

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

Date 11/28/01	Flight Number 1891	Main Goals of Flight Standard IMPROVE - 2 Vertical profile over Oregon Cascades in prefrontal conditions			
Project name IMPROVE-2		Which of the Main Goals were Essentially Accomplished? Profiled from 21000 ft to 14500 ft on SW-NE path. Could not go lower due to icing. Note: In addition to unusually strong winds (90 knots at 20,000 ft), cold front went thru. area during flight.  Measurements should encompass pre-frontal, frontal and post-frontal conditions. P-3 flew radar pattern.			
Engines on time 1810470	Engines off time 2329470				
Departure airport Paine	Arrival airport Eugene	Other Accomplishments			
Flight Scientist signature P.V. Hobbs					
Pilot signature		Additional Comments on Flight  IOP #1			
Surface met. & visual obs. a) At takeoff Light snow overcast b) In flight c) On landing				Ac	Clouds sampled in flight
				As	
				Ns	
		Sc			
Research crew Hobbs Rangno Wilson Vidal Salazar Roy Rasmussen Ken M. Larry S. calvin		St			
		Cu			
		Cb			
		Equipment failures 1) 1-DC (garbage) 2) J-W only on rarely. Poor connection? 3) Forward video?			

5.32 hrs

NCRP

TIMELINE FOR UNIVERSITY OF WASHINGTON FLIGHTS

Date: 28 Nov 2001 (Wed)

UW Flight Number: 1891

Goals of Flight: Standard IMPROVE-2 vertical profile over Oregon Cascades

Period of Flight (Engines on to engines off: UTC): 1810 - 2329 UTC

Locations: Paine → Research area (Oregon) → Eugene

Weather Conditions: Strong front moving across study area.

Main Accomplishments: Profile from 21,000 to 14,500 ft along SW-NE track thru study area. Could not descend lower due to strong icing potential.

Measurements should cover pre-, frontal and post-frontal conditions.

IOP #1

Approx UTC Time	Activity
1822	Take off from Paine Field
1822-2015	Transit to Oregon
2035-2048	At 43° 16.1' / 124° 29.9' on Oregon Coast SW of Santia
	Paise SW point and headed N
2048-2053	NE → SW descending at 21,000
2053-2107	SW-NE at 19,500 ft
2109-2132	NE → SW descending to 17,000 ft
2134-2148	SW → NE at 17,000 ft
2149-?	NE → SW descending to 14,500 ft



# IMPROVE II Status Report IOP<sup>a</sup>)

## November 27, 10 PM: IMPROVE II Project Update

The 00Z cycle model runs are in general agreement and suggest that substantial orographic precipitation will be occurring over the study area between 18 and 00 UTC tomorrow (10 AM and 4 PM).

The Convair 580 and NOAA P3 should close-doors at 8 AM and be in the study area by approximately 9 AM on Wednesday. The P3 should plan on a full duration flight--9 to 9.5 h--returning at 5-5:30 PM. The Convair 580 should be prepared for a double legged flight--flying from 8 am to 1 PM, refueling, and then flying from 2:30 PM to approximately 5:30 PM.

The Convair-580 will operate on the SW-NE flight track.

Study area forecast parameters during the flights are:

- 700-mb wind from 235 degrees at 80 knots
- S-Pol freezing level and Redmond freezing levels will range from approximate 8000 ft near 10 am to 5000 ft by the end of the IOP (4 PM)

The S-Pol radar should be switched on at 6 PM today (Tuesday).

Snow crystal observers should plan to operate from 7AM until 6 PM Wednesday.

Upstream sondes should plan to operate from 7 AM until 7 PM Wednesday.

Special NWS sondes should be launched from Salem at 15 Z , 18 Z , 21Z and 03Z.

Lcc-side ISS sondes should plan to operate from 7 AM until 7 PM Wednesday (15, 18, 21, 00 and 03Z).

There will be updates to this message until 7AM Wednesday morning.

Coord: CM Fcst: ER

**November 27, 2 PM:** At the meeting today IOP 1 was scheduled to begin tomorrow morning. A weak warm front will pass through the region overnight, followed by a cold front around 1-3PM tomorrow afternoon. The winds will turn more southwesterly after the frontal passage, potentially leading to significant orographic precipitation. Serious consideration was given to the possibility of a second IOP on Thursday morning to study orographic convection in the cold, unstable post frontal flow. There is considerable uncertainty in the forecast, including the timing of frontal passage. An update will be available at 10 PM tonight.

Tentative Aircraft Close-Door Time: 8 AM Wednesday  
S-Pol Surveillance Mode Start Time: 6 PM today (Tuesday)

**November 26, 2 PM:** At the meeting today it was decided that there will NOT be an IOP tomorrow

P-3

IOPE

TIMELINE FOR UNIVERSITY OF WASHINGTON FLIGHTS

Date: 28 November 2001

UW Flight Number: P-3 flight 1

Goals of Flight: Investigation of orographic precipitation ahead of and at a landfalling cold front.

Period of Flight (Engines on to engines off: UTC):

1944 to 0122 (Block to block) 5.6 h

Locations:

IMPROVE 2 operating area

Weather Conditions:

Vicinity of a cold front during 1st iteration of pattern; post-frontal during

Main Accomplishments:

2nd (truncated) iteration.

The principal objective of this flight was to collect radar and in-situ observations in support of the Comprehensive cloud microphysical observations taken by the Convair-580. The P-3 flight consisted of one full iteration of the standard 'lawnmower' pattern, and one partial iteration (three N-S legs, dropping the westernmost and easternmost segments of the pattern). The first pattern was executed more-or-less following the front across the Cascades and there was good echo coverage. The precip was on the wave during the 2nd pattern, especially in its northern half. The data systems worked very well, in general. Detailed flight notes were taken by Brad Small, radar scientist, and

Approx UTC Time	Activity
1944	Out of Blocks
1955	Takeoff
2006	Cloud tops near 3500m
2011	Radars operational
2030	Cloud physics probe data good
2041	Begin Descent to A

are available in the IMPROVE data archive.

Approx UTC Time	Activity
2042	In Precip Tops 10-12K'
2050	Beginning 1st Leg CLR below T=0 (Pt. A)
2056	Precip building in from W
2111	At F
2115	Begin 2nd NS 8000' 235@60Kts (Pt. G)
2126	Out of Precip, OVC and Sc Below
2130	End of 2nd NS (Pt. B)
2135	Begin 3rd NS In Precip (Pt. C)
2141	Nicely defined frontal shear wind 240 45- Kts
2148	Radar Temp. Down
2155	End of Run/Radar Back
2202	Begin 4th NS Run 16K'
2217	End 4th NS Above Precip
2222	Begin 5th NS Run ~11K'
"	Near top of echo
2235	Variable/thin undercast
2242	End of 5th NS Heading for K
2253	At K spiraling up to 14K'
2259	Begin run to Pt. G
2322	Begin N-S run to Pt. B
2324	Temporary Bad Winds
2330	Temp. out of precip, some show- ers remained of leg
2340	End of N-S (At Pt. B)
2345	start of 2nd NS (Pt. C)
2355	Begin solid precip ~Lat 44° 20'
"	LGT-MOD Chop
0001	Some Breaks in Precip
0006	End N-S (Pt. H)
0011	Start N-S (Pt. I)
0017	Hit sudden patch of MOD Chop at N end of Precip
0019	Tempor. out of precip
0022	North of all precip
0027	End of Final N-S leg
0116	Touchdown

0122

Block In

Report prepared by: Nick Bond

Date: 28 Nov. 2001

Flight 1891  
November 28, 2001  
Voice Transcriptions\*  
IMPROVE-2

PH: This is UW flight 1891, on 28 November, the first research flight for IMPROVE-2 orographic studies. On board Hobbs, Rangno, Wilson; and Roy Rasmussen and Vidal Salazar from NCAR; pilots Ken McMillen and Larry Sutherland. Also onboard we have Calvin Ingram the engineer. The purpose of this flight is to do the standard Convair-580 IMPROVE-2 vertical profile over the Oregon Cascades. We'll be flying along the southwest track in prefrontal conditions, sort of warm-frontal warm-sector conditions with the cold front on the Oregon coast.

6:26 PM

AR: Amorphous so far. Light snow at ground level, melting snow actually. Climbing up through this deck that seems to have low droplet concentrations, very stratiform. It's brightening now. Disc of sun is not visible.

PH: Hello Larry.

LS: Go ahead Peter.

PH: Just want to make sure I can contact you.

LS: We're at 6,800 ft and climbing to 15,000.

6:27 PM

VS: Can you hear me, Peter?

PH: Yes I can.

VS: CCN is starting a sequence at 0.3 supersaturation.

6:30 PM

PH: It looks to me as if the PVM is still not working.

TW: Hold on a second.

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\* AR = Art Rangno, CI = Calvin Ingram, KM = Ken McMillen, LS = Larry Sutherland, PH = Peter Hobbs, RR = Roy Rasmussen, TW = Tom Wilson, VS = Vidal Salazar

PH: But the J-W and the FSSP seem reasonable.

6:32 PM

TW: I'll need to zero the PVM. Are we in clear air right now?

PH: You might want to wait a little bit for zeroing in until we really get in clear air because we're in some cloud now. We're not getting good images on 2-DC.

6:34 PM

PH: There maybe something on the lens that will go away in drier air. That's the 2-DC.

6:35 PM

PH: We're in clear air now. This will be a good time to zero the PVM.

6:37 PM

PH: We're now getting good images on the PMS 2-DC. Since we're in clear air, these must be particles coming from the cirrus above.

6:38 PM

PH: FSSP-100 is looking nice and clean in clean air. We got rid of those counts in channel 1 that we had on the last test flight. Don did some work on the FSSP-100.

6:40 PM

PH: We are getting something on the CPI, but Art says it doesn't look fully functional.

6:41 PM

PH: Tom, do we have a CN counter on? Could you add that to my CCN strip chart.

TW: Okay. It takes usually about 20 min for it warm up, but I'll get it on there.

6:42 PM

PH: On the map, did you add Santium Pass and those locations? We need those, at least Santium Pass.

AR: A stratiform low edge here with a little layer it looks like within 1,000 ft of the aircraft shedding ice crystals. It looks scattered to thin broken and solid layers below. No higher cirrus clouds at least in this vicinity.

6:43 PM

PH: Tom?

TW: Yes.

PH: On this map, let's put Santium Pass and Sweet Home on our map.

TW: Okay.

PH: And also Salem.

TW: Okay.

AR: We're presently flying in a bit of a saddle area. Higher cloud tops back behind us in which we've got a few ice crystals, higher cloud tops ahead, stratiform ragged.

TW: Yes.

AR: Then off to the east looking toward the Cascades I see more well formed clouds with bubbly tops and almost cumulonimbus looking tops off about 50 nautical miles off about 8 o'clock.

6:45 PM

PH: Our flight track doesn't seem to be updating.

AR: I didn't notice any ice out of that little puff we just went through and under. Temperature about -20 to -21.

TW: Are the lat/longs in this manual?

PH: Some are but I'm not sure about those locations. Let me take a look. You see if you can get the flight track up.

6:46 PM

PH: Tom, it's N and M. N and M here for Santium Pass and Sweet Home.

AR: All probes seem to be functioning except the DMT has got its noise spikes. They're peaking out somewhere around 0.8-0.7.

PH: It doesn't have Salem on there I don't think.

AR: The CPI is working sporadically. We're getting some images but a lot of black.

PH: We're still in clear air, no cloud above us.

AR: I cranked the sensitivity up hoping that it would perhaps eliminate some of the black edges in case they were triggering on something we couldn't see. So I went from 375 to about 486 on the threshold.

6:48 PM

RR: CCN indicating 12/cc at 0.3%. It looks like it's working okay.

PH: Roy, you have to put your mike right on your lips and speak up or we won't be able to hear you.

RR: How's this.

PH: Right on your lips.

RR: CCN counter is at 12/cc at 0.3%.

PH: Are you working on our position plots, Tom?

TW: I'm straightening out these lat/longs.

AR: I think you're right, Peter, it's not updating.

PH: The winds look okay.

