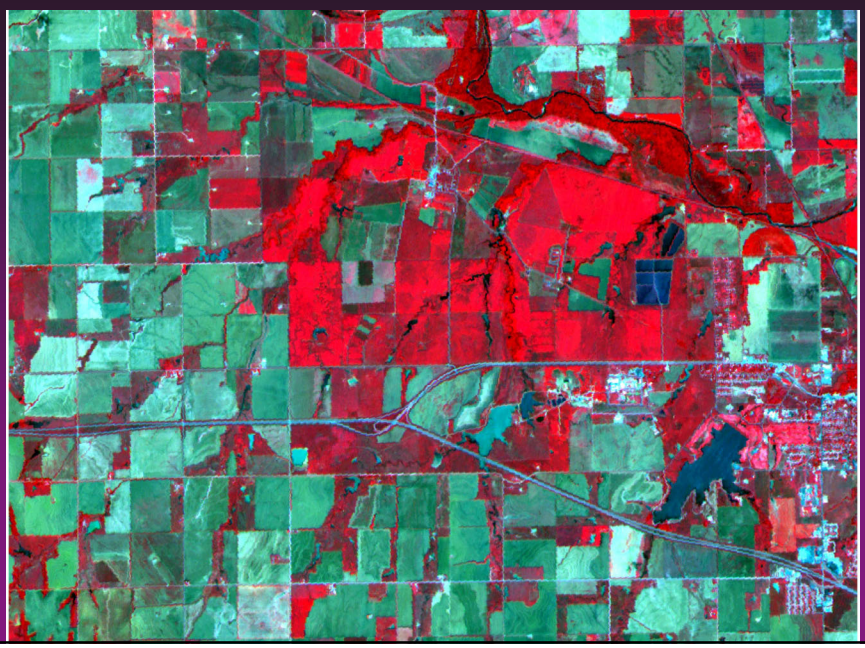
- Micronet with Soil Moisture
- Mesonet
- Mesonet with Soil Moisture
- ARM with Soil Moisture
- x NOAA Flux

- ARM CART
- Mesonet
- Mesonet with Soil Moisture
- W ARM Wind Profiler
- B ARM Boundary Facility

ASTER 60x60 km Scene June 10, 2002

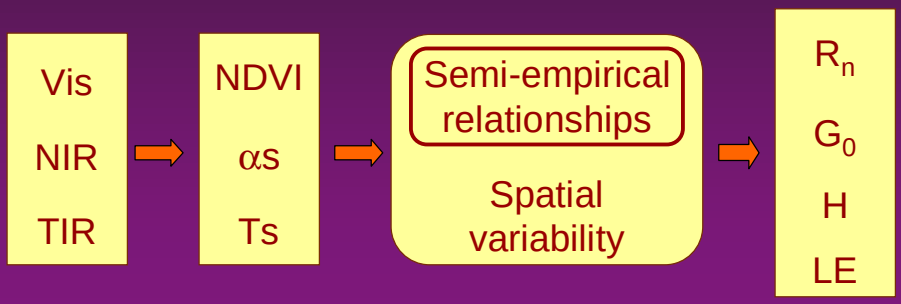


ASTER - El Reno, Oklahoma - June 10,2001



One source model : SEBAL

Spatialization procedure (Bastiaanssen, 1998)



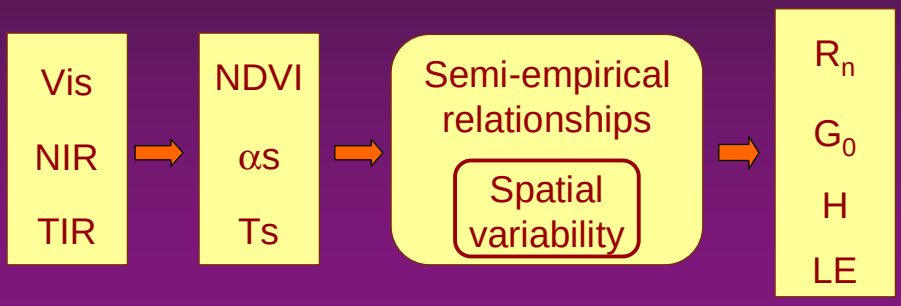
SEBAL : semi-empirical relationships

$$G_0 = R_n \times \underbrace{F_1(T_s, \alpha_s)}_{\text{Bare soil}} \times \underbrace{F_2(NDVI)}_{\text{Canopy extinction}}$$

$$H \leftarrow \begin{cases} Z_{0m} = \exp(a.NDVI + b) \\ Z_{0h} = Z_{0m} \times 0.1 \end{cases}$$

One source model : SEBAL

Spatialization procedure (Bastiaanssen, 1998)



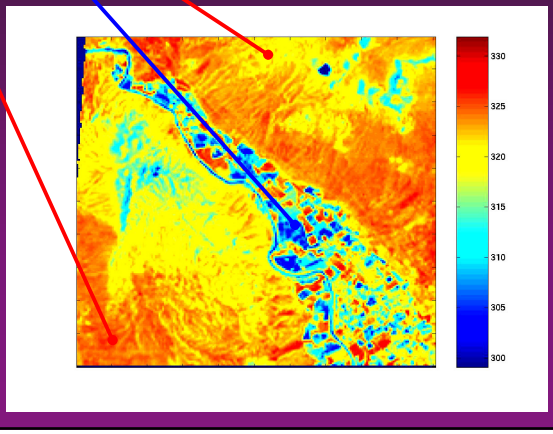
SEBAL : Spatial Variability, Jornada Example

