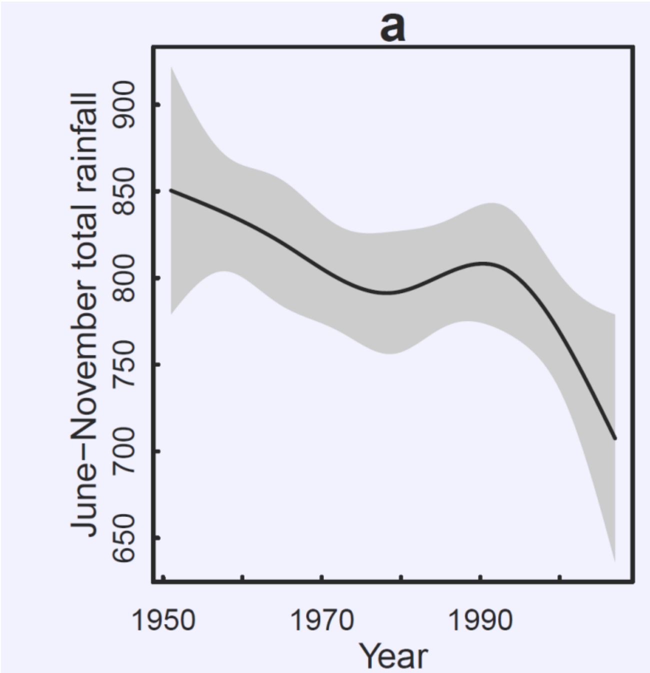
How can we Assess the Performance of Downscaled Climate Information for Ecosystems and Agriculture?

Jagdish Krishnaswamy & Milind Bunyan

Ashoka Trust for Research in Ecology and the Environment

Global and regional climate change context

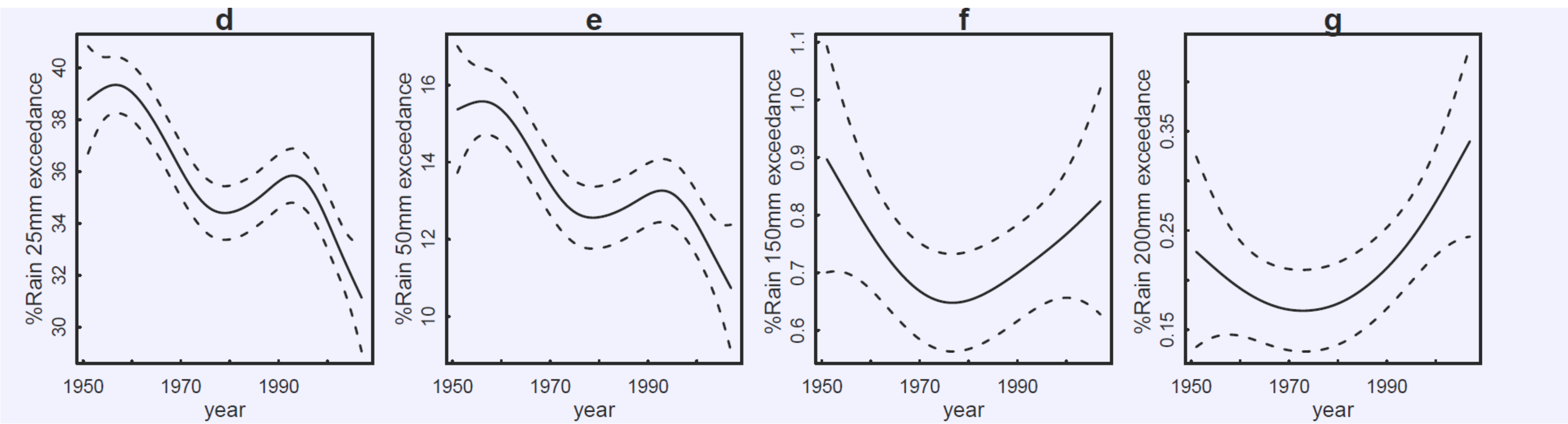
- Weakening Monsoon
- Changing intensity regime



Clim Dyn
DOI 10.1007/s00382-014-2288-0

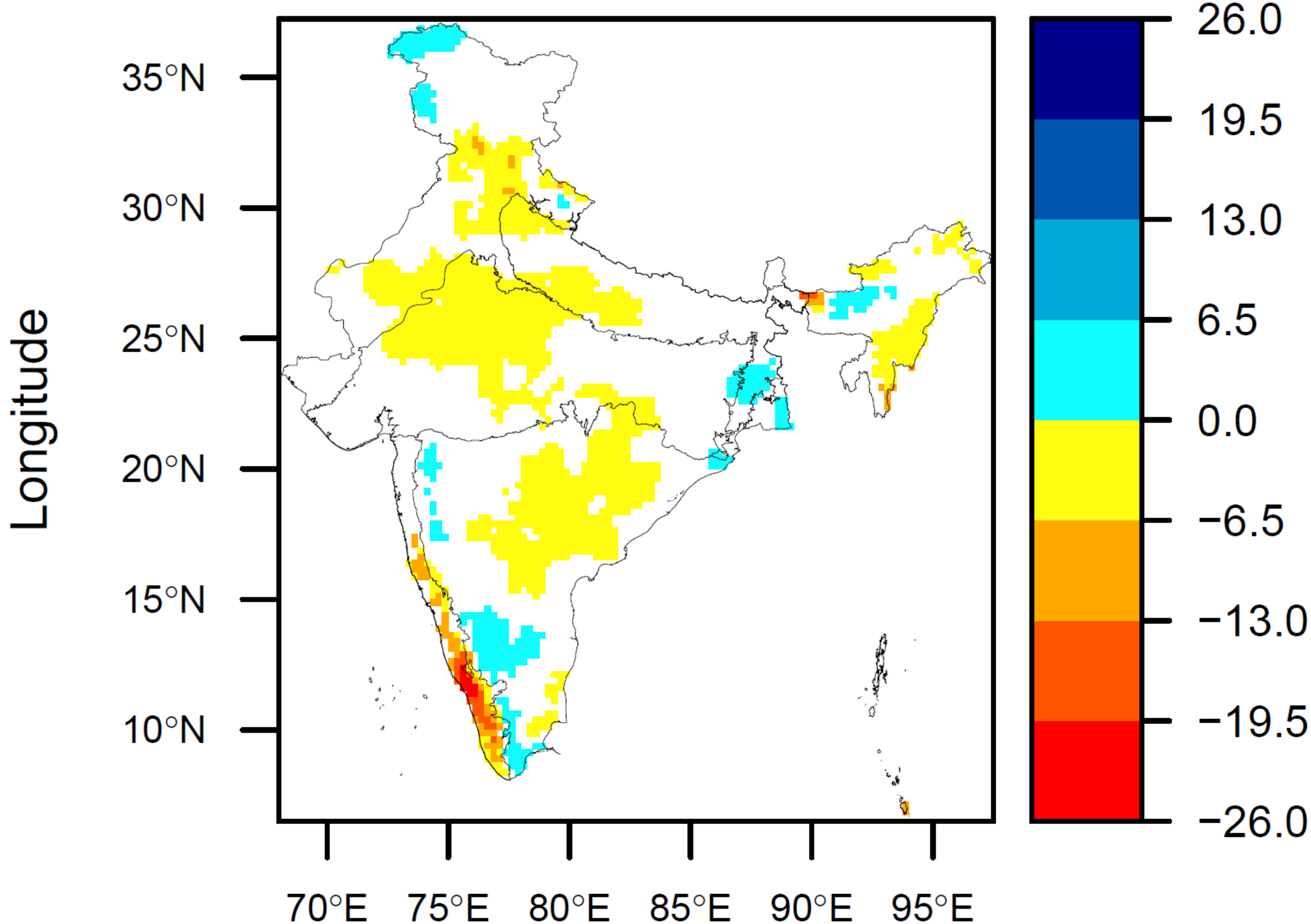
Non-stationary and non-linear influence of ENSO and Indian Ocean Dipole on the variability of Indian monsoon rainfall and extreme rain events

