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Continuous streamflow prediction in ungauged basins: long short-term memory neural networks clearly outperform traditional hydrological models

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Supplement

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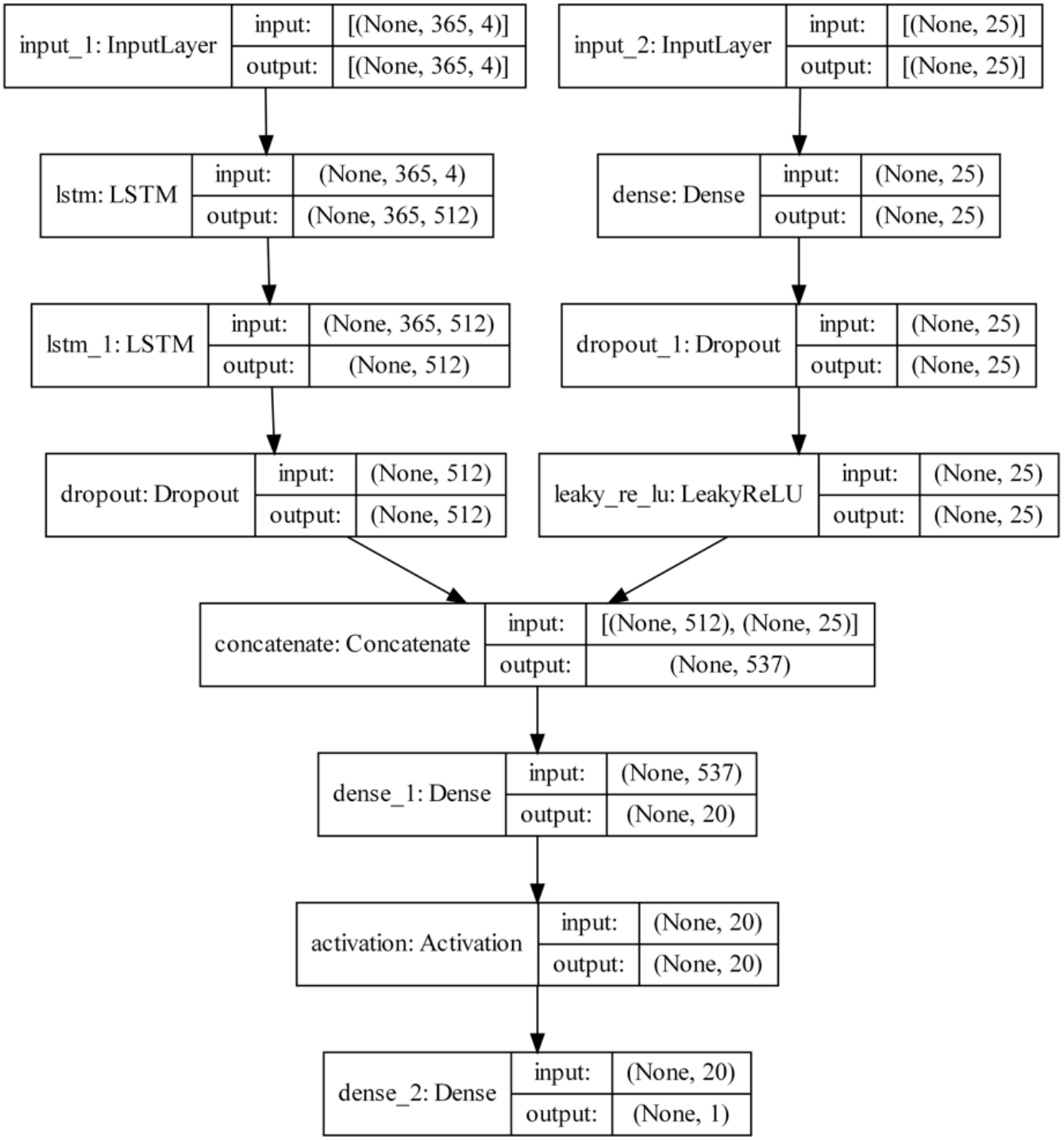

Figure S1: LSTM model structure implemented in this study. Numbers in parentheses in the input and output fields of each model represent the size of the inputs and outputs, respectively.

