MODELLING THE CARBON BALANCE OF AMAZONIAN RAINFORESTS: RESOLVING ECOLOGICAL CONTROLS ON NET ECOSYSTEM PRODUCTIVITY

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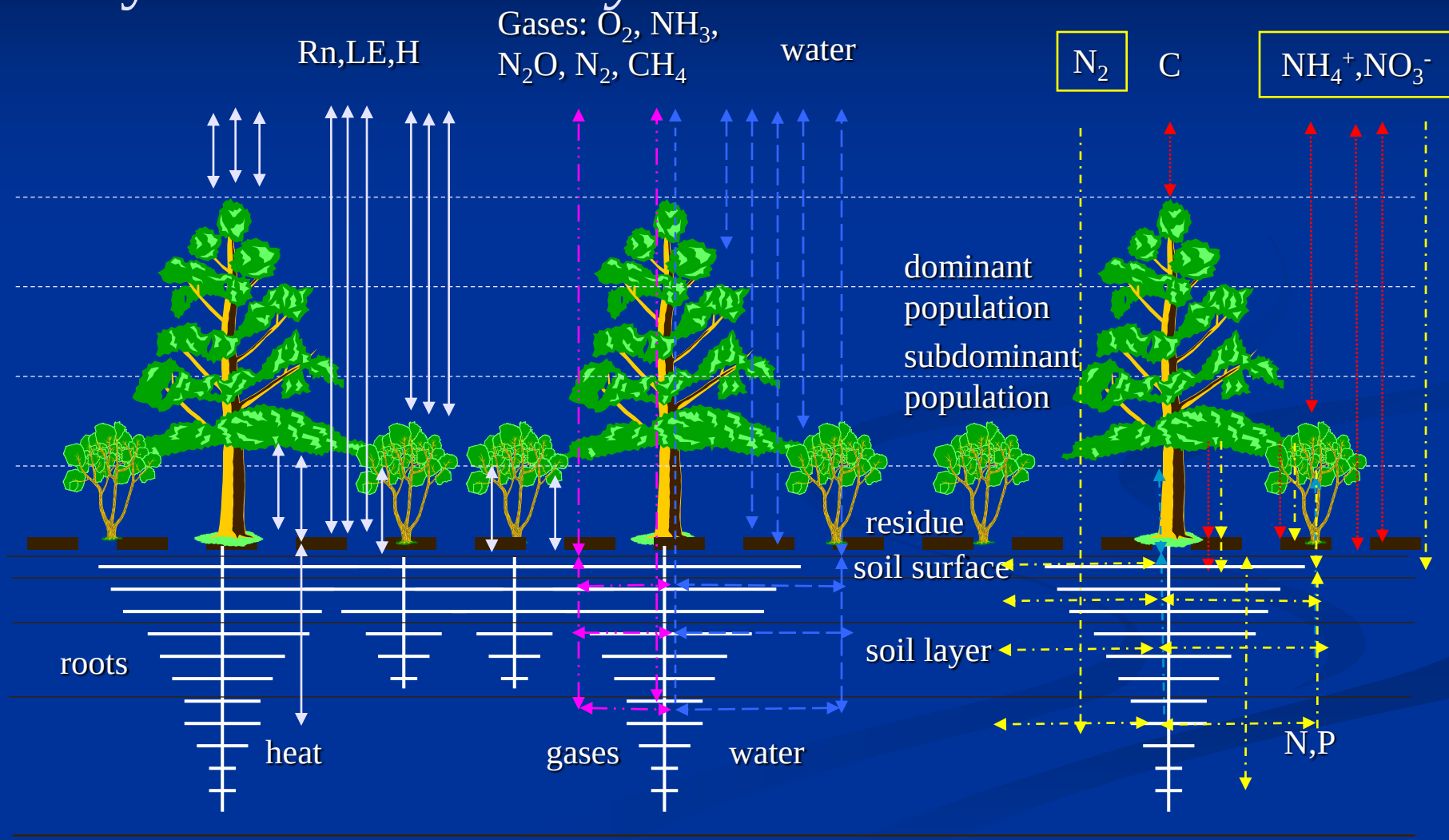
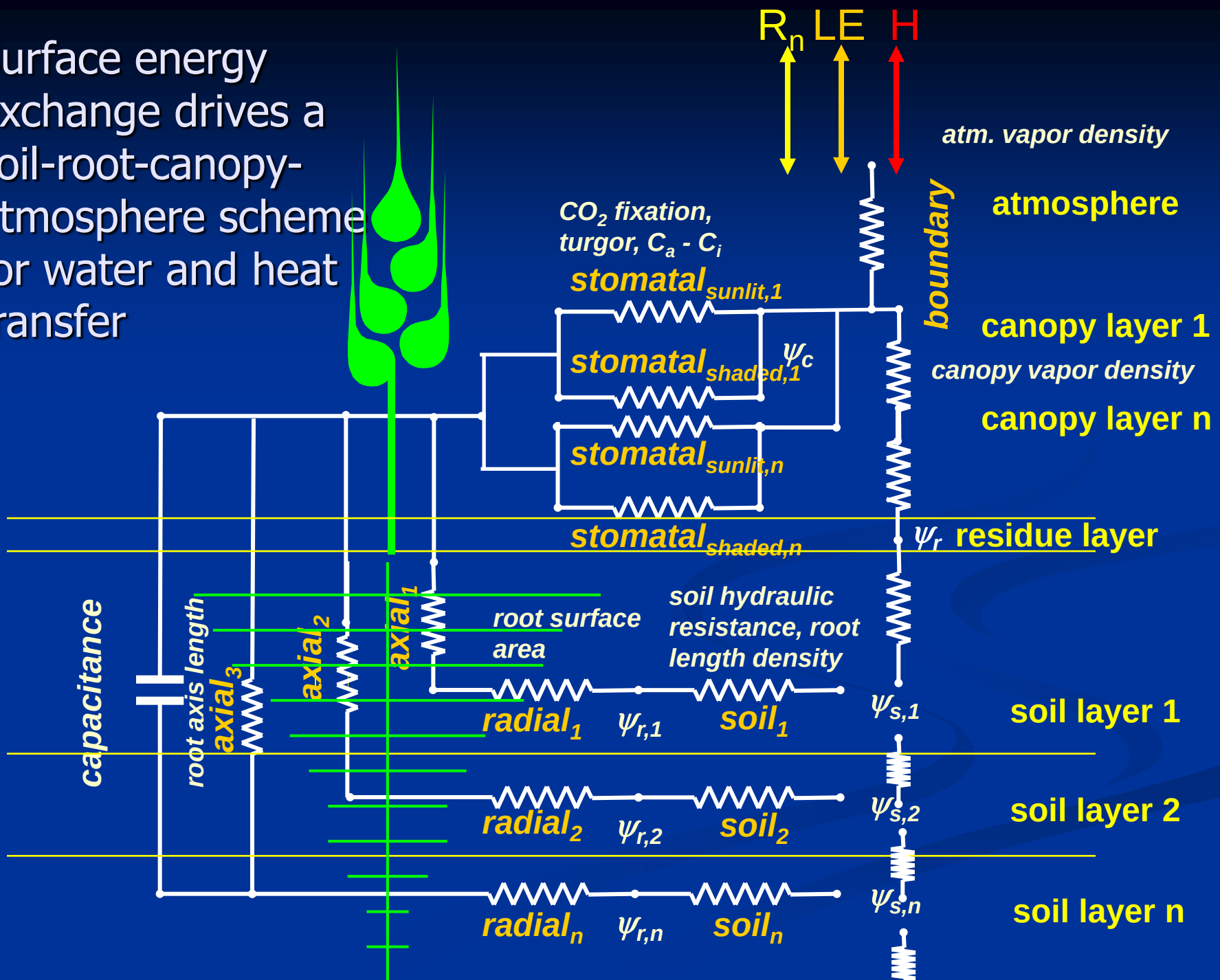
Introduction: Net CO_2 exchange of mature Amazonian rainforests is highly seasonal

