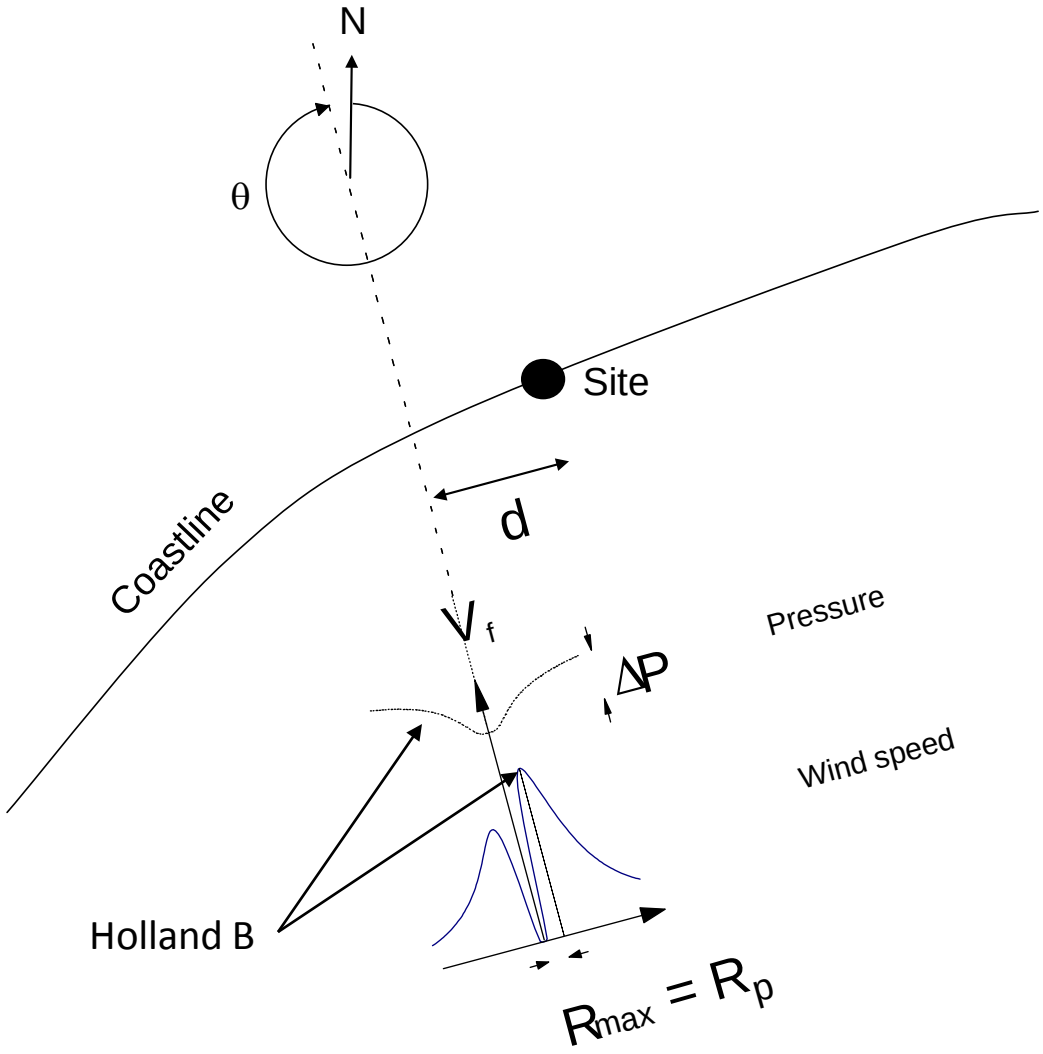
FEMA R-2
Coastal Flood Study
April 5, 2011 Technical Briefing

Statistical Characterization of
Storm Climate & JPM-OS Application
(Hurricanes & Nor'easters)

Background on JPM Method

- Focus: characteristics of storm at landfall (or just prior to; surge depends mainly on storm characteristics in the last ~ 90 nmi)
- Characteristics are treated as finite set random variables



