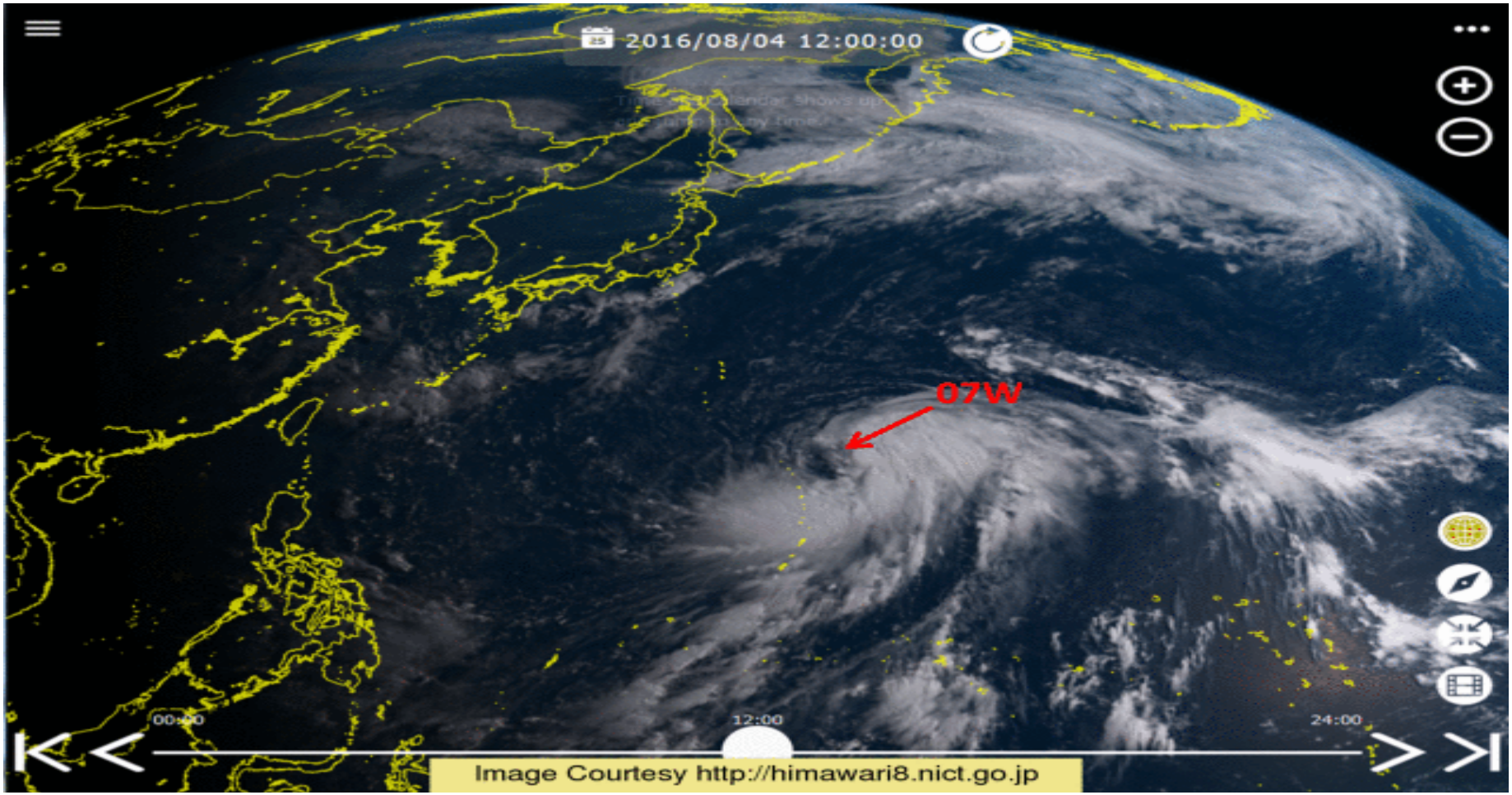
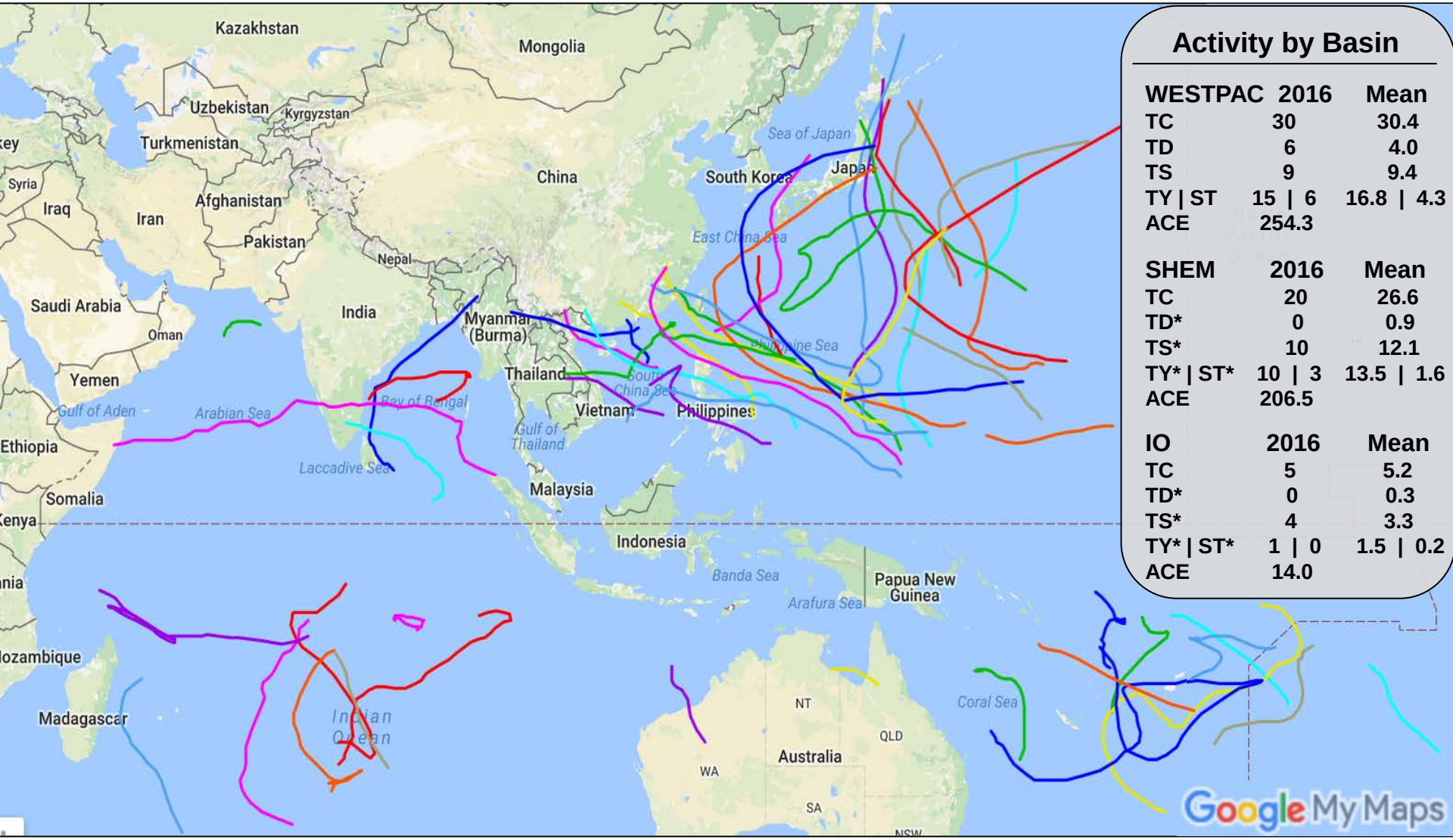
Joint Typhoon Warning Center



