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Henry K Johansen
Chief Scientist

OBSERVATIONS OF SPIRAL EDDIES ALONG THE NORWEGIAN COAST IN ERS SAR IMAGES

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Ocean eddies may be visible in ERS SAR images owing to surface roughness variations on the ocean. The SAR eddy signatures are categorised in two groups, dark spiral slicks and current shear eddies. This report contains location, distance to shore, seasonal distribution, direction of rotation, diameter and typical ocean depth for 61 observed eddy signatures. The SAR images may in some instances be used to estimate the eddy's orbital speed. The results indicate a close coupling between bathymetry and eddy signatures. 85% of the eddies rotate counterclockwise.

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OBSERVATIONS OF SPIRAL EDDIES ALONG THE NORWEGIAN COAST IN ERS SAR IMAGES

1 INTRODUCTION

Radar satellites are giving new insight into ocean mezoscale phenomena such as current shears and eddies. Since the launch of ERS–1 in July 1991, it has been thoroughly documented through measurement campaigns and modelling how SAR image signatures can be related to ocean surface roughness variations caused by a complex interplay of currents, winds and surface surfactants (5)(6)(7)(8)(13).

One type of SAR signature frequently occurring in coastal waters is the dark spiral slick. Through use of a numerical model (7), it was shown that the main features of two of the first dark spiral slicks reported in ERS–1 SAR images were consistent with the predicted water circulation. Hence, it was concluded that the dark spiral slicks had an oceanographic origin, and were not barely footprints of a wind pattern. Still, there has been much discussion as to whether dark spiral slicks in SAR images represent instant ocean circulation or if they are more complex expressions of the integrated wind and current history. A direct link between dark spiral slicks and ocean eddies would make SAR images directly applicable for improved ocean nowcasting and possibly forecasting.

The other type of eddy SAR signature may look like curved current shear. This signature is observed in water with higher wind speed compared with the dark spiral slick signature. One is not sure if these two signatures descend from the same origin, or have different oceanographic properties.

In this report we present comprehensive results on the occurrence and statistics of eddies in ERS–1 images from Norwegian waters. For each case, the following parameters have been measured: Location, distance to shore, direction of rotation, diameter and typical ocean depth. We have grouped the eddy signatures into two classes: Dark spiral slicks and current shear eddies. In addition a few examples of ocean ice eddies are presented.

2 OCEAN EDDIES

Ocean eddies may be generated on the front between different water masses, or by currents being influenced by certain bottom topography, coastline, or wind conditions.

It is well known that some ocean eddies may be observed by NOAA weather satellites (sea–surface–temperature), and it has also been shown that ERS–1 SAR images can reveal ocean eddy information. The satellite images give however only surface measurements and it is difficult to deduce three dimensional structures from satellite images only. Models are needed.

Due to the Coriolis effect, one would expect single eddies in the Northern hemisphere to rotate counterclockwise (CCW). An eddy tracking experiment carried out in the Norwegian Coastal Current by Johannessen et al. (10), provided a three dimensional velocity and thermohaline structure of mezoscale eddies. They found strongly asymmetric eddies that extended all the way down to the bottom. Enormous amounts of energy are involved in such deep eddies.

However, two Russian researchers (2) indicate that eddy signatures observed in satellite images are as usual of non–stationary nature and encompass only a comparatively thin near–surface layer of the ocean. The penetration into the depth was found to be limited by density stratification due to temperature and salinity (and then two–dimensional). Such eddies are produced by momentum to the near–surface layer of the water because of often available local sources (highly localised concentrations) of kinetic energies of various natures. Local kinetic energy sources available in the ocean– atmosphere system may be jet–like air–streams, unbalanced sea level and atmosphere pressure differences, local dynamic instabilities of fronts and currents, local winds focused by coastal geometry etc. (3).

Russian researchers (2)(3) have made some evolution analysis of "mushroom–like structures" from currents, eddies and fronts. These are structures of similar shape as eddies, but are recognised as "...quasi–symmetrical patterns of some 10 to 200 km in size consisting of a narrow jet which ends up in a pair of vortices of opposite sign, so that the whole structure is strongly reminiscent of the cross–section of a mushroom". It is found that these structures all increase to 70–80% of their final size in the course of ~24 hours or even less and later grow insignificantly. They further assume the generation in two phases, which in the first phase is the development by an (rapid) impulse effect (in 24 hours) and then the next phase without growing and ends with complete breakdown of the structure. In (5), it is concluded that large scale near–surface circulation would give velocities in the range 0.1 to 0.3 m/s and would need a period of 10 to 20 hours to form the larger, 5 to 20 km scale patterns of aligned slicks that can together trace out larger features such as sheared eddy–like feature.

3 SAR IMAGES

SAR images measure variations in radar backscatter from the sea. Figure 3.1 shows an overview of ocean surface signatures versus wind speed and radar backscatter values. Ocean eddies may be visible in SAR images owing to surface roughness contrasts and may appear in the satellite images like spiral lines in the surrounding sea.

Although eddies and whirlpools sometimes involve a substantial thickness of water, they are also manifested on the surface in the form, for example, of oily (smooth) slick patches creating the impressions of very calm waters. A first study of dark spiral slicks (7), presented three possible causes of the SAR signature:

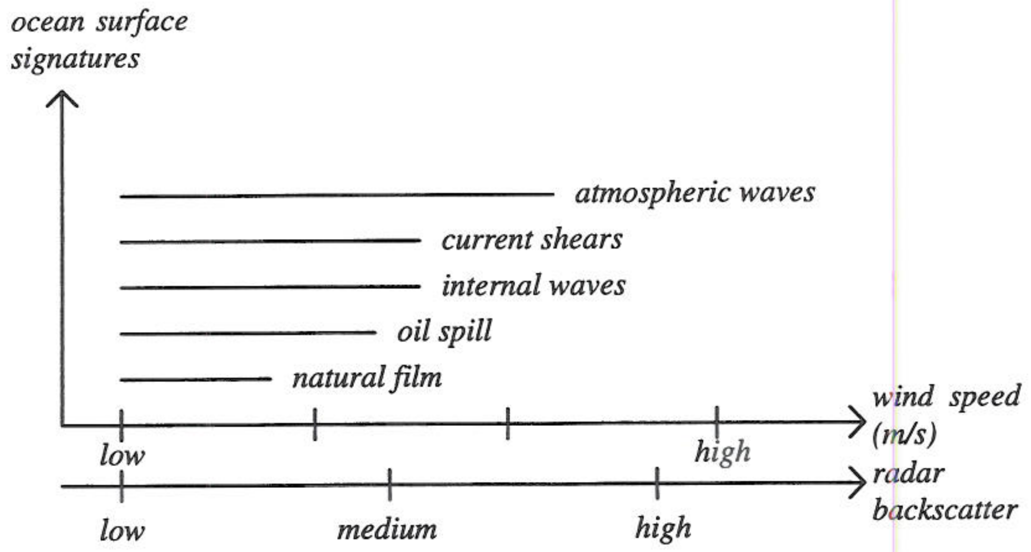


Figure 3.1 Visibility of ocean surface features versus wind speed and radar backscatter values. Eddy signatures may consist of natural film and/or current shear. Based on (8).

1. Surface slicks (surfactant molecules) can under suitable wind conditions remain as microlayers of natural surface film, and inhibit the growth of capillary and short gravity waves when small–scale turbulence (aligned in the direction of the lager scale eddy orbital motion) leads to convective motion in the water. The eddies sometimes become visible in brightness contrast because of the large quantity of fine suspended matter in the upper freshened layer, for example when the latter layer is being broken up in the upwelling region associated with the eddy (2). Readily visible are drifting ice, sludge, grease ice, accumulations of phytoplankton and algae.

2. Wave–current interaction across a current shear along the converging zones in the eddy can in turn appear as narrow zones of high (bright) and low (dark) backscatter dependent on the imaging geometry (9)(12).

3. The stability mechanism in the atmospheric boundary layer may undergo changes leading to different surface roughness, for example when turbulent upwelling cools the surface; the stratification in the boundary layer may undergo changes from unstable to neutral (or slightly stable).

It was concluded in (7) that the surface slick case was the most probable cause of visibility of the dark spiral slicks in the satellite images studied from the Norwegian waters. Natural surfactants or biological activity is closely associated with phytoplankton and could in principle be detected by satellites with ocean colour instruments (4)(14).

The dark spiral lines due to surfactants are expected to disappear at wind speeds of 5–7 m/s, since wind–induced mixing in the upper layer will redistribute the surface. At such wind speeds the eddy signatures seem to be related to direct wave–current interaction and look nearly like spiral formed current shears in the SAR images. The eddies have to disarrange the wind generated waves to be visible in the SAR images and consequently only the stronger eddies are observed. On the other side, when very low wind speeds (<2m/s) the sea surface looks totally dark and usually no eddies are seen (i.e. no influence on the Bragg–waves). To conclude, when favourable wind speed (2–12 m/s), ocean eddies may potentially be visible in the SAR images. At other wind speed conditions, the ocean eddies may in some instances be seen, for example by the way they move ice floes if sea ice is present.

Merely in every 5th image an eddy signature was found in our search. This may be due to the variable presence of "natural tracers" in the near–surface water of the ocean, the need for a favourable wind speed and a presence of an eddy. In a recent paper (13), Nilsson & Tildesley discuss some examples of currents and eddies in Australian water.

