

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

Date <b>10 Feb</b>	Flight Number <b>1859</b>	<p>Experimental Observations</p> <p>Detailed microphysical measurements in moving stack (2-20 ft) in <sup>off-west coast</sup> wide-cold frontal rain band under S-Pol radar surveillance from West port. (More convective elements moving up from south, merged with above rain band on diff. side <del>side</del>)</p> <p>(continued to sample this rain band on Flt 1860 on same day).</p>
Project name <b>IMPROVE-1</b>		
Engines on time <b>1430</b>	Engines off time <b>1205</b>	
Departure airport <b>Paine</b>	Arrival airport <b>Hogium</b>	
Flight Scientist signature <b>P. V. Hobbs</b>		
Pilot signature		
Surface met. & visual obs. at takeoff <b>Dark at T/O</b>		<p style="text-align: center;">Clouds sampled</p> <p>Ac</p> <p>As</p> <p>Ns</p> <p>Sc</p> <p>St</p> <p>Cu</p> <p>Cb</p>
Research crew <b>Hobbs Rangno Gray Wilson</b>	Equipment failure <b>JW failed at 1703 wct wh <del>engine</del> a/c discharged charge. Also CFI OTE</b>	

[ Star  
Justin  
David

[ Sutherland  
Eric  
Jerris

temporarily at 1703; came up again but inferior in a.c.s.

UNIVERSITY OF WASHINGTON FLIGHTS FOR IMPROVE  
(PHASE 1: 4 Jan - 14 Feb)

Date: 10 Feb 2001

UW Flight Number: 1859 (IOP<sup>12</sup> 11)

Goals of Flight: Sample rainband off Washington Coast.

Period of Flight (Engines on to engines off: UTC): 1430-2005 (5.58 hrs)

Locations: off Washington Coast; west of S-Pol radar at Westport.

Weather Conditions:

Main Accomplishments: Rainband

Detailed microphysical measurements from 2000 to 19,500 ft in wide-cold frontal (?) rainband with S-Pol radar coverage.

Approx UCT Time (UTC = local time plus 8 hours)	Activity
1430	Engines on
1437	Take-off from Paine Field
1437-1447	Climb to 9.5 kft (-14°C) (FL at 2200 ft)
1500-1507	Descend to 2 kft near Wash. Coast

Approx UCT Time (UTC = local time plus 8 hours)	Activity
1507-1540	Head to West point ( $47^{\circ}10'/125^{\circ}56'$ ) at 2 kft (Same precip.)
1540-1543	Turn at west pt.
1543-1612	Head east at $-20^{\circ}\text{C}$ level in cloud. Turn back west to $47^{\circ}11'/125^{\circ}37'$ climb to 4.5 kft
1617-1633	Head west at 4.5 kft ( $-6^{\circ}\text{C}$ )
1633-1636	Turn
1636-1642	Head east, climbing to 6.5 kft
1642-1645	Turn
1645-1654	Head west at 6.5 kft ( $-8^{\circ}\text{C}$ )
1654-1656	Turn
1656-1708	Head east climbing to 8.5 kft
1703	Electrical discharge from aircraft. Lost CFI temporarily and JW permanently)
1708	Turn at easterly point
1710-1720	Head west at 8.5 kft ( $-13^{\circ}\text{C}$ )
1720-1723	Turn
1723-1731	Head east climbing to 10.5 kft
1731-1732	Turn
1732-1739	Head west at 10.5 kft ( $-16^{\circ}\text{C}$ )
1739-1749	Turn and head east climbing to 13.5 kft ( $-22^{\circ}\text{C}$ )
1749-1750	Turn at easterly point
1750-1759	Head west at 13.5 kft
1800	Turn
1802-1809	Head east climbing to 16.5 kft
1809-1817	Head west at 16.5 kft ( $-30^{\circ}\text{C}$ )
1817-1819	Turn
1819-1824	Head east climbing to 19.5 kft ( $-38^{\circ}\text{C}$ ). Breaking out of top of band clouds to east.

1824 ~~1824~~ 1826(?)  
1826(?) - 1834?  
1834(?)  
1842-1903

Turn  
Head west at 19.5 kft  
Turn and climb  
Report prepared by: F. V. Hobbs

Head east to West point at 20.7 kft ( $-40^{\circ}\text{C}$ ) Date: 2/10/01

1905-1945

Land at Hoquiam  
2000 UTC.

Spiral descent on coast at 500  
ft/min then 1 kft/min to  
2 kft ahead of rainband but  
in "interesting precip" (S-Pol operator)

Flight Plan for IOP 11, Sat 10 Feb 2001

Aircraft Doors-Close Time:  
6:20 AM

Primary Flight Strategy:

Moving Stack

Est. rainband speed:

12 kts (6 m/s)

Est. cloud top:

20,000 ft. (6 km)

Est. freezing level:

1,800 ft. (500 m)

Starting lat/lon:

46° 54' N 124° 06' W (radar)

End of first leg lat/lon:

47° 17' N 126° 10' W

First leg altitude:

1,000 ft.

Second leg altitude:

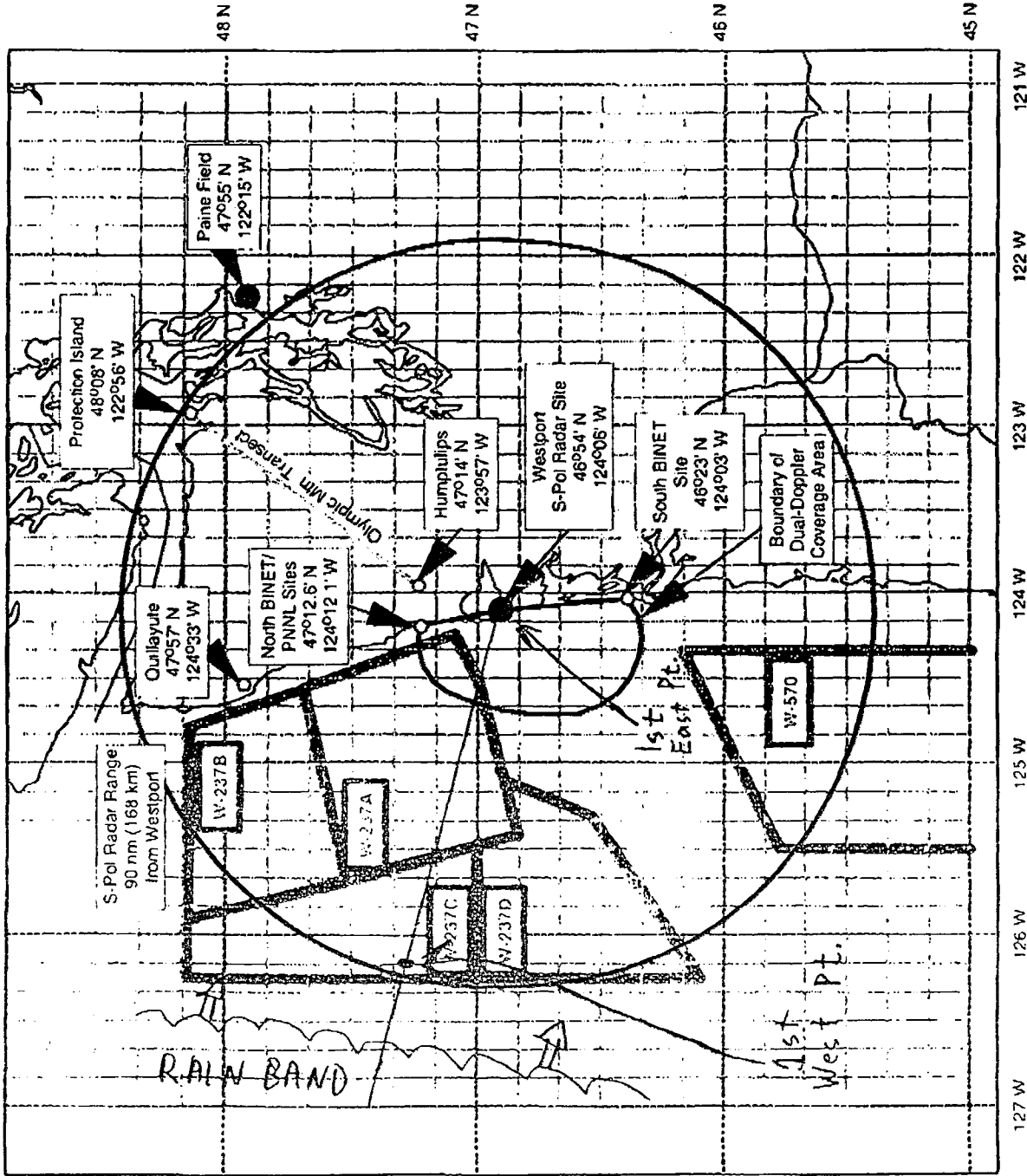
-1°C level

Approx altitude step thereafter:

2,000 ft.

Optional Strategies:

Oly. Mtn. Transect



Flight 1859  
February 10, 2001  
Voice Transcriptions\*  
IMPROVE-1

PH: This is UW flight 1859, 10 February. On board Hobbs, Rangno, Gray, Wilson; also, Stan, Justin and David as guest scientists; Sutherland (chief pilot), Eric (co-pilot) and Jerry Rhode is our backup pilot. We're going to head out to the coast to Westport and then we'll be flying out just slightly north of northwest at 1,000 ft and then we'll be going backward and forward through a rainband as it moves onshore.

6:34 AM

6:39 AM

AR: Post-takeoff of Paine Field by about 5 min and looking up at altocumulus perlucidus translucidus at the moon. It's the only sign of any incoming storm right now.

PH: Grant?

GG: Go ahead.

PH: I can't pull up my position plot.

6:41 AM

TW: I'll look into that.

PH: Everything else is coming up okay. Tom will look into it.

6:42 AM

AR: Over flying the stratus here in the southwest side of Puget Sound.

GG: Peter, when did you log on?

PH: I'm not hearing you very well.

GG: When did you log onto the system?

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\* AR = Art Rangno, DL = David Laskin, DS = Don Spurgeon, EC = Eric Cooper (pilot), GG = Grant Gray, JR = Jerry Rhode (pilot), JS = Justin Sharp, LS = Larry Sutherland (pilot), PH = Peter Hobbs, SR = Stan Rose, TW = Tom Wilson

PH: A little bit early maybe.

GG: You're getting everything else. I don't know why you wouldn't be getting that feed.

TW: I think I know what's wrong.

GG: Okay. Tom is on it.

PH: The Ophir is several degrees above the Cambridge.

6:44 AM

PH: Our usual noise on the DMT. The rest of liquid water meters look to be zero in clear air.

6:45 AM

AR: Continuing to have very cold conditions aloft,  $-5^{\circ}\text{C}$  at 850 mb,  $-12^{\circ}\text{C}$  at 700 mb, and I'm correcting for the t-stat offset. It's probably about a degree too low. Visibility is excellent more than 50 nautical miles at takeoff and aloft here no sign of haze. Noise on the HVPS is counting in clear air.

6:46 AM

TW: Peter, give it a try now.

PH: I've got it.

6:47 AM

PH: Hello Eric.

EC: Hello.

PH: Just making sure I've got contact.

EC: Sounds good.

6:50 AM

LS: Peter, are you up?

PH: Yes Larry.

LS: What do you want to cross the radar at?

PH: Let's be at the radar at 1,000 ft and head to our westerly point at 1,000 ft. When we get to our westerly point, we'll do a spiral upward. I'm not sure what the level will be. I want to go just above the freezing level and then we'll do a straight line, a level pass back to the radar at just above the freezing level.

LS: Okay.

PH: Art, what's the  $-1^{\circ}\text{C}$  level roughly?

AR: That should be around 2,500 to 3,000 ft today.

PH: Let's make it 3,000 ft then Larry for that level pass back to the east.

LS: Okay. I'll run it back at 3,000 ft. I'll see if I can get that, Peter.

PH: Okay.

