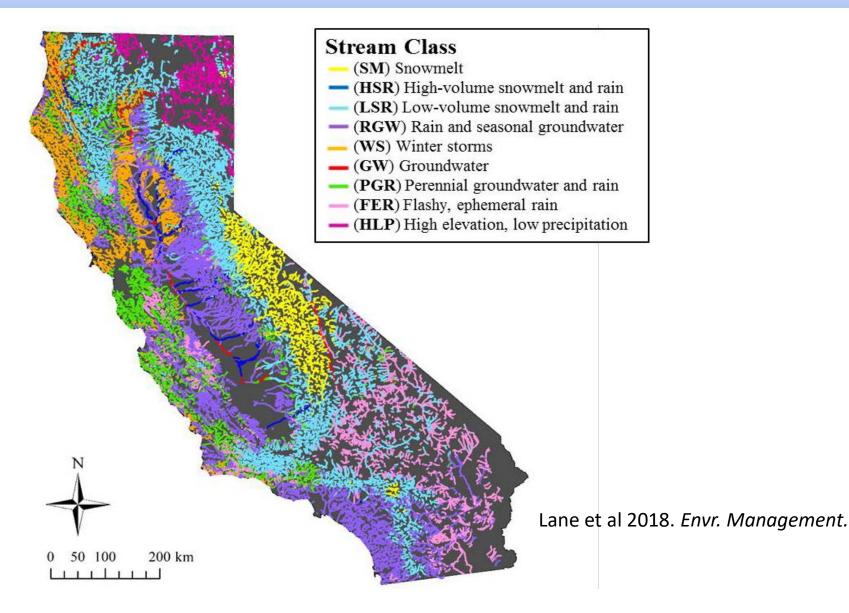
Functional Flows Calculator Technical Overview

