Assessment of regional climate variability using satellite radiation measurements

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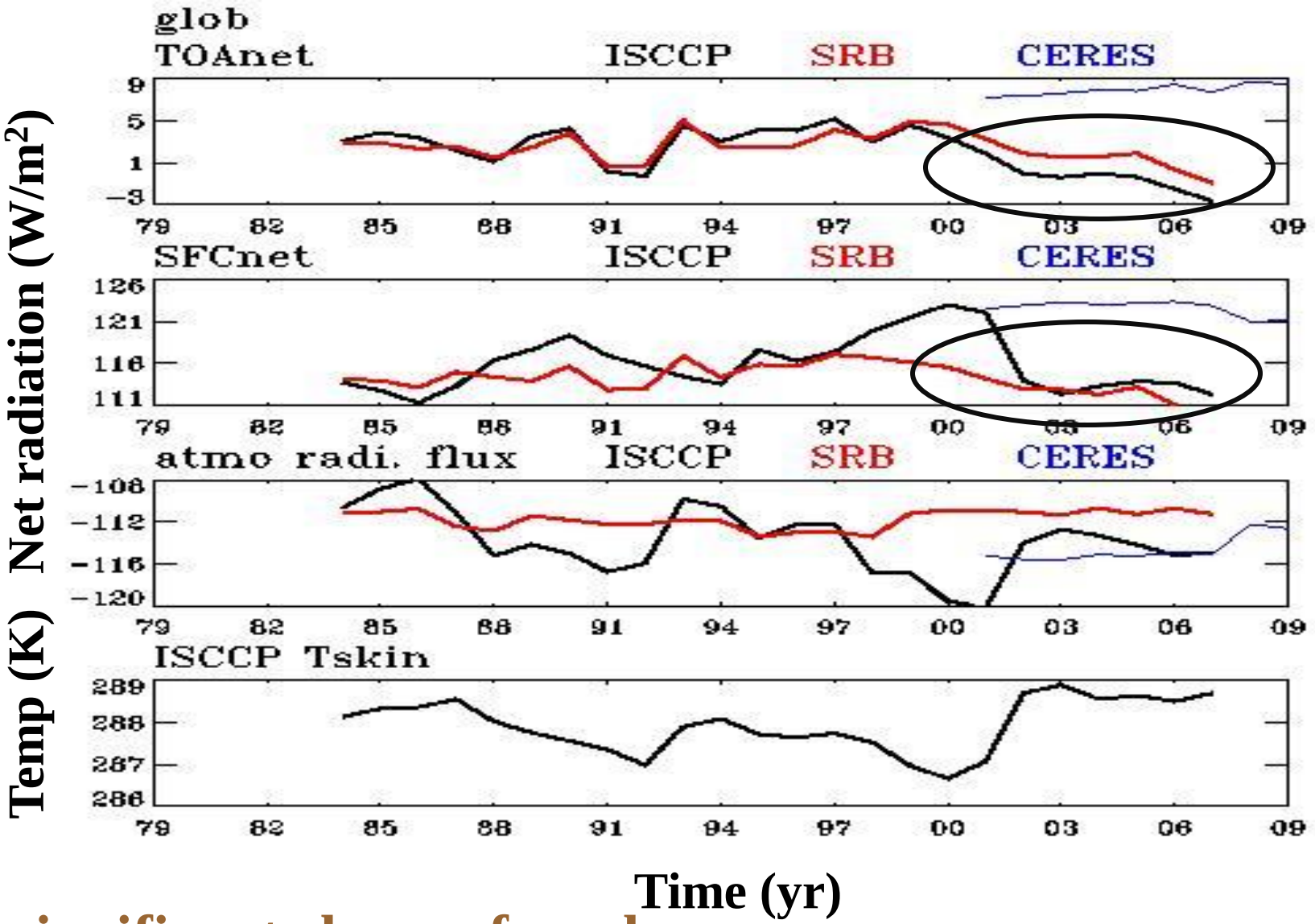
Introduction

- Global mean climate change and variability

  - advantage: large data set for average
  - signal is small for satellite:

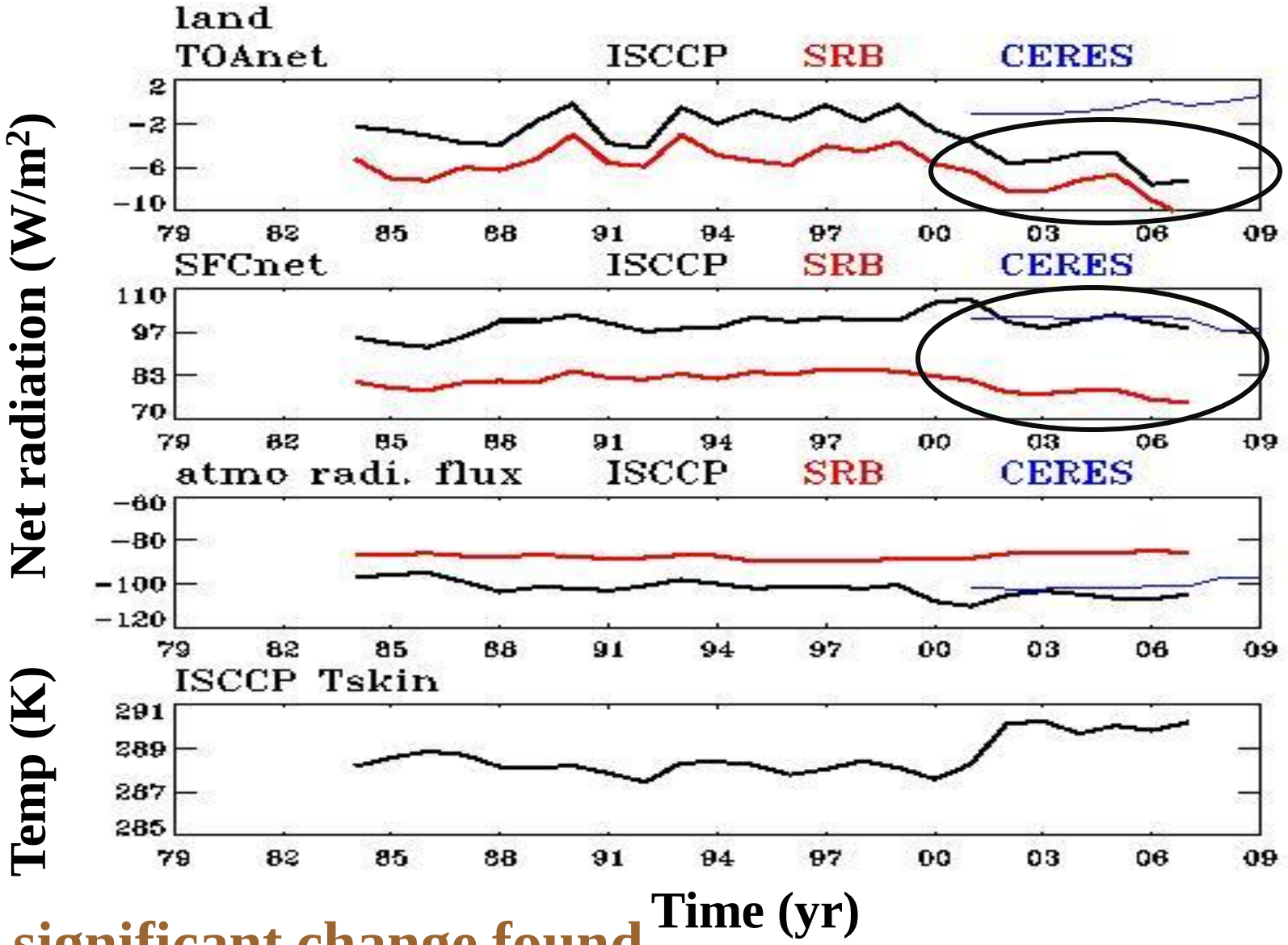
    0.65K for last 120 yrs
  - other factors potentially affect the detection of the climate change signal: clouds, ocean
  - in-situ measurements/sampling rates: low

Satellite global means



No significant change found

Satellite global land



No significant change found

Introduction (cont.)

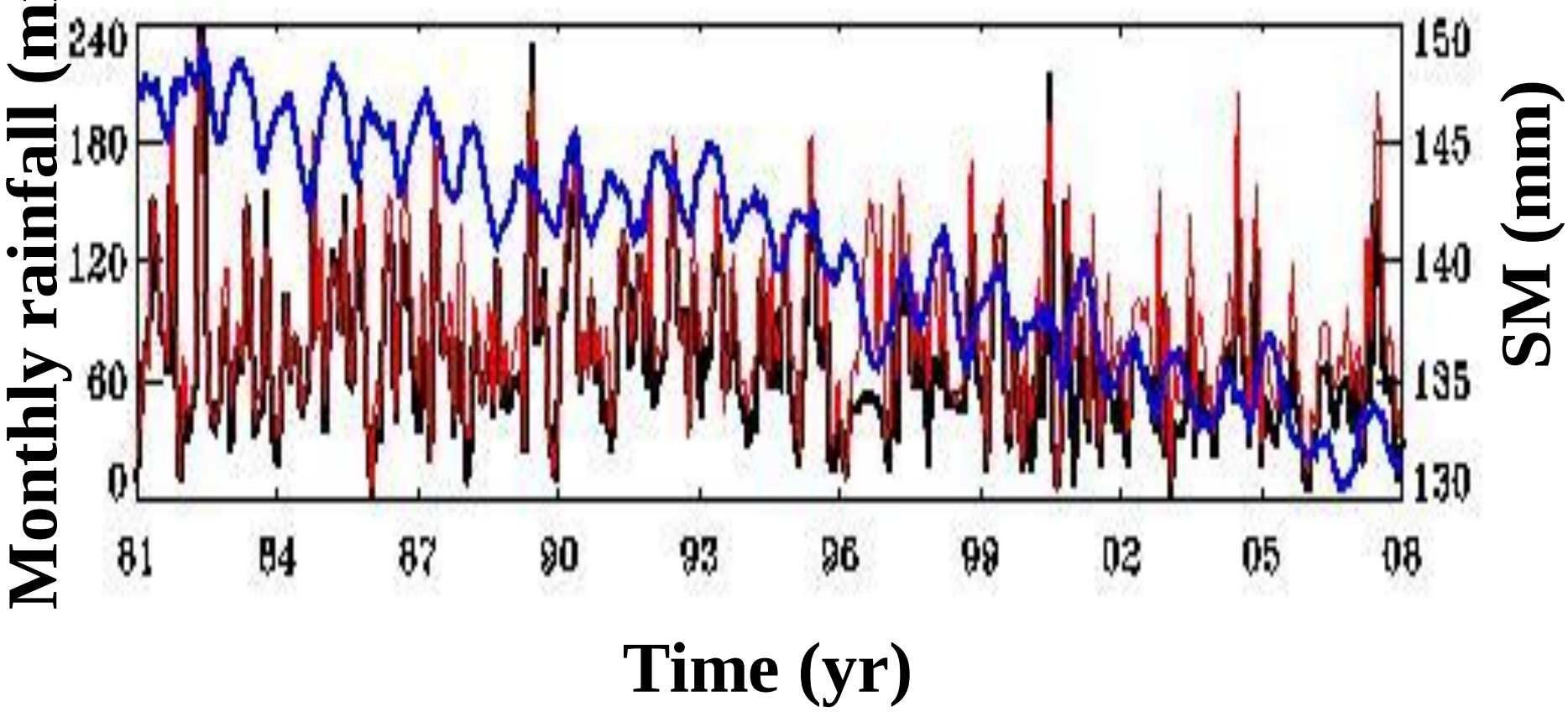
- Regional climate variations: certain areas
  - large regional variability
  - high sensitivity area such as polar regions
  - better long-term observations: e.g. in situ
  - direct impacts on socioeconomics

- Targeted area: Southern Great Plains
  - Hypothesis: During the satellite era (~ last 20 yrs), there were significant climate changes in the region.