$$H = \rho . C_p \frac{Ts - Ta}{Ra(u)}$$

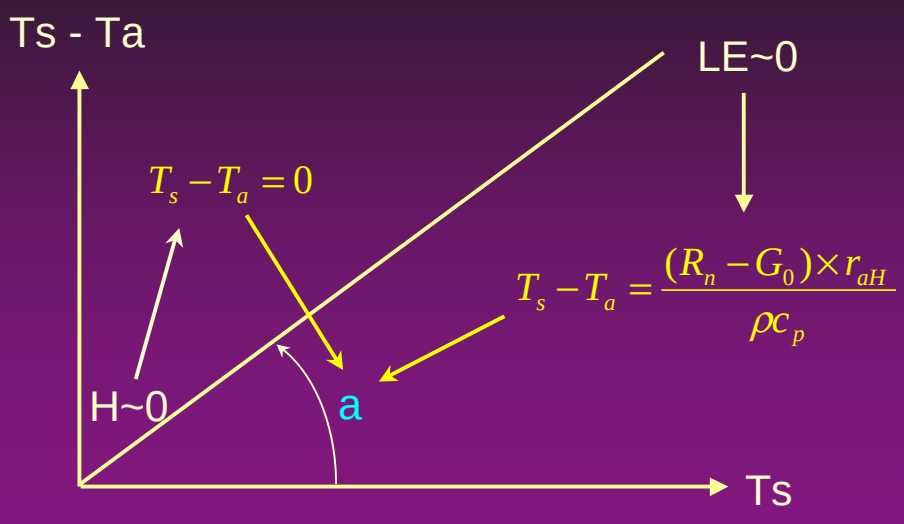
Variations

Ts

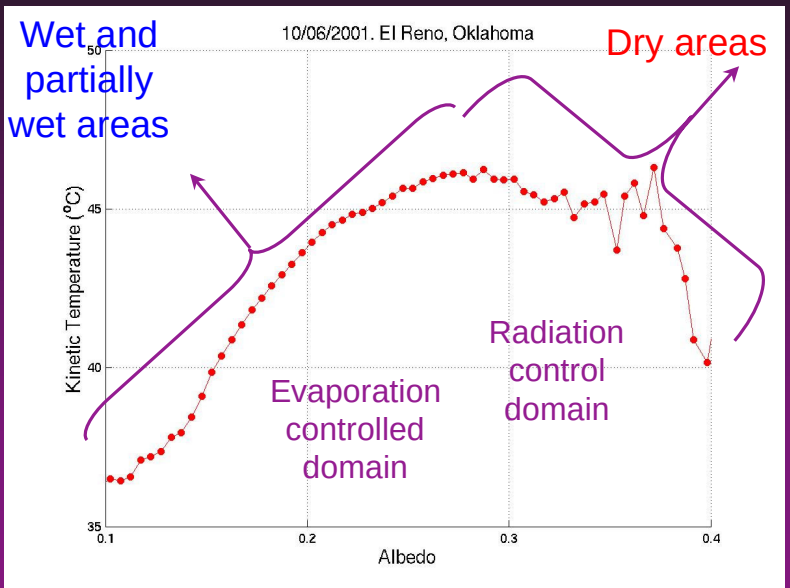
Dry areas properties



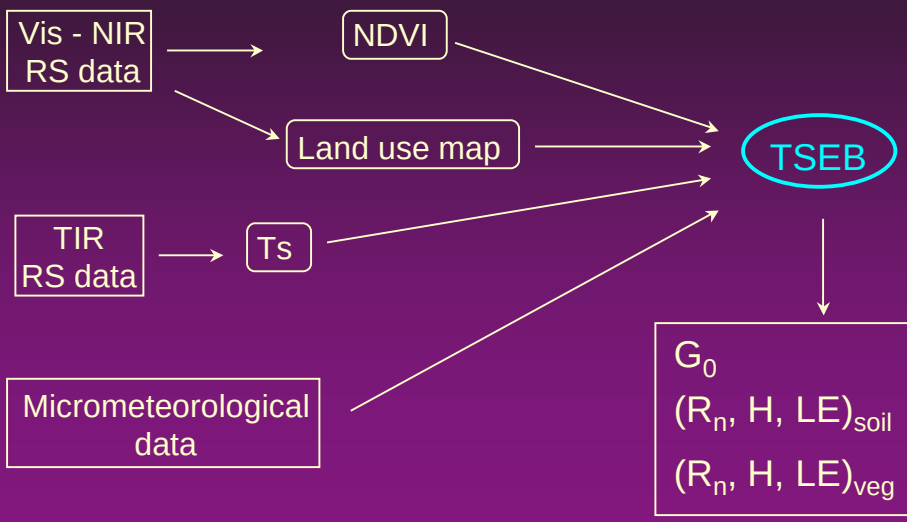
SEBAL : air temperature



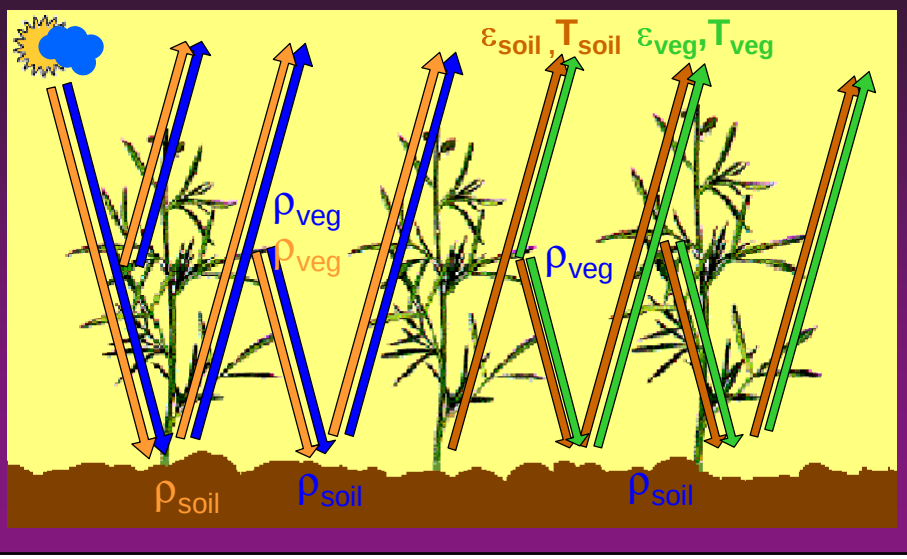
SEBAL : allocating dry & wet areas



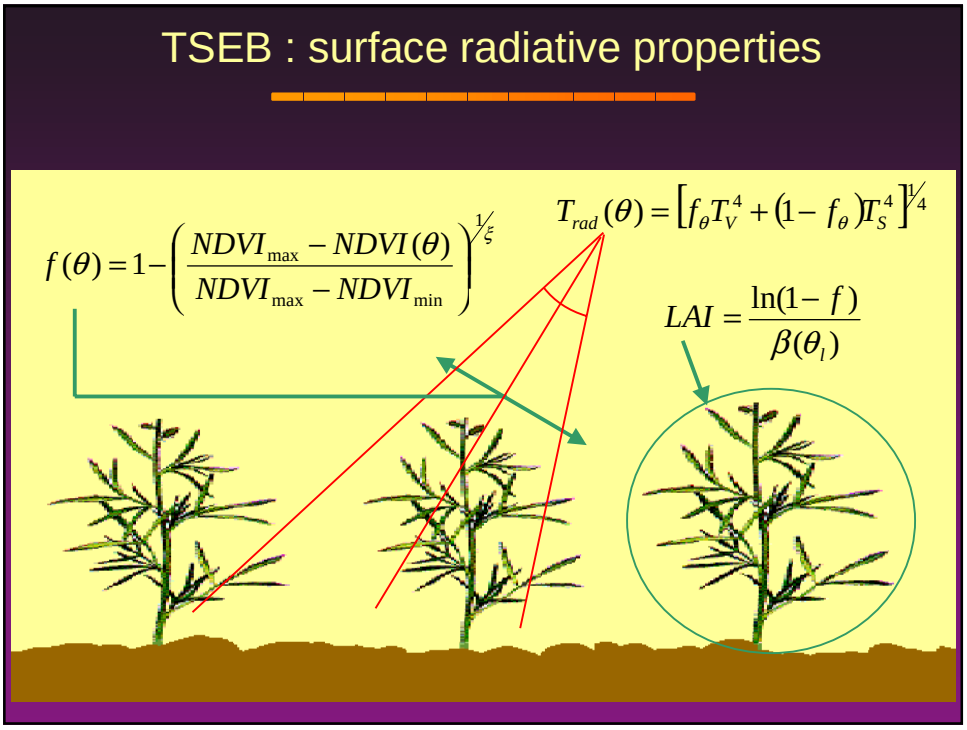
Two source model : TSEB



