IV PEACE Conference

17-19 September, 2008, Vladivostok, Russia

SATELLITE SAR SUPPORTING OF EXPERIMENTS IN THE EAST ASIAN SEAS

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Satellite SARs

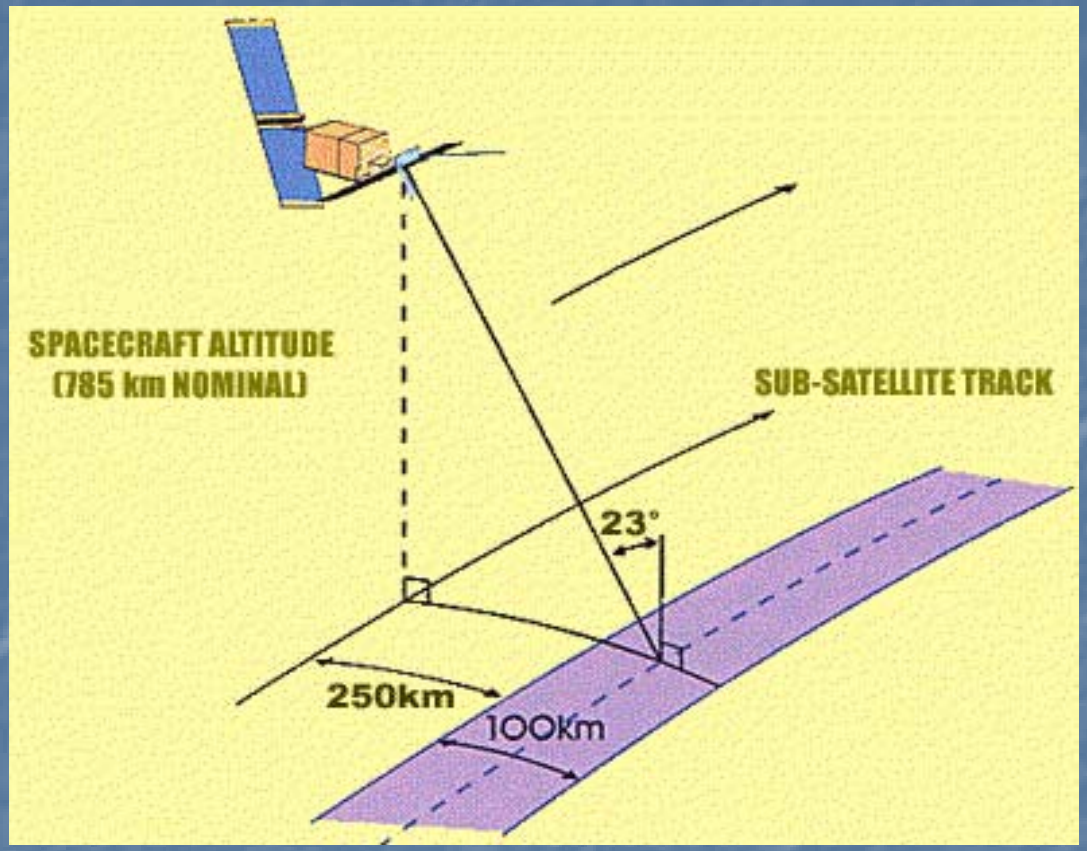
The purpose of our presentation is to show that satellite synthetic aperture radars can be used as the supplementary or sometimes main source of spatial high resolution data.

Satellite Synthetic Aperture Radar (SAR) is an instrument well suited for detection and investigation of the dynamic oceanic and atmospheric phenomena, sea ice and oil pollution.

At present, SAR images of the ocean can be obtained from ERS-2, Envisat, RADARSAT-1, RADARSAT-2, ALOS and several recently launched Italian and Germany satellites. China, Korea and other countries plan to launch satellites with a SAR in the nearest years.

SARs provide high resolution information on the sea surface features independently on sun illumination and cloudiness that is important both for the coastal and for open ocean experiments.

Satellite SARs



SATELLITE	ERS-1/2	Envisat
SENSOR	SAR	SAR
Frequency, GHz	5.3	5.3
Wavelength, cm	5.6	5.6
Polarization	VV	VV, HH
Incidence angle, deg	20-26	15-45 (variable)
Swath width, km	100	100-405
Ground resolution, m	25 x 25	25 x 25 150x150

European Remote Sensing Satellites:
ERS-1 was launched on 17 July 1991,
ERS-2 - on 21 April 1995 and
Envisat - on 1 March 2002.

Envisat ASAR

Ship experiments and SARs

The location of SAR image boundaries and time of observations are known in advance that allows planning their acquisition over the areas of ship expeditions.

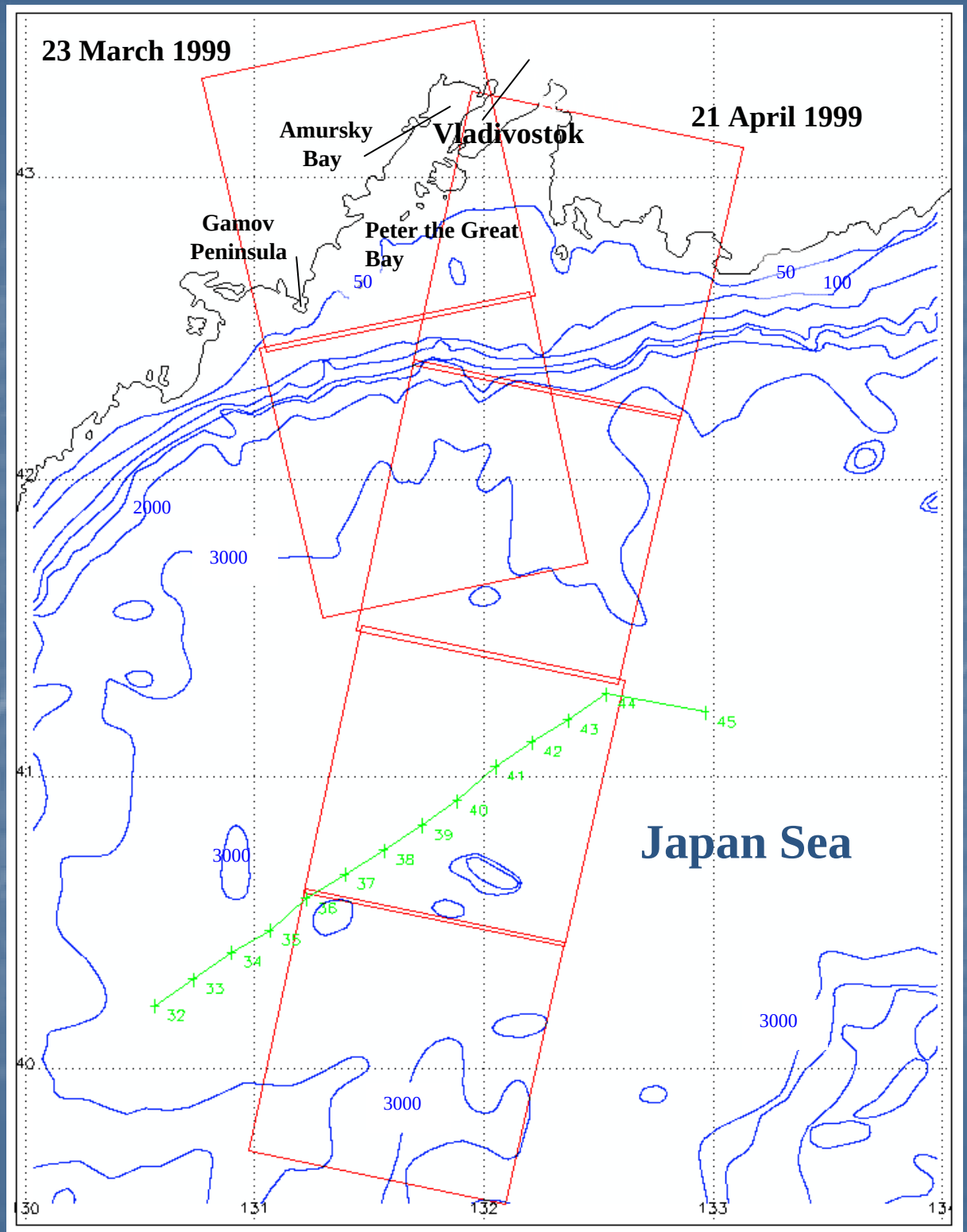
In turn, the coastal and ship observations of hydrological and meteorological parameters influencing on radar backscatter help to improve the SAR signatures interpretation and advance calibration of radar signals.

Satellite SAR supporting of ship expeditions in the East Asian Seas started at POI in 1993. SAR images were ordered at the European Space Agency (ESA) in the frames of several accepted research projects:

ESA AO3-401 project "Mesoscale oceanic and atmospheric phenomena in the coastal area of the Japan and Okhotsk seas: Study with ERS SAR and research vessels".

AO3-1291: "Soya Warm Current study with Quick look and Precision ERS SAR images".

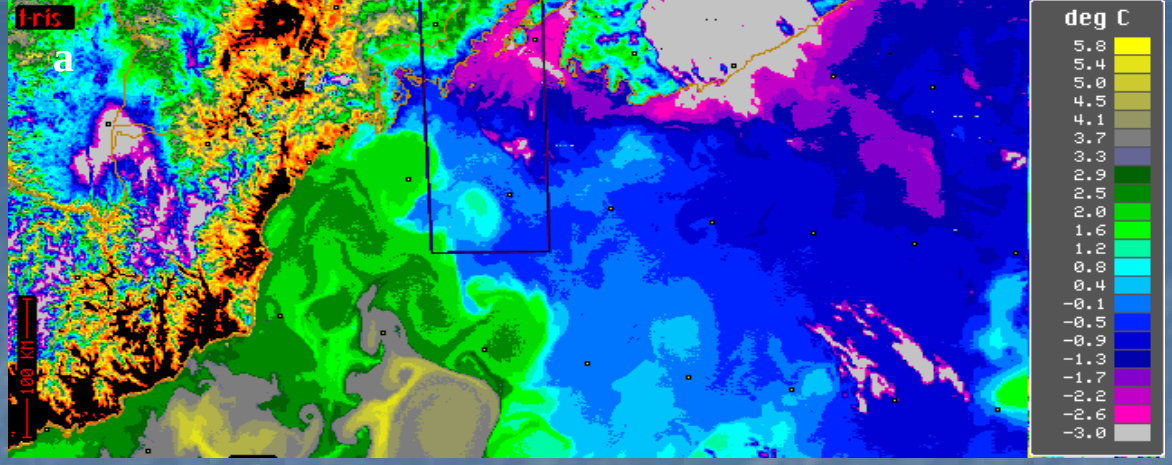
ESA ENVISAT PROJECT AO-ID-391: *"Study of the interaction of oceanic and atmospheric processes in the Japan Sea and in the Southern Okhotsk Sea"* .

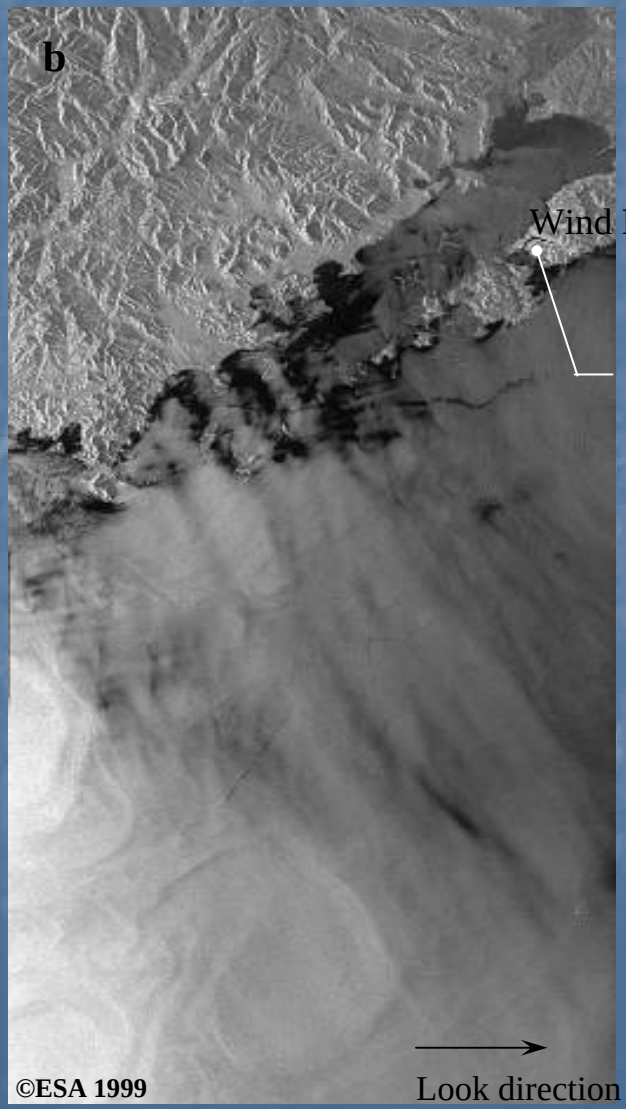


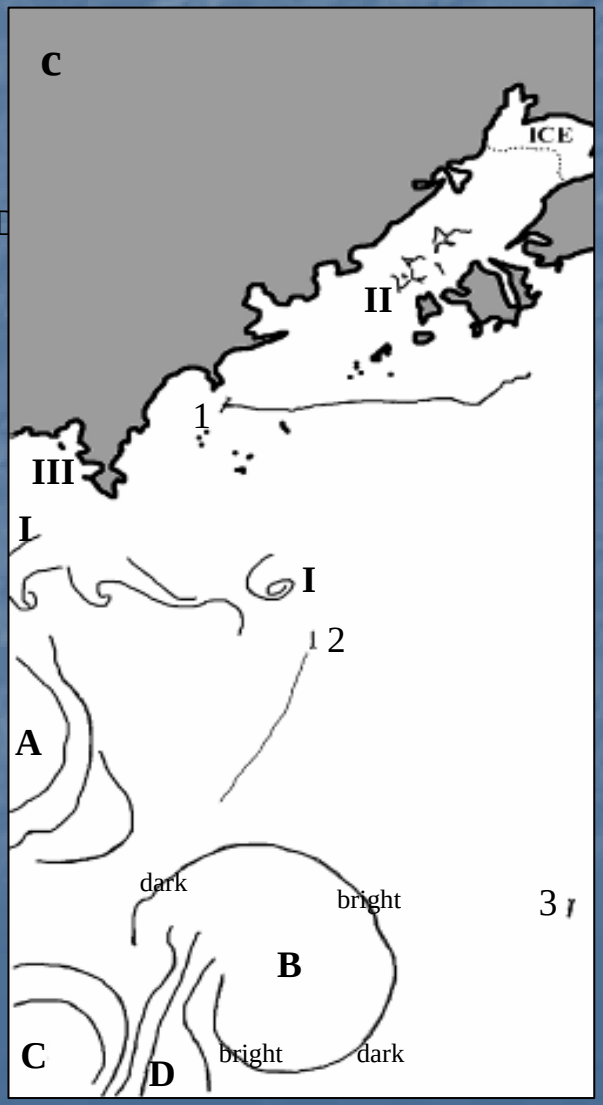
Ship expeditions on R/V "Pavel Gordienko" (32 cruise, April 1999) and satellite SAR images

Bathymetric map of the northwest Japan/East Sea. Red rectangles superimposed on the map show the boundaries of ERS-2 SAR images acquired on 23 March and 21 April 1999. Green line with numbers indicates ship track and crosses mark the location of hydrological stations carried out by R/V "Pavel Gordienko" on 18 –19 April 1999.

