CONFERENCE BROCHURE

OF THE

20th Congress of Hungarian Geomathematicians and 9th Congress of Croatian & Hungarian Geomathematicians "Geomathematics in multidisciplinary science - The new frontier?"

2017

Organizers

Hungarian Geological Society (HGS)

Geomathematical & Informatics Section of the HGC

MTA CSFK 2ka Palæoclimate Research Group

Cluster of Applied Earth Sciences

Geomathematical Section of the Croatian Geological Society

University of Zagreb, Faculty of Mining, Geology and Petroleum Engineering

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The South Transdanubian Regional Branch of the Hungarian Geological Society

Hungarian Academy of Sciences, Geomathematical Subcommittee of Committee on Geology and the Regional Committee in Pécs

Sponsors

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Chamber of Commerce and Industry of Pécs-Baranya

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SCIENTIFIC PROGRAM

Wednesday (10.05) - **Geostatistics today –** pre-conference short course by **János Geiger** (Venue: Chamber of Commerce and Industry of Pécs-Baranya, Pécs, Majorossy I. u. 36., 7625)

10:00- **Registration**
10:30-12:00 **Course lecture**
12:00-13:00 **Lunch**
13:00-14:30 **Course lecture**
14:30-15:00 **Coffee break**
15:00-16:30 **Course lecture**

Thursday (11.05) –

09:00- **Registration**

11:00-11:30 **Opening ceremony** with speeches by**:**

Ferenc Fedor - President of the Geomathematical and Informatics Section of the Hungarian Geological Society
Tamás Síkfői - President of the Chamber of Commerce and Industry of Pécs-Baranya
Zoltán Unger - Associate President of the Hungarian Geological Society

11:30-12:00 **Opening lecture** by **János Geiger** - **Statistical Process Control in The Evaluation of Geostatistical Simulations**

12:00-13:00 **Lunch**

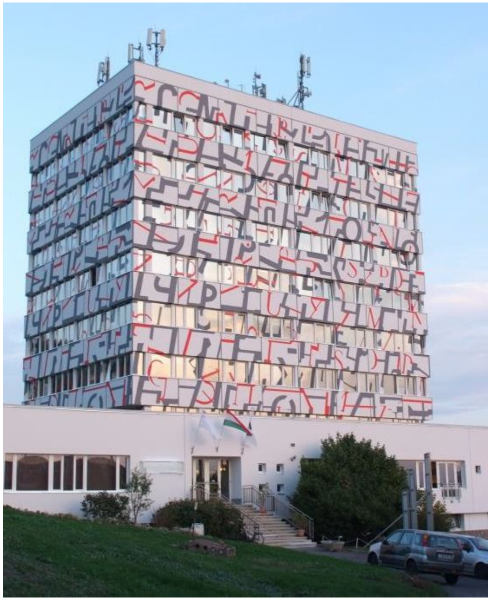
13:00-14:30 **Climate modelling past and future –** chair: István G. Hatvani

- Keynote speaker: **Gabriella Szépszó - Climate adaptation in Hungary: from the climate model outputs to the end-users**

- **Dániel Topál** Detecting breakpoints in annual $\delta^{18}O$ ice core records from North Greenland
- **Csaba Ilyés** Examination of 110 year long Rainfall Data using Spectral and Wavelet Analysis
- **Tímea Kalmár** Regional climate modelling with special focus on the precipitation-related fine scale processes
- **Péter Szabó** Sources of uncertainties in climate model results

