The Darfur Conflict Is Not a Climate Crisis

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Abstract: Data on rainfall patterns only weakly corroborate the claim that climate change explains the Darfur conflict that began in 2003 and has claimed more than 200,000 lives and displaced more than 2 million persons. Rainfall in Darfur did not decline significantly in the years prior to the eruption of major conflict in 2003; rainfall exhibited a flat trend in the thirty-years preceding the conflict (1972-2002). The claim that climate change explains the conflict rests on the observation that rainfall in Darfur has declined when comparing the present thirty-year period of 1972-2002 with earlier periods. But the characterization of rainfall in Darfur as "declining", with the implication of rainfall getting lower and lower right up to 2002, fluctuating around a declining mean, is misleading. The rainfall evidence suggests instead a break around 1972. This is strongly evident for El Fasher and El Geneina but less clear for the more southerly rainfall stations. Rainfall is basically stationary over the pre- and post-1972 sub-periods. A theory linking climate change around 1972 with an outbreak of conflict in 2003 is not compelling.

“Darfur, at its core, is a conflict of insufficient rainfall.”
Jeffrey Sachs

Introduction

Influential voices such as those of United Nations General Secretary Ban Ki Moon, former Vice President of the United States Al Gore, the United Nations Environment Program, Columbia University Professors Jeffrey Sachs and Mahmood Mamdani, and popular commentators such as Stephan Faris writing in *The Atlantic Monthly*, have recently proclaimed or insinuated the idea of the Darfur civil war as a climate crisis (Gore 2006; Sachs 2006; Faris 2007; Mamdani 2007; Moon 2007; United Nations Environment Program 2007). The contention is that climate change has led to declining rainfall and land degradation. These changes have intensified violent struggles over water, pasture and farmland. These struggles erupted into full-blown war in 2003. An influential report put it thusly (Young, Osman et al. 2005): “Declining rainfall and encroaching desertification have contributed to North–South migration which, combined with increasing population pressures, has created more direct competition for access to natural resources.” Mamdani (2007) argued that, “With the drought that set in towards the late 1970s, co-operation turned into an intense struggle over diminishing resources.” Sachs (2005) played to the peanut gallery: “Two things have happened. First, the population has doubled in the last generation, and second, the rainfall has gone down sharply. These are very hungry, crowded people, and now they are killing each other.” While non-environmental causes of the conflict are noted, the thrust of this emerging narrative of the Darfur crisis seems to be that if there had been more rain there would not have been war and consequent human catastrophe.

Careful attention should be paid to examining this explanation of the emergence of violence in Darfur, one of the world’s most significant conflicts. The fighting began in earnest in 2003, has led to over 200,000 excess deaths, and has forced over two million people to flee their villages for the comparative safety of refugee camps. The government of Sudan, which organized much of the violence perpetrated by the irregular militia known in Darfur as the *janjawid*, has long claimed that the conflict was a local, tribal conflict caused by environmental change.

The commentators suggesting a climate change explanation for the Darfur conflict usually present little data to validate their claims, instead relying on a general understanding that Darfur is part of the Sahel, and that rainfall has declined in the Sahel, and so therefore climate change may be the real culprit.

Data on Darfur rainfall patterns only weakly corroborate the claim that climate change explains the conflict. Rainfall in Darfur did not decline significantly in the years prior to the eruption of major conflict in 2003. Short-term droughts in 1984 and 1990 did not provoke wide-spread conflict. Rainfall in Darfur exhibited a flat trend in the thirty-years preceding the conflict (1972-2002). Some recent studies of satellite imagery of vegetation have shown a greening trend in Sahelian Africa, including Darfur, over the past twenty-five years. The claim that climate change explains the conflict rests instead on the observation that rainfall in Darfur has declined when comparing the present thirty-year period of 1970-2000 with the previous thirty-year period of 1940 to 1970, with the World Meteorological Organization’s 1961-90 reference period, or with the longer time period from the beginning of availability of rainfall records through 1970 (approximately 1920-1970). The data suggests that these longer-term changes are not general to Darfur but rather are observed in the northerly rainfall records from the stations at El Geneina and El Fasher in northern Darfur. More southerly rainfall stations in Darfur and neighboring Kordofan exhibit no such longer-term declines.

Explaining the contemporary Darfur conflict by a climate shift that happened more than 30 years prior (let alone 60 years prior) is unconvincing. The climate change that may have happened around 1970 would have shaped the life experiences of Darfur inhabitants who were 50-plus years old in 2003. Every other adult in the region, including residents of El Fasher, has seen 30 years of stationary rainfall patterns, population increase, animal stock increase, technological change, and general economic change. To argue that the quinquagenarians went to war after thirty years of discrepancy between the golden age of their childhoods and their present lowered rainfall realities hardly seems compelling when there is a perfectly good reasonable alternative explanation for the war.

The rainfall patterns of Darfur are similar to those of Sahelian Africa more generally. While semi-arid conditions of low rainfall with high variability both temporally and spatially are tough environments for humans, there is much evidence that Sahelian societies have coped through evolving strategies such as income diversification, agricultural intensification and migration, rather than large-scale violence. Life is not peaceful: there are endemic low-level struggles over resources, particularly between herders and farmers. However, conflict has not erupted into warfare because regional authorities and central governments have by-and-large projected their authority into Sahelian hinterlands and arrested violent situations before they have intensified. Other Sahelian sub-regions that have developed wide-spread conflict on the scale of Darfur, such as the long-lasting war in Chad and the various wars in Ethiopia and Eritrea, are only implausibly linked to climate change. Sahelian West Africa has seen no outbreak of larger-scale conflict.

What makes Darfur different from these other Sahelian regions? The answer is straightforward: an elite ruling the country from Khartoum that has previously and repeatedly revealed a willingness and ability to use large-scale violence, particularly against civilian populations, when threatened. This willingness to use large-scale indiscriminate violence was evident in the civil wars encompassing Southern Sudan and the Nuba Mountains. No other region of the Sahel has such an actor. The individuals that constitute the present military regime are being indicted or are being considered for indictment by the International Criminal Court, and the defense that they were embroiled in a local conflict induced by climate change has little merit.

