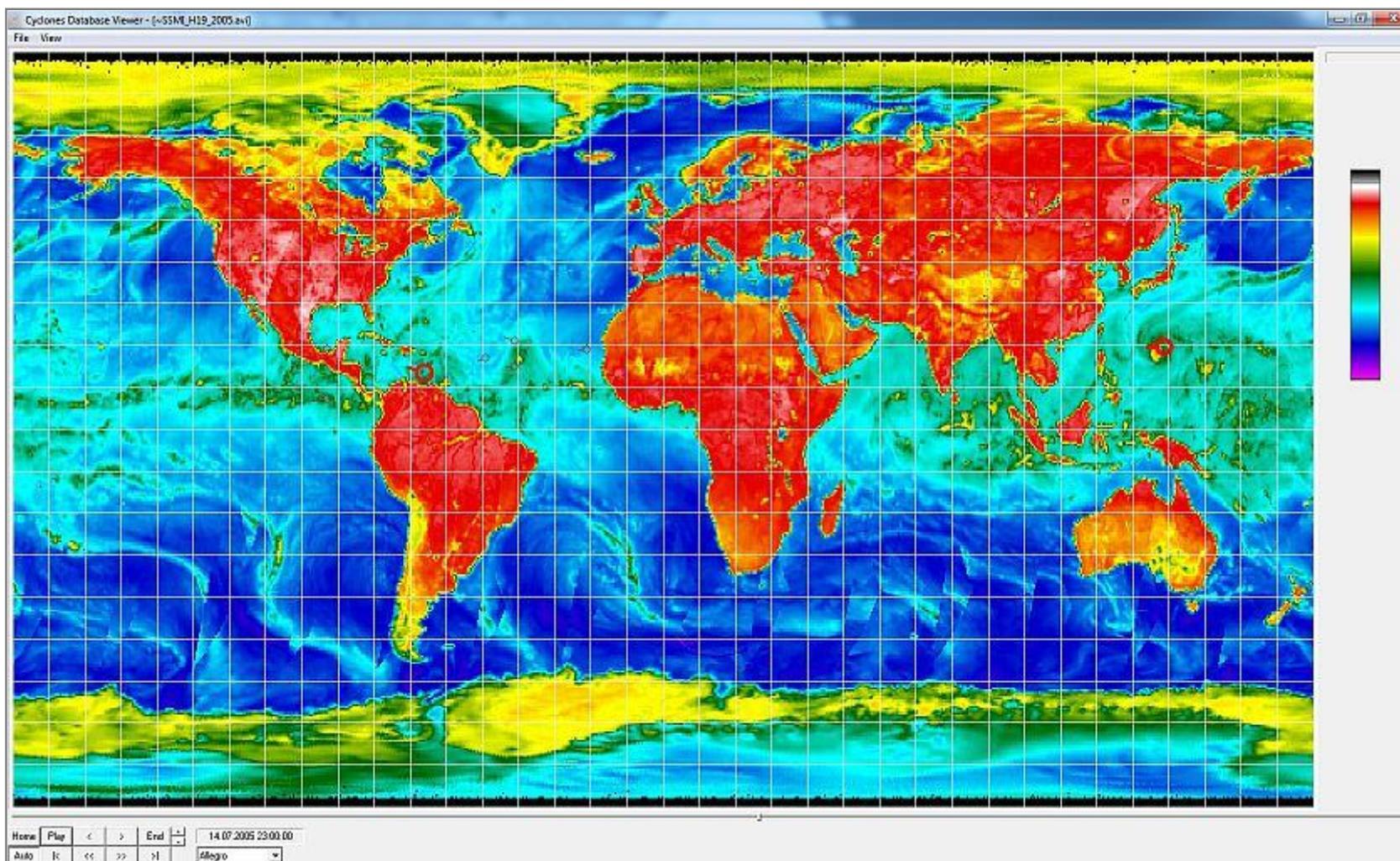


# Интерактивное спутниковое радиотепловидение системы океан-атмосфера Земли

Д.М. Ермаков, Е.А. Шарков, А.П. Чернушич

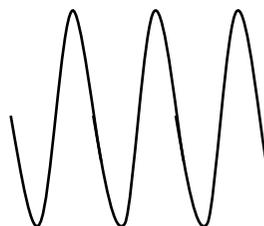
ФИРЭ РАН, ИКИ РАН

# Радиотепловые образы тропических циклонов

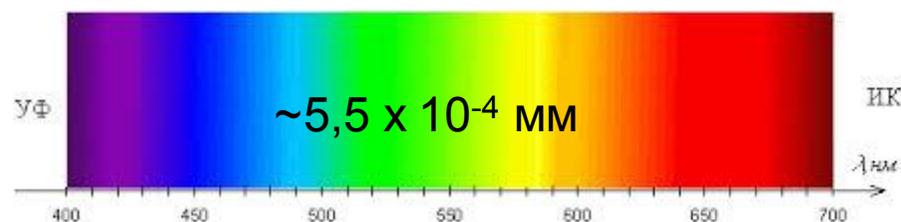


*Ермаков Д.М., Раев М.Д., Суслов А.И., Шарков Е.А.* Электронная база многолетних данных глобального радиотеплового поля Земли в контексте многомасштабного исследования системы океан-атмосфера. // Исслед. Земли из космоса, 2007, 1, С. 7–13.

# Радиотепловые портреты различных объектов



3 мм



Zrazhevskij A.Y., Golunov V.A., Ermakov D.M., Smirnov M.T., Novichikhin E.P., Golovachev S.P., Konkov E.V. The development of radiophysical methods for the polarization (including stereo) images acquisition in millimeter range related to problems of objects recognition, navigation, emergency management, security control and antiterroristic activity // IGARSS 2005, 4, P. 2258-2261.

# Атмосферные процессы

## мезомасштабные

Горизонтальный размер 10 – 1000 км



Бризы, фены, бора, мезоциклоны, мезомасштабные конвективные комплексы (системы), конвекция

## синоптические

Горизонтальный размер > 1000 км



Циклоны и антициклоны, фронты, воздушные массы



Тропические циклоны

- Климатические исследования, в т.ч., полярный перенос, парниковый эффект;
- Прогноз погоды;
- Предсказание и мониторинг природных катастроф и их последствий



