Potential Impacts of Aerosol- Land – Atmosphere Interactions

Dev Niyogi[1], Jih-Wang Wang[2], and Roger A. Pielke Sr.[2]

1. **University of Colorado at Boulder, Cooperative Institute for Research in the Environmental Sciences**
2. **Purdue University, Department of Agronomy and Department of Earth and Atmospheric Sciences**

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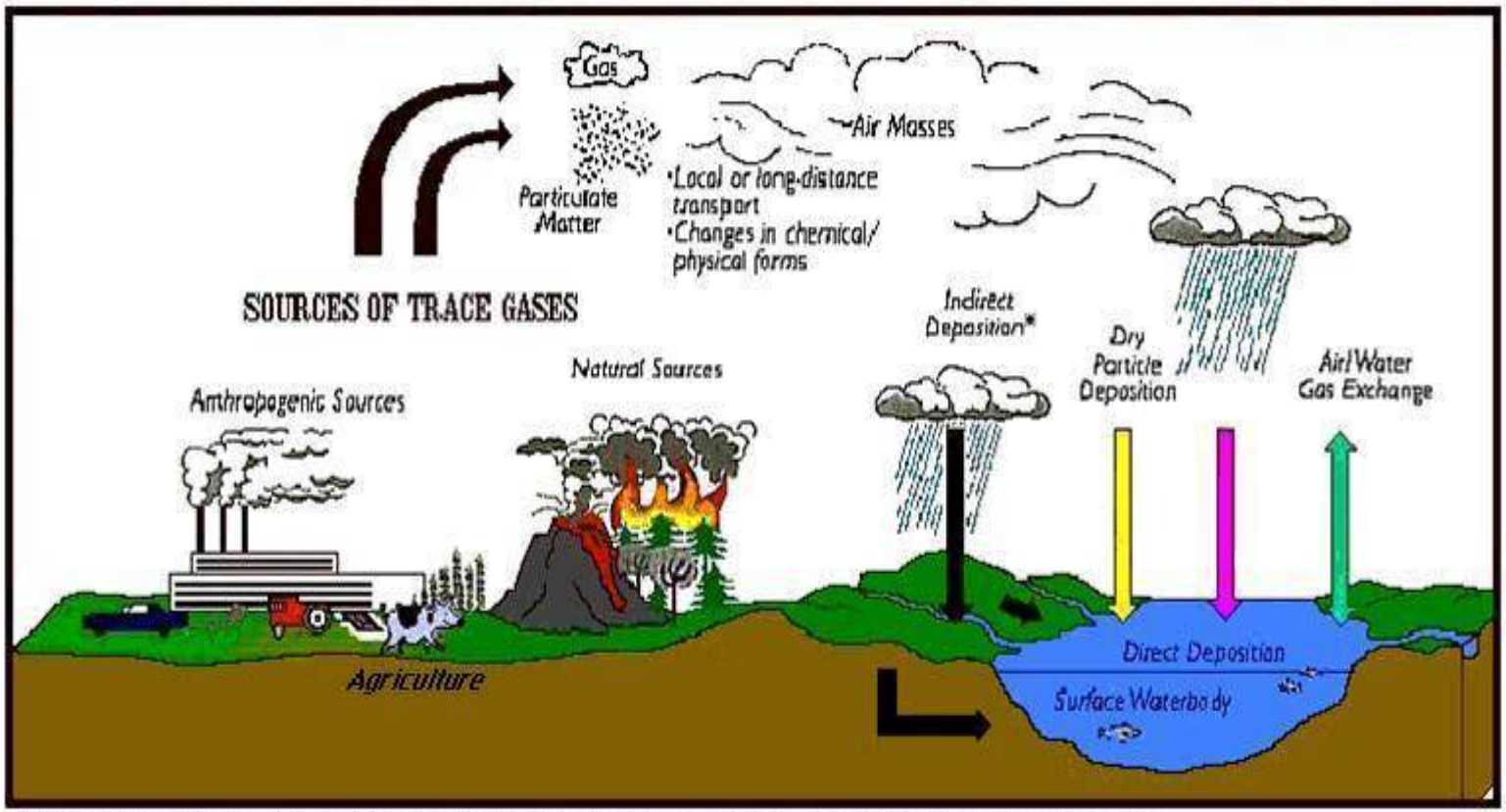
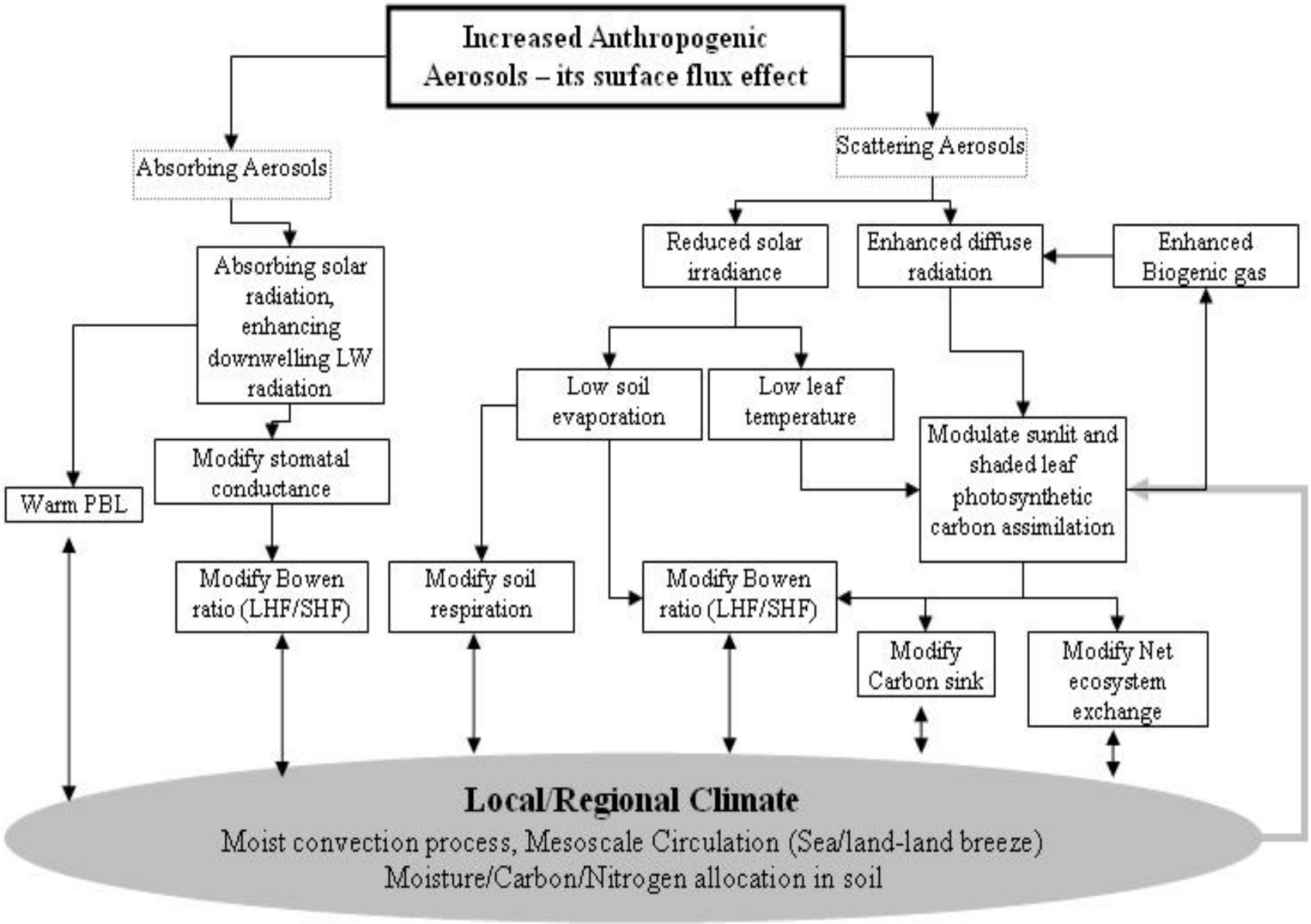
Motivation

