More extreme Indian Monsoon daily rainfall during El Niño summers

Spencer A. Hill

The City College of New York

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On the All-India Rainfall Index and Sub-India Rainfall Heterogeneity

Spencer A. Hill[1], Adam H. Sobel[1,2], Michela Biasutti[1], and Mark A. Cane[1]

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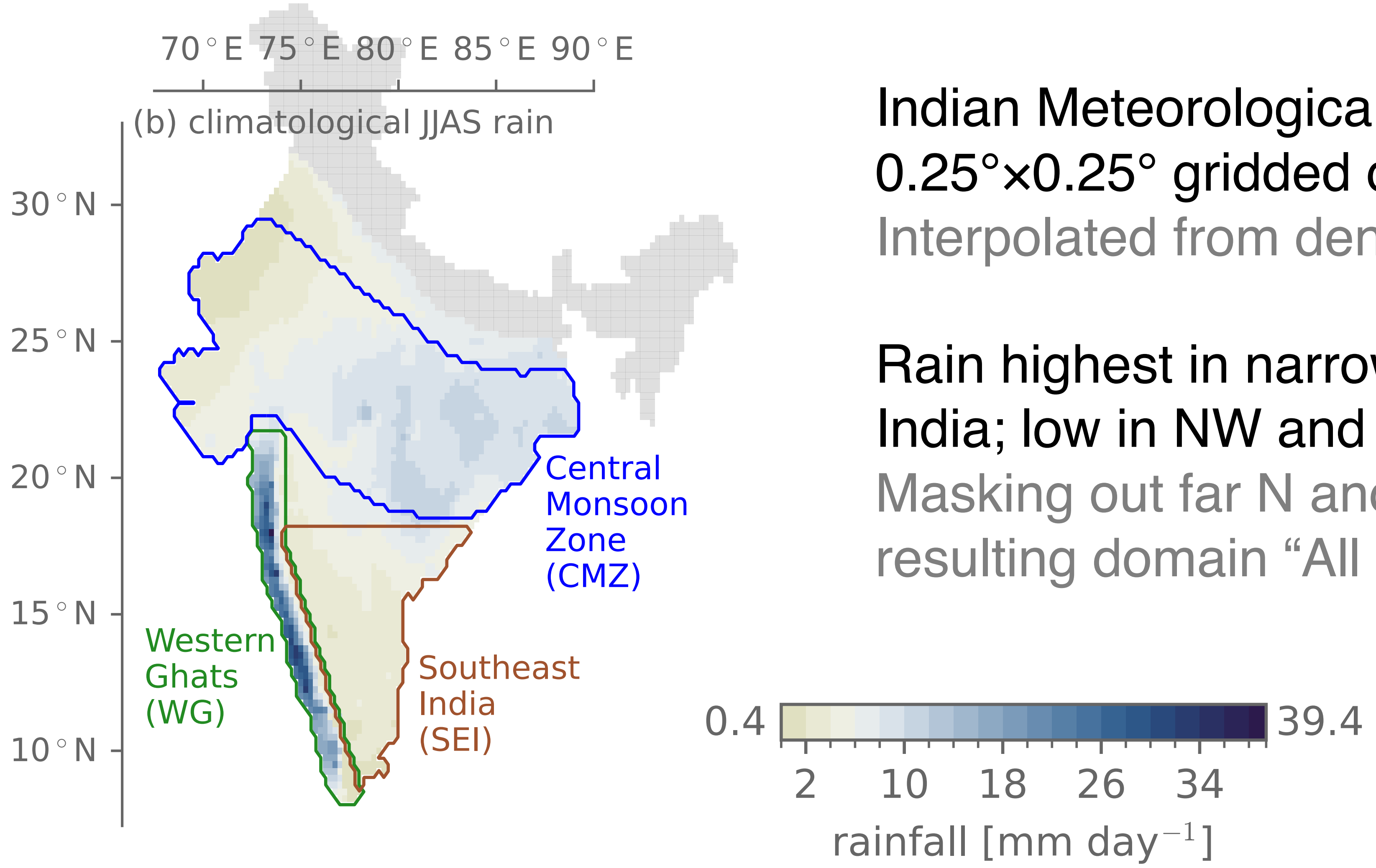
Spencer A Hill, Destiny Zamir Meyers, Adam H Sobel, Michela Biasutti, Mark A Cane, Michael K Tippett, Fiaz Ahmed