6:54 AM

AR: Now beginning to pick up cirrostratus overcast extending back behind the plane about 40 miles or so. We've been under flying that now looking back I can see some altocumulus with virga that we under flew while I was fiddling with the CPI. Nothing of any consequence on the horizon to the southwest yet. We had over flying stratus in the southwestern part of Puget Sound. The Olympics are clear except for the overlying cirrostratus clouds. We don't even have altocumulus right now ahead of us.

6:55 AM

TW: Grant?

GG: Go ahead.

TW: We might want to cycle power on the 2-D probes just because it's putting out a couple of blank slices and that's sometimes a sign that it's not working correctly.

GG: Also the two switches that used to be reversed, left and right, are no longer reversed.

TW: All right.

GG: They are as they say.

TW: I'll let you handle that.

GG: Roger that.

6:56 AM

AR: Passing through 750 mb with  $-14.4^{\circ}\text{C}$  as the indicated. It would be about  $-13^{\circ}\text{C}$ . No turbulence thus far on the flight. We're beginning our descent to Westport.

GG: They have been cycled.

6:58 AM

LS: Peter, could you take the first leg at 1,500 ft? Hello Peter?

GG: I think he's on the radio to the radar right not.

LS: Okay.

6:59 AM

PH: Eric?

LS: This is Larry.

PH: Were you trying to contact me?

LS: Yes. Could we do that first leg at 1,500 ft? Would that serve you as well?

PH: Yes. That would be okay.

LS: Okay.

AR: Just about to enter tops of a layer here at 7,500 ft. That would be altocumulus then. It's transparent and now I see true stratus down below. So here we go. About  $-10^{\circ}\text{C}$  so we ought to see maybe a little virga from this and looking ahead the clouds are thickening up quite rapidly. The moon is dimly visible because of a higher altocumulus layer now passing overhead and the thickening of the cirrostratus clouds.

7:00 AM

AR: We're coming out the bottom of the altocumulus layer.

PH: Getting better agreement now between the Cambridge and the Ophir with the Ophir just slightly above the Cambridge. It's got better as the flight has gone on.



AR: I don't see any virga anywhere. I didn't pick up any images.

7:01 AM

AR: I don't see any virga out of this, so definitely ice free at  $-10^{\circ}\text{C}$ . Clear below at this point. Lowering bases ahead and we have some lower stratus out about 10 o'clock. There maybe some precip actually off the right wing now that I look a little closer and we're approaching the Westport radar. The time is 150055.

PH: We're just coming up to the coastline.

7:03 AM

AR: There's definitely precip up toward the Olympics out of this stuff, but it's a heavier version than what we went through. The altocumulus opacus now probably above us is a bit thicker than what we passed through.

LS: Peter?

PH: Go.

LS: They're going to hold us at 3,000 ft until we're just offshore and then we'll drop down to 1,500 ft.

PH: Okay.

7:04 AM

AR: Water rippled here in the outflowing river below. The wind direction looks like it's about 110 looking at the plume from Hoquiam, 110, 120 to 130 something pretty normal there for Hoquiam airport. We expect to have more southerly flow offshore, so there should be a little turbulent zone. Passing now through 2,400 ft.

7:05 AM

PH: Larry?

LS: Go ahead Peter.

PH: I have a new westerly point for us.

LS: Okay. Go ahead.

PH:  $47^{\circ}10'/125^{\circ}57'$ .

LS: Okay. Thank you.

7:06 AM

LS: Peter, down at 1,500 ft for you.

PH: Thanks Larry. Our freezing level is about 2,200 ft on my altitude reading.

7:09 AM

AR: Isolated precip off the right wing ahead and off the left none in it. We have altocumulus opacus over us lowering it looks like down to stratocumulus levels and near foreground here. It still has a perlucidis pattern, which isn't so great in terms of telling us how much synoptic lift is going on. It maybe looks like a line of maybe heavy cumulus or lower stratocumulus.

PH: We're heading to our western point at 2,000 ft just below the freezing level. Our first westerly point is at  $47^{\circ}10'/125^{\circ}56'$ .

7:11 AM

PH: We're in clear air here overcast of stratocumulus. The sun is just coming up, white caps.

AR: Along our descent the wind is back from about 195 to 200 at 10 to 15 knots and now we're seeing 165 at about 10 knots, so this is pretty weak.

7:12 AM

AR: It looks like the rain is about 2 min ahead and it looks like it might be a wind shift line there. Is this it coming up here, Peter? Is that the frontal band?

GG: He's talking to the radar right now.

7:13 AM

AR: If this is the wind shift line, you expect a little light turbulence going through it.

PH: Yes Art.

AR: I was just saying it looks like maybe the wind shift line is ahead of us and we ought to be entering precip here in about 2 min. Is that the front out there now?

PH: It's a rainband. I don't know if it's a front.

AR: I was just wondering how much further our west endpoint is.

PH: We're going out to 47°/125°56'. So it's about another 60 miles out.

AR: Than this is probably not it.

7:14 AM

PH: Larry?

LS: Go ahead Peter.

PH: Are we going to be able to drop down to 1,000 ft?

LS: We can't get an IFR clearance down there, Peter. We're going to be in the clouds. We're going to have trouble getting back up.

PH: Yes. We're going to be into some precip ahead of us. If this is the best you can do, we'll stick with this.

LS: Okay. Let me see what I can do with the Center here.

PH: Thank you.

AR: We're starting to pick up some scud now at flight level 1,300 ft off the left wing and ahead as the ceiling is rapidly lowering.

LS: Peter, we're going down now to 1,000 ft.

PH: Okay. I can give you our easterly point if you want to take it.

LS: Okay.

PH: On the return trip, which we'll be doing after we've done our climb over our westerly point, and the easterly point will be 47°05'/125°09'.

LS: I've got it.

7:16 AM

PH: Larry.

LS: Go ahead.

PH: A good altitude for that return trip would be 2,500 ft. So at our westerly point, if we can climb to 2,500 ft, and then head back at that level to our easterly point.

LS: Okay.

AR: The precipitation looking a bit cellular here. I suppose it's not surprising considering the low temperatures aloft. I have a rain shaft off the right wing about 2 o'clock. It looks like our plus to me. Off around 9 to 10 o'clock, however, I can see quite a distance without any rain being indicated. It's looking a little cellular out here too. I guess that's not surprising with the low temperatures along that you quite a sharp rain shower off about 2 o'clock. It looks like it might be our plus to me. Off around 10 o'clock you can see quite a distance without any rain.

7:17 AM

AR: Now under flying the lowest cloud bases in the area by about 100 to 200 ft.

7:18 AM

GG: Put that fairly close to your lips.

PH: We've got position to descend to 1,000 ft about 5 min back there. We're heading out toward our rainband.

AR: Looking back at that R+ area, I can see a towering cumulus, heavy cumulus, kind of a water anvil sticking out in the side and that is merging with that altocumulus layer that is up there. I would think the major top goes above that, so those tops are indicated in the water anvil to be less than 10,000 ft for sure. Moon visible occasionally. The wind seems to have backed a little bit here 155 at 14 knots.

7:20 AM

AR: We have not yet had any precip indicated on our probes, but it was passing under a dark base here quite dramatic looking and maybe a drop of two coming out of it, but it certainly has not reached the mature stage where much is coming out of it.

7:21 AM

AR: Picking up a few raindrops back there and here finally. Not much wind down there. Look at that, Peter, no white caps. This is the first flight with no white caps. The flight level winds are 155° at about 10 knots is all. Looking pretty sad.

7:22 AM

AR: The winds have come around a little bit here, Peter, in the last 2 min or so. It went from about 155° at 10 knots to now we're getting 180° at about 14 knots. There doesn't seem to be any cloud line with that, so I'm sure that means much.

7:25 AM

GG: I was just looking at the back of the card and it looks as if we've only had one probe plugged in.

TW: That's kind of strange.

GG: Let's take a look.

TW: Okay.

7:26 AM

PH: Art?

AR: Yes.

PH: Are all the instruments up as far as you know?

AR: No. We don't have the 2-D probe.

PH: I was wondering about that. HVPS?

AR: Roger. That's working and we're getting indications of melting snow here.

PH: Is the radar working?

AR: Yes it is and cloud tops are running about 10,000 ft above flight level.

PH: It's pretty shallow then.

7:27 AM

AR: They've been rising so perhaps they'll get a little taller as we get closer to this frontal band or rain band. The winds have come around a little more. Now 210 at 12, so we're going through some kind of broad wind shift line I would have to say.

PH: Art?

AR: Roger.

PH: Did you check that the cover was off the 2-D probe?

AR: They don't put the cover on any more, Peter.

PH: Okay.

7:29 AM

AR: Still continuing in a very light rain, cloud base is easily visible. No particular down spouts. In fact the biggest "down spout" we had was the one that we missed. It passed off the right wing about 10 min ago. It looks very weak stratiform all see-through altocumulus/altostratus.

7:30 AM

AR: Visibility along the left out beyond the left or right wings greater than 3 kilometers and very light rain.

7:31 AM

AR: Continuing to fly in blotchy stratocumulus conditions with rain falling through it from what appears to be a thin stratiform layer topping out around on the radar here now about 10,000 to 12,000 ft above flight level. Just starting to nip some of the lower bases here so the cloud bases of the stratocumulus have continued to lower a little bit.

7:33 AM

AR: It looks like a bit of a line of stratocumulus ahead. Maybe that's a little more defined wind shift line in the next 2 to 3 min. Just as I say that, the wind is already shifting around at 235 now at a whopping 3 knots or 4 knots.

7:34 AM

AR: There is a line of enhanced stratocumulus ahead a couple of minutes now. I still don't see any white caps. That goes with the winds being fairly accurate.

7:35 AM

AR: It looks like the heaviest precip of our leg is just seconds ahead now as we begin to under fly this enhanced stratocumulus line.

PH: We're about 10 min or so longitude off of our westerly point.

AR: There it goes a little bump of turbulence corresponding with the base of that line of stratocumulus. The wind looks like it did come around a little bit more with that, so there is something helping to put that together. It's now about 255.

7:36 AM

LS: Hello Peter.

PH: Larry.

LS: We're 9 miles from our endpoint here and I see we've got at least 15 miles of weather ahead of us. Do you want to go on out and pick that up or not?

PH: We'll just keep going at this altitude to our westerly point. When we reach that point, we'll do a spiral up to 2,500 ft.

LS: Okay. We can just do that and our 8260 and then meet at 2,500 east point.

PH: Okay. Good.

7:37 AM

AR: Another patch of heavier precip just seconds ahead here, Peter. It looks our turnaround point might be in the middle of this.

7:39 AM

PH: More turbulent here.

AR: Indicating another little wind shift here as we went back to back into the southwest or south-southwest and now it's come around to 250 to 260.

PH: Yes. Pretty quickly.

AR: So there is some organization there too, so it's like there's been several little wind shifts in here and now the rain looks even heavier ahead. I can't see much in the forward direction. It's now beginning to brighten up. It looks like it's just almost a cellular-size element. Now it looks like some blue sky ahead too.

PH: Yes. Probably breaking out of the back edge of the rainband.

AR: Yes that would be my guess since it's so close to the point and the winds rolling at 250 again. It looks like a real big clearing on the horizon now dead ahead.

7:41 AM

AR: Grant, the 2-D is just not going to come up today?

GG: The card may have failed. Tom has the HVPS on one and the 2-D on the other. That's the new card and there is something wrong. We don't want to shut it down now and start playing around with it until we're in clear air. We have the HVPS and the CPI that are working well.

AR: Do you need clear air for some reason?

GG: Well, if we start bringing down probes, we'll bring down the CPI and the HVPS too and you'll get nothing.

AR: Well, I was just going to say there probably isn't going to be any clear air this whole flight.

GG: Well, then we probably won't have the 2-D.

AR: Are you saying that, if we spent 10 min in clear air, you could fix it?

