CASE STUDY: SNOWFALL EVENT OF JANUARY 23/24, 1999 IN SOUTHEAST ALASKA

Michael Richmond, WFO Juneau, AK
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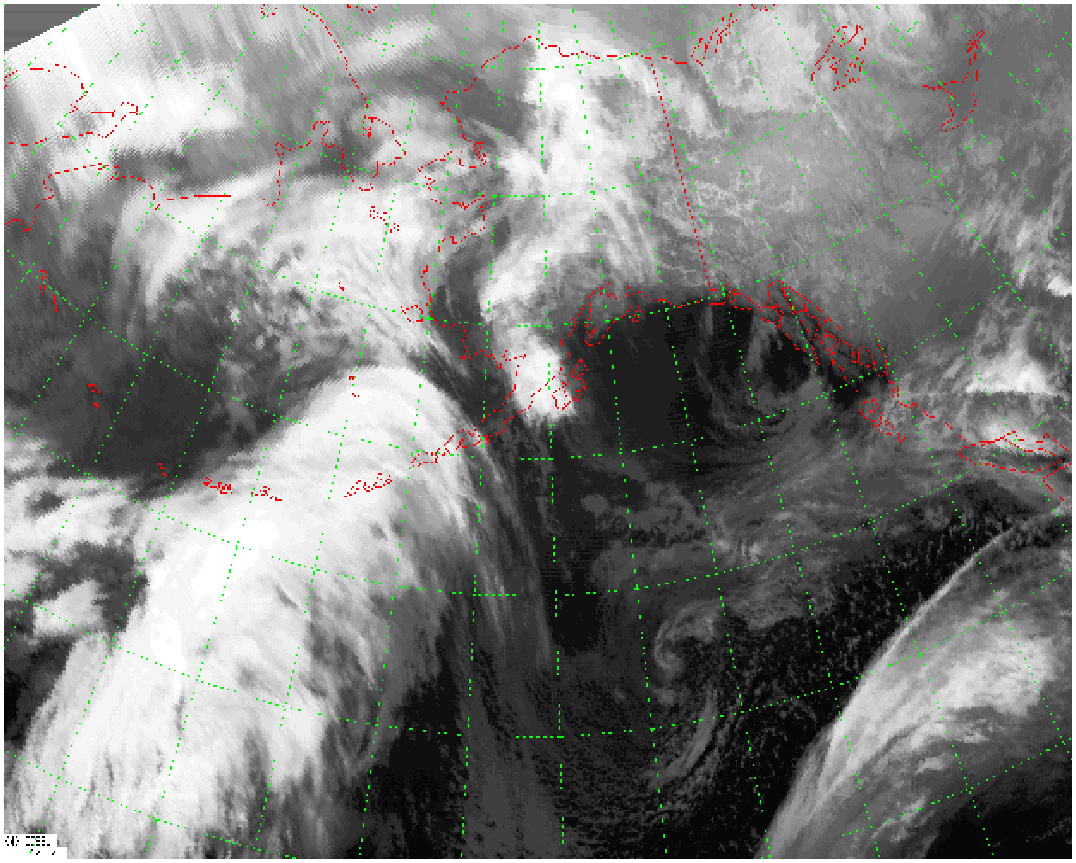
Overview:

The winter storm of January 23/24, 1999 in Southeast Alaska was an event that was well covered by the National Weather Service, Weather Forecast Office (WFO), Juneau, Alaska. Parts of the northern and central panhandle of Southeast Alaska received ten to fifteen inches of snow in less than 24 hours. Most notable of this event was the long lead time provided to the public by WFO Juneau. A winter storm watch for heavy snow was issued Thursday afternoon, January 21, for the following Saturday, January 23. The watch was issued to cover the northeast Gulf Coast, and northern and central Southeast Alaska, which is most of WFO Juneau's forecast area of responsibility. The purpose of this paper is to document the event, and discuss what model data gave the duty forecaster(s) the confidence to issue the winter storm watch 48 hours in advance of the event.