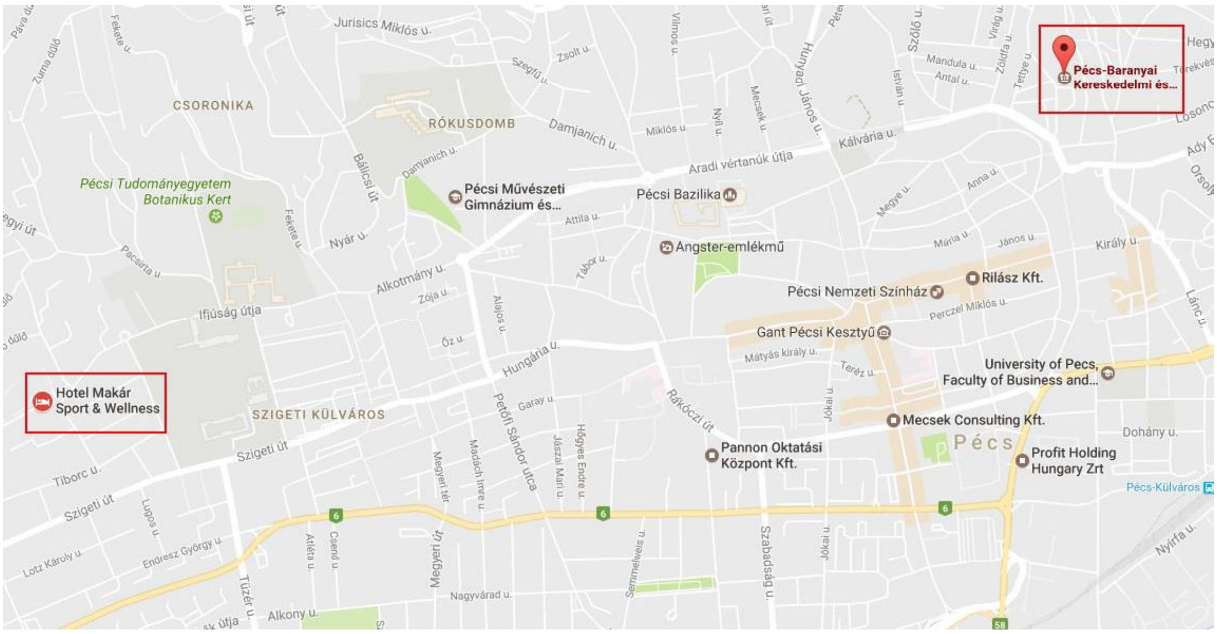
14:30-15:00 **Coffee break**

Conference venue



Hotel Makár
Pécs Középmakár dűlő 4, 7635

Chamber of Commerce and Industry of
Pécs-Baranya



EXAMINATION OF 110 YEAR LONG RAINFALL DATA USING SPECTRAL AND WAVELET ANALYSIS

Csaba Ilyés – Endre Turai – Péter Szűcs

University of Miskolc, Faculty of Earth Science and Engineering, Institute of Environmental Management

MTA-ME Research Group of Geoengineering

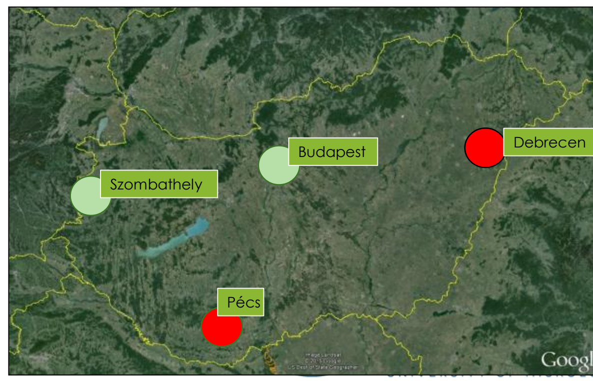
11-13 May 2017. Pécs, Hungary
20th Congress of Hungarian Geomathematicians and 9th Congress of Croatian & Hungarian Geomathematicians

INTRODUCTION

- On Earth approximately 400 000 km^3 volume of water is being transported annually in the water cycle.
- Which is affected by the changing climate and the meteorological extremities present in recent years.
- These changes in the behaviour of precipitation have an impact on the groundwater resources through the recharge, so we chose to investigate the precipitation

DATASET

- Hungarian Meteorological Service Online Database
- Cyclic properties of 110 year long data of annual and mothly rainfall
- Forecasting in Debrecen
- Wavelet-analysis from Debrecen and Pécs datasets



$$\cos(t) = \cos\left(\frac{2\pi}{2\pi}t\right) = \cos\left(\frac{2\pi}{T}t\right) = \cos\left(2\pi\frac{1}{T}t\right) = \cos(2\pi f t)$$

$$f = \left(\frac{1}{T}\right)$$

Where, *f* :frequency,
T=2*π*: period length

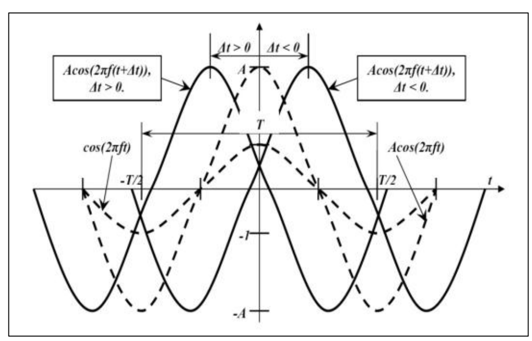
$$A * \cos(2\pi f t + \varphi)$$

Where, *A* :amplitude,
φ: phase angle

$$Re[F(f)] = \int_{-\infty}^{+\infty} f(t)\cos(2\pi f t)\,dt$$

$$Im[F(f)] = \int_{-\infty}^{+\infty} f(t)\sin(2\pi f t)\,dt$$

The real and imaginary spectrum gives the weights of the sin-cos components.



