The impact of EXtreme weather events on MINing operations

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A new perspective for the numerical slope stability of surface coal mines due to rainfall

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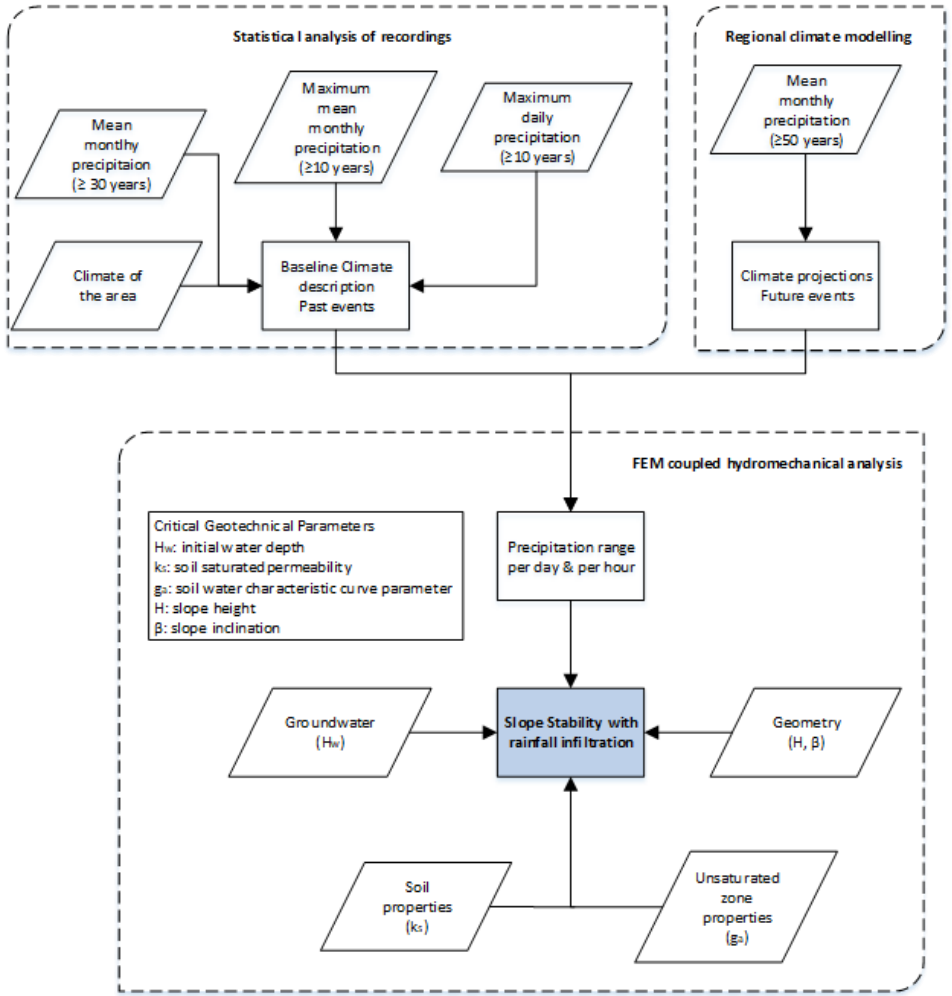
Katowice, 4-10-2022

Framework of analysis

Step 1: Current climate conditions from regional data

Step 2: Climate conditions projections (CORDEX)

Step 3: Rainfall consideration for the numerical analysis of slope stability (Finite Element Method)



Theocharis A.I., Zevgolis I.E., Deliveris A.V., Karametou R., Koukouzas N.C. From Climate Conditions to the Numerical Slope Stability Analysis of Surface Coal Mines. Applied Sciences. 2022; 12(3):1538. https://doi.org/10.3390/app12031538

