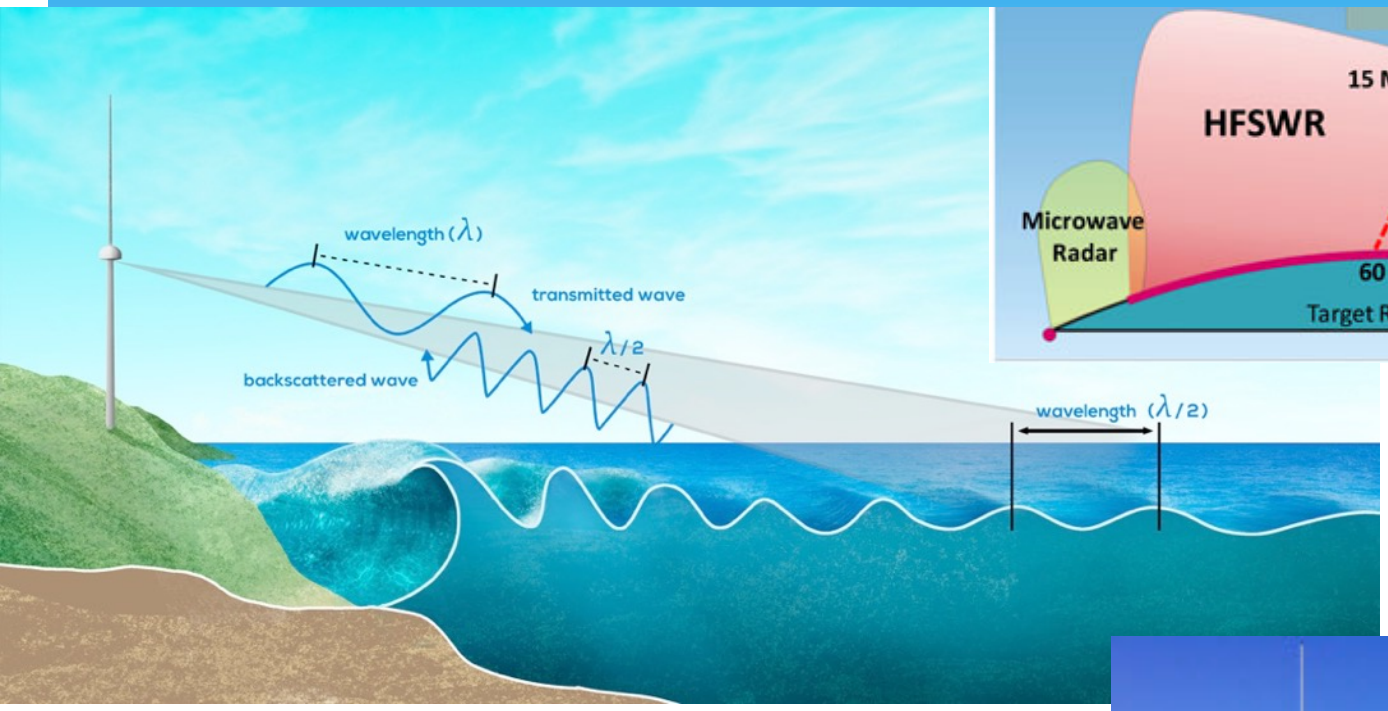
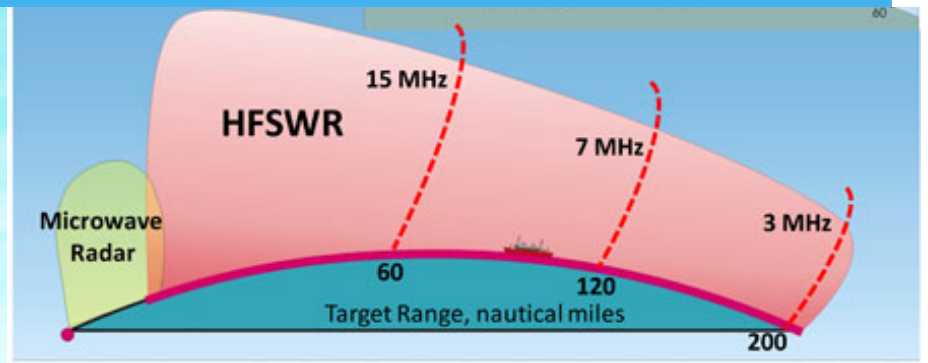
Inter-annual variability in surface currents over the California shelf measured by High-Frequency Radar

Douglas George and John Largier

Acknowledgements: Marcel Losekoot, UCD, Eric Terrill, Scripps/UCSD, Burt Jones, USC (now at KAUST), Libe Washburn, UCSB, Jeff Paduan, NPS, Toby Garfield, SFSU (now at SWFSC/NMFS/NOAA), Mike Kosro, OSU, Chad Whelan, CODAR, et al!

Talking Currents and RADAR





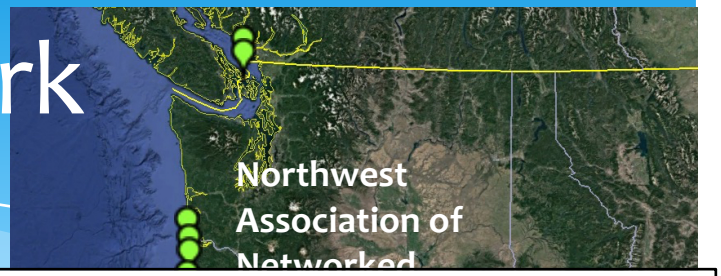
- Radio Detection and Ranging
- Use radiowaves to determine the movement of surface waters by bouncing off waves

