New Tropical Cyclone Intensity Forecast Tools for the Western North Pacific

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Operational Statistical-Dynamical Intensity Guidance Products

- West Pacific
  - *ST10* – 5-day max wind forecasts
    - STIPS model with ensemble of tracks
    - Input from NOGAPS, NCODA ocean analyses
- Atlantic/East Pacific
  - *SHIPS* – 5-day max wind forecasts
    - Input from GFS, Reynolds SST, OHC from satellite altimetry, GOES IR imagery
  - *LGEM* – Similar to SHIPS with more sophisticated prediction equation
  - *Rapid Intensification Index* – 24 hr Probability of $\Delta V \geq 30$kt
  - *Storm type classification algorithm*
    - Tropical, Subtropical, Extra-tropical
  - *Annular hurricane index* – Identifies special class of symmetric storms

Experimental Statistical-Dynamical Atlantic/East Pacific Intensity Guidance

- *Improved Rapid Intensification Index*
  - Version with lightning input (GOES-R3)
    - Being tested in GOES-R proving ground
    - Includes rapid weakening component
  - Version with total precipitable water, additional GOES data, surface flux predictors (JHT, GOES-R3)
- *Secondary eyewall formation index* (JHT)
  - Estimates probability in next 12, 24, 36, 48 hr
- *SHIPS/LGEM Improvements* (HFIP, JHT, GIMPAP)
  - Ensemble with forecasts and tracks from GFS, HWRF, GFDL, COAMPS-TC, additional global models
  - Adjoint version of LGEM for parameter fitting during forecast period and better use of pre-forecast input
    - Can run to 7 days or longer
  - Combining RII with LGEM to improve GOES utilization and RI forecasts

Models Being Transitioned to West Pac

(NOPP, HFIP and Proving Ground Support)

- Logistic Growth Equation Model (LGEM)
- Lightning-based Rapid Intensification Index
- Storm type classification algorithm
  - Testing to begin in 2nd half of 2011 typhoon season from CIRA

Logistic Growth Equation (LGE) Model

$$dV/dt = \kappa V - \beta(V/V_{mpi})^n V$$

(A) (B)

Term A: Growth term, related to shear, structure, etc

Term B: Upper limit on growth as storm approaches its maximum potential intensity (V_{mpi})

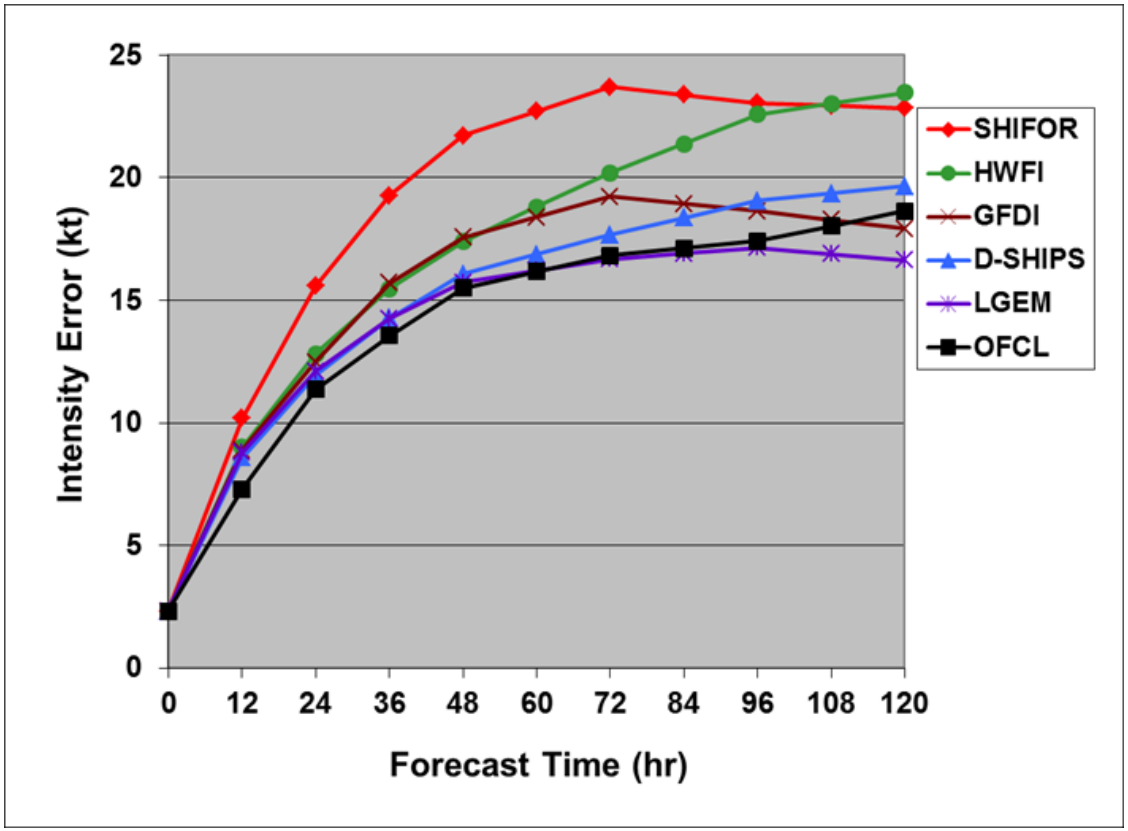
LGEM Parameters:

$\kappa(t)$	Growth rate (from SHIPS parameters)
β	MPI relaxation rate (constant)
$V_{mpi}(t)$	MPI (from SST)
n	"Steepness" parameter (constant)

Input from GFS forecast, SST analyses, GOES, satellite altimetry

Experimental versions with LEO TPW, lightning networks, satellite T,q retrievals

Operational Model Intensity Errors Atlantic 2007-2010



Operational Model Intensity Errors
Atlantic 2007-2010

Modifications for West Pac LGEM and RII

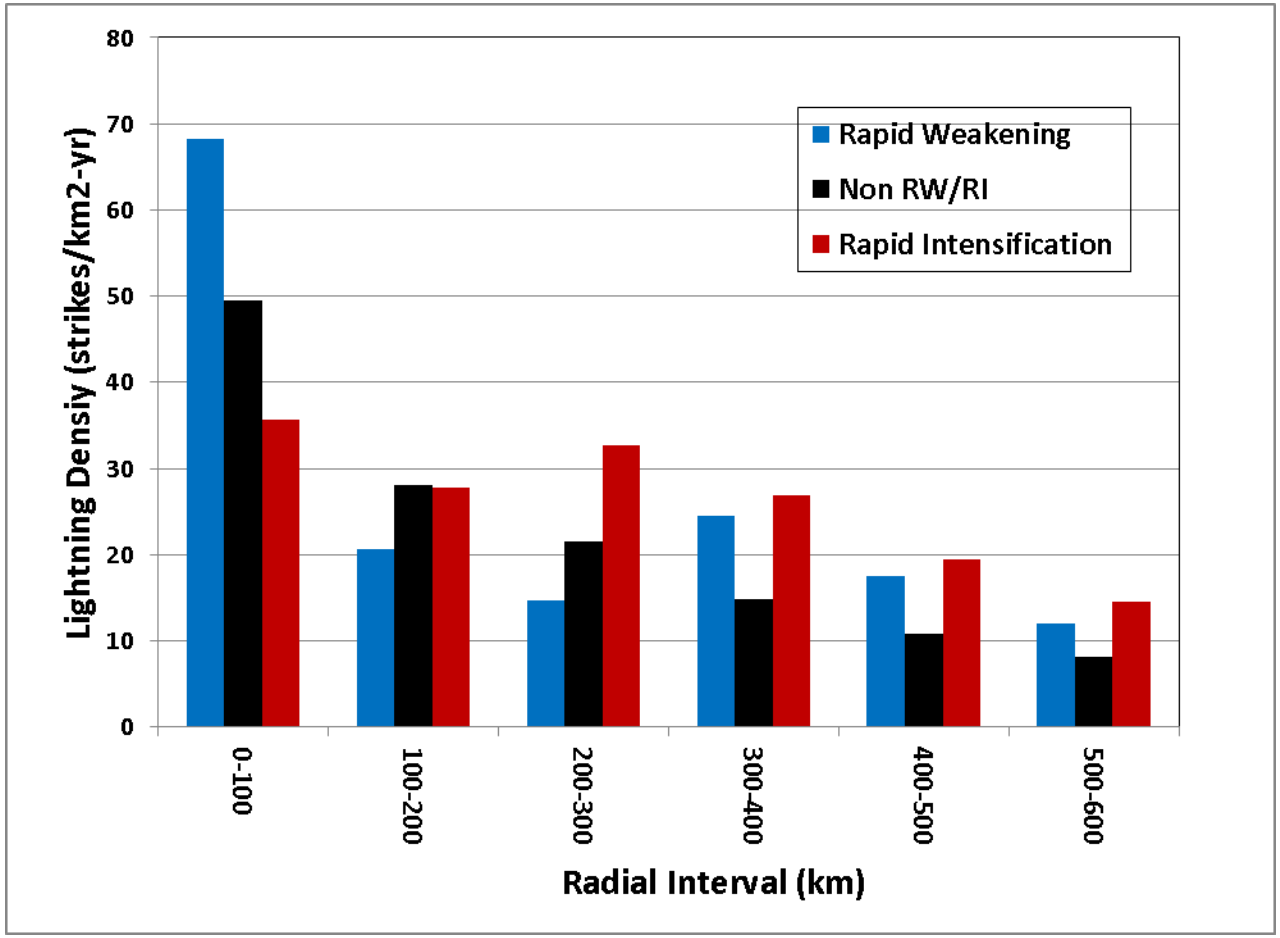
- 2001-2010 Developmental Sample
- Replace GOES input with MT-SAT
- Estimate maximum potential intensity from Bister and Emanuel (1998) instead of empirical formula
  - Improvement over Atlantic/East Pac version
- OHC from NCODA fields instead of satellite altimetry retrievals

