North Atlantic and East Pacific Tropical Cyclone Intensity Comparison with Integrated Kinetic Energy

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INTRODUCTION

- Integrated Kinetic Energy (IKE) is a metric that accounts for the full destructive potential of a tropical cyclone's (TC) wind field.
- An IKE database for 1990-2011 North Atlantic (NA) TCs has been created, and used to build a statistical prediction model for IKE in that basin.
- Sufficient data for IKE computation and diagnosis has been made available for East Pacific (EP) TCs dating back to 2004.

GOALS

- Compute IKE for EP TCs from 2004-2013, and compare with NA TCs.
- Compare the seasonal distribution and tendencies of IKE between the two basins.
- Compute rainfall volume (RV) across TCs in both basins, and correlate these values with IKE.

IKE METHODOLOGY

- Wind radii in the NE, NW, SW, and SE quadrants are provided by the Extended Best Track (EBT) dataset from Colorado State.
- Radii are measured for 34, 50, and 64 kt winds.
- IKE is computed as a volume integral of the wind field over a 1-m depth: $IKE = \int_V \frac{1}{2} \rho U^2 dV$
- Guidelines for IKE computation are described in Table 1 below.

Quadrant IKE contribution	Criteria	Mean wind ($m\,s^{-1}$)	Area (m^2)
IKE_{18-26}	$R_{26} > 0$	20	$0.25\pi(R_{18}^2 - R_{26}^2)$
	No R_{26}, $V_{MS} > 26$, $R_{18} > R_{max}$	20	$0.25\pi[R_{18}^2 - (0.75R_{max})^2]$
	No R_{26}, $V_{MS} < 26$, $R_{18} > R_{max}$	$0.25V_{MS} + 0.75(18)$	$0.25\pi[R_{18}^2 - (0.75R_{max})^2]$
	No R_{26}, $R_{max} = R_{18}$	18	$0.25\pi[R_{18}^2 - (0.5R_{18})^2]$
IKE_{26-33}	$R_{33} > 0$	27.75	$0.25\pi(R_{26}^2 - R_{33}^2)$
	No R_{33}, $V_{MS} > 33$, $R_{26} > R_{max}$	27.75	$0.25\pi[R_{26}^2 - (0.75R_{max})^2]$
	No R_{33}, $V_{MS} < 33$, $R_{26} > R_{max}$	$0.25V_{MS} + 0.75(26)$	$0.25\pi[R_{26}^2 - (0.75R_{max})^2]$
	No R_{33}, $R_{26} \le R_{max}$	26	$0.25\pi[R_{26}^2 - (0.5R_{26})^2]$
IKE_H	Max R_{33} quadrant, $R_{33} > R_{max}$	$0.25V_{MS} + 0.75(33)$	$0.25\pi[R_{33}^2 - (0.75R_{max})^2]$
	Max R_{33} quadrant, $R_{33} = R_{max}$	$0.25V_{MS} + 0.75(33)$	$0.25\pi[R_{33}^2 - (0.75R_{33})^2]$
	$R_{33} < R_{max}$	$0.1V_{MS} + 0.9(33)$	$0.25\pi[R_{33}^2 - (0.75R_{33})^2]$
	Not max R_{33} quadrant, $R_{max} = R_{33}$	$0.1V_{MS} + 0.9(33)$	$0.25\pi[R_{33}^2 - (0.75R_{max})^2]$

TABLE 1: Guidelines for computing IKE based on 34, 50, and 64 kt wind radii. Assuming air density of ~1 kg m^{-3} and a 1 m depth for our volume integral, all we need to determine is wind speed and the area of the wind field we integrate around.

DATASET INFORMATION

- 161 TCs in the NA, 143 in the EP.
- IKE values are computed at 6-hour intervals according to EBT dataset readings. 2882 fixes for the NA, 2169 for the EP.
- Rainfall data comes from TRMM-3B42 rainfall rate measurements, which come at 3-hour intervals.
- Rainfall volume computed by multiplying (Rate*area of grid cell*6 hours).

