Evaluation of Field-Collected Drifter and In Situ Fluorescence Data Measuring Subsurface Dye Plume Advection/Dispersion and Comparisons to High-Frequency Radar-Observation System Data for Dispersed Oil Transport Modeling

APPENDIX C – HIGH FREQUENCY RADAR DATA

A Final Report Submitted to

The Coastal Response Research Center

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Appendix C. High-Frequency-Radar Data

Appendix C contains summaries of the high-frequency-radar (HF-Radar, i.e., CODAR) data, plotted as trajectories using the HF-Radar data as vectors with no additional wind drift included and no horizontal dispersion. The trajectories were initialized at the center of the dye patch at the time and location where the first drifter was deployed. Figures of the mean current as vector maps at hourly intervals during each experiment are available on the CORDC FTP site (ftp://ftp.mpl.ucsd.edu/pub/CORDC/outgoing/OSPR/). For each experiment, comparisons of mean bearings (direction) and magnitudes of the HF-Radar and the shallowest drifter velocities are presented along with HF-Radar velocities projected to the shallowest drifter depth using wind drift.

C.1 Results for the November 8, 2005 Experiment

The 8 November 2005 experiment began at 10:26 PST (18:26 UTC) and ended approximately 16:15 PST (00:15 UTC on 9 November). Figure C.1-1 shows the trajectory of a neutrally-buoyant constituent using the HF-Radar data with no additional wind drift included and low horizontal dispersion (0.01 m^2/s). The trajectory was initialized at the center of the dye patch at the time and location where the first drifter was deployed (drifter #16767590 at 10:33 PST). All drifters were deployed with drogues at 1 m in this experiment. Figure C.1-2 shows a direct comparison between drifter and HF-Radar bearings (direction toward) and magnitudes.

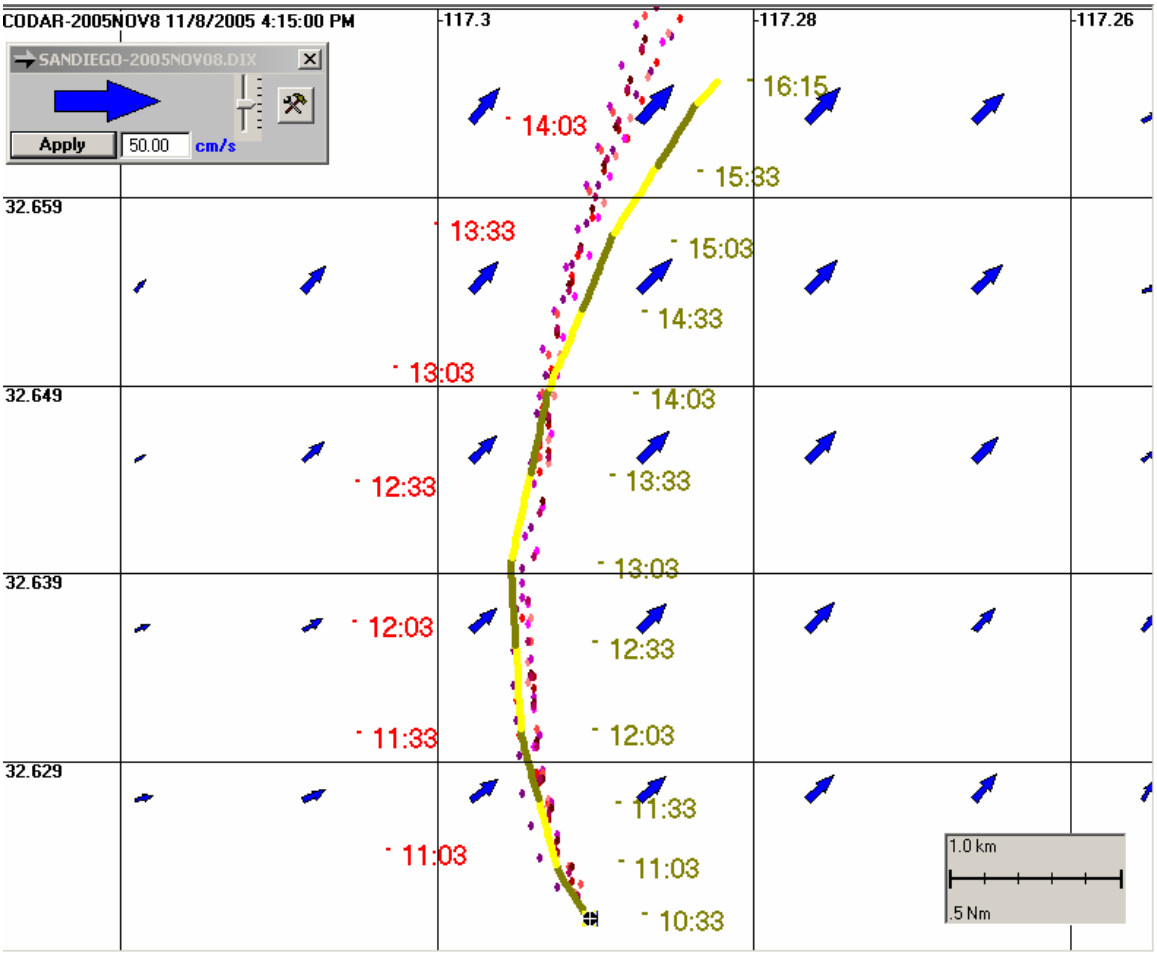

Figure C.1-1 Trajectory of a neutrally-buoyant constituent using the HF-Radar vectors up to 16:15 PST (grey line with times in black font) compared to drifter movement (red diamonds with times in red font) for the 8 November 2005 experiment. The arrow indicates the HF-Radar speed at the end time of the trajectory simulation.

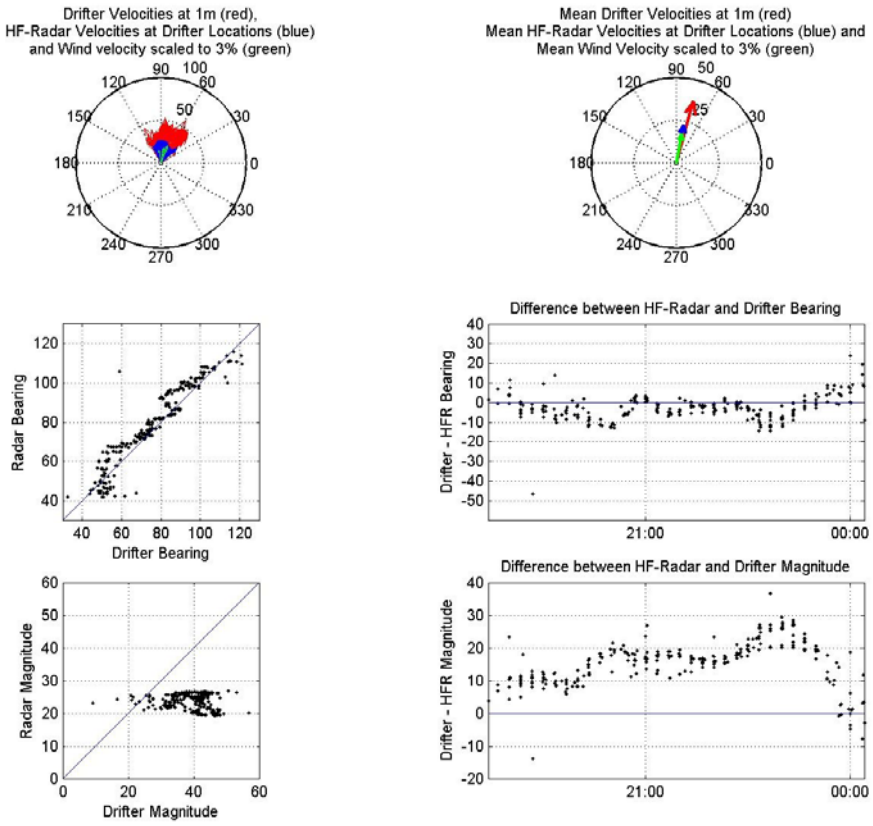

Figure C.1-2 Comparison between wind (scaled to 3%), drifter (drogued at 1 m) and HF-Radar bearings (direction toward) and magnitudes for the 8 November 2005 experiment.

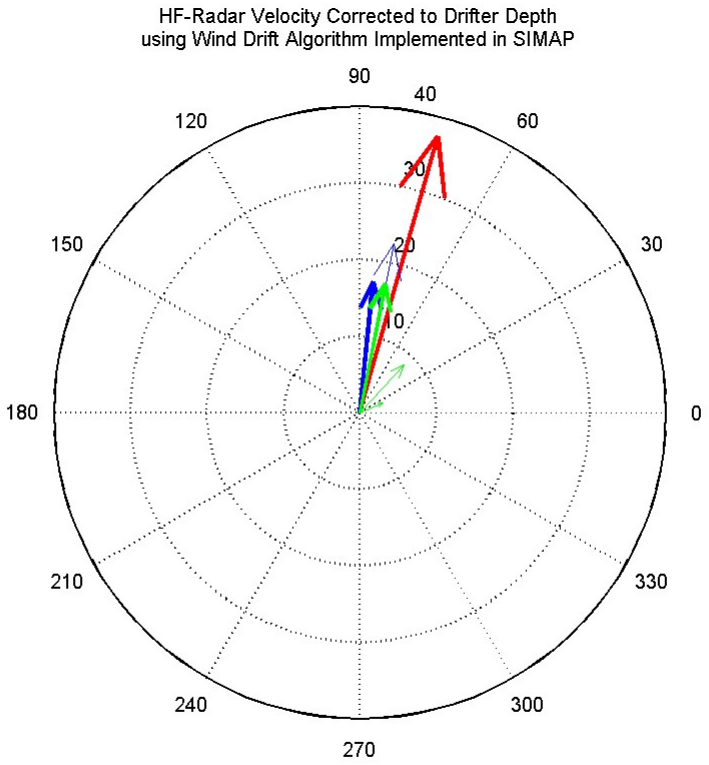

Figure C.1-3 Comparison between wind (scaled to 3%, bold green), mean wind drift (green) averaged over the upper 0.5m and at 1m corresponding to the HF-Radar integrated velocity measurement depth and drifter drogue depth, mean observed drifter velocity (1m, bold red), mean observed HF-Radar velocity (blue) and mean HF-Radar velocity projected to the drifter depth using wind drift (bold blue) for the 8 November 2005 experiment.

