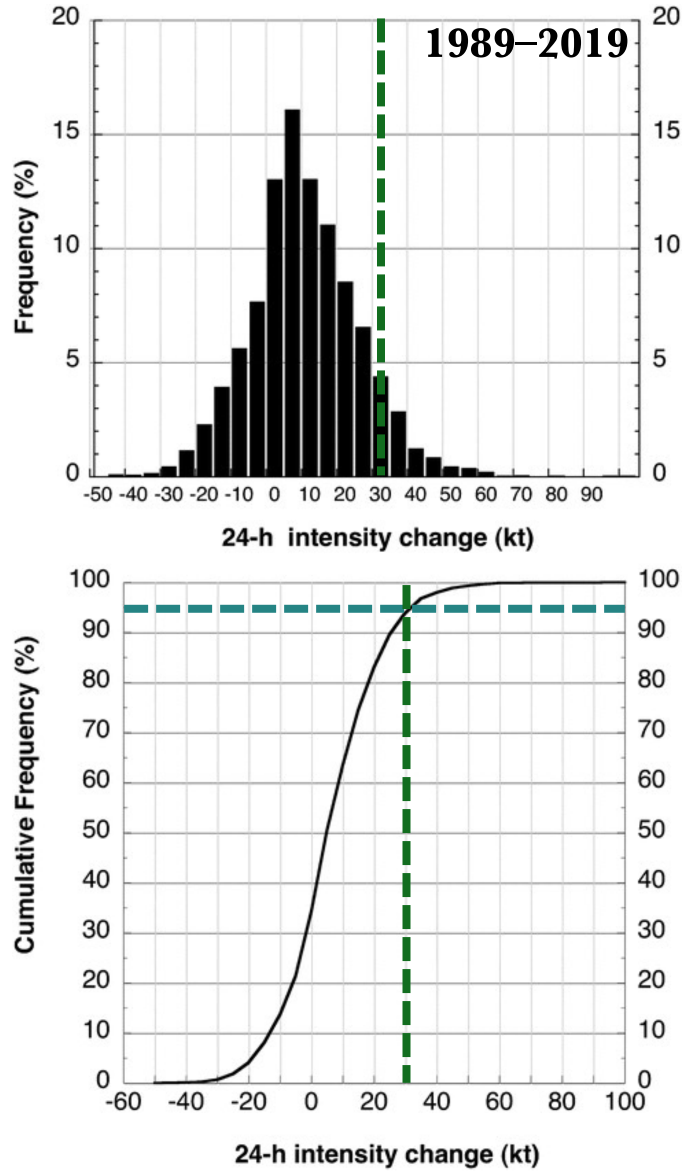
Rapid intensification: What is it?

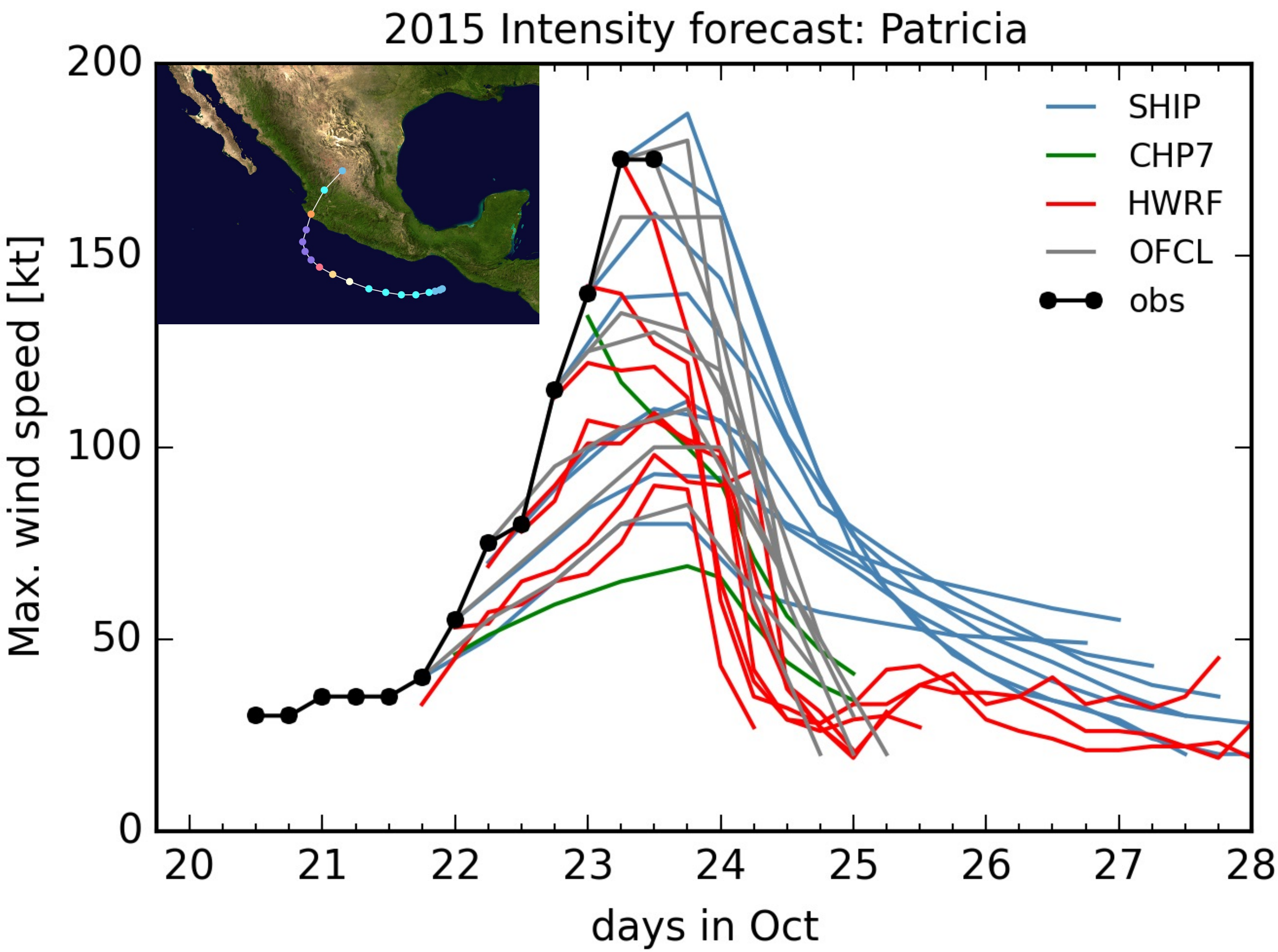


Kaplan & DeMaria (2003)
Kaplan et al. (2011):

~95th percentile
of over water
24-h intensity change

30 kt (15.4 m s^{-1})

Rapid intensification: Why do we care about it?



Wing and Lee (2016)

Rapid intensity change: 💩 forecasts ☹

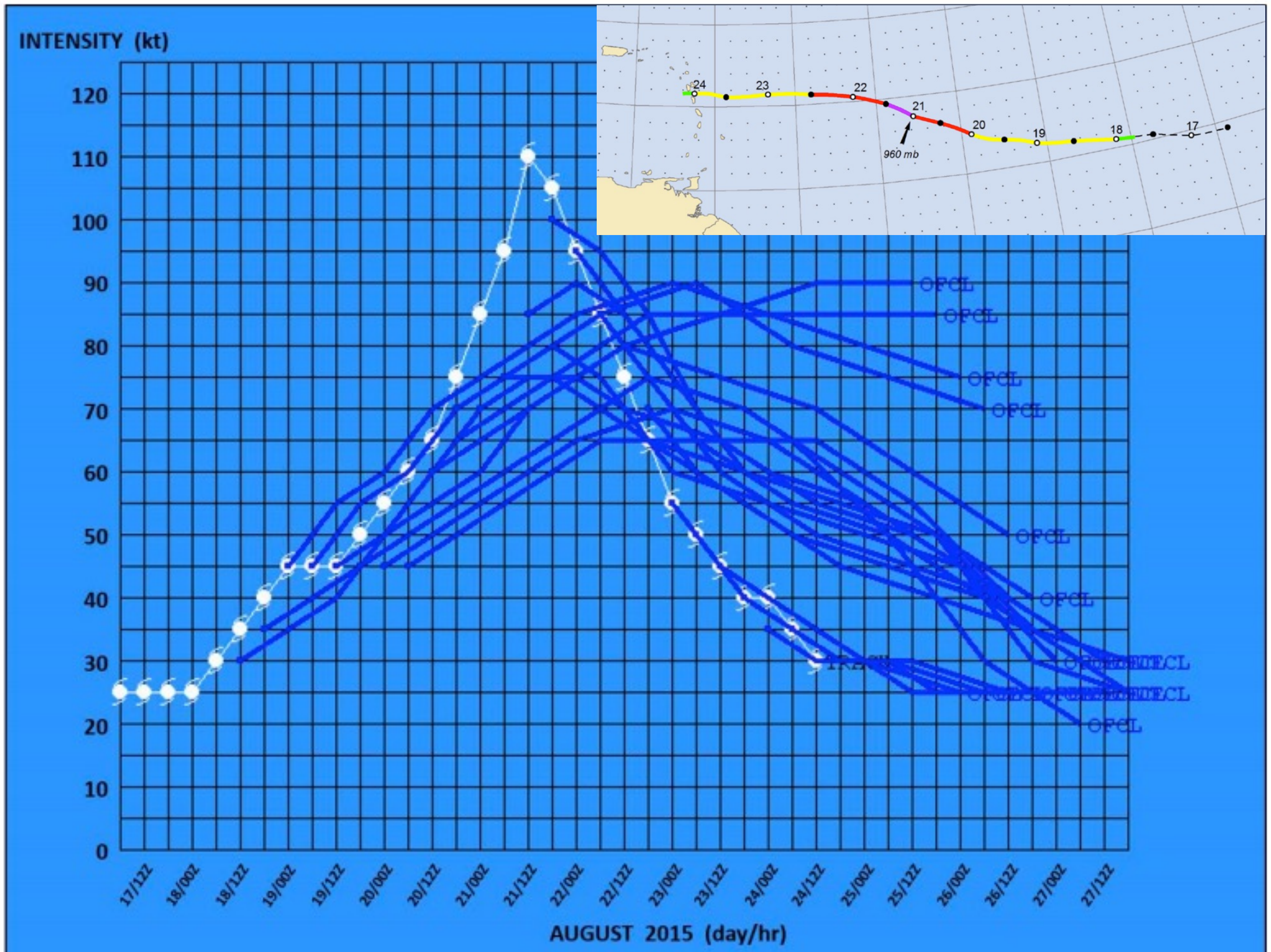
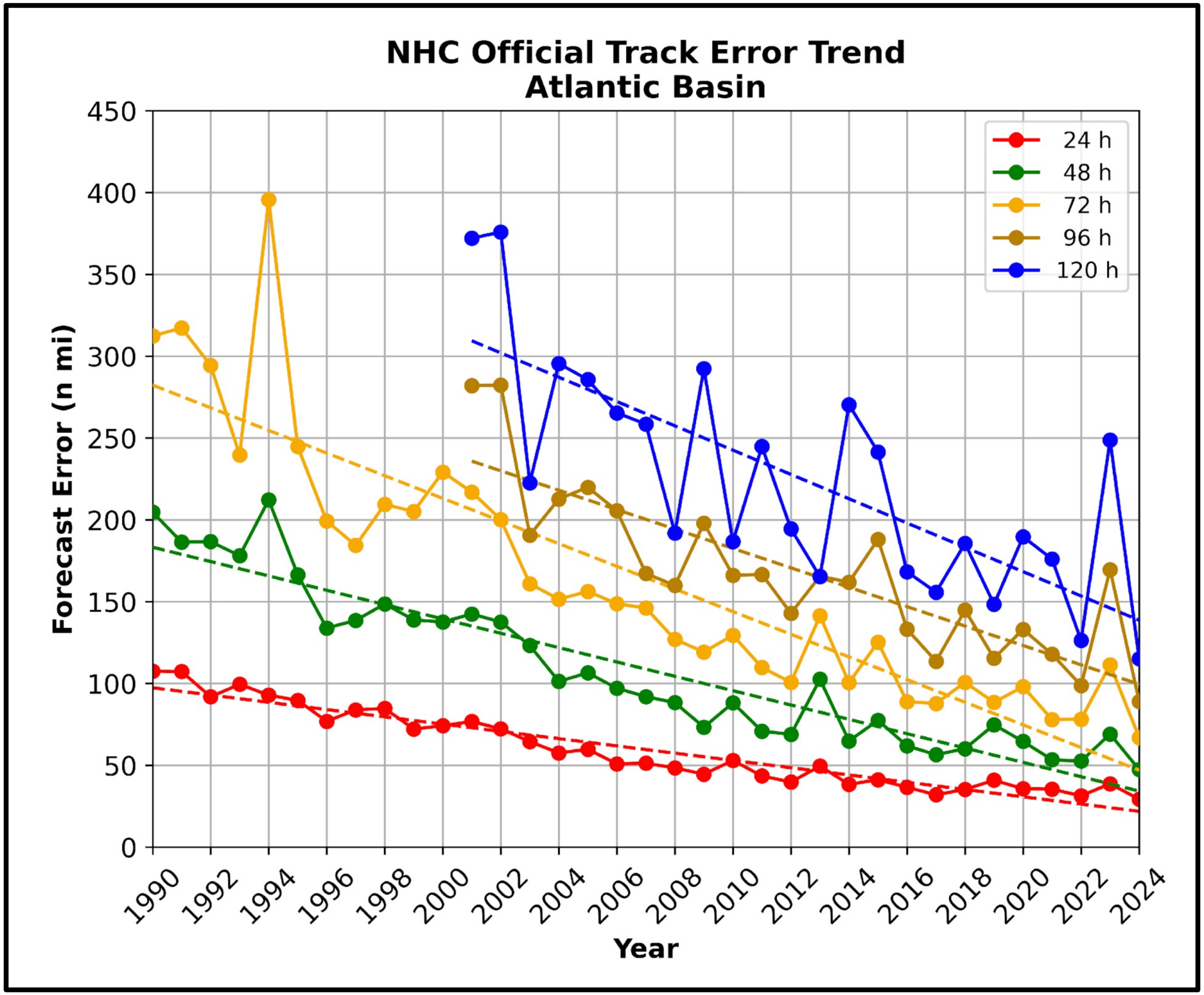
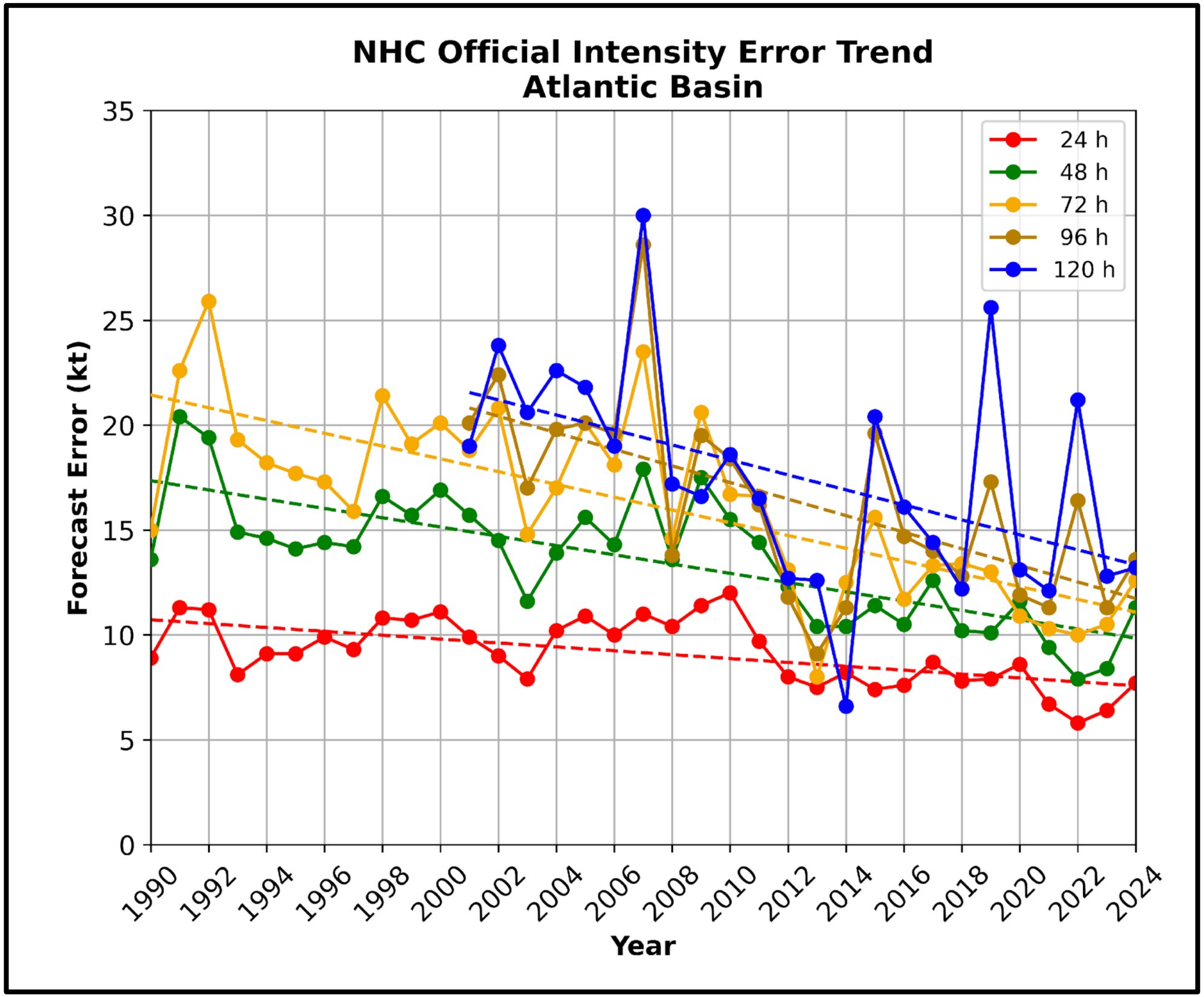


Figure 6. NHC official intensity forecasts (solid light blue lines) plotted against official intensity 'best track' (solid white line with tropical cyclone symbols) for Hurricane Danny, 18-24 August 2015.

