

Rain in Cumulus over Ocean (RICO)

R/V Seward Johnson Leg 2: Jan. 16 through Jan. 24., 2005.

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The Seward Johnson (SJ) departed Antigua on 6am LT Jan. 16 and took up station at 17 deg, 37.388N, 62 deg, 00.47 W on Jan 17, 12 Z, (0800LT). The boat track for the next 8 days is indicated in Fig.1. The SJ remained on the windward side of Barbuda for most of leg2, with the exception of Jan. 22, when it was SW of Palmetto Point (SW corner of the island), Barbuda, and the evening of Jan. 17th, when the SJ was also on the lee side of Barbuda though north of Palmetto Point. Initially sea swell was high and the boat maintained a strict upwind-downwind line to minimize rocking of the boat, later in Leg 2 the sea swell calmed and we tried to align the boat more with the direction of the cloud-level winds (Jan. 23 & 24). Generally the boat tracked 8-mile-long lines.

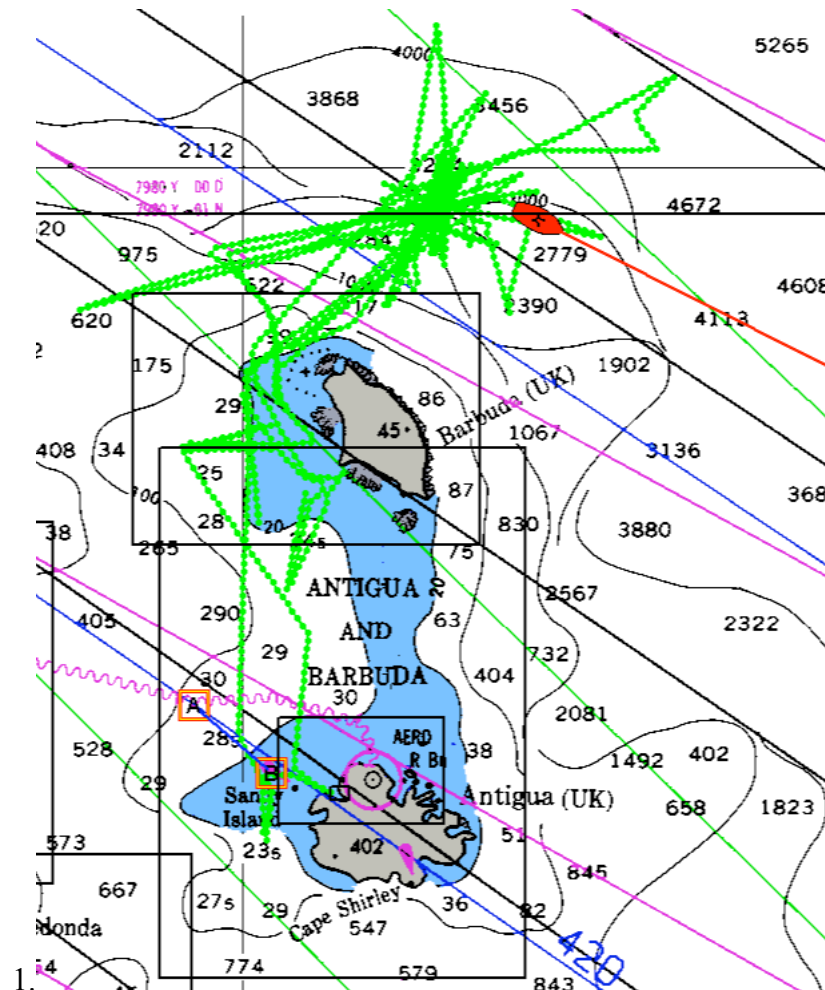


Fig. 1: Seward Johnson boat track, 1/16- 1/24

SONDES: We launched 6 Vaisala RS92 sondes per day; two of the sondes failed to transmit their data to the receiver, namely the 20Z sonde on Jan. 17th, and the last sonde of Leg 2 occurring on Jan. 25 0 Z. Thus we launched 49 successful sondes. Figure 2 is a time series of the sonde relative humidities and winds up to 5 km.

