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Communication

Looking for a More Comprehensive Approach

J. Javier Diez [1,*], Rosa M Paz [2] and Julien V. Monnot [3]

[1] Universidad Politécnica de Madrid. UPM FP7 SMARTeST Project leader. C/ Profesor Aranguren, s.n., 28032 Madrid; E-Mail: jjdiez@caminos.upm.es

[2] Universidad Complutense de Madrid. UCM FP7 SMARTeST Project. Rosa M Paz; E-Mail: rpaz@bio.ucm.es

[3] Universidad Politécnica de Madrid. UPM FP7 SMARTeST Project. C/ Profesor Aranguren, s.n., 28032 Madrid; E-Mail: jv.monnot@upm.es

* Author to whom correspondence should be addressed; E-Mail: jjdiez@caminos.upm.es; Tel.: +34-913-366-744

Abstract: The necessity/convenience for improving accuracy in determining the flood frequency is widely accepted further than among hydrologists, and is increasingly deepened in relationship with the statement of different thresholds related to the respective management systems. And both Scientific and Management Communities fully accept the necessity of living with determined levels of flood risk. Most of the approaches for "Advancing Methods" improving concentrate on the statistical ways, even since Climate in fact is not a Stationary process. The question is here reflected since the SMARTeST research and final highlights, policy and recommendations [1]. The paper looks at a better agreement between Hydrology and the whole Climate as the result of the Global Thermal Machine [2] and takes mainly into account a historical approach, trying to show the necessity of a wider collection and analysis of climate data for statistical approaches.

Keywords: Flood, Risk Management, Resilience, Stationary(iety), Climate, Thermal Machine, Multi-disciplinary, Historical Research, Basin and Coast, Field Work

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1. Introduction: improving flood estimation

The necessity for improving accuracy in flood estimation is widely accepted in old fields of flood risk management and not only among hydrologists, and is also increasingly deepened in relationship with the statement of different thresholds related to the respective management systems. It is occurring independently that both Scientists and Managers fully accept the necessity of living with determined levels of flood risk, looking for an adequate Risk (Resilience) Management.

Most of the approaches for “Advancing Methods” improving concentrates on the statistical ways, keeping or not their classical stationary background: Climate is not a Stationary process but some of its effects may be so considered in function of the lag time taken for the analysis, and depending on their particular nature; therefore the necessity of deeper and wider research about it (SMARTeST recommendation: “*Communication between multi-disciplinary partners*”). It is rarely considered however the review of data under a holistic phenomena perception, so these reflections.

Main question then is to identify the reasons for the necessity/convenience for Improving the Flood Estimation. Apart of the classic purely hydrological aim based on scientific and technical motivations looking for more accurate bases for designs, and likely among many others gotten from different points of view, it is possible to identify two immediate and compelling reasons both of them established as policy/highlights/recommendations in the last FP7 SMARTeST Project Conference [1]:

- Flood Risk Management requirement (SMARTeST recommendation: “*Complete flood risk mapping*”), and still further,

- Flood Risk (Resilient) Management requirement, (policy highlighted by SMARTeST as “*Integrated flood -resilience- risk management*”)

Second but not less relevant question is the ways in which improving proceedings and methodologies for estimations of peaks and frequencies.

2. How Improving Flood Estimation

Some cases of failure I forecasting dramatic cases of floods an another climate risks led to recover the Deterministic approaches, based now in a much wider observational data basis that reinforced the empirical approach to the understanding of natural hazards in within the climate actions. Otherwise important effort is being developed analyzing the L-momentums of the very widely observed samples, as the COST E-901 Action is currently developing. Another line in that action that is extremely relevant for the following questions of this epigraph, the statistical analysis and the stationary assumptions (in its strictly proper temporal frame as its combined spatial frame), is the renewed review of historical events, which might open great possibilities in improving accuracy.