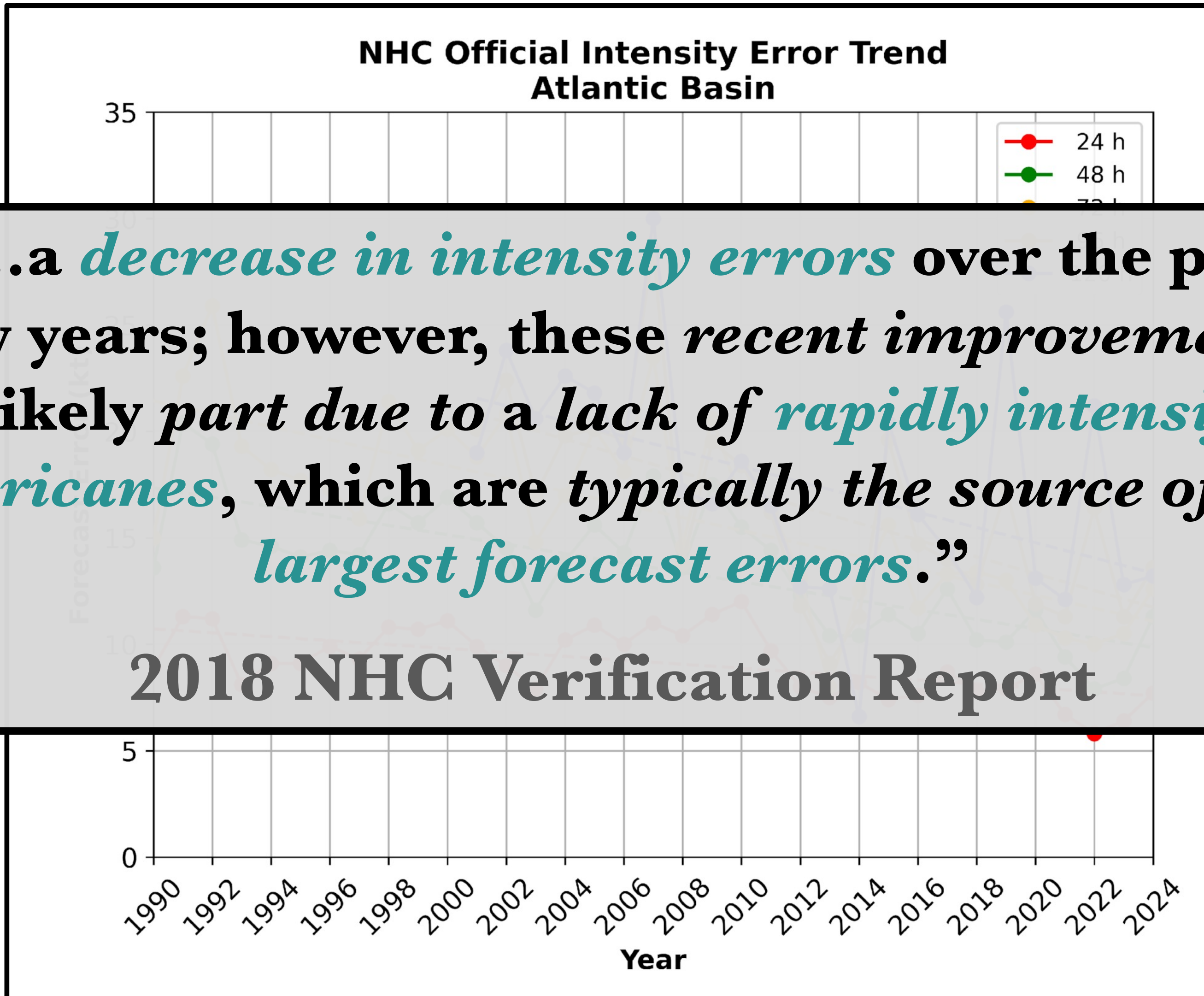
NHC official forecasts: Track errors



NHC official forecasts: Intensity errors



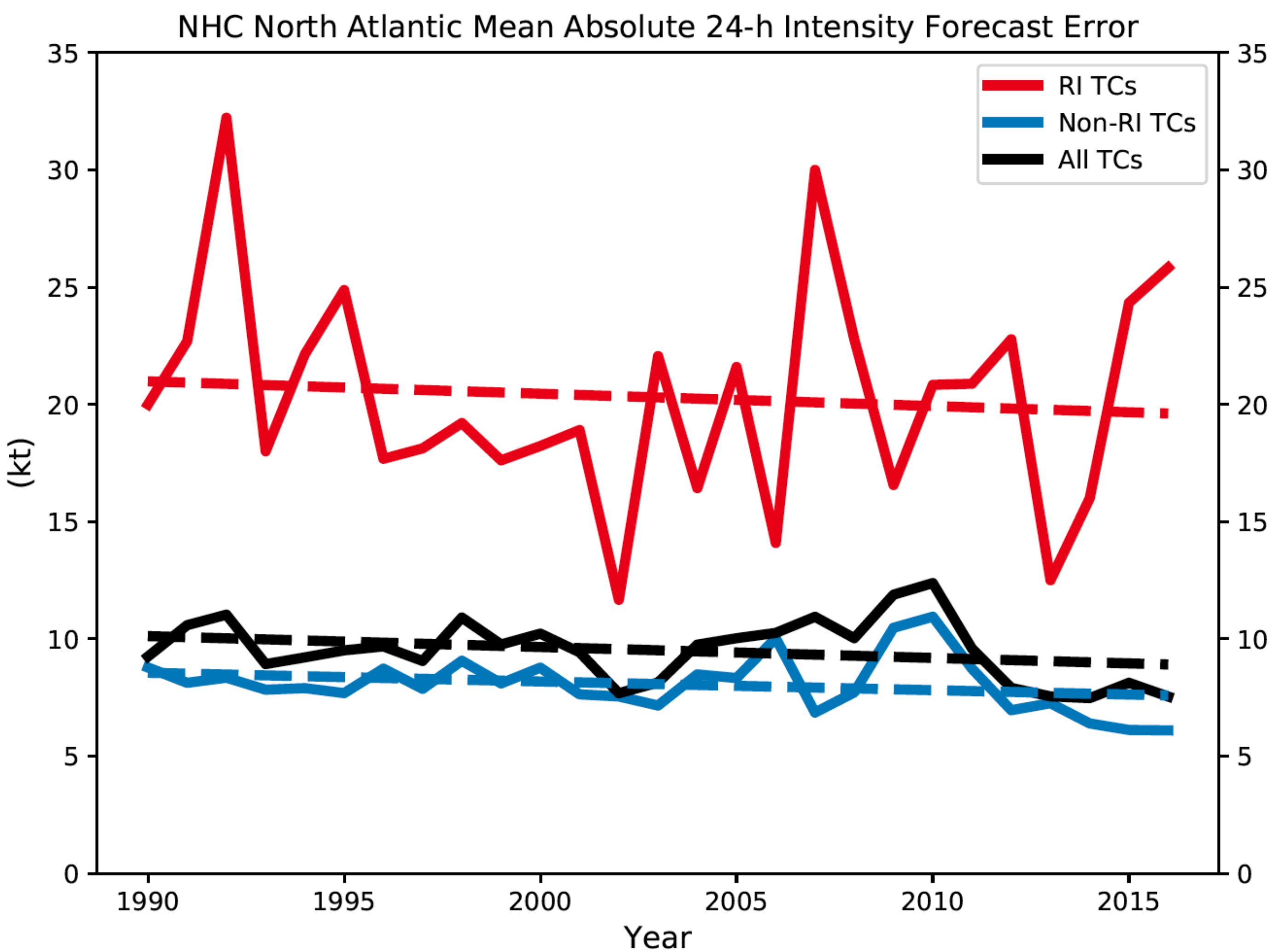
NHC official forecasts: Intensity errors



"…a *decrease in intensity errors* over the past few years; however, these *recent improvements* are likely *part due to a lack of rapidly intensifying hurricanes*, which are *typically the source of the largest forecast errors*."

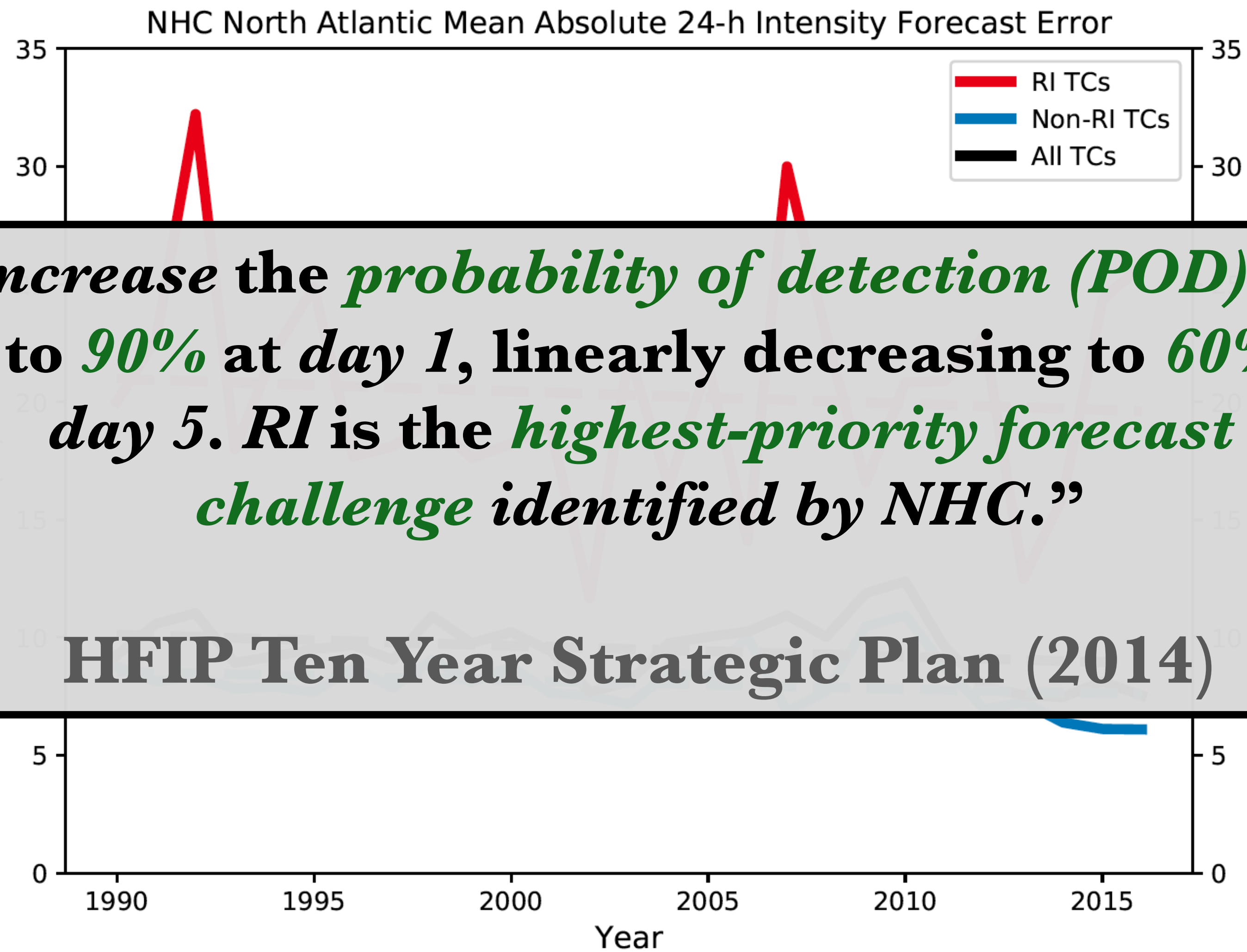
2018 NHC Verification Report

Rapid intensification: 💩 forecasts ☹



Fischer et al.(2019)

Rapid intensification: 💩 forecasts ☹



“*Increase* the *probability of detection (POD)* for *RI* to *90%* at *day 1*, linearly decreasing to *60%* at *day 5. RI* is the *highest-priority forecast challenge identified by NHC.*”

HFIP Ten Year Strategic Plan (2014)

Fischer et al.(2019)

Late 1980s intensity forecasting: Very little guidance

NATIONAL HURRICANE CENTER

MIAMI FLORIDA

To help forecast…

We can do better!

Late 1980s intensity forecasting: SHIPS is born!

The Statistical Hurricane Intensity Prediction Scheme (SHIPS)

Combines *predictors* from *climatology*, *persistence*, the *atmosphere*, and the *ocean* to *estimate changes* in *TC intensity*

DeMaria and Kaplan (1994)

Late 1980s intensity forecasting: SHIPS is born!

DeMaria and Kaplan (1994)

* GFS version *
* ATLANTIC 2021 SHIPS INTENSITY FORECAST *
* IR SAT DATA AVAILABLE, OHC AVAILABLE *
* IDA AL092021 08/28/21 00 UTC *

TIME (HR)	0	6	12	18	24	36	48	60	72	84	96	108	120	132	144	156	168
V (KT) NO LAND	70	78	86	94	101	109	116	110	103	93	81	74	70	71	73	71	70
V (KT) LAND	70	83	91	99	107	114	106	60	37	30	28	27	27	27	27	27	27
V (KT) LGEM	70	81	88	96	103	115	121	61	37	30	28	27	27	27	27	N/A	N/A
Storm Type	TROP	TROP	TROP	TROP	TROP	TROP	TROP	TROP	TROP	TROP	TROP	TROP	TROP	TROP	TROP	N/A	N/A
SHEAR (KT)	10	8	10	8	9	15	11	14	15	14	20	30	35	28	26	N/A	N/A
SHEAR ADJ (KT)	1	2	-4	-6	-3	-2	-1	0	5	-1	5	0	1	-3	0	N/A	N/A
SHEAR DIR	208	243	265	267	271	322	268	270	261	265	247	265	271	266	272	N/A	N/A
SST (C)	29.8	29.9	29.9	30.0	30.2	30.2	30.8	31.9	31.8	30.9	30.9	30.1	29.6	29.5	29.5	N/A	N/A
POT. INT. (KT)	167	169	169	171	172	172	171	170	171	171	171	171	162	161	162	N/A	N/A
ADJ. POT. INT.	158	159	157	158	160	154	160	170	171	156	154	139	134	136	137	N/A	N/A
200 MB T (C)	-52.4	-52.7	-52.6	-52.1	-51.9	-51.9	-51.7	-52.1	-51.8	-52.0	-51.8	-51.1	-50.4	-50.7	-52.0	N/A	N/A
200 MB VXT (C)	1.1	1.4	1.3	0.9	0.5	0.7	1.2	1.3	0.9	0.1	0.4	0.7	0.2	0.0	0.0	N/A	N/A
TH_E DEV (C)	9	8	8	9	8	7	7	4	6	3	5	2	5	0	2	N/A	N/A
700-500 MB RH	66	64	65	67	68	71	71	73	71	68	67	50	35	27	28	N/A	N/A
MODEL VTX (KT)	19	20	20	21	23	25	28	26	24	23	19	19	20	23	25	LOST	LOST
850 MB ENV VOR	38	22	12	14	9	-18	-11	-39	-15	-13	52	72	56	47	27	N/A	N/A
200 MB DIV	60	34	37	51	40	29	32	45	96	25	44	16	-11	-17	2	N/A	N/A
700-850 TADV	7	2	1	0	3	0	8	13	12	19	11	-7	-15	-31	-14	N/A	N/A
LAND (KM)	-31	105	249	392	357	145	-6	-82	-193	-351	-463	-564	-516	-370	-119	N/A	N/A
LAT (DEG N)	22.5	23.4	24.3	25.2	26.1	27.8	29.2	30.7	32.1	33.6	34.9	35.7	36.0	xx.x	xx.x	N/A	N/A
LONG(DEG W)	83.5	84.6	85.6	86.6	87.7	89.6	90.8	91.0	90.5	89.6	88.4	86.7	84.6	xxx.x	xxx.x	N/A	N/A
STM SPEED (KT)	13	13	13	13	13	10	8	7	8	8	8	8	10	13	14	N/A	N/A
HEAT CONTENT	91	123	93	108	145	77	44	7	7	6	6	5	4	4	4	N/A	N/A

FORECAST TRACK FROM OFCI INITIAL HEADING/SPEED (DEG/KT):320/ 13 CX,CY: -7/ 10
T-12 MAX WIND: 55 PRESSURE OF STEERING LEVEL (MB): 574 (MEAN=620)
GOES IR BRIGHTNESS TEMP. STD DEV. 50-200 KM RAD: 11.5 (MEAN=14.5)
% GOES IR PIXELS WITH T < -20 C 50-200 KM RAD: 98.0 (MEAN=65.0)
PRELIM RI PROB (DV .GE. 35 KT IN 36 HR): 71.6

INDIVIDUAL CONTRIBUTIONS TO INTENSITY CHANGE

	6	12	18	24	36	48	60	72	84	96	108	120	132	144	156	168
SAMPLE MEAN CHANGE	1.	2.	3.	4.	6.	8.	9.	10.	11.	12.	12.	13.	14.	15.	15.	16.
SST POTENTIAL	1.	3.	5.	6.	6.	6.	7.	9.	10.	11.	12.	12.	12.	10.	10.	9.
VERTICAL SHEAR MAG	-0.	-0.	0.	1.	1.	2.	3.	4.	4.	4.	2.	-1.	-3.	-5.	-5.	-6.
VERTICAL SHEAR ADJ	-0.	0.	1.	1.	1.	2.	2.	2.	2.	1.	1.	1.	1.	1.	1.	1.
VERTICAL SHEAR DIR	-0.	-0.	-0.	-0.	-0.	-0.	0.	1.	1.	2.	3.	4.	4.	5.	5.	5.
PERSISTENCE	3.	3.	3.	3.	1.	1.	1.	1.	0.	-0.	-1.	-1.	0.	1.	2.	1.
200/250 MB TEMP.	0.	0.	0.	-0.	-1.	-2.	-3.	-3.	-3.	-4.	-4.	-5.	-6.	-6.	-6.	-6.
THETA_E EXCESS	0.	0.	0.	0.	-0.	-0.	-1.	-1.	-1.	-1.	-0.	-0.	0.	1.	1.	2.
700-500 MB RH	-0.	-0.	-0.	-1.	-2.	-3.	-4.	-5.	-6.	-6.	-6.	-5.	-4.	-3.	-4.	-3.
MODEL VTX TENDENCY	0.	0.	1.	2.	4.	8.	5.	3.	0.	-5.	-7.	-6.	-3.	-1.	-1.	-2.
850 MB ENV VORTICITY	0.	-0.	-0.	-0.	-0.	-1.	-1.	-2.	-2.	-2.	-1.	-1.	-1.	-1.	-1.	-1.
200 MB DIVERGENCE	0.	0.	0.	0.	0.	0.	0.	1.	1.	1.	0.	-0.	-0.	-0.	-0.	-0.
850-700 T ADVEC	-0.	0.	-0.	-0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	-0.	-0.	-0.
ZONAL STORM MOTION	-0.	-0.	0.	0.	0.	0.	0.	0.	0.	1.	1.	1.	1.	0.	0.	0.
STEERING LEVEL PRES	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.	1.	0.	0.	0.	0.
DAYS FROM CLIM. PEAK	0.	-0.	-0.	-0.	0.	0.	0.	0.	0.	-0.	-0.	-0.	-0.	-0.	-0.	-0.
GOES PREDICTORS	1.	1.	1.	2.	1.	2.	2.	2.	2.	2.	2.	3.	3.	3.	3.	2.
OCEAN HEAT CONTENT	-0.	-1.	-1.	-3.	-4.	-1.	1.	1.	-0.	-0.	-0.	-0.	-0.	-0.	-0.	-0.
RI POTENTIAL	2.	6.	11.	17.	24.	23.	16.	8.	2.	-5.	-10.	-14.	-17.	-17.	-19.	-18.
TOTAL CHANGE	8.	16.	24.	31.	39.	46.	40.	33.	23.	11.	4.	0.	1.	3.	1.	-0.

