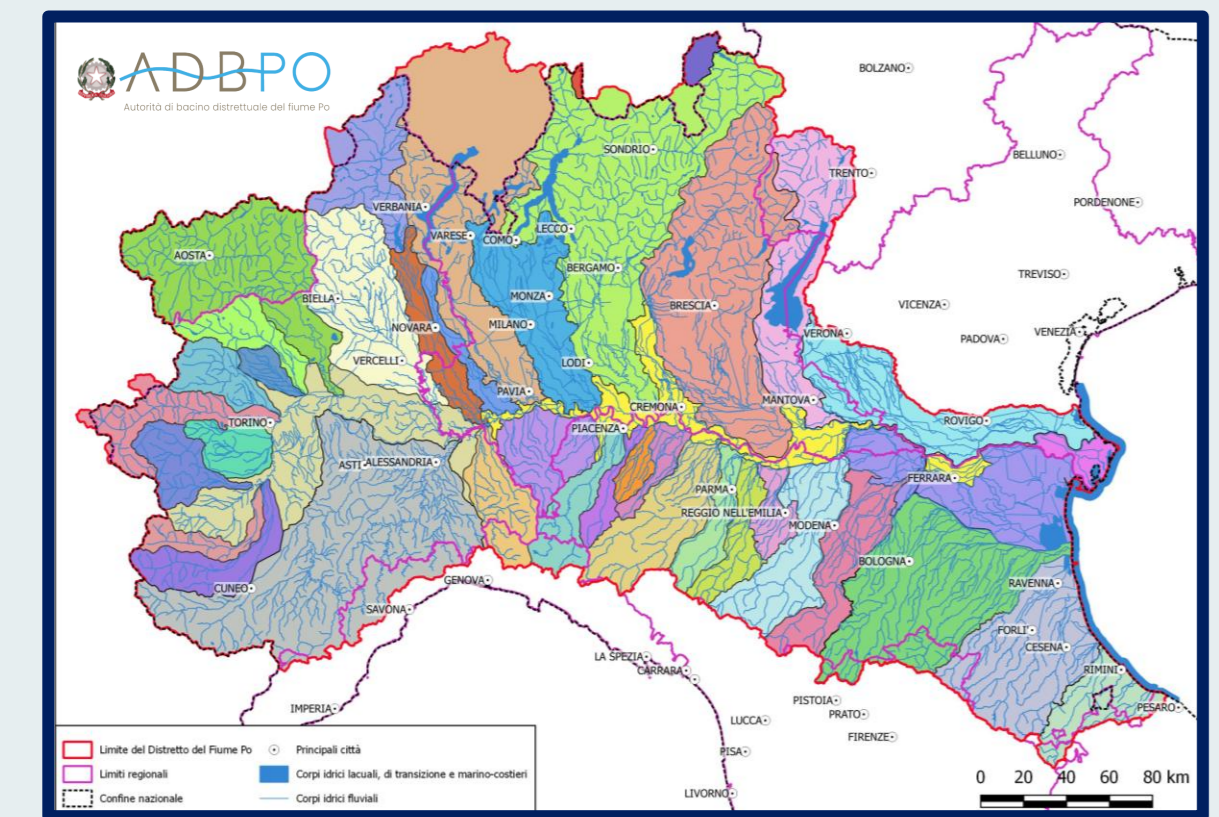


ASSESSING WATER AVAILABILITY AND DROUGHT DYNAMICS IN THE PO RIVER DISTRICT USING THE GEOFRAME MODELLING SYSTEM - THE SESIA RIVER BASIN CASE

Gaia Roati^{1,3}, Giuseppe Formetta², Marco Brian², Francesco Tornatore², Hossein Saleh³, Daniele Andreis^{3,4}, Shima Azim³, John Mohd Wan³, Andrea Farina², and Riccardo Rigon^{2,3}
 (1) Po River Basin District Authority, Parma
 (2) Department of Civil, Environmental and Mechanical Engineering (DICAM), University of Trento (Trento)
 (3) Center Agriculture Food Environment (C3A), University of Trento (Trento)
 (4) Edmund Mach Foundation, San Michele all'Adige (TN)



