

Research evaluation

EVALUATION REPORT OF THE UNIT HM&Co - Hydrologie météorologie et complexité

UNDER THE SUPERVISION OF THE FOLLOWING ESTABLISHMENTS AND ORGANISMS: École des Ponts ParisTech

EVALUATION CAMPAIGN 2024-2025 GROUP E

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High Council for evaluation of research and highter education



In the name of the expert committee :

Marc Brachet, chairman of the committee

For the Hcéres :

Coralie Chevalier, president

In accordance with articles R. 114-15 and R. 114-10 of the Research Code, the evaluation reports drawn up by the expert committees are signed by the chairmen of these committees and countersigned by the president of Hcéres.



To make the document easier to read, the names used in this report to designate functions, professions or responsibilities (expert, researcher, teacher-researcher, professor, lecturer, engineer, technician, director, doctoral student, etc.) are used in a generic sense and have a neutral value.

This report is the result of the unit's evaluation by the expert committee, the composition of which is specified below. The appreciations it contains are the expression of the independent and collegial deliberation of this committee. The numbers in this report are the certified exact data extracted from the deposited files by the supervising body on behalf of the unit.

MEMBERS OF THE EXPERT COMMITTEE

| Chairperson: | Mr Marc Brachet, Centre national de la recherche scientifique – CNRS, Paris |
|--------------|---|
| Experts: | Mr Remko Uijlenhoet, Faculty of civil engineering and geosciences Delft, the Netherlands |
| | Mr Wolfram Wobrock, Université de Clermont Auvergne, Aubière, (représentant de la Comeval) |
| | |

HCERES REPRESENTATIVE

M. Pascal Morin

REPRESENTATIVE OF SUPERVISING INSTITUTIONS AND BODIES

M. Jérôme Lesueur, Deputy director, teaching and research, École des Ponts ParisTech



CHARACTERISATION OF THE UNIT

- Name: The Hydrology Meteorology & Complexity Laboratory
- Acronym: HM&Co Lab
- Label and number: RNSR 201722302X
- Composition of the executive team: Ms. Ioulia Tchiguirinskaia, director; Mr. Daniel Schertzer, deputy director untill April 2022, now advising; Mr. Auguste Gires, risk prevention committee representative & deputy director; Ms. Albertine Fouala-Kimpa, General Secretary of HM&Co, half-time

SCIENTIFIC PANELS OF THE UNIT

ST Sciences et technologies ST3 Sciences de la Terre et de l'Univers ST2 Physics ST6 Information and Communication Science and Technology - STIC ST5 Engineering Science

THEMES OF THE UNIT

HM&Co's scientific goal is to establish the scientific foundation for developing nature-based solutions (NBS) to address urban meteorological and hydrological risks, aiming to enhance city resilience against extreme events. The unit employs stochastic multifractal modelling (accounting for anisotropy effects), experimental data on rainfall, wind and urban hydrology as well as the RADX (Dual-polarisation X-band radar) IT platform, all of which are combined within the Fresnel platform for data analysis and simulations. This seamless integration is one of the strong points of the unit's research themes.

HISTORIC AND GEOGRAPHICAL LOCATION OF THE UNIT

The Hydrology Meteorology & Complexity (HM&Co) laboratory, established in 2017 as the 12th research lab of the École Nationale des Ponts et Chaussées (ENPC), specialises in studying the interactions between urban systems and their environments across various time and spatial scales. Its roots trace back to the 'Multiplicity of scales in hydrology and meteorology' (MHYM) theme, launched at ENPC in 2003, which adopted a multi-scale approach – especially Universal Multifractals (UM) – for methodologies, data analysis, and stochastic modelling of complex systems. HM&Co is based on the ENPC ParisTech campus, housed in the Carnot building at Cité Descartes in Champs-sur-Marne.

RESEARCH ENVIRONMENT OF THE UNIT

HM&Co is a laboratory of the École Nationale des Ponts et Chaussées (ENPC), which resides under the tutelage of the Ministry of Ecological Transition and Territorial Cohesion. Recently ENPC joined the Institut Polytechnique de Paris (IPP), providing a solid institutional foundation (even though future relations with IPP do not seem yet to be completely defined). The unit has collaborated with other units, such as Laboratoire d'hydraulique Saint-Venant (LHSV) and Laboratoire dm Météorologie dynamique (LMD), in response to national and European initiatives (France Relance, PIA4, Horizon Europe).



UNIT WORKFORCE: in physical persons at 31/12/2023

| Catégories de personnel | Effectifs | |
|---|-----------|--|
| Professeurs et assimilés | 0 | |
| Maîtres de conférences et assimilés | 0 | |
| Directeurs de recherche et assimilés | 2 | |
| Chargés de recherche et assimilés | 1 | |
| Personnels d'appui à la recherche | 1 | |
| Sous-total personnels permanents en activité | 4 | |
| Enseignants-chercheurs et chercheurs non permanents et assimilés | 8 | |
| Personnels d'appui non permanents | 3 | |
| Post-doctorants | 2 | |
| Doctorants | 6 | |
| Sous-total personnels non permanents en activité | 19 | |
| Total personnels | 23 | |

DISTRIBUTION OF THE UNIT'S PERMANENTS BY EMPLOYER: in physical persons at 31/12/2023. Non-tutorship employers are grouped under the heading 'others'.

| Nom de l'employeur | EC | С | PAR |
|--------------------|----|---|-----|
| ENPC | 0 | 3 | 1 |
| Total personnels | 0 | 3 | 1 |

GLOBAL ASSESSMENT

The unit aims to provide a sound scientific basis to provide a solid scientific foundation for developing naturebased solutions to address urban hydro-meteorological risks. The unit employs a strategy combining stochastic multifractal modelling and experimental data on precipitation intermittency, wind fields and urban hydrology (supported by the RADX - Dual-polarisation X-band radar - IT platform), which are integrated into the Fresnel platform for data analysis and simulations. This integration is one of HM&Co's key strengths. However, the selfevaluation document's length and formal tone make it somewhat difficult to read. The unit's core theoretical expertise is highlighted by keywords such as: multifractal scaling laws, non-linearity, complex systems, heterogeneity, anisotropy, and 'blunt cascade'. These keywords are not always clearly connected by a scientific argument to the scientific activities, application projects, or to their overall importance for the unit's success. Quantitatively proving the superiority and relevance of this unique expertise over more traditional statistical methods for describing variability, heterogeneity, and extreme event distributions would also have benefited from greater emphasis in both the self-assessment document and presentations during the visit.

The unit operates with limited human resources: three senior researchers (two directeurs de recherche – DR one chargé de recherche - CR), one emeritus senior researcher, , and a research engineer (plus half-time secretary). This constraint poses challenges to the unit's viability, such as issues with radar data availability in recent years. Over the past five to six years, the unit has reinforced its presence at ENPC by securing permanent positions. However, it still faces a significant challenge in lacking dedicated technical support for installing and maintaining its advanced research equipment and associated databases, leaving it up to researchers to manage these tasks largely on their own with occasional support from equipment manufacturers.

HM&Co is a little, internationally recognised research unit known for its welcoming and inclusive approach to hosting staff. Several associated researchers and visiting scientists from partner universities contribute to its work. Despite its small size, the unit has a diverse funding portfolio, including public research subsidies and semi-private



investments. This supports its dual focus on fundamental research-such as addressing scale issues in urban geosciences-and applied research, including contributions to urban water management and the energy transition. Beyond its hallmark analytical tools in stochastic multifractals, the unit has recently made significant investments in observational capabilities, enhancing its appeal to prospective students, staff, and collaborators.

