Functionality of the water cycle and its variables

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Functionality and sustainability

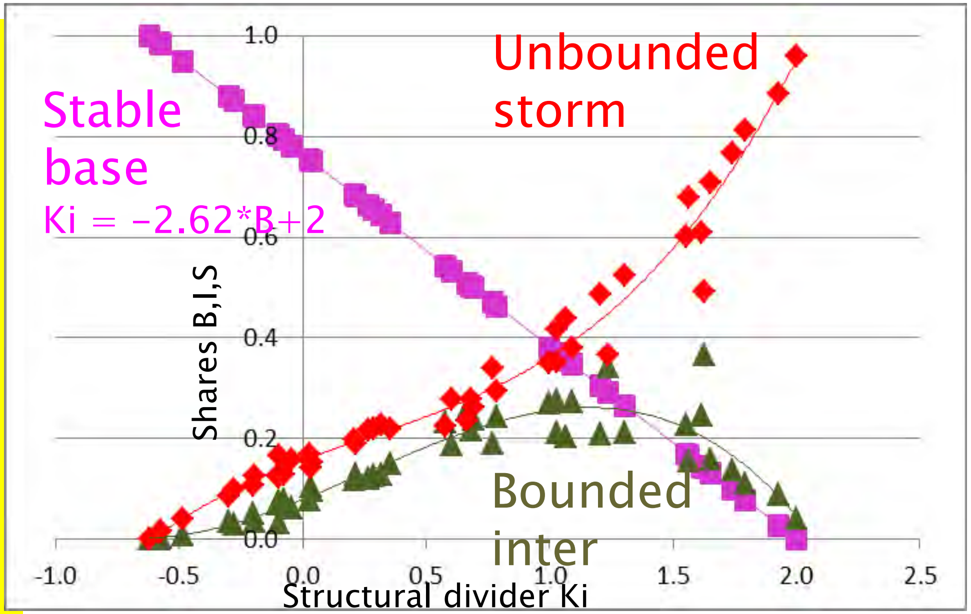
- The hypothesis is:
- the function of the water cycle is to support the life sustaining temperature regime and harmony between life destruction and creation. Thus, sustainability of the water cycle is its functional stability.
- How to differentiate and express mathematically the individual functions of the elements and variables from the entire water cycle? destructive and creative functions of the same variable under different conditions?

Method: the Harmonized Frequencies Analysis (HFA)

http://library.witpress.com/pages/PaperInfo.asp?PaperID=22080

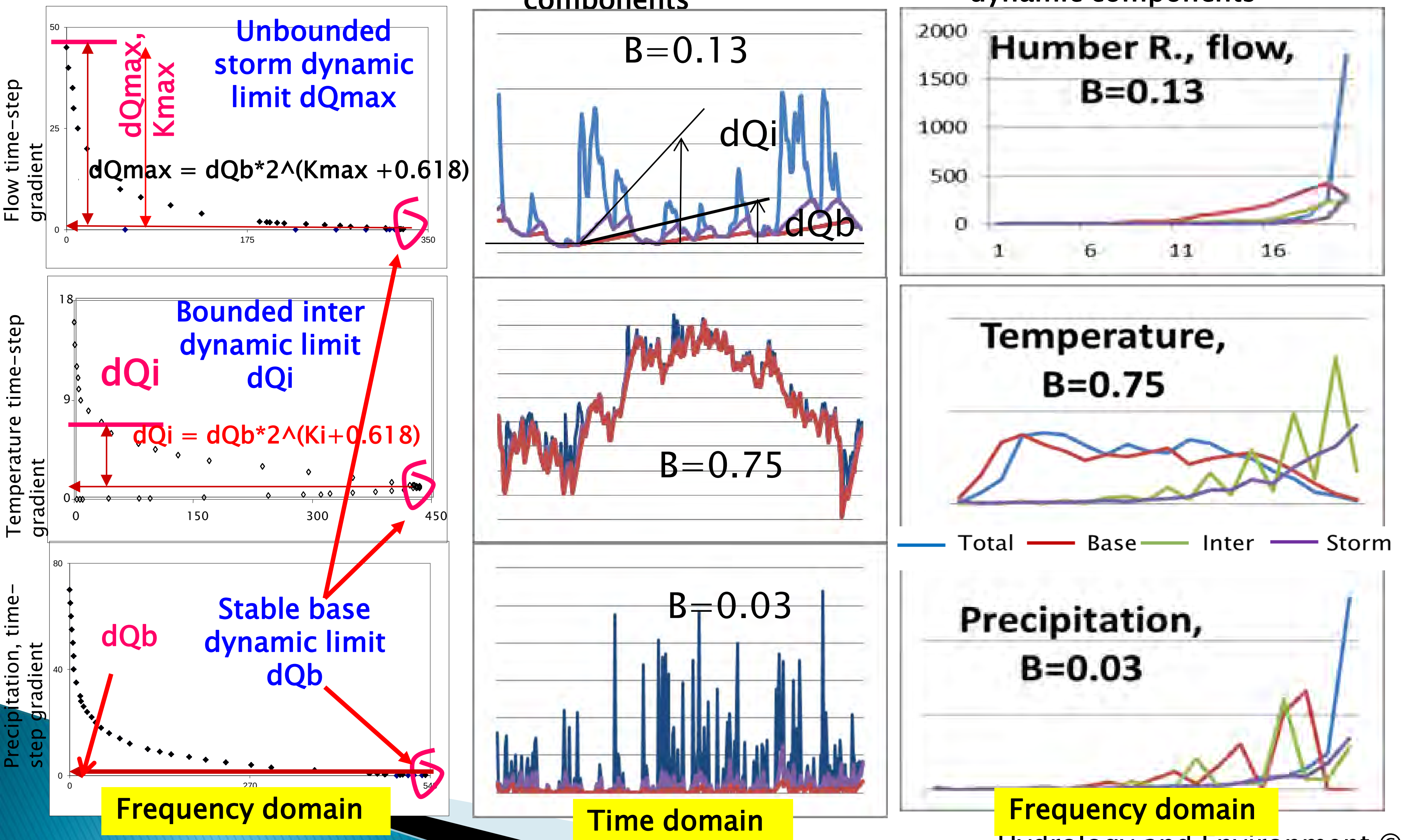
1. HFA is a system analysis where each variable is considered as a signal in the frame of the entire dynamic system of water
2. Each signal has combined sources, which can be separated based on different frequencies of the sources, their continuity and incompressibility of water
3. The relative dynamic components of each signal represent the statistically stable continual base component (B), the buffering temporary inter component (I), and destructive storm component (S): B+I+S=1(1- the **average monthly amplitude/range** of each variable for the considered time period)

