

Evaluation of the North American Regional Reanalyses over Complex Terrain: Examination of Grid Scale Precipitation and Downscaling to Higher Resolution

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Part I: Spurious Grid Scale Precipitation

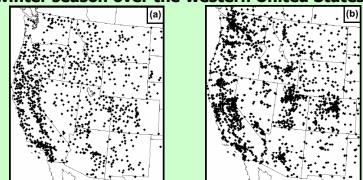
While developing a cyclone climatology for evaluation of the North American Regional Reanalysis (NARR), we discovered spurious grid-scale precipitation (SGSP) within the analysis domain on average ~370 times annually prior to 2003. Approximately 2000 SGSP events were found annually after 2003, even after an oceanic data processing error was corrected in the reprocessed analyses (West et al. 2006 http://www.met.utah.edu/jimsteen/SGSP_6.0.pdf).

SGSP occurs in many mesoscale numerical weather prediction models when the simulated atmosphere becomes convectively unstable and the convective parameterization fails to relieve the instability. In the NARR, most cases of SGSP are not caused by model shortcomings, but are caused by mismatches of the Eta 3h forecast and the assimilated precipitation data, resulting in anomalous latent heating, which in turn leads to grid scale instability and overturning.

Part II: Downscaling the NARR to Higher Resolution

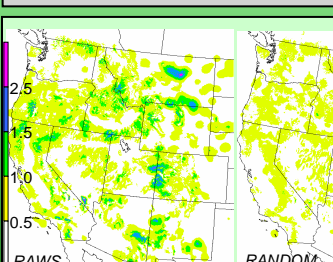
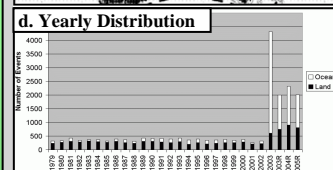
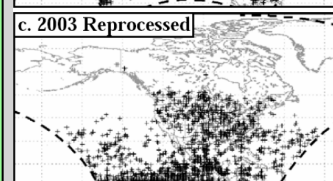
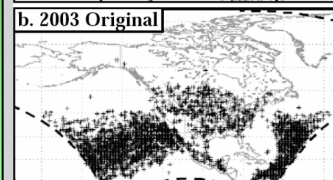
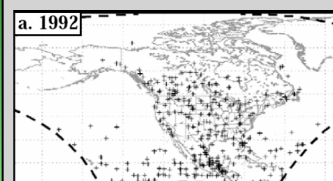
Development of high resolution (order 5 km) analyses is of considerable interest for many climate and weather applications. Methods are being investigated to downscale coarse resolution analyses to high resolution surface grids (e.g., Myrick et al. 2005, *Wea. Forecasting*). A prototype mesoscale analysis (the Real Time Mesoscale Analysis, RTMA) is now being generated by the National Centers for Environmental Prediction. Additional research is required to develop "Analyses of Record", i.e., the best possible analyses of the atmosphere at high spatial and temporal resolution to specify weather and climate (Horel and Colman 2005 *Bull. Amer. Meteor. Soc.*).

The NARR assimilate surface observations of pressure, wind, and moisture (no temperature) at first order stations only. The sensitivity of high resolution analyses to withholding sets of surface temperature observations has been examined for the 2003/2004 winter season over the western United States.



(a) Raws (land agency) (b) Other observations from MesoWest

Distribution of SGSP in the NARR



Sensitivity (°C) of the analyses to RAWs observations (left) and randomly withheld observations (right) during the 2003/2004 winter season

1979-2002

(a) ~370 SGSP events per year.

CMORPH Processing Error

(b) In January 2003, the NARR switched precipitation datasets over both land and oceans. A processing error with the oceanic data led to incorrect distribution/amounts of precipitation assimilated, which meant anomalous amounts of latent heat were also introduced into the model, causing widespread SGSP events.

2003-Present

(c) The processing error was corrected and the NARR was rerun for affected years, however, ~2000 SGSP events per year still occur in the 2003-present data.

(d) Yearly distribution of SGSP events shows the erroneous 2003 data and the marked increase in 2003. Also, pre-2003 events occur mostly over land, whereas post-2003 events are predominantly over the oceans.

Conclusions

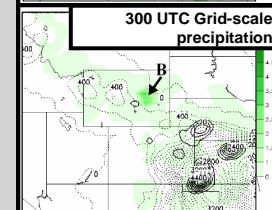
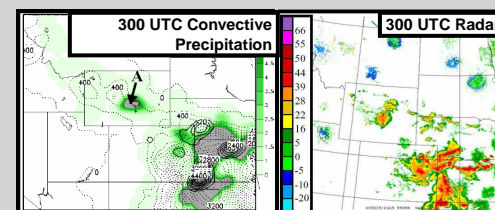
- Use the reanalyzed data after 2002
- Influence of SGSP likely to have little or no effect on long term means prior to 2003
- SGSP effects could be significant after 2002, especially for case studies of extreme events or automated searches for some types of extreme conditions

Conclusions

- Random withholding of observations from the analyses provides a baseline estimate of analysis quality
- Removing RAWs observations degrades analyses by an additional 0.5°C (0.9 m s⁻¹) when evaluated in terms of rmse over the entire season
- Temperature analyses were strongly affected during winter cold pools; wind analyses affected the most during active weather periods

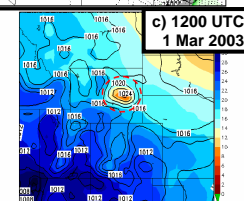
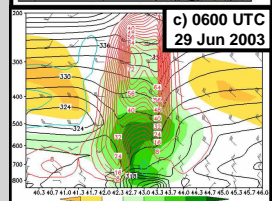
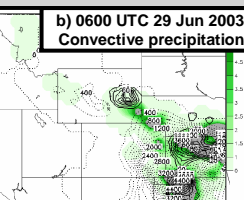
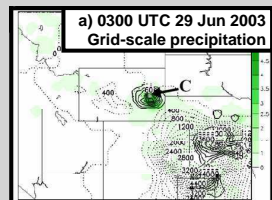
SGSP Example

-Antecedent Conditions



Precipitation produced by the convective parameterization at point A agrees with radar. Spurious area of gridscale precipitation is produced at point B, which develops into SGSP over the subsequent 3 h.

-Mature Conditions



(a,b) Virtually all precipitation is produced by the grid-scale scheme at point C. (c) SGSP features large vertical velocity maxima, sometimes >100 cm s⁻¹, locally high θ_e air, and relative humidity maxima. (d) SGSP is occasionally accompanied by low level cold pools and high pressure maxima resulting from sub-cloud evaporative cooling, which does not occur in convective parameterization. Precipitable water and low to mid-level vorticity maxima also usually exist (not shown).