A Comparison of Selected 500 mb Prognostic Charts with Actual 500 mb Features over the Northwestern United States

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Producing an accurate forecast is partially dependent upon a forecaster's knowledge of various model biases, weaknesses and strengths. This is especially true for the 3 to 5 day extended forecasts, when projecting a current synoptic field that far into the future can tax even the highly experienced forecaster's skills. This paper attempts to document some weaknesses and strengths of the dominant medium range 500 mb guidance available at this time.

Procedure:

One hundred thirty six 3, 4 and 5 day 500 mb prognostic charts were studied by overlaying the actual 500 mb fields onto the prognostic charts for the valid period of the forecasts. The prognostic charts covered 11 three to five day periods starting in late August, 1997 through early February, 1998. Features laying within a region bounded by 110W longitude to 150W, and 30N latitude to approximately 50N were studied, which covers the northwestern and inter-mountain US as well as a portion of the eastern Pacific Ocean. Roughly comparable numbers of MRF and ECMWF charts were studied (55 and 52 respectively), along with a smaller sample of UKMET charts (29). The NOGAPS model was not studied.

Synoptic features were studied in those cases in which they were forecast to occur, or actually occurred but were not forecast by a model. These features include Short Waves, Open Troughs, Closed Lows, Ridges and Split Flow parameters. All features were compared in relation to the position for which they were forecast, the offset expressed in nautical miles north, south, east or west. One degree of latitude on the AFOS polar charts equals 70 nautical miles (nm).

Results:

Flow over Boise...

Table 1 displays model performance in forecasting the directional flow over Boise in relation to the actual flow.

Table 1. Flow over Boise

Model	# of cases	Forecast flow within 20 degrees and from same quadrant as actual	Forecast flow within 45 degrees and from same quadrant as actual	Forecast flow not representative of actual flow
ECMWF	55	53%	78%	22%
MRF	52	44%	73%	25%
UKMET	29	45%	70%	28%

Slight discrepancies in the sum of the "within 45 deg." and "not representative" cases reflect a small number of inconclusive weak flow cases.

The ECMWF and MRF displayed a slight tendency to forecast the direction slightly clockwise from the actual flow, that is, if the prog forecasts west flow, the actual flow was more likely to be out of the southwest quadrant than northwest. On average the UKMET displayed no bias.

Heights over Boise...

Table 2 displays model performance in forecasting the 500 mb heights over Boise in relation to the actual heights.

Table 2. Heights over Boise

Model	# of cases	Forecast flow within plus or minus 2 dm of actual flow	Forecast flow within plus or minus 4 dm of actual flow	Forecast flow within plus or minus 6 dm of actual flow
ECMWF	55	42%	67%	87%
MRF	52	31%	49%	71%
UKMET	29	38%	59%	79%

None of the models displayed a clear bias to overestimate or underestimate the heights over Boise on average. Forecast heights were either higher or lower than the actual heights in roughly equal proportions for all three models.

Transient Eastern Pacific/Northwestern US Short Waves...

Short waves are defined here to include any disturbance in the 500 mb flow that was large enough to be detected on the AFOS 506 charts, up to larger waves that may be subjectively defined as weak troughs. All of the short waves studied were roughly oriented north to south.

The ECMWF showed the most skill at detecting these short waves. 70% of the short waves, however weak they were, were caught in the ECMWF progs. The MRF detected 64% of these short waves. The UKMET, with a roughly comparable number of cases, detected 69% of the waves. The ECMWF and MRF models forecast a shortwave when no shortwave occurred in only one case per model, a false alarm rate for both models of about 5%. The UKMET displayed a false alarm rate of 0%.

Percentages of actual axes falling within about 70 nm of the forecast axes are used to indicate overall forecast accuracy. Percentages outside 70 nm east or west of the forecast axis along with how many axes occurred within 140 nm of the forecast help illustrate the direction and extent of any biases the model may display.

Table 3 displays model performance in forecasting the position of the short wave axis in relation to the actual axis.