An area of potential growth lies in pursuing external funding opportunities, such as individual excellence grants from the European Research Council (ERC). These grants would not only signify recognition of research quality but also boost HM&Co's national and international standing.

The unit has maintained a strong publication record in international journals, with a focus on open-access publications. Despite the small number of permanent scientists, the publication output is significant, with contributions from PhD students, postdocs, and engineers. HM&Co adheres to principles of scientific integrity, ethics, open science and other relevant guidelines.

In recent years, HM&Co has broadened its research scope and strengthened its scientific foundations. However, its attractiveness and viability still heavily depend on the reputation of its retired senior researcher. This reliance could impact its ability to secure projects, attract students, and collaborate effectively in the future. Although HM&Co continues to contribute to socio-economic contexts through applied research, its expertise in fundamental science remains somewhat isolated. This may be due in part to its limited academic collaborations at the national level, particularly with teams using non-multifractal approaches in hydrological and atmospheric sciences. This challenge is especially relevant given the presence of other institutes working on similar topics—such as Météo-France and Cerema – Centre d'études et d'expertise sur les risques, l'environnement, la mobilité et l'aménagement – supported by the same governmental agency for sustainable development and ecology.



DETAILED EVALUATION OF THE UNIT

A - CONSIDERATION OF THE RECOMMENDATIONS IN THE PREVIOUS REPORT

The recommendations in the previous report were given in the form of three criteria. In a nutshell, they were: criterion 1 (scientific production and activities): 'Do not narrowly follow the funding opportunities.'; criterion 2 (unit's organisation and life): 'Find a remedy to the excessive number of non-permanent staff.'; criterion 3 (scientific strategy and projects): 'Find a solution to increase the size of the laboratory so that it has a certain sustainability.'

The recommendations for the first two criteria have been addressed in a positive manner, as permanent (Comeval-Commission for the evaluation of sustainable development researchers) positions have been obtained and the pressure for finding funds has been reduced.

However, although it was deemed 'urgent' no solution has yet been found to criterion 3: increase the size of the laboratory. The laboratory size remains at three permanent researchers: two permanent (and 1 emeritus) DR, one CR and one research engineer. During the past evaluation period, HM&Co considered not only internal growth, but also international growth through a common international structure such as a UMI (Unité mixte internationale). Unfortunately, despite existing international collaborations (in particular with the Imperial College London), this did not happen.

B - EVALUATION AREAS

EVALUATION AREA 1: PROFILE, RESOURCES AND ORGANISATION OF THE UNIT

Assessment on the scientific objectives of the unit

The unit's scientific objective is to provide the scientific underpinning for the development of nature-based solutions addressing urban hydro -meteorological risks. The strategy is to use stochastic multifractal modelling and experimental data on precipitation intermittency (rainfall and wind, RADX IT platform, etc.) integrated in the Fresnel platform in an environment for data analysis and simulations. This effective integration is the unit's strong point. However, the unit's limited human resources, namely two DR, one emeritus DR and one CR, poses viability problems, together with the lack of radar data availability in the past years.

Assessment on the unit's resources

HM&Co has established a solid financial and infrastructural base. The unit's scientific output and number of contracts are remarkable, given its limited human resources: two DR (and one emeritus), one CR, and a research engineer. Over the past 5–6 years, the unit has consolidated its presence within ENPC with permanent positions. It was noted during the visit that the future relations with the IPP are not yet well defined.

Assessment on the functioning of the unit

The ENPC's human resources management agrees with the school's compliance mandates and commitment to environmental preservation. However, achieving gender parity remains a challenge for HM&Co, as female researchers have not yet reached the 50% target. HM&Co's measures to protect scientific assets and information systems are thorough.



1/ The unit has set itself relevant scientific objectives.

Strengths and possibilities linked to the context

The objectives of HM&Co agree with national and international priorities, as seen through its contributions to the Contrat d'objectifs et de performance (COP) of ENPC, particularly in environmental and resource management. The unit's integration with the Ministry of ecological transition and the IPP provides a solid institutional foundation (even though future relations with IPP are not yet well defined), ensuring that its research conforms to societal needs, such as climate change adaptation and sustainable urban ecosystems. The unit's involvement in the scientific collegium of ENPC confirms this role and the collaboration with other units, such as LHSV and LMD, in response to national and European initiatives (France Relance, PIA4, Horizon Europe), strengthens the possibility of developing research solutions addressing hydro-meteorological risks and, especially the variability of precipitation – key issues highlighted by the Intergovernmental panel on climate change (IPCC) and the World meteorological organisation (WMO).

The unit sees its long-term future in its contribution to refinements of the strategy to adapt the United Nations 2030 Agenda for Sustainable Development. They feel that, in that framework, using traditional approaches such as the Pareto principle (the so-called 80/20 rule) to quantify distributions can be much improved by their original stochastic multifractal approach to variability.

The unit's methodological innovation, particularly the Fresnel platform, and its Software as a service (SaaS)oriented environment for data analysis together with multifractal non-linear modelling presents an original way to address complex urban resilience challenges. Also, its research into nature-based solutions, ecosystem services, and socio-environmental evaluations, incorporating the notion of shared value, reflects an approach that integrates scientific exploration with real-world applications. The focus on co-developing tools with local stakeholders (SIAVB, Syndicat Intercommunal pour l'Assainissement de la Vallée de la Bièvre) highlights a collaborative and adaptive approach to urban water management and resilience building. This original model advances the scientific community's understanding and strengthens the unit's ability to provide societal and economic impact.

Recent permanent recruitment stabilised the HM&Co unit: new statutory positions and the filling of critical roles such as R&D engineers and coordinator for nature-based solutions platforms secured a more solid human resource foundation to the unit. This reinforcement enables the unit to maintain its scientific dynamism and continue contributing to international collaborations, such as those with Imperial College London (ICL).

Weaknesses and risks linked to the context

The main risks and weaknesses are related to the sustainability of the unit's human resources. One immediate concern is the high dependency on key individuals for the leadership of strategic research initiatives. The unit's reliance on its few members: one emeritus senior researcher, two permanent DR and one CR, creates vulnerabilities in the long term. In this context, the now existing Comeval permanent positions did represent a positive development. However, should one of these researchers leave, the unit could experience a leadership gap that would strongly impact ongoing projects and collaborations. While new statutory positions have been filled, the time it took to secure these roles and the actual status of the RADX platform demonstrate a potential challenge in maintaining the pace of research and development when there is a shortage of qualified candidates.

Another area of concern is the unit's dependence on external funding and collaborations for the continuation of some key projects. While international collaborations, such as those with ICL, are a significant strength, they also come with risks. These collaborations, often reliant on complex joint projects and external funding, could be jeopardised by shifts in international research policies, funding cuts, or logistical challenges. The unit's open science initiatives and reliance on Saas models for collaboration, while innovative, also expose it to the risks associated with cybersecurity and data privacy, especially when engaging with international partners and large-scale data-driven research.

Additionally, the unit's ambitious agenda to integrate different scientific approaches and overcome the traditional so-called silo paradigm poses another challenge. While the multidisciplinary approach is essential for addressing the complexities of urban resilience and climate adaptation, there is a risk of fragmentation if the necessary interdisciplinary synergies are not fully realised. The shift from a more traditional 'silo' research to an interactive and multidisciplinary framework is not without obstacles, as it requires not only a conceptual shift but also institutional and cultural changes within the broader geophysical and urban planning communities. Failure to achieve effective cross-fertilisation between disciplines could slow down progress and reduce the overall impact of the unit.



