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Detrended Fluctuation Analysis of Precipitation Time Series

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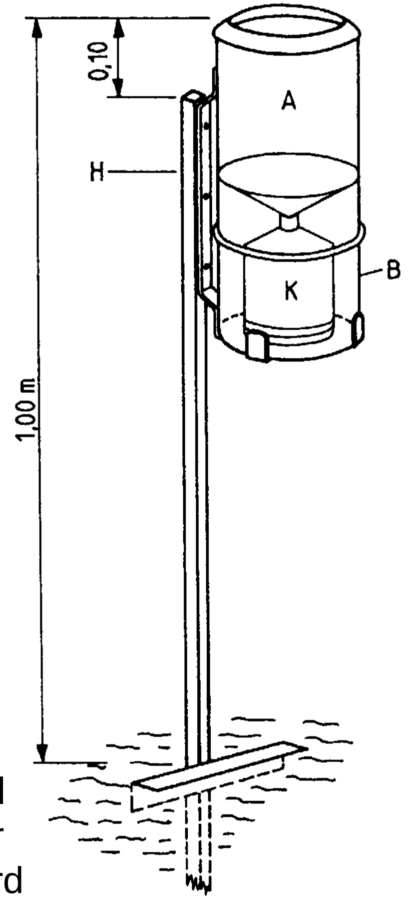
Content

Measurement



B: vessel
H: holder
K: tankard
A: collect vessel
(DWD 1986)

<u>unit:</u> [V/(S·t)]=m³/(m²·s)=m/s

<u>resolution:</u> 0.1 mm (per day)

