Summer school entitled:

Stuff we don't mention in the normal course of studies in School of Civil Engineering N.T.U.A.

July 3-9, 2023

Camping Rovies

Euboea

Report by G.-Fivos Sargentis

Artificial intelligence & 3D printing
Infrastructures and landscapes
Climate change
Wildfires and Floods. Risks in social cohesion
The role of water-energy-food nexus

ADDOPTML

campingrovies

North Euboea, camping ROVIES

Registrations:
fivos@itia.ntua.gr

Artificial intelligence & 3D printing. Ο ρόλος του μηχανικού
Κλιματική αλλαγή
Μεταβαλλόμενα τοπία (πυρκαγιές, μεταβολές χλωρίδας)
Τοπίο και έργα υποδομής
Ο ρόλος του πλέγματος νερού-ενέργειας-τροφίμων

campingrovies

Βόρεια Εύβοια, κάμπινγκ Ροβιές
Κόστος διανυκτέρευσης 5 €/ημέρα

Δηλώσεις συμμετοχής
email: fivos@itia.ntua.gr

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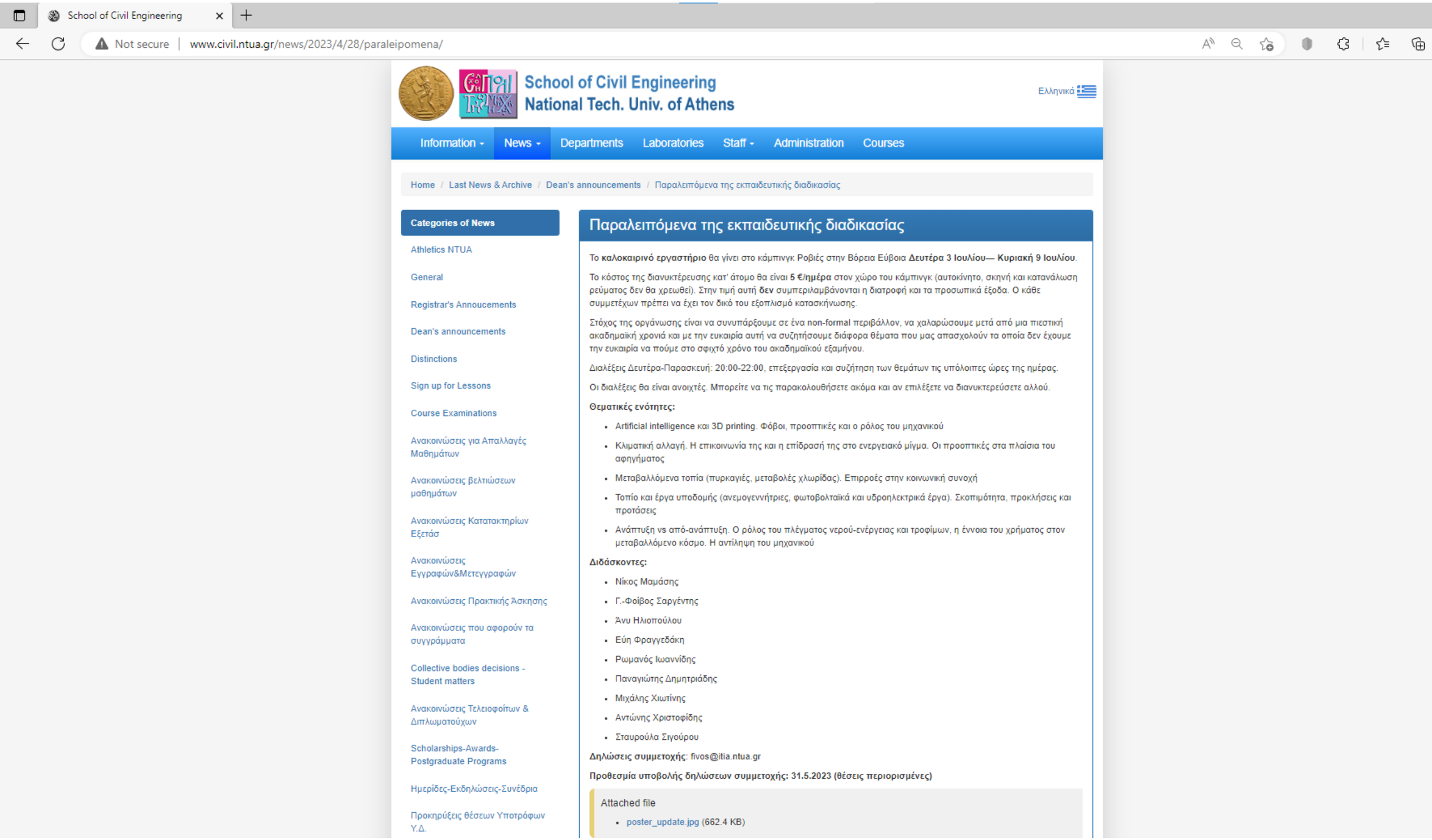
Προθεσμία υποβολής δηλώσεων: 31.5.2023 (θέσεις περιορισμένες)

Web INVITATION (1)



http://www.civil.ntua.gr/news/2023/4/28/paraleipomena/

Web INVITATION (2)

Εκδηλώσεις Camping Rovies

https://campingrovies.gr/paroches/ekdiloseis/

3 - 9 Ιουλίου

Μια ομάδα πρωτοπόρων Καθηγητών του Εθνικού Μετσόβιου Πολυτεχνείου οργανώνει **Καλοκαιρινό εργαστήριο** για τους φοιτητές του ΕΜΠ με ανοιχτές διαλέξεις για "καυτά" θέματα για το περιβάλλον.

Τις διαλέξεις μπορεί να τις παρακολουθήσει οποιοσδήποτε (είτε μένει στο κάμπινγκ είτε όχι). Δευτ – Παρ. 20:00-22:00μμ

Θεματικές ενότητες:

Artificial intelligence και 3D printing. Φόβοι, προοπτικές και ο ρόλος του μηχανικού

Κλιματική αλλαγή. Η επικοινωνία της και η επίδρασή της στο ενεργειακό μίγμα. Οι προοπτικές στα πλαίσια του αφηγήματος

Μεταβαλλόμενα τοπία (πυρκαγιές, μεταβολές χλωρίδας). Επιρροές στην κοινωνική συνοχή

Τοπίο και έργα υποδομής (ανεμογεννήτριες, φωτοβολταϊκά και υδροηλεκτρικά έργα). Σκοπιμότητα, προκλήσεις και προτάσεις

Ανάπτυξη vs από-ανάπτυξη. Ο ρόλος του πλέγματος νερού-ενέργειας και τροφίμων, η έννοια του χρήματος στον μεταβαλλόμενο κόσμο. Η αντίληψη του μηχανικού

Διδάσκοντες: Νίκος Μαμάσης, Γ.-Φοίβος Σαργέντης, Άνυ Ηλιοπούλου, Εύη Φραγγεδάκη, Ρωμανός Ιωαννίδης, Παναγιώτης Δημητριάδης, Μιχάλης Χιωτίνης, Αντώνης Χριστοφίδης, Σταυρούλα Σιγούρου

Artificial intelligence & 3D printing. Ο ρόλος του μηχανικού
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Προθεσμία υποβολής δηλώσεων: 31.5.2023 (θέσεις περιορισμένες)

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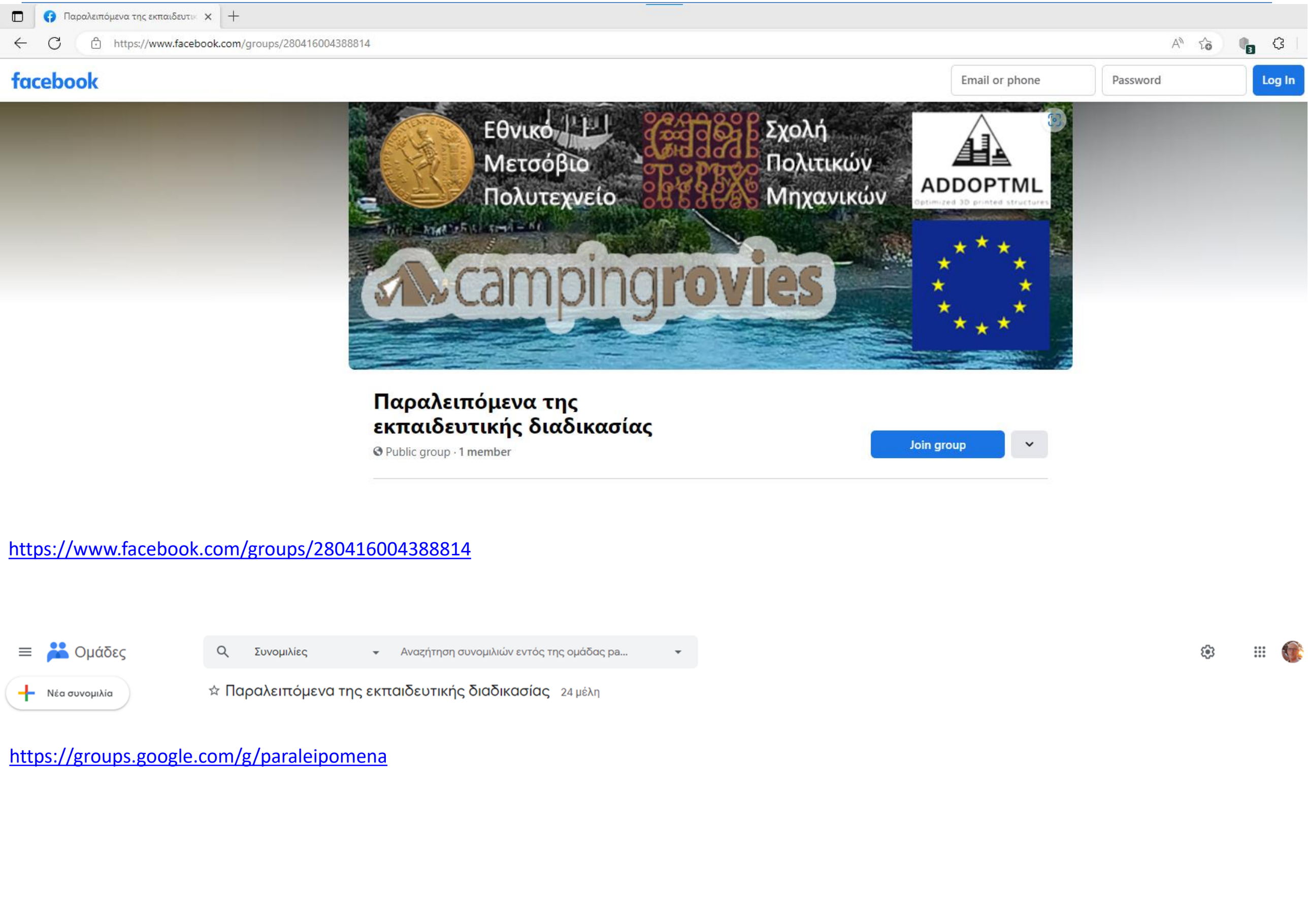
https://campingrovies.gr/ekdiloseis/

Coordination and promotion



https://www.facebook.com/groups/280416004388814

https://groups.google.com/g/paraleipomena

https://youtu.be/p35C6DOMLhw

Coordinators: G.-Fivos Sargentis, N. Mamassis and N. Lagaros

Lectures

Day 1.

"Artificial intelligence": Objections, prospects, and the role of the engineer
(more: https://www.itia.ntua.gr/el/docinfo/2309/)
Michalis Chiotinis (PhD candidate)

Language and meta-language models
(more: https://www.itia.ntua.gr/el/docinfo/2308/)
Antonis Christofides (PhD candidate)

Day 2.