CURRENT MAX WIND (KT): 70. LAT, LON: 22.5 83.5

Rapid intensity forecasting: SHIPS was 💩 at RI

During the development of SHIPs, TCs with the *largest 48-h intensity change*:

1) **were *smaller***
2) **experienced *weaker shear***
3) **had *less upper-level forcing***
4) **were *further from* their *MPI***

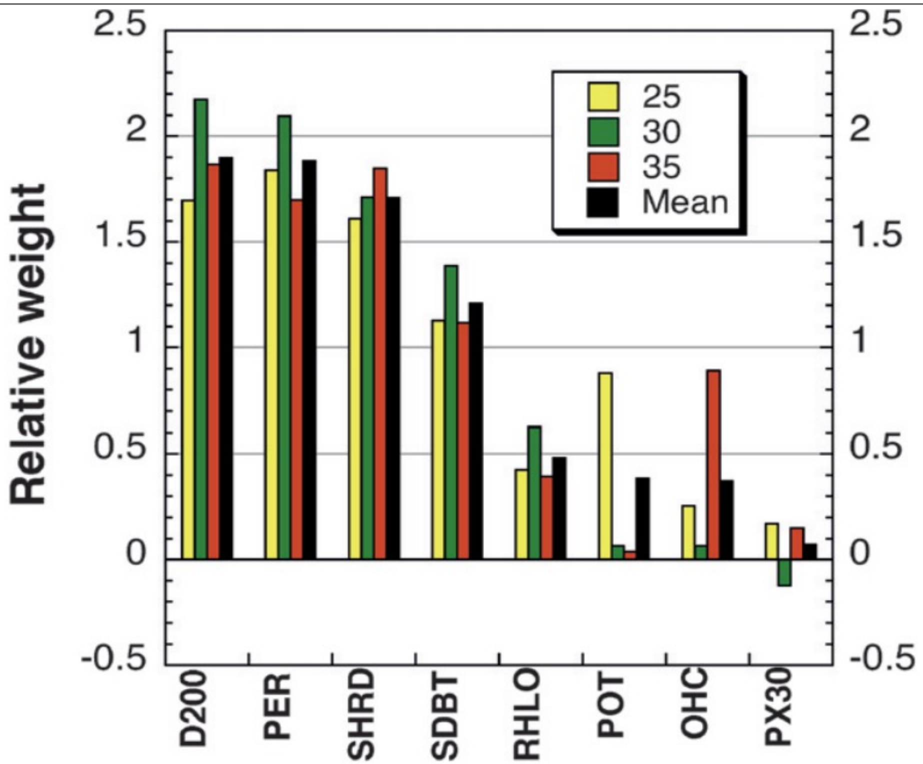
Rapid Intensity Index (RII)

Kaplan and DeMaria (2003)

Rapid intensity forecasting: The RII

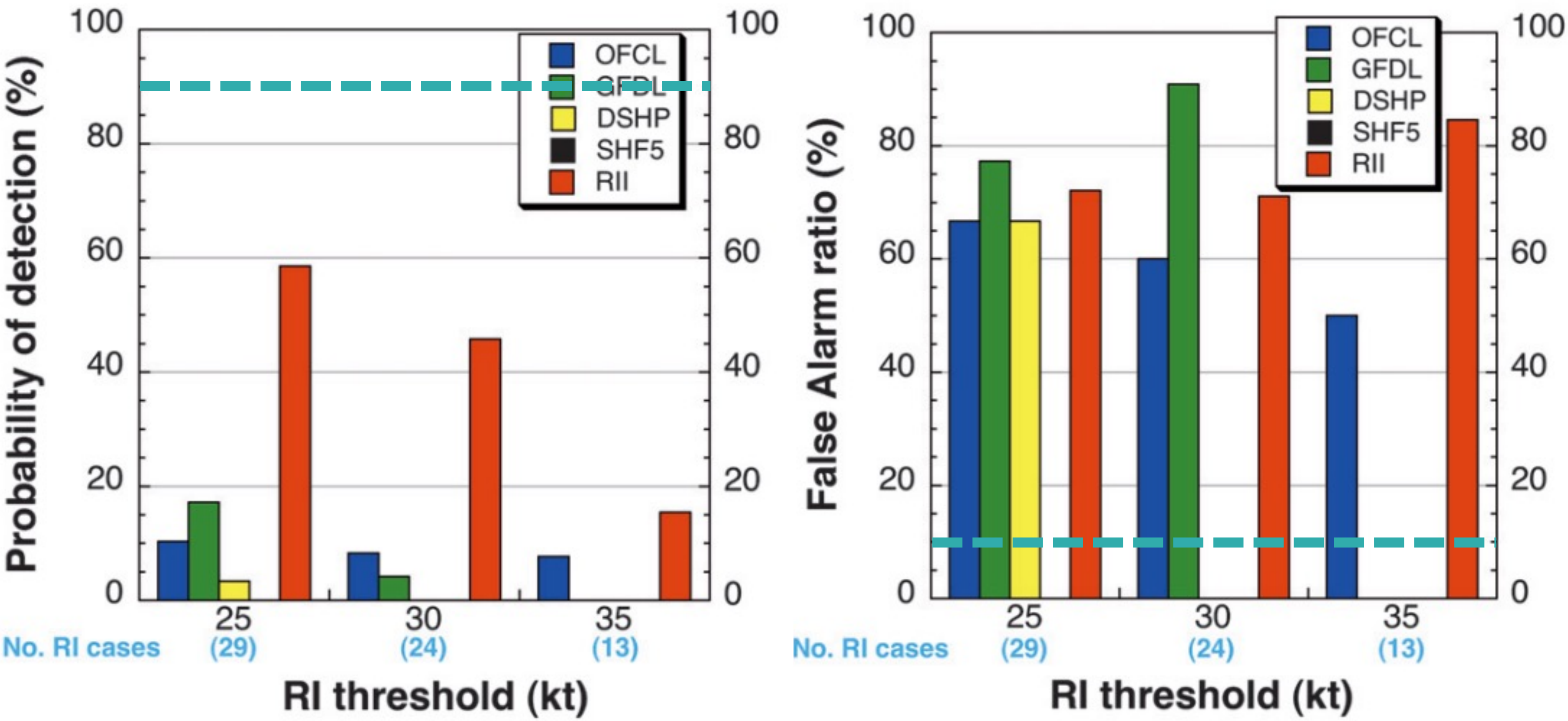
TABLE 3. The predictors used in the revised Atlantic RII index.

Predictor	Definition
PER	Previous 12-h intensity change
SHRD	850–200-hPa vertical shear of the horizontal wind from the 0–500-km radius
D200	200-hPa divergence from the 0–1000-km radius
RHLO	850–700-hPa relative humidity from 200–800-km radius
PX30	Percent area from 50 to 200 km covered by $\leq -30°C$ IR cloud-top brightness temperatures
SDBT	Std dev of 50–200-km IR cloud-top brightness temperatures
POT	Potential intensity (current intensity − maximum potential intensity)
OHC	Ocean heat content



Kaplan et al. (2010)

Rapid intensity forecasting: A long way from HFIP goals

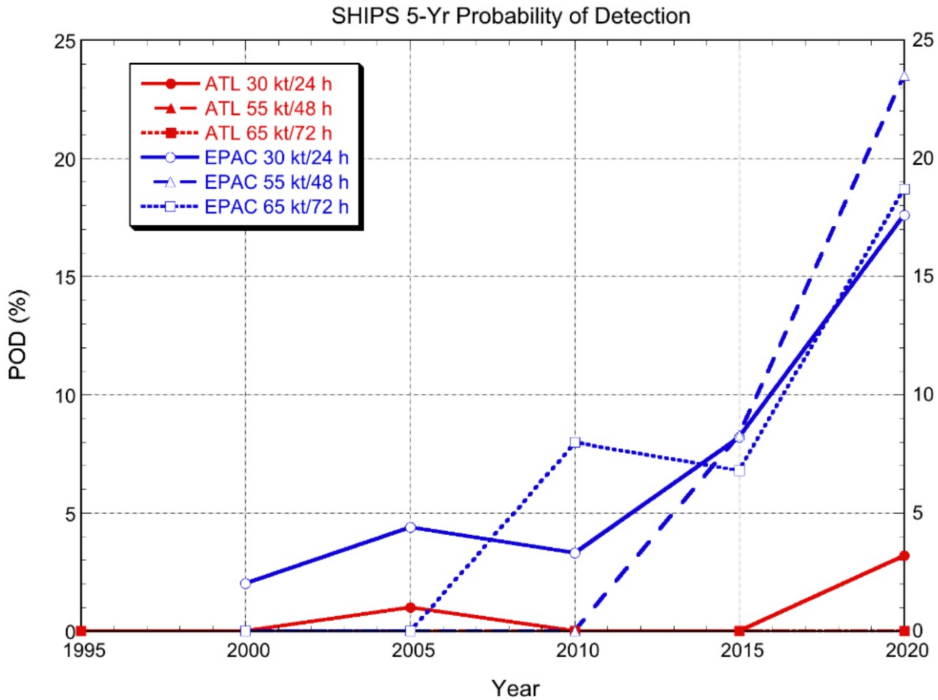


Kaplan et al. (2010)

Rapid intensity forecasting: Improvements to RII

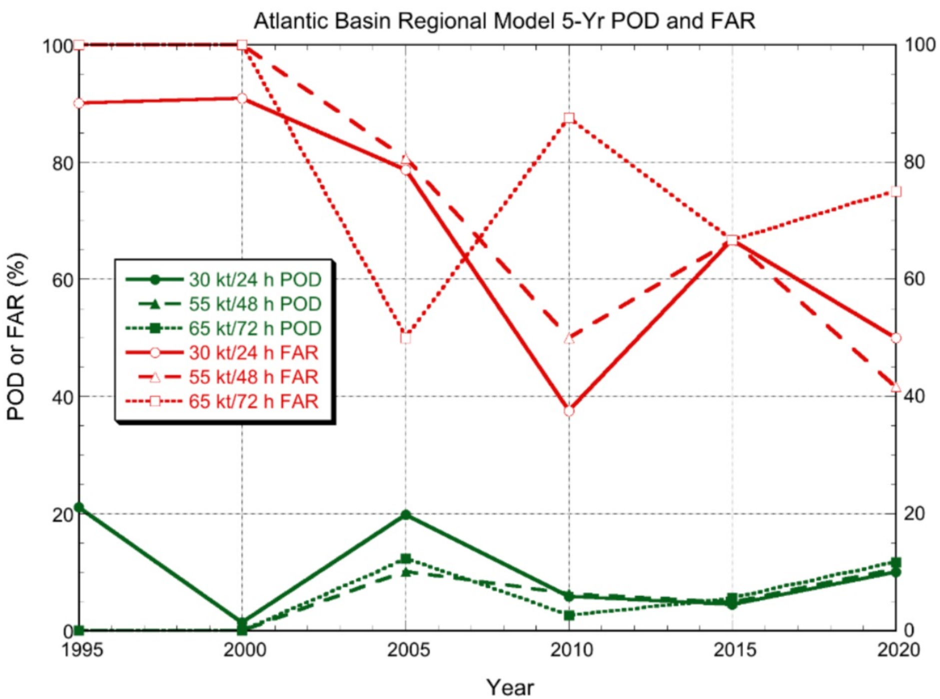
```
*                   GFS version                       *
* ATLANTIC     2021 SHIPS INTENSITY FORECAST          *
* IR SAT DATA AVAILABLE,        OHC AVAILABLE         *
*  IAN          AL092022  09/26/22  00 UTC            *

     ** 2021 ATLANTIC RI INDEX AL092022 IAN        09/26/22  00 UTC **
 (SHIPS-RII PREDICTOR TABLE for 30 KT OR MORE MAXIMUM WIND INCREASE IN NEXT 24-h)

     Predictor                Value    RI Predictor Range  Scaled Value(0-1) % Contributior
 12 HR PERSISTENCE (KT)      :   5.0    -49.5  to   33.0       0.66           13.8
 850-200 MB SHEAR (KT)       :   2.4     30.1  to    2.3       1.00            9.7
 HEAT CONTENT (KJ/CM2)       :  72.4      0.0  to  151.8       0.48            4.2
 STD DEV OF IR BR TEMP       :   9.7     36.6  to    2.8       0.80            7.9
 MAXIMUM WIND (KT)           :  50.0     22.5  to  137.5       0.72            5.7
 BL DRY-AIR FLUX (W/M2)      :  98.6    895.4  to  -55.0       0.84            6.7
 2nd PC OF IR BR TEMP        :   0.4      2.9  to   -2.9       0.43            2.5
 POT = MPI-VMAX (KT)         : 117.4     28.3  to  146.3       0.76            2.8
 D200 (10**7s-1)             :  88.8    -29.7  to  185.9       0.55            1.9
 %area of TPW <45 mm upshear :   0.0    100.0  to    0.0       1.00            0.8

 SHIPS Prob RI for 20kt/ 12hr RI threshold=  18% is   3.7 times climatological mean ( 4.9%)
 SHIPS Prob RI for 25kt/ 24hr RI threshold=  69% is   6.3 times climatological mean (10.9%)
 SHIPS Prob RI for 30kt/ 24hr RI threshold=  56% is   8.2 times climatological mean ( 6.8%)
 SHIPS Prob RI for 35kt/ 24hr RI threshold=  38% is   9.9 times climatological mean ( 3.9%)
 SHIPS Prob RI for 40kt/ 24hr RI threshold=  31% is  12.8 times climatological mean ( 2.4%)
 SHIPS Prob RI for 45kt/ 36hr RI threshold=  74% is  16.1 times climatological mean ( 4.6%)
 SHIPS Prob RI for 55kt/ 48hr RI threshold=  67% is  14.2 times climatological mean ( 4.7%)
 SHIPS Prob RI for 65kt/ 72hr RI threshold=  32% is   6.1 times climatological mean ( 5.3%)

Matrix of RI probabilities
------------------------------------------------------------------------------
  RI (kt / h)   | 20/12 | 25/24 | 30/24 | 35/24 | 40/24 | 45/36 | 55/48  |65/72
------------------------------------------------------------------------------
   SHIPS-RII:     18.3%   68.7%   56.0%   38.4%   30.7%   74.3%   66.8%   32.1%
```

Rapid intensity forecasting: A hint of improvement



SHIPS predictability in the eastern Pacific is better, but still well below 90%

HWRF has lowered false alarms, but POD is still dismal



DeMaria et al. (2021)

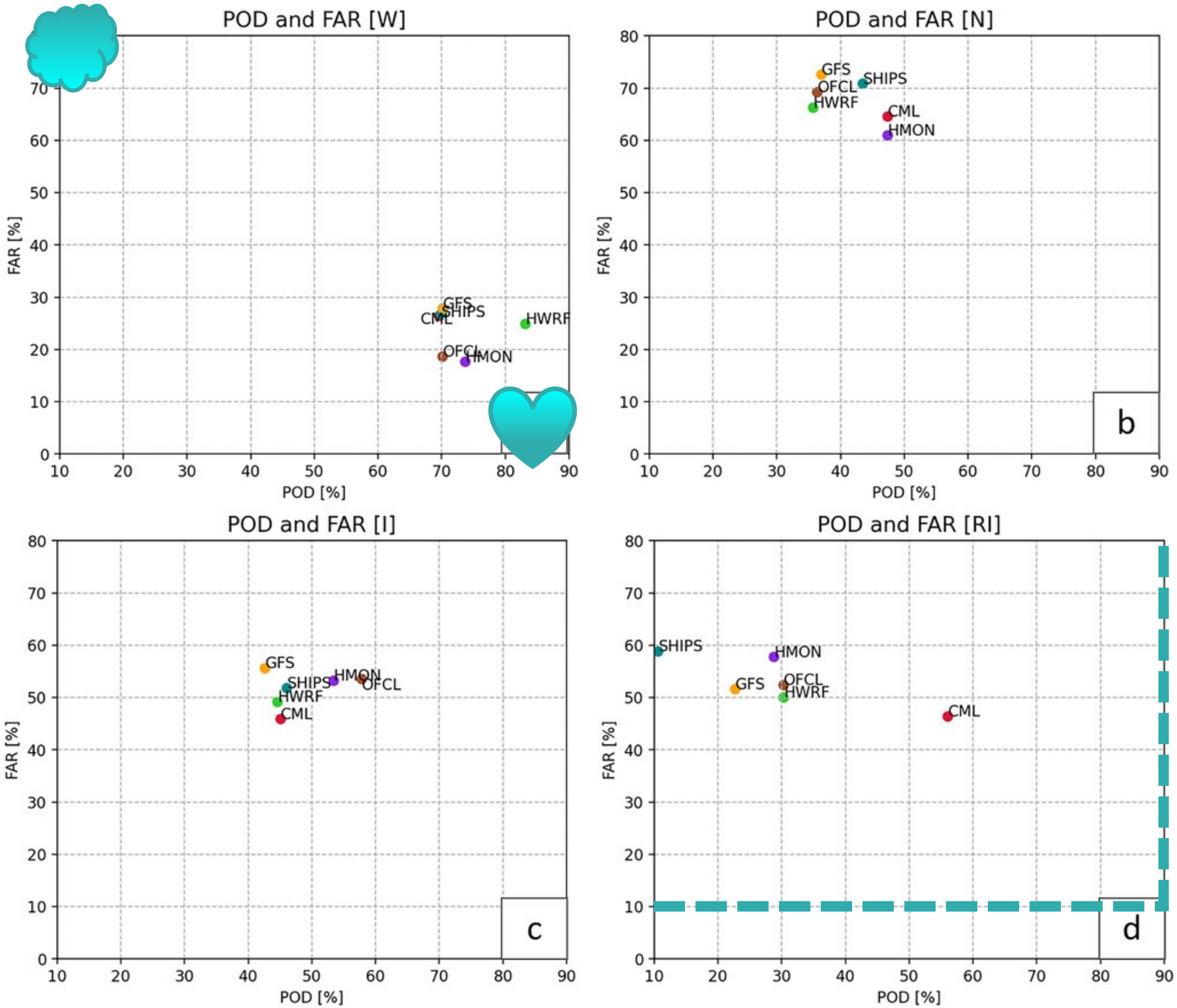
Rapid intensity forecasting: Enter machine learning!

