



Talence, January 4th 2021

Letter of recommendation for Dr. A. El Aouni

**To M. François Lott, President, National Committee, Section n. 19, CNRS**

Dear President Lott,

I have supervised the PhD thesis of Anass El Aouni («Lagrangian coherent structures and physical processes of coastal upwelling »), defended September 2019, which awarded Anass the prestigious « prix de thèse systèmes complexes » of ISC-PIF (see <https://iscpif.fr/recherche/prix-de-these/> ). In his thesis work, A. El Aouni showed an exceptional mastery of phenomenological representations of turbulence, in particular in its oceanographic aspects (Lagrangian coherent structures), of which he extended certain properties to solve environmental problems of great interest. The subject of Mr. El Aouni's thesis was centered on the study of the Lagrangian coherent structures associated with the phenomenon of "coastal upwelling", of great importance in oceanography. In signal and data analysis, turbulence represents a typical failure of classical linear approaches. The subject of Mr. El Aouni's thesis was therefore very ambitious and based in a particularly demanding way on multidisciplinary knowledge involving: physics of turbulence, chaotic dynamics, oceanography, signal analysis, remote sensing and computing. One of the major difficulties of this thesis subject was that it went well beyond a classic multidisciplinary approach: it was not a question of using tools from distinct scientific fields, but of effectively possessing in-depth knowledge in the physics of complex systems, in turbulent dynamics, in nonlinear physics and dynamic systems, in image processing and analysis of remote sensing satellite data, in ocean dynamics and in multiscale approaches to complex signals. Only the best students today can approach such topics with confidence and with the necessary hindsight. The study of mixing in nonlinear and turbulent dynamics is a difficult subject tackled in a very innovative way by Anass El Aouni in the context of physical oceanography. He first of all had the idea of relating the classical notion of Lagrangian coherent structure (LCS) defined from the Cauchy-Green tensor and in a recent formulation based on geodesics, to the study of the mixing between surface structure and chlorophyll\_a concentrations. It is necessary to have, as I said above, an intuition based on in-depth knowledge to realize straight away that this geodesic formulation was very adequate to the problematic of oceanic dynamics studied. As turbulence is not thought to fall under descriptions based on deterministic chaos, A. El Aouni made use of descriptors of fully developed turbulence originating from multifractal formalism (singularity exponents), which offers new insight in use of Lyapunov exponents in finite size. A. El Aouni then proposed two very innovative approaches for the definition and automatic determination of coherent Lagrangian vortices: the first geometric, the second frequential. These approaches are then applied, within the framework of a very in-depth international collaboration, to a special upwelling system (Canary Islands).

A. El Aouni was able to integrate and define a network of very high-level scientific collaborations, among others with the team of V. Garçon in Toulouse (LEGOS laboratory), as well as with the MERCATOR project, and his publication record was very impressive at the end of his thesis. The scientific production associated with this research testifies to the energy deployed by Anass during his PhD: 6 articles from very high level international journals (including one IEEE TGRS, one IEEE GRSL, two in the journal Chaos and one in the journal Physics of Fluids of the American Institute of Physics), 6 international conferences including 2 SIAM as well as increased visibility at the AGU (American Geophysical Union) which is a world reference in the geophysical community (Anass obtained an oral presentation at the AGU very early in the accomplishment of his thesis).

I proposed A. El Aouni to come as a PhD student in my team at the time he was very highly recommended to me by the late Prof. Aboutajdine, who pointed out to me at the time Anass as one of his most brilliant students. Anass' research project opens a wide range of fundamental and applied thematics for the years to come: the relationships between LCS, the notion of "Coherent Barrier" he wants to develop and predictability concepts in complex systems have the potential of making real breakthroughs theoretically. In geophysical sciences, and in oceanography, it is very likely, and A. El Aouni is perfectly aware of it, that such a notion of "barrier" must integrate concepts and data that can be learned from acquisitions, hence opening outstanding bridges with the science of complexity and machine learning. The consequences have considerable potential impact in many applications such as data assimilation, ocean dynamics and sea/atmosphere interactions and more generally many environmental problems, as this notion of barrier, when successfully precised (which is a remarkable research project), will be a correct solution for many problems in nonlinear fluid dynamics. This project is multidisciplinary in essence, and I have full confidence in A. El Aouni' strengths to build an extremely solid network of research collaborations that will encompass his skills both theoretically and in many aspects of signal processing and geophysical problems. The work done by Anass El Aouni during his post-doc at INRIA Grenoble demonstrates fully his abilities to fit into the european project C3S Ergo, which involved Anass in a deep collaboration with CERFACS and applied physicists.

**I recommend at the highest possible level the recruitment of A. El Aouni at CNRS.**

Best regards,

**Dr. H. Yahia**

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A handwritten signature in dark ink on a light blue rectangular background. The signature is stylized, starting with a large loop and ending with a long, sweeping horizontal stroke.