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On the selection of the most impactful storms from a synthetic Tropical Cyclone database

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Outline

- Project motivation & components
- Simple/fast wave model
  - Parametric wave model
  - Dynamic wave model (coarse resolution)
- Validation
- Size for storm selection
- Summary

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Motivation

- Project for Woodside Energy Ltd – their support is gratefully acknowledged
- Determine 1 in 10,000 ARI year winds and waves for Tropical Cyclones (TCs) on the North West Shelf
- Reliable observational record too short for direct analysis
  - ~40 years for position
  - ~15 years for intensity, structure
- Hence, require a synthetic track approach – here, 100 000 years

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Project components

PP32 Hindcasting historical tropical cyclone wind waves – Saima Aijaz et al.

Synthetic track database
- ~10M storms
- Location, motion, intensity, Rmax, Rgale
- Vortex model parameters
- Analogue storms
- Simple BL winds at POIs

Parametric vortex model
- Gradient level winds

Historical storms
- 17 notable cases
- Calibration and validation

Simple boundary layer model
- Uses statistical relationships between gradient and surface winds

Dynamical boundary layer model
- Kepert and Wang (2001), Kepert (2012)

Vortex blending
- Blends synthetic wind field with suitable environment.

Simple wave model

Storm selection
- Select cases for detailed modelling

Complex wave model
- WAVEWATCHIII® version 6.07
- 5/1 km grid
- Nested in global

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Parametric wave model

- Young (1988) extended Bretschneider's (1957) concept of equivalent fetch F as function of maximum wind speed v_m and forward speed v_{fm} …

$$\frac{F}{R'} = av_m^2 + bv_m v_{fm} + cv_{fm}^2 + dv_m + ev_{fm} + f$$

- R' is a scaled radius as function of r_m (radius to v_m)
- … and JONSWAP fetch limited growth relationship (Hasselmann et al. 1973)

$$H_{s\,\max} = 0.0016 \frac{v_m^2}{g} \left(\frac{gF}{v_m^2}\right)^{0.5}$$

$$T_{p\,\max} = 0.045 \frac{2\pi\, v_m}{g} \left(\frac{gF}{v_m^2}\right)^{0.33}$$