2/ The unit has resources that are suited to its activity profile and research environment and mobilises them.

Strengths and possibilities linked to the context

HM&Co's ability to adapt to its research environment demonstrates significant strengths. In 2023, institutional financing amounted to 325 K€, covering the salaries of statutory researchers and providing additional funding through the ENPC allocation system. This stable financial foundation enables the unit to maintain a strong base of personnel. Beyond institutional funding, HM&Co has been effective in securing external resources, raising approximately 4.5 million euros between 2018 and 2023. This averages 754 K€ per year, or 151 K€ per permanent researcher annually, illustrating the unit's robust capability to attract significant project-based funding. A notable strength is the unit's diverse funding portfolio, with 39.2% of resources sourced from industrial partnerships (Veolia, Régie autonome des transports parisiens - RATP, Soprema, etc.), 21.5% from ANR projects, and 13% from international programs. This broad distribution reduces reliance on a single funding source and strengthens resilience against potential financial instability. Moreover, 76% of the unit's financial resources are linked to collaborations with industrial partners. The unit's growth in financial resources—25% over the evaluation period – is another indicator of its capacity to capitalise on its environment despite challenges such as the Covid-19 pandemic. The successful integration of new scientific equipment from project budgets into the Fresnel platform is an example of HM&Co's strategic use of resources to enhance its research infrastructure. The unit's investment in high-performance computing through projects like the PIA3 TI (GA) CFHF-Territoires d'innovation (grande ambition) Construire au futur, habiter le future-and Veolia Chair also strengthens its technological capacity. These efforts contribute to maintaining state-of-the-art facilities and ensuring that HM&Co remains competitive in its research domain. Furthermore, the unit benefits from free-of-charge ENPC services, such as the Scientific and technical Information centre (IST), which provides valuable support in document management and scientific mediation. Overall, HM&Co has established a solid financial and infrastructural base, positioning itself as a highly adaptive and resourceful research unit within its environment.

Weaknesses and risks linked to the context

HM&Co faces weaknesses and risks linked to its research environment and resource mobilisation strategy. One challenge is the unit's dependency on external project-based funding. While 76% of HM&Co's resources involve industrial partners or communities, reliance on such partnerships could expose the unit to fluctuations. Contracts can be unpredictable, as evidenced by the cancellation of the framework agreement between ENPC and Université Mohammed VI Polytechnique (UM6P), which negatively impacted HM&Co's research project plans. This cancellation, coupled with the lack of competition in the Veolia tender for water management, caused a weakening of the unit's financial stability in 2021-2022, highlighting the risks associated with external dependency. Additionally, although the unit's resource base has grown by 25%, this increase did not fully offset these disruptions. Another point is the overhead charges levied by the ENPC Research Department on most research contracts (15%). Although projects funded by ANR benefit from lower overhead rates, this represents only 21.5% of the unit's funding. Whereas HM&Co has managed to maintain flexibility in managing project funds through local collaborative efforts, the need to rely on shared logistics and individual project leader oversight also presents risks. Furthermore, the unit's workspace constraints, despite the addition of new basement spaces for equipment maintenance and storage, may limit the potential for future growth. The fact that HM&Co needed to invest its own resources in furnishing and equipping these spaces, rather than receiving full institutional support, points to an ongoing challenge in balancing financial resource allocation between research and infrastructure needs. The Covid-19 pandemic illustrated how global crises can severely disrupt research activities. The multi-fractal approach is presented by HM&Co as a paradigm shift for hydrometeorology, which was undoubtedly the case when the unit's emeritus researcher published a series of authoritative papers on the subject in the 1980s-1990s. There appears to be an issue with how the unit perceives its strengths, as the proposed multi-fractal paradigm and its corresponding vision of hydrological and meteorological phenomena do not seem to have fully permeated the relevant scientific community. This appears to have led to frustration and a certain insularity among the unit's DR researchers, which could be detrimental to its other researchers. This is evident, for example, in the HM&Co self-assessment document (Area 1), where it is stated (in the weaknesses section): 'HM&Co has yet to ensure that suggestions on the physics of heterogeneity are taken into account in the IPCC reports."



3/ The unit's practices comply with the rules and directives laid down by its supervisory bodies in terms of human resources management, safety, environment, ethical protocols and protection of data and scientific heritage.

Strengths and possibilities linked to the context

The ENPC's human resources management agrees with the school's compliance mandates and commitment to environmental preservation. The proactive collaboration between human resources and staff representatives has culminated in the comprehensive management note for contractual agents, ensuring clarity and consistency in recruitment and employment processes. This memorandum streamlines administrative functions and acts as a catalyst for addressing previous recruitment challenges, exemplified by the case of a recent failed recruitment, which highlighted the importance of timely communication in retaining talent. The enhancement of recruitment processes is coupled with the fostering of diversity, equity, and inclusion (DEI) within the unit. HM&Co is committed to gender balance, with a target of 50% female researchers, even though this goal appears to be challenging to achieve in practice. Additionally, HM&Co's research agenda is intricately linked to sustainable development goals, particularly SDG 11 - Sustainable cities and communities, which emphasises resilience and sustainability in urban systems, thus reinforcing its role as a leader in addressing pressing environmental challenges. HM&Co's measures to protect scientific assets and information systems are thorough and multi-faceted. Key practices include intellectual property management, IT and data security, physical security, and staff training.

Weaknesses and risks linked to the context

There is ongoing tension between reactive recruitment for graduate students and postdocs and strategic staffing for permanent positions aligned with research goals. This may lead to talent shortages in key roles if positions lack proper justification and long-term funding. Achieving gender parity remains a challenge, as female researchers have not yet reached the 50% target, highlighting difficulties in effective DEI strategies. Additionally, relying on local non-permanent staff for permanent positions raises concerns about potential biases in hiring practices. The shift to remote work during the Covid-19 pandemic exposed weaknesses in digital communication tools, threatening team continuity and cohesion.

A challenge the unit is facing concerns the lack of dedicated technical support staff for installing and maintaining the sophisticated research equipment (and the associated databases) in its novel environmental observatories, forcing the unit's researchers to perform these tasks mainly by themselves, occasionally supported by the manufacturers of the equipment.

EVALUATION AREA 2: ATTRACTIVENESS

Assessment on the attractiveness of the unit

HM&Co is an attractive and internationally recognised research unit with a demonstrated capability to cover the observation, analysis and modelling of the variability of interactions between urban systems and their environment. HM&Co is known for its welcoming and inclusive staff hosting policy with colleagues (Imperial College of London, U.S. Department of Energy, national nuclear security administration, Max Planck institute for meteorology, Hamburg, etc.). The unit is successful in acquiring funding nationally and internationally, ranging from public research subsidies to (semi-) private research investments, helping the unit to realise both its fundamental and its applied research ambitions. Beyond the analytical tools related to stochastic multifractals, HM&Co has significantly invested in increasing its observational capabilities reinforcing the unit's attractiveness for future students, staff and collaborators.

- 1/ The unit has an attractive scientific reputation and is part of the European research area.
- 2/ The unit is attractive because for the quality of its staff support policy.
- 3/ The unit is attractive through its success in competitive calls for projects.



4/ The unit is attractive for the quality of its major equipment and technical skills.

