Ensemble variability in rainfall forecasts of Hurricane Irene (2011)

Molly B. Smith[1], Ryan Torn[1], Kristen L. Corbosiero[1], and Philip Pegion[2]

[1]University at Albany, State University of New York, Albany, New York; [2]CIRES, Boulder, Colorado

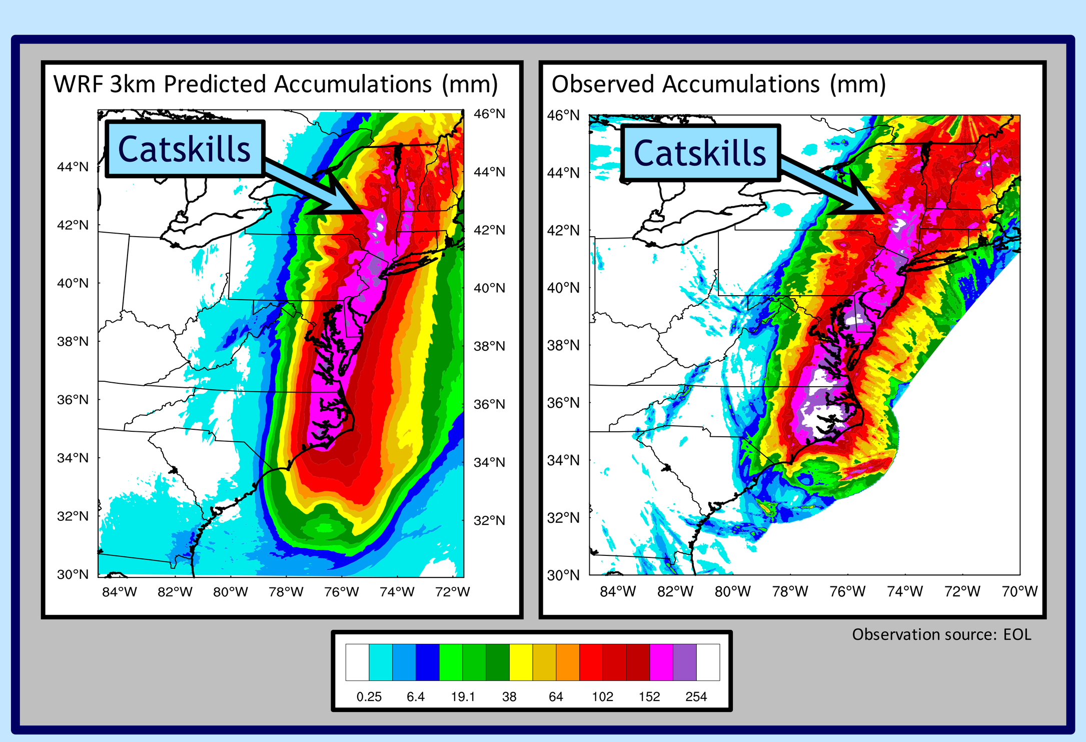
Motivation

- Landfalling TCs are often associated with widespread heavy precipitation, which can lead to devastating flood events.
- Relatively few studies have explored the sensitivity of precipitation forecasts for such events to model initial conditions.
- We explore the physical processes that modulate precipitation variability in ensemble forecasts of heavy rainfall events.
- This work uses Hurricane Irene (2011) as a case study.
  - Irene featured catastrophic inland flooding caused by widespread rainfall totals of 4-7 inches (100-175 mm).
  - Some parts of the Catskill region of New York in particular received up to 12 inches (305 mm).

