Stony Brook CSTAR:
From Ensemble Tools to Stakeholder Communication

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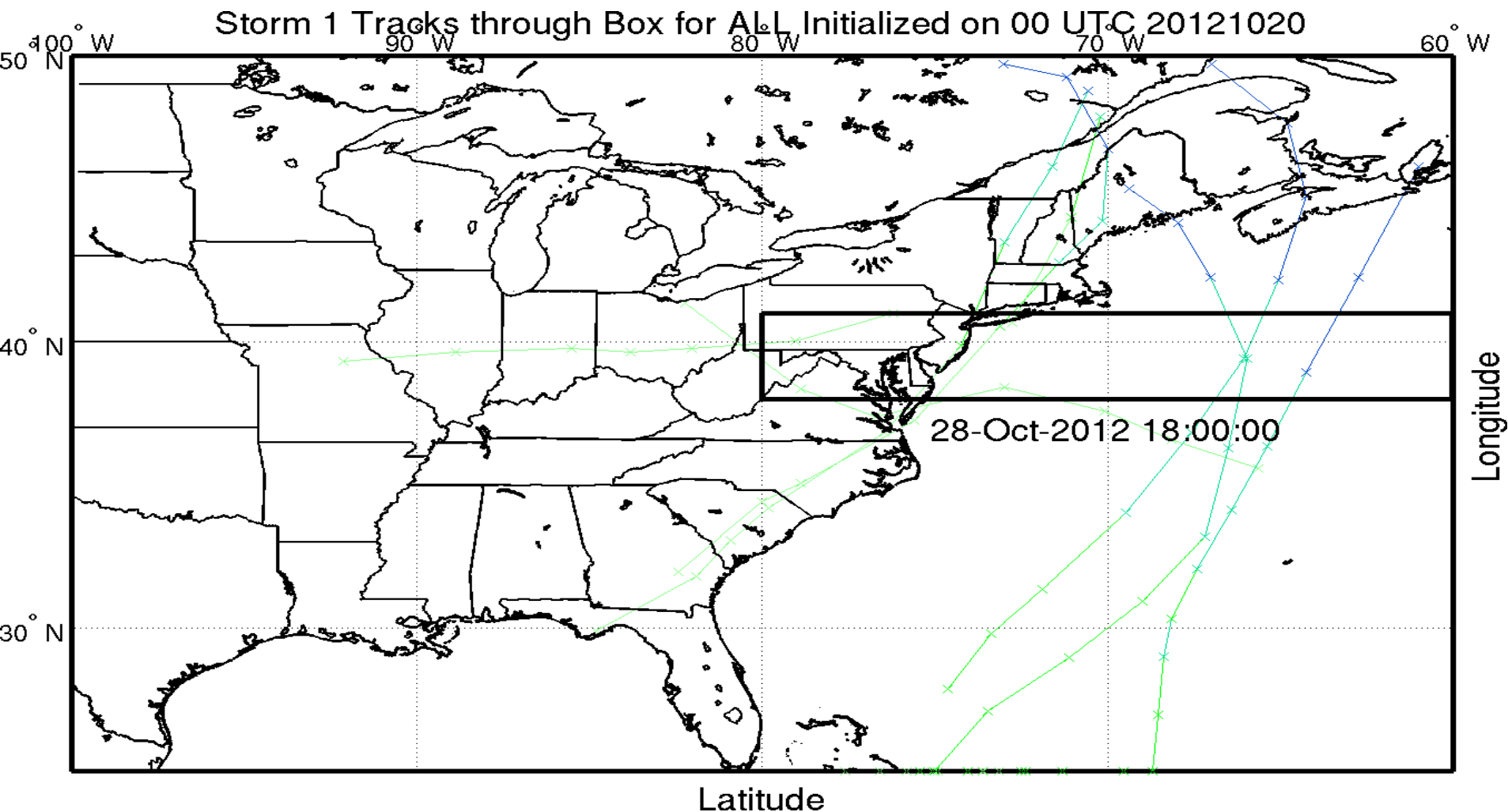
Stony Brook University

Initial CSTAR Motivation: Better tools to help the forecaster understand ensemble predictions
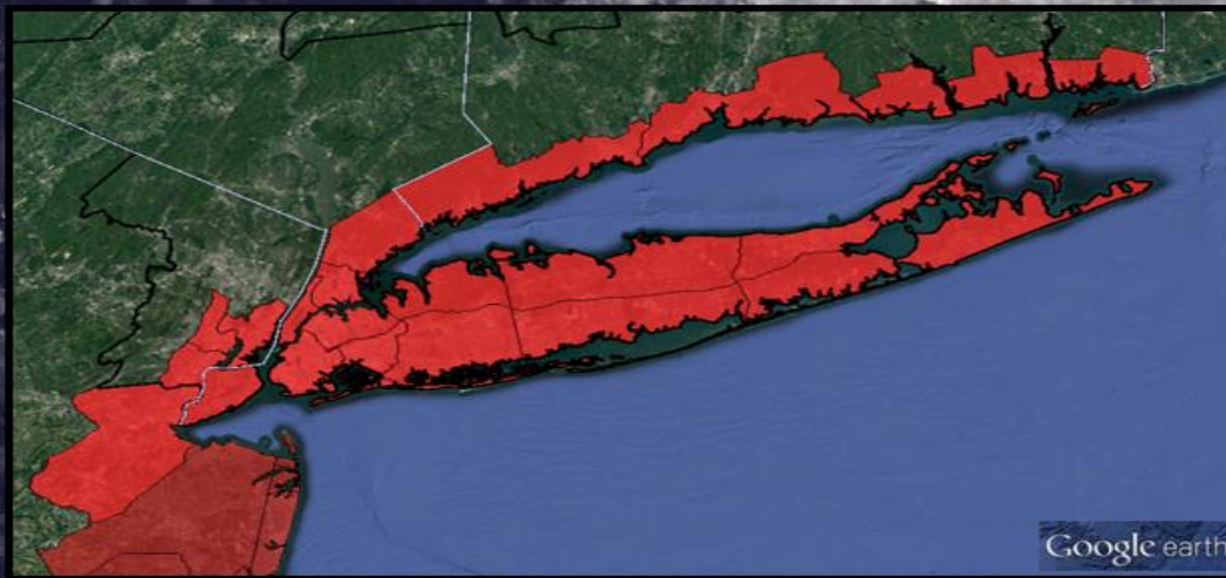
Can we make some sense out of the spaghetti?

Storm 1 Tracks through Box for ALL Initialized on 00 UTC 20121020

Communication Challenges: How Best to Communicate Multiple Hazards and the Uncertainty?

CSTAR Projects

 * Predictability of High Impact Weather during the Cool Season over the Eastern U.S: From Model Assessment to the Role of the Forecaster: 05/01/10 - 04/30/13

* An Evaluation and Application of Multi-Model Ensembles in Operations for High Impact Weather over the Eastern U.S.: 10/01/13 - 09/30/17

* Better Use of Ensembles in the Forecast Process: Scenario-Based Tools for Predictability Studies and Hazardous Weather: 7/01/17 - 06/30/20

* Improving Communication With Highly Vulnerable Societal Groups Through Partnerships, Audience Analysis, and Workshops: 5/01/22 - 04/30/25

Some CSTAR Tools

Ensemble Sensitivity: Determines upstream features leading to ensemble spread or dModel/dt

Clustering: Scenario determination and maps for 4-5 different clusters (using EC+GEFS+CMC).

Ensemble Cyclone Tracks: GEFS+CMC+FNOC+SREF tracks, track probabilities, and GEFS bias correction using cyclone verification.