Some missing elements in our aerosol budgets that need to be considered for future. Agricultural Air Emissions from Animal and Crop operations.

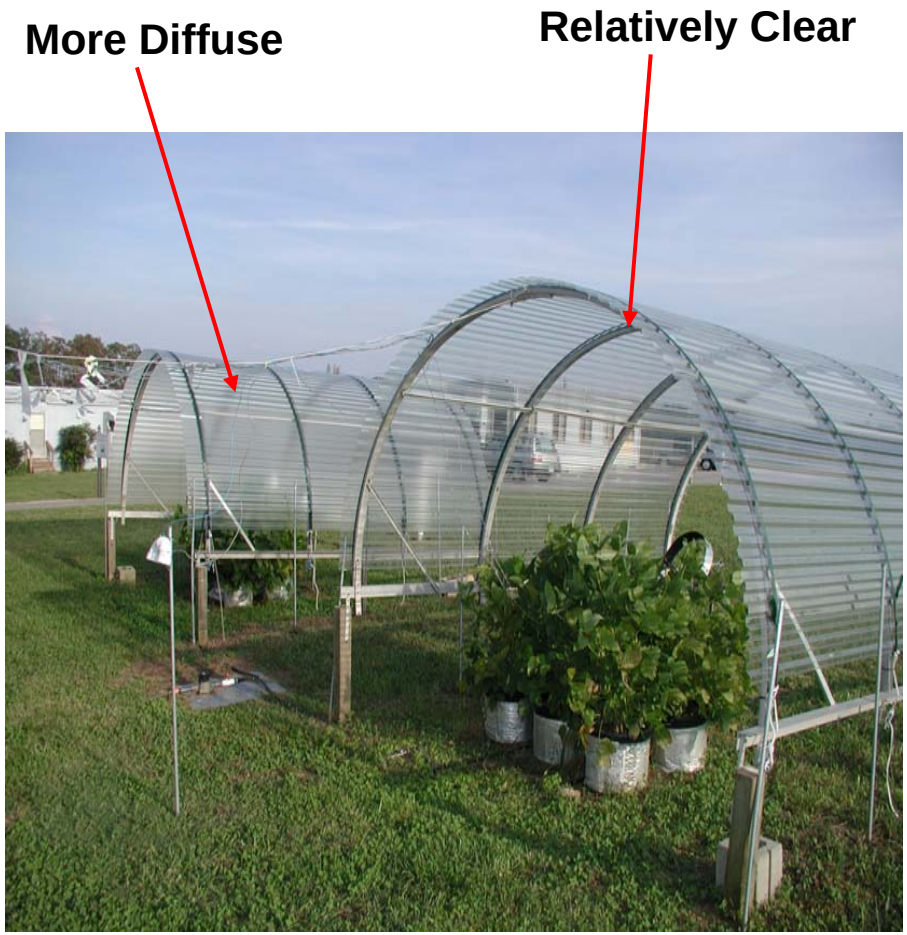


*Indirect deposition is direct deposition to land followed by runoff or seepage through groundwater to a surface water body.


Increased Anthropogenic Aerosols – its surface flux effect
Absorbing Aerosols
Scattering Aerosols
Absorbing solar radiation, enhancing downwelling LW radiation
Reduced solar irradiance
Enhanced diffuse radiation
Enhanced Biogenic gas
Warm PBL
Modify stomatal conductance
Low soil evaporation
Low leaf temperature
Modulate sunlit and shaded leaf photosynthetic carbon assimilation
Modify Bowen ratio (LHF/SHF)
Modify soil respiration
Modify Bowen ratio (LHF/SHF)
Modify Carbon sink
Modify Net ecosystem exchange
Local/Regional Climate
Moist convection process, Mesoscale Circulation (Sea/land-land breeze)
Moisture/Carbon/Nitrogen allocation in soil

Experiment Design and Model

A.



Soybean plants grown under different diffuse radiation conditions

		Glazing Material	
Parameter	**Ambient**	**Clear**	**Diffusing**
PPFD (µmol m^{-2} s^{-1})	958 ± 6 a	840 ± 6 b	755 ± 5 c
Diffuse:Total		0.389 ± 0.002 a	0.415 ± 0.002 b

B.

1. DSSAT (Decision Support System for Agrotechnology Transfer) ver. 4 was used.
2. The SOYGRO/CROPGRO and the DSSAT-Maize were used for soybeans and corn.
3. The model was calibrated for SE US using field observations from a research field site in North Carolina
4. The model was Run for 1998 growing season and the model input variables (T, Radiation, Rain) varied in an ensemble mode

Crop model studies to investigate effect of changes in

(a) Radiation

(b) Precipitation

(c) Temperature

(individually and simultaneously)

C.

- Cloud Detection
  1. 0.25º grid box
  2. F-test (variance) and t-test (mean) against previous clear-day reflectivity, using TRMM VIRS data.
- Linear Regression
  1. R_g
     - Adapted from Li *et al.*, 1993
     - Apply Roderick linear algorithm to split R_b and R_d
  2. $R_{gl,net}$ (decoupled from cloud top, using TRMM NDVI, NARR specific humidity, and TRMM 1B01 Ch4 Tb)
  3. LE is proportional to the multiplication of each component of the R_g and NDVI
  4. Regression onto Ameriflux data

$$LE = a[NDVI \times R_b] + b[(1 - NDVI) \times R_b] + c[NDVI \times R_d] + d[(1 - NDVI) \times R_d] + eR_{gl,net}$$

Results

A.