Jagdish Krishnaswamy · Srinivas Vaidyanathan · Balaji Rajagopalan · Mike Bonell · Mahesh Sankaran · R. S. Bhalla · Shrinivas Badiger



Krishnaswamy and Vaidyanathan unpublished 2017

Decline in the Indian Monsoon



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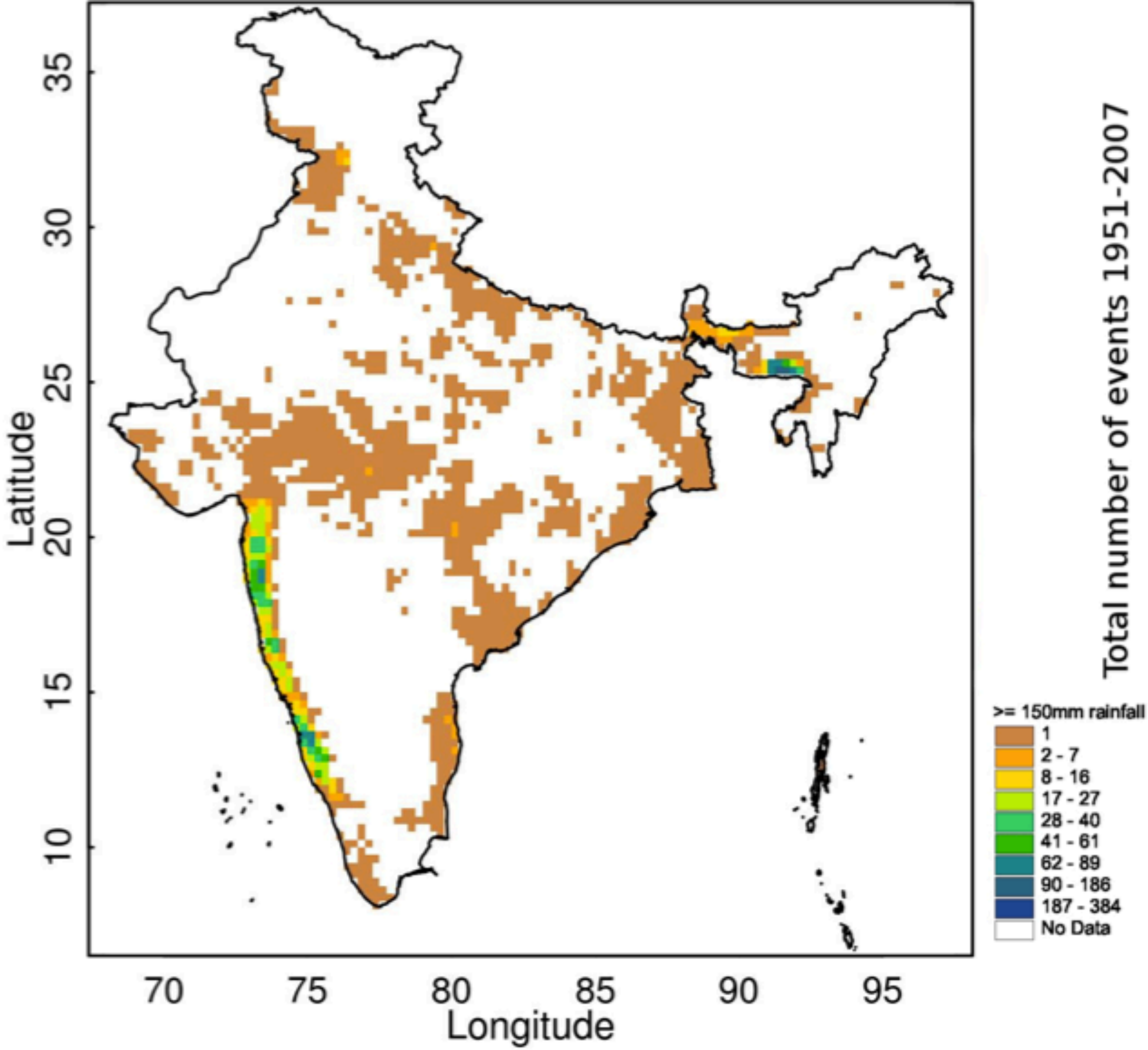


Total number of events 1951-2007
Latitude
Longitude
35
30
25
20
15
10
70
75
80
85
90
95
>= 150mm rainfall
1
2 - 7
8 - 16
17 - 27
28 - 40
41 - 61
62 - 89
90 - 186
187 - 384
No Data

Assessing the utility of climate downscaled products for ecosystem response?

- Do they reproduce key indices of historically observed trends (regional seasonality and intensity)?
- Do downscaled historical climate products explain hydrologic and vegetation dynamics?
- How can we assess their performance?

