KEMENTERIAN
ALAM SEKITAR DAN AIR
Ministry of Environment and Water

MALAYSIAN METEOROLOGICAL DEPARTMENT
MINISTRY OF ENVIRONMENT AND WATER

Technical Note No. 1/2021

Operational Guide JMA-MMD Oil Spill & Search and Rescue (SAR) Trajectory Model Version 1

Nursalleh K.Chang, Diong Jeong Yik, Muhammad Mikhael Cadorna and Lt Mohd Fakhrurazzi bin Mohd Shukeri TLDM

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Perpustakaan Negara Malaysia Cataloguing-in-Publication Data

Chang, Nursalleh K.
Operational Guide JMA-MMD Oil Spill & Search and Rescue (SAR) Trajectory Model. Version 1 / Nursalleh K Chang, Diong Jeong Yik, Muhammad Mikhael Cadorna and Lt Mohd Fakhrurazzi bin Mohd Shukeri.
(TECHNICAL NOTE ; NO. 1/2021)
ISBN 978-967-2327-07-3
1. Oil spills--Prevention.
2. Oil spills--Environmental aspects.
3. Government publications--Malaysia.
I. Diong, Jeong Yik. II. Muhammad Mikhael Cadorna.
III. Mohd. Fakhrurazzi Mohd. Shukeri, Lt. IV. Title.
V. Series.
628.1683

Published and printed by:
Jabatan Meteorologi Malaysia
Jalan Sultan
46667 Petaling Jaya
Selangor Darul Ehsan
Malaysia

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1.0 Introduction

The JMA-MMD Oil Spill and Search and Rescue (SAR) Trajectory Model (OSM) was originally developed in Meteorological Research Institute (MRI), Japan Meteorological Agency (JMA) where it considers physical and chemical processes in its trajectory simulation calculation. Present model in Malaysian Meteorological Department (MetMalaysia) uses sea current and sea surface temperature data from JMA global circulation model, MOVE-G or from First Institute of Oceanography (FIO). The OSM can be utilized in search and rescue mission whereby necessary modification can be made to project the movement of single floating object in the water.

This Operational Guide shall be used as guidance in setting up the input data and oil spill/SAR incident information to produce both graphical outputs and oil spill/SAR landing information. This document can also serve as a guide to new users to operate OSM, from detailing the model setup right up to producing graphical outputs. The document is meant to describe how to operate OSM at Malaysian Meteorological Department and National Hydrographic Centre.

The calculation of OSM for oil spill incident has considered the weathering effect of oil properties such as evaporation and emulsification. There are 3 essential steps involved in running the OSM:

1.1 Pre-Processing

This part consists of the following steps:

i. Wave and meteorology data preparation
ii. Convert data FIO
iii. Model parameters configuration

1.2 Model Execution

i. Converted data compilation
ii. Model parameters configuration
iii. Setup and Running the model execution script

1.3 Post-Processing

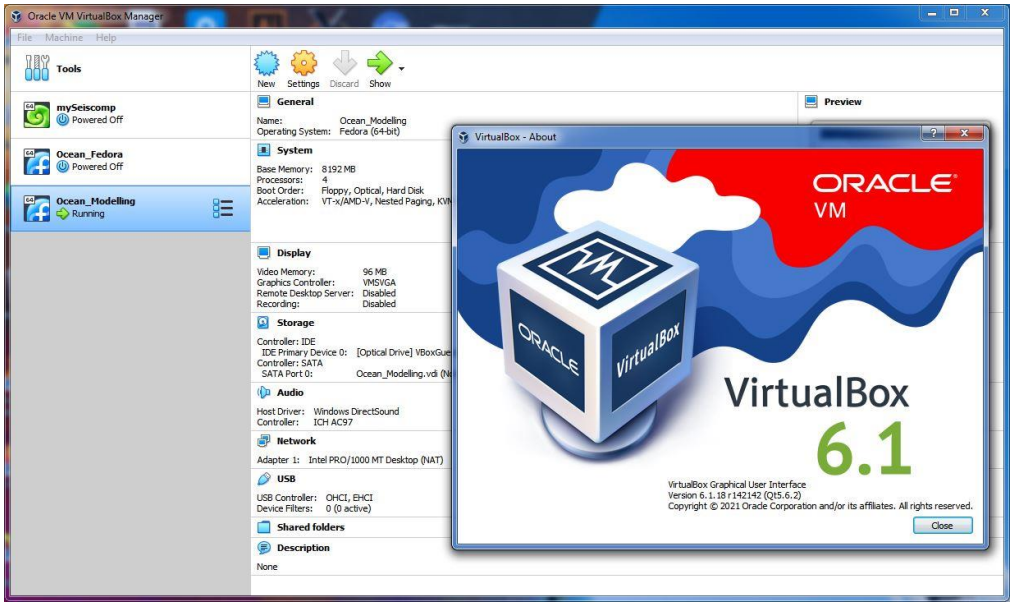
i. Graphical Output Setup
ii. Plot the graphical output using GMT
iii. Plot google map output (SAR)

Users will be able to execute the oil spill and SAR Trajectory Model using incident information. A brief interpretation of the simulation output using different sea current and sea surface temperature data (JMA MOVE-G and FIO) is also discussed in this document.

2.0 Environment and Software Setting

OSM is fully written in FORTRAN 90. The current version of OSM uses gfortran compiler although compiling with other Fortran compilers is possible with some minor modification. It also uses Generic Mapping Tools (GMT) as its post processing package. Details about GMT can be obtained from its website at **http://www.soest.hawaii.edu/gmt/**. The OSM output for SAR incident also can be plotted using Google Maps for more useful interpretation in line with current developments of technologies and needs.

Windows users can use LINUX on any virtual environment. The operating system in the virtual environment should be installed with necessary libraries and system to support the process of OSM. Alternatively, for Windows 10 users, user can opt to use Windows Subsystem for Linux Installation instead of using virtual environment. Example below uses VirtualBox6.1 :



To ensure the system can operate the OSM, there are few programs need to be checked or installed in the operating system:

1. The Grid Analysis and Display System (GrADS)
2. GCC Fortran (GFortran)
3. Generic Mapping Tools (GMT)
4. GNU Plot

Check the program are installed in the system:

```
[user@localhost ~l]$ which grads
/usr/bin/grads
```

If the program is not installed in the system:

```
[user@localhost ~l]$ sudo yum install grads
```

3.0 Folder and Data Setup

3.1 Setup home folder 'OilSpillModel':

[user@localhost OilSpillModel]$ pwd
/home/localhost/OilSpill Model

3.2 List the directory structure of **/home/user/OilSpill Model**

[user@localhost OilSpillModel]$ ls

```
Edit    Model    Plot
```

[user@localhost OilSpillModel]$ tree -d

```
├── Edit
│   └── DATA
│       ├── FIO
│       └── MOVE
├── Model
│   ├── bin
│   ├── DATA
│   ├── src0125
│   └── src025
└── Plot
    └── DATA
        ├── Map
        │   ├── Oilspill
        │   └── SAR
        └── point
            ├── Oilspill
            └── SAR
```

3.3 Here is brief explanation for the directories structure in ~/OilSpillModel:

Edit: Preprocessing folder; convert the FIO ocean data to binary.
Model: Execution Folder; Execute the model script.
Plot: Post processing folder; Execute the plotting to graphic.
DATA: All the needed data for model run.
FIO: Ocean data from FIO.
MOVE: Ocean data from JMA.
Bin: All executable file.
Src: All the FORTRAN 90 source codes for model and some tools.
Map: Output plotted graphic of model simulation.
Point: Output processed point.

4.0 Wave and Meteorological Data Preparation

4.1 List of Meteorological Data

i. The wave data is obtained from: JMA-MMD MRI3_S Wave Model.

ii. The current data is obtained either from:

a. JMA MOVE-G global circulation model, which is uploaded from JMA to Malaysian Meteorological Department (MET Malaysia) data server. The current data updated every 5 days, consists of 5-day mean surface current and sea surface temperature centred on day three.

or

b. First Institute of Oceanography (FIO) China, which uploaded from FIO Malaysian Meteorological Department (MET Malaysia) data server. The 12UTC current data updated every day, consist of wave, current and temperature for 5 days forecast.

4.2 Preparing Meteorological Data

Data downloaded from server MET Malaysia will be copied to directory folder data **/home/user/OilSpillModel/Edit/DATA/.**

[user@localhost OilSpillModel/Edit/DATA]$ ls

```
FIO    MOVE
```

When using **JMA MOVE-G** as a meteorological data, the data in folder MOVE will be copied directly without convert to directory **/home/user/OilSpillModel/Model/DATA/.**

[user@localhost OilSpillModel/Edit/DATA/MOVE]$ ls

```
ocean20210714_f.pdf      ocean20210714_jma.data
product2021071700.data
```

[user@localhost OilSpillModel/Edit/DATA/MOVE]$
cp ocean20210714_jma.data product2021071700.data
../../../Model/DATA/

When using **FIO** data as a meteorological data, the data will be converted to binary format (see Section 4.3 to convert data) before moving to directory **/home/user/OilSpillModel/Model/DATA/.**

[user@localhost OilSpillModel/Edit/DATA/FIO]$ ls

```
product2021071700.data
rmmd.2021073012.wave.nc
rmmd.rz.2021073012.ocean_temp_2021_07_30.nc
rmmd.rz.2021073012.ocean_temp_2021_07_31.nc
rmmd.rz.2021073012.ocean_temp_2021_08_01.nc
rmmd.rz.2021073012.ocean_temp_2021_08_02.nc
rmmd.rz.2021073012.ocean_temp_2021_08_03.nc
rmmd.rz.2021073012.ocean_temp_2021_08_04.nc
rmmd.tco.rz.2021073012.ocean_u_2021_07_30.nc
rmmd.tco.rz.2021073012.ocean_u_2021_07_31.nc
rmmd.tco.rz.2021073012.ocean_u_2021_08_01.nc
rmmd.tco.rz.2021073012.ocean_u_2021_08_02.nc
rmmd.tco.rz.2021073012.ocean_u_2021_08_03.nc
rmmd.tco.rz.2021073012.ocean_u_2021_08_04.nc
rmmd.tco.rz.2021073012.ocean_v_2021_07_30.nc
rmmd.tco.rz.2021073012.ocean_v_2021_07_31.nc
rmmd.tco.rz.2021073012.ocean_v_2021_08_01.nc
rmmd.tco.rz.2021073012.ocean_v_2021_08_02.nc
rmmd.tco.rz.2021073012.ocean_v_2021_08_03.nc
rmmd.tco.rz.2021073012.ocean_v_2021_08_04.nc
```

Copy wave data to directory
/home/user/OilSpillModel/Model/DATA/.