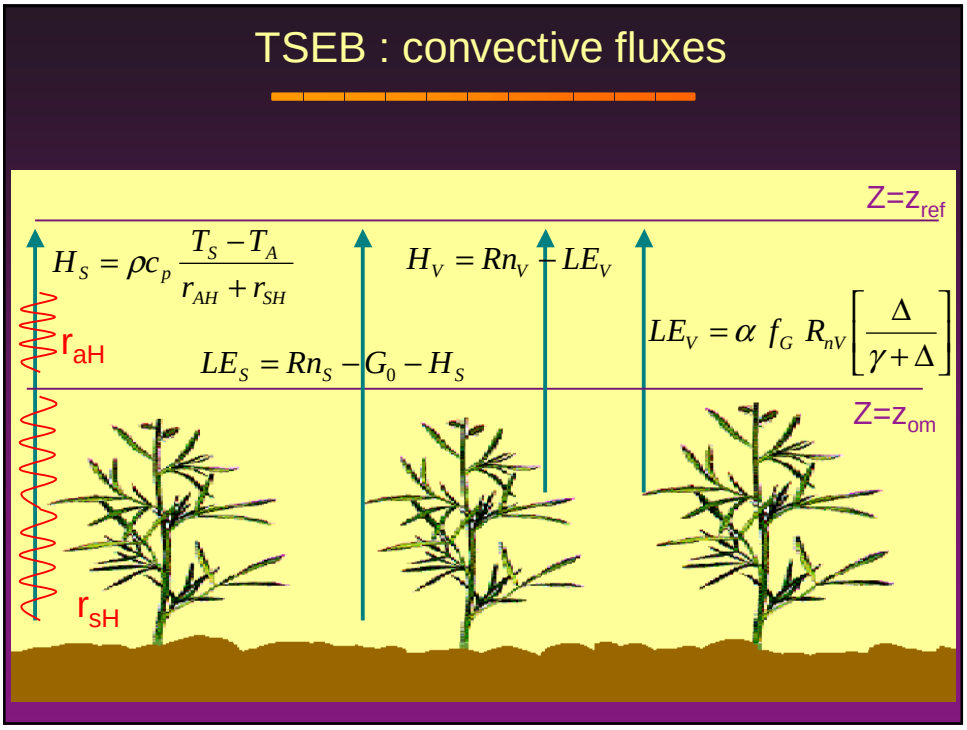
TSEB : radiative transfers



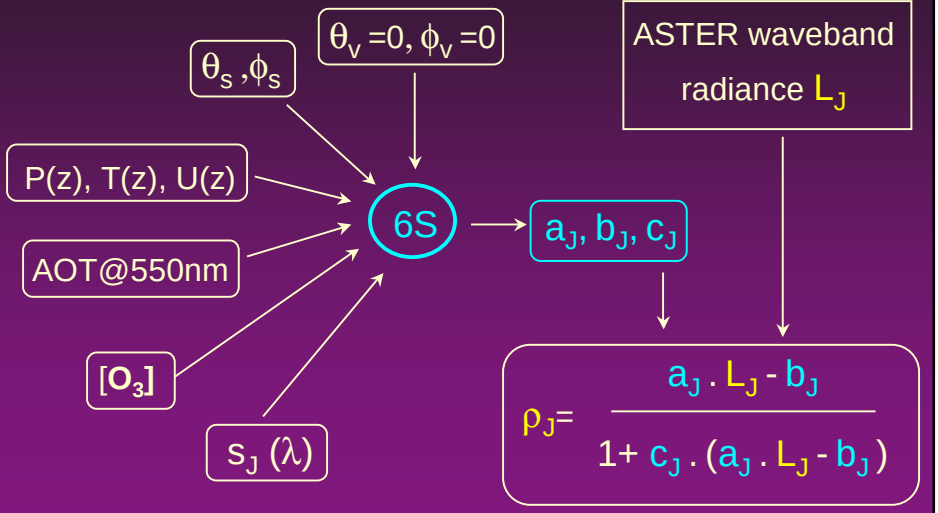
TSEB : surface radiative properties



TSEB : convective fluxes

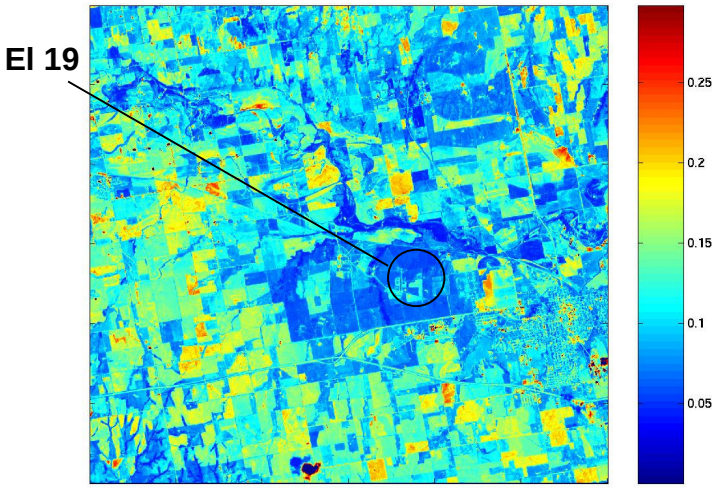


ASTER Vis-NIR data preprocessing

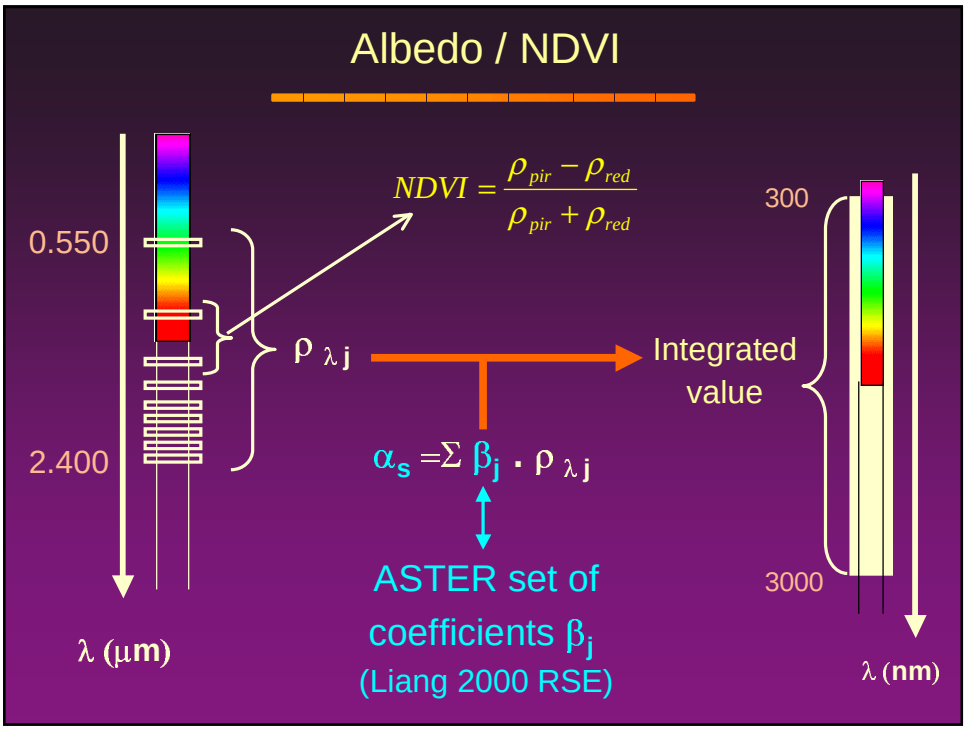


El Reno Pastures – EL 19

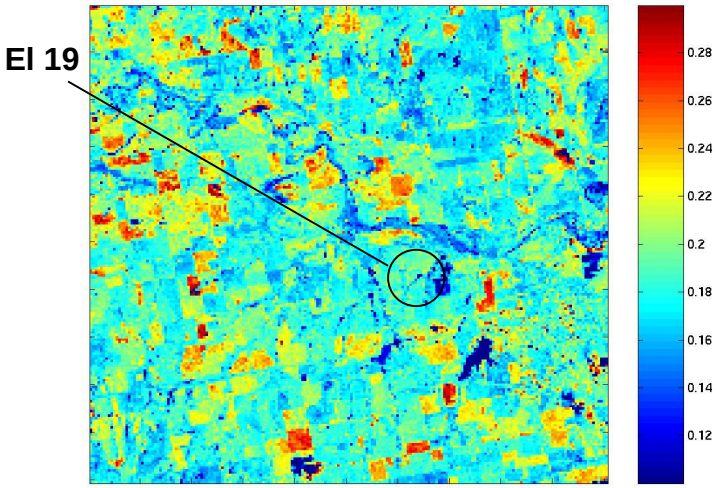
ρ @ 660 nm over El 19 area (June, 10, 2001)



