MEDSLIK evolution and recent developments to meet the MEDESS4MS

George Zodiatis and Robin Lardner
Stavros Stylianou, Elena Zhuk, Xenia Panayidou, Dmitry Solovyov and Andreas Nikolaides

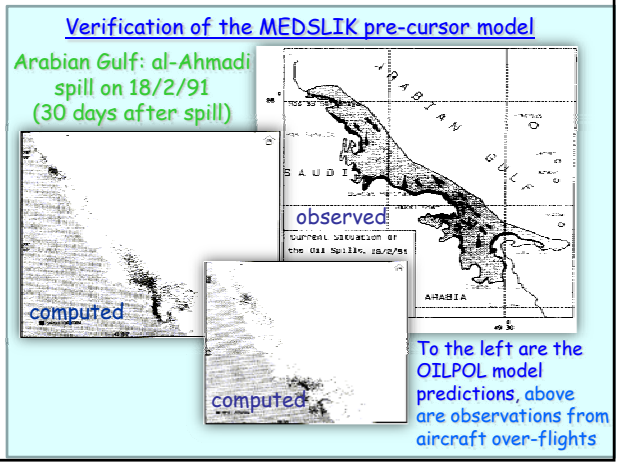
MEDSLIK Pre-cursor

- MEDSLIK fate and slick transport code based on the OILPOL model, which was developed and used during the Gulf War in 1991.

Lardner, R.W., W.J. Lehr, R.J. Fraga, and M.A. Sarhan (1988). Residual currents and pollutant transport in the Arabian Gulf. Appl. Math. Modelling ***12****, pp. 379-390.*

Al Rabeh, A.H., Lardner, R.W., Gunay, N. and Hossain, M. (1995) OILPOL - An oil fate and transport model for the Arabian Gulf. Proc. Fourth Saudi Engng. Conf. (King Abdul-Aziz Univ Press, Jeddah) Vol. V, pp. 415-427.

Verification of the MEDSLIK pre-cursor model



The beginning of the MEDSLIK

The MEDSLIK oil spill model, in pre-operational mode, was first developed in 1997 by Robin Lardner and George Zodiatis, to assist the implementation of the *"Sub-regional contingency plan for preparedness and response to major marine pollution incidents in the Mediterranean"* between the Republic of Cyprus, The Arab Republic of Egypt and the State of Israel, within the frame of a EU LIFE project in 1995-1998, coordinated by REMPEC.

MEDSLIK ...

- for years now is used by agencies throughout the Mediterranean for preparedness and real oil spill, as well for search and rescue operations.

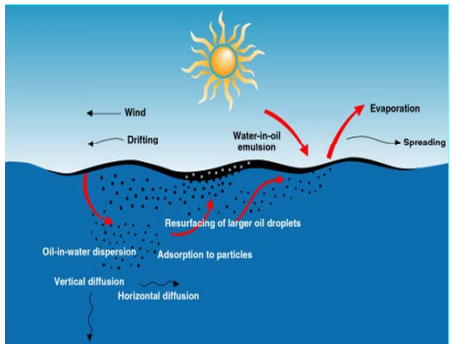
  Currently is used in Cyprus, Malta, Spain, Italy, Israel, Algeria, etc.
- Outside the Mediterranean was used for certain studies in the West Indian and in the China Sea.
  - pre-operationally it is used in the Black and Baltic Seas.
- **It has been used in many EU and other projects such as:** MFSTEP, MERSEA-1, MERSEA-IP, ECOOP, MyOCEAN, PREMARPOL, MEDESS4MS.
- It is coupled with EMSA-CSN and ESA ASAR imageries
  - for 24th forward and backward predictions
  - for supporting the response agencies to implement the EU Directive 2005/35, to identify the ships carrying out illegal oil spills

MEDSLIK general description

- Simplicity of use: MEDSLIK is a user-friendly software package designed not only to predict the transport, fate and weathering of an oil spill, but also to count a number of capabilities related as for example to the design of response, risk assessment, etc.
- Compatibility with PCs : The model runs on PCs or laptops under any version of Windows after Win95.
  Also, the new versions target the LINUX operating system
- Input data: The model following the developments in OO coupled with operational ocean and meteo forecasting data, and satellite oil spill data.

MEDSLIK general description

- MEDSLIK is a 3D oil spill model using a Monte Carlo method. The spill is divided into a large number (up to 500,000) of Lagrangian parcels of equal size. At each time step, each parcel is given a convective and a diffusive displacement.
- MEDSLIK incorporates the fate processes of evaporation, emulsification, viscosity changes, dispersion in water column and coastal impact and adhesion.
- The lighter components of the oil evaporate at a rate dependent on SST and wind speed. Emulsification of the residual component is simulated, and the viscosity changes of the oil are computed according to the amounts of emulsification and evaporation of the oil.



The Mackay et. al. schematic model of fate processes (evaporation, dispersion and emulsification)

In surface spills the evaporation of volatile oil components is a fast process and takes place in a period of hours.

Emulsification is the process of the formation of water-in-oil emulsion, often called "chocolate mousse"

MEDSLIK:parametrization of the transport and fate processes

Slick Transport

- The transport of the surface slick is governed by currents, waves (Stoke's drift) & wind.
- Diffusion of the slick is modelled by a random walk (Monte Carlo) model.
- Oil may be dispersed into the water column by wave action (Mackay & Buist algorithm).
- Dispersed oil is moved by currents only.
- Mechanical spreading of the initial slick is included (modified Fay algorithm).