Strengths and possibilities linked to the context for the four references above

HM&Co is a compact, close-knit unit with the mission to 'to cover the observation, analysis and modelling of the variability of interactions between urban systems and their environment over large ranges of time and space scales'. Since its inception in 2017, it has steadily expanded its already strong scientific reputation in the area of stochastic multifractals applied to the geosciences. Although this was originally largely connected to the individual scientific reputation of its (now partly retired) senior researcher, one of the 'founding fathers' of the theory and application of multifractals, the unit's younger senior researchers have steadily gained increased national and international visibility, significantly strengthening the scientific basis of the unit. Under the devoted leadership of its lab director, HM&Co has adopted and consistently followed a (in its own words) 'frugal and agile' research model. The historical strength of the unit in the area of stochastic multifractals and their applications to the geosciences, combined with the more recent reinforcement of its research basis and its supportive management style, together have contributed to an undisputed international recognition.

This recognition is to a significant extent due to the lab's visibility within the three main scientific societies in the geosciences, namely the European Geosciences Union (EGU), the American geophysical union (AGU), and the International union of geodesy and geophysics (IUGG), to which the International Association of Hydrological Sciences (IAHS) belongs. HM&Co is always strongly represented at the general assemblies of these societies (as well as at other, more dedicated conference series, notably Urban rain and the International precipitation conference), not only through its permanent scientific staff members, but also through its postdocs and (PhD) students. The unit's members do not only present their latest scientific advances, they are also actively involved in the planning and organisation of these international meetings, for instance through co-organisation of scientific sessions, townhall meetings, great debates, scientific 'campfires' and more. A particular laudable initiative led by HM&Co is the promotion of 'urban geoscience' as an important cross-cutting, societally relevant research theme with profound scientific questions to be tackled. These questions revolve around the multiplicity of scales and their interactions playing a primordial role in the urban environment. Advancing our understanding of the complexity of the hydrological and meteorological processes in metropolitan areas coincides with the core research focus of the unit.

Further underlining the unit's international reputation, HM&Co's researchers, notably the partly retired senior researcher, have received numerous academic accolades from the mentioned unions (notably EGU's Lewis Fry Richardson Medal and an AGU Fellowship) and other learned societies. In addition, the unit's students regularly receive travel grants to be able to attend such meetings and present their work. Another proof of HM&Co's scientific reputation is the fact that its researchers were asked to act as reviewers for IPCC's sixth assessment report, in collaboration with their colleagues from Imperial College London. Furthermore, its senior researchers play leadership roles in such international organisations, notably the partly retired senior researcher, who was recently elected as president of the International group on urban rainfall (IGUR), a working group of the International Water Association (IWA). Finally, as a logical consequence of its leading role in the (urban) geosciences, HM&Co has acted as an organiser of numerous national and international scientific project meetings at its premises on the ENPC campus.

HM&Co is known for its welcoming and inclusive staff hosting policy. This applies both to new researchers joining the unit, to its regular (inter)national visitors, as well as to new MSc and PhD students supervised by its scientific staff. To maintain the consistent scientific focus that characterises the unit, all new colleagues entering the team receive a basic training in the theory of stochastic multifractals and their applications in the (urban) geosciences. This guarantees that all team members speak the same language, which is a prerequisite for being able to jointly tackle the major scientific and societal challenges the unit has engaged in. The unit claims that 'the small size of HM&Co becomes a real advantage for this'. Furthermore, the strong international network of the unit allows many graduate students to spend significant time abroad as part of their training as researchers, a particularly enriching experience for the students as well as an excellent manner to spread the word internationally on the unit's research approach and philosophy. In many cases in the past, this has led to PhD degrees with the European doctorate label.

HM&Co is connected to several universities and research institutions abroad on the basis of collaboration agreements. Several associated researchers and/or scientific visitors of HM&Co hold professorships at universities with which HM&Co collaborates. In this respect, a particularly strong academic collaboration with the Environmental and water resources engineering (EWRE) section of Imperial College London has been developed. In addition, visits to HM&Co of the world-renowned hydrology professor Taikan Oki (University of Tokyo) in 2023 should be mentioned here. That the knowledge and expertise its doctoral students acquire during their doctoral training is much appreciated by future employers is exemplified by the fact that all of its recent graduates find new jobs within months after graduating. A downside of this attractiveness is that the unit faces



difficulties retaining excellent postdocs, who regularly find more stable and better-paid positions before completing their postdoctoral fellowships. Finally, underlining the unit's inclusive and open approach to scientific research, HM&Co is a strong supporter of open science, with the vast majority of its scientific papers being published in open access journals. The fact that several of its researchers act on editorial boards of such journals helps to further promote the unit's open science approach.

HM&Co is quite successful in acquiring external funding to realise its scientific ambitions, both at national level (ANR Evnaturb, RW-Turb Ra2DW subsidies, private sector investments) and at the international level (EU projects RainGain and Blue green dream funded by the European institute of innovation and technology - EIT, Interreg, Horizon Europe and comparable programs). The fact that the unit does not only depend on public research subsidies but also attracts (semi-) private market party investments (Veolia, RATP) in its research (notably through establishing so-called research chairs) demonstrates that HM&Co is able to connect its fundamental research line on stochastic multifractals in the geosciences to more applied research of direct relevance for societal stakeholders. The latter notably concerns research related to nature-based solutions for tackling urban water management challenges (floods, drought) and to the energy transition (hydro - meteorological phenomena associated with wind farms). The research unit appears to be particularly well connected to local stakeholders dealing with urban environmental issues in the Paris metropolitan area. The acquired funding from external parties is mainly used to support the employment contracts of doctoral students and postdoctoral fellows, as well as to acquire and maintain advanced research equipment.

HM&Co has historically been mostly associated with its contributions related to scale issues in the (urban) geosciences, notably through fundamental and applied research on stochastic multifractals. More recently, however, the unit has made significant investments in (1) developing software packages for environmental analysis and simulation and (2) acquiring advanced research hardware for environmental sensing. Examples of the former include software packages for multifractal analyses and simulations of environmental fields as well as for simulating hydrological processes in (peri-) urban river catchments (Multi-Hydro). Examples of the latter include: (1) a doppler-polarimetric X-band radar for weather surveillance over the Paris metropolitan area; (2) the Taranis platform (comprising optical and video disdrometers, weather stations, anemometers and a vertically pointing radar, all for detailed studies of hydrometeorological processes at the interface between the land surface and the atmosphere); (3) the Blue-green wave, a one-hectare undulating green roof, the largest of its kind in France, effectively acting as an open-air living laboratory to study nature-based solutions in an urban context. These investments in advanced research infrastructure during recent years have helped HM&Co to significantly broaden its experimental research portfolio, thereby significantly increasing its attractiveness for future students, staff members and collaborators.

Weaknesses and risks linked to the context for the four references above

Although during recent years, HM&Co has significantly strengthened its scientific basis and broadened its research scope, the attractiveness of the unit still hinges to a large extent on the reputation of its partly retired senior researcher, which in the near future may negatively affect the viability of the unit in terms of its project acquisition potential and its potential to attract new students, colleagues and collaborators. More in general, while a compact, close-knit unit such as HM&Co may be amenable to a 'frugal and agile' research model, it is also more prone to stochastic fluctuations caused by arrivals and departures of individuals.

In the self-assessment document, no collaborations with other hydrological research laboratories at the national academic level are mentioned (not even on the ENPC campus). This is especially true for other institutes working on hydrological risks and resilient cities supported by the same governmental agency for sustainable development and ecology, such as Météo-France, Cerema and others.

A currently untapped source of external funding concerns individual excellence grants from the European research council (ERC) and similar programs, which (beyond being a recognition of research quality in itself) could help HM&Co to further expand its attractiveness at a national and international level.

