Verification of forecasts of weather phenomena

Problems and issues

Mike Baldwin
Purdue University
Department of Earth and Atmospheric Sciences
Making verification more meaningful

- Evaluate forecast realism
  - Realistic variability, structure of fields
  - Do predicted events occur with realistic frequency?
  - Do characteristics of phenomena mimic those found in nature?

- Traditional objective verification techniques are not able to address these issues
Traditional verification measures for these forecasts

<table>
<thead>
<tr>
<th>Verification Measure</th>
<th>Smooth forecast</th>
<th>Detailed forecast</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean absolute error</td>
<td>0.157</td>
<td>0.159</td>
</tr>
<tr>
<td>RMS error</td>
<td>0.254</td>
<td>0.309</td>
</tr>
<tr>
<td>Bias</td>
<td>0.98</td>
<td>0.98</td>
</tr>
<tr>
<td>Threat score (&gt;0.45)</td>
<td>0.214</td>
<td>0.161</td>
</tr>
<tr>
<td>Equitable threat score</td>
<td>0.170</td>
<td>0.102</td>
</tr>
</tbody>
</table>
Subjective verification
Characterize the forecast and observed fields

- Verify the forecast with a similar approach as a human expert might use to visualize the forecast/observed fields
- Characterize features, phenomena, events, etc. found in forecast and observed fields by assigning *attributes* to each *object*
- Not an unfamiliar concept:
  - “1050 mb high”
  - “category 4 hurricane”
  - “F-4 tornado”
“1-2-3 rule”
“1-2-3 rule”
Other phenomena 1-14 day forecasts

- winter storms
- mesoscale convective systems
- heat waves
- droughts
- extended wet periods
- upper level pattern shifts
Terminology

• Objects
  – Things you wish to analyze
  – *Individuals, cases, subjects, entities, phenomena*

• Attributes
  – Descriptions of the objects
  – *Variables, features, descriptors, characteristics, properties*
Studies of specific phenomena

- Identification
Studies of specific phenomena

- Identification
- Characterization

Size = 200000 km$^2$
\[Elongatedness = 5.1\]
\[Symmetry = 0.9\]

Size = 160000 km$^2$
\[Elongatedness = 4.3\]
\[Symmetry = 0.4\]
Studies of specific phenomena

- Identification
- Characterization
- Comparison

Degree of similarity between these two objects = 0.86
Studies of specific phenomena

- Identification
- Characterization
- Comparison

Degree of similarity between these two objects = 0.59
Studies of specific phenomena

- Identification
- Characterization
- Comparison
- Cluster

These objects belong to the Linear MCS class
Object identification

• Image segmentation
  – Locate homogeneous regions within an image

• A couple of ways of doing this
  – Thresholding
  – Cluster analysis
  – Edge detection
  – Texture analysis

• Image processing
Many possible ways to characterize phenomena

- Shape, orientation, size, amplitude, location
- Flow pattern
- Subjective information (confidence, difficulty)
- Physical processes in a NWP model
- Verification information can be stratified using this additional information
Obstacles

• Data availability - high-resolution data assimilation
• Object identification and definition very user-specific
• How to distill the huge amount of verification information into meaningful “nuggets” that can be used effectively?
• What happens when conflicting information from different verification approaches is obtained?
Decision support

• How do we incorporate verification information into decision support systems?