Hydrological responses to precipitation extremes: an investigation of the National Water Model system in the San Francisco Bay Area using AQPI Gap-filling Radar

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AQPI Project Overview

The Advanced Quantitative Precipitation Information (AQPI) project is being implemented to improve monitoring and forecasting of precipitation, streamflow, and coastal flooding in the San Francisco (SF) Bay area using a combination of observations and numerical models. More details can be traced from AGU 2019 Poster A53L-3073 *"The role of X-band radars in rainfall estimation for complex terrain applications"*

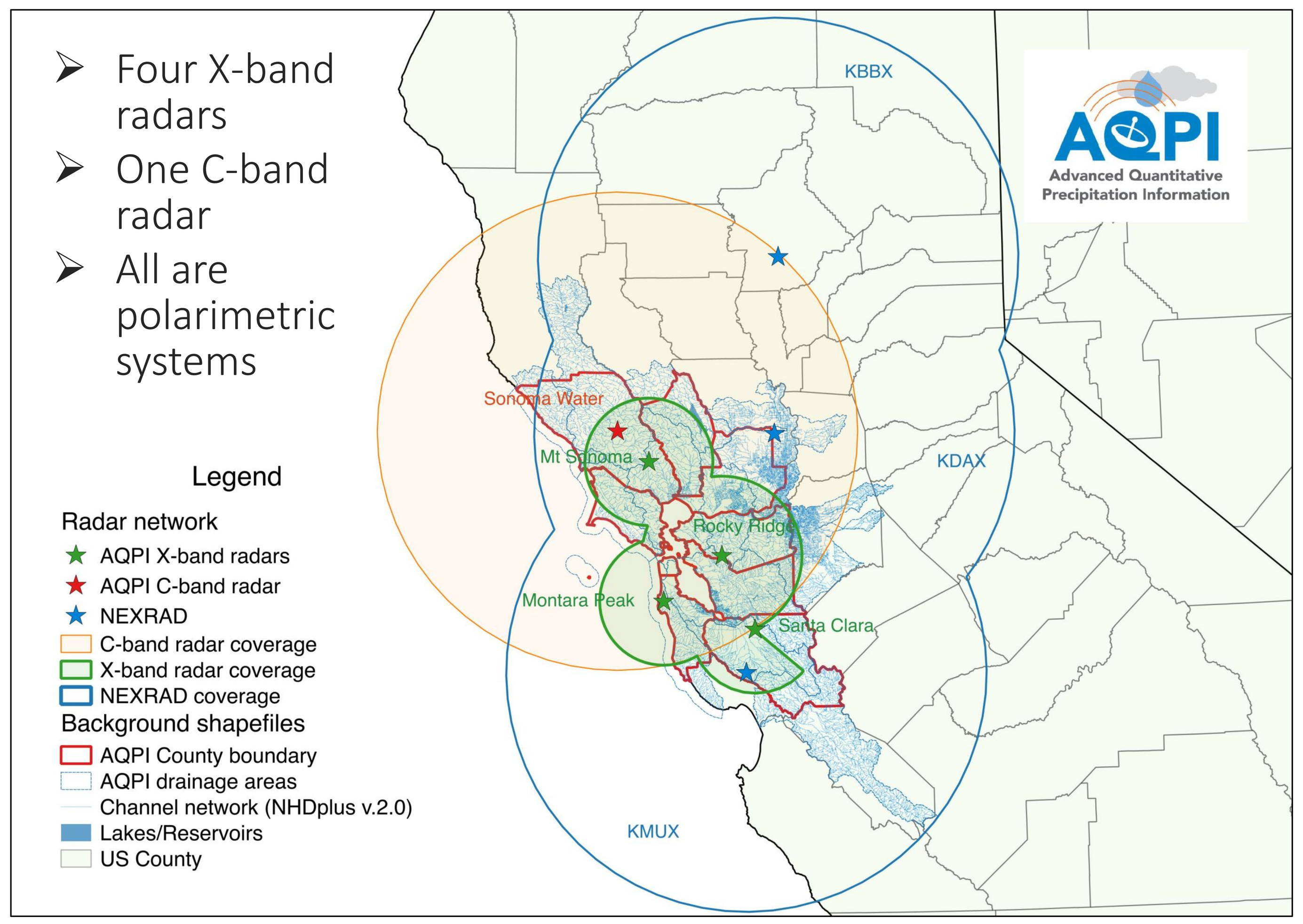

Fig. 1. The layout of AQPI radar network.