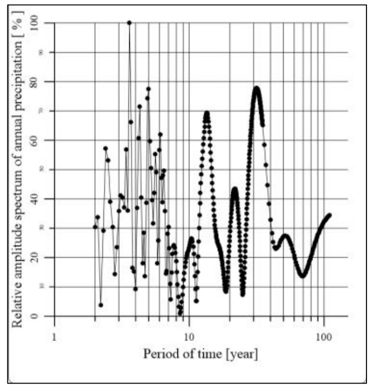
$$F(f) = A(f)e^{j\Phi(f)}$$

Fourier-spectrums based on the *cos(2πft)* and *sin(2πft)* functions.

Search for periodic components in *y(t)* precipitation functions.

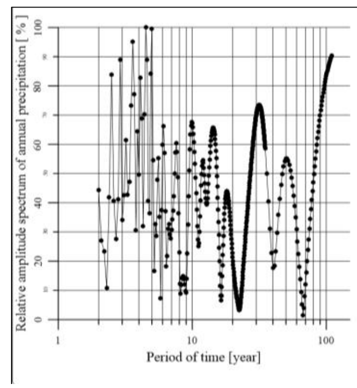
ANNUAL PRECIPITATION

- Debrecen
  - 16 cycles
  - 10 major, 6 additional
  - Most dominant: 3,6 year long
- Pécs
  - 17 cycles
  - 16 major, 1 additional
  - Most dominant: 4,5 year long
  - 2nd: 5 year long
- The annual dataset:
  - Time period: 1901-2010
  - 110 year
  - Number of samples: 110
  - Sampling rate: 1 yr



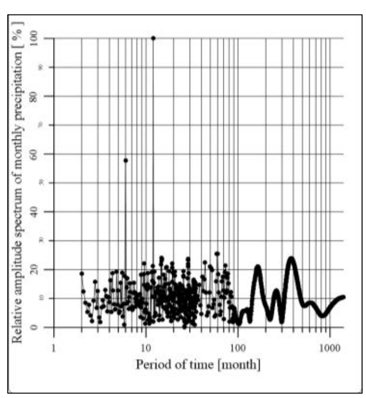
Debrecen

Pécs



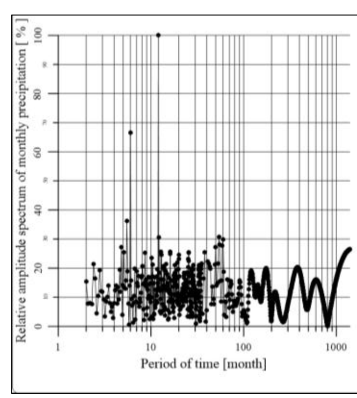
MONTHLY PRECIPITATION

- Most dominant:
  - 1 year long
  - 6 months long
- Debrecen
  - 43 cycles
  - Dominant:
    - 59, 14.7, 378 month long
- Pécs
  - 65 cycles
  - Dominant:
    - 5.5, 54, 12.2, 60 month long
- The monthly dataset:
  - Time period: Jan 1901. – Dec 2010.
  - 1320 months
  - Sampling rate: 1 month



Debrecen

Pécs



From annaul precipitation [yr]	$\frac{A(T)^{lok}_{max}}{A(T)^{abs}_{max}}$	From monthly precipitation [month]	$\frac{A(T)^{lok}_{max}}{A(T)^{abs}_{max}}$
5	80,17 %	1	94,16 %
3,5-3,6	71,25 %	0,5	61,97 %
11,8-13,5	66,11 %	4,92-5,00	28,61 %
2,8-3,1	57,27 %	1,13-1,15	23,14 %
6,1-6,3	52,36 %	1,2-1,21	23,08 %
4,5-4,6	47,36 %	3,42-3,67	22,83 %
7,5-7,8	38,79 %	0,4-0,43	22,76 %
		2,36-2,39	21,85 %
		4,17-4,50	20,88 %
		11,75-13,67	19,34 %
		2,8-3,17	17,35 %
		6,08-6,25	15,21 %
		7,58-7,67	10,56 %

