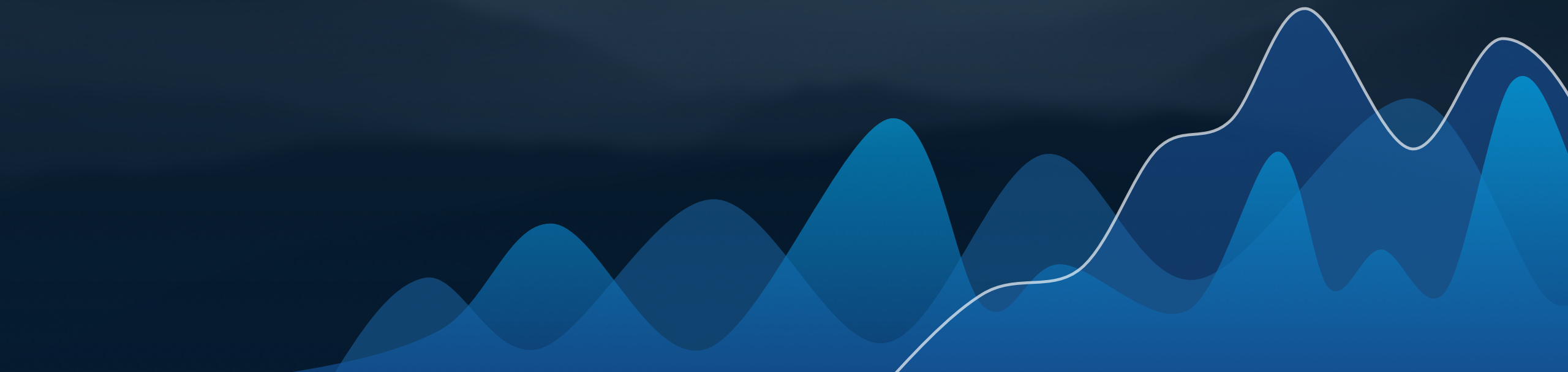
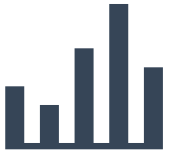
Cry me a river: Low water levels causing chaos in Germany