Table 3. Northwestern US Short Wave Axes

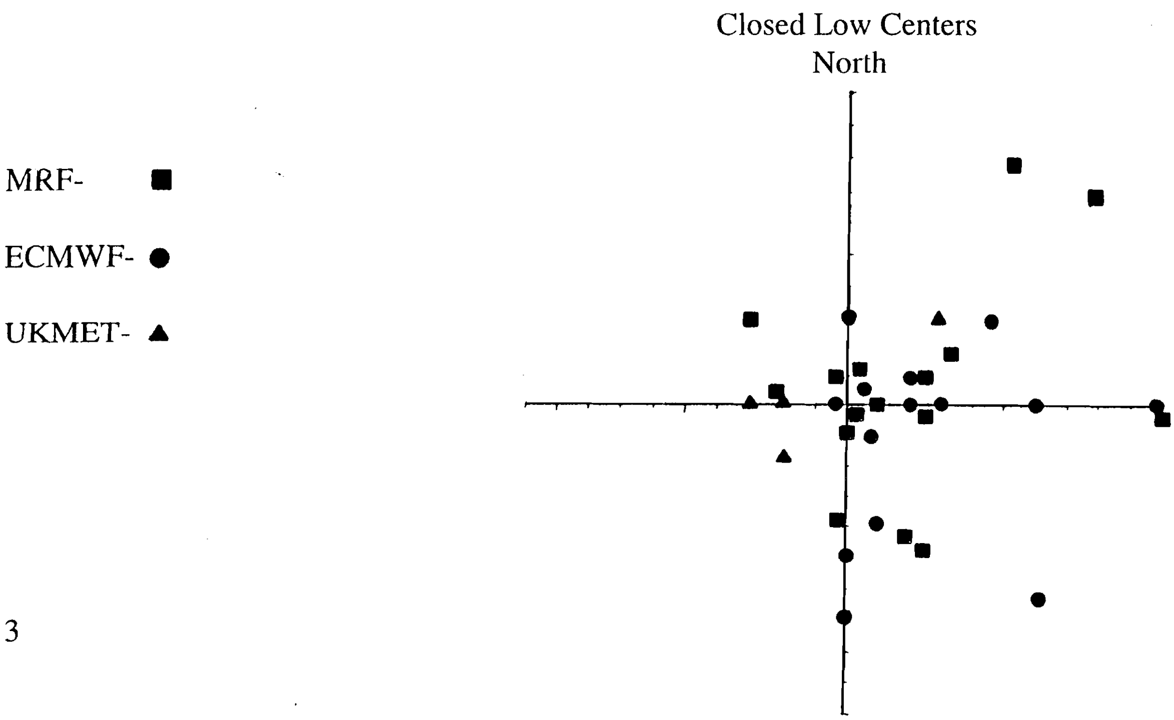
Model	# of cases	Short wave axis occurs within		Forecast position greater than 70 nm west	Forecast position greater than 70 nm east
		140 nm of forecast position	70 nm of forecast position		
ECMWF	20	79%	50%	30%	20%
MRF	22	64%	29%	43%	28%
UKMET	16	64%	36%	19%	75%

The ECMWF and the MRF tended to forecast the short waves too slow, while the UKMET showed a clear bias for forecasting the shortwave too fast. Both the ECMWF and the MRF showed a slight bias of under forecasting the relative strengths of the short waves. The UKMET was better at forecasting the relative strength of the waves with no apparent bias.

North Pacific Closed Lows...

The ECMWF forecast 82% of the closed lows that occurred, with the MRF detecting 76%. An open trough occurred when the ECMWF forecast a closed low (false alarms) in 19% of the cases. The MRF had a false alarm rate of only 4%. UKMET detection statistics were not computed due to limited sample size.

Actual positions of closed low centers in relation to the forecast center point are graphed below, with the origin being the forecast center point. Tick marks equal 70 nm.



Troughs associated with these closed lows were also studied...

