Improvements in Real-Time Tropical Cyclone Products

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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 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/

Currently Active Tropical Cyclones

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
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)
WP0207
YUT 2007 21 May 18UTC

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

http://www.aoml.noaa.gov/phod/cyclone/data/

OHC – WP02 2007 MAY18 18Z

http://www.aoml.noaa.gov/phod/cyclone/data/

kJ/cm^2
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

sh052007 12/27/06  03 UTC Intensity - Digital Dvorak vs. Best Track

Intensity (Vmax [kt])

Date/Time

00:00 00:00 00:00 00:00 00:00 00:00 00:00 00:00 00:00

Digital Dvorak Vmax
Warning Intensity

sh052007 12/27/06  03 UTC Digital Dvorak T-Num (Raw & 6-h Avg.) & CI

Dvorak T-Number

Date/Time

00:00 00:00 00:00 00:00 00:00 00:00 00:00 00:00 00:00

Raw T-Number
6-h Avg. T-Number
CI
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/ion 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](http://www.ssd.noaa.gov/PS/TROP/genesis.htm)
CURRENT TCFP PRODUCT – OVERVIEW (CONT…)

- CLIMATOLOGICAL FORMATION PROBABILITY (1949 – 2003)
- PERCENT LAND
- DISTANCE TO PREEXISTING 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 = \[ \int \int \int P(x,y,t) dx dy dt \]
UPDATING 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° grid)
    - Operational Analyses 2000-2003 (2.0° grid)
  - NHC/CPHC/DOD Best Tracks (1949-2006)
  - Satellite Water Vapor Imagery
    - GOES-W (1998 – 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

- 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.*
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*
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”
**Tropical RAMSDIS image animations:**

- **Global geostationary coverage:**
  - Meteosat-8 at 0 deg Ion
  - 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
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