

Satellite Image Characteristics of Intense Tropical Cyclones

Roger B Weldon May 2008

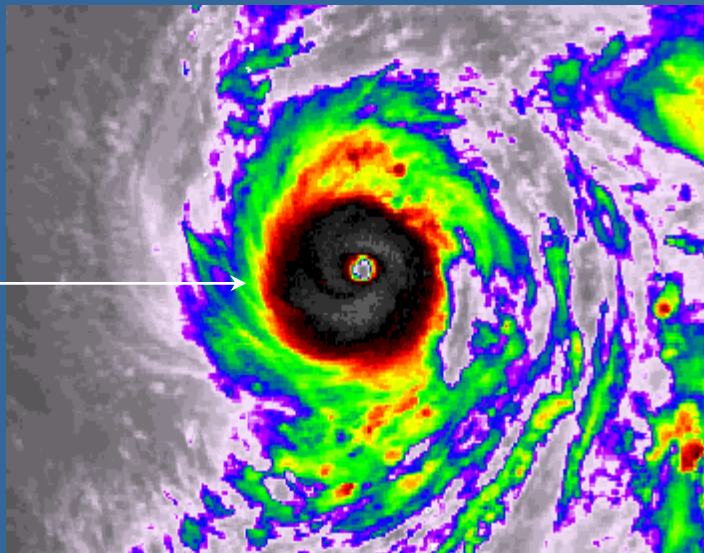
CDO

Central Dense
Overcast

Black Region

Min T -81 C

300mb AVN Winds
15z 15 Aug 02



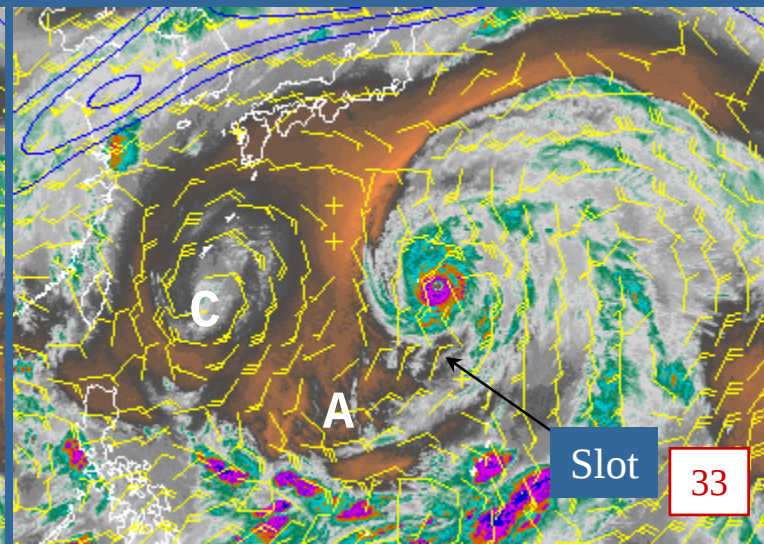
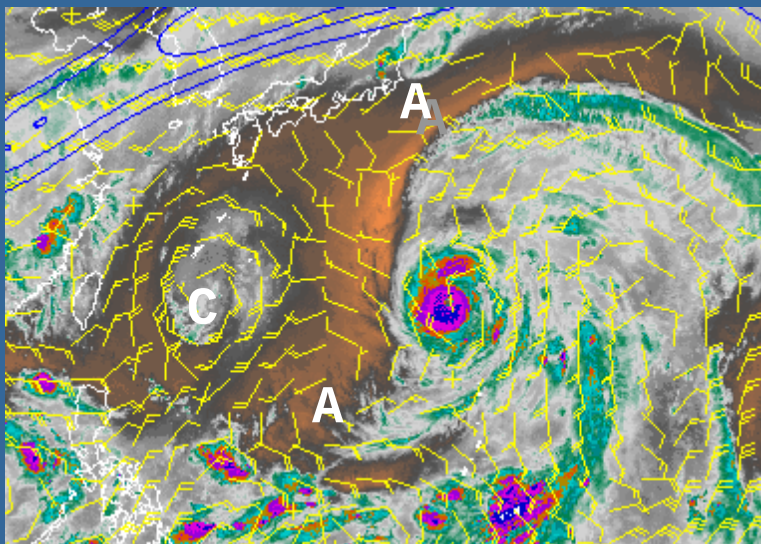
Typhoon Phanfone

130 knots Intensity

IR Image 1232z
15 August 2002



300mb AVN Winds
21z 15 Aug 02



Slot

33

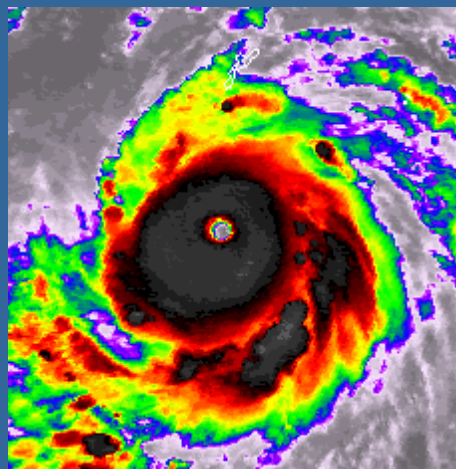
CDO Conditions Observed with Strong Tropical Cyclones

CDO conditions are compared for 26 tropical cyclones of intensity 140 kts or higher

IND-07 Sidr is an exception at 135 knots; however, only the real time “operational” data were available (Surely the intensity will be increased with the final “best track” data. The storm had Wilma characteristics during it’s second deepening phase I estimate the intensity at 150 kts or greater, based upon comparison with other strong storms

Storm	Intensity	IR Temperatures		WV Temp		Time/Date of Image
		Eye	CDO	Eye	CDO	
TA-05 Wilma	160 kts	- 7 C	-86 C	-26 C	-86 C	1215z 19 Oct 05
WP-04 Dianmu	155 kts	-21 C	-89 C	-46 C	-85 C	0825z 16 Jun 04
SWP-02 Zoe	155 kts	+17 C	-85 C	-20 C	-86 C	1132z 27 Dec 02
WP-04 Chaba	155 kts	+20 C	-82 C	-23 C	-79 C	2249z 23 Aug 04
TA-05 Rita	155 kts	+20 C	-82 C	-13.5C	-80 C	0332z 21 Sep 05
WP-01 Faxai	155 kts	+10 C	-78 C	-22 C	-86 C	0032z 23 Dec 01
TA-98 Mitch	155 kts	+18 C	-80 C	-18 C	-77 C	2015z 26Oct 98
WP-03 Maemi	150 kts	+19 C	-79 C	-21 C	-77 C	0002z 10 Sep 03
TA-05 Katrina	150 kts	+21 C	-75 C	-18 C	-74 C	1815z 28 Aug 05
IND-07 Sidr	150 kts *	- 20 C	-88 C	-39 C	-85 C	0000z 15 Nov 07
EP-02 Kenna	145 kts	00 C	-82C	-31C	-82 C	0600z 25 Oct 02
WP-02 Fengshen	145 kts	+16 C	-79 C	-17 C	-79 C	1332z 21 July 02
TA-04 Ivan	145 kts	+15 C	-80 C	-22	-79 C	0045z 12 Sep 04
TA-03 Isabel	145 kts	+20 C	-77 C	-19 C	-77 C	1915z 11 Sep 03
WP-03 Lupit	140 kts	+17 C	-85 C	-32 C	-81 C	0825z 26 Nov 03
WP-05 Haitang	140 kts	+21 C	-81 C	-27 C	-78 C	1049z 16 July 05
WP-05 Nabi	140 kts	+18 C	-79 C	-25 C	-79 C	1802z 01 Sep 05
WP-00 Bilis	140 kts	+15 C	-81 C	-20 C	-86 C	2132z 21 Aug 00
WP-00 Saomai	140 kts	+17 C	-79 C	-13 C	-79 C	1132z 10 Sep 00
SIO-02 Hary	140 kts	+13 C	-86 C	-23 C	-78 C	1730z 9 Mar 02
SIO-03 Kalunde	140 kts	+18 C	-76 C	-20 C	-71 C	0600z 8 Mar 03
SWP-02 Heta	140 kts	-21 C	-91 C	n/a	n/a	0225z 5 Jan 04
WP-01 Podul	140 kts	+16 C	-78 C	-15 C	-86 C	1232z 25 Oct 01
WP-02 Mitag	140 kts	+12 C	-85 C	-25 C	-86 C	0932z 5 Mar 02
WP-04 Ma-on	140 kts	+17 C	-82C	-25 C	-82 C	0325z 8 Oct 04
TA-05 Emily	140 kts	+17 C	-76 C	-20 C	-76 C	0015z 17July05 ⁴

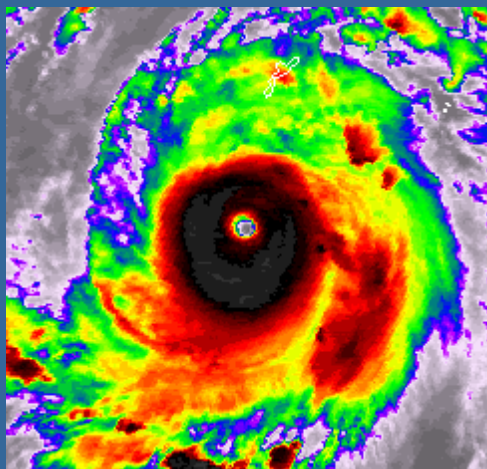
IR Imagery Display Curve and CDO (Central Dense Overcast) Temperatures



WP-03 Maemi IR (137 kts)
2002z 9 Sep 03

Max Eye Temp + 16 C

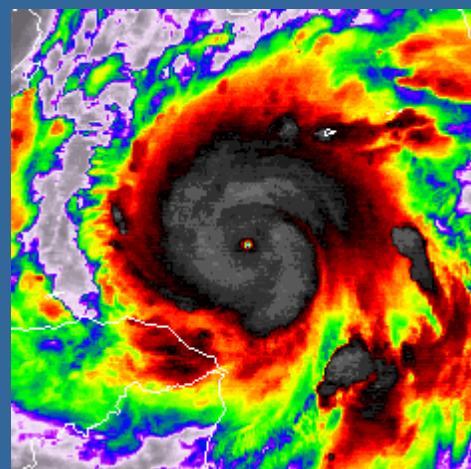
Min CDO Temp - 81 C



WP-03 Maemi IR 150 kts
0002z 10 Sep 03 24N Lat

+ 19 C

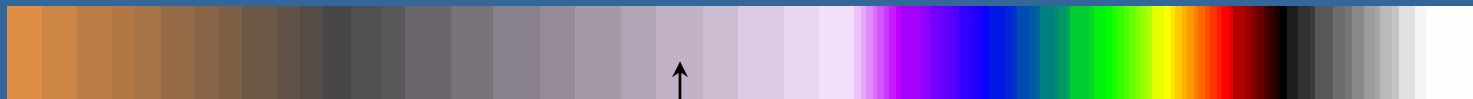
- 79 C



TA-05 Wilma IR 160 kts
1215z 19 Oct 05 17 N Lat

- 7 C

- 86 C



Warm Land



Zero C

Dark Red -70C

Black -79 C



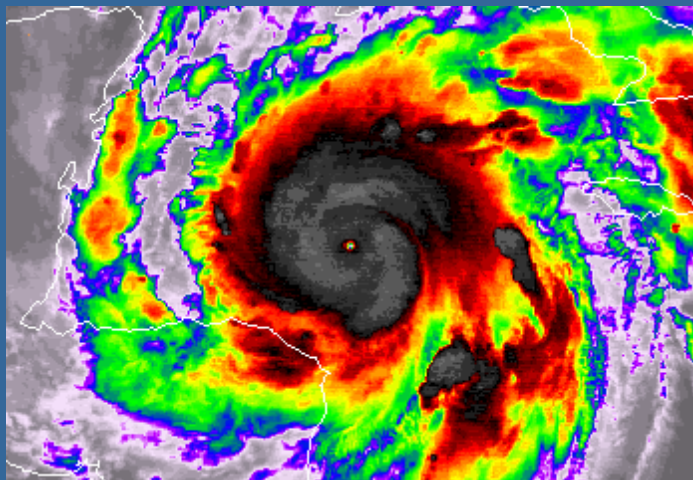
-81
-80 5

Storm comparisons at maximum intensity

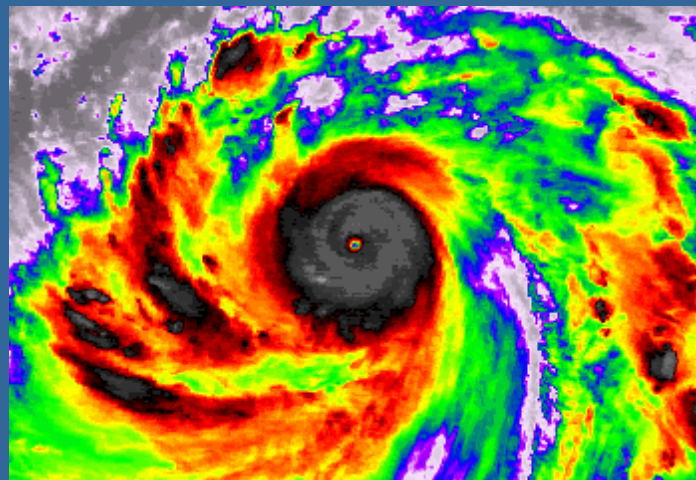
The following multiple panel images are all remapped to 4 kilometer resolution Sinusoidal Equal Area map projections. Each remap is centered on the eye of the storm.

Storm sizes are comparable, although they are located at different latitudes.

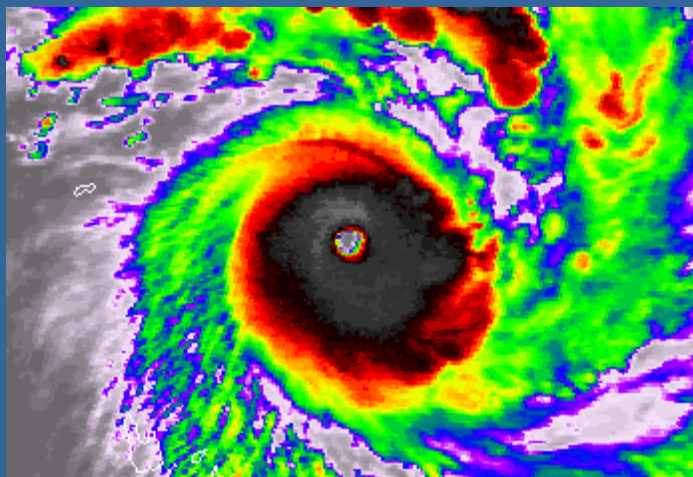
All images use the same IR display curve.



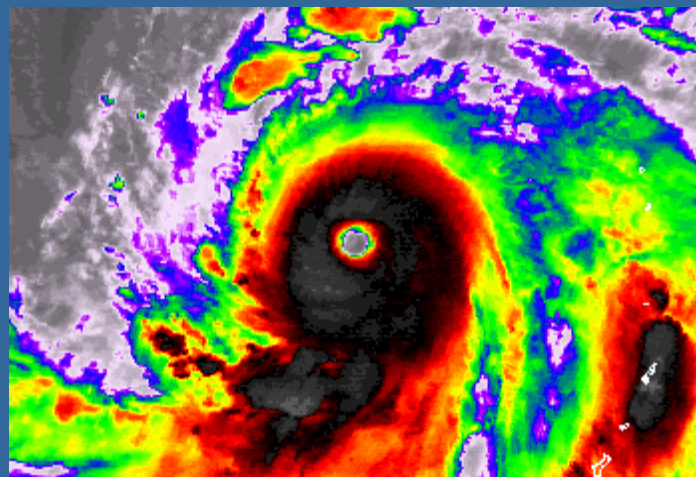
TA-05 Wilma 1215z 19 Oct 05 160 kts



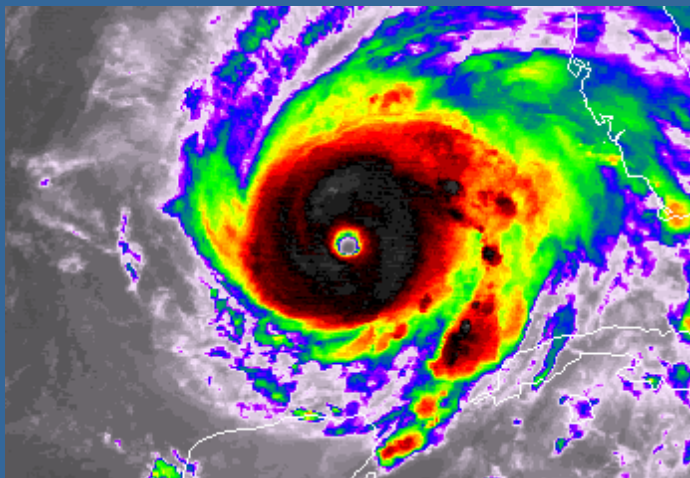
WP-04 Dianmu 0825z 16 June 04 155 kts



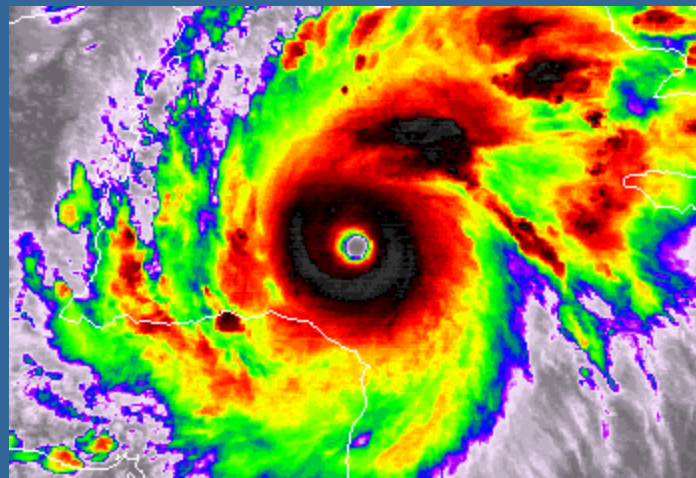
SWP-02 Zoe 1132z 27 Dec 02 155 kts



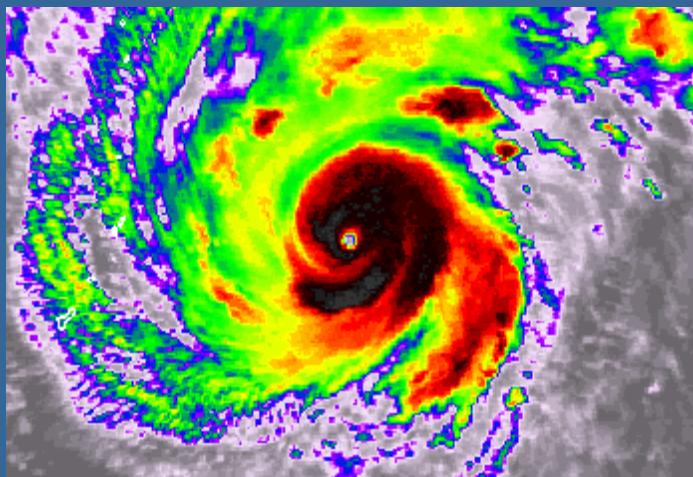
WP-04 Chaba 2249z 23 Aug 04 155 kts



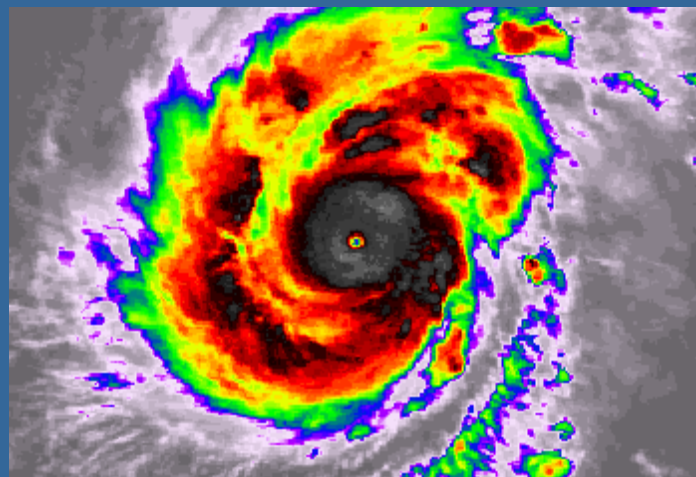
TA-05 Rita 0332z 22 Sep 05 155 kts



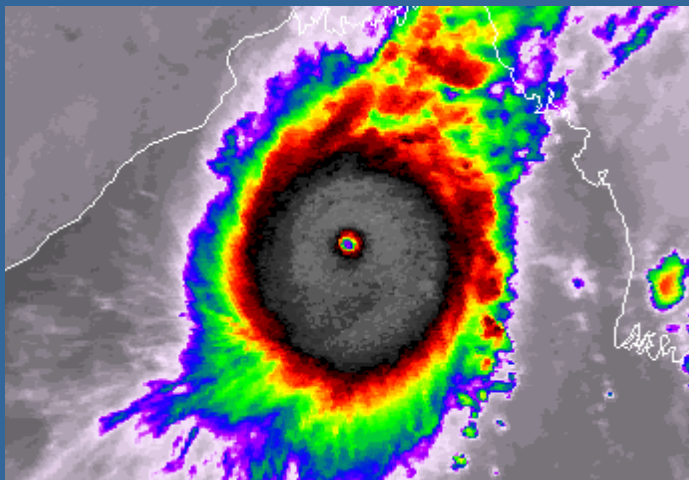
TA-98 Mitch 2015z 26 Oct 98 155 kts



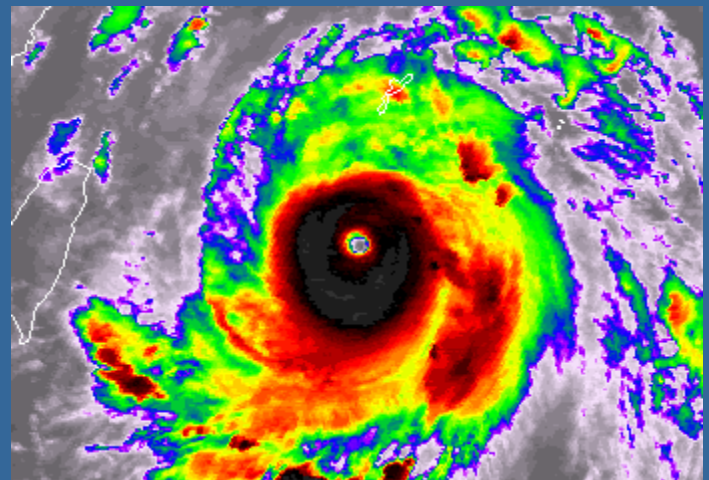
WP-01 Faxai 0032z 23 Dec 01 155 kts



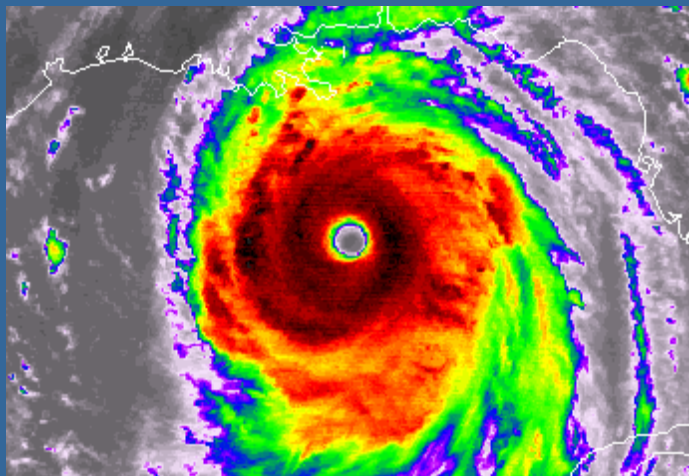
WP-01 Faxai 1232z 22 Dec 01 140 kts



IND-07 Sidr 0000z 15 Nov 07 150 kts **

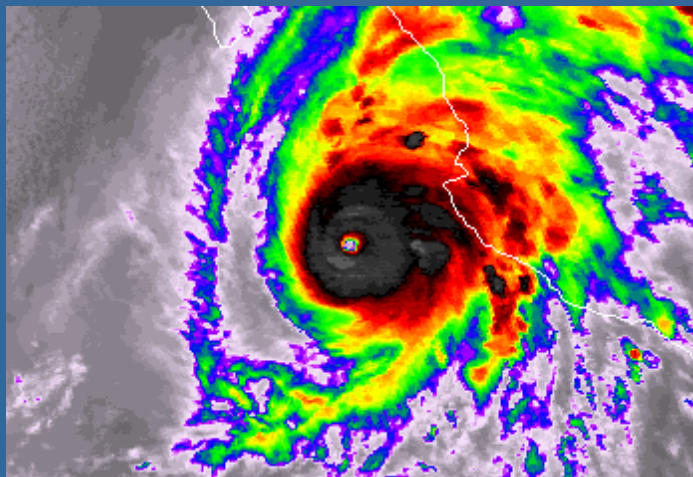


WP-03 Maemi 0002z 10 Sep 03 150 kts

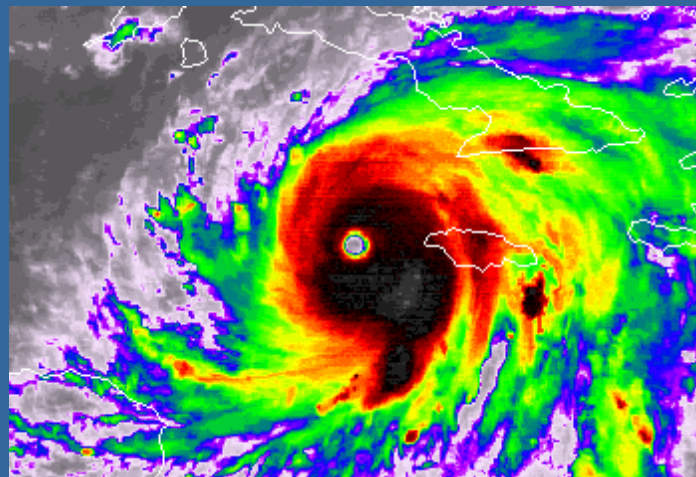


TA-05 Katrina 1815z 28 Aug 05 150 kts

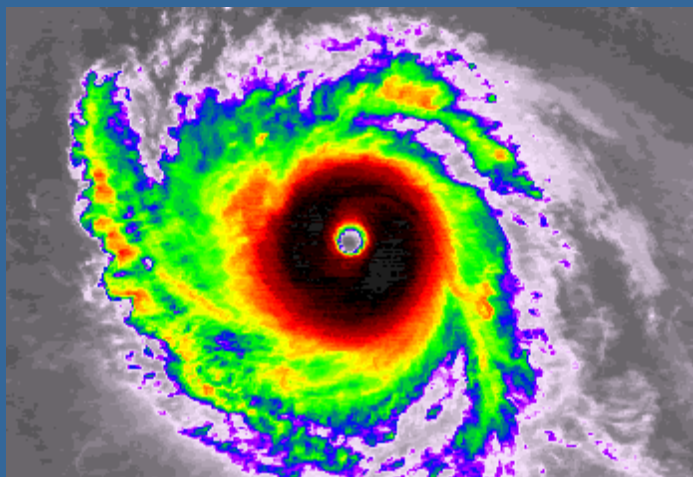
** My intensity for Sidr
JTWC operation intensity 135 kts



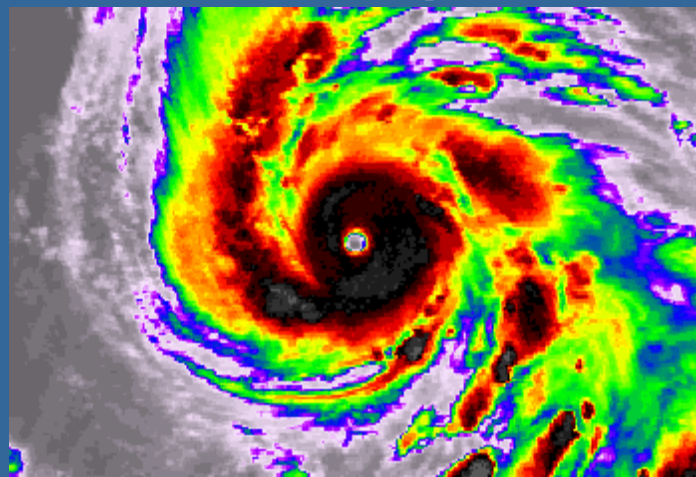
EP-02 Kenna 0600z 25 Oct 02 145 kts



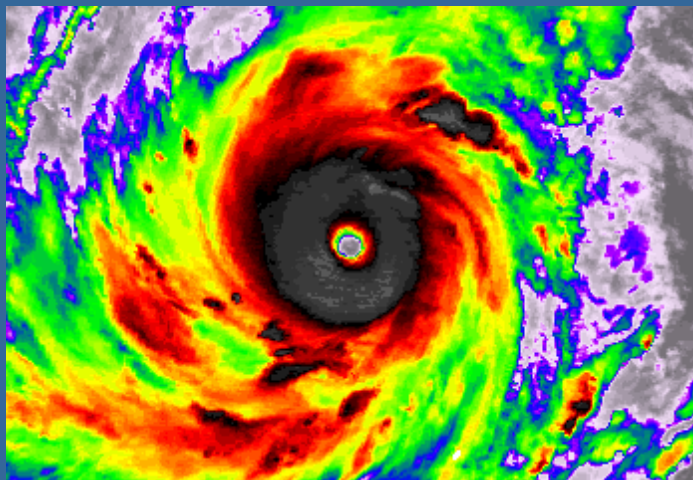
TA-04 Ivan 0045z 12 Sep 04 145 kts



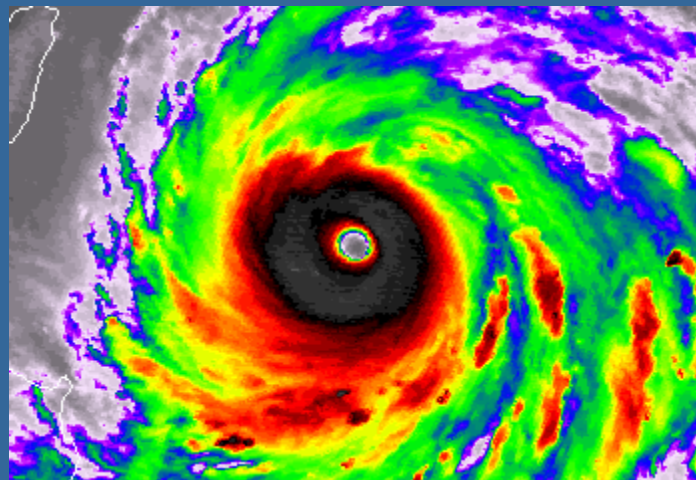
TA-03 Isabel 1915z 11 Sep 03 145 kts



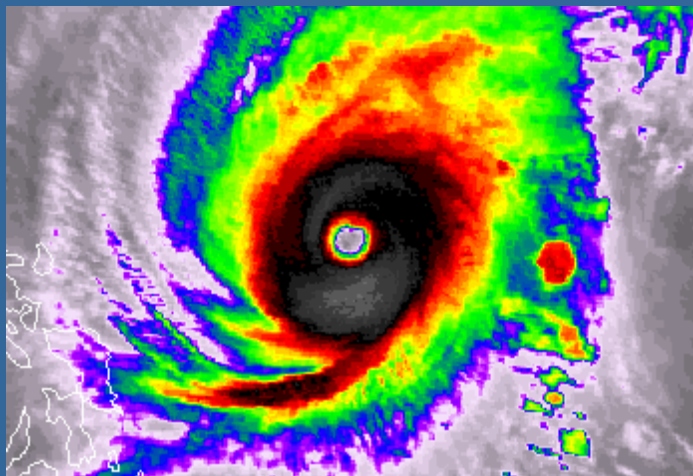
WP-02 Fengshen 1332z 21 July 02 145 kts



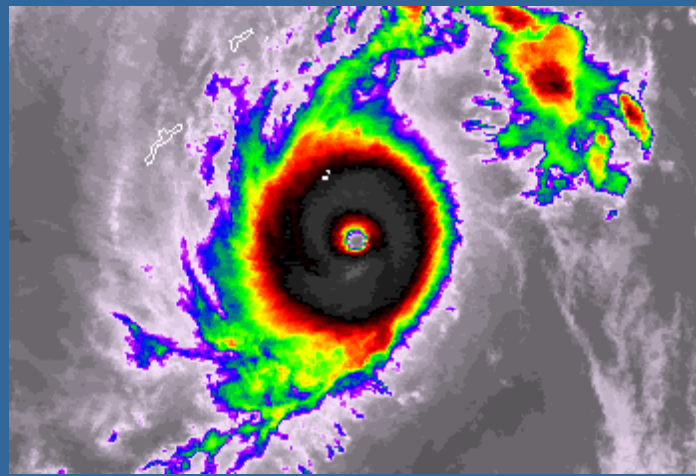
WP-03 Lupit 0825z 26 Nov 03 140 kts



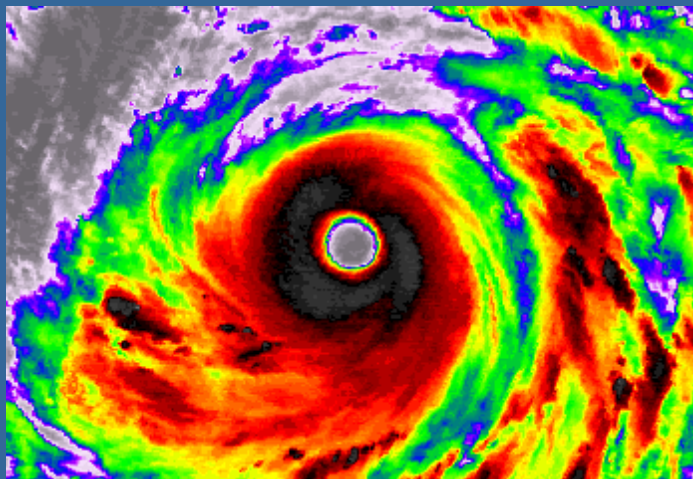
WP-05 Haitang 1049z 17 July 05 140 kts



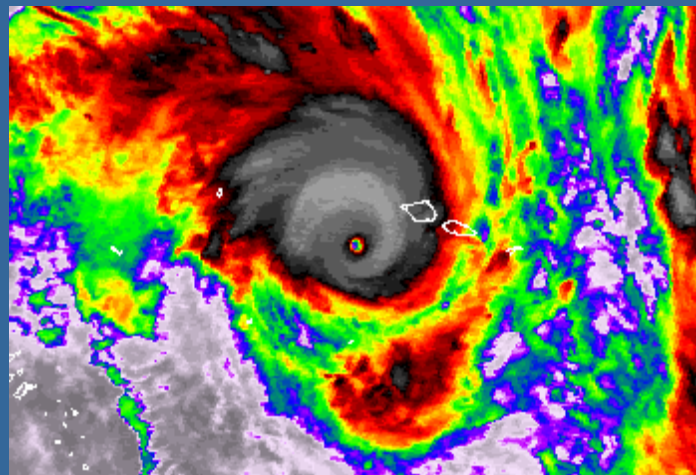
WP-02 Mitag 0932z 5 Mar 02 140 kts



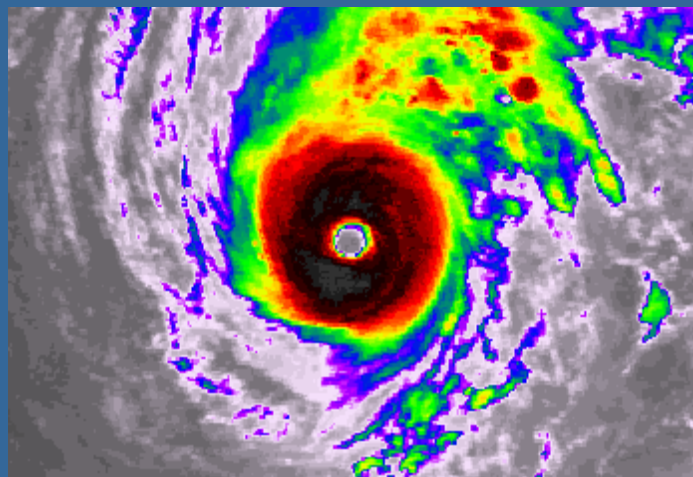
WP-04 Ma-on 0325z 8 Oct 04 140 kts



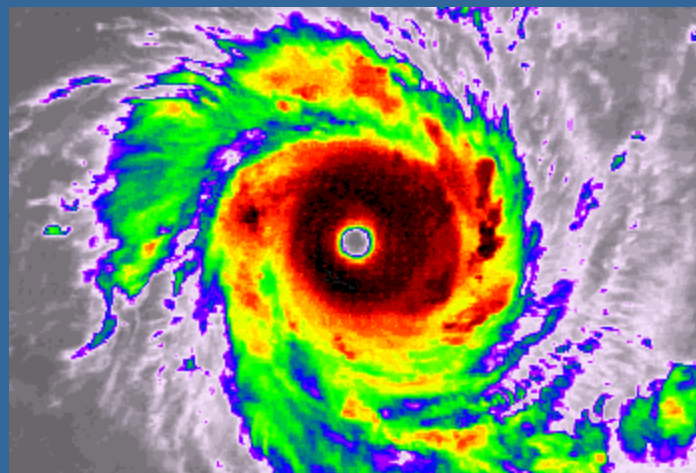
WP-05 Nabi 1802z 1 Sep 05 140 kts



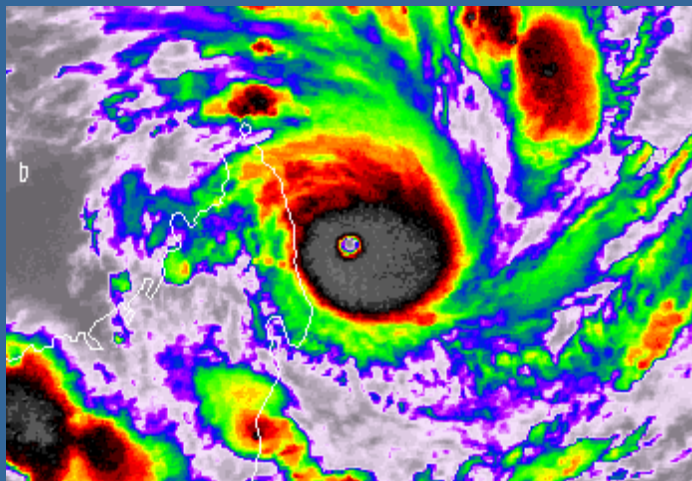
SWP--4 Heta 0225z 5 Jan 04 140 kts



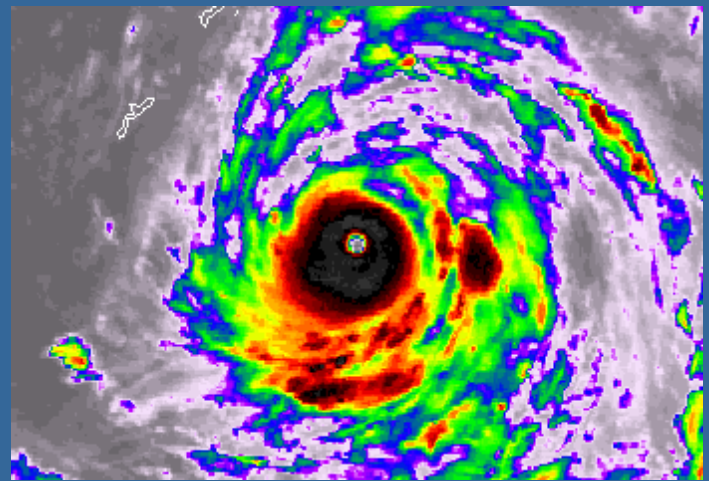
WP-01 Podul 1232z 25 Oct 01 140 kts



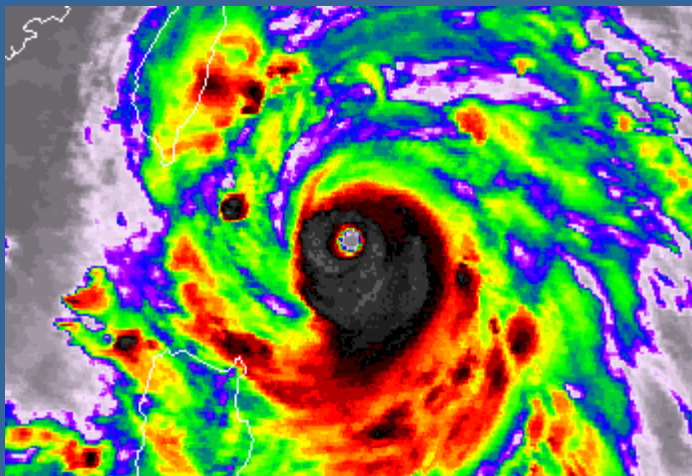
SIO-03 Kalunde 0600z 8 Mar 03 140 kts



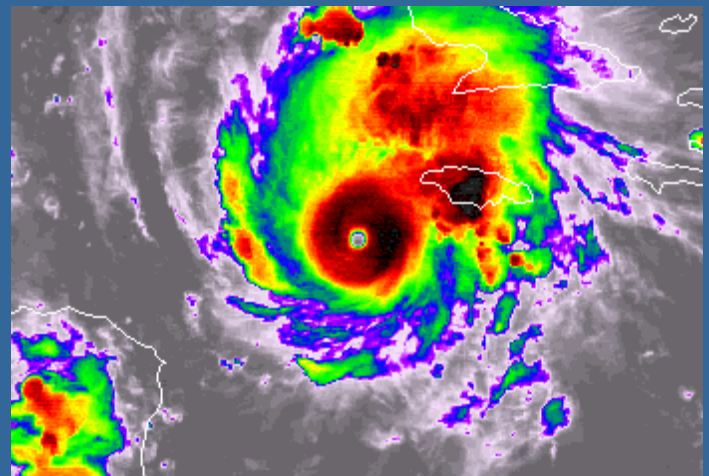
SIO-02 Hary 1730z 9 Mar 02 140 kts



WP-00 Saomai 1132z 10 Sep 00 140 kts



WP-00 Bilis 2132z 21 Aug 00 140 kts



TA-05 Emily 0015z 17 July 05 140 kts

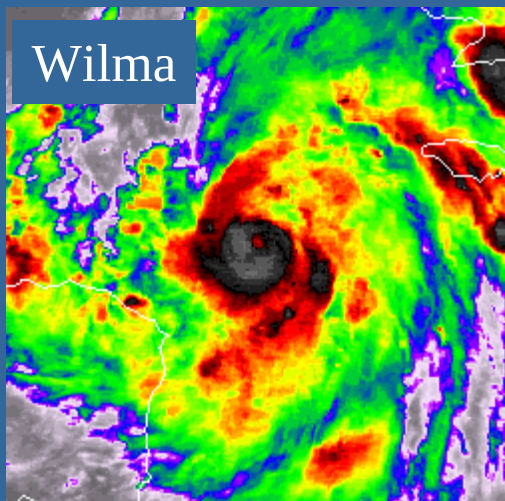
“Wilma Type” Storms

- Wilma Class
1. Very rapid intensification
 2. Very cold CDO top temperatures
 3. Very small eye diameter
 4. Storm track of eye - spiraled or looping pattern
 5. Relatively cool maximum eye temperatures
(likely due to eye size and angle of satellite view)

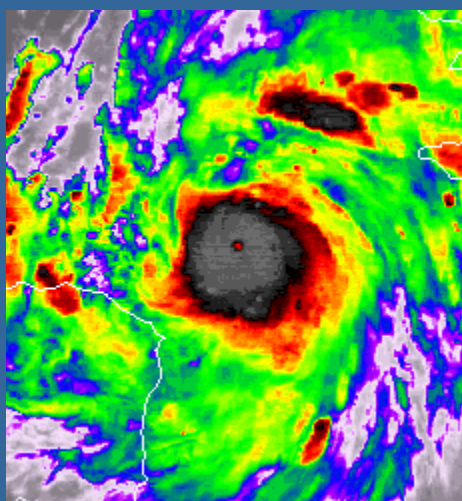
Storms in this category: TA-05 Wilma
WP-04 Dianmu
SWP-02 Heta
IND-07 Sidr
WP-01 Faxai

Perhaps: SWP-02 Zoe (eye size?)
SIO-02 Hary (second intensification)

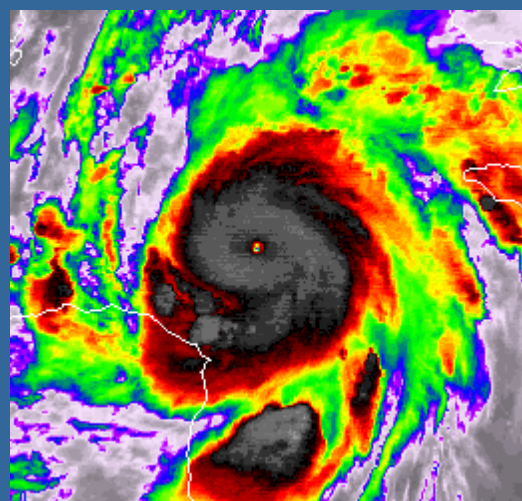
Wilma



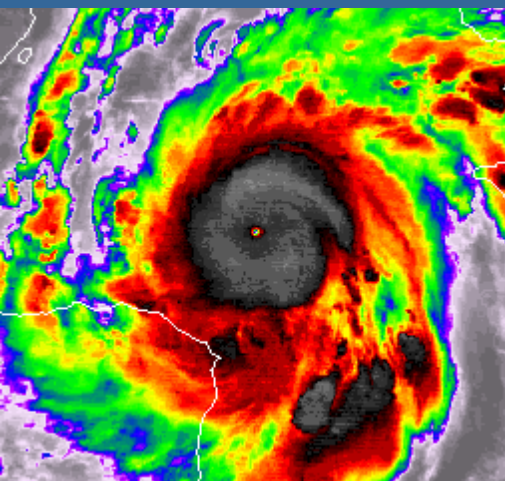
Wilma 2115z 18 Oct 05 (105kts)