September 11, 2018

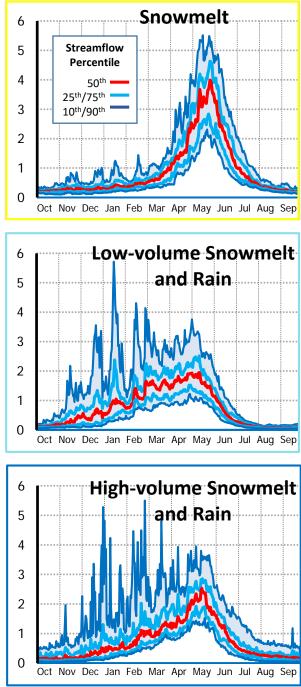
CEFF Technical Team

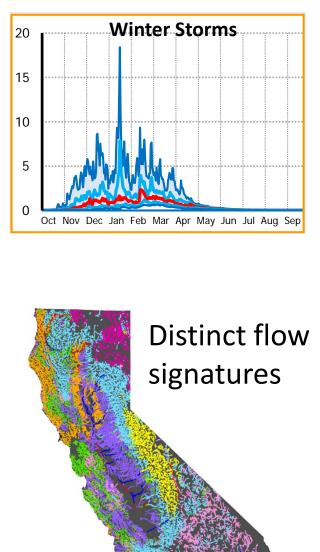


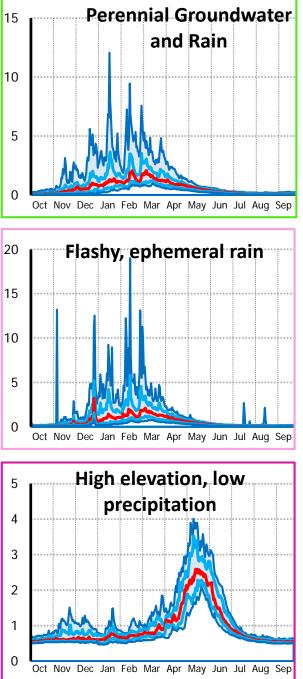
California's hydrology is complex



https://eflows.gitbook.io/project/website_summary#stream-classification



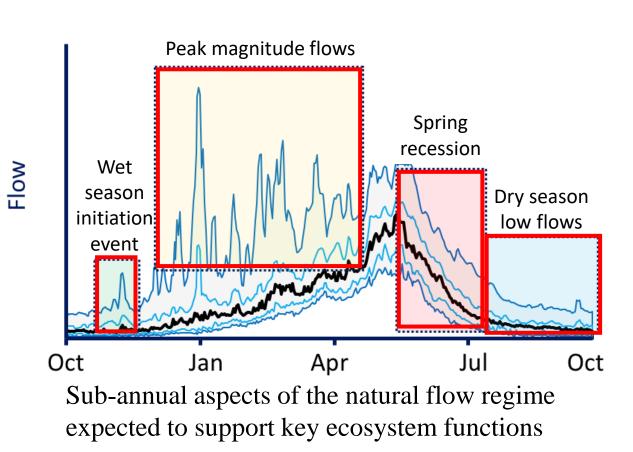




Need for flow metrics

- The natural flow regime is a primary control on ecological functioning
- Flow metrics are used to link key aspects of natural and altered hydrology to ecological response to inform environmental water management
- Many flow metrics have been proposed
 - Indicators of Hydrologic Alteration (TNC 1996)
 - Hydrologic Index Tool (USGS 2006)
 - 'Statistically significant' (Olden and Poff 2003, Archfield et al 2006, Yang et al 2008)
- Appropriate selection of flow metrics remains a major challenge due to metric redundancy, limited statistical power and ecological relevance

Functional flow components

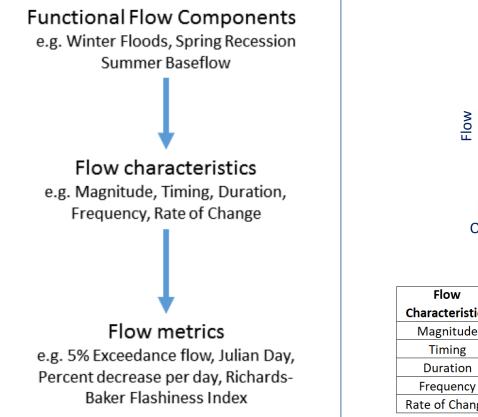


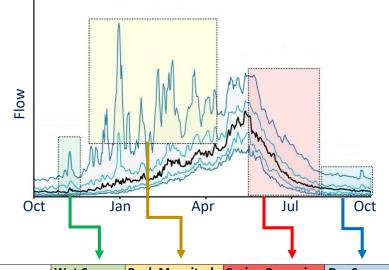


Constrain habitat, limiting for exotic species

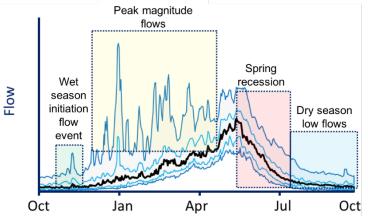
Yarnell et al. 2015 BioScience

Conceptual Model





Flow	Wet Season	Peak Magnitude	Spring Recession	Dry Season Low
Characteristics	Initiation	Flows	Flow	Flows
Magnitude	X	Х	Х	Х
Timing	X	Х	Х	Х
Duration	X	Х	Х	Х
Frequency		Х		
Rate of Change			Х	Х

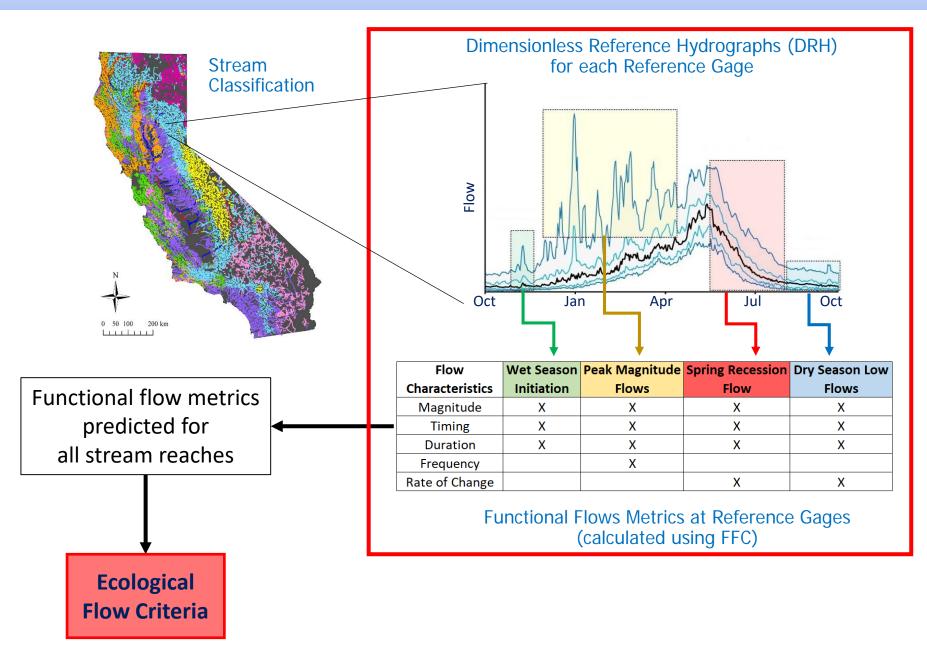


- 31 metrics
- 223 reference gauges in CA
- Annual metrics calculated for each reference Water Year (WY) on record (10 - 60 years)