Prelude:

Synoptic Discussion:
On Thursday January 21, a split flow existed at the mid and upper levels of the atmosphere over the Northern Pacific and Gulf of Alaska, from 700 millibars (mb) (roughly 10,000 ft) up through 300 mb (roughly 30,000 ft). This is illustrated in figures 1a - b - c, showing the 12Z (3am Alaska Standard Time) 1/21/99 300, 500 (about 18,000 ft), and 700 mb analyses. A mean ridge had existed for several days previously over northwest Alaska in the weaker northern flow branch of the jet stream. The stronger southern branch contained systems that were forming in the North Pacific off the coast of Siberia and moving east in the 45-53 degrees north latitude band. GOES IR imagery at 2330Z (230pm AST) on Thursday Jan. 21, 1999 (Photo at left) showed a large moisture band/occluded front associated with a still-deepening low just off the Siberian coast near the Kamchatka peninsula. The appearance of this frontal band, with its long moisture fetch, extending back to the subtropics, combined with the MRF/AVN model forecasts for the next three days, gave the duty forecaster sufficient confidence to issue the winter storm watch at 400 pm Thursday, January 21 for the following Saturday, January 23. The decision was based on the fact that some heavy snowfall events in Southeast Alaska are generated when moisture ahead of Pacific occluded fronts (the warm conveyor belt) "over-runs" an established low-level arctic air-mass over the inner channels and immediate coastline. This arctic air-mass is maintained by the outflow of cold arctic air from the interior of Alaska and the Yukon territory. Lifting of the maritime air-mass combined with the sub-freezing lower- layer temperatures combine to produce the event. A sub-freezing low-level layer or arctic air-mass, had evolved over Southeast Alaska for several days previous to January 21. Weak systems with ample clearing behind each one, moved over Northwest Alaska and into the Yukon. Dynamically-forced subsidence (sinking air) combined with strong radiational



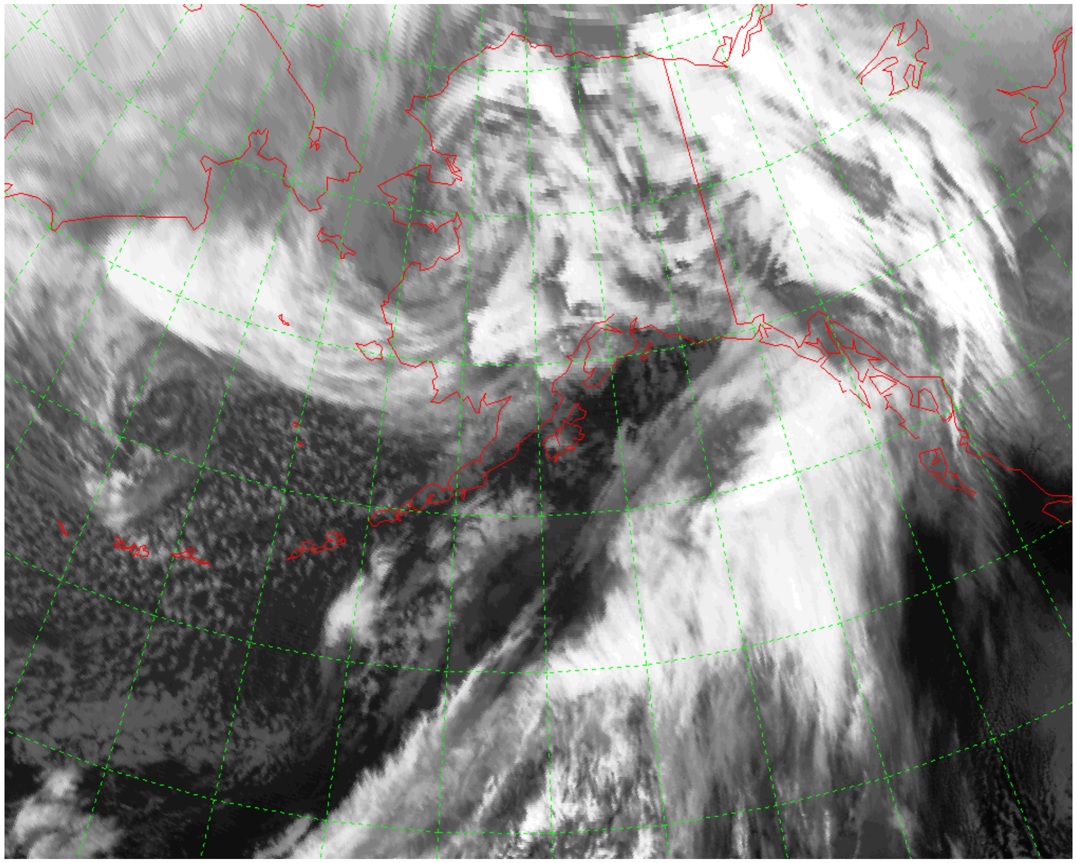
cooling caused a 1040+ mb "arctic high" to form in the Alaska interior by Thursday, January 21. The cold air was deep enough to flow through the coastal mountain gaps and over the passes into Southeast Alaska. The 18Z (9am AST) Jan. 21 Alaska surface analysis shows this (figure 3), the 1041 mb high in the Alaska/Yukon interior with an arctic frontal boundary in the Gulf of Alaska and North Pacific. The deepening 975 mb parent low of the system of concern is shown at 53 degrees north, 175 degrees east, as well.