4 OBSERVATIONS OF SPIRAL EDDIES ALONG THE NORWEGIAN COAST

We have analysed about 350 SAR images from Norwegian waters, measuring the following parameters: Location, distance to shore, seasonal distribution, direction of rotation, diameter and typical ocean depth. We have tried to distinguish between dark spiral slicks and current shear eddies. The images studied have not been sampled randomly along the Norwegian Coast, because of priority given to certain areas where FFI has conducted campaigns. The complete list of eddies is given in the Appendix.

4.1 Location and distance to shore

Figure 4.1 shows the position for the 61 observed eddies along the Norwegian coast. They are located in average about 60 km offshore.

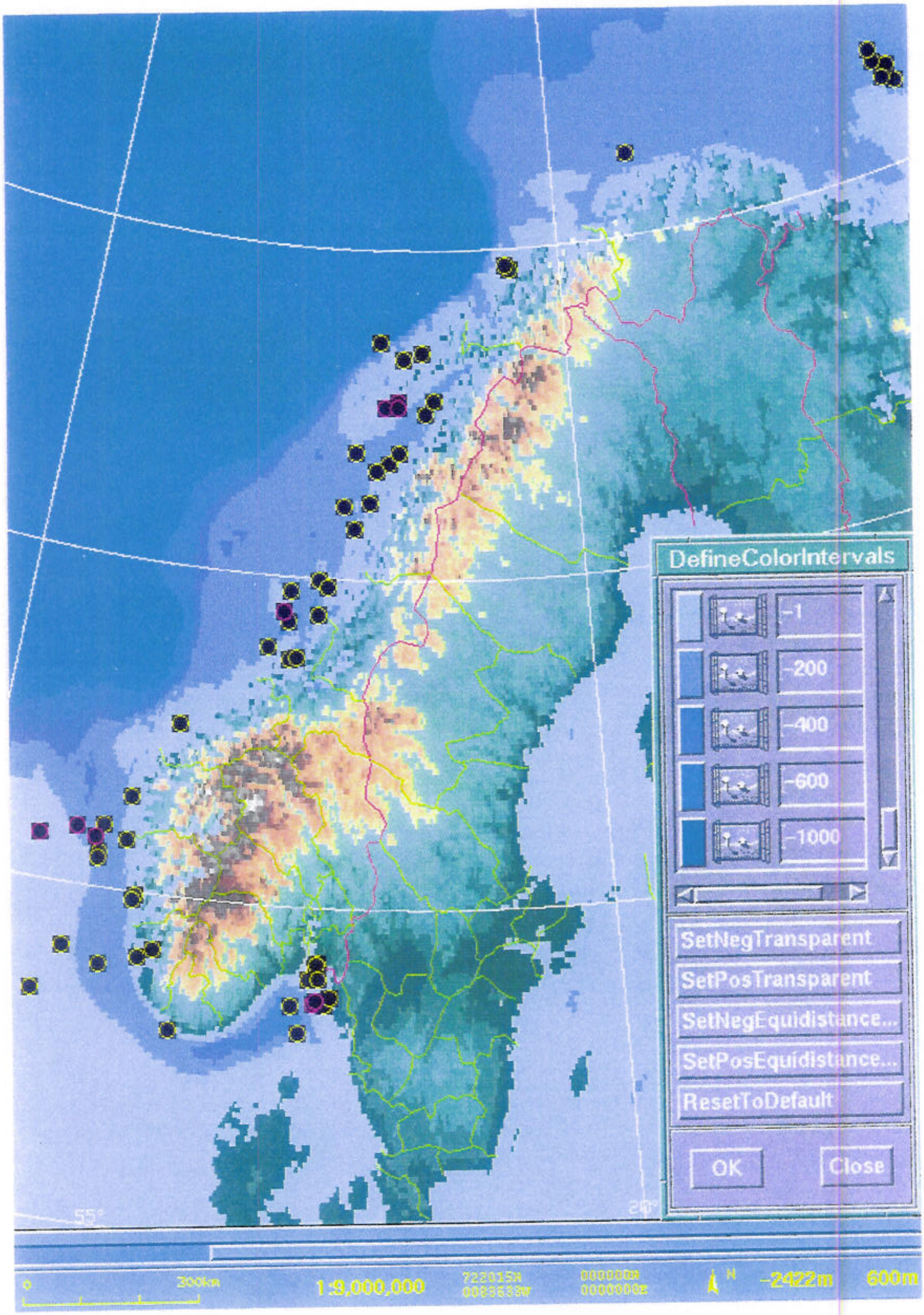


Figure 4.1 *Locations of eddies along the Norwegian coast. Ocean depth is indicated in shades of blue, on a grid of 5 * 5 minutes (9.3 km in North–South direction, 4.9 km at 59°N, 4.2 km at 65°N or 3.2 km at 69°N in East–West direction).*

Figure 4.2 shows a typical eddy signature in our images; dark spiral slicks in a surrounding brighter sea at quite low wind speed. The dark spiral slick signatures constitute about 50% of our data set.

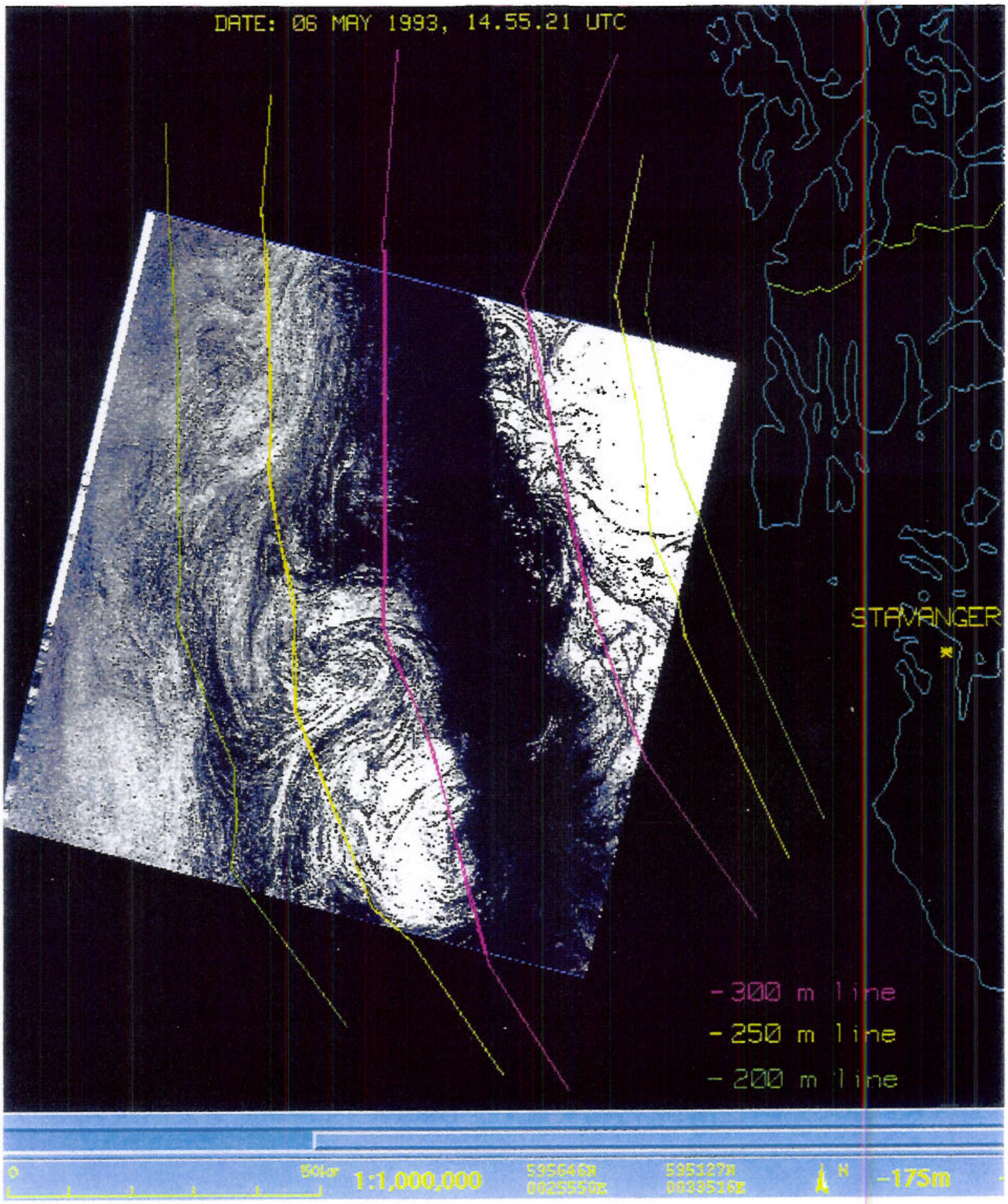


Figure 4.2 *ERS–1 image from 06 May 1993 with dark spiral slicks. The black zone in the middle of the image is situated over the Norwegian Trench. The colour–lines indicate the water depth.*

Eddies make currents visible at the very surface when transferring water around. Parts of the eddy have higher or lower relative wind speed than the surroundings, and therefore appear brighter or darker.

