

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

Date 1 Feb 2001	Flight Number 1856	Experimental Observations CV-580 profiled strong prefrontal rainband in S-Pa 1 dual-Doppler area. Comprehensive microphysical measurements from 1,000 to 21,000 ft in moving stack. Landed at Hoquiam for possible 2 nd flight, but no rainband between us on studied on Flt. 1856 at (observed) front. (Heavy rain at Hoquiam - from rainband studied - on landing.) See Flt 1857 for info on flight from Hoquiam to Rainier Field this same day.	
Project name IMPROVE (TOP #9)			
Engines on time 222 GUTC	Engines off time 0333		
Departure airport PAICE	Arrival airport HOQUIAM		
Flight Scientist signature P. V. Hobbs			
Pilot signature			
Surface met. & visual obs. at takeoff No precip. Broken AC		Ac	
		As	
		Ns	
		Sc	
		St	
		Cu	
		Cb	
Research crew Hobbs Rangno Spurgeon T. Wilson Eric Grinstead	Equipment failure Some poor CPI images (condensation ?)		
{ Eric Cooper Kenneth.			

Flight 1856
February 1, 2001
Voice Transcriptions*
IMPROVE-1

OK
2nd Draft

PH: This is flight 1856, 1 February. On board are Hobbs, Rangno, Spurgeon, Wilson, and Eric Gritmit; pilots Eric Cooper and Ken McMillen. This is IMPROVE IOP #9. We're going to fly directly out to the coast to the radar site. There's a strong cold front that's moving in and precip was detected by the radar some 150 miles off the coast an hour or so ago.

2:48 PM

AR: I just started my computer, so I don't know the altitude. It looks like we're at 6,000 ft or so, 7,000 ft. Climbing out toward the sun and toward the Olympics. We have stratiform altocumulus clouds, semi-lenticulars all over the Olympics. Actually just above the tops of the highest peak in the Olympics. Then out looking toward the south is more of a layer with at least one more liquid droplet layer above the main altocumulus layer. Then above that we have it looks like broken cirriform or overcast with thin spots would probably be more correct of cirrus spissatus and cirrostratus nebulosus. There will be some virga coming out of the lower clouds there, this lower altocumulus deck, which is interesting, because that will certainly lead to ice multiplication. By the way that deck top of Mt. Rainer is at about the 10,000-ft level.

2:50 PM

AR: My computer is up now. It says tans-alt is 7,700 ft and this is at 14:48:55 UTC, t-stat^r -4°.

2:51 PM

AR: At 9,000 ft we're just climbing on top. Actually we happen to be in a hole of this lower layer of altocumulus. Now I see that the precipitating layer ahead is quite a bit higher in altitude than this layer. Right now we're looking at two holes of altocumulus. The higher layer looks like it's going to be around 13,000 to 14,000 ft and the lower layer was at 9,000 ft.

TW: Don to "chat."

AR: A nice fall streak.

* AR = Art Rangno, DS = Don Spurgeon, EC = Eric Cooper (pilot), EG = Eric Gritmit, KM = Ken McMillen (pilot), PH = Peter Hobbs, TW = Tom Wilson

PH: Yes Ken.

KM: Did you call?

PH: No I didn't, but I assume we're heading straight out to Westport.

KM: That's affirm.

PH: Okay.

AR: Can you hear me? Don, can you copy?

PH: Who are you trying to talk to, Art?

AR: I was talking to Eric Gritmit back here. He had his button in the "chat" mode. So I was about to explain some of the buttons.

PH: I notice the Ophir is reading a few degrees above the Cambridge.

AR: Yes. That was a problem on the last flight. You might remember I was squawking the dew point temperatures being too high.

PH: Which do you think is correct?

AR: They were both too high on the last one, but I would always go with the Cambridge. It's always been the most reliable.

2:53 PM

PH: We've got good zeros on all the liquid water meters, PVM, J-W and FSSP in clear air. The only one that's out, as usual, is the DMT, which is recording 0.1, 0.1s, 0.5s in clear air.

AR: Eric, if you want to talk to people in the back, you use "sci" here and, if perchance you need to talk to the pilots, you talk on "all." But if you just want to say something for the recorder, "rec" is for record and, if you just want to talk about football, you go to "chat," that's not recorded.

PH: We've got a static temperature of -4.5°C at 9,800 ft.

2:55 PM

AR: The wind direction 245 at about 25 knots seems reasonable. We're backing as we go out. Unfortunately, we're going to pass to the right or north of the virga producing altocumulus there off the left wing, which I have a feeling would be needles and columns. It looks like it anyway. I'm not sure why I think it looks

like it. I think it's because it's so dense and the concentrations are usually high with needles and columns.

TW: Don?

2:56 PM

DS: Do you have a question, Peter?

PH: Is the PCASP connected?

DS: Sure.

PH: I'm not seeing any readings on the graph.

2:57 PM

DS: I suggest you stop the program and start it. You probably started it before I got the server up.

AR: While I wasn't looking some of the altocumulus has come up to this level, 700 mb, 9,800 ft tans-alt.

PH: I'm seeing something now.

AR: Droplet concentrations in the mid-10s (50, 60)/cm³.

PH: We're in cloud at 9,700 ft here.

AR: Liquid water content 0.1 g/m³. There's some virga from this here and there. So I wouldn't be surprised if we saw a burst of columns and needles, but they're not very thick. So it's probably in that temperature range.

PH: I'm not seeing anything on the CPI at the moment.

AR: We haven't hit anything yet, but I wouldn't be surprised. There's patchy virga here and there.

2:58 PM

PH: How do I bring up the 2-D image?

AR: You used to be able to click on that. I'm concerned because I thought I saw some particles hitting the black rock back here. So I'm a little concerned we didn't pick anything up.

2:59 PM

AR: Certainly that CPI should have been seeing some, if nothing else, bowling balls.

DS: It's just coming up right now, Art.

PH: I'm not seeing anything on the 2-D.

AR: Roger.

3:00 PM

AR: It sure looks to me like we're flying in some precip.

PH: Yes. We've got a $100/\text{cm}^3$ on the FSSP count.

AR: Yes. The 1-D probe is picking up quite a few particles and so I'm pretty sure there is something the matter with the 2-D probe. We're kind of flying at cloud base as you can see and, of course, the particles shouldn't be big enough for the 1-D probe unless we're up a little higher. Now you could argue that the cloud drops were big enough to go in there, but this looks like virga.

PH: We're getting something on the 2-D probe now. We've only got interference lines on the HVPS though.

AR: Yes. This is looking a lot better. I thought for sure there was something wrong with it back there. I don't know why it wasn't recording these drizzle drops. I see an ice crystal once in a while.

3:01 PM

PH: We're getting that background error again on the CPI.

AR: I have a feeling it's going to be a little balky again. Notice the temperature has dropped quite a bit since we leveled out at about 10,000 ft. It's gone from -5°C and -5.5°C to about -8°C now. Winds backed from 245° to 215° .

PH: Are you getting anything on your HVPS, Art?

AR: Nothing and I've closed the program down and restarted it. But on the other hand, these particles, single crystals and drizzle drops, maybe just a little too small yet. There's a little bit, although it's mostly noise. There maybe a real particle in there somewhere.

DS: If you look at the 2-D images on the 2-DC, they look far too small to be showing up the HVPS.

down below -20°C . So that bears looking into. We had a few problems with the 2-D, but otherwise it behaved very well. I think we got some very good data.

PH: Did you mention the J-W?

GG: Yes I did. One other thing, the radar antenna transfer switch something has to be done about that if we are every to use the radar again because it utterly fails at low temperatures. I will not switch.

PH: The next time we'll need that will be for phase 2 of IMPROVE next November. So it's not top priority at the moment. We won't carry the radar for the summer program.

6:19 PM

PH: We're setting up for our landing, buckle up. Everyone should take the things, all the safety equipment that you were given in the hangar, and return them to the same table.

6:20 PM END OF TAPE

AR: Right. That's what I was saying. They're probably a little bit too small yet. But if we start seeing some aggregates in the 2-DC, then we'll have to get worried.

TW: Also it needs to fill an entire strip before it will send anything.

DS: I wouldn't worry too much. I calibrated all this stuff yesterday. I was all working on the ground, so there's no reason why it should not be working now.

AR: Roger that.

DS: I left last night at close to 6:00 and that's when I shut stuff off. It was working up to that point.

3:04 PM

KM: Do you have any further plan of attack, Peter? Do we just go out to the radar site and out to the west point? Do you want the first altitude at 1,000 ft?