Methodology

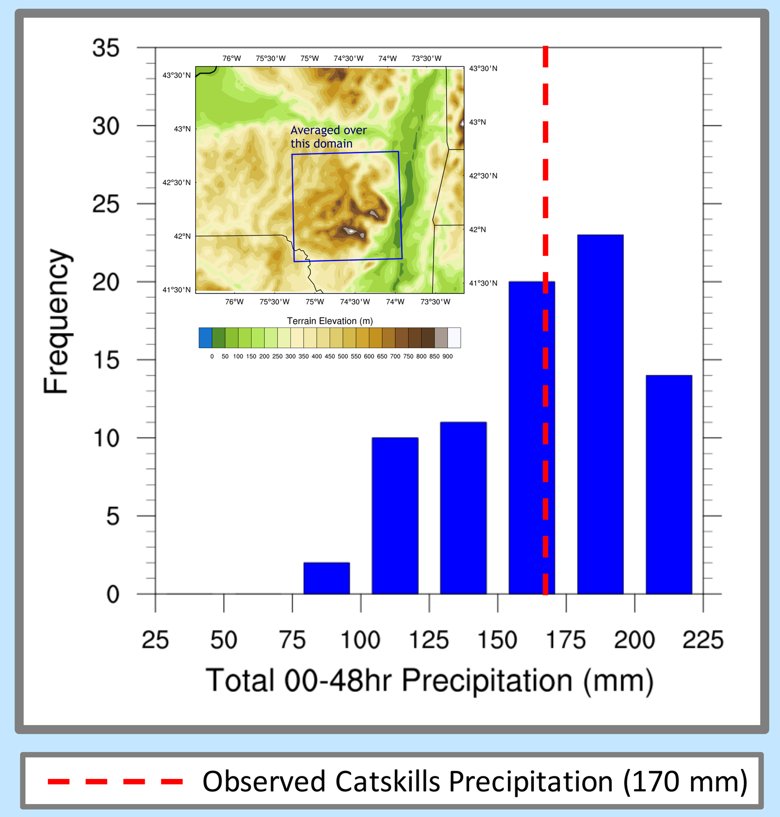
- An 80-member 0.5° GFS ensemble was initialized at 0000 UTC 27 August 2011 and run for 48 hours, until 0000 UTC 29 August.
  - These GFS ensemble forecasts were created with the operational version of the GFS in use from 2013-2015.
- The 80 members were then downscaled to 3 km with WRF, in order to better simulate the effects of terrain and mesoscale processes.
  - The physics used are comparable to those employed with the HRRR.
- Rainfall totals for the Catskills were analyzed in terms of variability between members.

WRF Ensemble Mean



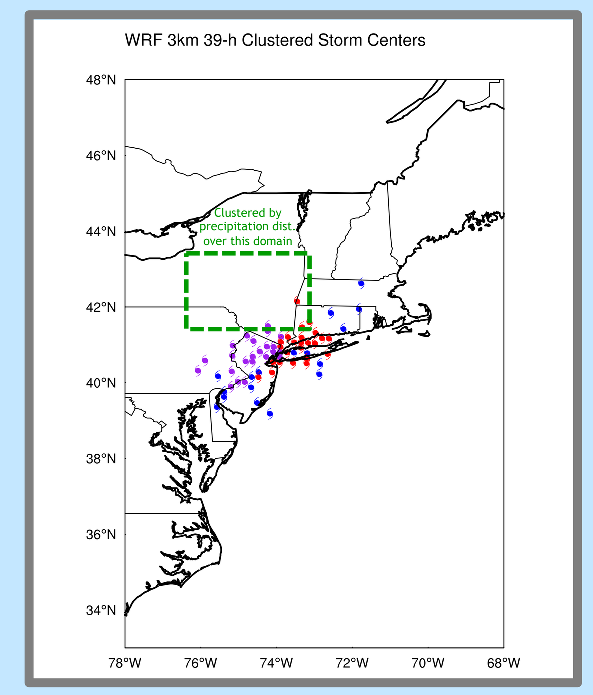
Although the ensemble mean slightly under-forecasts precipitation overall, it does very well in the Northeast, and manages to capture the peak accumulations over the Catskills.