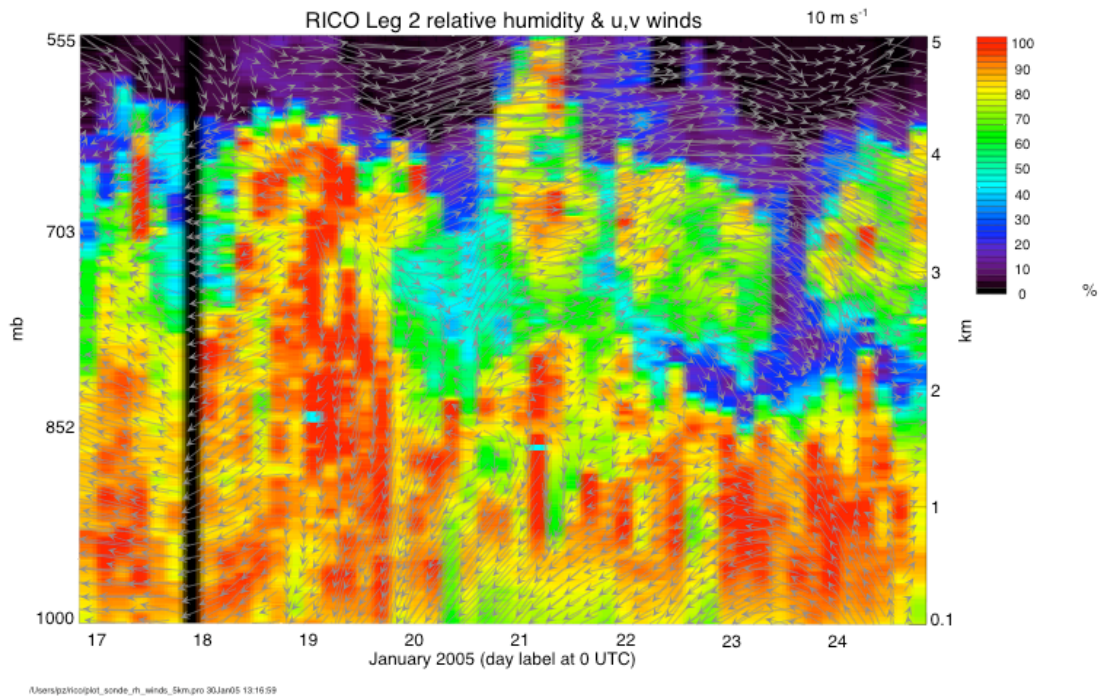


Fig. 2: Leg 2 sonde relative humidities and winds.

INSTRUMENTATION: The instrumentation on the boat included a scanning lidar, scanning K-band radar, vertically-pointing X band radar, mailbox radiometer, flux measurements, and a Lasair-II aerosol particle counter. The instrumentation functioned well most of the time. Exceptions were a mal-functioning aerosol particle counter on Jan 17th and part of the 18th, and a non-operational lidar on the morning of Jan. 20th. The lidar and K-band radar usually operated between 12Z (8amLT) and 21-22Z (5-6 pm LT) with earlier operations on those days with earlier aircraft flights. The K-band radar usually followed a 0-60 degree RHI scanning pattern, with a 0-120 scanning range on Jan. 21 from approximately 1730Z-19Z, and a vertically-pointing –only time period on Jan. 22 12-15Z as an intercomparison for the vertically-pointing X-band radar.

AIRCRAFT COINCIDENCE: Apart from overlap with the C130 during its large-circle dropsonde releases, several time periods were noteworthy for the coincident sampling of precipitating clouds by the shipboard instrumentation and aircraft. These time periods include: 1/17, 1410-1430Z (coincidence with the Wyoming King Air); Jan. 19, 1320-1350Z

and 1540-1700Z (approximate times; coincidence with the C130 and possibly the King Air); and Jan 24th, 1245-1330Z (C130 and King Air).

Images from the Spol radar on Barbuda and the shipboard NOAA K-band radar of such a coincidentally-sampled precipitating cloud are shown in Figures 3-6. The time period is Jan. 19, ~1630Z. Note that the Spol radar was looking north, and the K-band radar was viewing south.

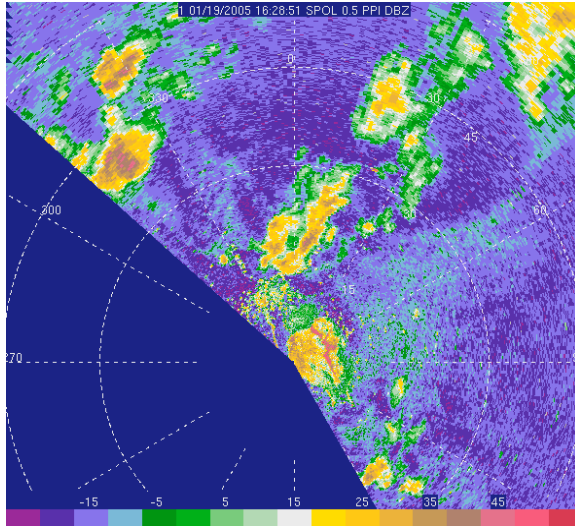


Fig. 3: Plan-Position Indicator (PPI) view by S-Pol radar, Jan. 19, 16:28 Z. Red dot indicates the Seward Johnson. Plot courtesy of Bjorn Stevens and Sabine Goeke.

