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Forecast of oil slick drift from Ulysse/ CSL Virginia and Grande America accidents

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Two recent accidents with a significant oil spill occurred near the French coast. One in the Mediterranean Sea and the other in the Bay of Biscay.

On October 7, 2018, the Tunisian ro-ro vessel Ulysses collided with the Cypriot container ship CSL Virginia at anchor off northern Corsica. The spilled bunker oil could not be fully recovered by the French and Italian anti-pollution vessels due to unfavourable weather conditions. Pellets and highly viscous patties arrived on the beaches of the French Riviera on October 16, 2018. The beaching dates and locations of the main slicks were perfectly predicted using the MOTHY drift model combined with the currents of the CMEMS MED-Currents system.

On March 12, 2019, the merchant ship Grande America sank at a depth of 4600 m, 350 km off the French coast, in the Bay of Biscay. It caused a spill of bunker oil and loss of containers. The MOTHY drift model is used daily during the aerial surveillance and recovery at sea period. It provides drift forecasts for oil slicks and containers up to 3 days in

deterministic mode and up to 10 days in probabilistic mode. Long-term modelling of residual diffused pollution is also carried out, in particular to manage continuous leakage from the wreck. A technical committee of experts meets daily to evaluate drift observations and forecasts. It focuses on the best choices of available ocean models. Drift forecasts did not indicate any oil arrival to the coast. This allowed the authorities to organise the response at sea without mobilising resources ashore. Indeed, no pollution was observed on the coasts.

INTRODUCTION

Two recent maritime accidents have caused oil spills near the French coast. They illustrate a risk of accidental spillage that is always present. While operational spills occur on average every week, they are voluntary and individually small. However, their frequency in certain areas makes them a matter of concern for the authorities. On the other hand, major oil spills from a supertanker producing black waves loaded with oil drifting towards the shore are very rare. The Haven incident (1991) was the only accidental oil spill from shipping that affected the French Mediterranean coastline for the past 45 years (Girin and Daniel, 2017). On the Atlantic coast, spills from the stranding of the Amoco Cadiz (1978) or the wrecks of the Erika (1999) and Prestige (2002) left their mark in people's minds (Daniel et al., 2002, 2004).

Forecasting the movements of oil slicks at sea and the expected location and time of their landing is of crucial importance for the authorities responsible for organising response at sea and protecting the coastline. Oil spill prediction is generally performed using a numerical model to predict the advection and weathering of oil at sea. Although the treatment of these processes can vary considerably from one model to another, they all critically depend on geophysical forcing to determine the fate of the oil spill, particularly its movement implying currents and winds. Oil spill models consider different forcing fields from data on wind, ocean currents, wave energy, Stokes drift, air temperature, water temperature and salinity, turbulent kinetic energy, depending on the settings used by the chosen model. Monitoring, forecasting and, to some extent, detection of marine pollution depends mainly on reliable and timely access to environmental data, observations and predictions products. Due to the quality of the ocean information provided and the simplicity of access to information, the observations and forecasts produced by the Copernicus Marine Environment Monitoring Service (CMEMS) service perfectly meet this need. Meteo-France, the French national meteorological service, provides its expertise for atmospheric data.

In the event of accidental marine pollution, Meteo-France has the obligation to implement, in conjunction with Cedre, pollutant drift forecasts and to provide the necessary human expertise for their interpretation. Meteo-France then activates its MOTHY drift model. Cedre can also activate the OILMAP drift model.

MOTHY is a comprehensive 3D model that tracks oil slicks on the water surface and in the water column. It has a unique feature with a system combining an integrated hydrodynamic model that calculates the high-frequency components of the current from wind and tidal data with a sophisticated Ekman-type scheme and the low-frequency currents of operational oceanography systems (Daniel et al., 2005). The first version of MOTHY was delivered 25 years ago (Daniel, 1996). The latest version, MOTHY v4, incorporates major updates consolidated by the experience of real events such as the Erika and Prestige oil spills in the Bay of Biscay.

OILMAP is a comprehensive model that tracks various hydrocarbon components at the water surface, in the water column and in the air. The first version of OILMAP was delivered more than 20 years ago (Spaulding et al., 1992). It is one of the main business models used worldwide by major oil companies and public institutions. The latest version, OILMAP v7 incorporates major updates to include new algorithms, consolidated by the experience of real events such as the Deep Water Horizon oil spill in the Gulf of Mexico (French McCay et al., 2016). The "trajectory" module is generally activated with the following settings: 3.5% of the wind speed of the atmospheric model and 100% of the surface current of the ocean model.