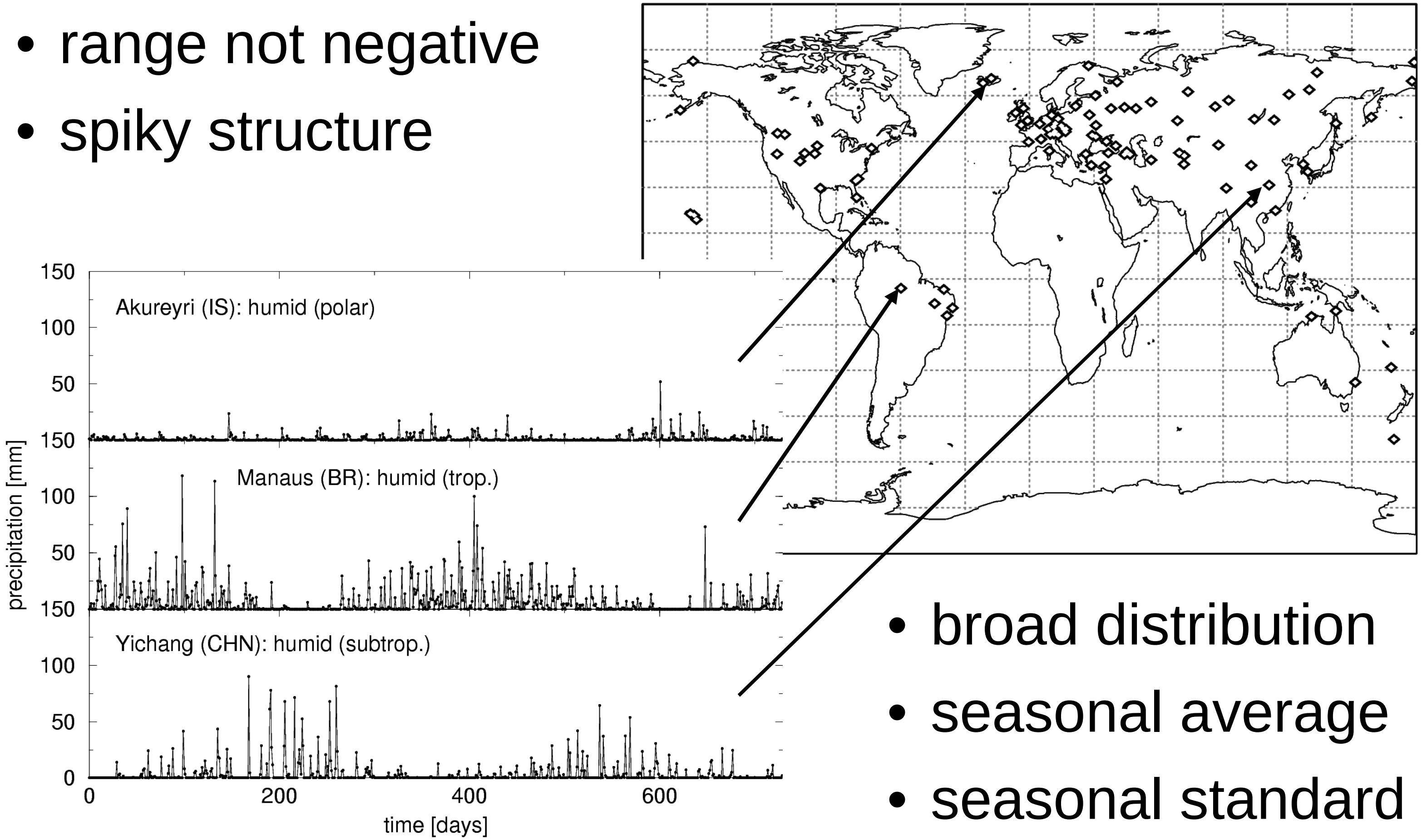
<u>problems:</u>

- moisture due to fog and clouds not registered
- strong influence of wind
- inaccuracy due to evaporation
- separate determination in case of snow and ice

