Modeled Lagrangian Drifters in the Gulf of Alaska

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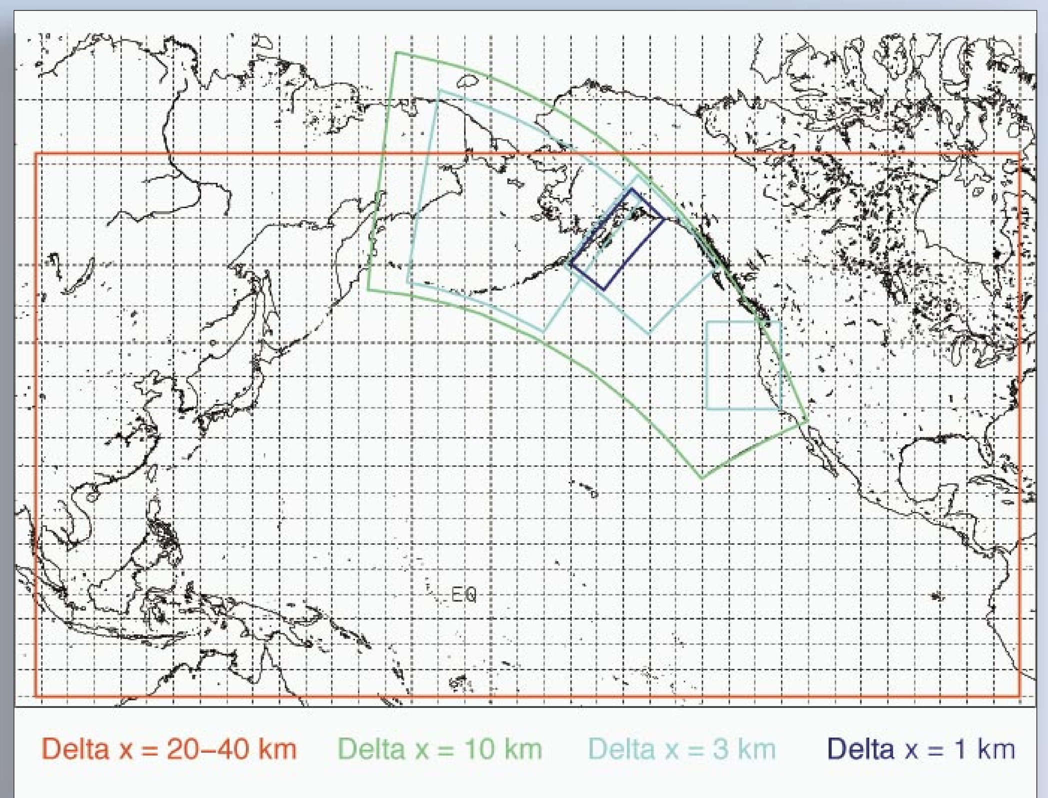

Figure 1. Nested grids. The large red North Pacific and the green Northeast Pacific (NEP) are being run by Al Hermann and Liz Dobbins at PMEL. The light blue boxes are nested within NEP and are: a California Current System (CCS) being run by Enrique Curchitser, the Gulf of Alaska being run by Kate Hedstrom, and a proposed project in the Bering Sea.

Introduction

The model used here is ROMS, the Regional Ocean Modeling System. It was run at a resolution of three kilometers, aligned with Al Hermann's NEP domain (figure 1). The COADS monthly mean fields were used for the surface forcing and NEP monthly fields were used for the open boundary conditions. The tidal forcing came from Mike Foreman while the fresh water inputs were a line source with monthly values from Tom Royer. The model was run for three (idealized) years.

One of the options in ROMS is to deploy numerical floats, or Lagrangian particles. We have chosen to deploy them in groups of forty. Each group is in a line with 20 at five meters depth and 20 at fifty meters depth. The locations are shown in figure 2: two groups off Sitka Island in SE Alaska, a double group off Cape Suckling, four groups in Prince William Sound, one by Montague Strait, one at the entrance to Cook Inlet and one within Cook Inlet.