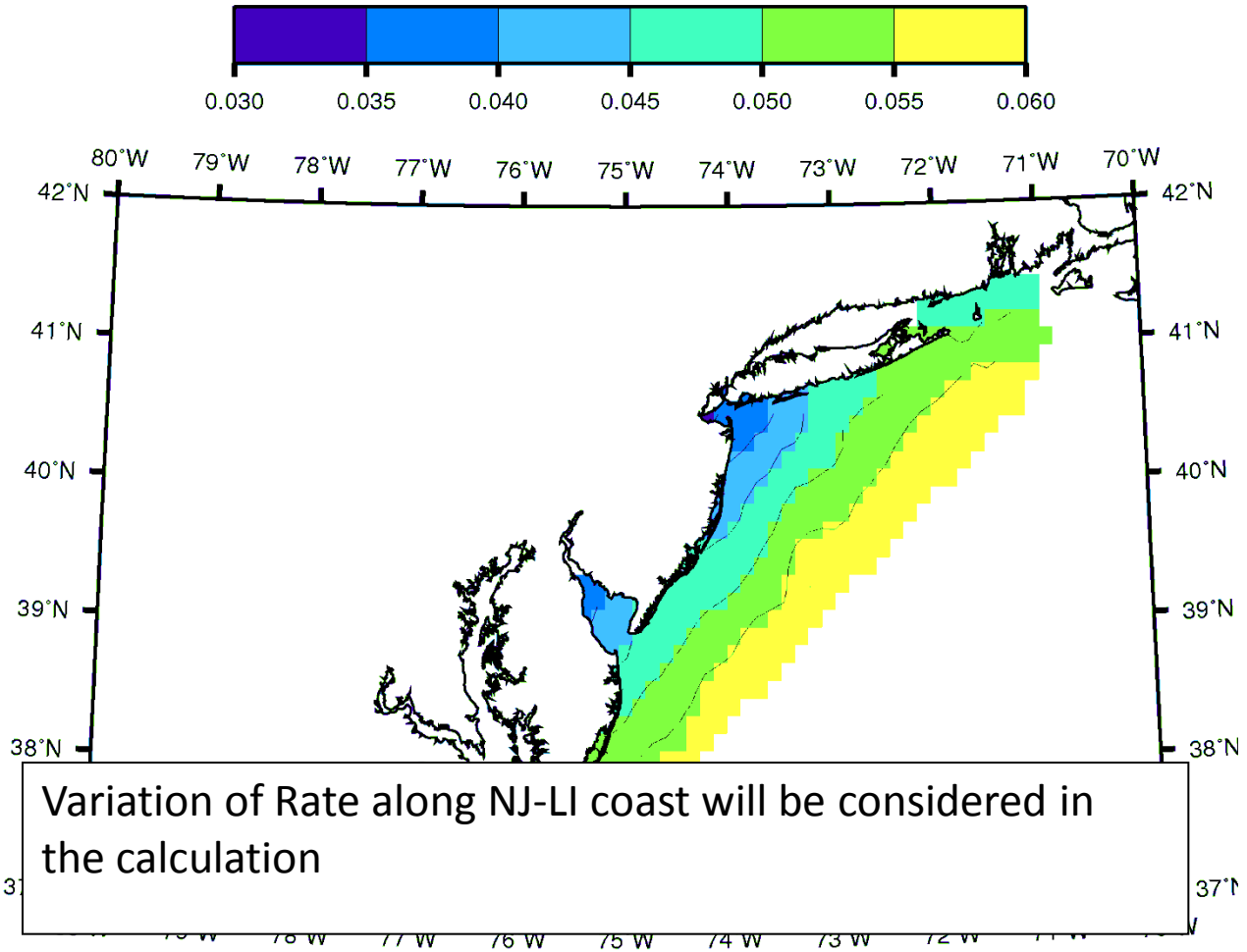
Data

Two data-sets provided by OWI

- All candidate storms (1900-2009; 236 storms, ~ 8,400 snapshots)
  - Coordinates
  - Central Pressure
  - Far-field pressure
- 30 well studied storms (single-vortex representation)
  - Coordinates
  - Central Pressure
  - Far-field pressure
  - Storm radius Rp (~radius of maximum winds)
  - Holland's B