Manifestations of thermal and dynamic structures on satellite SAR and IR images of the northwest JES (1 month before cruise).

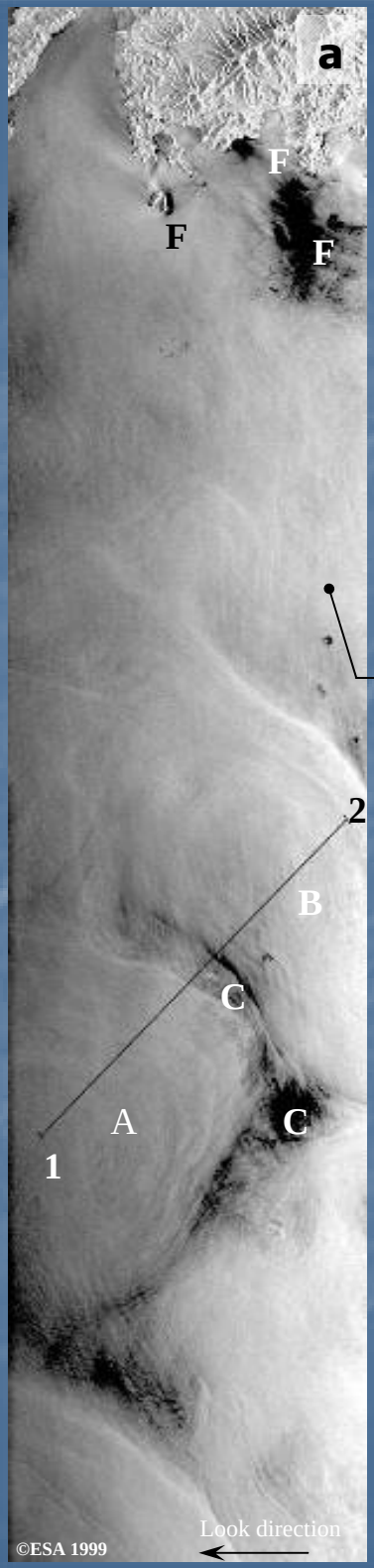


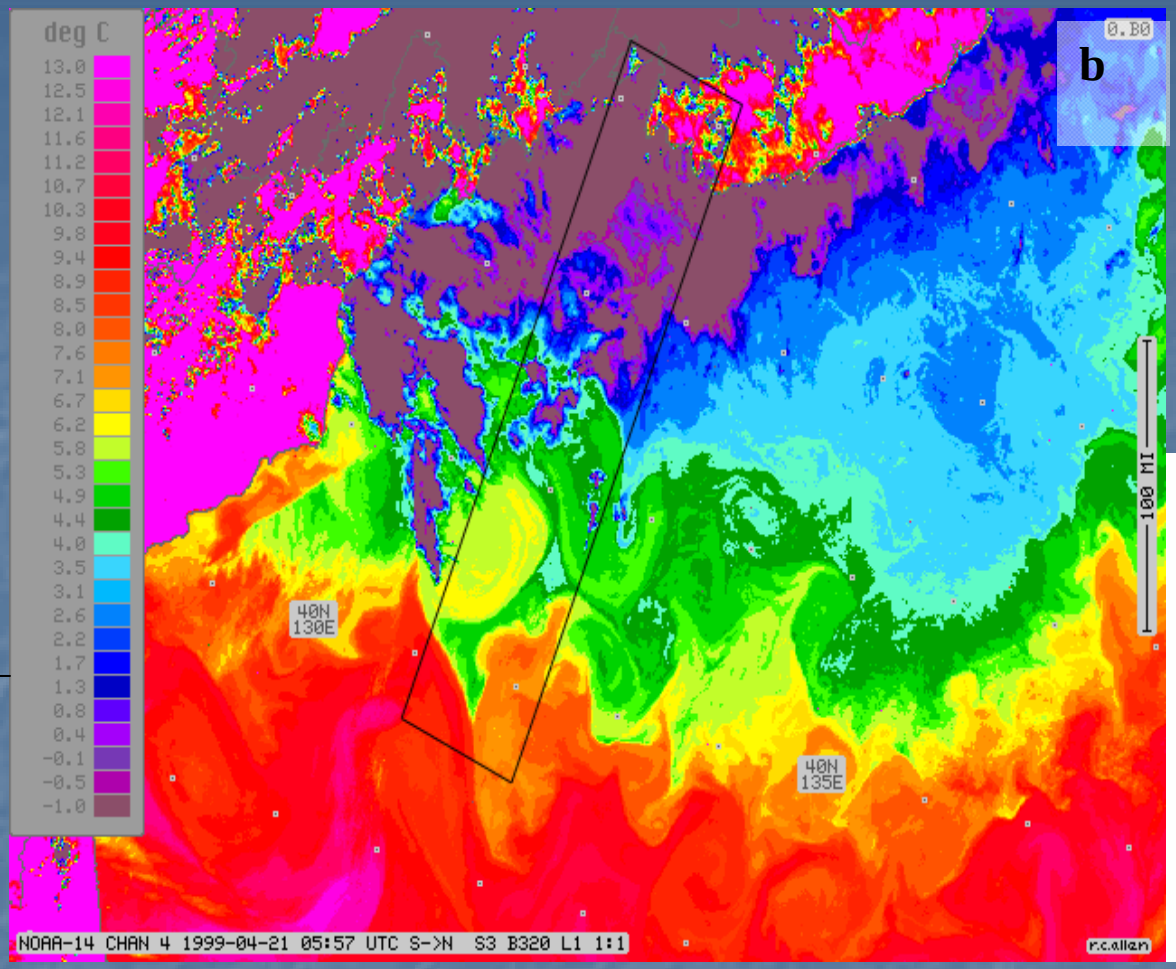


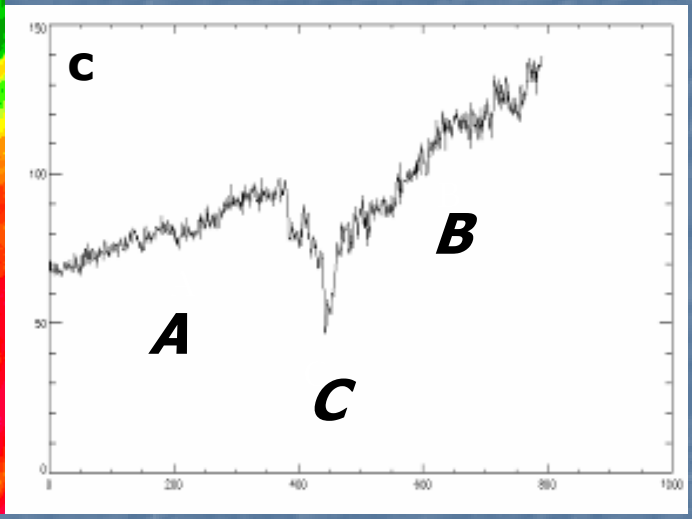


a) NOAA AVHRR image acquired on 23 March 1999, at 06:19 UTC. Dark rectangle indicates the location of the ERS-2 SAR frames.
b) ERS-2 SAR image acquired on 23 March 1999, at 13:27 UTC.
c) Interpretation scheme showing the location of contrast features on SAR image caused by dynamic factors (chain of eddy formations I-I), thermal and dynamic factors (eddies ***A, B*** and ***C***, streamer ***D***), fields of pack ice II, slicks III, and ship wakes 1, 2 and 3 (oil behind ships 1 and 2).

Eddies in the Japan/East Sea, 21 Apr 1999 г.





