Western Region Technical Attachment
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OROGRAPHIC EFFECTS: NGM VERSUS ETA

Thomas Cylke - WSFO Reno, NV

Introduction

Model topography can have a significant effect on precipitation patterns over the Sierra. After being conditioned to seeing very little, if any, QPF generated by the Eta model at Reno for much of the winter, forecasters at WSFO Reno were quite surprised when the Eta model generated precipitation over Reno on March 4, 1994. The Eta model was actually forecasting much more precipitation than the NGM (Fig. 1) in the 30 to 48 hour period on Sunday, March 6, 1994.

The synoptic weather pattern on March 6, 1994 could be classified as a typical precipitation event for the east slopes of the Sierra. A moist east to northeast flow in the low and middle levels resulted in clouds and precipitation confined to the east slope of the Sierra and extreme western Nevada, despite the strong synoptic-scale descent indicated by the NMC models (Fig. 2). The NGM and AVN models rarely forecast QPF in this situation since the flow is interpreted by these models to be downslope and the northeast flow is most often accompanied by cold advection at low levels.

The Eta model is a finite differencing model, similar to the NGM in many aspects. The Eta model, however, does have a more realistic representation of mountainous terrain and terrain gradients, since the eta coordinate, which is a variation of the sigma coordinate, allows step-like representation of the mountains. The NGM topography is representative of the mean ground height surrounding each grid point, but is very smoothed.

The Eta model, in this case, was able to minimize the downslope effect due to its enhanced resolution stepwise topography. By using PCGRIDS fields, one can actually compute vertical motion caused by the wind field advecting the surface pressure field, which approximates the model topography.

Evaluating the Results from Orographic Effects

By simply overlaying the pressure/topography fields of the Eta model and NGM with the 850 mb wind, one can see (Fig. 3a) that the downslope gradient on the Eta model begins near the northern California/Nevada border, as noted by the 984 mb pressure surface, while the NGM gradient begins farther east over west-central Nevada (Fig. 3b). By computing the advection of the pressure-topography by the 850 mb wind, one can quantify the upslope and downslope effects. Negative (positive) values show downslope (upslope) (Fig. 4). In this case, the Eta model indicated the strongest downslope effect near the northern California coast (Fig. 4a) while the NGM had the maximum downslope values near Lake Tahoe (Fig. 4b).

Model Output and Verification

On the morning of March 4, 1994, the forecaster was presented with major differences in the Eta model and NGM with respect to the vertical motion and QPF forecasts over western Nevada. This can be seen by comparing the FOUS output at Reno from 1800 UTC Saturday, March 5, to 1200 UTC Sunday, March 6, 1994 (Fig 1). The NGM had forecast only 0.07 inches of precipitation ending at 0000 UTC Sunday, followed by strong sinking motion of around 9 $\mu b\ s^{-1}$ early Saturday morning. The Eta model, by contrast, forecast 0.22 inches of precipitation and much weaker downward motion through 1200 UTC Sunday. In fact, rain ended at Reno around 1200 UTC Sunday morning, totalling 0.54 inches the previous 12 hours, double the Eta QPF and nearly 8 times the amount forecast by the NGM. Snow continued to fall along the east slopes of the Sierra until around noon Sunday, with 12 inches of new snow measured at the Mount Rose ski resort (northeast exposure), located about 15 miles southwest of Reno. Most other ski areas around Lake Tahoe measured only 2 inches of snow or less.

Conclusion

The Eta model finally outperformed the NGM with its better depiction of topography under a northeast flow. The Eta model did not forecast upslope in this case, however, it was able to minimize the effects of model downslope forecast by the NGM. While it is possible to quantify the upslope and downslope using PCGRIDS, one must remember that representing model terrain by the surface pressure field is still rather crude and, in some cases, synoptic-scale vertical motions may enhance or diminish the effects of downslope. This case shows the usually wet NGM QPF can be drier under certain flow patterns which result in downslope flow. The stepped Eta model should become more advantageous as model resolution increases, since model slopes will tend to be steeper and more numerous as higher resolution topography is described. The use of high resolution topography is essential for mesoscale forecasting of such quantities as wind and precipitation. This should become better defined with the higher resolution (30 km) Eta model.

