

1. Introduction

Motivation

- Tropical cyclone (TC) wind field modeling has generally assumed a non-varying, uniform outer TC size (Emanuel et al. 2006);
- Outer TC size, however, can exhibit substantial fluctuations over storm lifetime (Cocks and Gray 2002);
- Accurate estimates of TC hazards (e.g., storm surge) require realistic estimates of outer TC size (Lin et al. 2014).

Objective

Construct a simple statistical model for outer TC size for North Atlantic (NA) storms to improve quantification of TC hazards.

2. Methodology

Datasets

- NA TCs (maximum azimuthal-mean 10-m azimuthal wind ≥ 15 m/s) over ocean during 1979–2010 in IBTrACS (Knapp et al. 2010) are examined;

- TC wind field taken from 6-h 0.5° NCEP Climate Forecast System Reanalysis (Saha et al. 2010).

Methods

- Outer Size Metric: radius in which azimuthal-mean 10-m azimuthal wind equals 8 m/s (r_8) derived following Chavas and Vigh (2014);

- Statistical r_8 model provides r_8 at three TC lifetime milestones:

- TC Genesis r_8 ($r_{8,genesis}$);
- Lifetime Maximum r_8 ($r_{8,max}$);
- End of Lifetime r_8 ($r_{8,end}$).

- TC lifetime: length of time in which TC maximum azimuthal-mean 10-m azimuthal wind ≥ 15 m/s;

- Predictors for each lifetime milestone chosen using stepwise multilinear regression employing backward and forward selection at 5% confidence level;

- Model with median performance examined from 1000 model iterations constructed by randomly resampling TCs using bootstrap approach;

- 60% of cases are used for training and 40% of cases for validation

3. Results: Overview of Genesis r_8 Predicted from Statistical Model

Overview

Genesis SSTs and genesis Julian day are used to construct a multilinear regression model for genesis r_8 .

