Improvements in Real-Time Tropical Cyclone Products

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StAR Science Forum
May 31, 2007

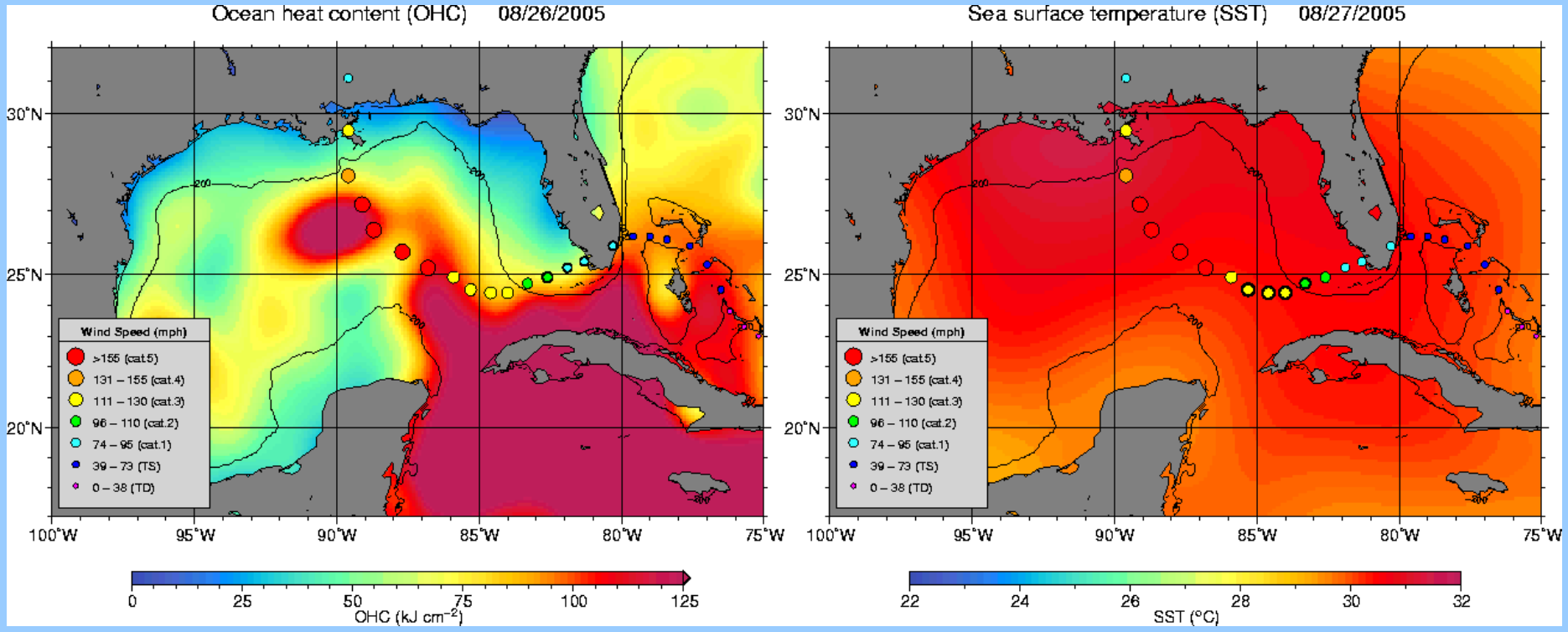
Outline

- Mark DeMaria
  - Improvements in the Statistical Hurricane Intensity Prediction Scheme (SHIPS) for the 2007 Hurricane Season
- John Knaff
  - The RAMMB Experimental Tropical Cyclone Web Page
- Andrea Schumacher
  - Extension of the NESDIS operational tropical cyclone formation probability product to the Central and Western Pacific
- Ray Zehr
  - Satellite support for the NOAA/AOML Hurricane Research Division annual field program

2006 Operational SHIPS Intensity Model

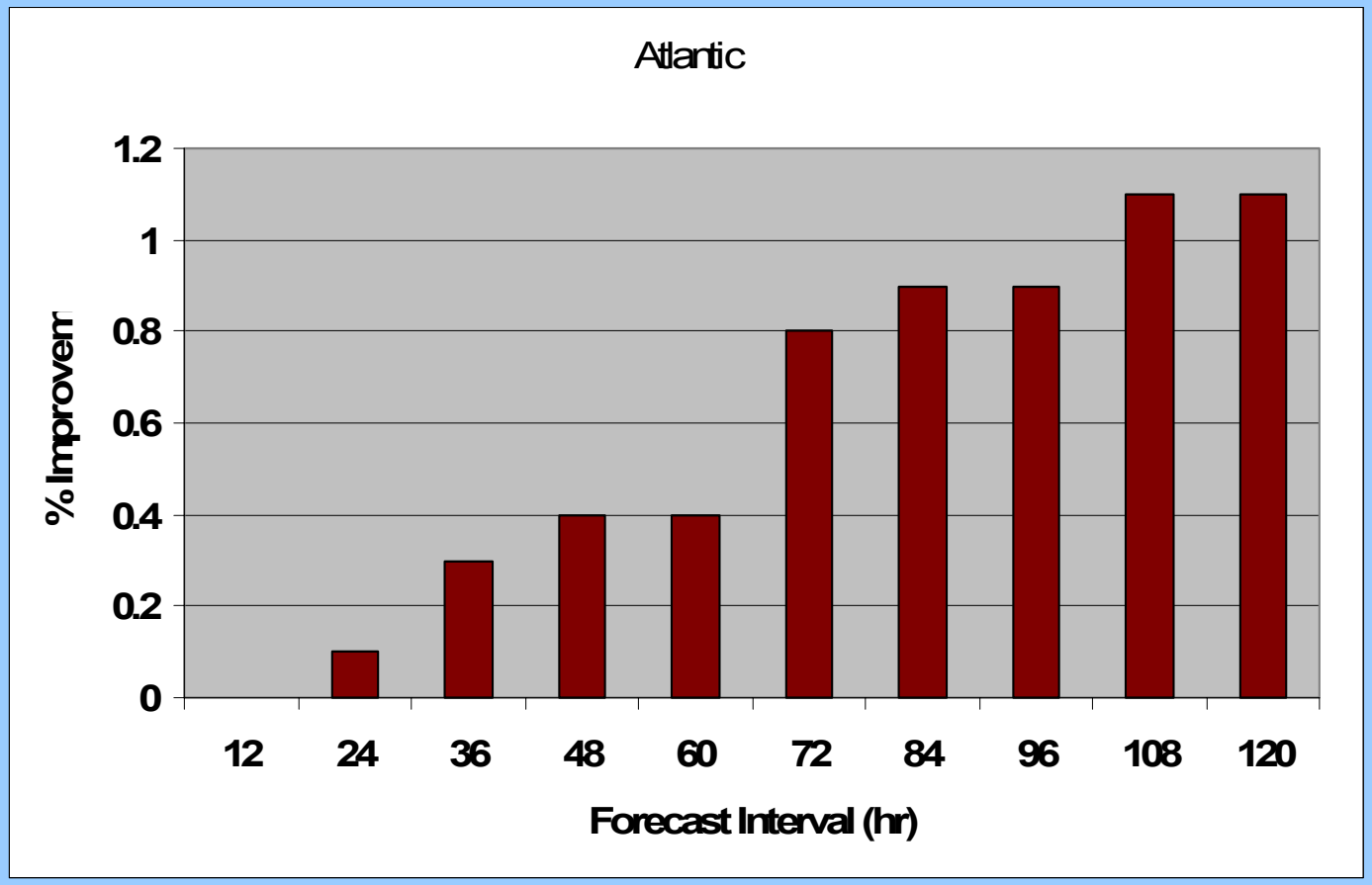
- Statistical-dynamical TC intensity prediction model
- 16 basic predictors
  - atmospheric from GFS forecast fields
  - oceanic from Reynold's weekly SST
  - climatology and persistence from ATCF input
- Satellite input
  - Ocean heat content from satellite altimetry
  - Convective parameters from GOES channel 4
- Empirical decay equation over land
- Experimental Logistic Growth Equation (LGE) version also run that uses time stepping procedure

Operational SHIPS Includes OHC from Satellite Altimetry Averaged Along the Storm Track as a Predictor



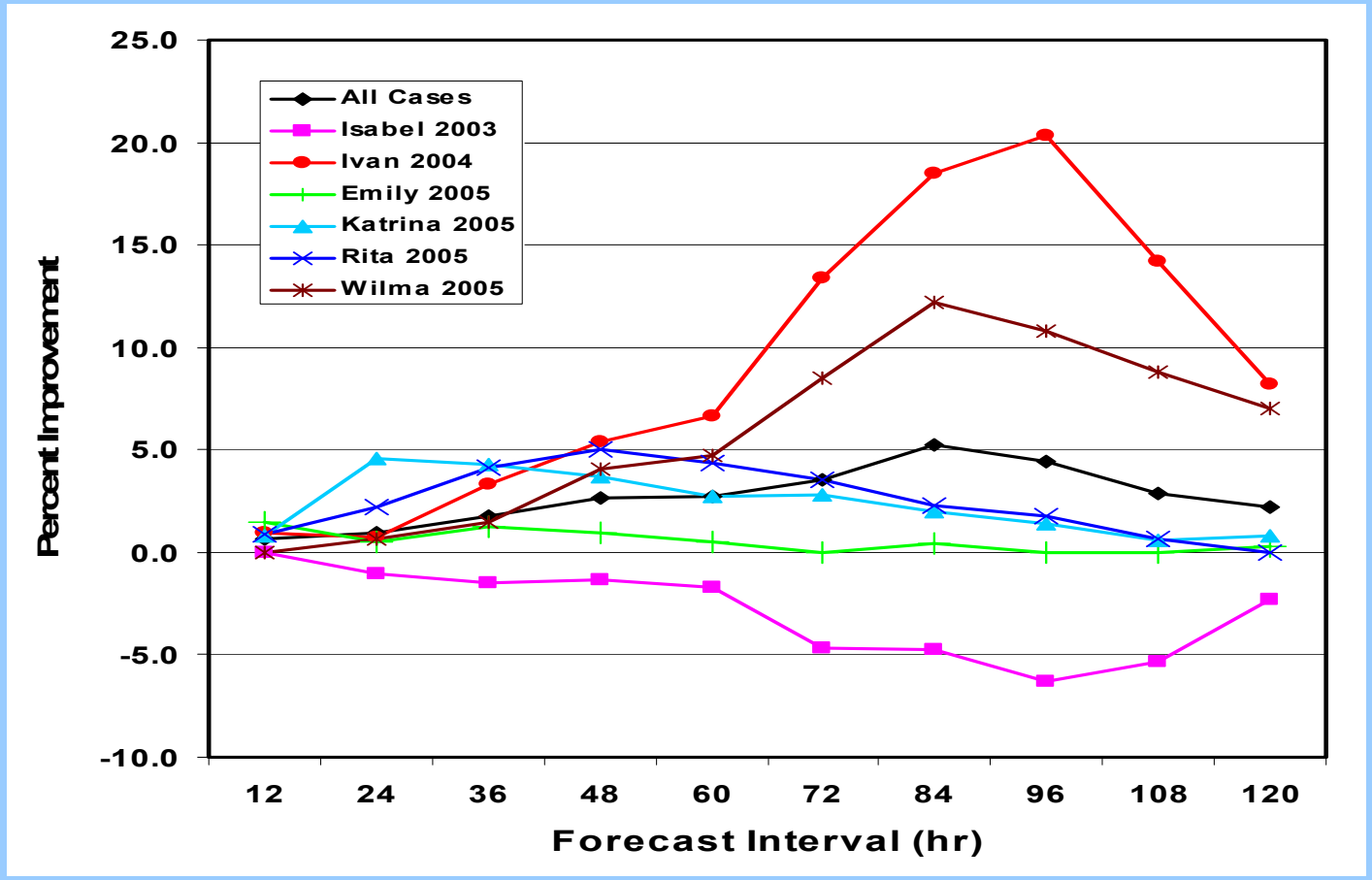
OHC **SST**

OHC Impact on SHIPS Forecasts



Atlantic Sample: **3072 SHIPS Model Forecasts 1995-2006**

OHC Impact Much Larger for Intense Atlantic Hurricanes



Improvements in Operational SHIPS Forecasts from OHC for all 2003-2005 Cat 5 Hurricanes (from Mainelli et al 2007)

SHIPS Improvements for 2007

- Re-tuning of coefficients based on 2006 cases
- Refinement of method for calculation of vertical wind shear
- Add new vortex predictor from NCEP GFS model
- New code installed on the NCEP IBMs (Mist/Dew) on May 9th

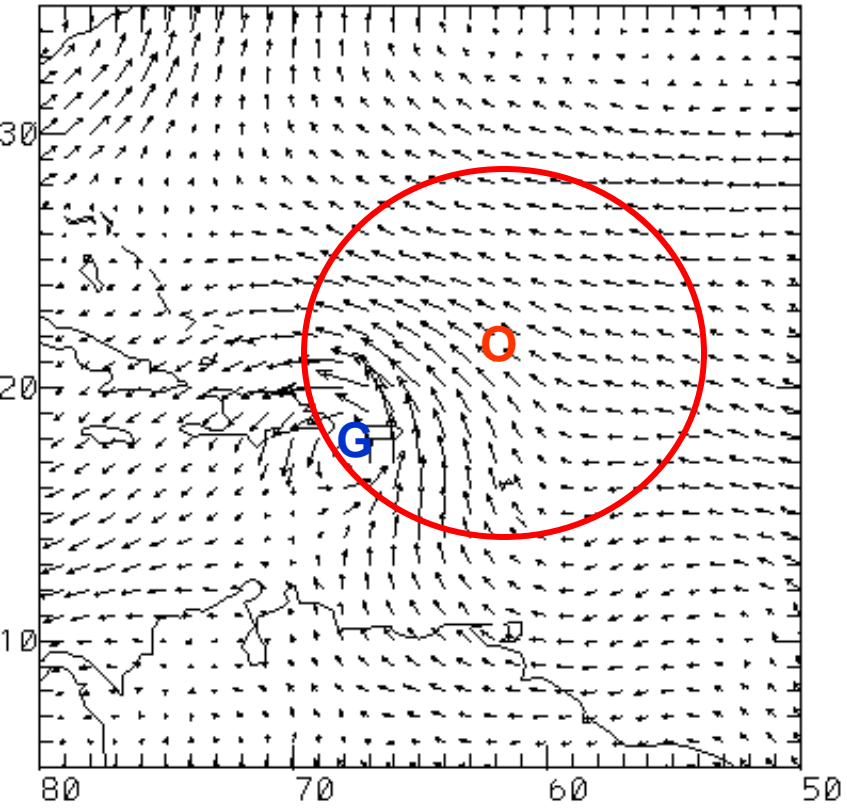
Improved Shear Calculation

- SHIPS uses NHC official track for center of shear calculation
- GFS vortex track can differ from NHC track
- Shear calculation uses large annulus to compensate (200-800 km)