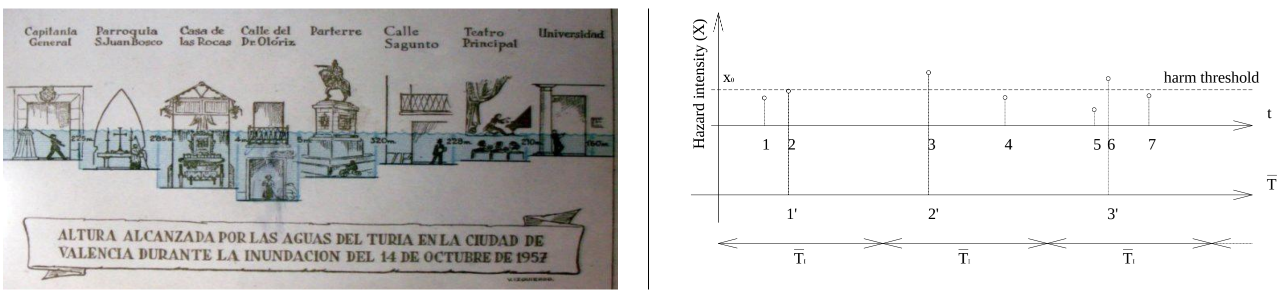
2.1. Statistic Analysis

But this renewal point of view did not reduces the main trust in statistical approaches but as a more or less transitory, complementary and particularized way of infilling the bourses under lack of data for statistic analysis. Nobody has supposed that statistics fails as scientific method of analysis but as insufficiently feed. In relation to this question two different topics has been worrying to applied statistical engineers for decades: the problem of extremes and the question of thresholds; and more recently they became to other two internal problems of the natural phenomena to be accurately explained by statistical description: the meaning of the different random *momenta* and the multivariate necessity for the adequate representative description of most of environmental engineering designs.

The consideration of the year as the natural basic climatic cycle early led to the concept of the annual regimes for the probabilistic description of climatic events. From the beginning, however, people empirically observed that the climate evolved from year to year being likely driven by multiyear cycles of also climatic nature. This is the origin of the "decadal" perception of the natural environmental phenomena. Further than popular perceptions cultivated people early thought on cycles of longer periods or even on trends, but the random nature of all this kind of phenomena was advancing at the same time hunting on their cyclic analysis. Therefore the extreme statistics appeared as a good analytical tool for forecasting great events constraining design or management of social and territorial actions mainly linked to the answer or protection face to (mainly) natural hazardous events.

Immediate difficulty for applying the *extreme statistics* is to determine the selection time of extremes, confronting from the beginning the use of annual peaks (with the inconvenient of needing a sufficient temporal series) versus the assumption (much less acceptable from a rigorous theoretical point of view) of the exceeding peaks over a threshold (POT) (with the added difficulty of defining it), what we can call as the *threshold question* (Figure 1). The natural yearly cycles in climate events and the availability of data / or the easy field measurements implementation in developed countries on some of environmental variables favoured the assumption of the more accurate first methodology though immediate discussion was open on the exponential function to apply. But some other then newly observed variables, f. e: Hs (Significant Wind Wave Height) in coastal engineering, moved to the second option (Saville in 1960, [3]) even as a rough method with just three gauging wave years. The short time period size of those observations and the tremendous space-time variability of the climatic events, both making very relative their assessment to a concrete sample, reopened the discussion on the relative statistical value of both methodologies, depending on the nature of their processes. Threshold likely is an alternative value for observed variable and time of observation.

Figure 1: Valencia case study shows that Resilient Management Capacity may affect the referent threshold



The application of the multivariate analysis may be considered more as a consequence of the type of the approached problem, whose determinant result is assumed to depend of several variables (dimensionality question) than a properly statistical problem itself, although the applied technology may be considered a consequence of the probabilistic methodologies.

The empirical-statistical methods, like that originally implemented for the determination of the hydrological PMF, early showed its applicability, just as integrated in a very complex methodological proceedings with very rigorous empirical determinations; and only assuming that no other accurate scientific estimation were possible or as a proceeding for deepening on their statistic nature in case.

Whatever we can do on for improving functions and methodologies advises us for the need of increasing the accurate data, mainly necessary both backwards on the time and along the spatial dominion affected by for a very well defined type of events, necessarily taking into the analysis the overlapping of apparently different types of events. From here the necessity of looking at the historic information and, further on, at the climate changes in the immediate over-historic passed.

