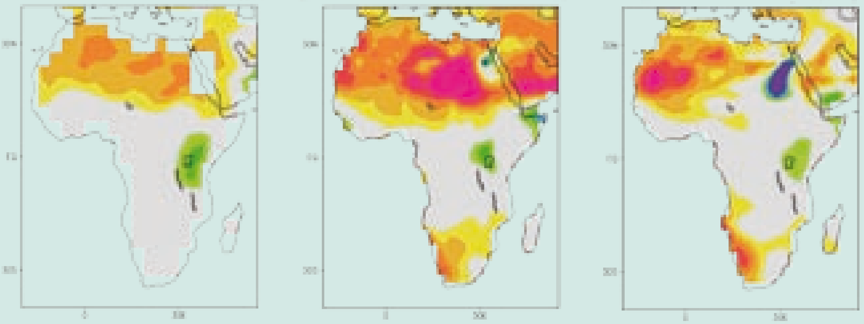
Changes in extreme weather in Africa under global warming



► Figure 1: *Percentage change in precipitation around 2050 compared with 1971-2000 in 6 models.*

► *Introduction*

Many of the impacts of climate change will materialize through changes in extreme events such as droughts, floods, and storms. Such extremes result in severe human suffering, and hamper economic development and poverty reduction. Unfortunately, assessments of climate change are often limited to mean temperature and precipitation. Knowledge of changes in extremes is sparse, particularly for Africa. This brochure presents selected results of such analyses for various parts of Africa, using the best climate models from the upcoming IPCC Fourth Assessment Report.

In some regions, different models project different trends in wet and dry extremes. In other regions however, models show clear trends such as increasing drought in the Kalahari and increasing floods in East Africa. Notably, in some regions, such as Somalia and eastern Ethiopia, our results show an increasing intensity of both floods and droughts. For more comprehensive results, please visit www.knmi.nl/africa_scenarios.

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Southern Africa

Four zones with a more or less uniform rainfall pattern are considered separately. Area averaged rainfall series for north-east South Africa, Zimbabwe, western Mozambique and southern Malawi and Zambia show that multi-decadal rainfall oscillations have occurred during the 20th century.

The models generally show a drying trend for much of the 21st century, although decade-to-decade rainfall fluctuations in the simulations are evident early in the century. The simulated annual cycles in a warmer climate show a one month delay of the rainfall onset and no shift in rainfall cessation months, thus implying shorter rainy seasons. This delayed seasonal rainfall onset is predicted even in the northern parts of southern Africa.

Extremely low rainfall (defined as the intensity of events occurring once every ten years) becomes less extreme over central south Africa and Lesotho, increasing by about 50% around 2100. While some inconsistencies are evident, most models simulate an increase of the extreme dry events over the Kalahari by up to 30%. Such conditions are favourable for a further eastward encroachment of the Kalahari desert. Owing to the inability of the models to simulate tropical cyclones/storms, which are one of the main sources of torrential rains and flooding, changes in southern African wet extremes are not included. For detailed results visit www.knmi.nl/africa_scenarios