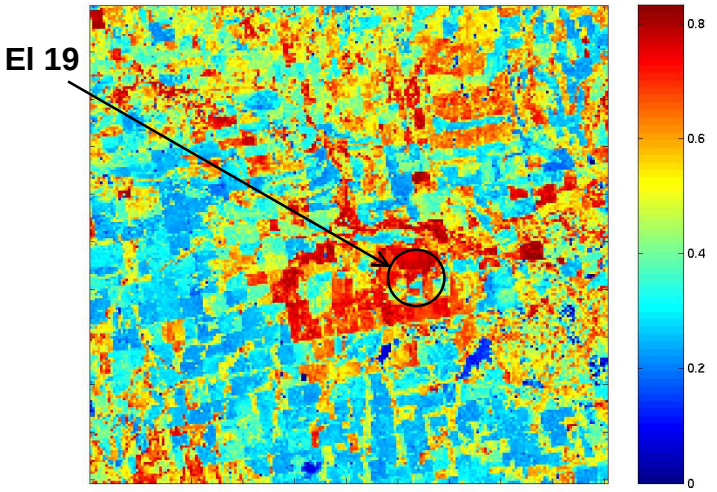
Albedo / NDVI



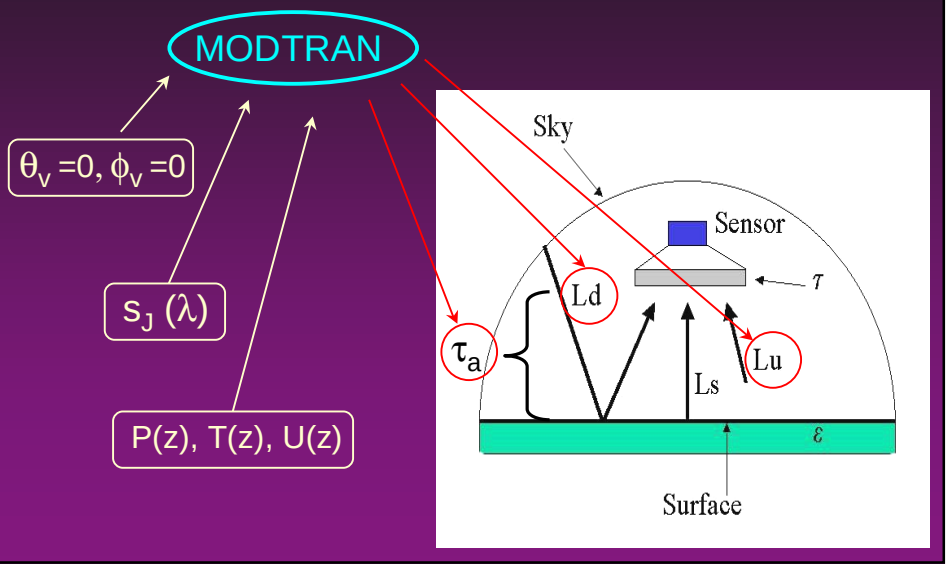
Albedo map over El 19 area (June, 10, 2001)



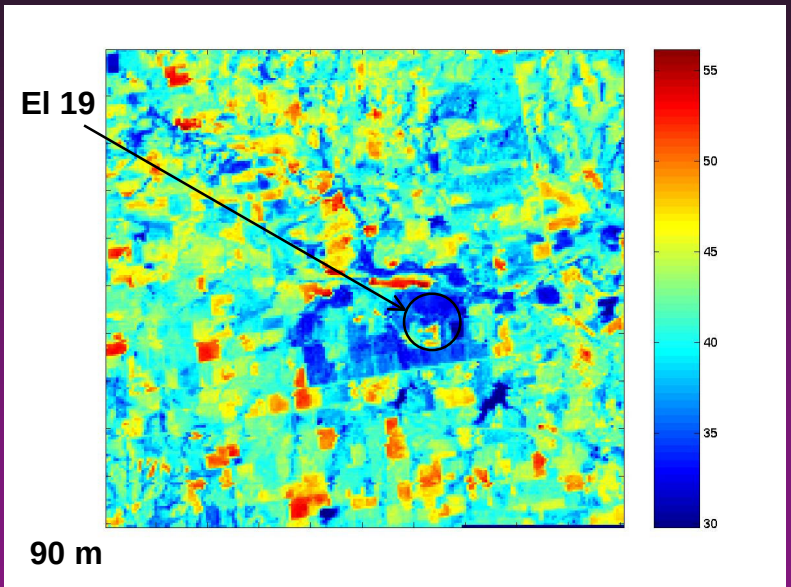
NDVI map over El 19 area (June, 10, 2001)



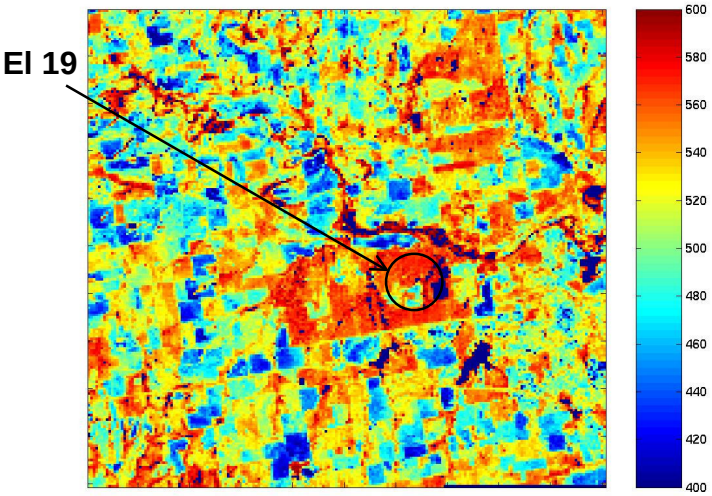
ASTER TIR data preprocessing



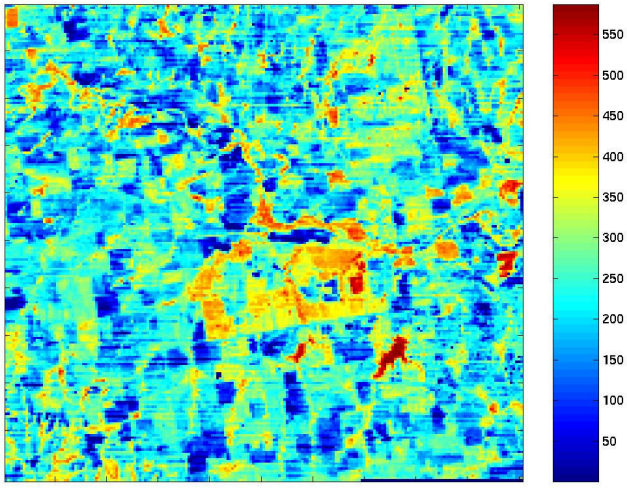
T_s map over El 19 area (June, 10, 2001)