Why SGP: Soil Moisture/Rainfall

GPCP CLM

CLM SM



top 3.4m soil

~10% decrease

Introduction (cont.)

- **Water cycle**
  - sfc: $P - E - D_{discharge} = \Delta SM / \Delta t$
  - atmosphere: $L_{prcip} \propto P$
- **Energy cycle**
  - sfc: $R_{net} - LH - SH = \Delta H_{storage}/\Delta t$
  - atmosphere: $R_{net} = L_{prcip} + H_{transport}$
  - TOA: R_{net}
- **Sat.-only obs couldn't balance E&W cycle**

Approaches

- **Evaluating trends and variability observed by satellites**
  - radiative energy: TOA, sfc, within atmos
  - other energy components: sfc latent & sensible heats; precip. (LH release)
  - interactions: meteorology & hydrology soil moisture, Tair, etc

- **Statistical analysis**
  - significant test, autocorrelation function

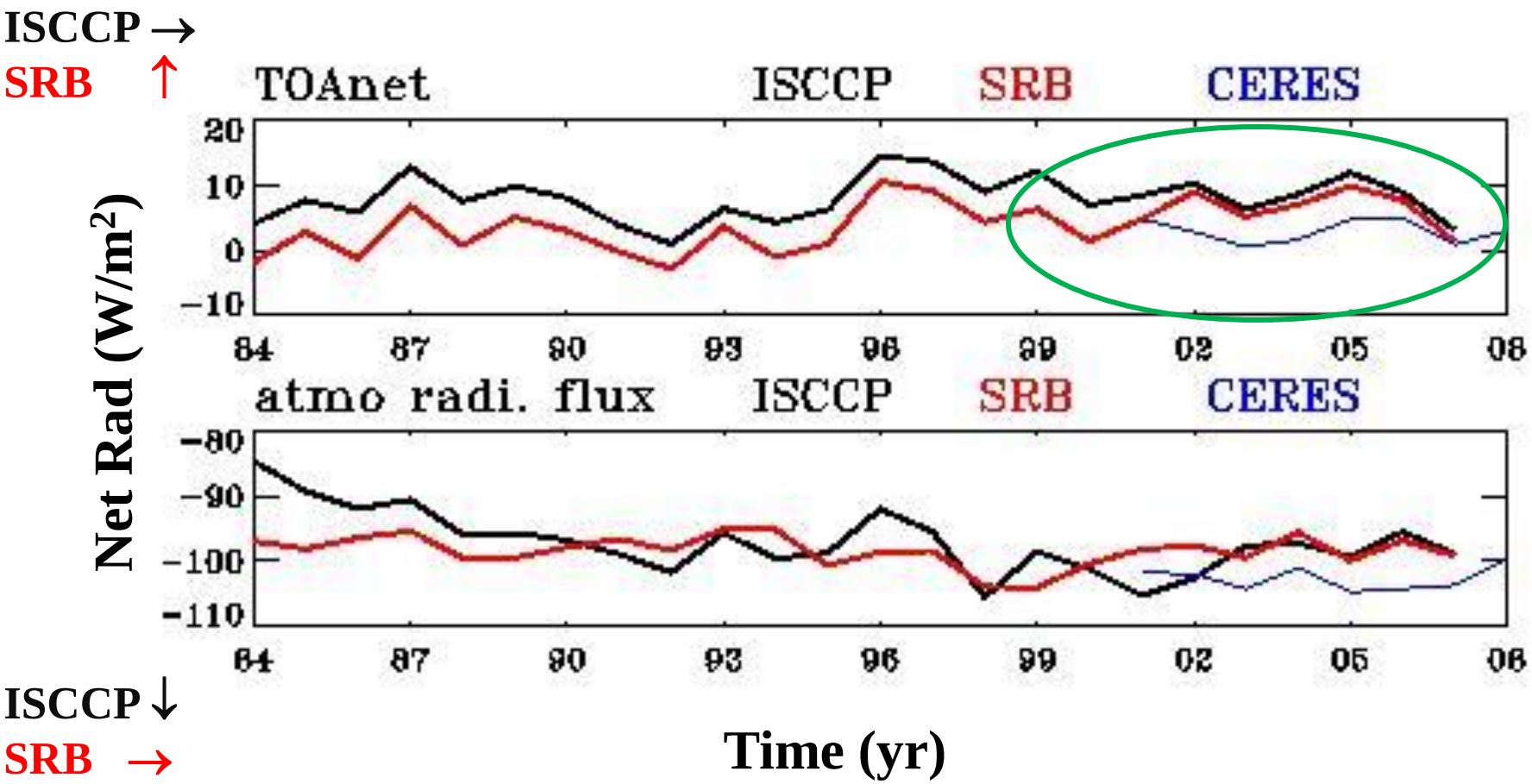
- **Natural or anthropogenic variability**
  - long-term (last 70 years) variability