[user@localhost OilSpillModel/Edit/DATA/MOVE]$
cp product2021071700.data ../../../Model/DATA/

4.3 Converting FIO data to binary file (skip if using JMA MOVE)

Change your directory to directory **/home/user/OilSpillModel/Edit**.

[user@localhost OilSpillModel/Edit/DATA/FIO]$ cd ../..

[user@localhost OilSpillModel/Edit]$ ls

```
convert_FIO.sh          FIO_orig.grads          temp.ctl
convert.log             FIO_OSM.ctl             ocean_edit_FIO.e
u.ctl                   DATA                    FIO_OSM_f.ctl
ocean_edit_FIO.f90      v.ctl                   file_convert.gs
how_to_convert.txt      ocean_edit_FIO_f.e      FIO_convert.gs
landdata_25_l.txt       ocean_edit_FIO_f.f90    FIO_orig.ctl
Land_Sea_125.txt
```

Execute file **convert_FIO.sh** by key in the date in format yyyy:m:d based on date of FIO data. Example :

[user@localhost OilSpillModel/Edit]$ ./convert_FIO.sh 2021 7 30

The script will be running, and part of the execution log will look like:

```
 9999   2390        3       2021        8       2       12        6
 9999   2404        2       2021        8       2       12        3
 9999   2424        1       2021        8       2       12        0
 9999   2443
-------------------------------------------------
 The model data reading was successfully ended
-------------------------------------------------
```

To ensure conversion is completed, "**The model data reading was successfully ended**" should appear at the end of the execution log.

After conversion is completed, the process will produce file ocean20210730_FIO_f.grads and ocean20210730_FIO_f.data in the directory **/home/user/OilSpillModel/Edit/.**

[user@localhost OilSpillModel/Edit]$ ls

```
convert_FIO.sh          FIO_orig.grads          temp.ctl
convert.log             FIO_OSM.ctl             ocean_edit_FIO.e
u.ctl                   DATA                    FIO_OSM_f.ctl
ocean_edit_FIO.f90      v.ctl                   file_convert.gs
how_to_convert.txt      ocean20210730_FIO_f.data
ocean20210730_FIO_f.grads                       ocean_edit_FIO_f.e
FIO_convert.gs          landdata_25_l.txt       ocean_edit_FIO_f.f90
FIO_orig.ctl            Land_Sea_125.txt
```

Move ocean file (.data) to directory **/home/user/OilSpillModel/Model/DATA/.**

[user@localhost OilSpillModel/Edit/DATA/MOVE]$
mv ocean20210730_FIO_f.data ../Model/DATA/

5.0 Model Setup

Before executing the OSM, necessary information should be input into the model. This information will be filled to the information card in order to get the correct setup for OSM prior to execution. The information card needs to updated and there is difference between oil spill and SAR incident information card. For oil spill, the information card is saved as **oilspill_card.text** and for SAR, the information is saved as **SAR_card.text**.

5.1 Oil Spill Model (for SAR skip to section 5.3)

Let's assume there is one oil spill incident occurs in Malaysian Water:

Date : 3 August 2021
Time of incident : 1800H (local time)
Location : 2.8 N, 101.2 E
Oil type : Bunker (long term)
Oil amount : 1000000 g/m^3

Edit the oilspill_card.text using vi editor.

Change your directory to **/home/user/OilSpillModel/Model/DATA**

[user@localhost OilSpillModel/Model/DATA]$ vi oilspill_card.text

```
*-------------------------------------------------------------------
* Calculation parameters of Oil spill prediction model.
*                                        2015/09/10   N.Kohno
*  233 * 177 (0.125 degree grid ) 72 hour calculation
*-------------------------------------------------------------------
 &grid
  nx = 233, ny = 177,
  lat_s = -5.0, lat_n = 17.0, lon_w = 95.00, lon_e = 124.00
 &end
 &calinfo
  icont = 0, dt = 60.0, nhours = 72, noutput = 1
 &end
 &accinfo
  year = 2021, month = 08, day = 03, hour = 10, minute = 00
  ac_lat = 2.8, ac_lon = 101.2, ioil = 1
 &end
 &oilinfo
  oil_amount = 1000000.0, spill_rate = 1000000.0, oil_type = 16
 &end
 &options
  isource = 0, idiff = 1, ichemi = 1, irndspill = 0,
  iarea = 0, icurvar = 0, iseaice = 0
 &end
 &srcinfo
  u_src = 0.00, v_src = 0.00, mass_source = 0, as_ratio = 0.5
 &end
```

Modify the information **highlighted field** accordingly to incident details by pressing “I” or <insert> to enable edit mode of vi editor.

Make sure the initial date of the current and wave meteorological initial is correct. These data must be initialized before the incident date (**&accinfo**). Time incident must be set to UTC time.

For **&calinfo**; **nhours**= set ‘**72**’ for 72 hours forecast data

For **ioil**= set ‘**1**’ for Oilspill Model.

For **oil_type**= set ‘**n**’ type of oil spill (Oil List table in Appendix A)

For **icurvar**= set ‘**0**’ **JMA MOVE-G** current data, ‘**1**’ **FIO** current data.

For details parameter setup, see **Appendix B**.

To save the edited work:

Press Esc key
Press “Shift” and “:” key
Type in wq!
Press “Enter” key

5.2 Edit the OilSpill.sh using vi editor.

Change your directory back one step to directory **/home/user/OilSpillModel/Model**.

[user@localhost OilSpillModel/Model/DATA]$ cd ..

[user@localhost OilSpillModel/Model]$ vi Oilspill.sh

```
#!/bin/sh
#-----------------------------------------------------------------
# This is a runscript to calculate the oil spill prediction.
#-----------------------------------------------------------------
# calculation information ( constant input )
ln -s ./DATA/oilspill_card.text fort.1

# Oil Data (input)
ln -s ./DATA/oil_list.txt fort.10

# land / sea attribution (input)
ln -s ./DATA/Land_Sea_125_in.txt fort.11

# current data (input)
ln -s ./DATA/ocean20210730_JMA.data fort.12

# meteorological data (input)
ln -s ./DATA/product20210730.data fort.13

# restart data (input)
ln -s ./DATA/mpcont1.dat fort.15
#-----------------------------------------------------------------
./bin/oilspill_f.e
#-----------------------------------------------------------------
# results for GMT plot ( output )
mv ./DATA/spill_*.txt ../Plot/DATA/point/Oilspill/

# product data ( output )
if [ -f fort.21 ]; then
  mv fort.21 ./DATA/mpcont2.data
fi

# product (output)
mv fort.31 ./DATA/oilspill.dat

# oil landing information (output)
if [ -f fort.41 ]; then
  mv fort.41 ../Plot/DATA/point/Oilspill/landing_info.txt
fi
rm fort.*
```

Modify the **highlighted field** accordingly to current (JMA or FIO) and wave meteorological data by pressing “I” or <insert> to enable edit mode of vi editor.

To save the edited work:

Press Esc key
Press “Shift” and “:” key
Type in wq!
Press “Enter” key

5.3 Search & Rescue Model

Let’s assume there is one SAR incident involving one fishing boat sunk in Malaysian Water:

Date : 3 August 2021
Time of incident : 1800H (local time)
Location : 2.8 N, 101.2 E
Weight Object : 300 kg
Percentage Sinking : 50%

Change your directory to **/home/user/OilSpillModel/Model/DATA**

[user@localhost OilSpillModel/Model/DATA]$ vi SAR_card.text

```
*-------------------------------------------------------------------
* Calculation parameters of SAR prediction model.
*                        2019/10/21 KC, 2015/09/10   N.Kohno
*  233 * 177 (0.125 degree grid ) 72 hour calculation*-------------------------
-------------------------------------------
 &grid
  nx = 233, ny = 177,
  lat_s = -5.0, lat_n = 17.0, lon_w = 95.00, lon_e = 124.00
 &end
 &calinfo
  icont = 0, dt = 60.0, nhours = 72, noutput = 1
 &end
 &accinfo
  year = 2021, month = 08, day = 03, hour = 10, minute = 00
  ac_lat = 2.8, ac_lon = 101.2, ioil = 0
 &end
 &oilinfo
  oil_amount = 0, spill_rate = 0, oil_type = 16
 &end
 &options
  isource = 0, idiff = 0, ichemi = 0, irndspill = 0,
  iarea = 0, icurvar = 1, iseaice = 0
 &end
 &srcinfo
  u_src = 0.00, v_src = 0.00, mass_source = 300, as_ratio = 0.5
 &end
```

Modify the information **highlighted field** accordingly to incident details by pressing “I” or <insert> to enable edit mode of vi editor.

Make sure the initial date of the current and wave meteorological initial is correct. These data must be initialized before the incident date (**&accinfo**). Time incident must be set to UTC time.

For **&calinfo**: **nhours** = set ‘**72**’ for 72 hours forecast data

For **ioil**= set ‘**0**’ for SAR Model (&oilinfo not be calculated)

For **icurvar**= set ‘**0**’ **JMA MOVE-G** current data, ‘**1**’ **FIO** current data.

For **mass_source** = set ‘**300**’ Mass of object sinking.

For **as_ratio** = set ‘**0.5**’ 50% Ratio of floating object body in air and sea.

For details parameter setup, see **Appendix C**.

To save the edited work:

Press Esc key
Press “Shift” and “:” key
Type in wq!
Press “Enter” key

5.4 Edit the SAR.sh using vi editor.

Change your directory step back one folder to **/home/user/OilSpillModel/Model**.

[user@localhost OilSpillModel/Model/DATA]$ cd ..

