



Assessing the Variability of Ephemeral Gully Erosion using High-Frequency Monitoring and GIS Modeling

Edouard Patault, Claire Alary, Christine Franke, Arnaud Gauthier, Nor-Edine
Abriakc

► To cite this version:

Edouard Patault, Claire Alary, Christine Franke, Arnaud Gauthier, Nor-Edine Abriakc. Assessing the Variability of Ephemeral Gully Erosion using High-Frequency Monitoring and GIS Modeling: Case study in a fully cultivated catchment (Pommeroye, Northern France). 2017 Fall Meeting, AGU, Dec 2017, New Orleans, United States. , 2017. hal-01657889

HAL Id: hal-01657889

<https://hal.science/hal-01657889>

Submitted on 7 Dec 2017

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Assessing the Variability of Ephemeral Gully Erosion using High-Frequency Monitoring and GIS Modeling

Case study in a fully cultivated catchment (Pommeroye, Northern France)

Patault, E.^{1,2,*}, Alary, C.¹, Franke, C.², Gauthier, A.¹, Abriak, N-E.¹

¹IMT Lille Douai, Civil Engineering and Environmental Department, F-59000, Lille, France

²MINES ParisTech, PSL Research University, Geosciences Center, 77305, Fontainebleau, France

*contact: edouard.patault@imt-lille-douai.fr

Paper number: H411-1566



Context & Challenges

- Ephemeral gullies → major contributor to erosion processes in agricultural catchments in the European loess belt [1].
- Temporal and spatial scale at which these processes occurs make it difficult to capture [2].
- On-site and off-site problems → property damage by mud floods + loss of cultivated soils.



Main objectives

- Develop an innovative high-frequency monitoring of ephemeral gullies.
- Identify hydro-sedimentary behaviors and main forcing parameters.
- Define a sediment budget to propose relevant actions for erosion reduction.
- Quantify temporal and spatial variability during subsequent rainfall events.

Study Area & Monitoring Station

- Pommeroye catchment (54 ha) in the European loess belt.
- Pleistocene silt resting on Seno-Turonian chalky soil.
- The ephemeral gully network is well-established and recurrent.

Climate	Oceanic
Avg. Annual. T°	11°C
Precipitation rate	1000±150 mm yr ⁻¹
Elevation	115-145 m (slope = 4.2%)

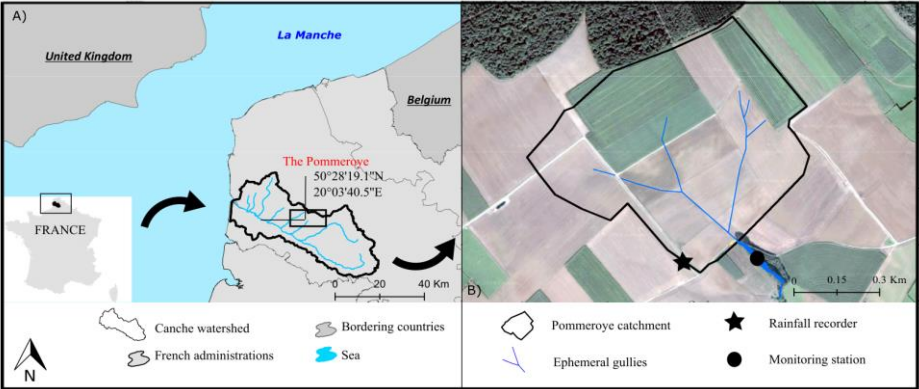
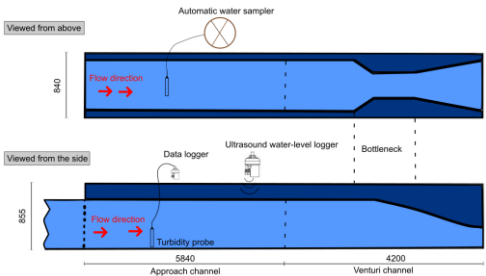


Fig.1: (A) Overview on the study region, (B) Map of the Pommeroye Catchment showing the location of the ephemeral gullies and instruments used in this study.



Fig.2: Different views of the monitoring station at the outlet of the Pommeroye catchment.

- Flow discharge and turbidity are recorded at the outlet during rainfall events.
- Estimation of sediment concentration, via automatically collected water samples.
- Correlation definition between the turbidity data and measured SSC.
- Precipitations recording by tipping-bucket rain gauge.