ACROSS HUNGARY

- Budapest
- Debrecen
- Pécs
- Szombathely

- 7 cycles from annual
- 13 cycles from monthly

FORECASTING - THEORETICS

- With the *A(f)* amplitude spectra and the *Φ(f)* phase spectra, the original measured data can be recalculated:

$$y(t) = \bar{Y} + \int_0^{+f_N} A(f) e^{j[2\pi f t + \Phi(f)]} df$$

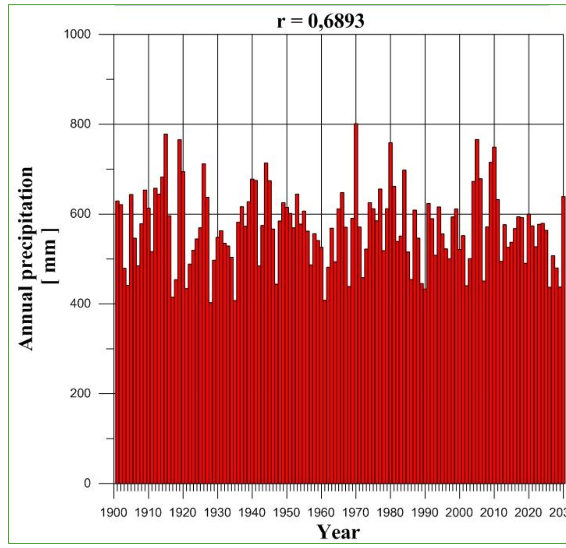
- With the major and minor cycles, and their period of time, amplitude and phase spectra values, the deterministic precipitation time series can be calculated:

$$y(t)^{det} = \bar{Y} + \frac{2}{T_{reg}} \sum_{i=1}^{18} A_i \cos\left[\frac{2\pi}{T_i}(t - 1901) + \Phi(T_i)\right]$$

FORECASTING

- 10 fmajor cycles
- R=0,6893
  - Medium correlation

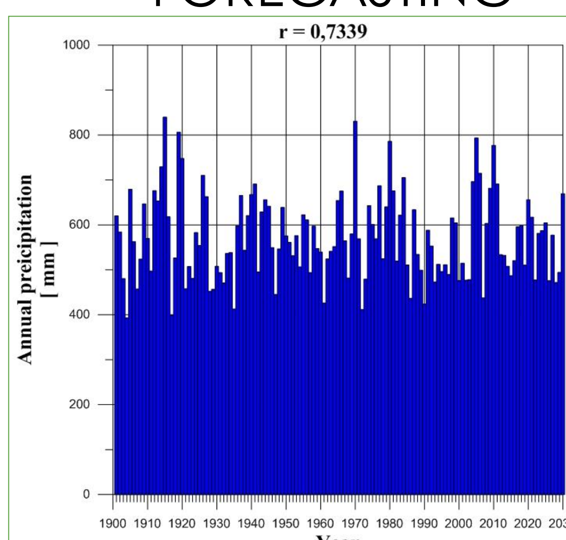
Year	Annual prec.
2011	632,2241
2012	494,7366
2013	576,3424
2014	526,2386
2015	537,4061
2016	567,6647
2017	594,0211
2018	592,067
2019	490,4126
2020	599,6852
2021	573,7112
2022	527,4424
2023	577,0714
2024	579,3427
2025	563,8536
2026	437,2421
2027	507,218
2028	480,0853
2029	437,4212
2030	638,9421



FORECASTING

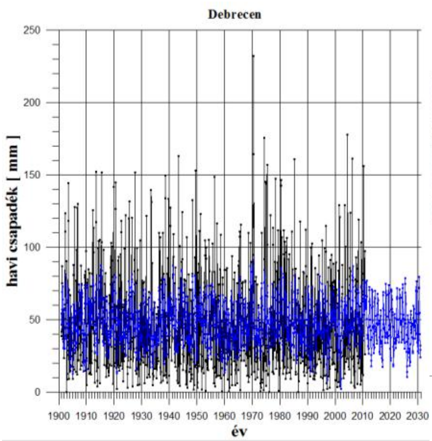
- All 18 cycles
- R=0,7339
  - Storng correlation

Year	Annual prec.
2011	690,8934
2012	534,0055
2013	532,3459
2014	507,6688
2015	486,8898
2016	520,2941
2017	595,7828
2018	598,6286
2019	510,3985
2020	656,009
2021	617,2546
2022	477,5907
2023	581,1527
2024	587,3426
2025	604,5649
2026	475,6356
2027	577,1597
2028	471,7733
2029	494,1645
2030	669,1239

