Tropical Cyclones in the North American Regional Reanalysis (NARR): Impact of satellite-derived precipitation assimilation over ocean

Stephanie E. Zick (sezick@ufl.edu) and Corene J. Matyas (matyas@ufl.edu),

Department of Geography, University of Florida, Gainesville FL

hurricane.geog.ufl.edu

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Introduction

Continued advancement in the realm of tropical cyclone (TC) forecasting of intensity and structure requires a more accurate depiction of these storms at model initialization. Since TCs form over the ocean where observations are sparse, satellite data has successfully been incorporated into numerical weather prediction (NWP) data assimilation systems, yielding more skillful track and intensity forecasts. However, derived precipitation is typically excluded. Within the North American Regional Reanalysis (NARR), there was a 2004 transition in the source of ocean precipitation. As a part of this transition, blocking of precipitation assimilation in the vicinity of TCs was turned off, providing a unique opportunity to investigate changes in TC structure as a result of the NARR's precipitation assimilation scheme. This study examines the impact of precipitation assimilation on TC precipitation forecasts; position, intensity, and size; warm core structure; and the moisture budget.

Objectives

To compare TC representation in NARR before & after the implementation of precipitation assimilation near TCs, focusing on:

1) TC precipitation distribution
2) TC position, size and structure.

Data

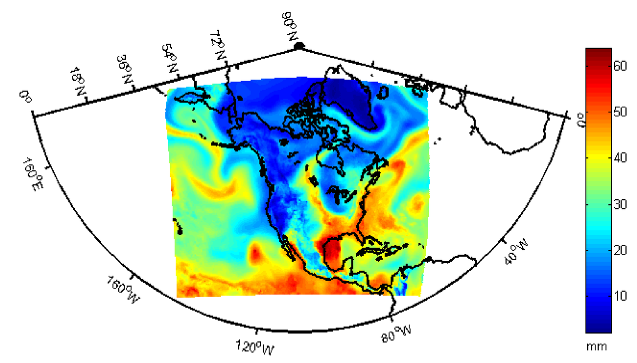


Fig 1. NARR Precipitable Water (mm) 18 UTC Jul 23 2008

- North American Regional Reanalysis (NARR) from NCEP/NCAR uses 1993 ver. of Eta Model
- 32 km horizontal grid with 29 vertical pressure levels, avail. 8 x daily
- assimilates high quality 1-hourly precipitation analyses (Mesinger et al. 2006)