GG: Well, we could troubleshoot it and see if it's the probe or the card. We'd swap cards. I don't know how long it would take Tom to swap the software from one card to the other, but that's what we'd have to do.

AR: Peter, did you catch any of this conversation?

PH: Yes I did. I think it's best to stick with what we've got rather than jeopardize that going down as well. Maybe when we've climbed out of cloud top later on in the flight and we've already collected some data, we could try bringing the 2-D up then. What do you think, Art?

TW: He's off the headset. He's back on now?

PH: What's your opinion, Art?

AR: Well, I'd probably look for some clear air.

PH: The danger is I'm told is that we may lose the other measurements.

AR: Maybe I misunderstood. I thought they were saying that maybe it would be safe if we did that in clear air. But if that 's the case, it's better to go on.

PH: Grant or Tom, if you fiddle around with the 2-D is there any chance we may lose the HVPS?

GG: We'll lose it for the amount of time that we're fiddling around.

PH: Yes, but there will be no problem bringing it up again.

GG: Presumably no.

TW: We can do one experiment with just taking down the HVPS and not the CPI.



PH: I'd better check with the radar to see how much further west we have to go to get into clear air.

AR: Roger or we could just wait and hold on here until we get to the east end.

PH: Yes. I think we'll do this easterly track anyway and then we'll reassess if we want to fiddle around with the 2-D.

AR: Roger. It sounds good to me.

TW: It doesn't need to be clear air, it just needs to be non-scientific air. You know, like when we're not doing a leg.

PH: Okay. I'll let you know.

GG: How long will it take you to swap from one card to the other, Tom?

TW: Hardly any time at all.

GG: Roger that. You're right, as long as we don't cycle power, it won't affect the CPI.

7:45 AM

AR: Flying in light snow at 2,000 ft here out of the water, which is a demonstration of how cold it is out here today. It's the lowest freezing level of any of the IMPROVE flights. Picking up some cloud droplets at this level, which we will most of the way back since we were at cloud base as we made our westerly leg.

7:47 AM

PH: Larry?

JR: Hello.

PH: Is this Larry?

JR: It's Jerry this time.

PH: I'm out of the contact with the radar at this altitude until we get in a little bit closer. But in the absence of any other information, when we get to the radar, we will turn back to the west and head back to our previous westerly point climbing by 3,000 ft. So we'll end up at 5,500 ft over our westerly point.

JR: Okay. When we start our turn we will go back up to 5,500 ft and we'll do that when we get in touch with the radar. Okay?

PH: Yes. At the moment, we'll just keep at this altitude heading back to Westport.

JR: Roger.

7:50 AM

AR: Conditions continue to be stratiform aloft. An occasional blip of droplet cloud here and actually we hit, as Peter was noting a second ago to David Laskin on the "chat channel" some liquid water up to about half a gram. So that was that stratocumulus line that we passed under earlier.

7:52 AM

AR: About 2 min ago.

PH: Art, what's the radar seeing now on the tops? What's the deepest the radar is seeing?

AR: Pretty consistent right around 10,000 to 12,000 ft above sea level.

PH: In terms of stepping up here, the steps we have been doing in the past have been 3,000-ft steps have they?

AR: That's affirmative.

PH: Maybe we could reduce that a little bit since it's not too deep.

AR: Roger. I'd probably do that. Tom, do you copy? Larry was saying the pilots might enjoy something like this up front, a laptop of some kind. Is that doable?

PH: Yes. It's just on the agenda. They just haven't got around to it yet. Our position plot would be particular useful for them I would think.

AR: Absolutely.

7:54 AM

AR: Still rather amorphous conditions here, light snow. We had some large aggregates through probably equal to the largest we've seen about 5 min ago. 2-D continues out. We're looking for some clear air to try and fix that. The sky is actually fairly bright indicating the precip here maybe falling from more like altocumulus with fall streaks all the way down to the ground without any enhanced stratocumulus cumulus buildup into it at this point. A while back we did hit some enhanced liquid water about 5 min ago and that seemed to correspond to that last most westerly line of stratocumulus that had the wind shift with it.

PH: Art?

AR: Roger.

PH: Tell Stan he can come up here now and I can give him a bit of information on what's going on.

AR: He's on the headset and he caught that.

7:55 AM

PH: I'm getting good CPI imagery and HVPS. The only thing we're missing then is the 2-D and we'll try to bring that up later.

AR: Roger.

TW: Grant to "chat."

7:56 AM

JR: Peter, Jerry.

PH: Go ahead Jerry.

JR: Yes. You talked to him yet? Do we have a westerly point yet?

PH: Let me try to contact him again. Standby.

JR: Okay.

7:57 AM

AR: A check of liquid water here and no doubt corresponding to one of those wind shift lines in the enhanced stratocumulus at the bottom that we under flew there a while back. There is about 0.5-0.7 g/m<sup>3</sup> liquid water content. The other thing of interest was the droplet concentration surged to over 200/cc. This is certainly continental origin aerosol. I would go along with at least that being part of the offshore flowing air ahead of the front that particular pumping of liquid water.

7:58 AM

PH: Larry or Jerry?

JR: Go ahead.

PH: I have a new westerly point. It's  $47^{\circ}11'125^{\circ}37'$ . As we head back to that point after we get to Westport, we'll be heading back to that westerly point. Let's climb up by 2,000 ft so we end up over our westerly point 2,000-ft above where we are now.

JR: Okay. You want to climb up 2,000 ft. Do you want to go all the way back to Hoquiam now or do you want to start our turn now?

PH: No. I want to head all the way back to Westport at this altitude, then we'll make our turn, then we'll head back to that westerly point I just gave you so we end up at 2,000 ft above our present altitude over our westerly point.

JR: Okay. All the way back to Westport and then we'll turn around 2,000 ft back up to go to this westerly point. Okay.

PH: Okay.

AR: Another lump of liquid water there and droplet concentrations over 400. That's really continental. So certainly between here and our westerly point, there's some sort aerosol air mass change.

8:00 AM

AR: That's in spite of south-southwest end winds here. But in Hoquiam if you've noticed, they were running about  $110$  to  $120^{\circ}$ . So probably followed that shallow offshore flowing friction layer air loaded with aerosol getting out here and rising up into this sort of lifting zone around this wind shift line. Cloud bases have risen up above flight level.

8:01 AM

AR: Just as I note that bases have dropped down again and here we go into the scruffy stratus fractus and ahead it looks like more of a solid cumuliform-type base.

8:02 AM

AR: Bases look like they're 500 ft below flight level here. Looking down the wing, visibility is reduced significantly even though the radar pod is visible. Now we're coming into some precip. Correction, it was my dome fogging. I thought for a minute it was heavier precip, but it wasn't. Sky darkening above. Liquid water contents significant for 500 ft. The radar pod is getting hard to see there for a second.

PH: For the tape then, we're half way back roughly or two thirds of the way back to our easterly point at  $-1^{\circ}\text{C}$  here. In and out of cloud in this rainband.

8:03 AM

AR: I don't know whether to believe it or not, but suddenly we're getting winds of 233 meters per second. The true airspeed looks okay. Last flight we had a problem with true airspeed and it affected the wind measurement, but this looks like it might be real, which is a little shocking here. I'm not real sure I believe it. Lots of white caps down there now. I didn't see those earlier.

PH: Here's the size distribution plot from the FSSP-100, which is our cloud probe. It's not seeing much now because we're not in cloud.

AR: Right. Bases have lifted up here. We've just exited that convective area back there and it looks pretty nasty. It doesn't seem to have any rain shafts suggesting it's pretty shallow.

PH: They could do there test here.

AR: Yes. It sounds like a great idea because that's so important.

PH: Grant, can you hear me?

GG: Yes.

PH: We're in clear air here. We can give you a few minutes here to do your test.

GG: Okay. Tom?

TW: Yes. I'll check it.

PH: We're going to try to get the 2-D probe up.

AR: Just sprinkles in this area.

8:05 AM

AR: I don't know if I just didn't notice or whether the wind has come up that much, but there are a lot of white caps down there now. On the way out, down low, I commented this other time on the tape about not having any white caps.

PH: I saw white caps on the way out, Art. I put it on the tape.

AR: I know you mentioned that, but right after that things dropped off and we were indicating 10-knot winds.

PH: Yes. We've got 14 knots here.

AR: Yes. We must have had a disturbance there in the winds of some kind. I mean not a real one. I suspect it's an artifact of some kind because back there it was indicating like 70 knots out of the south-southwest. This certainly looks much more realistic.

PH: The engineers are trying to bring the 2-D probe up. Still heading east at 2,000 ft until 2,500-2,200 ft to Westport. Clear air here.

8:07 AM

TW: Grant to "chat."

8:08 AM

AR: We've entered yet another cellular element out here today as we fly eastbound after a vault with the cloud bases rose up to about maybe 8,000 ft or so with sprinkles coming out of that stuff up there. Now this looks like kind of a dead convective element mostly rain shaft and not too many cumulus turrets, but rain does pick up to at least rain shower intensity.

8:09 AM

AR: White caps indicate there maybe...

PH: I just spoke to the radar. They think this rainband we're flying in now is an upper-level cloud front. If there is any front on the surface, it would be some occluded-type front, which is still west off the radar screen.

AR: Estimating winds 20-30 knots on the surface.

PH: Although we're in clear air here, we're getting a few little crystals falling out from this overcast above us.

AR: We just passed through kind of dying convective element there. It is probably light snow anyway at that level, but now it's another opening here.

8:10 AM

PH: Art, if it comes down to having to choice between the 2-D and the HVPS (I don't know if it will, but if it does), I think the HVPS is more valuable, don't you?

AR: I think in the context of this experiment I would agree.

8:12 AM

AR: We continue to fly in a major vault, that is a place where the cloud bases have risen up to about I think I would stick with about 8,000 ft msl. The lower clouds have dissipated and remain behind us here, but ahead there is a bit of a thickening and some rain off the right wing. Potentially altocumulus is evolving into perlucidis structure above the aircraft with some higher cirrus visible. Continuing numerous white caps estimating winds at 15-25 knots out of the east-southeast here, on the surface that is. The winds at flight level 166 at about 8 meters per second.

8:13 AM

GG: Peter, if you had your druthers, would you rather have the HVPS or the 2-D?

PH: Jerry?

JR: Peter, go ahead.

PH: Let's make our turn here and head back to our westerly point climbing by 2,000 ft.

JR: We'll start our turn now.

GG: Peter, if you had to make a choice, would you prefer the HVPS or the 2-D?

PH: HVPS.

GG: Roger that.

8:14 AM

GG: Tom?

TW: Yes.

GG: Go to "chat" for a second.

AR: Even Mt. Rainier is visible from right here.

PH: We overshot our easterly point there. We shouldn't have come this far east, but it gave them time to fiddle with the 2-D probe. So we're making our turn here, which is east of where we should have been. We didn't reach the coast, however, and as we head back to the west, we'll be climbing by 2,000 ft.

AR: Our turnaround point that was under some enhanced stratocumulus bases just above our flight level. Not nearly as vigorous as the enhanced stratocumulus-cumulus that we flew in before, but we did get a little light rain there.

8:16 AM

AR: Some light turbulence in cloud. Droplet concentrations over 200 there suggesting again continental origin. Again, they're not the stratocumulus rooted in boundary layer, however, the low bases we saw about 20 miles to the west.

PH: Jerry.

JR: Peter, go ahead.

PH: I think you misunderstood me. On these westerly climbs, we're going to be going up by 2,000 ft, but doing a steady climb so that we start off at our easterly point and then we end up 2,000 ft above our easterly point when we reach our westerly point. It looks as if you've climbed 2,000 ft right here, right?

JR: Yes we did. Do you want to climb just gradually and ease on up? It will be an awfully slow climb.

PH: Yes, but you've reached the altitude now. So let's just keep this 4,500 ft or whatever it is as we head west. We'll just keep constant altitude, but in future all our easterly tracks will be at constant altitude and all our westerly tracks will be very slow climb by 2,000 ft.