Introduction to Water-Energy-Food nexus
(more: https://www.itia.ntua.gr/el/docinfo/2310/)
Prof. Nikos Mamassis

The role of the water-energy and food nexus in prosperity
(more: https://www.itia.ntua.gr/el/docinfo/2318/)
Dr G.-Fivos Sargentis

Overpopulation and environmental determinism
(more info: https://www.itia.ntua.gr/el/docinfo/2317/)
Dr G.-Fivos Sargentis

Day 3.

Feasibility of the RE infrastructures: The role of beauty
(more: https://www.itia.ntua.gr/el/docinfo/2319/)
Dr G.-Fivos Sargentis

Spatial and architectural planning for the integration of infrastructure projects in the landscape
(more: https://www.itia.ntua.gr/el/docinfo/2321/)
Dr Romanos Ioannidis

Day 4.

Dealing with and management of natural disasters with emphasis on floods. *Part A*: Uncertainty analysis in flood risk assessment (natural process and flood model)
(more: https://www.itia.ntua.gr/el/docinfo/2315/)
Dr. Panayiotis Dimitriadis, Stavroula Sigourou (PhD candidate)

Dealing with and management of natural disasters with emphasis on floods. *Part B*: The importance of field investigation in flood risk assessment
(more: https://www.itia.ntua.gr/el/docinfo/2316/)
Dr. Panayiotis Dimitriadis, Stavroula Sigourou (PhD candidate)

Natural disasters with an emphasis on floods
(more: https://www.itia.ntua.gr/el/docinfo/2314/)
Stavroula Sigourou (PhD candidate)

Wildfires. Case study: The fire in Euboea 2021
(more: https://www.itia.ntua.gr/el/docinfo/2320/)
Dr G.-Fivos Sargentis

Day 5

Climate and Climate Change: Definitions
(more: https://www.itia.ntua.gr/el/docinfo/2311/)
Prof. Nikos Mamassis

The communication of "climate change“
(more: https://www.itia.ntua.gr/el/docinfo/2313/)
Prof. Nikos Mamassis

The role of climate change in civil engineering studies
Prof. Vicky Tsoukala

What is the "climate crisis" and what does it want
(more: https://www.itia.ntua.gr/el/docinfo/2284/)
Prof. Em. Demetris Koutsoyiannis

Day 1 (3.7.2023)

Day 2 (4.7.2023)


The role of energy in prosperity
Even if the causal link of energy consumption to GDP and life expectancy is questionable according to some researchers, by correlating recent global data on the current energy consumption with GDP and life expectancy, we identify interesting trends
Human energy

Day 3 (5.7.2023)

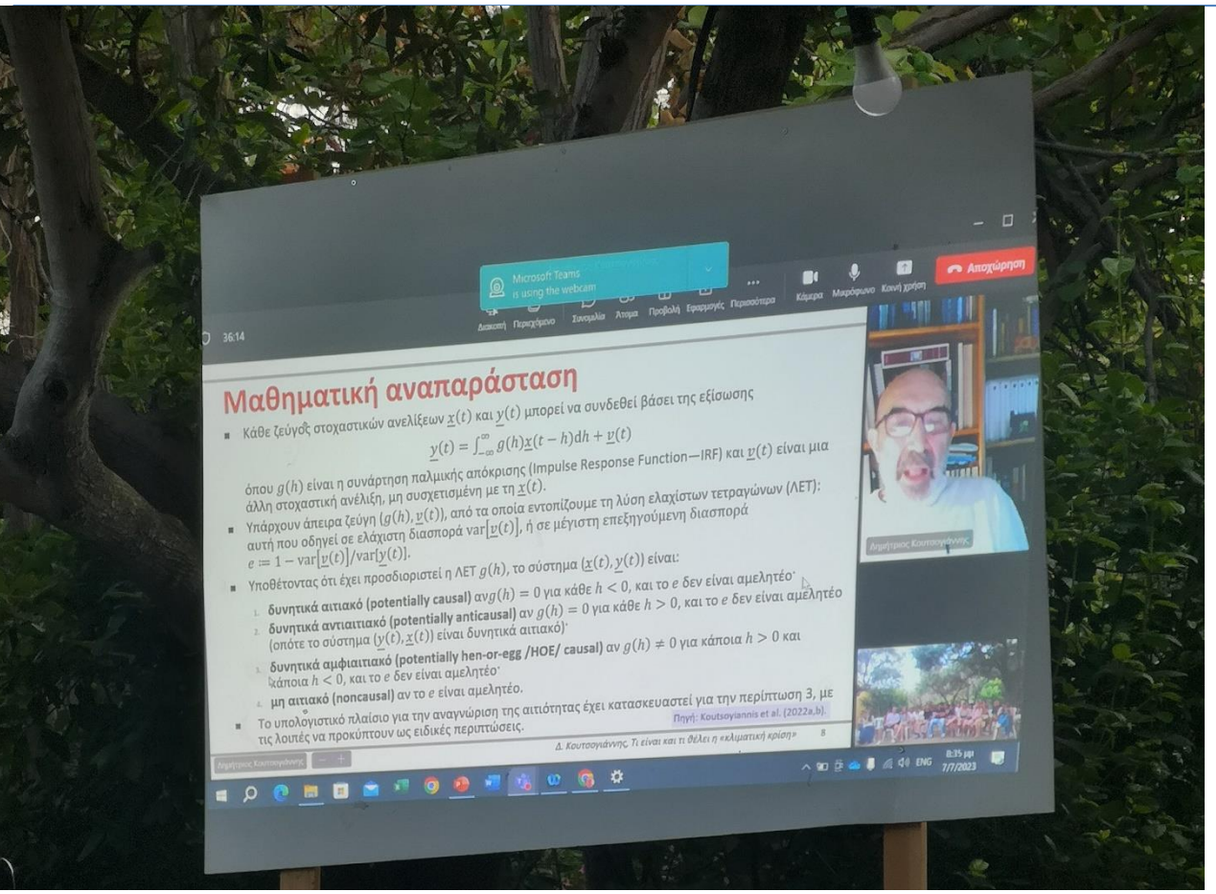
Day 4 (6.7.2023)


Observations of natural processes
Statistical estimation & time series synthesis
Stochastics
Stochastic process in continuous time
Stochastic process in discrete time

Day 5 (7.7.2023)


Πρόγνωση κλίματος
Μεγέθυνση διαταραχών στη χρονική εξέλιξη ενός μη γραμμικού φαινομένου
Χρονική εξέλιξη X1, X2,
Με ελάχιστα διαφορετικές αρχικές συνθήκες
X1=0.660001 X2=0.66
Χρονική εξέλιξη
X1-X2

Day 5 (7.7.2023)


Microsoft Teams
is using the webcam
Αποχώρηση
Κάμερα
Μικρόφωνο
Κοινή χρήση
36:14
Μαθηματική αναπαράσταση
Κάθε ζεύγος στοχαστικών ανελίξεων $\underline{x}(t)$ και $\underline{y}(t)$ μπορεί να συνδεθεί βάσει της εξίσωσης
$\underline{y}(t) = \int_{-\infty}^{\infty} g(h)\underline{x}(t-h)dh + \underline{v}(t)$
όπου $g(h)$ είναι η συνάρτηση παλμικής απόκρισης (Impulse Response Function—IRF) και $\underline{v}(t)$ είναι μια άλλη στοχαστική ανέλιξη, μη συσχετισμένη με τη $\underline{x}(t)$.
Υπάρχουν άπειρα ζεύγη $(g(h), \underline{v}(t))$, από τα οποία εντοπίζουμε τη λύση ελαχίστων τετραγώνων (ΛΕΤ): αυτή που οδηγεί σε ελάχιστη διασπορά $\mathrm{var}[\underline{v}(t)]$, ή σε μέγιστη επεξηγούμενη διασπορά $e := 1 - \mathrm{var}[\underline{v}(t)]/\mathrm{var}[\underline{y}(t)]$.
Υποθέτοντας ότι έχει προσδιοριστεί η ΛΕΤ $g(h)$, το σύστημα $(\underline{x}(t), \underline{y}(t))$ είναι:
1. **δυνητικά αιτιακό (potentially causal)** αν $g(h) = 0$ για κάθε $h < 0$, και το e δεν είναι αμελητέο·
2. **δυνητικά αντιαιτιακό (potentially anticausal)** αν $g(h) = 0$ για κάθε $h > 0$, και το e δεν είναι αμελητέο (οπότε το σύστημα $(\underline{y}(t), \underline{x}(t))$ είναι δυνητικά αιτιακό)·
3. **δυνητικά αμφιαιτιακό (potentially hen-or-egg /HOE/ causal)** αν $g(h) \neq 0$ για κάποια $h > 0$ και κάποια $h < 0$, και το e δεν είναι αμελητέο·
4. **μη αιτιακό (noncausal)** αν το e είναι αμελητέο.
Το υπολογιστικό πλαίσιο για την αναγνώριση της αιτιότητας έχει κατασκευαστεί για την περίπτωση 3, με τις λοιπές να προκύπτουν ως ειδικές περιπτώσεις.
Πηγή: Koutsoyiannis et al. (2022a,b).
Δ. Κουτσογιάννης. Τι είναι και τι θέλει η «κλιματική κρίση»
8
Δημήτριος Κουτσογιάννης
8:35 μμ
7/7/2023

Posters

Coordinators: G.-Fivos Sargentis, N. Mamassis and N. Lagaros

G.-F. Sargentis, P. Defteraios, N. D. Lagaros, and N. Mamassis. Values and costs in history
(more: https://www.itia.ntua.gr/el/docinfo/2332/)

G.-F. Sargentis, R. Ioannidis, E. Frangedaki, P. Dimitriadis, T. Iliopoulou, D. Koutsoyiannis, and N. D. Lagaros,. Wildfires
(more: https://www.itia.ntua.gr/el/docinfo/2331/)

D. Koutsoyiannis, and G.-F. Sargentis. Entropy and Wealth
(more: https://www.itia.ntua.gr/el/docinfo/2330/)

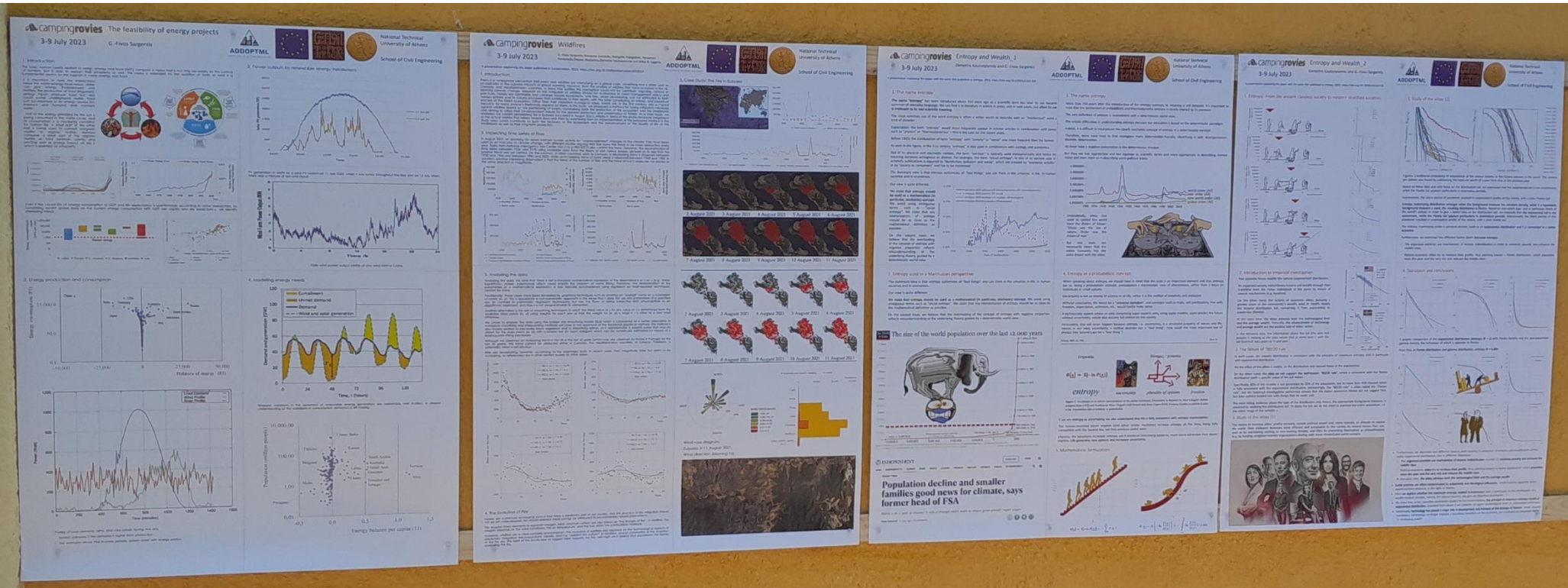
E. Frangedaki, 3D printing. Aspects and the role of engineer
(more: https://www.itia.ntua.gr/el/docinfo/2327/)