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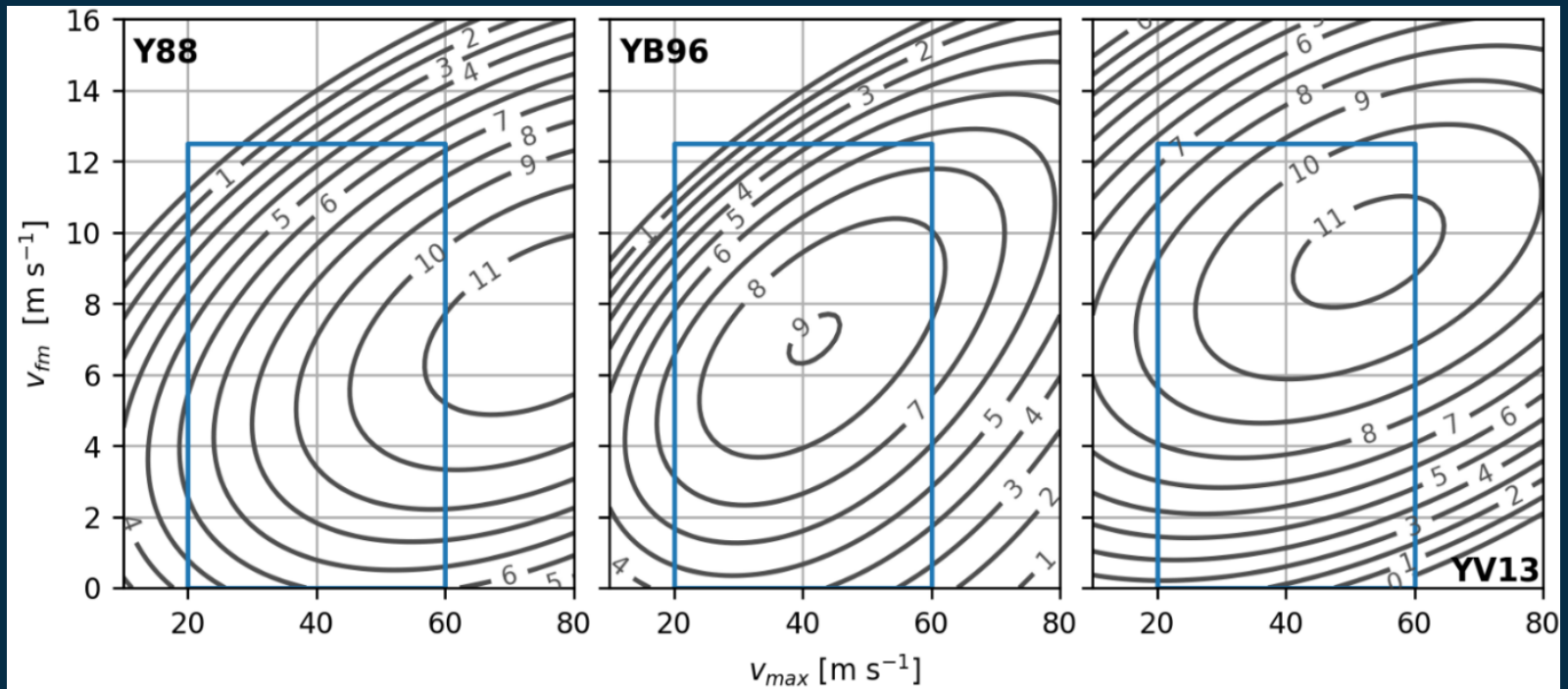
Parametric wave model

- Young (1988) – synthetic database (~43 storms)
- Young & Burchell (1996) – GEOSAT altimeter data (~100 storms)
- Young & Vinoth (2013) – altimeter data (~440 storms)



$\frac{F}{R'}$

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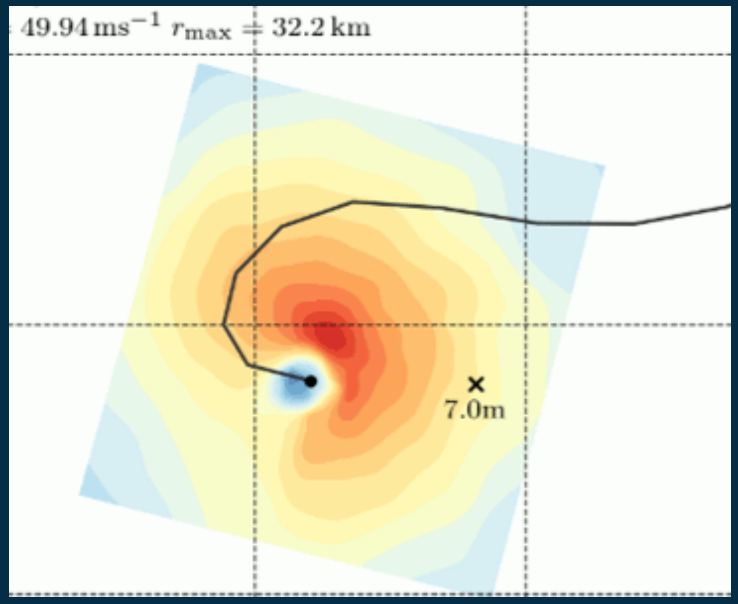
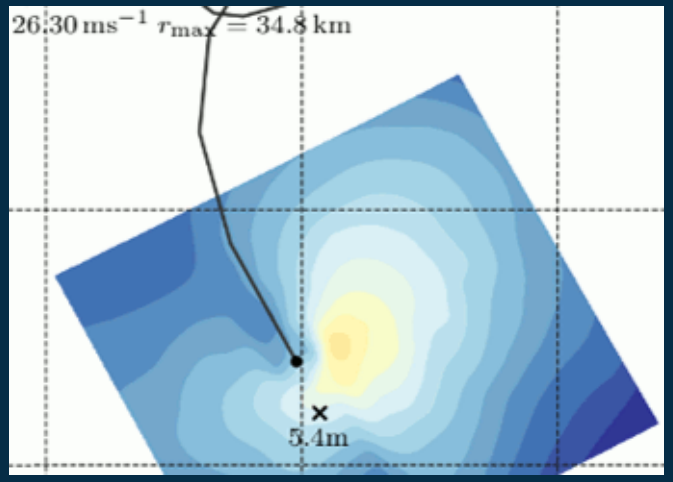
Parametric wave model