Short-term drought as a precipitating factor in the Darfur conflict

Darfur, the westernmost province in Sudan, like most of arid and semi-arid Africa, is marked by a good deal of climatic variability. It spans several environmental zones, ranging from Saharan Desert in the far north of the province to African Sahel and Savanna regions further south. Rainfall is characterized by marked seasonality with a long dry season and shorter wet season from June to October. Rainfall increases from north to south, with Saharan regions receiving low and intermittent rainfall, Sahelian regions ranging between 100-400mm per year, and Savanna regions ranging from 600-1000mm per year. The wet season is marked by much variability within years, between years, and across space.

Did a short-term rainfall decline precipitate the large-scale violence in Darfur in 2003? A number of commentators seem to have interpreted research by Miguel, et al. (2004) as suggesting that short term declines in rainfall precipitate conflict and then implied that Darfur experienced such a short-term decline in rainfall. Sachs (2005), for example, remarked that "… Africa is living so much on the edge that a recent paper [presumably Miguel, et al.], published last year, proved statistically that when the rains fail, the probability of war soars." Writing in *Scientific American*, Sachs (2006) observed that "… studies have shown that a temporary decline in rainfall has generally been associated throughout sub-Saharan Africa with a marked rise in the likelihood of violent conflict in the following months."

The Miguel, et al. (2004) study did not actually make the argument that rainfall declines directly caused conflict, instead suggesting that measures of change in rainfall could be used as instrumental variables in estimating how change in GDP per capita might influence conflict. They were clear that only as rainfall changes were mediated via incomes would there be a reasonable basis for empirically linking rainfall to conflict (p. 745): "While it is intuitively plausible that the rainfall instruments are exogenous, they must also satisfy the exclusion restriction: weather shocks should affect civil conflict only through economic growth." This is an important point for Darfur, because there has been limited research on how robust livelihood outcomes are to changes in rainfall. De Waal (1989), for example, argued that Darfur populations were quite resilient to extreme drought, and provoked a lively and continuing debate (Gray and Kevane 1993). Parallel research in West Africa has been assessing the adaptive capacity of Sahelian populations to drought conditions (Mortimore 1989; Mortimore and Adams 2001; Raynaut 2001). As we see below, rainfall declined only in northern Darfur, and the population of northern Darfur is highly mobile.

In any case, rainfall data shows no evidence of short-term decline in Darfur preceding the conflict; the years leading up to the crisis are not out of the norm of variability for the thirty year period prior to the crisis. Figure 1 shows data for the period 1972-2002 for four rainfall stations relevant to the situation in Darfur (El Geneina, El Fasher, Nyala and En Nahud, the latter in western Kordofan, the province neighboring Darfur). Figure 2 shows data for four locations in Darfur that are nodes for the 2.5°x2.5° latitude--longitude global array of rainfall estimates of the Global Precipitation Climatology Project (GPCP), a blending of various estimates from satellite and rain gauge measures (Adler, Huffman et al. 2003). GPCP data are available starting in 1979. A Google Earth image shows the locations of the rainfall stations and the GPCP nodes.

As is clear, there was no significant decline leading up to the conflict of 2003. Instead, substantial declines were recorded in 1984 and 1990. These declines did not provoke large-scale conflict, even though by they generated considerable population displacement.[1] Figure 3 presents the distribution of monthly rainfall for the four GPCP nodes, comparing 2002, the rainy season that preceded the large-scale conflict that erupted in the dry season of January 2003, to

[1] A digression is warranted here: in 1991 a former Islamist stalwart originally from Darfur , Daoud Bolad, resurfaced as commander of a Darfur branch of the Sudan People's Liberation Army (SPLA), which was fighting the military Islamist regime in Khartoum. Bolad was captured, tortured and executed. His threatened Darfur rebellion, if successful, may well have been attributed by future analysts to the poor rainfall of 1990. The sad circumstances of his death (and that of his comrades in arms) reveal a major shortcoming in cross-country and cross-regional analyses of conflict: they typically count as conflict only successful conflicts (ones that turn into large-scale conflicts). One may well imagine that years of low income do not stimulate conflict at all, but rather weaken a central army's ability to overcome a rebellion at a very early stage. Bad rainfall, in this logic, does not cause conflict, but rather enables successful conflict (from the point of view of the rebels). Given that most African regimes are illegitimate dictatorships, perhaps one should be hoping for less, rather than more, rain?

the drought years of 1984 and 1990. Rainfall was comparatively high in 2002 and evenly distributed, suggesting that if there was a proximate drought event that could have triggered a large-scale outbreak of violence, it would have been in 1984 or 1990.

The evident lack of a trend in the 30 year period 1972-2002 for the rainfall station data and the 23 year period 1979-2002 for the GPCP data is not an artifact of the starting date. For all ten starting dates over the period 1965-1974 and for all four rainfall stations, the estimated coefficient on the variable YEAR is not statistically significant in a regression explaining rainfall totals over 30 year periods. (These results are available upon request.) A similar result obtains for the GPCP data when estimating a linear trend for each span of years ending in 2002 and starting with 1979 and continuing through 1988. The coefficients on YEAR are not significant, with one exception. For the period 1988-2002 in the northwestern node, there is a positive trend. One 'false positive' in 40 regressions is even less than what we might expect just by chance.