Introduction



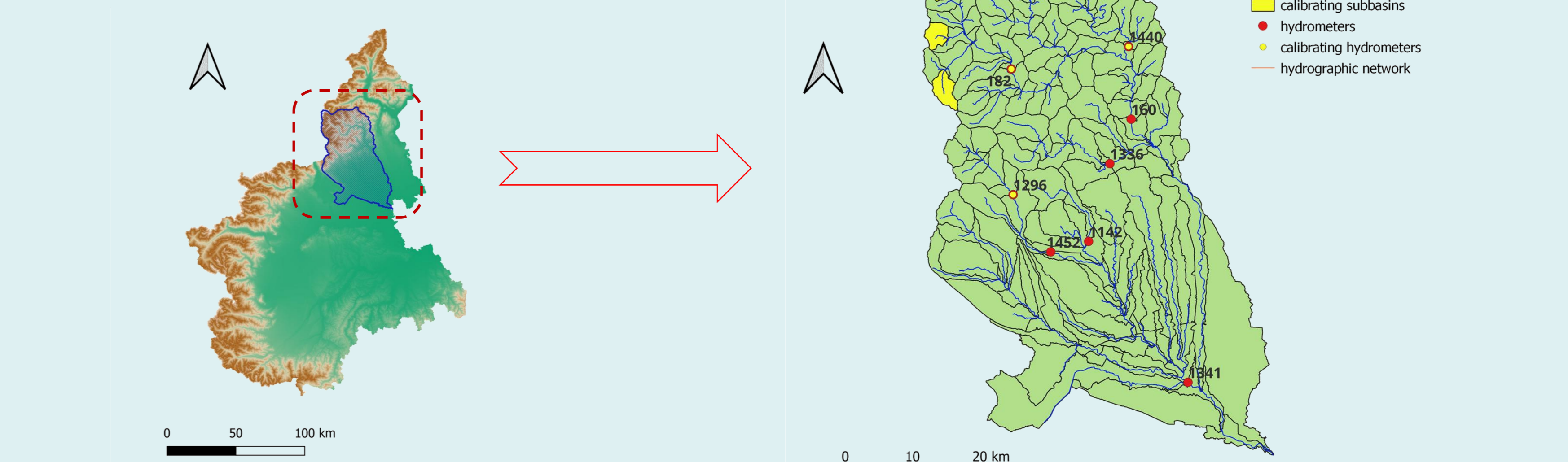
In 2021, the Po River Basin District Authority (ADBPO) undertook the implementation of the **GEOframe modelling system** on the whole territory of the district in accordance with the GCU-M (Gruppo di Coordinamento Unificato-Magre) to update the existing numerical modelling for water resource management.

- Better monitoring, estimation and simulation of the main hydrological variables characterizing the territory of the Po River district
- Water availability quantification across the entire Po River district and its tributaries
- Analysis of the water resources management impacts resulting from climate change or land use changes scenarios
- Identification of drought periods in real-time forecast and long-term prediction, including climate change impacts

Calibration strategy:

- 3 hydrological years
- KGE optimization
- "zonal calibration" on measured water discharge