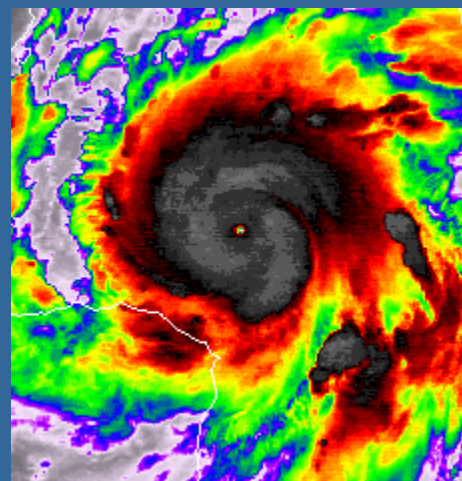
0015z 19 Oct 05 130 kts



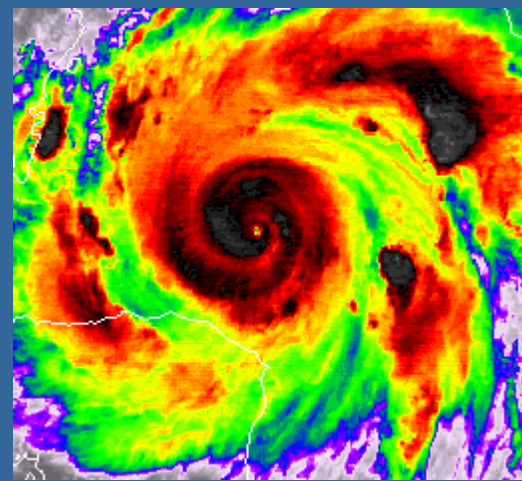
0615z 19 Oct 05 150 kts



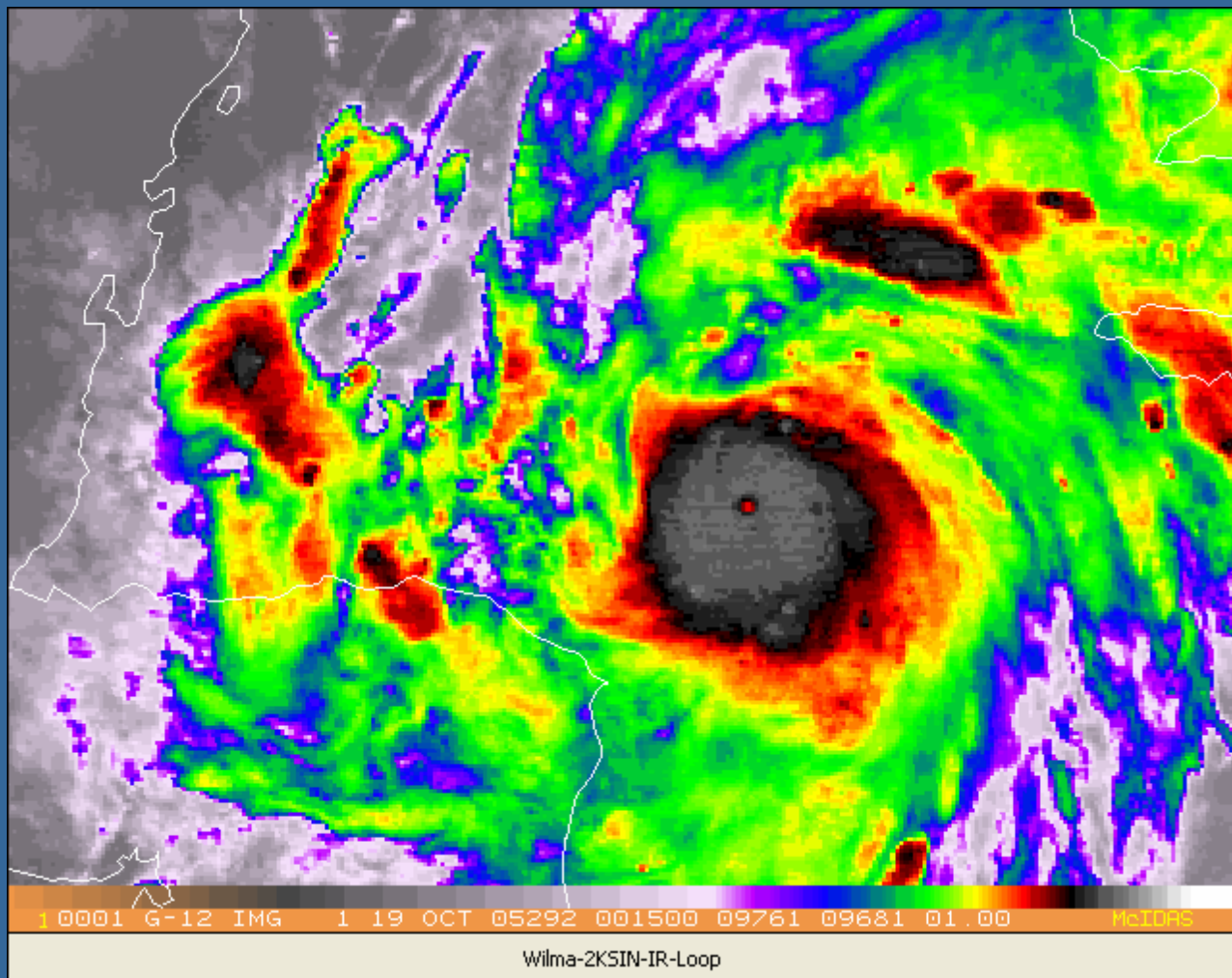
0915z 19 Oct 05 (155 kts)

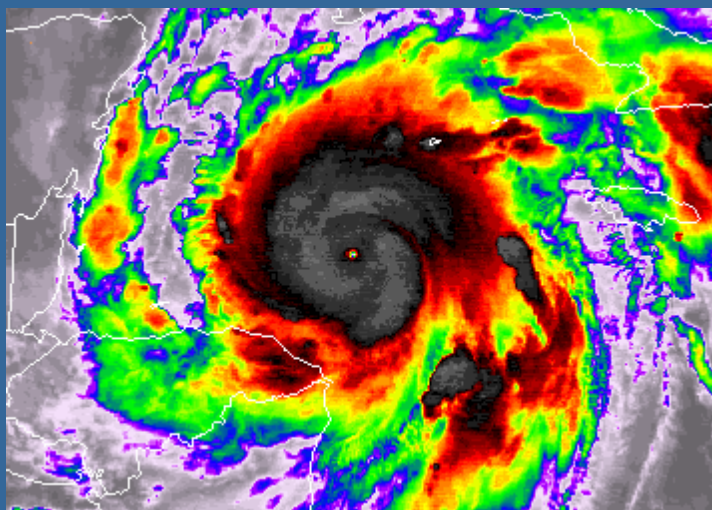


1215z 19 Oct 05 160 kts

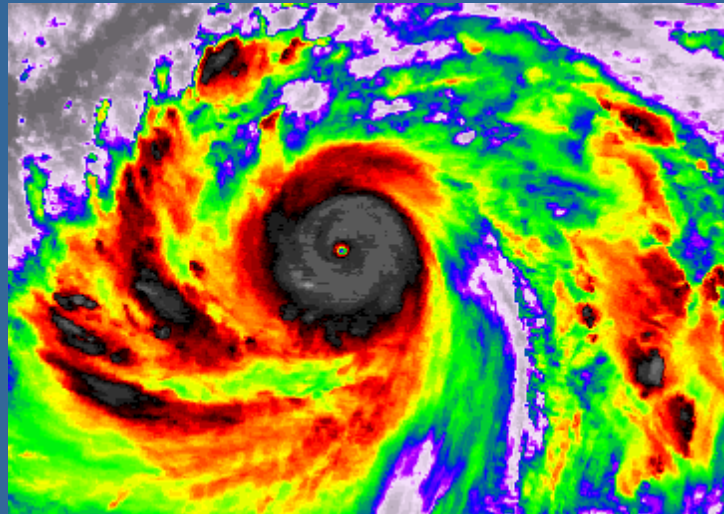


1815z 19 Oct 05 140 kts

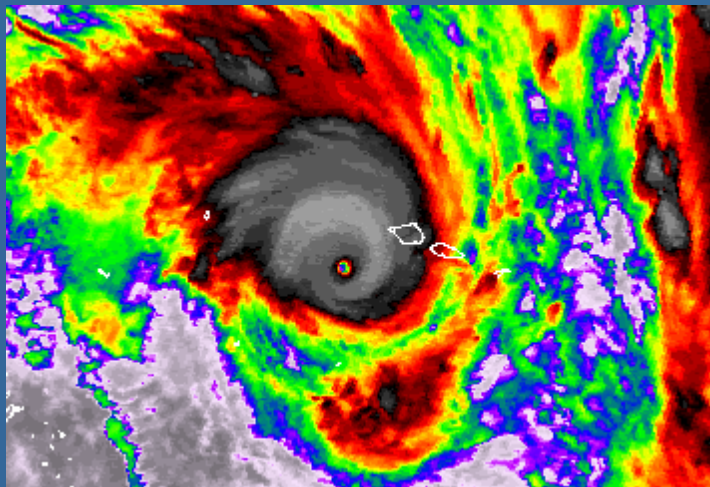




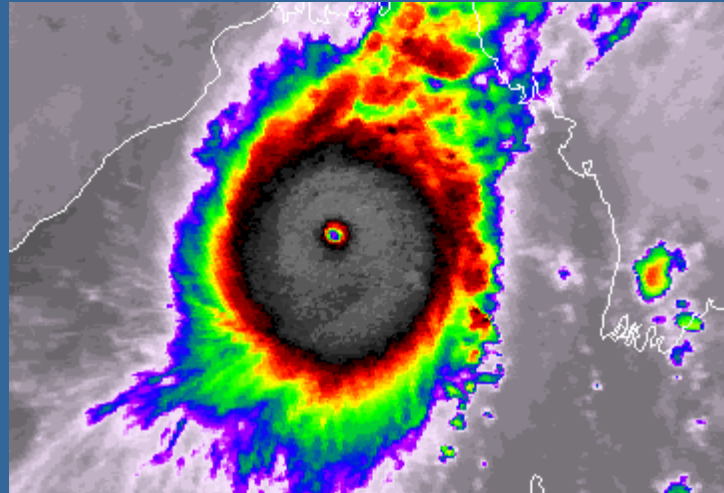
TA-05 Wilma 160 knots 1215z 19 Oct 05



WP-04 Dianmu 155 knots 0602z 16 June 04

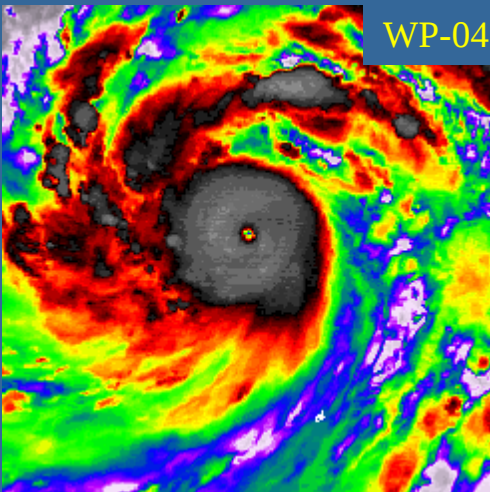


SWP-04 Heta 140 knots 0025z 5 Jan 04

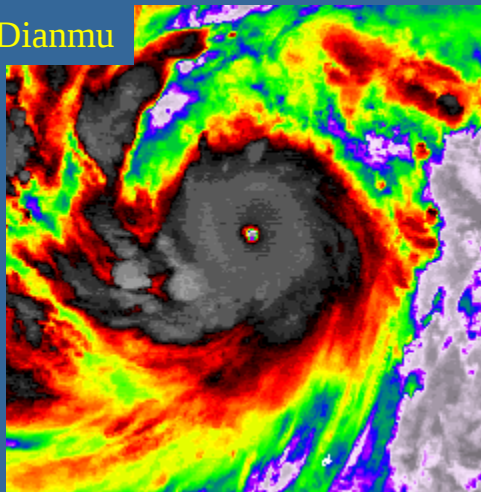


IND-07 Sidr 130 Kts** 0000z 15 Nov 07

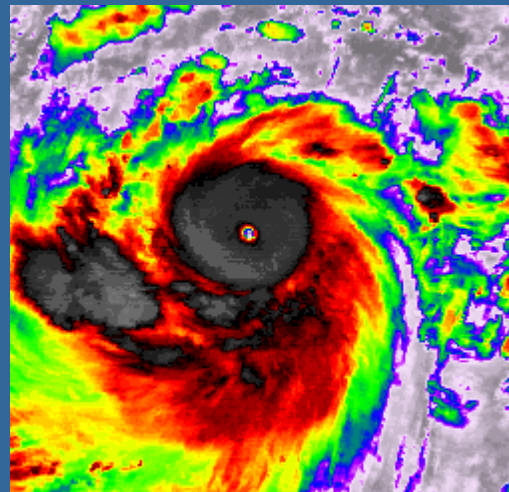
WP-04 Dianmu



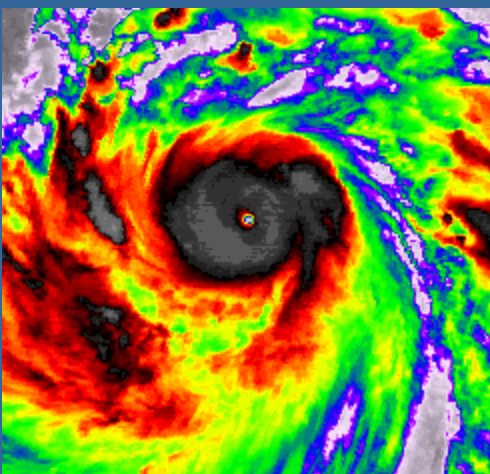
1202z 15 June 04 120 knots



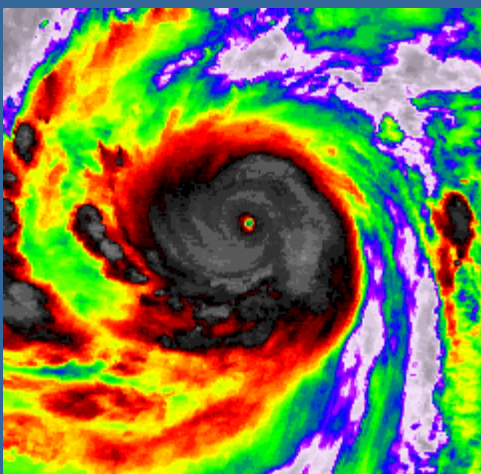
1802z 15 June 04 145 knots



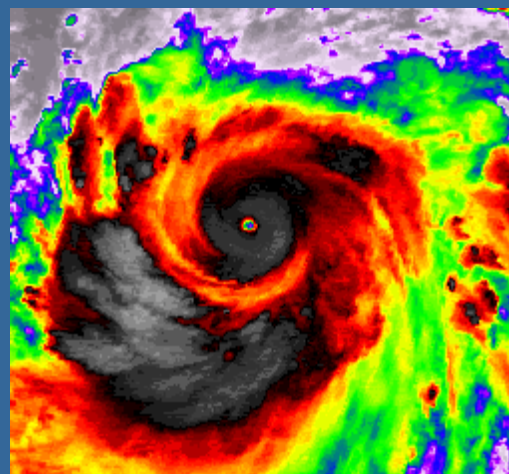
0002z 16 June 04 150 knots



0602z 16 June 04 155 knots

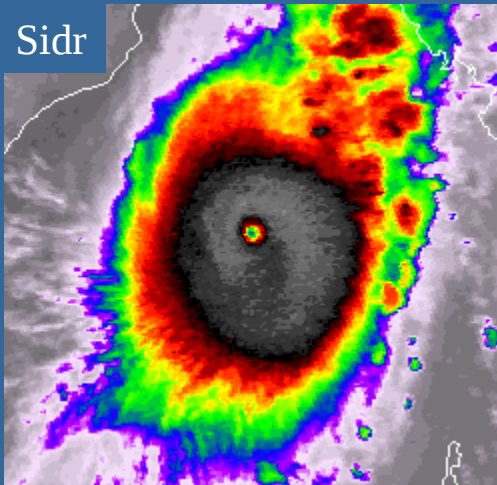


1202z 16 June 04 155 knots

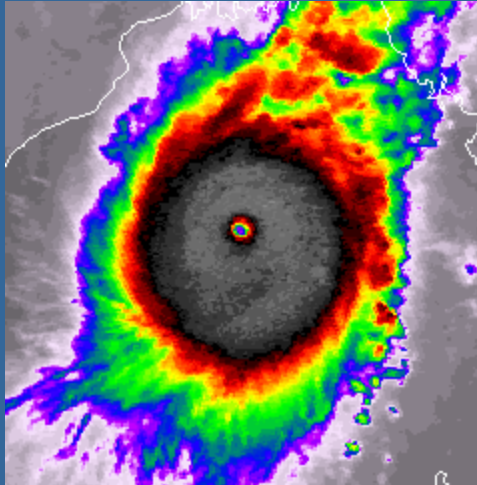


1802z 16 June 04 155 knots

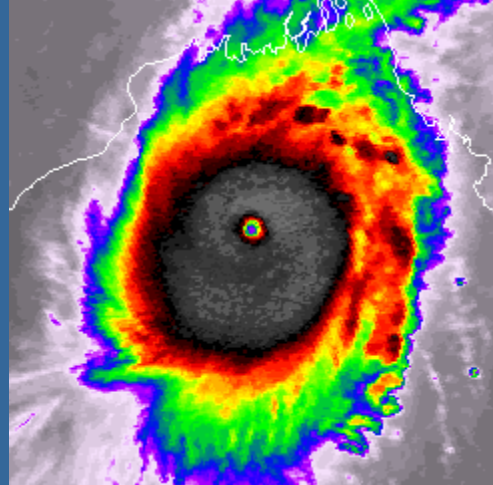
Sidr



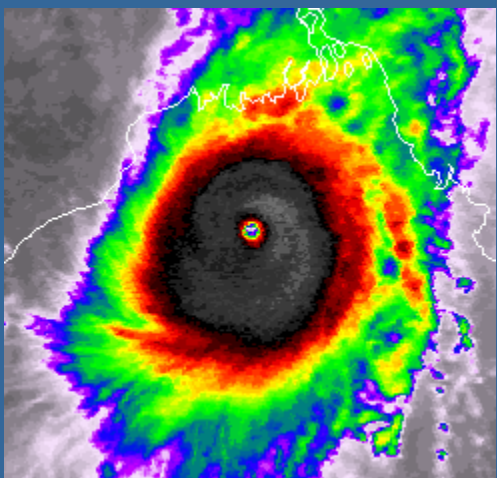
2100z 14 Nov 07



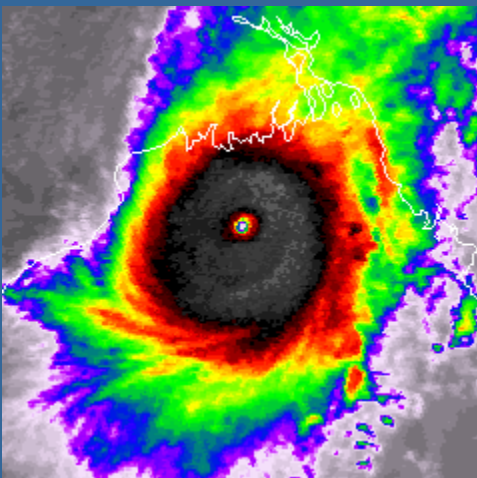
0000z 15 Nov 07



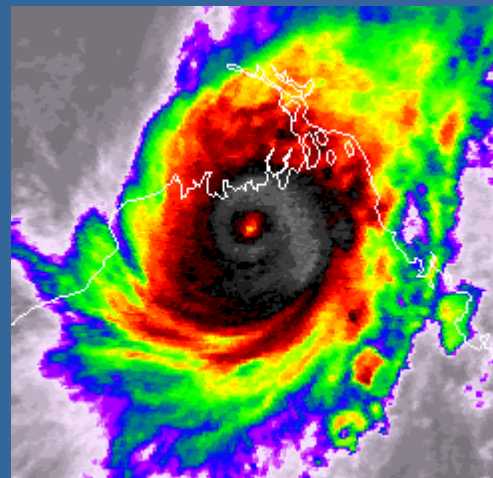
0300z 15 Nov 07



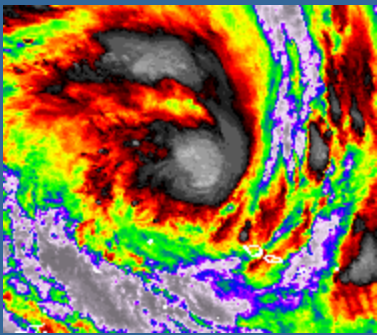
0600z 15 Nov 07



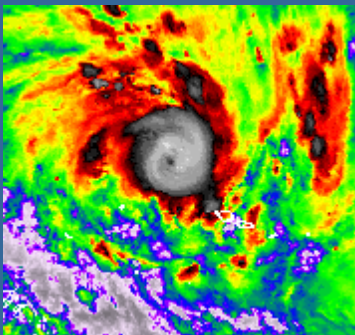
0900z 15 Nov 07



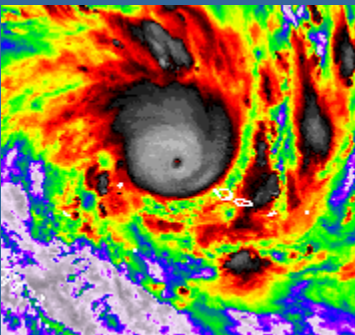
1200z 15 Nov 07



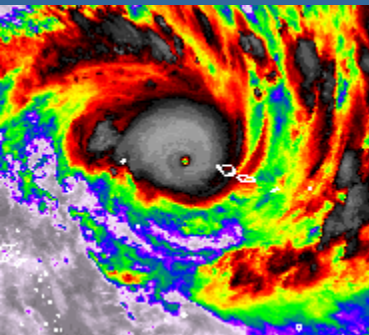
0025z 4 Jan 04 75kts



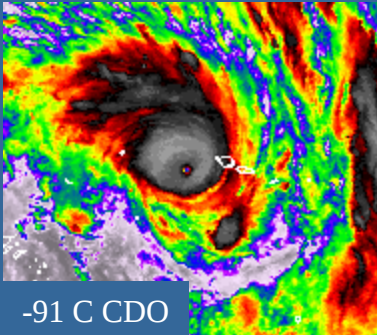
0625z 4 Jan 04 85 kts



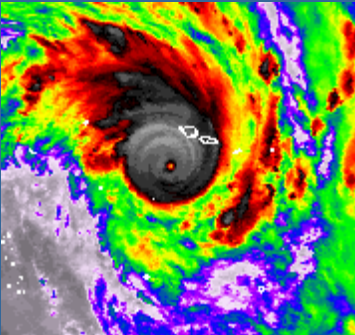
1225z 4 Jan 04 105 kts



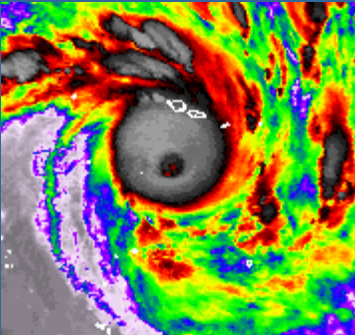
1825z 4 Jan 04 125 kts



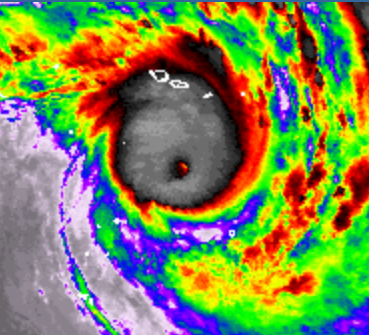
0025z 5 Jan 04 140 kts



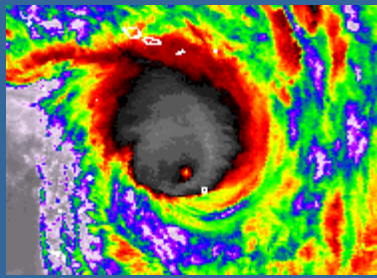
0625z 5 Jan 04 140 kts



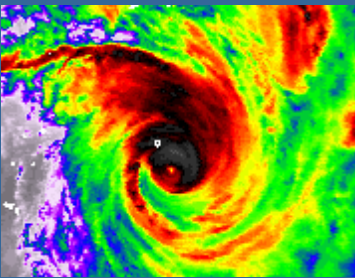
1225z 5 Jan 04 140 kts



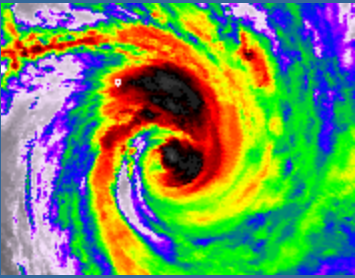
1825z 5 Jan04 130 kts



0025z 6 Jan 04 130 kts



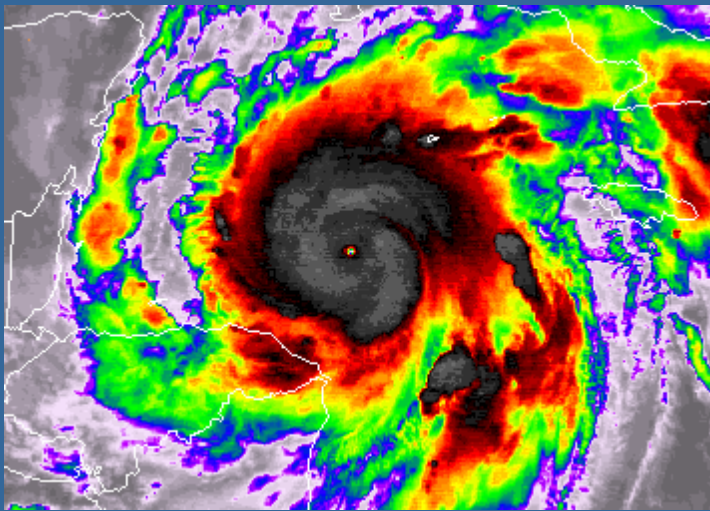
0625z 6 Jan 04 120 kts



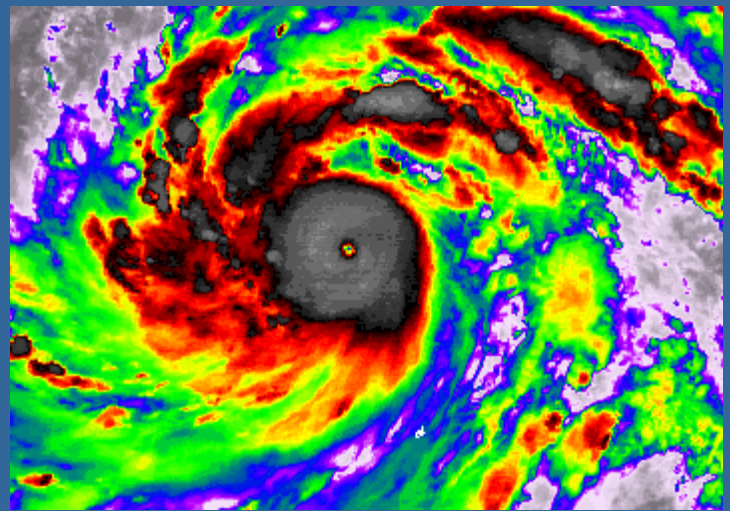
1225z 6 Jan 04 (110 kts)

SWP-04 Heta

Mercator Projections

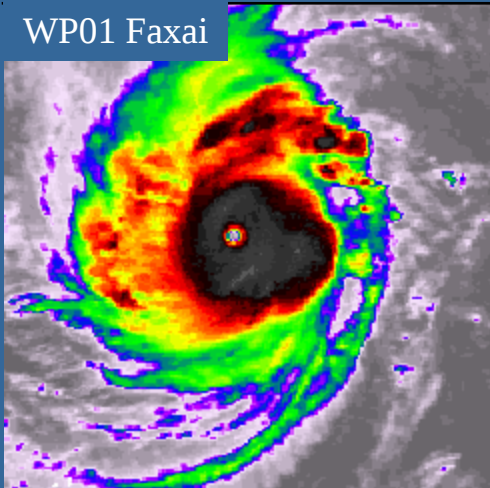


TA-05 Wilma 160 knots 1215z 19 Oct 05

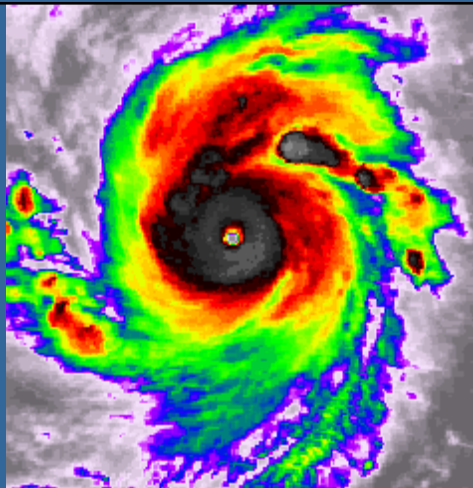


WP-04 Dianmu 120 knots 1202 15 June 04

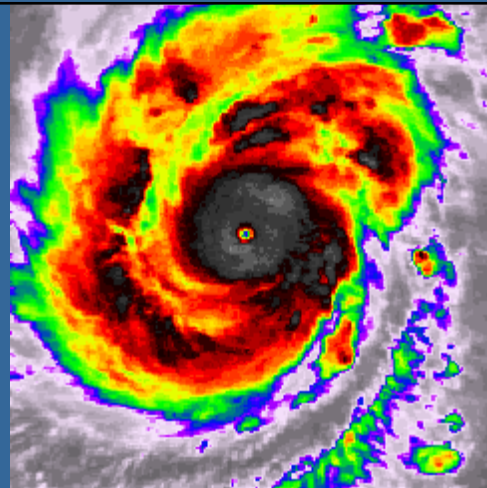
WP01 Faxai



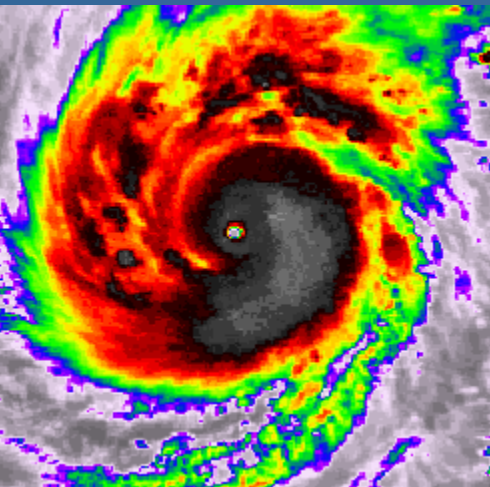
0032z 22 Dec 01 135 kts



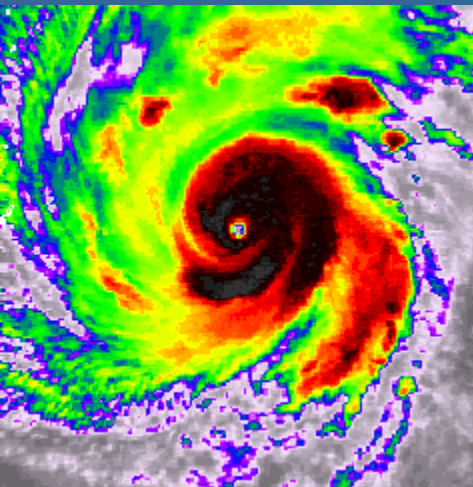
0632z 22 Dec 01 140 kts



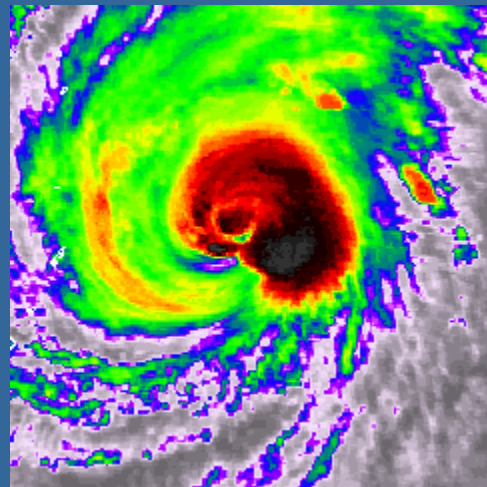
1232z 22 Dec 01 140 kts



1832z 22 Dec 01 150 kts



0032z 23 Dec 01 155 kts



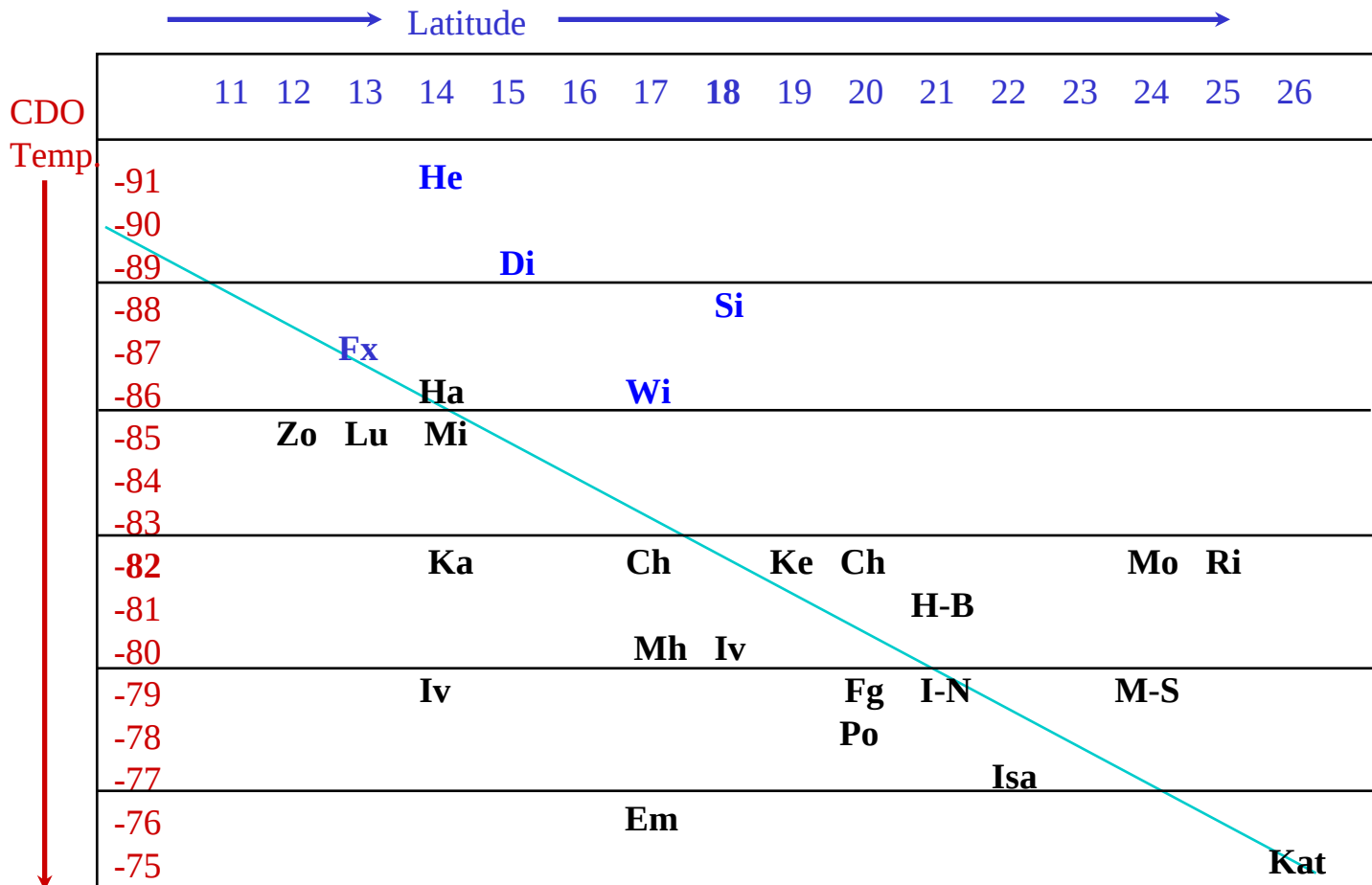
0632z 23 Dec 01 150 kts

CDO Temperatures VS Latitude of Storms

Minimum CDO temperatures measured by IR brightness temperatures are compared to the latitude of the storm center at the time of the measurements.

Although there were 26 storms, there are 29 data points. Typhoon Chaba had two maximum intensity phases; and, Hurricane Ivan had three.

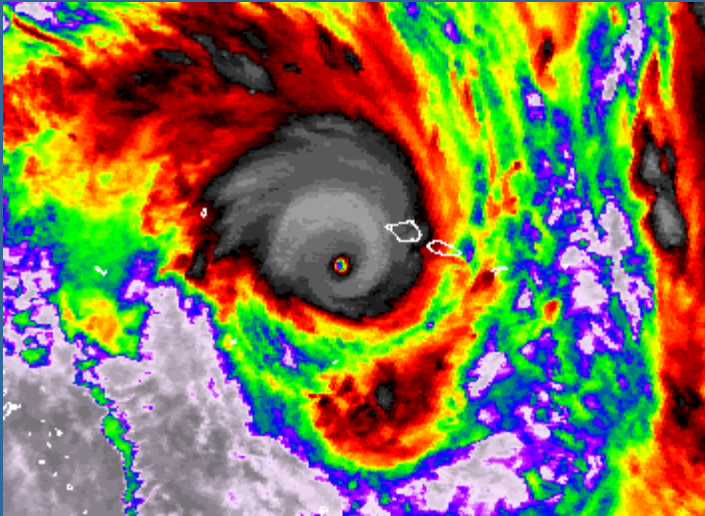
Storm	Intensity	Lat	IR Temperatures		WV Temp		Time/Date of Image
			Eye	CDO	Eye	CDO	
TA-05 Wilma	160 kts	17N	- 7 C	-86 C	-26 C	-86 C	1215z 19 Oct 05
WP-04 Dianmu	155 kts	15N	-21 C	-89 C	-46 C	-85 C	0825z 16 Jun 04
SWP-02 Zoe	155 kts	12S	+17 C	-85 C	-20 C	-86 C	1132z 27 Dec 02
WP-04 Chaba	155 kts	17N	+20 C	-82 C	-23 C	-79 C	2249z 23 Aug 04
TA-05 Rita	155 kts	25N	+20 C	-82 C	-13.5C	-80 C	0332z 11 Sep 05
WP-01 Faxai	155 kts	15N	+10 C	-78 C	-22 C	-86 C	0032z 23 Dec 01
TA-98 Mitch	155 kts	17N	+18 C	-80 C	-18 C	-77 C	2015z 26 Oct 98
WP-03 Maemi	150 kts	24N	+19 C	-79 C	-21 C	-77 C	0002z 10 Sep 03
TA-05 Katrina	150 kts	26N	+21 C	-75 C	-18 C	-74 C	1815z 28 Aug 05
IND-07 Sidr	150 kts *	18N	- 20 C	-88 C	-39 C	-85 C	0000z 15 Nov 07
EP-02 Kenna	145 kts	19N	00 C	-82C	-31C	-82 C	0600z 25 Oct 02
WP-02 Fengshen	145 kts	20N	+16 C	-79 C	-17 C	-79 C	1332z 21 July 02
TA-04 Ivan	145 kts	18N	+15 C	-80 C	-22 C	-79 C	0045z 12 Sep 04
TA-03 Isabel	145 kts	22N	+20 C	-77 C	-19 C	-77 C	1915z 11 Sep 03
WP-03 Lupit	140 kts	13N	+17 C	-85 C	-32 C	-81 C	0825z 26 Nov 03
WP-05 Haitang	140 kts	21N	+21 C	-81 C	-27 C	-78 C	1049z 16 July 05
WP-05 Nabi	140 kts	21N	+18 C	-79 C	-25 C	-79 C	1802z 01 Sep 05
WP-00 Bilis	140 kts	21N	+15 C	-81 C	-20 C	-86 C	2132z 21 Aug 00
WP-00 Saomai	140 kts	24N	+17 C	-79 C	-13 C	-79 C	1132z 10 Sep 00
SIO-02 Hary	140 kts	14S	+13 C	-86 C	-23 C	-78 C	1730z 9 Mar 02
SIO-03 Kalunde	140 kts	14S	+18 C	-76 C	-20 C	-71 C	0600z 8 Mar 03
SWP-02 Heta	140 kts	14S	-21 C	-91 C	n/a	n/a	0225z 5 Jan 04
WP-01 Podul	140 kts	20N	+16 C	-78 C	-15 C	-86 C	1232z 25 Oct 01
WP-02 Mitag	140 kts	14N	+12 C	-85 C	-25 C	-86 C	0932z 5 Mar 02
WP-04 Ma-on	140 kts	24N	+17C	-82C	-25 C	-82 C	0325z 8 Oct 0
TA-05 Emily	140 kts	17N	+17 C	-76 C	-20 C	-76 C	0015z17July05 ²⁴



Degrees
Celsius

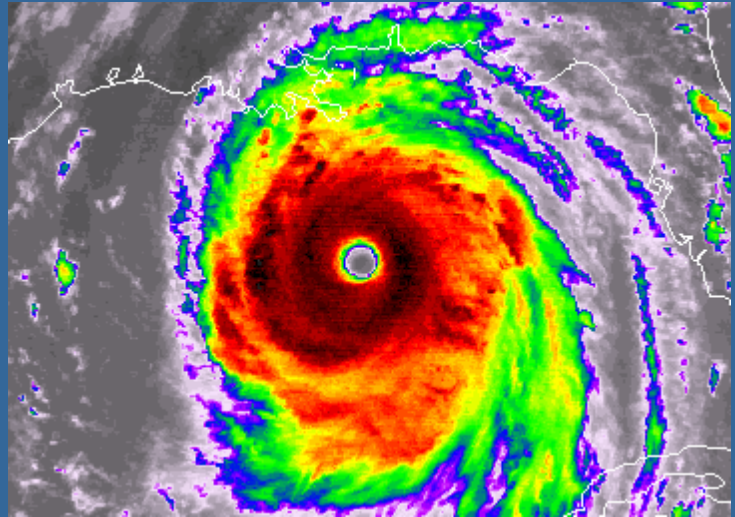
Blue Plots: Wilma type storms I-N = Ivan & Nabi M-S=Maemi & Saomai
H-B=Haitang & Bilis **Median Min Temp: -81.5C** **Median Latitude: 18 deg**
R Square Trendline = .38

