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A BRIEF COMPARISON OF 29KM AND 10KM ETA MODEL SIMULATIONS OF A SPRING SNOW EVENT

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Introduction

With unlimited computer resources, a numerical weather model could be designed with a 10km grid covering the globe. Such a model would resolve phenomena over a spectrum ranging from planetary scales down to 3-4 times the grid resolution (Ray 1986). However, due to limited computer resources, models are often designed with a low-resolution/large-domain grid to resolve planetary phenomena coupled to a high-resolution/small-domain grid to resolve small-scale phenomena over a local domain of interest. These types of models are called nested models, the high-resolution/large-domain grid is called a coarse grid, and the high-resolution/small-domain grid is called a nested grid.

Nested models can have one-way or two-way interactions between the grids. In a one-way interaction, the coarse grid passes information to the nested grid but not vice-versa. In a two-way interaction, information is passed both ways. Note that for a one-way interaction, the nested grid does not have to be run at the same time as the low-resolution grid. Rather, the coarse grid can first be run to completion and the nested grid can be "fed" information from the coarse grid at a later time. Local models use this approach, usually using NCEP model output for the larger domain.

The 29km Meso Eta receives its boundary conditions from the AVN run (roughly 100km resolution) of the Global Spectral Model (GSM). In this sense, the 29km Meso Eta is nested within the AVN model. The Mesoscale Modeling Branch of the Environmental Modeling Center (EMC) recently developed a 10km Eta grid for the western U.S. and a 15km grid for the Atlanta Olympics. These grids are nested within the 29km Meso Eta model. The 10km model's boundary conditions are interpolated from 29km Meso Eta output at 3hr intervals. Information is passed from the AVN to the 29km Meso Eta and from the 29km to 10km Meso Eta using one-way interactions.

This Technical Attachment (TA) compares three datasets:

(1) 0900 UTC 19 Apr 96, 10km nested Eta interpolated to a 20km grid;
(2) 0900 UTC 19 Apr 96, 29km Meso Eta interpolated to a 40km grid;
(3) 1200 UTC 19 Apr 96, 29km Meso Eta interpolated to a 20km grid.

The purpose of this TA is not to verify model forecasts but rather to compare how resolution can affect model results.

The 10km Meso Eta

The 29km Meso Eta model is initialized by the Eta Data Assimilation System (EDAS). Staudenmaier (WR-TA 96-06) describes the EDAS and Eta design. Since errors are often created near the boundaries of nested grids, care should be taken when examining phenomena near the boundary of a nested grid. Note that the boundaries of the 10km Meso Eta grid are near the western U.S. (Fig. 1). The same model physics are used for both the 10km and 29km Eta. The main difference between the two models is the domain size and horizontal/vertical resolution. Ten additional levels have been added to the 10km model, for a total of 60. Many of the additional levels are below 900mb, a feature designed for the Atlanta Olympics. For the western U.S., the main impact of these additional levels will occur over the Pacific Ocean along the West Coast. The fundamental timestep for the 10km grid is 24 seconds.

A 33 hour model forecast of the 29km model runs on a CRAY in about 35 minutes; the 10km nest is roughly 3 times slower. The 10km model has been run in an experimental mode every other day at 0900 UTC. After the Atlanta Olympics, the NCEP is planning to run the 10km Meso Eta over the West. The schedule has not been determined as of this date.

Comparison of 29km-output/40km-grid Data and 10km-output/20km-grid Data

Western Region forecast offices receive gridded model data on AWIPS grids over a Wide Area Network. The AWIPS grids have a pre-defined resolution. Eta output is interpolated to the AWIPS grids. It is hoped that in the future, AWIPS grids will be based on model resolution to avoid this interpolation step.

Figure 2 is a comparison of the 29km Meso Eta output interpolated to the 40km AWIPS grid (hereafter called the 29/40 data) to 10km output interpolated to a 20km grid (10/20 data). Figure 2 demonstrates the potential benefit of the 10/20 dataset. Figure 2 does not provide a fair comparison of the two model resolutions because the 29km output has been smoothed by interpolation to the 40km grid. At the current time, only 20 fields are included in the 10/20 dataset (see Appendix A). Two 27-hour forecasts of mean-sea-level pressure (MSLP), valid at 1200 UTC 20 April 1996 are compared. A MSLP trough is passing over north-central Utah and south-central Idaho. Based on the Utah Mesonet (Fig. 3a) and an IR satellite image (Fig. 3b), both model forecasts have roughly the correct timing of this feature. A wind shift from southerly to northwesterly occurred at the Salt Lake City Forecast Office between 1100 and 1200 UTC. (Note: the Utah Mesonet wind vectors are from observing stations that range from roughly 4,000 to 10,000 feet.) The winds in southwest Utah are still southerly but shift to northwesterly about one hour later. Salt Lake

City NWSFO reported light rain showers at 1400 UTC and light snow showers between 1500 and 2100 UTC. A total of 3 1/2 inches of snow and total of .40 inches of liquid water was recorded.

