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Calculation of Vegetation Indices with PAR and Solar Radiation Measurements

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Vegetation Indices

- NDVI – Normalized Difference Vegetation Index – indicator of vegetation health and carbon sink strength.
- LAI – Leaf Area Index – indicator of reflectance, density of vegetation, estimate soil surface heat flux.
- Fg – Green Vegetation Fraction – indicator of plant health and “greeness”.
- Normally used during growing season.
- Also exhibit seasonal trends throughout the year.

NDVI

NDVI = (NIR-RED)/(NIR+RED)

NIR (841-876 nm; MODIS) RED (620-670 nm; MODIS)

NIR (760 and 810 nm) RED (660 and 710 nm) Fermi MSR

Plants reflect well in the NIR to keep cool and absorb in visible wavelengths useful for photosynthesis.

NDVI from PAR and Solar

- Wilson and Meyers (2007) – upwelling, downwelling PAR (400-700 nm) to determine visible radiation ratio (R_{VIS}); partitioned downwelling global ($SOLR_{in}$) into visible (VIS_{in}) and near infrared (NIR_{in})

- $R_{VIS} = PAR_{out}/PAR_{in}$

- $VIS_{in} = 0.45 * SOLR_{in}$

- $NIR_{in} = 0.55 * SOLR_{in}$ (Weiss and Norman 1985)

- $VIS_{out} = R_{VIS} * VIS_{in}$
)
- $NIR_{out} = SOLR_{out} – VIS_{out}$

- $R_{NIR} = NIR_{out}/NIR_{in}$

- $NDVI = (R_{NIR} – R_{VIS})/(R_{NIR} + R_{VIS})$

Estimation of R_{VIS}

- No PAR measurements at ARM sites presently.
- Figure 3 in Wilson and Meyers (2007) little variation of the reflectance of visible radiation RVIS during a year for a grassland and that RVIS is very similar for grasslands in different climatic areas.
- Measurements for plain and temperate grasslands in Wilson and Meyers (2007) were used to determine the seasonal variation of RVIS for the SGP CF grassland.

Fg

- $Fg = (NDVI – NDVI_{min}) / (NDVI_{max} – NDVI_{min})$,

- $NDVI_{min}$ - minimum mid-day NDVI measured during winter for bare soil and/or dead vegetation.

- $NDVI_{max}$ - maximum mid-day NDVI measured during the height of the summer growing season.

