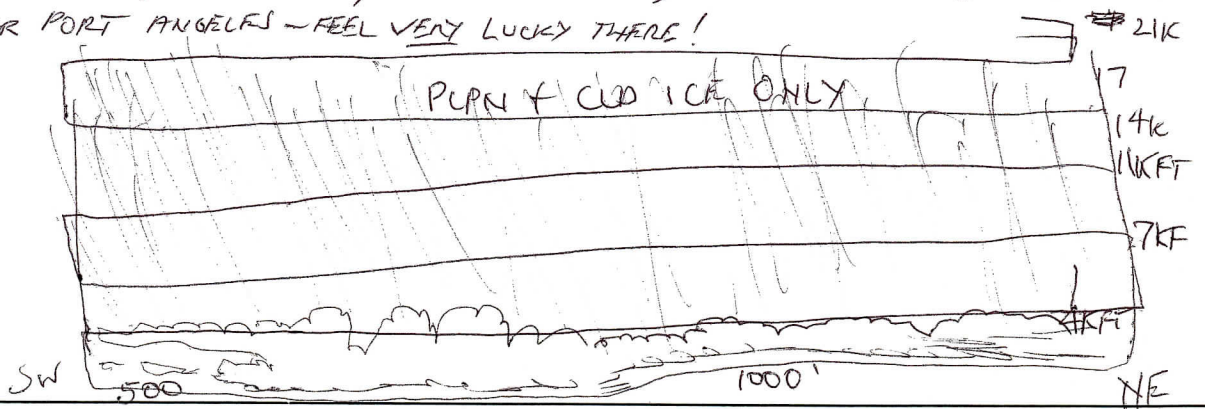


Aircraft Flight Log for the University of Washington, Cloud and Aerosol Research Group

Date 1-9-01	Flight Number 1849	Experimental Observations SAMPLED INCOMING OCCL FNTS, RGDY LOW CLDS, MODERATE SC CLUMPS FOR ABOUT 15-25 KM WHERE SLIGHT W/S LN WAS. WIND ~165° VEERED TO 48°-195°. VERY STG LOW + SFC WINDS. LOW RACING TO BC, (MOSTLY) WITH 2KFT INCREMENTS AS IN 1848 SAMPLING PROCEDURE WAS A STATIONARY MOVING STACK BEGINNING BELOW CLO BASE, FAST HDG OUT ALG A SWIRLY RADIAL FM WESTPORT AT ~1000 FT ASL, BUT, AS CLO BASES LWRD, DESCENDING TO 500' IN THE RGN OF THE SFC WINDSHIFT. LTL OR NO TEMP CHGS SEEN. BOUNDARY LYA CU-SC CLUMPS AND LINES ASSOC WITH WSHIFT DID NOT REACH 7KFT, BUT DID PRODUCE $>0.6 \text{ g m}^{-3}$ LWC AT 4KFT. VERY BROAD DROP SPECTRUM; TAIL 30-35 μm , SUF. FOR COL-COAL. PROCESS, PVEG S. MVB STACK TOP ~210KFT W/MOST CLO STILL ABV A/C. HIGHEST TOPS (VISUALLY) APPEARED TO BE A EACH END OF LEGS, SADDLE W SKY VSBL SW END/TWD MIDDLE OF BAND. NO LTL OR NO LWC AT 7KFT + ABOVE. X-TALS (FM HVPS) DECREASED IN SIZE UPWARD AS EXPECTED, W A GUESS THAT X-TALS WERE UNPRIMED. RIVAL LEG OF FLT WAS 8-N OLYMPIC TRANSECT ALG 123°30' MERIDIAN LOTS OF PCON, SOME LWC, AND SURPRISINGLY, NO BONE CRUSHING TURB IN LEE NEAR PORT ANGELES - FEEL VERY LUCKY THERE!	
Project name IMPROVE dur: 3:29			
Engines on time 2033 UTC	Engines off time 0202		
Departure airport HQM	Arrival airport		
Flight Scientist signature <i>C. Rangan / Mike Beaudin</i>			
Pilot signature <i>[Signature]</i>			
Surface met. & visual obs. at takeoff 120E35 @ 15+ THIN SPTS INOV C OCNL R--. HVIR RAIN OFFSHORE CIG LWRD OFFSHR SW-NW		Ac As Ns Sc St Cu Cb	
Research crew BOND RANGNO GRAY SPURGEON WILSON		Equipment failure 35GHZ RADAR CPI NOT INST. 2-DC - NO IMAGES HVPS - OCNL NOISE 1-DC CONCS LOW PVM DMT JW NOISY ROSKOVIT TAS NOISY	



WSHIFT,
FM OPA

Flight 1849
January 9, 2001
Voice Transcriptions*
IMPROVE

AR: Flight 1849 on board are Bond, Wilson, Rangno, Spurgeon, Gray. We're outbound into a frontal system at the boundary layer below cloud base that is. We're approximately 1,000 ft below cloud base. A ragged ceiling now rather different than what we saw before, which was a virga ceiling. Wind is still horrific out here probably 40 knots on the surface. Temperature +3.6°C at flight level 936 mbars. So it's pretty cool. Radar altimeter 1,200 ft. P-alt 2,000 ft. I don't know what that's about.

2:50 PM

AR: A large swell out there. It probably isn't any bigger than it was before, but it seems more pronounced now. We're experiencing light turbulence.

2:51 PM

AR: This is going to be a tough flight down at this level because we're going to make this first pass just below cloud base.

2:53 PM

AR: Larry, do you guys have your radar on up there?

LS: Yes we have.

2:54 PM

JR: Now we got it on, Art.

2:55 PM

NB: Larry, Nick here.

LS: Go ahead Nick.