JR: Very good. I got that.

AR: I think on the last flight, which had similar vertical spacing, there were about 150-200 ft per minute. Also the lift was about the same.

PH: Yes. I was trying to do what you did on the last flight, but Jerry misunderstood what I wanted. I think he's got it now.

AR: To be honest I don't think you're going to miss too much by not having done that.

PH: No.

AR: Because our vertical spacing is so tight. It's not like a layer. It's very unlikely that any layers will slip through the grid.

8:20 AM

AR: We have several layers here, surface stratus fractus, stratocumulus that we're flying in right now, very rag tag, 100 ft depth type stratocumulus above us, more stratocumulus also very thin. Above that still another thin layer, which allows the sky to appear rather bluish over the aircraft right now at 161830.

8:21 AM



AR: Flying in and out of sprinkles here. A very patterned looking cloud situation, very chaotic, lower stratus fractus from mid-sized cumulus. I'd say small cumulus actually. Then a haze of ice crystals falling through some scattered to broken altocumulus clouds very evident and possibly some cirrus up there. It's hard to tell whether it's high cirrus or the 10,000-ft variety at this point.

8:25 AM

AR: Ahead we're about to reenter that last heavy stratocumulus-cumulus zone that produced the very high droplet concentration. There were four groupings of clouds. It will be interesting to see if that liquid water gets up here to about 4,200 ft.

8:26 AM

AR: Here in just a minute or so we will be entering the most easterly of the four enhanced stratocumulus zones that we hit. It's kind of corresponding to some wind-shift activity at least at the surface.

PH: So it looks now as if we've got 2-D images.

AR: One thing you can see on the 2-D is a lot of riming. We're reentering this heavy cumulus-stratocumulus region and I just saw it looks like a gram of liquid water content, droplet concentration. That's pretty impressive.

8:27 AM

AR: Like three groupings. There was a grouping of three high liquid water zones in this east end. There was that one back toward the west end. It would be interesting to see if they all come through here at 4,000 ft if they make it up this high.

8:29 AM

AR: We have some lower temperature crystals here as we've exited the cumulus at least momentarily. They look unrimed but there are needles and columns here. We do have liquid water at  $-5.5^{\circ}\text{C}$  indicated. Wingtip being obscured there by higher liquid water contents.

PH: Jerry.

JR: Peter.

PH: I've got a new westerly point. It differs a little bit from the one I gave you earlier.

JR: Go ahead.

PH: We now should be heading at this altitude toward 47°09'/125°27'.

JR: 47°09'/125°27'. Okay.

PH: I've got a new easterly point for you when we turn around at that westerly point. The new easterly point, are you ready to go?

JR: Go ahead.

PH: 47°05'/125°05'.

JR: 45°05'/125°05'.

PH: Yes. Since we got sort of turned around a bit here, we're going to have to do our climbs going east instead of going west. So when we do our turnaround point at the westerly point and when we start heading east, let's climb steadily by 2,000 ft so we end up at 6,500 ft over our easterly point. That will be a slow climb.

JR: We'll do that. A slow climb up to 6,500 ft until we pass over the eastern point to 6,500 ft. We'll do that.

PH: Thank you.

AR: A large aggregate zone.

8:32 AM

AR: I stepped away for a second to look for a marezine pill, which I forgot to take.

JR: We're starting our gentle climb up 2,000 ft as we cross to the eastern point.

PH: Thank you.

AR: At our western point we're getting aggregates and some columns and needles. I missed about 1 1/2 min there looking for my stuff.

8:35 AM

PH: Jerry?

JR: Peter, go ahead.

PH: Just to confirm then, we're making our turn here at our westerly point, you'll then be heading to the easterly point I gave you and you'll be climbing slowly to hit 6,500 ft over our easterly point.

JR: That's affirmative.

PH: Thank you. We're making our turn at our westerly point now and then we'll be heading back east. We'll be climbing slowly to 6,500 ft as we head to our new easterly point.

AR: I guess they're thinking that this band will be out here long enough for us to do all these slow steps even though the small increments in the vertical even though the tops are fairly shallow. It's not going to go inland on us, is it?

PH: It's still quite a way offshore at the moment. We're going to be at 6,500 ft by the time we hit our easterly point and then the next step will take us to 8,500 ft. So it only needs a couple more steps to get to 10,000 ft.

AR: Right. The tops are probably running 10,000 to 12,000 ft. I was just thinking we're probably only half way there. I guess that's what they're thinking that we will have enough time and won't be impacted by orography.

PH: Well we can always increase the steps if we need to. I'll check with them to see how long they think it will take for the easterly edge of the band to get onshore. By the way, we got switched around here as you see on our climbs. We're supposed to be climbing as we go to the west, but instead we're going to be climbing as we go to the east because of the earlier confusion with the pilot. It doesn't matter though.

AR: Nope.

8:38 AM

PH: In fact, Art, at this slow rate of climb, there's probably not a great deal of need to do level runs for the whole leg.

END OF TAPE 1, SIDE 1

AR: If John thinks there's an upper-level front in the area, you'll probably want to see a level pass on one of those legs up there.

PH: Yes. I suppose so.

8:39 AM

PH: I just checked with the radar and this is a very slow moving band. So if the tops are indeed at 12,000 ft, we should have plenty of time to profile upwards before it hits the coast.

AR: I missed that, Peter. Are you talking to me or just a general note?

PH: I just spoke to John at the radar and it's a very slow moving band. So we should have plenty of time to profile up.

AR: Excellent.

8:41 AM

AR: Well here's something else we have seen, Peter, regarding the vertically pointed radar. Sometimes the closer we get to cloud top the farther away they get. We're indicating again that they're about 10,000 ft above the flight level, which now puts them at about 15,000 at this locale.

8:42 AM

AR: Looking outside flying in kind of amorphous conditions again not much detail out there. Crystals are unrimed and we've intercepted no liquid water on this ramp leg.

8:43 AM

AR: Are you on "science?"

JR: Peter, we're approaching our turn. We've got about 3 miles to go and we'll be headed back to the westerly point.

8:44 AM

PH: Jerry, where you trying to talk to me?

JR: Yes. We're just 2 miles from our turn, Peter, and we'll be heading back to our westerly point.

PH: Let me give an update to the westerly point. But in the meantime when you make your turn, head back to the west at this same altitude.

JR: Roger.

AR: The sky is starting to turn a little bluish now overhead as we get into this sort of region of stratiform only precip. Didn't hit any water so far on this leg.

PH: Jerry?

JR: Peter, go ahead.

PH: Our new westerly point will be  $47^{\circ}09'/125^{\circ}27'$ .

JR: Okay. Back to  $47^{\circ}09'/125^{\circ}27'$ . Roger.

PH: Right. We'll head there at 6,500 ft. Are we at 6,500 ft or 6,000 ft?

JR: 6,500 ft.

PH: So we'll head there at 6,500 ft.

8:45 AM

PH: We're making our turn at our easterly point. We'll be heading back west at this same altitude, 6,500 ft,  $-8^{\circ}\text{C}$ .

8:46 AM

PH: Just going through a lot of liquid water here going up to 1 gram per cc. Going through some cumulus here.

AR: Yes. It's coming up from the boundary layer because you can look at those FSSP concentrations. They're over 200 back there. Is this our turnaround point? Peter, are we turning around kind of in the middle of this nice cumulus?

8:48 AM

PH: I love the way our four liquid water meters are agreeing with we get into cloud, very good.

AR: Right. Peter, are we turning around here?

PH: We turning at our easterly point and we're heading west.

AR: It seems kind of funny to be turning around right in the middle. This is the best cloud we've hit in this whole leg.

PH: This is the easterly point that we were given by John.

AR: Yes. Don't we tweak those a little bit?

PH: Well we could do, but you never know how much to tweak them. I sort of go with what they're giving us from the radar. But we've made our turn now, so we might as well keep with it.

AR: Yes. I was thinking it being cumuliform I doubt if it extended more than a minute further.

PH: We didn't hit it though until we had sort of made our turn. We're out of our turn now and we sort of hit it halfway in the turn.

AR: Okay.

8:49 AM

AR: Tom's just got the concentration calculation up for the 2-D probe. It doesn't have any reject, so it's going to be a bit on the high side. In other words it's going to be counting a lot of artifacts. I'm going to look out the window and see if the concentrations are correct.

PH: Where's that concentration displayed? Is it on the 2-D imagery display?

TW: I haven't copied it your machine yet. I will in just a second. I was getting rid of those other problems first. If it runs okay for about 5 min on Art's machine, then I'll copy it over.

PH: No hurry.

8:50 AM

AR: Don't see anything. Aggregates are getting larger in here, however, several millimeters. It's bigger than I saw earlier on this leg. There's something going on here, maybe some liquid water ahead. Bluish sky not visible, so the cloud has thickened above us. Let's check the radar. Indicating about 3 divisions, which would be a little less than 3 kilometers above the aircraft.

8:54 AM

AR: No columns or needles to speak of in here.

JR: Peter, we're approaching the turning point. We've got about a mile to go.

AR: With that just now the sky is beginning to brighten. It looks like a good call. There was the enhanced stratocumulus at the west end, but it looks like we're going to over fly that.

JR: Peter, Jerry.

AR: I suspect we may have flown in-between cells. I wasn't up in the bubble the whole time, so I could have missed something.

8:55 AM

AR: This has fallen from a dendritic zone I should mention too. It's not surprising since it's about  $-9^{\circ}\text{C}$  indicated here at our west turnaround point.

PH: Jerry?

JR: Peter, go ahead.

PH: When we reach our westerly point, we'll be doing a turn and I'll give you the new easterly point.

JR: Okay. We're in our turn now, Peter.

PH: Our new easterly point is  $47^{\circ}01'/124^{\circ}54'$ .

JR:  $47^{\circ}01'/124^{\circ}54'$ . Roger.

PH: We'll be climbing slowly by 2,000 ft to end up at 8,500 ft over that new easterly point.

JR: Roger.

8:56 AM

PH: Art?

AR: Roger.

PH: That convective active activity we hit on our easterly point was actually a convective rain band that has nothing to do with what we're looking at. It had formed sort of in place ahead of our rainband, but they take us back through that on our next easterly track, which we're just starting on now.

8:58 AM

PH: Art, I see we've still got a problem with our dew point being higher than our static by about  $2^{\circ}\text{C}$ .

9:00 AM

AR: A little droplet cloud here at 6,800-ft tans-alt.

JR: Peter, Jerry.

9:01 AM

JR: Peter, Jerry.

PH: Yes Jerry.

JR: I assume you want to keep going up. We've got a block to 10,000 ft, so I'll have to get a higher altitude if that's what you need.

PH: Yes. Let's see if we can get up to 14,500 ft.

JR: Okay. I'll see if I can get a block all the way to 20,000 ft. That will give us some flexibility.

PH: Okay.

9:02 AM

AR: Able to make out altocumulus bases here. Precip has dropped off quite a bit. 2-D concentrations indicating low 10s per liter. It's probably too high. Visibility has been improved as I can make out these bases out the right wing here for at least a few kilometers above the aircraft off to the right. Get a sense of a slot developing just above the right wing of thinner precip and perhaps a slight bluish line. We're definitely in a weak part of this band.

PH: Jerry?

JR: Go ahead Peter.

PH: Our new westerly point will be  $47^{\circ}07'125^{\circ}24'$  and we'll be going back there at 8,500 ft after we reach our easterly point.

JR: Okay. The westerly coordinate will be  $47^{\circ}07'125^{\circ}24'$  and we're presently passing 8,000 ft for 8,500 ft and we'll do that level back.

PH: So we'll be going back level at 8,500 ft.

JR: Roger.

AR: We're beginning to come into the area where we hit that cumulus on the last leg.

PH: It may get a bit bumpy here because we're going to go a bit deeper into this convective rainband. I'm going to tell him not to turn yet. Jerry?



JR: Go ahead Peter.