arXiv:2404.12419
Under review

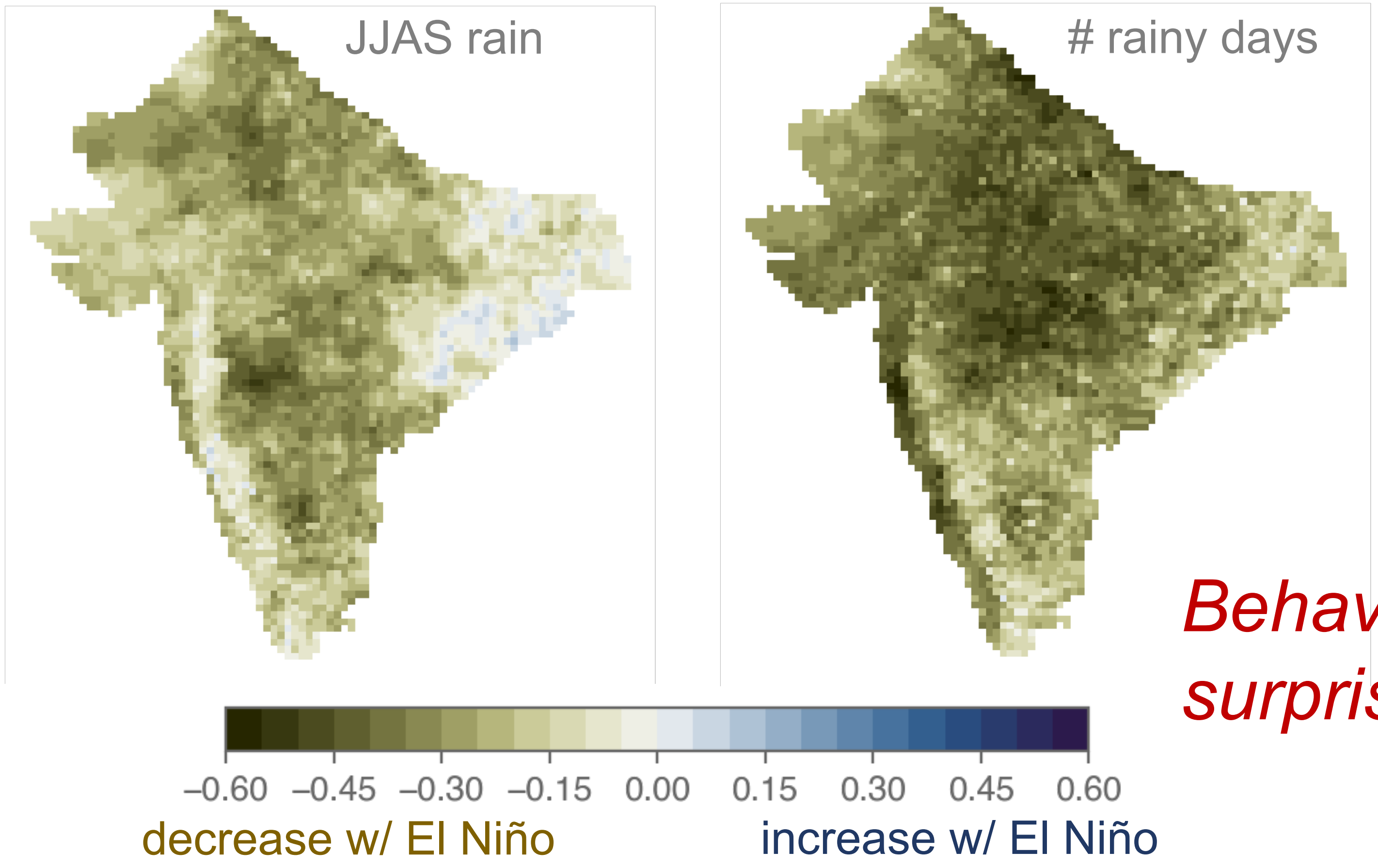
Indian summer monsoon rain is spatially heterogeneous in the seasonal mean



Indian Meteorological Dept (IMD)
0.25°×0.25° gridded daily rainfall, 1901-2020
Interpolated from dense rain gauge network

Rain highest in narrow SW band and Central India; low in NW and SE
Masking out far N and NE (data issues); resulting domain “All Monsoonal India” (AMI)

But interannually El Niño summers bring less JJAS rainy days and total rain nearly everywhere



Correlation coefficients w/ JJAS NINO3.4

All fields linearly detrended, 1901-2020

NINO3.4 from ERSST

Behavior of extremes under ENSO surprisingly under-studied!

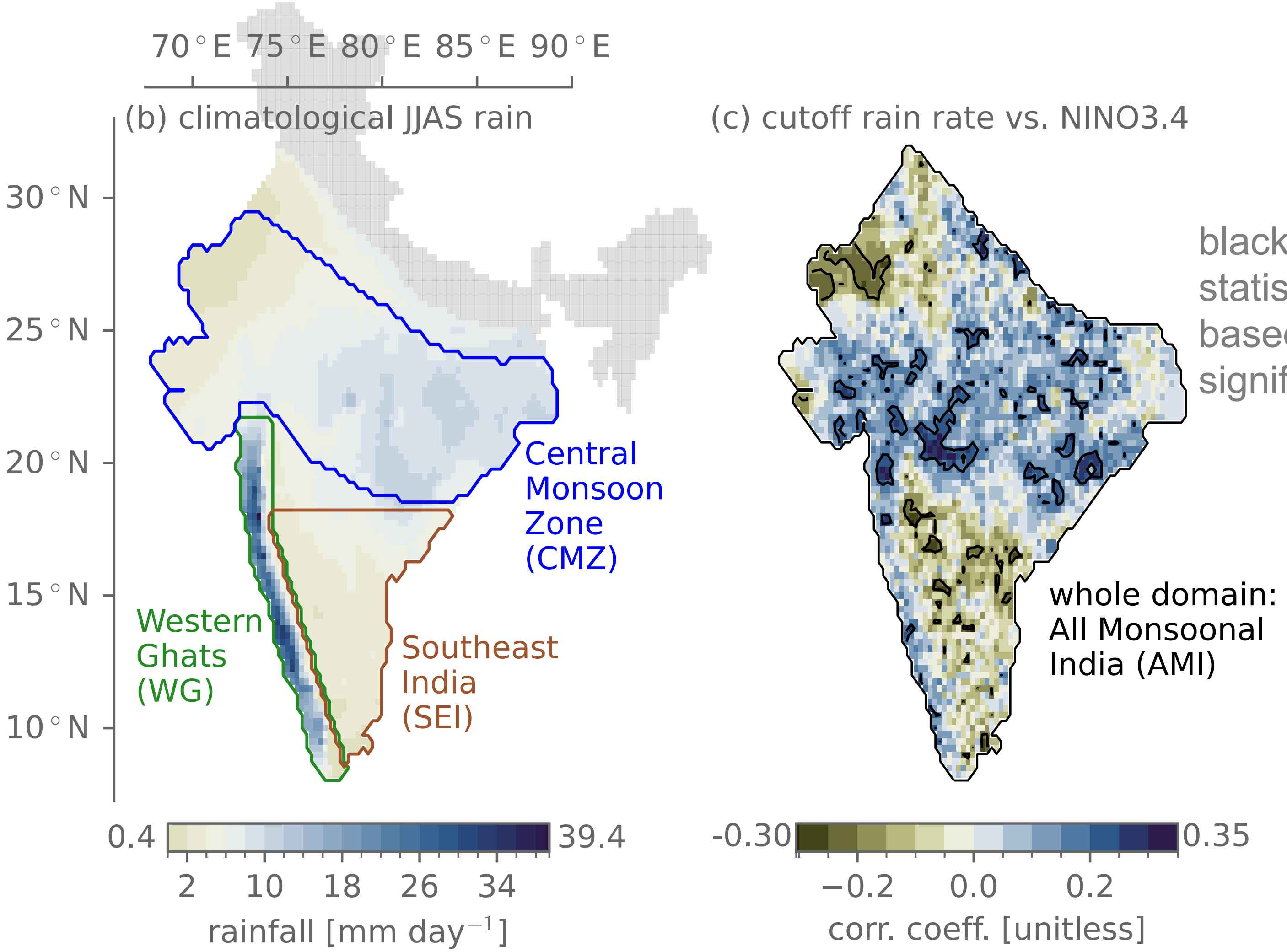
I will argue:

I. More extreme rain within wet regions, less within dry regions of India in summer under El Niño

II. These behaviors are largely explained by changes in the convective buoyancy metric B_L

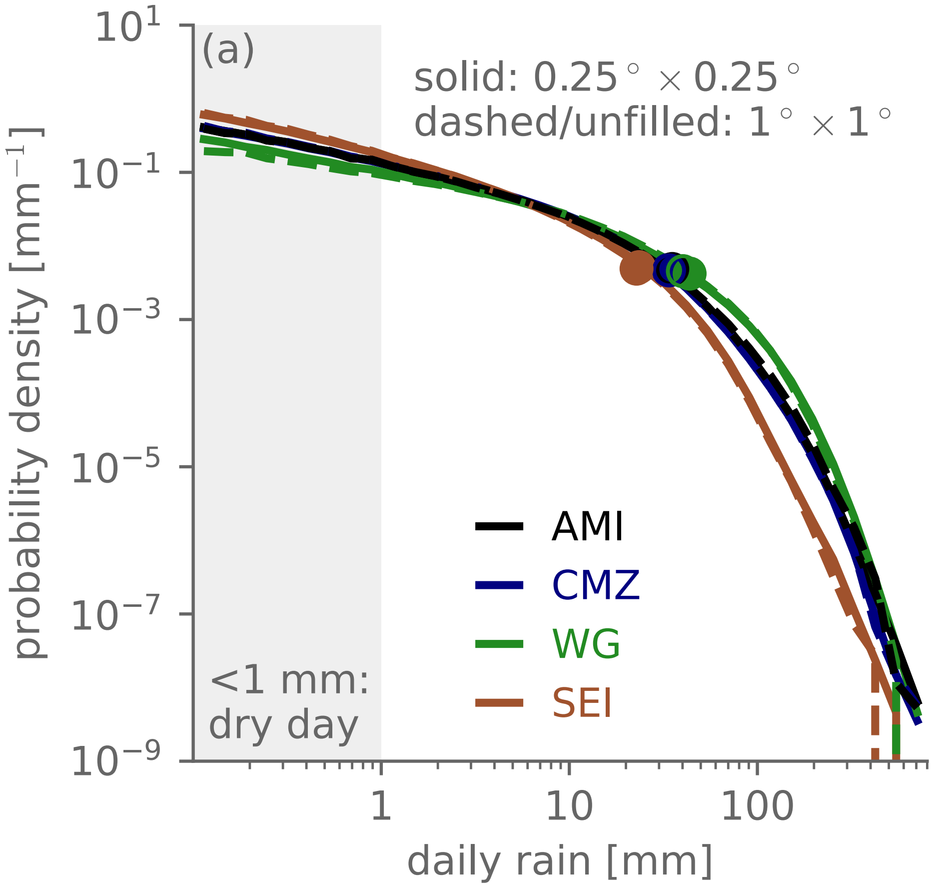
III. Those buoyancy changes may largely stem from shifts in synoptic monsoon low-pressure system tracks

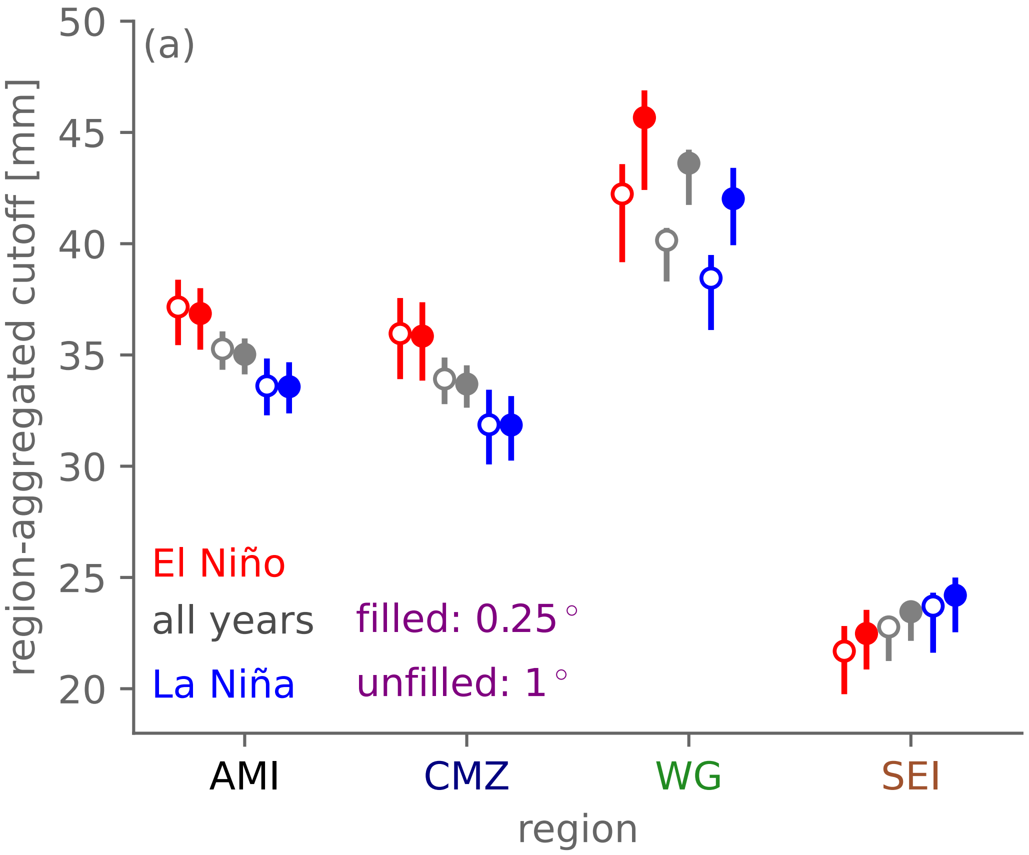
El Niño enhances extreme rain in the wet subregions but decreases it in the dry regions



black contours: statistically significant based on field significance test

This emerges in region-aggregated cutoffs too: enhanced in wet region, suppressed in dry