4. The universal dynamic structure of each variable and the entire water cycle of a certain time-space is represented by the Structural Harmony Chart (SHC)
5. The right wing tip of the graph (Ki>1.5, S>0.6, B<0.2) mainly represents the variables with destructive function; the left wing tip (Ki <0, B>0.75) mostly manifests their self-stabilizing functionality; all variables lying in between largely signify the buffering function

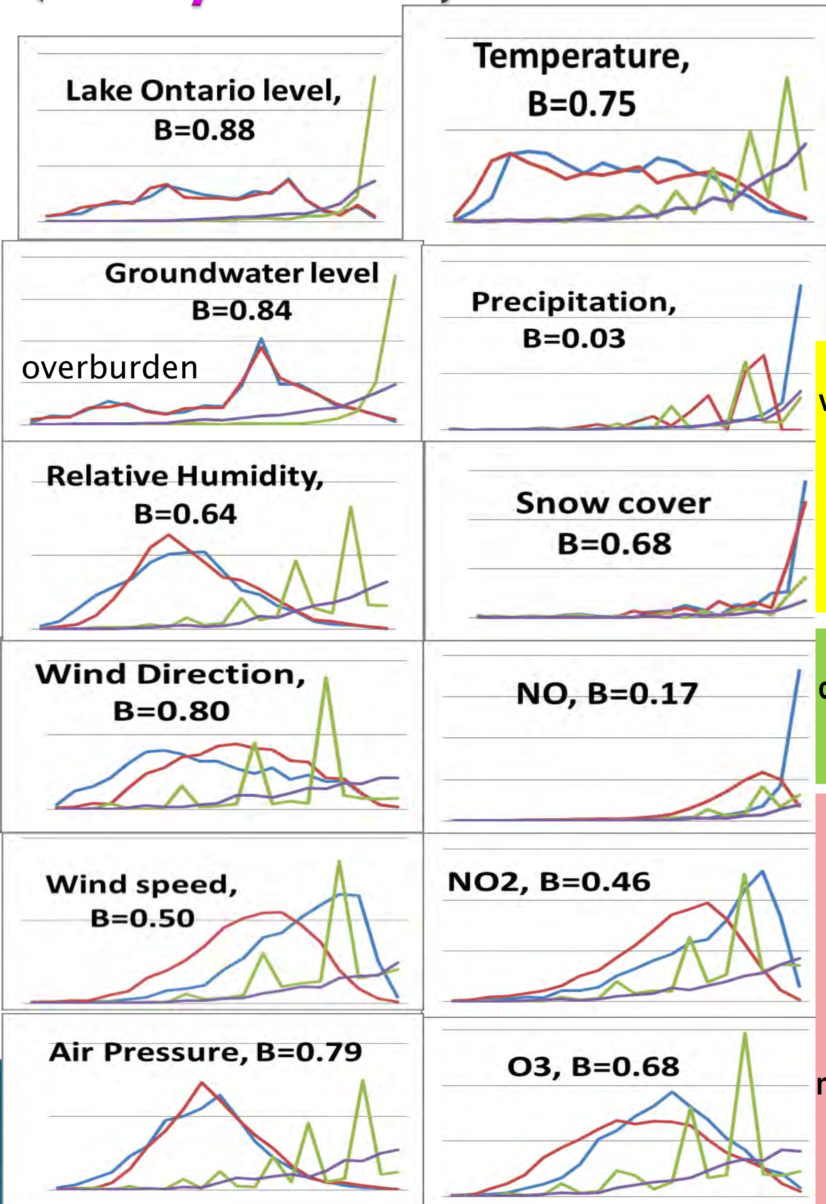


Signal processing: www.hydrology.ca/elasticity.xls or www.hydrology.ca/credit_r_chlorides_04_05.xlsm

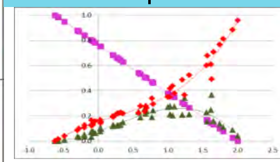
Frequency distribution of positive time-step gradients (dQ) → **Separation in base, inter and storm dynamic components** → **Frequency distribution of dynamic components**



Distribution of functionality within the system (daily scale, Toronto – Windsor 2007-12)