NB: We're still kind of on the east side of this wind shift line, so if we could keep this same course until we see a change in the direction of the winds and/or it kind of

* AR = Art Rangno, DS = Don Spurgeon, GG = Grant Gray, JR = Jerry Rhode (pilot), LS = Larry Sutherland (pilot), Nick Bond = NB, TW = Tom Wilson

opens up to suddenly a kind of cumulus field. We'd just like to keep going this way.

LS: Okay. You already have a wind shift on the water. It went from about 100° to about 160°.

NB: I would think that we should be able to see it at this flight level too. So yes, I'd kind of like to continue going this way if it's okay.

LS: Okay. We're just at the first point now, so do you just want to follow this heading?

NB: That's correct.

LS: Okay.

2:56 PM

TW: Grant?

GG: Go ahead.

TW: I don't know if you were on the headset when I was telling Don, but if there's a definitions file in your home directory, it will load that up after it loads up the one in the CARG PER directory.

GG: I see.

TW: So that's what was going on in this node was that there was a definitions file in Don's directory. So you might want to double check if you ever have any weird things happen that there's not a definitions file in your home directory.

LS: Nick, you've got your 90° shift already here.

NB: Okay. The winds I'm looking at aren't showing that. Was that right near the coast? There was more of an easterly component just because that kind of affects the land and that. But how long ago did you see that wind shift?

LS: Well, when we were 10 to 15 miles off it was right around 100° and now it's shifting around to at least 160°.

NB: Right. I guess I'd like to continue the course here at least for the next few minutes.

LS: Okay.

AR: I agree with you, Nick. I think that's just a local turning of the wind out there because clearly this is still pre-frontal.

LS: I'll correct that. It's at about 145° on that magnetic.

AR: Yes. That's what we're seeing back here. I would guess, Nick, that when you see something out of due south to 200°.

NB: Yes. I definitely want to see a westerly component to it. So more like, especially at this level, something like 200 or so.

LS: Okay.

AR: I think you're right. It's going to break out very spectacularly. When we get out there, we'll know it's gone by.

NB: Certainly the radar sees a much different character to the precipitation on the east side versus the west side of this wind shift.

2:59 PM

AR: It looks like maybe some clearing ahead out there.

TW: Grant, do you have a queue strip, you know a config file on any of these machines on here?

GG: My very own?

TW: Actually any one. I don't know the format off hand.

GG: Oh, queue strip?

TW: Yes.

GG: Oh, queue strip not quag strip?

TW: Yes.

GG: Let me check.

TW: It's no big deal if you can't find it. Actually can you grab me that floppy? Just push that in. Actually there might be one on there.

AR: We've got a thin spot up there actually going overhead, Nick. But notice off the right wing there at 1 to 2 o'clock, it looks like there's kind of a suspicious looking line that might be that wind shift. Where those lower cloud bases are running.

NB: Right. Yes. I see what you mean just that kind of little dark part there.

AR: That's my guess. That's what I think. So here we go. In the next minute or two, we may see some bumps.

NB: I'm going to check in with the radar guys. Tentatively when we get through this wind shift line, we'll climb up to something like 5,000 ft and kind of return along the same track that we came down on.

GG: Also Tom, I have one in my home directory if you need it.

3:02 PM

NB: Well, Art, your little kind of line is approaching right here, so we'll see if you're the swami or not, right?

AR: That's right. I would think that within the next 60 s, maybe 90 s, we would see something happen to the wind. I was looking for a little bump within the next 10 to 20 s.

3:04 PM

AR: Well, if this thing isn't in here, I'm going to pick up my swami hat.

NB: Say, Art, maybe you could put your mike a little closer.

DS: Make sure you're not turning it sideways again too.

AR: That's exactly what I was going to say. I probably turned it sideways again.

3:05 PM

AR: This right here is what I would have called it. I got fooled by some low bases there, but this one looked even better and it doesn't seem much is happening.

NB: Well, don't give up yet. I wouldn't be surprised if we break through here pretty fast.

AR: I do see a little blue sky there off in front of the left engine.

3:06 PM

LS: So Nick, we're starting to go into the bottoms. Do you want to slip down a few hundred feet and stay in visual?

NB: Sure. Yes. That would probably be best. Why don't you take it down? It doesn't look like it's going to be too rough or anything.

3:09 PM

NB: Say Larry, my impression is that the winds have come around just a little bit there on the surface, but compared to about 5 to 10 min ago I haven't seen a big change.

LS: I think it's exactly the same, Nick.

AR: That's my assessment as well. It's still running 160, 155, 165. I missed it. What I thought was clouds out there in kind of a line I thought that was the line, but it's not going to happen. Probably, Nick, it maybe even like you were saying just kind of mushy out here and then a big clearing.

NB: Yes. This kind of lower base is here. That's a good sign I think, but I guess we just have to see.

3:10 PM

AR: I have to say that in 20 odd years I've never seen white caps this big, like the one out there in front of the right wing. It's darkening up ahead. Maybe this is it.

3:11 PM

NB: The visibility sure just went down there.

AR: We nipped a cloud base, but generally overall you're right, Nick. It's rainier here too.

3:12 PM

AR: The winds are coming around about 12° now, so maybe we're getting close.

LS: Nick, we're down to 500 ft right now for your information.

NB: Right. I noticed. So you can hold it here.

AR: We have another dark area ahead that's a candidate for wind shift.

3:13 PM

AR: There are some big swells out there, Larry. How big would you say they were from your experience?

LS: I don't know, Art. I was estimating 20 to 30 ft.

AR: Wow.

LS: Maybe not that big, but it sure looks big. If you look at the curve on some of that spray that goes over the top, you can see how steep they are.

AR: Right. You could almost surf those.

NB: If you're in a boat you do.

AR: I guess that's right.

NB: Notice here that it's starting to lighten up quite a bit.

AR: Absolutely. I think there's some blue out there.

NB: And we're now seeing some 190s sometimes in the wind.

