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User's Manual for Long-Range Swell Forecasting Model

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14. ABSTRACT

At many parts of the world's coasts, swell waves arriving from a distant generation region are an important part of the local wave climate. To provide accurate swell forecasting, a ray tracing swell model was developed using directional wave spectra from a global wave model as input. The model propagates swell energy from source regions to the forecast sites along great circle routes. The effect of island blocking is considered using DBDB2 (2-minute bathymetry database). The swell model provides forecast up to 15 days and a web page (http://www7320.nrlssc.navy.mil/html/swell/swell.html) has been established for Navy users. This manual is written to provide detailed procedures for running the long-range swell forecasting model. Descriptions of input parameters, scripts, output files, and model applications are included.

15. SUBJECT TERMS

Long-range swell forecasting; Ray tracing swell model

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TABLE OF CONTENTS

USER'S MANUAL FOR LONG-RANGE SWELL FORECASTING MODEL

1.0 INTRODUCTION

At many parts of the world's coasts, swells (long period waves arriving from a distant generation region) are an important part of the local wave climate. It is well known that swells with periods greater than approximately 12 seconds can travel great distances with relatively little dissipation (Snodgrass et. al., 1966). Travel times for swell can exceed 10 days when propagating across the larger ocean basins, and the resulting swell spectra are very narrow-banded in both frequency, through dispersion, and direction, by virtue of their radiation away from the source region along geodesic paths (Munk et. al., 1963). This often is manifested in swell having the appearance of long-crested plane waves, and leads to greater spatial variations in wave height in shallow water when compared to more broad-banded local seas.

The present global wave model (WAM at NAVO or Wavewatch3 (WW3) at FNMOC) forecasts of the swell portion of wave spectra are limited in several ways. First, forecasts extend out to only 5-6 days owing to present limits on forecasting wind fields with any degree of accuracy. However, at any given WAM analysis time, many swell trains exist within the model domain. Once outside their source region, swell are generally insensitive to all but the strongest wind fields, and their arrival can be predicted beyond 5-6 days in most situations. Second, the WAM uses a 1 degree Lat-Lon grid. Only the largest islands (e.g. Hawaii) can be incorporated into WAM at this spatial resolution. Numerous smaller islands and island chains are therefore neglected, yet it is known that the net blocking effects of these islands can be significant (Munk et al., 1963). Finally, wave propagation scheme used by WAM and the present discretization of directional spectra into 15 degree bands, lead to an artificial broadening, or diffusion, of wave energy as it propagates for long distances through the model domain, which can cause swell energy biased low and the directional distributions too broad.

Under the Office of Naval Research (ONR) funding, a swell model based on the ray approach was developed by the Scripps Institution of Oceanography. The swell model extends the forecast to 10-15 days, which is very useful in planning naval operations. At the time of the model development, WAM forecasts of swell energy were often too low. The under-prediction was thought to be associated either with the first order propagation scheme of WAM or the deficiency in energy generating at the low frequencies (Wittmann and O'Reilly 1998). One would expect swell model to give better wave height prediction because of the lack of dissipation in ray approach. After extensive comparison with buoy data, the swell model does not show significant improvement of the wave height prediction over WAM (Rogers, 2002). In other words, the numerical diffusion due to propagation scheme such as that used in WAM is seldom the main source of error of the under-prediction. Rogers (2002) also shows that the main error of swell under-prediction is mainly associated with the negative wind speed bias of high wind speed of NOGAPS. Using a blended QuikScat altimeter wind and NOGAPS wind to drive the global wave model, swell prediction is significantly improved (Rogers and Wittmann, 2002). In 2003, NOGAPS high wind speed estimates are greatly improved after implementing a better cumulus parameterization. Consequently, the swell model performance is greatly improved. The swell model performance can only be as good as the source function, i.e. the global directional spectra, provided by WAM or WW3.

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2.0 MODEL DESCRIPTION

Barber (1958) demonstrated that spectral energy density of propagating waves is conserved along the great-circle path between any two locations,

$$E_1(t,f,\theta) = E_2(t-\tau,f,\theta_2) \tag{1}$$

where θ_1 and θ_2 are the starting and ending directions of the great-circle between two sites, and τ is the time lag for wave energy to propagate along the path. Equation (1) assumes there are no losses along the path owing to dissipation or nonlinear interactions, and can be viewed as a mapping of wave energy density from one location to another based on great-circle paths and group propagation speeds. Equation (1) is used to look back along ray path sending at the forecasting location to see how much energy was propagating towards the site in WAM analysis runs. Swell energy at a single location and time, t, based on the WAM analysis at a previous time, $t - \tau$, is constructed by mapping energy densities from the output WAM wave spectra at more distant lat-lon grid points, as dictated by the great-circle ray paths. Stated in terms of the buoy arrival direction, θ_a,

$$E(t,f,\theta_a) = E_{WAM}\left[t-\tau,f,\theta(\tau,f,\theta_a),\varphi(\tau,f,\theta_a),\lambda(\tau,f,\theta_a)\right] \tag{2}$$

where θ is direction of the great-circle path at the WAM grid point with latitude and longitude of φ and λ respectively. Equation (2) was modeled by backward ray tracing in ellipsoidal coordinates, thus including the effects of the slight flattening of the earth's poles. Great-circle ray paths were calculated over all possible arrival directions using small increments of θ_a. The mathematical formulas for great circle computations can be found in Snyder (1987) and Maling (1992) and are not repeated here. At selected energy propagation time lags τ (e.g. every 12 hours) the present ray direction θ and location (φ and λ) were saved. The ray path calculations are integrated with the DBDB5 global bathymetry data set to account for island blocking. DBDB5 contains averaged topography/bathymetry with 5 minute resolution. Rays that intersect DBDB5 grid points with a selected cutoff depth are stopped and no energy further along the path is mapped to the forecast site. After comparing with buoy data, the 300m depth cutoff has been found to adequately identify the regions populated by small islands or atolls.

The ray longitude and latitude computation are performed for each central frequency of the WAM model starting at a selected high cutoff frequency, e. g. at 0.086 Hz or 11.6 second. Once completed, one can conversely forecast swell by mapping energy densities from many different discrete WAM grid point and direction band combinations derived from the backward ray paths. In other words, the forecast swell spectrum, for a specific location and forecast hour, is the sum of partial contributions from global wave model output spectra at more distant locations as defined by the great circle paths and group propagation speed at each swell frequency. As illustrated in Fig. 1, rays for 17 second swell following great circle paths to Monterey, CA are plotted. It overlies on the global wave height plot. The concentric rings represent ray locations for the same arrival time. The first ring represents the location 12 hours away from Monterey whereas the rest are 24 hours apart.