Angel Island, San Francisco Bay

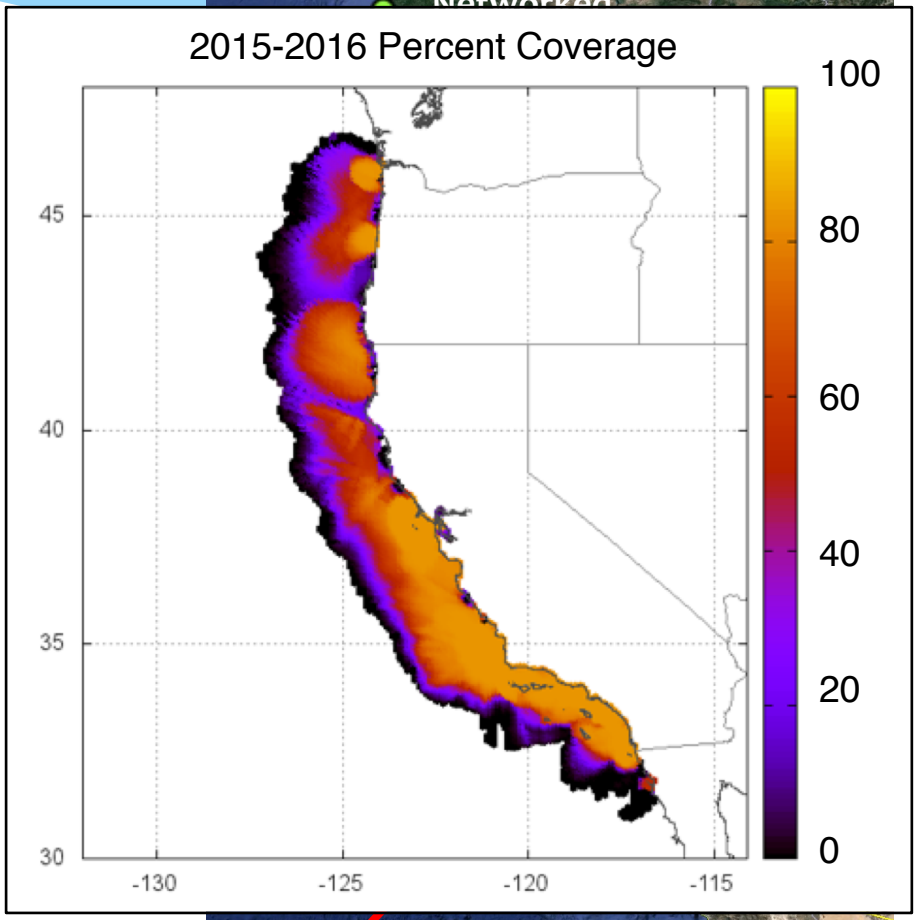
US West Coast HFR Network

- Three regional ocean observing networks (NANOOS, CeNCOOS and SCCOOS)
- 72 coastal stations, including 5 inside San Francisco Bay

US West Coast HFR Network

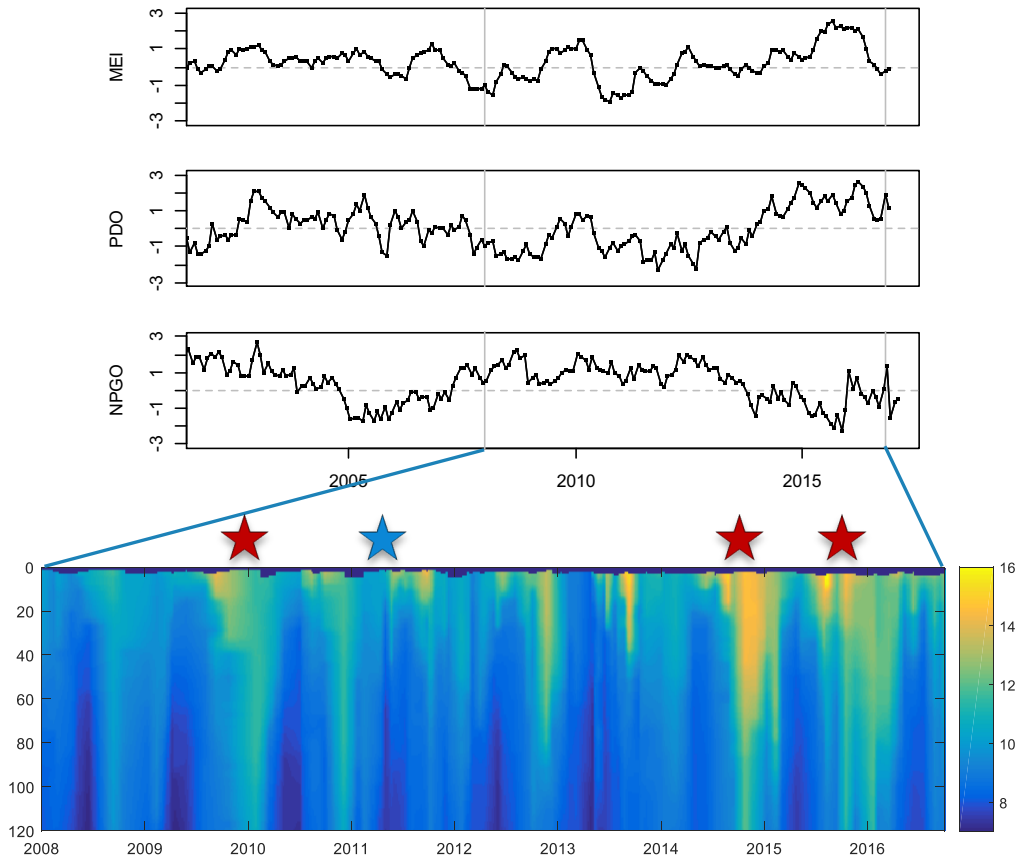


- Three regional ocean observing networks (NANOOS, CeNCOOS and SCCOOS)
- 72 coastal stations, including 5 inside San Francisco Bay
- Largest geographic coverage in last 10 years



US West Coast Regional Climate and Events

- Climate
  - Upwelling Season (March-August)
  - Relaxation Season (Sept-Jan)
- Events
  - 2009-10 El Niño
  - 2011 La Niña
  - 2014-2015 Warm Blob (Marine Heatwave)
  - 2015-16 El Niño