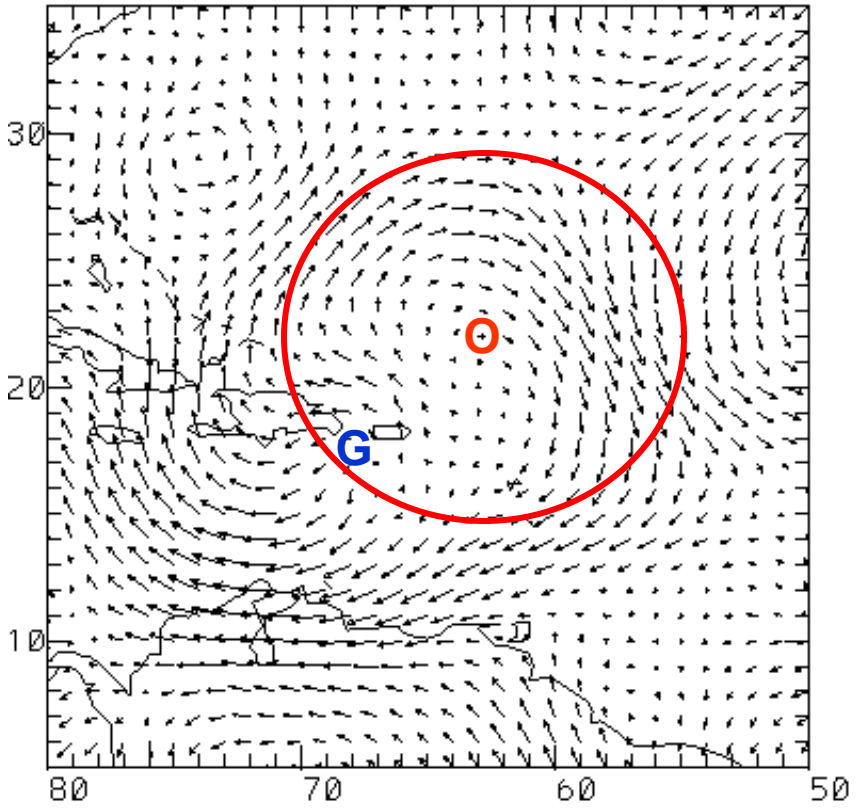
Example of NHC and GFS Track Mismatch

96 h Forecast for Frances from 27 Aug 2004 12 UTC

850 hPa



200 hPa



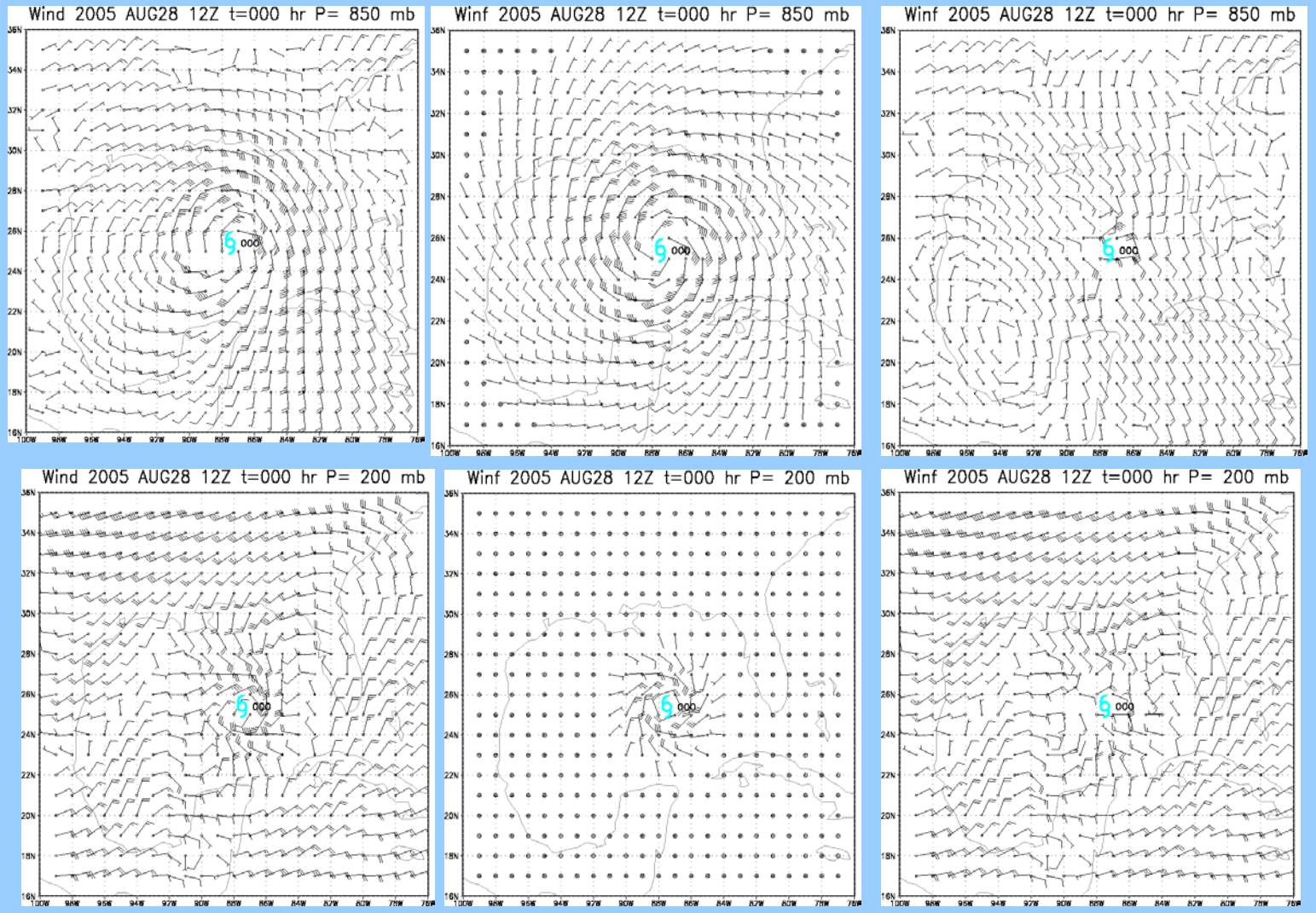
G = GFS position O = NHC Position

New Shear Algorithm

- Track location of GFS vortex at 850 hPa
  - Tracker finds location that maximizes 0 to 600 km symmetric tangential wind
  - Checks for reasonable translational speeds
  - Requires minimum cyclonic wind
- Symmetric circulation subtracted
  - Starts from outer radius where symmetric circulation is cyclonic
  - Subtraction radius decreases with height
- Shear calculation at NHC track position after vortex removed
- 0-500 km radius rather than 200-800 km annulus

Example of Vortex Removal

Total Wind **Symmetric Flow** **Residual**



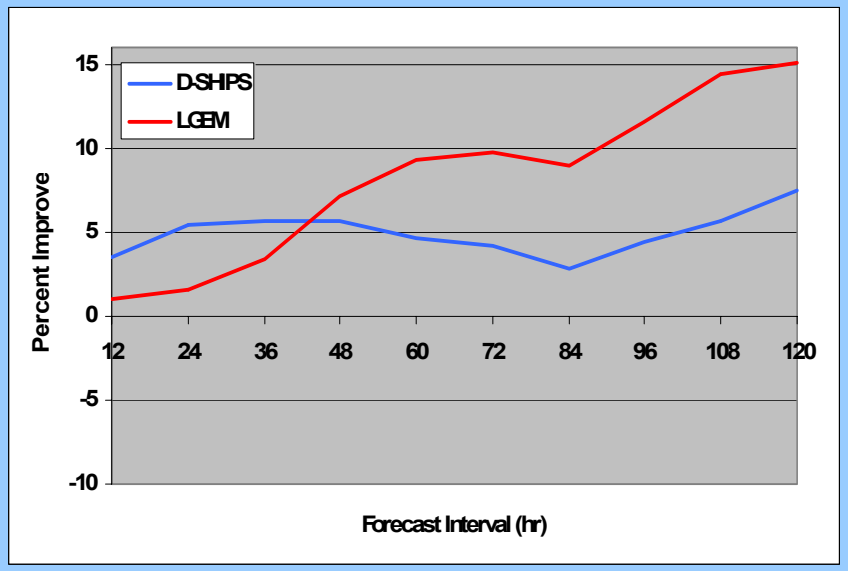
850 hPa

200 hPa

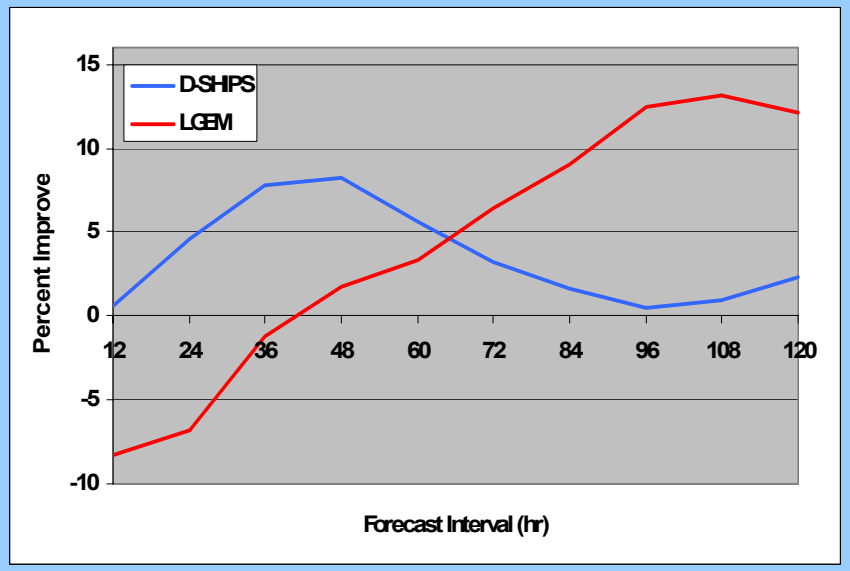
A New Predictor for SHIPS

- GFS vortex removal procedure provides 850 tangential wind
- 0-600 km average GFS tangential winds found to be significant intensity change predictor
- Added to 2007 SHIPS

2007 Model Compared to Operational SHIPS (Re-runs of 2004-2006 seasons)



Atlantic



East Pacific

The RAMMB Experimental Tropical Cyclone Web Page

http://rammb.cira.colostate.edu/products/tc_realtime/

RAMMB
Regional and Mesoscale Meteorology Branch

NOAA Satellites and Information
National Environmental Satellite, Data, and Information Service

CIRA
Cooperative Institute for Research in the Atmosphere

Cooperative Research Program | Office of Research and Applications/Center for Satellite Applications and Research

Currently Active Tropical Cyclones

- Current Active Cyclones
- Archive
  - 2007 Season
  - 2006 Season
- Additional Information
- Additional Links

Last Updated 7 Minutes Ago

Atlantic

No Currently Active Cyclones

Eastern Pacific

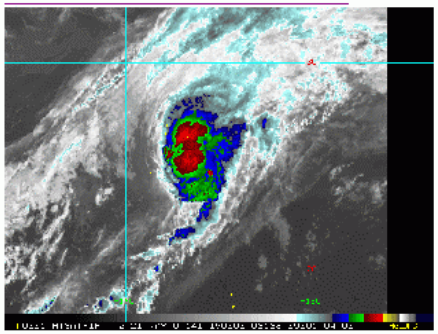
No Currently Active Cyclones

Central Pacific

No Currently Active Cyclones

Western Pacific

WP022007 - Hurricane YUTU



North Indian Ocean

No Currently Active Cyclones

Southern Hemisphere

No Currently Active Cyclones

Done | Internet | 100%

Purpose

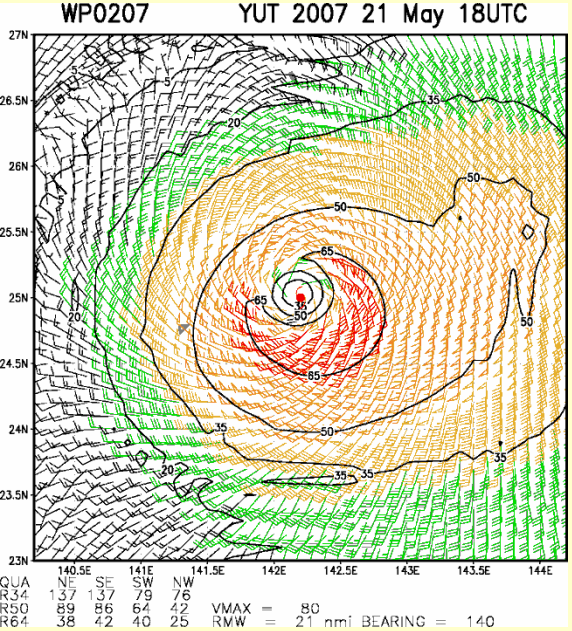
- To display real-time tropical cyclone products created and/or developed by RAMMB and CIRA scientists and products not available elsewhere.
- Serve these data to the public via a web integrated database designed to accommodate future product development.