MSLP charts often reveal the influence of model terrain. The 10/20 data (Fig. 2a) shows a tight MSLP gradient over California (lower-left corner of plot) and a low-pressure area in the lee of the Colorado Rockies. These features are not evident in the 29/40 plot (Fig. 2b). This demonstrates the terrain-related information provided by the 10/20 data.

Comparison of 10/20 and 29/20 Wind Fields

The 10km and 29km outputs can be compared more justly when both are interpolated to the 20km AWIPS grid. Figure 4 compares 10/20 data and 29/20 data. Note: the 29/20 data are from a 1500 UTC model run initialized 6 hrs later than the 0900 UTC 10km model run. Thus, the 29km Meso Eta forecast not only has a 6 hour advantage but also has the benefit of 1200 UTC Raob data. All plots shown are for the same valid time as section III, i.e., 1200 UTC 20 Apr 96.

Figure 4 shows the model winds at the 10-meter above-ground-level (AGL). For a description of the derivation of the 10m AGL winds, see Appendix B below. The 10/20 data (Fig. 4a) shows, in general, a more complex response to terrain. For example, in southwest Utah, the 10/20 wind field shows a more marked area of southwest flow than the 29/20 data (Fig. 4b). This southwest flow is supported by the Utah Mesonet (Fig. 3a) and is probably due to blockage of the westerly flow by the mountains of southwest Utah. The 29/20 wind field also shows an unrealistic easterly flow along the Wasatch Front (east of the Great Salt Lake) not evident in the 10/20 wind field.

Comparison of 10/20, 29/20 and 29/40 QPF Charts

The 0900 UTC model runs end at 1500 UTC and thus precipitation totals are not available for the entire event. The timing and amount of the 29km 1500 UTC model (29/20) forecast, .35 inches between 1200 UTC and 2100 UTC, are very close to observed values.

Swanson (1995) first noted the Meso Eta does not produce significant convective precipitation over elevated terrain except along the west coast. The problem has continued in spite of recent changes to the model physics. A different parameterization for convection for the Eta model is currently being tested.

Figure 5 shows 3 hour totals of precipitation (shaded) and 3 hour totals of convective precipitation (dashed contours) valid at 0900 UTC 19 Apr 96. The 29/40 forecast (Fig. 5b) does not show convective precipitation; however, the 29/20 forecast (Fig. 5c), initialized 6 hours later, does show light (.01 inch) amounts. This improvement could be due in part to the 1200 UTC raobs that went into the initialization of the 1500 UTC model run. It is interesting that the 10/20 data (Fig. 5a) also shows some light amounts of convective precipitation, indicating the convective processes may be sensitive to the Eta model's resolution. It is also possible that light precipitation amounts were produced by the 0900 UTC 29km Meso Eta, but were smoothed to zero by interpolation to the 40km AWIPS grid. As superior resolution grids become routinely available, a more accurate appraisal of the Eta's convective processes will be possible.

Conclusion

These few examples demonstrate some of the potential benefits of a 10/20 dataset. The 10km resolution terrain is clearly capable of improved terrain forcing, e.g., the deflection of the low-level winds by Utah's south-central mountains. The examples also demonstrate the importance of analyzing model data near the same resolution as the model's computational grid. After the 96 Atlanta Olympics, the EMC plans to resume running the 10km nest over the West. Current plans call for a 60-level/10km operational Eta in 1998.

Acknowledgments: The author thanks Tom Black (NCEP) for providing information on the 10km nested Eta model.

References

Ray, P.S. (ed.), 1986: *Mesoscale Meteorology and Forecasting*, American Meteorological Society, Boston, MA, p. 726.

Staudenmaier, M.J., 1996: A Description of the Meso Eta model. Western Region Technical Attachment 96-06.

Swanson Jr., R.T., 1995: Evaluation of the Mesoscale Eta model over the Western United States. Masters Thesis, University of Utah, 113pp.

APPENDIX A. LIST OF CURRENTLY AVAILABLE 10/20 FIELDS

DESCRIPTION	LEVEL1	LEVEL2	VCRD	PARM
MSL pressure	0		NONE	EMSL
stream function	250		PRES	STRM
temperature	2		HAGL	TMPK
relative humid	2		HAGL	RELH
zonal wind	10		HAGL	UREL
meridional wind	10		HAGL	VREL
total precip	0		NONE	P00M
convective prec	0		NONE	C00M
large-scale prec	0		NONE	S00M
snow depth	0		NONE	SNDM
categorical snow	0		NONE	WXTS
ctgrcl ice pell	0		NONE	WXTP
ctgrcl frzg rain	0		NONE	WXTZ
ctgrcl rain	0		NONE	WXTR
sfc Lftd index	500	1000	PRES	LIFT
low cld cover	0		NONE	LCDC
medium cld cover	0		NONE	MCDC
high cld cover	0		NONE	HCDC
total cld cover	0		NONE	TCDC
sfc lftd index	9700	9900	SGMA	LIFT

APPENDIX B. ETA MODEL 10M WINDS VERSUS 1000MB WINDS

The 1000mb wind field has proved to be superior than the 10m wind field at showing the effects of terrain. The 10m wind field is derived from the lowest Eta level above terrain using an Ekman Boundary Layer assumption. Any low level constant-pressure-surface Eta wind field (including 1000mb) is derived by holding constant at a given grid point the wind vector from the highest model level above terrain. The 10/20 1000mb wind field was not available for this TA so 10m AGL winds were used.