Dynamic vegetation response to climate

Sandesh Kadur

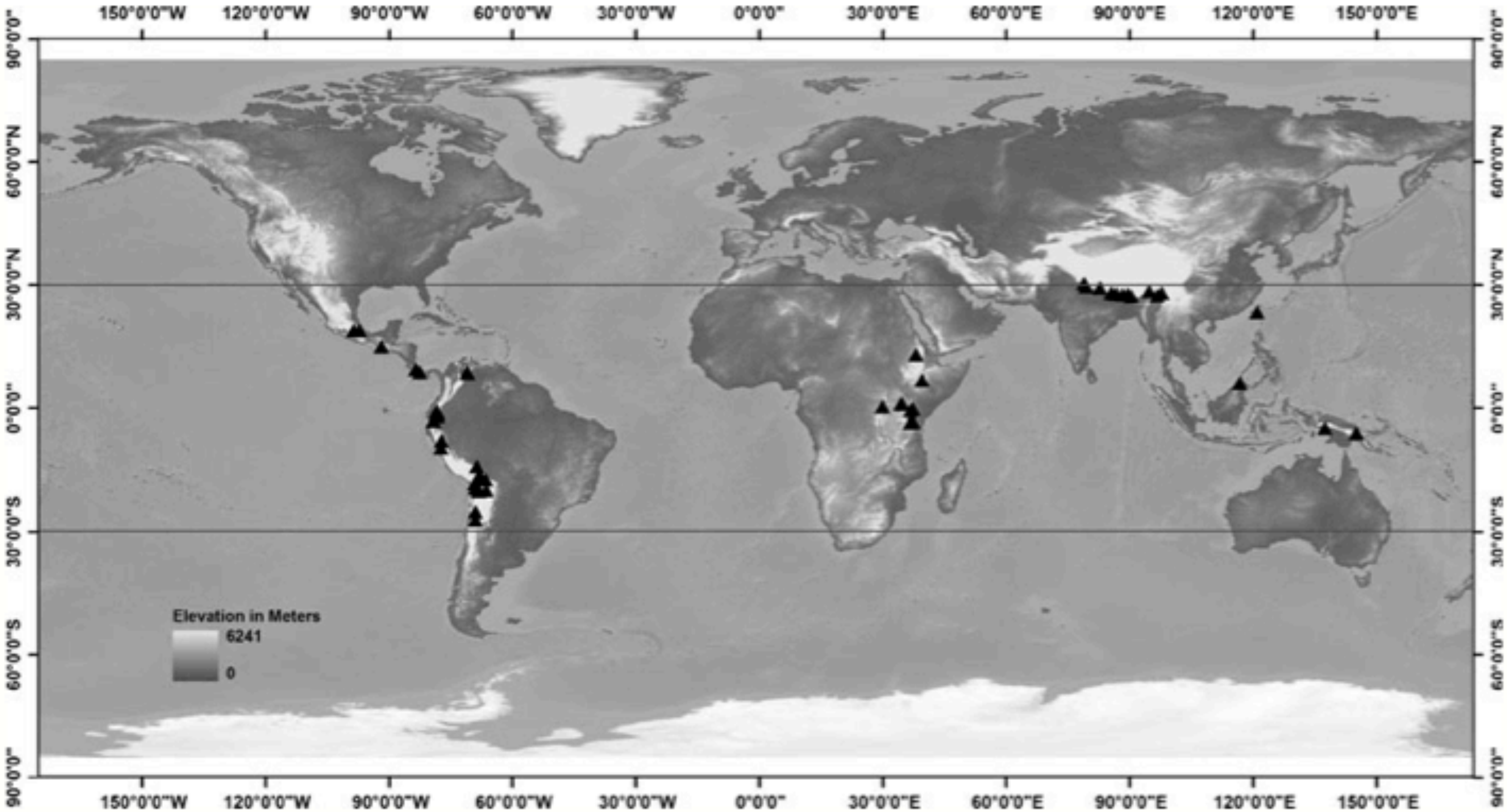


Fig. 1 Locations of 47 higher elevation National Parks that occur in the pantropical latitudinal belt 30°N–30°S included in our study. The overall elevation range for all sites was 1000–5887 m above m.s.l.

Global Change Biology

Global Change Biology (2013), doi: 10.1111/gcb.12362

Consistent response of vegetation dynamics to recent climate change in tropical mountain regions

JAGDISH KRISHNASWAMY*, ROBERT JOHN*† and SHIJO JOSEPH‡

**Suri Sehgal Centre for Biodiversity and Conservation, Ashoka Trust for Research in Ecology and the Environment, Jakkur Post, Royal Enclave, Sriramapura, Bangalore 560064, India, †Department of Biological Sciences, Indian Institute of Science Education and Research, Kolkata, Mohanpur, West Bengal 741 252, India, ‡Forests and Environment Program, Center for International Forestry Research, Jalan CIFOR, Situ Gede, Bogor Barat 16115, Indonesia*

