

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

Date <b>2-8-01</b>	Flight Number <b>1858</b>	Experimental Observations  TARGET OF FLIGHT WAS RELATIVELY NARROW, QUASI-STATIONARY COLD FRONTAL BAND (LATER CALLED AN OCCLUDED FRONT) ORIENTED N-S JUST OFF THE WA COAST. THE FLOW WAS SOUTHERLY, AT ALL LVLS. BECAUSE THIS BAND WAS LOCATED IN THE DEEP COLD AIR INSIDE THE BAROCLINIC ZONE, WINDS WERE RELATIVELY LIGHT 10-30KTS, AND THE TEMPS COLD (700mb, -12 TO -14°C). THE FLIGHT LEGS WERE RELATIVELY SHORT ~ 12 MIN DUE TO THE NARROWNESS OF THE BAND. MOST LWC IN SIDE BAND WITH COLD-FRNT LIKE LN CU-SC NLR LGR FRDR. SUPERCOOLED DZL, ICE MULT, GIANT AGGS, BUL. ROSETTES, GRAVEL OBSERVED.  MOON BRIGHTLY. USBL WHOLE LEG AC JUST ABV FL				
Project name <b>IMPROVE D=5:02</b>						
Engines on time <b>0153</b>	Engines off time <b>0655</b>					
Departure airport <b>PAE</b>	Arrival airport <b>PAE</b>					
Flight Scientist signature <i>(a. Reynolds for)</i> <b>N. Bond / A. Reynolds</b>						
Pilot signature <i>(Chulhwa)</i>						
Surface met. & visual obs. at takeoff <b>E5@-39R-F</b>						
Research crew <b>BOND GRAY SURGEON RANGNO</b>				Equipment failure  RZG LVL {		
						Ac
						As
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Sc						
St						
Cu						
Cb						

Flight 1858  
February 8, 2001  
Voice Transcriptions\*  
IMPROVE-1

6:09 PM

AR: We're a few minutes into the flight. It's 02:08. I'm going to back up here on the time to mention that as we took off I could see the city of Seattle and we were between droplet layers and flying in the precip.

6:11 PM

AR: After being down below here and working on the computer and getting it going and getting back to the bubble, we've since broken out on top of the main precipitating layer now above us is it looks like broken altocumulus.

GG: The antenna seems to be switching now.

6:16 PM

AR: The CPI is up.

DS: Art, you really can't turn the CPI on until the program is up. It just freezes everything.

AR: Don, you told me to turn on the probes so the software would know the probe was there. So I'm following your instructions.

DS: I must have said it backwards. I think I meant it the other way around.

AR: Okay. That's fine. I thought maybe it was good to get that thing warmed up.

KM: How's the temperature back there?

AR: It's excellent back here in the bubble area right now. It's beginning to warm up and it's very comfortable.

KM: Let us know if it changes.

DS: Anyway, Art, the images look good. The day I spent cleaning it and getting it dried out did the job.

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\* AR = Art Rangno, DS = Don Spurgeon, GG = Grant Gray, KM = Ken McMillen (pilot), LS = Larry Sutherland (pilot), NB = Nick Bond

AR: Very good Don.

6:17 PM

AR: We don't seem to have any overlying cirrus here. It's very cold about  $-14^{\circ}\text{C}$  here at just above 700 mb. So an extremely cold air mass looking to intersect a sharp cold frontal with heavy convection as seen on the Air Force weather agency visible satellite image of 2346. Right now everything is stratiform without indicating flow broken altocumulus kind of large globules more looking like stratocumulus, but nevertheless that is altocumulus being about 2,000 ft above the aircraft. There doesn't appear to be very much above us, perhaps some scattered patchy ice cloud. See lots of stars and we have a full moon tonight, but it's not up yet.

6:18 PM

AR: Ice crystals nice dendritic types of the type that were landing on the ground in Seattle. Some single stellars, a little riming indicated, and we're about to go into some higher tops and precip ahead. They look like they've kind of merged together with the higher layer, which I'm estimating (if I didn't say it before) is about 2,000 ft above the flight level. That would be the altocumulus layer.

6:20 PM

KM: We're about 40 miles out of Hoquiam where the radar site is at this time. Let us know what your first point is going to be as soon as you get it.

NB: Say Ken, Nick here.

KM: Standby.

AR: Gorgeous dendritic aggregates here. Very delicate looking suggesting not being rimed.

KM: Go ahead.

NB: Yes. At least when I talked to Mark, the same kind of track that he originally got kind of faxed was what he wanted to do. So our first point would be right over the radar site at  $46^{\circ}54'/124^{\circ}06'$ .

KM: Okay. So the first point is the radar site. We've got that. Do you have any westerly point yet?

NB: I'll call John in the next minute or two and check with that. Tentatively, it's about 25 nautical miles due west of that point.

KM: Okay. Thank you.

AR: Some of the aggregates just then were about half an inch in diameter according to the 2-DC, about 10-12 mm.

GG: The radar transfer switch is frozen downward again.

6:25 PM

KM: When do you want to start the first pass over the radar site?

NB: 500 to 1,000 ft if we can do that.

KM: Okay. I can probably give you somewhere close to 1,000 ft then. Okay.

6:27 PM

AR: Flying just at cloud top.

NB: Say, it looks like the 2-DC is kind of on the fritz.

AR: I don't think there's anything out there. We're just flying a few feet from cloud top and sometimes we find they're image free up there at least the large particles. I think maybe that's what is happening, but we'll check it. See that one last image there on the right is a streaker type thing. I'm sure you've probably seen those.

NB: Okay. Come to think of it, there's not much on the HVPS also.

AR: So far I can see fairly well actually because of the stars anyway.

DS: The probe is fine.

AR: I can't see the stars now.

6:29 PM

NB: I suspect you're going to get some kind of ice buildup on your bubble there.

AR: In the forward direction, yes it is. Kind of breaking out in here, Nick. You can make out a little of the dusky sunset yet. Just a minute ago we had a view out about 2 o'clock that was pretty nice.

NB: Yes. I'm on the wrong side of the plane for that.

AR: 2 o'clock.

6:30 PM

AR: I can see the horizon again. We're breaking out here if you want to take a gander up there at about 1 to 2 o'clock maybe even out the right wing, unless I'm looking at city lights.

NB: Yes. I think that might be downtown Aberdeen or something.

6:32 PM

AR: We're descending between layers now. We've left the ice shedding altocumulus layer. There was no precip reaching the ground according to the radar here.

DS: I just started recording on the forward video.

AR: Don, we won't need much after about 15 min here.

DS: You can't see much on the video camera anyway. It looks pretty black out there.

AR: It's amazing how it will be almost pitch black and in later viewing I'm surprised at how much you can see. But anyway in about 15 min you can probably just shut it off.

DS: Yes. I can't see anything on the screen right now, but that doesn't mean anything because I've got a pretty small screen.

NB: Ken, Nick here.

6:34 PM

LS: Nick?

NB: Yes. I have a new west point for you.

LS: Go ahead.

NB: It will be at  $46^{\circ}54'/125^{\circ}46'$ .

LS: Okay. We've got that. Nick, we've got that. We're coming up on the radar.

NB: Yes. It's okay. If we can continue this descent. When are we liable to get down to 1,000 ft.

LS: Standby. We can't descend until we're about 10 miles off the coast. If we get VFR at that time, then we can go ahead and descend real far. We might be stuck at 3,000 ft as long as we're IFR.

NB: Okay. Thanks.

LS: We just checked the radar site and we're outbound now.