Hydro-Sedimentary Response and Seasonal Trends

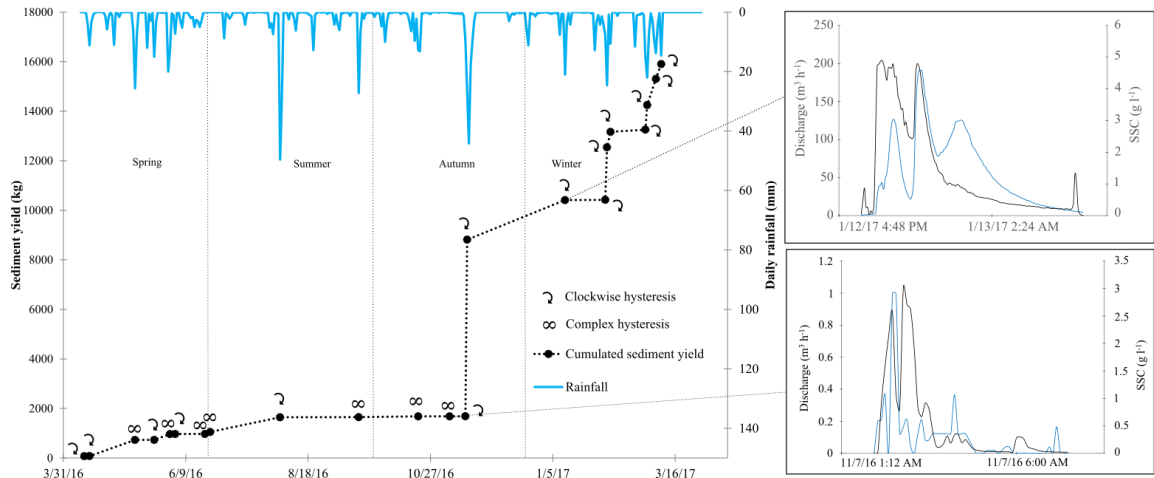


Fig.3: Cumulated sediment yield (kg) and daily rainfall (mm) recorded at the monitoring station during the first year, showing some example hydrograph pattern of different observed runoff events.

- Total Sediment Yield (SY) = 16.10³ kg; cumulated rainfall = 827.1 mm
- Maximum SSC observed in May (5g l⁻¹) as maximum rainfall intensities (76 mm h⁻¹).
- November: one event contributed to 45% of the annual SY.
- Q-SSC relationships corresponds to clockwise (68%) and complex hysteresis (32%).
- Clockwise hysteresis: rapid re-suspension and transport of sediment previously deposited in the gullies.
- Complex hysteresis: additional peaks → movement of other sources, more distant and probably coming from the fields.

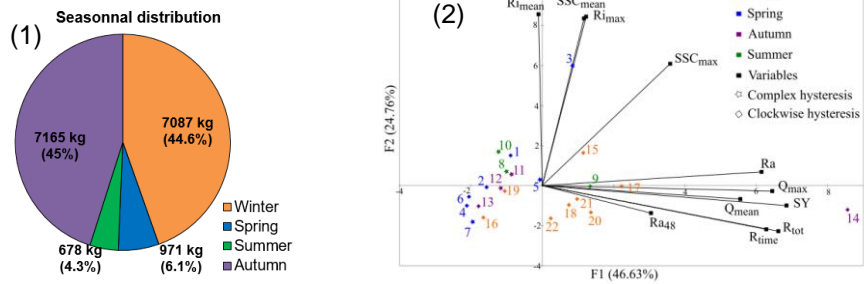


Fig.4: (1) Seasonal distribution of SY and (2) Bi-plot of PCA results on the first two components for the 22 runoff events.

Influence of Soil Surface Characteristics

Events	11/7/2016	3/8/2017
Rainfall characteristics		
Ra (mm)	17.5	14.6
Ri _{max} (mm h ⁻¹)	8	4
Ra ₂₄ (mm)	0.9	0.6
Hydro-sedimentary response		
R _{sed} (m ³)	0.57	2031.8
SY (kg)	0.6	595.1

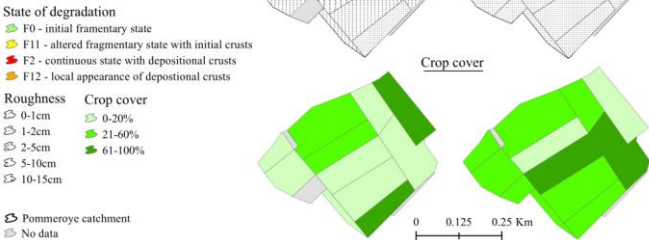


Fig.5: Evaluation of two similar runoff events regarding the temporal variability of soil surface characteristics in the fields of La Pommeroye Catchment