CONTENTS

TEAM

DATA



SOLUTION

BUSINESS

TEAM

Global **RANK 1st** Team

in Rhine Water Level prediction

TEAM

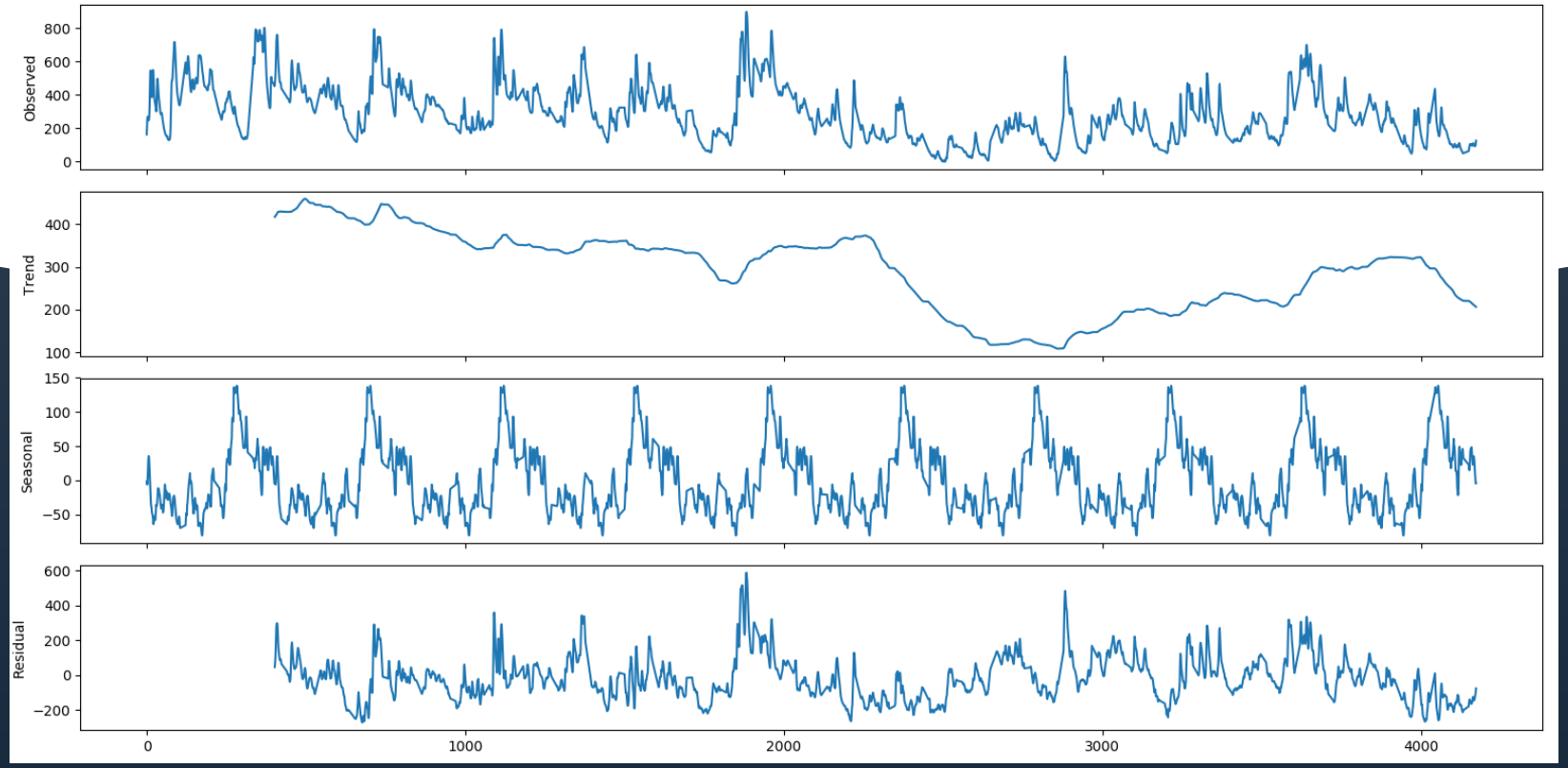
Rui Li(Math), Jiajie Li(Software), Shiqiao Meng(Civil)
Xiaotian Zhang(Civil), Xiaodong Bi(Computer Science),
Mingjian Tang(Math)

Feature Engineering

DATA

DATA

hydrology factors
geology factors
environment factors


Observed
800
600
400
200
0
Trend
400
300
200
100
Seasonal
150
100
50
0
−50
Residual
600
400
200
0
−200
0
1000
2000
3000
4000

	station_no	date	discharge	water_level	wa1	water_delta	dis1	discharge_delta
89352	6335060.0	1965-01-01	1240.000	110.0	NaN	NaN	NaN	NaN
89353	6335060.0	1965-01-02	1680.000	178.0	110.0	68.0	1240.000	440.000
89354	6335060.0	1965-01-03	1820.000	200.0	178.0	22.0	1680.000	140.000
89355	6335060.0	1965-01-04	1790.000	195.0	200.0	-5.0	1820.000	-30.000
89356	6335060.0	1965-01-05	1800.000	196.0	195.0	1.0	1790.000	10.000
89357	6335060.0	1965-01-06	1630.000	171.0	196.0	-25.0	1800.000	-170.000
89358	6335060.0	1965-01-07	1560.000	161.0	171.0	-10.0	1630.000	-70.000
89359	6335060.0	1965-01-08	1580.000	163.0	161.0	2.0	1560.000	20.000