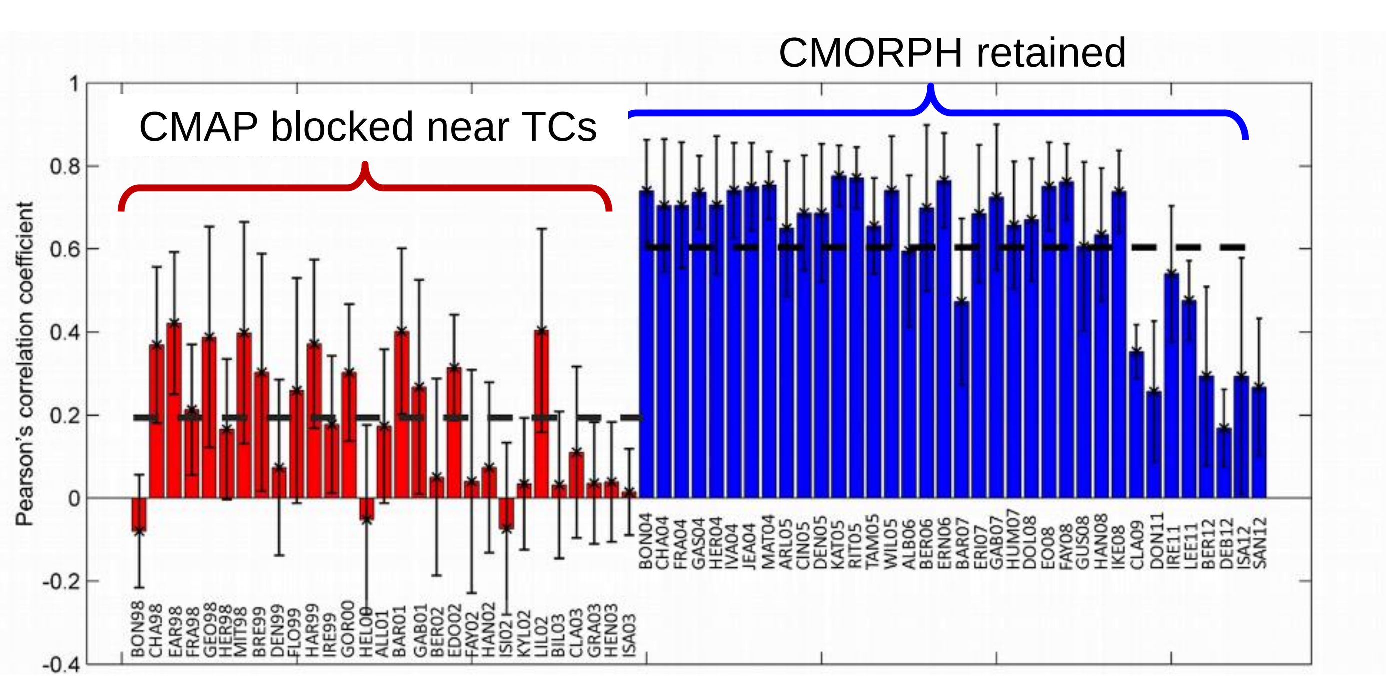


Fig 2. Correlations for NARR vs. TRMM 3B42 rain rates

Objective 1: Precipitation Distribution

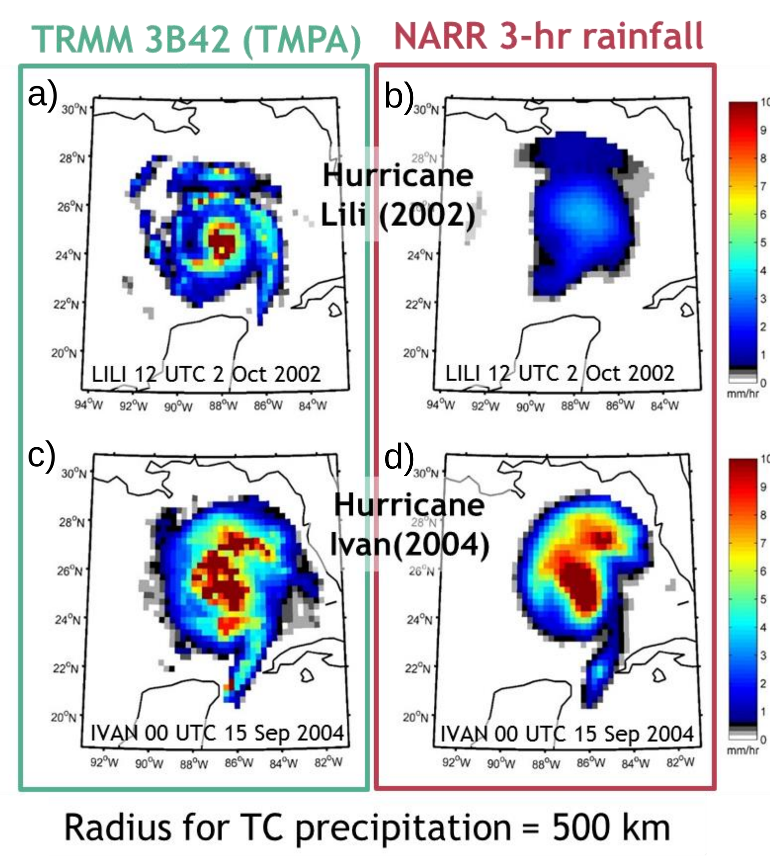


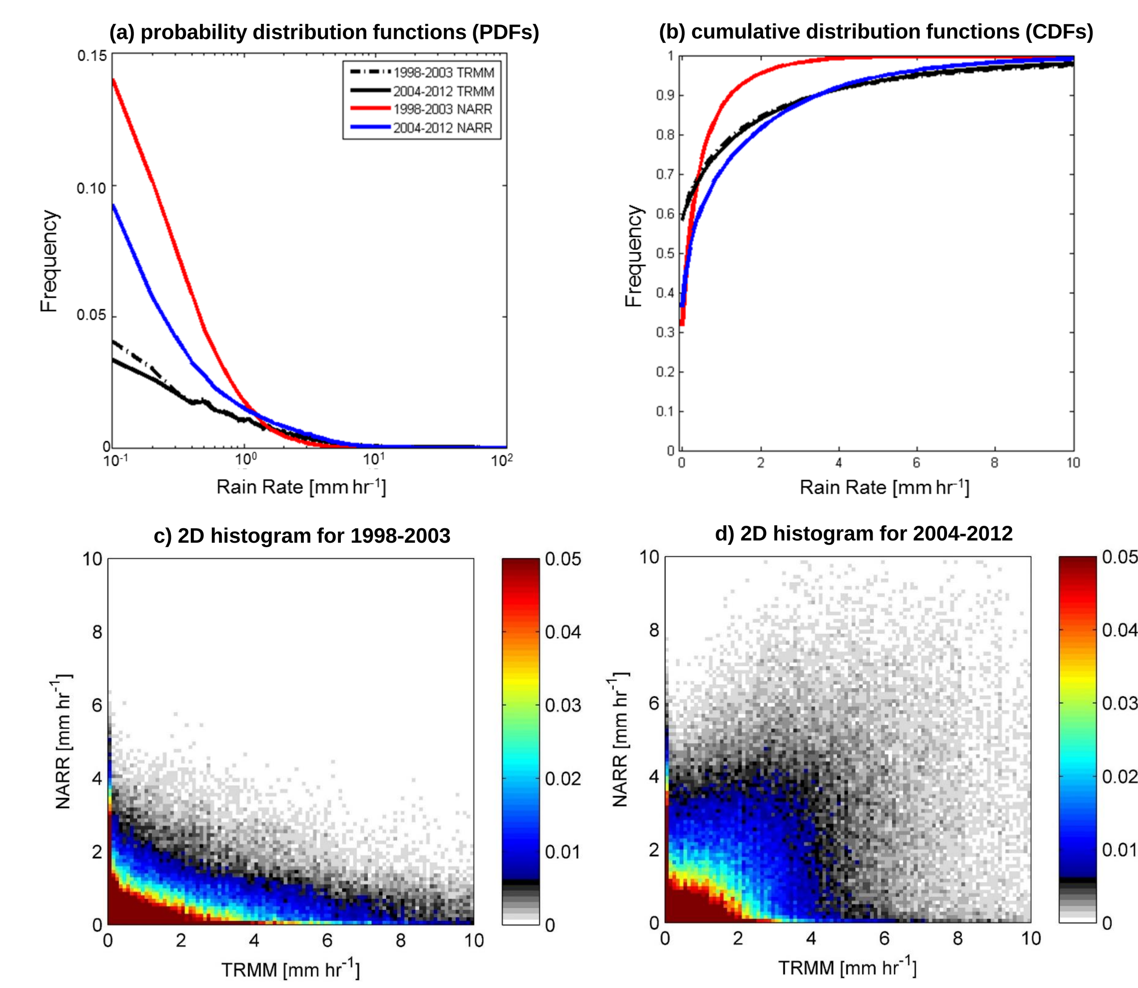
Fig 3. Precipitation structures in (left) TRMM 3B42 and (right) NARR data sets: (a and b) Hurricane Lili (2002) valid at 12:00 UTC, 2 October and (c and d) Hurricane Ivan (2004) valid at 00:00 UTC, 15 September.

Corresponding correlation between TRMM and NARR for Lili (Ivan) is r = 0.59 (0.77).