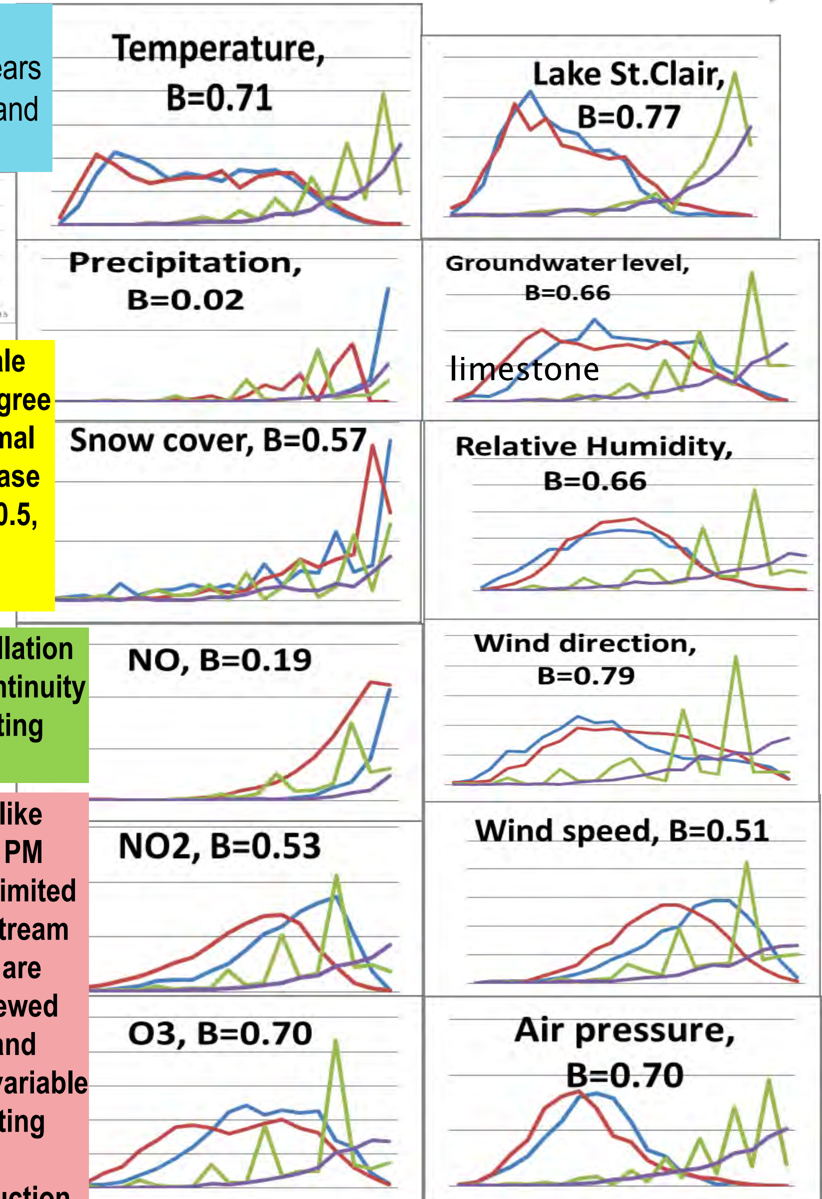
Bi-modality of temperature disappears if to consider warm and cold periods



Continual at this scale variables with high degree of freedom have normal distribution of their base components with B≥0.5, characterizing stabilization

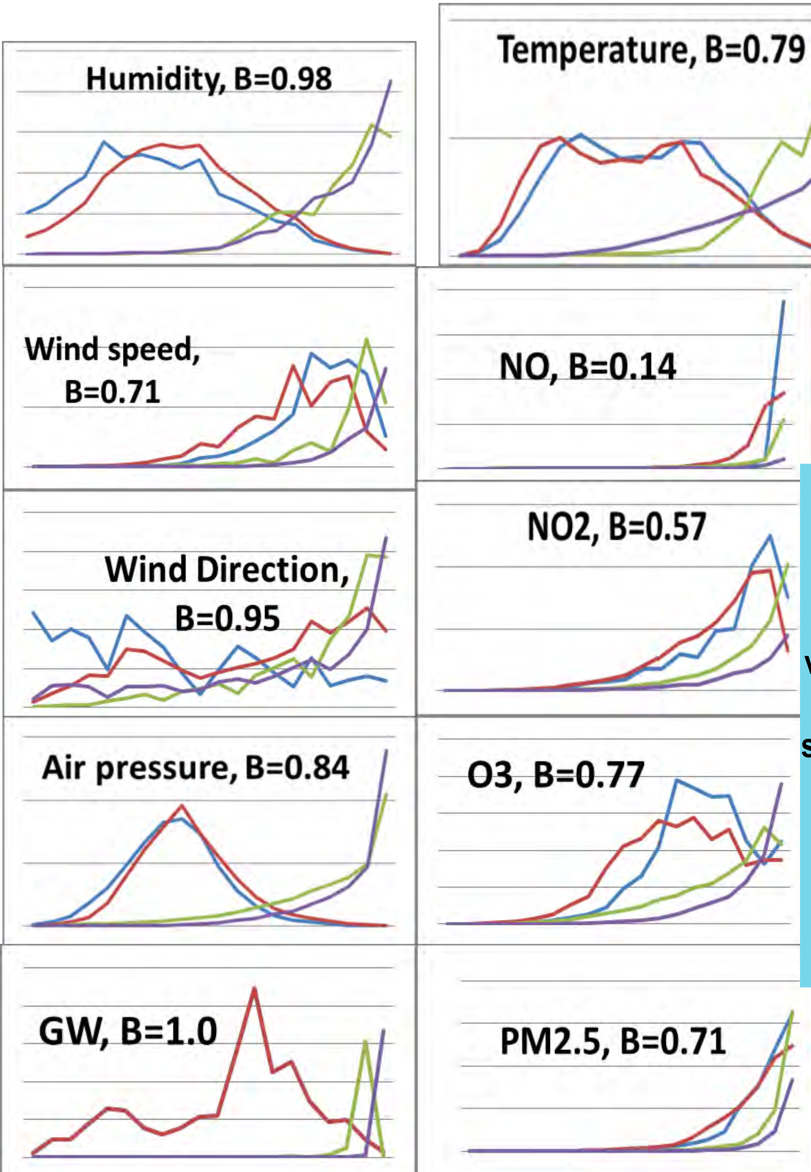
Multimodality or oscillation characterizes non-continuity and internal adjusting function

