Rapid automatic clean-up toolkit for large corrupted tidal datasets

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1. Introduction

- Tides are ubiquitous in estuaries, coasts and oceans around the world
- Tidal harmonic signals are observed in all hydrodynamic and water quality data sets
- More that 30,000 data sets from multiple sources are prone to error and need to be cleaned up to produce useful data
- Although QA/QC protocols exist, they are ad-hoc, quantity-specific, and not easily automatable
- We present a robust, **quantity-independent** workflow that produces QA/QCed data rapidly for **multi-spectral** signals

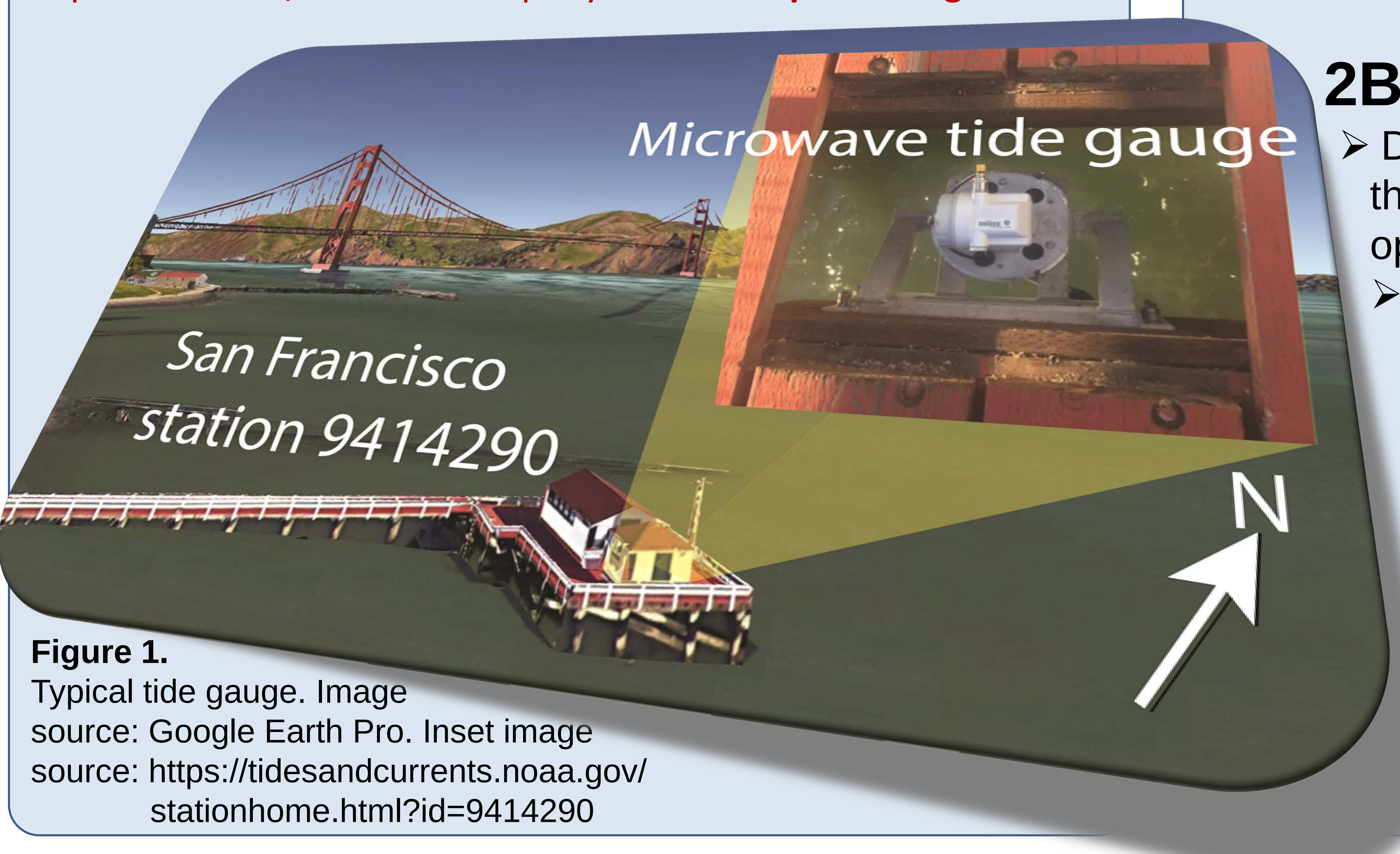


Figure 1.
Typical tide gauge. Image source: Google Earth Pro. Inset image source: https://tidesandcurrents.noaa.gov/stationhome.html?id=9414290

2A. Salient features

- Developed in MATLAB
- The toolbox corrects
  - o Blocky interpolation and noisy data
  - o erroneous outliers
  - o instrumentation bias such as spurious jumps and drifts
  - o narrow- and broad-spectrum spikes
  - o modulations in the true signal

