A downscaling model system for early warning flooding forecast

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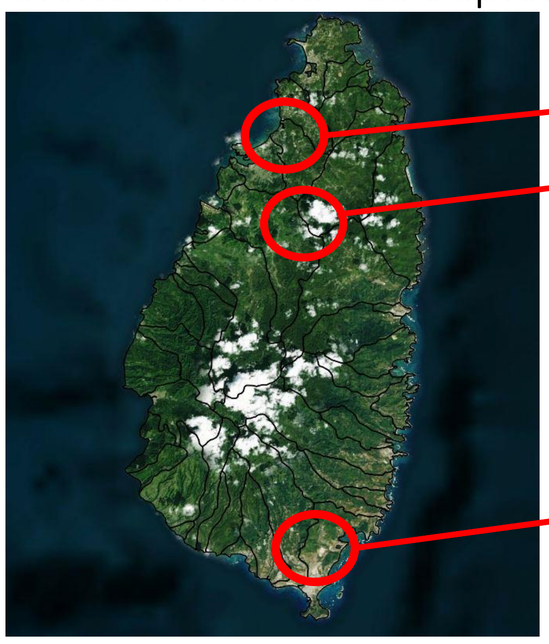
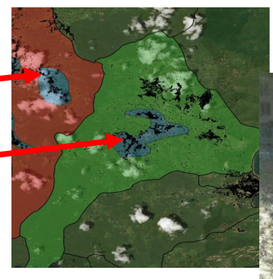
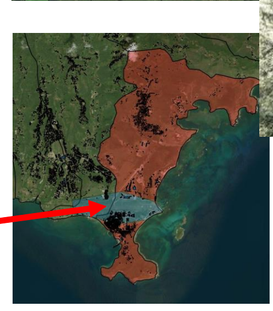
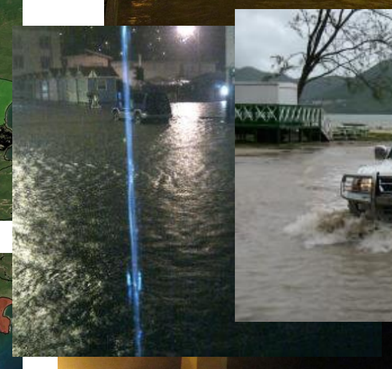
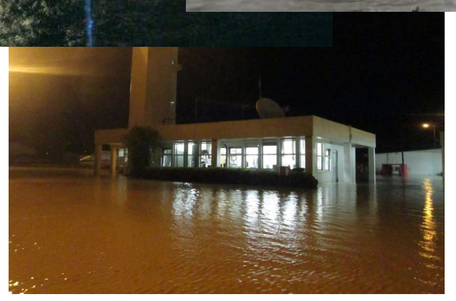








