

# **Microwave passive and active remote sensing: From Kosmos-243 and Kosmos-1500 to GCOM-W1 AMSR2 and Envisat ASAR and ALOS PALSAR**

*Леонид Моисеевич Митник*

*Тихоокеанский океанологический институт им. В.И. Ильчева ДВО РАН  
690041 Владивосток, ул. Балтийская 43, e-mail: mitnik@poi.dvo.ru*

*Пятая международная Школа-семинар  
«Спутниковые методы и системы исследования Земли»  
Таруса, 5 февраля – 3 марта 2014 г..*

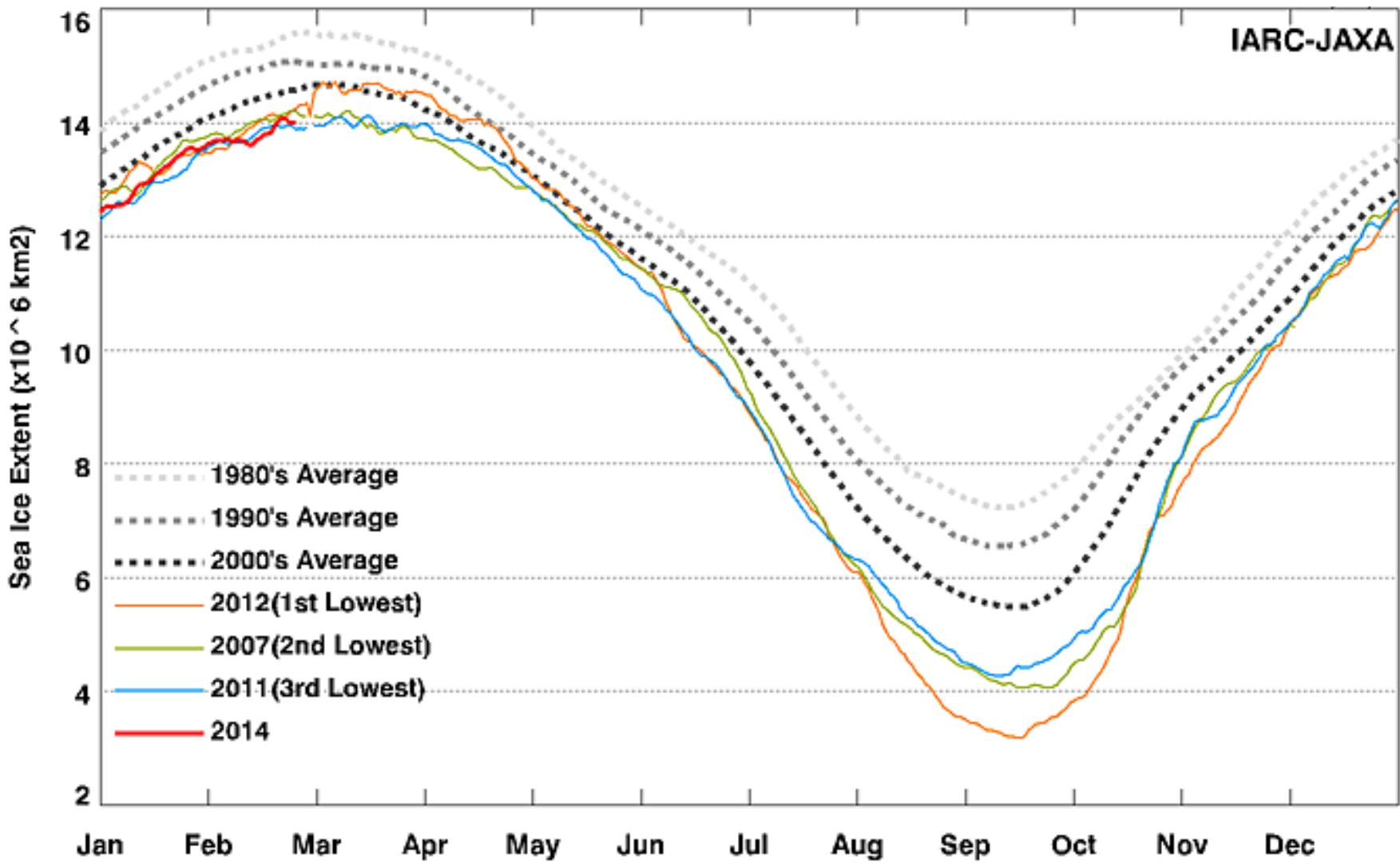


Таруса, 27 февраля, 07:50 Гр.

## Arctic Sea Ice Extent (Ver.2)

25 February 2014

IARC-JAXA



Sea Ice Extent  
02/25/2014



National Snow and Ice Data Center, Boulder, CO

median  
1981–2010

**25 February 2014**

# Космос-243 и Космос-384

Passive microwave sensing of the ocean started in the **U.S.S.R.** in the early 1960s. The first two satellites to carry four microwave radiometers into space were **Kosmos-243** launched in 1968 and **Kosmos-384** in 1970.

## Kosmos-243 Microwave Radiometer Specifications

<b>Wavelength (cm)</b>	8.5	3.4	1.35	0.8
<b>Center frequency (GHz)</b>	3.5	8.8	22.2	37.5
<b>Antenna pattern width (degree)</b>	8.6	4.0	3.6	4.0
<b>Efficiency (%)</b>	80	85	76	95
<b>Sensitivity (K)</b>	0.7	0.5	0.9	1.3
<b>IFOV<sup>*)</sup> (apogee) (km x km)</b>	50 x 50	22 x 22	20 x 20	22 x 22
<b>IFOV (perigee) (km x km)</b>	35 x 35	15 x 15	13 x 13	15 x 15
<b>Incidence angle (degree)</b>	0			

**\*) IFOV is Instantaneous Field Of View**

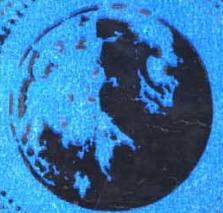
**KOSMOS-243**, the first satellite with microwave radiometers, was launched on 23 September 1968. Orbit inclination 71.3°, apogee - 319 km, perigee - 210 km.

# Brightness temperature registration on electrochemical paper

009  
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050  
051  
052

А.Е. БАШАРИНОВ, А.С. ГУРВИЧ, С.Т. ЕГОРОВ

# РАДИОИЗЛУЧЕНИЕ ЗЕМЛИ КАК ПЛАНЕТЫ



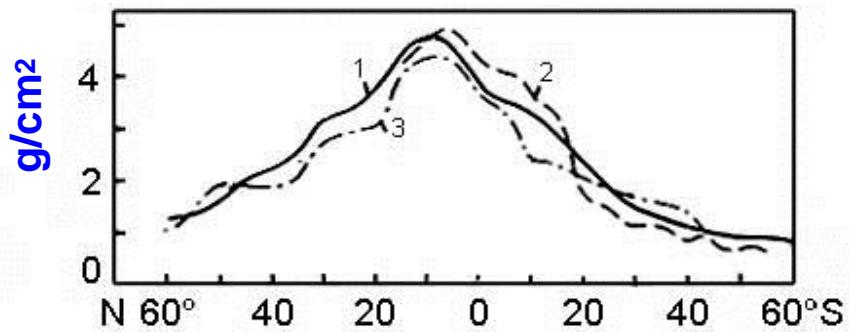
Издательство «Наука»  
Москва, 1974

## Космос-243 и Космос-384

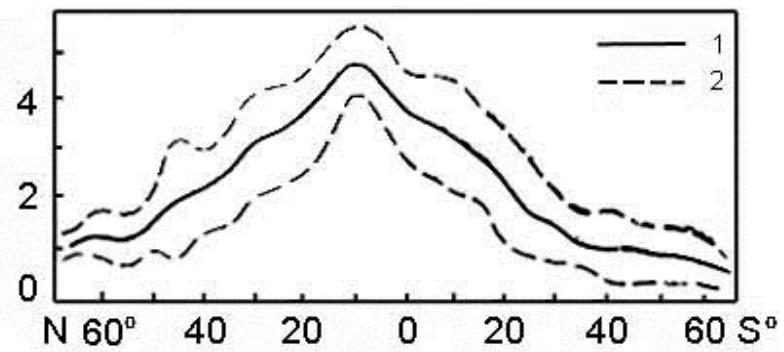
The possibilities of retrieving sea surface temperature, near-surface winds, total atmospheric water vapor content, total cloud liquid water content, and sea ice parameters were documented by *Basharinov et al. (1974)*.

# Kosmos-243

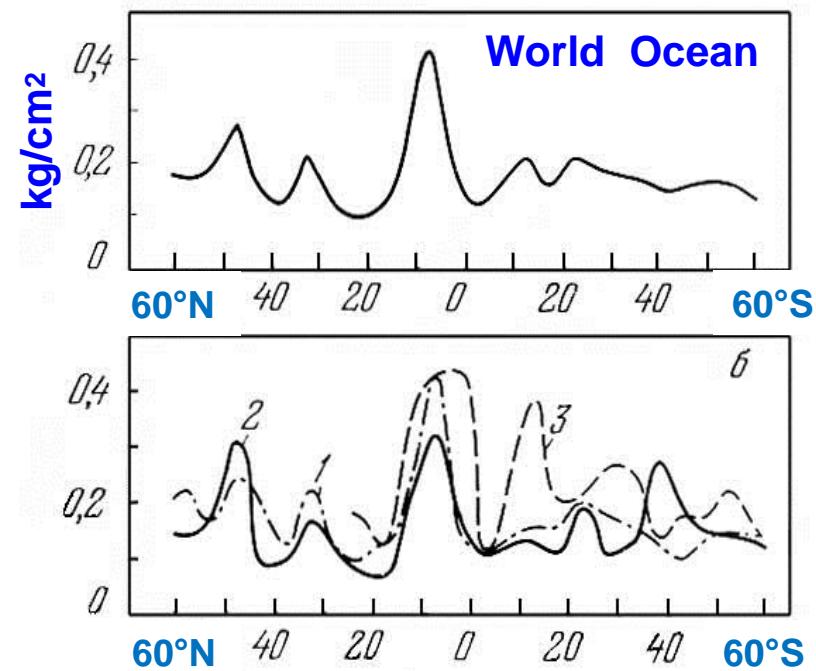
Total water vapor content over the Pacific (1),  
Atlantic (2) and Indian (3) Oceans



Total water vapor content over the World Ocean



Total cloud liquid water content

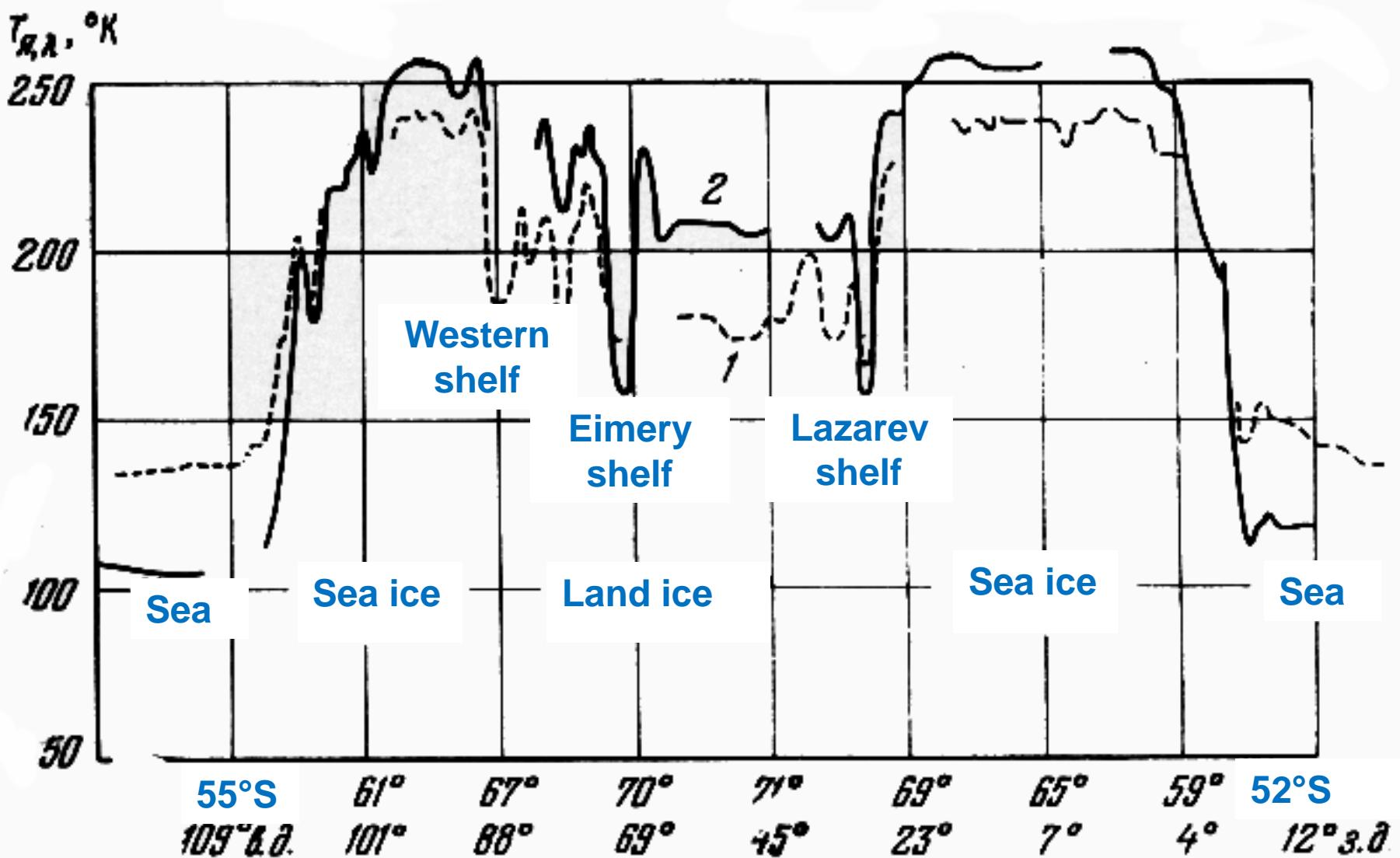


$$M_w = 1.24 \cdot 10^{19} \text{ g}$$

$$W_{\text{avg}} = 2.4 \text{ g/cm}^2$$

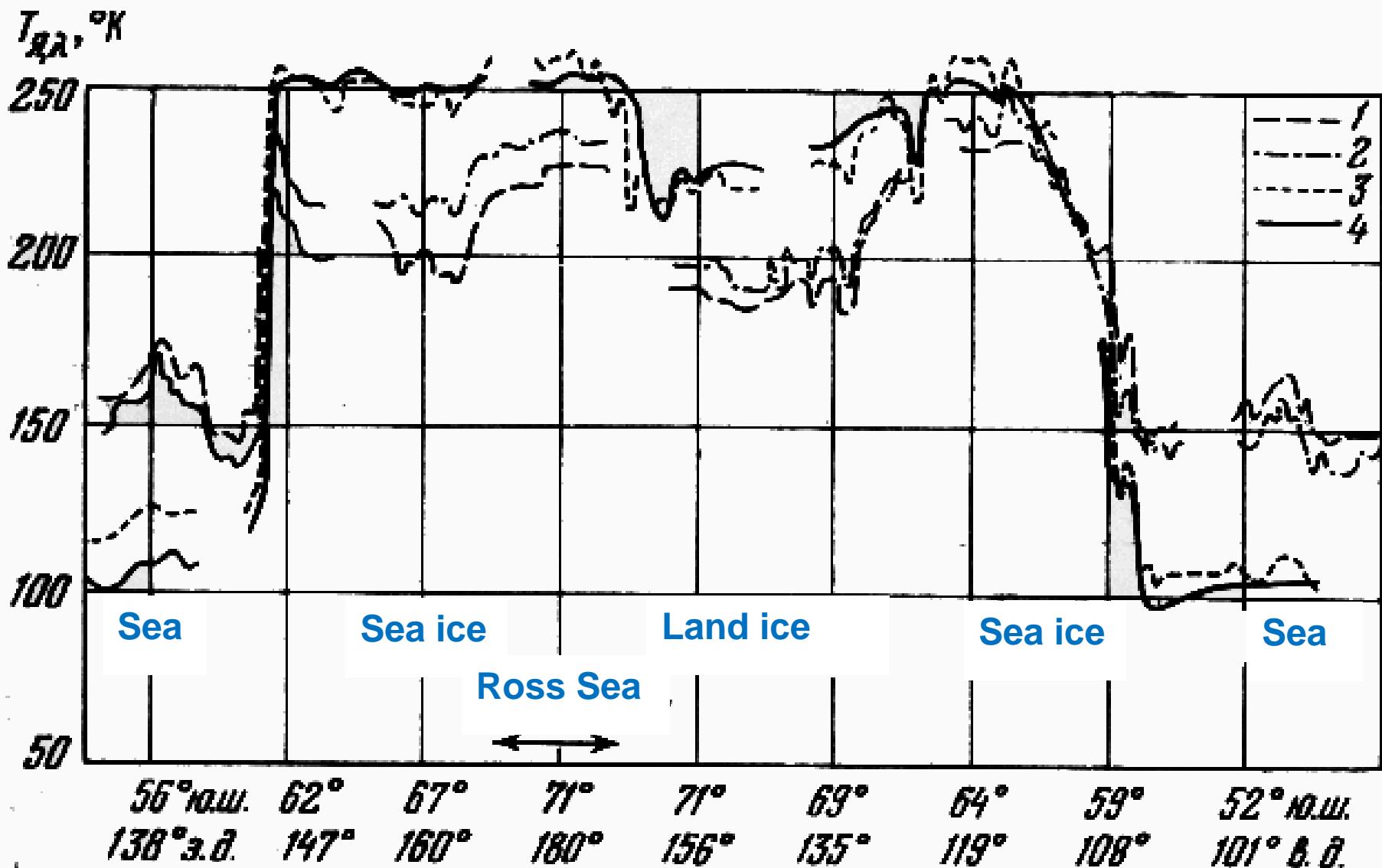
Latitude distribution of total water vapor content (left) and total cloud liquid water content (right) over the Pacific, Atlantic and Indian Oceans and World Ocean in September 1968 г. (*Basharinov and Mitnik, 1970*)

# Kosmos-243



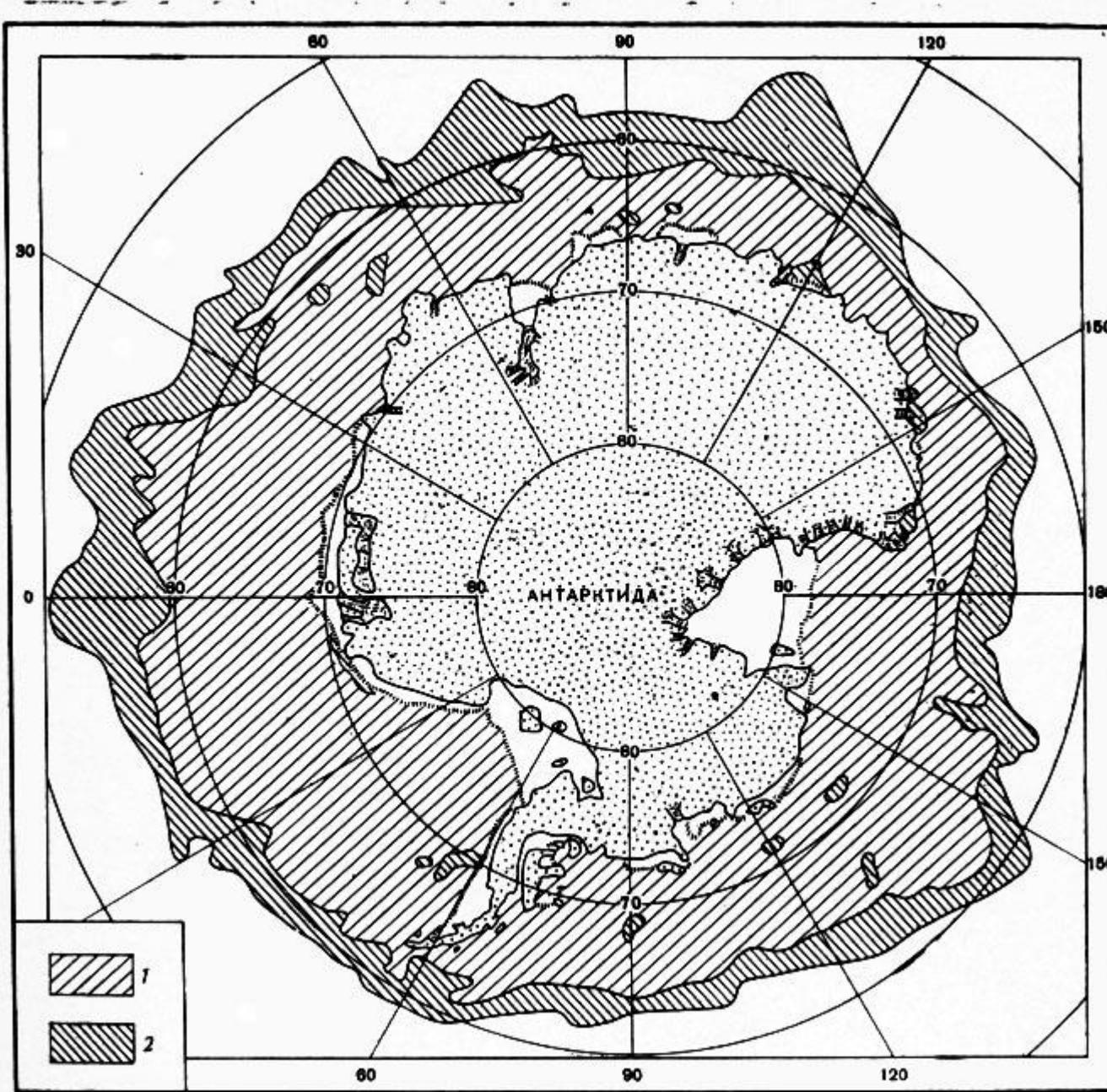
Brightness temperature variations over the Antarctic sea and land ice

# Kosmos-243



Brightness temperature variations over the Antarctic sea and land ice

# Kosmos -243

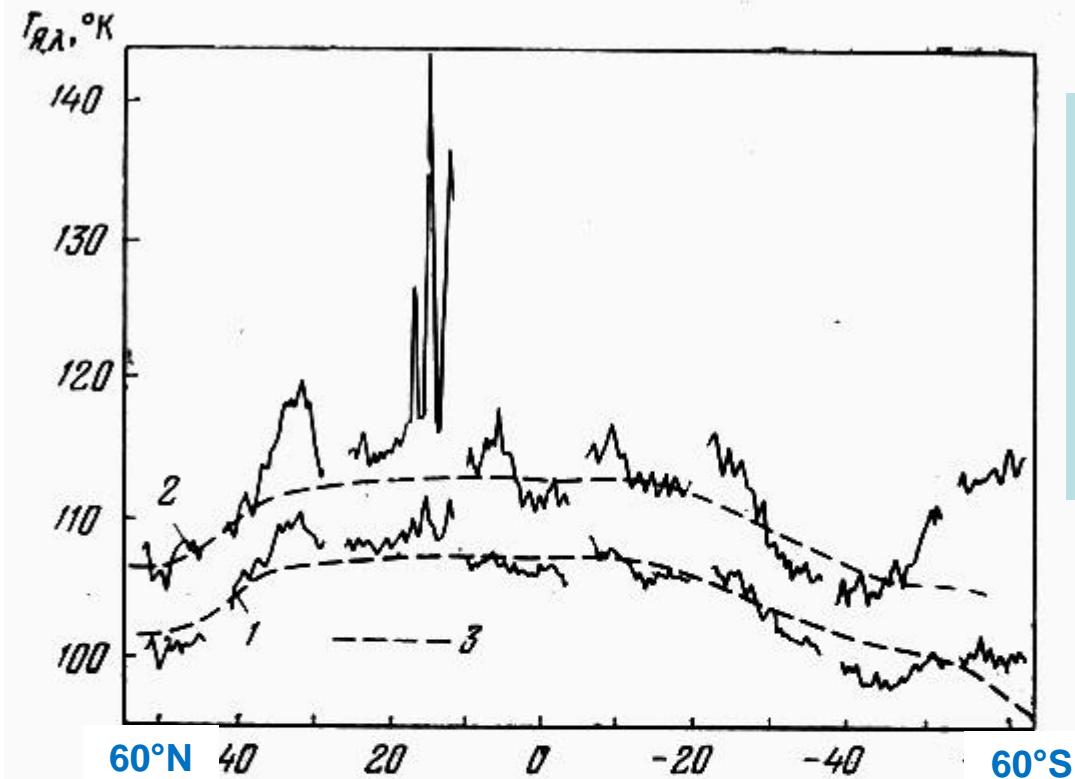


Sea ice  
concentration  
around  
Antarctic:

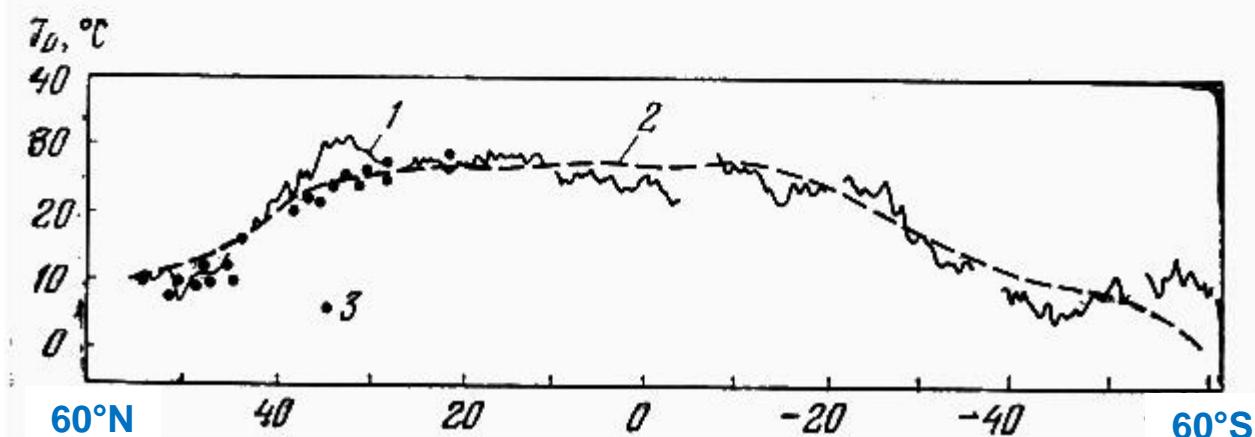
1 - C > 50%

2 - C < 50 %

# Kosmos-243 measurements



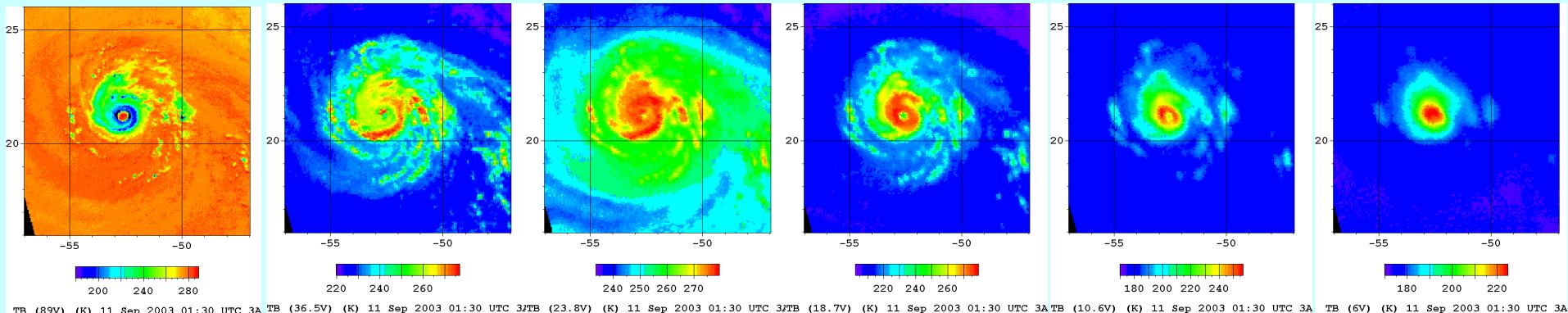
Brightness temperature variations at  $\lambda = 8.5$  cm (1) and at 3.4 cm (2) across the Pacific Ocean, and climatic distribution (3)



SST section across the Pacific Ocean retrieved from  $T_b(8.5)$  and  $T_b(3.4)$ .