RESULTS – IKE COMPUTATION

- NA TCs tend to have larger IKE, mainly due to the larger size of storms in that basin.
- Average IKE per TC fix peaks in September for both basins, with the NA exhibiting less of a drop towards the end of the season due to storms undergoing extratropical transition.
- Average IKE per storm fix at season's peak is 3 times higher in the NA than the EP (Fig. 1).

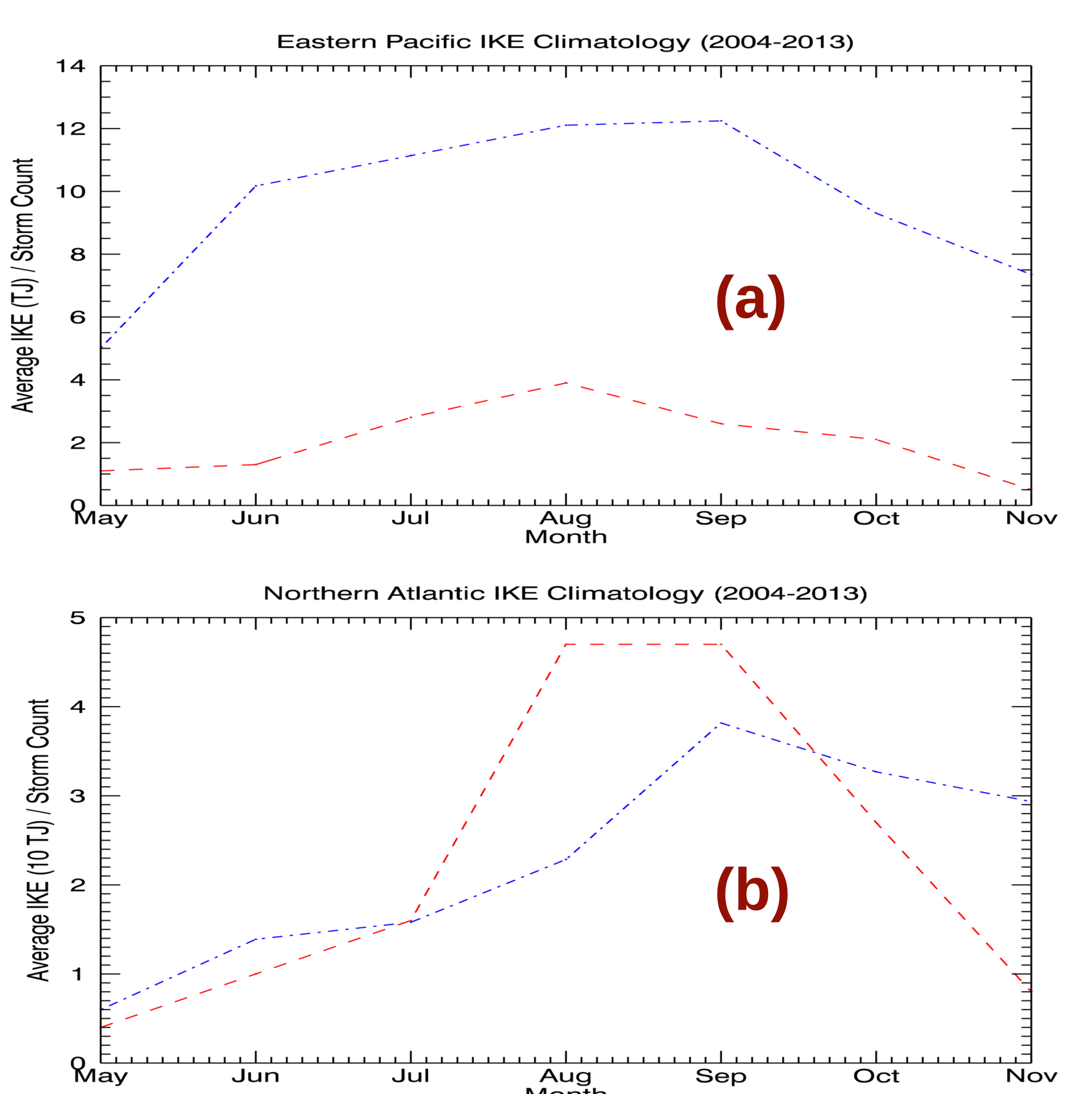


FIG. 1: Monthly climatology of IKE for (a) NA and (b) EP basins from 2004-2013. Included is both the average IKE of a TC fix and the number of storms per month.
--- = Average IKE per fix
--- = Average # of TCs per month