ULYSSE/ CSL VIRGINIA ACCIDENT

On the morning of October 7, 2018, the Tunisian ro-ro vessel Ulysses collided with the Cypriot container ship CSL Virginia. At the time of the incident, Ulysses was operating between Genoa and the Tunisian port of Rades, while the container ship was anchored approximately 28 km north of Corsica in the open sea. The bow of the Ulysses crashed into the starboard side of the container ship, causing a breach of several metres in the tanks of the CSL Virginia (figure 1). Bunker oil immediately escaped. The weather was mild, with little wind and waves and good visibility. The tug Abeille Flandre joined the two ships on the afternoon of October 7. The Jason ship equipped with all its pollution control equipment joined the area in the evening. At that time, the pollution extended over approximately 25 km, forming 7 distinct slicks. On the same day, the RAMOGEPOL agreement between France, Monaco and Italy in the event of maritime pollution was activated by the Maritime Prefect, and in the evening, response operations at sea began. An expert from Cedre was on site.

On October 8, a French ship and 3 Italian ships arrived to the area to complete the system. Maritime overflights carried out on the 8th and 9th by a French Navy aircraft to locate and assess the extent of the pollution, helping to recover fuel oil at sea by French and Italian ships. On October 9, the Brezzamare, an EMSA (European Maritime Safety Agency) vessel, came to reinforce response operations at sea.

Attempts to separate Ulysses from CSL Virginia were made on October 9. They successfully ended on the evening of October 11. On October 12, Ulysses, having obtained the agreement of its shipowner, left for a Tunisian port. The CSL Virginia remained at anchor surrounded by a pollution barrier. The Maritime Prefect ordered the anti-pollution vessels remaining in the area to pump the oil remaining at sea, assisted by air assets to locate the pollution slicks. On October 24, once the oil had been pumped out of the tanks and the double hull, the CSL Virginia was able to navigate towards the port of Constanta in Romania, escorted by the Abeille Flandre.

On October 13, the pollution at sea gradually moved northwards. French and Italian resources focused on recovering the slicks closest to the coast. Favourable weather conditions ensured the effectiveness of pollution control measures, i.e. recovery of the pollutant by pumping and trawling of the pellets formed at sea. On October 14, pollution recovery was facilitated by surveillance aircraft flights. As a result, the 12 anti-pollution vessels recovered more than 1,000 m3 of a mixture of hydrocarbons and seawater. Experts estimated that about 30% had evaporated or been absorbed by the environment. Response at sea then focused on trawling the oil pellets closest to the coast. On October 15, the weather being particularly unfavourable, only Jason vessel was able to carry out recovery operations at sea. On October 16, as the deterioration of the weather worsened, no response operations could be carried out.

On October 16, in the early afternoon, the first oil arrivals (in the form of pellets and highly viscous patties) were observed on the French Riviera. The Prefect of the Var then launched the POLMAR-Terre plan to coordinate the clean-up activities of the affected coasts and set up a crisis unit. In this context, they called on Cedre's expertise, which sent two experts to the site to assess the situation and elaborate an action plan to clean up the coastline effectively while respecting the environment. The next day, all polluted beaches were closed to the public while clean-up operations were organized: transporting equipment, setting up technical teams and an action plan. As the weather conditions were still not very favourable for the recovery of the pollutant at sea, only the Jason continued to fight at sea.

On October 18, land-based control operations began: collection of pellets, patties and small plates of fuel oil often mixed with Posidonia (aquatic plants) on beaches. On October 25, by the end of the day, pollution had impacted 49 beaches. Beach clean-up was carried out by 150 public actors. The private sector was also involved in beach clean-up through Le Floch Dépollution, a company employing 200 people.

Some 530 m3 of bunker oil escaped from the container ship, causing significant mobilization at sea: more than 500 people were engaged on land, at sea and in the air. More than 96,000 cumulative working hours, 34 French and Italian ships, 11 French and Italian aircraft (helicopters, planes and drones) were needed.

MANAGEMENT OF OIL SLICK DRIFT PREDICTIONS FOR ULYSSE/ CSL VIRGINIA ACCIDENT

At the request of the authorities in charge of accidental marine pollution, the National Forecast Center of Meteo-France was requested to provide meteorological support and drift forecasts. As usual in this type of situation, the response was made in close contact with Cedre. Indeed, accurate information on the nature and location of pollutants is essential for good predictions. The MOTHY model was used daily during the aerial surveillance and recovery at sea period. In the first few days, good visibility and a calm sea state allowed numerous observations to be made, which validated the predictions of a northeastward shift of the oil slicks. In this region, the Mediterranean Sea, the environmental forcings were easy to choose. For currents, the CMEMS MED-Currents model (Clementi et al., 2019) is a reference model and its relevance has been demonstrated in many previous cases. For winds, the expertise of the marine forecaster is essential. Depending on the situation, he can choose between the AROME and ARPEGE models of Meteo-France or the IFS model of the European Centre for Medium-Range Weather Forecasts (ECMWF).

