The hydrological aspects of sustainable development

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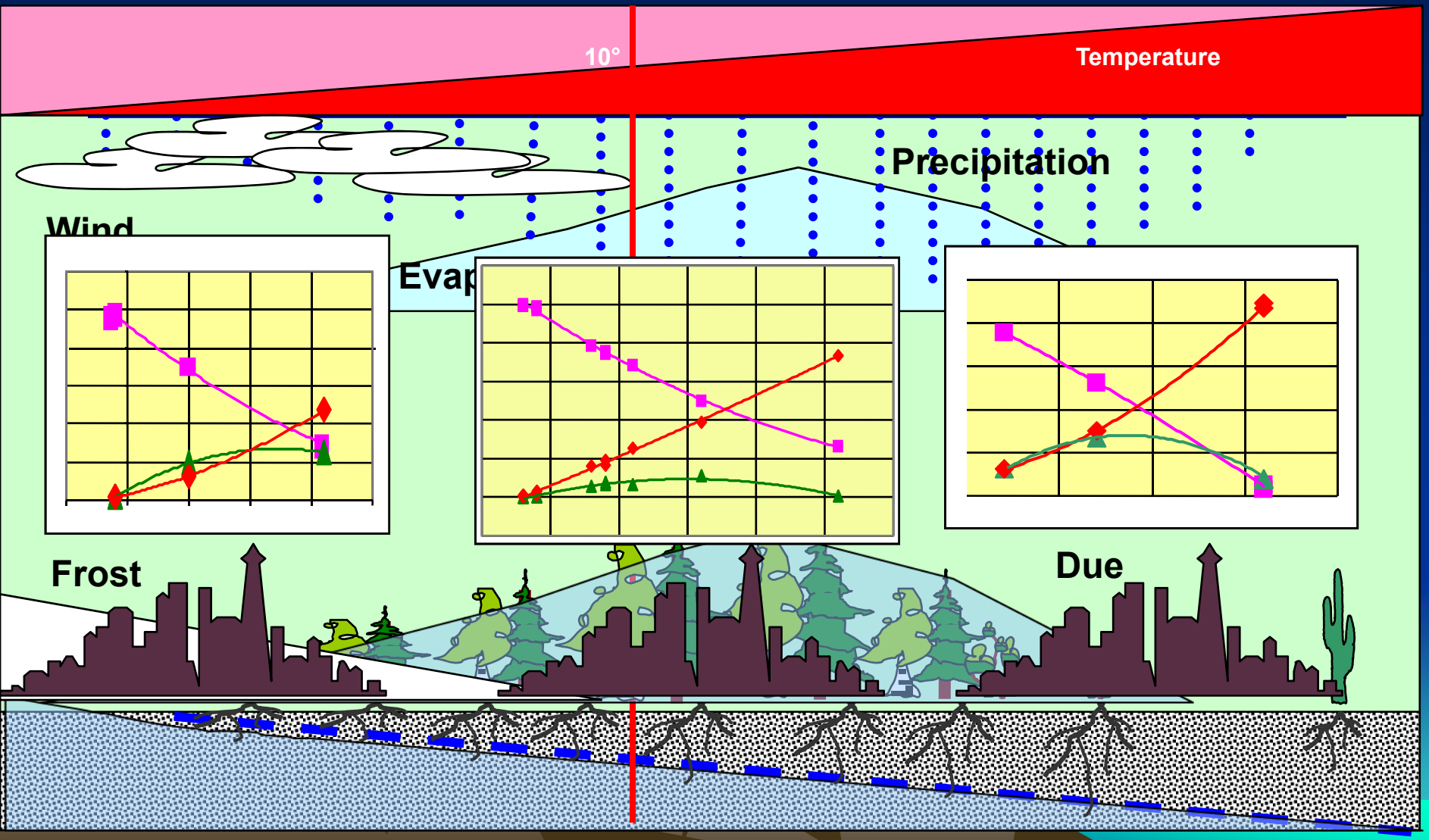
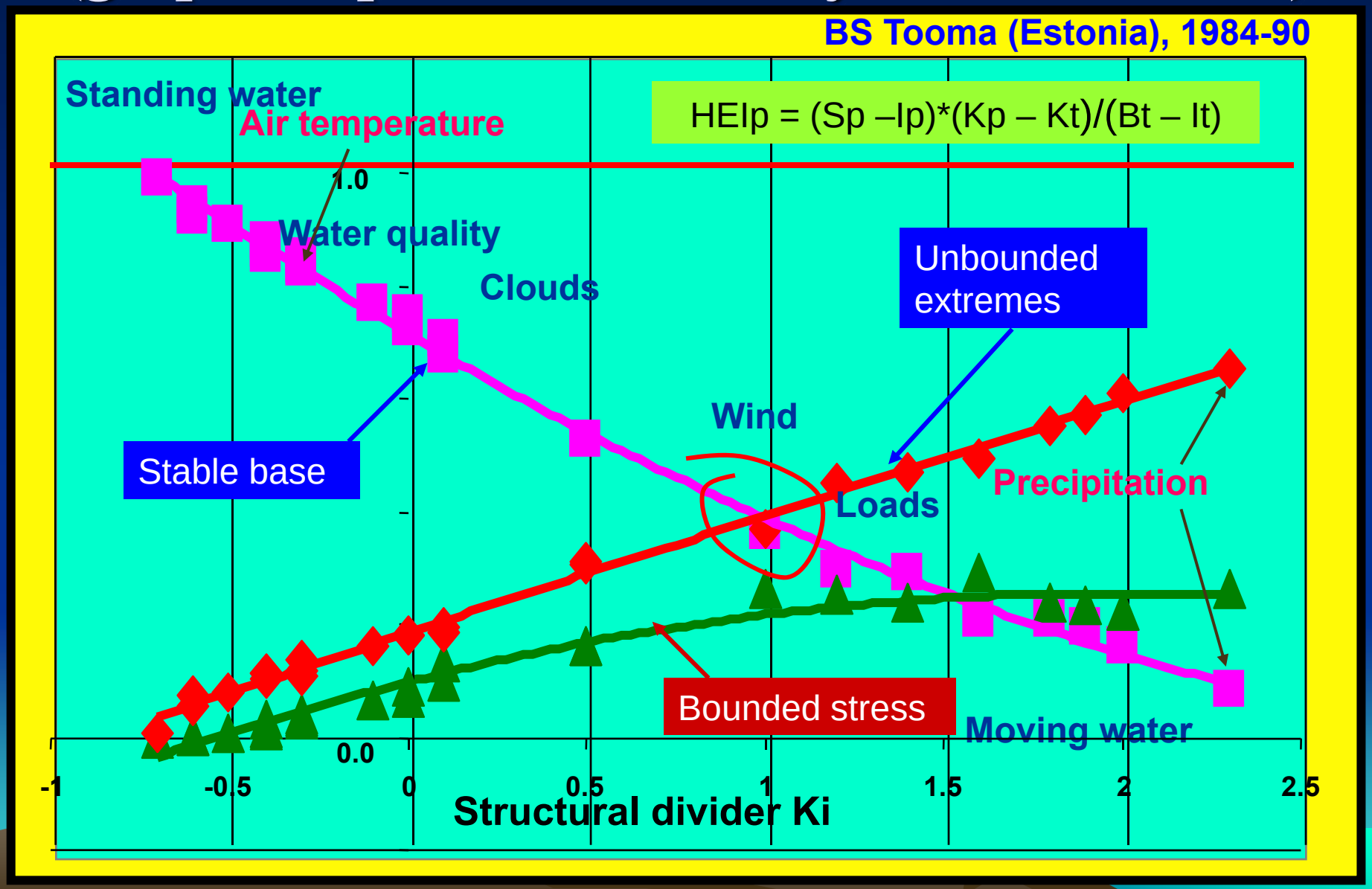
Objective

