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Global BROOK90 (R-package): an automatic framework to simulate the water balance at any location

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Photography encouraged

What tools do we have nowadays about modelling of water balance components at various locations on the Earth?

Currently available for global (at any location) modelling:

- Hydrological models proved to work well globally with resolution 30-1000 m
- Global reanalysis datasets with resolution 30-50 km
- Automatic libraries (R, Python) with 'boxed' models (from calibration to output)
- No automatic framework with good resolution from A to Z

Nobody needs models. Everyone needs results and services:

- Too many good models are already available
- Characteristics of a specific model are interesting only to a very few people
- End-user expert cares about model type, complexity, set-up, performance, results
- End-user non-expert cares about … *surprise-surprise* … results only.
- Stakeholders need a tool/service: simplicity, usability, universality

'Just drop a catchment and receive reasonable model output' Rubbish? Quatsch?

Main objectives:

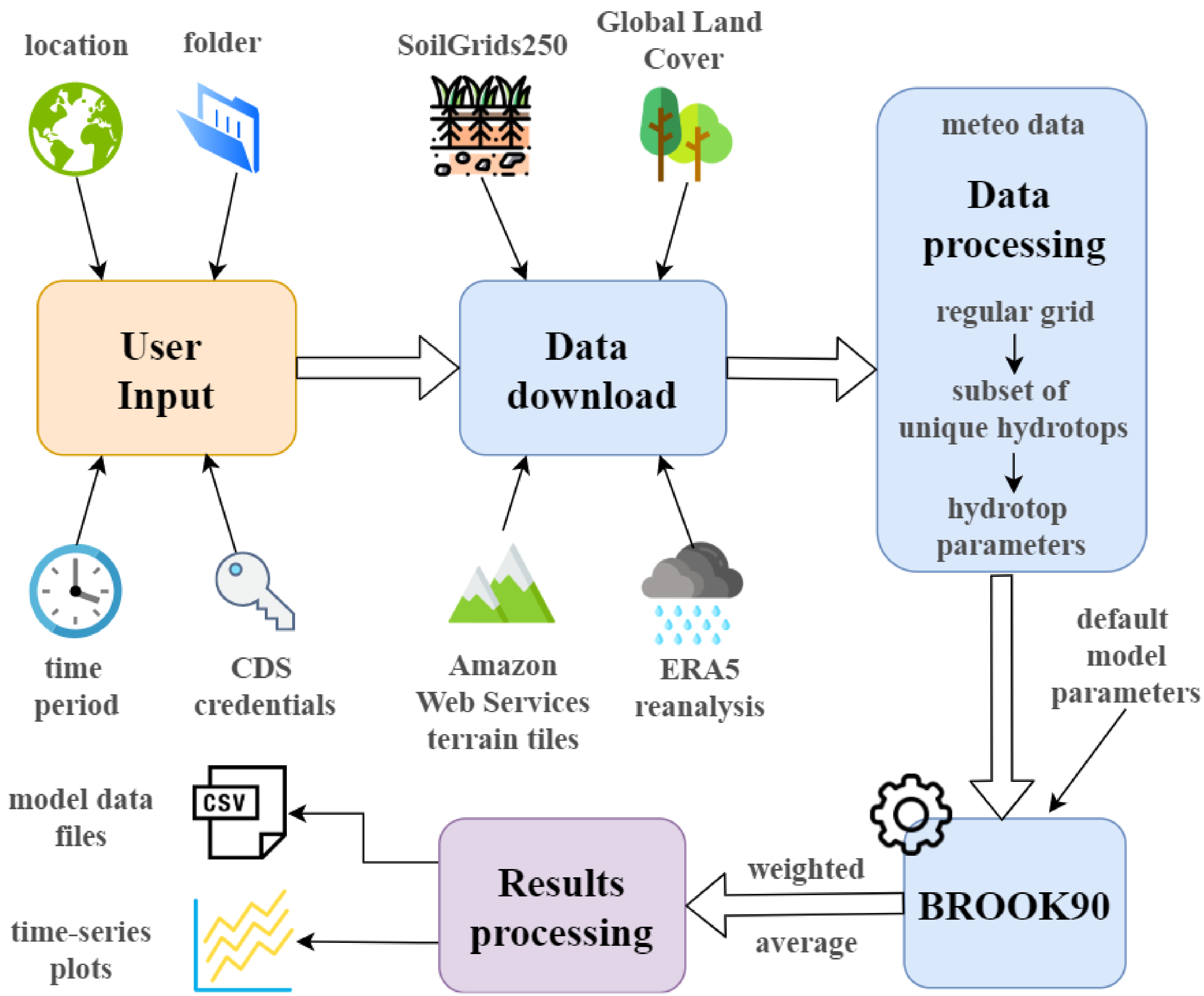
- To broaden the BROOK90 community by expanding the scope of its application
- To show the possibilities and limitations of the globally applicable modelling framework based on a lumped physical model and open-source input data
- To simplify the framework usability for non-experts by full automatization of the modelling process in an easy-to-use package
- A contribution to the open-sourced hydrological science community by the release of the package code