These floats were released four times a year and were followed for approximately ninety days each time. We will focus on the second year of the floats, which starts on day 400 of the model run, giving a float release during the middle of each season. The floats will be grouped into four regions and each group will be discussed in turn. The floats are all plotted with their depth colored according to the colorbar in figure 3. Floats that go below 200 meters are drawn with the darkest blue.

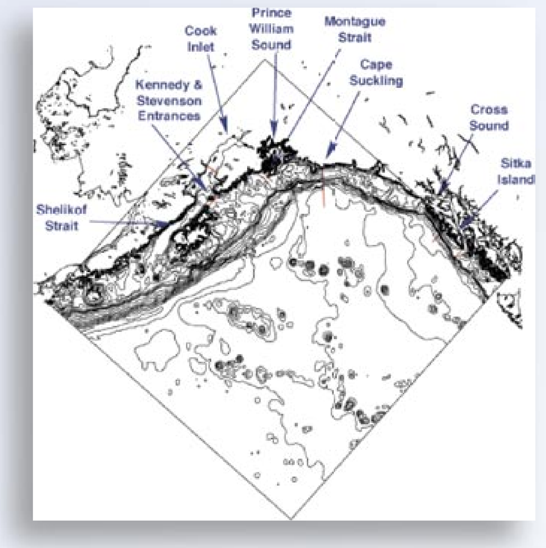

Figure 2. Map of the Gulf of Alaska showing the float release lines in red.

Figure 3. The colorbar used to indicate the depth on all the float plots.

