Utilizing Ensemble-based Anomalies to Anticipate Significant Events – A New Display Tool

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Overview

- Project background

- **GEFS anomalies compared to analyzed departures for Jan 2010 event**

- Situational Awareness Table
  - Using anomalies from an EFS

*Image courtesy KSL*
Project Background

• **Began as companion to Hart and Grumm (2001)**
  - Most anomalous events in western U.S. (1948-2006)
  - Anomaly return periods

• **Global Reanalysis (GR) climatology (1971-2000)**
  - Time of year variability (21-day running mean)
  - Temps, Heights, U- and V-wind, Wind Magnitude, Specific Humidity, MSLP, PW

• **Compare GEFS Mean to NCEP GR data**
  - Standard Deviations (SD) from climo
  - Reanalysis is 2.5° x 2.5° resolution
  - GEFS ~70 km (remapped to climo grid)

• **Synoptic scale anomalies**
  - Will NOT identify all high impact/significant events
  - Large anomalies FREQUENTLY associated with significant events

Flooding in Zion NP – Dec 2010
That was an anomalously good forecast...

- **January 3rd-8th, 2008** –
  - Massive western storm
  - Significant wind event
  - Up to 11 feet of snow in the Sierras

- **October 13th-14th, 2009**
  - Record California heavy rain event
  - Mudslides and flooding

- **January 19th-24th, 2010**
  - Significant western U.S. winter storm
  - Record setting precipitation event
  - Significant severe weather in southern CA and AZ (1st AZ TOR Watch since '93)
Jan 2010 - Heavy Rain and Flooding

- Rainfall amounts of 5-10” on favored slopes of Mogollon Rim
  - 2-4” in the lower elevations
  - Significant flooding
  - Numerous swift water rescues

- 40-60+ inches of snow above 7k feet in northern AZ (locally 90+)
  - Blizzard conditions across northern AZ
  - Significant roof damage in Flagstaff AZ
  - Food/water shortage and loss of basic services on Navajo and Hopi Res

- AZ set all-time 24-hour snowfall record (48” Sunrise Mountain)

Felicia Fonseca – AP
GEFS 700 hPa V-Wind and PW Anomalies

- **V-Wind Anomalies**
  - Day 7 - +2-3 SD
  - Day 5 forward - +3-5 SD into the rim

- **Precipitable Water Anomalies**
  - Day 7 - +2-3 SD
  - Day 5 forward - +3-4 SD
    - Magnitude a bit underdone

- **Significant PW anomalies coincident with large v-wind anomalies**
- Known heavy precipitation pattern
A New Champion…

- MSLP anomaly was the greatest in the Global Reanalysis (1948-2010)

- Anomaly of -8.7 broke previous record of -8.172 Columbus Day Storm 1962
  - GEFS forecast -7 SD anomaly at 114 hours and -8 SD anomaly by 60 hours

- Numerous all-time minimum pressure records set across the west
  - Los Angeles, San Diego, Fresno, Salt Lake City, Reno, Las Vegas, Phoenix, Flagstaff etc.
Data Overload...

- **Anomalies can provide a head’s up that something exceptional may happen**

- **Large volume of data (~1200 images each cycle)**
  - Unable to comb through this amount of data
  - Don’t need to interrogate every day
  - Need a way to draw our attention to important data

- **How do we identify which fields and levels we should look at?**
Anomaly Situational Awareness Table

- **New assessment approach**
- Quickly interrogate large volume of data
- ID elements/levels that require closer investigation
- Provide awareness of potentially significant or unusual event
- Early identification
- Potential to improve Decision Assistance
- Provide historical perspective

- **9 Domains available**
- Covering all of CONUS and Alaska

http://go.usa.gov/21i

5th NCEP Ensemble User Workshop - 9 May 2011
Anomaly Table - Functionality

- Displays largest anomaly for each element and time step in domain
  - Mouse-over to see level of greatest departure

- Table colors mirrored for pos/neg anomalies for simplicity

- Click on anomaly value to see images for that variable and time step in bottom frame
  - Click on bottom frame images to zoom

- Click on element to see grid
  - Display levels by forecast hour

http://go.usa.gov/21i
The table below shows anomalies for the Jan 2010 Event.