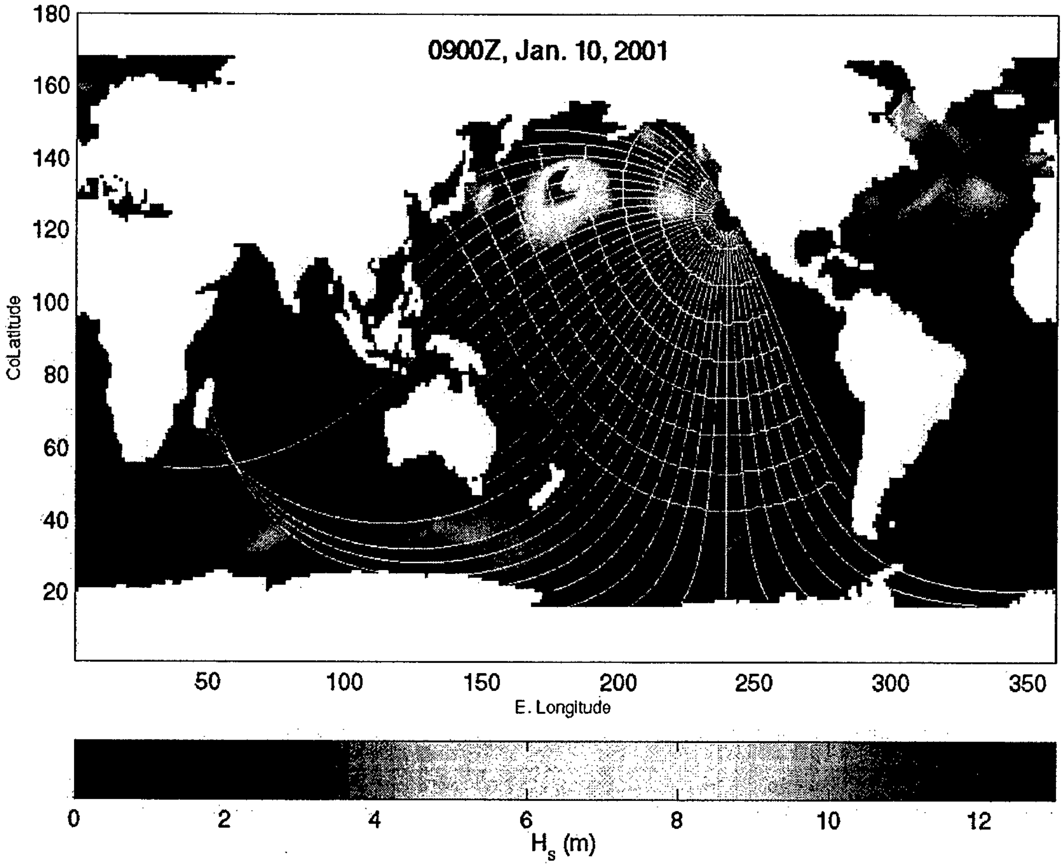

Fig. 1 – Wave rays corresponding to 17 second swell heading to Monterey, CA. The concentric rings represent ray locations with the same arrival time.

3.0 FORECAST MODEL INPUT AND OUTPUT INFORMATION

3.1 Global Directional Wave Spectra

Directional wave spectra for every grid point needs to be stored from the analysis run (Tau = 0) every 12 hours. This is converted into integer*2 numbers (44mb) and compressed into a ~10mb file with the name IYYYYMMDDHH.Z. The programs: reform2.f and conv2i.f used in the converting are included in the appendix. The "I" files are unformatted, direct access, and contain one spectrum (24 directions, 25 frequencies) per 1200 byte record. A lookup array relating each record to a lat-lon grid point is saved in the file "locations.dat" and is read by the forecast program.

3.2 Ocean-Land Boundary Information

An ocean-land boundary is needed to define where great circle wave propagation paths are blocked. The original version of the model used data from the DBDB5 data set (average elevation in 5 min x 5 min lat-lon squares). The model has been modified to use the recently developed DBDB2 database (`http://www7320.nrlssc.navy.mil/DBDB2_WWW/`). The program "land.f" is used to search the database for locations that are on the boundary of a particular elevation contour (e.g. z=0) and write the latitude and longitude values to a file to be used by the forecast programs. The land-sea output file, dbdb2_0.dat generated from land.f using blocking depth of 0 m is plotted in Fig. 2. The dbdb2_0.dat is the "true" 0 elevation land-sea boundary, and the South Pacific island chains are well represented. Global wave models will never have resolution high enough to resolve these islands.