AR: Yes. This is it.

NB: Art, how much behind it do you think we should go? I would say not far, but maybe a minute or two more?

AR: Yes. That's what I'd do. Yes.

NB: I'm going to get on the horn with the radar, but basically what we'd like to do is climb up to just above the freezing level and kind of reverse track.

LS: Nick, you're starting to get a wind shift now. It's shifted about 20° to 30°.

NB: Right. At least on what I'm looking at, it hasn't shifted around as much, but I see what you mean. Yes. At the surface it sure looks like it's happening more.

LS: It was 30° ahead of the wind and now it's up there about 50° to 60° the wind.

NB: Right. So maybe let's go a minute longer and then do the climb up to approximately 5,000 ft.

3:16 PM

TW: Grant, is your wind from 0° to 360°?

GG: Yes. On the strip chart, you can see a 20° shift.

3:16 PM

NB: I'm not able to raise the radar guys. I think we're too low and they're trying to talk through too much precip. So just like I said, let' take it up to just above the freezing level and kind of reverse course.

LS: Okay.

3:17 PM

AR: Looking back, Nick, you can really see that indication of a wind shift back that way. To bad it didn't look like that going into it.

3:23 PM

LS: Nick, we're orbiting out here until we can get an IFR clearance. We've got frequency congestion and we're kind of low.

NB: Yes. That's what I figured. So you have to stay down at this level rather than getting up to 5,000 ft, right?

LS: Yes. We can't get into the clouds until we get a clearance.

NB: Yes. Got you. I've not been able to raise the radar. I think we're just too low and too much precip in the way.

LS: We're too far out.

NB: We're near the outer limit of the radar's range. So it's a good thing we didn't go any earlier because we wouldn't have been able to get out here anyway.

3:26 PM

AR: We're flying in the bases of the stratocumulus clouds. There's kind of a shelf that extrudes westward from the wind-shift line. It maybe very weakly developed stratified clouds. Maritime droplet concentrations 50 or so peak, 60 maybe.

3:28 PM

LS: Okay Nick. We've got a clearance. So how high do you want to go? Hello Nick?

NB: Yes. I'm here. Go up to 5,000 ft and let's see if we can get to the freezing level. Tentatively head toward that point that I gave you before, which is $46^{\circ}47'124^{\circ}11'$.

LS: Okay.

3:29 PM

LS: Nick, did you want us to go to the first point you gave us or the second point?

DS: Standby 1. He's checking some stuff out.

NB: Sorry Larry. If we could repeat or kind of retrace our steps along that same radial for the next 10 min or so that would be good.

LS: Okay.

NB: Now I'm seeing two different temperatures, a $+1^{\circ}$ and a -0.8°C . Art, do you think we're to the freezing level yet?

AR: t-stat has been the one that we've relied on.

NB: Okay. That's the $+1^{\circ}\text{C}$. So we should keep going up, right?

AR: It's the negative temperature actually.

NB: Okay. It still seems like almost all water here.

AR: We haven't gotten any precip. That would be one of the deciders, if we fly at this level and see what appears to be snow out there not melting snow that will help discriminate between those two. I notice the other one is now reading -1° . We may have just needed to update the Shadin t-stat does not update sometimes for 3 to 15 s.

NB: Larry, this is probably high enough right here for us.

LS: Okay.

3:31 PM

AR: Nick, how much do you think that will go up the other side of this thing?

NB: Probably not a whole lot, maybe a degree or two.

3:32 PM

NB: Art, the two temperatures are showing kind of -2°C or so. Do you think we should go down just a tad?

AR: I was thinking if it gets a little warmer on the other side of us maybe we should stick it out here and see what we get and then maybe if it doesn't warm up too much.

NB: Yes. Good idea. Let's try to keep it as level as possible.

AR: And they're probably interested in the horizontal passes to some extent I would think. Where they can make contrast measurements.

3:33 PM

DS: Have you looked at the 1-D probe at all, Art? This stuff looks very good.

AR: Great. Again the only concern is and I'm sure that's corrected that where it says 1-D cloud probe and the label says "liters". There's nothing I can do about it. It's probably really per cubic centimeter.

DS: Is that in the text display?

AR: That's correct. Just like you had to change the other day and change knots to meters per second because it wasn't correct. You had to go into the file.

DS: Yes. You're on node #12 back there.

AR: Right. You might double check to see whether that is correct or not because I never say anything over two and I'm absolutely certain unless there's something terribly wrong with the probe that it's about 10 to 100 times that much in the upper portion of that cloud system.

DS: Well, if we add all these together, we're seeing anywhere from, just a rough eyeballing it, we're going through anywhere from 150 to 200 particles total count.

AR: Right. But that's not the concentration. The sample volume on that though is about 1 liter per s at 100 liters per s, but I'm not sure how many of those would be rejected whether we're looking at the total count.

DS: I ignored the rejected ones when I made that statement.

TW: Don, do you want me to change that to read "cc?"

DS: Yes. Why don't you?

TW: Okay.

DS: I'm going to roughly look at the equations and see if it makes sense.

AR: Yes. I want to make sure because that will tell us whether it's working properly or not. I mean there's this historical perspective that we should have 10s to 100s per liter in these kinds of clouds on the 1-D cloud probe.

3:36 PM

AR: While we were chatting, we had a big surge in liquid water. That might have been that frontal modest cumuliform cloud that we saw coming out the backside. There's another one, 0.7 that's pretty darn good. That's 0.7 grams per cubic liter.

TW: Don to "chat."

AR: I guess I missed some of that wind, but it looks like the wind is back now from 220° to 205°. Is that what you've noticed, Nick?

NB: Yes. I've been looking at that. I imagine that there would be some sheer in here. So I guess that's not so surprising.

AR: That would kind of match those two clumps of high liquid water content.

NB: Yes. I think you're probably right that the high liquid water content probably was the signature of the front or at least one part of the wind shift.