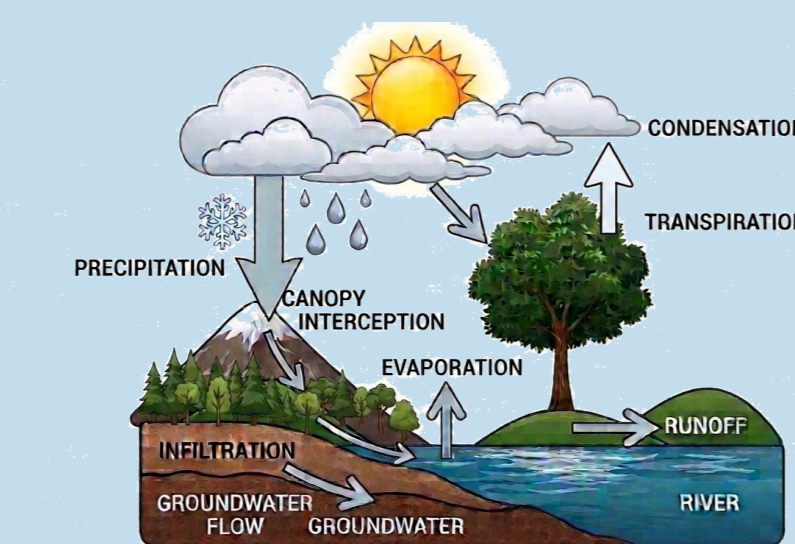
Study area



Legend: Sesia catchment (Palestro Sesia (PV)), calibrating subbasins, hydrometers, calibrating hydrometers, hydrographic network.

Objectives

- Deploy the **GEOframe** system over all the catchments in its territory
- Calibrate and verify the results obtained by the hydrological and hydraulic models against measured discharges and water levels across the whole area
- Analyze the water resources management impacts resulting from climate change or land-use changes scenarios



Snow component

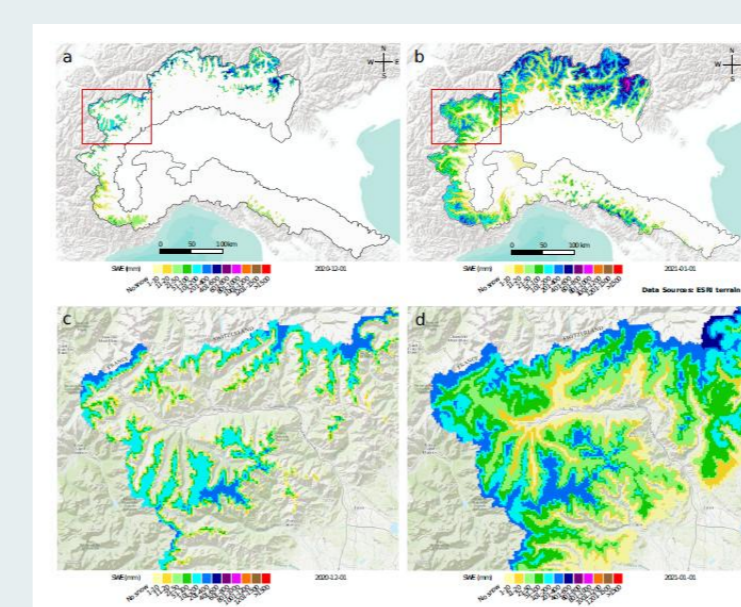
In a mountain catchments like the one of the Po River District, snow is a fundamental component of the water balance

- accurately quantifying snowpack storage to forecast seasonal river discharge, useful also for agriculture and energy production systems

HOCK'S ENHANCED MODEL
 DRIVERS: AIR TEMPERATURE & POTENTIAL SOLAR RADIATION
 ✓ Physically more realistic, better spatial representation
 ✓ Performance improved in mountainous basins (e.g., Alpine)
 ✓ Distinguishes north/south slopes with same temperature
 ✗ Requires DEM, complex computation, more calibration parameters