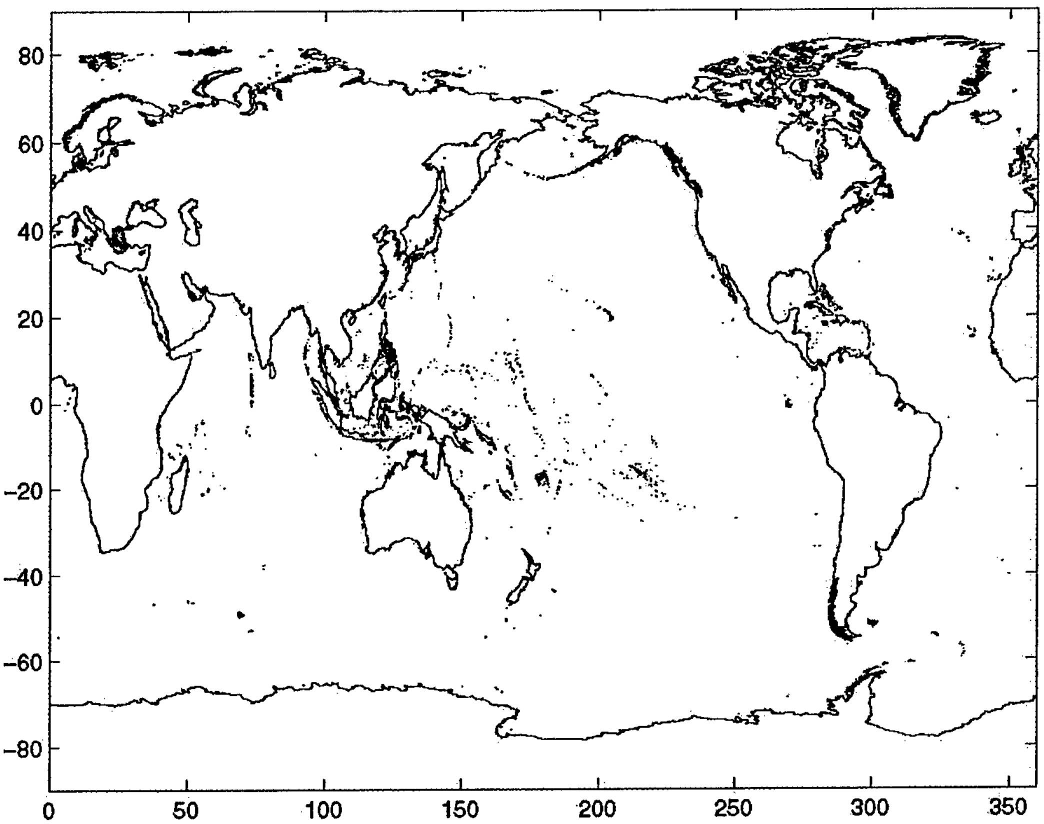

Fig. 2 – The 0 depth contours from DBDB2.

The MATLAB m-file "show_land.m" plots the above figure. Using the MATLAB "zoom" command to view smaller areas of the plot can be helpful in selecting a forecast site and judging how a particular land-sea boundary file will be interpreted by the forecast programs. In general, one needs to choose a forecast location in the deep water, i.e. depth more than 200 m, to avoid wave shoaling and refraction of swell in the shallow water. For more accurate shallow water swell prediction, one can use the deep water swell forecast as input to a coastal wave model such as SWAN (Booij et al. 1999). An example of such application is presented in section 5.0. If one wants to include small islands (e.g. the forecast site is near an island, or swell passes through extensive south Pacific island chains to reach the site), using a lower elevation (depth deeper than 0 m) to define the land-sea boundary can be useful in many, if not most, situations as it identifies more areas where swell blocking, refracting, or scattering by shallow bathymetry (effectively the same as blocking when far from the forecast site) will occur.

DBDB5 does not resolve many of the South Pacific islands. Therefore, 300 m instead of 0 m was chosen to be the "practical boundary" for most forecast sites. In Fig. 3, locations where the land-sea boundary of 0 m blocking depth from DBDB2 are compared with those from 300 m of DBDB5. The distribution of islands is remarkably similar in both cases indicating that the choice of 300 m for DBDB5 was appropriate.

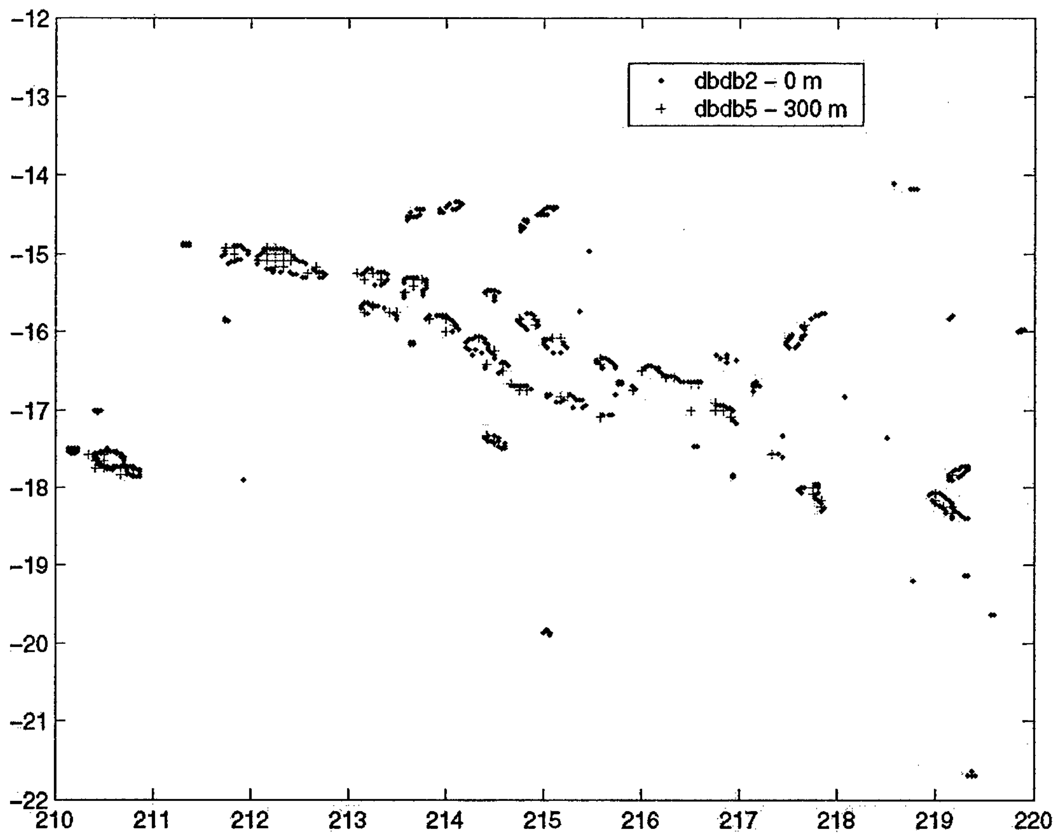

Fig. 3 – Land-sea boundary comparison of 0 m from DBDB2 and 300 m from DBDB5

The effect of island blocking for a forecasting location off Monterey bay, CA using DBDB5 and 300 m depth as blocking criteria is illustrated in Fig. 4. The model programs are designed to accept any land-sea boundary file. Other blocking or cutoff depths may be desired from the DBDB2 data set, or all or parts of higher resolution coastline data sets may be included at a future date if warranted.