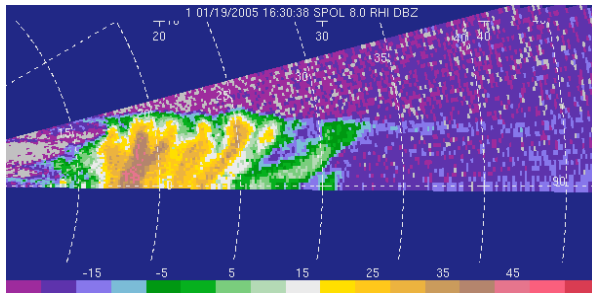


Fig. 4: Range-Height Indicator (RHI) view by the S-Pol radar, Jan. 19 16:30 Z, looking approximately north. Plot courtesy of Bjorn Stevens and Sabine Goeke.

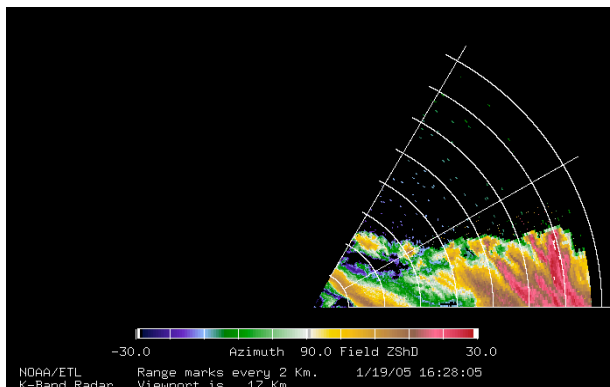


Fig. 5: RHI view by the scanning NOAA K-band (35 GHz, 8.66 mm) radar on the Seward Johnson, Jan. 19, 16:28, viewing approximately south. Plot by Bruce Bartram.

DAILY LOGS:

The following is a compilation of the daily summaries emailed each evening during this leg of the field experiment.

1/17/05:

Instrumentation: working robustly except for the Lasair II aerosol package.
Aircraft: 2 King Air flights

We arrived at the west point of our line north of Barbuda about 8 am, both the noaa-k cloud radar and the lidar came on then. The seas were moderate, and calmed further during the day. Clouds thinned noticeably during day, & the boundary layer was noticeably moister than yesterday.

The King Air passed over at 1252 UTC, and between 1410 and 1430 worked thick clouds also sampled by the ship - the day highlight. King Air returned during its 2nd flight, working near the ship from about 1800 UTC until 1850 UTC. They sampled some clouds downwind of the SJ that registered later on the ship instrumentation, but the clouds had significantly dissipated by then.

1/18/05:

Instrumentation: everything working, including the Lasair aerosol particle counter - (turned out to be a kink in the line)
Aircraft in proximity: C130,

Weather: stratus layer at about 11 kft all day, with some Cu underneath. Clearing as the day went on, winds became very calm (2-3 m/s). Light precip at the boat at 1440 and 1630.

The C130 passed near the ship twice at about 1600, coinciding with a sonde launch. C130 may have passed upwind of the ship at about 1820.

Last night we went back to the lee side of Barbuda, both to help acclimate seasick personnel and to give an assured opportunity for lidar maintenance. It is now quite calm here. We will stay here tonight and intend to remain wherever we spend our days from now on, towards sampling a representative diurnal cycle in the sondes, fluxes, and Xband. Tomorrow (1/19/05) we will begin lidar/radar operations by 11Z, not only to coincide with the early morning aircraft flights, but also because the last couple of days more of the cloud/precip activity has been in the early morning.

1/19/05.

Instrumentation: all working
Aircraft in vicinity: KingAir, C130, UKMet

SJ experienced an exciting day today ! 2 convective cells were well sampled by both the ship instrumentation and multiple aircraft.

At 1314Z we received the first echoes on the noaa K radar of a shower that we were in for almost an hour. Initially the convective cell was on the port side of the boat, then moved over the boat, providing good data to the vertically-pointing instrumentation for a solid hour. The cell thereafter moved to the starboard side and was well-sampled by the noaa K radar. The C130 and KingAir planes joined the shower at about 1324Z. We tried to chase the cloud, but failed to keep up.