PH: Let's not do our turn yet. Let's just keep heading on our easterly track even though it takes us beyond the point I gave you. See if we can get into this little bumpiness a bit more.

JR: Fine. We've got about 6 miles to go to the turning point, but we'll continue.

AR: Got hit by lightning.

PH: We got a lightning strike.

JR: Is everything okay back there?

PH: Yes. Everything is still running.

AR: That was quiet a thump. That was the loudest one I've heard.

PH: That was quite a strike and it was to the underside of the plane.

GG: I think we lost the CPI.

AR: Everything looks pretty good back here.

PH: Everything except the CPI. I saw the flash. I think it was from the underside.

AR: Cloud tops here only indicating about 3 kilometers above the aircraft here.

PH: Jerry, let's do our turn here. Turn back to the west.

JR: Okay. Turn back.

AR: That was a pretty interesting microstructure in that though.

JR: You want to go back through that lightning strike, huh?

PH: Well, I don't want to go deeper into this band here. It might get worse as we go east.

AR: It may have been with the top of the shower, as they are, I'm guessing this is one of those aircraft induced strikes that we hear about from time to time.

PH: I'm sure it was.

AR: We're still alive.

PH: The CPI is off though. Everything else seems okay, but the CPI has gone dead.

AR: I'll come up there and see if I can recycle the power or something and get it back to life.

GG: We're going to drop the HVPS and the 2-D.

PH: The 2-D is okay. Jerry, is your radar working?

JR: Peter, yes it is. Our radar is still okay.

PH: What radar color did you have on this convective cloud we're in now.

JR: Mostly green, Peter, and a little bit of yellow but mostly green.

PH: Yes. It wasn't a big rainband. It's not very deep. That was probably a self-induced lightning strike caused by the aircraft. As you heard on the tape, we took a lightning strike there in this convective rainband, but probably self-induced by the aircraft. Most things still seem to be working except the CPI went out. We're trying to reboot that now.

9:08 AM

PH: Jerry?

JR: Go ahead Peter.

PH: Are we making our turn and heading back to the west?

JR: Yes. We're in the turn right now and we'll be coming back around headed west.

PH: If you see any really convective clouds ahead, let's try to avoid them. I don't want to take another strike.

JR: We'll keep our eyes open.

PH: Everything working up at the cockpit?

JR: Yes. It looks good up here.

PH: We're lucky because that was quite a bang and I saw the flash. Usually we take some damage when we do that.

JR: Yes. It was probably static discharge off the airplane.

PH: I saw the flash out of my right window.

AR: Right, same here.

JR: We had a pretty good view of it too.

9:12 AM

JR: Just to confirm, Peter, we do the climbs on the eastbound legs, right?

PH: Right. That's correct, Jerry, we'll be going back at this altitude.

JR: Okay.

PH: Art?

AR: Roger.

PH: Did you get the CPI up?

AR: Yes. It looked like it was going to work. Let me come up and see. We're starting to come into some crystals here after a vault area of no precip. We're in no precip right now, not much.

PH: So for the tape, we've recovered from that discharge and we're now heading back to the west at 8,500 ft. We're going to try to avoid any cumulus if we see them ahead. We don't want to take another strike.

GG: We may have lost the J-W on that strike. It jumped up to about 2 grams per meter and it won't zero now.

9:13 AM

AR: We're picking up liquid water here again on this east end.

PH: Jerry?

JR: Go ahead Peter.

PH: We used to have on the old plane those little things that dangled from the wings to discharge the aircraft. I don't think we have those on this plane, do we?

JR: We've got them, but that was more of a discharge than they could handle.

GG: They're just designed to feed off charge gradually, but if you get into too big of an electric field it will go anyway.

AR: We're kind of coming into that same area. I can't make anything out.

PH: As Grant said, it looks as if we've lost the J-W, but the other three liquid water meters are still okay.

9:16 AM

AR: I can see the sun's disc, at least the sun's position here, through mainly ice cloud and droplet cloud. It's about a 45° angle back behind the tail now as we head westbound.

PH: We're westbound and we're south of the convective area that we hit on the eastbound leg. So I think he's steering around it a bit.

GG: Peter, did you happen to note the time of that lightning strike?

PH: No. I didn't get the exact time. Actually, we should be able to get it from that J-W spike.

GG: Roger that.

PH: It was about 17:05, around about there.

GG: Just about 12-13 min ago.

9:18 AM

PH: Yes. The strike was at about 17:03.

GG: Roger that.

9:19 AM

PH: I just spoke to the radar and our new points are going to keep us south.

JR: We're 2 miles from our westerly turning point, Peter.

PH: Okay and our new easterly point will be 47°05'/125°06'. That should keep us out of that convection.

JR: Fine, 47°05'/125°06'.

PH: We'll be climbing to 10,500 ft steadily.

JR: Roger.

PH: In talking to the radar, that convection rainband is developing quite nicely now with a strong inflow looking like a big Cb, but we're not going to go into that on our next easterly track. We're going to stick with the rainband we're working on.

9:22 AM

PH: Art, would you come and check the CPI. No, it's okay. It's clicking over again now. I thought it was frozen, but it is back up. It's not clicking over as fast as the 2-D though.

GG: We were just talking about that, Peter, and it's still counting particles, but the camera might be on the fritz there.

9:24 AM

GG: There we got some images.

AR: I stepped away and tried to work on the CPI to get that going, so I missed observations here for about 5 min. Looking back I can no longer see the sun's position.

GG: Peter, give me a heads up when you feel we're in the clear and we'll get another background for the CPI.

PH: Okay.

AR: Sometimes, Grant, you can luck out when the concentrations are a little low and nail one. Anyway, I actually did get a pretty good background there in the midst of some precip. We might just try taking backgrounds periodically.

GG: Okay.

PH: Probably won't get into the clear until we get back to our easterly point and we're just starting to head back there now.

TW: If your map starts getting a little cluttered, you can hit the number keys. Like if I hit one, it will only show about one 10-min back.

AR: The sky does not have any bluish tinge here as we come to our westerly leg at 8,400 ft.

9:26 AM

AR: The sun's position becoming evident off about 2 o'clock as we head east through ice cloud and possibly some droplet cloud. Cloud tops indicated to be between 2 and 3 kilometers above aircraft, so they continue to go up as we near cloud top.

9:28 AM

AR: Still seeing sun through ice cloud. It was quite bright there for a minute and now it's beginning to dim toward the center of our line. There's kind of a thin spot here toward the middle. No droplet clouds between the aircraft and the sun. Crystals look unrimed as well.

9:29 AM

AR: The sun has disappeared. Picked up a droplet cloud up there. I missed when it disappeared, but I believe there's an altocumulus layer between us and the sun now.

JR: We're approaching our easterly point here. We have 2 1/2 miles to go, Peter.

GG: He's off the headset right now, Jerry.

JR: Okay.

9:30 AM

AR: Fairly bright but no sun visible.

GG: Peter, Jerry just said we had about 2 miles to go to the easterly point.

JR: Peter, Jerry.

PH: Jerry, I'll get a new westerly point for us. Standby.

JR: Standby.

AR: The sun has just popped out, brightening. I see no signs of any convection in this area, 1729.

PH: Jerry?

JR: Go ahead Peter.

PH: Our new west point is 47°07'/125°24'.

JR: 47°07'/125°24'.

PH: And we'll be going back at this altitude.

JR: Roger.

9:32 AM

AR: Liquid water clouds visible. There's something. It might be a fall streak of some kind. We make our turn here.

9:34 AM

AR: Shred droplet clouds in here. It looks like a turret back toward the sun's position, very soft looking cumuliform turret with an ice cloud above. Another uneventful leg again mainly glaciated. In fact I didn't see any liquid water along this fast ramp up to 9,900 ft. The sun brightly visible.

9:37 AM

AR: The sun occasionally disappearing behind droplet clouds. There's one. There's still some liquid water up here above about 9,900 ft,  $-17^{\circ}\text{C}$  indicated. For a stratiform cloud by the way, they're not turrety.

9:38 AM

PH: Jerry?

JR: Go ahead Peter.

PH: New easterly point.

JR: Go ahead.

PH:  $47^{\circ}03'/124^{\circ}57'$ .

JR:  $47^{\circ}03'/124^{\circ}57'$ . Okay.

PH: Climb slowly to 12,500 ft.

JR: Roger.

9:39 AM

PH: For the tape, it does appear that we've now lost the CPI due to that discharge we had, but we are getting 2-D images and the HVPS.

AR: Peter, how much research time do we have left here?

PH: Well, we're 3 hr into the flight, so probably another 2 hr or so.

AR: I was just wondering. Tops from the radar are still indicated to be about 2 kilometers or so above the aircraft. The radar being such as it is, probably the smallest ice crystals are not even being read. So we're probably going to have to go, I'm guessing, 18,000-20,000 ft to really top this thing out at this point.

PH: We'd better increase our steps then. Jerry?

JR: Jerry, Peter.

PH: On this leg to the west, let's climb by 3,000 ft instead of 2,000 ft.

JR: Okay. You want to climb 3,000 ft rather than 2,000 ft.

PH: Yes.

AR: The other thing, Peter, there doesn't seem to be very much going on above us. It looks all glaciated, so it's not like there's some major contributing layer doing something. It looks all ice pretty much. There was a little droplet shred cloud that went by, but it looks pretty much like probably linear growth pattern to cloud top. You know the crystals just get smaller as we get closer to the top would be my guess from here. I don't think we'll miss anything by increasing those steps at all.

9:41 AM

PH: We're just making our turn at the westerly point.

GG: Tom, are you on?

TW: Yes.

GG: Take a look at the 2-D. Now I don't know if we're flying through anything, but it's not painting anything right now and the HVPS is. I didn't know if you were still in control of it or not.

TW: I am. Let me watch it for a second.

GG: Roger.

9:44 AM

TW: Grant to "chat."



GG: I think it's being used, but I'll switch over.

PH: Art, it looks as if we're near the top of this now.

TW: Art, are you seeing any particles?

PH: No. I'm not seeing any at the moment.

9:45 AM

PH: Art?

AR: Yes. I'm back on the headset.

PH: It looks as if we're pretty near the top of this now.

AR: And pray tell what makes you think that?

PH: I'm seeing the sun for the first time.

AR: We've been seeing the sun here on a couple of legs. Most of the last 2 legs I've been able to see the sun's position. This type of top just goes on and on and on. The radar is still indicating about 2 kilometers to cloud top.

PH: I'm wondering about the imagery now. I'm not getting much coming up on the 2-D or the HVPS.

GG: Just taking a look at it.

PH: And the CPI has gone out.

AR: Yes. Something is wrong there. I didn't notice that. Tom's fiddling or going to fiddle with the 2-D.

9:46 AM

TW: Grant?

GG: Roger.

TW: I restarted the ap and nothing really happened. I could recycle power. I could wiggle the cords.

GG: Well let me go recycle power. It's not going to hurt the CPI right now because it's kind of dead anyway.

PH: For the tape, we've got problems now. The 2-D is out and the HVPS.

GG: Power has been cycled.

PH: Okay. The 2-D has just come back. Tom wiggled the cords and the 2-D is back. What about the HVPS?

GG: I cycled powered. The HVPS is cycling, but it's not seeing any large particle. Wait a minute.

TW: I restarted the ap on that one. It kind of looks like something might be on the lens possibly.

GG: Either that or the laser power is down.

JR: We're getting some ice out there.

9:47 AM

PH: Jerry?

JR: Go ahead Peter.

PH: Our new westerly point, 47°07'/125°17'.

JR: 47°07'/125°17'.

PH: That's it.

9:49 AM

PH: We're getting images again on the CPI. Art just played with it.

GG: We seem to have a lot of condensation inside there again.

PH: Well, we've been cooling off here. We're at -22°C ambient now. So it's probably getting some condensation inside. HVPS is still out or maybe it's just that these particles are too small for it to be recording.

GG: I think it's okay. We're getting a streak that indicates we took a little moisture.

PH: I think it's just very tiny particles probably.