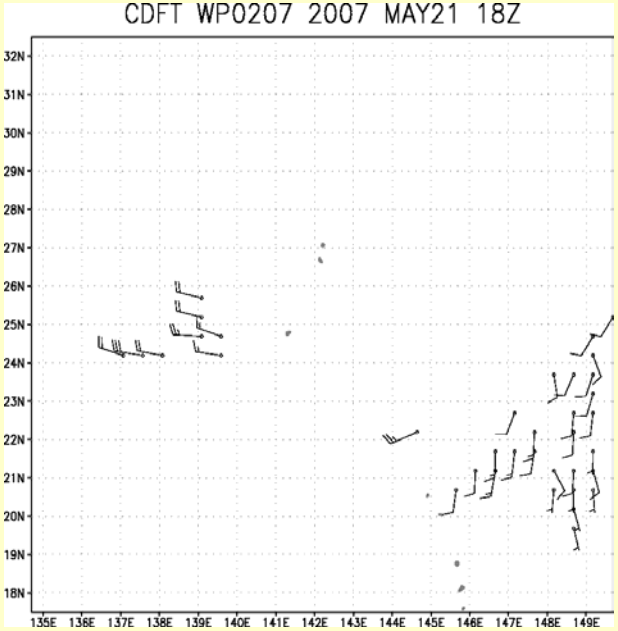
Information Content

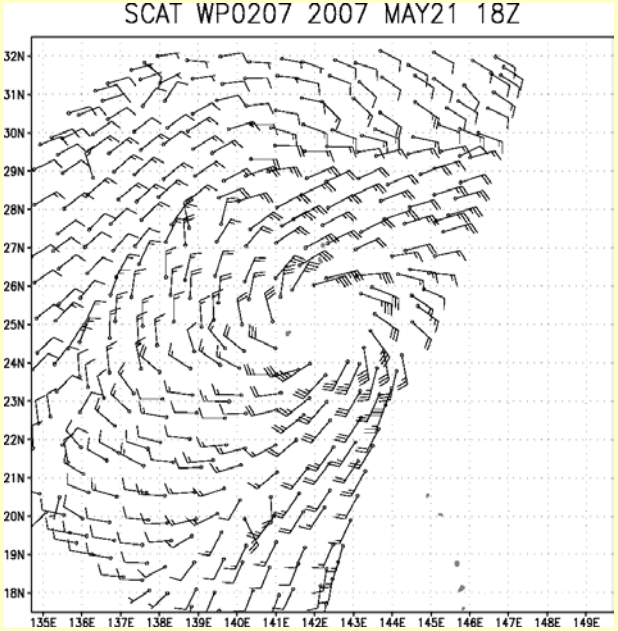
Globally occurring tropical cyclones

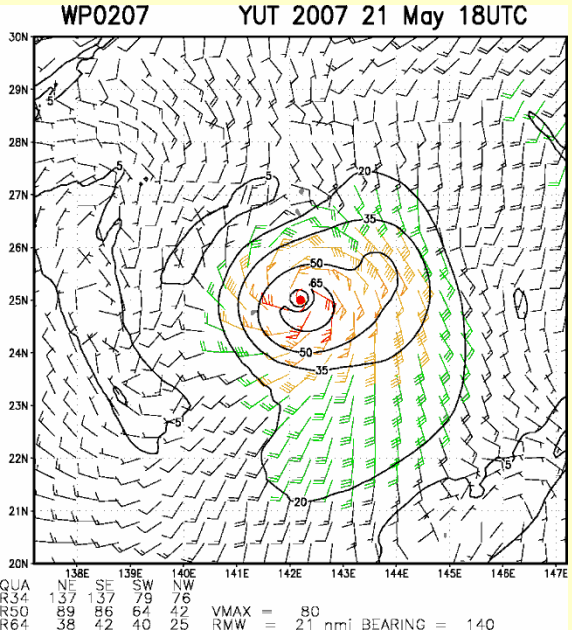
- Track history and current forecasts from NOAA (NHC or CPHC) or DOD/JTWC
- Earth relative IR loops (4-km Mercator)
- Storm relative LEO IR and Vis (1-km Mercator)
- **AMSU-derived radius vs. height cross sections (T and V_{grad}) and intensity estimate time series**
- **Earth relative oceanic heat content + forecast track**
- **Multi-platform satellite only tropical cyclone surface wind analysis**
- **Digital Dvorak intensity estimate time series**
- **Storm relative TPW and water vapor imagery**

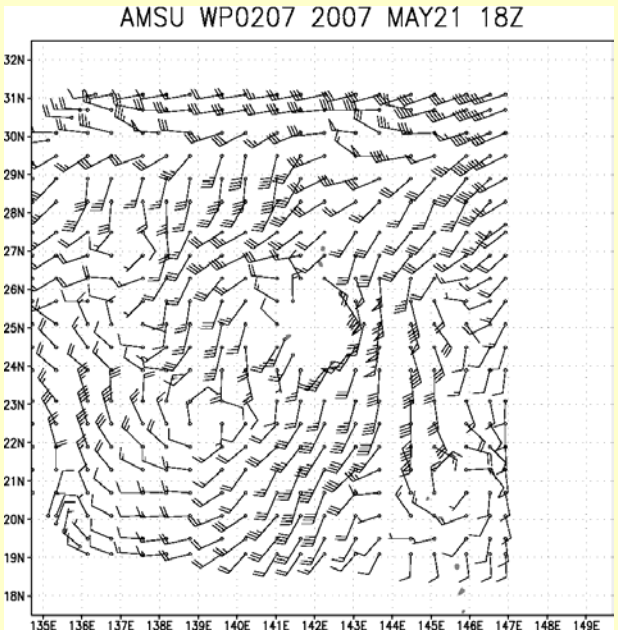
Experimental Product Examples (TC wind analysis)

