Ensemble-based exigent analysis of Hurricane Irene (2011)

Atmospheric and Environmental Research

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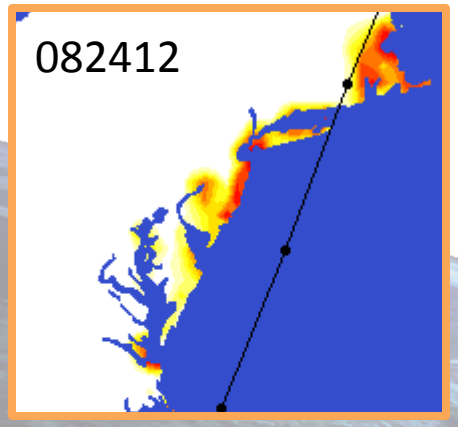
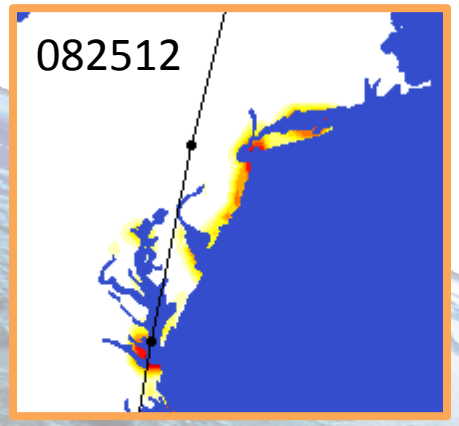
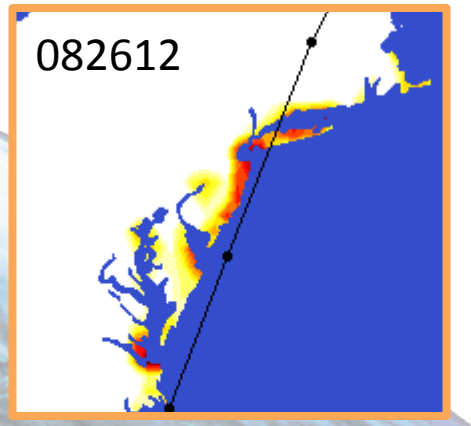
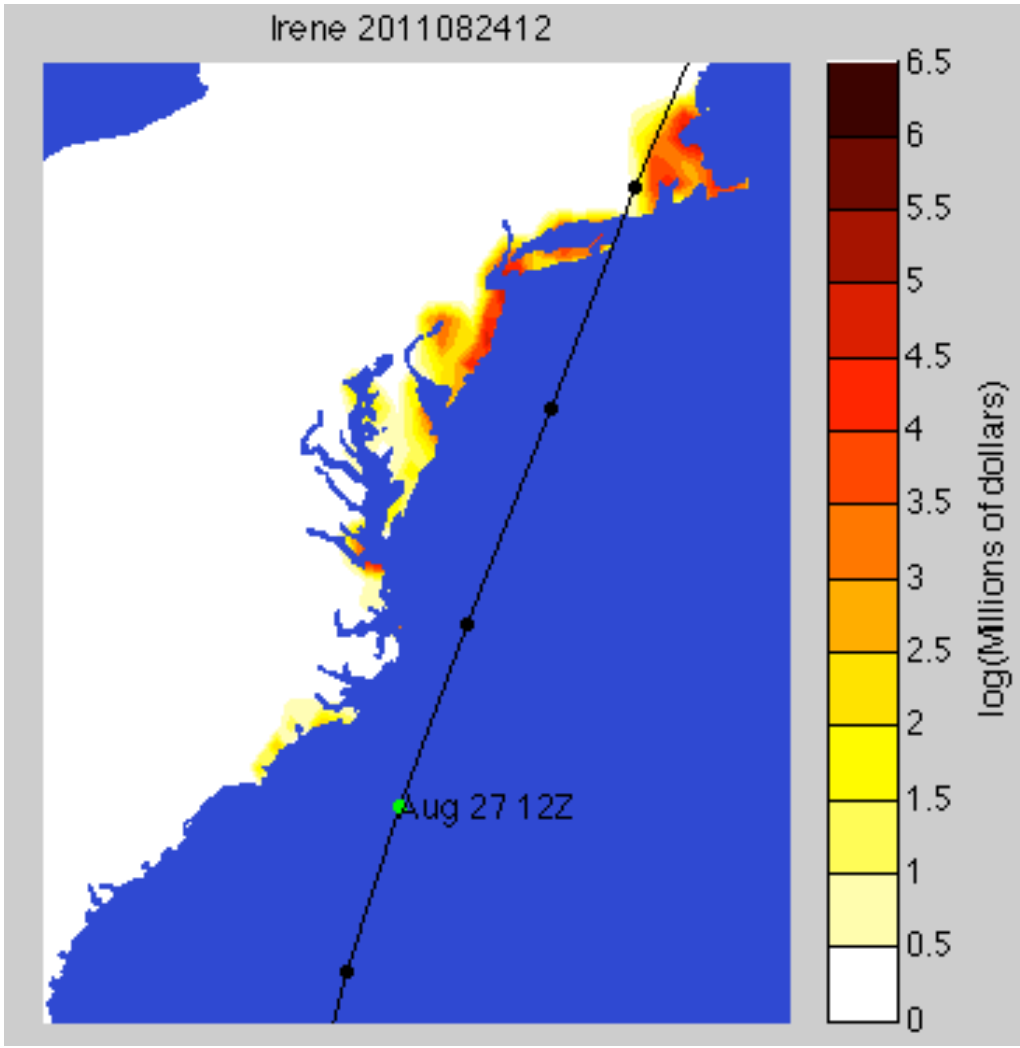
Daniel Gombos and Ross Hoffman



