Ekman pumping along the Seward Line in the Northern Gulf of Alaska

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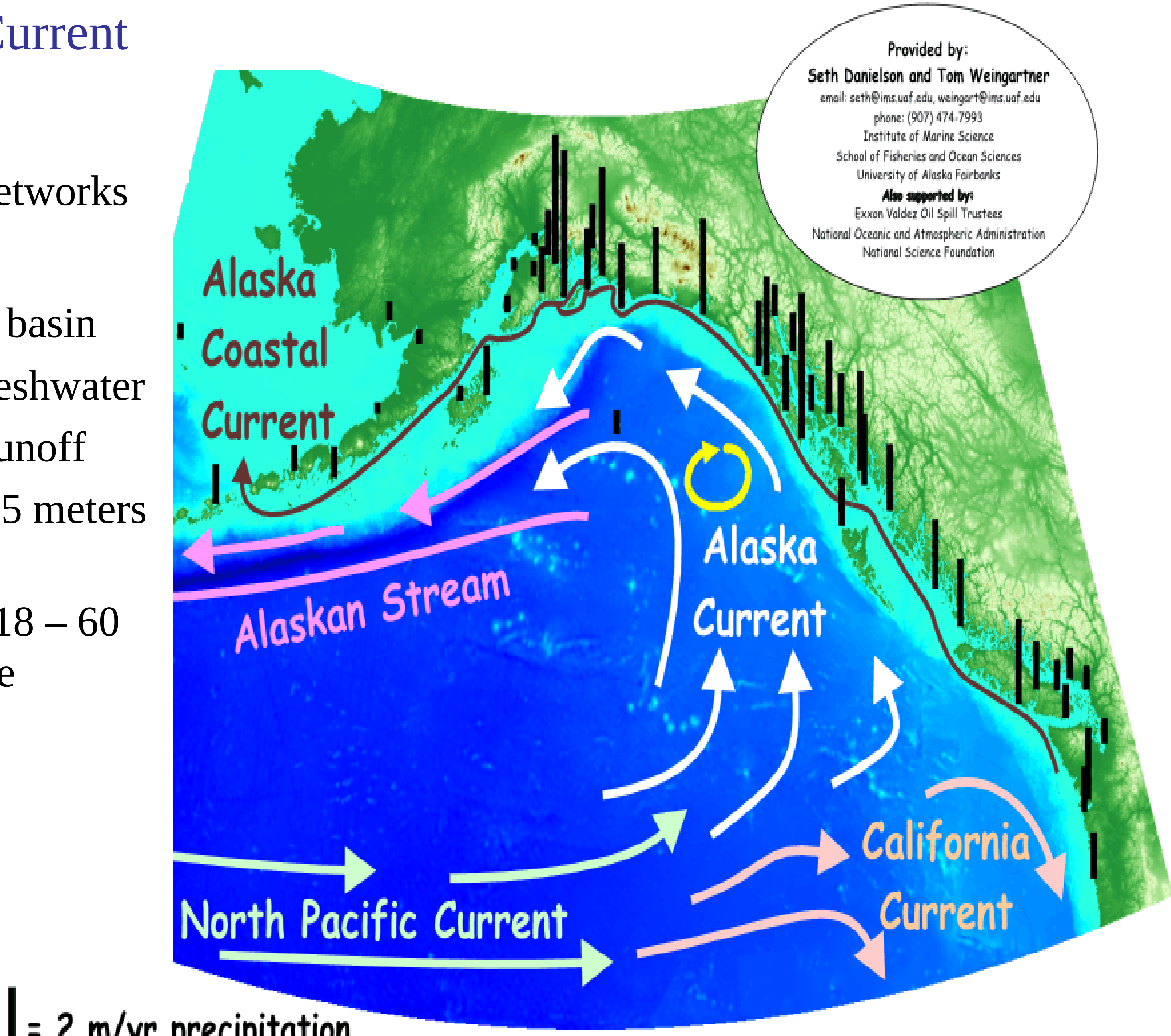
Supported by the Steller Sea Lion Project (CIFAR), U.S. GLOBEC Northeast Pacific (NEP GLOBEC) and the Long Term Observing Program (NSF/NOAA)

Outline

- Background: Ocean/Atmosphere
- Data: GLOBEC and QuikSCAT
- Results: Correlations of hydrographic data with Ekman transport (QuikSCAT and UI) and Ekman pumping
- Conclusions

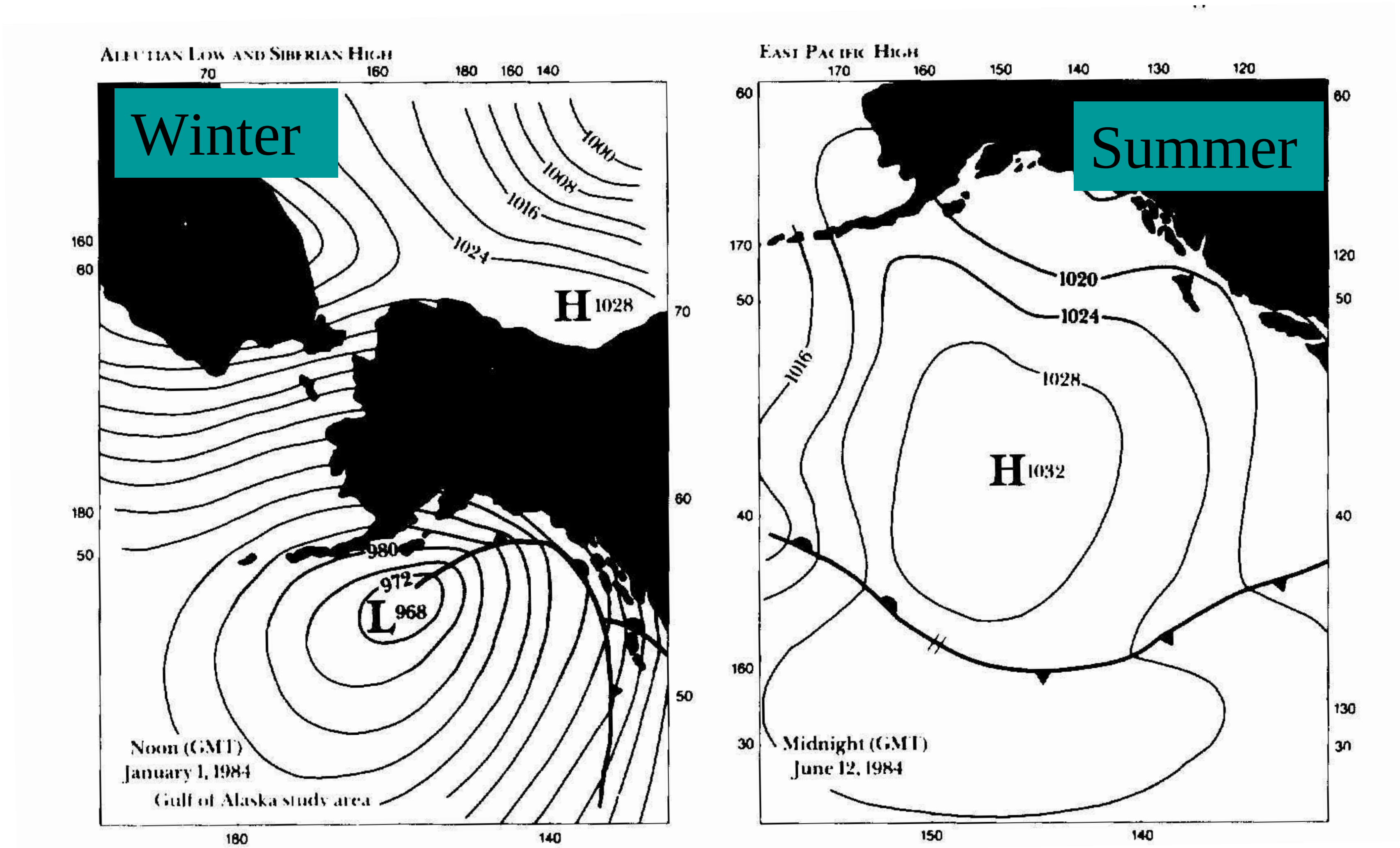
Region and Dynamics:
Alaska Coastal Current

- No major river networks
- High Mountains
- Narrow drainage basin
- Line source of freshwater
- ACC driven by runoff
- Alaska Current ~5 meters per minute
- Alaska Stream ~18 – 60 meters per minute



Region and Dynamics: Aleutian Low and East Pacific High

- Aleutian Low produces cyclonic winds
- Winds are compiled in Upwelling Indexes (UI)
- UI has 80% of days in October through March downwelling producing
- UI has 50% of days in July through August upwelling producing



Cross Shelf Transport:
How do nutrients get onto the shelf?