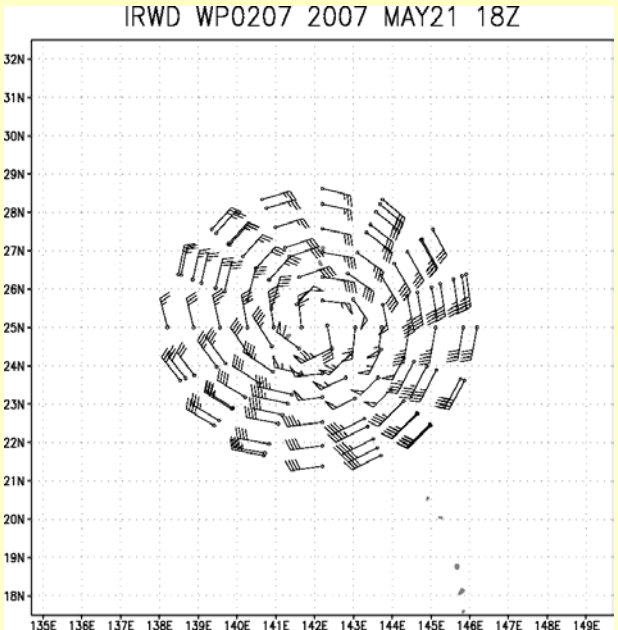


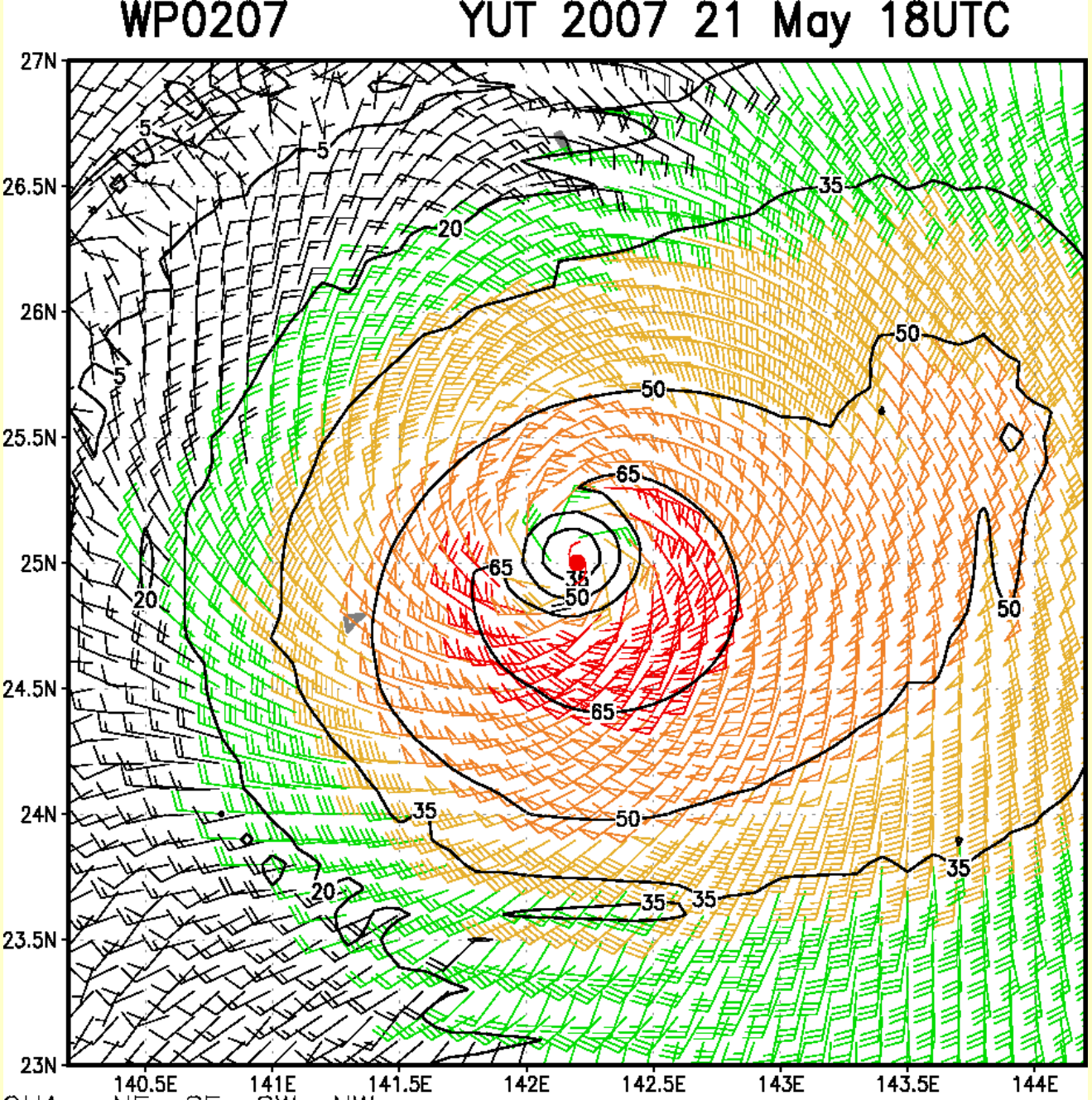








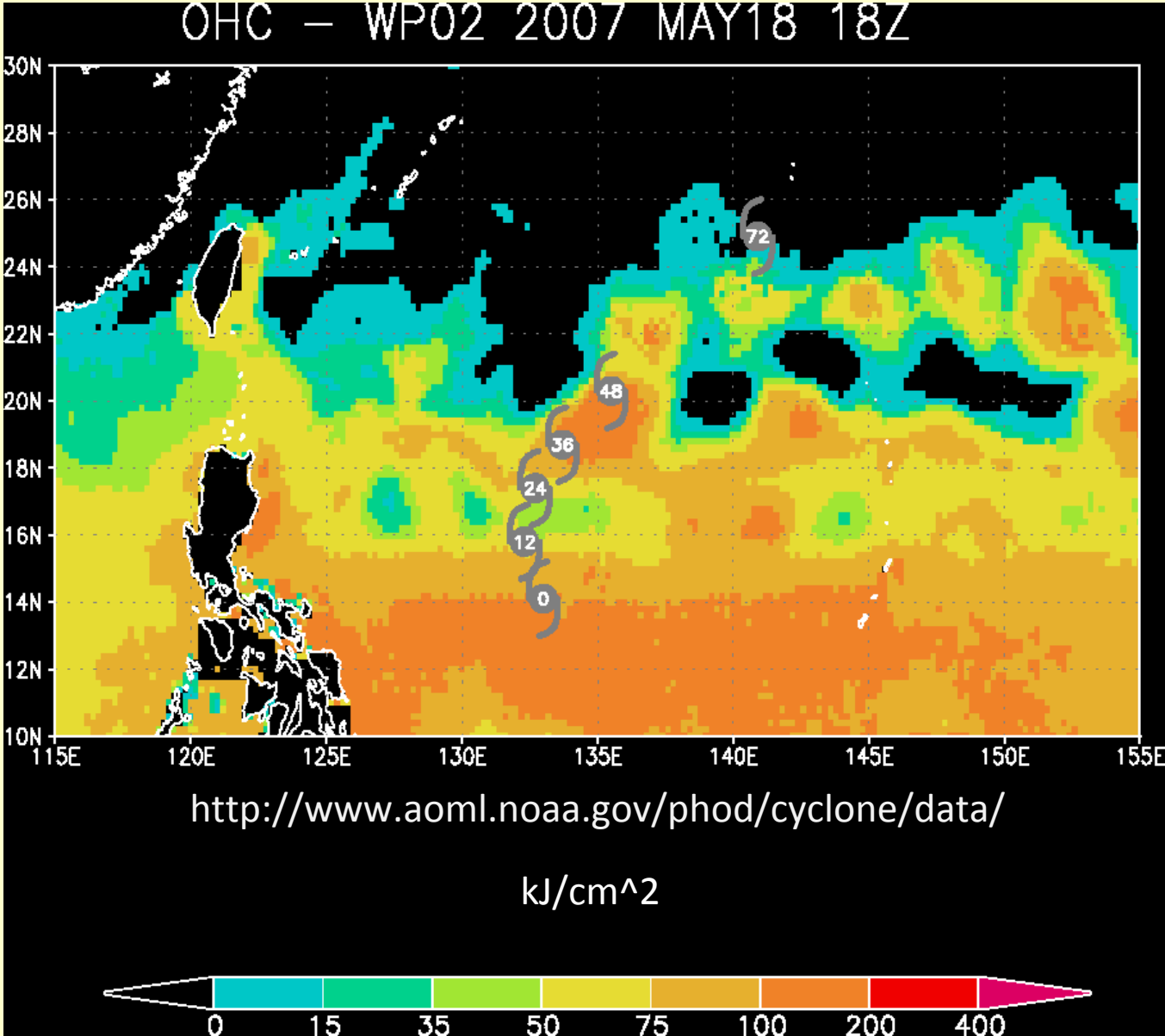




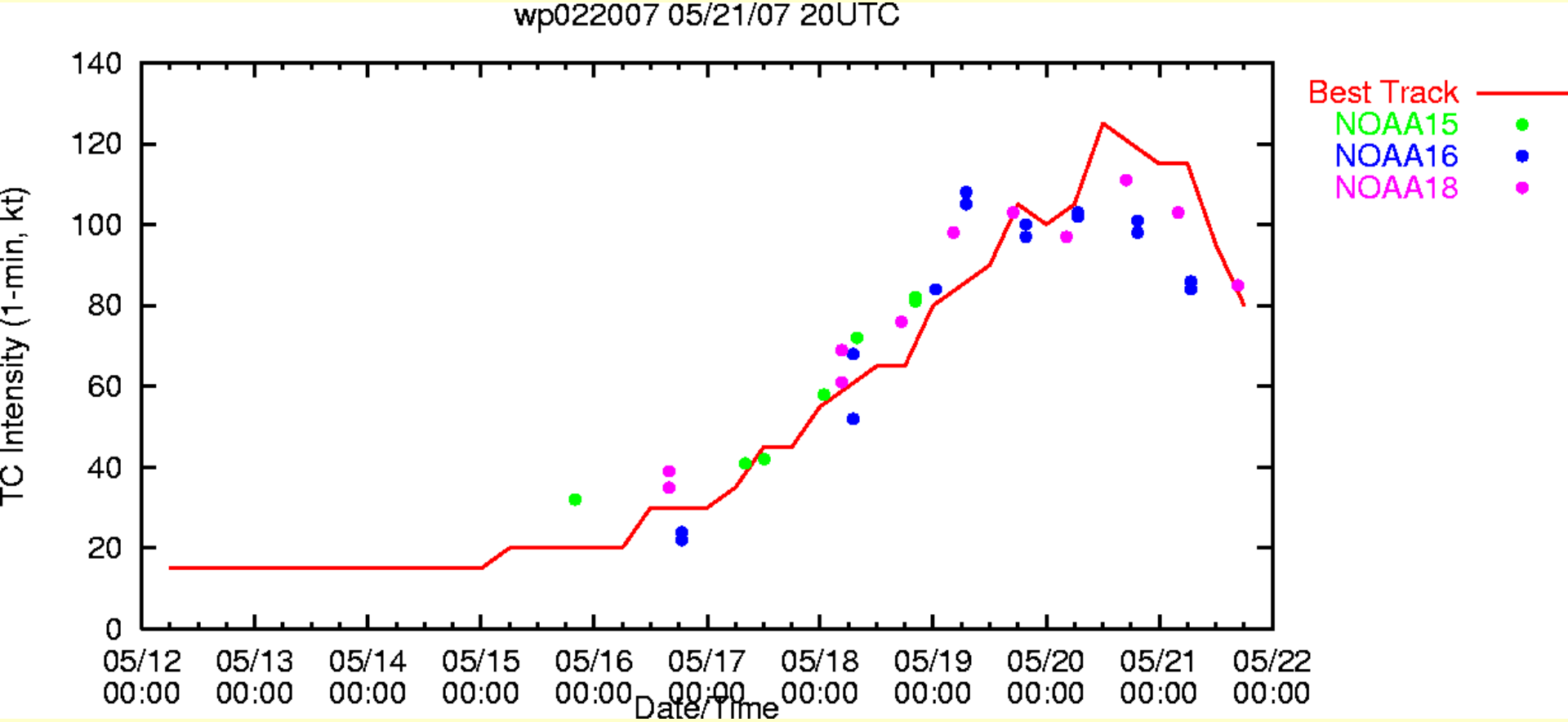
QUA	NE	SE	SW	NW	
R34	137	137	79	76	
R50	89	86	64	42	VMAX = 80
R64	38	42	40	25	RMW = 21 nmi BEARING = 140

Experimental Product Example (oceanic heat content)

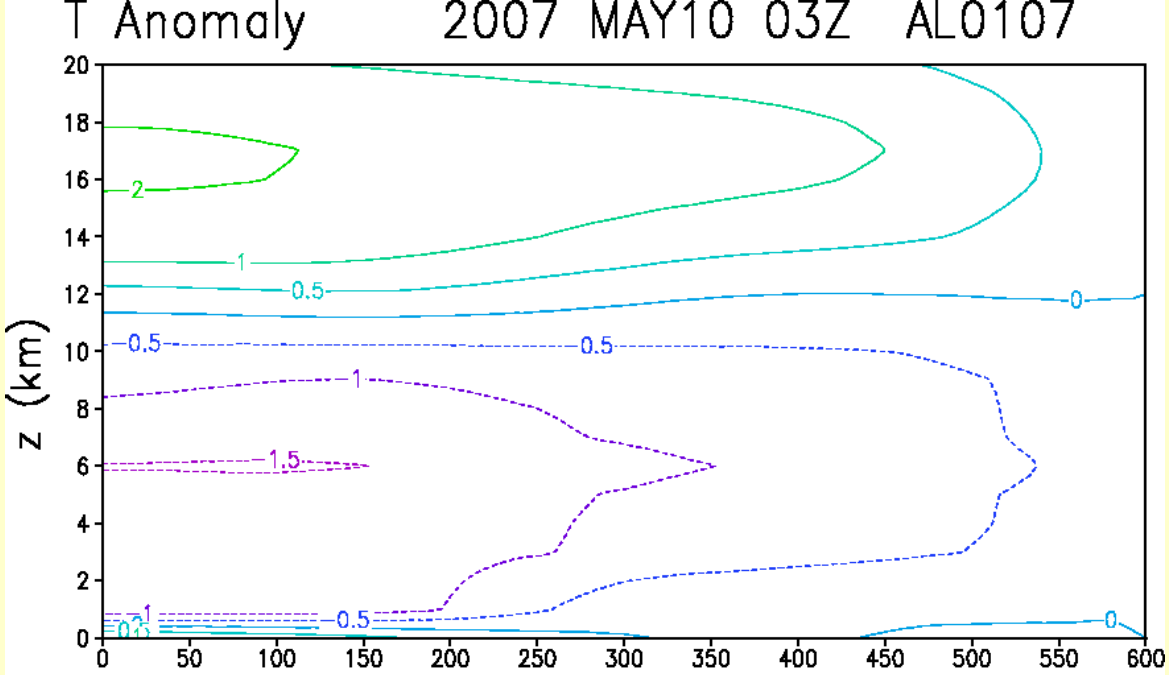
Data provided by G. Goni at NOAA/AOML

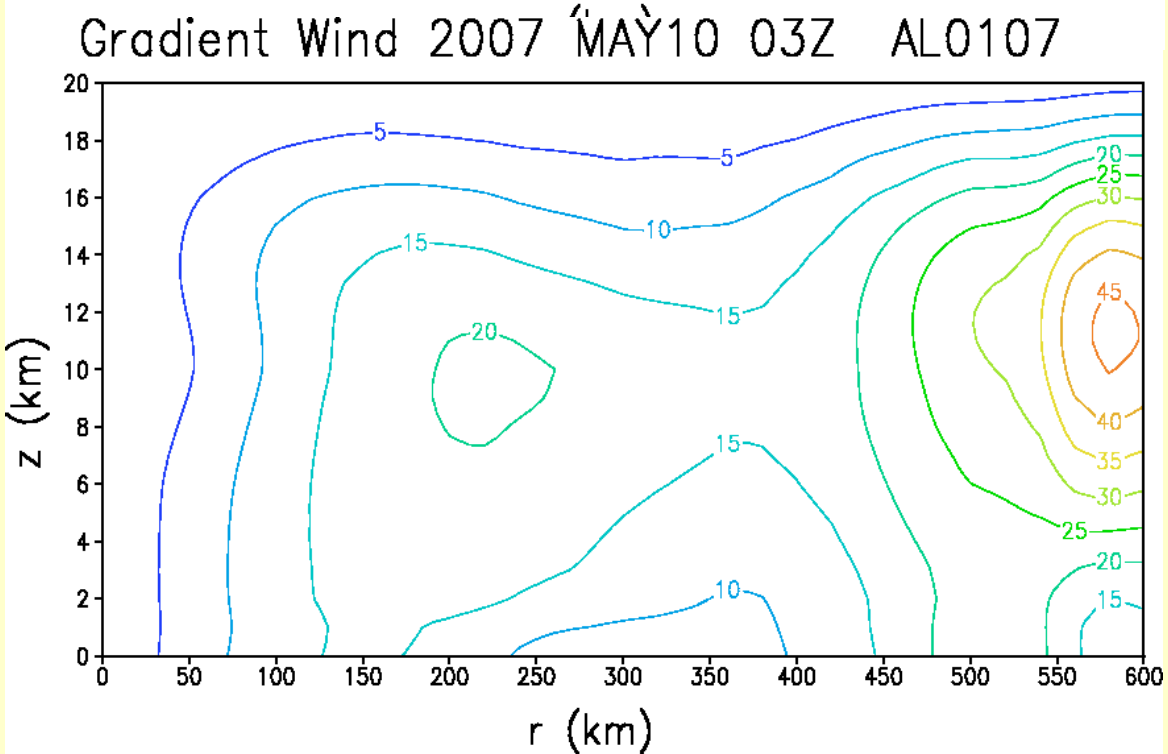


Operational Product Example (AMSU intensity)



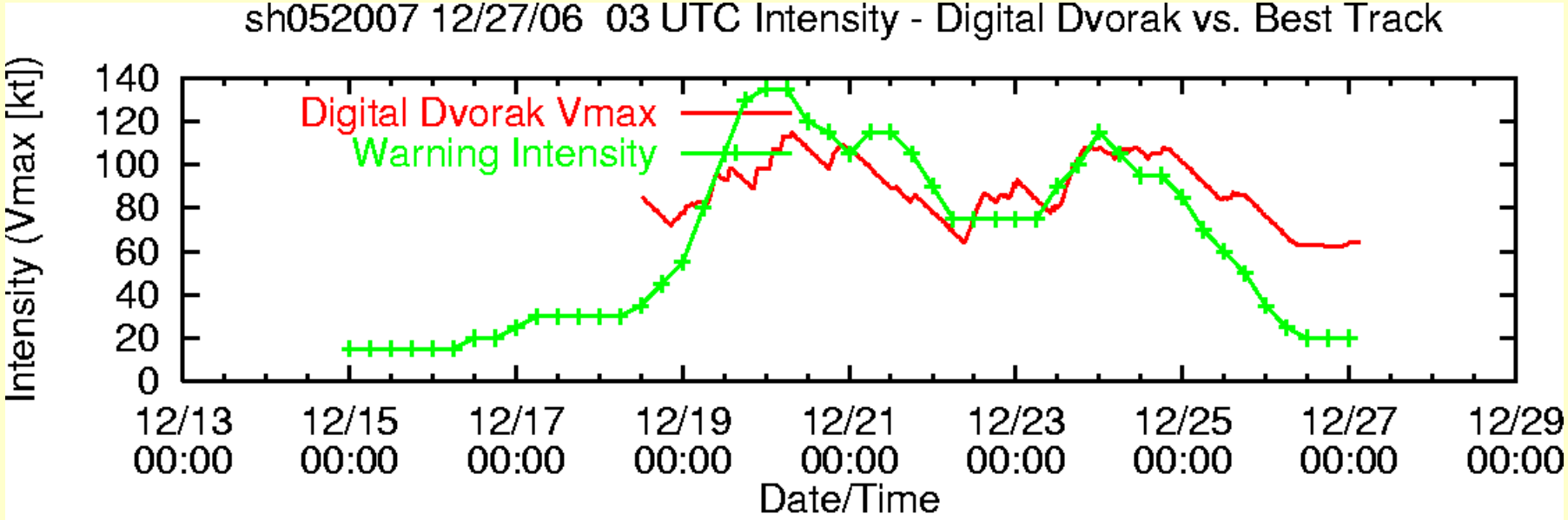
Available for all active tropical cyclones at ftp://ftpprd.ncep.noaa.gov/pub/data1/amsu