CDR Jillene M. Bushnell
Commander, Joint Typhoon Warning Center
Tropical Cyclone Operations and Research Forum (TCORF)

2016 JTWC Warned Tropical Cyclones



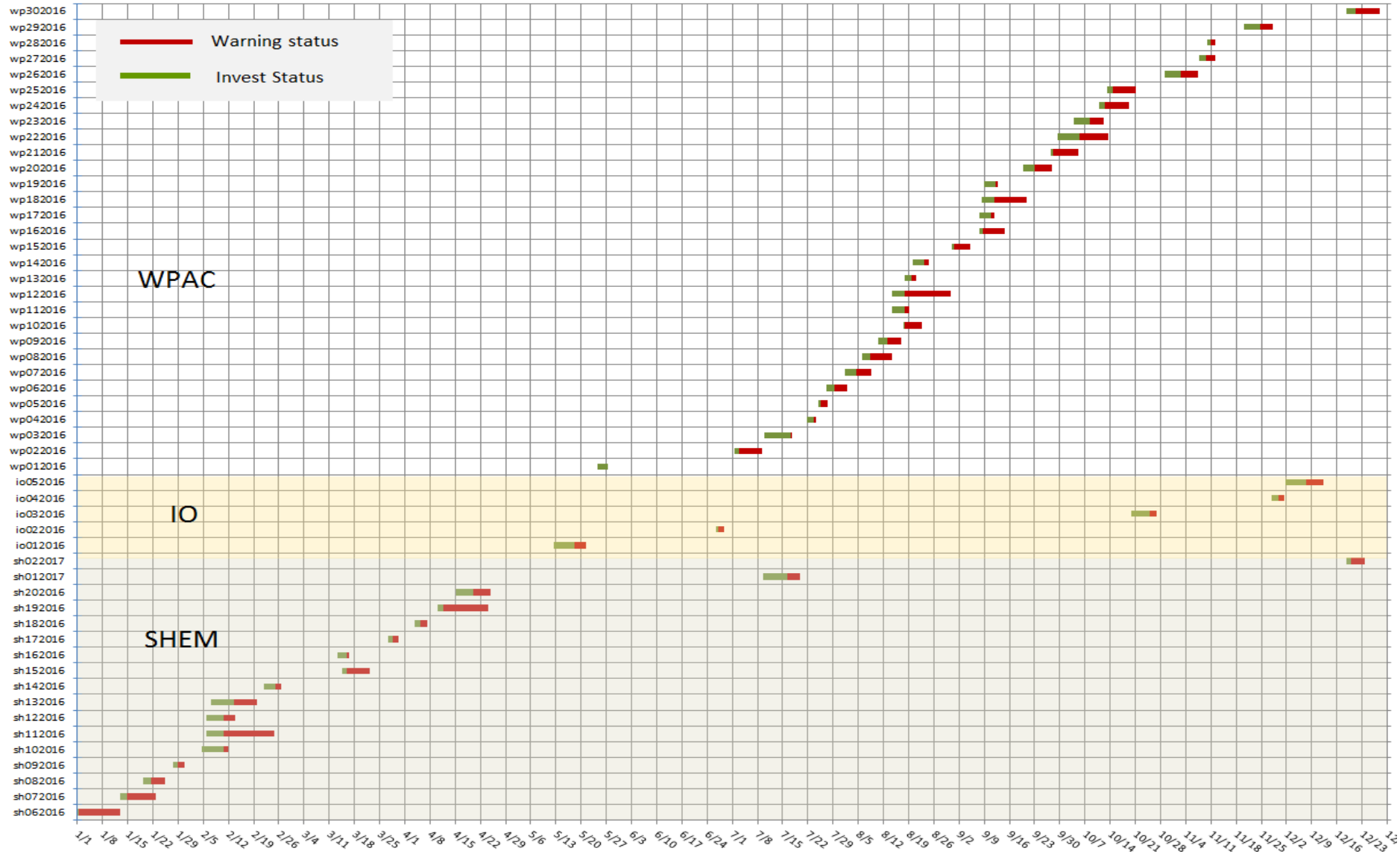
Activity by Basin

WESTPAC	2016	Mean
TC	30	30.4
TD	6	4.0
TS	9	9.4
TY | ST	15 | 6	16.8 | 4.3
ACE	254.3	

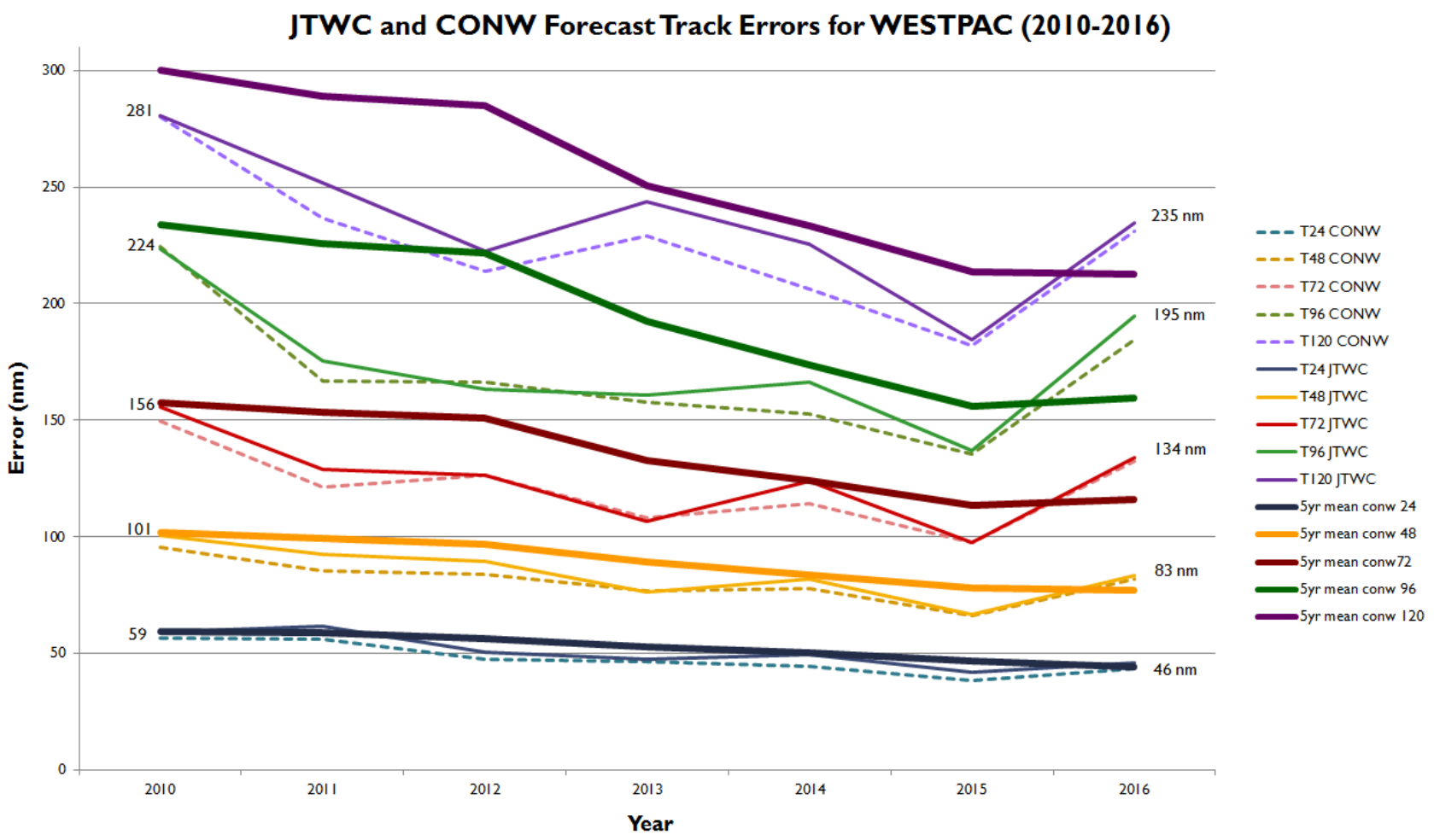
SHEM	2016	Mean
TC	20	26.6
TD*	0	0.9
TS*	10	12.1
TY* | ST*	10 | 3	13.5 | 1.6
ACE	206.5	