Table 4 displays model performance in forecasting closed low trough axes in relation to the actual axes.

Table 4. Trough Axes Associated with Closed Lows

Model	# of cases	Trough axis occurs within 140 nm of forecast position	Trough axis occurs within 70 nm of forecast position	Forecast position greater than 70 nm west	Forecast position greater than 70 nm east
ECMWF	21	36%	29%	50%	21%
MRF	22	57%	36%	43%	21%
UKMET	5	80%	60%	20%	40%

While none of the models did especially well, the MRF was marginally better than the ECMWF with slightly over half of the forecast axes within 140 nm of the actual axes, with both models displaying a westward forecast bias. The UKMET displayed the best performance, however only 1/4 as many cases were studied.

Eastern Pacific/Northwest US Deep Open Troughs...

The ECMWF and the UKMET detected all of the troughs that occurred. The MRF failed to forecast two troughs that occurred, a failure rate of 14%. All of the models did reasonably well in forecasting the relative strength of the troughs.

Table 5 displays model performance in forecasting deep open trough axes in relation to the actual trough axes.

Table 5. Deep Open Trough Axes

Model	# of cases	Trough axis occurs within 140 nm of forecast position	Trough axis occurs within 70 nm of forecast position	Forecast position greater than 70 nm west	Forecast position greater than 70 nm east
ECMWF	14	43%	29%	62%	9%
MRF	14	57%	33%	67%	0%
UKMET	11	45%	45%	45%	10%

None of the models did particularly well in forecasting deep open trough positions. The MRF was marginally better than the other models, displaying a tighter grouping of forecast axes positions to the west of the actual position. All of the models displayed a marked tendency to forecast the trough axis too far to the west of the actual position.

Northwest/Inter-mountain US Ridges...

Ridges are defined here as short wave or long wave ridges between 115W longitude and 130W. In all studied cases the ridge axis was roughly north to south.

The ECMWF detected 91% of the ridges that occurred while the MRF detected 81%. The UKMET, with about half as many cases studied, detected 88% of the ridges. The false alarm rate for the ECMWF and MRF was 0%. The UKMET forecast a ridge when none occurred in one case, a false alarm rate of 6%.

Table 6 displays model performance in forecasting Northwest/Inter-mountain US ridge axes in relation to the actual axes.

Table 6. Northwest/Inter-mountain US Ridge Axes

Model	# of cases	Ridge axis occurs within 140 nm of forecast position	Ridge axis occurs within 70 nm of forecast position	Forecast position greater than 70 nm west	Forecast position greater than 70 nm east
ECMWF	32	80%	66%	17%	17%
MRF	27	64%	41%	32%	27%
UKMET	16	73%	47%	20%	33%

The ECMWF was the best predictor of Northwest/Inter-mountain ridge positions with a tight grouping of 80% of the forecast axes within 140 nm of the actual axis with no bias of forecasting the ridge too fast or slow when averaged over all cases. Biases for the MRF and UKMET were not significant, however the groupings of forecast axes around the actual axes were broader and looser than the ECMWF.

Split Flow Cases...

The parameters characterizing the split flow pattern that were studied include the position of the center of the difluent region, the position of the center of the col region, the position of the center of the confluent region, the position of the northern branch short wave axis (if one occurred) and the position of the southern branch short wave axis.

Both the ECMWF and the MRF forecast 83% of the splits that occurred. The UKMET, with about half as many cases studied, detected 84% of the splits. The MRF did forecast splits in 3 cases with no split occurring. This is a false alarm rate of 14%. The ECMWF and UKMET displayed false alarm rates of 0%.