# Hurricane Isabel, 11 September 2003

*Vertical polarization*



89 GHz

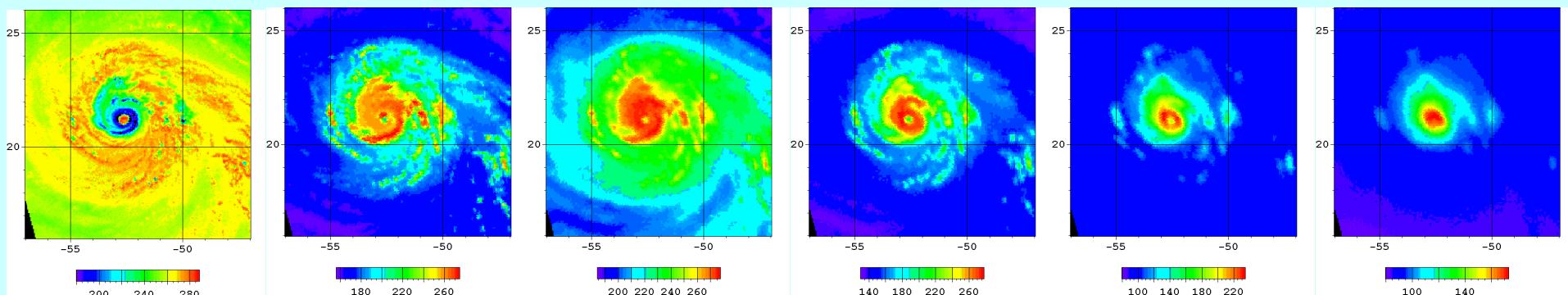
36 GHz

24 GHz

19 GHz

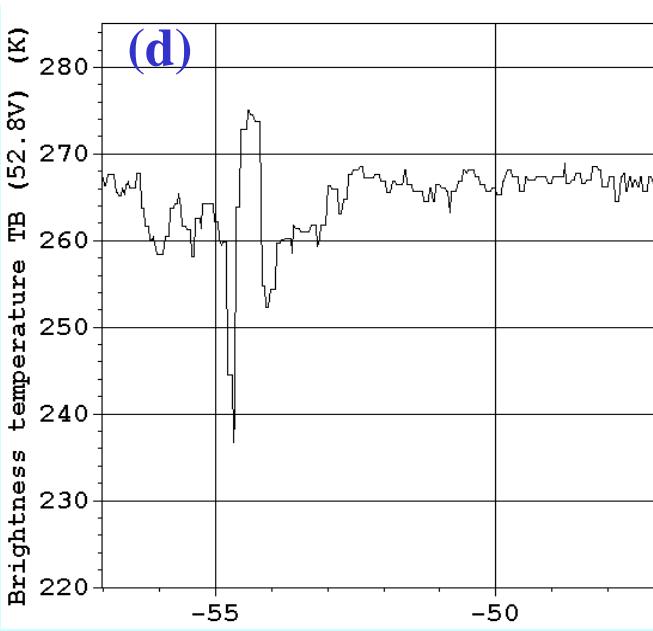
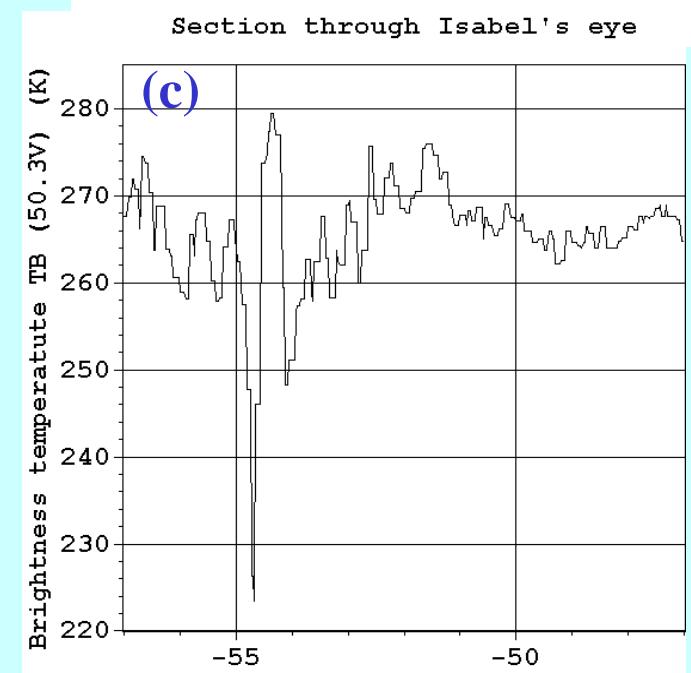
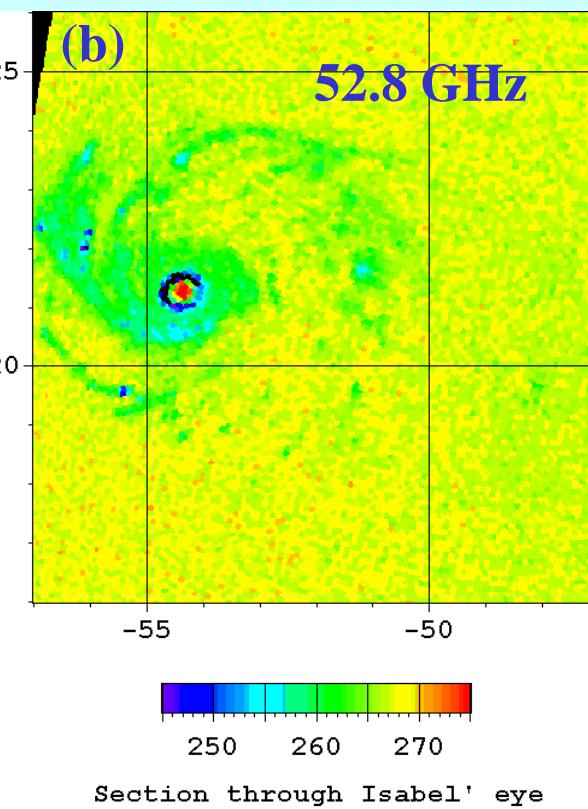
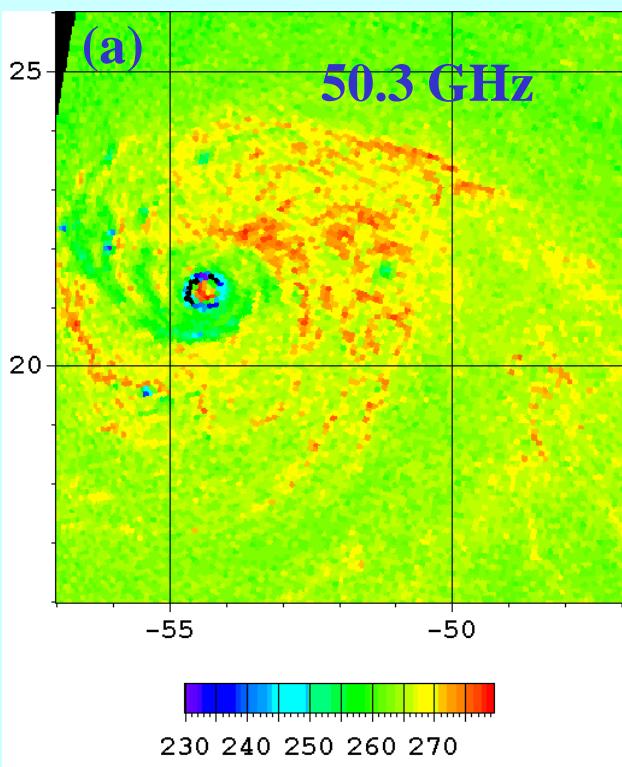
11 GHz

7 GHz

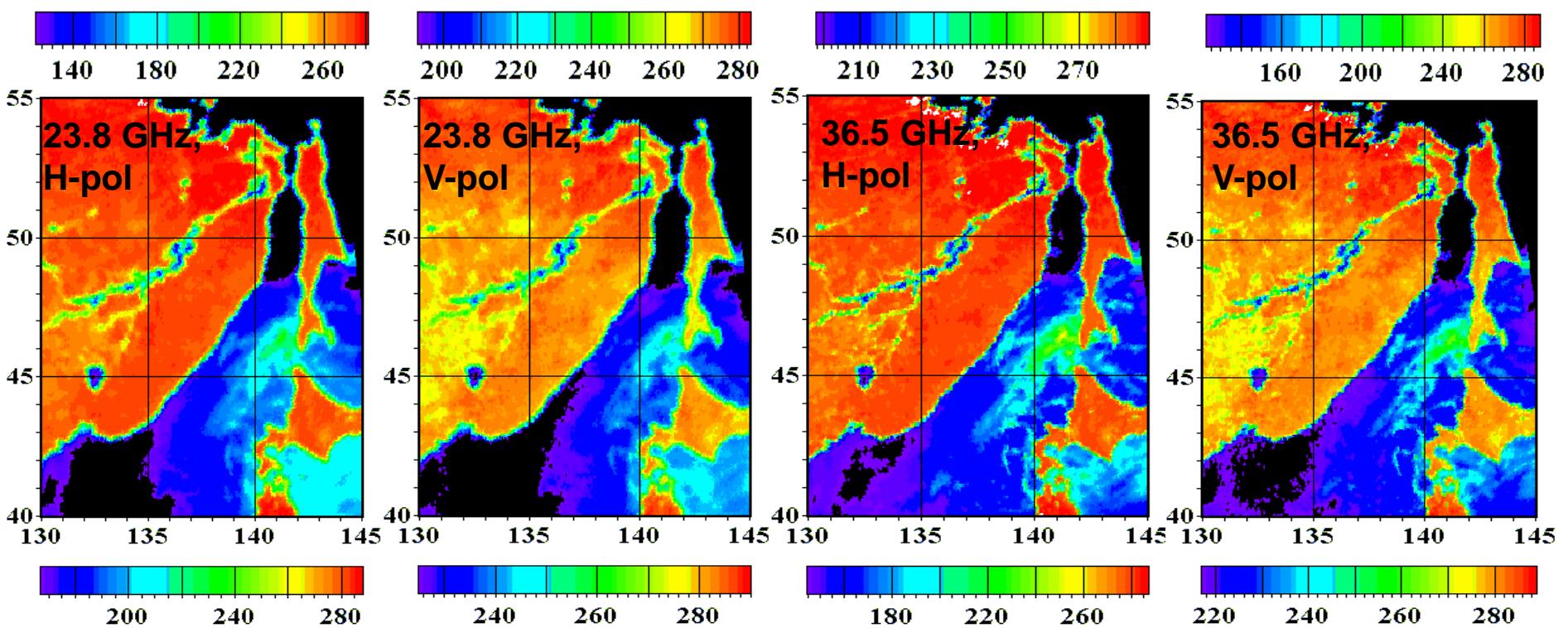
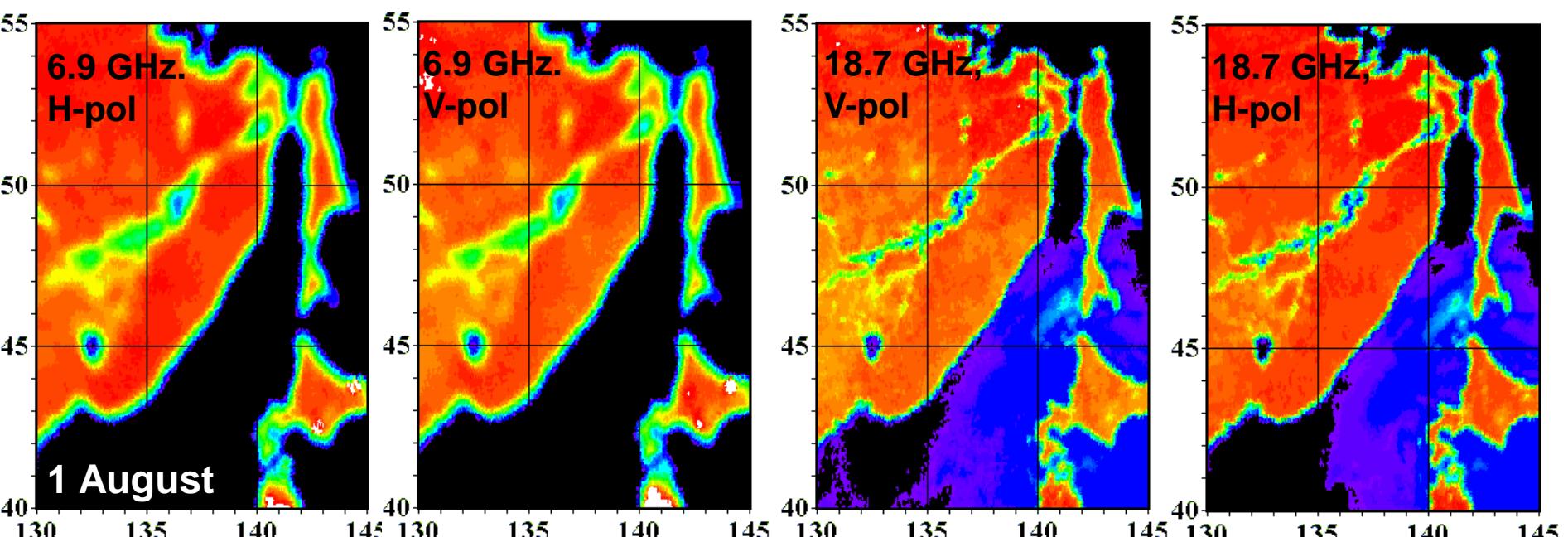


*Horizontal polarization*

# Hurricane Isabel, 11 Sep 2003, 14:30 UTC

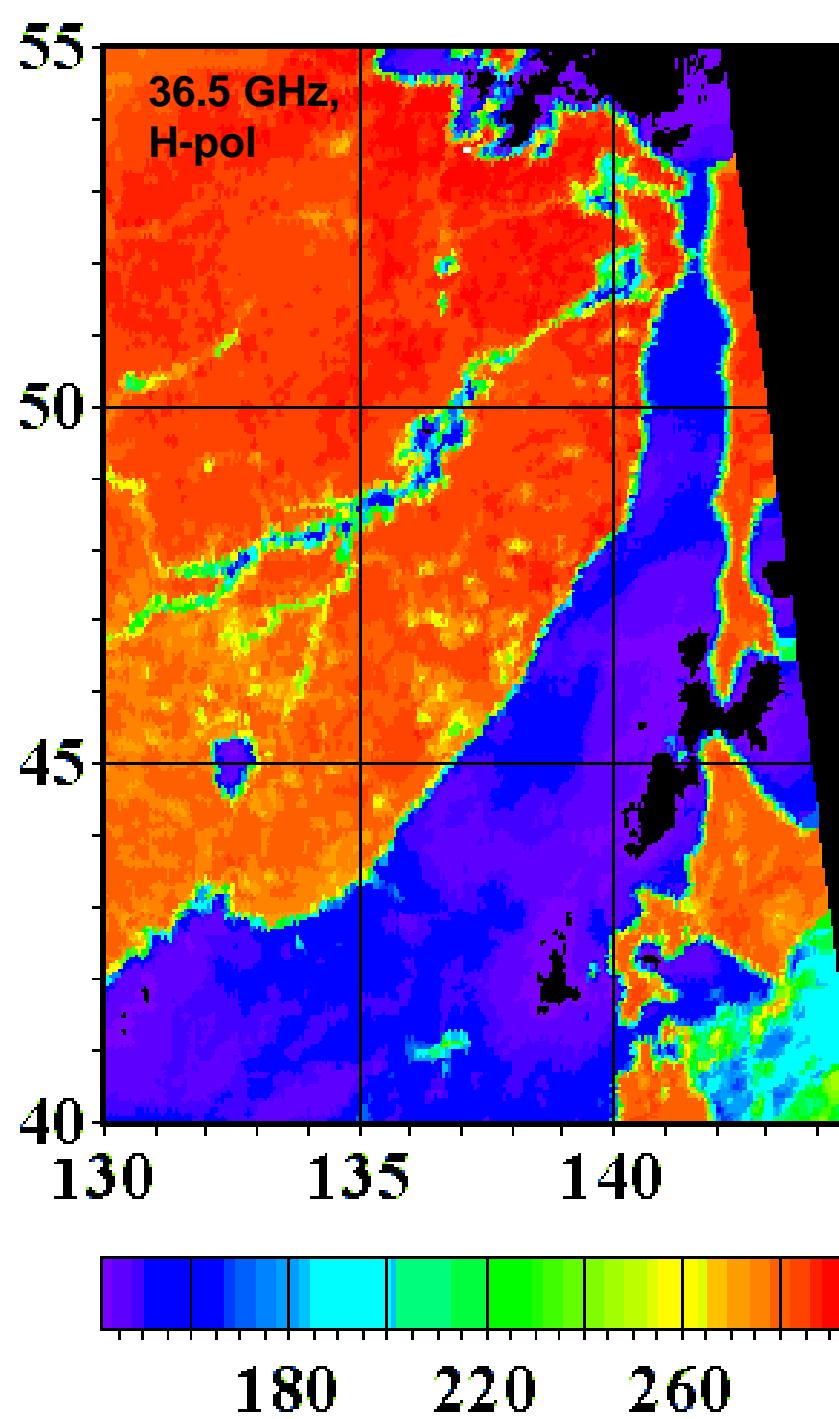
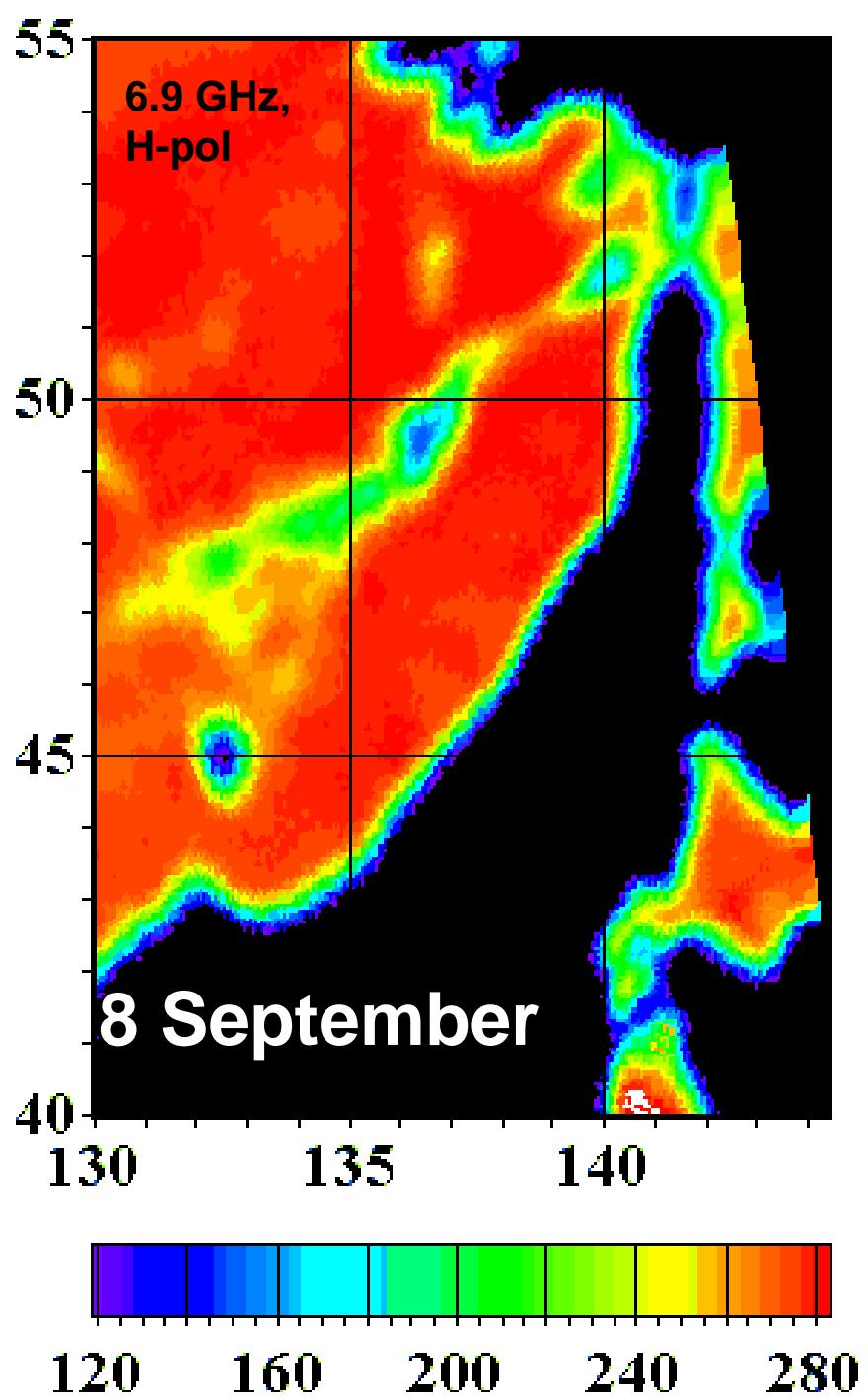


ADEOS-II AMSR  
brightness  
temperatures at  
50.3 GHz (a) and  
52.8 GHz (b) and  
sections through  
warm core in its  
center (c) and (d)

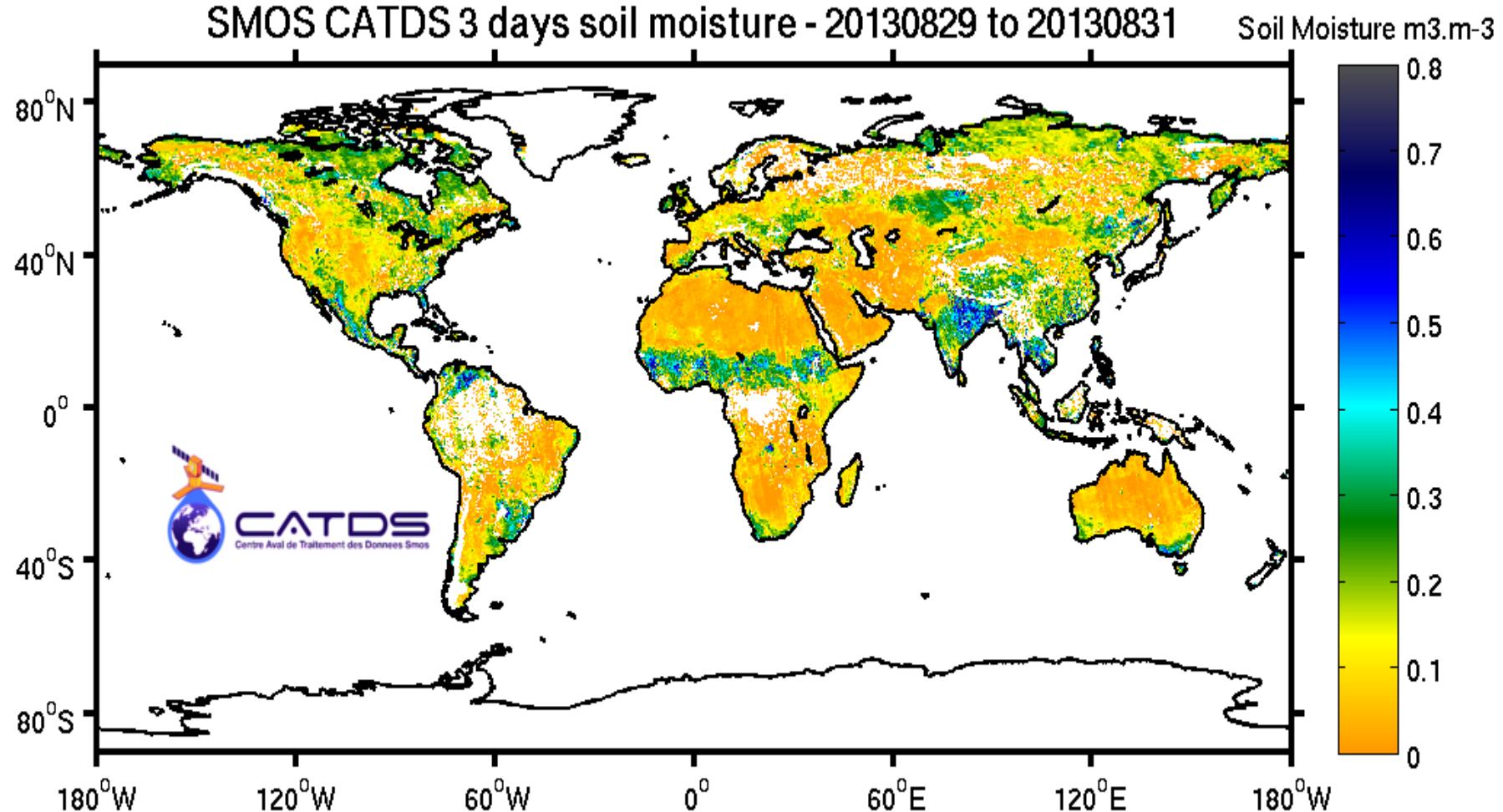


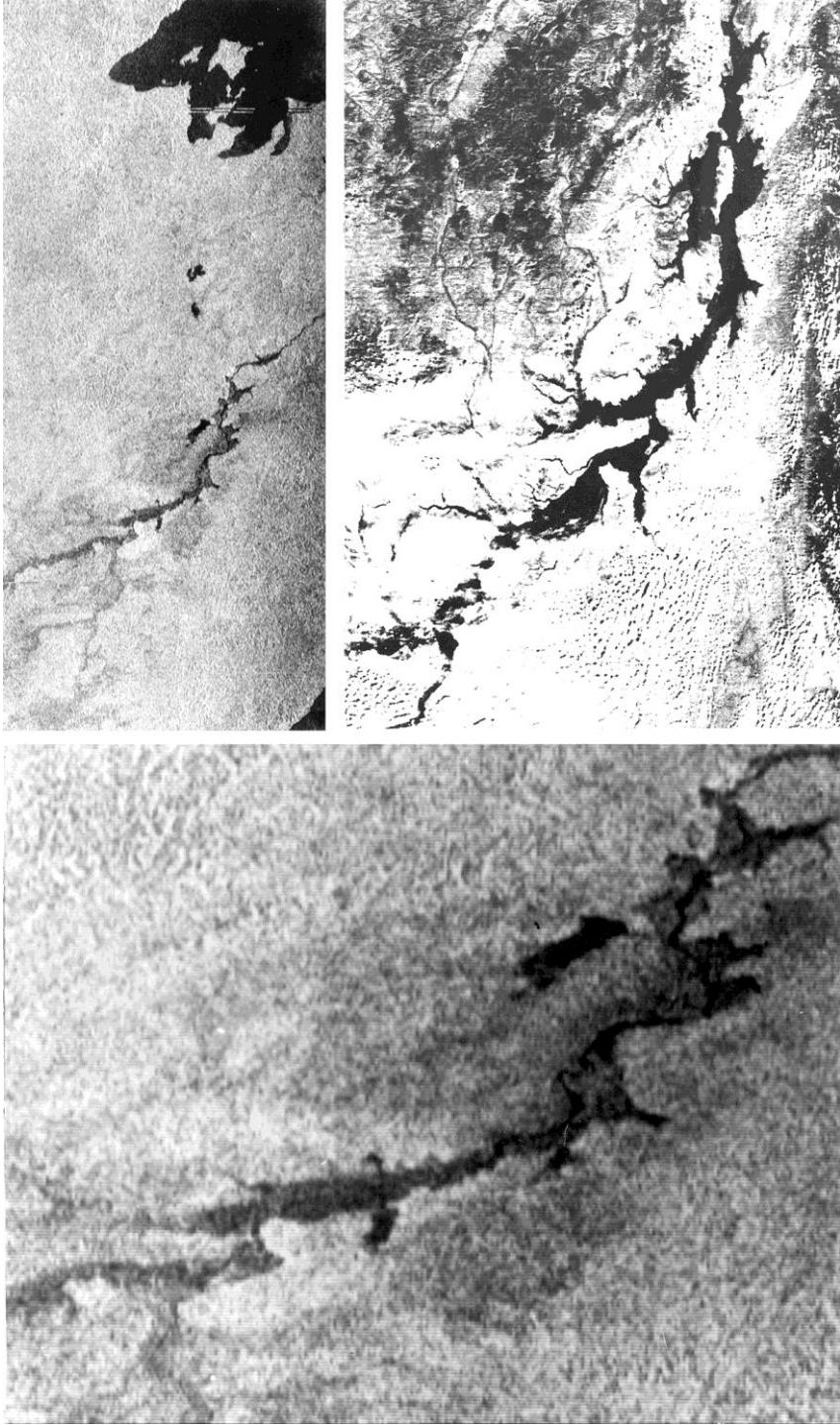
# 8 September. Aqua MODIS





# SMOS CATDS 3 days soil moisture - 20130829 to 20130831



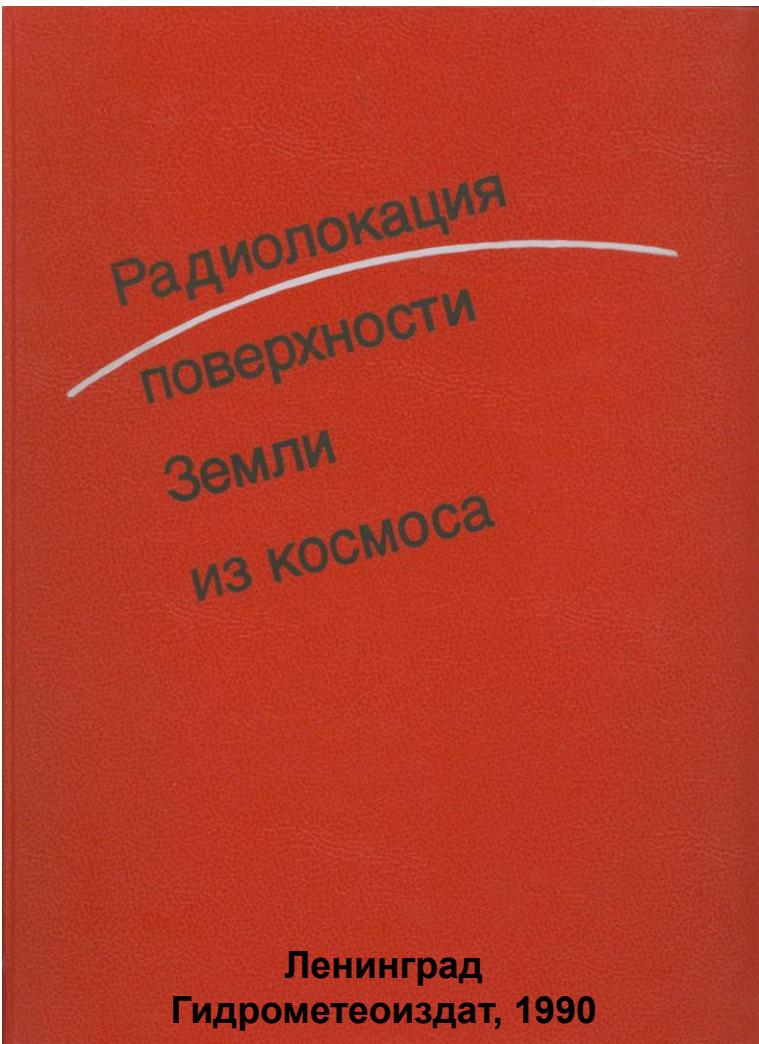


# Rain flood in Amur area on radar and visible images

**On possibility of usage of passive microwave techniques to control dynamics of flooding / *Remote Estimates of Total Moisture Content*. 1984. Moscow. P. 97-102.**

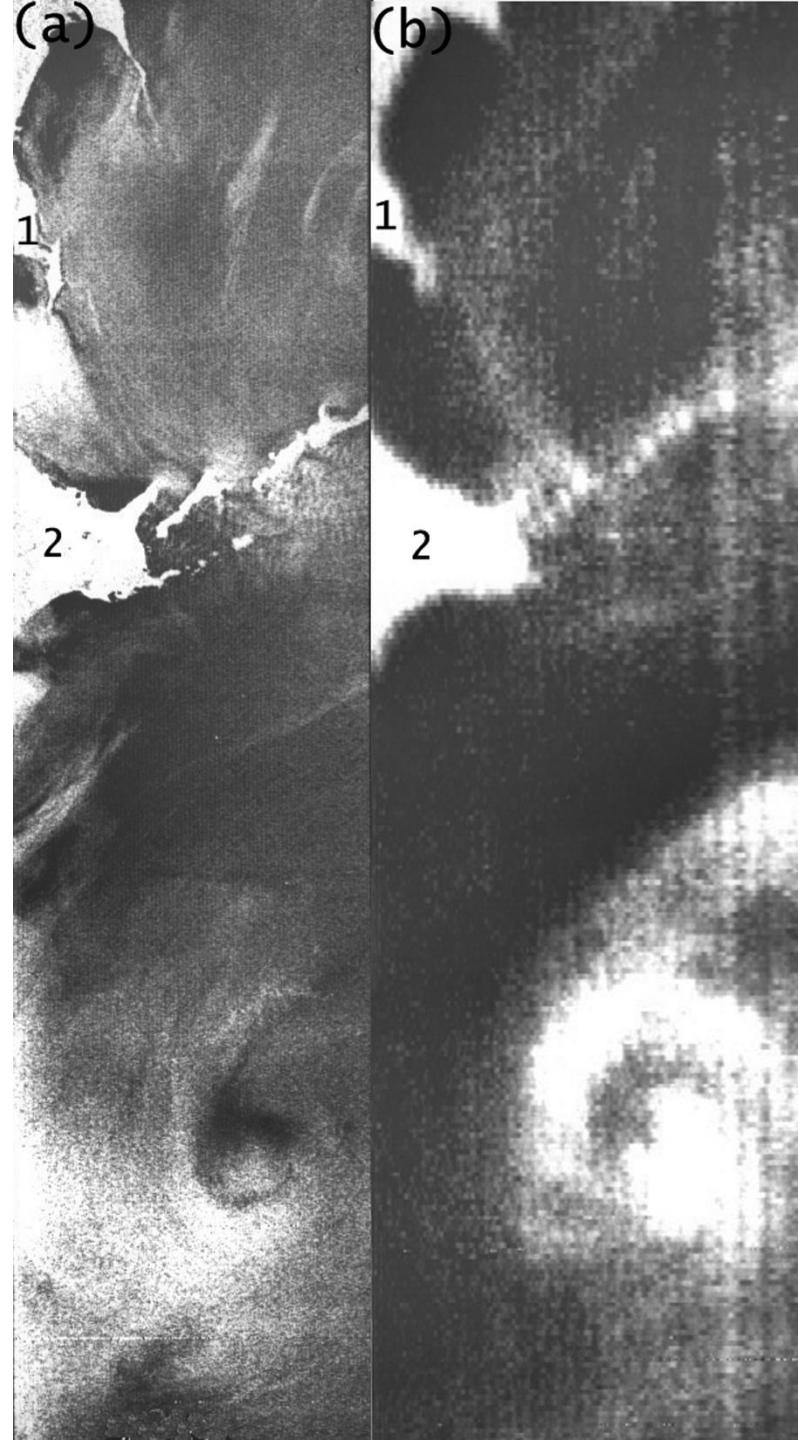
**Use of satellite data in study of Amur River rain flood // *Water resources*. 1988. No. 5. P. 102-107.**

*Kosmos-1500 – the first satellite with Real Aperture Radar onboard – was launched in September 1983. Parameters: wavelength 3.15 cm, VV-polarization; swath width 460 km, spatial resolution 2.1-2.8 x 0.8-3 km), RM-0.8 – scanning microwave radiometer, wavelength 0.8 cm, H-polarization; MSD-M – multichannel scanning device operating at visible and near-infrared range.*



Similar sensors were installed on Kosmos-1602 (1984) and Kosmos-1776 (1986), as well as on Ocean series satellites (Kalmykov, 1996).