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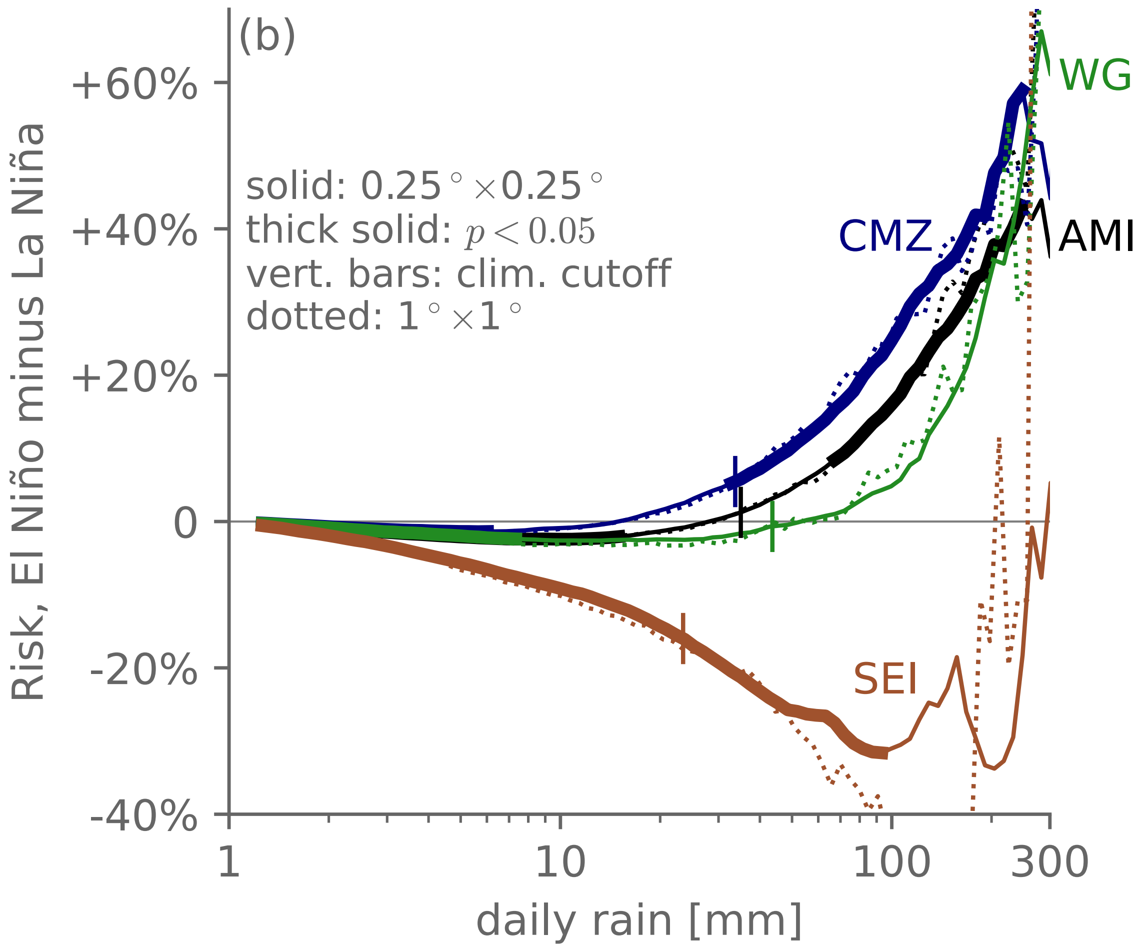
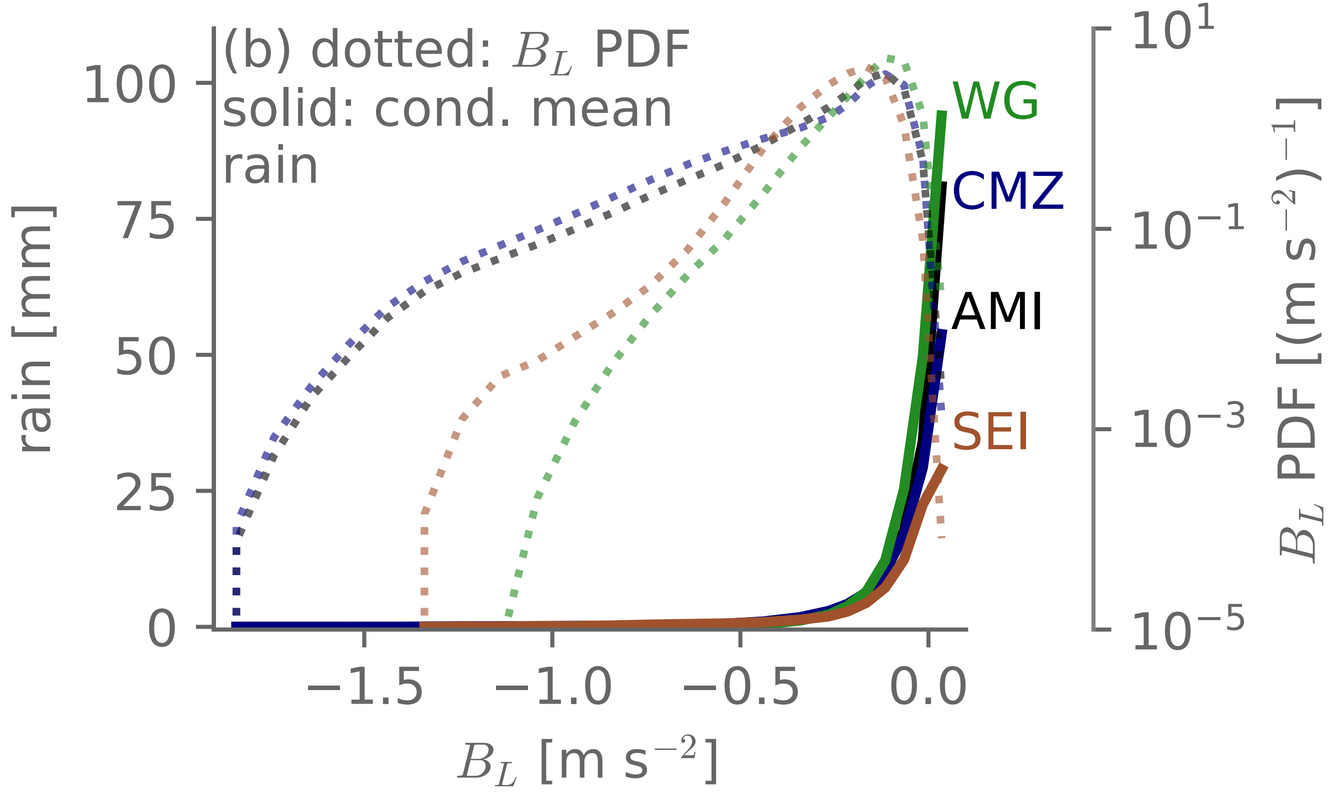


