**High Wind Gas Exchange Cruise Summary, Nov 09 2013**

**Caveat:** This report summarizes raw or minimally processed data and the descriptions are subjective. It is offered as an immediate record of cruise conditions and selected activities as details remain fresh in memory. Further analysis will no doubt modify some conclusions and descriptions, and participants are encouraged to correct or amend information, adding details as appropriate.

**Measurements**

|  |  |  |
| --- | --- | --- |
| **Affiliation** | **Instrumentation** | **Objective** |
| NOAA PSD3 | Wind, motion, CO2 & H2O | Heat & CO2 flux and trans. coeff. |
|  | Laser altitude | Wave height |
|  | T/RH/P, rain, PIR/PSP, SST | Bulk flux parameters |
| U Hawaii | Wind, motion, DMS & CO2 | DMS & CO2 flux and trans. coeff. |
|  | Chilled mirror hygrometer | Bulk humidity |
|  | Seawater DMS | DMS trans. coeff. |
| UCSD | CI-TOFMS | OVOC flux and exploratory obs. |
| PML | Wind, Motion, PTRMS | MeOH & Acetone flux and trans. coeff. |
| UW JISAO / PMEL | pCO2 equilibrator system | CO2 trans. coeff. |
| U Leeds | CLASP aerosol spectrometer | Aerosol flux |
|  | Whitecap imagery | Whitecap fraction |
|  | Waverider buoy | Directional wave spectra (h >1m) |
| Columbia U / LDEO | High speed whitecap video | Whitecap fraction and wave breaking statistics |
|  |  |  |
| **Large Spar Buoy:** |  |  |
| NOC Southampton | Wave wires & video | High frequency wave spectra & whitecaps |
| U Southampton | Bubble camera | Large bubble size distribution |
|  | Bubble resonators | Small bubble size distribution |
|  | Sonar | Bubble plume evolution |
|  | Foam camera | Sea surface foam coverage |
| U Leeds | Current - turbulence probe | Sub-surface turbulence & current (3m?) |
|  |  |  |
| **Small Spar Buoy:** |  |  |
| NOC Southampton | Wave wires & video | High frequency wave spectra & whitecaps |
| U Leeds | Current probe | Buoy-relative current |

**Description of Stations and Activities (see Table 1):**

Knorr departed Nuuk pier at approximately 2300 UTC on Oct 9 and stood off in the fjord for about 6 hours for a deployment & recovery test of the large spar. At 0500 Oct 10 the ship began a transit leg from Nuuk south along the Greenland coast in moderately rough seas and declining westerly winds in the wake of a strong low pressure system.

**Station 1:** A forecast for strong northerly winds led to the decision to set Station 1 at 59N 50W, commencing 1000 Oct 11. Deployed Waverider (hereafter WR) and large spar. SST 6.5°C. Ship seawater system air-locked from 1830 to 2130. WR recovered later that night when it’s tether became fouled in the ship’s props; redeployed Oct 12. Wind speed remained above 15 m/s for ~12 hours, declining on Oct 13. Large spar damaged on recovery, subsequently repaired with assistance from the ship’s engineers over the next few days. Noted a large bias in DMS concentration between the ship’s underway seawater line and CTD samples. Began chlorination of the ship’s seawater lines on departure from Station 1.

Weather forecasts show strong winds at the S tip of Greenland within 24 hours. Begin transit to 59N 43W at 1630 on Oct 13.

**Station 2:** Facing strong winds and rough seas, we halt transit at 1200 Oct 14 and set Station 2 at 58.47N 44.95W. Seawater line chlorination stopped at 0815. pCO2 resumed at 0900. Small spar WR deployed between 1200 and 1300. This station characterized by very strong winds from the NE with large wind sea. Wind speed exceeds 20 m/s for 16 hours on Oct 14-15. DpCO2 marginal at the start (-30 ppm) but improves as we drift west with the buoys. SST 7°C. The small spar followed current to the west while the WR drifted faster with the current and wind to the WSW. WR recovered Oct 17 at 1130 and small spar at 1320.

Following Station 2: a long transit south along 46W on Oct 17-18 with calm seas and easterly winds < 10 m/s.