References

Black, T.L., 1992: Forecasts from NMC's high resolution eta model. Preprints, *Symposium on Weather Forecasting*. Atlanta, Georgia, Amer. Meteor. Soc., 10-13.

Chaston, P., 1994: Graphical Guidance - 1994 Edition, pp. 59-60.

Eise, J.S., 1994: Determining orographic effects using PCGRIDS. Central Region Technical Attachment - Gridbit #8.

Western Region Scientific Services Division, 1992: An introduction to PCGRIDS data and the Eta-X. Western Region Technical Attachment No. 92-37.

SELECTED ETA FOUS OUTPUT FOR: 03/04/12Z

	12Z FRI	18Z FRI	00Z SAT	06Z SAT	12Z SAT	18Z SAT	00Z SUN	06Z SUN	12Z SUN	STA: RNO	
DDFF	2405	2804	2508	2713	3112	0102	0111	0322	0421	BLYR WIND	
VVV	+01.8	+01.0	+01.6	+01.0	+01.3	+01.2	+02.4	-00.4	-02.5	700 VV	
LI	+02	+02	-02	-01	+00	-01	-02	+02	+05	LIFTED IDX	
T1	+46	+44	+46	+42	+37	+35	+35	+32	+22	BLYR T(F)	
TD1	+26	+26	+36	+35	+31	+32	+32	+29	+20	BLYR TD(F)	
T3	+03	+02	+03	+00	-02	-03	-03	-06	-10	922-872 T	
T5	-03	-03	-04	-06	-08	-10	-10	-11	-11	816-755 T	
HH	555	553	554	551	546	543	544	540	537	THICKNESS	
R1	46	48	69	74	79	89	87	92	91	BLYR RH	
R2	52	36	41	61	83	86	82	71	26	965-473 RH	
R3	55	63	84	72	39	37	41	38	20	473-181 RH	
PTT	----	0.00	0.00	0.00	0.00	0.02	0.11	0.06	0.03	6HR PRECIP	.22

NNNN>##<A
<ZCZC RNOWRKFRH
TTAA00 KRNO 041537

SELECTED NGM FOUS OUTPUT FOR: 03/04/12Z

	12Z FRI	18Z FRI	00Z SAT	06Z SAT	12Z SAT	18Z SAT	00Z SUN	06Z SUN	12Z SUN	STA: RNO	
DDFF	3103	3003	3010	3414	0206	0207	3616	0432	0532	BLYR WIND	
VVV	-03.0	-01.5	-01.0	+00.0	+01.7	-01.0	+01.1	-08.6	-09.0	700 VV	
LI	+03	+02	+01	+00	+00	-01	-03	+04	+04	LIFTED IDX	
T1	+44	+46	+51	+48	+44	+39	+41	+33	+30	BLYR T(F)	
TD1	+29	+32	+26	+29	+30	+34	+37	+16	+10	BLYR TD(F)	
T3	+03	+03	+04	+03	+01	+00	+00	-04	-06	922-872 T	
T5	-02	-03	-04	-05	-08	-08	-08	-07	-07	816-755 T	
HH	554	554	554	551	549	546	546	542	540	THICKNESS	
R1	56	59	37	48	58	84	86	48	43	BLYR RH	
R2	49	37	55	79	89	98	98	72	42	965-473 RH	
R3	39	47	55	60	36	53	57	51	30	473-181 RH	
PTT	----	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.00	6HR PRECIP	.07