T. Iliopoulou, and D. Koutsoyiannis. A cool look at rainfall climatic changes in Greece and worldwide

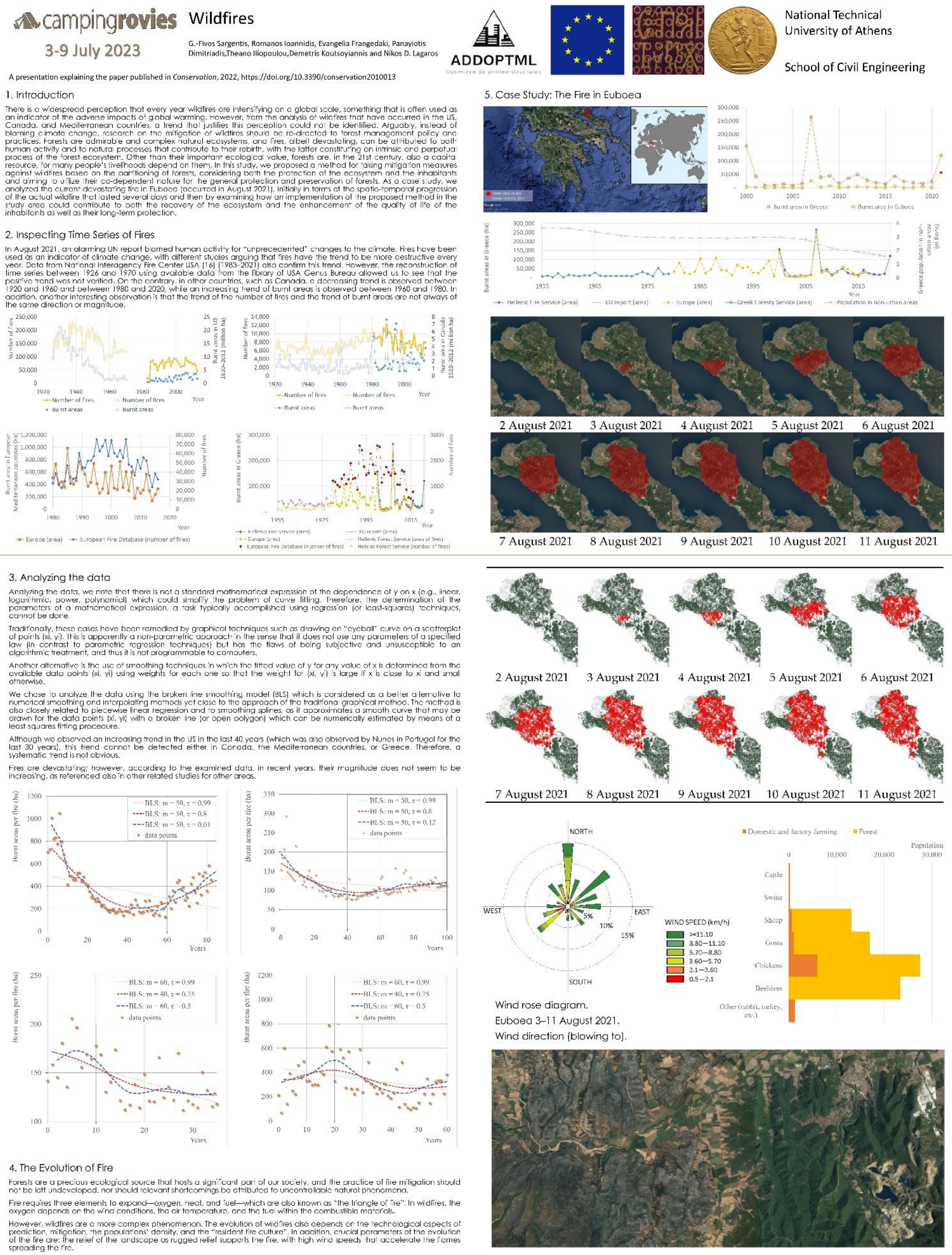
(more: https://www.itia.ntua.gr/el/docinfo/2325/)

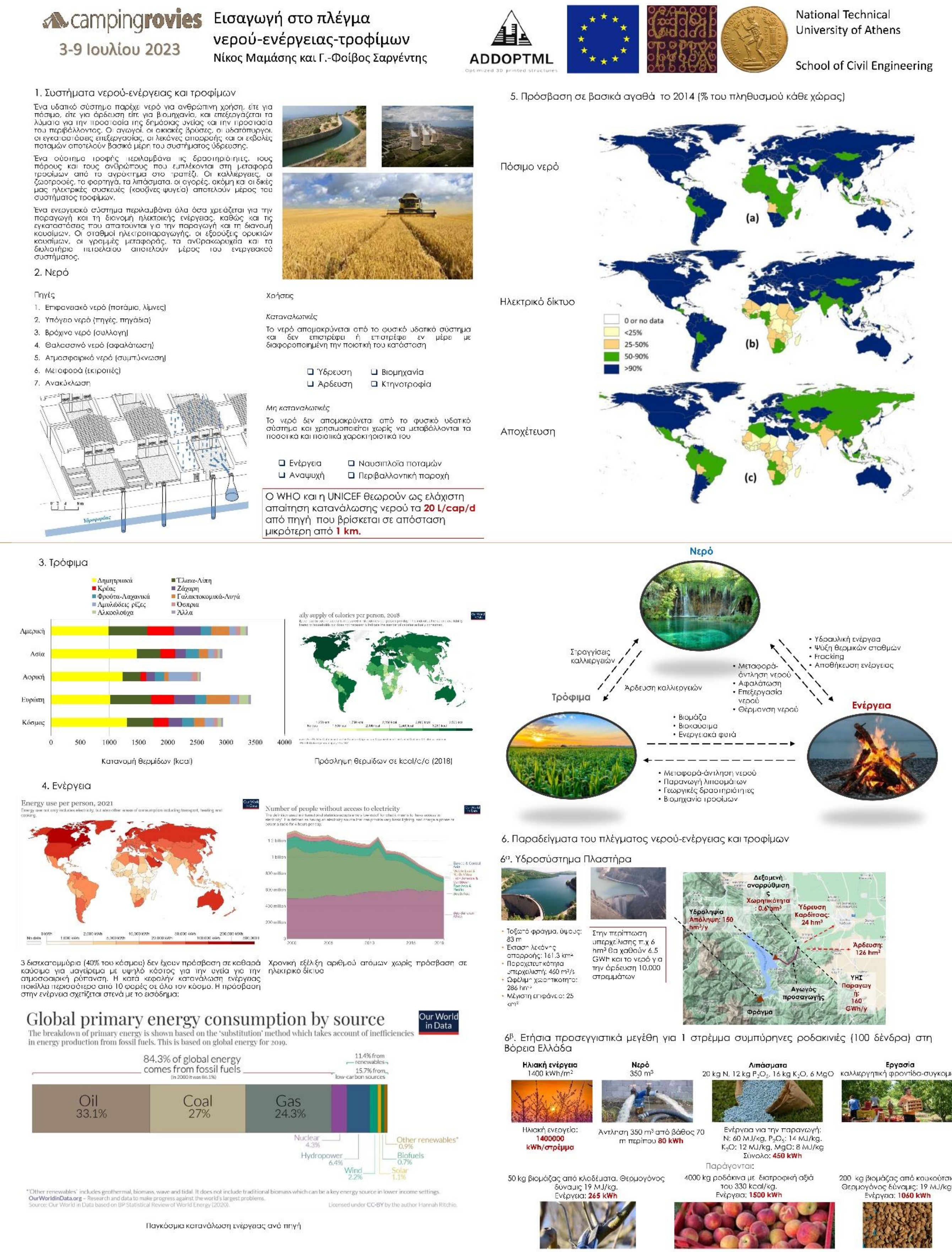
G.-F. Sargentis. The feasibility of energy projects
(more: https://www.itia.ntua.gr/el/docinfo/2328/)

N. Mamassis and G.-F. Sargentis. Introduction to water-energy-food nexus
(more: https://www.itia.ntua.gr/el/docinfo/2329/)



Posters


campingrovies
3-9 July 2023
Wildfires
G.-Fivos Sargentis, Romanos Ioannidis, Evangelia Frangedaki, Panayiotis Dimitriadis, Theano Iliopoulou, Demetris Koutsoyiannis and Nikos D. Lagaros
ADDOPTML
National Technical University of Athens
School of Civil Engineering
A presentation explaining the paper published in Conservation, 2022, https://doi.org/10.3390/conservation2010013
1. Introduction
2. Inspecting Time Series of Fires
5. Case Study: The Fire in Euboea
2 August 2021
3 August 2021
4 August 2021
5 August 2021
6 August 2021
7 August 2021
8 August 2021
9 August 2021
10 August 2021
11 August 2021
3. Analyzing the data
Wind rose diagram.
Euboea 3–11 August 2021.
Wind direction (blowing to).
4. The Evolution of Fire


campingrovies
3-9 Ιουλίου 2023
Εισαγωγή στο πλέγμα νερού-ενέργειας-τροφίμων
Νίκος Μαμάσης και Γ.-Φοίβος Σαργέντης
ADDOPTML
National Technical University of Athens
School of Civil Engineering
1. Συστήματα νερού-ενέργειας και τροφίμων
2. Νερό
5. Πρόσβαση σε βασικά αγαθά το 2014 (% του πληθυσμού κάθε χώρας)
Πόσιμο νερό
Ηλεκτρικό δίκτυο
Αποχέτευση
Ο WHO και η UNICEF θεωρούν ως ελάχιστη απαίτηση κατανάλωσης νερού τα 20 L/cap/d από πηγή που βρίσκεται σε απόσταση μικρότερη από 1 km.
3. Τρόφιμα
Νερό
Τρόφιμα
Ενέργεια
4. Ενέργεια
Global primary energy consumption by source
Oil 33.1%
Coal 27%
Gas 24.3%
Πανκόσμια κατανάλωση ενέργειας ανά πηγή
6. Παραδείγματα του πλέγματος νερού-ενέργειας και τροφίμων
6α. Υδροσύστημα Πλαστήρα
6β. Ετήσια προσεγγιστικά μεγέθη για 1 στρέμμα συμπύρηνες ροδακινιές (100 δένδρα) στη Βόρεια Ελλάδα

Posters

campingrovies

3-9 July 2023

Τίτλος:

3D printing. Προοπτικές και ο ρόλος του μηχανικού

Ευαγγελία Φραγγεδάκη, αρχιτέκτων μηχανικός, ΕΔΙΠ, ΕΜΠ

ADDOPTML Optimized 3D printed structures

National Technical University of Athens

School of Civil Engineering

1. Εισαγωγή

Η 3D εκτύπωση στον κατασκευαστικό κλάδο (μέθοδος προσθετικής κατασκευής -Additive Manufacturing) είναι μία τεχνολογία που τα τελευταία χρόνια πρωταγωνιστεί, καθώς προστίθενται ολοένα και περισσότερες εφαρμογές στην υλοποίηση ποιοτικών και συνάμα πιο χαμηλού κόστους κτιρίων. Πλέον κτίρια, αλλά και ολόκληρες συνοικίες, υλοποιούνται από εξελιγμένα ρομποτικά συστήματα, ικανά να παράγουν δομές υψηλών προδιαγραφών. Η διαδικασία γίνεται σε ένα αυστηρά ελεγχόμενο εργοστασιακό περιβάλλον, γεγονός που **μειώνει τα σφάλματα** και **μειώνει αισθητά τον χρόνο κατασκευής**, με αποτέλεσμα κτίρια με **μικρότερο κόστος.** Η μεθοδολογία αυτή εφαρμόζεται σταδιακά για την μαζική παραγωγή κτιρίων με εντυπωσιακά αποτελέσματα.