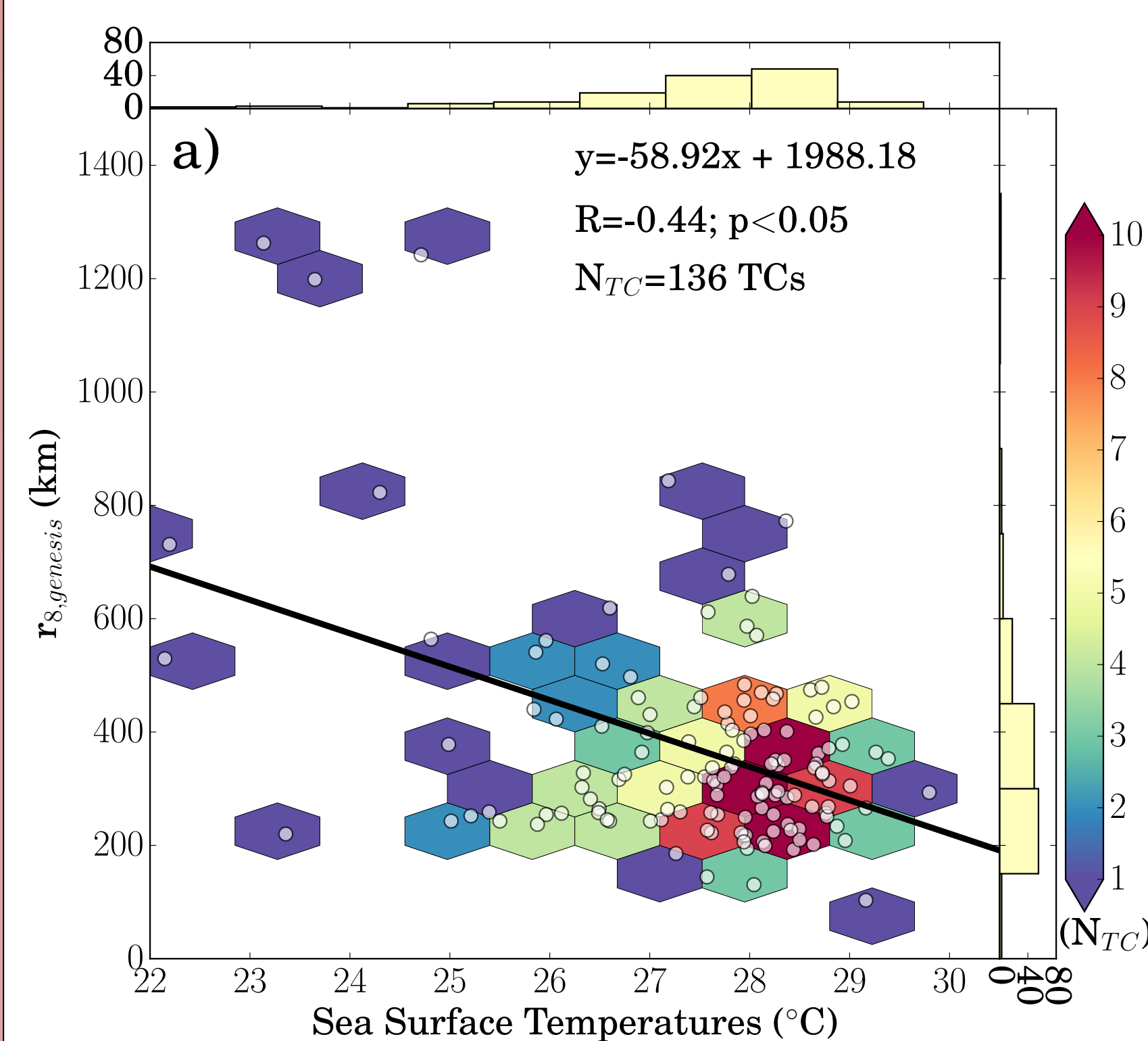
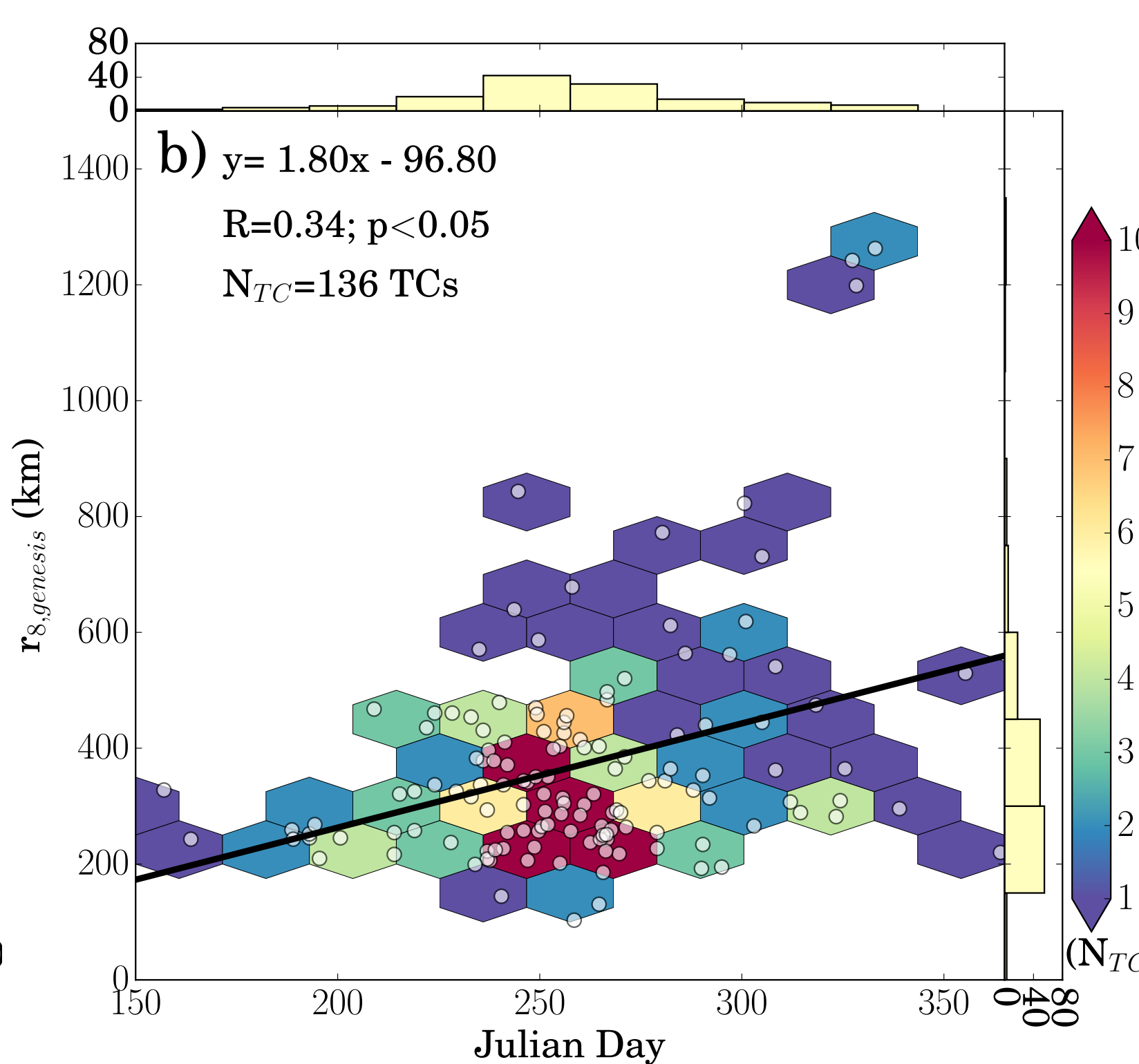


Fig. 1: Joint histograms of relationships used to construct genesis r_8 model including (a) genesis SSTs (°C) versus genesis r_8 (km) and (b) genesis Julian day versus genesis r_8 (km) for all TCs. The black line represents the simple linear regression line.