When weather conditions deteriorated, monitoring oil slicks was more difficult due to a lack of observations. But the grounding of the oil slicks on the peninsula of Saint Tropez (French Riviera) was forecasted two days in advance (figure 2).

GRANDE AMERICA ACCIDENT

On March 10, 2019, the Grande America ship, operating from Hamburg (Germany) to Casablanca (Morocco), was about 260 km off the French coast, when a fire broke out on board. The vessel carried 365 deck containers, 45 of which contained dangerous goods and 2,000 vehicles (cars, trucks, trailers, construction machinery) on its car decks. The MRCC (CROSS Étel) was informed of the situation and shortly before midnight, the ship's captain informed the maritime authorities that the situation on board had deteriorated. The Maritime Prefect of the Atlantic gave the order to the high seas tug Abeille Bourbon to reach the area where the Grande America was located. Meanwhile, at about 2 a.m., the captain abandoned the ship with 25 crew members and a passenger who was on board. They boarded a lifeboat under bad weather conditions. Coordinated by the MRCC, the British vessel HMS Argyll, came to rescue the 27 people, all were rescued.

On March 11, around 10 a.m., the Abeille Bourbon arrived on site and began fighting the raging fire. The Maritime Prefect of the Atlantic gave notice to the shipowner Grimaldi Group to take all necessary measures to put an end to the danger posed by the Grande America in the French Exclusive Economic Zone. As part of the assistance to a ship in difficulty, the Maritime Prefect decided to move to a higher level of alert, in particular with the setting up of a crisis management team in which Cedre was involved.

On March 12, at around 3.30 pm, the ship sank at a depth of 4,600 m, 350 km from the French coast with about 2200 tonnes of bunker oil on board.

On March 13, an oil slick, about ten kilometres long and one kilometre wide, was located by the maritime patrol aircraft. The Maritime Prefect of the Atlantic ordered the Argonaute vessel to reach the area of the shipwreck and start anti-pollution operations.

On March 14, an observation flight by the French Navy surveillance aircraft revealed two distinct slicks. One, approximately 13 km long by 7 km wide, was above the wreckage, the other, approximately 9 km long by 7 km wide, seemed less compact than the first. These were about 20 kilometres apart. Due to bad weather conditions, anti-pollution means could not be used. Daily flights were carried out by the French Navy to monitor the evolution of the pollution. The European Maritime Safety Agency (EMSA), at the request of the Maritime Prefect, provided support for satellite monitoring in order to identify possible pollution slicks at sea. The Drift Committee, a technical committee bringing together experts in meteorology, oceanography, oil behaviour and pollution control from Cedre, Meteo-France, Ifremer and Shom, started to meet. The Drift Committee is responsible for providing the maritime authorities with consistent and relevant information on oil drift, observations and forecasts on a daily basis.

On March 15, weather conditions were still very bad, so the two oil slicks spotted on the 14th could not be relocated by aerial observations. A new slick was found near the wreck, 4.5 km long by 500 metres wide, with a compact appearance, confirming the leak of oil from the wreck. Despite the sea state, anti-pollution operations began in the afternoon, with 3 ships of the French Navy and one ship chartered by EMSA. Two floating containers, one about 30 km from the northeast of Grande America, the other 90 km to the east, were observed and the shipowner was responsible for their recovery. The Biscaye Plan was activated and as part of this France-Spain cooperation, a Spanish tugboat equipped with anti-pollution equipment would arrive in a few days. Bunker fuel samples are analysed in Cedre's Polludrome® to determine the weathering of this pollutant. The aim is to define a suitable control strategy at sea, as well as on land if pollution were to arrive on the coast.

On March 16 and 17, the weather conditions were bad with waves of 4 metres and a wind of 35 knots. Despite these conditions, response operations at sea continued. The system of ships in the area was completed by the tug TSM Kermor, chartered by the Atlantic Maritime Prefecture. The aerial observations carried out by the French Navy's Falcon 50 maritime surveillance aircraft still confirmed the presence of an oil leak located above the wreckage.

On March 18, weather conditions began to improve, and response operations continued with the installation of floating booms and trawls. In the wreckage area, an iridescence with heavy fuel oil piles was visible on the surface. The oil slicks identified at the beginning of the sinking drifted to the south-east. The shipowner, having chartered a tugboat, retrieved a floating container and towed it to La Rochelle. The shipowner would also recover one of the two survival boats, drifting about 35 km from the shoreline.

