Verification of Tropical Cyclone Genesis Prediction in a Suite of Operational Global Numerical Weather Prediction Models

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NOAA ESRL Boulder CO

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The Riehl Reason I'm doing TC genesis as an answer to *The Question*…

"This is all well and good Mike…

The Question…

when giving a seminar at CSU in the 1980s…

"This is all well and good Mike…

but why (on earth) are you doing this? *#%!!"

The Question…

"This is all well and good Mike…
but why (on earth) are
you doing this? *#%!!"

Uncle Bill Gray

The Question…

"This is all well and good Mike…
but why (on earth) are
you doing this? *#%!!"

Uncle Bill Gray

a.k.a 日本でときどき

"Beer Glay"

WARNING! WARNING! WARNING!

The State Department has determined that the following slide contains subtle and possibly silly British humour. Americans, especially those with small children, are cautioned…

And the Answer is…

because Bob Gall (HFIP) “asked” me to…

And the Answer is…

because Bob Gall (HFIP) "asked" me to…

so "***Bob's Your Uncle!***"

The Riehl Answer does come from operations…

as expressed in the JTWC watch phrase of the early 1980s

because Bob Gall (HFIP) "asked" me to…

so "***Bob's your uncle!***"

The **TCAD** principle – namely:

The Answer…for the modeling purposes

Bob Gall (HFIP) "asked" me to…

so "Bob's your uncle"

The **TCAD** principle – namely:

Tropical **C**yclones **A**re **D**iagnostic

in other words…

in a Yogi Berra-ism I picked up from Uncle Bill

Bob Gall (HFIP) "asked" me to…

so "Bob's your uncle"

The **TCAD** principle – namely:

Tropical **C**yclones **A**re **D**iagnostic

"You can observe a lot just by watching"

but when…OOG because GIG

TCAD really means…

Bob Gall (HFIP) "asked" me to…

so "Bob's your uncle"

The **TCAD** principle – namely:

Tropical **C**yclones **A**re **D**iagnostic

"You can observe a lot just by watching"

Typhoon Come All Die!!!

Operational Motivations (O2R)

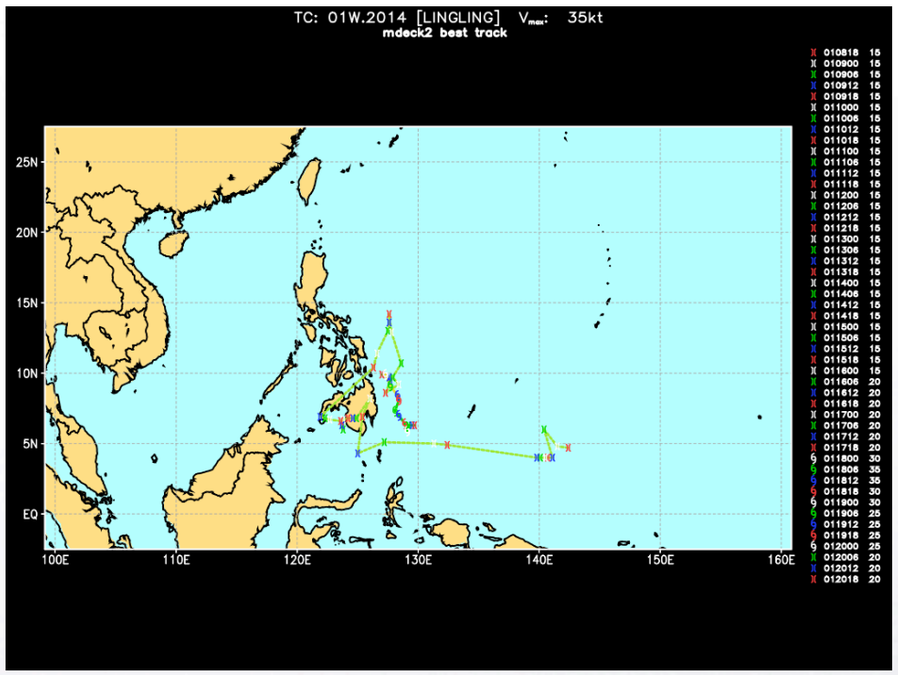
…maybe those d!*#%ng models are pretty good after all…

"The models are getting downright phenomenal in their skill and usefulness. Several days ago, the NVG and GFS began picking-up on 91W making it to the Philippines, and these two models have been (somewhat) consistent in track and timing ever since."

Mark Lander,UofGuam in an email to tstorm.org list on 2014010909

```
2014010818      A1W.2014 015 ----   4.7  142.4E  --- ---  303.1 11.9 B  NT NW  ---   1/38  lf: 0.00
2014010900      A1W.2014 015 ----   4.8  141.5E  --- ---  303.1 11.9 B  NT NW  ---   2/38  lf: 0.00
2014010906      A1W.2014 015 ----   6.0  140.4E  --- ---  303.1 11.9 B  NT NW  ---   3/38  lf: 0.00
2014010912      A1W.2014 015 ----   4.0  141.1E  --- ---  206.5  4.5 B  NT NW  ---   4/38  lf: 0.00
.
.
2014011706*     A1W.2014 020 1007   9.7  127.9E  --- ---  230.0  2.0 C  DB NW  ---  35/38  lf: 0.00 INVEST    <**Genesis
2014011712*     A1W.2014 020 1007   9.7  127.6E  --- ---  255.0  2.0 C  DB NW  ---  36/38  lf: 0.00 INVEST    <**Genesis
2014011718*     A1W.2014 020 1005   9.9  127.0E  --- ---  280.0  4.0 C  DB NW  ---  37/38  lf: 0.00 INVEST    <**Genesis
2014011800*     A1W.2014 030 1000   9.9  127.3E  --- ---  304.1  1.8 B  TD NW  ---  38/38  lf: 0.00           <**Genesis
2014011806*      01W.2014 035  996   8.9  127.8E  --- ---  156.3  4.9 B  TS WN  TJM  20/30  lf: 0.00 LINGLING  <**Genesis
2014011812*     01W.2014 035  996   8.4  128.3E  --- ---  138.1  7.4 B  TS WN  TJM  21/30  lf: 0.00 LINGLING  <**Genesis
.
.

2014011918      01W.2014 025 1004   6.6  128.7E  --- ---  140.4  3.9 B  TD WN  SJB  26/30  lf: 0.00 LINGLING
2014012000      01W.2014 025 1008   6.3  129.0E  --- ---  135.2  4.2 B  TD NW  ---  27/30  lf: 0.00 LINGLING
2014012006      01W.2014 020 1004   6.3  129.2E  --- ---  121.1  2.9 B  TD NW  ---  28/30  lf: 0.00 LINGLING
2014012012      01W.2014 020 1004   6.3  129.5E  --- ---   90.0  2.5 B  TD NW  ---  29/30  lf: 0.00 LINGLING
2014012018      01W.2014 020 1007   6.3  129.7E  --- ---   90.0  2.5 B  TD NW  ---  30/30  lf: 0.00
2014 01W   TS LINGLING   : 35 : 3.2; 7.2 :  8.9 127.9 : 010818<->012018 :  6.3<->11.9  :126.3<->129.7 : 0.8 : 0.1 : 0: 0: 0:     :
tG:222 9X: 91W  1st: 011800
```