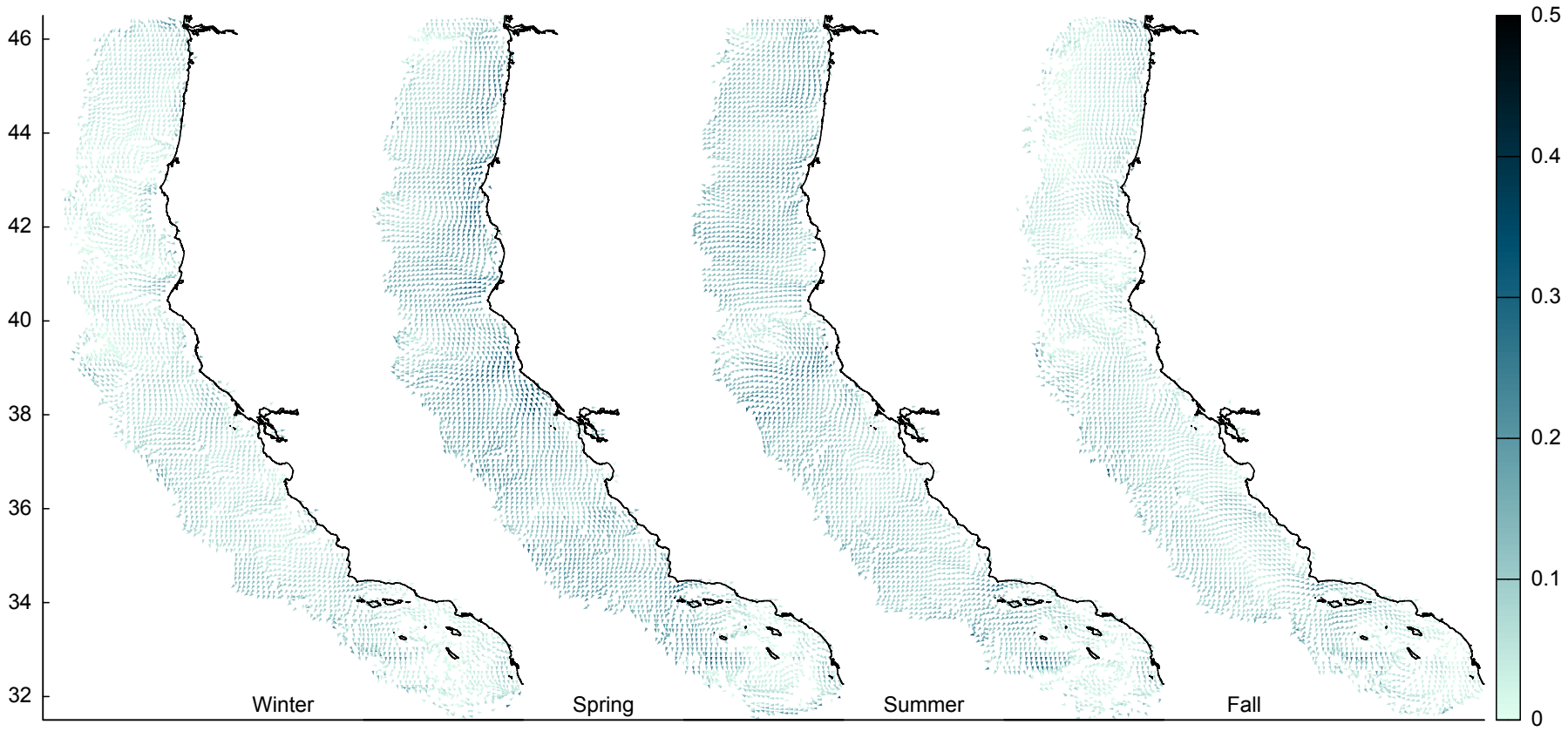
A Decade of Data (2008-2018)

Seasonal mean flow

Headland jets

Offshore flow

Seasonal eddies



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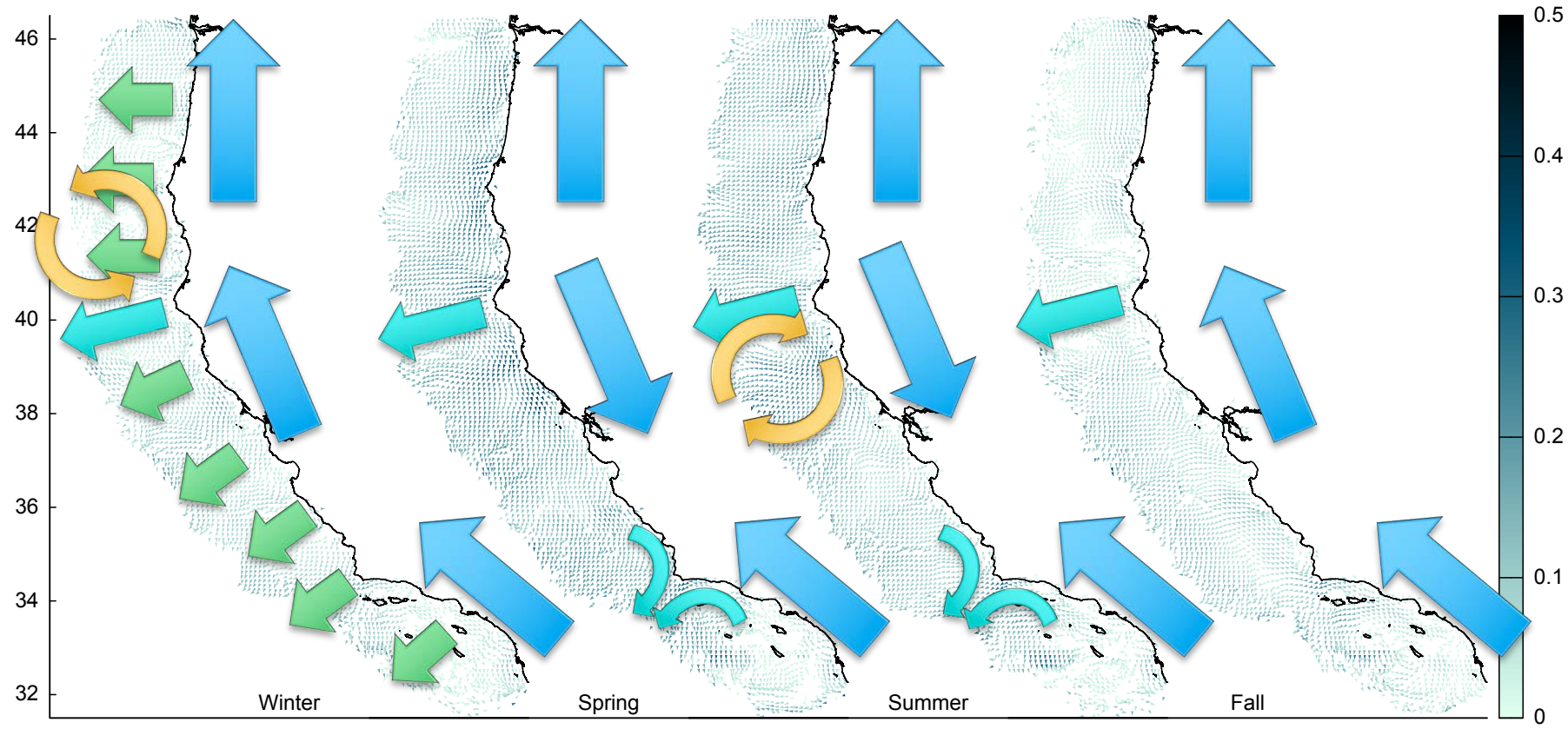
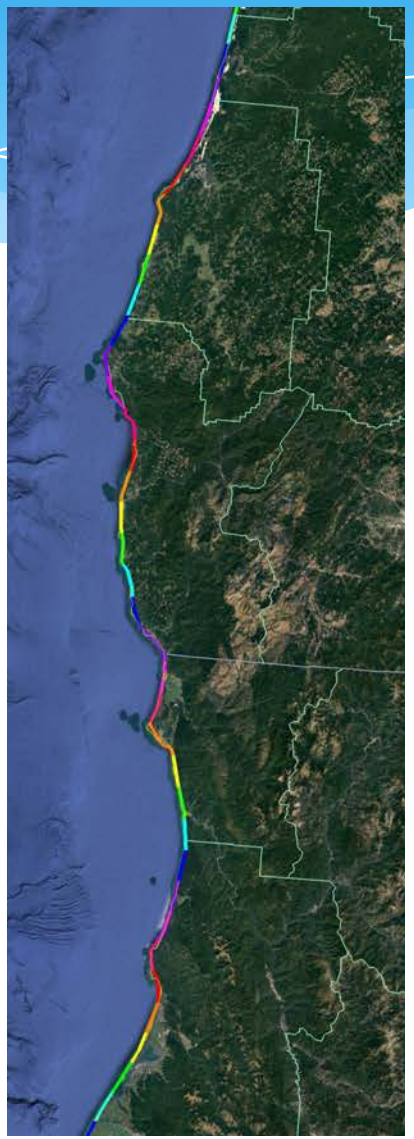


