TRACKING MODELS DEVELOPMENT
APPLICATION TO MESOSCALE CONVECTIVE SYSTEM RAINFALL IN THE SAHEL

Postdoc in mathematics applied to hydrology -
Grenoble, France

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The two years postdoctoral fellow will benefit from INRIA work environment:
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She/he will be based in both Hydrology and Applied Maths departments of Grenoble University, and she/he will work in close collaboration with applied mathematicians and hydrologists. In particular, she/he will be part of the COSTA BRAVA project team:
http://www.math.univ-toulouse.fr/COSTA$_$BRAVA/index.php

The West African region is strongly sensitive to climate variability and the population is highly vulnerable to climatic fluctuations. Studying the impact of climate – and for that purpose mostly rainfall – variability on various components of the water cycle and agriculture requires being able to simulate the rainfall regime in its present state and under various hypothesis of modifications. In this respect, the stochastic modeling approach is promising as it allows developping models for which confidence in the estimates and predictions can be evaluated. In the work proposed here, the focus is on making use of rainfall system monitoring provided by satellite remote sensing. Micro-wave and IR satellite data allow in particular characterizing the behaviour of the mesoscale convective systems through automated methods for tracking the systems and estimating the rainfall intensities. The basic premise of a multiple target tracking problem is to follow targets through a sequence of images, each of these images containing information about the locations - and perhaps other attributes - of the targets. Here the targets are convective systems which are larger than a prescribed threshold. Usually, tracking algorithms are dependent on an identification algorithm, which records the location of each target that it finds in each image. It may also record other information such as intensity, size or shape of the target. In our case, this identification algorithm has already been performed by physicists, providing a valuable database.
The approaches to target tracking have been extensively studied in the engineering literature over the past forty years. The non-statistical approaches solve an optimization problem by shuffling the labels of the observations around to create tracks that optimize some criteria. The speed and the simplicity of such approaches make them attractive, however they are

difficult to initiate (birth of targets) and to terminate (death of targets), and they do not allow to derive confidence in the estimates.
Stochastical approaches thus provide an attractive alternative to the above techniques .

The first part of the work proposed here will consist in implementing a model developed in Storlie *et al.* (2005, 2009) on a test set to evaluate its performances, our ability to infer the parameters, and the meaning of these parameters. This algorithm should then be run on our data set, and compared with previous results by Mathon & Laurent (2001) or by Mathon et al. (2002). The model developed by Storlie *et al.* (2009) is a continuous time stochastic model to multiple target tracking, which allows in addition to birth and death, splitting and merging of the targets. The location of a target is assumed to behave like a Gaussian Process when it is observable. Targets are allowed to go undetected. Then, a Markov Chain State Model decides when the births, death, splitting or merging of targets arise. The tracking estimate maximizes the conditional density of the unknown variables given the data. The problem of quantifying the confidence in the estimate is also addressed. Particular attention should be paid to the modeling of initiation and vanishing locations, in relation with diurnal cycle.
In conjunction with the location and state models, models for additive information can be incorporated. By other information, one may think about size, intensity, … The best information to use and the way to take it into account will have to be studied to outperform the basic model in a second time.
In a third time, extremal properties of our data may be investigated by running this dynamic spatio-temporal model on large time scale.

References
Storlie, C. B., Lee, C. M., Hannig, J. & Nychka, D. (2009). Tracking of Multiple Merging and Splitting Targets: A Statistical Perspective (with discussion).} Statistica Sinica {19}, 1, 1-52.
Storlie, C. B. (2005). PhD dissertation. Tracking of multiple merging and splitting targets with application to convective systems.
Mathon, V., Laurent, H. & Lebel, T. (2002). Mesoscale Convective Systems Rainfall in the Sahel}. American Meteorological Society.
Mathon, V. & Laurent, H. (2001). Life cycle of Sahelian mesoscale convective cloud systems. Q. J. R. Meteorol. Soc. {127}, 377-406.

How to apply
Applications must be submitted by email at clementine.prieur@imag.fr joining a curiculum vitae and motivation letter.

The ideal candidate will have a PhD in applied mathematics, with experience in scientific computing. The candidate should be willing in developing tight collaboration between physicists and statisticians. A strong background in programming (R, Matlab) is required.