In several images' (figure 4.2, figure 4.4) we have observed eddies situated exactly at the border between, in all probability, two different water masses. Water masses containing different temperature and/or salinity can give different surface roughness (due to the stability mechanism). When the water in an eddy consists of water masses other than the surroundings, this may lead to different wind stress. Therefore, the eddy may appear as brighter or darker spiral lines in the sea. In several occasions we have also observed a displacement of the border line because of such eddy location.

(11) has measured the radial cross–section in an anticyclonic ring of the Gulf Stream and found that the water in the "jet" is much warmer and less salty as compared to the surrounding waters. Typically, eddies in Norwegian waters are less extreme.

Figure 4.3 shows an eddy in water with wind speed larger than 5 m/s. The spiral lines may look both brighter and darker than the surrounding sea, depending on the imaging geometry. This is typical for current shears. Sometimes it is possible to get a "three dimensional" impression viewing such eddy images. Figure 4.4 gives such impressions too, and the eddy in this image also appears close to the border line between, in all probability, two different water masses.

Figure 4.3 *ERS–1 image from 07 May 1994. Notice the eddy to the South. One can get an artificial "three dimensional" impression viewing this eddy. In the Vestfjorden area ocean features are often observed in SAR images (1).*

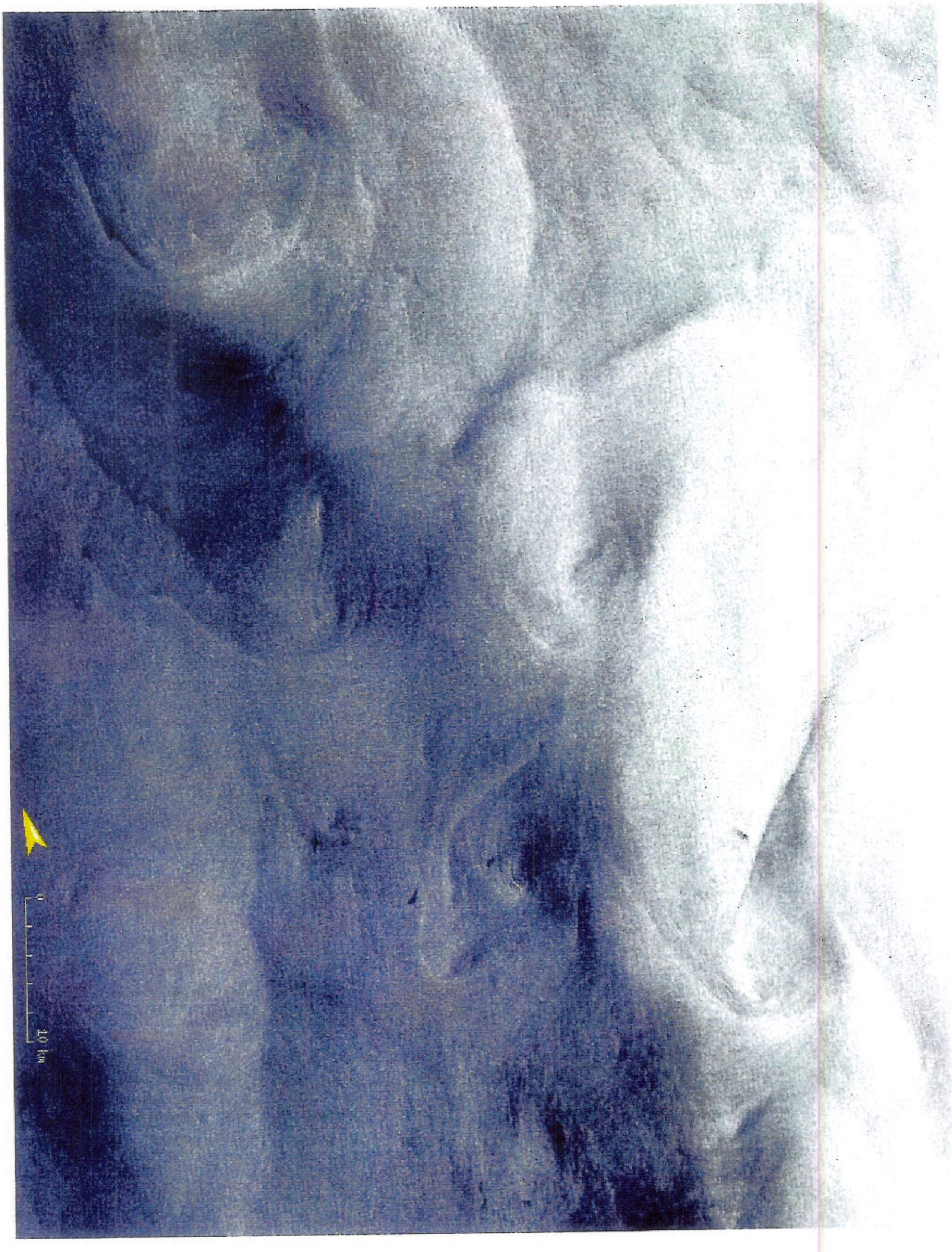


Figure 4.4 ERS–1 image from the Barents Sea 21 February 1995. Eddies are seen as curved current shears. One can also get an artificial "three dimensional" impression when viewing this image. Signatures of different water masses are seen.

4.2 Seasonal distribution

Table 4.1 shows seasonal distribution of the observed eddies.

Season	Number of observed eddies		
	Dark spiral slicks	Current shear eddies	Sum
Spring (Mar., Apr., May)	10	11	21
Summer (Jun., Jul., Aug.)	12	3	15
Autumn (Sep., Oct., Nov.)	5	3	8
Winter (Dec., Jan., Feb.)	2	15	17

Table 4.1 Seasonal distribution of eddies along the Norwegian coast.

The high number of cases in the winter months is most striking. One would expect that calm wind conditions are more prevalent during summer and more favourable for this kind of ocean signatures to be detectable in SAR images. The higher occurrence in the spring months may be due to a bloom in the spring (19). With the onset of summer heating, a cap of warmer water forms, which isolates the winter water below and conserves the phytoplankton in the light. With the onset of stronger winds and unstable conditions in the fall, one would expect a lower occurrence of dark spiral eddies. A closer study reveals that nearly all of the summer cases are dark spiral slicks, while nearly all of the winter cases are current shear eddies. The exceptions are eddies created under special conditions (the Maelstrøm, oil slick or brash of ice). The spring and autumn cases are nearly 50/50% mix.

4.3 Direction of rotation

In our search only nine cases of eddies turning clockwise (CW) were found. These eddies were located in the outermost part of Oslofjord, Foldafjord, Sognefjord and Vestfjord. The CW eddies are marked with red circles in figure 4.1.

In the Oslofjord two clockwise (CW) eddies appear. The eddy (or circulation) shown in figure 4.5 appears with branch of sludge ice. Wind information from two meteorological stations nearby show gentle breeze. The wind direction measured was from North (Færder) and West–Southwest (Fornebu) (18). Notice how the eddy turns away from the shallow water outside Strømstad.