Reference dataset

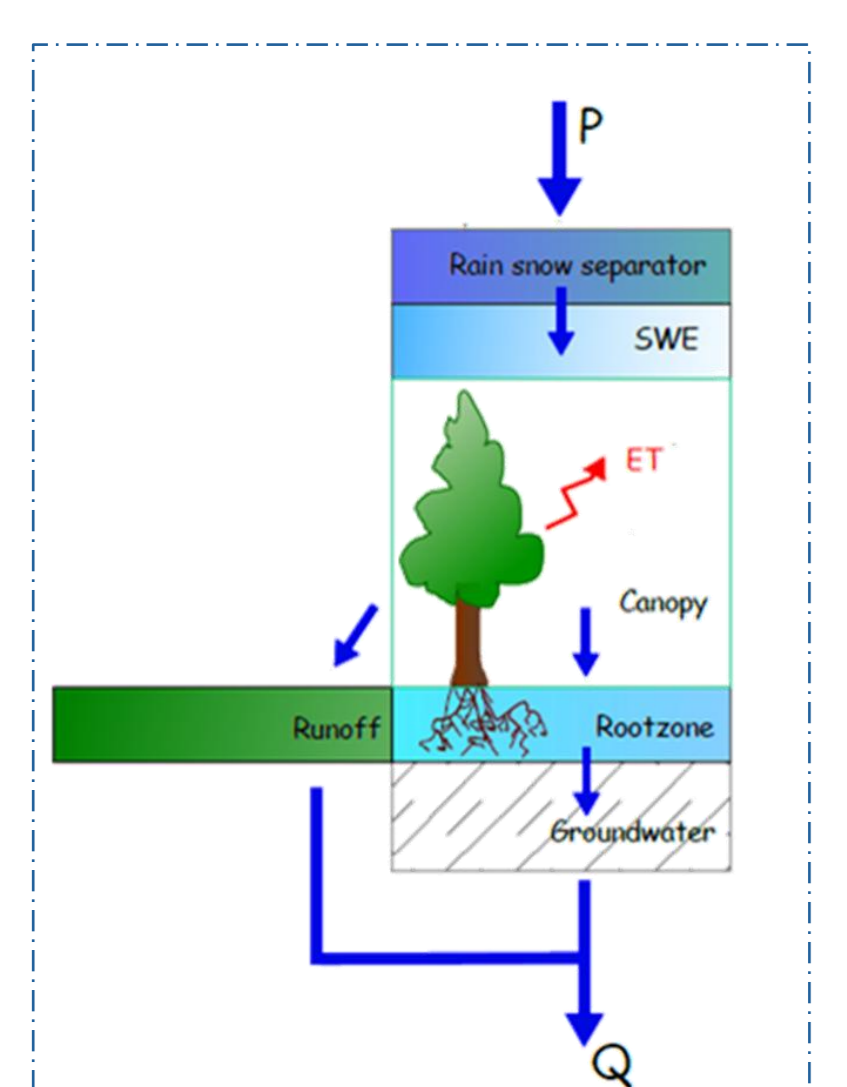
scientific data
 OPEN 30-years (1991-2021) Snow Water Equivalent Dataset in the Po River District, Italy