6:36 PM

AR: No stars, continuing in light liquid water content. FSSP 100 or so, 120/cm<sup>3</sup>. Liquid water contents 0.2, 0.3 g/m<sup>3</sup> at times and we're holding steady at 3,700, -3.1°C, and occasional drizzle drops of the smaller variety off around 100 to 200 microns. The wind hasn't changed much direction. At least at 700 mb it was about 215 meters per second and here it's 197 at 14 meters per second and 0.4 g/m<sup>3</sup> in liquid water content.

6:37 PM

LS: Nick?

NB: Yes. Nick here.

LS: If you could talk them into moving that track up about 10 miles north into the warning area, we could go down as low as we want to go.

NB: Okay. I'll check in about that. But pretty soon here, do you think we could drop at least to 3,000 ft, right?

LS: Yes, in another minute.

AR: Precipitation increasing with the addition of columnar ice. Notched columns nicely presented. No long needles yet. Flying just above -3°C, so we're in the Hallet-Mossop zone.

6:39 PM

AR: Grant, do you copy?

GG: Yes.

AR: I guess the switch is okay now?

GG: Well, it wasn't switching. Oh, there it went up. Okay. It's looking up now.

AR: Roger. I just noticed that.

GG: Yes. There's something goofy going on there. It was working okay yesterday, but just after we took off it was frozen again.

6:40 PM

AR: Tops now looking at this radar about one division, 5 nanoseconds, indicating only 750 meters. So these must be aggregates of needles and columns. At first I mistook them, I was about to say that they were lower temperature crystals, but they apparently are not. I'll probably have to check the CPI for that for sure since I can't see well enough from here.

6:42 PM

AR: Liquid water content is still appreciable, but down to about 0.1-0.2 g/m<sup>3</sup>. Droplet concentrations now varying maritime in the middle tens.

LS: Nick, we got 2,000 ft here for now.

6:43 PM

LS: Nick, did you get that? We're going down to 2,000 ft.

GG: He's on the radio right now.

NB: Hi Larry. It's Nick. I'm back. I talked with John about moving our whole pattern a little further north. But he thinks if we can get down to 2,000 ft, that that's low enough.

LS: Okay. We're out of 3,000 ft for 2,000 ft.

6:44 PM

AR: Precip seems to have ended with a burst of drizzle as we pass through the freezing, which was right around 2,500 to 2,700 ft.

6:45 PM

NB: Yes. This is plenty low enough. We're definitely in all rain and temperatures are well above freezing. So this is good.

LS: Okay. Here we are.

AR: Starting to get some small raindrops. Still continuing to find liquid water. Droplet concentrations a little higher than earlier, now getting into continental range, 150, over 200/cm<sup>3</sup> there. We're losing some ice.

6:46 PM

NB: Art, you might notice these wind speeds now are getting up to 18-19 meters per second. Quite a bit stronger than thought.

AR: Right. Those are the strongest winds we've seen at any level if I caught all the winds anyway. I think that up at 700 mb it was about 10 and 12 meters per second if I recall.

NB: Yes. That's correct. They're all going together with a little bit more vigor than we initially saw. Also, there is definitely an easterly component with it down here, 166° or so.

AR: Roger that. It has certainly come around and along with that I have seen some droplet concentrations over 200/cm<sup>3</sup>, which certainly suggests a land origin for that aerosol loading of these clouds anyway. If we do hit a front, it will be interesting to see those. They should drop off.

6:48 PM

AR: Larry, do you see anything on your radar ahead?

LS: We sure do, Art. Just coming into it here in about another 1 min, a nice band here.

AR: Thanks.

6:51 PM

NB: Art, have you been watching the J-W at all?

AR: I don't pay too much attention to it. I mainly watch the FSSP and the PVM liquid water contents.

NB: Yes. I'm not sure how important that is because I haven't seen anything but zeros when I've glanced at it.

AR: Yes. It could be dead. They were all working on the last flight. All of them except the FSSP had some noise problems.

GG: I seem to have activity on the J-W here. It's zero right now, but it was following the others fairly closely about 20 min ago.

NB: Okay. I figured there would be at least some liquid water out here.



AR: We're kind of between clouds right now.

GG: I'm not getting much activity on the 2-D or the HVPS either.

AR: It must be the calm before the storm. There's a sharp band out here ahead.

6:53 PM

GG: The HVPS is starting to pick up now and the 2-D

6:54 PM

AR: Here we go.

6:55 PM

AR: Gee, is that it?

NB: I don't think so. Our winds are only 180°. They have only come around about 10° to 15°. So that's not a cold frontal rainband. It's maybe a rainband.

AR: Right. I've got some pretty big drops here on the bubble and I can hear them through this thick bubble. They're pretty large. Of course, they could have some ice in them at this temperature.

DS: Yes. Some of the spots on the CPI look like they're probably solid blocks because we're getting Fresnel rings around them and I can't remember what that real bright spot in the center is called, but that's caused by the diffraction of the laser around a very small hard object.

LS: Say, Art, did you find me a cup?

AR: We only have the shop sized ones, but I'll certainly bring something up to you.

LS: Okay. I'll appreciate it.

AR: Do you have any condiments up there?

LS: We're without anything.

6:56 PM

LS: Nick, we've got about 2 min to go. Do you have a point for us?

NB: Yes. What I'd like to do is kind of go along on that same track. Let's see we're at 2,000 ft here. Probably at 4,000 ft, so spiral up to 4,000 ft and then we're going to do a level leg back to the east. Once we get up there, I'll get a new east point.

LS: Okay. I can make that climb in the 8260 and then we'll just check it and go back east.

NB: Sounds good.

AR: Do you have anything in your radar out here, Larry?

LS: Yes. We've got a fairly large target just to the south of us and 10 miles ahead. So we'll go into it in the climb.

NB: Well, if you do see that ahead maybe if we could continue this to that point that would be good.

LS: You know it's just a little tip out there. I don't think it's worth your while.

NB: Okay.

AR: I'm seeing some stars now.

NB: Yes, Art, and the winds have come around from 200 or so. So we're getting a westerly component at least.

AR: Gee, very disappointing.

7:01 PM

LS: Nick, we can go another 5 miles out here if you want and see if there's anything in that that you want.

NB: Yes. I guess that wouldn't hurt. I don't think we're really pressed for time so to speak.

LS: Okay.

7:02 PM

DS: It's almost Friday.

GG: Your point being.

DS: The point being the strangeness should be expected.

AR: Tops are running about 3 kilometers above the aircraft at this locale. They would probably be debris clouds from some cumulonimbus because we're not getting rain at this level at this second anyway, 190130. It's working its way down now. So let's see if the radar is correct.

7:03 PM

AR: It looks like it ought to be raining right here, but I don't see the 2-D rolling over.

7:04 PM

AR: Some cloud wisps. It looks like there's just enough dusk light that we're coming into it looks like a cumulus here just ahead. We'll see if that's correct. Another 30 s then.

7:05 PM

AR: More stars visible.

LS: Nick, we'll just stay for a little bit of this stuff here, but there doesn't seem to be much.

NB: Right. I see our winds are coming around even more from the south now. So I guess at this point if we could climb up and actually I'm not sure if 4,000 ft will be too high, but maybe 3,000 ft would be better.

LS: Nick, I think we're through it. I see the stars ahead, so do you want to go ahead and do our reversal and climb?

NB: That's correct, but it might 3,000 ft rather than 4,000. We'll just have to see what the temperature is when you get up there.

AR: Yes. I think the freezing level of 2,700 ft back there. I guess it's a little lower out here now.

