Recent Developments in Operational Climate Prediction

Edward O’Lenic
Chief, Operations Branch
NOAA-NWS-Climate Prediction Center
Chair: AMS Committee on Climate Services
November 17, 2011
Outline

• Sources & Nature of Climate Variability
• The Making and Meaning of the Forecasts
• Relative Accuracy (skill) of Forecasts
The main function of the weather-climate system is to erase differences in temperature and density caused by seasonal and regional variations in solar heating.
Where Forecasts Come From

- **NATURAL HAZARD**
  - **PUBLIC NEED**
  - **SCIENCE & MODELS**
    - **RESEARCH, INT’L COLLAB**
  - **NOAA SCIENCE AND OPERATIONS INFRA-STRUCTURE**
    - **KNOWLEDGE**
      - **PRACTICAL APPLICATION**
        - **OPERATIONS, BIG COMPUTERS**
  - **PUBLIC FORECASTS/DECISION SUPPORT SERVICES**
Events on short time scales (weather) are related to longer-lived events (climate).
Sources of Predictability: Weeks → Years

- Tropical ocean temperatures drive low-frequency variability
- Trend (Court (1967), Huang et al (1996))
- Linear Statistics (Barnston, 1994)
- Ocean-Land-Atmosphere (van den Dool (2006))
- Pacific Decadal Mode (PDO) (Hare, 1997)
- 30-60-Day Tropical Mode (MJO) (Madden, Julian, 1994)
- Dynamical model-derived signals (Saha et al, 2006)
The Walker Circulation: Weaker=El Nino, Stronger=La Nina
ONI: AN INDEX OF ENSO STATUS

The Oceanic Nino Index (ONI) is the 3-month average Nino 3.4 value. The most recent ONI value (August – October 2011 average) is -0.4°C.
El Nino

La Nina
Near- and Long-Trends and Prediction

- Short-term trends over the last 10-15 years work very well, until they change.
- Long-term trends:
  - Precipitation time series is non-stationary
  - Temperature is rising rapidly
  - CO2 concentration is ~400 ppm, ~ 150 ppm higher than the prior 650K years.
  - The absolute moisture content of the atmosphere is rising.
  - We are currently in a relatively wet period, relative to 1250-1800 or so.
Feb-Mar-Apr
La Nina
Snow
Composites

Feb-Mar-Apr
La Nina
Temperature
Composites

Feb-Mar-Apr
La Nina
Precipitation
Composites
Dynamical Model Forecast: NCEP CFS Nino 3.4 Sea Surface Temperature Forecast 13 Nov 2011

Dec-Jan-Feb 2011/2012

Jan-Feb-Mar 2012

Feb-Mar-Apr 2012

The CFS ensemble mean=dashed line
Dealing with Uncertainty at CPC: Skill Masking

Canonical Correlation Analysis (regression) temperature forecast at stations, in units of 1/10 standard deviation.

Font size indicates 4 Categories of skill:

“+” ~ 0.3>AC

“8” ~ 0.3≤AC≤0.44

“8” ~ 0.45<AC<0.59

“8” ~0.6≤ AC

AC = Anomaly Correlation

Source: NOAA-NWS-Climate Prediction Center
CPC Probabilistic Forecasts

1-Week Total Precipitation Forecast for November 21-27

1-Month Total Precipitation Forecast for November

3-Month Total Precipitation Forecast for Nov-Dec-Jan

8-14-Day Forecast, Made Daily

1-Month Forecast, Made 2x / Month

3-Month Forecast, Made 1x / Month

10% 33.3% 66.7% 90%

B N A

MADE 20 OCT
MADE 31 OCT
MADE 13 NOV

3- Month Total Precipitation Forecast for Nov-Dec-Jan

1-Month Total Precipitation Forecast for November

1-Week Total Precipitation Forecast for November 21-27

Ed O’Lenic, ASCE Conference, November 17 2011
Anomaly (Inches) of the Mid-value of the 3-Month Precipitation Outlook Distribution for DJF 2011–12