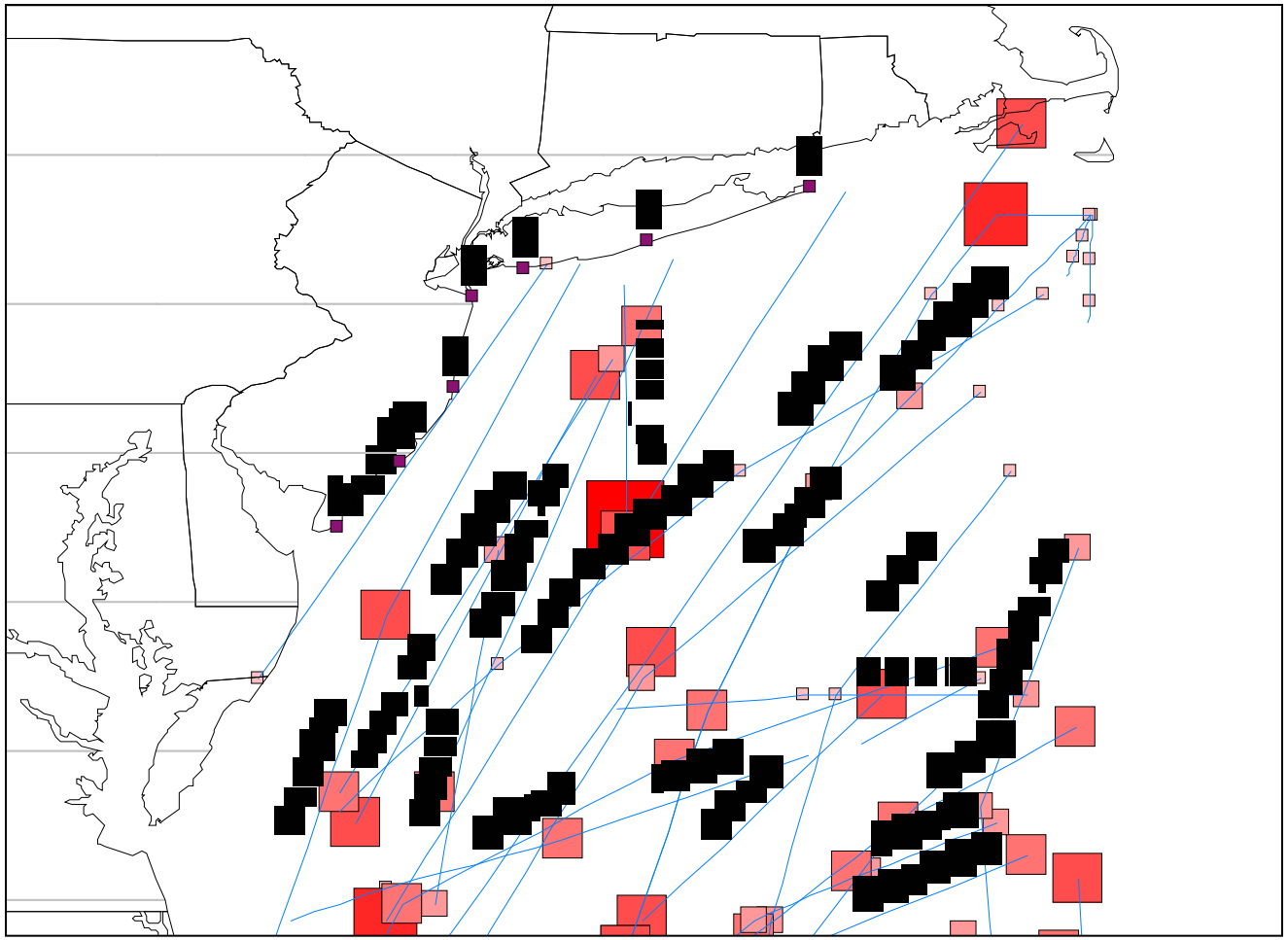
Forward speed and storm heading computed from coordinates, rather than using values in OWI files (different purposes)

Results for Rate λ

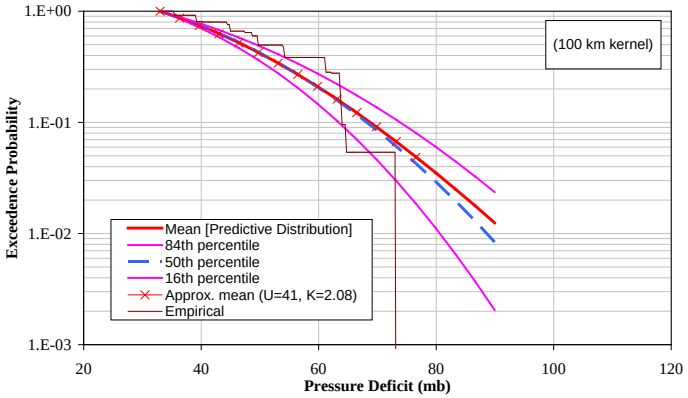


Variation of Rate along NJ-LI coast will be considered in the calculation

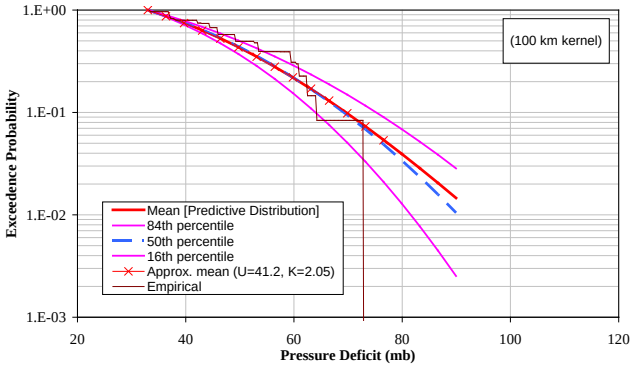
Storms Considered for Analysis of ΔP



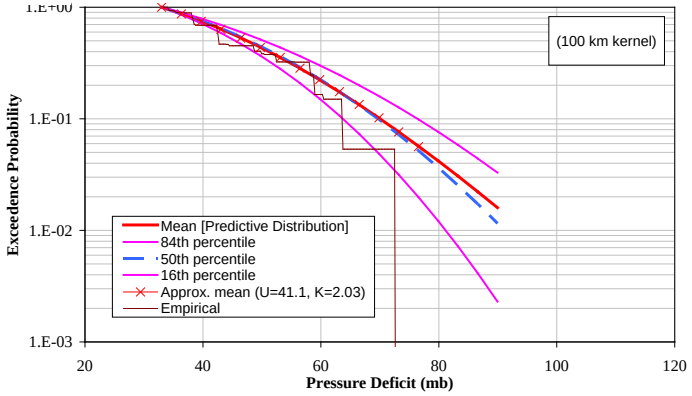
Complementary Cumulative Distribution of DP at Reference Site 1 (38.95 N, 74.84 W)