[user@localhost OilSpillModel/Model]$ vi SAR.sh

```
#!/bin/sh
#-----------------------------------------------------------------
# This is a runscript to calculate the oil spill prediction.
#-----------------------------------------------------------------
rm fort.*
# calculation information ( constant input )
ln -s ./DATA/oilspill_card.text fort.1

# Oil Data (input)
ln -s ./DATA/oil_list.txt fort.10

# land / sea attribution (input)
ln -s ./DATA/Land_Sea_125_in.txt fort.11

# current data (input)
ln -s ./DATA/ocean20210730_FIO_f.data fort.12

# meteorological data (input)
ln -s ./DATA/product20210730.data fort.13

# restart data (input)
ln -s ./DATA/mpcont1.dat fort.15
#-----------------------------------------------------------------
time ./bin/oilspill_f.e
#-----------------------------------------------------------------
# results for GMT plot ( output )
mv ./DATA/spill_*.txt ../Plot/DATA/point/SAR

# product data ( output )
if [ -f fort.21 ]; then
  mv fort.21 ./DATA/mpcont2.data
fi

# product (output)
mv fort.31 ./DATA/oilspill.dat

# oil landing information (output)
if [ -f fort.41 ]; then
  mv fort.41 ../Plot/DATA/point/SAR/landing_info.txt
fi
rm fort.*
```

Modify the **highlighted field** accordingly to current (JMA or FIO) and wave meteorological data by pressing “I” or <insert> to enable edit mode of vi editor.

To save the edited work:

Press Esc key
Press “Shift” and “:” key
Type in wq!
Press “Enter” key

6.0 Model Execution

After updating 2 files (information card and model parameter file) according to the incident details, the OSM is now ready for executed.

Oil Spill Model (FOR SAR go to section 6.2)

6.1 Execute the Oilspill.sh script.

Make sure you are still in the correct path **/home/user/OilSpillModel/Model**

[user@localhost OilSpillModel/Model]$ ./Oilspill.sh

The script will be running, and part of the execution log will look like:

```
== SUBROUTINE OUTPUT ==========================
 The amount of spill  :    10000000.0
 Evaporation ratio (%)  :    8.96621990
 The water content (%)  :    20.4927559
 == SUBROUTINE MAINLOOP ============================
output time: 2021  8  3  0  0    0
 == SUBROUTINE OUTPUT ==========================
 The amount of spill  :    10000000.0
 Evaporation ratio (%)  :    8.99106312
 The water content (%)  :    21.5462360
-------------------------------
Program was successfully ended.
-------------------------------
real      0m37.469s
user      0m34.969s
sys       0m0.624s
```

Make sure the execution log prints “Program was successfully ended.” This indicates all calculations are completed.

After model execution is completed, the result in point will be appear in the directory **/home/user/OilSpillModel/Plot/DATA/point/Oilspill.**

[user@localhost OilSpillModel/Plot/DATA/point/Oilspill]$ ls

```
landing_info.txt  spill_014.txt  spill_029.txt  spill_044.txt  spill_059.txt
 spill_000.txt    spill_015.txt  spill_030.txt  spill_045.txt  spill_060.txt
 spill_001.txt    spill_016.txt  spill_031.txt  spill_046.txt  spill_061.txt
 spill_002.txt    spill_017.txt  spill_032.txt  spill_047.txt  spill_062.txt
 spill_003.txt    spill_018.txt  spill_033.txt  spill_048.txt  spill_063.txt
 spill_004.txt    spill_019.txt  spill_034.txt  spill_049.txt  spill_064.txt
 spill_005.txt    spill_020.txt  spill_035.txt  spill_050.txt  spill_065.txt
 spill_006.txt    spill_021.txt  spill_036.txt  spill_051.txt  spill_066.txt
 spill_007.txt    spill_022.txt  spill_037.txt  spill_052.txt  spill_067.txt
 spill_008.txt    spill_023.txt  spill_038.txt  spill_053.txt  spill_068.txt
 spill_009.txt    spill_024.txt  spill_039.txt  spill_054.txt  spill_069.txt
```

Search & Rescue Model

6.2 Execute the SAR.sh script.

Ensure you are in directory **/home/user/OilSpillModel/Model**

[user@localhost OilSpillModel/Model]$ ./SAR.sh

The script will be running, and part of the execution log will look like:

```
== SUBROUTINE OUTPUT ==========================
 The amount of spill :    10000000.0
 Evaporation ratio (%) :    8.96621990
 The water content (%) :    20.4927559
 == SUBROUTINE MAINLOOP ==============================
output time: 2021  8  3  0  0    0
 == SUBROUTINE OUTPUT ==========================
 The amount of spill :    10000000.0
 Evaporation ratio (%) :    8.99106312
 The water content (%) :    21.5462360
-------------------------------
Program was successfully ended.
-------------------------------
real      0m37.469s
user      0m34.969s
sys       0m0.624s
```

Make sure execution log prints ‘Program was successfully ended.” This indicates all calculations are completed.

After model execution is completed, the result in point will be appear in the directory **/home/user/OilSpillModel/Plot/DATA/point/SAR.**

[user@localhost OilSpillModel/Plot/DATA/point/SAR]$ ls

```
landing_info.txt   spill_014.txt   spill_029.txt   spill_044.txt   spill_059.txt
 spill_000.txt     spill_015.txt   spill_030.txt   spill_045.txt   spill_060.txt
 spill_001.txt     spill_016.txt   spill_031.txt   spill_046.txt   spill_061.txt
 spill_002.txt     spill_017.txt   spill_032.txt   spill_047.txt   spill_062.txt
 spill_003.txt     spill_018.txt   spill_033.txt   spill_048.txt   spill_063.txt
 spill_004.txt     spill_019.txt   spill_034.txt   spill_049.txt   spill_064.txt
 spill_005.txt     spill_020.txt   spill_035.txt   spill_050.txt   spill_065.txt
 spill_006.txt     spill_021.txt   spill_036.txt   spill_051.txt   spill_066.txt
 spill_007.txt     spill_022.txt   spill_037.txt   spill_052.txt   spill_067.txt
 spill_008.txt     spill_023.txt   spill_038.txt   spill_053.txt   spill_068.txt
 spill_009.txt     spill_024.txt   spill_039.txt   spill_054.txt   spill_069.txt
```

7.0 Post Processing

The last process of OSM is the Post Processing which is executing the GMT script to produce trajectory map of a given oil spill and SAR trajectory. For Oil spill model, it contains simulation with different weathering component namely evaporation and emulsification of oil particle. Evaporation component have been included in **spillplot_evp.sh** wile for emulsification component it can be found in **spillplot_eml.sh**. For oil spill trajectories without weathering effect, users can execute **Oil_Spill_plot.sh**.

Oil Spill Model

7.1 Edit the Oil_Spill_plot.sh using vi editor.

Change your directory to **/home/user/OilSpillModel/Plot**

[user@localhost OilSpillModel/Model/DATA]$ cd ../Plot

[user@localhost OilSpillModel/Plot]$ ls

Oilspill_Auto.sh	SAR_Auto.sh	DATA
Oil_Spill_plot.sh	**spillplot_eml.sh**	plot-SAR-maps.sh
spillplot_evp.sh	my.SAR_plot.sh	tmp.txt

[user@localhost OilSpillModel/Plot]$ vi Oil_Spill_plot.sh

```
#!/bin/csh
# GMT Plot NHM
#
# Purpose: grid plot (Japan Sea)
# GMT progs: gmtset grdcontour psbasemap pscoast
# Unix progs: rm
#
set area = -JM7.2i
set range = -R117/120/4/7        -> (Latitude and longitude range of the map)
#---- initial time set     -> (set this initial time according to time of wave and meteorological data)

set Year        = 2021
set Mon         = 07
set Day         = 30
set Hour        = 00
set kt          = 0
while( $kt <= 72 )
set ft = $kt
if( $kt < 10 ) set ft = 0$kt
if( $kt < 100 ) set ft = 0$ft
set spill_data = ./DATA/point/Oilspill/spill_$ft.txt
set output_file = ./DATA/Map/Oilspill/Spill_area_$ft.ps
set png_file = ./DATA/Map/Oilspill/Spill_area_$ft.png
```

```
#---- date title
set MM = $Mon
if( $Mon < 10 ) set MM  = 0$Mon
set DD = $Day
if( $Day < 10 ) set DD  = 0$Day
set HH = $Hour
if( $Hour < 10 ) set HH  = 0$Hour

set datehour = $Year/$MM/$DD' '$HH':00  UTC = '$kt
echo "100.75  3.683  20  0  4  LT  "$datehour | gmt pstext $area $range -W255/255/255 -
C0.03/0.03 -N -O >> $output_file

#
convert -flatten -rotate 90 $output_file $png_file
```

Set the **highlighted field** with the correct value consist of:
   i. Latitude and longitude range based on SAR position in order to get visual of Oil spill simulation on the map.
   ii. Initial time according to wave and meteorological data.
   iii. Forecast duration in hours.
   iv. latitude and longitude to place a date and time series text on map.

To save the edited work:

Press Esc key
Press “Shift” and “:” key
Type in wq!
Press “Enter” key

7.2 Execute the Oil_Spill_plot.sh.

After changing the parameter detail, then execute the **Oil_Spill_plot.sh** script to produce the graphical output.