$\Rightarrow$ errors up to 25%

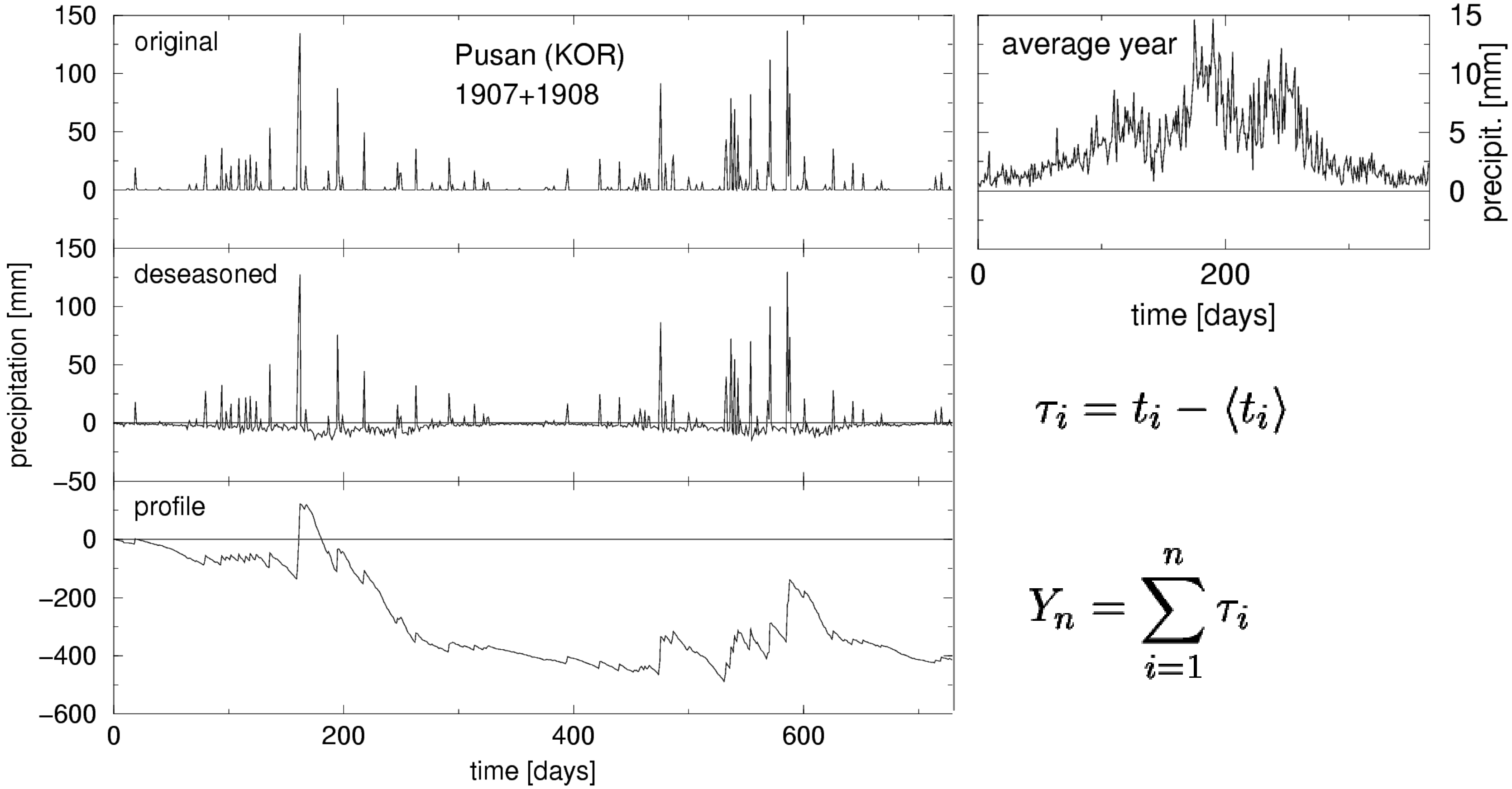
Patterns and properties

- range not negative
- spiky structure



- broad distribution
- seasonal average
- seasonal standard deviation

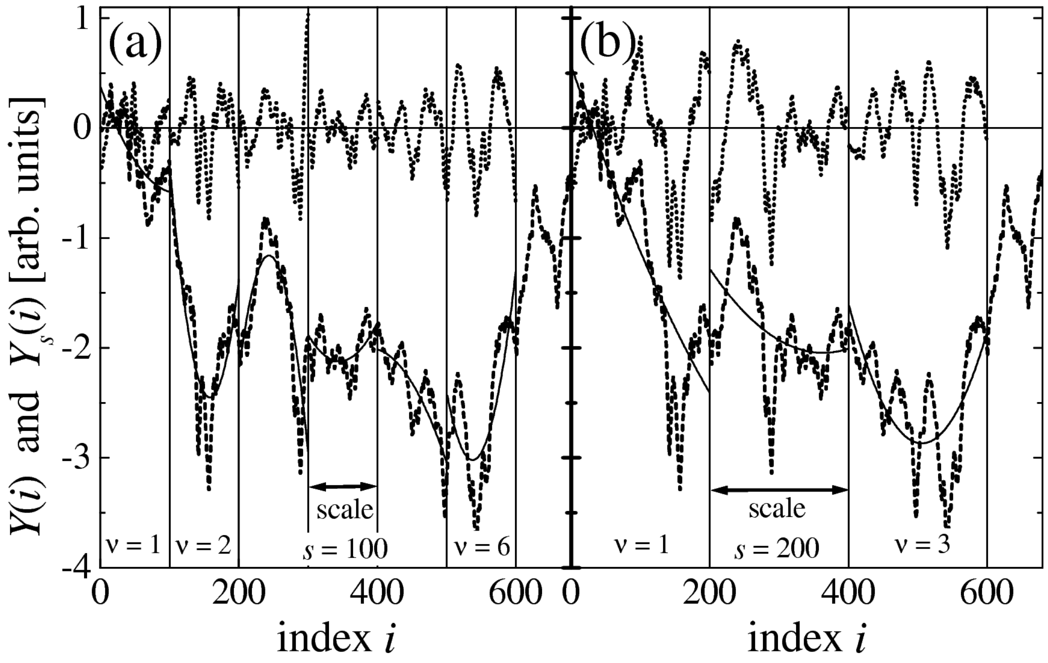
Deseasonalisation



$$\tau_i = t_i - \langle t_i \rangle$$

$$Y_n = \sum_{i=1}^{n} \tau_i$$

Detrended Fluctuation Analysis (DFA)



after: J. W. Kantelhardt et al.