Dashed lines are the median 3-month precipitation (inches) based on observations from 1981–2010. Shaded areas indicate whether the anomaly of the mid-value is positive (green) or negative (brown) compared to the 1981–2010 average. Non-shaded regions indicate that the absolute value of the anomaly of the mid-value is less than 0.1. For a given location, the mid-value of the outlook may be found by adding the anomaly value to the 1981–2010 average. There is an equal 50–50 chance that actual conditions will be above or below the mid-value. Please note that this product is a limited representation of the official forecast, showing the anomaly of the mid-value, but not the width of the range of possibilities. For more comprehensive forecast information, please see our additional forecast products.
PRECEPITATION OUTLOOK FOR DJF 2011–12
1.5 MONTH LEAD OUTLOOK - MADE October 20 2011
Climate Division 6 (Ohio)

Point forecast: 8.33''
Anomaly: .49''
Normal (center): 7.84''
25%: 60.3
Skew: .85
Median: 7.56''
50% conf interval: 7.19'' to 9.56''
90% conf interval: 5.69'' to 11.48''

WARNING:
The upper 3% and lower 7%
(i.e. <7%, >93%) of each
curve have particularly high
uncertainty; use cautiously.

Note: If there is no black line,
final forecast and the normal
condition are the same.

Prob of highest 10% (above 10.39''): 13.5%
Prob of above normal (above 8.68''): 42.7%
Prob of near normal (7.06 to 8.68''): 34.6%
Prob of below normal (below 7.06''): 22.7%
Prob of lowest 10% (below 5.69''): 4.8%

Center: 7.38 Mean: 8.01 Median: 8.15
Anomaly of 15 year center: -.46''
Anomaly (deg F) of the Mid-value of the 3-Month Temperature Outlook Distribution for DJF 2011–12

Dashed lines are the median 3-month temperature (degrees F) based on observations from 1981–2010. Shaded areas indicate whether the anomaly of the mid-value is positive (red) or negative (blue) compared to the 1981–2010 average. Non-shaded regions indicate that the absolute value of the anomaly of the mid-value is less than 0.1. For a given location, the mid-value of the outlook may be found by adding the anomaly value to the 1981–2010 average. There is an equal 50–50 chance that actual conditions will be above or below the mid-value. Please note that this product is a limited representation of the official forecast, showing the anomaly of the mid-value, but not the width of the range of possibilities. For more comprehensive forecast information, please see our additional forecast products.
MEAN TEMPERATURE OUTLOOK FOR DJF 2011–12
1.5 MONTH LEAD OUTLOOK – MADE October 20 2011
Climate Division 15 (Northern Minnesota)

Point forecast: 9.01 °F
50% conf interval: 6.00 °F to 12.01 °F
Anomaly: -1.57 °F
90% conf interval: 1.68 °F to 16.34 °F

Confidence: Shift direction: Contraction
Integrated: 1.78 Fail + .97 Lo + .18 Fail

Prob of highest 10% (above 16.44 °F): 4.8%
Prob of above average (above 12.55 °F): 21.3%
Prob of near average (8.61 to 12.55 °F): 32.2%
Prob of below average (below 8.61 °F): 46.4%
Prob of lowest 10% (below 4.72 °F): 16.8%

Center: 10.01 Mean: 10.01 Median: 10.38
Anomaly of 10 year center: -0.57 °F

WARNING:
The upper 7% and lower 3%
(i.e. <7%, >93%) of each
curve have particularly high
uncertainty; use cautiously.

Note: If there is no black line,
final forecast and the normal
condition are the same.
DJF Temperature Distribution for Climate Div. #015

El Nino

Neutral

La Nina

Temperature (°F)
SKILL: A RELATIVE MEASURE OF PERFORMANCE

Skill = \frac{\# \text{ Forecasts Correct} - \# \text{ Correct by chance}}{\# \text{ Forecasts, Total} - \# \text{ Correct by chance}}

Skill = \text{Fractional Improvement by forecast over random}

−1 \leq Skill \leq 1 \text{ for a 2-class (Above, Below only) system.}

−0.5 \leq Skill \leq 1 \text{ 3-class (Above, Normal, Below) system.}
Tropical ocean temperatures drive low-frequency variability.

El Nino, La Nina, PDO, MJO are nominally predictable.

Statistical and dynamical models are used.

Uncertainty in observations, models, and the chaotic nature of the atmosphere lead to probabilistic forecasts...

Which have some accuracy, relative to random.

Most applications focus on energy trading, and extreme event impacts.