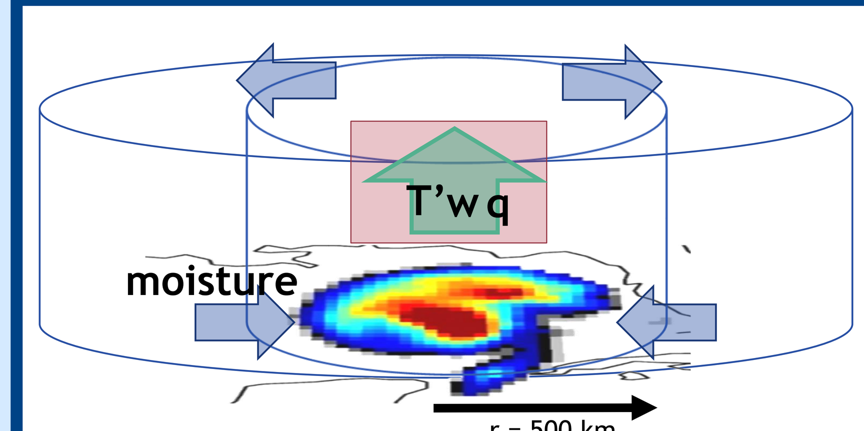
Reduction (enhancement) in light (heavy) precipitation frequency in 2004-2012 TCs, leading to a better match with TRMM 3B42 and NEXRAD rain rates

Two distinct eras: Precipitation Statistics

Fig 4. Comparison of over-ocean rain rate (mm h−1) distributions within 500 km of TC center for Best Track positions within 10° latitude/longitude of U.S. coastline: (a) probability distribution functions (PDFs), (b) cumulative distribution functions (CDFs), and (c & d) 2-D histograms (bin size = 0.1 mm h−1) of NARR versus TRMM during 1998–2003 and 2004–2012 time periods.



Conclusion



Development of precipitation assimilation techniques from radar and satellite datasets will be valuable to the construction of better-quality TC forecasting tools, including improved water budgets

Publication

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Objective 2: TC Position Size & Structure

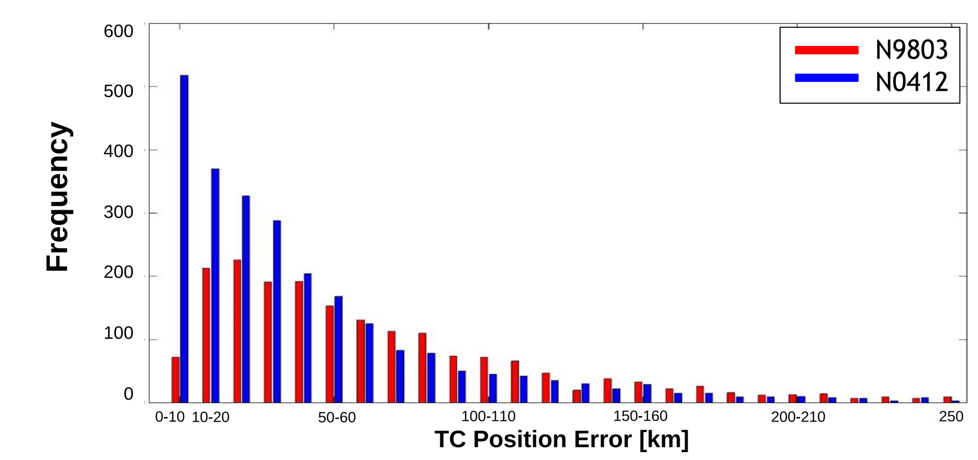

Fig 5. TC position error frequency distributions. Bin widths are 10 km.