- Young (1988) pre-computed spatial wave fields with 2G wave model for a range of v_m and v_{fm} (radius to maximum wind speed was fixed)

$H_{s\,\max} = 10.9\text{m}$
$v_m = 49.9\text{m s}^{-1}$
$v_{fm} = 2.4\text{m s}^{-1}$



$H_{s\,\max} = 7.3\text{m}$
$v_m = 26.3\text{m s}^{-1}$
$v_{fm} = 5.3\text{m s}^{-1}$



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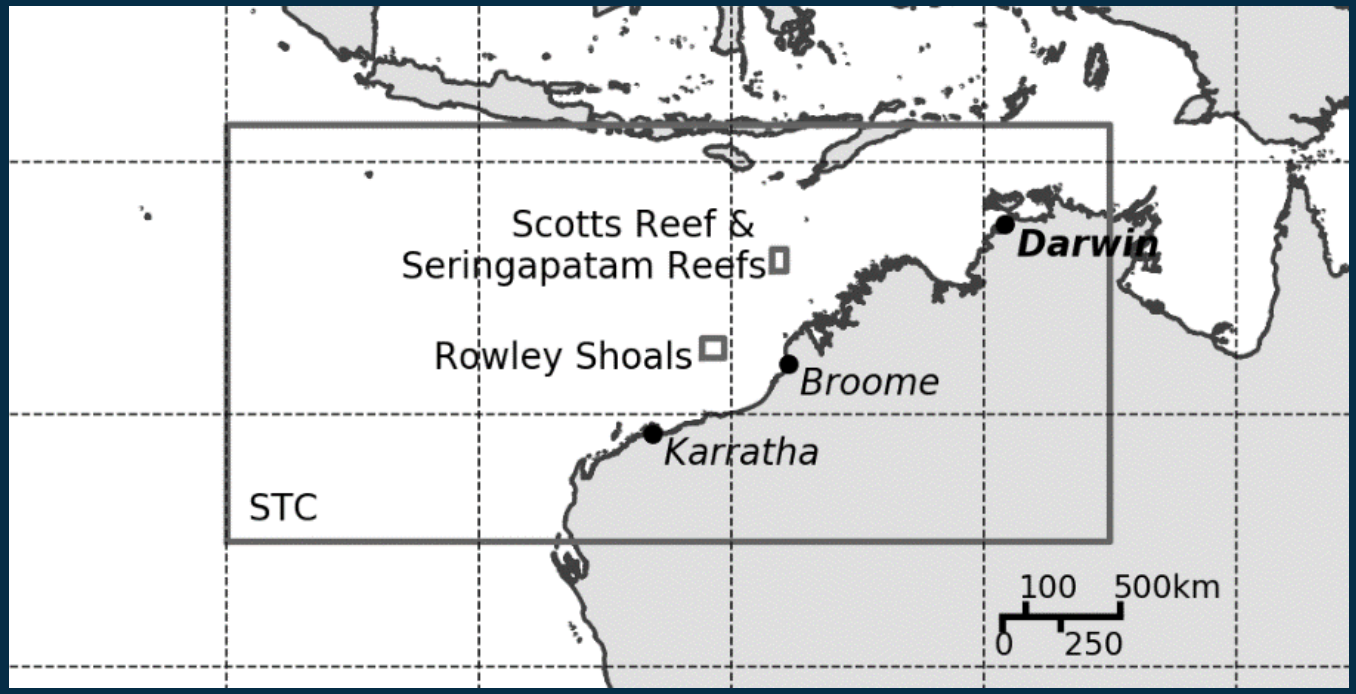
Complex wave model