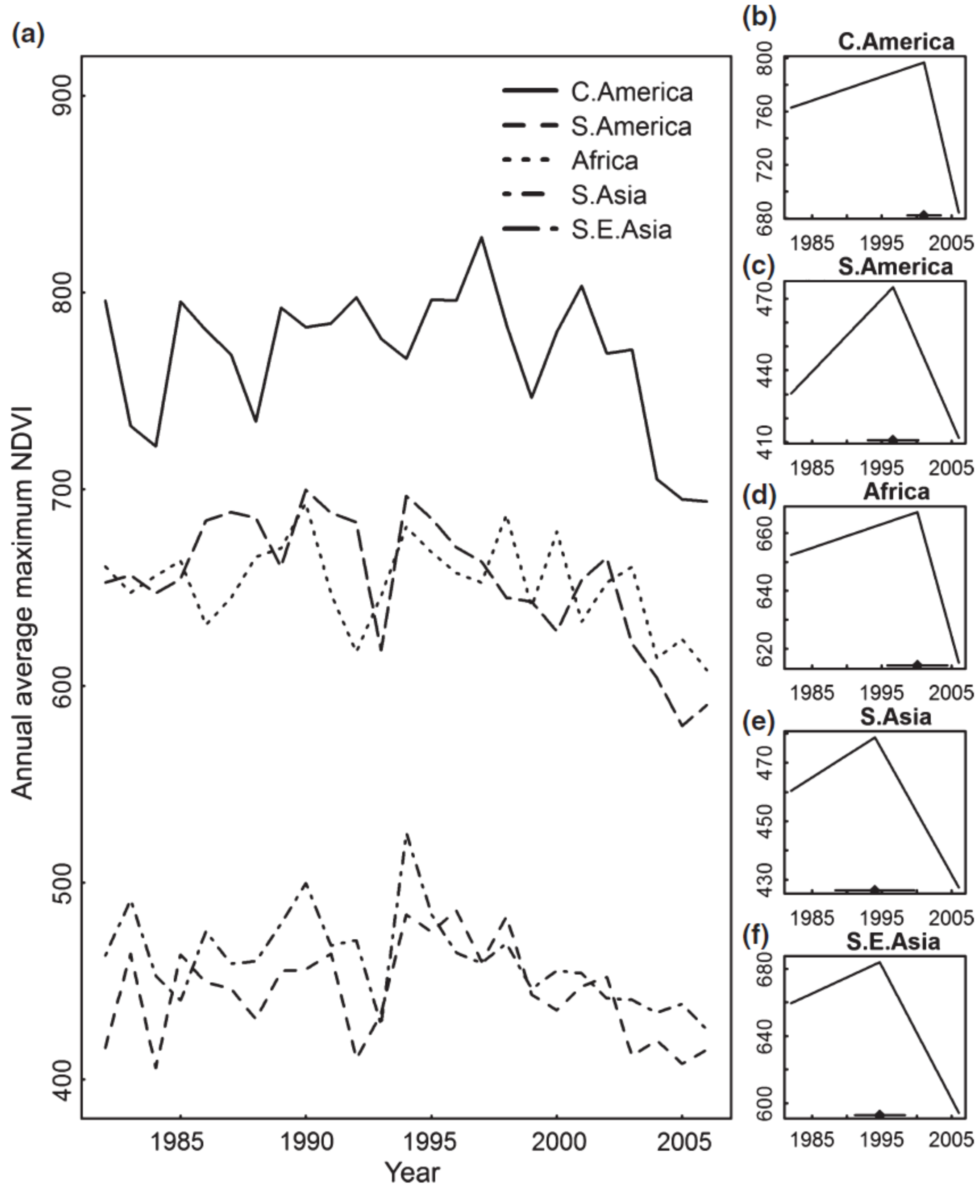
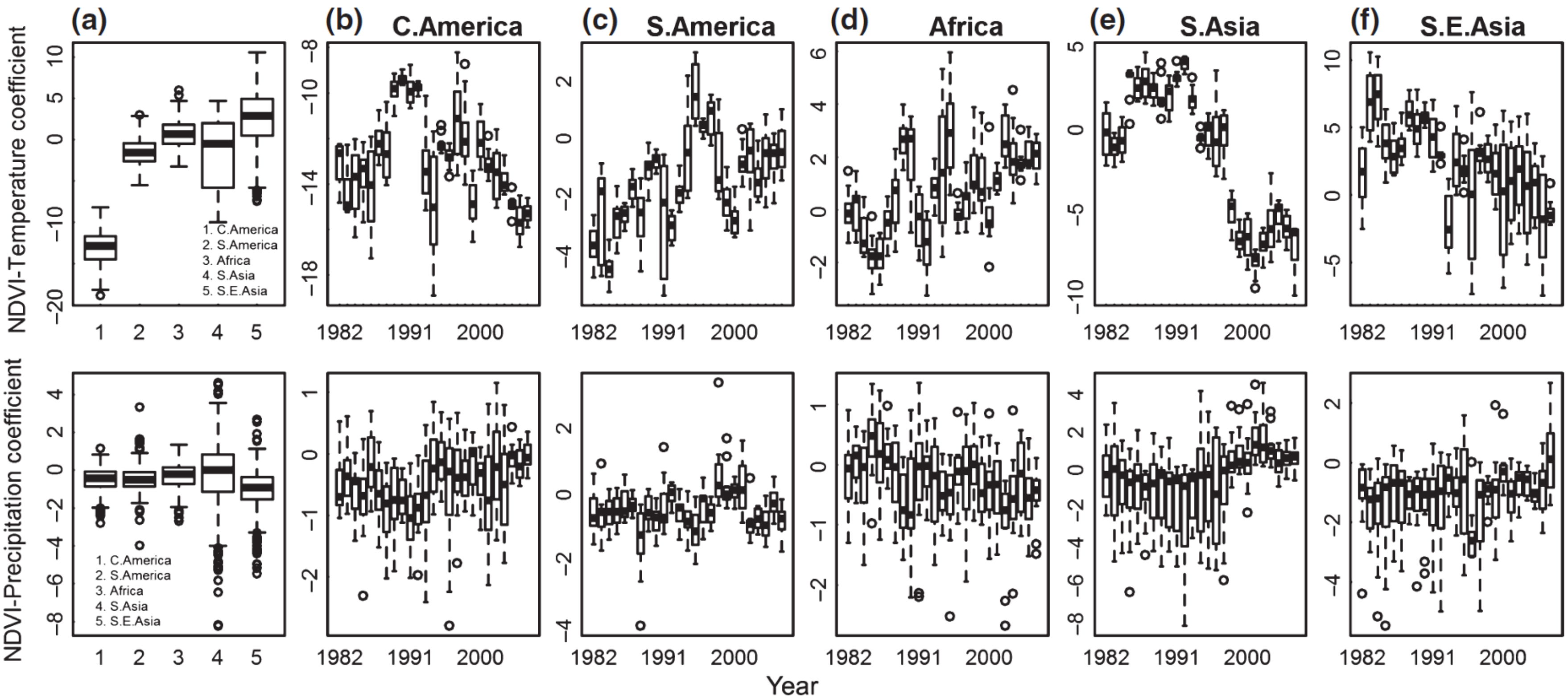