Experimental Forecast Algorithm: The Lightning-based Rapid Intensification Index (L-RII)

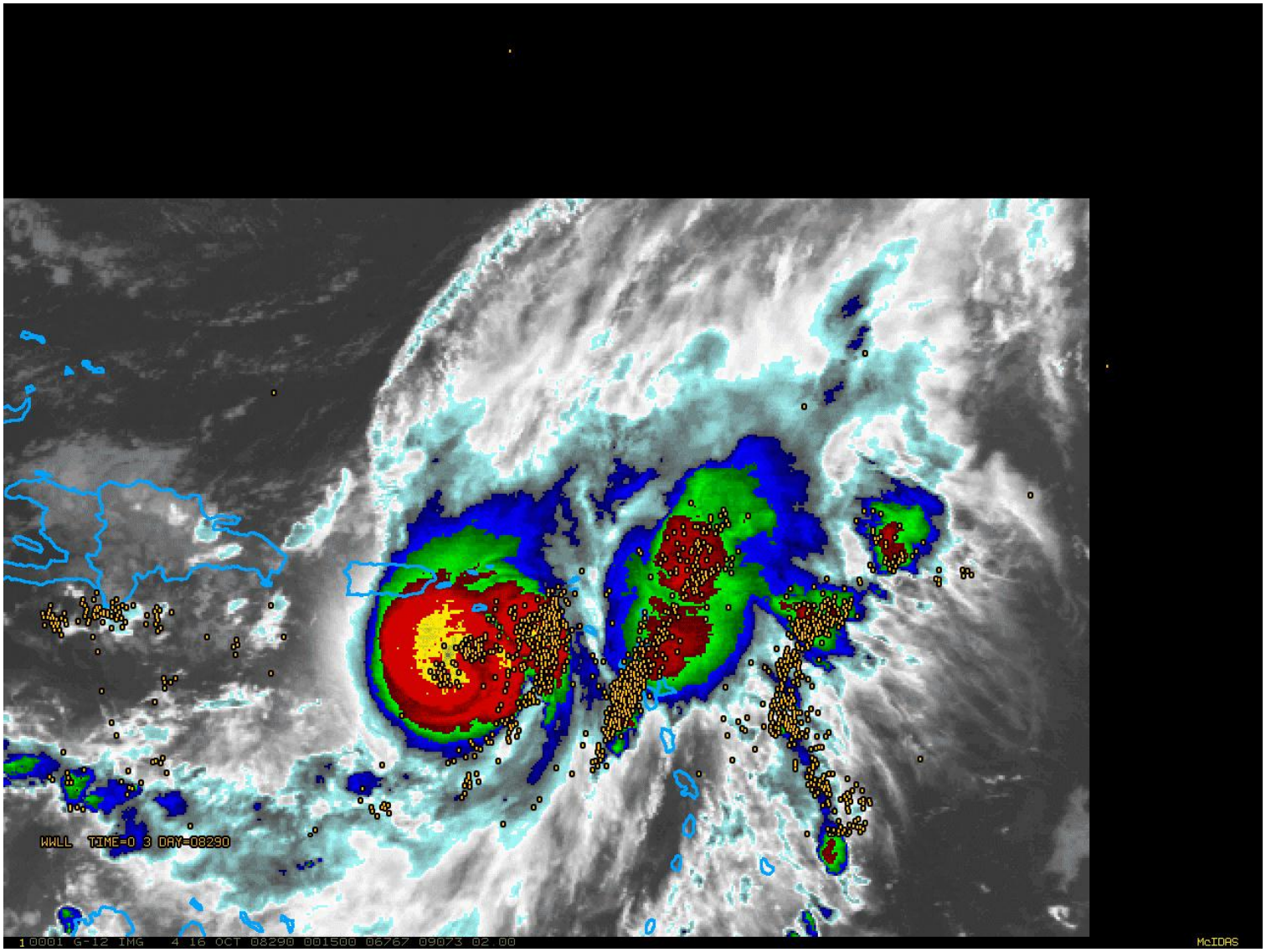
- Linear discriminant analysis
  - Optimally weights multiple inputs to separate data sample into 3 classes
    - Rapid weakening, average intensity change, rapid intensification
- NHC operational RII algorithm includes 8 inputs
  - GFS, Reynolds SST, GOES, satellite altimetry
- Add 2 lightning parameters for L-RII
  - Inner core density (0-100 km)
  - Rainband density (200-00 km)
- Versions with and without lightning from same developmental sample
- Provides probability of RW, RI in the next 24 hr