[user@localhost OilSpillModel/Plot]$ ./Oil_Spill_plot.sh

Graphic processing completed.

```
psbasemap [INFORMATION]: Central meridian not given, default to 100.85
psbasemap [INFORMATION]: Map scale is 8.57476 km per cm or 1:857476.
psbasemap [INFORMATION]: Constructing the basemap
psbasemap [INFORMATION]: Central meridian not given, default to 100.85
psbasemap [INFORMATION]: Map scale is 8.57476 km per cm or 1:857476.
psbasemap [INFORMATION]: Constructing the basemap
psbasemap [INFORMATION]: Central meridian not given, default to 100.85
psbasemap [INFORMATION]: Map scale is 8.57476 km per cm or 1:857476.
psbasemap [INFORMATION]: Constructing the basemap
psbasemap [INFORMATION]: Central meridian not given, default to 100.85
psbasemap [INFORMATION]: Map scale is 8.57476 km per cm or 1:857476.
[user@localhost Plot]$
```

Search & Rescue Model

7.3 Edit the my.SAR_plot.sh using vi editor.

Change your directory to **/home/user/OilSpillModel/Plot**

[user@localhost OilSpillModel/Model/DATA]$ cd ../Plot

[user@localhost OilSpillModel/Plot]$ ls

Oilspill_Auto.sh	SAR_Auto.sh	DATA
Oil_Spill_plot.sh	spillplot_eml.sh	plot-SAR-maps.sh
spillplot_evp.sh	**my.SAR_plot.sh**	tmp.txt

[user@localhost OilSpillModel/Plot]$ vi my.SAR_plot.sh

```
#!/bin/csh
# GMT Plot NHM
#
# Purpose: grid plot (Japan Sea)
# GMT progs: gmtset grdcontour psbasemap pscoast
# Unix progs: rm
#
set area = -JM7.2i
set range = -R117/120/4/7        -> (Latitude and longitude range of the map)
#---- initial time set     -> (set this initial time according to time of wave and meteorological data)

set Year        = 2021
set Mon         = 07
set Day         = 30
set Hour        = 00
set kt          = 0
while( $kt <= 72 )
set ft = $kt
if( $kt < 10 ) set ft = 0$kt
if( $kt < 100 ) set ft = 0$ft
```

```
#---- date title
set MM = $Mon
if( $Mon < 10 ) set MM  = 0$Mon
set DD = $Day
if( $Day < 10 ) set DD  = 0$Day
set HH = $Hour
if( $Hour < 10 ) set HH  = 0$Hour

set datehour = $Year/$MM/$DD' '$HH':00  UTC = '$kt
echo "100.75 3.683 20 0 4 LT "$datehour | gmt pstext $area $range -W255/255/255 -C0.03/0.03 -N -O >> $output_file
```

Set the **highlighted field** with the correct value consist of:
   i. Latitude and longitude range based on SAR position in order to get visual of SAR simulation on the map.
   ii. Initial time according to wave meteorological data.
   iii. Forecast duration in hours
   iv. Latitude and longitude to place a date and time series text on map.

To save the edited work:

Press Esc key
Press “Shift” and “:” key
Type in wq!
Press “Enter” key

7.4 Execute the my.SAR_plot.sh.

After changing the parameter detail, then execute the **my.SAR_plot.sh** script to produce the graphical output using GMT plot.

[user@localhost OilSpillModel/Plot]$ ./my.SAR_plot.sh

Graphic processing completed.

```
psbasemap [INFORMATION]: Central meridian not given, default to 100.85
psbasemap [INFORMATION]: Map scale is 8.57476 km per cm or 1:857476.
psbasemap [INFORMATION]: Constructing the basemap
psbasemap [INFORMATION]: Central meridian not given, default to 100.85
psbasemap [INFORMATION]: Map scale is 8.57476 km per cm or 1:857476.
psbasemap [INFORMATION]: Constructing the basemap
psbasemap [INFORMATION]: Central meridian not given, default to 100.85
psbasemap [INFORMATION]: Map scale is 8.57476 km per cm or 1:857476.
psbasemap [INFORMATION]: Constructing the basemap
psbasemap [INFORMATION]: Central meridian not given, default to 100.85
psbasemap [INFORMATION]: Map scale is 8.57476 km per cm or 1:857476.
[user@localhost Plot]$
```

7.5 Execute the plot-SAR-maps.sh

For SAR Model, there are google map plot using google map by execute the **plot-SAR-maps.sh** script/

Ensure your directory is **/home/user/OilSpillModel/Plot**

[user@localhost OilSpillModel/Plot]$ ls

Oilspill_Auto.sh	SAR_Auto.sh	DATA
Oil_Spill_plot.sh	spillplot_eml.sh	**plot-SAR-maps.sh**
spillplot_evp.sh	my.SAR_plot.sh	tmp.txt

[user@localhost OilSpillModel/Plot]$ ./plot-SAR-maps.sh

Graphic processing completed.

8.0 Output Check

Oil Spill Model

8.1 Map Output

Change directory to **/home/user/OilSpillModel/Plot/DATA/Map**

[user@localhost OilSpillModel/Plot]$ cd DATA/Map/Oilspill

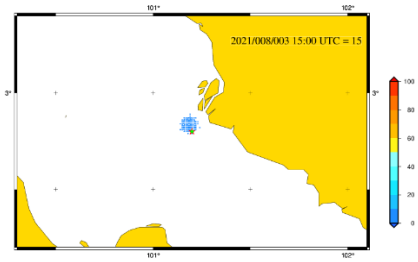
[user@localhost OilSpillModel/Plot/DATA/Map/Oilspill]$ ls

Spill_area_000.png	Spill_area_024.png	Spill_area_048.png
Spill_area_000.ps	Spill_area_024.ps	Spill_area_048.ps
Spill_area_012.png	Spill_area_036.png	Spill_area_060.png
Spill_area_012.ps	Spill_area_036.ps	Spill_area_060.ps

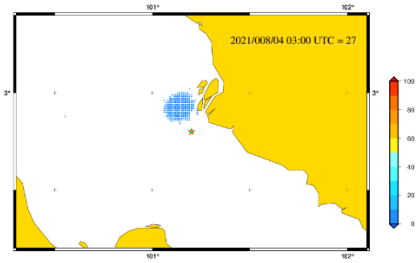
View the png files.

[user@localhost OilSpillModel/Plot/DATA/Map/Oilspill]$ $ eog *.png

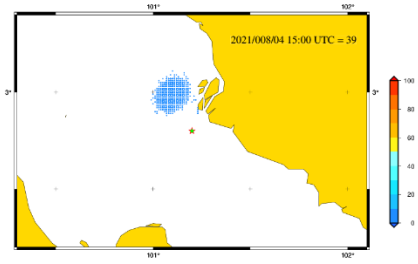
Spill with evaporation scale:



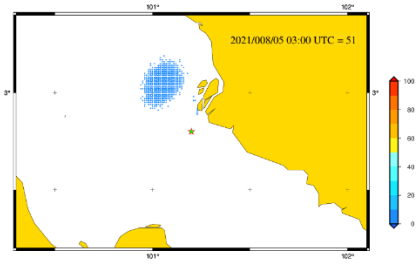
Simulation of evaporation after 5 hour



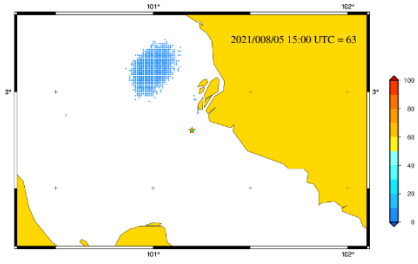
Simulation of evaporation after 17 hour



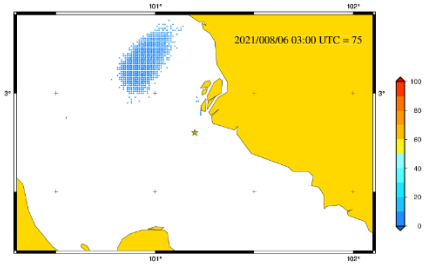
Simulation of evaporation after 29 hour



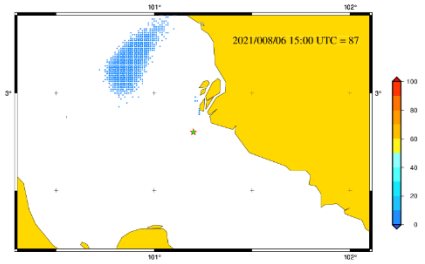
Simulation of evaporation after 41 hour



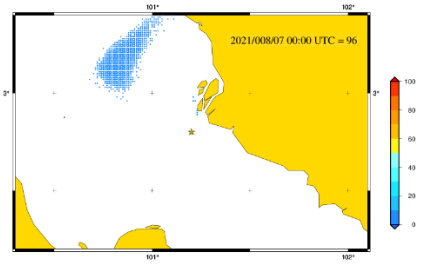
Simulation of evaporation after 53 hour



Simulation of evaporation after 65 hour

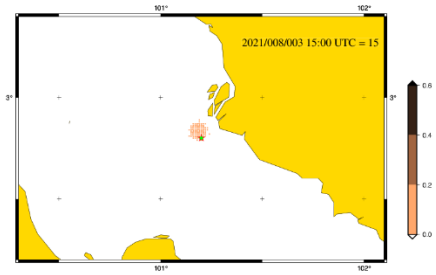


Simulation of evaporation after 77 hour

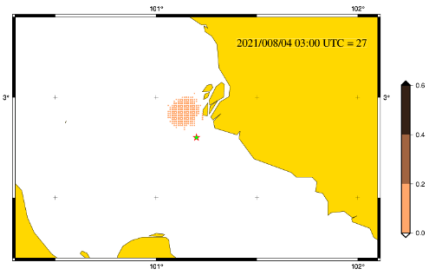


Simulation of evaporation after 86 hour

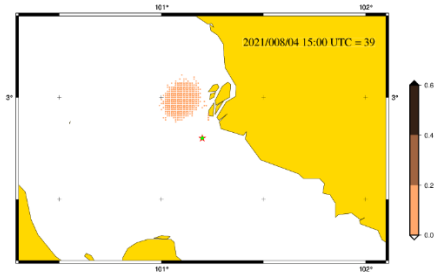
Spill with emulsification scale:



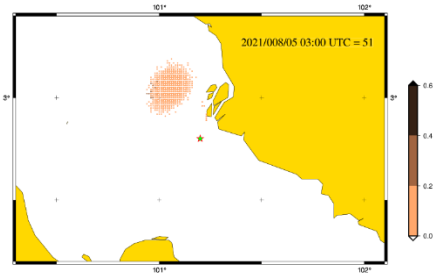
Simulation of emulsification after 5 hour



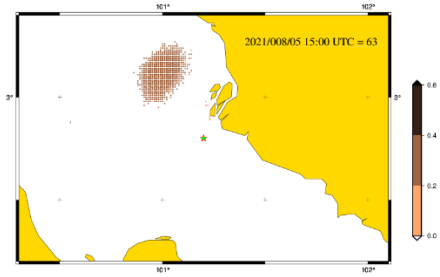
Simulation of emulsification after 17 hour