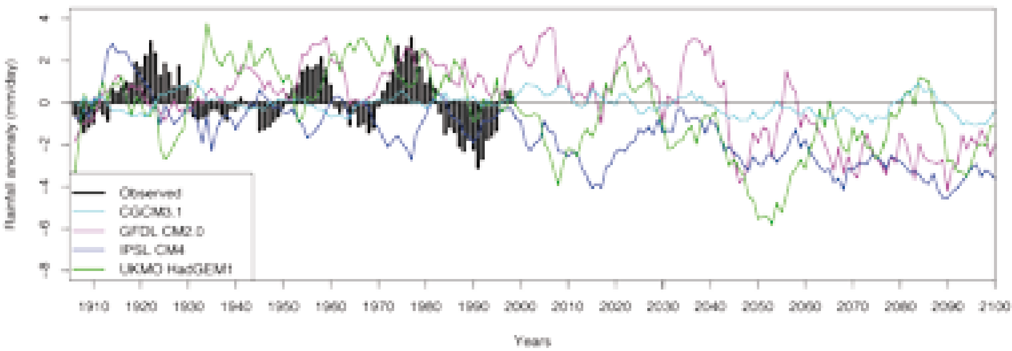
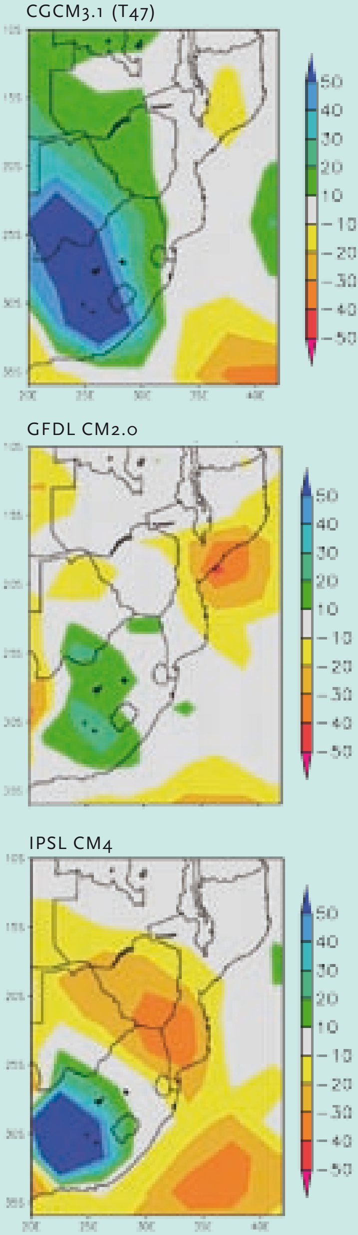
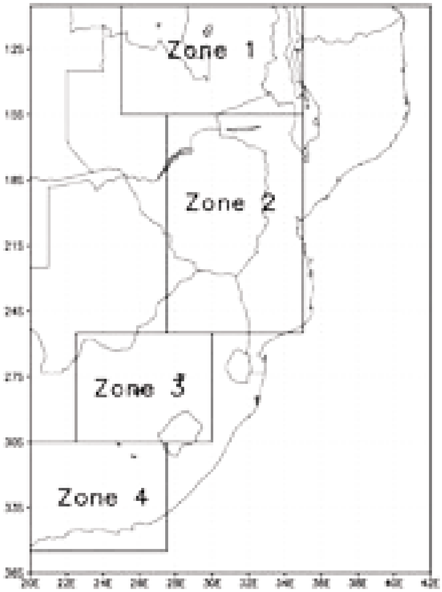


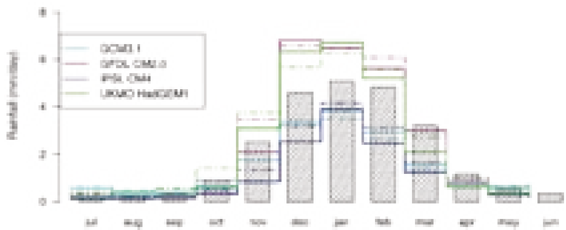
Figure 2: *Observed and simulated summer rainfall in southern Africa zone 2 (Zimbabwe and surroundings).*



▶ Figure 5: *Changes in amount of rain around 2100 in low rainfall events in Southern Africa that occur once every 10 years.*



▶ Figure 3: *Homogeneous rainfall regions for Southern Africa.*



▶ Figure 4: *Observed (bars) and simulated seasonal cycle of rainfall in southern Africa zone 2 (Zimbabwe and surroundings). The dotted (solid) lines for each model are for the present (future) climate.*

East Africa

Much of East Africa is characterised by two rainfall seasons with peaks centred around March-May (MAM; long rains), and September-November (SON; short rains). Southern Tanzania receives highest rainfall during austral summer.

Time series of area averaged rainfall observed over the Rift Valley and its vicinity show that much of this area has experienced a slight wetting trend over the 20th century. Some small-scale inhomogeneities in rainfall caused by local features (such as mountains and lake-land contrasts) and short-term fluctuations do not hide this trend. This is the case in both seasons.

Three of the four analysed models project a continuation of the wetting trend over much of East Africa during both seasons. There are also high prospects of rainfall increase in the Great Lakes region and much of Uganda. The simulated annual cycle shows that it is the rainfall intensity in a given season that is likely to increase; there is little evidence of a notable change in the duration of the rainy season. However, the tendency of the models to underestimate the total precipitation during the long-rains season limits the confidence on predictions in a future climate.