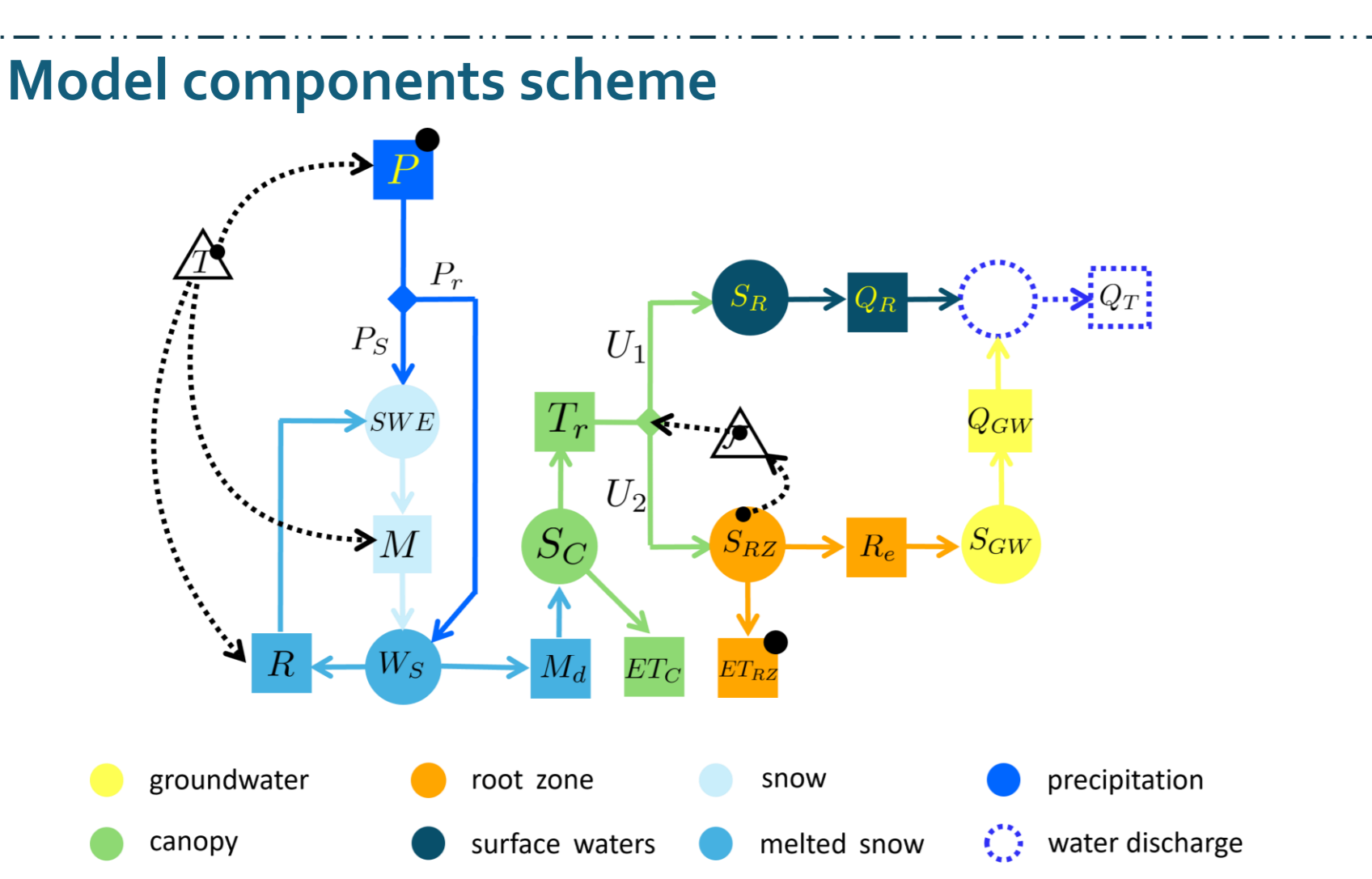
John Mohd Wani, Gaia Roati, Matteo Dall'Amico, Federico Di Paolo, Stefano Tassin, Kelly E. Gleason, Marco Brian, and Riccardo Rigon, Analysing long-term (1991-2021) daily records of Snow Water Equivalent in the Po River District, Italy, submitted to Nature Climate Change, 2025

The GEOframe system:

- Conceptual semi-distributed hydrological model
- Developed by a scientific international community, led by the University of Trento
- Open source
- Flexible and modular
- Suited for operational applications



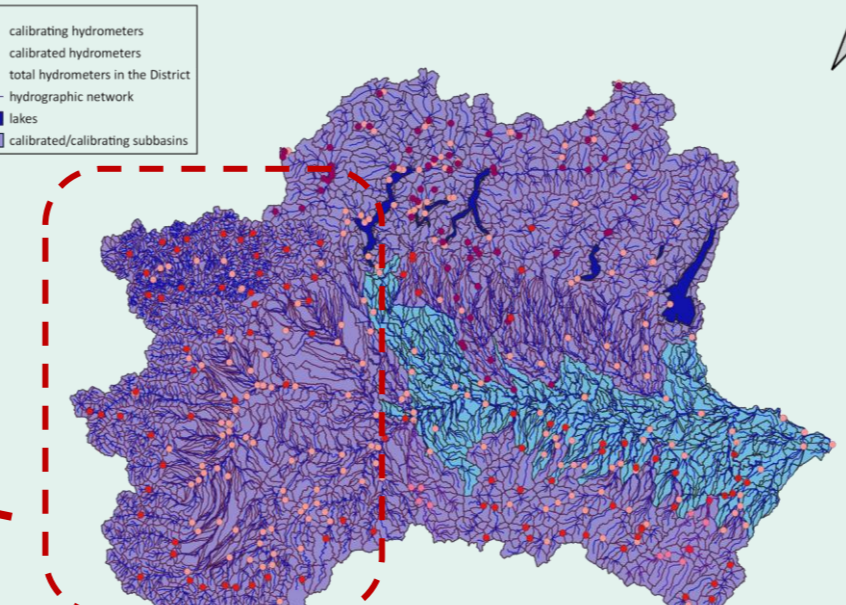
Model components scheme



Legend: groundwater, canopy, root zone, surface waters, snow, melted snow, precipitation, water discharge.