9:50 AM

PH: Art?

AR: Roger.

PH: If we want to speed up our ascent, then we probably should be climbing on both legs instead of going back again to the west at this altitude.

AR: If there isn't that much time left, I think I would still keep that straight leg in there. We discussed this before. Nick brought that point up and the guys down there wanted us to have one straight leg.

PH: Okay.

GG: We're seeing some larger particles now and they are showing up as large particles on the HVPS.

AR: We're getting pretty good liquid water here, so maybe it's around one of those turrets. We're in that area toward the east end.

JR: We're at our turning point, Peter, and heading back.

PH: Okay. We'll be going back at this altitude.

JR: Roger.

9:51 AM

AR: Definitely significant water up here. Look at that, 0.5 at  $-23^{\circ}\text{C}$ . You can imagine how the icing is piling up at this moment.

PH: Actually our window doesn't look too bad.

AR: Just kind of come into this and, of course, that would be another area where we're eligible for a little electricity.

PH: I notice on this penetration now the FSSP liquid water is significantly higher than the DMT and the PVM. Now earlier they were in excellent agreement.

AR: Yes. That's a good point. That might be some ice crystal contributing to our artifact liquid water or spurious liquid water. I'll have to check that out. You'd be surprised though. Normally you don't see much of a contribution from ice crystals beyond a few hundreds maybe a tenth at the most.

PH: We're in this convective region again, which I was trying to avoid.

AR: Right. It's probably translating up from the south. So what we went through before is probably to the north of us and this is new stuff.

9:53 AM

PH: The imagery is back up.

AR: Yes. So far so good again.

GG: Electronics needs a rest too.

AR: I tend to believe the FSSP on that because now we're in quite a bit of ice and yet you see the liquid water content being calculated as only less than a hundredth. We'll look at it I guess when we go down to the ground and see what the heck was going on there.

9:54 AM

PH: Still got this temperature/dew point problem, Art.

AR: Yes. I just don't think there is much that we can do about it in especially these lower temperatures. It just does not look good. I know Don has cleaned the chilled mirror a couple of times and it didn't seem to help. I don't know if it's aging and it's beyond use or what.

PH: I think the 2-D and CPI have stopped again. No. The CPI is going again there. I think the 2-D has stopped.

9:56 AM

PH: I think the 2-D has stopped again, Grant.

GG: Tom is on it.

TW: I restarted the ap and it didn't make a difference.

GG: Do you want me to do a power cycle.

TW: If you want, the CPI is running, I think, slowly.

GG: Let me stop the CPI probe for a second and then we'll do a power cycle and bring it up again.

9:57 AM

GG: Cycling. We're back on.

PH: The 2-D is up again. Do we have some loose connection there?

GG: It's possible. There's a connector on the back of this card that broke when we were fiddling around, at least a tab on it broke and anything could have happened there.

9:58 AM

GG: Tom, if it stops again, I'm just going to try power cycling before we actually restart the ap.

TW: Okay.

JR: We've got 3 miles until our turning point, Peter.

PH: Yes. Our new easterly point is  $47^{\circ}03'/124^{\circ}57'$ .

AR: We're picking up for the first time a  $22^{\circ}$  halo as we get closer to cloud tops.

PH: Did you read that, Jerry?

JR:  $47^{\circ}03'/124^{\circ}57'$ .

PH: Correct and we'll be climbing steadily to 16,500 ft.

JR: Climbing to 16,500 ft. Roger.

10:00 AM

PH: The new easterly point I've just given to the pilot, which we'll be heading for shortly, will keep us clear of that convective band that we've been hitting on the easterly end of our leg.

AR: As we get higher too, we'll be able to see that coming I think as well because the ice cloud will be thinning even if we're not at top. It's starting to look like bullet rosettes here. It probably goes along with that halo up there that we had a minute ago. The crystals are coming from at least  $-30^{\circ}\text{C}$  or lower temperatures.

10:01 AM

PH: We've made our turn at our westerly point and we're now heading back east climbing to 16,500 ft.

10:04 AM

AR: Sun continues brightly visible and we have half a 22° halo above us. Looking for the turrets, if I can see them up ahead here as we approach our east end.

10:06 AM

AR: I can see most of the 22° halo here. The radar says the tops are only about a kilometer above the aircraft, the radar tops.

10:07 AM

AR: It looks like we're over flying those convective tops that we went through before at the east end. Right now I don't see anything at this level, but I do see cloud tops below us back behind the right wing.

PH: Jerry?

JR: Go ahead Peter.

PH: Our new westerly point will be 47°05'/125°11'.

JR: 47°05'/125°11'. Okay.

PH: Right. We'll be going back at this altitude, 16,500 ft, when we reach 16,500 ft here.

JR: Roger.

10:09 AM

AR: Here's some droplet clouds coming into view. Actually how much longer until we turn around?

PH: We're just coming up to our easterly point. We've broken out here.

AR: That must be the turret tops right over there about 12 to 2 o'clock.

PH: Right.

AR: I think that's it.

PH: They've kept us clear of those.

10:10 AM

PH: Our rainband has gotten pretty narrow now.

AR: Yes. I was noticing that. We're hardly going anywhere and we turn around. It sounds like it might be dissipating. We've sucked all the life out of it with that lightning strike.

PH: Yes. I hope it hasn't done too much damage to the fuselage. I've got the impression it was up front of the plane.

AR: I thought it was in the back myself just from the way it shook back there, but it was probably misleading. The front has completely disappeared here, so this is kind of a great turnaround point because it looks like we're picking up a little liquid water. It's much more interesting than that totally glaciated leg that we just flew.

10:12 AM

PH: Yes. The FSSP is still reading a little bit higher than the DMT and PVM. The J-W is out.

AR: Here is a situation where there might be so many tiny crystals up here that the FSSP will actually artificially indicate liquid water. So I'd be a little suspicious of the FSSP up here. As the sun went behind this stuff, I really didn't see that much droplet cloud. It looked really more glaciated by far, although there were some droplets around. It didn't look like it had droplets, but was filled with these small ice crystals. Giving some of that cotton candy-look.

10:13 AM

PH: At 16:05 here the outside temperature is  $-30^{\circ}\text{C}$ . Getting a bit chilly.

10:14 AM

PH: Jerry?

JR: Go ahead Peter.

PH: How much more time on station?

JR: Standby 1.

10:14 AM

JR: We can give you about an hour and 10 min, Peter.

PH: Thank you.

AR: There's some droplet cloud passing by the plane now. It looks like it might be at our level and then another level maybe 2,000 or 3,000 ft up. Definitely there's some irisation in it.

10:15 AM

PH: Art, when we start to head back east on next leg not the current leg, we'll be climbing to 19,500 ft. Do you think that's going to put us near the top?

AR: I think so, Peter. Looking back there we just exited that sort of semi-turret at the turnaround point.

PH: Good, because we've only have about another hour and a quarter on station.

AR: That's how much higher from the present level?

PH: That will be 3,000 ft above where we are now.

AR: I think we will be at the top 95% of the storm, I'll put it that way. We probably won't clear it completely, but certainly it will be very blue. The sky will look pretty darn blue and we'll be flying in probably pretty low concentrations of crystals will be my guess now.

PH: Does this rainband differ much from the one you looked at on the last flight?

AR: I think it resembles it quite a bit especially above 5,000-6,000 ft there it looked like almost the same thing. That is nothing but ice about 5,000-6,000 ft we did see a little water above that in this one, and then just looking at mainly unrimed crystals all the way to the top except because the vertical legs were with the vertical implements were a little small. We didn't get to cloud top because the pilots were concerned about the alternate because the general forecast for Everett is pretty bad at that point and so we didn't quite get as much time as expected and didn't push it over the top to get to the top. We couldn't do it.

PH: Hopefully we'll do it today.

JR: We've got about 2 miles until our turning point, Peter.

PH: Okay.

10:17 AM

AR: It looked to me like maybe the showerless tops were back there where that turret was. We'll probably clear that, but won't clear this stuff to the west of that in this sort of ice crystals haze that we're in now.



10:18 AM

PH: Jerry?

JR: Peter, go ahead.

PH: A new easterly point, 47°03'/124°57'.

JR: 47°03'/124°57'. Roger.

PH: We'll be climbing to 19,500 ft.

JR: Roger.

10:19 AM

PH: These legs have gotten somewhat short because they're trying to keep us out of the leading edge of this rainband to the east, which is the convective portion that seems to be merging with the leading edge of our rainband. That's why the legs have gotten short.

AR: I see. It didn't look like anything too bad back there to the east, but I think we might even over fly some of that stuff.

10:20 AM

PH: We're making our turn at our westerly point turning around to head back east. Still picking up good images on the CPI and the 2-D.

AR: Yes. Isn't that great? It looks like maybe the back edge is just visible out there about 2 o'clock of this stuff. You can see it starting to turn blue.

GG: I'm going to take this opportunity to swap audiotapes.

END OF TAPE 1, SIDE 2

10:21 AM

PH: We're just about completed our turn at our westerly point and we're heading east climbing to 19,500 ft.

10:22 AM

AR: Continuing in ice crystal haze. A 22° halo now looks like it's complete. Now the 22° halo is complete and the lower arc looks like it's below the aircraft. So we're in halo producing ice crystals.

10:24 AM

PH: What's the cabin pressure, Jerry?

JR: It's below 10,000 ft, Peter.

PH: Okay.

JR: It's about 9,000 ft.

10:25 AM

AR: This is a familiar scene. The freezing top up here, Peter, looks like we've made most of it and then the little shreds of cirrus that seem to be separate as a rule anyway.

PH: Jerry?

JR: Go ahead Peter.

PH: The new westerly point is 47°05'/125°10'.

JR: West is 47°05'/125°10'.

PH: Correct, so we'll go back at this altitude.

10:26 AM

AR: At our east point here we have higher stratiform tops to the east apparently it's part of another rainband. The radar people do not want us to sample for unknown reasons.

PH: As we make our turn at our easterly point, we topped out this rainband to the east anyway and that's at 19,500 ft.

AR: Altitude is 18,586 ft. That's the tans-alt. That's the true altitude.

PH: Yes. I've been using the pilot's altitude, so as not to confuse things.

AR: Exactly. That's the thing to do. Then you're turning in that rainband just to the east of us. It's all ice. There's nothing to be particularly concerned about. So if they wanted us to do a cloud top or near cloud top profile, we could certainly do it. Next time maybe.

PH: Yes. Let's do that on the return trip.

AR: As I was starting to say before, we do have the higher separate cirrus layer. It is shedding ice crystals here and there into the lower ice haze cloud. So cloud top here depends I guess on which one you want I suppose.

PH: How much higher is this stuff above us.

AR: I've got to get a fix on it right now. I'm fogged up a little big back here in the bubble. Hang on.

PH: I'm sure it's much higher than it looks.

AR: It is not very general though, Peter, like some of the other ones we've seen. As you can see out the window about 2 o'clock, it's kind of scattered to broken.

PH: Yes.

AR: There's a little saddle here in the ice cloud top and then we'll go back into it at this level in probably a minute or two. We will top it out here but then we'll go back into the deeper part of the ice cloud that was at the west end.

10:30 AM

PH: We're heading back west at 19,500 ft.

AR: We're coming into some ice here now.

PH: Just tipping the tops of this rainband now.

10:31 AM

AR: Very nice little tuft up here.

PH: So this is tipping the tops rather than stuff falling from them.

JR: Peter, Jerry.

PH: Yes Jerry.

JR: If you want to climb back up another 3,000 ft, I'll have to change the block altitude.

PH: We're heading west at this altitude at the moment, 19,500 ft. That's as high as we're going to go because we've topped it out now.

JR: Just wanted to check so I could get a clearance if we needed it.

PH: I'm not quite sure what we're going to do next.

AR: It's a little bit deeper at the west edge, Peter. We're just tipping the tops of those and then they kind of rise up here another 1,000 to 2,000 ft or so maybe at the very deepest tippy top.