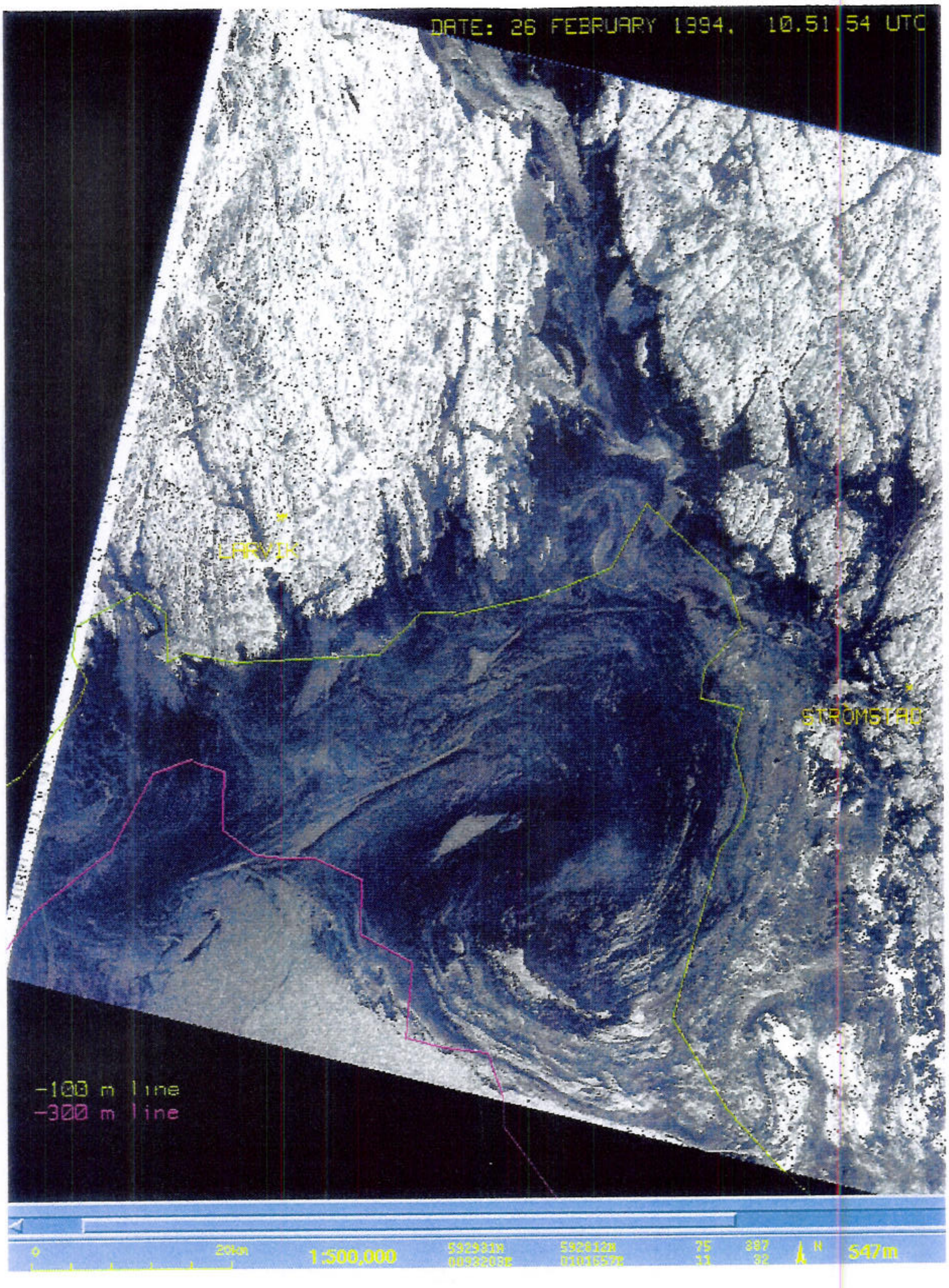


Figure 4.5 *ERS–1 image from outside Oslofjord 26 February 1994. Several ships with wakes are seen in the image and also branches of sludge–ice (16). The colour–lines indicate water depth.*

In the Moskenes Sound in Lofoten strong tidal currents appear. The Maelstrøm creates a whirlpool–like feature in the West of the sound when 1/2 or 3/4 low tide currents are forming backwater (1). Figure 4.6 shows this phenomenon.

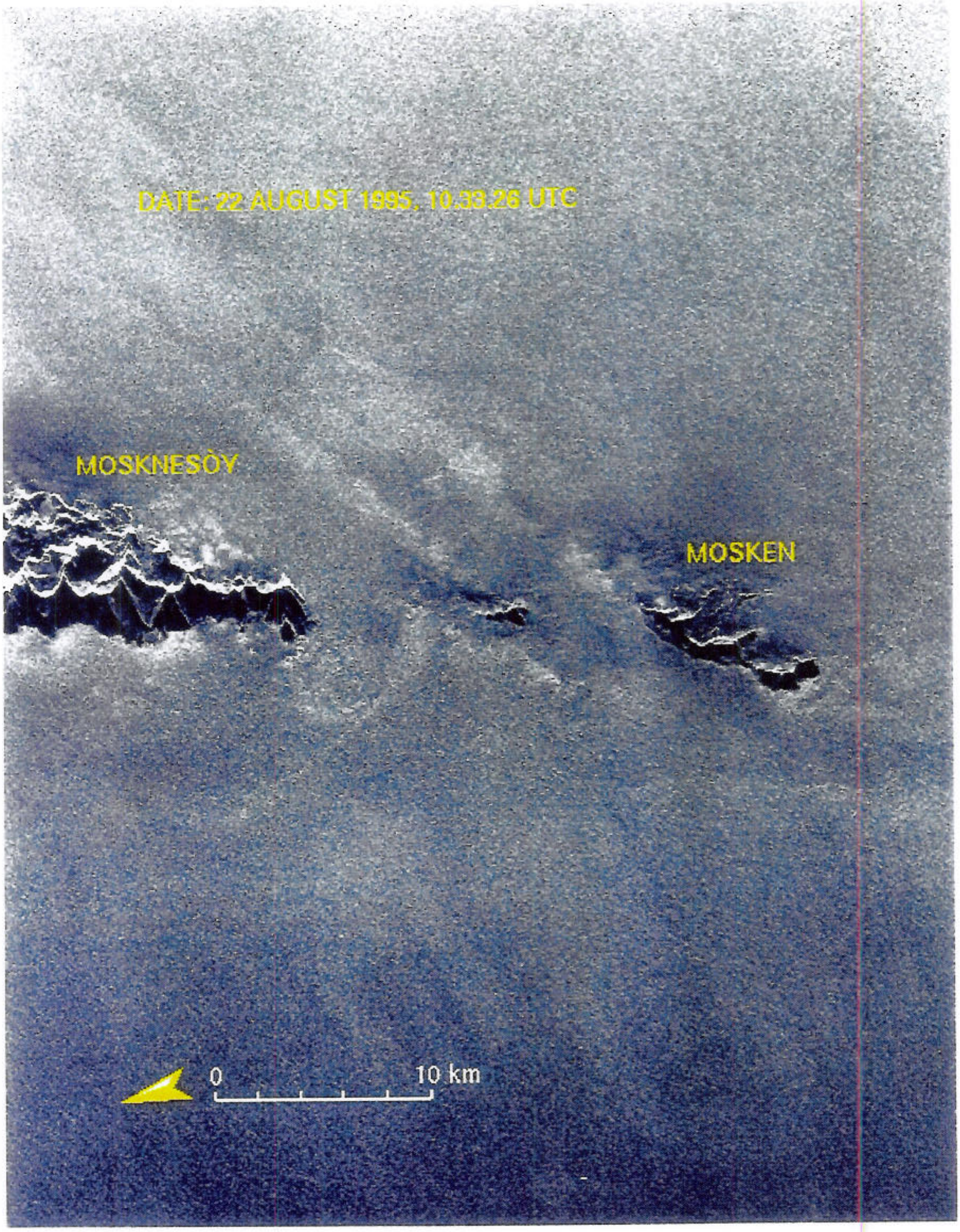


Figure 4.6 ERS–1 image from the Moskenes Sound 22 August 1995, showing the famous Maelstrøm. Such eddies are created due to tides and certain underwater obstacles.

Currents may meet underwater formations that steer the water into CW eddies. This is observed in the images from the outermost part of Foldafjorden and Sognefjorden (figure 4.8). The interplay between topography and strong currents may be visualised by the schematic sketch from the Western part of Norway (figure 4.7).

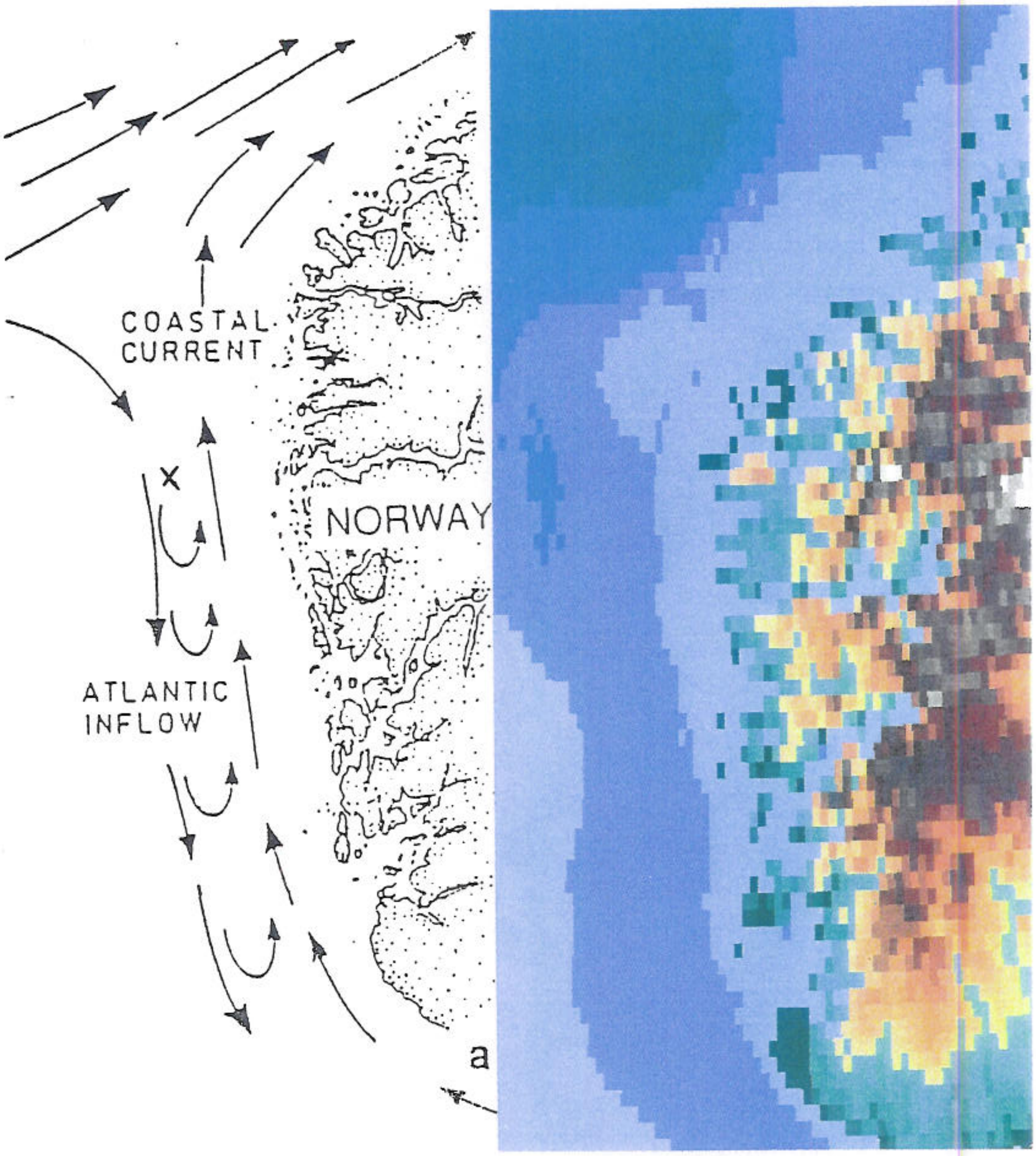


Figure 4.7 *Schematic sketch of the usual occurring currents outside the Western coast of Norway (from (10)). The Atlantic inflow in the Norwegian Trench and the coastal current are shown. Ocean depth is indicated in shades of blue. The cross indicates the position of the eddies in figure 4.8.*

We then conclude these nine cases of CW eddies to be a result of "mass–current–principle"; probably a tide or other strong current combined with underwater obstacles.

