Evidence suggests that spatial skills are highly malleable and that training in spatial thinking is effective, durable, and transferrable. Understanding how meteorologists employ spatial skills in the forecasting process has implications for operational weather forecasting and meteorology education. This study began with exploratory research that identified mental animation and disembedding as key spatial skills used in weather forecasting. A follow-on pilot study tested the instruments, collected think-aloud data and found a correlation between spatial skills and forecasting. The complete study, in progress, is investigating the effect of spatial thinking, working memory and expertise on forecast task performance.

**Research questions:**
1. What are the primary spatial skills used by meteorologists?
2. How do experts and novices use spatial skills differently?

**Methods**

**Sample**:
- 25 undergraduate meteorology students, 12 graduate meteorology students, and 50 professional meteorologists. N = 93.

**Data collection**:
- Survey data were collected at the annual meeting of the American Meteorological Society, January 2016, followed by online administration in Spring 2016.

Participants were introduced to 6 spatial skills described in the literature and interacted with 9 charts from a weather event in 2015. Examples:

- Mental animation: Developing a plausible scenario of a sequence of events based on static information (e.g., which direction will the last gurn group when the string is pulled?).

Results:

<table>
<thead>
<tr>
<th>Percent of sample reporting using each spatial skill by image</th>
<th>Undergraduate</th>
<th>Graduate</th>
<th>Professional</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mental Animation</td>
<td>48.0%</td>
<td>46.8%</td>
<td>46.8%</td>
</tr>
<tr>
<td>Mental Rotation</td>
<td>34.7%</td>
<td>18.4%</td>
<td>18.4%</td>
</tr>
<tr>
<td>Disembedding</td>
<td>55.3%</td>
<td>85.3%</td>
<td>85.3%</td>
</tr>
<tr>
<td>Perspective Taking</td>
<td>70.4%</td>
<td>70.4%</td>
<td>70.4%</td>
</tr>
<tr>
<td>Object Location</td>
<td>72.4%</td>
<td>72.4%</td>
<td>72.4%</td>
</tr>
<tr>
<td>Spatial thinking</td>
<td>63.3%</td>
<td>79.6%</td>
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</tr>
</tbody>
</table>

**Participants responded yes or no to “Did you use this type of spatial thinking?” after interpreting each weather image, producing a total of 54 data points for each participant.**

### Results

**Analysis of verbal think-aloud data align with findings from the exploratory study: novice meteorologists made superficial interpretations of the plots without attempting to conceptualize spatial representations. Initial process models:**

- Novices: surface plot, 850 mb chart, 500 mb chart, 300 mb chart, base map
- Experts: 300 mb chart, 500 mb chart, 850 mb chart, surface chart, base map

**Results of linear regression predicting performance on forecast task:**

<table>
<thead>
<tr>
<th>Variable</th>
<th>β</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spatial thinking score</td>
<td>.685</td>
<td>3.622</td>
<td>&lt;.005</td>
</tr>
<tr>
<td>Expertise score</td>
<td>.613</td>
<td>3.241</td>
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</tr>
</tbody>
</table>

*Both spatial thinking ability and expertise positively predicted performance on the forecast task, F(2, 14) = 9.694, p < .005, n = 14.

**Potential Implications**

The purpose of this research is to understand the cognitive underpinnings of weather forecasting. This is motivated by a desire to improve atmospheric science education broadly and weather forecaster training specifically, including multiple operational meteorology forums and training pipelines. The overall goal is to improve student learning and the ongoing training of the current and future weather forecasting workforce.

**Methods**

**Sample**:
- Anticipated 60 total comprised of students and faculty in university meteorology programs along with operational meteorologists at National Weather Service offices.

**Data collection**:
- Ongoing through Fall 2017.

In addition to spatial thinking tests, participants are completing a matrix span test of working memory, expertise survey and meteorology concept inventory. Scores will be used in regression analysis to evaluate their effect on forecasting skill and to test for interactions. A process model developed from verbal protocol data will describe processes used by novice and expert forecasters. Example:

**Proposal**

- Spatial thinking and cognitive processing in meteorology
- Understanding how meteorologists employ spatial skills in the forecasting process has implications for operational weather forecasting and meteorology education.
- This study began with exploratory research that identified mental animation and disembedding as key spatial skills used in weather forecasting.
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**Research questions:**
1. What do experts and novices use spatial skills differently?
2. What do experts and novices use in conjunction with working memory, domain knowledge, spatial relations, and expertise during weather forecasting?

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