- 01W.2014 was 91W for 222 h before JTWC issued 1st warning
- **similar to observations of the NHC specialists 2006-2008 that if the big three models (GFS/ECMWF/UKMO) forecast the formation of a cyclone, in a similar location, then…**

ingredients of the TCgen2 model diagnostic system

http://ruc.noaa.gov/hfip/tcgen (password protected, .com excluded)

- TIM (**T**Cs **I**n **M**odels) ***cyclone tracker*** – Marchok, GFDL
  - ***tracker mode*** – track cyclones from an initial position in the initial conditions (*a priori*)
  - ***genesis mode*** – find and track cyclones *during* the integration (*a posteriori*)
  - measure of ***model cyclone strength*** – "scaled Tropical Depression days" (sTDd)
- ***Genesis definition – operational per NHOP/PACOM***
  - ***30-h window*** around the first advisory(NHC)/warning(JTWC) to give the 00/12 UTC models ***three shots*** at the foul line ***to forecast genesis***
- ***TC demographics*** of ?TCs and ***SPUR***ious hurr***ICANES***
- Scheme to ***match model*** cyclones (genesis & tracker) ***to real ?TCs***
  - ***closeness defines a 'hit' or correct forecast*** – compare positions of ?TCs to model TCs within a 24-h window ending at the forecast tau, e.g., 60-84 h for the D+3 forecast
  - a bit of an accounting nightmare…with so many possible model v real TC comps
- ***Weather maps + model diagnostics***
  - ***sanity check*** the tracker and matching scheme ***; synoptic evaluation***
  - ***basin-wide, over-ocean precipitation + ratio of convective/total precip***

The Models

2009-2013 May-October (~8 Tb)

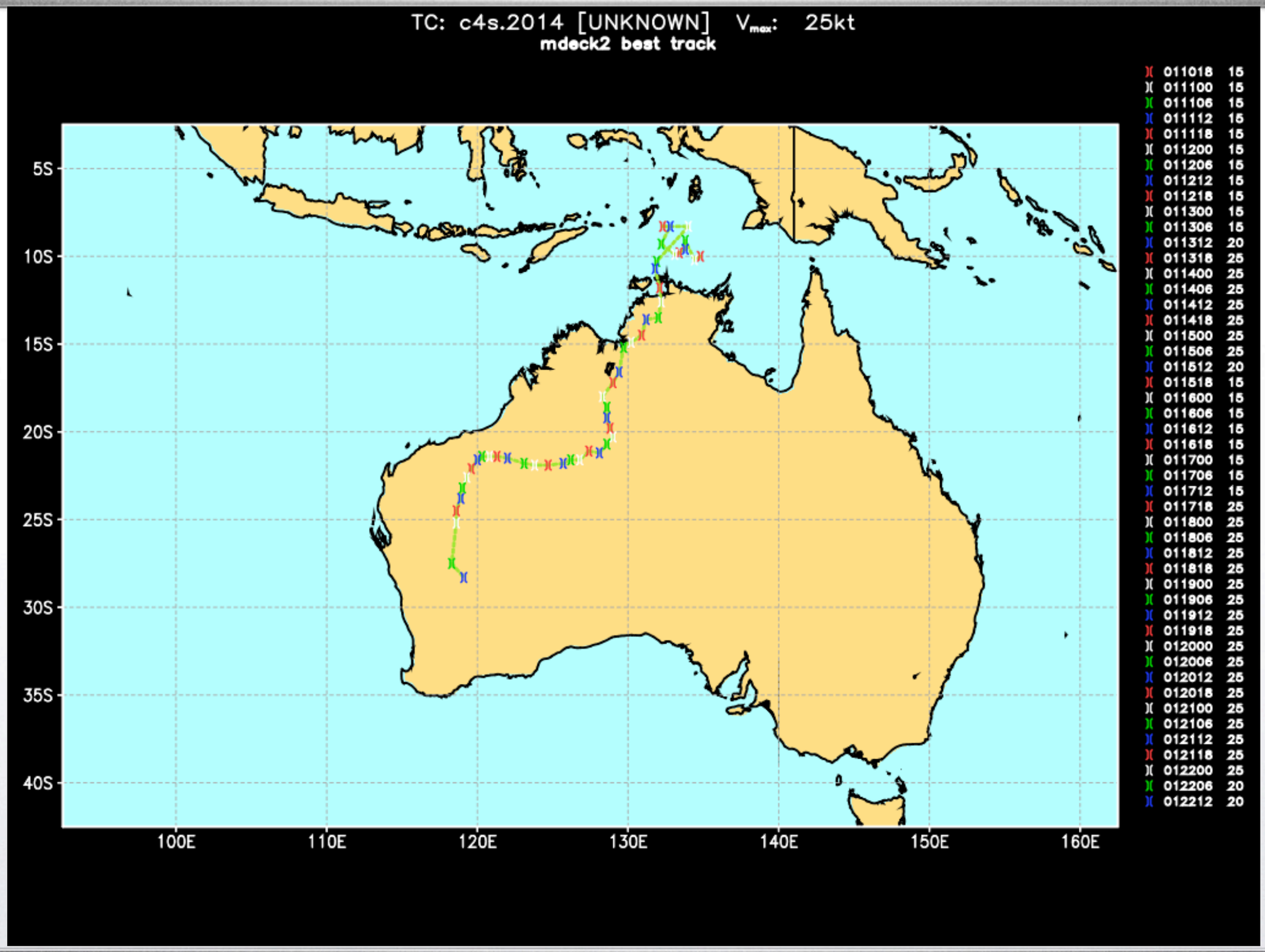
ATCF ID	Model	Resolution circa 2013	Comments
AVNO	GFS T574L64	27 km **L64**	3DVAR-EnKF Hybrid/GFS 2012 physics
FIM8	FIM G8	30km **L64**	3DVAR-EnKF Hybrid/2011 GFS physics, dynamical core improves
FIM9	FIM G9	15 km **L64**	same as FIM8 except higher res
CGD6/CMC2	CMC GDPS	25 km **L79**	major update in 201305; 4DVAR
UKM2	UKMO UM	~32 km **L70**	upcoming major upgrade in 201405, 4DVAR
NGPC/NAVG	NOGAPS NAVGEM	37 km **L50**	4DVAR-AR; SL dynamical core/GFS cumulus
ECMT/ECM2	ECMWF HRES	16 km **L137**	IFS cycle 38r2 (25 JUN 13) increased vertical res; sfc drag; shallow cu…