3:37 PM

AR: Here's another big piece of liquid water and very broad spectrum out to 30 to 35 microns, so certainly very rimable droplets out there.

LS: Nick, we're just about 7 miles south of that point you gave us out there.

NB: Right. I'll call up. Stay on this same course. I'll call up the radar right now and see if they have a northeast point for us.

LS: Okay.

3:39 PM

NB: Say Larry, I've got the northeast point for you now.

LS: Okay. Give me about 10 s to get setup here and we'll copy. Okay. Go ahead.

NB: That would be 46°54'/124°09'.

LS: Say that lat again.

NB: The latitude is 46°54' and the longitude is 124°09'.

LS: Okay. Do you want us to go direct there now?

NB: Sure. When we get to that point, we'll climb 3,000 ft and essentially head along back out to our kind of former endpoint.

LS: Okay. The second point you gave me.

NB: Well, no. Actually I guess it was what our turnaround point which was near 46° 125'41 I believe it was. We probably won't go out that far, but just heading along that radial.

LS: Okay.

3:43 PM

NB: Art, I see the temperature now is starting to inexorably creep up.

AR: I think it went up about a degree in the last 2 min because I was looking at it not so long ago and it was -2.5°C and then suddenly it was -1.5°C.

NB: Okay. It may have been a little faster than I thought. I think we're at a good level though.

LS: I don't know what it is, Nick, but we're getting some lift in here from something.

NB: Yes. That's what I figured. We're getting higher liquid water contents. It's actually a little cooler showing that we are getting a little rise in motion right here.

3:45 PM

NB: Say Art, you might be interested. When I last talked to John, he asked if we broke out into the clear air. He thought that we would just be having kind of bright sunshine out where we were.

AR: There was a big hole actually, but it was 10 to 20 miles further out. I could see some white cumulus tops from the very horizon. So they were a way out, but there was something like that.

NB: You'll notice here, the liquid water contents have dropped way off. The temperature climb went down. We just kind of saw a little sort of some sort of bubble with its roots in the boundary layer.

AR: Yes. That's pretty interesting. We're still at the same level too because at the time I saw the temperature falling I thought well maybe we're climbing. Now it's dropped back down again.

3:47 PM

AR: How much farther to the endpoint, Nick?

NB: The endpoint is 46°54'/124°9' and so we've got about it looks like 20 miles or so.

LS: You've got 15 miles to go.

NB: 15, sorry.

AR: We don't seem to be affected in the low cloud area now. The bases have gone up and that higher layer is precipitating is headed out much like this morning since these clouds were lower and a little bit more like liquid water clouds. There were above us at _____ and then the cloud bases lowered on the way out. Then raggedy tattering sort of mess with the lower cloud bases marks the frontal zone rather than a good sharp line in these clouds.

3:49 PM

LS: Okay Nick. We're going to climb to 3,000 ft now and proceed back southwest bound to where we turned around the last time.

NB: Yes. That's exactly right. During the climb here, I'll be talking to the radar. I could almost shout to them actually. They're right underneath us.

3:52 PM

AR: Nick, how many passes do you think we'll be able to make on this flight on this thing? Do you have any number in mind that you think we'll be to pin it down?

3:53 PM

AR: Per up and per down both quite dirty with old water drops and mud and something on them.

3:54 PM

NB: Larry, Nick here.

LS: Go ahead Nick.

NB: I've got a new southwest point for us. It's 46°39'/124°29'. We're probably high enough right now if you can level out here it would be fine.

LS: Okay.

3:55 PM

AR: This is a great level for the Hallett-Mossup region. I was actually in here talking to the radar, Nick, and asking how many more legs we might view thinking that if

we climb too high we might get out of the Hallet-Mossup zone, which is kind of particular to this microstructure.

NB: Art, I can barely here you.

AR: I don't know how I'm doing this, but I'm turning that microphone sideways every time. I was just saying I'm glad we leveled out here. This is great for the Hallet-Mossup region for secondary ice development and had we climbed too high we might not have sampled this and so I was going to ask you how many legs we had just to make sure we could maybe slip this in.

NB: Right. I vaguely recall from KOS that we want this -4° to -5°C was kind of a good place to be.

3:56 PM

NB: Art, Nick here.

AR: Yes.

NB: Just for what it's worth, the new point that John gave us is not nearly as far back as we were before and I was just wondering if you have any idea of what they're seeing that we're not seeing?

AR: The only thing I would guess is that thing is really scooting on in here and it's all just translation not any particular thing. I guess we don't have to go into the clearing. I think John thought we were going to go into a clear sky overhead mode, but I guess he decided that maybe we didn't have to based on where we were before and he's kind of invected that point along at the speed of the front.

NB: Yes. Even that seems kind of fast for me, but perhaps he's just wanting to keep us in kind of the real juice.

AR: Right.

3:58 PM

NB: Art, it looks like we're seeing none of those kind of boundary layer plumes along here. I haven't seen any of the real kind of high liquid water contents or anything.

AR: I was looking for them, but aren't they still ahead?

NB: I think we were hitting some by this point on the way up there. But I wouldn't be surprised if they are kind of boundary layer phenomenon and they're just not able to get up this high.

AR: That's right because that wind shift isn't much that's for sure. I don't have my map up, so I'm just kind of going by gut feeling here. But I guess I'd be surprised if they didn't pop out somewhere in here. I'm looking ahead and I'm sort of expecting to say cumulus ahead, but you know I'll make it out 5 s before we go into it. Yes, we're going quite a way now.

NB: Yes. I'm still kind of puzzled why John wants us to turn around so soon because we are approaching the kind of turnaround point before too long.

AR: Oh good grief. Maybe he's made a mistake up there on the lat/long.

LS: Nick, in another 2 min we're going to be at our endpoint there.