EVALUATION AREA 3: SCIENTIFIC PRODUCTION

Assessment on the scientific production of the unit

The unit published a significant number of articles in various international journals (mainly open access) mainly in the best journals in the discipline. Publications are of high quality. The number of publications is important with respect to the low number of permanent scientists. Next to them also all other members of HM&Co (PhD students, postdocs and engineers) participate in publications. HM&Co strictly complies with the principles of scientific integrity and ethics and with the applicable guidelines in this field.



- 1/ The scientific production of the unit meets quality criteria.
- 2/ The unit's scientific production is proportionate to its research potential and properly shared out between its personnel.
- 3/ The scientific production of the unit complies with the principles of research integrity, ethics and open science. It complies with the directives applicable in this field.

Strengths and possibilities linked to the context for the three references above

The unit has published 56 articles of high quality in numerous international journals mainly in the field of hydrology (Science of the total environment, Urban water journal, Journal of applied meteorology and climatology, ...). Articles focusing on complex sciences and their application are published in journals open for a broader scientific public. Most publications are available in open access. In addition, members of the unit contributed to international conferences with 92 communications.

The type of published papers ranges from results on new theoretical developments and advances in complexity sciences and physics of heterogeneity to observational findings obtained from the multiple instrumentation (radar, rain gauges, disdrometer, micrometeorology, soil) which were setup and operated by the research group and their partners. Most publications are based on the theory of stochastic multifractals applied to the fields of hydrological risks and urban resilience. The development and application of the hydrological model Multi-Hydro also presents a key element in numerous publications. By this means innovative themes in urban hydrology like Natural Based Solutions were tackled.

The editorial policy of the unit guarantees very good recognition of its research results. The scientific production of the unit is in line with the Declaration on research assessment (Dora).

The production level exceeds the level expected for a small unit. HM&Co takes great care to ensure that each contribution is properly recognised. PhD students and postdoctoral scientists are leading authors of most papers. Engineering staff and external partners (academic or industrial) do also participate in the list of authors. Thus, shared rules are applied by the unit also enabling that priority is given to quality.

All researchers of the unit as well as their partners are committed to communicate science to the professional and public audience in a responsible manner. To achieve this, all research trainees and early career scientists at HM&Co become acquainted with the principles and standards of good scientific practice, guided by their research supervisors and the scientific integrity referent of ENPC.

HM&Co strictly complies with the principles of scientific integrity and ethics. It complies with the principles of open science, as well as with respect to the collected environmental data.

Weaknesses and risks linked to the context for the three references above

Numerous essential results discussed in the unit's report include references to short conference proceedings, but references to the corresponding peer-reviewed journal articles are missing. The unit should be more accurate in the compilation of their list of publications.



Assessment on the inclusion of the unit's research in society

Inclusion of the unit's research in society is very good. HM&Co researchers transfer any research result, that may have an economic interest. Industry and/or local authorities are actively involved in most research projects. This strategy makes it possible to co-finance the full spectrum of the unit's research activities, including funding not only doctoral students and postdoctoral researchers, but also long-term contractual staff. Until 2021 the unit could benefit from the Chair in hydrology for a resilient city, endowed by Veolia. New collaborative projects with economical partners are under way and new possibilities of short-, medium- and long-term partnerships in collaboration with the ENPC's Co-innovation lab are in preparation.

- 1/ The unit stands out for the quality and the amount of its interactions with the non-academic world.
- 2/ The unit develops products for the cultural, economic and social world.
- 3/ The unit shares its knowledge with the general public and takes part in debates in society.

Strengths and possibilities linked to the context for the three references above

The scientific and technological scope of HM&Co focuses on the resilience of our urban systems, which are highly vulnerable to extreme weather like extreme winds, heat waves and heavy rainfalls. The activities with socio-economic partners mainly concern the following three (partly interrelated) topics: (1) Nature-based solutions to improve climate adaptation actions, (2) full-scale developments to increase the resilience of our cities to water management challenges; and (3) transitions towards shared economic values, including increased performance and optimisation of alternative energy production.

Topics (1) and (2) mainly concern the EU LIFE Artisan - Accroître la résilience des territoires au changement climatique par l'incitation aux solutions d'adaptation fondées sur la nature - project (2020-2027), merged with the National Plan for Adaptation to Climate Change (PNACC, coordinated by the Office français pour la biodiversité), as well as the national project PIA3 TI (GA)-CFHF, managed by SGPI (Secrétariat général pour l'investissement) and Caisse des Dépôts, supporting the French Program of investments for the future.

The Artisan project aims to strengthen capacities and create the framework necessary to contribute to the multiplication of local nature-based adaptation projects during the 2020 decade. The use of different bluegreen solutions (pools, green roofs, storm gardens, etc.) can essentially help for stormwater management to store and to slow down water runoff, as well as improving urban climate by cooling the atmospheric surface layer through evapotranspiration of the vegetation. Inside the project Artisan HM&Co contributes to several actions related to the experimental monitoring of pilot sites, the development of performance evaluation tools and their promotion in terms of teaching.

Within the PIA3 TI (GA)-CFHF project, several small size enterprises (Soprema, Boralex, Rain++) developed their activity on the promotion of NBS to improve the resilience of the Île-de-France region, again mainly on problems of flooding and heat islands.

The unit's contribution to the project TIGA-CFHF (Building in the future, living in the future), consists in their research developments on the shared value which will be finalised with user-friendly software for better environmental and societal management.

Topic (3) concerns the collaboration with FEM (France énergies marines) for the optimisation of alternative energy production (project Nemo). HM&Co's task as part of the Nemo (Nouvelles méthodes pour la mesure et la modélisation de la turbulence éolienne en mer) collaborative project is the characterisation of offshore wind fluctuations and turbulence in a scale invariant framework. This will be achieved using both on-site high-resolution anemometry and lidar observations for comparison. The general objective of the project is the standardisation with FEM of a scale-invariant metric to quantify extreme winds.



A main contribution of HM&Co to the socioeconomic world is the scientific investigation of blue-green solutions (BGS, e.g., green roofs), which appear to be quite a relevant tool to make the city more resilient in the face of threats like heat waves and heavy rainfalls while quality of life improves. HM&Co's efforts concern all research activities of the unit, i.e. short to long-term in situ experiments and observations (blue-green wave, X-band radar), development and improvement of hydrological models (Multi-Hydro) up to the multifractal analysis and modelling to provide user-friendly tools for cities (Société du grand Paris, Certivéa, Jardin de Gally).

HM&Co's policy on participative science activities and valorisation is well established as indicated by the Artisan and TI (GA)-CFHF projects. Another example is the Chair of Hydrology for resilient city, endowed by Veolia. In this context the unit contributed operational tools to combat flooding, in understanding of essential constraints and challenges of local flood risk (Bièvre valley) and contributed as well to the implementation of an automated management system for hydraulic works (managed by the industrial partner SIAVB). In addition, two patents were already granted to HM&Co researchers: the first one is the disdrometer patent (European patent EP3246692, 2018), a second one is a 'Corolle' patent BR098614/FGA/AMD (revegetation with innovative green structures made of a composite material).

The unit shares its knowledge with the public through classical media (France Info, BFM TV, France Culture) and also social networks (X, Linkedin, YouTube) and participates in debates in society (e.g. Resilience of urban systems, conferences on the future of transport and the challenges of decarbonisation). In addition, HM&Co works closely with the ENPC communication department. The unit engages in co-creation and knowledge transfer, policy-related advice by providing briefings and media contributions, as well as developing software, data libraries and patents.