Cook Inlet

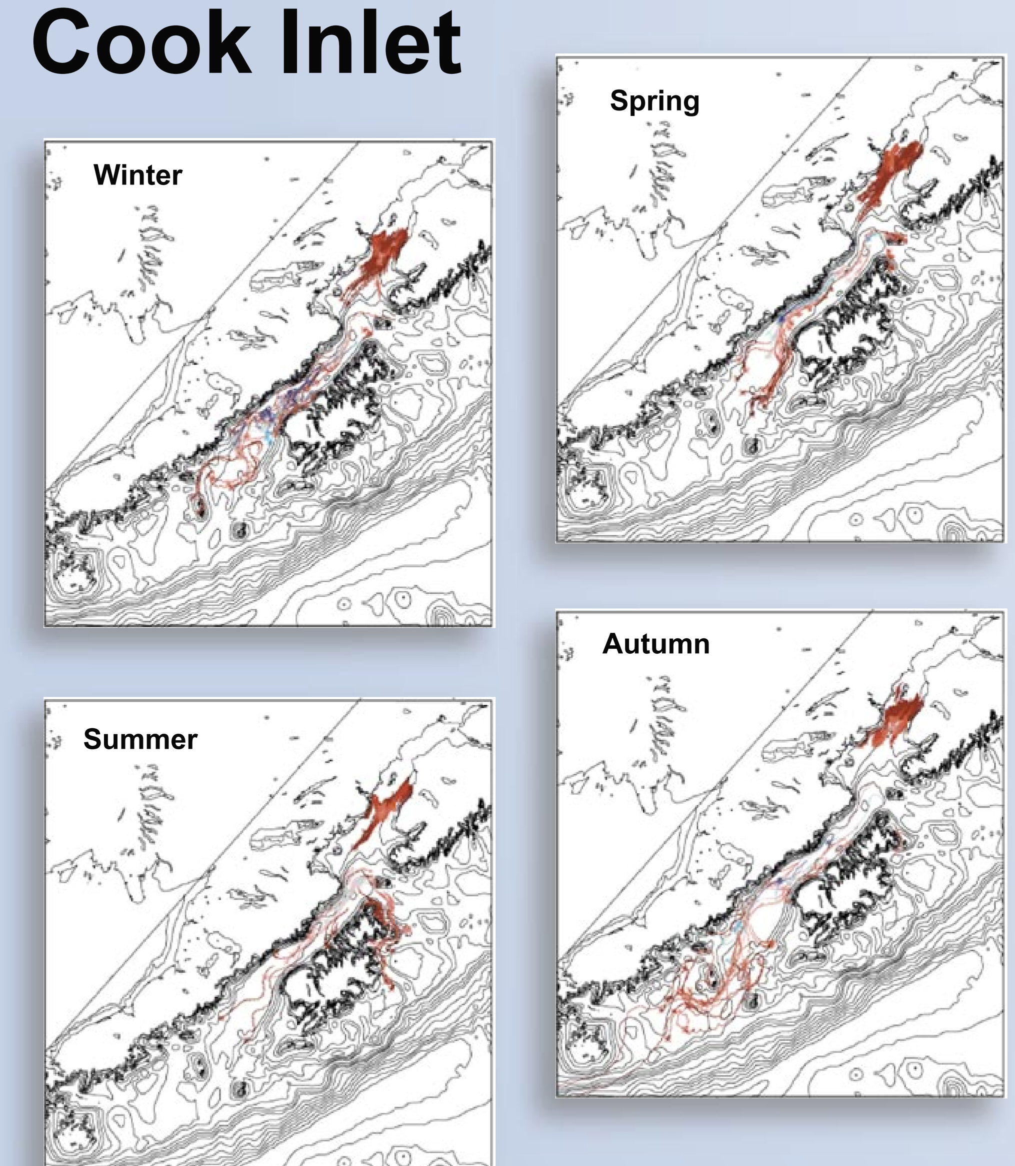

Figure 7. The Cook Inlet and entrances floats, showing days 10 to 20 for each season.

The floats shown in figure 7 were released within Cook Inlet and across Kennedy and Stevenson Entrances. Days 10 to 20 are shown for each season.

The flow within Cook Inlet is quite weak, except for a strong tidal movement up and down the inlet. The residual flow is primarily to the north on the eastern side and to the south on the western side.

The southern side of Stevenson Entrance can act as an exit, most notably in the summer.