The models show a high degree of agreement in simulating an increase in the extreme high rainfall over East Africa. Notably, in northern Kenya, southern Ethiopia and Somalia an increase of more than 20% in the very extreme (one-in-100-years) high rainfall events is simulated for around 2100. Over the same areas, there are indications of a decrease in the severity of the dry rainfall extremes. Hence excessive rainfall events are more likely than the opposite dry extreme. The indications of an increase in extreme rainfall events during the long-rains season could have long-term implications for flood impacts. A mild exception is southern Tanzania, where low rainfall events are expected to become more severe, while the high rainfall events do not show a notable change.

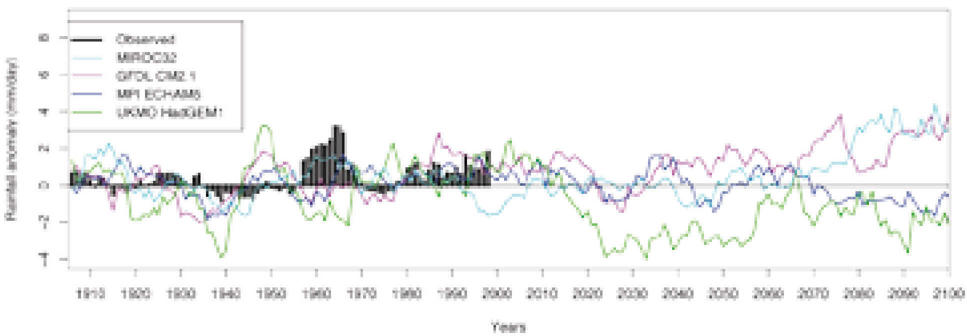
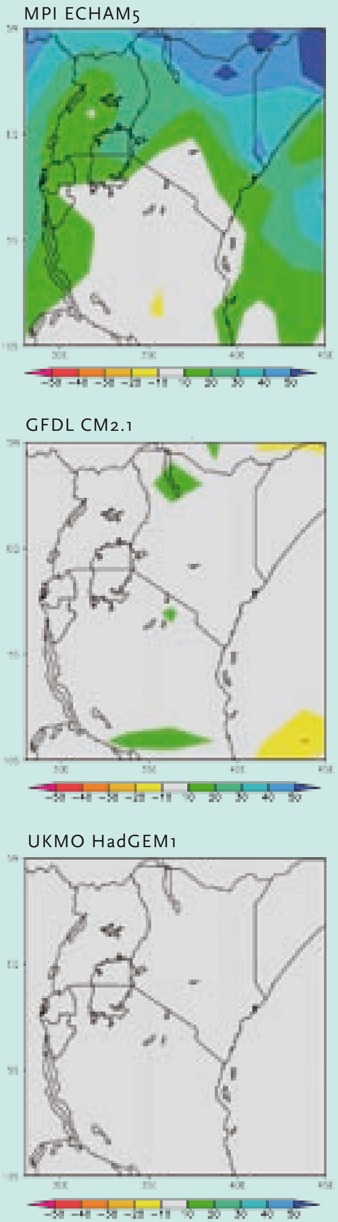
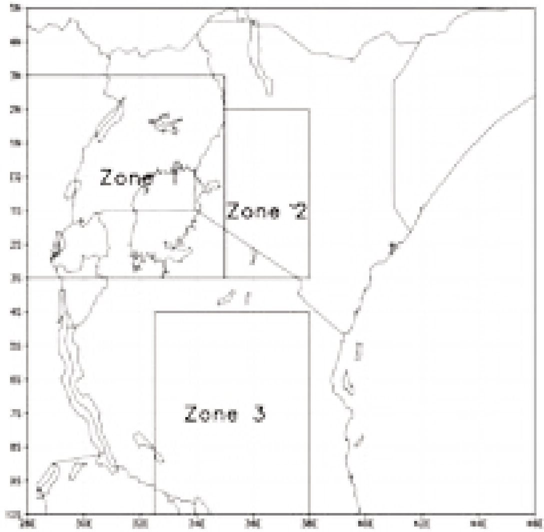