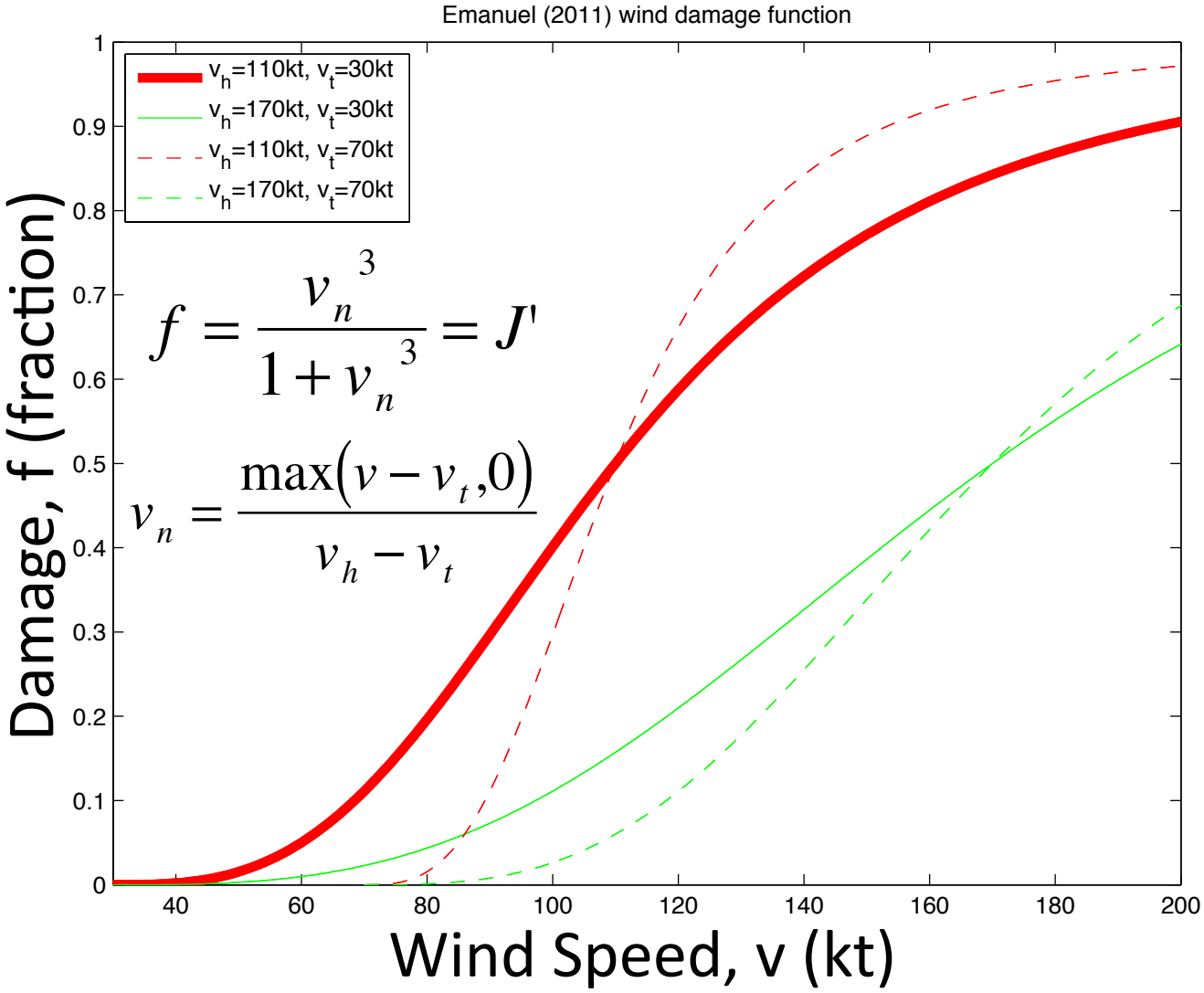




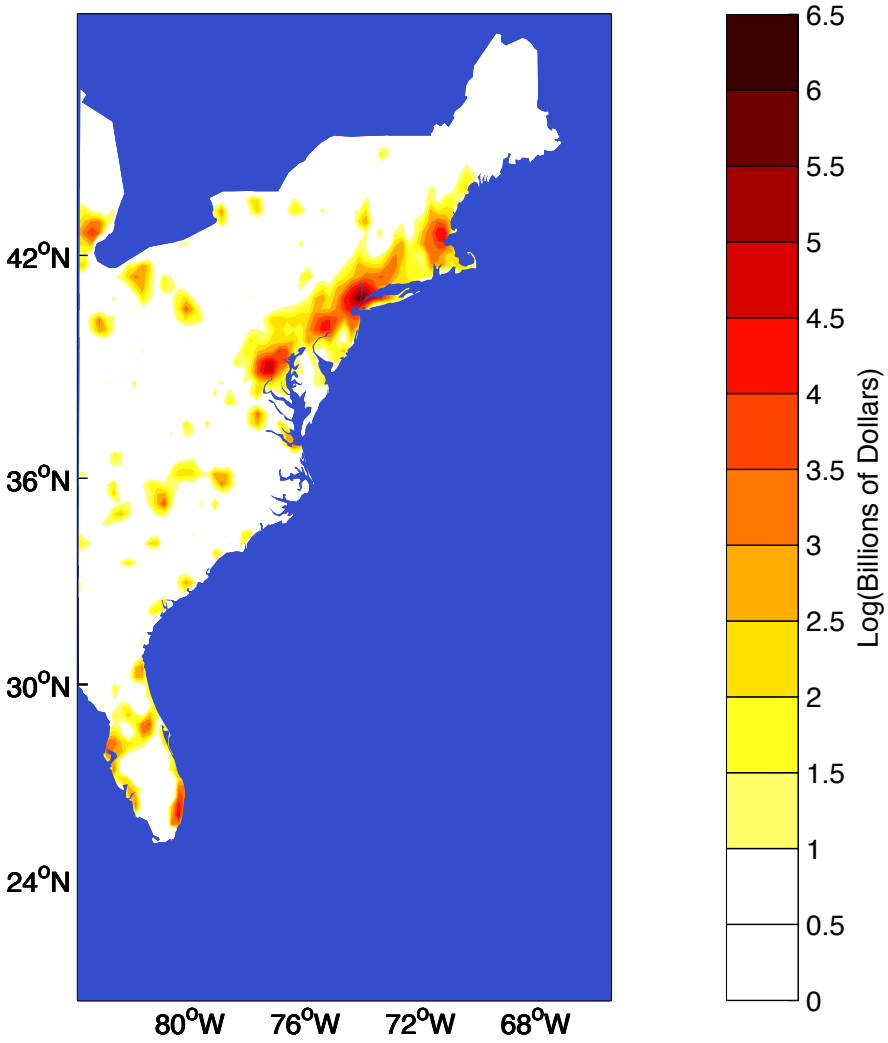