Ensemble Rossby Wave Packets: GEFS wave packet amplitude probabilities and spread.

Spread-Anomaly Tool: Compare GEFS spread to climatological spread (Need GEFS Re-forecasts)

Ensemble Clustering: A R2O CSTAR Success Story

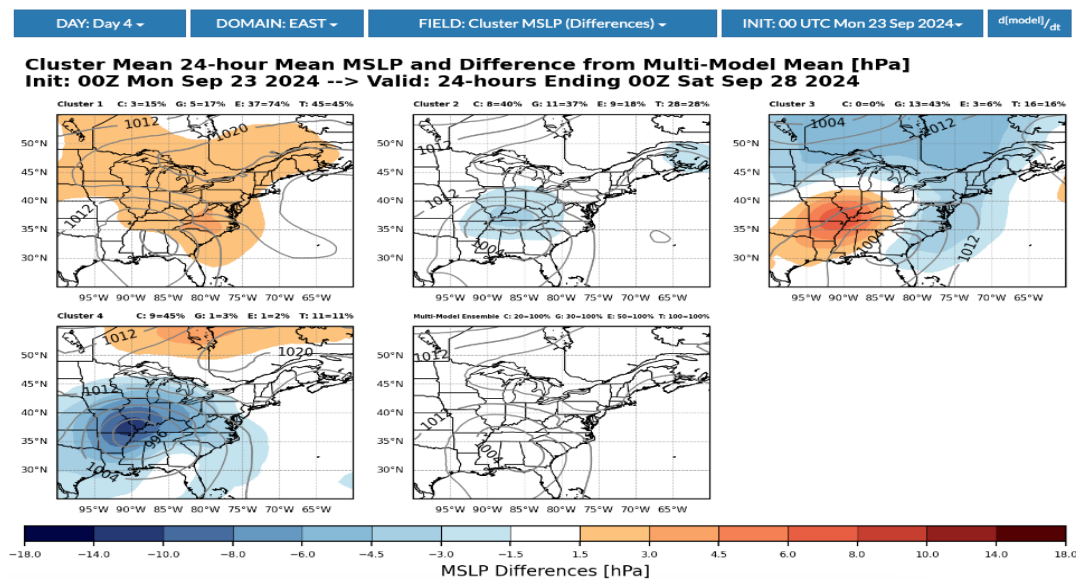Start (2013): RL0: Lunch conversation → RL1: Class project

→ RL4 (2017): Cluster CSTAR webpage

→ RL7 (2021): WPC cluster page (JTTI support)

→ RL8-9 (2023): Operational WPC page and clustering within DESI

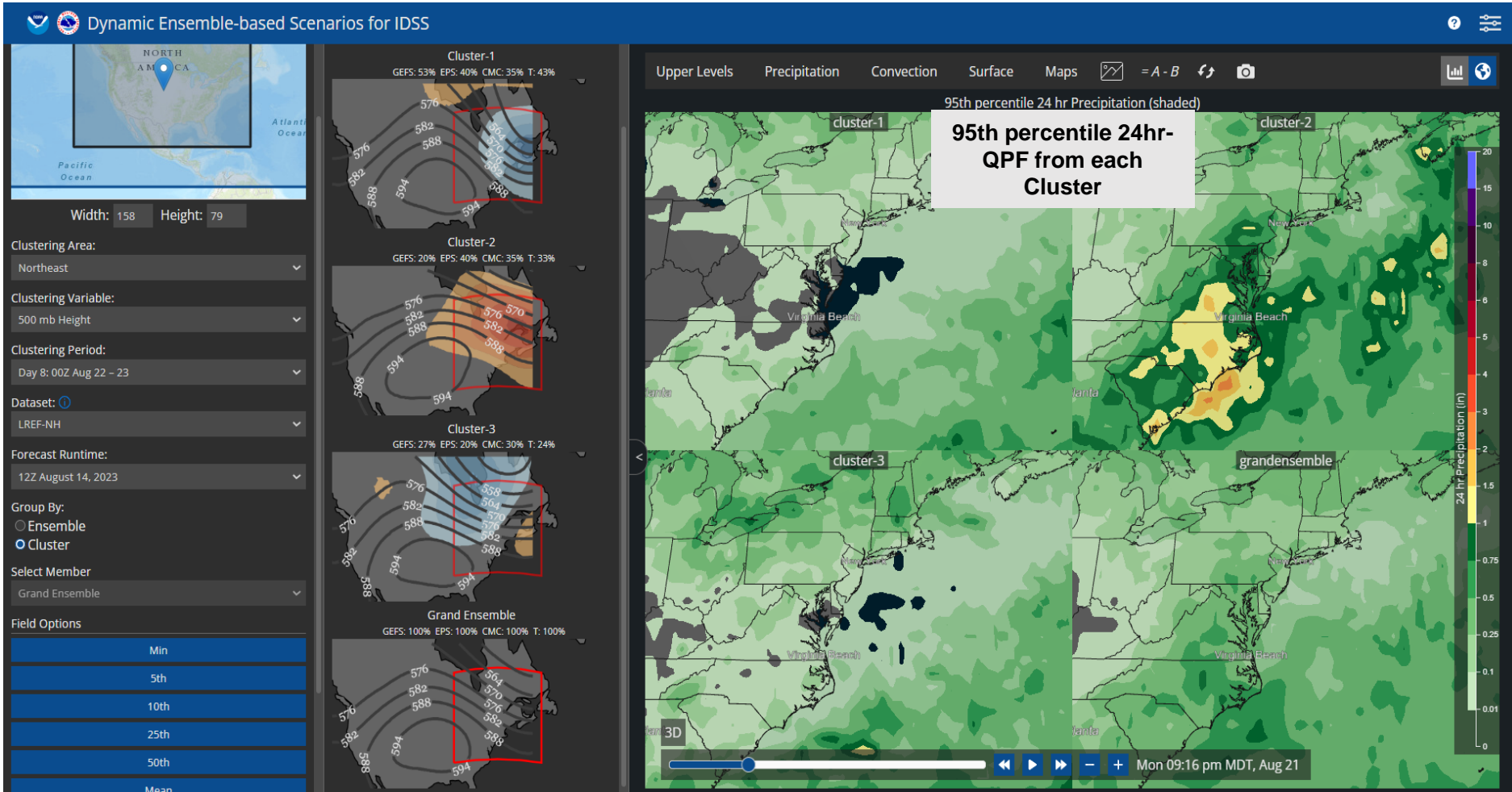https://www.wpc.ncep.noaa.gov/wpc_ensemble_clusters/day_3_9_mslp/view.php?
https://www.wpc.ncep.noaa.gov/wpc_ensemble_clusters/day_3_9_plus_esa/view.php?

DESI Interface for Clusters (Available in all NWS WFOs)

How the clustering does it work?