Parsing a Decade of High Resolution Data

1. Seasonal variability
   - Search for latitudinal upwelling signals
2. Inter-annual variability
   - Search for changes associated with ocean climate events
3. Cross-shelf variability
   - Search for structure and dependence on shoreline for current steering

Flow-Shoreline Orientation Analysis

- Relationship of flow to shoreline orientation
  - Simple coast broken into ~10 km segments and orientation extracted
  - Weekly U, V 6-km current data extracted from 20-km wide bands at 10, 20, 50, and 100 km from shore
  - Current data rotated to be alongshore and cross-shore



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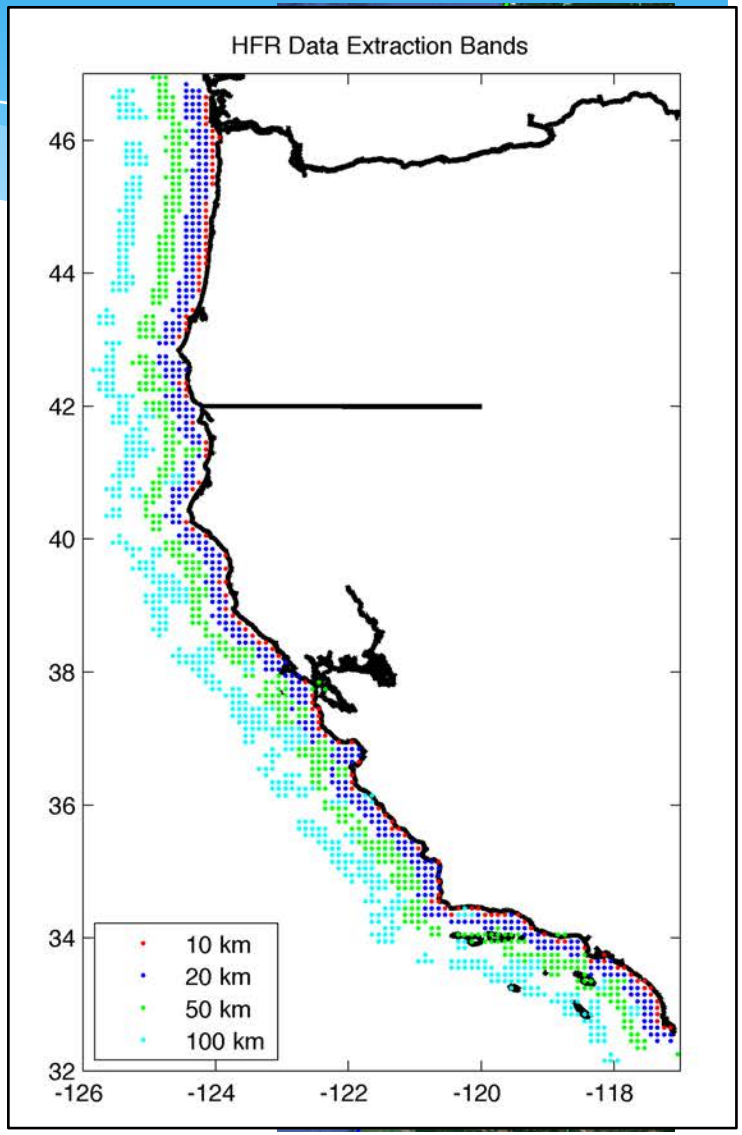