TC Demographics

pTCs, TCs, mTCs, aTCs and the ***SPURICANE***

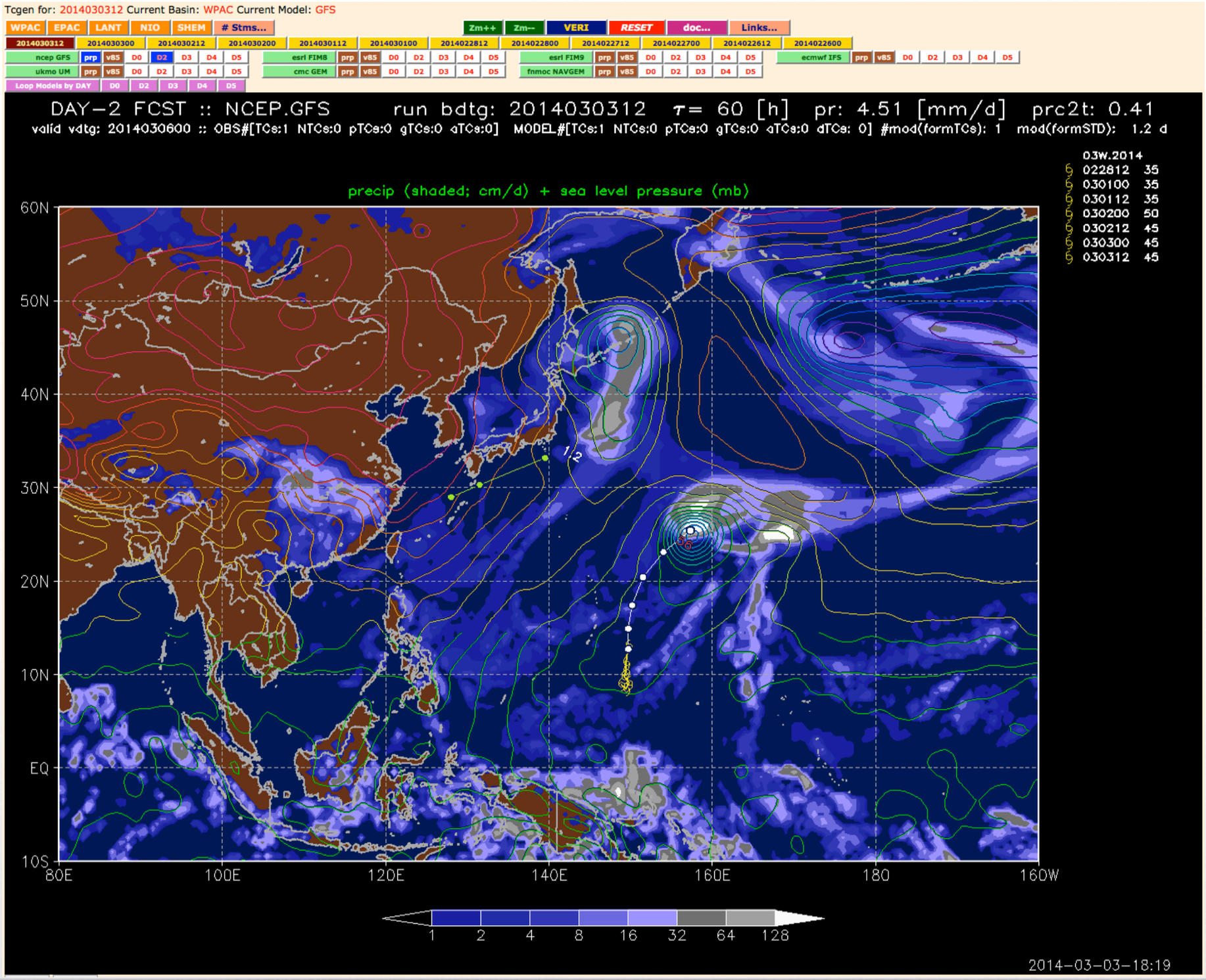
Type	Naming	Features
TC	**01-49 numbered TCs** 01W.2014 TC #1 in WESTPAC in 2014	tropical cyclone as analyzed by JTWC/NHC ATCF TC designations: TD, TS, TY, HU, STY, [SD, SS] ***ATCF non-TC designations: PT, XT, ET***
pTC	**9X or INVEST** systems 94S.2014 – the landphoon over eastern OZ	pre/potential TC as analyzed by JTWC/NHC ATCF designations: LO, DB, WV ***Database of pTCs in WPAC/SHEM/IO 1999-2013; LANT/EPAC 2006-2013***
mTC	**TGNNNN** **NN or 9X**	model cyclone from a tracker genesis mode – 1.5 mb center-outer deficit
aTC	**TGNNNN**	initial mTC that the model maintains for >= 24 h into the forecast, not associated with a TC/pTC
SPURICANE	**TGNNNN**	***I. mTC that cannot be associated with a TC, pTC, aTC*** ***II. mTC associated with a dissipated ?TC***