Kolmogorov-Smirnov test on TC Position Error		
Mean	Median	Standard Deviation
67.4	52	50.8
44.0	31	45.8
k = 0.23 ($p < 0.01$)		

Table 1. TC position error statistics

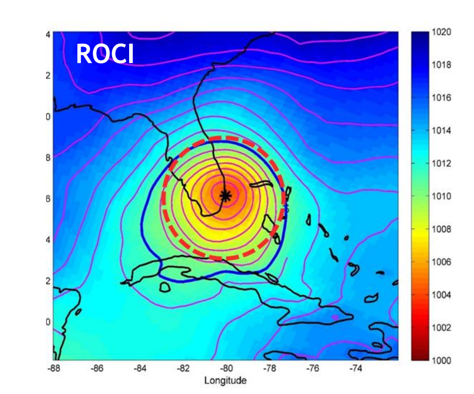

Fig 6. Objectively determined (solid blue) and extended best track (EBT: dashed red) radius of outermost closed isobar (ROCI)

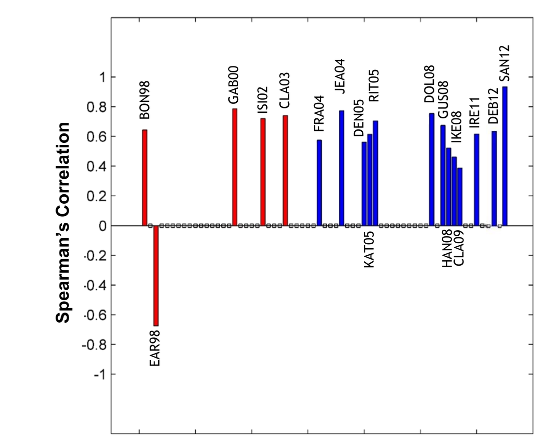

Fig 7. Mean lifetime ROCI in NARR vs EBT and Spearman's correlation coefficients ($p < 0.05$) for evolution of ROCI

Pearson's chi-square test on ROCI	
# signif. storms	# not signif.
4	25
13	23
$\chi^2 = 4.14$ ($0.05 > p > 0.02$)	

Table 2. TC ROCI statistics

Statistically significant improvements in TC position & size compared with Best Track