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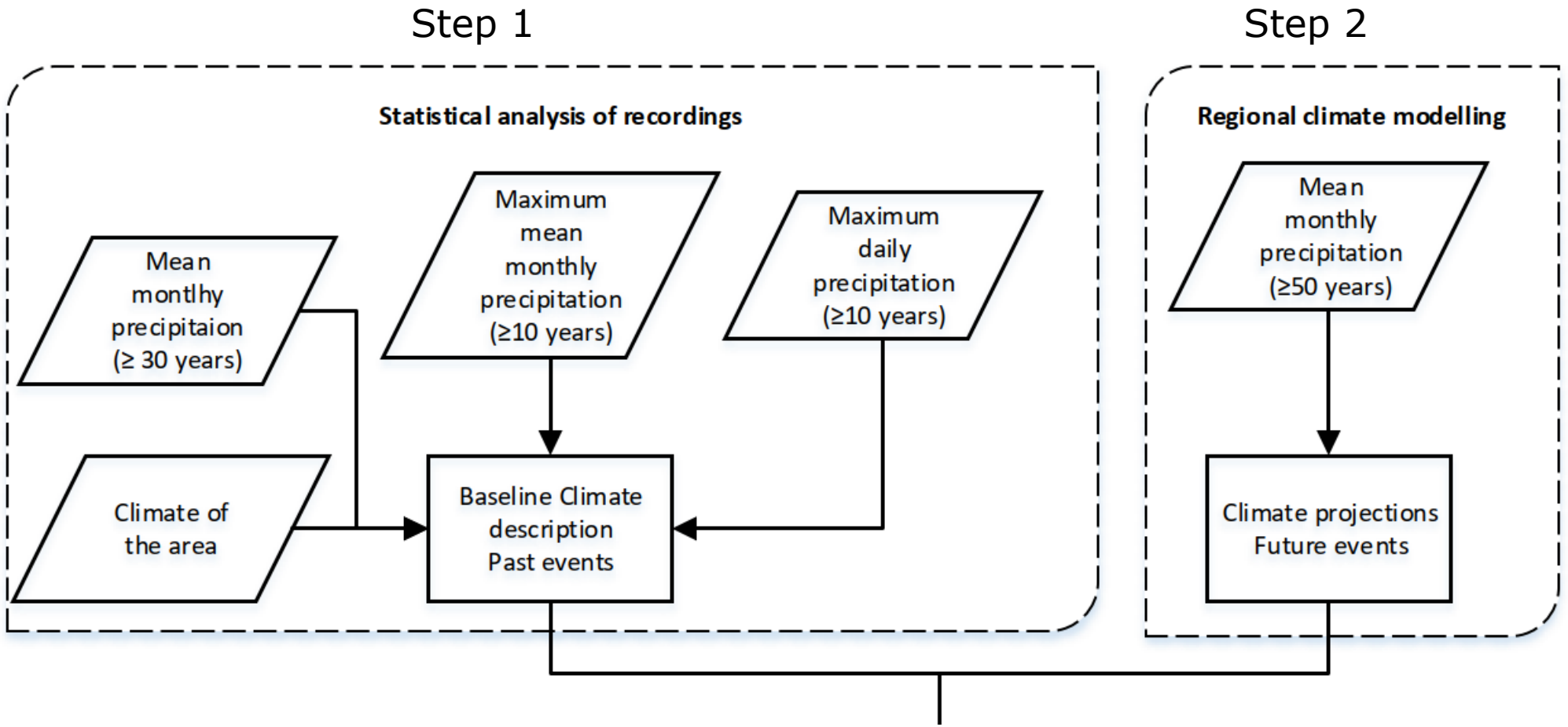
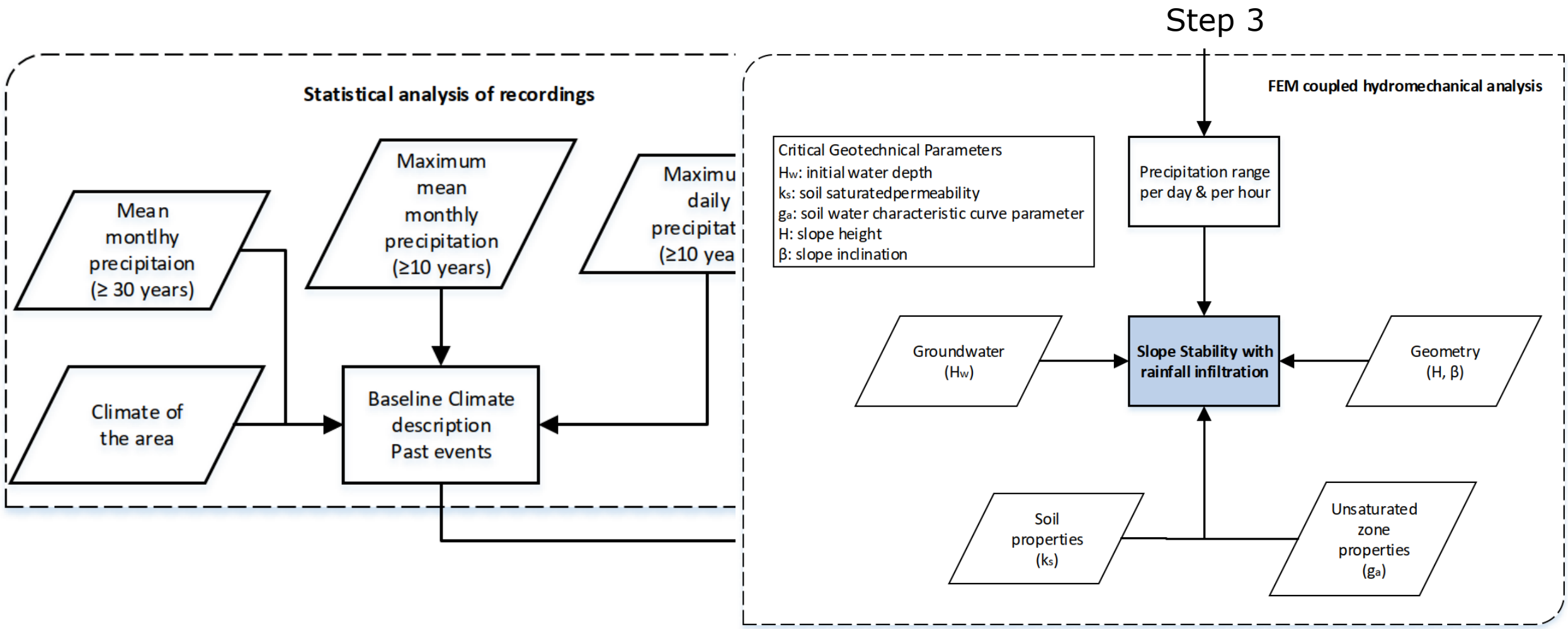