SEBAL R_n map over El 19 area (June, 10, 2001)



SEBAL LE map over El 19 area (June, 10, 2001)

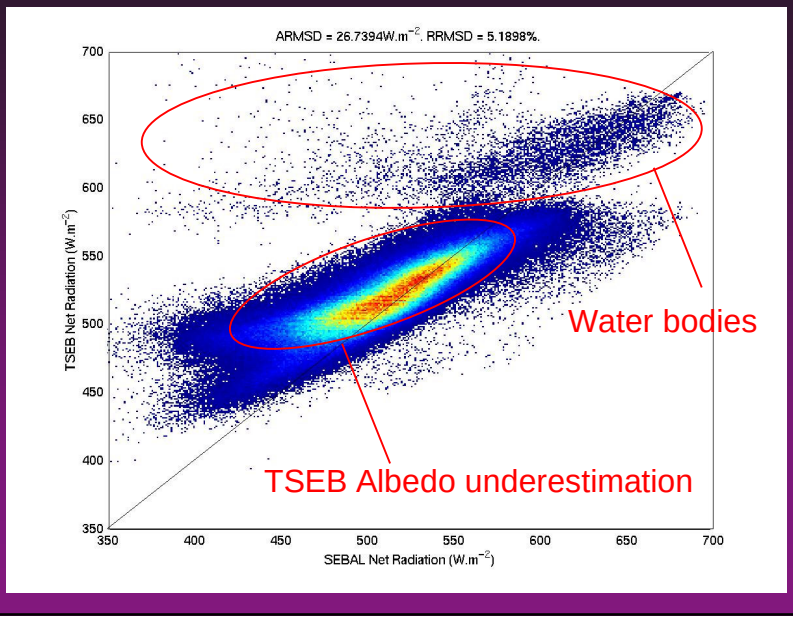


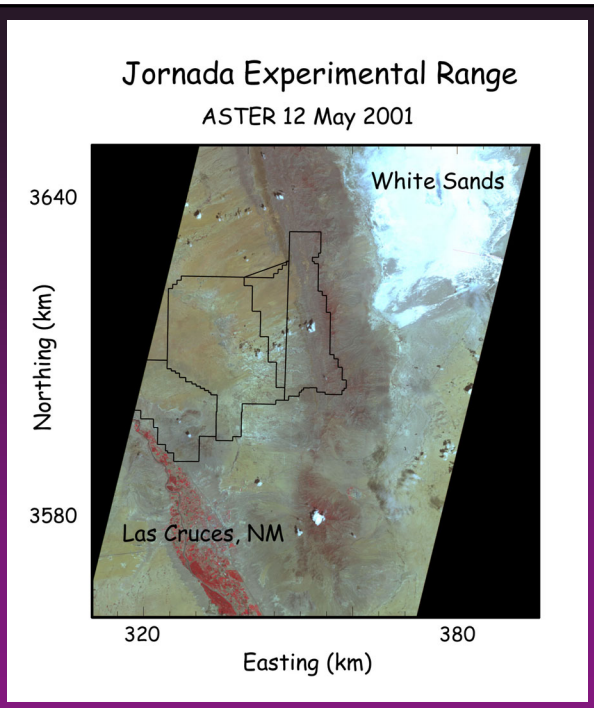
Model validation (June, 10, 2001)

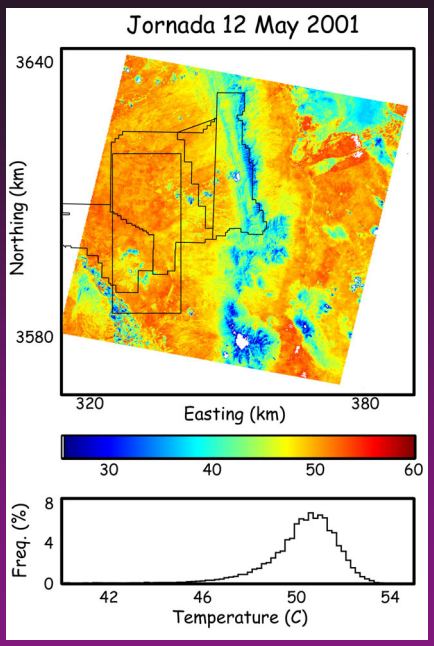
Source	R_n	G_0	H	LE
El Reno 19	552	19	129	405
TSEB	566 (4)	70 (4)	126 (11)	370 (14)
SEBAL	563 (8)	70 (3)	108 (37)	385 (45)