NB: Yes. So if we could climb up now, Larry, up to 3,000 ft rather than 4,000 ft I think would be about the right level.

LS: Okay. Then I'll start a reversal now. Okay?

NB: Yes. That's good.

AR: I was just looking at the radar in the up position and that looked like kind of a convective debris cloud with a lower hanging virga in the middle and sort of a sliding upward in a low toward the edges of it. I never did get new images on the

2-D suggesting that it didn't make it down, although the radar seemed to indicate that it was getting to the ground early. I don't know, maybe my 2-D is stuck here.

DS: No. The particles are barely showing up on the FSSP. They were in the lower four or five channels.

AR: Roger. That would be those low clouds, the wisps.

DS: The CPI would verify that as well because particle drops that show are very, very tiny.

7:08 PM

DS: Art, do you get a chance to look at any of the calibration stuff I gave you?

7:09 PM

DS: Art, go to "chat."

7:12 PM

AR: Nick, by the way, we think t-statr is reading perhaps a degree too low.

7:13 PM

AR: We're going back into that debris cloud and this time there was at least a sprinkle. No stars visible.

NB: Art, you were saying something?

AR: Yes. Our t-statr, which is probably our best temperature, is probably a degree maybe a degree and a fraction too low.

NB: So you think we're actually at a temperature above freezing here?

AR: Yes. That would be my best guess here, slightly above freezing.

NB: Okay. Larry, Nick here.

LS: Go ahead.

NB: I have a new eastern point for you. It's  $46^{\circ}54'/125^{\circ}01'$ . If we could climb another 500 ft, that would be helpful and then level out at that point.

LS: Okay.

7:15 PM

AR: We're going underneath that debris cloud here. But at 3,000 ft we're getting precipitation down to flight level, nice big unrimed aggregates. They look like they may be dendritics and I can see them going by the tail light.

7:17 PM

AR: I don't see any high temperature crystal habits. Unadjusted t-stat  $-1.9^{\circ}\text{C}$ .

7:18 PM

AR: I'm not getting liquid water. Actually, until just as I said that we had a little wisp go by. A wisp of about 10. It looks like a pretty decent snowstorm right here.

7:19 PM

DS: Those are probably the biggest things I've ever seen go through the HVPS.

AR: Right. I'm looking at them in the headlight I'd guess you'd say of the aircraft and then the tail light back here and I'd have to agree. They're about the biggest one we've seen.

7:20 PM

NB: There seems to be a lot of little kind of cloud droplets there or small raindrops just stick them together, right?

AR: I'm not sure how that works to be honest after all these years. We've certainly seen dry conditions in pretty good aggregates, but that's certainly something we'd look for is some cloud droplets that kind of grew. I think the one thing we've noticed, and it doesn't happen with water, is that as soon as the concentrations get above one per liter then you start seeing aggregates.

7:21 PM

NB: Well, it looks like we're kind of starting to go through that wind shift again. The wind is picking up a little bit, kind of coming around a little bit east of south. When I spoke with John Locatelli last time, he was calling this an occluded front rather than a cold front and I think he's right.

AR: I'll be darned. Yes you're right, Nick. I see that wind shift now and suddenly the snowflakes got a lot smaller here too.

7:22 PM

AR: According to our radar tops are running about 3 kilometers above the flight level.

NB: Larry, Nick here.

LS: Go ahead Nick.

NB: Yes. Just to kind of anticipate what's going to happen next. What we'd like to do is do one of these very slow ramps heading back to the west along the same latitude line (the 46°54') and so we'll use a west point of 125°46'. The same one as before.

LS: We'll go back to the same point as before.

NB: Well, actually we went past it on our last run, but the one the radar thought was the kind of the end of the precip before.

LS: Roger.

AR: Nice big liquid water signature there, Nick.

7:24 PM

NB: Larry, Nick here again.

LS: Go ahead Nick.

NB: I'm not sure exactly how long it will take us to get out there to that western point again, but I get something like about 150 ft a minute. What we'd like to do is kind of start at 3,500 ft where we're at now and kind of end up at 5,500 ft once we get out there.

LS: Okay.

NB: It's one of these ramps, one of these very slow ramps that we're talking about.

LS: Okay.

7:26 PM

NB: I'm kind of puzzled why John has us wanting to stop right around here. It looks like we're in pretty good stuff right now.

AR: Yes. Is this the east endpoint?

NB: Yes.

LS: Okay Nick. We'll start our turn and we'll figure out a rate of ascent for you once we start going west bound.

NB: Okay. Appreciate it. Thanks. I'm going to talk to the radar for a couple of minutes here. I'll be offline.

7:27 PM

AR: Continuing very maritime droplet concentrations. We did not see the increase in the droplet concentrations going across this transect up the front at 3,200 ft tans-alt.

7:28 PM

LS: Nick, it's going to take us about 14 min to get out there. So do you want to climb to 5,000 ft?

NB: Yes. Actually, the point is not quite as far. It turns out that the western part of the band is so weak that we don't need to go out quite that far, but something like  $125^{\circ}38'$ . So if we could be at around 5,500 ft when we get there, that would be good. Sorry to change it on you.

LS: Okay.

GG: Liquid water probe agreement is pretty good at the levels we're seeing right now.

DS: Yes. I've been watching them. Even the DMP does a good job when we get above a certain level.

AR: Yes.

GG: I think we solved that noise problem.

DS: Yes. I suspect if we did that the DMT would agree with all the other ones.

AR: We don't have anything to hang our heads about there.

7:30 PM

DS: How's the dew point looking to you, Art?

AR: I haven't looked at the dew point. It should be at or slightly below the t-stat.

DS: Well, they're doing that. They don't read quite the same however.

AR: The Ophir is a little too high even if you take a degree off the t-stat, which is indicating right around freezing. That would be over 100% humidity.

DS: Yes.

AR: Other than that, the chilled mirror looks pretty darn good.

DS: On the last flight, I went back and did an electronic calibration and with any luck it should be fine. Actually, what I should have you do sometime or if I think about it when I'm back at the UW is grab a swing cyclometer and I could do a calibration.

AR: That's a good idea.

DS: I do have one out at the hangar, but it fell to the Eatwell syndrome (anything dark and unbreakable).

AR: I see it flew away.

DS: Yes.

7:32 PM

DS: There's a lot of water right here.

AR: Yes. You're right about that. This is probably that same sort of leading edge of this frontal thing we went through about 10 min ago.

DS: Yes. But it almost got up to a gram per cubic meter.

AR: When we went through it before it was up around  $0.7 \text{ g/m}^3$ , I think. The highest number I saw was like  $0.72 \text{ g/m}^3$  and it was matched both in the FSSP and the PVM.

DS: Yes. The last time I saw like  $0.9 \text{ g/m}^3$  there it was matched by PVM, FSSP and J-W. I didn't get up to DMT before we got out of it.

7:33 PM

AR: Here comes the big snowflakes again.

DS: Have we collected enough data yet on snowflakes to prove that they all are different?

AR: No. In fact a lot of the hexagonal plates look pretty much the same as far as I can see.



NB: Say, did you happen to get a peak for how deep the tops are in that kind of leading edge from the radar?

AR: No. I wasn't watching at that instant. Right now we're indicating about 2 kilometers to 3 kilometers above the flight level. Yes. That would have been interesting damn it. I'll try to remember that next time.

7:35 PM

GG: Don, go to "chat" for a second.

NB: Larry, Nick here.

LS: Go ahead Nick.

NB: I see we're pretty much out of our turnaround point. If we could come back at about 5,500 ft level flight back to the east and I'm going to tentatively say along  $46^{\circ}54'$  again of course, but it would be to  $124^{\circ}52'$ .