Synopsis

- Genesis r_8 dependent on genesis SSTs (Fig. 1a) and, to lesser extent, genesis Julian day (Fig. 1b);
- Implies high-latitude, late season TCs generally have largest r_8 (Fig. 1);
- Statistical model produces r_8 values that are moderately correlated with reanalysis r_8 (Fig. 2).

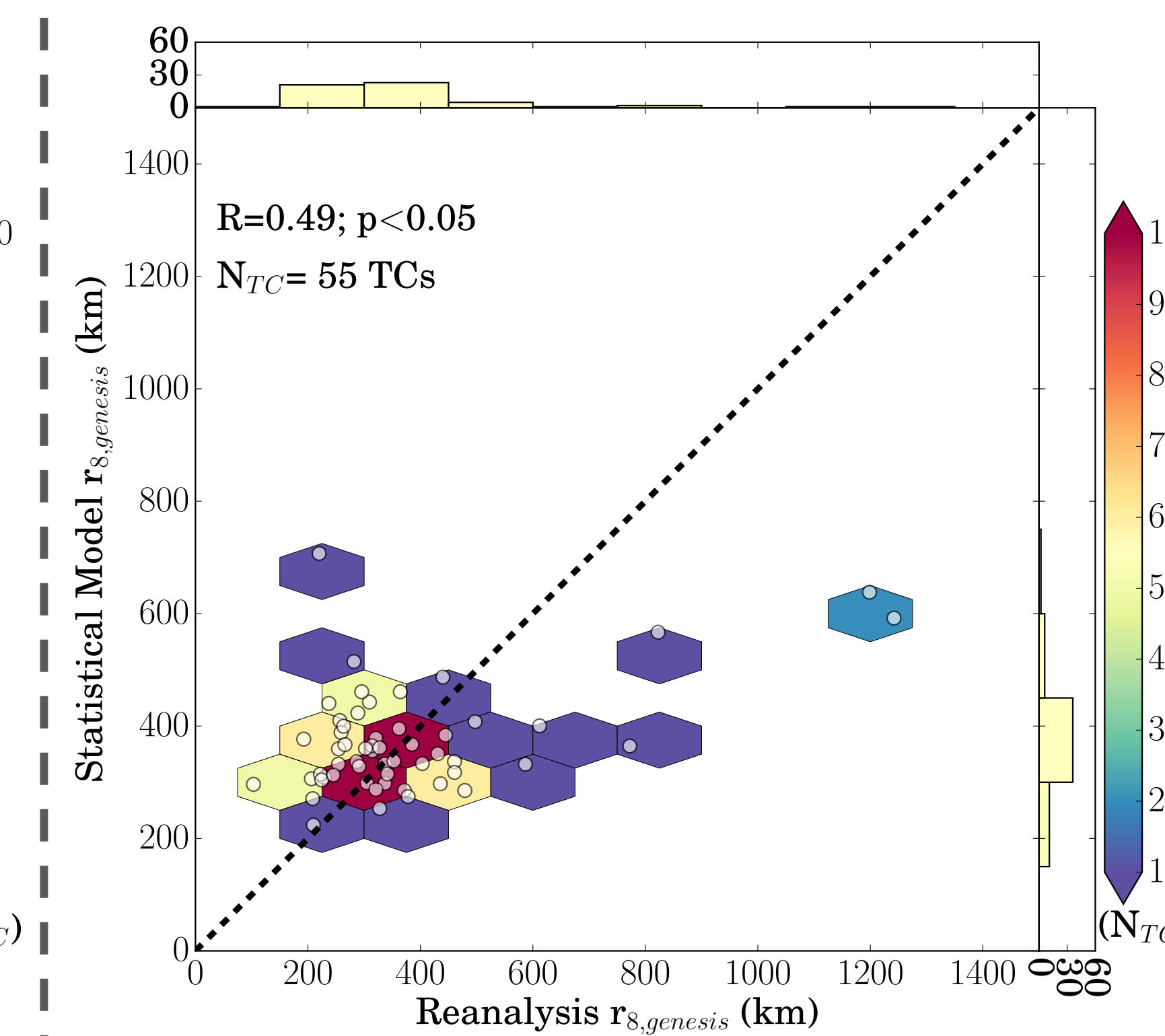


Fig. 2: Joint histogram of reanalysis genesis r_8 (km) versus statistical model genesis r_8 (km) for validation cases. The dashed black line denotes the 1:1 line.