1. Experimental oceanographic satellite «Kosmos-1500»
2. Physical basis of radar sensing from satellites
3. Side Looking radar system of «Kosmos-1500»
4. Preprocessing of RAR data
5. Characteristics of sea surface
6. Characteristics of sea ice
7. Characteristics of land ice

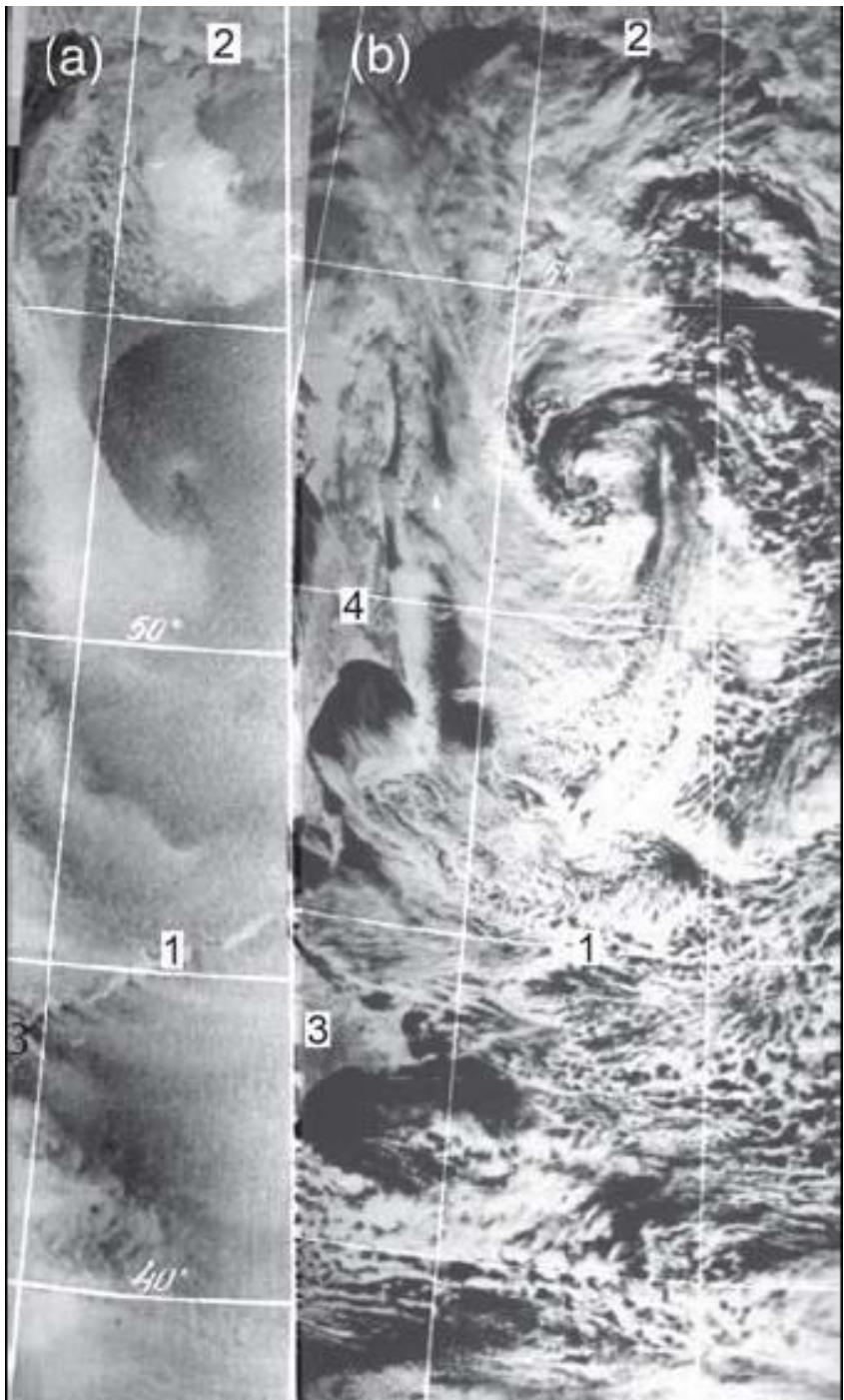


## Tropical storm Agnes

TC Agnes as seen by the RAR (a) and the 0.8-cm microwave radiometer (b) carried aboard *Okean-1*. These images were taken on 31 July 1988 in the western North Pacific in the vicinity of Sakhalin (1) and Hokkaido (2) Islands. Changes in brightness temperature in (b) are due to precipitation, cloud liquid water, and wind action.

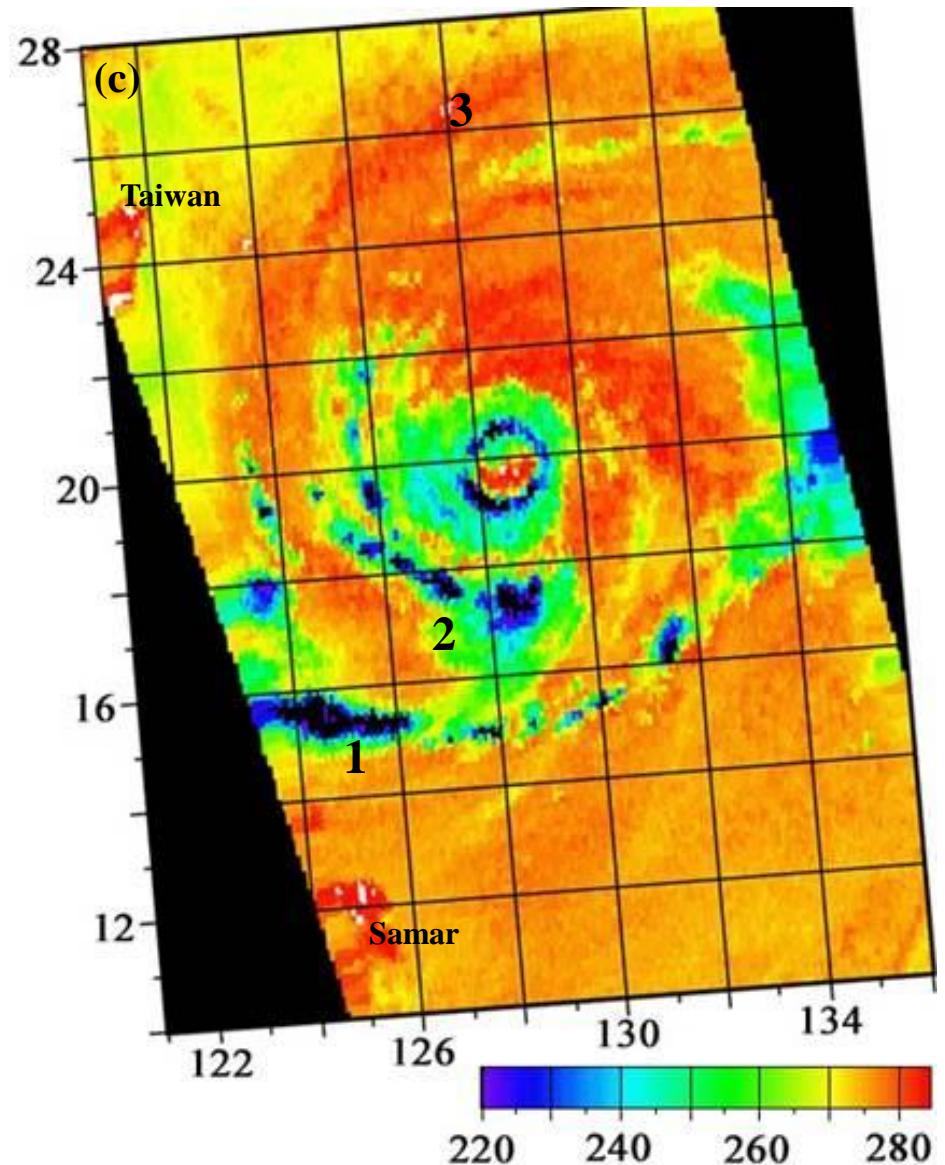
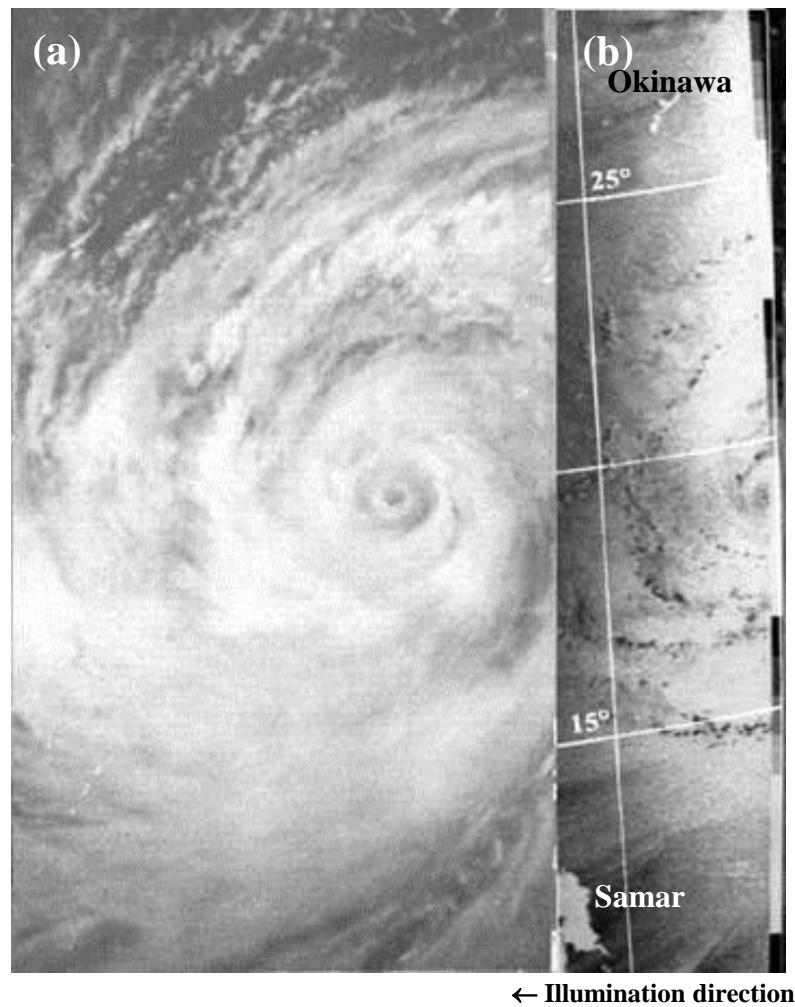
The unique capability of this series, the *simultaneous acquisition of overlapping images by three different sensors at three different wavelengths*, enabled an improved interpretation of measurements and a reduction in errors of retrieved parameters. (Such a capability would be employed on later satellites such as TRMM and ADEOS-II.)

# Sea surface

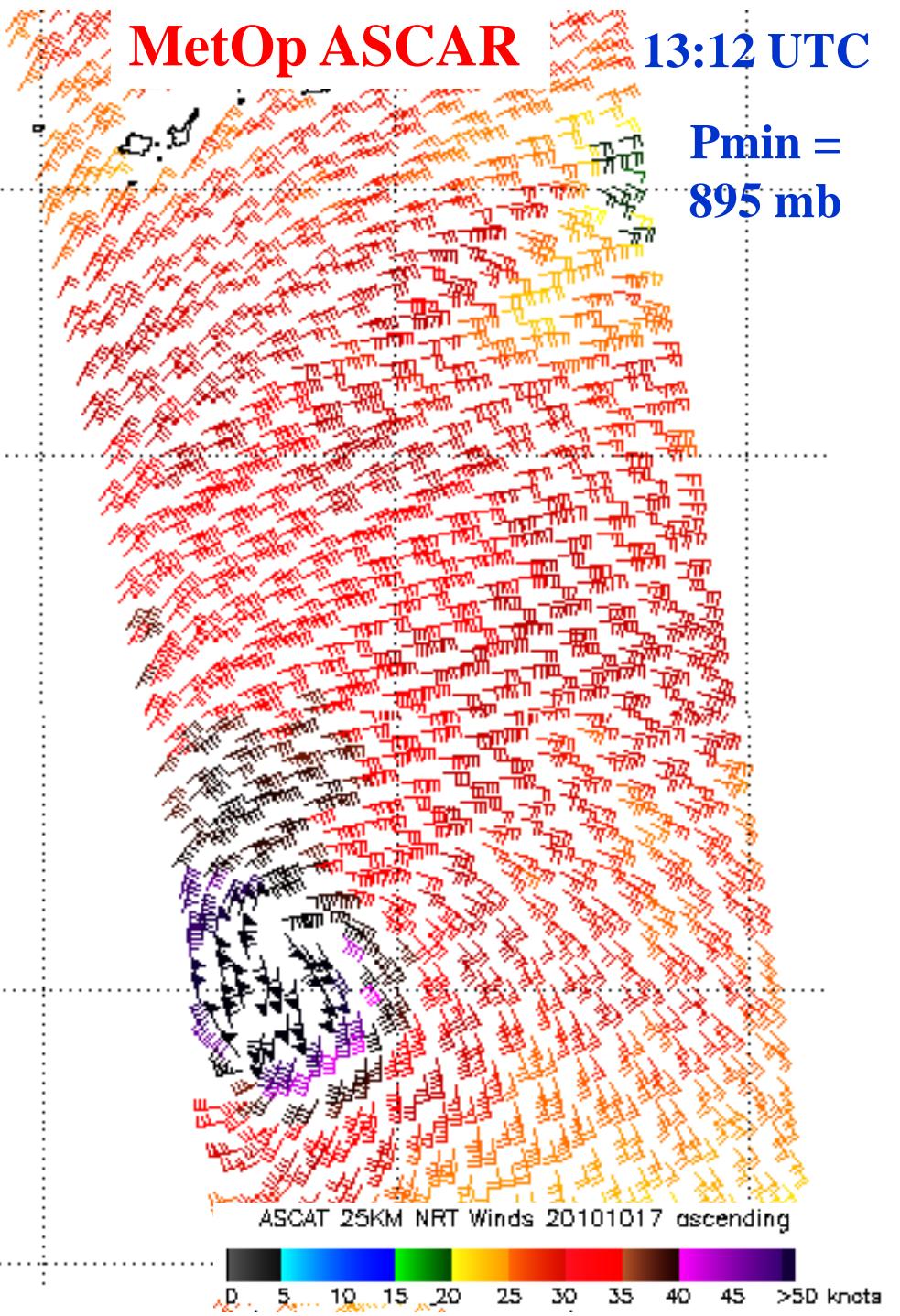
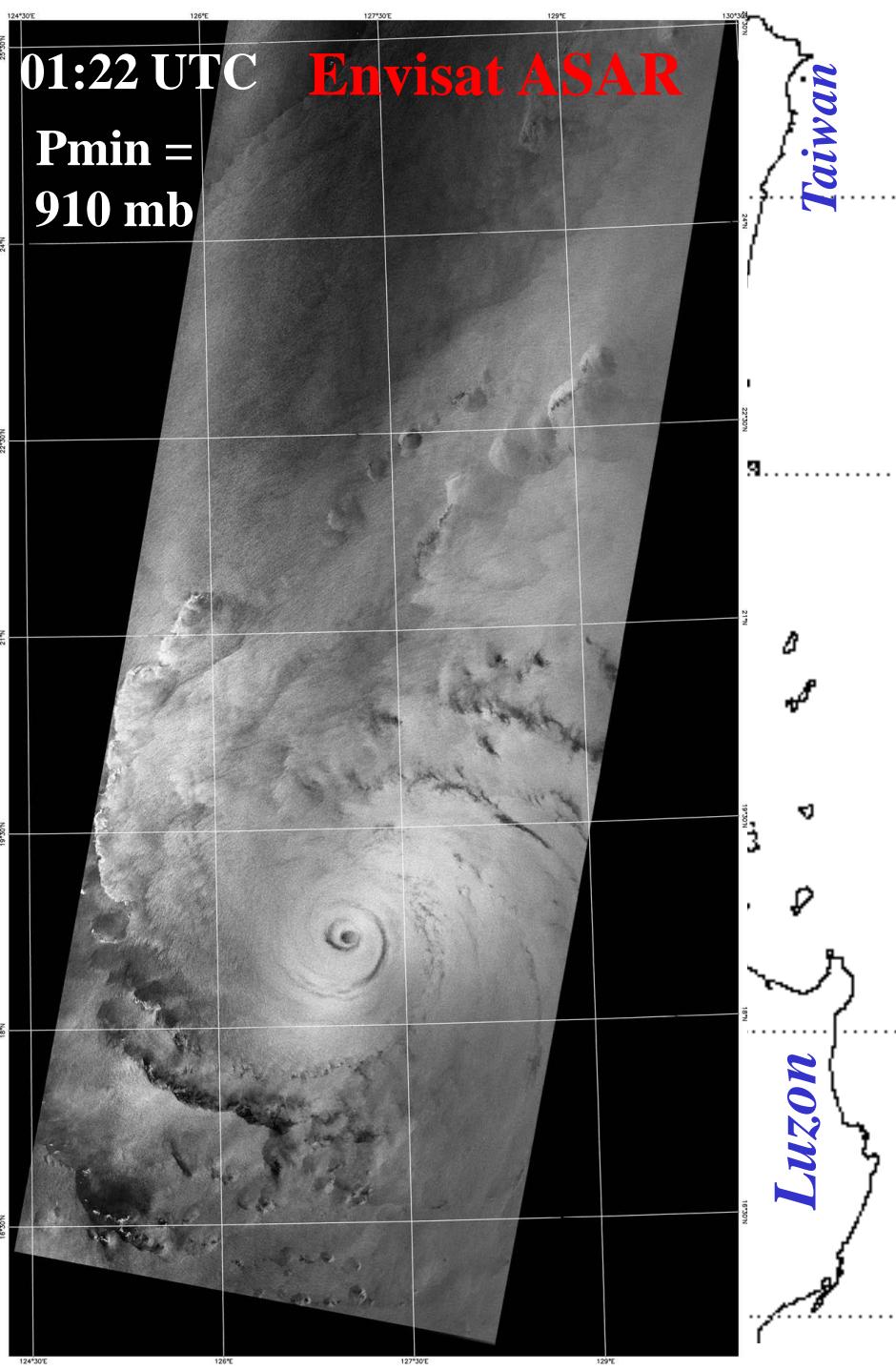


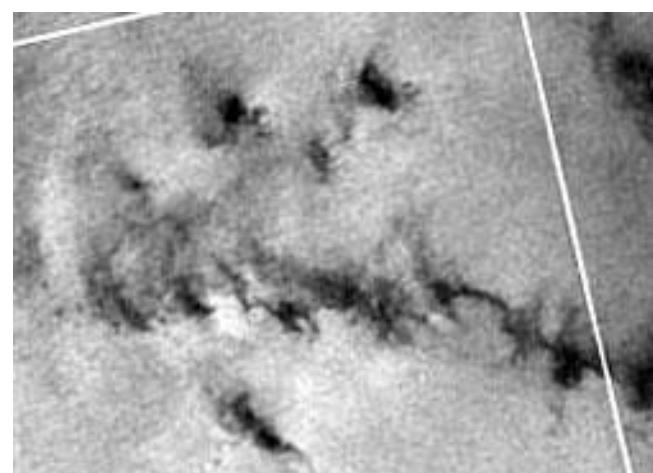
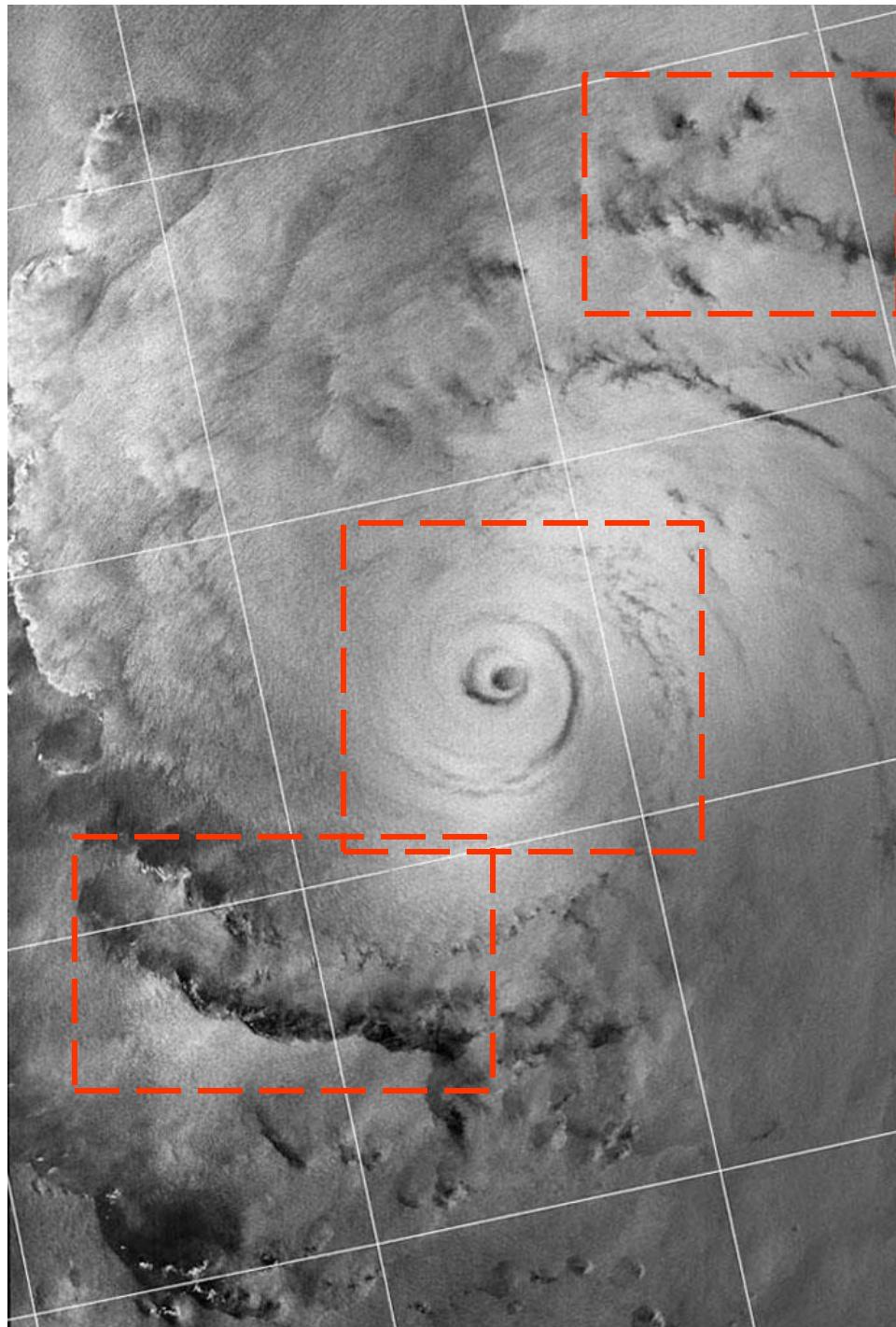
Seen on the left (a) is a *Real Aperture Radar (RAR)* and on the right (b) a visible image of an occluded cyclone over the Okhotsk Sea taken by **Kosmos-1500** on 29 December 1984. Iturup Island (1), northern coast of the Okhotsk Sea (2), Hokkaido (3), and Sakhalin (4) are identified. Brightness of the **RAR** image is influenced by wind speed and direction (relative to the radar direction), with brightness increasing with increasing wind speed. Comparison of two images shows a high correlation of wind field in (a) with cloudiness in (b). Radar images such as this have demonstrated their potential for monitoring the sea surface under all-weather conditions.

# Typhoon Herb, 29 July 1996. Rain cells and bands

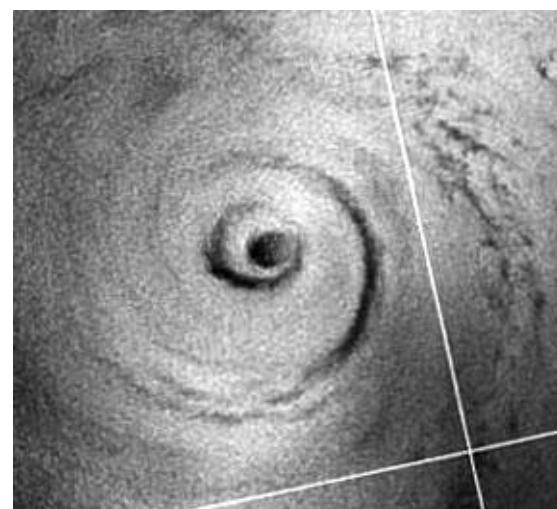


Okean-7 visible (a) and radar (b) images and DMSP SSM/I brightness temperature at frequency 85 GHz (c)

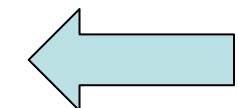




Rain cells

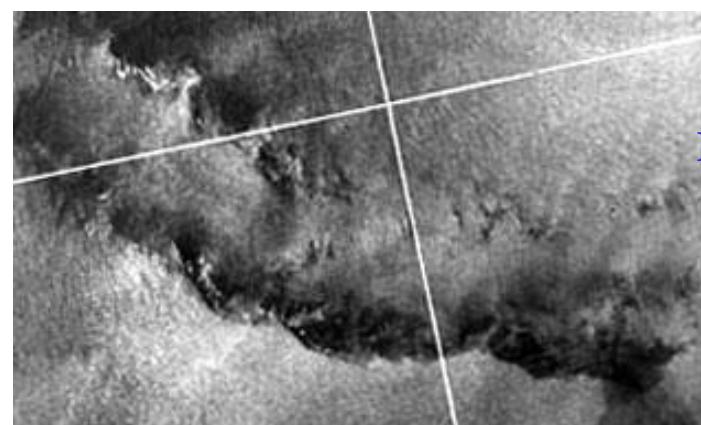


Sensing  
direction



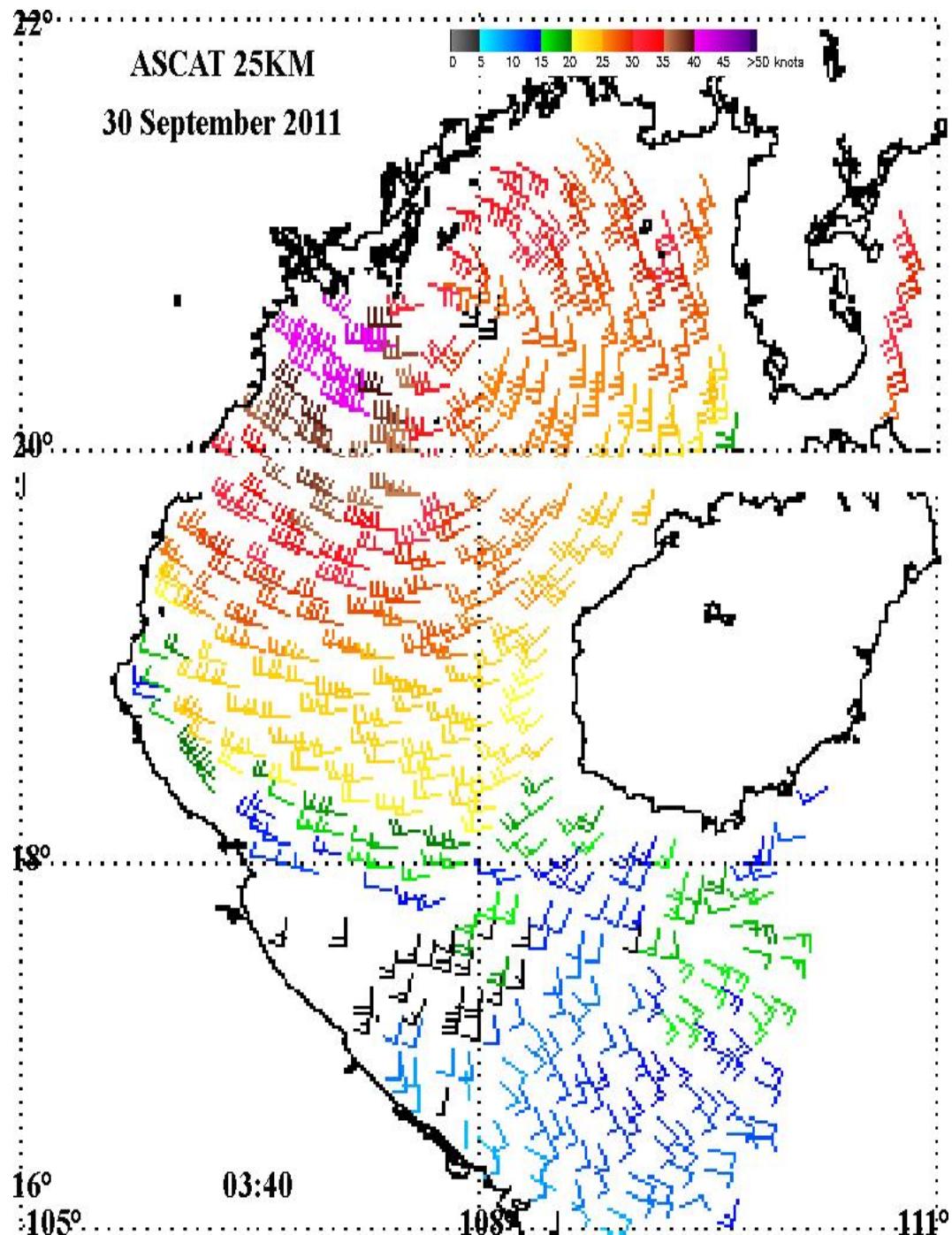
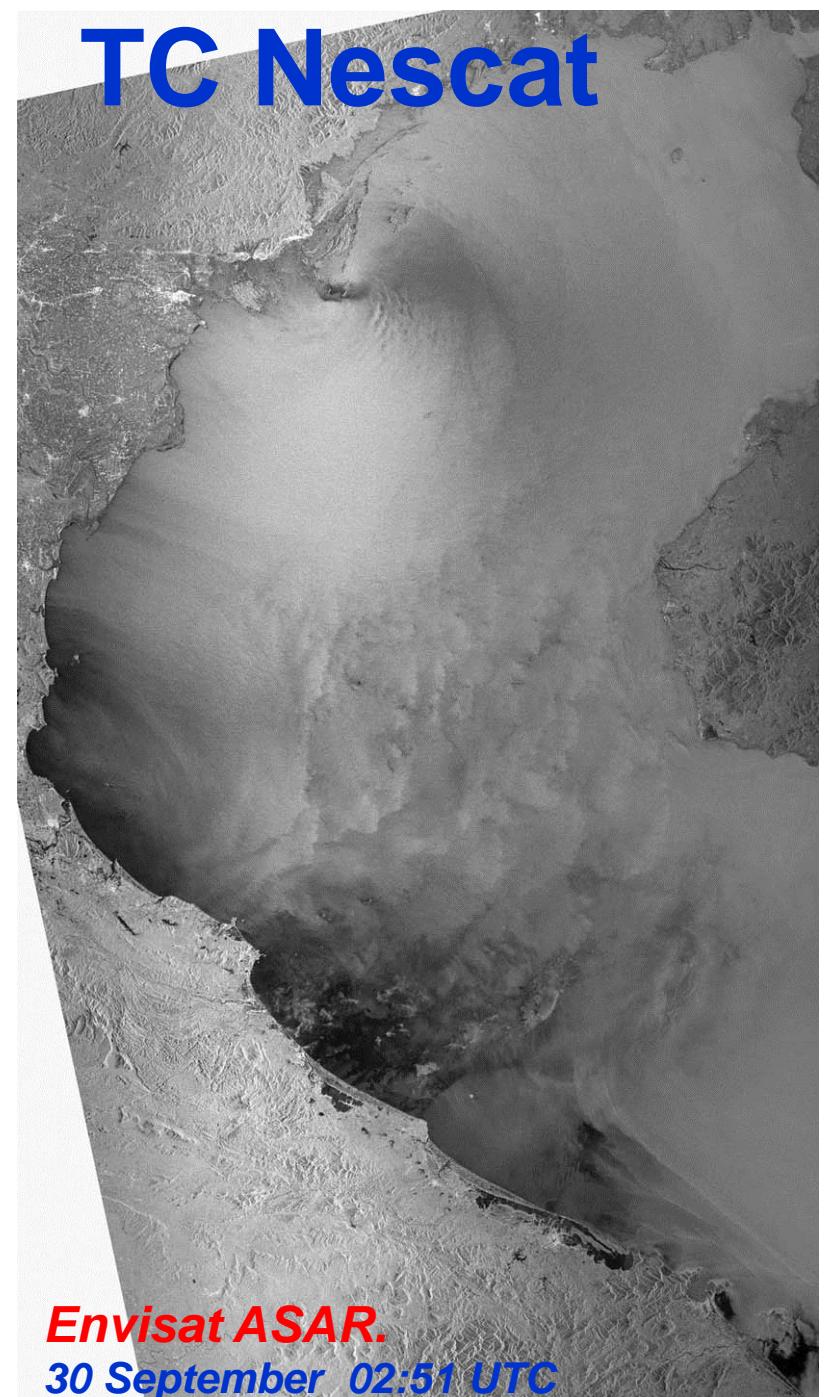
Eye and eye  
wall