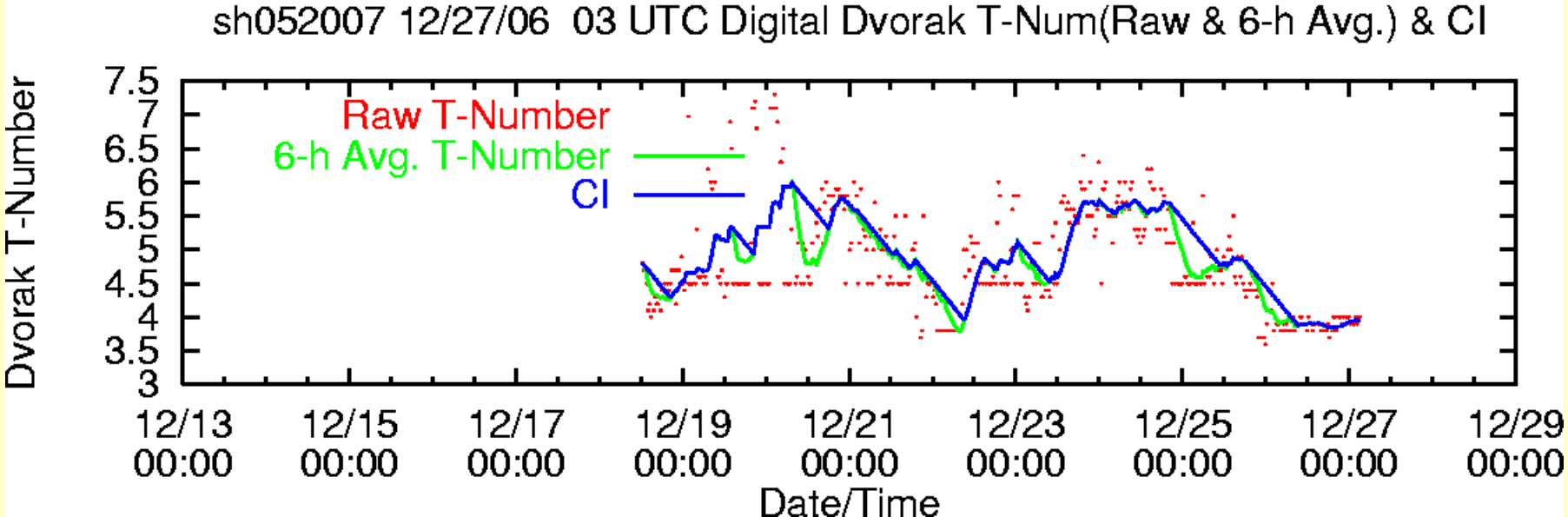




Example: Subtropical Storm Andrea

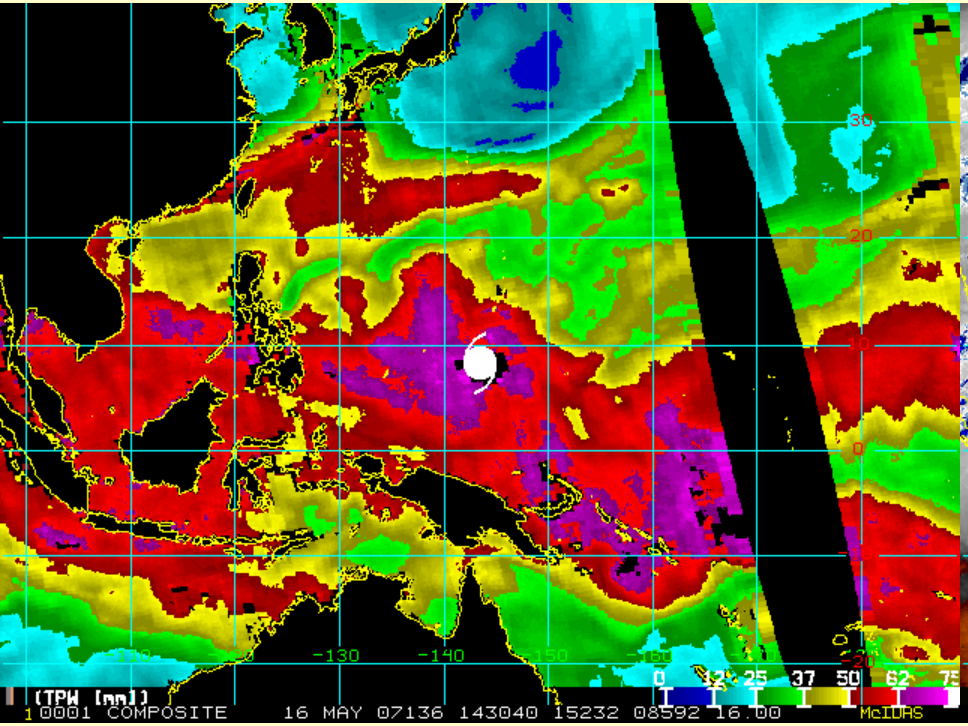
Digital Dvorak Intensity Estimates



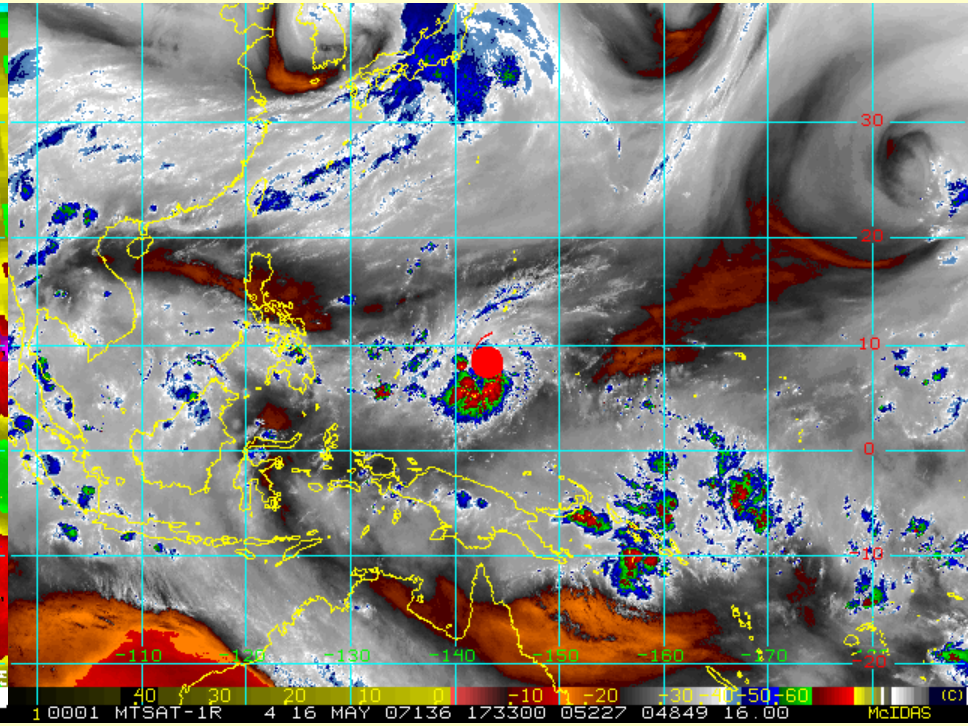


Example Water Vapor Products

Storm Relative
Total Precipitable Water



Storm Relative
Water Vapor Imagery

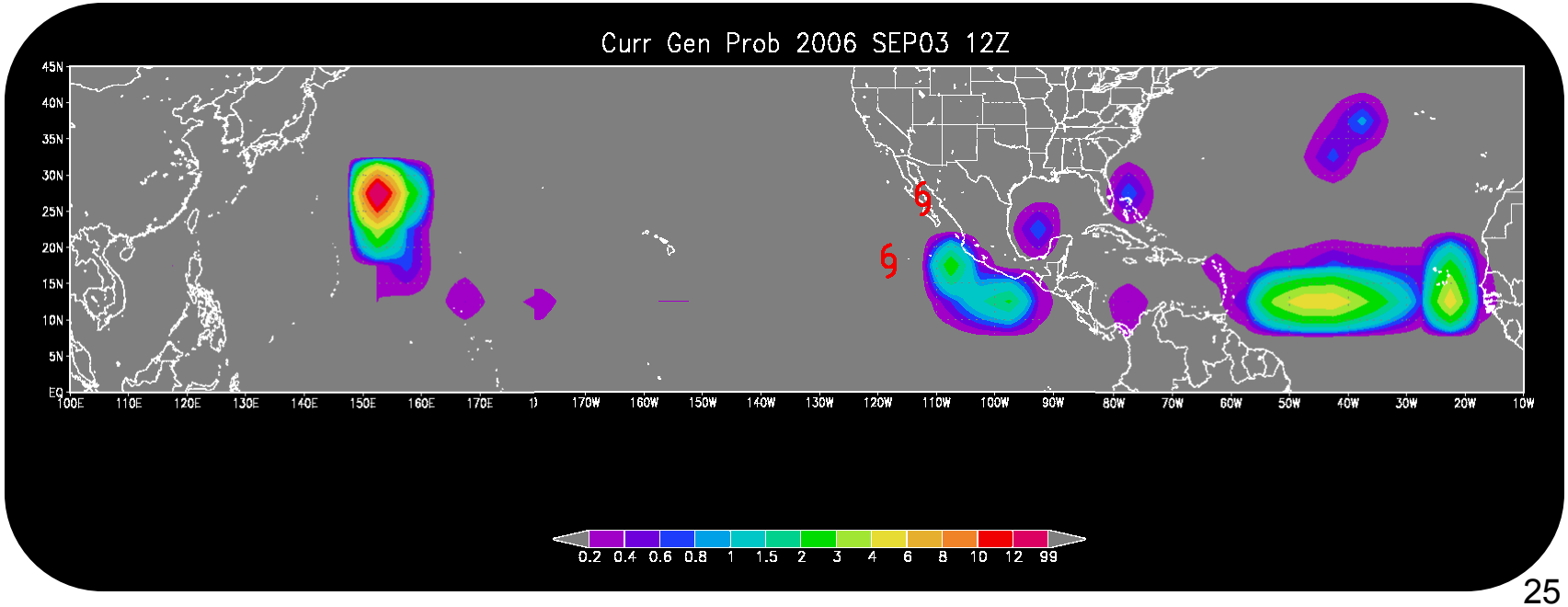


Blending of AMSU and SSM/I
TPW is explained in
Kidder and Jones (2007, JAOT)

Future

- Add New products
  - STIPS and SHIPS forecast time series
  - 1-km forecast track relative visible imagery
  - Kinetic energy time series derived from the surface wind analyses
- Transition (try to) the experimental products
  - Multi-platform surface wind analysis
  - Ocean heat content
    - Use in STIPS based consensus
    - WMO website (maybe)
- Respond to user requests

Extension of the NESDIS Tropical Cyclone Formation Probability Product to the Central and Western Pacific



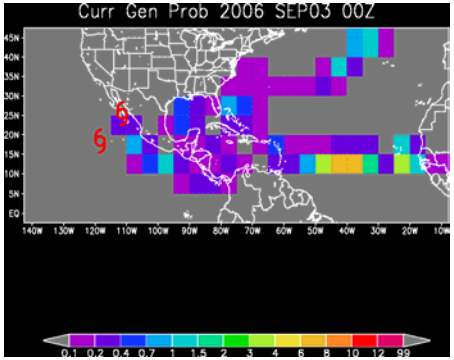
CURRENT TCFP PRODUCT - OVERVIEW

- Determines the 24-hr probability of TC formation within each 5° x 5° lat/lon grid box within the product domain (0° to 45° N, 140° to 350 W°)
- Uses the following data sources:
  - NCEP GFS operational analyses
  - GOES-East water vapor imagery
  - NHC Best tracks
- Running operationally at SSD since 2004 hurricane season.
- Shows plots of domain-wide formation probabilities, predictor values, and sub-basin time series. Updates every 6 hours.
- Available at : http://www.ssd.noaa.gov/PS/TROP/genesis.htm

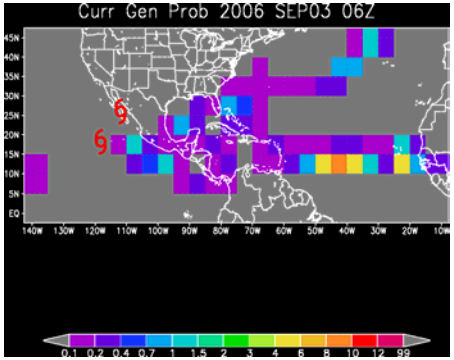
CURRENT TCFP PRODUCT – OVERVIEW (CONT…)

- CLIMATOLOGICAL FORMATION PROBABILITY (1949 – 2003)
- PERCENT LAND
- DISTANCE TO PREXISTING STORM
- CLIMATOLOGICAL SST
- VERTICAL SHEAR (800 – 250 hPa)
- 850 hPa CIRCULATION
- VERTICAL INSTABILITY
- GOES COLD PIXEL COUNT
- CLOUD-CLEARED WATER VAPOR BRIGHTNESS TEMP.

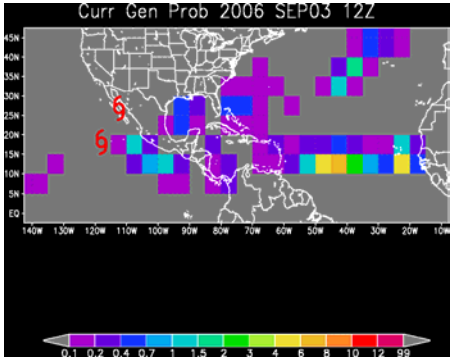
CURRENT TCFP PRODUCT EXAMPLE – FLORENCE 2006



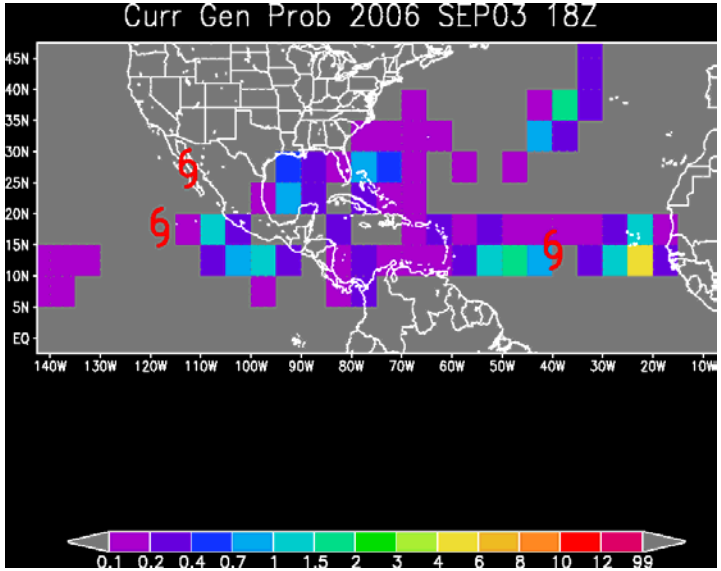
- 18 hr



- 12 hr



- 6 hr



- 0 hr = Time of TC Genesis

CURRENT PRODUCT - VERIFICATION

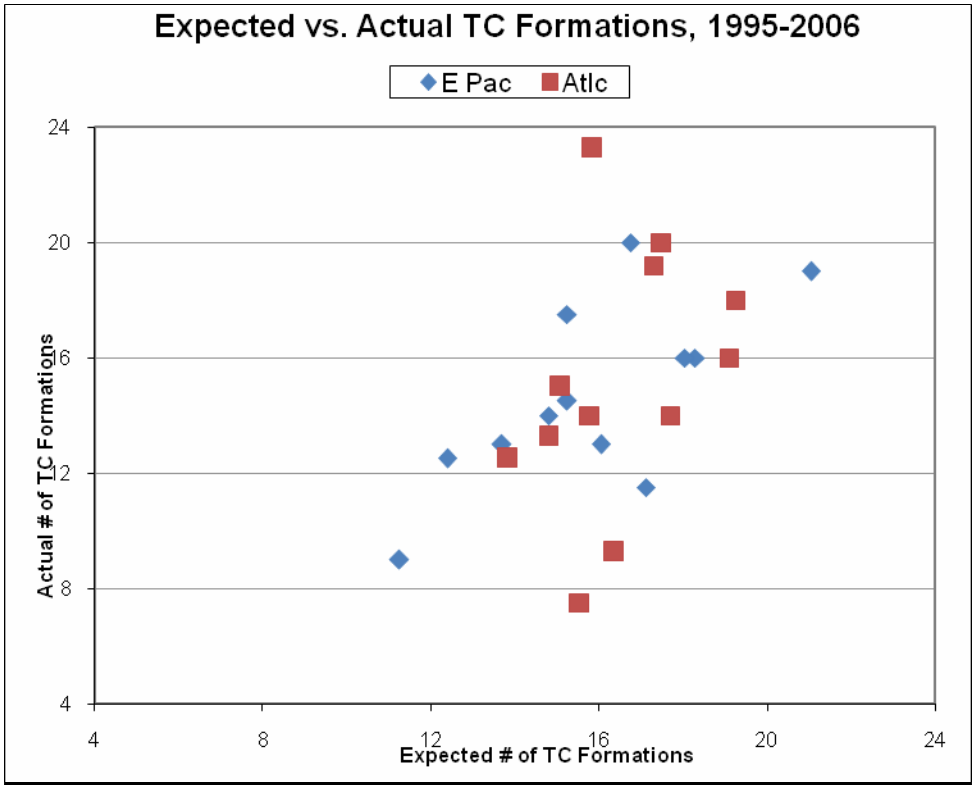
Dependent probabilities are skillful by two measures

- Brier Skill Score
- Relative Operating Characteristic (ROC) score

Interannual Variability

Expected Yearly # TCs =

$\iiint P(x,y,t)dxdydt$

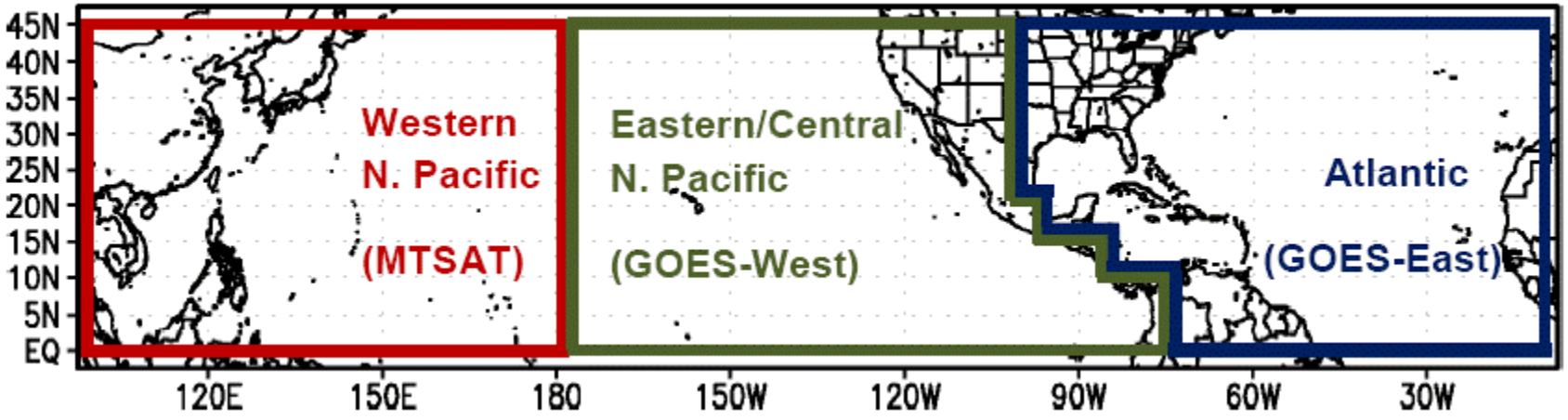


UPDATED TCFP PRODUCT

- Expanded domain to cover Central & Western N. Pacific Basins
- Compiled data for algorithm development in Central & Western Pacific regions
  - NCEP global GFS fields
    - Reanalysis 1980-1999 (2.5^{o} grid)
    - Operational Analyses 2000-2003 (2.0^{o} grid)
  - NHC/CPHC/DOD Best Tracks (1949-2006)
  - Satellite Water Vapor Imagery
    - GOES-W (1998 – present)
    - GMS-5/GOES-9/MTSAT-1R (2000 – present)
- Updated screening and algorithm processes, using data through 2005 for developmental sample sets

UPDATED TCFP PRODUCT – EXPANDED DOMAIN

- Expanded domain longitude eastward to 100° E (covers Central & Western N. Pacific Basins)
- Redefined basins based on satellite coverage
- Performed separate screening steps and discriminant analysis on each of the 3 basins.

