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# A WEB APPLICATION FOR NEAR REAL TIME DISTRIBUTION OF TROPICAL CYCLONE HEAT POTENTIAL ESTIMATES

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## 1. INTRODUCTION

This work is part of the hurricane component of CBLAST, and consists in estimating the upper ocean heat structure in tropical regions using remote sensing procedures. The Tropical Cyclone Heat Potential (TCHP), defined here as proportional to the integrated vertical temperature from the sea surface to the depth of the 26ºC isotherm, are believed to play a significant role in the sudden intensification of tropical cyclones (TC).Near real time availability of this parameter, estimated using blended sea height anomaly (SHA) data from the altimeter constellation, sea surface temperature (SST) from infrared and microwave sensors in combination with climatologies and within a reduced-gravity ocean scheme, are computed and distributed with the aim to help improving tropical cyclone intensity forecasts. We show here results presented in the web page **http://www.aoml.noaa.gov/phod/cyclone/data,** which distributes global fields of TCHP, SHA, SST and of the depth of the 20º C (D20) and 26º C (D26) isotherms. We also describe here the methodology used to obtain and validate these fields.

## 2. DATA AND CALCULATIONS

### *2.1 Altimeter Data*

The SHA data used in this study is distributed by the Altimeter Data Fusion Center (ADFC) in the Naval Oceanographic Office (NAVO). Daily blended SHA values, computed from fields provided by the altimeter constellation, are routinely pulled, reformatted and stored in the local database where they become accessible for TCHP estimates.

### *2.2 Sea Surface Temperature Data*

We use SST from two main sources, namely the microwave imager on board the Tropical Rainfall Measuring Mission (TRMM) Microwave Imager (TMI), and the optimum-interpolated SST (OISST) from the NOAA/National Center for Environmental Prediction (NCEP)/Environmental Modeling Center (EMC). The TMI SST products were produced by Remote Sensing Systems and sponsored by NASA's Earth Science Information Partnerships (ESIP): a federation of information sites for Earth Science; and by NASA's TRMM Science Team. They cover from 40ºN to 40ºS, because of the satellite near-equatorial orbit, at a 0.25º pixel resolution. Atmosphere is nearly transparent at microwave frequencies and data from sensors operating in this range are less affected by clouds. This is a clear advantage over infrared SST. To obtain a nearly complete coverage of the world ocean, the 3-day averaged SST product is used. The NOAA/NCEP/EMC SST product also provides truly complete global coverage. SST fields are computed on a weekly basis on a regular spatial grid following Reynolds et al. (2002), and are created by optimal interpolation of AVHRR SST data that have been adjusted relative to in situ SST from buoy and ship observations.

### *2.3 Climatologies*

The annual mean depth of the 20º C isotherm and the reduced gravity *g'* are calculated from the World Ocean Atlas 2001 (WOA01). This dataset provides objectively analyzed fields for a number of geophysical variables as described by Conkright at al. (2002). The monthly relationship between D20 and D26 are also computed from the monthly WOA01 fields.

### *2.4 TCHP Fields*

The TCHP fields are computed using a modified technique that builds on a method to investigate the upper ocean thermal structure from altimetry (Goni et al, 1996), and later adapted for tropical regions (Shay et al, 2000). This methodology combines near real time observations of sea height anomalies from blended altimetry and sea surface temperature satellite data with climatological temperature and density fields within a two-layer reduced-gravity scheme. The synthetic temperature profiles are then estimated using the values obtained from the fields of sea surface temperature and the altimeter-derived D20, along with historical information on the shape of the profiles in the region. The SHA track data are interpolated using a Successive Corrections Method (SCM), where the initial estimated value is modified interactively by the observations. The SCM algorithm (Bratseth, 1986) is very efficient computationally when compared with standard Optimum Interpolation techniques, to which it converges.

Given the strong relationship that exists between the depth of the upper ocean mixed layer (with water temperatures generally above 26$^{o}$C) and TC genesis, it is therefore rational to address the issue of TC intensification by estimating the thermal (heat) content in the upper ocean from the sea surface to the depth of the 26$^{o}$C isotherm. Within this reasoning, the term *hurricane heat potential* was introduced to estimate the field of integrated vertical temperature from the sea

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surface to the depth of the 26°C isotherm, in an area of the Gulf of Mexico using eXpendable BathyThermographs (XBT) temperature profiles (Leipper and Volgenau, 1972). The TCHP is then estimated by integrating the temperature profile from the sea surface to the depth of the 26°C isotherm:

TCHP (x,y,t)=

=D(x,y) $c_p$ ∫ f{[0(x,y,t), , (x,y),<$'(x,y)>,$h_m$(x,y)],z} dz    (1)

where D is the mean density of the upper layer waters, 0 is the sea height residue, , is the mean reduced gravity scaled by the acceleration of gravity, $' is the mean barotropic component of the sea height anomaly, $h_m$ is the mean upper layer thickness and z is the water depth. These estimates are being carried globally and in near-real time to cover all seven oceanic basins where tropical cyclones occur, as well as in the tropical Pacific Ocean.