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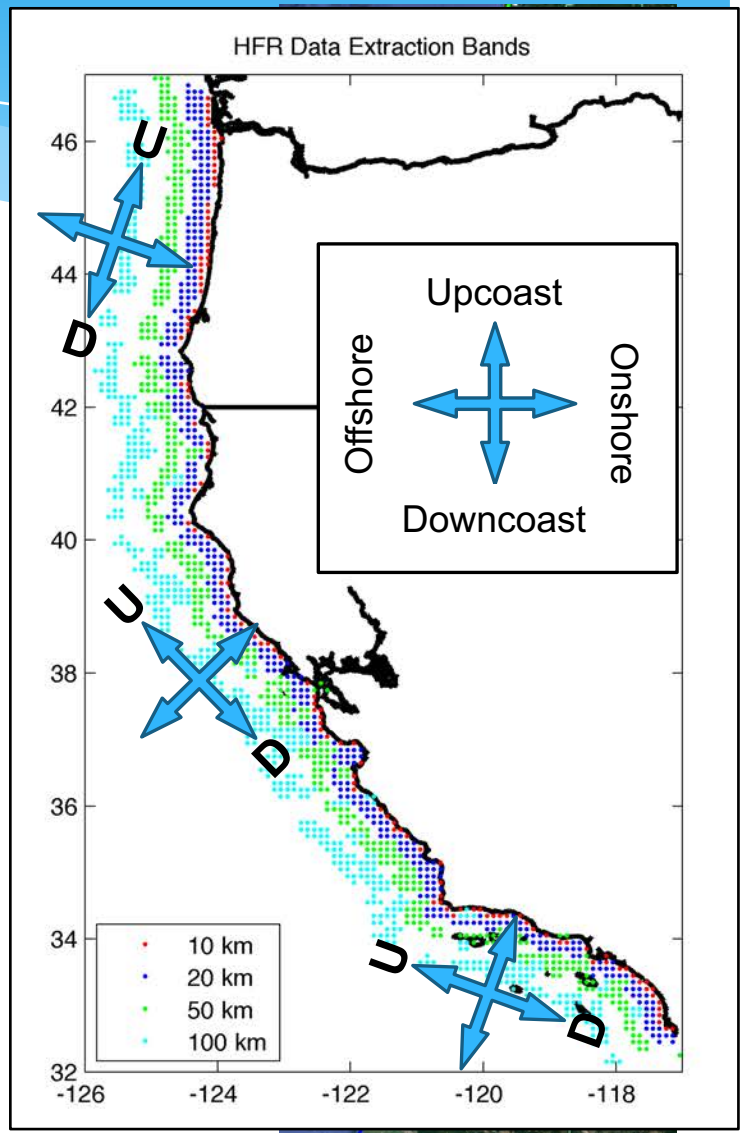
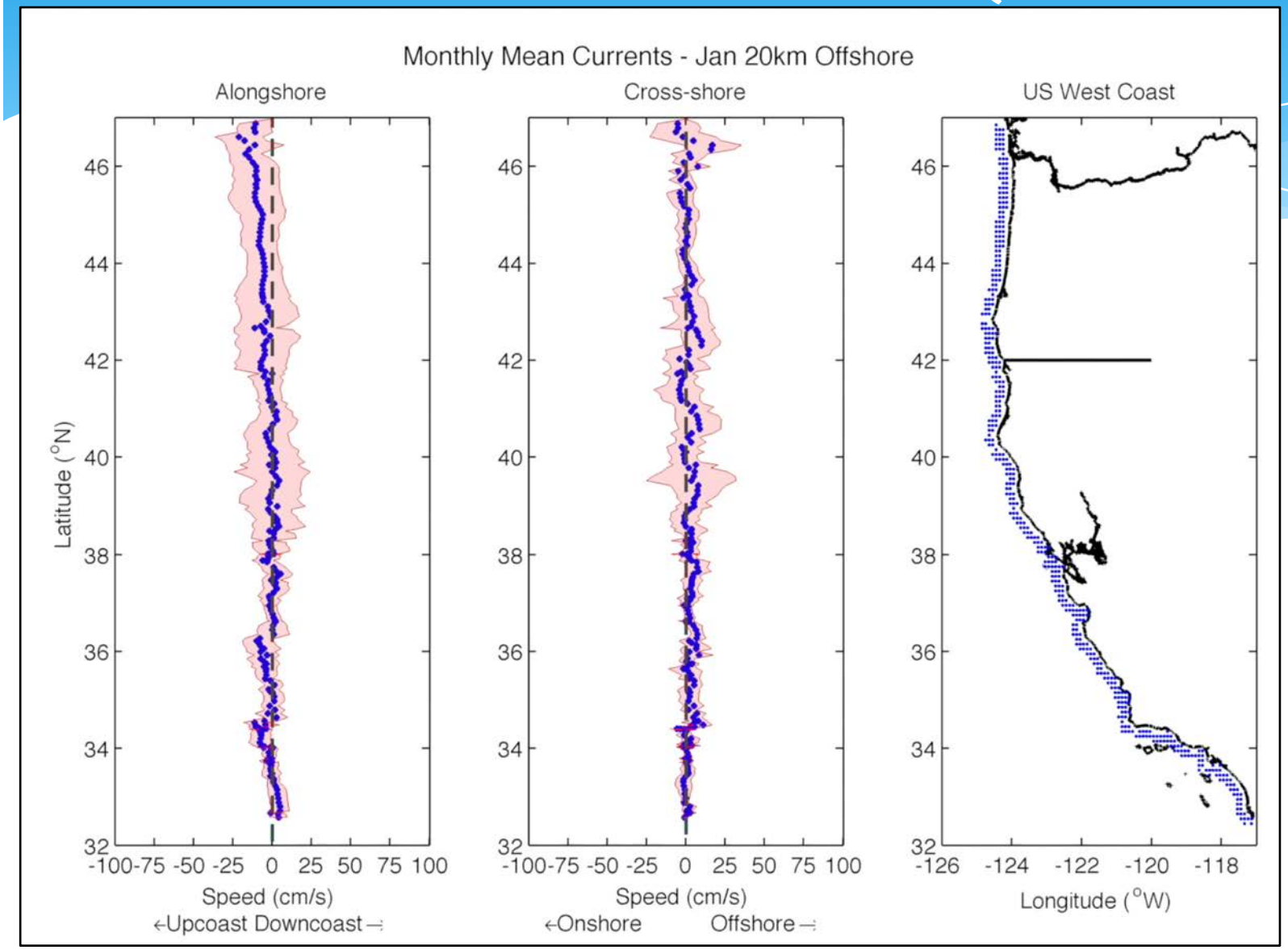
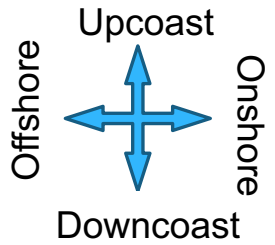
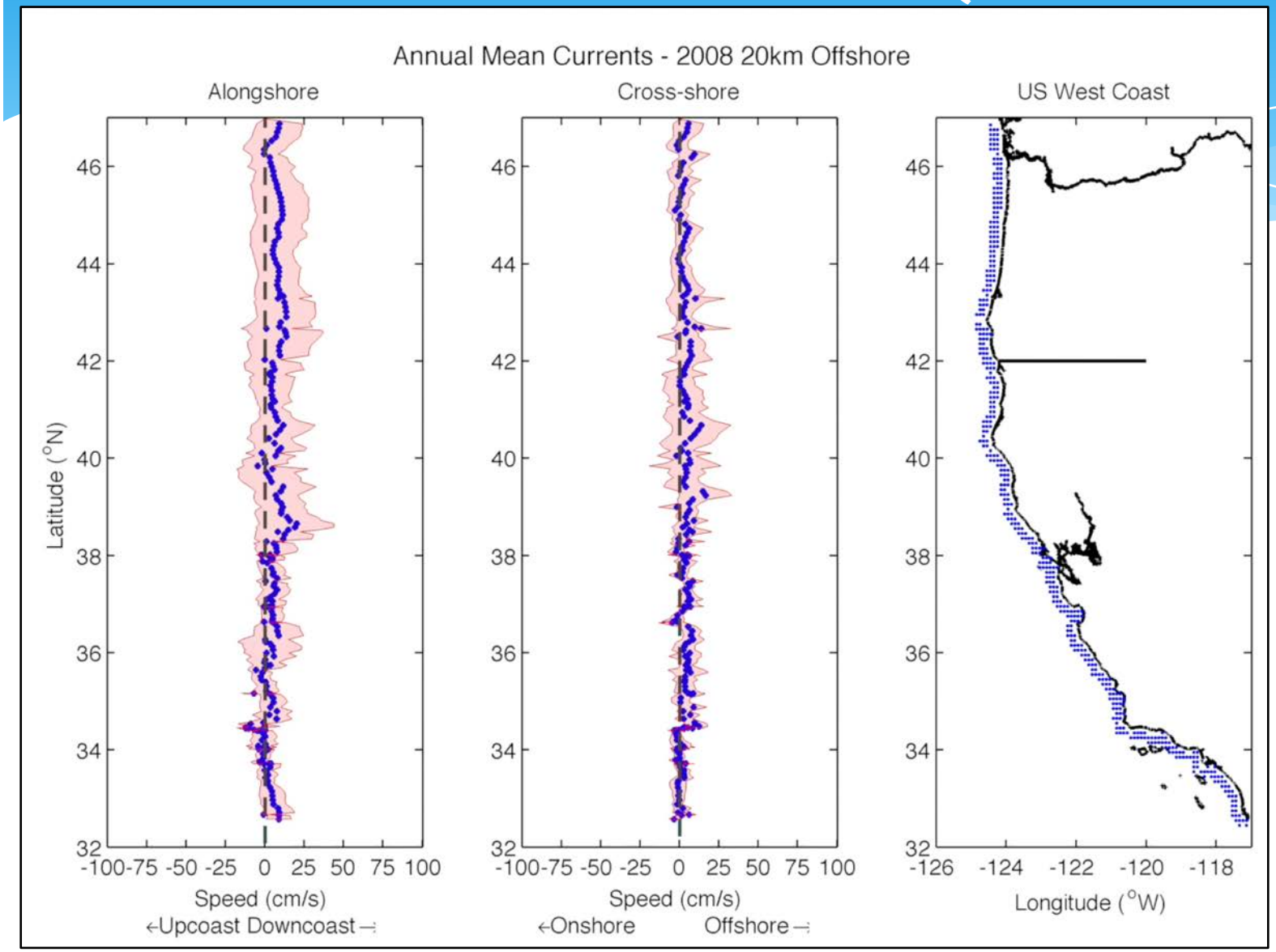


