

# Evaluating the Response of the Terrestrial Biosphere to Significant Drought

Ian M. Shiach<sup>1,3</sup>, Ian T. Baker<sup>2,3</sup>, A. Scott Denning<sup>2,3</sup>

<sup>1</sup> The Colorado College, Colorado Springs, CO

<sup>2</sup> Colorado State University, Fort Collins, CO

<sup>3</sup> Center for Multiscale Modeling of Atmospheric Processes, Fort Collins, CO

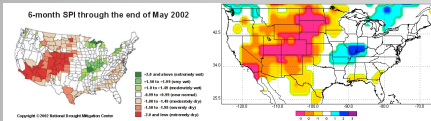


## INTRODUCTION

### How does the biosphere respond to drought?

- If our understanding of drought is adequate, this should be reflected in our climate models.
- Known historical droughts should:
  - Be evident in model precipitation data
  - Be accompanied by realistic responses in physiological variables

### How do we define drought?



(Left) Actual 6-month SPI map for May 2002. (National Drought Mitigation Center). (Right) Modeled 6-month SPI map for May 2002.

- Standardized Precipitation Index (SPI)
- SPI values below -1
- See references

## OBJECTIVE

- To investigate our understanding of drought-related processes in the biosphere by examining how realistically the SiB3 model responds to famous droughts

## DATA

### Simple Biosphere Model 3 (SiB3)

- SiB3 is a land-surface parameterization scheme used to simulate biophysical processes and ecosystem metabolism (Baker et al. 2010)
- This study utilized a global simulation of SiB3 for the years 1983-2006, which was forced with meteorological analysis products from the National Centers for Environmental Prediction (Baker et al. 2010)
- See references

## METHODS

- Using FORTRAN, SPI maps produced at 3-, 6-, 12-, and 24-month averaging intervals
- Similar maps (using "Standardized Variable Index" or SVI) produced for gross primary production, respiration, transpiration, sensible and latent heat flux (variables with gamma distributions)
- Raw anomaly maps produced for net ecosystem exchange, humidity stress, soil water stress, temperature stress (variables with non-gamma distributions)

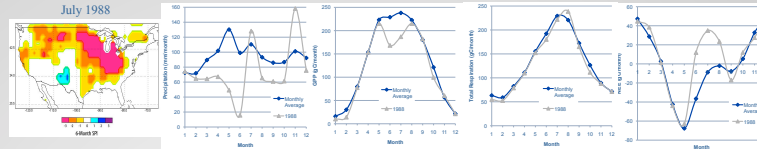


- Performed analysis of drought and anomaly maps for physiological variables in terms of duration, intensity, spatial extent
- Performed analysis of SiB3 data at representative points for deviations from mean monthly averages

## RESULTS

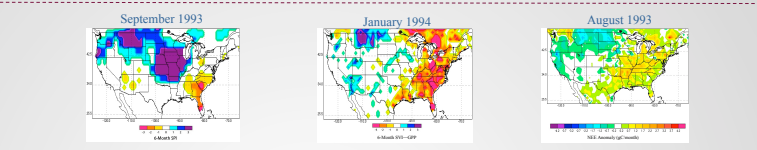
### U.S. Midwest—1988

- Appears consistent with expected behavior



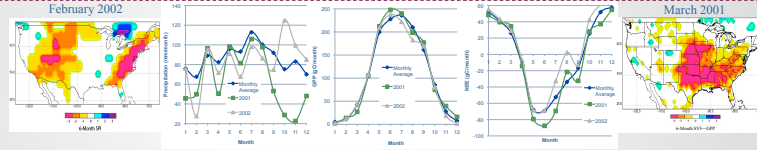
### U.S. Southeast—1993

- Drought largely absent from SPI analysis
- Responses are evident in GPP and NEE



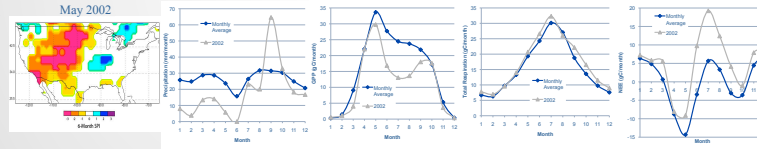
### U.S. Southeast—2001

- Possible under-response
- GPP and NEE are not suppressed despite drought conditions



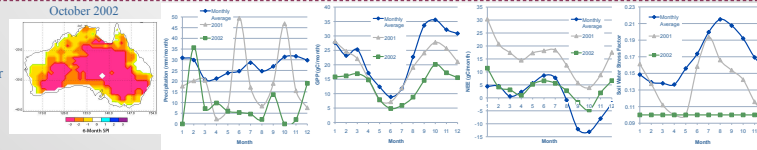
### U.S. Southwest—2002

- Appears consistent with expected behavior



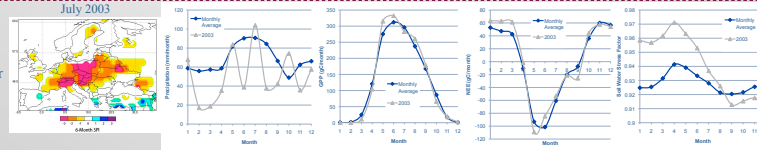
### Australia—2002

- Possible under-response
- Soil water stress factor does not recover over time



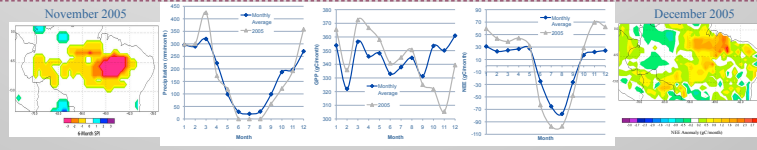
### Europe—2003

- Possible under-response
- Soil water stress factor remains high from past precipitation despite drought



### Amazonia—2005

- Possible under-response
- Drought not apparent in 12- and 24-month SPI analyses



## CONCLUSIONS

- The SiB3 model responds heterogeneously to drought
  - Two droughts and related physiological responses were represented in a realistic manner
  - Four droughts appeared to have unrealistic model responses, with the model being either over- or under-sensitive
  - One drought was absent from SPI analysis but was evident in physiological variable response
- Our understanding of the effects of drought on physiological behavior is not complete
  - Determining why the model differs from reality will help to better this understanding

## FUTURE WORK

- Quantitative analysis of SiB3 SPI, SVI, and raw anomaly maps
- Thorough statistical analysis of variable distributions and relationships
- Comparison of model data with observational data
- Analysis of additional model points
- Examination of other drought indices
- Analysis of post-2006 data from future SiB runs

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## CONTACT INFORMATION

ian.shiach@coloradocollege.edu  
902 N. Cascade Ave.  
Colorado College WB#1355  
Colorado Springs, CO 80946-1355