- Net sources during the rainy season
  - Less CO_2 uptake with less radiation?
  - More CO_2 emission from wetter soil?
- Net sinks during the dry season
  - More CO_2 uptake with more radiation, sustained by water deep in the soil profile accessed by deep roots?
  - Less CO_2 emission from drier soil?

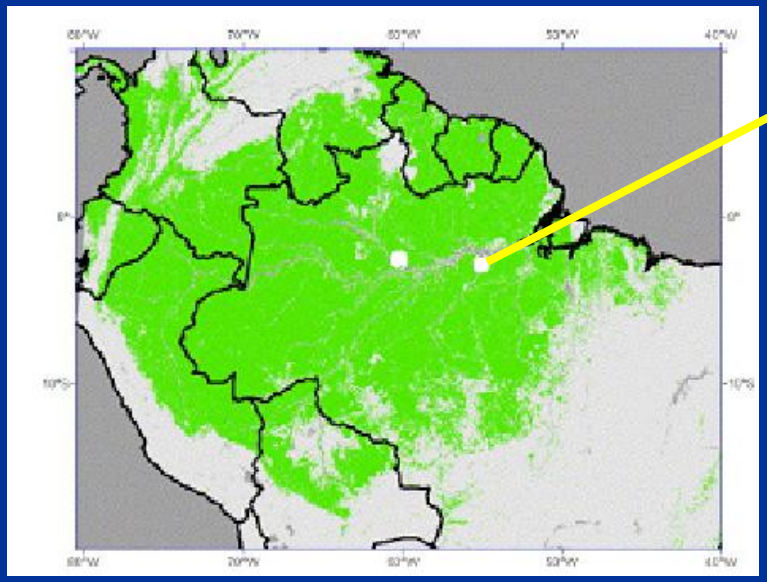
Test hypotheses for these controls through the ecosystem model *ecosys*

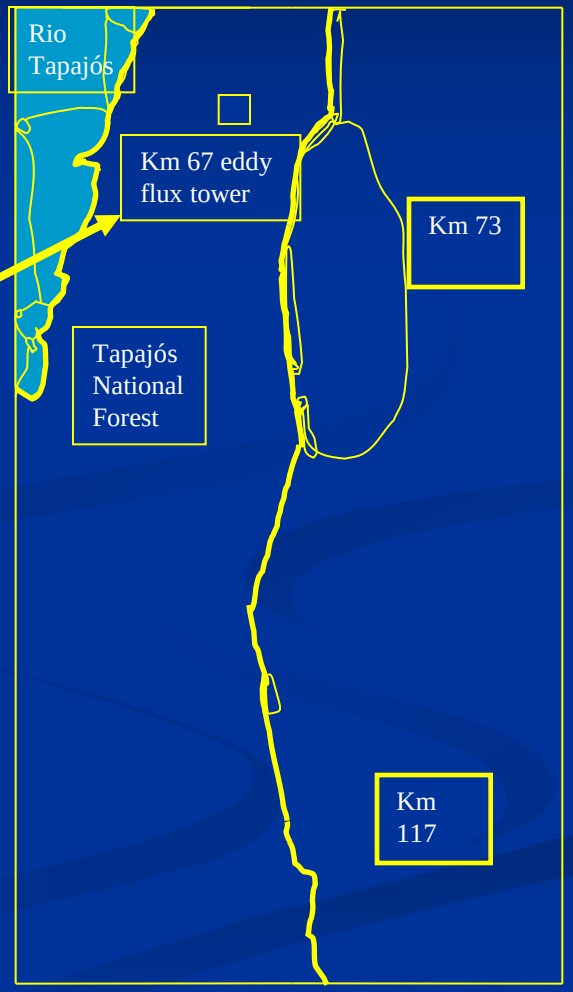


Surface energy exchange drives a soil-root-canopy-atmosphere scheme for water and heat transfer