Complementary Cumulative Distribution of DP at Reference Site 3 (39.82 N, 74.08 W)



Complementary Cumulative Distribution of DP at Reference Site 6 (40.74 N, 72.87 W)



Probabilistic Model for Storm Characteristics

Parameter	Distribution Type	Distribution Parameters	
ΔP (mb)	Truncated Weibull*	U=41.2	K=2.05
Rp (km)	Lognormal	median=Vickery-Wadhera (2008)**	σ_{lnRp}=0.44
Vf (kt)	Normal	mean=6+0.4ΔP	σ=7
θ (deg)	Normal***	mean=22 (23 in LI)	σ=10
B	Normal	mean=1.1	σ=0.2

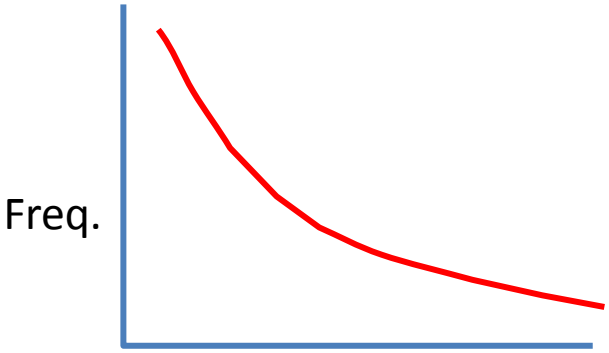
* $P[\Delta P > x] = c\exp[-(x/u)^k]; \quad x > \Delta P_0(33\text{mb})$

**Eq. for median: $\ln(\text{RMW}) = 3.015 - 6.291 \times 10^{-5}\Delta p^2 + 0.0337\Psi;$

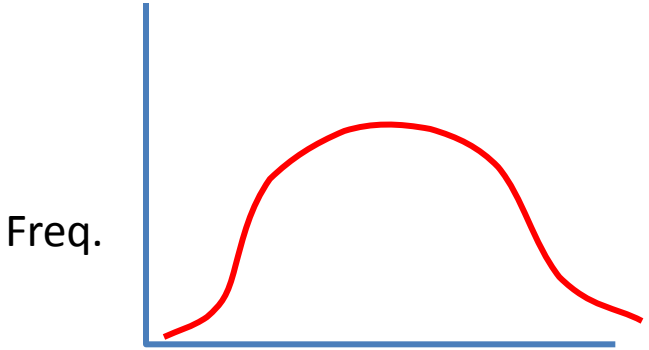
*** truncated at 26 deg for NJ

FITTED DISTRIBUTION FUNCTIONS

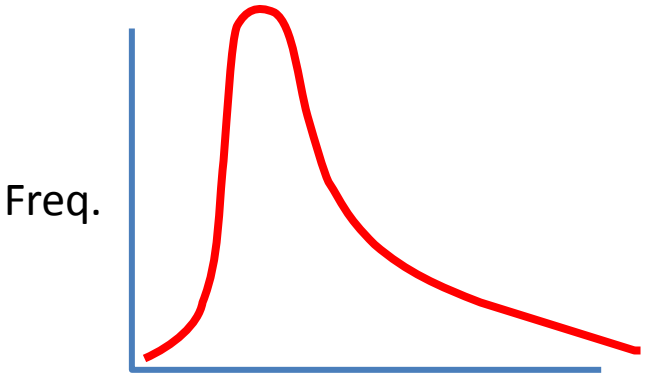
Schematic examples



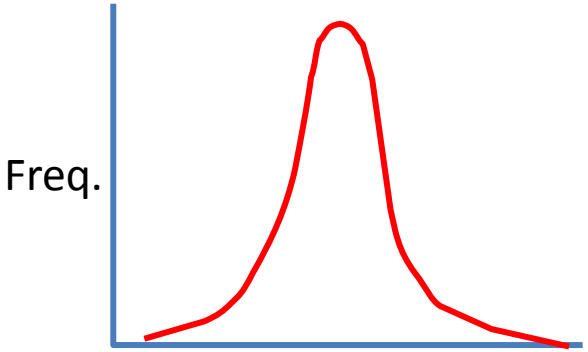
Parameter 1 $(e.g.\Delta P)$



Parameter 3 $(e.g.V_F)$



Parameter 2 $(e.g.R_{MAX})$



Parameter 4 $(e.g.\theta)$

Back to JPM and JPM-OS

$$P[\eta_{\max(1\,yr)} > \eta] = \lambda \int \ldots \int_{\underline{x}} f_{\underline{X}}(\underline{x}) P[\eta(\underline{x}) > \eta] d\,\underline{x}$$