From March 19 to 23, good weather conditions allowed the pollution control system to deploy booms, contain and pump the pollutant. The first area was located above the sinking point of the Grande America, where a continuous leak, rising from the wreck, spread~~s~~ to the sea surface. The joint work of the various vessels in the area, three French tugboats assisted by the Argonaute and two Spanish tugboats, was effective. The second area concerned the initial pollution that drifted to the south-east of the sinking point. Recovery work was facilitated by aerial observation flights. Two French response vessels were engaged to recover the pollutant that forms small slicks scattered on the sea surface. Fuel oil formed small clusters on the sea surface (size between 50 and 100 cm) and sheen. Several floating containers containing food products and inflatable boats were spotted and recovered by the shipowner. The drift committee confirmed that the risk of coastal pollution could not be excluded in the long term, but the 10-day drift forecasts excluded any arrival at the coast.

In the last week of March, smaller quantities of pollutant were processed by ships. They mainly concerned those that continued to rise and to be observed above the wreck.

At the beginning of April, pollution control entered a new phase. From an emergency, the situation had evolved into a more vigilant and long-term management. For several days, despite good sea conditions and visibility in the Bay of Biscay, satellite and aerial observations had not been able to locate any significant pollution in the areas of the forward front. This did not mean that these small pollution areas had completely disappeared, but they could no longer be treated. Above the wreck, small amounts of pollutant continued to rise and were treated. The drift committee has stopped meeting since April 2 but continues to monitor the situation. The risk of pellets arriving on the French coast is not excluded, but a massive arrival is now ruled out.

MANAGEMENT OF OIL SLICK DRIFT PREDICTIONS FOR GRANDE AMERICA ACCIDENT

Forecasts of oil slick drifts using the MOTHY model were carried out by Meteo-France from March 12, at the request of the authorities. From March 14, the Drift Committee, a technical committee bringing together experts in meteorology, oceanography, oil behaviour and pollution control from Cedre, Meteo-France, Ifremer and Shom, started to meet. The Drift Committee was responsible for providing the maritime authorities with consistent and relevant information on oil drift, observations and forecasts on a daily basis (figure 3).

The MOTHY model is used daily during the aerial surveillance and recovery at sea period. It provides drift forecasts for oil slicks and containers up to 3 days in deterministic mode with the ARPEGE atmospheric model and up to 10 days in probabilistic mode with the 50 scenarios of the ECMWF ensemble forecast (figure 4). Long-term modelling of residual diffused pollution was also carried out over several months, specially to manage continuous leaks from the wreck (figure 5).

The MOTHY model used the currents from both systems that were immediately available: the operational Mercator global ocean analysis and forecast system at 1/12 degree (Drevillon et al., 2008) and the operational IBI (Iberian Biscay Irish) ocean analysis and forecast system at 1/36 degree (Sotillo et al., 2015).

Seven Self-locating datum marker buoys (SLDMB) were dropped near the oil slicks. They are drifting surface buoys designed to measure surface ocean currents. SLDMB is based on the Davis-style drifter design, which attempts to minimize the effects of wind and surface waves by reducing the surface above the ocean surface to small floats and an antenna. Below the surface is a series of drogue vanes up to 70 cm long that capture the ocean current. An antenna receives the GPS signal and transmits the location to the authorities. These buoys were very useful in assessing the quality of the operational oceanography systems used. Over time, their trajectories diverged from the trajectory of oil slicks, the latter being more sensitive to wind.

Significant discrepancies were found between ocean models. Finally, the drift predictions closest to the observations were obtained with the currents provided by the ocean model of lower resolution (figure 6). This shows the importance of having several ocean models and the difficulty of using high-resolution ocean forecasts that generate many eddies whose precise location is sometimes difficult to model.

Due to the distance to the coast and variable wind regimes, 10-day drift forecasts did not indicate any oil arrival at the coast. The drift committee was able to confirm that the risk of coastal pollution could not be excluded in the long term, but that there was no risk in the medium term. This allowed the authorities to organise the response at sea without mobilising resources ashore. Indeed, no pollution has been observed on the coasts.

CONCLUSIONS

These two accidents illustrate the response provided to the authorities in terms of drift prediction, difficulties and successes. They highlight the main challenge for data providers in the future, namely improving the accuracy of current forecasts. Therefore, international collaboration should continue to consolidate work on validation measurements and model comparisons. It is particularly necessary to include spatially explicit estimates of uncertainty, both for forcing data and for the results of the oil spill model. From this point of view, ensemble forecasting is a very promising research area for quantifying the uncertainties inherent to drift prediction at sea. It should be further studied. Products should be delivered to users efficiently and should be provided with adequate spatial and temporal resolution. The interaction between users and production must be an important criterion for future developments.