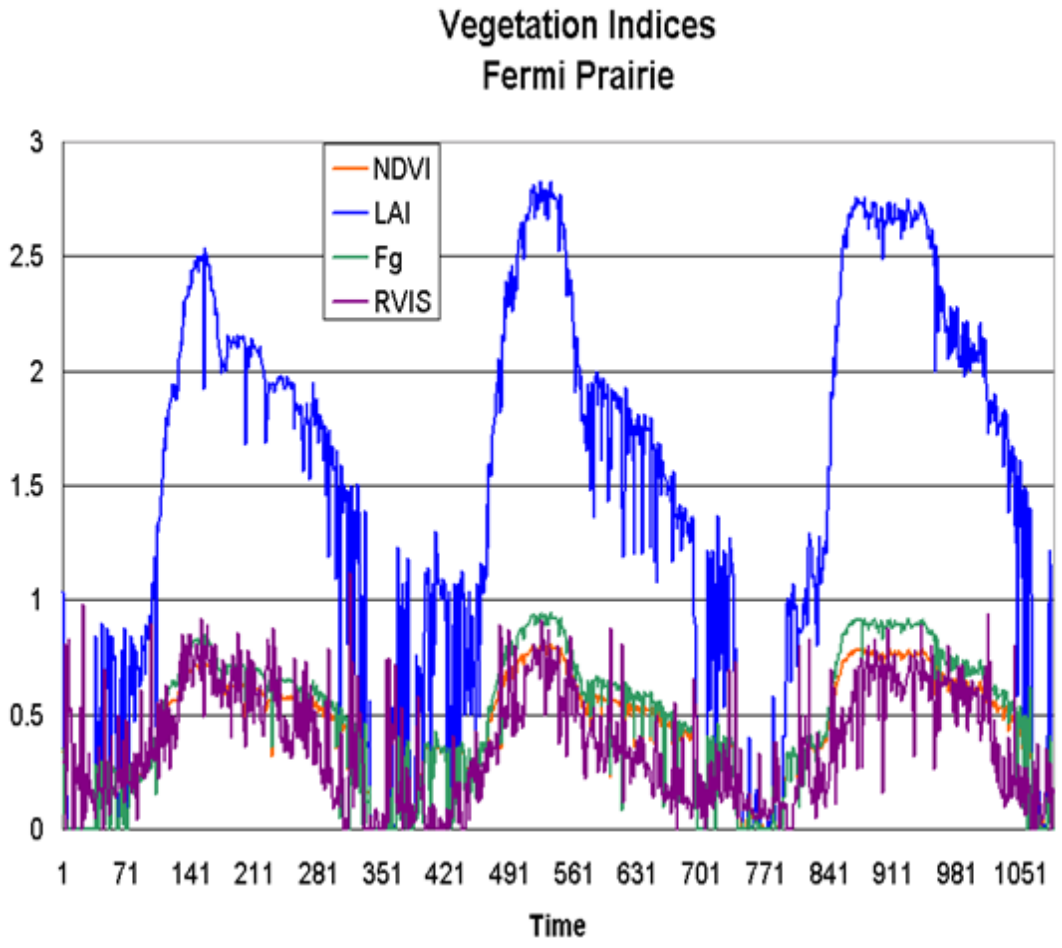
LAI

- $LAI = LAI_{max} \times Fg$,

- LAI_{max} - maximum mid-day LAI during the growing season.

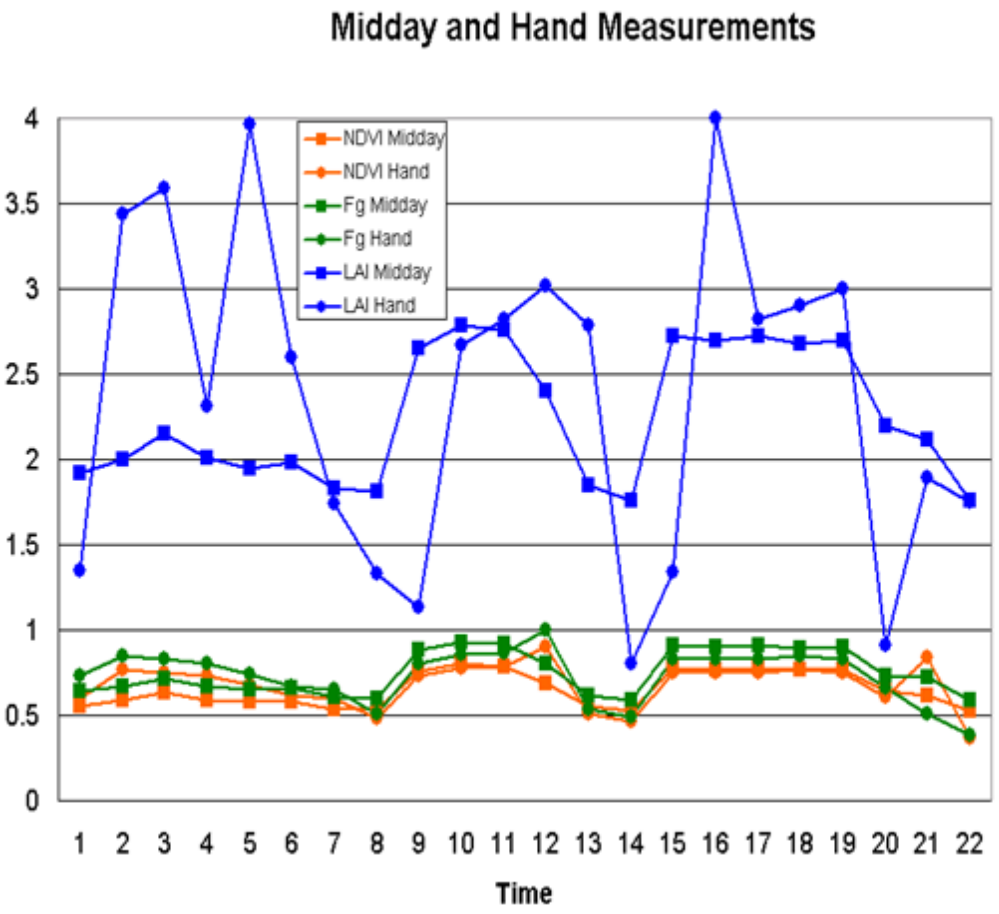
- LAI_{max} is normally determined from at least one full year of data.