89360	6335060.0	1965-01-09	1800.000	197.0	163.0	34.0	1580.000	220.000
89361	6335060.0	1965-01-10	2430.000	283.0	197.0	86.0	1800.000	630.000
89362	6335060.0	1965-01-11	3480.000	409.0	283.0	126.0	2430.000	1050.000
89363	6335060.0	1965-01-12	3960.000	459.0	409.0	50.0	3480.000	480.000
89364	6335060.0	1965-01-13	3590.000	421.0	459.0	-38.0	3960.000	-370.000
89365	6335060.0	1965-01-14	3000.000	354.0	421.0	-67.0	3590.000	-590.000
89366	6335060.0	1965-01-15	2610.000	306.0	354.0	-48.0	3000.000	-390.000
89367	6335060.0	1965-01-16	2410.000	280.0	306.0	-26.0	2610.000	-200.000
89368	6335060.0	1965-01-17	2320.000	268.0	280.0	-12.0	2410.000	-90.000
89369	6335060.0	1965-01-18	2850.000	336.0	268.0	68.0	2320.000	530.000
89370	6335060.0	1965-01-19	3910.000	454.0	336.0	118.0	2850.000	1060.000
89371	6335060.0	1965-01-20	3910.000	454.0	454.0	0.0	3910.000	0.000
89372	6335060.0	1965-01-21	3790.000	442.0	454.0	-12.0	3910.000	-120.000
89373	6335060.0	1965-01-22	3250.000	383.0	442.0	-59.0	3790.000	-540.000
89374	6335060.0	1965-01-23	2790.000	329.0	383.0	-54.0	3250.000	-460.000