Long-term rainfall trends

Sahelian Africa experienced a very dry second half of the 20th century, including two significant and severe droughts in and around the 1973 and 1984 seasons. Simple linear regression analysis for the wide swath of the Sahel from Eritrea to Senegal suggests that over the past hundred-year period there has been a downwards trend in rianfall. Large fluctuations in climate, however, are an inherent feature of climate in Sahelian regions. Interdecadal and interannual variability are the norm (Hulme 2000). Nicholson ( ) argues that during the 1820s and 1830s abnormally dry conditions prevailed with many lakes drying up. Rainfall then returned to higher levels, but the first decades of the 20th century, particularly the 1910s and 1920s, were also a period of low rainfall. Sahelian rainfall increased to high levels from the 1930s-1960s. The late 1960s until the 1990s represented a period of lower rainfall (Foley, Coe et al. 2003). The evidence of the 1990s is of mean rainfall levels above the 1960-1991 average. As noted above, indices of vegetative cover also suggest improvements in the last decade (Prince, Wessels et al. 2007).

In Darfur, longer-term trends are less apparent. At one time it was thought that rainfall was declining rapidly (Eldredge, Khalil et al. 1988). As seen above, there has been no trend in rainfall in Darfur for the thirty year period 1972-2002. For longer period of time, say 50 year periods, there is also little evidence of a decline. Table 1 reports the coefficients on the variable YEAR in regressions explaining rainfall totals over 50 year periods. Since the starting date used in estimating a trend might generate a spurious trend (if the start date was an outlier year of high rainfall), we estimate the trend coefficient for every start date. Each time period is fifty years or, for those where fifty years would go beyond 2002 (the end date of interest), the number of years included in the time period is 2002 minus the starting year. The more southerly rain stations of Nyala and En Nahud exhibit no trend at all for these 50 year periods. The northern rain stations are mixed. For El Geneina a negative trend is estimated if the starting year is in the 1940s or early 1950s. These were periods of above average rainfall in El Geneina, and so using them as the start date to estimate a trend results in a statistically significant negative trend. But after 1954 there is basically no trend. For El Fasher there is no long term trend when starting in the earliest years. But there is a strong negative trend when starting the time period in the 1960s, years of high rainfall in El Fasher. (None of the rainfall stations have statistically significant trends when the start date is in the period 1965-71.)

Because of the importance of El Fasher as the rainfall station perhaps most relevant to the outbreak of the war in 2003, it is worth examining the data more closely. Figure 4 shows the rainfall levels measured at El Fasher for the period 1917-2002. A simple regression of rainfall on year for the full period yields a coefficient that is statistically significant, and suggests a gradual decline in rainfall over the 80 year period, on the order of .4 mm decline per year. But the notion of gradual decline is highly misleading. Instead, what seems to have happened to rainfall in El Fasher is a break in 1972 in the basically stationary time series of rainfall. Prior to 1972, rainfall fluctuated around a mean level of 175 mm per year. After 1972, rainfall fluctuated around a mean level of 150 mm. As noted above, there had been no trend decline in rainfall in El Fasher for thirty years prior to the outbreak of major conflict in 2003. If the two time periods are treated separately, simple regression analysis indicates no statistically significant trend for either time period.

The downwards trend over the long durée is also apparent using the historical monthly precipitation dataset for global land areas from 1900 to 1998, gridded at 2.5° latitude by 3.75° longitude resolution, created by Hulme (1998) for the Climate Research Unit of the University of East Anglia.[2] As seen in Figure 5, the levels estimated for the node located at 12.5° latitude and 26.25° longitude, which is approximately 150 km to the southeast of El Fasher, are much higher than those of the El Fasher rain station (presumably because the interpolation is using rain stations that all lie to the south of the El Fasher rain station, the northernmost in Darfur). The slope of the trend for the full time period is a decline of .75 mm per year. Again, the trend line (not shown) is misleading, because the real story of rainfall is of a break around 1972 to a lower mean. The other three nodes that are included in Darfur also exhibit similar patterns. Long term rainfall station data is quite similar, though En Nahud exhibits a long term upwards trend and a higher mean level after 1972.

Comparing 30 year means is a common data presentation technique in climatology. Figure 6 shows the rainfall in Darfur for the period 1970-2002 when presented as a deviation from the 30 year mean of the 1961-90 period, the current World Meteorological Organization reference period. For El Fasher, the fifteen years prior to 2002 were almost invariably lower than average rainfall, with 1998 the very worst year. For En Nahud, just across the Darfur border in the neighboring region of Kordofan, rainfall had been above average the reference mean for the decade previous to 2002.

Figure 7 presents for El Fasher the deviations from the 1961-90 mean, but now for the entire time series. It is clear that the period 1970-2002 is lower rainfall compared with the earlier 1940-1970 year period, though the difference is largely due to the 1960-70 period of high rainfall. Going back further in time one finds that the 1950s were very similar to the 1980s and 1990s.

To summarize the longer-term data, the characterization of rainfall in Darfur as "declining", with the implication of rainfall getting lower and lower, fluctuating around a declining mean, is misleading. The rainfall evidence suggests instead a break around 1972. This is strongly true for El Fasher and El Geneina but less clear for the more southerly rainfall stations. Rainfall is basically stationary over the pre- and post-1972 sub-periods.

Long-term decline in rainfall as an explanation of conflict

The evidence of rainfall patterns is not consonant with the narratives of Darfur as a climate crisis alluded to in the introduction. These appear to suggest conflict erupting from an implacable decline in rainfall that began, according to various commentators, in the 1970s, or 1980s, or from

[2] 'gu23wld0098.dat' (Version 1.0) constructed and supplied by Dr Mike Hulme at the Climatic Research Unit, University of East Anglia, Norwich, UK. The work was supported by the UK Department of the Environment, Transport and the Regions (Contract EPG 1/1/85).

the beginning of the rainfall record in 1917 (for El Fasher). Instead, we have a structural break. Can a 20% decline in mean rainfall around 1970 explain the conflict in 2003?