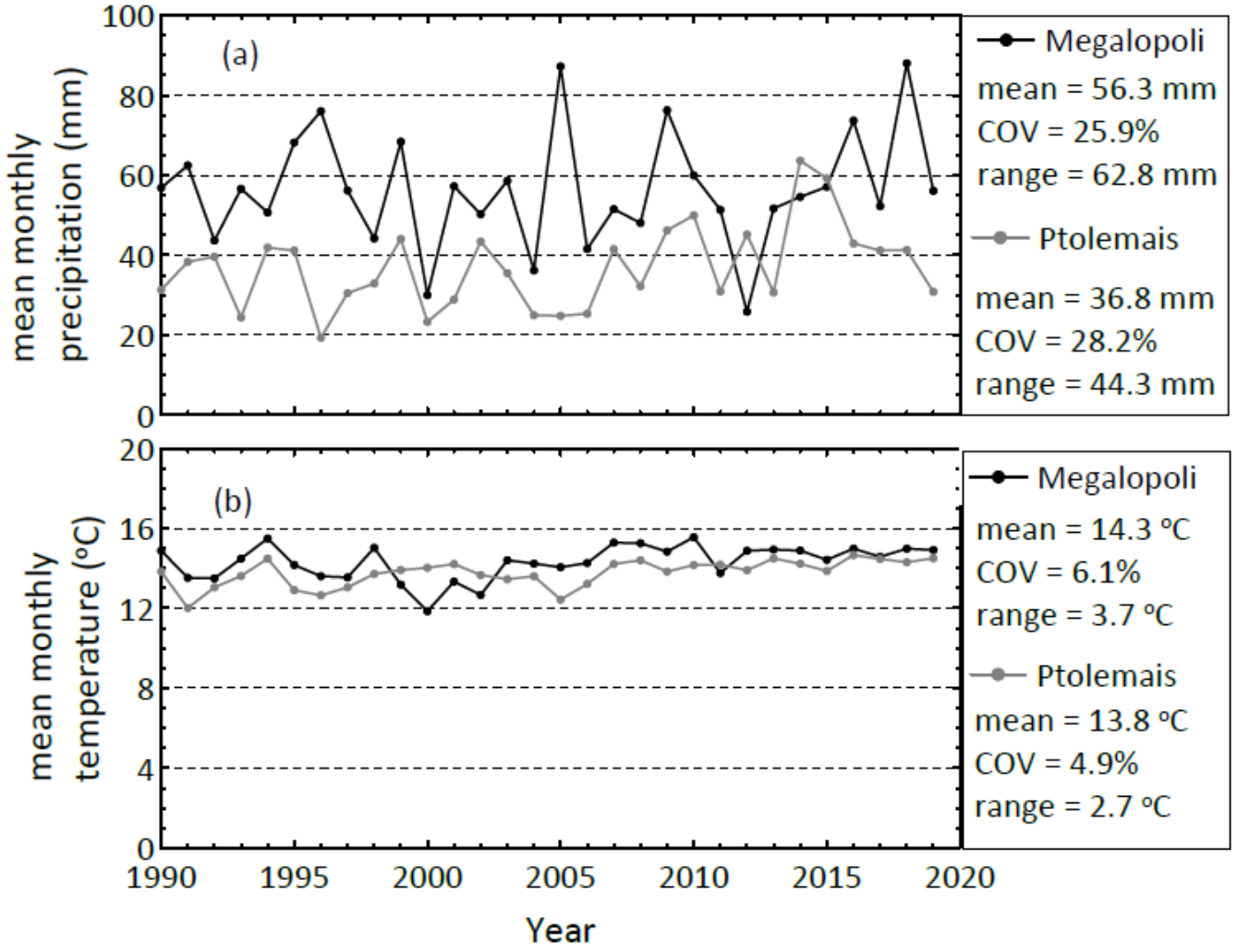