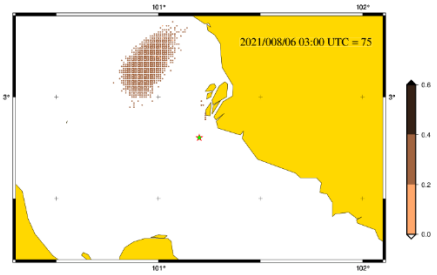
Simulation of emulsification after 29 hour



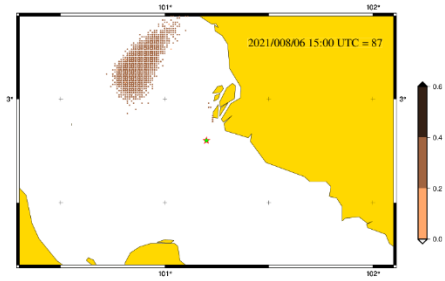
Simulation of emulsification after 41 hour



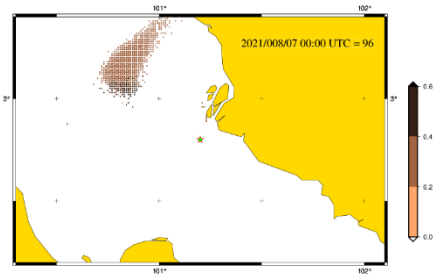
Simulation of emulsification after 53 hour



Simulation of emulsification after 65 hour

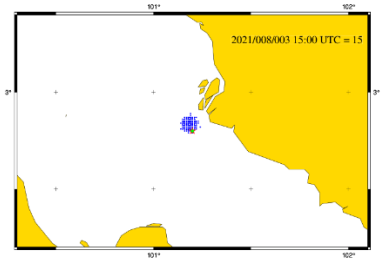


Simulation of emulsification after 77 hour

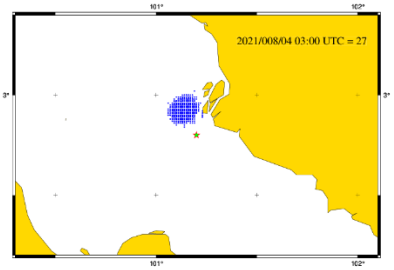


Simulation of emulsification after 86 hour

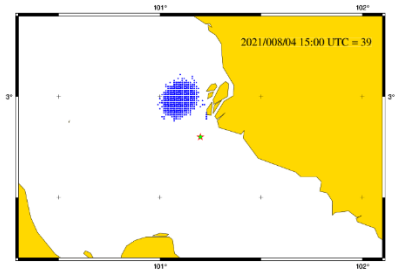
Spill without weathering effect:



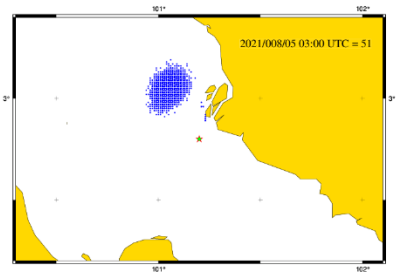
Simulation of emulsification after 5 hour



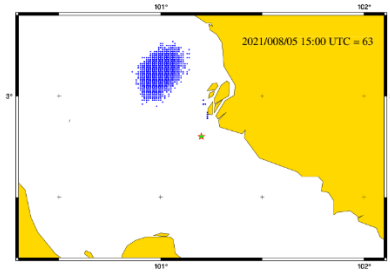
Simulation of emulsification after 17 hour



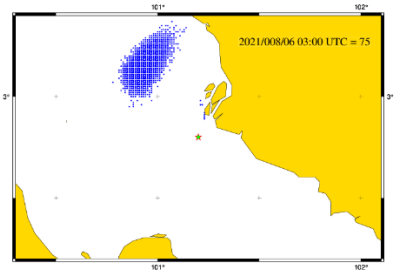
Simulation of emulsification after 29 hour



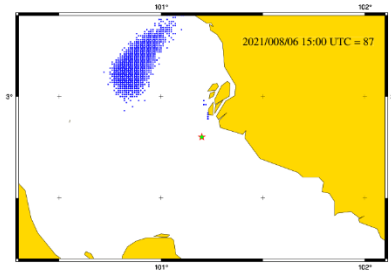
Simulation of emulsification after 41 hour



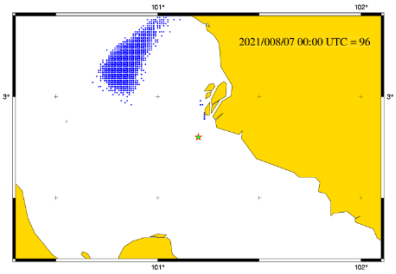
Simulation of emulsification after 53 hour



Simulation of emulsification after 65 hour



Simulation of emulsification after 77 hour



Simulation of emulsification after 86 hour

8.2 Landing Information

Change directory to **/home/user/OilSpillModel/Plot**

[user@localhost OilSpillModel/Plot]$ cd DATA/point/Oilspill

[user@localhost OilSpillModel/Plot/DATA/point/Oilspill]$ ls -lrta

```
drwxrwxr-x. 1 user user      22 Jul 19 12:43  ..
-rw-rw-r--. 1 user user 2124800 Aug  1 14:17 'spill_***.txt'
-rw-rw-r--. 1 user user 2124800 Aug  1 14:17  spill_001.txt
-rw-rw-r--. 1 user user 2124800 Aug  1 14:17  spill_002.txt
-rw-rw-r--. 1 user user 2124800 Aug  1 14:17  spill_003.txt
-rw-rw-r--. 1 user user 2124800 Aug  1 14:17  spill_004.txt
-rw-rw-r--. 1 user user 2124800 Aug  1 14:17  spill_005.txt
-rw-rw-r--. 1 user user 2124800 Aug  1 14:17  spill_006.txt
-rw-rw-r--. 1 user user 2124800 Aug  1 14:17  spill_007.txt
-rw-rw-r--. 1 user user 2124800 Aug  1 14:17  spill_008.txt
-rw-rw-r--. 1 user user 2124800 Aug  1 14:17  spill_009.txt
-rw-rw-r--. 1 user user 2124800 Aug  1 14:17  spill_010.txt
-rw-rw-r--. 1 user user  761100 Aug  1 14:18  landing_info.txt
```

View the text file to see oil landing information.

[user@localhost OilSpillModel/Plot/DATA/point/Oilspill]$ less landing_info.txt

```
Oil has landed at:     2.89   101.23
     at the time: 2021    8    4    2   58    0
Oil has landed at:     2.89   101.23
     at the time: 2021    8    4    3    6    0
Oil has landed at:     2.89   101.23
     at the time: 2021    8    4    3   14    0
Oil has landed at:     2.89   101.23
     at the time: 2021    8    4    3   36    0
```

The landing info will give information of oil particle landfall at position **latitude** and **longitude** at time **yyyy mm dd hh mm kk**

SAR Model

8.3 Map Output GMT Plot

Change directory to **/home/user/OilSpillModel/Plot**

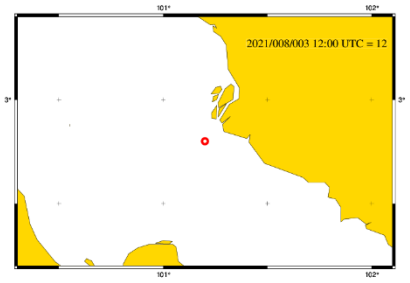
[user@localhost OilSpillModel/Plot]$ cd DATA/Map/SAR

[user@localhost OilSpillModel/Plot/DATA/Map/SAR]$ ls

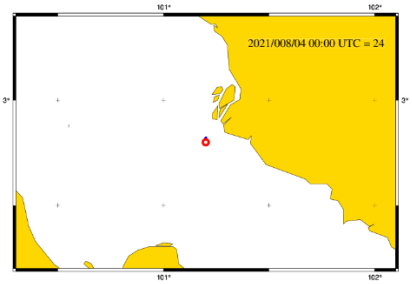
SAR_area_000.png	SAR_area_024.png	SAR_area_048.png
SAR_area_000.ps	SAR_area_024.ps	SAR_area_048.ps
SAR_area_012.png	SAR_area_036.png	SAR_area_060.png
SAR_area_012.ps	SAR_area_036.ps	SAR_area_060.ps

View the png files.

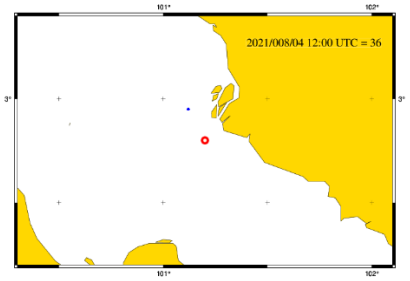
[user@localhost OilSpillModel/Plot/DATA/Map/SAR]$ $ eog *.png



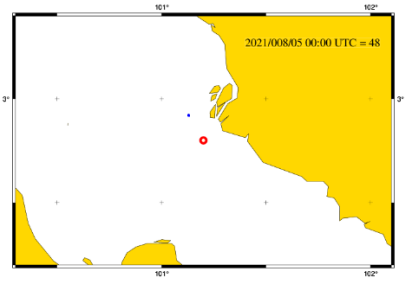
Simulation of trajectory object after 2 hour



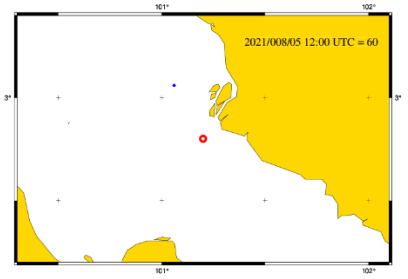
Simulation of trajectory object after 14 hour



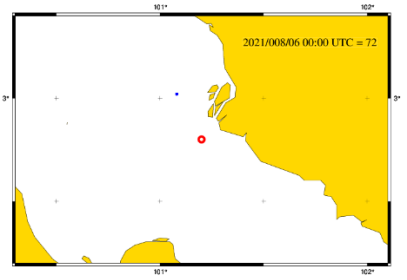
Simulation of trajectory object after 26 hour