Fate processes included in the model

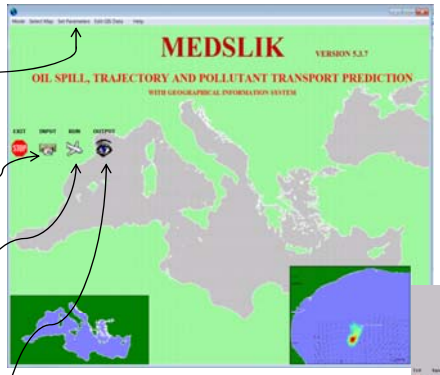
- Evaporation of the lighter oil fractions (Mackay)
- Mixing in the water column by wave action (Buist & Mackay)
- Oil viscosity changes
- Beaching on the coast and absorption depending on the coastal type (Shen, Yapa &Petroski, after Torgrimson)

- **The fate algorithms of the model have received extensive experimental laboratory calibration in the past.**
- **There is a exist an updated manual of 180 pages with the used algorithms, examples and instructions of using the MEDSLIK**

MEDSLIK main modules

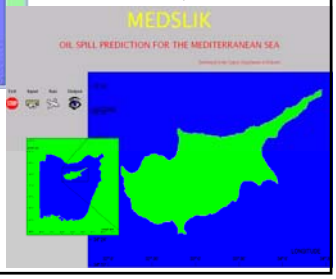
There are 4 major modules

- A setup module for selecting the domain and of the model parameters
- A visual interface for input the spill and met-ocean data, as well initiate response capabilities
- A run module that performs the simulations providing also diagnostics
- A visual interface for viewing the output results.



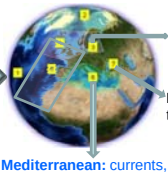
MEDSLIK today's start-up screen, latest version, 5.3.7

MEDSLIK first start-up screen, late 90s



Ocean data forcing for MEDSLIK oil spill and floating objects predictions

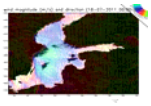
MEDSLIK has been adapted to use the ocean products from MyOCEAN regional forecasting systems, those of the Med, Black and Baltic seas.



Baltic Sea: currents, temperature

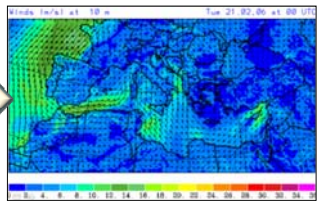
Black Sea: currents, temperature

Mediterranean: currents, temperature

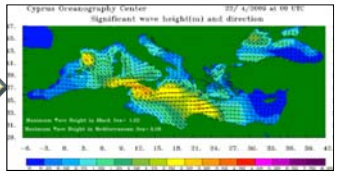


In addition, MEDSLIK has been adapted to use most of the sub-regional and coastal forecasting system of MONGOOS

The SKIRON hourly forecast winds for the Med and Black seas are used in MEDSLIK. The ECMWF and UK met office winds may also be used to cover other European areas.



MEDSLIK uses also the CYCOFOS waves forecasts for estimating the influence of waves to the oil drift; i.e. Stoke's drift in the Med and Black seas.



Major features of MEDSLIK

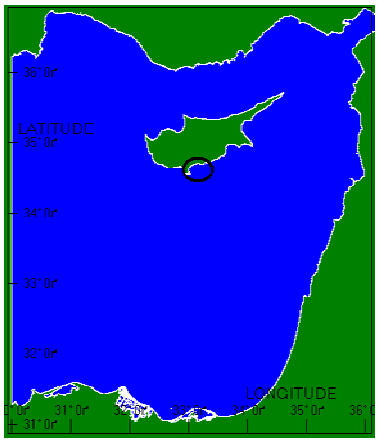
- The model allows to switch from coarse to high resolution forecasting data, when the slick passes from a coarse to a higher resolution domain.
- The model allows assimilation of slick and drifters observations to correct the predictions, if is needed.
- Allows to locate the slick source at any given water depth.
- The effect of deployment of oil booms can be examined.
- Simultaneous oil spills or floating objects from moving or drifting ships can be modelled together.
- Backtracking to identify the source of slicks or floating objects.
- Includes a simple GIS to allow information on resources.
- Integration with AIS-Automatic Identification of Ships

Major features of MEDSLIK (Cont.)

- A transport prediction model for general pollutants is incorporated into the MEDSLIK.
- The Run module has the ability to restart a run that has finished and carry on the simulation for an extended period.
- Ice data form and moving source of oil are incorporated
- The REMPEC db with more than 220 different types of oil parameters is included
- Additional regions can be added by the user to the Select Map menu.
- MEDSLIK adaptation in complicate coastlines, such as for example estuaries and ports
- The user can choose the 'pixel' size to be used for graphing the slick.
- The wind, currents and SST at points along a trajectory can be shown.
- More information on the state of the oil is printed on the output form.
- The beaching algorithm has been modified to provide a reduction in the rate of absorption of beached oil, when the existing loading becomes high.
- A help menu is incorporated

MEDSLIK predictions during real incident

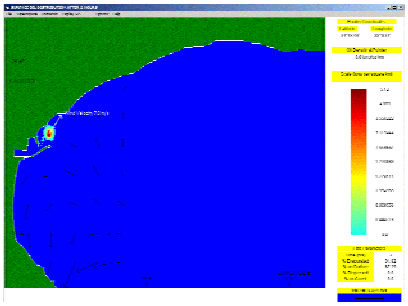
MEDSLIK applications using CYCOFOS and in-situ winds



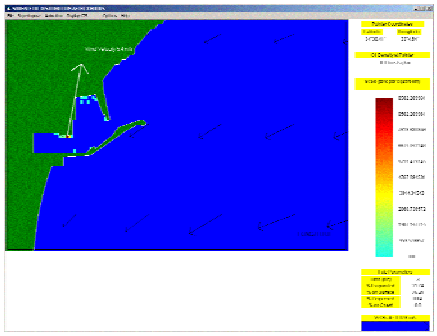
The place of oil spill incident, at 06:00 UTC, 8 May 2004

Preparation of booms deployment in the Limassol port just after the oil spill incident, 8-11 May 2004

MEDSLIK simulations using CYCOFOS forecasts



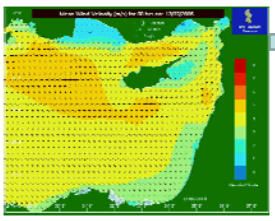
Application#3: after escape of the small portion of the oil spill through the port entrance,
simulations from 08:00h on 10 May to 11:00h on 11 May 2004



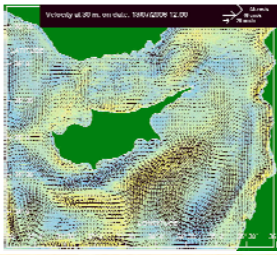
Application#2: after deployment of booms at the port entrance,
simulations from 06:00h on 8 May to 11:00h on 11 May 2004

Lebanese oil pollution crisis, July 2006: Biggest so far oil spill incident in the Eastern Mediterranean.