FIGURES

Figure 1: a breach of several metres in the tanks of the CSL Virginia

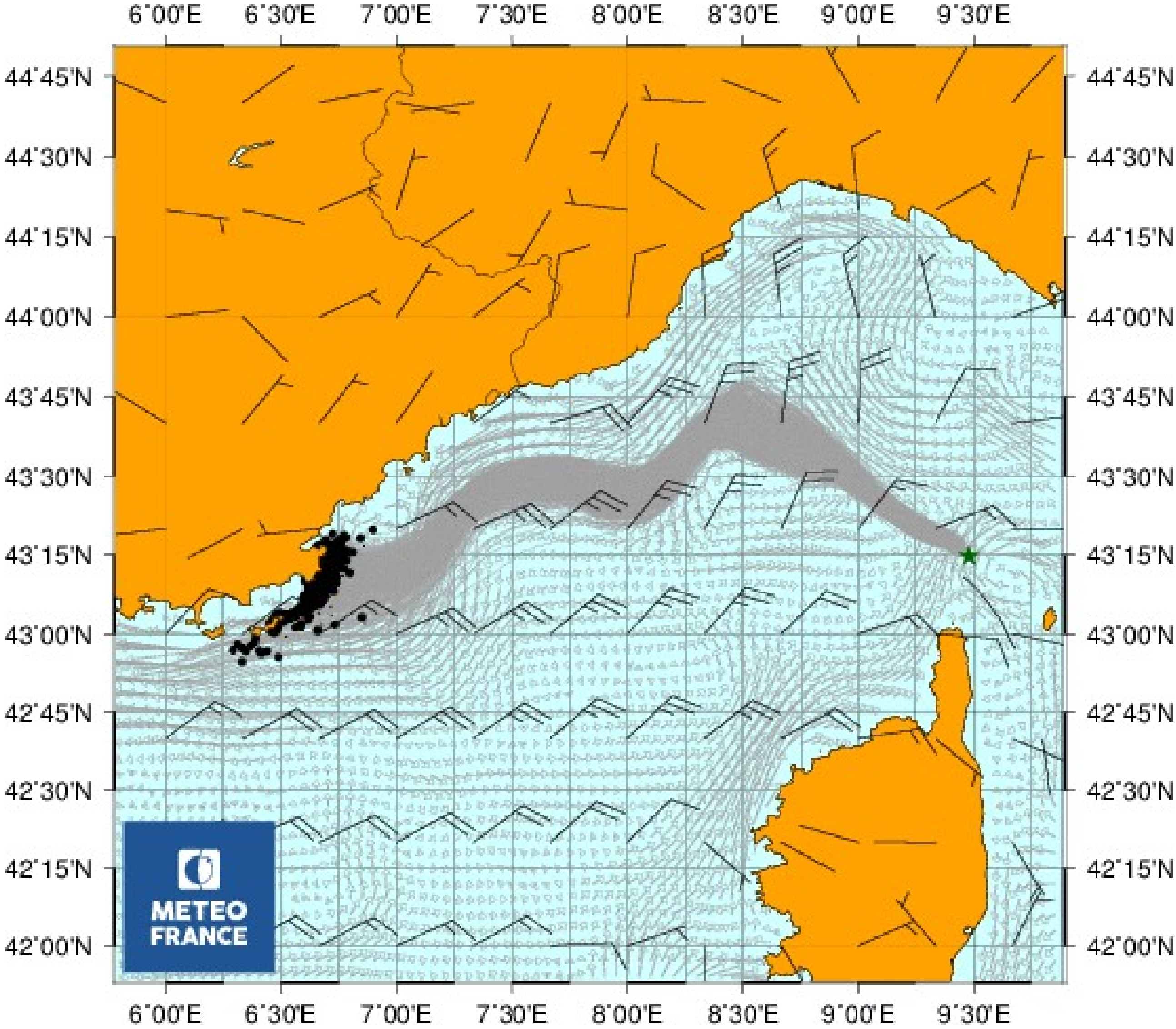

Figure 2 : MOTHY output from a simulated 10 day drift from the Ulysse/CSL Virginia accident (dark green star north of Corsica). Particle tracks : in grey using ocean current data from the operational CMEMS MED-Currents ocean analysis and forecast system at 1/24 degree and ARPEGE winds at 1/10 degree. Particle landing in black on the Saint Tropez peninsula (French Riviera).