Coldest and Warmest CDO Top Temperatures



SWP-04 Heta 140 knots 0025z 5 Jan 04

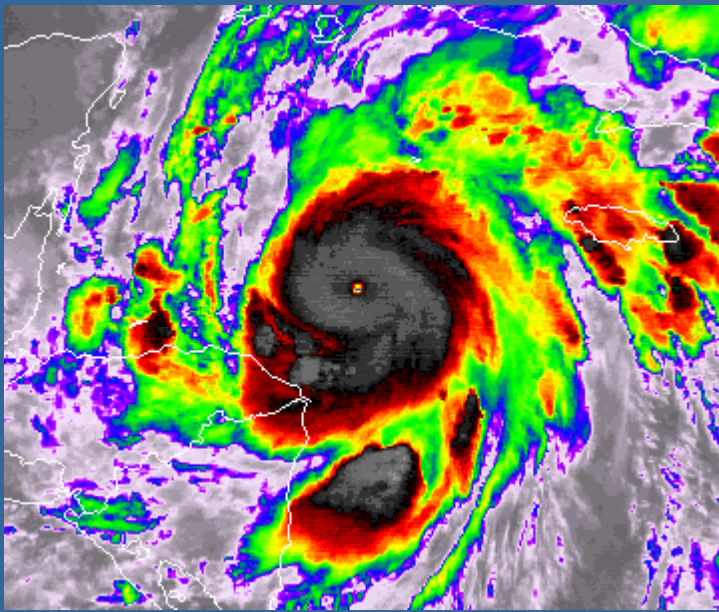
Min CDO Temp **-91 C** 14 S Lat



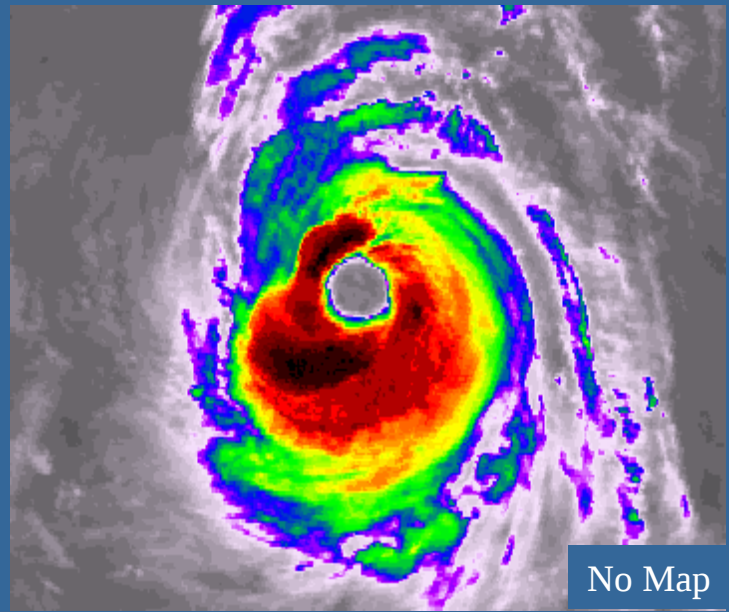
TA-05 Katrina 150 knots 1815z 28 Aug 05

Min CDO Temp **-75 C** 26 N Lat

Eye Diameters



TA-05 Wilma 0615z 19 Oct 05

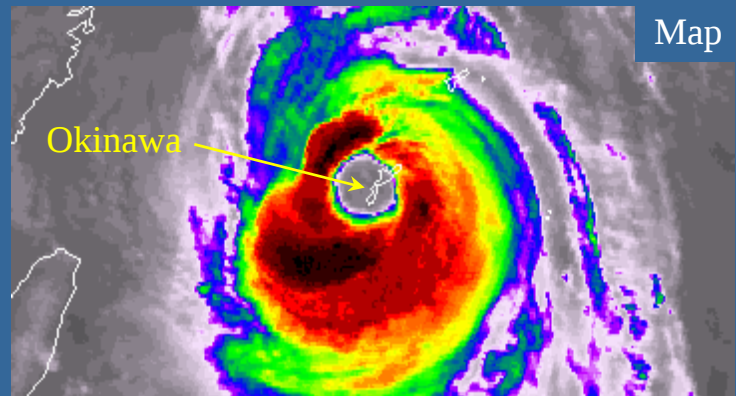


No Map

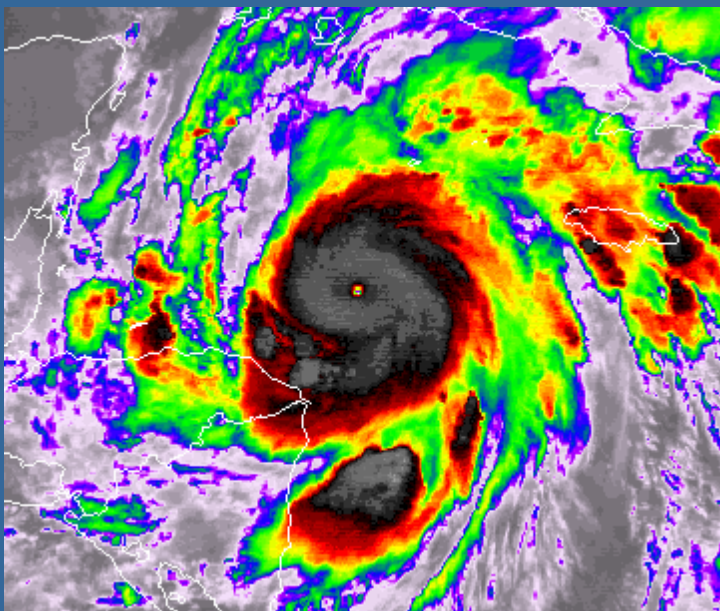
WP-02 Sinlaku 1547z 4 Sep 02

	Wilma	Sinlaku
Eye Diameter nautical miles	2	60
Storm Intensity knots	150	95

Both images remapped to 4 km resolution
Sinusoidal Equal Area Map Projections

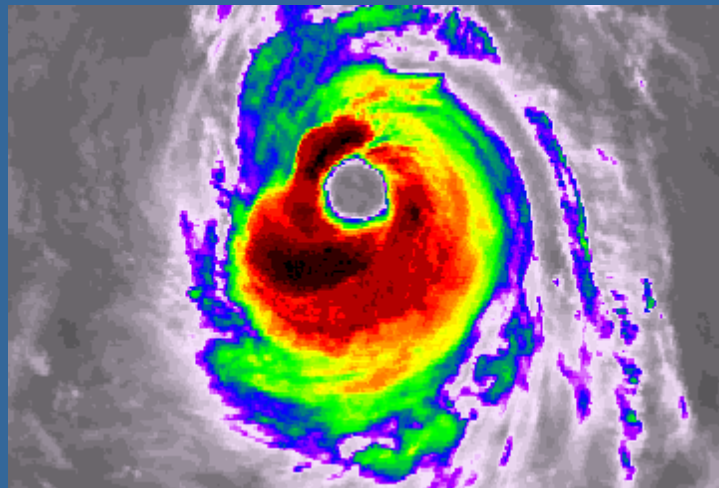


Map

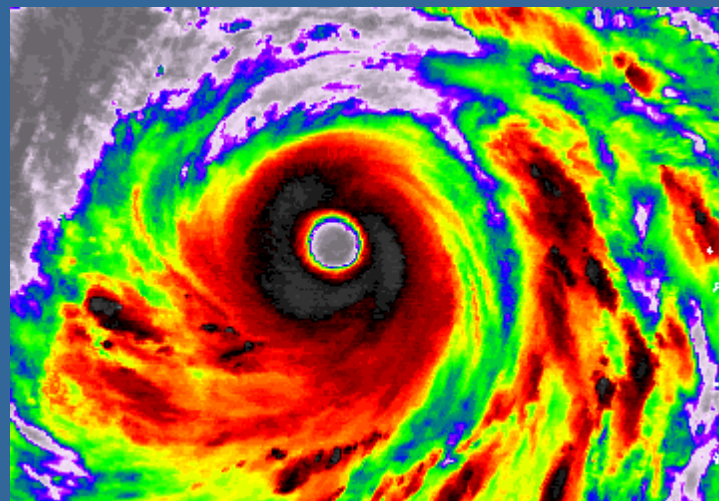


TA-05 Wilma 150 kts 0615z 19 Oct 05

Eye Diameters: Wilma 2 nm
 Sinlaku 60 nm
 Nabi 45 to 50 nm



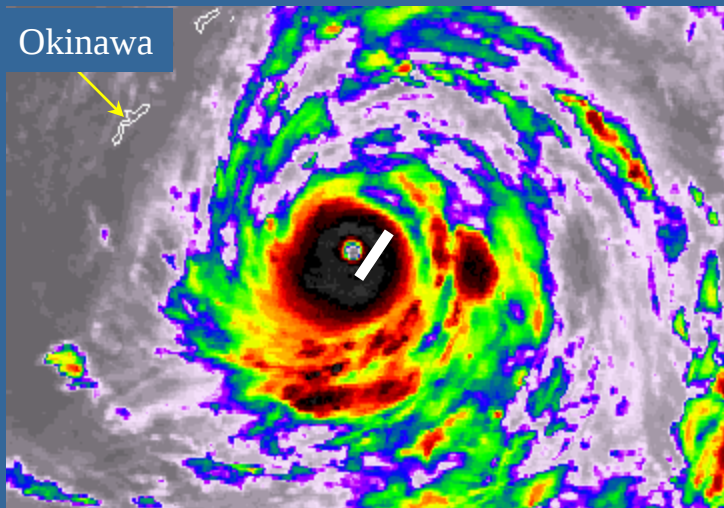
WP-02 Sinlaku 95 kts 1547z 4 Sep 02



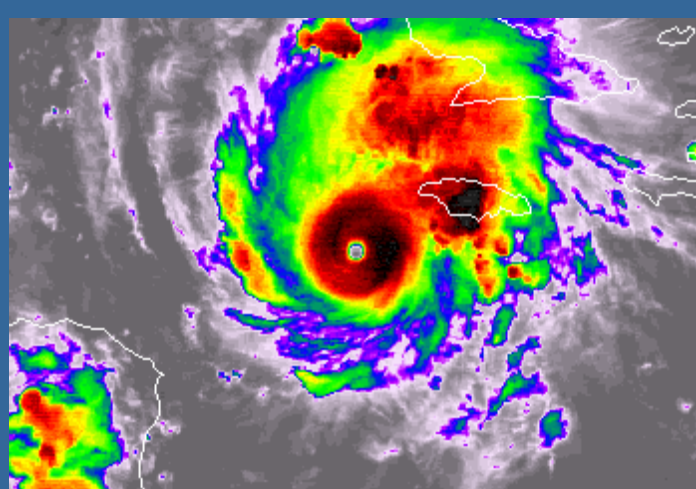
WP-05 Nabi 140 kts 1802z 1 Sep 05

Storm Sizes

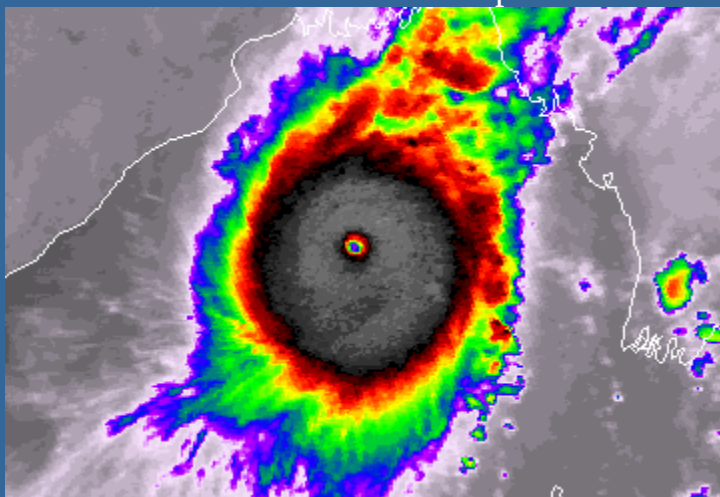
Okinawa



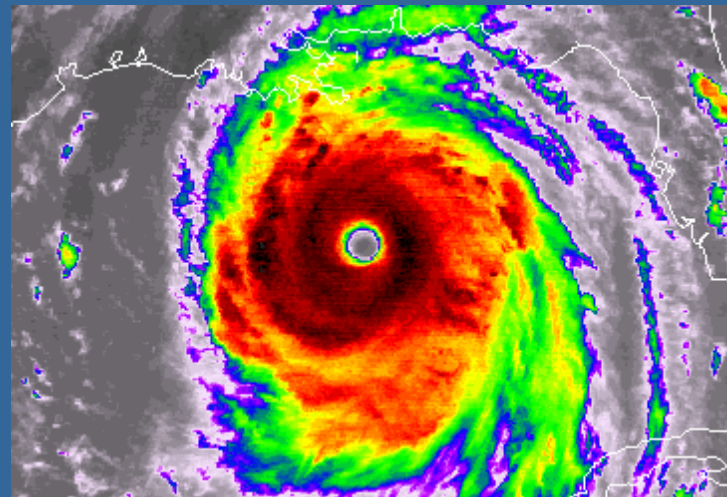
WP-00 Saomai 1132z 10 Sep 00 140 kts



TA-05 Emily 0015z 17 July 05 140 kts



IND-07 Sidr 0000z 15 Nov 07 (150 kts)



TA-05 Katrina 1815z 28 Aug 05 150²¹ kts

Water Vapor Eye Warming

The maximum measured 6.7 micrometer brightness temperature in the Eyes of the storms are observed to **warm with time** during **storm intensification**

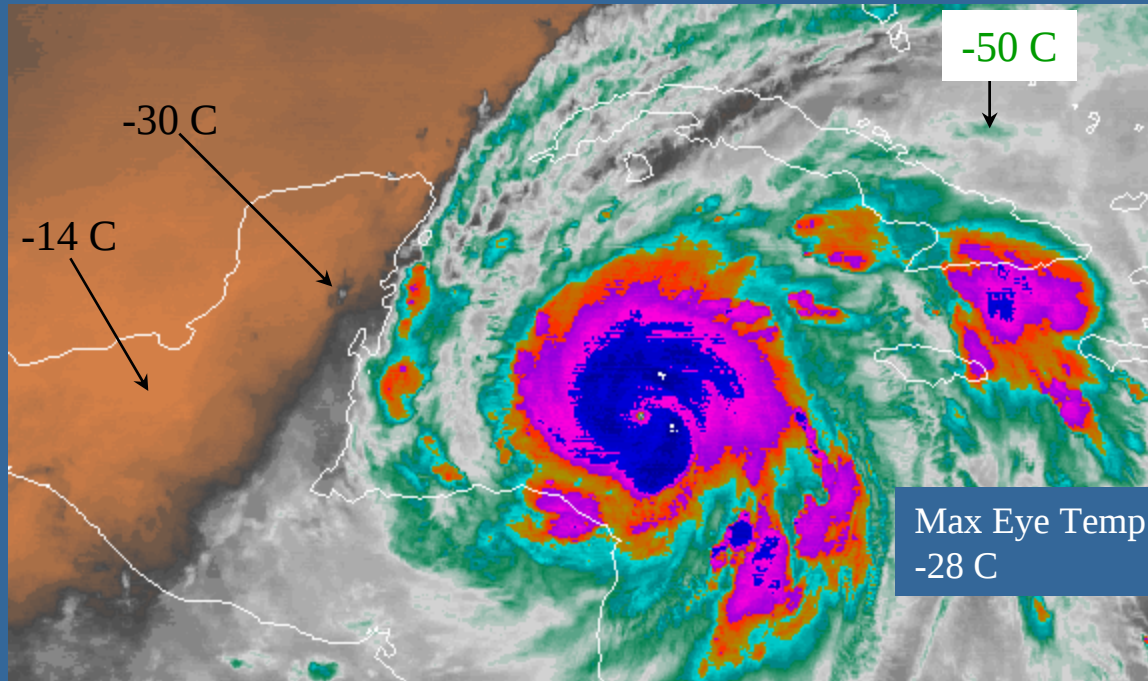
Typical rates: Depends on the intensity range of the storms

Not a useful relationship for “Wlima type” storms (eyes too small)

Problems with the width 6.7 bands such as Goes 9. Brightness Temperatures are colder (from a higher more shallow layer)

Water Vapor Display Curve

TA-05 Wilma 1145z 19 Oct 05 6.7 micron



Arrows pointing to the color scale bar indicate specific temperature values:

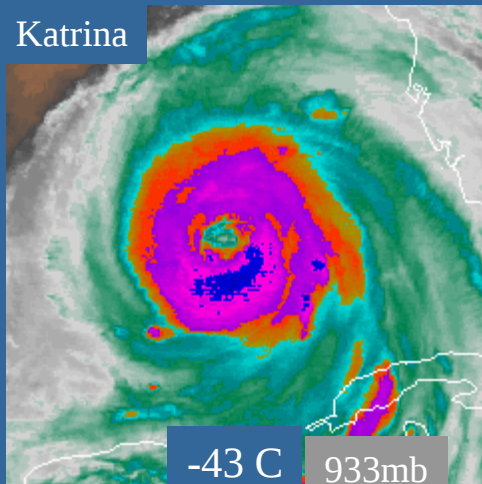
- 3 C
- 15 C
- 30 C
- 61 C
- 70 C
- 77 C
- 85 C

33

Introduction

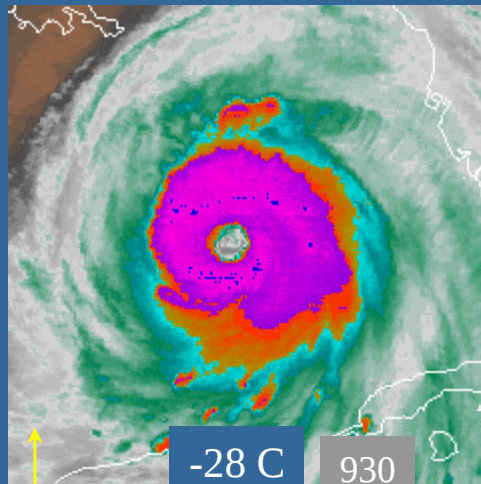
WV Eye Warming and Storm Intensification

Katrina



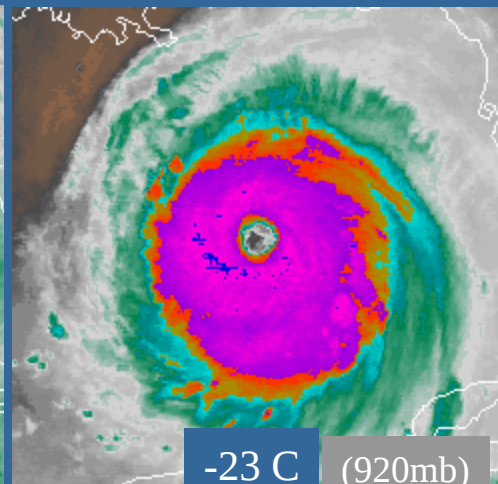
-43 C 933mb

0315z 28 Aug 05 113 kts



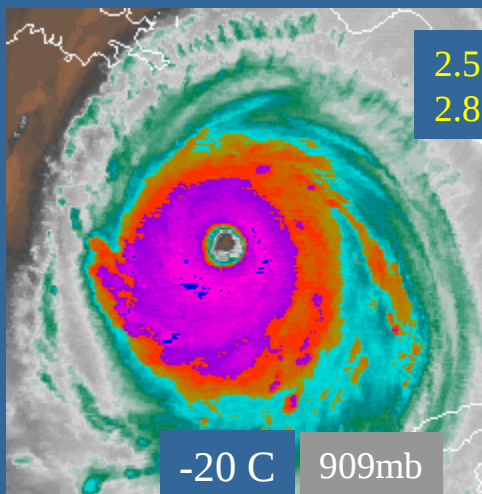
-28 C 930

0615z 28 Aug 05 125 kts



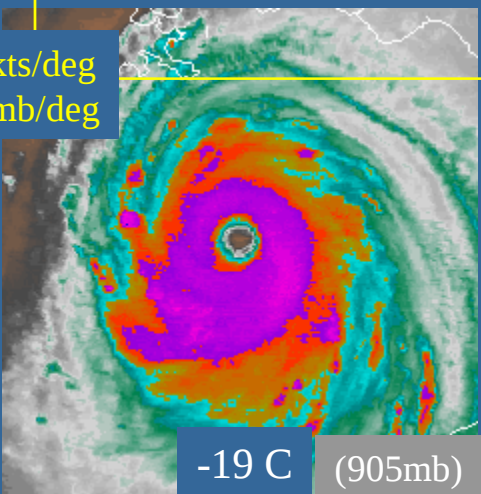
-23 C (920mb)

0915z 28 Aug 05 (135 kts)



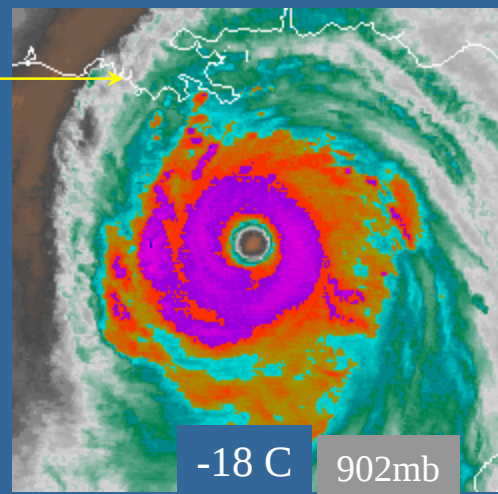
-20 C 909mb

1215z 28 Aug 05 145 kts



-19 C (905mb)

1445z 28 Aug 05 (147 kts)



-18 C 902mb

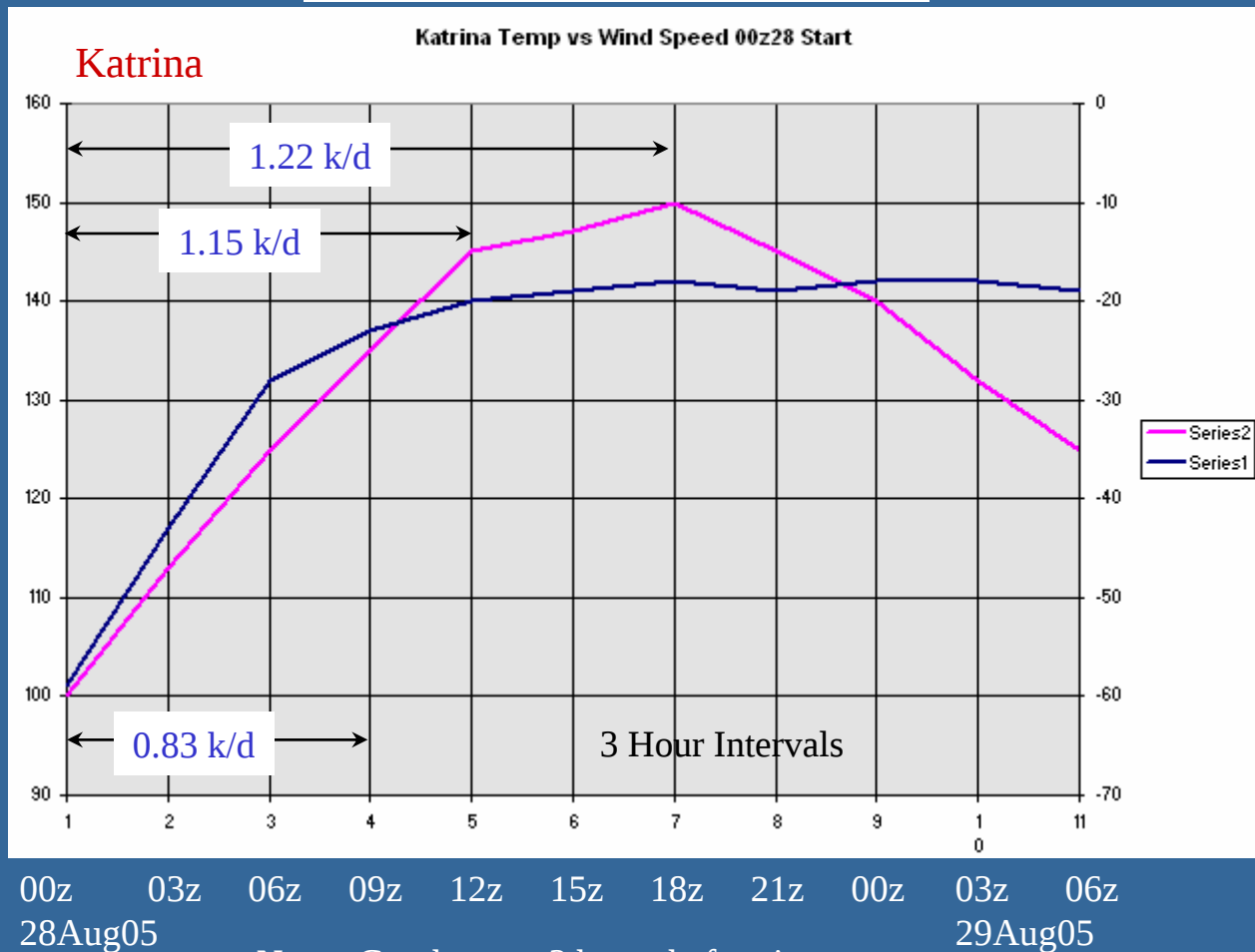
1815z 28 Aug 05 150 knots

2.5 kts/deg
2.8 mb/deg

Equal Scales
1 knot = 1 degree

WV Eye Temperature
Wind Speed Intensity

Blue Line
Magenta Line

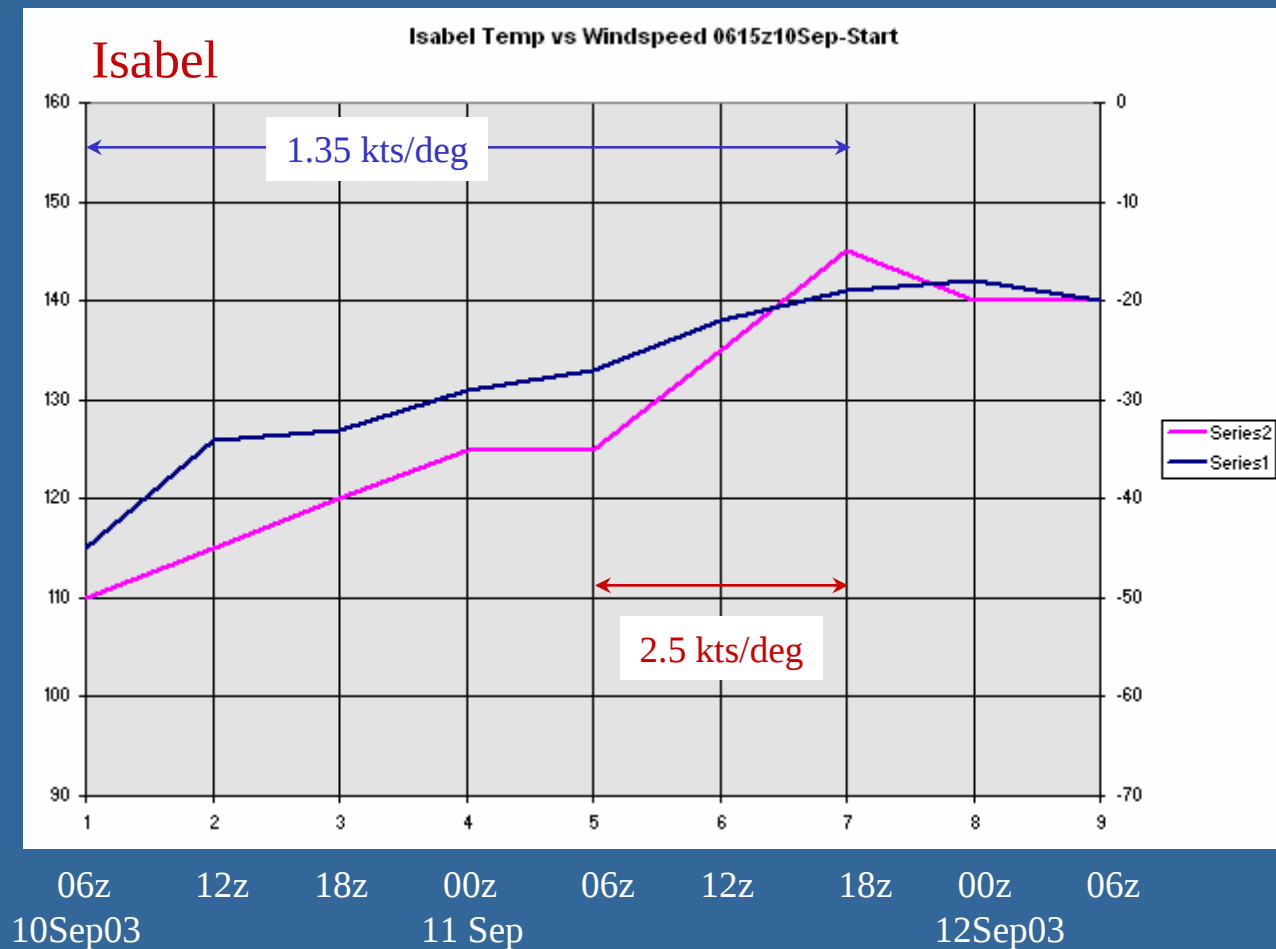


Note: Graph starts 3 hours before images

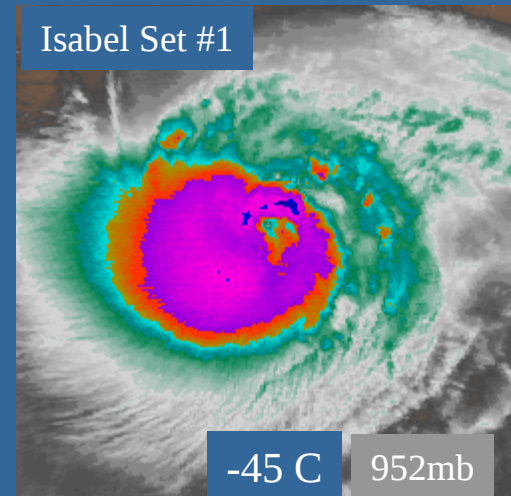
Isabel

Equal Scales
1 degree = 1 knot

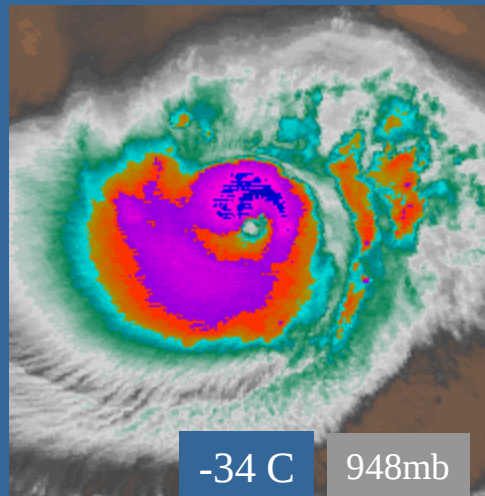
WV Eye Temperature Blue Line
Wind Speed Intensity Magenta Line



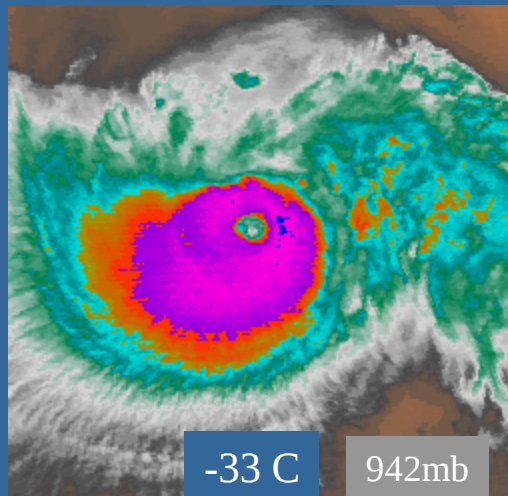
Isabel Set #1



0615z 10 Sep 03 110 kts

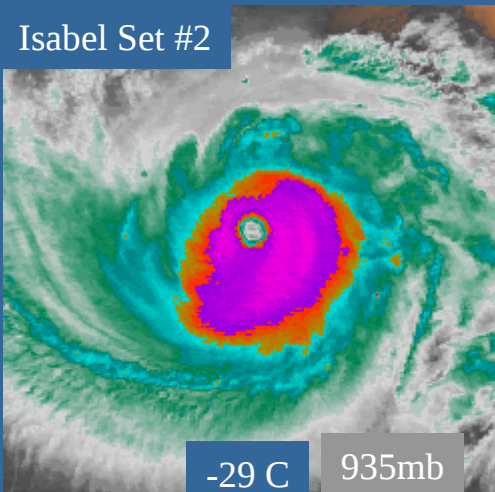


1215z 10 Sep 03 115 kts

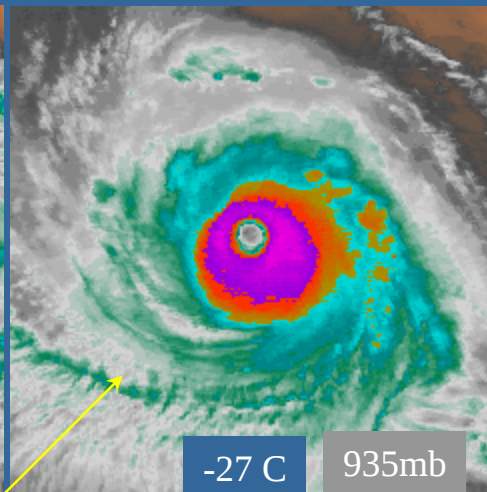


1815z 10 Sep 03 120 kts

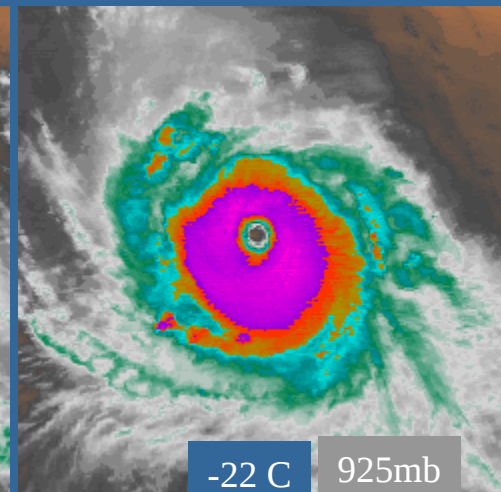
Isabel Set #2



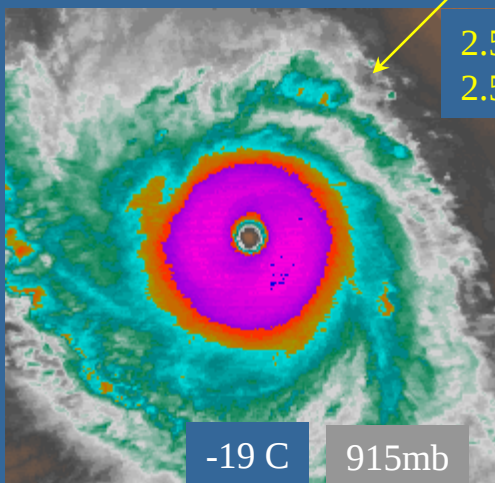
0015z 11 Sep 03 125 Kts



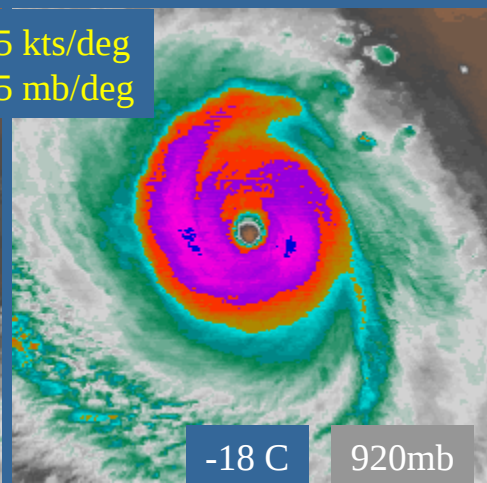
0615z 11 Sep 03 125 kts



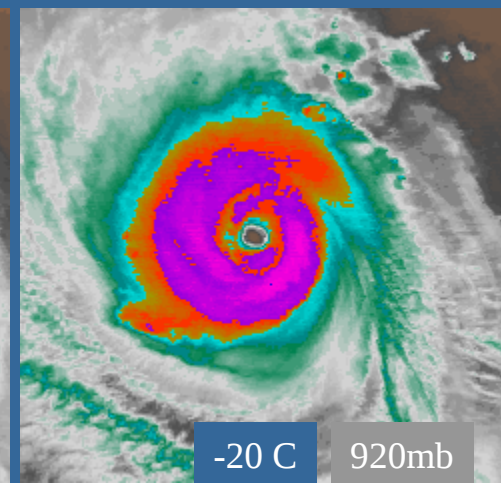
1215z 11 Sep 03 135 kts



1915z 11 Sep 03 145 kts



0015z 12 Sep 03 140 kts



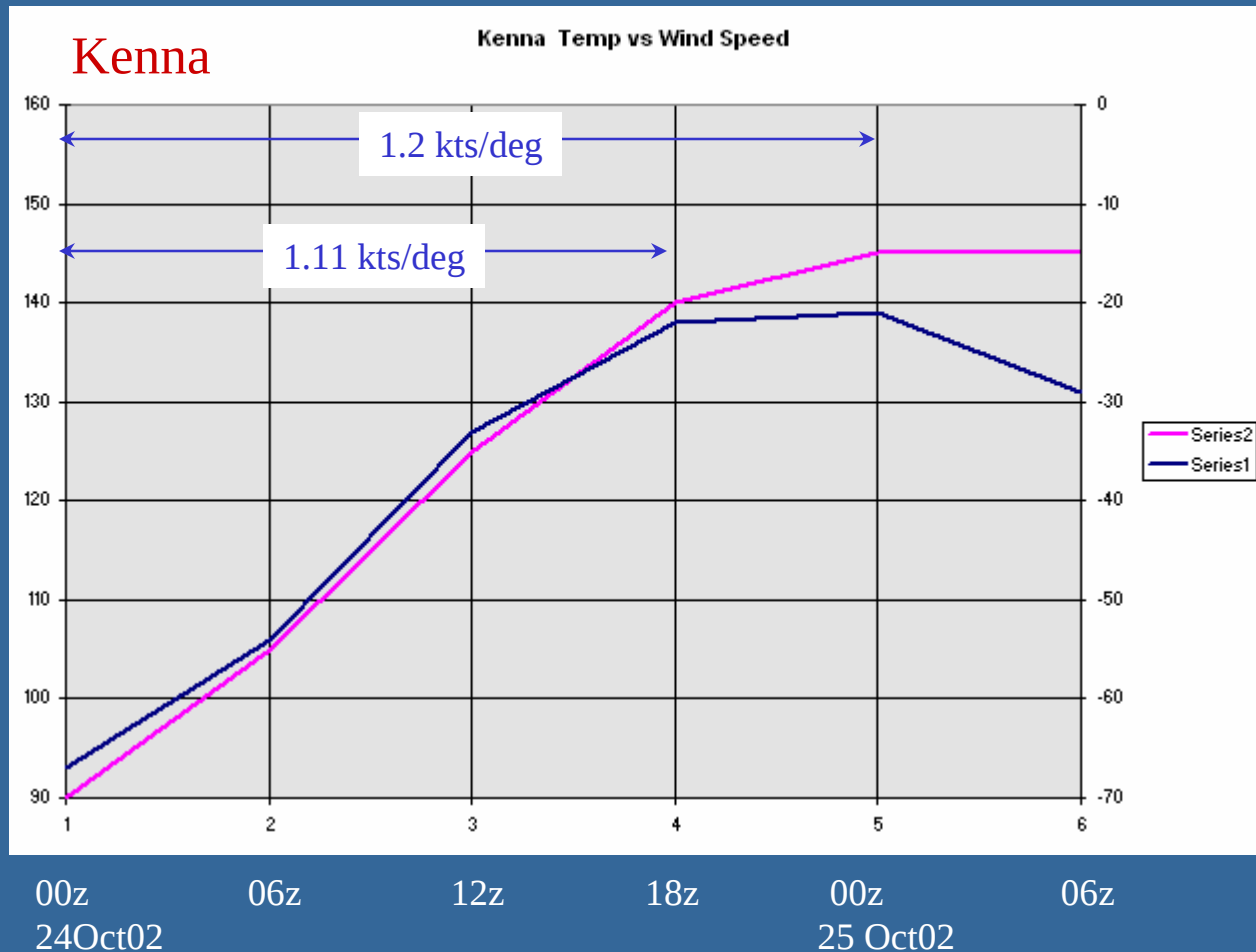
0345z 12 Sep 03 140 kts

2.5 kts/deg
2.5 mb/deg

Equal Scales
1 degree = 1 knot

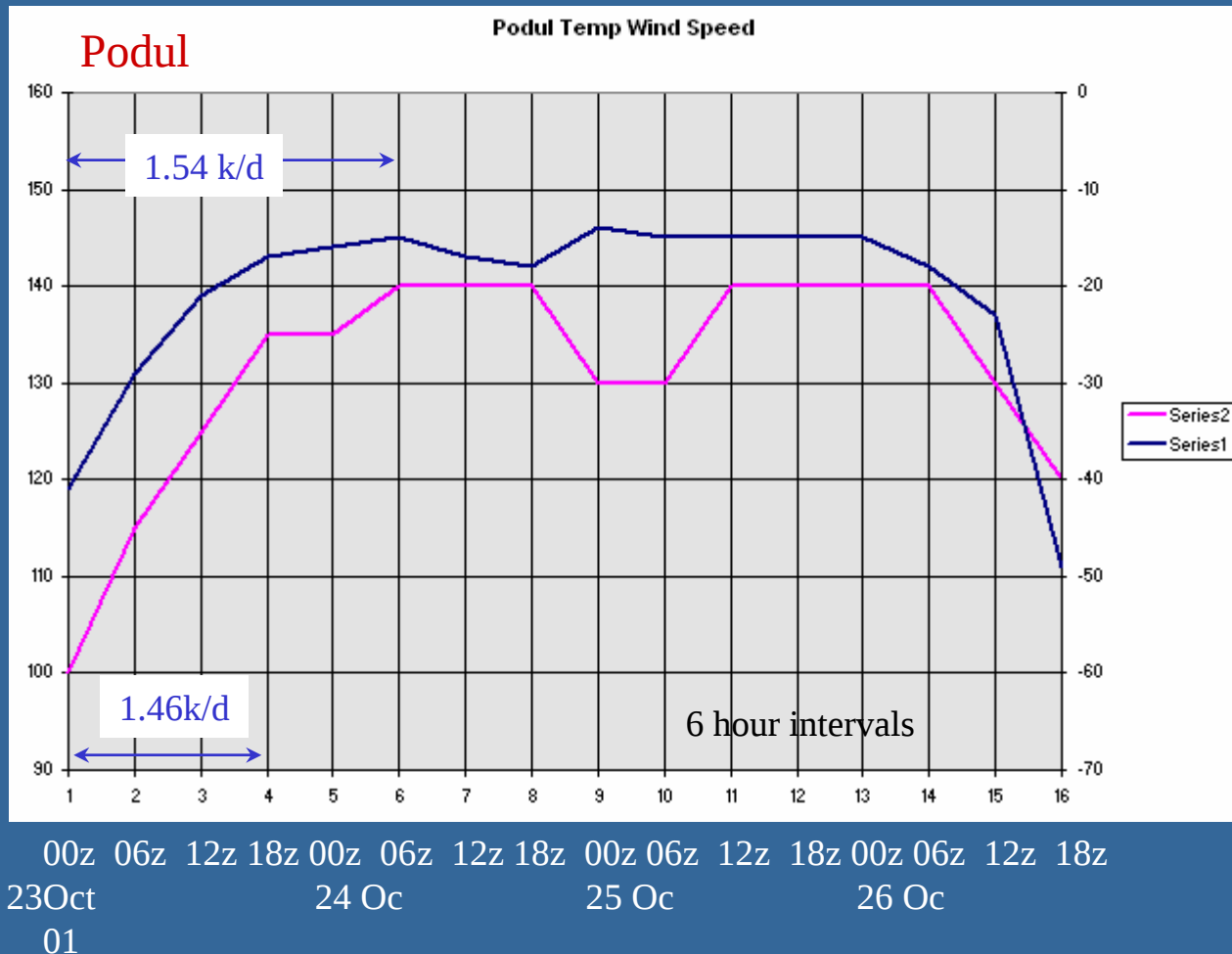
WV Eye Temperature
Wind Speed Intensity

Blue Line
Magenta Line

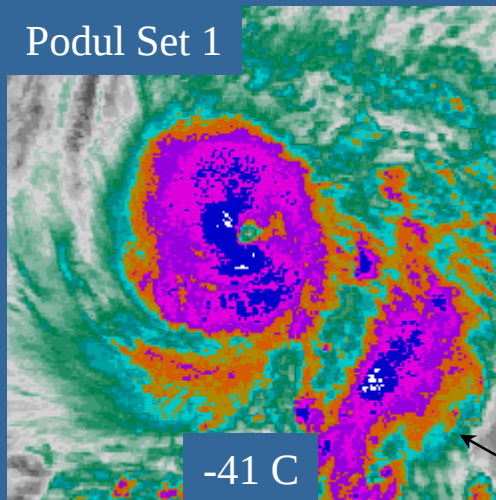


Equal Scales
1 knot = 1 degree

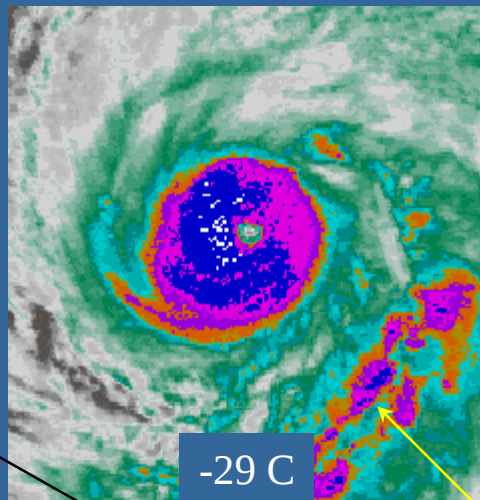
WV Eye Temperature Blue Line
Wind Speed Intensity Magenta Line