Short name	Long name	Radius (km)	Level (hPa)
CLAT	Center latitude	—	Surface
CLON	Center longitude	—	Surface
dINT12	$T - 12$ wind speed change	—	Surface
RMW	Radius of maximum sustained wind	—	Surface
SST	Sea surface temperature	0–300	Surface
ShearS	Shallow-layer shear magnitude	200–800	850 and 700
ShdirS	Shallow-layer shear direction	200–800	850 and 700
ShearM	Medium-layer shear magnitude	200–800	850 and 500
ShdirM	Medium-layer shear direction	200–800	850 and 500
ShearD	Deep-layer shear magnitude	200–800	850 and 200
ShdirD	Deep-layer shear direction	200–800	850 and 200
CAPE_US	Upshear convective available potential energy (CAPE)	0–400	Surface
CAPE_DS	Downshear CAPE	0–400	Surface
HLCY_US	Upshear helicity	0–400	3 km
HLCY_DS	Downshear helicity	0–400	3 km
RHMI	Midlevel relative humidity (RH)	200–800	700–500
Land	Land proportion underneath the storm	0–300	Surface
D200	Divergence at 200 hPa	200–800	200
C850	Convergence at 850 hPa	0–300	850
dT500	Temperature difference between core and environment at 500 hPa	Inner: 0–300; outer: 200–800	500
WV1	Wavenumber-1 amplitude of wind field	0–300	—

Short name	Long name	Radius (km)	Level (hPa)
SHX	Sensible heat flux	0–150	Surface
LHX	Latent heat flux	0–150	Surface
CB	Convective burst	RMW	500–200
POT	Max potential intensity minus current intensity	—	—
PS	Precipitation symmetricity	0–200	Surface
Ro	Local Rossby number	—	10 (m)
MSE	Column-integrated moist static energy	0–300	1000–100
Tilt	Vortex tilt (geopotential height vortex center)	—	850 and 450
INRH	Inner-core RH	0–150	900–400
INRH_US	Upshear INRH	0–150	900–400
RHLO	Low-level RH	0–300	850–700
RHHI	High-level RH	0–300	500–300
dT350	Temperature difference between core and environment at 350 hPa	Inner: 0–300; outer: 200–800	350

Ko et al. (2023)

Rapid intensity forecasting: Machine learning (CML): Improved skill



Ko et al. (2023)

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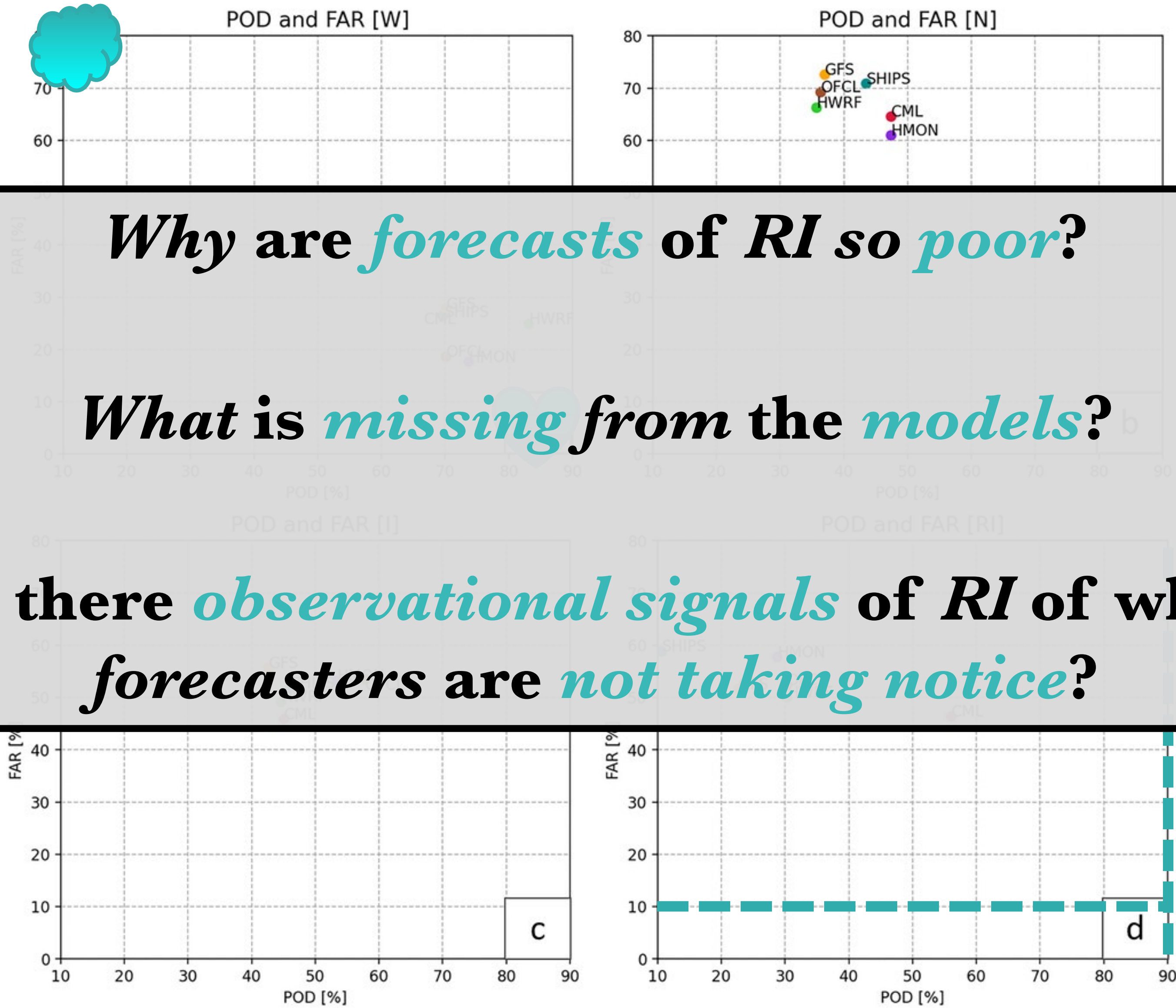


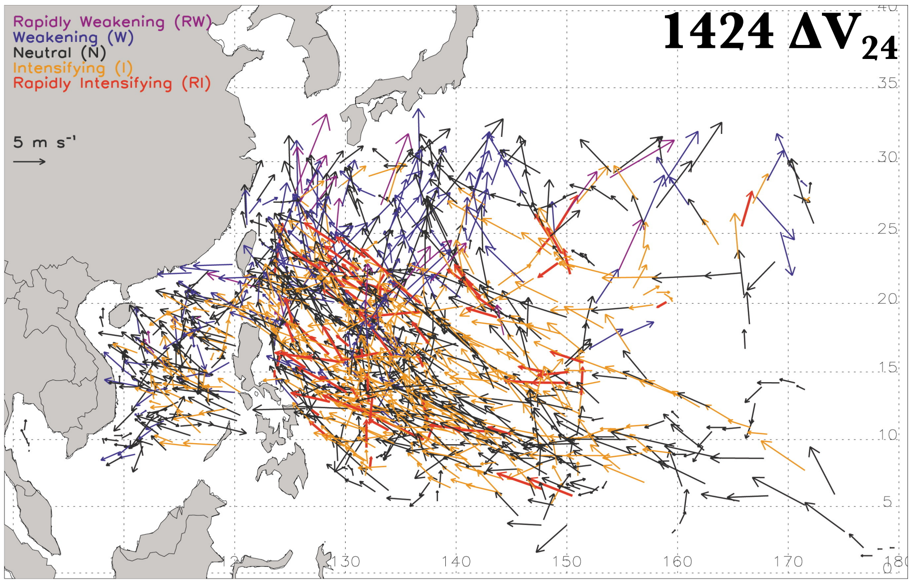
Why **are** ***forecasts*** **of** ***RI so poor*****?**

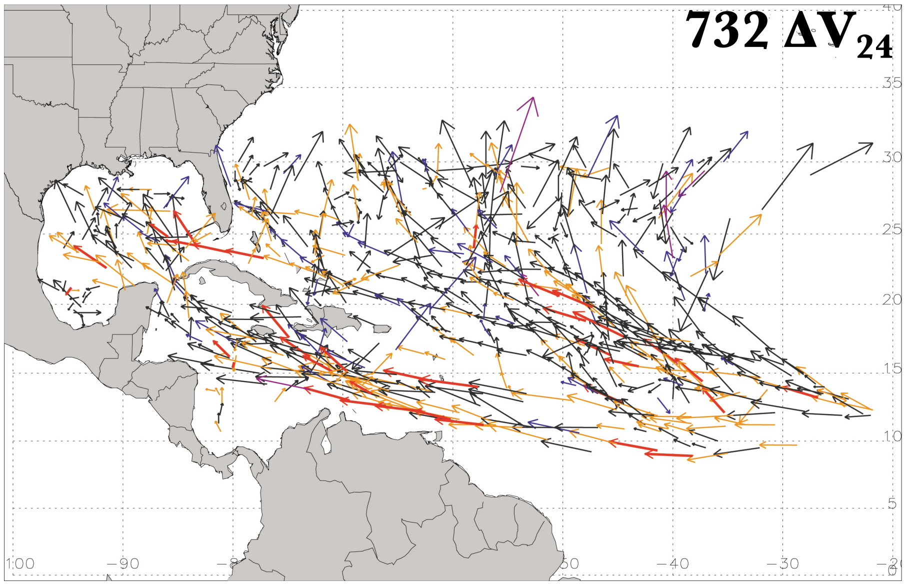
What **is** ***missing from*** **the** ***models*****?**

Are there ***observational signals*** **of** ***RI*** **of which** ***forecasters*** **are** ***not taking notice*****?**

Ko et al. (2023)

Rapid intensity forecasting: Why are models so 💩?





Hendricks et al. (2010):

"While *some environmental differences* were found *between RI* and *weakening/neutral TCs*, an interesting result is that the *environments* of *RI TCs* and *intensifying TCs* is *quite similar*."

Why are models so 💩?
RI environments aren't so different

Quantity	Basin	W	N	I	RI	RI - W	RI - N	RI - I
Deep-layer shear (m s^{-1})	ATL	11.24	11.80	9.89	8.24	**−3.00**	**−3.56**	**−1.65**
SST (°C)	ATL	28.23	27.96	28.58	28.93	**0.70**	**0.97**	0.35
850-hPa relative humidity (%)	ATL	73.93	76.27	76.12	76.45	**2.52**	0.18	0.33
500-hPa relative humidity (%)	ATL	48.83	50.98	52.43	53.97	**5.14**	**2.99**	1.54
850-hPa divergence (10^{-6} s^{-1})	ATL	−1.63	−1.19	−1.40	−1.25	0.38	−0.06	0.15
200-hPa divergence (10^{-6} s^{-1})	ATL	4.61	3.02	3.37	2.84	**−1.77**	−0.18	−0.53
$\partial\theta_E/\partial p$ (10^3 K Pa^{-1})	ATL	0.35	0.28	0.32	0.31	−0.04	0.03	−0.01
850-hPa vorticity (10^{-6} s^{-1})	ATL	7.71	6.91	6.48	5.00	−2.71	−1.91	−1.48

Hendricks et al. (2010):

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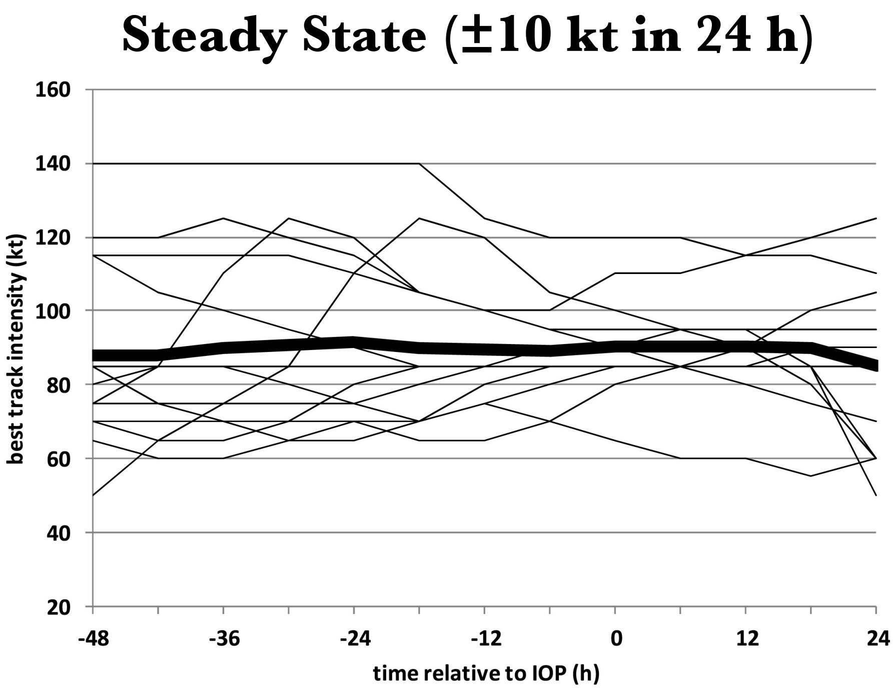
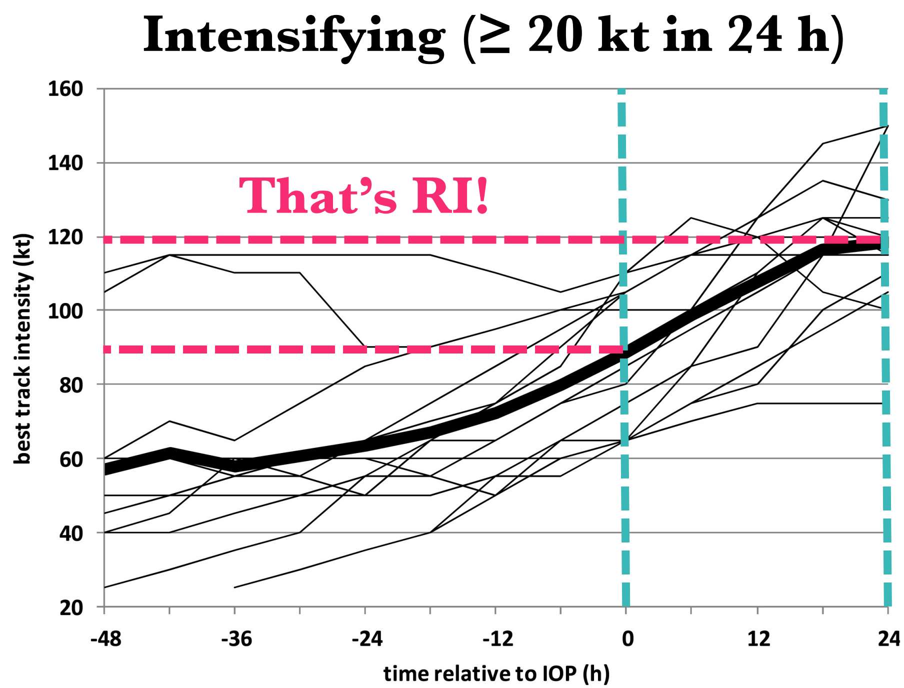
<u>Hendricks et al. (2010):</u>

"…*RI* is mostly *controlled by internal dynamical processes*. These processes are *inherently less predictable*; therefore, *RI may never be well predicted by mesoscale models*."