2.2. The Question of the Stationariety

Stationariety is a theoretical frame-hypothesis established for assuming some methodological procedures in the study of natural random processes supposed to remain stationary. Such hypothesis has been in fact assumed to fit to a virtual state, as just a methodological component of the analysis in climatic processes, which is maintained just meanwhile its results may be considered consistent.

The conditions for assuming a process to be stationary are actually very restricted in the statistical approach and let us apply the stochastic analysis, very powerful in fact but very restricted in its outcomes too. Its greatest success may be valued in the field of the probabilistic distribution of the climatic variables: wind, wind wave, humidity, pressure… in a clear time-space dominion, and even in the analysis for their yearly average regimes. The random extreme values were very successful till being applied to times (and likely spaces) larger than stationary hypotheses permits to. Fails in extreme variable determinations for functional or structural calculations have awoken an angry reaction against such hypothesis as if it were answering to the climate nature instead to methodological requirements before realizing that it had been extended or applied much further its restricted application field.

Climate in fact, however, cannot be considered stationary along its whole time evolution and space expression. Its large temporal and spatial term changes are fast/abrupt enough to have a variable perception, and the same happens with its different phenomenal expressions. But in the temporal and spatial short term some of its phenomena/parameters may be considered stationary in function of the time lag or spatial stretch taken for the analysis, and depending on their particular nature.

This assumption is fruitful in within a certain dominium, not further; and many predictions in many fields of climatic phenomena are being likely extended further from the applicable dominium, without completing the elements for adequate hind/forecasting; therefore the necessity of deeper and wider research about it is the first step to take into consideration. To do so we need to implement the way of increasing data for future analysis that permit obtaining old/ancient data for a compatible analysis backwards and, as the time-stationary question may be extended, "*mutatis mutandi*", to the spatial analysis, these takes us to the necessity of extended information on the spatial scales to be joined to the mere temporal hydrological data and permit right dominion boundaries for admissible stationary hypotheses, improving so the random samples on both time and space analysis.

The time approach may be driven through the climate variation observed since the very peak of the last glaciations, around 18 000 years b p (Figure 2) [2]. The spatial approach leads to two meaning observations, both linked with the external geodynamics (leaving apart here the geo-morph-dynamic impacts from internal geodynamics) and driven by climatic phenomena: the one comes from the spatial variability of the hydrological events affecting one (or several in relationship) areas, and the other comes from the morph-dynamic answers of territory to the fluid-dynamic (water and air, what takes us it itself further backwards in the Climate analysis) actions.

Changes in the morphology of Valencia Coastal plain and basins may be detected: i) between maps separated not more than 400 years, and ii) a unique vulnerable area may be hazarded by two different Flood Risk sources/paths (Figure 3). In this spatial view "*stationariety*" must be understood as homogeneity or low gradient, and it may be accepted in the very long term analysis but likely not in the current discussion. In figure 3, spatial changes may affect the permanence on time of the processes because of morphological evolution through (i) flooding or (ii) running conditions [2, 4, 5].

Figure 2. Major Climate Variations along current Interglacial period.