# Открытая спутниковая информация

SSMIS F16	01	02	03	04	05	06	07	08	09	10	11	12
2003										v7	v7	v7
2004	v7											
2005	v7											
2006	v7											
2007	v7											

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Atmospheric River Watch

suzaku.eorc.jaxa.jp/GCOM-W/data/data\_w\_dpss.html

## Global Change Observation Mission -Water

# GCOM-W

水循環変動観測衛星

TOP About GCOM-W About AMSR2 Data Products Publication Earth Monitoring

GCOM-W Home > Data Products > Data Providing Service

## Data Products

- Definition of Processing Levels
- Standard Product
- Research Product
- Data Providing Service

### AMSR/AMSR-E products order by GCOM-W1 Data Providing Service

Allow us to notification to you our newly established website that as of August 22, 2011 we have launched a website in order to provide users for JAXA's newly satellite data service by "GCOM-W1 Data Providing Service". We hope that you will drop by and use our website as follows.

Please visit: <https://gcom-w1.jaxa.jp/auth.html> (Japanese, English)



On the website, the product of the microwave radiometer containing AMSR2 of GCOM-W1 is provided with this service. In addition, it is distributing of the standard products by the following satellite sensors for the time being.

\*The new AMSR2 products will be updated with completion of product distributing preparation in which JAXA will schedule a launch for the fiscal year of Japan 2011.