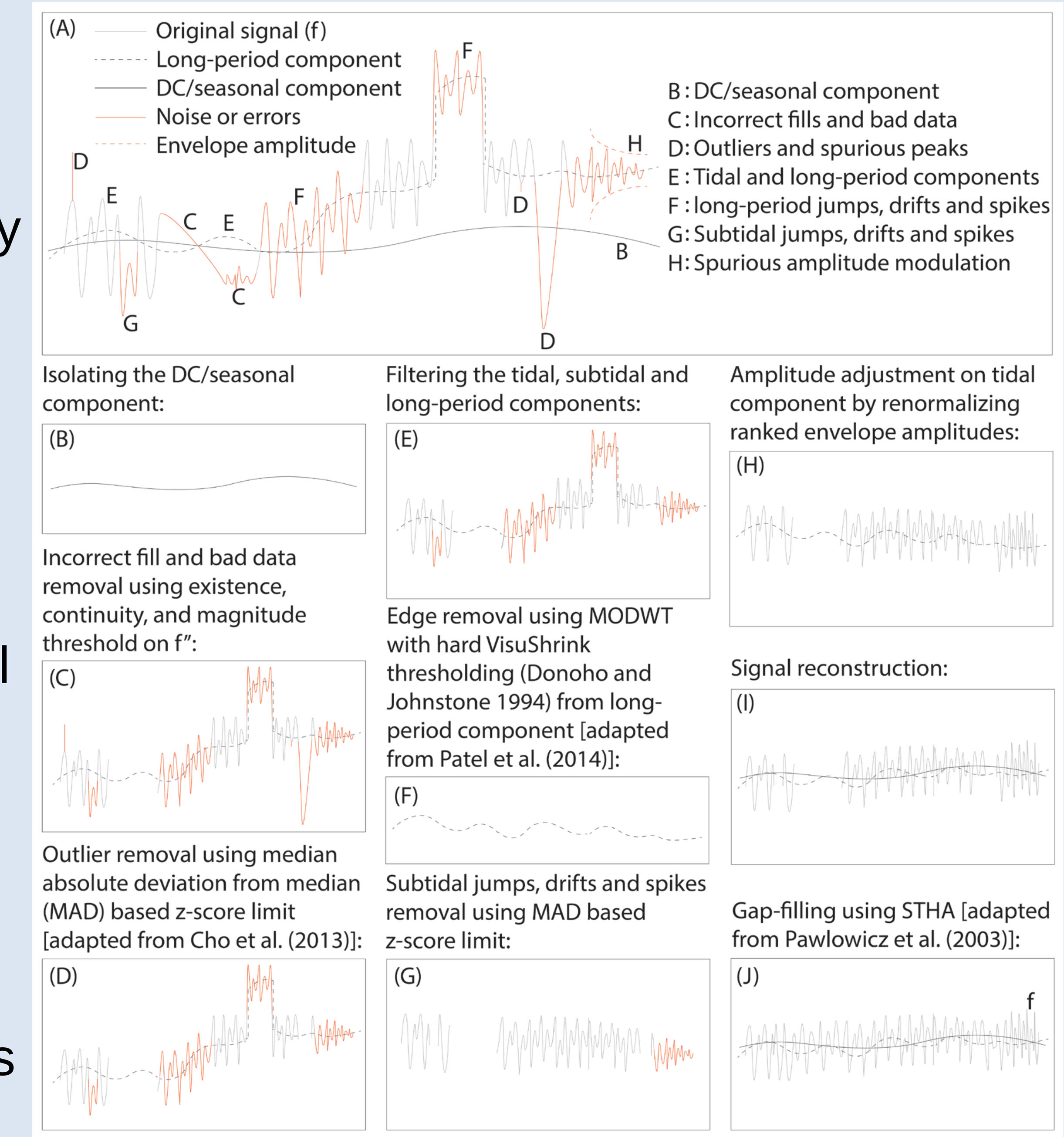


Figure 2. Workflow for signal clean-up from all locations

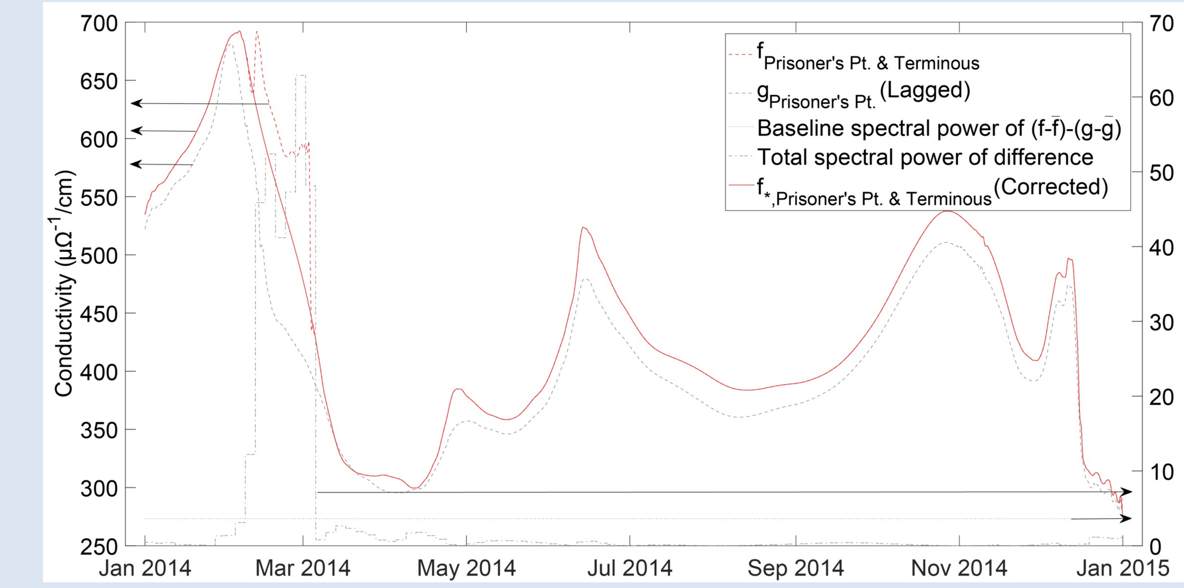
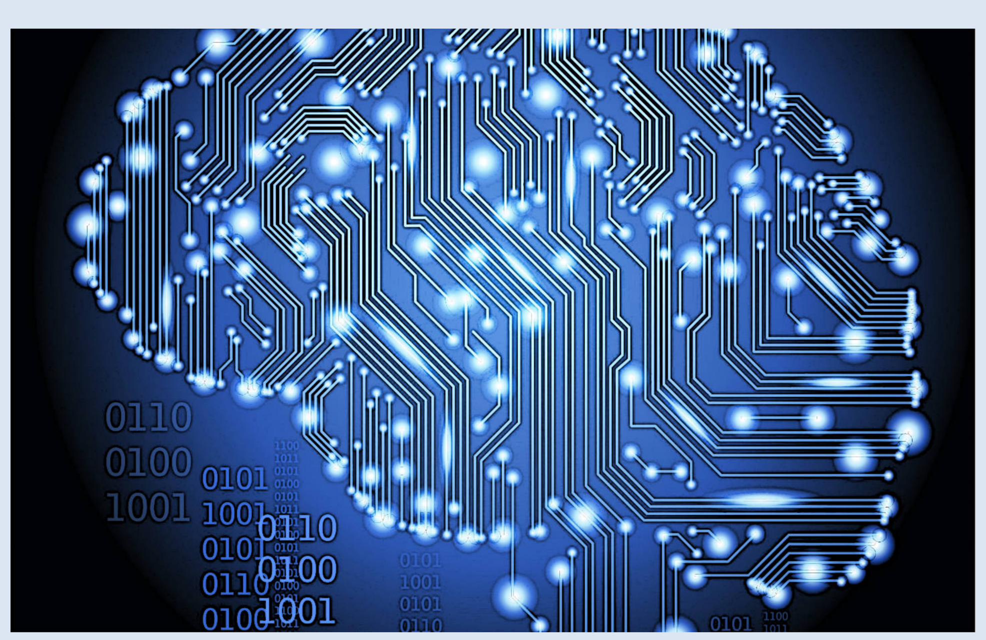


Figure 3. Dealing with estuarine signals: subtidal low-pass filtered residual of the target signal to which the edge and outlier removal algorithms have been applied is the first pass DC component, f. The same operations applied to a signal from a nearby station is the spatial neighbor signal, g. g is shifted by the lag between itself and f. The incorrect jump in f is then removed by first removing points in f at times when the total spectral power, P(t), of the adjusted difference, exceeds the baseline spectral power, $\bar{P}$, by some threshold value, and then replacing these points with a cubic spline interpolation. This procedure gives the DC component of the target signal, f_*.

2B. Methodology

- ➢ Data is censored to the instrument's operational range
  - ➢ Thresholding on signal's temporal derivatives to remove gross errors, followed by moving median threshold to remove outliers.
    - ➢ Surviving signal is decomposed
      - ➢ Long-period component is subject to maximal overlap discrete wavelet transformation to remove multi-scale edges
- ➢ Local information in the subtidal and tidal components is compared relative to the whole signal to correct spurious amplitude modulations and sudden biases
- ➢ Signal components are added to recover the uncorrupted signal, and large data gaps are filled with short term harmonic reconstruction
- ➢ For estuarine locations, the correlation in the spectrogram between two nearby stations is used first to quantify and remove river influence in the signal.