AR: Do you see how thin this layer is, look straight up?

3:06 PM

AR: The coast is in view now I should say and we just past a little virga producing altocumulus. It had drizzle drops.

DS: He's talking to the station right now, Ken. So as soon as he's off, I'll ask him. He's getting a point and altitude at this time.

KM: Okay.

3:07 PM

PH: Ken.

KM: Go.

PH: We're going to start off over the radar and I'll give you a southwesterly point to head for.

KM: And what altitude would you like?

PH: 1,000 ft.

KM: Okay.

PH: The southwesterly point will be $46^{\circ}22'/126^{\circ}10'$.

KM: Would you give me those again, Peter?

PH: Yes. $46^{\circ}22'/126^{\circ}10'$.

KM: So that's our southwesterly point.

PH: Yes. We start at the radar and we head to that point at 1,000 ft.

3:08 PM

PH: You have the lat/long of the radar don't you, Ken?

KM: Yes we have.

AR: As we approach the coast at 700 mb, the wind has backed as I mentioned from 245 at 700 mb in Puget Sound at 210 at about 34 knots. So that's up in speed about 10 knots from the earlier. Also the temperature is remaining around -7°C . We're just about to begin our descent now. The temperature dropped about 2°C in our transit leg here to Westport. Most of the time we were underflying the higher-level altocumulus cloud just barely, sometimes at cloud base, but it's certainly less than 1,000 ft thick. Yet it was producing a very light fine virga here and there. Looking offshore the bottoms go down and the altocumulus layer thickens and must merge with other layers because I can see much more virga especially in the northwest quadrant. Clouds had kind of raggedy faces suggesting maybe a stable layer a little bit like undulatus, but not ragged undulatus, I would say, suggesting to me anyway that there maybe a stable layer interface at that level, which was just above 700 mb. Checked the sounding at 00 for that from Quillayute. I keep forgetting about the radar. No need to estimate the thickness of the cloud. The radar is suggesting the cloud layer is also about 1,000 ft thick or less. It's certainly less than a third of the width of the 5-nanosecond divisions here.

PH: We're going to be heading out to our southwesterly point. We'll be starting over the S-Pol radar and head out over 100 miles to the southwest roughly at 1,000 ft. We should hit precip as we travel out on that line. Our first point we're heading for from the radar is at $46^{\circ}22'/126^{\circ}10'$. That will be our point B. The radar where we're starting from will be our point A.

3:13 PM

AR: There is the Hoquiam pulp mill plumes and they seem to be going more or less easterly. There's the Hoquiam airport off about 10 o'clock.

3:15 PM

AR: Those plumes look heavily stratified coming out here. They don't seem to gain altitude at all. If anything they are trapped closer to the ground as they get closer to the water, the big pond here west of Hoquiam. We're starting to pick up a little turbulence, although, there is no white caps on the out-flowing river pond here. Looking from the left wing to the right wing it thickens up as it should off toward the horizon and it's very, very multi-layered. I see at least three obvious layers counting the ice cloud over it. The radar is not really picking up much of that ice cloud. Still only picking up the altocumulus, but it looks like we're going to be adding altocumulus as we head in this direction. Those altocumulus clouds look like they're going to be a little bit lower than the ones we flew in. Here and there and north oriented north-south lines are lines of virga, thin fairly light virga not reaching the ground.

3:17 PM

PH: We're just coming up to the Westport radar to start our first leg out to our point B to the southwest at 1,000 ft.

3:18 PM

PH: Just passing over the radar site now. In clear air here.

TW: Don to "chat."

PH: No white caps.

AR: Not yet.

PH: We should hit some precip on our way out here at this altitude.

AR: That's at least 5 min away. It's out there, but it's a long way out, which is good.

PH: Probably 150 miles or so.

AR: It's not that far away before we get into it. I would think the farther out it is the better it is for our measurements today.

PH: Right.

3:19 PM

AR: The darker transition zone of the ocean water here off the left wing. It might indicate a sudden increase in the winds. I'll check that out.

3:20 PM

AR: Just past over some kind of change in the color of the ocean here off the left wing.

PH: I'm a bit concerned about the CPI. I think we're seeing the same problems we had on the last flight, flashing red lights.

AR: I'll come up and take a look at it. We're indicating 170° at about 40 knots at this level.

PH: Yes. A few white caps now.

3:21 PM

KM: If anyone back there gets a chance, could you bring us up one cup of coffee please?

DS: Okay. No problem.

AR: It seems to be working right now, Peter. That background there that's up on the screen is a good one.

PH: Okay. Why are we getting the red flashing?

AR: There are some problems around the edge of having something go out I would say, but we've been able to operate the thing with good imagery with several things indicating they're not completely in spec.

AR: About 170° now at almost 50 knots at flight level.

3:24 PM

PH: Did Ken get his coffee? Maybe Eric can give the pilots their coffee.

EG: Sure. It will be right up.

PH: We've got to keep the pilots happy.

AR: Probably about 5 more minutes to the first precip.

3:25 PM

PH: They're taking us quite a way out on this track because we're going from 124° longitude to 126° roughly.

AR: Roger. I wonder how much of the precip we're seeing is this virga that's just above us?

PH: The next leg we'll go above the freezing level for the return trip.

3:25 PM

AR: Just the lowering that we have and the way this is put together out here makes me think this is probably going to be the heaviest rainband we've hit yet.

3:27 PM

PH: Ken.

KM: Go.

PH: I have a slightly revised point that we're heading for now.

KM: Go ahead.

PH: 46°15'/126°33'.

KM: 46°15'/126°33'.

PH: Correct. So that's where we're heading now. When we get there we will be climbing up to; I'm not sure what altitude it will be. We want to go just above the freezing level. I'm not quite sure where that is. Then we'll be heading back on a similar route.

KM: Okay.

PH: Art.

AR: Roger.

PH: Did you notice where the freezing level was?

AR: I have to say I didn't, but it was -7°C at 10,000 ft and it's +8°C here, so I would split the difference and say it's 6,000 ft.

PH: Okay. About 6,000 ft. Ken?

KM: Go.

PH: Our guess is that return trip will be around about 6,000 ft.

KM: Okay. Do you want to do a spiral in climb or do it in the reversal?

PH: We can just do a spiral climb.

3:30 PM

TW: I think what happens here is some stuff gets stuck on the lens when we go up and down on the HVPS.

PH: Ken.

KM: Go ahead.

PH: What we'll do is the same that we did on the last flight. We'll make our climb from 1,000 ft to about 6,000 ft a steady climb on the return trip, so that we end up at about 6,000 ft over the radar. Then on the trip out again to the southwest, we'll be at a constant altitude. So each trip out, we'll be at a constant altitude and, each trip back to the coast, we'll be doing a steady climb.

KM: Okay.

3:32 PM

PH: Ken

KM: Go ahead.

PH: I understand that if we need it we do have access to the military areas today.

KM: Yes. From about now on.

PH: Okay.

AR: We're just starting to get the first raindrops.

3:33 PM

PH: We're picking up images on the HVPS. They look okay and on the 2-D. Got some light rain here.

3:35 PM

AR: There are no scud clouds yet just the overlying nimbostratus with liquid layers oriented north-south at the bottom. It looks like it is sort of light rain, kind of a banded structure that we've just past. We're at 233440 and we're coming into a light rain area with liquid cloud bases. Bases not obscured by precipitation. That goes on for maybe 5 min.

3:37 PM

KM: How's the cabin temperature back there?

PH: It's okay Ken for me.

AR: It's a little warm way in the back.

KM: Okay. We'll turn it down slightly.

AR: Ken is adjusting the cabin heat. We'll see how that compares with our Rosemount temperature.

PH: We don't know if the CPI is going to do its job today yet. It's flashing low image intensity, recording disabled and things like that.

AR: Recording disabled should not be present.

PH: It stopped raining again.

AR: Yes. We just past through back there a very light rainband oriented north-south and there's another one just coming up here in another couple of minutes and we'll go back into the rain. There maybe even sprinkles here.

3:39 PM

AR: One thing that's a little different being this far out, Peter, is we don't have that lower scud cloud that we've normally seen out here. So maybe it's a little bit dry yet the offshore flow is still fairly desiccating to this system.

PH: Yes. We're recording about 730 ft here. I'm wondering why it's not closer to 1,000 ft.

AR: You might be using the standard altimeter. The pressure is very low out here. He may think he's a little higher than he actually is. Actually we've descended a little bit too, which would kind of go with flying a pressure contour.