LS: Okay. You want to go back to  $124^{\circ}52'$ .

NB: Right. Along this same latitude line.

LS: Right.  $46^{\circ}54'$ .

NB: Yes. That's the same latitude we've been flying. Larry, Nick here.

LS: Go ahead Nick.

NB: Just a slight modification to that last point. Precip is filling in a little more, so extend it just a bit further east to  $124^{\circ}49'$ .

LS: Okay. We can do that.

NB: At that point, we'd like to do another one of those slow ramp ups from the 5,500 to the 7,500 ft approximately the same kind of western point we just went to.

LS: Okay.

7:46 PM

LS: Nick, was that  $124^{\circ}29'$  on that easterly coordinate?

NB: Correction  $124^{\circ}49'$ .

LS: Okay 49'.

7:47 PM

LS: Nick.

NB: Go ahead.

LS: Maybe you'd better run over that plan on that westbound leg again for me, how high we're going to climb and how far out we're going to go.

NB: Okay. We'll be starting at 5,500 ft and ending up near 7,500 ft. If we're off a little bit, it doesn't matter that much. I'd like for the western point to be 125°38'.

LS: Okay. We've got that.

7:49 PM

NB: Everything has really kind of quieted down in here. I guess it will be a few minutes before we hit that kind of more intense part of the band. Art, if you could be looking at the radar then, that would be good.

7:50 PM

AR: Entering drizzle. Tops indicated to be about 750 above aircraft.

7:52 PM

NB: What happened to all our snow? It just seems like all we're getting here is round things.

AR: Right. Supercool drizzle. Tops are indicated only to be about a kilometer above the aircraft, but we'll get more ice in it now.

GG: Art, let me know when and if you want to point downward.

AR: Thanks Grant. Tops are ramping up now about 2 kilometers above the aircraft. We had that drizzle there at about 1 kilometer.

NB: Certainly we can easily get up there then. So this will be one of which we'll profile the whole thing. By the way, according to John and the radar guru, we will not at this turnaround point we'll still in precip, but what he's seeing is something kind of sneaking in from the south and he wants us to work this main band that we're doing.

AR: Roger. Okay. Tops probably got up to about 3 kilometers above the aircraft there just for a minute, actually less than that, and presuming we'll still hit that big liquid water signature again here.

7:54 PM

AR: We must be coming into that now.

7:56 PM

AR: These tops are a little less actually maybe between 2 and 3 kilometers above the aircraft.

NB: Yes. It must be a lot of supercooled drops. I can hear them hitting my little bubble here.

AR: It looked as if there was a grauple or two in there too.

NB: Maybe that was it. Yes. That's more likely I guess. One thing that I've seen before in that kind of zone there, the winds were about 160° or something and now they're back to 170°. It looks like boundary layer air with a little bit more of the easterly component is getting squirted up right in that kind of convergence line.

AR: That's interesting. I didn't notice that change in the wind.

NB: It's just sort of retaining the momentum of its kind of source or its history kind of.

7:58 PM

AR: The tops now about 2 kilometers above the aircraft. The tops are running about 1,500 meters now above the aircraft.

8:00 PM

AR: Now the tops are less than a kilometer and stars are visible.

8:02 PM

NB: Larry, Nick here.

LS: Go Nick.

NB: I figure judging by how long it took us to get out there last time maybe about 200 ft a minute would be about the right ascent rate.

LS: Okay. Do you want to start that crossing the point westbound?

NB: Yes. That would be good.

LS: Nick, we're right back in our point now. We're starting to turn and climb.

NB: Hi Larry.

LS: Starting up at 20 ft a minute.

NB: Sounds good.

8:08 PM

GG: How does down sound to you, Art?

AR: How does what?

GG: Down for the radar.

AR: Let's leave it in the up position for a little longer, so I can kind of keep track of the tops here.

GG: Roger that.

DS: Nick, you have to stare at every instrument intently all at once. I'll be back in about 30 s.

8:09 PM

LS: Nick, do you have a new point for us?

NB: Yes. Tentatively it would be 124°39'.

LS: Okay.

8:16 PM

NB: Yes and on this eastbound run we'd like to do it at constant level of 7,500 ft.

LS: Roger.

8:20 PM

LS: Nick, we're eastbound now at 7,500 ft.

NB: Thanks. Sounds good. We may not actually end up going quite as far east as I indicated, but that's a good place to shoot for the 124°39'.

8:21 PM

NB: Art, correct me if you think I'm full of it, but I'm getting kind of the impression that the western part of this band at least as we step up is kind of a little more vigorous than it was when we were first out here.

AR: I think you're absolutely right.

NB: John seems to be indicating that maybe the eastern end perhaps is kind of running into those easterly components off the coast or something, but is getting kind of chewed up or just doesn't seem to be making an progress on that side.

AR: Well, I'll be darned. What I noticed was that on that return ramp leg there out to the west that we didn't hit that pile of liquid water that was sort of toward the front end of this thing or front middle. That was kind of disappointing. I don't know whether it's a hole and it's translating to the north and we just went between cells or whether it's just not reaching 5,000 or 6,000 ft.

NB: Yes. I think we went through the zone where it was. There was some little enhanced chop there kind of about 40% of the way into that one. I think that's where the heaviest stuff was, but I wasn't really watching liquid water though.

AR: I think you're absolutely right. There was a chop that picked up in that same area, but it just wasn't accompanied by much liquid water this time around.

DS: We're getting higher is more of the stuff just freezing so we're getting less liquid water from it.

AR: Yes. I think that's it. It just didn't reach up this high and it's confined to below 5,000 ft, I guess, and that's kind of surprising to me. I just thought it would piling up to at least 10,000 ft.

NB: Yes. I think just the kind of low level convergence just isn't extending that high. It's fairly stable and so the boundary layer is kind of getting extruded up but only to so high.

DS: It's not that cold out there.

AR: It's pretty darn cold for the other flights we've been on. It's like -14°C at 700 mb. I was thinking this was going to have a little more pop up to 700 mb.

DS: Yes. We're reading about -9°C on t-stat right now.

AR: Right. The Shadin static temperature is  $-6^{\circ}\text{C}$  and the Ophir air temperature, which is uncorrected, is  $-1.6^{\circ}\text{C}$ , so if you were to correct that.

AR: Yes. The Ophir I looked at that a time or two now and it's certainly not outside air.

DS: No. It is pretty close to outside air, but it's very slow. I mean it has a lot of air flushing over it, but the can is right around the corner here. It's a pressure vessel. It also has a lot of mass, so it takes a long time to change.

GG: Don, are the 2-D or the HVPS required a reset?

DS: I've reset them once because the HVPS stopped.

GG: It seems to me that they're running very raw.

DS: Yes, they are. It will be nice when I get the other 2-D program that Tom wrote. I'll be able to get the concentrations then too. We have an upgrade for you, Art, as soon as Tom gets done debugging it.

AR: That will be great.

8:26 PM

DS: In fact, SPEC will get to see it tomorrow.

NB: Here's that same zone we've gone through a couple of times.

AR: Yes. We've got some liquid water this time.

8:30 PM

AR: Tops indicated to be about 1,500 meters above the aircraft here.

NB: Yes. We'll certainly do two more kind of out and back. But whether a third would be useful also, we'll have to look at closely.

8:31 PM

LS: Nick, have you got a west point for us?

NB: Yes. This time let's do  $125^{\circ}30'$  and again probably about a 200 ft/min climb rate would be about right.

LS: You say the same climb rate?