Research question

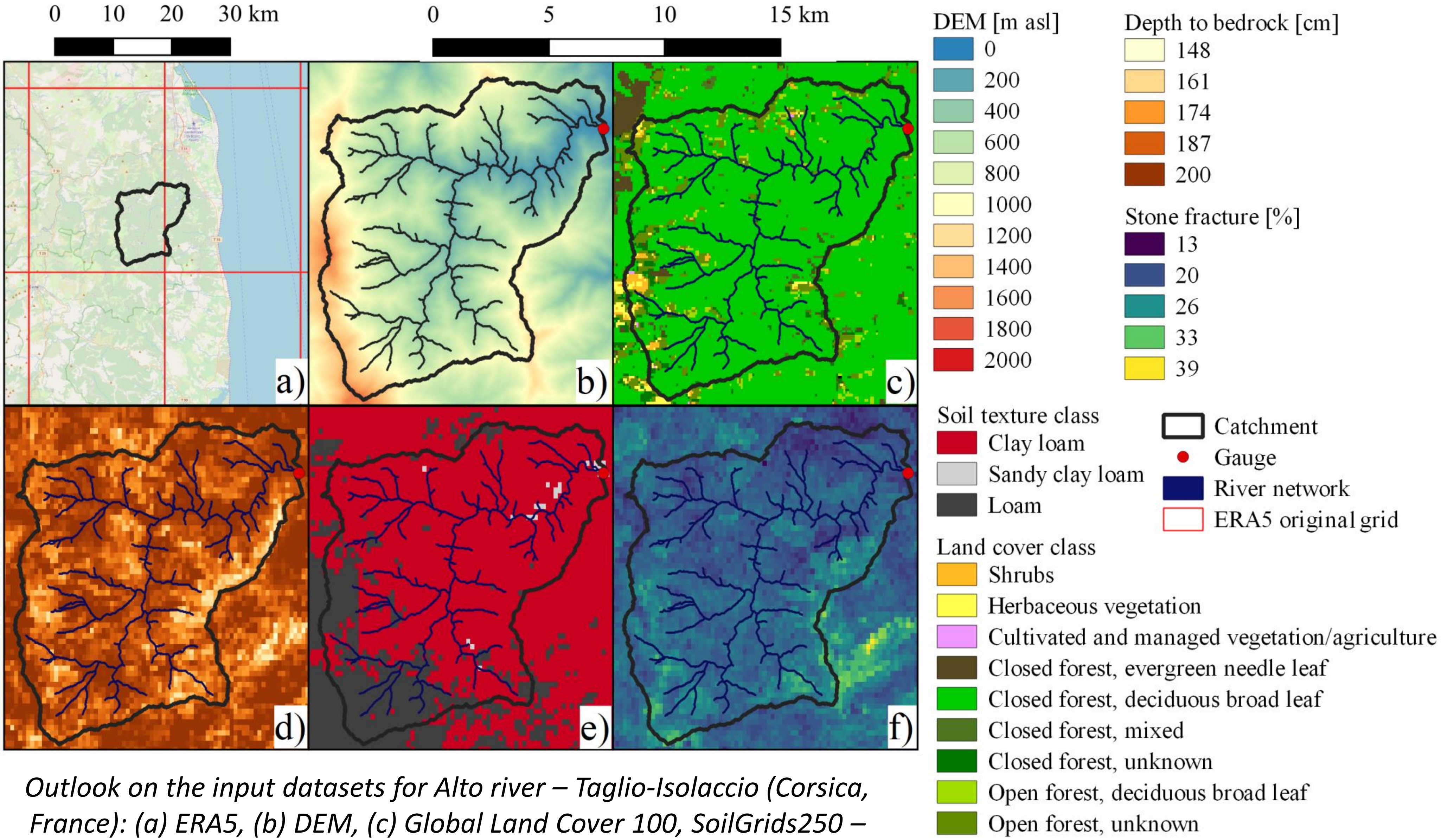
- Is a reasonable model output achievable by deploying a non-calibrated lumped hydrological model based on global parameterization and forcing?
- What are potential uncertainties and limitations of such a framework?