AR: Absolutely, I was just going to comment they're right on the money for what was predicted about 220° at something in this neighborhood 40 meters per second.

PH: The TANS is working fine. Something else is stopping the position plot coming up.

AR: Here's a nice towering cumulus under this top out there about 2:30-2:00. I notice that on the satellite image it looked like the clear front was about to come onshore at 0900 local.

PH: Right, but in our research area of the Oregon Cascades by about 4 PM local.

AR: Roger. I got the impression, Peter, that it might be moving a little faster than that, but we'll see. That's why I've been kind of looking at that pile of clouds out there

off the right wing and out to about 1 o'clock and wondering if that might be more than just the coast range lift. I guess we'll find out.

PH: It could be.

6:50 PM

PH: We're at 19,000 ft so I assume we're pressurized.

AR: Yes, I'm not having strange thoughts.

PH: That's unusual Art.

AR: Roger.

6:51 PM

VS: The CN...seems not to be working okay. I haven't seen CO particles for the last few minutes.

PH: The CCN or the CN?

VS: The CN.

PH: The CN takes a while to warm up. It may not be warmed up yet. Larry?

LS: Peter. What time did you have us out?

PH: Engines on do you mean?

LS: Both if you have them.

PH: Engines was 18:10 Zulu and takeoff was 18:22.

LS: Thanks Peter.

PH: We don't have a position plot at the moment. What's our location?

LS: Standby 1.

AR: Peter, Tom was just checking that and he tells me that is our current position plot. That's what the lat/long puts it, so I guess we're going quiet a ways out of the way to get down some area before we can turn southbound.

PH: But mine hasn't updated for 10-20 min.

LS: The display up here is not right either. It looks like we're just west of Olympia now at 13 miles.

PH: Okay.

TW: That's about where it shows me as being on in the position plot.

PH: Well it may, but it doesn't seem to be changing.

TW: You're zoomed out pretty far, so you're not going to be seeing big jumps.

PH: Okay. If it's working, great.

AR: You ought to make sure you're hanging onto things when we're going in here because we are eligible for significant turbulence at almost any time.

6:53 PM

PH: I have my doubts that the PVM has been fixed.

AR: I think it's okay, Peter. Back here I can see the small liquid water elements that we've passed through about 5-10 min ago.

PH: We'll get a good test later on.

AR: Yes. There's just not much liquid water up here in these guys at least in the tops we've been flying in. I think if we hit some of the more rounded ones we'll certainly get a bump, but these raggedy guys aren't going to have anything in them.

6:54 PM

PH: Did the liquid get checked in the CN counter?

AR: I did talk to Don about that. I didn't look at it personally. Whether Don did or not, I did not get a report back.

6:55 PM

VS: I think the CN counter is already warmed up and it's still reading zero.

AR: There may not be a whole lot up here. I'm sure there has to be one, but I notice PCASP is reading a tenth to 1 or 2 or 3.

VS: I'm reading 61 at 0.3 supersaturation is 23.5.

AR: Tom, do you copy?

TW: Yes I do.

AR: Do you remember when it came up we tried to look at the butanol supply on the CN? Did you see anything when you looked?

TW: What do you mean did I see anything, like is it full or not?

AR: Right, exactly. When we were talking about having maybe to move that forward station there, the engineer's station.

TW: I don't even see a gauge that shows how full it is.

AR: Yes. That's right. Now you're reminding me. That's right, there was no window to look at the butanol level in that thing. I'm not sure whether Don went later and checked that out, do you remember?

TW: I have not talked to him about it.

PH: That's something you should check, Art, before each flight and make sure it's topped up on the ground.

AR: Roger that.

PH: Because it evaporates very quickly.

AR: Roger.

PH: Normally the aerosol guy would take care of that, but we will not have an aerosol guy on these flights.

AR: That's right. It kind of fell between the cracks.

VS: I'm not sure the pump is on, so that might be the problem. I don't know what to turn it on. Can somebody come here and check it?

AR: Tom, do you know how to turn that on for him, because I don't?

TW: I can take a look. I don't really know how to turn the pumps on. Usually they just come on I thought, but I'll check. It will be about a minute or two here. I'm right in the middle of something.

6:58 PM

PH: Did you get a lat/long for Salem or not?

TW: Yes I did.

PH: Good. Just for the record, I note that my wristwatch and my digital camera are running about 2 min ahead of the UTC time on the computer.

7:00 PM

TW: If you restart your map program, it should give you the new locations.

PH: Okay.

AR: I didn't catch when this happened, but the temperature at constant level here has dropped about 3-4°C over the last 15 min to half an hour. It's probably reflecting that upper trough moving in.

7:02 PM

PH: At 19:03 I took a picture on my digital camera looking southwest showing the cloudscape beneath. It's 19:03 UTC on the computer clock.

7:04 PM

PH: A note for the tape that on my digital camera the times are in local time, Pacific Standard Time, that is 8 hr behind the UTC times.

7:06 PM

AR: It now appears that that cloud enhancement off the right wing from about 1 o'clock to way back behind the tail to about 5 o'clock and then off the left wing is mainly orographically produced enhancements, not any particular feature moving through the warm sector here. You've got to figure that cooling off aloft and it's probably still warming up some below that we'll probably see more of this stuff in maybe a little deeper cloud tops as the day wears on until that cloud front comes by.

7:07 PM

TW: We're going to be going pretty high here, so you guys might want to put on your oxygen masks.

7:10 PM

AR: We're flying down the Willamette Valley here just crossed the Oregon border flying down over near Portland and heading into the Willamette Valley. We're in kind of in a saddle area of the clouds. Enhanced cumuliform clouds off the left

wing and right wing reflecting the coast range on the right or to the west and the Cascades on the left, very chaotic cloud pattern. We have some totally ice areas below us, fall streaks from altocumulus-like clouds here at well below the aircraft. I'd estimate here, by cloud movement, maybe a kilometer or more below the aircraft at this exact point and then we're coming up on even a rift line in these clouds below the aircraft and that corresponding possibly to the. Well I take that back. We've passed the Columbia River, so I was going to make a mistake there. Ahead we have very turbulent looking clouds rising up to this level and above this level and glaciating very quickly it appears from the ghosts of ice crystals that remain on some of them just dead ahead to the left. They are not, however, well put together. They look very ragged even in the kind of the droplet remnant there and so I suspect they are pretty old slow growing...

PH: Ken.

AR: ...clouds, like castellanus turrets.

KM: Hello.

PH: Can you give us some heat back here? It's getting a bit cold around the feet.

7:14 PM

AR: I should mention these cumuliform clouds off the right wing to the west are most of them pretty well glaciated even though they retain some of their roundness, cumuliform appearance. An awful lot of them seem to be just completely ice crystals and very little liquid water with an isolated exception.

7:15 PM

PH: We've got a pressure altitude in the cabin of about 12,000 ft, so if want to take oxygen you should do.

TW: If you stop using the oxygen, make sure you disconnect it from the ceiling otherwise the oxygen keeps flowing. So make sure you disconnect it.

7:18 PM

AR: Coming up to a region of protruding wispy glaciated cloud tops. We might see the turbulence pick up just a bit in the next 1-2 min.

7:19 PM

AR: We're just entering a glaciated cloud top, turbulence beginning to pick up and off the left wing is a little wisp of the remnant droplet cloud, just a shred cloud. Trying to look down to see if it's rooted in the boundary layer, which I doubt, but

I want to check. It looks more like I may have mentioned before that it maybe large castellanus elements based at the mid-levels, a feature often associated with warm sector regions. Peter, out there just ahead of the right wing are some large cumulonimbus turrets estimated 100 nautical miles or more out. That might be the cold front out there because there's no reason for those guys to be there other than that.

PH: Okay, Art. Thanks.

TW: Art, have you getting any 2-DC?

AR: We should have got a little burst back there about 30 s ago we went through a cloud top of ice crystals.

TW: I saw nothing.

AR: That's not good because they may not have been very large, but there should have been something. I'm going to come up and I'll look at the CPI and see if it triggered on any of that.

PH: The starting point for our vertical profile will be at  $43^{\circ}16.1'/124^{\circ}29.9'$ , which puts our starting point just close to the Oregon coast. We'll be starting there at 21,000 ft. At that altitude we got wind speeds of about 80 knots, so we're going to be drifting quiet a way to the east. But we reckon that by the time we get down to 10,000 ft, we will be just about over the Cascade crest.

7:23 PM

AR: On the CPI the last crystal image on it was 1914, which would have been before the little thing we just went through. That seems strange to me because I don't think we went through anything before that, but maybe there was an isolated crystal out there.

PH: Tom, did you look at the CN and see if there is anything that can be fixed?

TW: I looked at it. I didn't notice anything I could do. Usually the pumps turn on when I turn on the circuit breakers.

PH: Is the instrument itself showing any output?

TW: It's showing zero.

PH: It's not right. It's not working.

TW: It doesn't show that it's low on liquid.

PH: There is some indicator on that?

TW: It just shows if it has some or not and it shows that it has some.

PH: You told me one of the CN counters was working on the last test flight, CNC-1 I think.

TW: I think it was CNC-2, but I can double check.

7:24 PM

AR: Heck, I thought we were going to go through a cloud there. Are we in a descent mode here pretty quick, Peter?

PH: No, we're going to be at 21,000 ft, our starting point on the west coast. Just on the coast of Oregon will be our starting point.

AR: Roger, as you can see there's not much up here. The cloud tops are higher to the east, but I'm estimating that's probably over or even downstream of the Cascades. That's going to be close. I take that back.

PH: Do you think tops will be near 21,000 ft?

AR: I think we're going to get into something. We're going to have a lot of clear air between here and there unless we go westbound and sample these guys off about 1 to 2 o'clock.

PH: We've got our starting point. It's going to be  $43^{\circ}16.1'/124^{\circ}29.9'$  is our start point.

7:25 PM

PH: Larry?

LS: Go ahead, Peter.

PH: When we get to our start point, if we find we're not in-cloud at 21,000 ft, we'll drop down to an altitude that does put us into cloud.

LS: I understand.

AR: Peter, would you want to stay at 21,000 ft if it looked like there was cloud ahead?

PH: Yes, if there was substantial cloud. If we're in cloud more than 50% of the time, than we'll do it.

AR: Okay. Roger. Peter, I was just thinking it occurs to me maybe clear air is valuable too because of the MMS's attempt to predict cloud water/cloud ice. You know maybe flying in clear air provides some validation as well.

PH: Yes. We'll take a look at it when we get to our start point.

7:27 PM

TW: Art, let me know if you see any more clouds coming that we can test the 2-DC on.

AR: Roger that. I'm waiting for that too.

TW: Because if it isn't firing, it would be good to reset it as soon as possible.

AR: Roger that. We were on the edge of that little wisp of cloud, but it looked to me like our contrail, the exhaust trail that we produced, was in it.

7:28 PM

AR: I just went and checked the time of the CPI computer. In the lower right-hand corner it says 7:23 PM, that's UTC, which of course makes it 1923. So that seems to be okay. I started to worry because we didn't get any crystals in that wisp of cloud we went through.

PH: Larry?

LS: Go ahead Peter.

PH: What's the cabin pressure?

LS: It's at 11,500 ft, Peter.

PH: Thank you. Still pretty chilly back here.

LS: Okay. I'll turn it up.

7:30 PM

AR: Temperature at flight level has dropped to about  $-25^{\circ}$  and that's Rosemount static. I'm not sure if that's the correct one. The reverse flow is  $22^{\circ}$ , about  $3^{\circ}$  warmer and that would suggest the temperature has been falling. We're actually taking a more southwest element now that would be directly into the 90 knot headwind we have. Notice we have 90 knot headwind.

7:33 PM

PH: We're still above cloud top here heading toward our starting point to the southwest of us on the Oregon coast. I don't know if the P-3 is in the air. I haven't had any message on that.