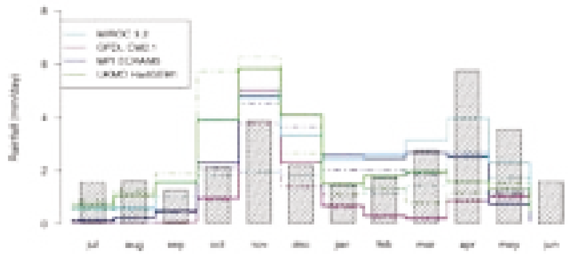
Figure 6: *Observed and simulated short-rains in East Africa zone 2 (Rift Valley).*



▶ Figure 9: Changes in the amount of rain around 2100 in short rain high rainfall events that once every 100 year.



▶ Figure 7: *Homogeneous rainfall regions for East Africa.*



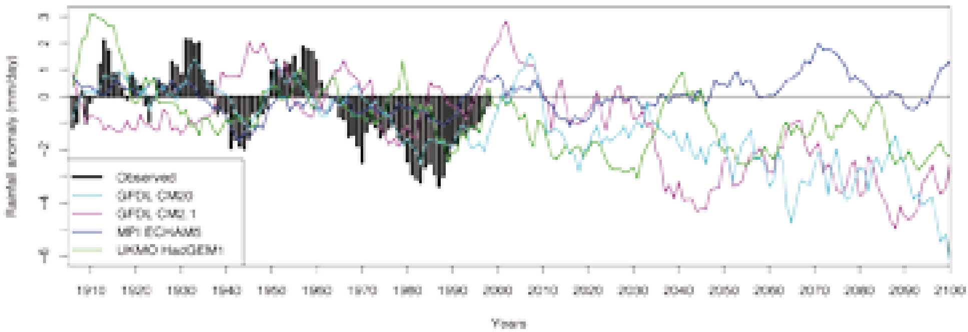
▶ Figure 8: *Observed (bars) and simulated seasonal cycle of rainfall in East Africa zone 2 (Rift Valley). The dotted (solid) lines for each model are for the present (future) climate.*

North-east Africa

In the west, the Nile region consists of the semi-arid area of eastern Sudan, whereas the mountainous east is much wetter. In the east, this region contains the northern parts of Somalia. On the basis of the observed differences in the climate, two rainfall regions are considered. The time series for area averaged rainfall over both eastern Sudan and central Ethiopia show that rainfall shortage has been predominant during the last decades of the 20th century. There is evidence of a continuation of the drying trend in the future climate. However, some models indicate a likelihood of wetter mean conditions in future climate over parts of northern Ethiopia bordering the Red Sea. The simulated annual cycle for Ethiopia shows a shift in both the rainfall onset and cessation dates by about a month. This result implies a shift of the whole rainy season with October receiving more rainfall than in the present climate. A similar shift is expected in eastern Sudan.

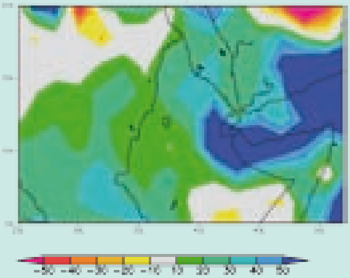
Whereas the models show differing responses in the mean over Ethiopia, with some models projecting more rain, others less, both the dry and wet extremes are simulated to increase in severity in a future climate. In the drying models the wet extremes do not change, but the dry extremes increase in severity. In the models that show an increase in mean precipitation the opposite occurs: dry events do not change, but the wet events increase in severity.

In Somalia there is more consistency, with most models showing an increase in high rain seasons by more than 20% over much of the country.

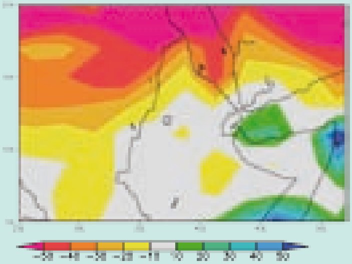


► Figure 10: *Observed and simulated summer rainfall in Northeast Africa zone 1 (Nile area).*