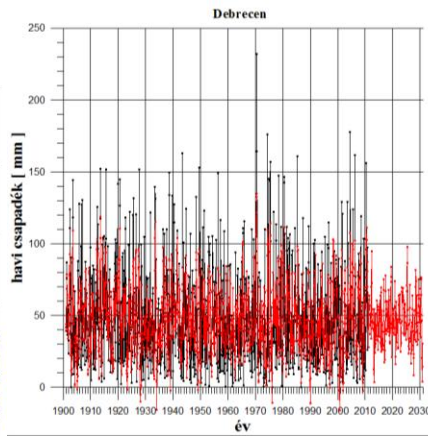


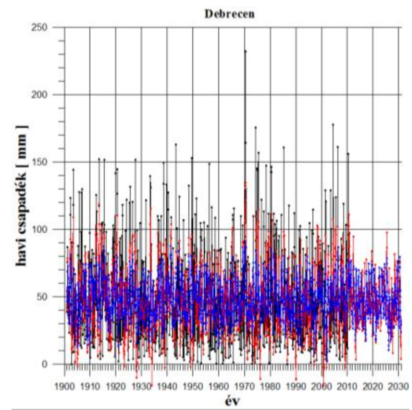
FORECASTING

15 cycles
R=0,4735



164 cycles
R=0,6237



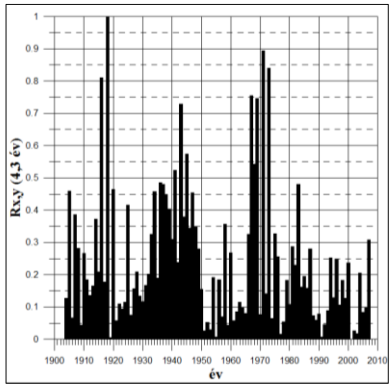


WAVELET ANALYSIS

- Wavelet time series analysis is a well-known method to investigate the time-dependence of a cycle within a time series.
- The periodic components from the previous examinations were used for this analysis.
- The wave packet used for the calculation was a 1 year long period of time sine wave.

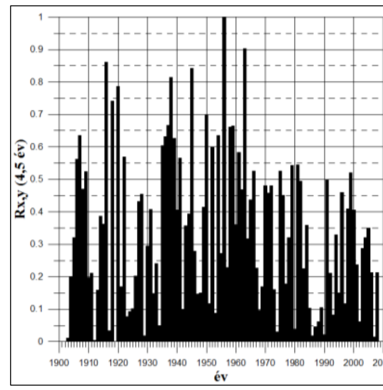
WAVELET ANALYSIS

- Local Maximum:
  - Debrecen
    - 1956, 1963, 1916, 1945 and 1938
  - Pécs
    - 1918, 1971, 1973 and 1916
- Local Minimums:
  - 1910's, 30's and in the 70's

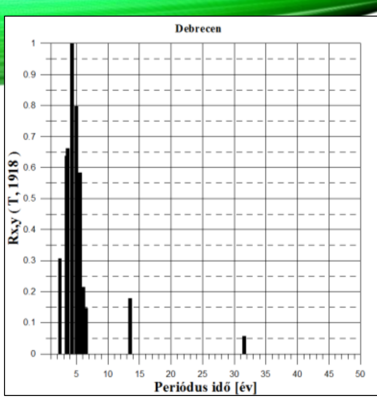


Debrecen

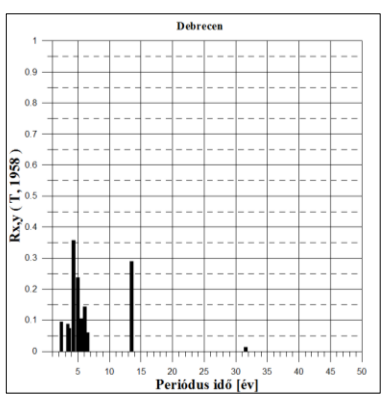
Pécs

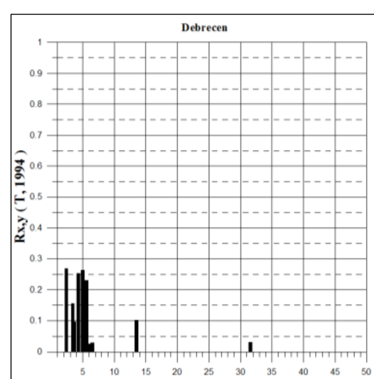


WAVELET ANALYSIS



Time-dependence in Debrecen Hungary





CONCLUSIONS

- Several cycles calculated from long-term rainfall timeseries'
- Both locally and country-wide
- From these cycles forecasting can be calculated
- Future:
  - Connection with the shallow groundwater.
  - Calculating the time lag between rainfall cycles and groundwater.

ACKNOWLEDGEMENTS

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THANK YOU FOR YOUR ATTENTION!