4. Results: Overview of Lifetime Maximum r_8 Predicted from Statistical Model

Overview

Timing of lifetime maximum r_8 is used to predict change in r_8 between genesis and its lifetime maximum value. Timing of lifetime maximum r_8 is calculated using linear regression with TC lifetime.

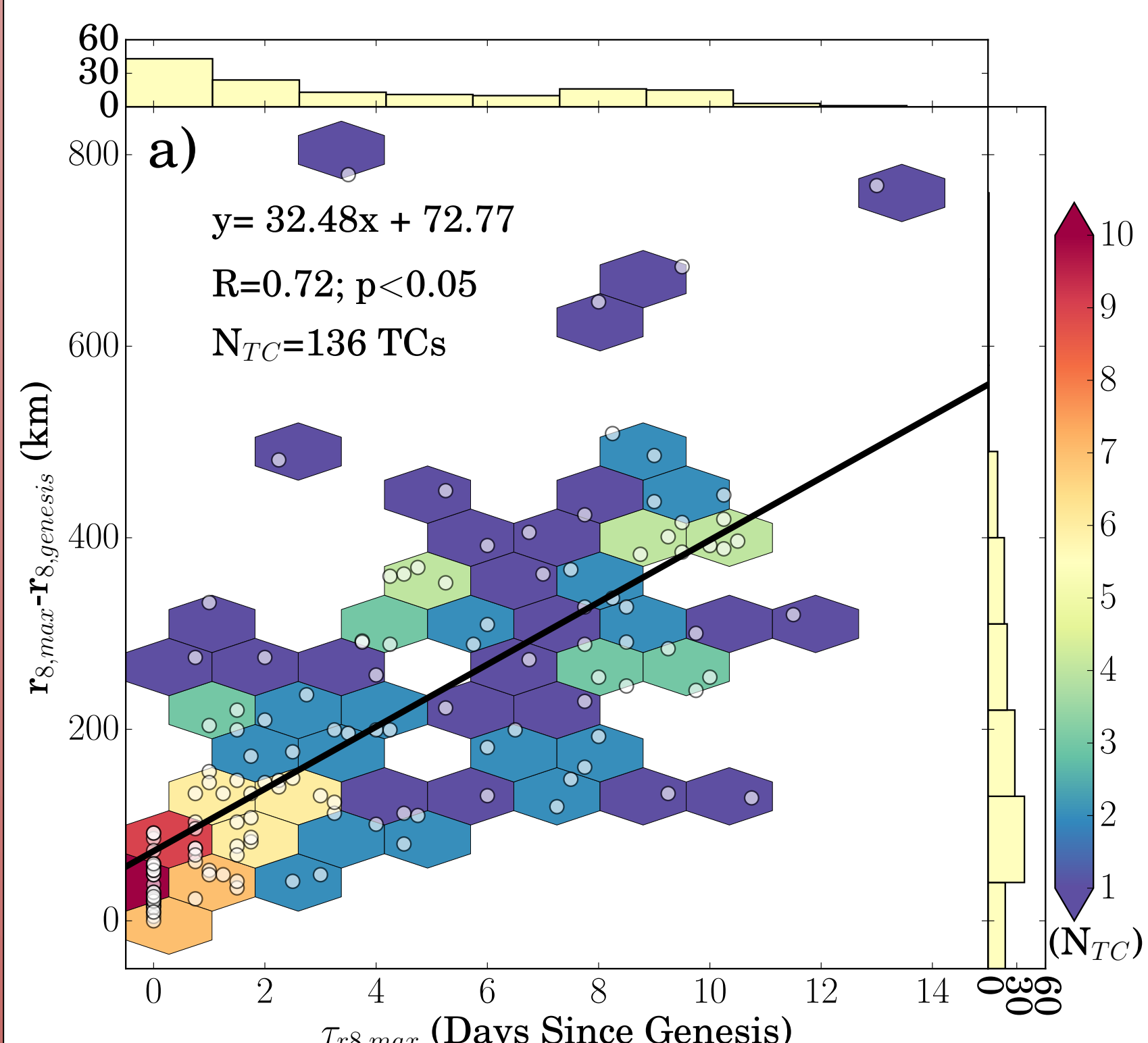


Fig. 3: Joint histograms of relationships used to construct lifetime maximum r_8 model including (a) the timing of lifetime maximum r_8 (days since genesis) versus the difference between lifetime maximum r_8 and genesis r_8 (km) and (b) timing of lifetime maximum r_8 (days since genesis) versus TC lifetime (days since genesis). The black line represents the simple linear regression.