- To introduce the concept and its features of a new hydrological method of the environmental assessment: **the Harmonised Frequencies Analysis™ (HFA)**
- To highlight its contribution to sustainable development:
  - The technical solution for indivisibility of hydrosphere as a self-organised dynamic system (universal, scale-invariant, simple…)

The concept: Indivisibility of hydrosphere



Structural Harmony Chart of Hydrosphere™ (graphical performance of dynamic structure)



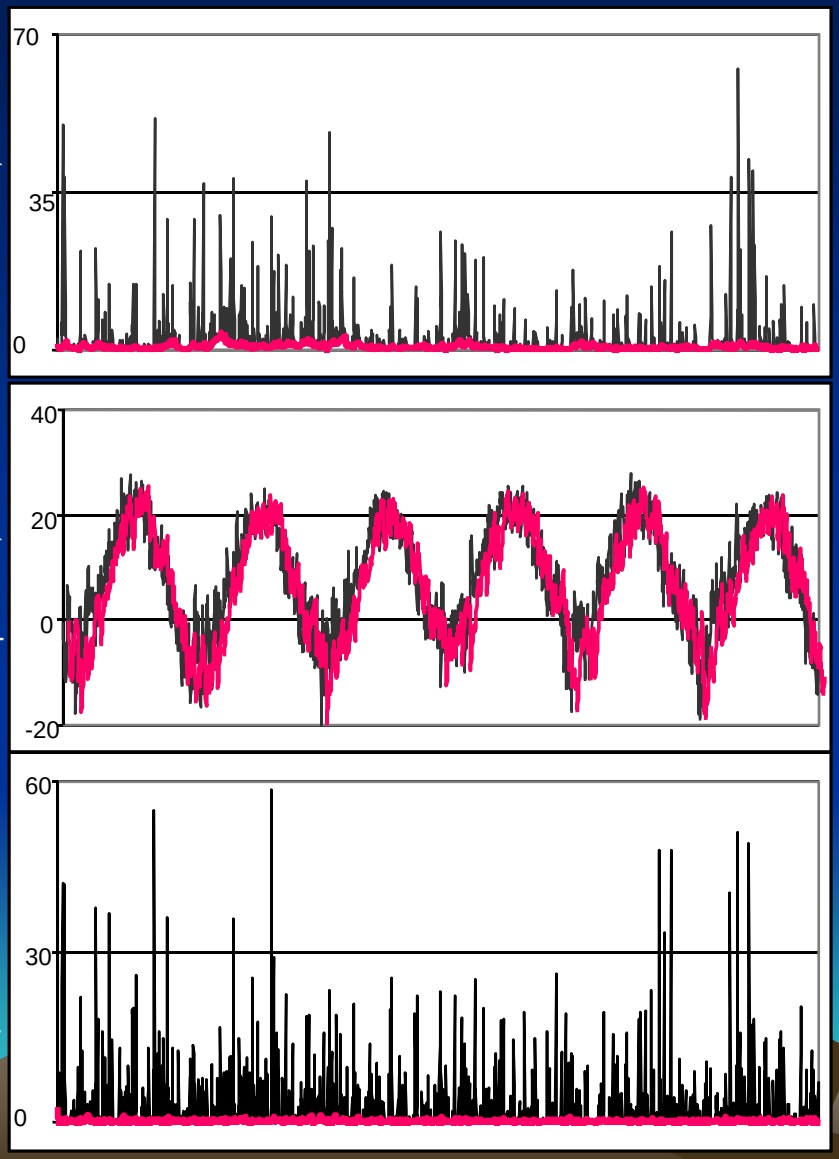
Structural Harmony Chart of Hydrosphere™ (numerical performance)