C.2 Results for the March 21, 2006 Experiment

The 21 March 2006 experiment began at 11:43 PST (19:43 UTC) and ended approximately 13:50 PST (22:50 UTC). Figure C.2-1 shows the trajectory of a neutrally-buoyant constituent using the HF-Radar data with no additional wind drift included and low horizontal dispersion (0.01 m^2/s). The trajectory was initialized at the center of the dye patch at the time and location where the first drifter was deployed (drifter #15723677 at 11:49 PST). All drifters were deployed with drogues at 1 m in this experiment. Figure C.2-2 shows a direct comparison between drifter and HF-Radar bearings (direction toward) and magnitudes.

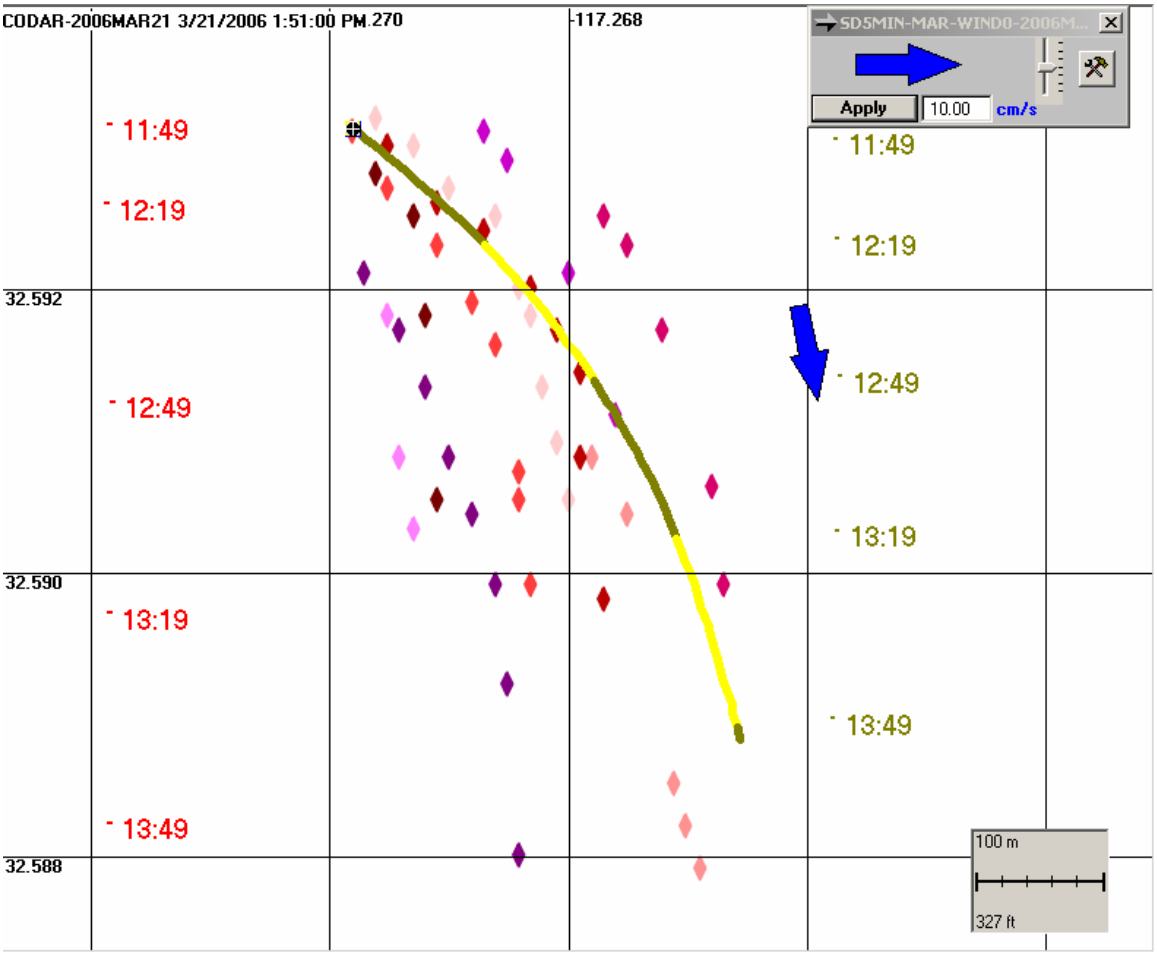

Figure C.2-1 Trajectory of a neutrally-buoyant constituent using the HF-Radar vectors up to 13:51 PST (grey line with times in black font) compared to drifter movement (red diamonds with times in red font) for the 21 March 2006 experiment. The arrow indicates the HF-Radar speed at the end time of the trajectory simulation.

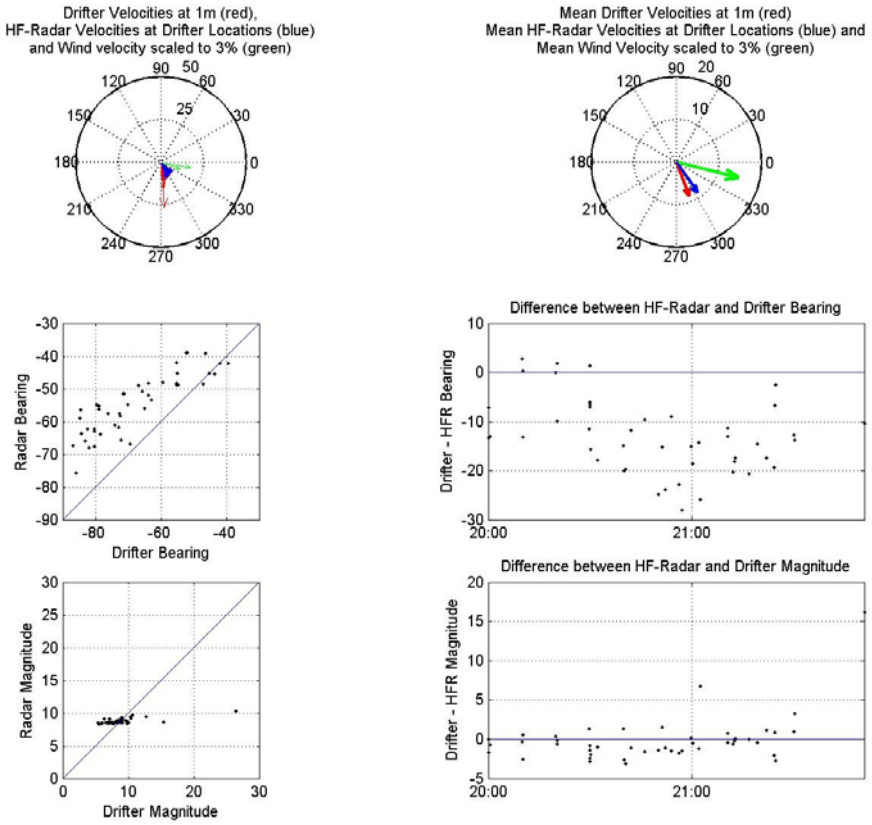

Figure C.2-2 Comparison between wind (scaled to 3%), drifter (drogued at 1 m) and HF-Radar bearings (direction toward) and magnitudes for the 21 March 2006 experiment.