RESULTS – IMPACT OF LOCATION

- Track tendencies align with expectations. Higher IKE values tend to occur over open waters at lower latitudes.
- A notable exception to this is NA TCs which undergo extratropical transition and expand, especially late in the season (Fig. 2).
- Longer-lived TCs which accumulate more TIKE (Track IKE) tend to develop over eastern longitudes of each basin.

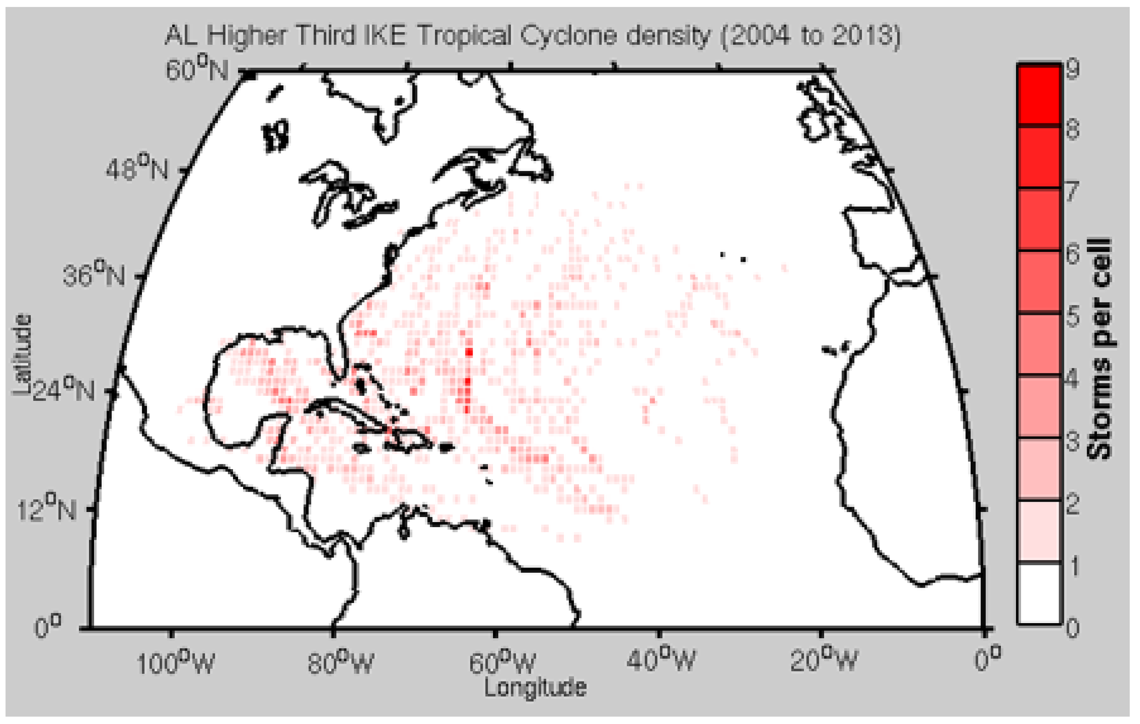


FIG. 2: Track density of TC fixes in the top third of our dataset for IKE. Heavy over open waters and in extratropical transition zone in NA.

RESULTS – RAINFALL VOLUME

- This quantity also measured higher over the NA, about 2.5 times higher per individual storm fix.
- Strong correlation between IKE and RV, particularly over the NA (R^2 = 0.64).
- Use of a simple linear regression model based on this proved to be a decent forecast for rainfall at low IKE (Fig. 3).