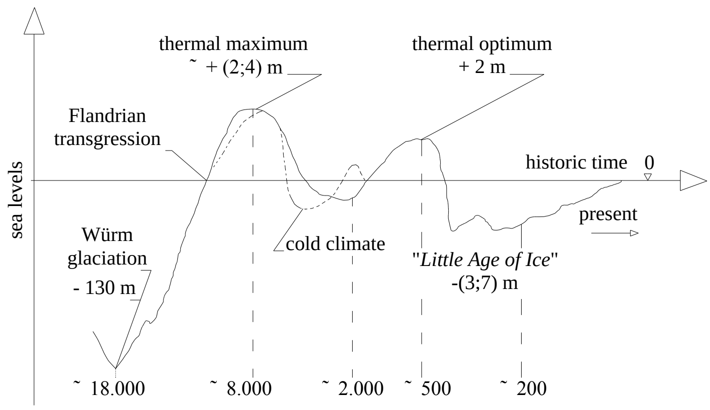
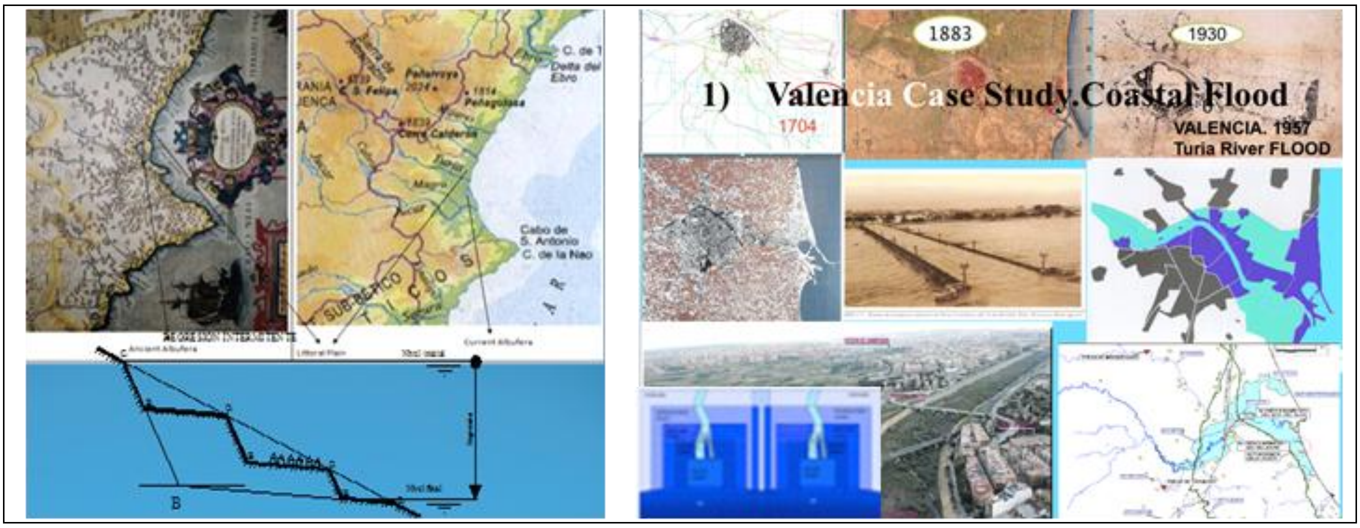


Figure 3. (a) Figure 3 ii) Changes affecting hydrological performance; (b) Coastal zone changes in last 400 years. Plains extend and cliffs regress.



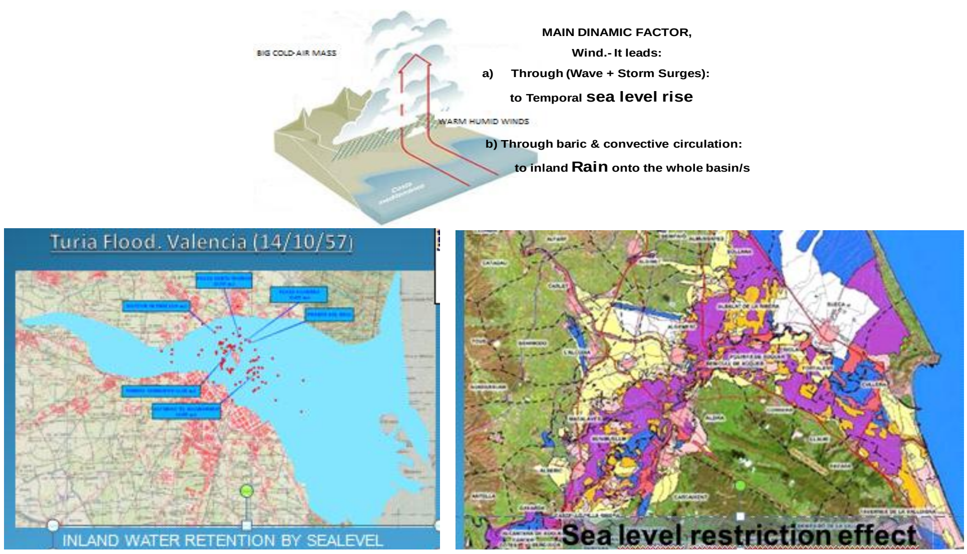
3. Hydrology, Climate and the "Thermal Machine"