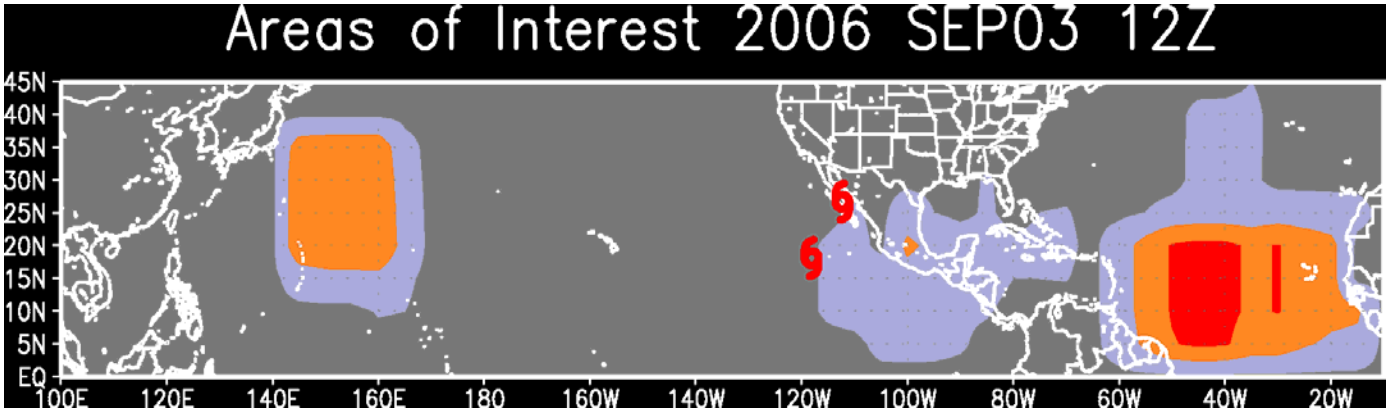


UPDATED TCFP PRODUCT - MODIFICATIONS

- Added 2004 & 2005 to GOES-E sample set
- Defined screening values and discriminant weights on each of the 3 basins, separately
- Used a Finer Screening Process
  - Updated screening eliminates 5% of genesis cases and 75% of non-genesis cases (increase in eliminated non-genesis cases of ~5% → improve discriminant analysis)
- Added of 850 hPa Horizontal Divergence as a Predictor

UPDATED TCFP PRODUCT – WEB PAGE

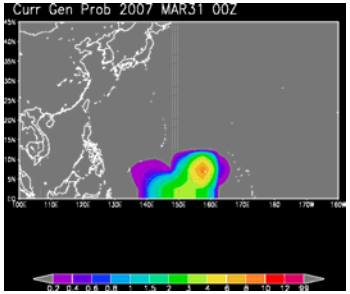
- Updated/extended TCFP product currently running at CIRA, available at http://rammb.cira.colostate.edu/projects/gparm/
- Main Page: points out areas of interest for TC genesis formation, links to web page for each basin



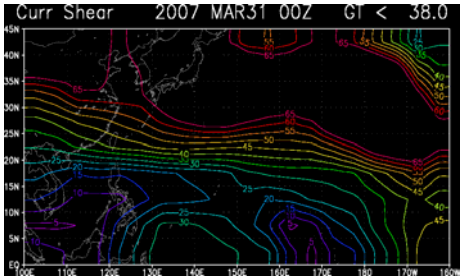
Eg. Main Page graphic from 9/3/06 12Z, 6 h prior to the formation of Florence in the Atlantic & 5 days prior to the formation of WP14.

UPDATED TCFP PRODUCT – WEB PAGE (CONT…)

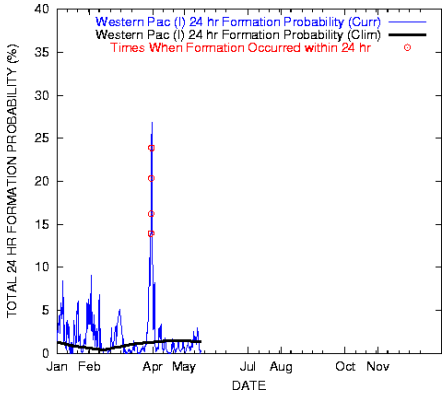
- Example: Western Pacific Web Page Images:



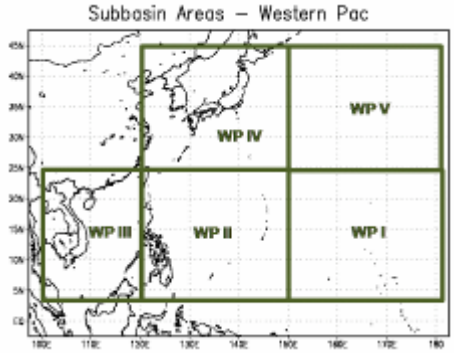
Formation Probability (real-time, climatological, & anomaly)
Eg. Real-time TC formation probability 3/31/07 0Z.



Predictor Values (real-time, climatological, & anomaly)
Eg. Real-time vertical shear, 3/31/07 0Z.



Time Series of Formation Probability & Predictor values summed over subbasins within each basin
Eg. Formation Prob over WPI



UPDATED TCFP PRODUCT – FUTURE

- The updated NESDIS TCFP product will be run locally at CIRA and compared to the current product (running at SSD) throughout the 2007 hurricane seasons.
- Extended product will be evaluated/verified at end of 2007 seasons.
- After evaluation, the extended product will be transitioned to operations with the help of SSD (Ops begin date Jun 2008)

Satellite support for the NOAA/AOML Hurricane Research Division (HRD) annual field program

- Background / History:
  - AOML/HRD: Miami, FL
    - NOAA's research aircraft (two WP-3D turboprops and a Gulfstream IV-SP jet) flown by NOAA's Aircraft Operations Center (MacDill AFB Tampa, FL)
  - RAMSDIS
    - “Tropical RAMSDIS”, July, 1995, RAMM/CIRA
    - 1996 – “HRD RAMSDIS”

SMOKING

UNITED STATES DEPT OF COMMERCE

Tropical RAMSDIS image animations:

- Global geostationary coverage:
  - -- Meteosat-8 at 0 deg lon
  - -- GOES-12 at 75W
  - -- GOES-11 at 135W
  - -- MTSAT at 140E
  - -- Meteosat-7 at 62E

1) large area water vapor

2) matching large area visible (combined with night-time 3.9 micrometer)

3) six movable 4-km Mercator areas (floaters)
   - IR
   - VIS / 3.9

4) two 1-km center relative visible animations using rapid scan images

Tropical RAMSDIS supplemental data types:

- conventional surface observations

- conventional ship and buoy (moored and drifting) observations

- radiosonde observations

- satellite high density winds (from CIMSS, Wisc)

- scatterometer (Quikscat) winds

- numerical model analyses and forecasts (1. NCEP GFS, 2. UKMET, 3. NOGAPS modified by satellite winds from CIMSS)

- hurricane track forecasts from TPC/NHC

Tropical RAMSDIS products:

IMAGE:

- CIRA blended total precipitable water
- satellite microwave (SSMI, AMSU, TRMM, AMSR-E)
- sea-surface temperature
- cloud cleared 3.9 micrometer night-time skin temperature
- long wave difference (dust)

ANALYSIS:

- digital Dvorak hurricane intensity estimate
- vertical wind profile areal wind averaging

(for vertical shear analysis, using numerical model fields)

Additional RAMM real-time TC products and RAMSDIS accessible data:

- Tropical cyclone surface wind analysis
- Ocean heat content
- AMSU intensity estimates and vertical structure analysis
- RAMM Genesis parameter

- high resolution polar orbiter images (MODIS and AVHRR)
- NexRad NWS radar

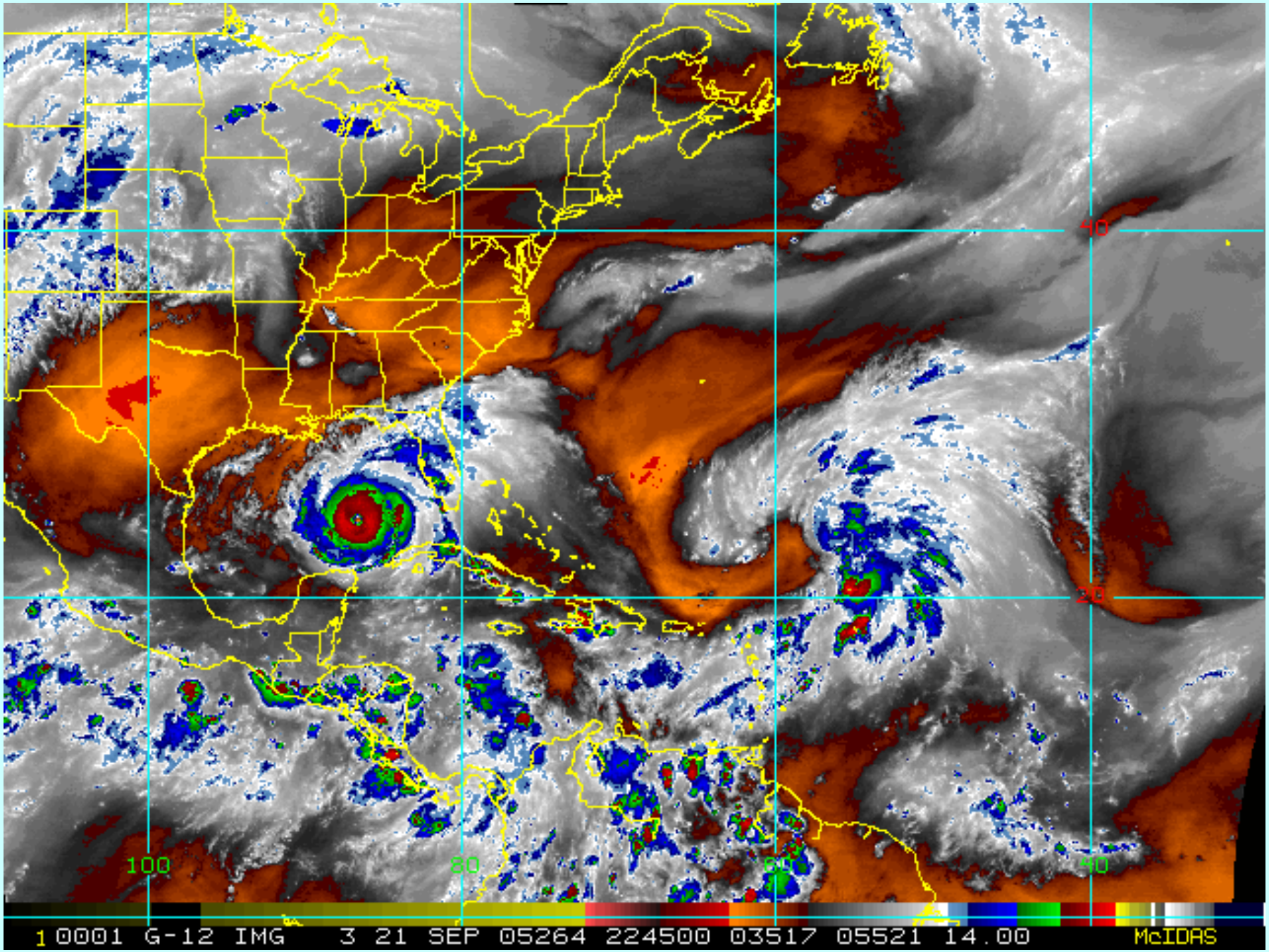
- SHIPS and STIPS (Statistical Intensity forecast guidance)