The Main Event:

By 12Z (3am AST) Saturday, January 23, the frontal zone had moved east, as the parent upper-level low moved northeast into the Bering Sea near St. Paul Island. The upper-level ridge which had been in place over Western Alaska and the Bering Sea had crossed the Gulf of Alaska and was now aligned southwest to northeast over the Southeast Alaska panhandle. The surface arctic boundary was still in place just offshore of the panhandle as cold arctic air continued to flow out of the interior from the arctic high. The arctic high, in turn, began sliding southeast in response to the upper-level changes. Figure 4 shows the Alaska surface analysis at this time. Note the cold air in place at the surface, temperatures of -19F at Whitehorse, YT, and Dease Lake, BC, and 17F at Juneau. Significant snowfall began in Yakutat after 13Z, as seen in table 1, surface observations. Significant snowfall did not begin in Juneau until 22Z (1pm AST) however (table 2).

The upper-level and surface analyses for 00Z Sunday January 24, or 3pm AST, show the event at its peak. The surface analysis (figure 5a) shows the main surface low with two centers in Western Alaska with the arctic boundary just near Yakutat but still south of Juneau, while the occluded front stretched back into the central Gulf of Alaska and North Pacific. A strong, saturated southwest flow existed at 500 mb through 850 mb (roughly 6,000 ft) (figs. 5b - c) with warming temperatures, a typical over-running scenario, while surface temperatures at Juneau were still in the 20's (table 2). Yakutat, because of its open exposure to the southwest and the Pacific Ocean, warmed to 34 degrees at 00Z, and the snowfall changed to rain. Low-elevation sites in the central and northern panhandle of Southeast Alaska at this time, from Petersburg and Wrangell north to Skagway and Haines, were all reporting snow, and continued to do so for many more hours as the event progressed. One other feature worthy of mention at this time is the 300mb analysis, figure 5d. A strong southwest jet with a maximum wind speed core in excess of 130 knots is in the North Pacific, aimed at the panhandle. The northern panhandle and eastern gulf coast are on the left-

front quadrant of this feature, and remained so through 12Z (3am AST) Sunday, as can be seen in figure 5e. This is a location of favorable dynamics for large-scale lifting and so was certainly a factor in the duration and amount of snowfall received in the northern panhandle.



A GOES IR image from 21Z (Noon AST) Saturday, January 23 (Photo at right) shows the main frontal band moving into the panhandle, at which time the snow in Juneau was just about to begin (see table 2).

Wind profiler time-series data from Lemon Creek, about three miles east of the Juneau airport, proved to be very informative for the duration of this event. The profiler data clearly showed the southeast winds associated with the colder low-level arctic air-mass, up to three to four thousand feet above mean sea level (m.s.l). Winds veer to the southwest between four and seven thousand feet m.s.l., the lower-levels of the over-running associated with the frontal band.

Snowfall amounts for this event (noon Sat. 1/23 to noon Sun. 1/24) were as follows.

In the Juneau vicinity:

Airport: 10"
WFO Juneau (Mendenhall Valley): 15.5"
Mendenhall Valley Observer: 14.4"
Mendenhall Boulevard)
Tee Harbor: 11"
Downtown Juneau: 10"
North Douglas Observer: 12.2"

Other reports from sites in Southeast Alaska include:

Haines: 12"
Skagway: 11"
Yakutat: 8.8"
Petersburg: 7"