Weaknesses and risks linked to the context for the three references above

The projects PIA3 TI (GA)-CFHF as well as LIFE Artisan regroup a very large number of academic and nonacademic participants. Herein HM&Co bears responsibility for transversal actions on shared values in urban hydrology and resilience. In addition, several other projects (e.g., Ra2DW Radar rainfall drop size distribution and wind with Taiwan national university and FEM-Nemo) in the area of meteorology (rain microphysics, turbulence and wind) are also ongoing at HM&Co. The quantity and the diversity of the projects, combined with the limited workforce of HM&Co (3 researchers), create a certain risk for the unit to successfully accomplish all its responsibilities.

Most projects are certainly supported by PhD students and postdoctoral scientists. But their participation also requires technical training and academic supervision, presenting additional workload for the responsible scientists.

The positioning of the unit in the different steps of the innovation process is not detailed and cannot really be identified in the self-evaluation document. It is also quite difficult to assess the technology readiness level of the unit's products and to what extent they match the expectations of end users. Unfortunately, these details could not be addressed during the audition due to time constraints.

The self-evaluation document explains contributions to the development of core projects for several small size enterprises but does not give any indication on the impact of the unit on the economic, social or cultural position of its economic partners and 'the exploitation of its assets'.

HM&Co plans to prepare the new market for small size NBS enterprises by providing radar data in which a nowcasting component will be included. This activity appears quite expensive for a unit of subcritical size.



ANALYSIS OF THE UNIT'S TRAJECTORY

The 'Multiplicity of scales in hydrology and meteorology' (MHYM) theme was established at ENPC in 2003, emphasising its significance in urban water cycle research. It employs a multi-scale approach, particularly Universal multifractals (UM), which is foundational for methodologies, data analysis, and stochastic modelling of complex systems. The MHYM was then led by the actual HM&Co emeritus researcher, recognised for his contributions with the European geophysical union (EGU) Lewis Fry Richardson medal in 2015. In 2017, the Hydrology Meteorology & Complexity (HM&Co) lab was officially formed as the twelfth research laboratory of ENPC, focusing on analysing the interactions between urban systems and their environments over a range of time and space scales.

HM&Co develops nature-based solutions (NBS) for urban hydrological risks. The unit uses stochastic multifractal modelling (including anisotropy effects), experimental data on rainfall and wind, and the RADX IT platform, which are integrated in the Fresnel platform for data analysis and simulations. This effective integration is the unit's strong point. A research example is the 'Chaire de recherche RATP : Adaptation du patrimoine bâti de la RATP aux conséquences du changement climatique'. A teaching example is the module in the ENPC Master 2 Ville environnement tTransport): 'Défis, sciences & outils pour la transition des villes et territoires' that HM&Co is teaching, with a hands-on approach to the RADX IT platform.

Recent results on the extreme variability of geophysical fields and the blunt extension of discrete multifractal cascades have validated HM&Co's scientific approach to variability. Also, new applications to radar estimation of high-resolution rainfall and urban management of rainwater have been obtained in the current Ra2DW project (an international project between the department of civil engineering of Taiwan National University (NTU) and HM&Co).

In 2021, ENPC signed a multi-year objective and performance contract (COP) with the Ministry of Ecological Transition, outlining strategic directions for 2022-2026. HM&Co played a crucial role in this development. The ENPC's strategic initiative, 'Les Ponts Ambition 2030', invites open discussions about future developments, integrating feedback from various institutions through workshops.

Three key perspectives have emerged from these discussions:

(1) Integration of ENPC into IP Paris: This aims to streamline collaboration and enhance research synergies.

(2) Coordination of research and teaching: This involves harmonising these two pillars of ENPC's activities to foster new collaborative approaches.

(3) Strengthening climate change mitigation efforts: A commitment to addressing the impacts of climate change through research and action.

HM&Co's overall objective remains to provide disruptive concepts, methodologies, observations, models, and simulations to increase the sustainability of urban systems and their resilience to water, weather, and climate extremes. These problems have complexities that result from strong nonlinear interactions in and between systems over a wide range of space-time scales that generate an extreme multiscale variability with complex chains of causality.

With respect to previous years, the strategy, for the next five years was detailed in the unit's auto evaluation document 'Five-Year Roadmap Overview' and during the visit.

The strategic direction for HM&Co over the next five years is the continuation and extension of previous efforts. A key example of this progression is provided by the comparison between the former EU project Blue green dream and the current EU project Artisan. The former was a conceptual project focusing on nature-based solutions, but with little emphasis on climate change. In contrast, Artisan emphasises nature-based adaptation solutions (NBAS), specifically geared towards climate adaptation, with a focus on large-scale implementation. This shift from conceptual to practical application is essential in climate adaptation efforts and requires broadening the scope of scientific collaborations.

To successfully implement large-scale NBAS, HM&Co will continue expanding its partnerships, both nationally and internationally. Nationally, key collaborations include: the CNRS Research Groups (GDR) turbulence, multifractal analysis and Thematic Networks (RT) Anais – Analyse et interactions, geophysical and astrophysical fluid mechanics; the French water partnership; The French mathematical society; The higher council of Meteorology. Internationally, HM&Co contributes to several scientific organisations, including: American geophysical union; Asia Oceania geosciences society; European Geosciences Union; European physical society; International union of geodesy and geophysics; Joint International Water Association/International Association for Hydro-environment Engineering and research Committee on Urban Drainage; Unesco Complex system digital campus. These collaborations align with the priorities of the Ministry of Ecological Transition and Territorial Cohesion and ENPC's mission to lead the ecological and energy transitions.



RECOMMENDATIONS TO THE UNIT

Recommendations regarding the Evaluation Area 1: Profile, Resources and Organisation of the Unit

Based on the self-assessment document and observations during the unit's visit, it appears that the radar has been non-operational since 2021, with available data predating this period. Considering that the projects of the unit with their socio-economic partners aim for quantitative precipitation estimates, the committee recommends that the unit and the school's executive board ensure effective support from ENPC for the radar and other hydrometeorological instruments. Hiring a research engineer to manage the radar's operational functionality, maintenance, regular updates, signal processing, and data handling would be essential. It will also be crucial to validate RADX measurements with those of Météo-France radars. This is a prerequisite for using the radar in 'nowcasting' mode as envisioned.

If the unit wants to achieve its research ambitions, it is essential to invigorate communication of the multi-fractal paradigm to the hydrological and meteorological communities (including climatology). While the unit has produced numerous high-quality publications in specialised journals, book chapters and books, these seem more focused on consolidating HM&Co's expertise rather than convincing 'non-believers' of the paradigm's validity and value. Efforts should be made to explicitly demonstrate, for instance, that using the multi-fractal approach to quantify heterogeneity (e.g., extreme event distributions) enables the development of new statistical indicators that outperform those currently used by hydrological and meteorological agencies.

In terms of interactions with academic colleagues and the broader scientific community, HM&Co seems relatively insular and somewhat defensive. Over the next 5–6 years, it is important to cultivate a more open mindset. This would benefit HM&Co by promoting the dissemination of its unique knowledge and further enhancing its scientific reputation.

Currently, HM&Co primarily leverages its unique expertise in socio-economic contexts through a steady flow of applied research projects. However, in terms of scientific progress, this expertise appears largely confined within the unit due to a lack of academic collaborations, particularly at the national level, with teams using non-multi-fractal approaches in hydrological and atmospheric sciences. The committee recommends fostering such collaborations, which would enable HM&Co researchers already strongly involved in hydrology to broaden their horizon regarding other hydrological approaches, while the HM&Co researchers specialised in multi-fractal methods and extreme events could establish stronger connections with Météo-France, for instance.