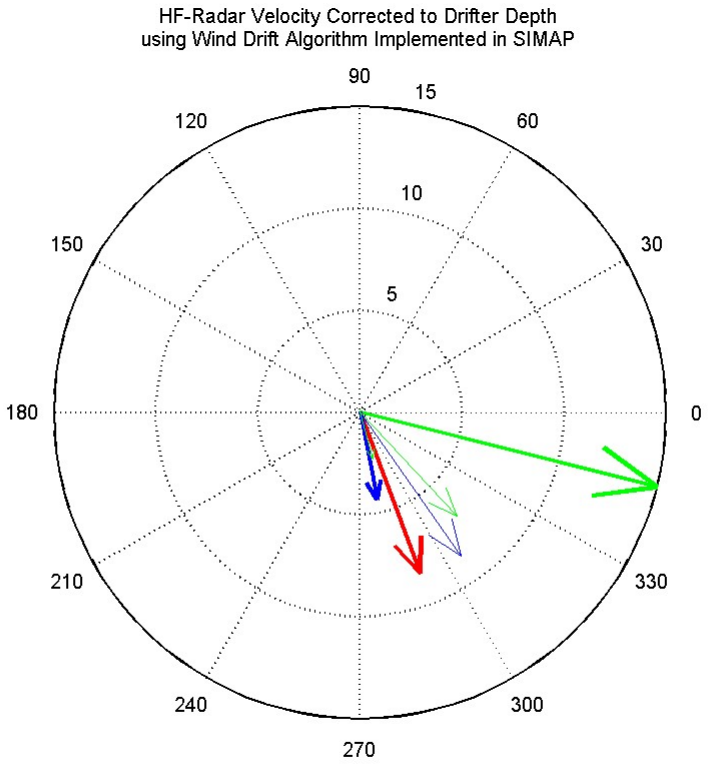

Figure C.2-3 Comparison between wind (scaled to 3%, bold green), mean wind drift (green) averaged over the upper 0.5m and at 1m corresponding to the HF-Radar integrated velocity measurement depth and drifter drogue depth, mean observed drifter velocity (1m, bold red), mean observed HF-Radar velocity (blue) and mean HF-Radar velocity projected to the drifter depth using wind drift (bold blue) for the 21 March 2006 experiment.

C.3 Results of March 22, 2006 Experiment

The 22 March 2006 experiment began at 10:00 PST (18:00 UTC) and ended approximately 14:45 PST (22:45 UTC). Figure C.3-1 shows the trajectory of a neutrally-buoyant constituent using the HF-Radar data with no additional wind drift included and low horizontal dispersion (0.01 m^2/s). Drifters were deployed with drogues at 1 m or at 5 m in this experiment. The trajectory was initialized at the center of the dye patch at the time and location where the first 5-m drifter was deployed (drifter #16766605 at 10:00 PST). Figure C.3-2 shows a direct comparison between drifter and HF-Radar bearings (direction toward) and magnitudes.

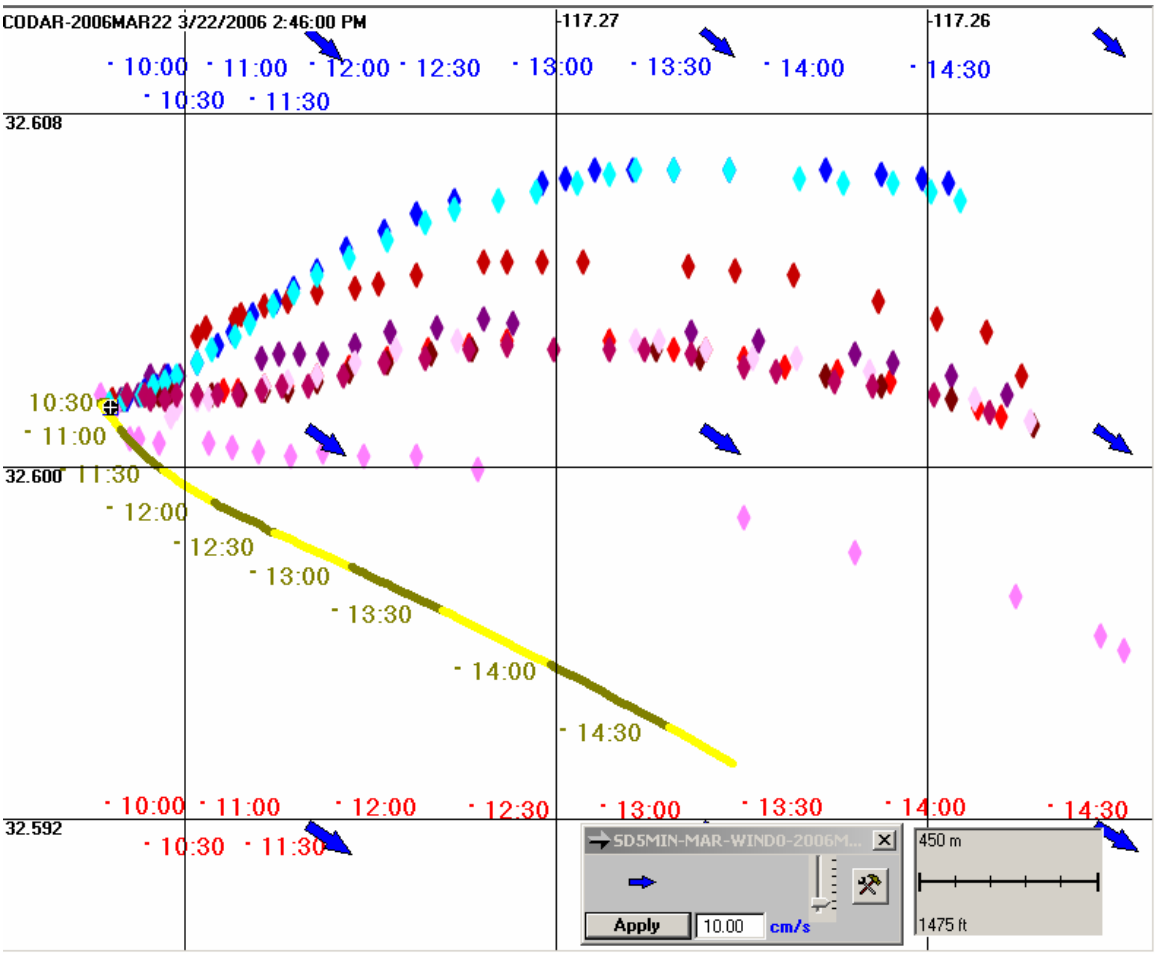

Figure C.3-1 Trajectory of a neutrally-buoyant constituent using the HF-Radar vectors up to 14:46 PST (grey line with times in black font) compared to drifter movement (at 1 m: red diamonds with times in red font; at 5 m: blue diamonds with times in blue font) for the 22 March 2006 experiment. The arrow indicates the HF-Radar speed at the end time of the trajectory simulation.

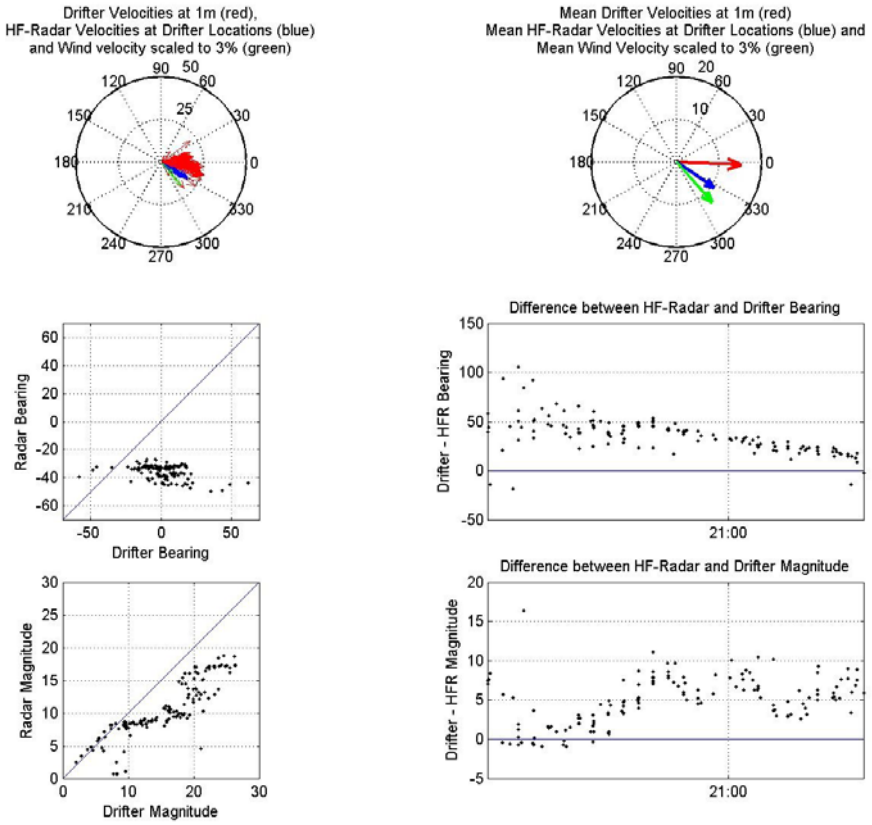

Figure C.3-2 Comparison between wind (scaled to 3%), drifter (drogued at 1 m) and HF-Radar bearings (direction toward) and magnitudes for the 22 March 2006 experiment.