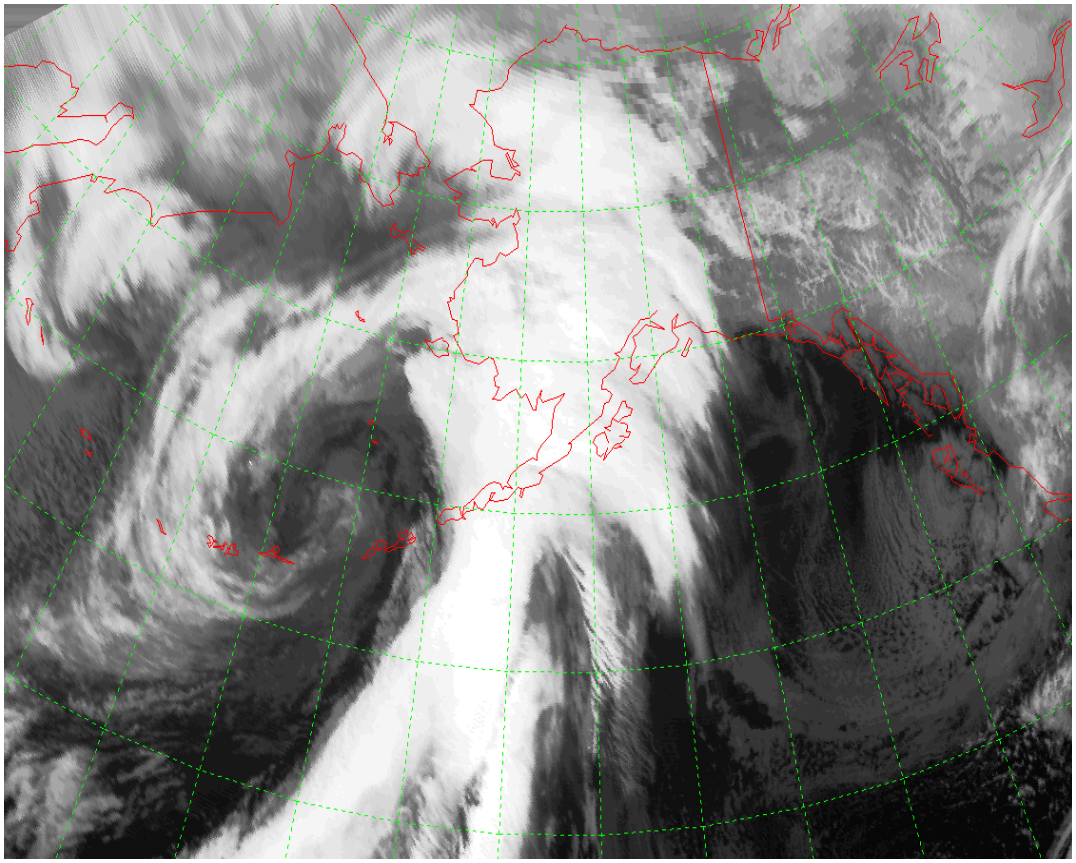
Model Performance:

The goal of this section is to show what forecast model data influenced the duty forecaster(s) to issue a winter storm watch with 48 hours of lead time. While on duty before and during this event, I was working the public shift, and did not issue the preliminary watch, Thursday afternoon, January 21. A combination of model forecasts and interpretation of satellite imagery were used in the decision to issue the watch, however. The AVN forecast model, which runs out through 72 hours, is one of a suite of computer-generated weather forecasting models produced twice daily by the National Center for Environmental Prediction (NCEP), in Washington DC. The other models used most frequently by the NWS are the short-range (0-48 hours) ETA and NGM, and the longer range MRF (0-240 hours). All these models use input data from many sources, satellites, surface land and sea-based observations, balloon soundings, and airplane reports. This data is input to these models which simulate the current weather patterns over North America and the entire Earth, then generate forecasts based on the current pattern, all using very complex physics to simulate the many processes at work.

The AVN 500mb height forecasts for 60 and 72 hours were a little slow on the timing and slightly weak on the strength of the southwest flow at 500mb. The 60 and 72 hour AVN surface and 1000-500mb thickness forecast charts compared favorably with the actual analyses for the same time period however. The model forecasts clearly showed a strong warm advection pattern developing, one indication of the significant over-running precipitation potential, though it was also a little slow on the timing of the features and over-forecast the strength of the surface high in the North Pacific, south of Alaska. The same charts for the same time period from the 00Z (3pm AST) Jan. 21 run of the MRF also verified fairly well with the analyses at 00Z and 12Z Jan. 24. The 00Z Jan. 21 MRF model run was also a little slow on the timing of the overall pattern progression, however, and also over-forecast the strength of the 500mb ridge over the North Pacific, and the corresponding surface high.

