# Eulerian and Lagrangian measurements of flow and residence time on a fringing reef flat embayment, American Samoa

From Curt April 1, 2014:

Basically, what is the goal of the manuscript? Lay out the background of the problem in the beginning of the Introduction, move into the more specific gap in our understanding that we're trying to pursue, then state because of this, we did X to learn Y at the end of the Introduction. The Study Area is background information on the specific study area - both subaerial and subsurface. Methods outline the methods used - both instruments and specific calculations; you don't need the detail of your proposal - just give a reference for methods like progressive vectors and EOFs. Results are the data - not methods. You can compare the results to other studies to put them in context, but don't explain why you think you're seeing the patterns you're seeing - that's for the Disucssion. Break it out by oceanographic and meteorologic forcing, ADCP data, and drifter data. The Discussion is where you first discuss how well the Lagaranian and Eulerian methods compare, then characterize the findings by the different types of forcing and why you think you're seeing these patterns you see in the data. You then can discuss the relevance to residence times and what they mean for sediment, nutrient uptake, etc. Wrap it all up with the big take-away message. Coral Reefs does not have a "Conclusions" section.

# Outline:

*Goal for the manuscript:*

This manuscript describes how Eulerian and Lagrangian methods were used to map water circulation and the resulting water residence times over a shallow, fringing reef experiencing sediment stress.

## Introduction

**Background of the problem:** Water residence time is important for biological processes like sediment dynamics but spatially distributed flows are hard to quantify.

* Water residence time is controlled by wave, wind and tidal forcing, modulated by tide height at the reef crest.
* Eulerian measurements capture long term conditions but difficult to get a lot of spatial info since expensive
* Lagrangian good for spatial coverage but are short term, uncertainty in range of sampled conditions.
* GPS drifters are smaller, and cheaper now, can use lots of them to observe flows.
* Storlazzi (2006) combines them to get best of both worlds

**Specific knowledge gap:** What is the water residence time over the Faga’alu reef flat and how does it change under wave, wind and tidal forcing?

**So we did “X” to learn “Y”:** We compared the spatially extensive Lagrangian measurements with the longer term Eulerian measurements to calculate spatially distributed water residence time under different “end-member” forcing conditions.

## Study Area

*Background info on specific study area: subaerial and subsurface*

* Location, size, layout, depths of reef
* Description of seasonality and prevailing waves, winds, and tides
* Previous studies/data: Not much except for Vetter (2013), and none is published

## Methods

O*utline the methods used - both instruments and specific calculations; you don't need the detail of your proposal - just give a reference for methods like progressive vectors and EOFs*

**Combining Lagrangian and Eulerian methods**

* Description of Lagrangian, Eulerian, other methods (models, remote sensing etc.)
* How they are combined (Storlazzi 2006)

**Lagrangian measurements: drifters**

* Others have used them for these reasons, their advantages and disadvantages are, haven’t used them in reef flats though
* This is how they were designed and made
* This is how they were deployed and collected data

**Eulerian measurements**

* Others have used them for these reasons, their advantages and disadvantages are, they can be compared with Lagrangian measurements like
* This is how they were deployed and collected data

**Ancillary data**

* Data used to define forcing conditions
* Wave data was recorded by a DOBIE, then modeled from WW3 for the ADCP week
* Wind data recorded with weather station in Faga’alu, NOAA NDBC station at DMWR
* Tide data recorded by NOAA NDBC station at DMWR
* Forcing end-members are determined post-deployment, using the recorded data

**Analytical methods**

* Methods used: Progressive vectors, EOF’s, mean flows and residence times
* Progressive vectors are used to compare flow at ADCP to flow tracks from drifters, show if flow directions and speeds are variable away from ADCPs, they’re calculated….
* EOF’s compare dominant flow directions, they’re calculated by spatially binning the drifter data and calculating an EOF for each bin
* Mean velocity is calculated from spatial bins and used to calculate residence times; and compare with ADCP mean velocity to see if short Lagrangian measurements compare to long term ADCP (are mean velocities similar between methods)

## Results

*Results are the data - not methods. You can compare the results to other studies to put them in context, but don't explain why you think you're seeing the patterns you're seeing - that's for the Discussion. Break it out by oceanographic and meteorologic forcing, ADCP data, and drifter data.*

**Oceanographic/meteorologic forcing data-Tide, Wind, Wave**

* Tide, wind and wave conditions during the study period were…, allowing study of forcing end members
* Table 1
* Wind forcing: 2014 Year Day (YD) 47-49, mean wind speed/direction and max gust
* Tide forcing: YD 50-51, tide range?, wind speed, wave height?
* Wave forcing: YD 52- 55, max wave height

**ADCP data**

* Data was collected YD 47-55; water level fell below on AS3
* Max velocity was at AS1, YD ## in NW direction
* Tide forcing showed slower flow speeds, more variable direction
* Wind forcing showed slower flow speeds, more variable direction
* Wave forcing showed faster flow speeds, more constant direction

**Drifter data**

* 30 deployments were made, 22 coinciding with ADCP deployments YD 47-55
* Tide forcing showed slower flow speeds, more variable direction
* Tide: drifters more erratic direction but faster speeds than Wind; cross-reef drifter tracks
* Wind forcing slower flow speeds, more variable direction
* Wave forcing showed faster flow speeds, more constant direction

**Progressive Vectors**

* ADCP showed little variation in flow direction but drifters followed the contours of the shore, and slowed at deep pools on south reef
* Tide:
* Wind:
* Wave

**EOF’s**

* Some spatial bins have more observations than others, some none at all; ADCP many more observations so more certain
* ADCP more ellipsoid at AS1 and AS2, more circular at AS3, same as drifters

**Mean velocity/Residence Times**

## Discussion

*The Discussion is where you first discuss how well the Lagrangian and Eulerian methods compare, then characterize the findings by the different types of forcing and why you think you're seeing these patterns you see in the data. You then can discuss the relevance to residence times and what they mean for sediment, nutrient uptake, etc.*

**Patterns observed under different forcings and why**

* Faster flow speeds, more constant flow directions under high waves
* Slower flow speeds, more variable flow directions under wind and tide forcing
* Cross-reef flow observed under wind and tide forcing but not under wave forcing

**How well did Lagrangian and Eulerian compare?**

* Progressive vectors showed that Lagrangian captured the flow patterns better, and the flow diretions were influenced by the reef/shore morphology
* Both methods showed the main differences between the north and south reefs: flow speeds are slower and flow directions more variable over the north reef than the south reef

**Relevance to residence times, sediment and nutrient uptake**

* Residence times are much higher on the north reef and deep pools of south reef, which are also closest to the stream mouth, increasing influence of sediment and nutrient inputs in these areas

*Wrap it all up with the big take-away message* *No Conclusion in “Coral Reefs”, give big take-away message*

**Take-away message**

Residence time is mainly controlled by wave forcing, and is much higher on the northern reef flat, increasing the impact of land-based sources of pollution from the river.