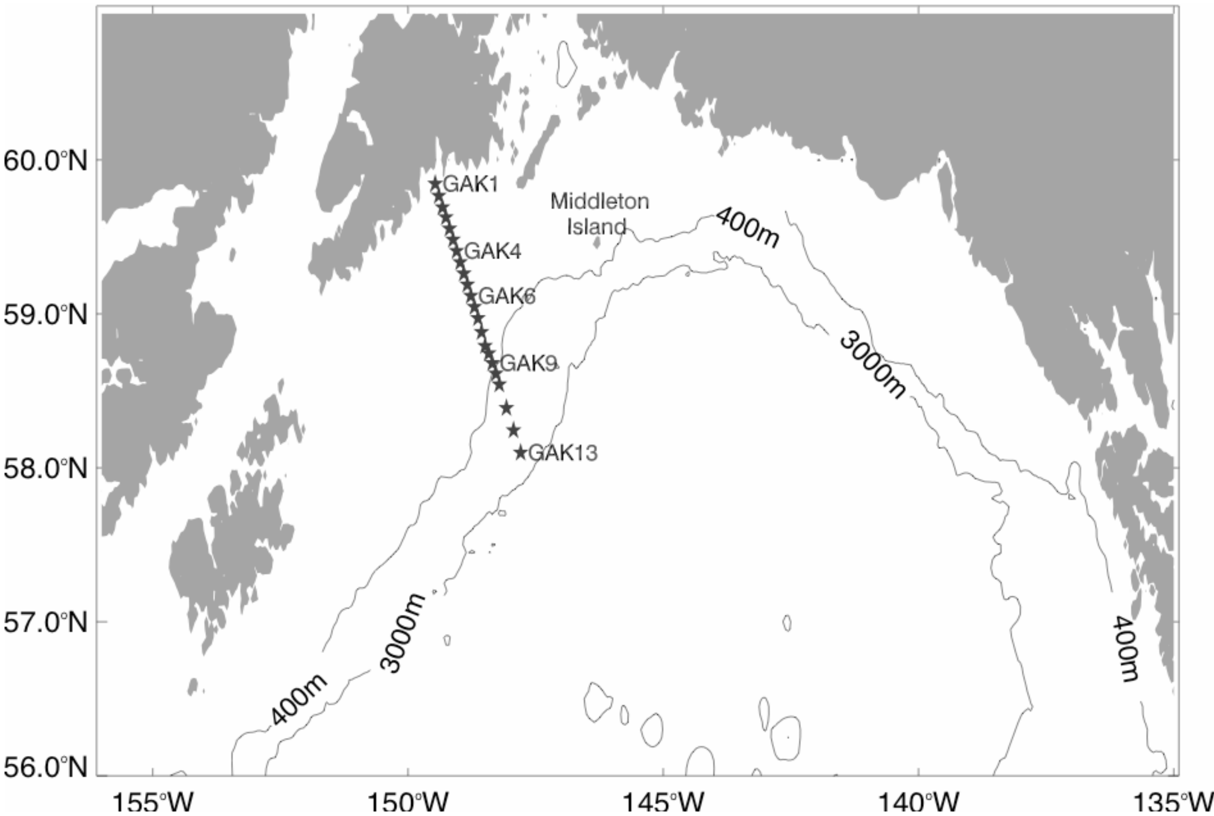
Possible mechanisms

1) Nutrients transported from central Gulf of Alaska in the Ekman Layer (Stabeno et al. 2004)
2) High nutrient water is brought onto the shelf in the bottom boundary layer triggered by the weakening of the alongshore geostrophic transport (Weingartner et al. 2005)
3) Surface offshore flow due to alongshore pressure gradients and entrainment cause onshore flow in the bottom (Royer 2005)
4) Increased salinities and nutrients measured in Hinchinbrook Canyon (Childers et al. 2005)
5) Large anticyclonic eddies can enhance shelf-slope exchange and promote upwelling (Okkonen et at. 2004)

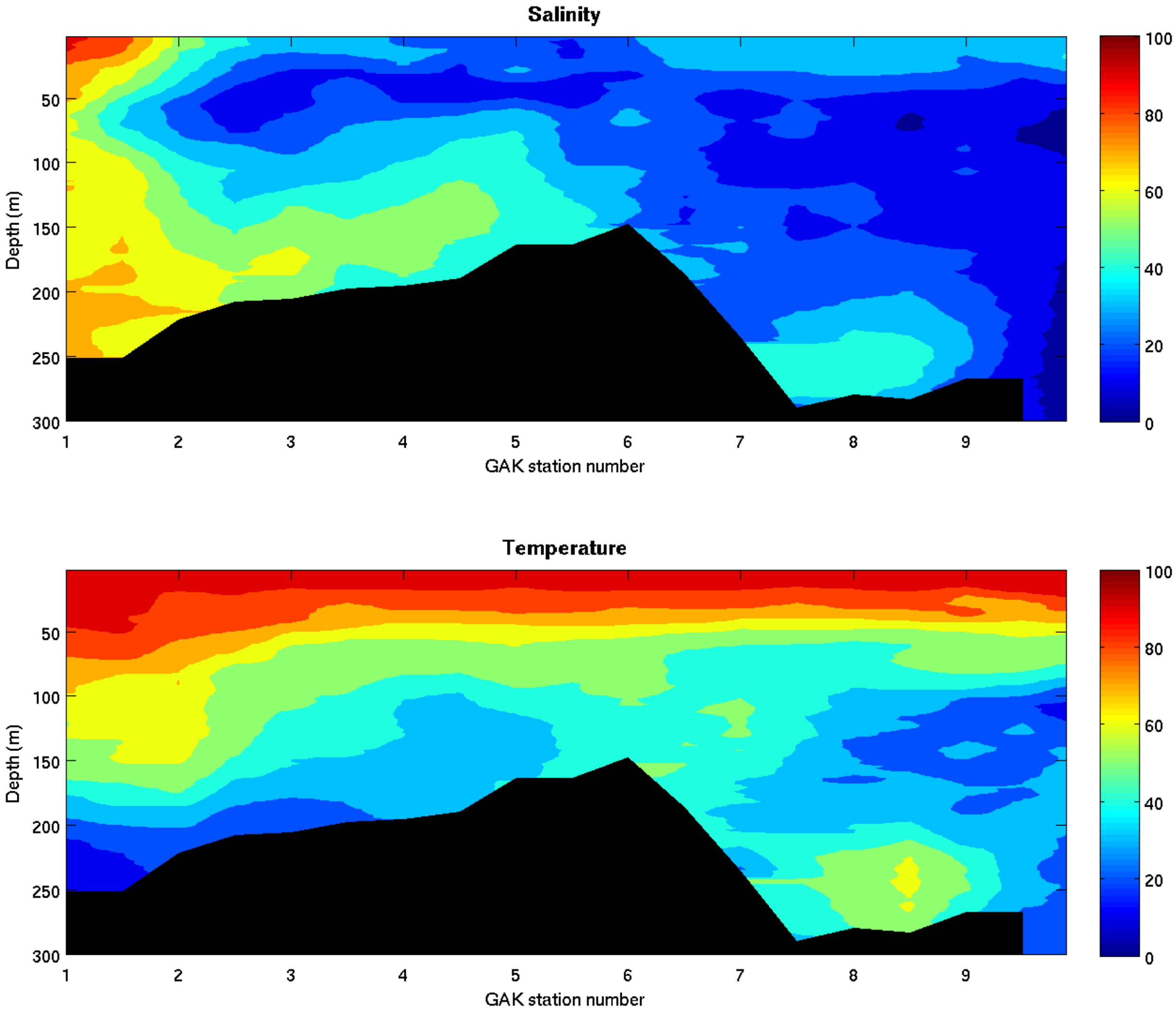
2, 3 and 4 need mixing to bring nutrients to the euphotic zone (Sarkar et al. 2005)