Synopsis

- Larger increases in r_8 following genesis associated with later onset of lifetime maximum r_8 (Fig. 3a);
- Later onset of lifetime maximum r_8 strongly associated with longer TC lifetimes (Fig. 3b);
- Statistical model r_8 exhibits moderate skill in predicting reanalysis r_8 (Fig. 4).

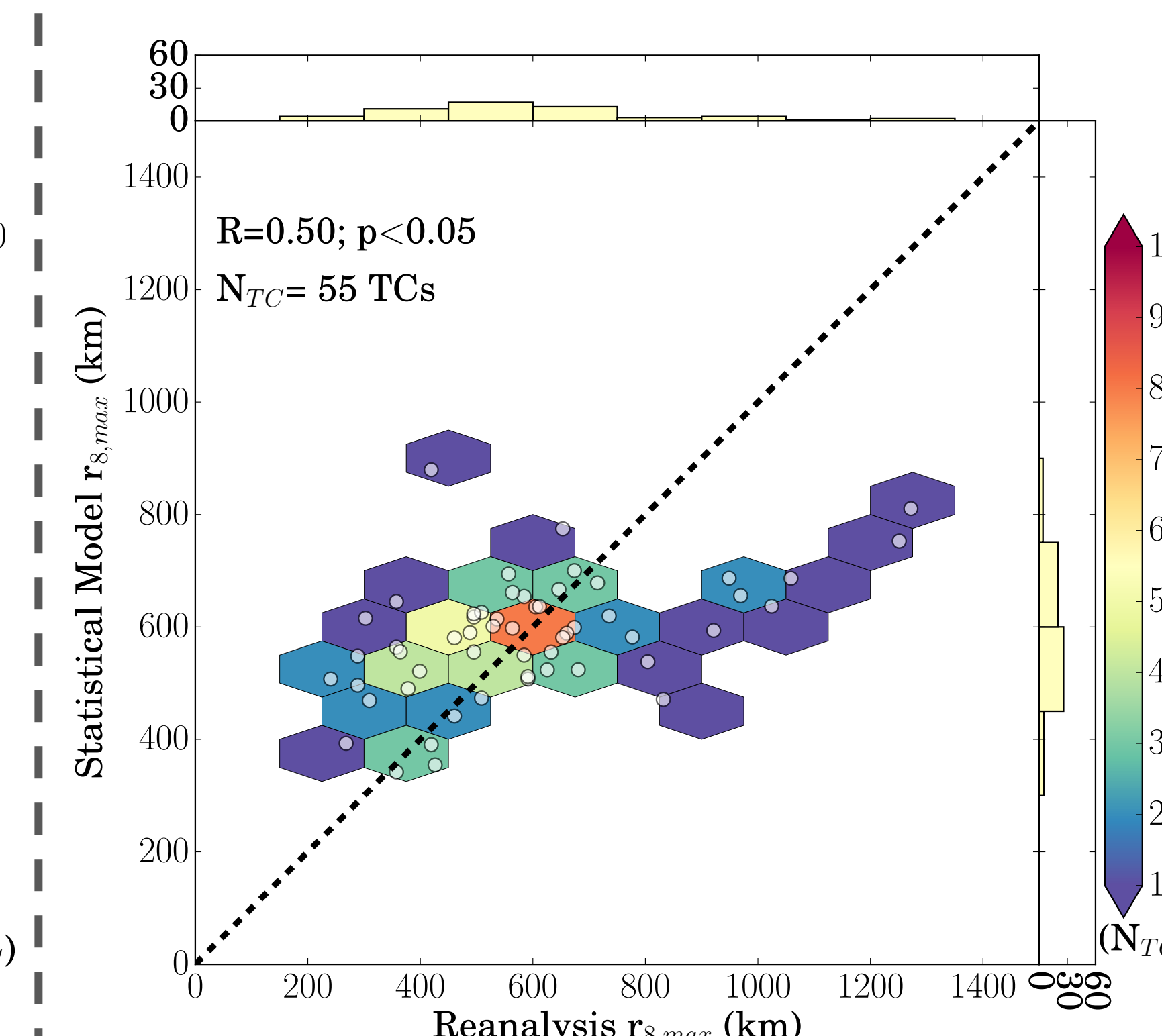


Fig. 4: Joint histogram of reanalysis lifetime maximum r_8 (km) versus statistical model lifetime maximum r_8 (km) for validation cases. The dashed black line denotes the 1:1 line.