First two EOFs are calculated for a variable (e.g., SLP, QPF, 500Z) and region of interest. Next, we use k-means clustering to assign members to cluster scenarios

First two EOFs for reference

EOF 1
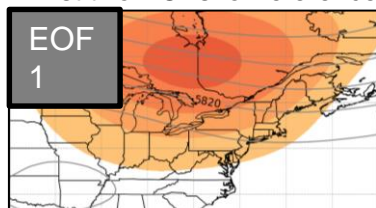
Leading uncertainty mode:
Amplitude of pattern

EOF 2
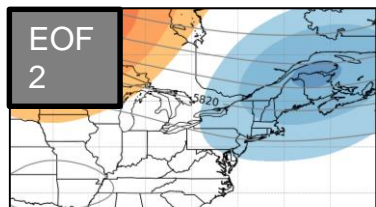
Secondary uncertainty mode:
W-E pattern position

Principal component (PC) phase space shows us the forecast scenario for each ensemble member (and system)

Members with positive PC1 will look more like EOF1 whereas members with negative PC1 will look opposite EOF1

K-means clustering groups members with similar scenarios

(WPC pg keeps # clusters fixed at 4)

PC1-PC2 Phase Space
Init: 00Z Fri Aug 11 2023 -->
Valid: 24-hours Ending 00Z Mon Aug 21 2023
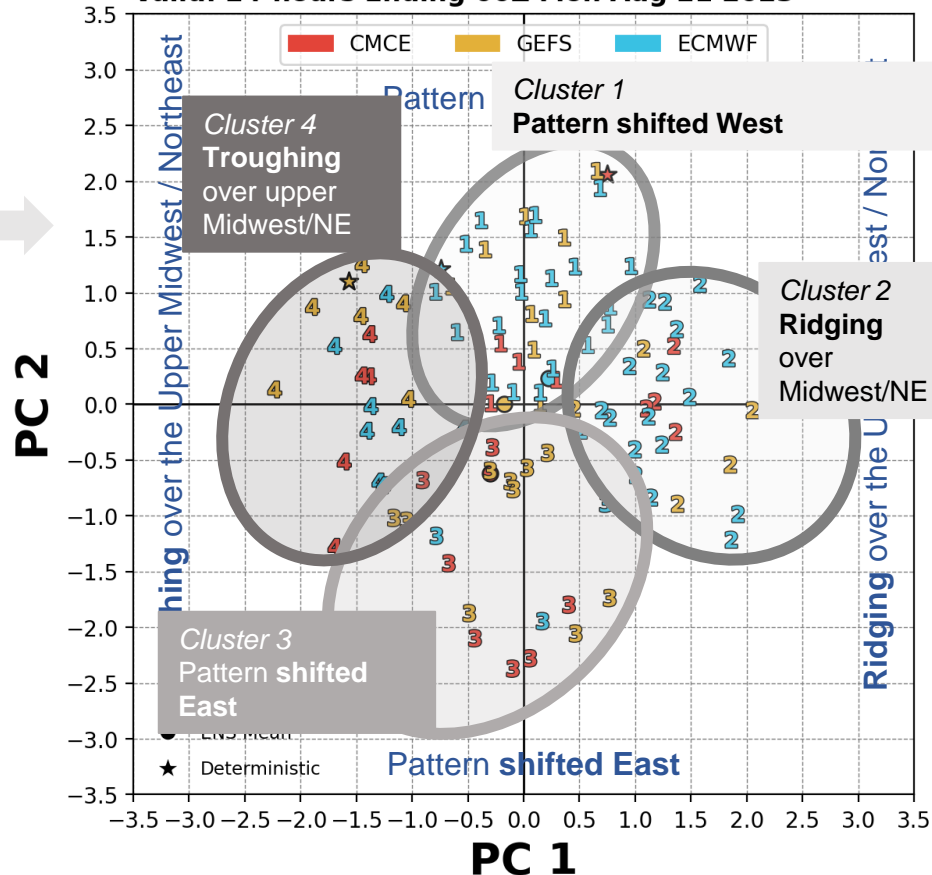
Don't even need to look at EOFs or PCs to use!

Can skip straight to the cluster forecasts (of 500-hPa heights in this case)

Cluster Mean 24-hour Mean 500-hPa Heights and Difference from Multi-Model Mean [m]
Init: 00Z Fri Aug 11 2023 --> Valid: 24-hours Ending 00Z Mon Aug 21 2023
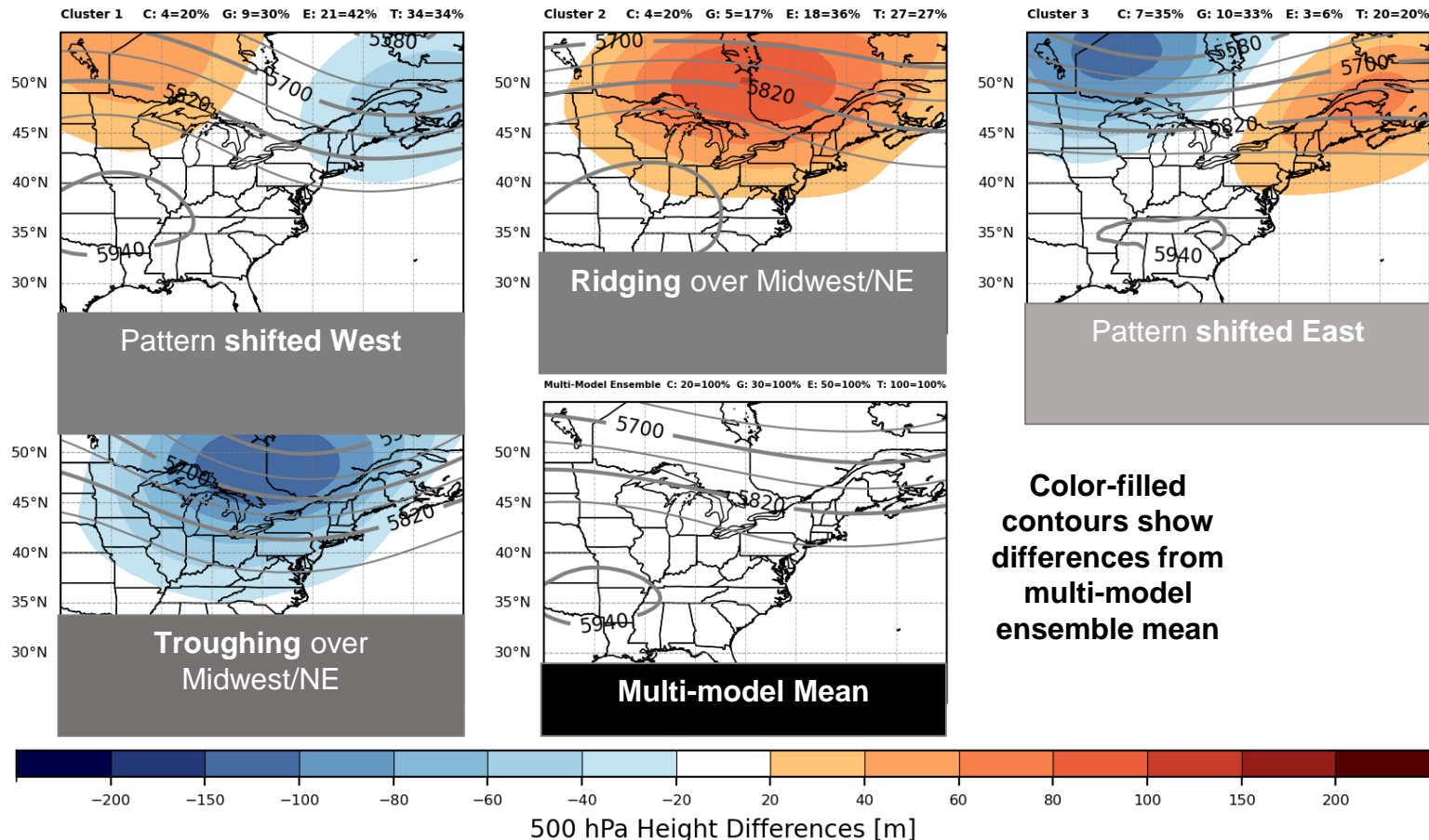
Forecast Cluster Survey: Wanted more information of the origin of some the uncertainty and clusters..
Revisit CSTAR Ensemble Sensitivity Analysis (ESA) Tool (now RL6 at WPC – will be RL8 with help of a JTTI project)
ESA Example… Hurricane Helene
Predictability Challenges at Day 3+ Lead Times for Helene