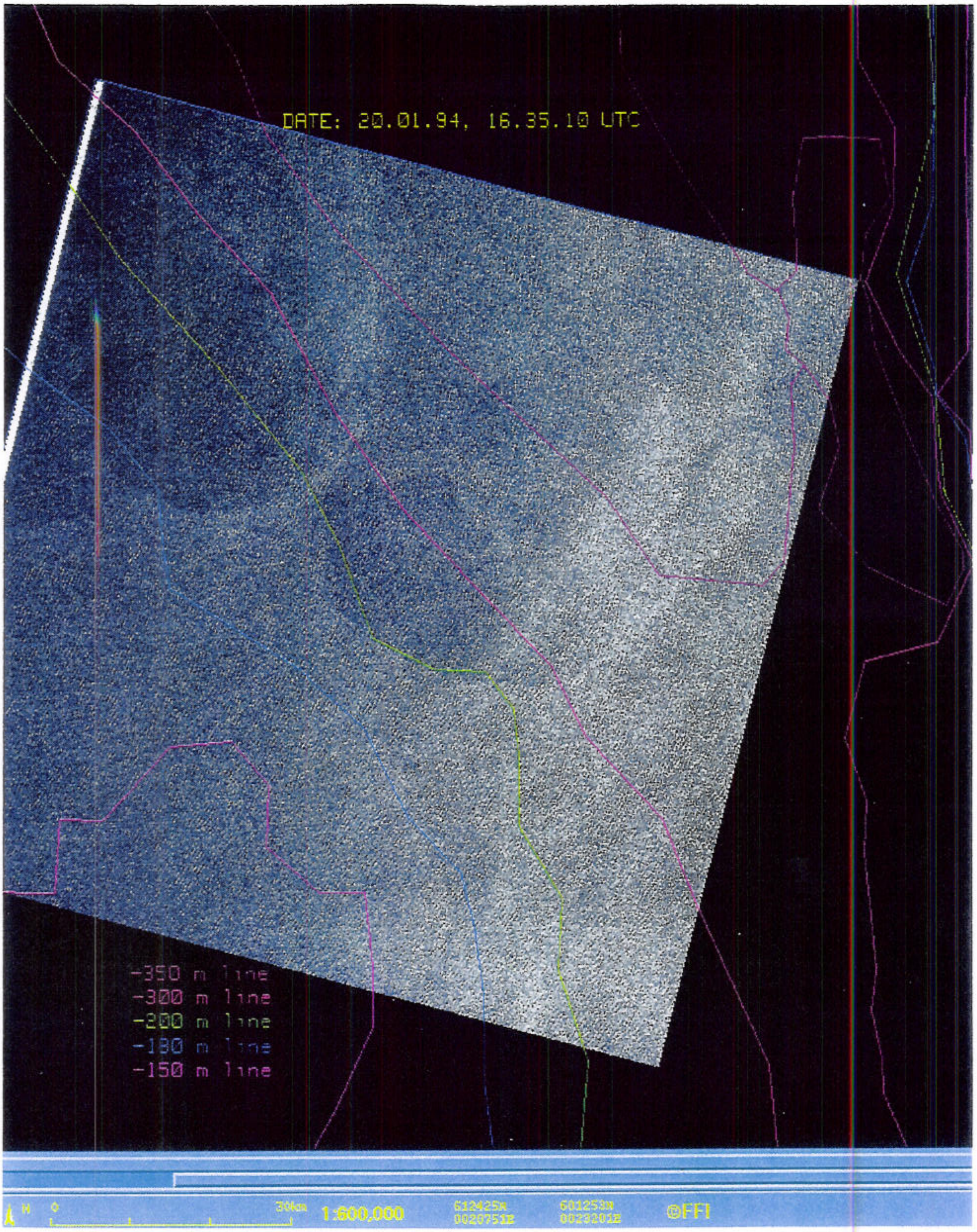


Figure 4.8 *ERS–1 image from the West coast of Norway 20 January 1994. The colour lines indicate water depth. The two parallel eddies are both 35 km in diameter.*

4.4 Diameter

In our analyses we found an average diameter for the eddies as shown in table 4.2. In (6), eddies are defined as circular ocean currents having a horizontal scale of between 10 and 100 km. We have thus extended the use of this term to a somewhat smaller scale. A graphical illustration is shown in figure 4.9.

Direction of rotation	Average diameter	Eddy signature	Average diameter
CCW	7.4 km	dark spiral slicks	6.8 km
		current shear eddies	8.0 km
CW	22.8 km	dark spiral slicks	30.0 km
		current shear eddies	19.2 km

Table 4.2 Averaged diameter for different eddy signatures

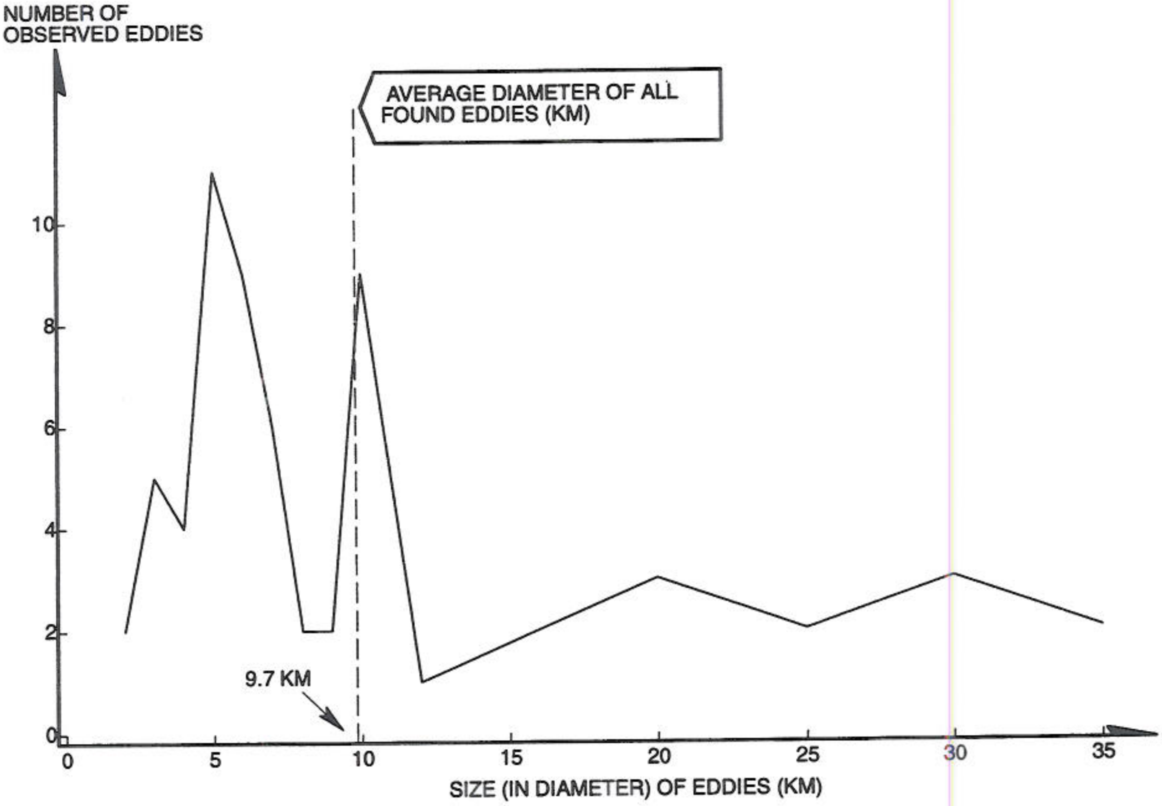


Figure 4.9 Diameter and average diameter for eddies along the Norwegian coast.

4.5 Typical ocean depth

The dividing line between the two lighter blue areas in figure 4.1 shows the 200 m water depth. From 70 degree North and southwards to 63 degree North, a threshold appears 200 m below water (figure 4.10). From 63 degree North and southwards, the Norwegian Trench cuts into the North Sea (figure 4.7). Strong currents (for example the Atlantic current) against such thresholds may generate different ocean signatures seen in the SAR images. Usually the spiral eddies turn CCW but nevertheless some CW eddies may appear (chapter 4.3). We found 90% of the eddies to be located along the 200 m threshold.