Soybean yield responses to growth under Clear and Diffusing glazing materials (mean ± SE). Plants were harvested for determination of biomass (Biomass) at 88 days after planting (DAP), and for seed yield (Yield) at 153 DAP. Values in parenthesis indicate percent change from the Clear treatment. Statistics: $P \leq 0.1$ (†).

Harvest	Parameter	Clear	Diffusing
	Height (cm)	55.6 ± 1.4	56.1 ± 1.4
	Branch number (plant^{-1})	17.3 ± 1.4	18.0 ± 1.4
	Leaf dry mass (g plant^{-1})	45.4 ± 3.0	52.0 ± 3.0
	stem dry mass (g plant^{-1})	19.2 ± 1.5	19.8 ± 1.5
	Branch dry mass (g plnt^{-1})	51.7 ± 3.9	63.0 ± 3.9 (+22%) †
	Pod dry mass (g plant^{-1})	67.3 ± 8.0	75.4 ± 8.0
	Root mass (g plant^{-1})	30.1 ± 2.6	28.8 ± 2.6
	Total dry mass (g plant^{-1})	213.7 ± 15.2	239.0 ± 15.2
	stem leaf area (m^2 plant^{-1})	0.19 ± 0.01	0.20 ± 0.01
	Branch leaf area (m^2 plnt^{-1})	1.21 ± 0.08	1.41 ± 0.1 (+16%) †
	Total leaf area (m^2 plant^{-1})	1.40 ± 0.08	1.61 ± 0.1 (+15%) †

Harvest	Parameter	Clear	Diffusing
Yield			
	Pod number (plant^{-1})	397 ± 32	394 ± 32
	Seed mass (g plant^{-1})	173 ± 15	179 ± 15
	Mass per seed (g)	0.20 ± 0.01	0.19 ± 0.01
	Stem mass (g plant^{-1})	43 ± 4	49 ± 4

B.