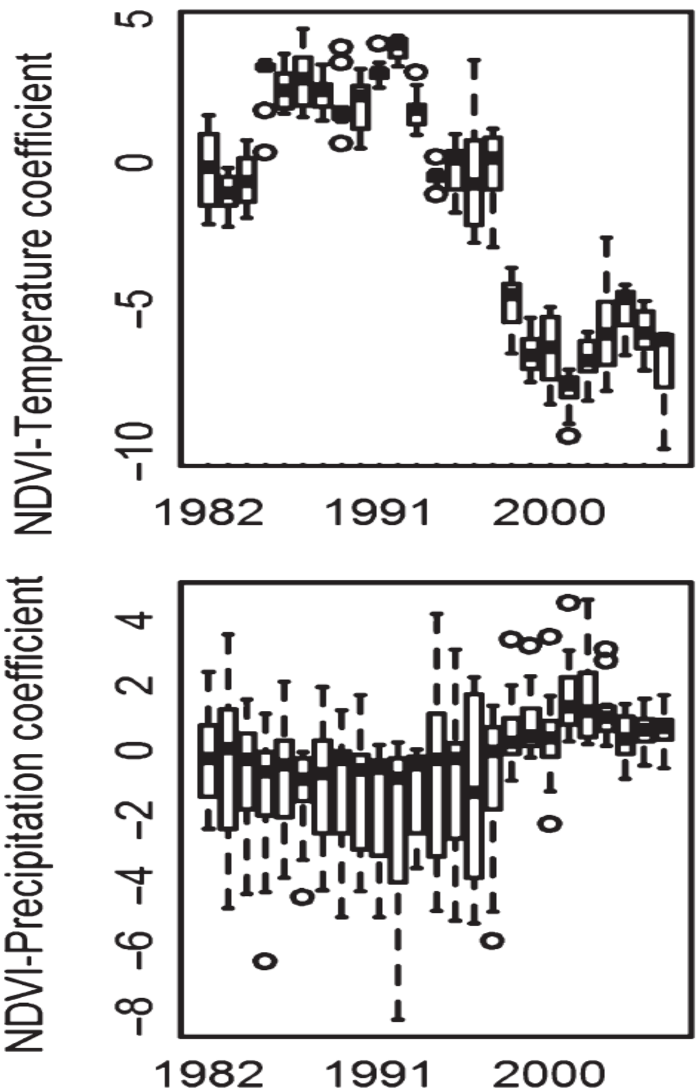
Fig. 2 (a) Trends in annual maximum NDVI greenness of mountain vegetation over the period 1982–2006 for five continental regions located in pantropical latitudes. The time series of NDVI for each region was obtained by averaging across time series for all sites within each region. (b–f) Segmented regressions of annual maximum NDVI. Breakpoints and corresponding standard error bars are indicated on the abscissa in each panel.

Dynamic vegetation response to climate



$$NDVI_t = Level_t + B1_t(Temperature_t) + B2_t(Precipitation_t) + e_t$$

Dynamic vegetation response to climate

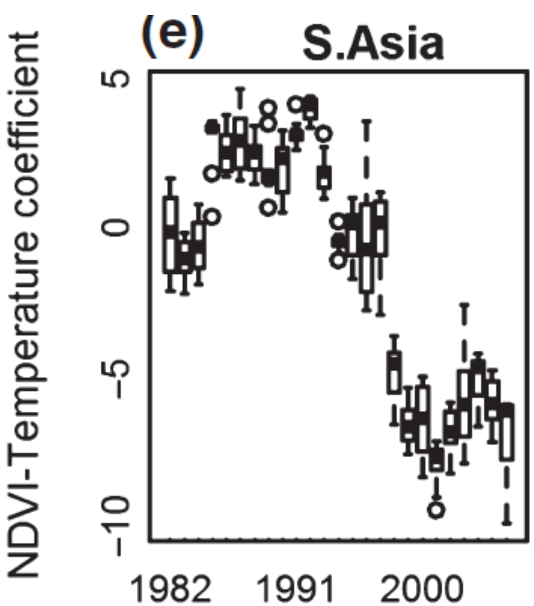


In the Himalayas…

- Strong negative trend in NDVI-temperature coefficient
- Inconsistent trend and high variation in NDVI-Precipitation coefficient
- Indicative of temperature-related moisture stress in the Himalayas

Dynamic vegetation response to climate

- At high elevation, trees subjected to low water potential and undergo severe temp. and H_2O stress
- A record 31°C observed in April 1999
- From Sep 98-May 99, 26.5 mm rainfall was received in 3 days in January and March



- Zobel et al 2001. Patterns of water potential among forest types of the central Himalaya. *Current Science*, *80*(6), pp.774-778.
- Zobel, D.B. and Singh, S.P., 1997. Himalayan forests and ecological generalizations. *BioScience*, *47*(11), pp.735-745.
- Poudyal et al 2004. Patterns of leaf conductance and water potential of five Himalayan tree species. *Tree Physiology*, *24*(6), pp.689-699.