1. create profile
2. segments of scale-size S
3. polynomial fit in each segment
4. calculate variance for each
5. average over all segments and square root

Detrended Fluctuation Analysis

$$Y_n = \sum_{i=1}^{n} \tau_i$$

cumulation

$$Y_i(S) = Y_i - p_\nu(i)$$

deviation to fit

$$F_\nu^2(S) = \langle Y_i^2(S) \rangle = \frac{1}{S} \sum_{i=1}^{S} [Y_{(\nu-1)\cdot S+i}(S)]^2$$

fluctuations in segment

$$F(S) = \sqrt{\frac{1}{K_S} \sum_{\nu=1}^{K_S} F_\nu^2(S)}$$

average over segments
(fluctuation function)

$$\boxed{F(S) \sim S^\alpha}$$

power law

$\alpha = 0,5$	uncorrelated
$\alpha > 0,5$	long-range corr.
$\alpha < 0,5$	anti-correlated

DFA $\leftrightarrow$ (auto-) correlation function

$$C(S) = \langle \tau_i \tau_{i+S} \rangle = \frac{1}{N-S} \sum_{i=1}^{N-S} \tau_i \tau_{i+S}$$

correlation function

$$C(S) \sim S^{-\gamma}, \qquad 0 < \gamma < 1$$

long-range correlations

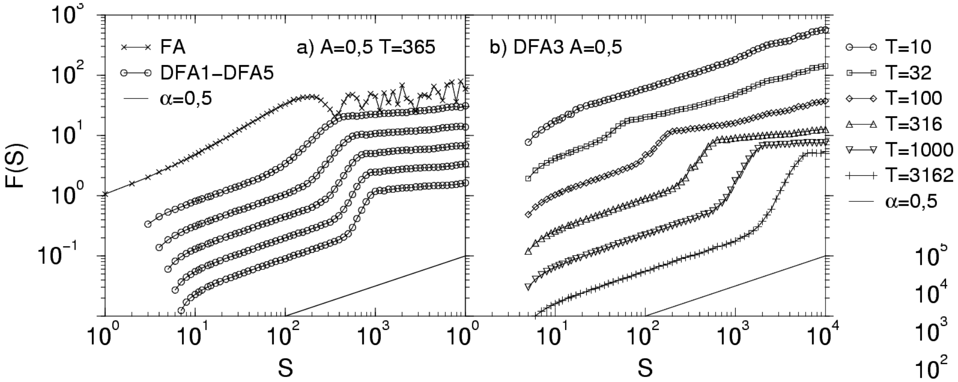
$$\boxed{\alpha = 1 - \frac{\gamma}{2}}$$