Figure 1: Crop Yield (Biomass) over Time at Various Radiation Levels

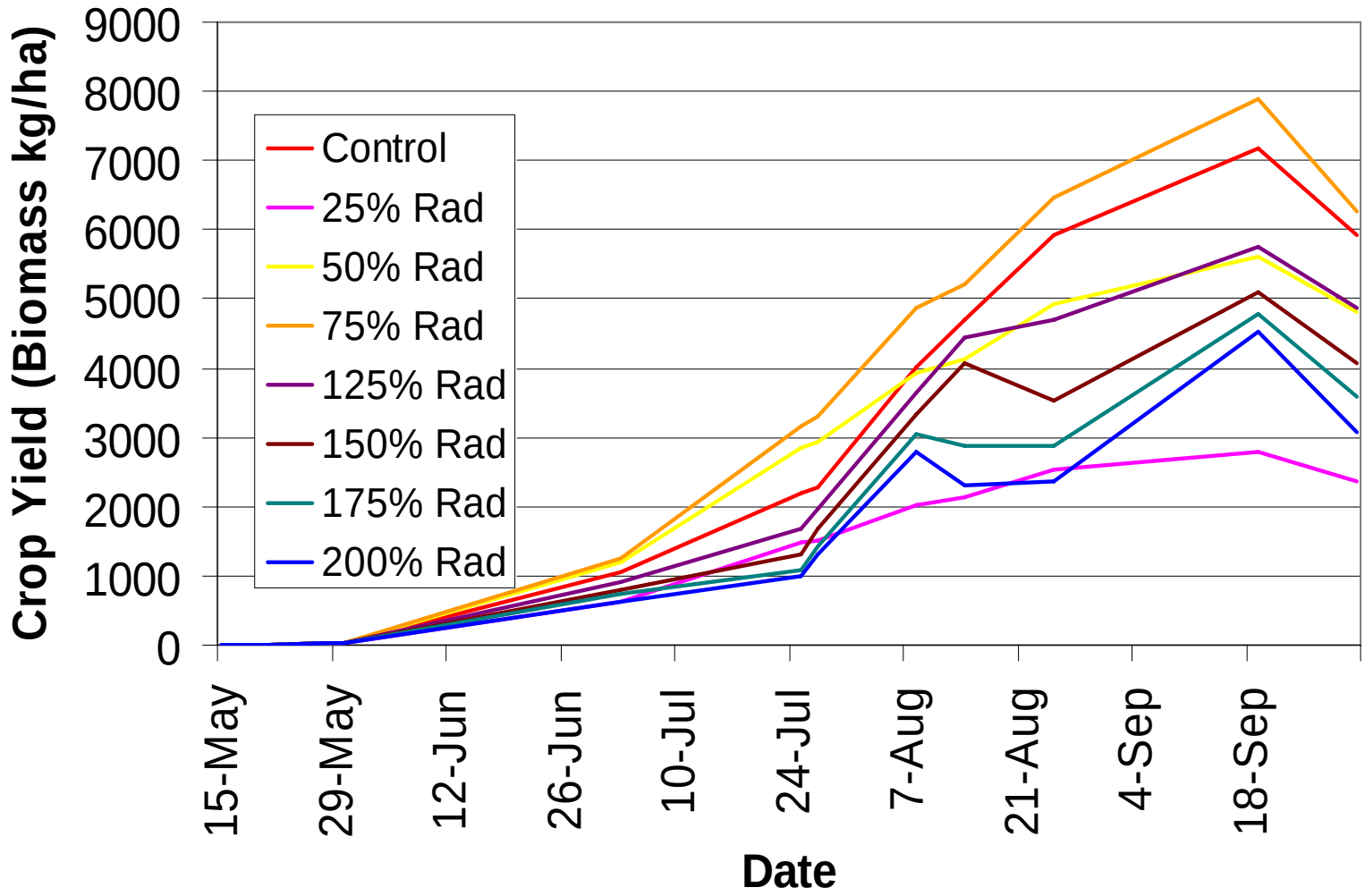


Figure 2: Crop Yield Over Time at Various Levels of Precipitation