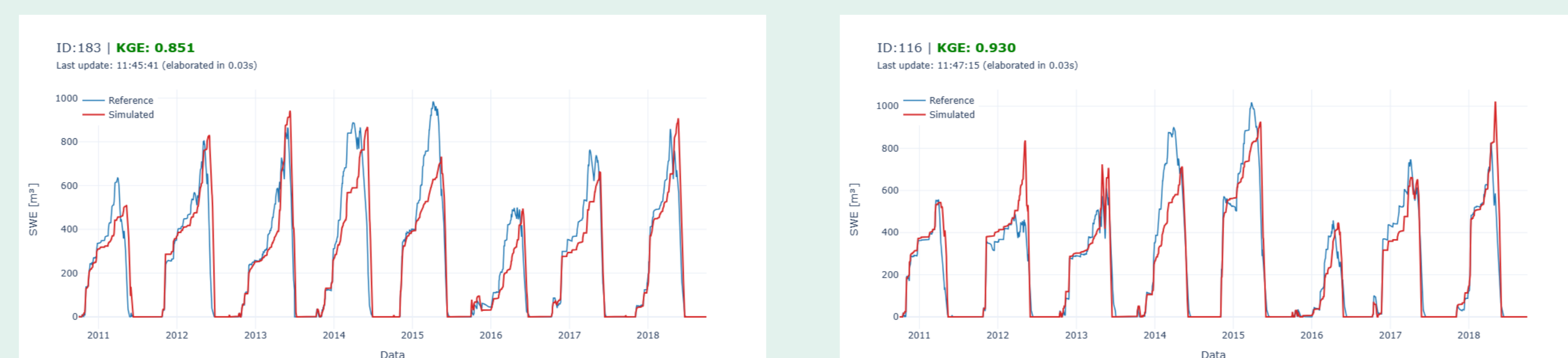
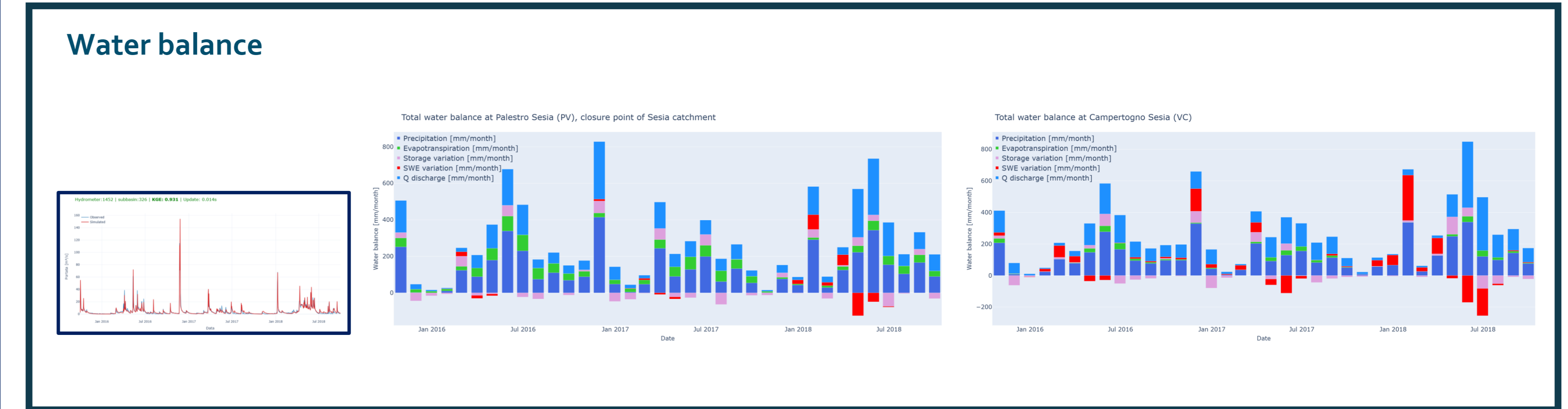
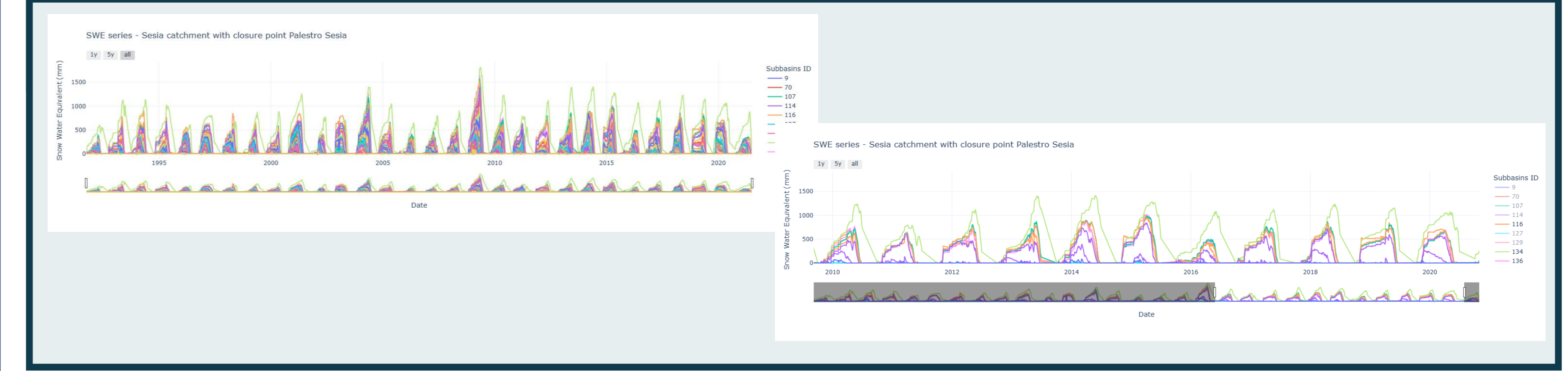
Snow component calibration