NB: Right. There's the boss talking.

AR: It's funny. Maybe you should call him back and make sure. Hey, we're still going through this. Because my understanding was, in fact, we were supposed to take precedence if we hadn't popped out.

NB: Yes. I'll check with him. Larry, just keep this course for the time being if you would.

4:05 PM

LS: Nick, are you up? Would somebody get a hold of Nick and tell him that we're at our endpoint.

TW: He wants you to continue in this direction until otherwise told I think.

4:06 PM

NB: Larry, Nick here. Yes. If we could keep on this course for another 10 or 15 miles, hopefully we'll break through this and then make the climb up another 3,000 ft. Larry, Nick here.

LS: Go ahead.

NB: Yes. If we could just kind of continue on this course for another 10 miles or so, we should be kind of breaking through this according to our friends on the ground and then we'll climb another 3,000 ft and just kind of head back on the same track.

LS: All right.

4:07 PM

NB: Say Art, do you see anything ahead that makes you think like we're getting near something?

AR: No. The forward view hasn't changed at all in every direction as far as I can tell. We do have heavy stratocumulus, very dense looking stratocumulus below us and maybe that is the top of that boundary layer stuff. Maybe it's not going to get up here. I'm beginning to think you've got this psyched out.

NB: Well liquid water contents are now just starting to come up in the 0.1 g/m³ region. It's nothing like the 0.5 to 0.8 g/m³ we were seeing.

AR: Yes. If it's coming up from the boundary layer at this level, you expect to see a gram or more in any turret coming up even at this modest level.

4:09 PM

AR: Okay. We're starting to see some brightening now. You can see it too, Nick, I'm sure at 1 o'clock and with that also the lower clouds are starting to look a little more tattered.

NB: Okay. That's good. Then I think we're in pretty good shape with the latest point established.

4:10 PM

JR: Got a break in the layer about 1 o'clock.

AR: Roger that. That's the back end.

4:11 PM

AR: Actually, it would be very pretty out there, Jerry, if we went that far. It would be just gorgeous, the sun setting, all the layers of clouds and vast open ocean with cumulus here and there. It would be gorgeous.

JR: Yes, but you wouldn't be happy, Art.

AR: Well I kind of like cumulus clouds better than this flying in the fog for 6 h.

NB: Well I think the desire for basically a homogeneous kind of air mass is being fulfilled during this second phase of this flight. Boy, I don't see much in the way of wind shifts or temperature changes.

LS: Nick, did you want to climb in the reversal here?

NB: Yes. Let's keep going just for maybe a minute or so longer. Maybe we'll actually kind of clear this a little bit more, then climb 3,000 ft and head back on the same radial.

LS: Okay. It's starting to open up out in front of us now.

4:12 PM

NB: Art, what do you think? Is it time to climb?

AR: Sorry. I keep turning this mike the wrong way. Yes. It looks like nothing but stratiform light precip ahead and it's sort of lifting and fading. We won't clear all the precip here, that is the complete backside for probably another 2 min, but probably what's out there is trivial.

NB: Okay. We might as well climb up here and kind of head back toward the northeast.

LS: Okay. Here we go.

NB: Art, I figure maybe shoot for around the -8°C level or something.

AR: You know, from this level I would probably go to -12°C or so and look at the bottom of that dendritic zone and see what's fallen out of there in terms of fragmentation and that kind of thing. But heck, it's probably not going to make that much difference because if there's no growth mechanisms between say -10° or wherever we'll be, -11° , why it won't make that much difference to be at -11° or -12° or -13°C .

NB: Yes. I'm just trying to kind of figure out the end gain here. We'll probably do three more legs I would imagine. So back at -8°C and then out again at -12°C or something and then the final one in at whatever.

AR: Whatever we climb to?

NB: I think it's more going to be wherever the tops are at.

AR: It's starting to get pretty out there.

NB: Yes. This is definitely a good place to turn around. There was no reason to go too much farther southwest.

4:15 PM

JR: Look at those clouds off to the right, Art. They kind of look like a wave.

AR: Yes. Isn't that pretty.

NB: The setting sun does help.

AR: Yes. I see those clouds you were talking about, Jerry.

JR: It looks like wave action out there.

AR: You see we're bouncing off the ocean. All that airflow is rising and falling with the ocean swells. Ha ha.

4:16 PM

LS: Hello Nick.

NB: Yes Larry.

LS: That fueller misunderstood me, so he filled the mains for us. So we've got plenty of fuel if that's your intent.

NB: Okay. I'm just talking it over with the radar with how many. We'll certainly do one more out and back after this one. We're talking about whether they'll be two more and just how high these clouds go.

LS: Okay.

4:21 PM

NB: Hi Larry, this is Nick. The new northeast point, which is basically the same one we've been going to, is $46^{\circ}54'/124^{\circ}6'$.

LS: Okay. That's just about 1 1/2 miles east of where we were before.

NB: Yes. Essentially the same is fine.

LS: Okay.

4:22 PM

NB: Art, you might have noticed that our winds are down a little bit. That's exactly what the forecast soundings for Astoria and Quillayute were showing also that the kind of wind max it around 850 mbars or something like that and then dropping off with height to a certain extent.

AR: Well I'll be darned.

NB: What good are we, right?

AR: Yes. I know. What good are we? Cliff will be having a drone plane flying offshore next year.

LS: Nick, the front is past Hoquiam now and the altimeter is starting to rise there or the barometer rather.

NB: Right. I would anticipate that these legs or going to get kind of shorter and shorter as the whole thing moves in. But basically this same radial is a good one for us to just kind of stay on.

AR: Larry, did you get a wind direction out of Hoquiam?

LS: No, Art, I didn't.

4:25 PM

NB: Yes. I'd actually be kind of surprised if the wind shift is through there and that the pressure is rising and it is now that I think about it a little bit curious.