Fig. 1 ETA/NGM FOUS output from 1200 UTC, March 4, 1994 for Reno

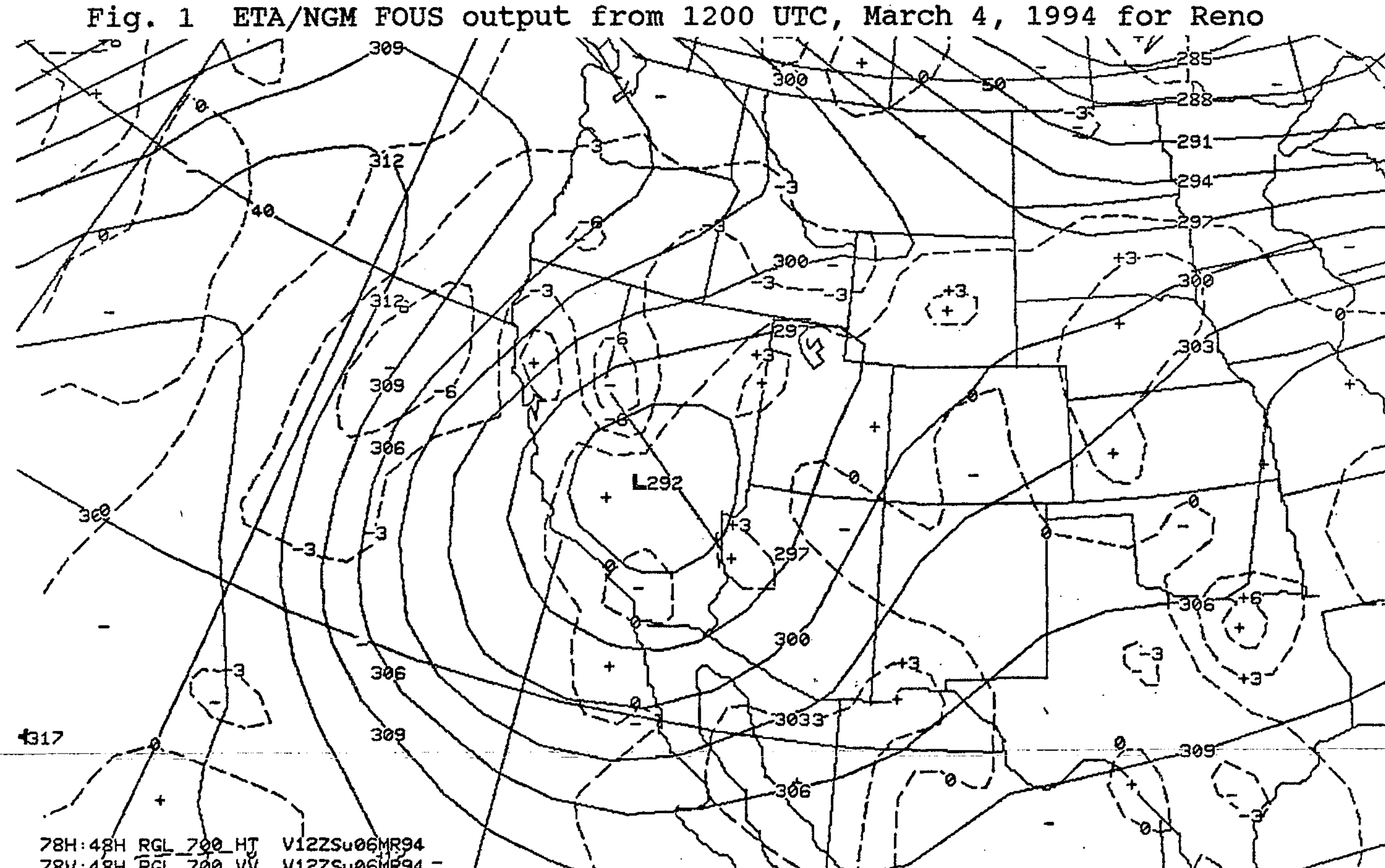
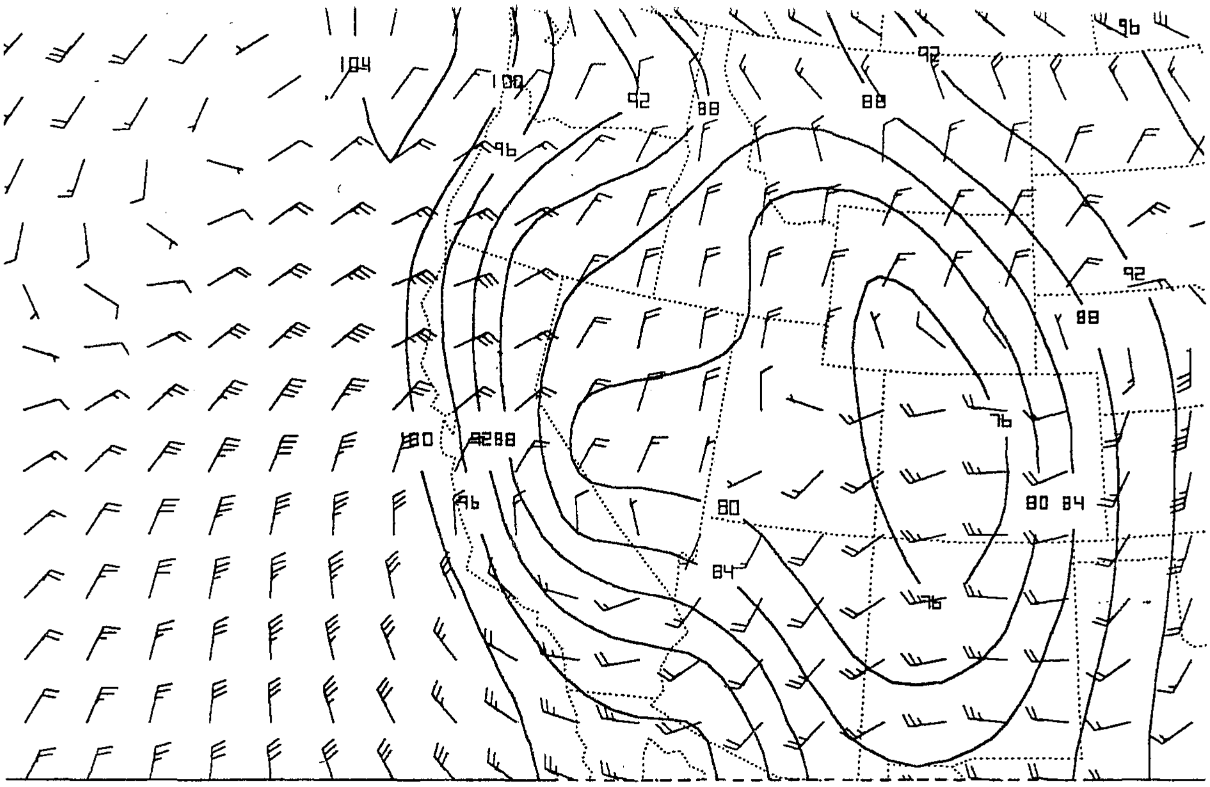