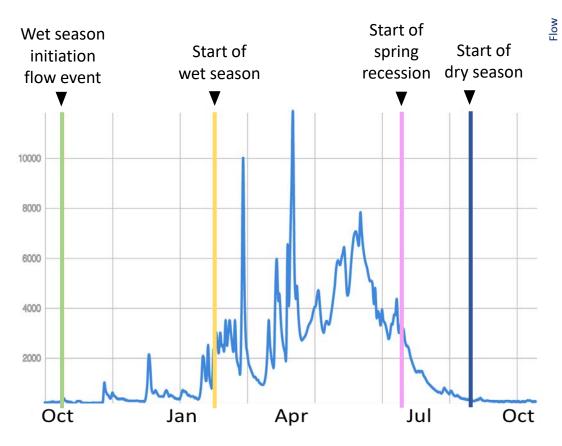
	Flow		
Flow Component		Units	Metric
Annual	Magnitude	cfs	average annual flow
	Rate of change	percent	coefficient of variation
Wet Season	Magnitude	cfs	event peak magnitude
Initiation	Timing	date	event start date
Flow Event	Duration	days	event duration
Peak Magnitude	Timing	date	start date of wet season
Flows	Magnitude	cfs	wet season baseflow (10P)
	Magnitude	cfs	peak magnitude: 2%, 5%, 10%, 20%
	Timing	date	event start date: 2%, 5%, 10%, 20%
	Duration	days	event duration: 2%, 5%, 10%, 20%
	Frequency	count	# of events/year: 2%, 5%, 10%, 20%
Spring	Magnitude	cfs	magnitude at start of spring recession
Recession Flows	Rate of change	percent	median daily flow percent decrease
	Timing	date	start date of spring recession
	Duration	days	from recession until dry season
Dry Season	Magnitude	cfs	baseflow magnitude (10P)
Low Flows	Timing	date	start date of dry season
	Duration	days	from dry season to start of wet seasor
	Frequency	count	# of no-flow days

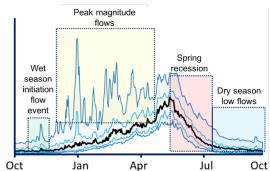
https://eflows.gitbook.io/project/website_summary#functional-flow-calculator

CEFF Tier 1



Timing metrics form foundation for all other functional flow metrics





Wet Season Initiation Event

Flow

Initiation event timing

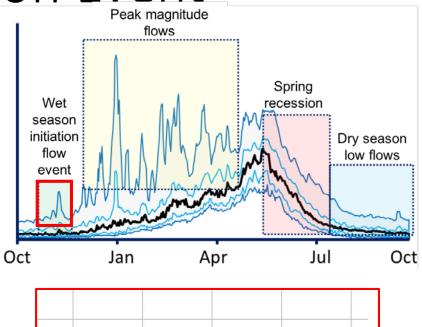
 First date from Oct 1 – Dec 15 that flow exceeds 2x previous dry season baseflow or 1 cfs, whichever is larger.

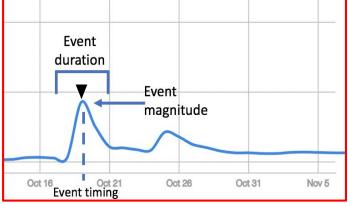
Initiation event magnitude

• Peak magnitude during initiation event.

Initiation event duration

 Number of days from the start to peak magnitude of initiation event.





Peak Magnitude Flows

Flow

For 2%,5%,10%, and 20% exceedance flows:

High flow timing

 Date of peak flow for each high flow exceedance event

High flow magnitude

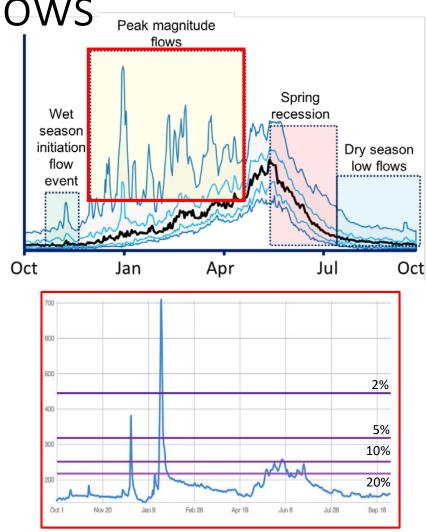
 Peak magnitude above the high flow exceedance threshold