Τα κύρια χαρακτηριστικά των μεθόδων τρισδιάστατης εκτύπωσης είναι: **η ελευθερία στη γεωμετρία της μορφής**, **η ταχύτητα ολοκλήρωσης των έργων**, **η αποφυγή χρήσης ξυλότυπων**, **η μειωμένη παραγωγή απορριμμάτων**, **ο φιλικός εν γένει χαρακτήρας τους ως προς το περιβάλλον**, τη φύση και την ασφάλεια (Sanjayan, et al., 2019). Εκτός από κατοικίες, έχουν εκτυπωθεί γέφυρες, υποστυλώματα, στοιχεία ύδρευσης και αποχέτευσης και αστικός εξοπλισμός.

Η ευρεία εφαρμογή της τρισδιάστατης εκτύπωσης σκυροδέματος στον κατασκευαστικό τομέα είναι προς το παρόν περιορισμένη κυρίως σε σεισμογενείς περιοχές λόγω έλλειψης προτύπων και οδηγιών, τα οποία αποτελούν πεδίο έρευνας στα επόμενα χρόνια.

Εικ1. α. Εκτυπωτής σκυροδέματος, Endhoven-Unersity-of-Technology

B. Apis Cor (American company from Melbourne) printer with nicknamed 'Frank'.

2. Η ιστορία της τρισδιάστατης εκτύπωσης

Οι ρίζες της τρισδιάστατης εκτύπωσης χρονολογούνται από τα μέσα της δεκαετίας του 1980, όταν επινοήθηκε η στερεολιθογραφία ή SLA. Το SLA λειτουργεί ως λέιζερ υψηλής ισχύος και μετατρέπει την υγρή ρητίνη σε στερεό υλικό, σταδιακά στρώμα – στρώμα. Ως τρισδιάστατη εκτύπωση θεωρείται γενικά κάθε τεχνολογία που δημιουργεί εξαρτήματα με πρόσθετο τρόπο. Ακόμη και σήμερα, η SLA εξακολουθεί να είναι μια από τις πιο δημοφιλείς τεχνολογίες τρισδιάστατης εκτύπωσης, ωστόσο έχουν αναδειχθεί και άλλες τεχνολογίες 3D printing όπως η επιλεκτική πυροσυσσωμάτωση με λέιζερ (SLS), η μοντελοποίηση λιωμένης εναπόθεσης (FDM) και η άμεση εναπόθεση μετάλλων (DMD).

Για περισσότερο από μια δεκαετία, η τρισδιάστατη εκτύπωση έχει χρησιμοποιηθεί με αντιπροσωπευτικά έργα στον τομέα των κατασκευών, όπως:

- **Το 2004**, στο University of Southern California (USC) ξεκίνησε η 3Dεκτυπώση για μία τοιχοποιία, γεγονός που αποτέλεσε την είσοδος της τεχνολογίας στον κατασκευαστικό κλάδο.
- **Το 2014**, ολοκληρώθηκε στο Άμστερνταμ μία κατοικία (First 3D Printed House to Be Built In Amsterdam, Archdaily, 2014).
- **Το 2016**, ολοκληρώθηκε ένα πολυώροφο κτίριο στην Κίνα από την WinSun (Starr, M., 2015), ενώ την ίδια χρονιά, το Dubai Future Foundation έχτισε το «Γραφείο του Μέλλοντος», ένα σημαντικό ορόσημο για την τεχνολογία στον τομέα των εμπορικών κατασκευών, με ένα κτίριο 250τ.μ. που κατασκευάστηκε από έναν μεγάλο τρισδιάστατο εκτυπωτή με διαστάσεις 36,5 x 12 x 6μ., ενώ η κατασκευή διήρκεσε μόλις 17 ημέρες. Σήμερα, η αγορά κατασκευών τρισδιάστατης εκτύπωσης αναπτύσσεται γρήγορα και αναμένεται να φτάσει το 1.5 δισεκατομμύριο δολάρια μέχρι το 2024.

Εικ. 2 α. XtreeE co-designed this structure with Marc Dalibard architect and EECT Architecture & Design Research, διαστάσεις: 4 x 1 x 1 m. β. The longest 3D-printed concrete bridge from the Tsinghua University School of Architecture, dezeen.com, γ. ... pa. A., designboom, 2022, Nest Research Building by ETH Zurich, Dübendorf, Switzerland.

3. Είδη εκτύπωσης σκυροδέματος και Προσθήκη οπλισμού

Οι δύο βασικές μέθοδοι που υιοθετήθηκαν στην τεχνολογία προσθετικής κατασκευής (AM) με τσιμεντοειδή υλικά είναι η εναπόθεση με βάση την τεχνική της εξώθησης (επιλεκτική απόθεση υλικού με εξώθηση (3DCP) και είναι παρόμοια τεχνική με το μοντέλο εναπόθεσης που χρησιμοποιείται σε τεχνολογίες πολυμερών και μετάλλων, αλλά και οι μέθοδοι κλίνης σε σκόνη (επιλεκτική σύνδεση, χρησιμοποιώντας τσιμεντοειδή υλικά ή με πλήρωση του τυπωμένου ξυλότυπου, όπου ένα στρώμα άμμου ως μήτρα, καλύπτεται επιλεκτικά από τσιμέντο το οποίο αποτελεί τον δραστικό παράγοντα, ο οποίος ενεργοποιείται χρησιμοποιώντας υδρατμούς) (Lowke, et al., 2018).

Σε ορισμένες περιπτώσεις ενσωματώνεται οπλισμός για την ενίσχυση των τυπωμένων τμημάτων σκυροδέματος προκειμένου να βελτιωθεί η δομική τους απόδοση στην κατασκευή (Nerella, V. N., et al. 2018). Οι μέθοδοι ενίσχυσης μπορούν να ταξινομηθούν ανάλογα με τη θέση του οπλισμού, εξωτερικός ή εσωτερικός καθώς και αν έχει εγκατασταθεί πριν ή μετά την εκτύπωση σκυροδέματος. Ο οπλισμός μπορεί να εισαχθεί είτε χειροκίνητα στα κοίλα μέρη που ετοιμάζονται στην κατασκευή, είτε ρομποτικά (Wangler , et al., 2016). Η ταυτόχρονη εκτύπωση οπλισμού και σκυροδέματος δεν είναι εφικτή τελικά λόγω της υψηλής θερμοκρασίας που δημιουργείται από την εκτύπωση χάλυβα. Επίσης έχει εφαρμοστεί η διαδικασία εκτύπωσης «lost formwork», όπου τυπώθηκε αρχικά το εξωτερικό κέλυφος και στη συνέχεια έγινε χύτευση με σκυρόδεμα. Το Institute for Advanced Architecture of Catalonia (IAAC, 2019), σε συνεργασία με την WASP (Ιταλική εταιρεία με 3d εκτυπωτές), εφάρμοσε 3DP με μείγμα πηλοκονιάματος. (Εικ. 3). Στη συνέχεια κατασκευάστηκε το έργο "Γαία", εκτύπωση με πηλοκονίαμα χώρου κυκλικής κάτοψης (Gomaa, M, et. Al, 2022).

Εικ.3 α. Εκτύπωση με πηλό (WASP, 2019) β. Ολοκλήρωση κτίσματος στο IAAC γ. τοποθέτηση ωμόπλινθων (adobe) (WASP,2019). δ. Κτίριο Γαία, Ιταλία, WASP 2019. ε. Εκτύπωση κτίσματος Γαί από τη WASP

4. Σύγκριση παραδοσιακής δόμησης και 3d εκτύπωσης

Τα δεδομένα σύγκρισης της παραδοσιακής κατασκευής με σκυρόδεμα και της τρισδιάστατης εκτύπωσης βασίζονται στην εμπειρία που αποκτήθηκε από το έργο στην Aix-en-Provence. Μελετήθηκαν οι περιπτώσεις με την τεχνική χύτευσης με χρήση χαλύβδινων καλουπιών και της εκτύπωσης, με αποτέλεσμα **συνολικό κέρδος 62,5%** (βάση ρεαλιστικών τιμών στο ίδιο κοινωνικο-οικονομικό περιβάλλον της Δυτικής Ευρώπης).

Κύριος λόγος για τη διαφορά κόστους (εκτός από το κέρδος που προσδιορίστηκε στο χρόνο, τα υλικά και το εργατικό δυναμικό) είναι η μη χρήση εξειδικευμένου υλικού και εξειδικευμένης διαμόρφωσης καλουπιού, γεγονός που επιτυγχάνεται με χρήση της μεθόδου lost formwork.

Συγκριτικά ως προς την κατανάλωση υλικών:

3d ptining/ Σκυρόδεμα 3D Εκτύπωσης: 650 kg και Σκυρόδεμα Χυτευσής UHPC: 1600 kg, Χαλύβδινες Ενισχύσεις (Ινες_): 50 kg

Παραδοσιακή κατασκευή/ Σκυρόδεμα Χύτευσης UHPC: 2250 kg, Χαλύβδινες Ενισχύσεις (Ινες): 50 kg

Σύγκριση ως προς το χρόνο εργασιών

3d ptining/ : Βελτιστοποίηση ψηφιακού σχεδιασμού και το σχεδιασμός διεργασιών: 3 ημέρες, Δημιουργία Μοντέλου: 3 ημέρες.

Τρισδιάστατη εκτύπωση του εξωτερικού κελύφους σε σκυρόδεμα: 2 ημέρες

Παραδοσιακή κατασκευή/: Ρυθμίσεις: 1 ημέρα Δημιουργία Ατσάλινου Καλουπιού: 3 ημέρες, Χύτευση Σκυροδέματος στο Κέλυφος: 1 ημέρα Χύτευση Σκυροδέματος στο Καλούπι: 1 ημέρα.

Οι υπόλοιπες εργασίες όπως ρυθμίσεις, μεταφορά στο σημείο εγκατάστασης, σύνδεση, επικάλυψη (φινίρισμα) είχαν κοινή διάρκεια και στις δύο περιπτώσεις.

Σύνολο 15.5 ημέρες με **3d ptining και** 18.5 ημέρες στην **Παραδοσιακή κατασκευή, οπότε ο κ**ατασκευαστικός χρόνος μειώθηκε 16.2%.

Εικ. 4. α.Συνεδριακό Κέντρο της Ντόχα (Donofrio, M., 2016) β. Qatar National Convention Centre / Arata Isozaki (Archdaily 2011)

5. Ευκαιρίες και προκλήσεις για τους Μηχανικούς

Οι συμβατικές διαδικασίες κατασκευής όπως, η εγκατάσταση οπλισμού, η χύτευση σκυροδέματος και η πλινθοδομή συνεπάγονται βαριά χειρωνακτική εργασία και εμπεριέχουν πολλούς παράγοντες επικινδυνότητας. Αυξάνοντας τον βαθμό αυτοματοποίησης, η προσθετική κατασκευή μπορεί να μειώσει τη χειρωνακτική εργασία και να βελτιώσει την ασφάλεια στο χώρο εργασίας (Keating, et al., 2017). Οι τεχνικές προσθετικής κατασκευής θα μπορούσε επίσης να χρησιμοποιηθούν για κατασκευαστικά έργα σε ακραίες περιβαλλοντικές συνθήκες, όπως για παράδειγμα σε μέρη που έχουν πληγεί από φυσικές καταστροφές, πολεμικές ζώνες ή σε άλλους πλανήτες. Άλλοι παράγοντες που χρειάζονται περεταίρω μελέτη είναι :

Α. Κίνδυνος συρρίκνωσης του ξηρού εκτυπωμένου στοιχείου σε θερμό κλίμα.