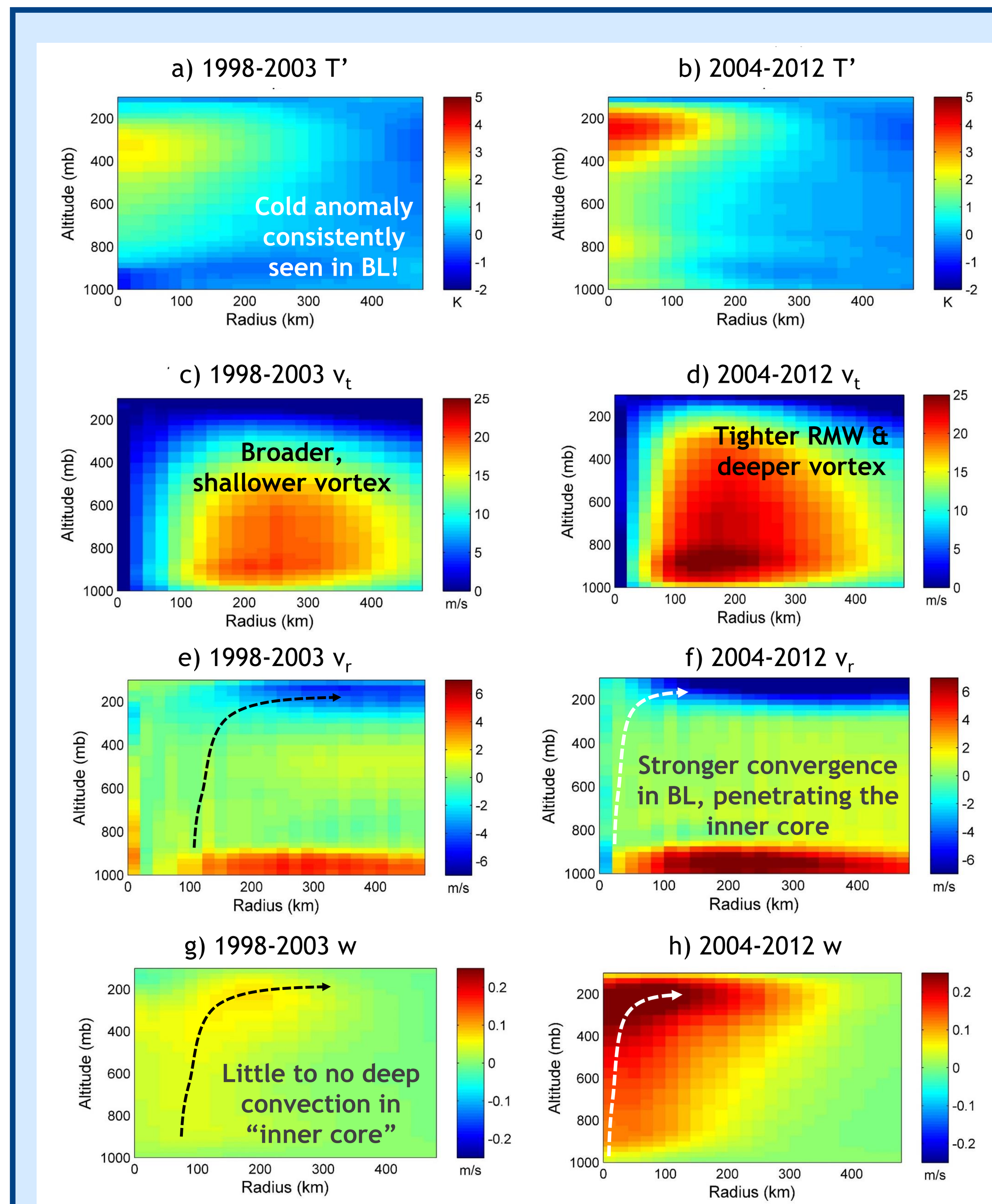

Fig 8. 9-storm composite radial cross section of azimuthally averaged temperature perturbations and winds

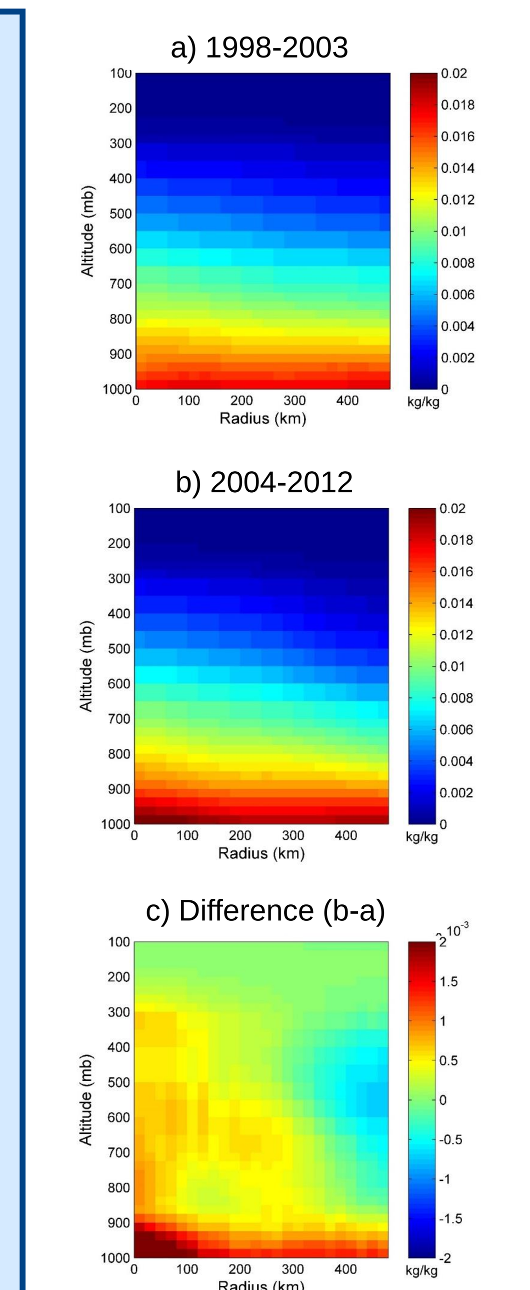

Fig 9. 9-storm Specific Humidity Composites

Improved representations of temperature, winds and atmospheric moisture