Trends of CAPE in ERA-40

Kathrin Riemann, Klaus Fraedrich and Frank Lunkeit
Meteorological Institute, University of Hamburg, Germany

Motivation

Convective available potential energy (CAPE) plays a major role in severe storms and tornado development (Romero et al., 2007; Brooks et al., 2003). The influence of global warming on severe weather during the last decades is a major issue, thus a trend analysis on CAPE is made to explore whether the climate change has an impact on CAPE. The trend is analysed for each season based on monthly mean values of CAPE calculated from the European Centre for Medium-Range Weather Forecasts (ECMWF) reanalysis (ERA-40) between 1958 and 2001. Furthermore, a detrended fluctuation analysis (DFA) is applied to CAPE in order to distinguish between a trend and a long time memory.

Data and Methodology

- temperature and relative humidity of ERA-40
- 6 h interval for the years 1958 until 2001
- global fields on a horizontal grid with spacing of ~ 1.125°
- Surface based CAPE is calculated pseudo adiabatically
- Mann Kendall trend test used to compute trends
- trends are only examined if their probability exceeds 90%
- linear regression to estimate the magnitude of a trend
- artificial warming trend in ERA-40 before 1979 (Bengtsson et al., 2004)
  ➔ additional trend tests for the years 1958-1978 and 1979-2001
- DFA to distinguish between a trend and a long time memory
- DFA obtains power law scaling of low frequency variability, $P(f) \propto f^{-\beta}$
  ➔ if scaling exponent β is positive, a long time memory exists (Fraedrich and Blender, 2003)
- DFA is analysed for a period of 1-15 years

Results (•) and Conclusions (➔)

1. Trend analysis

- trends of CAPE exist in most parts of the world
- regions with positive trends outnumber regions with negative trends considerably
- magnitude of trends changes with number of years used (Fig.1)
  ➔ as number of years increases, magnitude of the trend decreases
- changes of sign of trend in several regions before and after 1979
  e.g. centre of Africa: 1958-1978: -25 J/(kg*10a)
  1979-2001: 20 J/(kg*10a)
- similar in South Africa, South America and regions of the Southern Ocean
  ➔ trend of CAPE doesn't seem to develop linearly over time
- Europe: negative trend in the Mediterranean from December until February between 1958 and 2001
- neg. trend in Europe confirmed in decrease in cyclone activity by Trigo and Davies (2000)
- additional trend test on the 2 metre temperature (not shown) resembles the results of the CAPE trend analysis
  ➔ strong connection between the 2 m temperature and CAPE
  ➔ climate change respectively global warming seems to have an impact on CAPE
  ➔ further investigations into the magnitude of the detected trend and into its indicated non linear behaviour are necessary