AR: Every once in a while you see one where it's not taking a sharp rise, it's just kind of bottoming out and then beginning to turn up. That happens a little ahead of the wind shift. Yes, I think you're right. I doubt whether that wind shift has got there.

4:26 PM

NB: It looks like the HVPS might be kind of flaky here.

AR: The wind is picking on more than one person's flight. The CPI and the HVPS were just not quite ready for prime time.

4:27 PM

LS: Nick, it looks like we're at the northern coordinates there. Do you want me to turn around and climb 3,000 ft?

NB: Yes. That's correct.

LS: Okay.

4:28 PM

NB: Larry, Nick here.

LS: Go ahead.

NB: Our southwest point along this leg is $46^{\circ}42'/124^{\circ}26'$. It should be basically along the same radial.

LS: Okay.

4:32 PM

AR: This has been pretty boring. I haven't seen much in the way of change in the horizontal legs here, bursts of crystals, large crystals, changes in visibility, and what have you here at this particular time, which is 003240. Looking over head it does appear that there is a liquid water layer, embedded altocumulus layer, above the flight level. Probably 70% confidence level on this one. I'm not really clear if that is what's up there. Our flight level is just about 13,000 ft. Estimating liquid water layer maybe 16,000 ft.

4:35 PM

AR: Since we don't have the 2-DC, I have to judge riming by the HVPS and you can't tell a thing really on that. However, I would say that there's a little indication of riming.

NB: Hey Art, Nick here.

AR: Yo.

NB: So our wind speeds just within the last 5 min have picked up from 18 meters per second. They're close to 30 meter per second. I'm not sure what that's all about. Do you have any idea how much more kind of precip in cloud we've got above us?

AR: When we came out of the back side there, it looked to me like the tops were going to be above 20,000 ft. I didn't get a hard look at it and I don't know that I could do any better.

NB: Can you figure out why there would be such a speed increase here? I'm a little baffled by that.

AR: Yes. I would just be grabbing at straws. I've no idea. That seems very unexpected to me. The temperature dropped a little bit, but I don't know. I think the direction is pretty much the same or did it swing around too a little bit?

NB: The direction seems about the same. What is implies is just actually quite a bit of convergence at this level, which is just kind of bizarre.

AR: It's sort of interesting and whatever the temperature was it seems to have gone back to where it was, so it probably wasn't anything real.

LS: Nick, about another minute to our southern point there. Up 3,000 ft and reverse, is that the scoop?

NB: Yes. I'd just like to discuss with Art briefly whether we should maybe continue on again just a little bit farther. It seems like the radar always kind of underestimates how far this stuff is.

LS: Okay.

NB: So Art, what do you think, kind of continue a little bit further in this?

AR: Let me take a quick look downward. Sometimes if we're in that overhang that has some precip aloft you think you're in the precip, but actually you're just in some overhanging clouds. I guess you could probably look down and see what you see, if you see the sea surface or not.

NB: Yes. I don't really see any there. But you're a better judge here.

AR: Let me just take a gander at it.

4:41 PM

AR: I'd say we should bare on here a little bit farther only because when we broke out of that frontal zone we lost the thick stratocumulus, the glorified stratocumulus, really that was in that wind shift zone that didn't even peak up to 7,000 ft. Right after we got out of that then that stuff kind of thinned out and became more broken to scattered and that should allow us to see down and say here we go. There's a clearing out about 1 o'clock now, Nick.

NB: It's definitely lightening up, so maybe in another minute that would be a good time to turn around Larry.

LS: Okay.

AR: If we just keep talking long enough, then we break out. We'll probably run out of tape.

4:42 PM

NB: Yes. It looks like some pretty thick stuff above us. I don't know if 3,000 ft will bring us back up into it. But like you were saying, the tops here are pretty thick.

AR: Right. This kind of stuff is going to go way up. I'm guessing it would be about 25,000 to maybe even 30,000-ft level that we saw encroaching on us when we made that last clear air turn. There were the higher tops of what I think was this band. When you get around and get around the other side, you can see all this merges. That higher layer just merges down into the lower stuff here.

4:43 PM

NB: Larry, I'll check in with the radar, but right now you can go back toward that last point that we had before, $46^{\circ}54'/124^{\circ}6'$.

LS: Okay.

4:44 PM

NB: So Art, Nick here. John wanted us to keep flying this as long. As we were still in precip, he's very keen on getting the stuff near the tops.

AR: Okay Nick. I had another thought on that. After I thought about that first band we went through and how the second one looked as we turned around and went back just before it came into the research area. I think my tops were too high. I think they're going to be in the 20,000 to 25,000-ft region. I think this is going to be one of those where the third portion has the higher tops. I'm trying to put together a picture here of one of these mushy fronts that sometimes we see with the high tops that sometimes we can detach from the frontal system itself and move off. I have a feeling this might be that kind of colder type. So I'm guessing we're going to get something we can fly in and get to the tops now.

NB: Okay. So that's all the more reason. Now as it's moving on, we have to go less and less far to just kind of go ahead and do another run out to it and back.

4:47 PM

NB: Now I'm correct in assuming that the 1-D probe is working okay, right?

AR: That's affirmative. It looks like it is producing a normal spectrum.

4:48 PM

AR: If there's a fly in the ointment on that, it's that the indications were, if you took them at face value of 0 and 1 or 2 per liter, and if that turns out to be the case if that's a correct calculation per liter, then there is something wrong because we would certainly not be seeing values that low in this kind of cloud situation.

NB: Larry, Nick here. I see we're approaching our kind of magic endpoint.

LS: That's right.

NB: So like we've been doing, climb up to 19,000 ft and just kind of reverse course. At this time, I don't think we're going to have to go quite as far as we did before. So for the southwest point probably $46^{\circ}42'/124^{\circ}26'$ would work pretty well.

LS: Okay. Say those again.