3:41 PM

AR: Now we're coming back up according to the radar altimeter anyway.

PH: How's the radar working?

AR: It looks real good. It's pointed up.

PH: What are you seeing?

AR: I see tops that are about 5 kilometer above the aircraft according to this and there is a melting level signature at about 2.5 kilometers.

PH: Okay. It's not very deep then.

AR: Well I take that back. I counted the divisions as kilometers instead of 750 meters. So it would be about 5,500 for the melting level. But I think we will not see the smallest ice crystals at the very top would be my guess. But it would be nice if there are a shower. But I suspect we're probably going to see deeper clouds when we get into the real precip here in the main frontal rainband.

3:42 PM

AR: In fact, we just past through another one of these oriented north-south sprinkle bands and now ahead it looks like in a couple of minutes more significant rain.

PH: I notice the HVPS picks up a few sprinkles before the 2-D does.

AR: That's interesting. I'm not sure why that is.

PH: I'm wondering if the 2-D is frozen.

AR: I don't think there's anything out there right now. Right now the HVPS looks like its just got noise.

PH: Just got some nice images.

AR: I should probably restart my program. Yes. You're right. There goes a drop. I think in this situation where it is just a sprinkle the HVPS has so much sample volume that you're likely to see something in there. In a sprinkle as a 2-D only sample in a couple of liters per second is not going to see very much and then it has to hold its buffer there until it fills up.

DS: That's what I was about to point out. It takes a lot longer to fill the buffer up because of the sample volume.

PH: That's the big advantage of the HVPS.

3:44 PM

AR: The bottom of these clouds have these little undulatus aspect to them. I'm guessing that's always associated with the base of an inversion of some kind. So I'm guessing there's going to be a pretty pronounced stable layer and without the low scud these bases are running up there probably 4,000 ft or so.

3:45 PM

PH: We've got plenty of white caps here.

AR: Yes. The motion certainly got more into the winds. Back there when we were indicating almost the same velocity, 170 at 40 to 35 knots, there were fewer white caps. I'm not sure why that is, but certainly the ocean is getting more enthusiastic about the storm.

3:46 PM

AR: It looks like we're entering this heavier rain area now in the next 30 s if we haven't already. The radar altimeter is indicating less than 600 ft now.

3:47 PM

AR: It's coming back up. That turned out to be just a band of precip rather than the main bang. The visibility now is much lower ahead, so maybe this is it. Looking back at the tail, we have good visibility at least several kilometers and ahead probably down below 2 kilometers.

3:48 PM

AR: We're about to enter the front of this heavier band in the next 10 s.

PH: Ken.

KM: go.

PH: What altitude do you have?

KM: 1,000 ft.

PH: Okay. Because on my radar altimeter I have 700 ft.

KM: Yes. My radar altimeter reads the same thing. Ours is reading a little bit low.

PH: I think you're reading something related to pressure and the pressure is lower up here. So I think they're reading correctly based on how they're calibrated.

KM: When we went over Hoquiam I had checked them and the radar altimeter was about 200 to 300 ft lower than our pressure altimeter. So that should have been a pretty good check there.

PH: The radar altimeter is correct I think.

KM: Do you want us to go up to 1,000 ft on the radar altimeter?

PH: No. Stick to this.

AR: Do you notice, Peter, how much the visibility has decreased now. It's probably less than a kilometer off the wings and fore and aft.

PH: Ken, as visibility decreases as it will do as we go west, you might feel a bit happier at 1,000 ft on the altimeter.

KM: Okay.

3:50 PM

AR: Drop sizes here aren't very big. It's really more like glorified drizzle I'd say and the radar is suggesting two layers. I take that back. Just as I said that they connected together. So the cloud tops are 5 to 6 kilometers above the aircraft.

3:51 PM

PH: They're sure sending us a long way out today at low altitude.

AR: Yes. When you gave out that 126°32' I was thinking that's going to be interesting.

PH: I'd be happier at a higher altitude.

AR: Do you know if we're supposed to go through the frontal band or whether we're just in a preliminary band?

PH: No. I don't think. Well, the surface front is not going to come through until about midnight. No. There will be an upper level front that we may hit at various times.

3:51 PM

AR: Here again the visibility has improved after that lowering and now looking at probably a kilometer compared to less than a kilometer back there. Still in very light rain.

3:52 PM

AR: Visibility is lowering again. We're coming into another lower visibility area, but this time you can see the drop sizes have increased tremendously over that other low visibility area we were in about 3 min ago.

3:54 PM

AR: Still liquid clouds visible at base, the base of the precipitating layer overhead. They're still elevated probably at 3,000 to 4,000 ft above the aircraft at this time.

DS: Eric and Tom to "chat."

3:55 PM

PH: We're in some steady rain here.

AR: Right now we're starting to pick up some scud at flight level off the right wing there, above the left wing.

3:56 PM

PH: Art, we're going to do the same as we did last time. On the return trip we'll be climbing steadily so we hit 6,000 ft, or just above the freezing level, over the radar.

AR: Sounds good.

3:57 PM

PH: We'll be heading back to the radar initially and we want to end over the radar at 6,000 ft. On the way back they may cut us short. We may not go all the way back, but I'm out of communication with them at this low altitude. A lot of noise on the J-W. The PVM doesn't look too bad.

3:58 PM

AR: We're starting to get our first cloud droplets. These scud clouds have continued to lower in base and so now some are passing below the aircraft and some we've past through, a couple anyway.

PH: Yes. I'm getting 5/cc on the FSSP. We're not too far off our southwesterly point.

AR: Right. It looks like we're going to turn around right in the middle of this thing.

3:59 PM

PH: We're going to have to cut these legs short if we're going to cover much altitude.

AR: At least the first jump up to the freezing level is significant. I'd be willing to bet this is the heaviest rain we've flown in. I haven't seen drops quite this big way over a couple of millimeters, a few of them anyway.

4:00 PM

PH: Don.

DS: Go ahead Peter.

PH: Do you think the CPI is working?

DS: I think there's a laser problem on that. It's starting to come back up again, but I was looking at the background. When I restarted it I was hoping to jumpstart it again. This number is going to have to come up a little brighter. It's starting to get brighter. As soon as it gets brighter, you'll start getting images again.

PH: Do we have a spare laser on the ground?

DS: No. They're very expensive. I don't know if it's a laser per se or if there's moisture inside the instrument. I cleaned all the optics I could get to without pulling it off the plane yesterday because I was doing calibrations and things and that takes a good day to get to the stuff I did. Then to pull this will take about a day too and then go through it and clean all the stuff internally.

PH: Okay.

DS: I did have it working on the ground and it looked fairly good. But when we first started it, there was moisture someplace again. I don't know if we got that from the first rain bursts we flew through or if it's inside the machine itself.

AR: Well, did you notice it happened after our descent from 10,000 ft because remember we were up at 10,000 ft when we came down.

DS: Yes. I did know, Art. I didn't have it up yet. It's slowly getting brighter. The background is now up to 75, so we'll probably start getting images here pretty soon.

AR: Right. Well it has never really liked the rain. I mean we certainly learned that in KWAJEX.

DS: It doesn't like the rain and it doesn't like a great deal of moisture internally or in the exit. It's hard to keep it out of the instrument.

AR: Yes. It needs an umbrella until we get to the freezing level.

TW: Hey Art, what's your favorite t-stat?

AR: t-statr.

DS: Likewise. I also put the t-tot, which t-statr is derived from.

PH: My favorite is English breakfast.

DS: Oh, I thought it would be Earl Gray.

TW: So Art, is it okay that the static temperature is below the dew point?

AR: It's a problem with the dew point measurement we're having right now.

TW: Why is that?

AR: The dew point should never be higher than the ambient temperature because that indicates humidity way over 100% and you wouldn't have that.

PH: If you look at the two dew point traces you see they're differing. The Cambridge and the Ophir differ.

TW: They're not a whole bunch. They're kind of oscillating around each other. But they're both static temperature almost always.

AR: Well not almost always, this is something I have been watching and the last couple of flights this has been a problem and I've called it out on my squawk sheets.

PH: Ken, are we just about at our point?

KM: We're right at it now.

PH: We'll do our turn here and head back to the radar, climbing steadily.

KM: Right.

AR: I can see one of those Kona coffee plantations down there.

4:05 PM

PH: Yes, they sent us right out to our boundary point 3.