The ETA model run from 12Z (3am AST) Friday, January 22 proved to be fairly accurate in the timing and strength of the system, and gave the duty forecasters that day continued confidence in maintaining the heavy snow watch for the following day. The ETA 36 and 48 hour 850 mb height and temperature forecast charts clearly showed a strong southwest flow with warmer maritime air moving into the much colder arctic air in place, and compared favorably with the 850mb analyses for 00Z and 12Z January 24. The ETA 36 hour and 48 hour 850 mb temperature forecasts in fact were highly accurate in this case. This is important because the 850mb (roughly 6,000ft) temperature is a critical value used by forecasters in WFO Juneau to assess snowfall potential; 850mb temperatures greater than -4C generally are associated with rain at sea level sites in Southeast Alaska. Other ETA forecast charts from the same 12Z Friday January 22 run for the same time period were equally as accurate and detailed in forecasting this event. The 36 and 48 hour ETA 500 mb height forecasts showed the strong southwest flow developing , and the ETA 36 and 48 hour 700mb height/vertical velocity forecasts showed the strong southwest flow as well as significant upward vertical motion moving into the panhandle. The ETA 36 and 48 hour Quantitative Precipitation Forecast/1000-500 mb relative humidity forecast charts, and the corresponding 1000-500 mb thickness and surface pressure forecast charts forecasted a significant moisture field and precipitation amounts for the panhandle during the evening of Saturday, January 23 through the early morning of Sunday January 24, along with strong warm-advection in the 1000-500 mb thickness field, key signatures of a warm over-running snowfall event. While not totally accurate in all details, mainly in the structure and strength of the surface lows, this 12Z Friday, Jan. 22 ETA model run was on track with the timing and strength of this system. The Nested Grid Model (NGM) also had a good overall handle on this system in the 36 and 48 hour

forecast time period; it agreed in general with the ETA model forecast information, specifically concerning the depth of the moisture field and the 850 mb temperatures.



A GOES IR image from 18Z (9am AST) January 22 (Photo at left), shows the frontal band still maintaining a strong subtropical moisture feed, holding together, and movement of the parent surface and upper-level low in the model-forecasted northeasterly direction. This, combined with the continuity of the models in forecasting this event, maintained the forecaster's confidence of its occurrence such that the Winter Storm Watch for heavy snowfall was upgraded to a Winter Storm Warning at 1300Z (4am AST), January 23. The warning of course, verified in the area of its coverage, the eastern Gulf Coast and northern Southeast Alaska.

Summary:

The heavy snowfall event of January 23-24, 1999 over Southeast Alaska was a typical warm-advection/over-running precipitation case, where low-level arctic air provided a net sloping surface for ascent of warmer moist air above 4000 feet m.s.l., while the low-level cold air layer was able to maintain a depth necessary to keep precipitation in the form of snow. MRF and AVN model runs at 60-84 hours along with GOES IR imagery analysis gave the duty forecaster on Thursday, January 21 sufficient confidence to issue a winter storm watch for heavy snowfall at 400 pm, 48 hours in advance of the event. Subsequent model runs, especially the ETA model, continued to show a significant snowfall event for Saturday evening/Sunday morning 1/23-1/24 developing, and helped maintain forecasters' confidence in the event. Overall this was an excellent example of the National Weather Service's capability of providing valuable and timely weather information to the public well in advance of a potentially threatening weather event. This example also clearly illustrates one of the categories of weather systems that generate heavy snowfall in southeast Alaska.

Table 1, Yakutat Surface Observations, 12Z Jan. 23 to 20Z Jan. 24

PAYA	SKY CONDITIONS	VSBY	WX	SLP	TT	DP	WIND	ALT	APP
231200	OVC027	10	S-	275	21	18	0000	034	
231253	OVC025	3	S-F	268	23	20	0000	033	-23
231324	OVC015	2	S-F	265	21	19	0803	031	