Β. η προστασία από δυσμενείς περιβαλλοντικές συνθήκες, όπως υπεριώδη ακτινοβολία, έκθεση σε νερό, χημικά αλλά και υψηλές θερμοκρασίες.

Η προσθετική κατασκευή προσφέρει μεγάλη ελευθερία σχεδιασμού στη μορφολογία του κτιρίου, ενώ παράλληλα μπορούν να συνδυαστούν ποικίλες πρώτες ύλες. Επίσης κατά την εκτύπωση υπάρχει η δυνατότητα να παραχθούν τμήματα που αποτελούνται από αξιολογημένα υλικά-διαδικασίες, π.χ. αυξημένη αντοχή σε περιοχές της εκτύπωσης με έντονη φόρτιση ή σε περιοχές με κενά διαφόρων σχημάτων και μεγεθών, όπως τις περιοχές για Η/Μ εγκαταστάσεις (Zhang B., et al., 2018).

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3-9 July 2023

The feasibility of energy projects

G.-Fivos Sargentis

ADDOPTML Optimized 3D printed structures

National Technical University of Athens

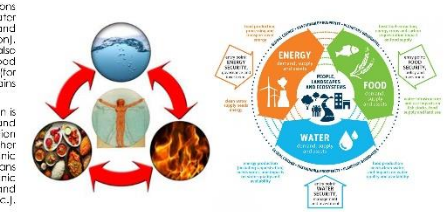
School of Civil Engineering

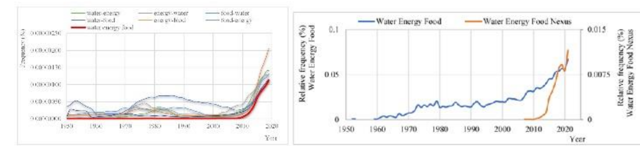
1. Introduction

The basic human needs related to water, energy and food (WEF) compose a nexus that is not only necessary for the survival of humans, but is able to explain their prosperity as well. This nexus is extended by the addition of land, as land is a fundamental source for the support of water-energy and food.

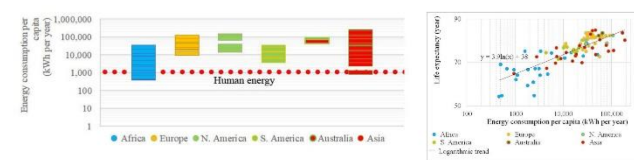
It is important to note the interactions inside the water-energy-food nexus; water can give energy (hydropower) and multiply the production of food (irrigation). energy inputs produce food but also could pump underground water. food can be assumed as an energy source (for livestock and humans) and contains water.

Half of the energy provided by the sun is being consumed in the water cycle, and its consumption is a necessary condition for human life. A small part of the other half is being used to convert inorganic matter to organic matter. Humans consume a small part of the organic matter as food (animals, plants) and another part as energy (wood, oil, etc.), which is essential for prosperity.

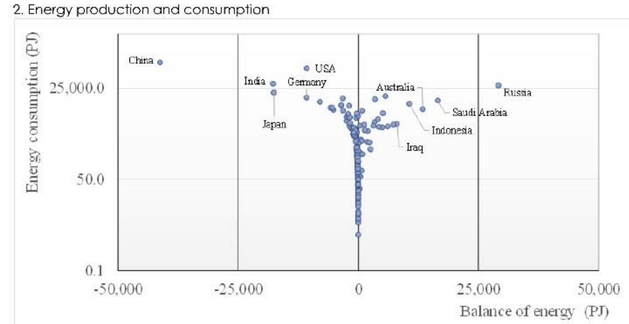


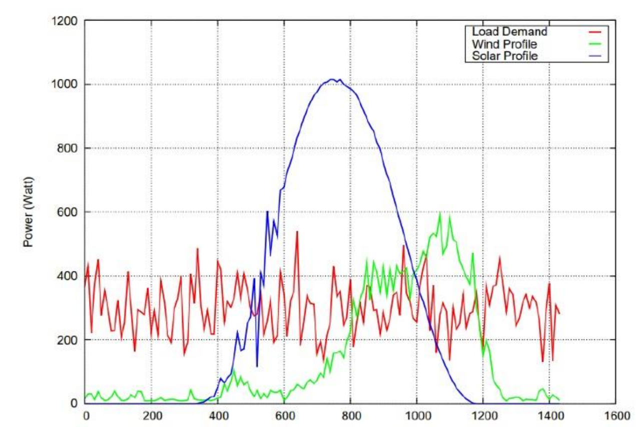


Even if the causal link of energy consumption to GDP and life expectancy is questionable according to some researchers, by correlating recent global data on the current energy consumption with GDP per capita and life expectancy, we identify interesting trends



2. Energy production and consumption

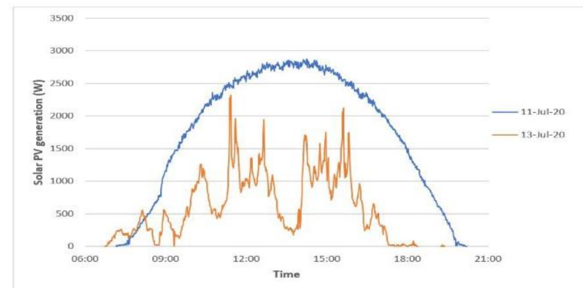




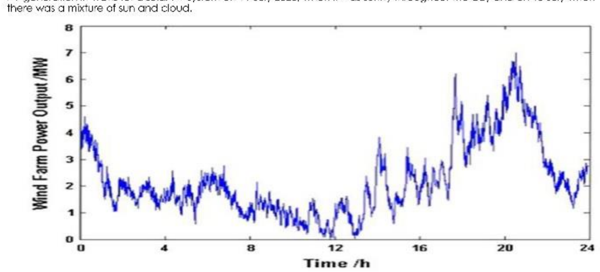
Profiles of load demand, wind, and solar power during one day

- System collapses if the demand is higher than production
- The examples shows that in some periods, system works with energy surplus.

3. Power outputs by renewable energy installations

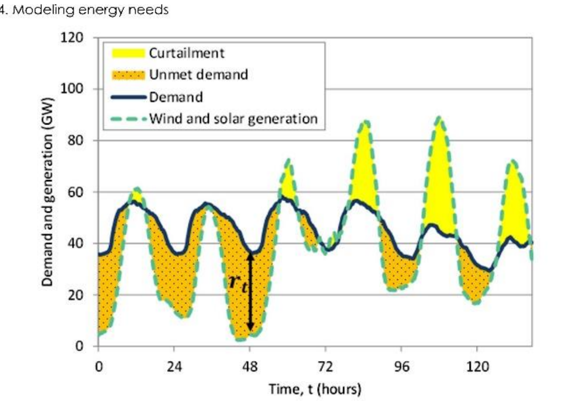


PV generation in watts for a solar PV system on 11 July 2020, when it was sunny throughout the day and on 13 July when there was a mixture of sun and cloud.

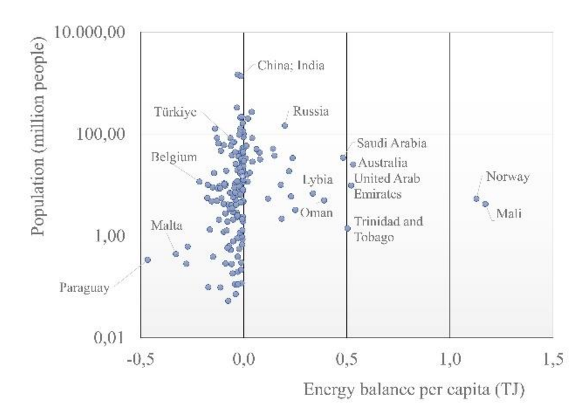


Daily wind power output profile of one wind farm in China.

4. Modeling energy needs



Whereas variations in the dynamics of renewable energy generation are reasonably well studied, a deeper understanding of the variations in consumption dynamics is still missing.



Posters

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3-9 July 2023

Entropy and Wealth_1

Demetris Koutsoyiannis and G.-Fivos Sargentis

ADDOPTML
Optimized 3D printed structures

National Technical University of Athens

School of Civil Engineering

A presentation explaining the paper with the same title published in *Entropy*, 2021, https://doi.org/10.3390/e23101356

1. The name entropy

The name "entropy" has been introduced about 150 years ago as a scientific term but later its use became common of everyday language. We can find it in literature in poetry in press, and in web posts, but often its use is irrelevant to its real scientific meaning.

The most common use of the word entropy is when a writer wants to describe with an "intellectual" word a kind of disorder.

Expectation: the term "entropy" would more frequently appear in scholar articles in combination with terms such as "physics" or "thermodynamics"—this is the case for the recent years.

Before 1960s the combination of term "entropy" with "society" or "social" was more frequent than the former.

As seen in the figure, in the 21st century "entropy" is also used in combination with ecology and economics.

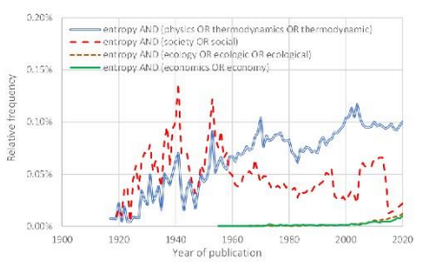
Out of its physical and stochastic context, the term "entropy" is typically used metaphorically and hence its meaning becomes ambiguous or diverse. For example, the term "social entropy", in one of its earliest uses in scholarly publications is equated to "dereliction, pollution and waste", which are created by "economic activity" or by "society as consumers" and has to be minimized.

The dominant view is that entropy epitomizes all "bad things" one can think in the universe, in life, in human societies and in economics.

Our view is quite different.

We insist that entropy should be used as a mathematical (in particular, stochastic) concept. We avoid using ambiguous terms such as "social entropy". We claim that any interpretation of entropy should be as close to the mathematical definition as possible.

On the second issue, we believe that the overloading of the concept of entropy with negative properties reflects misunderstanding of the underlying theory, guided by a deterministic world view.



2. Entropy used in a Malthusian perspective

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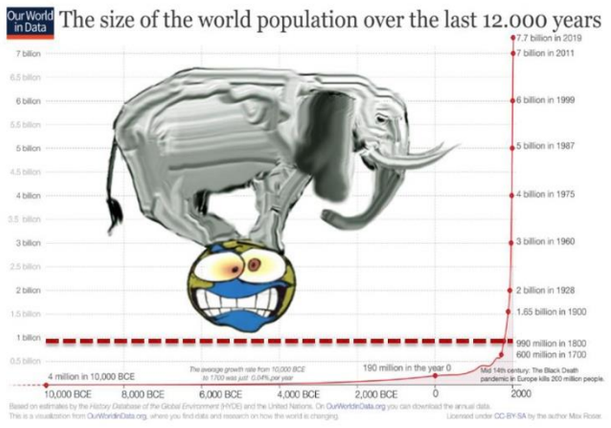


3. The name entropy

More than 150 years after the introduction of the entropy concept, its meaning is still debated. It's important to note that the connection of probabilistic and thermodynamic entropy is clearly implied by its pioneers.

The very definition of entropy is inconsistent with a deterministic world view.

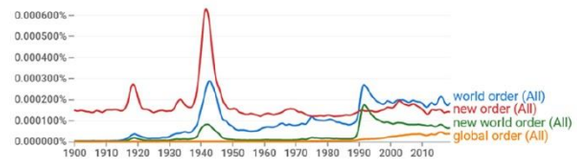
This entails difficulties in understanding entropy because our education is based on the deterministic paradigm.