Global BROOK90 concept

- Minimum required input from the end-user
- Automatic data download, processing, modelling and result storage
- Incorporation of the last advances in global datasets
- Easy to operate
- Modelling of the most widely requested variables on physical basis
- Proved reasonable output
- Good potential for the further improvements of the framework itself and implementations as various services



Scheme of the Global BROOK90 framework



Outlook on the input datasets for Alto river – Taglio-Isolaccio (Corsica, France): (a) ERA5, (b) DEM, (c) Global Land Cover 100, SoilGrids250 – depth to bedrock (d), soil texture classes (7th layer) (e) and soil coarse fragment fracture (7th layer) (f).

Current ‘interface’ and workflow

Run_framework.R*

Source on Save | Run | Source

```r
### 25/03/2020 update

### Mandatory set-ups ###
catchment_path = 'D:/WORK/brook90_improvement/validation_discharge/test_wernersbach/wb.shp'
time_start = '01/01/2017' # min: 02/01/1979
time_end = '15/04/2020' # max: current date minus 5-7 days
cds_user = '28735' # ERA5 user ID
cds_key = '20901d6e-0f08-4d25-8eac-5d2130197dfb' # ERA5 key (pass)

### Run framework ###
brook90.framework (catchment_path=catchment_path,
                   cds_user=cds_user, cds_key=cds_key,
                   time_start=time_start, time_end=time_end,
                   # optional defaults
                   model_dir = NA,                                      # folder to put results
                   output_variables = c('swatt','floww','precc','evpp'), # p.s. see full list below
                   cut_warmup_period = 30,                              # in days
                   meteo_averaging = 'weighted_mean' )                  # weighted_mean/mean/nearest_grid

### List of all variables:
# 'swatt'  # soil water volume (total)
# 'floww'  # total streamflow
# 'precc'  # precipitation from input
# 'evpp'   # evaporation
# 'rnett'  # net precipitation
# 'ptrann' # potential transpiration
# 'irvpp'  # evaporation rate of intercepted rain
# 'isvpp'  # evaporation rate of intercepted snow
```