C4S.2014 (the 3rd 94S pTC) – OZ Landphoon



TCgen2 – front page – FCST mode – forecasting

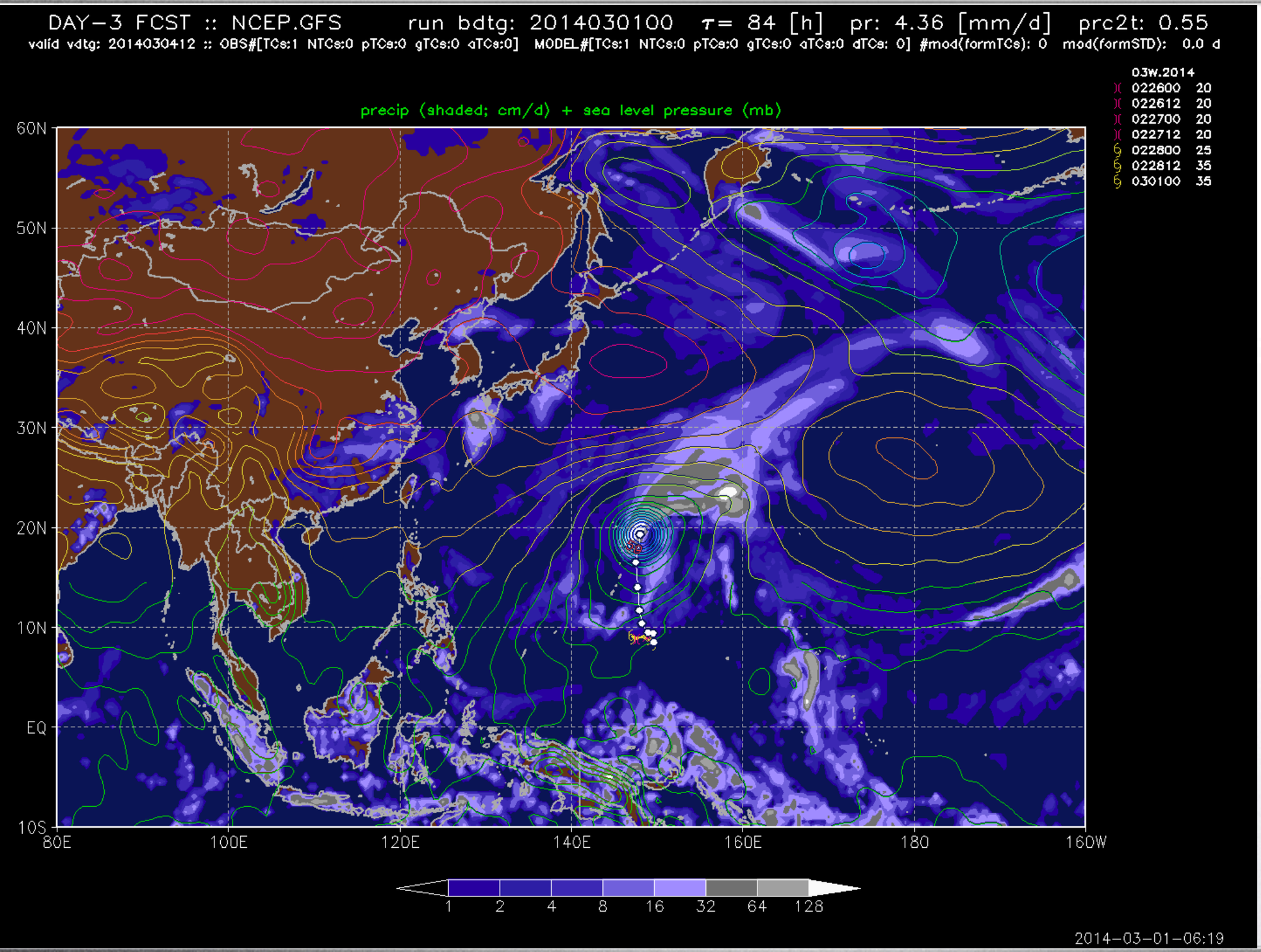
http://ruc.noaa.gov/hfip/tcgen



- 7 global NWP models
- +12 h model forecast for consistency with forecast e.g, day+2 (D2) uses 36-60 h model forecast
- ***tropical, ocean-only precip stats for model diagnostics…***
- model and observed ? TCs
- ***FCST*** (forecast) & ***VERI*** (verification) modes
- single model or loop mode

TCgen2 – two WxMAP2 product: thermo (precip)

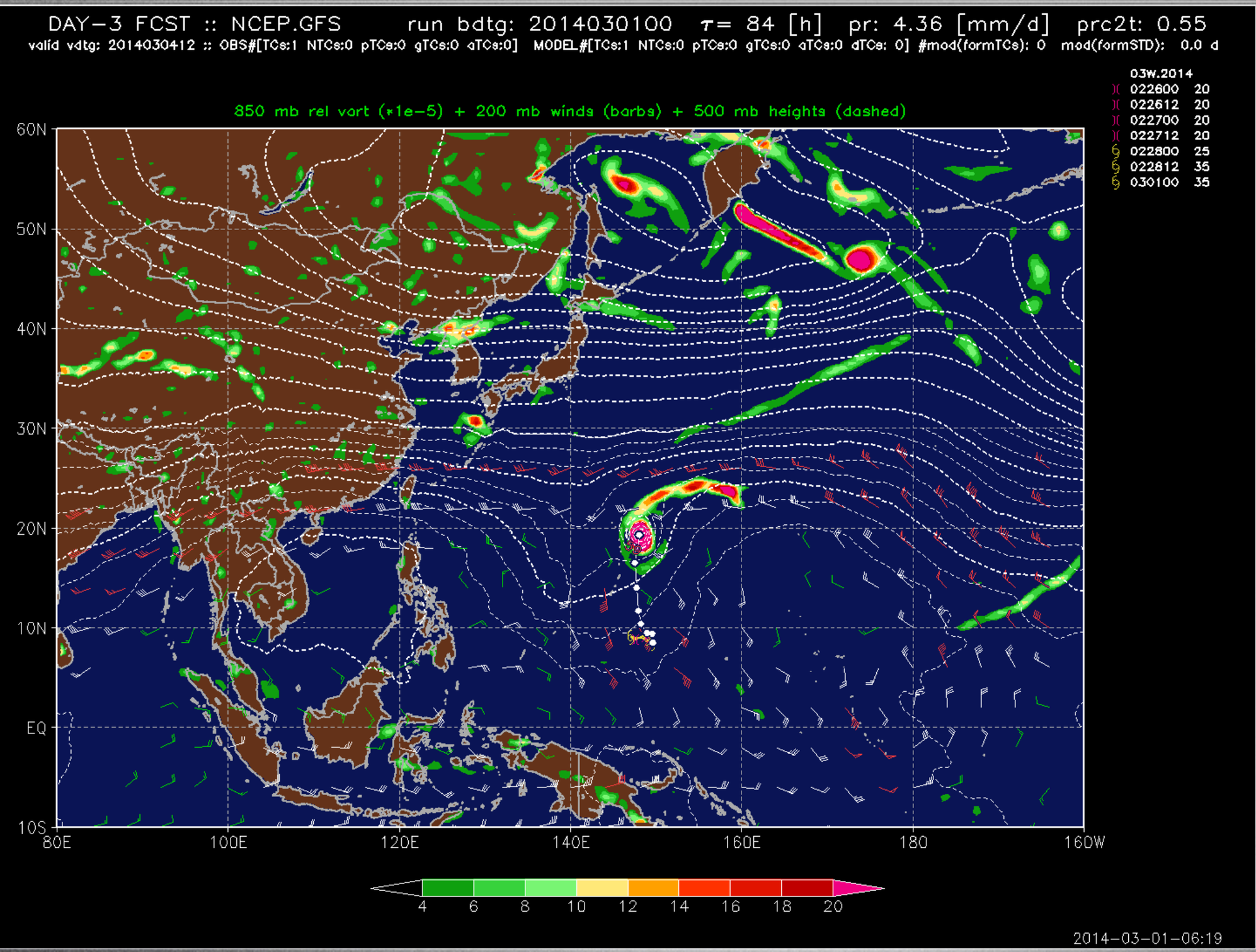
http://ruc.noaa.gov/hfip/tcgen



- ?TCs & genesis/IC trackers
- thermo (precip) and mass (sea-level pressure)
- D3 forecast (tau 84) for 03W verifying today (030412)

TCgen2 – two WxMAP2 products: dynamical (NHC 850 McAdie chart)