Standard approach (JPM):

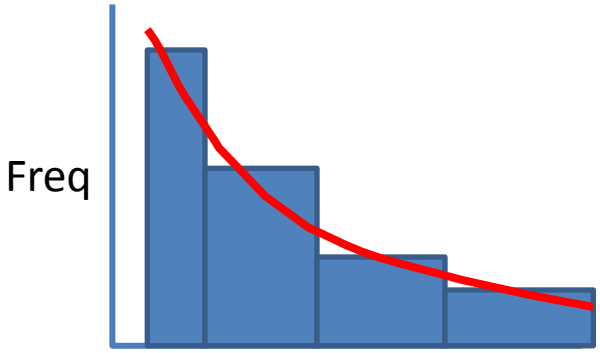
$$P[\eta_{\max(1\,yr)} > \eta] \approx \lambda \sum_{i_1} \cdots \sum_{i_m} f_{\underline{X}}(x_1, \ldots x_m) \Delta x_1 \cdots \Delta x_m P[\eta(x_1, \ldots x_m) > \eta]$$

1. Discretize each distribution (say, 4 values for each)
2. Consider all possible parameter combinations
   - 4^6=4,096 storms for single-vortex representation of windfield (6 parameters)
   - 4^9=262,144 storms for two-vortex representation of windfield (9 parameters)
3. Generate windfield and perform ADCIRC calculations for each storm
4. Compute exceedence probabilities

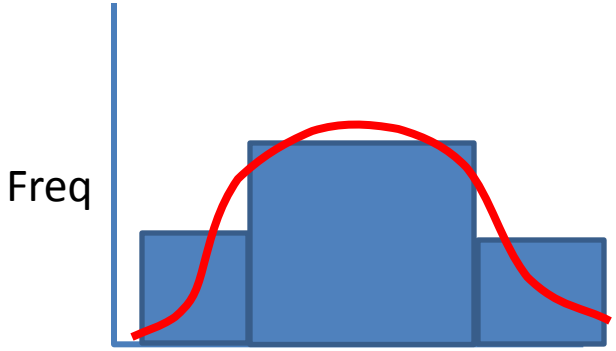
“Curse of Dimensionality”

DISCRETE REPRESENTATIONS

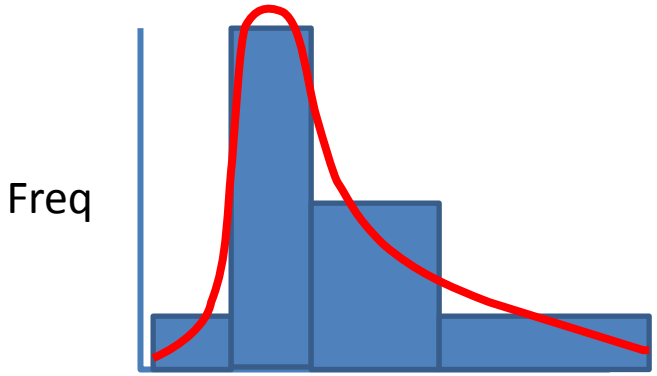
Schematic representation only



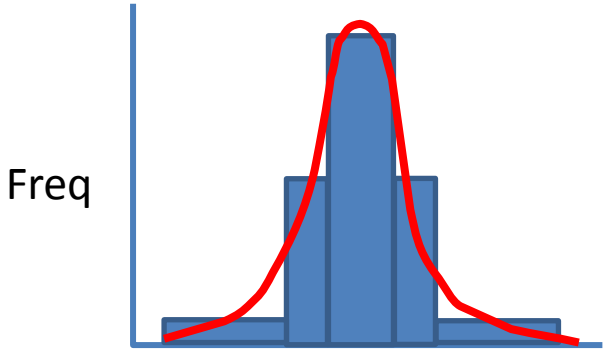
Parameter 1



Parameter 3



Parameter 2



Parameter 4

Total = 16 Bins

Full JPM Parameter Set

		Number of Parameters
1.	Central pressure deficit	1
2.	Radius of max. wind (or Pressure radius)	1
3.	Holland B (or B_1 & B_2 & E_1)	3
4.	Azimuth	1
5.	Forward speed	1
6.	Landfall Location	1
7.	Storm landfall tide phase and height (P, A)	2
8.	Track variations	1
9.	Wind/pressure field variations	1
10.	Model resolution	1
		13

If ~ 3 bins per parameter ($\sim 3^{13} = 1{,}594{,}323$) x 7 tracks = ~11,160,261