EPS Accumulated 24-hour Precipitation (inches)
Init: 00z Sep 24 2024   Forecast Hour: [84]   valid at 12z Fri, Sep 27 2024

TROPICALTIDBITS.COM
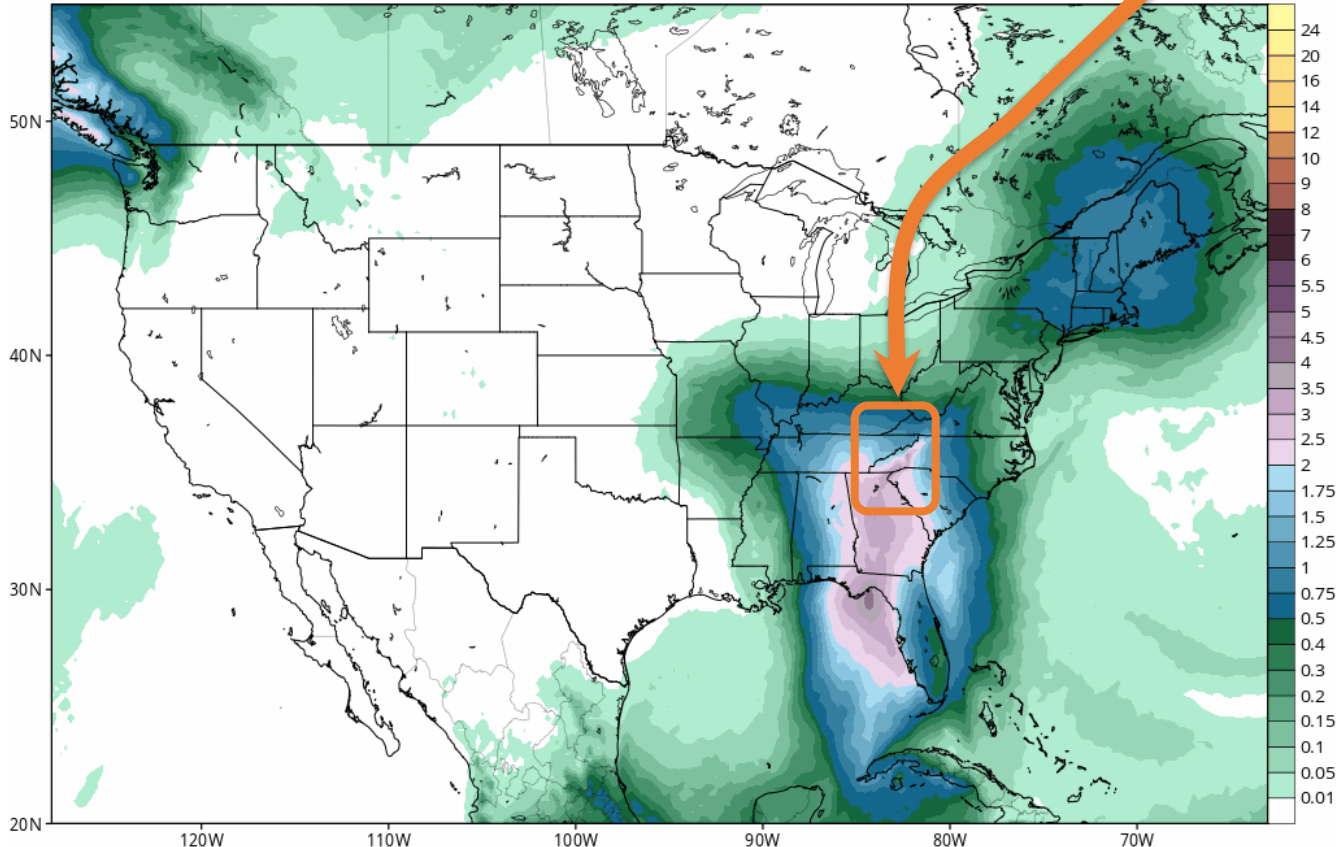
Correct interaction and phasing of the mid-upper low over the Mid South and Helene is crucial to correct QPF in the Southern Appalachians. Notice big increases on ECMWF ensemble around the 12 UTC run on September 25.

*Pulled from WPC Event Review Slide Deck

What were the main modes of ECMWF uncertainty for the 24-h QPF on 9/27?

ECMWF mean QPF increases, shifts main corridor slightly NE, and distinguishes two local QPF maxima as initializations approach event

Main uncertainty (EOF1) continues to be SW-NE positioning of QPF max, with more nuanced positional uncertainty for later forecasts

EOF1 of 24hr-averaged QPF at f120 | 21% Variance Explained
Initialized: 2024-09-23 00:00:00 | Valid: 2024-09-28 00:00:00 (Day 4)

EOF Pattern (m)
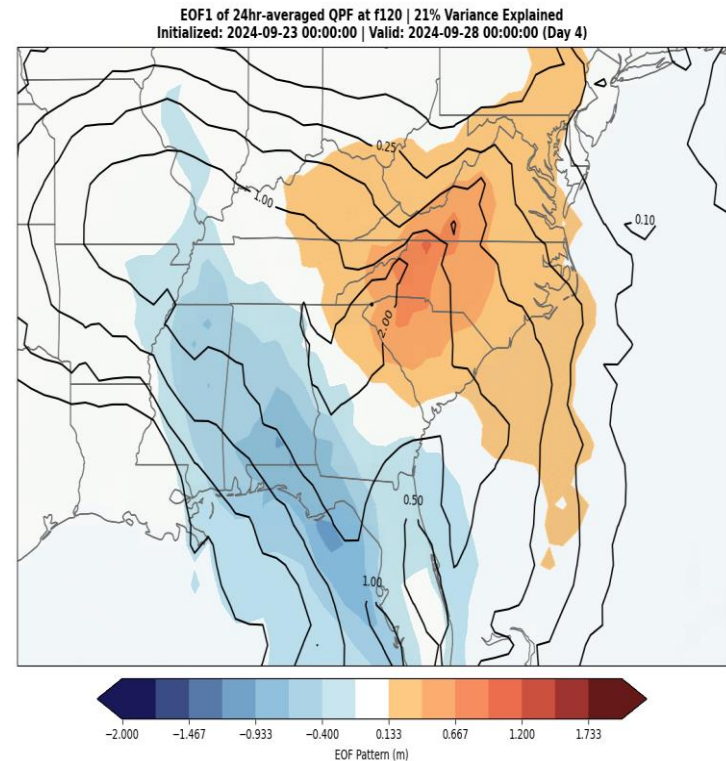
Sensitivity of Positional Uncertainty back to early ECMWF 500-hPa heights – **9/23 00 UTC Init**

Position of QPF in SW-NE direction largely tied to W-E position of 500-hPa trough upstream

Members with faster trough have higher QPF for the Carolinas and less QPF further south

Position of QPF max in SW-NE direction also strongly tied to phase speed of Hurricane Helene

SENSITIVITY OF: 24-hr Averaged QPF PC1 at 09/28/2024 00 UTC (Day 4)
SENSITIVITY TO: 500-hPa GPH at 09/23/2024 06 UTC (f006)   INIT: 09/23/2024 00 UTC