Spatial variability inside E19 field

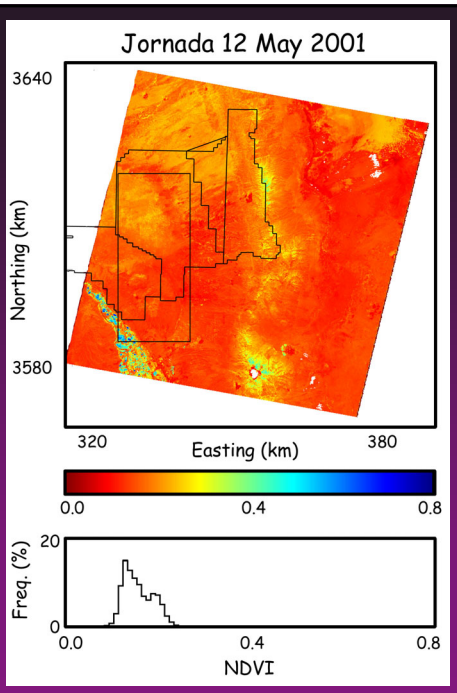
Model comparison : R_n





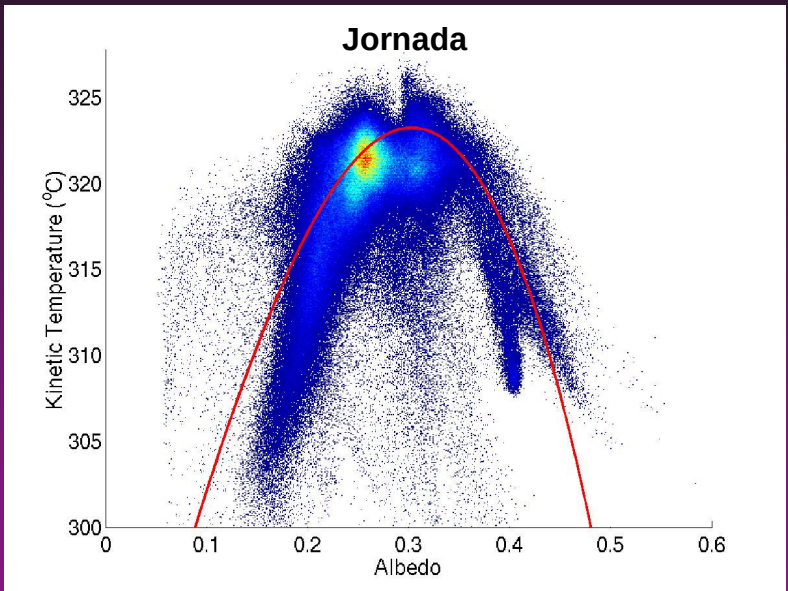


ASTER Surface Temperature

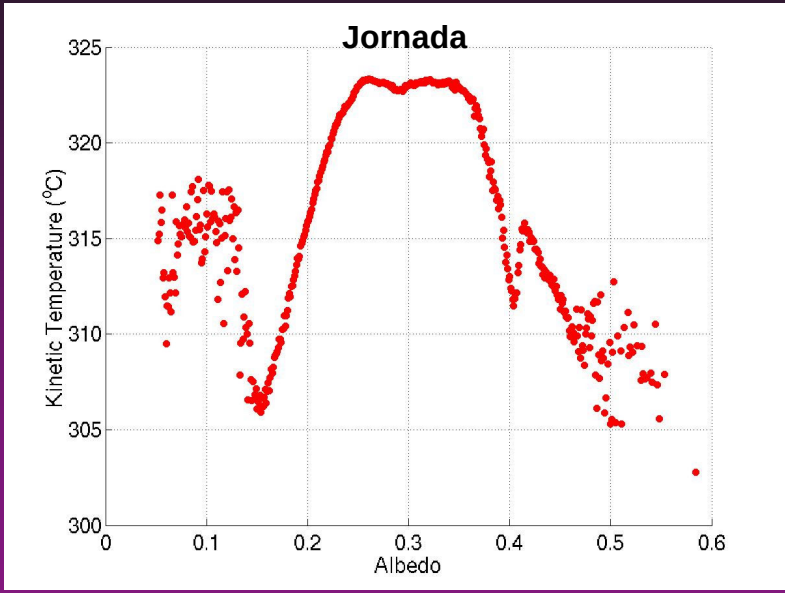


ASTER NDVI

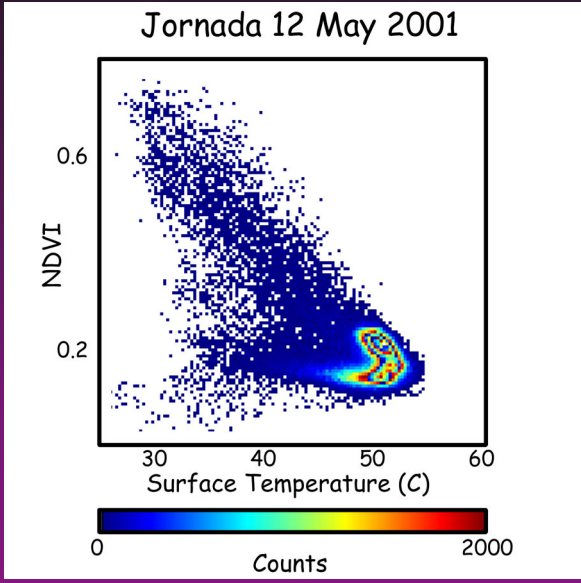
Model hypothesis / SEBAL



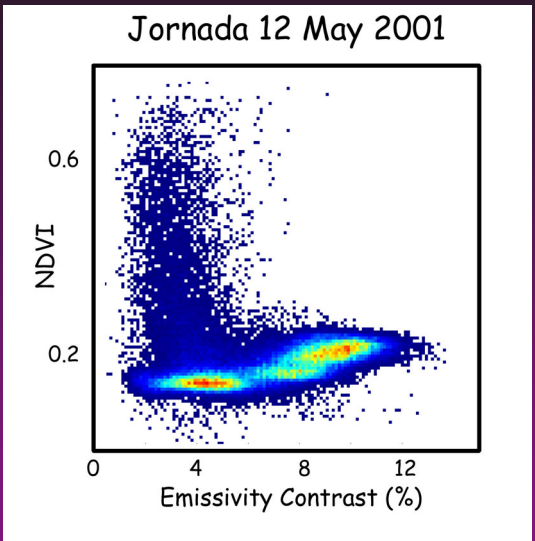
Model hypothesis / SEBAL



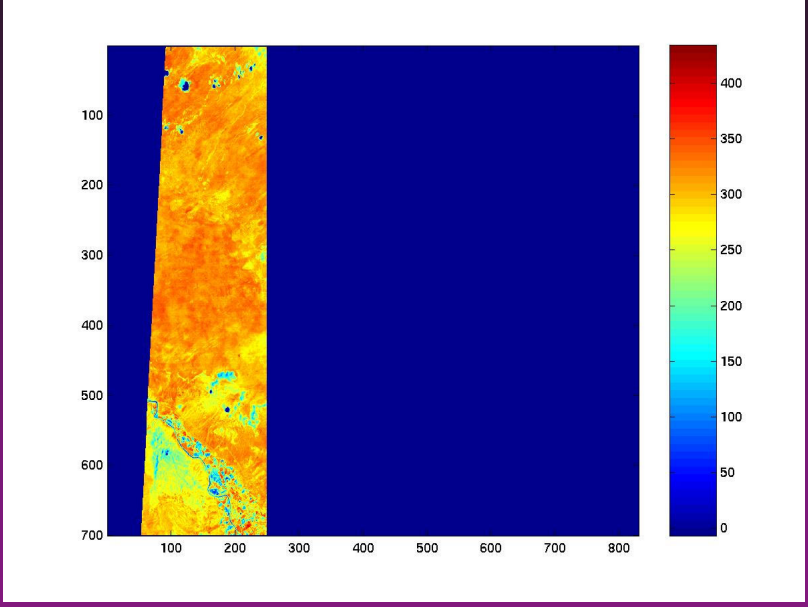
NDVI vs. Surface Temperature



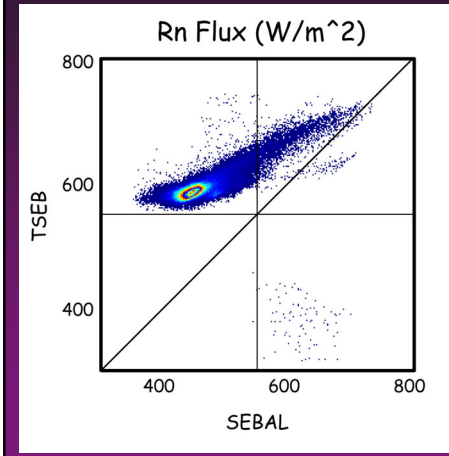
NDVI vs. Thermal Emissivity Contrast

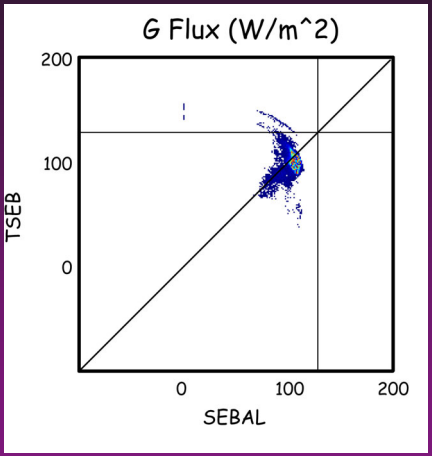


Sensible Heat (W/m^2) May 12, 2001

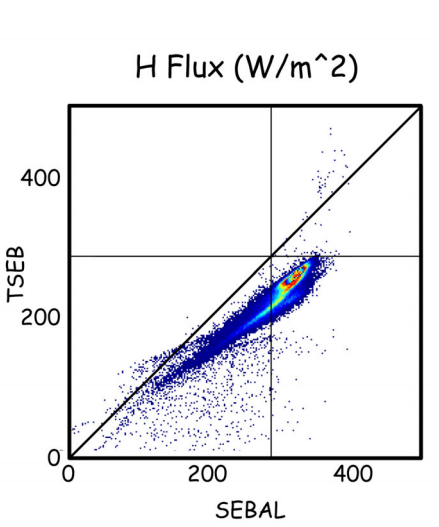


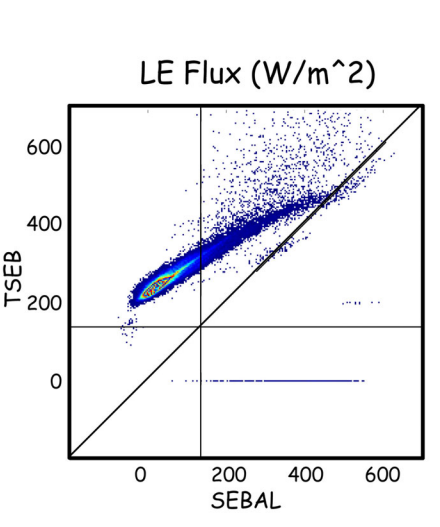
Net Radiation and Soil Flux at Jornada



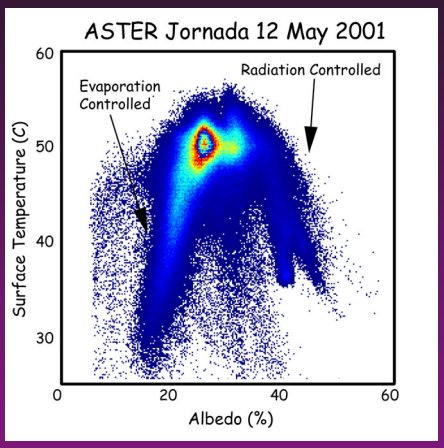