relation of exponents

$$\boxed{\alpha = \frac{1}{2}(1 + \beta)}$$

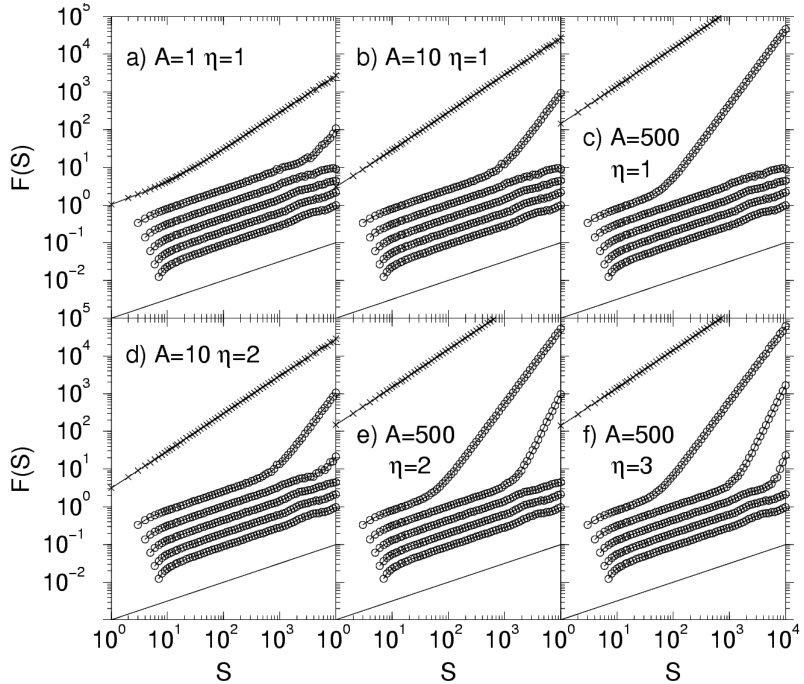
relation to exponent of power spectrum

Effects of non-stationarities on DFA