Risk ratio: empirical probability of exceeding a given rain intensity in El Niño years divided by same probability in La Niña years

Uptick in likelihood in wet regions occurs near the climatological cutoff (vertical bars)

Thicker curves = statistically significant (permutation test)

Mechanism: use a bulk measure of convective buoyancy, B_L, to explain the rainfall behaviors



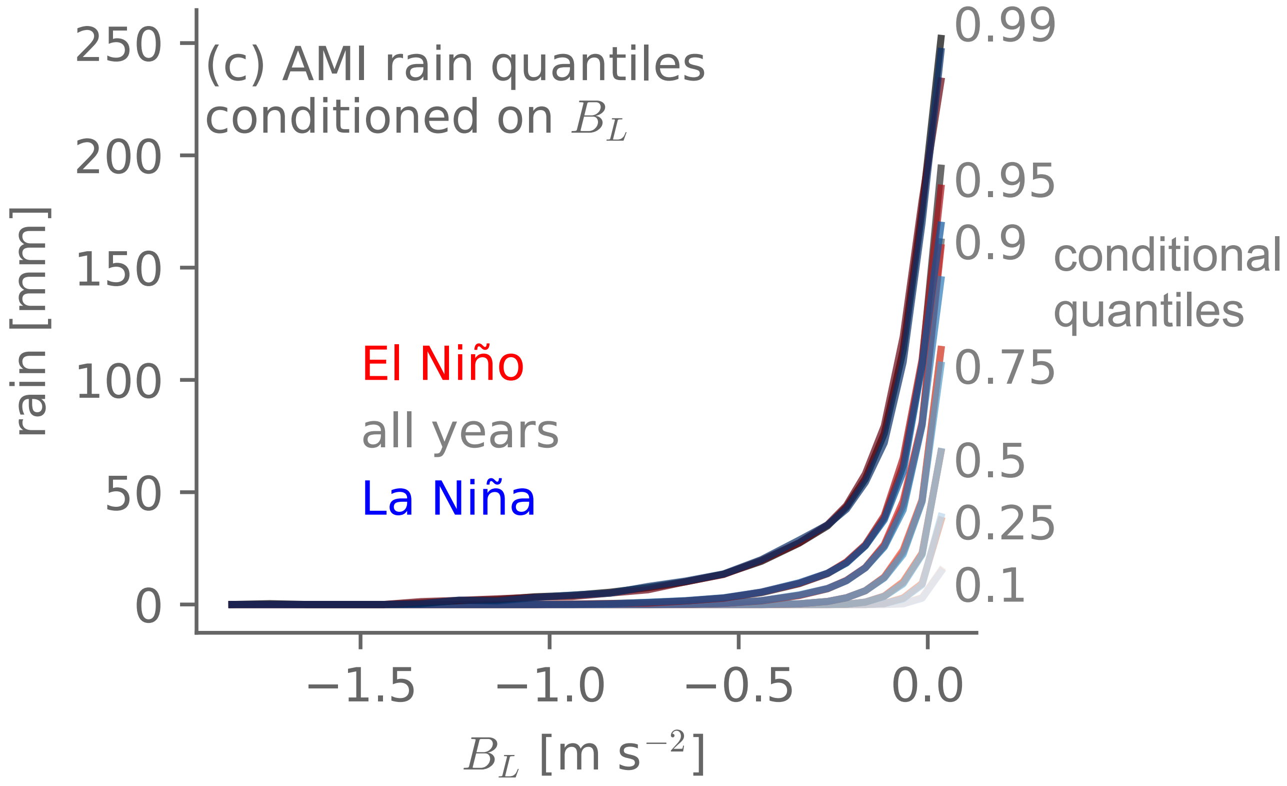
B_L: Ahmed et al 2020

Sum of two terms:

1) Undilute buoyancy of subcloud layer relative to lower free troposphere ("instability")

2) Diluting effect of subsaturated air in lower free troposphere ("moisture")

B_L strongly controls tropical rainfall including throughout the Indian summer monsoon