Full JPM Parameter Set

		No. Para.
–	**MAJOR PARAMETERS**	
1.	Central pressure deficit	1
2.	Radius of max. wind (or Pressure radius)	1
3.	Holland B (or B_1 & B_2 & E_1)	3
4.	Azimuth	1
5.	Forward speed	1
	OTHER PARAMETERS	7

- Landfall Location
- Storm landfall tide phase and height (P, A)
- Track variations
- Wind/pressure field variations
- Model resolution

If ~ 3 bins per parameter ($\sim 3^7 = 2{,}187$) x 7 tracks = ~15,309)

Full JPM Parameter Set

Reduce to one parameter with sensitivity tests

- **MAJOR PARAMETERS**
- **Central pressure deficit** 1
- **Radius of max. wind (or Pressure radius)** 1
- **Holland B** 1
- **Azimuth** 1
- **Forward speed** 1

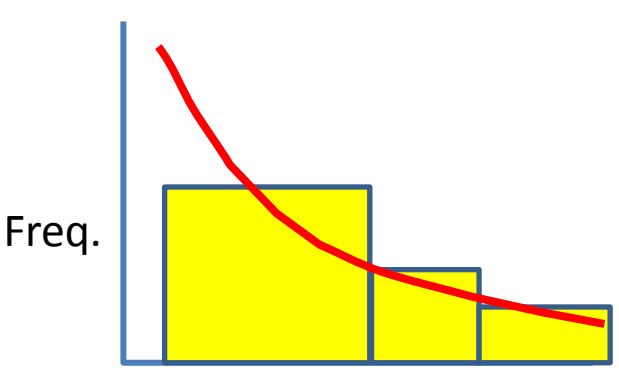
OTHER PARAMETERS 5

- **Landfall Location**
- **Storm landfall tide phase and height (P, A)**
- **Track variations**
- **Wind/pressure field variations**
- **Model resolution**

If ~3 bins per parameter ($\sim 3^5 = 243$) x 7 tracks = ~1,701

ILLUSTRATION OF JPM-OS METHOD OPTIMIZED PARAMETER BIN SELECTIONS

Schematic examples



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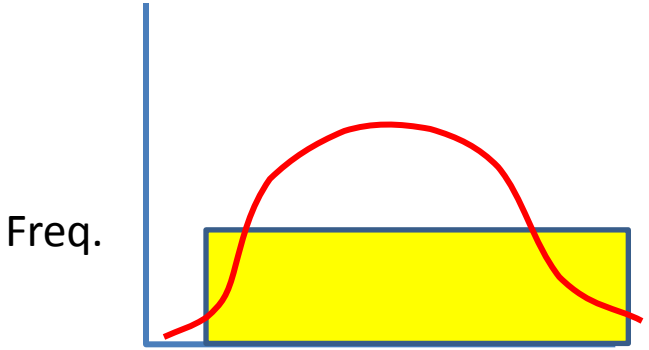
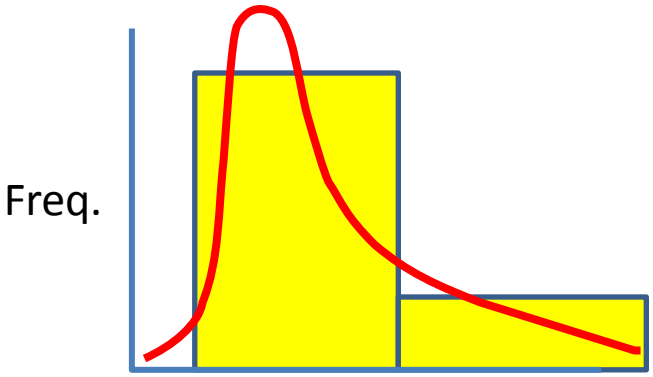
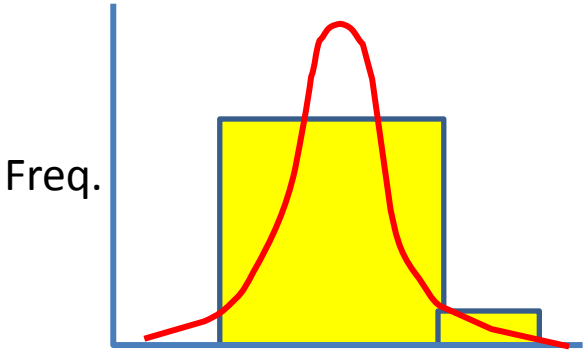