Indeed, it is difficult to incorporate the clearly stochastic concept of entropy in a deterministic mindset.

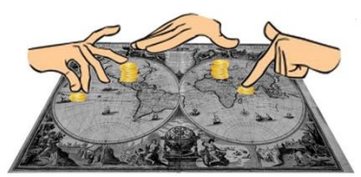
Therefore, many have tried to find analogues more deterministic-friendly, identifying it with disorganization, disorder, deterioration.

All these have a negative connotation in the deterministic mindset.

But they are less appropriate and less rigorous as scientific terms and more appropriate in describing mental states and even more so in describing socio-political states.



- Undoubtedly, elites that want to control the world have the dream of Steyer: "Chaos was the law of nature; Order was the dream of man."
- But this does not necessarily mean that the entire humanity has the same dream with the elites.



4. Entropy as a probabilistic concept

When speaking about entropy, we should have in mind that the scale is an important element and that entropy per se, being a probabilistic concept, presupposes a macroscopic view of phenomena, rather than a focus on individuals or small subsets

Uncertainty is not an enemy of science or of life; rather it is the mother of creativity and evolution.

Without uncertainty, life would be a "universal boredom", and concepts such as hope, will (particularly, free will), freedom, expectation, optimism, etc., would hardly make sense.

A technocratic system where an elite comprising super-experts who, using super-models, could predict the future without uncertainty, would also assume full control on the society.

Fortunately, this will never happen because entropy, i.e. uncertainty, is a structural property of nature and life. Hence, in our view, uncertainty is neither disorder nor a "bad thing". How could the most important law of physics (the Second Law) be a "bad thing"?

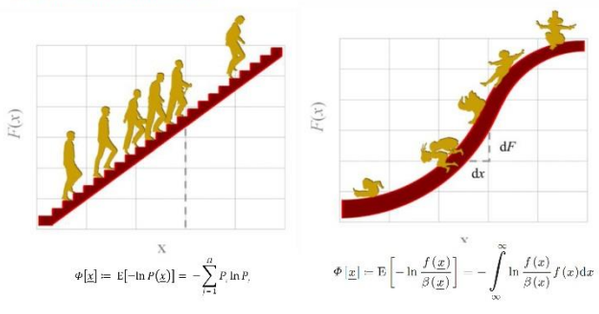
Figure 4. An attempt at an artistic representation of the notion of entropy. Uncertainty is depicted by Marc Chagall's Palette (adapted from [105]) and freedom by Marc Chagall's *Self-Portrait with Seven Fingers* [106]; δύναμις (Greek) or *potentia* (Latin) is the Aristotelian idea of potency or potentiality.

If we see entropy as uncertainty, we also understand that life is fully consistent with entropy maximization.

The human-invented steam engines (and other similar machines) increase entropy all the time, being fully compatible with the Second law, yet they produce useful work.

Likewise, the biosphere increases entropy, yet it produces interesting patterns, much more admirable than steam engines. Life generates new options and increases uncertainty.

5. Mathematical formulation



$$\Phi[\underline{x}] := \mathrm{E}[-\ln P(\underline{x})] = -\sum_{i=1}^{n} P_i \ln P_i$$

$$\Phi[\underline{x}] := \mathrm{E}\left[-\ln \frac{f(\underline{x})}{\beta(\underline{x})}\right] = -\int_{\infty}^{\infty} \ln \frac{f(x)}{\beta(x)} f(x)\mathrm{d}x$$

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Entropy and Wealth_2

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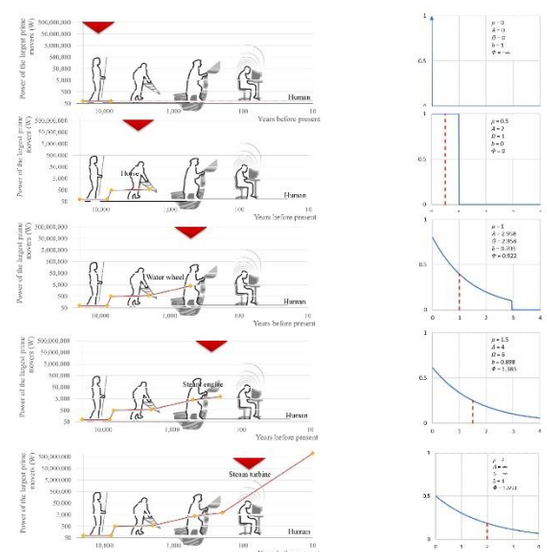
1. Entropy: From the ancient classless society to modern stratified societies



2. Introduction to empirical investigation

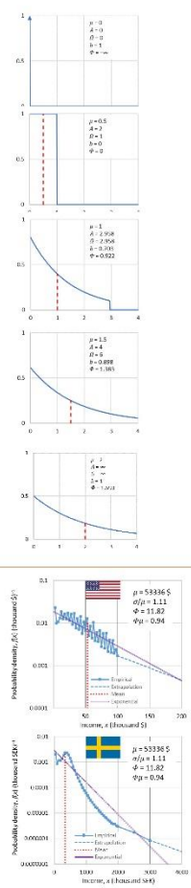
Two opposite forces modify the natural (exponential) distribution:

An organized society redistributes income and wealth through their transferal from the richer individuals to the purer by means of several mechanisms (e.g. taxation).

On the other hand, the actions of economic elites, pursuing a greater share of the community's wealth, tend to modify mostly the income distribution tail, converting it from exponential to power-law (Pareto).

At the same time, the elites advance both the technological limit and the average wealth. Naturally, the advancement of technology and average wealth are the positive side of elites' action.

In the retrieved data, the information about the tail (the very rich people) is missing as the data values end at some level c with the last bunch of data given as "c and over".



3. The failure of "80/20 rule"

In both cases, the income distribution is consistent with the principle of maximum entropy, and in particular with exponential distribution.

Yet the effect of the elites is visible, as the distribution tails exceed those of the exponential.

On the other hand, the data do not support the well-known "80/20 rule", which is consistent with the Pareto distribution (with a specific value of the tail index).

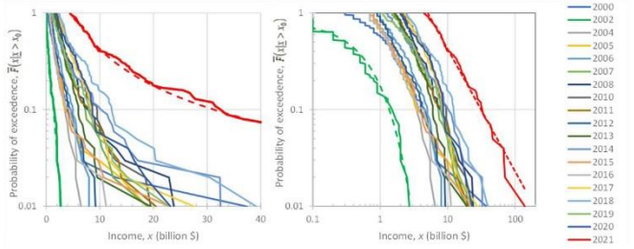
Specifically, 80% of the income is not generated by 20% of the population, but by more than 40% thereof, which is fully consistent with the exponential distribution. Interestingly, the "80/20 rule" is often called the "Pareto rule", but the historical investigation performed reveals that the Italian economist Pareto did not suggest that, but later authors loaded him with things that he never said.

The most telling evidence about the type of the distribution and, hence, the appropriate background measure, is obtained by studying the distribution tail. To study the tail, we do not need to examine the entire population, i.e. the entire range of the variable x.

4. Study of the elites (1)

The means to increase elites' profits certainly include political power and, more recently, an attitude to control the world. Their endeavor becomes more efficient and acceptable by the society by several means they use, such as by overstating existing or non-existing threats, and then by presenting themselves as philanthropists (e.g. by funding nongovernmental organizations dealing with these threats) and world saviours.

5. Study of the elites (2)



Figures: Conditional probability of exceedance of the annual income of the richest persons in the world. The income per person was found by subtracting the total net worth of a year from that of the previous year.

Based on these data and with focus on the distribution tail, we concluded that the exponential tail is not uncommon, while the Pareto tail appears particularly in anomalous periods.

Impressively, the latest period of pandemic resulted in unprecedent profits of the richest, with a clear Pareto tail.

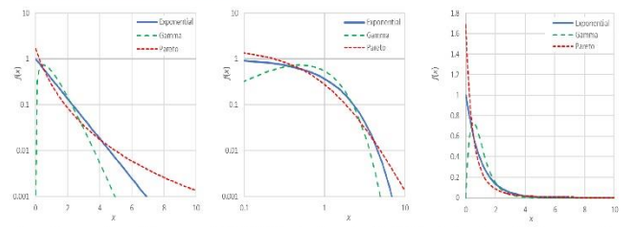
Entropy maximizing distribution emerges when the background measure has constant density, while if a hyperbolic background measure is used, the resulting distribution is Pareto. Based on real-world data, and in particular, those of the world's richest, in order to give a better idea on the distribution tail, we conclude that the exponential tail is not uncommon, while the Pareto tail appears particularly in anomalous periods. Impressively, the latest period of the pandemic resulted in unprecedent profits of the richest, with a clear Pareto tail.

The entropy maximizing under a constant density, leads to an exponential distribution and it is connected to a stable economy.

Furthermore, we examined two different factors (both decrease entropy):

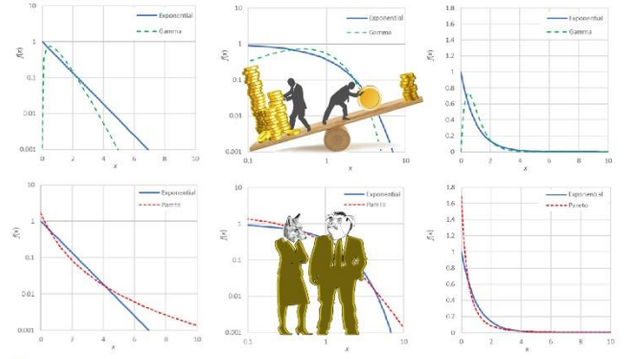
- The organized societies use mechanisms of income redistribution in order to minimize poverty and enhance the middle class.
- Politico-economic elites try to increase their profits, thus pointing toward a Pareto distribution, which populates more the poor and the very rich and reduces the middle class.

6. Discussion and conclusions



A graphic comparison of the exponential distribution (entropy $\Phi = 1$) with Pareto density and the two-parameter gamma density, the behaviour of which is opposite to Pareto.

Note that, in Pareto distribution and gamma distribution, entropy $\Phi = 0.884$.



- Furthermore, we examined two different factors, both leading to reduction of entropy and modification of the stable exponential distribution, but in different directions.
  1. The organized societies use mechanisms of income redistribution in order to minimize poverty and enhance the middle class.
  2. Politico-economic elites try to increase their profits, thus pointing toward a Pareto distribution, which populates more the poor and the very rich and reduces the middle class.

  At the same time, the elites advance both the technological limit and the average wealth.
- Social sciences are often contaminated by subjectivity and ideological influences, which become apparent when examined from distance, in the light of history.
- Here we explore whether the maximum entropy, applied to economics and, in particular, to the distribution of a wealth-related variable, namely the annual income, can give an objective description.
- We show that under plausible constraints related to the mean income, the principle of maximum entropy results in exponential distribution, bounded from above if we consider an upper technological limit, or unbounded otherwise.
- Historically, technology has played a major role in development and increase of the entropy of income. Under current conditions, technology no longer imposes a bounding condition on the economy, yet it remains an important factor in increasing wealth.

Posters

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3-9 July 2023

Values and Costs in History

G.-Fivos Sargentis, Panos Defteraios,
Nikos D. Lagaros and Nikos Mamassis

A presentation explaining the paper with the same title published in *World*, 2022, https://doi.org/10.3390/world3020014

1. Introduction

The history of civilization is a pursuit of wealth. Related archeological data indicate that the growth and storage of wealth was a basic function of human societies that led to stratification. The analysis of the data presented in Section 2 shows that this pursuit is aimed at increasing the life expectancy through access to water, food and energy.

Unfortunately, the quantification of the value of wealth varies both temporally and spatially. The values of gold and silver that are considered archetypal symbols of wealth, in recent history, they have fluctuated over a wide range, as demonstrated in Section 3. For this reason, we also examined the values of wheat, which is a necessary quantity for the survival of humans over time. Additionally, we compare the values of wheat in different phases of history, and we find their correspondence of these values with the present.