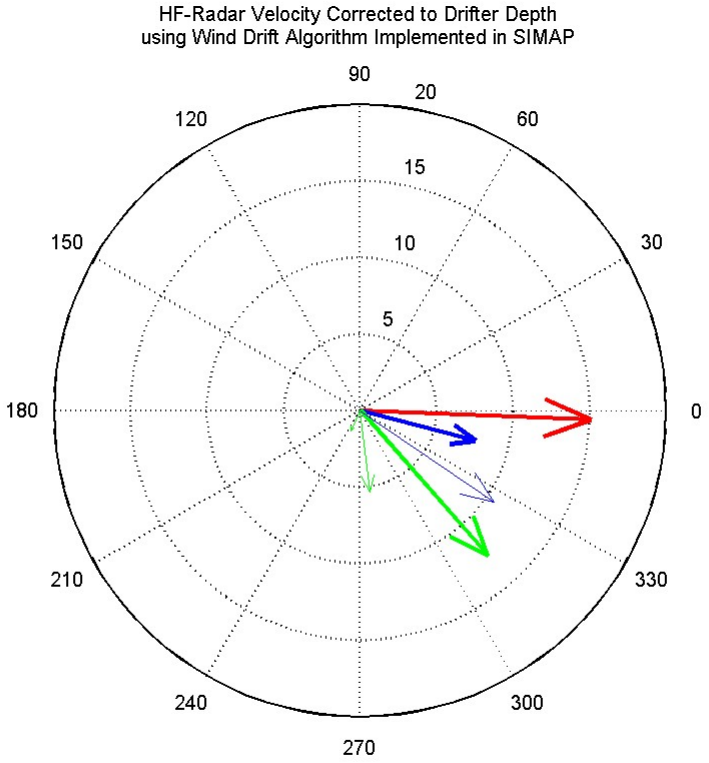

Figure C.3-3 Comparison between wind (scaled to 3%, bold green), mean wind drift (green) averaged over the upper 0.5m and at 1m corresponding to the HF-Radar integrated velocity measurement depth and drifter drogue depth, mean observed drifter velocity (1m, bold red), mean observed HF-Radar velocity (blue) and mean HF-Radar velocity projected to the drifter depth using wind drift (bold blue) for the 22 March 2006 experiment.

C.4 Results for the June 21, 2006 Experiment

The 21 June 2006 experiment began at 12:11 PDT (19:11 UTC) and ended approximately 16:00 PDT (23:00 UTC). Figure C.4-1 shows the trajectory of a neutrally-buoyant constituent using the HF-Radar data with no additional wind drift included and low horizontal dispersion (0.01 m^2/s). Drifters were deployed with drogues at 2 m or at 4 m in this experiment. The trajectory was initialized at the center of the dye patch at the time and location where the first 2-m drifter was deployed (drifter #16757863 at 12:19 PDT). Figure C.4-2 shows a direct comparison between drifter and HF-Radar bearings (direction toward) and magnitudes.

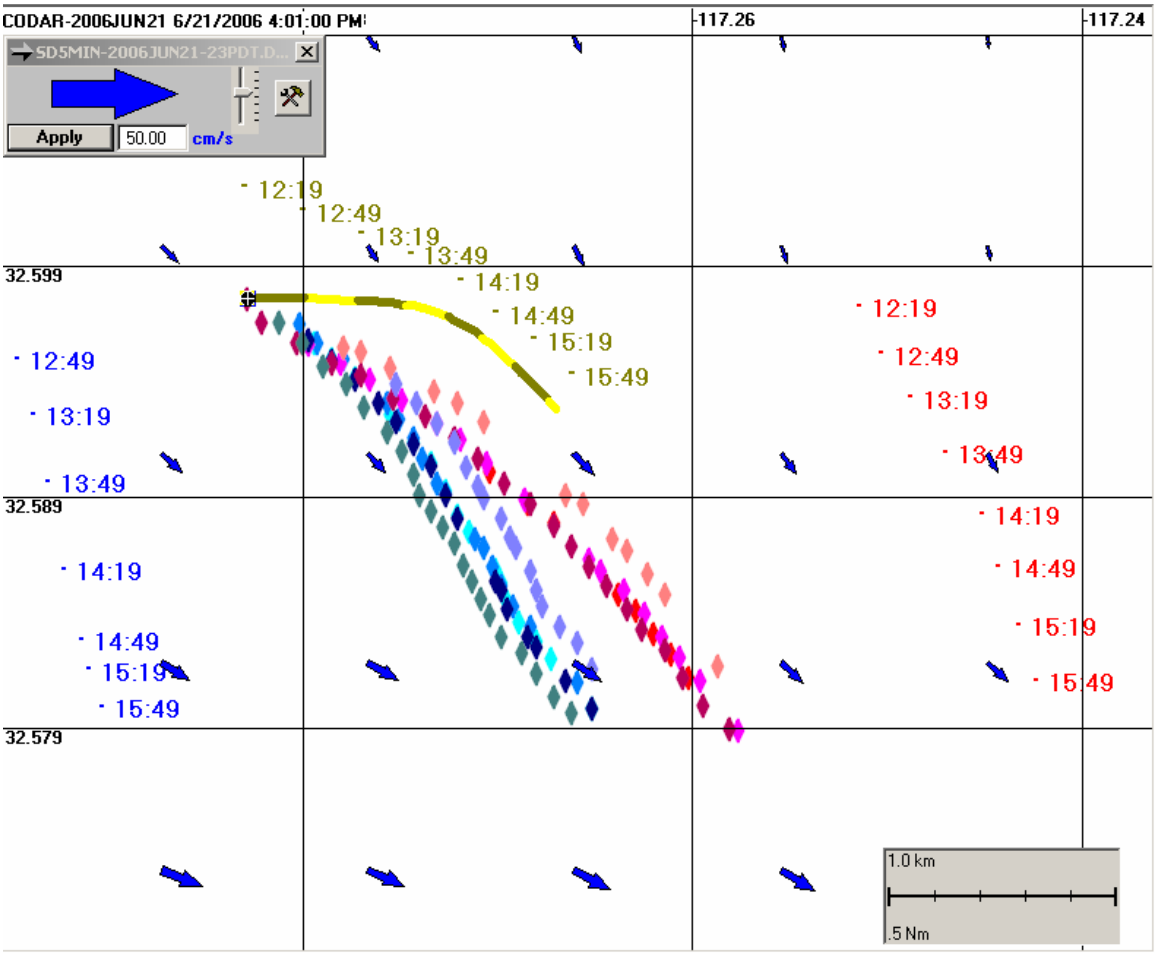

Figure C.4-1 Trajectory of a neutrally-buoyant constituent using the HF-Radar vectors up to 16:00 PDT (grey line with times in black font) compared to drifter movement (at 2 m: red diamonds with times in red font; at 4 m: blue diamonds with times in blue font) for the 21 June 2006 experiment. The arrow indicates the HF-Radar speed at the end time of the trajectory simulation.

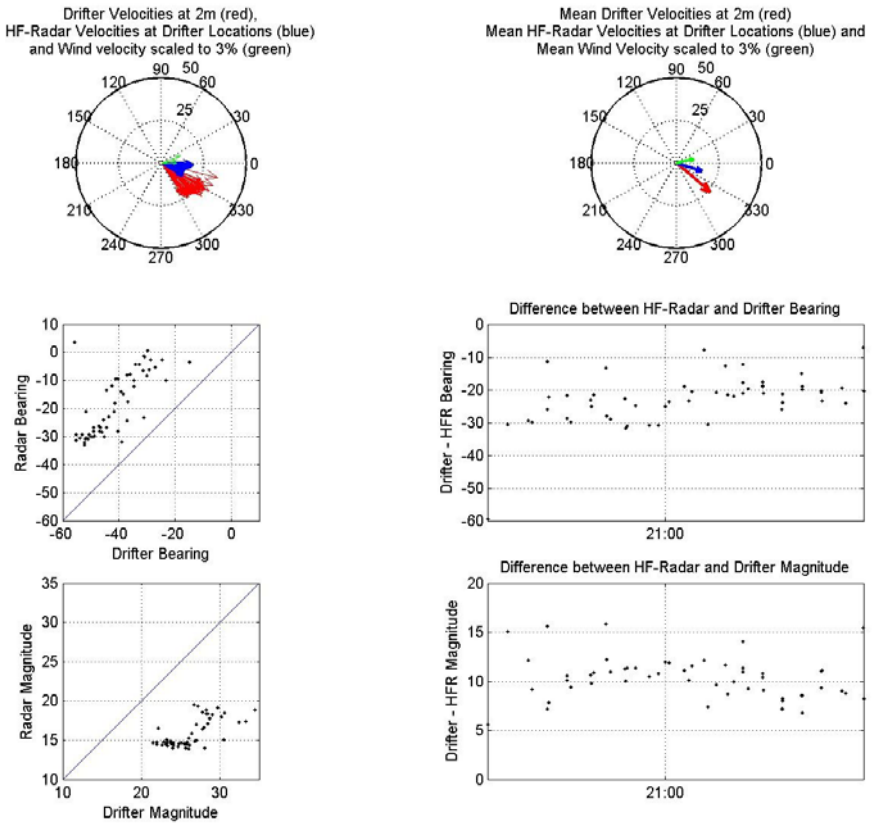

Figure C.4-2 Comparison between wind (scaled to 3%), drifter (drogued at 2 m) and HF-Radar bearings (direction toward) and magnitudes for the 21 June 2006 experiment.