For more information about AQPI, visit https://www.esrl.noaa.gov/psd/aqpi/

Research Motivation

We are assessing the performance of the gap-fill radar Quantitative Precipitation Estimation (QPE) and its impact on streamflow forecasts. We explore the impact of AQPI radar-based precipitation on the hydrological processes during selected rainfall events in the SF Bay region. The NOAA National Water Model (NWM), built on the WRF-Hydro community modelling system, is implemented for testing the hydrological responses.

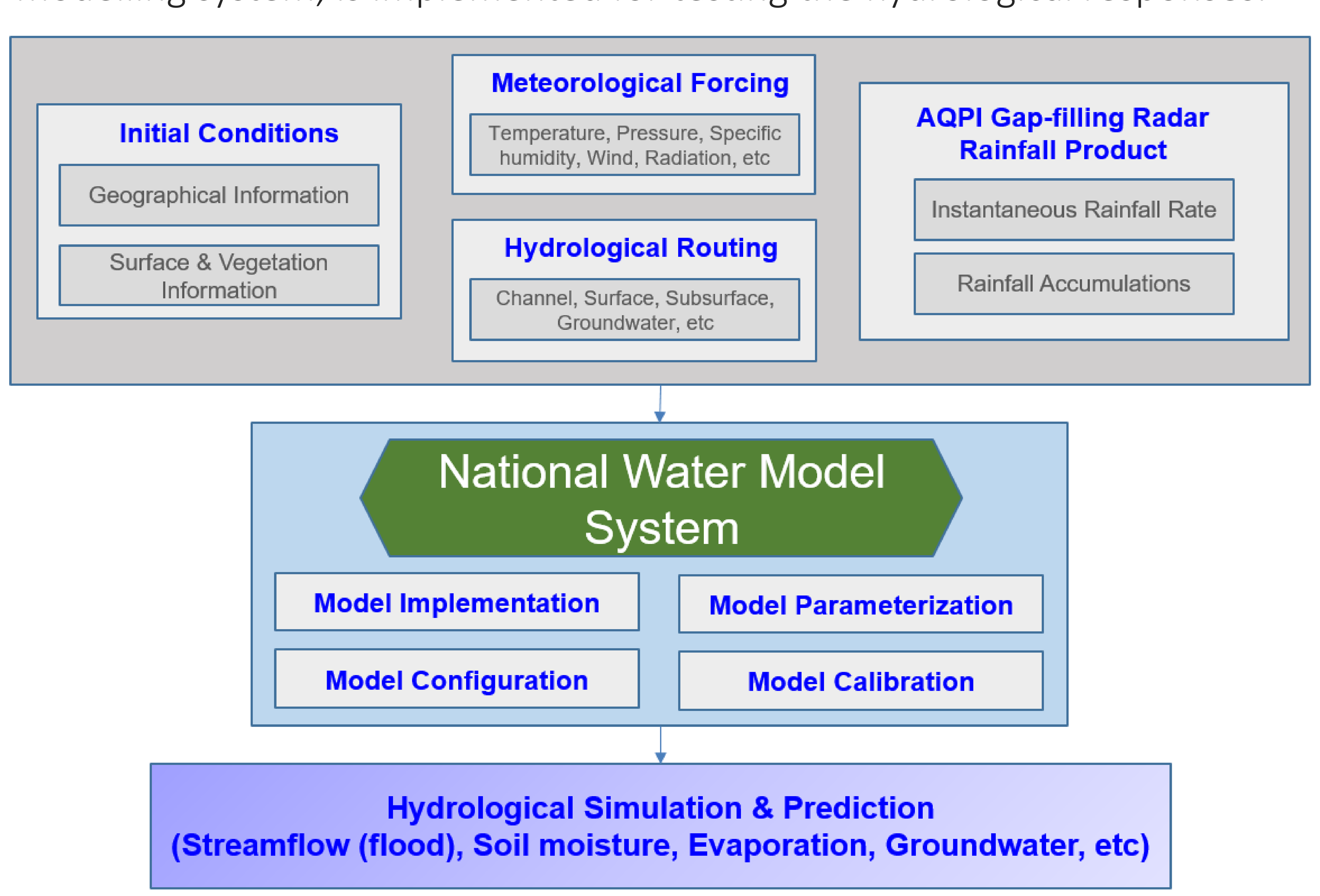