As an example of how misleading the "implacable decline" narrative can be, consider the argument of Sachs (2007) argued that: "Rapid population growth - from around 1 million in 1920 to around seven million today – has made all of this [rainfall decline causing environmental degradation] far more deadly by slashing living standards." It is imperative to recall that the population of Darfur in 1970 was probably on the order of 1.5 million persons. After 33 years of rainfall at the lower average, the population in 2003 at the outbreak of the conflict was likely to have been on the order of 6 million.[3] To suggest a Malthusian trap or "carrying capacity limit" setting in at the lower mean rainfall level of the post-1972 period is belied by the actual lives of farmers and pastoralists in Darfur.

Certainly living standards declined during the sharp and intense droughts of the early 1970s and 1984, but there is little evidentiary basis for a claim that living standards in general declined for the population of Darfur over the long term. More than likely, Darfur was no different from the rest of the Sahel: improvements on many dimensions of living standards (morbidity and mortality, education, migration opportunities, livelihood diversification) were coupled with increased vulnerability to market-mediated changes in terms of trade. Investments were made in schooling infrastructure, productive infrastructure (boreholes for watering holes, diesel pumps for market gardening), and market access infrastructure (railroad, telecommunications, air travel). The general economic development of Sudan (irrigated schemes, mechanized schemes, urbanization in central Sudan) offered increasing opportunities for farmers and herders in Darfur to sell more output at better prices, to purchase consumer goods (flashlights, plastic buckets), and to earn incomes through livelihood diversification (especially seasonal migration). Increasing integration into market society, and livelihoods changed by infrastructure investment did, however, probably increase vulnerability. Households that were formerly largely self-sufficient increasingly came to see their standard of living determined by their choices about what productive activities to specialize in (become a mechanic? purchase a diesel pump?). The result was most likely increased social differentiation of the kind observed nearly everywhere in the Sahel during the 20th century, rather than a "slashing" of living standards.[4]

It is easy to imagine that growth stalled in the early 1980s, with the resurgence of civil war in 1983 and mismanagement of national economic policy and infrastructure. There seems to be consensus that Darfur society became much more weaponized during the 1980s with an influx of Chadian militias, Darfur residents joining the Sudan Armed Forces to fight against the SPLA, and encouragement of local militia groups in southern Darfur to raid southern Sudan). But the violence of the 1980s was more likely to have increased wealth in Darfur at the expense of southern Sudan, rather than impoverished Darfur. Indeed, there are numerous accounts of how pastoralists from southern Darfur increased raids on Dinka cattle herders of southern Sudan

[3] Sachs adds a million people to Darfur. De Waal suggests the population of Darfur in 1984 was 3.2 million. A growth rate of 3.7 would have been needed to attain 7 million. This would have been one of the highest growth rates in the world (for a region supposedly becoming immiserized by declining rainfall). A more likely growth rate of 3.0% would have generated a population of 6 million.

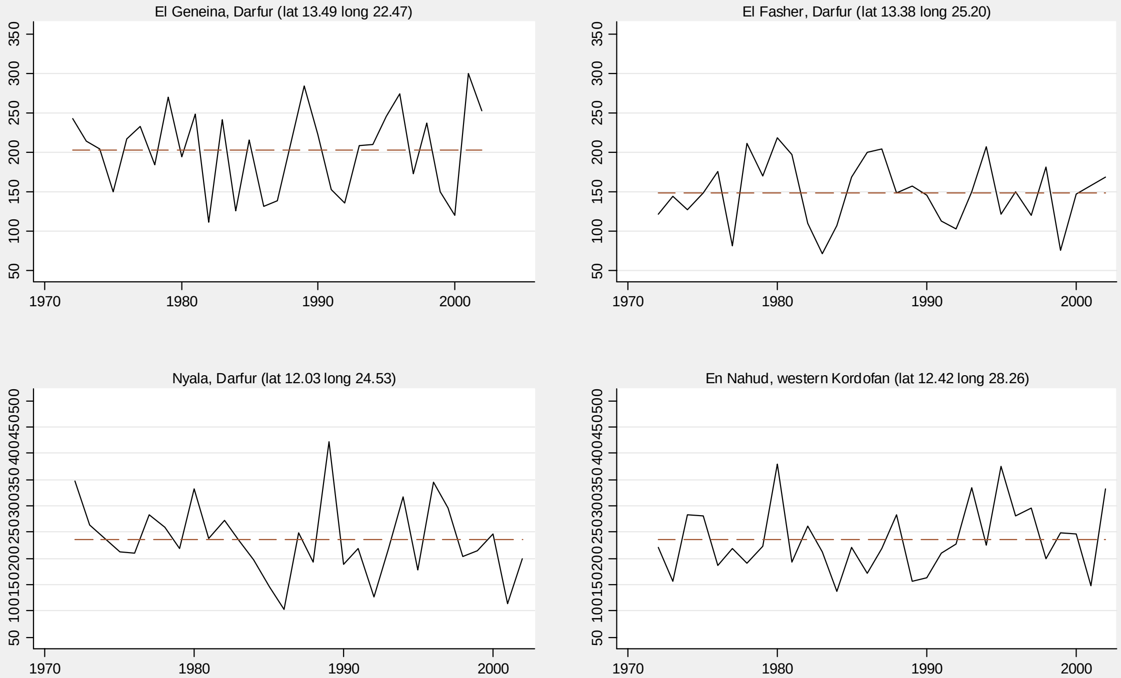
[4] The war in Darfur was clearly an ethnic war between groups with major differences in livelihood strategies. The reasoning offered by Sachs suggests that the more likely conflict to arise would be conflict between sub-groups pursuing similar livelihood strategies. Nomads would battle nomads for reduced number of watering points, pastoralists would battle pastoralists for the more limited pasture, and farmers would battle farmers for lands along seasonal streams or sandy soils where millet thrives even with low rainfall.

after the drought of 1984. Likewise, Darfurian participation in the Sudan Armed Forces and allied irregular troops would have meant increased remittances back to Darfur.