Test seasonal effects on net CO_2 exchange in *ecosys* vs. EC measurements at Santarém km 67





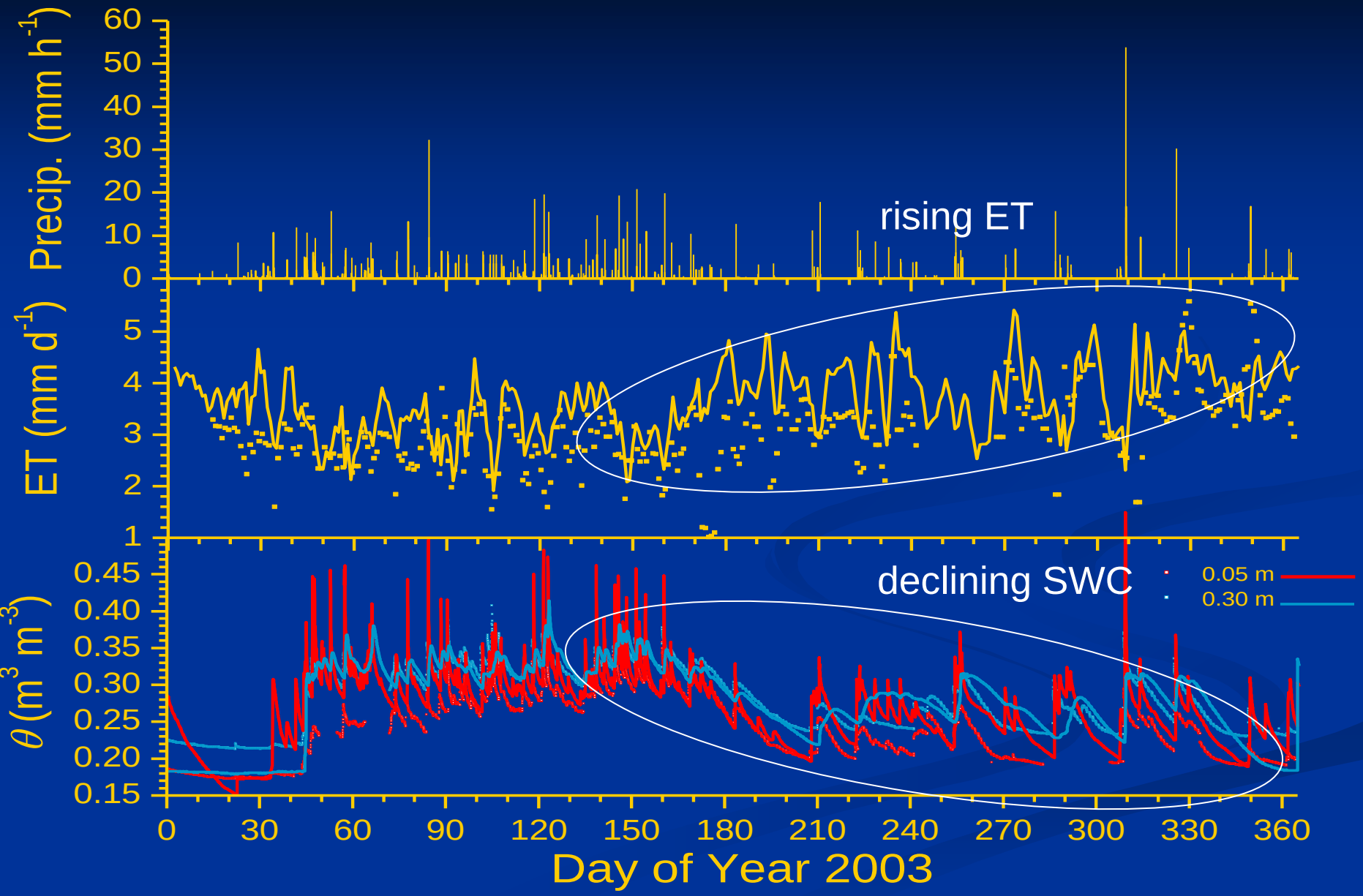
Model Experiment

- physical and chemical properties of nutrient poor clay oxisol (Silver et al., 2000)
- biological properties of overstory and understory plant populations (broadleaf evergreens)
- plant populations seeded during model year 1890
- model run to 2010 under repeating cycles of hourly weather data recorded km 67 EC flux tower during 2002 – 2004.
- background mortality rate of 2% per year, raised to 5% per year every 5^{th} year
- herbivory through daily removals of standing leaf mass to give annual removals of 10%
- C_a rose hourly from 275 to 385 μmol mol^{-1}.
- NH_4^+-N, NO_3^--N and $H_2PO_4^-$-P in precipitation was 0.1, 0.05 and 0.01 g m^{-3}

Model Test: How well were measured CO_2 and LE fluxes simulated?