DATA: NEP GLOBEC

- Oct. 1997 to Dec. 2004
- Months sampled: March, April, May, July, August, October and December
- 45 cruises
- Seward Line: 23 stations
- Over 200 km long
- Nutrient were sampled at every GAK station
- Biological process studies were conducted at 3 locations along the Seward Line



% of variance explained by the annual signal



Why we are interested in QuikSCAT data?

- ***Interannual*** variability of hydrographic anomalies are not highly correlated with discharge and UI anomalies
- Sparse wind observational data

Coastal mountain chains cause unique wind patterns

•Katabatic winds

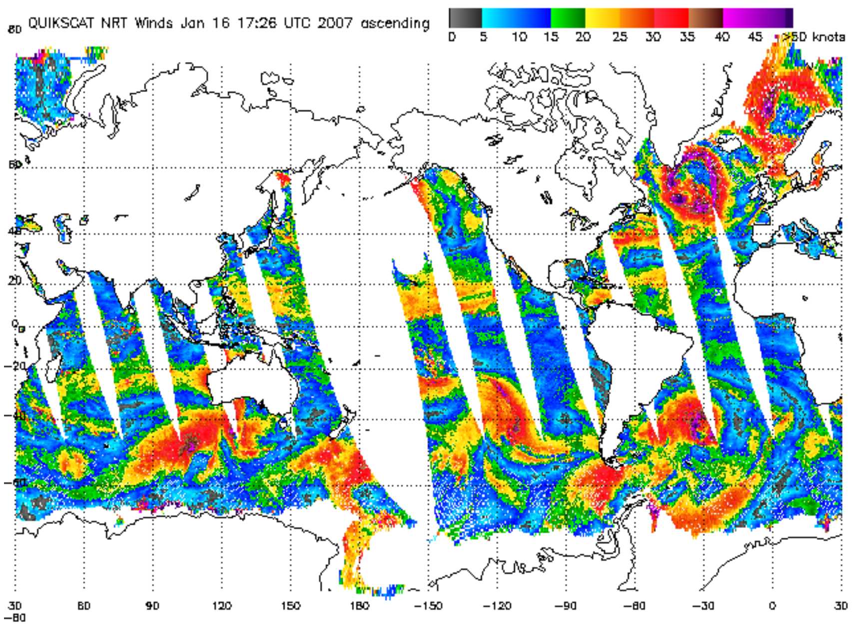
•Barrier Jets

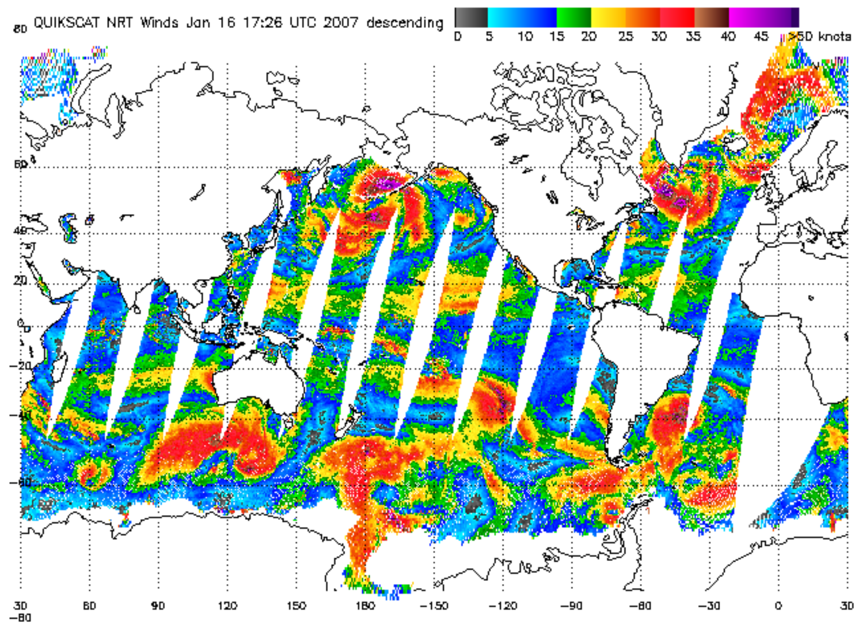
•Strong near shore winds

How are the hydrographic data correlated to the wind forcing?