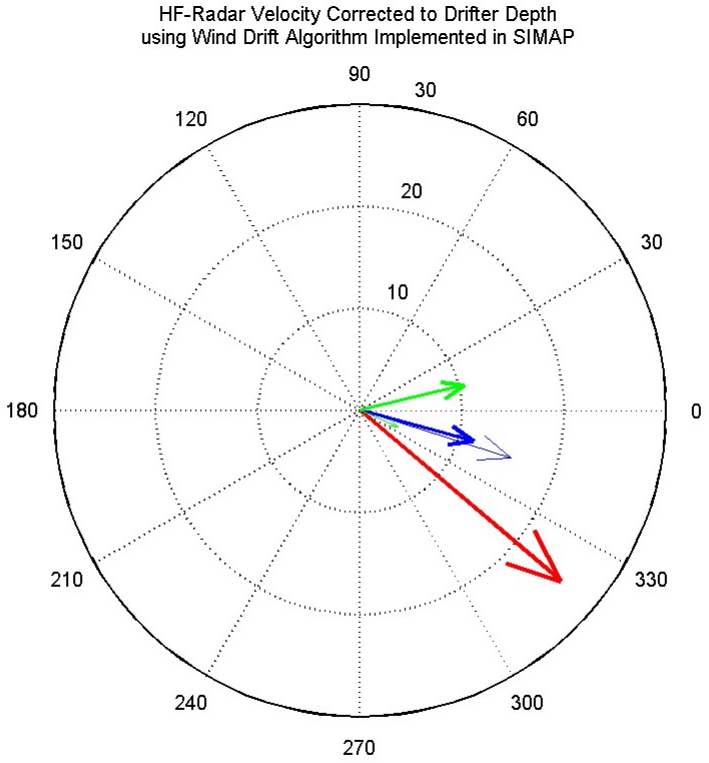

Figure C.4-3 Comparison between wind (scaled to 3%, bold green), mean wind drift (green) averaged over the upper 0.5m and at 2m corresponding to the HF-Radar integrated velocity measurement depth and drifter drogue depth, mean observed drifter velocity (2m, bold red), mean observed HF-Radar velocity (blue) and mean HF-Radar velocity projected to the drifter depth using wind drift (bold blue) for the 21 June 2006 experiment.

C.5 Results for the June 22, 2006 Experiment

The 22 June 2006 experiment began at 14:49 PDT (21:49 UTC) and ended approximately 17:50 PDT (00:50 UTC, 23 June). Figure C.5-1 shows the trajectory of a neutrally-buoyant constituent using the HF-Radar data with no additional wind drift included and low horizontal dispersion (0.01 m^2/s). Drifters were deployed with drogues at 2 m or at 4 m in this experiment. The trajectory was initialized at the center of the dye patch at the time and location where the first 2-m drifter was deployed (drifter #16757863 at 15:09 PDT). Figure C.5-2 shows a direct comparison between drifter and HF-Radar bearings (direction toward) and magnitudes.

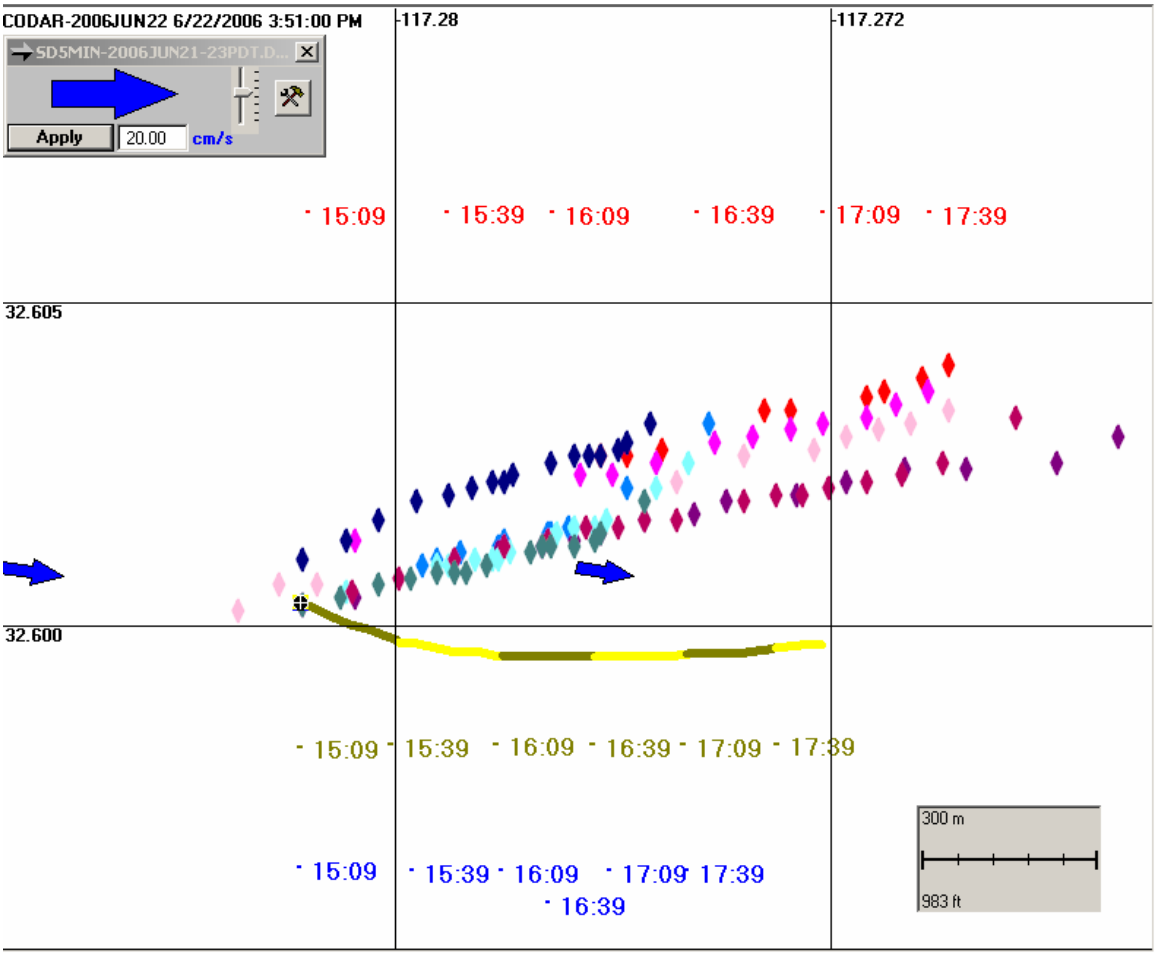

Figure C.5-1 Trajectory of a neutrally-buoyant constituent using the HF-Radar vectors up to 17:51 PDT (grey line with times in black font) compared to drifter movement (at 2 m: red diamonds with times in red font; at 4 m: blue diamonds with times in blue font) for the 22 June 2006 experiment. The arrow indicates the HF-Radar speed at the end time of the trajectory simulation.

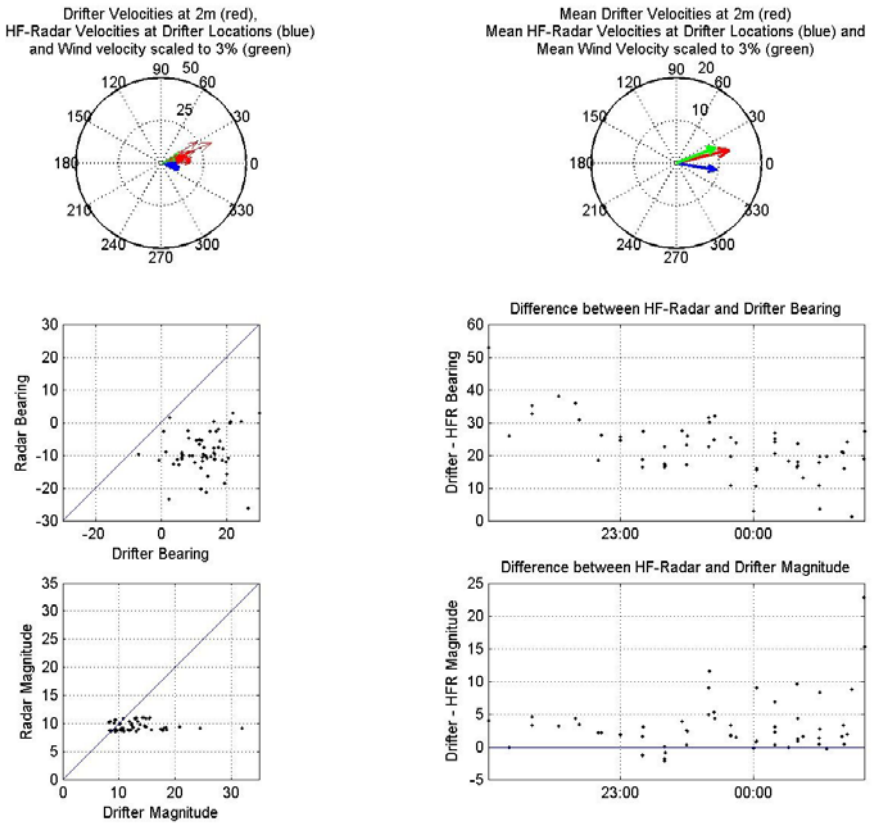

Figure C.5-2 Comparison between wind (scaled to 3%), drifter (drogued at 2 m) and HF-Radar bearings (direction toward) and magnitudes for the 22 June 2006 experiment.