7:35 PM

AR: We're getting pretty close to some of these wispy cloud tops off the right wing about 2 o'clock, actually a little better form than we saw before where they were completely rags and shreds and wispy with fall streaks. One of them over there is at least mounded and nice and round. They have a tad of liquid water and most of it is glaciated and it's kind of a rivulet of convection that extends to about 2 o'clock or would be about south-southwest through northeast. It seems to extend actually all the way to the Cascades where there are higher tops back there that extend above the flight level estimating 30,000 ft over the Cascades back there for the highest top and actually off the wing here the highest tops probably about 1,000 ft above flight level, make it somewhere around 22,000 ft.

PH: Larry?

LS: Go ahead Peter.

PH: Looking ahead, do you think 21,000 ft is going to put us in those clouds?

LS: No, I don't think so, probably down around 20,000 ft.

PH: Let's try to start there at 20,000 ft then.

LS: Okay. It's still quite a ways out there, Peter, so we'll be able to get a better look when we get closer.

PH: Okay.

7:38 PM

AR: Larry, do have an ETO to the western endpoint?

LS: Standby one.

AR: Thank you.

7:40 PM

AR: Peter, off the right wing there in the distance might be that cold front. That's the line I was...

PH: It could be. It's quite a trek out here to get to our starting point.

AR: I don't think we'll see this kind of headwind on any other storm. This is exceptional.

PH: Yes, 90 knots.

AR: Exactly.

7:41 PM

LS: Art, did you copy? It's 30 min down there to the start point.

AR: It's 30 more minutes?

LS: 30 more minutes.

AR: Wow. Thank you. Did you copy that, Peter?

TW: He's talking on the radio.

VS: I was checking the pump on the CN and the power connection just came off. That's the problem. I'm going to try to get it fixed.

TW: The power connection on the pump?

VS: That's correct.

AR: Peter, do you copy?

PH: Yes. When I don't copy it's because I'm on the radio talking to the radar.

AR: Roger. I understood that. Did you catch the estimate from Larry?

PH: No. I missed that.

AR: 30 min to our endpoint.

PH: It's going to be nearly 2 h, Art, since takeoff.

AR: Roger.

7:42 PM

AR: I don't think we'll have a problem at this flight level. It looks like the tops are kind of edging upward in that direction.

PH: Well I assume the radar people know where they are and that's why they put us at 21,000 ft. They said there was a small band over there to the southwest of us.

AR: Roger. Okay.

PH: They'll be scanning along this southwest-northeast line.

7:43 PM

PH: Larry?

LS: Yes Peter.

PH: Where do you plan on landing today?

LS: Salem.

PH: Good.

7:44 PM

LS: Peter, are you still anticipating a second flight starting back out at the same point?

PH: I don't know about starting at the same point, but definitely a second flight. I imagine it will be close to the same point.

LS: Okay. We will probably change that destination either to Eugene or Corvallis.

PH: All right.

AR: Peter, there are Beavers and Ducks!

7:45 PM

AR: Tom, do you copy?

TW: Yes I do.

AR: We have a cloud dead ahead here in about a minute so we should get some signal on our probes, our 2-D and CPI.

TW: Thank you.

AR: I'll let you know when we go in.

7:46 PM

AR: We might start picking up a few rogue crystals in here almost any time Tom.

7:48 PM

AR: It looks like the main part of this coming up here from right now for the next 20 s.

TW: I think we're getting strips, aren't we?

AR: Roger that. I have to adjust my eyes. I can't see anything after I come out of bubble.

TW: I think we got two strips.

AR: That didn't look like enough to me. It's thin, but there's more ahead here. We're going to be in and out here for awhile.

7:49 PM

PH: We're getting something now, just a little liquid water here.

7:50 PM

PH: It looks as if Art still has problems with the CPI. He's trying to bring it up again.

7:51 PM

PH: The 1-DC cloud probe is not working. It's showing erroneous counts. That's something that Don didn't get around to looking at.

AR: We have much deeper clouds ahead. They should give us a nice test of our instruments. A little more constitution, it's kind of raggedy, ill formed shred-like clouds with lots of ice and not a lot of droplet cloud apparent except in a few raggedy areas.

PH: Art, we're still getting erroneous counts on the 1-DC.

AR: Yes. Don didn't get a chance to work on it so unless there is a miracle his cleaning is probably not going to do anything.

PH: The CPI is saying low image intensity.

AR: Sorry, my volume was down. What did you say, Peter?

PH: The CPI is saying "low-image intensity."

AR: Yes. That's been pretty characteristic of this thing since we got it back, but it seems to work. When it is working we get nice images from it.

PH: That's good.

AR: We did pass that along to Pat at SPEC and he was not concerned about that particular error message.

7:53 PM

PH: Larry?

LS: Yes Peter.

PH: The P-3 taxied out about 10 min ago.

LS: Okay.

PH: Tom, did you get the forward video up?

TW: I will not know until we're on the ground.

PH: Okay.

AR: I'm trying to keep a few more voice notes on the recording because it is a doubtful situation.

TW: No matter what it will not have any time stamp on it.

AR: That's good to know. I didn't know that. Thanks, Tom, for telling me and reminding me and I suppose we're getting audio, right?

TW: We're definitely getting audio and there's just a minute possibility we will have video.

AR: The time stamp on the audio talking clock is working?

TW: Yes.

PH: Just for the tape this is a problem with the video is we had a problem with one of the computer recorders in the testing the other day. What was it that went out, Tom?

TW: The entire flight data engineering computer and we only had time to replace the QNX side of the computer. We didn't have time to rebuild the Windows hard disk.

PH: Okay.

7:56 PM

LS: Peter.

PH: Go Larry.

LS: Depending on what time we enter the system, the tops, if we want to make the first stage at 19,500 ft, suppose we enter that thing at 20,000 ft. That's only 5 min if we want to back over it. So probably on that first one what we'll do is just make a 360° with kind of a racetrack there and then come back over it 5 min later. That will pick up that particle at 19,500 ft and then we can go under the 25 min descents.

PH: Okay. Fine. If you can make contact with the P-3 say in about 15 min or so, you can let them know what the tops are like out here.

LS: Okay. We'll be talking to him when he comes up.

7:58 PM

AR: At 11:58 the forward video is looking straight ahead at a saddle of cloud with raggedy convective clouds on the left and in that picture there should be a little sliver of lenticular crossing the top of a slanting nearly glaciated castellanus-like turret (flight 1891). In the far distance would be the high cloud shield to the say 11:30 position. At 1 o'clock is distant mounding clouds possibly associated with the cold front. Along with that the upstream tail of a lenticular-like cloud probably at 28,000 ft to 30,000 ft.

VS: The CCN will be down for 10 min while I rewet the pads.

7:59 PM

PH: What do you have there, Tom, some crispy doughnuts?

TW: Just Pringles, oh, you mean in the box here? It would be nice if I had some Crispy Cremes here.

8:00 PM

PH: Still getting our usual erroneous counts on the DMT in clear air.

8:01 PM

PH: Larry?

LS: Go ahead Peter.

PH: What altitude are you reading?

LS: Say again Peter.

PH: What altitude do you have?

LS: 21,000 ft right now. Flight level 210.

PH: I've got 210.5.

LS: Yes. It was quite an altimeter drop. We're flying on a standard pressure up here, which is going to put it different from the actual altitude above sea level.

PH: Yes. The tans-alt is at 20,300 ft.

LS: Okay.

AR: There's something you don't see too often. Back behind the tail off to the say 5 o'clock position, we have the reverse shearing fall streaks from the altocumulus-like tops behind the plane out back about 5 miles. In other words, they are slanting toward the east, which you don't see too often, and I think John Locatelli has talked about that as being associated with cold air advection at the flight level, the cloud level.

PH: Larry?

8:02 PM

LS: Go ahead Peter.

PH: The altitudes that the radar people will give me will be of course above ground level. So they'll correspond to my tans-altitude, which is running almost exactly 1,000 ft below the pressure altitude.

LS: Okay. So what we'll do, Peter, is get a block altitude and you can tell us what altitude you want to go down to.

PH: Yes, it will be about 1,000 ft below this at least.

LS: Okay.

AR: Peter, there will be a number of tops that do come up to this level to the left off toward the east that you cannot see actually. The nice convective feature of some type just off the left wing goes for at least maybe 100 kilometers in length.

PH: Okay. We'll fine-tune it when we get on site.

AR: Roger.

LS: What we'll do, Peter, is try to let down further out, where a cloud top is, then get a block altitude and work on that.

PH: Okay. Did the air traffic control people recognize you?

LS: It seems like they do.

PH: Great.

AR: Peter, in the past there are saddle areas and if Larry accidentally goes down to the saddle area, we'll be way to far below the tops of the features you'll probably want to study in those bands. I found that sometimes there's a miscommunication here and suddenly we're down at 12,000 ft and we really want to be up higher.

PH: Well you can work with Larry as usual on that, Art.

AR: Roger. Will do.

PH: The instructions from the radar are to start at 21,000 ft and all I'm saying is that's above ground level.

AR: Right. As you see out here we're going to go in and out that's for sure. But we might be out there over the Cascades that it will be more solid and we'll pick that data point up over the measuring sites.

VS: CCN is back on line. It's reading around four numbers per cc.

PH: When you give your CCN counts, will it always be at 0.3% supersaturation?

VS: That's correct.

PH: Unless you say otherwise?

VS: That's correct. Yes.

8:06 PM

PH: We're still fighting these 90-knot winds here from about 235° true north.

8:07 PM

AR: Larry and I were talking about that, Peter, and we're going to be in and out at this level. You know you have a lot of clear air and then hit some tops and then go into some deeper stuff it looks like over the Cascades. That's probably what the radar folks are talking about off to the east there, these deeper layered clouds.

PH: We'll stay with this then.

AR: It hadn't occurred to me before this flight, but maybe sticking with the plan and then you fly in clear air and the model is predicting a lot of clouds here. You've provided quite interesting data because maybe it's forecasting, you know, ice supersaturation and water supersaturation and what have you and there's nothing here.

8:10 PM

RR: Yes, I would agree with that Art. I think that's a very interesting thing to do as well.

PH: On my text data I've got a CCN readout of 150/cc. Is that correct?

VS: No. From the instrument I'm reading 11.5 at the moment.

PH: I wonder why we're recording 148 on the computer output?

VS: There maybe an error in the formula. We can check that.

LS: Peter, we're at our southwest point. We're going to start letting down the cloud tops and get oriented on this leg and I guess we're just going to have to circle until we get down near cloud tops to start it.

PH: Fine, Larry. Just let me know when you're starting your trek toward the northeast.

LS: Okay.

AR: Larry, you don't think we're going to be in those tops out there off about 10 o'clock?

LS: Could well be Art. We're going to take a look at it here and do an 82 60 we'll call it first at about another 500 ft below.

AR: Because I'm thinking we were just talking about this and we were kind of thinking maybe we'd be better to stick with the plan and we're certainly going to pick up some clouds out there in my estimation.

PH: Let's stick with the plan, Larry, the 21,000 ft.

LS: You want to start it at 21,000 ft?

PH: Yes. On your pressure altitude it's going to be about 20,000 ft.

LS: Okay. I'm at 20,000.

PH: This is about the right altitude.

LS: I've got us at 20,000 ft now on the correct altimeter setting.

AR: You don't want to be misled by this saddle deck of clouds down there. That's way below the tops of that convective line that have been off the left wing.

PH: Do you think this looks good here, Art, or do you want to go up 1,000 ft.

AR: I would pound it out at the 21,000 ft and just stay with the plan because I think those tops are right up there and we can nail down cloud top temperature in case there's some problems there in satellite imagery, get the (ice) germs.

LS: Peter?

PH: Yes Larry.

LS: If we extend up northeast on the track about 15 miles for our start point, we will be in clouds.

PH: Okay. Let's climb 1,000 ft.

LS: Okay.

AR: Also it's hard to tell from this vantage point, but it looks like it all merges into one deep layer over the Cascades unless I'm looking at some lee wave phenomenon. That's a question that will have to be answered by the radar folks themselves. You can see that, Peter, now off the right wing you can this is a convective band that goes off there from about 1 o'clock to 3 o'clock and way behind the tail.

PH: Right. Yes.