One of the main recommendations from the previous report was to find a solution to increase the unit's size to strengthen its viability. However, despite being deemed 'urgent', no definitive solution has yet been found. HM&Co did consider international growth through a joint international structure such as an International mixed unit (UMI). Unfortunately, despite existing international collaborations (notably with Imperial College London), this has not materialised. Uncertainties surrounding IPP and ENPC's involvement in IPP seem to be contributing factors. The experts reiterate the urgency of finding a solution to broaden the scientific basis of HM&Co, either as a separate unit or as a research group within another unit (or units). ENPC should clarify its position on the importance and structure of IPP, as this clarification could help the unit to orient itself with respect to this important development in the Parisian research and education ecosystem. In the long term, the unit should reflect on addressing its subcritical size.

Recommendations regarding the Evaluation Area 2: Attractiveness

In order to maintain its status as an attractive and internationally recognised research unit, the directors of HM&Co and ENPC should collaborate to find ways to reinforce the unit's scientific basis, notably by securing dedicated technical support staff for installing and maintaining its advanced research equipment and associated databases and eventually by hiring additional researchers, strengthen collaborations with other institutes working on hydrological risks and resilient cities supported by the same ministry, such as Météo-France, Cerema and others, create an environment where researchers are stimulated to consider applying for individual excellence grants from the European research council (ERC) or similar national programs.

Recommendations regarding Evaluation Area 3: Scientific Production

The committee encourages HM&Co to continue its publication strategy into the future, respecting the principles of research integrity, ethics and open science.



Recommendations regarding Evaluation Area 4: Contribution of Research Activities to Society

HM&Co researchers have established strong collaborations with societal partners. To continue this collaboration and to create new partnerships, HM&Co should define the mission of the Fresnel platform as part of the ENPC's Co-Innovation Lab and ensure its functioning, jointly with the support of its supervising authority (ENPC). As forecasting as well as nowcasting are fundamental tasks of Météo-France, the unit must seek a straightforward collaboration with Météo-France for its radar projects with operational purposes.



RESPONSES TO SUPERVISING BODIES CONCERNS

Response to the ENPC's point of attention on HM&Co.

ENPC indicates in its point of attention that it does not have the means to massively strengthen HM&Co in the near future and that it is therefore studying the possibility of changing its status to that of a research team attached to an existing ENPC laboratory.

In response to this point raised by the ENPC supervisory body, we would like to reiterate some of the points already made in our general recommendations.

The unit's scientific output and number of contracts are remarkable, despite its limited human resources: two DR (and one emeritus), one CR and one research engineer. Over the last 5-6 years, the laboratory has been consolidated with permanent posts. HM&Co remains a very small laboratory, which is a weak point. For example, the radar stopped working in 2021 and the data currently used dates from before 2021. The committee recommends hiring a research engineer to look after the radar in terms of operational running, maintenance, regular updating and signal and data processing.

One of the main recommendations of the previous Hcéres report was to find a solution to increase the size of the laboratory in order to make it more sustainable. Although this was deemed 'urgent', no solution has yet been found. HM&Co has envisaged international growth through a joint international structure, a UMI (Unité mixte internationale). Unfortunately, despite existing international collaborations (notably with Imperial College London), this has not happened. This failure seems to be perceived at the unit level as being caused by uncertainties about the IPP and whether or not the ENPC will invest in the IPP.

A slightly different possibility was also mentioned during the visit: attaching one of the DR researchers to one laboratory and the other CR researcher to another. This would enable HM&Co hydrology researchers to broaden their horizons to include non-multi-fractal hydrological approaches, and HM&Co researchers who specialise in multi-fractals and extreme events to have more links with Météo France, for example.

It would seem necessary to discuss these developments rapidly and openly with the director of the unit, and in particular with its two researchers and its IT engineer.

The chosen solution must be able to maintain the unit's existing strengths, in particular its leading scientific activity, its researchers, its research engineer, its radar equipment, its rain gauge equipment and its data analysis and simulation platform.



CONDUCT OF THE INTERVIEWS

Date

Start: 20 November 2024 at 08:30 a.m.

End: 20 November 2024 at 17:00 p.m.

Interview conducted: on-site

INTERVIEW SCHEDULE

Jour 0 – 19 novembre

19h00 : Dîner de travail du comité en huis clos (restaurant au centre-ville)

- Jour 1 20 novembre
- 08 :30 08 :45 : Accueil du comité et des participants

08:45-09:00: Introduction de la visite par le conseiller Hcéres (P. Morin)

Présence : membres du Comité, conseiller Hcéres, représentants des tutelles, direction de l'unité, responsables des thèmes, ouvert au personnel de l'unité

09 :00 – 10 :00 : Présentation de l'UR et du bilan des activités (I. Tchiguirinskaia) Présentation (30 min) - Discussion (30 min)

Présence : membres du Comité, conseiller Hcéres, représentants des tutelles, direction de l'unité, responsables des thèmes, ouvert au personnel de l'unité

10:00 - 10:45: Présentation de la trajectoire Présentation (40 min) - Discussion (30 min)

Présence : membres du Comité, conseiller Hcéres, représentants des tutelles, direction de l'unité, responsables des thèmes, ouvert au personnel de l'unité

10:00-10:10: Orientation scientifique confirmée (A. Gires)

10:10-10:20: Ponts 2030, outils scientifiques et informatiques ouverts pour les ingénieurs (G. Drouen)

10 :20 – 10 :30 : Chaire RATP : Adaptation du patrimoine bâti de la RATP aux conséquences du changement climatique (P.-A. Versini)

10:30-10:40: Trajectoires croisées sur les multifractals (D. Schertzer)

10:40-11:10: Discussion sur la trajectoire

11 :10 - 11 :20 : **Pause-café**

11:20 – 11:45: Échanges sur les exposés et les ambitions de l'UR dans le nouveau contexte d'IP Paris Présentation (10 min) - Discussion (15 min)

Présence : membres du Comité, conseiller Hcéres, représentants des tutelles, direction de l'unité, responsables des thèmes, ouvert au personnel de l'unité

11 :45 - 12 :30 : Rencontre huis clos avec les tutelles

Présence : membres du Comité, conseiller Hcéres, représentants des tutelles, sans la direction de l'unité 12 :30 – 13 :45 : **Déjeuner servi sur place et visite des installations expérimentales**

Présence : membres du Comité, conseiller Hcéres, représentants des tutelles, direction de l'unité, responsables des thèmes, ouvert au personnel de l'unité

13 :45 – 14 :30 : Rencontre huis clos avec les chercheurs de l'unité et les personnels d'appui à la recherche

Présence : membres du Comité, conseiller Hcéres, personnels concernés de l'unité, sans la direction de l'unité 14 :30 – 15 :00 : **Rencontre huis clos avec les doctorants, post-doctorants et CDD Recherchede l'unité**

Présence : membres du Comité, conseiller Hcéres, personnels concernés de l'unité, sans la direction de l'unité 15 :00 – 15 :45 : **Rencontre huis clos avec la direction de l'unité**

Présence : membres du Comité, conseiller Hcéres, direction de l'unité

15 :45 – 16 :00 : **Pause-café**

16:00 - 17:45: Rencontre huis clos du comité d'experts

Présence : membres du Comité, conseiller Hcéres

17:45 – 18:00 : Message de conclusion du Président

Présence : membres du Comité, conseiller Hcéres, direction de l'unité 18 :00 **Fin de la visite**

PARTICULAR POINT TO BE MENTIONED

N/A



GENERAL OBSERVATIONS OF THE SUPERVISORS

Champs-sur-Marne, le 11 mars 2025



Objet : Observations de portée générale sur le rapport d'évaluation - DER-PUR260025178 - HM&Co - Hydrologie météorologie et complexité.