R_{VIS}, NDVI, LAI, Fg - Fermi Ameriflux Prairie 2005 - 2007 (PAR, SOLAR)



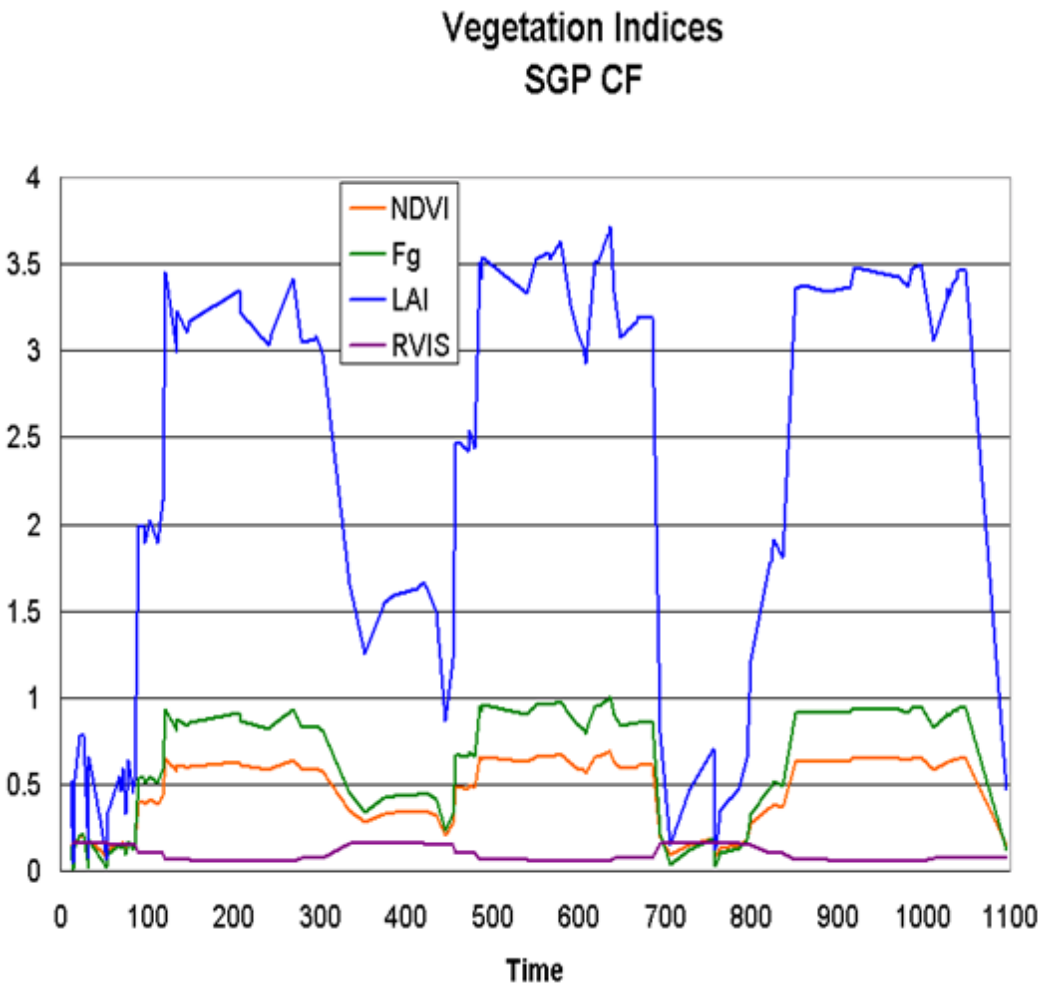
- 2005 a minor drought year
- 2006 fast growing invasive clover plant, Melilotus alba
- 2007 normal year