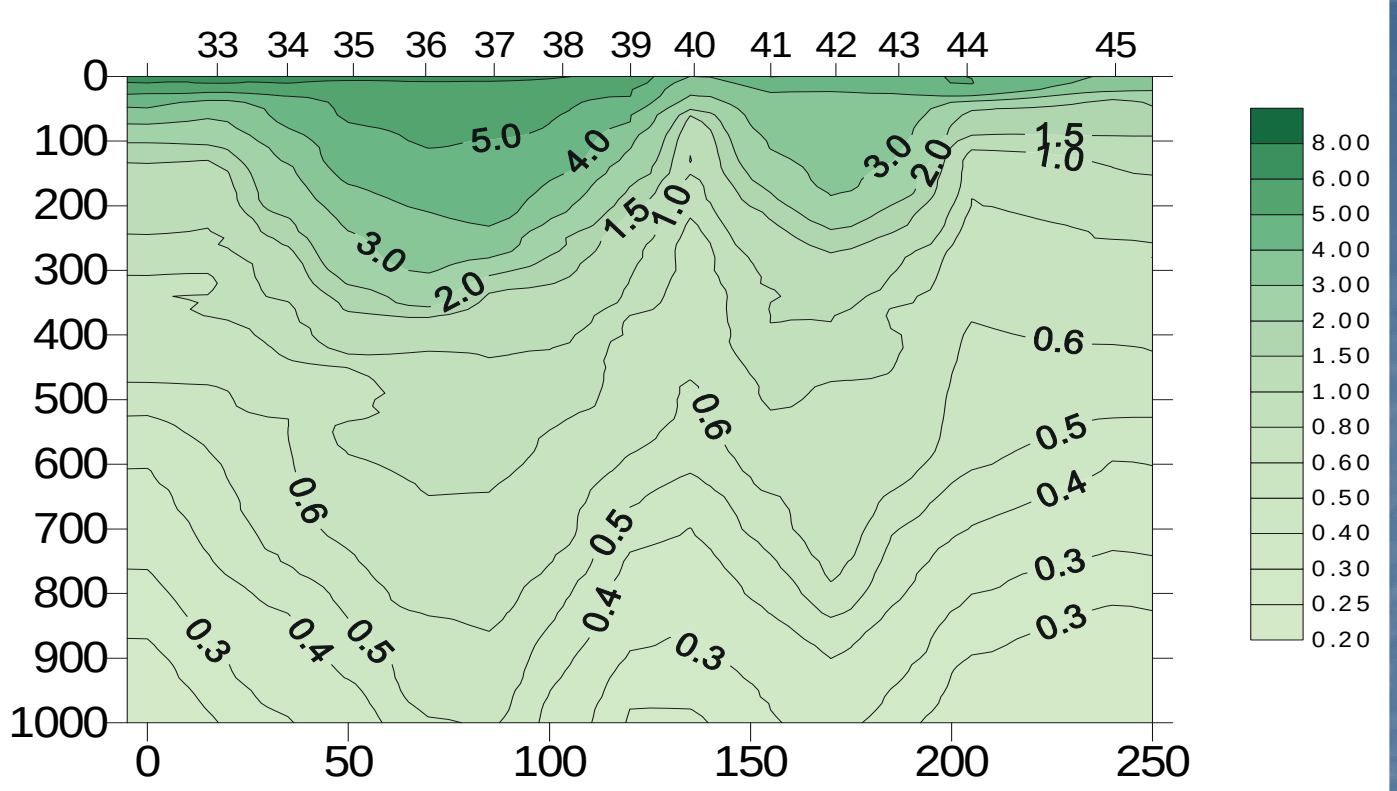


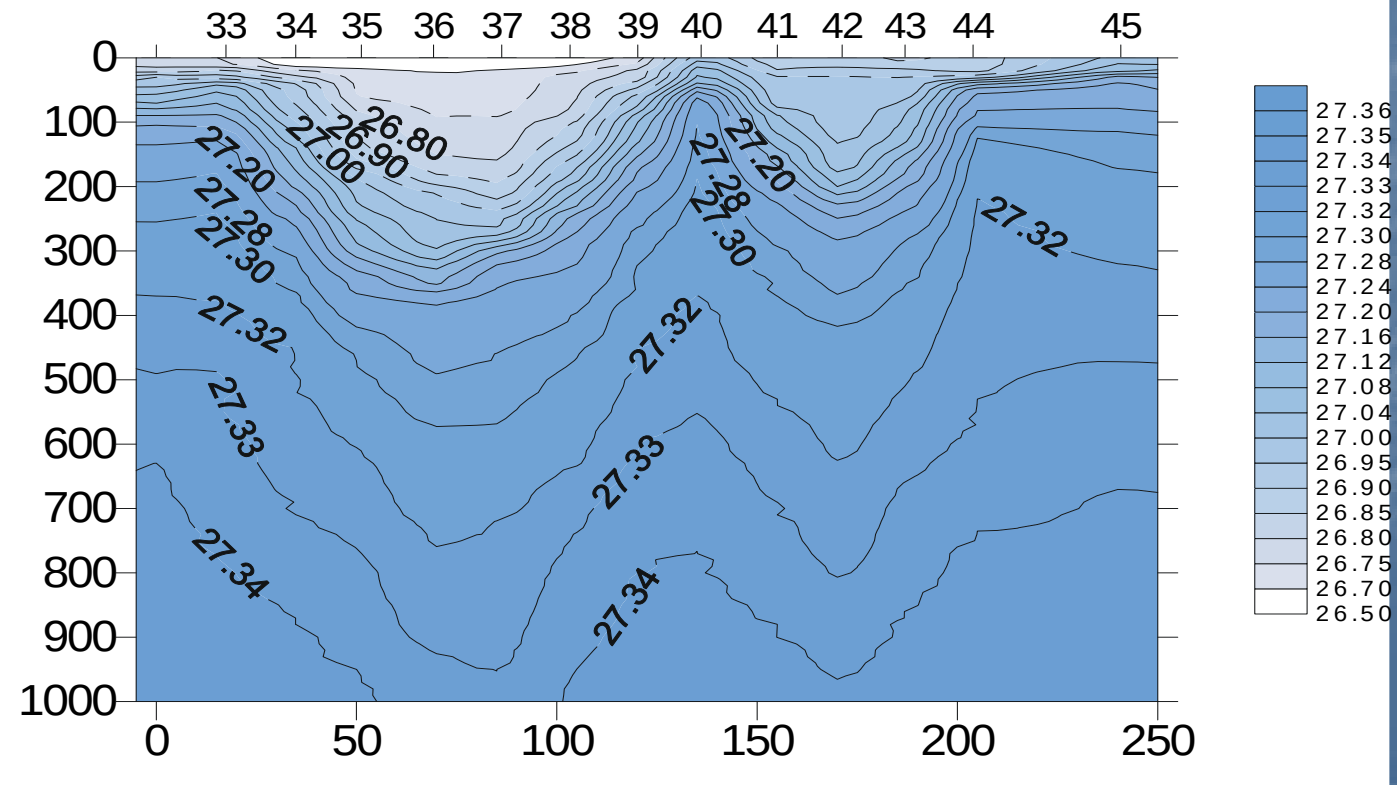
a) ERS-2 SAR image acquired at 01:58 UTC. ***A*** and ***B*** – anticyclonic eddies, ***C*** – band of colder water, ***F*** – areas covered by natural films.

b) NOAA AVHRR image acquired at 05:57 UTC. Rectangle indicates the location of the ERS-2 SAR frames.

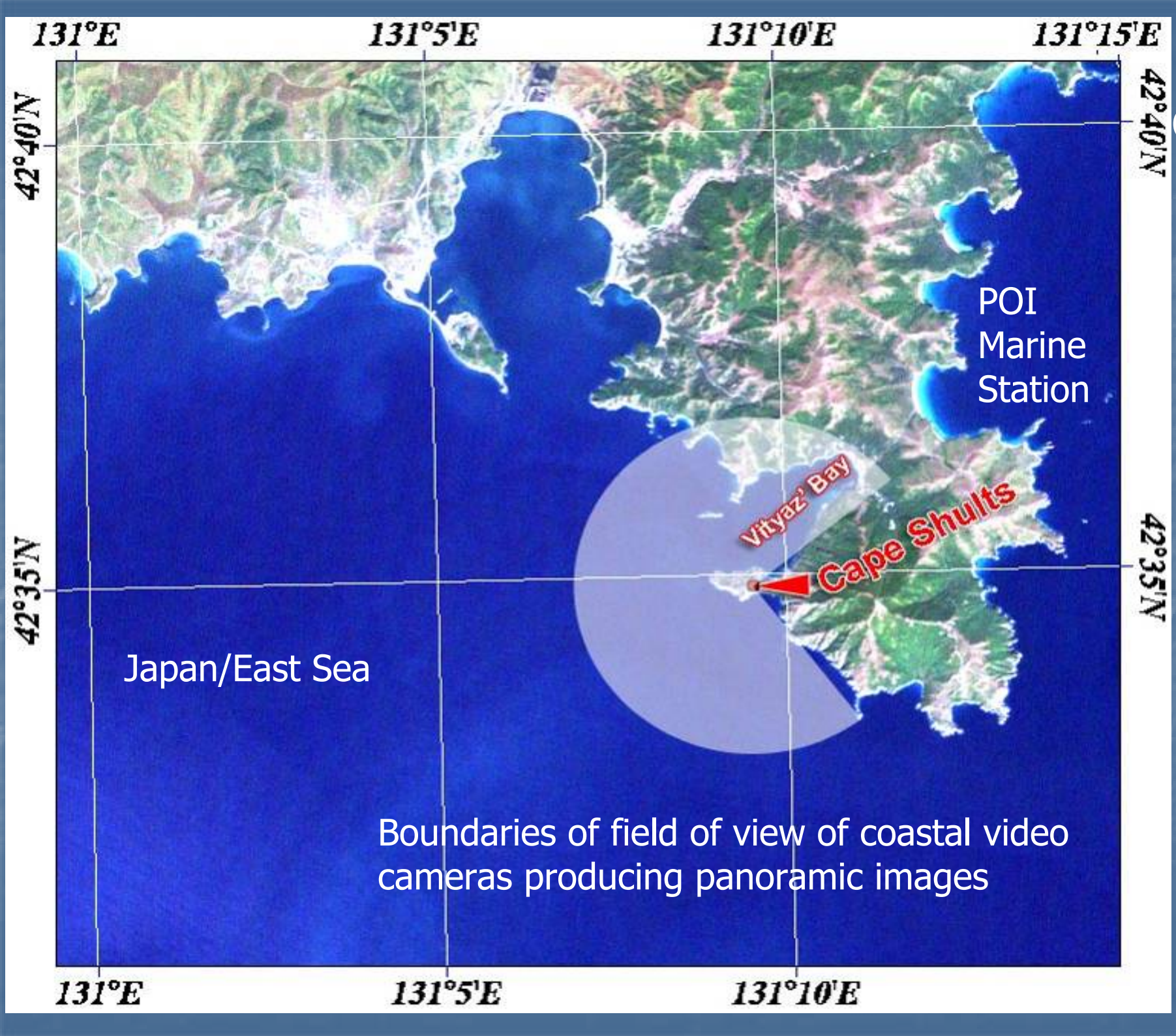
(c) Sampling profile along line 1-2, crossing eddy A, band of cold water *C* and eddy *B*.

Ship observations of anticyclonic eddies



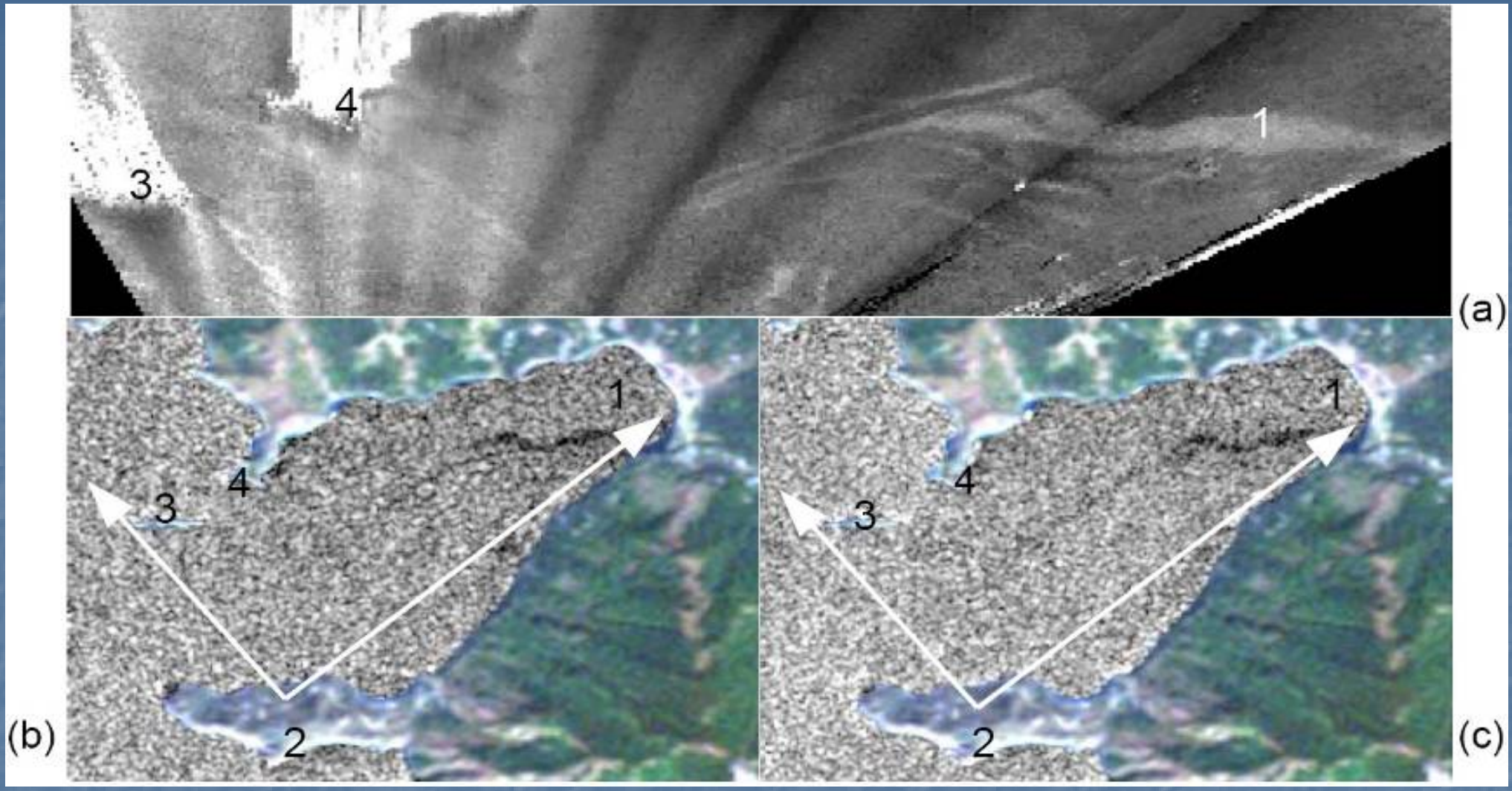


Distributions of temperature (a) and density (b) of the upper layer (0- 1000 dBar) across anticyclonic eddies ***A*** and ***B*** as measured by RV "Pavel Gordienko", on 18 April 1999. Location of hydrological stations was shown above.



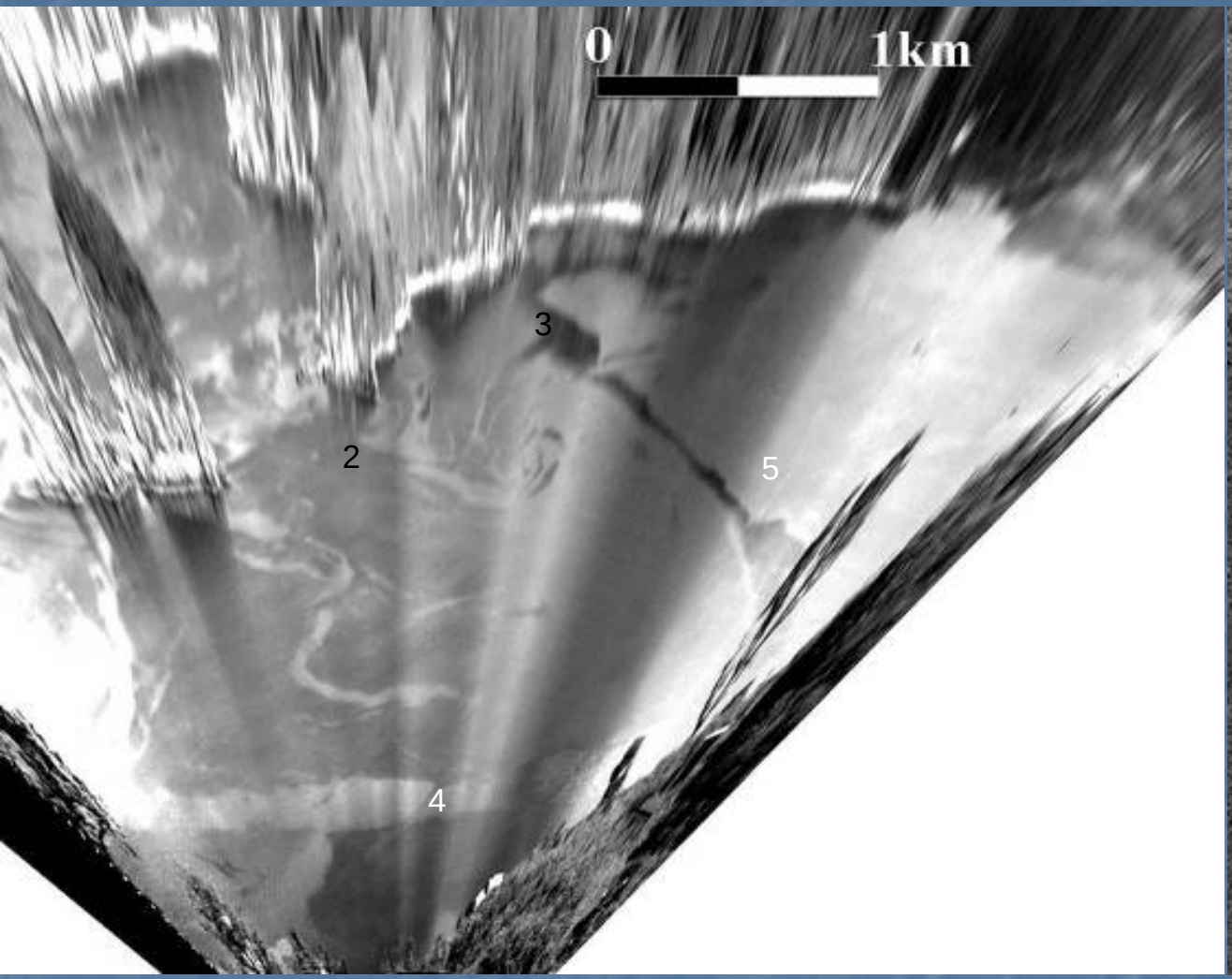
Coastal observations and satellite SAR images