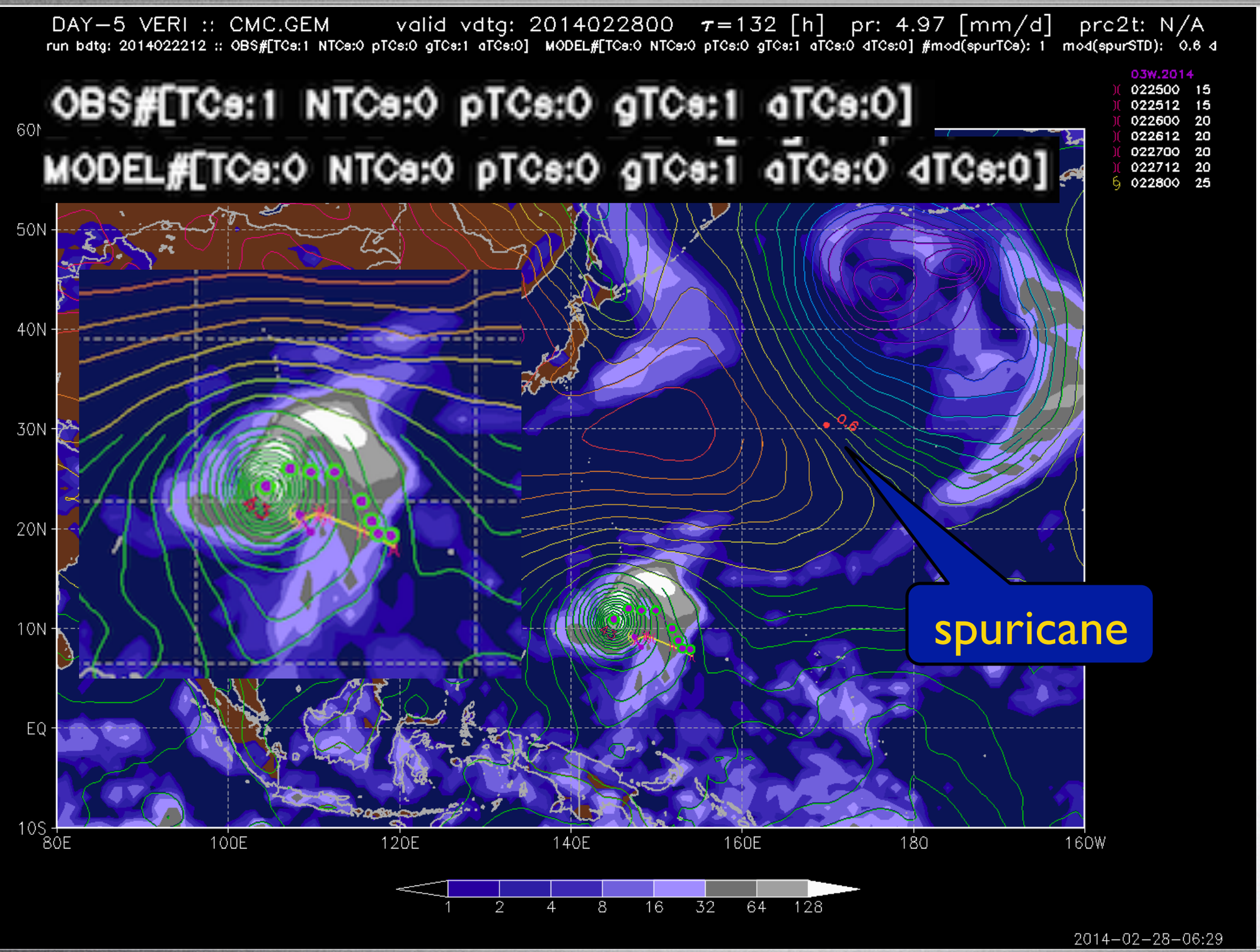
http://ruc.noaa.gov/hfip/tcgen



- dynamics – 850 mb relative vorticity
- mass – 500 mb heights – STR & breaks
- dynamics – 200 mb wind – shear

TCgen2 – VERI mode – verification – CMC CGDP D+5 03W

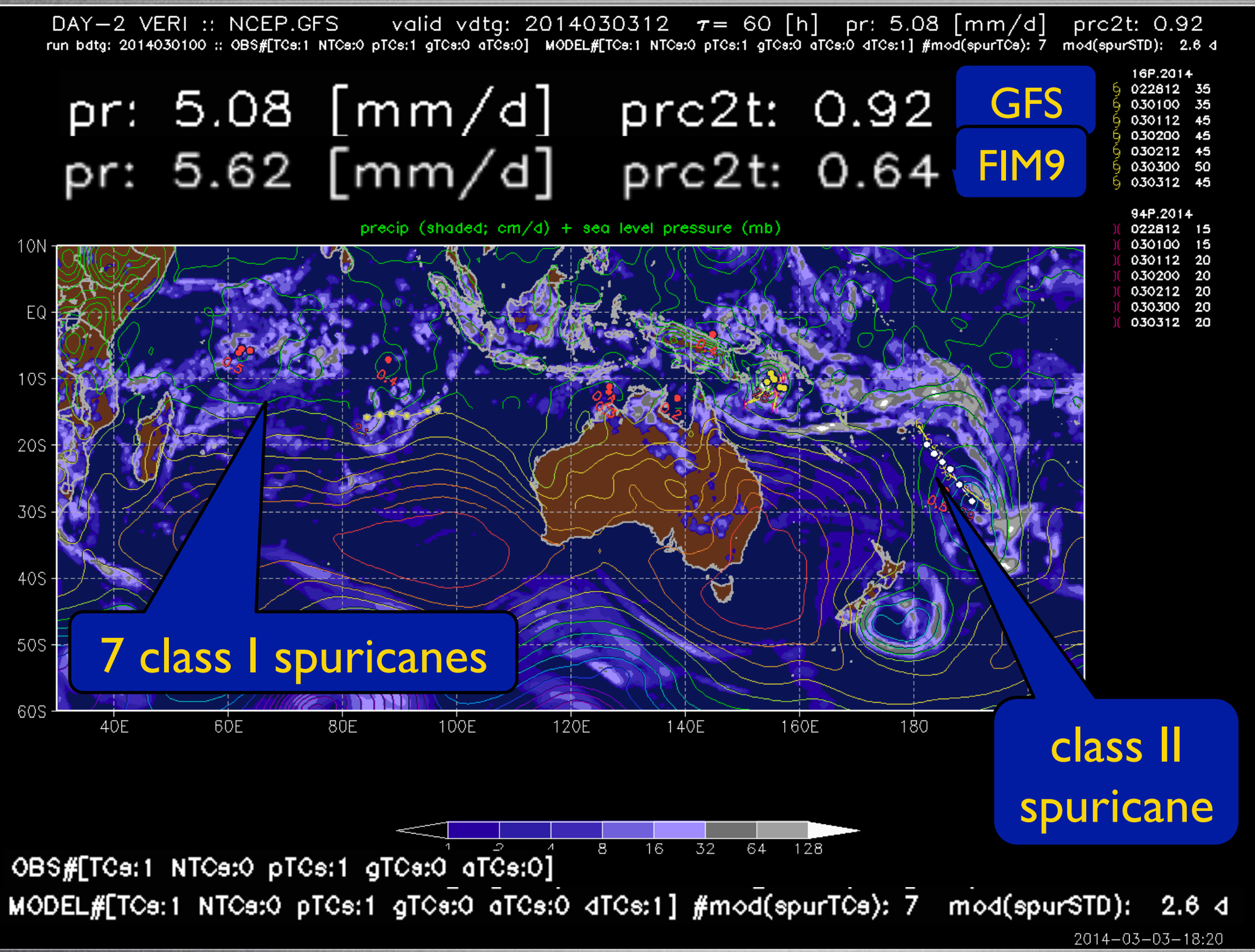
http://ruc.noaa.gov/hfip/tcgen



- first JTWC warning for 03W on 2014022800 – genesis
- CMC mTC located 'near enough' to 03W to be declared a 'hit' of genesis forecast Vmax=43 kt
- spuricane on top of tropical band