In Section 4, we examine the case study of Hadrianic aqueduct's construction costs, in order to approach and describe the construction of the aqueduct, a related research project [2] was implemented, including in situ research [3] and underground explora-tions.

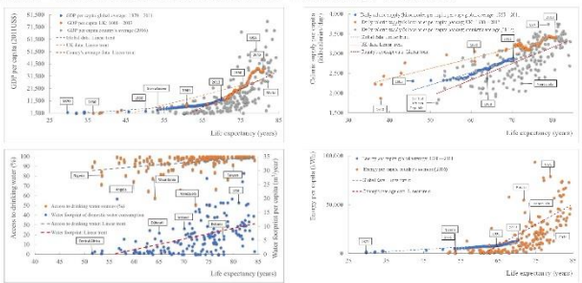
The Hadrianic aqueduct of Athens was built in the early second century AD at a time when there was an economic and social continuity from the first century. The available literature gives data from inscriptional evidence, with the correlations between the prices of wheat per liter and the wages of various professions at that time.

In order to quantify the cost of the Hadrianic aqueduct, we describe in detail how it was constructed, we analyze the labor-times required and we calculate the total cost with the corresponding labor and wages of the Roman period.

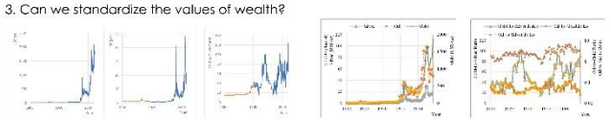
The study correlates the values in antiquity with values of today's prices (February 2022) in Greece, which is the place of construction of the aqueduct, and we estimate the costs of a similar project using modern material techniques.

Overall, this paper presents a holistic approach of values and costs in history, comparing the prosperity of society in different eras, using standardized measures such as wheat wages and water footprint per capita. Furthermore, this paper presents a unique analytical description of the Hadrianic aqueduct, a large-scale infrastructure construction in antiquity, estimating its cost in standardize values.

2. True Wealth. Life Expectancy related to the Water–Energy–Food Nexus



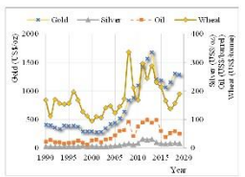
3. Can we standardize the values of wealth?

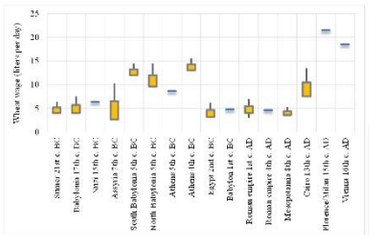


4. Correlations between wealth in antiquity and now

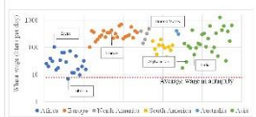
There, the absolute dominance of the dollar in the markets and strict adherence to trade agreements even between struggling and powerful economies and the linking of the dollar to gold at USD 35 per ounce were established. However, as the US had devalued dollars currency, with a unilateral proclamation on an August Sunday in 1970, Richard Nixon suspended the convertibility of the dollar into gold.

Although many analysts at the time predicted the end of the dollar, in an ingenious move that can be said was looking back to the archetypal association of capital with energy, two years later, the Americans, through the mediation of Henry Kissinger, came to an agreement with the Saudis, and in exchange for guarantees of their security, persuaded them to make all oil transactions in dollars, releasing the values of gold, silver and oil in a wide range of fluctuations. However, we have to note that, even before the petrodollars, their ratio was fluctuated.





It is almost impossible to estimate the value of wealth based on the exchange rate of the currencies or the value of precious metals in historical eras. However, as wheat is the basic element of the digestive menu of humans, and we have historical information of its cost and wages, we estimated the wheat wages (i.e., the liters of wheat that can be bought by a daily wage).



5. Case Study: The cost of Athens' Hadrianic Aqueduct

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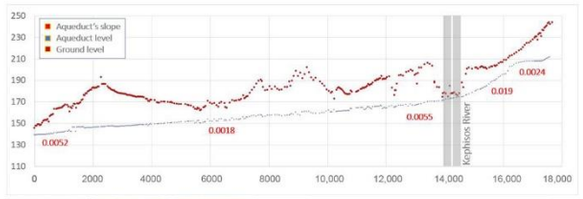
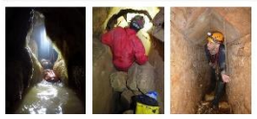
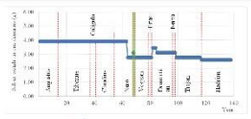
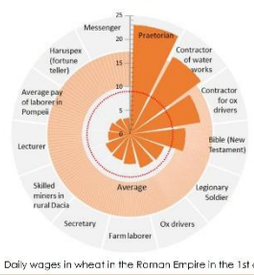
School of Civil Engineering

6. Athens' Hadrianic Aqueduct









Daily wages in wheat in the Roman Empire in the 1st c. AD

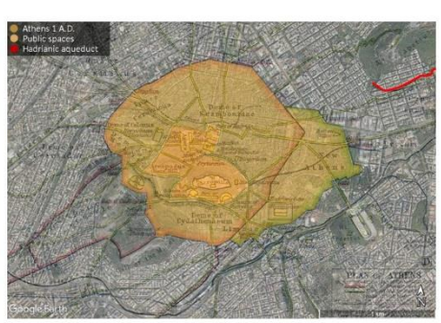
7. Conclusions

The values of the commonly used symbols of wealth (gold and silver) changed throughout history by social issues, as the demand for gold and silver can vary wildly with a fixed supply, which can lead to equally wild swings in their prices.

We know that humanity hunts real wealth (Water Energy Food), with large-scale infrastructures and economies of the scale making this more efficient.

This paper describes the frame of the social conditions when the Hadrianic aqueduct was build. An analytical technical description with volumes of excavations and cooling areas is also presented.

Analyzing global data, we showed that about 1.4 billion people live in present under the average lower wages in antiquity.



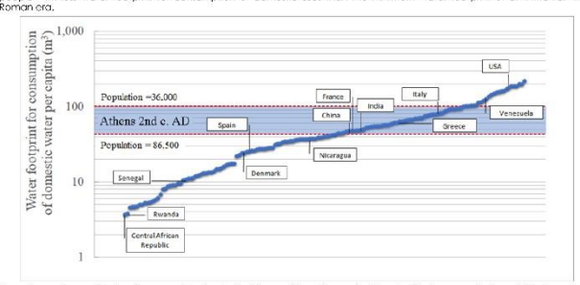
Assuming the same technological methods for underground projects as in ancient Laurion mines, we gave a first estimation of the total humans needed in the efforts for the construction. The estimated value was about 2,000,000 labor days for different specialties. Inspecting the social aspects and salaries in the Roman era, we assumed the stratification and the organization of the construction site.

We made an optimum hypothetical construction site, and we organized the workers in shifts as continuous workers (24 h constantly).

According to our approach, we found that the maximum number of laborers that could work on this construction should be about 4000 people and will end the construction in less than two years. However, in the literature, it is referred that the time of construction is between 6 and 15 years. We estimated that the aqueduct could be con-structed in 15 years approximately by 500 workers or in 6 years approximately by 1200 workers.

Analyzing the daily wages of different specialties, we estimated that the total daily wages for the construction of the Hadrianic aqueduct in antiquity in wheat was 14.250.000 kg, and silver was 3800 kg. However, we did not include the costs of tools, animals and supplementary sources. We estimated that, using today's prices in Greece (February 2022), the wheat wages of antiquity (14.250.000 kg) cost about 7.150.000 EUR, and the wages in silver (3800 kg) cost about 2.500.000 EUR. Further research could examine the project funding scheme in antiquity.

Finally, we showed that the Hadrianic aqueduct changed the life of Athenians, giving them daily at least 10,000 m3. We investigated the range of the population in Roman Athens, and we estimated a range of the water footprint of the consumption of domestic use per Athenian. We found that, according to the global standards, there are about two billion people with less water footprint for consumption of domestic uses than the minimum water footprint of an Athenian in the Roman era.



Overall, we showed that, with present technological innovations, the cost of the Hadrianic aqueduct would be less than in antiquity. However, we noted that humanity has not made great progress in the last 2000 years, as about one third of the population lives with less food and water than Athenians during the Roman era.

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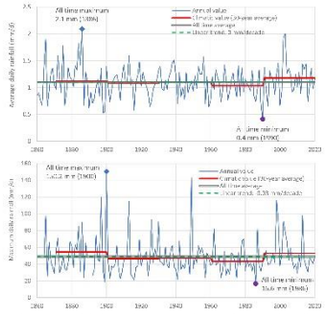
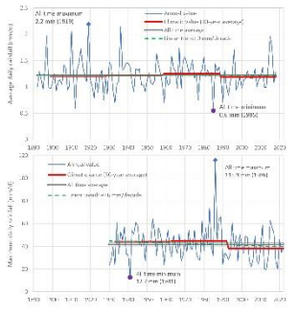
A cool look at rainfall climatic changes in Greece and worldwide

T. Iliopoulou and D. Koutsoyiannis

In the context of implementing the European Flood Directive in Greece, a large set of rainfall data was compiled for the entire country. This set included ground rainfall data as well as non-conventional data from reanalyses and satellites. This dataset was also investigated from a climatic perspective using the longest of the data records to assess whether or not they support the climate crisis doctrine. Monte Carlo simulations, along with stationary Hurst–Kolmogorov (HK) stochastic dynamics, were also employed to compare data with theoretical expectations. Rainfall extremes are proven to conform with the statistical expectations under stationarity. The only notable climatic events found are the clustering (reflecting HK dynamics) of water abundance in the 1960s and dry years around 1990, followed by a recovery from drought conditions in recent years.



Time series of daily precipitation series in Athens, at the Hill of Nymphs station of the National Observatory of Athens (average daily values start in 1860 with a total length of 161 years; daily and maximum daily values start in 1864 with a total length of 155 years). The graph also shows (a) the high and low records, (b) the climatic values (30-year averages), and (c) the fitted linear trends. (Upper): average daily rainfall; (lower): maximum daily rainfall.



Time series of daily precipitation series in Thessaloniki (average daily values start in 1892 with a total length of 127 years; daily and maximum daily values start in 1930 with a total length of 93 years). The graph also shows (a) the high and low records, (b) the climatic values (30-year averages), and (c) the fitted linear trends. (Upper): average daily rainfall; (lower): maximum daily rainfall.

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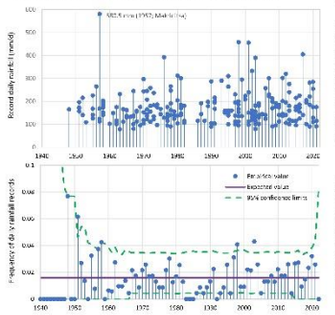
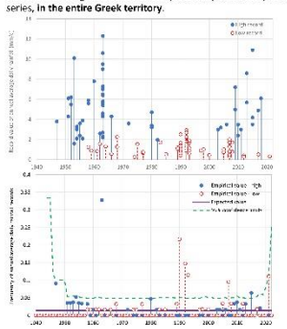
National Technical University of Athens

School of Civil Engineering

Records of maximum daily precipitation depth (upper) and **frequency** thereof per year (lower) for the 238 stations with long time series of annual maxima, **in the entire Greek territory.**



High and low records of average daily precipitation depth per year (upper) and **frequency** thereof per year (lower) for the 62 stations with long time series of complete daily or monthly time series, **in the entire Greek territory**.