Framework of analysis

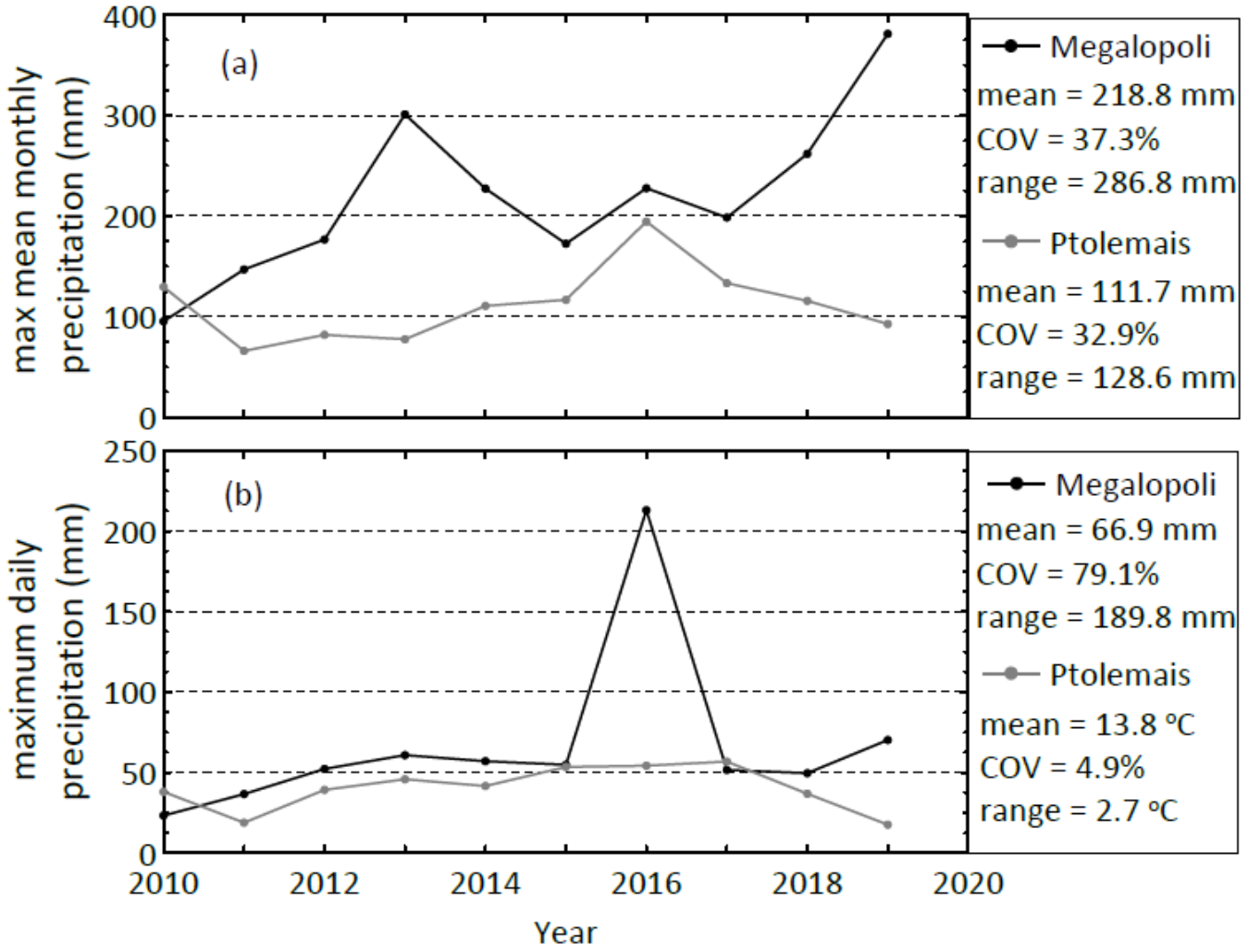


Current baseline climate conditions from regional historical data



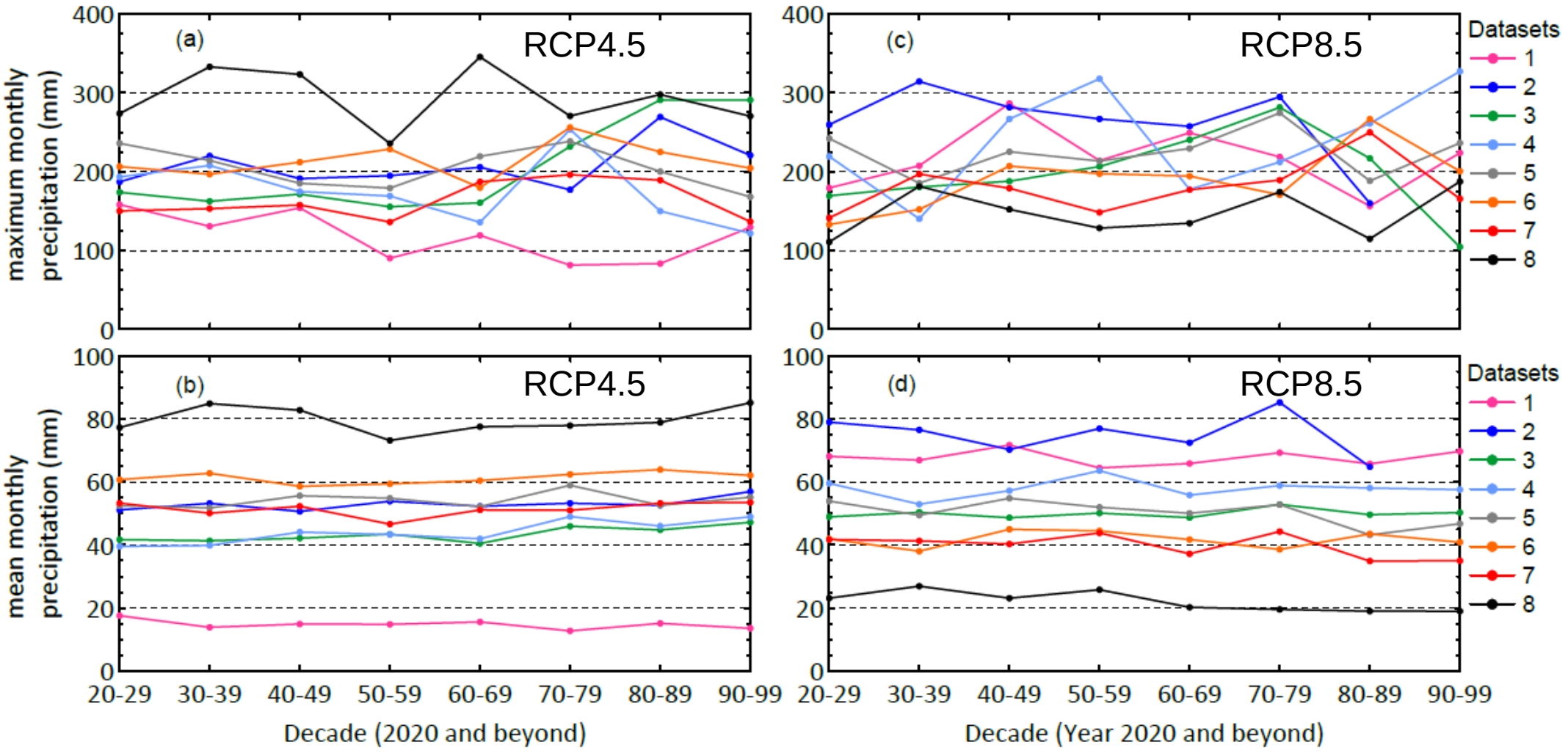
30 years of measurements

Current baseline climate conditions from regional historical data



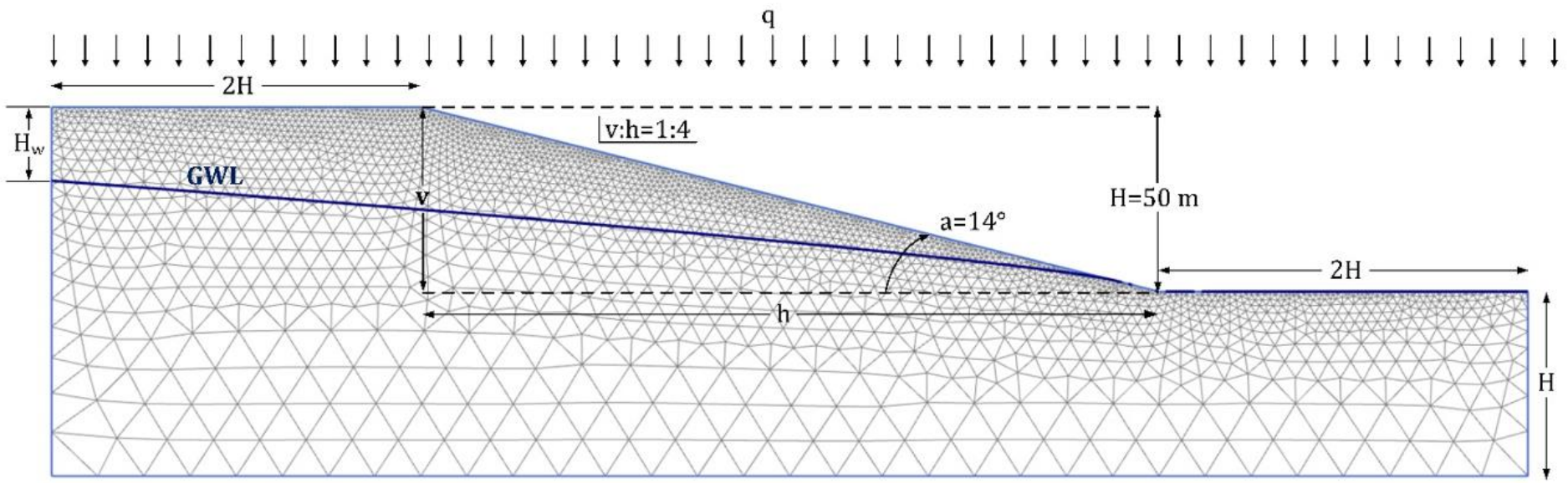
10 years of measurements

Projection of future climate conditions using CORDEX



Mean and maximum monthly precipitation projections for 2020-2099