High flow duration

 Continuous duration that flow remains above threshold

High flow frequency

 Number of times threshold is exceeded per water year



Peak Magnitude Flows

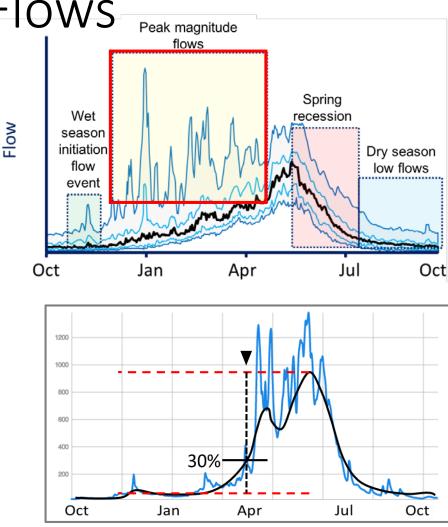
Two additional wet season metrics:

Wet season start timing

 First date flow is above 30% relative magnitude of difference between baseflow and smoothed wet season peak flow

Wet season baseflow magnitude

 10th percentile daily flow from the start of the wet season to the start of the dry season.



Spring Recession Flows

Flow

Recession start timing**

 Start of transition from wet season high flows to dry season low flows

Recession start magnitude

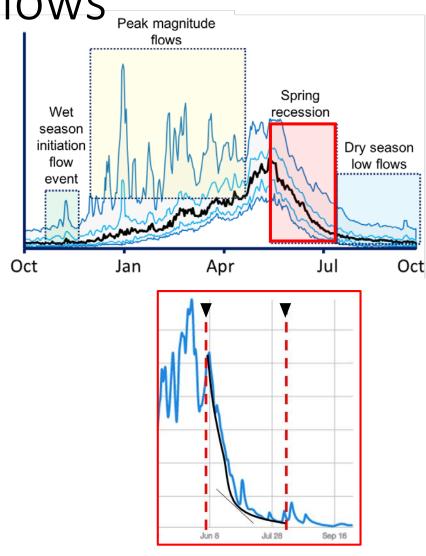
• Flow magnitude at start of recession.

Recession duration

• Duration from start of recession to start of dry season

Recession rate of change

 Median daily rate of change over recession duration, considering only days with negative rate of change.



Dry Season Low Flows

Dry season start timing

 First date from recession start to end of WY that magnitude <12.5% wet season max flow and rate of change -> zero.

Low flow magnitude

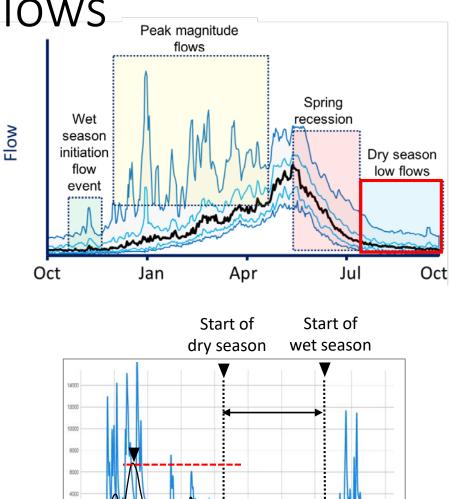
 10th percentile daily flow from start of dry season to start of wet season.

Low flow duration

 Duration from start of dry season to start of wet season.

no-flow days

 Number of days with zero flow magnitude during low flow period



12 5%

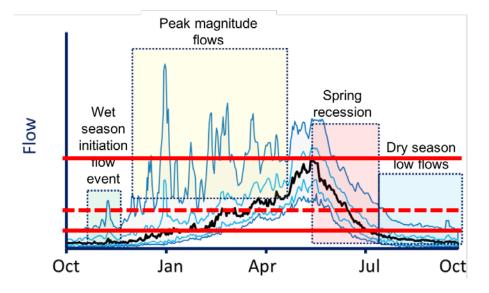
Annual

Average annual daily flow

• Mean daily flow over WY

Coefficient of variation

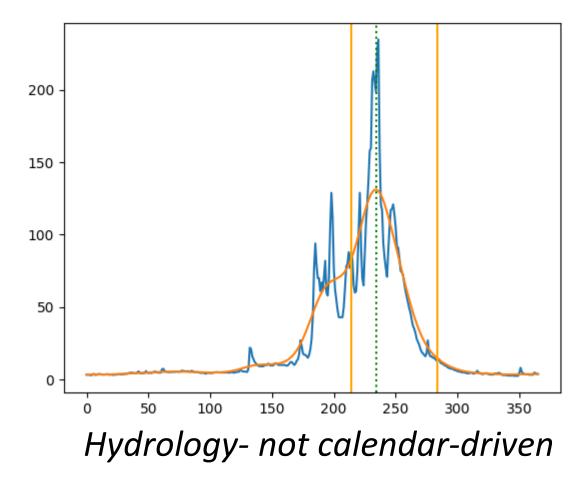
 Standard deviation of daily flow divided by average annual flow