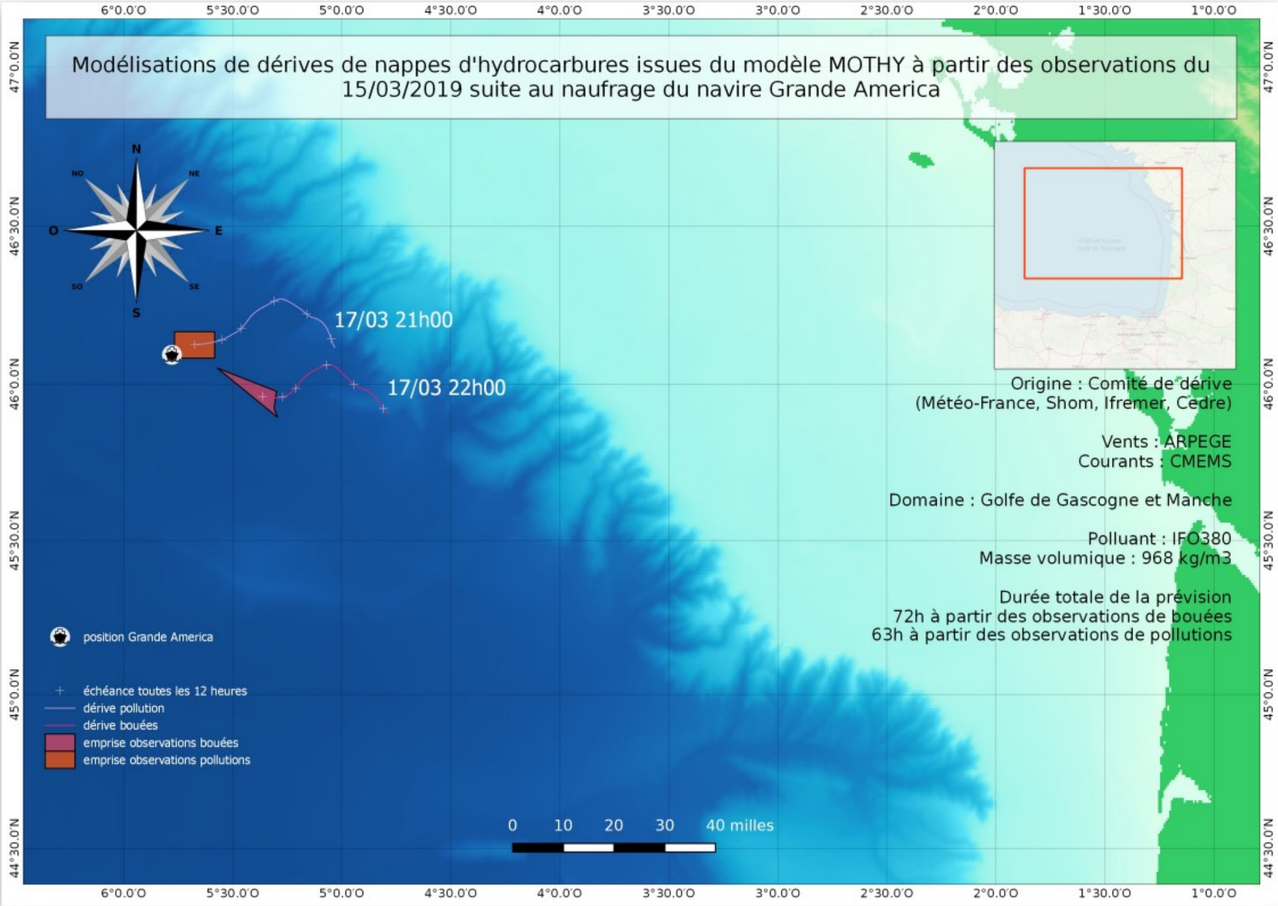

Figure 3 : Example of summary chart produced by the Drift Committee indicating the observed position of the oil slicks and their expected position 3 days later.