AR: Right. I was noticing it's marked on my map thanks to Tom. That's exactly right. A nice droplet cloud here. One of the things that we don't have today that we've seen is with the south-southeast flow out to this point. Sometimes these droplet clouds have had more continental droplet concentrations where it's been 150-250/cm³ and out here it's looking pretty maritime. Some of those high readings were also in rain, so they are probably all just due to wash out.

4:06 PM

AR: The temperature dropped about 2°C since our coastal leg began at this altitude, about +7°C at the coast and about +5°C right now.

4:07 PM

PH: We've climbed quite a bit though Art. We're at 1,200 ft now.

AR: Yes. My radar altimeter says 1,000 ft, but we have climbed a little bit. It has cooled off here that's for sure, maybe not all 2° more like 1.5°.

PH: We've completed our turn and we're starting to head back toward the Westport radar.

4:12 PM

AR: It looks like we're entering some sort of stable layer. The way the temperature has gone up about a degree here as we climb and the winds are veering. About 200° at 60 knots here at 1,500 to 2,000 ft. The temperature is continuing to go up.

DS: Art, go to "chat" for just a second.

4:13 PM

AR: In this climb I noticed a stable layer between the surface and about 2,500 ft. The temperature remaining about +5.5° and then began to drop off. But here again it seems to be rather stable as we pass through trans-alt 3,000 ft. When I was looking at the clouds, I actually thought the stable air was going to be more up in here. So we'll have to see what happens in the next few minutes whether the temperature holds again.

4:18 PM

AR: After flying and climbing through the boundary layer clouds out there, we've kind of been just flying in precipitation with droplet cloud. Oh, I can see droplet cloud just above the aircraft, so we'll be entering some more liquid water on the way up here. Drop size continues to be substantial indicating rain rather than drizzle some millimeter-size drops on the 2-D. As we go out this way, I suppose precip will decrease as it did in the reverse on the way out here. The precip increased drastically in the last 10 to 20 miles or so and before that it was fairly minimal.

4:19 PM

PH: Ken.

KM: Go ahead.

PH: What we want to do is to spiral up to 6,000 ft at this location and then head back to our south-westerly point at 6,000 ft.

KM: Do you want to spiral up right here?

PH: Yes.

KM: Okay. Any particular rate of climb?

PH: Not too fast. Let's make it 500 ft/min.

4:20 PM

PH: I just made contact with the radar. They turned us around about a third of our way back to the radar. They want us to spiral up to 6,000 ft here and then head back to our southwesterly point at 6,000 ft.

AR: It was quite a switcharoo on there part.

PH: Yes. To keep us in the rainband they want us to work between this location and the southwesterly point.

AR: Yes. That's true actually. There wasn't much out further east of us that's for sure.

4:23 PM

PH: It looks as if our best liquid water readings today are going to be the PVM and the FSSP.

AR: At 4,900 ft I can still see the surface. There are some scud clouds around, but generally that's scattered. Correction on that. Those aren't scud clouds.

4:25 PM

PH: Ken.

KM: Go.

PH: We want to head back to our southwesterly point not to the radar.

KM: I thought we were continuing on to the radar. Okay. Southwesterly point.

PH: They want to keep us in this rainband between about this point and the southwesterly point.

4:27 PM

PH: We had a little miscommunication there. Ken thought we wanted to climb 6,000 ft and continue to head to the radar. So he's now turning, 6,000 ft, turning back to the southwest and move the heading back to our southwesterly point.

4:29 PM

PH: Art, I see we've got a temperature here of just below freezing. Maybe it would be good to climb another 500 ft or so and get a nice firm distance between us and the freezing level. What do you think?

AR: Yes. I'd go along with that, Peter. In fact I'd go 1,000 ft because there is a little bit of a bias on t-statr toward the low side, so it might be erroneously low.

PH: Okay.

AR: I was concerned we weren't see enough snow particles. We were still seeing too many raindrops on the 2-DC.

PH: Ken, can we also climb 1,000 ft as we head back to the southwest?

KM: Sure.

PH: You can do the climb pretty quickly. 1,000 ft/min is fine.

AR: Passing just under the aircraft were soft cumuliform looking turrets. We didn't hit those, but I can see them down there. They seem to be rooted in the boundary layer. As best I can tell, I can still make out for a fleeting moment the ocean surface however.

4:31 PM

PH: You might want to come and look at the CPI, Art. We've got trouble with the CPI with maybe moisture in the system or weak laser. We're not quite sure.

DS: What we're seeing here is moisture in the system and the power has come up again. So maybe there's some moisture that's just blocking something. I guess I'm going to have to pull the probe off and go through it.

AR: Yes. There's probably nothing you can do about it, Peter, unless it dries out at higher altitudes, which I would expect some improvement when we get up in the 10 to 20 range we would start to see a little better in the way of imagery.

PH: So we're now at 6,700 ft and -2°C heading back to the southwesterly point.

AR: This is more of the imagery you would expect to see really at 0°C. So I'm a little worried about t-statr being exactly accurate.

TW: It's been mirroring the Shadin s-temp pretty well.

AR: That's true. You can certainly say that. I've watched both of them. But anyway there's a lot of supercooled rain back there coming down on us.

PH: We're getting good crystals now.

AR: Right.

4:33 PM

PH: Ken.

KM: Go.

PH: I have a new southwesterly point for us.

KM: Standby. Go ahead.

PH: It's 46°20'/126°20'.

KM: 46°20'/126°20'.

PH: Correct.

KM: Do you want to proceed to that point now?

PH: Yes at this altitude. Not too far off where the old southwest point was.

4:36 PM

AR: Looking at the sounding I had forgotten about the stable layer and so these little cumuliform elements that we've topped here are actually part of the over running of the marine boundary layer clouds. Liquid water was jumping up there on 0.3. It's fairly substantial when it's there.

4:37 PM

PH: The CPI is clicking over with some occasional images apparent. It just seems to have got condensation on some of the optics.

4:38 PM

AR: I think the instrument is lagging the outside temperature so it remembers the higher temperatures as you go upward and colder and it's the other way around on the way down where it's remaining a little behind the ambient temperature on the way down. I just hope it defogs and it's not out for the whole flight.

DS: Regardless it looks like I'm going to have to pull it off the wing and go through it again.

AR: Does it have like a desiccant in there or something. Isn't that something they were worried about in KWAJEX?

DS: Yes. You need a desiccant in there, but maybe it's used up again.

PH: Maybe we should just replace that.

DS: Yes. I mean if we were getting any moisture in there we've been flying through an awful lot of water.

AR: Yes. But it looked bad even before we started hitting the precip. That was after that descent from 10,000 ft and just when you were starting it up and looking at all that mottling that I think Peter mentioned.

DS: There's only one little packet of desiccant in there. I don't think there's any way in the world that it could keep up with moisture all over the entire thing. I don't think you could put enough desiccant to do that unless you put enough in there to disrupt the laser beams.

AR: Is that something we could change every flight just as a matter of routine?

DS: No.

PH: You know desiccant should dry out and be reusable. So maybe getting some warm air in there before the flight would help the desiccant to dry out and be ready to activate again.

AR: Yes. That's a good point.

DS: Yes. And as far as changing before every flight, Art, that requires removing the instrument from its housing, which is about half a day's work to get it out.

PH: You can't do it in place.

DS: To get to the desiccant, you have to remove the instrument from its can and that's not as easy as removing these other instruments from their cans because the way the wiring is done.

AR: Okay.

PH: We're not going to be flying tomorrow. The next flight is likely to be Sunday. So I think the top priority would be to try to get the CPI up.

DS: Yes. I'll just have to remove it from the can and if there's moisture in it I'll just dry it all off and see if I can get it going again. It just looks like there's moisture on something someplace in there and I should be able to wipe it out and that should solve this problem.

PH: Everything else seems to be working fairly well.

DS: It's been a long road, but we're getting there.

PH: The dew point needs to be looked at some time. It's about 1°C or so above the static and that's the Cambridge I think.

EC: We're about 15 miles from the southwest point. Where do you guys want us to go next?

PH: I'll check. I know we'll be climbing 3,000 ft and I'll get a new point for us.

4:42 PM

AR: Except for the passing clouds here, the sky has been amorphous on this whole leg, no detail, thinning or what have you above the aircraft.

4:43 PM

AR: We've had lower layers visible.

PH: Eric, when we reach our southwesterly point, we'll do our 180° and we'll head back to the following new point to the northeast. Are you ready for it?

EC: Yes. I copy.

PH: 46°30'/125°48'.

EC: Okay. 46°30'/125°48'.