IO	2016	Mean
TC	5	5.2
TD*	0	0.3
TS*	4	3.3
TY* | ST*	1 | 0	1.5 | 0.2
ACE	14.0	

2016 JTWC Tropical Cyclone Timeline

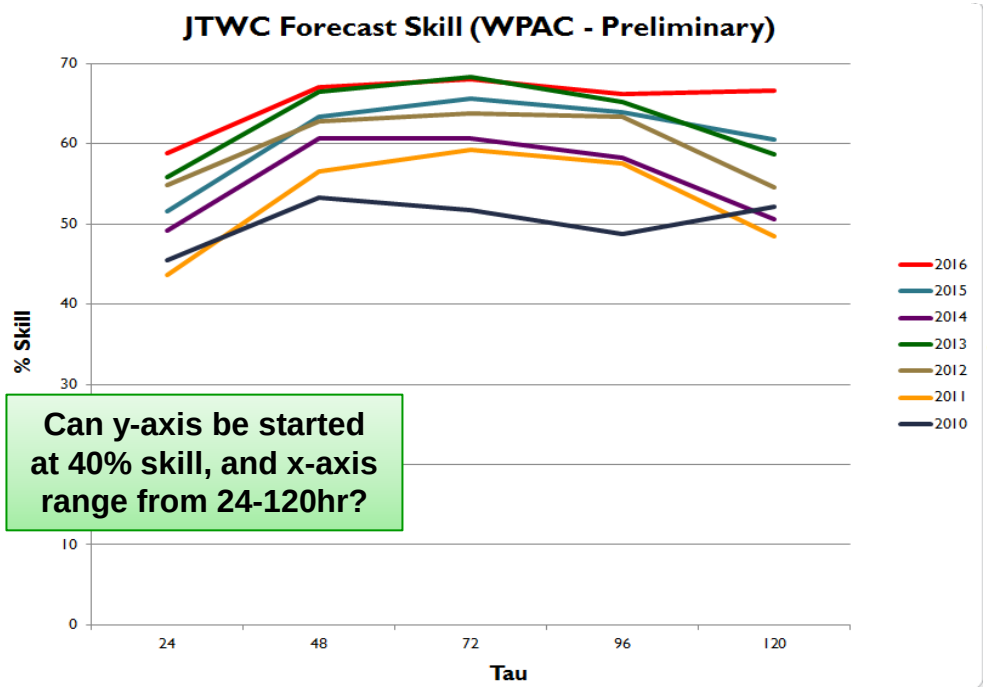


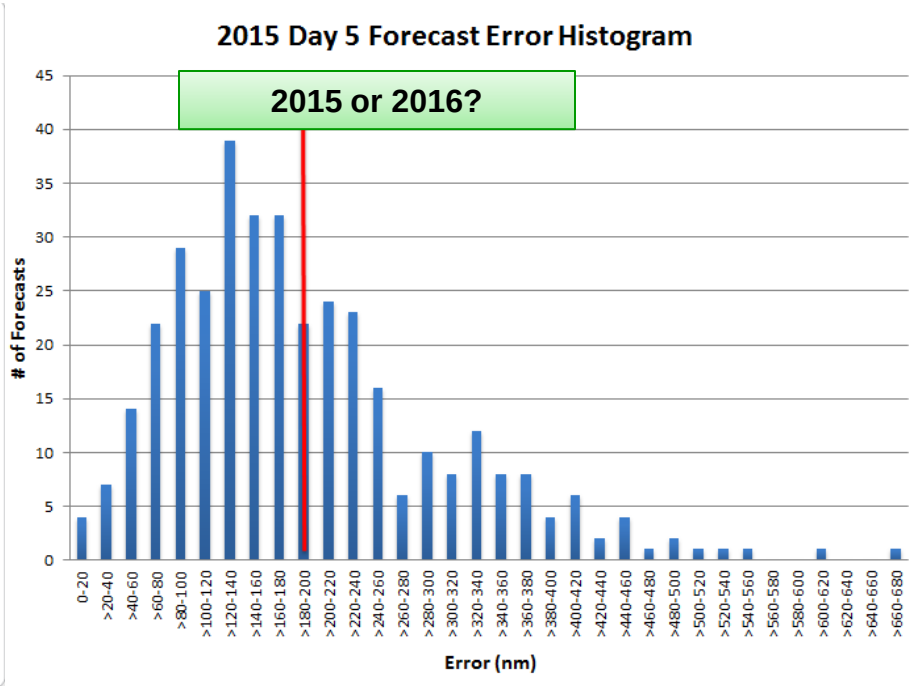
2016 JTWC and CONW Forecast Track Errors (*Preliminary)



- **2015 was a record, so 2016 appears worse … let's take a close look.**

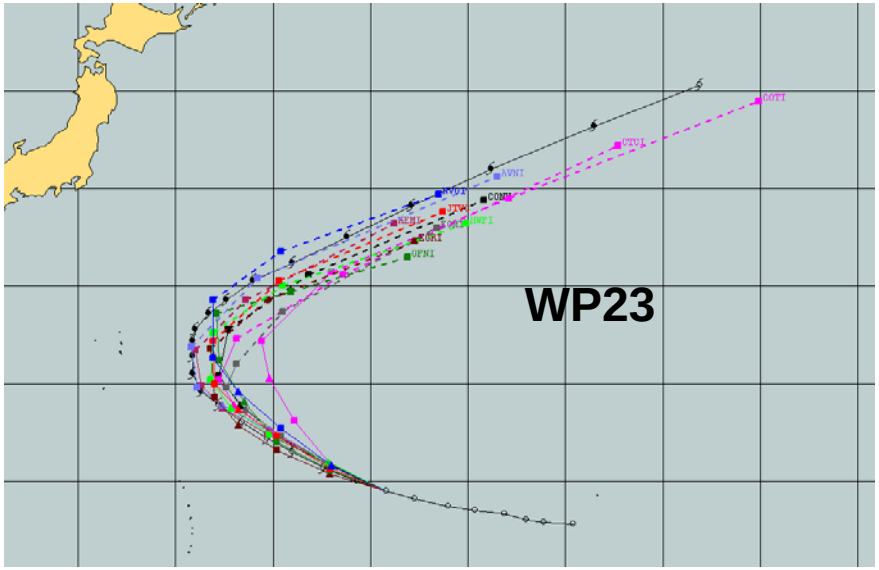
2016 JTWC and CONW Forecast Track Errors (*Preliminary), Cont'd