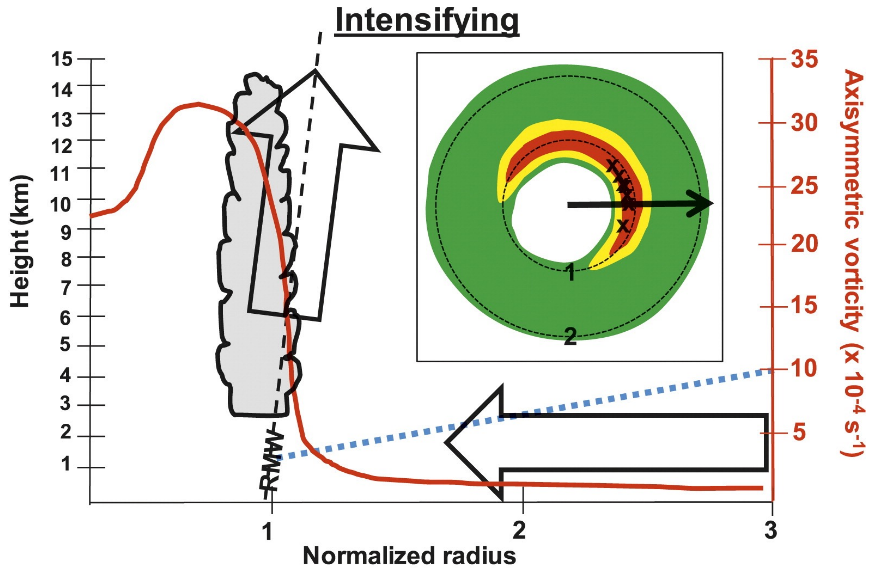
Rapid intensification: Internal dynamical processes

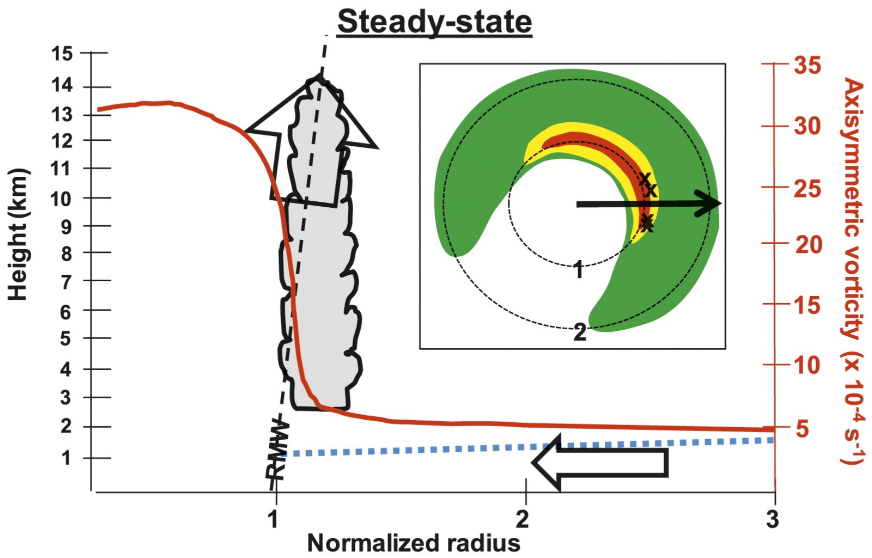




Rogers et al. (2013)

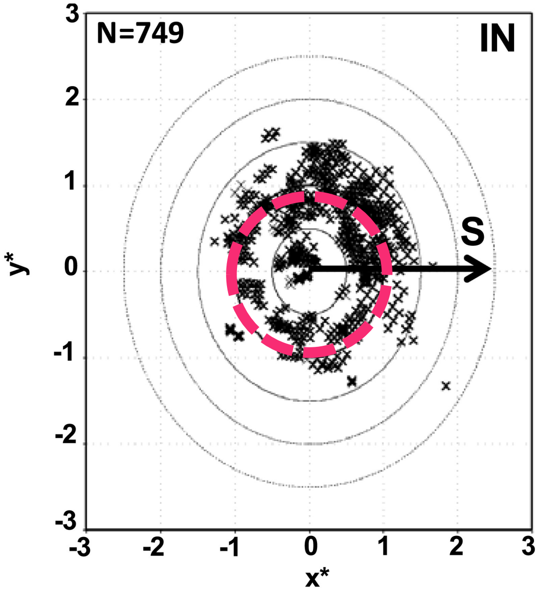
Rapid intensification: Internal dynamical processes

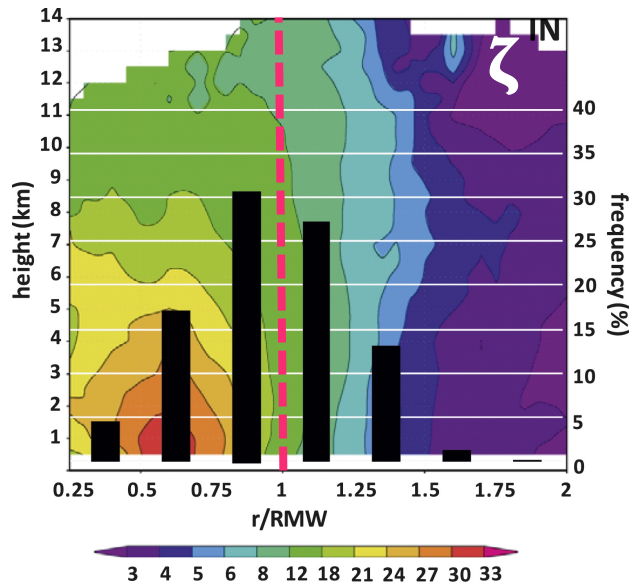


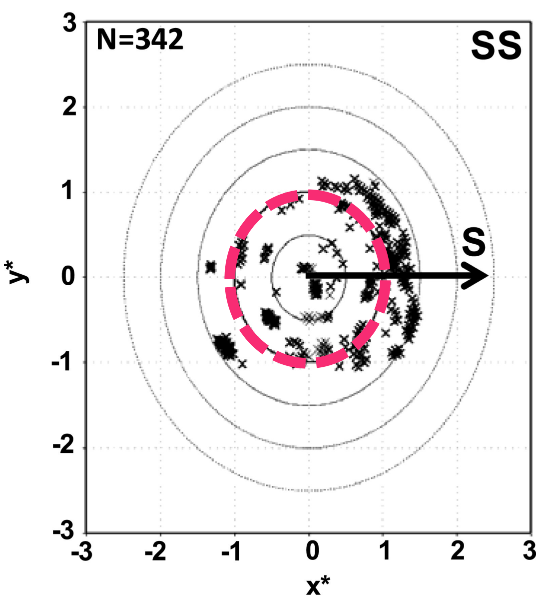


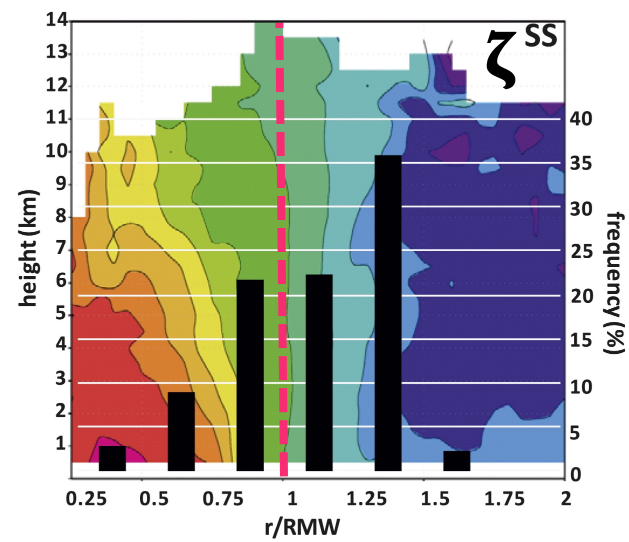
Rogers et al. (2013)

Internal dynamical processes: Convective bursts



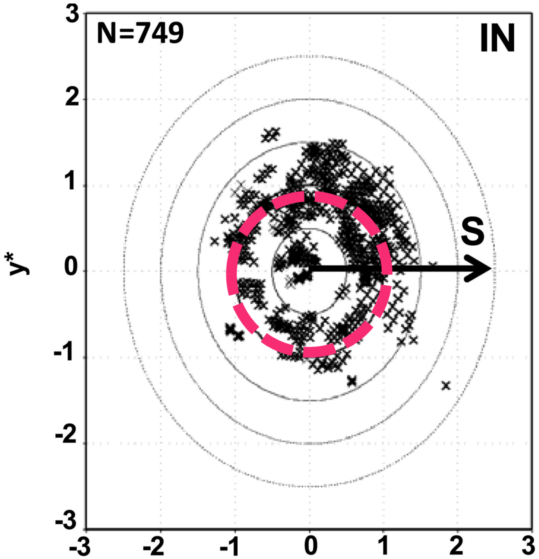


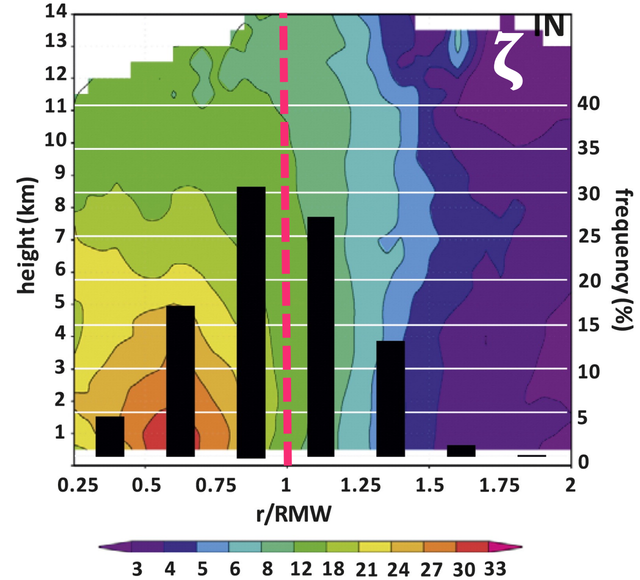


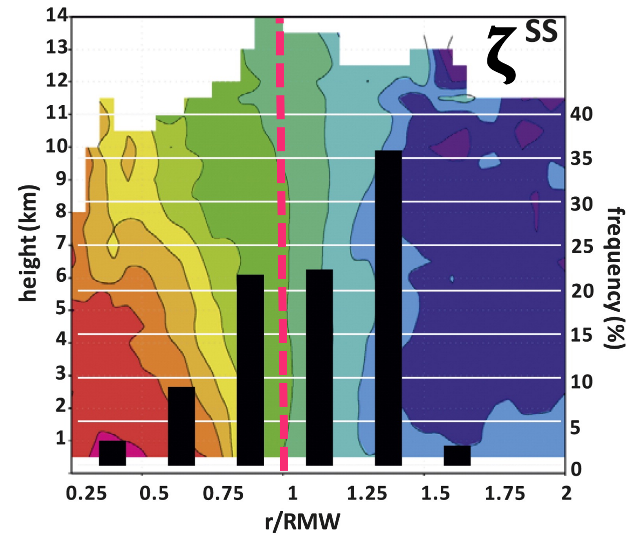


Rogers et al. (2013)

Internal dynamical processes: Convective bursts







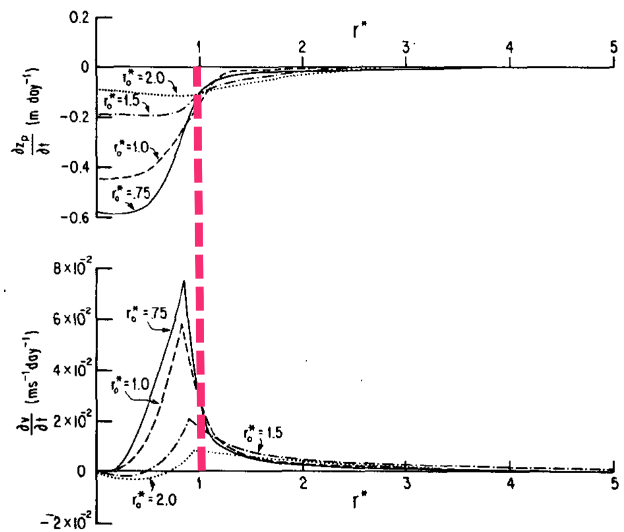
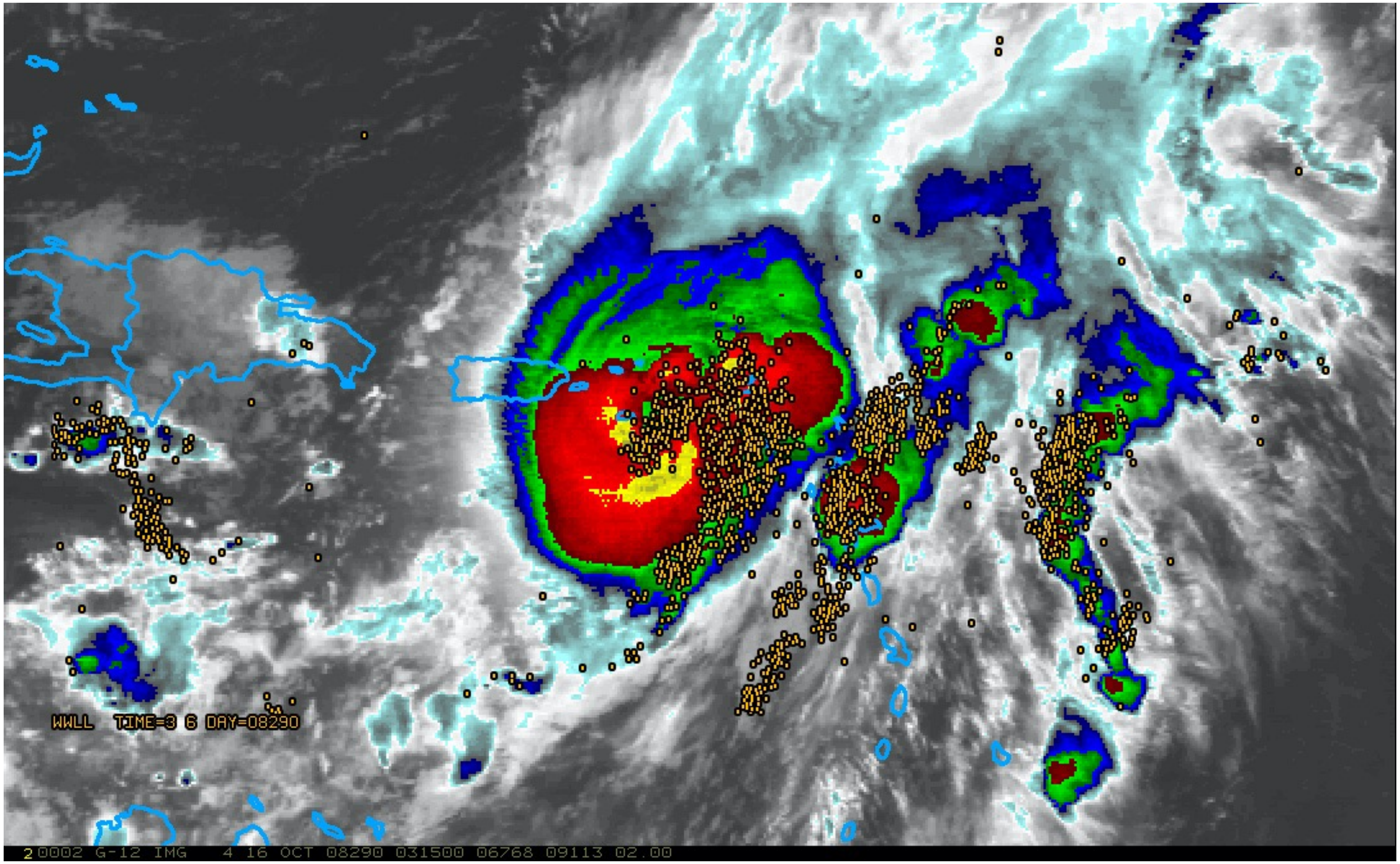


FIG. 11. The surface tendencies of pressure height and tangential wind produced by heat sources at $z_0^* = 0.5$ and $r_0^* = 0.75$, 1.0, 1.5 and 2.0.

Rogers et al. (2013)

Shapiro & Willoughby (1982)

Convective bursts: Lightning!



TC lightning: Forecasters are willing to use it!

NATIONAL HURRICANE CENTER
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

ANALYSES & FORECASTS ▾ DATA & TOOLS ▾ EDUCATIONAL RESOURCES ▾ ARCHIVES ▾

Tropical Storm CRISTINA

ZCZC MIATCDEP3 ALL
TTAA00 KNHC DDHHMM

TROPICAL STORM CRISTINA DISCUSSION NUMBER 6
NWS NATIONAL HURRICANE CENTER MIAMI FL EP032014
800 PM PDT TUE JUN 10 2014

Cristina is intensifying this evening. The compact central dense overcast has become more circular, and hints of an eye have been apparent in geostationary satellite images. The initial intensity is increased to 55 kt, in agreement with unanimous Dvorak classifications of 3.5/55 kt from TAFB, SAB, and UW-CIMSS ADT.

Although the curved bands beyond the inner-core region remain fragmented, a considerable amount of lightning has been occurring in a rain band located about 120 n mi to the south-southwest of the center. Recent research has documented that lightning in the outer bands of the tropical cyclone circulation is often a precursor of significant intensification. The only apparent factor that could limit strengthening during the next couple of days is mid-level dry air, which has been an issue for Cristina during the past day or so. In about 3 days, Cristina is expected to move into an environment of stronger southwesterly shear and over cooler waters, which should end the strengthening trend and cause the cyclone to weaken. The NHC intensity forecast is slightly higher than the previous one, and is pretty close to the intensity model consensus IVCN.

Cristina has wobbled a little south of due west during the past 6 hours, and the latest initial motion estimate is 265/5. A westward to west-northwestward motion is forecast during the next day or so while the cyclone remains on the south side of a mid-level ridge over northwestern Mexico. After that time, a turn to the northwest is predicted when the ridge weakens and shifts eastward. The NHC track forecast is an update of the previous one, and close to a consensus of the GFS and ECMWF models.