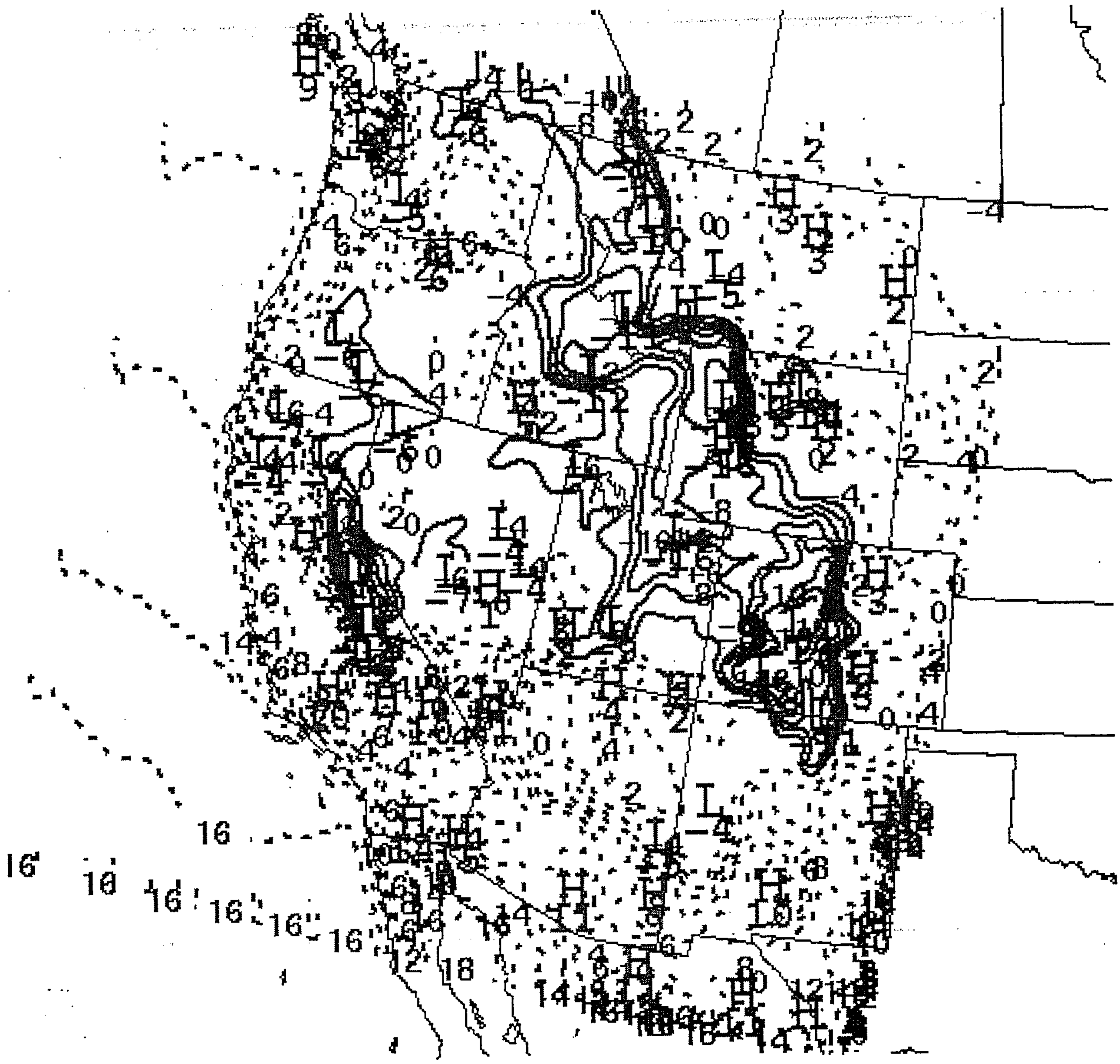


Fig. 1. 10km Western Nest 2m above ground level temperature field valid at 1200 UTC 20 Apr 96. The contour interval is 2 degrees C. Solid (Dashed) contours are negative (positive) values. The edges of the contours indicate the domain of the nested grid.