On July 2006, the oil tanks at Jieh power station, located 30 km south of Beirut and directly on the coast, were hit by bombs. About 15,000 tons of oil was spilt into the sea.
Request from: REMPEC/IMO, European Civil protection agency, etc



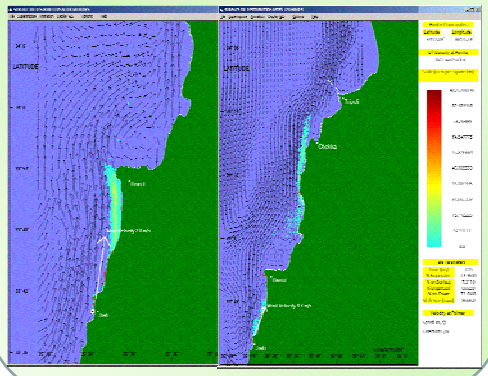
The SKIRON winds during 13 July-10 August 2006. Between Cyprus, Lebanon and Syria the winds were generally southwesterly, with speed up to 5 beaufort.



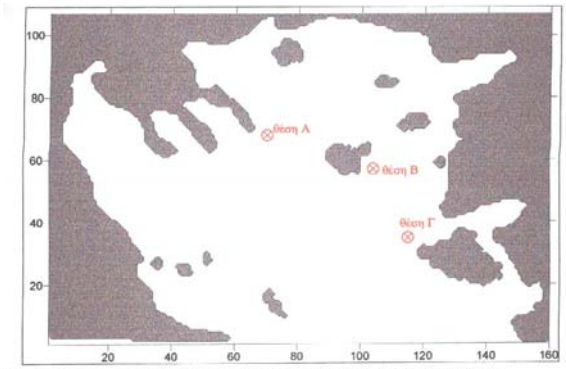
The CYCOFOS currents during 13 July-10 August 2006 along the Lebanese and Syrian coast were directed northwards, with velocities as high as 30 cm/s.

MEDSLIK predicted slick position after

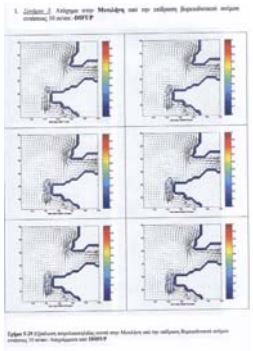
2.5 days & 5 days

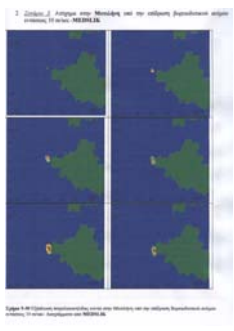


Inter-comparison exercises :
oil spills positions in the North Aegean where MEDSLIK and DIFUP oil spill models were applied (Koftis 2002)



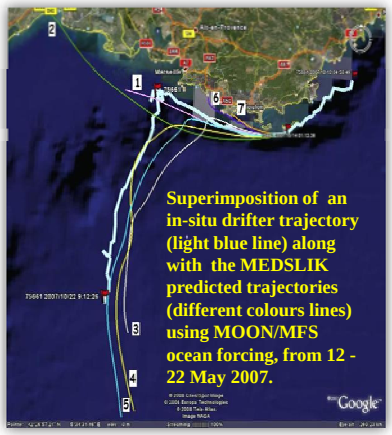
Σχήμα 5-2 Χάρτης της περιοχής με τις τρεις θέσεις εμφάνισης πετρελαιοκηλίδας που εξετάζονται





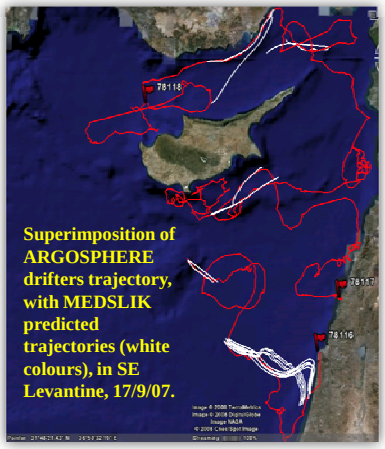
Inter-comparison of MEDSLIK floating objects trajectories predictions with drifters trajectories, Mediterranean, MERSEA-IP

Liguria Sea, south France



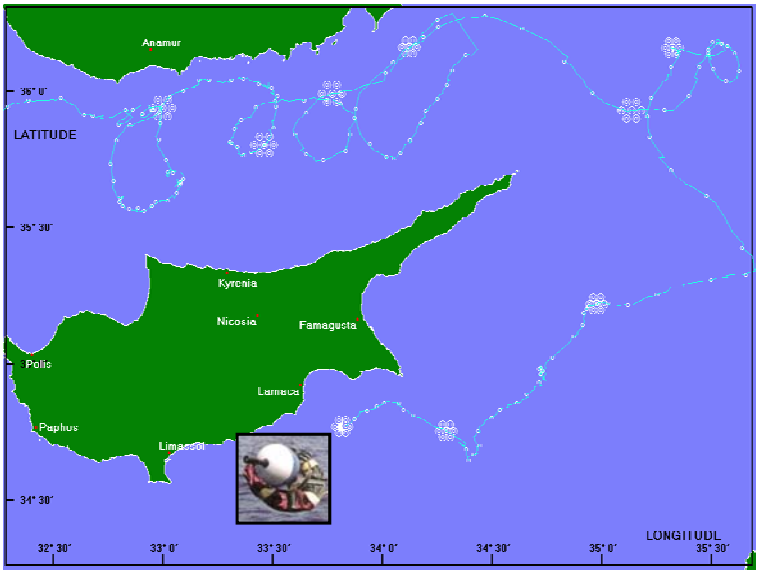
Superimposition of an in-situ drifter trajectory (light blue line) along with the MEDSLIK predicted trajectories (different colours lines) using MOON/MFS ocean forcing, from 12 - 22 May 2007.