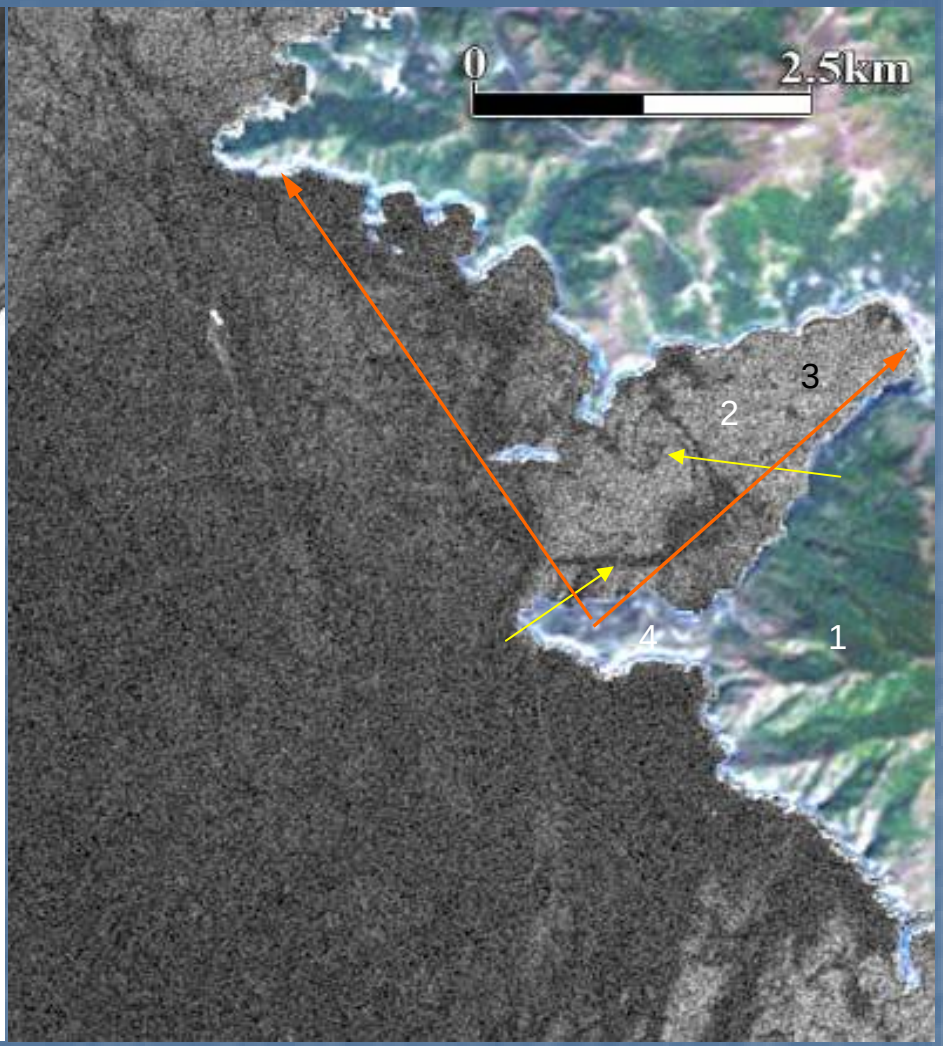
Experiments with artificial slicks were conducted and *in situ* data were collected.



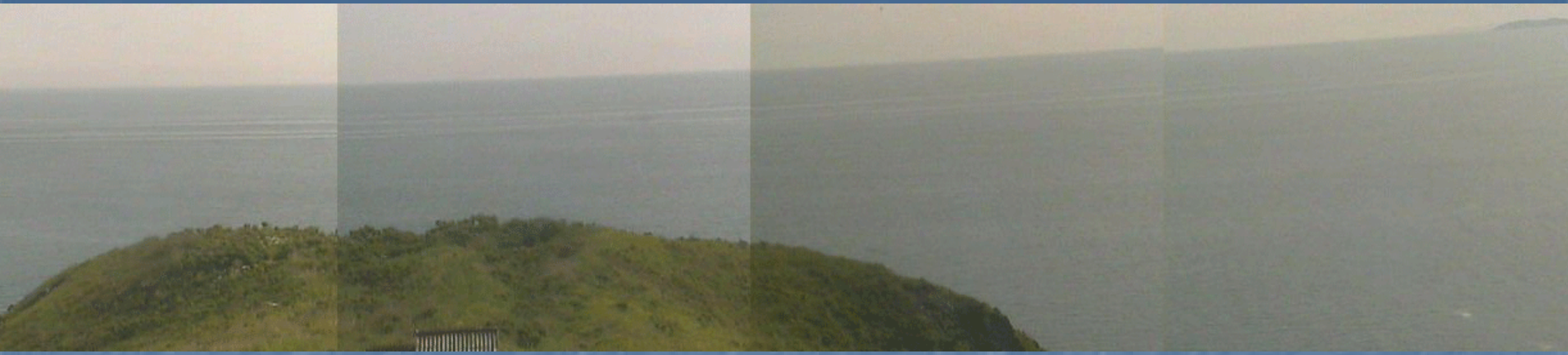
Panoramic image of Vityaz' Bay taken by a coastal video system from Cape Shults during Envisat ASAR sensing and transformed on a plane (a). Light elongated band of variable width (1) is biogenic slick, (2) – two small islands, (3) – cape on the southern coast of Vityaz' Bay. Envisat ASAR images of Vityaz' Bay taken on 20 September 2003 at 01:33 UTC at VV-pol (b) and HH-polarization (c). White arrows show the boundaries of field of view of coastal video camera. Biogenic slick has a dark tone on both images, however, there are differences in its appearance.

Simultaneous Envisat ASAR and ground-based optical observation of biogenic and artificial slicks in Vityaz' Bay. 5 Sep 2005, 01:30 UTC

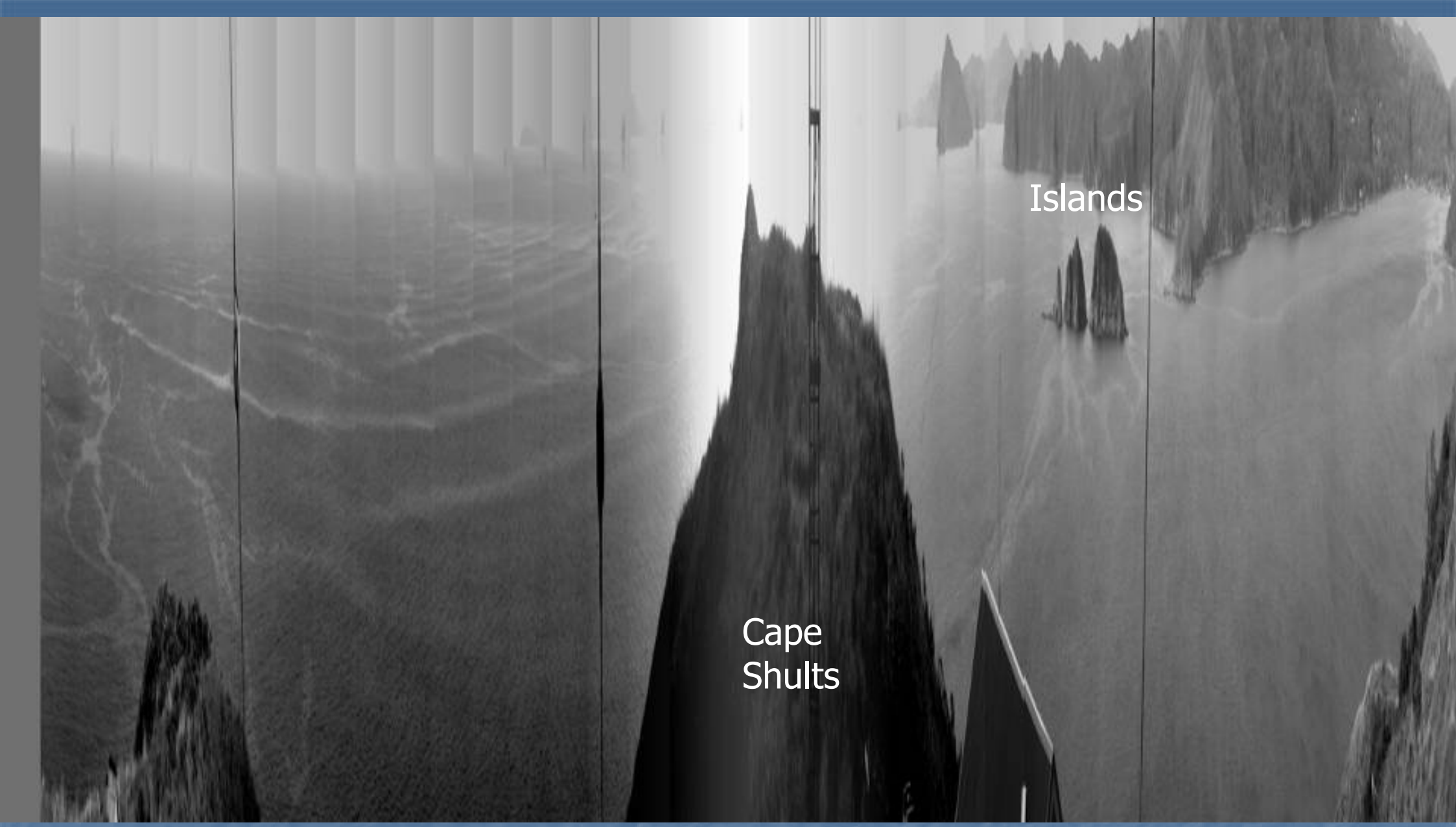




(a) Panoramic image obtained by a video camera from Cape Shults and transformed onto a plane and (b) fragment of Envisat ASAR image: (1) Cape Shults, (2) island, (3) cape on opposite side of Vityaz' Bay, (4) artificial slick band formed by oleic acid and (5) a cyclonic slick spiral formed by biogenic film. The boundaries of panoramic image are shown by red arrows in (b).