Table S1: HSAMI model parameters

Parameter	Units	Description
X_1	-	Summer PET scaling factor
X_2	-	Proportion of summer PET corresponding to winter PET
X_3	cm/°C/d	Degree-day factor for daytime snowmelt
X_4	cm/°C/d	Degree-day factor for nighttime snowmelt
X_5	°C	Threshold temperature for daytime snowmelt initiation
X_6	°C	Threshold temperature for nighttime snowmelt initiation
X_7	°C	Minimum temperature threshold to accelerate rain induced snowmelt
X_8	-	Parameter that relates snowmelt conditions to the snow covered proportion of the watershed
X_9	-	Parameter that relates freezing conditions to the proportion of surface runoff
X_{10}	cm/d	Daily rainfall rate necessary for 50% of surface runoff when the soil is completely dry
X_{11}	cm/d	Daily rainfall rate necessary for 50% of surface runoff when the soil is saturated
X_{12}	cm	Water in unsaturated zone which cannot flow by gravity
X_{13}	cm	Maximum water quantity which can be contained in the unsaturated zone
X_{14}	cm	Maximum water quantity which can be contained in the aquifer before turning into surface runoff
X_{15}	-	Surface water proportion which flows through the intermediary hydrograph in normal conditions
X_{16}	-	Surface water proportion which flows through the intermediary hydrograph when unsaturated zone is full
X_{17}	cm/d	Outflow rate from the unsaturated zone to the saturated zone
X_{18}	cm/d	Outflow rate from the saturated zone which constitutes the base flow rate
X_{19}	cm/d	Outflow rate from the interflow storage which constitutes the interflow rate
X_{20}	d	Time to peak of surface unit hydrograph
X_{21}	-	Shape parameter of the surface unit hydrograph
X_{22}	d	Time to peak of the interflow unit hydrograph
X_{23}	-	Shape parameter of the interflow unit hydrograph

Table S2: HMETS model parameters

Parameter	Units	Description
ddf_{min}	mm/°C/d	Minimum degree-day-factor
ddf_{plus}	mm/°C/d	ddf_{plus}: Maximum degree-day-factor ($ddf_{min} + ddf_{plus} = ddf_{max}$)
T_{bm}	°C	Base melting temperature
K_{cum}	mm^{-1}	Empirical parameter for the calculation of the degree-day-factor
fc_{min}	-	Minimum fraction for the snowpack water retention capacity
fc_{plus}	-	Maximum fraction of the snowpack water retention capacity ($fc_{min} + fc_{plus} = fc_{max}$)
C_{cum}	mm^{-1}	Parameter for the calculation of water retention capacity
T_{bf}	°C	Base refreezing temperature
K_f	mm/°C/d	Degree-day factor for refreezing
Fe	-	Empirical exponent for the freezing equation
ET_{eff}	-	Fraction of the potential evapotranspiration
c_r	-	Fraction of the water for surface and delayed runoff
c_{vp}	-	Fraction of the water for groundwater recharge
c_v	-	Fraction of the water for hypodermic flow
c_p	-	Fraction of the water for groundwater flow
LV_{max}	mm	Maximum level of the vadose zone
LP_{max}	mm	Maximum level of the phreatic zone
α_1	-	Shape parameter α for the gamma distribution used on the surface unit hydrograph
β_1	-	Rate parameter β for the gamma distribution used on the surface unit hydrograph
α_2	-	Shape parameter α for the gamma distribution used on the delayed unit hydrograph
β_2	-	Rate parameter β for the gamma distribution used on the delayed unit hydrograph

Table S3: GR4JCN model parameters

Parameter	Units	Description
X_1	mm	Production storage capacity
X_2	mm	Groundwater exchange coefficient
X_3	mm	One day ahead maximum capacity of the routing store
X_4	d	Time base of unit hydrograph
C_{TG}	-	Ponderation coefficient of the thermic state
K_f	mm/°C/d	Degree-day factor