EOF1 for Reference
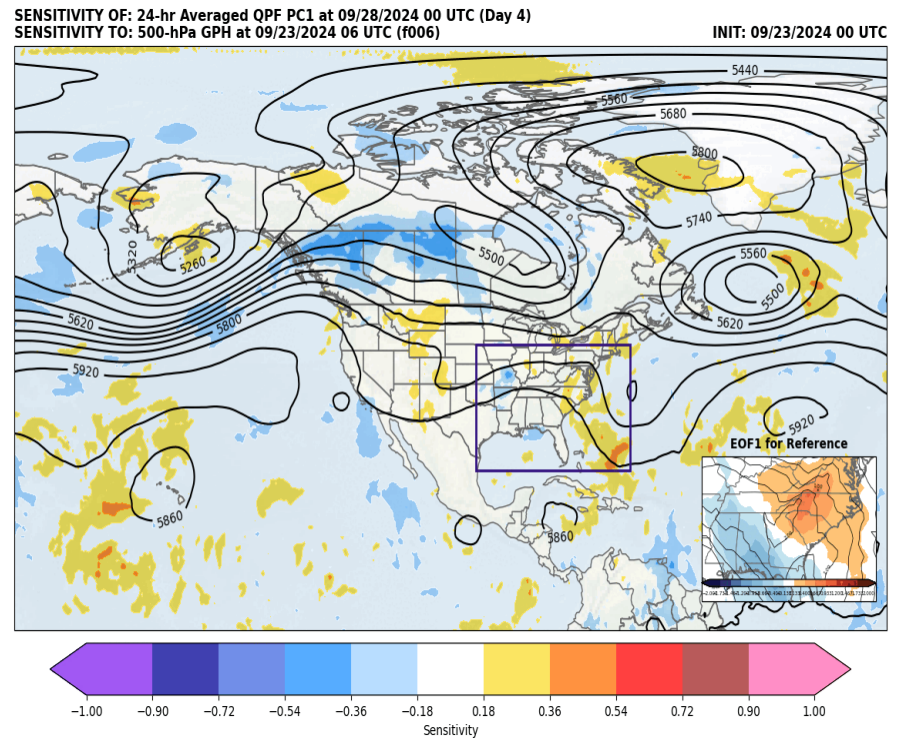
Sensitivity

Soon to be operational on WPC ESA Page:
Web GUI to Draw Floater Domain

Ensemble Sensitivity Analysis(ESA) Floater Domain

Lower Latitude: 24.089077081118017
Upper Latitude: 43.06574551573731
Lower Longitude: 262.1080130338669
Upper Longitude: 292.36960709095
Forecast Day: Day 6
Forecast date: 2024-09-27

Click box icon to draw a floater domain. Latitude / Longitude fields above will automatically adjust based on the box drawn.

Select Forecast Day for specific lead time at which to run ESA, and double check that this matches the valid Forecast Date.

Submit Domain

When you're done setting up your floater domain, select "Submit Domain".

Domain Metadata

Successful Floater Domain Creation

Domain Attributes:

Lower Longitude: 262.1080130338669

Upper Longitude: 292.36960709095

Lower Latitude: 24.089077081118017

Upper Latitude: 43.06574551573731

Forecast Day: 6

Forecast Date: 2024-10-29

Please allow some time for the requested domain to process, then check the images here.

Back to Floater Domain

The GUI will direct you to another page confirming the Floater Domain submission and its attributes.

After 10-20 minutes, ESA graphics for your chosen domain will be available at the link provided.

** There is an ESA Tutorial link under development and there will be an online 1-hour seminar/tutorial for forecasters hosted by WPC (Austin Colman) and myself (BrianC) in early to mid December 2024… Look for email invite!!!

CSTAR Communication Workshops in 2019

Workshop #1 ("The Essentials")
• See and Be Seen
Improvisation-based activities to help you focus on and connect with your audience.
• Designing a Vivid Message Part I
• Just a Minute (JAM) Session (Groups of 8)
Practice talking about your work in clear, vivid and concise ways.
• Practice 3-minute Briefings

Workshop #2 ("Stakeholder Interaction")
• Matching the Message to the Audience
• Rehearsing and refining – Participants practice talks for stakeholder audiences
• Roleplaying – Participants listen and interact as if they are stakeholders. Provide feedback from cohort and instructors
• Circuit Training with Stakeholders on day2

Colle, B.A., R. Auld, K. Johnson, C. O'Connell, T.G. Taylor, and J. Rice, 2021: Improving communication of uncertainty and risk of high-impact weather through innovative forecaster workshops. *Bull. Amer. Meteor. Society*, **102**, 1424-1430. https://doi.org/10.1175/BAMS-D-20-0108.1

A few photos
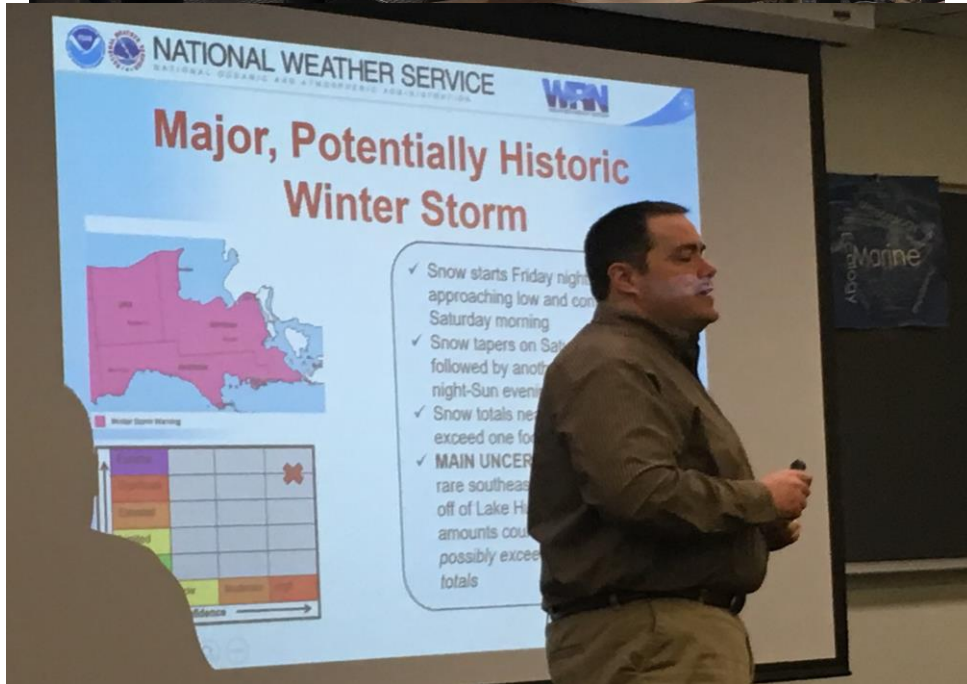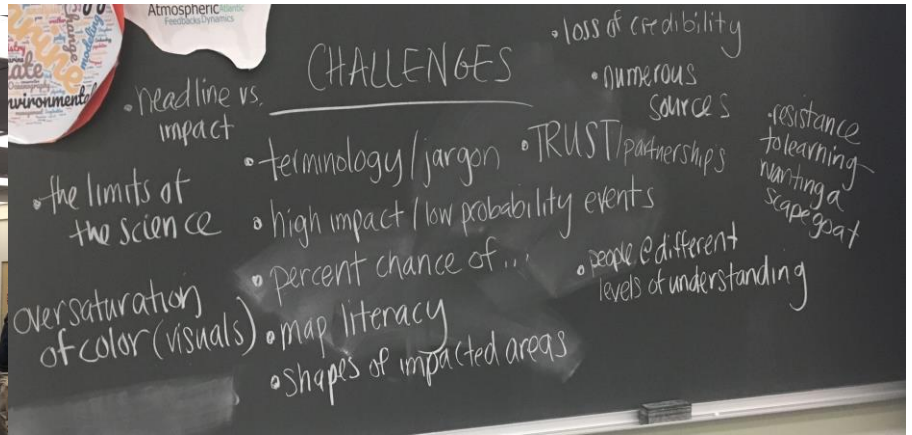
Some Forecaster Feedback:

"… **I've caught myself making assumptions about how users or partners might interpret our forecasts**. Due in part to the lessons taught at our workshops, I've consciously tried to avoid making those assumptions and to actually take the time to communicate with the partners to ensure clarity. "

"…**we've added "one-pager" briefings as an option for messaging to our partners**. Those are great for **including a mix of text and visuals** to convey relevant information in a more concise way… we've been receiving requests from people to be added to our briefings email distribution list, so this is encouraging that the info is actually getting out there and that people might be finding it useful."