	station_no	date	discharge	water_level	wa1	water_delta	dis1	discharge_delta
89352	6335060.0	1965-01-01	1240.000	110.0	NaN	NaN	NaN	NaN
89353	6335060.0	1965-01-02	1680.000	178.0	110.0	68.0	1240.000	440.000
89354	6335060.0	1965-01-03	1820.000	200.0	178.0	22.0	1680.000	140.000
89355	6335060.0	1965-01-04	1790.000	195.0	200.0	-5.0	1820.000	-30.000
89356	6335060.0	1965-01-05	1800.000	196.0	195.0	1.0	1790.000	10.000
89357	6335060.0	1965-01-06	1630.000	171.0	196.0	-25.0	1800.000	-170.000
89358	6335060.0	1965-01-07	1560.000	161.0	171.0	-10.0	1630.000	-70.000
89359	6335060.0	1965-01-08	1580.000	163.0	161.0	2.0	1560.000	20.000
89360	6335060.0	1965-01-09	1800.000	197.0	163.0	34.0	1580.000	220.000
89361	6335060.0	1965-01-10	2430.000	283.0	197.0	86.0	1800.000	630.000
89362	6335060.0	1965-01-11	3480.000	409.0	283.0	126.0	2430.000	1050.000
89363	6335060.0	1965-01-12	3960.000	459.0	409.0	50.0	3480.000	480.000
89364	6335060.0	1965-01-13	3590.000	421.0	459.0	-38.0	3960.000	-370.000
89365	6335060.0	1965-01-14	3000.000	354.0	421.0	-67.0	3590.000	-590.000
89366	6335060.0	1965-01-15	2610.000	306.0	354.0	-48.0	3000.000	-390.000
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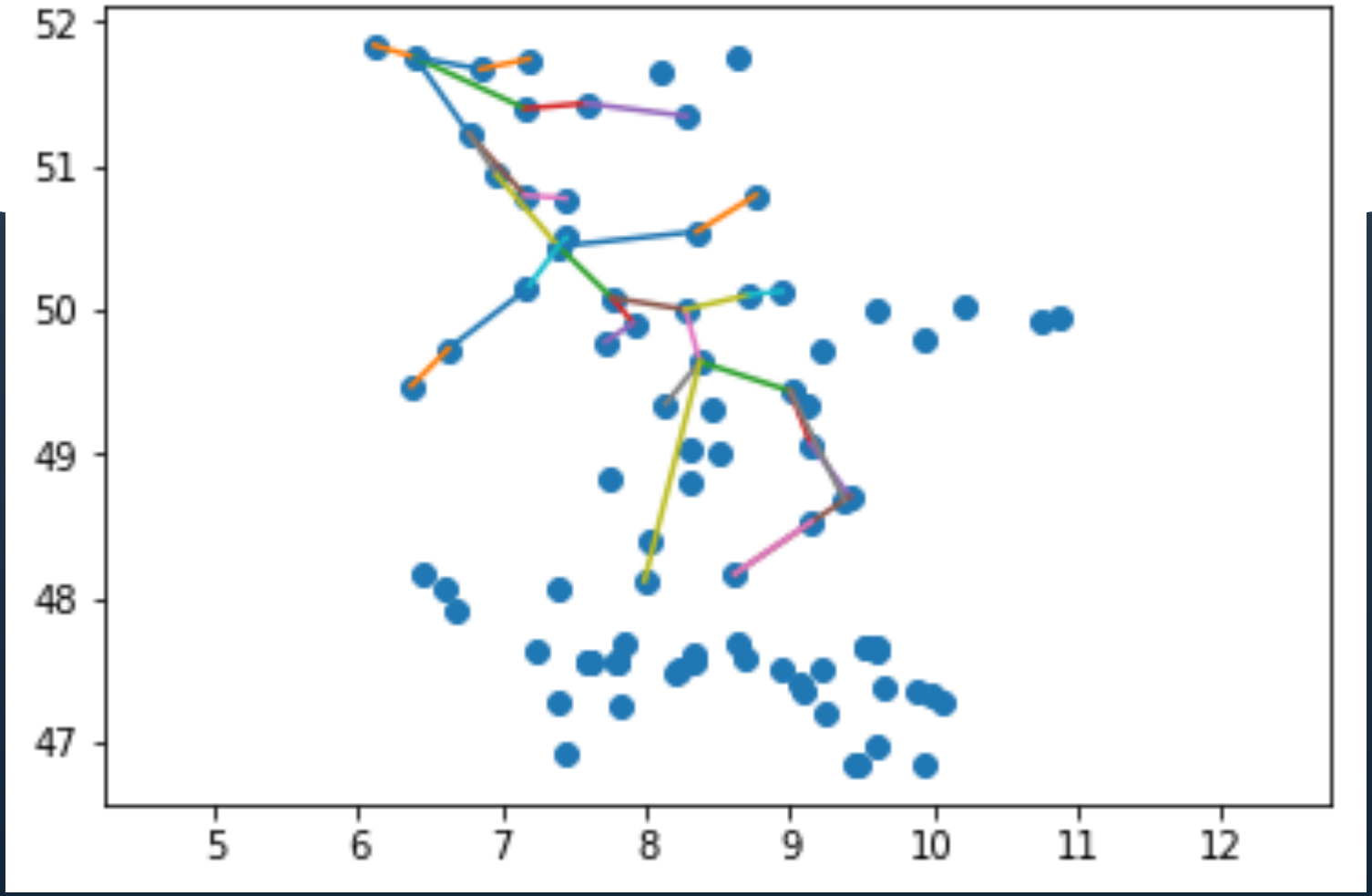
89371	6335060.0	1965-01-20	3910.000	454.0	454.0	0.0	3910.000	0.000
89372	6335060.0	1965-01-21	3790.000	442.0	454.0	-12.0	3910.000	-120.000
89373	6335060.0	1965-01-22	3250.000	383.0	442.0	-59.0	3790.000	-540.000
89374	6335060.0	1965-01-23	2790.000	329.0	383.0	-54.0	3250.000	-460.000