Levantine Basin



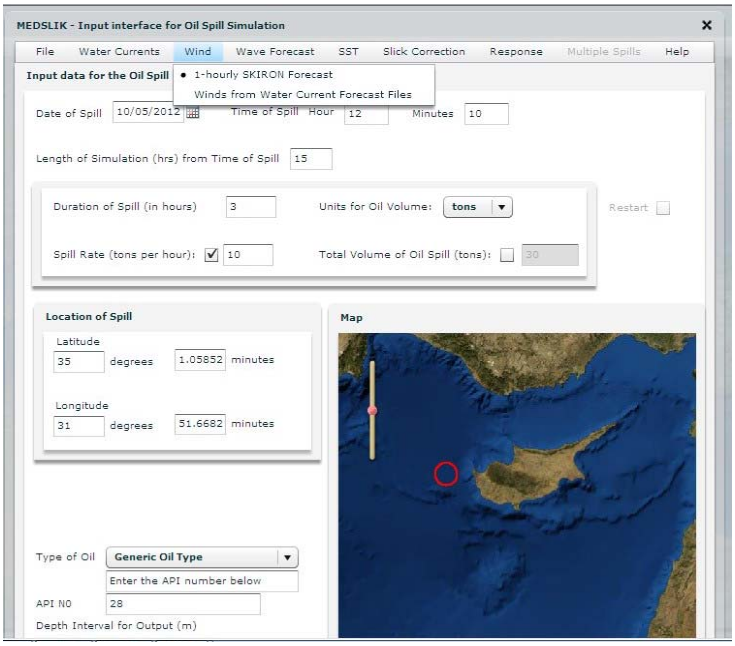
Superimposition of ARGOSPHERE drifters trajectory, with MEDSLIK predicted trajectories (white colours), in SE Levantine, 17/9/07.

Inter-comparison of MEDSLIK multiple virtual floating objects trajectory predictions, using an SVP type drifter, ECOOP project

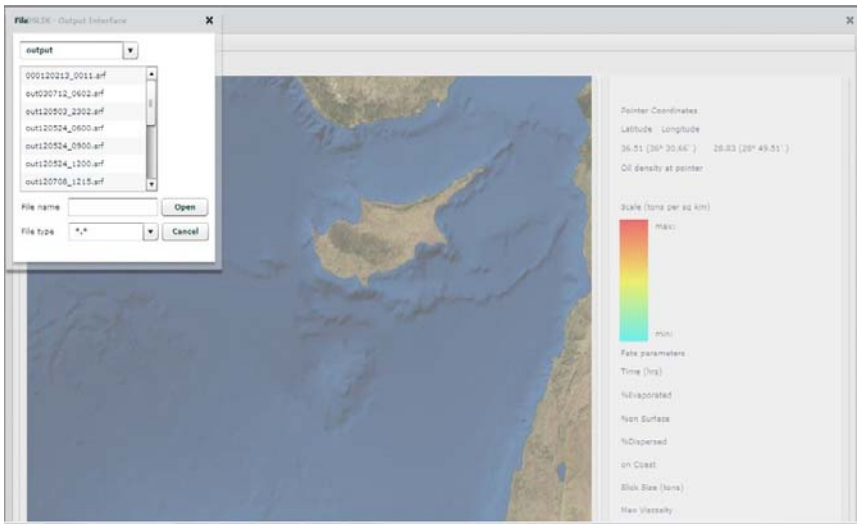


MEDSLIK multiple virtual floating objects 24h predictions, from February – March 2008, NE Levantine, using CYCOFOS forecasts.