"**During some recent high profile weather events**, such as Isaias, we posted WPC and NHC graphics to social media in support of our own office's messaging. Given user comments, this is an important lesson for us, because **well-designed graphics, perhaps accompanied by brief and relevant text, should be able to "speak" for themselves and not lead to confusion**."

Latest CSTAR Project: How do socially vulnerable communities get weather information and take action? -- Need partnerships!!

* Work with NYC EMs, community leaders, and others to connect with socially vulnerable communities

* Obtain a better understanding of the needs, vulnerabilities, and challenges of with respect to extreme events (e.g., hurricane Ida 2021).

* Language challenges.. Chance to evaluate NWS Translation Tool!!

Gilbert, C., Li, R., Colle, B., Moses, J., & Golden, S. (2024). Investigating the role of community organizations in communicating extreme weather events in New York City: A content analysis. *Risk Analysis*. In press.

Li, R., Gilbert, C., Moses, J., & Colle, B. Impact of Direct Experience and Perceptual Factors on Disaster Preparedness and Response: A PADM Analysis in Vulnerable Communities in New York City. *International Journal of Disaster Risk Reduction*. In revision.
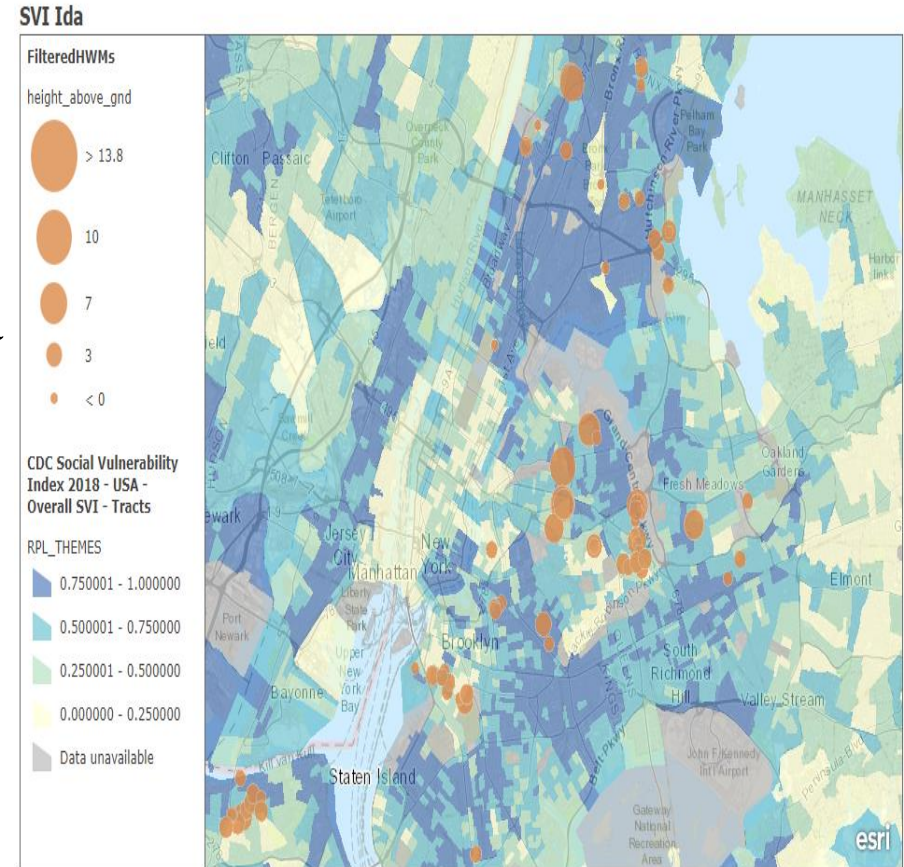
Figure: Ida flood locations around NYC overlaid on CDC Social Vulnerability Index (plot courtesy of Dave Radell –SOO NYC).

Thank you CSTAR Graduates

David Stark (M.S., 2012) – NWS Lead Forecaster at Upton, NY

Matthew Souders (M.S., 2013) –Weather Analytics, New Hampshire

Michael Layer (M.S., 2014) – Weatherworks, Hackettstown, NJ

Michael Erickson (Ph.D., 2015) – NOAA WPC/CIRES

Minghua Zheng (Ph.D. 2016) - (Scripps/3WCE) – Research Scientist (ESA and DA)

Nathan Korfe (M.S. 2016) – Research Meteorologist at WindLogics, MN

Taylor Mandelbaum. (M.S. 2018)— Meteorologist NY Power Authority

Benjamin Kiel– (M.S. 2021) – Univ. Alabama/Huntsville

Summary: Thank you CSTAR!!