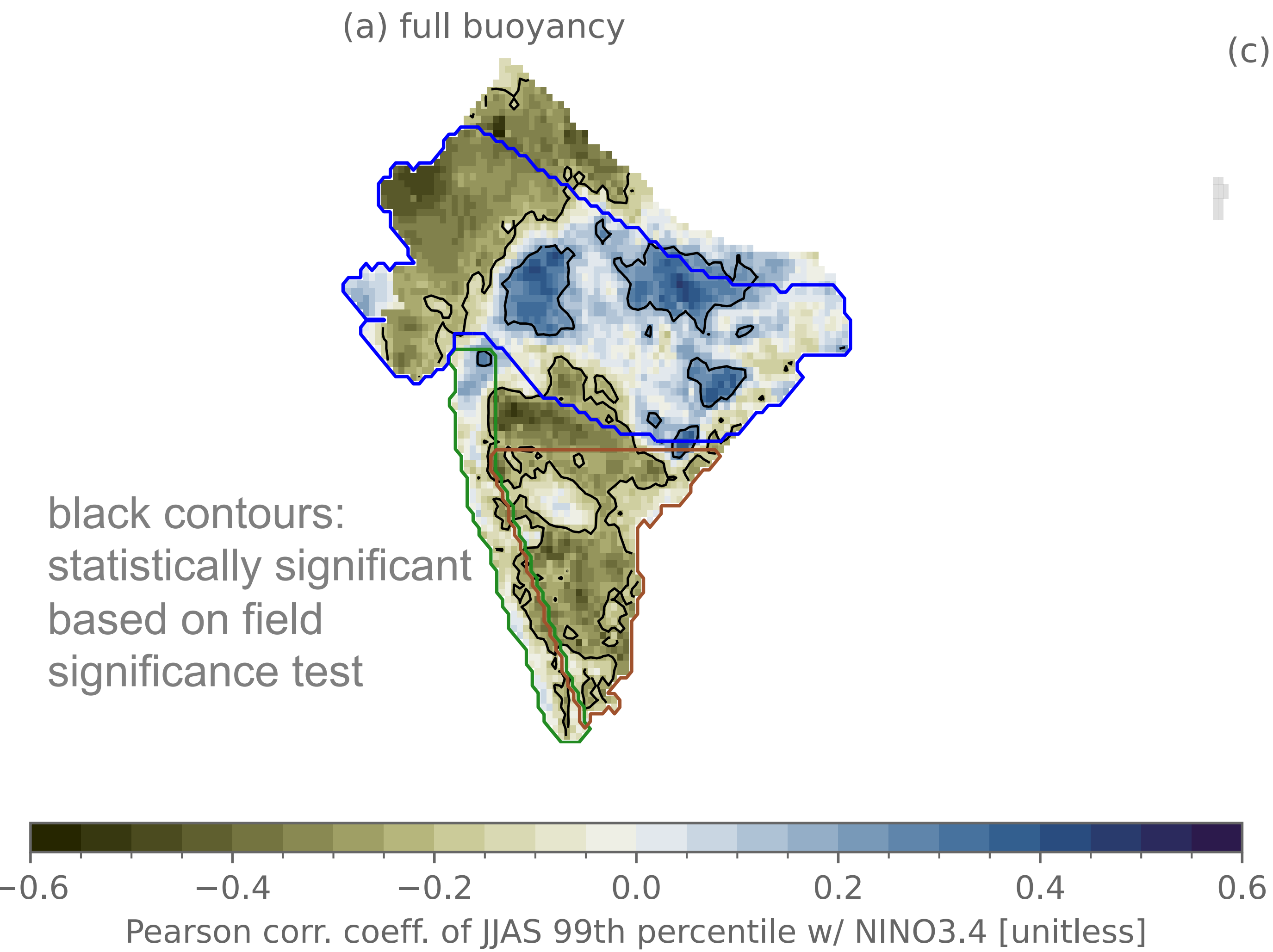


To first order, relationship is not ENSO-dependent

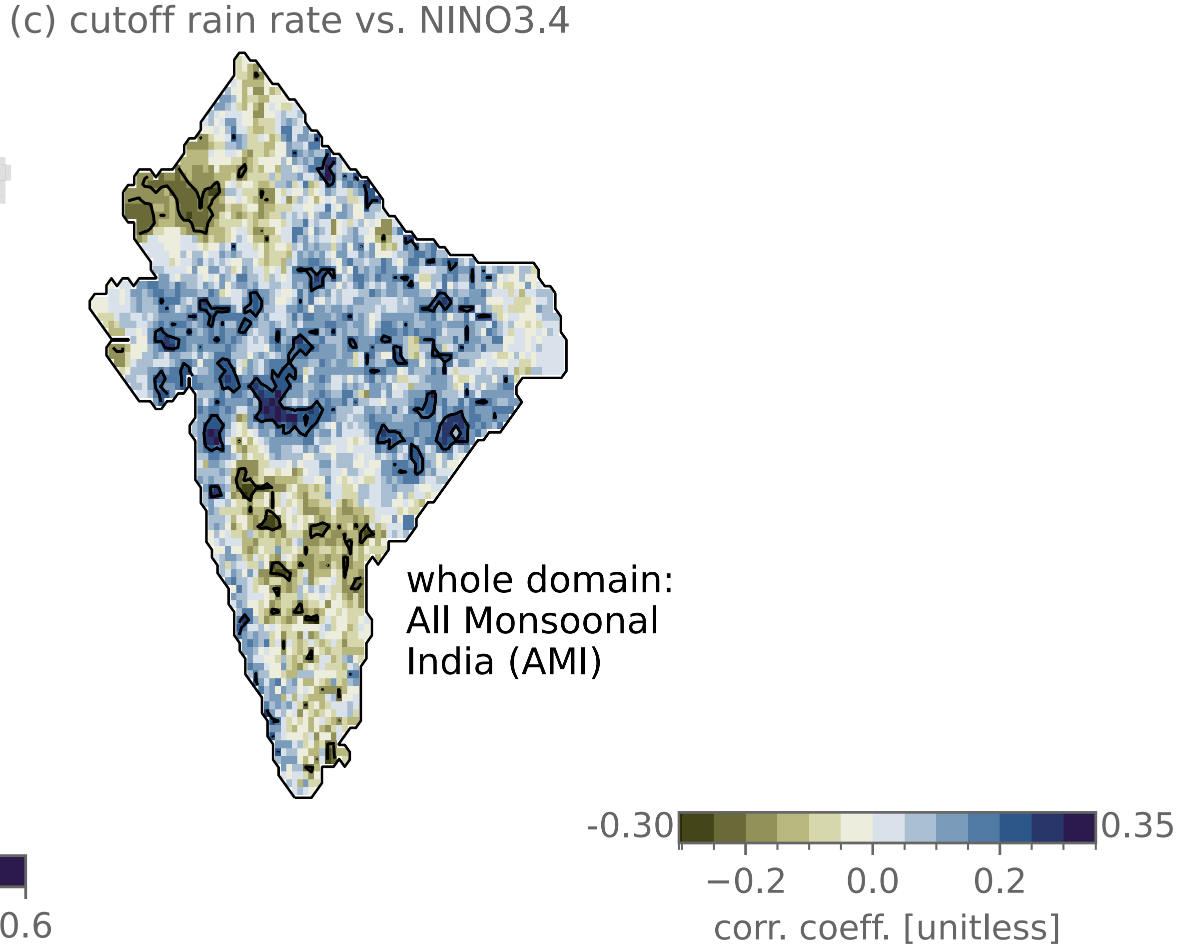
So we can ask how the extreme buoyancy likelihoods change under ENSO to understand what the rainfall extremes are doing