Irene exigent property damage :: 082412



Emanuel (2011) wind damage function



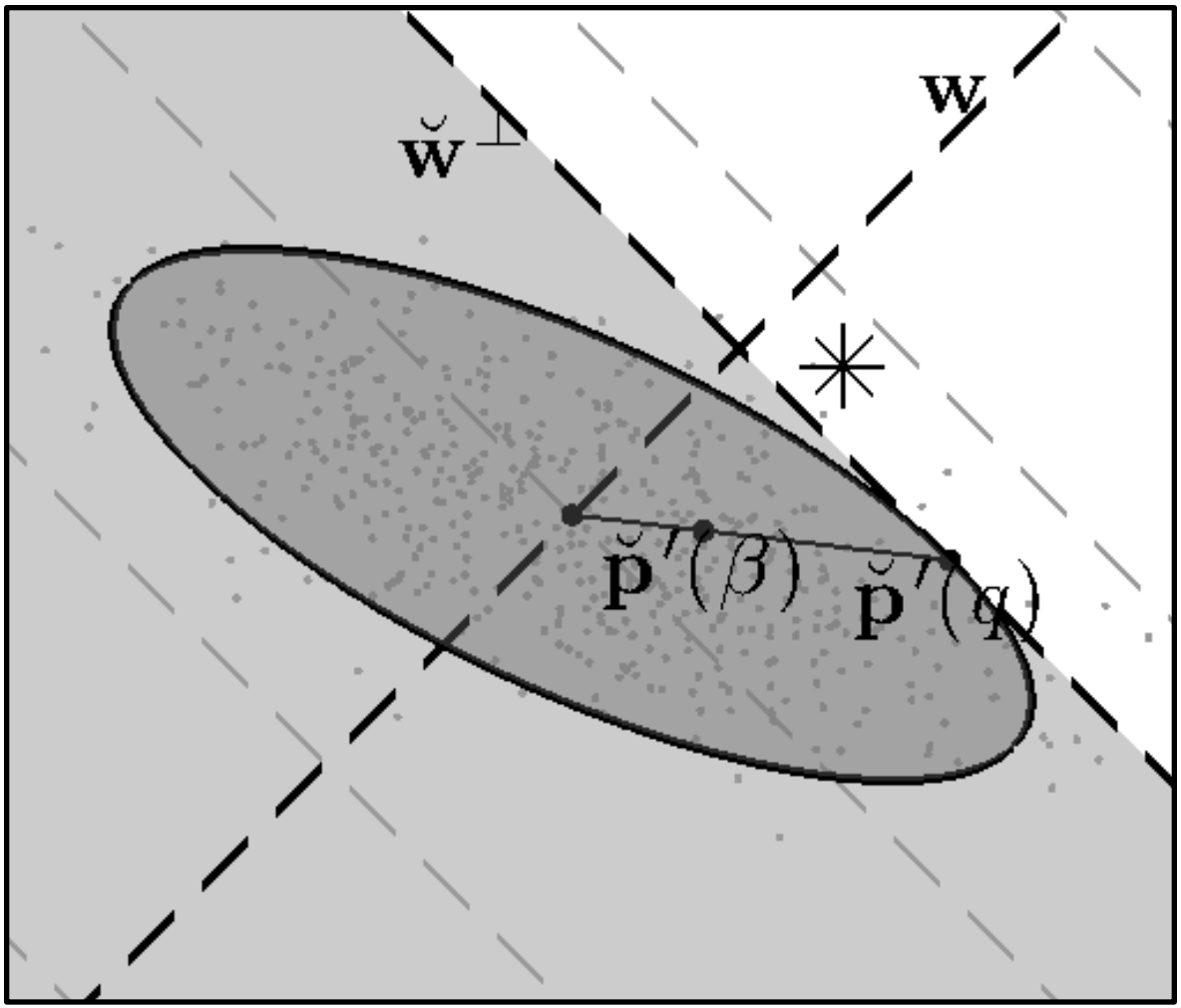
U.S. occupied household value (log $B)