### *2.5 Validation*

Procedures to validate the results are being developed. As a major source of field data, global XBT and CTD profiles are routinely collected from the GTS and stored in the local databases. These data streams are also made available on the web through the CoastWatch Caribbean Node (**http://cwcaribbean.aoml.noaa.gov).**

## 3. PRODUCT DISTRIBUTION

Daily and weekly estimates are routinely generated and placed online for publicly availability. The daily THCP products use the SST from the TMI sensor, while the weekly THCP maps are created using the NCEP Reynolds Optimally Interpolated SST dataset. A new experimental weekly product involving weekly averaged TMI SST is being evaluated. In addition to the global fields, we show in detail the seven major ocean basins where tropical cyclogenesis take place (Fig. 1):

1) Atlantic basin, including the North Atlantic Ocean, the Gulf of Mexico, and the Caribbean Sea.
2) Northeast Pacific basin from Mexico to about the dateline.
3) Northwest Pacific basin from the dateline to Asia including the South China Sea.
4) North Indian basin, including the Bay of Bengal and the Arabian Sea.
5) Southwest Indian basin from Africa to about 100E.
6) Southeast Indian/Australian basin (100E to 142E).
7) Australian/Southwest Pacific basin (142E to about 120W).

Besides the near-real time TCHP estimates (in kJ $cm^{-2}$), we started providing in June 2004, we also supply the SST, SHA, D20 and D26 maps, in these seven basins plus in the tropical Pacific Ocean during all year. The web page also provides users with background information on some episodes of rapid intensification and their link to the TCHP fields in the Atlantic and western Pacific basins.

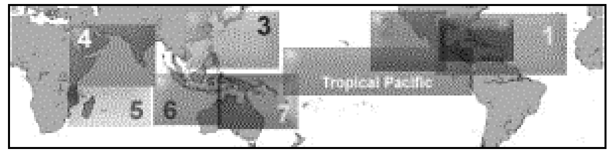


Figure 1. Seven major Tropical Cyclone basins.

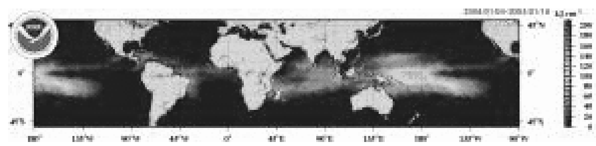

Figure 2. Weekly global TCHP map for the week ending Jan 10th 2004.

Weekly TCHP, D20, D26, SST and SHA maps, as well as 1°x1° ASCII TCHP data, are accessible since Oct 1992 and maintained up-to-date (Fig. 2). To keep consistency with OISST files, we consider the week starts on Sunday and ends on Saturday. A calendar-type Java applet and Flash application have been developed to enhance usability and facilitate user access to the range of products provided.

## 4. REFERENCES

Bratseth, A. M., 1986. Statistical interpolations by means of successive corrections. *Tellus, Ser. A*, **38**, 439447.

Conkright, M.E., R. A. Locarnini, H.E. Garcia, T.D. O'Brien, T.P. Boyer, C. Stephens, J.I. Antonov, 2002: World Ocean Atlas 2001: Objective Analyses, Data Statistics, and Figures, CD-ROM Documentation. National Oceanographic Data Center, Silver Spring, MD, 17 pp.

Goni,G.,S.Kamholz,S.Garzoli,and D.Olson,Dynamics of the Brazil-Malvinas confluence based on inverted echo sounders and altimetry*, J.Geophys. Res*., **101**, 16273–16289, 1996.

Leipper, D. and D. Volgenau, 1972: Hurricane heat potential of the Gulf of Mexico, *J. Phys. Oceanogr*., **2**, 218-224.

Shay, L.K., G.J. Goni, P.G. Black, 2000: Effect of a warm ocean ring on hurricane Opal, *Mon. Wea.Rev*., **128**, 1366-1383.