Fig.2 48 hour forecast from NGM valid 1200 UTC Sunday, March 6,1994 of 700 mb heights and vertical motion.



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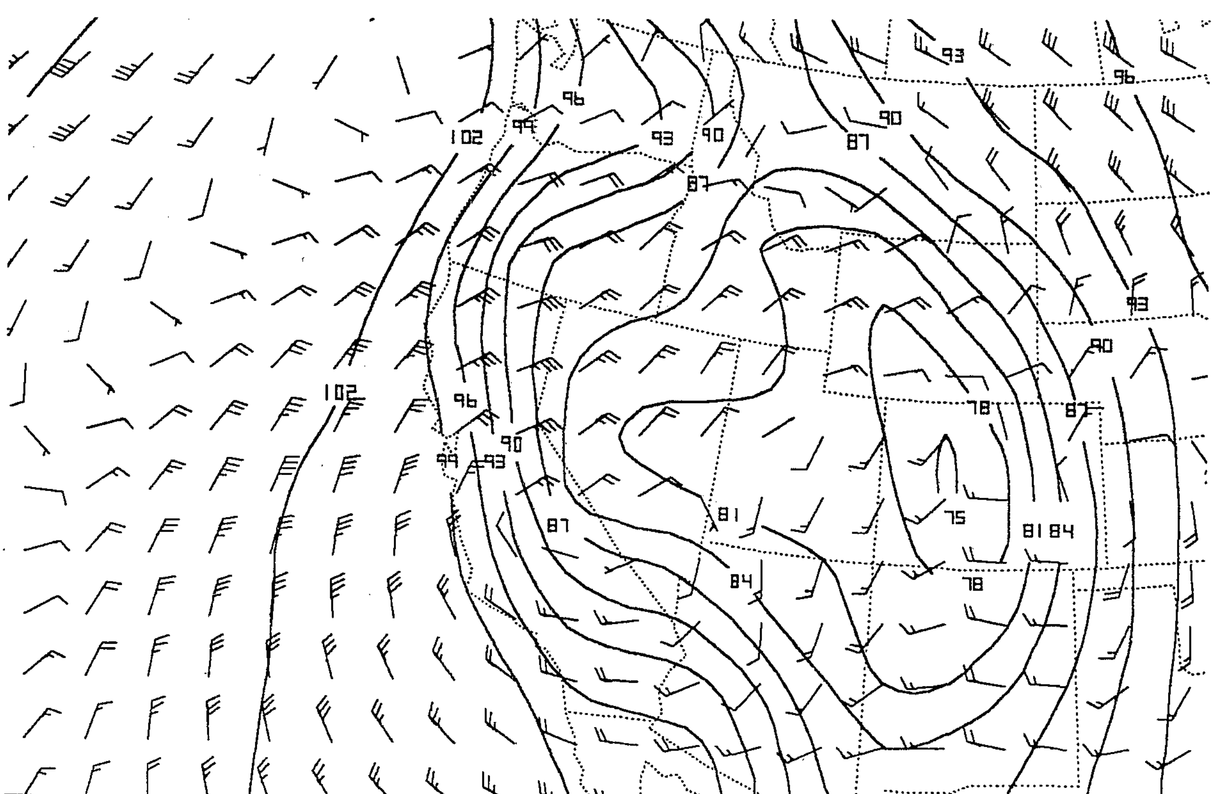