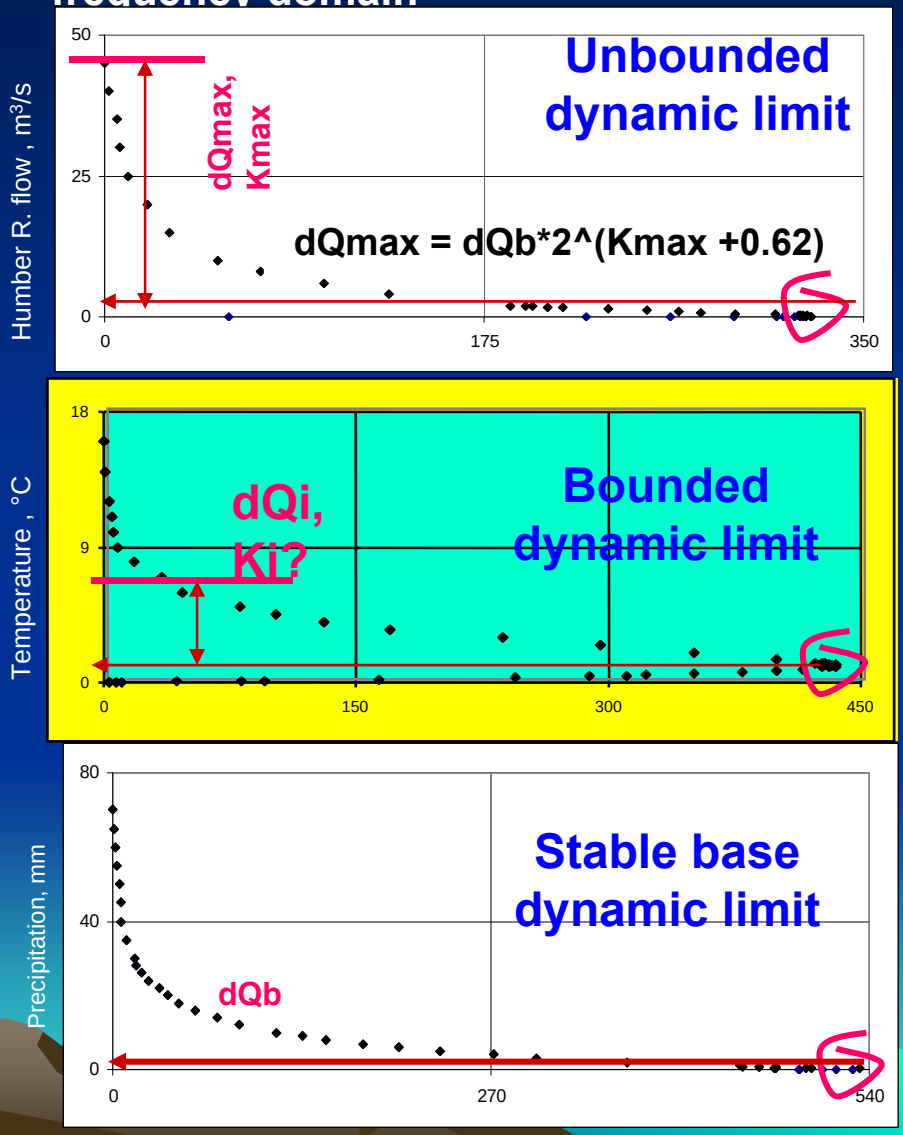
Pearson Airport and surroundings, 2006, daily resolution