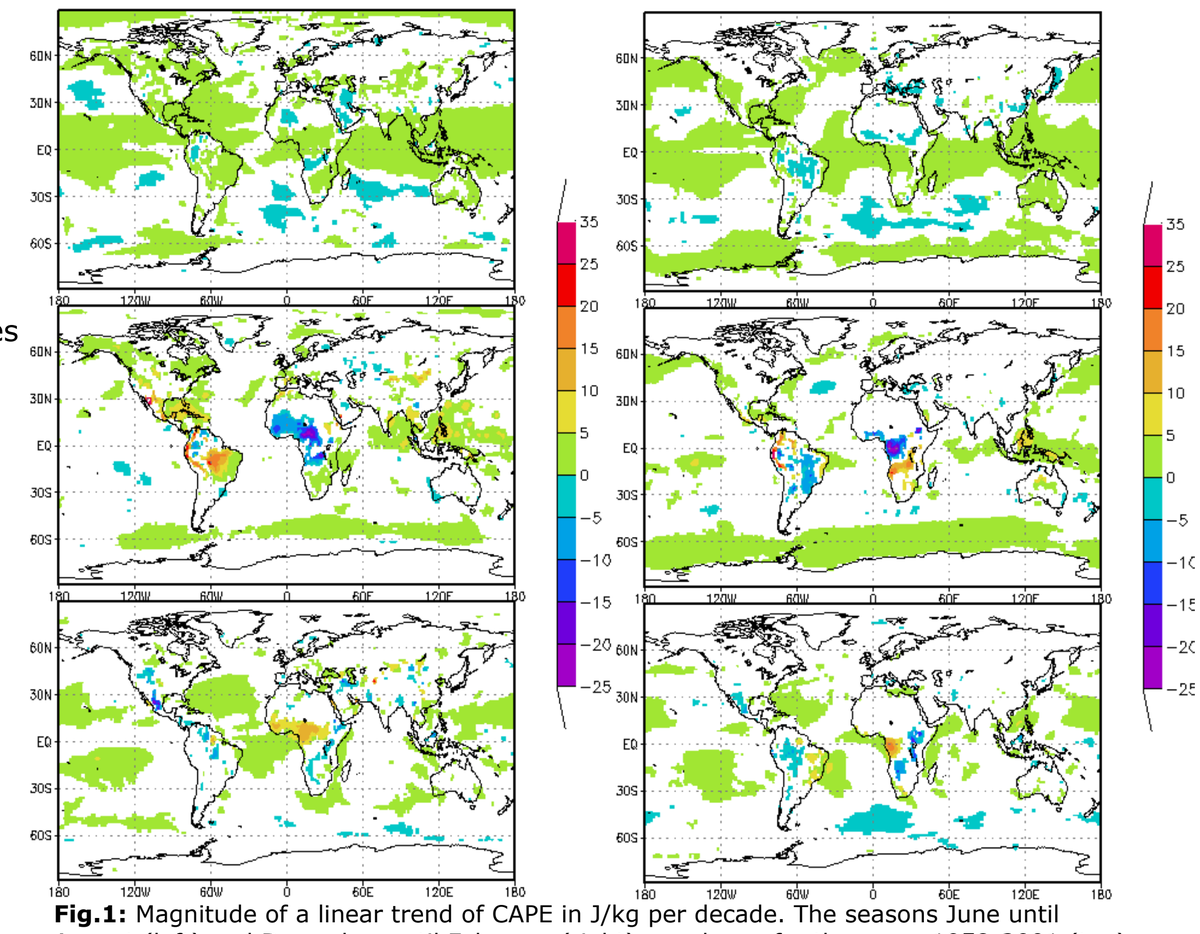

Fig.1: Magnitude of a linear trend of CAPE in J/kg per decade. The seasons June until August (left) and December until February (right) are shown for the years 1958-2001 (top), 1958-1978 (middle) and 1979-2001 (bottom).

2. DFA

- positive values of β in most regions where a trend occurs (Fig.2)
- positive values of β indicate a memory longer than 15 years
  ➔ long time memory underlies the time series of CAPE
  ➔ impact on the development and the magnitude of a trend
  ➔ further investigations into how strong the impact on the trend is are necessary

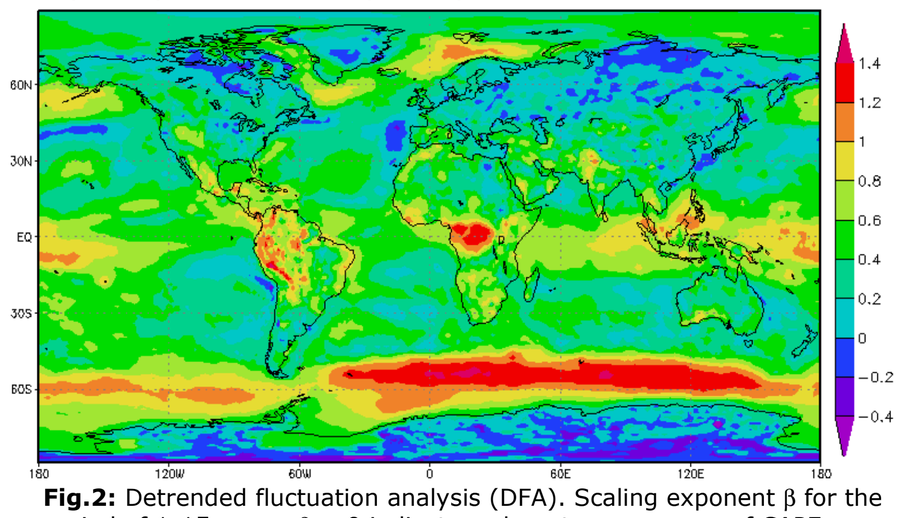

Fig.2: Detrended fluctuation analysis (DFA). Scaling exponent β for the period of 1-15 years. β > 0 indicates a long term memory of CAPE.

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Kathrin Riemann
Meteorological Institute, University of Hamburg, Bundestrasse 55, D-20146 Hamburg, Germany
since 1st of Sept. 2007: International Max Planck Research School on Earth System Modelling IMPRS-ESM,
Bundestrasse 53, D-20146 Hamburg, Germany
kathrin.riemann@zmaw.de