- 10 hydrological years
- KGE optimization
- "zonal calibration" on SWE
- starting parameters: calibrated parameters on water discharge



Module	Parameters	Description	
SNOW & ICE MODULE (Adopted Hock Model)	meltingTemperature	[-3, 3] °C	Controls accumulation & melt. Threshold temp for melt.
	combinedMeltingFactor	[1e-5, 1]	DDF-style coefficient.
	freezingFactor	[1e-5, 1]	Refreezing coefficient.
	radiationFactor	[1e-5, 0.01]	Solar radiation influence. Liquid water holding capacity.
	α _f	[1e-5, 1]	Fixed Parameters (α _f , α _s) for Rain/Snow Partitioning (Temperature Index)
SOIL & ROOT ZONE MODULE	K _c	[1e-4, 1.2]	Crop coefficient for ET.
	p	[1e-3, 0.99]	Depletion factor.
	S _{RootZoneMax}		Max root zone storage capacity.
	g	[0.1, 7]	Water movement coefficient (g).
RUNOFF GENERATION MODULE	p _{Bsoil}	[0.1, 7]	Partitioning coefficient (fast/slow flow).
	c	[0.1, 10]	Surface runoff coefficient (c).
	d	[0.1, 10]	Surface runoff coefficient (d).
	S _{RunoffMax}		Max fast-flow reservoir storage.
GROUNDWATER & BASEFLOW MODULE	e	[1e-4, 7]	Groundwater coefficient (e).
	f	[0.1, 7]	Groundwater coefficient (f).
	S _{GroundWaterMax}	[10, 1500]	Max groundwater reservoir storage.

WHY CALIBRATION?
 Enhance consistency with observed data | Reproduce timing & magnitude of fluxes | Better simulate overall water balance & discharge

Activity developments

- Snow component parameters validation
- Further calibration of the remaining components on measured water discharge
- SWE estimation in recent years
- Further validation on water discharge
- Snow component calibration for the District area