Parameter	dQb	N	Kmax	Ki	Monthly amplitude			HEI	Correlation analysis with chlorides			
					Base	Inter	Storm		Ranged averages		Ranged ABS averages	
Temperature, °C	1.09	59	2.0	0	0.73	0.15	0.12		0.093	Precipitation T	0.267	Wind T
Dew Point, °C	1.84	60	1.6	-0.4	0.90	0.03	0.07	0.03	0.091	Humidity T	0.266	PM2.5 T
Stn Pressure (kPa)	0.19	59	2.7	0.1	0.73	0.08	0.19	0.02	0.091	Precipitation I	0.259	Temp T
Visibility (km)	2.49	59	1.5	-0.62	0.99	0.00	0.01	0.01	0.089	PM2.5 T	0.255	Wind direction T
Wind Direction (10's deg)	1.50	69	3.1	0.3	0.65	0.16	0.19	0.02	0.084	Precipitation S	0.254	Pm2.5 B
Relative Humidity (%)	4.86	71	2.4	-0.1	0.80	0.05	0.15	0.02	0.082	Precipitation B	0.239	Humidity I
Precipitation, mm	0.1	84	8.0	3.2	0.02	0.14	0.84	3.8	0.080	Snow T	0.234	Precipitation B
Wind Speed (m/s)	0.48	80	3.1	1	0.47	0.19	0.33	0.27	0.076	PM2.5 S	0.234	Temp B
Snow, cm	0.49	17	2.5	-0.3	0.86	0.02	0.12	0.06	0.071	PM2.5 B	0.234	Pressure T
AQI, units	2.30	89	2.8	0.5	0.59	0.23	0.18	-0.02	0.068	Snow S	0.224	Etobicoke level T
NO, ppb	1.10	83	5.2	1.9	0.21	0.31	0.48	0.54	0.067	Etobicoke level T	0.219	Precipitation I
NO2, ppb	2.30	75	2.8	0.3	0.58	0.17	0.25	0.03	0.067	Etobicoke level S	0.219	Precipitation T
Nox, ppb	4.50	79	3.1	0.9	0.44	0.24	0.32	0.08	0.063	Humidity I	0.219	Etobicoke level B
O3, ppb	1.80	73	3.5	0.8	0.52	0.26	0.22	0.01	0.063	Humidity B	0.218	Pressure B
PM 2.5, µg/m³	1.80	76	2.2	0.6	0.55	0.23	0.22	-0.04	0.061	PM2.5 I	0.214	Wind I
Humber R., level	0.017	39	4.2	1.7	0.27	0.30	0.43	0.45	0.057	Wind I	0.211	Wind B
Humber R., flow	0.559	38	5.7	2.4	0.12	0.27	0.61	1.40	0.056	Humidity S	0.204	PM2.5 I
Mimico Cr., level	0.006	51	5.5	2.4	0.13	0.28	0.59	1.30	0.056	Wind T	0.201	Pressure S
Mimico Cr., flow	0.019	49	9.0	3.4	0.02	0.09	0.89	4.65	0.055	Temp I	0.198	Precipitation S
Etobicoke 2, level	0.011	42	5.5	2	0.18	0.28	0.54	0.91	0.052	Etobicoke Level I	0.198	Humidity S
Etobicoke 2, flow	0.039	42	7.9	3	0.05	0.17	0.78	3.13	0.047	Wind direction S	0.194	Wind direction S
Etobicoke Cr. level, m	0.013	48	4.8	1.9	0.22	0.28	0.49	0.68	0.046	Snow I	0.192	Humidity I
Etobicoke Cr., flow	0.170	46	7.2	3	0.05	0.21	0.74	2.76	0.043	Wind direction T	0.189	Cl Etobicoke B
Chlorides conc, mg/l	30.0	87	3.9	2.5	0.14	0.20	0.66	0.87	0.042	Wind S	0.185	Wind direction B
Chlorides load, t	2.00	112	9.2	3.6	0.00	0.02	0.97	5.56	0.041	Wind direction I	0.184	Wind S
Copper conc, mcg/L	0.36	185	7.0	2.8	0.10	0.15	0.75	3.41	0.036	Temp S	0.181	Humidity B
Copper loads, kg	0.00006	136	7.2	3.5	0.02	0.07	0.92	4.65	0.034	Cl Etobicoke I	0.180	Pressure I
TDS conc, mg/l	56.0	86	3.1	2	0.30	0.16	0.54	0.11	0.033	Cl Etobicoke T	0.179	Etobicoke level I
TDS load, ton	4.70	123	5.8	3.5	0.01	0.04	0.95	4.31	0.032	Cl Etobicoke S	0.179	Etobicoke level S
Turbidity, formazin	0.69	157	7.1	2.8	0.07	0.20	0.73	1.99	0.019	Snow B	0.178	Wind direction I
Turbidity load, ton	0.095	125	9.2	3.6	0.01	0.06	0.93	5.91	0.018	Wind B	0.167	Snow I

Simplicity: the SimpleBase Delineation Model™

Variables in time domain, daily scale → **Positive daily changes (dQ) distribution in frequency domain**