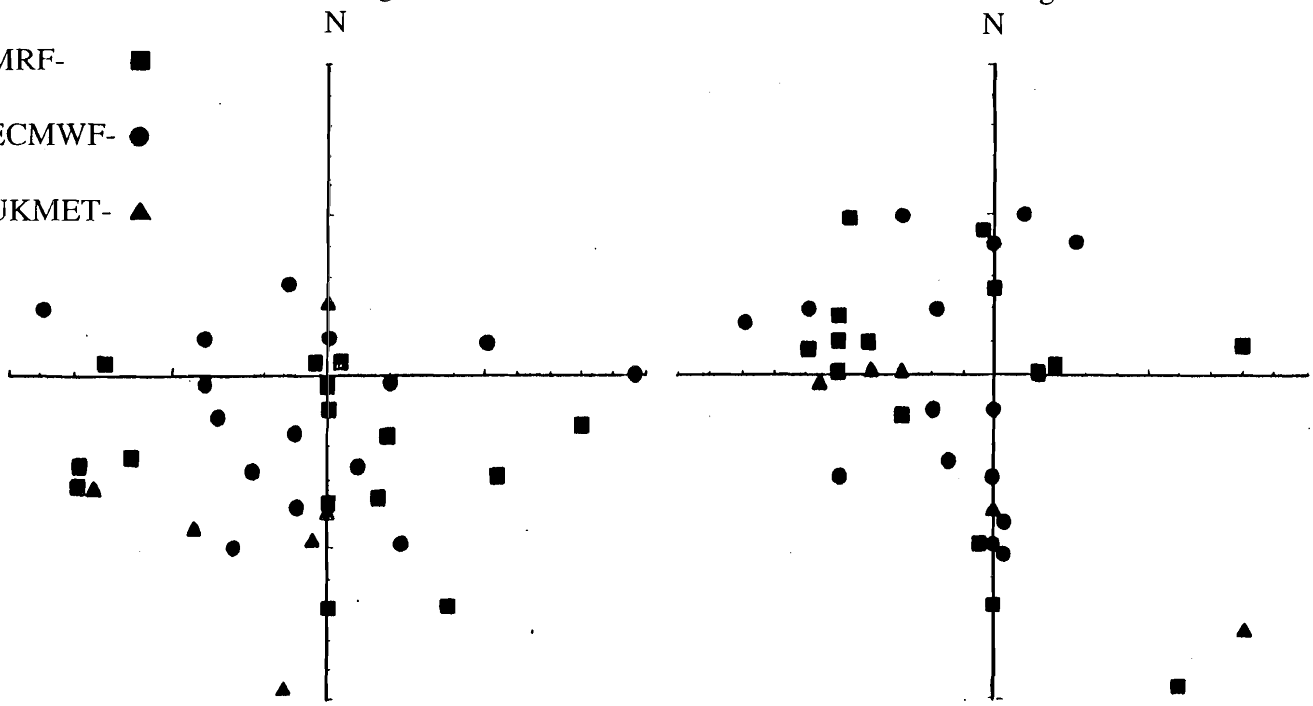
Positions of the difluent and confluent regions in relation to the forecast region are graphed below, with the origin being the forecast center point. Tick marks equal 70 nm.

Difluent Regions   Confluent Regions

MRF- ■

ECMWF- ●

UKMET- ▲



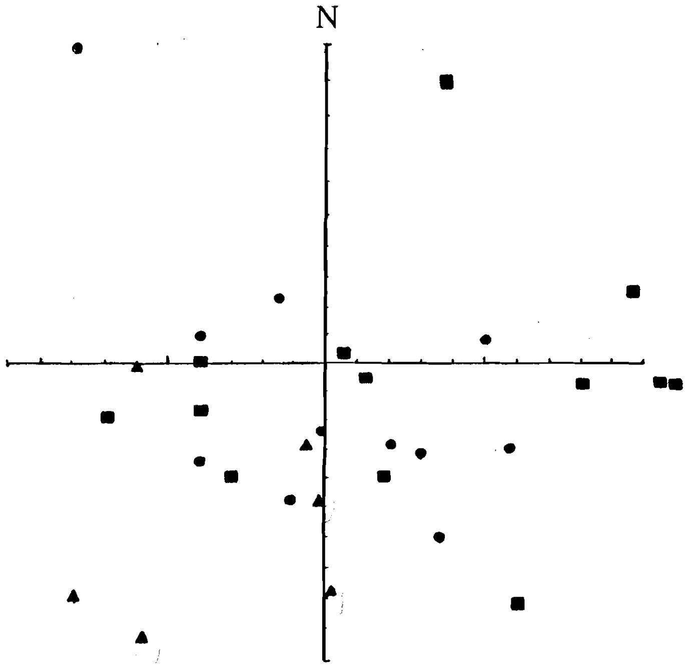
Positions of the center of the of the col regions in relation to the forecast col centers are graphed below, with the origin being the forecast center point. Tick marks equal 70 nm.