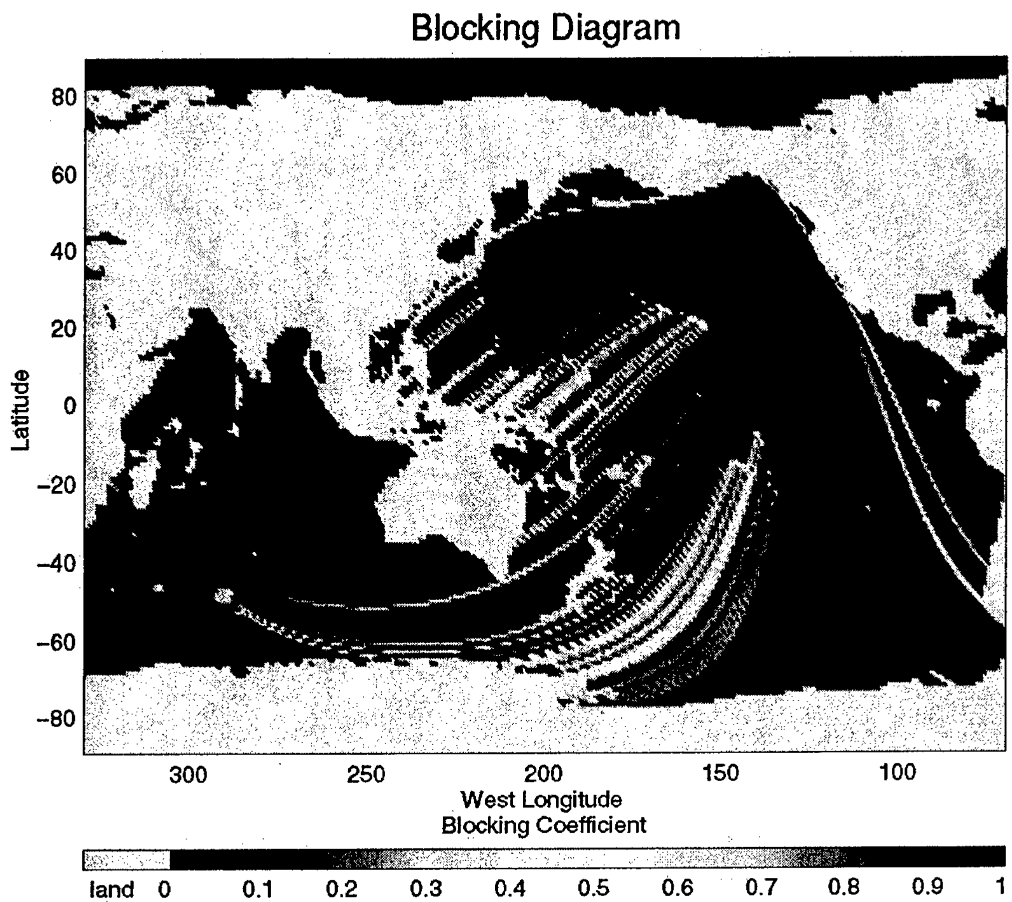

Fig. 4 – Island blocking for a forecasting location off Monterey bay

3.3. Generating Macro Files for Forecast Sites

The forecast model is built around the idea that the user wants to obtain updated long-range swell forecasts at a specific lat-lon site each time the output file from the WAM model is updated. In other words, the same forecast calculations/extractions from a WAM model I-file will be performed repeatedly with each new I-file update. The program "swell_macro.f" performs the great circle calculations and generates a file which contains the basic information necessary to extract energy spectra data from the I-file for a specified range of forecast hours. This program also reads the specified land-sea boundary file to include the blocking of great circle paths.

Program input is:

1. header character record for site (this is used for titles in plots)
2. name of output macro file (always use *.mac ending)
3. latitude and longitude of forecast site
4. starting forecast hour, ending hour, and time step
5. number of WAM frequency bands to include
6. land-sea data file to use for blocking

Files generated for different sites can be combined into one script. A separate macro output file is generated for each site. The output files all have *.mac filename extensions for easy identification by shell scripts designed to post-processing for multiple forecasting sites. The macro files are unformatted, sequential access, and can be fairly large (~10mb) depending on the exposure of a forecast site and the number of WAM frequency bands and forecast hours included. A sample C shell script is included in the appendix.

3.4 Generating Forecasts

The program "swell_for.f" makes the actual forecasts. The program extracts the WAM energy densities from I-file as a function of the forecast hour, frequency, and arrival direction at the forecast site. This is done using the information in the swell macro file created by swell_macro.f

Program input:
1. macro file name
2. WAM or WW3 I-file to use

Program output:
1. htd.dat – Hs, Tp, Dp and Tp for each forecast hour
2. fspec.dat – frequency spectrum for each forecast hour (m^2/hz)
3. dspec.dat – integrated (across freq.) directional spectrum for each forecast hour (m^2/radian)
4. date.dat – file with WAM analysis date and forecast site header for use in plotting
5. dirspec.dat – directional spectrum for each angular and directional band (m^2/degree/hz)

3.5 Summary procedures to automatically update forecast plots

1. Compile the fortran programs: swell_macro.f and swell_for.f

2. Generate the macro files for the test site by running the C shell script: make_macros.csh

One needs to examine the forecasting locations in bathymetry plots to select the blocking depth. If the corresponding bathymetry file such as dbdb2_xxx.dat does not exist, run land.f program.

3. Edit path settings at the top of the C shell file update_forecast.csh to work with your system

The script creates new jpeg format files for all the sites with macro files. The jpeg files are given names that correspond to the macro file names (e.g. bali.mac produces a plot called bali.jpeg) and these are moved to a specified web site directory.

4. Edit the getswell.sh script which downloads the latest I file and runs the update_forecast.csh.

5. Launch a cron job for getswell.sh.

Once in a while, I file is not generated for a particular hour. Then the user needs to update the newdtg.txt file to catch up.

4.0 GENERATE FORECAST PLOTS

The MATLAB m-file "show_for.m" presently reads the output files date.dat, htd.dat and dspec.dat and makes a two panel plot of the information. The program does not print anything to the screen, but instead generates a jpeg plot called "matlab.jpeg" using a second matlab file called "screen2jpeg.m". One can use other file output options, but the screen2jpeg.m generates a picture size best fitted for a web page. Fig. 5 is an example forecast location west of Monterey Bay, CA. The top plot of the figure is the forecast significant wave height (H_S) in meters and the expected arrival time. Tp is the peak wave period and Dp is the peak wave direction (true compass heading waves are arriving from) at the peak wave period. For example, swell with a significant wave height about 3.5 m is expected to arrive approximately 5.5 days from 1-17-2003, 6Z (GMT).