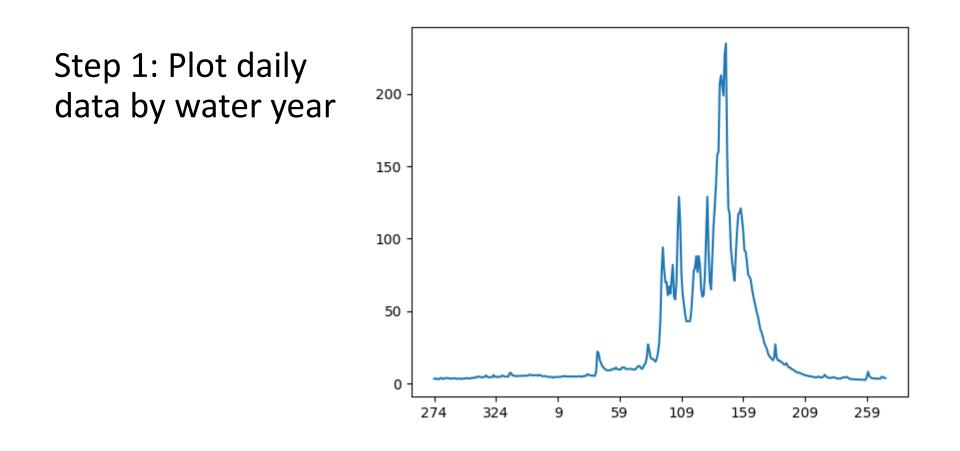
Identification of relevant hydrologic features using signal processing techniques



- Feature detection
- Windowing

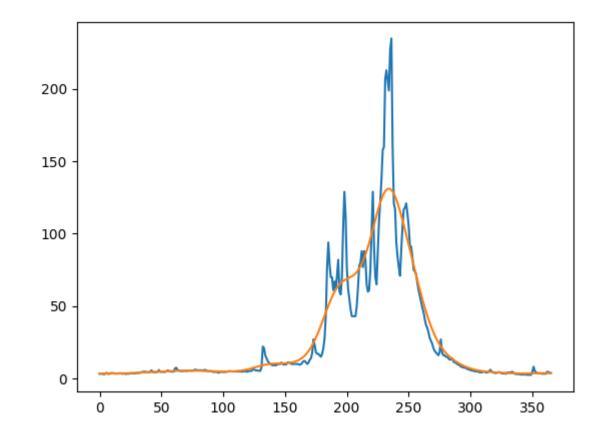


Example: Spring Recession Start Timing



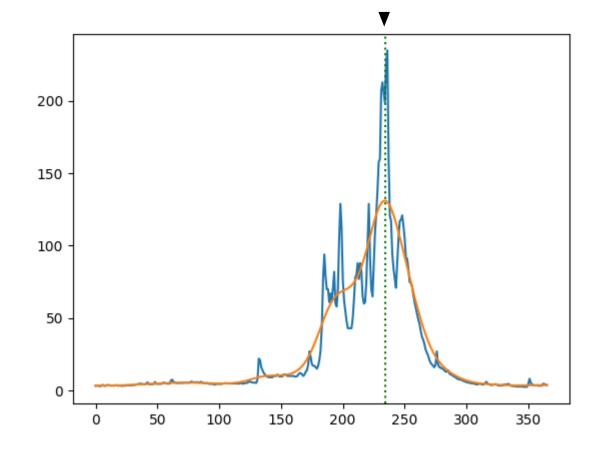
Example: Spring Recession Start Timing

Step 2: Smooth data with Gaussian filter



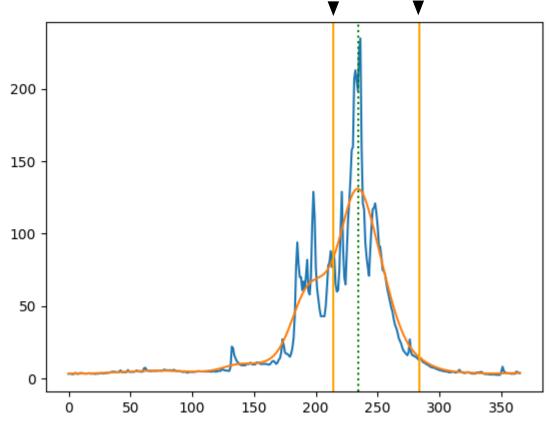
Example: Spring Recession Start Timing

Step 3: Identify last major peak (center of mass of wet season)



