“For every complex problem, there is a solution that is Simple, Neat, And Wrong.”

“H. L. Menken”
CBRFC AHPS PROJECT

A cooperative effort between:

[Logos for CIRES, NOAA-CIRES Climate Diagnostics Center, Colorado University of Colorado at Boulder, and CBRFC]
**Goals**

Introduce probabilistic 14 day meteorological forecasts (ensembles) into a river forecast system.

Capture and display the uncertainty.

Verify the process.
Method

Medium Range Forecast Model

Downscale to Model Variables

Mean Areal Temperature and Precipitation Ensembles

ESP Model

Probabilistic River Forecasts
Medium Range Forecast (MRF) Model

• Global Meteorological Model
• Many Atmospheric Variables
• Frozen Version
• Run Daily at CDC
• ~70km Spatial Resolution
MRF Spatial Resolution

WAY TOO LARGE!

Need to Relate to Basin...
Downscaling

**MRF Variables:**
- 2m air temp
- Precipitation
- 700mb Relative Humidity
- Sea Level Pressure
- 10m Vector Wind
- Total Column Precipitable Water

**Basin Scale Variables:**
- Mean Areal Temperature
- Mean Areal Precipitation
Downscaling Method

1. Relates historical MRF scale variable to historical basin scale variables through multivariate linear regression equations. For example:

   \[
   \text{Basin MAP} = a_1(MRF \text{ Precipitation}) + a_2(MRF \text{ wind}) + \ldots
   \]

2. Equations developed in (1) are applied to future MRF forecasts to produce forecasts of basin scale variables.

3. Multiple values at a particular time step are generated to create ensembles.
Downscaling Results

Example:
26 Ensembles of MATs for Each Sub-Basin
MRF is colder than normal in this case.
ESP Method

ESP uses initial states from the operational hydrological model along with ensembles of MAT/MAP as input.

Each ensemble is ran through the model.

Ensembles of streamflow are produced.

Ensemble distributions are analyzed and turned into probabilistic forecasts.
MRF derived MAT/MAPs are attached to historical years ("ensembles") and 'fed' to ESP.
Input into ESP

MRF derived MAT/MAPs related to the entire year of historical ensembles.
Schematic of Using Ensembles from MRF (day 1-14) As Input to ESP

Days 1-14

Ensembles From The ‘Frozen’ MRF

Blending/Attachment

Days 15-365

Ensembles From Historical Data
Week 1        Week 2                     Week 3 – 4                  APR-JUL

Instantaneous Flow: 6 hour time step
Volume
Peak
Various Probabilities

Volume
Peak
Various Probabilities

Seasonal Volume
Seasonal Peak
Various Probabilities

Information We Will Verify
Project Area: 27 Segments Above Cameo, Colorado River

All recently recalibrated and set up for ESP.
## RUN ESP – EACH BASIN – TWO WAYS – EACH DAY

<table>
<thead>
<tr>
<th>Week 1</th>
<th>Week 2</th>
<th>Weeks 3-52</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>HISTORICAL ENSEMBLES OF MAPS/MATS – NOT WEIGHTED BY CPC FORECASTS</strong></td>
<td></td>
<td></td>
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</tbody>
</table>

| 2      |         |            |
| **MRF ENSEMBLES OF MAPS/MATS** | **HISTORICAL ENSEMBLES OF MAPS/MATS – NOT WEIGHTED BY CPC FORECASTS** |

### Future Plans

| 3      |         |            |
| **MRF ENSEMBLES OF MAPS/MATS** | **WxGEN ENSEMBLES OF MAPS/MATS – WEIGHTED BY DOWNSCALED CPC FORECASTS** |

| 4      |         |            |
| 1-5 day HPC | 1-10 day TA CPC | **HISTORICAL ENSEMBLES OF MAPS/MATS – WEIGHTED BY CPC FORECASTS** |

| 5      |         |            |
| **MRF ENSEMBLES OF MAPS/MATS** | **HISTORICAL ENSEMBLES OF MAPS/MATS – WEIGHTED BY CPC FORECASTS** |
ESP flow time series

Exceedence Probabilities MRF and Historical for 02-21 for GBYC2H_F

Six hour instantaneous flow values at six probability levels are saved.
Web Page Example

Probabilities from ESP (shaded) Using Historical MAPs and MAPs Equally Weighted Plotted with Deterministic Forecast and Historical Exceedance Values
Web Page Example

Probabilities from ESP (shaded) Using Historical MAPs and MAPs
Equally Weighted and ESP (lines) Using Maps And Mats Derived from The MRF Ensembles Plotted with Deterministic Forecast and Historical Exceedance Values
ESP peak flow

Smaller peaks because MRF is colder for first 14 days causes less melt.
Smaller volumes through week 4 due to “banking” of water in colder than normal period leads to larger April – July volume.
Future Plans

Use Statistical Weather/Climate Generator In Lieu of Historical Ensembles

Use Experimental Technique to Downscale CPC Forecasts/Apply to Historical and WX/Generator

Use Finer Grid MM5 Forecasts to Produce Downscaled MAPS/MATs

Investigate Downscale Errors – Lumps or Points
Information We Will Save In Relational Table-PRIME Key Fields

Location/Station ID
PEDTSEP
Type of units for analysis window
number of units for analysis window
creation date time
beginning date time or window
carryover date time
carryover group
probability distribution
weighting scheme
blend future precipitation initial weight
blend future precipitation hours of weighting
blend future precipitation final weight
blend future precipitation number of days of blending
blend future temperature initial weight
blend future temperature hours of weighting
blend future temperature final weight
blend future temperature number of days of blending historical data type
historical time step
beginning year of historical data
ending year of historical data