$P_{\min} = 910 \text{ mb}$



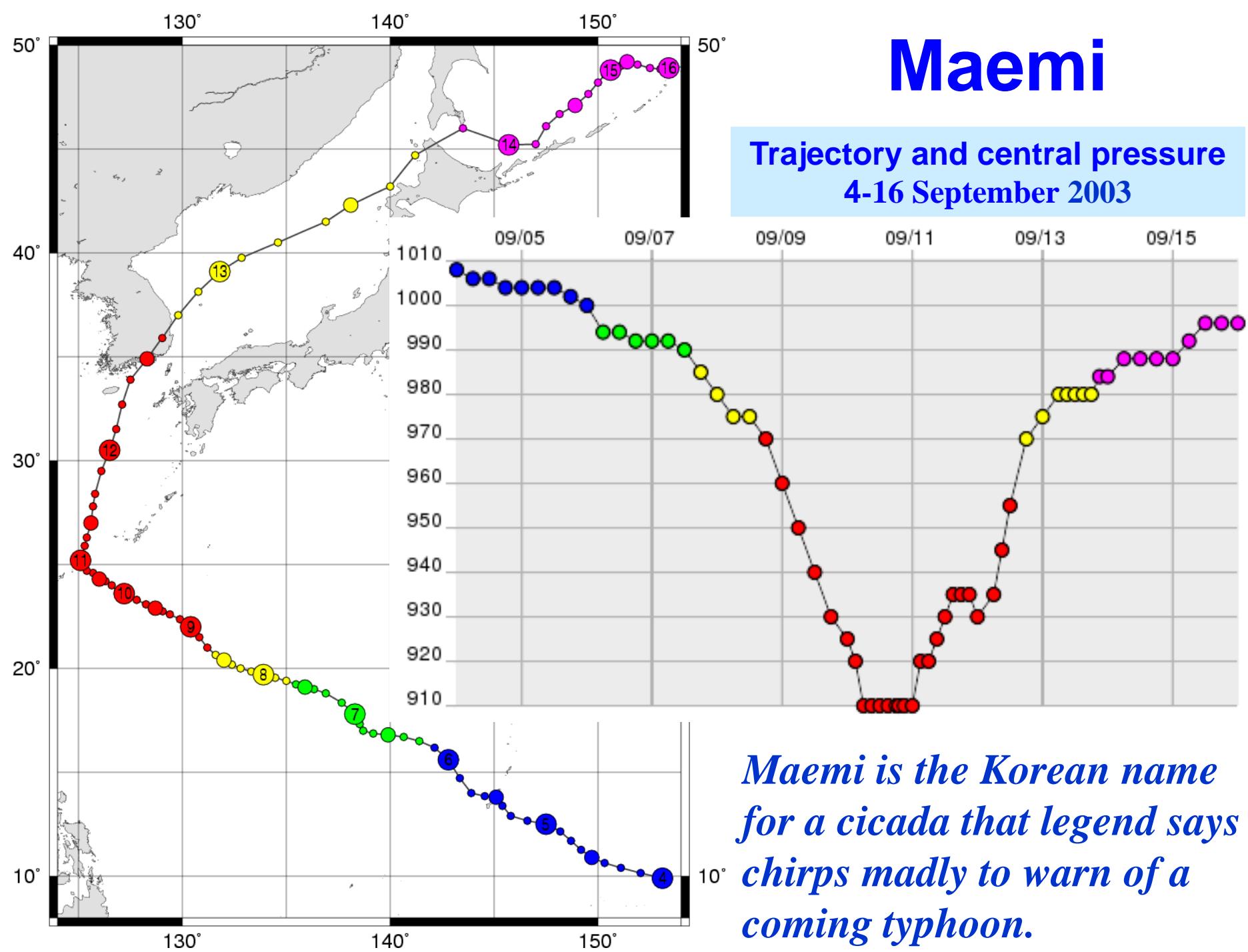
Rain bands,  
squalls

# TC Nescat

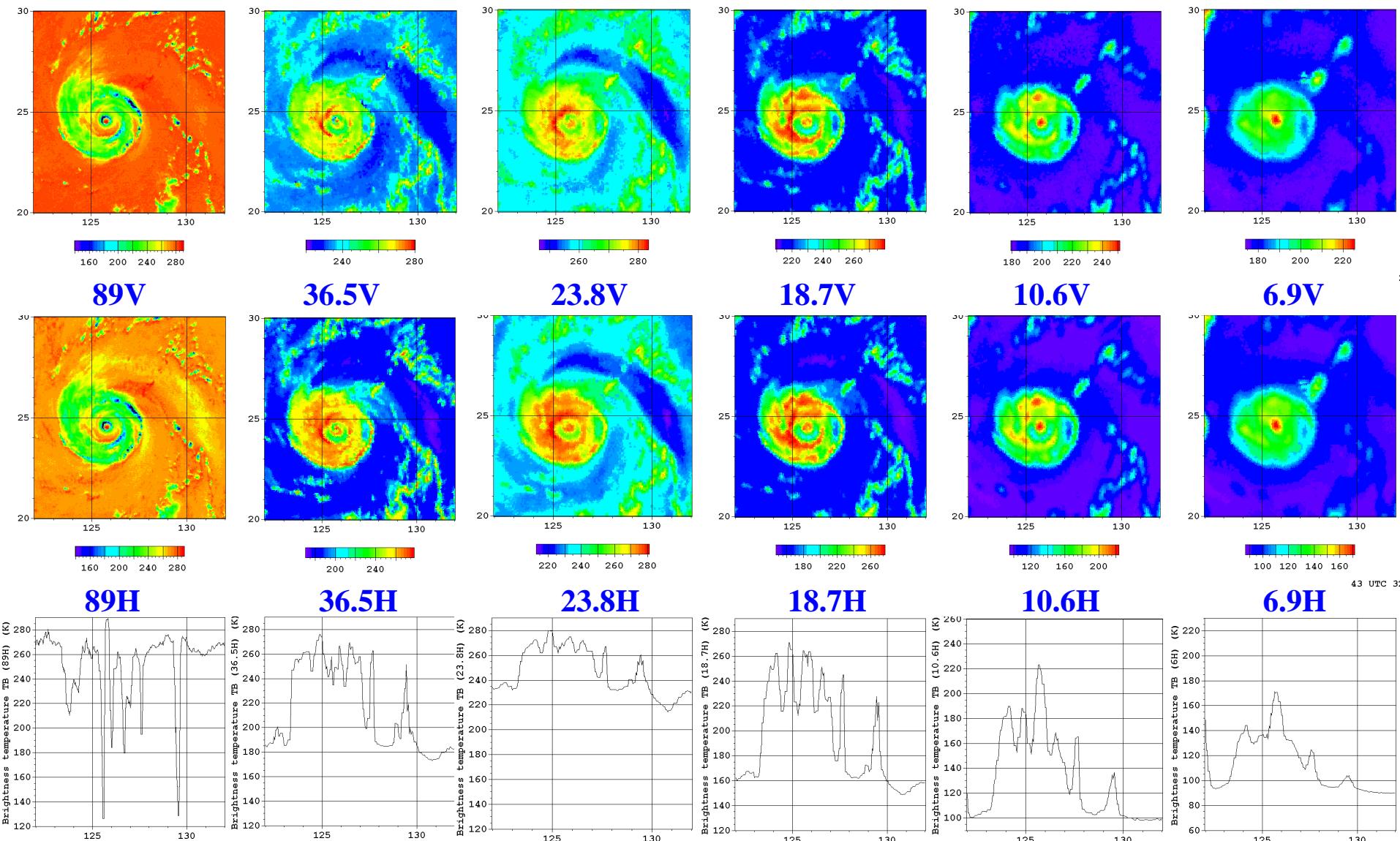


# Maemi

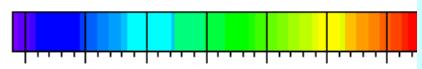
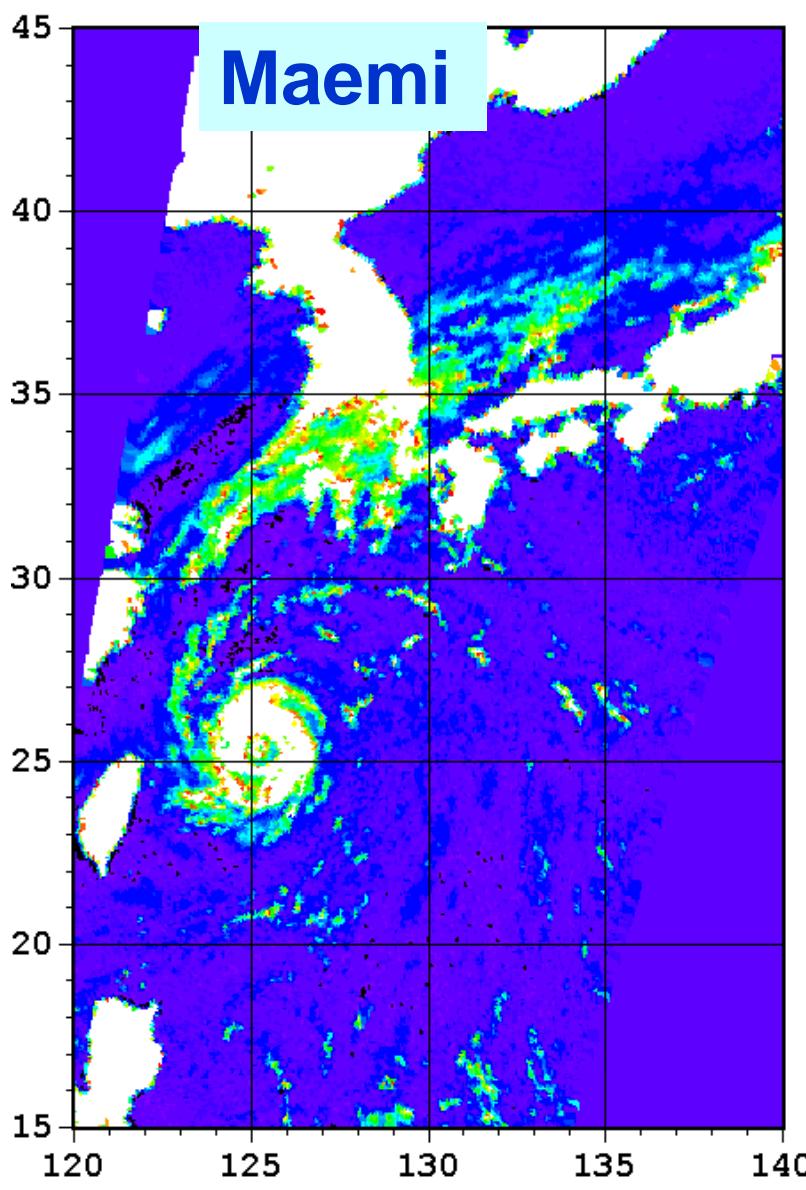
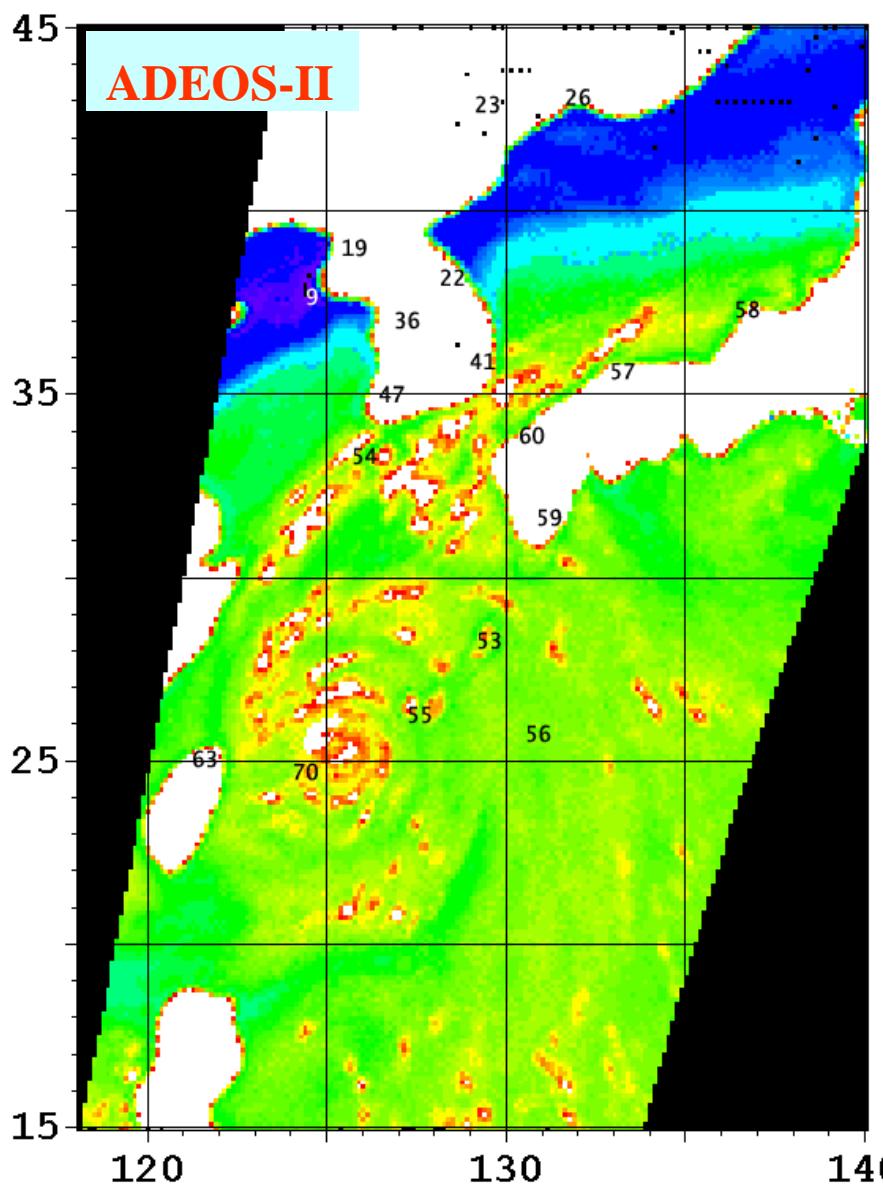
Trajectory and central pressure  
4-16 September 2003



# Typhoon Maemi

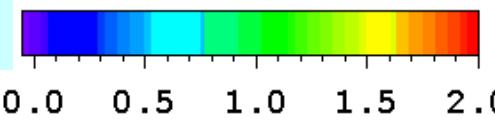


AMSR brightness temperatures of typhoon Maemi taken on 10 Sep 2003 at 13:43UTC



11 Sep 02:07 UTC

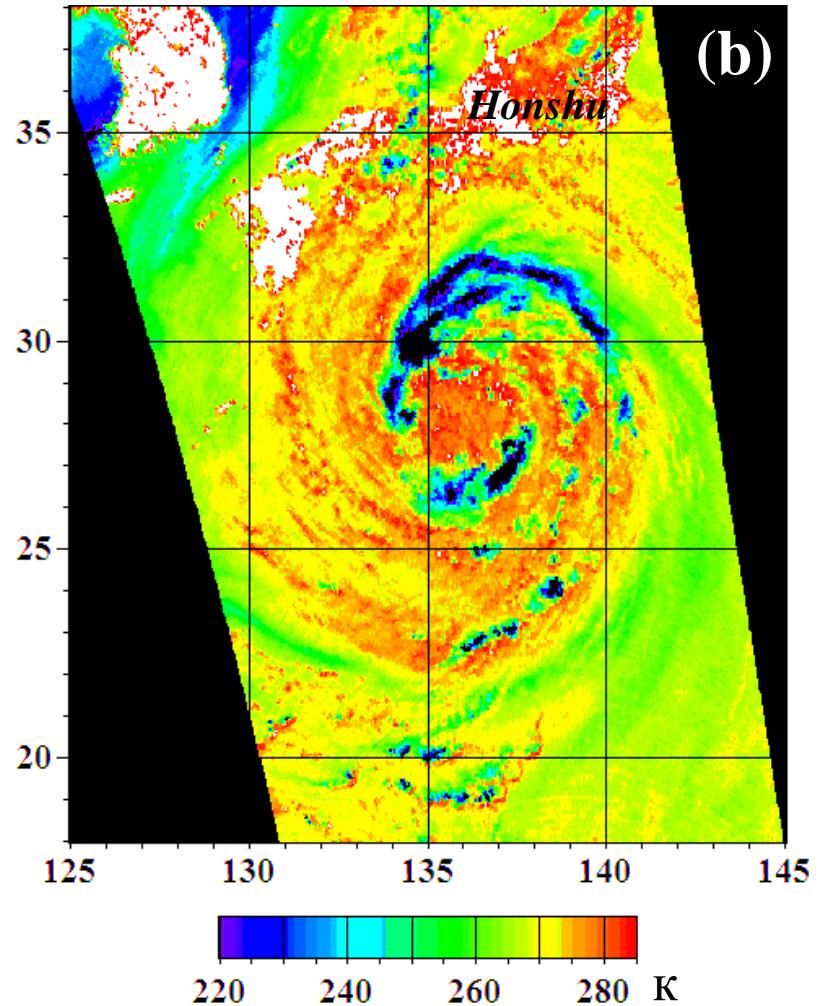
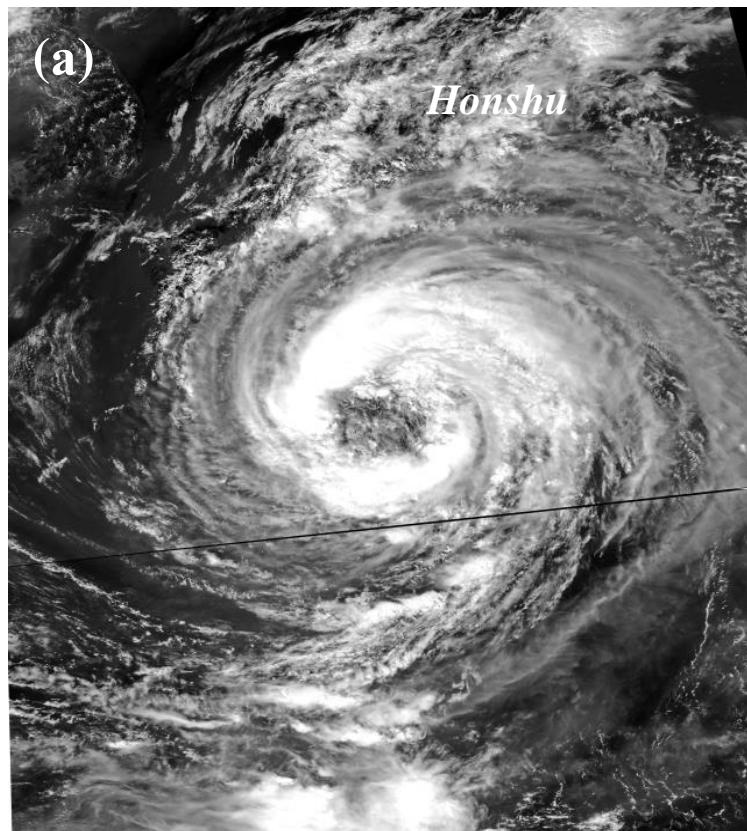
Water vapor kg/m<sup>2</sup>



Clouds (kg/m<sup>2</sup>) 11 Sep 03 07D

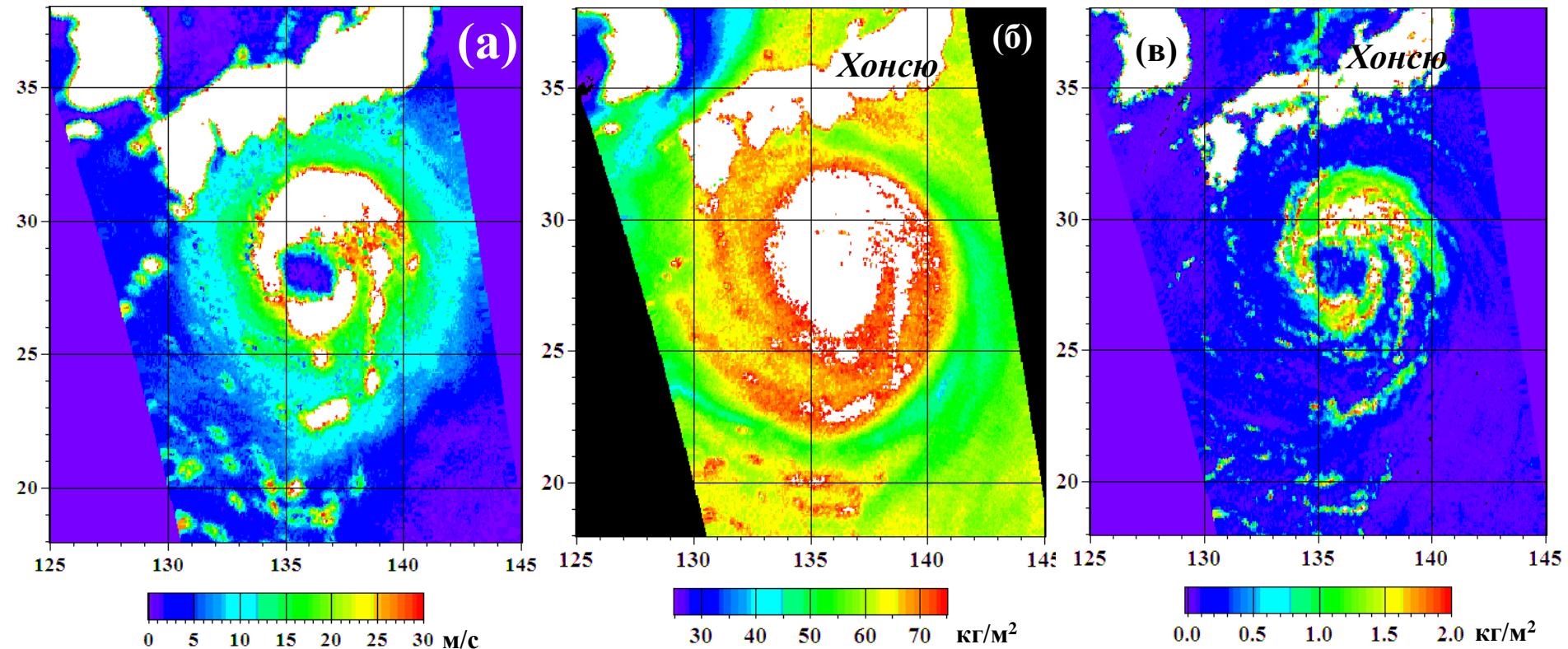
# Typhoon Talas, 1 September 2011

## Aqua AMSR-E



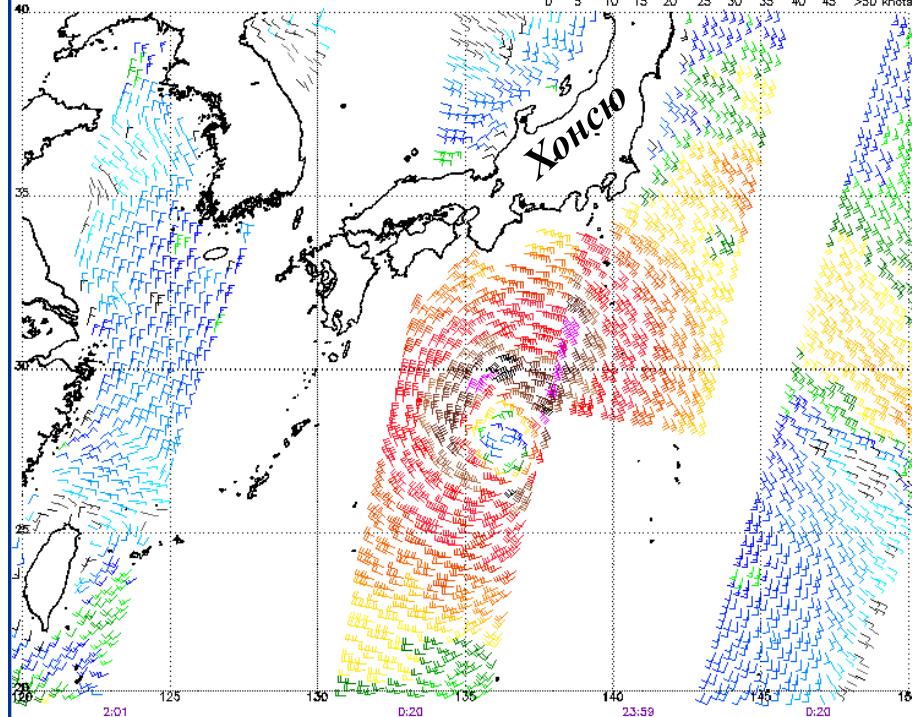
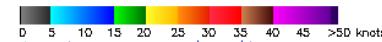
Aqua MODIS visible image (a), and brightness temperature at frequency of 89 GHz with H-polarization (b) at 04:40 UTC

# Typhoon Talas, 1 September 2011, 04:40 UTC

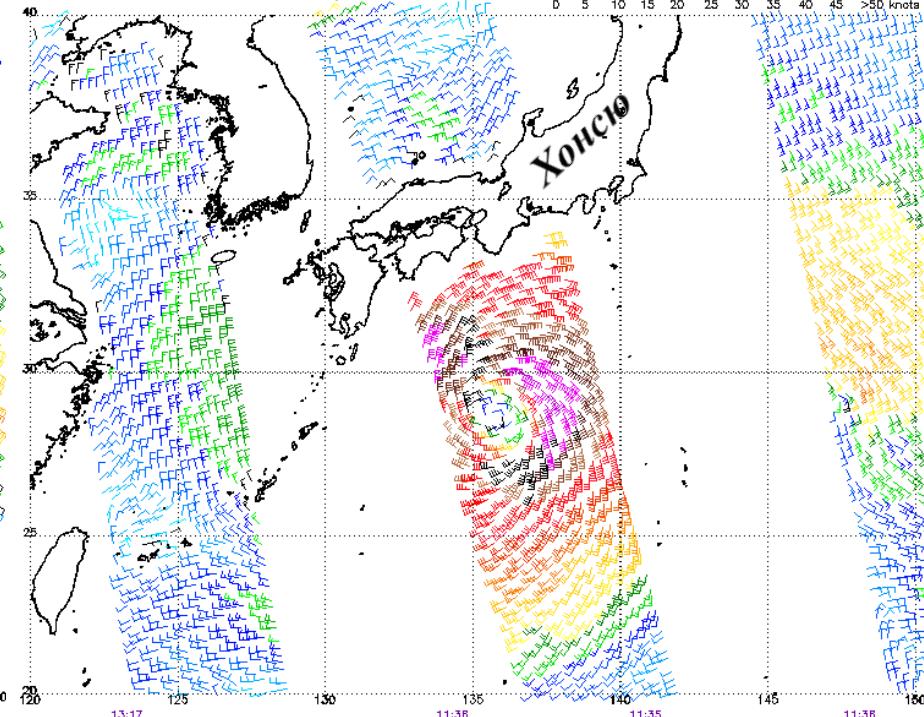
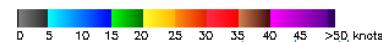


Wind speed (a), atmospheric water vapor (b) and total cloud liquid water content (c) retrieved from **AMSR-E** data

ASCAT 50KM NRT Winds 20110901 descending



ASCAT 50KM NRT Winds 20110901 ascending

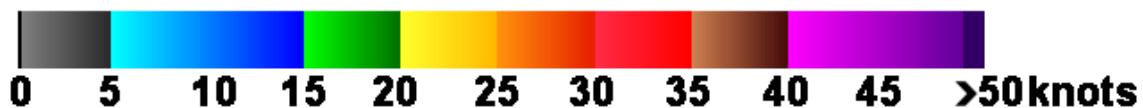


Note: 1) Times are GMT 2)Times along bottom correspond to measurement at 30N  
3)Data buffer is 22 hrs from 20110901 4) Black circles indicate possible contamination