NDVI, LAI, and Fg - Fermi Ameriflux Prairie 2005 - 2007 (MSR/ceptometer and PAR, Solar)



- MSR/ ceptometer five locations
- PAR/Solar one location
- NDVI, Fg agreement
- LAI worse

SGP CF NDVI, LAI, Fg, R_{VIS} 2005-2007

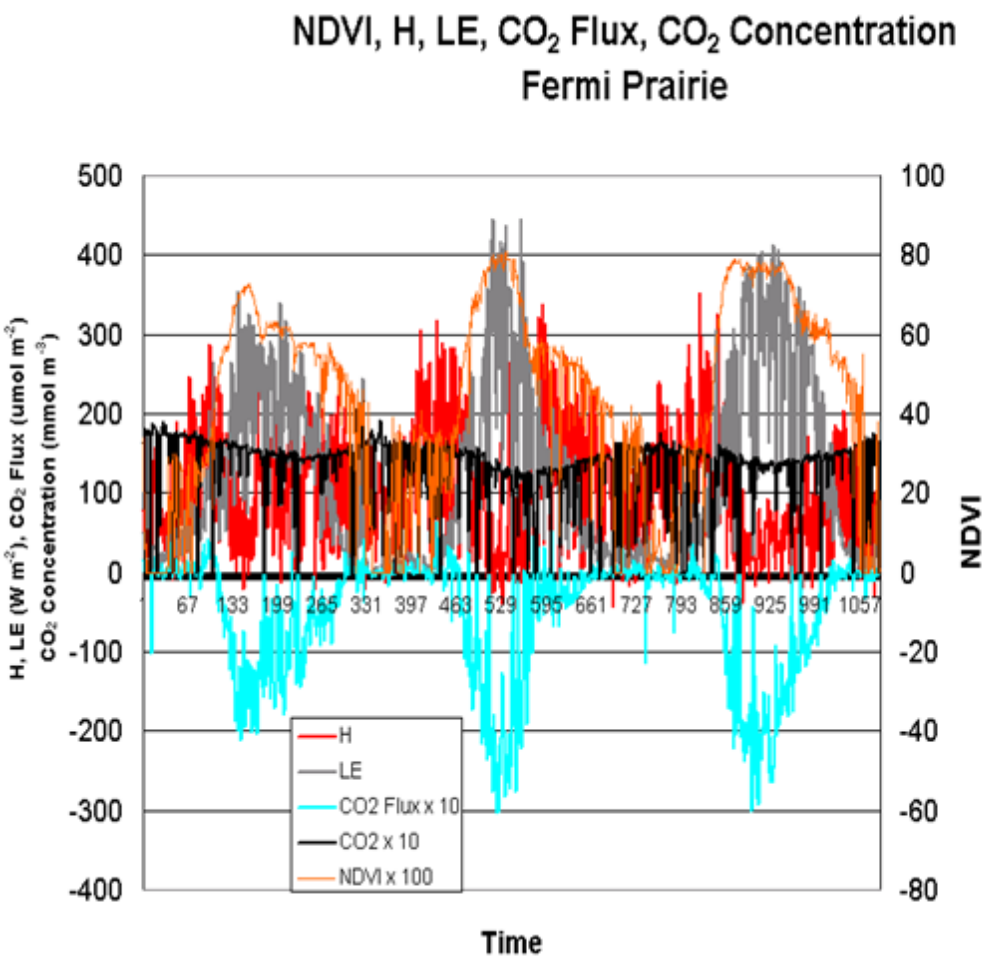


- Very similar to Fermi prairie values
- Typical of temperate grasslands
- Agree with MODIS values (Wilson and Meyers 2007)

Differences – Fermi and SGP CF

- $NDVI_{max}$, $NDVI_{min}$ - SGP CF grassland 0.69 and 0.07
- Fermi prairie - 0.81 and 0.04
- LAI_{max} - SGP CF grassland 3.69
- Fermi prairie – 2.8
- SGP CF grassland denser; Fermi prairie more diverse