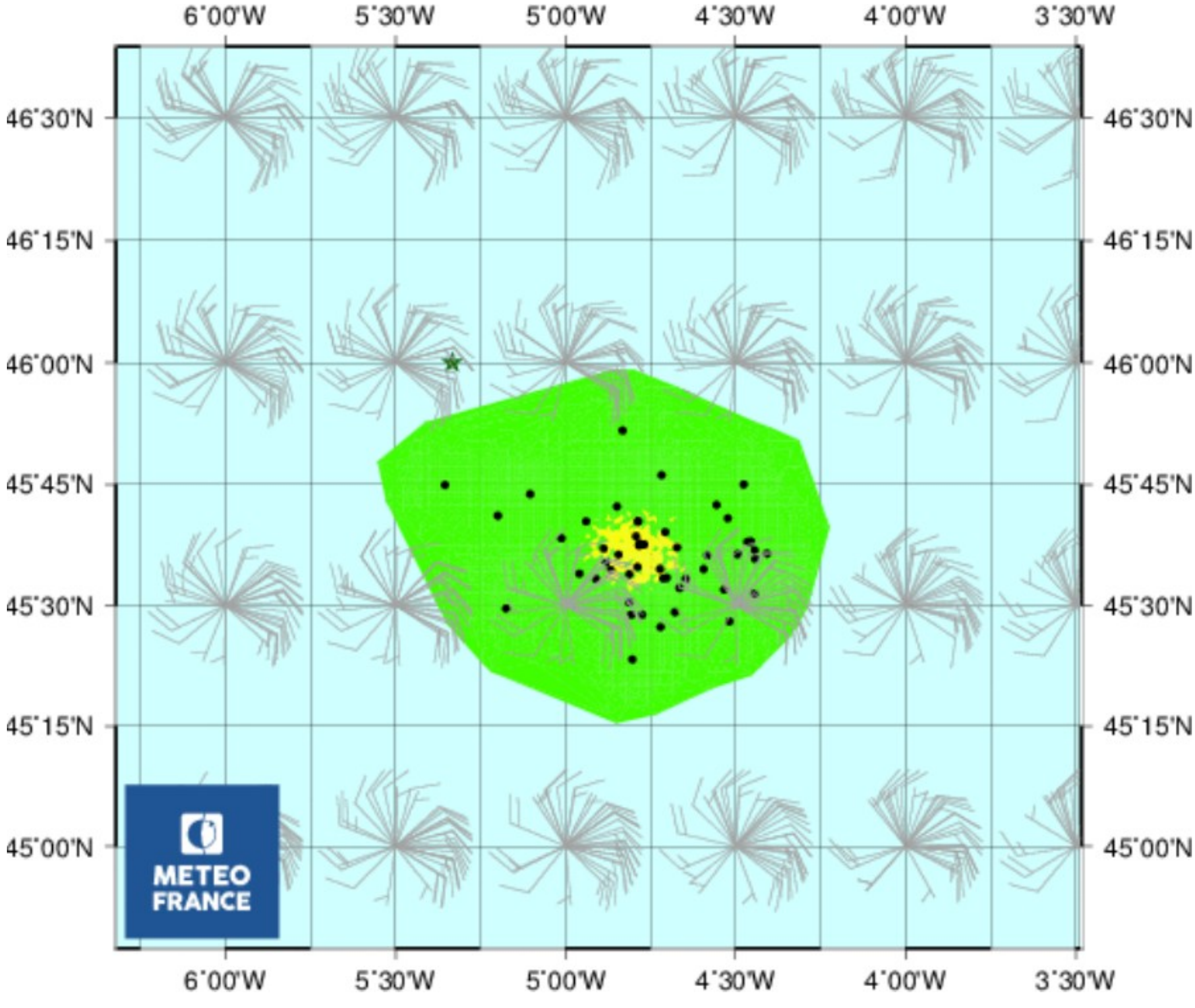

Figure 4 : 10-day ensemble forecast, using the 50 scenarios of the ECMWF ensemble forecast, showing a general drift to the southeast with wide dispersion. The black spots are the barycenters of the oil slick heads. At least 1 scenario forecasts oil on the green zone. More than 25% of the scenarios predict oil in the yellow zone. The wind barbs confirm the dispersion at this time.