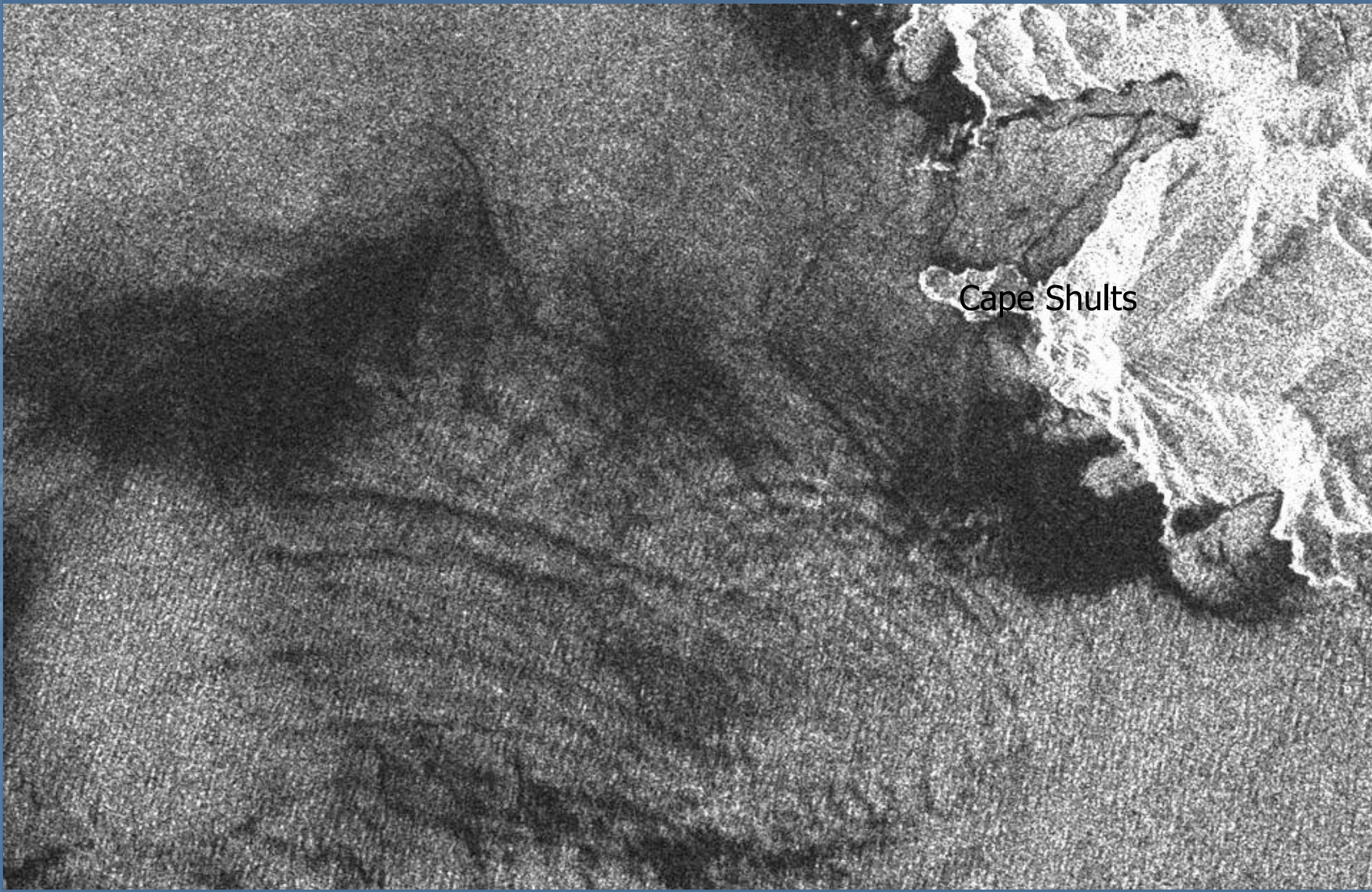


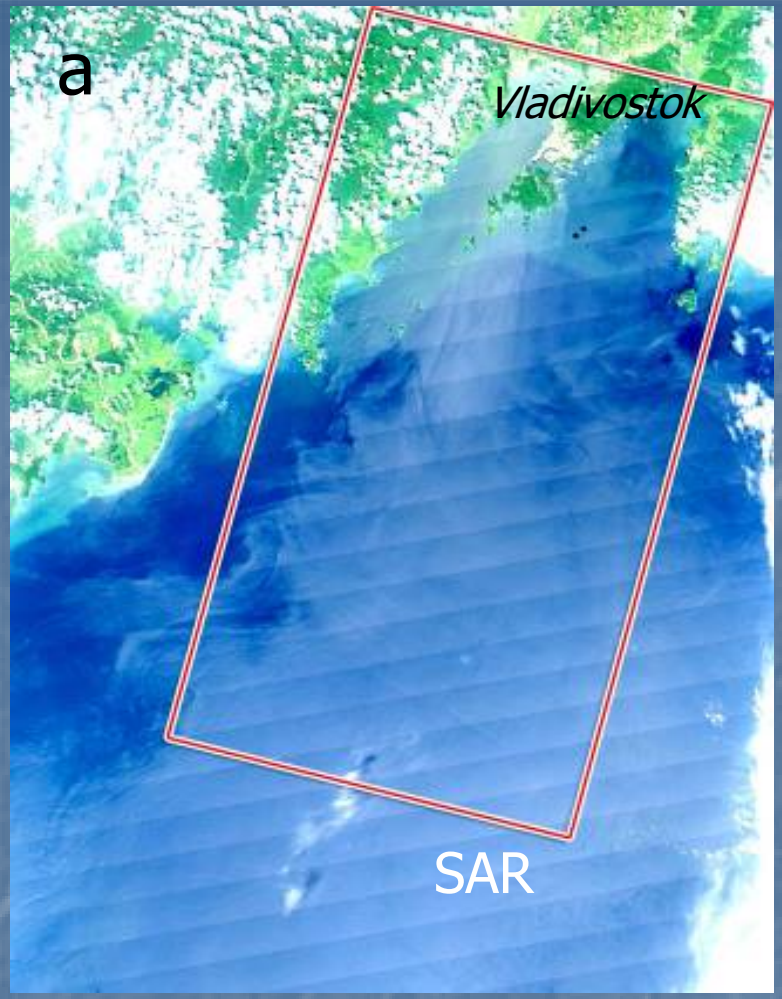
Video recording of surface munifestation of the internal waves propagated oncoast the Cape Shultz’ on 22 June 2008 at 06:00-9:00 UTC.

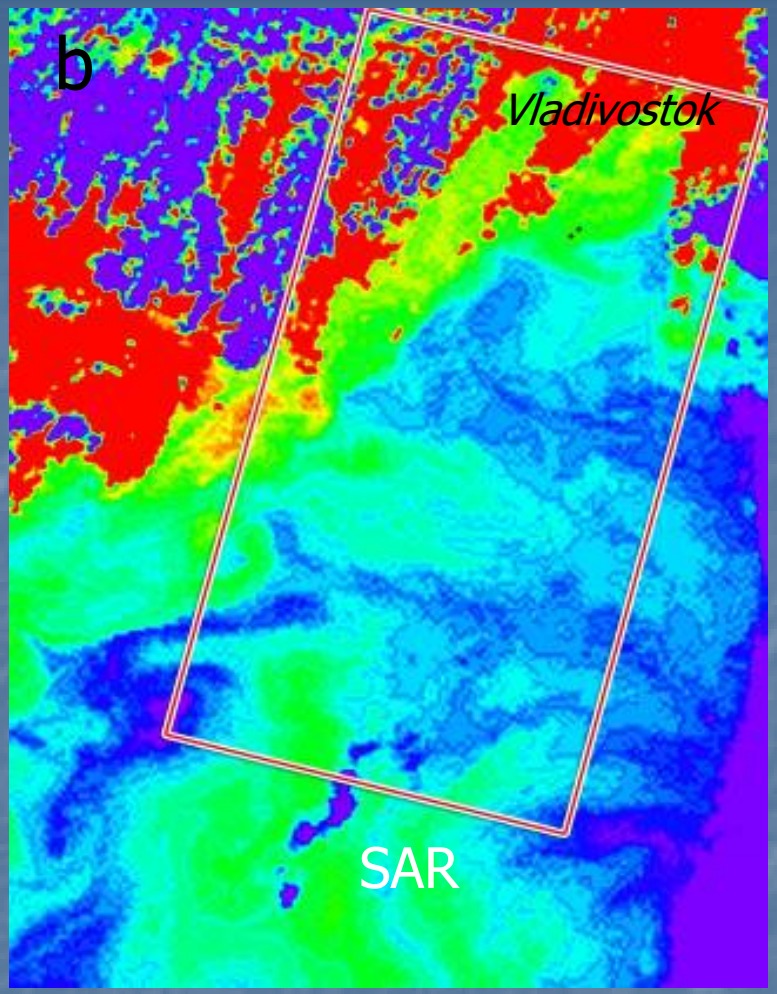


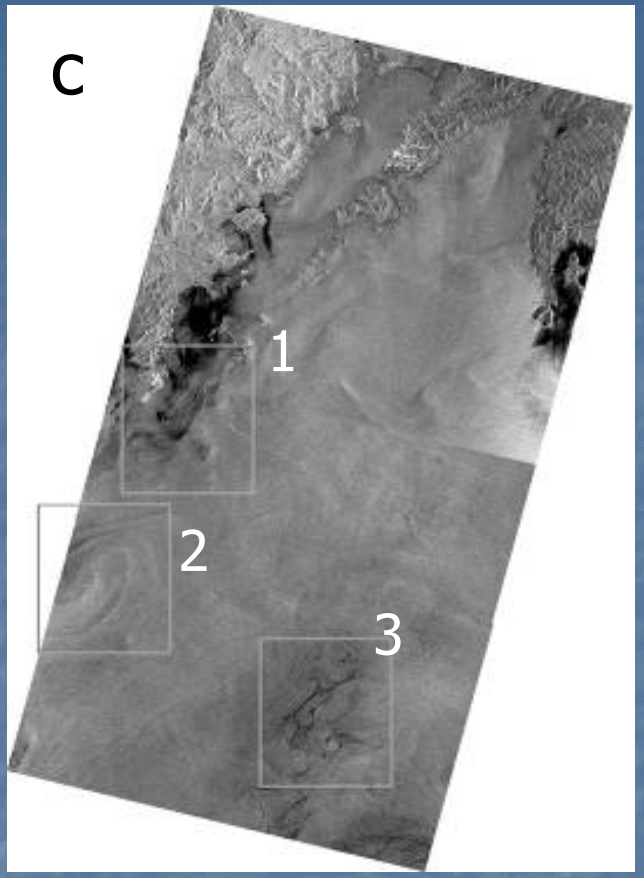
Internal waves propagating toward Vityaz' Bay on panoramic image taken by a video camera on 22 June 2008 at 06:00 UTC

Envisat ASAR image acquired on 22 June 2008 at 13:00 UTC



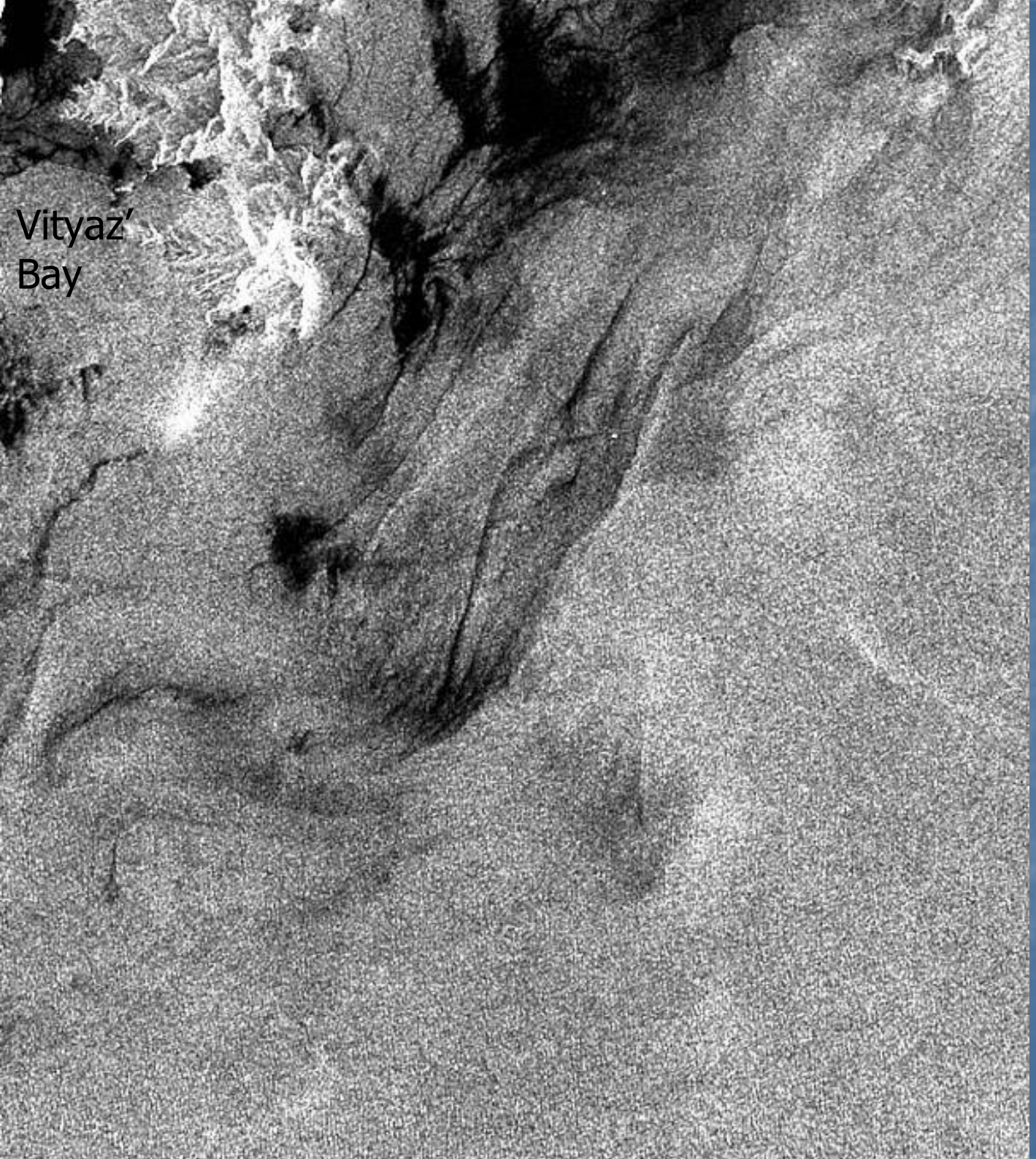






Terra MODIS visible (a) and infrared (b) images taken at 02:25 UTC and Envisat ASAR image (c) taken at 01:30 UTC on 25 August 2008.

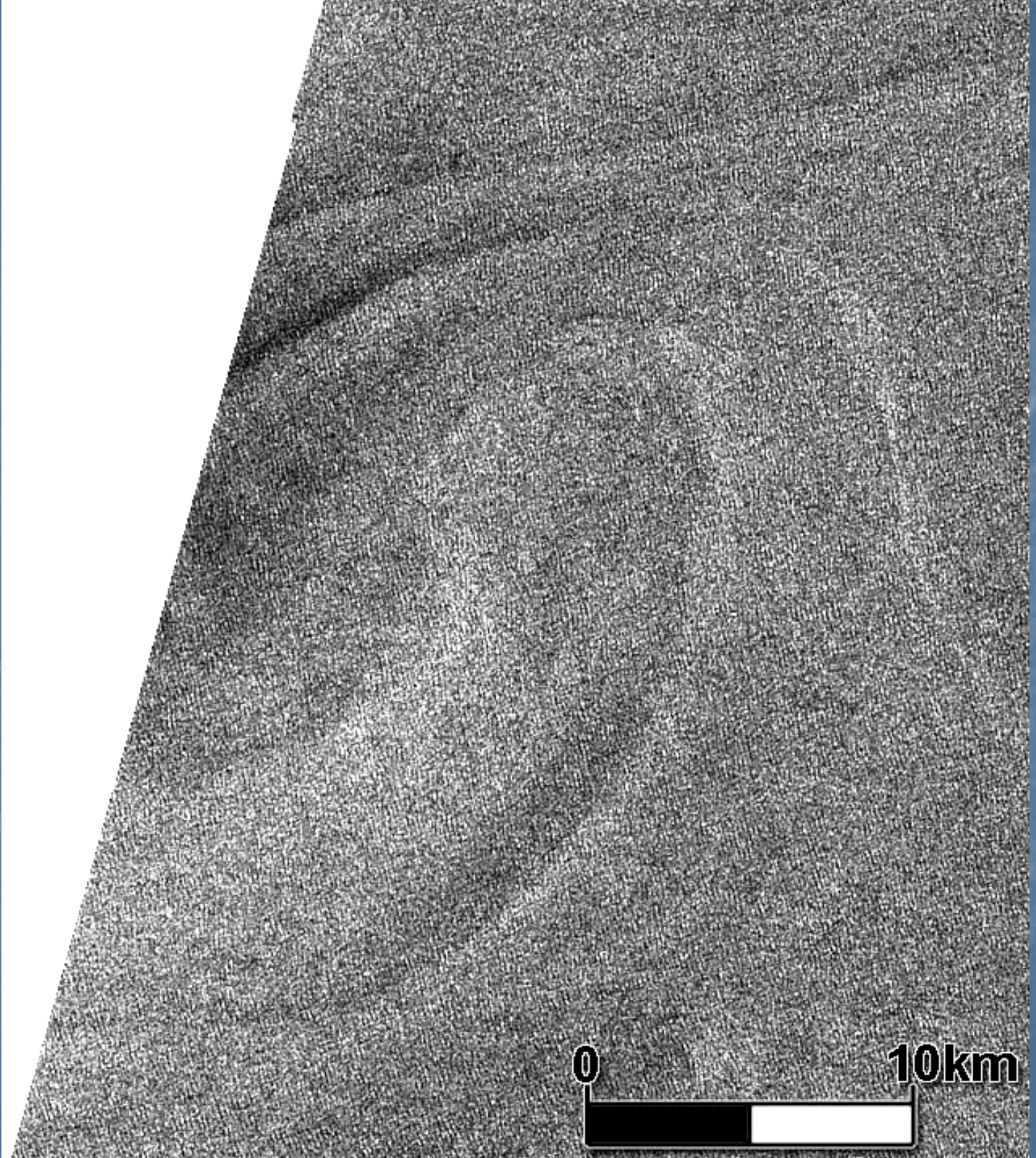
White rectangles in (c) note the boundaries of enlarged fragments 1, 2 and 3.