Findings

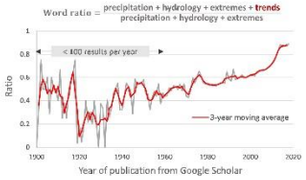
1. The 1950s and early 1960s were particularly wet.
2. This wet season reached its peak but also ended in the hydrological year 1962-63, in which 1/3 of all records of average annual rainfall are gathered.
3. A 20-year climatically neutral period followed until the early 1980s.
4. The climate then entered a 20-year drought, peaking in the five-year period from 1988-89 to 1992-93. It is characteristic that in four of these five years (excluding 1990-91 which was not dry), more than 50% of low records occurred.
5. The last twenty years, after the hydrological year 2002-03, have returned to neutral conditions, although the hydrological years 2006-07 and 2014-15 marked deviations from normality, with a dry and a wet year, respectively.
6. In summary, the most important climatic events are the intensely wet hydrological year 1962-63 and the grouping of dry years shortly before and after 1990, while the alternation of dry and wet periods is notable.

Reference:

D. Koutsoyiannis, T. Iliopoulou, A. Koukouvinos, N. Malamos, N. Mamassis, P. Dimitriadis, N Tepetidis, and D. Markantonis, In search of climate crisis in Greece using hydrological data: 404 Not Found, *Water*, 15 (9), 1711, doi:10.3390/w15091711, 2023.

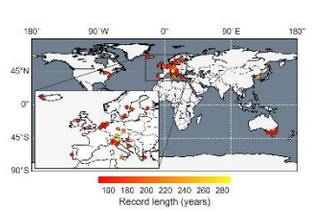
Are trends effective models for future rainfall projections?

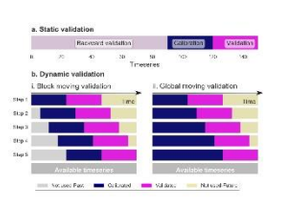
Non-stationarity approaches have been increasingly popular in hydrology, reflecting scientific concerns regarding intensification of the water cycle due to global warming. A considerable share of relevant studies is dominated by the practice of identifying linear trends in data through in-sample analysis. Here, the problem of trend identification is reframed using the out-of-sample predictive performance of trends as the reference point for model selection. A systematic methodological framework is devised in which linear trends are compared to simpler mean models, based on their performance in predicting climatic-scale (30-year) annual rainfall indices, i.e. maxima (AM), totals (AT), wet-day average (WDAV) and probability dry (PD), from long-term daily records. Analysis of empirical records spanning over 150 years of daily data suggests that future long-term variability is better captured using local mean models rather than trends. In line with theoretical findings for persistent processes, it is shown that prediction-wise, simple is preferable to trendy.



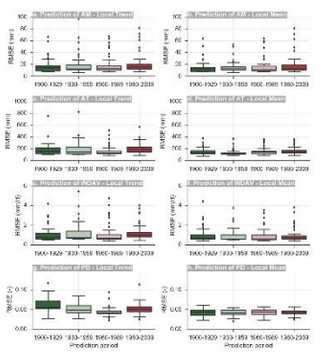
Temporal evolution along with three-year moving average of the ratio of the occurrence of the word 'trends' in Scholar items containing the words 'precipitation', 'hydrology' and 'extremes'

Local trend vs the local mean in projecting annual maxima for the 60 longest rainfall stations.

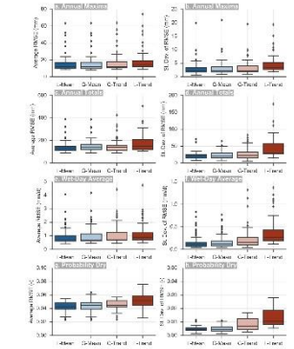




Boxplots of the RMSE distribution from the static validation application to the stations with data in all four prediction periods, 1900-1929, 1930-1959, 1960-1989, 1980-2009, for the local mean (L-Mean) and local trend (L-Trend) models, for all rainfall indices.



Boxplots of the average RMSE and standard deviation of RMSE as estimated for each station from moving window application of the local (L-) mean, global (G-) mean and local (L-) and global (G-) trend for all the indices.



Findings

Future rainfall variability is on average better predicted by mean models, as local trend models identify features of the process that are unlikely to survive the end of the calibration sample, either being extreme observations, or 'trend-like' behaviour.

➢ This empirical finding suggests that the large inherent variability present in the rainfall process makes the practice of extrapolating local features in the long-term future dubious, especially when the complexity of the latter increases.

➢ Prediction-wise, it is shown that simple is preferable to trendy.

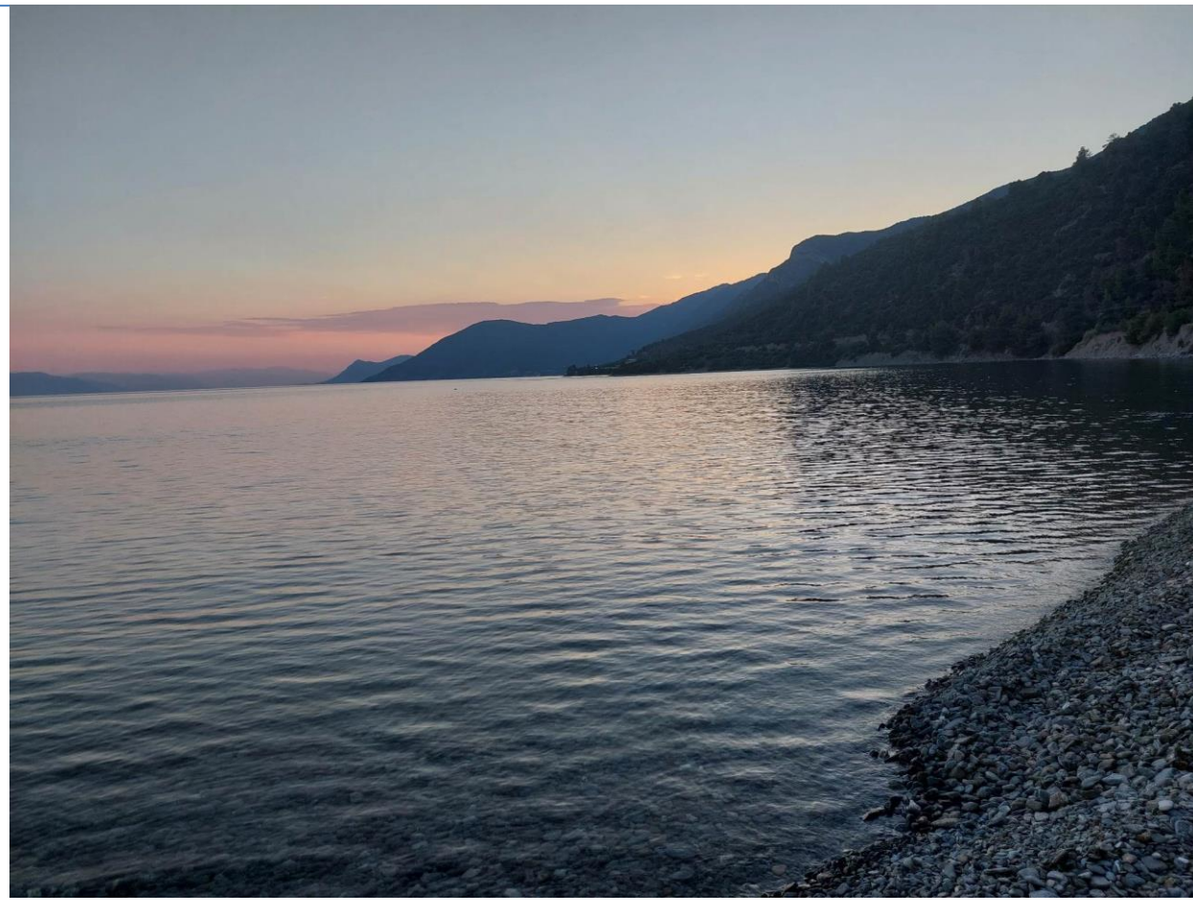
Reference:

T. Iliopoulou, and D. Koutsoyiannis, Projecting the future of rainfall extremes: better classic than trendy, *Journal of Hydrology*, 588, doi:10.1016/j.jhydrol.2020.125005, 2020.

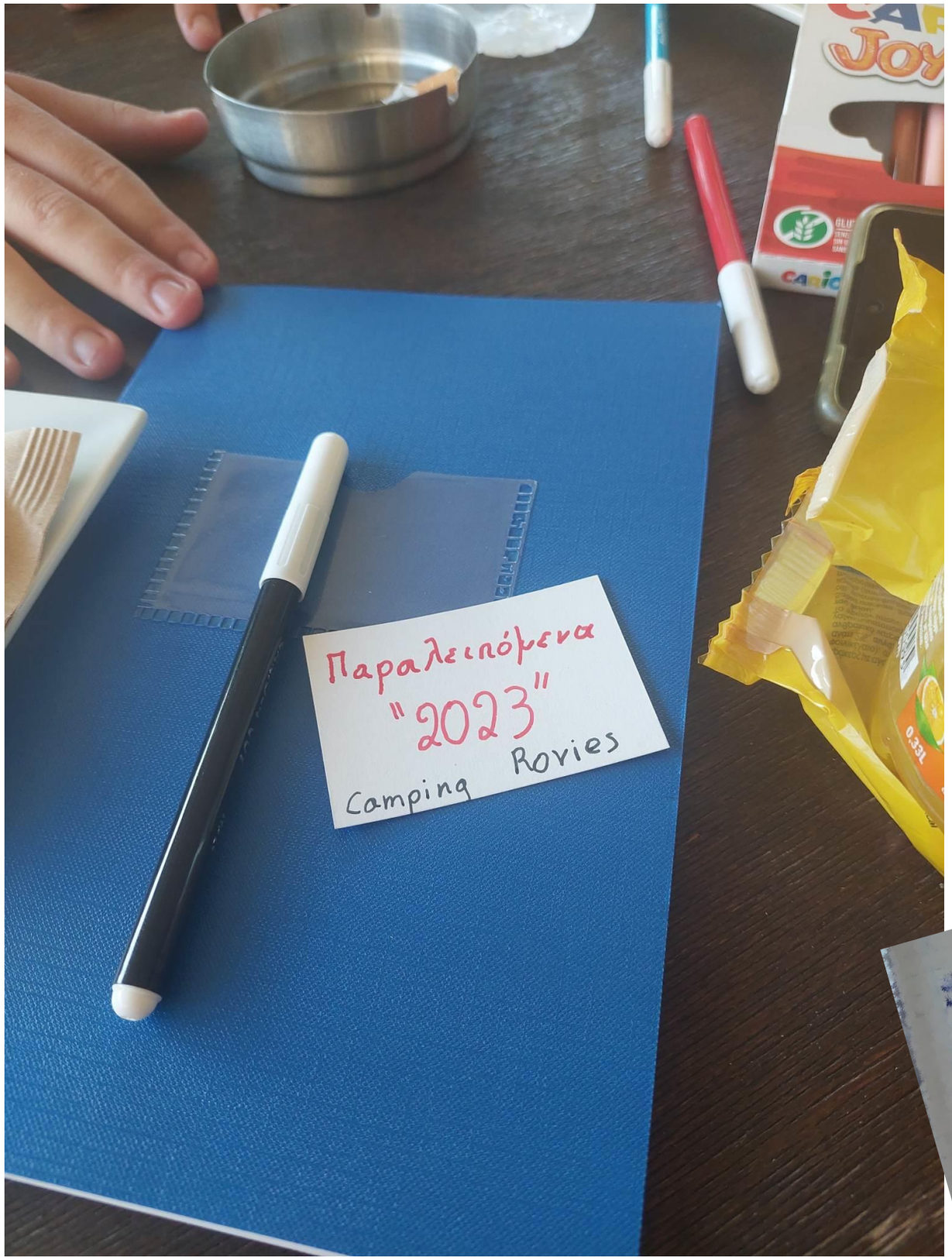
Presentation of posters

Other activities in the morning

Other activities in the evening



Scrapbook with the impressions of the students



The last photo

This summer school was supported by the ADDOPTML project: “ADDitively Manufactured OPTimized Structures by means of Machine Learning” (No: 101007595) belonging to the Marie Skłodowska-Curie Actions (MSCA) Research and Innovation Staff Exchange (RISE) H2020-MSCA-RISE-2020.