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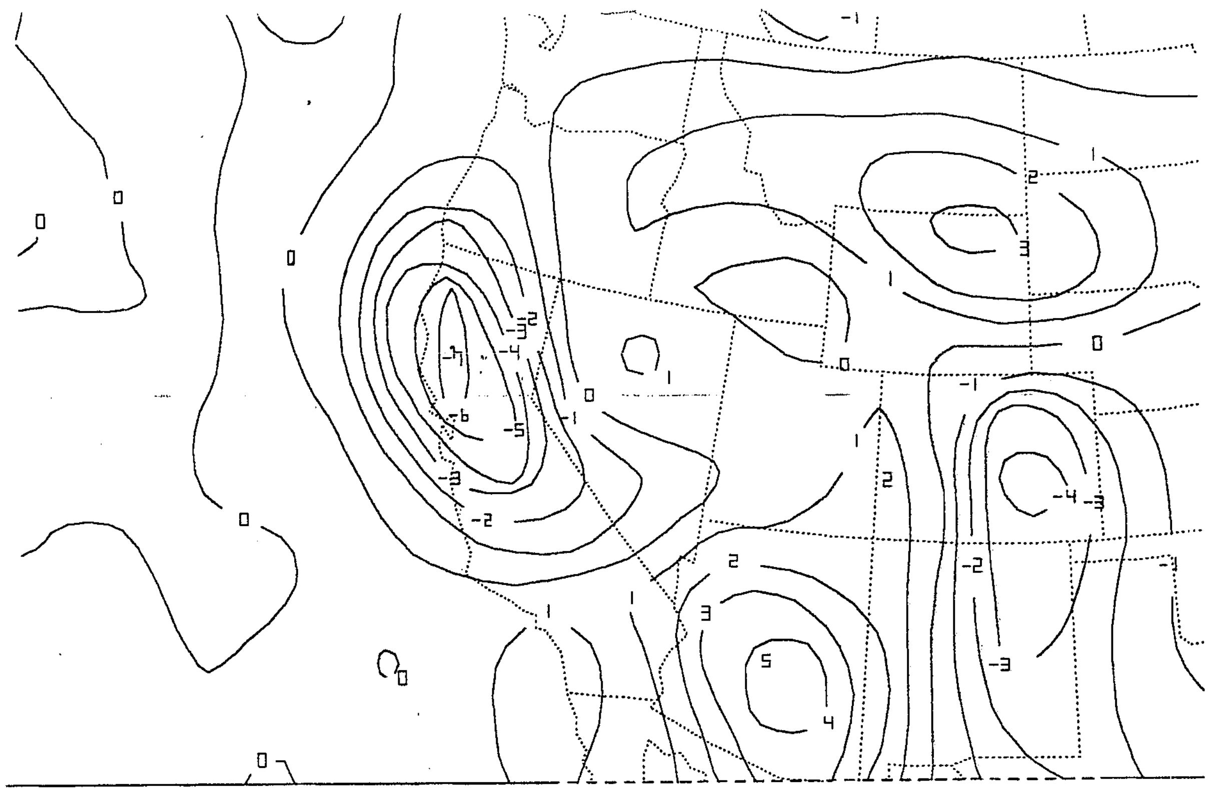
Fig. 3 Pressure/Topography overlayed with 48 hour forecast of 850 mb wind field. a) by ETA model, and b) by NGM model.