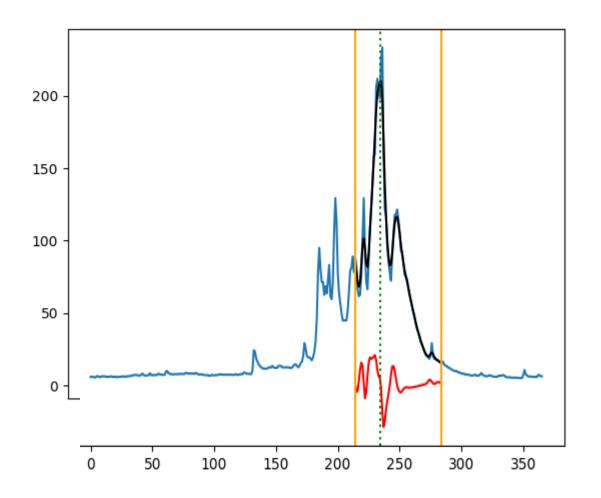
Example: Spring Recession Start Timing

Step 4: Set dynamic search window around peak



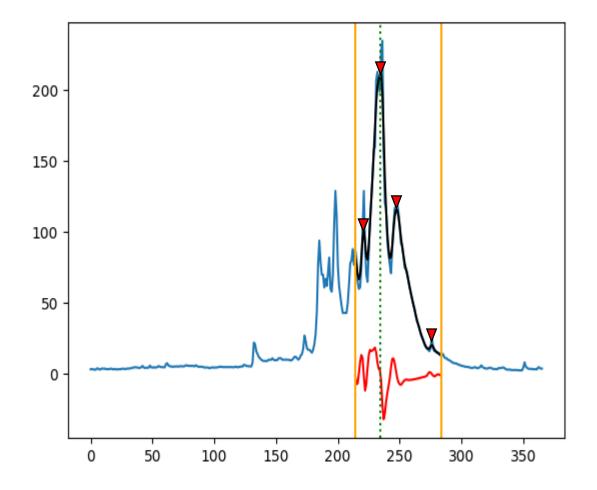
Example: Spring Recession Start Timing

Step 5: Apply a tighter smoothing curve within window (black) and calculate its derivative (red)



Example: Spring Recession Start Timing

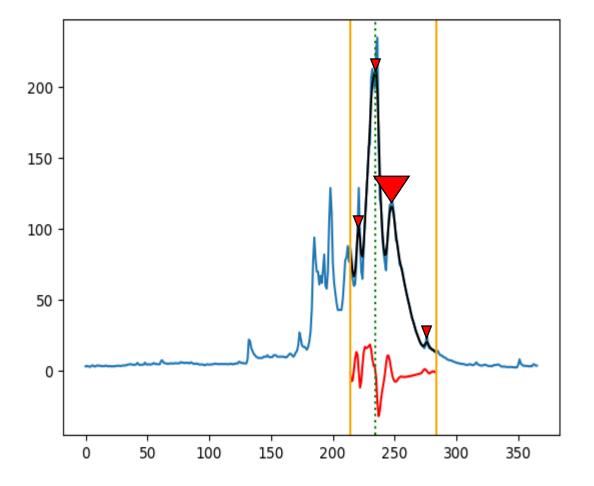
Step 6: Identify local peaks where derivative (red) flips from + to -



Example: Spring Recession Start Timing

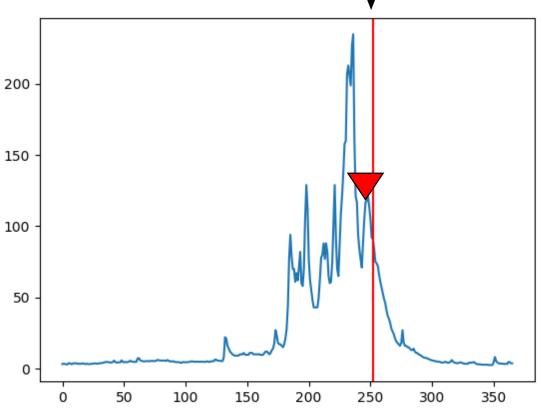
Step 7: Identify last peak with sufficient:

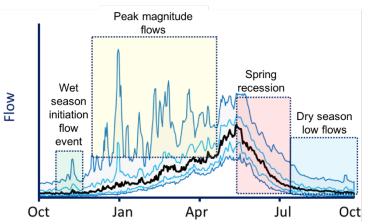
- Relative magnitude
- Duration
- Rate of change