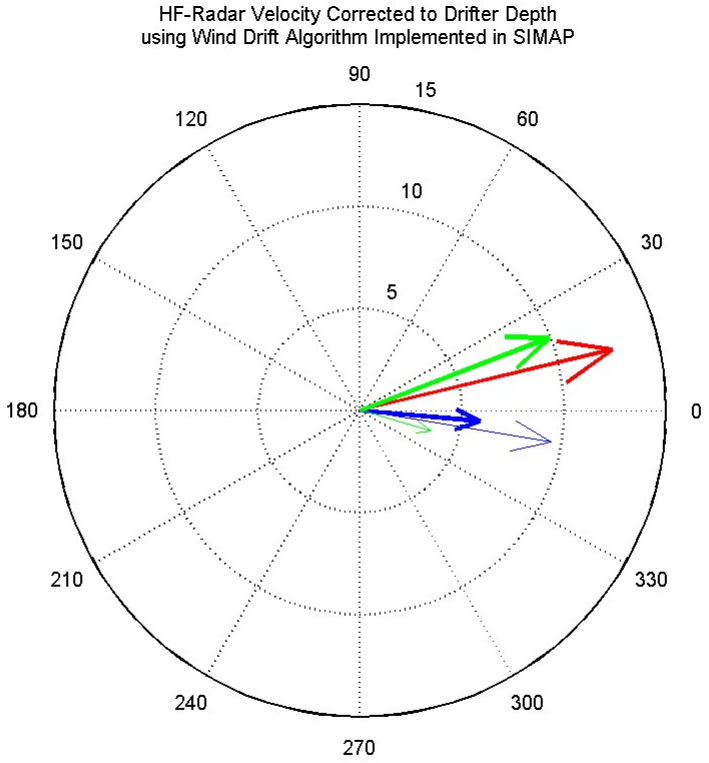

Figure C.5-3 Comparison between wind (scaled to 3%, bold green), mean wind drift (green) averaged over the upper 0.5m and at 2m corresponding to the HF-Radar integrated velocity measurement depth and drifter drogue depth, mean observed drifter velocity (2m, bold red), mean observed HF-Radar velocity (blue) and mean HF-Radar velocity projected to the drifter depth using wind drift (bold blue) for the 22 June 2006 experiment.

C.6 Results for the November 1, 2006 Experiment

The 1 November 2006 experiment began at 11:50 PST (19:50 UTC) and ended approximately 15:30 PST (23:30 UTC). Figure C.6-1 shows the trajectory of a neutrally-buoyant constituent using the HF-Radar data with no additional wind drift included and low horizontal dispersion (0.01 m^2/s). Drifters were deployed with drogues at 2 m or at 4 m in this experiment. The trajectory was initialized at the center of the dye patch at the time and location where the first 4-m drifter was deployed (drifter #16757573 at 12:09 PST). Figure C.6-2 shows a direct comparison between drifter and HF-Radar bearings (direction toward) and magnitudes.

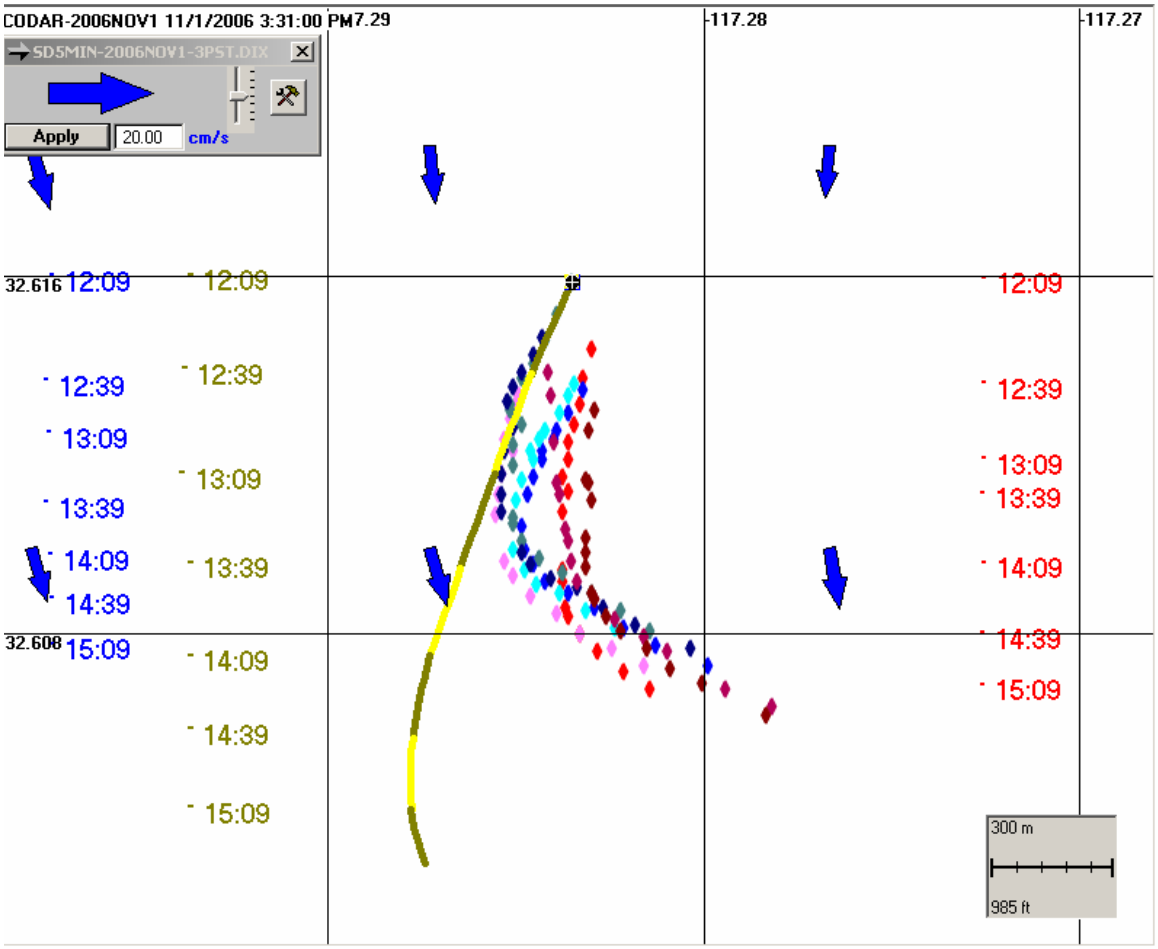

Figure C.6-1 Trajectory of a neutrally-buoyant constituent using the HF-Radar vectors up to 15:31 PST (grey line with times in black font) compared to drifter movement (at 2 m: red diamonds with times in red font; at 4 m: blue diamonds with times in blue font) for the 1 November 2006 experiment. The dark navy blue drifter (initially under the trajectory path) stayed within the dye patch for the entire experiment. The arrow indicates the HF-Radar speed at the end time of the trajectory simulation.

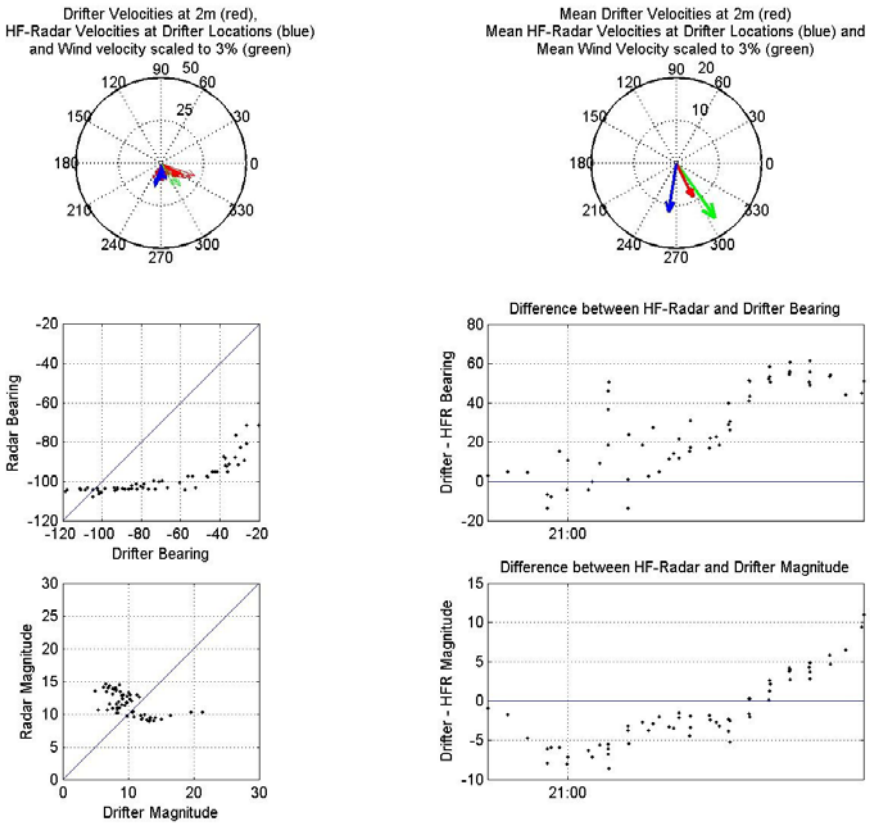

Figure C.6-2 Comparison between wind (scaled to 3%), drifter (drogued at 2 m) and HF-Radar bearings (direction toward) and magnitudes for the 1 November 2006 experiment.