Input from the end-user

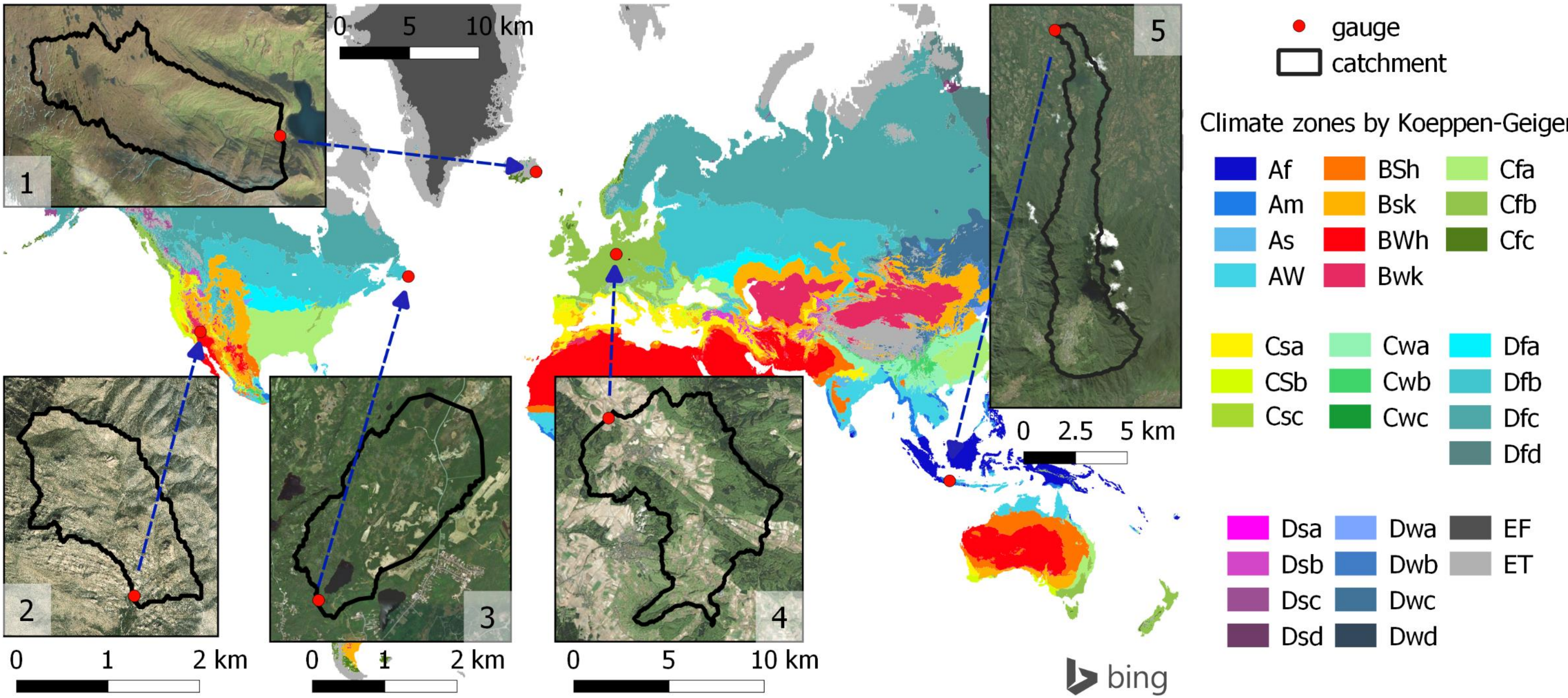
- Operates under R-Studio (up to now)
- Requires to register for ERA5 data
- Requires ‘pacman’ lib pre-installed

Printing statements: major execution milestones

```
"Started download of DEM"
"Finished download of DEM"
"Started download of Soil dataset"
"Finished download of Soil dataset"
"Started download of Land cover dataset"
"Finished download of Land cover dataset"
"Started download of Meteo dataset"
"Finished download of Meteo dataset"
"Data processing:"
"       catchment slope and grid -> completed"
"       raw soil data -> completed"
"       raw land cover data -> completed"
"       unique hydrotops subset -> completed"
"       soil and land cover pars for hydrotops -> completed"
"       meteo and P dataframes -> completed"
"Applying BROOK90 for each unique hydrotop"
"       hydrotop 1/8 -> completed"
"       hydrotop 2/8 -> completed"
"       hydrotop 3/8 -> completed"
"       hydrotop 4/8 -> completed"
"       hydrotop 5/8 -> completed"
"       hydrotop 6/8 -> completed"
"       hydrotop 7/8 -> completed"
"       hydrotop 8/8 -> completed"
"Saving results and plots"
"Starting data download 2020-02-16 10:59:41"
"Starting data processing 2020-02-16 11:07:09"
"BROOK90 for each hydrotop 2020-02-16 11:07:20"
"Saving results 2020-02-16 11:07:23"
"End 2020-02-16 11:07:39"
```

Validation. Examples.

(swear these aren't the best ones)