- 3800x1800 km
- 0.05º spatial resolution (dedicated 0.01º grids around reef areas)
- 5º directional resolution (to avoid GSE)

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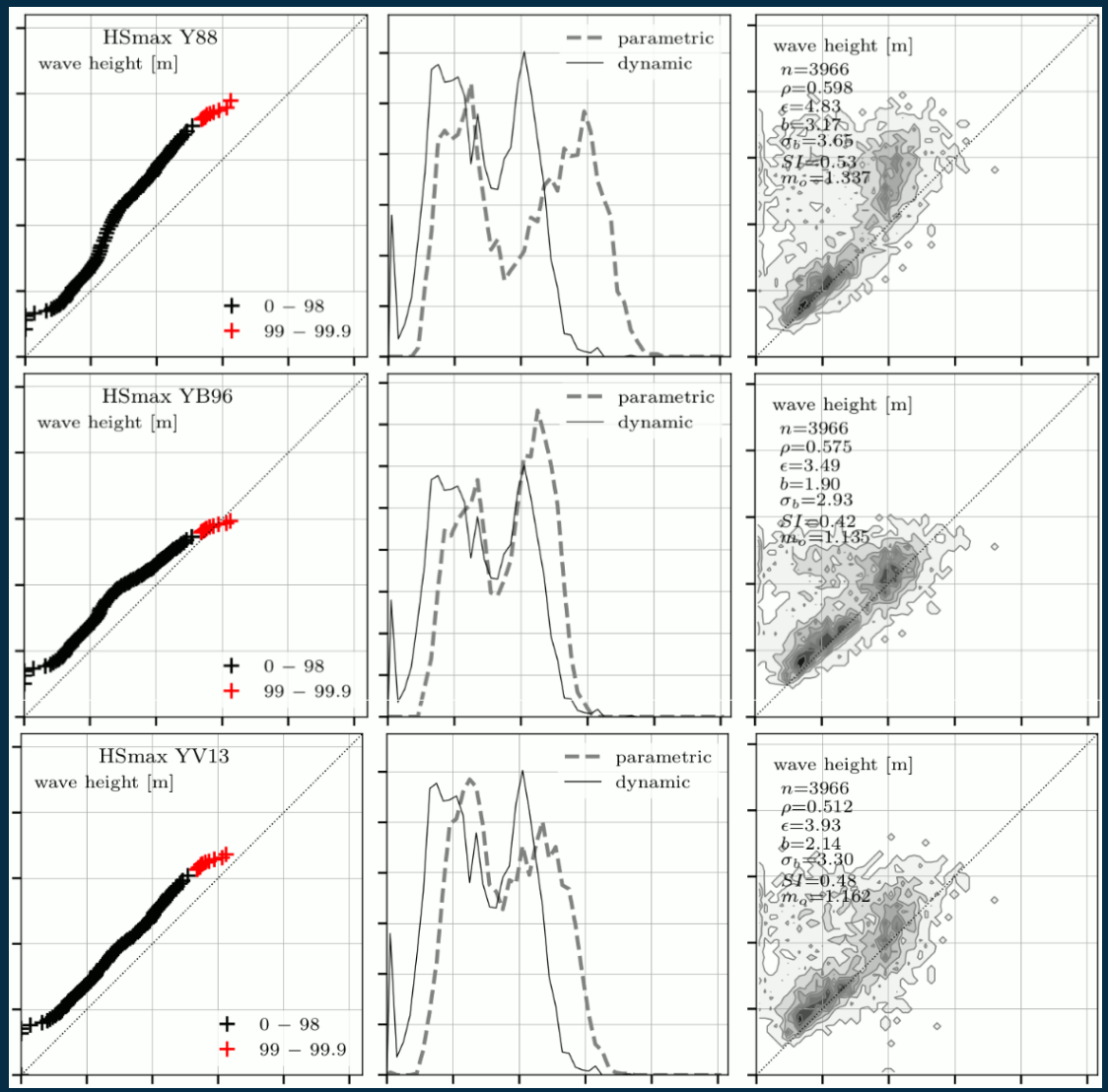
Parametric wave model