Parameter 3 $(e.g.V_F)$



Parameter 2 $(e.g.R_{MAX})$



Parameter 4 $(e.g.\theta)$

Total = 8 Bins

Using JPM-OS Parameter Set

MAJOR PARAMETERS

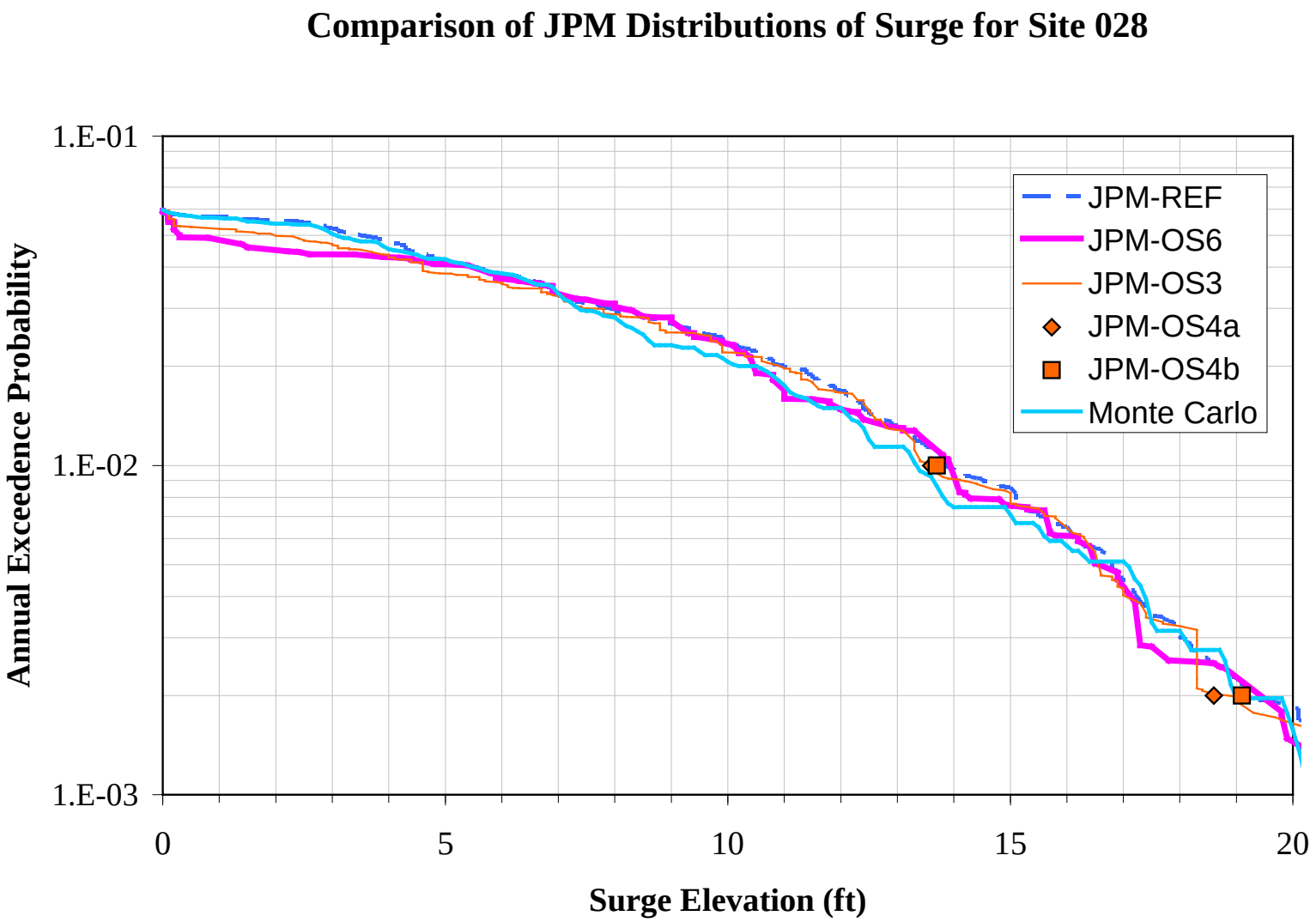
- Central pressure deficit
- Radius of max. wind (or Pressure radius)
- Holland B Azimuth
  Forward speed
-

OTHER PARAMETERS

- Landfall Location
- Storm landfall tide phase and height (P, A)
- Track variations
- Wind/pressure field variations
- Model resolution

Only important ranges = 35 x ~ 7 tracks = ~ 245 simulations

Comparison of Reference and JPM-OS Sets: Results (Toro et al. paper)



Consider the Other Parameters

MAJOR PARAMETERS

- **Accounted for with JMP-OS**
-

OTHER PARAMETERS

- **Landfall Location**
- **Storm landfall tide phase and height (P, A)**
- **Track variations**
- **Wind/pressure field variations**
- **Model resolution**

Included in the track count

Only important ranges = 35 x ~ 7 tracks = ~ 245 simulations

Consider the Other Parameters

MAJOR PARAMETERS

- **Accounted for with JMP-OS**
-

OTHER PARAMETERS

- **Landfall Location**
- **Storm landfall tide phase and height (P, A)**
- **Track variations**
- **Wind/pressure field variations**
- **Model resolution**