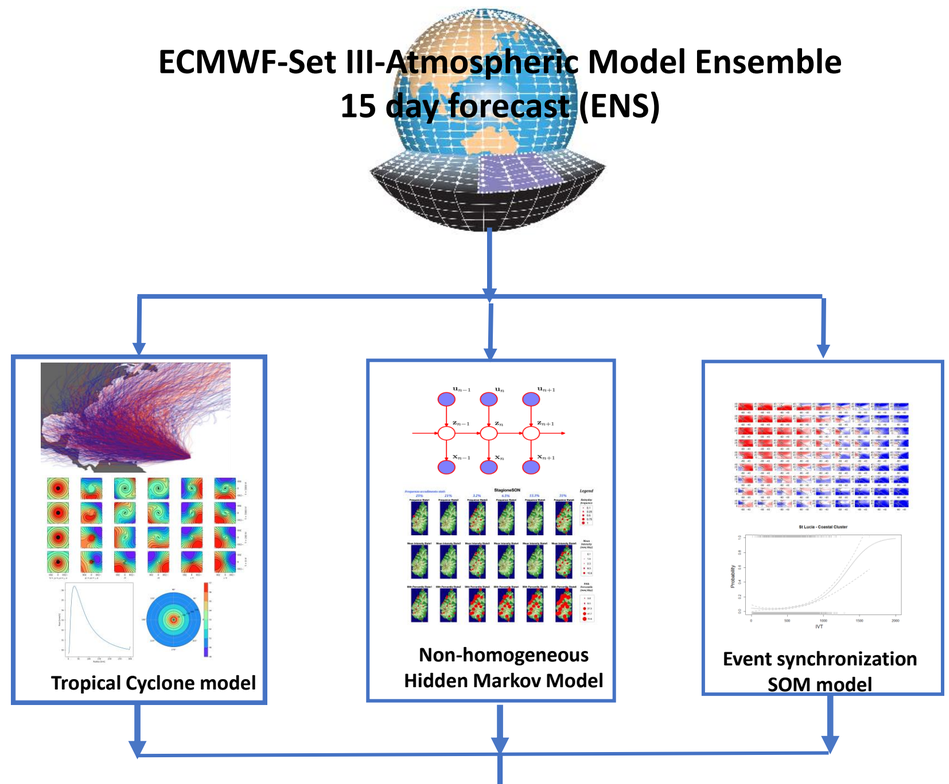


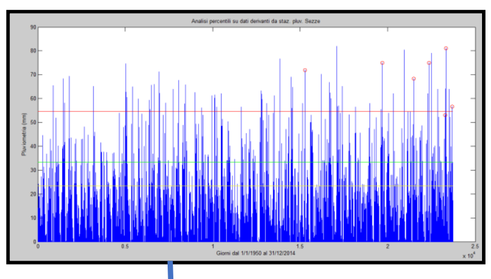
Floods are among the most damaging natural hazards, and globally the most significant disaster type in terms of loss of human life. Early warning flooding forecast at the local scale are crucial to manage emergency to avoid life losses and reduce damages, especially in areas where the high level of urbanization and the intensive use of soils increase the flood hazard, societal exposure and vulnerability.

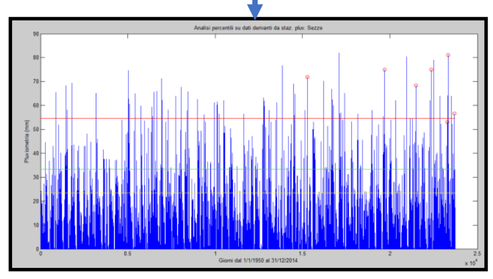
A local scale flooding Early Warning System (EWS) is proposed for the St. Lucia island (Caribbean), which is constituted by an ensemble of flooding risk forecast subsystems which is potentially applicable to Atlantic tropical and extra-tropical regions. The EWS activation occurs at different temporal and spatial scales. The time scales considered are: a) 0-2 hours, nowcasting; b) 24-48 hours, short range; c) 3-14 days, middle to long range. Spatial scale are associated to the most relevant phenomena: synoptic/global scale, to capture the influence of large scale atmospheric circulation patterns, storms and hurricanes; microscale for local precipitation recorded by a weather station; mesoscale referred to the rainfall/runoff phenomena at basin scale.

Long-middle, short flooding risk forecast

INPUT	Attribute of Tropical cyclones occurred in the past and hourly rainfall time series (track, wind speed, SLP,…)	- Geopotential at 850 hPa and Integrate Vapor Transport (IVT) atmospheric fields - Daily rainfall time series	- Geopotential at 850 hPa and Integrate Vapor Transport (IVT) atmospheric fields - Daily Rainfall amount time series	-DEM -Land Cover -Rainfall Hyetograph -Streamflows or river depth measures -Sea levels (storm surges)
MODEL	Model to translate the tropical cyclone attributes in rainfalls and floodings	SOM-event synchronization model to identify the probability of occurrence of extreme hydrological events exceeding a threshold	Non-homogenous hidden markov model to predict occurrence and intensity of rainfall conditioned to atmospheric predictors	2D Hydraulic model able to simulate wet and dry conditions, transcritical flows and that allows direct rainfall application
OUTPUT	Probability of flooding	Probability of exceedence of rainfall amount thresholds able to produce flooding	- Trend of daily rainfall amount and confidence intervals - Probability of occurrence of location, timing and extent of flooding	Timing, Location and extent of flooding areas

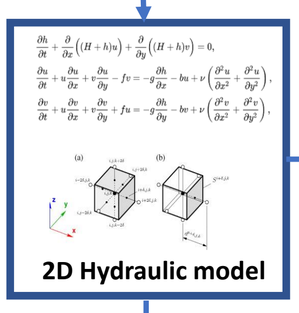


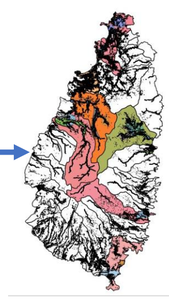




Tropical Cyclone model: physical based model that links the rainfall intensity field to the TC attributes (Track, maximum wind Vm, the radial position Rm of *V*m)