Exigent analysis

- What is the worst case total damage $J=w^{T}p'$
- Worst case?
  - Damage increases as wind speed increases and as area affected increases.
  - What p' maximizes J over all scenarios on the 90^{th} probability percentile, estimated from the ensemble
  - Feasible p's constrained by the correlations in the forecast ensemble

2d example



Exigent algebra

- Use Lagrangian multiplier to Maximize $J = w^T p'$ Constrained by $Q_p^2 = p'^T \mathbf{S}^{-1} p'$
  - Where $Q_p^2 = \chi^2(1/q)$ [Inverse χ^2 of q]
- Solution is $p'_{MAX} = (Q_p/Q_w)\mathbf{S}w$
  - Where $Q_p^2 = w^T \mathbf{S} w$
- Example
  - p'=fraction of value damaged by max sustained winds (max over entire forecast)
  - w= summed value of US occupied households closest to each grid-point

Case 3: Irene property damage :: 082412

$$(\overline{\mathbf{p}} + \breve{\mathbf{p}}') \circ \mathbf{w}$$

$$v_h = 110kt$$

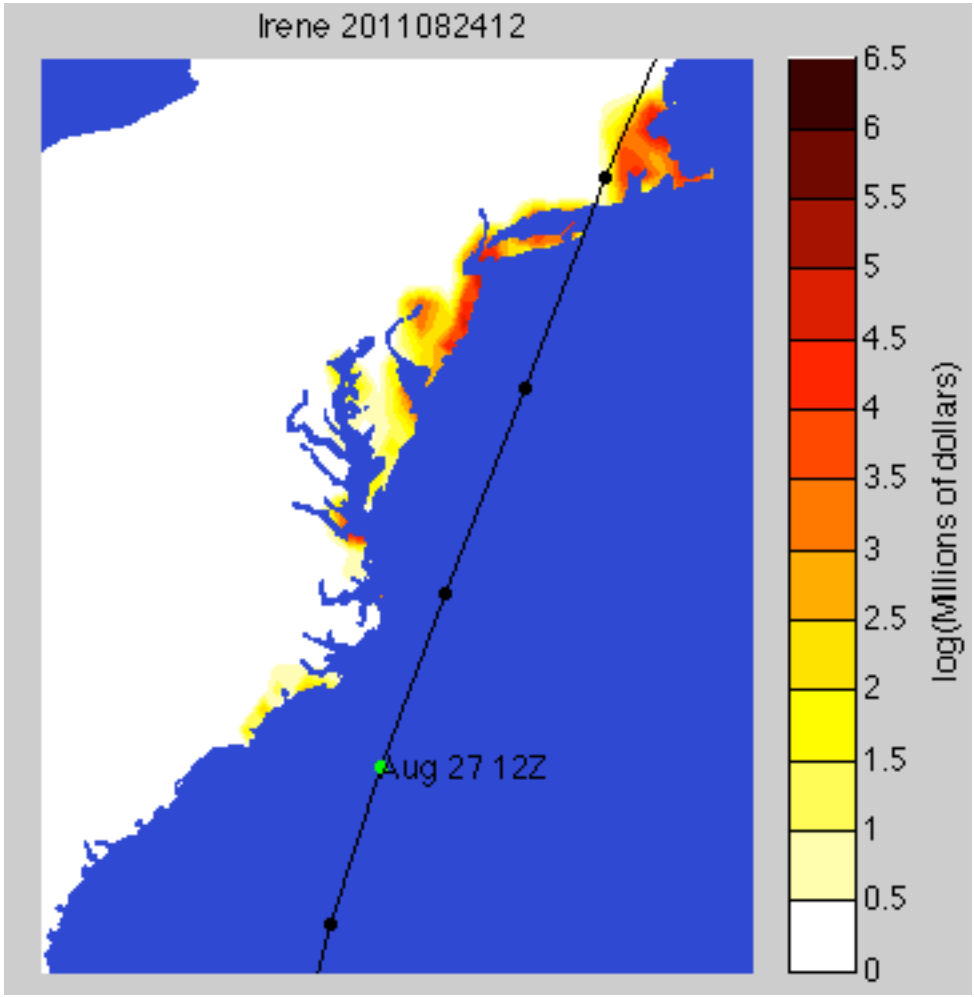
$$v_t = 30kt$$

$$\nu = n_p \sim 12$$

$$q = 0.9$$

w = US occupied household dollar value

Note: values for v_h and v_t chosen to produce most extreme damage



Case 3: Irene property damage :: animate

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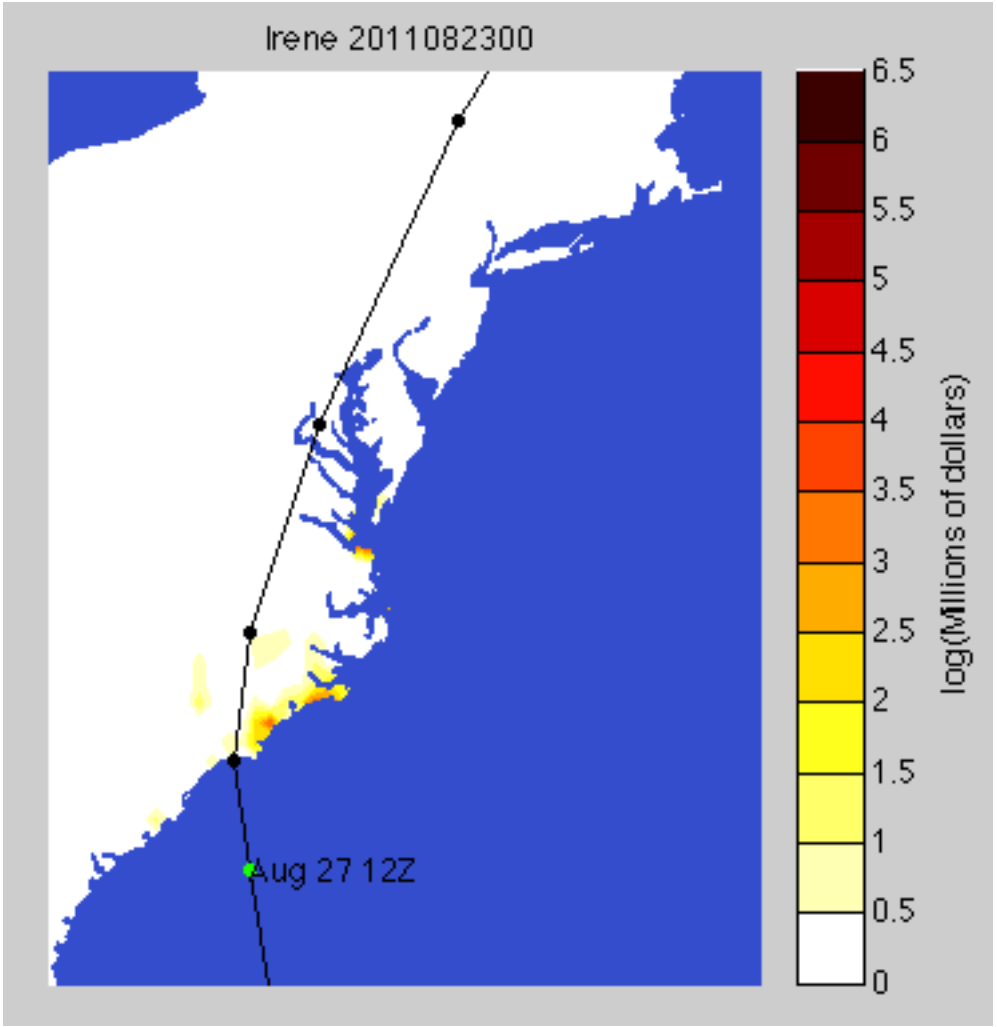