Fragment 1

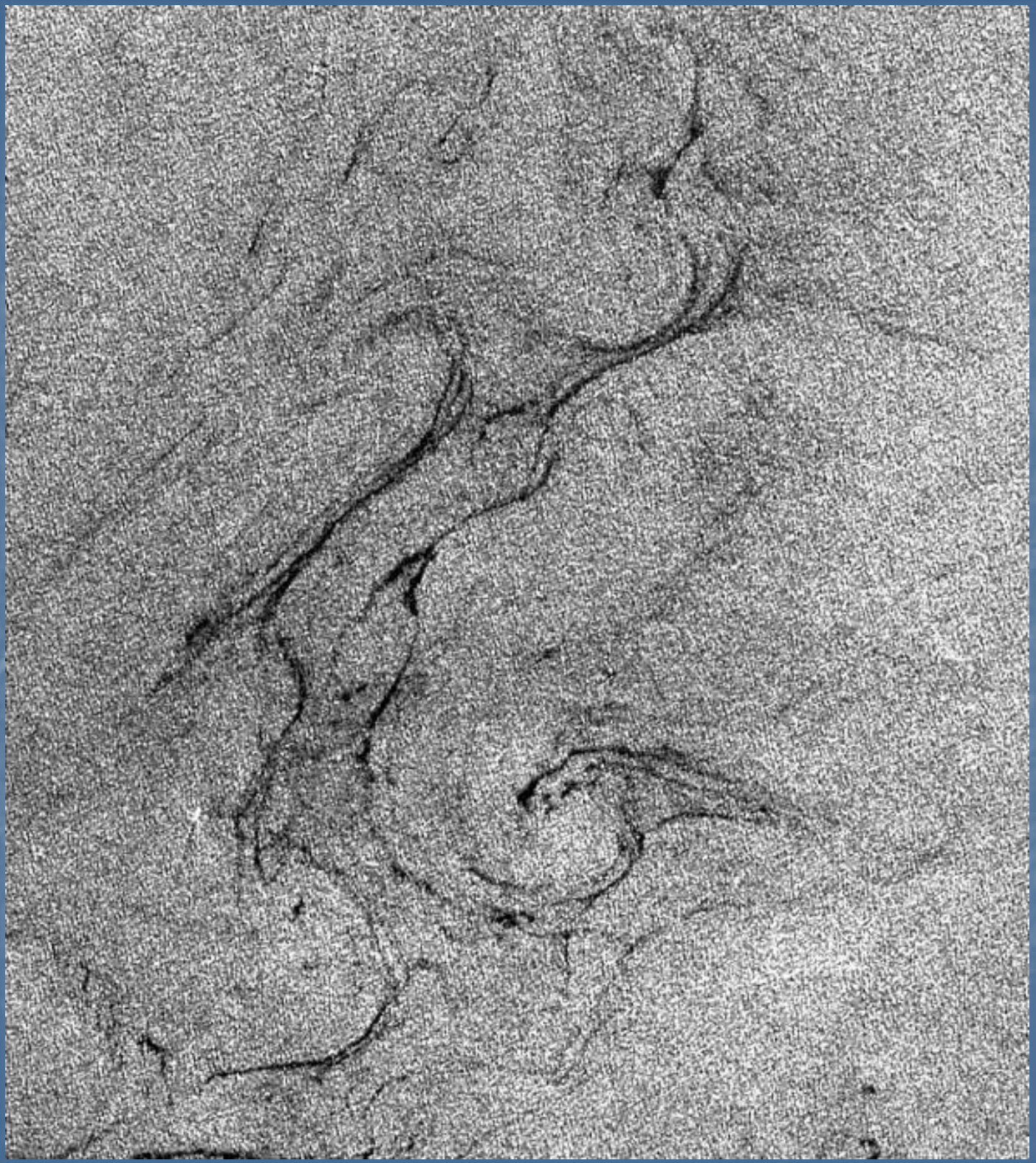
Vityaz' Bay and POI Marine Station "Cape Shults".

Manifestations of dynamic and thermal contrasts.



Fragment 2.

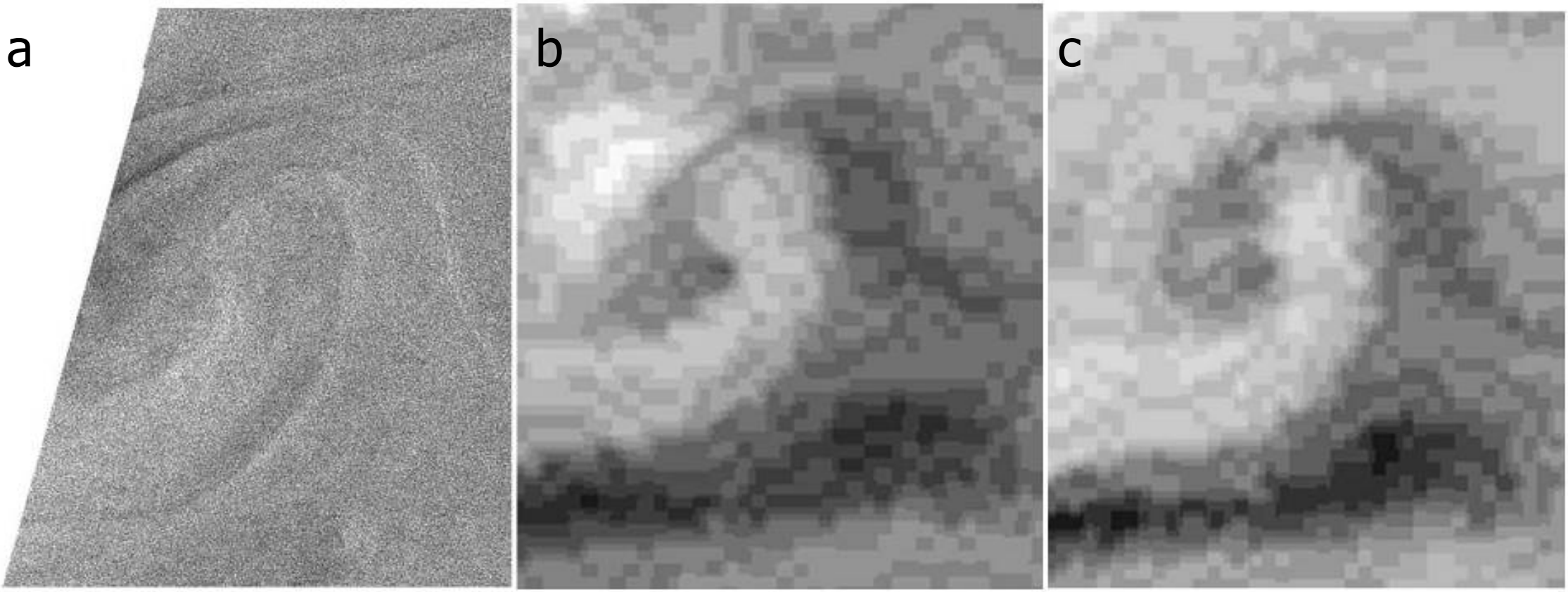
Spiral cyclonic eddy
Manifestations of dynamic and thermal contrasts



Fragment 3.

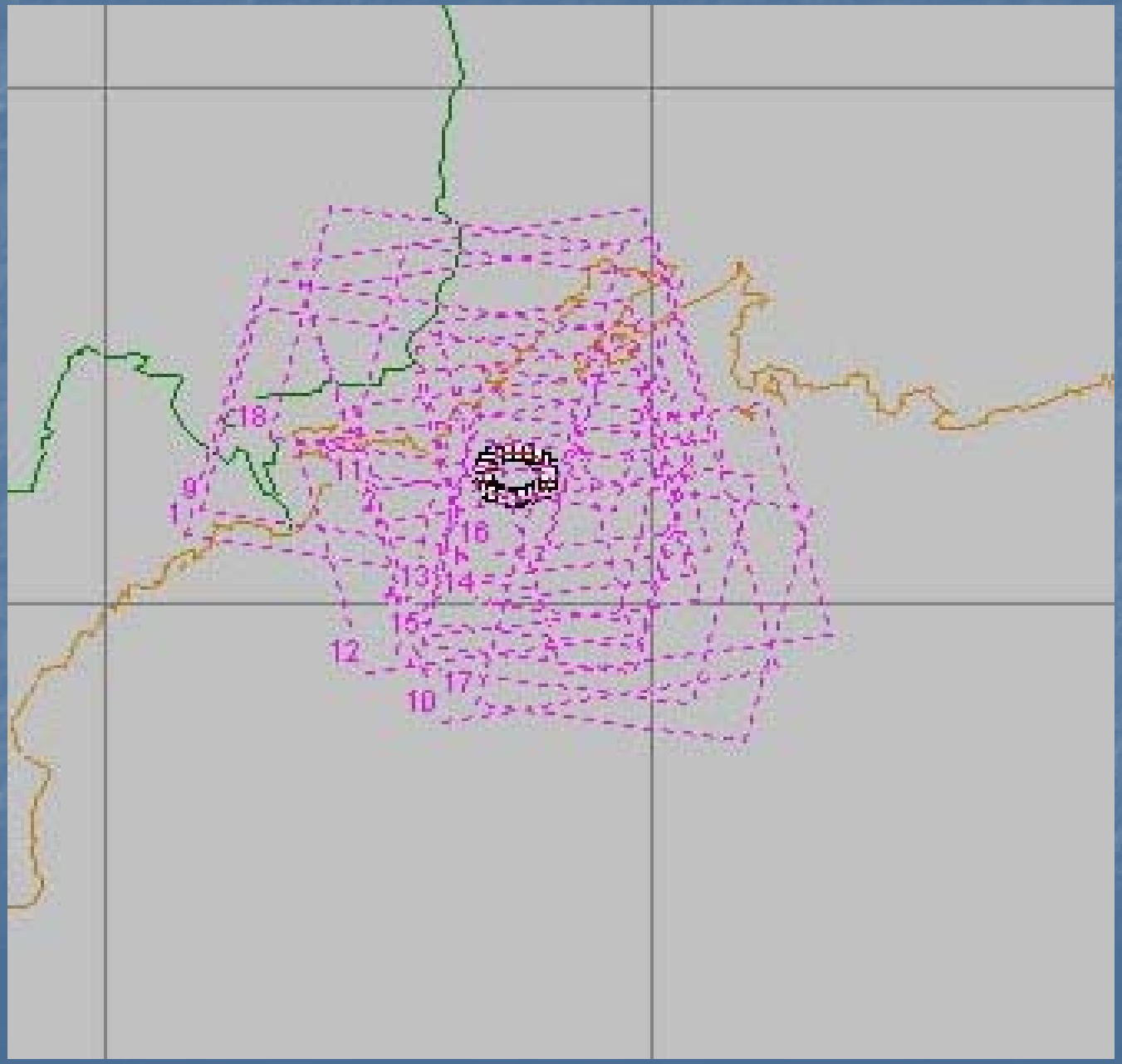
Surface circulation.
Filamentary slicks and spiral eddy.