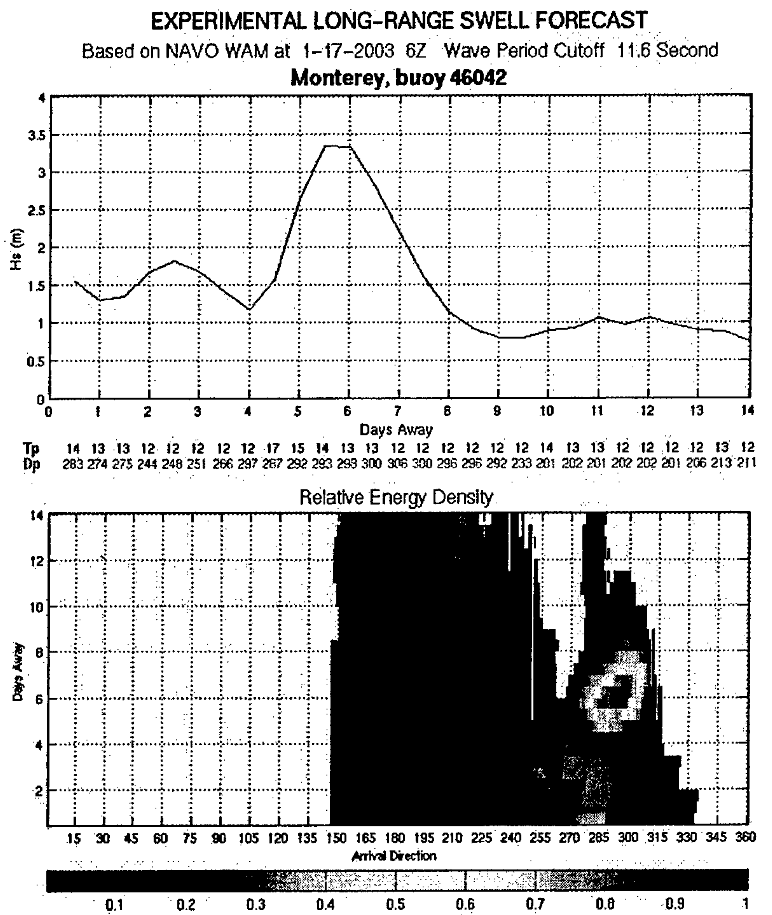

Fig. 5 – Sample swell forecast plot using WAM for a site west of Monterey Bay, CA.

The bottom plot is the relative energy density plotted as a function of arrival time and arrival direction. The arrival direction is where the waves are arriving from with zero being due north. Higher relative energy (and thus higher relative wave heights) is denoted in deep red while lower energy is shown in deep blue (this is a floating color scale to maximize resolution and cannot be compared directly with other sites or previous plots). For this example, the swell energy expected to arrive in 5 days in the top plot, will be arriving primarily from the west-northwest (299 degree). It should be noted that swell model is a pure wave propagation model, not a generation model. In addition, the present implementation only uses WAM Analysis (Tau=0) output. Forecast swell generation (Tau>0, i.e. 5 day forecast) is not included in the swell forecasts. In other words, the swell forecast can be further extended for five more days. Forecast should be checked daily in the event that additional swell energy is generated along the great circle routes to the forecast site.

The forecasting programs (swell_macro.f and swell_for.f) have been modified to read directional spectra generated by WW3. New locations.dat and mac file for the forecasting site were generated. A sample plot for the same date but using WW3 under blended QuikScat and NOGAPS wind is shown in Fig. 6. It is noted that WW3 has different run time hours from WAM, i.e. 0 and 12 Z.

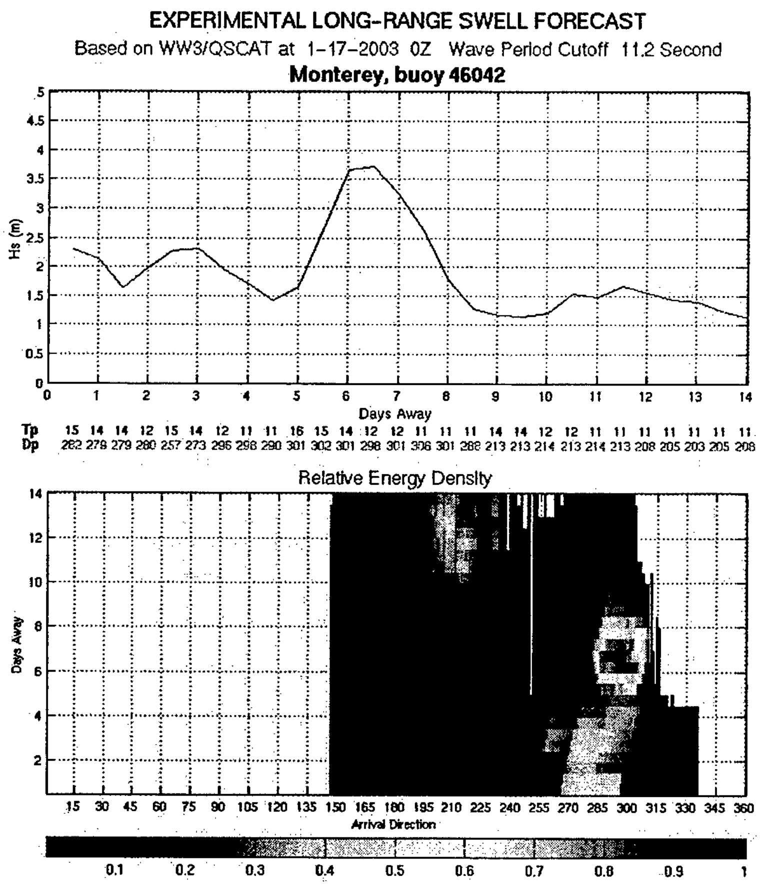

Fig. 6 – Sample swell forecast using WW3 under blended QuikScat and NOGAPS wind.

5.0 APPLICATIONS

To support the need of long range swell forecasting, a web page (http://www7320.nrlssc.navy.mil/html/swell/swell.html) has been established since 2000. There are frequent users, e.g. from NAVPACMTOCCEN/JTWC. In another application, the swell forecasting was requested and provided for the recovery operation of the Ehime Maru off Hawaii in 2001.