NOAA/NESDIS/Office of Research and Applications

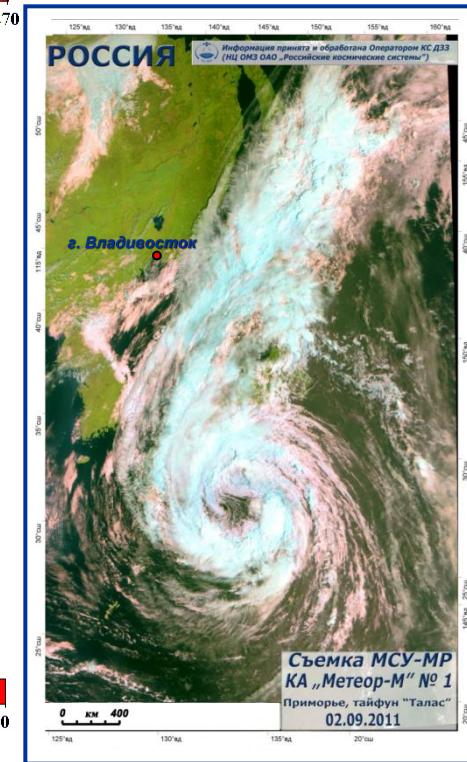
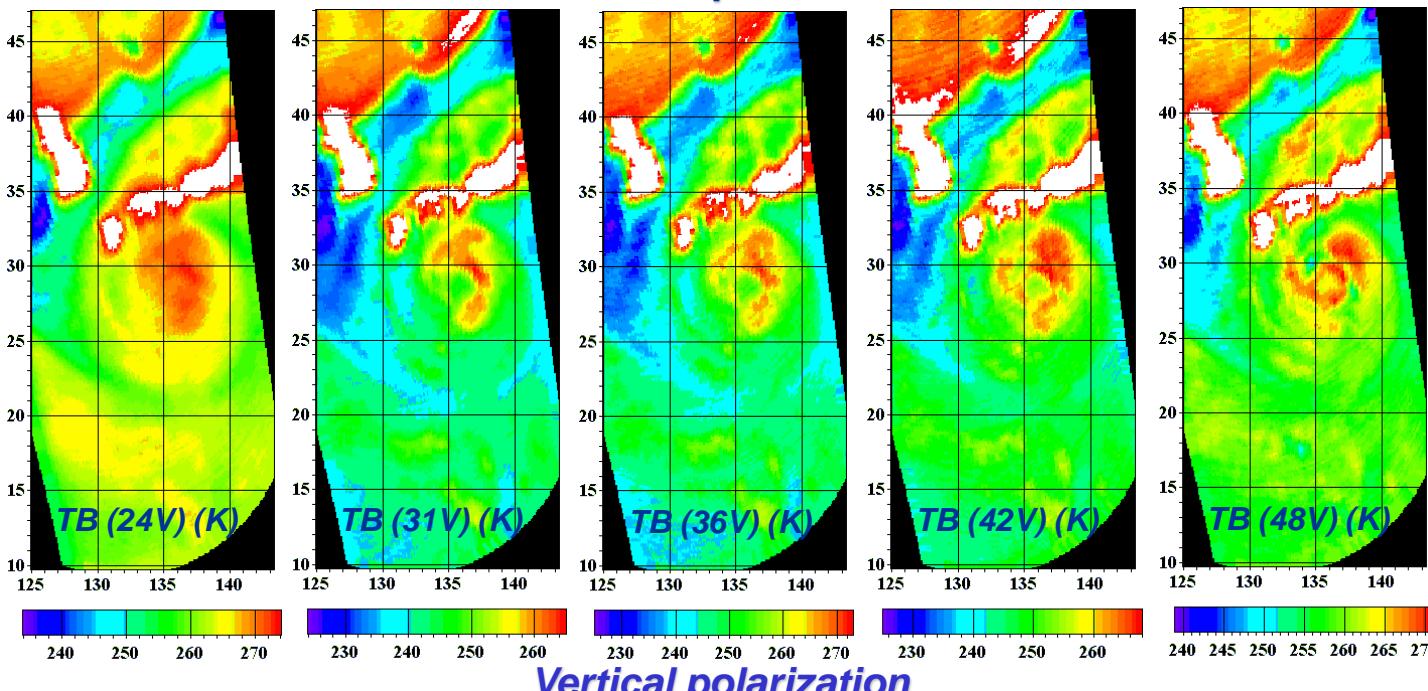
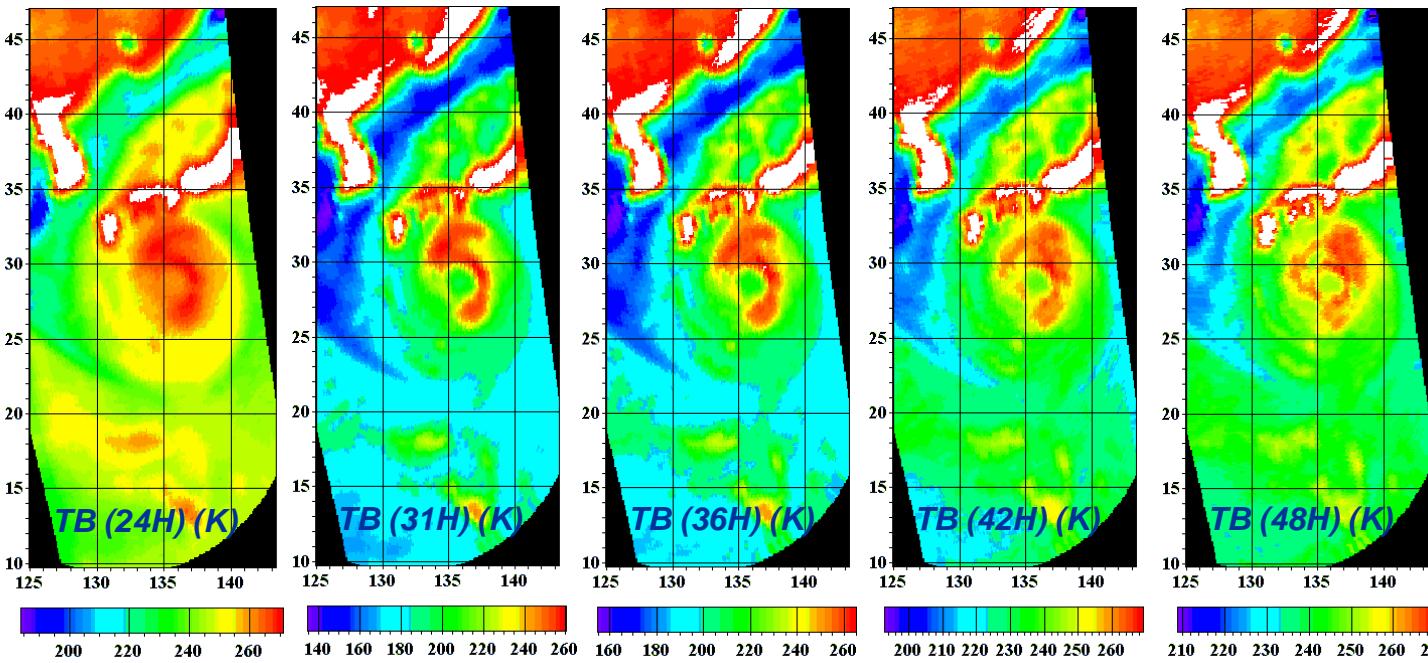
Note: 1) Times are GMT 2)Times along bottom correspond to measurement at 30N  
3)Data buffer is 22 hrs from 20110901 4) Black circles indicate possible contamination

NOAA/NESDIS/Office of Research and Applications

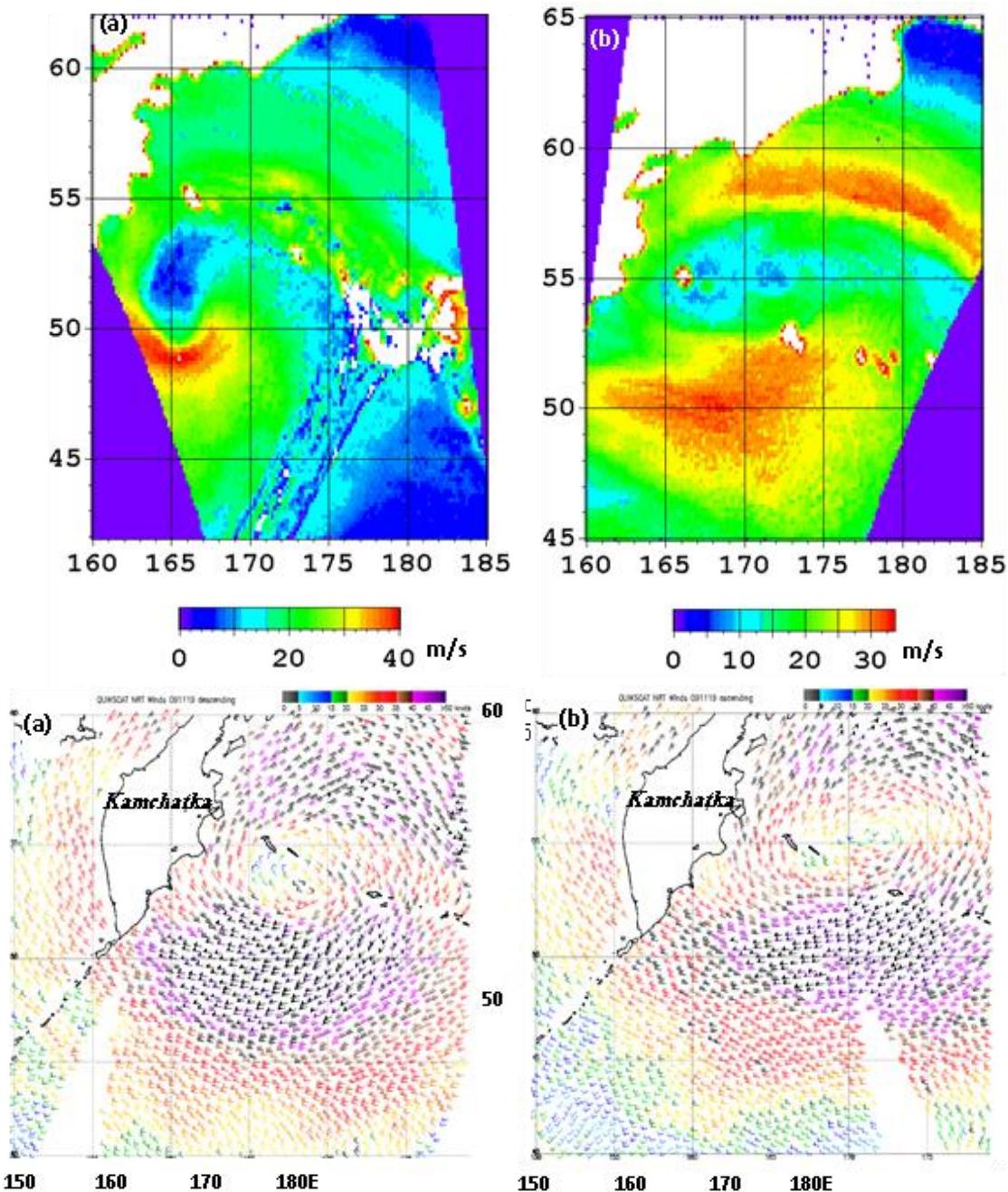


*MetOp ASCAT-derived wind field on 1 September 2011 at descending (00:20 UTC) and ascending (11:35 UTC) orbits*

*Meteor-M №1*  
*MTVZA-GYa*  
*brightness*  
*temperatures*  
*acquired on*  
**1 September 2011**  
*at 13:18 UTC.*



# Extratropical cyclone over the Bering Sea and Pacific Ocean on 19 November 2009.



Wind fields retrieved from  
Aqua *AMSR-E* data at 01:25  
UTC (a) and at 14:55 UTC (b)  
And from по данным  
*QuikSCAT* scatterometer (c) at  
07:29 UTC and at 17:14 UTC.

# Mesoscale organized structures in the marine boundary layer of the atmosphere. Cold air outbreak

(a)

Sakhalin

Kamchatka

(b)

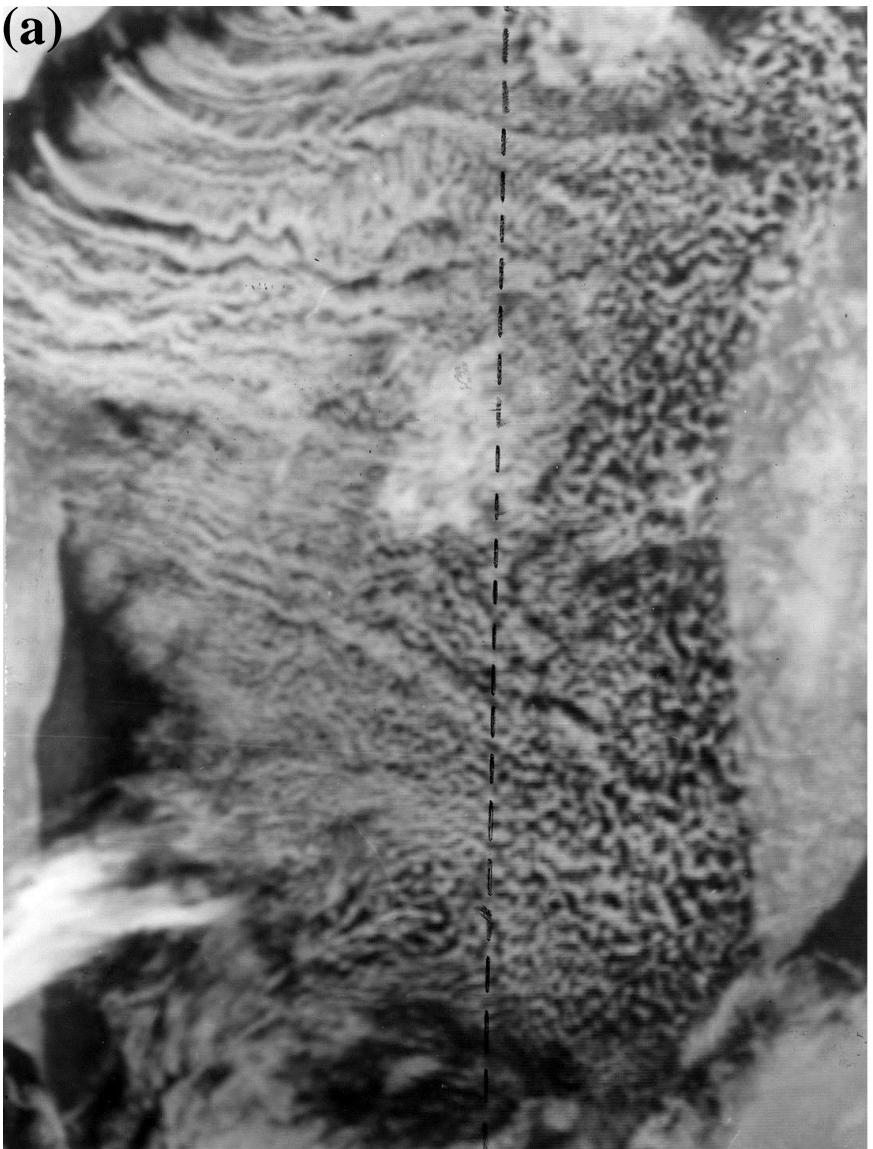
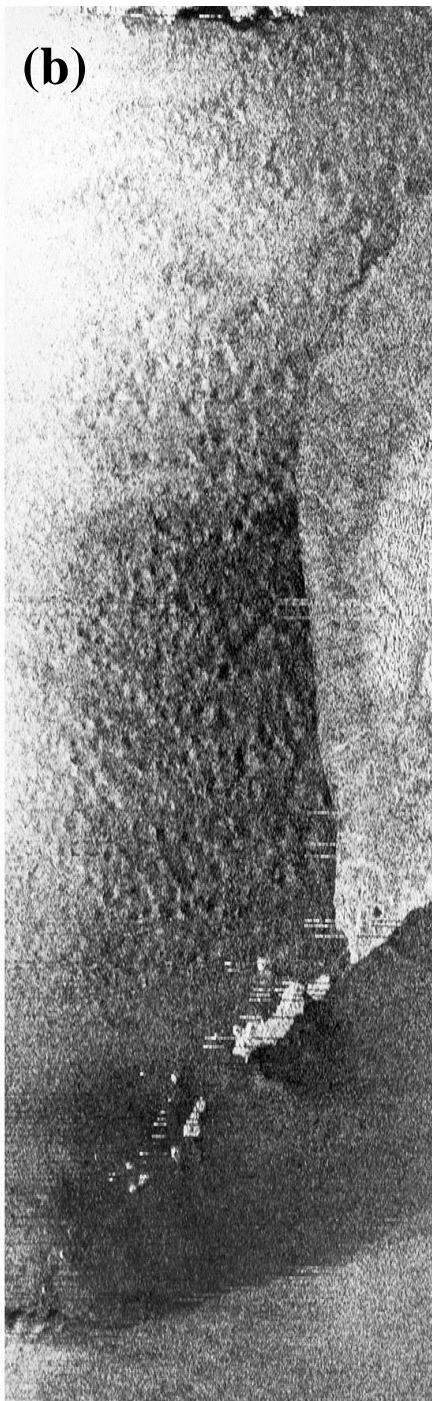
Sakhalin

Kamchatka

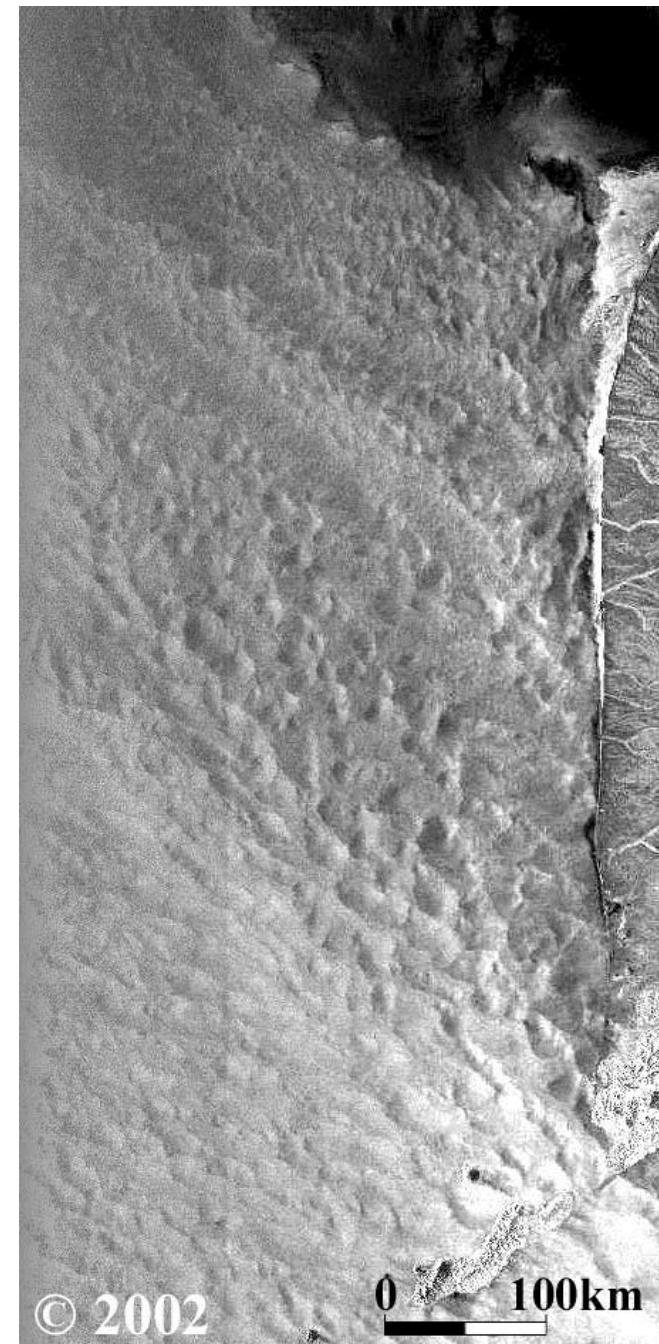
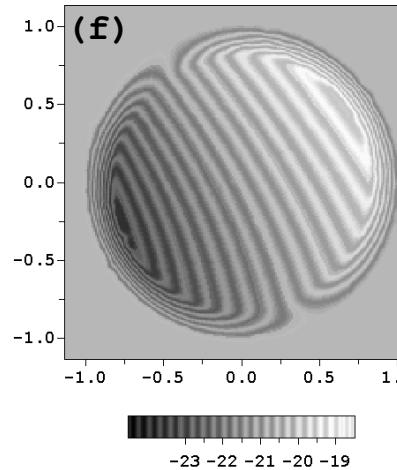
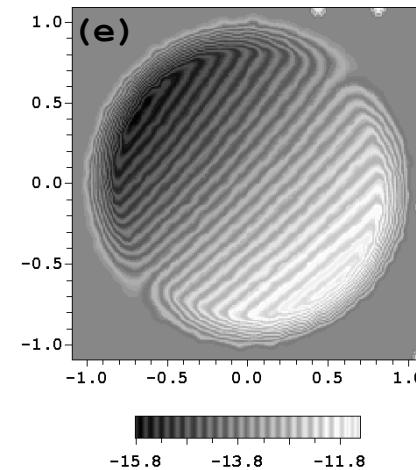
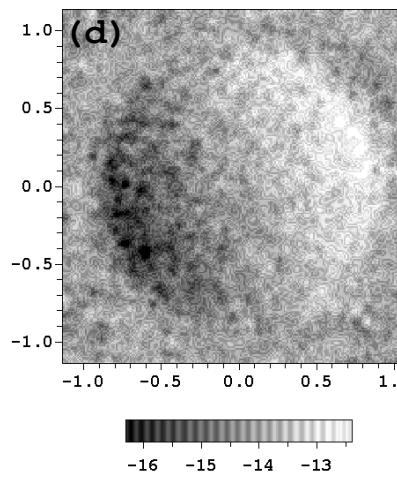
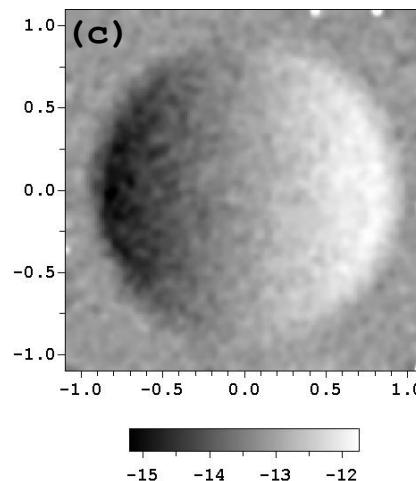
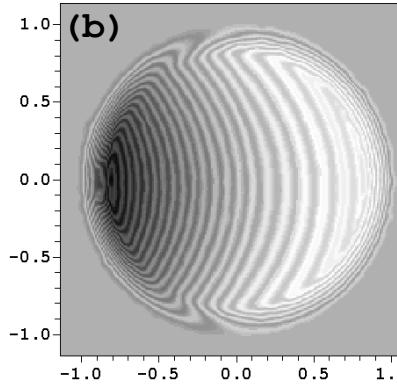
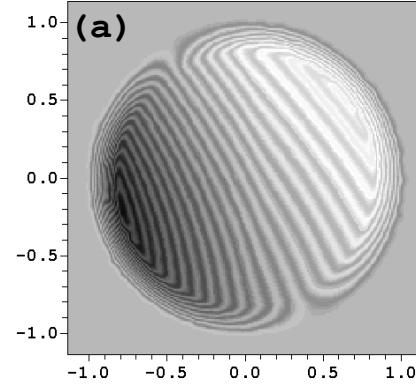
**GMS-5 visible (a) and IR (b) images of the Okhotsk Sea taken on 20 December 2002 at 02 UTC (a), and 12 UTC (b)**

# Mesoscale convective rolls and cells over the Okhotsk Sea:

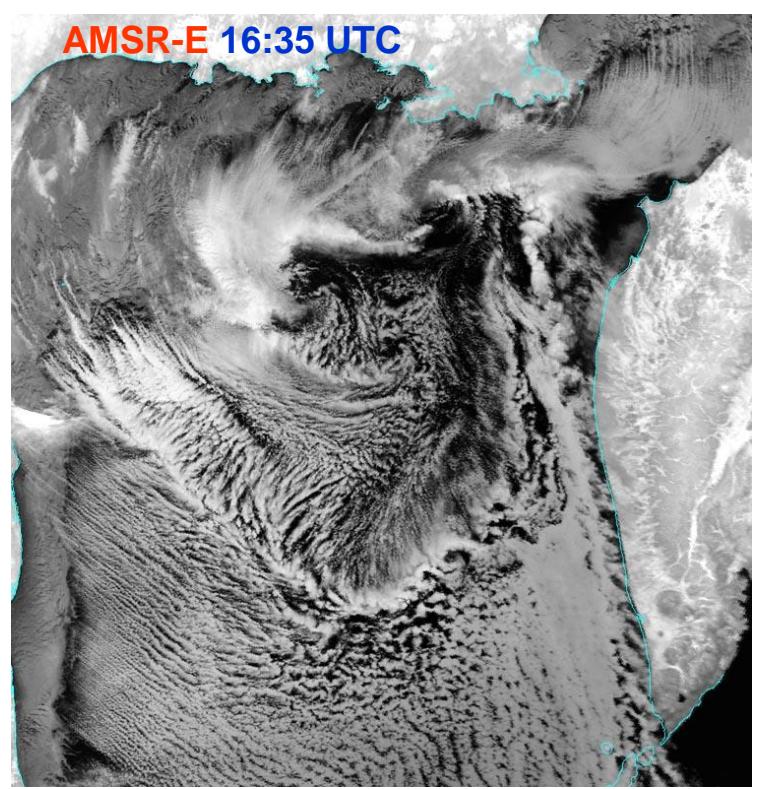
**(a) visible image,  
(b) RAR image**



# Mesoscale convective cells. SAR image

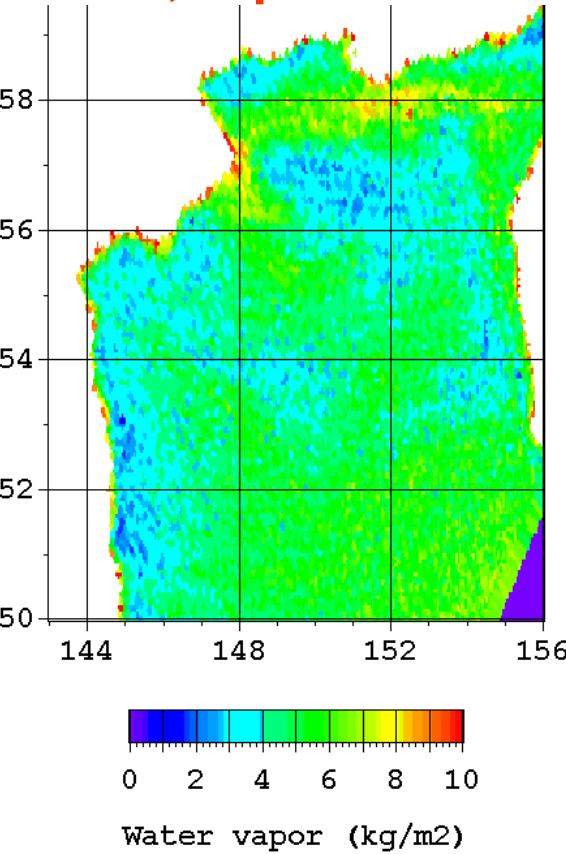
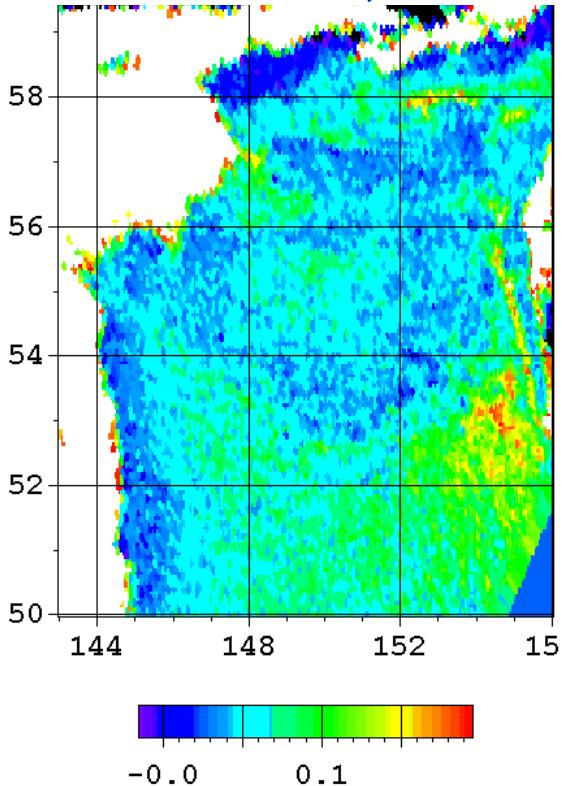


AMSR-E 16:35 UTC



ASAR 11:34 UTC

30 December, Envisat ASAR, Aqua AMSR-E

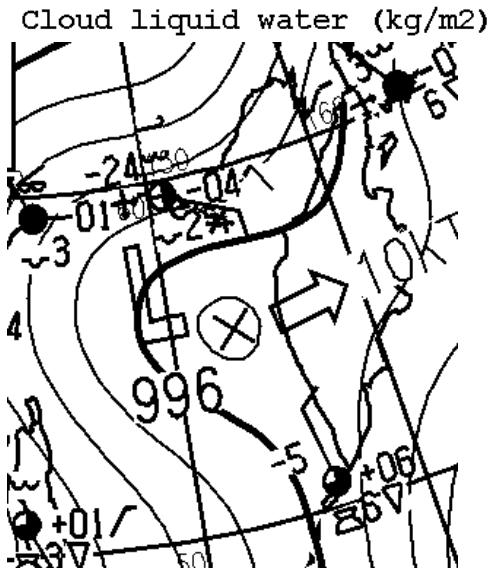


Cloud liquid water (kg/m<sup>2</sup>)

-0.0 0.1

Water vapor (kg/m<sup>2</sup>)

0 2 4 6 8 10



Surface analysis map  
of the JMA for 12 UTC

**Океан-7 RAR (a) and visible (b) images of the Pacific Ocean taken on 31 Jan 1996 at 06:10 UTC.**

(a)

(b)