Data Sets

- Radiation: SRB, ISCCP, CERES
- GLDAS: CLM, VIC, NOAH, and MOSIC
- Global Precipitation Climatology Project: GPCP
- Historical Climatology Network (HCN)

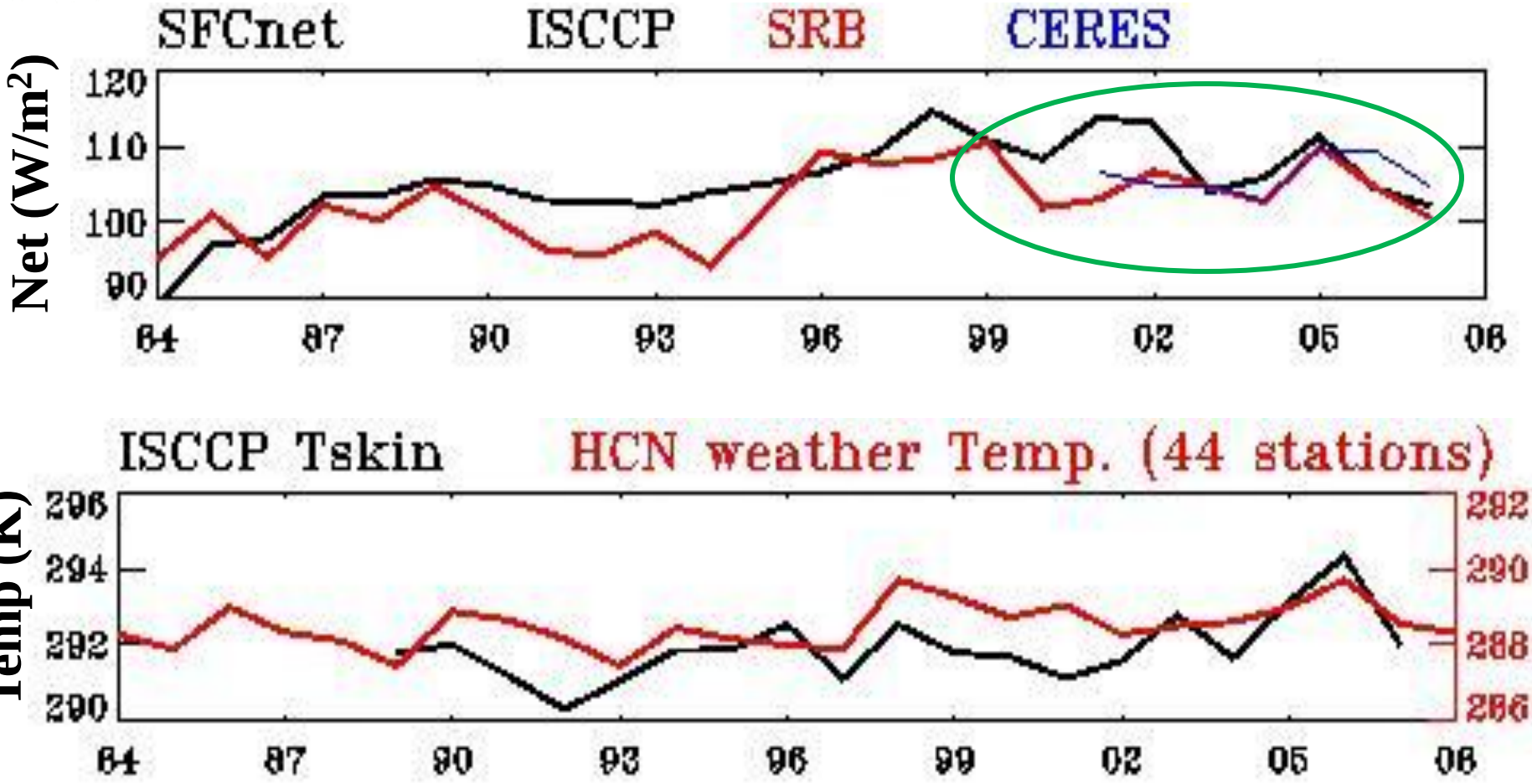
  Oklahoma: 44; US: 1219 stations
- Princeton land data set: turbulent fluxes
- Gravity Recovery and Climate Experiment (GRACE)