Fig. 2. The general flowchart in this study

Study Area and AQPI Radar Performance

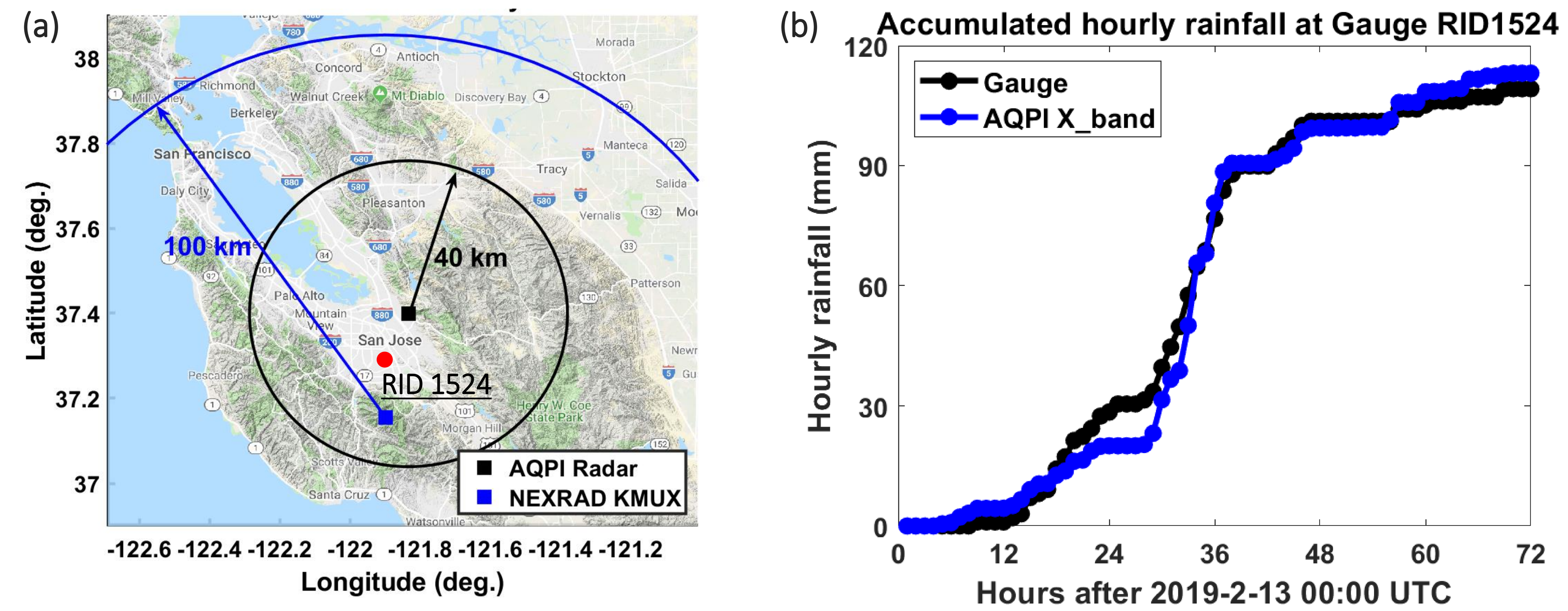

Fig. 3. (a) The study area and selected rain gauge site and (b) AQPI radar performance as compared with rain gauge RID 1524 over a heavy rainfall event in San Francisco Bay Area

Model Calibrated Parameters

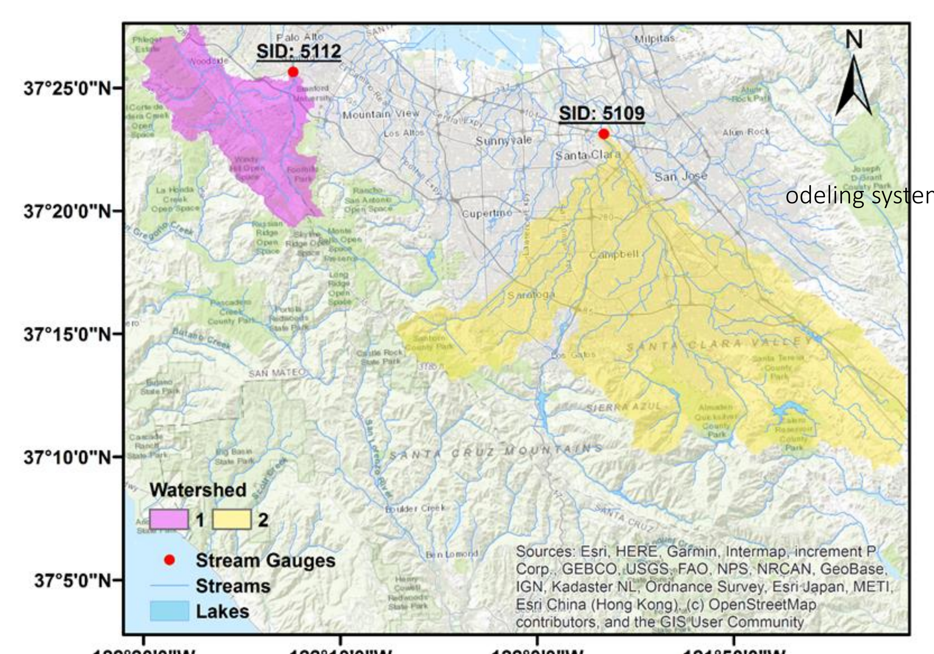

Fig. 4. Locations of two watershed used in this study

Table 1. The optimal stream network parameters used in this study, which is calibrated from Jan 1 to 31st, 2019 in the study domain