In addition to provide a swell forecast for a particular site, the swell model can also provide boundary conditions for other regional wave models in shallow water region. A wave and swell forecasting web page is set up to support the ONR Nearshore Canyon Experiment (NCEX) (http://www7320.navy.mil/NCEX/NCEX_mod.htm) in Southern California Bight. Both swell model and WW3 provide the input boundary condition for the wave model SWAN. The energetic swells in the Scripps Canyon area during the NCEX time period (Oct-Dec 2003) are the predominant driver of complex nearshore processes. The NCEX area along with the nested SWAN grids and DBDB2 land-sea boundary points are shown in Fig. 7. The blocking of swells by these islands is adequately represented in the swell model. It is noted that DBDB5 is totally unusable for this area. In DBDB5, Most of the islands are not represented regardless of the choice of blocking depth. The directional spectra from swell model provide the boundary forcing to initialize the outer SWAN grid (defined by the large box, with 4 minute grid resolution), which in turn provides boundary forcing to the inner SWAN grid (small box, approximately 2 second resolution). A sample SWAN forecast wave height plot for the nearshore grid is shown in Fig. 8.

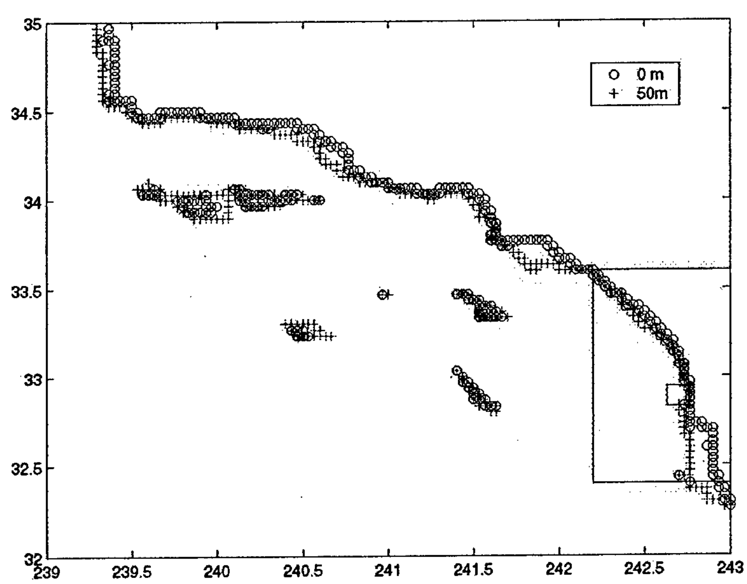

Fig. 7 – Nested NCEX SWAN grids, and with 0 m and 50 m blocking depths from DBDB2

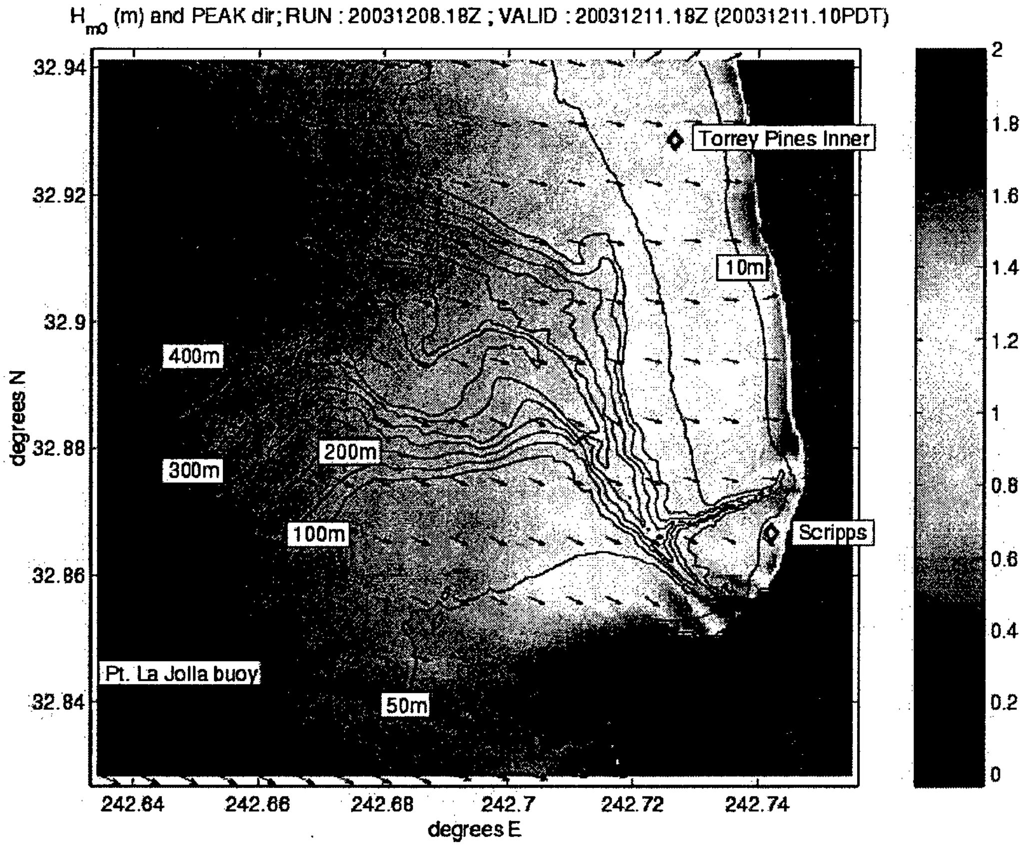

Fig. 8 – Sample SWAN wave height forecast using the swell model as input (from NCEX web page)

In summary, the benefits of the swell model can be listed as:

1. extension of swell forecast range from 5 to 15 days
2. enhanced directional resolution (2-5 degree vs. 15 degree)
3. blocking effects of island groups are incorporated. Due to the limit of global wave model resolution, island blocking cannot be included, thus causing an over-prediction for certain locations.

In addition, the swell model provides a scientific tool for evaluating wind wave generation models as demonstrated by Rogers's study (2002). In terms of limitation, the swell model assumes no dissipation, the model tends to over-predict for shorter period swells. This can be avoided by choosing a cutoff period longer than 12 second.

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program. The developer of the original model source code is Dr. William C. O'Reilly at the Scripps Institution of Oceanography.