HFA: 3 types of frequency distributions

Chloride's loads, daily

Humber R. flow, daily

Direction of maximal wind gust, daily

Chloride' loads, monthly

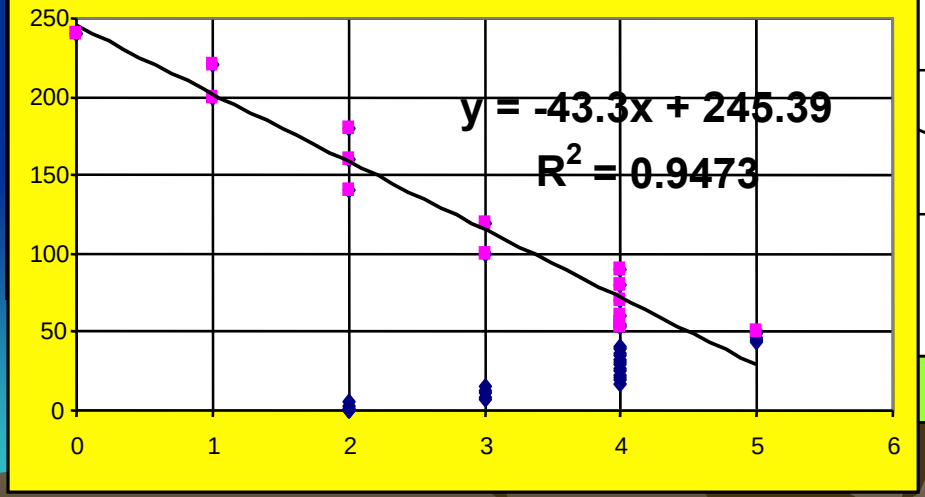
Wind direction, monthly

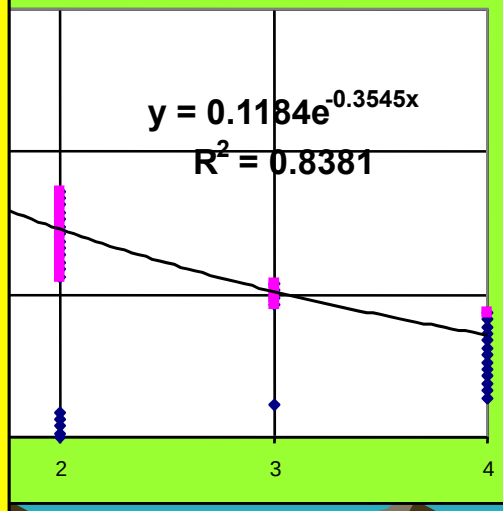
Average air temperature, monthly

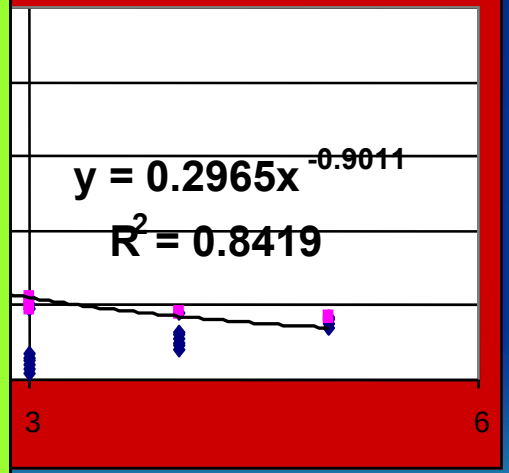
Lake level, yearly

Air pressure, yearly

Precipitation, yearly



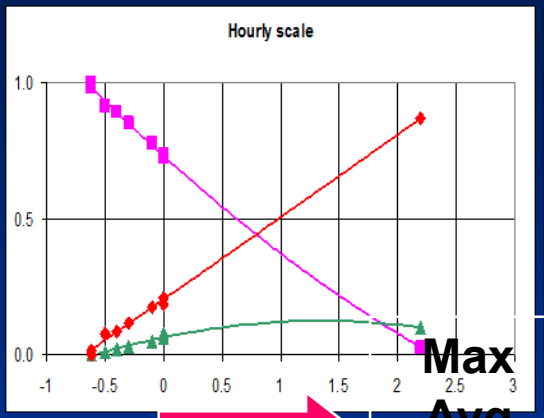


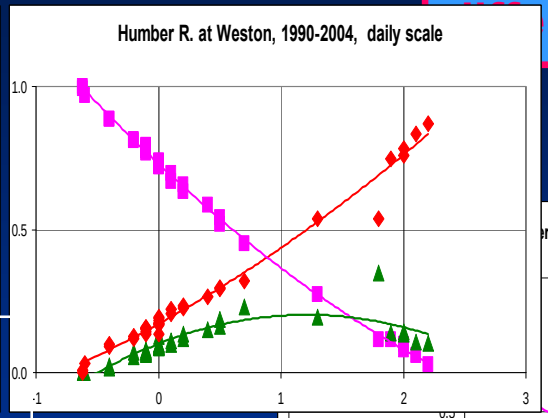


Scale invariance, universality

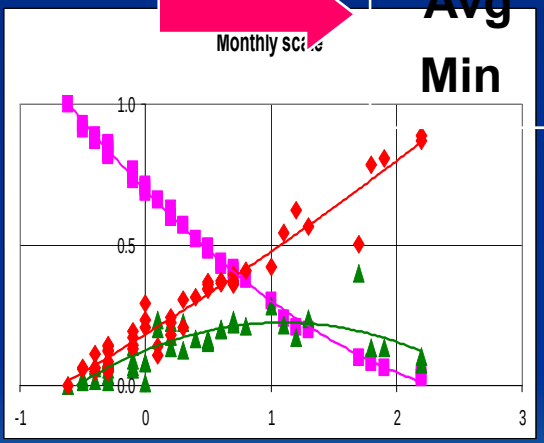
Time-scale invariance

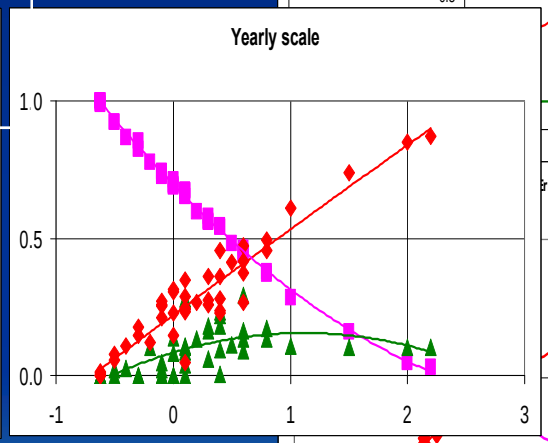
The same time resolution: daily, at
rent locations and space scales

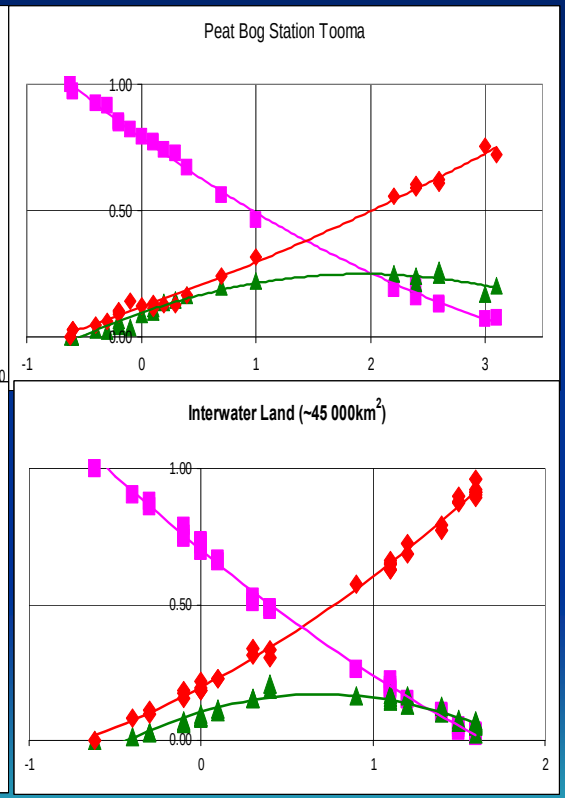




Max
Avg
Min







The same spacetime: Toronto GTA for the periods of 1990-2004 **hourly, daily, monthly, yearly**

Space scaling for daily resolution
(point, area of 25 km², watershed of 795 km², area of ~ 45 000 km²)

Accuracy

The model for 7Q2 predicting based on 38 stations of Southern Ontario:**

$$7Q2 = 3.08*10^{-2}\ Area^{0.95}\ BFI^{3.88} \quad (1)$$

BFINDEX: R^2 = 90%; 3 stations are excluded
SimpleBase: R^2 = 92%; no station is excluded

A new equation of 7Q2 estimation for the whole area was developed based on the SimpleBase Delineation Model parameters:

$$7Q2 = 37*10^{-5}*Area^{0.91}*BFI^{2.65}*Kmax^{0.29}*Nd^{0.92} \quad (2)$$

R^2 = 96%; no station excluded

Where

- **Kmax** – maximal structural divider (amplitude);
- **Nd** - frequency of baseflow fluctuation

*"Regional Low Flow Frequency Relations for Central Ontario" by Robert K. McLean and W. Edgar Watt, Canadian Water Resources Journal, Vol. 30, No 3, 2005

Summaries

- HFA, being the universal, scale-invariant, simple and accurate hydrological method of the environmental assessment based on indivisibility and self-organization of the hydrosphere dynamic structure, is the perfect controlling and governing tool for sustainable development at any scale.

Thank you!

Let's discuss it!