FORECAST POSITIONS AND MAX WINDS

INIT	11/0300Z	15.2N	103.9W	55 KT	65 MPH
12H	11/1200Z	15.4N	105.0W	65 KT	75 MPH
24H	12/0000Z	15.8N	106.4W	70 KT	80 MPH
36H	12/1200Z	16.5N	107.7W	75 KT	85 MPH
48H	13/0000Z	17.2N	109.0W	75 KT	85 MPH
72H	14/0000Z	18.7N	111.5W	70 KT	80 MPH
96H	15/0000Z	19.6N	113.5W	55 KT	65 MPH
120H	16/0000Z	20.0N	115.5W	35 KT	40 MPH

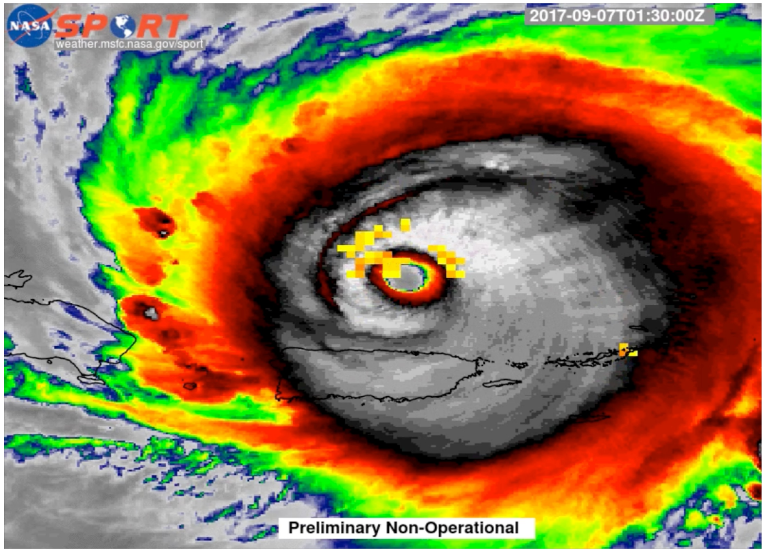
$$
Forecaster Cangialosi

NNNN

ZCZC MIATCDAT1 ALL
TTAA00 KNHC DDHHMM

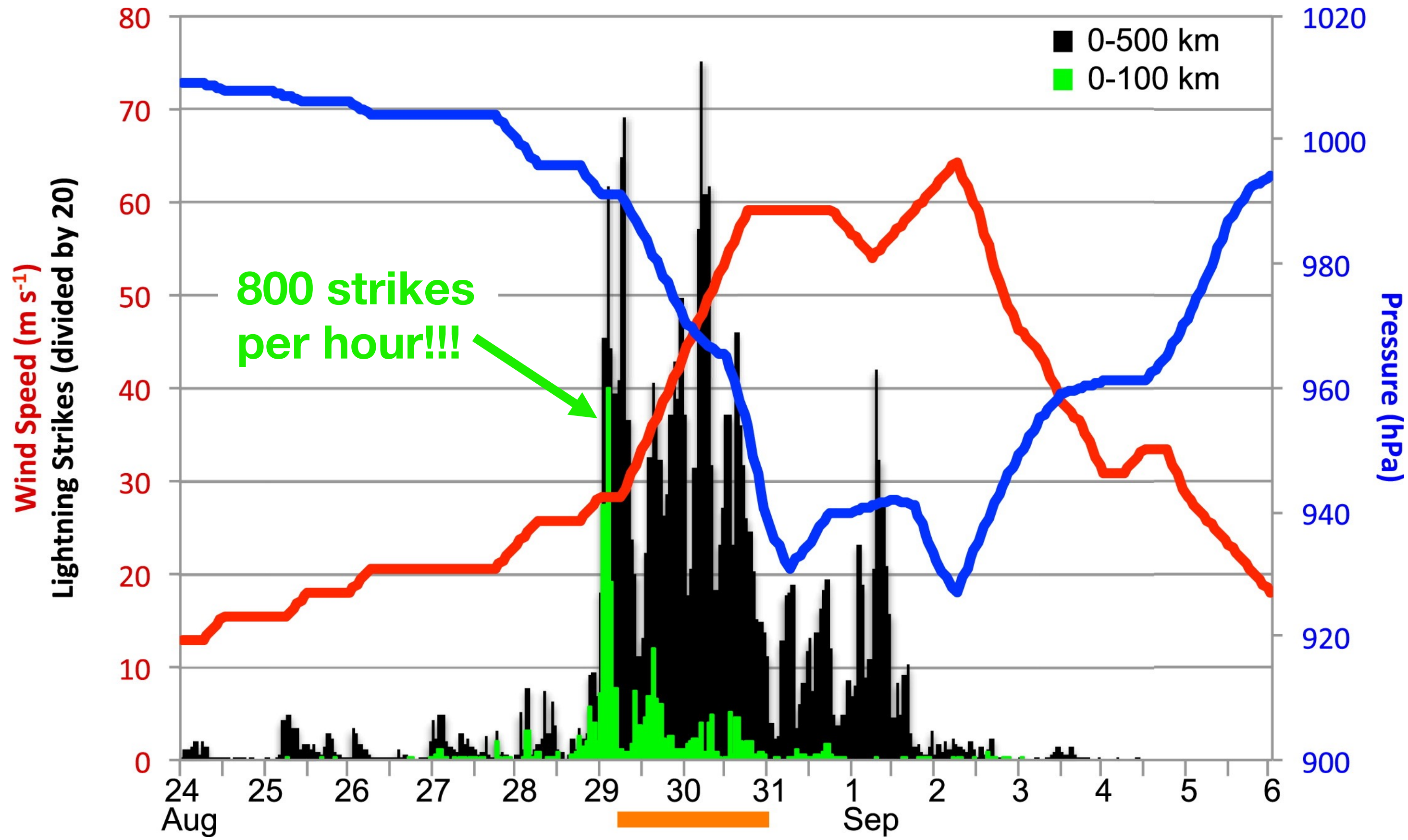
Hurricane Irma Discussion Number 32
NWS National Hurricane Center Miami FL AL112017
1100 PM AST Wed Sep 06 2017

Earlier radar observations from the San Juan WSR-88D showed a concentric eyewall, and observations from an Air Force Hurricane Hunter aircraft showed a secondary wind maximum over the northwest quadrant. These phenomena may be associated with some weakening, but since the central pressure hasn't risen much the intensity is held at 160 kt at this time. Moreover, the concentric eyewall has become less apparent in recent radar imagery. Considerable lightning activity has been noted in the eyewall of Irma, which research has shown to sometimes be a harbinger of weakening. Notwithstanding, low vertical wind shear and warm waters along the forecast track of Irma should allow it to remain a very powerful hurricane during the next several days. The official intensity forecast is similar to the previous one except at day 5 when stronger shear should cause more weakening. This forecast is generally above the intensity model consensus.



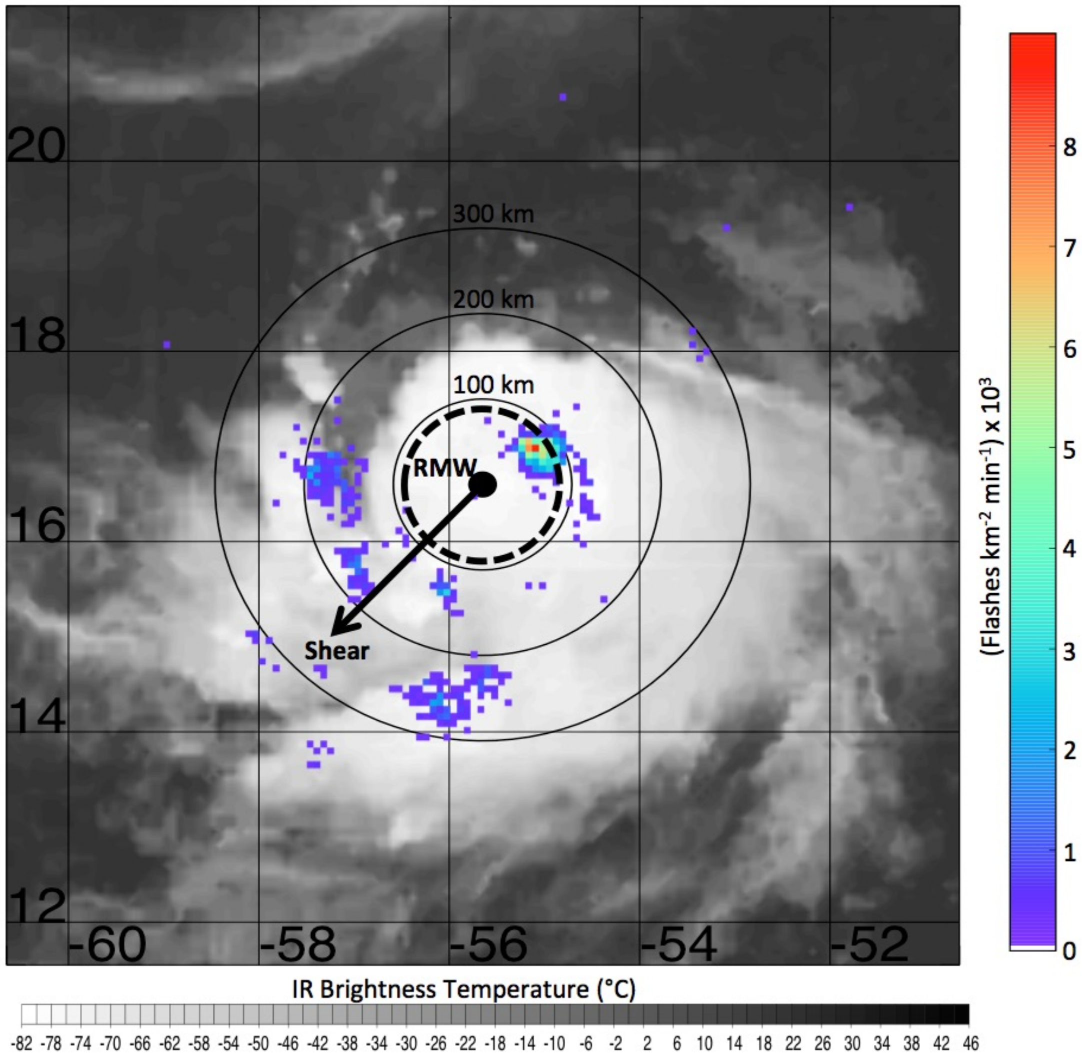
Lightning in TCs: Hurricane Earl (20120)

Hurricane Earl (2010)



Stevenson et al. (2015, 2016, 2018)

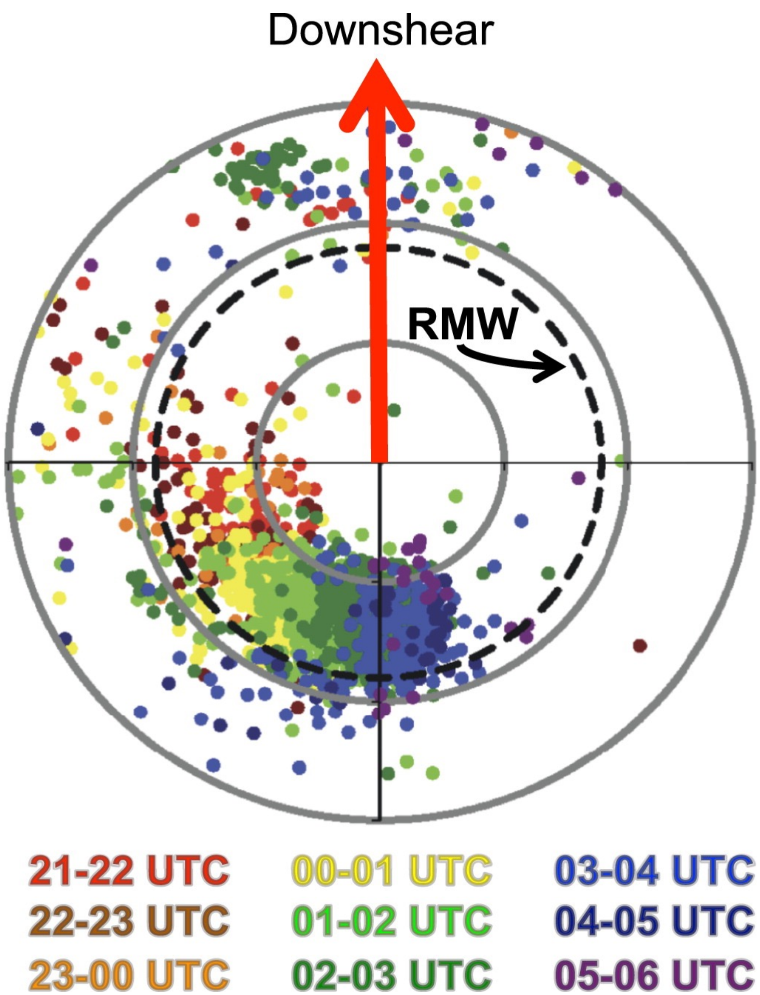
Lightning in TCs: Hurricane Earl (20120)



Stevenson et al. (2015, 2016, 2018)

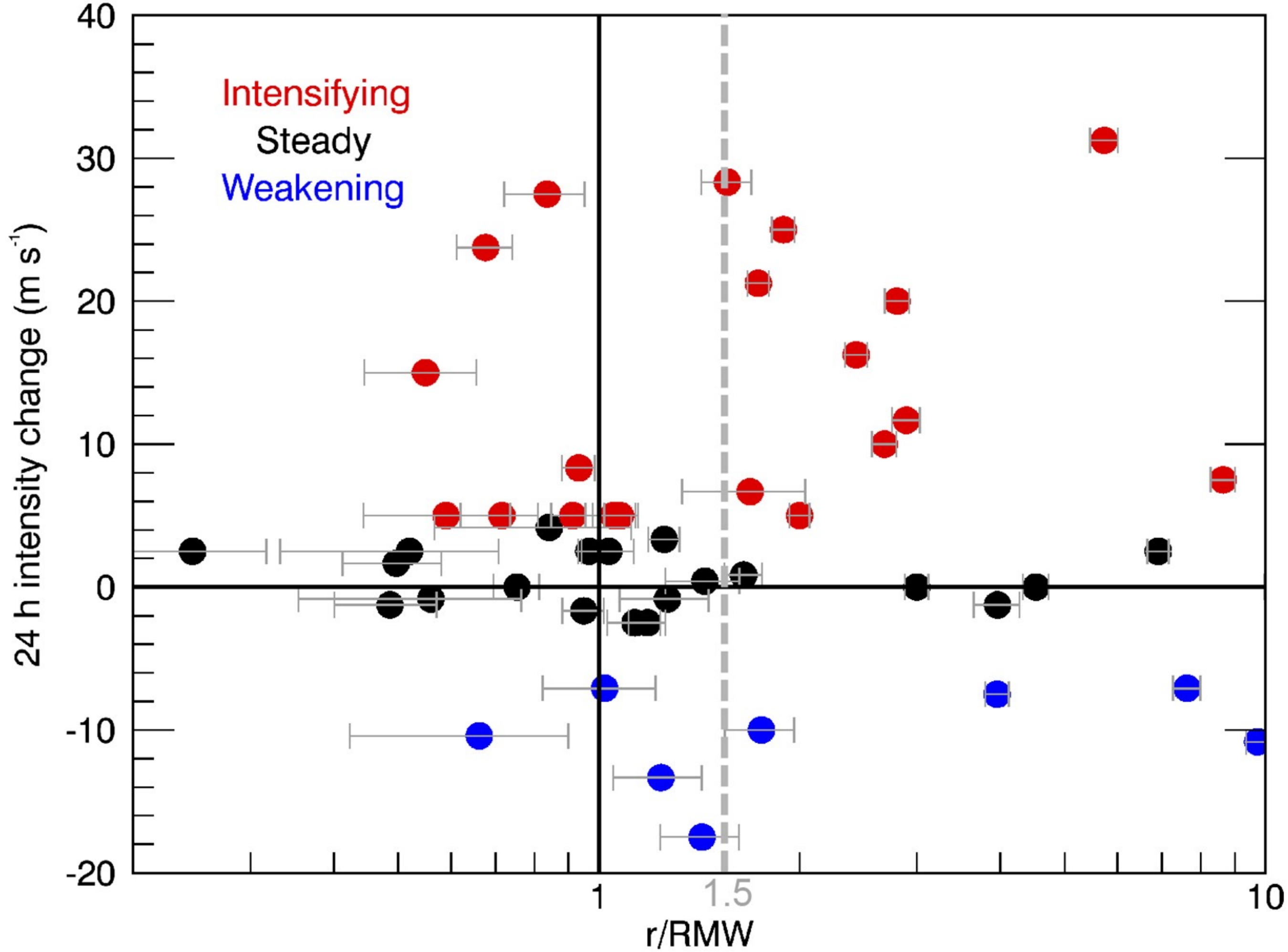
Lightning in TCs:
Earl's burst was upshear and inside the RMW

Hurricane Earl (2010)