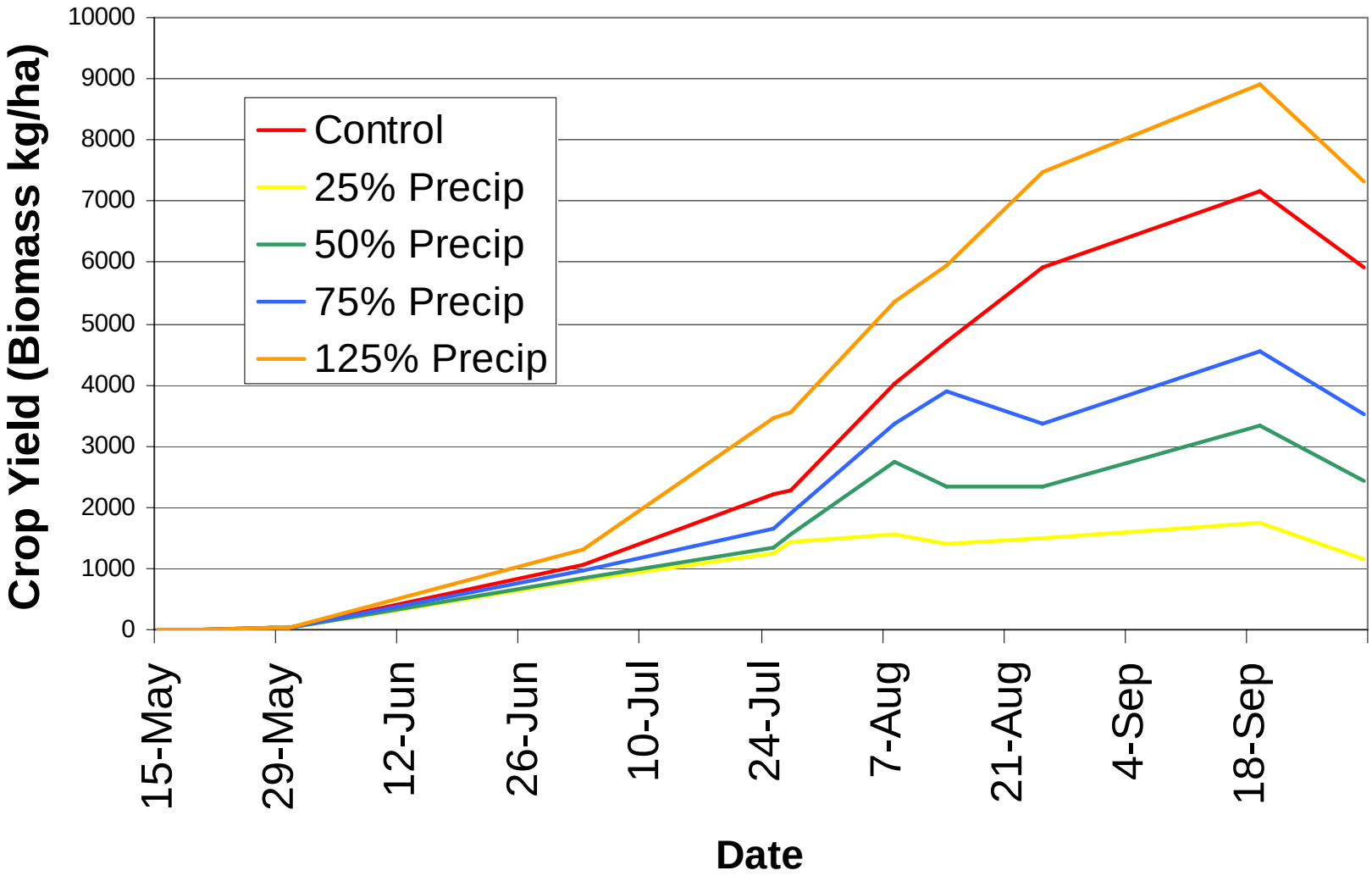
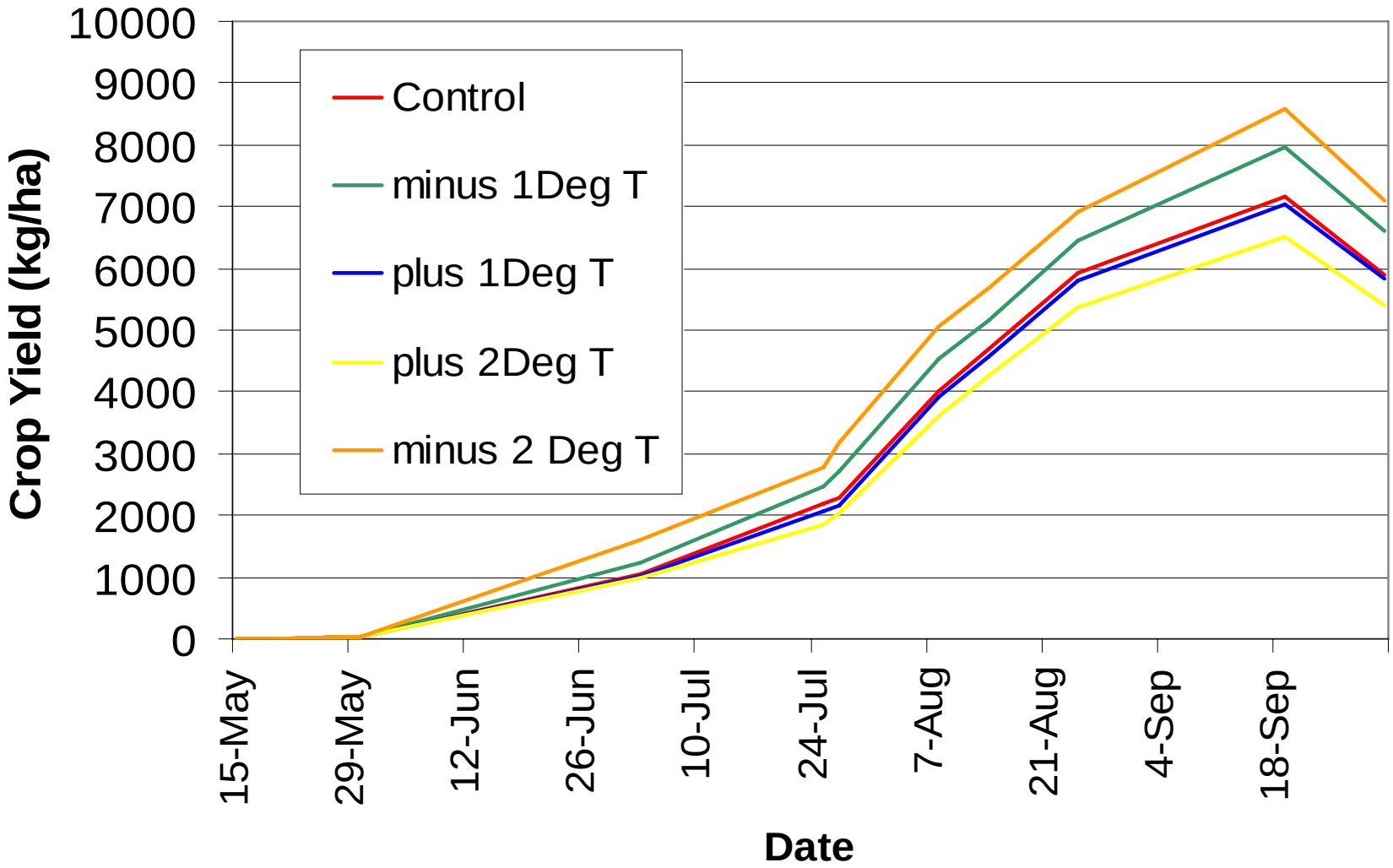