PH: You think we should climb a little bit more on the leg back?

AR: No. I don't think so. I think we're close enough.

PH: So do I. I don't think there's any need to climb any more here.

AR: That's right. That higher layer, that I'm estimating is probably another 2,000 ft, I don't see a whole lot coming from that. There's a couple little wisps from uncinus-type, but they're very isolated.

10:32 AM

AR: This is probably the area of the deepest tops right in here. Got a full 22° halo so they're up there still a way, a couple thousand feet maybe at this little hump.

10:33 AM

AR: If we're really looking for something to do, I suppose we could do that and really nail down the top of this thing.

JR: Peter, we're approaching our turning point now.

10:34 AM

PH: Jerry?

JR: Go ahead Peter.

PH: When we get to our westerly point, then I want to head back east at this altitude (no climb) back to Westport and then go into land at Hoquiam for refueling and a possible second flight.

JR: Okay. You want to go back to Hoquiam and land in Hoquiam for refueling.

PH: Yes.

JR: Okay.

PH: Let's stay at 19,500 ft until we get to Westport and then I'll hand it over to you to land at Hoquiam.

JR: Okay.

10:35 AM

AR: Peter, at this west end, the cloud tops were probably 2,000 ft higher than the flight level on this hump at cloud top.

PH: Okay. I have him going back at this altitude and we'll go through the convective rainband to Westport. Then we'll land so you can get a nice hamburger, Art, refuel and standby for a possible second flight. They're seeing some rainbands coming in now on the edge of the radar range.

AR: Great. Looking forward to that burger.

10:36 AM

PH: Larry?

LS: Go ahead Peter.

PH: When we land at Hoquiam, we should take a look at the fuselage and see if we can find that hole.

LS: What hole is that?

PH: I think there will be a hole from that discharge we had.

LS: I doubt it. I think the static plates probably took care of it, but we'll check it.

PH: We usually do find some little hole somewhere.

LS: That may be. Are you ready to go to Hoquiam now?

PH: No. I told Jerry what we wanted to do. I'll repeat it to you. We're heading back at this altitude to Westport and then I'll hand it over to you to land at Hoquiam.

LS: Okay.

10:37 AM

PH: Larry?

LS: Go ahead Peter.

PH: As we approach Hoquiam, we probably will go through those convective turrets that we got the turbulence on earlier on in the flight, but at this altitude it shouldn't be too bad.

LS: Okay.

AR: I don't believe they extend to this level, Peter, from what I saw on our east turnaround point.

10:38 AM

PH: So I don't think we're missing much by not going another 2,000 ft up here. I don't think anything is going on up there that we haven't seen here.

AR: The only thing is the crystals would be just that much smaller. That's the only thing we've missed some little increment of growth.

PH: Shall we ask them to climb a thousand feet?

AR: Well, if we've got plenty of time, I wouldn't mind nipping that thing at the top. Frankly, I was a little surprised after I spoke to you about this level being okay, the size of the crystals we were seeing in the humped up tops here at the west end.

PH: Let's give it a try. Larry?

LS: Go ahead.

PH: Do you think we could climb 1,000 ft as we head for Westport? That would just top us out of this cloud.

LS: I'll see if I can get a clearance.

AR: Rubbish. That's right. He's got to get a new altitude block, so that's going to take some time.

10:39 AM

PH: Also that's going to be a pretty steep descent from 20,000 odd feet down to Hoquiam.

AR: I don't know how much time he's got, but just to prevent some water buildup in there maybe we should go slow anyway.

PH: Yes.

AR: I think one of the times that you went up to 500 ft/min, we were able to keep the instruments pretty clean.

PH: I've never understood on descent we shouldn't be fogging up or doing any damage really as we warm up.

AR: The instruments cold and that's where the problem comes in. They have a little greater thermal mass and so they're still at  $-22^{\circ}\text{C}$  when we're going through  $21^{\circ}$ ,  $20^{\circ}$ ,  $19^{\circ}$ .

PH: Yes. That's true. Infinite number of dew point hygrometers.

10:41 AM

PH: I don't quite see what we're doing now. We're still heading west.

AR: I think he's waiting to get a block before he turns around. Another problem with a 500-ft descent, as you know, is it will take 30 min to get to the ground. I don't know if we have that much time.

PH: We're only 4 hr and 5 min into the flight, so we've got 2 hr.

AR: It would certainly be best to do it that way I think. It will save us some headaches later.

PH: Yes. Particularly if we can do it in something interesting and not just in clear air.

10:42 AM

PH: If we have that second flight today, that will be about the end of our flying for IMPROVE.

AR: Because of hours or lack of weather ahead?

PH: Hours basically. I mean if something really nice came in by Wednesday, we would do it, but I don't see that on the horizon. Wednesday is our official end of project.

AR: Roger.

PH: How are you doing, Larry?

LS: I've got you at 20,700 ft.

PH: Good. So we'll do that back to Westport. Now before we descend into Hoquiam, I don't want to descend very rapidly and spoil our instruments. So I'd like to come down offshore at 500 ft/min before you come into Hoquiam.

LS: Okay.

10:44 AM

AR: Up here ahead, Peter, we'll pop out the side of these deeper tops at the west end and then we'll go back into top toward the east end. There's kind of a big saddle in the middle of this thing.

PH: Okay. I've asked Larry to descend at 500 ft/min offshore. We might want to choose some sort of location where we'd prefer to do that if we have a choice.

10:46 AM

AR: If our eastern rainband doesn't do it, we could probably do that.

PH: What's your altitude, Larry?

LS: 20,700 ft.

10:47 AM

PH: Larry?

10:48 AM

PH: We're seeing some nice bullet rosettes here at  $-40^{\circ}\text{C}$  as we head back at 20,700 ft to Westport. Just skimming the tops of the rainband. Still not quite got to the top of this system, but it's only a few thousand feet above us and probably nothing different above.

AR: Roger. Remember those cirrus cases in Barrow we just couldn't get to the top. I would always estimate 28,000 ft and it would be 32,000 ft.

PH: Two more, two more, two more.

AR: Right. It's kind of the same thing in here. You think you're so close to the top and then you end up climbing a kilometer and you're still not there.

10:50 AM

PH: Can you see that rainband ahead, Art?



AR: Not really. We haven't come into that saddle region unless some higher tops have moved in from the south. Actually I would have expected it by now. In other words, I would have expected us to be flying in clear air at about this point. There are no particular features ahead that I can see.

PH: It's getting chilly.

AR: Yes, you can say that. I can't hold onto the ring here in the back. It's just too cold.

PH: I notice our Shadin true airspeed is okay, but our other true airspeed that we compute is way off.

AR: It looks like they're reading about the same thing. There it goes. It's dead.

GG: We just lost trans-altitude. There it's back. They look in pretty much agreement actually.

PH: They're okay.

10:53 AM

AR: This is definitely different than what we saw on the leg westbound out here. We were definitely over flying ice crystals in this area on the way out. So something is most likely affected from the south. There's a nice little cirrus generating cells here, nice fall streaks off the left wing.

PH: We maybe coming into that convective rainband.

AR: Yes. I'm looking out. A little more structure in here to the ice. There are my little fall streaks. I guess this is what is left of the little saddle we had before, but it's certainly narrower than it was. Then we'll be going back into some heavy ice concentrations here momentarily. That must be the saddle.

LS: Peter?

PH: Yes Larry.

LS: Just so I can coordinate with ATC, after we get to the radar site, can we come back offshore there about 10 to 15 miles and do our 500 ft/min descent?

PH: That will work well.

LS: Okay.

10:55 AM

AR: What's our cabin pressure now Larry?

LS: It's 11,000 ft.

GG: Art, regarding the radar what do you want to do during the descent? Do you want to take data or can I have that time to clear the disk for the next flight?

AR: Yes. Why don't you go ahead and do that and we'll point it down if we can.

GG: I'm talking about stopping recording data.

AR: Okay. When we get to our official endpoint here and Peter will let us know, why don't you stop taking there.

LS: Did somebody say they want a descent back there?

AR: I was yammering on the wrong channel.

LS: Okay.

GG: I'll just keep taking data until the endpoint.

AR: Yes. That's what I think would be the cleanest thing to do. Then while we're starting that descent, you can probably. How long does it take to change that?

GG: A long time, probably take 20 min anyway.

AR: I guess we have to do it.

GG: Yes or not take any data on the next flight.

AR: Right.

PH: What's the problem, Art?

GG: I need to clear the radar disk for the next flight and I need about 15 to 20 min to do it.

PH: Okay. We're going to do a descent. Now if it turns out that that descent is in clear air, which I doubt, you can do it then. But if we're getting measurements, I'd prefer you not to do it then. But I think after we've done the descent and when they're setting up to do their approach, you should get 15 min there.

GG: Hopefully I can get it done in that period of time. We can run just the computers on the gel cells after we land.

AR: Grant, did you say it's going to fill up? I thought maybe that's what the problem might be.

GG: Say again.

AR: Were you saying the disk was filling up?

GG: Yes it does. It's a small partition we're working.

AR: How much time do you think we have left on that?

GG: It's hard to say. We probably have another hour.

AR: I understand.

GG: Do you want me to point it down?

AR: Yes. I think that would be the thing to do now.

GG: We'll probably never get it to go back up again.

AR: Even if we land?

GG: No. But it will be down for the duration of the flight.

PH: I don't want it to go down yet. I want to do our descent and see if that puts us in the rainband when we descend.

AR: I think if we look down at it when we...

PH: I can't hear you, Art.

AR: Can you hear me now?

PH: Not very clearly.

AR: I've got the mike resting on my lips. I was thinking we could turn it down when we get to our east endpoint.

PH: That's when we're going to do our descent and, if that descent were in the rainband, I'd prefer not to lose those measurements. If on the other hand, it's fairly clear and we're not getting anything interesting, then that's the time to take it down.

AR: I meant point the radar downward.

PH: I was talking about emptying the disk. Is that what you're talking about?

GG: We were talking about pointing the antenna downward.

PH: Sorry, I misunderstood you. I thought you were talking about emptying the disk and, therefore, we wouldn't get any measurements while you were doing that.

GG: That's true. We have to do that before we get to the end of the flight, so we can clear the disk for the next flight.

PH: I'd say there are two issues here.

GG: Right.

AR: Right.

PH: I'll leave the radar to you, Art, because you're back there looking at it. I was talking about emptying the disk.

AR: I was just going to say that maybe on this descent we point it downward to see what we fly in beneath. We've done a pretty good job looking upward here on this thing.

PH: That's fine.

AR: We'll know what cloud top is from our flight here.

GG: We're almost to the radar probably a couple of minutes away.

11:03 AM

AR: Peter, the radar is that east endpoint this time?

PH: Yes it is.

11:04 AM

AR: Grant, I guess we can give it a shot and point it downward now. Do you want to try and point it downward?

LS: Peter, we're just 2 miles from the beach. Do you want to start the descent for over the beach there?

PH: That will be fine. Yes.

LS: Okay.

PH: We're just about over the Westport radar now and we're going to start a descent of 500 ft/min.

AR: One thing I noticed back there, Peter, is the ice crystals got quite a bit larger in size. It looked like that very highest cirrus layer moved with the icy haze cloud at that east end of the rainband. I wish we had a little longer time for growth.

PH: Yes that's what John was saying. They just merged these two rainbands now.

11:05 AM

AR: I was talking about the cirrus cloud merging not the actual rainbands. They connected together in this eastward point and they seem kind of connected here actually as we circle the radar and we begin our descent downward. A nice 22° halo the whole way.

11:06 AM

PH: Art?

AR: Yes.

PH: Go on "chat." We're starting our spiral descent over the radar.

11:08 AM

PH: This is going to take about 40 min.

TW: Grant?

GG: Yes. Go ahead Tom.

TW: When we're getting close to land, should I flip that de-ice to the center position?

GG: I do it just at the very last minute.

TW: Okay.

GG: As long as we're moving through the air we should be all right even if it gets warm down there, which I can't imagine happening.