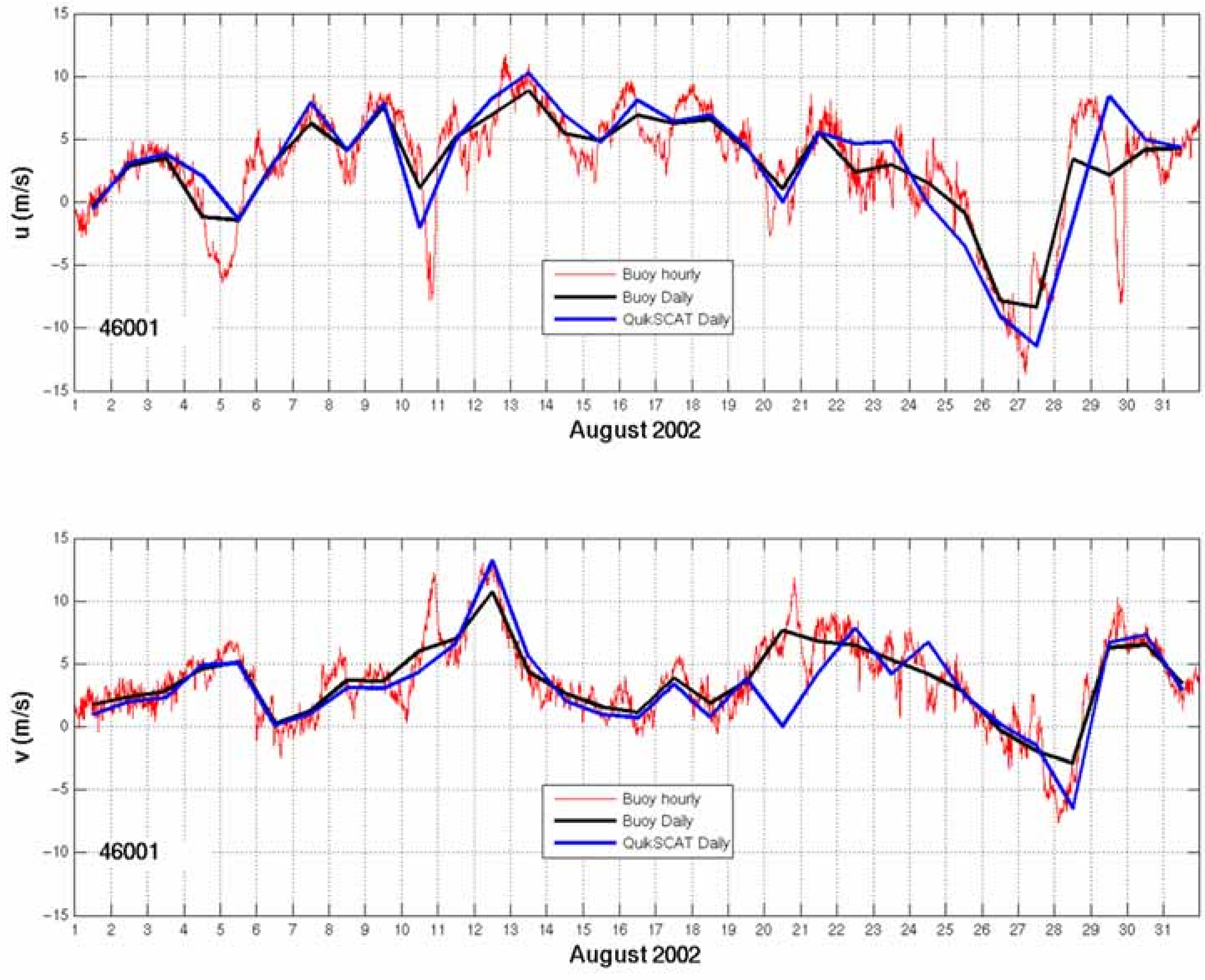
DATA: QuikSCAT Satellite

- Operational from July 1999 to present
- Magnitude and direction of wind at 10 m height
- Twice daily measurements: Ascending and Descending => averaged for daily
- 1800 km wide band
- 25 km resolution, new algorithm 12.5 km
- Cloud coverage doesn’t prevent collection
- Heavy rain affects quality