Info of most relevant stations
—(correlation analysis)—>
hydrological information



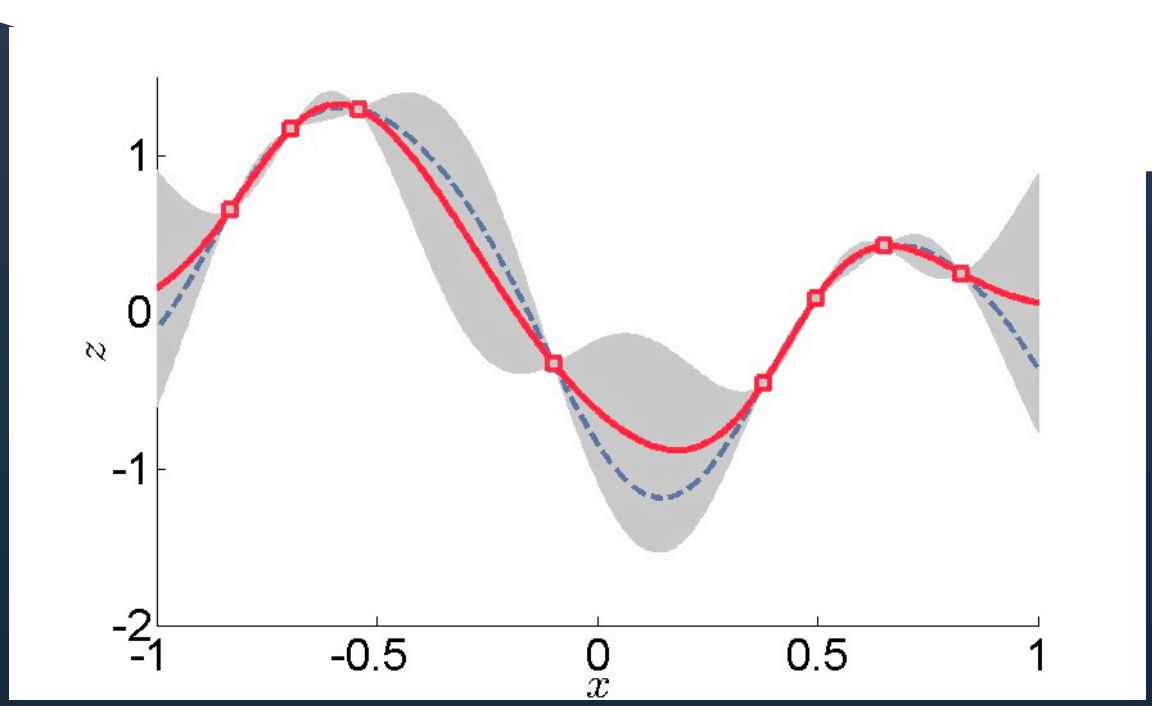
PRECIPITATION

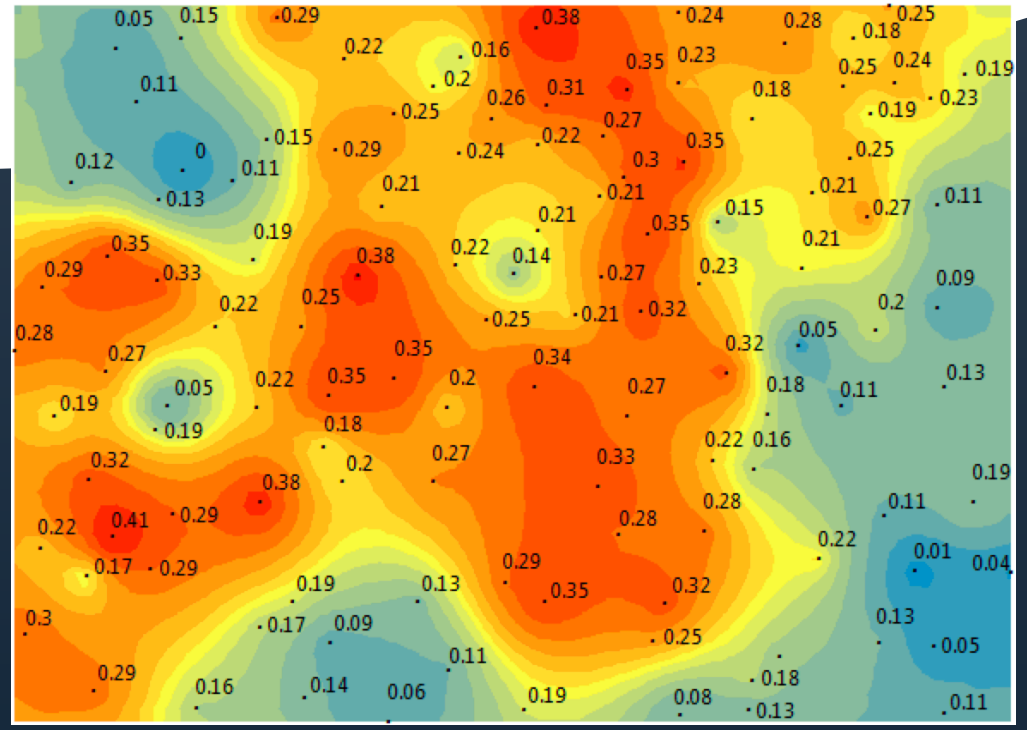
Variable	Unit	Description
RS	mm	daily precipitation height
RSF	numeric code	precipitation form 0 = no precipitation (conventional or automatic measurement), relates to WMO code 10 1 = only rain (before 1979) 4 = unknown form of recorded precipitation 6 = only rain; only liquid precipitation at automatic stations, relates to WMO code 11 7 = only snow; only solid precipitation at automatic stations, relates to WMO code 12 8 = rain and snow; liquid and solid precipitation at automatic stations, relates to WMO code 13 9 = error or missing value or no automatic determination of precipitation form, relates to WMO code 15