There are some strong down-welling events within Shelikof Strait; we capture them better with the Kennedy Entrance floats than the Montague Strait floats (figure 6), which whipped through in the ACC.

The ACC is quite unsteady in the broad plain between Kodiak Island and the Shumagin Islands. It doesn't become organized again until it gets to the eastern side of the Shumagin Islands where it has to go south to get around them. Figure 8 shows a closer view of the autumn floats 10 and 20 days after their position shown in figure 7.

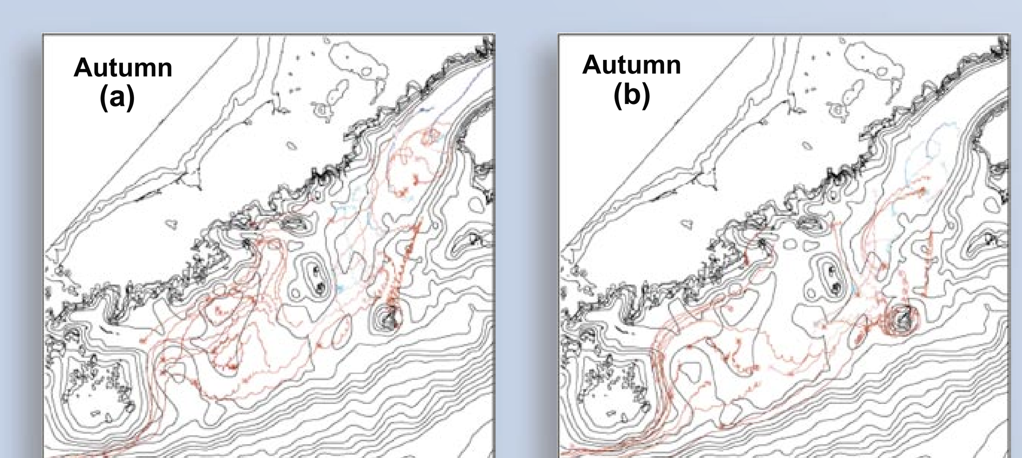

Figure 8. The Cook Inlet and entrances autumn floats, showing (a) days 20 to 30 and (b) days 30 to 40

Prince William Sound

Figure 9 shows the first eight days of the Prince William Sound floats.