*Hokkaido*

*Honshu*

Sensing  
direction

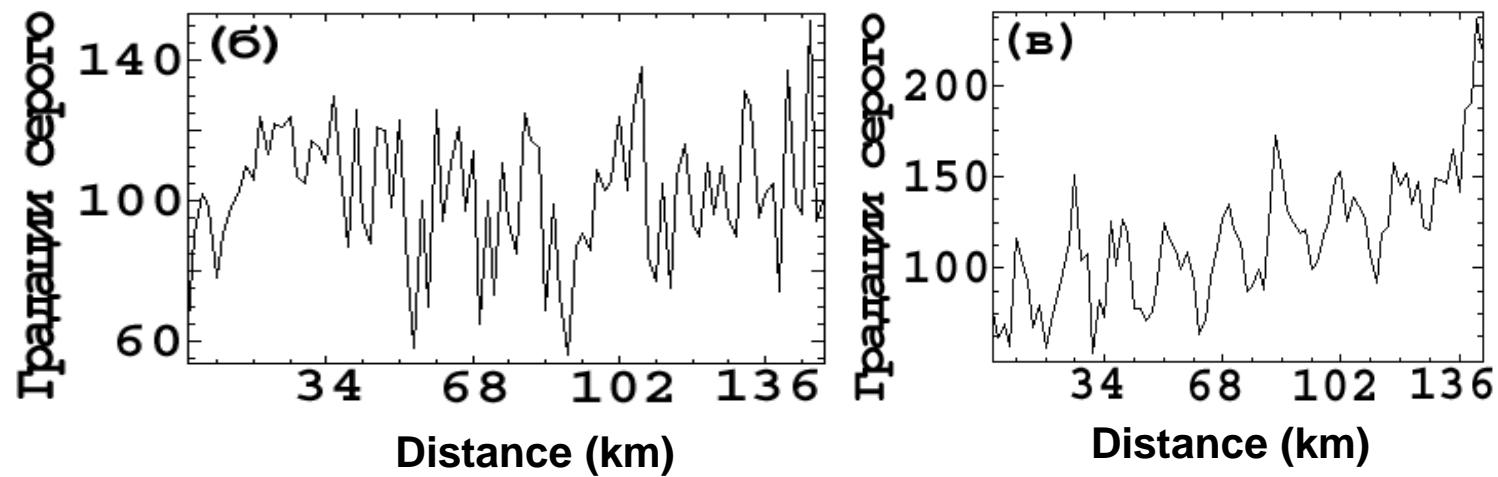
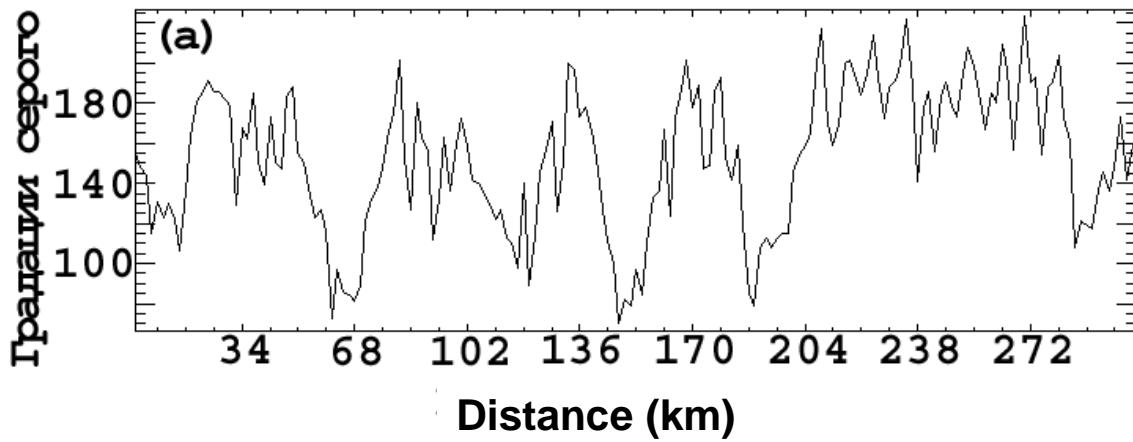
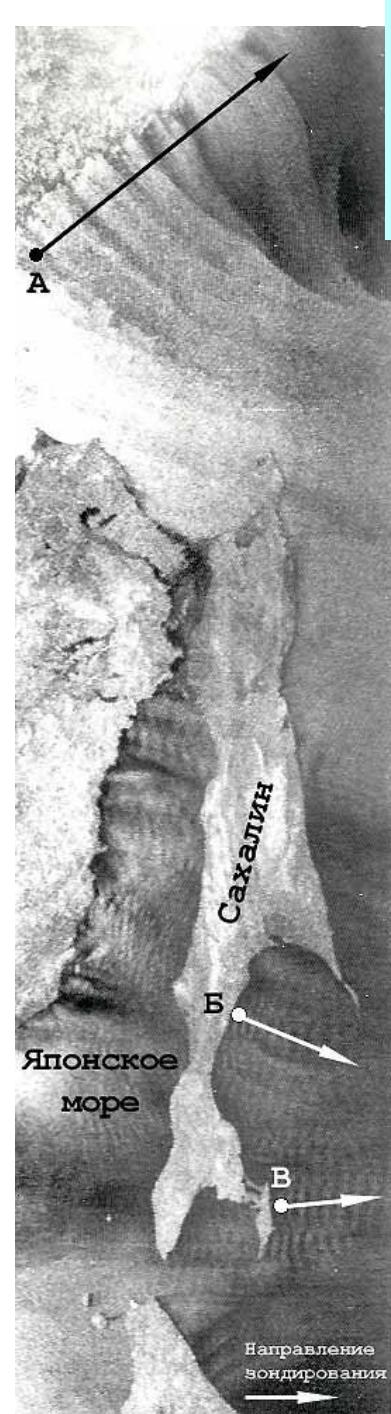
*Hokkaido*

*Honshu*

**Океан-7 RAR  
image taken on  
27 January 2000  
at 11:57 UTC.**

# Ocean-7 RAR image of the Northwest Okhotsk Sea, Northern Japan Sea and Sakhalin acquired on 19 November 1996 at 18:26 UTC

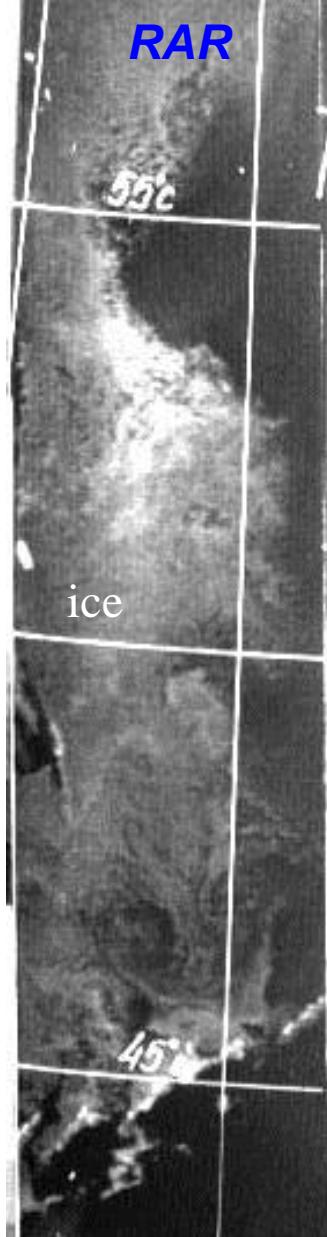
Brightness variations along sections A (a), B (b) and C (c).



# Sea ice on Океан-7 images



24 January 1996

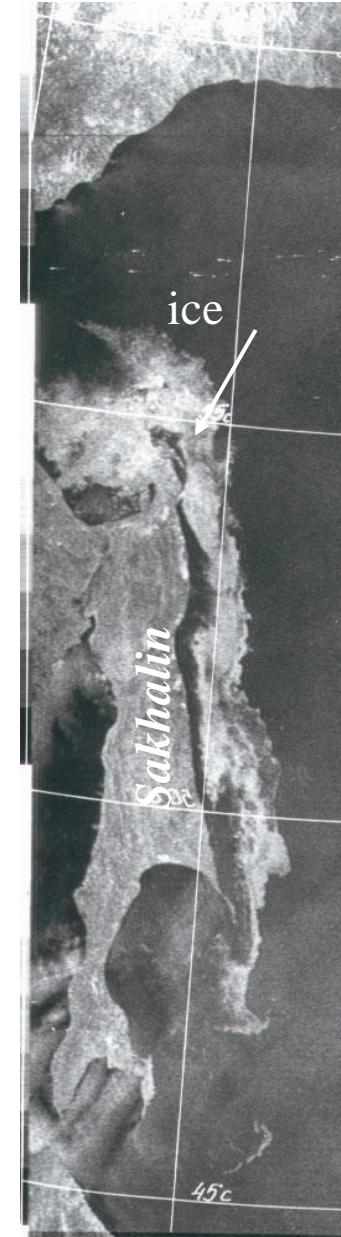


28 March 1997



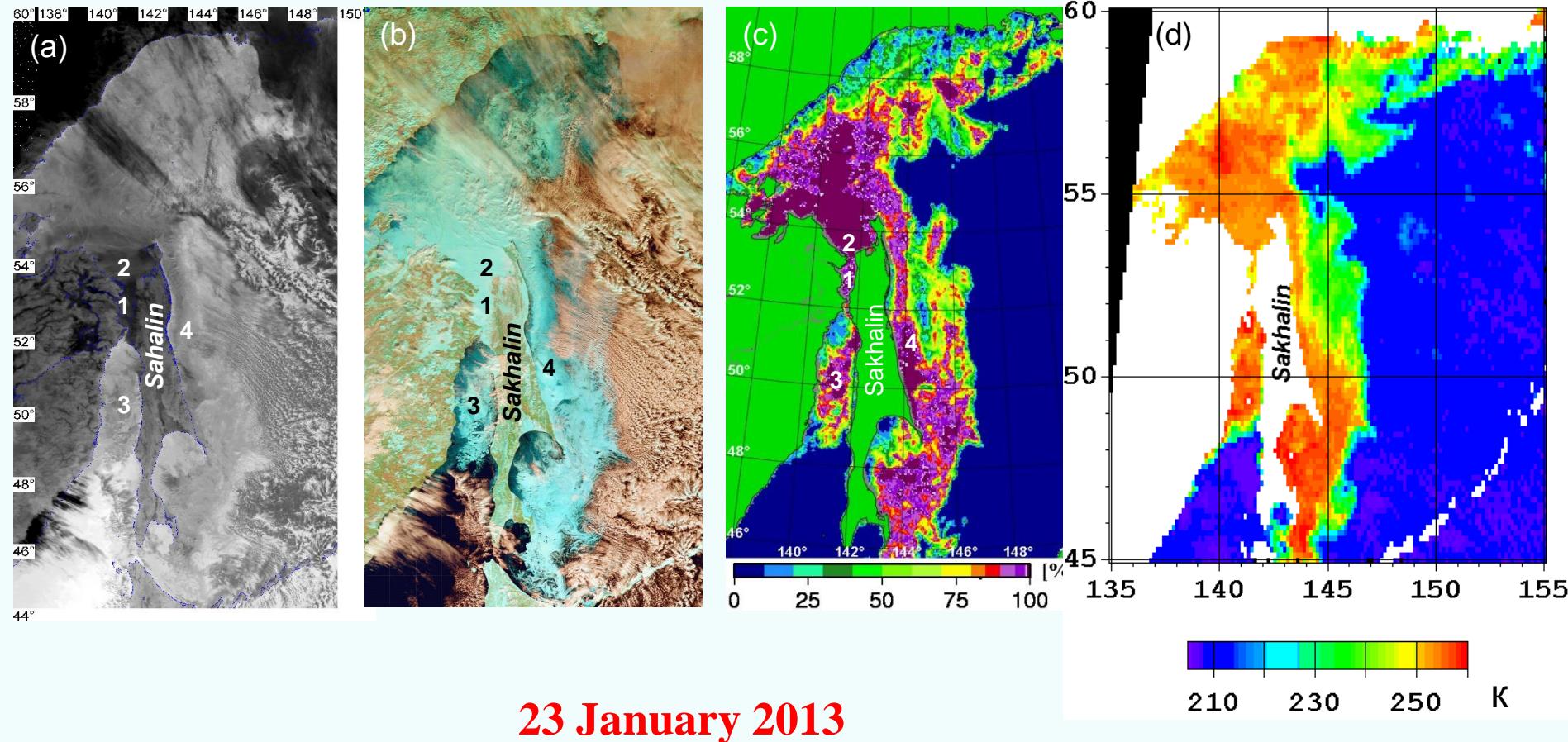
swath width

RAR



4 May 1996

# Joint analysis of visible, infrared and passive microwave data



23 January 2013

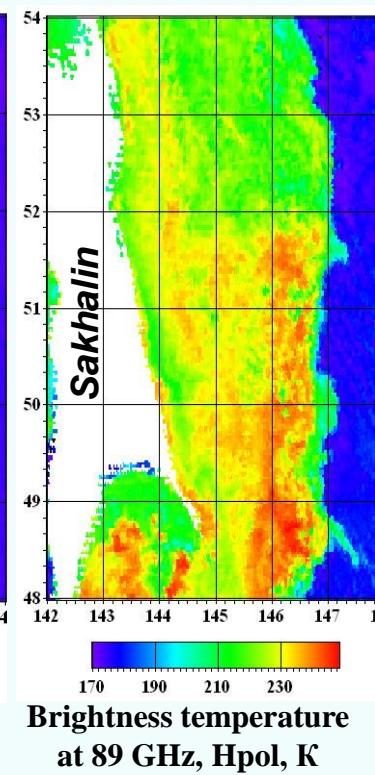
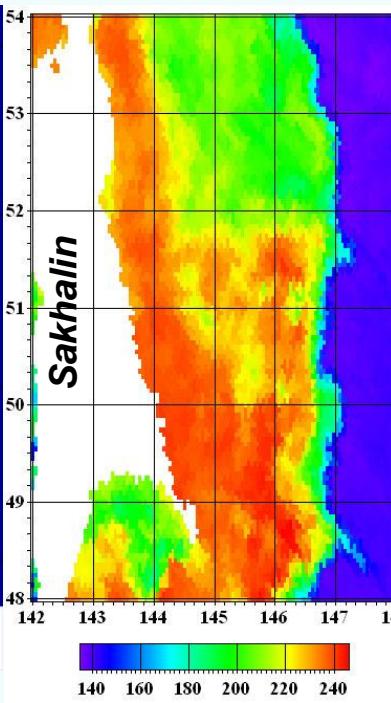
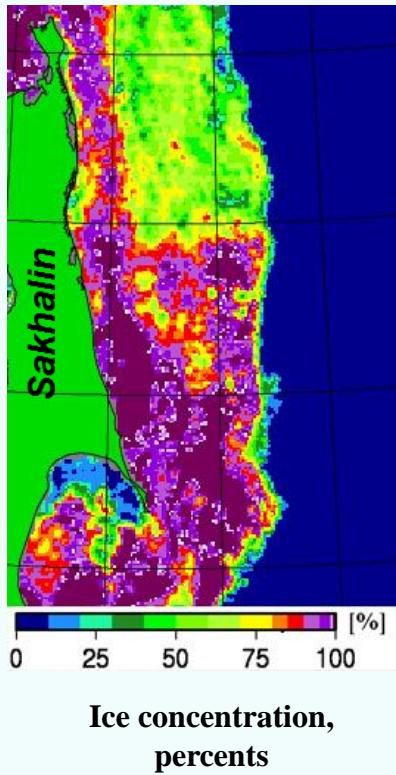
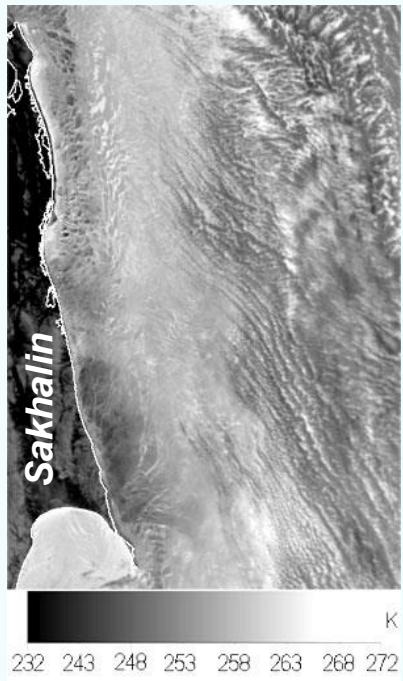
a) Aqua MODIS IR-image, at 02:55 UTC.

b) Aqua MODIS visible image at 02:55 UTC.

c) Ice concentration map (Bremen University) derived from GCOM-W1  
AMSR2 brightness temperatures Tb(89V), Tb(89H) at 02:45 UTC.

d) AMSR2 Tb(89H) at 02:45 UTC.

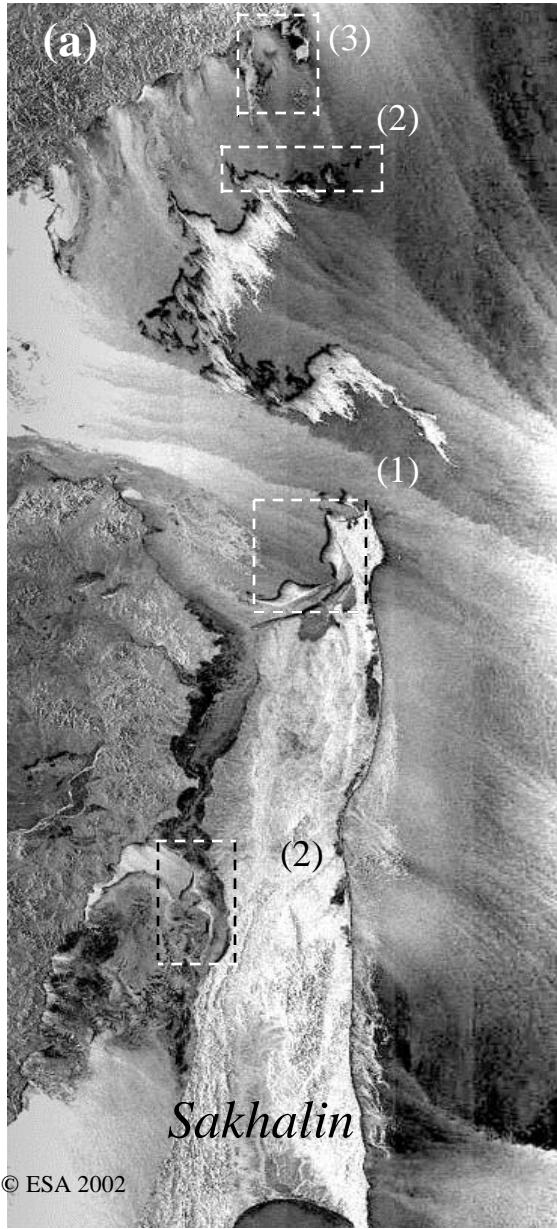
# Sakhalin Eastern shelf, 11 February 2013



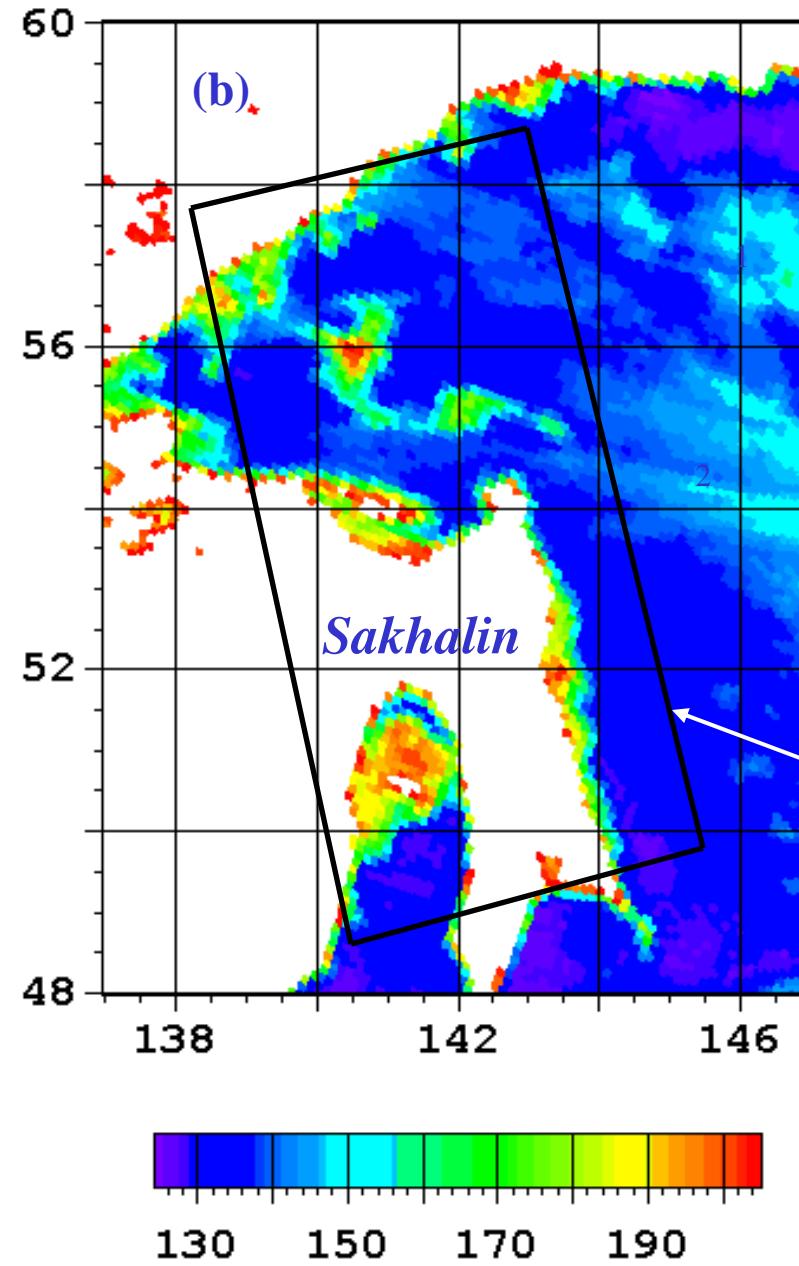
Air temperature -26°C, southwestern wind 2 m/s

- a) **Aqua MODIS IR-image**, at 03:25 UTC.
- b) **Aqua MODIS visible image** at 03:25 UTC.
- c) **Ice concentration map** (Bremen University), 03:17 UTC
- d) **AMSR2 Tb(36H)** at 03:17 UTC
- e) **AMSR2 Tb(89Γ)** at 03:17 UTC

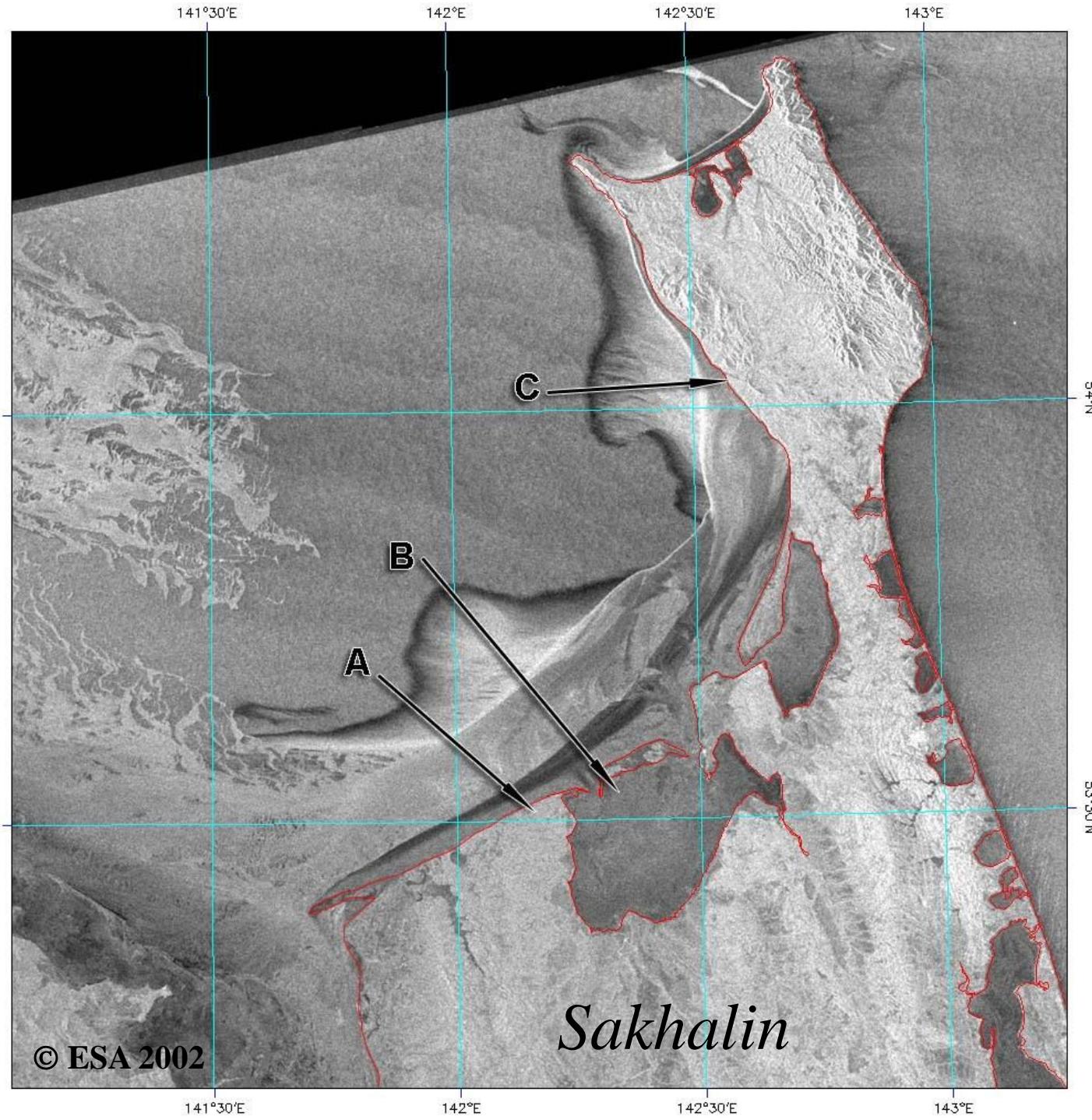
9 December 2002



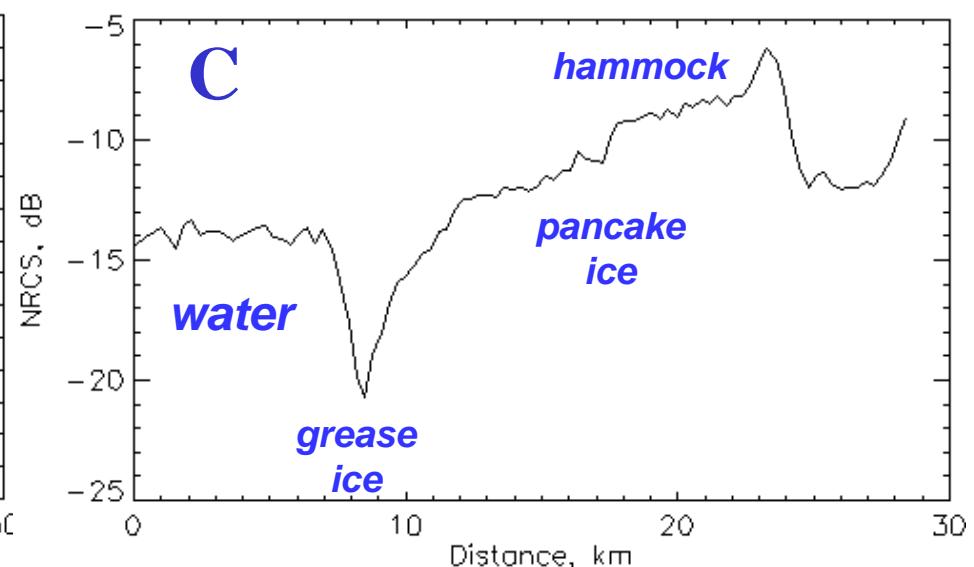
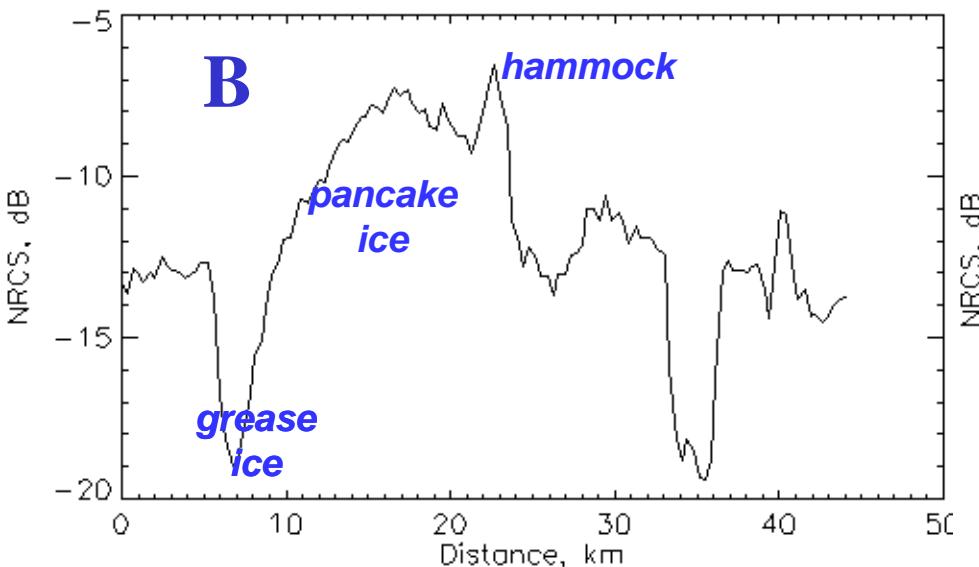
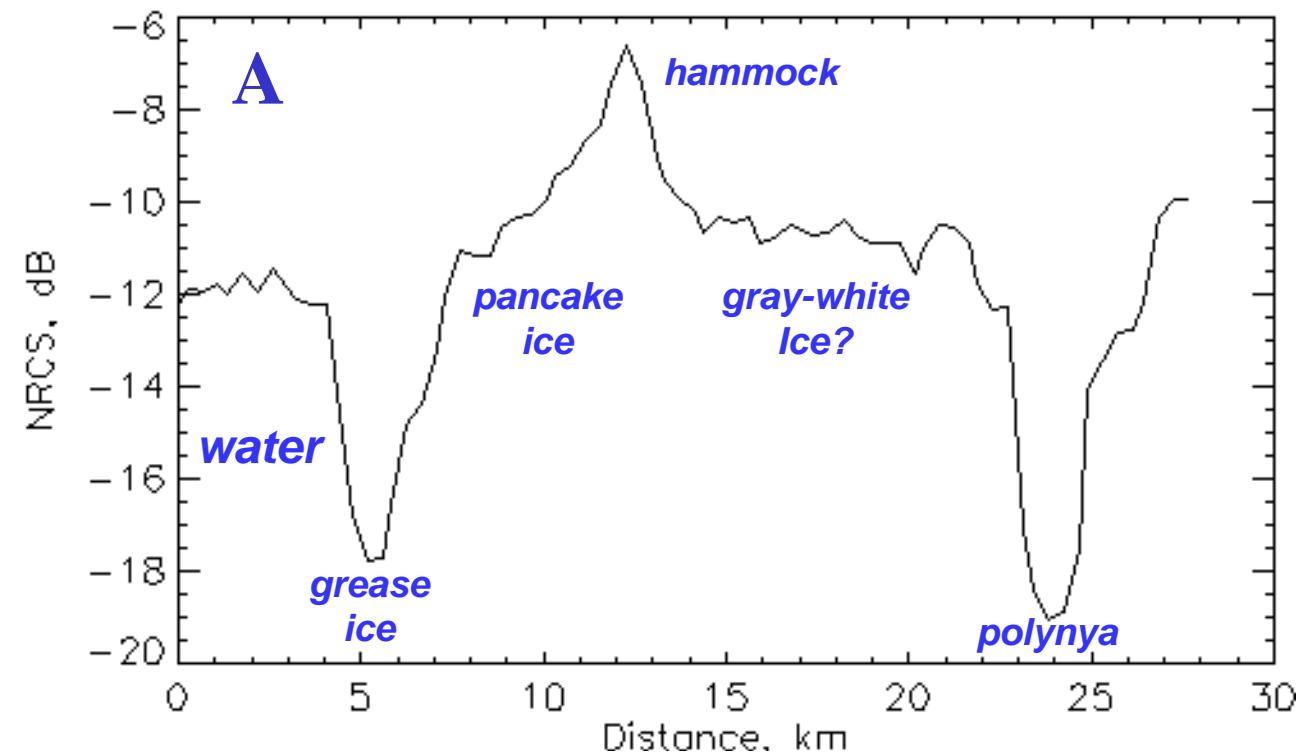
# Western Okhotsk sea



**Envisat  
ASAR  
HH  
9 Dec 2002  
12:11 UTC**



# NRCS profiles







PALSAR

03:55 Гр.