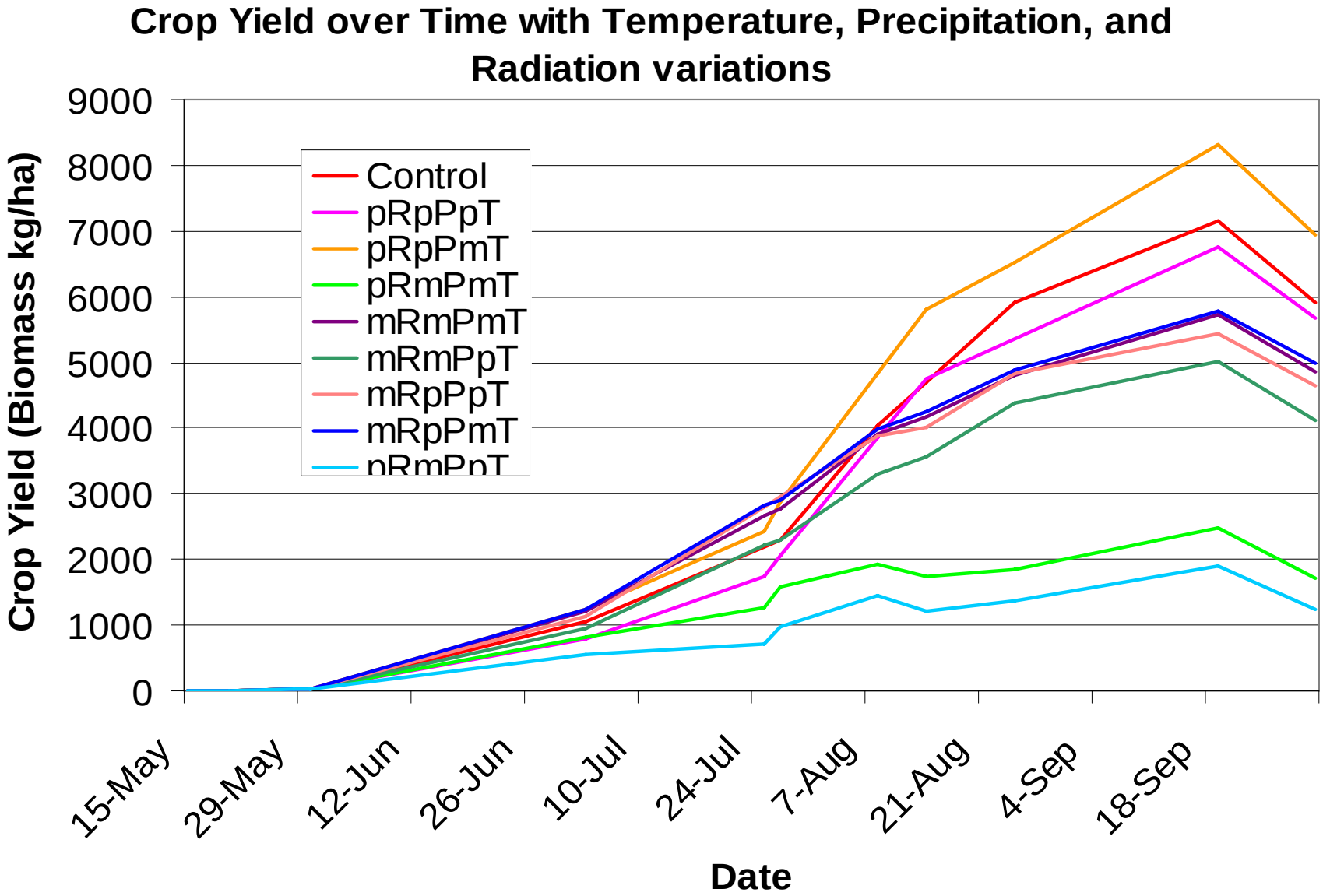
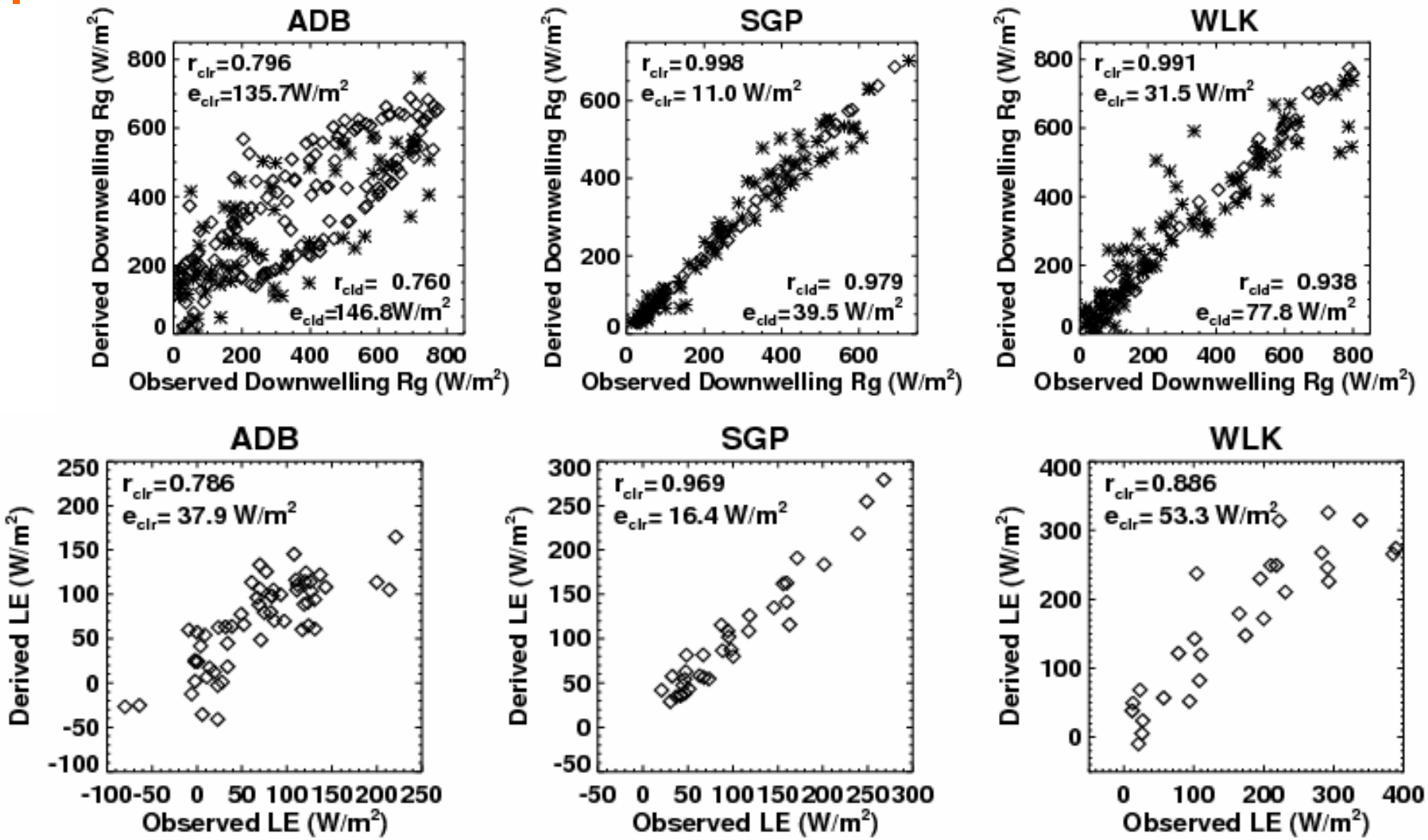