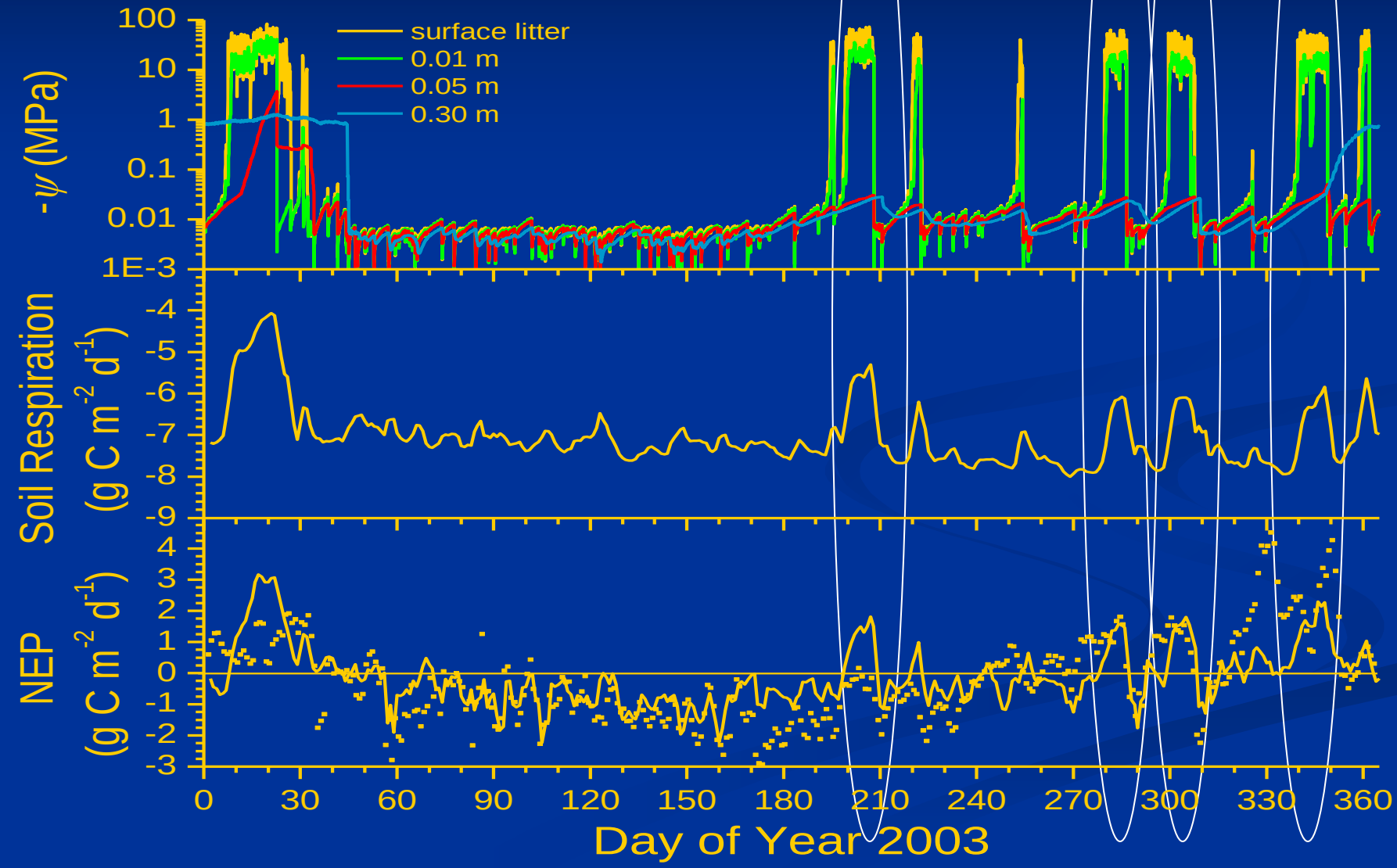
Year	*n*	*a*	*b*	R^2	RMSD
	CO_2 (μmol m^{-2} s^{-1})				
2003	4744	0.89	0.91	0.80	5.1
2004	3998	0.86	1.04	0.73	5.8
	LE (W m^{-2})				
2003	5043	-30	0.90	0.79	63
2004	4642	-29	0.92	0.73	72