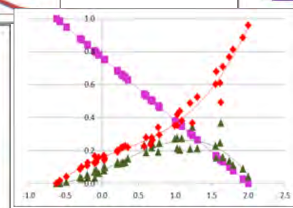
Flowing formation like stream flow, NO or PM having a source and limited by channel or wind stream degree of freedom are characterized by skewed base distribution and negative exponent of variable representing adjusting through destruction/reconstruction

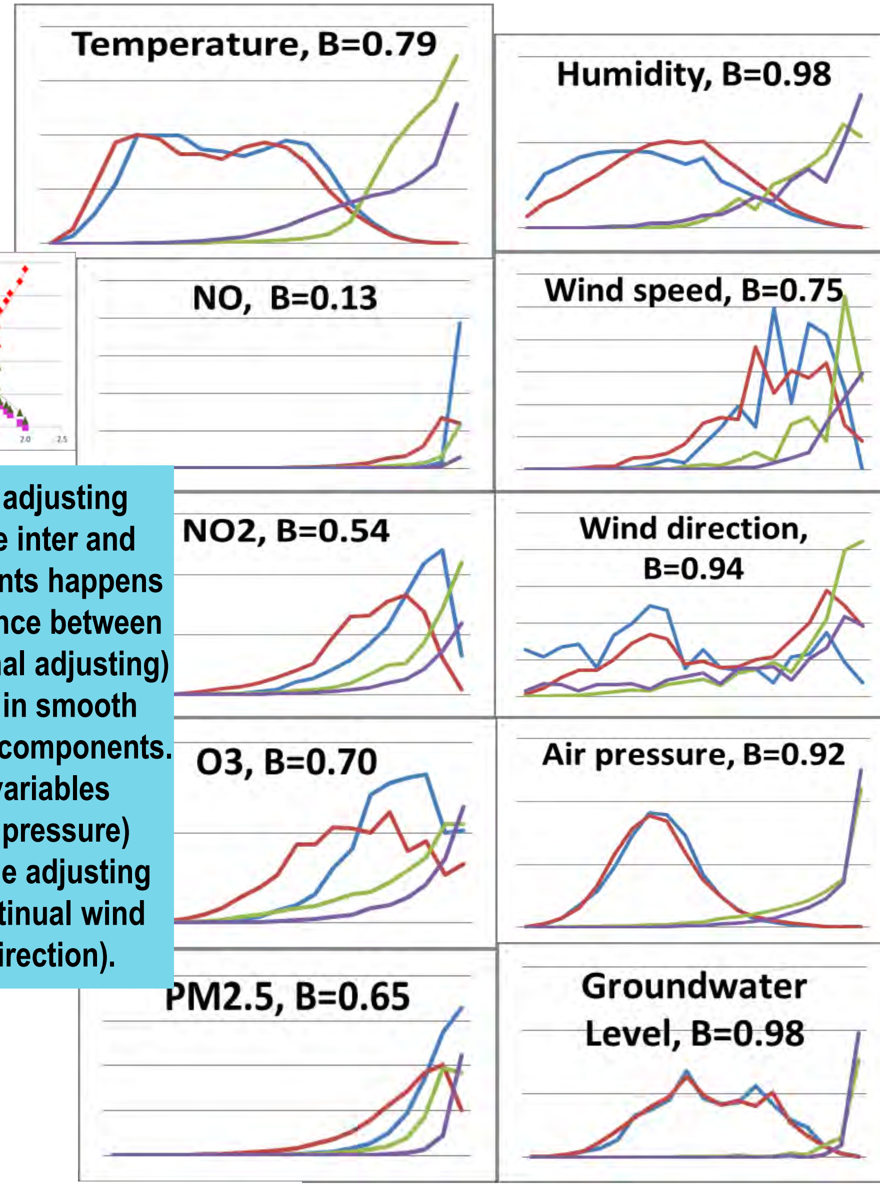


Total Base Inter Storm

Distribution of functionality within the system (hourly scale, Toronto – Windsor 2007-12)