Limitations

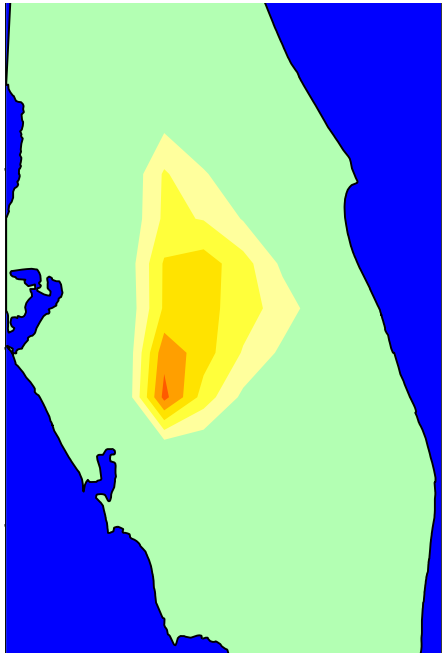
- Must estimate d.o.f.
- Ensemble should be multi-Gaussian (mG)
- Solution is in subspace spanned by the ensemble
- We solve a linear problem, but problem is inherently nonlinear when variables are not mG.

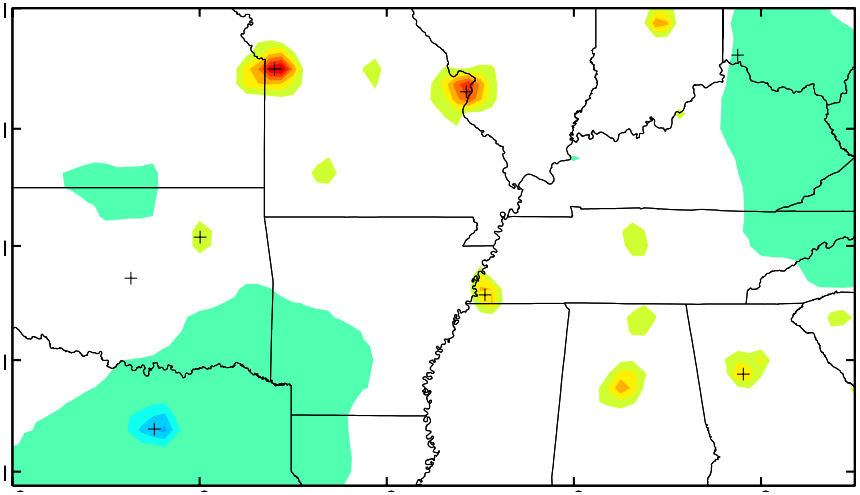
Refinements

- Transform non-mG ensembles into mG ensembles.
  - For nonlinear transforms, damage functional becomes nonlinear
- Linearize nonlinear problems and use an iterative solution method

Applications

- Citrus freeze events
- HDD :: energy demand
- Tornado potential
- Route planning
- Road conditions
- Etc…..





Summary :: Irene property damage