Col Regions

MRF- ■

ECMWF- ●

UKMET- ▲



Northern Branch Short Waves...

Table 7 displays model performance in forecasting northern branch short wave axes in relation to the actual axes.

Table 6. Northern Branch Short Wave Axes

Model	# of cases	Short wave axis occurs within 140 nm of forecast position	Short wave axis occurs within 70 nm of forecast position	Forecast position greater than 70 nm west	Forecast position greater than 70 nm east
ECMWF	10	60%	30%	20%	50%
MRF	12	58%	33%	50%	17%
UKMET	5	50%	40%	0%	60%

Forecast accuracy was generally equal but not high for any of the models. The ECMWF and UKMET displayed clear biases towards forecasting the axis too fast and the MRF too slow. With a comparable number of ECMWF and MFR sample cases, the ECMWF displayed the tightest grouping of forecast axes about the actual axes.

Southern Branch Troughs...

No tight groupings of actual troughs versus forecast positions were observed with any of the models. Axes of actual southern branch troughs were scattered between 700 nm west of the forecast axes and 840 nm east for the MRF. For the ECMWF the actual axes were scattered from 560 nm west of the forecast axes to 490 nm east of it, making the ECMWF marginally but not much more useful than the MRF for southern branch trough forecasts. For the UKMET the spread was from 350 nm west of the forecast to 140 nm east, but with a significantly smaller number of sample cases.

Summary:

In forecasting the direction of the 500 mb flow over Boise, the ECMWF was the better model. The MRF and UKMET showed roughly equal skill for second place.

In forecasting the heights of the 500 mb surface above Boise, The ECMWF was significantly better than the MRF and UKMET. The UKMET was second best with the MRF third. On average no bias was reflected high or low by any of the models.

In forecasting transient short waves over the northwest, The ECMWF was the best model, but tended to prog the wave slightly too slow and too weak. The UKMET was second best, but tended to prog the wave too fast. UKMET was the best at forecasting the relative strength of the wave. The MRF was third and tended to prog the wave too slow and too weak.

In forecasting closed lows over the north Pacific, the ECMWF and the MRF showed comparable probabilities of detection, with the MRF displaying a smaller false alarm rate. Results of which model was the best forecaster of closed low positions is somewhat ambiguous between the MRF and ECMWF. For forecasting the axis of the associated trough, the MRF and UKMET were better than the ECMWF.

In forecasting deep open troughs over the Eastern Pacific and Northwest US, the UKMET was marginally better than the MRF due to the MRF's slight failure to detect rate. The ECMWF was third, with all the models displaying a bias of placing the axis too far west (prog too slow).

In forecasting ridges over the northwest, the ECMWF was the best model with no bias on average of forecasting the ridge east or west. The MRF was second best with the UKMET third.

In forecasting split flow patterns, the ECMWF was marginally better in placing the location of the diffluent region and col. All three models showed a bias of forecasting the diffluent region and col region too far north of the actual position. With all three models the confluent region tended to be progged too far to the east of the actual region. The ECMWF and MRF showed roughly equal skill in forecasting the general location of the northern branch short wave, with the MRF on average forecasting the axis too slow. The ECMWF and UKMET tended to forecast the axis too fast. None of the models did well with the southern branch trough, however the ECMWF was slightly better than the MRF, with inconclusive results for the UKMET.