Rainfall and slope stability - FEM numerical model



Finite Element model for an open pit slope

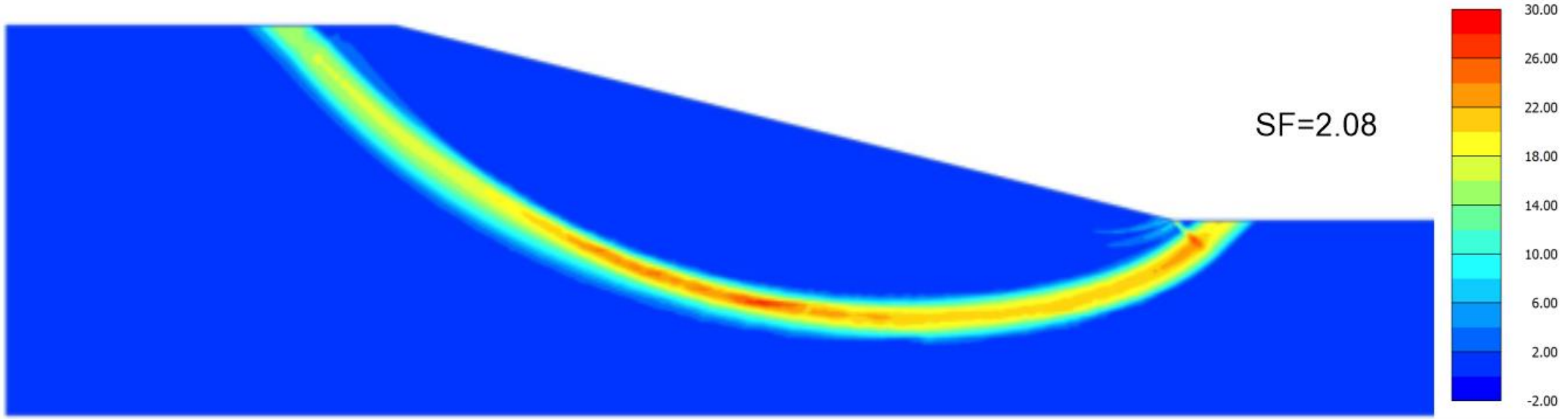
q=0.8 mm/h
q=2.2 mm/h
q=3.6 mm/h
q=5.0 mm/h
q=6.4 mm/h
q=9.0 mm/h
q=17.0 mm/h

→ Range of precipitation imposed at numerical models

Rainfall and slope stability – important geotechnical parameters

Parameter	Symbol	Value
Young's modulus	E' (MPa)	50
Poisson's ratio	ν' (-)	0.25
Effective cohesion	c' (kPa)	50
Effective friction angle	ϕ' (°)	25
Dilation angle	ψ (°)	0
SWCC parameter	g_a (m^{-1})	0.01
SWCC parameter	g_n (-)	1.3
SWCC parameter	g_l (-)	0.5
Bulk water unit weight	γ_w (kN/m^3)	9.81
Unsaturated soil unit weight	γ'(kN/m^3)	16
Saturated soil unit weight	γ_s (kN/m^3)	18
Void ratio	e_o (-)	0.8181
Residual saturation degree	S_r (-)	0.2
Saturated saturation degree	S_s (-)	1.0
Saturated permeability	k_s (cm/s)	10^{-4}
Horizontal stress coefficient	K_o (-)	0.3333