1. liquid precipitation
2. new snow
3. old snow

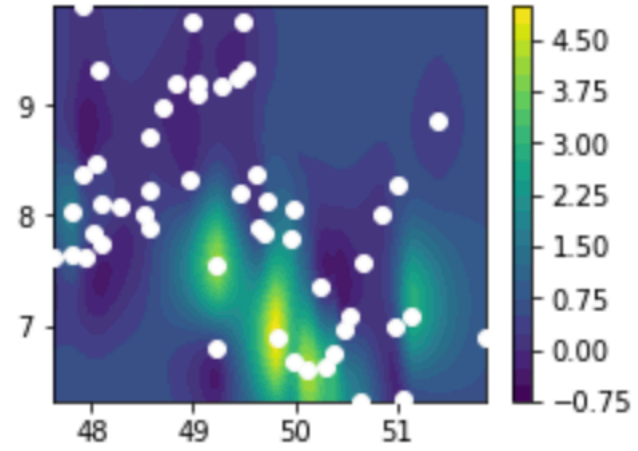
$$f(RS) = \begin{cases} RS, & RSF = 1, 4, 6, 9 \\ 0.5RS, & RSF = 8 \\ 0, & RSF = 0, 7 \end{cases}$$

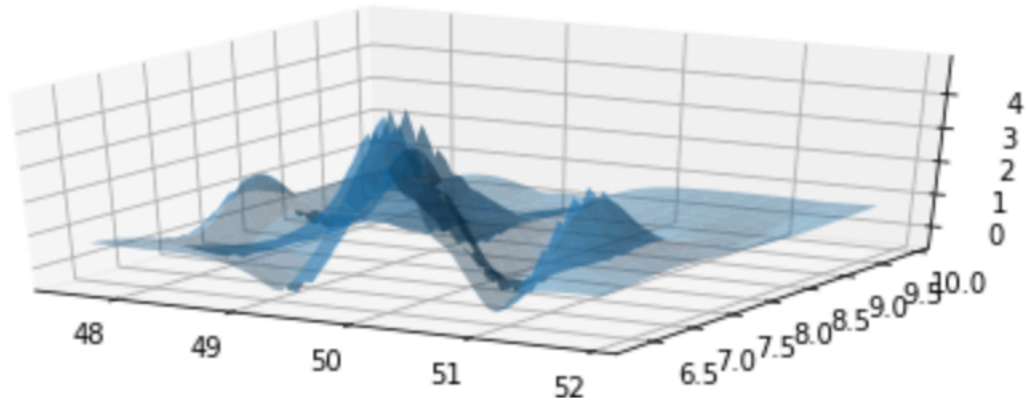
Kriging & Co-Kriging