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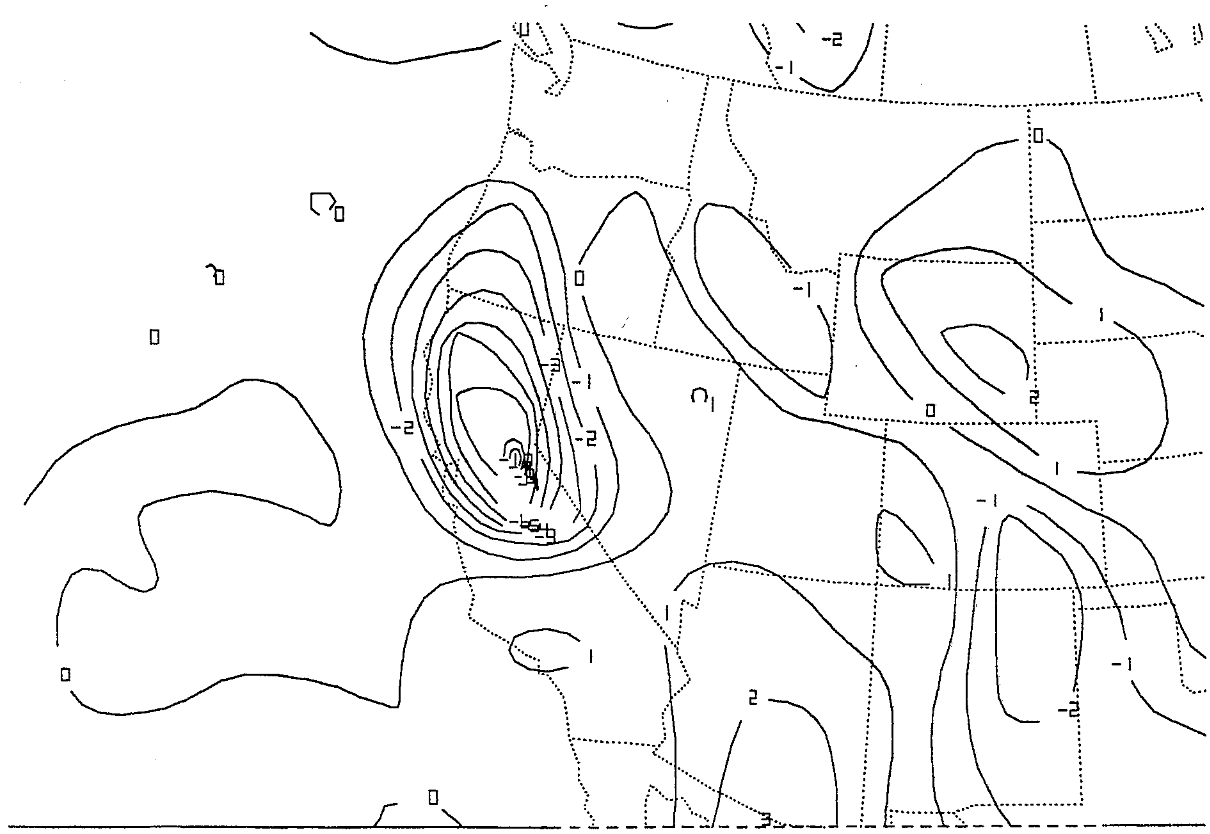

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94/ 3/ 4/12--ADVT PRES 0000 WIND SLVL 850 F48

Fig. 4 Forecast of Advection of Pressure/Topography by 850 mb winds valid 1200 UTC, Sunday March 6, 1994: a) by ETA, b) by NGM