PH: As we progress from the southwesterly point to that new point to the northeast, we'll climb steadily by 3,000 ft so we end up at that northeasterly point at about 9,500 ft.

EC: Okay.

4:45 PM

PH: For the tape, we're working a rainband between a southwesterly point at about 46°20'/126°20' and a northeasterly point at about 46°30'/125°48'. We'll be running constant altitudes from the northeast to the southwest...

END OF TAPE 1, SIDE 1

AR: Aggregates look pretty heavily rimmed and in some places almost like approaching graupels. There must be pretty good liquid water up there.

4:47 PM

DS: I just went back and did a quick electronic calibration on the Cambridge dew point. Let's see if that makes a difference. There is a true mode you put it in and you set the electronics. It had drifted just a little bit.

4:48 PM

PH: By looking at the readout here, it doesn't seem to have made much difference. We've got a static temperature of -2°C and a dew point from the Cambridge, which is sort of oscillating, around -1° to -0.5°C. So it's still about a degree warmer than the static.

DS: Give it a little bit of time to stabilize. I do see it dropping around very close to what the static or just slightly below the static temperature.

AR: There appears to be a little brightening in here at 0047 possibly between one of those rainbands that were substructures of a whole massive rainband that were commented on from the surface pass. I can't make out any cloud detail however. It appears to be an overall slight brightening.

4:49 PM

AR: The radar is in the upward position and tops have gone down. Standby one. They were running about 5 kilometers above the aircraft and at this location they are running about 4 kilometers it says, which would put them around 20,000 ft

4:51 PM

EC: What would you guys like to do after this?

PH: I think I told you. We're still heading to our southwesterly point, aren't we?

EC: No. We've already turned around. We're heading back.

PH: Oh, we've made our turn?

EC: Yes.

PH: Okay. How long ago did we make our turn?

EC: About 7 min ago or so.

PH: Okay. I'll have to contact them and see what they want us to do, but it's going to be something like climbing another 3,000 ft and heading back toward the southwest.

EC: Okay.

AR: Peter, maybe we'll level out at 10,000 ft. I think that's the leg that we'd be on, Peter, because we're climbing now to 10,000 ft and I presume we'd do a level pass at 10,000 ft. Is that correct?

PH: Yes.

4:55 PM

AR: We're nearing the riming-splintering zone. Don't see too many splinters, but there has been one or two in the 2-D imagery. The liquid water droplet cloud does seem to be present from time to time in the least wisp adding up to only a few per cc here, which means it may only be an artifact of the ice crystals at concentrations of up to 5/cc. Still amorphous, no indication of structure in here like we've sometimes seen in the internals of a storm or such as we saw back there at our turnaround point.

4:57 PM

PH: Ken.

KM: Go.

PH: I have a new southwesterly point for us.

KM: Go ahead.

EC: Ready to copy.

PH: $46^{\circ}23'/126^{\circ}10'$ and we'll go back there at our new altitude, which you're climbing now to about 10,000 ft is it?

KM: 9,500 ft.

PH: Okay. So we go back there at 9,500 ft.

EC: Okay. So just go back there at the same altitude.

PH: Yes. When we're heading southwest, we'll be at constant altitudes and, when we're heading northeast, we'll be climbing.

4:58 PM

PH: Eric, if you can let me know when we reach our northeast and southwesterly point, that will be a help.

EC: Okay. We've just past our northeast point and we're heading to the southeast point.

PH: Okay.

5:01 PM

PH: Art?

AR: Roger.

PH: How far above us are the radar tops?

AR: They're continuing to be about 5 kilometers to 4 kilometers at the lowest there's a saddle there. I'd put them around 20,000 ft to 25,000 ft something in that range and that's with a little added on because of the tendency of the radar to underestimate the tippy-tippy top where the crystals are very small.

PH: You said 4 kilometers above us, so roughly 10,000 ft.

AR: More of depth.

KM: Could someone bring me up some water when you get a chance, two waters?

PH: Art?

AR: Roger Peter.

PH: So did you agree with me about 10,000 ft above us.

AR: Right. 20,000 to 25,000 ft agl.

PH: Okay.

AR: That's adding a little bit because probably the smallest crystals might not be seen.
So we're going to have to up as high as we can.

5:04 PM

DS: The radar disk just filled up and so it will be down for a few minutes while we transfer stuff.

5:06 PM

AR: Continuing no Hallet-Mossop-type secondary splinters being produced. There are occasionally needles and columns, but not in any particular significant number. However, we are heading toward the more active end of the rainband here to the southwest.

TW: Don, to "chat."

AR: Maybe we'll see more liquid water at Hallet-Mossop there.

5:07 PM

AR: Still no sign of any detail above the aircraft. This round no sign of thickening or thinning. Peter, is your 2-D imagery updating?

PH: No, it's not Art.

AR: Don, do you copy?

5:09 PM

AR: I think Don is going to cycle power or something here.

5:10 PM

EC: We're just coming up on the southeast point and do you want us to climb then?

5:11 PM

AR: Eric, I think he's talking to the radar right now.

EC: Okay.

PH: Go ahead.

EC: We just hit the southeast point and turned back to the northeast point. What altitude would you like us to climb to?

PH: One moment and I'll get back to you.

AR: Don, what did you have to do to the 2-D to light it up again?

DS: Go again, Art, I was on "chat."

AR: What did you have to do to light up the 2-D again? I closed the program a couple of times and brought it back, but it didn't do anything.

DS: Occasionally, for unknown reasons, the probe just stops and sometimes it behaves the entire flight and sometimes it doesn't. Then I have to cycle the power on it.

AR: Thanks.

DS: Of course, it inevitably happens when I'm not watching it.

AR: Isn't that the truth. Just at this end when the 2-D lit up and the power was recycled, we're seeing many more ice splinters here possibly associated with the Hallet-Mossop mechanism. I haven't seen any droplet concentrations of significance though. We are in our turn to head back and climb.

PH: Eric?

EC: Yes. Go ahead.

PH: We'll be heading back to our same northeasterly point we had before and climbing steadily to 12,500 ft.

EC: Okay.

5:13 PM

AR: There's some droplet cloud passing by the wing now. We haven't started to climb yet. Lots of needles now.

5:14 PM

PH: Eric.

EC: Go ahead.

PH: The northeast point we should head for I've got a slightly different location for you.

EC: All right, I'm ready to copy.

PH: 46°34'/125°20'.

EC: Roger. 46°34'/125°20' and you want us to go there right now, right?

PH: Yes. We'll head there now climbing to 12.5 ft.

EC: 14.5 ft for the altitude?

PH: 12,500 ft. Each climb will be about 3,000 ft.

5:16 PM

AR: As we climb to 12,500 ft, still no sign of any storm gradient here in terms of looking outside. No thin spots. The lower droplet clouds are barely detectable.

5:20 PM

PH: Eric.

EC: Go ahead.

PH: I have a new southwest point for us.

EC: Okay. Just a second here. I'm ready to copy.

5:27 PM

AR: Indicating some liquid water.

EC: Roger. 46°30'/125°45'.

PH: And we'll be doing that at our present altitude.

5:27 PM

AR: There's more ahead, but it looked like we happened to climb as it turned out in a hole in a little bit of a layer. It wasn't much of a layer, but it just turned out we missed the drop cloud.

END TAPE 1, SIDE 2

PH: My best guess at the moment is that we're going to carry on doing what we've been doing here up to our maximum altitude, which I guess will be about 21,000

ft today, and that will take about another hour or so. Then we'll go in to land at Hoquiam to refuel and have dinner before the second flight.

EC: Okay. I'll tell Ken here.

AR: There's only one fly in the ointment. I think that café there in the airfield closes at around 5:00 or 6:00 pm. So I'm not expecting we'll be able to get dinner but that's okay.

PH: Well, I hope everyone brought sandwiches.

5:29 PM

PH: That's the only place there, is it?

AR: Yes. That's right. I think you have to go into town to find anything else. I hope there will be somebody there to fuel the plane.

PH: Yes. We're assuming that's the case. I did ask Larry early on in the project whether or not refueling is possible at all times at Hoquiam and he said, "no problem."

AR: That's good news.

PH: But we'll see.

AR: Right.

PH: Ken?

KM: Go.

PH: Do you anticipate any problem refueling at Hoquiam after 6 o'clock?

KM: No, but they're supposed to be notified.

5:31 PM

AR: Ken, about the notification, is that also true for the hamburgers down there?

KM: I don't know anything about that. That's a good point though.

PH: You can see Art's priority on this flight.

AR: Right.

KM: He's not alone.