I.e. if more extreme convective buoyancy days, expect more extreme rainfall days

For much of the domain, right-tail buoyancy days and extreme rainfall responses agree in sign

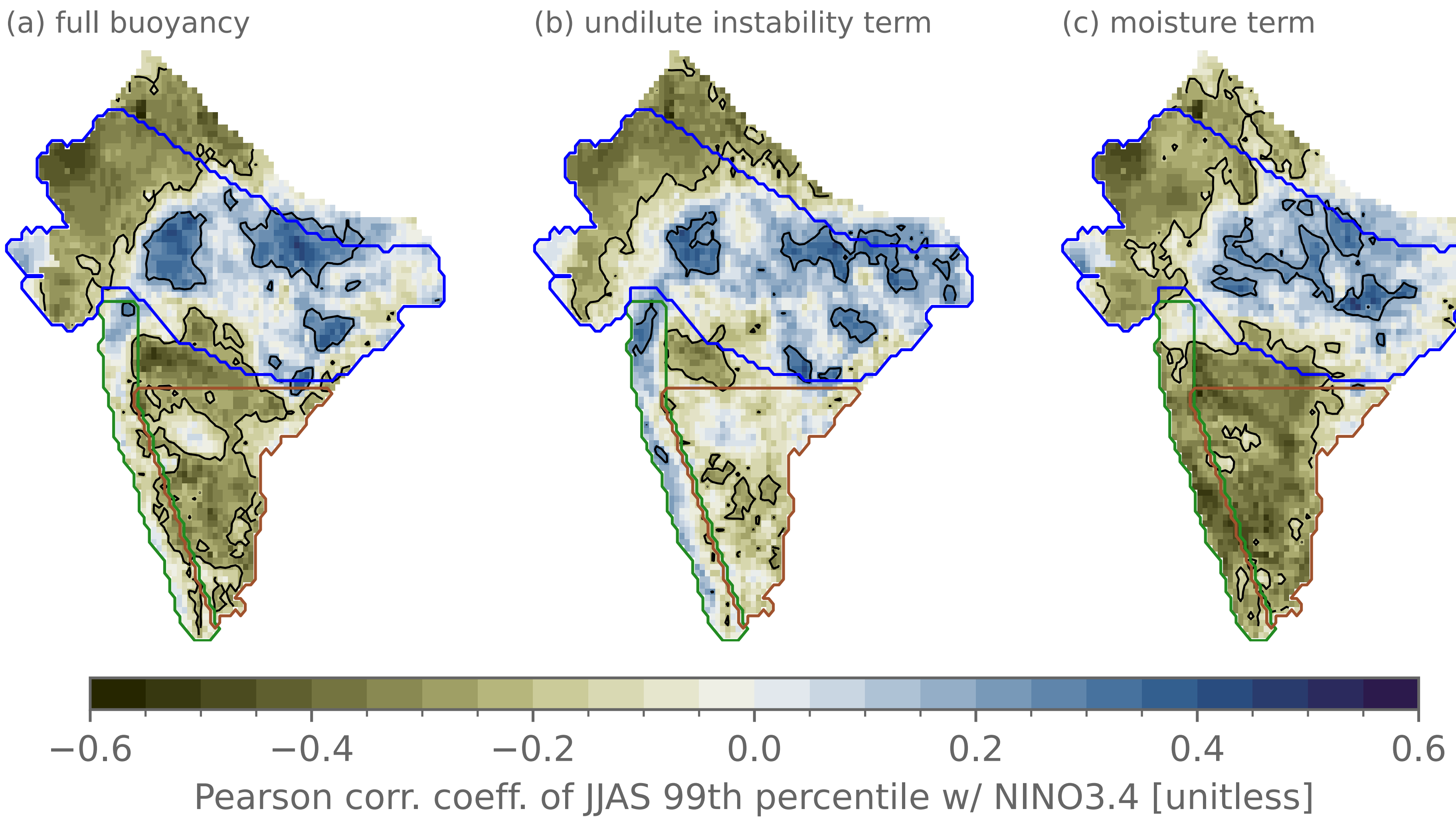


black contours: statistically significant based on field significance test



whole domain: All Monsoonal India (AMI)

Both the undilute instability and lower-free tropospheric subsaturation contribute