TCgen2 – VERI mode – ***SPURICANES*** class 1 & 2 – NCEP GFS D+2 forecast

http://ruc.noaa.gov/hfip/tcgen



- GFS correctly forecasts both TC 16P and pTC 96P
- **7 class I spuricanes but sTDd <= 0.5 d**
- model maintained a **TC that dissipated – class II spuricane**

TCgen2 – seasonal verification – atLANTic 2013 – D+2 & D+5

http://ruc.noaa.gov/hfip/tcgen

slide 24

TCgen Stats :: **Gentau: 60 [h]** Basin: LANT Year: 2013 Models: CMC.GEM, ECMWF.IFS, ESRL.FIM, NCEP.GFS, FNMOC.NAVGEM, ESRL.FIM9, UKMO.UM

D+2

Storm	CMC.GEM	ECMWF.IFS	ESRL.FIM	NCEP.GFS	FNMOC.NAVGEM	ESRL.FIM9	UKMO.UM	
01L.2013 [TS 055 kt] ANDREA	3/ 3.1	3/ 2.0	2/ 1.1	2/ 1.7	0/----	2/ 1.5	2/ 1.9	86
02L.2013 [TS 040 kt] BARRY	0/----	0/----	1/ 0.4	0/----	0/----	1/ 0.5	0/----	29
03L.2013 [TS 055 kt] CHANTAL	0/----	0/----	0/----	0/----	0/----	0/----	0/----	----
04L.2013 [TS 050 kt] DORIAN	3/ 1.4	1/ 0.9	1/ 0.5	2/ 1.0	2/ 0.6	1/ 0.5	1/ 0.3	100
05L.2013 [TS 035 kt] ERIN	1/ 0.3	1/ 0.3	1/ 0.5	1/ 0.5	1/ 0.4	0/----	1/ 0.3	86
06L.2013 [TS 050 kt] FERNAND	0/----	0/----	0/----	0/----	1/ 0.9	0/----	0/----	14
07L.2013 [TS 050 kt] GABRIELLE	3/ 2.6	3/ 1.5	3/ 2.0	3/ 2.3	3/ 1.8	2/ 1.6	3/ 2.0	100
08L.2013 [TD 030 kt] EIGHT	0/----	2/ 0.6	0/----	3/ 1.7	0/----	0/----	0/----	29
09L.2013 [HU1 075 kt] HUMBERTO	2/ 0.6	3/ 1.3	2/ 1.3	2/ 1.3	0/----	2/ 1.0	2/ 1.2	86
10L.2013 [HU1 075 kt] INGRID	1/ 0.5	3/ 0.9	2/ 1.1	2/ 0.6	2/ 1.0	3/ 1.6	1/ 0.4	100
11L.2013 [TS 045 kt] JERRY	0/----	0/----	1/ 0.5	0/----	0/----	1/ 0.6	0/----	29
12L.2013 [TS 055 kt] KAREN	0/----	1/ 0.3	1/ 1.0	1/ 0.7	3/ 1.8	-1/----	2/ 0.8	83
13L.2013 [TS 045 kt] LORENZO	0/----	1/ 0.3	0/----	0/----	1/ 0.7	0/----	0/----	29
14L.2013 [TS 055 kt] MELISSA	3/ 4.0	2/ 2.4	2/ 2.6	2/ 2.6	2/ 2.4	2/ 2.6	2/ 2.2	100
bottomline by model	50	71	71	64	57	62	57	

TCgen Stats :: **Gentau: 132 [h]** Basin: LANT Year: 2013 Models: CMC.GEM, ECMWF.IFS, ESRL.FIM, NCEP.GFS, FNMOC.NAVGEM, ESRL.FIM9, UKMO.UM

D+5

Storm	CMC.GEM	ECMWF.IFS	ESRL.FIM	NCEP.GFS	FNMOC.NAVGEM	ESRL.FIM9	UKMO.UM	
01L.2013 [TS 055 kt] ANDREA	3/ 3.0	3/ 1.6	1/ 0.3	3/ 2.2	1/ 0.2	1/ 0.7	0/----	86
02L.2013 [TS 040 kt] BARRY	2/ 0.6	2/ 0.8	3/ 0.9	1/ 0.4	0/----	3/ 1.0	1/ 0.7	86
03L.2013 [TS 055 kt] CHANTAL	0/----	0/----	0/----	0/----	0/----	0/----	0/----	----
04L.2013 [TS 050 kt] DORIAN	2/ 0.8	0/----	0/----	1/ 0.4	0/----	0/----	0/----	29
05L.2013 [TS 035 kt] ERIN	0/----	0/----	0/----	3/ 1.2	0/----	1/ 0.5	0/----	29
06L.2013 [TS 050 kt] FERNAND	0/----	1/ 0.4	0/----	1/ 0.4	0/----	0/----	0/----	29
07L.2013 [TS 050 kt] GABRIELLE	3/ 3.7	2/ 0.7	1/ 0.5	2/ 1.5	2/ 1.1	0/----	3/ 2.0	86
08L.2013 [TD 030 kt] EIGHT	0/----	0/----	0/----	2/ 0.7	1/ 0.5	0/----	0/----	29
09L.2013 [HU1 075 kt] HUMBERTO	3/ 1.9	3/ 1.3	0/----	2/ 1.6	1/ 0.2	2/ 1.5	3/ 1.5	86
10L.2013 [HU1 075 kt] INGRID	0/----	1/ 0.3	0/----	3/ 1.5	0/----	0/----	0/----	29
11L.2013 [TS 045 kt] JERRY	2/ 2.4	0/----	0/----	0/----	3/ 1.7	0/----	0/----	29
12L.2013 [TS 055 kt] KAREN	2/ 1.4	1/ 0.2	2/ 2.3	2/ 1.5	0/----	-1/----	1/ 0.5	83
13L.2013 [TS 045 kt] LORENZO	3/ 3.0	0/----	0/----	0/----	0/----	0/----	0/----	14
14L.2013 [TS 055 kt] MELISSA	3/ 3.6	2/ 1.7	2/ 2.5	2/ 2.0	2/ 2.0	2/ 1.7	2/ 1.9	100
bottomline by model	64	57	36	79	43	38	36	

box color	key
-1/----	no model run
0/----	0 forecasts of genesis
1/ 0.5	1 of 3 forecast verified
2/ 1.5	2/3 forecasts verified
3/ 3.6	3/3 forecasts verified
----	0%
14	< 25 %
29	25 >= % < 75
83	>= 75