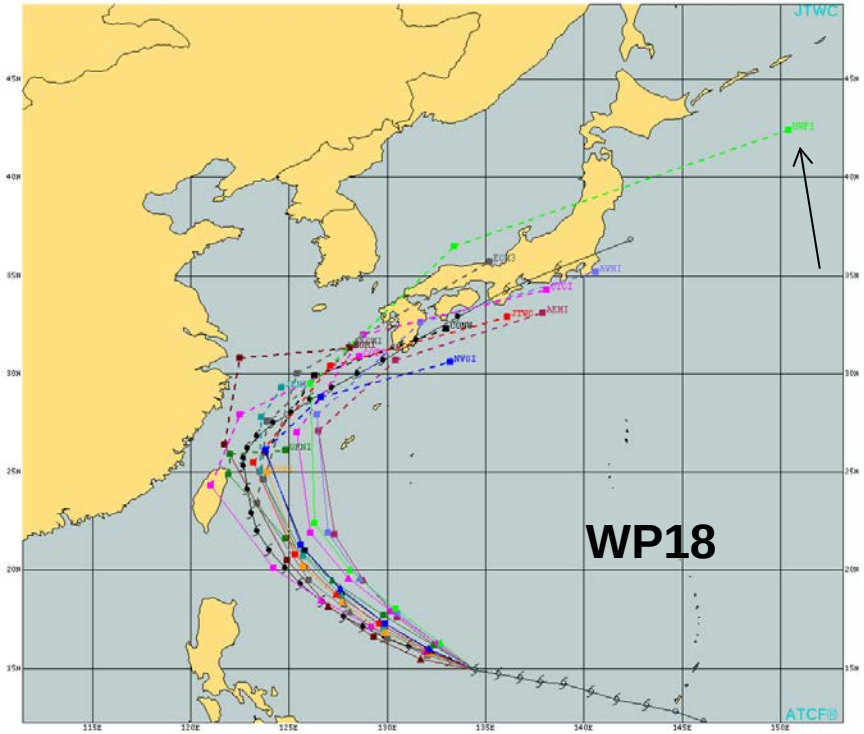


- CLIPR error indicates significantly more difficult storms to forecast
- 5-day CLIPR error increased 51% over 2015, JTWC error increased 27%
- Error distribution was flat (fewer big busts)
- Analysis capabilities negatively impacted by loss of RSCAT and F19

2016 Largest Forecast Errors

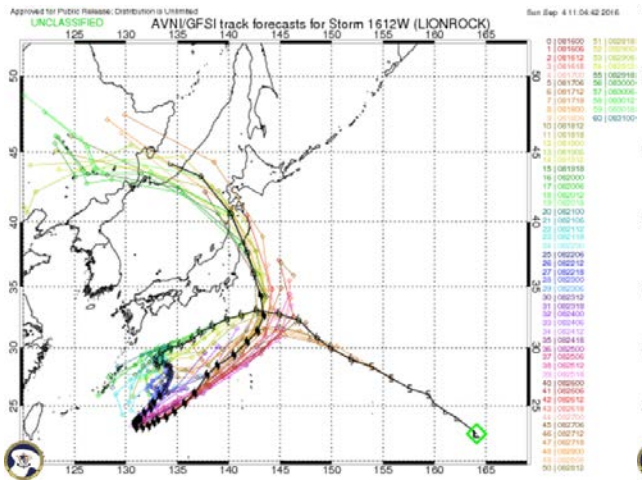


- First warning of WP23
- Good aid agreement – 740nm error was along track
- COAMPS showed faster motion, but higher cross-track error

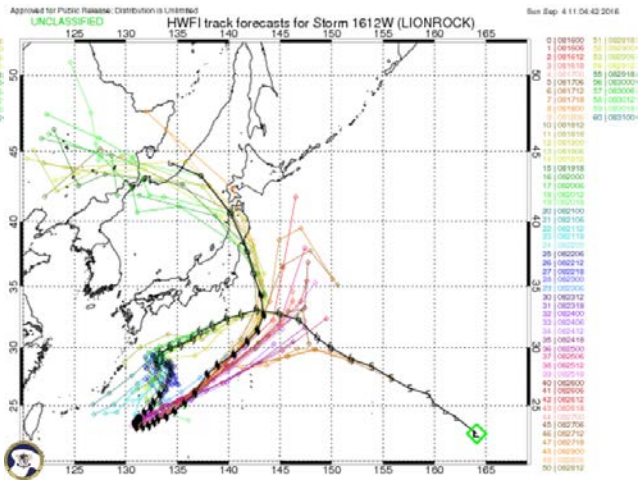


- Four early warnings for WP18
- Again, error mostly along-track
- HWRF was particularly fast

