Research Topic for the ParisTech/CSC PhD Program
(one page maximum)

****Field (cf. List of fields below):***
9. Mathematics and their applications 10. Physics, Optics

Subfield:
Stochastic processes, symmetry groups. Hydrodynamics.

Title: Analysis and simulations of extremely variable vector fields

ParisTech School: Ecole des Ponts ParisTech
Advisor(s) Name: Daniel SCHERTZER
Advisor(s) Email: Daniel.Schertzer@enpc.fr
(Lab, website): laboratoire Hydrologie Météorologie et Complexité (HM&Co)
https://hmco.enpc.fr

Short description of possible research topics for a PhD: (10-15 lines in English + optional figure)
The fast deployment of low-cost and more accurate measurement devices have paved the way to high resolution turbulent wind fields, in particular short term forecasting, e.g. for wind energy. Unfortunately, the conventional observables used so far for statistical data analysis, as well as for stochastic modelling, have been scalar ones (e.g., the ubiquitous "structure functions").
On the contrary, there had been recent developments on multifractal vectors based on the stochastic algebra of their generators that theoretically overcome these shortcomings. However, even in the case of what seems to be the simplest case, i.e. Levy-Clifford algebra, there a large number of parameters, therefore of theoretical choices to be done. This thesis will therefore first investigate the extensions to the vector case of multifractal analysis techniques and apply them to various data sets to get some empirically based choices among various candidates. This will enable to proceed to simulations and stochastic short term forecasts (nowcasts).

Required background of the student: (Which should be the main field of study of the applicant before applying)
Ideally a background on both stochastic processes and hydrodynamics, with some insights on symmetry groups. A first part of the thesis will be devoted to update knowledge in those domains, if needed.

A list of 5(max.) representative publications of the group: (Related to the research topic)
Lovejoy, S. and Schertzer, D. (2013) The Weather and Climate: Emergent Laws and Multifractal Cascades. Cambridge U.K.: Cambridge University Press. p.1-491.
Schertzer, D., Tchiguirinskaia, I., Lovejoy, S. and Tuck, A. F. (2012) 'Quasi-geostrophic turbulence and generalized scale invariance, a theoretical reply', Atmos. Chem. Phys., 12, pp. 327–336.
Schertzer, D. and Tchiguirinskaia, I. (2015) 'Multifractal vector fields and stochastic Clifford algebra', Chaos: An Interdisciplinary Journal of Nonlinear Science, 25(12), p. 123127. doi: 10.1063/1.4937364.
Schertzer, D. and Tchiguirinskaia, I.,(2017), An Introduction to Multifractals and Scale Symmetry Groups, in Fractals: Concepts and Applications in Geosciences. Ghanbarian, B. and Hunt, A. (eds) CRC Press, 1-28.
Schertzer, D. and Tchiguirinskaia, I. (2018) 'Pandora Box of Multifractals: Barely Open ?', in Tsonis, A. A. (ed.) Advances in Nonlinear Geosciences. Cham: Springer, pp. 543–563. doi: https://doi.org/10.1007/978-3-319-58895-7_25.