NB: Yes. Maybe just a tad faster than on that last leg. We're not going to be going, I think, quite as far west. It took us last time about 12 min to get out there. So something like a 200 ft/min.

LS: How high do you want to climb?

NB: To 9,500 ft.

LS: Okay.

8:34 PM

AR: Lots of moonlight, stars, we have broken into the clear at least at our level.

GG: Do you want to switch down?

NB: Larry, Nick here.

LS: Go ahead Nick.

NB: We're basically through all the goodies here. If you can turn here and head back starting from here, that would work for me.

LS: Okay. We can do that.

8:35 PM

AR: Moonlight, Nick, if you look out the right window you can see this thing back there. It's not looking really like much.

8:36 PM

NB: I think he may have missed that, Art, he's talking on the radio to John and the guys back at the coast.

AR: Thanks Don. It wasn't important anyway. I'm guessing if the forward video is on, it might actually pick something up.

DS: As a matter of fact it is. I just thought I'd just leave it run, Art, because it's kind of a backup of state parameters.

AR: That's a very good point. Good thinking.

DS: But you can actually see the clouds and stuff out there. It's incredible. I've also got the big screen up. It's incredible how low a light level these things will go to these days.

AR: Isn't that the truth.

NB: Art, I'm back.

AR: I was just saying you could really make out a lot of the cloud detail with this bright moonlight back there and this band is looking pretty sad to me. It looks like with the models showing that low surface. At any rate, it's kind of drifting down toward Astoria by tomorrow morning. You get the impression this band may never make it onshore. It will just kind of sit out there and circulate up around the low as it reforms or redevelop, propagates to the southeast.

NB: Yes. I think there is something to that and certainly they're not thinking of an Olympic transect for us for that reason. I think it has some attraction in that it is just kind of parked out here and even though its dynamics might be changing slowly, certainly in terms of a steady state sort of thing, I couldn't ask for much more.

AR: Yes. You're sure right about that.

NB: As we kind of notice, John thought it was kind of starting to bulge a little bit more to the west and what he sees are more the changes associated with this band is stuff running up along it from the south. So our changes are we'll just keep on working the same line maybe a couple more times.

END OF TAPE 1, SIDE 1

AR: Our flight level I think was around 5,000 ft.

8:59 PM

AR: The moon still visible through it looks like just ice cloud right now. There go some droplet clouds. So there's still droplet cloud above us. It looks like at least 4,000 ft above us, that from the rate of movement.

NB: Larry, Nick here.

LS: Go ahead Nick.

NB: Just a slight correction to our endpoint. That should be 124°44'.

LS: Okay. 124°44'.

9:00 PM



AR: We're still flying in some ice crystals, but a thin layer of altocumulus now very plainly visible. The moon is very bright at times.

9:01 PM

AR: Moon now dimming through ice cloud overhead.

9:02 PM

AR: Altocumulus cloud does not seem to be present here.

9:03 PM

AR: It looks like we're in a low droplet concentration cloud that's having a little drizzle in it. Drizzle size drops around 100 to 200 microns back there.

NB: Yes. This has been about the most active part of the band that we're approaching right now. So this guy maybe dying.

9:04 PM

NB: Is it in my imagination or why is it that I see better dendrites on the 2-DC than on the CPI?

AR: That's just a size thing.

NB: That's what I figured. So you're just looking at the little end of the stars and that sort of thing?

AR: Right.

DS: How big does the CPI go, Art, do you recall?

AR: Yes, about 2.5 mm, but the camera is following on anything down to about 10 microns that goes through them because there are so many more 10 micron particles than there are millimeter particles. All you're going to see on the CPI in snow are the little real fragments.

DS: Okay. We occasionally get a bigger one that goes through.

AR: Right. It's very rare and most of the time they're smashed. They're broken up either because of the tube or hitting on the edge or something.

9:09 PM

LS: Nick, how about west point for us?

NB: Okay. That's a good question. Let's say the same turnaround point that we used before, which I think was about  $125^{\circ}40'$  or so. Hang on a second. I think it was  $125^{\circ}40'$  or so.

LS: How about 44'?

NB: Okay. So on this one our east point here of course is  $124^{\circ}44'$ . Again, we'll want to do that 200 ft a minute climb up to 11,500 ft or so.

LS: The last point we left back there was  $125^{\circ}40'$ .

NB: I think we actually flew past that.

LS: That's right. We did.

AR: The moon is becoming visible now.

9:11 PM

AR: It's broken out the east side here again.

NB: Yes. I see we're still getting kind of a little blip every now and again, but that's basically it.

DS: There's the moon straight ahead of us. It just went behind the cloud.

NB: Larry, as you can probably tell, we've kind of broken out here. So if you can do it, this would be as good a time as any to turn and head back.

LS: Okay and do you want to do that climb again?

NB: Yes. That same sort of slow ramp up.

LS: To 11,500 ft?

NB: Correct.

LS: Okay.

9:12 PM

AR: The moon was obscured just before we went into the precip here by altocumulus opacus at the east end of the band. That seemed to transform into only ice cloud above us. That would here in the precipitating main band in deeper clouds.

9:17 PM

NB: Art and Grant, on this one I'd like to have the cloud radar pointing up so we get a new estimate of the echo top just figuring out our end game here.

GG: We'll try. Suddenly the switch is sticking again.

NB: In my conversation with John, he thought it made sense to try to arrange it so we would have one leg that was basically in precip most of the way but near the top, and then the final one to be just kind of going in and out of the tops.

9:18 PM

AR: We're going to try to get it in the up position.

GG: The darn thing was working very well for quite a while there. Nick, I'm not near a screen. What's the outside temperature?

NB: It looks to be  $-13^{\circ}$  to  $-14^{\circ}$ C.

GG: Yes. It's pretty cold. This thing might be stuck.

NB: Okay.

DS: We need to feed the pilots more coffee.

AR: We have an altocumulus layer up there going by, Nick. I can give you an estimate on that. It looks like it's 3,000 to 4,000 ft above the flight level.

NB: Yes. Then that might be the one that we can flip on the very last one. If we kind of precede in the manner we have, we'll be at 11,500 ft at the end of this, come back east bound at 11,500 ft, go out on one more ramp and then come back maybe at 14,000 ft or something and my guess would be that we'd be kind of going in and out of them.

9:20 PM

AR: We've got much higher tops in this area. The moon is disappearing through glaciated cloud. We have at least 2 kilometers at that flight level.

9:24 PM

LS: Nick, let's have that east point again.

NB: That would be  $125^{\circ}50'$ .

LS: Got you.

NB: I'm sorry, 124°50'.

LS: Okay.

9:28 PM

LS: Nick, here comes your reversal.

NB: Sounds good.

AR: Looking ahead the solid deck of altocumulus or stratocumulus at the west end turnaround point out ahead of the aircraft with enhanced feeder ice cloud or middle cloud above them. We're not going to be entering that. It looks like a second band, although it does seem to connect the band we have been flying through looking off to the south. The moon visible through droplet cloud, altocumulus. Estimating ~15,000 ft above flight level.

9:30 PM

AR: There's an altocumulus layer at this end estimating about 500 ft above flight level.

9:31 PM

AR: On both sides of this band there were shelves of altocumulus clouds above the aircraft and when we got into the deepest tops, which I was estimating were more than 2 kilometers above flight level, the altocumulus was obliterated by all the ice.

9:32 PM

AR: Still have the clear icing on the bubble here. I forgot to mention the type of icing earlier. It's like a window pane practically it's that clear.