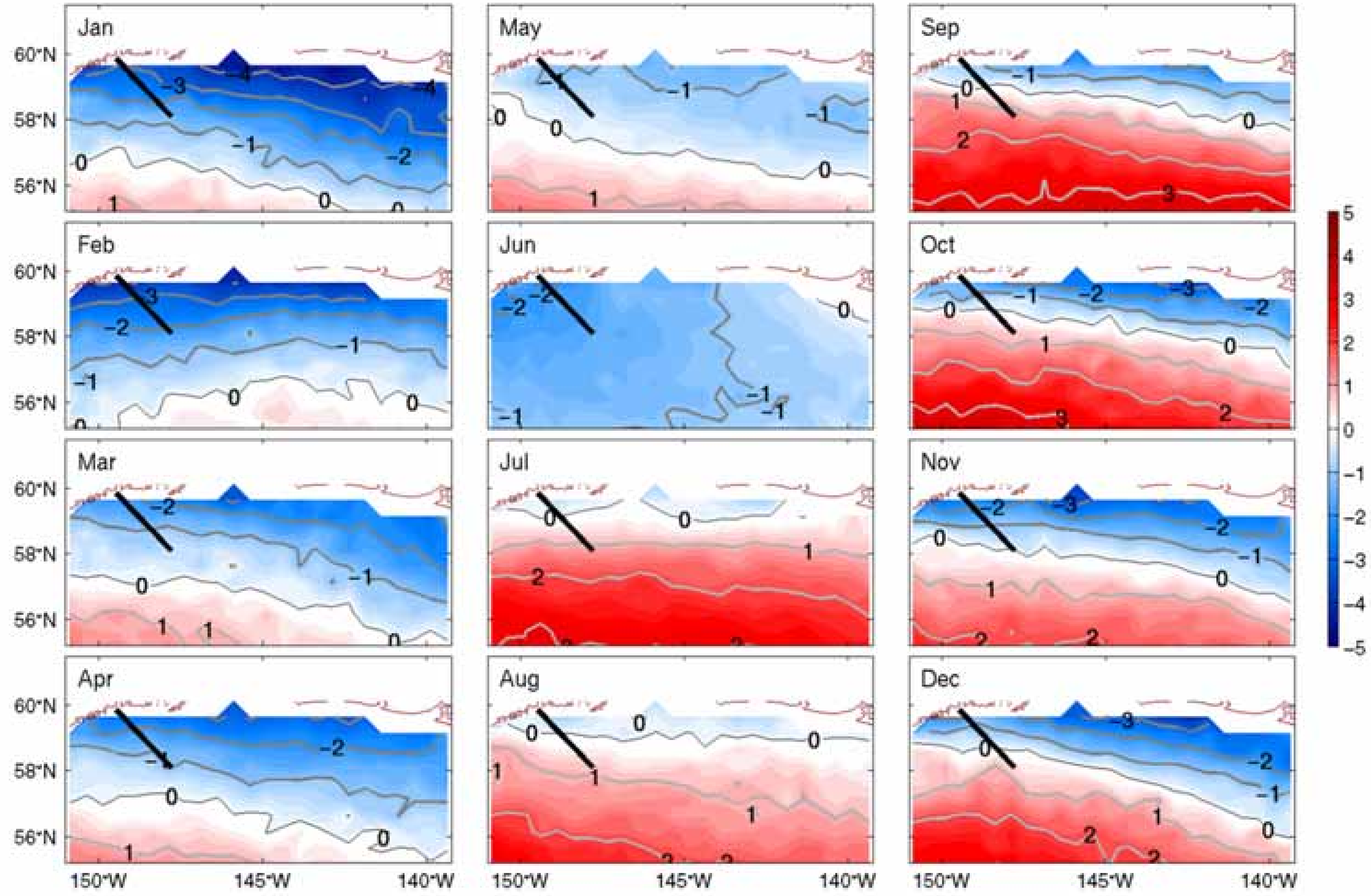


Comparison between Buoy and QuikSCAT



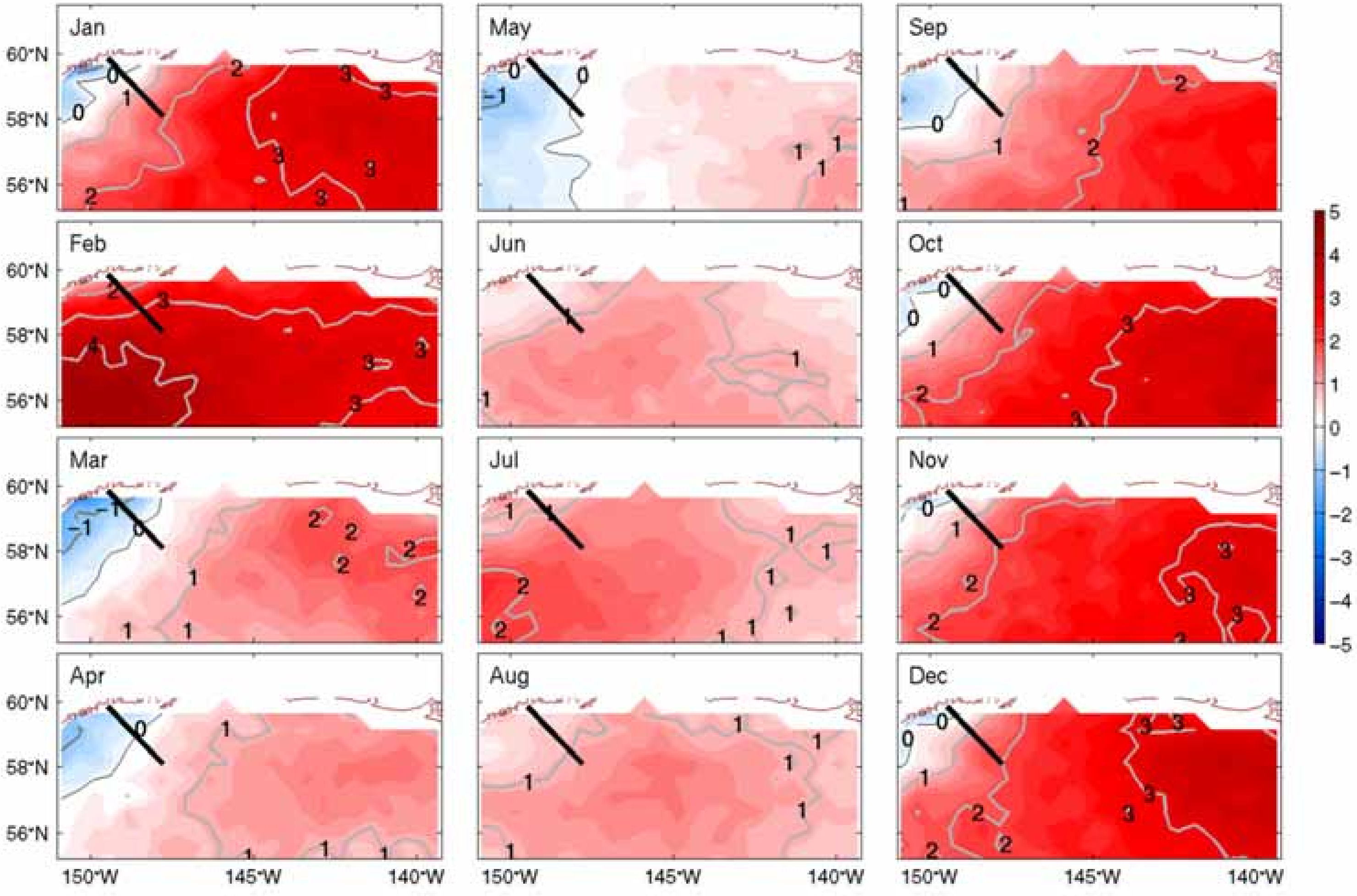
Regional Winds: u component

Red = eastward
Blue = westward



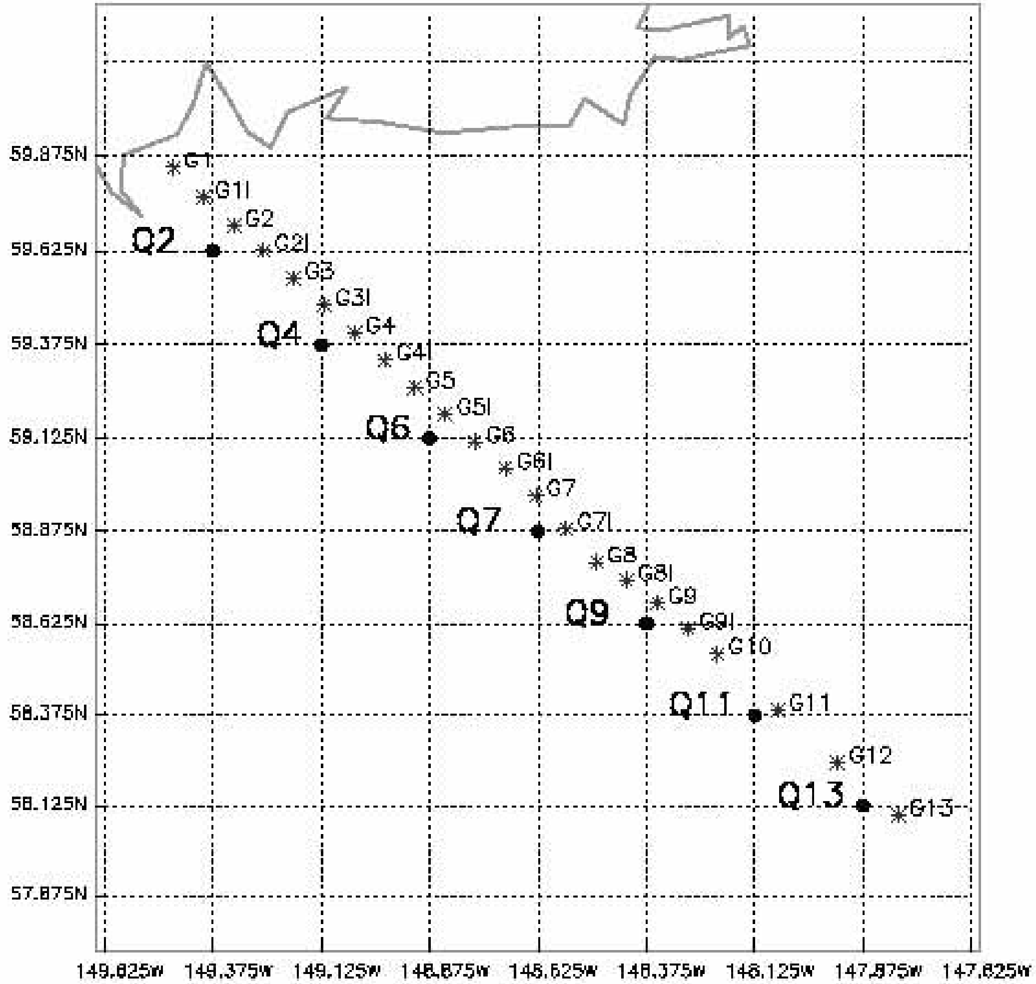
Regional Winds: v component

Red = northward
Blue = southward



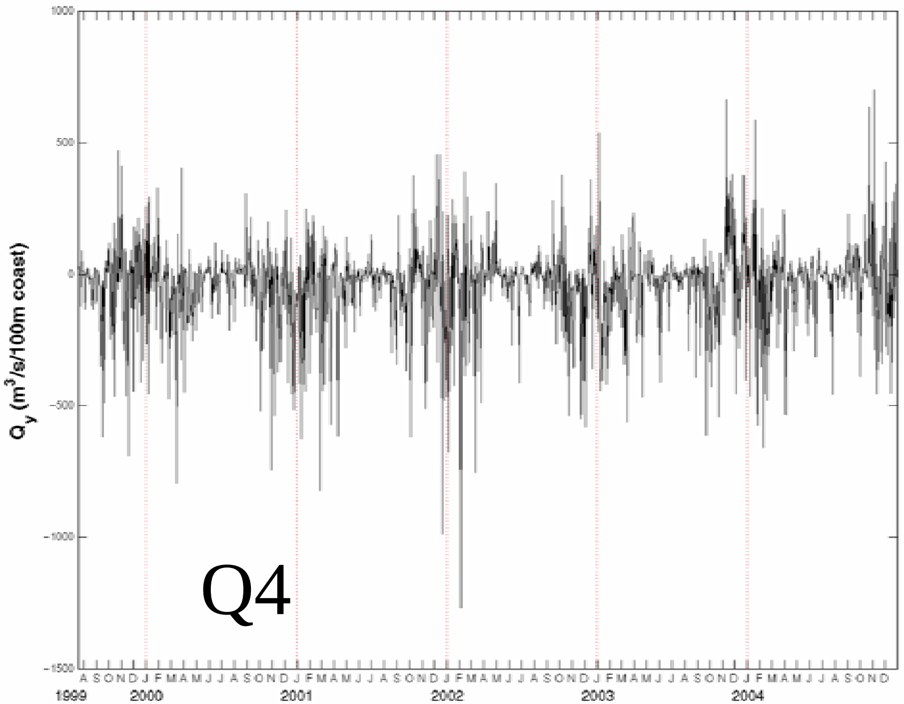
QuikSCAT Gridded Data

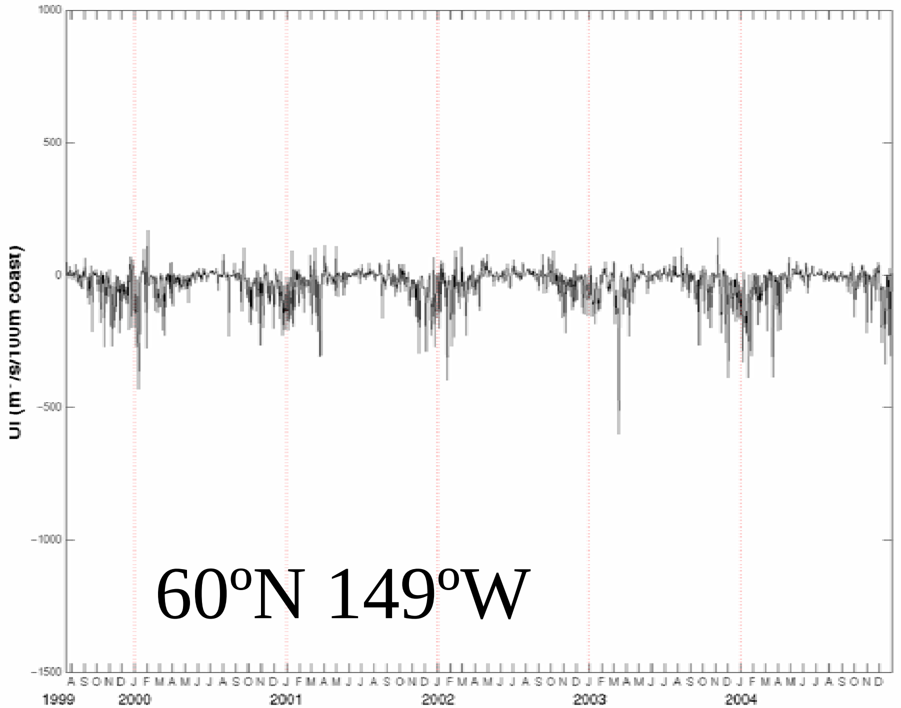
- 0.25 X 0.25 degree grid