OnLine:

http://rammb.cira.colostate.edu/products/tc_realtime/

http://www.ssd.noaa.gov/PS/TROP/genesis.html

http://www1.cira.colostate.edu/RAMM/Rmsdsol/TROPICAL.html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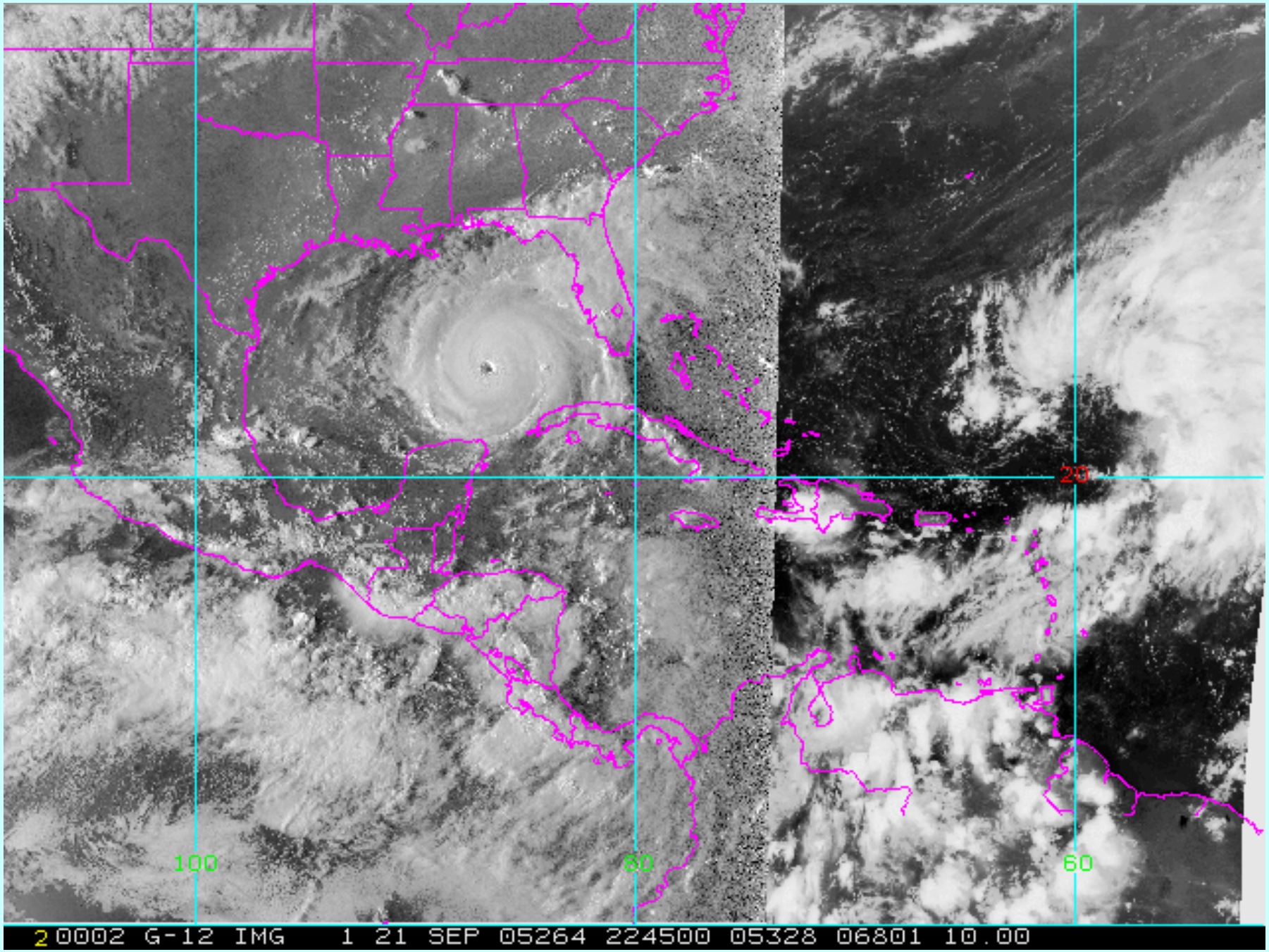
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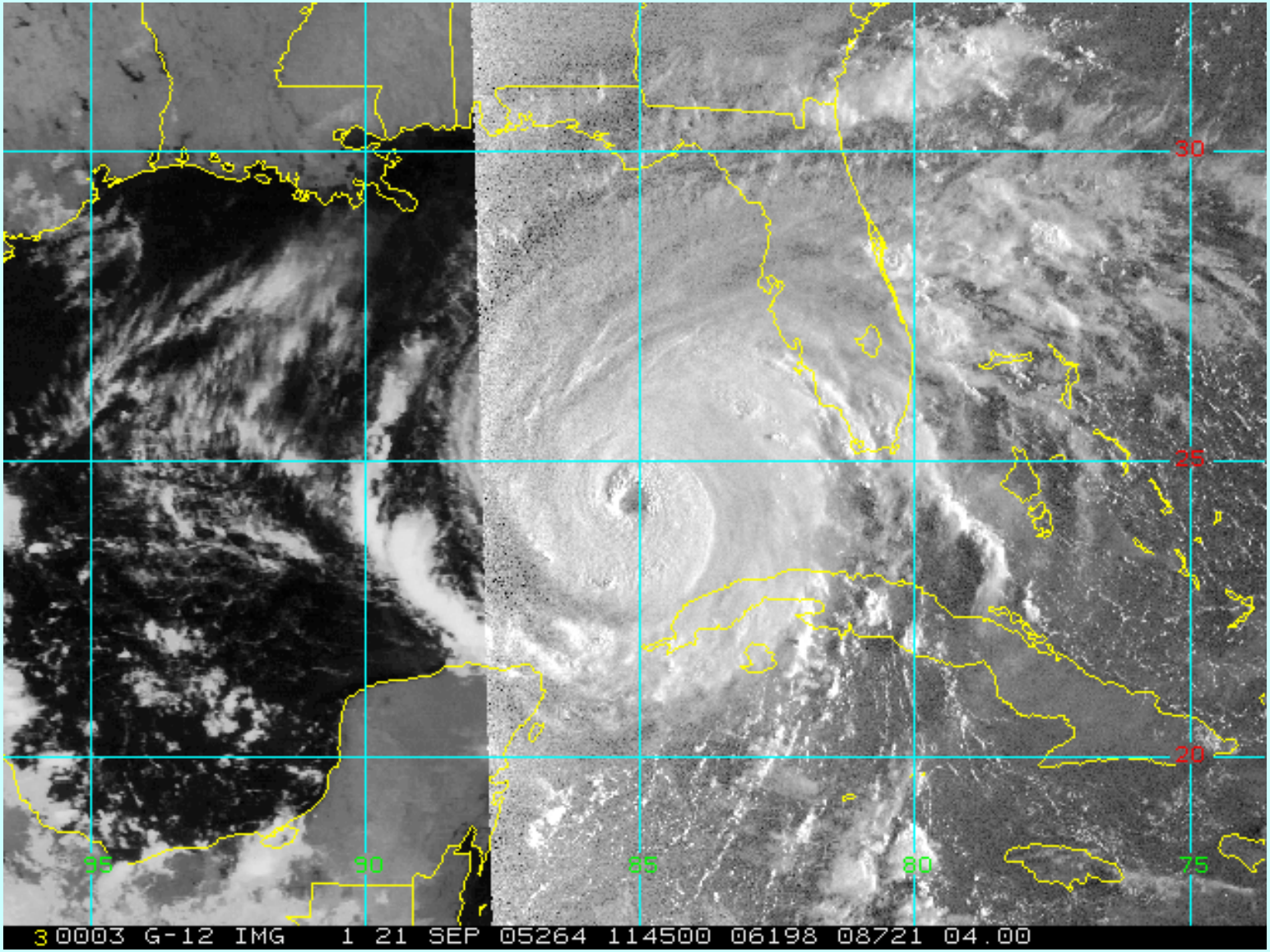
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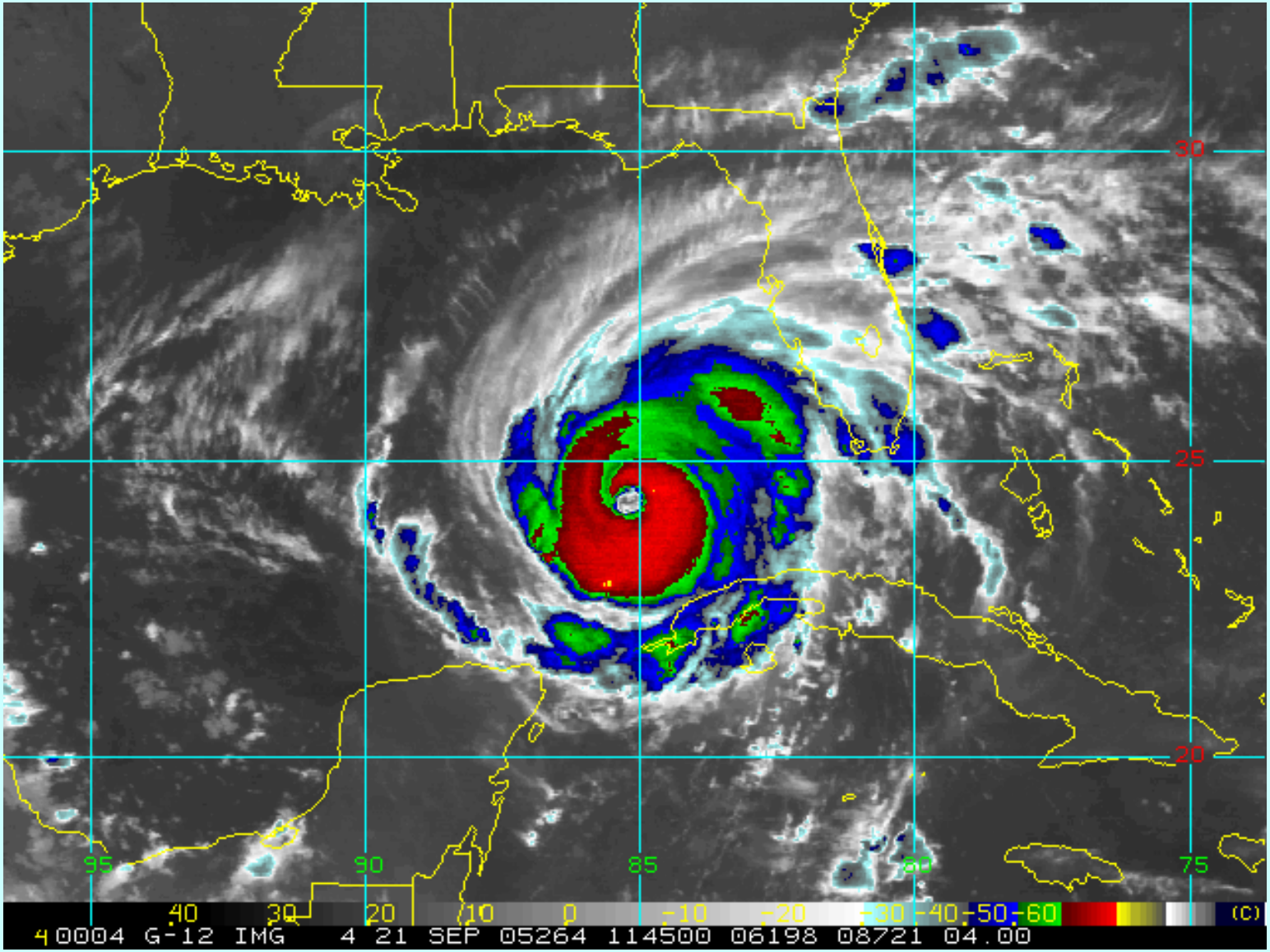
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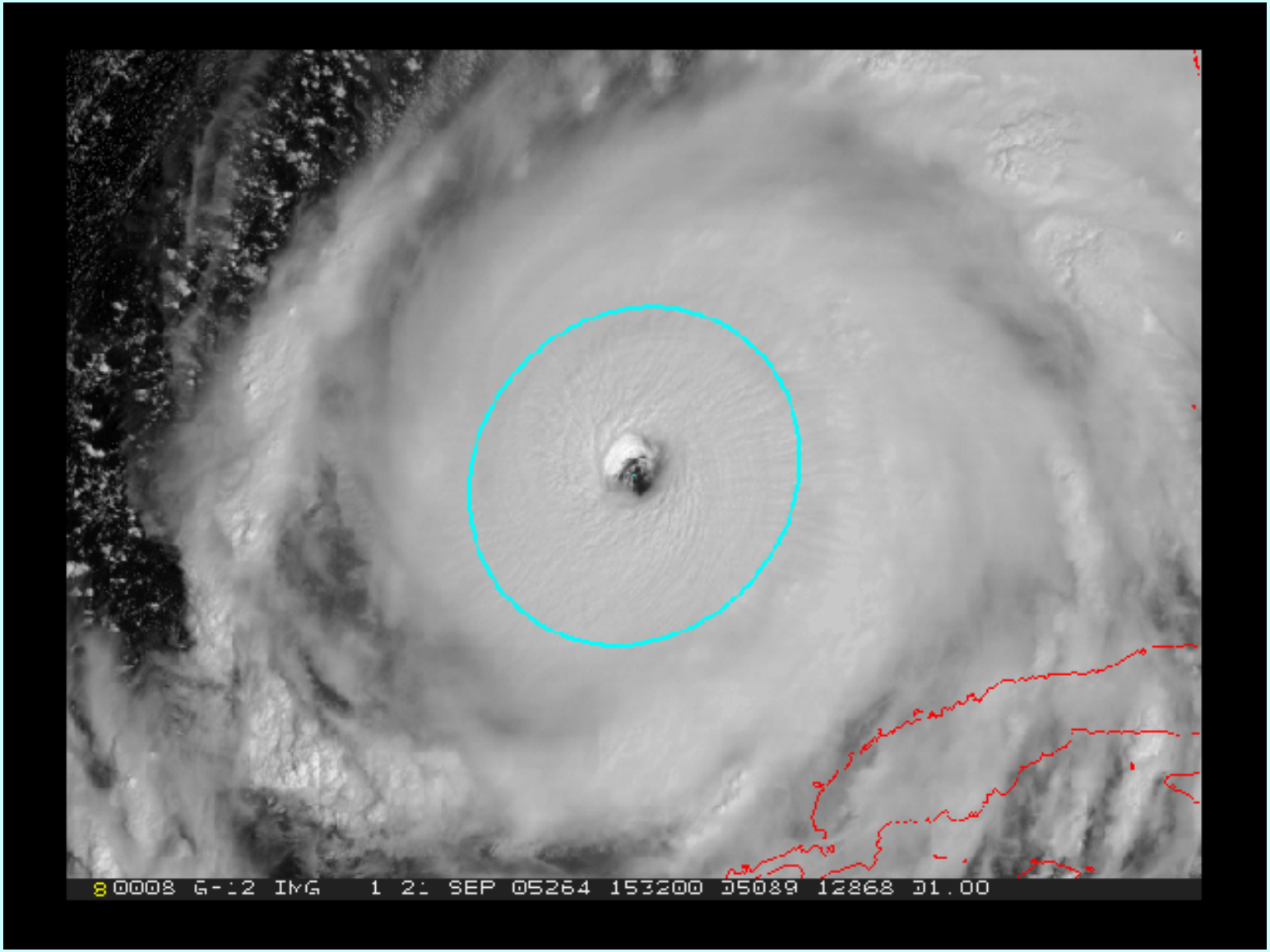
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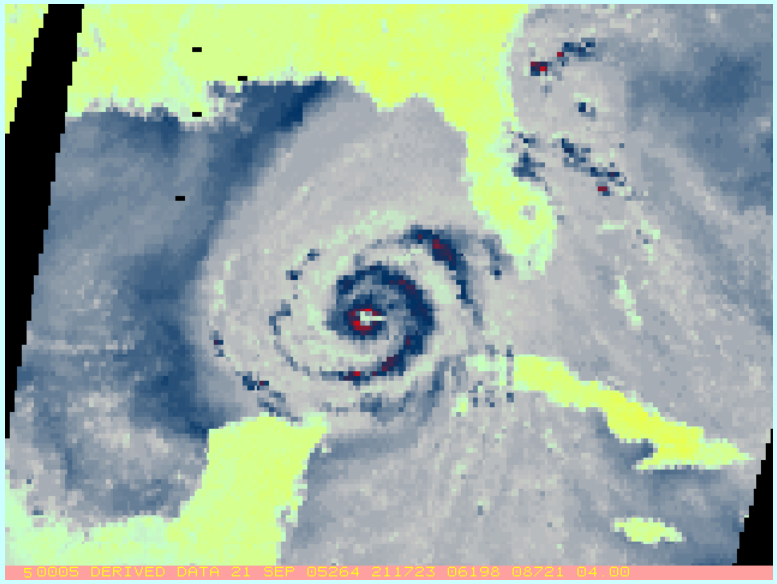
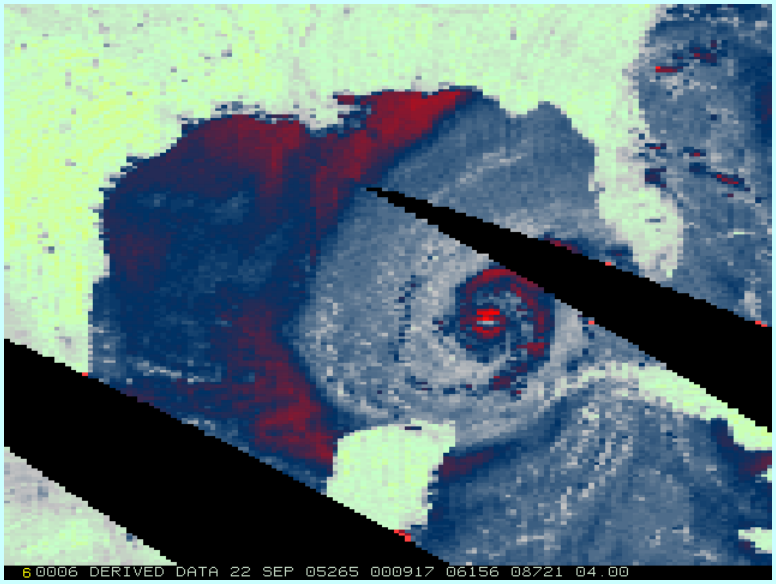
Microwave images