1

2

3

3

24 января  
2011 г.

MODIS,  
спутник  
Aqua

1

2

3

3

1 – гладкий  
лед

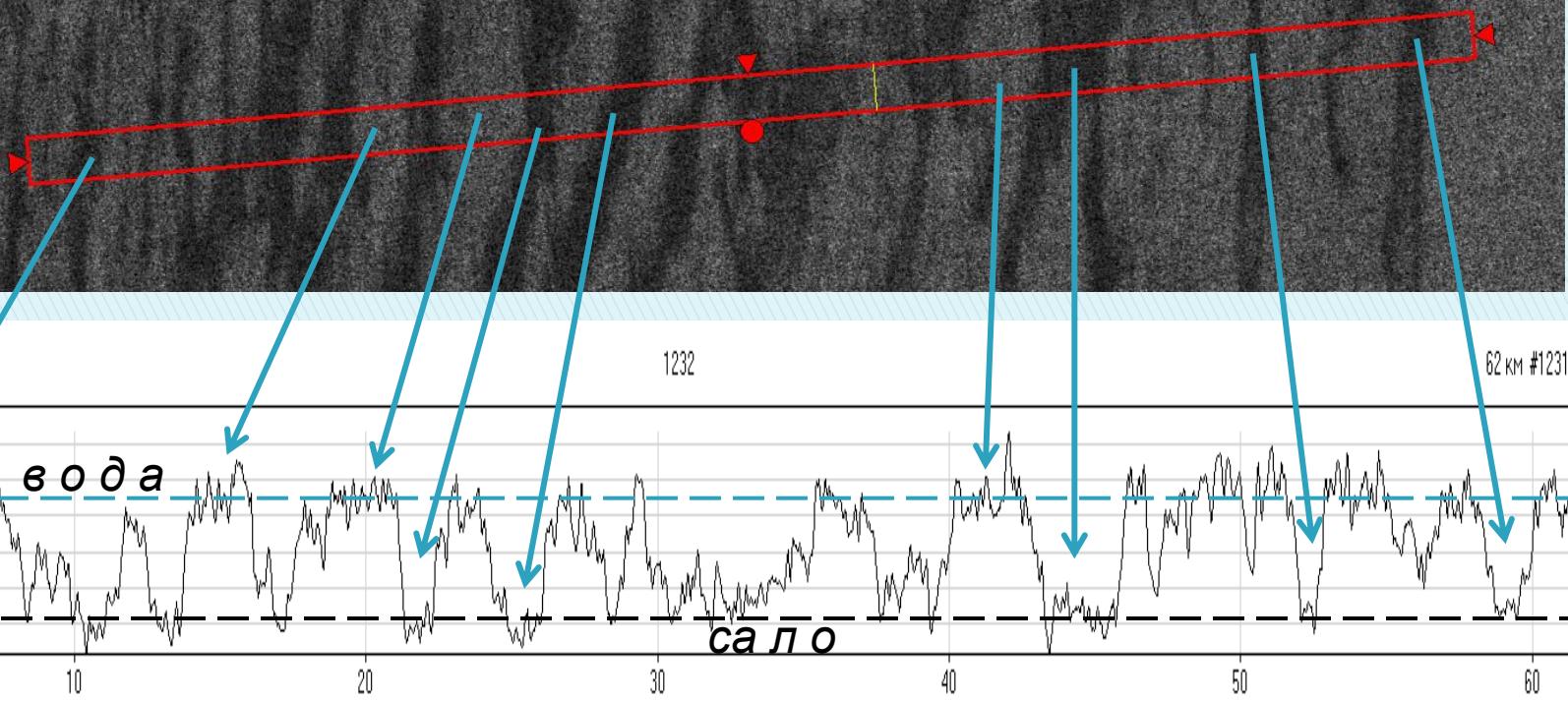
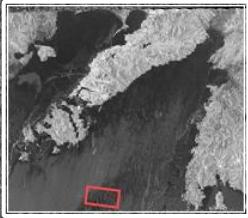
2 – открытая  
вода  
3 – ледяное  
сало

спутник  
Landsat

1

2

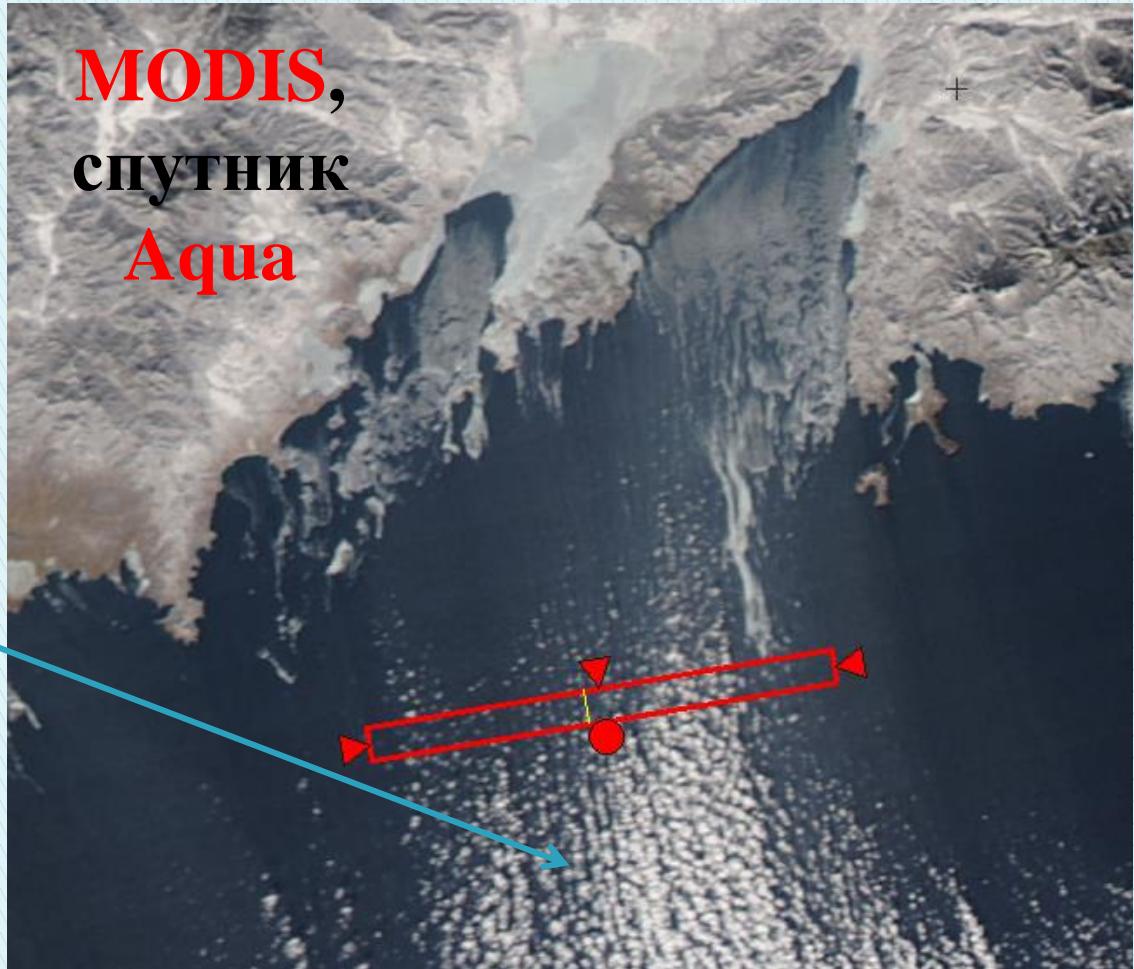
3



24 января  
2011 г.

Валиковая конвекция в  
пограничном слое

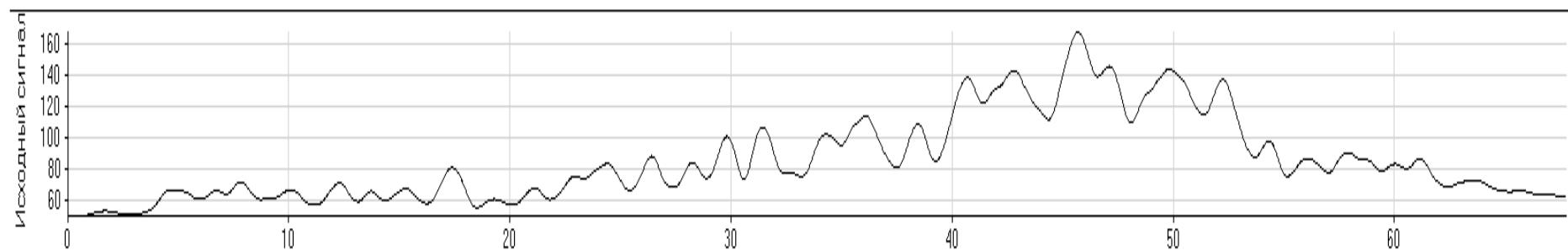
MODIS,  
спутник  
Aqua



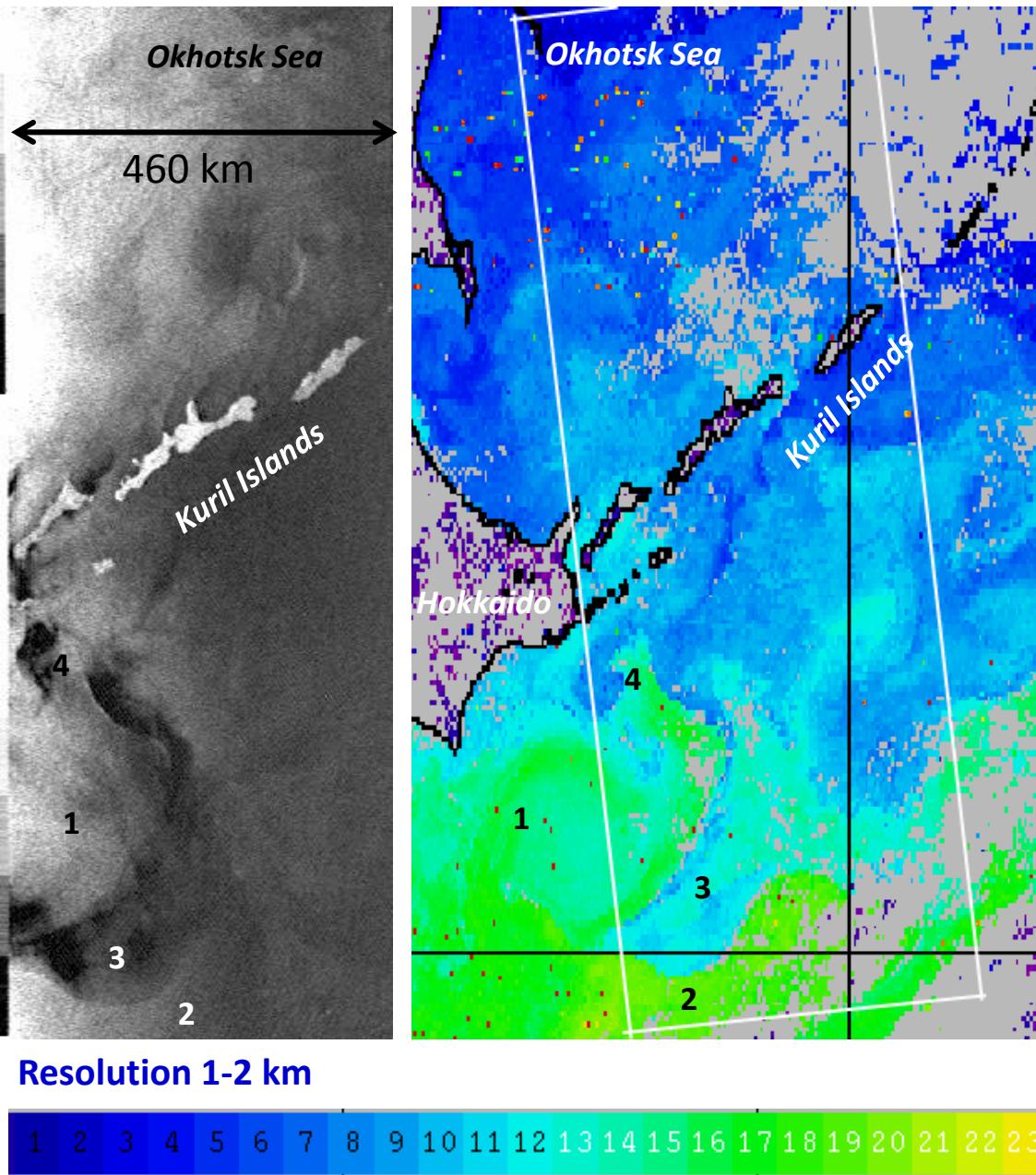
0 км #0

272

68 км #271



# Kuroshio-Oyashio and synoptic eddies



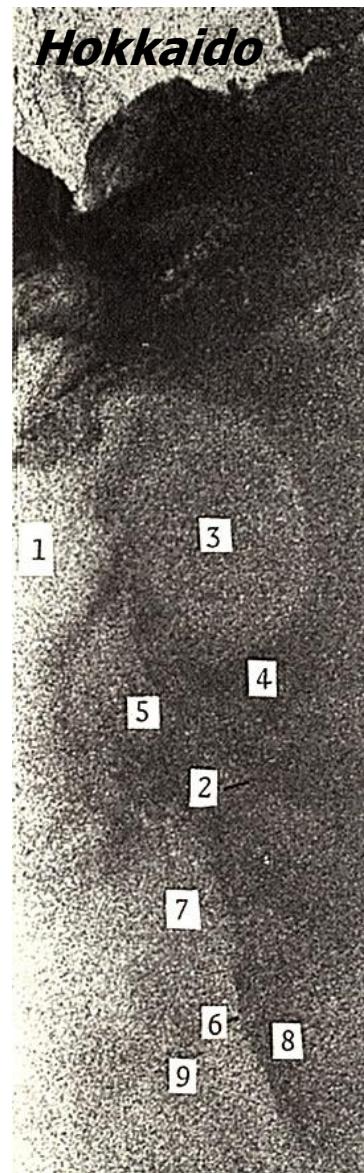
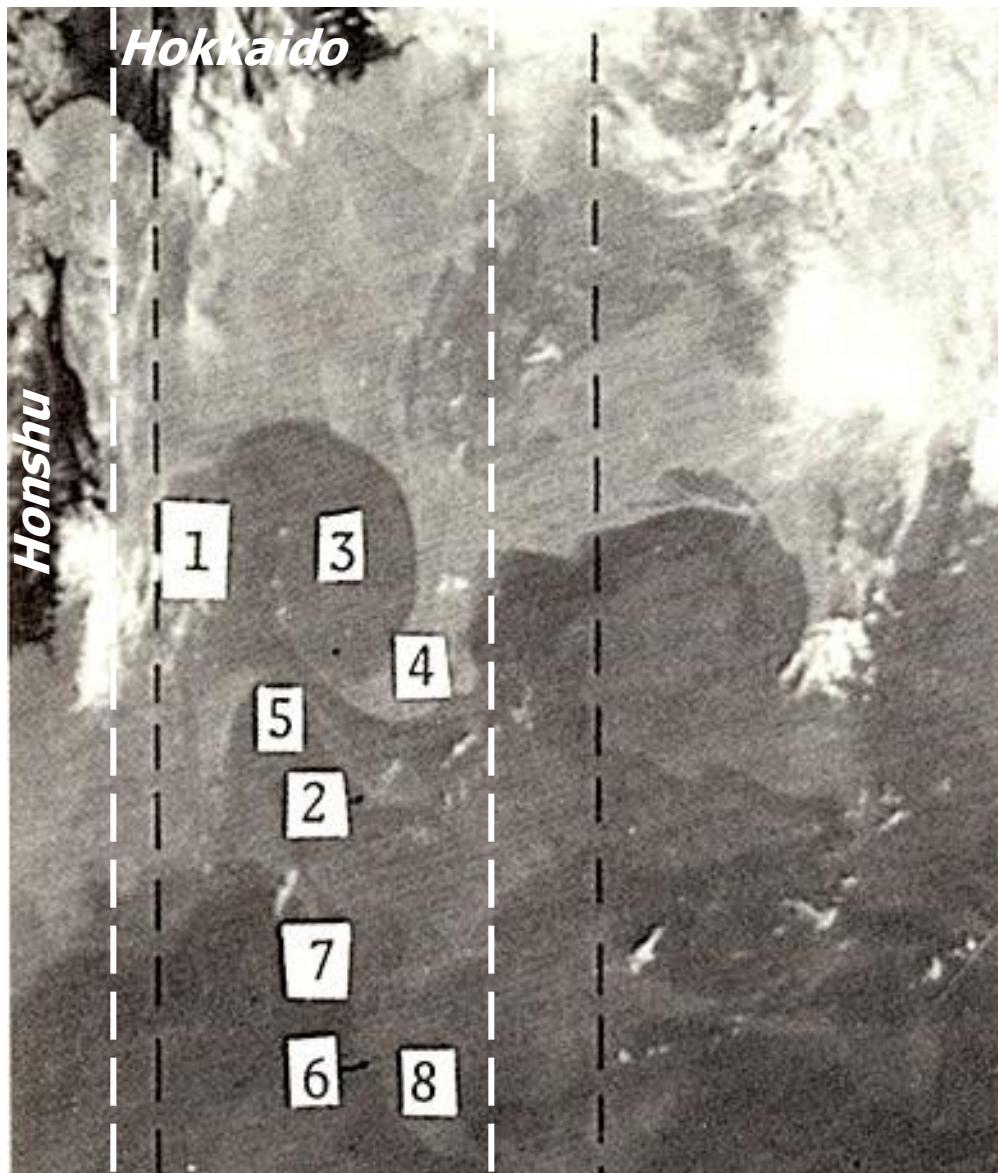
Okean-7 X-band Real Aperture Radar (RAR) and NOAA AVHRR-derived SST.  
20 November 1999.

*White rectangle marks the boundaries of RAR image.*

Wind speed to the south of *Kuril Islands* was 5-6 m/s. *Anticyclonic eddy 1*, *warm Kuroshio waters 2* and *cold Oyashio waters 2* are revealed due to high radar contrast.

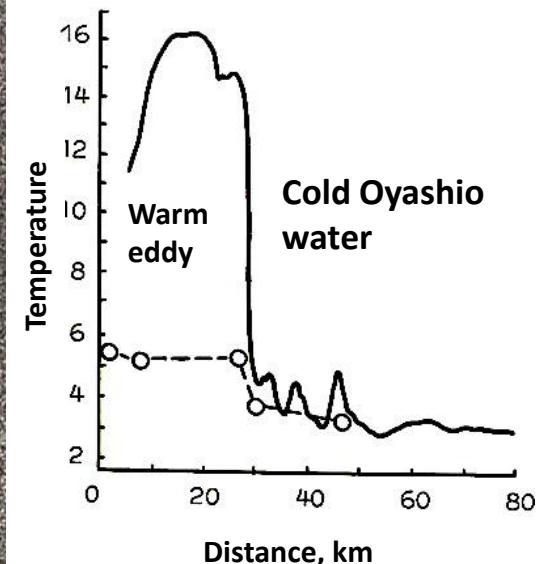
Fine details of SST field (such as *warm streamer 4* and others) are clearly depicted on the **RAR** image. SST contrasts reach  $12^{\circ}\text{C}$  at the eddy boundary.

# Kuroshio-Oyashio transition zone

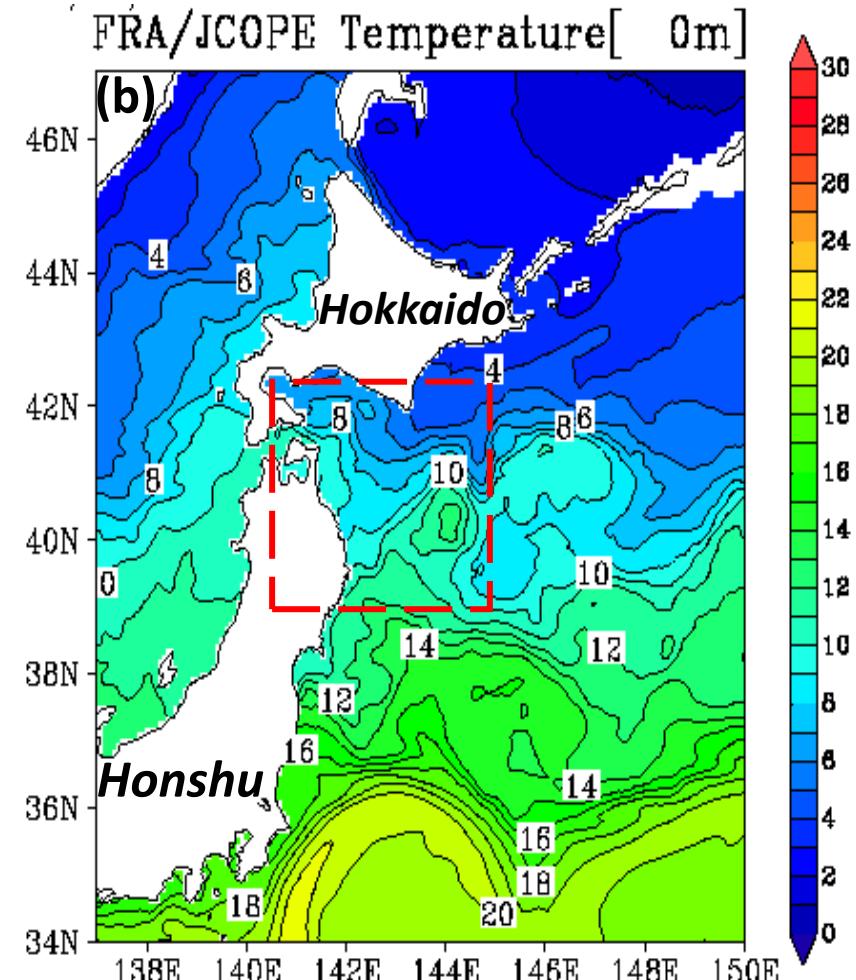
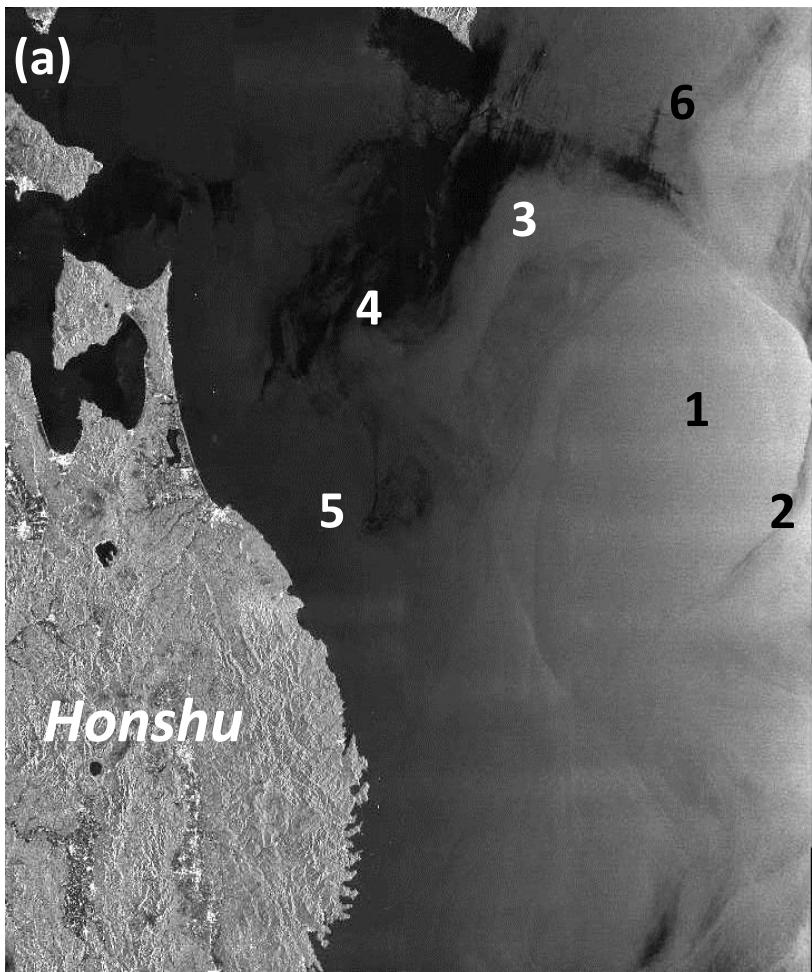


Resolution 1-2 km

**NOAA-10 AVHRR  
infrared image  
acquired on 30  
April 1987 (left)  
and  
Kosmos-1500  
Real Aperture  
Radar image**



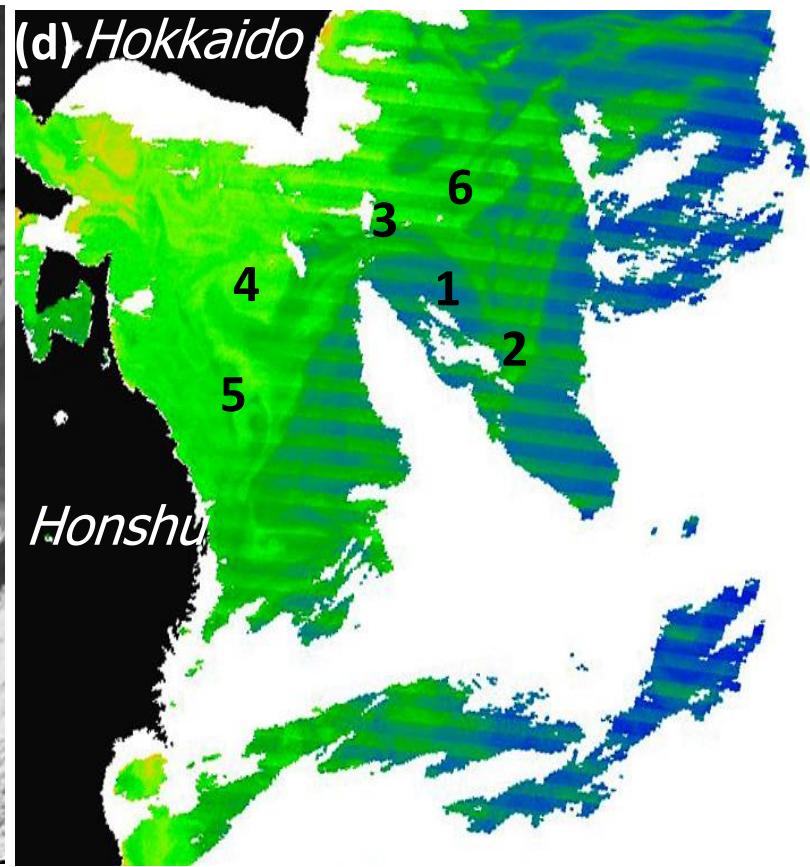
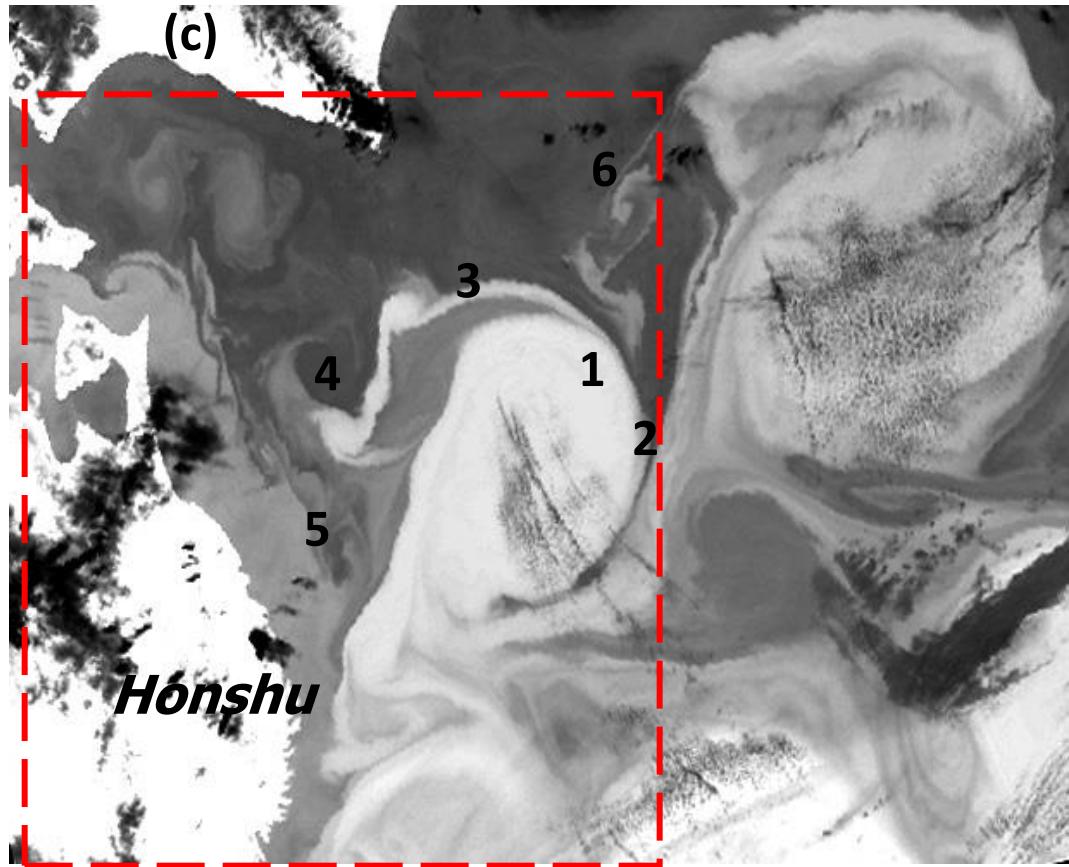
# ALOS PALSAR. Anticyclonic eddy



PALSAR image acquired on 18 April 2009 at 01:10 UTC; (b) sea surface temperature map for the same day submitted by Fishery Research Association. Red rectangle marks the boundaries of PALSAR image. 1 – warm waters, 2- cold waters , 3 – warm streamer, 4-6 and 5 – cold small eddies, 6 – warm small eddy.

# Aqua MODIS. 19 April 2009, 03:40 UTC

(c) Infrared image (31-st channel) and (d) chl-a field



1 – warm waters, 2- cold waters , 3 – warm streamer, 4 and 5 – cold small eddies, 6 – warm small eddy. Red dotted rectangle marks the boundaries of PALSAR image.