Stream Order	Bw (m)	HLINK (m)	ChSSlp (m/m)	MannN
1	3.0	0.02	1.00	0.55
2	5.0	0.02	0.75	0.75
3	7.5	0.02	0.50	0.50
4	10	0.03	0.25	0.25
5	20	0.03	0.15	0.10
6	40	0.03	0.10	0.05
7	60	0.03	0.05	0.04
8	70	0.10	0.05	0.03
9	80	0.30	0.05	0.02
10	80	0.30	0.05	0.01

Table 2. The optimal channel, runoff, and groundwater parameters used in this study, which is calibrated from Jan 1 to 31st, 2019 in the study domain

Type	Parameter	Description	Unit	Value
Channel Parameters	Bw	Parameterized width of the bottom of the stream network	m	3.0
	HLINK	Initial channel depth	m	0.02
	MannN	Manning's roughness coefficient	Dimension	1.0
	ChSSlp	Channel side slope	m/m	1.0
Runoff Parameters	refkdt	A tuneable parameter that significantly impacts surface infiltration and hence the partitioning of total runoff into surface and subsurface runoff	unitless	3.0
	RETDEPRTFAC	Multiplier on retention depth limit	unitless	1.0
	LKSATFAC	Multiplier on lateral hydraulic conductivity	unitless	1000
Groundwater Parameters	Zmax	Maximum groundwater bucket depth	mm	50
	Expon	Exponent control ingrate of bucket drainage as a function of depth	dimensionless	3.0

Hydrological simulations in two watersheds

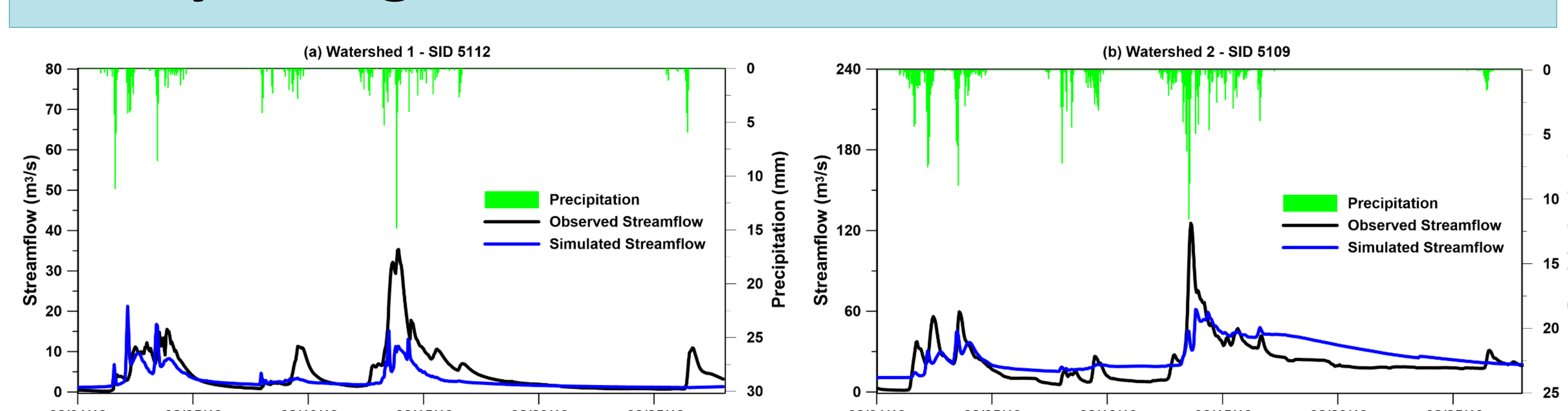

Fig. 5. Hydrological simulations in two watersheds of SF Bay area using AQPI radar rainfall product as forcing precipitation input during Feb 1-28th, 2019