Dynamic vegetation response to climate

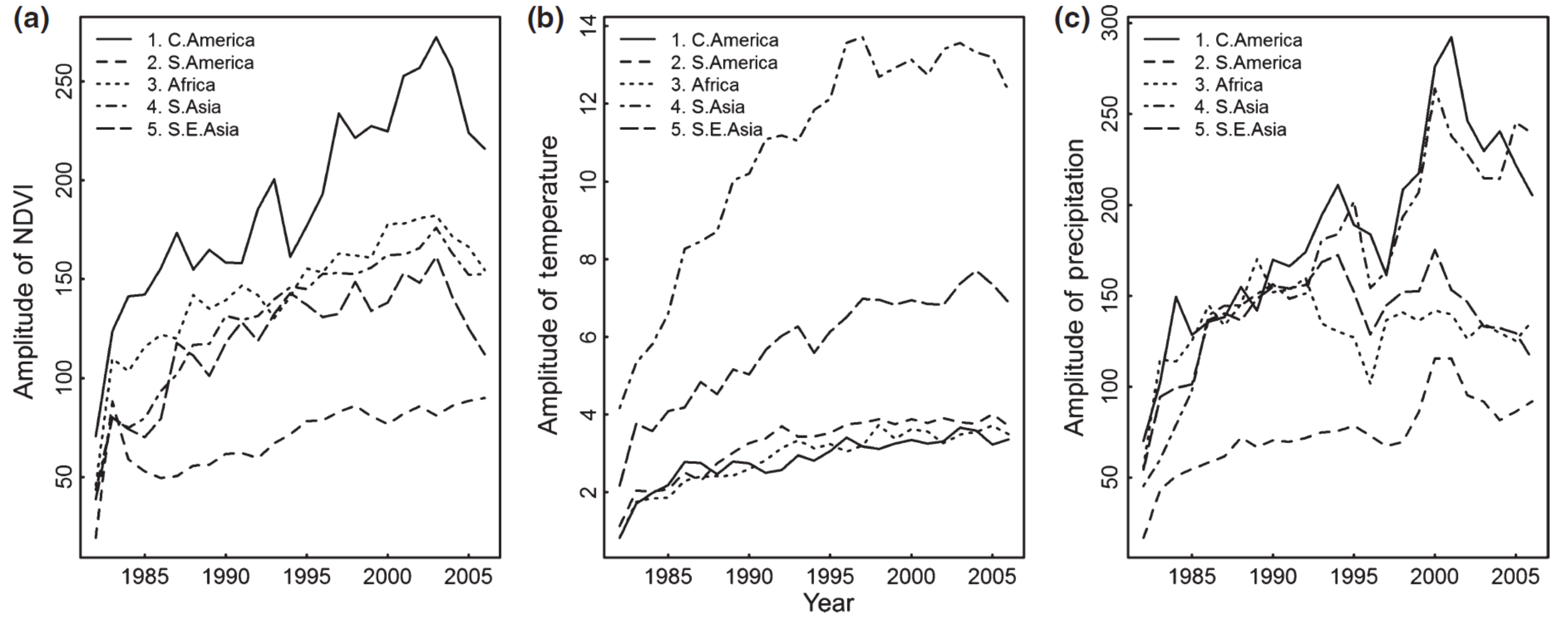
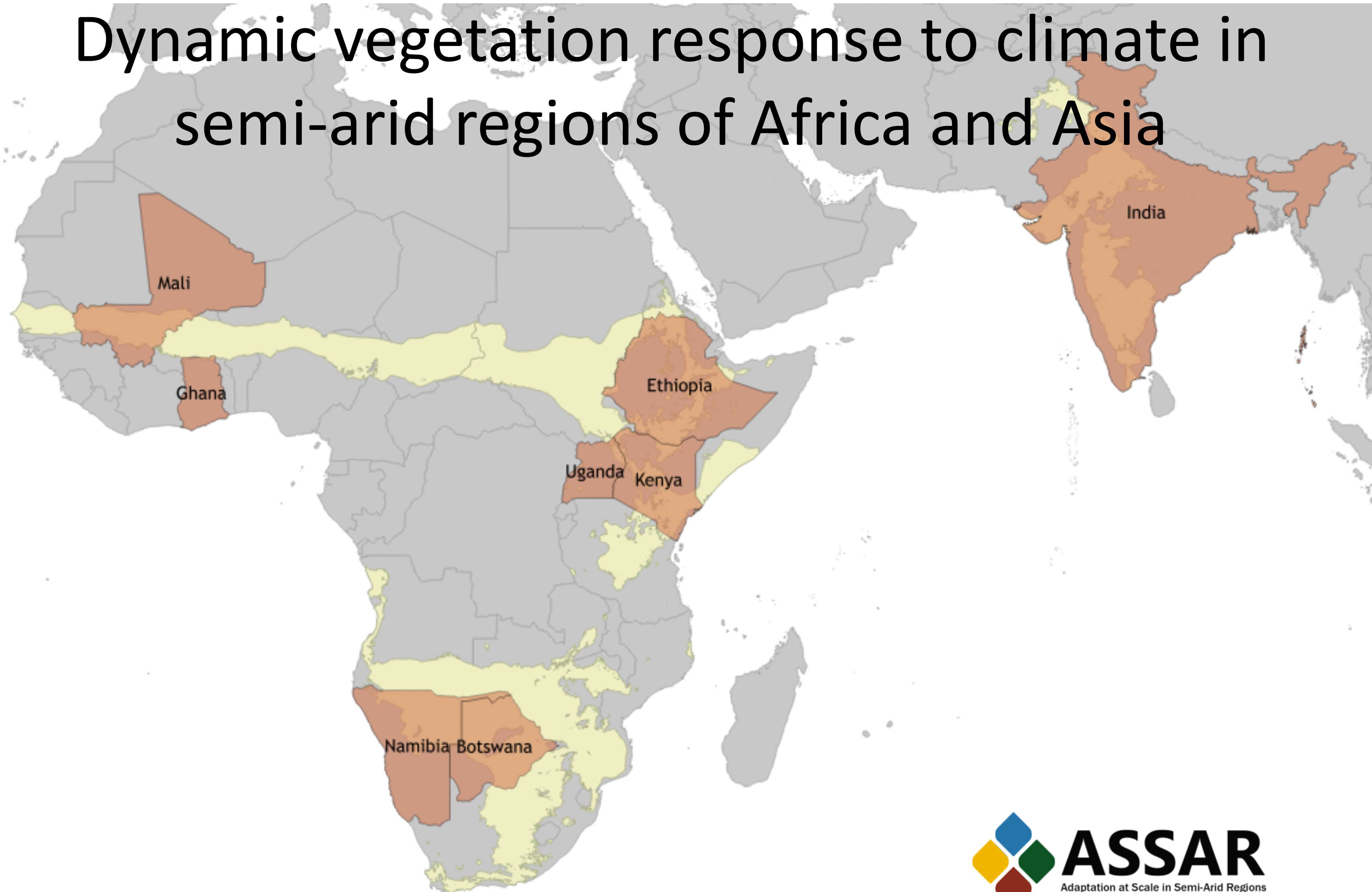


Fig. 4 Amplitude of seasonal NDVI cycles (a), and amplitudinal variation in mean monthly temperature (b) and monthly precipitation (c) in each year during the period 1982–2006. The amplitude for each year was calculated after decomposing the time series into level and cyclic-oscillation components using a dynamic model. Each time series is an average for each region, obtained after averaging across individual amplitude estimations for sites within each region.

Can we reproduce seasonality dynamics with downscaled climate products?

Dynamic vegetation response to climate in semi-arid regions of Africa and Asia



ASSAR
Adaptation at Scale in Semi-Arid Regions

Dynamic vegetation response to climate

- Greening and Browning trends
- Trends in seasonal NDVI cycles
- Loss of temperature positivity (indicative of temperature-related moisture stress)
- Response to rainfall episodes and perturbations

Inter-annual dynamics of water stress

Reg Environ Change
DOI 10.1007/s10113-016-1017-0
CrossMark
ORIGINAL ARTICLE

Intra-annual dynamics of water stress in the central Indian Highlands from 2002 to 2012

Benjamin Clark[1] · Ruth DeFries[1] · Jagdish Krishnaswamy[2]

- Hydrologic model (modified version of Sacramento Soil Moisture Accounting Model)
- Accounts for the water demand across 5 sectors; domestic, industrial, power generation, irrigation and livestock
- Estimates gross water use from surface and groundwater sources and includes consumptive and non-consumptive water.

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- Model represents the amount of water that must be available to meet the demand of a sub-basin. Non-consumptive use of water is returned to surface water so that it is available for downstream re-use
- To avoid stress, water supply must meet the total water withdrawals.