- 7 QuikSCAT locations along the Seward Line



Ekman Transport

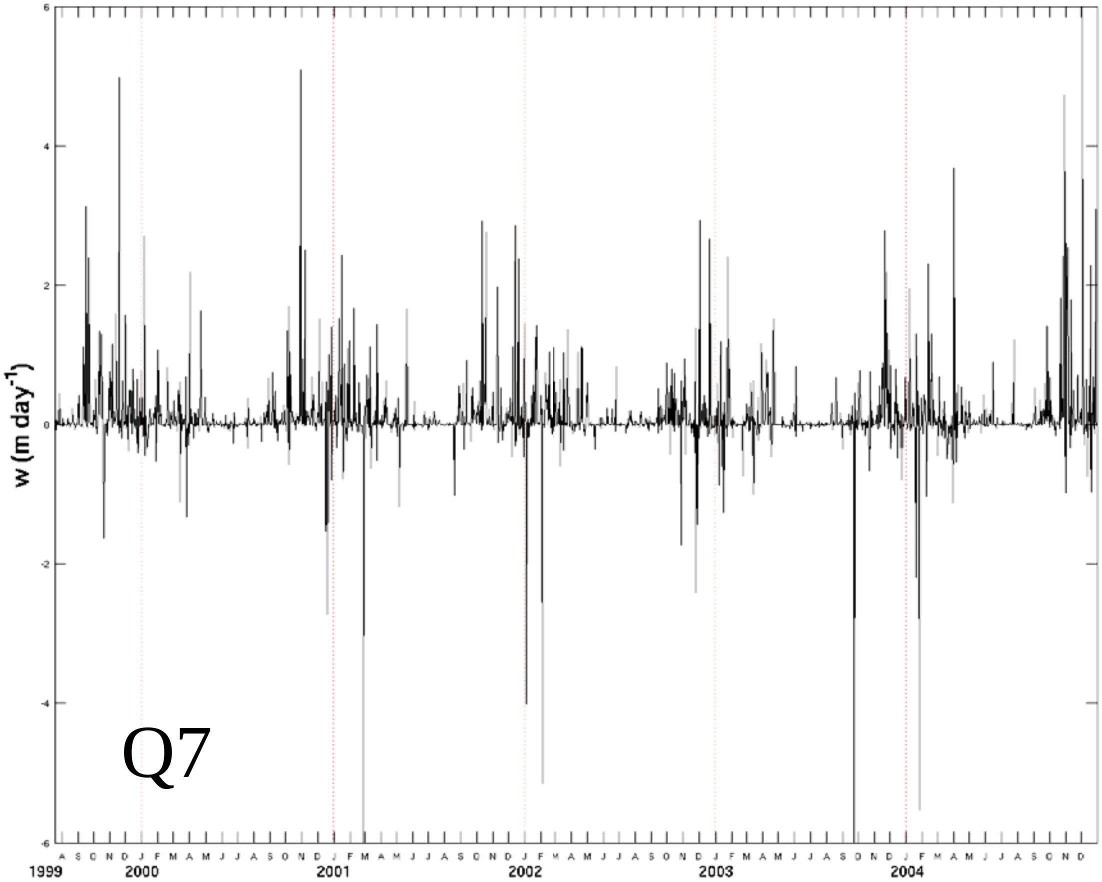
- Ekman transport was calculated for the 7 QuikSCAT locations
- Converted to UI units
- Positive values = upwelling
- Negative values = downwelling





w produced by Ekman Pumping

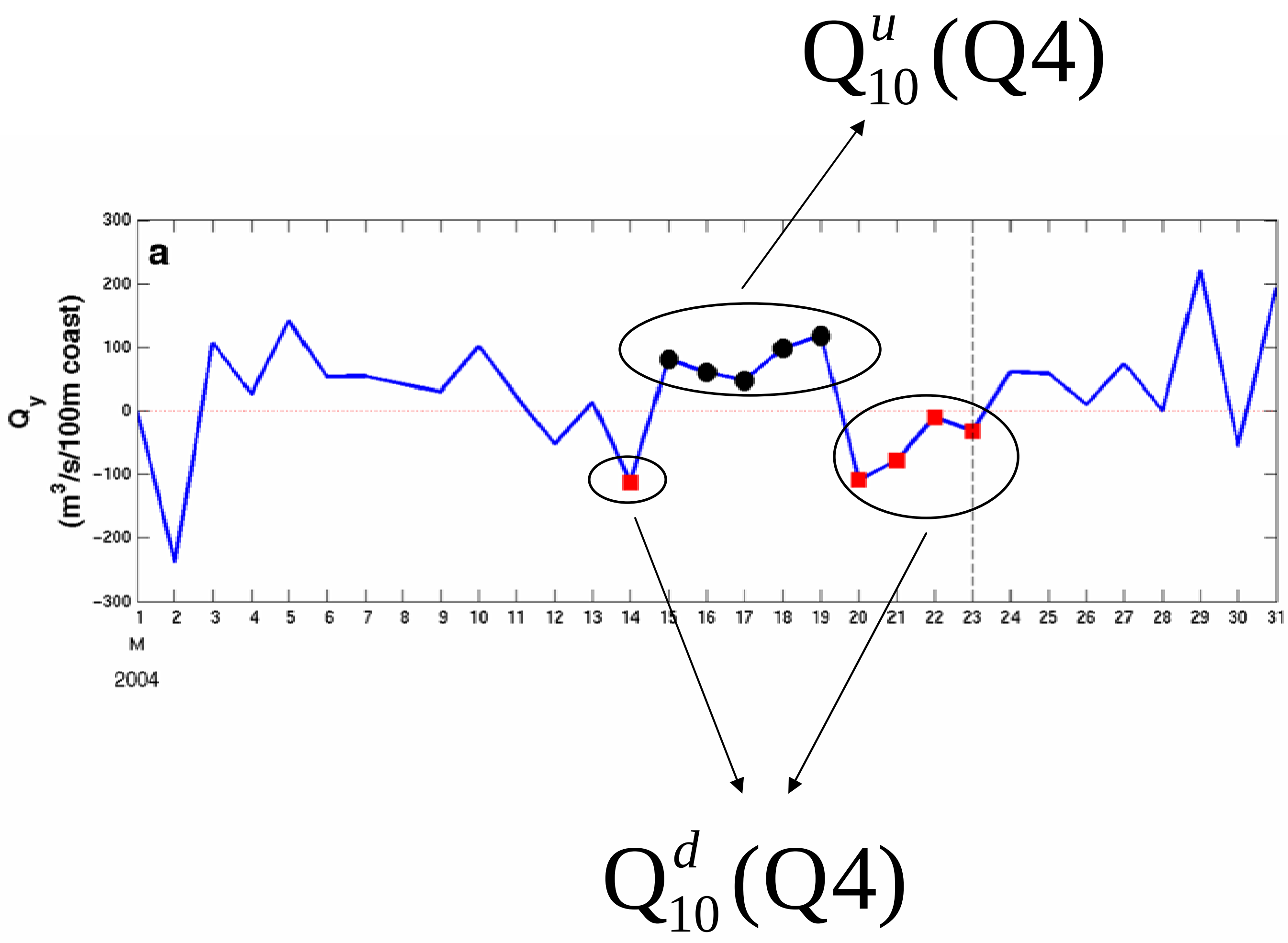
- Ekman pumping calculated for the 7 QuikSCAT locations
- Curl of wind stress calculated using center differencing
- Units m/day