At 1528Z the C130 (and maybe the King Air ?) were nearby in another shower, to the port side of the boat (thus the convxn was outside the range of the noaa K radar). The shower arrived at the SJ at about 1537Z. We swung the boat around, and this time we were able to track with the (slowly-moving) cell. The noaa K sampled this cell for about an hour, up to about 1700 Z. We think the C130 and maybe the King Air continued to work the same cloud. It was very satisfying to us that this time we could successfully chase the cloud of interest.

After this excitement we returned to our line. The day cleared and both the lidar and noaa radar shut off at 20Z (4pmLT).

The soundings showed weak winds (1-4 m/s) throughout the depth of the BL and immediately above. The inversion at 650-600 mb throughout the day was striking - a drop in RH from 75% at 650 mb to near 0 at 600 mb, along with a temperature inversion of about 2.5 K. Coincident with this, cloud tops appeared fairly smooth to the radar.

I've attached a gif of the noaa reflectivities from 1628, as well as a visual of the 14Z cell as it was nearing the coast of Barbuda, just fyi.

1/20:

Instrumentation: all working
Aircraft in vicinity: none (down day)

Little activity at the SJ today. Winds were high, up to 10 m/s. The morning was clear and dry. The noaa radar and the lidar operated from about 16Z to 20Z (noon-4pmLT). A cloud boundary was apparent for a time, between a stratus covered air mass and scattered Cu, this later gave way to only small scattered Cu.

1/21:

Instrumentation: Lidar down 12Z-15Z
Sara Tucker identified a non-functioning controller, replaced it with spare

Aircraft in vicinity: King Air

Morning very clear, small shallow Cu developed as day progressed, registered as -30 - -25 dBZ on the noaa radar. The King Air arrived approximately 1730, running long legs alongside and across the boat for the next 1.5 hours. Bruce Bartram changed the noaa strategy to scan 0-120 degrees (from his normal 0-60 deg), towards optimizing close aircraft passes. The radar may have pinged the King Air at about 1743. The cloud field did not develop much, at 1900 KingAir took off, we turned the radar off shortly thereafter. The lidar ran for another hour until 20Z, focusing on volume and sector scans only (towards retrieving mean and residual winds).

1/22

Instrumentation: all good
Aircraft in vicinity: none

We moved ourselves closer to the estimated locale of the Barbuda cloud plume for the day, and worked an 8 mile line close to that of the prevailing surface wind, with its northern point at 17deg 32.5N, 61deg 53.0W. Between 11Z and 14Z we were surrounded by many lightly precipitating Cu clouds, including many rainbows. We took this opportunity to do an intercomparison between the noaa radar and the Xband radar, and placed the noaa radar in a vertically-staring mode from 1200 to 1440 Z. Then reverted back to 0-60 scans for the noaa radar as the cloud field shallowed. By 19Z we were in mostly clear, calm conditions. We closed

down the noaak radar at 19Z and the lidar an hour later.

1/23

instrumentation: all good

Boat location: NNE of Barbuda

Suppressed convective conditions, but enough vertical development to sustain some precipitation. Light precipitation was often present around the boat, sometimes so light it was detectable on the noaak radar but not obvious to the eye. Cloud fraction decreased during the day but very light precip was observed at all hours. The noaak radar and the lidar began running by 10Z. Sea swell was low, we could alter our boat direction without increasing the rocking of the boat, and shifted direction at 1118Z to approximately match cloud-level winds. The aircraft UKMet & KingAir worked elsewhere, some coincident with the C130 on its upwind circles. Radar turned off at 1930, lidar at 20Z..

1/24

Instrumentation: all working

aircraft in vicinity: C130, KingAir, UKMet

boat location: NNE of Barbuda, slightly east of previous

Day highlight occurred between 1245 and 1330, during which the shipboard lidar & noaak radar, and the C130 & Wyoming King Air all sampled the same vigorous convective cell.

Winds calm and predominantly from the south. Cu convxn, when it occurs, is more vertically developed than yesterday. Noaak radar and lidar on at 9Z, hoping to catch some early-morning precip, but no such luck. A convective cell developed to our portside that attracted the C130 and King Air at about 13Z. We swung around and sampled it on the noaak&lidar in its fully developed and dissipating stage - 2 vertical km of 30 dBZ -, also some coincident data w/ the 2 aircraft if we're lucky. At 1320Z we may have coincident radar scans with the King Air. Aircraft and radar worked the same cloud up to approximately 1330, after which the aircraft left for more promise to the SE.

Another coincident sampling by ship & C130 of a much smaller cloud at ~ 1415. Beginning at 17Z we more or less tracked due west north of Barbuda, which is now the lee side given the southerly winds. Radar and lidar off at 18Z, experiment ended for us at 0Z on 1/25, 8pmLT.