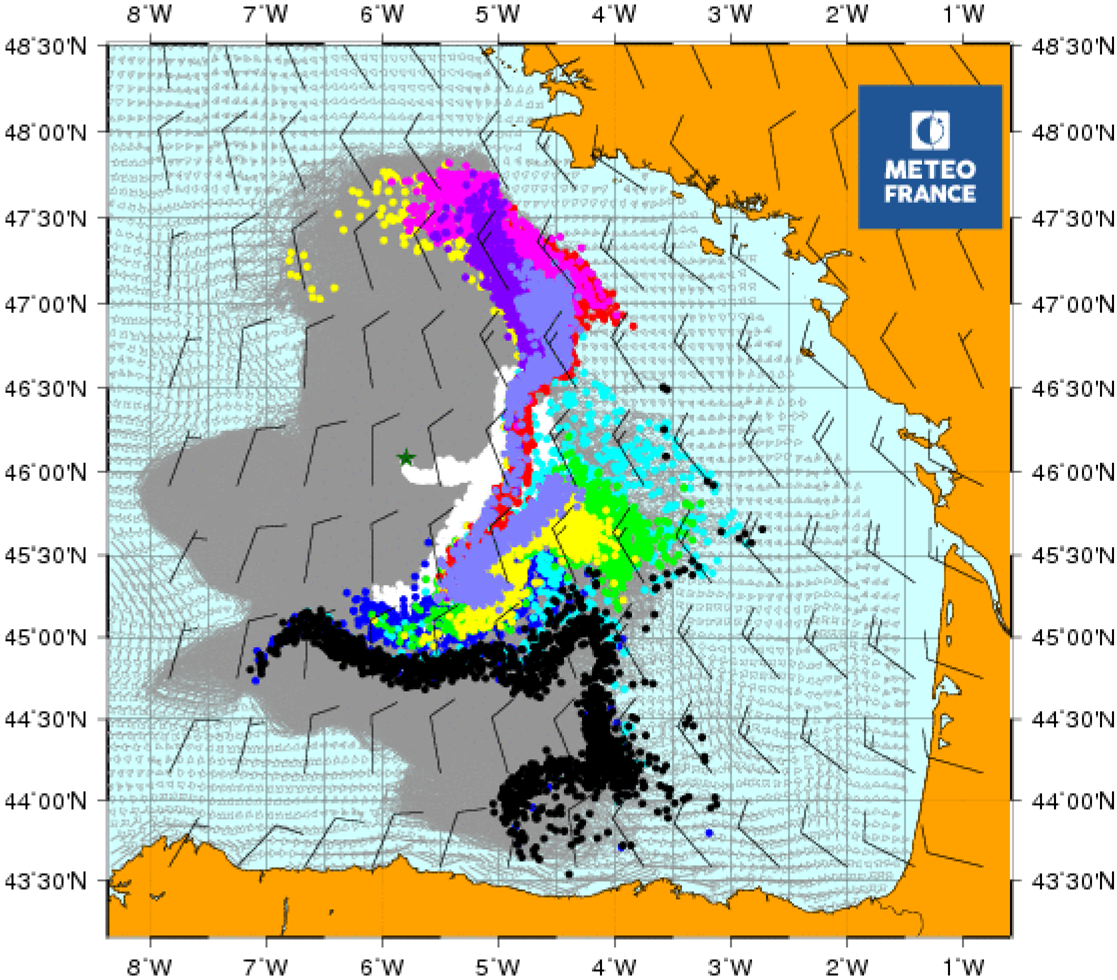

Figure 5 : MOTHY output from a simulated 2 month-leak from the Grande America wreck (dark green star near 46°N-6°W). The black spots are the oil released on the day of the accident. The colour dots are the oil released during the 35 days of continuous leakage from the wreck. The white dots represent a potential risk after the leaks have been sealed. In grey, the trajectories where the oil has been during the 2 months. Ocean current data are from the operational Mercator global ocean analysis and forecast system.Wind data are from ARPEGE model.

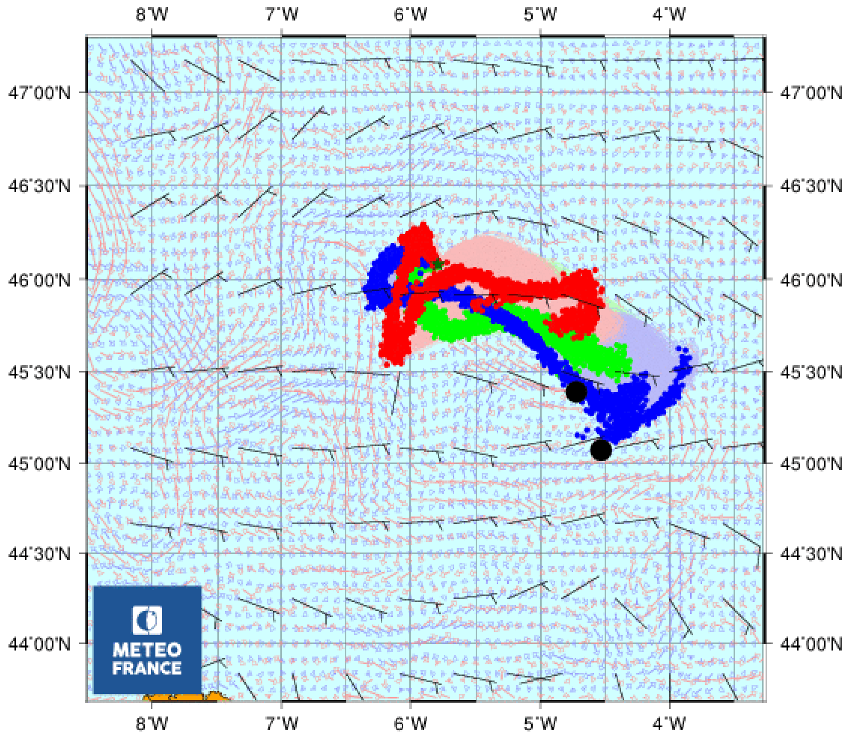

Figure 6 : MOTHY output from a simulated 10 day-leak from the Grande America wreck (dark green star near 46°N-6°W). Black disks are aerial observations. Particle drift: green, without ocean current data, red, using ocean current data from the operational IBI (Iberian Biscay Irish) Ocean Analysis and Forecasting system at 1/36 degree, blue, using ocean current data from the operational Mercator global ocean analysis and forecast system at 1/12 degree.

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