PH: A lot of noise on the J-W today.

5:34 PM

PH: Art, the green there is the PVM. Now that's just started. Earlier on we had a lot of noise on the J-W and now it's more on the PVM.

AR: Right. The J-W looks pretty good right now.

PH: It's funny. When the J-W stopped its noise the PVM came in at about 19 min ago.

DS: Yes. I don't doubt there is any correlation between the two.

5:35 PM

PH: Art?

AR: Roger.

PH: Art and Ken?

KM: Go ahead.

PH: You know what we might do at Hoquiam, we might just order a delivery of pizza or something from town.

KM: Yes. We can do that.

AR: I just wonder how fast they'll be.

PH: I think we're going to have quite a bit of time on the ground is my guess waiting for that front to come in.

KM: We're in our reversal now.

PH: You need a new point, don't you?

5:37 PM

EC: We just passed the southeast point and we're heading for the northeast point now. What would you guys like for altitude?

AR: I think he's talking to the radar folks here, but my bet is 3 K.

PH: Eric or Ken?

EC: Go ahead.

PH: Our new northeast point is $46^{\circ}40'/125^{\circ}07'$.

EC: Right, $46^{\circ}40'/125^{\circ}07'$ and what about altitude?

PH: We'll be climbing by 3,000 ft, so we'll be going up to 15,000 ft at a steady climb.

DS: Radar is now recording again.

5:39 PM

PH: Just for the tape, we're continuing our backward and forward, northeast to southwest through this rainband. It's a shifting stack moving steadily toward the east as the rainband moves in the same direction. We're just climbing 3,000 ft. Climbing as we go from southwest to northeast. Then, on the reverse leg back to the southwest, we'll keep at constant altitude.

AR: On that leg there were no gradations in the band. Ken, what's our cabin pressure today at this level anyway?

KM: 5,000.

5:44 PM

DS: I've been watching the static temperature for quite a while. The Shadin static temperature and t-totr are within a tenth of a degree of each other. I think t-statr the computations that are being done may not be 100% accurate.

AR: It's certainly reflecting closer to the actual temperature outside, I'll put it that way.

DS: What are you using for your judge, Art, ice crystals?

AR: Right. The ice crystals and the lapse rate over the last vertical climbs that we've done since the surface are still pretty steady. And you're looking at what?

EC: What do you guys want to do for the next point?

PH: Standby.

DS: I'm looking at the Shadin static temperature and t-totr. I have t-statr up as well.

AR: Well, t-totr is going to be too high that's for sure because there is a bit of a dynamic effect on that t-statr even though I think they tried to design it out. This comes from our flybys for example.

DS: Yes. Understood.

5:46 PM

PH: Ken?

KM: Go ahead.

PH: I haven't got a new southwest point yet, but we'll be returning at this altitude and I'll get you one in about half a minute.

KM: Okay. I'll start the reversal.

PH: Ken?

KM: Go.

PH: Our new southwest point is $46^{\circ}34'/125^{\circ}27'$.

EC: Roger. $46^{\circ}34'/125^{\circ}27'$.

PH: Correct.

5:47 PM

AR: It's almost dark now and still at that last leg couldn't tell any gradient of this particular band at all. Looking at the tail light, I do see the twinkley flashes of unrimed ice crystals.

EC: We are headed toward that southwest point.

PH: Okay. What do you think our maximum altitude will be today?

KM: Around 20,000 to 21,000 ft.

PH: Okay. We're not going to break our 32,000 ft record then.

KM: Say again.

PH: We're not going to break our 32,000 ft record.

KM: Not down here.

5:50 PM

AR: That seems funny, I think we were able to get to 20,000 ft in Kwajalein.

PH: Yes. Sort of strange since he's got such a light load.

AR: Certainly in Kwajalein it was probably the least dense atmosphere we'll probably ever fly in.

DS: Another thing to keep in mind is they didn't have to turn de-ice on in Kwajalein.

AR: We flew above the freezing level quite a few times. It wasn't much above freezing level, but we certainly flew above the freezing level quite a few times at around that level.

DS: Yes.

KM: Could someone bring me up a cup of coffee, just one coffee?

DS: On its way.

5:52 PM

PH: Ken?

KM: Go.

PH: In Kwajalein, which of course was much hotter, we quite often got quite a bit higher than 21,000 ft didn't we?

KM: Not that I recall. We were loaded with ice and I think we may have made it up to 21,500 ft once.

AR: Ken, do you have a cup up there? We don't seem to have any Styrofoam cups back here.

KM: Yes. I have one.

PH: We're getting some images that are recognizable on the CPI despite the condensation background, mainly columns as far as I can see.

5:53 PM

KM: We're about 7 miles out this point ahead of this there. What's the next point?

PH: Standby. As far as altitude goes, we'll be climbing 3,000 ft up to 18,000 ft on the return trip and I'll get a new point for you.

KM: I understand we're going up to 18,000 ft after this.

PH: Yes.

5:55 PM

PH: Ken.

KM: Go ahead.

PH: Our new northeast point will be $46^{\circ}47'124^{\circ}37'$.

KM: $46^{\circ}47'124^{\circ}37'$.

PH: Correct.

5:56 PM

KM: We're at the southwest point now and starting our reversal and of the turn we'll start our climb to 18,000 ft.

PH: Okay.

5:57 PM

PH: We're getting reasonable images on the CPI.

6:00 PM

PH: We're just starting our return trip back to the northeast. We'll be climbing from 15,000 ft to 18,000 ft.

6:01 PM

AR: By the way, this place the Hangar Café that we've eaten at they have a bird burger they call it and the diameter is about the same size as a Frisbee plate.

PH: Don't torture yourself, Art.

6:02 PM

PH: Ken?

KM: Go.

PH: I have a new southwest point for you.

KM: Standby. Go ahead.

PH: It will be 46°40'/125°0'.

KM: Okay. Say again. I got the 46°40'.

PH: 125°0'.

KM: 125°00', okay.

PH: Yes. That will be at 18,000 ft.

6:07 PM

PH: Art? How far are the tops above us now?

AR: We've got it in the down mode since we got up so high. I can have it switched though, but they've been running still about 5,000 to 7,000 ft. Hang on just a second. Yes, it's still more than a kilometer. It's more like 4,000 to 5,000 ft according to this. Then if you add a little bit for small ice crystals, it would probably be about 5,000 ft.

PH: As usual it's going to be just beyond what we can do.

AR: Roger. Sometimes there have been saddle regions that we've actually cleared because we haven't had it pointed up lately. Who knows, maybe we'll exit some ice and go into an open spot and then go back in, which at least would be something at the top.

PH: You haven't seen any stars or the moon?

AR: No. I was just up there looking around for something and I haven't seen it yet. Of course the moon will be a little bit bigger so I have a better chance, but I'm guessing at 21,000 ft I will be able to see the moon, pick it out somewhere.

PH: These legs are within the dual-Doppler area. When we land at Hoquiam, there's a chance that the NOAA P-3 aircraft, which is flying outside of our area at the moment and will not come into our area until we land. The plan is that after we land they come in and they do an airport dual-Doppler survey of this same rainband that we've been looking at.

AR: That sounds pretty exciting. Have they given any indication of how long on the ground they think they'll be? Is it a quickie turnaround or sitting around for a while I wonder?

PH: Well, the frontal passage at the surface is estimated to be at 11 PM. They don't know yet if there are any other rainbands ahead of that front other than the one we're looking at now. It could be that we land on the ground and we don't have a second flight. But if they see another rainband coming in behind this one we're working now, then they'll get us up and it should all be over at 11 PM. Perhaps we should be ordering pizza from the air here.

AR: Yes. Just get that Iridium phone out.

TW: I got my cell phone.

PH: But do you have the Visa number.

TW: I've got the CARG Visa number. That will do probably.

6:14 PM

PH: Ken?

KM: Go.

PH: Are you in touch with Hoquiam Air Traffic Control?

KM: We're in touch, but we can barely read them.

PH: Ask them to keep that hamburger shop open for another hour.

KM: We tried to do that, but I don't know what we're going to get until we get in closer and can get better radio contact.

PH: We're pretty close now.

KM: Yes, we should be. I think maybe they just have a bad radio.

6:15 PM

PH: So we're southwest bound at 18,000 ft?

KM: That's right.

AR: That's affirmative.

PH: Ken?

KM: Go.

PH: The NOAA P-3 is up today in this area. But it's not coming into our area here until we land. They're to the west of us some distance. But when we land, the plan is they will fly over this same rainband that we're working now and do an airborne dual-Doppler survey of that rainband and then they'll clear out of the area when we get up for our second flight.