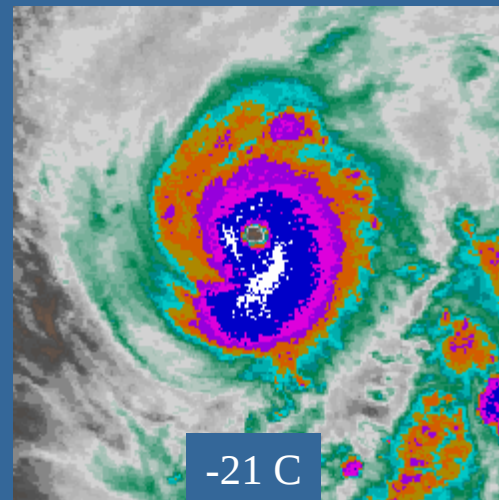
Podul Set 1



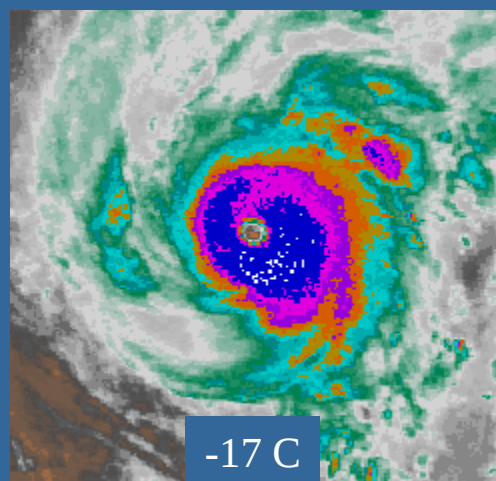
0032z 23 Oct 01 100 kts



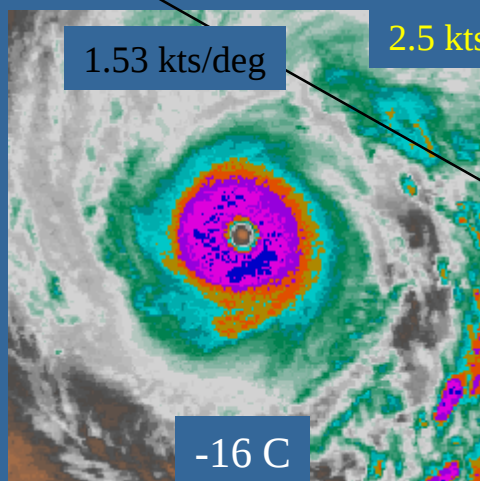
0532z 23 Oct 01 115 kts



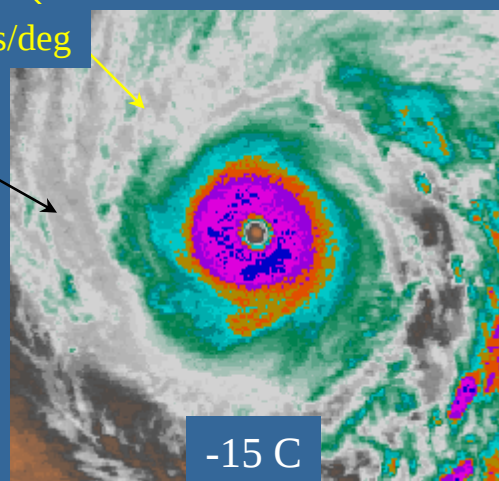
1232z 23 Oct 01 125 kts



1831z 23 Oct 01 135 kts



0031z 24 Oct 01 135 kts

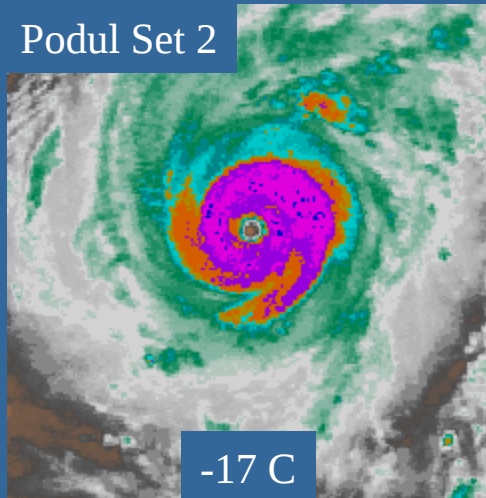


0633z 24 Oct 01 140 kts

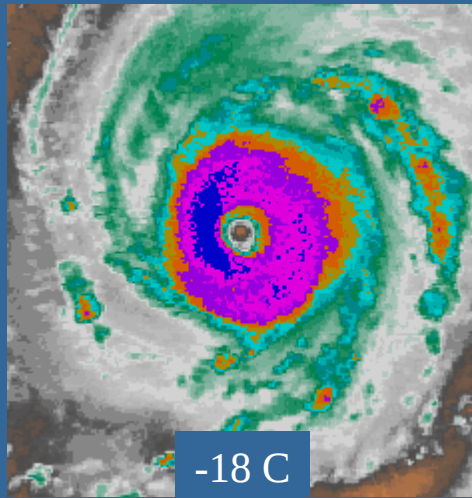
1.53 kts/deg

2.5 kts/deg

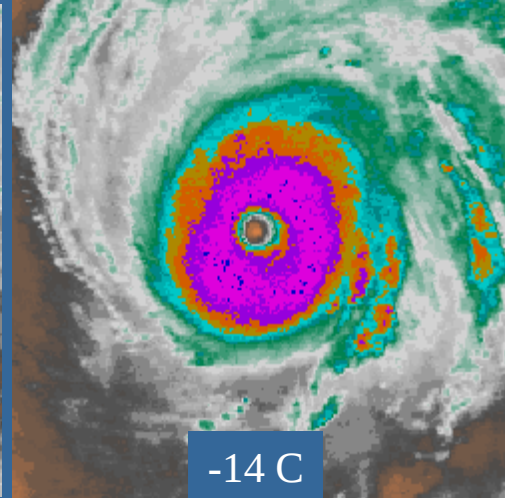
Podul Set 2



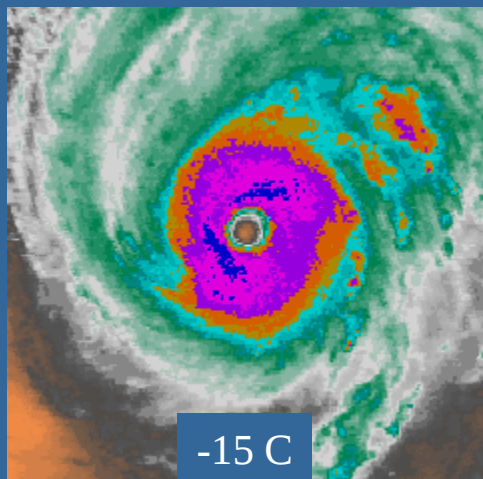
1233z 24 Oct 01 140 kts



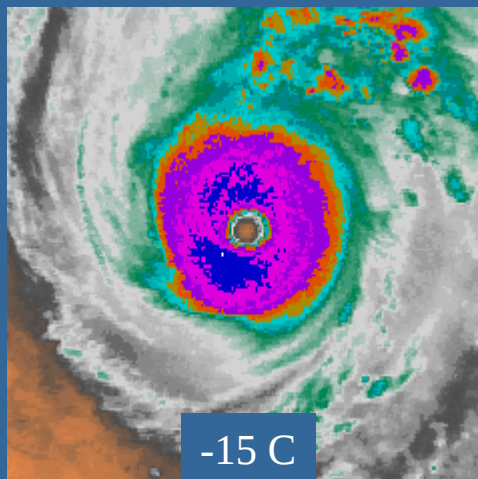
1831z 24 Oct 01 140 kts



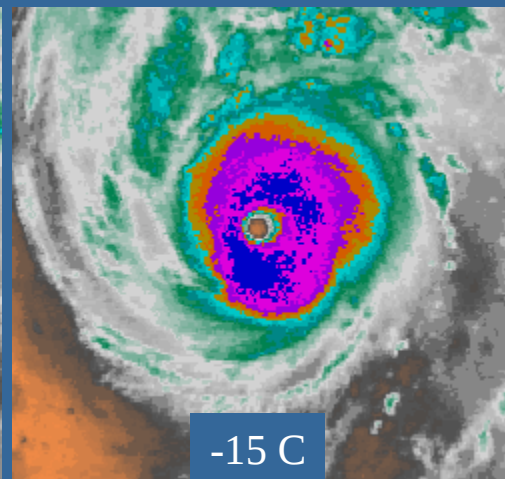
0031z 25 Oct 01 130 kts



0632z 25 Oct 01 130 kts

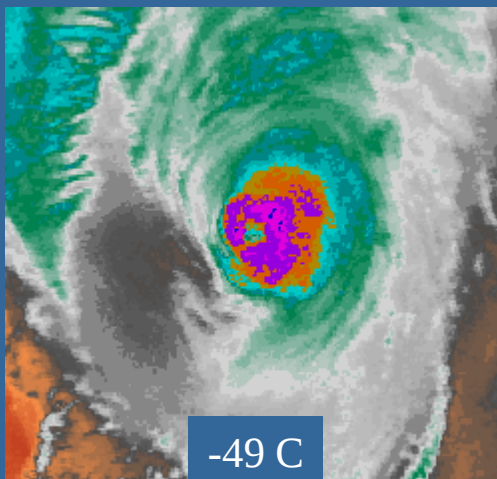
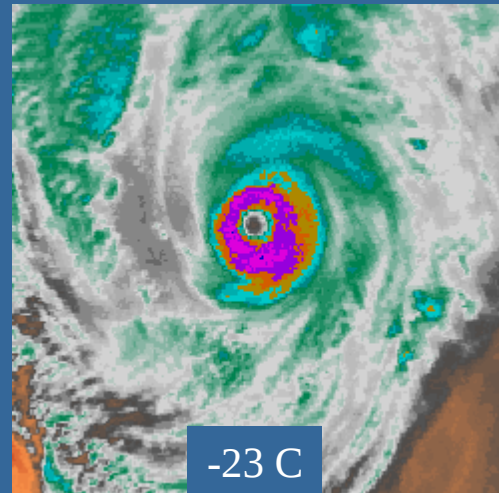
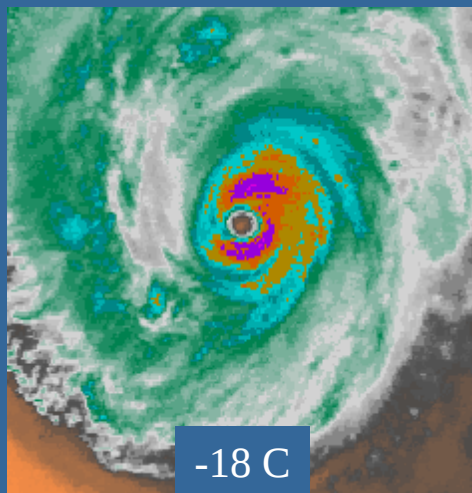
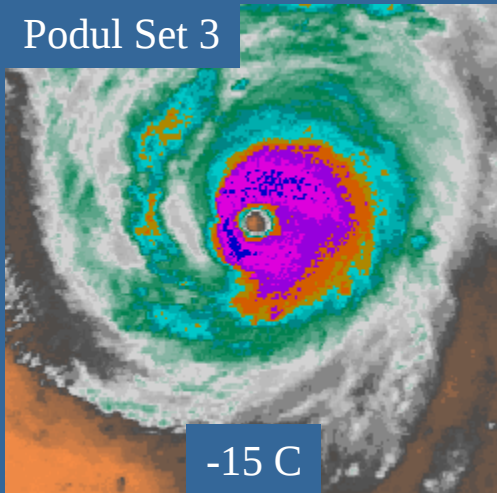


1232z 25 Oct 01 140 kts



1832z 25 Oct 01 140 kts

Podul Set 3



Wide and Narrow Water Vapor Bands

Wide Bands METEOSAT Early GMS (GMS-5) GOES 12

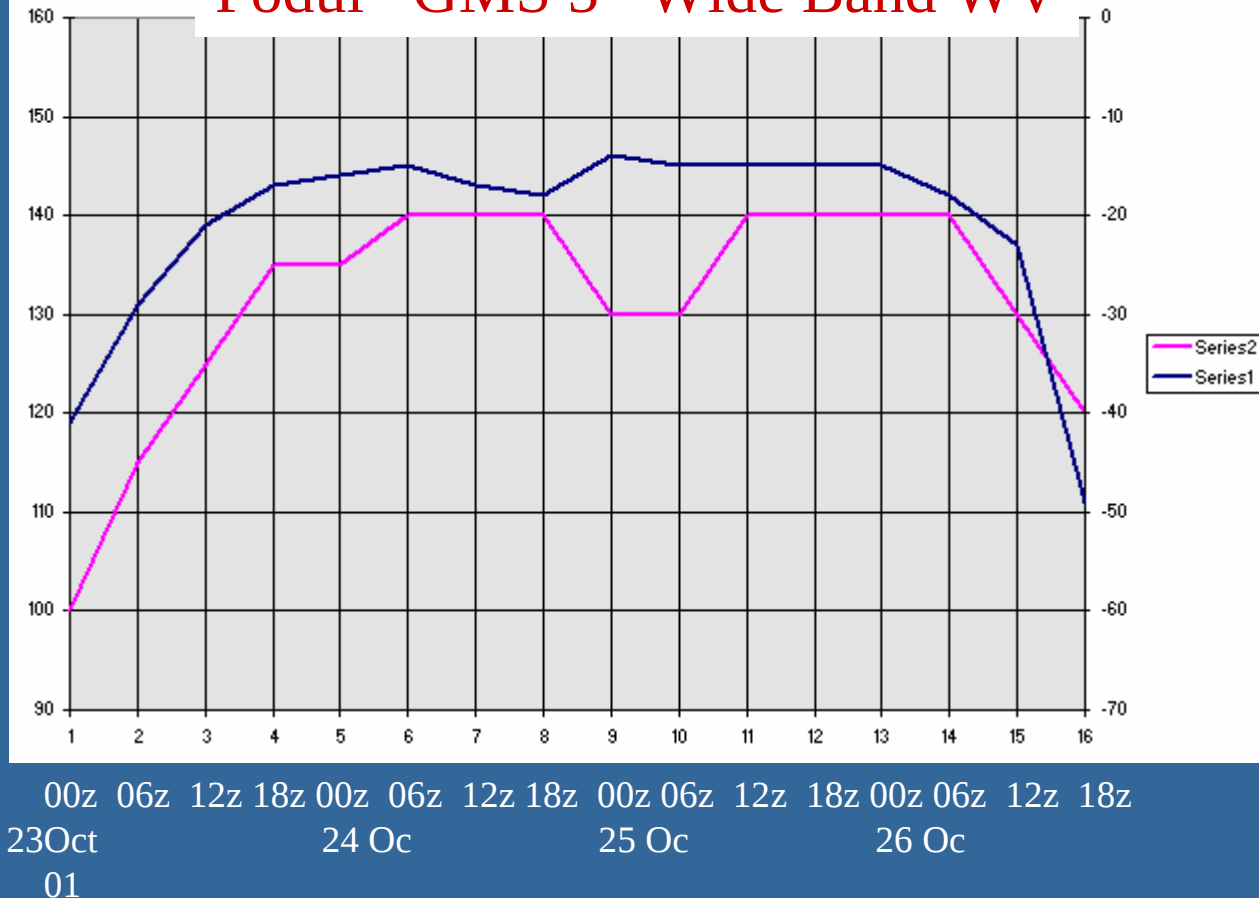
Narrow Bands GOES 9 West Pac New Japanese Satellite
GOES 8 10 11

Wind WV Bands show a deeper layer of the atmosphere and yield
warmer brightness temperatures

WV Eye Temperature
Wind Speed Intensity

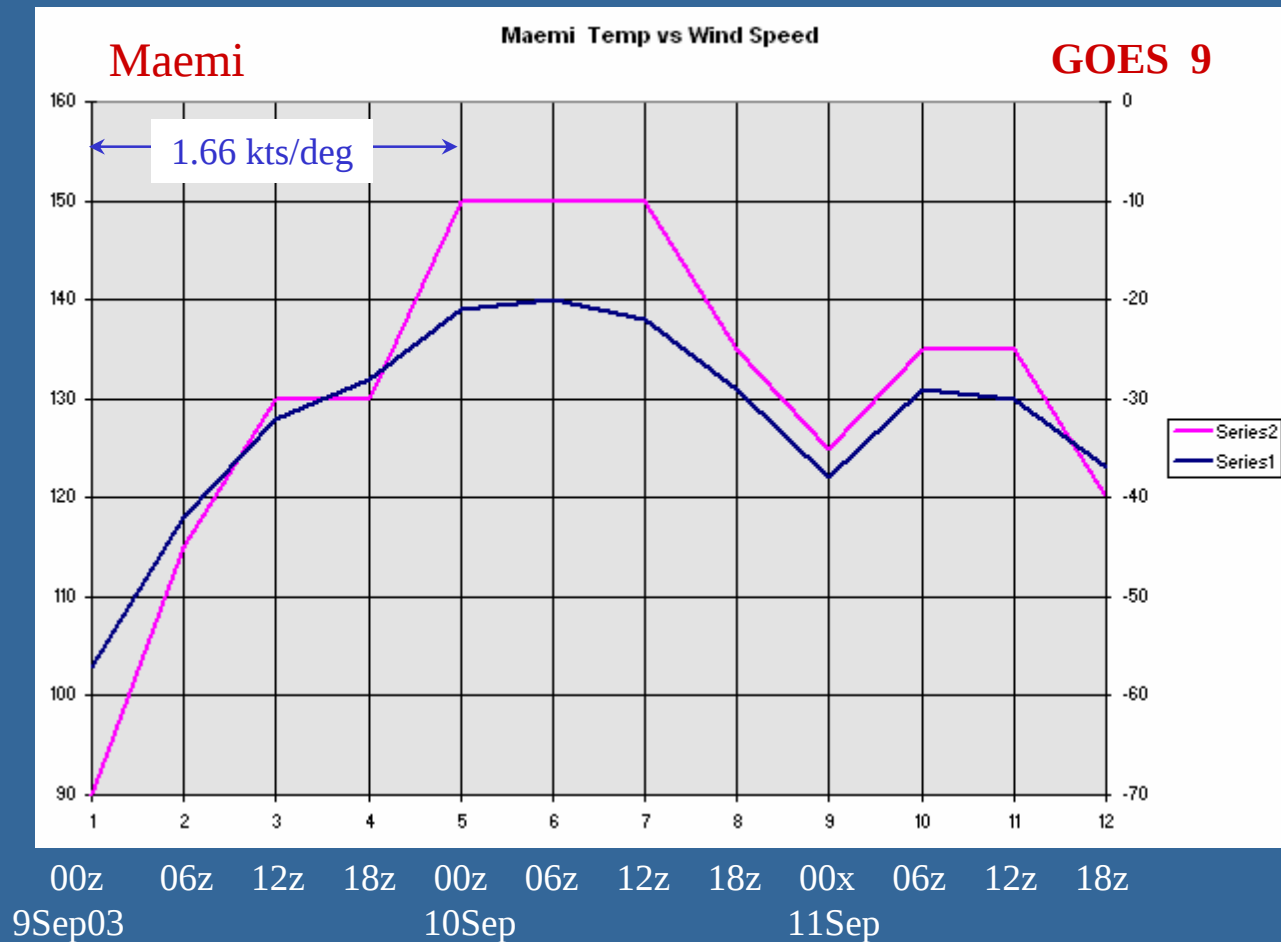
Blue Line
Magenta Line

Podul GMS 5 Wide Band WV



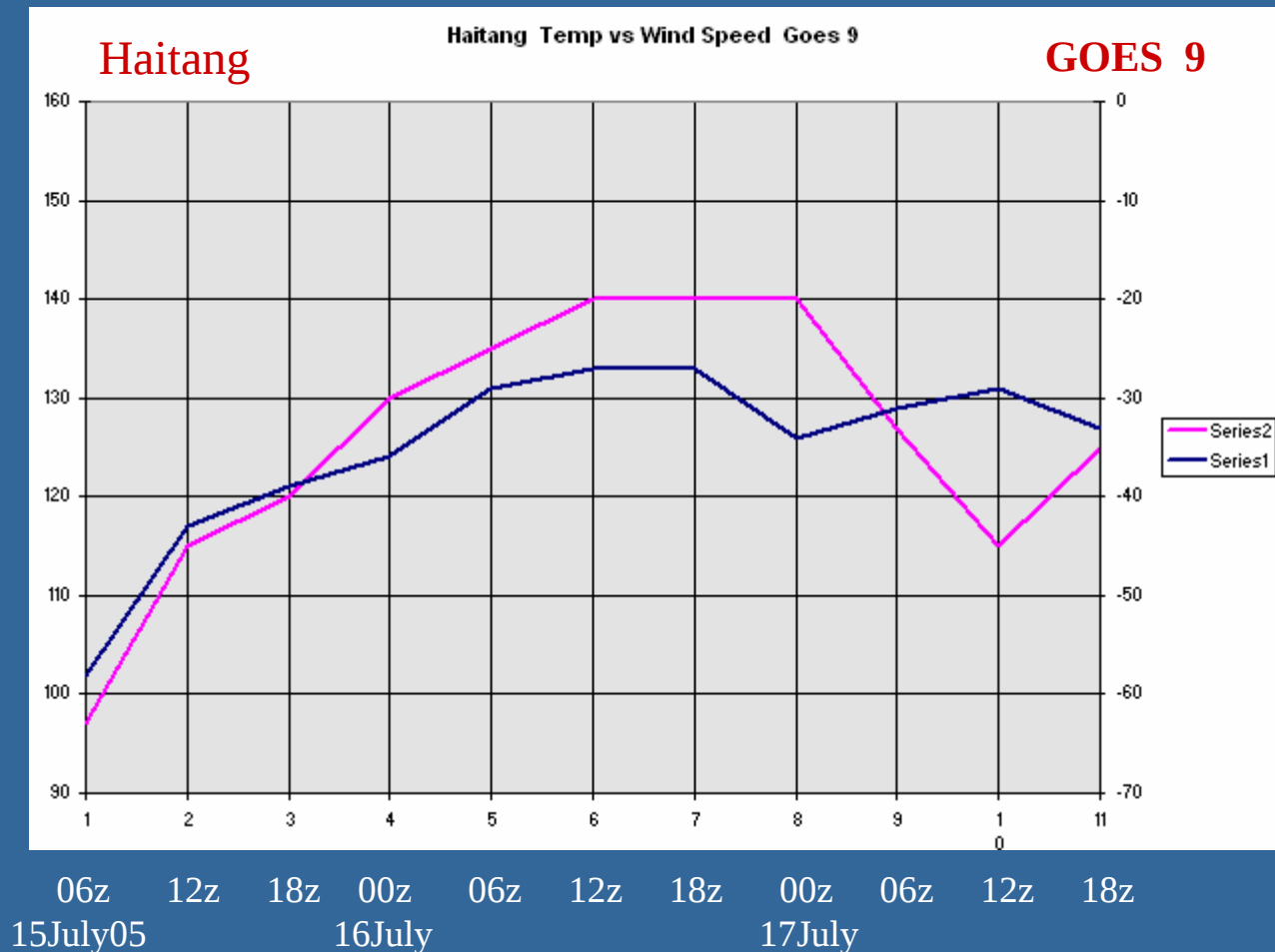
Equal Scales
1 knot = 1 degree

WV Eye Temperature Blue Line
Wind Speed Intensity Magenta Line



Equal Scales
1 knot = 1 degree

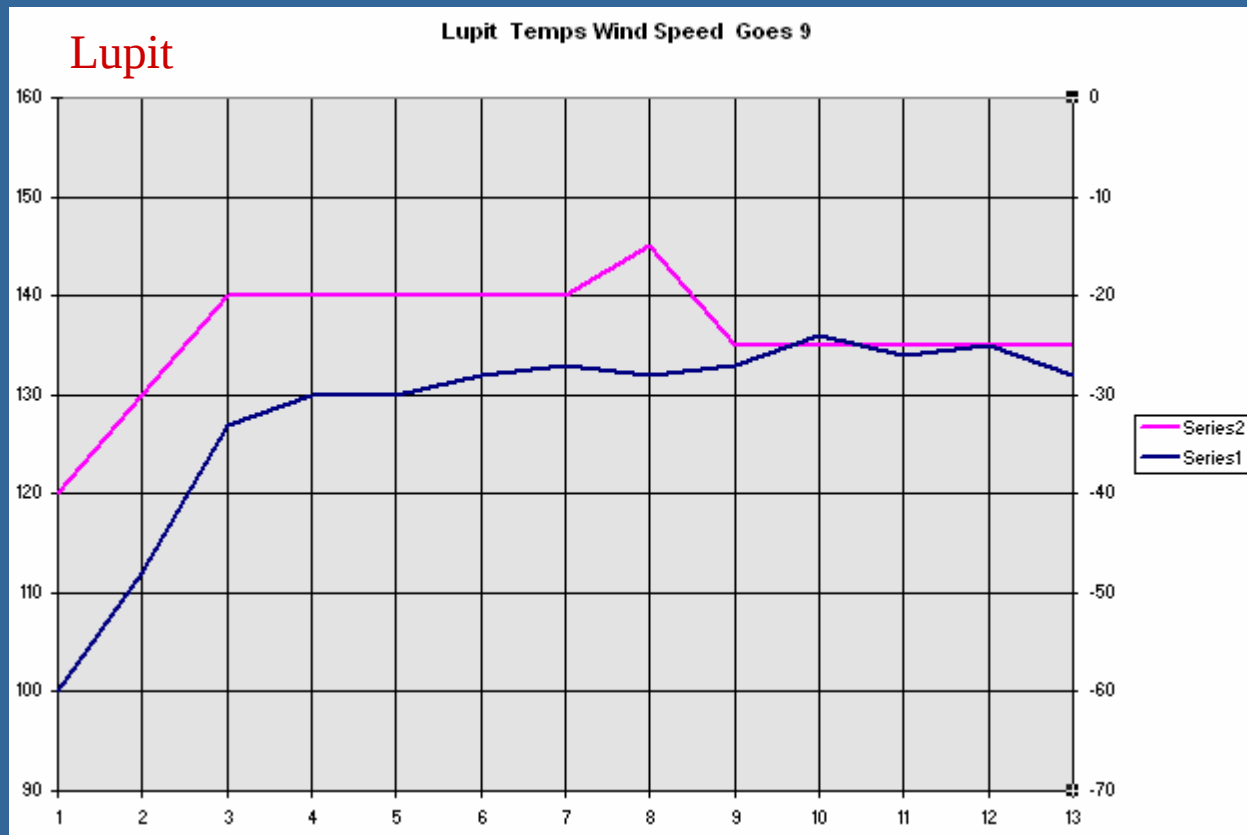
WV Eye Temperature Blue Line
Wind Speed Intensity Magenta Line



Equal Scales
1 knot = 1 degree

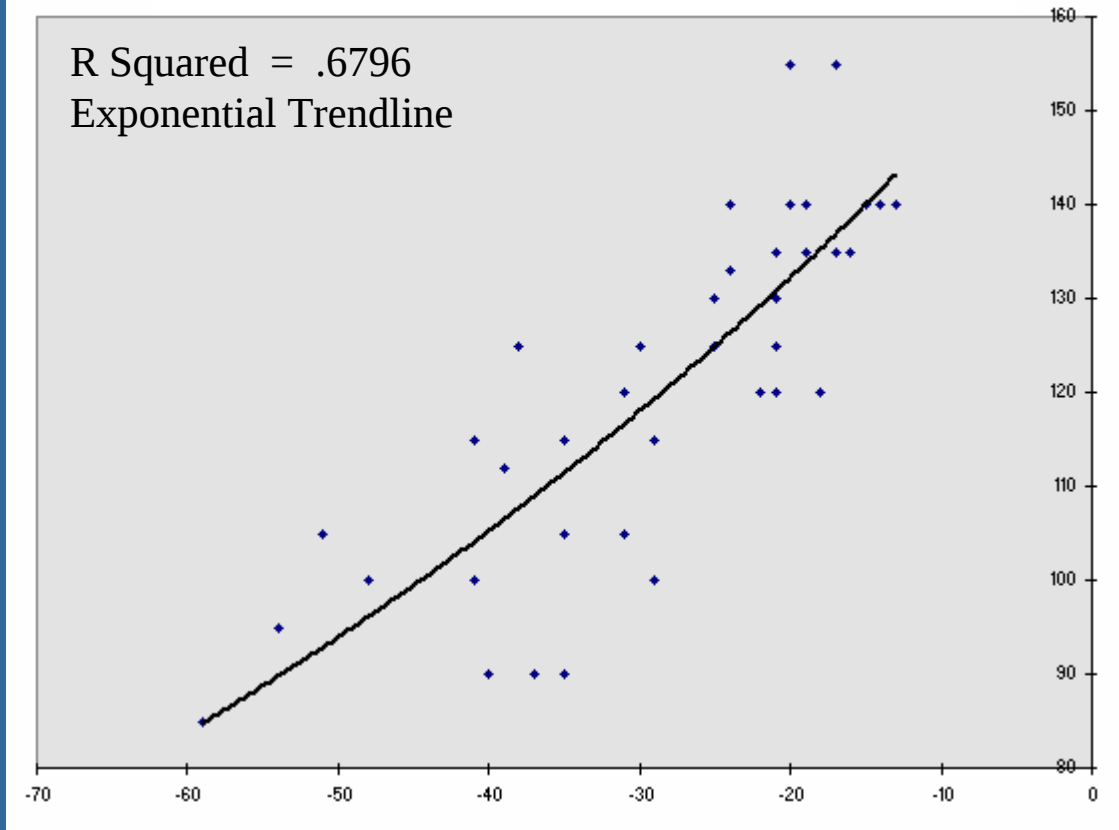
WV Eye Temperature
Wind Speed Intensity

Blue Line
Magenta Line



JTWC Band Comparison

Wide Band WV



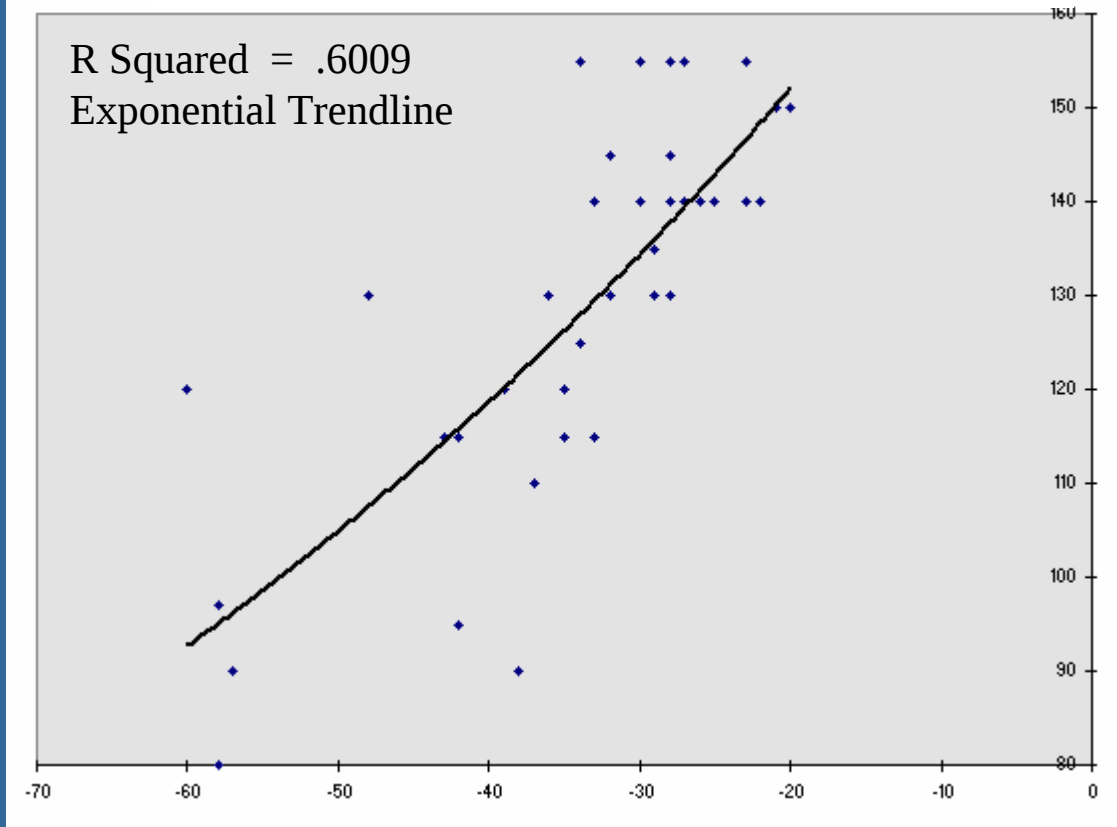
COLD

39 Data Points

WARM



Narrow Band WV



COLD

42 Data Points

WARM



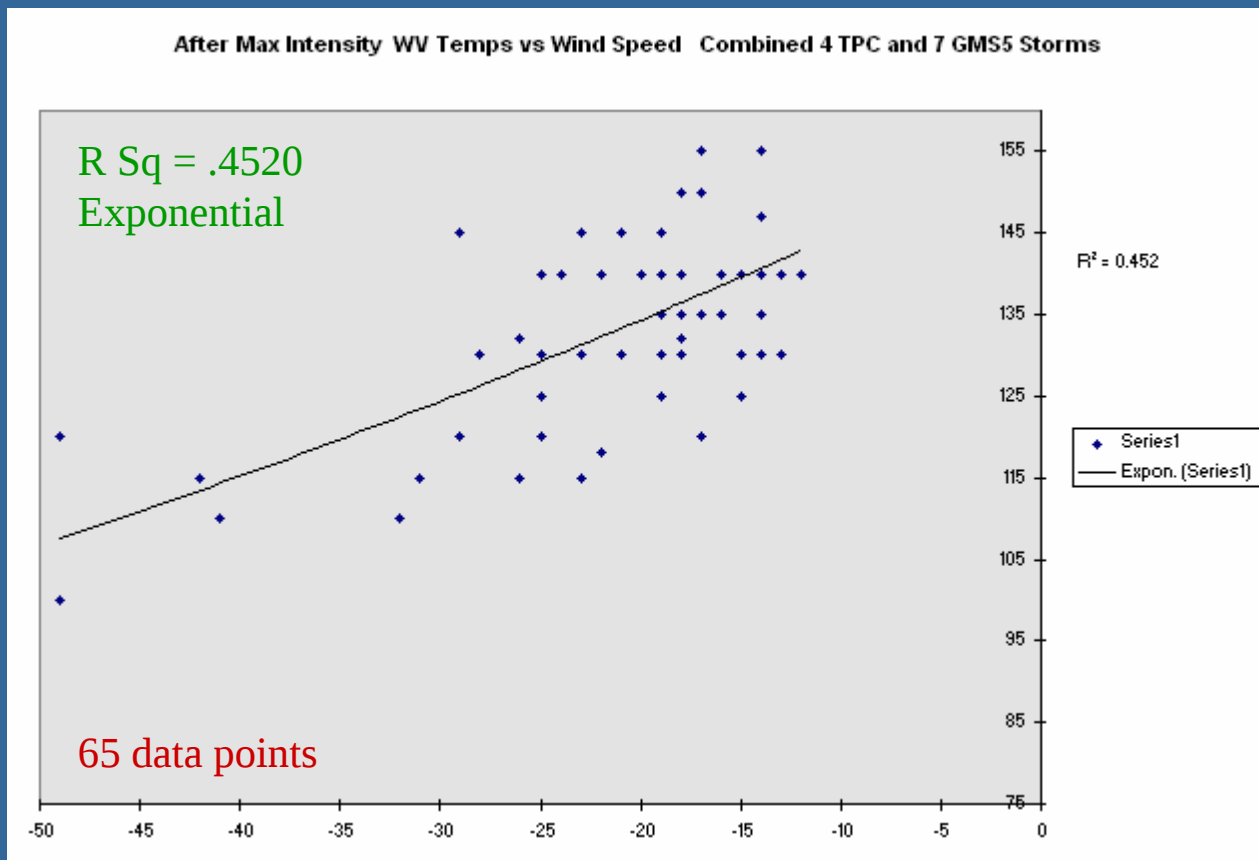
53

After Reaching Maximum Intensity

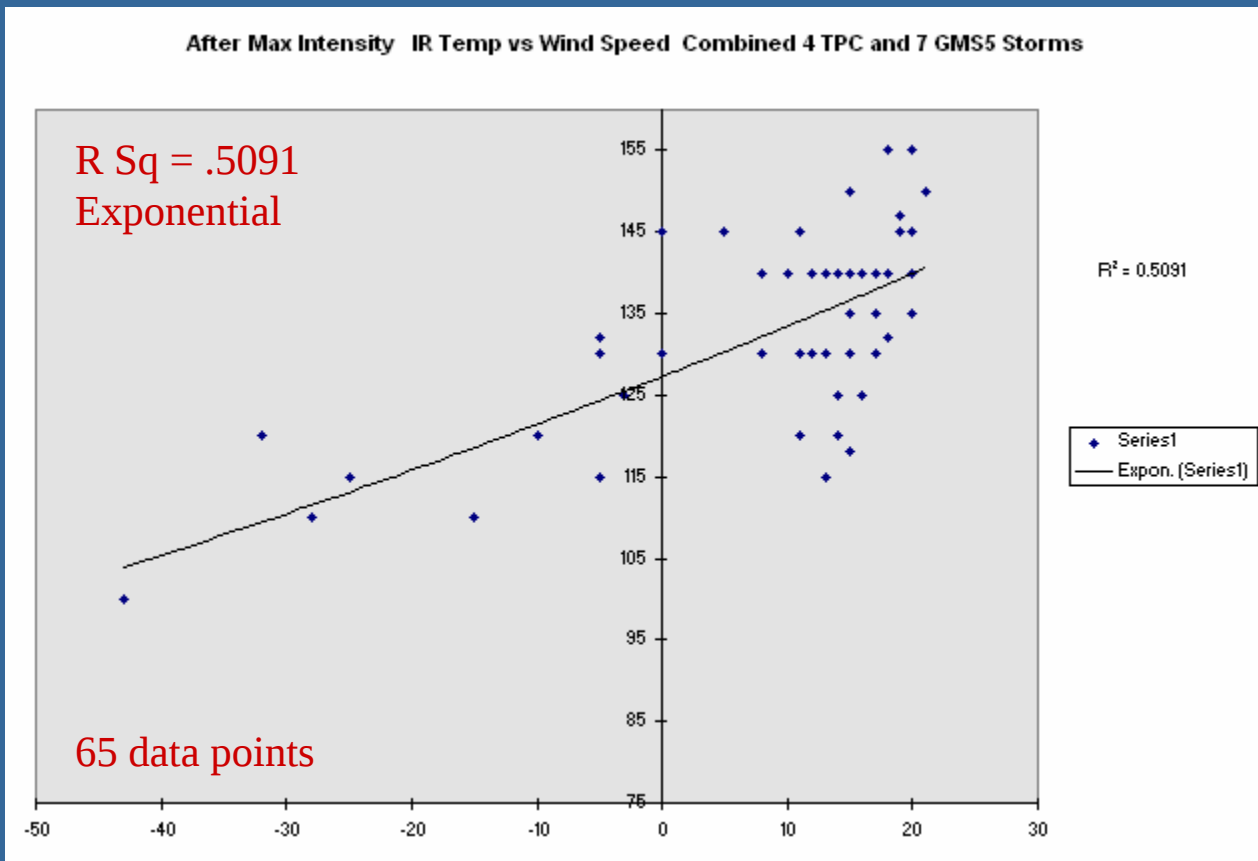
Problems After Reaching Maximum Intensity

4 Contributions to WV Eye Temperature - Storm Intensity Correlation

1. WV Eye Temps Remain Too Warm
When storms ingest dry air at small angles to the cold cloud shield.
CDO intrudes and eye restructuring or replacement occurs.
2. WV Eye Temps Cool Rapidly
When opening adjacent flow enters the cold cloud shield at large angles,
CDO begins to Deform. “Red Eye” effect often precludes the deforming.
3. Long track storms became deformed, then recovered, but often with large cooler eyes
4. The “Human Contribution” Storm intensities were decided by human decisions. Eye temperatures were measurements of radiation.

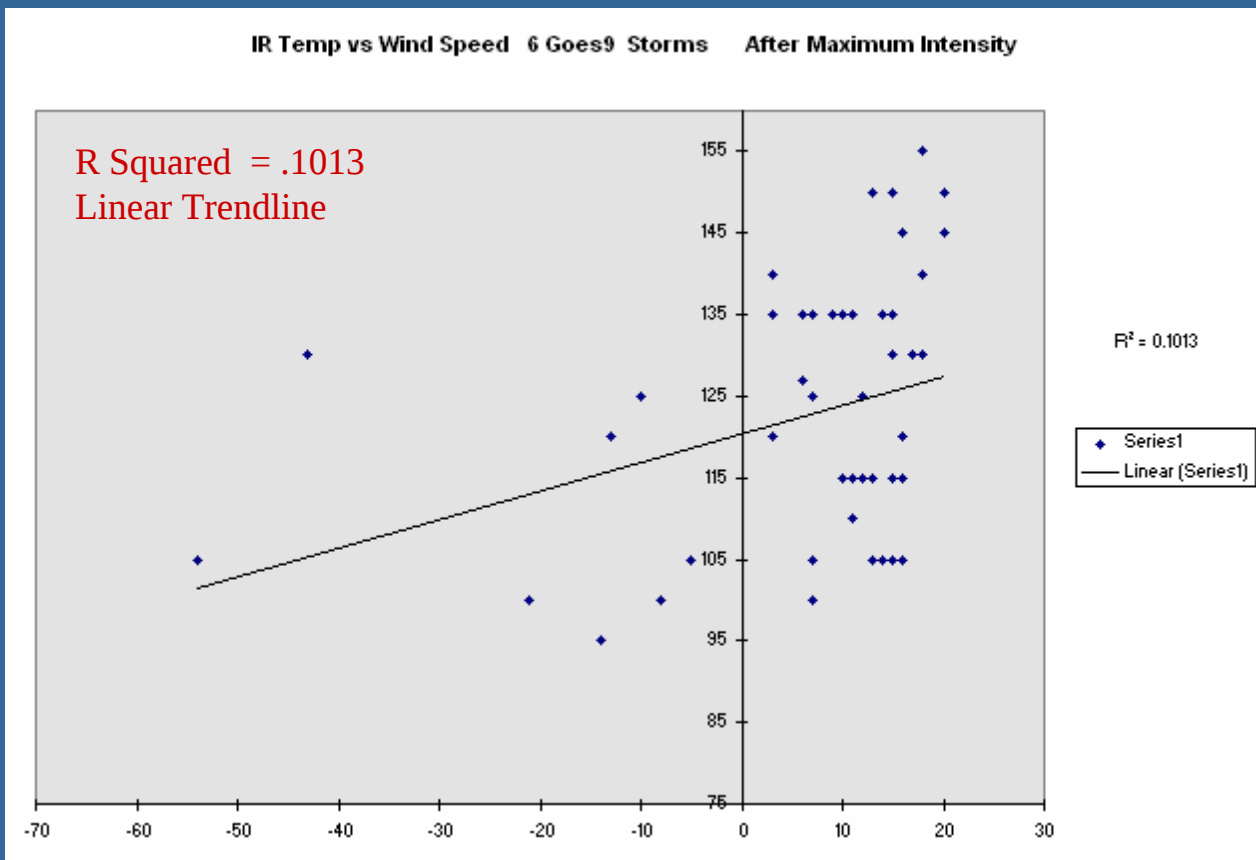


After Max Intensity IR Temp vs Wind Speed 11 TPC & GMS Storms





After Max Intensity IR Temp vs Wind Speed 6 Goes 9 JTWC Storms



R Squared Values After Max Intensity 3 Storm Sets

11 Storms 4 TPC Storms 6 Goes 9 Storms
68 points 33 points

WV Exponential	.452	.041	
WV Linear	.425	.014	.067
IR Exponential	.509	.397	
IR Linear	.480	.052	.101

Dry Air Intrusions

Dry Air enters the Cold Cloud Shield at **Small Angles**

Dry Air is **Ingested** into the storm **Eye Re-structuring**

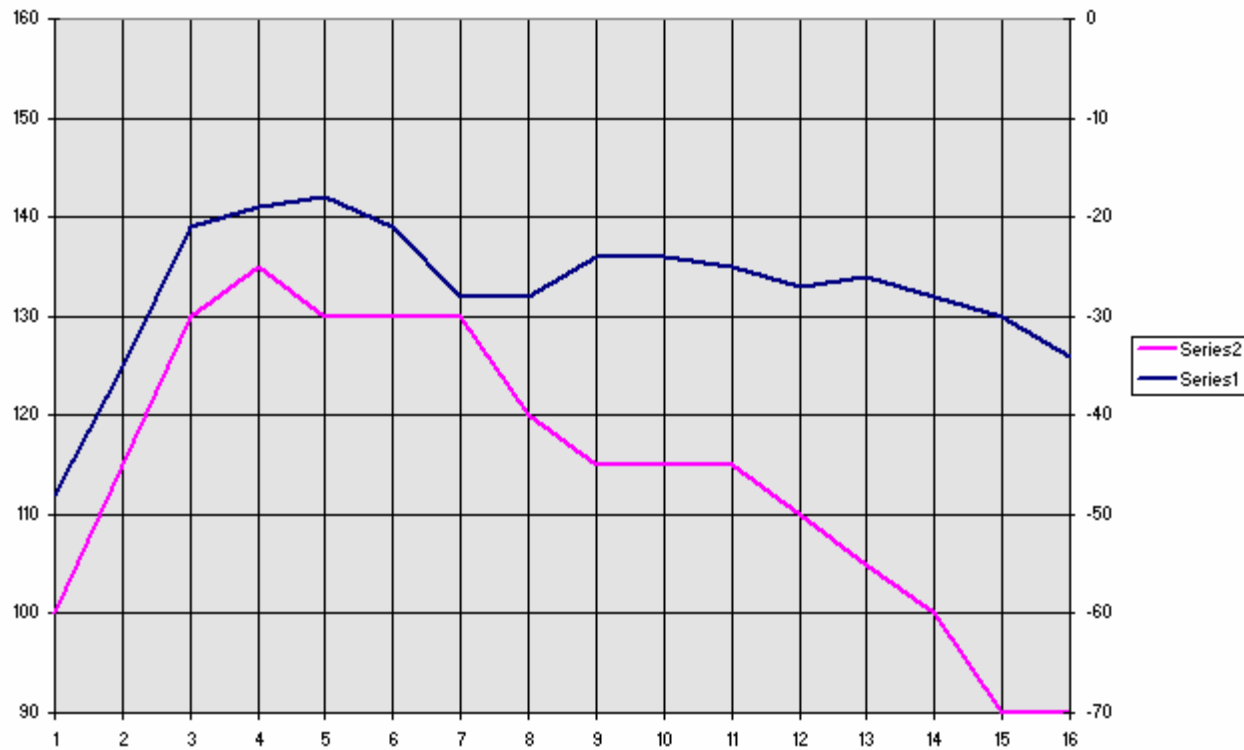
and **Eye Replacement** are likely Overall CDO Pattern remains circular