Example: Spring Recession Start Timing

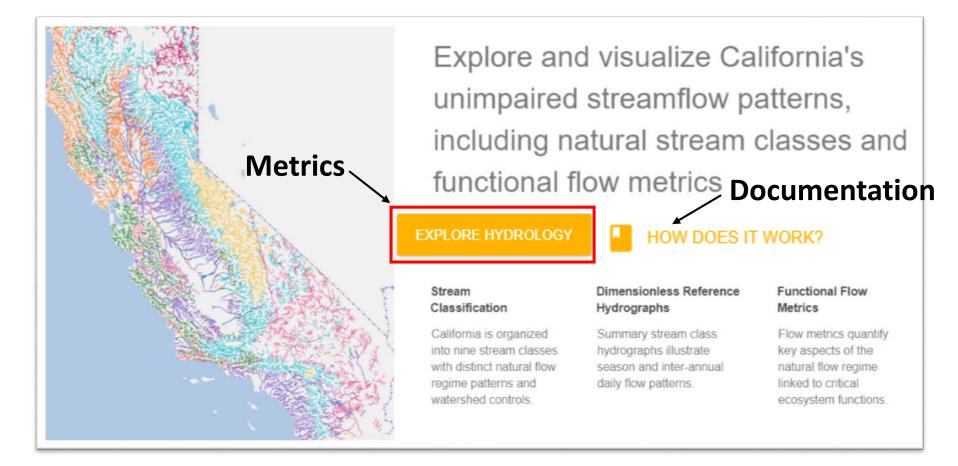
Step 8: Set start date 4 days after peak flow (to remove individual storm effects)





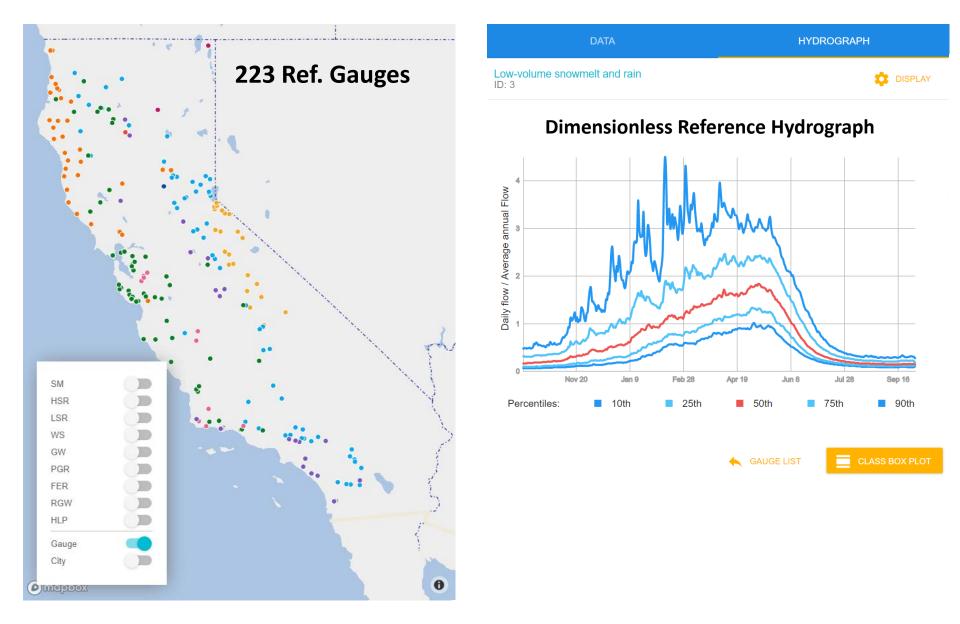
	Flow									
Flow Component	Characteristic	Units	Metric							
Annual	Magnitude	cfs	average annual flow							
	Rate of change	percent	coefficient of variation							
Wet Season	Magnitude	cfs	event peak magnitude							
Initiation	Timing	date	event start date							
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	Duration	days	from dry season to start of wet season							
	Frequency	count	# of no-flow days							

Functional Flows Calculator (FFC)