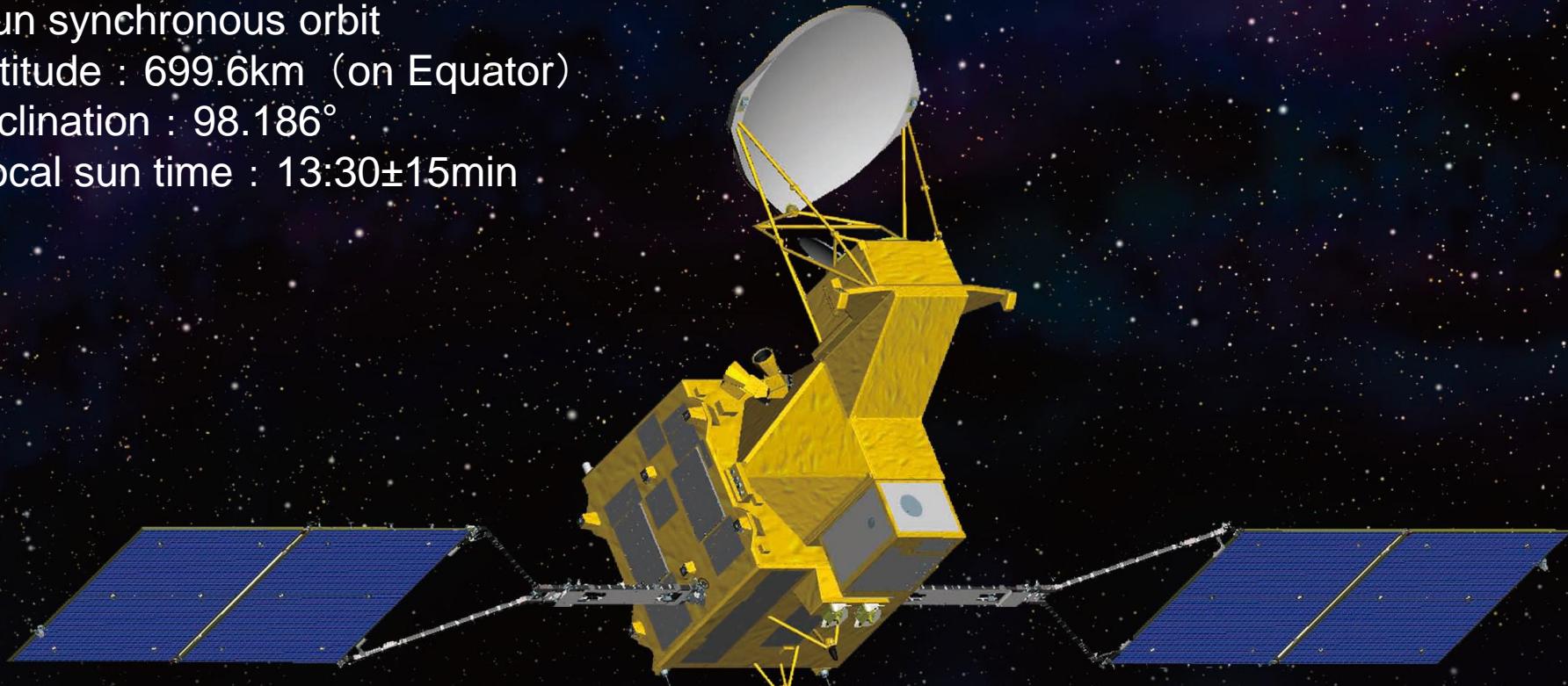
# GCOM-W1 (Japan). 18 May 2012

Sun synchronous orbit

Altitude : 699.6km (on Equator)

Inclination : 98.186°

Local sun time : 13:30±15min



Advanced microwave scanning radiometer **AMSR2** for observation outgoing emission of land, ocean and atmosphere at 7 frequencies between 7 and 89 ГГц.  
Самая большая в мире спутниковая вращающаяся антенна.

# AMSR2

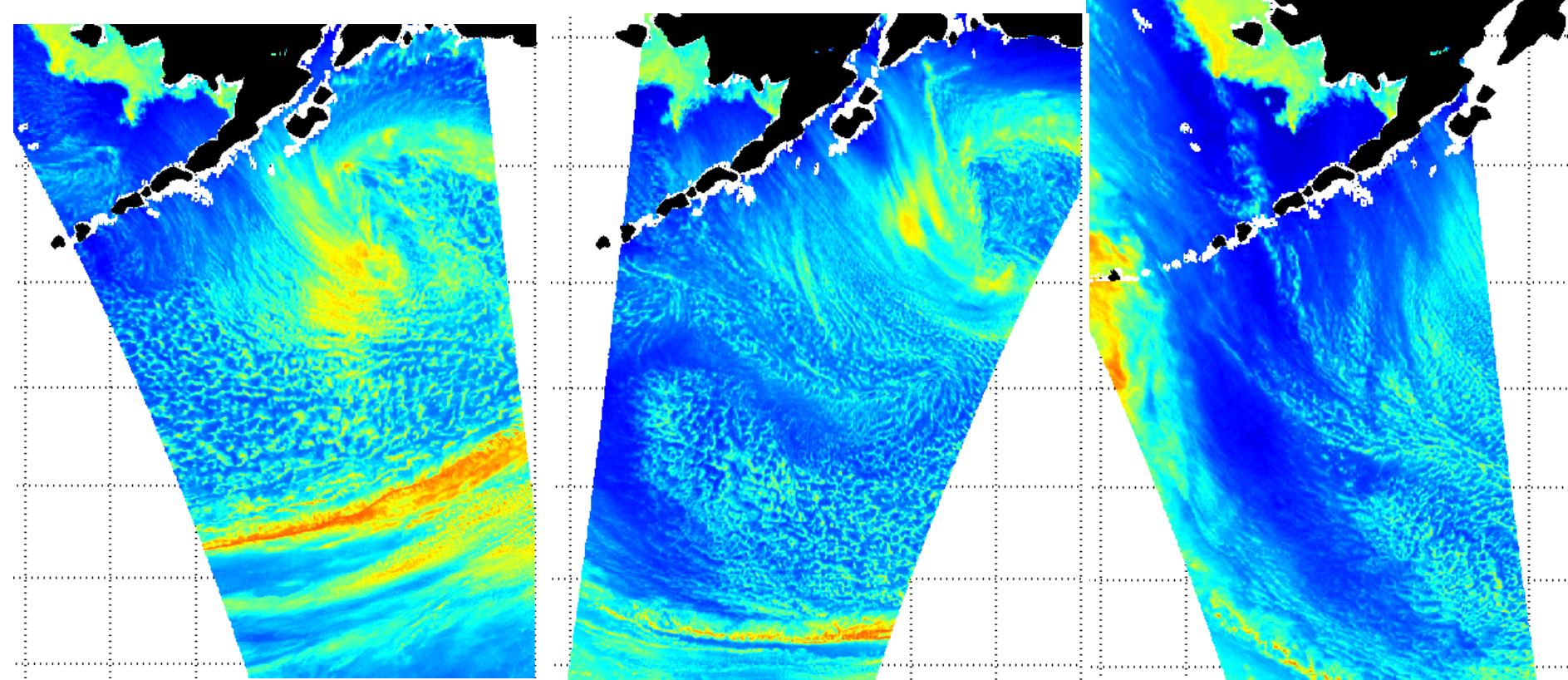


# Extratropical cyclone. GCOM-W1 AMSR2, 18-19 December 2012

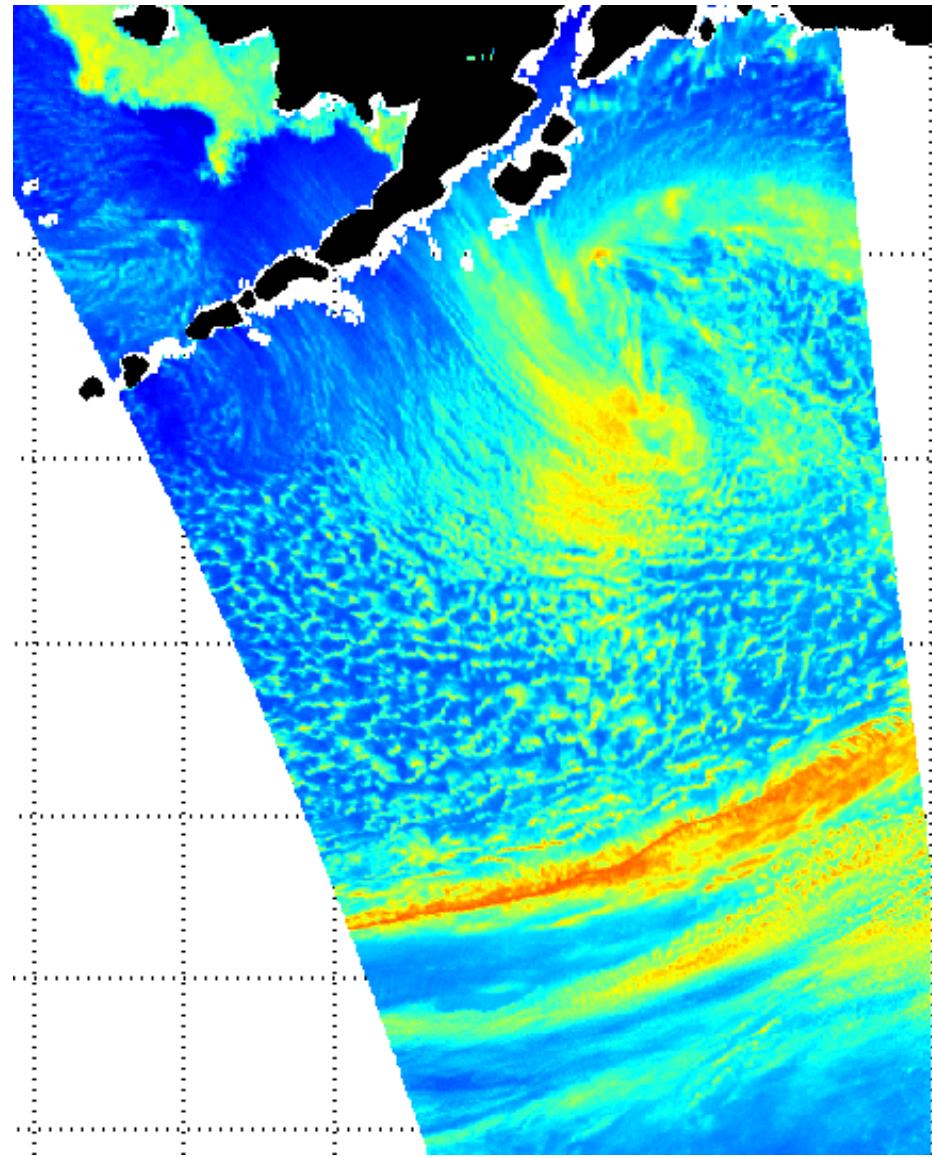
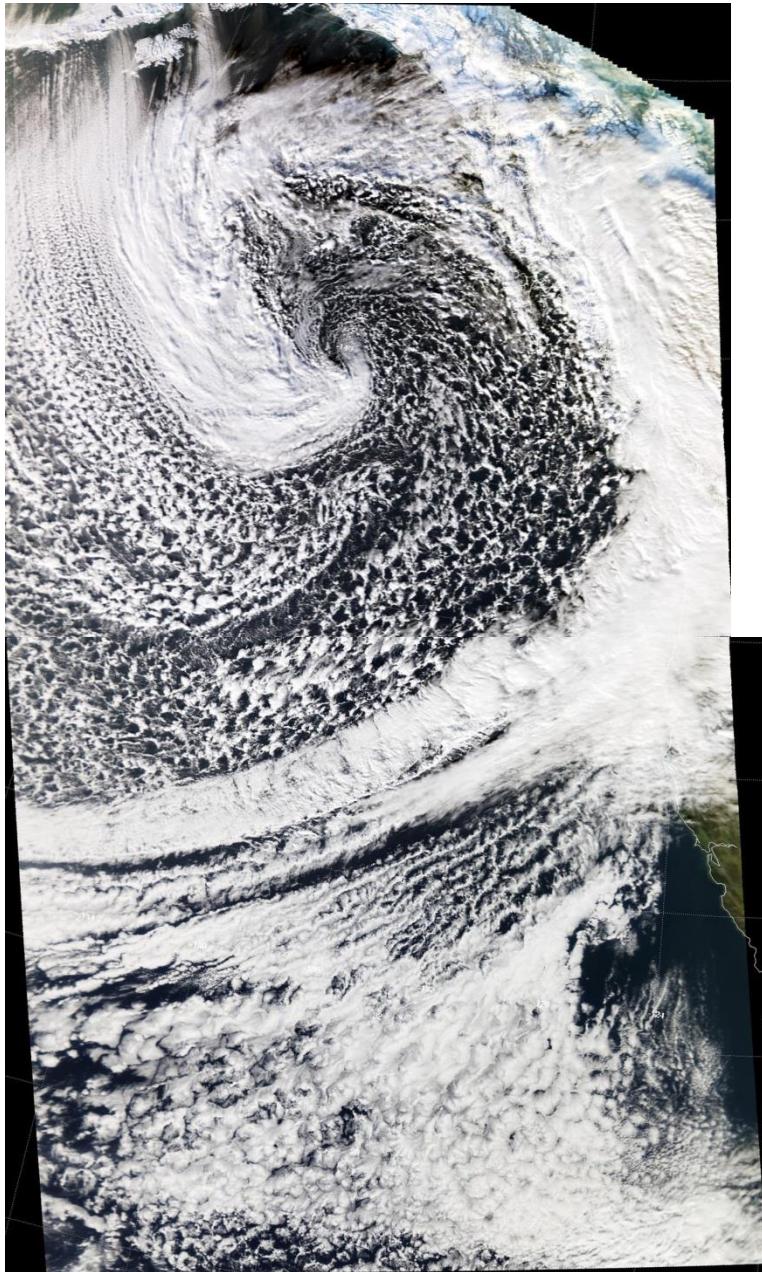
23:00

12:30

23:40

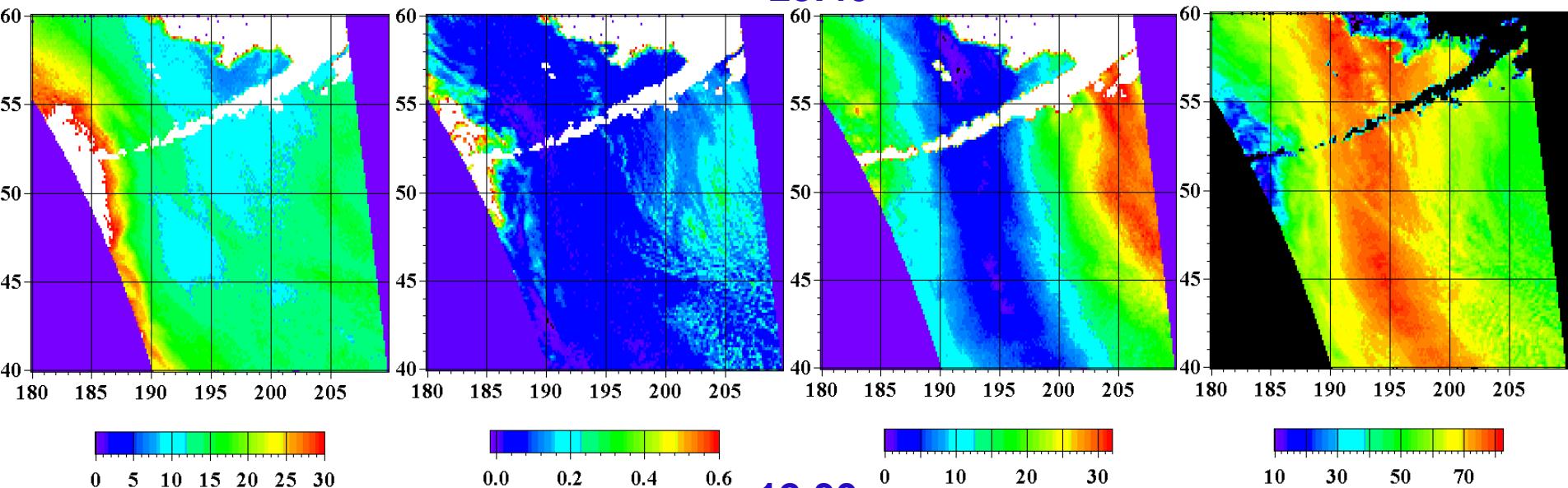


# Extratropical cyclone, 19 December 2012

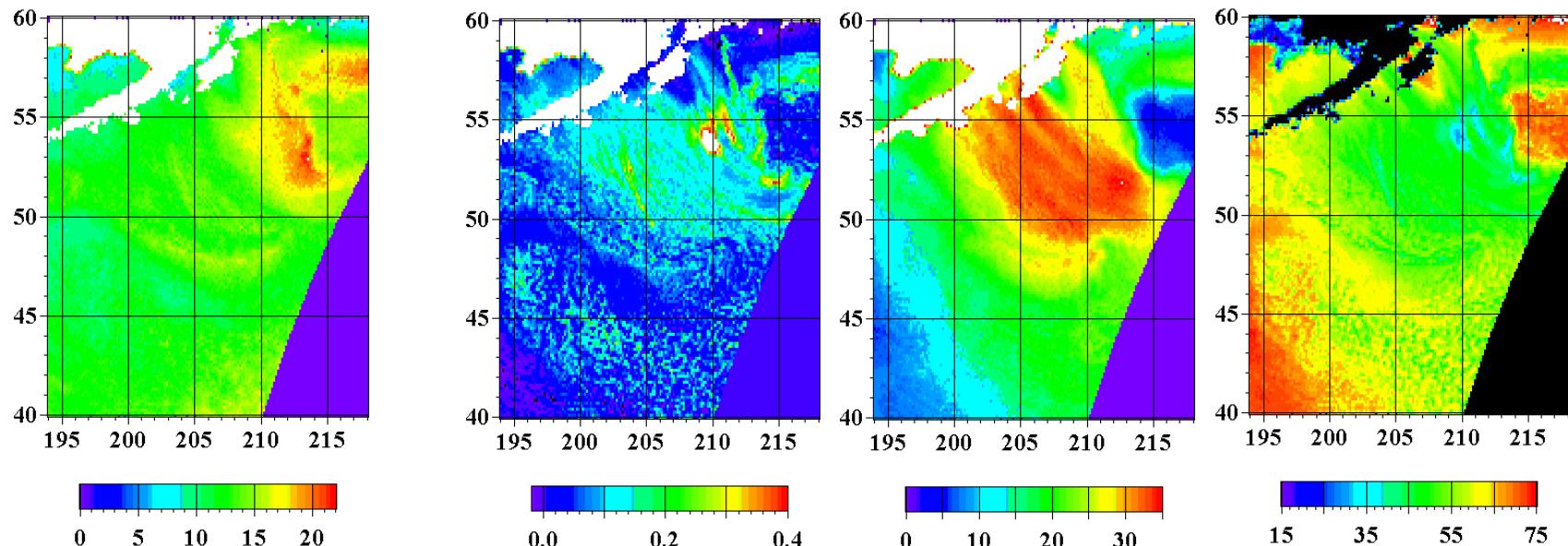


# 19 December 2012, cyclone and cold air outbreak

23:40

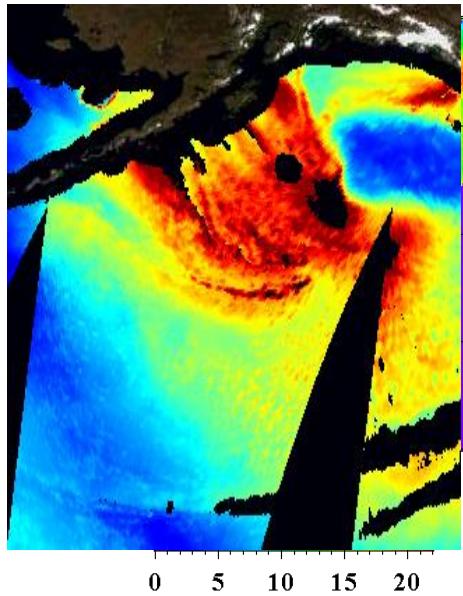


12:30

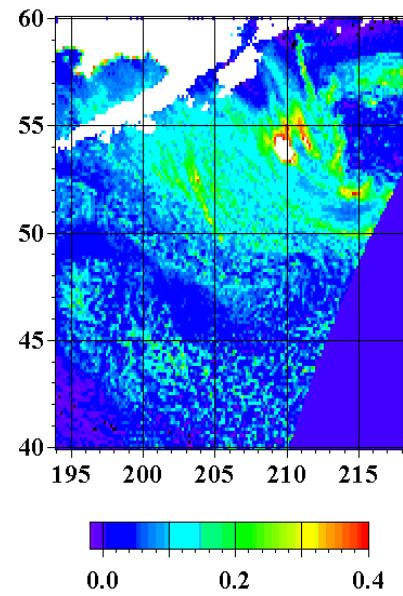


19 December 2012

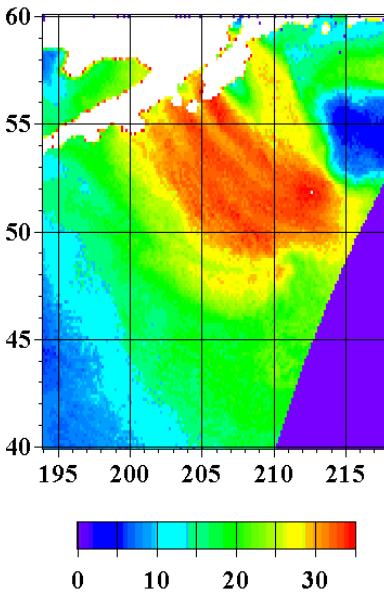
12:30



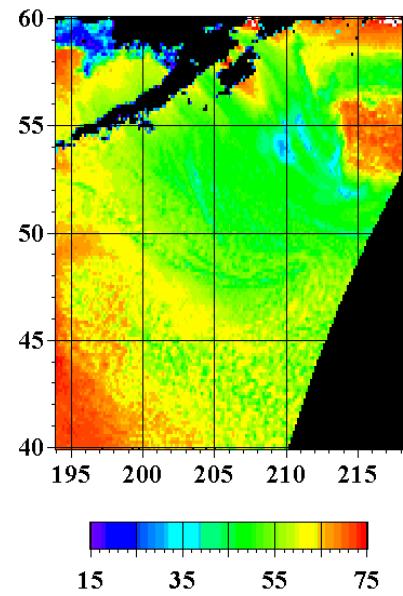
0 5 10 15 20



0.0 0.2 0.4

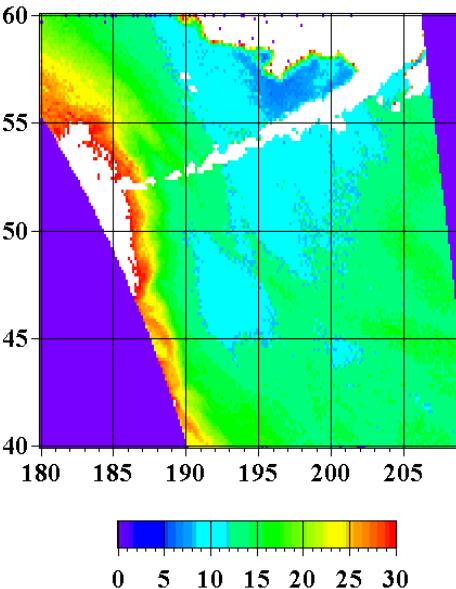


0 10 20 30

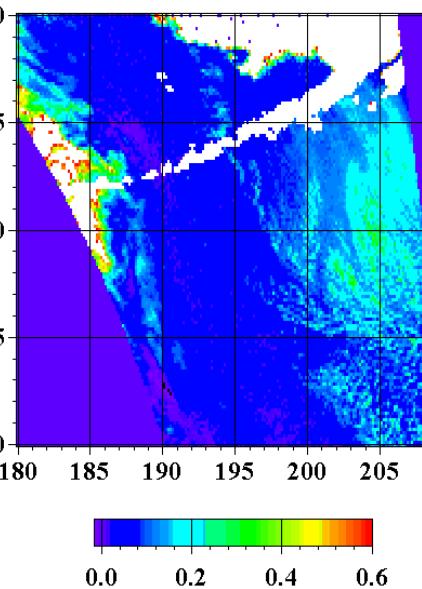


15 35 55 75

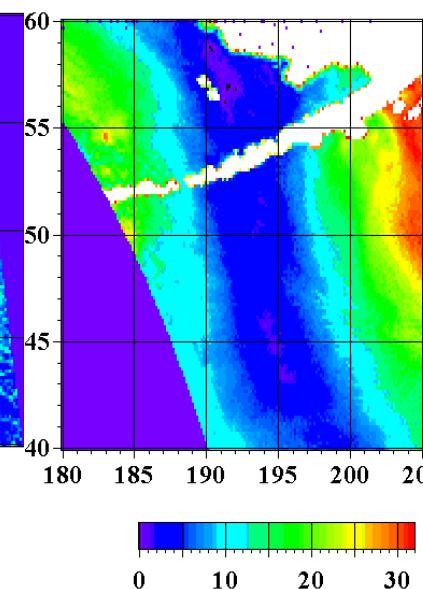
23:40



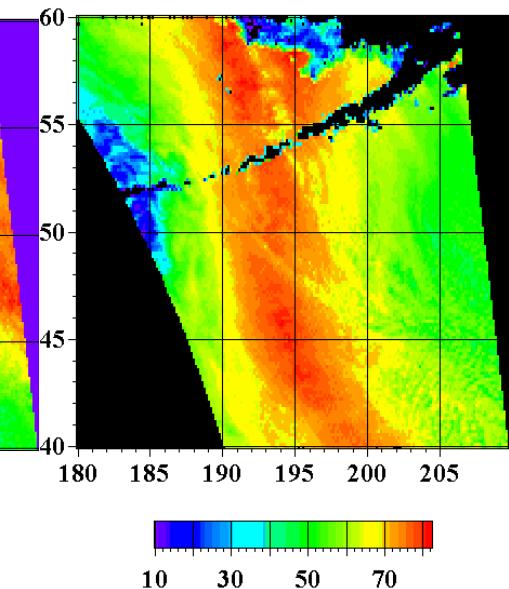
0 5 10 15 20 25 30



0.0 0.2 0.4 0.6



0 10 20 30



10 30 50 70

**Cosmos 243**

**National Space Science Data Center Collection Search**

**Results: There were no data collections returned.**

**Компрессор масляный FIAC Cosmos 243**

**NSSDC/COSPAR ID: 1983-099A**

The Cosmos 1500 tested a new sensors and methods of data collection and processing. Cosmos 1500 had the capability of overlapping and processing images from its sensors. Data from Cosmos 1500 were sent directly to ships or automated data receiving stations and was applied in navigation in northern oceans. The instrument complement was highlighted by an all-weather Side-Looking Real Aperature radar (SLRAR) operating at 9.5 GHz. other instruments included a multispectral scanner (MSL), a scanning high-frequency radiometer (SHF), and transponders for collecting data from ice and buoy transmitters.

[Фонарь КОСМОС "ACCU 1500LEDRUB" аккум., обрезиненный ...](#)  
[shop.hyperauto.ru](http://shop.hyperauto.ru) › ... › [Фонари](#)

[Характеристики Kosmos 1500 Ni-MH R6 \(AA\) - Никс](#)

[www.nix.ru/.../1.2V\\_1500mAh\\_Size\\_AA\\_60679.html](http://www.nix.ru/.../1.2V_1500mAh_Size_AA_60679.html) [Translate this page](#)

Купить Kosmos 1500 Ni-MH R6 (AA) цена, характеристики, фотографии, тесты

Амурский залив. Подспутниковый эксперимент. Сотрудники лаборатории раздвигают ледяные поля перед зондированием  
**PALSAR**



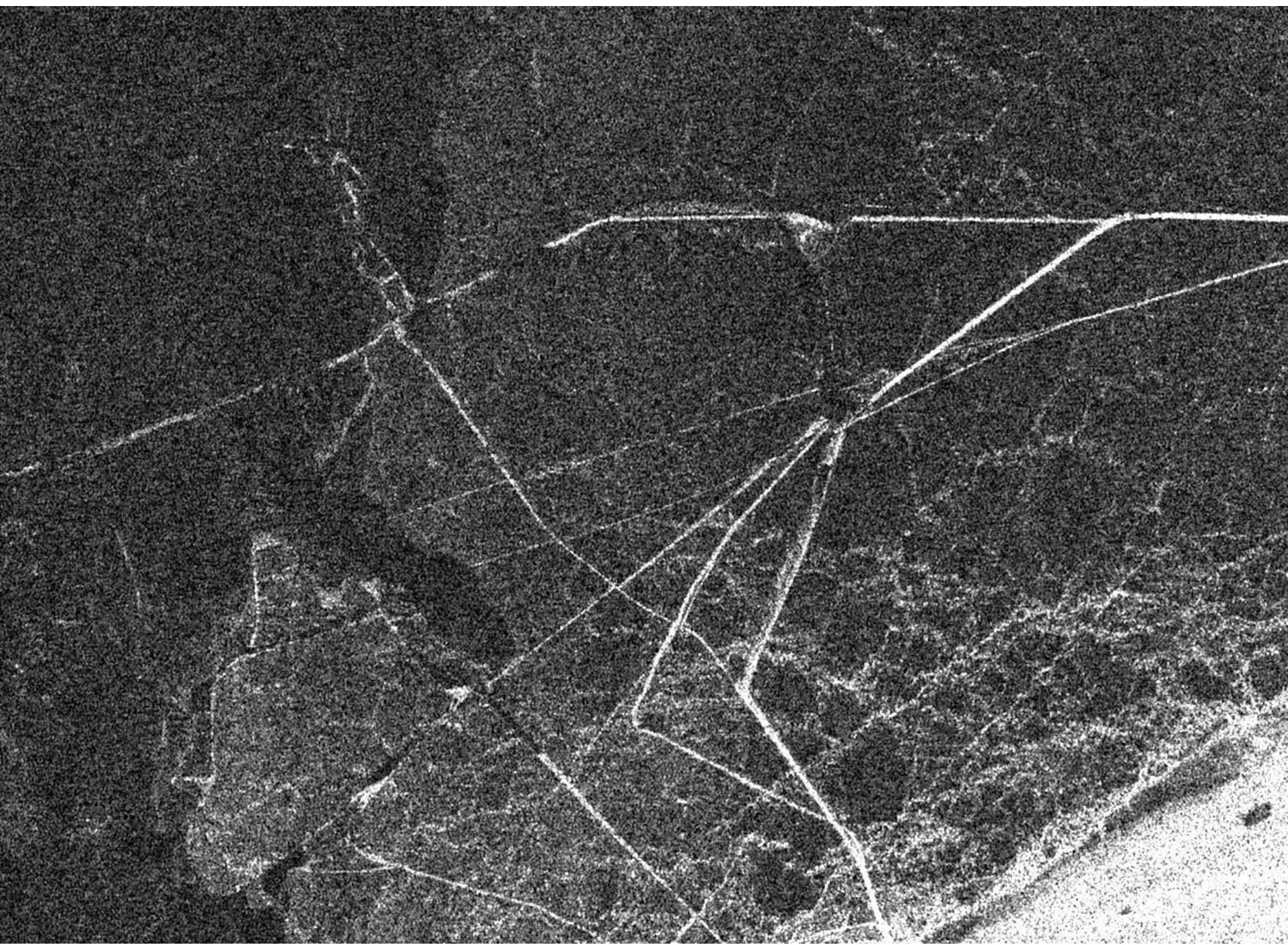
Трецина во льду создана. На горизонте Коврижка



# ALOS PALSAR. Лед в Амурском заливе

ТОИ, ИАПУ  
ТИГ, ДВГИ

13 января 2007



Цветы

доброжелательным и внимательным исследователям

Залив Петра Великого

# Conclusions