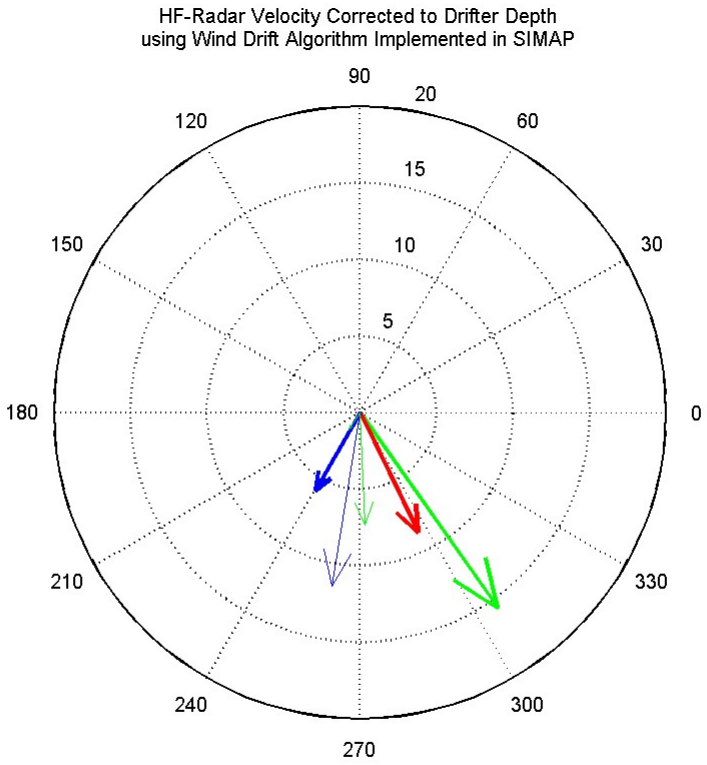

Figure C.6-3 Comparison between wind (scaled to 3%, bold green), mean wind drift (green) averaged over the upper 0.5m and at 2m corresponding to the HF-Radar integrated velocity measurement depth and drifter drogue depth, mean observed drifter velocity (2m, bold red), mean observed HF-Radar velocity (blue) and mean HF-Radar velocity projected to the drifter depth using wind drift (bold blue) for the 1 November 2006 experiment.

C.7 Results for the November 2, 2006 Experiment

The 2 November 2006 experiment began at 11:19 PST (19:19 UTC) and ended approximately 15:00 PST (23:00 UTC). Figure C.7-1 shows the trajectory of a neutrally-buoyant constituent using the HF-Radar data with no additional wind drift included and low horizontal dispersion (0.01 m^2/s). Drifters were deployed with drogues at 2 m or at 4 m in this experiment. The trajectory was initialized at the center of the dye patch at the time and location where the first 4-m drifter was deployed (drifter #15660155 at 11:29 PST). Figure C.7-2 shows a direct comparison between drifter and HF-Radar bearings (direction toward) and magnitudes.

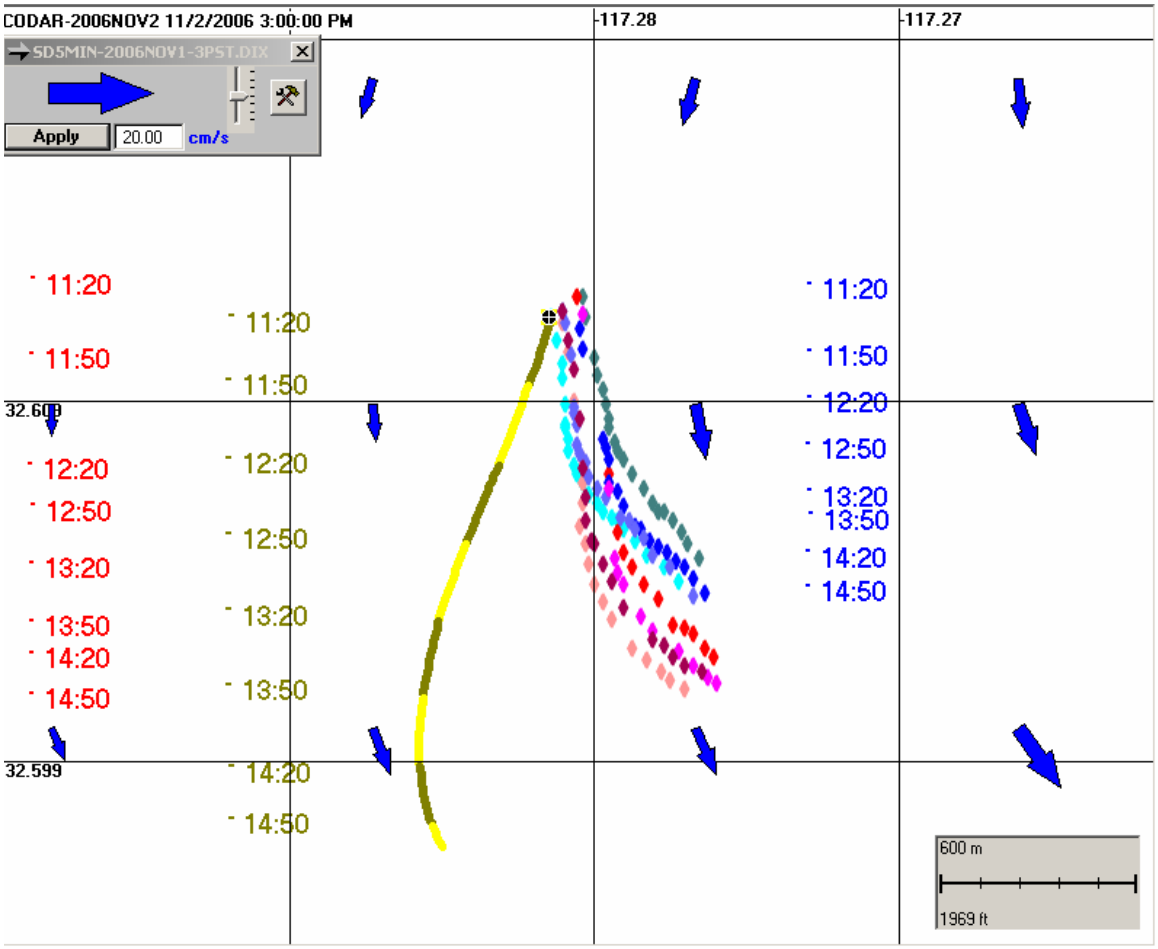

Figure C.7-1 Trajectory of a neutrally-buoyant constituent using the HF-Radar vectors up to 15:00 PST (grey line with times in black font) compared to drifter movement (at 2 m: red diamonds with times in red font; at 4 m: blue diamonds with times in blue font) for the 2 November 2006 experiment. The light blue drifter stayed within the dye patch for the entire experiment. The arrow indicates the HF-Radar speed at the end time of the trajectory simulation.

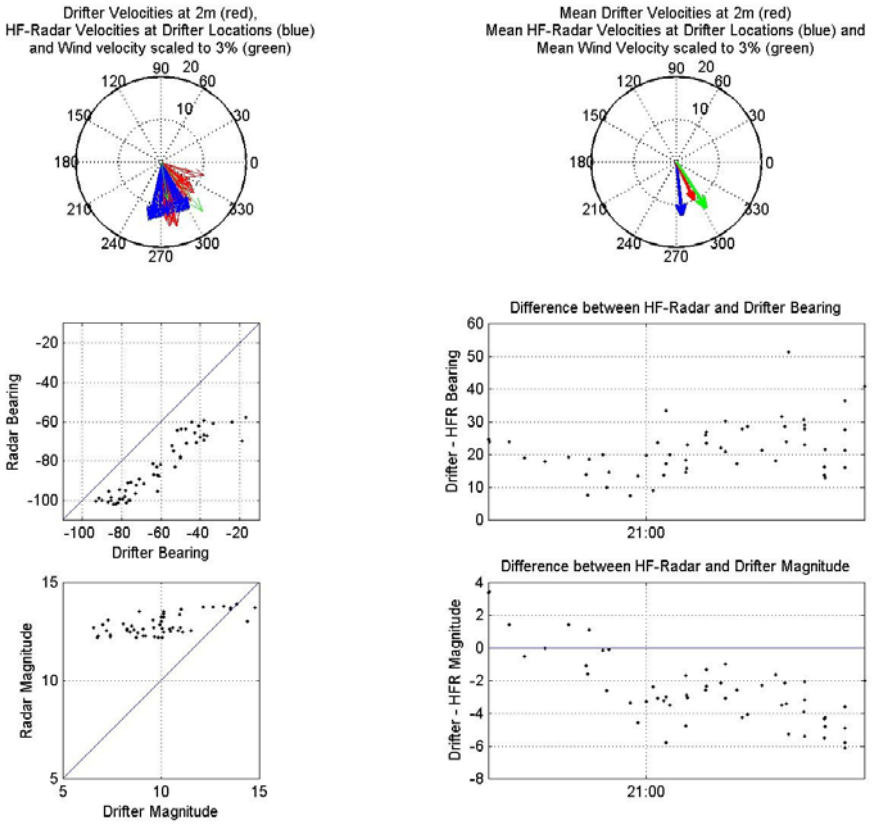

Figure C.7-2 Comparison between wind (scaled to 3%), drifter (drogued at 2 m) and HF-Radar bearings (direction toward) and magnitudes for the 2 November 2006 experiment.