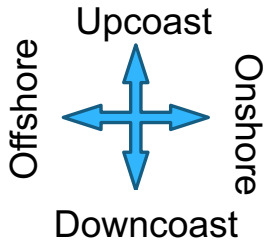
Seasonal Current Trends (2008-2018)



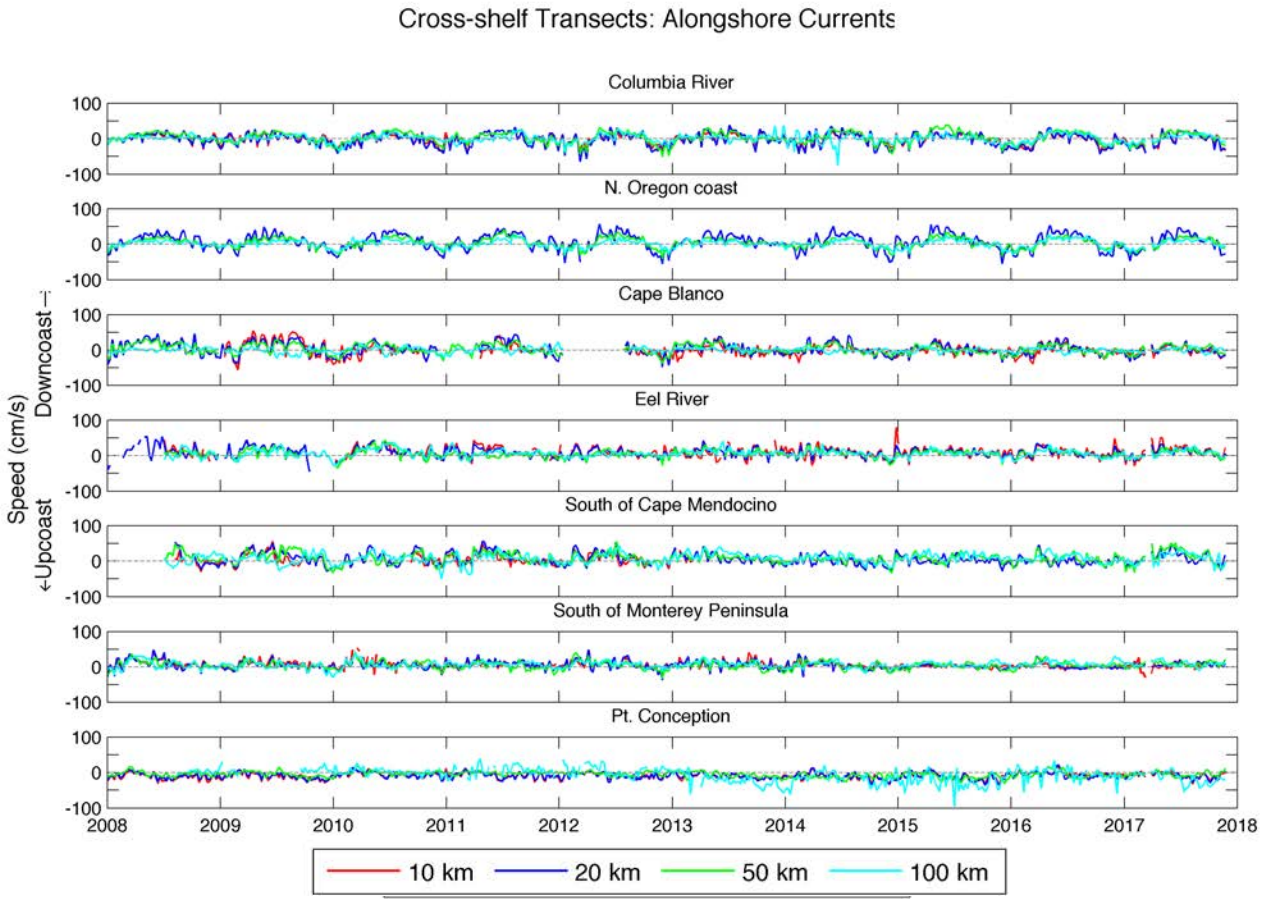


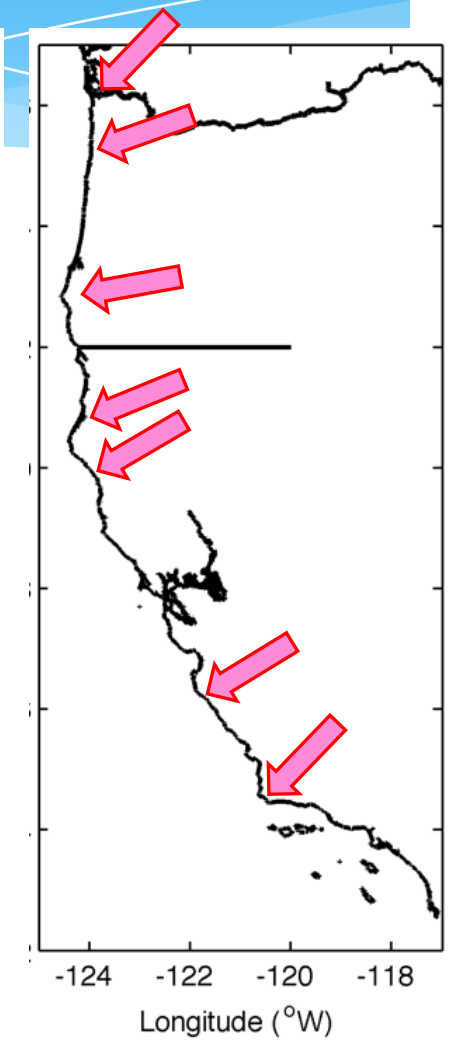
Annual Current Trends (2008-2018)