NB: For what it's worth, Art, the winds for much of this flight have been stronger, at least the MM5 model had prog based on this 12 Z run this morning. So perhaps that's one kind of drawback here. We've talked about before how we'd like if the model got the flow right and this is all we'd have to worry about.

KM: Nick, we've got about 45 min left out here.

AR: Thanks, Nick, for that insight.

NB: Yes. Thanks for the word, Ken. What we'd like to do would be to kind of head back toward the east. Let's make a  $125^{\circ}50'$  and then do one more run to the west not quite as far as we went before.

KM: Okay. We're headed back for that  $124^{\circ}46.54'$  at this time and we're about 12 min out of that point.

NB: Right. So from that point we have 45 min or we have 45 min from now?

KM: 45 min from now.

9:35 PM

KM: Nick, from that point you probably got 45 min.

NB: Okay. Hang on a second and let me think about our strategy here. So, Art, I don't know if you were listening there, but now I would like to get up near the top of this one so maybe this strategy here would be to kind of ramp up on this one and then head back at 13,000 ft or something. What do you think about that?

AR: I think with the time remaining you're right. We're going to have to climb up a little faster either now or later, a bigger jump on the next one, the next level.

NB: Maybe what we should do is kind of truncate the sides of it so we just go through kind of the main part of it and make sure we get that part.

AR: Roger. That makes sense to me. The part where the tops are high is fairly small as you can imagine.

NB: Larry and Ken, Nick here.

LS: Go ahead.

NB: Just so that we can make sure that we get to the top of this one within our time, why don't we do a climb again at 200 ft/min and just kind of ramp up on this east bound leg also.

LS: Okay.

NB: What I'm envisioning is kind of the same maneuver we've been doing, but to have the kind of legs just kind of whittled down on both the west and the east ends.

LS: Okay.

9:37 PM

AR: The moon is not visible.

9:38 PM

AR: The moon has disappeared there for about 10 to 20 s.

9:39 PM

NB: I'm going to talk to the radar for a couple of minutes, so I'll be temporarily offline.

LS: Right.

AR: Indicating mixed phase clouds above us. Droplet cloud embedded in what I think is a deeper ice cloud. Now it's completely glaciated as before.

DS: There's the moon, Art.

AR: Yes. There's a lot of ice crystals between here and there though. It's sometimes misleading because you can see the moon looks pretty bright, but I can tell we're going to have to climb a good 2 kilometers to get above it right here.

DS: Yes. I can kind of see the moon fading in and out.

9:40 PM

AR: Combo clouds above us now, droplet clouds embedded in generally glaciated deep cloud.

9:41 PM

NB: So, Art, Nick here.

AR: Roger.

NB: So there's still plenty of echo above us then it sounds like right around these points, right?

AR: That's affirmative. I was estimating 2 kilometers above aircraft there about a minute ago. A little shallower now, we're getting out toward the altocumulus shelving on the sides of the deeper ice cloud probably comprising the main part of the band.

NB: What I'm inclined to do here is that on each of these, I don't know if this will kind of mess up the interpretation, but to do each of these as ramps at the same kind of 200 ft/min sort of thing. So instead of a flat "Z" kind of a stretched out "Z".

AR: Roger, I understand. I'm not sure exactly how that would work out whether there should be level legs maybe with steeper ramps, I don't know. I'd have to think about it. I'm not really a synoptician anymore.

NB: Yes. The way to think about it is the pictures for the journal article, right, and on the level legs is the information just a lot more valuable than on the ramps.

AR: Right.

9:43 PM

AR: Then it looks like we passed out of the main part. We're still in ice crystal cloud, but the moon is very brightly visible as you can see.

NB: Right. There are just tiny little bits on the HVPS and all that.

AR: Just as I say that, there is another little chunk of thicker clouds coming across here. I don't know if it's a double structure or whether it's just some "noise" as far as that band goes. The radar being in the down position does show rain to the ground, so I guess it's just a little more than just some outrigger cloud.

9:45 PM

AR: The moon is not even visible here. Premature illumination of exiting the band.

NB: Maybe we're getting pretty close to 13,500 ft here, so maybe returning back at this level might work out and then as we can see that we won't have to go as far west as we did before and then kind of take it from there.

AR: That sounds good.

NB: Larry, Nick here.

LS: Go ahead Nick.

NB: When we get to our kind of east point here of 124°50', we would then like to take it back west at the level we'll be at, which I think is going to be around 13,500 ft. We won't go as far west as before plus our ground speed is picking up some in this thinner air, so I think we're okay in terms of time. Is the time constraint due to the fuel considerations or your duty day?

LS: Fuel considerations basically and the weather is not real good back at Paine Field.

NB: That's what I figured that we'd have to leave for an alternate. Okay. What we're looking at is our turnaround point here and then we'll have one more outbound-inbound and that would do it.

LS: Okay. We're starting our turnaround now.

9:47 PM

AR: While we're flying in precip, precip is not reaching the ground at this locale.

NB: We're in a roll right now, so maybe it's not even pointing where you think it is.

AR: It's getting a ground return, although now as it comes around I'm certainly getting a precip to the ground signal now.

9:48 PM

NB: By the way, the constraint on our time appears to be just the weather is pretty bad at Paine Field, I guess the ceilings or whatever, so they have to leave quite a bit of fuel for getting to an alternate.

9:49 PM

NB: So, Art, your job on this westbound run is to figure out when we should stop, when we've kind of run out about the higher stuff and then also what a good level would be for the return.

AR: Is there just one more return?

NB: Unless there was a real kind of small little zone that we could kind of step up into, I think this might be it.

9:50 PM

LS: Nick, did you want to start climbing on this westbound leg?

NB: No. I think I would like to do this one at 13,500 ft.

LS: Okay.

NB: How are we doing on time? Do you have kind of a firmer estimate there?

LS: We've got about 25 min and then we have to start it back. So that should be time to go out there, probably come back and then head for home if you want to make the Olympic transition.

NB: We will not be doing an Olympic Transect.

LS: Okay. We can give you a little extra time then.



NB: Okay. One thing depending on what we find on this outbound is we might want to do kind of a little sort of back and forth in the middle of this band where it sticks up the highest.

LS: Okay.

NB: Kind of a layered cake sort of thing or wedding cake rather where it just gets smaller as you go up.

9:51 PM

AR: We're picking up a little bit of that higher altocumulus layer that's been visible above the aircraft here. It almost looks like there are some drizzle drops back there, you know, very small ones of the 100 micron nature. Kind of amazing for  $-19^{\circ}$  to  $-20^{\circ}\text{C}$ .

NB: I'm going to take to the radar now and I'll be temporarily offline.

9:52 PM

AR: Moon in and out. Droplet clouds above aircraft. It looks like at least one layer and I think at times two droplet cloud layers at this point.

LS: Nick?

DS: He's talking to the radar people. He'll be back in a moment.

AR: Moon is not visible now.

NB: Larry, Nick here.

LS: We have to be over Hoquiam in 40 min from now and Hoquiam is roughly about 10 min from our position now. So when we get out at the end of this point, we'll have another 10 min to play with.

NB: Okay. Yes, we'll definitely not be going as far west as we have been going.

LS: Okay.

AR: So, Nick, one more level pass or one ramp, what do you think? I guess what I'm getting at is we're going to have to climb a long way to get anywhere near the top of this judging by the size of the ice particles in here and just the visual on the moon. To get anywhere close, we'd probably have to climb like 5,000 ft or so.

9:54 PM

DS: He's talking to the radar again, Art.

NB: Larry, Nick here. Did you ring?

LS: No.

NB: Sorry.