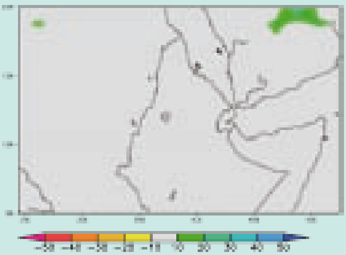
MPI ECHAM5



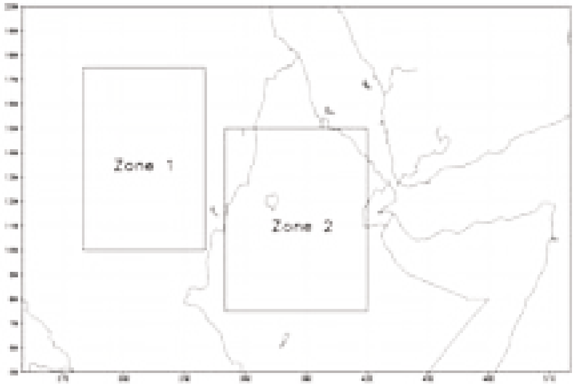
GFDL CM2.0



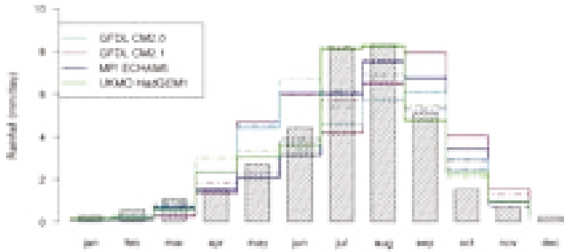
UKMO HadGEM1



▶ Figure 13: *Changes in amount of rain around 2100 in North-east Africa high rainfall events that occur once every 10 years.*



▶ Figure 11: *Homogeneous rainfall regions for North-east Africa.*



▶ Figure 12: *Observed (bars) and simulated seasonal cycle of rainfall in Northeast Africa zone 1 (Nile area). The dotted (solid) lines for each model are the present (future) climate annual cycles for zone 2.*

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Changes in mean precipitation

In some regions, there is an encouraging degree of agreement between changes in mean precipitation simulated in climate model experiments for the IPCC fourth Assessment Report, in other regions such as the Sahel, the models diverge. Common features in most models include: a trend toward wetter conditions in the Nile area of North Africa and in Lake Victoria/East Africa, and a drying trend in the Namib and Kalahari deserts in southern Africa.

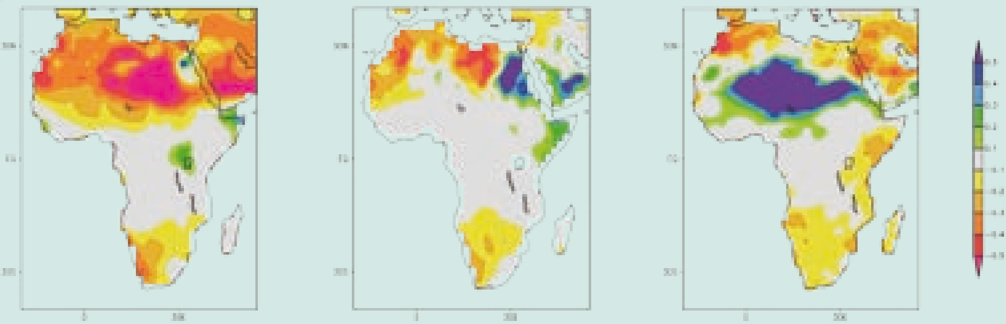

Figure 1 (cont'd): *Percentage change in precipitation around 2050 compared with 1971-2000 in 6 models.*

Technical details

For each selected region, 4-6 models have been objectively selected on the basis of their ability to adequately represent the observed 20th century precipitation patterns. For these models we investigated the likely changes in precipitation using the SRES A1B scenarios from 2050 to 2200 (forcing constant after 2100 at 2×CO_2). For each of the selected IPCC models we computed 10-year and 100-year return values by fitting a Generalized Pareto Distribution to the 20% driest or wettest seasons in the current and future climates. The changes were calculated as the ratio of these return values.

The GHCN v2 rainfall stations for each region were clustered into homogeneous zones based on the 1921-1990 year-to-year variations in total precipitation. Monthly rainfall has been stratified into seasonal totals according to the main rainfall season for each homogeneous zone, taking into account biases of the models.

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KNMI is the Dutch national centre for information on weather, climate and seismology

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