Approach

- Hydrologic model (modified version of Sacramento Soil Moisture Accounting Model)
- Accounts for the water demand across 5 sectors; domestic, industrial, power generation, irrigation and livestock
- Estimates the gross water use across sectors from surface and groundwater sources and includes consumptive and non-consumptive water.
- It represents the amount of water that must be available to meet the demandof a sub-basin. Non-consumptive use of water is returned to surface water so that it is available for downstream re-use
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Inter-annual dynamics of water stress

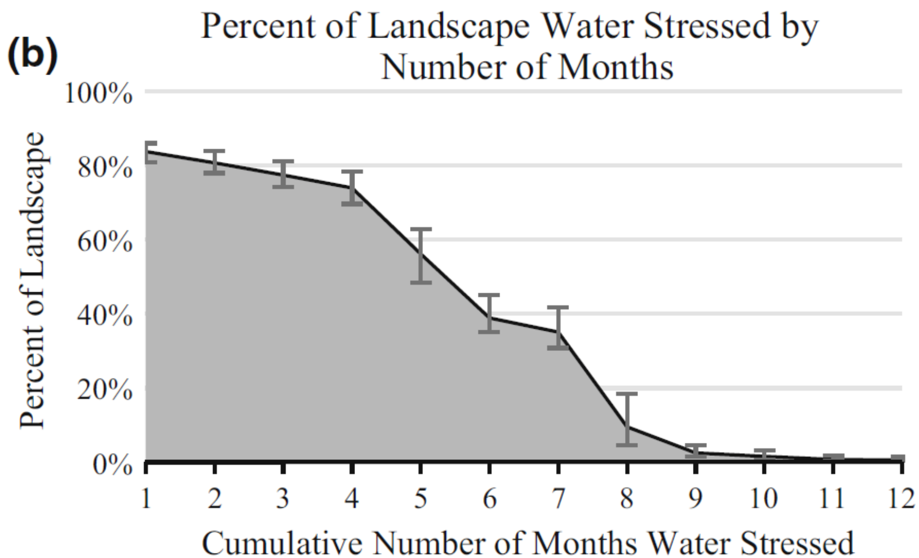
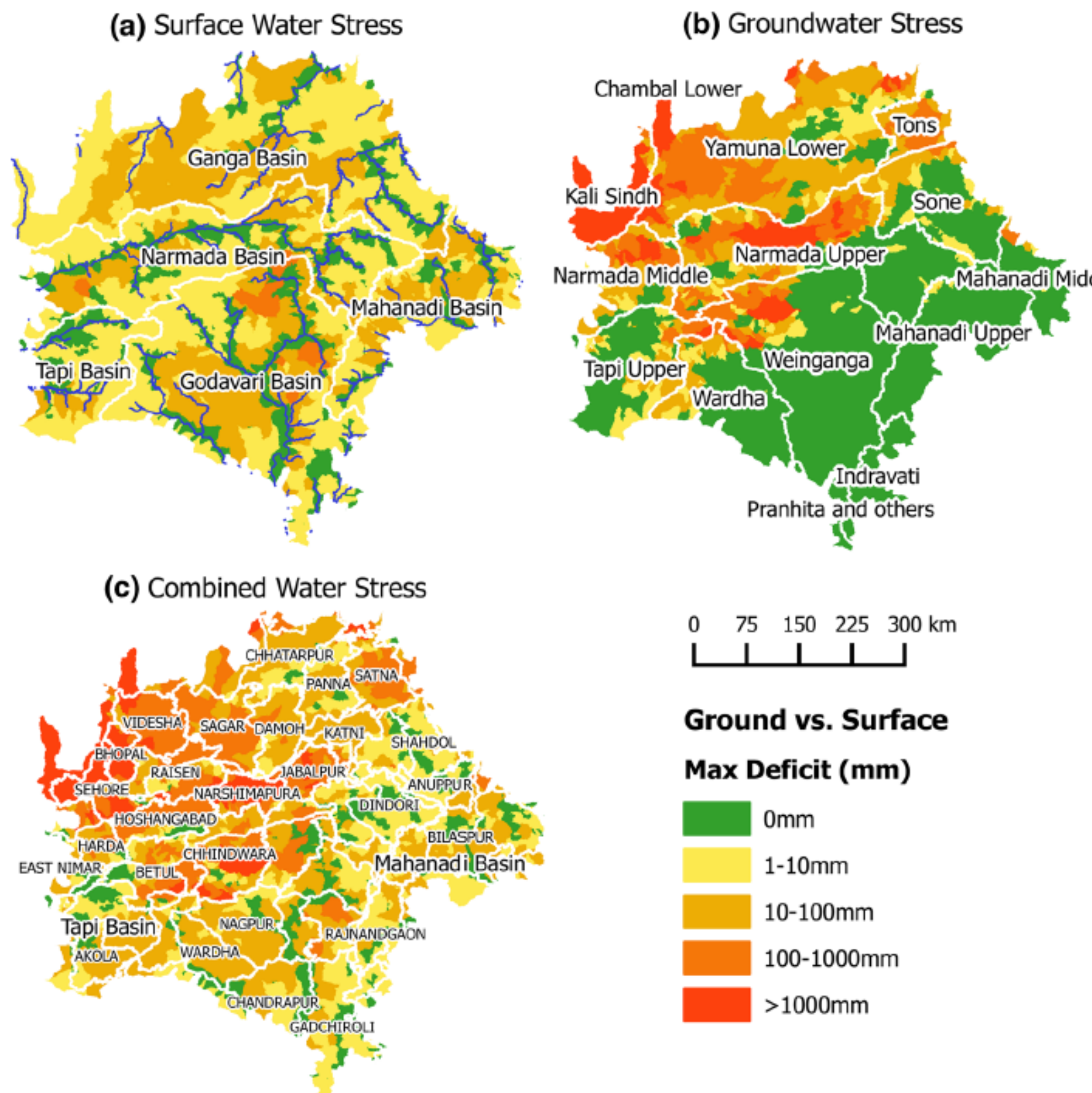


Fig. 1 **a** Inter-annual area weighted median WaSSI (*black*) and GWaSSI (*gray*). Precipitation (*gray bars*) shows the effect of the monsoons in reducing water stress and recharging the groundwater deficit (GWaSSI). Water stress is most severe during the rabi growing season when irrigation is used. **b** Percent of the landscape water stressed (GWaSSI > 1) by the number of months of water stress. Calculation is based on the median values from 30 monthly simulations of the period 2002–2012 for 1780 sub-basins. *Error bars* represent the interquartile range (n = 587,400)