5. Results: Overview of End of Lifetime r_8 Predicted from Statistical Model

Overview

Difference between timing of lifetime maximum r_8 and TC lifetime is used to predict change in r_8 between its lifetime maximum and end of lifetime values.

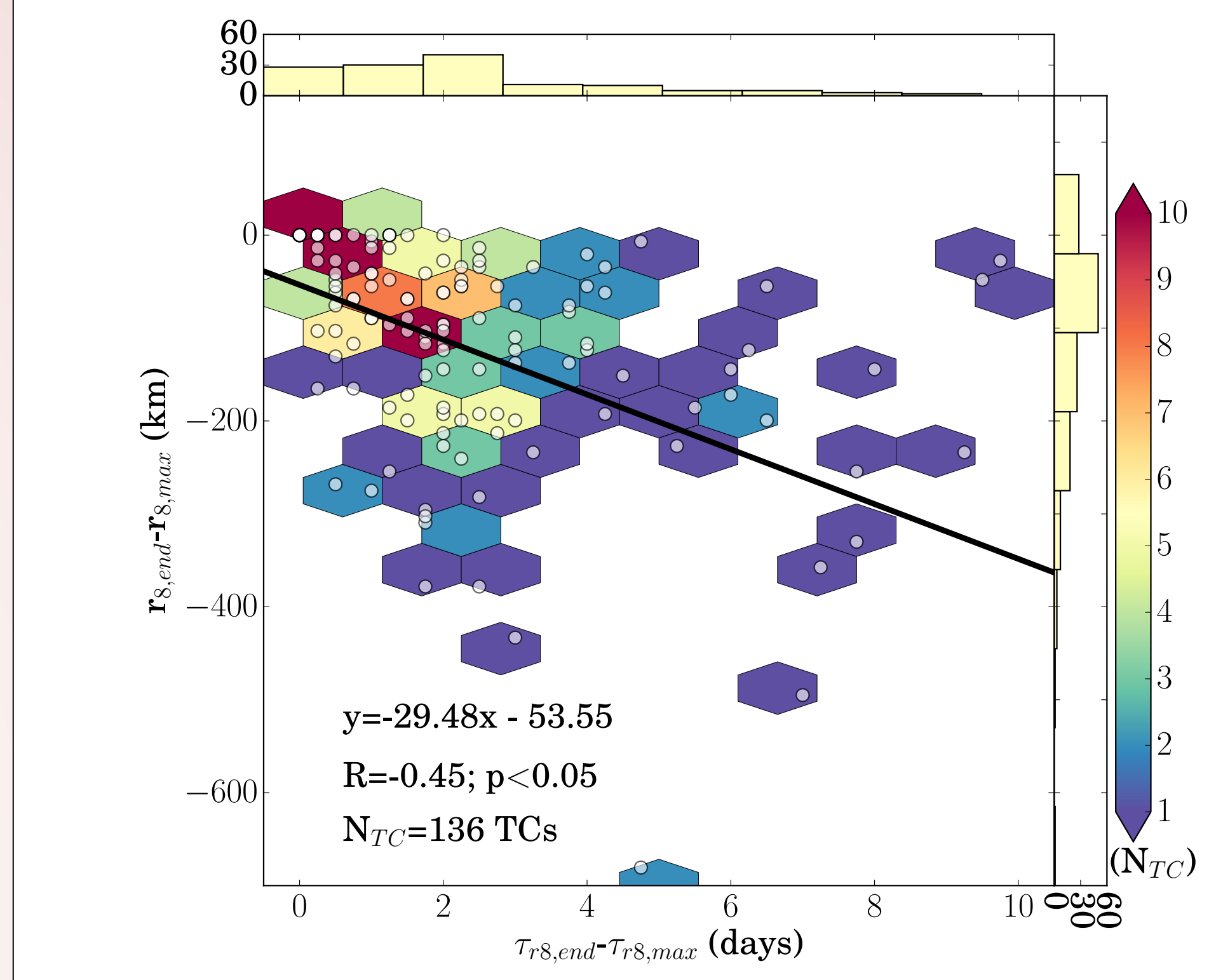


Fig. 5: Joint histogram of relationship used to construct end of lifetime r_8 model using difference between timing of lifetime maximum r_8 and end of lifetime versus the difference in r_8 between these two respective lifetime milestones. The black line represents the simple linear regression line.

Synopsis

- Largest TCs exhibit lifetime maximum r_8 at end of TC lifetime (Fig. 5);
- Statistical model at end of lifetime generally captures decrease in r_8 following lifetime maximum r_8 (Fig. 6).