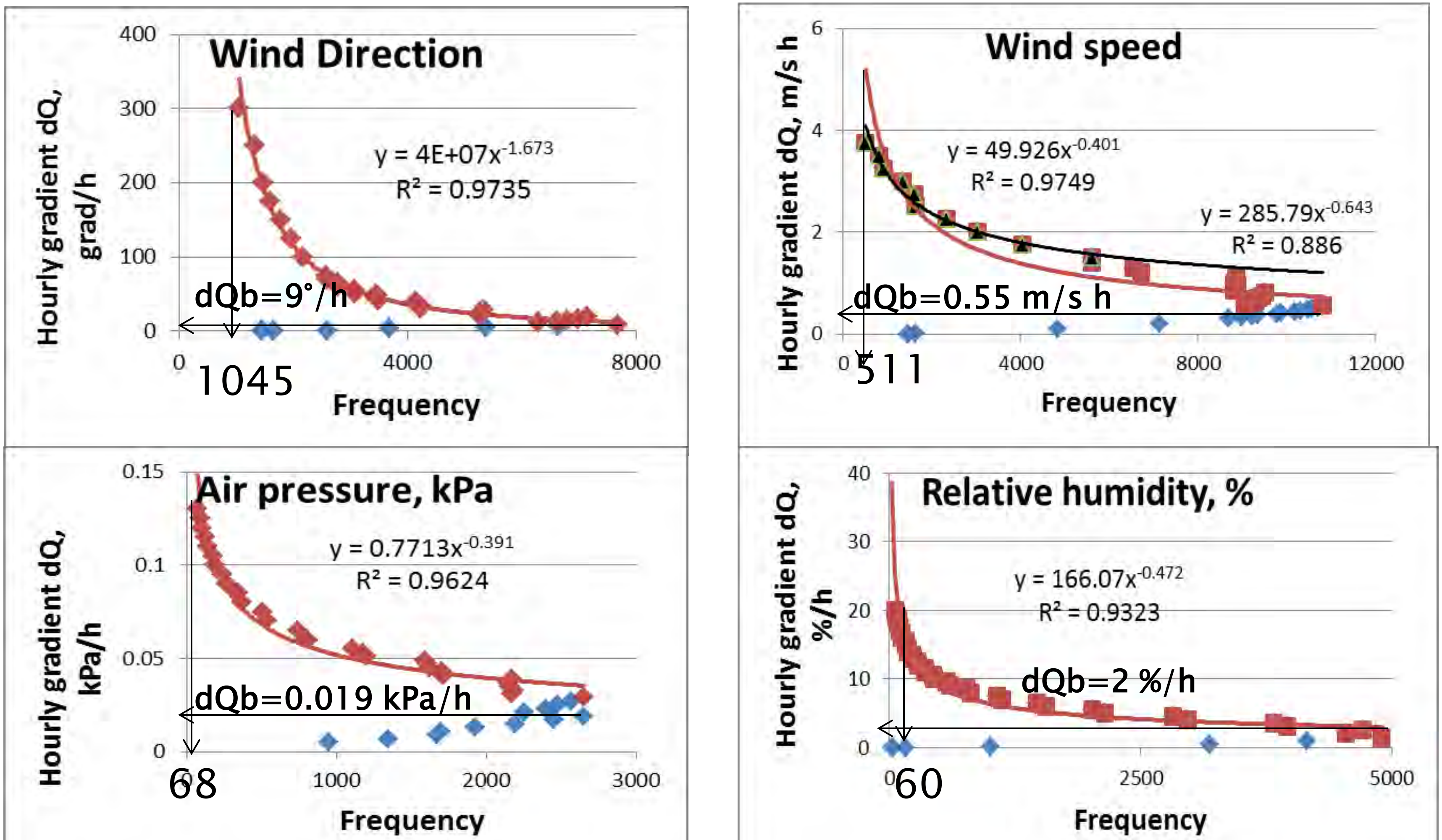




At this scale, adjusting function of the inter and storm components happens through resonance between variables (external adjusting) which is seen in smooth shapes of these components. Stabilizing variables (humidity, air pressure) control/ limit the adjusting ones (non-continual wind speed and direction).