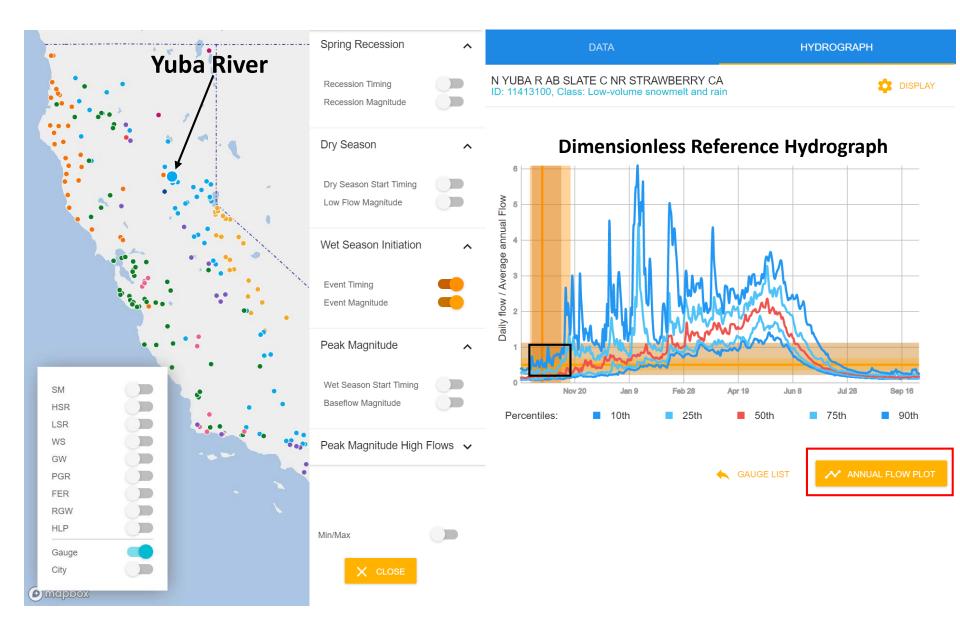


https://eflows.ucdavis.edu

Functional Flows Calculator (FFC)



Functional Flows Calculator (FFC)



Spring Recession									
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Dry Season									
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High-volume snowmelt and rain Gauge Count: 7	~	e (cfs)	6000						
Low-volume snowmelt and rain Gauge Count: 65	~	Flow Value (cfs)	4000						
Winter storms Gauge Count: 34	~	L	2000						
Groundwater Gauge Count: 1	~		Oct 1 No	w 20 Jan 9	Feb 28	Apr 19	Jun 8 Jul 2	8 Sep 16	
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Flashy, ephemeral rain Gauge Count: 12	~		1968	Slide	e the bar to chang	ge the water yea	rļ	1986	
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Y-axis Percentile 0.99									
Hydrograph Overlay									

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FFC – Reference Gauge Data

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FFM - Documentation

🖉 E-Flows

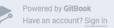
eFlows Overview

eFlows Overview

Last updated 7 days ago

eFlows Website Purpose

The eFlows Functional Flow Calculator (FFC) quantifies key hydrologic aspects of the annual flow regime from any daily streamflow time series. The FFC produces dimensionless reference hydrographs (defined below) and a suite of functional flow metrics that quantify functional flow components, referring to portions of the annual flow regime expected to serve distinct geomorphic or ecological functions (Yarnell et al. 2015). Results are presented visually and data can be directly downloaded. Users of the FFC can also install and run the FFC on their own computer; for more information see the FFC installation section. The hydrographs and metrics enable comparisons of streamflow patterns across regions, natural stream classes, and various forms and magnitudes of flow alteration. The FFC generates 31 metrics describing aspects of streamflow timing, magnitude, duration, frequency, and rate of change, organized into four functional flow components: 1) wet season initiation flows, 2) peak magnitude flows, 3) spring recession flows, and 4) dry season low flows (Table 1).



Stream Classification

Q Search

CONTENTS

eFlows Website Purpose Stream Classification Dimensionless Reference Hydrographs Functional Flow Calculator Functional Flow Metrics Annual Metrics Wet Season Initiation Flow Peak Magnitude Flows Spring Recession Flows Dry Season Low Flows

https://eflows.gitbook.io/project/website_summary

FFC - Documentation

E-Flows Q Search CONTENTS eFlows Overview Introduction About Installation Last updated 26 days ago Metrics) To Test build passing

About

The functional flows calculator (FFC) quantifies key aspects of the annual flow regime based on long-term daily streamflow time series data, producing a broad suite of descriptive functional flow metrics. These metrics are meant to characterize ecologically relevant components of any flow regime in a robust, objective manner to enable comparisons of streamflow across regions, natural stream classes, and various forms and magnitudes of flow alteration. The FFC generates metrics describing aspects of streamflow timing, magnitude, duration, frequency, and rate of change, organized into four seasonally-based functional flow components: 1) wet season initiation flows, 2) peak magnitude flows, 3) spring recession flows, and 4) dry season low flows.

Powered by GitBook Have an account? Sign in This project uses Python3 for its processing algorithm, React, Mapbox, and D3 for front end web development, and Express, Sequelize, and Postgres for the server.

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To Run the Script (Calculate To Report Errors and Bugs

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