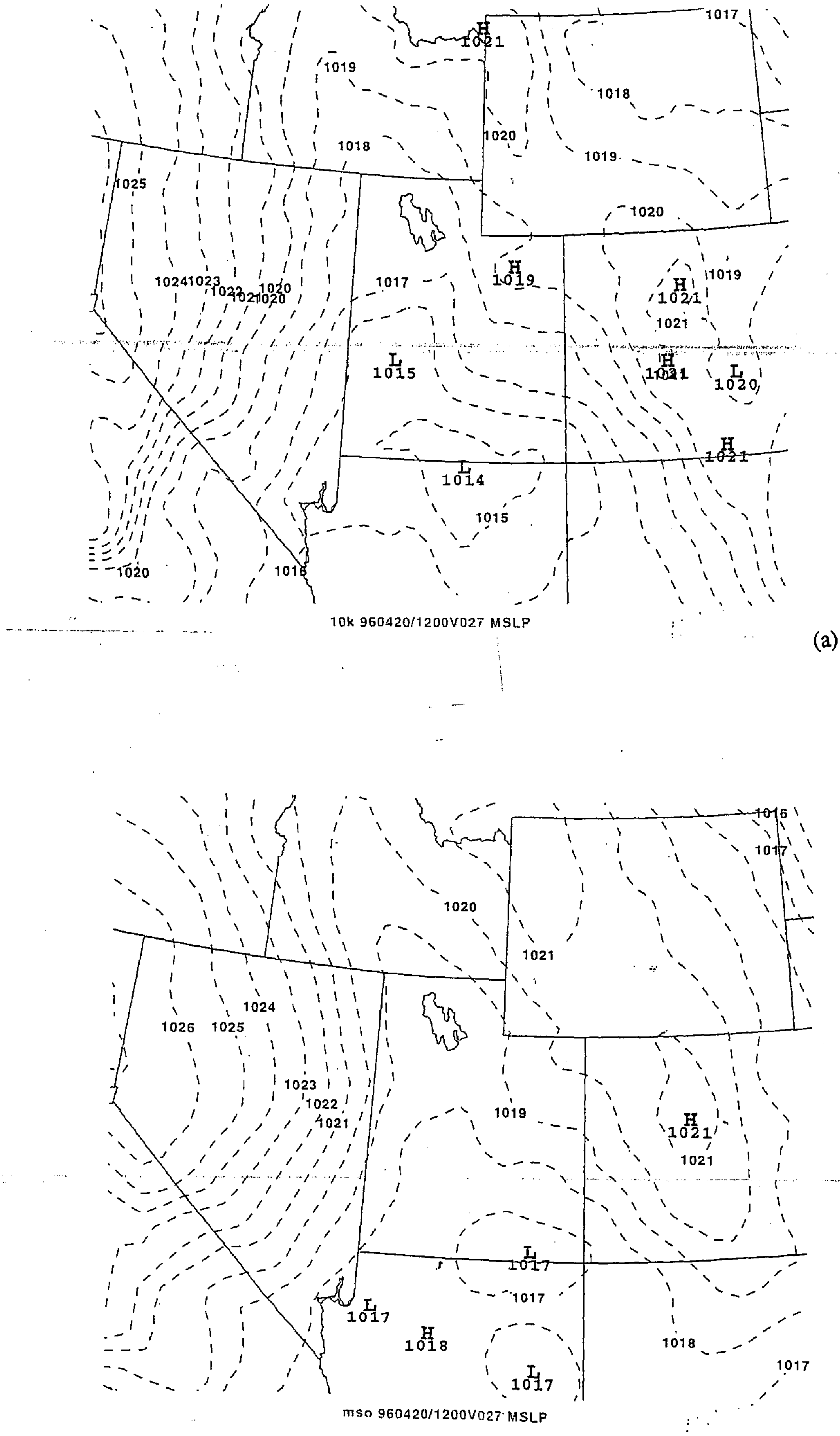
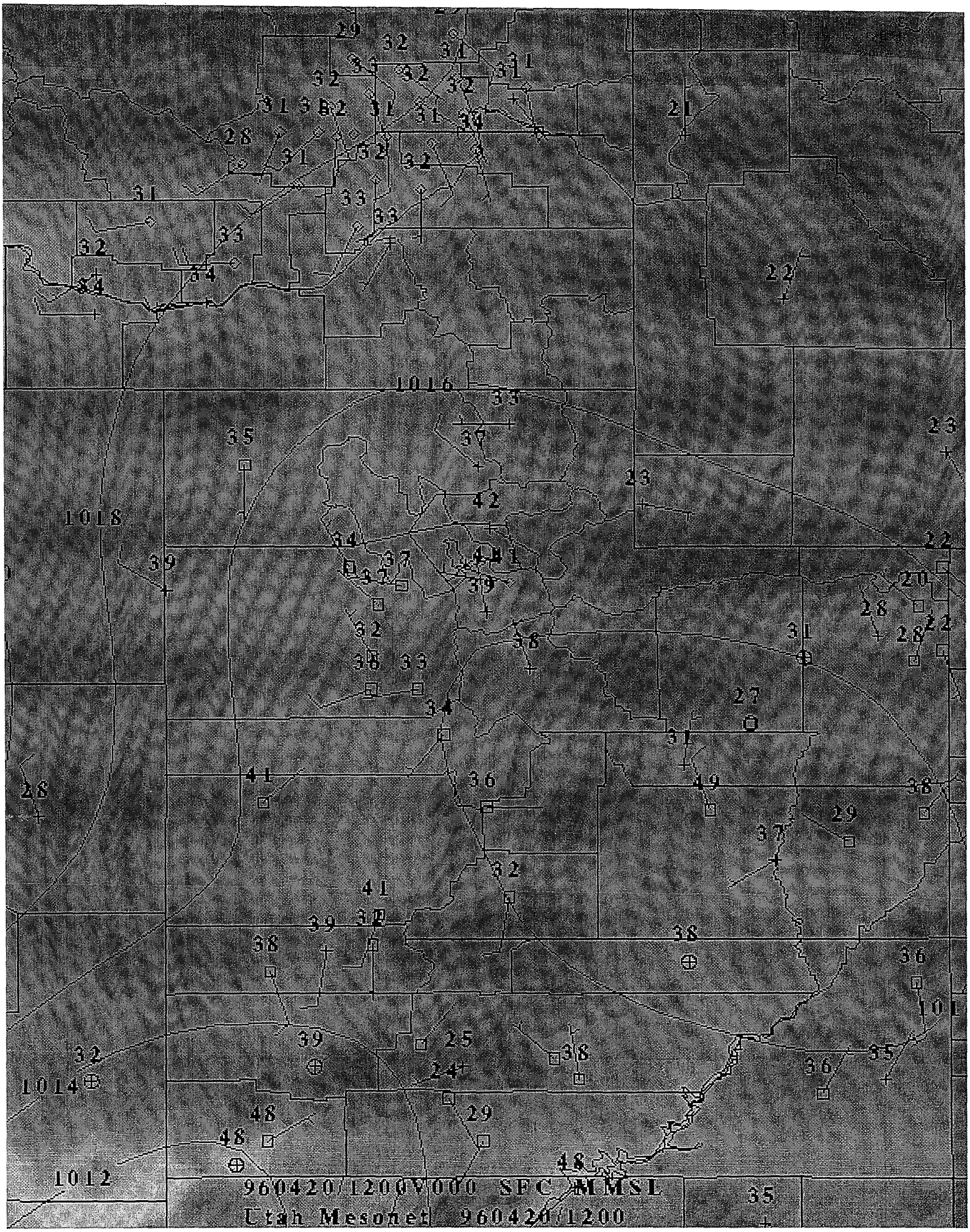