AR: Then you see those higher clouds in the background off the right wing and those to me look like they're over the Cascades and sometimes we see the orographic clouds kind of merge with that stuff. But as I say, I can't really tell from here. I wouldn't trust my estimate from this far away.

PH: Where we get into a bit of confusion on the altitude is that Larry is now reading 21,000 ft on his pressure altitude, but actually above ground level we're only 20,000 ft. So that's why I said go up 1,000 ft because that's where the radar wanted us at 21,000 ft above ground.

AR: I'm sure they have a good reason for that and I think we will nip these tops here in this convective feature.

PH: But I have to be careful when I say to Larry I want you at 21,000 ft. He's reading 21,000 ft now, but he's a 1,000 ft below where I want him.

AR: Yes. That's right.

8:14 PM

LS: Peter, we're starting our reversal now and we're just going to come back around here to be over.

PH: Fine and you can do your climb up to that 1,000 ft as we head to the northeast.

LS: We're there now.

PH: Very good. Thank you.

8:15 PM

PH: Tom?

TW: Yes.

PH: I've got UTC time on my map display, which is correct of 2015, but on the 2-DC it's 1949.

TW: That was the time of that particular strip, the last strip that came through.

PH: Okay. It doesn't read current time on that one.

TW: It might be down at the bottom of that window, the very bottom next to that green button. I think you just covered it up. See that big green button down there?

PH: I've got it. I have to be careful of that.

8:16 PM

AR: For the forward video we are orbiting here at 2016. We did a 360° for some reason. Larry, are we setting up here, is that why we were doing a 360°?

LS: We're doing a reversal right now, Art.

8:18 PM

PH: Larry?

LS: Yes Peter.

PH: I have a point for you to head toward.

LS: Go ahead.

PH: 43°56.0'/122°54.9'.

LS: Okay. When do you want to head for that?

PH: That's the heading we should be doing now and at this altitude that will be our northeast point.

LS: So let's change from that point Quebec.

PH: Sorry, what was that Larry?

LS: That was change from the point Quebec?

PH: No. Our starting point remains as it was. That's where we just started from a few minutes ago. That point I just gave you should be our northeast point. Does that look right?

LS: Okay.

AR: Peter, I've gotten confused here because we're going back to the southwest and back offshore. Is that what you want to do?

PH: No. Let me talk to the radar again because I assumed this was our northeast point. Keep on this heading for the time being, Larry, to the northeast.

LS: Okay. We're southwest now, Peter.

PH: You're heading northeast, aren't you?

LS: Negative. We're back southwest because we went over our point right away there.

PH: We want to be at our starting point and heading to the northeast.

LS: We were already over that one when we started that turn and we're descending now to 19,500 ft to be back at the 19,500 point. Do you want to start this over at the southwest point?

PH: No. I'm confused now because I thought we were at our starting point and that we were going to be heading over Sweet Home toward the radar.

LS: Well we were, but you wanted to start the thing at the southwest point, which meant we basically had to start a reversal to go down to 19,500 ft. I think the easiest thing, Peter, is to climb up and start this thing again.

PH: Okay.

LS: Okay.

PH: The first leg at 21,000 ft should be from southwest to northeast.

LS: Okay.

8:20 PM

PH: So Larry that's as on page 40 of our ops manual.

LS: Okay. But you want to start your first sample at that point P, which is the first coordinate that you gave me.

PH: Correct. That will be our southwest point. So that's the top left-hand point on page 40.

LS: Right. Peter, that's going to be at 21,000 ft, so we need to go ahead and start our reversal in time to be back at 1905, 15 min later.

PH: I wouldn't worry too much about the altitudes exact. More important is that we get heading out toward the mountains at altitude that puts us in cloud.

LS: Okay. We won't be getting into cloud at that southwest point because there's no clouds there.

PH: No. But as we head toward the mountains towards the northeast, we should be getting into cloud.

LS: Okay. I've got you now.

AR: Roger. We were just about to enter cloud when we made that turn back there. That's what surprised me. As I say, there's a bank in the direction of the

Cascades, which I presume the radar people are looking at when they talk about tops of 21,000 ft or want us at 21,000 ft. Have we talked to them lately about tops though?

PH: I'm more concerned about getting us on track rather than tops at the moment.

8:23 PM

PH: So Larry?

LS: Yes Peter.

PH: That second point I gave you then makes sense, doesn't it, as the northeast point that we would be heading for?

LS: It should be. Yes, it checks, Peter.

PH: Good. Once we get on that track, then you can work with Art to adjust the altitude.

AR: Here's what it looks like, Peter, we'd do a nice job on cloud top in this convective line back behind the tail and then we'd have another clear area and then we'd be heading into cloud. But the space between the tops of this convective feature and the next group of clouds that are higher, it looks like it's going to be maybe 5 min of clear air before we get there. But then again that's ground truth for the model I suppose.

8:24 PM

AR: It sure looks like post-cold frontal out there over the water. Look at those big clearings out there now and the cumulus clouds.

TW: He's on the radio.

AR: I'm just talking to everybody in general. Maybe this feature behind us is the band that was coming on shore at 0900 local.

8:26 PM

LS: Peter?

PH: Yes Larry.

LS: They've moved that point up about 50 or 60 miles from the original end point, which probably is going to mean we're going to cross that thing way before we get down to 10,000 ft.

PH: Let's just take the points that they give us and assume that they...(end of tape)

TAPE 1, Side 2

PH: Are we at our southwest point heading northeast yet?

LS: We're right past the southwest point to get lined up for it. I'll call you when we cross it.

PH: I'll just keep giving you our new point. I've given you the northeast point that you're heading for now. Just before we get there I'll give you a new southwest point and so on.

LS: Okay.

8:28 PM

PH: Larry?

8:30 PM

PH: Larry?

LS: Yes Peter.

PH: I just spoke to the radar again and they've got a canned computer program, which they're using, that tries to take into account the rate at which we should be descending and times and all that. So I think the best thing we can do is just take the points they give us.

LS: Okay. Peter, we just passed our southwest point. We're doing another reversal now and go back over it.

PH: Let me know when we go back over. Also, Larry, the P-3 is heading for its first point A on our diagrams for the P-3.

AR: Peter, where is our northeast endpoint? Is that over the Cascades?

PH: I don't know exactly where it is, but it's up toward the northeast of where we are now.

LS: Peter, we're doing our reversal. When we get headed back southwest bound, we're going to start descending to 19,500 ft.

AR: We're just crossing the coastline and we'll be heading back offshore, Peter.

PH: Why don't we from this point head to our northeast point? I don't think there's any need to go back off the shore.

LS: Okay.

PH: Just head to the northeast point I gave you.

LS: Once we get headed northeast bound, Peter, do you want to start descending then?

PH: No. That first northeast track is at constant altitude. Look at page 40.

LS: Okay.

AR: Maybe they're giving us some bad points. You know with these extremely strong winds they're probably estimating that the crystals landing on them are coming from a long, long way up wind and they think they're forming out here and we have no clouds. Are they aware that we have no deep clouds out here?

PH: They've got the radar on us. I just discussed this with Mark and we decided to go with the points he gives us.

AR: I wonder if he's reading his numbers correctly because if we're just going back and forth a few miles something has to be off.

PH: We're going to head northeast at this altitude heading toward the Cascades, which should put us in cloud, right?

LS: Okay. We'll return to this altitude when we get to that point.

PH: Do you see anything wrong with that, Art?

AR: Well he thought he was at his northeast endpoint when we just crossed the coastline of Oregon.

PH: No. He didn't.

AR: Well on my chart, maybe there's something wrong with it. Right now it shows us on the coast of Oregon.

PH: That's right. That's our southwest point roughly. Our northeast point is way up near  $44^{\circ}/122.54^{\circ}$ .

AR: Right. That's a long way off, but we haven't done that yet.

PH: That's right. We're just starting to do it now. We're just starting to head northeast for the first time.

AR: I thought he turned back.

PH: Don't worry about it, Art.

AR: I'm not going to worry about it anymore.

LS: Peter, we're 62 miles from that point you gave me and we're going to maintain this altitude until we get there.

PH: That's it. Right.

AR: Okay. We're all one on one.

8:35 PM

AR: Now we should, Peter, hit some cloud tops in about 4 or 5 mins. There's a convective feature off the right wing.

PH: That's good.

AR: Actually I thought it was something moving along with the air mass, but there's also the possibility that it's a standing feature forced by the mountains here.

8:36 PM

PH: This northeast point we're headed for now is just a little distance southwest of Sweet Home. That's where the crystals should be starting out from high up that we'll be tracking as we head progressively toward the northeast for the remainder of the flight.

AR: Roger.

PH: Larry?

LS: Go ahead Peter.

PH: Is this a good time to chat?

LS: Yes, go ahead.

PH: Do you have our page 40 up there?

LS: I will in just a minute. I've got it Peter.

PH: Do you see our upper-most track there? It starts from the southwest point.

LS: Affirm.

PH: And goes constant altitude and it ends up almost over the S-Pol radar.

LS: Right.

PH: That's pretty much what we're doing now. That S-Pol radar is pretty much at our northeast point that I gave you. Maybe it's a little further northeast, but it's roughly there.

LS: Okay. So that's going to be where we start our reversals and descents.

PH: Exactly, and before we reach that point I will give you a new southwest point to head for on your descending path.

LS: Okay. So you want to do this on distance now and not on time?

PH: We'll do it just on lat/longs.

LS: Okay.

8:38 PM

TW: Art, can you give me a heads up on some particles?

AR: You've got about 2 min.

8:39 PM

VS: So the CN counter is working pretty well now. It's showing 52 particles per centimeter cubed. CCN at 0.3 supersaturation is showing around 3.8 \_\_\_\_\_ per cc.

PH: Larry?

LS: Go ahead Peter.

PH: After we reach our northeast point, I can now give you the southwest point to head for.

LS: Okay. Go ahead.

PH: It will be 43°53.2'/123°0'.

LS: 43°52.2'/123°.

PH: 123°, yes, correct, and that will be on descending path when we head back to the southwest.

LS: Okay.

8:40 PM

PH: What do you see ahead, Art?

AR: Peter, I was just coming back here to talk to Larry. Larry, it looks like we're going to go right through the middle of that clump in what, 30 s or a minute or so?

LS: Yes. Probably, we're going pretty fast.

AR: Thanks. We definitely want to go through it.

8:41 PM

AR: I can just see the top coming into view ahead, Peter. We will definitely be well into this, a fairly newly risen top. We should have a little bit of liquid water in it, although it's creeping up in elevation.

8:42 PM

AR: Probably see some crystals beginning any time now and then there will be a kind of a peak bang when we get into the solid part of this. There shouldn't be really much in the way of turbulence whatsoever.

PH: Don't see anything yet.

AR: These are rogue crystals. They maybe left over from something else. Okay, 5 s, 3, 2, 1, 0. Entering cloud.

PH: Good images on the HVPS and on the 2-DC.

LS: Peter.

PH: Yes Larry.

LS: When we reverse back to that new point you gave me, you don't need to really be on that track, do you? You can just do a 180° and go back.

PH: Yes. It doesn't have to be exactly.

LS: Okay.

AR: That was great. We're going to be in and out. There are tops ahead. We'll be in some clear air here and then a few ice crystals from this shelf cloud off the right, which we'll pass under some remnant of it. So there will be some rogue crystals in here I'm pretty sure. Then a little bit further down the row it looks like we're going into some solid tops. That is they'll be contiguous for a good distance. They're looking rather stratiform compared to that little bubble we went through.

PH: No liquid water there. I got good crystals on the 2-DC and on the HPVS. I wasn't looking at the CPI so I don't know if it caught anything. Would those images still be on the CPI if they were there, Art?

AR: That's affirmative.

PH: I don't see anything.

AR: I'll come up and take a look.

8:44 PM

PH: I do see some liquid water now. It's come up. It was just slow coming up. Yes, good liquid water there about 0.15 on the J-W, actually on the FSSP, and the PVM seems to be working. There's quiet a time delay there between that coming up on my display and the actual cloud penetration.

8:45 PM

PH: Larry?

LS: Go ahead Peter.

PH: Also provided you don't have to deviate very much, more than a few miles from our track, we want to hit the clouds.