NOAA NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION U.S. DEPARTMENT OF COMMERCE
ESRL GLOBAL SYSTEMS DIVISION

TCgen2 – seasonal verification – WPAC 2013 – D+2 & D+5

http://ruc.noaa.gov/hfip/tcgen

TCgen Stats :: **Gentau: 60 [h]** Basin: WPAC Year: 2013 Models: CMC.GEM, ECMWF.IFS, ESRL.FIM, NCEP.GFS, FNMOC.NAVGEM, ESRL.FIM9, UKMO.UM

D+2

Storm	CMC.GEM	ECMWF.IFS	ESRL.FIM	NCEP.GFS	FNMOC.NAVGEM	ESRL.FIM9	UKMO.UM	
01W.2013 [TS 045 kt] SONAMU	-1/----	-1/----	-1/----	-1/----	-1/----	-1/----	-1/----	----
02W.2013 [TD 025 kt] SHANSHAN	-1/----	-1/----	-1/----	-1/----	-1/----	-1/----	-1/----	----
03W.2013 [TS 055 kt] YAGI	3/ 3.6	0/----	3/ 2.5	3/ 2.6	1/ 0.3	3/ 2.6	2/ 1.0	86
04W.2013 [TS 035 kt] LEEPI	3/ 3.1	3/ 1.8	3/ 2.4	3/ 2.5	3/ 1.6	3/ 2.5	3/ 2.4	100
05W.2013 [TS 035 kt] BEBINCA	2/ 1.7	1/ 0.9	3/ 3.1	3/ 2.0	3/ 1.4	3/ 3.1	2/ 1.3	100
06W.2013 [HU1 065 kt] RUMBIA	3/ 1.8	3/ 1.7	3/ 1.8	3/ 1.3	3/ 1.8	2/ 1.1	3/ 0.9	100
07W.2013 [HU4 125 kt] SOULIK	3/ 3.7	3/ 1.4	1/ 0.4	1/ 0.4	0/----	1/ 0.5	2/ 1.2	86
08W.2013 [TS 040 kt] CIMARON	3/ 3.0	3/ 2.8	3/ 3.8	3/ 3.9	3/ 3.1	3/ 2.1	3/ 2.8	100
09W.2013 [TS 060 kt] JEBI	3/ 1.6	3/ 1.5	2/ 2.1	3/ 2.6	3/ 2.3	3/ 2.0	3/ 1.5	100
10W.2013 [TS 040 kt] MANGKHUT	3/ 2.9	3/ 2.6	3/ 2.9	3/ 2.6	3/ 2.9	2/ 1.4	3/ 2.0	100
11W.2013 [HU4 130 kt] UTOR	1/ 0.2	2/ 0.6	1/ 0.3	2/ 0.7	1/ 0.4	-1/----	2/ 0.7	100
12W.2013 [HU1 075 kt] TRAMI	3/ 2.5	3/ 1.5	3/ 2.2	3/ 1.9	3/ 1.8	2/ 1.6	3/ 0.8	100
13W.2013 [TD 025 kt] THIRTEEN	3/ 2.5	3/ 1.5	3/ 2.2	3/ 1.9	3/ 1.8	2/ 1.6	3/ 0.8	100
14W.2013 [TS 055 kt] KONG-REY	3/ 3.5	2/ 1.6	3/ 3.7	3/ 3.5	3/ 2.0	2/ 2.5	2/ 1.8	100
15W.2013 [TS 050 kt] TORAJI	3/ 2.3	3/ 2.6	3/ 3.0	3/ 3.7	3/ 1.5	3/ 1.9	3/ 2.5	100
16W.2013 [TS 060 kt] MAN-YI	3/ 4.2	3/ 2.2	3/ 4.0	3/ 3.5	3/ 2.3	2/ 2.8	3/ 1.6	100
17W.2013 [HU5 140 kt] USAGI	3/ 3.7	3/ 1.8	3/ 3.0	3/ 2.7	3/ 1.5	3/ 3.0	2/ 0.8	100
18W.2013 [TD 025 kt] EIGHTEEN	3/ 3.1	3/ 2.3	3/ 2.6	3/ 2.0	3/ 2.2	3/ 2.7	3/ 2.4	100
19W.2013 [HU2 090 kt] PABUK	2/ 3.2	3/ 3.1	2/ 3.4	2/ 3.0	1/ 1.3	2/ 4.0	2/ 2.4	100
20W.2013 [HU2 090 kt] WUTIP	3/ 2.7	3/ 2.3	3/ 2.5	3/ 2.3	3/ 2.2	2/ 2.0	3/ 2.2	100
21W.2013 [TS 035 kt] SEPAT	3/ 3.4	3/ 2.7	3/ 3.3	3/ 2.9	3/ 2.7	2/ 2.3	3/ 2.7	100
22W.2013 [HU2 090 kt] FITOW	3/ 3.4	3/ 2.7	3/ 3.3	3/ 2.9	3/ 2.7	2/ 2.3	3/ 2.7	100
23W.2013 [HU4 125 kt] DANAS	2/ 1.6	2/ 1.3	3/ 2.3	3/ 2.0	3/ 1.6	1/ 0.8	3/ 1.4	100
24W.2013 [HU3 105 kt] NARI	0/----	1/ 1.4	1/ 1.3	1/ 1.3	1/ 0.9	0/----	1/ 1.1	71
25W.2013 [HU4 115 kt] WIPHA	2/ 1.1	3/ 2.1	3/ 3.2	3/ 3.0	3/ 2.3	2/ 2.0	3/ 2.4	100
26W.2013 [HU5 140 kt] FRANCISCO	2/ 1.5	2/ 1.4	1/ 0.3	1/ 0.6	3/ 0.8	0/----	1/ 0.6	86
27W.2013 [TD 025 kt] TWENTYSEVE	2/ 1.8	1/ 0.7	2/ 2.0	3/ 2.6	1/ 0.7	1/ 0.9	0/----	86
28W.2013 [HU5 140 kt] LEKIMA	3/ 1.8	3/ 2.3	3/ 2.6	3/ 2.0	2/ 1.6	2/ 1.8	3/ 2.2	100
29W.2013 [HU3 100 kt] KROSA	3/ 2.8	3/ 2.4	3/ 3.2	3/ 2.5	3/ 2.2	0/----	3/ 1.9	86
30W.2013 [TS 035 kt] THIRTY	3/ 2.4	3/ 2.1	3/ 2.4	3/ 2.4	1/ 0.7	1/ 0.8	3/ 2.1	100
31W.2013 [HU5 170 kt] HAIYAN	2/ 1.6	3/ 1.6	3/ 2.0	3/ 2.0	1/ 0.7	1/ 0.8	3/ 2.1	100
32W.2013 [TD 025 kt] PODUL	3/ 3.5	2/ 1.8	2/ 2.2	2/ 2.7	2/ 2.3	1/ 1.2	2/ 1.9	100
33W.2013 [TD 030 kt] THIRTYTHRE	1/ 0.4	0/----	0/----	1/ 0.4	1/ 0.8	1/ 0.4	0/----	57
bottomline by model	97	94	97	100	97	90	94	

n Stats :: **Gentau: 132 [h]** Basin: WPAC Year: 2013 Models: CMC.GEM, ECMWF.IFS, ESRL.FIM, NCEP.GFS, FNMOC.NAVGEM, ESRL.FIM9, UKMO.UM