The gist of this discussion is that there is little evidentiary basis for knowing how the shift in rainfall regime altered the incomes and expectations of farmers and pastoralists in Darfur. The set of income opportunities would generally have been expanding for most people in Darfur after the one-shot change in rainfall regime in 1972 because of economic change in central Sudan and the civil war. The thesis of steady impoverishment would seem to rely on an assessment that the lower level of mean rainfall meant that the deviations below mean hurt more, and deviations above mean helped less, than in the past. This possibility is intuitive and reasonable, a kind of declining sandbars theory of livelihoods- a change in ocean currents means than big storms carry more sand away, and regular currents are no longer strong enough to replenish. There is no data to tell which one was more likely to have been happening in the years prior of 2003.

Figure 1: Rainfall (annual mm.) at four rain stations in Darfur area, 1972-2002

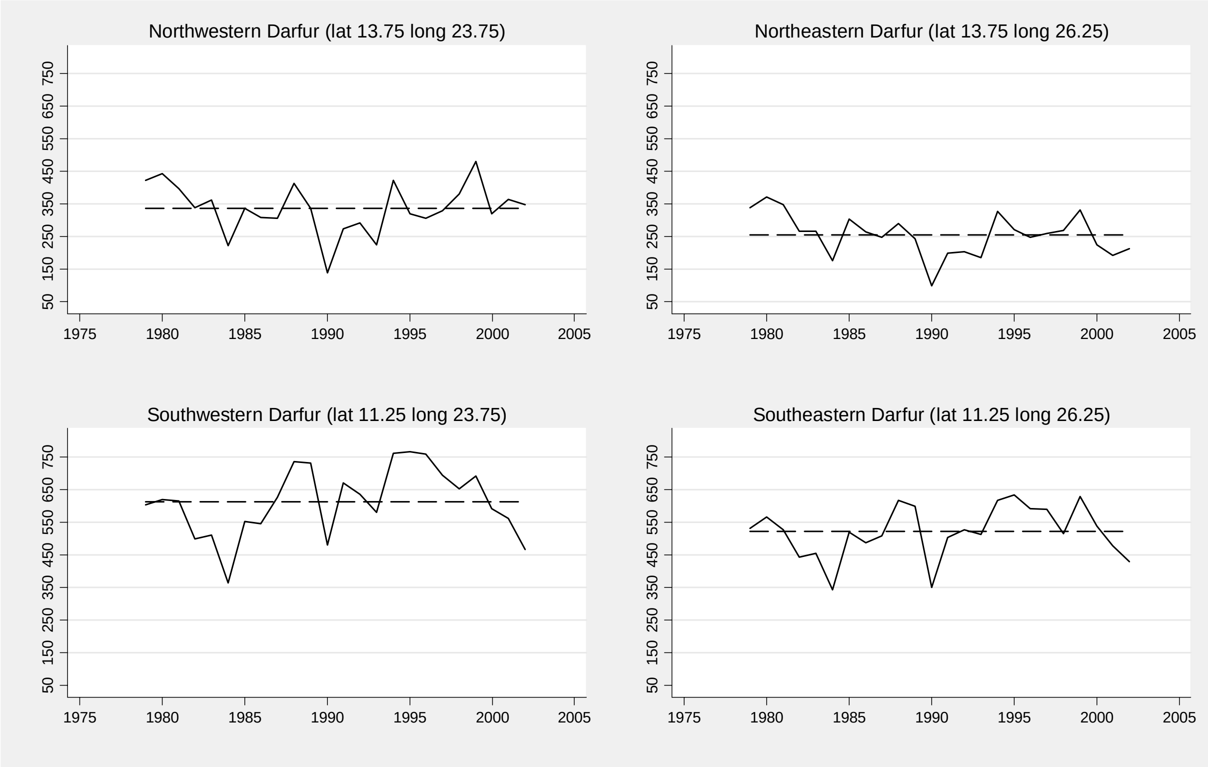
(dashed lines are 30-year means)



Source: Sudan rain station data provided by David Lister, Climatic Research Unit, University of East Anglia

Figure 2: Rainfall at four latitude-longitude nodes in Darfur (annual mm.), 1979-2002

(dashed lines are 23-year means)