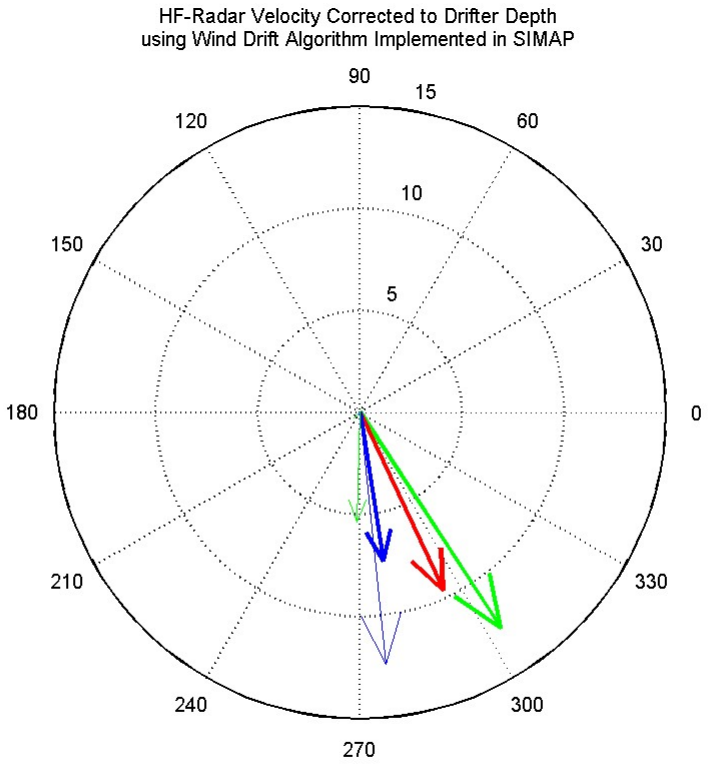

Figure C.7-3 Comparison between wind (scaled to 3%, bold green), mean wind drift (green) averaged over the upper 0.5m and at 2m corresponding to the HF-Radar integrated velocity measurement depth and drifter drogue depth, mean observed drifter velocity (2m, bold red), mean observed HF-Radar velocity (blue) and mean HF-Radar velocity projected to the drifter depth using wind drift (bold blue) for the 2 November 2006 experiment.

C.8 Results during the August 9, 2006 Dye Release off San Francisco

The 9 August 2006 dye release began at 11:50 PDT (19:50 UTC) and was tracked until approximately 13:30 PDT (20:30 UTC) when the dye became too diffuse to effectively photograph. Figure C.8-1 shows the trajectory of a neutrally-buoyant constituent using the HF-Radar data with no additional wind drift included and low horizontal dispersion (0.01 m^2/s). No drifters were deployed in the area of the dye release. The trajectory moved northward and then to the southeast after the change in the tide at 14:00 hours.

Figure C.8-2 shows the HF-Radar trajectory overlaid on the dye images, using only the trajectory up to 13:30 when the last image was taken (i.e., before the change in the tide). Comparison with Figure C.8-3 shows that the HF-Radar predicts the same path as the dye, but a slower trajectory than the actual dye movements.

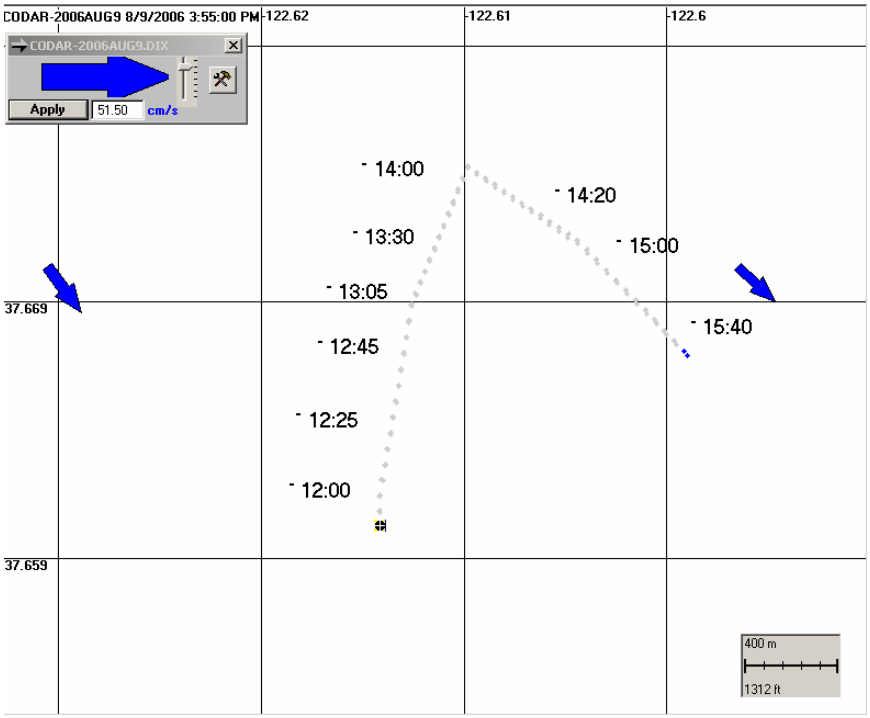

Figure C.8-1 Trajectory of a neutrally-buoyant constituent using the HF-Radar vectors up to 15:40 PDT (grey line with times in black font) for the 9 August 2006 experiment. The arrow indicates the HF-Radar speed at the end time of the trajectory simulation.

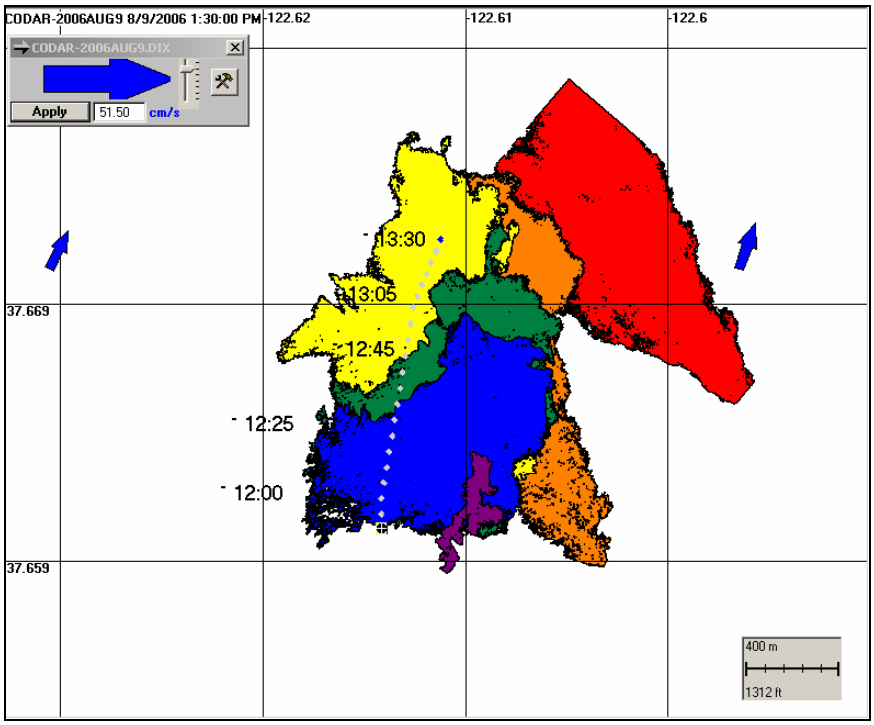

Figure C.8-2 Trajectory of a neutrally-buoyant constituent using the HF-Radar vectors up to 13:30 PDT (grey line with times in black font) for the 9 August 2006 experiment overlaid on dye locations based on shape files derived from selected images. The arrow indicates the HF-Radar speed at the end time of the trajectory simulation.

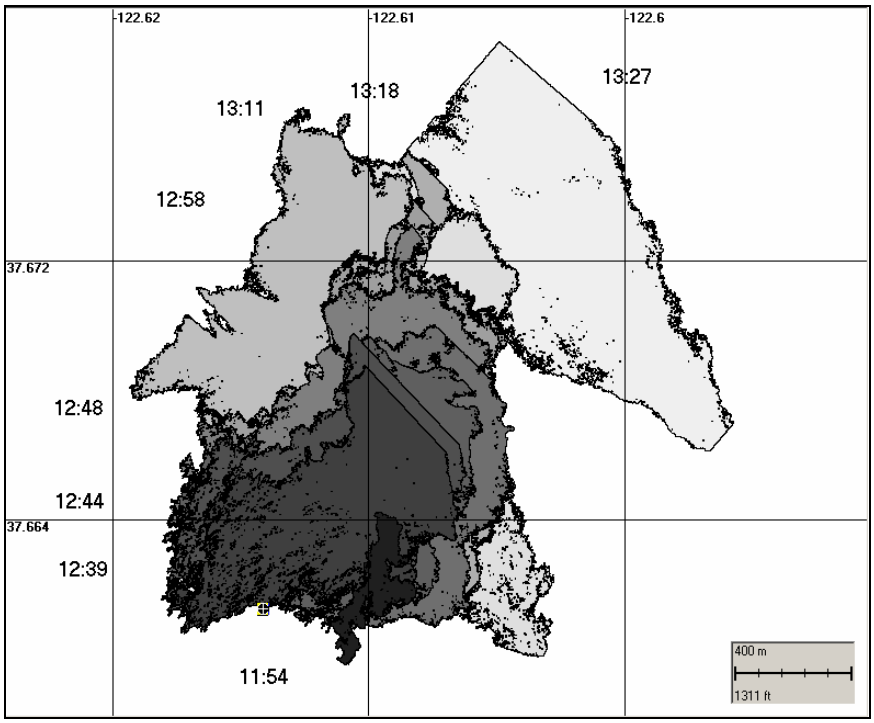

Figure C.8-3. Dye plume dimensions and movements over time for the 9 August 2006 experiment.