The anterior discussion comes into the necessity of understanding the Climate, its scope on meteorological and environmental space-time phenomena and the relationship among them, so in the complex global performance as in the local and transitory elemental meteors. Climate is more than the addition of the spatial and temporal climatic phenomena and goes further than the temporal succession of the multiplicity of atmospheric and oceanic events identified as climatic. Climate is the consequence as a whole of the global dynamics (*Thermal Machine*) [6] established on the Planet as driven by the thermal gradients generated by sun radiation on the planet surfaces. There are so an aspect of locality composed by multiple local thermal machines varying on the time and across the mentioned surface, and a global aspect resulting from the whole local aspect but driving it also in an involving way.

The first climatic phenomenon appearing, due to the scarce air inertia, is the wind [7] that displaces the atmospheric vaporised water and drugs ocean surface; it leads to a complex atmospheric mechanic-dynamic thermal circuit. Temperatures immediately generate evaporation and pressure gradients on the sea surfaces unleashing the also complex hydrological multiplicity of circuits. Wind drug forces finally generates a) wind waves, b) storm surges and setups and c) currents, immediately affected by planet rotation (Coriolis) and thermo-salinity boundary conditions through density gradients, both of the affecting all power transportation through mass displacements. The last consequence of the increasing complexity and dimension of the ocean currents is the generation of the transoceanic currents, whose size and Thermal and kinetic inertia supposes a tremendous feedback on the much lighter atmospheric cycles. So the importance of the Gulf Stream (the greatest and warmest current on the planet) on the planetary climate, further than its inclusion in the Broecker's conveyor belt.

Following this reasoning no hydrologic global phenomenon may be wholly correctly understood out of that whole complex Thermal Machine. But the same analysis may be driven in any local thermal machine affecting any hydrology determinant flood event (Figure 4) [2]. The SMARTeST Valencia case study permits a right understanding of the local phenomenon known as "gota fría (cold drop)" [2] which is just the lighter reactivation on the still worm western Mediterranean basin of an extra-tropical cyclone having crossed above the Iberian Peninsula whose backside N-NE circulation has been drugging down since Polar Circle extremely cold air masses remaining over the whole Peninsula and more northern and southern.

Figure 4. (a) Cold drop and . (b) sea level restriction.



The high cold/dry air mass, the hot sea surface layers, the drug winds and the coastal length sierras generate a convective air movement and a condensation process causing intense and extensive rains on great basin areas, and the sea level highs while wind drugs by wind and wave set ups plus low pressure storm surge. Flood (flash, pluvial or fluvial) may happen at any catchment of the basin but in coastal zones it can be accentuated by high sea level. The situation is analogous in the case of extra tropical cyclones in the rest of Europe and other places of the planet, under hurricane/typhoon tropical conditions and even with Monsoon occasions [4, 5]. The duration of the high level corresponds to the duration of the cold drop event, and in small to moderate basins, as Valencia's and most Mediterranean, the coincidence of fluvial flood and high sea level is highly probable and affects very mainly to Coastal Zones. In grater basins as Ebro, Rhone, Po, and most of North-Europe's that dramatic coincidence may happen or be delayed till a following low pressure episode, depending of the time of accumulation, snow melt conditions and basin regulations, but current sea level is always a main factor in most of floods, even further inland than mere coastal zones.

4. First Conclusions

The discussion has driven several times to the necessity of increasing and improving the data for analysis, whatever the way of doing it with rational methodologies, and to reach these date the reassessing of old data may be so significant as the collecting of new ones; in this sense the holistic comprehension of the nature of the flood events may be the major road to the do it, taking so into account the nature of the climate and its flood events, and as like former conclusions may be assumed:

- There are obvious needs for improving flood estimations, and the necessity comes from different fields of environmental and developing areas.
- The support to try out new alternatives for statistic analysis may be reinforced.
- The question of *Stationariety* must be assumed too by analogy to spatial analysis, but it must not suppose a break because it does not affect the climate pattern. The hypotheses may be assumed in certain conditions but understanding the Climate as it is, the result of the *Global Thermal Machine*.
- The necessity for a deeper research on the evaluation of the available data as on getting more and longer series put in very high value the historical research of flood events.
- Winds and Rains are combined variables in the Global **thermal machine** as in the more local and temporal thermal machines that develop the Climate and its variable (local/temporal) whether.
- Sea level rarely produces sea-water flood but restricts inland evacuation, to inland coastal floods.
- Rains generate pluvial (flash), fluvial and even groundwater floods, generally combined, especially in coastal zones

5. Flood Risk (resilient) Management

The Flood Risk Management may be considered a new stage in the human position facing the Flood Hazards when realising the unavoidability of their derived risks. Important factor to reach this attitude was the conceptual separation between the hazard itself, submitted to the random laws and the vulnerable character of every element to be considered in any Risk analysis. The nature of the perception of the Risk itself is a consequence of the population increasing and of its trends in settlement decisions [8]. After that, the assumption of risk as a datum for the analysis more than an element to avoid has led to the development of the management attitude.

Management early drove however to the conscience of the impossibility of reducing risk by assessing hazard, absolutely far from our reach, but to manage vulnerability. From this point on the interconnection among the two concepts, apparently and perhaps initially independent, becomes increasingly obvious. Managed risk feeds back the assumed vulnerability and, through it and their thresholds, the proper assessment of hazards. Fruit of this more or less clear perception is the recent incorporation of the resilience concept to flood risk management (SMARTeST, 2008 FP7 call). Though having been in origin a concept related to Material Reology, Resilience was soon adopted in many other fields of knowledge and management, mainly in health disciplines, where it takes a special wide meaning in relation with the human behaviour. This last aspect has in fact tremendous incidence in the flood risk management through the human factor impact on most of the actions to live with and survive on the flood damages. Therefore the proposal of speaking of flood risk (resilient) management, in whose scope SMARTeST has recommended the major "Communication between multi-disciplinary partners" and to "Consider the full array of flood events". In this sense the previously assumed necessity for a deeper research, that had been addressed in longer (historical reinforcement of research) and more accurate series of data, SMARTeST claims for i) "*Historical research -learning from the pass-"* and for ii) "*Deeper/more multi-disciplinary climate/hydrology/subsidence research"*.

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Among the most relevant flood risk (resilience) management targets is so to improve the frequency analysis, which requires not only more data and accuracy in their treatment but a much deeper knowledge of the nature of the events; numerical models came to help in this task for several decades on already, tough much work has still to be done in the near future to wide its comprehensive capability [9]. In any case however the model contrast tasks demands much greater efforts mainly on field works, reviewing the case studies and widening/deepening on historical works ("More Field Work & Model contrast" plus "Longer Series and Wider Spatial Scales of Data" SMARTeST recommendations).

"Field Work" is much more urgent and possible necessary than numerical approaches, and therefore the historical approach, best way the acquire new suitable data from the past for longer series and wider nets, is being increasingly adopted (SM: "Historical research -learning from the pass-" recommendation), even by statistics when looking for the possibility of enlarging through it their temporal series, mainly looking for the assessment of a better link between Climate and Hydrology and, in within it, between the hydrologic parameters and the wider and more controlled land use conditions (SM:"Deeper and more multi-disciplinary climatic/hydrologic/subsidence research" policy); and the threshold event concept acquires here new meanings (Figure 1). But it might be afraid a relatively scarce attention to the links between Hydrologic conditions and other parts of the Double Thermal Machine Circuit which determine the Climate, in one of whose cycles the hydrological processes are part of (SM: "Consider full array of flood events" policy).

6. Conclusions

As final conclusions of these personal reflections, and reaffirming the anticipated assessments it is possible to set:

- The new flood (frequency) risk (resilience) management paradigm affects thresholds and consequently the POT analysis.
- The concepts Hazard and Vulnerability are not independent in fact and both feedback on Risk management.
- Global change must not be perceived as an external superimposed superstructure but as the consequence of a changing world, which we are living in and transforming to.
- Progress in forecasting must take into account the complex nature of events and collect/use their different climate parameters for the research analysis.

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