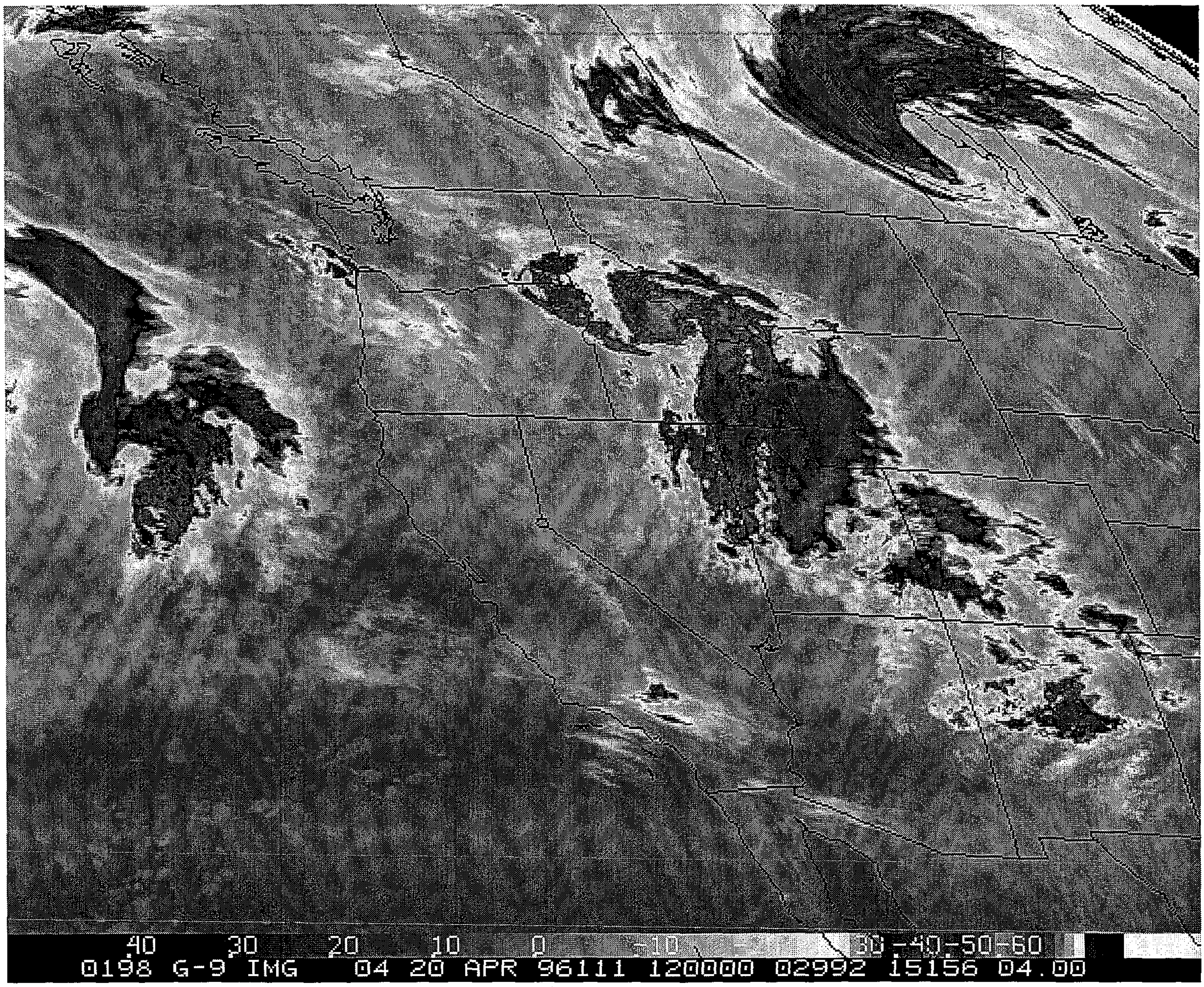
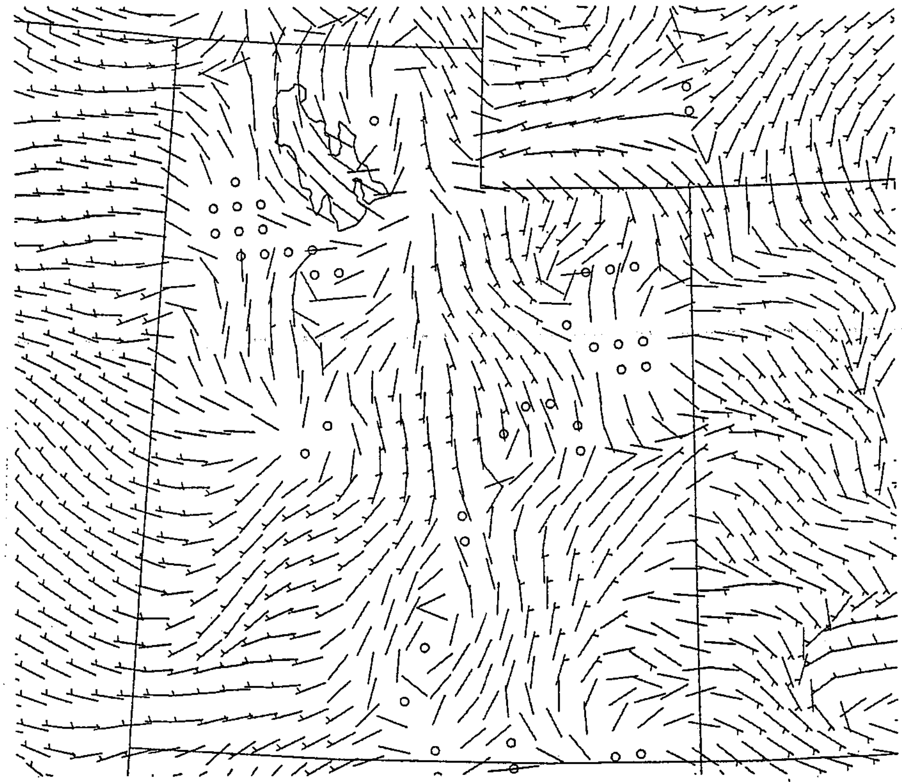