There is the most visible shear between the 5 meter and 50 meter floats in the sound. Elsewhere, the floats have to go deeper to be going in different directions from the surface current.

The flow in the eastern basin is often (but not always) clockwise.

The flow in the western basin has some smaller circular motions, but also a flow to the south through Knight Island Passage and Montague Strait.

The flow through Hinchinbrook Entrance is variable and contains vertical shear. Some of the floats exit through the entrance in the spring and summer, while others enter from other regions. At 3 km resolution we have three points across the entrance, which is less than adequate. The 1 km grid should do better in the sound, but will not resolve all of the narrow passages.

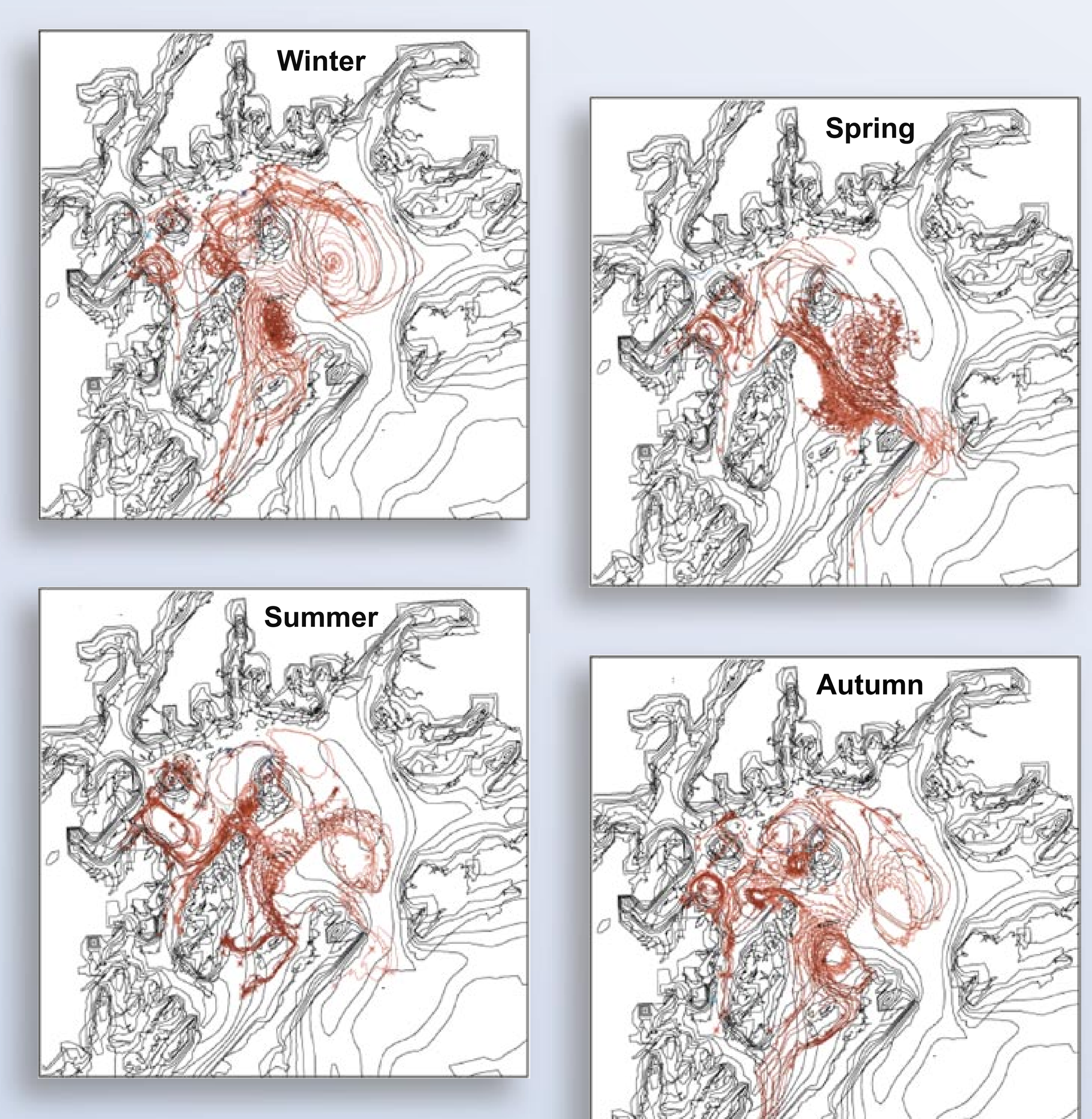

Figure 9. The Prince William Sound floats, showing the first eight days for each season.

Cape Suckling and Montague Strait

The floats released off Cape Suckling and just outside Montague Strait are shown in figure 6. Days 15 to 25 are shown for each season.

The corkscrew-look to some trajectories is due to the semidiurnal tide.

In all seasons there is both an Alaska Coastal Current (ACC) hugging the coast and an Alaska Stream (AS), out at the shelf-break. The strength of both currents varies seasonally, with the ACC being strongest in the fall and the AS being weakest in the fall.

The region between the ACC and the AS is more chaotic and has some very slow-moving spots. There can be significant vertical velocities on the shelf.

The ACC can leave the coast at Kayak Island, at the Chiswell Islands south of Seward and in Shelikof Strait where meanders form and grow. Also, the ACC primarily goes into Cook Inlet through Kennedy Entrance, then jumps across to the western shore to head south once again.