D+5

Storm	CMC.GEM	ECMWF.IFS	ESRL.FIM	NCEP.GFS	FNMOC.NAVGEM	ESRL.FIM9	UKMO.UM	
2013 [TS 045 kt] SONAMU	-1/----	-1/----	-1/----	-1/----	-1/----	-1/----	-1/----	----
2013 [TD 025 kt] SHANSHAN	-1/----	-1/----	-1/----	-1/----	-1/----	-1/----	-1/----	----
2013 [TS 055 kt] YAGI	3/ 3.9	0/----	2/ 1.5	3/ 3.5	3/ 2.1	2/ 1.4	0/----	71
2013 [TS 035 kt] LEEPI	1/ 1.4	1/ 0.2	3/ 3.0	1/ 0.5	3/ 2.1	3/ 1.9	0/----	86
2013 [TS 035 kt] BEBINCA	1/ 0.5	1/ 0.5	0/----	3/ 2.7	3/ 2.6	1/ 0.5	1/ 1.1	86
2013 [HU1 065 kt] RUMBIA	2/ 1.1	3/ 1.3	1/ 0.5	3/ 1.7	3/ 1.4	2/ 1.0	3/ 1.7	100
2013 [HU4 125 kt] SOULIK	3/ 3.3	0/----	0/----	0/----	3/ 2.2	0/----	1/ 0.3	43
2013 [TS 040 kt] CIMARON	3/ 5.8	3/ 6.1	3/ 7.8	3/ 8.0	3/ 5.9	1/ 0.5	3/ 4.2	100
2013 [TS 060 kt] JEBI	3/ 4.0	1/ 0.3	1/ 0.9	2/ 0.8	0/----	2/ 1.4	2/ 0.7	86
2013 [TS 040 kt] MANGKHUT	2/ 3.1	2/ 2.0	3/ 3.4	3/ 3.2	2/ 1.5	2/ 2.5	3/ 2.7	100
2013 [HU4 130 kt] UTOR	3/ 1.6	3/ 1.1	1/ 0.9	0/----	3/ 1.9	-1/----	3/ 1.2	83
2013 [HU1 075 kt] TRAMI	3/ 4.0	1/ 0.5	3/ 3.6	3/ 3.9	2/ 0.9	1/ 0.7	1/ 0.4	100
2013 [TD 025 kt] THIRTEEN	3/ 4.0	1/ 0.5	3/ 3.6	3/ 3.9	2/ 0.9	1/ 0.7	1/ 0.4	100
2013 [TS 055 kt] KONG-REY	3/ 2.8	2/ 0.4	0/----	0/----	3/ 1.0	0/----	2/ 1.5	57
2013 [TS 050 kt] TORAJI	3/ 4.5	3/ 3.2	2/ 1.4	3/ 2.5	3/ 2.4	3/ 2.2	3/ 1.9	100
2013 [TS 060 kt] MAN-YI	3/ 2.8	1/ 0.2	2/ 2.0	3/ 1.4	3/ 1.9	2/ 1.3	1/ 0.3	100
2013 [HU5 140 kt] USAGI	2/ 1.2	0/----	2/ 3.6	2/ 3.5	3/ 2.5	0/----	2/ 2.0	71
2013 [TD 025 kt] EIGHTEEN	3/ 3.0	3/ 1.9	3/ 2.9	3/ 1.5	2/ 1.0	3/ 2.9	3/ 1.8	100
2013 [HU2 090 kt] PABUK	3/ 4.0	3/ 2.4	2/ 2.4	3/ 2.2	2/ 1.5	1/ 1.2	2/ 1.4	100
2013 [HU2 090 kt] WUTIP	3/ 4.0	3/ 3.8	1/ 1.2	3/ 3.1	3/ 4.7	0/----	3/ 3.1	86
2013 [TS 035 kt] SEPAT	3/ 4.3	3/ 1.6	3/ 3.7	3/ 2.1	3/ 2.5	2/ 2.6	2/ 1.3	100
2013 [HU2 090 kt] FITOW	3/ 4.3	3/ 1.6	3/ 3.7	3/ 2.1	3/ 2.5	2/ 2.6	2/ 1.3	100
2013 [HU4 125 kt] DANAS	2/ 2.8	2/ 1.7	2/ 1.2	3/ 2.8	3/ 1.4	1/ 0.6	2/ 0.9	100
2013 [HU3 105 kt] NARI	3/ 4.3	2/ 2.4	3/ 5.3	3/ 4.2	1/ 1.5	1/ 0.4	3/ 4.1	100
2013 [HU4 115 kt] WIPHA	3/ 4.4	3/ 1.6	0/----	2/ 2.3	2/ 1.8	2/ 3.2	3/ 1.8	86
2013 [HU5 140 kt] FRANCISCO	0/----	0/----	0/----	0/----	1/ 0.5	0/----	0/----	14
2013 [TD 025 kt] TWENTYSEVE	2/ 2.6	0/----	1/ 1.0	1/ 1.0	0/----	2/ 1.6	0/----	57
2013 [HU5 140 kt] LEKIMA	2/ 1.8	3/ 2.0	3/ 2.5	3/ 1.9	3/ 2.4	2/ 1.9	2/ 1.5	100
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bottomline by model	97	81	84	84	94	80	87	

box color	key
-1/----	no model run
0/----	0 forecasts of genesis
1/ 0.5	1 of 3 forecast verified
2/ 1.5	2/3 forecasts verified
3/ 3.6	3/3 forecasts verified
----	0%
14	< 25 %
29	25 >= % < 75
83	>= 75

NOAA NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION U.S. DEPARTMENT OF COMMERCE
ESRL GLOBAL SYSTEMS DIVISION

Takeaways

- **TCgen2** was developed based on NHC operations (**O2R**) for HFIP
- **FCST mode** consistent with NHC operations, e.g., use 36-60 h model solution for D+2 forecast
- **VERI mode** to see how the models are doing in real time, based on a detailed comparison of model v observed (NHC/JTWC-analyzed) (p)TCs
- in **WPAC/EPAC 2013** models had **100%** correct genesis forecasts at **D+2** reduces to ~80% at D+5
- **LANT 2013** genesis forecasts much **less skillful**, perhaps because the season had the lowest hurricane ACE in the last 48 years…
- a **comprehensive** and vetted **dataset** of **pTCs** – 1999-2014
- **verification** of **pTC** forecasts, **analyzed model TCs**, **7-d forecasts**…

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- a **comprehensive** and vetted **dataset** of **pTCs** – 1999-2014
- **next steps: spuricanes, verification** of **pTC** forecasts, **analyzed model TCs**, **7-d forecasts**…

Thank You
Mahalo
どうもありがとう　ございます

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“dough-moe a-**rig**-e-toe”

as Uncle Bill would say