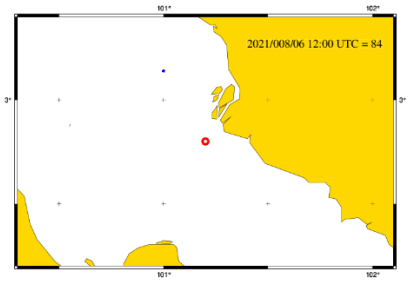
Simulation of trajectory object after 38 hour



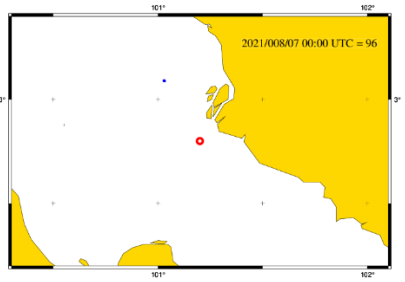
Simulation of trajectory object after 50 hour



Simulation of trajectory object after 62 hour



Simulation of trajectory object after 74 hour



Simulation of trajectory object after 86 hour

8.4 Map Output Google Plot

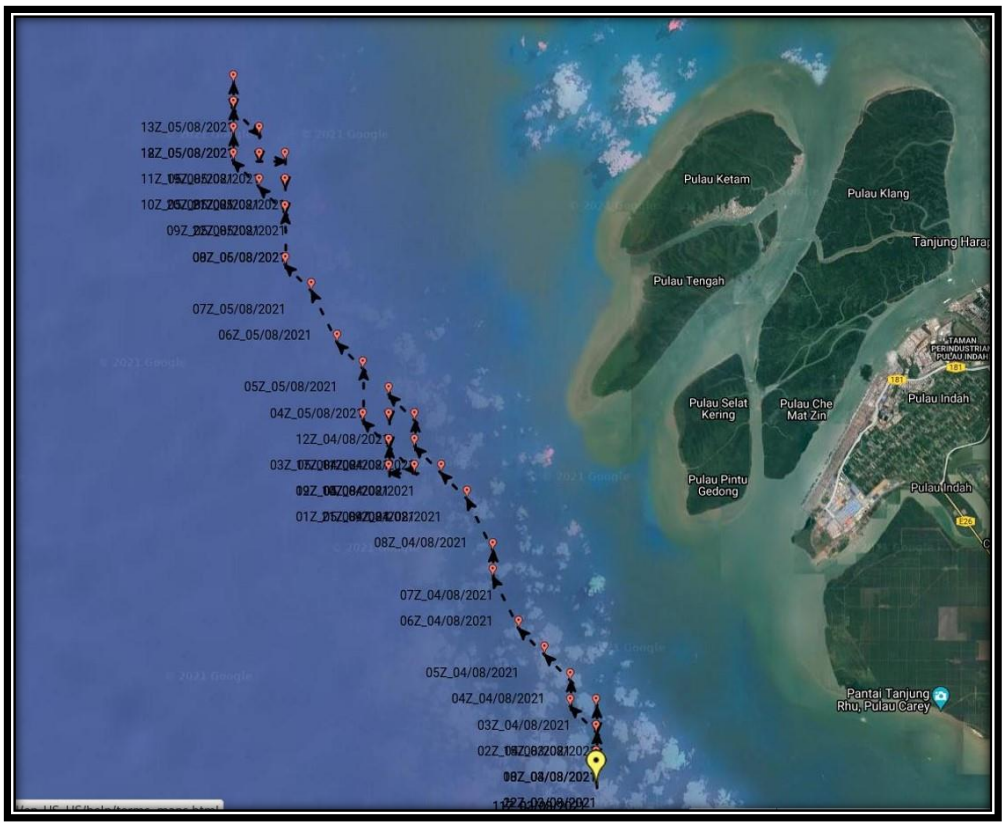
Change directory to **/home/user/OilSpillModel/Plot**

[user@localhost OilSpillModel/Plot]$ ls

evprate.cpt	locations.txt	plot-SAR-maps.sh	**sar-map.html**
DATA	gmt.conf	my.SAR_plot.sh	spillplot_eml.sh
depth.cpt	gmt.history	Oilspill_Auto.sh	PS_font_info.d
emulsion.cpt	Oil_Spill_plot.sh	SAR_Auto.sh	spillplot_evp.sh
tmp.txt			

View the the google map files.

[user@localhostOilSpillModel/Plot]$ xdg-open sar-map.html



8.5 Landing Information

Change directory to **/home/user/OilSpillModel/Plot**

[user@localhost OilSpillModel/Plot]$ cd DATA/point/SAR

[user@localhost OilSpillModel/Plot/DATA/point/SAR]$ ls -lrta

```
drwxrwxr-x. 1 user user      22 Jul 19 12:43  ..
-rw-rw-r--. 1 user user 2124800 Aug  1 14:17 'spill_***.txt'
-rw-rw-r--. 1 user user 2124800 Aug  1 14:17  spill_001.txt
-rw-rw-r--. 1 user user 2124800 Aug  1 14:17  spill_002.txt
-rw-rw-r--. 1 user user 2124800 Aug  1 14:17  spill_003.txt
-rw-rw-r--. 1 user user 2124800 Aug  1 14:17  spill_004.txt
-rw-rw-r--. 1 user user 2124800 Aug  1 14:17  spill_005.txt
-rw-rw-r--. 1 user user 2124800 Aug  1 14:17  spill_006.txt
-rw-rw-r--. 1 user user 2124800 Aug  1 14:17  spill_007.txt
-rw-rw-r--. 1 user user 2124800 Aug  1 14:17  spill_008.txt
-rw-rw-r--. 1 user user 2124800 Aug  1 14:17  spill_009.txt
-rw-rw-r--. 1 user user 2124800 Aug  1 14:17  spill_010.txt
-rw-rw-r--. 1 user user  761100 Aug  1 14:18  landing_info.txt
```

View the text file to see oil landing information if available.

[user@localhost OilSpillModel/Plot/DATA/point/SAR]$ less landing_info.txt

```
Oil has landed at:     2.89   101.23
     at the time: 2021    8    4    2   58    0
Oil has landed at:     2.89   101.23
     at the time: 2021    8    4    3    6    0
Oil has landed at:     2.89   101.23
     at the time: 2021    8    4    3   14    0
Oil has landed at:     2.89   101.23
     at the time: 2021    8    4    3   36    0
```

The landing info will give information of object landfall at position **latitude** and **longitude** at time **yyyy mm dd hh mm kk**

9.0 Auto Run Script

To execute the OSM, the user should follow every step above and fill the correct incident details to ensure the OSM running smoothly. To simplify the above processes, an autorun script is also provided. With this auto run script, the users only need to fill up the information details on execution script.

Oil Spill Model

9.1 Execute Oil Spill Model

Change directory to **/home/user/OilSpillModel/Plot**

[user@localhost OilSpillModel/Plot]$ ls

Oilspill_Auto.sh	SAR_Auto.sh	DATA
Oil_Spill_plot.sh	spillplot_eml.sh	plot-SAR-maps.sh
spillplot_evp.sh	my.SAR_plot.sh	tmp.txt

Before executing the script, the details of incident have to be confirmed for input the parameter in the script later. As example:

Input Parameter	Details	Remark
DTG FIO Ocean Data (yyyy:m:d)	2021 8 2	FIO data only
DTG of incident (yyyy:mm:dd:hh:mm)	2021 08 03 10 00	UTC time
Location (Degree Format)	2.8 N, 101.2 E	Klang Waters
DTG Initial wave data (yyyy:mm:dd:hh)	2021 08 03 00	UTC time
Forecast duration (Hours)	72	
Oil type	Bunker (long term) – 16	Code refer oil list table (see Appendix A)
Oil amount (g/m^3)	1000000	

Execute file Oilspill_Auto.sh by key in the 'DTG FIO Ocean Data'

[user@localhost OilSpillModel/Plot]$ ./Oilspill_Auto.sh 2021 8 2

The script will be running and key in incident details as table above.

```
  9999   2404        2       2021        8        2        12        3
  9999   2424        1       2021        8        2        12        0
  9999   2443
 -------------------------------------------------
   The model data reading was successfully ended
 -------------------------------------------------
Enter Lat and Long of incident
2.8 101.2
Enter the date and time of incident
2021 08 03 10 00
Enter initial time wave data
2021 08 03 00
Enter the forecast duration in hour
72
Enter oil amount
1000000
Enter oil type
16
```

The OSM will be running and completed when "**OilSpill Model running successfully"** appear.

```
psbasemap [INFORMATION]: Central meridian not given, default to 101.2
psbasemap [INFORMATION]: Map scale is 8.57476 km per cm or
1:857476.
psbasemap [INFORMATION]: Constructing the basemap
psbasemap [INFORMATION]: Central meridian not given, default to 101.2
psbasemap [INFORMATION]: Map scale is 8.57476 km per cm or
1:857476.
OilSpill Model running successfully
```

The SAR Model processing have completed and to check graphical output as described in **subpara 8.0.**

SAR Model

9.2 Execute SAR Model

Change directory to **/home/user/OilSpillModel/Plot**

[user@localhost OilSpillModel/Plot]$ ls

Oilspill_Auto.sh	**SAR_Auto.sh**	DATA
Oil_Spill_plot.sh	spillplot_eml.sh	plot-SAR-maps.sh
spillplot_evp.sh	my.SAR_plot.sh	tmp.txt

Before executing the script, the details of incident have to be confirmed for input the parameter in the script later. As example:

Input Parameter	Details	Remark
DTG FIO Ocean Data (yyyy:m:d)	2021 8 2	FIO data only
DTG of incident (yyyy:mm:dd:hh:mm)	2021 08 03 10 00	UTC time
Location (Degree Format)	2.8 N, 101.2 E	Klang Waters
DTG Initial wave data (yyyy:mm:dd:hh)	2021 08 03 00	UTC time
Forecast duration (Hours)	72	
Weight Object (kg)	300	
Percentage Sinking (%)	50	Refer to report (sunk or partly submerged)