Source: GPCP 2.5x2.5 dataset

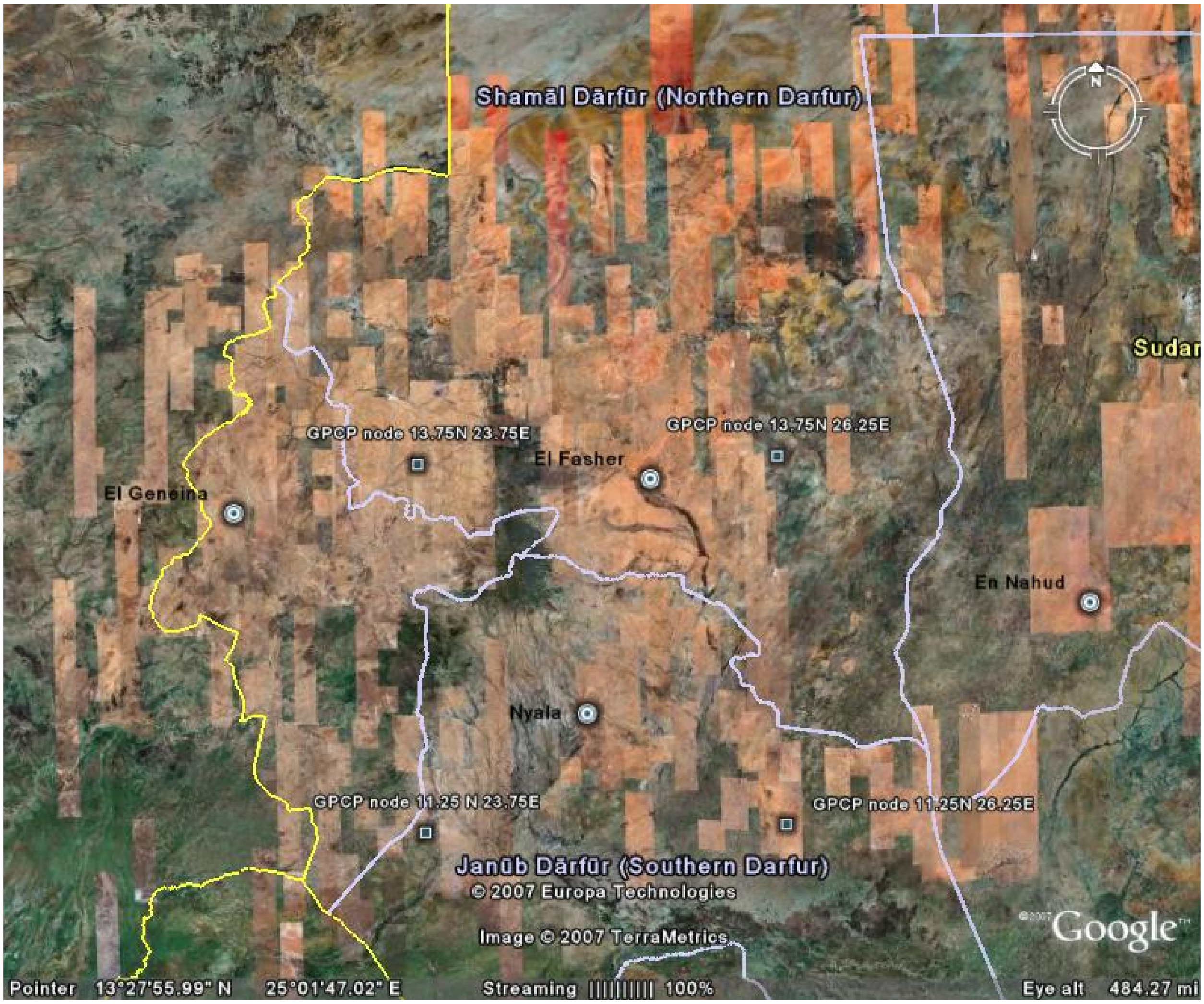
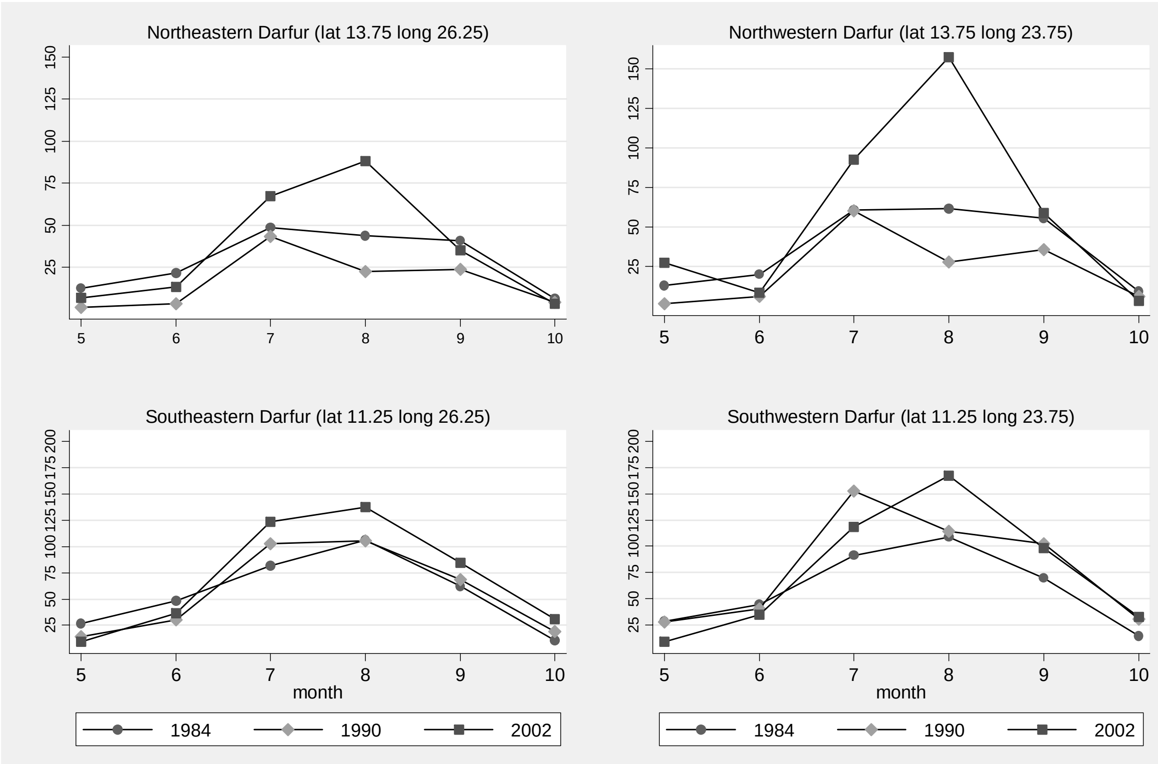

Shamāl Dārfūr (Northern Darfur)
Sudan
GPCP node 13.75N 23.75E
GPCP node 13.75N 26.25E
El Fasher
El Geneina
En Nahud
Nyala
GPCP node 11.25 N 23.75E
GPCP node 11.25N 26.25E
Janūb Dārfūr (Southern Darfur)
© 2007 Europa Technologies
Image © 2007 TerraMetrics
Google
Pointer 13°27'55.99" N 25°01'47.02" E
Streaming 100%
Eye alt 484.27 mi