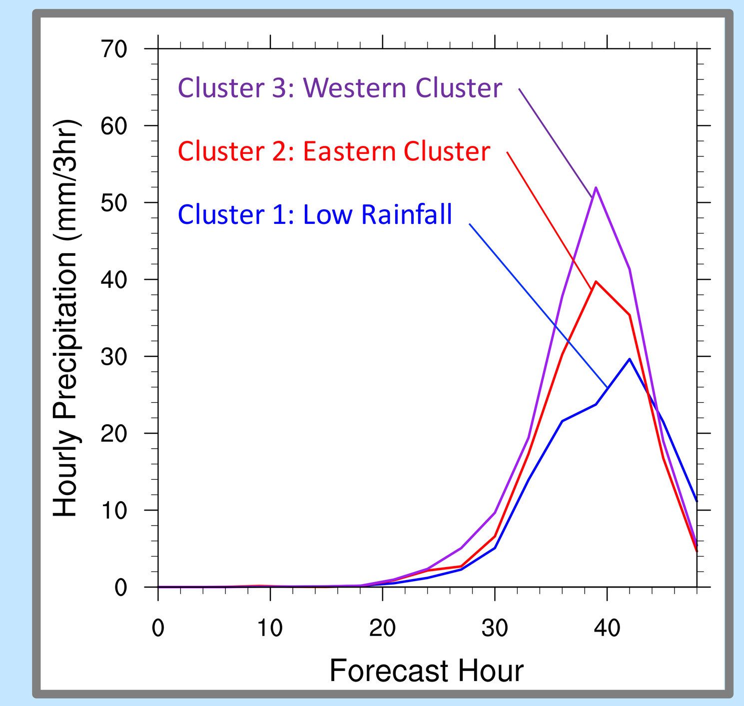
00-48-h Catskills Ensemble Precipitation Distribution



Substantial variability exists between members.

To determine the cause of this variability, the ensemble members are clustered based on the 39-h horizontal distribution of precipitation over southeastern New York.





Cluster 1 is the residual cluster, so the focus of this study is to compare the wet, western Cluster 3 with the dry, eastern Cluster 2.

Conclusions

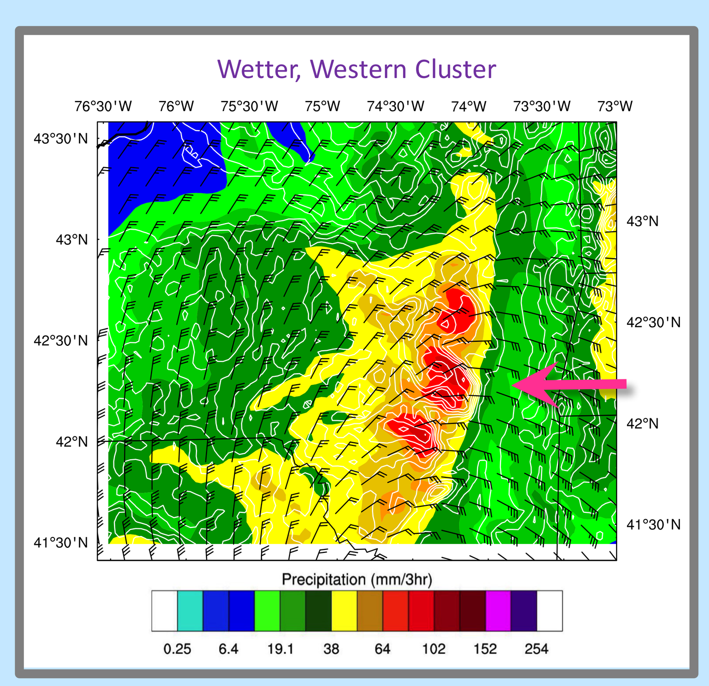
- Precipitation in the wetter, western members appears to be driven by a combination of terrain effects, synoptic forcing, and high available moisture.
- Precipitation in the drier, eastern members appears to be driven primarily by synoptic forcing, as less moisture was available during the period that had strong upslope forcing.
- Clustering ensemble members into specific forecast scenarios can reveal more information than just using the ensemble mean and standard deviation.