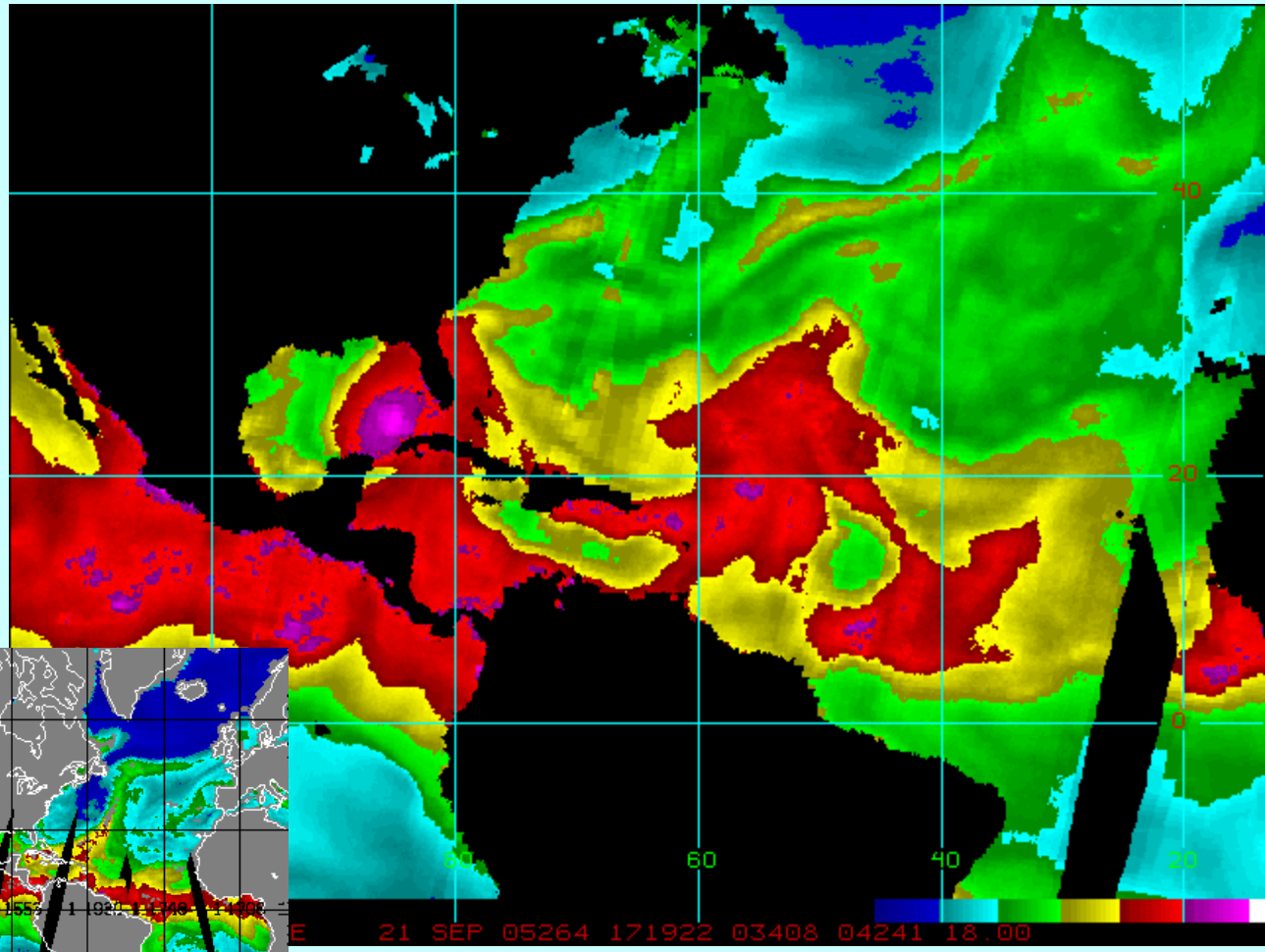


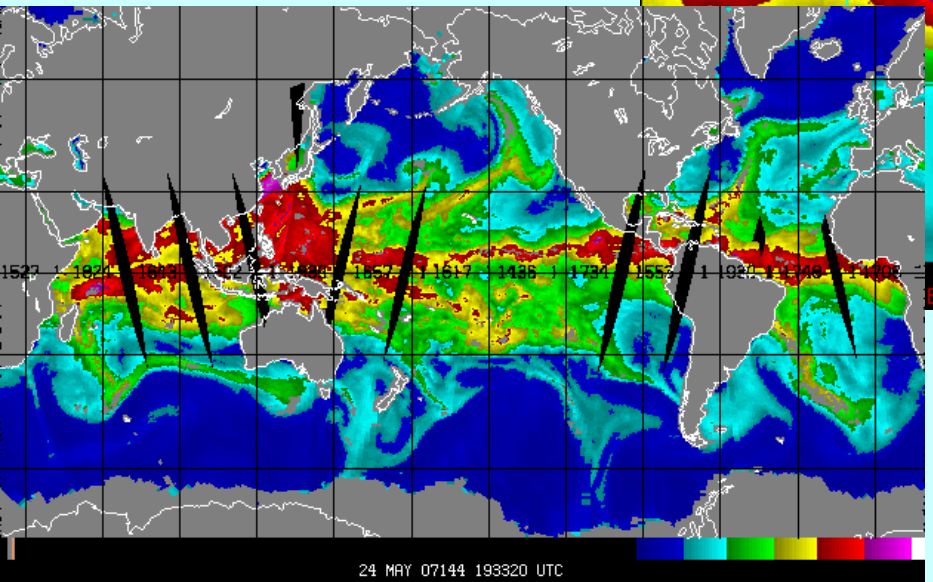
4-km Mercator to match VIS and IR floaters

8 types:

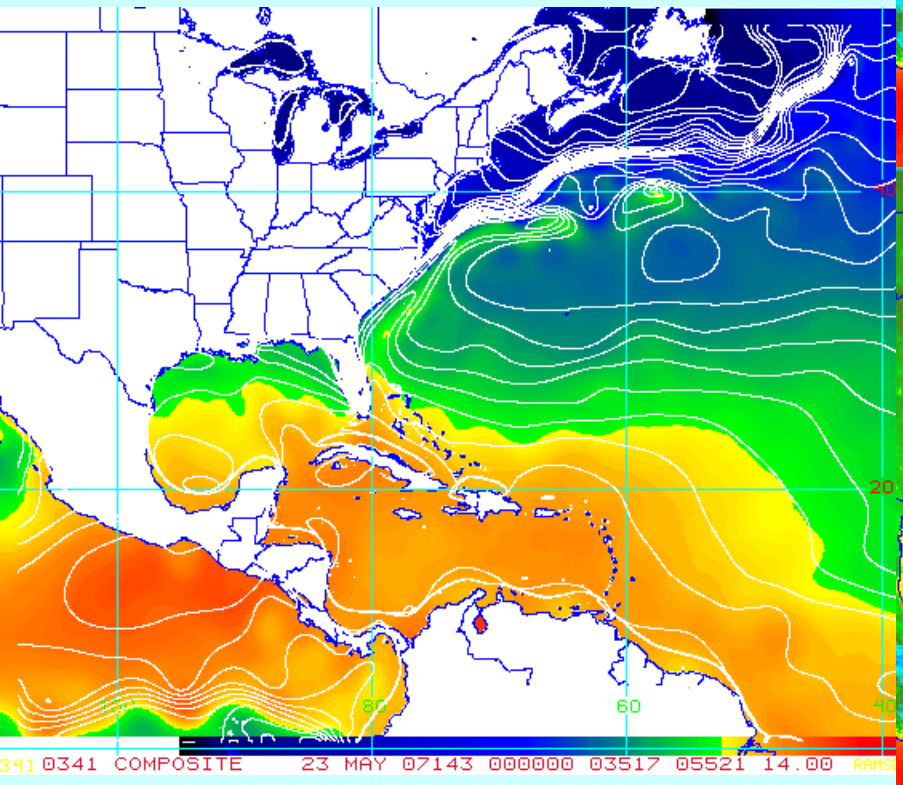
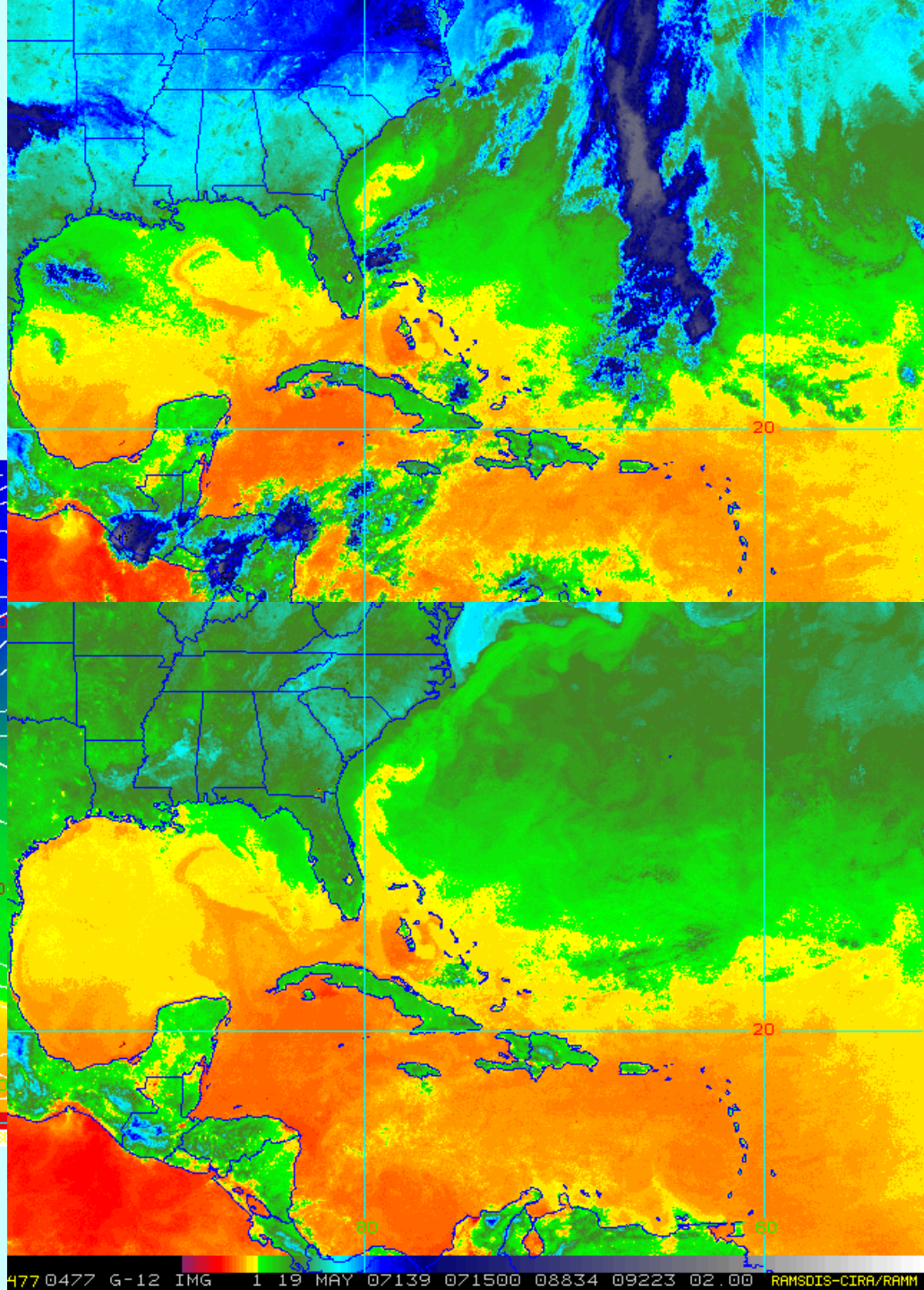
1) SSMI 85 Ghz
2) AMSU 89 Ghz
3) TRMM 85H
4) TRMM 85PCT
5) TRMM 37PCT
6) TRMM 37V
7) AMSU CH-7
8) AMSU CLW

CIRA's Blended Total Precipitable Water -- Kidder and Jones





Sea-surface temperature and

cloud-cleared GOES

3.9-micrometer images