6:17 PM

KM: Where's the NOAA P-3 working out of?

PH: California somewhere, mid-California coast.

KM: Probably some place like Palm Springs.

PH: Probably. They're flying mainly off the California coast, but they have this one flight up into our area because of this good front that's coming in.

6:18 PM

KM: Do you have a new northeast point, Peter?

PH: Yes Ken. It's $46^{\circ}50'/124^{\circ}25'$.

6:21 PM

KM: $46^{\circ}50'/124^{\circ}$ what?

PH: $124^{\circ}25'$.

KM: $46^{\circ}50'/124^{\circ}25'$. Thank you.

PH: Yes. We'll be climbing to our maximum altitude on that leg back to the northeast. Ken?

KM: Go.

PH: We'll get to our southwest point and we'll then go back to the northeast point I just gave you. That will put us up at about 21,000 ft. Then we'll do a leg down to the southwest at 21,000 ft and then we'll do a final spiraling descent at some point yet to be given and then we'll go into land at Hoquiam.

6:23 PM

KM: Okay. We're at the southwest point and commencing our turn.

AR: That wasn't a real good one, but it looked a little bit rimed to me here. Actually that kind of goes along. That's been one thing that's somewhat consistent is that when we get to the southwest endpoint it seems to be the stronger part of the band and so it's possible even though at 18,000 ft there's still a drop.

PH: Do you want to be on this line, Art, or on "chat?"

AR: I thought I was on "chat."

PH: Ken.

KM: Go.

PH: What's the cabin altitude?

KM: Standby. It's about 7,000 ft.

PH: Good.

KM: When we get up to 21,000 ft, we'll be over 10,000 ft. Maybe Don would want to turn on the oxygen back there.

6:25 PM

AR: Still can't see any stars, moon, what have you up there, suggesting this is really deep. There's a droplet cloud and now we are getting some bullet rosettes. Actually, we've been getting them for the last couple of legs really. So the temperatures, where the crystals are forming and growing, are certainly below -30°C .

6:29 PM

EC: We're coming up on our southeast point here.

KM: Do you want to give us the next point, Peter?

PH: Ken, the new southwest point is in fact the same as the one before, $46^{\circ}40'/125^{\circ}00'$.

EC: $46^{\circ}40'/125^{\circ}00'$ and that's our northeast point?

PH: No. That's our southwest point. We're at our northeast point now and that's the same as the southwest point we had previously. We'll be going there at this altitude. What we want to do then, when we get down to our southwest point, is a

spiral down to 1,000 ft; we want to end up at that 1,000 ft over the radar. After we've done that spiral we'll head in to land at Hoquiam. The radar folks want to know our estimated time of arrival at Hoquiam, so they can get the gas truck there. Did you get all that Eric or shall I repeat it?

KM: Not right now. We're cranking stuff in, Peter.

6:34 PM

KM: Peter, what rate do you want to descend in the spiral?

PH: We descend, Ken, at such a rate that we hit the radar at 1,000 ft. Is that too fast?

KM: No, but we're going to be spiraling down over the radar?

PH: No. We start our spiral at our southwest point and so we'll be drifting to the northeast descending and ending up at 1,000 ft over the radar, but that maybe a pretty rapid rate of descent.

KM: Let us get headed for this next point and see what we can work out here, Peter.

PH: Okay. We're trying to do too much ahead.

AR: Yes. That's probably going to be a couple 1,000 ft a minute.

PH: Yes.

KM: So we anticipate drifting back over the radar from the southwest point?

PH: Yes. From the southwest point, we'll start our descent at the southwest point and we want to end up over the radar. But I think if we ended up over the radar at 1,000 ft per minute, that rate of descent would be pretty rapid.

AR: That's not too bad. I could easily do that, Peter, because we've gone at 2,000 ft/minute in KWAJEX.

6:36 PM

PH: I don't want to spoil the CPI by coming down too quickly.

AR: Well, it's a good idea. Probably the 2-D and HVPS will probably go down too. There would certainly be a good likelihood of it.

PH: Right.

KM: Peter, it's going to take us 9 min to get to this point you've set up. I guess it's near the radar site. A spiral down at 1,000 ft per minute, that's going to be 21 min. So we're looking at 30 some minutes out, another 15 is 45 min to Hoquiam, if that's what you had in mind.

6:37 PM

KM: Peter, are you up?

PH: Yes. We're now heading southwest. Is that correct? Can you hear me, Ken?

KM: Peter.

PH: Can you hear me Ken or Eric? Can you hear me, Ken?

AR: I can hear you back here, Peter.

PH: Ken's not hearing me for some reason.

KM: I'm hearing you now.

PH: Okay Ken. So we're now heading southwest?

KM: That's right.

PH: We'll do that at this altitude. When we reach our southwest point, we want to turn back to the northeast, head toward the radar and descend to 1,000 ft.

KM: Okay. We'll be descending en route?

PH: Yes. Descending en route from the southwest point toward the radar, so we end up at 1,000 ft over the radar. My question is, what would the rate of descent be if we do that?

KM: I don't know that yet until we know what our ground speed is from the southwest point toward the radar.

PH: Okay. So our guess is it's going to be about 2,000 ft/min.

KM: How many miles is it?

PH: Well, it looks as if it's about 60 miles.

KM: Okay.

PH: Then after that, after we've reached that point over the radar, we head into Hoquiam. They want to know at the radar site our estimated time of arrival at Hoquiam, so they can get the fuel truck there.

KM: I think it will be about 45 min from now.

PH: Okay.

6:40 PM

AR: A droplet cloud here. (^{seen} from dome ~~radar~~ in ~~of~~ strobe or a/c headlights)

PH: About 10/cc.

AR: Yes. It's the first liquid water we've seen since about 6,000-7,000 ft.

PH: Can you see the moon?

AR: Nope. I haven't seen a single star or moon.

PH: So cloud tops may still be 5,000 ft above us here.

AR: Yes. In fact, these bullet rosettes are suggesting maybe -30°C or so. We have quite a way to go, -30° to -40°C . The radar is showing about a kilometer and a half now.

PH: Where are you seeing the bullet rosettes? I don't see them on the 2-D.

AR: I'm looking on the 2-D, Peter.

PH: I'm not seeing them.

AR: I'm seeing them back here. Okay if you want to take a look. They're broken and they're irregulars. You're not going to see perfect ones.

PH: Okay.

AR: Indicating the tops are about 15,000 meters above the aircraft right now. It's really the radar.

6:42 PM

PH: Occasional columns and sort of irregulars and plate-like things on the CPI.

6:43 PM

AR: Just looking at the CPI imagery, it looks a little bit better than it did lower down and there aren't too many rosette images, although I did see a couple. I think it's because that instrument is biased toward firing on the little irregular stuff. The bullet rosettes are typically, when they are there, they are a little bit larger and less numerous, so statistically they're not showing up in the camera.

6:44 PM

TO SUMMARY

KM: Peter, we're doing our reversal back to the radar site and descending en route.

PH: Okay. To end up at the radar site and 1,000 ft.

KM: That's what we're going to try to do.

PH: Thank you.

TO SUMMARY

PH: Still picking up a very few droplets here but just one or two per cc.

AR: I think probably will be the ice crystals. That's typically what you get when you're just flying in glaciated cloud, two, three, five, four or something like that. When it gets up to around ten, then you're pretty sure you've got some drops out there. But in this area, it's probably not droplets but missized ice crystals.

PH: Just going through about 18,000 ft, temperature -18°C .

AR: That's not very cold for 500 mb. It really is still way out in the warm part of this trough, which I'm sure is going to have 500 mb temperatures of about -30°C . So we have a long way to go before we get anywhere near that cold front and that colder air aloft, that's for sure. It ought to be. I'd say he was talking about four very strong one I would think.

6:53 PM

AR: That's interesting because the temperature has increased 12°C or so and nothing has crashed on us.

DS: Every now and then a man gets lucky.

AR: Yes. I'm real surprised.

PH: Through 14,000 ft at temperature -13°C . Everything seems to be still working. Getting good images on the CPI.

(in the descent)

AR: Yes. Maybe we have a faulty hypothesis about this condensation.

6:56 PM

PH: I'd expect that if you start off cold and warm things up it's going to get better. Ken?

KM: Go.

PH: Let's see what we get when we get down to 1,000 ft, but we may have fairly strong onshore winds to come into land.