Figure 3: Distribution of monthly rainfall in Darfur in 1984, 1990 and 2002

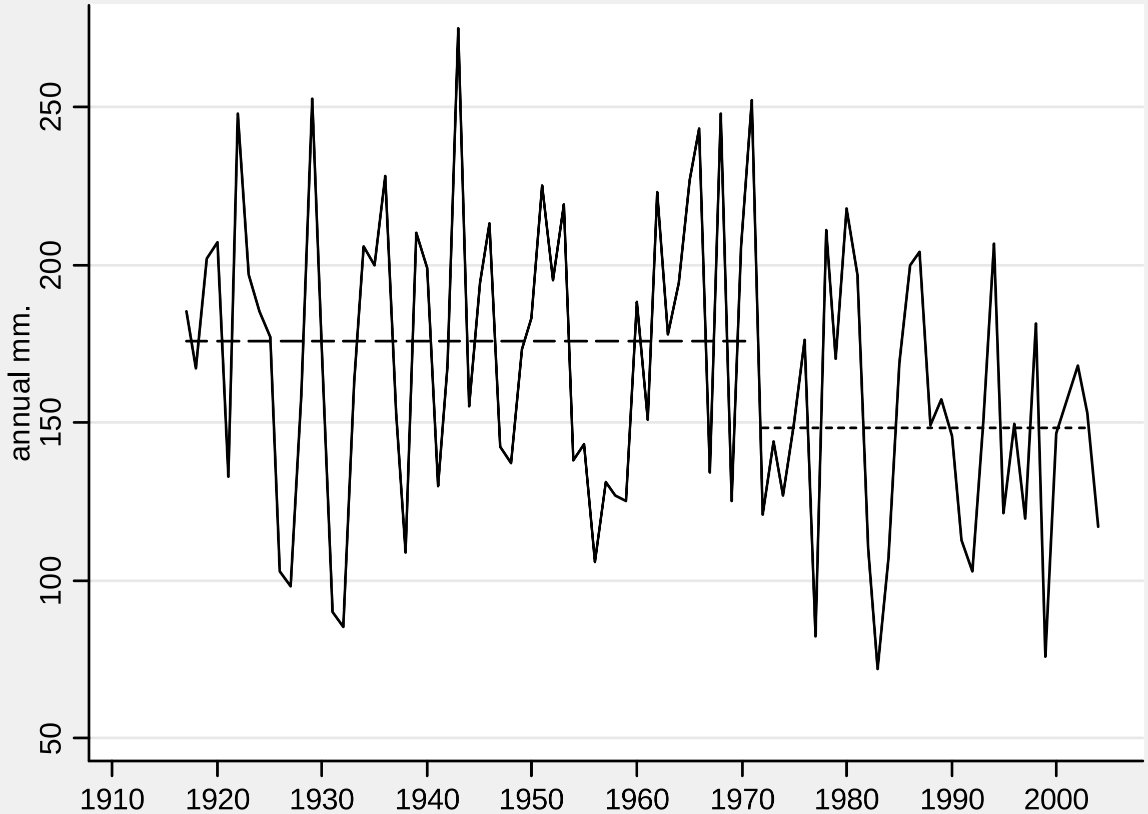


Source: GPCP 2.5x2.5 dataset

[redacted]

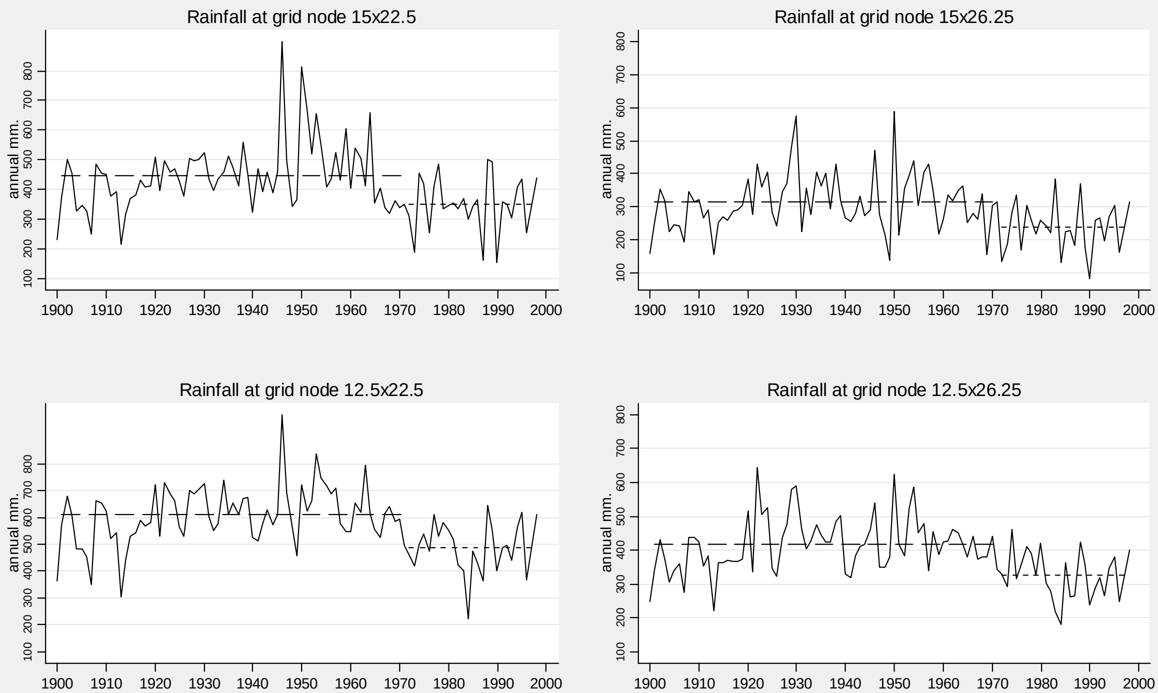
Figure 4: Rainfall El Fasher station, 1917-2002, Darfur

(dashed lines are means for period 1917-1971 and 1972-2002)



Source: Sudan rain station data provided by David Lister, Climatic Research Unit, University of East Anglia