TOA & in-atmosphere radiation



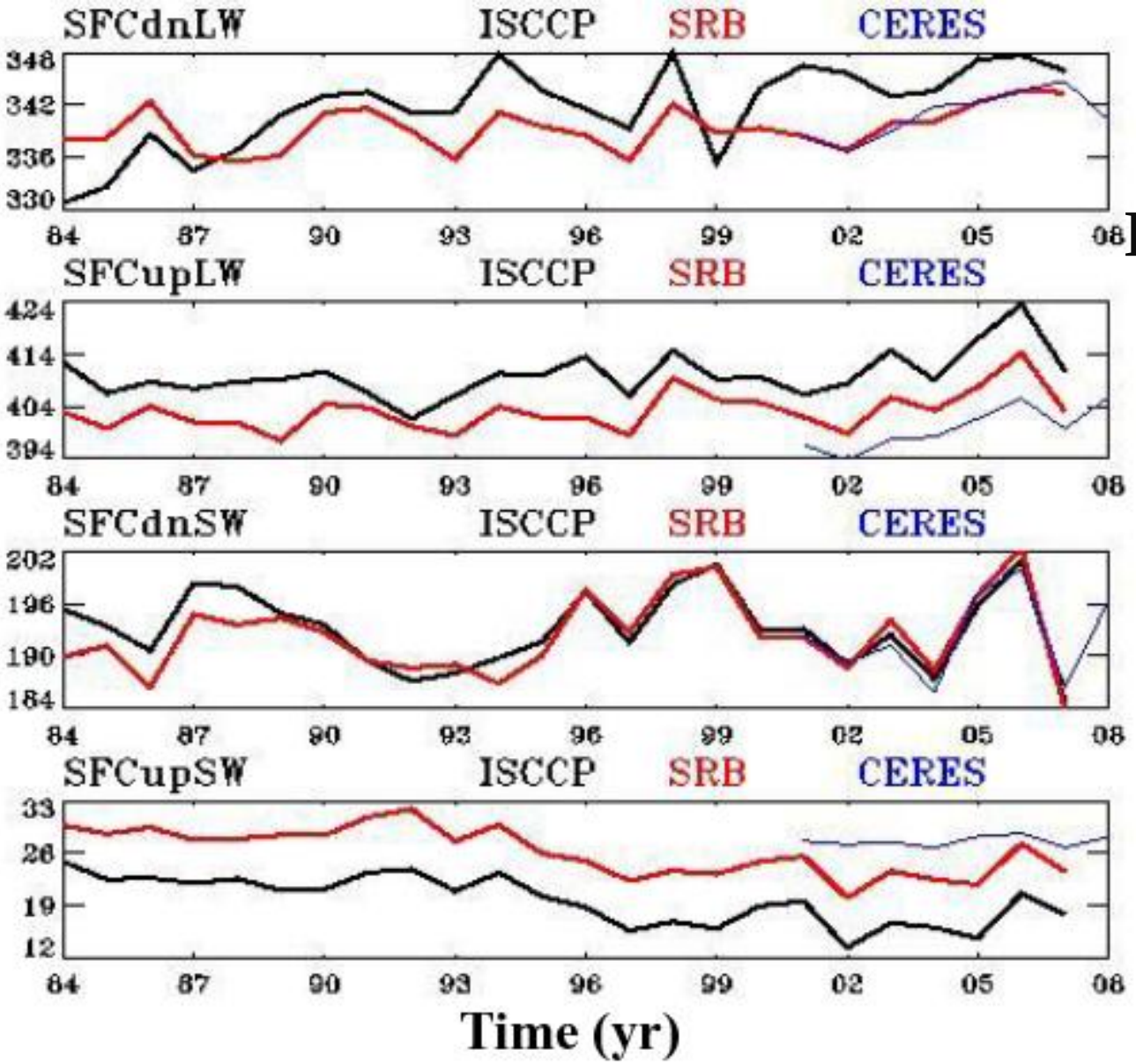
some indications in increase & decrease in TOA & within-atmospheric, respectively, net radiation