Fig. 2. 10km Western Nest Mean-Sea-Level Pressure field valid at 1200 UTC 20 Apr 1996 for (a) the 10km model output on the 20km AWIPS grid and (b) the 29km model output plotted on the 40km AWIPS-grid. The contour interval is 1mb.

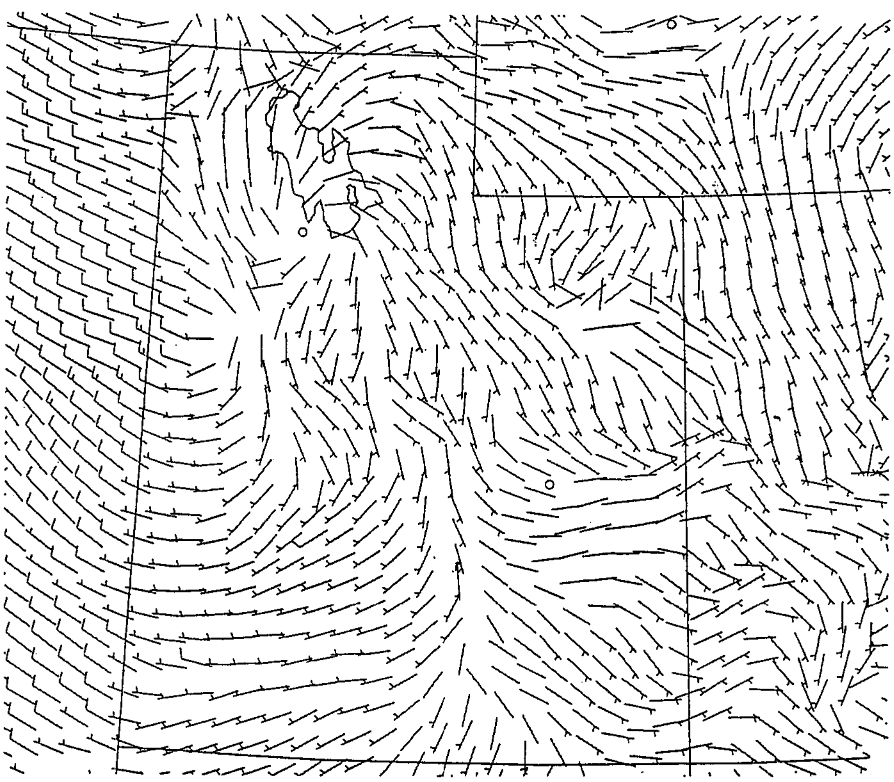
Fig. 3. Valid at 1200 UTC 20 Apr 96: (a) Utah Mesonet and (b) 4km IR Goes-9 Satellite image.