Madame, Monsieur,

Le 19 février 2025, vous nous avez transmis le rapport d'évaluation du laboratoire HM&Co - Hydrologie météorologie et complexité.

Comme demandé, vous trouverez ci-dessous les observations de portée générale sur ce rapport, rédigée par l'École nationale des ponts et chaussées.

L'ENPC tient tout d'abord à remercier les membres du comité pour leur travail minutieux et détaillé d'évaluation des travaux et de l'organisation du laboratoire HM&Co.

Le rapport émet des appréciations élogieuses concernant la qualité des recherches conduites par les chercheurs de ce laboratoire. Ces évaluations positives renforcent notre détermination à soutenir ces travaux dans un cadre stable et pérenne.

Nous avons également pris note des observations des membres du comité, qui ont souligné la fragilité du laboratoire, notamment en raison de sa petite taille : trois chercheurs, un ingénieur de recherche et un chercheur retraité. Ce constat avait déjà été établi lors de la précédente évaluation Hcéres, et le rapport indique qu'aucune solution n'a été apportée au cours des cinq dernières années.

La difficulté à accroître l'effectif du laboratoire HM&Co doit être considérée à la lumière des réelles possibilités de recrutement dans le contexte actuel, extrêmement tendu, où les créations de postes de chercheurs, enseignants-chercheurs et personnels d'appui à la recherche sont rares.

Néanmoins, l'ENPC partage l'avis du comité selon lequel la situation de HM&Co nécessite une réflexion approfondie afin que les travaux de recherche originaux et de qualité puissent se poursuivre et se développer. Cette réflexion sera menée en étroite collaboration avec les chercheurs de HM&Co, en s'appuyant sur les nombreuses recommandations du rapport d'évaluation, dans le but de proposer une nouvelle organisation qui sera mise en œuvre avant la fin du prochain mandat.

Nous vous prions d'agréer, Madame, Monsieur, l'expression de nos respectueuses salutations.

Xavier CHATEAU Directeur-Adjoint de la Recherche.

École nationale des ponts et chaussées 6 et 8 avenue Blaise-Pascal, Cité Descartes Champs-sur-Marne F-77455 Marne-la-Valée cedex 2 tél. 33 (0)1 64 15 30 00 fax. 33 (0)1 64 15 34 09 www.ecoledesponts.fr



March 11th, 2025

Reference: E2026-EV-0772517T-DER-ER-DER-PUR260025178-ST3-HM&Co-RT Object: General observations on the evaluation report

We would like to sincerely thank the Hcéres experts for their time and thoughtful evaluation of our laboratory. One challenge, which may seem paradoxical, is that despite its sub-critical size, our unit covers a vast scientific landscape. Our research is focused on extremely variable processes on large ranges of spatio-temporal scales, both for analysis and for simulation, and with various applications. Certainly, with an emphasis on the interactions between urban systems and geophysics, but this field is also very vast. Furthermore, our epistemological approach is intentionally disruptive: we aim to master this complexity by developing concepts and tools with both a broad, universal scope and significant novelty compared to traditional methodologies and statistical indicators. For example, we explore strongly non-Gaussian stochastic processes, which easily lead to divergences in statistical moments, whereas classical statistical approaches assume all moments to be convergent.

In this line of thought, it appears that the committee of experts preserved the diversity of perspectives of its members in its report, concatenating different contributions without seeking to obtain a consensus. This is illustrated by some contradictory statements and factual errors (reported in a separate file). That should prompt readers to read the report in its entirety to form their own opinion. The correction of factual errors would in turn strengthen the impartial reading.

We also regret that the *"formal tone"* of our self-evaluation document made it *"somewhat difficult to read"*. While formal language is, by definition, the language of professional reporting, we may have underestimated the methodological sensitive division existing in the scientific field of hydrology between those who practice classical statistics and those who prefer to move to stochastic processes.

Therefore, HM&Co researchers regret that this difficulty in reading could have led to certain shortcuts and misinterpretations:

- The reformulation of our scientific objectives and keywords in a way that significantly narrows their scope, subsequently leading to questions about "their overall importance for the unit's success";
- The quotation of sentences from our self-assessment document, which are presented out of context and may support opinions that contradict our original statements;
- The omission of multiple collaborations with national and regional institutions including Météo-France, Cerema, OFB, Ademe, CSTB, INRAE, and several universities or academic networks - which were extensively detailed in our self-assessment document, presentation, and joint scientific publications. This omission gives the misleading impression that "HM&Co seems relatively insular and somewhat defensive";
- The repeated emphasis on HM&Co's limited human resources, initially cited as a risk due to our sub-critical size, yet paradoxically followed by a suggestion that this issue could be addressed by *"attaching one junior researcher to one laboratory and the other junior researcher to another."* At present, the definition of "junior researcher" in the context of HM&Co remains unclear.

Hydrologie Météorologie et Complexité (HM&Co) École nationale des ponts et chaussées | Institut Polytechnique de Paris 6-8 av. B. Pascal, 77455 Marne-la-Vallée Cedex 02 France sec. +33 6415 3634 <u>hmco.enpc.fr</u> In fact, the strong relationship between HM&Co researchers is a key-factor explaining part of the successes achieved in funding research projects and a production level exceeding the level expected for a small unit (according to the words of the committee). They are used to collaborate in the projects' proposals and implementation, but also in courses development (e.g., DSOTV). The personal and scientific association and complementarity of the different members is clearly a strength for the lab. For this reason, splitting the lab is surely the worst decision to take. It would break the good dynamics that has led to the success of HM&Co during the last period.

Joining the call of French Minister of Higher Education and Research to defend *"the very principles of academic freedom, of free research, driven by curiosity, but also of the anticipation of the great challenges of our century",* the HM&Co researchers highlight the following statements of the report, as being highly relevant and particularly important for future developments of our unit:

- "HM&Co is an attractive and internationally recognised research unit with a demonstrated capability to cover the observation, analysis and modelling of the variability of interactions between urban systems and their environment. HM&Co is known for its welcoming and inclusive staff hosting policy with colleagues (Imperial College of London, U.S. Department of Energy, national nuclear security administration, Max Planck institute for meteorology, Hamburg, etc.). The unit is successful in acquiring funding nationally and internationally, ranging from public research subsidies to (semi-) private research investments, helping the unit to realise both its fundamental and its applied research ambitions. Beyond the analytical tools related to stochastic multifractals, HM&Co has significantly invested in increasing its observational capabilities reinforcing the unit's attractiveness for future students, staff and collaborators." (p.10)
- "The unit published a significant number of articles in various international journals (mainly open access) mainly in the best journals in the discipline. Publications are of high quality. The number of publications is important with respect to the low number of permanent scientists. Next to them also all other members of HM&Co (PhD students, postdocs and engineers) participate in publications. HM&Co strictly complies with the principles of scientific integrity and ethics and with the applicable guidelines in this field." (p.12)

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Ioulia Tchiguirinskaia, Director of HM&Co

The Hcéres' evaluation reports are available online: www.hceres.fr

Evaluation of Universities and Schools Evaluation of research units Evaluation of the academic formations Evaluation of the national research organisms Evaluation and International accreditation



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