Seasonal patterns of rainfall, ET and SWC during 2003

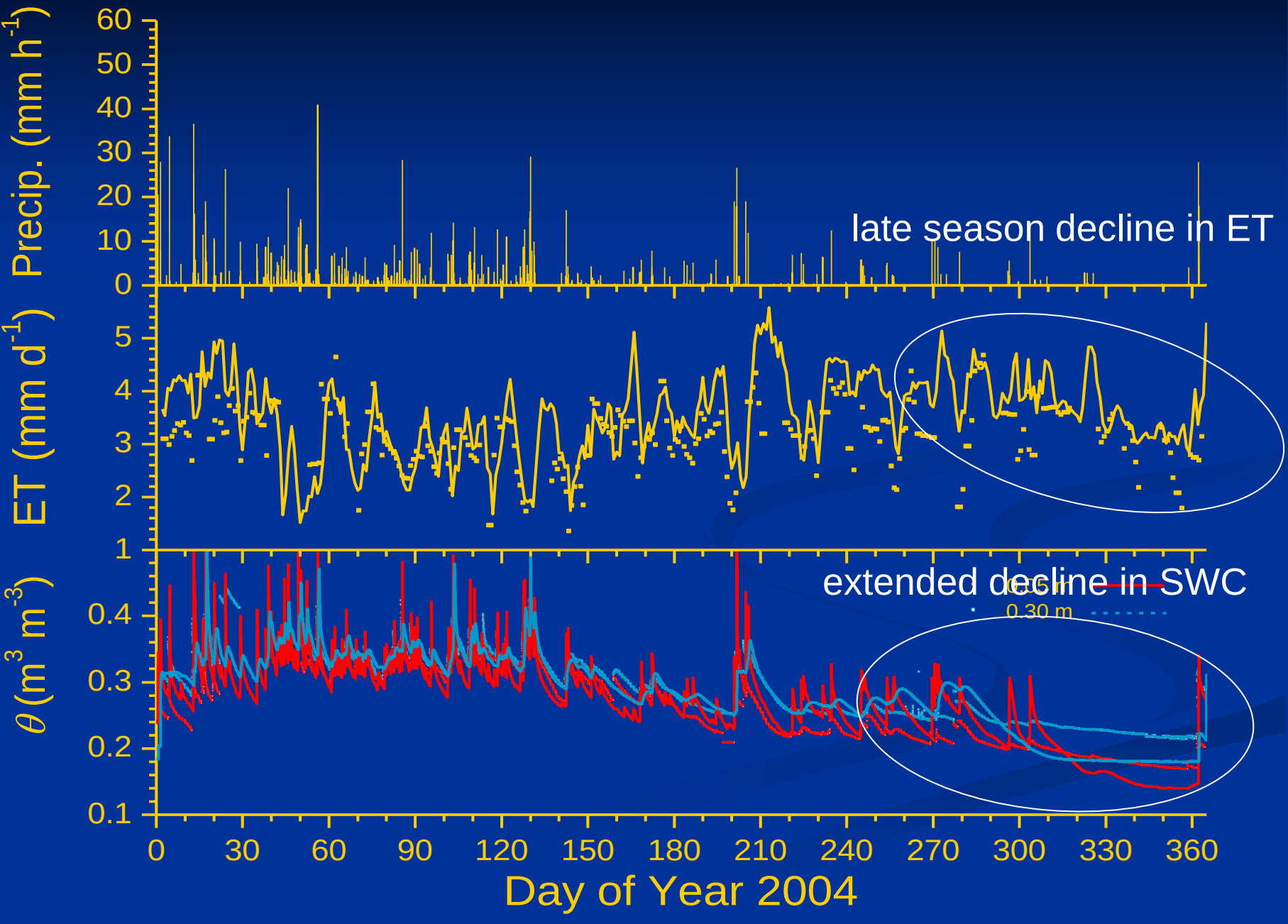


Seasonal patterns of surface drying and NEP in 2003

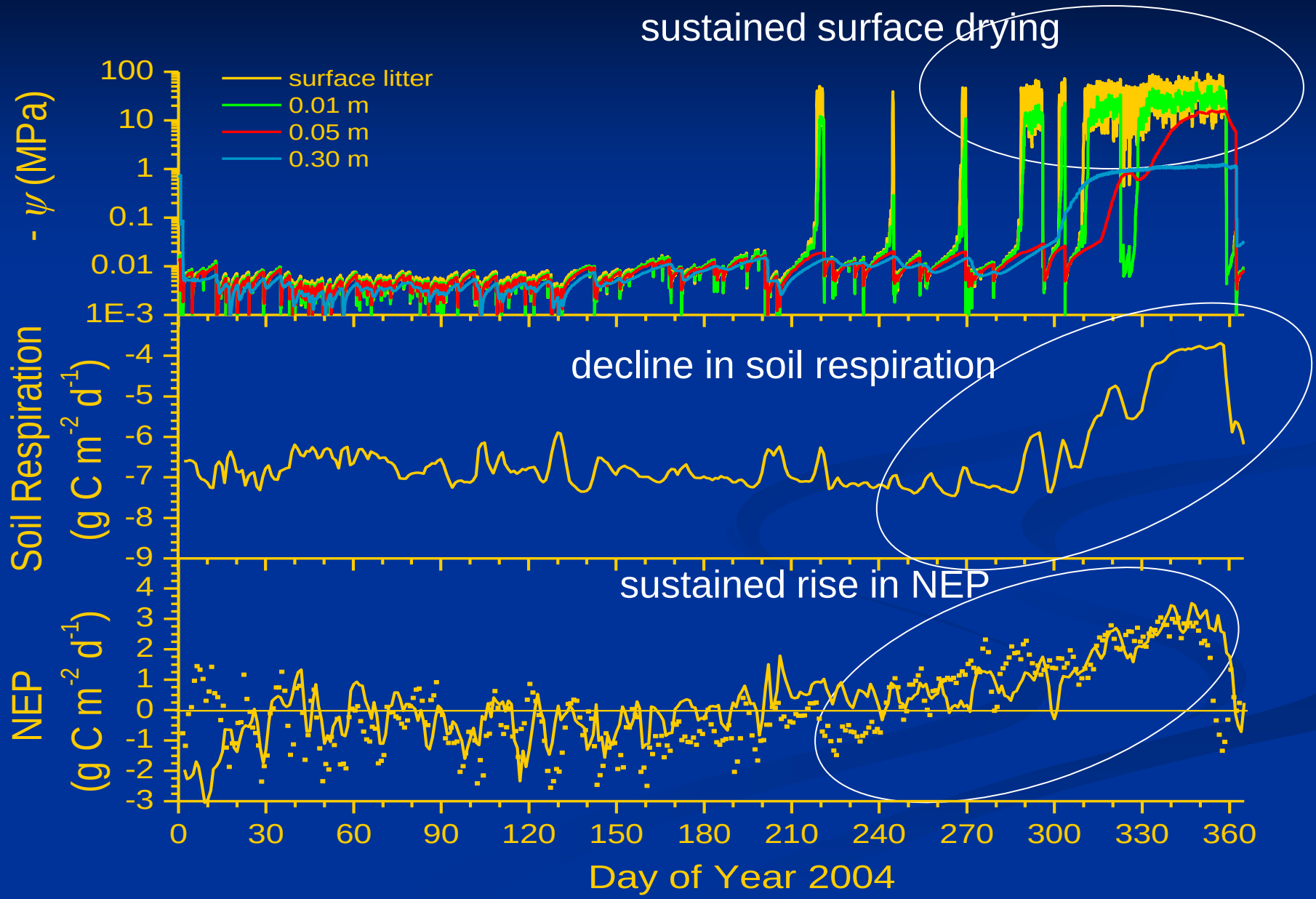
Surface drying reduces soil respiration, raises NEP