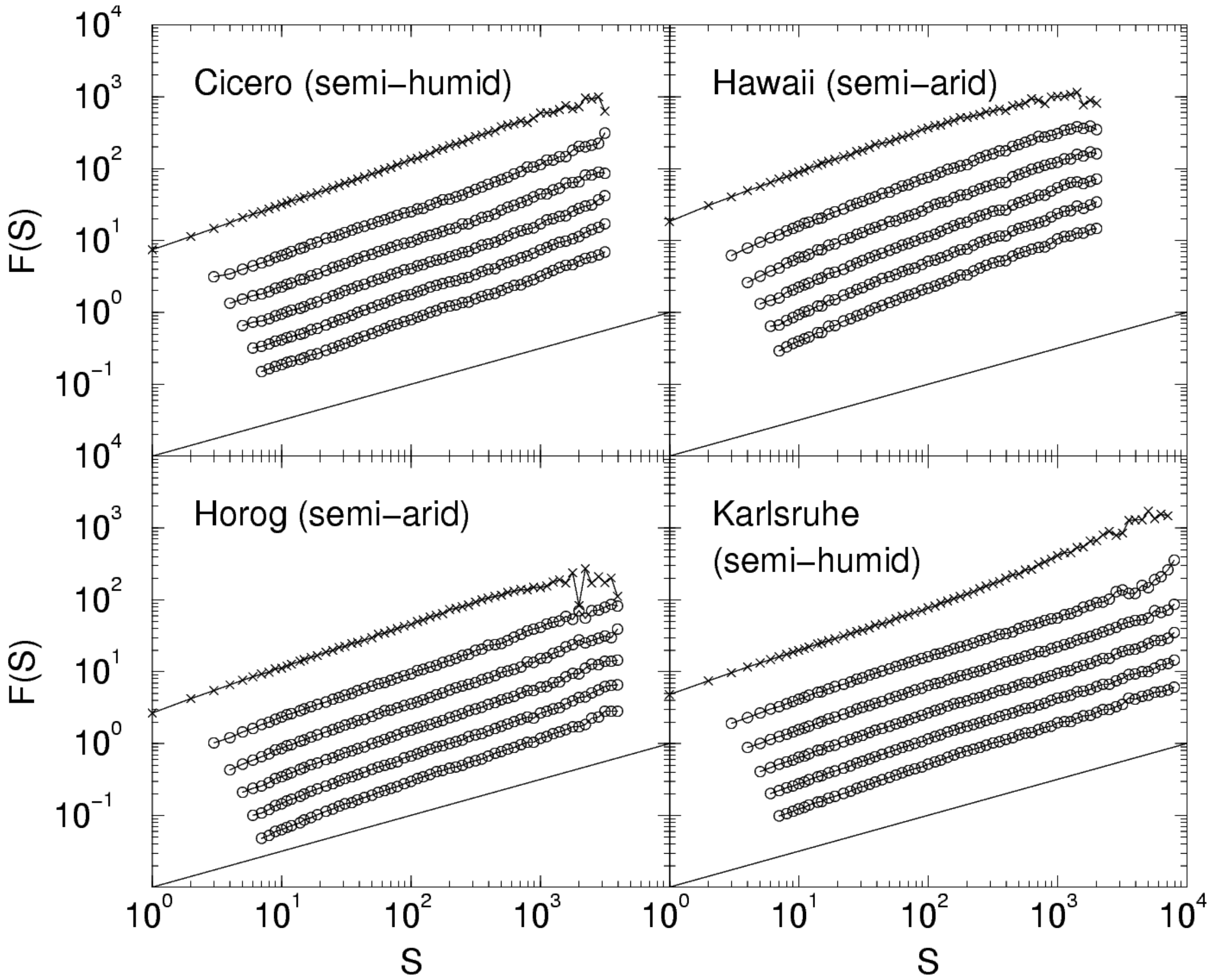


$$\hat{t}_i = t_i + A \cdot \sin\left(\frac{2\pi \cdot i}{T}\right)$$

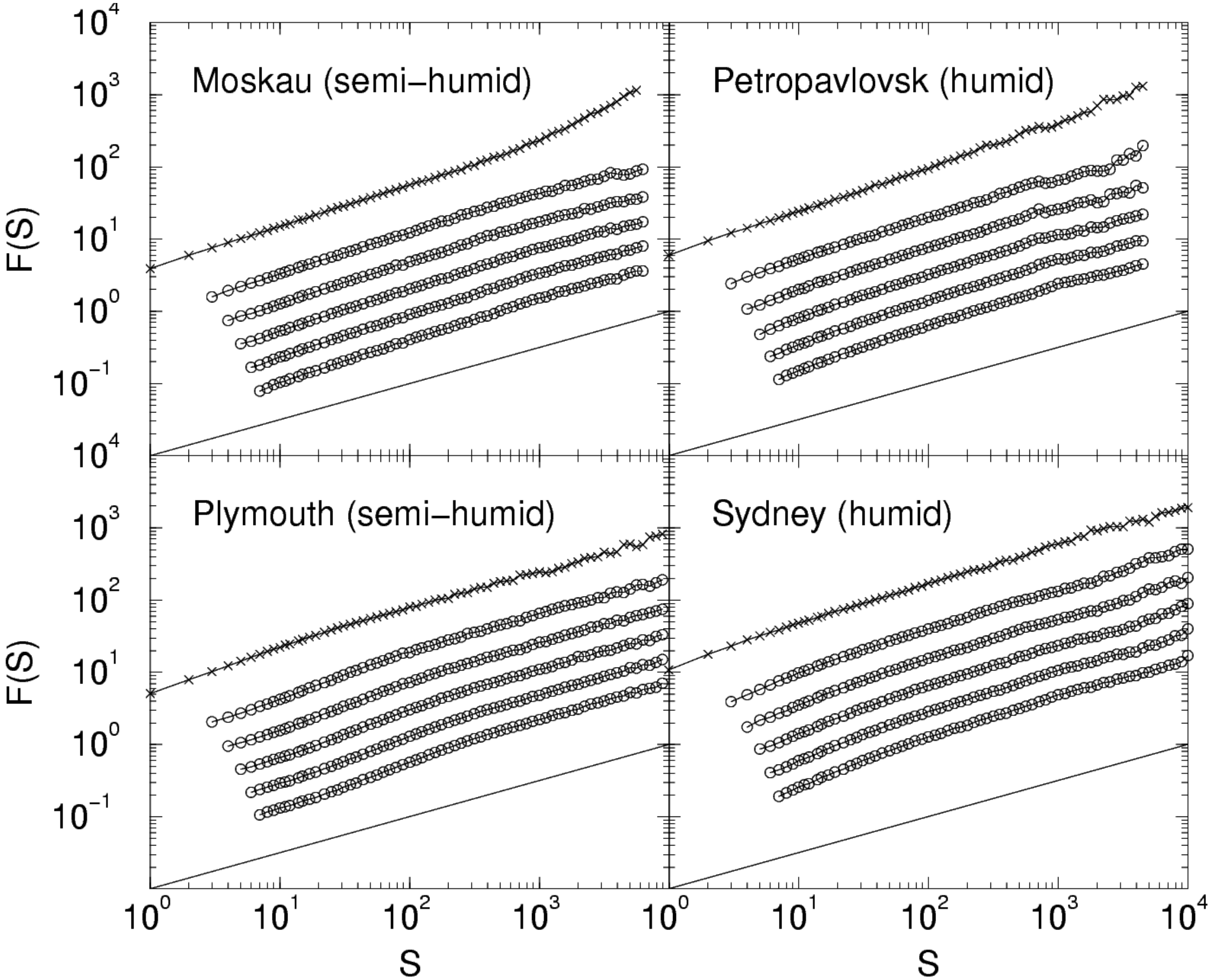
$$\hat{t}_i = t_i + A \cdot \left(\frac{i}{N}\right)^{\eta}$$