Sfc radiation & temperature

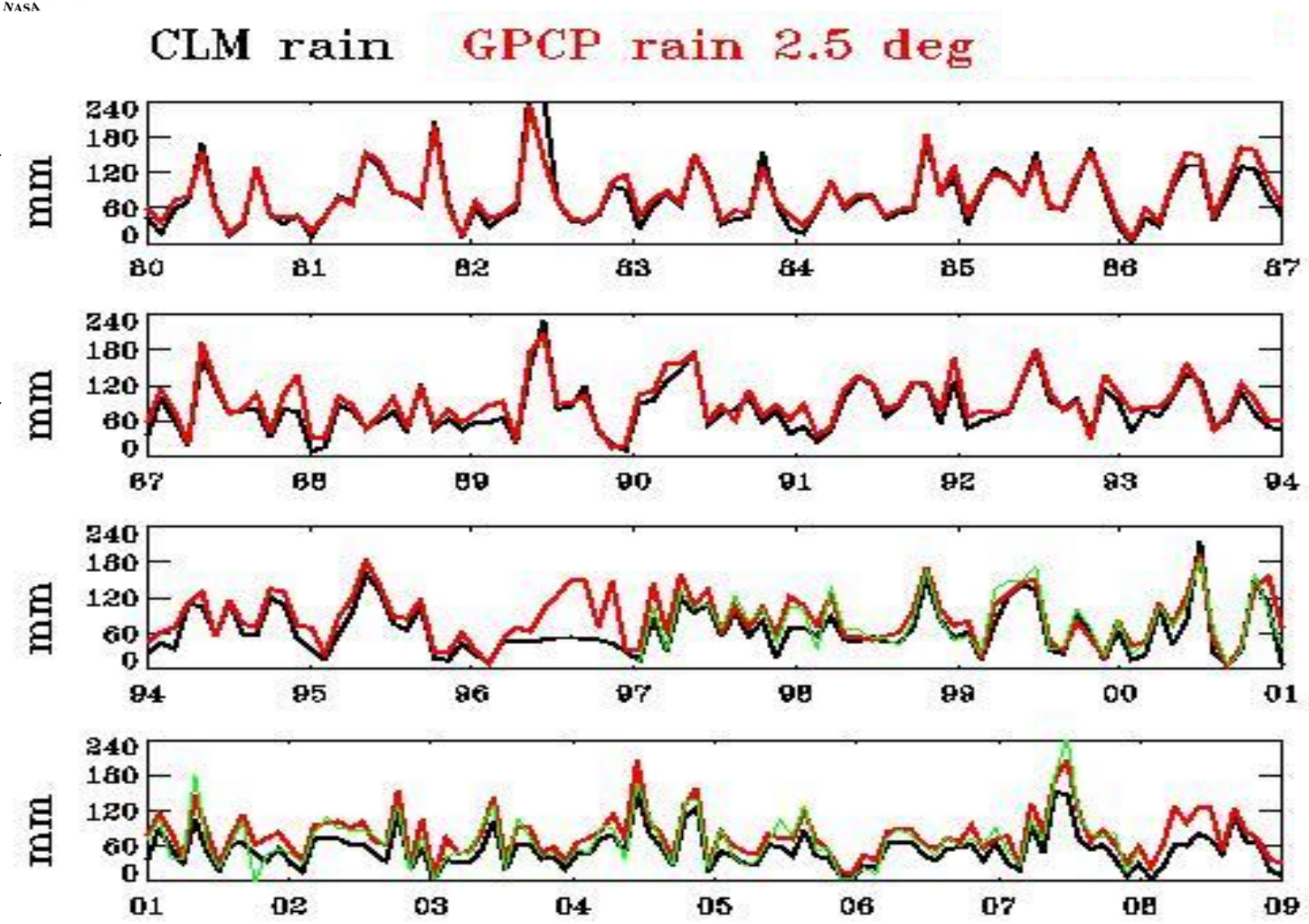


considerable increases in sfc net radiation & temperature

Sfc radiation: LW & SW



Precipitation



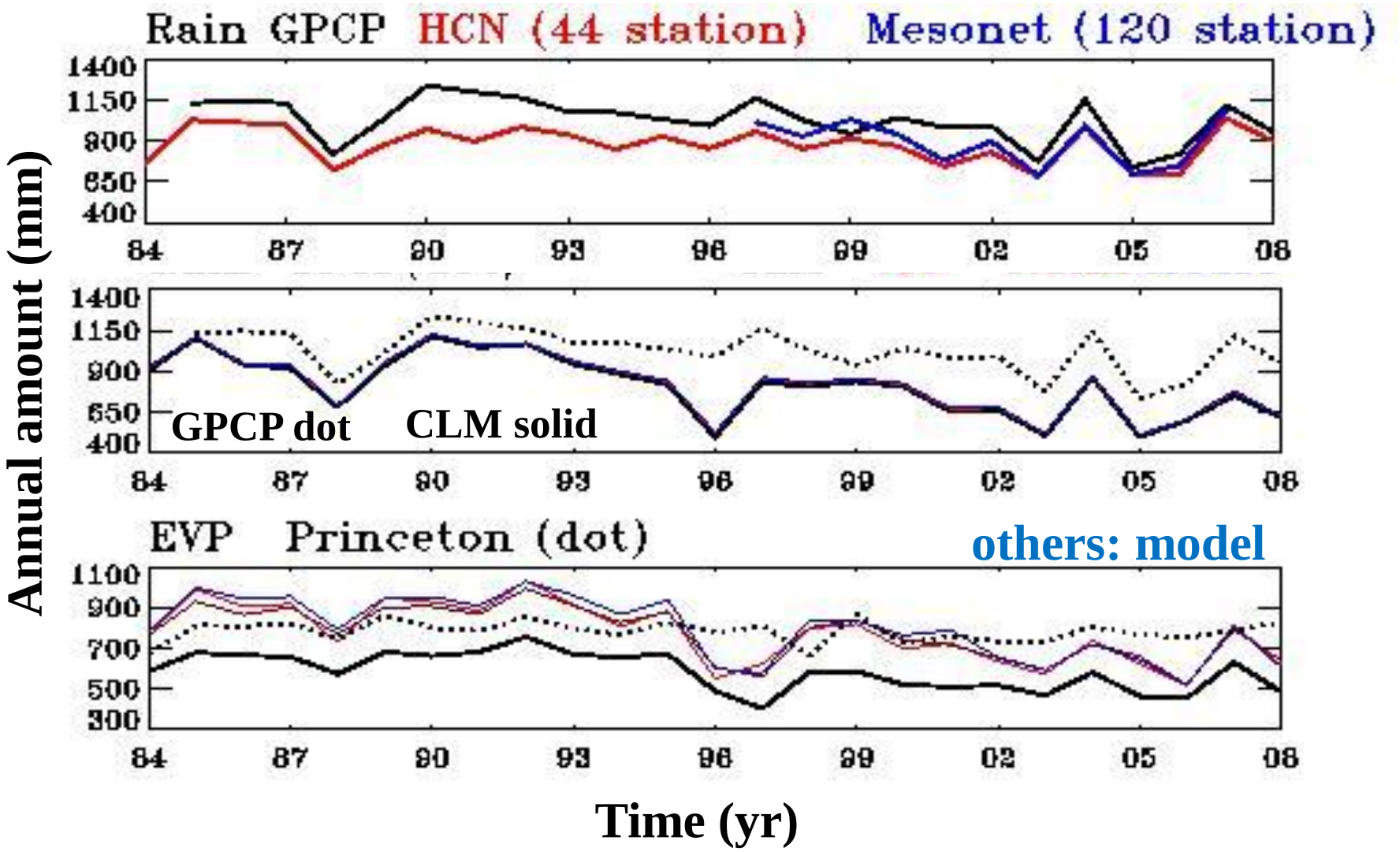
Rainfall amount (mm/month)

decreasing variability?