NB: It's $46^{\circ}42'/124^{\circ}26'$. The same ones we said before but that we flew past. This time that's about where we'll fly to.

4:52 PM

NB: So Art, do you think there's any reason to start taking these legs a little further inland to kind of follow them in with the system itself?

AR: The only reason why you'd do that I guess is for the microstructure, but we're running a little bit short as we get higher up because of the low resolution of the HVPS. I guess overhead of the radar and in the immediate vicinity they're not really getting much in the way of data. Is that correct?

NB: Yes. That's a good point. It probably makes sense just to stay out here along this same track that we've paved essentially.

AR: It doesn't seem to be changing much with time.

4:53 PM

NB: I'm switching to talk to the radar.

4:54 PM

LS: Say Nick, did you want 19,300 ft or did you want 19,000 ft?

NB: It doesn't matter that much. I guess 3,000 ft from our last leg. Whatever that gives us. I know there's an offset on the altitude I'm looking at here. Yes. So 3,000 ft above the last one.

LS: Okay.

4:56 PM

LS: We're level now.

NB: Say Art, Nick here. So what John is looking for here on our last leg (we're heading southwest now, but on our last in-bound leg heading toward the

northeast) is something as high as we can go but still in precip. If you have any sort of ideas of where that might be, that would be good.

AR: I think we are going to have to push it above 20,000 ft. That's for sure. I don't see any thin spots up there, although sometimes that's misleading. I think we might have to go to 25,000 ft as we did before. There was a bit of a top that we did hit at 25,000 ft in the first rainband. The stuff in the second one, the leading edge, at least was above 25,000 ft. So I'm guessing that if it slopes down it's still going to be in the 20,000 to 25,000-ft region anyway.

NB: Right. Since we're at 19,000 ft here, we want to go at least to 22,000 ft, but the question is whether we want to try to get it higher than that.

AR: Roger. I think we're going to go up there and find out. I really can't tell without a sun or moon out there to really judge the thickness a little better.

NB: Right. I assume you heard that, Larry, that when we get to this southwest point we'll climb up to at least 22,000 ft and probably a bit higher than that and just kind of see what level we head back on.

LS: Okay. It's going to take us a while to get to 22,000 ft and I can't guarantee you we're going to do it because in the clouds here we have to have our anti-icing on.

NB: Yes. Roger that.

AR: Yes. We should break out there. I think we still may break out underneath the higher shelf.

4:59 PM

AR: There's a thin spot overhead lasting about 2 or 3 min and now it's gone. It's hard to tell whether it's because the sun is setting or it's really gone. I don't see it now. At that time it gave me an impression that the cloud tops were sloping downward as we head southwest, but no sign of that now.

5:04 PM

AR: Do you need me to log out or anything, Tom?

TW: No.

5:26 PM

TW: You might want to go to the instrument page or the startup page here actually and just recycle all those node 1, node 7, node 9.

DS: I don't need to do anything with it.

TW: No. I restarted it actually.

DS: So node 1, check. Node 7 check. Node 9 check. Okay. Those are all up. I don't have a display now on the server.

TW: Yes. I'm watching it back here actually.

GG: We have data again.

TW: Okay. I don't think we were recording.

5:32 PM

AR: Our lens went catty wampus here. It's awful cold at 10,000 ft. It is -18° , -19°C .

DS: The reverse flow thermometer says it's -6.4°C .

AR: That's credible. I'm reading out -19.5° ...

END OF TAPE, SIDE 1

DS: ...second as well so.

GG: The Shadin is showing 0° and 72 meters per second.

DS: Yes.

AR: What do you think happened there? When this thing shut down before that, everything was looking pretty good as I recall.

DS: I would trust those, Art. Those are probably correct.

AR: No way. No way in the world.

TW: You always say "no way," Art.

NB: Yes. There's no way it's -18° or -20° at 10,000 ft.

DS: That's an incorrect capture. I'm not sure what he's looking at there because the reverse flow says -6.7°C . He may be looking at the Shadin temp or something like that.

AR: That's the same one I've been looking at the whole flight. It's been correct the whole flight and it's the same winds. The winds certainly aren't 255° at 70 meters per second. That's way out of whack.

5:34 PM

GG: Take a look at your true air speed and your ground speed, Art.

AR: True air speed is 190 meters per second. I can go with that.

GG: Ground speed is 110. It's almost 80 meters per second difference.

AR: Yes. That's where that's coming from. I think we had some icing event. Something has clogged that thing up.

GG: The ground speed is derived from the TANS.

TW: That true air speed being so high is not going to. I don't think the HVPS might not like that too much.

GG: Yes. The true air speed seems to be a bit high, doesn't it?

AR: Yes it does.

GG: And that comes from the Shadin.

AR: That depends. We have the Rosemount true air speed and the Shadin true air speed.

GG: Well, the calculations I'm making for the winds come from the Shadin.

AR: True air speed has been 190.9° and hasn't changed a decimal here, so it's dead.

GG: It just changed to 190.8.

AR: Yes. That's right. Just as I said that.

GG: It does seem a little high.

5:36 PM

AR: The chilled-mirror dew point temperature is -11°C . In this situation it should be very close to the ambient temperature. Whoops, there goes t-stat. It's now -9°C . There we go.

TW: The TANS just started working again.

LS: Nick, are you up?

NB: Yes. I'm here. I'm waiting for my turbulence though.

AR: Yes. I was thinking that maybe they're just coming over the edge here, so I'm going to sit down.

LS: We're going to Paine now. We just checked your endpoint.

NB: Well, no. Is that 48°13'?

LS: No. 148°13'. It was 48 00.

NB: I tried to give 48°13'. Is it possible to kind of continue north?

LS: Well, I've already turned off your heading there, but I can.

NB: Yes. I'd appreciate it actually. Yes. Continue north here for 13 more miles.