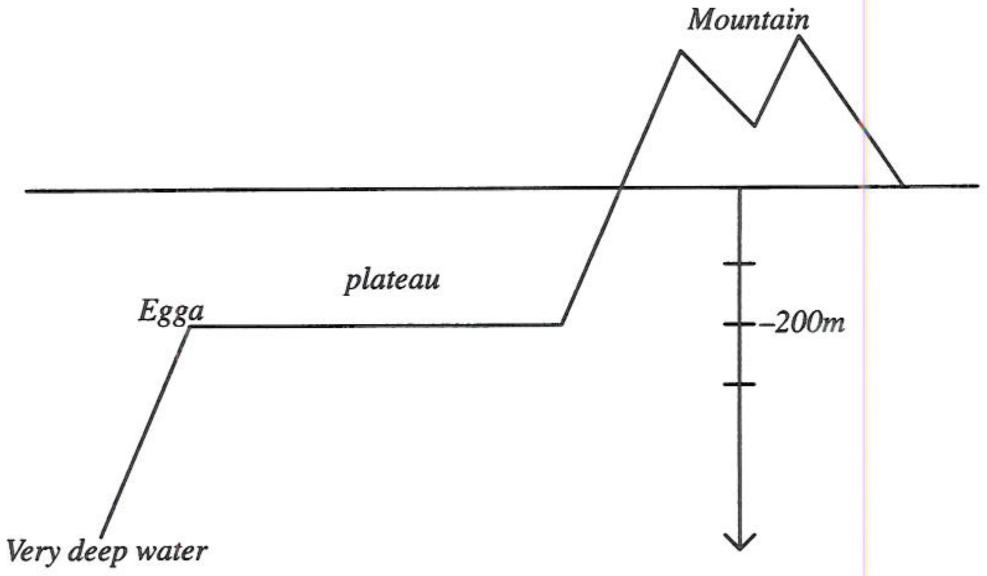
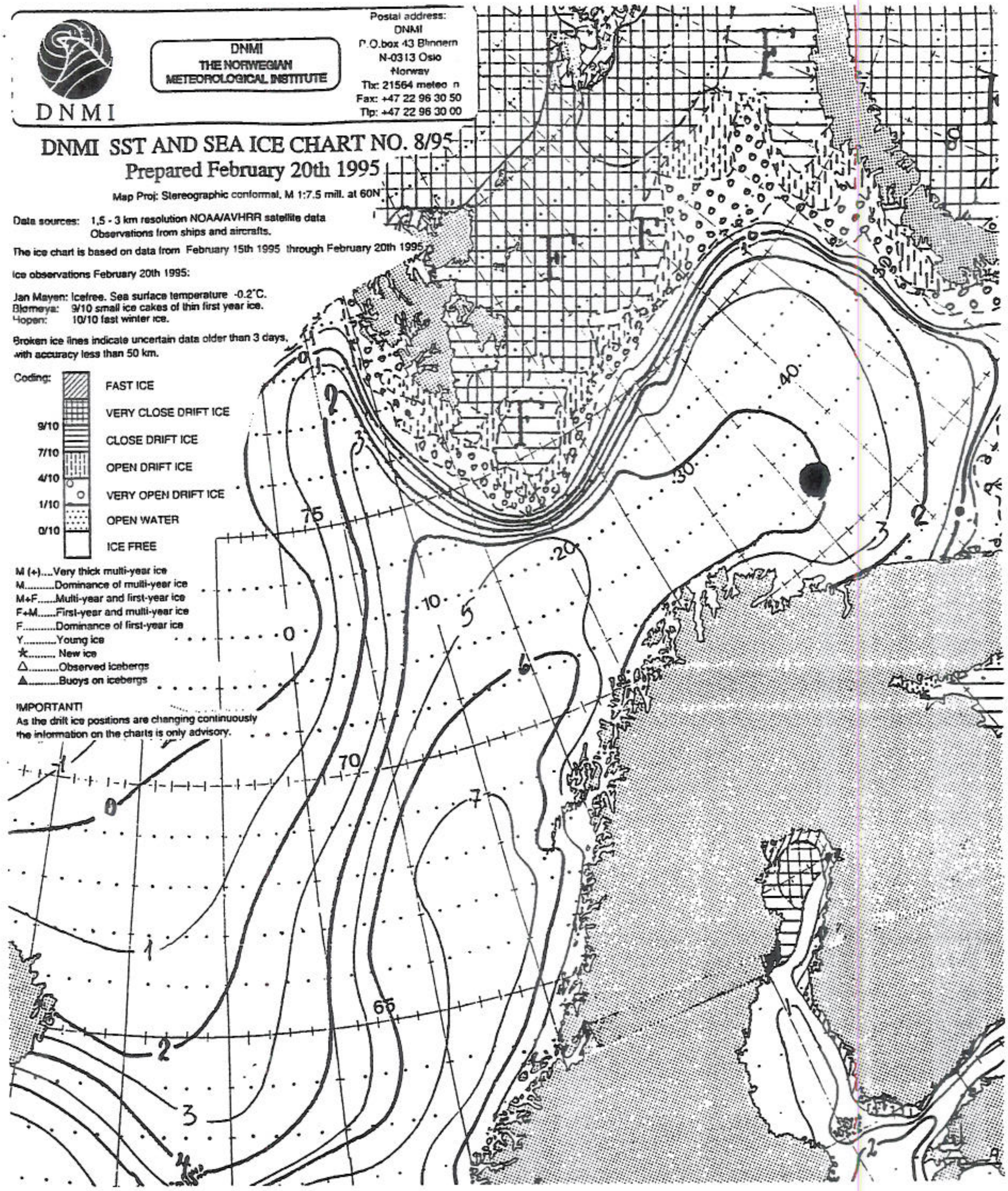


Figure 4.10 The threshold 200 m below water along the Northwest coast of Norway. The threshold is often referred to as the "Egga" in the Norwegian literature.

The ERS–1 image in figure 4.2 shows an example from the Norwegian Trench. A large eddy is situated at the border between probably two different water masses. Another example from North of Norway shows five eddy locations (figure 4.4) situated at the division between water masses of slightly different temperature (figure 4.11). Figure 4.11 shows DNMI sea–surface–temperature and ice chart the day before the SAR image (figure 4.4). Note the temperature profile in the North–South direction.

Strong (tidal–) currents through channels and against obstacles, such as in the Moskenes Sound (figure 4.6), may generate eddies outside the 200 m level.



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DNMI SST AND SEA ICE CHART NO. 8/95
Prepared February 20th 1995

Map Proj: Stereographic conformal, M 1:7.5 mill. at 60N

Data sources: 1,5 - 3 km resolution NOAA/AVHRR satellite data
Observations from ships and aircrafts.

The ice chart is based on data from February 15th 1995 through February 20th 1995

Ice observations February 20th 1995:

Jan Mayen: Icefree. Sea surface temperature -0.2°C.
Bjørnøya: 9/10 small ice cakes of thin first year ice.
Hopen: 10/10 fast winter ice.

Broken ice lines indicate uncertain data older than 3 days, with accuracy less than 50 km.

IMPORTANT!
As the drift ice positions are changing continuously the information on the charts is only advisory.

Figure 4.11 Sea–surface–temperature and ice chart from DNMI, 20 February 1995 (17). The eddies' locations (figure 4.4) are marked with a black circle. Notice the temperature profile in this area, going in North–South direction.

4.6 Eddies in the sea ice zone

The marginal ice zones of the oceans and seas adjoining the ice cover often have quite specific conditions contributing to the origin of local jet currents, eddies, fronts and upwellings (2).

Figure 4.12 shows eddies outside the close drift ice (figure 4.13) at the end of the continental shelf of Greenland. Notice the ice floe formations and how it makes the eddies visible in the SAR image.