Execute file SAR_Auto.sh by key in the ‘DTG FIO Ocean Data’

[user@localhost OilSpillModel/Plot]$ ./SAR_Auto.sh 2021 8 2

The script will be running and fill the incident details as table above.

```
  9999   2404        2       2021        8        2        12        3
  9999   2424        1       2021        8        2        12        0
  9999   2443
 -------------------------------------------------
   The model data reading was successfully ended
 -------------------------------------------------
Enter Lat and Long of incident
2.8 101.2
Enter the date and time of incident
2021 08 03 10 00
Enter initial time wave data
2021 08 03 00
Enter the forecast duration in hour
72
Enter the weight object (kg) and percentage submerge (%)
300 50
```

The SAR Model will be running and completed when "**SAR Model running successfully"** appear.

```
psbasemap [INFORMATION]: Central meridian not given, default to 101.2
psbasemap [INFORMATION]: Map scale is 8.57476 km per cm or
1:857476.
psbasemap [INFORMATION]: Constructing the basemap
psbasemap [INFORMATION]: Central meridian not given, default to 101.2
psbasemap [INFORMATION]: Map scale is 8.57476 km per cm or
1:857476.
SAR Model running successfully
```

The SAR Model processing have completed and to check graphical output as described in **subpara 8.0.**

APPENDIX A

Oil Data List

Name	Number	Name	Number
Adgo - long term	1	Komineft	44
Adgo - short term	96	Lago	45
Alberta Sweet Mixed Blend	2	Lucula	46
Amauligak	3	Main Pass Block 306	47
Amauligak - f24	4	Main Pass Block 37	48
Arabian Light	6	Malongo	49
Arabian Medium	5	Mayan crude	50
ASMB (offshore)	7	Mississippi Canyon Block 194	51
Av Gas 80	8	Nektoralik	52
Avaion J-34	10	Nerlerk	53
Avalon	9	Ninian	54
Barrow Island	11	Norman Wells	55
BCF-24	12	North Slope - Middle Pipeline	56
Beiridge Crude	97	North Slope - Northern Pipeline	57
Bent Horn A-02	13	North Slope - Southern Pipeline	58
Beta - short term	98	Nugini	59
Beta - long term	14	Orimulsion 400 - dewater	115
Boscan	99	Orimulsion plus water	60
Brent	15	Oseberg	61
Bunker C - Light (IFO-250)	100	Panuke	62
Bunker C - long term	16	Pitas Point	63
Bunker C - short term	101	Platform Holly	64
Carpenteria	17	Platform Irene - long term	65
Cook inlet - Granite Point	18	Platform Irene - short term	111
Cook Inlet - Swanson River	19	Point Arguello - comingled	66
Cook Inlet Trading Bay	20	Point Arguello Heavy	67
Corrosion Inhibitor Solvent	102	Point Arguello Light	68
Delta West Block 97	21	Point Arguello Light	69
Diesel - Anchorage - long term	22	Polyproylene Tetramer	116
Diesel - Anchorage - short term	103	Port Hueneme	70
Diesel - long term	23	Prudhoe Bay - new stock	72
Diesel (regular stock)	104	Prudhoe Bay - old stock	71
Diesel fuel - Southern - long term	24	Prudhoe stock b	73
Diesel fuel - Southern - short term	105	Rangely	74
Dos Cuadros	25	Santa Clara	75
Ekofisk	26	Ship Shoal Block 239	76
Empire Crude	27	Ship Shoal Block 269	77
Endicott	28	Sockeye	78
Eugene Island Block 32	30	Sockeye Sour	79

Eugene Island Block 43	31	Sockeye Sweet	80
Eugene ls. 224 - condensate	29	South Louisiana	81
FCC Heavy cycle	106	South Pass Block 60	82
FCC Medium cycle	107	South Pass Block 67	83
Federated	32	South Pass Block 93	84
Gasoline	33	South Timbalier Block 130	85
Green Canyon Block 109	34	Statfjord	86
Green Canyon Block 65	35	Sumatran Heavy	112
Gulfaks	36	Sumatran Light	87
Hondo	37	Taching	113
Hout	38	Takula	88
IFO-180	108	Tapis	89
IFO-30 (Svalbard)	39	Terra Nova	90
IFO-300 (old Bunker C)	109	Thevenard Island	91
Iranian Heavy	40	Waxy Light and Heavy	92
Issungnak	41	West Delta Block 30 w/water	114
Jet 40 Fuel	42	West Texas Intermediate	93
Jet Fuel (Anch)	43	West Texas Sour	94
Jet Fuel (Anch) short term	110	Zaire	95

Oil list.txt data format

Elements

1. oil number
2. Evaporation type (1: logarithmical, 2: root, 3: constant)
3. Evaporation coefficient a
4. Evaporation coefficient b
5. Density of oil (g/m^3): from oil data catalogue of Environment Canada
6. Temperature of oil for density calculation (°C)
7. Changing rate of density by temperature (g/m^3 / °C)
8. Changing rate of density by evaporation (g/m^3 / %)
9. Undefined
10. Emulsification index (1: yes, 0: no)

APPENDIX B

Oil Spill Card

```
*-------------------------------------------------------------------
* Calculation parameters of Oil spill prediction model.
*                                        2015/09/10   N.Kohno
*  233 * 177 (0.125 degree grid ) 72 hour calculation
*-------------------------------------------------------------------
 &grid
  nx = 233, ny = 177,
  lat_s = -5.0, lat_n = 17.0, lon_w = 95.00, lon_e = 124.00      } 1
 &end
 &calinfo
  icont = 0, dt = 60.0, nhours = 72, noutput = 1                 } 2
 &end
 &accinfo
  year = 2021, month = 08, day = 01, hour = 02, minute = 00      } 3
  ac_lat = 2.39, ac_lon = 101.89, ioil = 1
 &end
 &oilinfo
  oil_amount = 1000000.0, spill_rate = 1000000.0, oil_type = 16  } 4
 &end
 &options
  isource = 0, idiff = 1, ichemi = 1, irndspill = 0,             } 5
  iarea = 0, icurvar = 0, iseaice = 0
 &end
 &srcinfo
  u_src = 0.00, v_src = 0.00, mass_source = 100000, as_ratio = 0.5  } 6
 &end
```

1	Fix value for model grid 233 * 177 (0.125 degree grid). Value set based on model resolution	DO NOT CHANGE THE VALUE
2	**icont** = Set '**0**' new data, '**1**' continuous from previous data **dt =** Time step in sec. Set '**60**' for 60 sec **nhours** = Duration forecast data. Set '**72**' 72 hours, '**120**' 120 hours **nonoutput** = Output interval. Set '**0**' 0 per step, '**1**' 1 per step	
3	**year, month, day, hour, minute** = Set date and time of incident in UTC time **ac_lat =** Set latitude of incident in degree format **ac_lon** = Set longitude of incident in degree format **ioil** = Condition spill type. Set '**0**' others, '**1**' oil	The incident date after the date of meteorological data initial date
4	**oil_amount** = Total amount of oil (g/m^3) **spill_rate =** Spill rate (kl/hour) **oil_type** = Number of oil kind. (See Appendix A)	
5	**isource** = Condition of source. Set '**0**' fixed, '**1**' drifting **idiff =** Difffusion calculation. Set '**0**' no, '**1**' yes **ichemi** = Chemical change. Set '**0**' not considered, '**1**' considered **irndspill** = Random spill. Set '**0**' no, '**1**' yes **iarea** = Vast spill or point. Set '**0**' point, '**1**' area **icurvar =** Revision of current. Set '**0**' JMA data, '**1**' FIO data **iseaice** = Sea ice consider. Set '**0**' no, '**1**' regarded as land, '2' considered	
6	**u_src** = Source velocity. Drifting speed u component (m/s) **v_src =** Source velocity. Drifting speed v component (m/s) **mass_source** = Mass of source (kg). Weight of Vessel **as_ratio** = Air/Sea ratio (percentage)	Considered source oil spill (vessel) moving

APPENDIX C

SAR Card

```
*-----------------------------------------------------------------
* Calculation parameters of SAR prediction model.
*                        2019/10/21 KC, 2015/09/10   N.Kohno
*  233 * 177 (0.125 degree grid ) 72 hour calculation
*-----------------------------------------------------------------
 &grid
  nx = 233, ny = 177,
  lat_s = -5.0, lat_n = 17.0, lon_w = 95.00, lon_e = 124.00      } 1
 &end
 &calinfo
  icont = 0, dt = 60.0, nhours = 72, noutput = 1                 } 2
 &end
 &accinfo
  year = 2021, month = 08, day = 01, hour = 02, minute = 00      } 3
  ac_lat = 2.39, ac_lon = 101.89, ioil = 0
 &end
 &oilinfo
  oil_amount = 0, spill_rate = 0, oil_type = 0                   } 4
 &end
 &options
  isource = 0, idiff = 0, ichemi = 0, irndspill = 0,             } 5
  iarea = 0, icurvar = 1, iseaice = 0
 &end
 &srcinfo
  u_src = 0.00, v_src = 0.00, mass_source = 300, as_ratio = 0.5  } 6
 &end
```

1	Fix value for model grid 233 * 177 (0.125 degree grid). Value set based on model resolution	DO NOT CHANGE THE VALUE
2	**icont** = Set '**0**' new data, '**1**' continuous from previous data **dt =** Time step in sec. Set '**60**' for 60 sec **nhours** = Duration forecast data. Set '**72**' 72 hours, '**120**' 120 hours **nonoutput** = Output interval. Set '**0**' 0 per step, '**1**' 1 per step	
3	**year, month, day, hour, minute** = Set date and time of incident in UTC time **ac_lat =** Set latitude of incident in degree format **ac_lon** = Set longitude of incident in degree format **ioil** = Condition spill type. Set '**0**' others, '**1**' oil	The incident date after the date of meteorological data initial date
4	**oil_amount** = Total amount of oil (g/m^3). Set '**0**' oil not considered **spill_rate =** Spill rate (kl/hour). Set '**0**' oil not considered **oil_type** = Number of oil kind. (See Appendix A). Set '**0**' oil not considered	
5	**isource** = Condition of source. Set '**0**' fixed, '**1**' drifting **idiff =** Difffusion calculation. Set '**0**' no, '**1**' yes **ichemi** = Chemical change. Set '**0**' not considered, '**1**' considered **irndspill** = Random spill. Set '**0**' no, '**1**' yes **iarea** = Vast spill or point. Set '**0**' point, '**1**' area **icurvar =** Revision of current. Set '**0**' JMA data, '**1**' FIO data **iseaice** = Sea ice consider. Set '**0**' no, '**1**' regarded as land, '**2**' considered	For SAR Model all parameter not be considered
6	**u_src** = Source velocity. Drifting speed u component (m/s) **v_src =** Source velocity. Drifting speed v component (m/s) **mass_source** = Mass of source (kg) **as_ratio** = Air/Sea ratio (percentage)	Mass source is considered as mass boat or human body