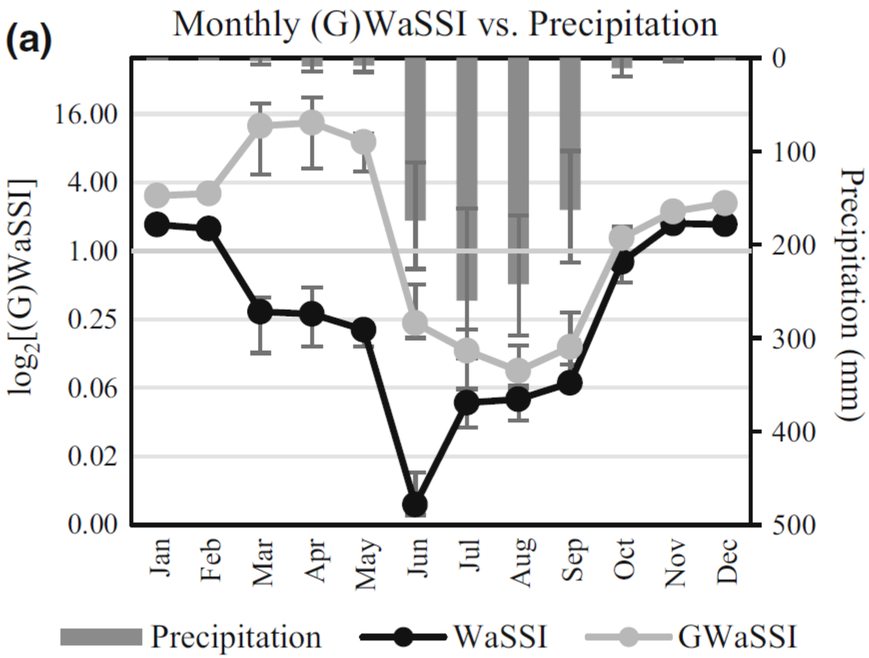
- A large portion of the landscape experiences water stress for at least some months of the year
- Only 16% of the area remains unstressed throughout the year.

Inter-annual dynamics of water stress

Fig. 3 Spatial distribution of maximum water deficiency within a year. **a** Surface water deficiency. **b** Groundwater deficiency. **c** Combined surface and ground water deficiencies. Map **b** also contains the Tehsils that the CGWB (2011b) identified as groundwater stressed in 2009. Supplementary materials contain maps of the uncertainty (interquartile range) of the model simulations for each map (S9–S11)



Inter-annual dynamics of water stress



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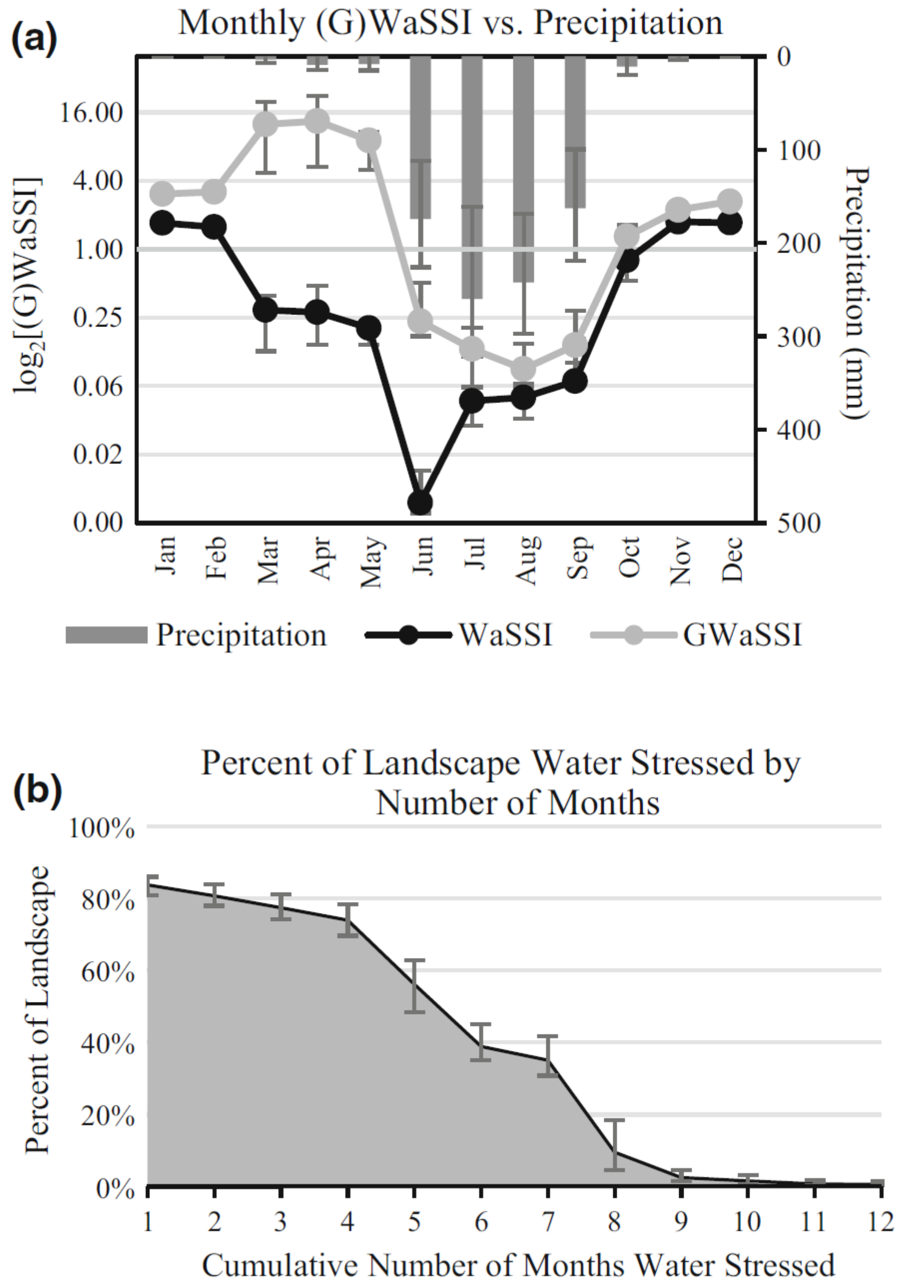
- Rabi season irrigation results in 74% of the landscape experiencing water stress for four or more months in a year
- Can we get similar results if downscaled climate data products are used?



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Key results and implications

- A large portion of the landscape experiences water stress for at least some months of the year
- Only 16% of the area remains unstressed throughout the year.
- Rabi season irrigation results in 74% of the landscape experiencing water stress for four or more months out of the year
- Can we get similar results when we feed the model with downscaled climate data products rather than observed?

Opportunities and Concerns

- Dynamic mechanistic or data-driven hydrology and vegetation models can be used to assess performance of downscaled climate products
- Can we reproduce key observed seasonal and inter-annual and longer term cycles and trends?
- Climate is only one of the drivers of vegetation; need to address effects of other global and regional drivers e.g. nitrogen deposition, disease

Opportunities and Concerns