LS: Okay. We're just going to be sticking our nose in it, Peter, and then starting our turn back. So we should be in it for probably for about 3 min.

PH: Okay. Let me know at each point when we're back heading in the other direction.

LS: Okay. I'll tell you when we're back southwest bound.

8:46 PM

LS: Peter, we're starting our reversal.

8:47 PM

PH: Art, I'm seeing some triggering on the CPI, but I can't make out the crystal shapes. Oh just about, they're pretty faint. Maybe they're there.

LS: Peter.

PH: Yes.

LS: That new point you gave that we're going back to is only about 7 or 8 miles back from the northeast point.

PH: Yes. Let's go with it.

LS: Okay.

8:48 PM

LS: Peter, we're only 6 miles northeast of that point, so we're going to go back past it so the wind doesn't blow back over and then come back over it and then where are we heading next.

TW: Larry, he was talking on the radio.

LS: Okay.

AR: I'm sorry, say again Larry. I'm sorry, Larry, could you say again and I could relay it to Peter. If you want to repeat it, that's fine too.

LS: Art, that second point you gave us is only 7 or 8 miles back to the southwest of the first point. So we're going to go back over it here in about another 2 min. We'll just go out a little bit to the southwest of it and reverse and come back over at 195. We went to go west of it because the wind doesn't blow us past in the turn.

AR: Larry, could you say again. We're just past the northeast point. Is that what you're saying? I missed some of that.

LS: That's right. We're past the first northeast point, but we're only going back to the southwest less than 10 miles before we reverse again.

AR: And that's the latest points given to us from the guys on the ground, I presume?

LS: Affirm.

AR: Larry, you know, they need to be up here and look at this sky, I think, because those crystals are probably falling on them probably fell out of that stuff out there about 10 o'clock-11 o'clock I'm guessing.

LS: Okay. I missed everything there, Peter, because we were talking up here.

8:50 PM

LS: Does anybody have any idea where we're going on the next northeast point?

PH: Yes Larry, I can give you that.

LS: Go.

PH: It will be  $43^{\circ}44.8'$ / $123^{\circ}21.2'$ .

LS: Okay. Give me the northern coordinates again.

PH:  $43^{\circ}44.8'$ .

LS: Okay.  $43^{\circ}44.8'$  and  $123^{\circ}21.2'$ .

PH: That's it. These are short legs, but that's what they want.

LS: Okay.

PH: On this leg that we're on now heading to the southwest again, we're going to be descending.

8:52 PM

AR: Look at the convection out there, Peter. It's got to be pretty chaotic on the ground.

TW: It looks like we're heading pretty south right now. Maybe we're turning.

PH: Yes. I'm referring to these as southwest and northeast, but they may not be exactly.

AR: The forward video in turn at 12:52 local, our 2052 shows nice cumulonimbus with an illuminated left side, which would be the south side. Dead ahead a streak of cirrus. That same band that on the south side is more like an altocumulus lenticularis and we're flying amid cumulonimbus-like turrets here, very soft, look weakly with weak updrafts.

PH: We're turning at our southerly point.

LS: Peter, we're 2 miles to the southwest of the point 2 you gave us.

PH: Okay. Aren't we at the lat/long of this new southwest point?

8:53 PM

PH: Yes. I see where we're at. So you're making your turn now to head back toward the northeast point.

LS: Affirmative.

PH: That will be at constant altitude.

LS: Affirm.

AR: Peter, would you like us to stretch these turns a little bit to get a nip of cloud top?

PH: Yes. We can do that.

AR: Okay. We're going to miss this one that you see going by the right wing here just barely. Missed that by just a couple hundred yards, less even.

PH: We don't want to do that. If it's just a minor shift, let's do it.

LS: Peter, the last point you gave me is southwest of the previous point.

PH: Okay. Did you get 43°44.8'/123°21.2'?

LS: That's affirm and that's back down to the southwest and we're about 15 miles from it. We're going back southwest to get there.

PH: Okay. Let me check with them again.

8:55 PM

PH: Larry?

LS: Go ahead.

PH: Let's make a turn here and then head to the following point to the northeast.

LS: Go ahead with the point.

PH: 44°3.7'/122°37.9'.

LS: Okay. Say those again.

PH: 44°3.7'/122°37.9'.

LS: Okay. I still didn't get that northern coordinate.

PH: 44°3.7'/122°37.9'.

LS: Okay. 44°03.7' and 122°37.9'.

PH: No. 44°3.7'.

LS: Okay. It's got to be a 03.7' because the minutes have to be two digits.

PH: That's what he gave me, 44°3.7'.

LS: Okay. I'm sure that's what he meant.

8:59 PM

AR: We're making our turn far short of the Oregon Coast this time. There was only one turret extending up to this level when we were making that turn and it would have been unlikely we would have gone through it actually. That's probably the reason why we are changing the point. The undercast below us is very ruffled. It looks like active stratocumulus I would call it. It's solid, no breaks. Then looking off the right wing toward the Cascades, there are lots of turrets and plus the tops of this lower deck rises up and then out of that upward sloping deck are turrets that extend maybe another thousand to several thousand feet above the main deck. That would be looking from 1 o'clock to 3 o'clock right now at 2100 Z, say 2101. Then back behind us and (also) over the Cascades or near the Cascades there are much higher glaciated tops. It looks like they extend to maybe 25,000 to 30,000 ft. In that range at least one particular top does. They are very clumpy looking. It doesn't look so much like a line, but rather a standing pattern. It's difficult to tell whether this has been a line. I think maybe that it was and that it has encroached on the Cascades as we finished our endpoint over the Oregon Coast.

—Talking about N & S views of Cascades while in turn.

LS: Peter, it looks like we've 28 miles to go to that point you gave me.

9:02 PM

PH: Larry?

LS: Go ahead, Peter.

PH: Our new southwest point.

LS: Okay. Shoot.

PH: 43°40.0'/123°33.9'.

LS: Okay. I got it.

AR: It looks like we're about 2 min to cloud.

PH: Larry, on that leg we'll be descending to 18,500 ft.

LS: Okay.

9:05 PM

PH: Art, what do you think about these cloud penetrations? We haven't had many.

AR: That's affirmative. We're about to come up on some clouds. These will last longer than the last one because we're a little lower. I see an aircraft dead ahead. It looks like it's about 25,000 ft. It wouldn't be the P-3, would it?

PH: The P-3 should be on station. Unless they're coming in very high they should be way down low.

AR: Larry, is that the P-3 up there dead ahead.

LS: No. I don't think so, Art.

PH: The P-3 should be on station now, so you might try giving them a call.

LS: Okay. We're talking to him, Peter.

AR: We may hit a few ice crystals here and then there will be a huge increase here in about say 15 to 20 s.

9:06 PM

AR: Unlike the last one, this one looks like an older turret that's come up here. It's very frayed looking. There doesn't appear to be any liquid water at least at this end of it, this side of it, and we have a couple flakes of altocumulus cloud up there just above the aircraft maybe within 1,000 ft to 2,000 ft. 5 s to main cloud. It will be quite a duration here. It may go over 30 s.

PH: You may want to check the CPI, Art, because I don't think the images are very good.

AR: Roger. Will do.

PH: I can see some of them, not many.

9:07 PM

LS: Peter, we're reversing and descending down to 18,500 ft.

9:08 PM

PH: We're not getting very good contrast on the CPI images, but we are recording images. We did get some liquid water on that last penetration. Pretty nice liquid water actually as well as crystals. The FSSP seems to be working well. In fact the FSSP is now reading higher values than the PVM, but I don't have any J-W. The J-W seems to have dropped out, which I had at the beginning of the flight.

AR: I'm not very sure there's any liquid water in that. Sometimes when the crystals are small you will see some counts in the FSSP, a few. It's raw for them to go over 5 unless the crystals are really small.

PH: No, I think there was. I think both the PVM and the FSSP tracked.

LS: We're southwest bound at 18,500 ft.

PH: Both the PVM and the FSSP showed liquid water there, but we lost our J-W.

AR: More ice crystals here falling out of cloud remnant. No base, nothing underneath us just mainly fall streak and a little tuft of liquid above us. I can see actually a bit of a cloud bow.

9:10 PM

PH: Did you hear that, Art? We've lost the J-W. We had it at the beginning of the flight.

AR: We didn't get anything now.

PH: No, not J-W.

AR: Larry, can you give us kind of the middle of this thing. I want just a couple of degrees to the left. Right there, that looks perfect. Thank you. Take a look at J-W on this one, Peter. This should have a little bit of water in it.

PH: Will do. The PVM and FSSP look good. A little bit on the FSSP, but the J-W has just dropped out. Getting any signals, Art?

TW: I'm not seeing any.

PH: We had it at the beginning.

9:11 PM

AR: This is a pretty big, not a complete cloud bow, but a cloud bow below and behind the right wing there from time to time. There are definitely some drops up here.

9:12 PM

AR: Larry, is that cloud something we can do without going too far there about 11:30? There doesn't seem to be much else around. It's just about at it's peak development. About 5 s to a fairly well shaped turret here. It looks pretty young. We're talking about glacial (slow) updrafts with a cloud bow off the right wing.

Did you see the liquid water in that one, Peter, on the instruments because there should have been a little bit.

TW: He's on the radio. I didn't see anything on the J-W.

AR: How about the PVM?

TW: I was not watching those.

AR: Okay. I'll look back here.

RR: The DMT had some, but I didn't see any on the J-W or PVM.

AR: Right. I do see a little bit there on the FSSP. Sometimes there are little tiny ice crystals in there and the FSSP, as you know, will indicate a little bit spuriously. Of course, there was enough to get a little icing signature, that is a little film on this rod back here.

TW: Are we in dry air right now, Art?

AR: That's negative.

9:14 PM

PH: Larry?

9:15 PM

PH: Larry?

LS: Go ahead Peter.

PH: I have a new northeast point for you.

LS: Go ahead.

PH: 44°15.5'/122°13.5'.

LS: 44°15.5'/122°13.5'.

PH: Right. We descended about 2,500 ft didn't we from the last point?

LS: No, Peter, only 1,000 ft.

PH: Oh, we're supposed to be descending by 2,500 ft.

LS: We've given the 18,500 ft so we'll go down to 17,000 ft.

PH: Right, 17,000 ft. Each leg to the southwest we'll descend by 2,500 ft.

LS: Right.

9:16 PM

PH: So Larry.

LS: Is that about it?

PH: What was the previous altitude before we started to descend?

LS: 18,500 ft.

PH: The previous altitude was 18,500 ft?

LS: On the northeast bound leg we were at 19,500 ft and we descended to 18,500 and now we're going down to 17,000 ft.

PH: Right, 19,500 down to 17,000 ft.

9:17 PM

AR: There is this sheet of cloud you see dead ahead and off the right wing has been expanding almost like time-lapse here in the last half hour to hour. At one time it was just a little sliver and, I don't know, I would guess there is some vort max well up stream that's triggering one of these. You've see these sliver clouds in the satellite imagery, which just kind of explode and expand downwind of the vort max. I'm guessing we're actually looking at that happening right in front of us.

It's amazing how much air that thing has covered and built up in the last half hour. It's actually getting close to the Cascades so there maybe some orographic lifting going on with this air mass too, so I'd better watch it (with my glib explanations).

9:19 PM

PH: At 2118 UTC I took my second photograph on my digital camera showing upper-level cloud and cloud below us and we're flying in clear air.

AR: Is our endpoint going to take us to this next cloud ahead?

LS: What did you say, Art?

AR: Is our endpoint beyond this cloud ahead?

LS: That's affirmative. There's still another 27 miles.

AR: 27 miles. Thank you. Can you go through the middle of that in case we're heading toward a saddle? It looks like we're heading toward a saddle from my viewpoint. Can you take the guy on the right there about 2° right?

LS: Affirm.

9:21 PM

AR: Yes. Right there in that shaft a nice little fallstreak coming out of this old turret that once stuck up it looks like probably 1 kilometer above flight level looking at the movement of the top there going above the bubble. But now all of that is kind of focused that precip is focused into this fallstreak which we're entering now. Thanks, Larry, that was great.