DS: It was Art who was talking.

NB: Off with his head. So, Art, talking to John, he was surprised that there would be echo here at 15,000 ft. We're currently at 13,500 ft. But you think we'd be running into stuff I assume.

AR: Absolutely. I was mumbling there that if you wanted to get anywhere near the origin point of this thing from the size of the ice crystals and from what I see out the window here, we'd have to climb a good 5,000 ft.

NB: Yes. I don't think that's going to happen.

9:57 PM

NB: Larry, Nick here.

LS: Go ahead Nick.

NB: I've got for this western point 125°24'.

LS: 125°24', okay.

NB: At that point tentatively, I'd like to climb to 15,500 ft and return at that level.

LS: Okay.

9:58 PM

AR: Certainly in the thinning phase now, Nick. Whether it's going to be a complete clearing I don't know. Also we have a 22° halo around the moon.

9:59 PM

NB: Do you think that we should shoot for a 3,000 ft climb rather than 2,000 ft?

AR: Yes, as much as you can get. We're certainly out the backside now.

NB: Okay.

AR: Even though we're getting a little ice here, the ice tops kind of slope down in this region. There's a saddle right there.

10:00 PM

NB: Larry, Nick here.

LS: Go ahead Nick.

NB: I'm not sure if this is too much to ask for, but if you could get us 16,500 ft rather than 15,500 ft that would probably help.

LS: Yes, we can go 16,500 ft.

NB: Yes. I knew that the plane could get there, but just whether that chewing up the time and the fuel or whatever.

LS: That's no problem.

10:01 PM

NB: So what might be kind of a little unfortunate about this flight is that there is kind of a very high vertical resolution down low, but that's going to be stretched out in vertical pie. I don't know if that's the way you'd want it, but that's the way it's going to be.

AR: I can't imagine 1,000 ft is going to make too much difference because there is not a lot going on up here at this level. I think we're above all the droplets. No, that's not true. I take that back. There was still droplet cloud above us in that last pass.

NB: I have to apologize a little bit about the time management. I didn't figure on the issues related to the fuel sort of things.

AR: I didn't expect the tops to be as high as they're turning out to be either.

10:02 PM

AR: There's a problem with true airspeed, Don. I see it in the 2-D probe images.

10:03 PM

AR: I don't think we're going 250 knots.

DS: I hope not.

NB: It would be fun if the winds were 70 meters per second though.

AR: Right. The winds, of course, are affected too. I wonder what happened.

10:04 PM

GG: We had this happen a couple of flights ago, didn't we?

DS: It's hard to say, Art, they're all doing the same thing.

AR: The images look better now. They're not those little slivers. Still a little squashed.

DS: Is there a jet stream up here?

AR: No.

GG: The true airspeeds are way high. Even the indicated airspeed is too high.

DS: Yes. I just looked and they're all doing the same thing.

10:05 PM

GG: I wonder if the static port is frozen or something.

DS: That's a possibility I suppose.

NB: That's the first thing that I thought of, but I wasn't sure. I would have figured that they would make that pretty bullet proof.

DS: It's probably fairly.

GG: Have you checked with the pilots to see what they're indicating?

AR: With the temperature we're not even to 500 mb and it's  $-36^{\circ}$  to  $-37^{\circ}\text{C}$ . That means the 500 mb temperature must be around  $-40^{\circ}\text{C}$ .

LS: Nick, what's your eastern point?

NB: It looks like the same one we had before,  $124^{\circ}50'$  or so, and then I guess the plane is kind of yours. We're running out of time here, right?

LS: Yes, pretty much.

DS: You might check and see what they've got for indicated airspeed or true airspeed.

NB: In our instruments, we're having a problem with the true airspeed and the indicated airspeed. How are you guys doing in that regard?

LS: We have 152 knots indicated up here and that's about 30% more, so about 195 knots would be our true.

DS: Yes that's what we've got from Shadin. So they've got the same thing we do.

NB: Well I don't think that's right. The winds just aren't that strong.

LS: Are you talking about ground speed or true airspeed?

NB: True airspeed. It looks like the ground speed is fine.

LS: I would say that our true airspeed should be up around about 190 knots.

AR: 190 knots?

NB: Yes. It shows us that we have 190 meter per second.

LS: I don't know what the meters per second would be.

NB: Essentially it's twice as knots as meters per second, so that would be 380 knots or something, which I don't think is happening.

AR: I have a correction on that temperature because that's overcorrected for the ram effect and that's why it's  $-38^{\circ}$ . It's probably really  $-32^{\circ}$  or something.

NB: Art, we're collecting decent stuff along here. I see the 2-DC probe.

LS: Nick, it looks like we've lost the airspeed indicator on the right side probably from ice.

NB: Yes. So hopefully that won't be a problem for you.

LS: Well it will be if we don't lose it, but it should melt out on descent.

DS: Yes. We're using the same ones that the co-pilot uses.

10:09 PM

DS: That's one way of doing it.

AR: Just probably a few hundred feet below little slivers of droplet clouds. It's kind of amazing considering that it's probably  $-33^{\circ}$  or  $-34^{\circ}\text{C}$  here. There are sort of ice cloud that's way above us.

LS: Nick, we're 4.5 miles from our endpoint and from there we're going to head for Hoquiam and home.

NB: Okay. Will so. Thanks.

DS: Things are getting pretty quiet now anyway as far as droplets or crystals.

AR: Right.

GG: It sure has done amazing things with the wind speed.

NB: That's right. I would assume even before it were to melt down they could kind of sublimate and maybe kind of clear its throat.

AR: We're topping some of the altocumulus shelving on either side of that deeper ice crystal cloud. We have ice crystal cloud above us and we'll probably see a crystal or two dropping down to this level. But other than that that's the end of that band, Nick.

NB: Right. It's their plane now.

10:11 PM

NB: I still feel a little bad that I didn't kind of check on the time we had out here. We could have gotten up higher definitely if we had budgeted for it.

AR: I don't think you missed much. On that last pass, the only thing we had was a glaciated kind of cirroform cloud with a little exception of a little of a couple of droplet clouds that did pass by there for a moment, but I think as far as it goes, when we've climbed up in situations like this, it's just been a steady...

LS: Nick, we're going down to 15,000 ft and with that excel rate and head home.

NB: Yes. That sounds good. Thanks.

AR: The steady diminution of the crystal sizes and maybe that can be backed out.

NB: That makes me feel a little better if it in fact is kind of rather uninteresting from the kind of cloud precip point of view then that's good.

AR: The moon was extremely bright all along that pass. So I'm sure 99% of the precip mass was below our flight level.

10:13 PM

NB: In case you didn't hear the pilots, we're descending down to 15,000 ft and kind of speeding up some out of research mode.

AR: We're still taking about a flight tomorrow?

NB: Good point. I'll check with the radar.

DS: I wanted to thank you, Art, you haven't filled up 2 tapes today.

AR: Yes. I'm trying to keep it down.

10:14 PM

NB: Just talking to the radar regarding a possible flight tomorrow, it is a stand down day.

LS: Okay.

NB: You can sleep in your bed tonight that is if you can get there.

10:16 PM

AR: Larry, I notice it's getting cooler back here as we descend. I noticed that before. Why does that happen when we descend, what happens since it tends to cool off in the back?

KM: When we get up to altitude it just takes a while for the airplane to cool off and then when it gets cold I've been pushing this thing to manual ever since we arrived at the higher altitude. So it's just going to take a while to work.

AR: Droplet cloud tops here.

