Forecasting Minimum Temperatures for Dugway Proving Ground Using the 850 to 700mb Thickness

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The Beginning

• Objective: To develop a method to enhance the accuracy of forecasting minimum temperatures at Dugway Proving Ground

• The project basics
  • The forecaster will determine the overnight weather conditions
  • Enter the data into an application
  • A projected low temperature will emerge
Step 1

- Where did this project conception come from?
  - Mark Struthwolf *Forecasting Maximum Temperatures through Use of an Adjusted 850 to 700mb Thickness Technique*

- SAMS 01 (Ditto) determined to be the focus location
  - Data back to 1988
  - Main forecasting location

- Is a temperature and thickness correlation going to work for the minimum temperature?
The beginning

• Time period breakdown
  • Viewed weekly / bi-weekly / monthly / seasonally

• Where to get the sounding data from?
  • Elko (1608m) / DPG (1324m) / Salt Lake City (1288m)

• Sounding time? 00 UTC or 12 UTC?
  • 12Z was decided because it correlates best with the time of the minimum temperature

• Before I continued I wanted to make sure there was at least a minimal correlation
First Plots

- Scatter plots
  - Minimum temperature vs. 12Z 850 to 700mb thickness
  - Plotted by month & season (DJF, MAM, JJA, SON)

- SAMS 01 minimum temperature and corresponding days SLC 12Z thickness
- Statistically I decided to go with a time period of seasons

\[ y = 0.1593x - 213.9 \]
\[ R^2 = 0.2395 \]

\[ y = 0.1977x - 276.31 \]
\[ R^2 = 0.5819 \]
Applying variables

• Next step is separating out the variables
  • Clouds, wind, precipitation, etc.

• Wind: from SAMS 01 wind speed was averaged from sunset to sunrise for every day

• Precipitation: noted if any recordable amount fell between sunset and sunrise

• Clouds: IR Satellite data was viewed hour by hour between sunset and sunrise for every day

• Other: snow cover, wind direction, previous days high temperature
Applying Variables

- Variables were broken down accordingly
  - Wind speed: $X < 5\text{mph} / 5 < X < 10\text{mph} / X > 10\text{mph}$
  - Clouds:
    - Clear $< 3$ hours of clouds
    - $3$ hours of clouds $\leq$ Partly Cloudy $\leq 3$ hours of no clouds
    - Overcast $< 3$ hours of no clouds

- Other variables
  - Snow cover didn’t have a significant correlation
  - Wind direction didn’t affect the minimum temperature
  - No help from the previous days maximum temperature
  - Soil moisture did not have enough data
  - Inversion strength
Putting it all Together

• Individual scatter plots were created for each set of variables

• Obvious correlations occurred
Data Collection

• Data was collected for four years
  • Winter*: 450
  • Spring: 370
  • Summer: 360
  • Fall: 350
• Total number of data points: 1530
  *5 years of data collected

• Additional years will be added
Challenges

- Fog
- Any occurrence at DPG is recorded in a log book
- Does not include non-business days / hours
  - Viewed SLC & HIF observations
  - SAMS 01 relative humidity sensors

\[
y = 0.1328x - 186.31 \\
R^2 = 0.246
\]
Challenges

• Snow cover
  • Only recorded at DPG during the 18Z observation
  • Only recorded if amount is above 0.50 inch

• Used the NWS regional snow analysis for weekends and overnight
  • Data only archived back to 2003

• Bottom line
  • Snow cover was determined not to have a direct correlation with the thicknesses
Challenges

- Precipitation
  - Differences are both random and small
- Accounting for ± 1-2° F
- Virga?
- Winter precipitation an entirely different problem
- Snow melt

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<td>Sum: OVC &lt; 5 = 0.7066</td>
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<td>OVC = Overcast</td>
<td>Units of wind are MPH</td>
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Bottom line, precipitation is not be a mitigating factor
Challenges

• Season transition periods

• Examples
  1. 03/13/06: 1506 meters / partly cloudy / wind < 5mph
     Actual low = 8
     Spring forecasted low = 20
     Winter forecasted low = 12
  2. 03/05/06: 1549 meters / clear / wind < 5mph
     Actual low = 18
     Spring forecasted low = 24
     Winter forecasted low = 17

• How do you know when to use one season vs. another?
Challenges

- Extreme low temperatures
  - I separated the temperatures that fell below 5 °F
- Inversion strength?
  - Have not unlocked the key yet
- Is this the best method to deal with extreme low temperatures?
Verification

16 random points selected from 1998 / 1999

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<th>date</th>
<th>thickness Meters</th>
<th>clouds</th>
<th>winds MPH</th>
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<th>Actual Temp</th>
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</table>
How does a forecaster use this?

- First you have to forecast
  - The forecaster needs to know the overnight cloud and wind conditions

- Need the 850 to 700mb thickness

- What has the trend been for the last few days?

- Have an estimated temperature in mind before you use the application
Application

• This is the application that the forecasters use to input the forecasted conditions

![Application Interface]

- Select the season
- Enter the forecasted 650-700mb thickness at 12Z
- Select the overnight cloud conditions
- Select the overnight wind conditions

The forecasted minimum temperature is

The standard error is ±

The temperature and thickness correlation is
Model Output

- Currently, tracking the thicknesses
  - 4DWX - WRF virtual sounding tool
    - 11Z / 14Z / FA model runs
  - NSHARP - NAM
    - 12Z model run
  - U of Wyoming - SLC actual sounding data

- Preliminary results are positive
  - Model data seems to trend 2-5 meters lower than actual
Future/Current Work

• Adding more years of data
  • Statistically this will make the forecasts better

• Investigating the inversion strength
  • Relating to the outlying data points

• Continuing to verify model thickness outputs

• Distributing the application to other forecasters
Closing Points

• This is only meant as a tool for forecasters to use
  • If you don’t get the overnight weather conditions you are not going to have a successful forecast!

• DPG forecasters are currently using the application with proven success