KM: Onshore? We've got the offshore winds by the weather report.

PH: At this altitude anyway. I mean we're still way up there at 10,000 ft and we've got 212° from true north.

AR: If we had onshore winds, it would indicate the front has gone by.

PH: That can't be the case. Let's wait until we get down low and see what we've got.

6:58 PM

AR: At this point I'm feeling the ducting get hotter by the second.

PH: About 60 knot winds here, Art, and 200°.

AR: Yes. They've been even higher than that, of course up higher actually. Actually they're pretty good in spite of this steep...

KM: Peter, it looks like we're going to get to the radar site before we get to our 1,000 ft. Do you want us just to spiral then?

PH: Yes. Then just spiral down over the radar site to 1,000 ft and then head into Hoquiam. At this level, Ken, 8,500 ft, we've got about 60 knot winds from 200° true north.

7:00 PM

AR: I wasn't paying attention. What was our descent down on this leg?

KM: We were getting about 1,500 per minute rate of descent.

PH: Through my numerous radio links, I've ordered pizza for us, but we'll see if it turns up.

AR: Wow!

KM: I hate pizza.

AR: We're coming back into some droplet cloud here. The 2-D and HVPS are beginning to act up now.

DS: There's starting to fog finally. I recognize the symptoms from the way the 2-DC looks.

PH: Yes. We've got about 20 drops per cc now. The CPI still looks okay.

DS: Yes. It's still giving us some, but it's starting to drop out too. Oh, I was thinking the HVPS. Pardon me.

PH: The CPI is okay. That's a pretty rapid rate of descent. Ken?

KM: Go.

PH: Let's decrease our rate of descent here to 1,000 ft/min.

KM: Roger.

PH: We're over the radar site descending, spiral descent. In through some nice pockets of liquid water here. That was very good agreement between our liquid water probes, Art, you look at them. Gee, which one do you take?

DS: Doing a spiral I wouldn't trust the values because they're not getting the stuff through them in the correct orientation.

PH: Good point.

7:03 PM

AR: Liquid water is about the same area as we saw when we first started on this band. It's popping out around 6,000-7,000 ft and extending all the way down to the surface.

PH: PVM and J-W are agreeing pretty well.

7:03 PM

PH: It looks as if DMT is out on it's own.

7:04 PM

PH: Our wind speed has gone bad, Art. It's reading about 80 knots.

DS: It will correct when we go level again.

AR: It's because we're turning.

PH: The wind direction maybe okay.

DS: I wouldn't trust that either until the ground is straight and level because it can't make correct vectors.

AR: Right. If you thought the winds were turning, they kind of flop around. They might be right because of accident by some point, but you can't trust it really. Lots of rain outside, but not much in the way of imagery.

PH: I think the CPI is okay. It's got a lot of drops on it. Maybe this rate of descent just doesn't help us much.

AR: It did seem like we got away with it until the temperature got higher than -10°C or so. I think between -5° and -10°C is when we started losing stuff. So maybe we can do it at those lower temperature.

DS: Yes. It's when we start getting into the warm moist air coming into contact with the cold surfaces that we have problems. HVPS is starting to come back. With any luck, maybe the 2-DC will here shortly too.

7:06 PM

AR: Also, I would expect the turbulence is going to increase quite a bit here in the next 30 s to a minute as we descend back into that layer of those intersecting winds that we tend to have out here, the east wind and the more southerly wind offshore.

PH: We might as well buckle up now for the landing anyway we're very close to Hoquiam.

DS: I'll start shutting down the CPI.

PH: No. Hold it for a moment.

DS: If power goes down, it crashes the system and I may not be able to get it back up if it damages something.

PH: Well, we're still at 1,500 ft and we're coming down to 1,000 ft and then they'll set themselves up to come in and land.

DS: Okay.

7:08 PM

DS: There's the turbulence.

7:09 PM

PH: Okay. We're at 1,000 ft and +5°C temperature. That completes our descent over the radar. Ken, it's in your hands now.

DS: Let me know when I can shut down the CPI.

PH: Shut it down.

7:10 PM

DS: Peter, you can shut the switch off over there. It should be right there next to the green light. There you go. Thanks.

PH: Is the forward video still on? Can I get it up here?

DS: No. We don't have a Java server for QNX, unfortunately. I can switch it here though if you look around and see it.

PH: I'd just as soon see it when we're coming into land. Is everyone buckled up?

DS: It looks like it. It looks like HVPS is down for the count.

7:12 PM

PH: Will that be okay for the next flight?

DS: It may yet come back. It's starting to get a little bit better, but there's still some condensation on the lens.

7:13 PM

PH: What winds do we have now?

DS: 178° from true north at about 60 knots.

7:14 PM

PH: Art?

TW: He's sitting down in the back.

PH: Okay.

DS: We're kind of heading back out to sea here.

PH: Well that's maybe how he's coming into land. I switched my computer off. I thought we were coming into land.

DS: He must be setting up on a vector.

TW: I'm backing up the radar data now.

DS: Okay.

7:16 PM

PH: This is rough, coming into a strange airport at night in fairly strong winds. Are we heading back inland?

DS: I'll put it up here.

7:17 PM

PH: Are you sure you're not looking at our old track?

7:18 PM

PH: What are the winds?

DS: Until we stop turning, it would be hard to tell you exactly what they are. But right now, they're reading about 100 knots.

PH: I can't believe 100 knots.

DS: The Shadin stopped giving winds. Where's the airport located at on this peninsula?

PH: Hoquiam is a bit inland. You know that blue going inland there. It's a bit to the east.

DS: It's in this area?

PH: There. Yes. I don't know where the airport is. You landed here recently, didn't you?

DS: Yes. But I was busy shutting down or bringing up the data system. It looks like it's right in here someplace.

PH: Ken, how are we doing?

KM: We're 8 miles out, another 15 from the field.

PH: Okay.

KM: We have pretty good winds.

PH: Yes. I know. It's a bit of a challenge, a strange airport, nighttime and strong winds.

7:21 PM

DS: Is the light level low enough up there?

7:22 PM

PH: It's raining pretty hard here.

DS: The airport must be right here on this little spit.

7:23 PM

PH: No. That's where Ocean Shores is.

DS: I'm about to shut the data system down.

7:24 PM

PH: Can you bring up the forward video?

DS: You can't see a whole lot out there. There's just a little bit of dim light up ahead.

PH: I think he must be coming into land now.

DS: Yes.

7:25 PM

DS: I've got to take to take this down in a nice fashion as well.

PH: Yes. We're coming in now. He's doing another turn.

7:26 PM END OF TAPE

Summary of UW Flight 1856

6:44 PM

PH: I'm going to summarize this flight. It's been pretty straightforward. It's been a track through backward and forward, southwest to northeast, through a rainband ahead of a cold front offshore. We've been profiling it from 1,000 ft up to 21,000 ft stepping up in 3,000 ft increments with level tracks every 3,000 ft and then on the reverse track climbing 3,000 ft. We've been doing that for the whole flight. We're just at our final southwest point.

TO MAIN TEXT

PH: So just doing our final leg for the northeast descending fairly rapidly to take us from 21,000 ft down to 1,000 ft over the radar. Then we'll heading into land. Art, do you want to do a summary?

AR: Sure. Microstructurally this wasn't as interesting as I thought it was going to be. No liquid water except for a little patch of embedded altocumulus up around 21,000 ft just a couple of minutes ago. Other than that, mostly unrimed aggregates all the way down to the level that we did see liquid water and that was around 7,000 ft. Both clouds were situated in an inversion layer of warm over running situation that the base of that was near the surface actually out there and then topped out around 6,000-7,000 ft as I recall. I note that over running inversion was crammed with stratocumulus clouds, liquid water contents up to 0.3-0.4 at the most and had a little bit of a cumuliform aspect to it. Then the only other liquid droplet clouds that we found were really kind of shred clouds at our most southwestern point. That was a little unusual because we've seen those low stratus fractus and stratocumulus clouds much more plentiful out in the area of the rain compared with today where those kind of clouds were restricted only to about the last 10 nautical miles maybe 20 nautical miles of our southwesterly first run at this prefrontal rainband. So that was a little different than the last band we sampled where there was lots of liquid water all the way up to the highest level flown also at 21,000 ft. That fits with a lot of the earlier studies that I think this group has done where these prefrontal bands are mostly glaciated in the regions ahead of the front and then if we do fly in that frontal band I would expect we'd see a lot more liquid water and a more interesting situation.

PH: Thanks Art.

TO MAIN TEXT