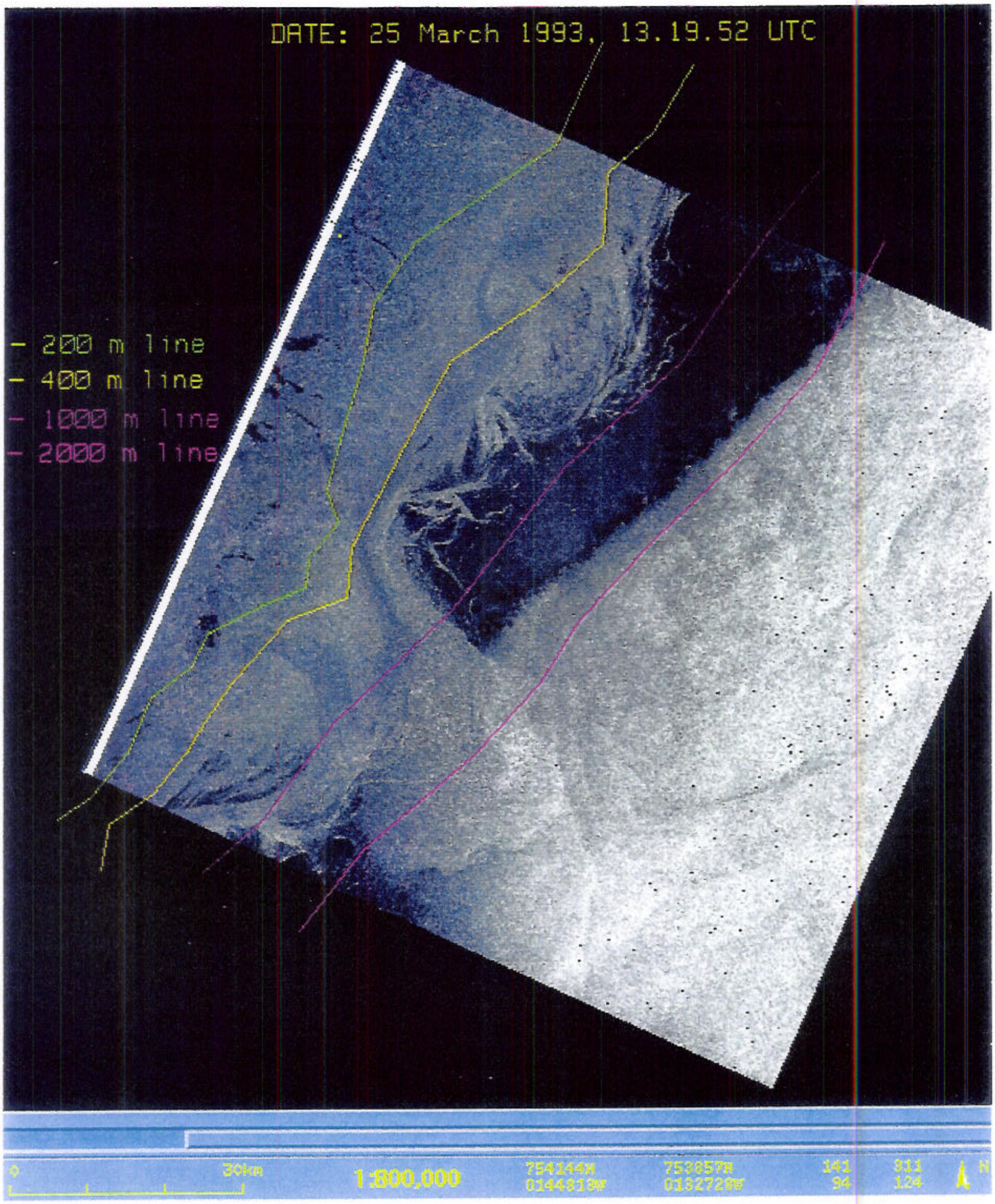

Figure 4.12 ERS–1 image from the East of Greenland, 25 March 1993, showing two eddies outside close drift ice, at the end of continental shelf. The colour–lines indicate water depth.

Eddies in the ice–zone, or exactly flow of drifting ice, are observed in ERS images. In (2), such observations are explained by interactions between the ocean and the atmosphere in the area of the ice edge. Stepwise changes accompanied with freshening, salinization or temperature contrast which for example modifies the wind system resulting

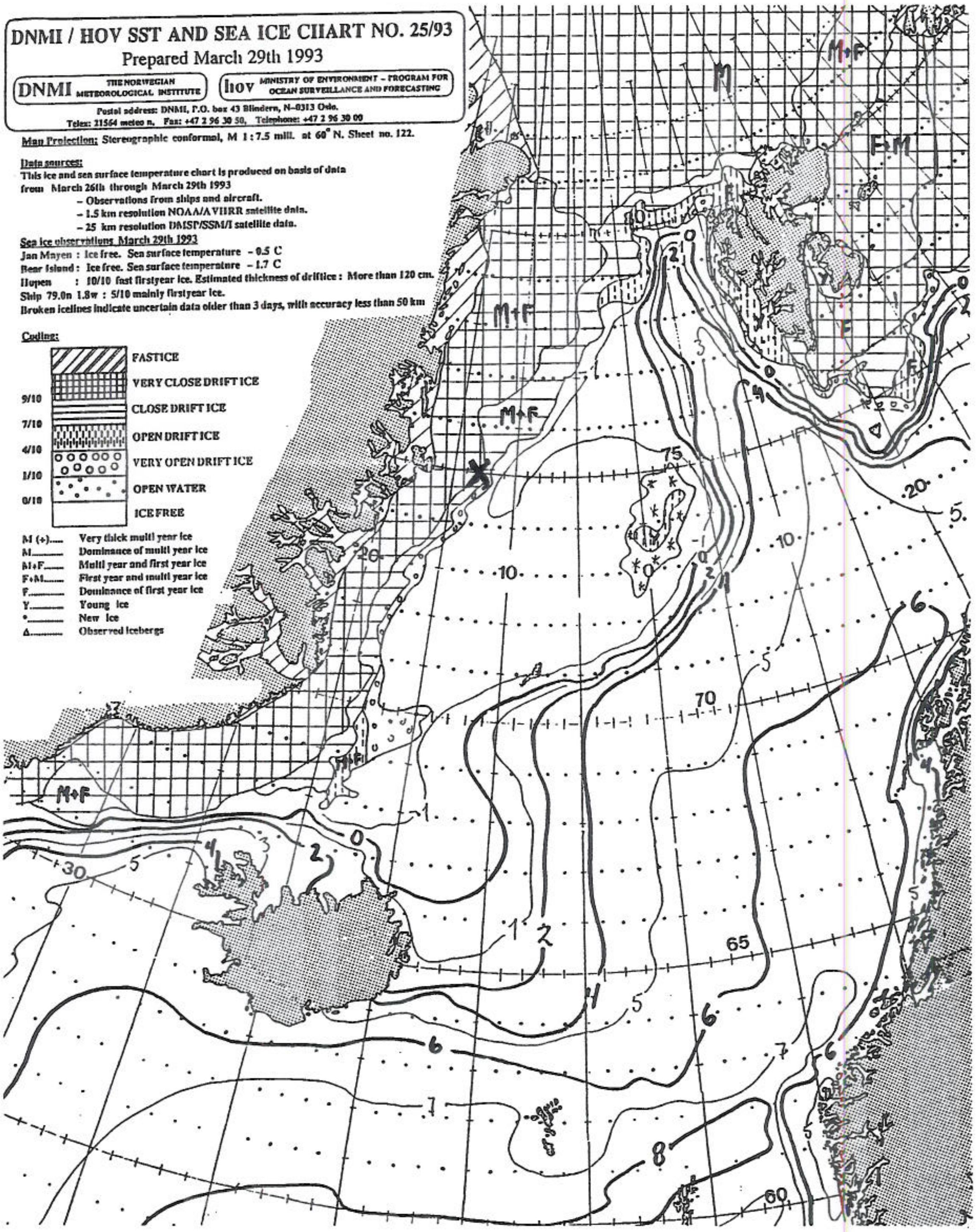

Figure 4.13 Sea–surface–temperature and ice chart from DNMI 29 March 1993 (15). The eddies' locations (figure 4.12) are marked with a cross. Notice the ice–edge position and the temperature profile in the area.

in "ice breeze" and other interesting dynamic (and thermal) effects. Also the presence of thin (10–20 m) water layer at the very surface with sharp, strong thermal and salinity gradient to a lower boundary layer often prevents the transmission of an impulse to the under–laying layers from wind–wave turbulence generated in the top layer (2). The near–surface layer is then very mobile and highly reactive to all the local pulse effects (for example local inhomogeneities of the wind field, rapid ice motion, changes in atmospheric pressure, etc.).

In regions where the ice forms only in winter and disappear completely in summer (the seasonal ice zone), similar eddy features are observed in winter and early spring. Figure 4.5 shows branches of (sludge) ice (under the Olympic Games in Lillehammer) in the outermost part of the Oslofjord.

4.7 Eddy evolution and orbital speed

From our sequence of satellite images, it is nearly impossible to consider the evolution of eddies, whether they are growing or decaying or estimate the strength of the eddies. We have not necessarily image–time–series from an area containing eddies to do such evolution analysis.

However, from the wakes behind ships it is possible to estimate the orbital speed of the eddies. In the images in figure 4.14, ships are just passing through the eddies. Assuming the ship speed to be 14 knots, the distance from ship to eddy and the displacement of the wake measured, the two eddies will have an estimated maximal speed of 0.8 m/s and 1.7 m/s. These values are a bit large (according to (2)) for the 30 km and 20 km in diameter eddies. Seldom the speeds are larger than 1 m/s (2)(10) in such eddies. In (13), it is documented that an intense warm–core eddy flows counterclockwise at speeds up to 1.5 m/s.