40 30 20 10 0 -10 30-40-50-60
0198 G-9 IMG 04 20 APR 96111 120000 02992 15156 04.00

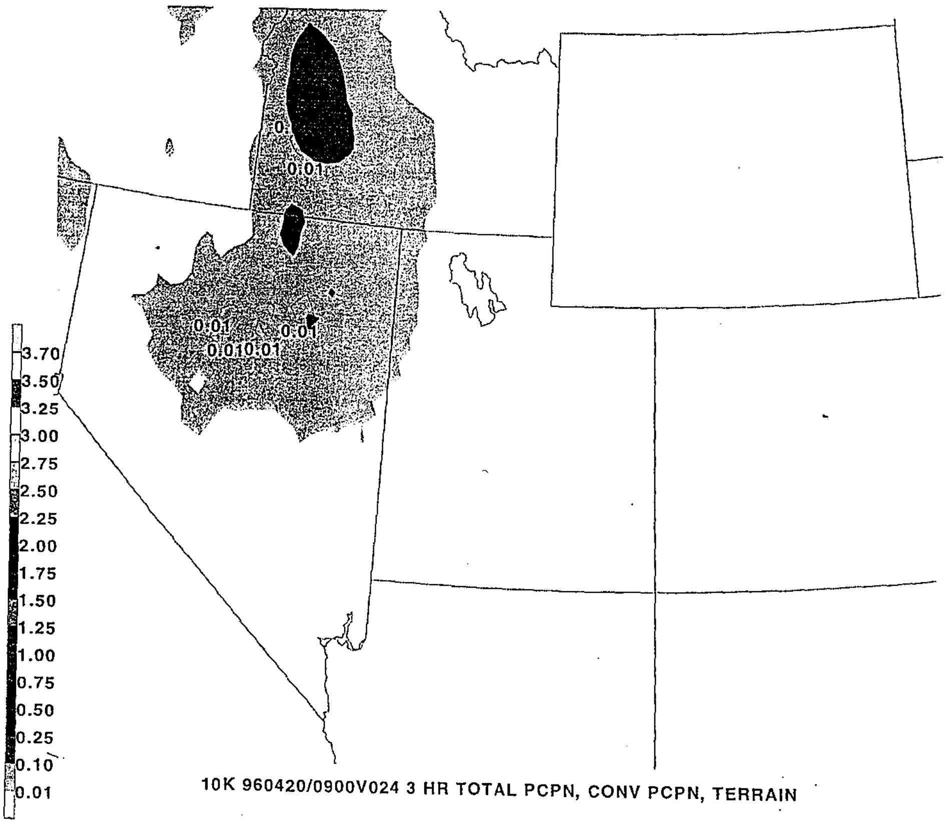


(a)