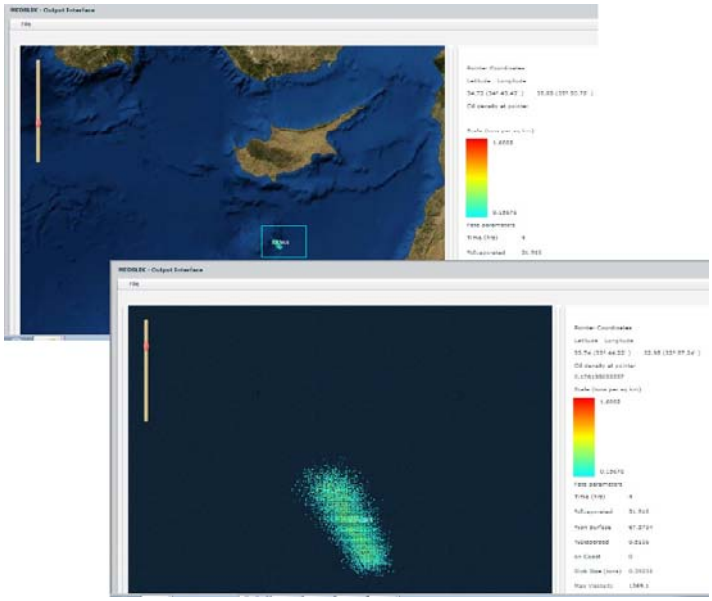
MEDSLIK Online: Input form

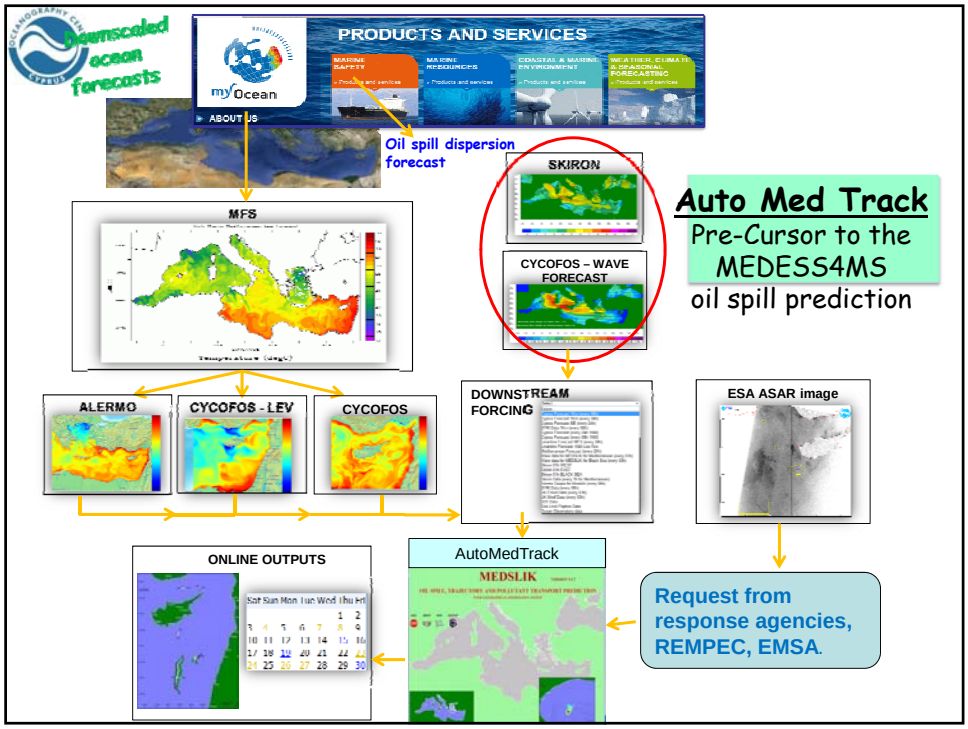


MEDSLIK Online: Output form, selection of files

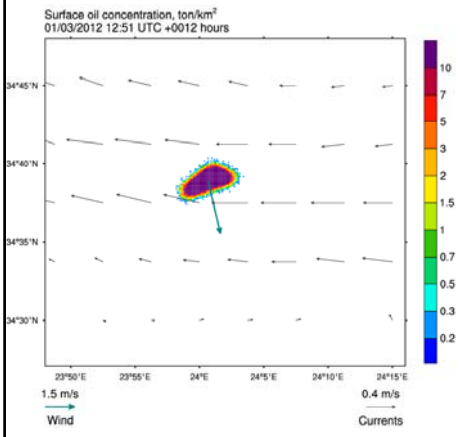


MEDSLIK Online: Output form, visualization of slicks



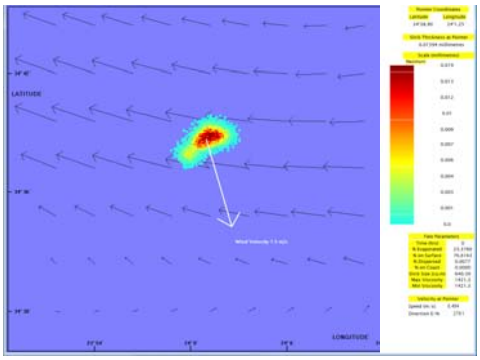


Inter-comparison : MEDSLIK Vs MEDSLIK II



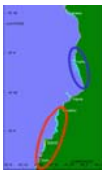
Example of MEDSLIK 5.3.6 oil spill application using MyOCEAN MFS data for oil spill prediction at a position south Cretan island, 1/3/2012.

Example of MEDSLIK-II oil spill application using MYOCEAN MFS data for oil spill prediction at a position south Cretan island, 1/3/2012.

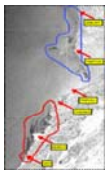


Conclusion

- MEDSLIK is one of the Marine Safety Downstream Systems, not only for Med, that made use of the GMES MyOcean products.
- MEDSLIK is successfully used by several agencies throughout the Mediterranean for preparedness and real oil spill and search and rescue response. The MEDSLIK implementation during the Lebanon oil pollution crisis, in summer 2006, demonstrates the benefit of having an operational downscaled and downstream forecasting system in place.

MEDSLIK 

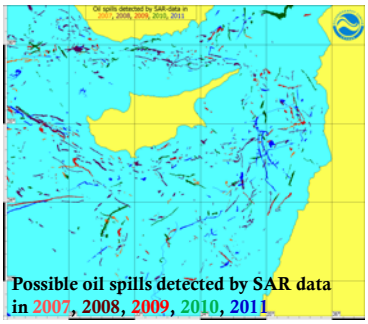
MODIS 

SAR 

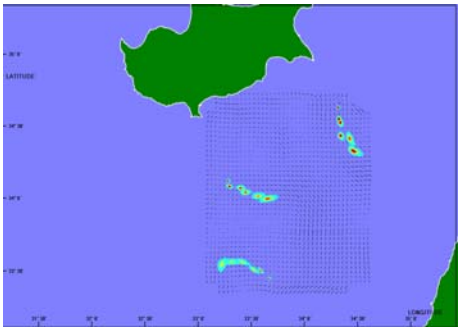
UN map 

- The CYCOFOS/MEDSLIK implementation nowadays made possible to assist the response agencies in the implementation of the EU Directive 2005/35.

Today, the role of the MEDSLIK system becomes important for assisting the response agencies, in view of the hydrocarbon exploration in the EEZ of Cyprus and of the neighboring countries.



Possible oil spills detected by SAR data in 2007, 2008, 2009, 2010, 2011



Risk map assessment from hypothetical oil spills from platforms 2,9,12: oil spill predictions for 18–21/5/12

Ocean Sci. Discuss., 9, 1973–2000, 2012
www.ocean-sci-discuss.net/9/1973/2012/
doi:10.5194/osd-9-1973-2012

Ocean Science Discussions

Predictions for oil slicks detected from satellite images using MyOcean forecasting data

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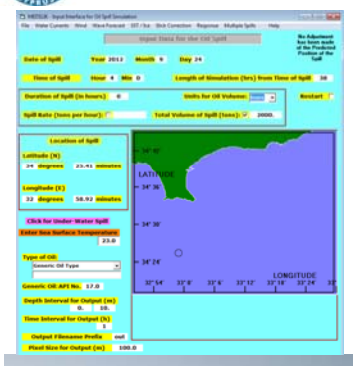
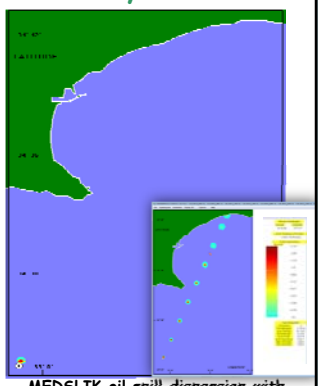
Example of oil booms deployment in the Cyprus coastal zone, Levantine Basin, in MEDSLIK and in reality