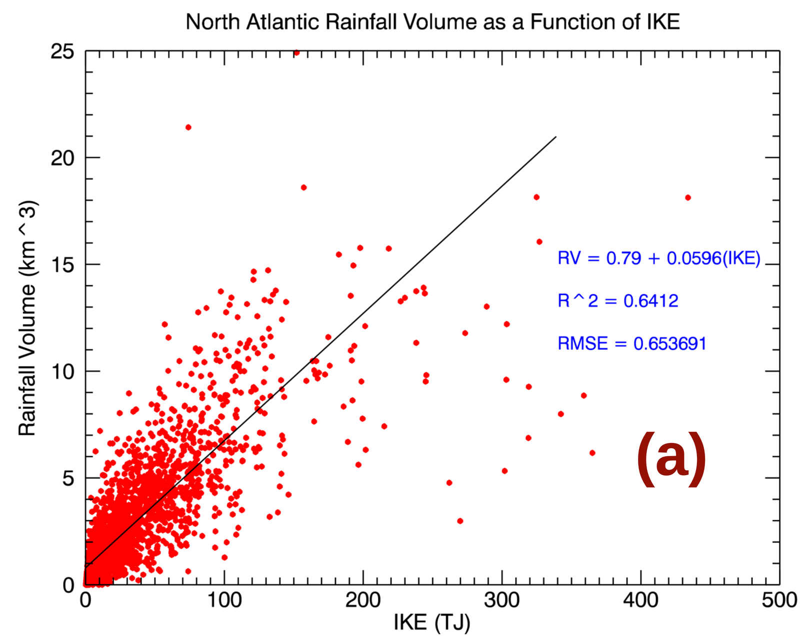
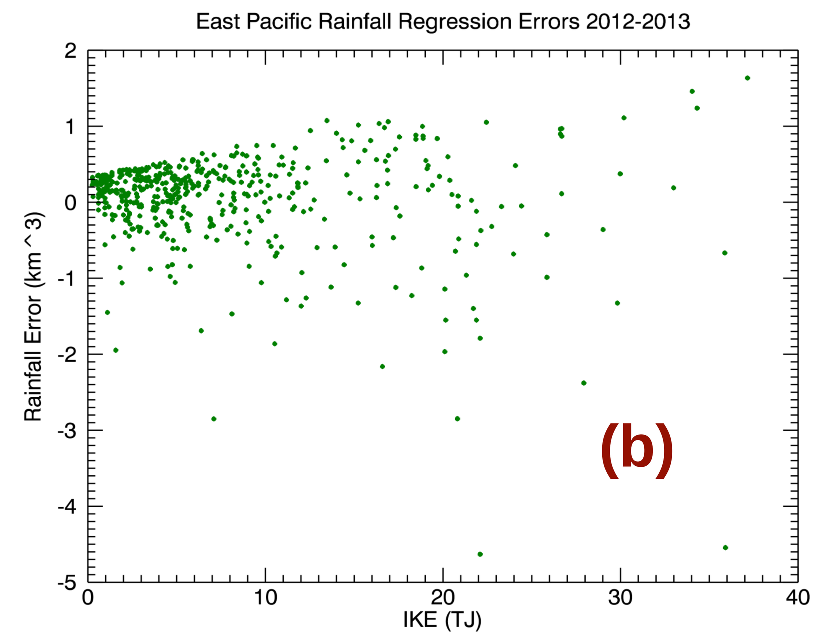


FIG. 3: (a) NA rainfall volume as a function of IKE. (b) Errors in 2012-2013 EP rainfall volume prediction using linear regression from 2004-2011 RV and IKE data.



CONCLUSIONS

- A more widespread destructive potential exists in NA TCs generally, due to the wider extent of damaging winds and rainfall.
- Storms with low IKE can still produce plenty of rainfall, contributing to flooding and storm surge threats.
- Correlation between IKE and rainfall volume is promising for using IKE to predict total TC rainfall (perhaps distribution within the TC as well) down the road.

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