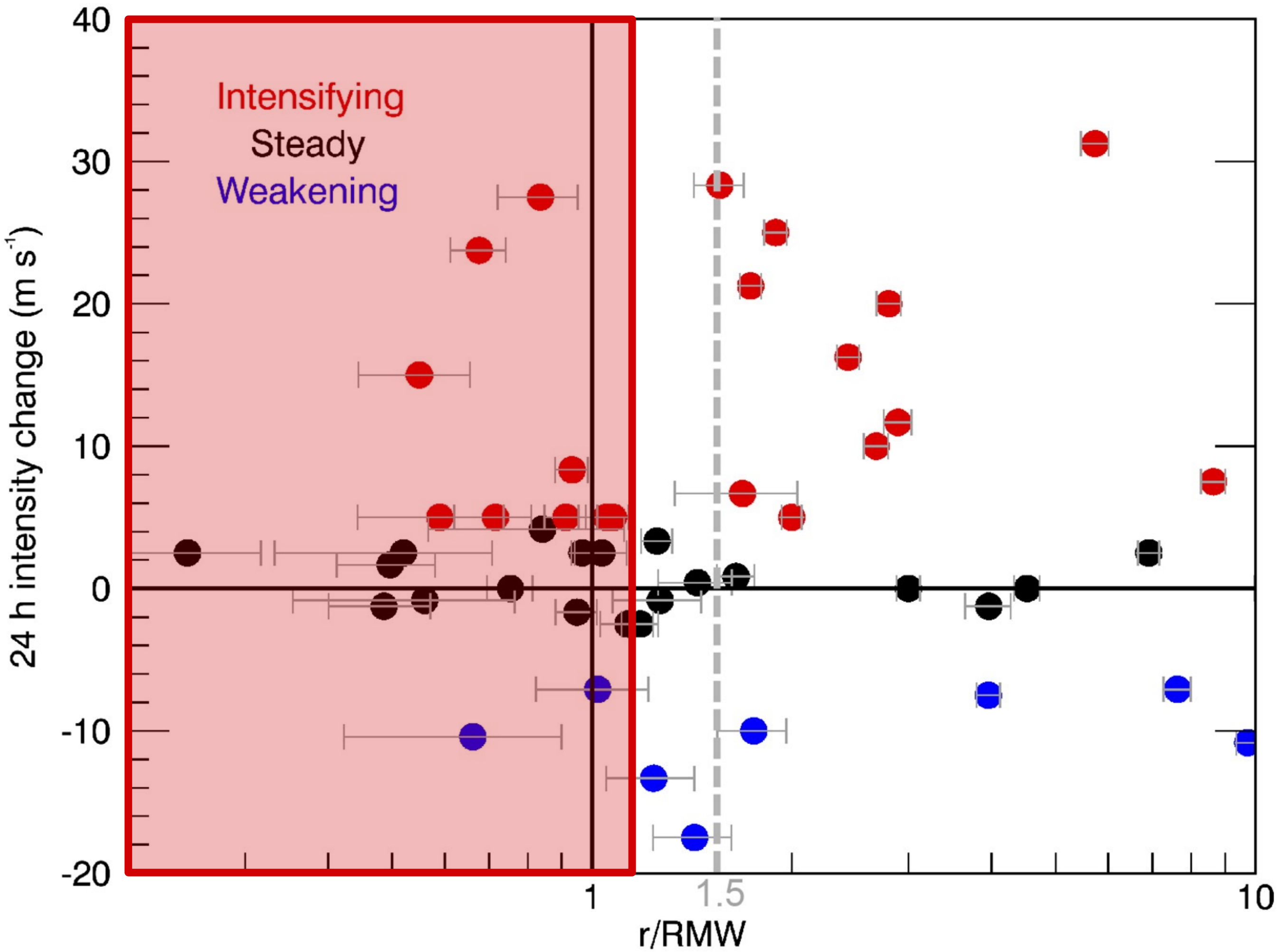
Stevenson et al. (2015, 2016, 2018)

Lightning in TCs: Inside the RMW is key!



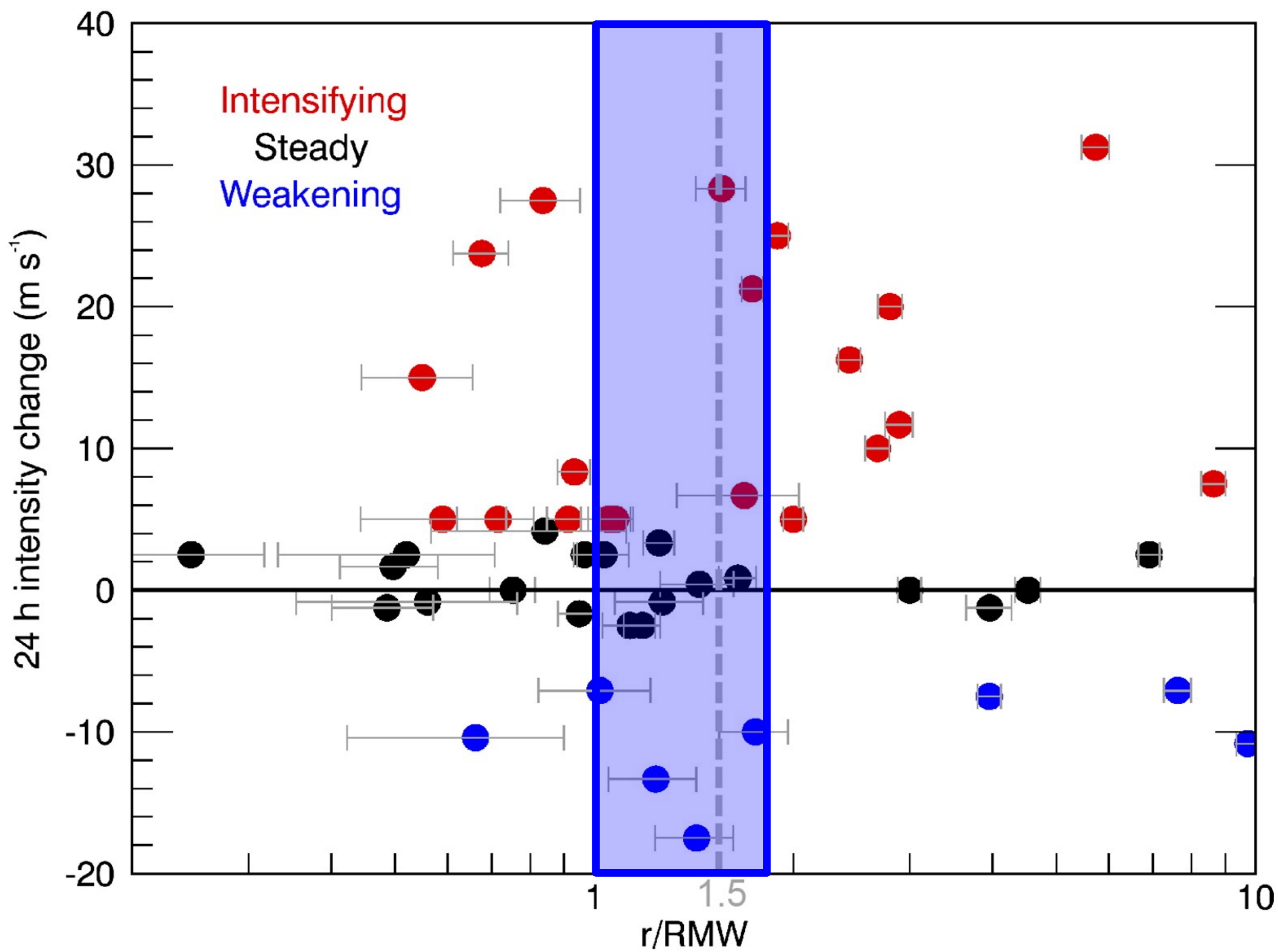
Stevenson et al. (2015, 2016, 2018)

Lightning in TCs: Inside the RMW is key!



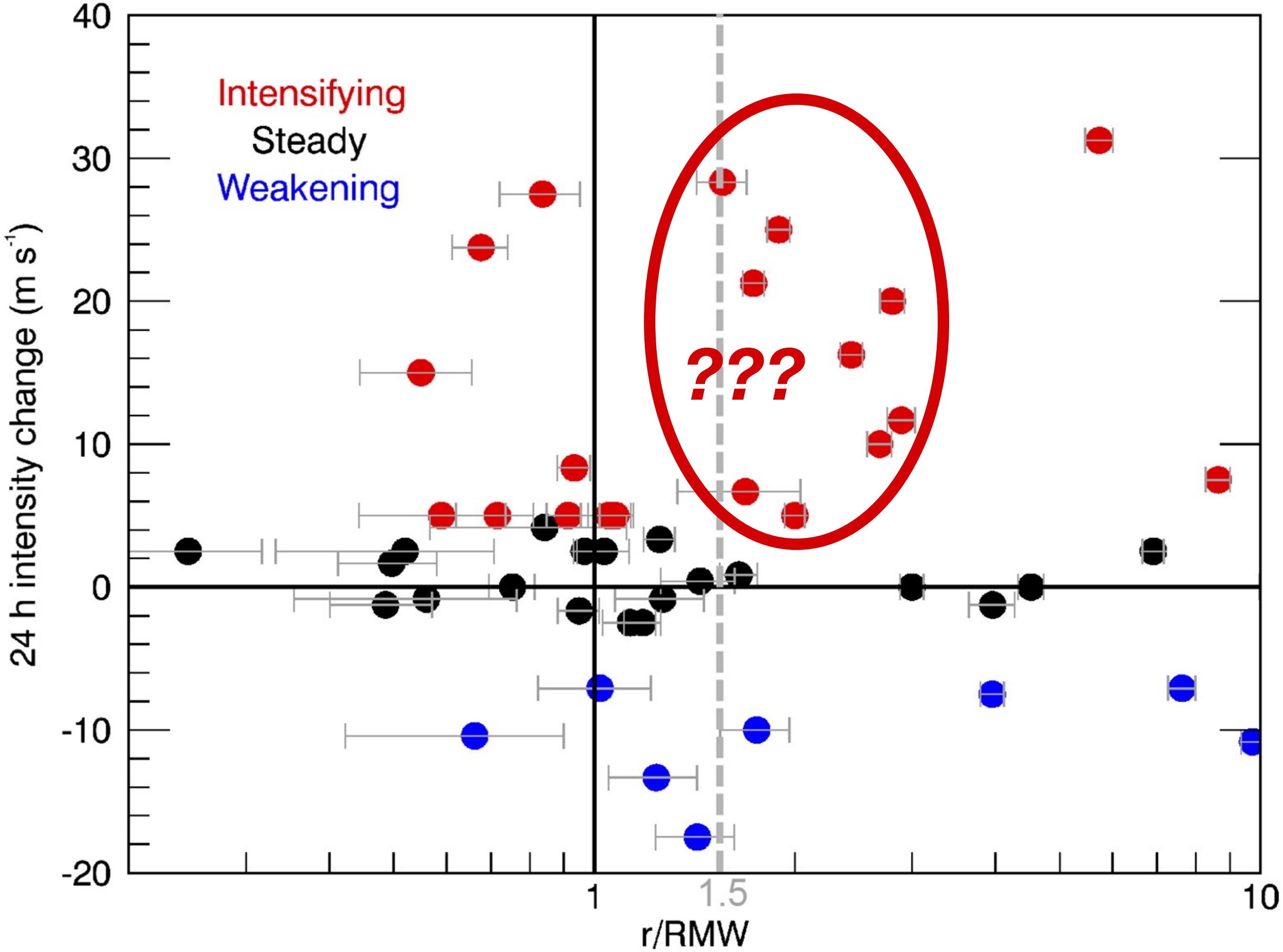
Stevenson et al. (2015, 2016, 2018)

Lightning in TCs: Inside the RMW is key!



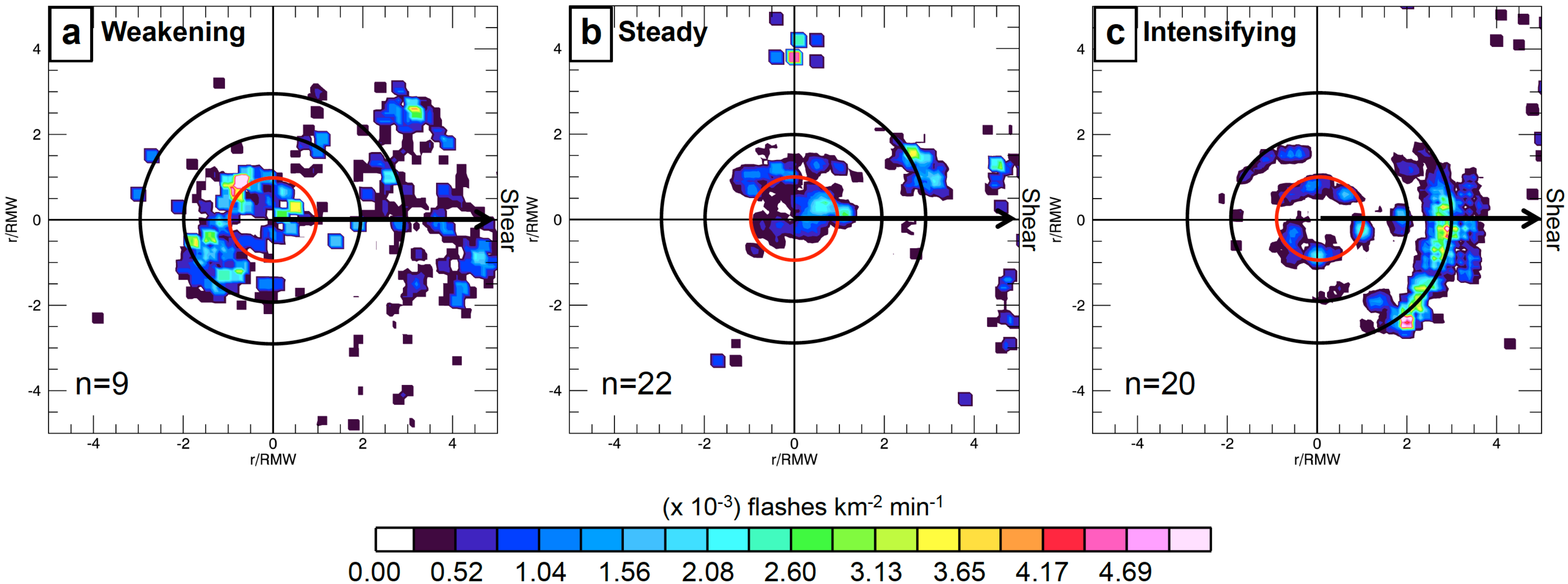
Stevenson et al. (2015, 2016, 2018)

Lightning in TCs: Inside the RMW is key!



Stevenson et al. (2015, 2016, 2018)

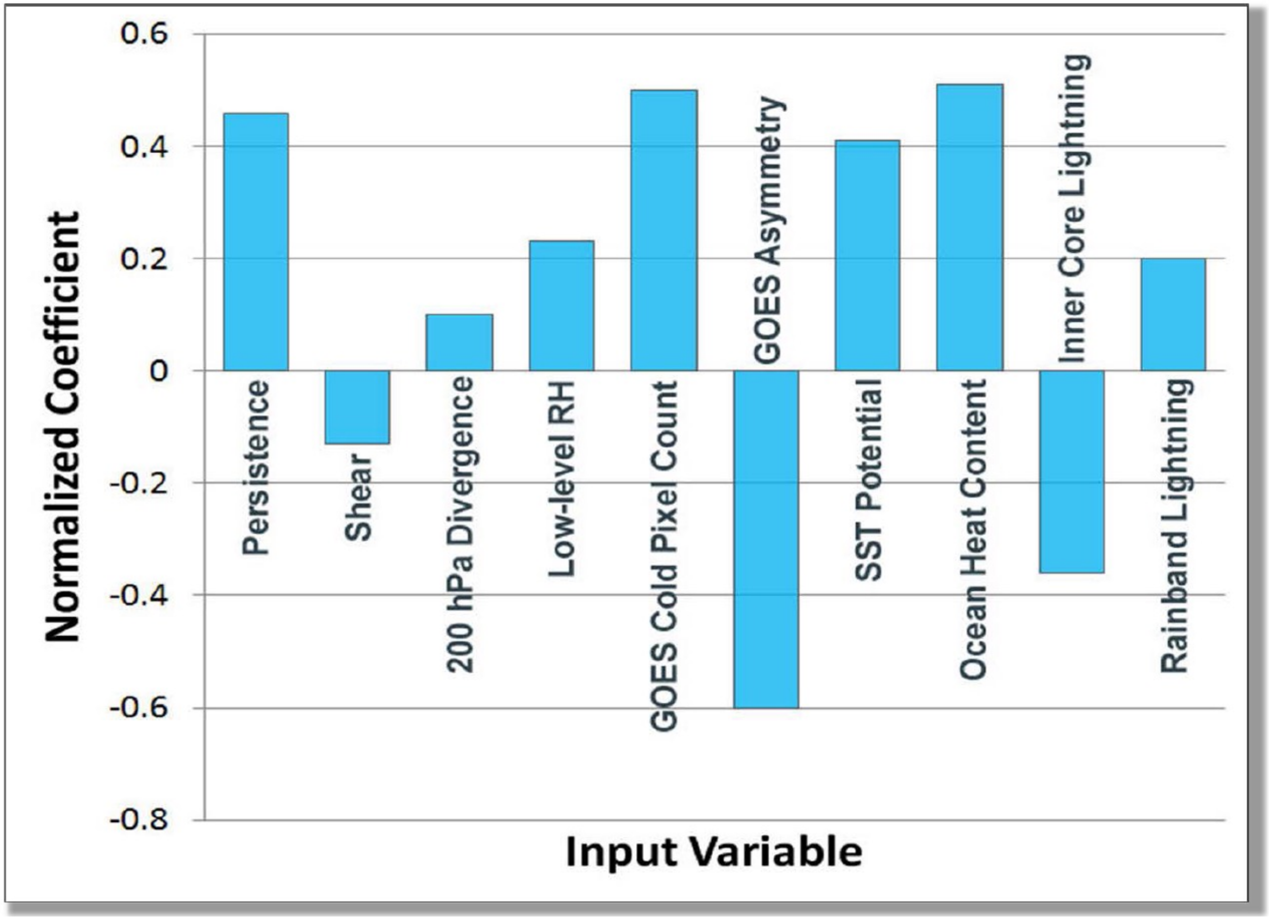
Lightning in TCs: Inside the RMW and in the rainbands!