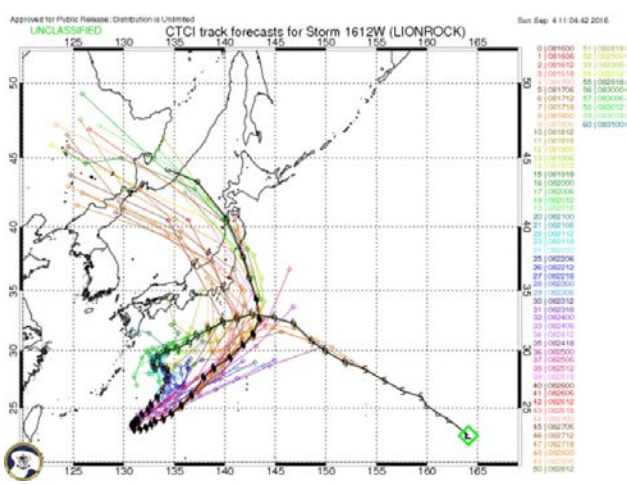
WP 12 - Lionrock



GFS



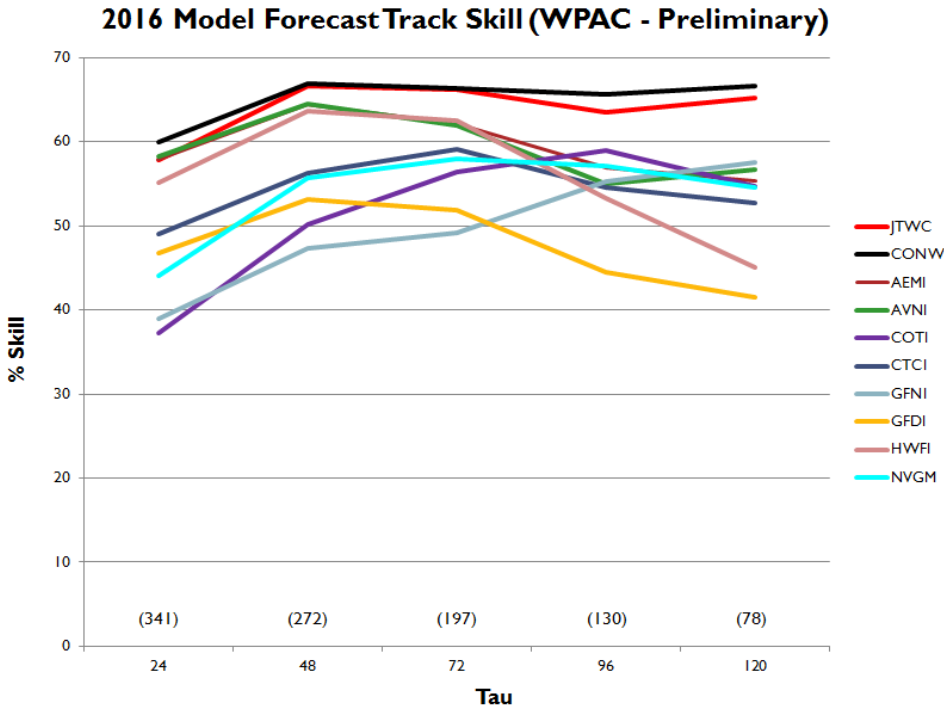
HWRF

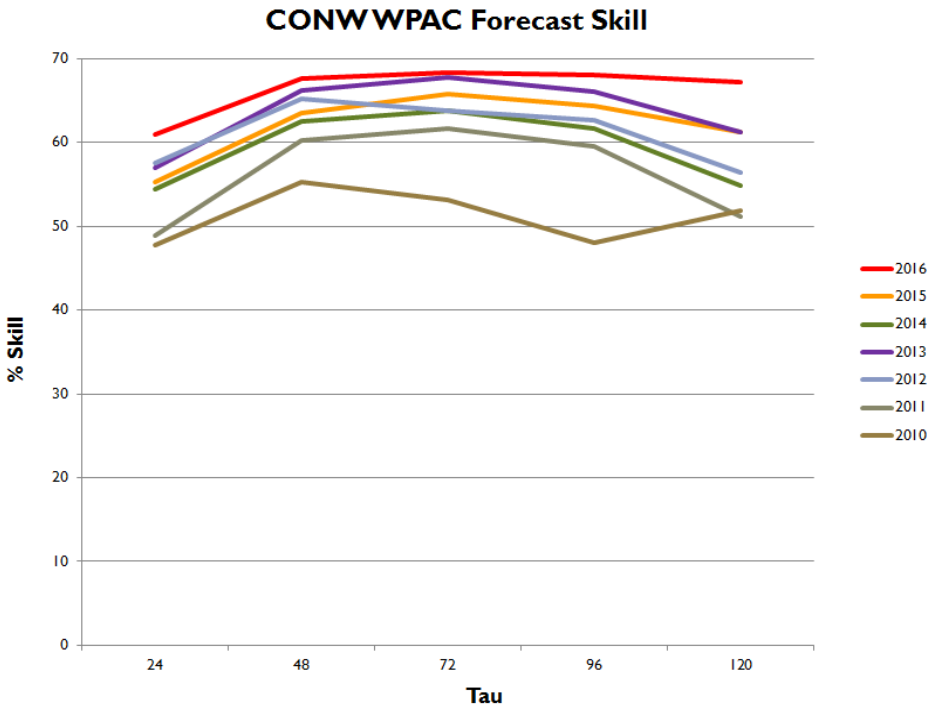


CTCI

- **Despite a very complex track, model guidance was generally very good, particularly after the intensification phase**
- **Five-day mean track errors were only 153nm (CONW) and 192nm (JTWC)**

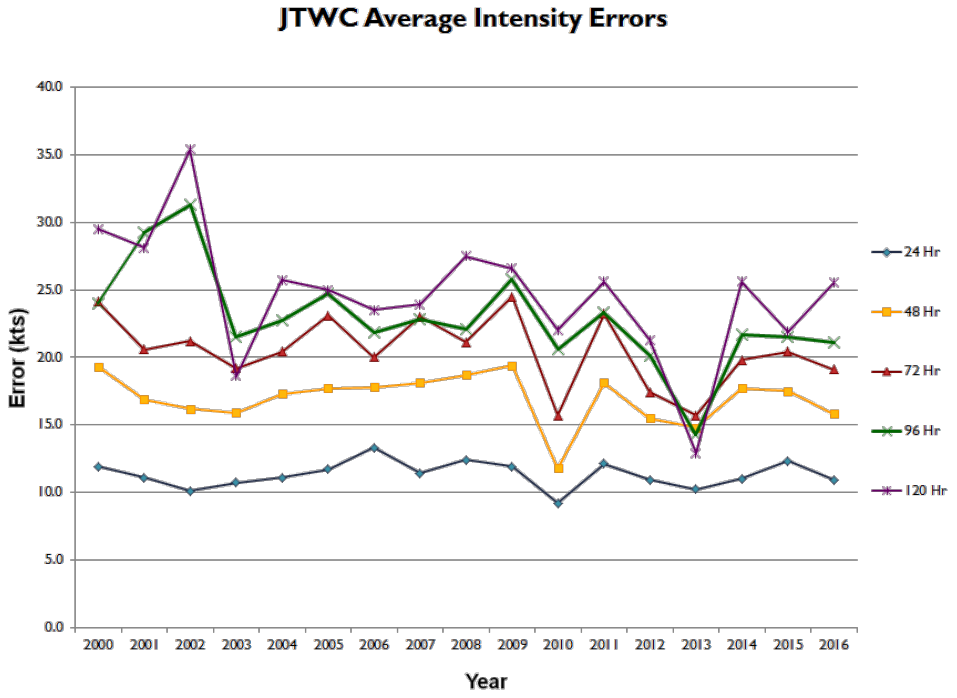
2016 Model Track Forecast Skill





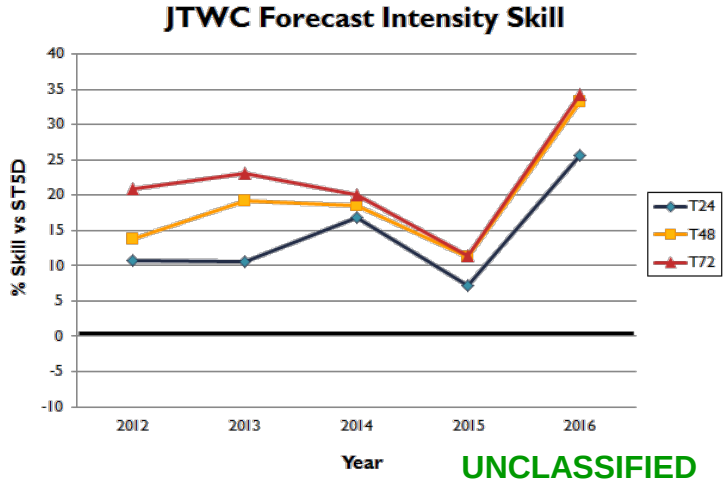
- CONW still beat all members
- ECMWF and UKMET (not shown) on par with GFS through day-3, best members at days 4 & 5
- NVGM-driven COTI and GFDN outperformed GFS counterpart at days 4-5

2016 JTWC Forecast Intensity Error (* Preliminary)



- Mean errors improved over 2015 except day-5
- Despite small mean error improvement, skill was significantly improved over previous 5 years

- TC intensity change, particularly onset and duration of RI still #1 forecast improvement priority
- JHT project to evaluate MI cyan ring as an RI predictor in WPAC in process