Equal Scales
1 knot = 1 degree

WV Eye Temperature Blue Line
Wind Speed Intensity Magenta Line

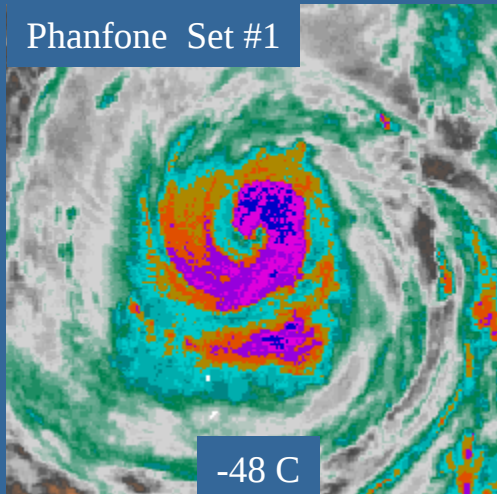
Phanfone

Phanfone Temp vs Wind Speed

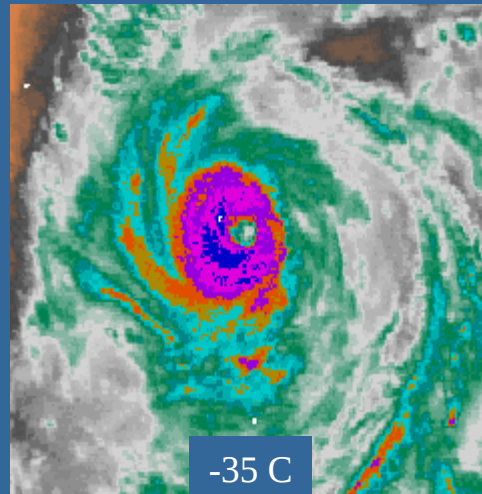


00z 06z 12z 18z 00z 06z 12z 18z 00z 06z 12z 18z
15Aug 16Aug 17Aug 18Aug
02

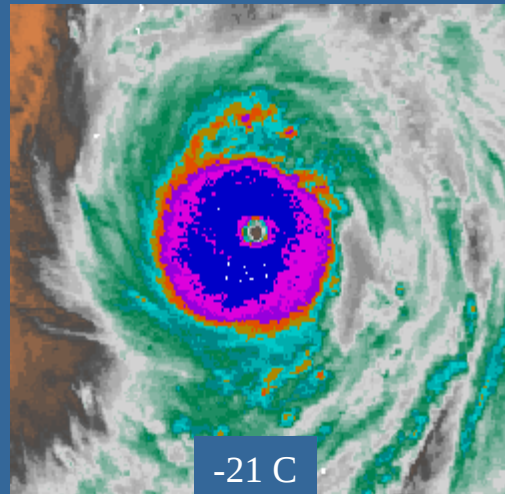
Phanfone Set #1



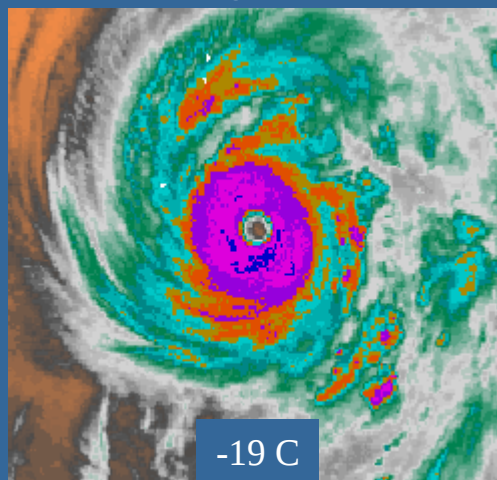
0032z 15 Aug 02 100 kts



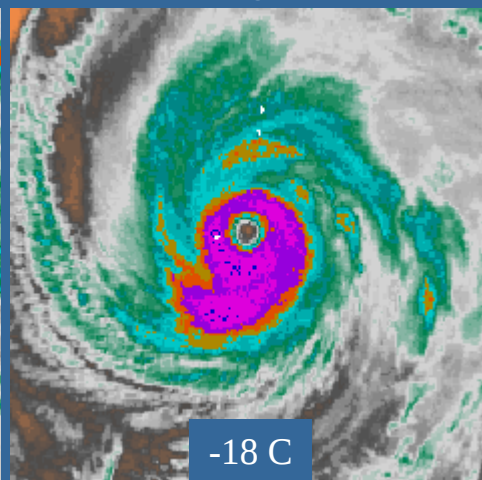
0632z 15 Aug 02 115 kts



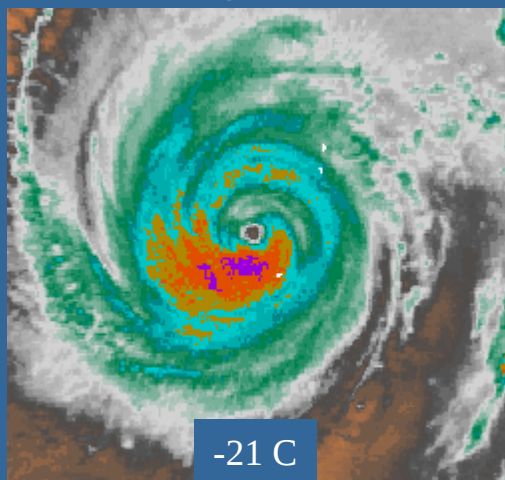
1232z 15 Aug 02 130 kts



1832z 15 Aug 02 135 kts

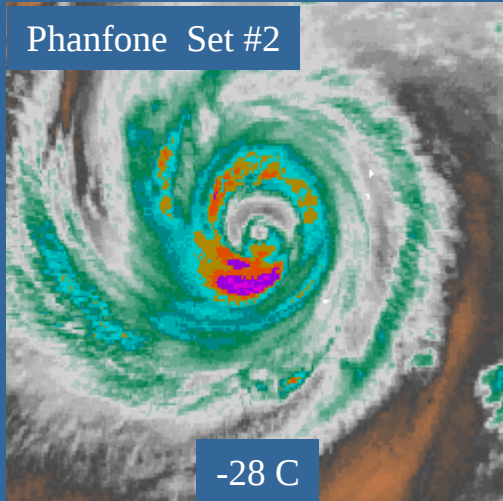


0032z 16 Aug 02 130 kts



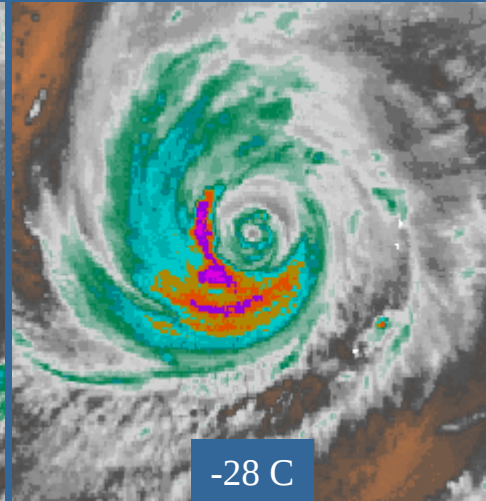
0632z 16 Aug 02 130 kts

Phanfone Set #2



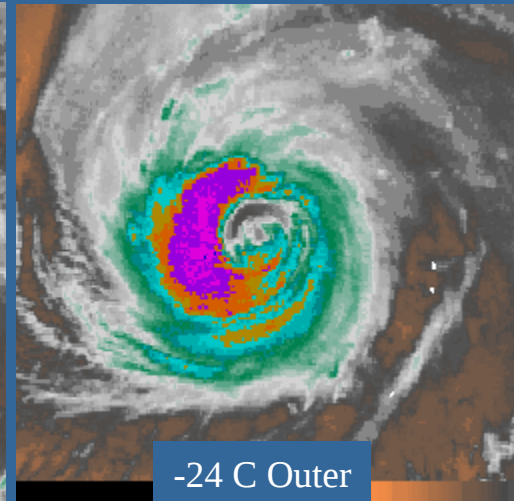
-28 C

1232z 16 Aug 02 130 kts



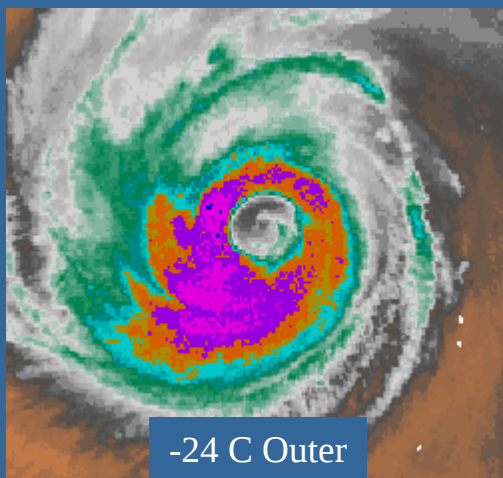
-28 C

1832z 16 Aug 02 120 kts



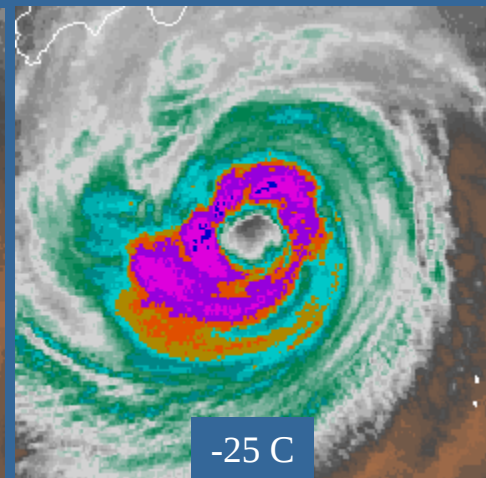
-24 C Outer

0032z 17 Aug 02 115 kts



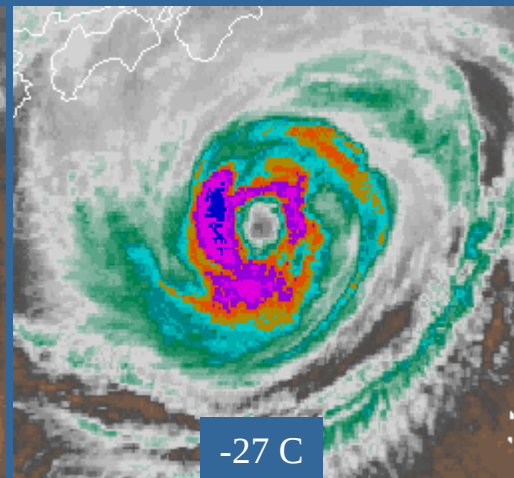
-24 C Outer

0632z 17 Aug 02 115 kts



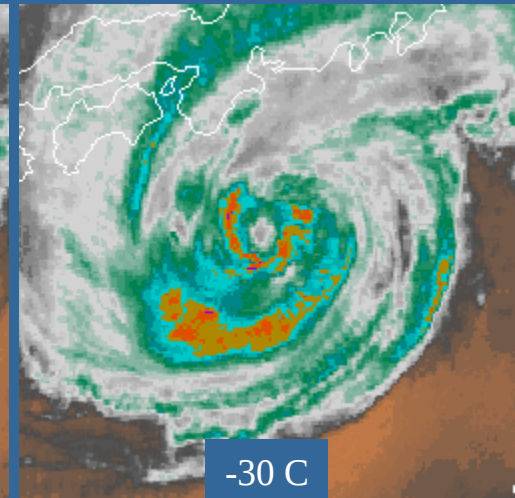
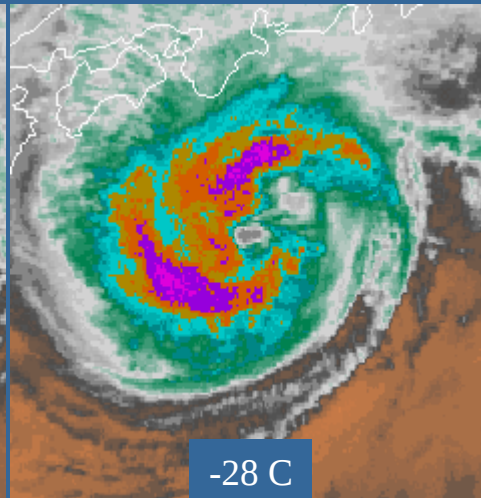
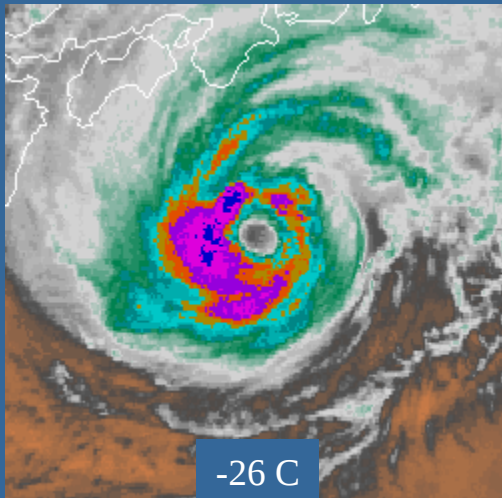
-25 C

1232z 17 Aug 02 115 kts



-27 C

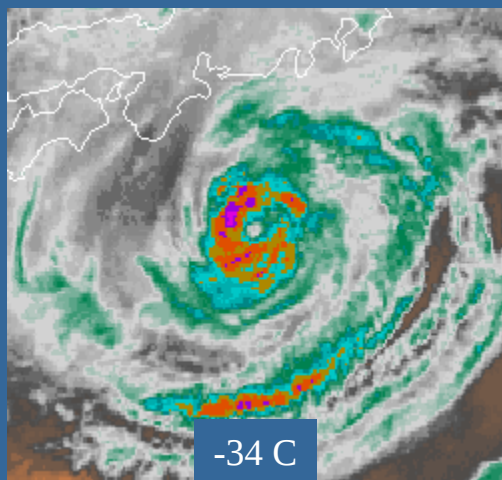
1832z 17 Aug 02 110 kts



0032z 18 Aug 02 105 kts

0632z 18 Aug 02 100 kts

1232z 18 Aug 02 90 kts



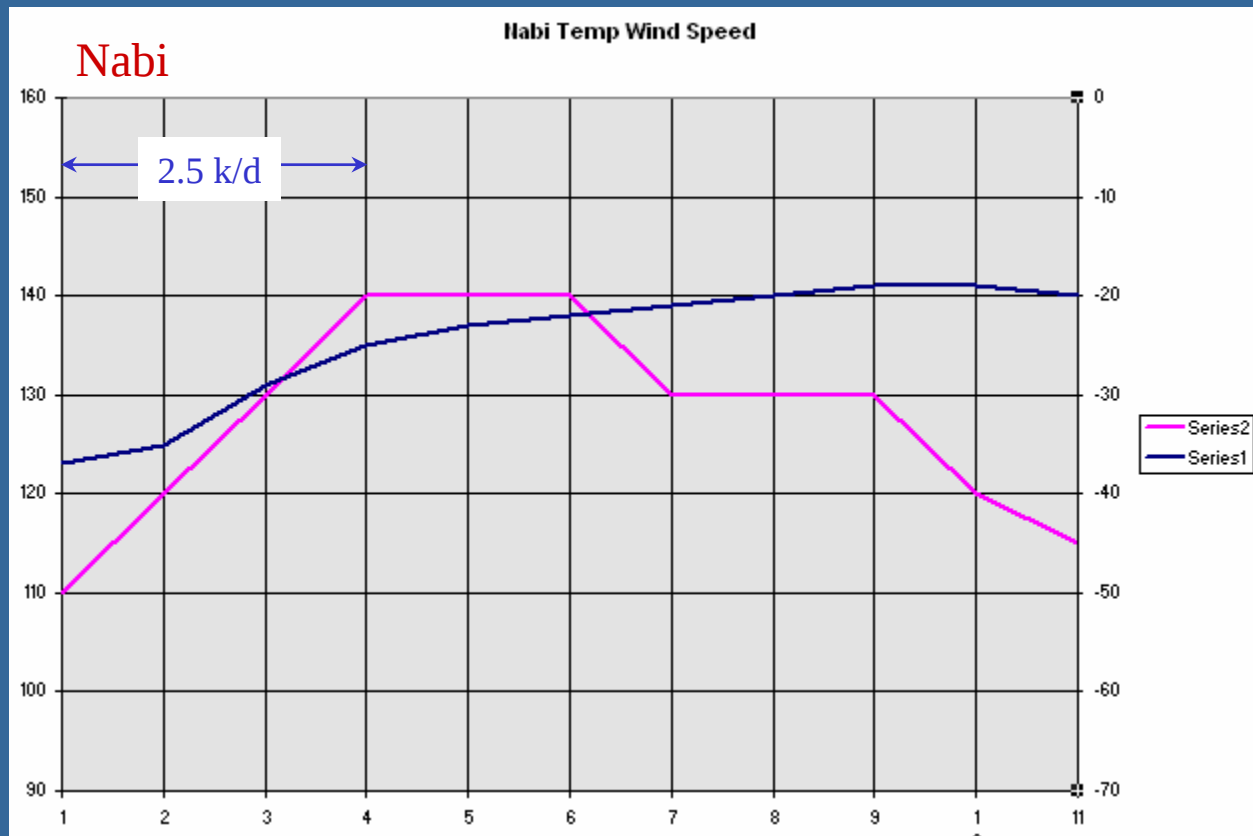
Phanfone Set #3

1832z 18 Aug 02 90 kts

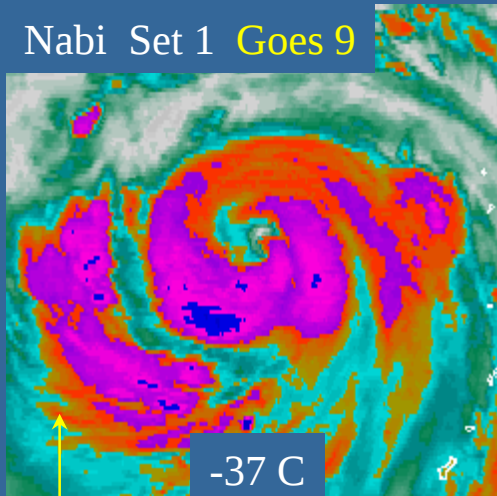
Equal Scales
1 knot = 1 degree

WV Eye Temperature
Wind Speed Intensity

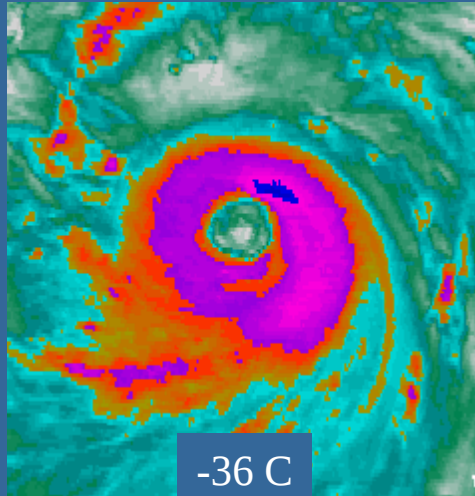
Blue Line
Magenta Line



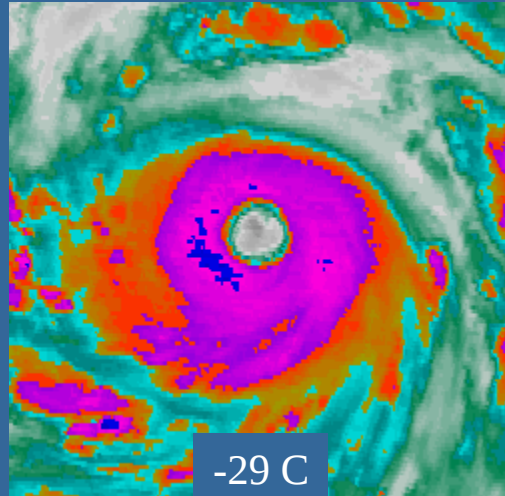
Nabi Set 1 Goes 9



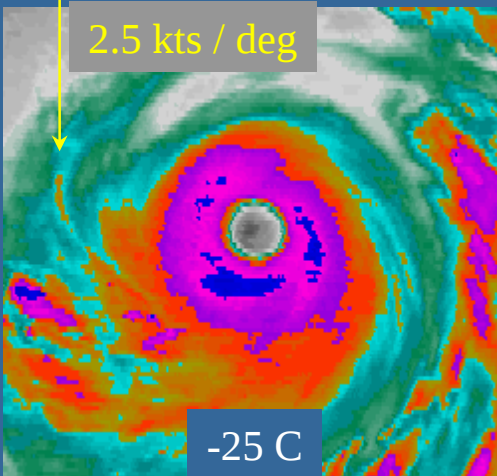
0002z 1 Sep 05 110 kts



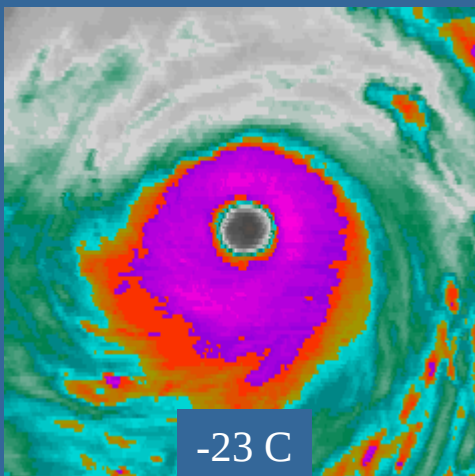
0602z 1 Sep 05 120 kts



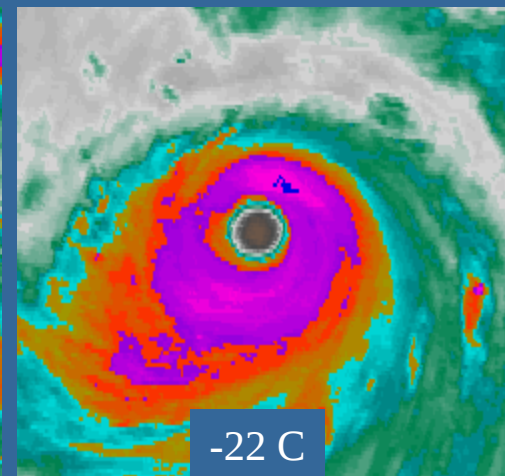
1202z 1 Sep 05 130 kts



1802z 1 Sep 05 140 kts



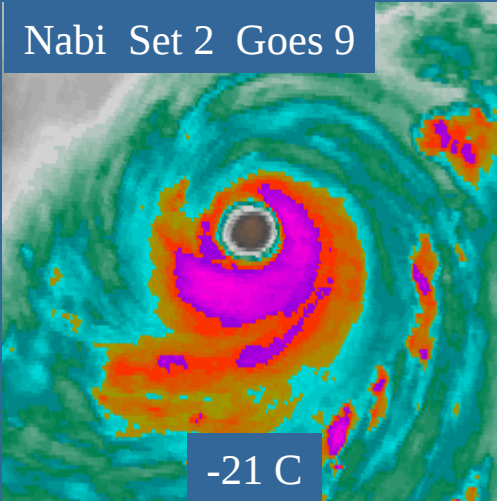
0002z 2 Sep 05 140 kts



0602z 2 Sep 05 140 kts

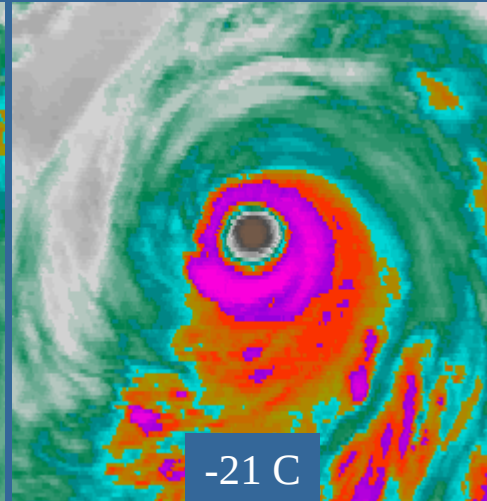
2.5 kts / deg

Nabi Set 2 Goes 9



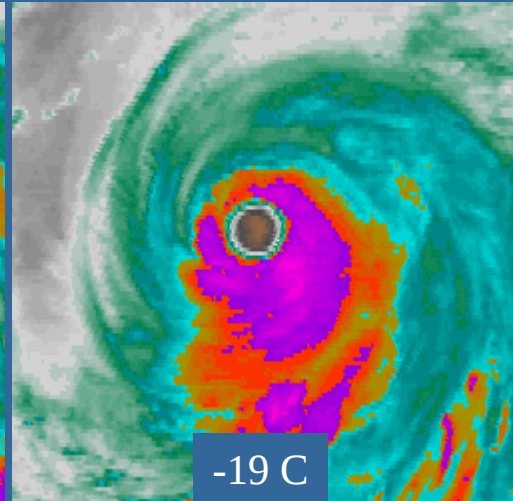
-21 C

1202z 2 Sep 05 130 kts



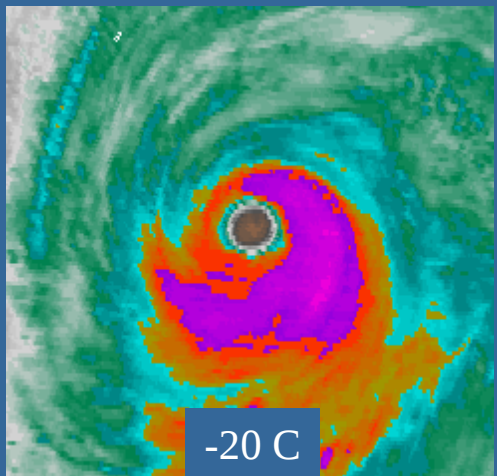
-21 C

1802z 2 Sep 05 130 kts



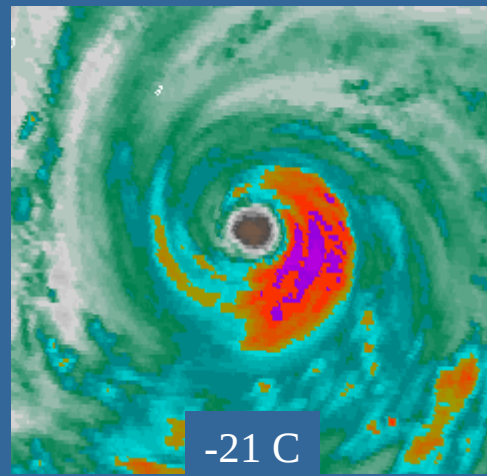
-19 C

0002z 3 Sep 05 130 kts



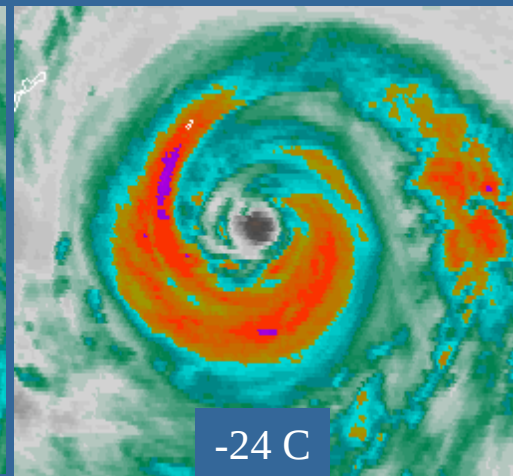
-20 C

0602z 3 Sep 05 120 kts



-21 C

1202z 3 Sep 05 115 kts



-24 C

1802z 3 Sep 05

CDO Deforming

Winds cross TC Cold Cloud Shield at Large Angles with “open” flow.

The CDO becomes Deformed

The event is often signaled in advance by “RED EYE”

The eye cools very rapidly prior to the CDO becoming deformed

EPAC-02

Hurricane Kenna

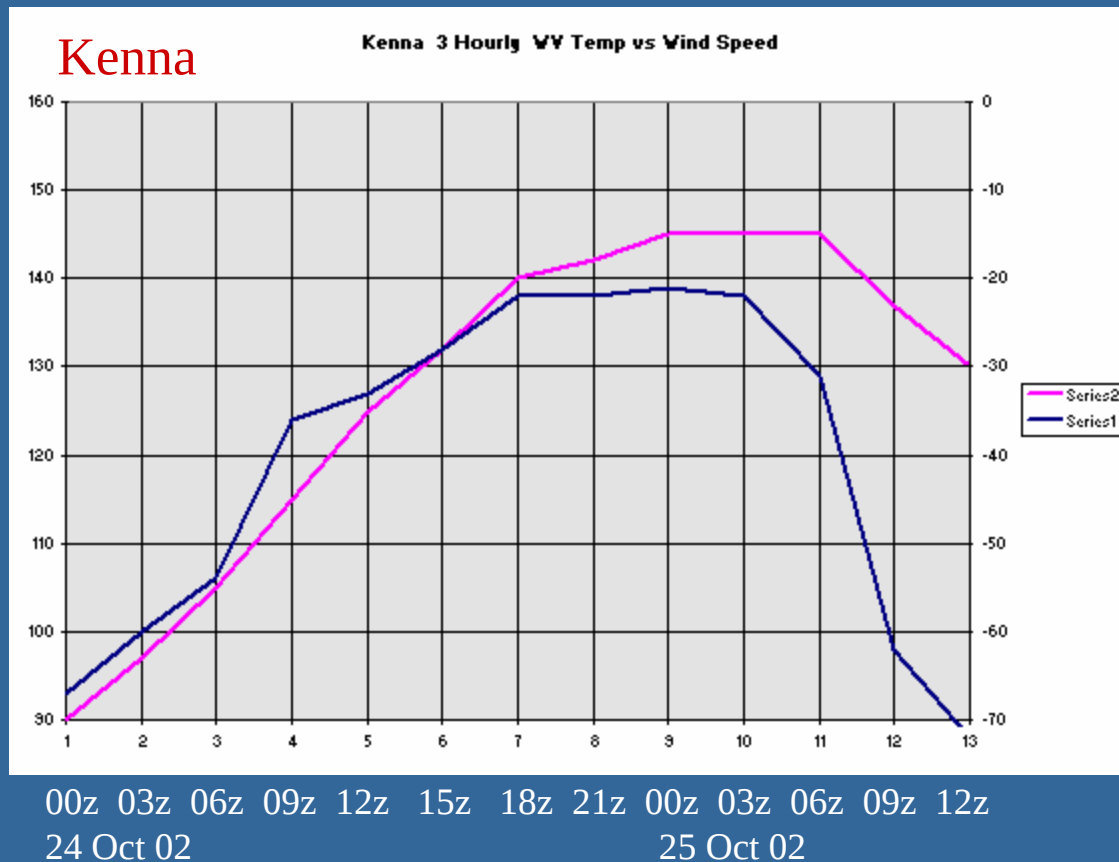
Right Turn 2

360 to 035 degrees

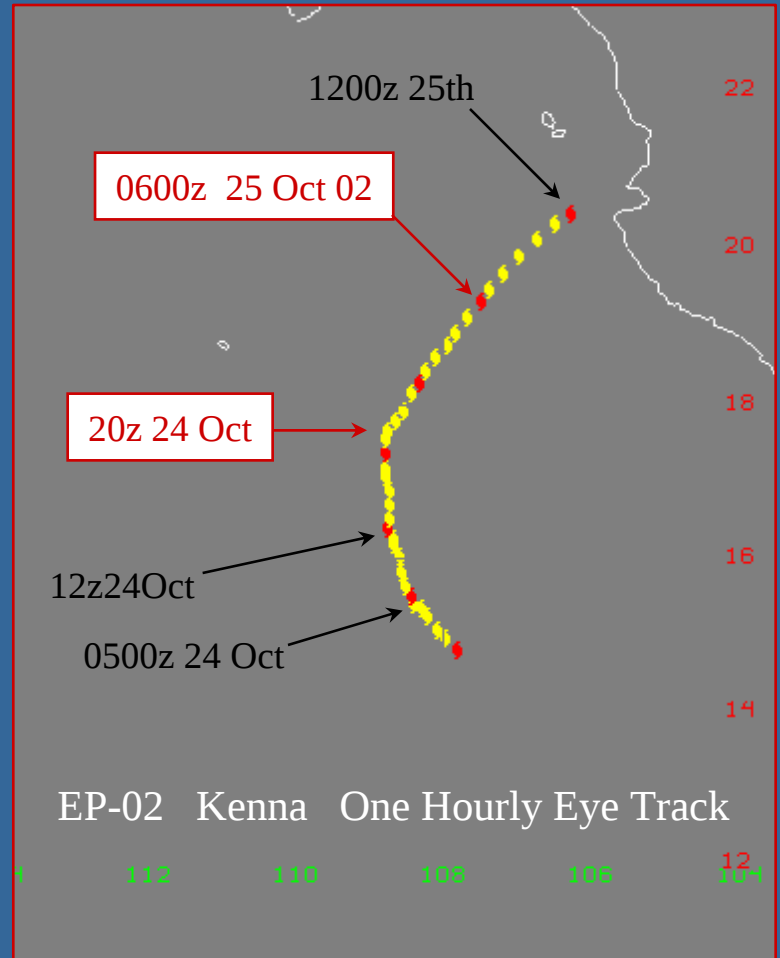
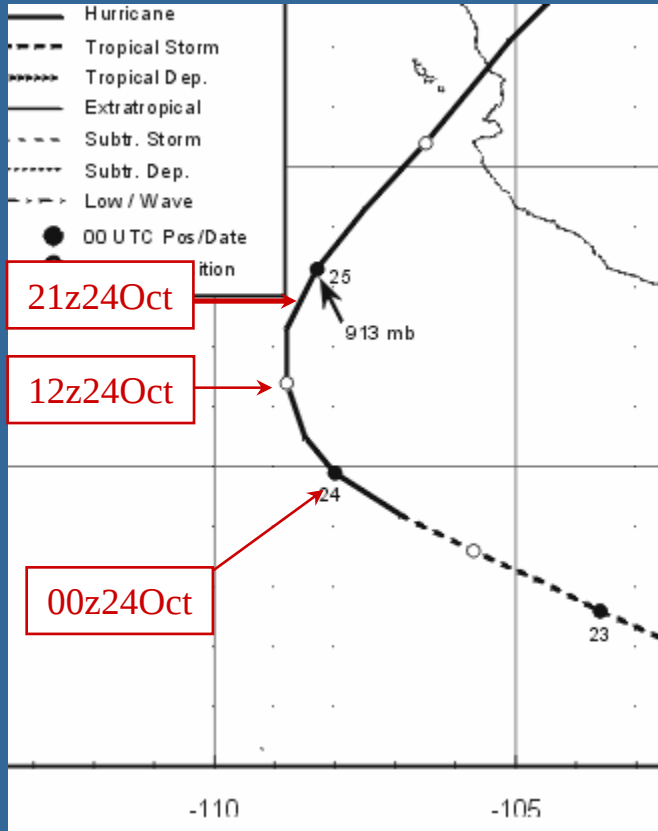
Kenna moved into digging westerlies and made a “hybrid” category right turn between 20z and 21z 24 October. Dry air with “open” flow arrived at the CDO about 03z 25 October. Both IR and WV eye temperatures cooled rapidly between 06z and 09z. The CDO deformed by 12z. CDO top temperatures did the “Taiwan burst”.

Equal Scales
1 degree = 1 knot

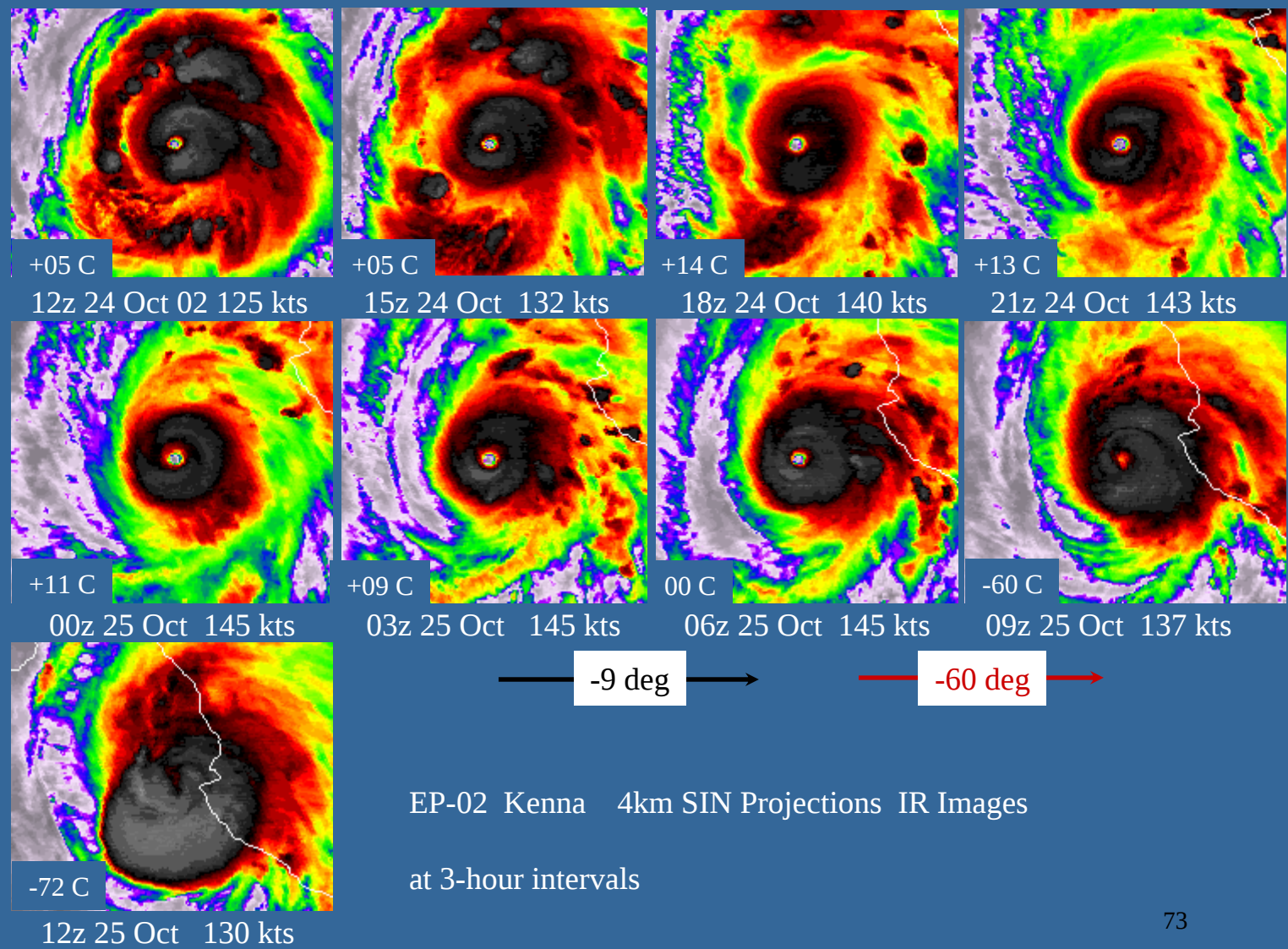
WV Eye Temperature Blue Line
Wind Speed Intensity Magenta Line

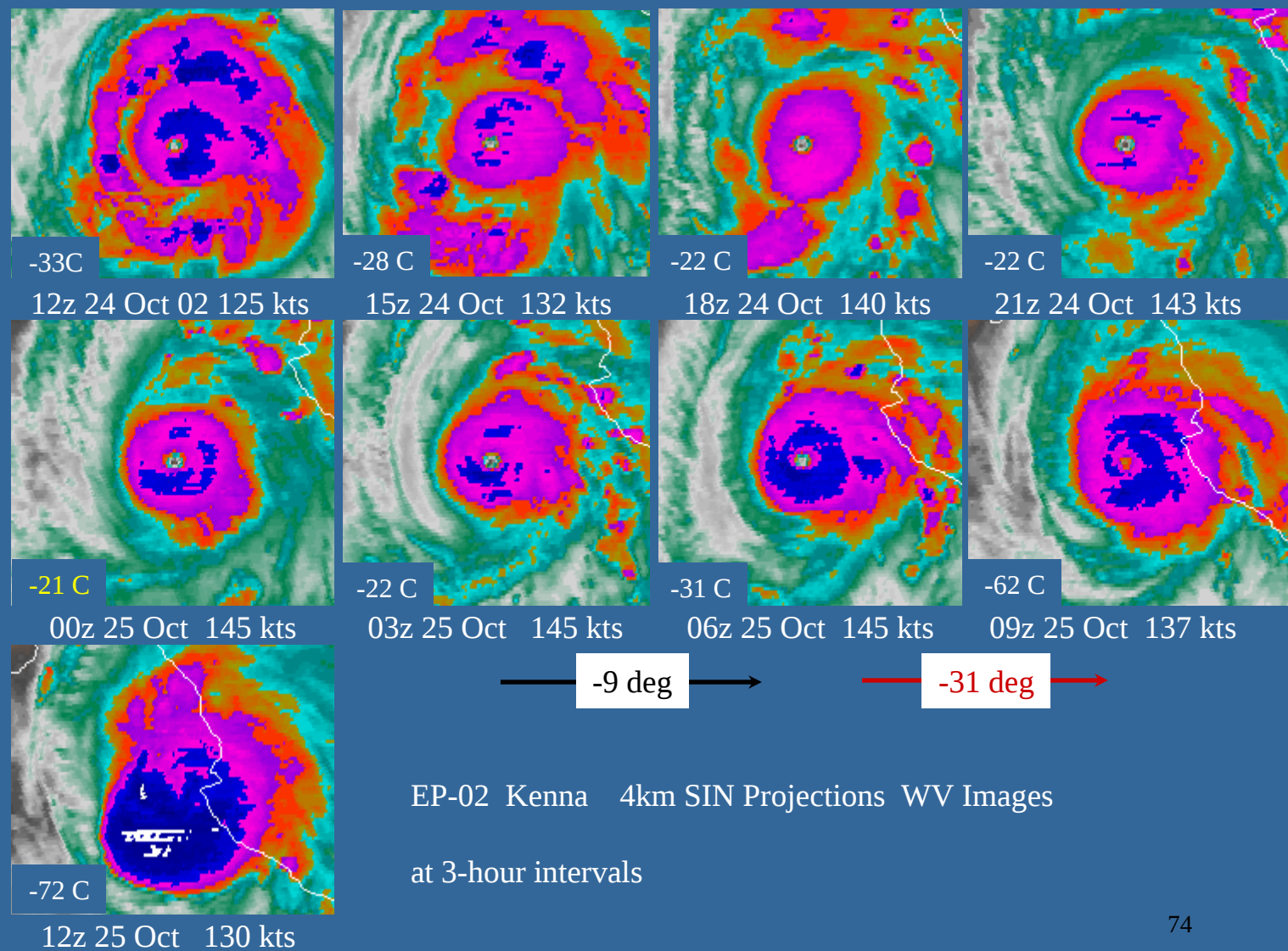


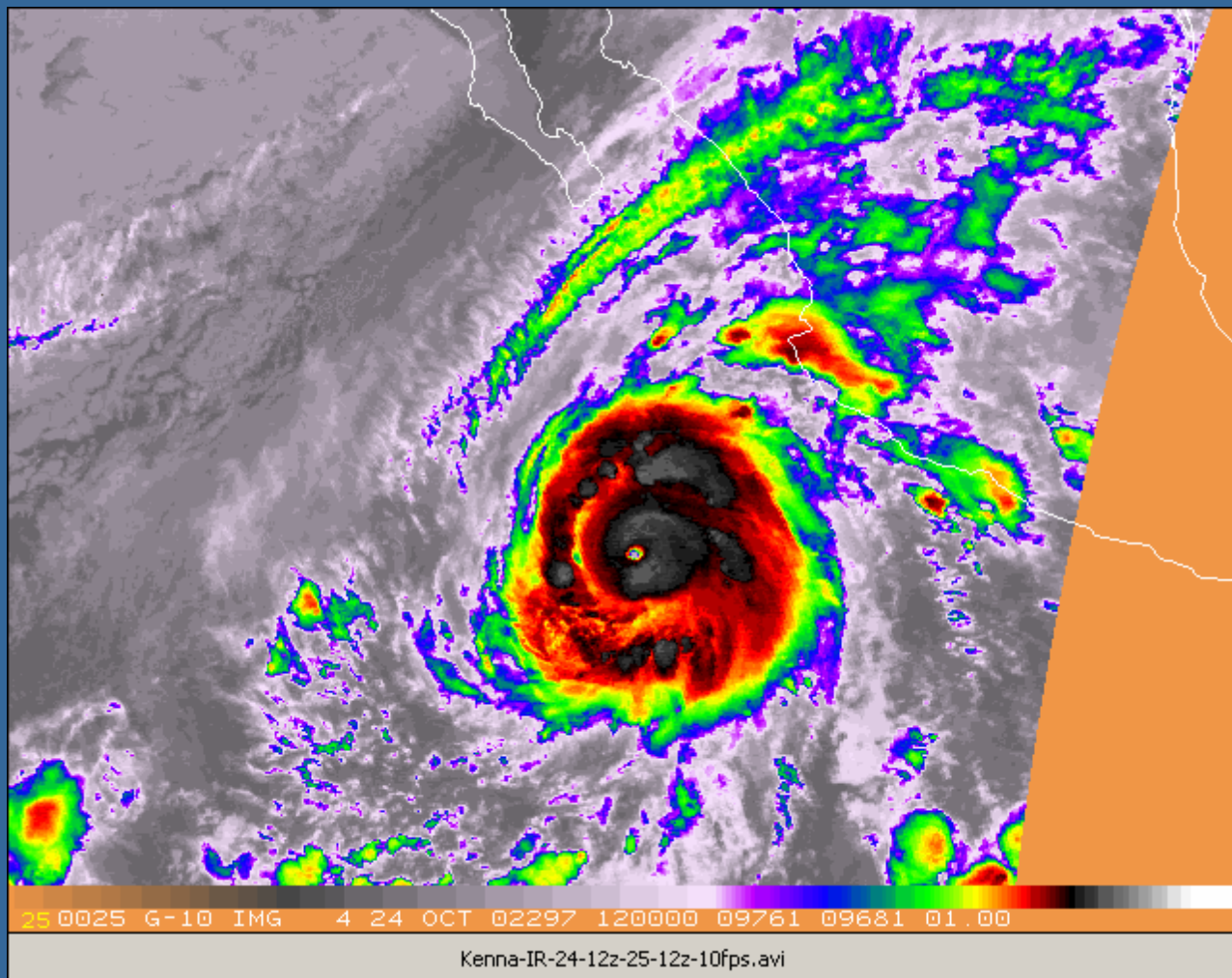
EP-02 Kenna

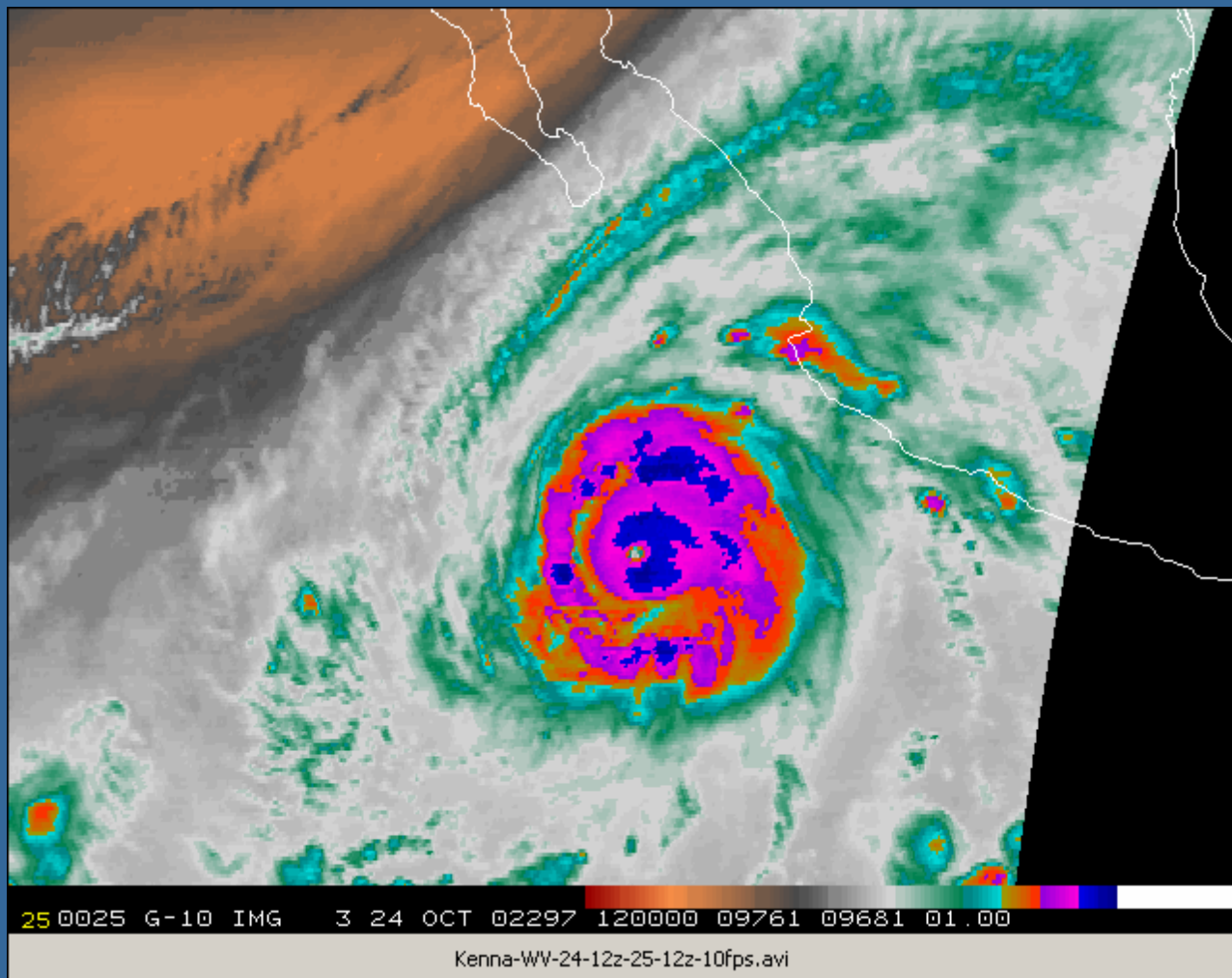


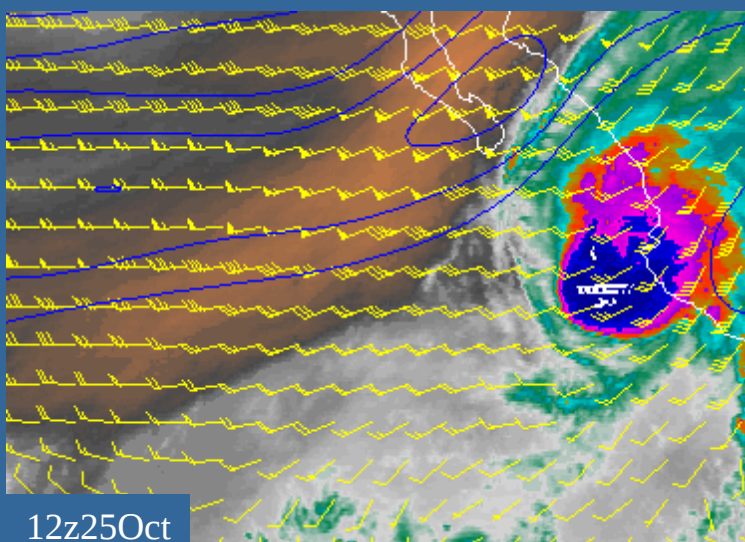
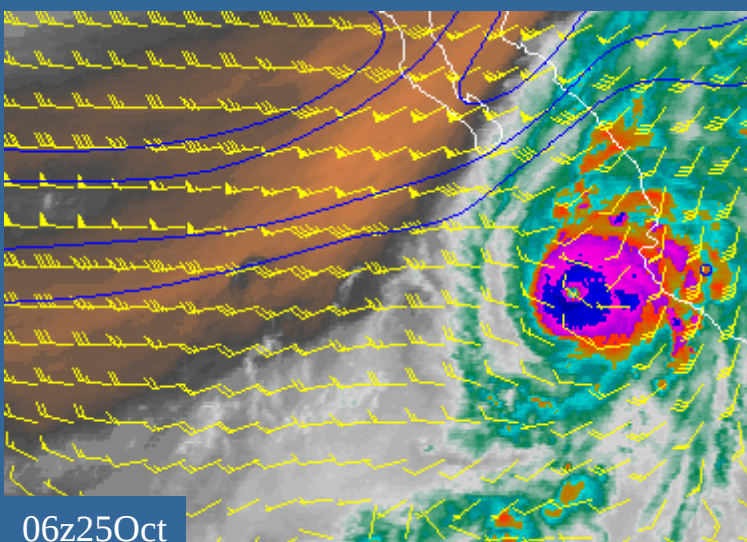
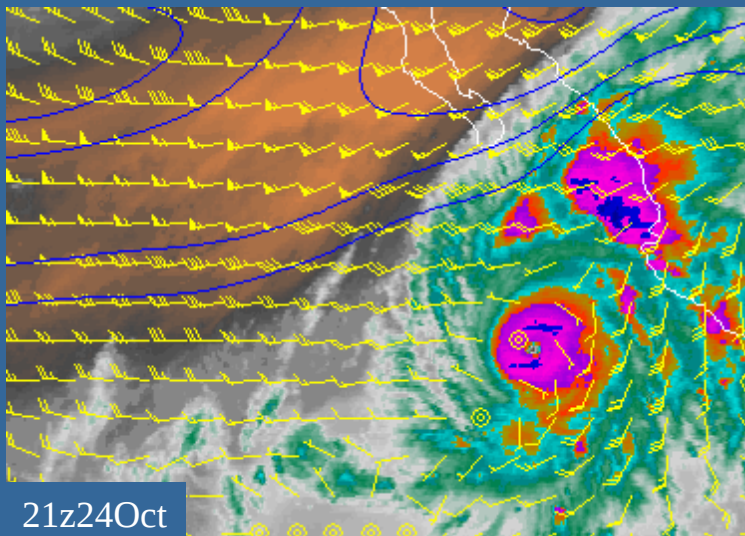
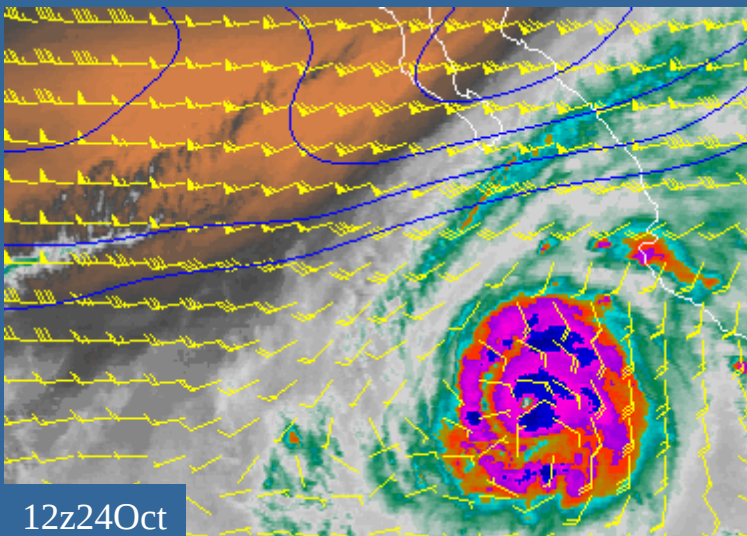
EP-02 Kenna One Hourly Eye Track