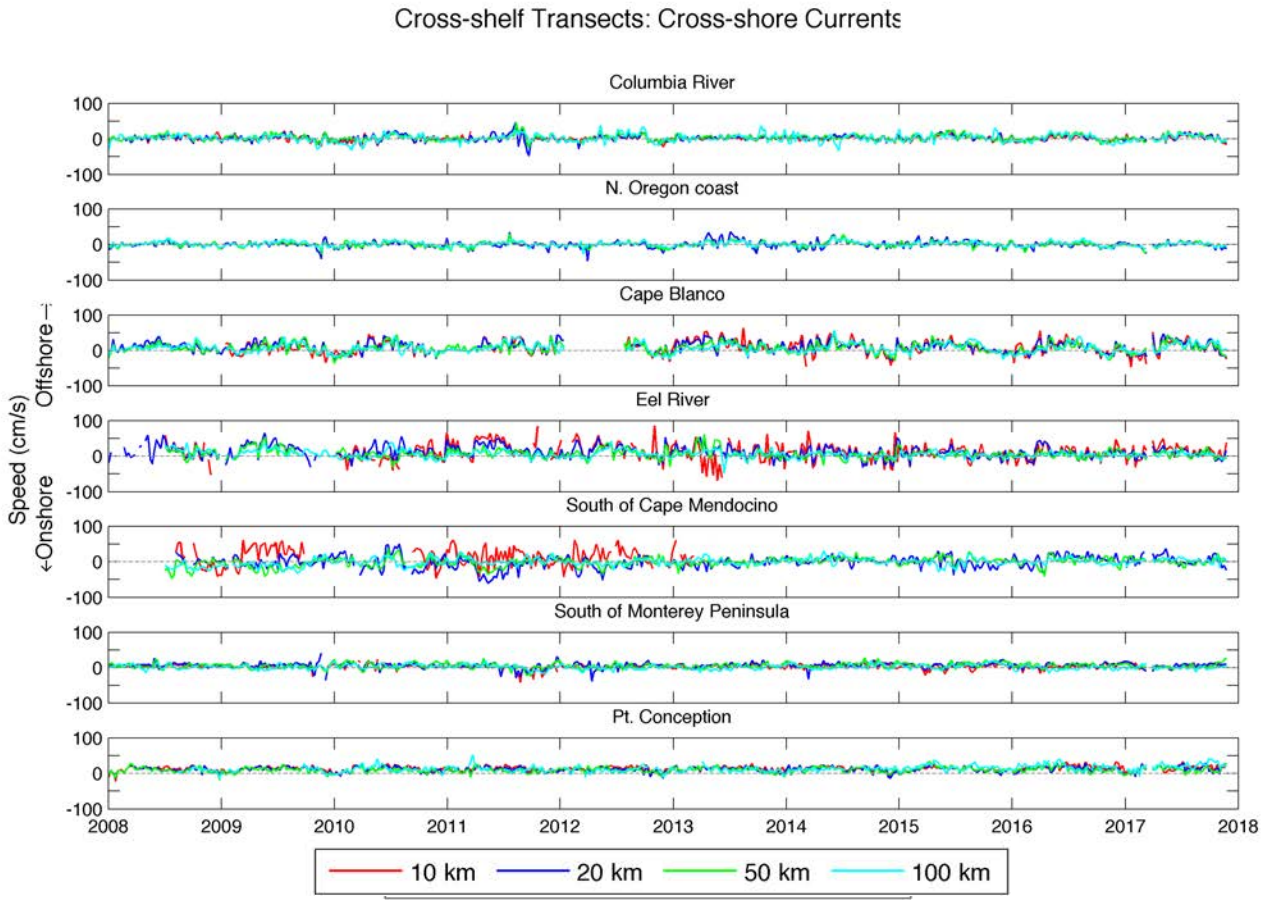


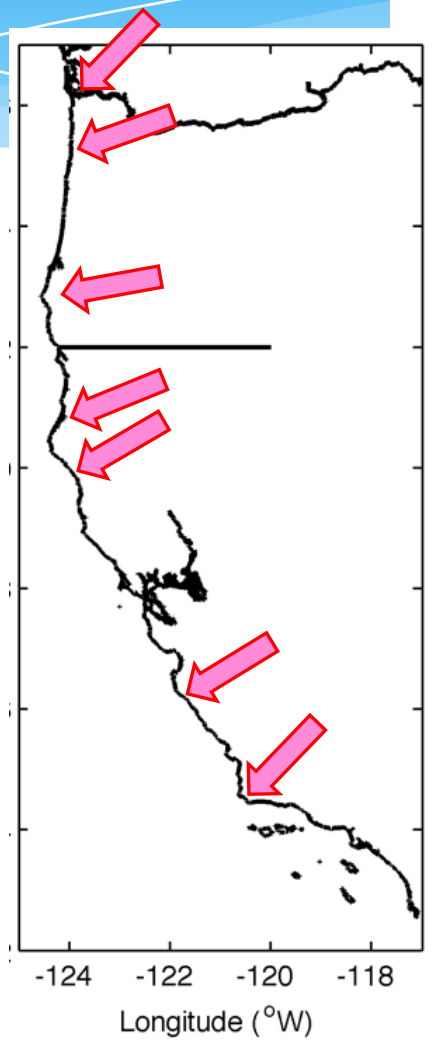
Cross-shelf Transects (Alongshore Currents)





Cross-shelf Transects (Cross-shore Currents)





Parsing a Decade of High Resolution Data

1. Seasonal variability
   - Upwelling and relaxation signals very strong from Oregon to San Francisco Bay zone
2. Inter-annual variability
   - Ocean climate events suppressed the normal southerly flows in 2015-2016
3. Cross-shelf variability
   - Eddies and jets identifiable using the 20- and 50-km offshore regions

What's Next

- Correlation Analysis
- Forcings Analysis (shoreline steering, meteorology)
- Anomalies Analysis