- Wave model comparison Parametric vs. dynamic
- ~2,000 storms
- Maximum Hs
  - RMSE 3.5-4.8 m
  - BIAS 1.9-3.2 m
  - Correlation 0.5-0.8



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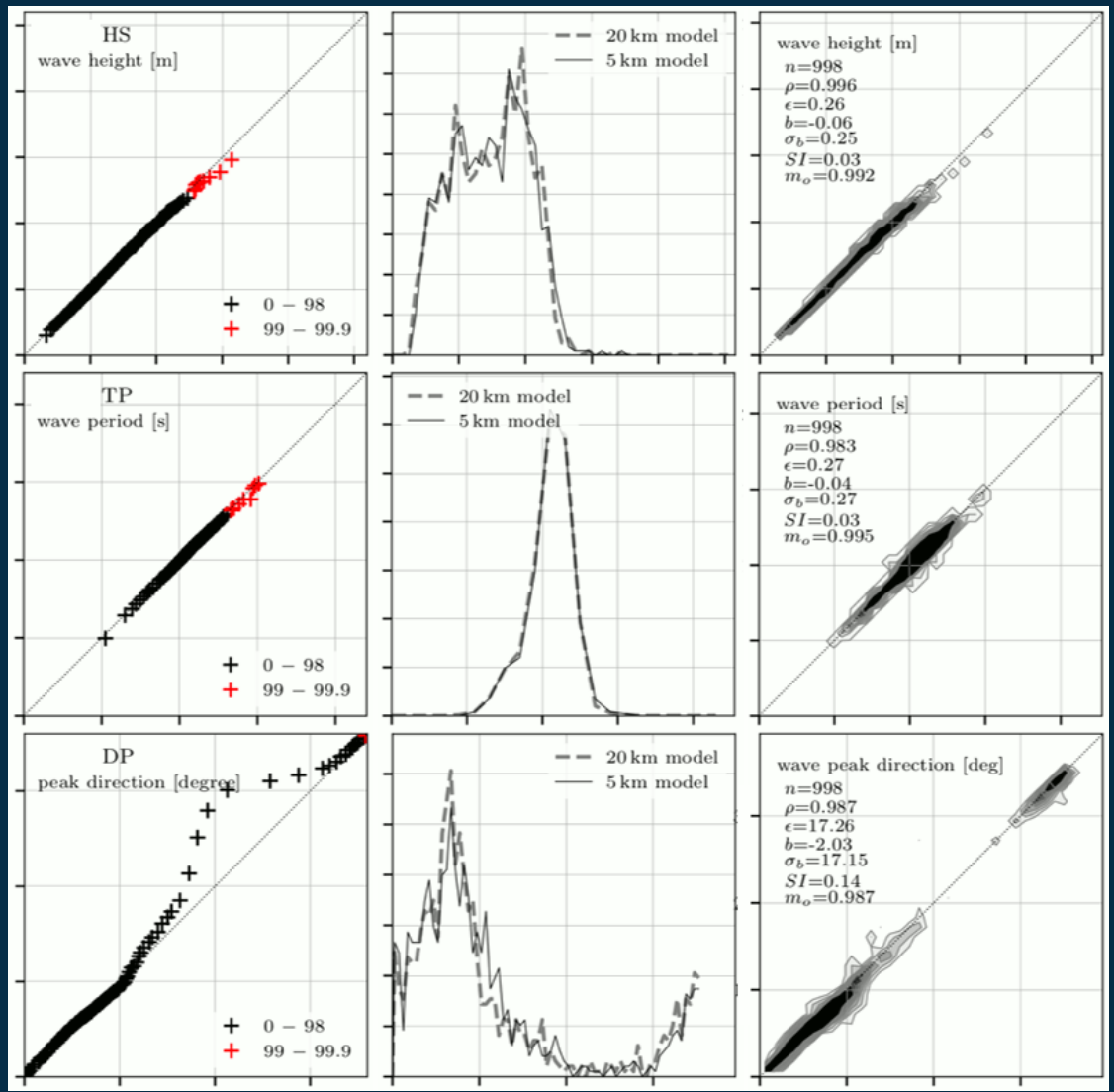
Coarse resolution wave model