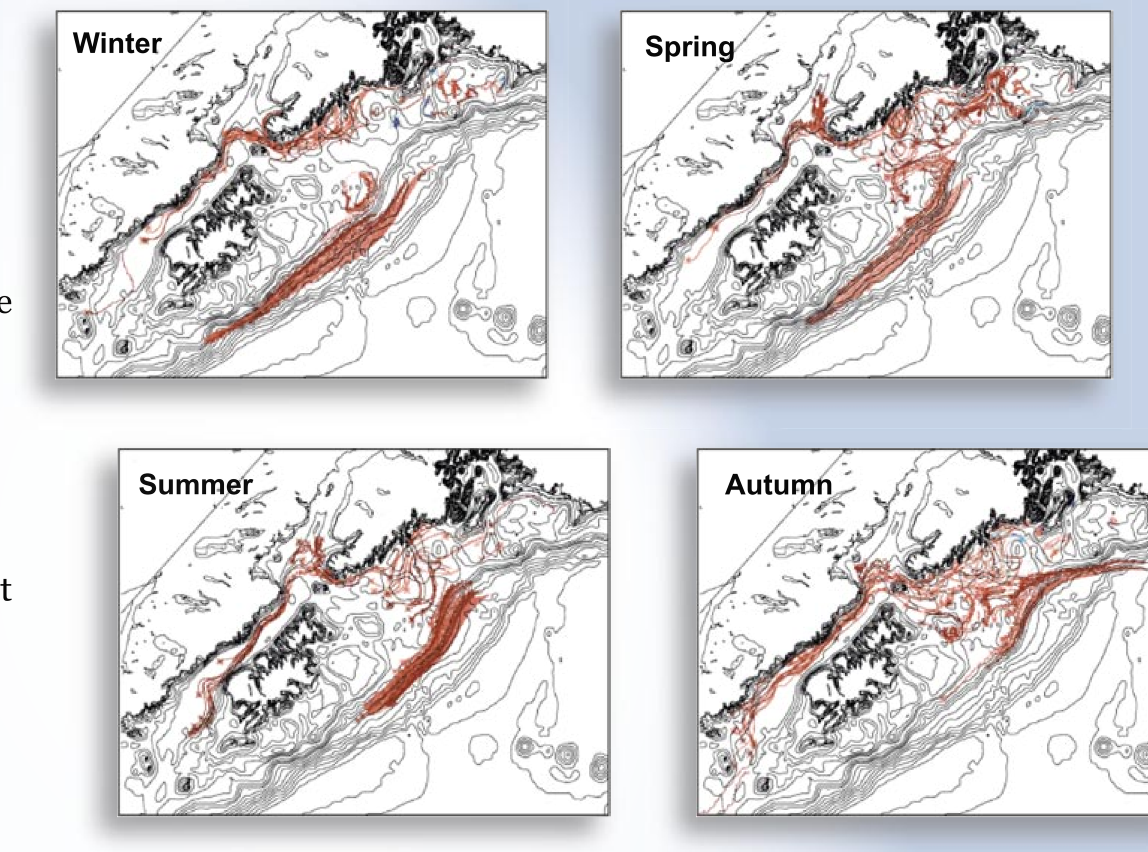

Figure 6. The Cape Suckling and Montague Strait floats, showing days 15 to 25 for each season.

Southeast

The float tracks for the southeast Alaska floats are shown in figure 4. Days 10 to 20 are shown for each season.

The Alaska Coastal Current (ACC) is strongest in the fall. The fresh water inflow is strongest in September, leading to a strengthening of the coastal buoyancy current.

The floats onshore of the shelf break-behave differently from those offshore. The offshore floats get caught up in a slow-moving eddy-field, while the onshore floats go more rapidly northwards.

The onshore floats primarily follow the coast south of Cross Sound, but have more variability to the north where the shelf is wider.

The shelf eddies are smaller than those offshore, being trapped between the coast and the shelf break. Figure 5 shows the winter floats 20 days after figure 4. It shows that the floats caught in the offshore meander have been re-entrained into the ACC. Also, at least 10 of the floats have been down-welled to deeper than 100 meters depth. These vertical motions occur at several locations on the shelf.

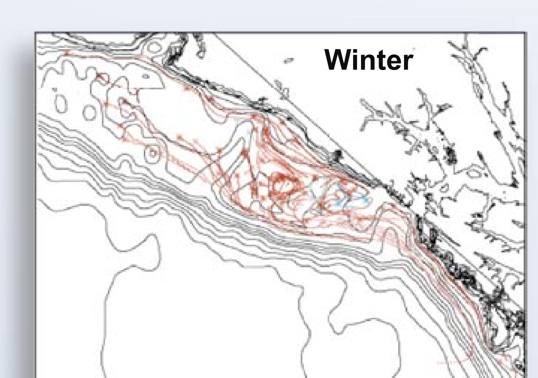

Figure 5. Closer view of the Southeast Alaska winter floats, showing days 30 to 40.