Stevenson et al. (2015, 2016, 2018)

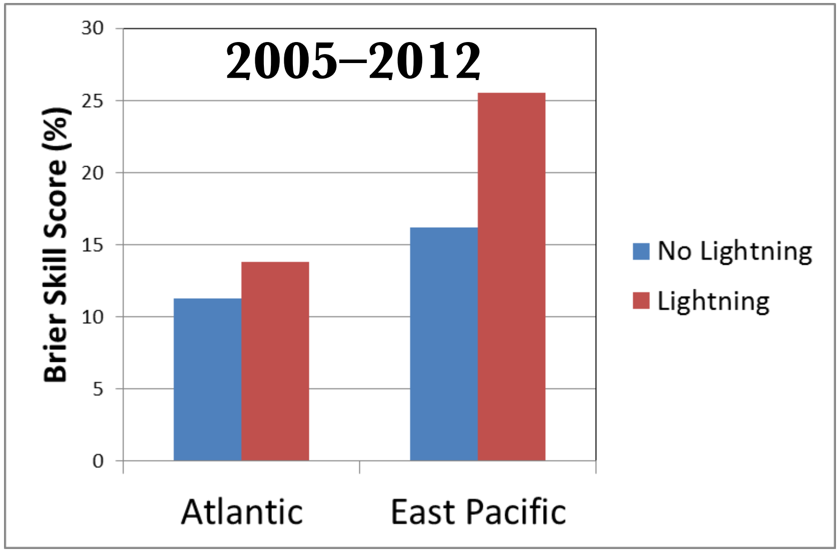
The RII:
Lightning predictors have an impact

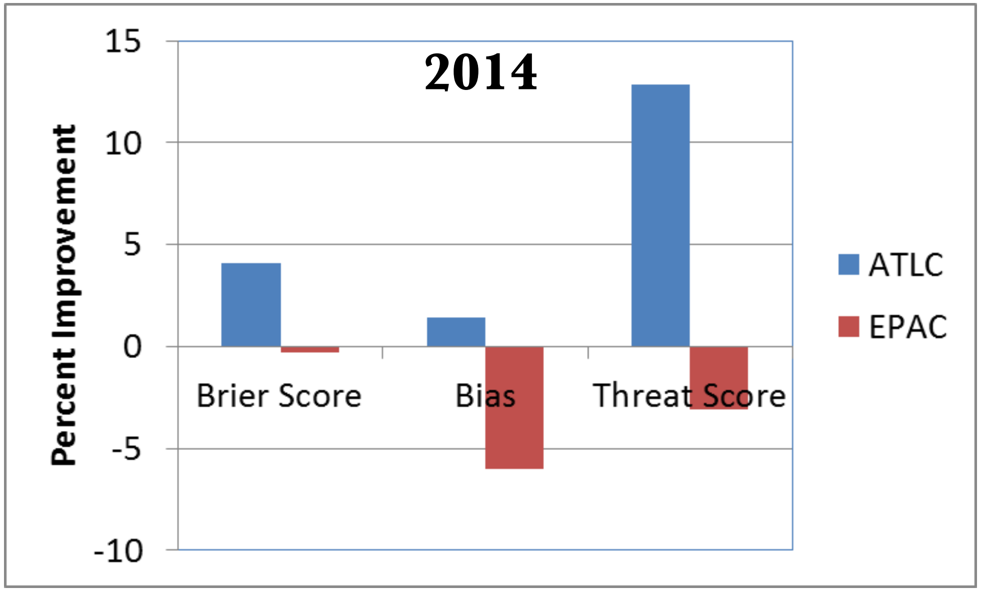
Normalized Discriminant Weights
(Atlantic RII Algorithm)



DeMaria (2012)

The RII: Lightning predictors have an impact



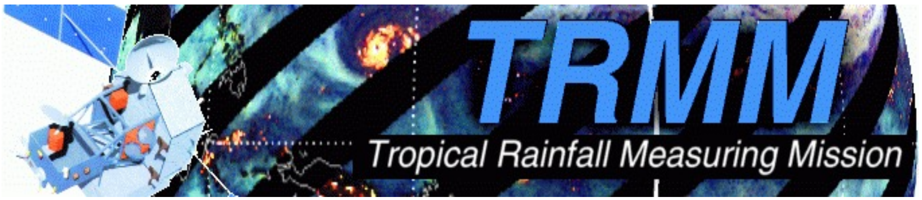


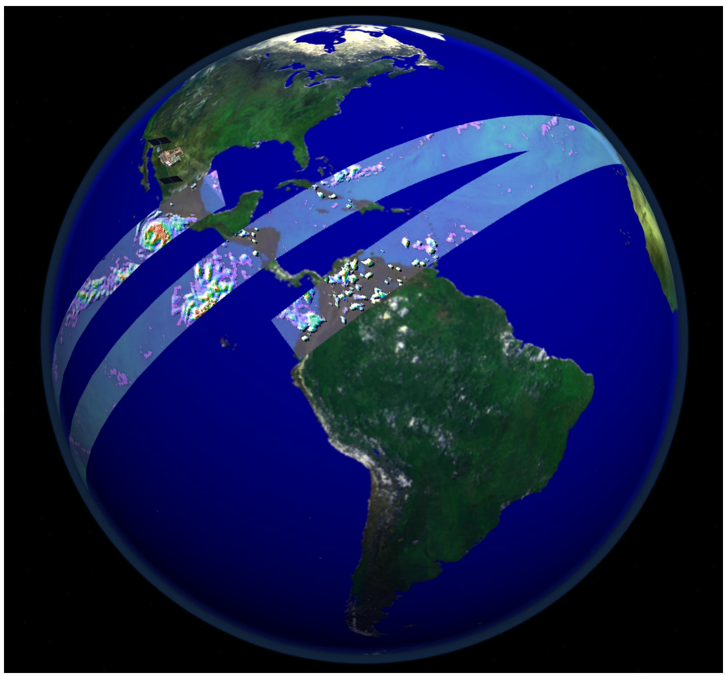
DeMaria (2013)
Schumacher and DeMaria (2015)

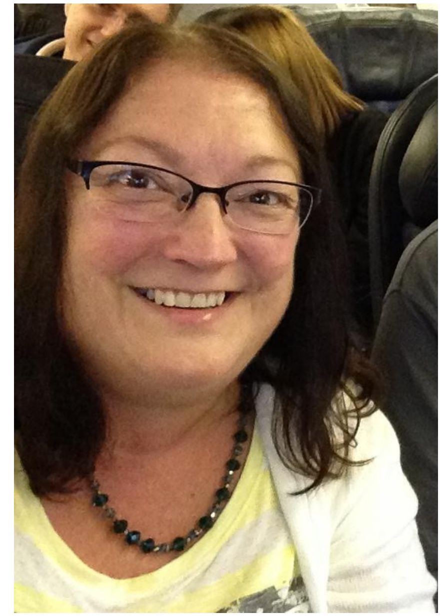
Improvements to RII:
No lightning parameters (yet!) ☹

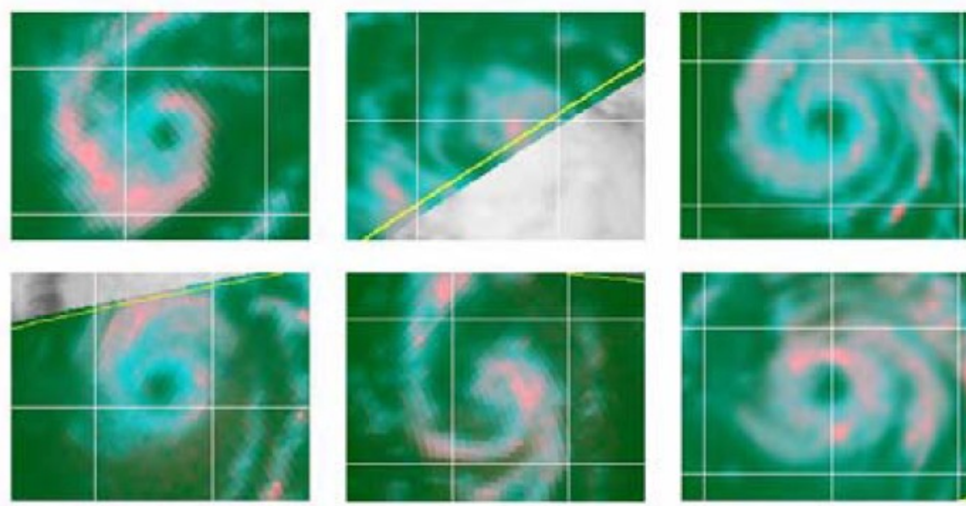
```
*                  GFS version                     *
* ATLANTIC     2021 SHIPS INTENSITY FORECAST       *
* IR SAT DATA AVAILABLE,       OHC AVAILABLE       *
*  IAN          AL092022  09/26/22  00 UTC         *

    ** 2021 ATLANTIC RI INDEX AL092022 IAN        09/26/22  00 UTC **
(SHIPS-RII PREDICTOR TABLE for 30 KT OR MORE MAXIMUM WIND INCREASE IN NEXT 24-h)

    Predictor                   Value   RI Predictor Range  Scaled Value(0-1) % Contributior
12 HR PERSISTENCE (KT)      :    5.0    -49.5  to   33.0       0.66           13.8
850-200 MB SHEAR (KT)       :    2.4     30.1  to    2.3       1.00            9.7
HEAT CONTENT (KJ/CM2)       :   72.4      0.0  to  151.8       0.48            4.2
STD DEV OF IR BR TEMP       :    9.7     36.6  to    2.8       0.80            7.9
MAXIMUM WIND (KT)           :   50.0     22.5  to  137.5       0.72            5.7
BL DRY-AIR FLUX (W/M2)      :   98.6    895.4  to  -55.0       0.84            6.7
2nd PC OF IR BR TEMP        :    0.4      2.9  to   -2.9       0.43            2.5
POT = MPI-VMAX (KT)         :  117.4     28.3  to  146.3       0.76            2.8
D200 (10**7s-1)             :   88.8    -29.7  to  185.9       0.55            1.9
%area of TPW <45 mm upshear :    0.0    100.0  to    0.0       1.00            0.8

SHIPS Prob RI for 20kt/ 12hr RI threshold=  18% is   3.7 times climatological mean ( 4.9%)
SHIPS Prob RI for 25kt/ 24hr RI threshold=  69% is   6.3 times climatological mean (10.9%)
SHIPS Prob RI for 30kt/ 24hr RI threshold=  56% is   8.2 times climatological mean ( 6.8%)
SHIPS Prob RI for 35kt/ 24hr RI threshold=  38% is   9.9 times climatological mean ( 3.9%)
SHIPS Prob RI for 40kt/ 24hr RI threshold=  31% is  12.8 times climatological mean ( 2.4%)
SHIPS Prob RI for 45kt/ 36hr RI threshold=  74% is  16.1 times climatological mean ( 4.6%)
SHIPS Prob RI for 55kt/ 48hr RI threshold=  67% is  14.2 times climatological mean ( 4.7%)
SHIPS Prob RI for 65kt/ 72hr RI threshold=  32% is   6.1 times climatological mean ( 5.3%)

Matrix of RI probabilities
------------------------------------------------------------------------------
  RI (kt / h)   | 20/12 | 25/24 | 30/24 | 35/24 | 40/24 | 45/36 | 55/48  |65/72
------------------------------------------------------------------------------
   SHIPS-RII:     18.3%   68.7%   56.0%   38.4%   30.7%   74.3%   66.8%   32.1%
```

Rapid intensity forecasting: Microwave data



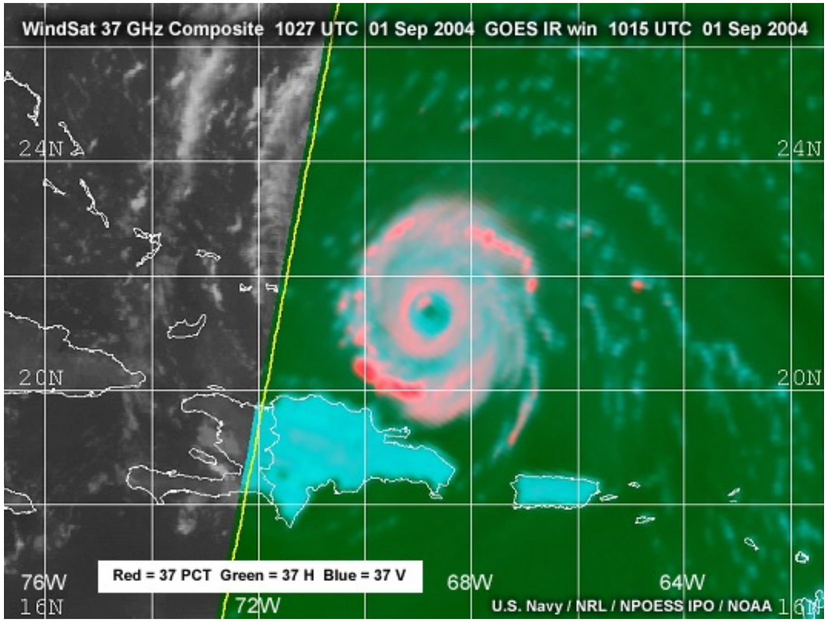






Kieper (2008)

Rapid intensity forecasting: Microwave data



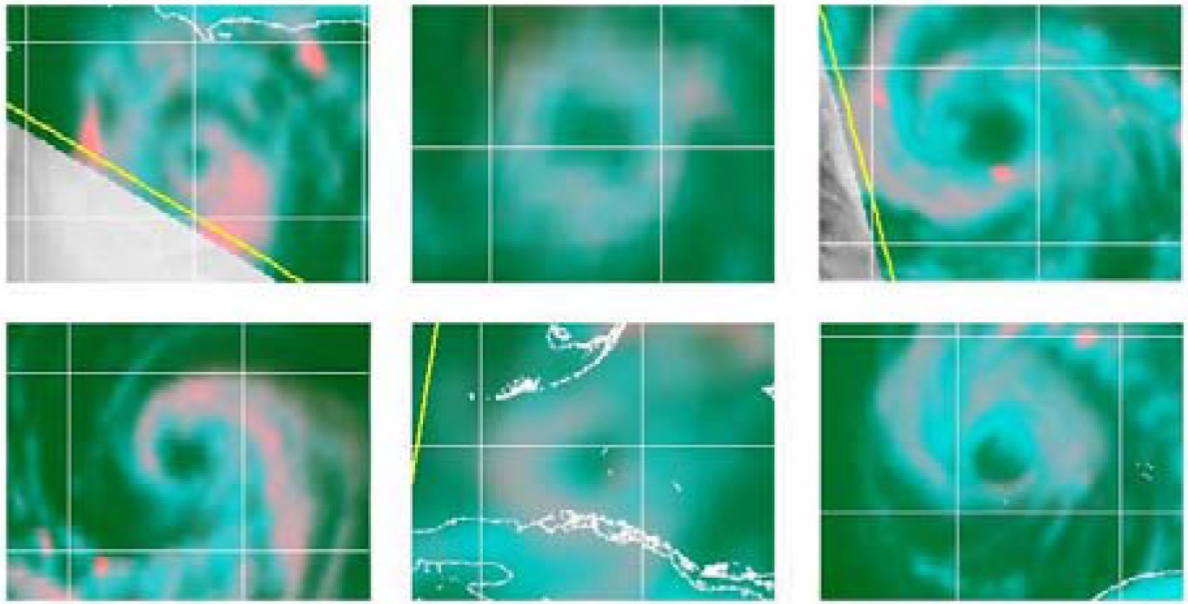
<u>NRL-developed 37-GHz color composite</u>

Polarization correction temperature (*PCT*)
of the vertical and horizontal 37-GHz channels

Warm ocean (green), cold ice (pink),
shallow clouds (cyan)

Lee et al. (2002); Kieper and Jiang 2012

Rapid intensity forecasting: Improvements using microwave data



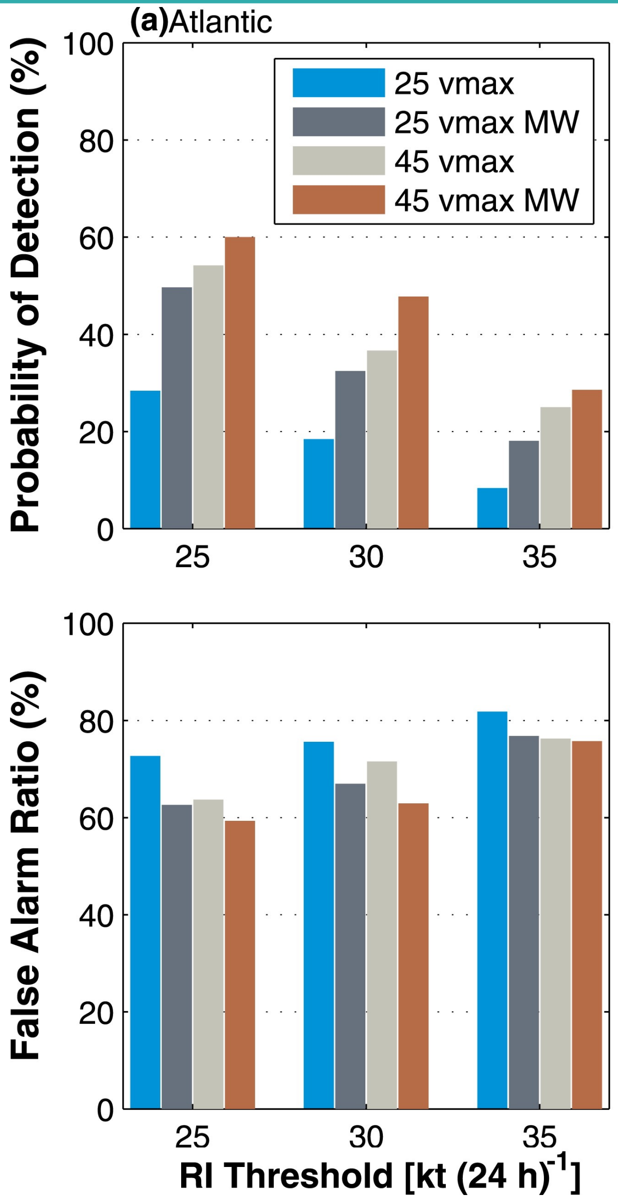
37-GHz ring **is a *good predictor* of *RI* when the *environment* is *favorable* (SHIPS)**

82% of *RI cases* have a *ring* at, or before, the start of RI

Ring **is *precipitative*, mainly *shallow convection***

Kieper and Jiang 2012; Tao and Jiang (2015)

RI model with microwave predictors: Still 💩 forecasts, but better with MW



Rozoff et al. (2015)