10:17 PM

AR: Flying through altocumulus clouds here at 14,400 ft according to tans-alt, a little cumuliform looking almost to a weak castellanus. A little turbulence bump there. What's interesting is the temperature indicated to be  $-35^{\circ}\text{C}$ , but that's erroneously corrected. We're getting almost possibly a few drizzle looking drops. The temperature probably in the upper  $-20^{\circ}\text{s}$ .

10:19 PM

NB: Getting a nice little tail wind here. Our ground speed is 130 meters per second.

AR: Yes. That's pretty good. I notice the wind direction is 080°.

NB: That's all the goofed up true air indicators. What we're really making is better time than usual based on the navigation system.

AR: Roger. I misunderstood what you said. You said ground speed, didn't you?

NB: Art, do you want to do your summary or do you want to wait a bit or whatever?

AR: I can do a summary here.

NB: If you want a few minutes to collect your wits and freshen up, that's fine.

AR: I find it doesn't help. That's the problem.

NB: There's nothing left to collect?

AR: It didn't get any better.

#### TO SUMMARY

DS: The true airspeed is back. At some point we're going to have to start shutting stuff down.

NB: Art, are you getting anything of interest here?

DS: I mean like the CPI, radar and stuff that's not easy to get to from the engineer's seat.

AR: Probably the radar could be powered down. The other stuff I'd like to see it continue more into Puget Sound.

GG: I'll get the radar, Don.

DS: Okay.

GG: I quit taking data a couple of minutes ago to transfer the data out of the acquisition file onto the other side anyway.

DS: We've got another 10 to 15 min before we'll be landed.

GG: Roger that.

10:34 PM



AR: Larry, do you have the weather at Paine Field today?

KM: Yes. It will be 2600 scattered, about 2200 broken, 6,000 overcast, winds 1008.

AR: Thanks. No precipitation I guess.

KM: They didn't mention any.

NB: The east wind there is indicative kind of like you suggested, Art. You know the southerlies never really kind of the warm air never really surged in.

AR: I just wonder if it isn't going to flop around to the north by tomorrow morning.

NB: Yes. I think the progs had that to a certain extent. Not a big push, but basically we'd have some weak north winds.

10:35 PM

AR: The moon is clearly visible through shallow droplet clouds above probably these are clouds topping out at  $-5^{\circ}$ ,  $-7^{\circ}\text{C}$  or so.

10:40 PM

AR: Don, how much time do you need to shut down and do all the things you need to do?

DS: Not a great deal of time. There are just a few things that are out of reach, but Grant is going to take care of one of those. I don't need to worry about the radar.

AR: Another minute or two.

10:43 PM

DS: It just takes to get the data copied as well.

AR: That's what I was concerned about. How much time do you need for that? Coming into this last layer now.

DS: Probably 5 min if everything goes well, maybe a little longer.

AR: Okay Don. Thanks. You can go ahead and shut everything down.

DS: Okay Art.

10:45 PM

GG: Hey Don, hold off killing inverter 5 as long as you can, can you?

DS: Yes.

GG: Just about got all that stuff copied over.

DS: Yes. I just started the process of copying the data over myself, so it looks like it's going to copy. I'm also copying it to my laptop, double jeopardy.

10:46 PM

DS: Is the power cranked down on the radar?

GG: Yes.

10:47 PM

DS: I'm going to shut down the recording stuff as well.

END OF TAPE

#### Summary for UW Flight 1858

AR: I guess I'll just mention what I found interesting today. This band resembles some of the other bands that we've sampled that had the many embedded droplet layers. There must have been three or four above the flight level of 9,000 ft, most of which we did sample, and those were primarily located on the east side of the band. I won't go into all the details. The band itself seemed to be comprised of, at least where the highest cloud tops were, the glaciated core. I judge that from looking at the moon when we were in those deeper parts and all you could see were no sign of any droplet clouds between the aircraft and the moon. On the sides of this deeper cloud there were shelves of droplet clouds out there. The one of the other characteristics that we've seen before is the boundary layer cloud on the east side having very continental characteristics. I saw one droplet concentration in that heavier liquid water content region that sort of floated the main part of that frontal band there and having over 300/cc. That's as high as we've seen in any offshore cloud in this project so that really shows that that was the continental origin air that was feeding in. I think Nick talked about some substructure of that air feeding into the band out there that he could deduce from the winds. So I thought that was pretty interesting and that particularly east side high liquid water zone did extend up to about 9,000 ft, but we didn't hit it on every pass. We did miss it on one pass. Evidently some of the cellular structure was translating off to the north when we were flying our constant east to west route. I'll just finish up by saying that again we saw a tremendous complexity in the cloud microstructure from drizzle drops being observed at  $-15^{\circ}\text{C}$ . Some

altocumulus clouds momentary in a saddle region of one of our legs. Drizzle drops down around the  $-3^{\circ}\text{C}$  level in shallow clouds down there that of themselves were precipitating needing no help from above. This was one of the liquid layers out in the east side of that the stratocumulus deck. Drizzling and then later apparently as the tops of that deepened up tremendous amounts of ice multiplication. Huge needle aggregates there and that was on our first pass on the way descending out and passing just west of Westport as we were about to begin our first leg. Again lots of ice multiplication here and there and then in other places of course the deeper of course the lower temperature crystals feeding into these lower clouds from those higher tops. So all in all pretty complicated for a band that's really kind of sitting there and fairly steady state, lots of complications in the cloud microstructure.

NB: Okay. Thanks. Just to summarize what we did on the flight, we went directly to the Westport radar and did a series of runs along a latitude line of  $46^{\circ}\text{-}54'$  due west from the Westport radar. It was sort of a modified "Z" pattern in the vertical, again 12 runs total. The first outbound started at 4,000 ft and then fairly quickly descend down to 2,000 ft. We were at temperatures of  $1^{\circ}\text{-}2^{\circ}\text{C}$  at the west end of that leg. That was followed by the inbound leg at 3,500 ft and then a series of slow ramps and then level legs. So the next outbound was a ramp from 3,500 to 5,500 ft followed by a level leg at 5,500 ft. Then another outbound ramp from 5,500 ft to 7,500 ft followed by an inbound at 7,500 ft. A ramp at 7,500 ft to 9,500 ft followed by an inbound at 9,500 ft. Finally on our last outbound ramp at 9,500 ft to 11,500 ft, at that point, we were at the west part of the precip band. It was clear that there was some more echo above us, so on the inbound here we went at a ramp on that part from 11,500 ft to 13,500 ft and then finally the last two legs were level at 13,500 ft and 16,500 ft. These legs were approximately 35 nautical miles wide. The weather that we encountered this was probably an occluded front with a low-level wind shift of about  $40^{\circ}$  at the lowest few thousand feet and basically convergence up to about 7,000 ft or so with weak divergence above that. In the central eastern part of the band where the echo was stronger and the crystals were bigger and all that sort of good stuff, we could see up to about 7,500 ft. The signature of low-level boundary layer air being sort of ascending upward in a plume with enhanced easterly wind components in there. That kind of boundary layer plume also included a little bit of enhanced turbulence and then enhanced liquid with water contents. This whole flight was in very cold conditions. The freezing level something like around 2,000-3,000 ft. For example, at 700 mb, the temperature was  $-12^{\circ}\text{C}$  or so. All the instruments seemed to work very well through the entirety of the flight. One last thing though, getting back to the meteorology is that the band made very little progress toward the east. We had the impression, both from our measurements and from discussions with the radar, that it was getting eroded on its east edge. That there were fresh elements moving along the band from south to north that were kind of tended to replenish more on the west side or as kind of filling in on the west. So that's the summary of the flight.