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Appendix A - Scripts for creating automatic swell updates

1. make_macro.csh is used to generate *.mac files for forecasting sites

```
# Cshell for creating swell forecast macro files

# Monterey Bay (NOAA 46042) site example

#  swell reach this site from extremely distant southern hemisphere
#  storms, so using a 12 hour forecast time step out to 20 days
#  (480 hours).  Also using wave period cutoff around 11-12 seconds
#  as long range swell decay for T < 12 sec or so.
#

swell_macro << end
West of Monterey Bay, CA
montbay.mac
37
237
12 480 12
11
../land/dbdb2_0.dat
end

# offshore of san diego

swell_macro << end
SW of San Clemente Island, CA
sandiego.mac
32
240
12 480 12
11
../land/dbdb2_0.dat
end

# A site south of Pearl Harbor on Oahu

swell_macro << end
South of Pearl Harbor, HA
pearl.mac
21.1083
202.0435
12 480 12
11
../land/dbdb2_0.dat
end

# Two Indonsesia area examples

# Both of these site typically get swell from the Indian Ocean
# and the propagation distances are shorter than for CA south swell,
# So I shift the swell period cutoff to something closer to 7-8 seconds.

# Phuket, Thailand

# this site is inside a chain of islands that are not well
#  resolved by the WAM model.  The starting forecast hour here
#  is 18 hours instead of 12 so that all the forecast data is
# extracted from WAM spectra outside these islands

swell_macro << end
West of Phuket, Thailand
phuket.mac
8
97
18 486 12
14
../land/dbdb2_0.dat
```

```
end

# Bali, Indonesia
swell_macro << end
South of Bali, Indonesia
bali.mac
-9.5
115
12 480 12
14
../land/dbdb2_0.dat
end

# Deep Water off Hawaii North

swell_macro << end
North of Hawaii
hawaiinorth.mac
23
202
12 480 12
11
../land/dbdb2_0.dat
end
```

2. getswell.sh is used in the cron job to automate the swell forecast for the web page

```
#!/bin/sh
set -x
#setenv KRB5_CONFIG /common/krb5/krb5.conf
cd /home/tides/hsu/swell/swell_for/navo
dtg=`cat newdtg.txt`
echo $dtg
dir=`echo $dtg | cut -c1-6`
dir2=`expr $dir + 1`
#end of year fix
month=`echo $dtg | cut -c5-6`
if [ $month = 12 ]; then
  yr=`echo $dtg | cut -c1-4`
  yr2=`expr $yr + 1`
  month2=01
  dir2=$yr2$month2
  echo $dir2
fi
echo $dir2
ifile=I$dtg.Z
#get the I file assuming JD may be getting the file for me
if [ ! -s $ifile ]; then
 /common/krb5/krcp -X vincent:/u/home/dykesj/data/SWELL/$dir/$ifile $ifile
 /common/krb5/krcp -X vincent:/u/home/dykesj/data/SWELL/$dir2/$ifile $ifile
fi
# added to prevent advancing dates if file is not copied or ticket is expired
if [ ! -s $ifile ];then
 echo $ifile not ready
 exit
fi
echo $dtg > dtg.txt
#start to compute swell forecast
csh swell_forecast.csh
#increase dtg for 12 hours
newdtg=`incdate.perl $dtg 12`
echo $newdtg > newdtg.txt
/bin/rm swellfile*
echo completed
```

3. incdate.perl is used to change the date and time for I file

```
#!/common/utilities/bin/perl
# modify the WAM date-time-group
# KFM - change (4/20/00) to read in and write out four digit year
# KFM - change (4/20/00) to allow for negative incrementing
# last date of month 1 - 12
   @dnm=(00,31,28,31,30,31,30,31,31,30,31,30,31);
# spilt out year, month, day, and hour
   $yy=substr($ARGV[0], 0, 4);
   $mm=substr($ARGV[0], 4, 2);
   $dd=substr($ARGV[0], 6, 2);
   $hh=substr($ARGV[0], 8, 2);
# check for leap year
   if($yy % 4 == 0){$dnm[1]=29};
# read in time increment in hours
   $inc=$ARGV[1];
# add time increment to hours
   $hh=$hh+$inc;
# check if hours greater than 24, if yes increment day
   if($hh >= 24){$days=$hh/24;$hh=$hh%24;$dd=$dd+$days};
# check if hours less than 0, if yes decrement day
   if($hh < 0){$hh=$hh+24;$dd--};
   if($dd < 1){$dd=$dnm[$mm-1];$mm--};
   if($mm == 0){$dd=$dnm[11];$mm=12;$yy--};
# check if day greater than last day of month, if yes increment month
   if($dd >= $dnm[$mm]+1){$dd-=$dnm[$mm];$mm++};
# if month greater than 12, increment year
   if($mm > 12){$mm=1;$yy++};
# print out new date-time-group
   printf "%4.4d%2.2d%2.2d%2.2d\n",$yy,$mm,$dd,$hh;
```