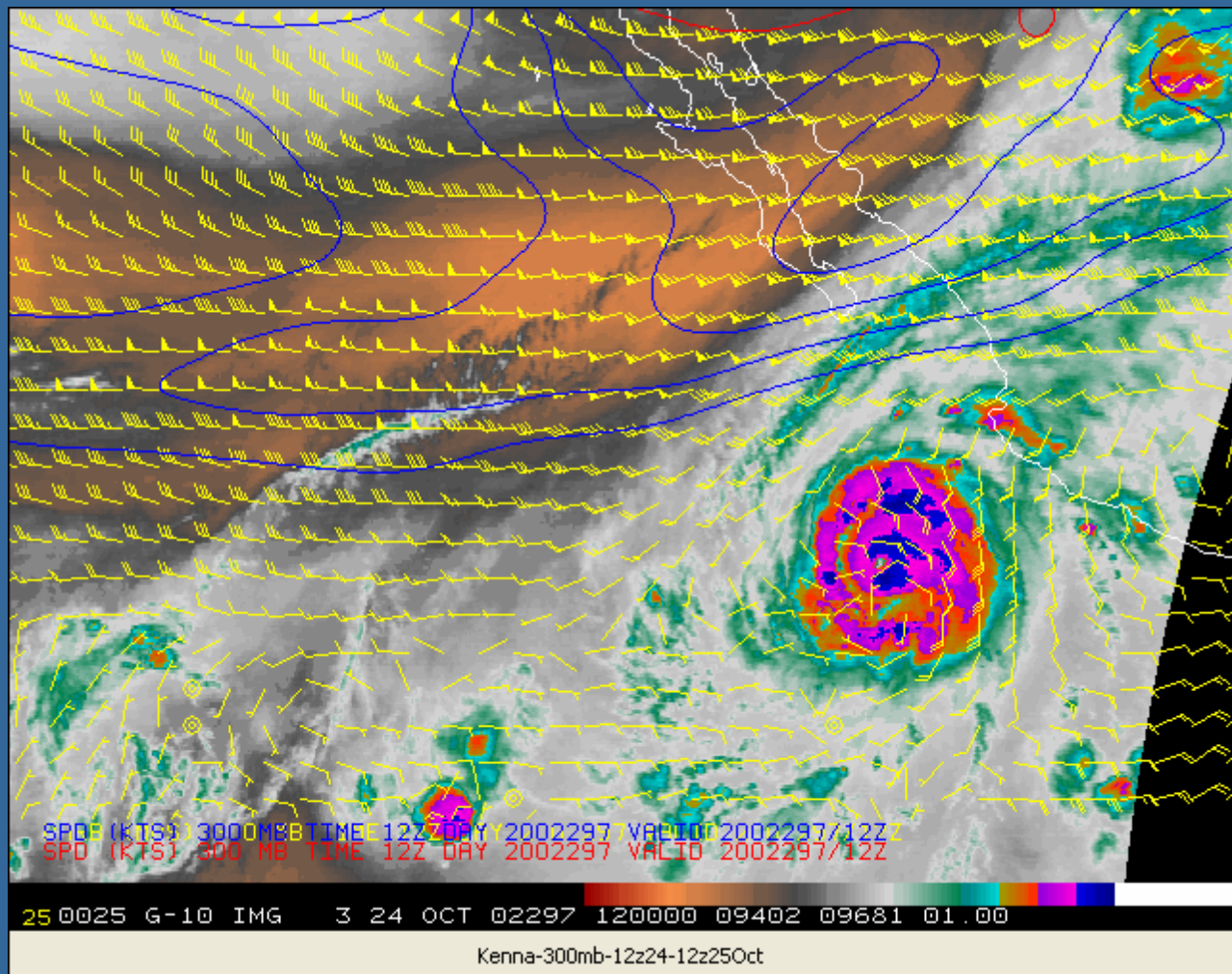












Ma-on

-58 C

0002z 7 Oct 04 80 kts

-38 C

0602z 7 Oct 90 kts

-33 C

1202z 7 Oct 115 kts

-28 C

1802z 7 Oct 130 kts

-27 C

0002z 8 Oct 140 kts

-26 C

0602z 8 Oct 140 kts

-68 C

1202z 8 Oct 140 kts

-71 C

1802z 8 Oct 135 kts

-32 deg

No eye on WV imagery
Totally deformed patterns

Began to vertically separate
similar to Kenna and Sidr

-54 C

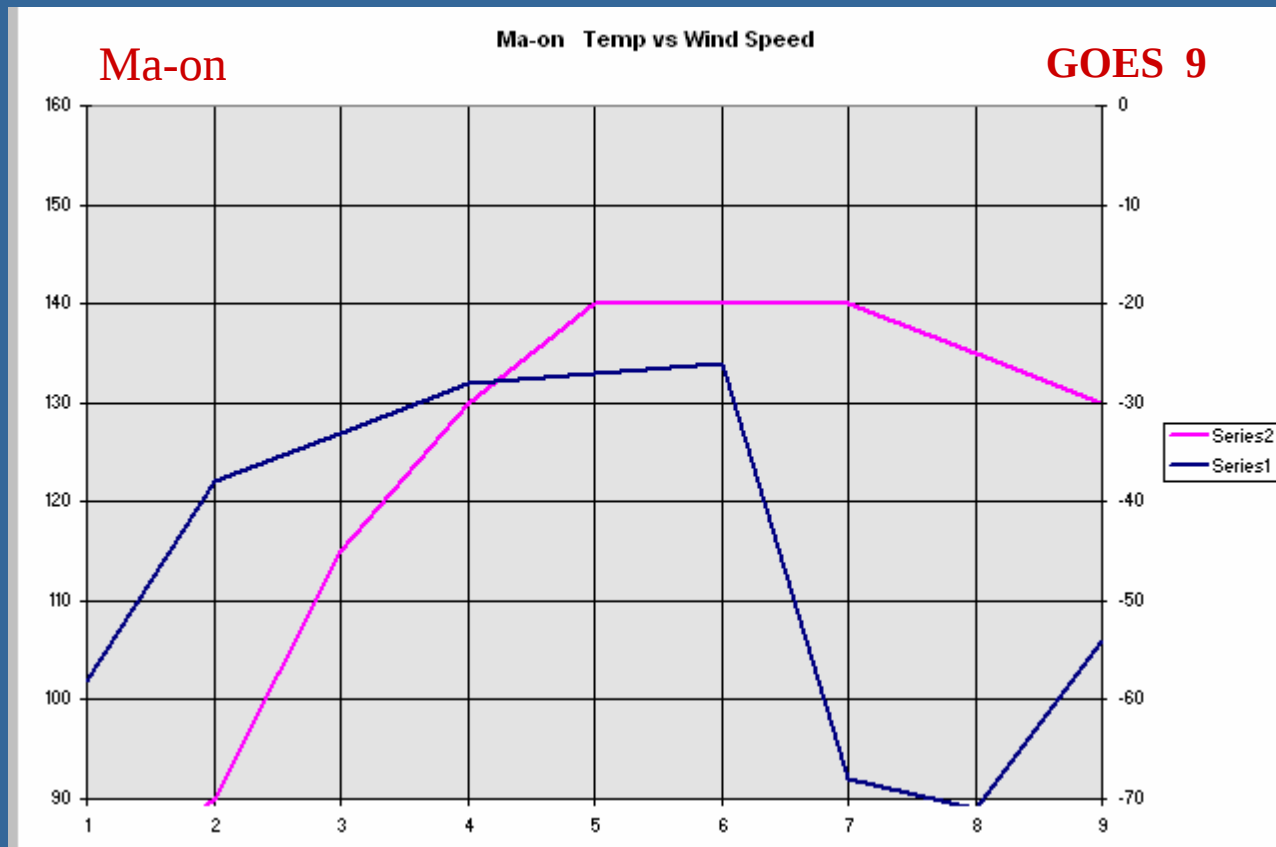
0002z 9 Oct 130 kts

0602z 9 Oct 105 kts

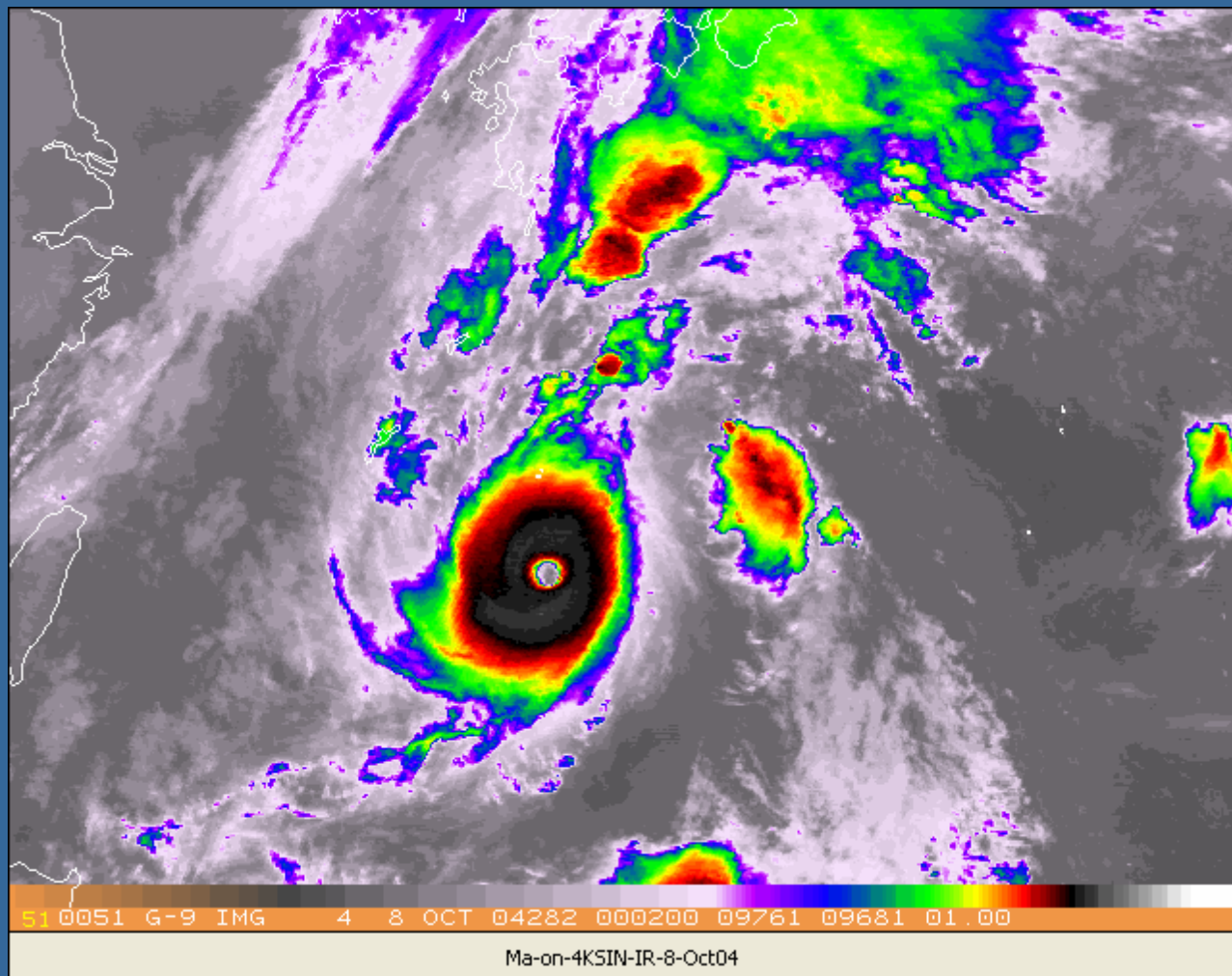
1202z 9 Oct 85 kts

Equal Scales
1 knot = 1 degree

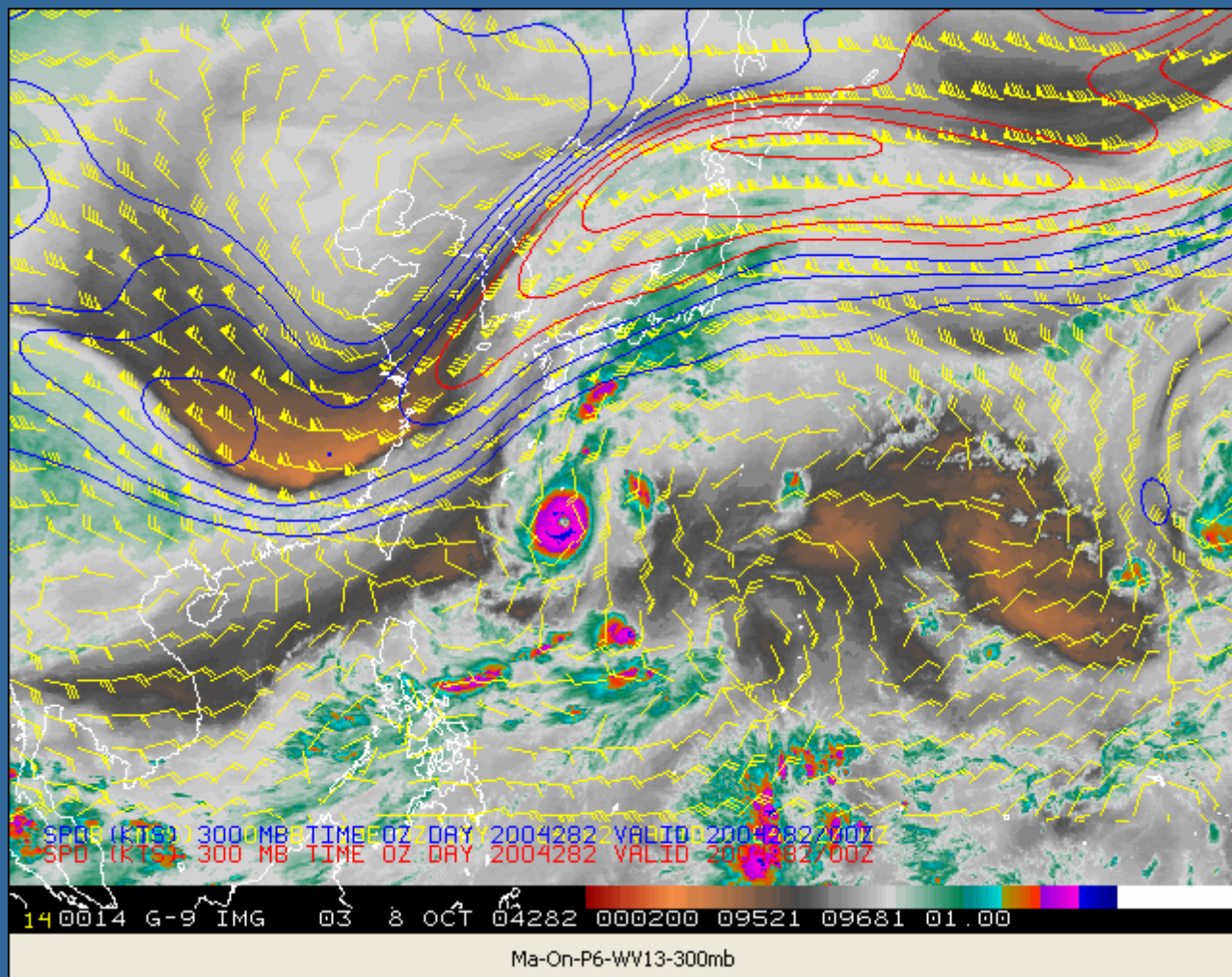
WV Eye Temperature Blue Line
Wind Speed Intensity Magenta Line



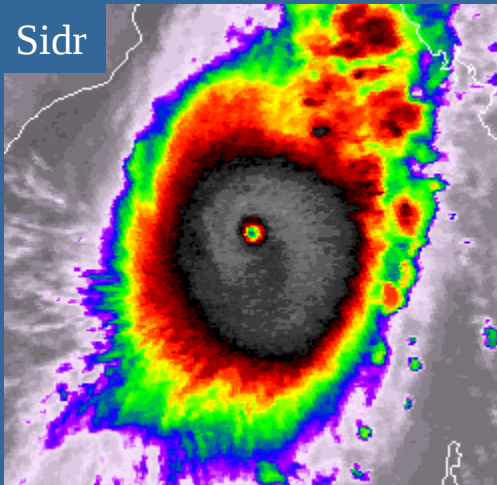
0002z 0602z 1202z 1802z 0002z 0602z 1202z 1802z 0002z
7Oct04 8Oct04 9Oct04



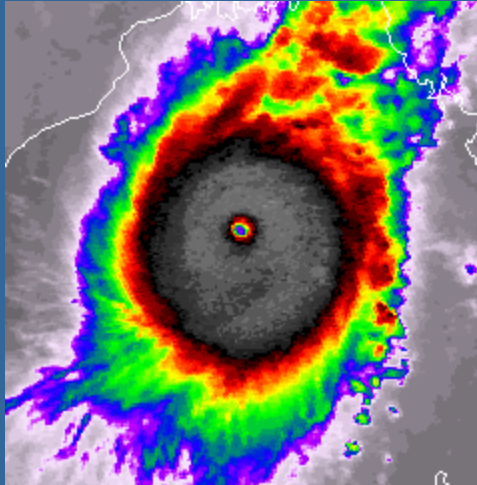
WP-04 Ma-on 4KSIN IR Loop 0002z 8 Oct - 0002z 9 Oct 04



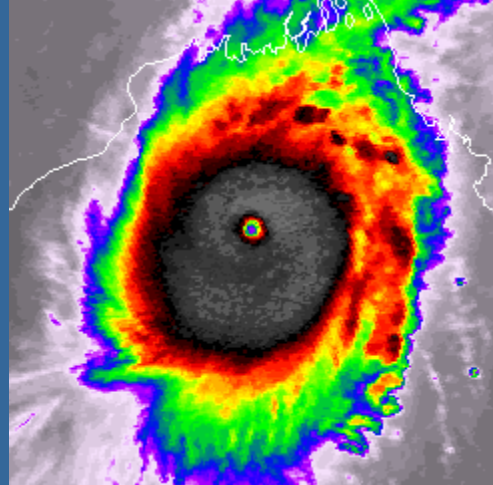
Sidr



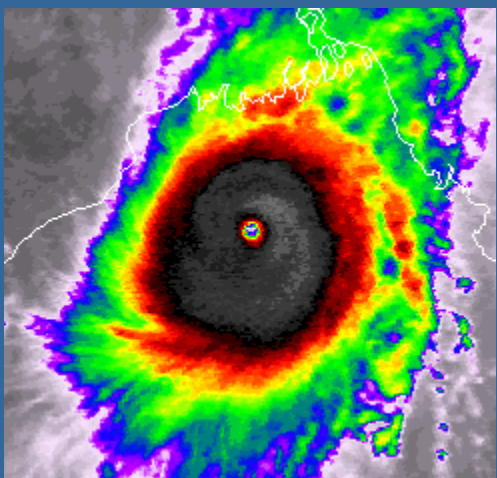
2100z 14 Nov 07



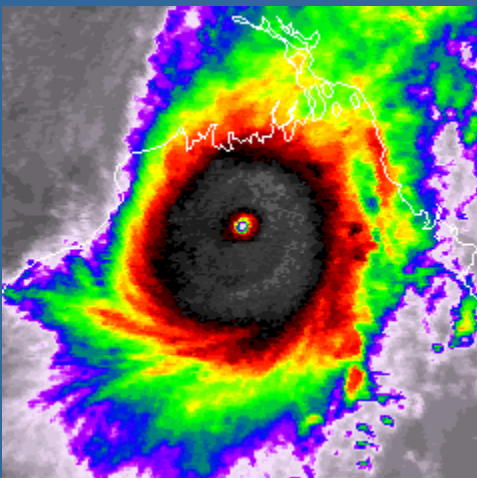
0000z 15 Nov 07



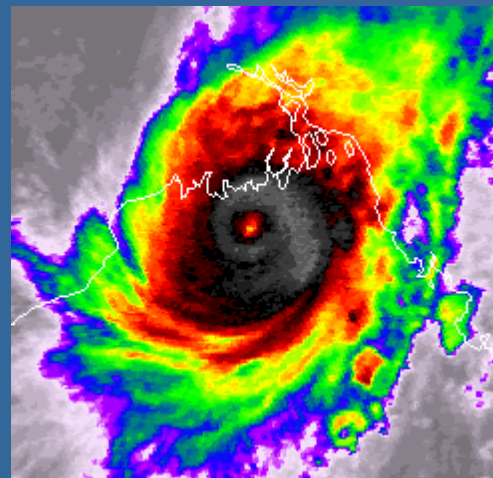
0300z 15 Nov 07



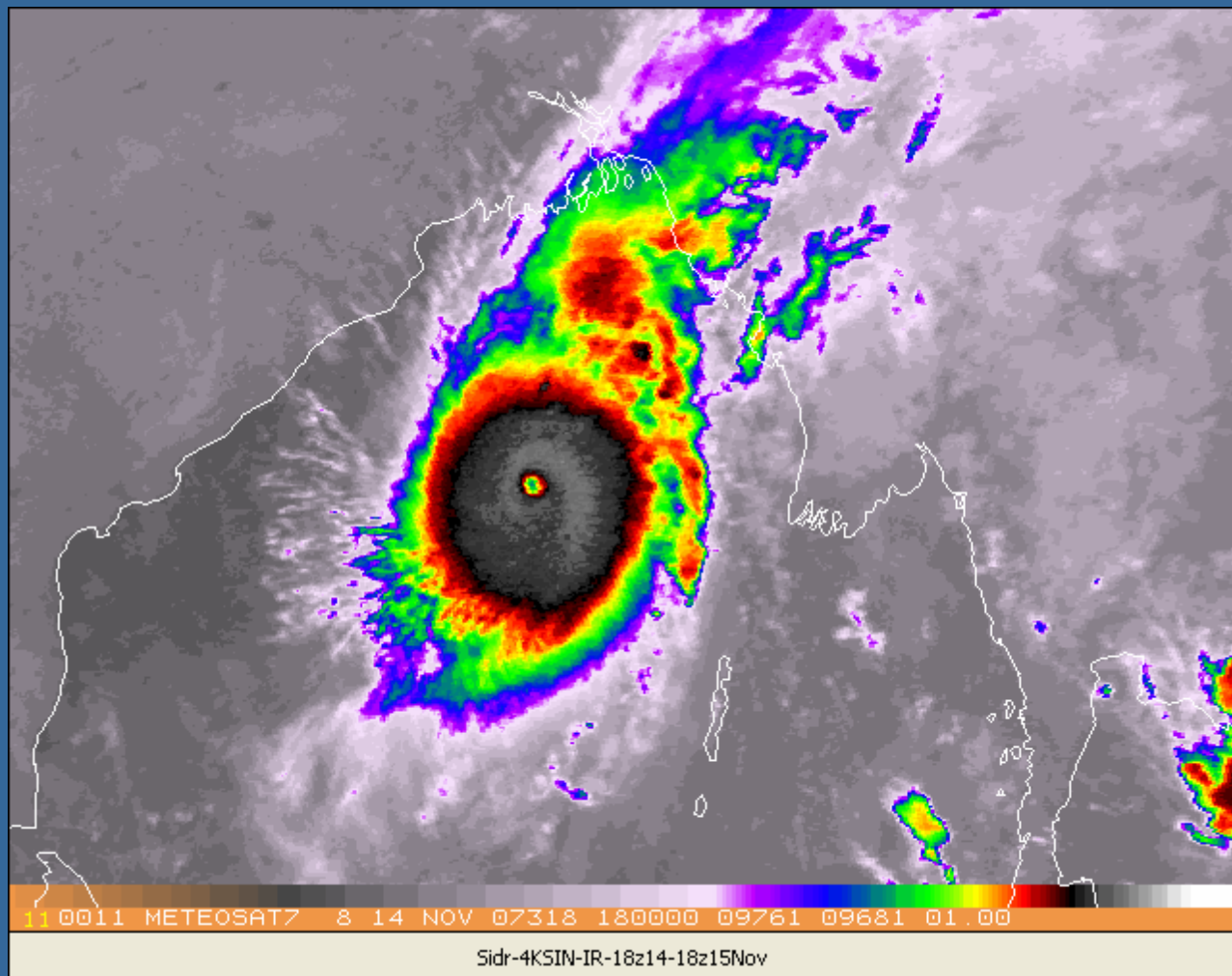
0600z 15 Nov 07



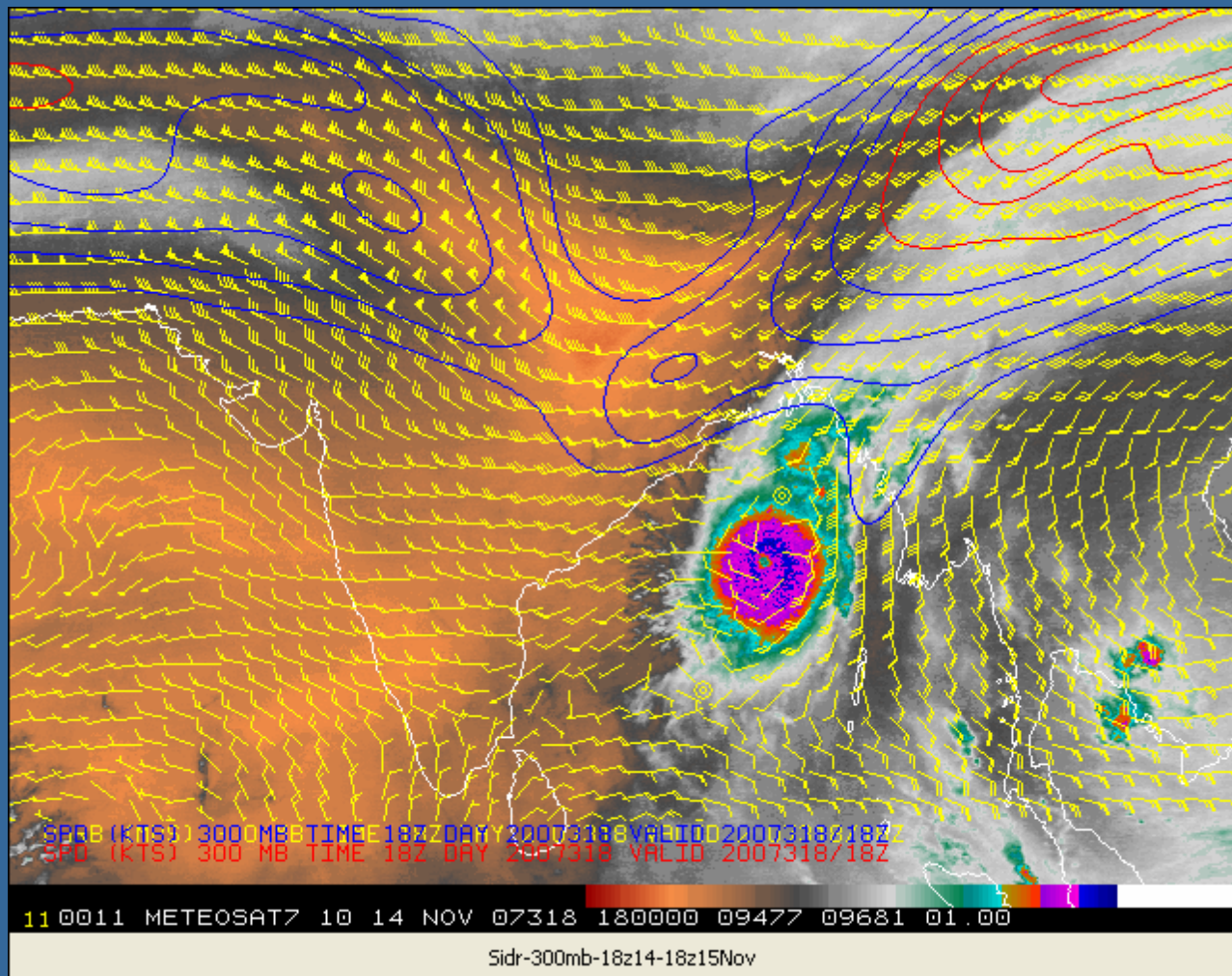
0900z 15 Nov 07



1200z 15 Nov 07

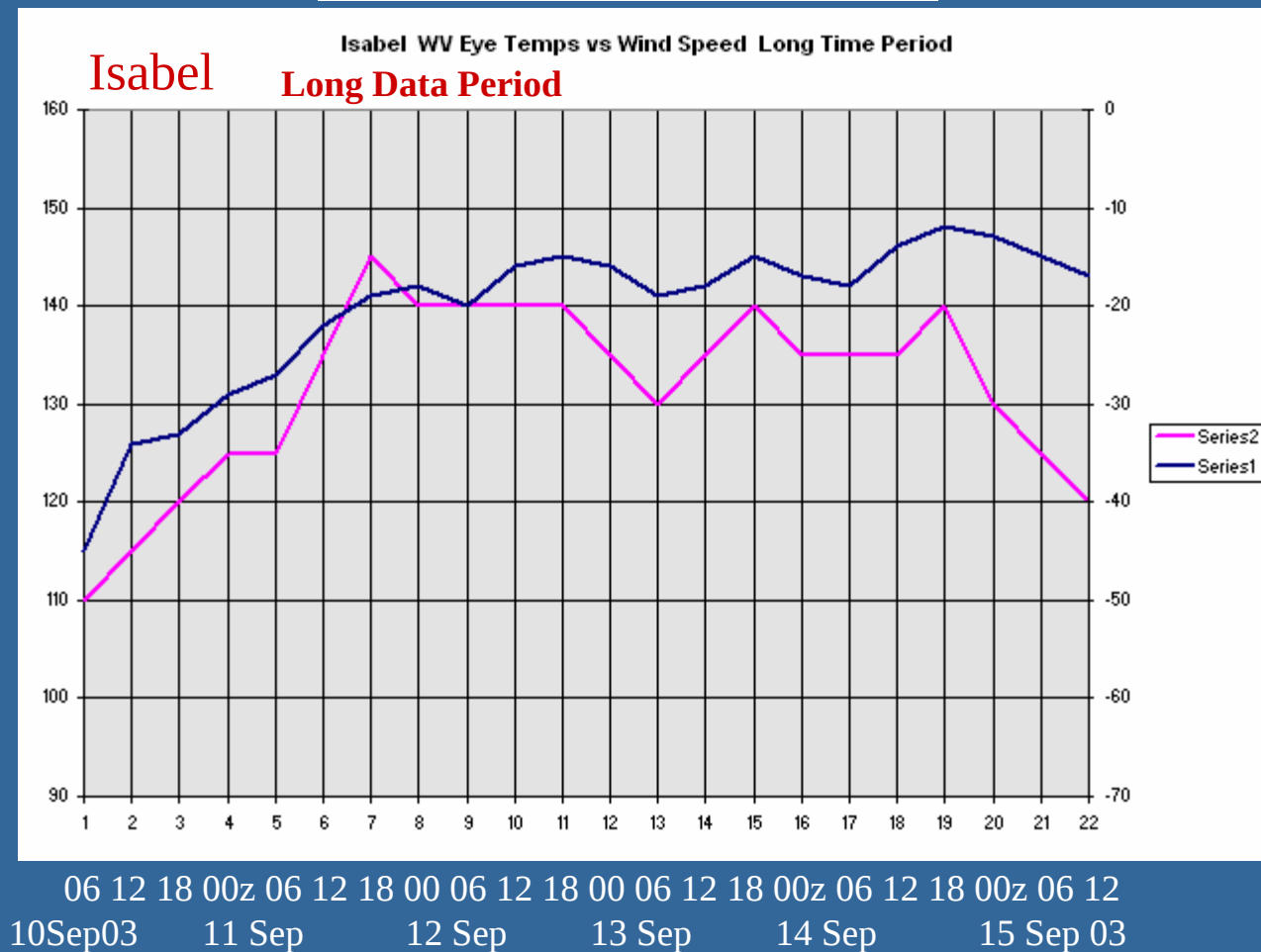


IND-07 Sidr 4KSIN IR Loop 1800z 14 Nov - 1800z 15 Nov 07



Equal Scales
1 degree = 1 knot

WV Eye Temperature Blue Line
Wind Speed Intensity Magenta Line



Eye Temperatures and Storm Intensity

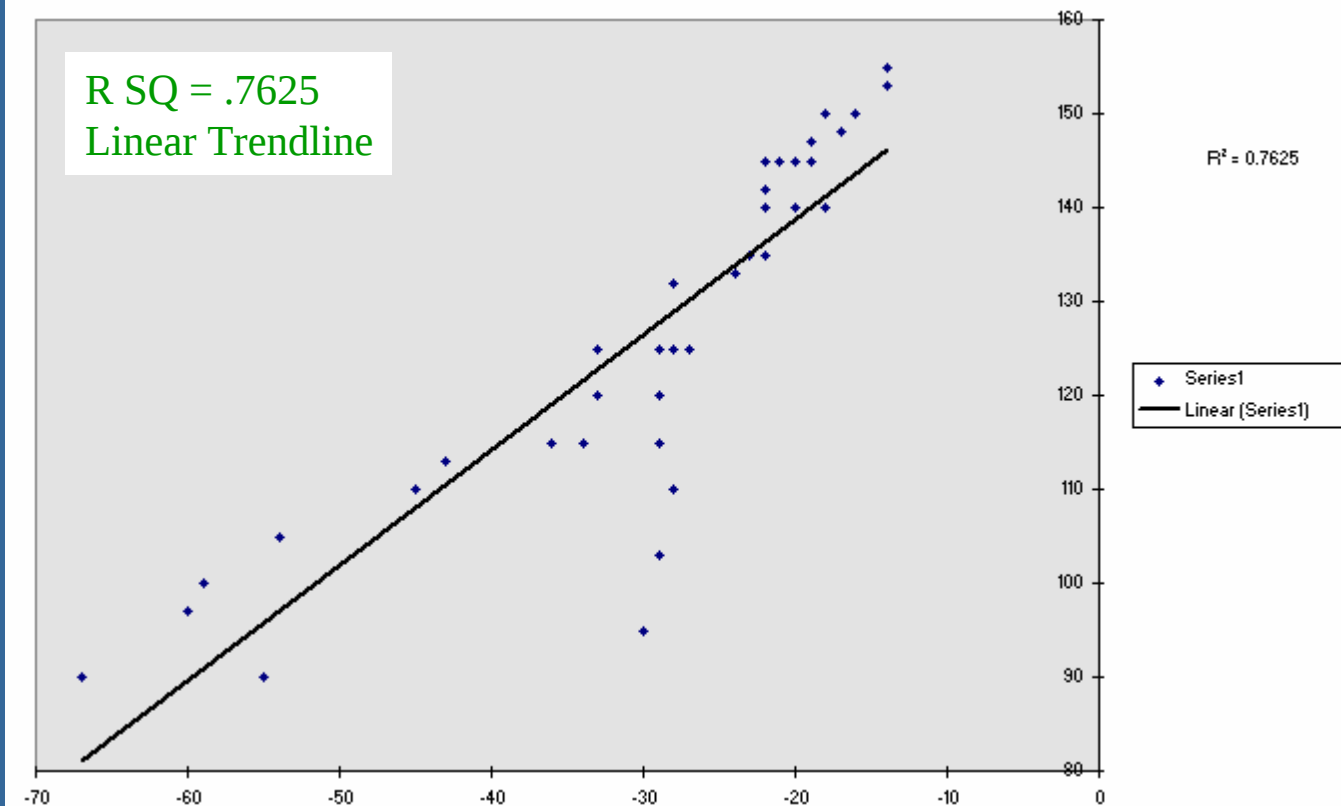
Scatter Diagrams and Trendline R Squared Values