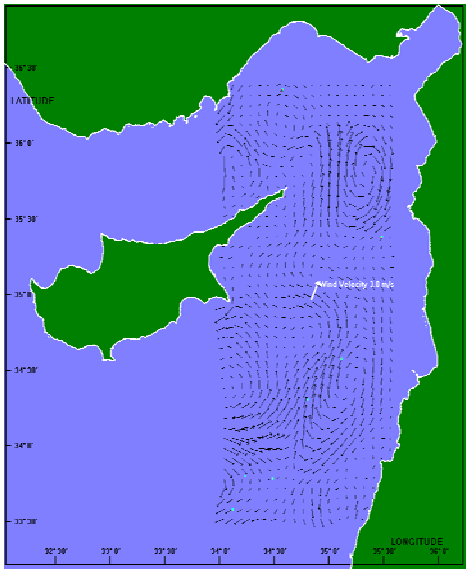
Oil booms location during the national oil pollution response exercice of NIRIIS 2012.

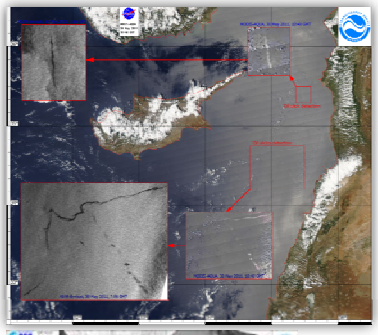
MEDSLIK oil booms location

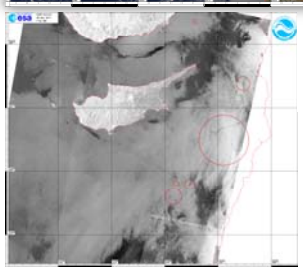


MEDSLIK oil spill dispersion with oil recovery application.

Oil spill predictions from moving or drifting vessel



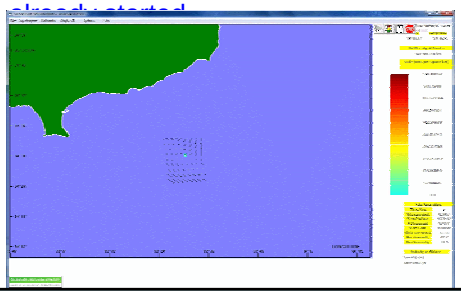


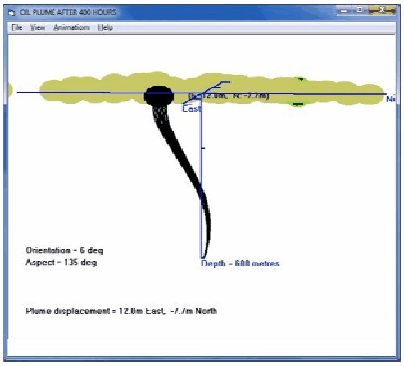


Sub-Surface Oil Spills

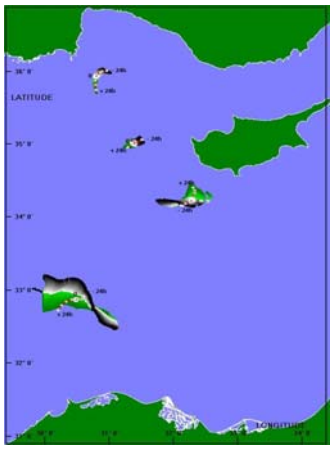
MEDSLIK can model an under-water leakage of oil, for example in the case of a sunken tanker. In such a case most of the oil will remain in a coherent plume as it rises to the surface.

Once the oil reaches the surface it is behave exactly as for a surface spill except for the emulsification that has





MEDSLIK 24h forward & backtracking predictions using ESA images – Eastern Mediterranean

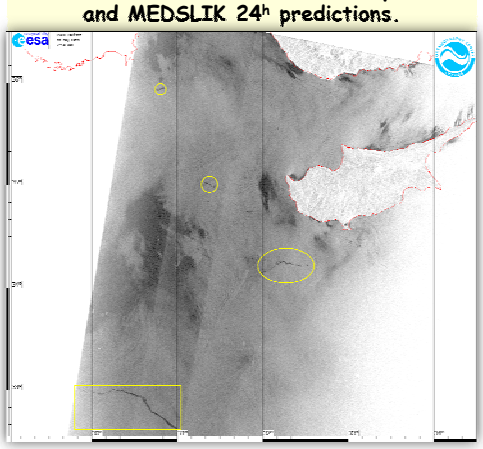


White: initial oil slick position: 0h (date/time of observation)

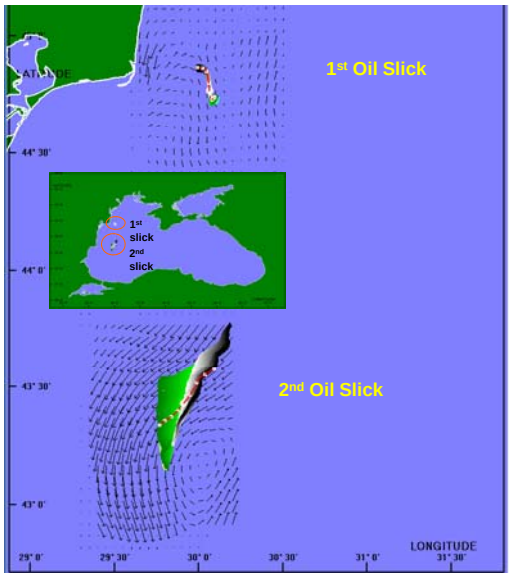
Dark green: forecast +24h

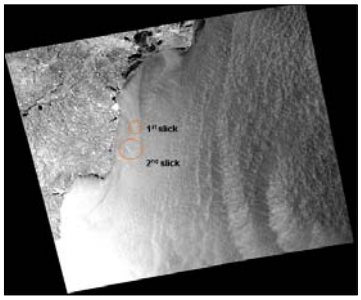
Black: backtracking -24h

ESA oil slicks detection on 19 May 2011 and MEDSLIK 24h predictions.