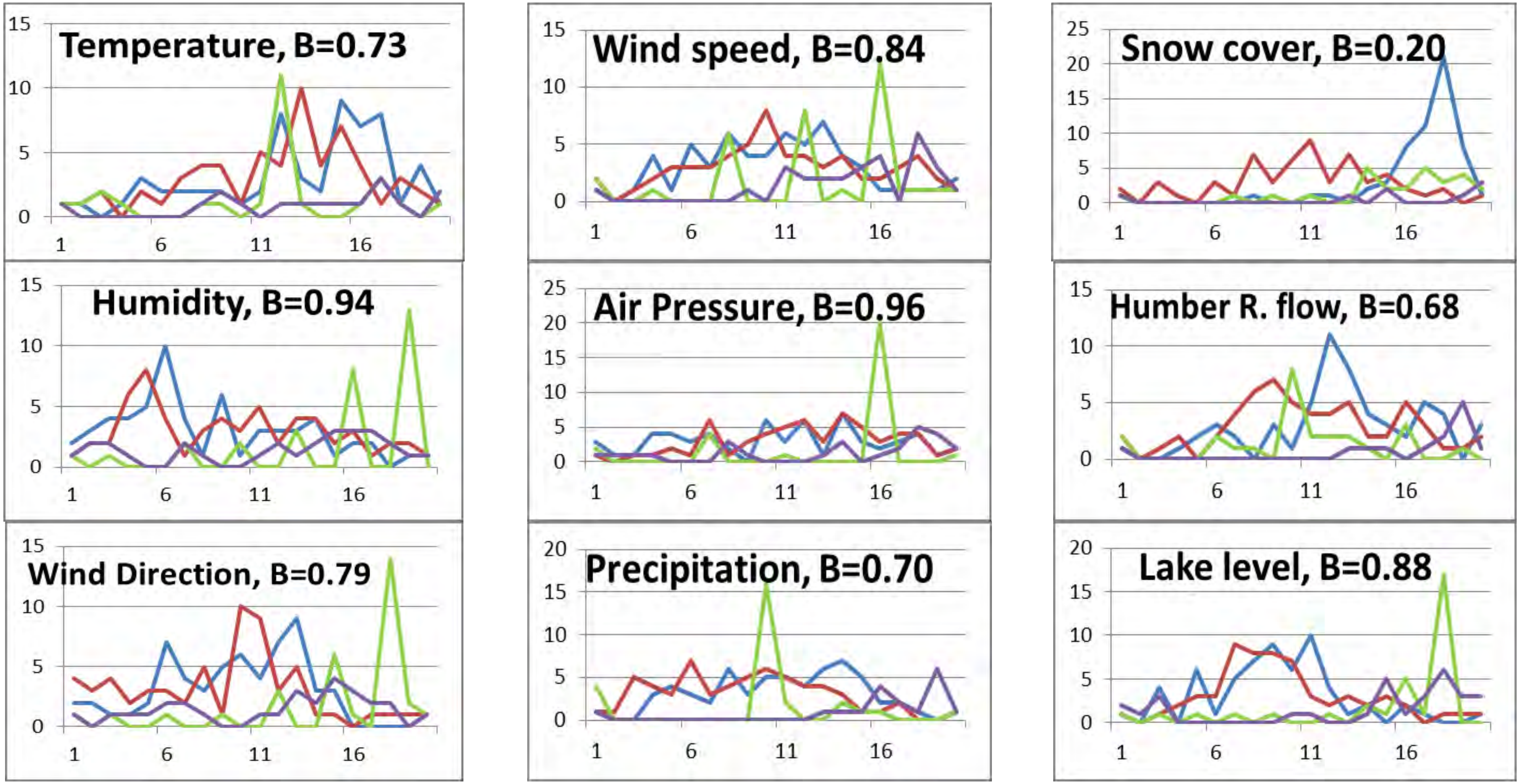
Total Base Inter Storm

Frequency distribution of hourly gradients/changes for main tornado variables, Toronto, 2007-2012



Wind speed and direction have 511 and 1045 times the hourly change bigger than 10 folders of steady ones (dQb) during the period. Humidity and pressure have 60 and 68 respectively. This prevents possible single extreme of change per hour seen from the given equations: over 110000 turns around for wind direction, 50 m/c for its speed, 0.8kPa for pressure and 166% for humidity.

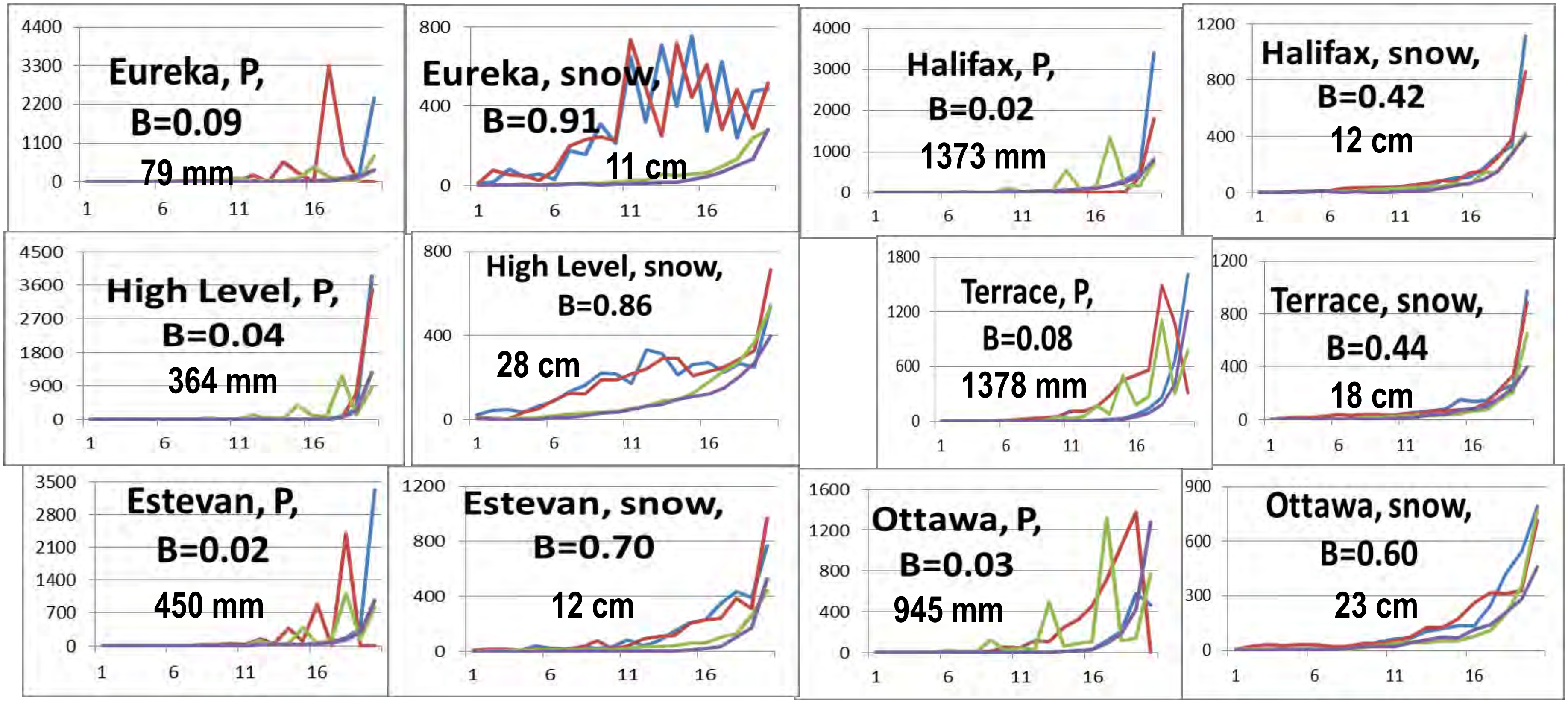
Distribution of functionality within the system (yearly scale, Toronto, 1953-2006)



At this scale, where ranges of all variables are very small, they perform only buffering function despite of their continual nature and high B values; there is no real relationship between variables

Total Base Inter Storm

Functional variability of precipitation and snow cover (Canada1990-2010)