- Fun and productive science

- Train highly motivated and creative students

- Students have been able to get good jobs within the NWS and private sector

- Interactions with forecasters and operational centers

- Opportunity to impact forecast operations

- Personal growth – e.g., learning more about social science part of problem…

Extra Slides

Ensemble Webpage Cyclone Tracks – "Box-method"
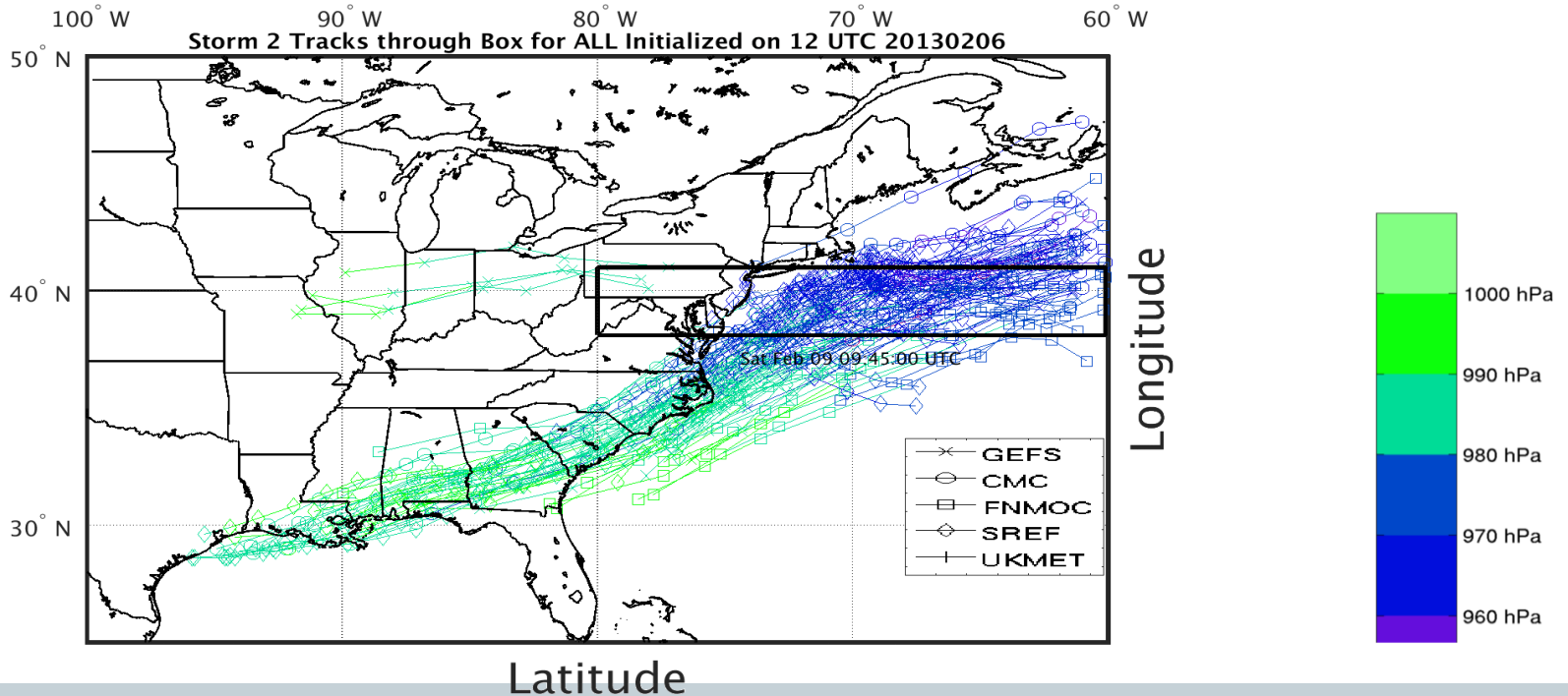
- The box-method isolates only those storms that enter a prespecified domain, and plots the entire lifespan of the storm. This graphic simultaneously displays uncertainties in storm position and intensity.

New CSTAR: Project Objectives

* Work with NYC EMs, NWS, city officials, and others to connect with HVSG communities

* Obtain a better understanding of the needs, vulnerabilities, and challenges of HVSGs with respect to extreme events (e.g., hurricane Ida 2021).

* Explore new technological strategies to gather survey information during these storm events, as decisions are being made.

Figure: Ida flood locations around NYC overlaid on CDC Social Vulnerability Index (plot courtesy of Dave Radell –SOO NYC).

* Develop methods of risk communication in ways that improve user comprehension, reception, and response in HVSGs.

* Enhance NWS services for HVSGs that are at greater risk for experiencing negative impacts related to extreme weather events such as flooding, heat, and hurricane landfalls.