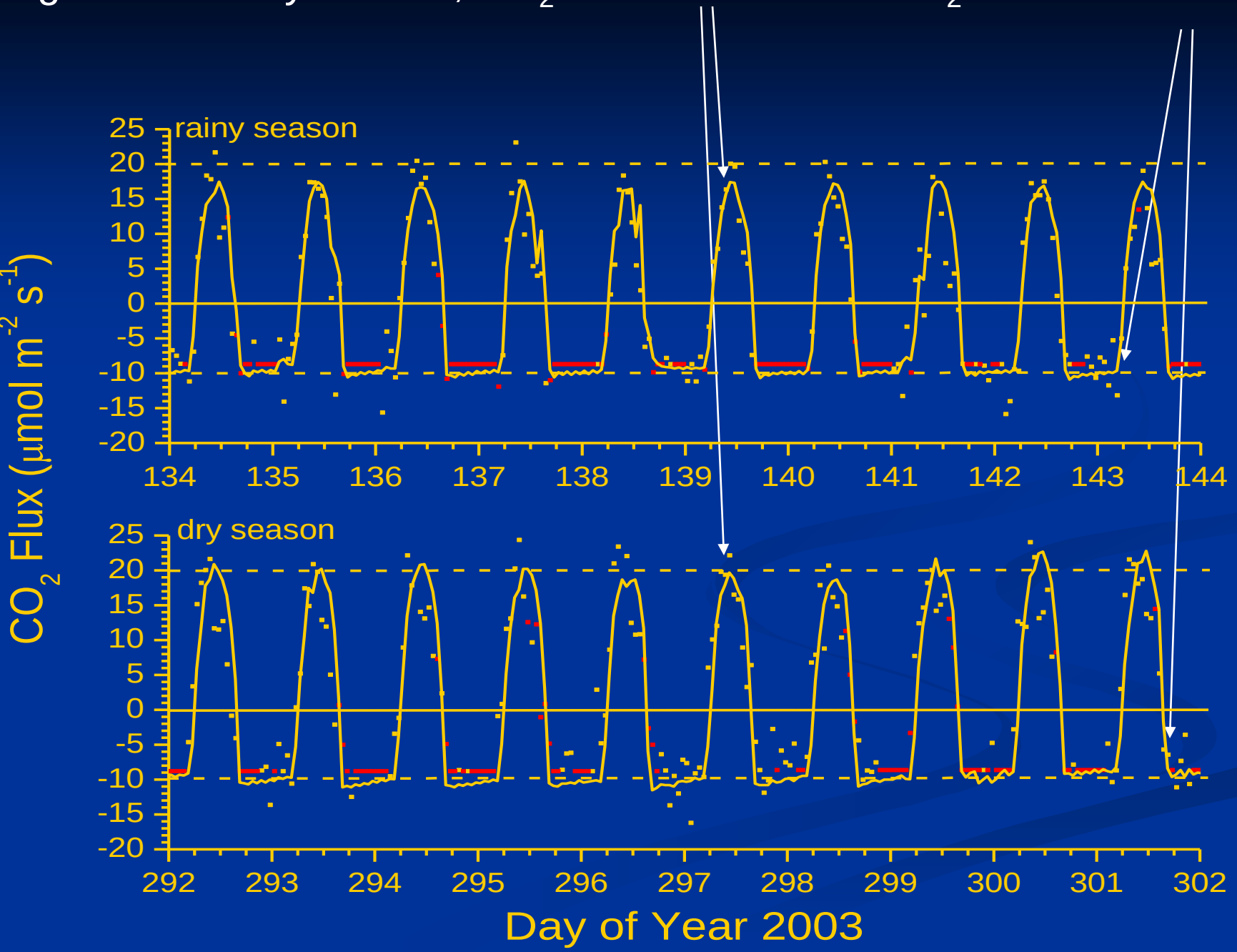
Seasonal patterns of rainfall, ET and SWC during 2004