Included in the track count

Special tests show that these can be accounted for in each storm simulation

Consider the Other Parameters

MAJOR PARAMETERS

- **Accounted for with JMP-OS**
-

OTHER PARAMETERS

- **Landfall Location**
- **Storm landfall tide phase and height (P, A)**
- **Track variations**
- **Wind/pressure field variations**
- **Model resolution**

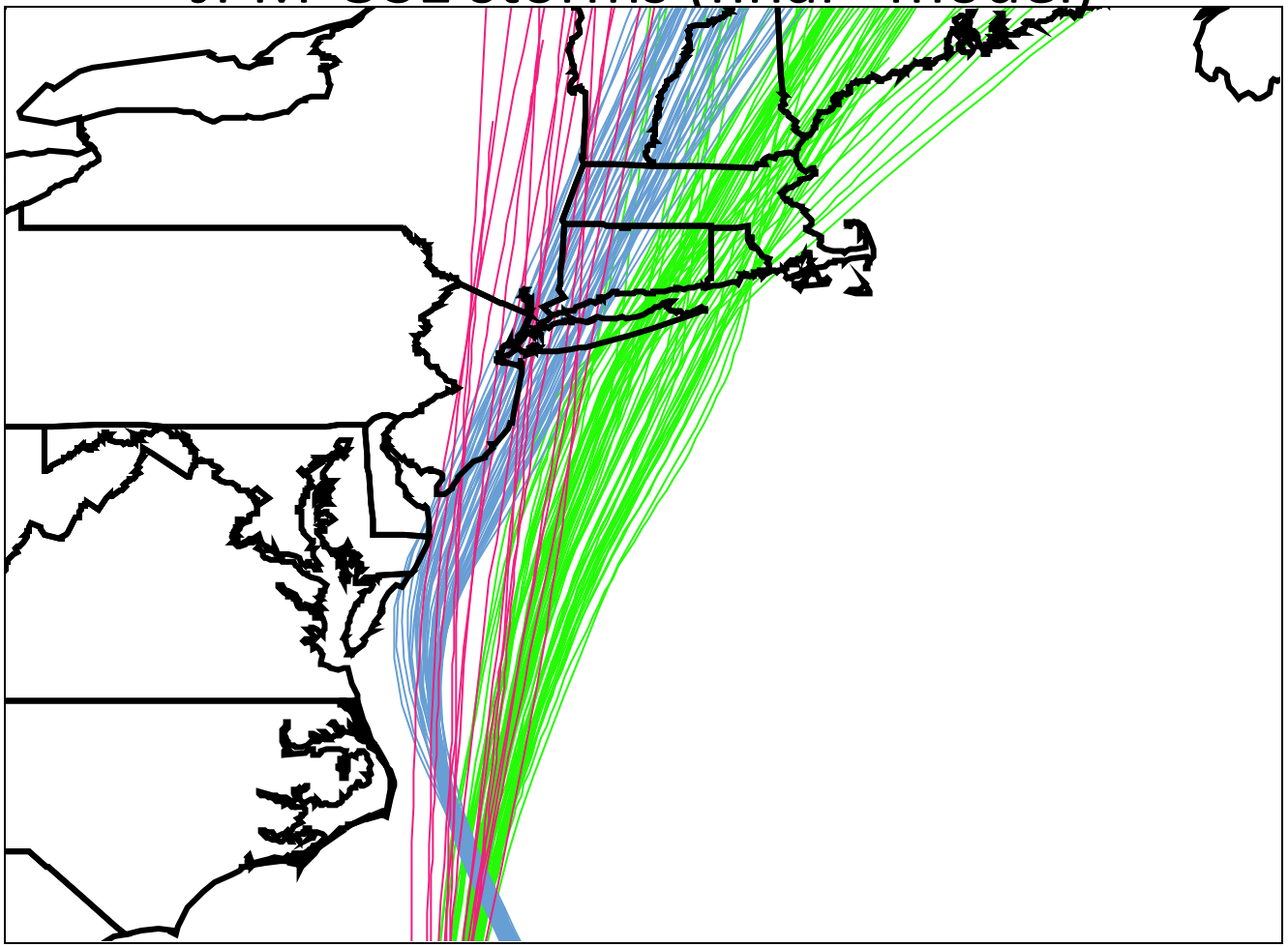
Included in the track count

Special tests show that these can be accounted for in each storm simulation

Handled in post-processing with variability term

Only important "resized" bins = 35 x ~ 7 tracks = ~ 245 synthetic hurricanes

JPM-OS1 storms (final* model)



*As of last week: need to introduce latitude-dependent ΔP and Rp and possibly add some storms to the East

Summary

- Hurricanes
  - JPM-OS with 35 Synthetic Storms each on a set of approximately 6 to 9 tracks (depending on storm size)
  - Consider only storms with $\Delta P > 33$ mb (Cat $\geq$ 2)
- Nor'easters
  - Key storms = 12 and total = 30
  - EST analysis

Questions
&
Discussion