Hydrological responses to heavy rainfall

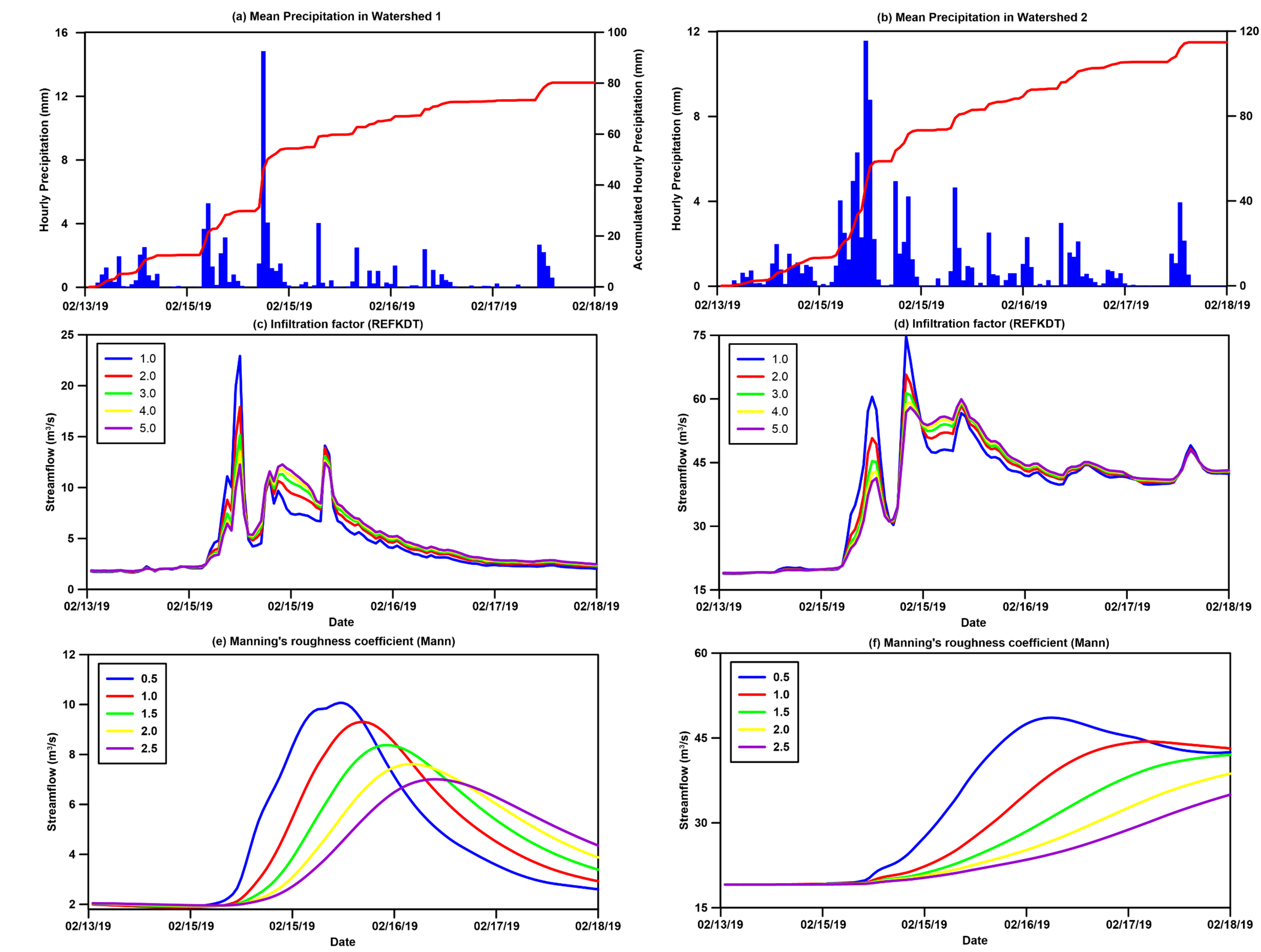

Fig. 6. Hydrological responses to AQPI radar products under various surficial conditions (i.e., (c-d) infiltration factor, (e-f) channel Manning's roughness , in two watersheds of SF Bay area (i.e., watershed 1 on the left side and watershed 2 on the right side over a heavy rainfall event during Feb 13-17th, 2019

Summary

- The AQPI X-band radar provides reasonable QPE without gauge-based correction compared to gauge measurements.
- Following model calibration, the NWM system is capable of reproducing observed streamflow hydrographs in terms of runoff volumes and overall curves in the selected watersheds of SF Bay area.
- As seen from both Figs.5 and 6, hydrological responses to AQPI radar rainfall products are well presented based on the NWM system at two stations in Feb 13-17th, 2019.
- This study initially demonstrates the sensitivity between AQPI radar rainfall extremes and hydrological extremes under various surficial conditions in the SF Bay area.

References

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