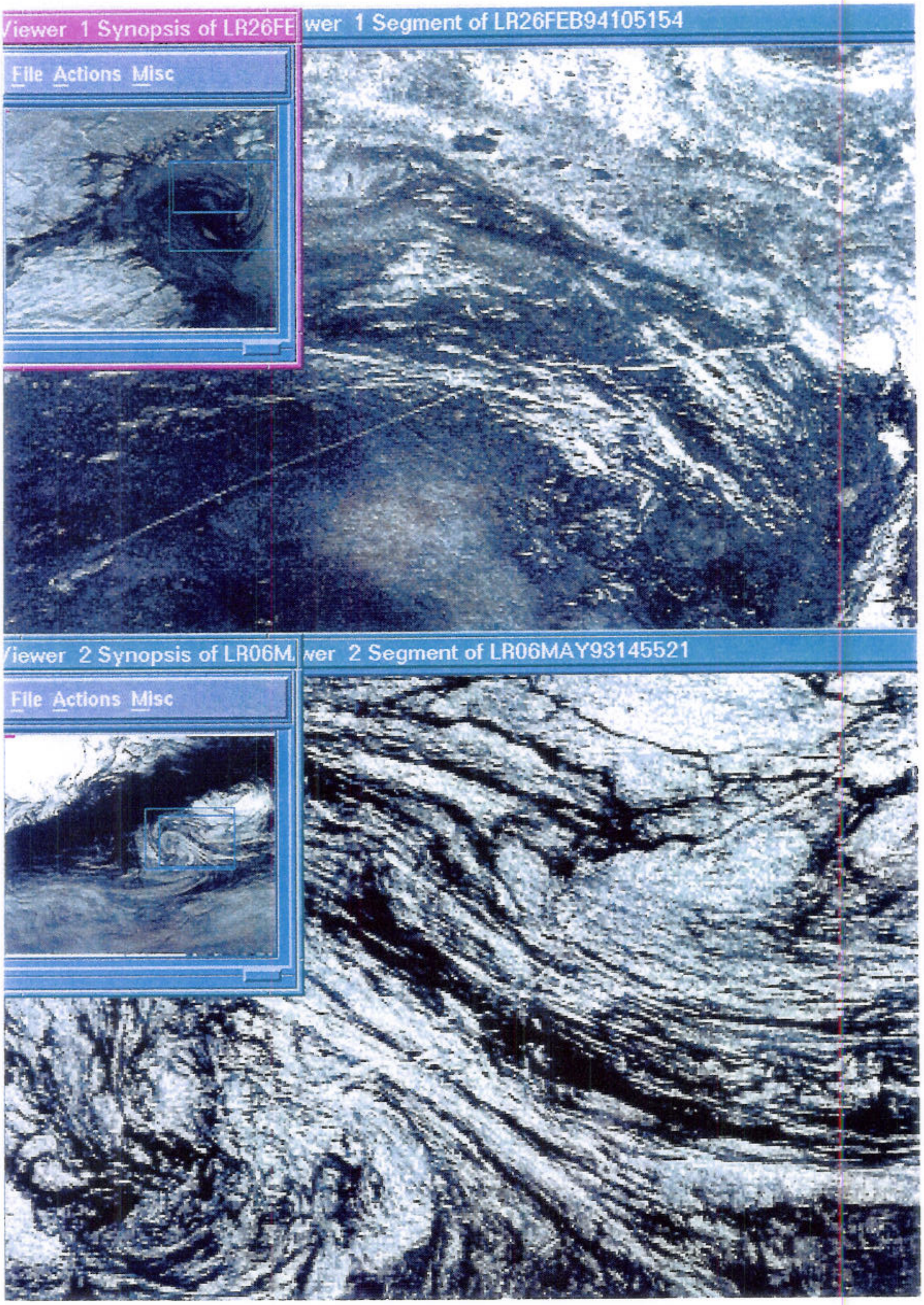

Figure 4.14 Magnification (3x) of figure 4.2 and figure 4.5, showing ships passing through the eddies.

5 CONCLUSION

We have analysed ocean eddy signatures in ERS SAR images from Norwegian waters.

The main results of this report can be shortly summarised in the table below.

Number of images analysed	About 350 images
Number of observed eddies	61
Percentage of dark spiral slick/current shear signatures	50/50%
Average diameter	9.7km
Percentage counterclockwise eddies (average diameter)	85% (7km)
Percentage clockwise eddies (average diameter)	15% (23km)
Average distance from shore	60km
Seasonal distribution (Spring, Summer, Autumn, Winter)	34%, 25%, 13%, 28%
Percentage located near the 200m water depth contour	90%

Table 5.1 Eddy statistics

The majority of eddy signatures can be categorised in two groups: Dark spiral slicks and current shear eddies. The dark spiral slicks occur at low wind speed conditions and they are visualised by surface slicks. Dark spiral slicks are usually not found during the winter months. At higher wind speeds the eddies look more like curved current shears. The two types of signatures do not appear in the same images. With that, it is reasonable to believe that the two types of signatures discussed are manifestations of the same phenomenon under different wind conditions.

We therefore believe the eddy signatures to have an oceanographic origin. The observed eddy features seem to be complex expressions of the integrated wind and current history, not barely footprints of a wind pattern. Moreover, the high occurrence of eddies near the 200m water depth contour and our discussion of the clockwise–rotating cases, indicate a close coupling between bathymetry and eddy features in ERS SAR images and seem to justify a closer study of this subject.

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APPENDIX

A LIST OF EDDIES IN ERS SAR IMAGES

Date	Positions		Size (dia-meter) km	Comments x=dark spiral slick signature
	North	East		
21.08.91	635207	090235	3	x, current shear
23.10.91	591318	103036	2	x, in light wind
22.11.91	590200	102000	2	x, in light wind
13.03.92	675013	123843	7	CW, Maelstrøm, windy, current shear
23.03.92	694810	172316	7	special underwater topography, similar 6/1–96
25.05.92	584059	105040	3	x, ships without wakes, almost no wind
25.05.92	584042	105044	5	x, ships without wakes, almost no wind
03.10.92	605245	042010	10	x, current shear, Bergen
12.10.92	584002	103207	25	CW, Oslofjord
21.12.92	584629	110016	6	(x), an oil slick eddy, current shear, Oslofjord
26.03.93	650545	095258	5	strong currents
26.03.93	581316	100749	4	CW/CCW, strong current shear, special underwater topography
26.03.93	665408	121922	10	current shear, special underwater topography, windy, several eddies
06.05.93	585741	040105	20	x, current shear, almost no wind, ships with wakes, special underwater topography
09.05.93	603819	033122	6	x, current shear, almost no wind
20.06.93	661703	113627	5	x, almost no wind, "mushroom like structure"
12.07.93	642546	085413	3	x, bright sea
15.07.93	673922	134304	4	x, almost no wind
19.07.93	583732	095118	8	x, light wind, outside Larvik, ships
16.08.93	645258	085512	5	x, many small eddies in a light wind area
17.08.93	645931	101233	6	x, many small eddies, current shear, ligh wind
17.08.93	643305	095613	5	x, light wind
18.08.93	635404	091633	9	x, light wind, outward currents in a gulf
26.09.93	613131	041713	5	probably rain
09.10.93	675131	140342	5	x, light wind
10.10.93	604613	013440	8	CW, special underwater channel, slicks nearby, Sognefjorden
02.12.93	600328	045117	4	eddy is brighter than the sea, windy
20.01.94	605115	031921	35	CW, special underwater topography, windy, Sognefjorden
20.01.94	605750	024155	35	CW, special underwater topography, windy, Sognefjorden
08.02.94	591650	103521	3	eddy is brighter than the sea, windy, Oslofjorden
10.02.94	603206	032928	6	windy, current shear eddy
25.02.94	610245	033239	6	windy, current shear eddy
26.02.94	584237	103625	30	(x), brash of ice, CW, ships with wakes, light wind, Oslofjorden
07.03.94	591546	103335	3	x, light wind, Oslofjorden
04.05.94	684344	114732	10	eddy is brighter than the bright sea
07.05.94	670322	110056	20	CW/CCW, bright sea, current shear eddy, internal wave trains

24.05.94	595916	044480	10	x, ships, light wind
24.05.94	590750	050931	6	x, light wind
24.05.94	591645	053526	4	x, special turbulence caused by a "gulf", light wind
24.05.94	643341	084422	30	x, CW, light wind, Foldafjorden
24.05.94	640121	081441	25	x, light wind
05.06.94	590258	103740	7	windy, internal waves, current shear, very strong currents, Oslofjorden
16.06.94	682930	124717	6	x, light wind
06.07.94	670310	124021	6	windy, ships, current shear eddy, Maelstrøm
13.02.95	580615	062134	20	windy, current shear eddy
21.02.95	582910	020829	10	current shear, special underwater topography, current shear eddy, ships
21.02.95	712046	363200	10	light wind, current shear eddy, current shear
21.02.95	713753	362439	5	light wind, current shear eddy, current shear
21.02.95	714317	354837	5	light wind, current shear eddy, current shear
21.02.95	715531	354627	9	light wind, current shear eddy, current shear
21.02.95	712733	360231	6	light wind, current shear eddy, current shear
04.03.95	624416	053160	10	windy, atmospherical waves or special underwater topography, rain, current shear eddy
05.03.95	655340	110341	10	windy, current shear eddy
05.03.95	661414	103918	7	windy, current shear eddy
05.03.95	664723	114921	5	windy, current shear eddy
18.07.95	674501	120742	30	x, CW, light wind, Maelstrøm
18.07.95	683338	133520	10	x, light wind, other small eddies too
22.08.95	675013	123843	5	CW, windy, lighter than the sea, Maelstrøm
19.09.95	590900	025113	7	x, light wind, many small eddies
06.01.96	695253	171345	12	windy, current shear eddy, special underwater topography, Senja
13.01.96	712122	231619	7	windy, current shear eddy