### Southwest Table: January 2010 | 12z run

|        | 0  |  6 | 12 | 18 | 24 | 30 | 36 | 42 | 48 | 54 |  60 |  66 |  72 |  78 |  84 |  90 |  96 | 102 | 108 | 114 | 120 | 126 | 132 | 138 | 144 | 150 | 156 | 162 | 168 | 174 | 180 |
|--------|----|----|----|----|----|----|----|----|----|----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Height | -5.4 | -5.5 | -5.4 | -6.0 | -7.3 | -8.1 | -8.2 | -7.4 | -6.7 | -5.3 | -4.8 | -4.2 | -4.1 | -3.7 | -3.1 | -2.5 | -2.4 | -2.8 | -2.6 | -3.0 | -2.9 | -2.5 | -2.5 | -2.3 | -2.0 | -2.5 | -1.7 | -2.0 | -1.4 | -1.4 | -1.4 |
| Temp   | 3.8 | 4.2 | 4.7 | 4.4 | 4.3 | -4.5 | -4.7 | -4.7 | -4.5 | -4.1 | -3.5 | -4.0 | 4.6 | 4.5 | 4.1 | 3.8 | 3.8 | 3.5 | 3.4 | 3.2 | 2.8 | 2.3 | 2.0 | 1.7 | 1.4 | 1.2 | -1.5 | -1.4 | 1.5 | -1.5 | 1.8 |
| U-Wind | 4.0 | 4.3 | 4.4 | 5.0 | 5.6 | 6.4 | 5.8 | 6.5 | 6.5 | 6.0 | 5.2 | 4.7 | 5.5 | 3.6 | 3.5 | 3.4 | 3.1 | -2.2 | -2.7 | -2.3 | 2.5 | 1.7 | 2.1 | -1.9 | -2.0 | 1.7 | 2.0 | 1.6 | 2.0 | 1.7 | 1.8 |
| V-Wind | 4.1 | 5.0 | 5.0 | 5.2 | 6.1 | 7.3 | 8.6 | 8.4 | 7.4 | 7.0 | 4.7 | 4.3 | 2.9 | -2.7 | -2.6 | -3.6 | -3.4 | -3.4 | 2.2 | -2.7 | -2.6 | 2.3 | -2.1 | -1.6 | -1.9 | -2.2 | -2.4 | -2.2 | -2.1 | 2.0 |
| SHum   | 2.7 | 2.3 | 2.5 | 2.6 | 3.0 | 3.4 | 3.7 | 3.4 | 4.3 | 3.2 | 3.0 | 2.1 | 2.1 | -1.9 | 1.9 | 1.9 | 2.3 | 2.1 | 2.7 | 2.3 | 2.8 | 2.2 | 2.6 | 2.2 | 2.5 | 1.9 | 1.9 | 1.5 | 1.7 | 1.8 | 2.5 |
| MSLP   | -5.3 | -5.7 | -5.4 | -5.8 | -7.1 | -8.2 | -8.4 | -7.6 | -6.8 | -5.5 | -4.4 | -3.7 | -3.4 | -3.2 | -2.6 | -2.2 | -1.8 | -2.1 | -2.5 | -2.2 | -2.3 | -2.7 | -2.2 | -2.0 | -1.5 | -1.6 | -1.2 | -1.3 | -1.4 | -1.3 |
| PWAT   | 2.1 | 1.9 | 2.7 | 2.6 | 3.5 | 3.6 | 3.6 | 3.7 | 3.4 | 3.1 | 2.8 | 2.1 | 1.4 | 1.3 | 1.3 | 1.1 | 1.6 | 1.8 | 2.0 | 1.8 | 2.3 | 1.8 | 2.2 | 1.7 | 1.7 | 1.6 | 1.6 | 1.4 | 1.4 | 1.5 | 2.1 |

Links on the left hand side will open in a new tab. Click [here](http://www.wrh.noaa.gov/slc/projects/anomaly/frames.html) to view this table in a new window where those links will load in a frame below the table.

Or

[http://go.usa.gov/21i](http://go.usa.gov/21i)
Anomaly Loops

- Anomaly loops available on western U.S. anomaly page (NWS only)
- Loops GEFS mean and associated anomalies
- Four most recent runs are available (all 9 domains)
- Can quickly look back at run-to-run consistency
- Monitor evolution of forecast anomalies
Archive Data – Upon Further Review...

- **Anomaly images**
- Archive began Dec 7th, 2009
- Western U.S. CONUS and Alaska domains available

- **Situational Awareness Tables**
- Archive begins Jan 5th, 2010
- All nine domains archived
EFS Issues Remain!

- **Data assimilation, model physics, and resolution** all lack relative to the control run

- **Events falling outside envelope of solutions**
  - EPS output remains under dispersive (Novak 2009)
  - Limits forecaster ability to objectively assess uncertainty

- **Spread amongst EFS members would place a drag on significant anomalies**
  - Large anomalies in the EFS mean indicate limited spread

- **Limited spread = Under dispersion or high probability outcome?**
Summary

• Anomalies from GEFS mean have proven very useful in anticipating significant events

• Historic western U.S. Storm 18-23 Jan 2010
  • Record breaking rain and snow and MSLP
  • Significant severe weather event (rare TOR watch)
  • 5-7 day GEFS indicated potential for significant event
    – Anomalies well correlated with significant weather

• Situational Awareness table helps identify element(s) and time frame (s) of concern
  • Improved data management
  • Can result in improved DSS
  • Appropriately directs forecaster attention

Photo courtesy UDOT
The Road Ahead

- **Update to 1980-2010 Climatology**
- Update return periods

- **Collaborate with NCEP/EMC to update climatology to CFSR**

- **Work with Rich Grumm on SREF**

- **Database anomalies**
  - Identify frequency of forecast anomalies

- **New displays?**