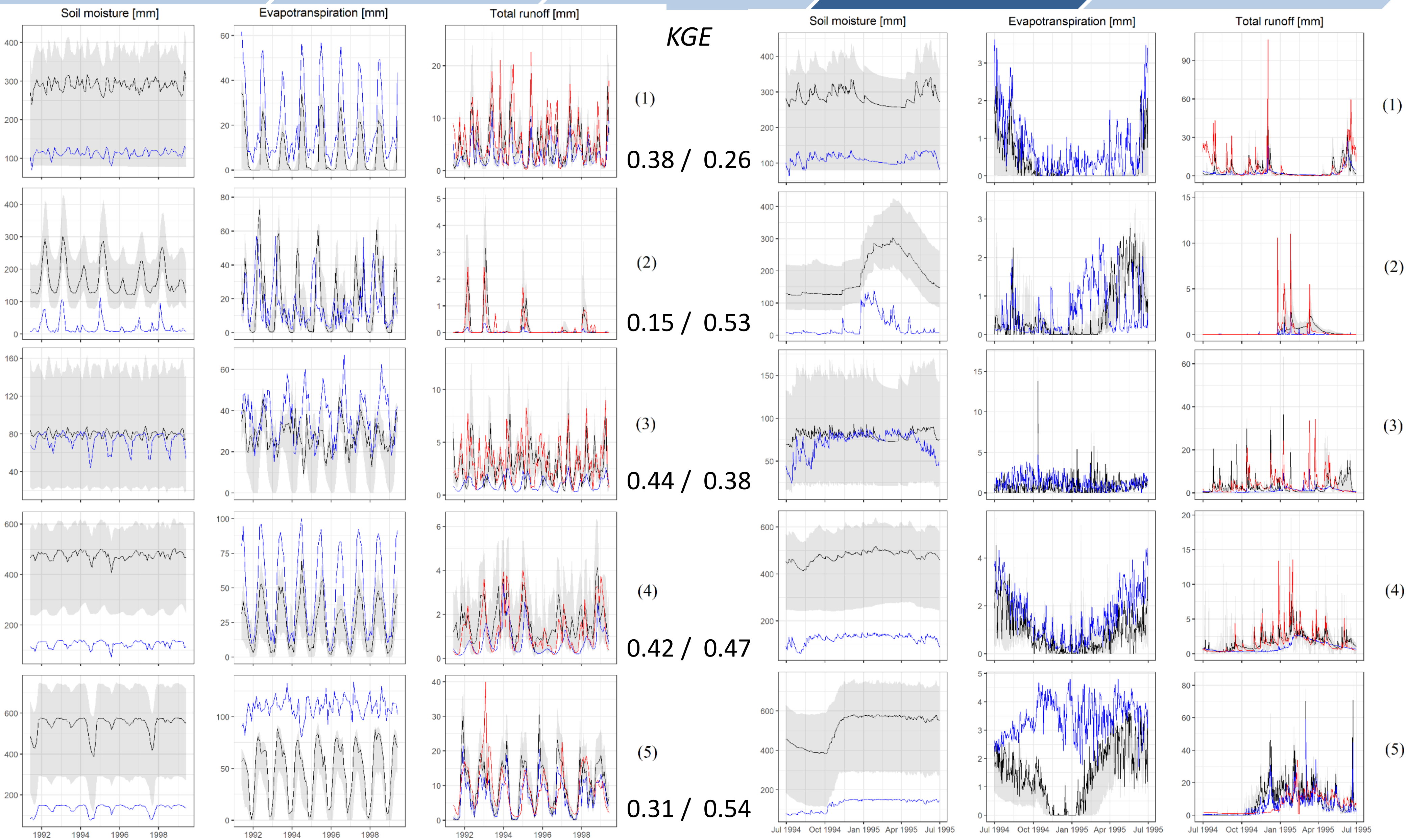


Outlook on the chosen catchments. Numbers near the catchments refer to table below.