You know the (higher) cloud above us is an ice cloud at this juncture straight above the aircraft though it's so young there are no long fallstreaks coming from it, so it would be almost certain that there are no crystals coming from this higher layer.

9:22 PM

PH: Larry?

9:23 PM

LS: Go ahead Peter.

PH: You're keeping us at research speed, aren't you?

LS: That's affirmative.

PH: Okay. Are we nearly at our southwest point?

LS: No. We've got about another 8 min to go.

PH: Fine. I've given you the northeast point. I won't get ahead too far. We'll wait until we're heading northeast before I give you the new southwest point. Art?

AR: Roger Peter. I'm back in the bubble.

PH: We're coming down to 17,000 ft. We're nearly there, 17,000 ft. That's the altitude they have us heading back to the northeast, but that's going to take us just above cloud top, isn't it?

AR: Well, maybe right in this area. You'll definitely go into more clouds back behind the tail without doubt.

PH: Okay. We'll stick to this then.

AR: Yes. It will be a much more cloud "cloudful" full track on the way back at 17,000 ft.

PH: Good.

9:27 PM

PH: It's a pity about that J-W. It was working nicely for awhile. In fact on the last test flight it worked okay and now it's gone out again.

AR: Absolutely. It looked just beautiful on the last test flight and when the DMT came in they were right on a coincident.

PH: I'm not even displaying the DMT now because it's so noisy, but we do have good FSSP and PVM liquid water.

AR: I think the DMT is providing some information in some clouds. I think the liquid water content has to be over a threshold, but it does come back in and here and there it will provide something.

PH: It think there must be some loose wire on the J-W.

AR: Roger. That would fit.

9:28 PM

AR: I've got a nice irisation up there from this upstream end of this cloud I was referring to before, which is actually like one of these lenticulars that glaciates downstream, but the upwind part is all water.

LS: Peter?

PH: Go.

LS: What altitude do you want when we head back northeast bound?

PH: We're going to be at our 17,000 ft. Every leg to the northeast is at constant altitude.

LS: Okay. So we'll be at 17,000 on the north leg.

PH: 17,000 ft, yes.

AR: And we're indicating 17,200 ft on this leg.

PH: Yes. The legs to the southwest are all descending and the legs to the northeast all constant altitude.

AR: Roger. That's right.

9:30 PM

PH: How are the CCN measurements doing? I've got zero readout now.

VS: I think you're looking at the \_\_\_\_\_. The CN counter is reading 150 right now and the CCN at 0.3 is reading at 11.2.

PH: The CN has come up has it?

VS: Yes. It looks like it's working okay.

PH: Okay. On my text display, my CCN-rt is now zero. It just jumped up to 250 there.

VS: There might be something wrong with some constants or something. We'd better check that out.

PH: You said you were reading 150, didn't you?

VS: The CN particles. The CCN is around 23.

PH: I'm wondering is this is labeled correctly on my text data because the reading I'm getting looks more like it should be the CN.

LS: Peter, we're at the southwest point and we're going to start our reversal back to the northeast.

PH: Thank you Larry.

9:33 PM

PH: Tom, could you check that whether I've got the right things on here. It says CCN-rt, but it seems to be reading the CN. What it should be is it should be the CCN at 0.3 supersaturation.

TW: That is definitely CCN-rt your last one. There is also CCN-ss (supersaturation), which you can display also. Which has been matching, I think, what they've been saying like 0.29.

PH: What is CCN-rt, what is that?

TW: It's concentration.

PH: At what supersaturation?

TW: What was that?

PH: At what supersaturation?

TW: I'd have to check. I don't know exactly.

PH: It should be at 0.3 percent supersaturation.

VS: There might be some coding in the formula.

PH: Also every now and again it drops to zero as it is now.

VS: I'm reading from the instrument 21 at 0.3.

PH: I'm not too concerned about what I see on the CCN. I'm just concerned about what is being recorded on our computer and I assume what I see is what is being recorded.

VS: I think the voltages are being recorded so that's fine.

9:35 PM

AR: I think it's going to be a few minutes before we get back into that area. When you asked me about clouds at 17,000 ft, it's going to be a few minutes before we get back to that point where the cloud tops slope up and we get the longer cloud penetrations than the previous run.

PH: Larry?

9:36 PM

PH: Larry?

LS: Go ahead Peter.

PH: I have a new southwest point for you.

LS: Go ahead.

PH: 43°48.7'/123°11.5'.

LS: 43°48.7' and 123°11.5'.

PH: Correct and we'll be descending to 2,500 ft.

LS: Okay. That will be about 14,500 ft.

PH: That's correct.

9:37 PM

AR: Larry, what's the cabin pressure these days?

LS: About 9.2, Art, I'm going to turn it down a little bit more.

AR: Thanks.

PH: I'm coming off the headset for 5 min.

VS: I just rewetted the pads and restarting the CCN.

AR: A slight degree of turbulence there as we started to pass under this altocumulus lenticular-like cloud, that is the southwest end of it. I know no other apparent reason.

9:39 PM

AR: It looks a little more like a frontal convective line off the left wing and behind the left wing coming on shore. Pretty solid looking band and these cumulonimbuses that are connected to one another, probably topping out at 20,000 ft or so, not too high. Looking back behind the tail see a little fibrous fallstreaks amid the altocumulus clouds that are probably only about 50 meters thick. It kind of looks a little bit more like almost perlucidis now with undulatus little rolls and nice irisation now also present. At a higher level just ahead, it will be just ahead in the video and off to the right wing is a band of cirrus with fine fallstreaks, none of which appear to be reaching much below the cirrus at all.

9:41 PM

AR: Larry, how many more minutes in this heading?

LS: 6.

9:42 PM

PH: Still no cloud.

AR: Roger. We should be going into these upward sloping cloud tops within the next minute. I would guess, Peter, this time it will be pretty solid for the remainder of the leg.

PH: Yes. We've had quite a bit of flying time here without much cloud.

AR: You know this has got to be valuable for the MM5 because you know to fix clouds at these various levels, 3-10, 10-20, above 20 and all that kind of thing, and here we are providing that ground truth. I'm sure it just can't see what we've experienced on this flight, but we can make it better. It looks like about 10 s to cloud. Cloud tops look pretty darn liquid here. Big cloud bows down there. We'll be picking up some icing here. We'll want to keep track of that.

PH: We're picking up crystals now.

9:44 PM

AR: Cloud bow off the left wing and dead ahead.

PH: We've got about 0.3 grams per cubic meter of liquid water on the FSSP on that cloud penetration.

AR: Yes. I saw that.

PH: FSSP and PVM are in nice agreement. Have you looked at the FSSP spectra, Art?

AR: That's affirmative.

PH: Does it look okay?

AR: No.

PH: Really?

AR: I'm sorry. I'm talking about past flights. No, I have not looked at it today I still have to say. I'm looking at the liquid water in the FSSP compared to the other probes and that's usually a proxy for the spectrum being okay.

PH: Guess what? The J-W just switched in.

AR: Roger.

PH: Definitely some loose connection somewhere.

9:46 PM

AR: Looking up it looks like clouds are deepening upward above the aircraft looking at the disc of the sun there and watching it become increasingly dim.

9:47 PM

PH: Getting some decent liquid water here. The J-W is running below the FSSP and the PVM.

AR: Looking back it looks pretty convective actually a little less stratiformy that the stuff we started into. There are definitely turrets back there. It looks like a lot of them iced out, but very ragged weak looking turrets. No real good solid rounded mounds in the exact path that we took although there are some better shaped ones in the vicinity.

LS: Peter, we're starting a 180 back to the southwest there.

PH: Thank you.

LS: It looks like that point is about 50 miles behind us there.

9:48 PM

AR: As we go back, we'll be descending 2,500 ft, Peter, is that it? (But we didn't do that, descended into cloud and then flew level until 22:13.)

PH: That's correct.

AR: And here's where icing might be something to keep an eye on because instead of being in clouds a few minutes we'll probably be in clouds from maybe 5-10 min, you know, -15, -17, that kind of thing.

PH: We picked up some icing just on that little cloud penetration we just did.

AR: We sure did. I suspect the amount of ice crystals will probably be increasing on the way down at least the ones we're counting. But this storm is so powerful, I'm not sure there will be enough crystals to take out the liquid condensate.

PH: The J-W has dropped out again.

9:51 PM

PH: GPS is working. Art's playing with the CPI. I'm not getting any images at the moment. The 2-DC is showing plenty of images. Starting up the CPI again.

9:52 PM

VS: The CCN is off because we're in cloud.

9:53 PM

LS: We're at 14,500 ft, Peter.

PH: Larry?

LS: Go ahead.

PH: A new northeast point.

LS: Go ahead.

PH: 44°20.8'/121°58.3'.

LS: 44°20.8'/121°58.3'.

PH: That's correct and that should put us almost over Santium Pass at the crest of the Cascades.

LS: Okay and from that point, Peter, what do we do?

PH: Well I don't want to get too ahead on the lat/longs, but from that point we'll come back to the southwest again descending 2,500 ft.

LS: Okay.

PH: I think if we get too far ahead on the points we get confused.

AR: We're sort of getting some semi-freezing rain in here, drizzle.

9:55 PM

RR: I see some evidence for a "freezing drizzle" for the last minute or so.

AR: Absolutely. I just went up and checked it on the window. It's absolutely melting drizzle drops or they're certainly drizzle drops.

PH: Just see a beginning on the top of the wing.

AR: Right. It's something you have to keep a close eye on.

PH: Right. That's all we have to do is keep a close eye on it.

AR: Here comes the snow again. We need all the snow we can find.

RR: My guess is that the cloud top came down wherever we were and now it's getting deeper again.

AR: That's an excellent observation. I have to say I didn't see anything here. It wasn't like the disc of the sun popped out. It's been totally absent on this leg because I was looking out here at the wing and the icing situation. I would have noticed that.

PH: Art, I'm not seeing any images on the CPI.

AR: I know. We're having a problem.

PH: None at all now.

AR: Roger. I'll be right back up there.

PH: The other instruments seem to be working very well except for the 1-D cloud probe. Liquid water content here is about 0.1 grams per cubic meter.

9:57 PM

PH: Our liquid water has increased a bit here, about 0.15. Back there a bit it's now gone down again. Maybe crystals. Maybe cloud probe has got very good quality data on it. Large irregulars, some dendrites.

10:00 PM

RR: The 2-DC is showing spherical images and the liquid water is pretty high.

PH: The liquid water is 0.1, 0.2. I'm not seeing many spherical images. I'm seeing mainly crystals.

RR: I now see crystals as well. About a minute ago there were some spherical images as well.

PH: We'll be popping out of this cloud soon.

10:03 PM

PH: The CPI is working again, although not the way it should. We're at least getting some images.

10:04 PM

AR: Larry, what's your comfort level with the ice here?

LS: Well as long as we can keep this airspeed up around 170 I think we're probably all right.

AR: What's our MVA in this area?

LS: Hang on. We can go down over the valley now, so it's down around 6,000 ft.

AR: Roger. That's good because I'm getting a little concerned about this freezing drizzle that seems to be intermittent and continuous with the snow out there. Here we go. Maybe we're going to pop out of these tops here pretty quick as we get out over some dry air.

10:05 PM

PH: Just clipping the tops of these clouds here. Liquid water going up to about 0.3 in them.

RR: I see drizzle drops too, Peter.

AR: It looks like cloud tops are running about 1,000 maybe 1,500 ft above the aircraft at that moment back there. At some point here we should pop out. I don't believe they're sloping cloud tops. We should just pop out in the clear here virtually (any minute).

PH: We've got many 10s of ice crystals per liter here.

AR: The clouds look very ragged by the way. They do seem to have fallstreaks. These are comprised of drizzle drops and some are ice crystals.

PH: Some freezing drops. Some supercooled drops here, drizzle drops.

10:07 PM

AR: We've got almost half a gram there of liquid water content in the FSSP. At, it says,  $-14^{\circ}\text{C}$ .

10:08 PM

PH: I'm wondering if we're maybe seeing the front edge of the cold front.