- Coarse vs. complex
- Setup a 0.20º grid
- Comparison at point
- Significant wave height
  - RMSE 0.26m
  - BIAS -0.06m
  - Correlation 0.996
- Peak period
  - RMSE 0.27s
  - BIAS -0.04s



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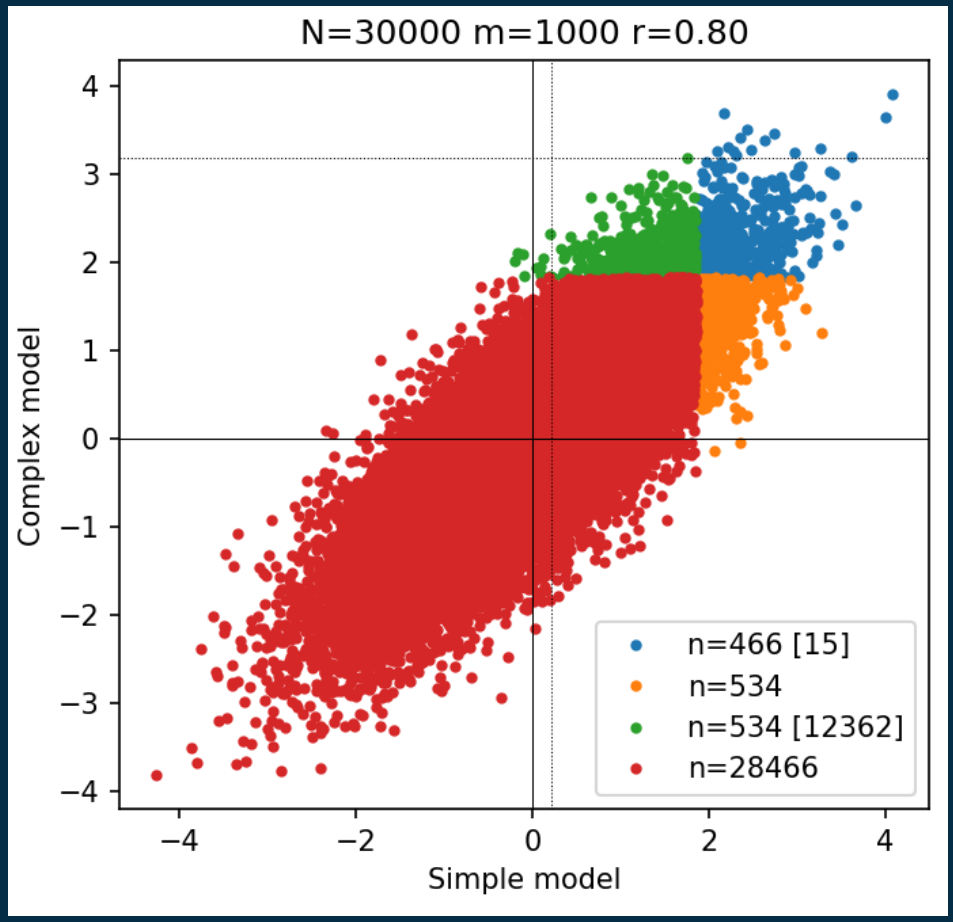
Storm size estimate