Inter-annual correlation of alongshore currents

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
2008										
2009	0.18									
2010	0.27	0.16								
2011	0.27	0.25	0.16							
2012	0.13	0.08	0.22	0.19						
2013	0.19	0.14	0.10	0.18	0.09					
2014	0.12	0.13	0.22	0.11	0.22	0.15				
2015	0.17	0.15	0.19	0.16	0.20	0.17	0.22			
2016	0.18	0.22	0.20	0.19	0.14	0.10	0.17	0.13		
2017	0.21	0.19	0.28	0.21	0.23	0.09	0.15	0.15	0.30	

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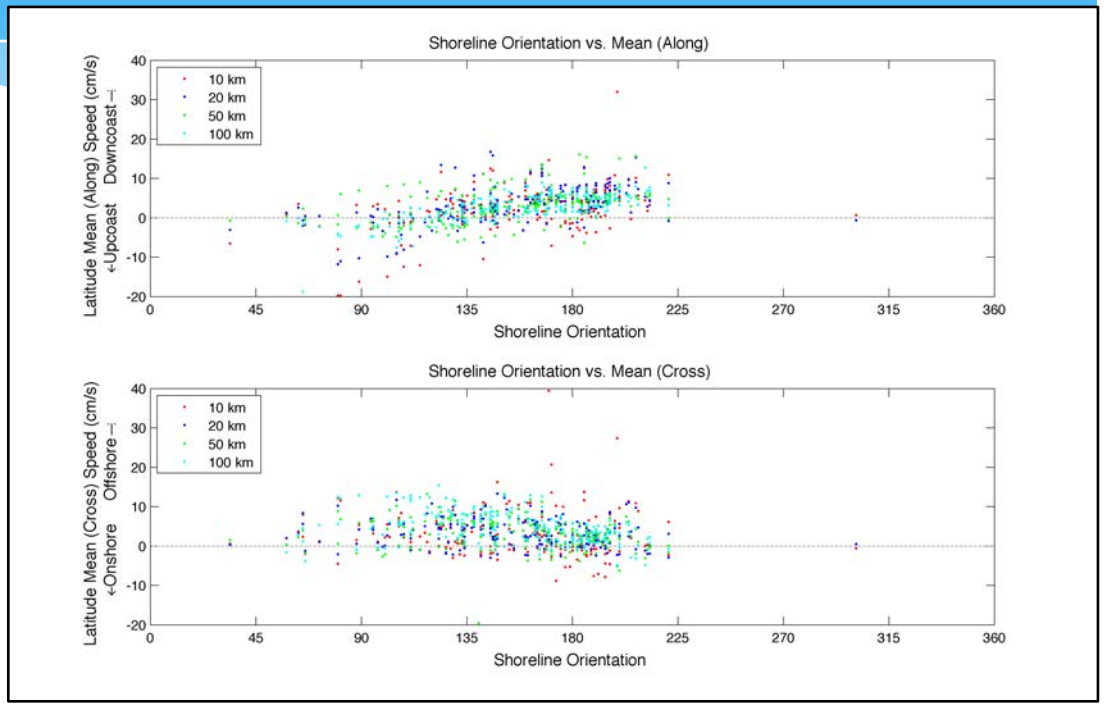

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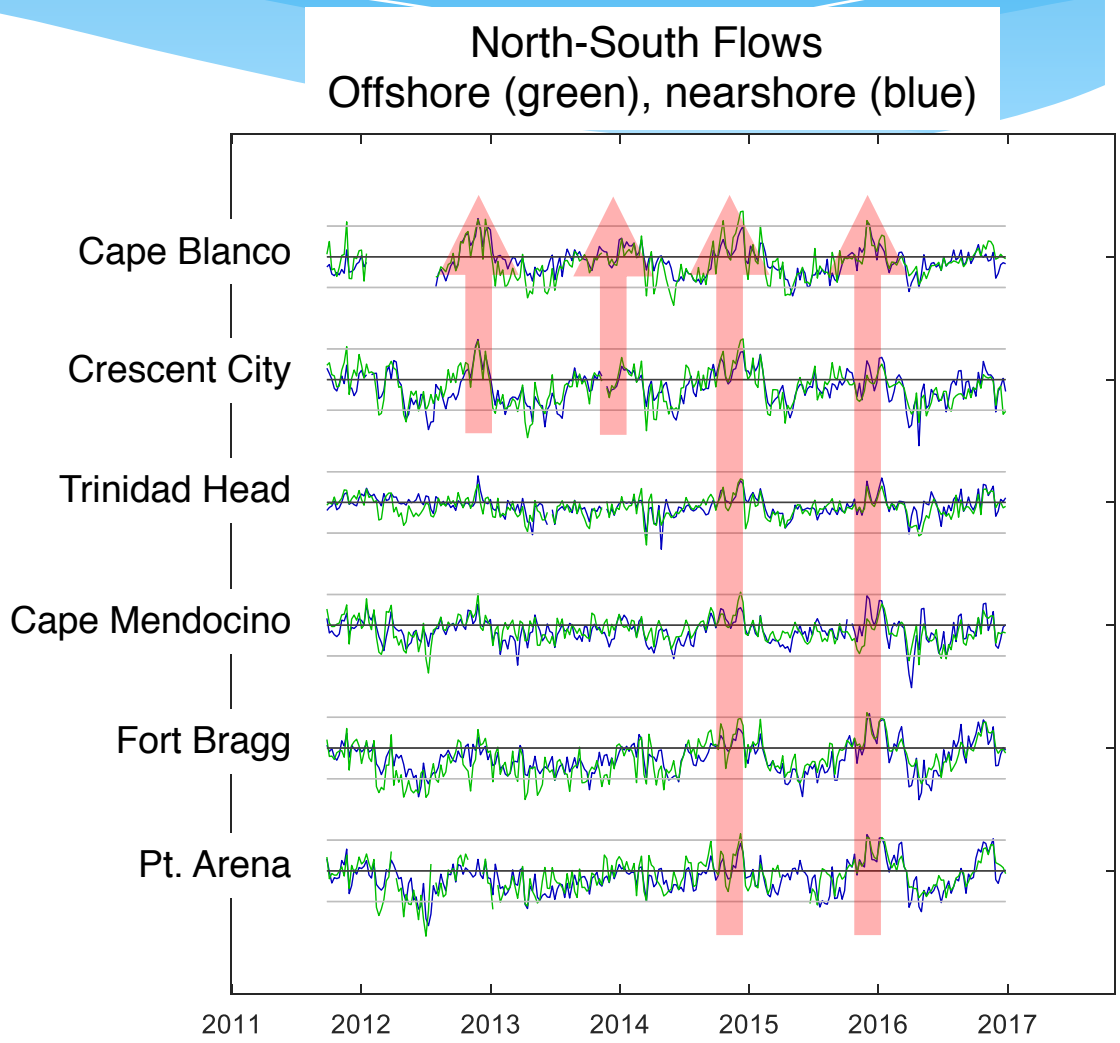

Thank you!

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