231353	OVC013	1 1/2 S-F	255	23 21	0805	029	-31
231453	BKN017 OVC037	1 3/4 S-F	246	25 24	0906	026	-26
231553	BKN013 OVC022	1 1/2 S-F	232	25 24	0906	022	-36
231653	VV004	3/4 S-F	215	27 26	0909	017	-40
231753	BKN004 OVC011	3/4 S-F	204	29 28	1109	014	-42
231853	0VC002	1/4 S+ZF	195	30 29	1109	011	-37
231953	VV002	1/4 S+ZF	180	31 29	1213	007	-35
232053	BKN004 OVC013	1/4 SF	161	32 30	1313	002	-43
232153	0VC007	2 S-F	143	34 32	1114	996	-52
232253	BKN006 OVC015	2 1/2 R-S	132	34 34	0804	993	-48
232353	BKN013 OVC018	4 R-S	127	34 33	0304	991	
240053	BKN023 0VC041	10 R-	120	33 33	1005	989	-23
240153	BKN013 OVC021	4 RF	116	34 33	1206	988	-16
240253	OVC004	4 R-F	108	33 33	1105	986	-19
240353	0VC004	4 RF	101	33 33	0604	984	-19
240453	SCT004 OVC012	10 R-	096	33 33	1108	982	-20
240553	BKN024 OVC032	6 R-F	091	34 33	1107	981	-17
240653	OVC015	10	086	33 32	1007	979	-15
240753	BKN010 OVC015	1 1/4 S-F	080	33 32	1205	977	-16
240853	BKN007 OVC018	2 S-F	075	33 32	1304	976	-20
240953	BKN006 OVC014	1 1/4 S-F	071	32 32	0000	975	-15
241053	BKN015 OVC032	6 R-S	067	33 32	1405	973	-13
241153	BKN005 OVC014	1 S-F	066	32 32	1504	973	-09
241253	BKN009 OVC030	3 RS-F	064	33 32	1305	972	-11
241353	BKN045 OVC060	6 F	060	33 32	1204	971	-07
241453	OVC004	3 F	059	32 32	1104	971	-07
241553	OVC002	1 3/4 F	057	32 32	1404	970	-07
241653	OVC002	2 F	057	32 32	1205	970	-03
241753	OVC002	4 F	055	33 32	1407	970	-04
241853	OVC004	3 F	057	33 33	1104	971	00
241953	OVC004	3 RS-F	057	33 32	1207	971	00

Table 2, Juneau Airport Surface Observations, 19Z Jan. 23 to 20Z Jan. 24

PAJN	SKY CONDITIONS	VSBY WX	SLP	TT DP	WIND	ALT	APP
231753	OVC041	10	274	20 9	0713	034	-18
231853	SCT034 OVC041	9 S-	270	20 11	0917	033	-16
231953	SCT034 OVC041	10	264	21 12	0815	031	-18
232053	BKN028 OVC041	7	257	23 13	0914	029	-17
232153	BKN015 OVC025	5 S-	246	24 15	0815	026	-24
232253	VV014	3 S-F	238	23 19	1017	024	-26
232353	VV014	3 S-F	229	24 21	0916	021	-26
240053	VV014	2 S-F	222	25 23	1016	019	-24
240153	VV007	1 1/4 S-F	212	26 25	1120	016	-26
240253	VV008	1 S-F	200	27 25	1122	012	-29
240353	VV006	3/4 S-F	191	27 26	1119	010	-31
240453	VV006	3/4 S-F	180	27 27	1118	006	-32
240553	BKN005 OVC010	1 S-F	168	28 27	1223	003	-32
240653	OVC010	1 3/4 S-F	156	28 27	1120	999	-35
240753	BKN010 OVC015	1 3/4 S-F	143	29 28	1018	995	-37
240853	BKN007 OVC010	1 1/4 S-F	131	29 28	1116	992	-37
240953	VV006	1 S-F	120	30 29	1117	989	-36
241053	VV006	1 S-F	109	30 29	1014	985	-34
241153	OVC009	2 S-F	099	30 30	1114	982	-32
241253	BKN007 OVC012	1 1/2 S-F	089	31 30	1012	979	-31
241353	VV006	1 S-F	082	31 31	1011	978	-27
241453	VV005	1 S-F	078	31 31	0910	976	-21
241553	VV007	1 1/2 S-F	073	31 31	1111	975	-16
241653	VV007	1 1/2 S-F	075	32 31	0809	975	-07
241753	VV010	2 S-F	081	32 31	0906	977	+01

241853	VV010	1 1/2 S-F	085	32 31	0905	978	+12
241953	VV013	2 S-F	088	32 32	0806	979	+13

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