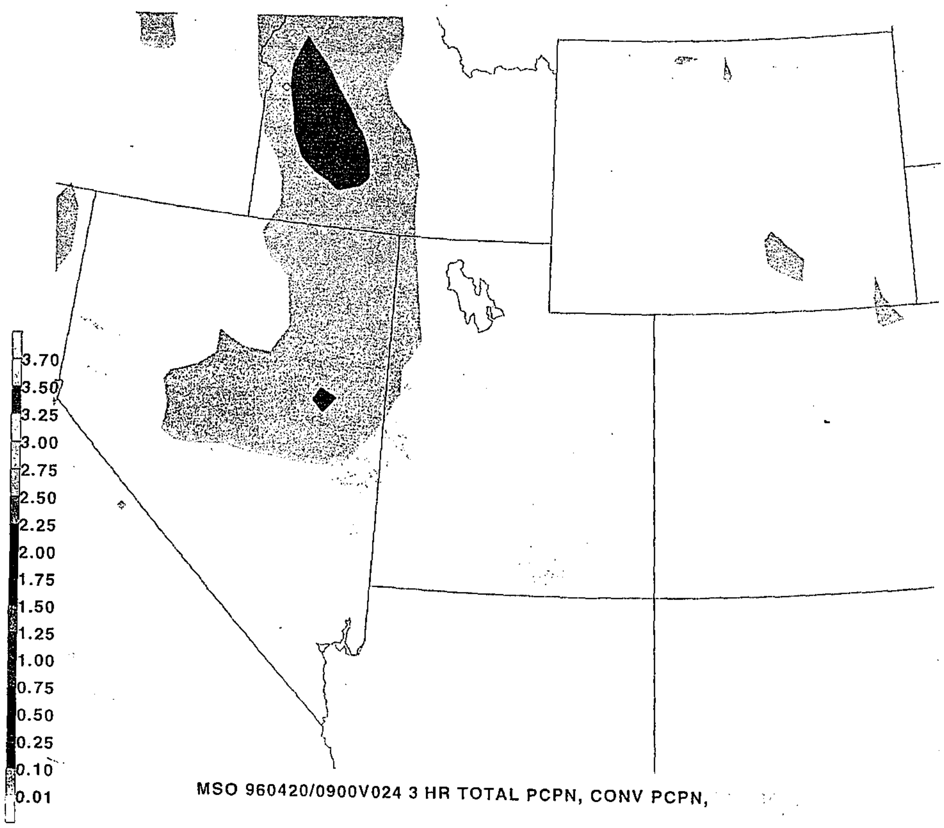


(b)

Fig. 4. 10m AGL model wind fields valid at 1200 UTC 20 Apr 96 on the 20km AWIPS grids for (a) 10km Eta output and (b) 29km Eta output. The forecast time is 27hr for (a) and 21hr for (b).

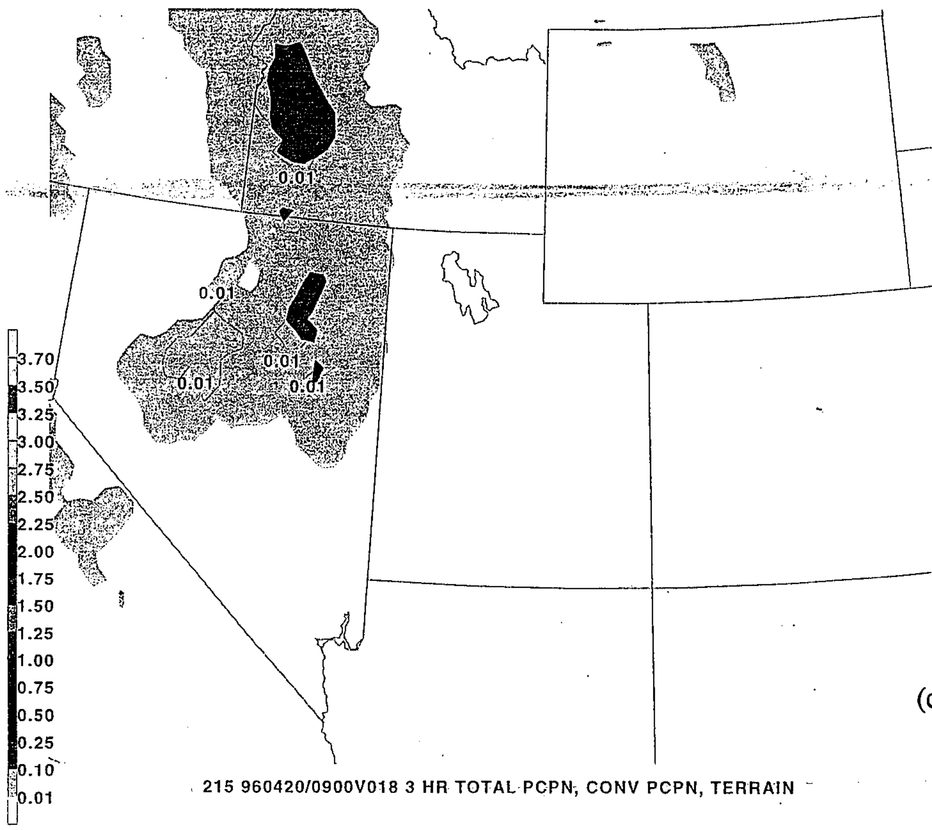


(a)



(b)

Fig. 5. Three hour precipitation totals valid at 1200 UTC 20 Apr 96 for (a) 10km Eta output on the 20km AWIPS grid; (b) 29km output on the 40km grid and (c) 29km output on the 20km grid. Forecast time is 24hr for (a) and (b) and 18hr for (c). Filled contours are grid-scale precipitation at .01 and .10 inch levels. Dashed contours are convective precipitation at .01 inch intervals.



215 960420/0900V018 3 HR TOTAL PCPN, CONV PCPN, TERRAIN