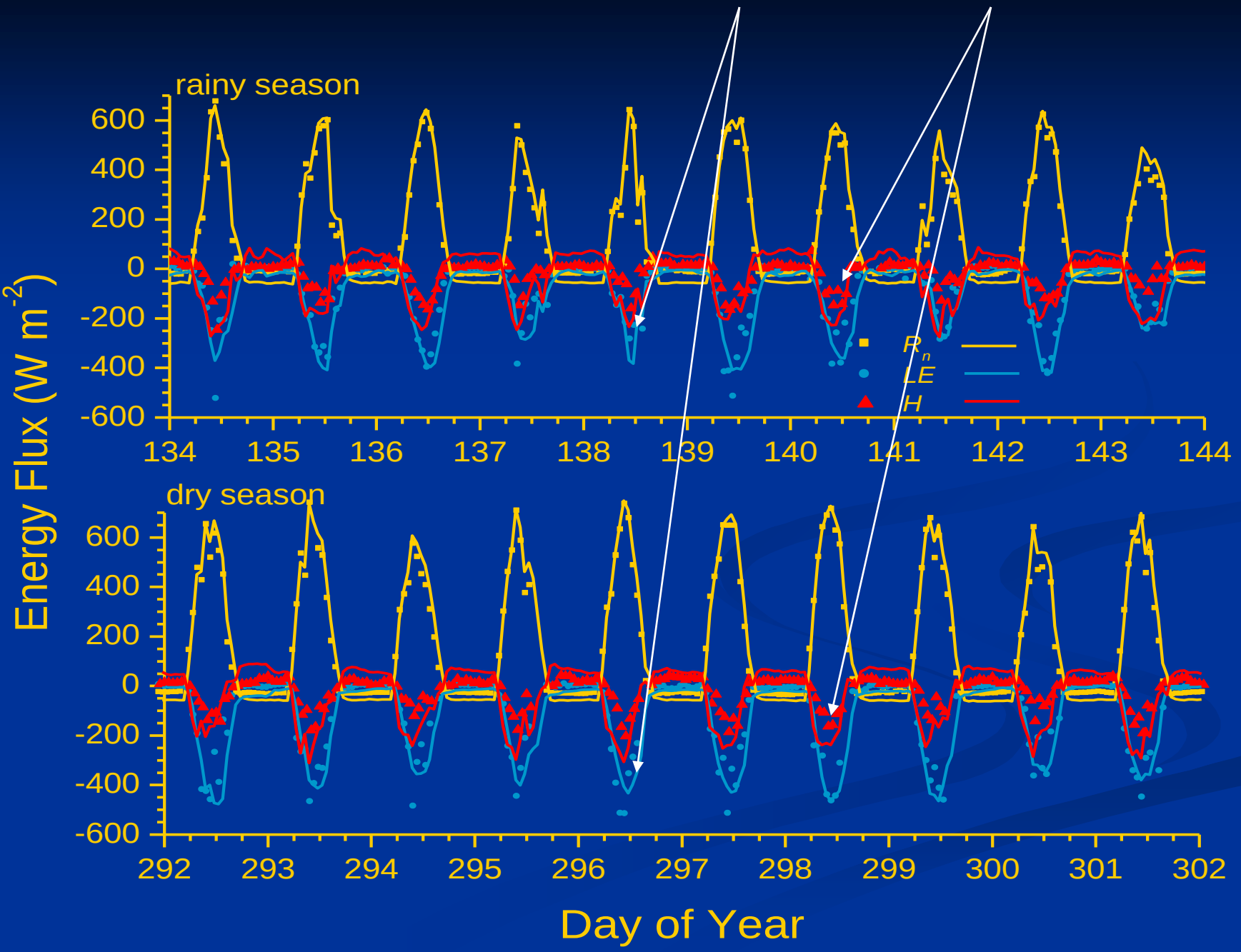
Seasonal patterns of surface drying and NEP in 2004



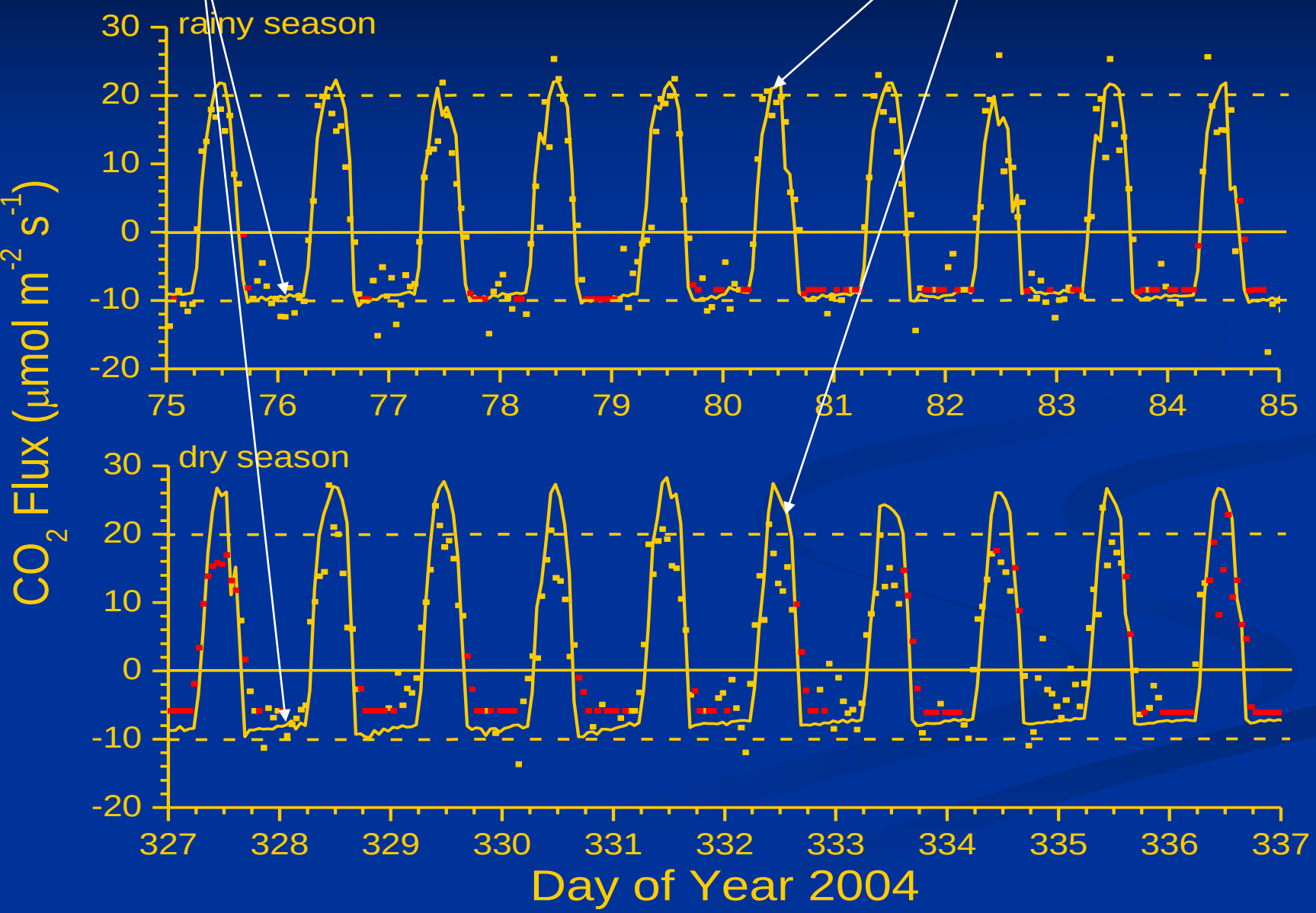
During the 2003 dry season, CO_2 influxes rose but CO_2 effluxes did not