TPC Only

Rita Isabel Katrina Kenna

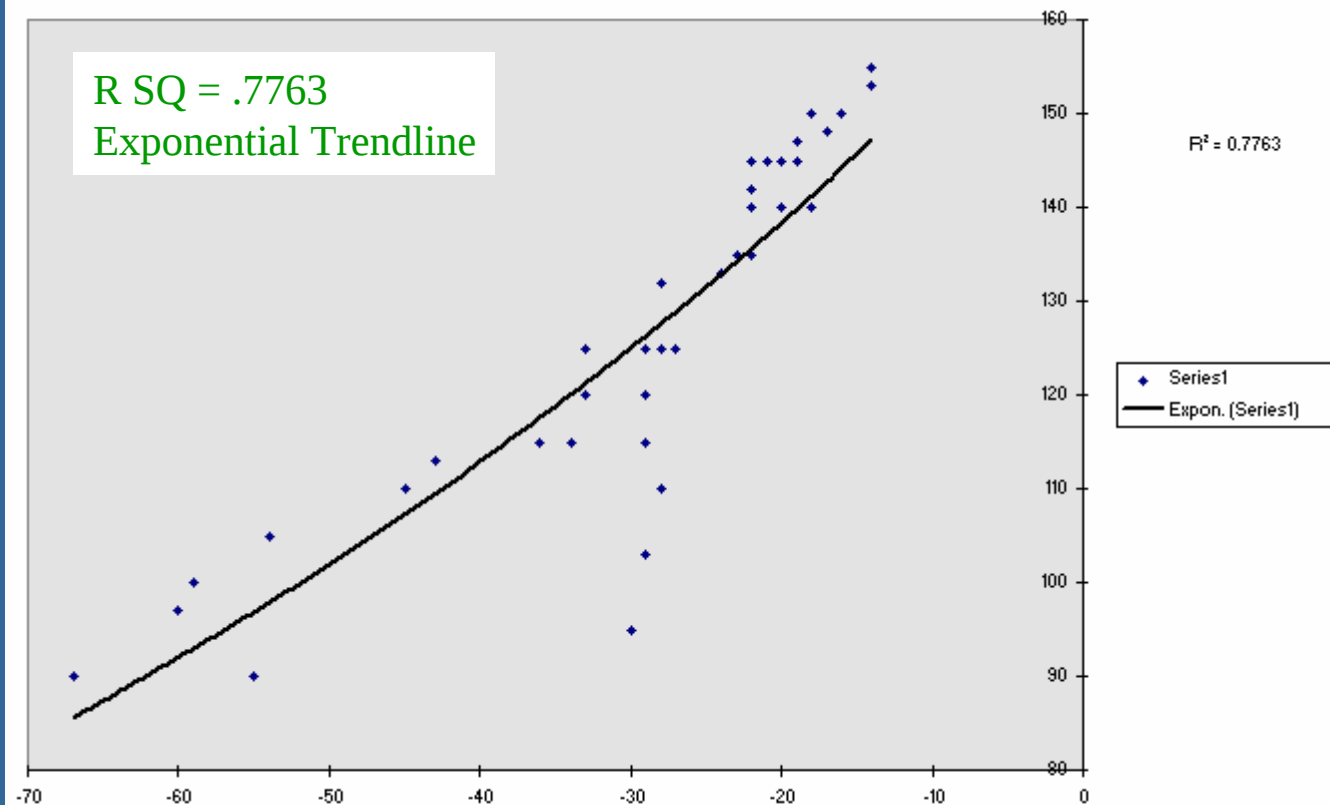
38 Data Points

WV Temp vs Wind Speed 4 TPC Storms: Katrina, Isabel, Kenna, Rita



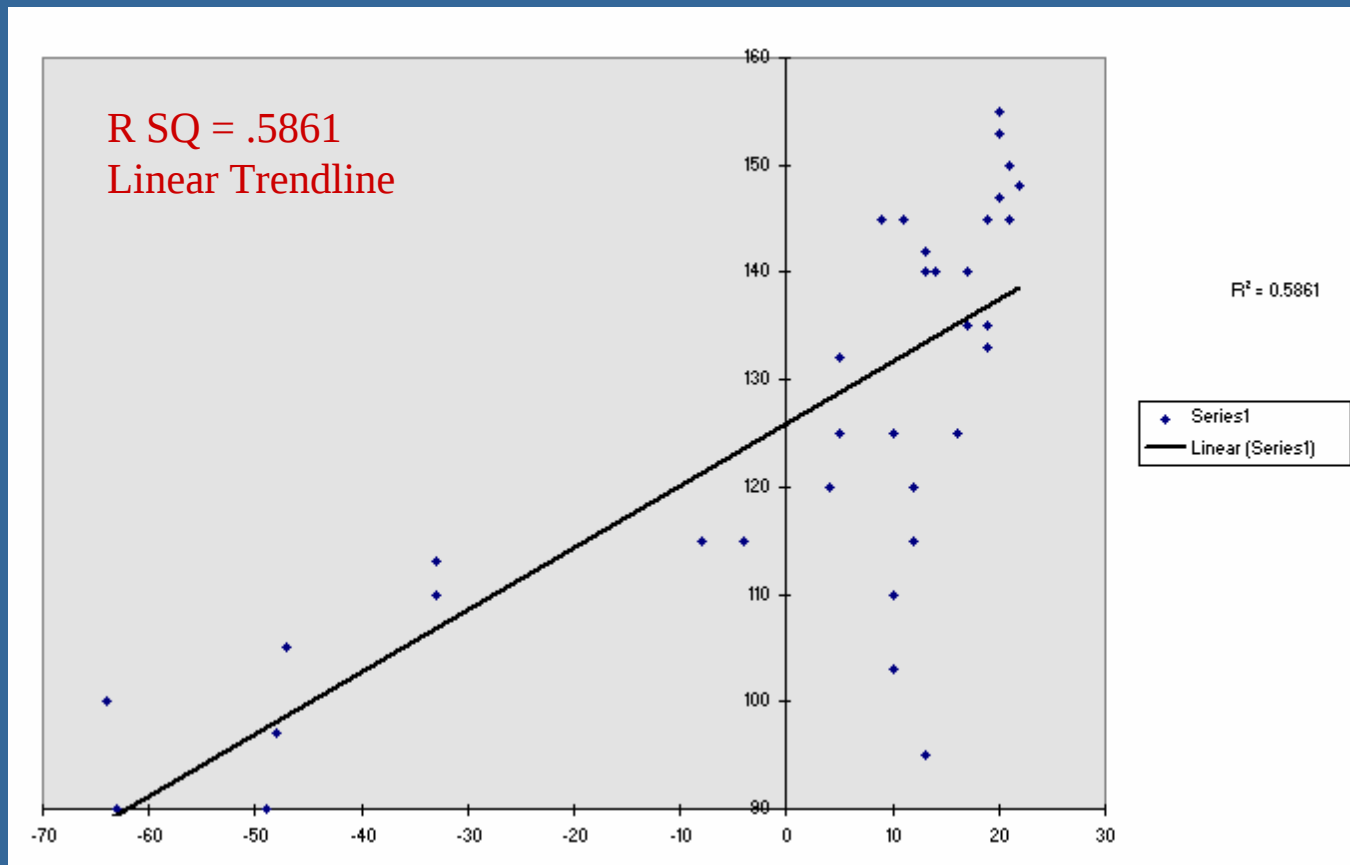
38 Data Points

WV Temp vs Wind Speed 4 TPC Storms: Katrina, Isabel, Kenna, Rita



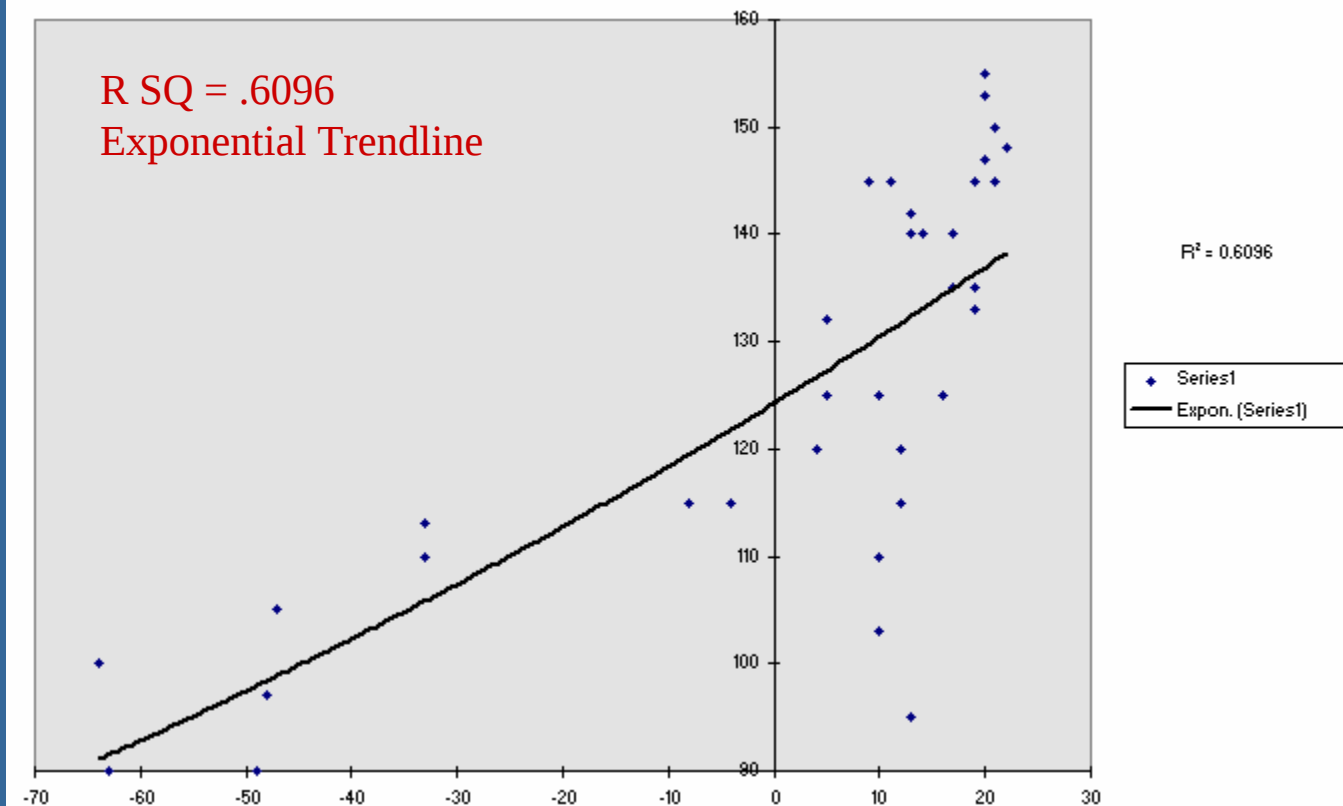
38 Data Points

IR Temp vs Wind Speed 4 TPC Storms: Katrina, Isabel, Kenna, Rita



38 Data Points

IR Temp vs Wind Speed 4 TPC Storms: Katrina, Isabel, Kenna, Rita



38 Data Points

R Squared Summary

4 TPC Storms

Water Vapor	Exponential Trendline	.7763
Water Vapor	Linear Trendline	.7625
IR	Exponential Trendline	.6096
IR	Linear Trendline	.5861

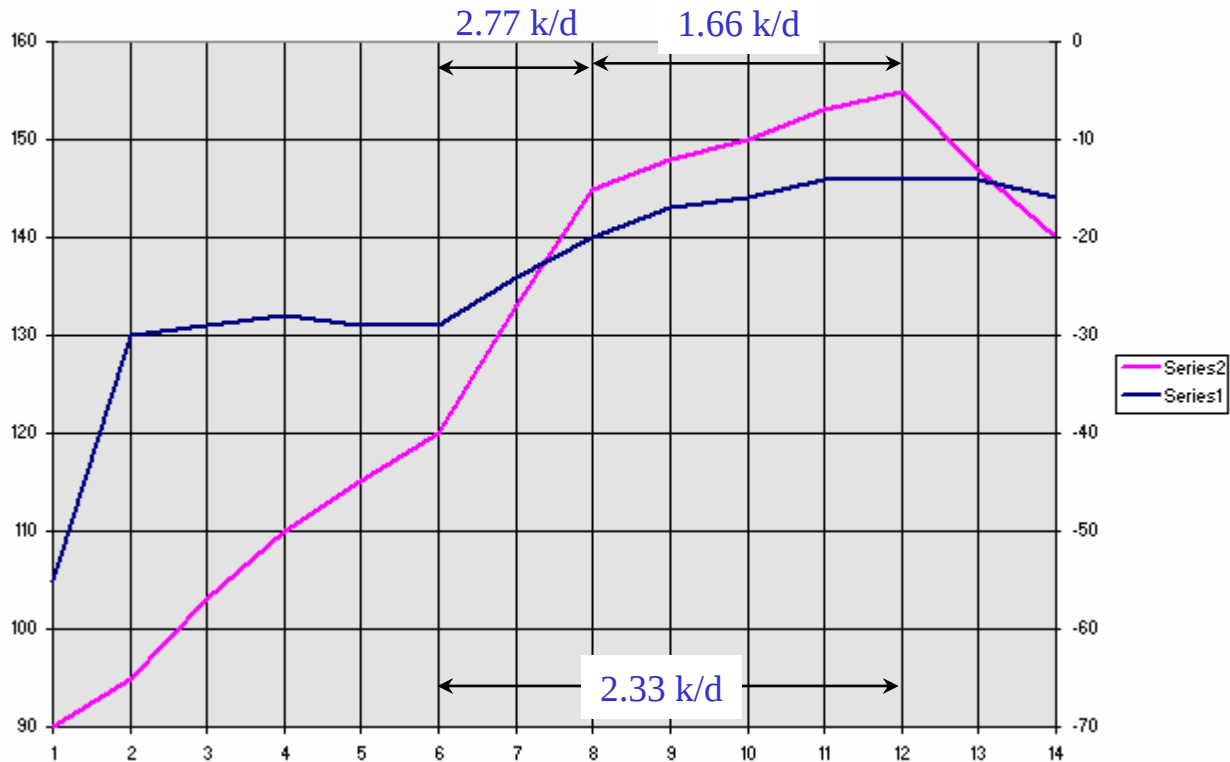
RITA Structure Changes

Equal Scales
1 knot = 1 degree

WV Eye Temperature Blue Line
Wind Speed Intensity Magenta Line

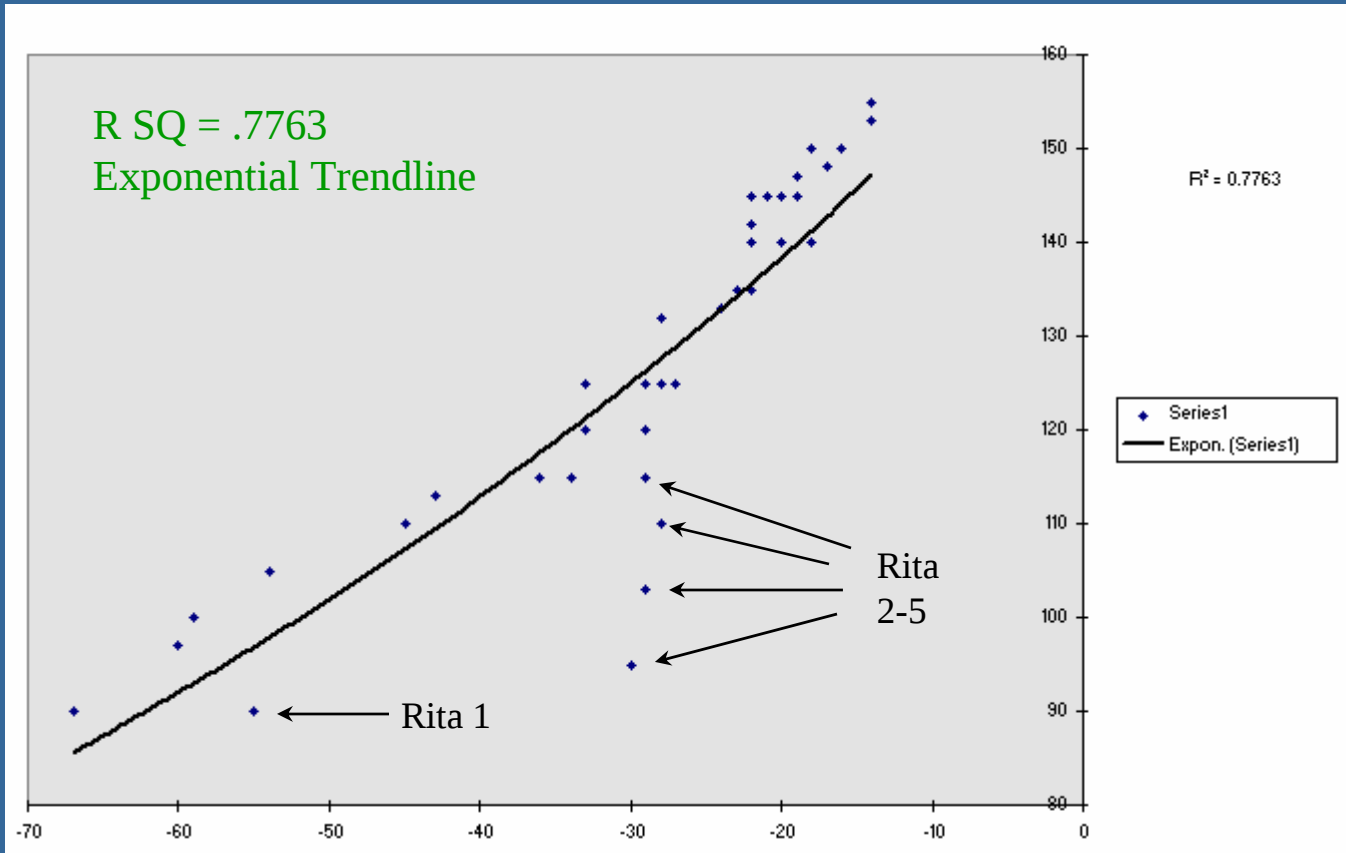
Rita

WV vs Wind Speed Rita Full Period



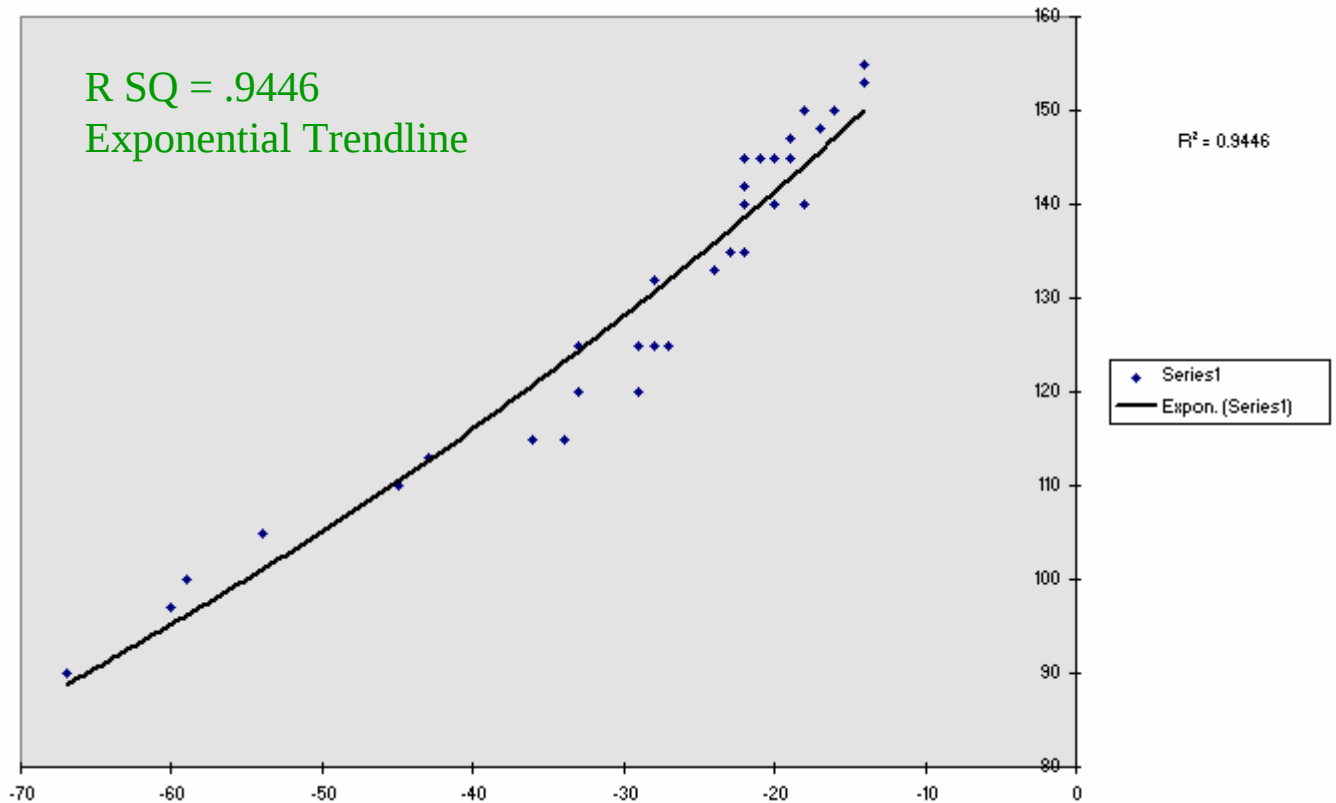
21z 00z 03z 06z 09z 12z 15z 18z 21z 00z 03z 06z 09z 12z
20 21 Oct 22 Oct

WV Temp vs Wind Speed 4 TPC Storms: Katrina, Isabel, Kenna, Rita



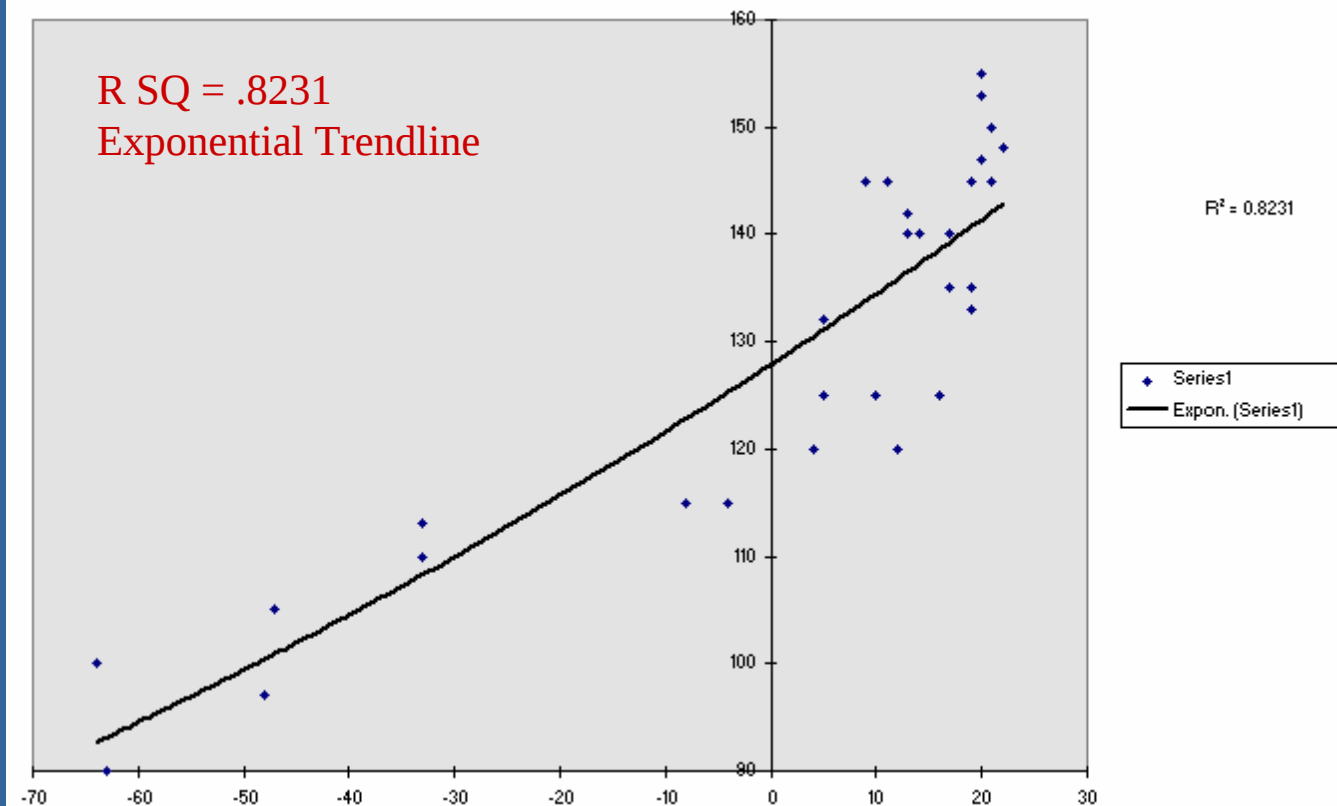
38 Data Points

WV Temp vs Wind Speed 4 TPC Storms: Katrina, Isabel, Kenna, Rita

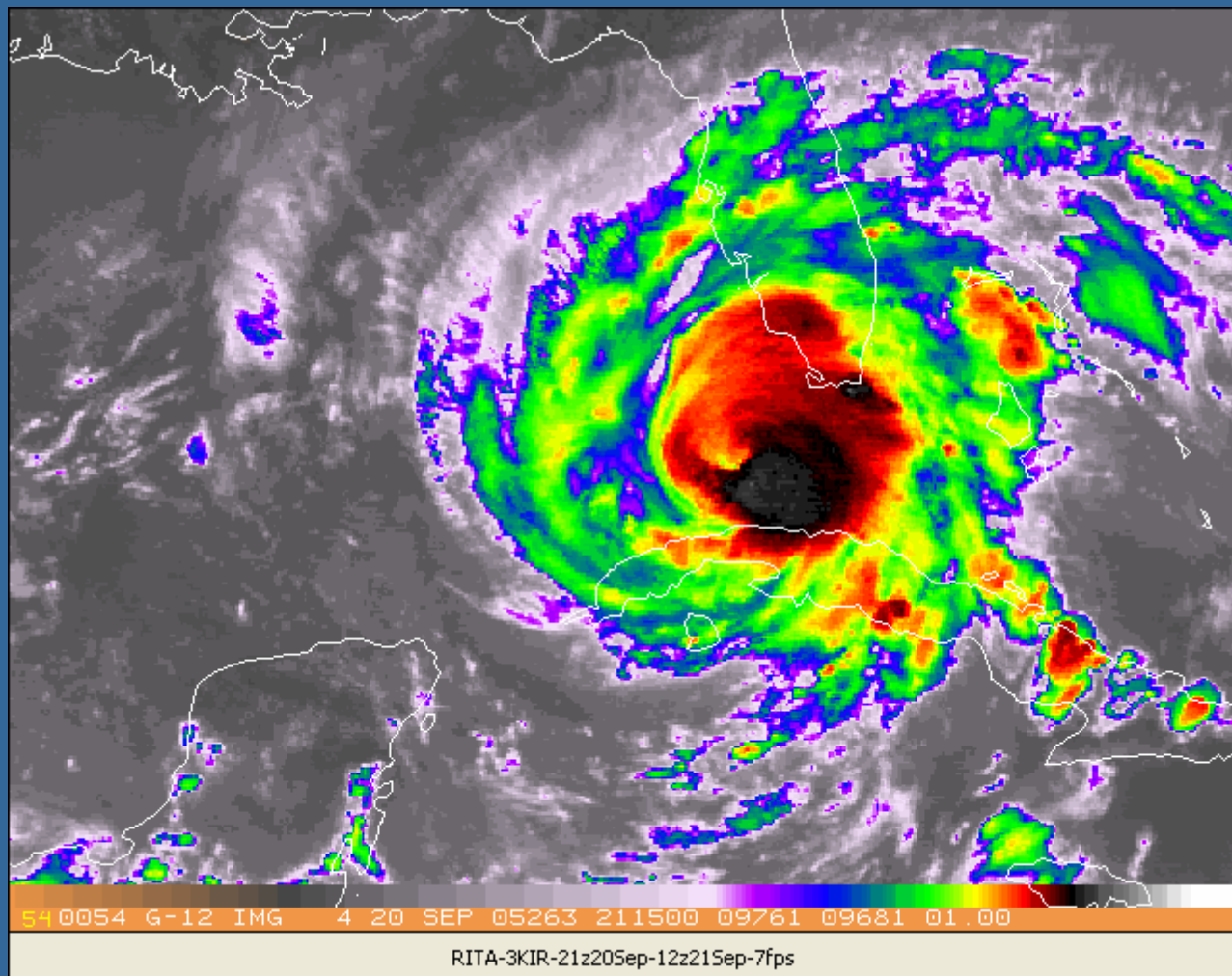


38 Data Points

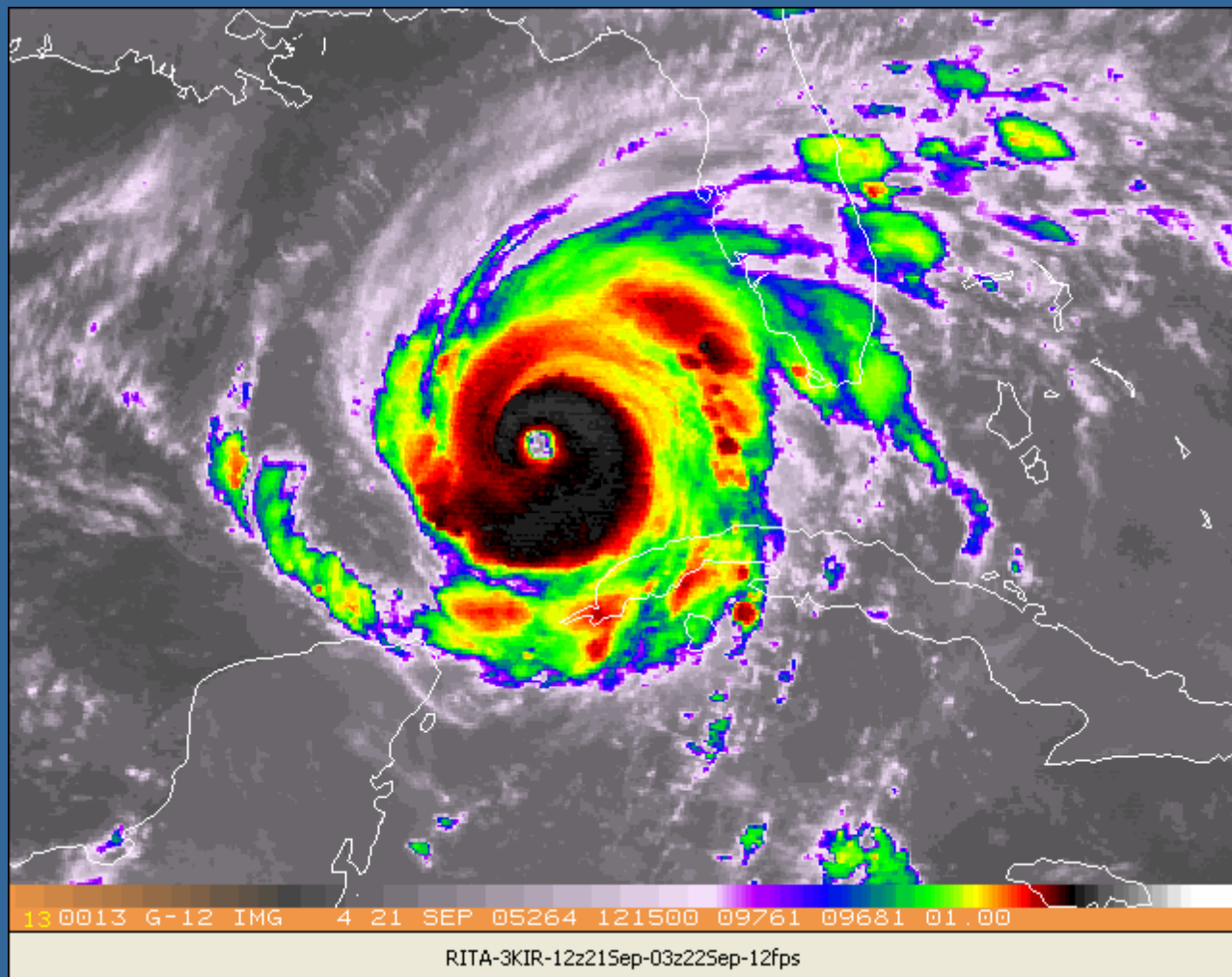
IR Temp vs Wind Speed 4 TPC Storms: Katrina, Isabel, Kenna, Rita



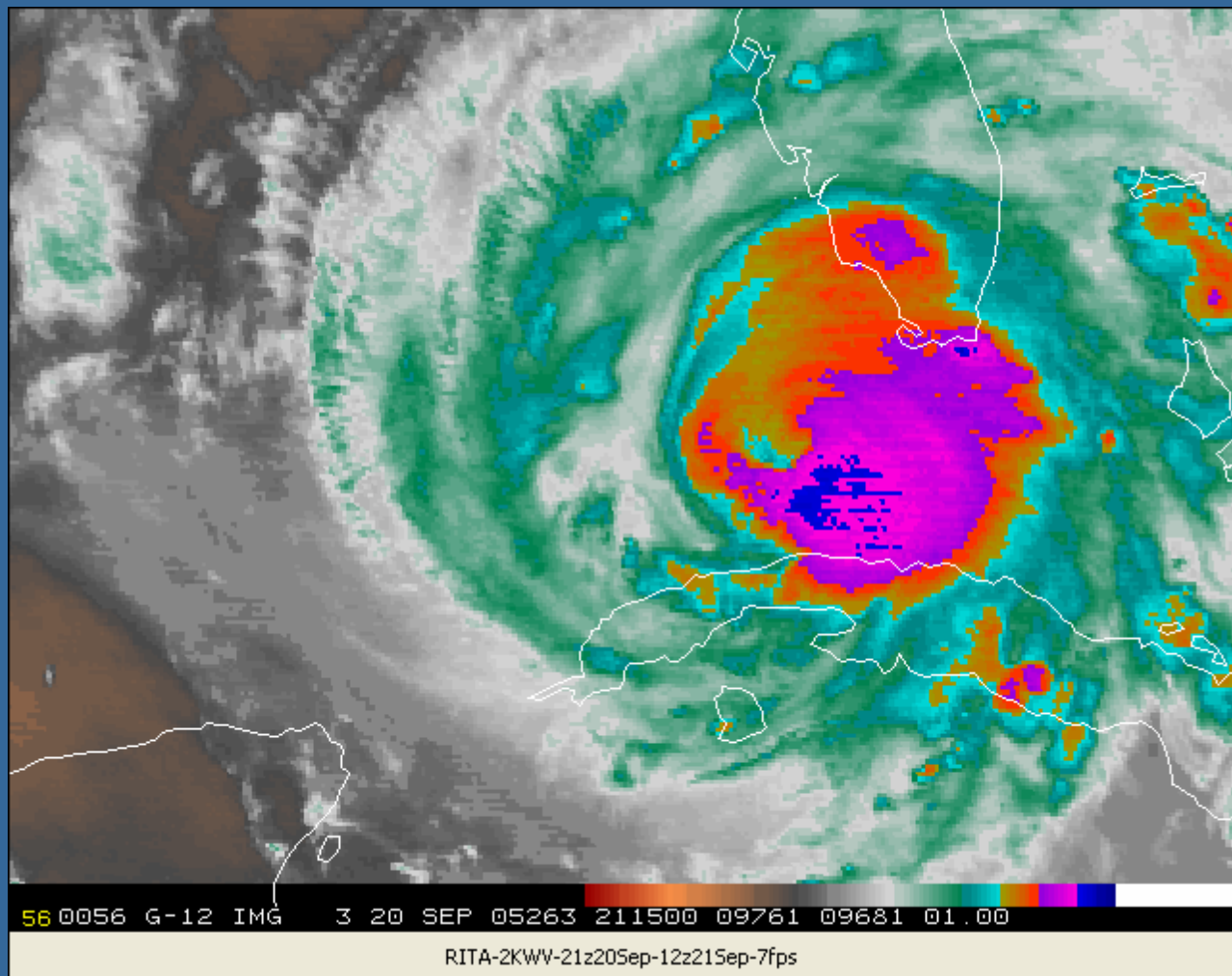
33 Data Points

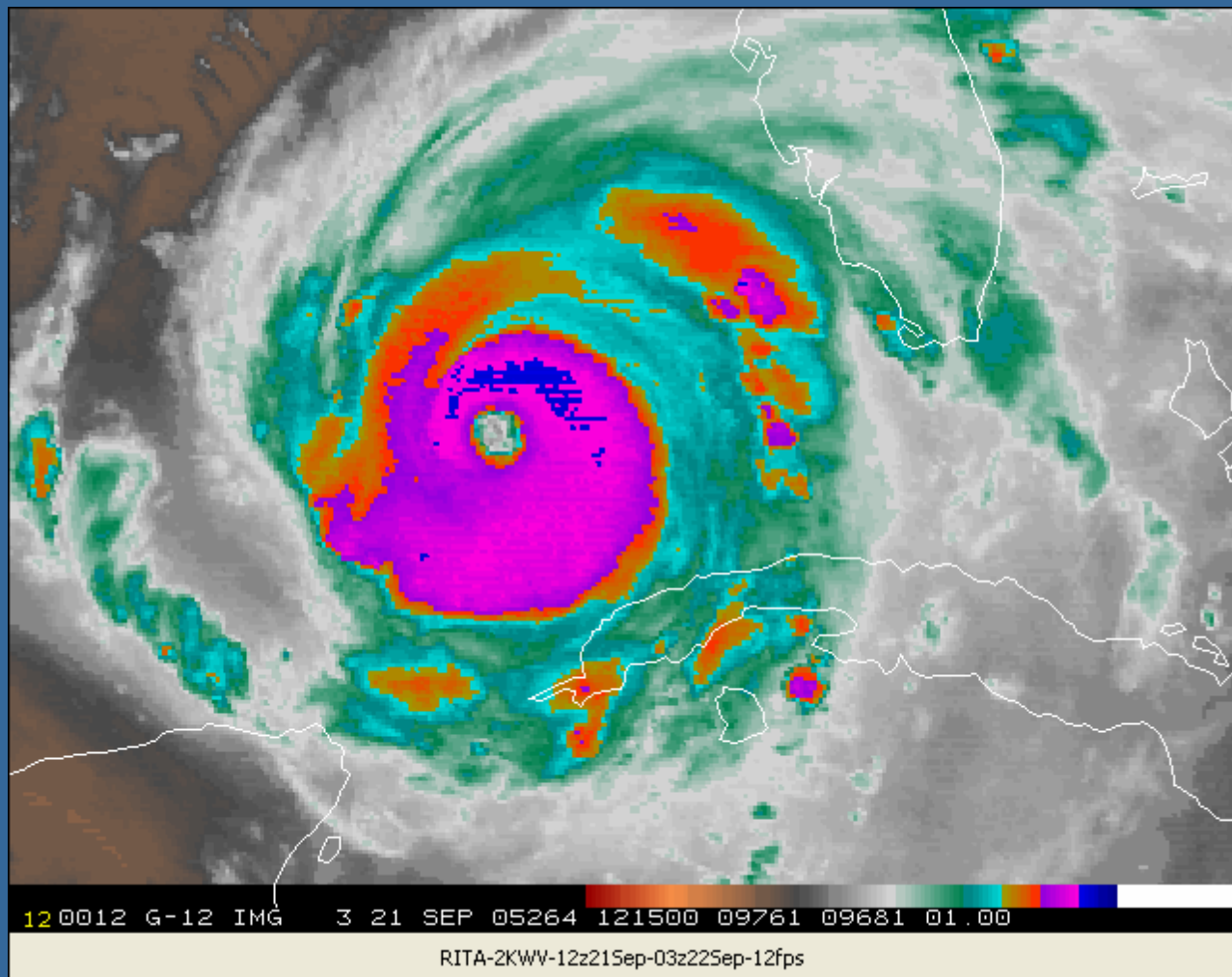


TA-05 Rita 3 km IR Loop 2115z 20 Sep - 1215z 21 Sep 05 7 fps



TA-05 Rita 3 km IR Loop 1215z 21 Sep - 0332z 22 Sep 05 12 fps

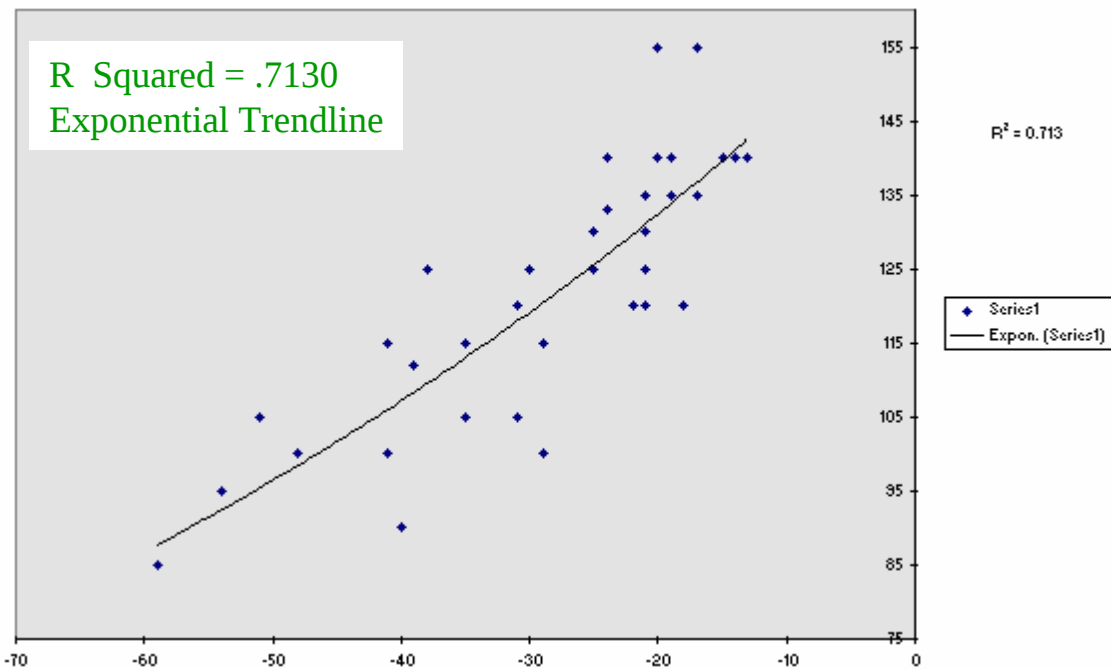




7 JTWC Storms

Wide Band WV

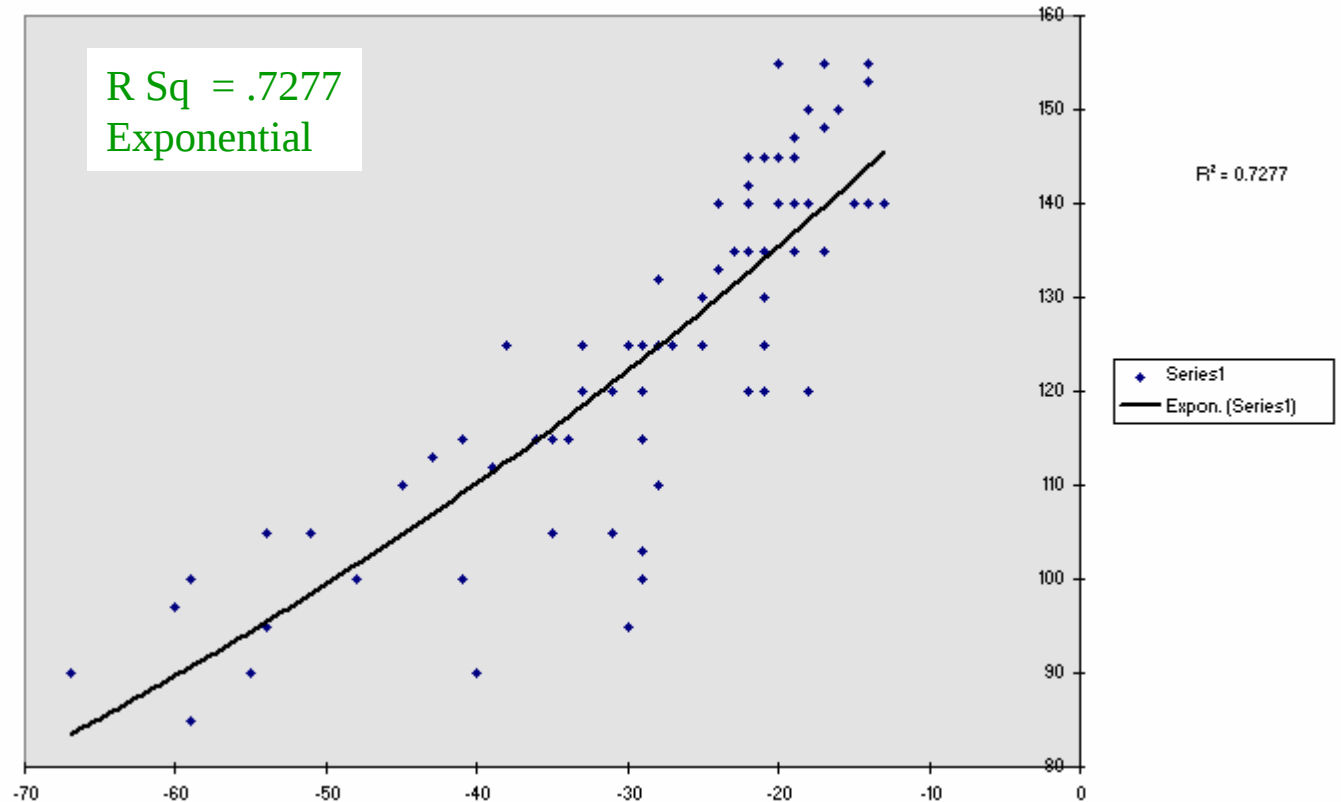
WV UP Kalunde, Saomai, Bilis, Podul, Zoe, Hary, Phanfone