AR: On the 22° halo the bottom of the halo is below the flight level showing that we are flying in a halo producing ice crystals still.

11:10 AM

PH: We're at about 14,000 ft on our spiral descent over the Westport radar at 500 ft/min collecting good measurements on the way down. We'll be landing at Westport, have lunch there, and decide if we want to do a second flight or not. There are a couple of German scientists that have been at the Westport radar and they're going to come out to Hoquiam to take a look at the plane while we're on the ground.

11:19 AM

PH: Tom, go on "chat."

11:20 AM

PH: Art?

11:23 AM

PH: Art?

11:24 AM

PH: Is Art on the headset?

11:28 AM

PH: Art?

AR: I was thinking.

PH: Is that Art there?

AR: Yes I'm back here again.

PH: Okay. What sort of sizes does the HVPS switch in?

AR: These pixel sizes are 200 microns, so we should start seeing some in the 500-micron range. That would be 2 pixels or so.

PH: It's just starting to pick up something.

AR: On that display the 500-micron particles would be little dots. Two pixels wouldn't be very big there.

PH: It starts to pick up some dots, which are 500-micron particles. Is that when it comes in?

AR: It would be something around there, yes. Actually you should see down to 200 microns, but it doesn't really start registering I don't think until we see about someplace between 200 and 500 microns in size.

PH: This descent is turning out to be useful. In addition to getting us on the ground, we're going through 10,000 ft and we've got measurements all the way down. The temperature here is  $-15^{\circ}\text{C}$ .

11:30 AM

AR: We're starting to pick up our first droplet clouds in here at about 10 K.

PH: Yes. We might get a bit of convection as we descend here.

AR: Yes. I'm looking around for something now. If we continue descending in this area, the tops shouldn't be higher than 10 because I was able to pick out the sun's disc and then it was all just that ice stuff above us. So if we continue to go down in this stuff, we won't hit any of the good stuff.

LS: Peter?

PH: Yes.

LS: How low did you want to go on this 500-ft/min descent?

PH: Let's go down to about 2,000 ft and then I'll hand it over to you to land.

LS: Okay.

PH: It might get a little bit convective as we descend.

LS: Okay.

AR: We shouldn't hit any of those tops at 15,000 ft though at least from this point as long as we spiral in this location.

11:32 AM

PH: This descent we're doing, I just spoke to the radar, is actually probably ahead of the rainband that we were flying in that we think was a wide cold frontal rainband, but it's still in some interesting precip area.

AR: We were unable to get the radar to point downward. It's frozen in its upward position.

PH: Is that frozen because of the cold or electronic problem or what?

GG: It's frozen because of cold. The transfer switch out in the wing gets too cold to activate. Bob's going to try to duct a little bit of hot air from the engine over to it. Actually that brings up a question, is the radar going to stay on or come off?

PH: It will come off for the next project.

GG: Okay.

PH: How are you doing on the bat?

GG: As soon as we get some e-prompts.

LS: Peter?

PH: Yes Larry.

LS: We've got conflicting traffic here. Some guy is below us and wants to get through. We've got to wait for him and that will take us 15 or 20 min. But if we go on right down now, we'd be ahead of him and get on the ground.

PH: What rate of descent would you want to do?

LS: Probably 1,000 ft/min.

PH: Okay. Let's not do more than that or we'll fog up, but 1,000 ft we'll try.

LS: Okay.

PH: Sorry Grant. What were you saying?

GG: Bob come up with a suggestion as a place to mount the BAT. I had a conversation with Crawford and he was very much opposed to putting it out at the wind tip because he's just had no luck with installations like that. So Bob came up with an idea of putting it beside the nose and there's a blind spot where the CAR never looks. So we could put it there and it wouldn't occlude the CAR and it could just stay on for either nose. It's mechanically simple as well. Electronically there was an incompatibility and they've worked it out and they're sending me some new e-prompts for the thing. So maybe in a couple of weeks we'll have it back.

PH: Okay. There's some nice liquid water here.



GG: Let me know when I can shut down radar acquisitions because I do need some time to transfer data.

PH: Let's complete this descent. They're going at 1,000 ft/min now. Let me ask Larry how long it's going to take to land after I hand it over to him. Larry?

LS: Okay Peter.

PH: After we reach 2,000 ft and I had it over to you, about how long do you think it will be before we land?

LS: Less than 5 min.

PH: Could we make it a bit longer than that, 15 min so we can download our data?

LS: I suppose we can. Once we're down probably below 3,500 ft, we should be VFR and then we can do what we want.

PH: Let's do that then. Did you hear that, Grant?

GG: Yes. I'll just stay on here and listen for when you hand it over.

PH: When we get to 2,000 ft on this descent, then you can start downloading.

LS: Peter?

PH: Yes.

LS: How about we just stay out westbound until we're clear and then we can cancel our IFR and we don't have to wait for that approach.

PH: Okay.

LS: I'll see if Center will allow that.

PH: Nice liquid water there going up to about 0.4. Good agreement on our three working probes.

11:39 AM

AR: Are we okay with the computer here?

PH: What do you mean?

AR: It looks like we lost our probes?

PH: Really? They look okay to me.

LS: Peter, we're going to have to hold at 6,000 ft here for a little while until we get some traffic out from under us and then we'll go on down. Would you like to pick up that 500 ft/min again?

PH: 1,000 ft/min is okay. But once we get to 2,000 ft and I hand it over to you, we need about 15 min then to download before we land.

LS: Okay.

11:40 AM

AR: A wire pulled out of the laptop.

PH: Mine does that from time to time. So we're holding at 6,000 ft for air traffic and then we'll continue our descent to 2,000 ft at 1,000 ft/min. Then I'll hand it over to Larry to land and he's going to give us 15 min to download our data.

11:41 AM

TW: Grant to "chat."

11:43 AM

PH: It looks as if the CPI has given up.

AR: It really doesn't like to descend too fast.

PH: 1,000 ft/min we're descending now. It shouldn't give up though. It should still flash up, shouldn't it?

LS: Peter, we're going to have to go down another 1,000 ft and try to get VFR out here.

PH: That's okay. I'll hand it over to you now, Larry. Just give us 15 min before we touch down.

LS: Okay.

PH: Grant, you can start downloading.

TW: Something might have happened out there. It seems like all the probes just kind of went kaput all of a sudden on that wing.

PH: Which ones were those, which wing is that?

TW: The one that has all the 2-D probes on it.

PH: That's the right wing?

TW: Yes.

PH: The 2-D has stopped. Grant's downloading now.

TW: That shouldn't make a difference. That's different data.

PH: Still getting HVPS. It's stopped now. It's back up the 2-D.

11:46 AM

PH: Went through some heavier precip here, a bit bumpy at 1,000 ft.

11:47 AM

PH: We're lower than I thought. We're more like 500 ft. We've got VFR here. We're just maneuvering out offshore now. I've handed it over to the pilots to set up for a landing. Let me know when you finish your downloading, Grant.

GG: I will.

11:48 AM

AR: I was fixing the probe there. I was away for about 5 min. During that time, we descended down to about 500 ft above the surface. tans-alt is 376, radar-alt 360. I'm not going to move around too much. But coming up ahead is a stratocumulus line likely to be a wind shift. A few white caps right now, 170 at 16 knots or 17 knots. Made a little turn there, it might be 195.

11:51 AM

AR: It's back to 170. It was probably just due to a little turn there that we made that gave the impression of a wind shift.

PH: Larry?

LS: Yes Peter.

PH: We've got about 20-knot wind from 180 according to my measurements.

LS: Okay.

AR: I'm indicating about 165° at 20 meters per second.

PH: It's very variable. The wind speed particularly variable. It was down near 10 meters per second a moment ago. See it's 14 now. The wind direction is varying from like 180° to 160°.

AR: We're coming into some kind of rainband here. Maybe a wind shift in here too.

PH: Just waiting for Grant to complete the downloading and then we'll head into land.

AR: Right. It looks like the 2-D probe is out again.

TW: It looks that way. I don't know what happened there. It was on that descent.

GG: Actually what we can do on this download, if we keep the inverter prop after landing, we can operate on the gel cells for a while like 30 min.

PH: Do you want to do that?

GG: Yes. Why don't you go ahead and get it on the ground. The data transfer is running.

PH: Okay. Larry, we can go in and land now.

AR: How many minutes, Larry, would you estimate to Hoquiam?

PH: I think he's busy.

AR: Right. That's true.

LS: Yes Peter.

PH: We can in and land now.

LS: Okay.

AR: What's our ETA?

GG: Tom, don't shut down inverter #5.

TW: Okay.

GG: Thank you.

PH: Buckle up.

11:54 AM

TW: I think my download is still being processed too.

GG: We'll all download together.

AR: There was a bit of wind shift back there. You were calling it 165 to 180 and so forth. Now it's back to 130° or so, 140°. So there's definitely with that band of rain that started back there.

PH: Yes.

11:55 AM

PH: We'd better do a quick summary here.

TO SUMMARY

12:00 NOON

PH: Now back over near the Westport radar and it's in the hands of the pilots now to bring us into land. They're probably coming around to land heading south. Probably heading east as Hoquiam is east of the Westport radar.

12:01 PM

PH: Tom, go to "chat." Winds now out of 85 north.

12:02 PM

PH: Coming into land. Touchdown soon.

12:03 PM

TW: Grant?

GG: Go ahead.

TW: I don't switch the main inverter switch off, do I?

GG: No. You can switch off 1, 2, 3 and 4. Just leave the 28-volt switch up.

TW: Okay.

GG: You'll probably see the voltage on the 28 volt jump to 0 when they shut down the engines, but don't worry about it. We'll still be on the gel cells.

TW: Okay.

12:05 PM

GG: Engines off at 05.

12:06 PM END OF TAPE

### Summary of UW Flight 1859

PH: We've spent most of this flight looking at a wide cold frontal rainband. That's what we think it is. We've profiled it from about 1,000 ft up to 21,000 ft. We got pretty good measurements for most of the flight. At the end of the flight, we did a spiral down over the Westport radar, S-pol radar, from 21,000 ft down to 2,000 ft. We're now heading into land at Hoquiam to refuel and prepare for a possible second flight. Art, summary. Someone put Art on the headset.

11:56 AM

PH: Is Art on the headset?

GG: He has his headset on, but he's not looking in this direction.

PH: Art, can you hear me?

AR: I can now. I was just shutting the computer down and was going to sit down.

PH: Do a quick summary.

AR: This rainband was almost like the last rainband and there were several now that kind of fit this pattern. All water confined to below about 7,000 ft. The substructure of this band was such that at the lowest level we detected I think it was three slight wind shifts and they were each one accompanied by enhanced stratocumulus/cumulus clouds that we under flew on the way out there. These areas had between them higher cloud bases with more like stratocumulus with the wind shifting being associated with lower cloud bases. After that pass we did our vertical increments and I'll let you describe those. The last liquid water we hit tended to be toward the east end where there was some heavy convection. We reached the peak of this project by exceeding 1 gram per cubic meter at one point and I think that might have even been in the area where we had that lightning strike. At that same time, we saw more graupel on this particular flight than any other flight. It was a little rougher at least in that one area than anything we've

seen before. As far as the ice crystals above, say 10,000 ft it was just pretty much lined growth that seemed to me in mottle size. I didn't see any rimed crystals above 10,000 ft. They were all dry looking aggregates or single crystals above that level. I think beginning around 12,000 ft we started to pick up the cirroform type crystal. Bullet rosettes were starting to show up here and there. Then, of course, as we got higher up to around 20,000 ft, mostly composed of bullet rosettes and plates and short columns.

PH: I should mention that there was a convective rainband that was closer into the shore while we were looking at the wide cold frontal rainband and we intercepted that on some of our easterly traverses. It was in that that we got discharged that knocked out the CPI for awhile. We got it back up again. Then we tended to try to keep clear of that rainband. Eventually that convective rainband merged with our wide cold frontal rainband as the flight went on.