AR: I didn't see anything out there that was that close, but then again it's not too far off (now) from the time that they were expecting it.

PH: Well the convection here, you know, over the plains.

AR: I see now the liquid water is going up to at least half a gram. It's certainly an enthusiastic stratocumulus anyway.

10:09 PM

AR: I guess I'm surprised by how long it's taken us to break out. It's though we've been profiling these mainly, at least often completely, liquid tops as they slope up toward the Cascades and back down toward the valley.

PH: Did you hear that bang? I think that was icing coming off.

AR: I'm not surprised. It's picked up quite a bit here in the last 3 or 4 min even.

PH: I think we maybe getting into some cumulus tops here from the cold front.

10:10 PM

PH: Larry, how much further to our southwest point, how much longer?

LS: About 5 miles, Peter.

PH: Okay.

LS: Peter, you ought to be advised that carrying all this weight we're burning a lot of fuel down here. So I don't think we have an awful lot longer on station out here, probably less than an hour.

PH: Keep me updated on that.

LS: Right.

AR: Peter, another thing that has concerned me is the amazing amount of drizzle we've found amidst the ice. When we first started into this stuff back there, it looked like it was going to convert to snow underneath the liquid top, but that didn't happen. What I'd be concerned about now is that we try to take this road back in there. At a lower level those drizzle drops would get that much bigger because there's going to be water all up the column to the top of these clouds with the synoptic system of this strength. So we're likely to see something a little more than freezing drizzle in these upslope areas. It might turn to freezing light rain intermittent with the ice.

PH: We're due to go back at this same altitude, 14.

AR: Right, which will be lower than what we started at.

PH: That's right.

AR: That's why I'm concerned because whatever drizzle is probably going to continue to grow in the column it's falling to because I'm almost positive there would be liquid water of an accretable size.

PH: That's icing.

AR: Above that level so it's not just the liquid drops that would be icing on the plane, but it would be the liquid precipitation-sized drops.

PH: How do the top of the wings look, Art?

LS: Peter?

PH: Yes Larry.

LS: We're going to climb about 500 ft and try to get on top of this stuff and shed some of this ice.

PH: Right. Okay. Although temperatures are going to be lower up there.

LS: Yes, but we'll get in the clear air and some of it will disappear.

PH: Let's do that. We're getting concerned about the amount of ice we were hearing shedding.

LS: Did you hear it back there?

PH: Yes. We've been hearing ice shedding.

LS: Okay.

AR: We've got about a half an inch to an inch built up on the Pilewskie radiometer probe.

PH: Larry, let's just circle here for a while and see if we can get rid of most of this ice.

LS: Okay.

AR: Another alternative would be to spiral descent and spiral back up, but I don't know if that's plausible or viable.

PH: From the fuel point of view I don't think it is.

AR: We'd have to go down to probably about 6,000 to 7,000 ft to reach the freezing level at this point. It was 9,000 ft earlier this morning in this area. I'm sure it's dropped a bit now.

RR: Cloud tops look like -11, -12, which is ideal for this freezing drizzle that we're seeing.

10:13 PM

VS: CCN is back on at 0.3 supersaturation.

10:15 PM

AR: Check on 1.

10:16 PM

VS: CN is showing some 1,700 counts at this altitude and CCN at 0.3 supersaturation is showing 58.

PH: Roy can you hear me?

RR: Yes.

PH: I don't want to go back at that level and pick up more ice than we did that time. We've got about another hour on station. What do you think would be a good altitude to go back that would minimize the icing but above freezing?

RR: You mean below freezing.

PH: Below the freezing point yes. Above the freezing altitude.

RR: I'd go just maybe 500 ft or so higher than we did. If you go down any lower, you're going to get more drizzle.

PH: That doesn't add much to the data set, does it?

RR: No.

PH: You think everywhere below where we were is going to be worse icing?

RR: Correct. If the cloud tops are -11, it's just going to get worse as you go down. It will accrete and grow and have higher liquid water contents. The other option is if you want to try to get a vertical profile is to do a missed approach to an airport. I'm not sure if you're set up for that or not.

PH: That's not going to give it to us over the mountains so that's what we're interested in.

RR: Right. I would say this maybe what you get.

10:19 PM

AR: The only chance I think, Peter, is if they lost all the ice. It's going to take, even though it's very dry here, dewpoint depression is 20°C.

TW: He's on the radio.

AR: You have to do a descent, lose all ice and go back. We might make a pass out the other side into the dry air in the eastern side of the Cascades.

TW: Peter is on the radio.

10:20 PM

AR: I'm going to miss not going back, but I think it's prudent not to go back at a lower level, you know at our lowest MVA, because of the possibility of freezing rain instead of freezing little drizzle drops only because you just don't see this situation. So it would be great to plow through and get a data point and see what

happens to those guys on the way down. Do they really stay liquid beginning at -14 or so and at -8 they're still liquid?

RR: Another thing you could do is sawtooth near cloud top go in and out.

TW: The recording has stopped right now so hold on.

TAPE 2, SIDE 1

TW: We're recording again.

RR: What I was suggesting is you could do a sawtooth near the cloud top if you want to try to just go in and out of it. That way you could go into the cloud and then come back out and shed any ice and then go back in again.

AR: Roger. That's true. I think in a way we're kind of following the sloping cloud top down at least from the bubble here. Although we weren't terribly close to cloud top, we're within a few hundred feet at the beginning of this leg, but certainly toward the middle (of the cloud) and at end.

LS: Peter.

AR: I thought that wouldn't provide too much different measurements than we have now.

LS: Peter.

TW: He's on the radio right now.

LS: Okay.

PH: I'm back here.

RR: I was suggesting, Peter, that you might do a sawtooth near cloud top if you want to go and just continue to document the evolution of the system.

PH: Well we've done 17,000 ft and we've done down to 4,500 ft. We could go back at 15,000 ft.

TW: Larry was trying to get a hold of you.

PH: Or 16,000 ft. I think we'd pick up less ice there, wouldn't we?

RR: Yes. I think that would be good.

PH: Hi Larry.

LS: Peter, we're down to about 2 h of fuel and it's all depending on if we go up that northeast bound leg past Corvallis very far we're going to be carrying a hell of a lot of ice. We're carrying out 500 more horsepower just to maintain our airspeed. So we're thinking it might be a good idea to drop into Eugene and fuel up now.

PH: Larry, I've just been discussing this with various people back here and the radar people. If we went back to the northeast point I gave you last time, but a higher altitude, let's say 16,000 ft, we will pick up less ice there. That's really about our only option. We don't want to go down lower because we'll pick up more ice, but higher I think we should be okay.

LS: Okay. We can give that a try and see how it works.

PH: So we'll return to the northeast point I gave you last time, the 44°20.8' etc. at 16,000 ft.

AR: That's 700 ft higher than the current altitude.

PH: We came out at 14,500 ft and we went in at 17,000 ft, didn't we? Let's go back at 17,000 ft, Larry.

LS: Okay, 17,000 ft.

AR: That was my recollection we started down at 17,000 ft and ended up here at 14,500 ft or something.

10:24 PM

PH: The P-3 had to climb to shed its icing and it was down lower than we were.

RR: That confirms that there is definitely a lot of accretional growth here.

10:25 PM

AR: Peter, have they said anything about where the cold front is? It looks like that band is just about on the coast now.

PH: Let me check on that.

10:25 PM

AR: It looks like we'll be reentering the cloud top in about 1 min or so.

10:26 PM

AR: Just a few more seconds and not really any strong convective protuberances here. Pretty much uniform cloud top at least as far as most of the bulges go. Then they slope upward toward the northeast. So we'd be going deeper under cloud top as head off in this direction.

10:28 PM

LS: Peter, we're back northeast bound again.

AR: In and out of cloud tops now. Higher broken cirriform cloud. No ice trails down to these clouds however.

10:29 PM

VS: The CN is off.

PH: For the tape, we did complete our northeast to southwest leg descending from 17,000 to 14,500 ft. Picked up a lot of icing and had to come out over the southwest point to shed the ice in the clear air. Decided not to go back at lower altitudes because of the potential for heavy icing and the fact that the P-3 was picking up quite a bit of ice down there. So we're now going back to the northeast point at 17,000 ft.

10:30 PM

LS: Peter, we're about 4 min from our northeast point.

10:31 PM

PH: Larry?

LS: Go ahead.

PH: So we're heading back to the northeast now at 17,000 ft. Where did you want to land?

LS: We want to land at Eugene.

PH: Eugene, okay. Let's wait until we get to our northeast point to make a final decision on that.

LS: So you want to go back southwest bound on track before we make our decision?

PH: No. Let's get to our northeast point first. How far are we from that point? Pretty close aren't we?

LS: 15 miles.

PH: Let's then head back. We're going down to 16,000 ft on the way back to Eugene.

LS: Okay. So we'll go back to the previous point, which will take us right south of Eugene, if that's what you want?

PH: That will be fine.

LS: Okay.

10:33 PM

AR: We should be reentering cloud top here in a few seconds.

PH: We're not getting anything on this leg. I was hoping we'd get a bit more.

AR: Down at this end we will get more. There was a saddle region back there. It's kind of interesting. I don't think we had that before, but then I guess we were a little bit lower or maybe it just got missed around the clouds.

PH: Nearly at our northeast point though. Larry?

LS: Go ahead, Peter.

PH: Let's proceed a bit beyond our northeast point to get into this cloud ahead.

LS: You want to go back up? How much further do you want to go, Peter?

PH: We'll let you know when you can turn around.

LS: Okay.

10:34 PM

AR: It looks like tops are a couple hundred feet above aircraft.

LS: Peter, could you tell us how much further you want to go northeast?

PH: Let's say about another 10 miles.

AR: That was at 2234 Z.

10:35 PM

AR: Cloud tops continuing to run just a couple hundred feet to maybe a peak of 500 ft above aircraft. We have above that an overcast layer of it looks like cirrus and combined with some embedded altocumulus. That's going to prevent any cloud top recovery from satellite imagery I'm quite sure. No fallstreaks of any appreciable length from that higher layer at this point.

10:37 PM

LS: Peter, we're reversing back now toward the southwest. When do you want to let down to 16,000 ft.

TW: He's on the radio right now, but I'll tell him you were talking to him.

10:38 PM

TW: Peter, Larry wanted to talk to you.

PH: Yes Larry.

LS: We're southwest bound now, Peter.

PH: Okay. So we're heading back to Eugene now and it would be nice if we could just descend steadily through the cloud as we head back to Eugene. If we get into any icing that's too much, you can just climb back out of it.

LS: Okay. We're southwest bound and we'll start on down to 16,000 ft.

PH: I'm waiting to hear from the radar what they want us to do after we land. We are actually in the cold front here. The cold front has moved on shore fairly fast and that's where we were picking up that icing in those convective turrets, as I thought.

LS: Okay.

AR: Peter, from this vantage point, there really aren't turrets up here. They don't really protrude anyway. It looks like they're kind of an ideal orographic situation. There were turrets, however, in a line of cumulonimbus clouds connected together off to the west of us. No that should be pretty darn close to our west endpoint by now I would think.

PH: But you remember when we were at our last leg from the northeast back to the southwest when we were descending and picking up the icing. I said that I thought we were in the cold front and in fact we were.

AR: I was just saying that from top side here there weren't any cumulonimbus-type clouds around. It was pretty flat.

PH: Well the radar shows it over this location now.

AR: Roger. I'm looking.

10:40 PM

RR: We often see icing, Peter, in the air overriding the cold front. So I think you maybe right.

PH: So the plan is we're descending now as we approach back to Eugene, land at Eugene, and then we'll see if we're going to have another flight or not.

10:41 PM

TO SUMMARY

10:50 PM

PH: In clear air here we're getting particles from this thin layer above us on the 2-DC and on the HVPS and on the CPI.

AR: Well we're sort of nipping these tops a little bit, Peter. It's not coming from that layer up there. That's kind of obscuring though it's up there, but it's obscuring the satellite view of this stuff.

PH: The 2-DC was really clipping over when we were in clear air just a few minutes back there.