3. Use of Machine Learning for optimal parameter selection



- For long signals, optimal breakpoints are identified by optimizing ratio of computational cost to short term harmonic analysis efficacy using gradient descent learning
- Thresholding and outlier detection parameters are optimized using a cost function and gradient descent learning
- Other operations could potentially be optimized as using machine learning as well

4. Results and discussion

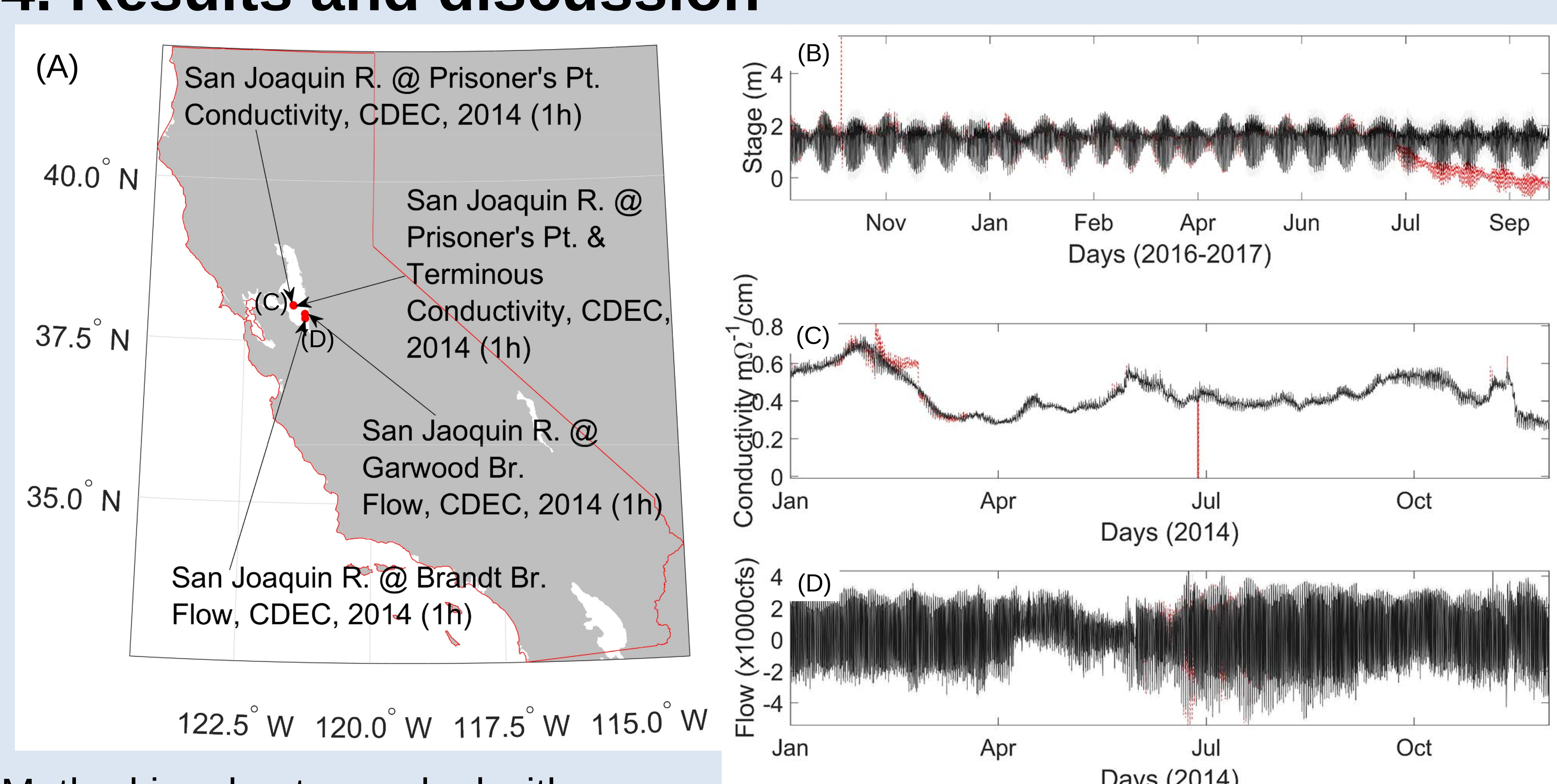


Figure 4. Results: (A) Estuarine locations, (B) Correction of signal drift at Bournemouth, England, (C) Correction of jump and outliers in salinity, (D) Robustness to good data

Method is robust, can deal with different quantities, multispectral signals, and can be improved using machine learning.

5. References

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