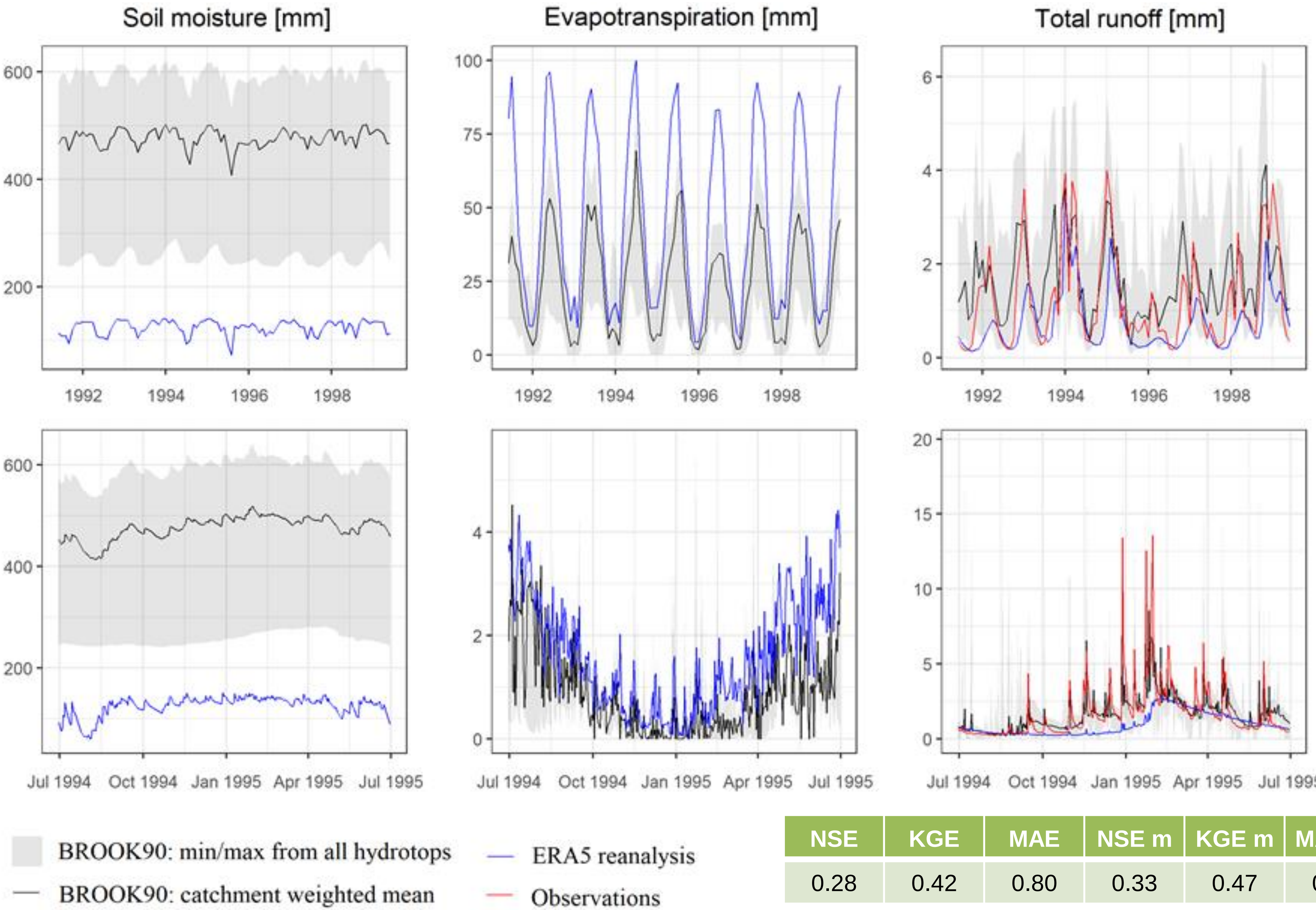
Catchment characteristics.

Number	River-gauge	Area [km²]	Climate	Relief[1]	Land cover[1]	Soil texture[1]
1	Fossa – Eyjolfsstadir	115	polar, tundra	flat	herbaceous/bare vegetation	loam, sandy loam
2	Caruthers Creek – near Ivanpah	2.2	arid, desert/steppe, cold	hilly	shrubs	sandy loam
3	Northeast Pond River – Pond River	3.9	continental, without dry season, warm summer	flat	closed forest (evergreen needle leaf)	loam
4	Lenne – Oelkassen	65.6	temperate, without dry season, warm summer	flat	closed forest (deciduous broad leaf) / cropland	loam, silt loam
5	Kupang Kali – Pagarukir	34.7	tropical, rainforest	hills	closed forest (evergreen, broad leaf)	clay loam, clay

[1] dominant



Performance of Global BROOK90 vs ERA5 and Q observations on monthly (left) and daily (right) scale



NSE	KGE	MAE	NSE m	KGE m	MAE m
0.28	0.42	0.80	0.33	0.47	0.61

Performance of Global BROOK90 vs ERA5 and Q observations for Lenne – Oelkassen

Outcome: first fully automatic open- source framework to model the water balance at any location

Main scope

- Reliable simulations of vast number of water balance components in a small catchment or a single site
- Downscaling of global reanalysis datasets to a hydrotop scale
- Non-specialists with limited prior knowledge of hydrological modelling, parameterization, calibration, etc.
- Locations where it is hard/impossible to get catchment/site characteristics and meteorological data (data scarcity)

Future

- Global validation (discharge, FLUXNET) – already in progress
- Product / services development (near operational soil drought monitor)

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DRESDEN concept

Where to find me: ResearchGate **/Ivan Vorobevskii/**

Thank you!
Dankeschön!

Presentation PDF will be available on EGU2020 web page.

Session EOS7.10. Open Hydrology: Advances towards fully reproducible, re-usable and collaborative research methods in Hydrology

'Drop a catchment and receive model output':
Introduction to an open-source R-Package to model the water balance wherever you want