Fragment 2. Spiral cyclonic eddy on satellite images obtained on 25 August 2008. Manifestations of dynamic and thermal contrasts



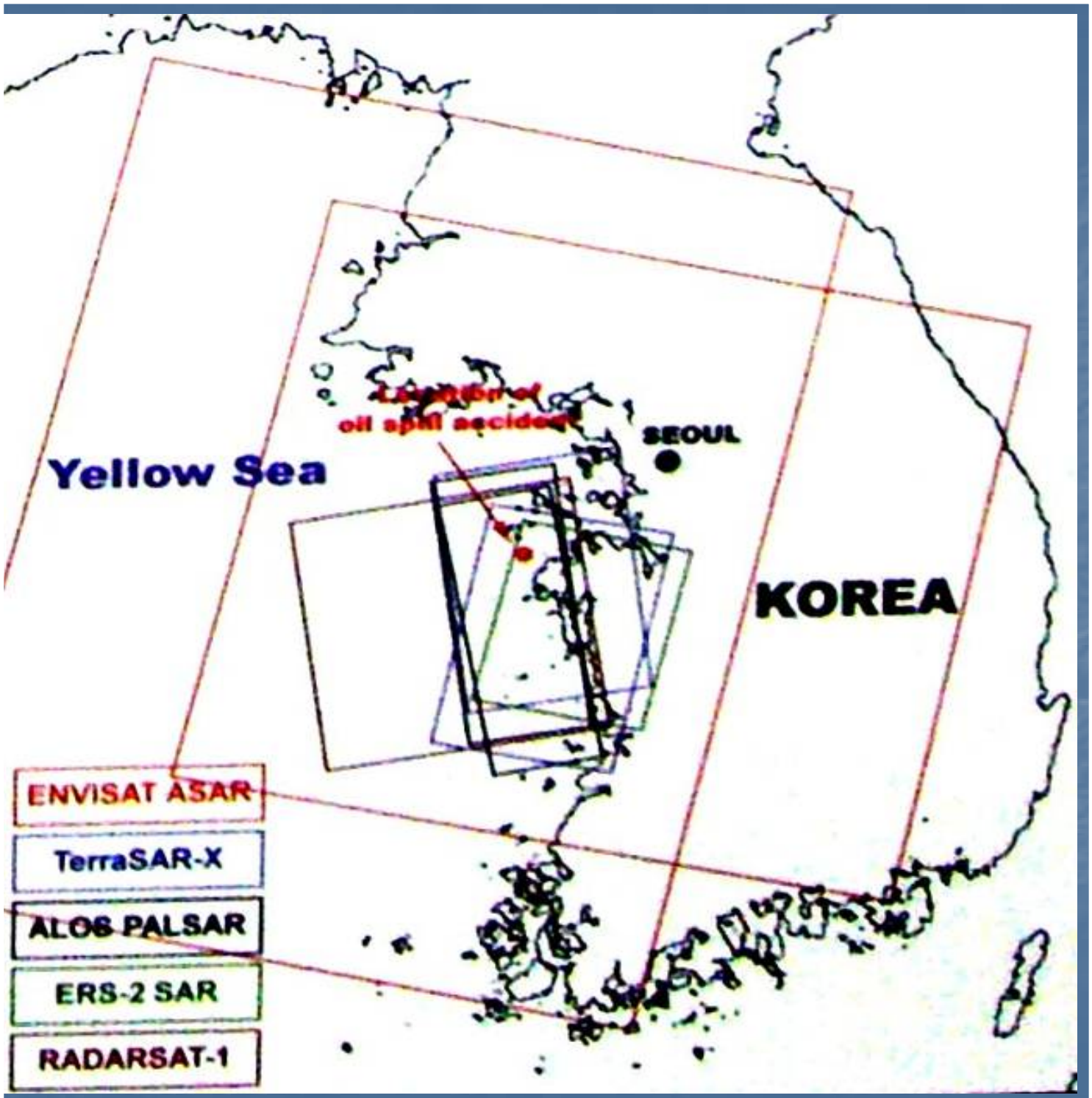
(a) Envisat ASAR image taken at 01:30 UTC
(b) Terra MODIS infrared image taken at 02:25 UTC
(c) Aqua MODIS infrared image taken at 04:05 UTC

Satellite SAR supporting of ship experiments to study and monitoring of Peter the Great Bay



Area the size of 10 km to the east of Bol'shoi Pelis Island will be 16 times within Envisat ASAR narrow bands in October 2008. Maximum amount of images during 5 days is equal to 4. This situation is repeated approximately 1 time per month.

Satellite SAR sensing of oil spill near the west coast of the Korea

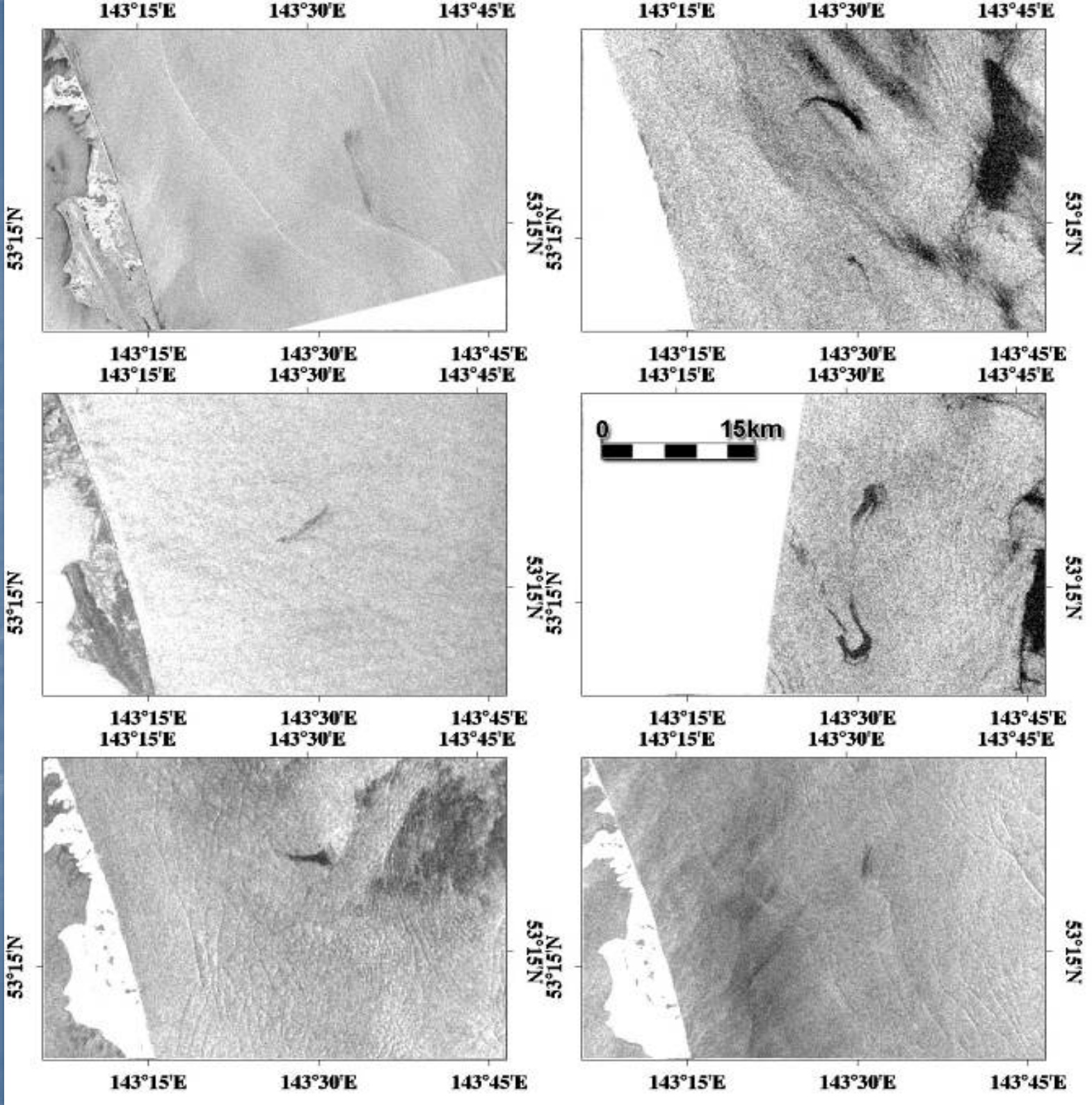


Satellite SAR observations of oil spill on the west coast of Korea

Date	9 Dec 14:03	11 Dec 01:40	11 Dec 09:31	11 Dec 13:46	12 Dec 21:44	14 Dec 01:40	14 Dec 02:15	20 Dec 09:28
Satellite	ALOS	Envisat	RADAR-SAT	ALOS	Terra SAR-X	Envisat	ERS-2	Terra SAR-X
Wavelength, cm polarization	23.5	5.6 HH	5.6 HH	5.6 HH, VV, HV, VH	3.15 VV	5.6 HH	5.6	3.15 VV
Wind speed, m/s direction		5.3 10°	5.9 13°		6.1 328°	6.6 347	6.6 345	5.1 349
Damping ratio, dB		6.9	4.5		7.1	2.2	3.4	3.3
Oil spill area, km^2		1400 (K) 1555 (C) 1300 (R)			400 (K) 550 (C)	350 (K) 332 (C)	340 (K) 420 (R)	>410 (K)

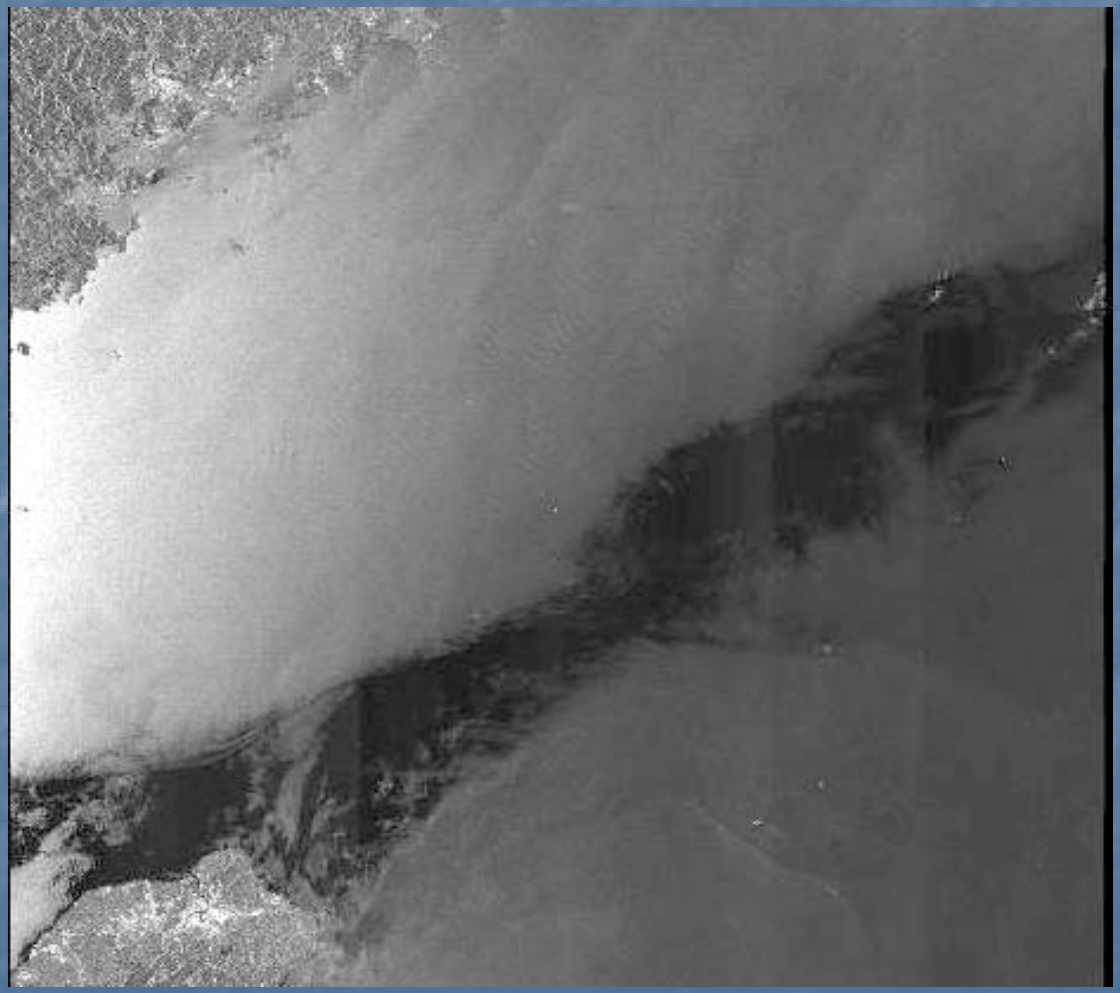
The first Envisat ASAR image was acquired on 10 December, however, it covered only a part of oil spill area.

Duk-jin Kim, Jinho Kang, Boyeol Yoon, Younsoo Kim and Yongseung Kim. Observation of crude oil spill off the west coast of Korea using TeraSAR-X, Envisat, ERS-2, RADARSAT-1, and ALOS. *IGARSS'08. Boston, 6-11 July 2008.* Remote sensing Division, Satellite Information Research Institute, Korea Aerospace Research Institute



Oil spills resulted from bottom seepage in the Okhotsk Sea near northeastern Sakhalin