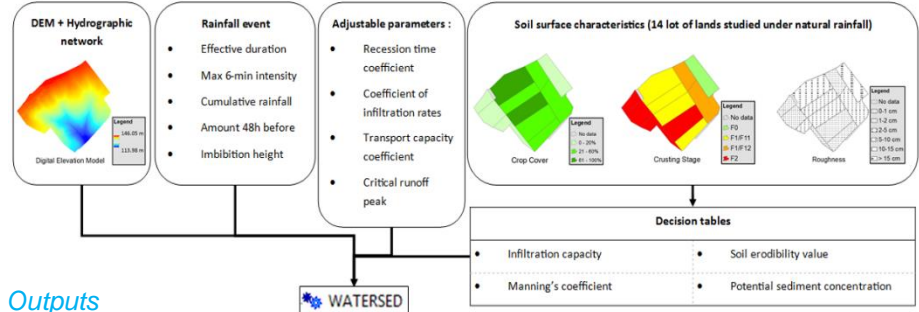
Evaluation of soil surface characteristic influence on the SY (study of soil degradation at plot scale [1 m²]):

- Successive rainfall events → complete degradation of the soil structure over time.
- Two similar rainfall events → heterogeneous hydro-sedimentary response.
- Initial fragmentary state and high roughness allow better infiltration of the rainfall.
- Sedimentary crust and low roughness → prevention of precipitation infiltration and induction of higher sediment remobilization.
- Even with increase of crop cover (better soil protection) → degradation of soil structure is dominant impact factor on the SY.

Modeling Contributions

Since spatial variability of sediment remobilization couldn't be quantified using hydrograph pattern, another approach was tested with the use of the GIS model "Watersed" [3].

Inputs



Outputs

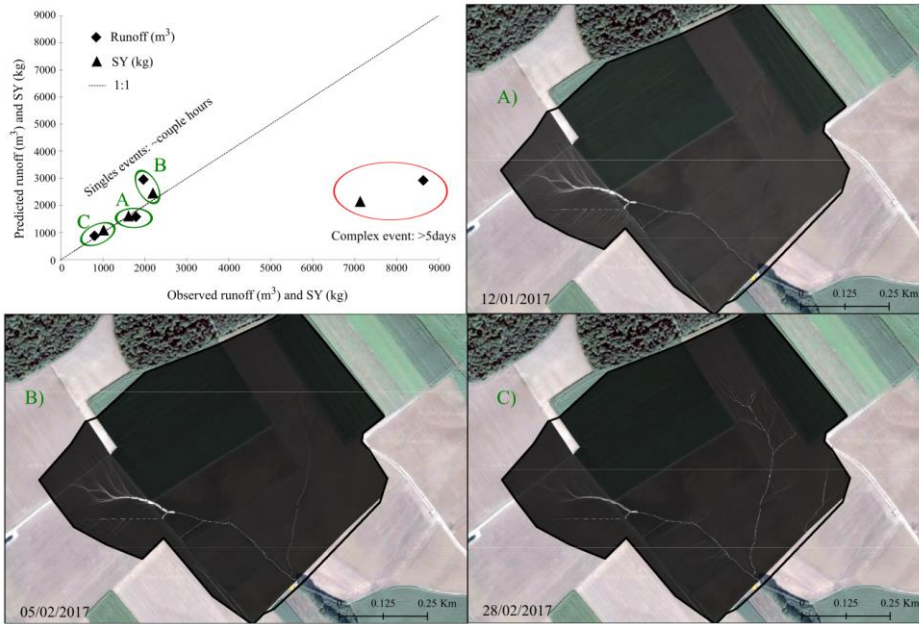


Fig.6: Simulations of three erosive events with the model and comparison with observed data.

- Output allows to visualize and quantify the spatial variability of sediment remobilization for different runoff events.
- First simulations are consistent with the observed data and showed that gullies are not constantly activated depending on the event characteristics.
- Complex events → difficult to simulate and need further research.

Conclusion & Perspectives

- Precise sediment budget characterized by high seasonal variability.
- Two main hydro-sedimentary behaviors + main forcing parameters identified.
- State of degradation + roughness = dominant impact factor on the SY
- Test effect of soft hydraulic solutions with an additional module in the model.
- Assess the temporal variability of the hydro-sedimentary response over successive hydrologic years.

Acknowledgements

This work was financially supported by the Agence de l'Eau Artois-Picardie. We would also like to acknowledge technical support from the SYMCEA (SYndicat Mixte Canche Et Affluents) and the Chambre d'Agriculture Nord-Pas-de-Calais, France.

References

[1] J. Poesen, K. Vandaele, B.V.a.N. Wesemael, Contribution of gully erosion to sediment production on cultivated lands and rangelands, Erosion and Sediment Yield: Global and Regional Perspectives (Proceedings of the Exeter Symposium July 1996), IAHS Publ. 236 (1996) 251-266.
[2] J. Marzol, J.B. Ries, J. Poesen, Short-term versus medium-term monitoring for detecting gully-erosion variability in a Mediterranean environment, Earth Surface Processes and Landforms 36 (2011) 1604-1623.
[3] V. Landemaine, Erosion des sols et transferts sédimentaires sur les bassins versants de l'Ouest du bassin de Paris: analyse, quantification et modélisation à l'échelle pluriannuelle, Ph.D. thesis, Université de Rouen Normandie, 2016.