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2016 Operational Highlights

Implemented first of its kind TC Wind Radii improvements

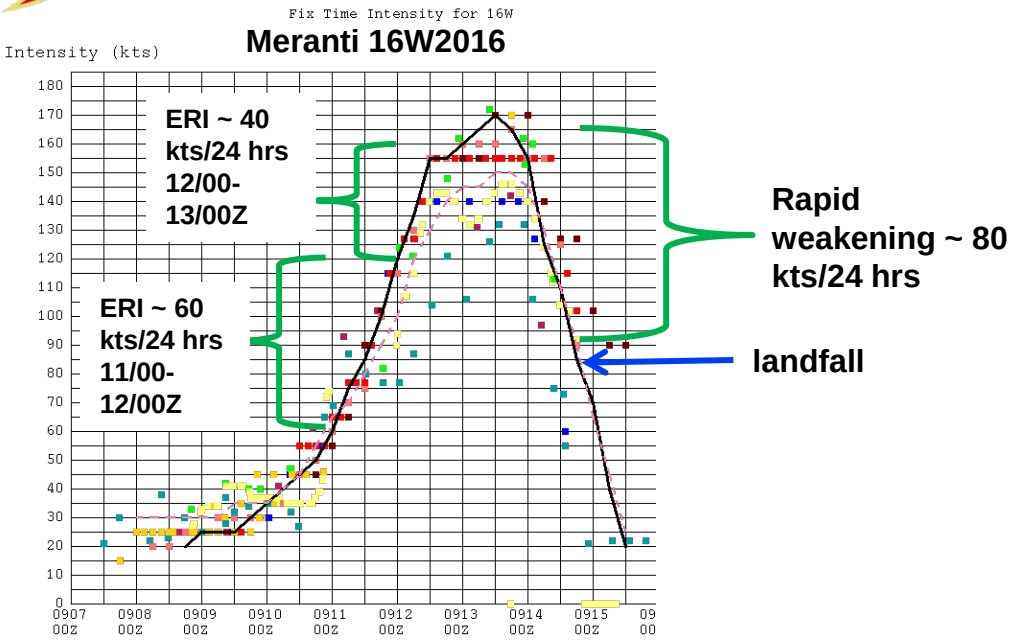
- *2009 PACOM TC forecast goals included "predict the radius of 35 and 50 knot winds within 20% by quadrant through 168 hours"*
- *Specific new capabilities implemented:*
  - ***35, 50 and 65 knot wind radii forecasts extended to days 4 and 5***
  - ***Wind radii forecasts over land***
  - ***Wind radii forecasts on extra-tropical systems***
- *Decreased radii forecast errors by 20%-30%*
- *Enabled improved resource protection decisions and increased operational maneuver space*
- *Funded as FY15/16 UFR's ,already demonstrated significant return on investments in numerical modeling, analysis/forecast techniques, and training*

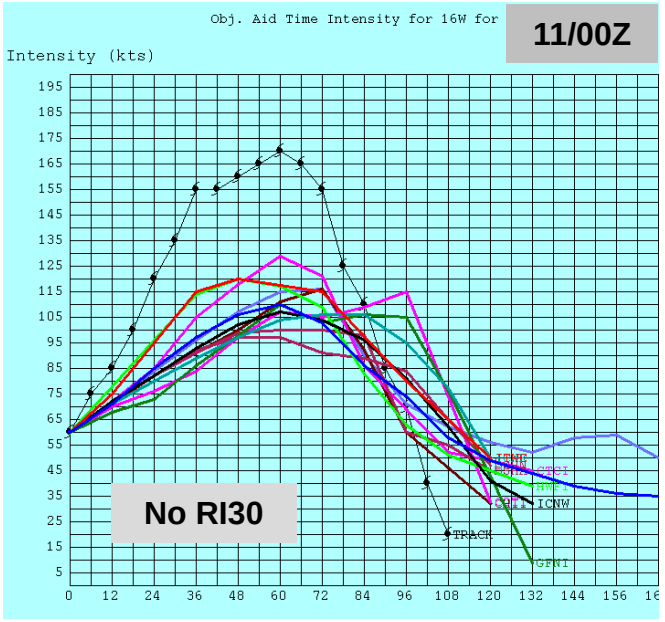
Accomplishments are attributed to the outstanding dedication and consistent superior performance of my team of USN & USAF professionals… none of this is possible without them!

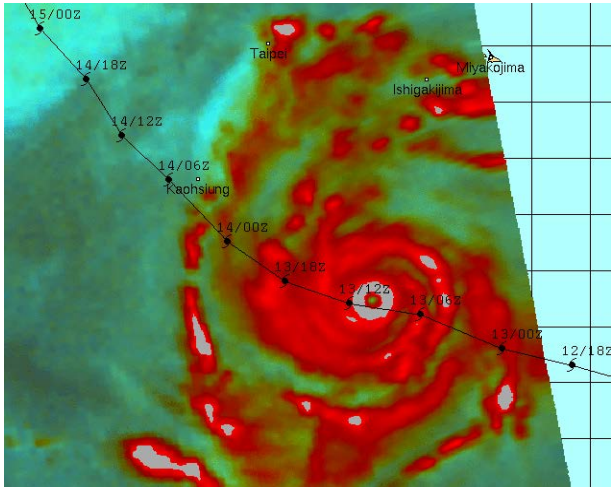
2017 JTWC R&D Needs

Priority	Need
1 TC Intensity Change	***Basin-specific*** **(WESTPAC, SHEM, NIO, SIO, and SWPAC) probabilistic and deterministic** ***forecast guidance for TC intensity change*****,** ***particularly*** **the onset, duration, and magnitude of** ***rapid intensity change*** **events (including ERC, over-water weakening, etc.) at 2-3 day lead times.**
2 TC Structure Specification	***Basin-specific*** **(WESTPAC, SHEM, NIO, SIO, and SWPAC) probabilistic and deterministic guidance for the** ***specification*** **(analysis and forecast)** ***of key TC structure variables*****,** ***including*** **the production of 34-, 50- and 64- knot wind radii and a** ***dynamic*** **(situational) confidence-based** ***swath*** **of potential 34-kt wind impacts**
3 Data Exploitation	**Techniques or products that** ***improve*** **the utility and** ***exploitation of microwave satellite, ocean surface wind vectors, and radar data*** **for fixing (center, intensity, radii) TCs, or for diagnosing RI, ETT, ERC,** ***etc*****. (*****e.g*****., develop a "Dvorak-like" technique using microwave imagery).**
4 TC Track Improvement	**Model enhancements or guidance to** ***improve TC track forecast skill and*** **the** ***conveyance of probabilistic track uncertainty*****. Includes development of guidance-on-guidance to identify and reduce forecast error outliers resulting from large speed (e.g., accelerating recurvers) and directional (e.g., loops) errors, or from specific forecast problems such as upper-level trough interaction, near/over-land, elevated terrain, and extratropical transition.**
5 TC Genesis Timing and Forecast	**Guidance to** ***improve*** **the** ***forecasting of TC genesis timing*** **and the subsequent track, intensity and structure of pre-genesis tropical disturbances at both the short-range (0-48 hours) and the medium-range (48-120 hours), that exhibits a high probability of detection and a low false alarm rate. Techniques to diagnose and predict the formation of TCs via transition of non-classical disturbances (e.g. monsoon depressions, sub-tropical, hybrids, etc).**

Pri 1:TC Intensity Change







As modeling and guidance improves, forecasters are taking more "risks" to forecast-RI, however…

- More guidance tuned to JTWC basins needed, with longer lead times and more ΔI bins
- Models have improved, but still poorly forecast onset, duration, and magnitude of RI and RW
- Eyewall replacement cycle is common in RI systems/super-typhoons, but onset and duration poorly forecast
- All lead to large mean error statistics - Is it time for new metrics?

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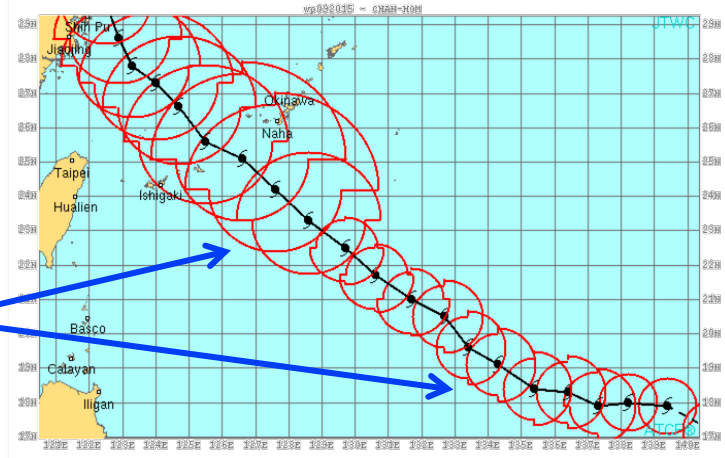
Pri 2: TC Structure Specification