During the 2003 dry season, Rn and LE rose, but H/LE did not



During the 2004 dry season, CO_2 influxes did not rise, while CO_2 effluxes declined

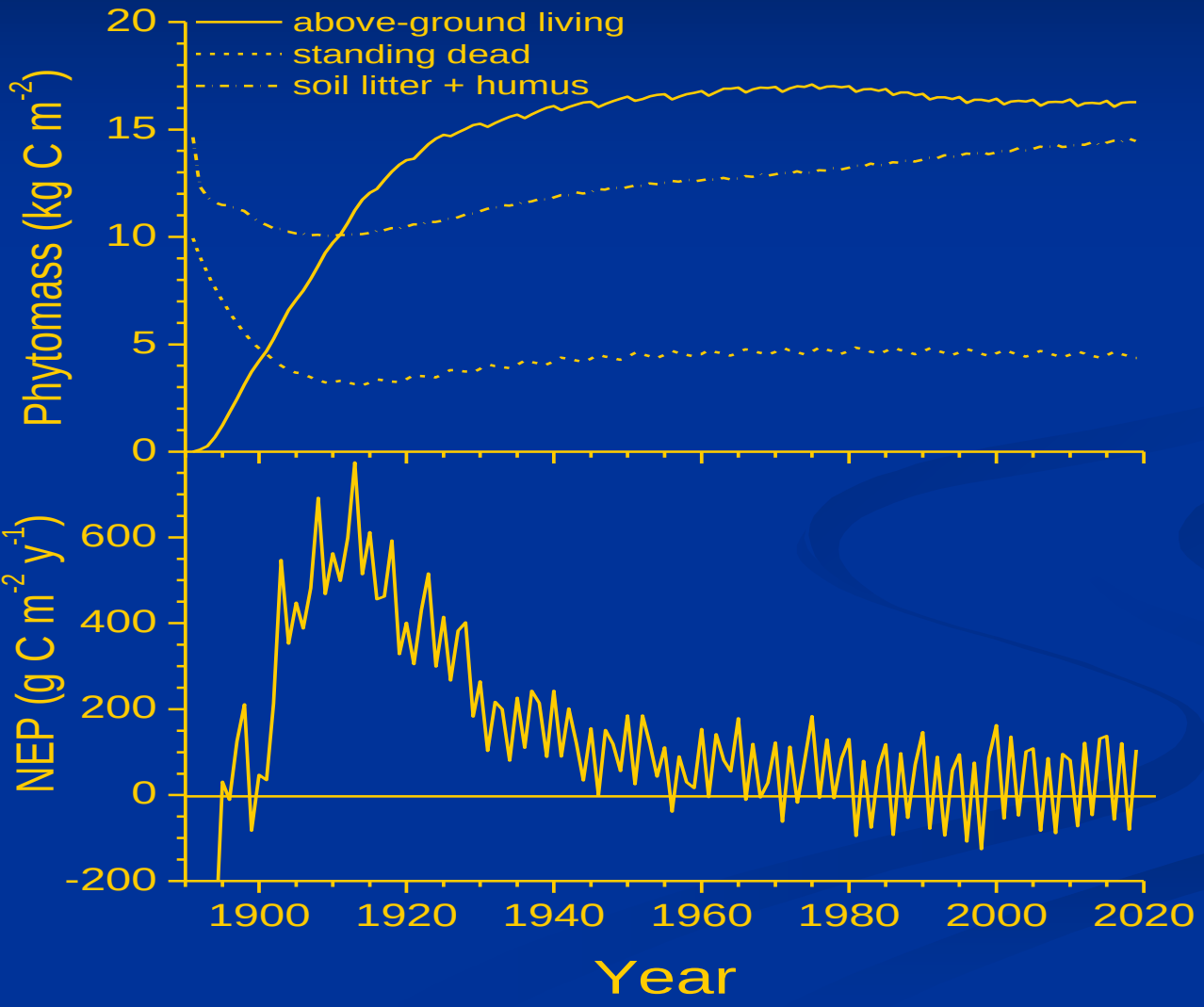


C Balances modelled by ecosys and estimated by EC and biometric measurements at SR67 in 2003 and 2004

	2003		2004		
	M	EC & B†	M	EC & B	Other*
GPP	3720	3171	3862	3195	3000
Ra: above	1201		1372		1550
Ra: below	1333		1303		550
NPP above	516		849		640
NPP below	670		338		260
Rh	1224		1074		850
Reco	3758	3262	3749	3173	2950
DIC,DOC	8		13		
NEP	**-46**	**-91 ± 49**	**+100**	**+22 ± 45**	**+50**

† from Hutyra et al., 2008; * for central Amazonian forests from Chambers et al. (2004b)

Can we simulate long-term forest NEP from this model?



What causes net CO_2 exchange of mature Amazonian rainforests to be highly seasonal?

- Net sources during the rainy season
  - Less CO_2 uptake with less radiation
  - More CO_2 emission from wetter soil
- Net sinks during the dry season
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