**Station 3:** Forecast for strong winds sets Station 3 at 54.1N 46W on Oct 18 1800. This station characterized by a steady increase in NE wind speed over Oct 19 with coincident development of wind sea, peaking at about 0000 Oct 20 with ~9 hours U > 15 m/s, followed by a gradual reduction in wind and seas into Oct 21. The buoys drifted in a large cyclonic (CCW) eddy. DpCO2 started at ~-60 ppm and finished at about -50 ppm. Start of station appeared to be an area of increased productivity and upwelling, but we drift out of that over the first day. SST 8.7°C. WR recovered Oct 21 1130 and large spar about 20 nm NE at 1415.

Forecast is for calm conditions over the next 2 days with a significant low pressure system arriving on Oct 24. Over Oct 22-23 we conduct a survey of seawater pCO2 and DMS via the following waypoints: 54.3N 46.5W; 53.5N 49.4W; 53.0N 49.5W; 53.0N 47.7W; 54.0N 46.0W; and 53.5N 46W.

**Station 4:** On the basis of observed pCO2 and wind forecasts, Station 4 is established at 53.5N 45.4W at 0900 Oct 24. This station characterized by the passage of a very strong low-pressure system, with P = 960 mb at 0400 Oct 25. From 1200 Oct 23 through Oct 24, as the low approached, wind veered from southerly to easterly, increasing gradually to 20 m/s. As the eye of the low passed over, pressure reached a minimum and winds decreased to ~6 m/s with fog. Then, very rapidly, from 0700 to 0800 on Oct 25, westerly wind grew to >20 m/s. This transition led to an initially chaotic sea state, subsequently developing into a full wind sea with 10 m waves under westerly wind. Wind dropped below 20 m/s just after 0000 Oct 26 and declined further over the course of the day, but waves remained large. Recovered WR at 1200 on Oct 27 and the large spar at 1400. SST 10.4°C. DpCO2 was -55 ppm early on Oct 25 but was reduced to ~ -35 ppm during the height of the storm and remained at that level to the end of the station.

**Station 5:** With the forecast showing continued high winds in the area we remain at the Station 4 site for Station 5. Buoys deployed at 1500 Oct 28 (?). Westerly winds increased quickly during Oct 28 and remained > 15 m/s over the next two days. DpCO2 was marginal at this station, ranging from -40 to -30 ppm for most of the time, drifting up to -20 ppm toward the end. Sea state for this station was chaotic and mixed, with strong swell from the NE (coming from the N lobe of the Oct 25 low pressure system) mixed with wind seas from strong westerly winds. Ship motion characterized by strong roll. Wind, motion, rain, T/RH and laser altimeter sensors from the NOAA flux system failed during this station due to a power short and we plan for subsequent repairs in a few days in calmer conditions near Newfoundland. SST 8.6°C.

Forecasts for the following 2 days were for moderate winds with some indication of stronger winds developing just E of Newfoundland. Oct 31 1200 we begin a transit W to a station on or near the Newfoundland shelf influenced by flow from the Labrador current.

**Station 6:** Established 1900 01 Nov just short of the continental shelf in cooler, fresher water just east of the core of the Labrador current. Large spar, WR and small spar all deployed at this site, with the small spar tethered to ship. Winds increased to >15 m/s for most of 02 Nov. DpCO2 -40 to -50 ppm for the entire period. WR and small spar recovered 03 Nov 1220 and large spar 1340.

With a forecast for calm weather over the next several days we depart for Strait of Belle Isle at 1500 Nov 03. On Nov 04 we make a short stop in the strait to examine NOAA met sensors, and on Nov 05 we stop again to complete repairs and bring wind, rain and T/RH sensors back on-line. The transit continues south on very calm seas with light headwinds to a point south of Nova Scotia.

**Station 7:** This station sited just off the continental shelf, avoiding currents and clear of shipping lanes and other restricted areas. 0900 Nov 7 we arrive at 41.45N 64W in very calm, warm conditions. SST and air temperature 20°C with high humidity. WR, large and small spar buoys deployed again. All buoys drifting with the ship following the small spar. The small spar is recovered each evening. We recover the WR and reposition each morning to the location of the large spar, redeploying the WR and small spar.

Strong southerly winds develop over Nov 07 but at 0600 Nov 08 a cold front passes and winds die quickly, veering northerly. Temperature and humidity drop and northerly winds strengthen over the course of the day. This station is notable for atmospheric instability behind the front with SST 20°C and air temp 10°C, resulting in numerous squalls with hail and rain over the course of Nov 08 and 09. Large spar finally recovered 0900 Nov 10 and we reposition to the point of origin for this station.