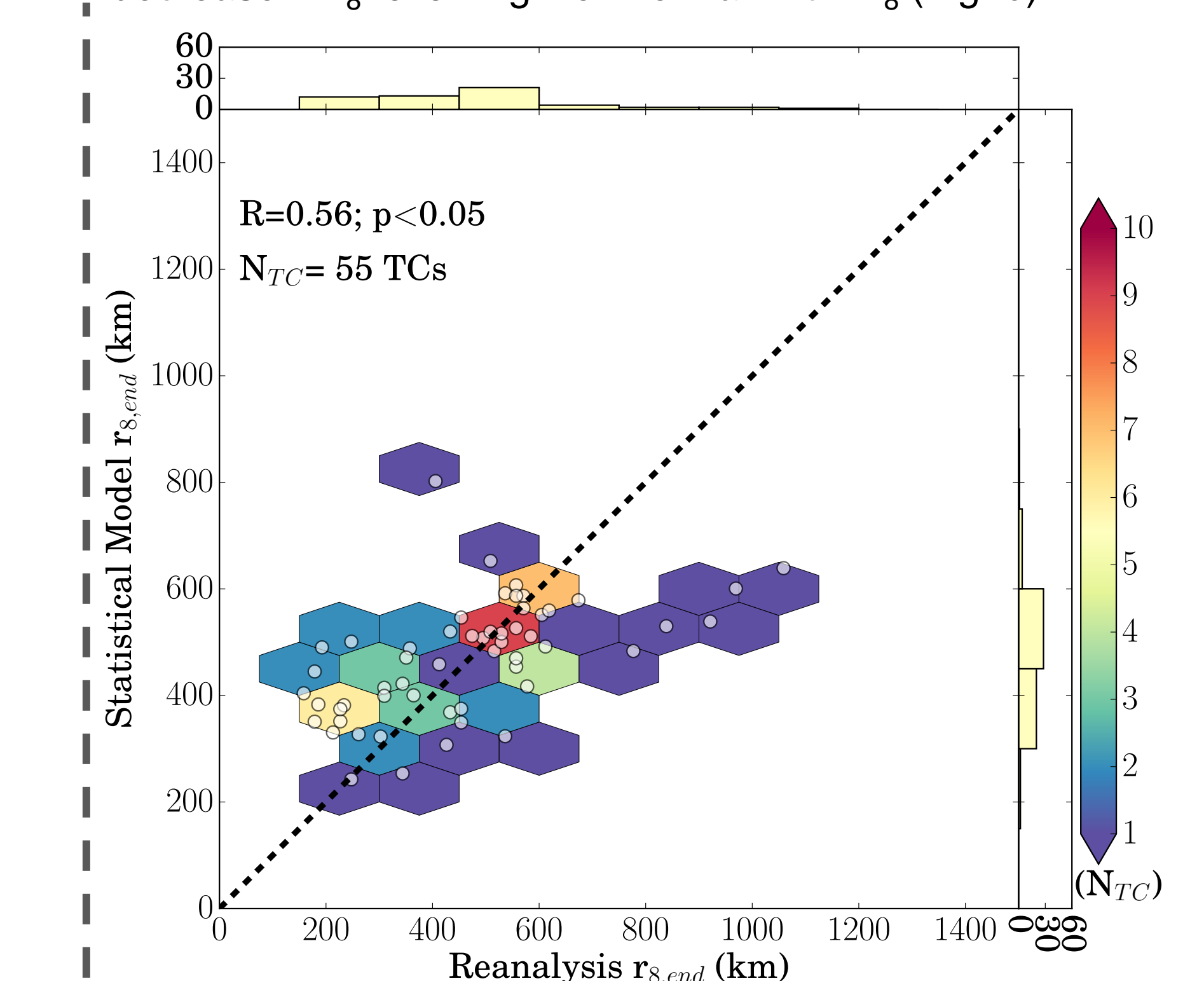


Fig. 6: Joint histogram of reanalysis end of lifetime r_8 (km) versus statistical model end of lifetime r_8 (km) for validation cases. The dashed black line denotes the 1:1 line.

6. Results: Validation of 2017 Case Studies

Overview

Statistical model performance assessed for 2017 Hurricanes Irma and Maria.

Synopsis

- Genesis r_8 from statistical model for Hurricanes Irma and Maria compares well with reanalysis (Fig. 7);
- Statistical model r_8 has difficulty capturing later portions of Hurricane Irma's lifetime r_8 evolution (Fig. 7a);
- Model is able to reasonably reproducing lifetime evolution of r_8 for Hurricane Maria (Fig. 7b).