Figure 3: Crop Yield over Time at various Average Year Temperatures




Crop Yield over Time with Temperature, Precipitation, and Radiation variations
Crop Yield (Biomass kg/ha)
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
Control
pRpPpT
pRpPmT
pRmPmT
mRmPmT
mRmPpT
mRpPpT
mRpPmT
pRmPpT
15-May
29-May
12-Jun
26-Jun
10-Jul
24-Jul
7-Aug
21-Aug
4-Sep
18-Sep
Date

C.



Upper panels: Comparison of derived and observed downwelling shortwave radiation, both for clear (◊) and cloudy (*) days. ”r” is correlation coefficient, and “e” is root mean square error.

Lower panels: Comparison of derived and observed net longwave radiation, only for clear days.

Conclusions

1. Aerosols effects of net radiation can impact the surface terrestrial biosphere-atmosphere interactions significantly and thus are important influences on the climate system.
2. Results provide a significant relation between aerosol loading and CO_2 fluxes.
3. There is evidence that aerosols can affect latent heat fluxes possibly via feedbacks associated with temperature, humidity and albedo.
4. The biogeochemical / biophysical responses of aerosols need to be considered in land surface models.
5. These effects are important for both weather forecast models (since it affects latent heat flux and hence the energy balance) and regional climate models (as it affects CO_2, H_2O fluxes and hence the potential for plant growth).
6. NDVI and “diffuse to direct radiative flux ratio” both need to be considered for photosynthesis rate
7. The value of using satellite remote sensing data to derive surface energy flux has been shown.

Acknowledgement

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