- Pre-screen synthetic database (n=30,000)
- Parametric wave model with a correlation 0.80
- Consider top 1,000 storms
- Only 15 would actually be in the tail of the distribution
- If 95% of 1,000 storms should be represented in the tail one would need to model 12,362 storms



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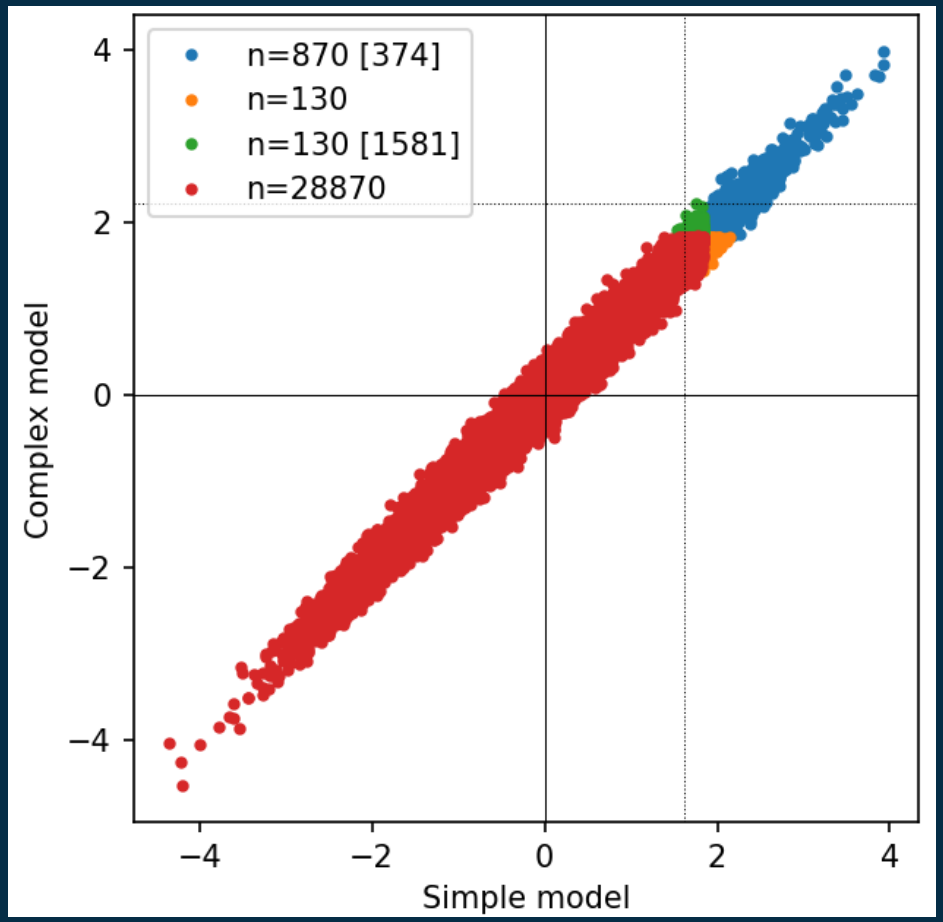
Storm size estimate

- Coarse wave model with a correlation 0.99 (n=30,000)
- 374 storms would actually be in the tail of the distribution
- If 95% of 1,000 storms should be represented in the tail distribution one would need to model 1,581 storms



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Summary

- Parametric and coarse wave models evaluated for storm selection for synthetic tropical cyclone database
- Low accuracy of the simple wave model inflates the number of storms candidates that represent the tail of the distribution
- Coarse wave model has possibility to provide additional storm parameters for the storm selection process (i.e. $H_s, T_p, \theta_p, v_m, r_m, v_{fm}$, etc.)
- Cost per storm (7 day simulation)
  - Parametric wave model ~0.02 CPU hours
  - Coarse (wind + wave) model ~1 CPU hour
  - Complex (wind + wave) model ~1,000 CPU hours

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Questions?

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