2005-2010 Atlantic Sample

Lightning Density for RW, Avg, RI Cases



6 hour WWLLN Lightning Strikes
Hurricane Omar 16 Oct 2011



Storm Type Discriminators
(Tropical, Subtropical, Extratropical)

- From blended ocean products
  - SST
- From GFS
  - 150 hPa T*
  - Vertical instability parameter *
  - 700-850 hPa T gradient from thermal wind eqn.*
  - r=500 km symmetric 500 hPa tangential wind
  - r=500 km symmetric 300 hPa tangential wind
  - 850-200 hPa shear
  - 0-500 km average 200 hPa meridional wind
- From NHC advisories
  - Northward component of translational velocity
  - Translational velocity magnitude
- From GOES
  - 50-200 km %GOES pixels colder than -10°C
  - 0-30 km average GOES IR brightness T

***Could be from JPSS ATMS/CrIS Retrievals**

Modified SHIPS Text File

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*   ATLANTIC SHIPS INTENSITY FORECAST      *
*      GOES DATA AVAILABLE                 *
*      OHC  DATA AVAILABLE                 *
*  EARL        AL072010  09/01/10  12 UTC  *
```

TIME (HR)	0	6	12	18	24	36	48	60	72	84	96	108	120
V (KT) NO LAND	110	109	110	107	108	105	97	89	76	62	46	33	18
V (KT) LAND	110	109	110	107	108	105	97	89	68	49	31	30	15
V (KT) LGE mod	110	109	108	108	107	103	95	82	62	44	34	34	35
Storm Type	TROP	TROP	TROP	TROP	TROP	TROP	TROP	TROP	EXTP	EXTP	EXTP	EXTP	EXTP
SHEAR (KT)	16	15	17	17	13	16	24	19	22	43	58	37	17
SHEAR ADJ (KT)	-1	0	0	-2	-1	5	0	7	5	10	2	-1	5
SHEAR DIR	164	175	186	219	190	194	198	191	216	217	183	182	229
SST (C)	29.7	29.8	29.9	29.9	29.7	29.1	27.6	23.7	16.1	18.5	14.2	9.2	10.7
POT. INT. (KT)	166	168	170	169	166	156	135	100	75	79	71	66	66
ADJ. POT. INT.	156	158	157	154	148	139	120	90	71	73	68	65	64
200 MB T (C)	-50.5	-49.9	-50.0	-49.8	-48.9	-49.0	-48.0	-47.4	-46.8	-44.4	-42.7	-42.4	-43.6
TH_E DEV (C)	9	10	10	10	8	8	5	5	1	0	0	0	0
700-500 MB RH	57	53	49	48	53	50	49	55	53	48	39	57	71
GFS VTEX (KT)	33	34	36	31	35	35	36	38	36	36	33	30	23
850 MB ENV VOR	83	101	78	53	54	16	8	46	130	204	282	318	223
200 MB DIV	91	76	34	10	37	19	51	77	70	110	76	92	68
700-850 TADV	26	29	36	28	17	9	-6	56	-17	50	-47	-19	26
LAND (KM)	521	612	633	597	555	272	233	193	-21	145	-141	72	314
LAT (DEG N)	24.5	25.8	27.1	28.5	29.8	32.8	36.3	40.0	43.8	47.8	51.9	55.4	58.3
LONG(DEG W)	71.6	72.7	73.7	74.3	74.8	74.8	73.2	69.9	65.7	62.4	60.4	58.6	56.8
STM SPEED (KT)	15	16	15	14	14	17	20	24	24	22	20	17	15
HEAT CONTENT	71	65	52	48	39	38	0	0	0	0	0	0	0

Summary and Future Plans

- West Pac versions of LGEM, RII and Storm Type classification under development
  - Experimental real time runs from CIRA starting Sept 1st
  - Possible candidates for transition to JTWC through NRL
- Improvements also possible from JPSS
  - Temperature/moisture soundings in storm environment from ATMS/CrIS
    - Input to Emanuel MPI to improve LGEM
    - Improved vertical instability predictors in LGEM, RII