Contact: Molly Smith, mbsmith@albany.edu

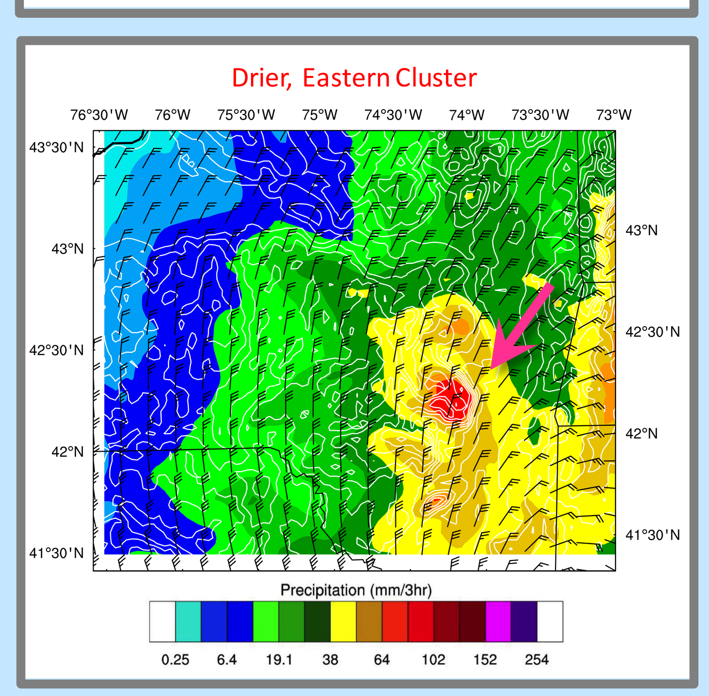
Three hypotheses to explain the variability between the wet and dry clusters:

1

Wetter members have stronger upslope forcing over the Catskills than drier members.



The wet members featured easterly winds into the steep eastern slopes of the Catskills.



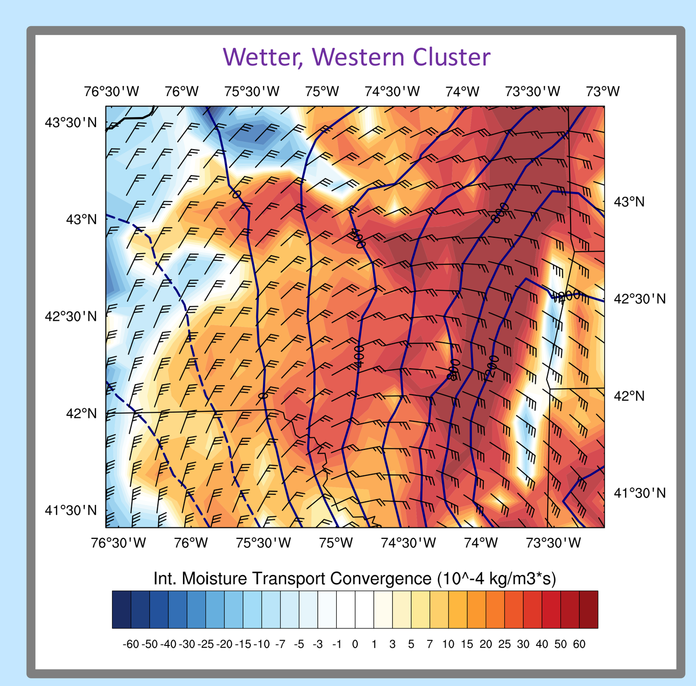
The dry members featured northeasterly winds into more gradual inclines.

Forecast Hour: 39
900-hPa Winds
3-hourly Precipitation
Topography contoured in white

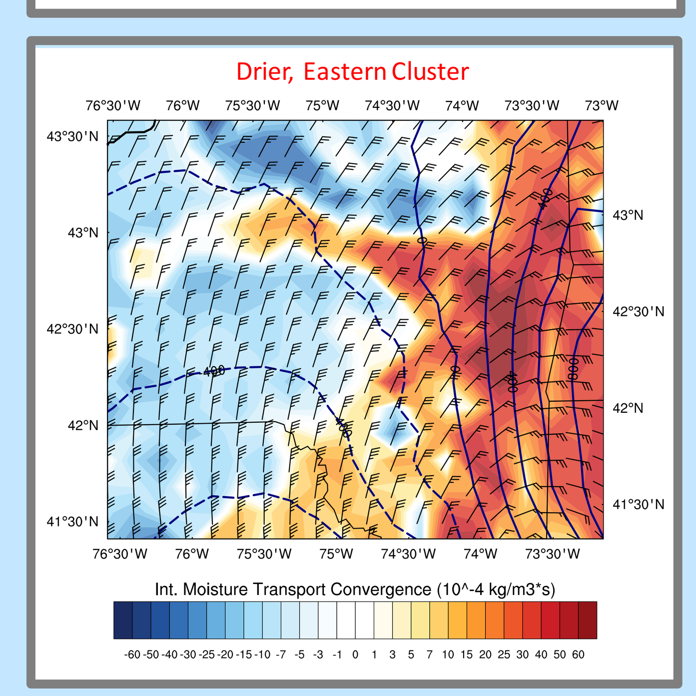
Hypothesis Supported!