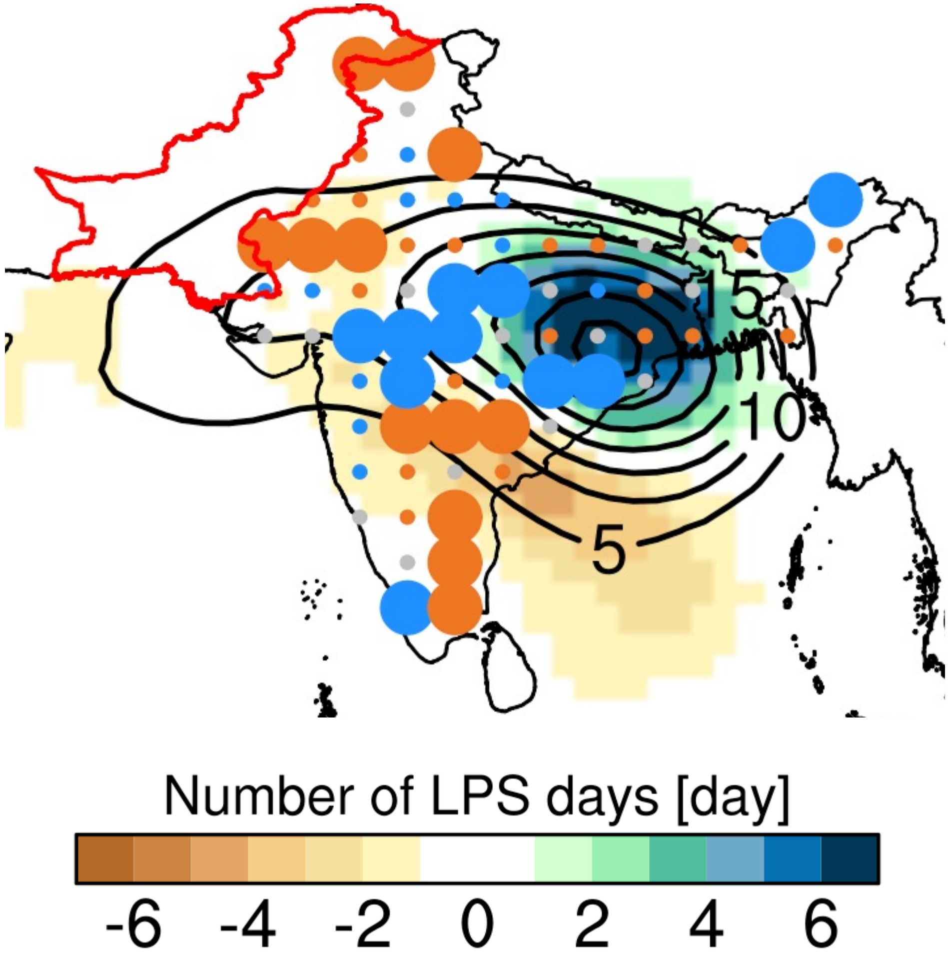
Buoyancy signals appear to be results of shifts in the tracks of the synoptic low pressure systems

Black contours: climatological LPS track density (”LPS days”)

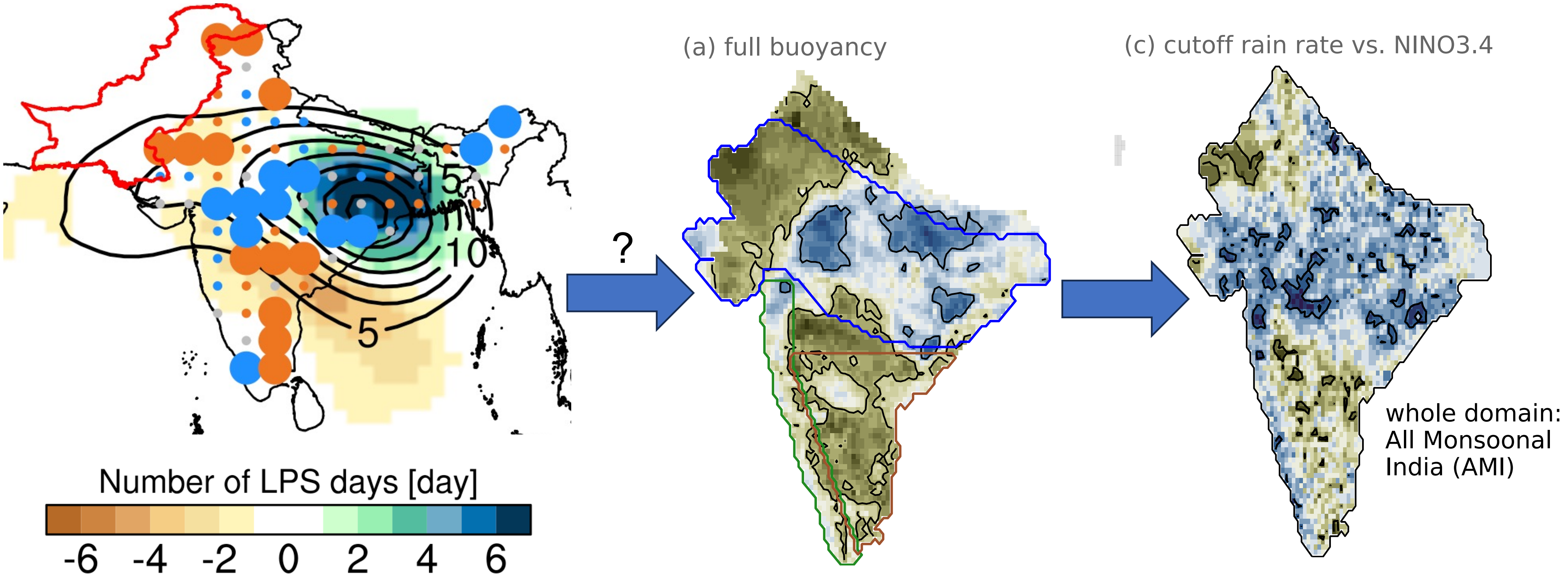
Shading: El Niño minus La Niña LPS days

Circles: less or more LPS-related extreme rain for El Niño summers

Manuscript in prep w/ Yujia You, Michela Biasutti, and Mingfang Ting



So *perhaps* the high-buoyancy cores of LPSs shifting more fundamentally causes the extreme rainfall changes



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