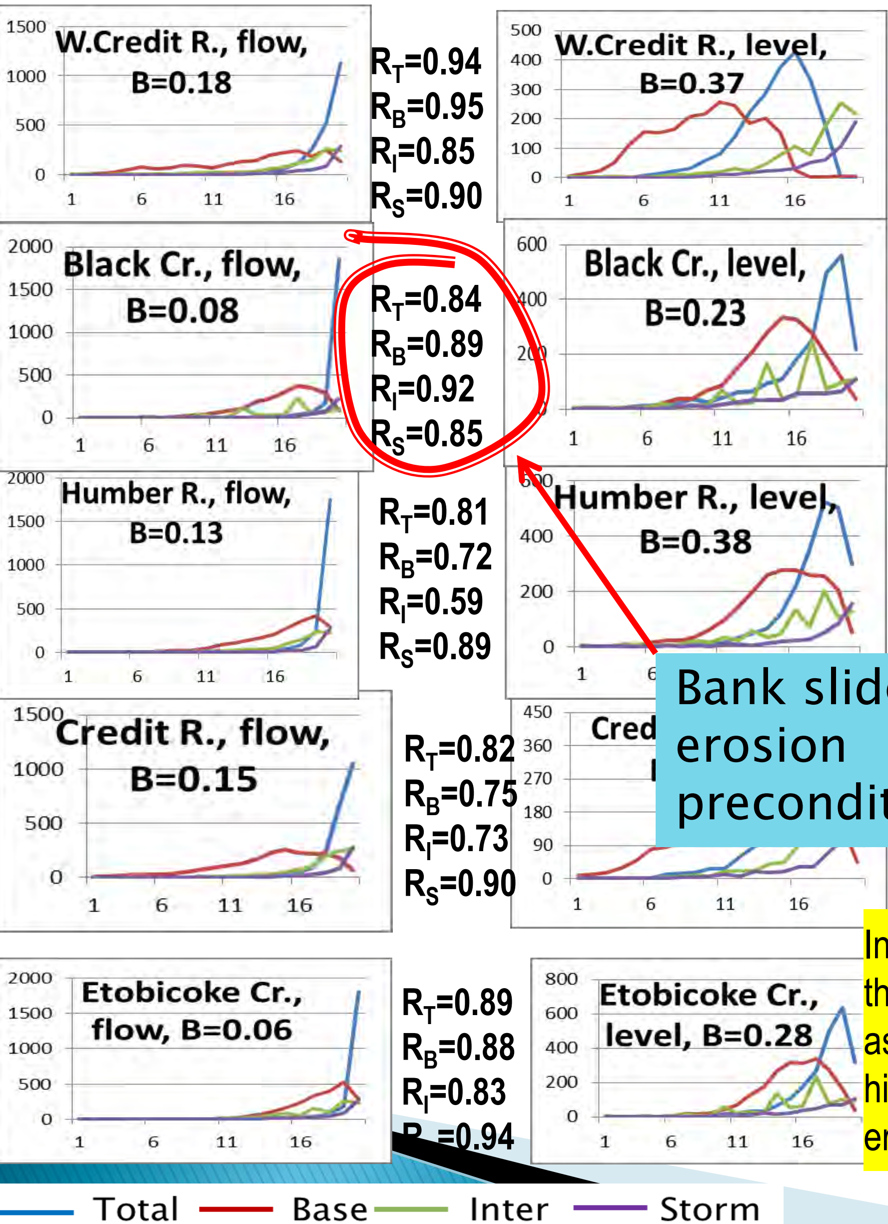


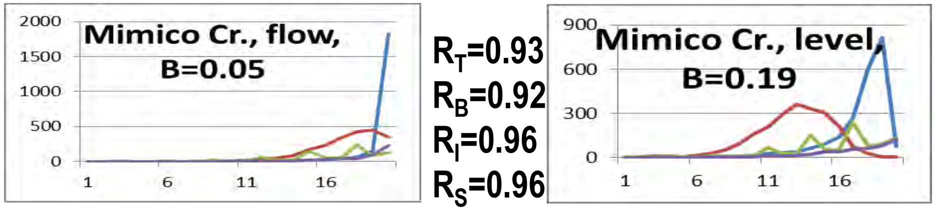
Neither amount of precipitation nor the depth of snow cover can affect the shape of distribution, but their functionality, especially for snow. The higher the base component is, the more buffering function prevails the removing one: at Eureka (B=0.91) it stays long 10 months at the same depth adjusting it through tiny amount of almost daily frost; in Halifax and Terrace snow can be delivered and melt several times a winter showing this in the shape of curves. The base component of precipitation and snow represent due and frost related to the condition of local surface; the inter component of precipitation characterizes the adjusting capacity of the local atmosphere, and storm component characterizes the flashy delivery of needed water from outside providing temperature and humidity adjustment.

Total Base Inter Storm

Functional variability of river flow and level: Canada 2004-2009:

www.hydrology.ca/pdf/erosionMIA.pdf, www.hydrology.ca/pdf/erosion.pdf





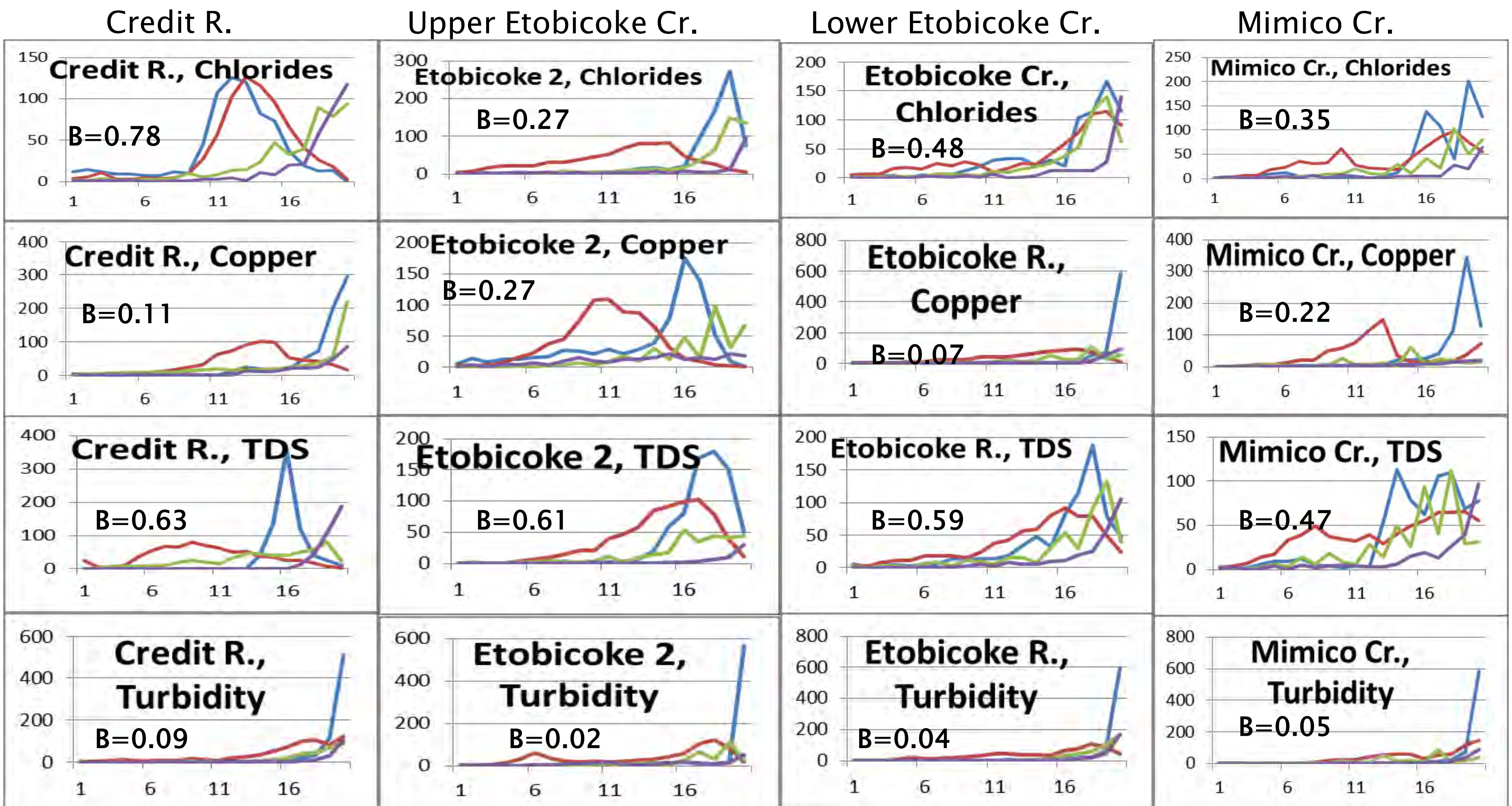
HFA power parameters of level and specific yield for several locations, 2004-2009

Station	Variable	PBD	PID	PSD	Sum
Etobicoke Cr.	yield	0.35	1.70	0.44	2.49
	level	2.2	6.9	0.34	9.4
Mimico Cr.	yield	0.43	2.09	0.51	3.03
	level	2.1	7.6	0.50	10.2
Humber R.	yield	0.14	0.51	0.13	0.78
	level	1.3	2.9	0.29	4.4
k Cr.	yield	0.61	2.56	0.36	3.53
	level	3.4	10.9	0.52	14.8
lit R.	yield	0.14	0.71	0.48	1.33
	level	1.8	5.5	0.69	8.0
W. Credit R.	yield	0.10	0.46	0.56	1.12
	level	1.9	6.7	2.07	10.7

In terms of combined functionality of level and flow in a flood event, there are two controversial functions seen from distribution: inundation as stabilization and construction (formation of a meadow) function of high levels, and destructive function of the high flow in the form of erosion. Inundation has to be designed along with flow.

Functional variability of river water quality, Canada (2004-05)

www.hydrology.ca/credit_r_chlorides_04_05.xlsm,
www.hydrology.ca/pdf/urban_contamination.pdf



Consideration of dynamic components of variables gives possibility to model them taking into account their multi-functionality

Total Base Inter Storm

Conclusions

- Functionality of the water cycle and its variables can be identified using graphical tools of Harmonized Frequencies Analysis: SHC and frequency distributions of variables' dynamic components
- SHC identifies functionality of each variable through its dynamic structure – combination of base, inter and storm dynamic components dividing them according the base share in three groups of functional prevalence: steading, adjusting and destructing (no one variable is uni-functional!)
- Density distributions of variables and their components allow to specify the following:
  - The function of dynamic steadying can be associated with the normal distribution (unimodal and symmetric) of the base component B≥0.5 for continual variables with high degree of freedom at the hourly and daily scales; intermittent variables do not have normal distribution under any conditions
  - The adjusting or buffering function can be revealed as multimodality or delimited oscillation in distribution of either a variable (precipitation, snow) or its component at any scale;
  - Negative exponential or hyperbolic shape of the distribution for a variable either continual or not or its component (storm or inter) characterizes its pervasive role as destructive one implying variable meaning of destruction (from removing to delivering): there is no destruction in nature!