NDVI, H, LE, CO2 Flux, CO2 Concentration Fermi Prairie

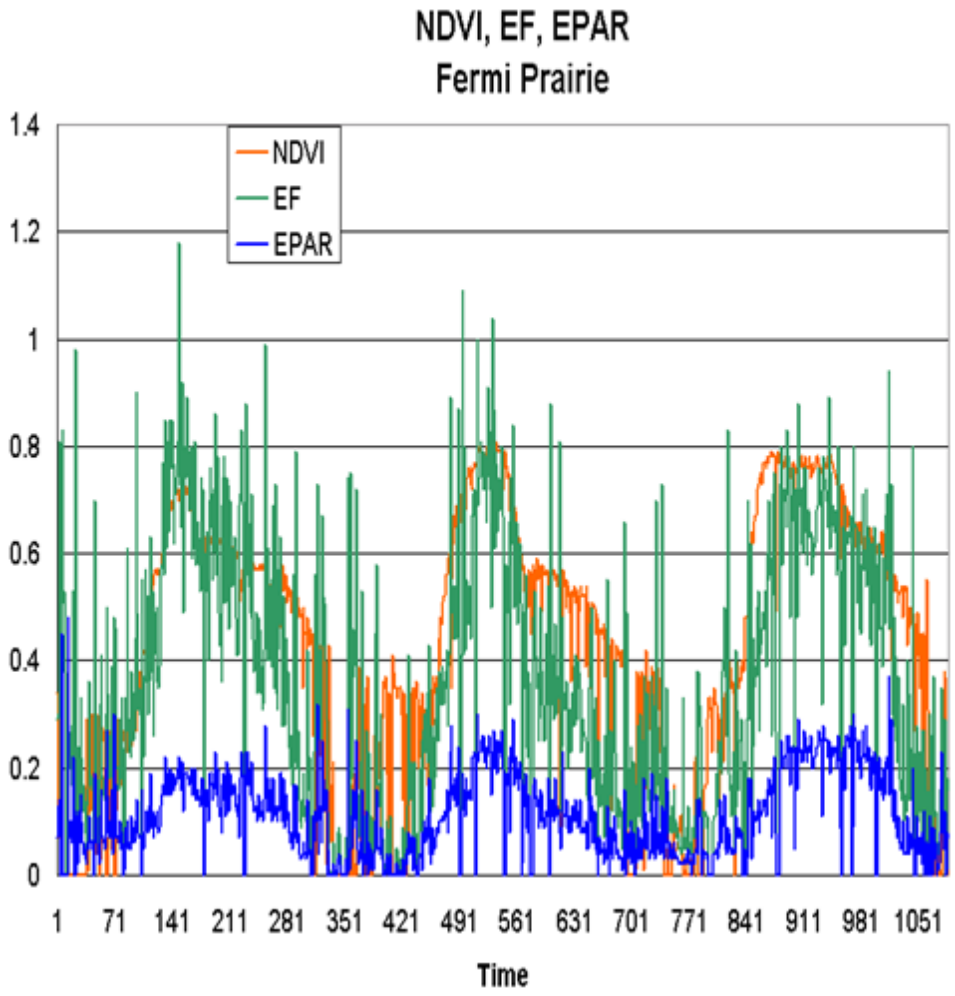


- LE and CO_2 flux track with NDVI during middle of growing season
- Poor NDVI prediction in the early part and latter part of the growing season.
- NDVI underpredicts LE during the peak part of the Melilotus growing season in 2006.
- Significant decrease in CO_2 concentration in 2006 corresponding to the rapidly growing Melilotus alba

Evaporative Fractions

- EF = LE/(Rn-G)
- ES = LE/solar shortwave
- EPAR = LE/APAR
- APAR = net PAR
- ES better than EF long-term LE trends
- Satellites measure solar better than RN-G

NDVI, EF, and EPAR 2005-2007 Fermi Prairie



- NDVI is a better predictor of EF through most of the growing season than of just LE
- NDVI does not do as well at predicting EPAR
- EF ratio is best predicted by vegetation indices calculated from surface measurements.

Conclusion

The inclusion of upwelling and downwelling PAR measurements in conjunction with SIRS measurements of upwelling and downwelling solar radiation would enable valuable site specific vegetation indices to be determined with great confidence and employed for land use applications in computer models.

Recommend Satlantic PAR 600LIN – $1200 each
high quality filter
delrin body
excellent spectral response