Rainfall and slope stability – failure surface



Failure surface characterized by large shear strains for the reference slope

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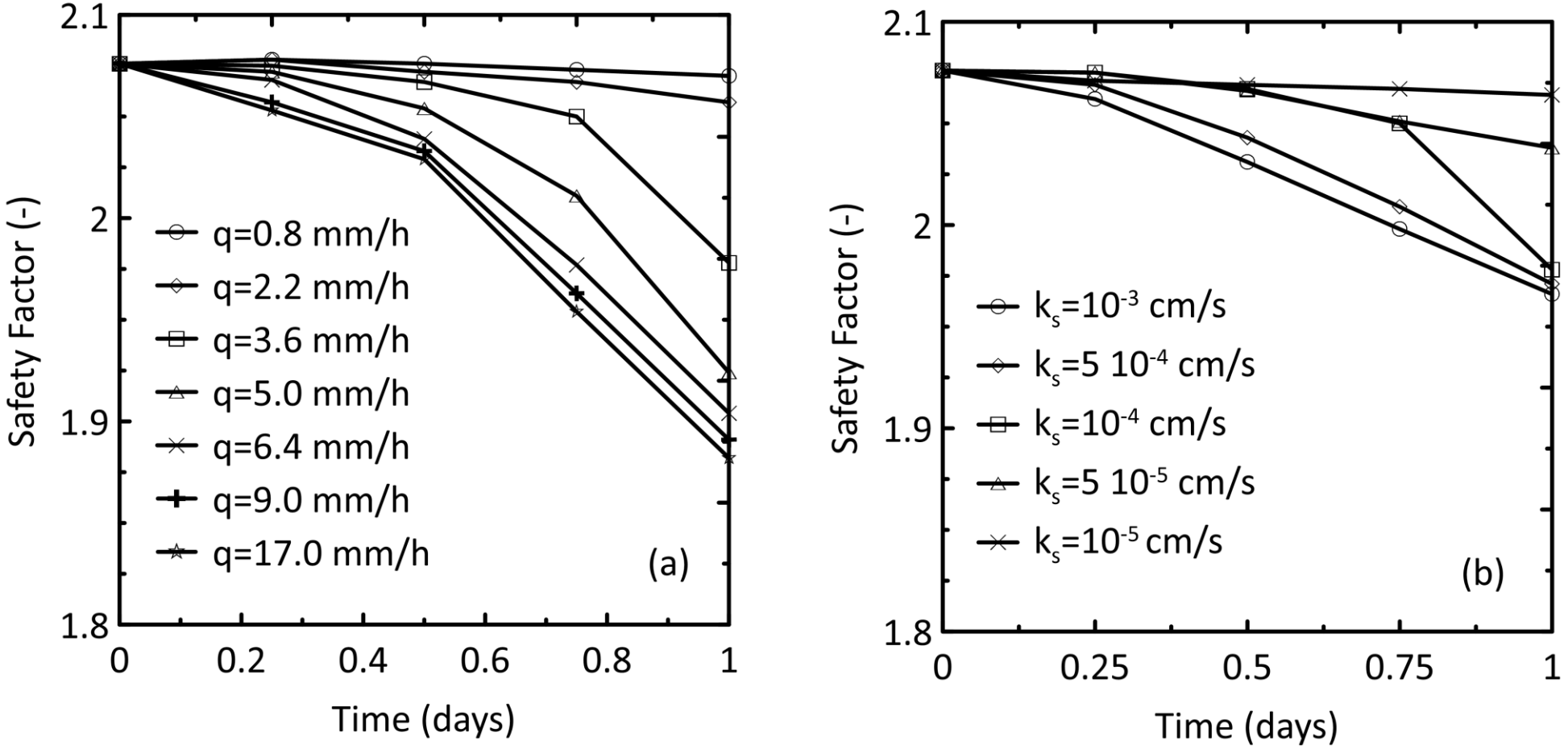
Deliveris A.V., Theocharis A.I., Koukouzas N.C., Zevgolis I.E. Numerical Slope Stability Analysis of Deep Excavations Under Rainfall Infiltration. Geotech Geol Eng 40, 4023–4039 (2022). https://doi.org/10.1007/s10706-022-02135-4

Rainfall and slope stability – parametric analysis



Slope safety factor variation with rainfall time duration

Conclusions

- A framework for integrating climate projections in the stability analysis of open-pit lignite mining slopes was established.
- This framework was applied to typical slope cross-sections encountered in Greek open-pit lignite mining operations
- For the Greek regions, the recorded rainfall intensities varied between 1 and 9 mm/h. Higher values denoting violent rains (q > 10 mm/h) were also spotted.
- The recorded range of rainfall intensities is not expected to alter significantly in the future, regardless of the postulated emission scenarios.
- According to FEM numerical analysis, soil-water characteristic curve parameters has the greater impact on the reduction rate of the pit slope's safety factor during rainfall.
- The rainfall intensity q showed a modest effect in the rate of safety factor's reduction.

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Thank you for your attention!

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