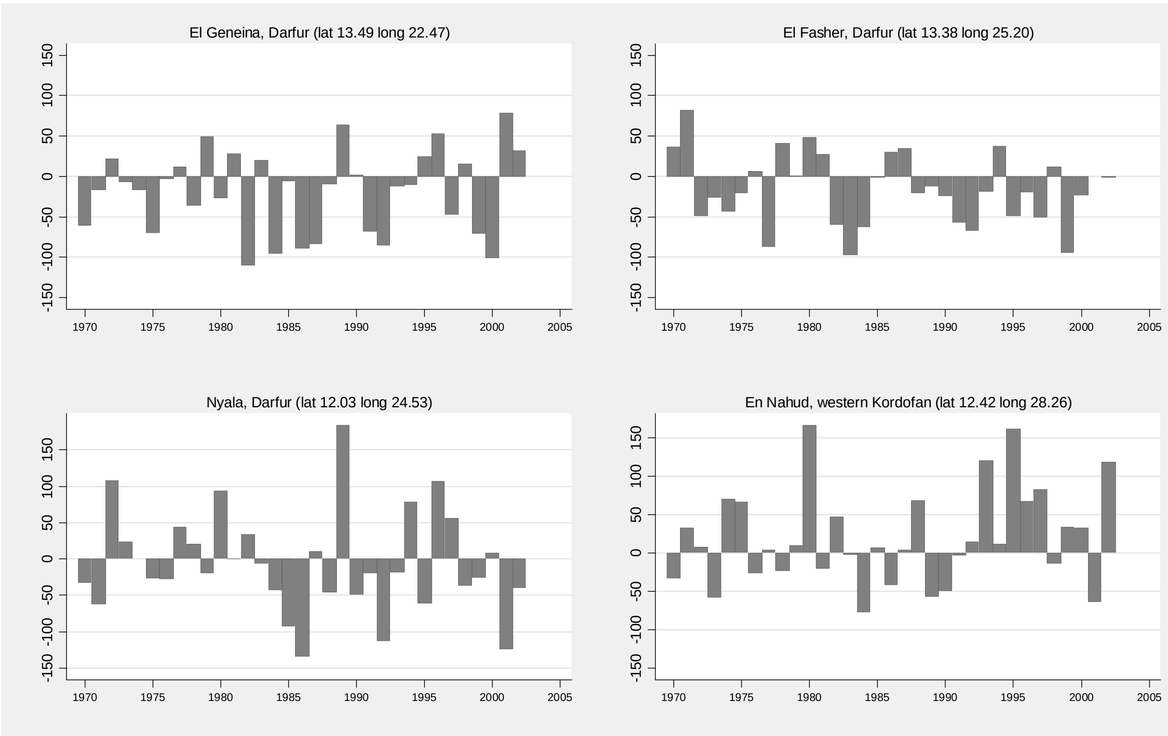
Figure 5: Rainfall in four latitude-longitude nodes in Darfur, 1900-1998
(dashed lines indicate mean levels for 1900-71 and 1972-1998)



Source: gu23wld0098.dat (Version 1.0), provided by Mike Hulme, Climatic Research Unit, University of East Anglia

Figure 6: Deviations from local 1961-1990 mean

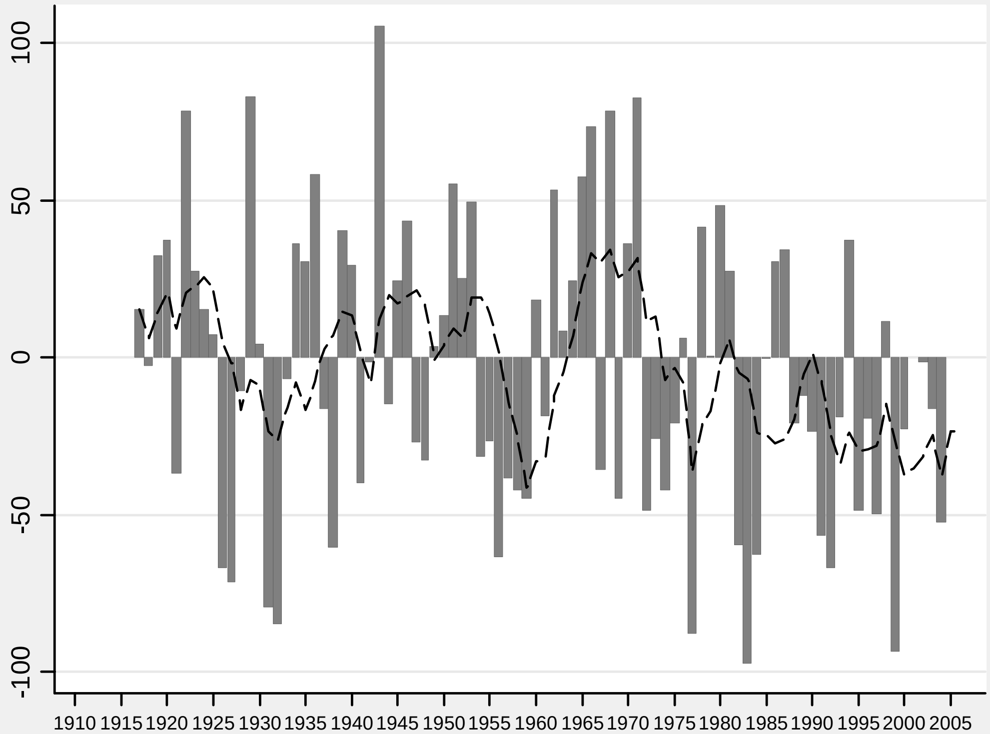
four rain stations in Darfur area, 1970-2002



Source: Sudan rain station data provided by David Lister, Climatic Research Unit, University of East Anglia

Figure 7: Deviations from 1961-1990 mean, El Fasher, Darfur

(dashed line is five year moving average of deviations)



Source: Sudan rain station data provided by David Lister, Climatic Research Unit, University of East Anglia

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