MEDSLIK 24h forward & backtracking predictions using EMSA CSN images- Black Sea





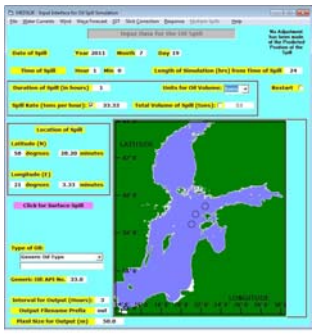
EMSA CSN oil slicks detection on 11th January 2009 and MEDSLIK 24h predictions.

White: initial oil slick position: 0h (date/time of observation)

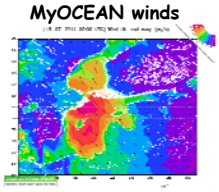
Dark green: forecast +24h

Black: backtracking -24h

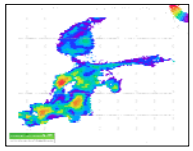
MEDSLIK 24h forward & backtracking predictions using ESA images - Baltic Sea

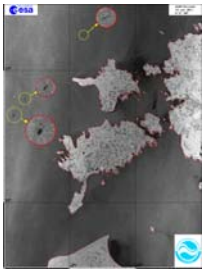


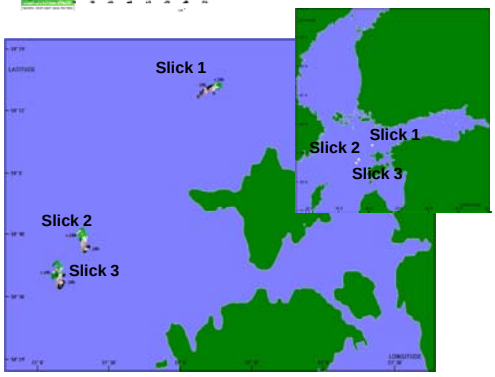
MyOCEAN winds



MyOCEAN currents



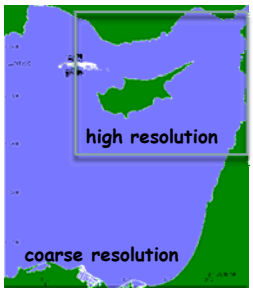


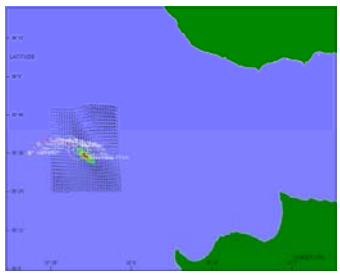


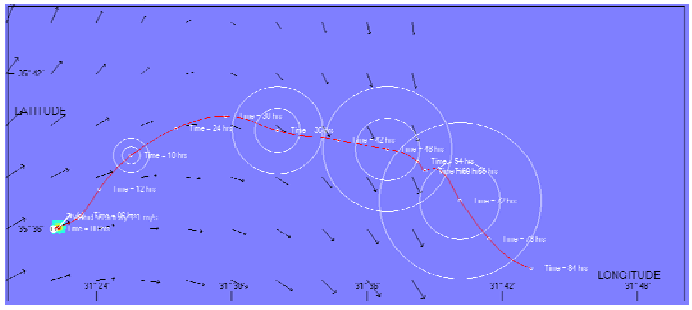
Oil slicks detection on 19 June 2011 using ESA images and MEDSLIK 48hrs F&B oil drift predictions.

Example of MEDSLIK oil spill & floating objects predictions in the Eastern Mediterranean Levantine

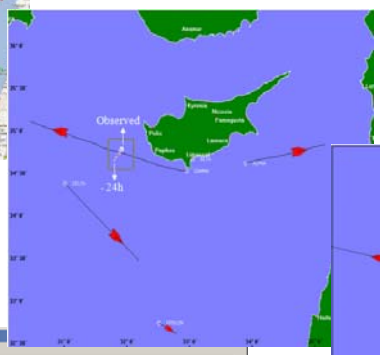
The model allows to switch, while is running, from coarse to high resolution ocean forecasting data, when the oil slick or floating objects passes from a coarse to higher resolution domain.



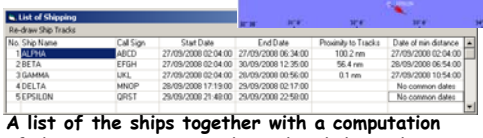




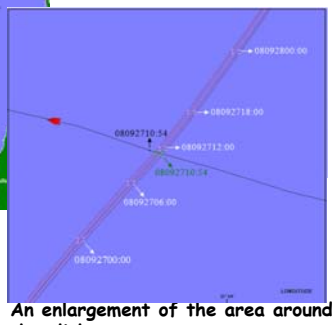
Integration of AIS the with MEDSLIK to assist the agencies to implement the EU Directive 2005/35



Ship tracks on 27 September 2008 together with the hindcast track of a slick observed on the morning of the next day.



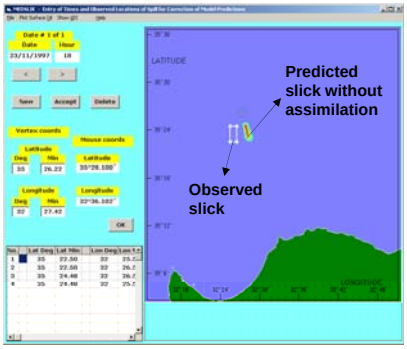
A list of the ships together with a computation of their nearest approach to the slick track.



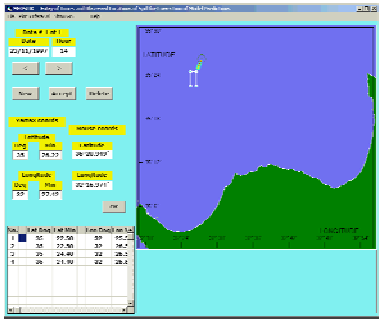
An enlargement of the area around the slick.