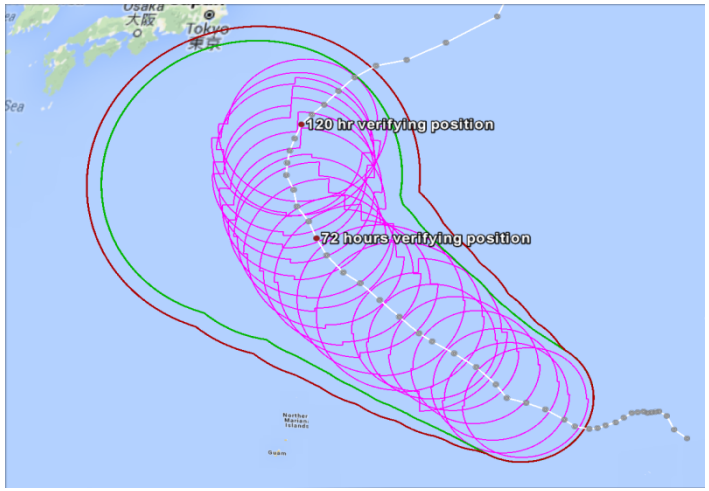
Accurate forecasts of TC winds are critical for DOD resource protection

Addressed small bias in JTWC wind radii estimates and "jumps" in size when scatterometry becomes available



JTWC made significant improvement in TC structure forecasts in 2016 with NRL,CIRA objective guidance

- Refinement of new **wind radii guidance**, GPCE probabilities, and re-development of radii cliper ongoing
- More **modeling emphasis on TC structure** needed (positive feedback loop)
- **Development of a dynamic swath** of potential 34-knot winds using GPCE consensus spread. Funded effort to update GPCE-AX
- Continue post-season best-tracking efforts.



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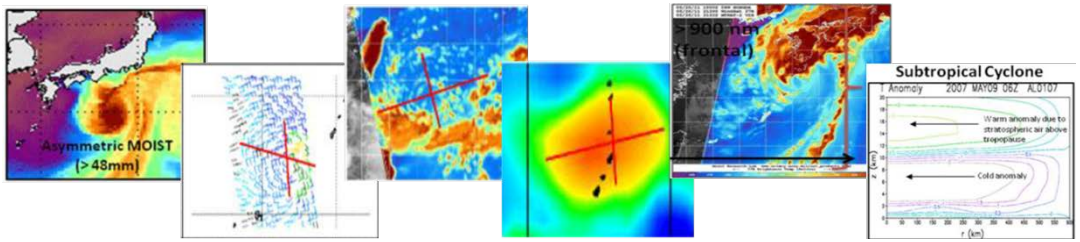
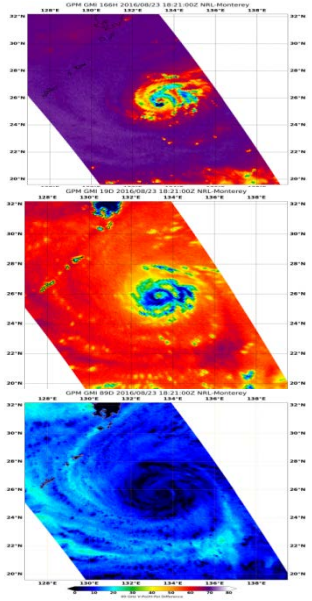
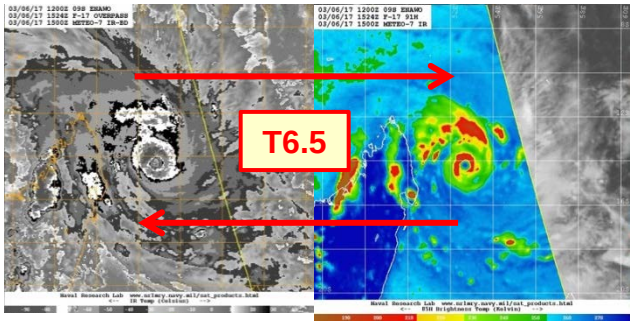
Pri 3: Data Exploitation

- Techniques or products that **exploit expanded GEO data**
  -- Channel differencing / enhancements to locate LLCC
- Techniques or products that **exploit non-traditional MW data**
  -- Low / High frequencies (6 / 19 / 166 GHz)
- **Basin specific** diagnostic tools for **intensity change** using **MW** data
  -- Kieper Cyan Ring, etc.
- **Dvorak-like** intensity analysis **technique** from **MW** data
- **Cyclone phase** analysis using TPW/MW/SCAT/VIS/IR/VORT
  -- Tropical / Sub-Tropical / Extra-Tropical





ATLANTIC 37 GHz Ring Only and PMWRing RI INDICES
NOCKTEN WP30 2016 12/24/16 0 UTC
TMI,SSMI,SSMIS,AMSR2 and WINDSAT Total Overpass Orbits: 1
==========RI FORECAST BY THE 37 GHz Ring only and PMWRing RI INDICES DURING PAST 6 HOURS==========
===37 GHz Ring Only RI Forecast:===
FUTURE 24-HOUR INTENSITY INCREASE >= 30 KT (RI): YES
===PMWRing RI Forecast (based on 37 GHz Ring and 5 additional 37/85 GHz predictors):===
PROB OF RI FOR 25 KT RI THRESHOLD= 61%
PROB OF RI FOR 30 KT RI THRESHOLD= 58%
PROB OF RI FOR 35 KT RI THRESHOLD= 49%
PROB OF RI FOR 40 KT RI THRESHOLD= 41%