decrease trend

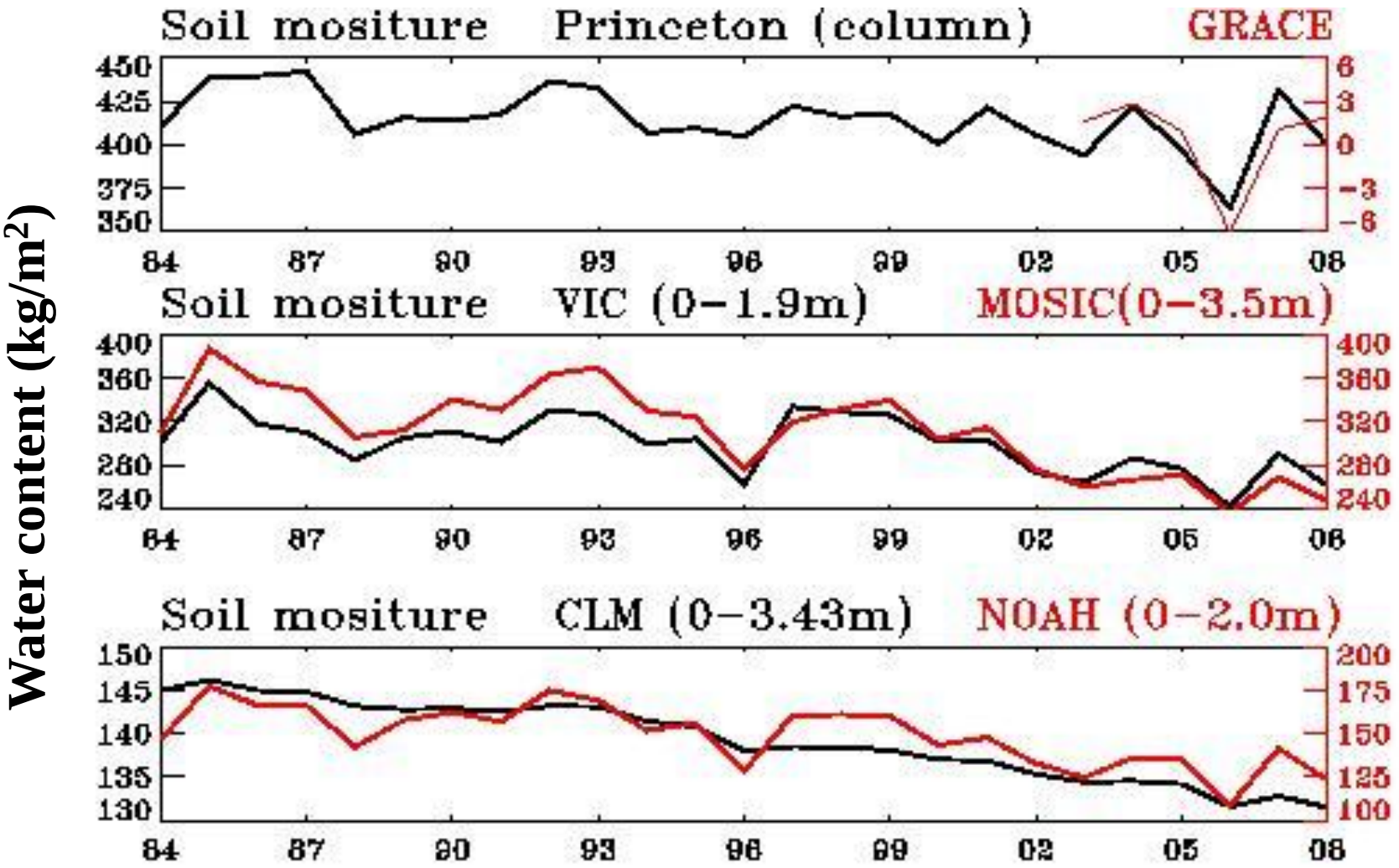
Time (yr)

Evap & rainfall measurements



decreases

Moisture storage (assimilation)



decreases

storage: no absolute

Trend detection

	mean	std	corr. coeff.	significant level (1-P)
ISCCP R_{TOA}	8.008	3.395	0.175	60.2%
SRB R_{TOA}	3.865	3.868	0.506	94.4%
ISCCP R_{atm}	-97.085	4.832	-0.596	95.2%
SRB R_{atm}	-98.466	2.337	-0.259	71.6%
CLM LH	46.418	7.207	-0.629	94.1%
NOAH LH	61.449	10.012	-0.664	96.0%
MOSIC LH	62.336	11.489	-0.696	96.8%
CLM SH	43.459	7.236	0.333	75.5%
NOAH SH	33.666	9.090	0.478	89.6%
MOSIC SH	39.072	10.822	0.619	94.4%

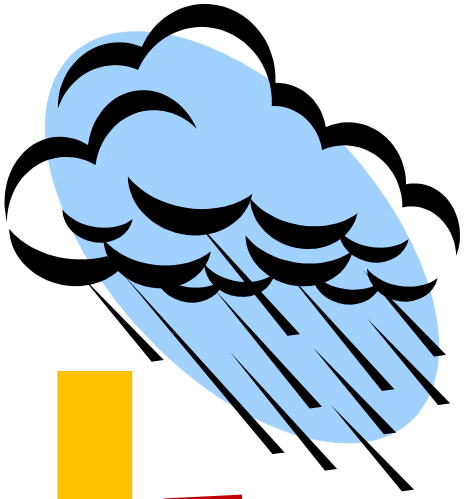
Trend detection

	mean	std	corr. coeff.	significant level (1-P)
ISCCP Rsfc	105.1	5.62	0.619	94.1%
SRB Rsfc	102.3	4.78	0.536	92.4%
CERES Rsfc	105.1	2.85		
ISCCP Tskin	291.841	0.803	0.438	92.2%
HCN Tair	288.490	0.591	0.438	92.5%

Trend detection

	mean	std	corr. coeff.	significant level (1-P)
GPCP P	1026.935	130.840	-0.413	90.3%
HCN P	891.337	110.325	-0.273	83.0%
CLM E	585.183	90.881	-0.630	94.1%
Prnctn E	781.997	50.754	-0.095	38.2%
CLM SM	139.272	4.463	-0.981	~100%
Prnctn SM	414.597	17.233	-0.512	96.6%