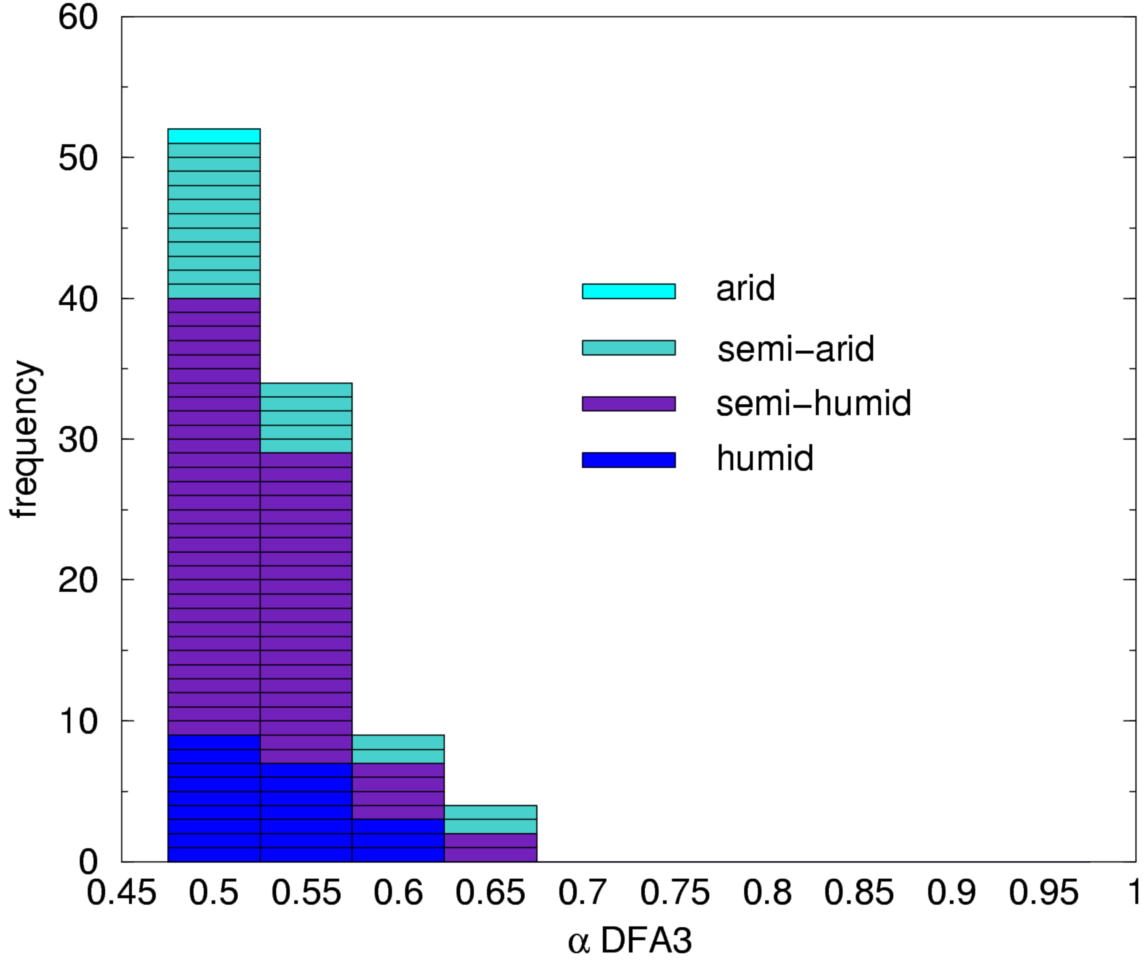
Analysis of precipitation time series



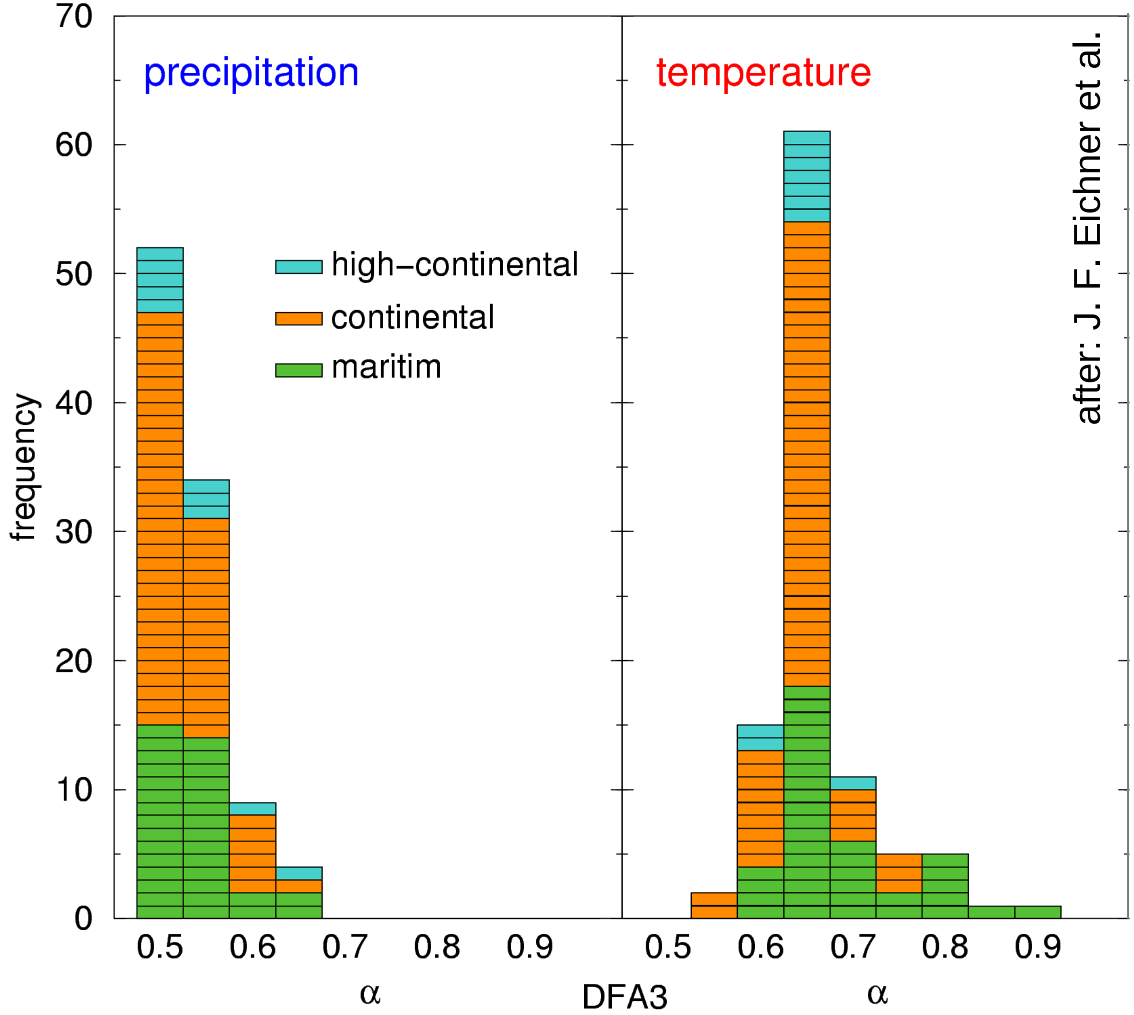
Analysis of precipitation time series



Classification in terms of water balance



Comparison to temperature analysis



classification in terms of climate region

Conclusion

- most analysed precipitation time series are just slightly correlated or uncorrelated (long-range)
- series of some sites have bigger fluctuation exponents up to 0.67 (Ipagua)
- unrelated to climate and geography
- but: in many cases short-range correlations exist

Perspectives

- Multifractal Analysis (MF-DFA)
- Fourier Phase Randomization Method (nonlinearity)
- Modelling

:^v

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