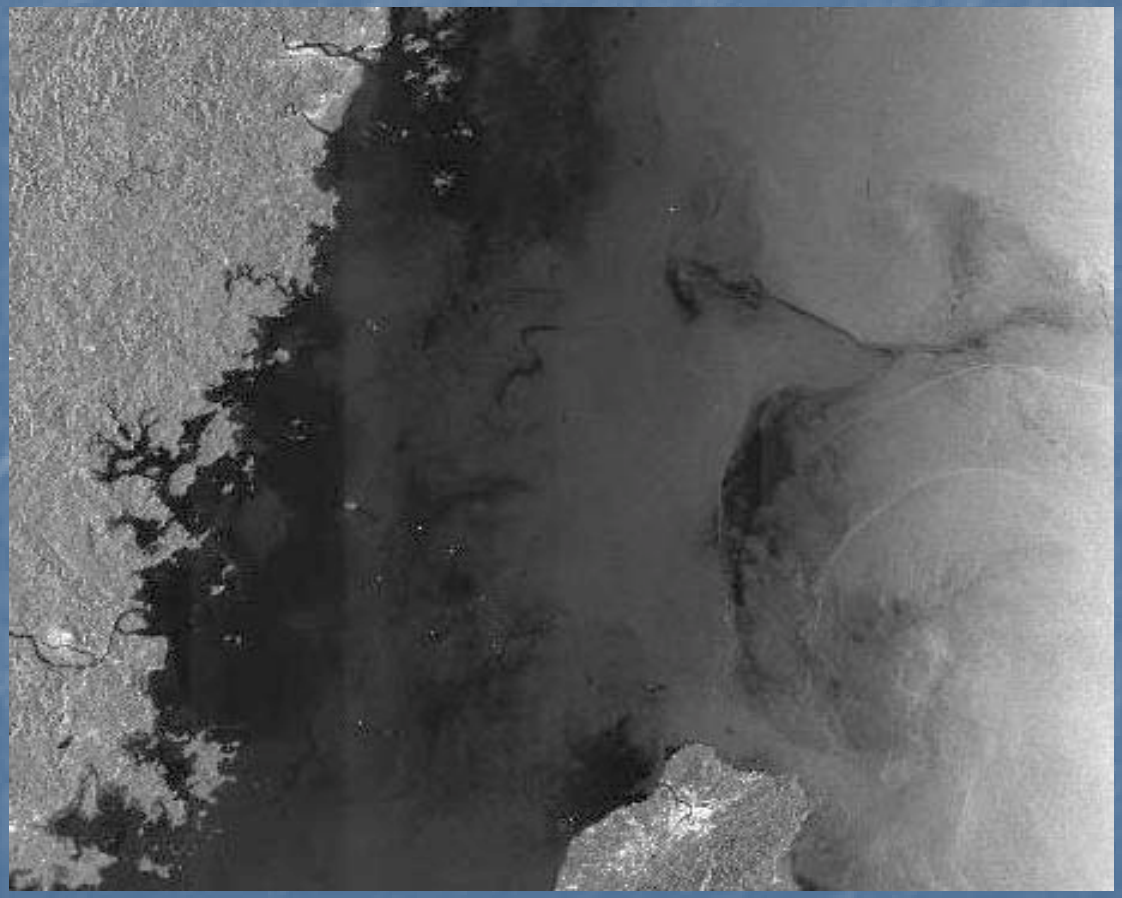
East-China Sea



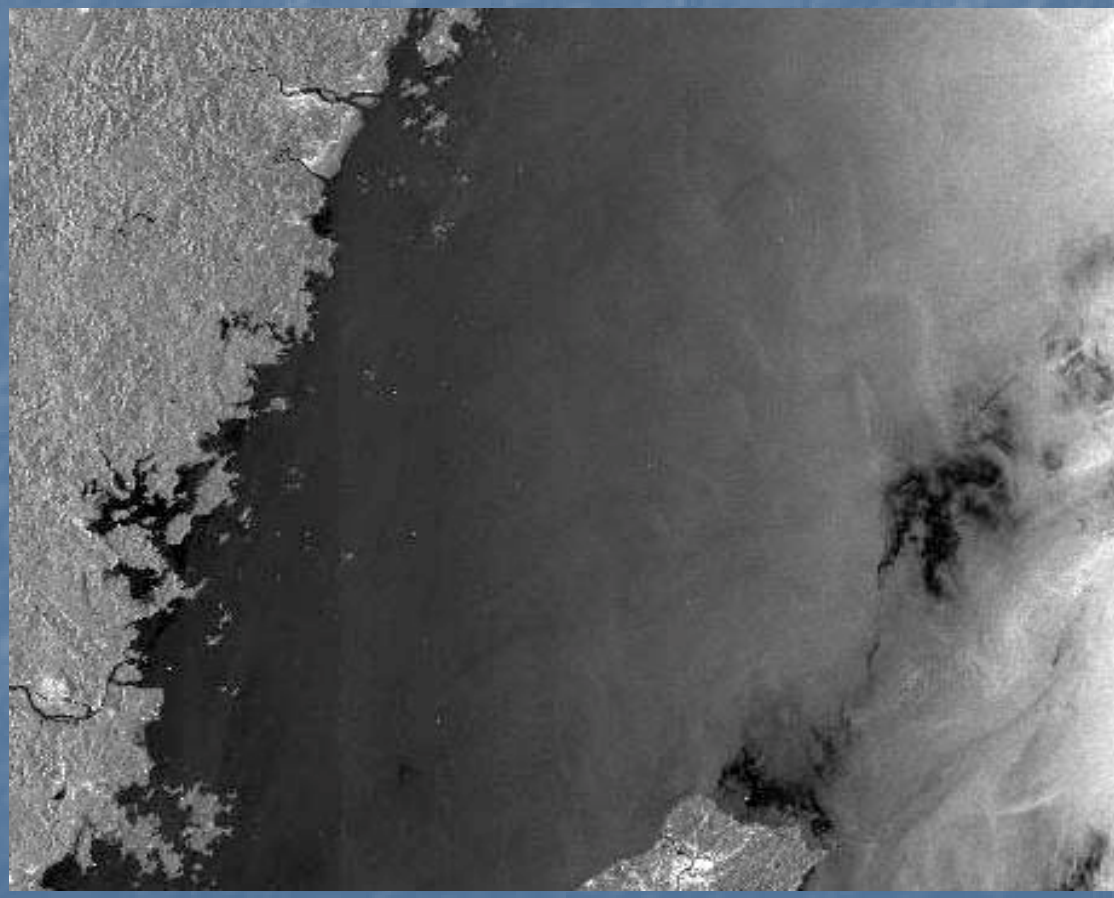
11 March 2004

11 November 2004

East-China Sea

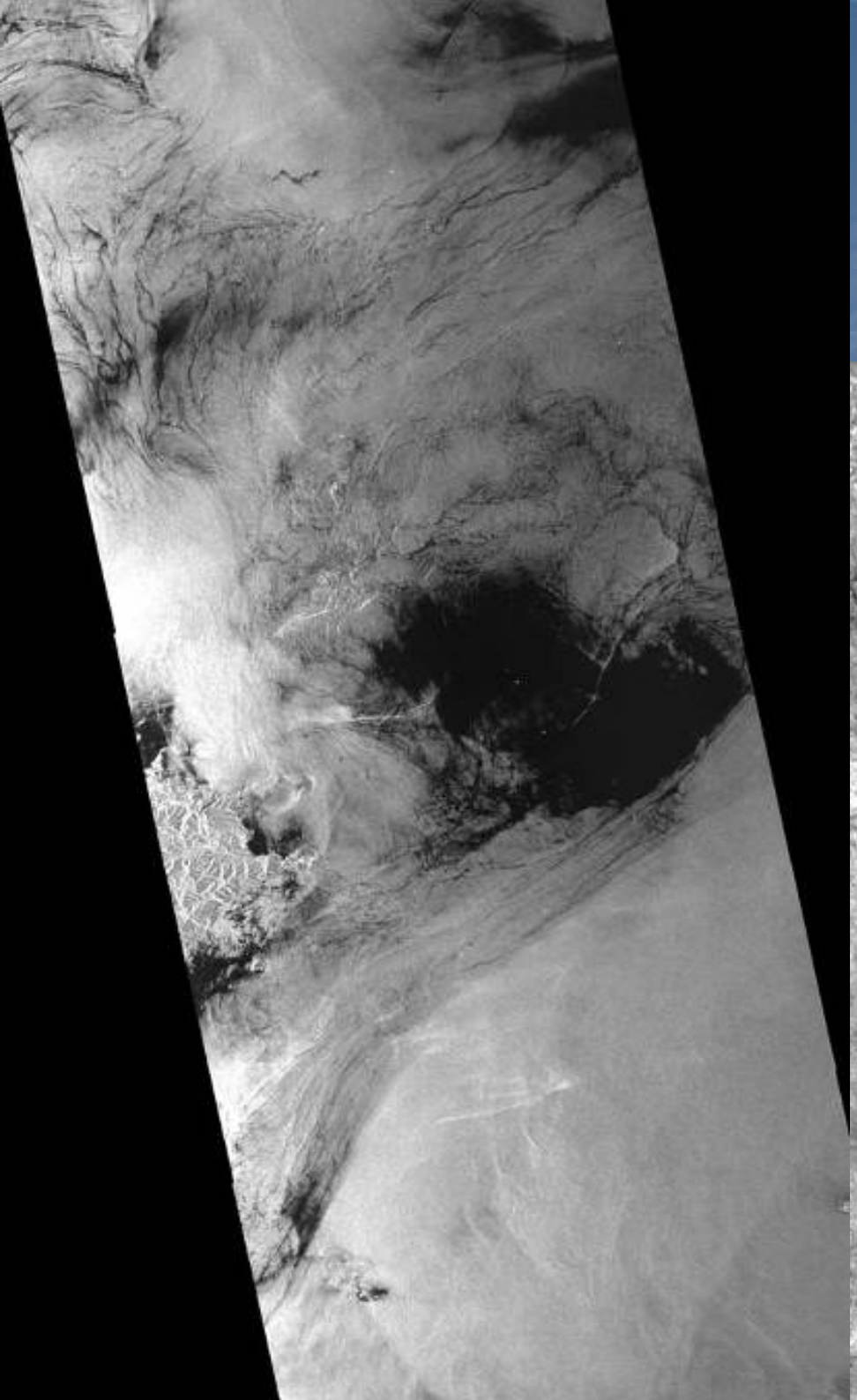


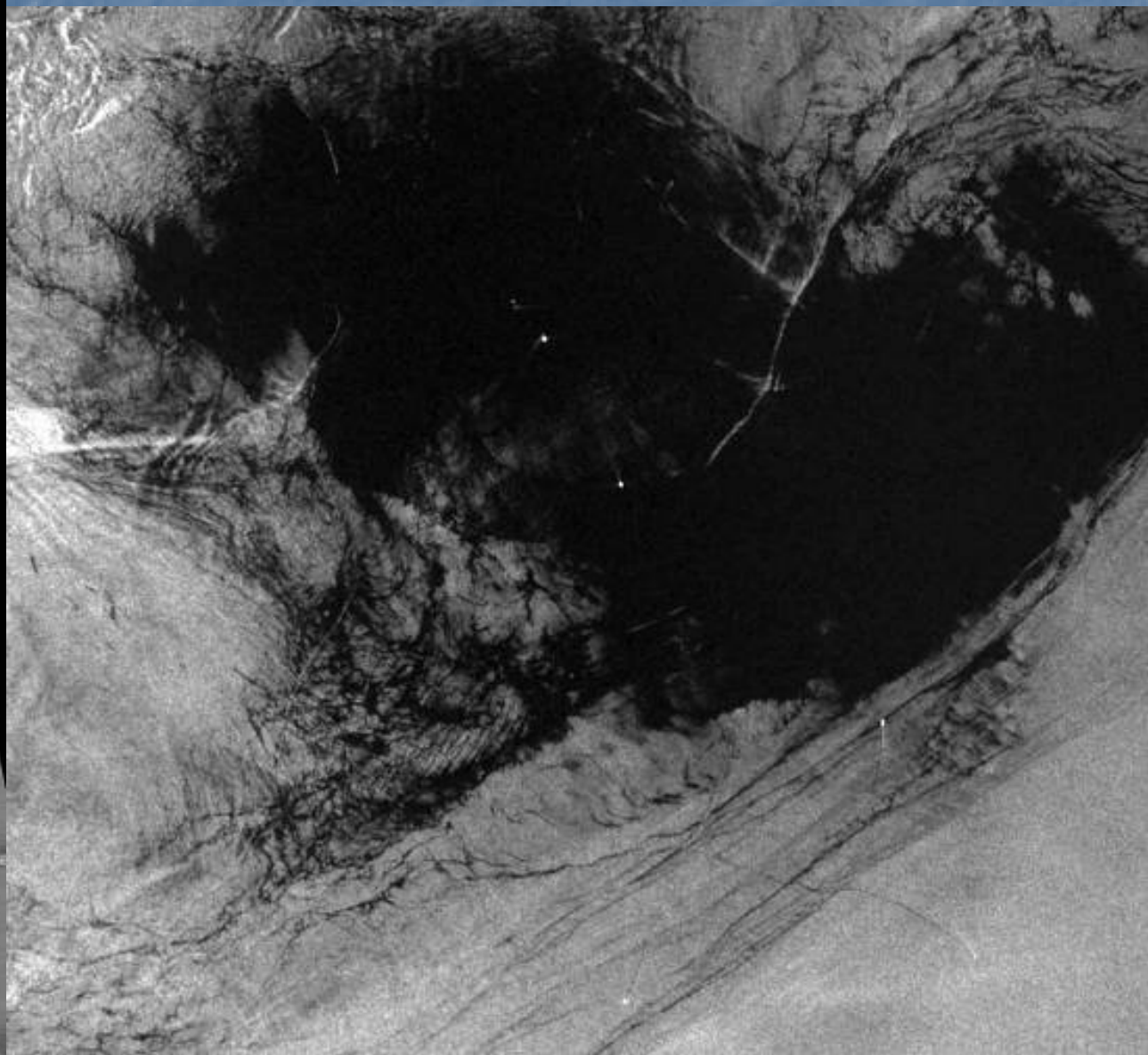
25 July 2005



10 July 2006

East-China Sea
Envisat ASAR.
26 May 2007





7. Conclusions

Satellite SAR is a valuable instrument to study the dynamic phenomena of different scales both in the ocean and in the atmosphere. Power of a SAR increases strongly when SAR images are analyzed together with supplementary remote and *in situ* data.

SAR images can serve as an important supplementary or main source of high-resolution spatial information during ship and coastal experiments.

Of special interest is the study of the narrow contrast bands (lines) caused by the current features associated with oceanic and coastal fronts of different origin, eddy formations, internal waves, etc.

This work is partly supported by RFBR Projects: 06-05-96076-p_yostok_a, and 08-05-99109-p_ofi

Conclusion

Examples of satellite SAR images that were important supplementary or main source of information on oceanic dynamic phenomena in the coastal and open areas of the Japan and Okhotsk Seas as well as at POI Marine Experimental Station Cape Shults were presented. Comparison of SAR signatures caused by coastal fronts, eddies, internal waves and sea ice with close in time visible and infrared satellite images and ship measurements is carried out demonstrating the importance of 2D information on the sea surface obtained at the different spectral ranges.

As opposite to visible (ocean color) and infrared (thermal) contrasts SAR sensing is sensitive to