Construction of wind time series for correlations with hydrographic data

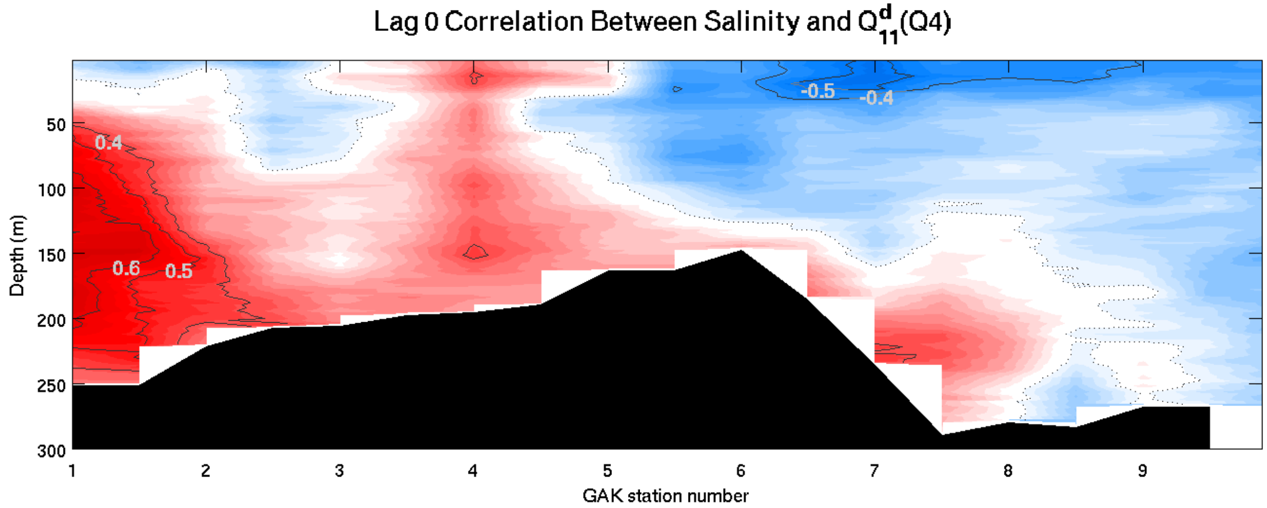
- Construct time series with 34 dates, the number of cruise from Aug 1999 – Dec 2004
- Consider upwelling and downwelling separately
- Variable time integration