Kepert, Jeff. "The dynamics of boundary layer jets within the tropical cyclone core. Part I: Linear theory." *Journal of the Atmospheric Sciences* 58.17 (2001): 2469-2484.
Langousis, A., & Veneziano, D. (2009). Theoretical model of rainfall in tropical cyclones for the assessment of long-term risk. *Journal of Geophysical Research: Atmospheres*, *114*(D2).
Langousis, A., & Veneziano, D. (2009). Long-term rainfall risk from tropical cyclones in coastal areas. *Water resources research*, *45*(11).
Orton, P. M., Conticello, F. R., Cioffi, F., Hall, T. M., Georgas, N., Lall, U., ... & MacManus, K. (2018). Flood hazard assessment from storm tides, rain and sea level rise for a tidal river estuary. *Natural hazards*, 1-29.



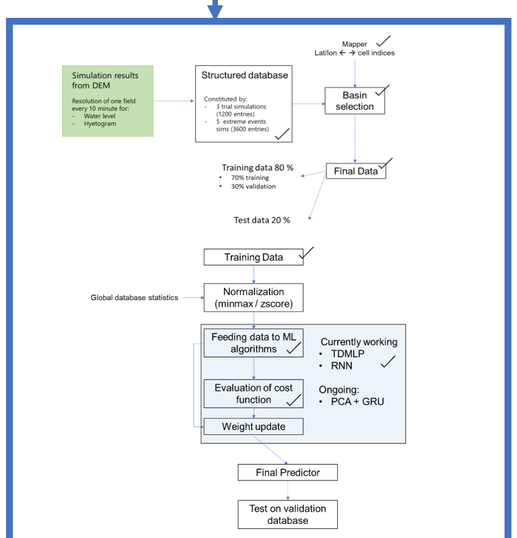


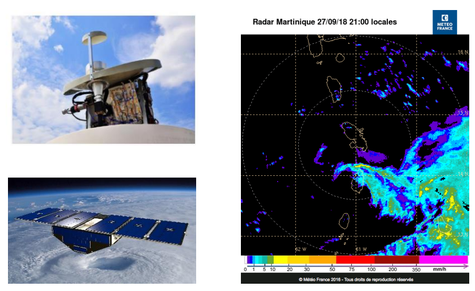
NON-Homogeneous Hidden Markov Model: for each significant season the model simulates the daily amount and occurence of rainfall and their spatial distribution as a function of atmospheric predictors (850 hPa Geopotential distribution and IVT)

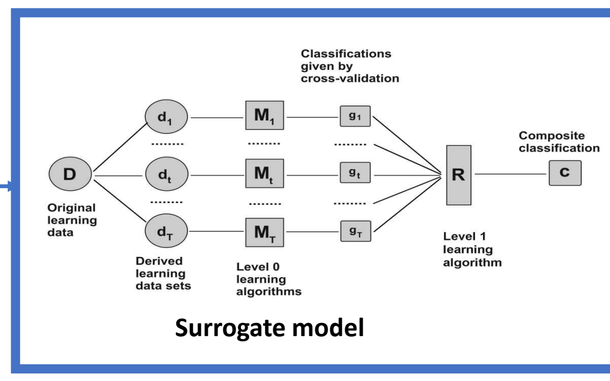
Cioffi, F., Conticello, F., Lall, U., Marotta, L., & Telesca, V. (2017). Large scale climate and rainfall seasonality in a Mediterranean Area: Insights from a non-homogeneous Markov model applied to the Agro-Pontino plain. Hydrological Processes, 31(3), 668-686.
Cioffi, F., Conticello, F., & Lall, U. (2016). Projecting changes in Tanzania rainfall for the 21st century. International Journal of Climatology, 36(13), 4297-4314.

Event synchronization/Self Organize Maps model: combines non-linear, non-parametric methods to link heavy precipitation events (HPEs) to atmospheric circulation states. Geopotential configurations are identified, which tend to drive HPEs. For these geopotential states, the probability of HPE occurrence as a function of IVT is calculated through a local logistic regression model.

Conticello, F., Cioffi, F., Merz, B., & Lall, U. (2018). An event synchronization method to link heavy rainfall events and large-scale atmospheric circulation features. International Journal of Climatology, 38(3), 1421-1437.







NOW CASTING

Construction of Flooding risk maps and of surrogate model

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