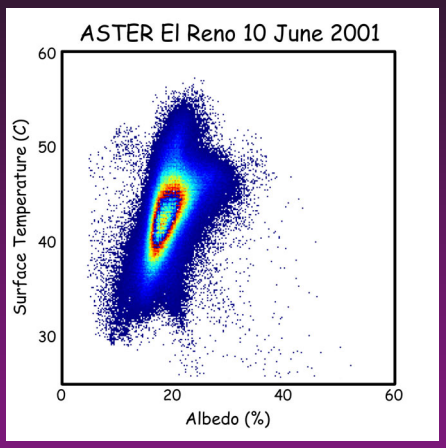
Sensible & Latent Heat Fluxes at Jornada



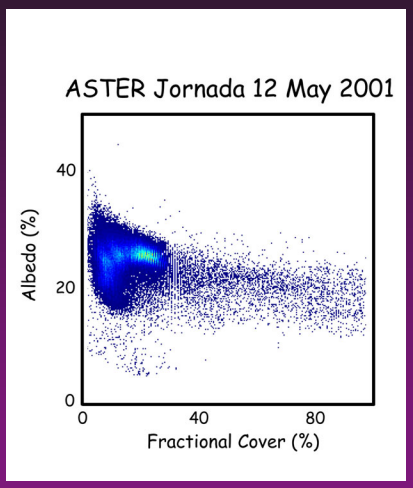


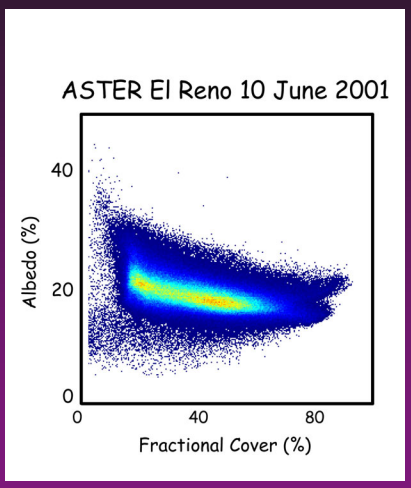
SEBAL: Computation of r_0 and u*





TSEB: Soil & Vegetation Albedo

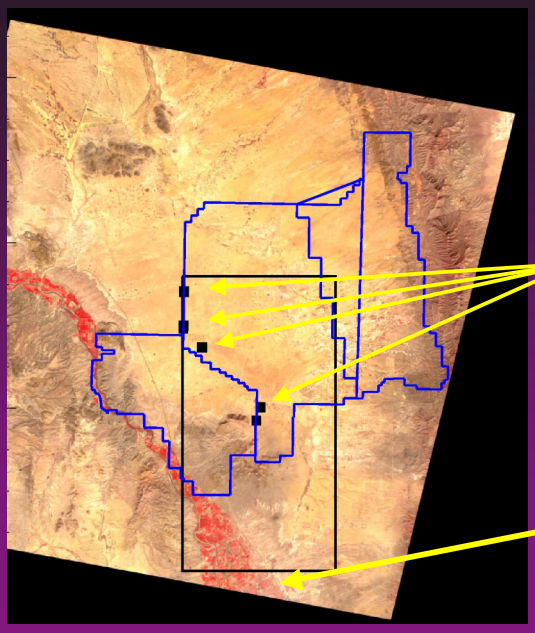




15 May 2002 Surface Flux Estimates

Site	H	LE	G	Rn
Grass	411 (7) 377	0 8	92 (2) N/A	505 (1) N/A
Transition (Bowen)	419 (7) 326	0 91	88 (2) 121	509 (1) 538
Mesquite	418 (35) 364	0 22	89 (8) N/A	508 (7) N/A

ASTER TSEB Ground Observation



Spatial Resolution Effects

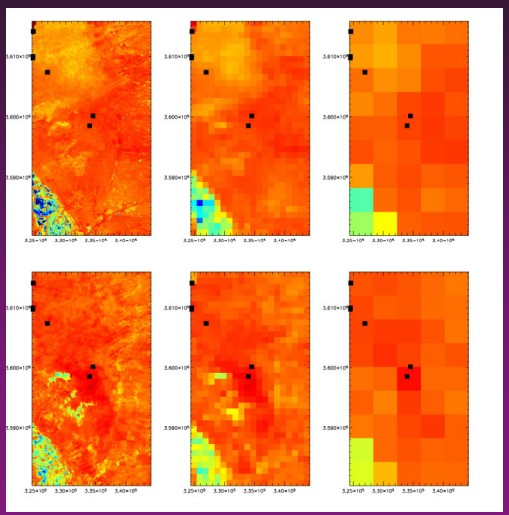
- Dominant heterogeneity at scales < 35m
  [Pelgrum et al. 2000 WRR (36)]
- ASTER TIR resolution 90m
- Are 90m- 4km resolutions sufficient to Accurately estimate surface temperature & energy fluxes?