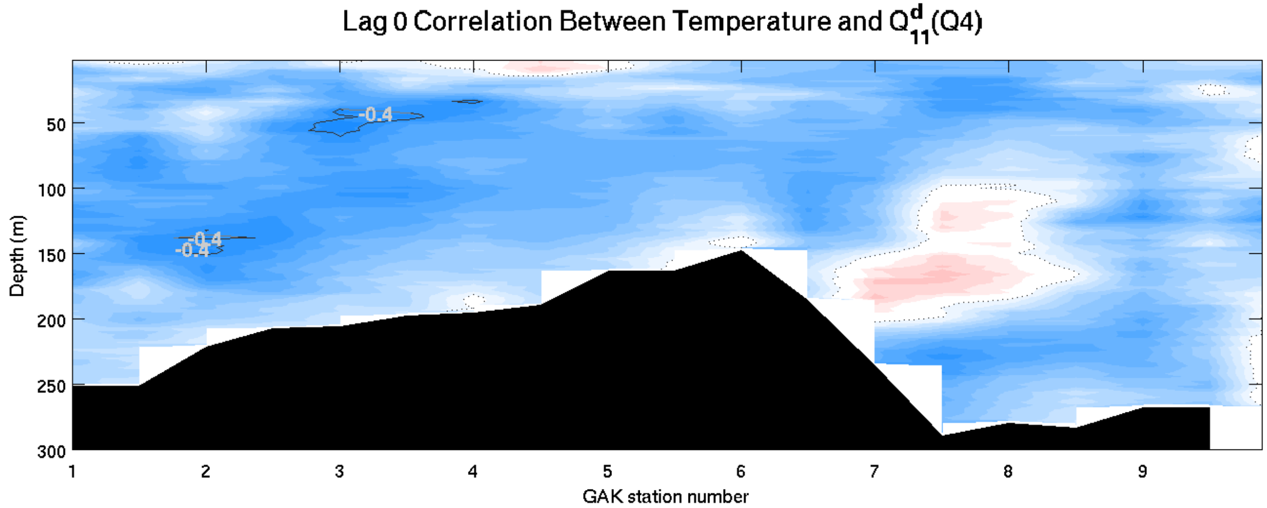
Example:
time series integration



Correlation of Ekman transport with hydrographic anomalies

$$Q_{11}^{d}(Q4)$$

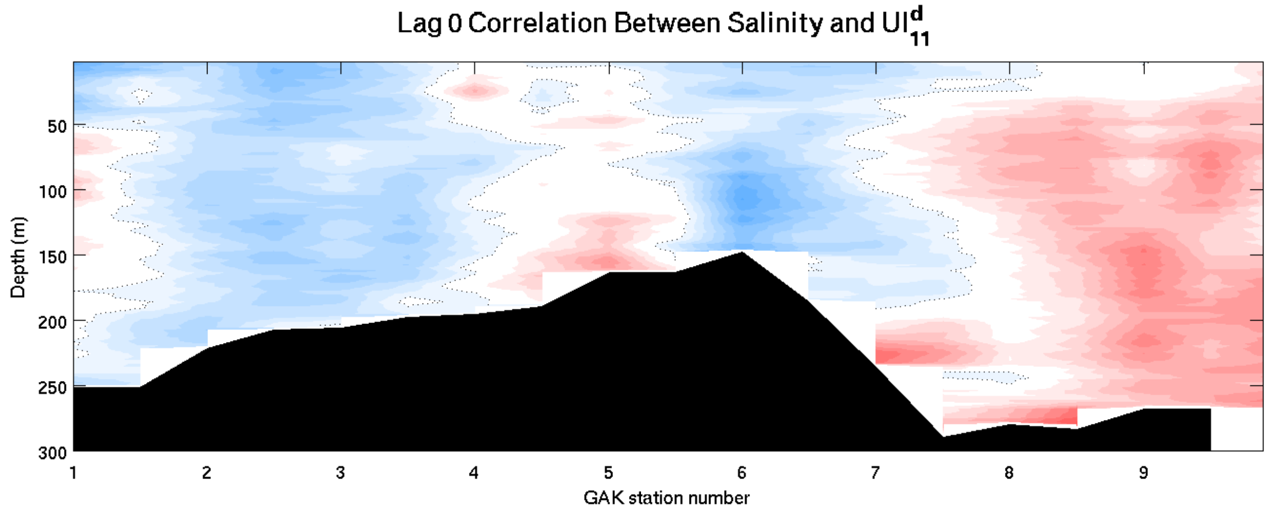


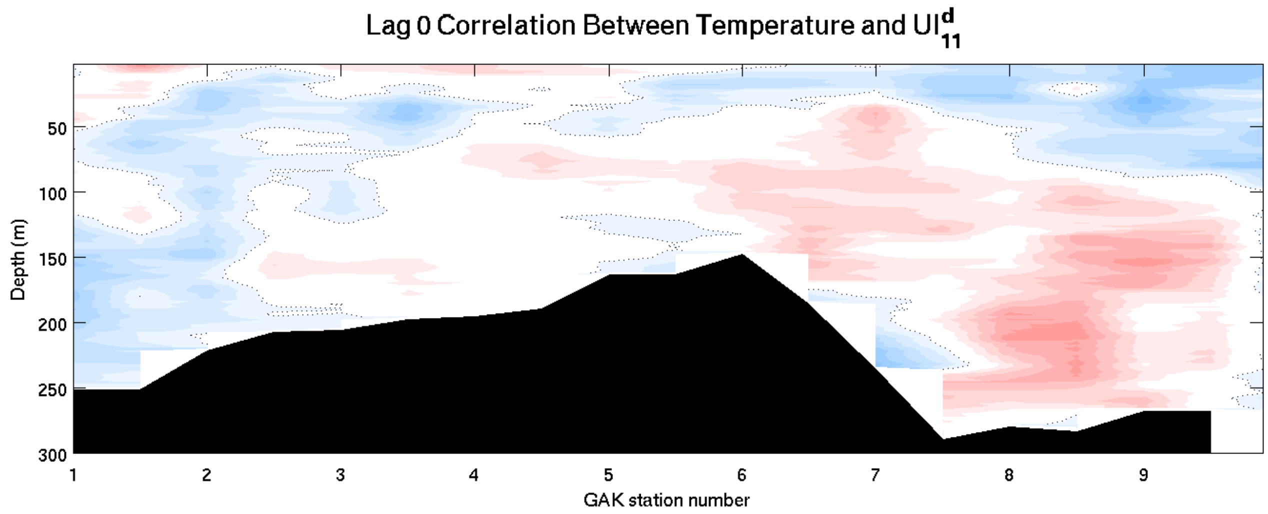


Correlation of UI with hydrographic anomalies

UI_{11}^{d}

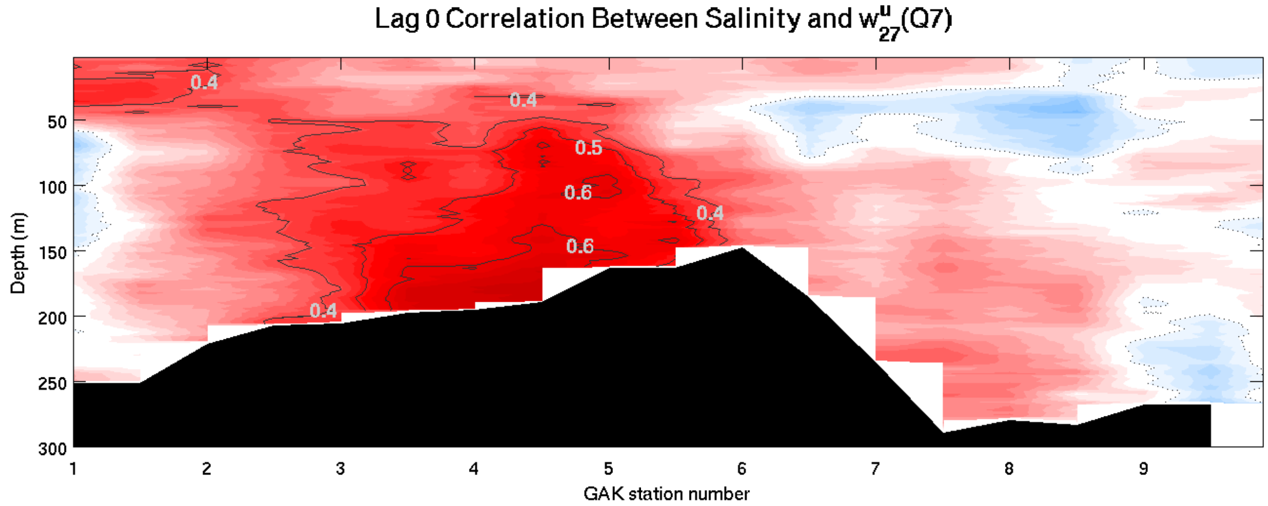
No significant correlations at lag 0

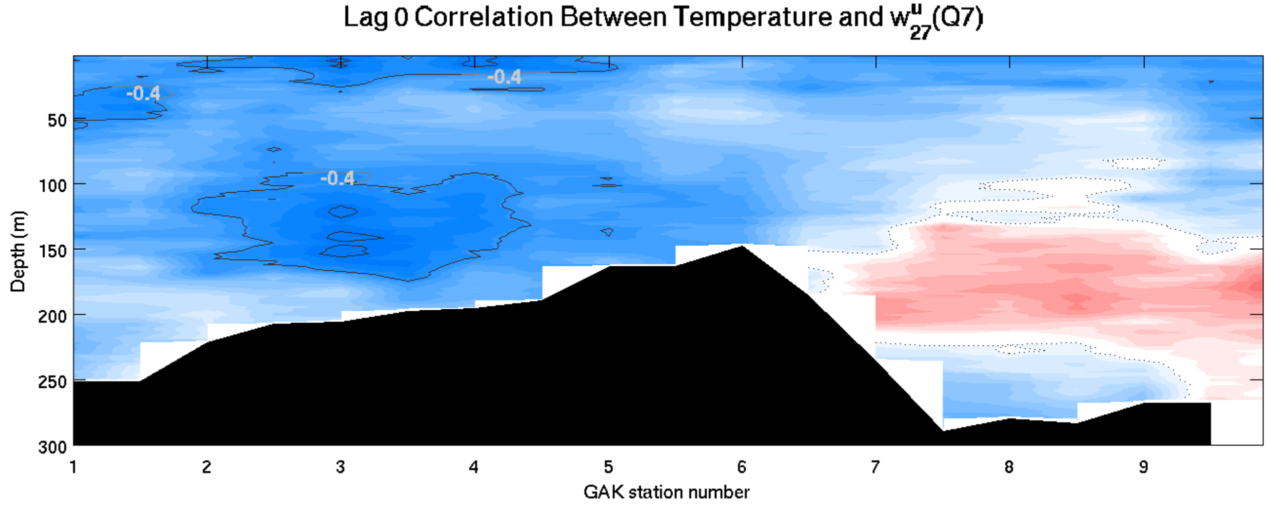




Correlation of w with hydrographic data

$$w_{27}^{u}(Q7)$$





Conclusions

- Ekman transport: 11 days, GAK1 – GAK2
- Ekman pumping: 27 days, GAK3 – GAK5
- UI no significant correlations at lag 0, but significant correlations at lag -1
- Bottom onshore flow could be brought to the surface by w