35 Data Points

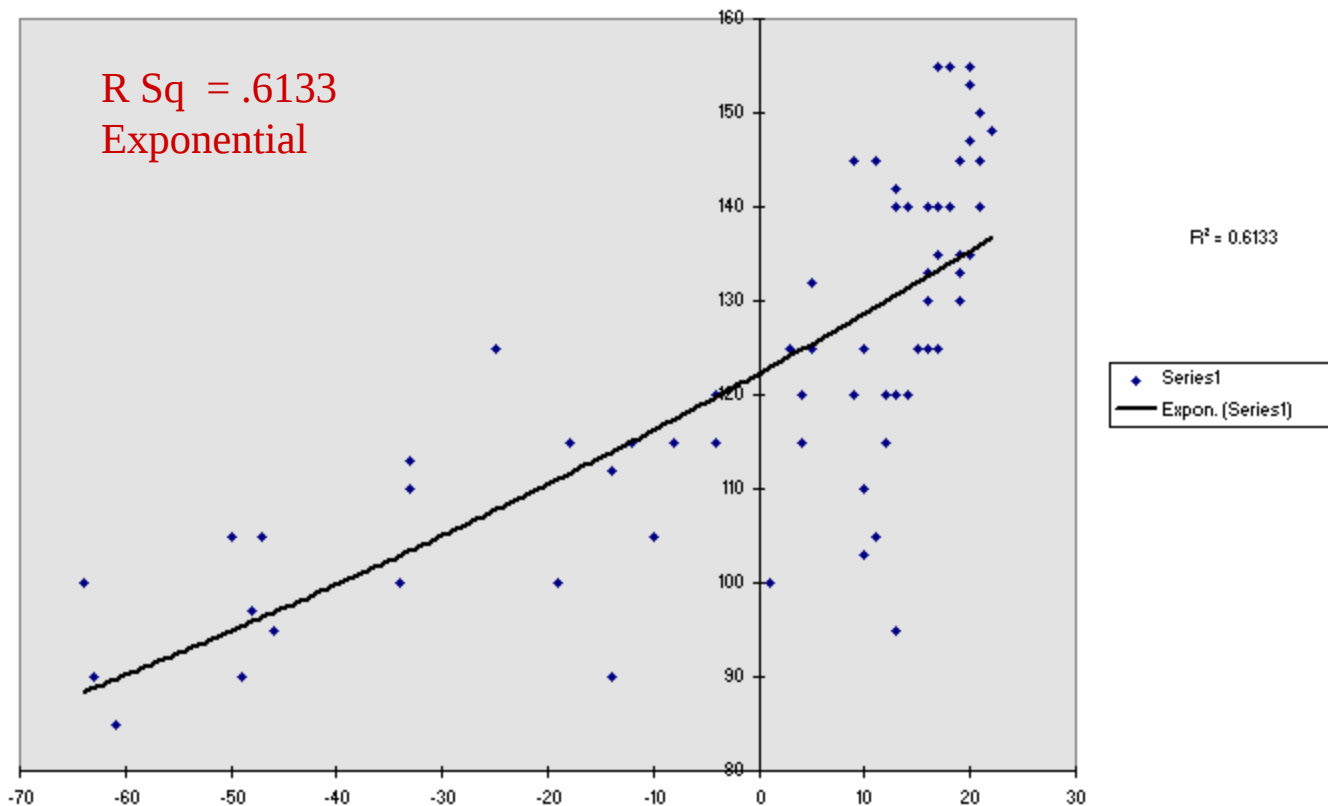
11 Storms
4 TPC + 7 JTWC Wide Band

WV Temp vs Wind Speed 11 Storms: 4 TPC + 7 JTWC Storms



73 Data Points

IR Temp vs Wind Speed 11 Storms: 4 TPC + 7 JTWC Storms



73 Data Points

GOES 9

Narrow Water Vapor Band

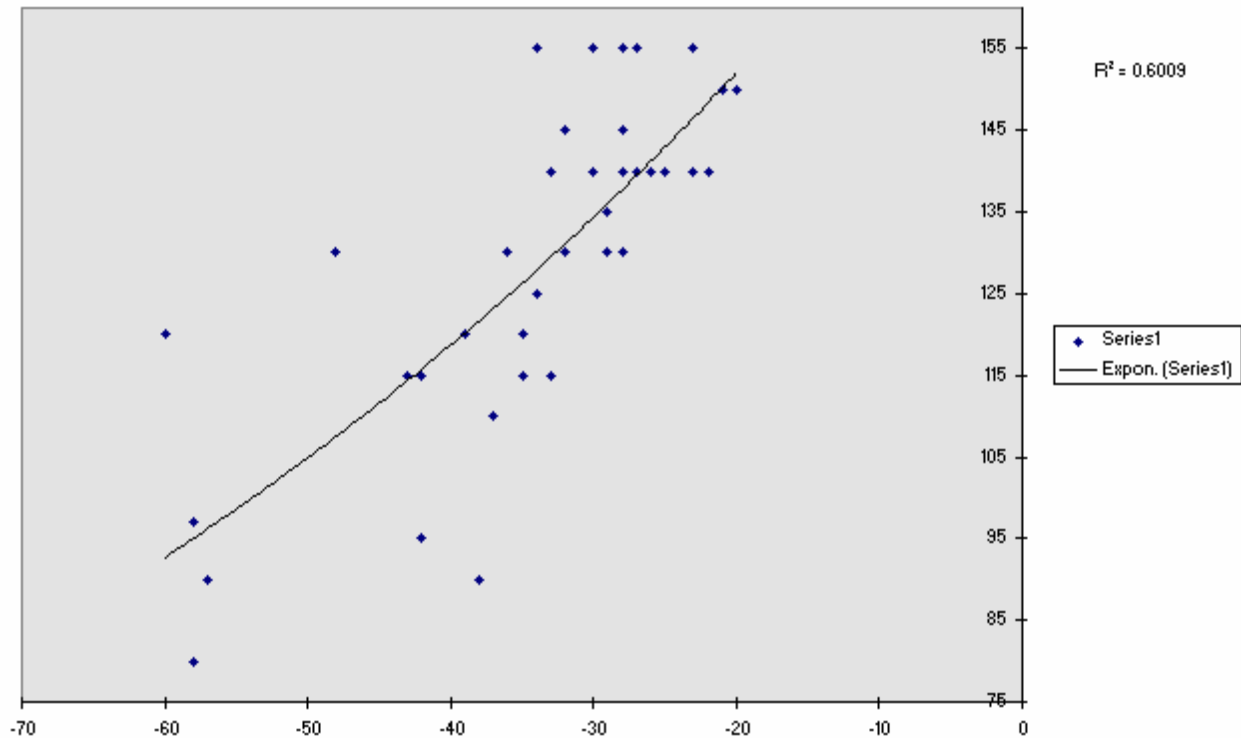
6 Storms

Best WV R Squared Value = .6108

WV Temp vs Wind Speed 6 JTWC Narrow Band Storms

42 data points

JTWC UP Narrow Band WV Goes 9

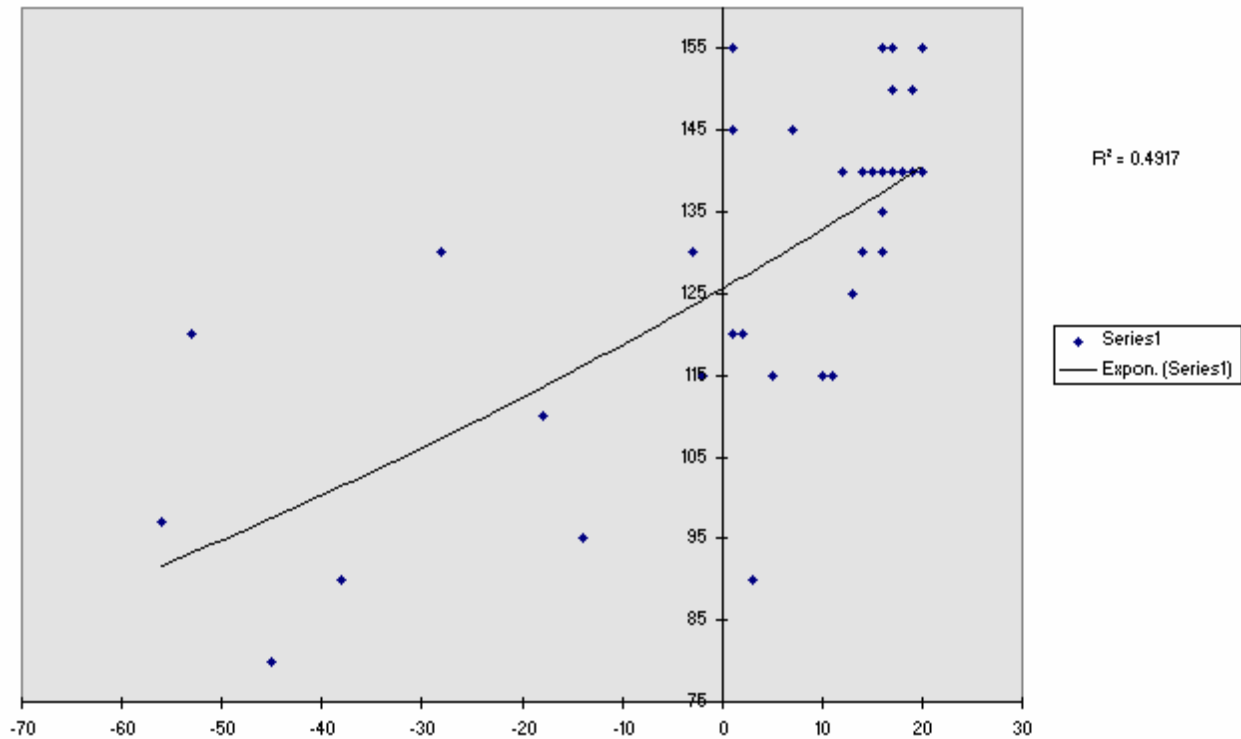


R Squared = .6009 Exponential Trendline

IR Temp vs Wind Speed 6 JTWC Narrow Band Storms

42 data points

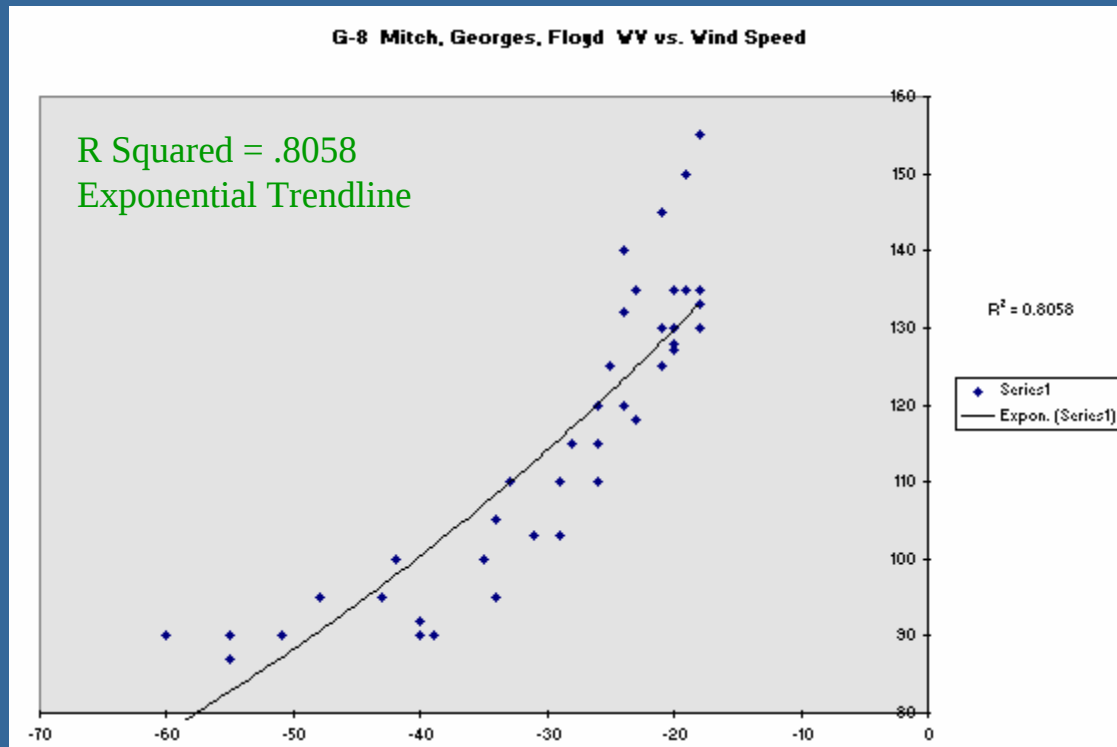
IR Temp vs Wind Speed 6 Narrow Band JTWC Storms



R Squared = .4917 Exponential Trendline

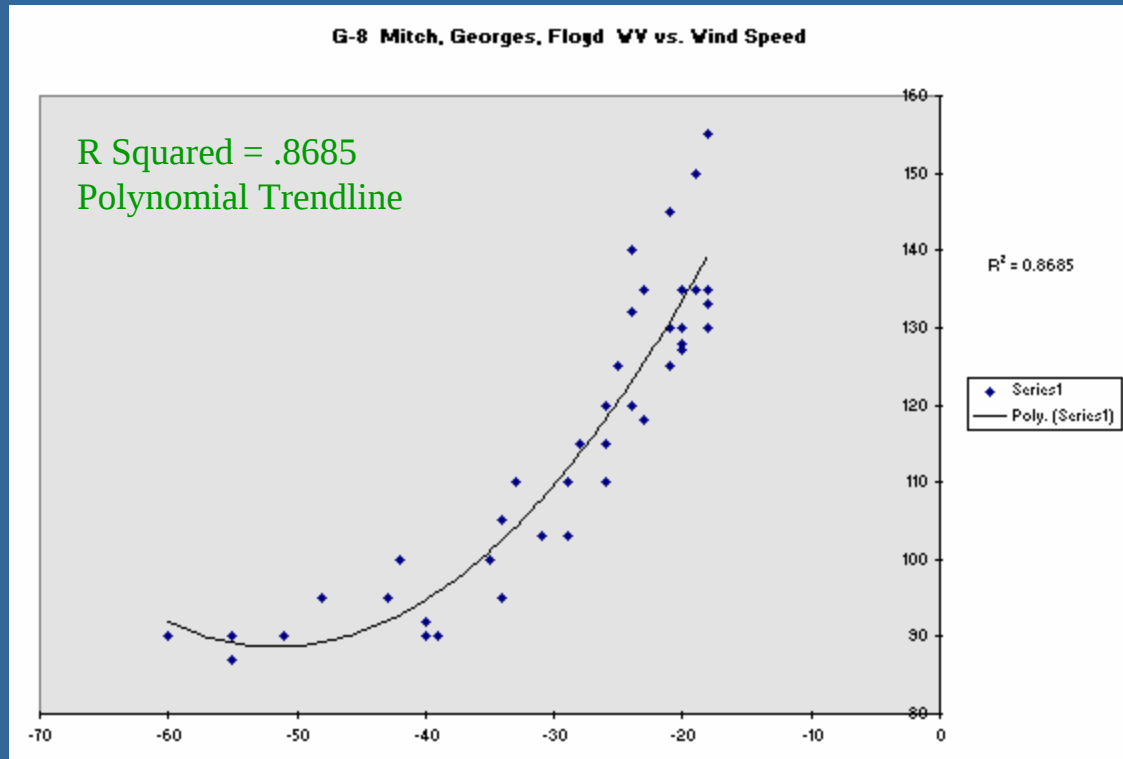
TPC Narrow Band Storms

WV Temp vs Wind Speed Goes-8 Mitch, Floyd, Georges



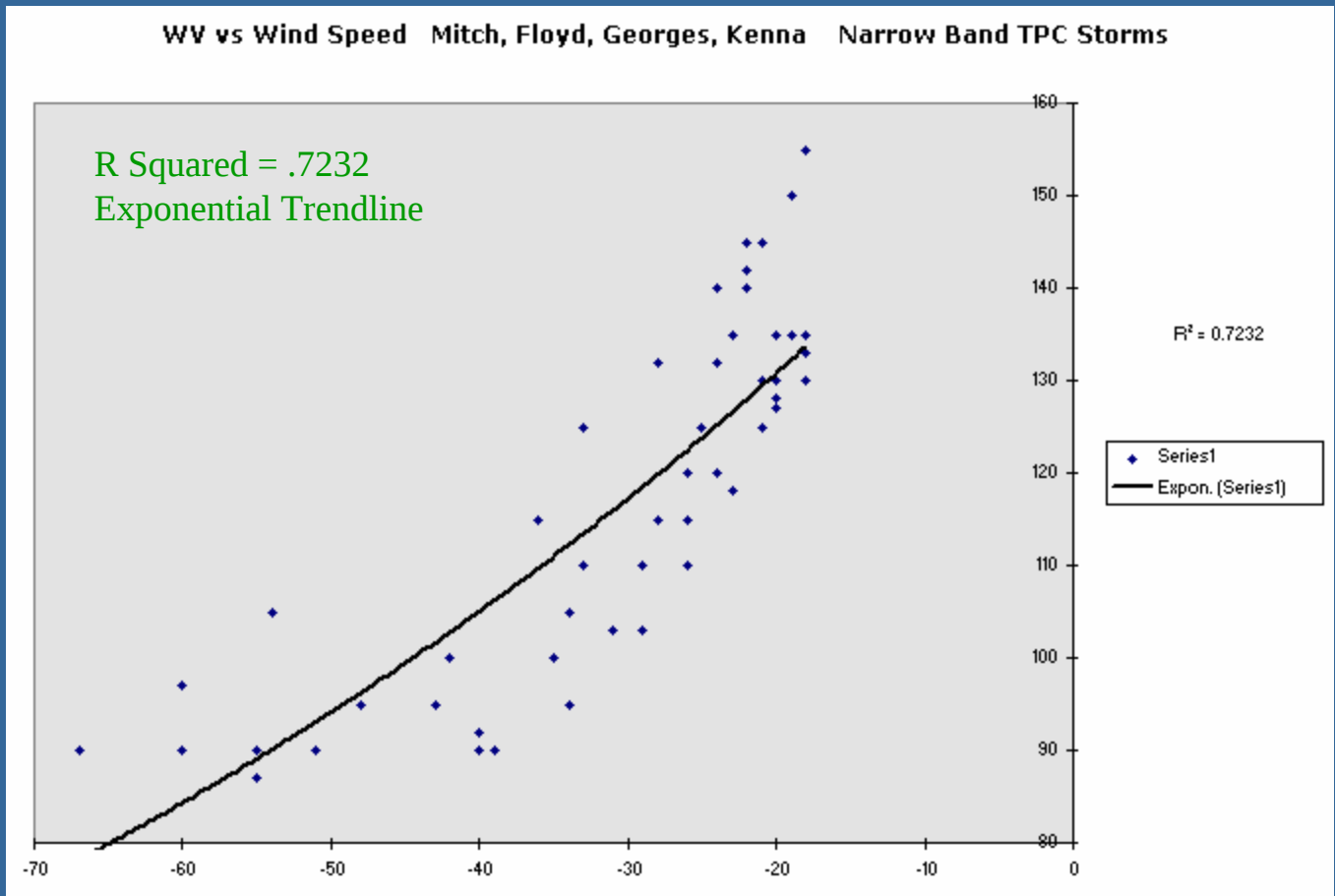
43 Data Points

WV Temp vs Wind Speed Goes-8 Mitch, Floyd, Georges

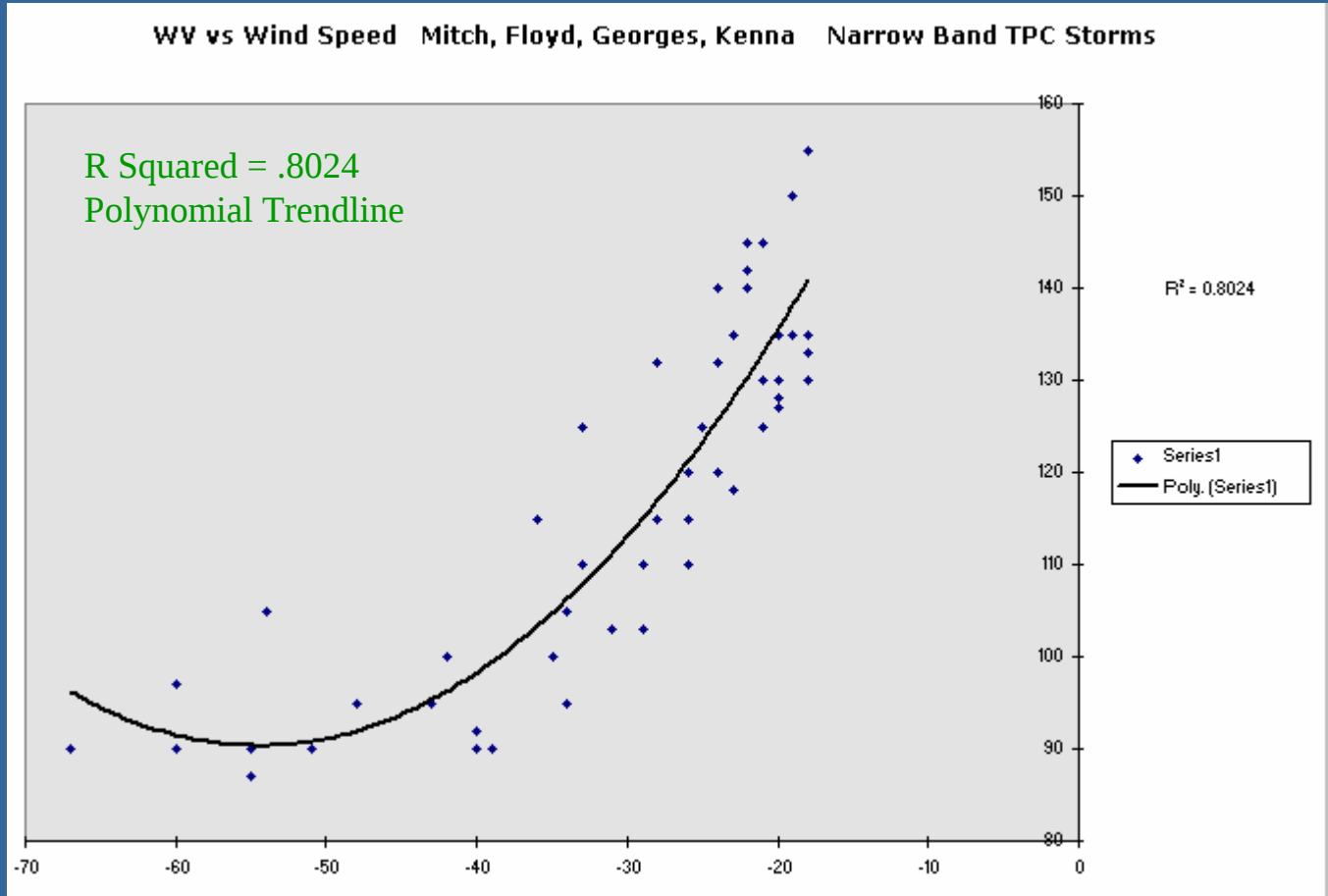


43 Data Points

WV Temp vs Wind Speed Goes-8 Mitch, Floyd, Georges, Goes 10 Kenna



WV Temp vs Wind Speed Goes-8 Mitch, Floyd, Georges, Goes 10 Kenna



R Squared Summary

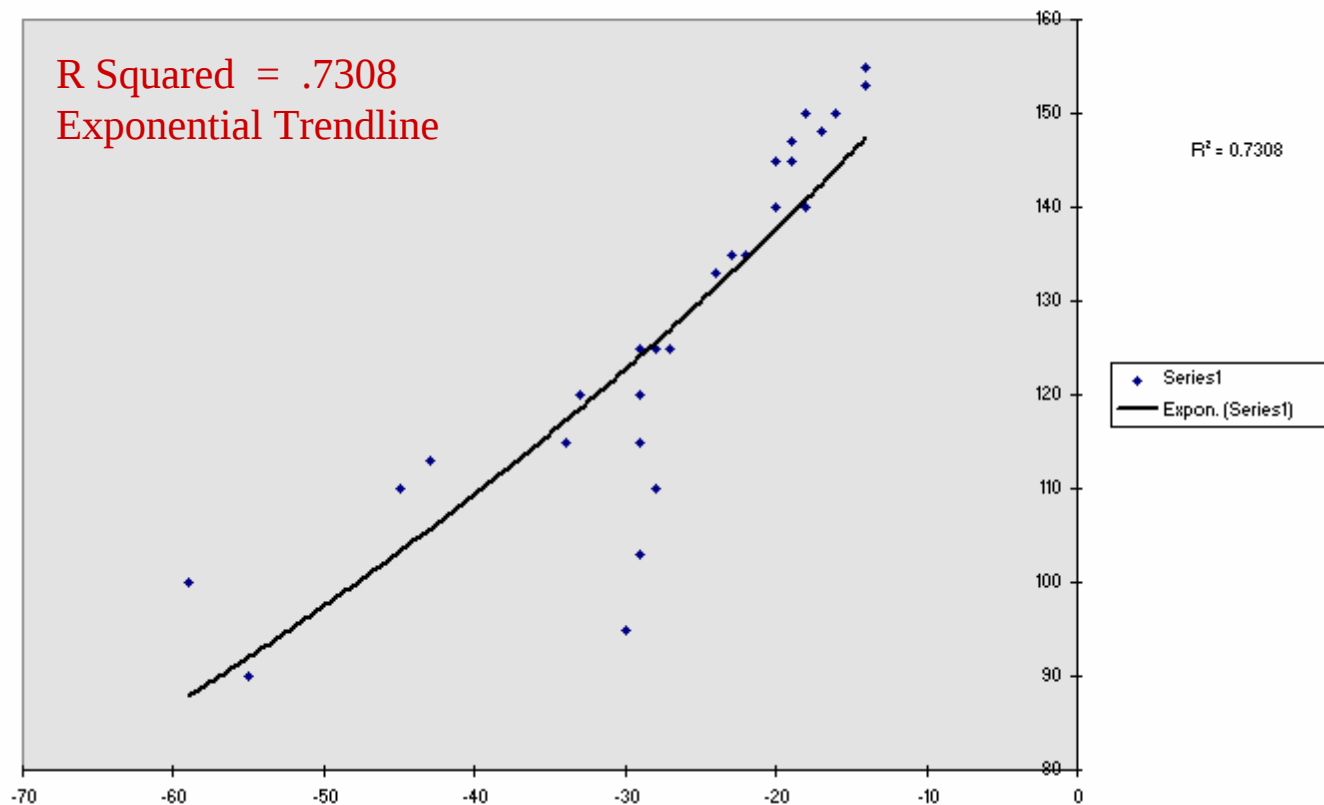
Exponential Trend Lines

	WV	IR
4 TPC + 7 JTWC Wide Band Storms	.7277	.6133
7 JTWC Wide Band Storms	.7130	.6417
6 Goes 9 Typhoons	.6009	.4917
3 Goes 8 Storms	.8058	.5282
3 Goes 8 + 1 Goes 10	.7232	

Comparison TPC Narrow and Wide WV Bands

WV vs Wind Speed Goes 12 Storms Karina Isabel Rita

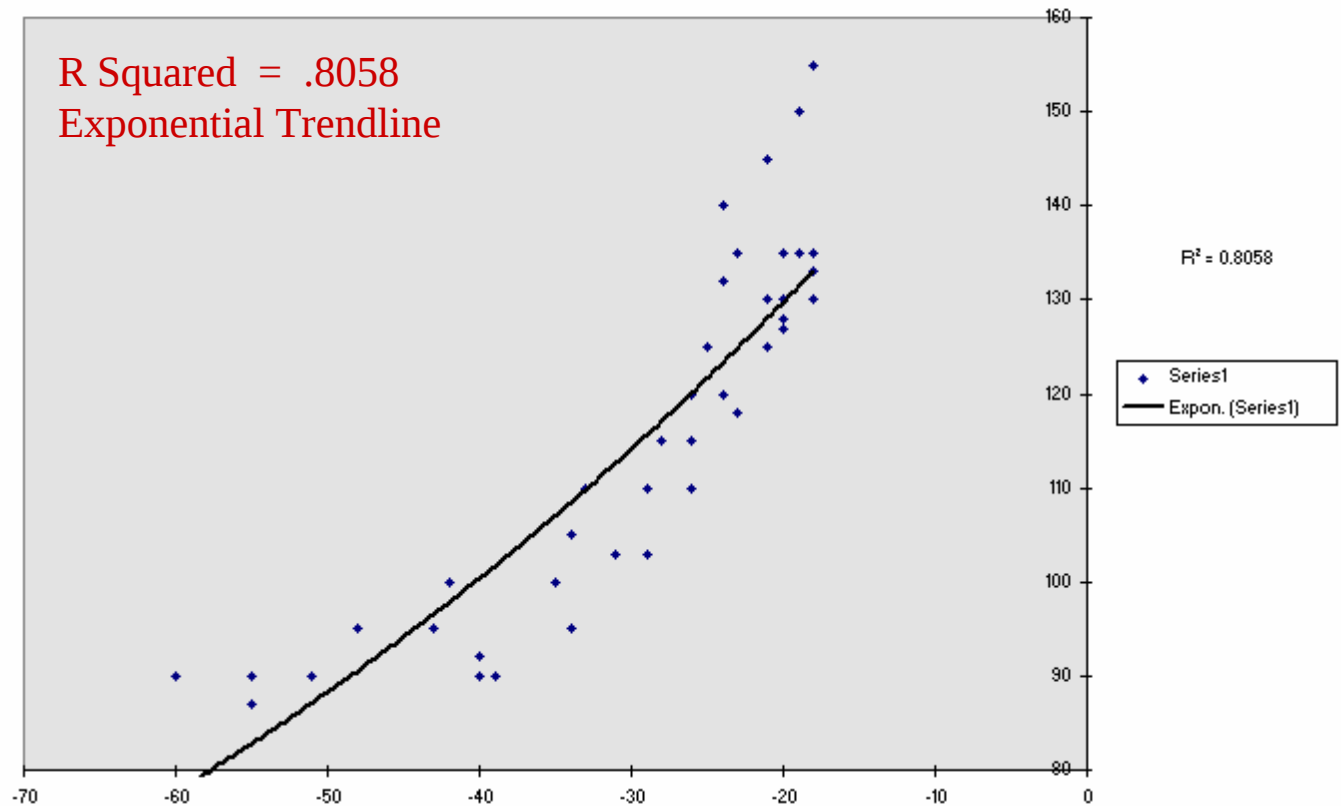
WV vs Wind Speed 3 TPC Goes-12 Storms Katrina, Isabel, Rita



28 Data Points

WV vs Wind Speed Goes 8 Storms Mitch, Floyd, Georges

G-8 Mitch, Georges, Floyd WV vs. Wind Speed



43 Data Points

Throw out the reasoning

All Intense TPC Storms with Recon Flight Data contributing to Intensity Calls

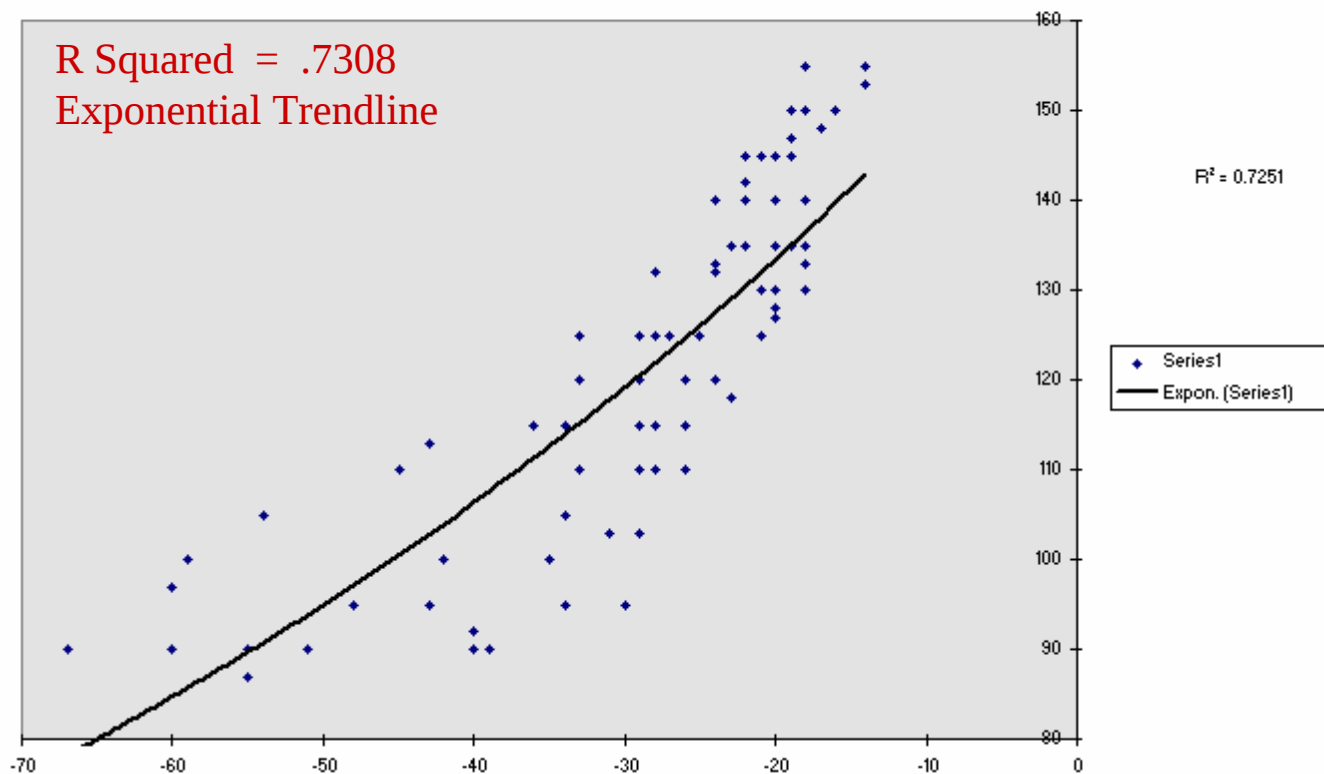
Data from Goes 8, Goes 10, (Narrow) Goes 12 (Wide)

All Intense JTWC Storms without Recon Flight Data contributing to Intensity

Data from GNS-5 Meteosat 5 (Wide) Goes 9 (Narrow)

WV vs Wind Speed All 7 Intense TPC Storms Goes 8 and Goes 12

WV vs Wind Speed All 7 TPC Intense Storms
Katrina, Isabel, Rita, Mitch, Floyd, Georges, Kenna

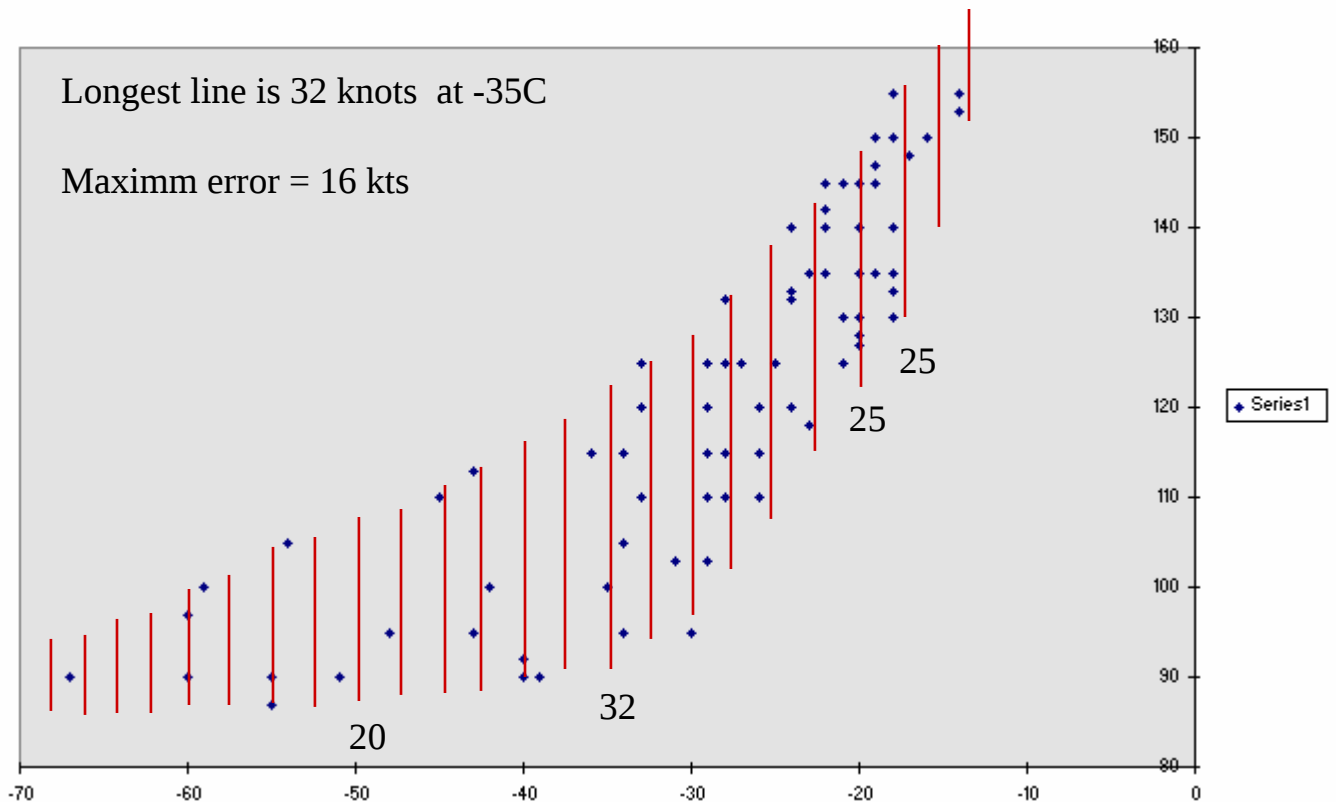


Table

Constructed
from the
combined
Goes 8
Goes 10
Goes 12
WV Up
Set

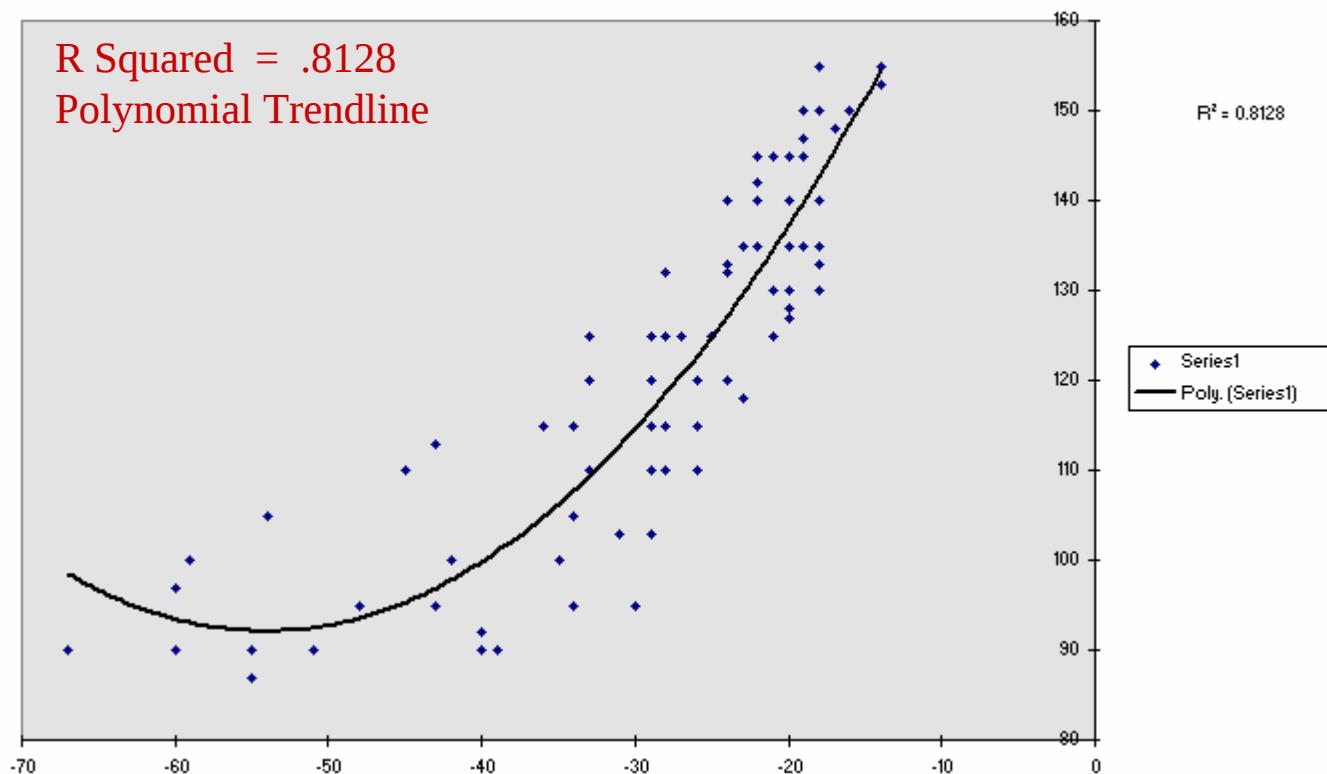
WV Eye Temp	Wind Speed	Wind Speed Change	Change knot/degree
-15 C	160 kts		
		20 kts	4.0 kts/deg
-20 C	140 kts		
		14 kts	2.8 kts/deg
-25 C	126 kts		
		8 kts	1.6 kts/deg
-30 C	118 kts		
		6 kts	1.2 kts/deg
-35 C	112 kts		
		5 kts	1.0 kts/deg
-40 C	107 kts		
		5 kts	1.0 kts/deg
-45 C	102 kts		
		4 kts	0.8 kts/deg
-50 C	98 kts		
		4 kts	0.8 kts/deg
-55 C	94 kts		
		4 kts	0.8 kts/deg
-60 C	90 kts		
		3 kts	0.6 kts/deg
-65 C	87 kts		
		2 kts	0.4 kts/deg
-70 C	85 kts		

WV vs Wind Speed All 7 Intense TPC Storms Katrina, Isabel, Rita, Mitch, Floyd, Georges, Kenna



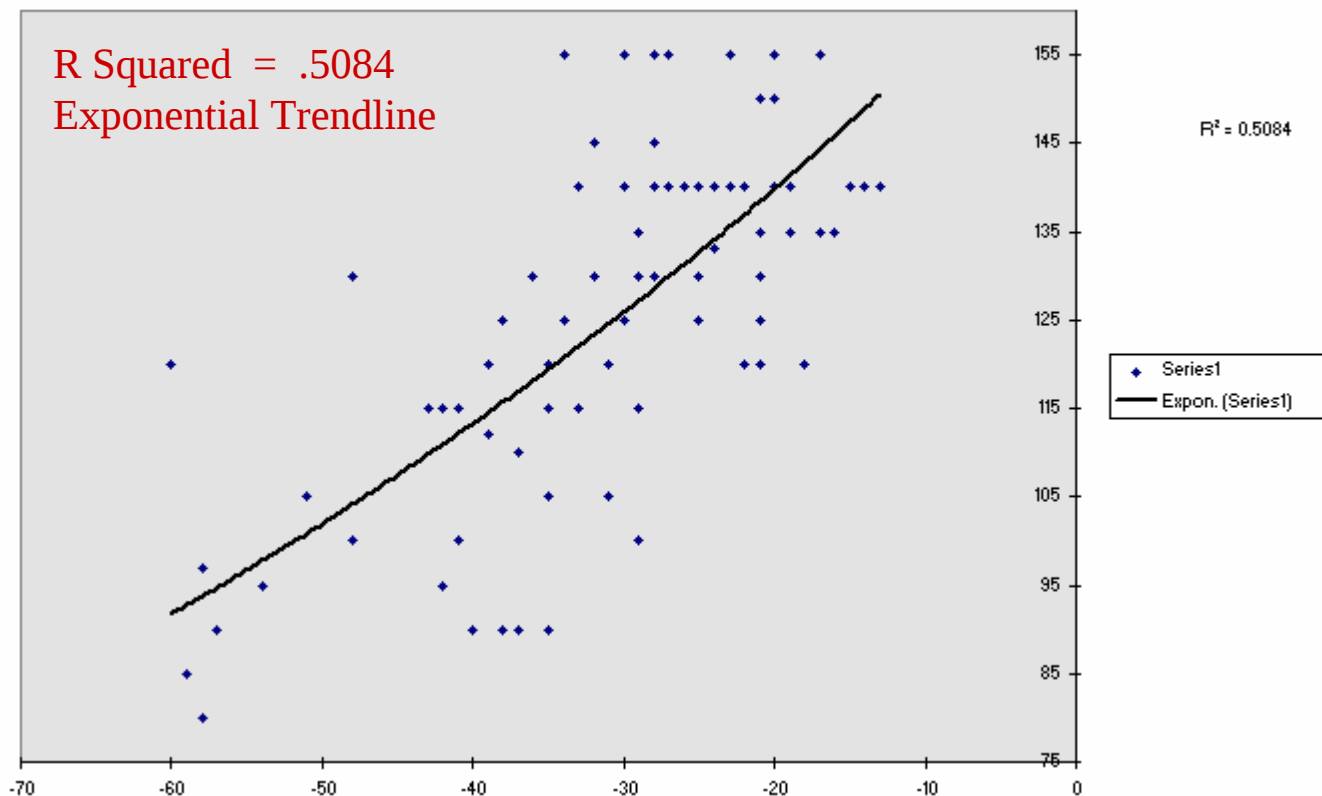
WV vs Wind Speed All 7 Intense TPC Storms Goes 8 and Goes 12

WV vs Wind Speed All 7 Intense TPC Storms
Katrina, Isabel, Rita, Mitch, Floyd, Georges, Kenna



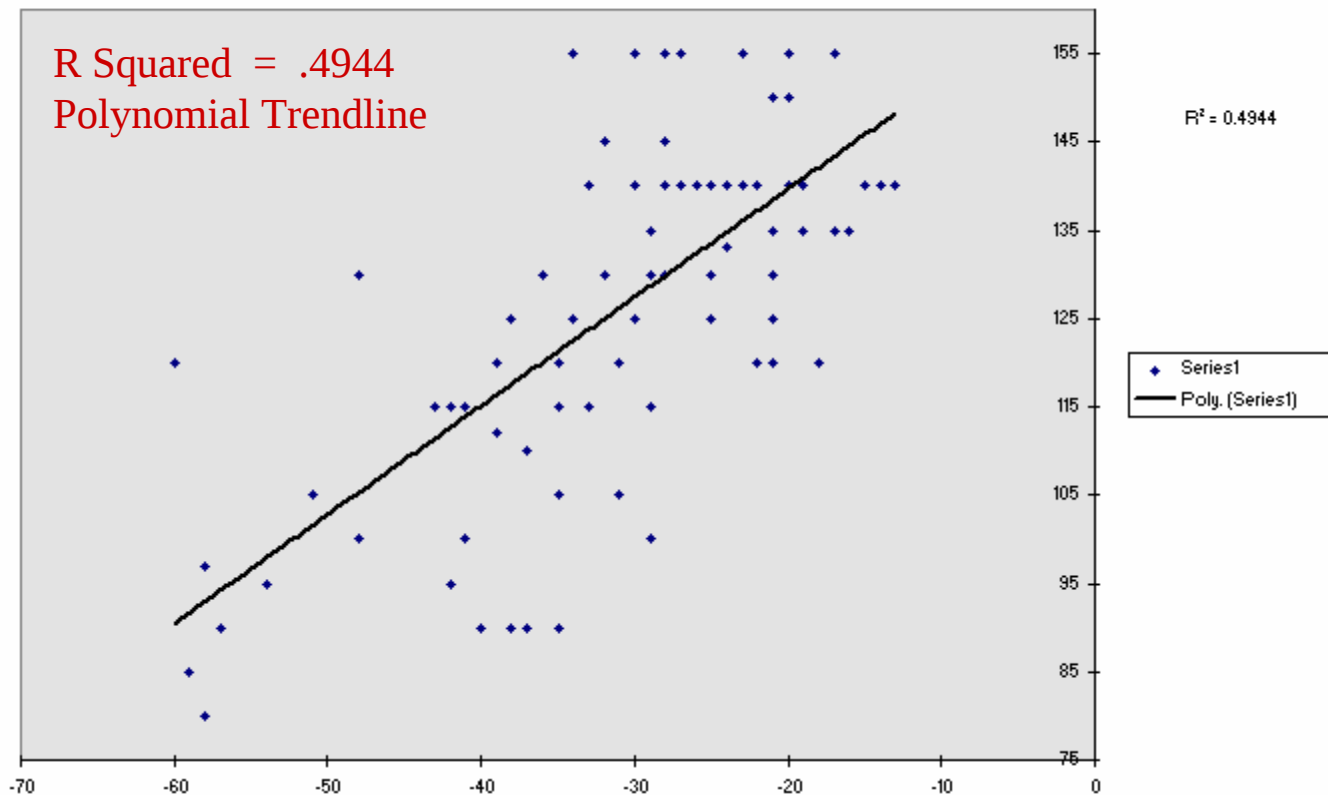
WV vs Wind Speed All 13 JTWC Storms Wide & Narrow WV Bands

WV vs Wind Speed All 13 JTWC Storms Wide and Narrow WV Bands



WV vs Wind Speed All 13 JTWC Storms Wide & Narrow WV Bands

WV vs Wind Speed All 13 JTWC Storms Wide and Narrow WV Bands



Some Results of this Study

Recognize Wilma Type Storms

(Not the only very rapidly deepening storms)

CDO Top Temperatures Vary with Latitude

Value of WV Eye Temperatures

Best Correlations with Wind Speed Intensity - During Intensification

Not Useful with Very Small Eye Diameter Storms

After initial intensification

WV Eye Temps Too Warm Intruded Storms

WV Eye Temps Too Cold Deformed CDO's

WV Eye Temp still useful if take other factor into account

WV Eye Temperatures better than IR Eye Temperatures

For Operational Use: More extensive study required

Last Slide