15 May 2002 Jornada, NM

90 m 990 m 3960 m

NDVI

Temp



0.6
0.3
0.0

55.0
40.0
25.0

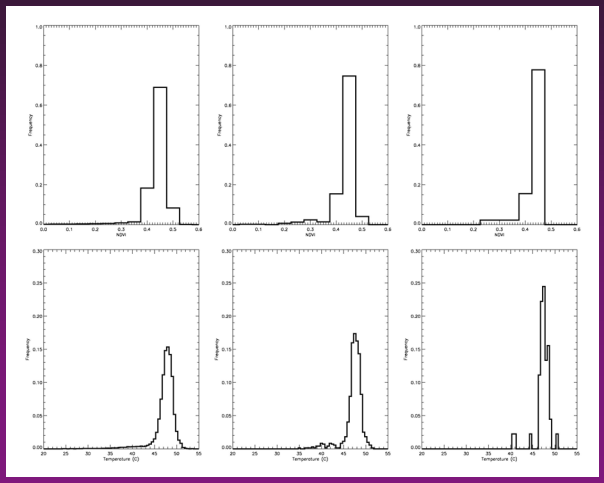
No significant bias due to observations at these resolutions

15 May 2002 Jornada, New Mexico

Mean NDVI/Temp Don't Change for these Scales

90 m 990 m 3960 m

NDVI



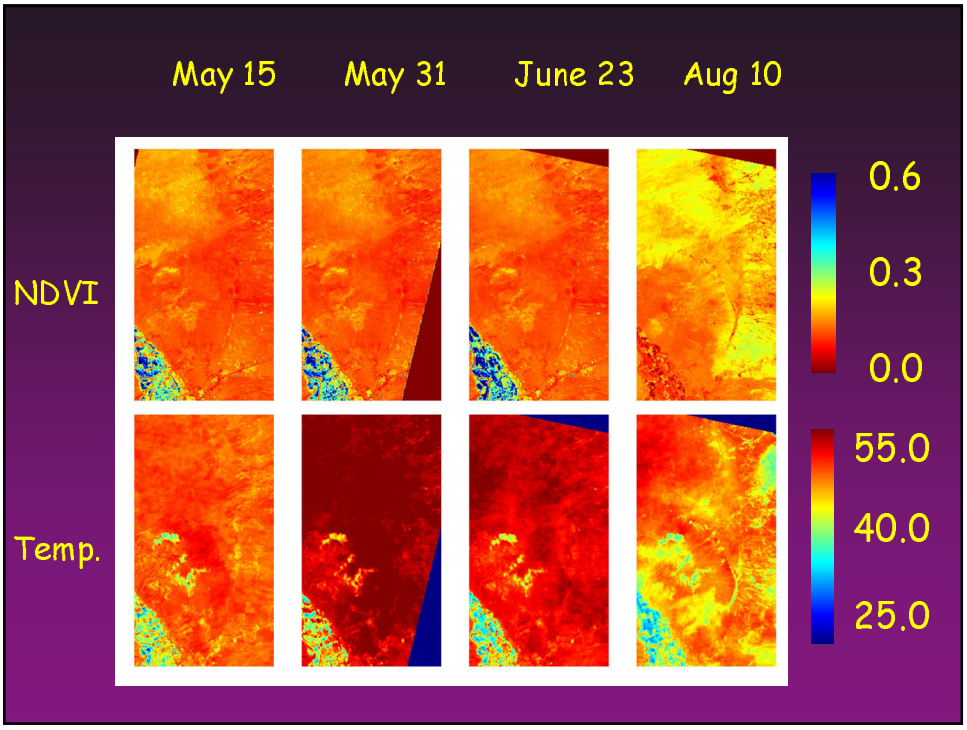
0.0 - 0.6

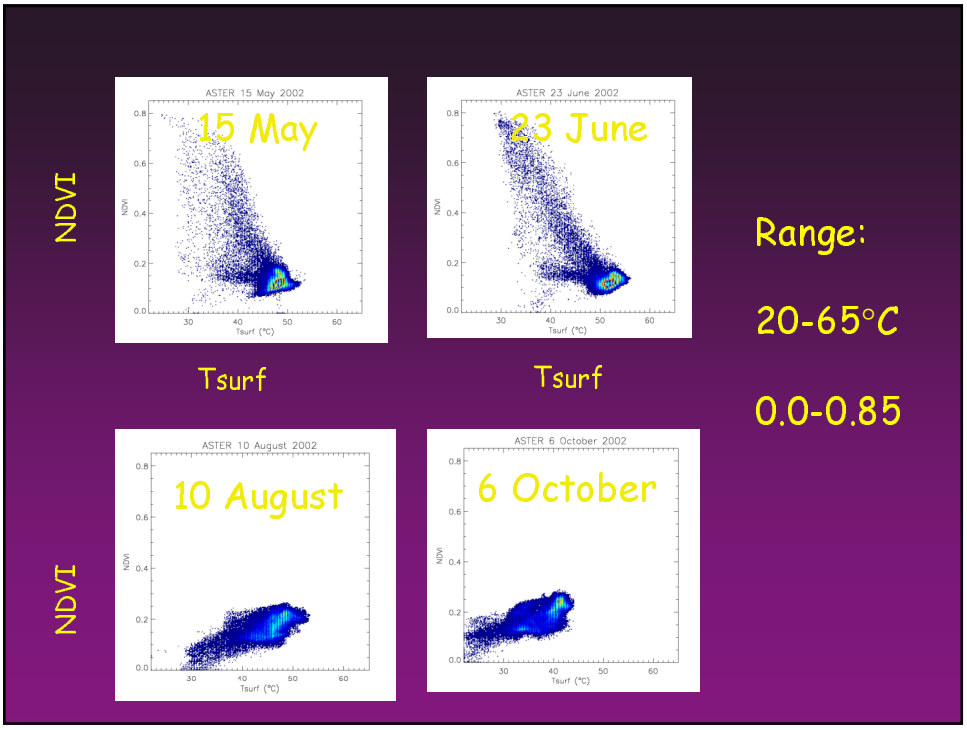
Temp

20 - 55 C

Temporal Effects

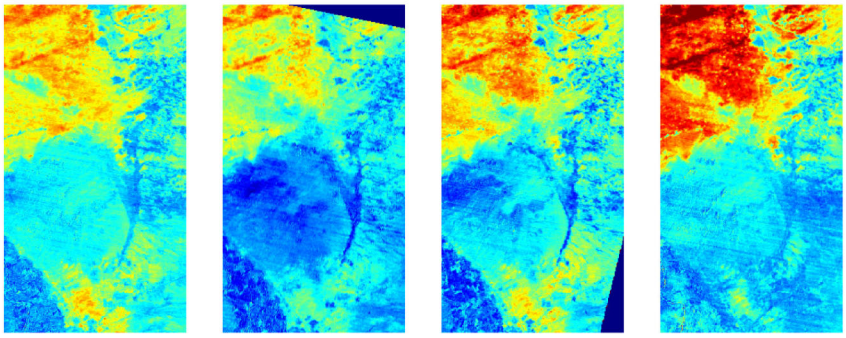
- Sequence of 10 ASTER scenes 15 May – 23 November 2002.
- Evaluate surface energy balance estimates under different conditions.


May 15
May 31
June 23
Aug 10
NDVI
Temp.
0.6
0.3
0.0
55.0
40.0
25.0


NDVI
ASTER 15 May 2002
15 May
ASTER 23 June 2002
23 June
Tsurf
Tsurf
Range:
20-65°C
0.0-0.85
NDVI
ASTER 10 August 2002
10 August
ASTER 6 October 2002
6 October

Emissivity Contrast at Jornada

May 15 | Aug 10 | Sep 20 | Oct 6



-Soil moisture effects
-Atmospheric correction errors

Conclusions

- Beginning of SEBAL / TSEB comparison over ASTER dataset
- Validating with field measurements gave good results
- SEBAL and TSEB R_n net radiation well agreed
- G_0 overestimated with TSEB (R_n overestimation?)
- SEBAL and TSEB spatially distributed H & LE very different
- Forcing TSEB albedo estimates using with ASTER data