Assimilation of observed slick

The predicted slick position can be corrected on the basis of the assimilation of an observation of its actual position.

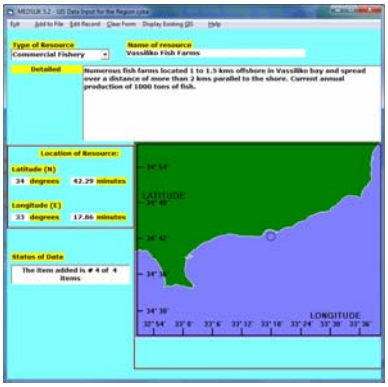


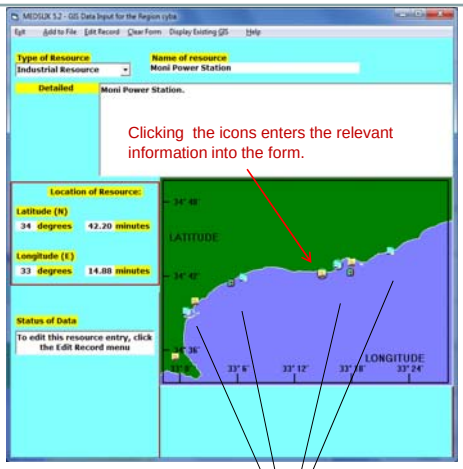
It shows the predicted slick away from the observed slick, the latter is represented by a rectangle.



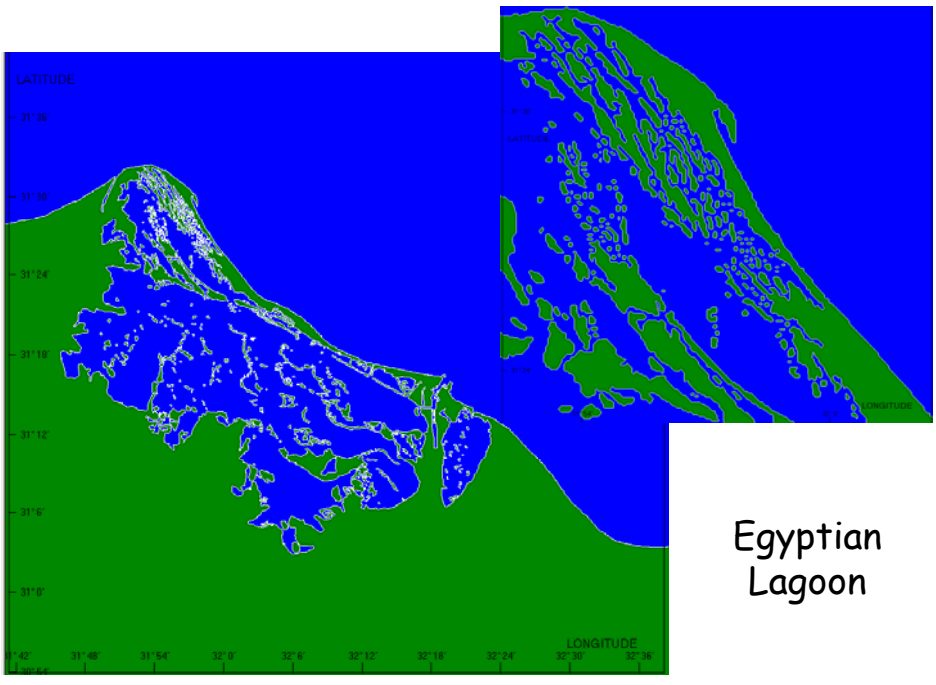
The prediction of the slick is adjusted in order to take into account the assimilation of the observed slick.

MEDSLIK includes a simple GIS that is of useful to the response agencies.



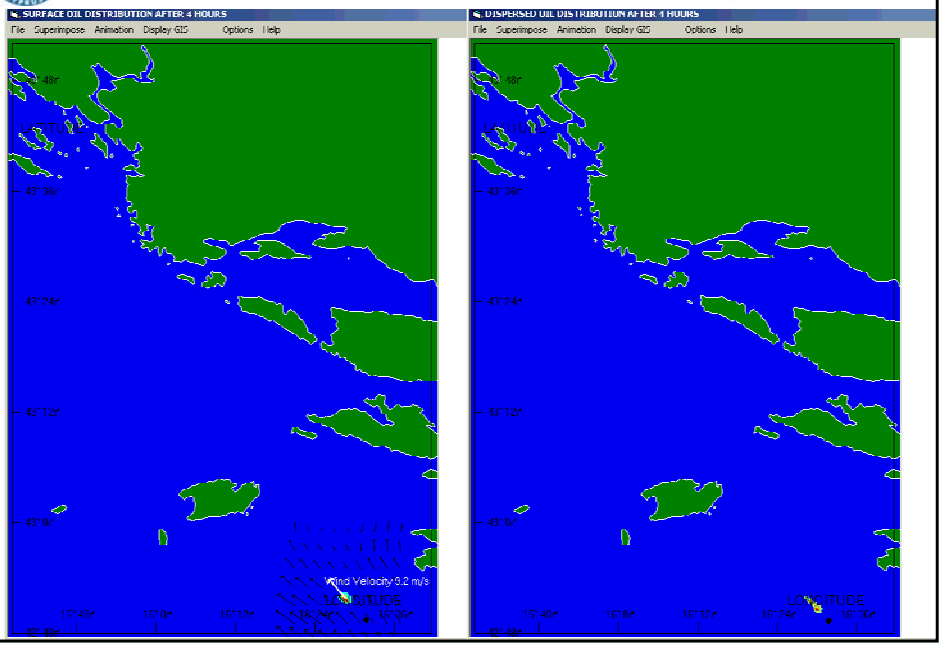


Resources are marked with an icon depending on the type of resource, including relevant information for each of the resources.



Egyptian Lagoon

An example of 60 hours application in the eastern central Adriatic using the November 2004 MFS-ADRICOSM forecasting products



MEDSLIK for oil spill application in the ports and adjacent areas in Gibraltar