APPENDIX D

Auto Run Script (Oil Spill Model)

```
#!/bin/sh
#############################################################################
#This script will automatically be running Oilspill Model from input the data to plotting map of the incident
#
#Written by Fakhrur Shukeri at 20 July 2021
#                                                #
#############################################################################
#
#Copy data to the Data folder
dirku=~/OilSpillModel

#Remove Old File
rm ${dirku}/Model/DATA/product*.data
rm ${dirku}/Model/DATA/ocean*.data
rm ${dirku}/Plot/DATA/point/Oilspill/*.txt
rm ${dirku}/Plot/DATA/Map/Oilspill/*.ps
rm ${dirku}/Plot/DATA/Map/Oilspill/*.png

#Copy new wave data
cd ${dirku}/Edit/DATA/FIO/
find -name product*.data -exec cp {} ${dirku}/Model/DATA \; -printf "%f\n" > ${dirku}/Model/tmp1.txt

#Read and assign the date of the incident
cd ${dirku}/Edit/

if [ $1$2$3 ]
then
  file1=oilspill_card.text
  file2=OilSpill.sh
  file3=Oil_Spill_plot.sh
  DTG=$1$2$3
  ${dirku}/Edit/convert_FIO.sh $1 $2 $3
else
  echo "You must specify the date of the initial meteorology data!"
  echo "example: ./SAR_Auto.sh 2021 07 12 --->for 20210712 FIO Meteorology data"
  exit
fi

#Input Lat Long Position of Incident
echo "Enter Lat and Long of incident"
read Lat Lon

#Set range of Plotting Map
 l_lat=`expr "$Lat - 0.6" | bc`
 u_lat=`expr "$Lat + 0.6" | bc`
 l_lon=`expr "$Lon - 0.9" | bc`
 u_lon=`expr "$Lon + 0.9" | bc`
 date_lat=`expr "$Lat + 0.49" | bc`
 date_lon=`expr "$Lon + 0.2" | bc`

#Input date and time of incident
echo "Enter the date and time of incident"
read iYear iMonth iDay iHour iMin

#Input initial time wave data
echo "Enter initial time wave data"
read mYear mMonth mDay mHour
```

```
#Input forecast hour
echo "Enter the forecast duration in hour"
read fHour

#Input Parameter of Oil
echo "Enter oil amount"
read OilAmount

echo "Enter oil type"
read OilType

#Move processed ocean data to Model folder
find -name ocean$1*.data -exec mv {} ${dirku}/Model/DATA \; -printf "%f\n" > ${dirku}/Model/tmp2.txt

#Change information in Oilspill card and Oilspill script
cd ${dirku}/Model/DATA/
  sed -i 's/nhours = .*/nhours = '$fHour', noutput = 1/' $file1
  sed -i 's/year = .*/year = '$iYear', month = '$iMonth', day = '$iDay', hour= '$iHour', minute = '$iMin',/'
$file1
  sed -i 's/ac_lat = .*/ac_lat = '$Lat', ac_lon = '$Lon', ioil = 1/' $file1
  sed -i 's/oil_amount = .*/oil_amount = '$OilAmount', spill_rate = '$OilAmount', oil_type = '$OilType'/'
$file1

#Execute Oilspill Model
cd ${dirku}/Model/
  sed -i '19 s/ocean.*/'$(awk '{print}' tmp2.txt)' fort.12/' $file2
  sed -i '23 s/product.*/'$(awk '{print}' tmp1.txt)' fort.13/' $file2
  ${dirku}/Model/OilSpill.sh
  rm tmp1.txt tmp2.txt

#Change parameter in Plotting Script
cd ${dirku}/Plot/

  sed -i '17 s|range = .*|range = -R'${l_lon}'/'${u_lon}'/'${l_lat}'/'${u_lat}'|' $file3
  sed -i '22 s/Year = .*/Year = '$mYear'/' $file3
  sed -i '23 s/Mon  = .*/Mon  =   '$mMonth'/' $file3
  sed -i '24 s/Day  = .*/Day  =   '$mDay'/' $file3
  sed -i '25 s/Hour = .*/Hour =   '$mHour'/' $file3
  sed -i '28 s/while( $kt <= .*/while( $kt <= '$fHour' )/' $file3
  sed -i '79 s+echo ".*+echo "'${date_lon}' '${date_lat}' 20 0 4 LT "$datehour | gmt pstext $area $range -
W255/255/255 -C0.03/0.03 -N -O >> $output_file+' $file3

#Plot the incident to map
  ${dirku}/Plot/Oil_Spill_plot.sh
echo "OilSpill Model running successfully"

#end of script
exit
```

APPENDIX E

Auto Run Script (SAR Model)

```
#!/bin/sh
###############################################################################################
#This script will automatically be running SAR Model from input the data to plotting map of the incident
#
#Written by Fakhrur Shukeri at 20 July 2021
#                                                #
###############################################################################################
#
#Copy data to the Data folder
dirku=~/OilSpillModel

#Delete old file
rm ${dirku}/Model/DATA/product*.data
rm ${dirku}/Model/DATA/ocean*.data
rm ${dirku}/Plot/DATA/point/SAR/*.txt
rm ${dirku}/Plot/DATA/Map/SAR/*.ps
rm ${dirku}/Plot/DATA/Map/SAR/*.png

#Copy new wave data
cd ${dirku}/Edit/DATA/FIO/
find -name product*.data -exec cp {} ${dirku}/Model/DATA \; -printf "%f\n" > ${dirku}/Model/tmp1.txt

#Read and assign the date of the incident
cd ${dirku}/Edit/

if [ $1$2$3 ]
then
  file1=SAR_card.text
  file2=SAR.sh
  file3=my.SAR_plot.sh
  DTG=$1$2$3
  ${dirku}/Edit/convert_FIO.sh $1 $2 $3
else
  echo "You must specify the date of the initial FIO meteorology data!"
  echo "example: ./SAR_Auto.sh 2021 07 12 --->for 20210712 FIO Meteorology Data"
  exit
fi

#Input Lat Long Position of Incident
echo "Enter Lat and Long of incident"
read Lat Lon

#Set range of Plotting Map
 l_lat=`expr "$Lat - 0.6" | bc`
 u_lat=`expr "$Lat + 0.6" | bc`
 l_lon=`expr "$Lon - 0.9" | bc`
 u_lon=`expr "$Lon + 0.9" | bc`
 date_lat=`expr "$Lat + 0.49" | bc`
 date_lon=`expr "$Lon + 0.2" | bc`

#Input date and time of incident
echo "Enter the date and time of incident"
read iYear iMonth iDay iHour iMin

#Input initial time wave data
echo "Enter initial time wave data"
read mYear mMonth mDay mHour
```

```
#Input forecast hour
echo "Enter the forecast duration in hour"
read fHour

#Input weight and percentage submerge object
echo "Enter the weight object (kg) and percentage submerge (%)"
read iWeight iSub
iSub_Percent=`expr "scale=1; $iSub / 100" | bc`

#Move processed ocean data to Model folder
find -name ocean$1*.data -exec mv {} ${dirku}/Model/DATA \; -printf "%f\n" > ${dirku}/Model/tmp2.txt

#Change information in SAR card and SAR script
cd ${dirku}/Model/DATA/
  sed -i 's/nhours = .*/nhours = '$fHour', noutput = 1/' $file1
  sed -i 's/year = .*/year = '$iYear', month = '$iMonth', day = '$iDay', hour= '$iHour', minute = '$iMin',/'
$file1
  sed -i 's/ac_lat = .*/ac_lat = '$Lat', ac_lon = '$Lon', ioil = 0/' $file1
  sed -i 's/mass_source = .*/mass_source = '$iWeight', as_ratio = 0'$iSub_Percent'/' $file1

#Execute SAR model
cd ${dirku}/Model/
  sed -i '17 s/ocean.*/'$(awk '{print}' tmp2.txt)' fort.12/' $file2
  sed -i '20 s/product.*/'$(awk '{print}' tmp1.txt)' fort.13/' $file2
  ${dirku}/Model/SAR.sh
  rm tmp1.txt tmp2.txt

#Change parameter in Plotting Script
cd ${dirku}/Plot/
  sed -i '17 s|range = .*|range = -R'${l_lon}'/'${u_lon}'/'${l_lat}'/'${u_lat}'|' $file3
  sed -i '22 s/Year = .*/Year = '$mYear'/' $file3
  sed -i '23 s/Mon  = .*/Mon  =  '$mMonth'/' $file3
  sed -i '24 s/Day  = .*/Day  =  '$mDay'/' $file3
  sed -i '25 s/Hour = .*/Hour =  '$mHour'/' $file3
  sed -i '28 s/while( $kt <= .*/while( $kt <= '$fHour' )/' $file3
  sed -i '78 s+echo ".*+echo "'${date_lon}' '${date_lat}' 20 0 4 LT "'$datehour | gmt pstext $area $range -
W255/255/255 -C0.03/0.03 -N -O >> $output_file+' $file3

#Plotting the map
  ${dirku}/Plot/my.SAR_plot.sh
  ${dirku}/Plot/plot-SAR-maps.sh
echo "SAR Model running successfully"

#end of script
exit
```

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ISBN 978-967-2327-07-3
9 7 8 9 6 7 2 3 2 7 0 7 3