Ensemble Sensitivity Based on EOF1 Pattern
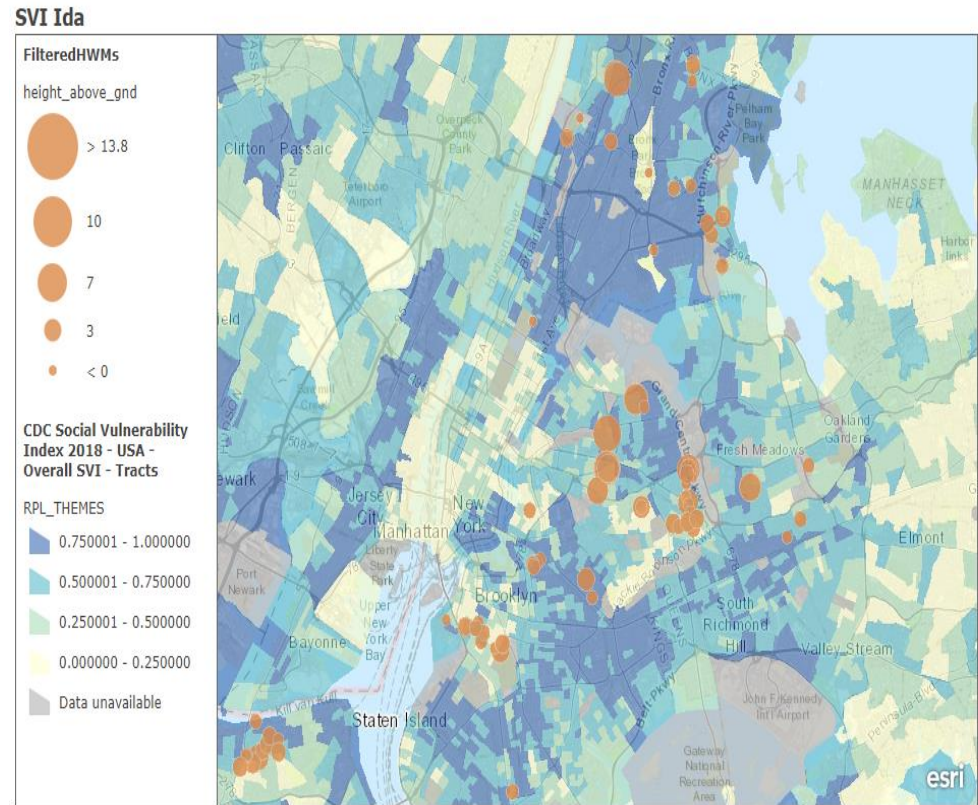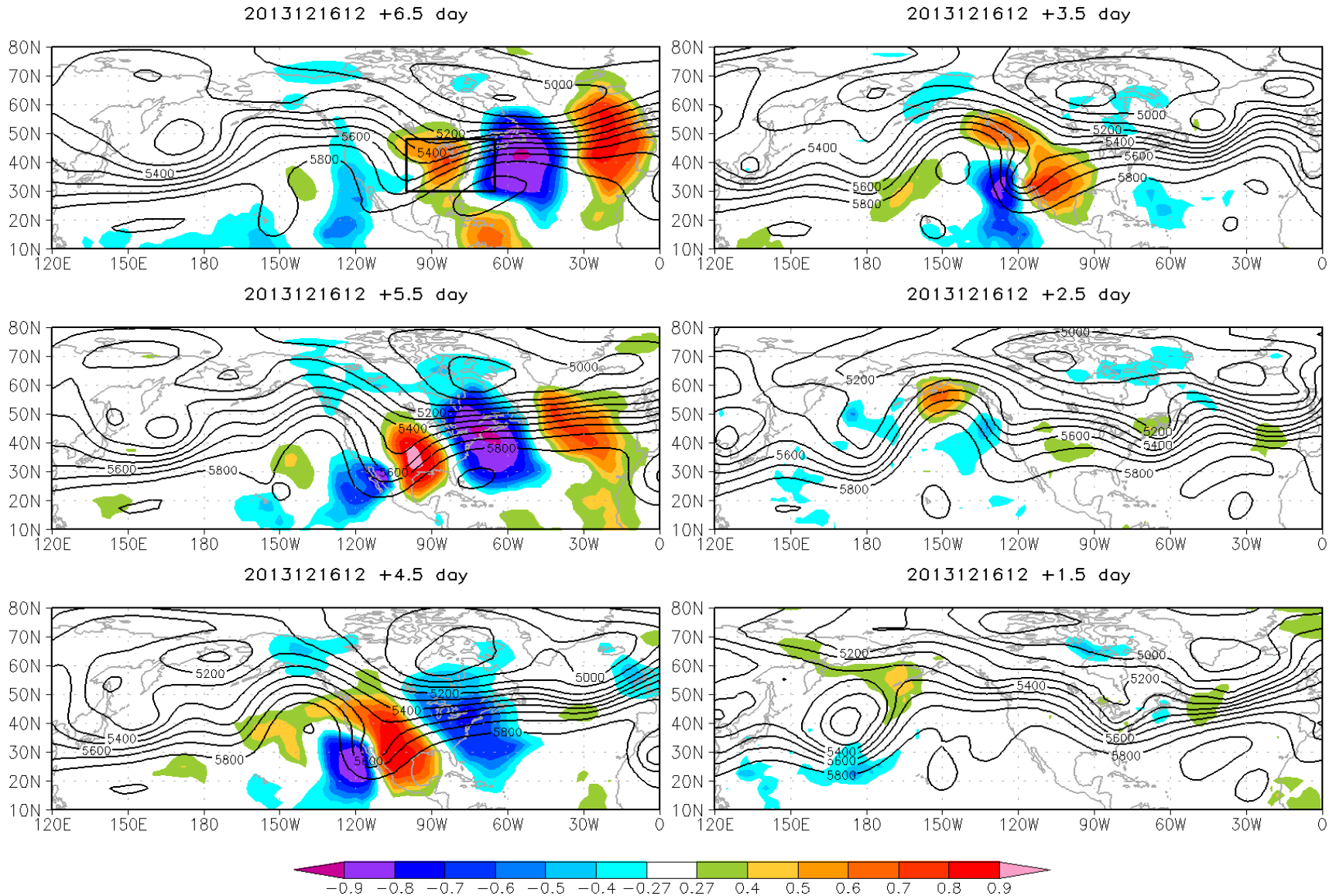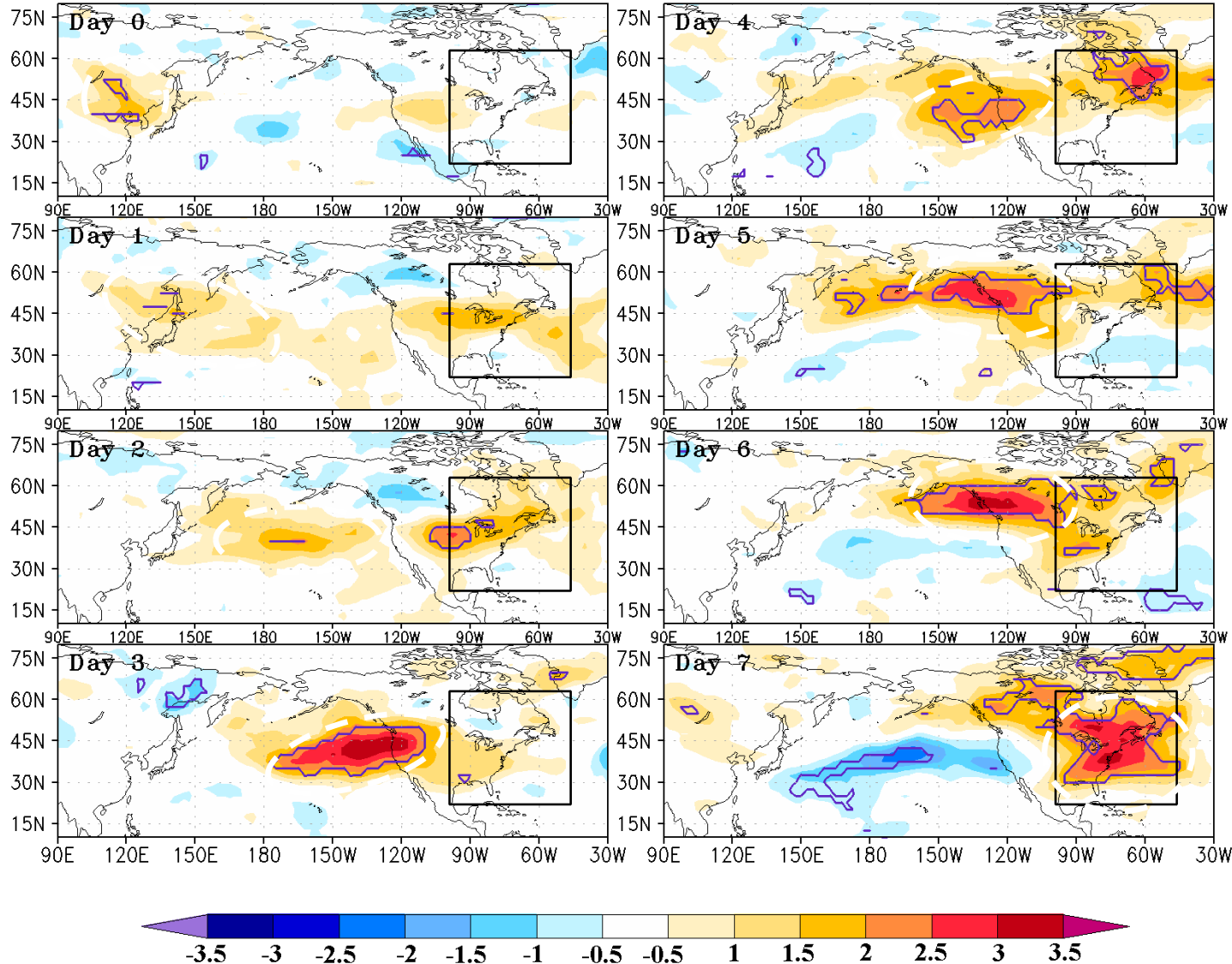
Composite Rossby Wave Packet Anomalies
for 75 large error cases for 300Z in the GFS day 7 (2007-2012)

Initial Positive RWPA
Anomaly Develop and
Propagate into VR

Unit: m/s

The purple contour
corresponds to 95%
significance level

Welcome to the GEFS Ensemble Wave Packet Plotter

Current Model Cycle (00Z after 5 AM EST, 12Z after 6 PM EST)

Variable Set	f00	f12	f24	f36	f48	f60	f72	f84	f96	f108	f120
GEFS 300 hPa Z and WPA (mean/spread)	X	X	X	X	X	X	X	X	X	X	X
GEFS Probability of Exceedence	X	X	X	X	X	X	X	X	X	X	X
WPA dEnsemble/dt											
GFS Op. WPA/300Z + GEFS Spread											

Variable Set	f132	f144	f156	f168	f180	f192	f204	f216	f228	f240	f252
GEFS 300 hPa Z and WPA (mean/spread)	X	X	X	X	X	X	X	X	X	X	X
GEFS Probability of Exceedence	X	X	X	X	X	X	X	X	X	X	X
WPA dEnsemble/dt											
GFS Op. WPA/300Z + GEFS Spread											

Variable Set	f264	f276	f288	f300	f312	f324	f336	f348	f360	f372	All
GEFS 300 hPa Z and WPA (mean/spread)	X	X	X	X	X	X	X	X	X	X	X
GEFS Probability of Exceedence	X	X	X	X	X	X	X	X	X	X	X
WPA dEnsemble/dt											
GFS Op. WPA/300Z + GEFS Spread											

Previous Model Cycle

Variable Set	f00	f12	f24	f36	f48	f60	f72	f84	f96	f108	f120	f252
GEFS 300 hPa Z and WPA (mean/spread)	X	X	X	X	X	X	X	X	X	X	X	X
GEFS Probability of Exceedence	X	X	X	X	X	X	X	X	X	X	X	X
WPA dEnsemble/dt												
GFS Op. WPA/300Z + GEFS Spread												

(http://wavy.somas.stonybrook.edu/wavepackets/home.html).
Figure 8 shows the cover of the page, in which users can