AR: From back here I see little bits of cloud going by and I'm guessing that's what it was, but certainly not from that higher layer. I can guarantee you that, not yet anyway. It started out as a sliver when we started this flight off the offshore there and it has just been expanding. I went on some kind of soliloquy there about how big it was getting. I'm sure on the satellite imagery this is going to be a spectacular looking growth of cloud.

PH: I was surprised it wasn't a much deeper system.

AR: I am too.

10:52 PM

PH: This is where we pick up the liquid water in this stuff.

AR: Larry, is your radar working up there?

LS: Art, it has been smoking the whole trip here. I don't know whether it's just the ice on the ray dome or what it is.

PH: It think this is the cold front.

10:54 PM

PH: Taking in lots of liquid water here and ice crystals. A little bit bumpy.

RR: Starting to get a little ice on the wing.

10:55 PM

PH: This will probably be our best profile as we come into land except it's not over the mountains.

AR: We're flying level right now though. Is he gradually descending do you think?

PH: Hardly at all. We're in these cloud tops at about -15 again.

LS: Peter, this is Larry. We need to climb and get out of this stuff. So we're going back up to 17,000 ft.

PH: Okay. We're getting shedding ice again so they're going to climb back to 17,000 ft.

10:56 PM

PH: Larry, this is the cold front I think and you're getting into convective clouds. We're getting some shedding ice back here again.

LS: Yes. It was building on the wings again. The heater can't keep up with it.

10:57 PM

AR: The cloud tops have settled back here just above aircraft at 200 back there. Our flight level here maybe 100 ft above aircraft.

10:58 PM

AR: The time 2257. We just exited most of the stratiform tops. Looking back I don't see any bulges. There are mounding portions though, but nothing you would call cumulonimbus. Some day when I (can) look ahead, I'll see if there's a front out there. Nearly popped out on top of these sloping clouds and looking back there is a congestus-type cloud top. Probably we didn't actually go through it, unfortunately, but it's probably a good kilometer above the general level back

there. So there's definitely embedded convection, significant convection. I did not see that last time.

11:00 PM

PH: The cold front is now actually over Santium Pass, so over the Cascade crest and these convective clouds we've been flying in will be our post frontal.

11:01 PM

PH: Larry?

LS: Go ahead Peter.

PH: The cold front is through us now. It's over the Cascade crest, and we're looking here at post frontal situation. That's why you're picking up the icing in these cumulus. What's your plan now?

LS: We're about 22 miles from the southwest point. From there we'd like to go on in and land at Eugene.

PH: Right. Let's do that.

LS: Okay.

PH: Do we have enough fuel to get back to Paine Field?

LS: Negative.

PH: Okay. They're trying to decide whether they want to get us up for another flight today or not.

LS: I think we're starting to think this is a bit too much ice for this airplane.

PH: Yes. I've told them that we won't want to fly in this icing again here. There's no reason to. But this was I think a rather unusual situation with this system that came in today. I don't think this is going to be the usual.

AR: I agree, Peter. Peter, off the right wing was what I was wondering if that was not the cold front, that line of convection out there, but I guess it wasn't.

PH: No, it's through the Cascade crest now.

AR: Thanks. It must just be piled up on the coast range.

PH: I think the problem was here, Larry, we were combining a frontal situation with an orographic upflow. Normally what we're going to be looking for is just the orographic and not the frontal.

LS: Okay. That stuff we went through just out there to the east of Eugene anywhere from 14,500 to 16,000 ft was really accumulating. As a matter of fact, we're carrying a lot of extra horsepower here just to maintain altitude. So we suspect we're dragging some ice out there somewhere.

PH: There's not much ice on the top of the wings. There maybe a little bit, but not much. I've got a lot of ice on my forward windscreen as probably you have.

AR: It's about 1.5 inches out at the top of the Pilewskie probe.

PH: Do you see much on the wings though?

AR: Negative.

11:05 PM

PH: Art?

AR: Roger Peter.

PH: I'm really pleased with the FSSP and the PVM showing very good agreement.

AR: Exactly right and you have to give credit to Don on that for doing a good job of the alignment of the FSSP. He nailed it and I think it's going to be one of the best flights in the whole thing.

AR: We've had a good PVM measurements if we hadn't had those two consecutive human errors. I was pretty sure that was going to work.

PH: Are you sure it was human errors?

AR: Whether we're human or not could be questioned.

11:08 PM

PH: Tom, another couple of things you could add to the map the next flight is Eugene and Corvallis.

11:09 PM

TW: Are those lat/longs in that book?

PH: I'm not sure. Take a look.

11:10 PM

PH: Well this is looking pretty post frontal here now.

AR: Yes.

AR: Peter, as we come around back there about 4 o'clock now, do you see where the sun is illuminating those clouds, those lower clouds? That's about where we came from so it's a nice picture of the way those clouds are stacked up there. Sort of flat top. Actually the tops are a little bumpier like they were off to the right a little bit in the absolutely flat top in the sun. Anyway, you get the feel for this orographic situation really nicely over there.

11:12 PM

PH: At 2312 UTC I took a picture of that cloud stacking up there that Art just mentioned.

AR: It really hasn't changed over that whole. That's what's great about this flight I think, Peter, is we really had several hours of pretty steady state.

PH: We'll have to get a different aircraft though if we're going to get down into that sort of icing condition.

AR: I was really starting to think about DRI when we were doing that slant down the upslope side. Because as you know when they went over the Sierras that fateful day, they were going paralleling the slope downward and the icing increased and down it went killing all on board.

RR: Well I think we've learned something since then.

AR: That's right.

RR: Good thing you had me on board.

Egad! We were on top of this situation; see p. 51-52.

PH: That's what I was thinking.

AR: Seeing that much drizzle, I knew from our conversations and so forth and plus I know what drizzle does it gets bigger on the way down especially on a day like this where the column of water is going to go right down the mountain top. You're probably looking, if in fact it doesn't convert to ice, rain all the way down and then, of course, you're talking about supercooled rain and then you're really in trouble.

RR: It will be really interesting to see the obs at the surface to see if anything had reached the ground.

AR: Absolutely, this is going to be so fascinating.

PH: Watch out with your head in the dome, Art. There's a lot of ice being shed at the moment.

AR: Right. I'm not in the dome right now, but thanks for mentioning it. We may fog up some instruments on the way down. So if they start acting crazy, that's probably the reason why.

11:14 PM

AR: Ice is melting off the 2-D. You can see the streakers now coming as that ice becomes to melt and streak across the lenses.

11:17 PM

TW: Peter, I'm going to have to shut down early because we've got to sit in back for our approach.

11:18 PM

PH: Larry.

LS: Go ahead Peter.

PH: How long do you think it will be before we land?

LS: Probably 7 min.

PH: Thank you.

TW: I've got to shut stuff down now because we have to sit in back for landing.

PH: Hold on a moment.

TW: Calvin just told me to go back.

11:19 PM

PH: Okay. We're finished here.

## Summary of UW Flight 1891

10:41 PM

PH: I'm going to do a quick summary of this flight. We got off about 2 hr late because of unexpected, unforecast snowfall at Paine Field. We then headed to a point that was on the coast southwest of Santiam Pass in Oregon. We started our planned profile near 21,000 ft heading to the northeast. Then we dropped down and worked our way backward and forward, southwest to northeast, using lat/longs given to us from the S-Pol radar. On the descent from 17,000 to 14,500 ft on our northeast to southwest leg, we picked up more icing than we were happy with, and we knew that if we continued to descend the icing would get even worse. So we decided not to go lower. Instead we did another track back at 17,000 ft from southwest to the northeast. We just finished that leg, and we are now heading back to the southwest descending from 17,000 ft as we head toward Eugene.

The instruments worked pretty well. Good liquid water measurements on the PVM and the FSSP-100. The J-W, however, is very intermittent; it was out most of the time just occasionally coming into play, so there is some loose connection there. Good 2-DC data. Good HVPS data. Some CPI data, but the images are not very distinct. The P-3 was up; I think it did most of its prescribed pattern beneath us. It also got into icing problems and had to break away at one point. They've also lost their deicing equipment on one engine. So it remains to be seen what effect that has on their future flying.

Not a bad flight, a little tough one with which to start the project, because we couldn't complete the full vertical profile, which would have been nice, but safety comes first. So I think we've got some reasonable data, and we may do better next time.

PH: Art, would you like to give a summary?

AR: Roger. I thought this was a fantastic flight. Certainly nothing like we've seen before. We had the 850-mb wind at 50 knots or so. This was, of course, predicted by the model, we didn't actually measure that, and 10,000-ft winds of about 70 knots, again predicted by the model, and of course, our 500-mb winds approaching 90 knots. So it was an exceptional situation mainly warm-sector flying. I think, as we traversed out from Paine Field, there was a temperature gradient that we went through about 15 min to 30 min we may have hit some higher-level representation of the warm front or something going on there. I have to correct that. Actually the temperature was falling, which would go with the vort advection/invection at that level, which is accompanied by temperature falls. The cloud development here was one where we generally had moderate convection I would say inside this stuff with protruding tops up to about 20,000-25,000 ft when we first arrived. Then, as the day wore on, the tops seemed to become more stratified, although there was embedded convection within it that

produced liquid water contents up to about half a gram I think was the maximum that I saw. On top the tops sloping upward from the valley to the Cascades keeping in mind that strong flow toward the Cascades, not of course perpendicular to it, but having a component toward the Cascades. So I thought it was one of our better quasi-steady state situations. I think for me, one of the big surprises, microstructurally, was to find bursts of drizzle inside the snowstorm that was occurring over the Cascades. That remains a bit of a mystery right now, but our guest here, Roy Rasmussen, told me this is fairly common and I'll certainly join the club on that in this situation. I'll have to look at the data and see what exactly was going on here. I only wish we could have pounded out that lowest level, although it would have been hazardous and possibly causing our death, but to see what happened to that drizzle on the way down and especially whether the boys at the ground were seeing drizzle on the ground. That would have been incredible. Droplet concentrations very maritime, very low, and indicating little modification and hence the ability of collision coalescence to be rampant today.

PH: Roy, would you have to give a summary?

RR: I also thought this was a very nice flight for us. The CCN instrument worked well. We got very low CCN measurements, 20-30/cc. The presence of some freezing drizzle was exciting for me and confirmed what we've seen in the mid-west and the east that when we get the cloud tops near  $-12^{\circ}\text{C}$  or slightly warmer that we do get freezing drizzle. What I was seeing is that as soon as we got significant amounts of dendritic or otherwise crystals the drizzle went away. As the crystal concentration went down, which was likely due to the warmer cloud tops, we got more drizzle forming. So these pockets I suspect are due to warmer cloud tops and so I'm excited to go back and look at the higher cloud top temperatures if we can see the cloud tops with satellite and see what's going on and also go back and look at the data. So all in all it was a good flight.

PH: Good. This descent we're doing now should be good as well. We're getting good profile here as we descend through 16,000 ft as we head toward Eugene. Does Vidal want to say anything?

VS: Roy already said pretty much everything about the CCN, good data from the CCN. At the beginning of the flight, we had some problems with the CN counter, so some of the recommendations that I have is that we'll probably have to check the formulative rules. We'll look at the data from the CCN that has been recorded and I guess we need to check the connections on the CN for future flights.

PH: The CN may have needed a long warm-up time, because it started off very cold. It got cold soaked overnight and that instrument does take a while to come up. We do need to check the methanol level, maybe that's something you can check every time, Vidal. Don can show you how we to do it. You have to be careful with that methanol though because it's a nasty liquid to work with. You don't

want to be spilling it anywhere.

VS: Yes. I'm familiar with the CN counter. I actually had to plug one of the power strips into a power supply because it was off the instrument. That's what I meant.

PH: Tom, anything?

TW: I don't think so. I've written down everything I need to do or kind of look over.

PH: But do you want to make a note on what instruments from your point of view were not working?

TW: The J-W, but you've already mentioned that, and the CPI. Those were the two biggies I think.

PH: Also the PMS 1-DC is not working at all.

TW: I'm pretty sure Don was aware of that and he just didn't have time to look at it.

AR: Exactly.