Regional climate variation

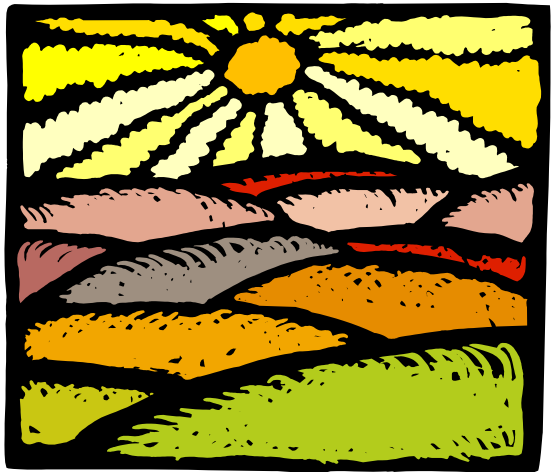


Ta

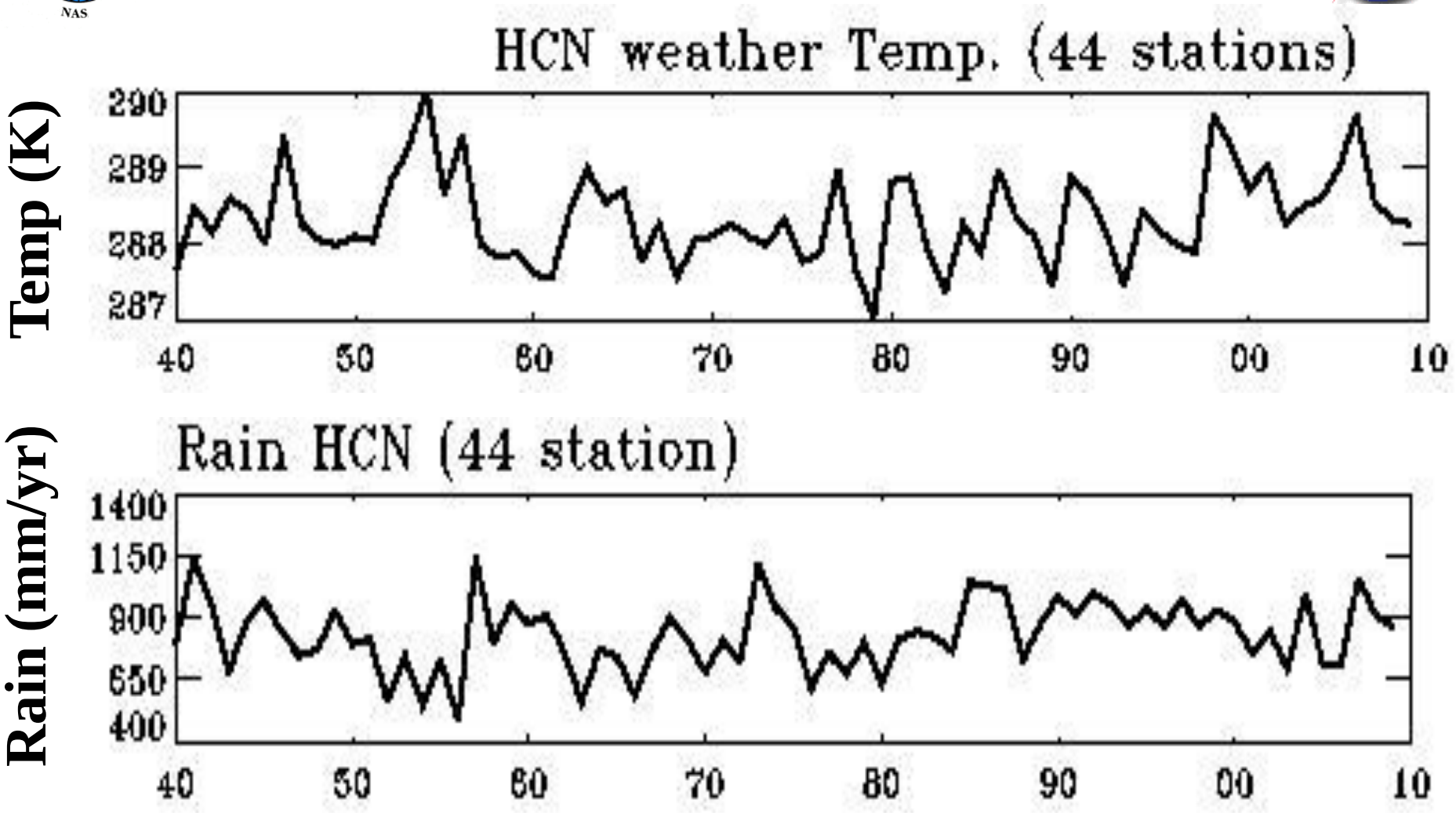
SH +

LH −

Rad +



Long-term historical records



Long-term trend test

	mean	std	corr. coeff.	significant level (1-P)
HCN Temp	288.3	0.597	0.097	43.8%
HCN Prcip	830.7	141.9	0.184	76.0%

According to the historical 70-yr records no significant climate changes are found. Natural variability ?? Some differences

Summary

- Although detections of regional climate changes are very difficult due to tremendous variability, there are some regions, e.g., poles and SGP, that have high sensitivity for climate variation.

- Radiation fields over the SGP region have significant changes during the last two decades or so. The surface net radiation has increased about 5 to 10%. Accompanying with these radiation changes, land surface turbulent latent and sensible heat fluxes have also considerable decadal variations. However, the trends are not the same for LH and SH fluxes.

Summary (cont.)

- During the same time period, precipitation amounts also high-likely reduced. Also, the temperature is significantly increased, an important indication of regional variation.

- All observed changes in E&W cycles are support of the result of assimilations that the SGP region is getting drier recently, which could have significant impacts on socioeconomics.

- Considering multi-decadal time scale climate, natural variability cannot be ruled out for the observed variation during the last two decades.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Thank You!