2

Wetter members have greater moisture convergence over the Catskills than drier members.



The wet members featured larger values of moisture convergence over the Catskills.



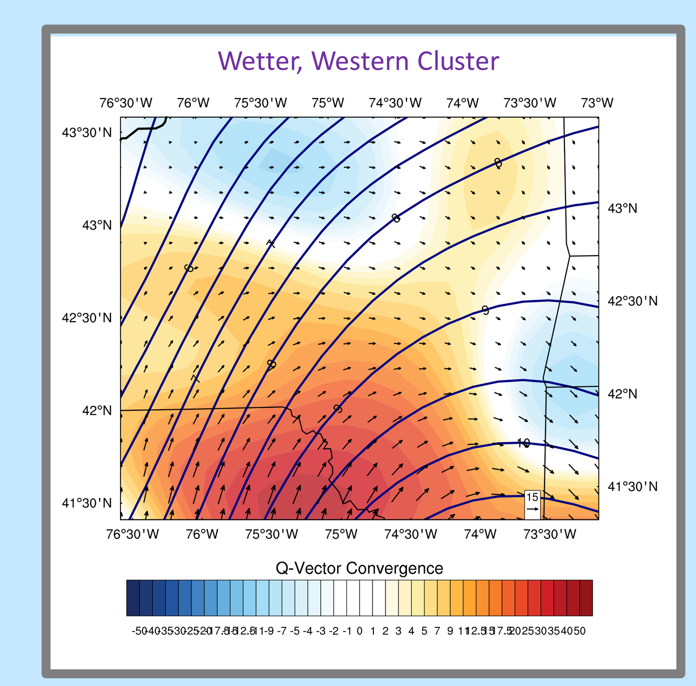
The dry members featured smaller values of moisture convergence over the Catskills.

Forecast Hour: 39
1000–700-hPa Mean Winds
Integrated Moisture Trans.

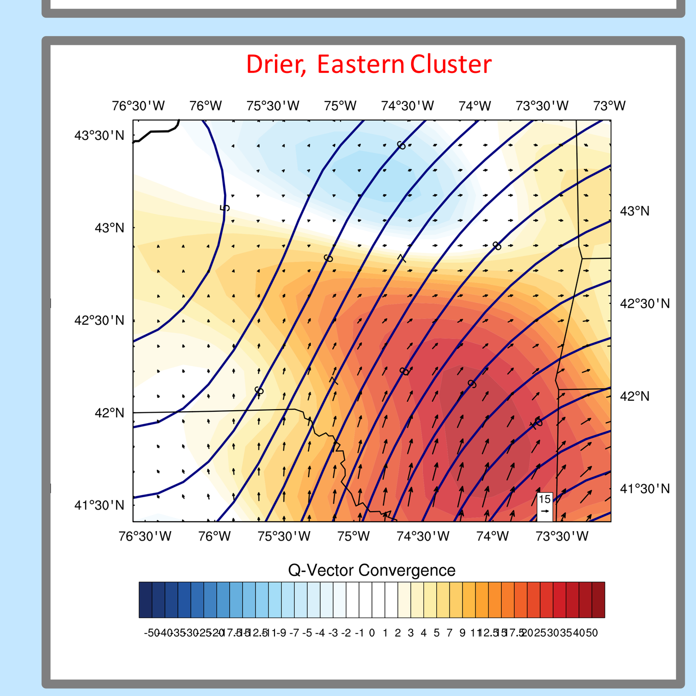
Hypothesis Supported!

3

Wetter members have stronger Q-vector convergence over the Catskills than drier members.



The wet members featured *less* Q-vector convergence over the Catskills.



The wet members featured *more* Q-vector convergence over the Catskills.

Forecast Hour: 39
700-hPa Isotherms
700-hPa Q-Vector Conv.

Hypothesis Not Supported!