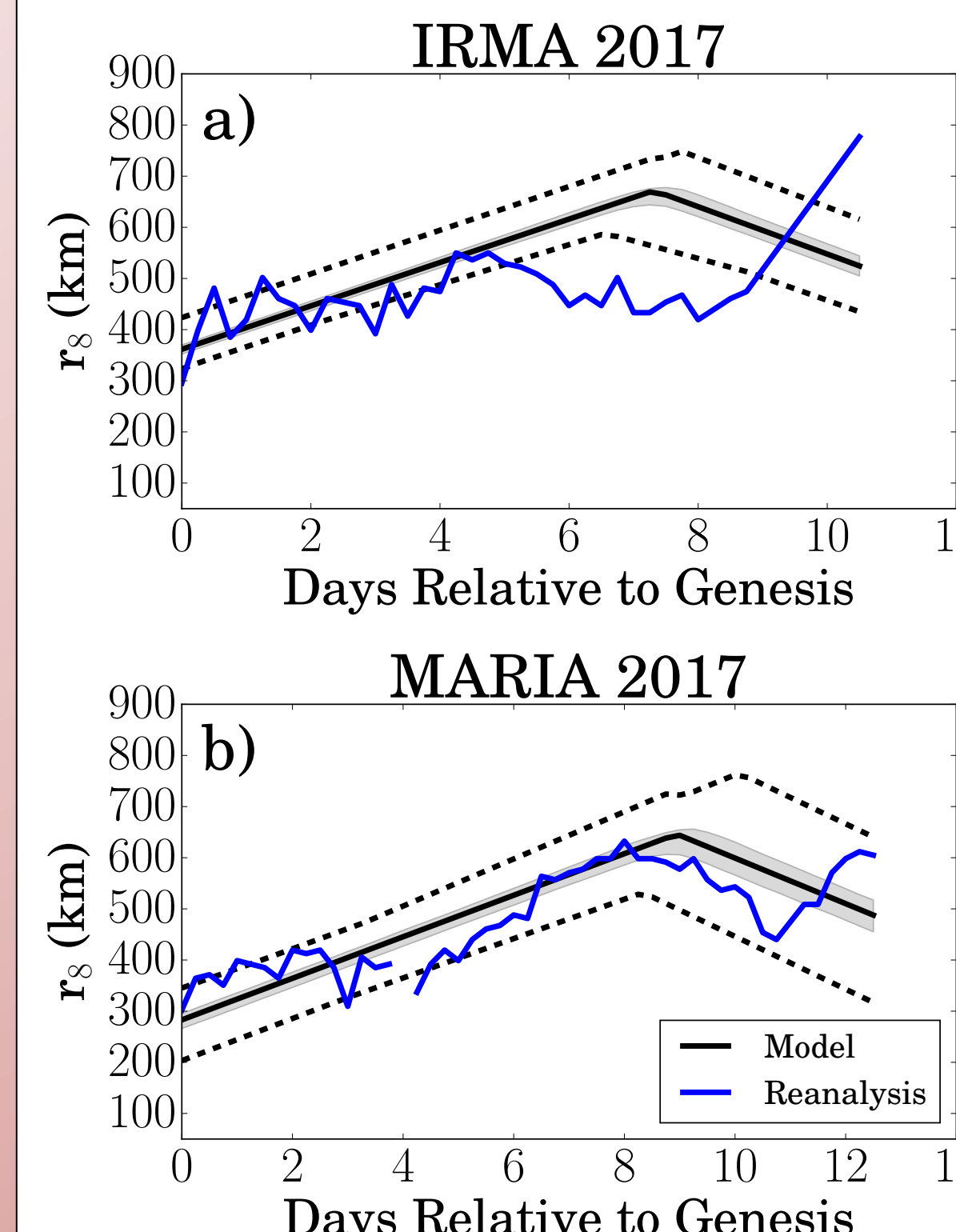


Fig. 7: Time series for 2017 Hurricanes (a) Irma and (b) Maria of reanalysis r_8 (km; blue line) derived from NCEP CFSTR v2 (Saha et al. 2014) and statistical model median r_8 (km; black line) and its 95% confidence interval (km; gray shading) and the lower and upper quartile of statistical model r_8 (black dashed lines) derived from the 1000 model iterations constructed by resampling the training dataset.

7. Summary and Discussion

- Larger genesis r_8 associated with cooler SSTs and later genesis dates in TC season (Figs. 1–2);
- Larger lifetime maximum r_8 associated with later onset of lifetime maximum r_8 during TC lifetime (Figs. 3–4);
- Larger end of lifetime r_8 associated with lifetime maximum r_8 occurring at end of lifetime (Figs. 5–6);
- Statistical model does not capture extremes of distribution, as expected for linear model;
- Statistical model performs well for 2017 cases given limited input (Fig. 7).

8. Acknowledgments and References

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