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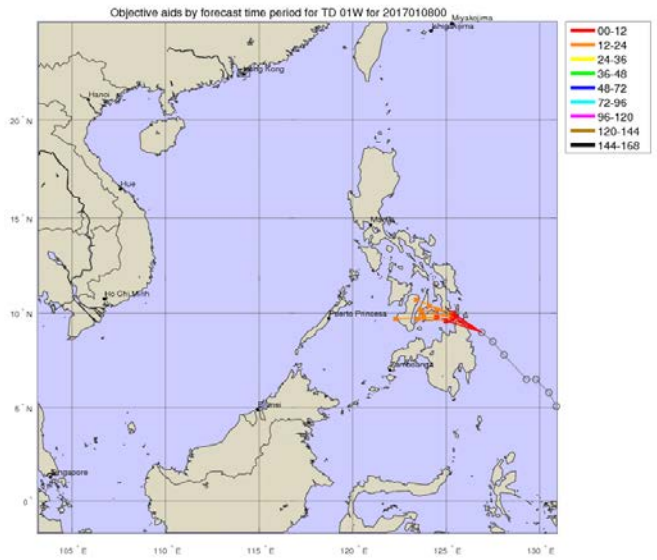
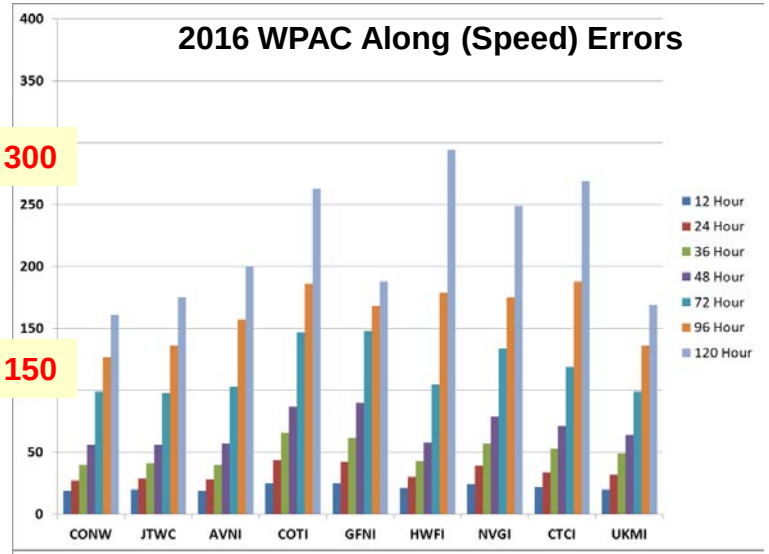
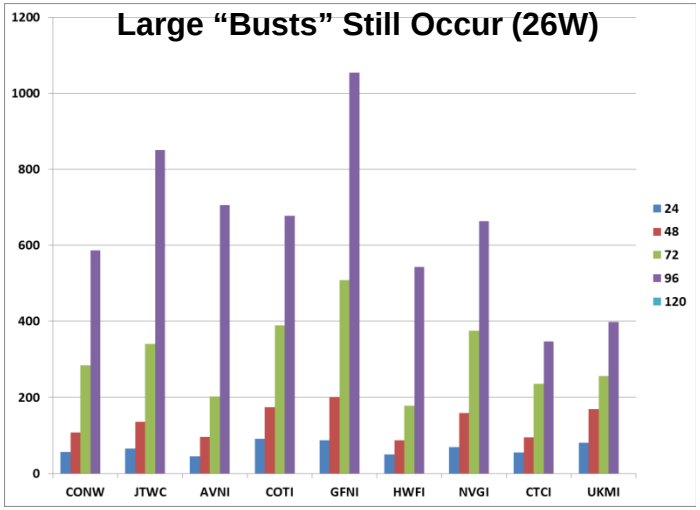
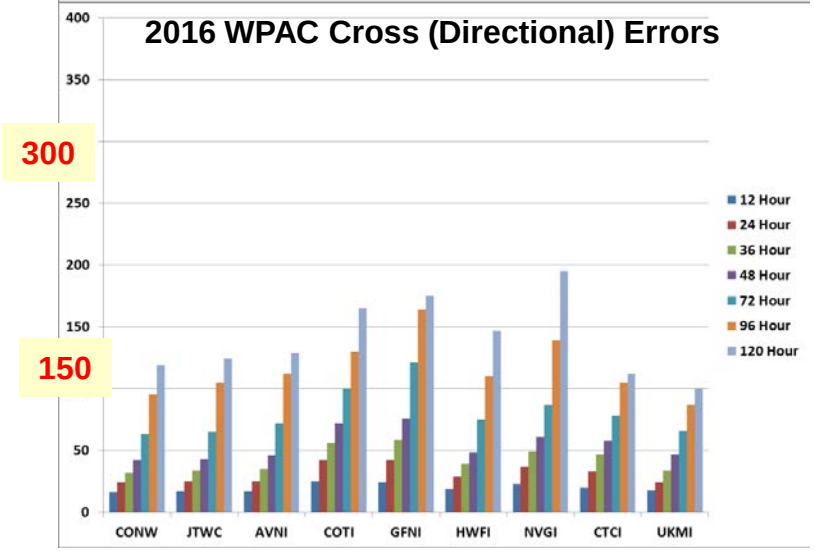
Pri 4: TC Track Improvement









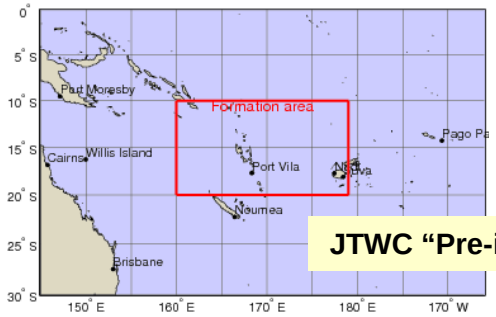
Pri 5: TC Genesis Timing and Forecast

Current status for Preinvest P97P (based on 022400Z forecast)
Updated 2/25/2017 at 01:20Z

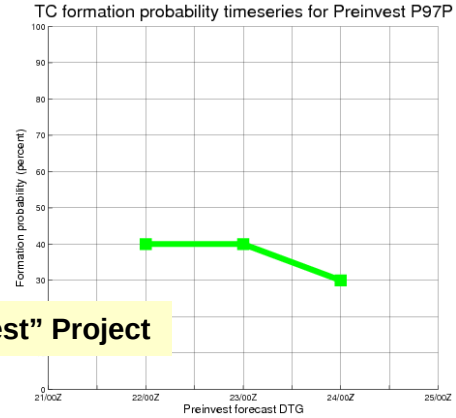
TC formation probability: 30%
TC formation may occur between 25/12Z and 27/12Z
Estimated time to formation: 1.4 days (~26/12Z)

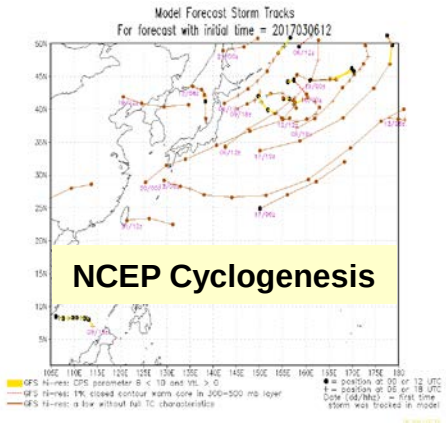
Projected classification timeline
Invest: 21/12Z
Low: 23/12Z
Medium: 24/12Z
High: 25/12Z
First warning: 26/12Z

Corresponding invest designator: XXX

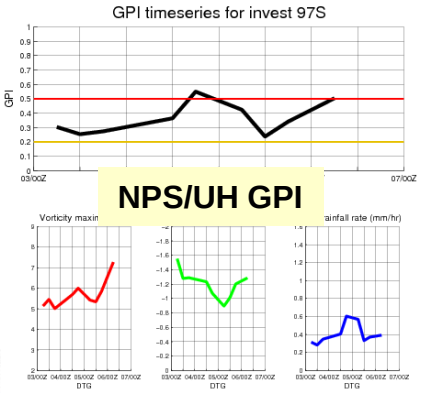


JTWC "Pre-invest" Project

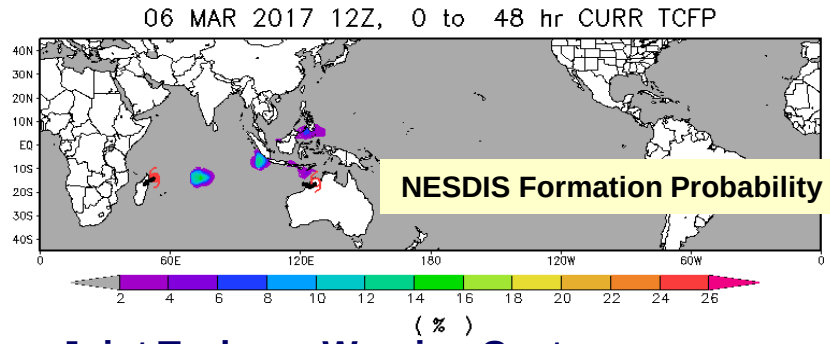




NCEP Cyclogenesis



NPS/UH GPI



NESDIS Formation Probability

- Improve the forecasting of **TC genesis timing** and the **subsequent track, intensity and structure** of pre-genesis tropical disturbances globally
- Need guidance at the short-range (**0-48 hours**) and medium-range (**48-120 hours**)
- Must exhibit **high probability of detection** and **low false alarm rate**
- Develop techniques to diagnose and predict the **formation of TCs** via transition of **non-classical disturbances** (e.g. **monsoon depressions, sub-tropical, hybrids, etc**.)

Questions?