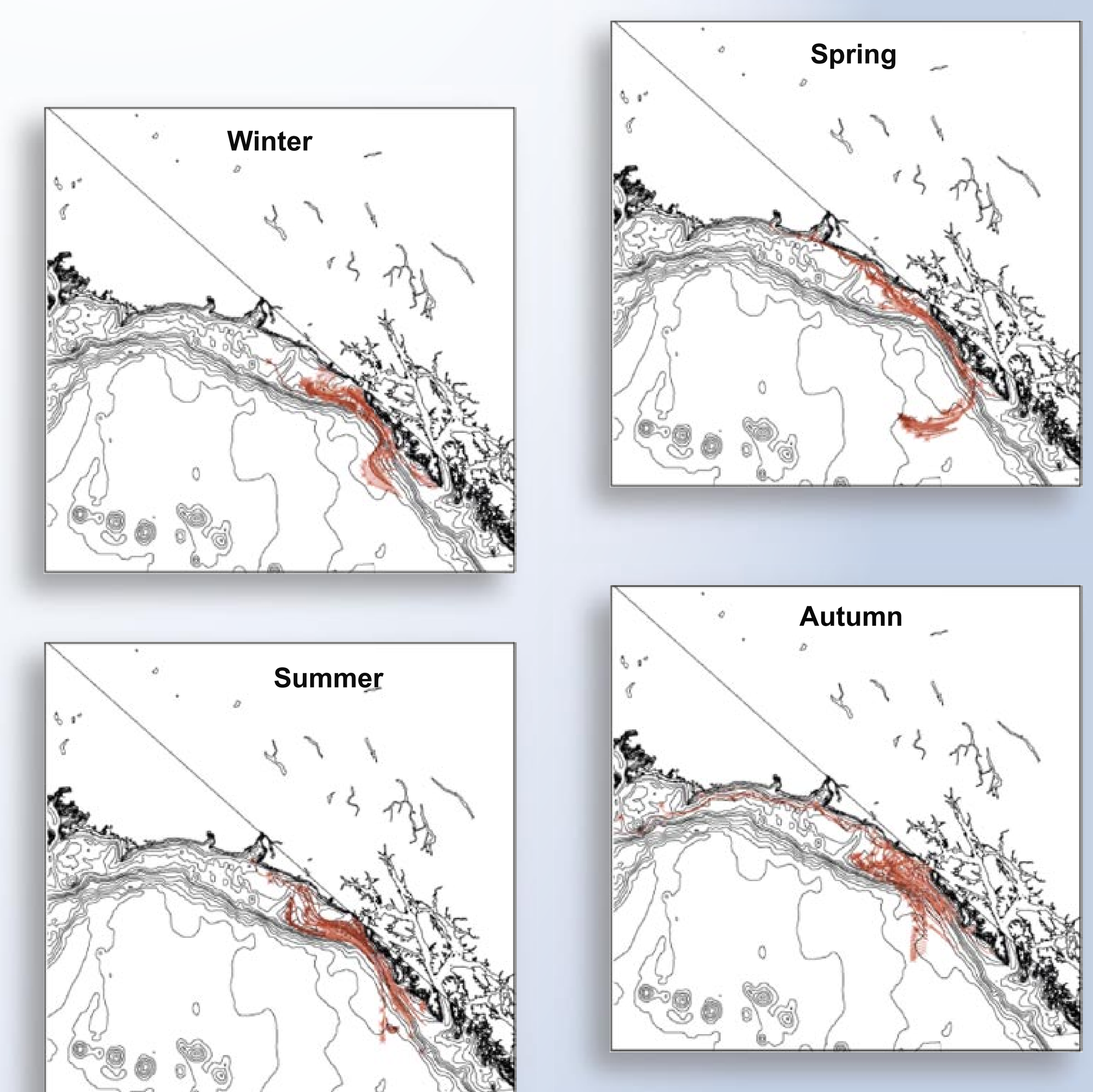

Figure 4. The Southeast Alaska floats, showing days 10 to 20 for each season. For all the float figures, the latest float position is shown by a star. Also shown are some representative isobaths.

Conclusions

The floats are an interesting way to see what the model is doing, although some of the conclusions could also be reached by looking at the Eulerian fields.

The flows described are for an idealized year with smooth forcing.

We look forward to seeing how this will change with forcing fields that include storms and other interannual variability.

See talks and posters by Hermann and Musgrave for comparisons between the model and data.

To do list

- use NCEP daily winds on all nested models.
- improve the fresh water fluxes (river inflow) and the bathymetry.
- run for specific years, including 2000 and 2001.
- run with a coupled ecosystem model.
- add the one kilometer resolution domain (dark blue in figure 1)
- add the Bering Sea domain with sea ice.
- 3-D visualization in a Cave environment.

Acknowledgments

The model was run on the IBM SP at the Arctic Region Supercomputing Center. The version of the model used was developed at NOAA's Forecast Systems Laboratory and uses their SMS library.

Arctic Region Supercomputing Center