4. swell_forecast.csh is used to compute swell forecast and generate graphics.

```
#! /bin/csh

#
# Cshell to automatically update long-range swell forecast plots
#

# ------------------------------------------------------------
#  ***** NOTE  NOTE  NOTE  NOTE  NOTE  NOTE  NOTE  NOTE ****
#
#  A few settings have to made here when using this on a new machine
# ------------------------------------------------------------

# set the DISPLAY environment variable for use by MATLAB. This
#  shoule be the name of the machine running this shell. Nothing
#  should actually appear on the screen, but MATLAB does use the
#  machine's graphics card to make jpeg files.

#setenv DISPLAY wipeout:0
setenv DISPLAY tides:0
set ename='hsu@nrlssc.navy.mil'

# set path the your matlab executable directory

set mlpath='/common/utilities/bin'
# set path to the directory where you want to put the
# jpeg plots (e.g. the website directory), use
#
# set webpath='.'
#
# if you want to keep them in this same directory

set webpath='/net/tides/surf1/swell/public_html'
# path for storing daily data
```

```
#------------------------------------------------------------
#  Done with user settings
#------------------------------------------------------------

#------------------------------------------------------------
#  Start making forecasts
#------------------------------------------------------------

echo -
echo -     Starting Long-range Swell Forecast Update
echo -

#----------------------------------------------------------

echo -
echo -  Looking for new WAM I-file ....
echo -

#--------------------------------------------------------------
# Swell forecast section
#--------------------------------------------------------------

# first, uncompress Ifile
#echo -
#echo -  uncompressing ....
#echo -
set dtg=(`cat dtg.txt`)
set ifile=I$dtg.Z
uncompress $ifile
#set ifile=I$dtg
#set ifile=(`ls I*`)
#uncompress $ifile
# find all the macro files (*.mac) in this directory and make
#  forecasts for each one
set mf=(`ls *.mac `)

echo -
echo -  Making long-range forecasts  ....
echo -

# loop through macro files and make forecast plots

foreach i ($mf)

# run swell_for for the *.mac file using the new Ifile
swell_for.x << end2
$i
$ifile:r
end2

#cat fspec.dat >> $forepath/I$i:r_8fspec.dat
#need to add htd for different range
#cat htd.dat > /surf1/swell/swell_for/navotest/I$i:r_8htd.dat

# create jpeg plot using MATLAB.  This is designed to run in
#  the background. No pictures should appear on the machines
#  screen
echo -
echo -  Making plot with MATLAB  ....
echo -
#$mlpath/matlab -nosplash < show_for.m

# check if specialized matlab script exists for this site
#  (e.g. show_bali.m)

if( -e show_$i:r.m == 1 ) then

# if so, use it

echo Using MATLAB script show_$i:r.m
$mlpath/matlab -nosplash < call_show_$i:r.m
```

```
# otherwise, use default script show_for.m

else
echo Using MATLAB script show_for.m
$mlpath/matlab -nosplash < call_show_for.m
endif

# move the jpeg file to a filename that is consistent with the
# name of the macro file (e.g. bali.mac will produce a plot
# called bali.jpeg
\cp -f matlab.jpeg $i:r.jpeg
\mv -f matlab.jpeg /surf1/swell/swell_for/navotest/jpeg/$i:r"$ifile:r".jpeg
# transfer the new jpeg file to the web page directory
#  OR do a ftp/rcp to transfer to a differnt machine here
\cp -f $i:r.jpeg $webpath

# end of macro file loop
end

# recompress the Ifile to save disk space.  You can also
#  delete it at this point if you don't want to save them
#echo -
#echo -  recompressing $ifile:r ....
#echo -

compress $ifile:r
mv $ifile  /surf1/swell/swell_for/navorun/ifiles
# all done
exit
```

Appendix B - Matlab Utilities

1. Show_for.m is used to generate graphic files for web page.

```
%  show_for.m
%
%  MATLAB script to make plot of
%  swell forecast model output
%
%  version for swell_for.f
%

close
h=figure('color','w','position',[ 10 10 800 800],'visible','off');
set(gcf,'defaulttextcolor','k');

% top axis is for Hs plot

axes('position',[ 0.1300    0.5200    0.7750    0.3439]);

load htd.dat
tot=htd;
xh=tot(:,1)./24;
plot(xh,tot(:,2))
xlabel('Days Away')
ylabel('Hs (m)')
grid on;
set(gca,'xtick',[0:1:max(xh)])
set(gca,'fontsize',9)

% get number of forecast hours from the data is htd.dat
nfor=max(size(xh));

fid=fopen('date.dat');
x=fscanf(fid,'%i',[4]);
h=fscanf(fid,'%c');

yy=get(gca,'ylim');
set(gca,'ylim',[0 floor(yy(2))+1],'xlim',[0 max(xh)]);
yy=get(gca,'ylim');

text(.5*max(xh),1.3*yy(2),...
'EXPERIMENTAL LONG-RANGE SWELL FORECAST',...
'fontsize',15,'horizontalalignment','center')

text(.5*max(xh),1.03*yy(2),...
['FNMOC WAM Analysis Time: ' int2str(x(2)) '-' ...
int2str(x(3)) '-' int2str(x(1)) '  ' int2str(x(4)) 'Z'],...
'fontsize',13,'horizontalalignment','center')

blank=' ';
i=max(find(h(2:60) ~= blank));
title(h(1:i+1),'fontsize',14,'fontweight','demi')

%  add Tp and Dp information below plot

nl=floor(nfor/20);
for j=1:nl:nfor
%[j]=find(xh == i);
text(xh(j),-.15*yy(2),int2str(tot(j,3)),'horizontalalignment','center',...
'fontsize',9)
text(xh(j),-.20*yy(2),int2str(tot(j,4)),'horizontalalignment','center',...
'color','r','fontsize',9)
end

text(-.5,-.15*yy(2),'Tp','fontweight','demi')
text(-.5,-.20*yy(2),'Dp','fontweight','demi','color','r')

% lower axis is for energy density color contours
```

```
axes('position',[ 0.1300    0.0500    0.7750    0.3439])
set(gca,'zlim',[0 70])

fid=fopen('dspec.dat');
spec=fscanf(fid,'%g',[360 nfor]);
i=find(spec == 0);
spec(i)=spec(i)*NaN;

x=1:1:360;
y=xh;
pcolor(x,y,sqrt(spec(1:360,:)'))
colormap(jet)
shading flat

set(gca,'zlim',[0 50])
set(gca,'xlim',[1 360])
set(gca,'xtick',[15:15:360])
set(gca,'xcolor','k')
set(gca,'ycolor','k')
set(gca,'fontsize',9)

xlabel('Arrival Direction')
ylabel('Days Away')
title('Relative Energy Density','fontsize',12)
grid on;

%  option below to make jpeg file of plot on the screen
%  (can be run in background on machine by setting the
%   Visble option to "off" in the figure command at the
%   top of this script)

screen2jpeg('matlab.jpeg')

%quit
```

2. screen2jpeg.m is used to generate picture with right size for web page.

```
function screen2jpeg(filename)
            %SCREEN2JPEG Generate a JPEG file of the current figure with
            %   dimensions consistent with the figure's screen dimensions.
            %
            %   SCREEN2JPEG('filename') saves the current figure to the
            %   JPEG file "filename".
            %

            %    Sean P. McCarthy
            %    Copyright (c) 1984-98 by The MathWorks, Inc. All Rights Reserved

            if nargin < 1
               error('Not enough input arguments!')
            end

            oldscreenunits = get(gcf,'Units');
            oldpaperunits = get(gcf,'PaperUnits');
            oldpaperpos = get(gcf,'PaperPosition');
            set(gcf,'Units','pixels');
            scrpos = get(gcf,'Position');
            newpos = scrpos/90;
            set(gcf,'PaperUnits','inches',...
               'PaperPosition',newpos)
            eval(['print -djpeg ' filename ' -r90'])
            drawnow
            set(gcf,'Units',oldscreenunits,...
               'PaperUnits',oldpaperunits,...
               'PaperPosition',oldpaperpos)
```