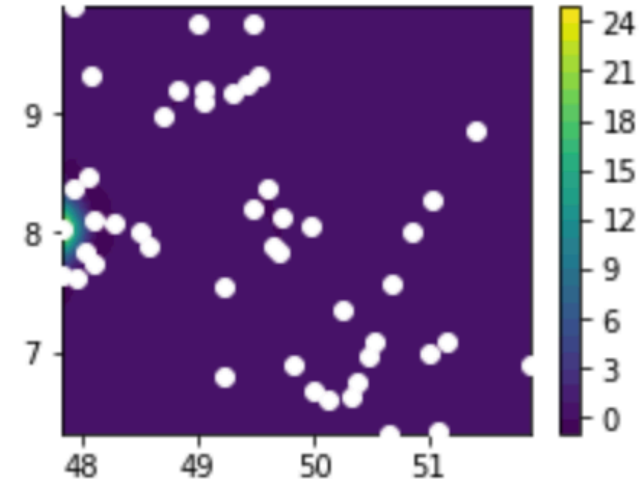


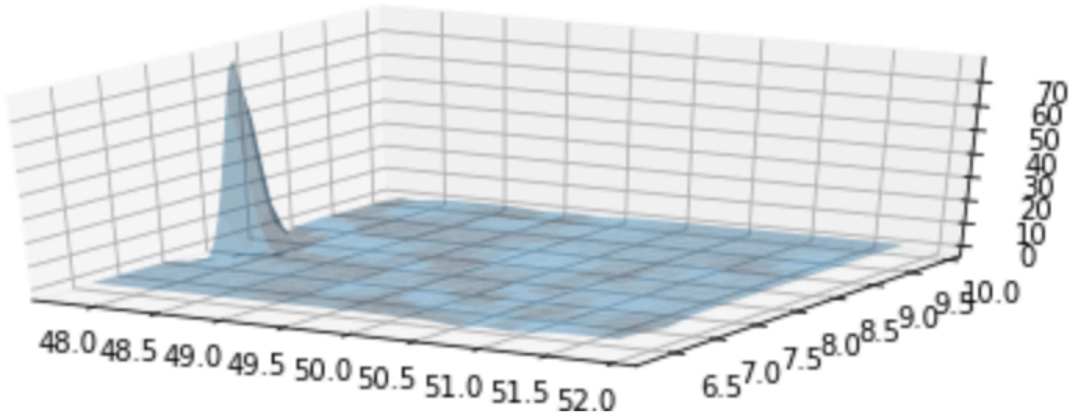


Kriging & Co-Kriging





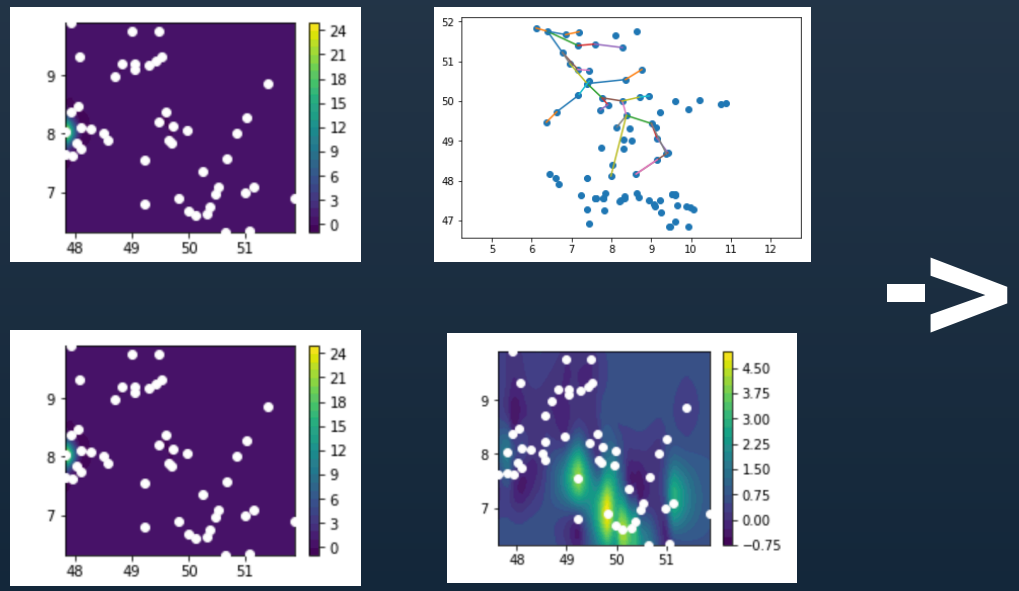


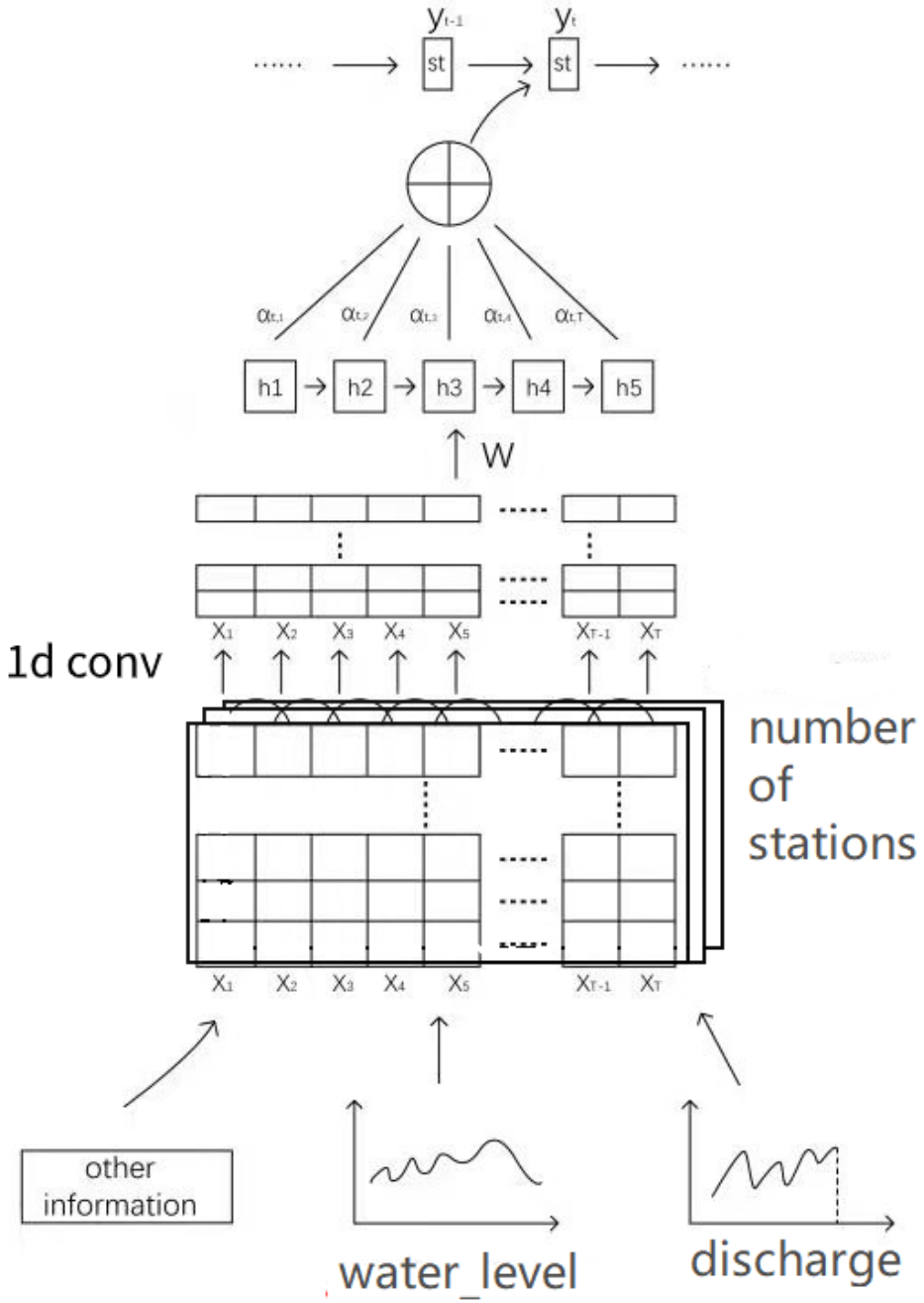


SOLUTION

CNN+LSTM

CNN+LSTM




y_{t-1}
y_t
st
st
$\alpha_{t,1}$
$\alpha_{t,2}$
$\alpha_{t,3}$
$\alpha_{t,4}$
$\alpha_{t,T}$
h1
h2
h3
h4
h5
W
1d conv
X_1 X_2 X_3 X_4 X_5 X_{T-1} X_T
number of stations
other information
water_level
discharge

BUSINESS

Success is favor for the person who is prepared!

THANKS