AR: Oh man! I thought we had just gotten away with something. Now I'm sure we're going to get that turbulence in the next 13 miles. I think you did say 38 even there, Nick.

NB: Yes. Sorry.

5:38 PM

NB: It looks like Port Angeles is right below us there.

AR: Yes. Beautiful. I'm still shocked at the small _____ there. I figured that by now certainly we'd see some bumps.

NB: Nick, we're going to have to make our turn here real quick because we're going into Canadian air space.

NB: Okay. Roger that.

5:42 PM

AR: Testing 1, 2, 3.

GG: Loud and clear.

AR: This is supposed to be record. Test.

DS: You're broken, Art.

AR: Yes. I think so. Oh rubbish.

DS: You're recording up here, so go ahead and go for it.

AR: It's a sure sign of dementia. I'm turning a knob that I'm not connected to.

TO SUMMARY

5:50 PM

NB: So Larry, do you want us in the back of the plane again?

AR: When he gets close, he can't talk to anybody. He may eventually answer you.

TW: Don to "chat."

5:51 PM

DS: So do either you, Nick, or Art have wishes for keeping stuff running to any particular time?

NB: Yes. I don't need anything else. I don't think we necessarily need to have things running. What about you, Art?

DS: Art? It takes about 5 or 10 min to copy this stuff at this point and we're about that many minutes out. Tom?

TW: Why don't you go ahead and shut it down. We're only like 5 or 10 min out now, so I'd go ahead and do it now.

TW: Okay.

5:53 PM

DS: Do you have the server shut down?

TW: Yes I do. I was hitting my mouse button to talk.

DS: That doesn't work to well.

TW: No. It doesn't.

GG: If the mouse responds, you're in trouble.

DS: Squeak, squeak.

TW: I think that would be a wiring problem.

DS: No. That would be a physics problem because we'd have some kind of odd tunneling going on.

5:53 PM END OF TAPE

Summary of UW Flight 1849

AR: I was going to squeeze in a little summary here but on the record of what worked and what didn't work and a few weather words. Nick, it's kind of a tradition on the flight to say what you thought of it in a paragraph or so.

DS: Go for it.

NB: So Art, do you want me to do one too?

AR: Yes. Peter will be looking for it. If you want to start out and say how you thought the flight went in general, what essentially we did, how many legs and so forth if you have that there. If you don't, we're pretty close to landing. I don't find it a big deal if it's not there.

NB: Right. Why don't you go ahead and go first? I don't know exactly how many legs we did. I could count them up. Yes, I'm willing to do it. So why don't you go ahead and let me know when you're done.

AR: Okay. I'll just say it out loud then I guess. Today's flight we had two flight actually, one in a pre-frontal band. Well I'll let Nick cover that kind of stuff because I might get the jargon mixed up. Anyway I'll talk about what did work.

We had some improvement in our 1-D probe, which did not work in the last few flights. It was fixed by Don and maybe Grant. (crosstalk) ...have good spectra the whole flight. So that filled an important gap in our precip spectra, the small end anyway. The HVPS was generally going through its periodic outages. They seemed to be particularly when we were changing elevations. So maybe temperature changes, pressure changes were altering some electronics in some way or condensation on the lens possibly when we were descending. It's hard to say, but most of the time it was good. We had good winds again. The temperature looked good. t-stat seemed to be solid most of the time. There was one period when we had some glitches and the temperatures were not accurate for maybe 5 to 10 min. Other than that I thought the liquid water measurements were good. The other thing we really lack is a CPI, which is being repaired, and the 2-

DC, which has still got some tough problems to solve. They maybe intermittent or something. That's about it.

Cloud-wise the first system I'll mention was one in which we approached and had largely virga as we entered the precip. In the lower cloud was falling precip. Then as we got into it we sampled a few brief little cloudlets here and there, but generally it did not have significant liquid water.

In the second flight we were back in the richer liquid water content near the ground wind shift. We had water contents up to about 0.7 in some of the stratocumulus clouds around I think it was 5,000 ft. All these clouds did not extend much above 5,000 ft. At 7,000 ft we didn't hit nor did I see any top of that wind shift line forced heavier stratocumulus/cumulus mediocris line and, in fact, that was kind of tattered. It really wasn't in a good line, but in several clumps of clouds over maybe a 5 to 7-min period over which time the wind was shifting gradually. Not much in the way of temperature discontinuity either. The water on the bottom of the broad spectrum good for riming accretion, so it was doing it's part even if it wasn't much to add a little bit to the precip. Aloft mainly glaciated. We didn't see any embedded altocumulus that we sometimes see in the more active systems. Cloud tops were as a rule above 20,000 ft and they were glaciated.

I think that's about all I'm going to say. We're almost going to land anyway.

NB: Right. All I need to add to that is that there were a total of 7 legs flown on the first phase through the pre-frontal rainband probably associated with the cold front aloft. We had precip up to 17,000 ft on that one. The second one was a rainband probably associated with an occluded front and a wind shift at the surface. It had 9 legs in that one with precip up to 22,000 ft. That one it was either asking to see the cooler plumes of boundary layer moisture up to the 4,000 ft level but not up to the 7,000 ft level. So there was a lot at 4,000 ft. Quite a bit of horizontal gradients in liquid water content. So that will be something interesting to look at perhaps. For the Olympic transect, definitely precip on the windward side and very little on the leeward side and almost no turbulence to my surprise. That's all.

AR: Yes. If I have any more surprises, I'm going to think I don't know anything about weather.

GG: This is Grant. I just wanted to add that our faithful little KA-band radar, which was working great yesterday and on our last flight, apparently suffered some damage maybe in a heavy landing or maybe there's water in the wave guide. But it gave a serious arc and we shut it down. So we need to trouble shoot that.

AR: Thanks, Grant, for mentioning that. I'd forgotten that altogether.