< Sensor (as of January, 2013) >

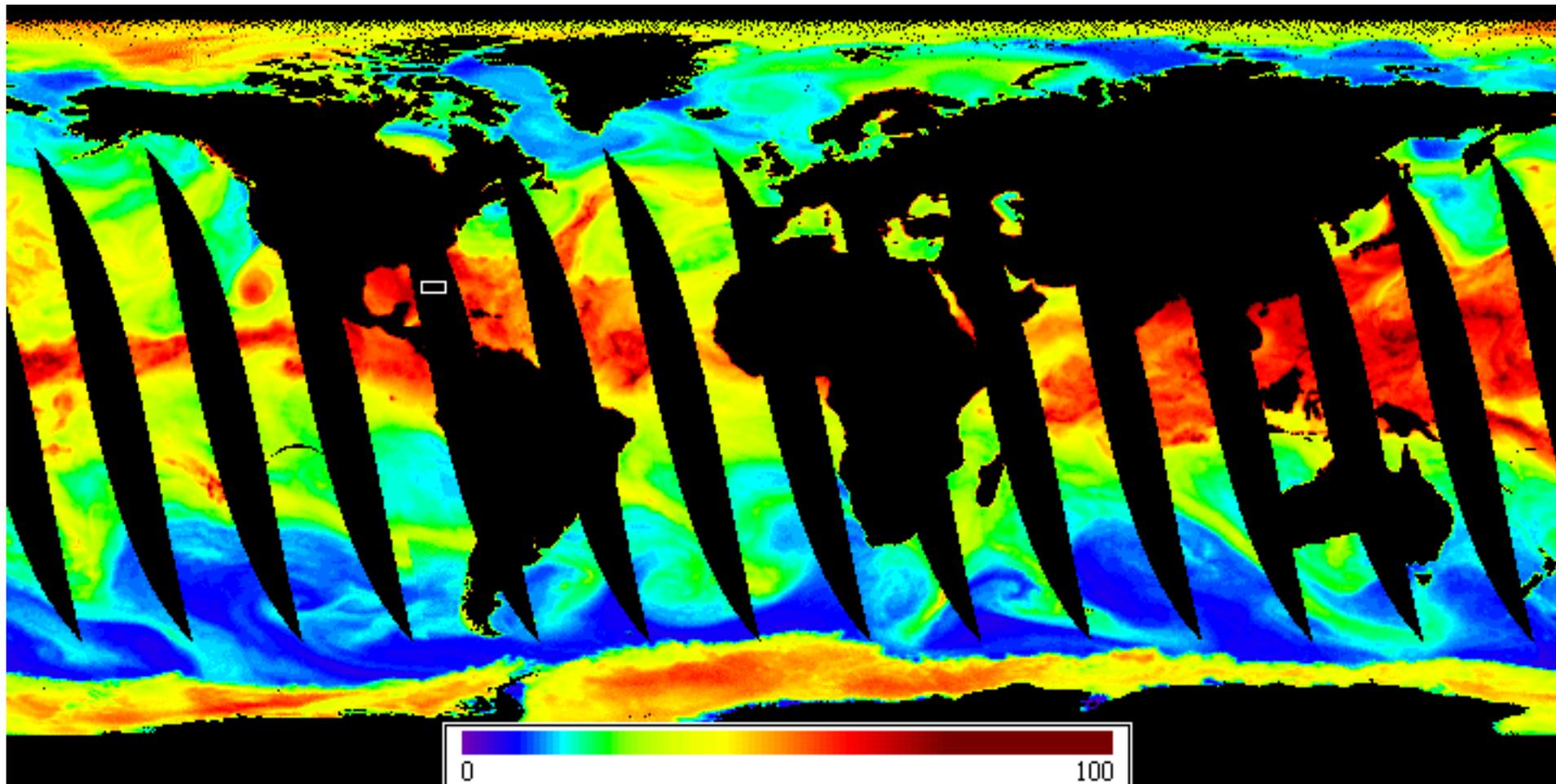
- AMSR: April/04/2003 - October/24/2003
- AMSR-E: June/01/2002 - Observation Halted
- AMSR2: January 25, 2013~ (Level1) released, May / 2013~ (Level2 or more) (plan)

On the website we have posted details about all of our products, new information, the online ordering system, and so on that are essential to know more about our "GCOM-W1 Data Providing Service". Please feel free to visit our new website fully loaded with convenient functions as follows!

Please visit: <https://gcom-w1.jaxa.jp/auth.html> (Japanese, English)

\* The user's registration is newly necessary in order to use this service.

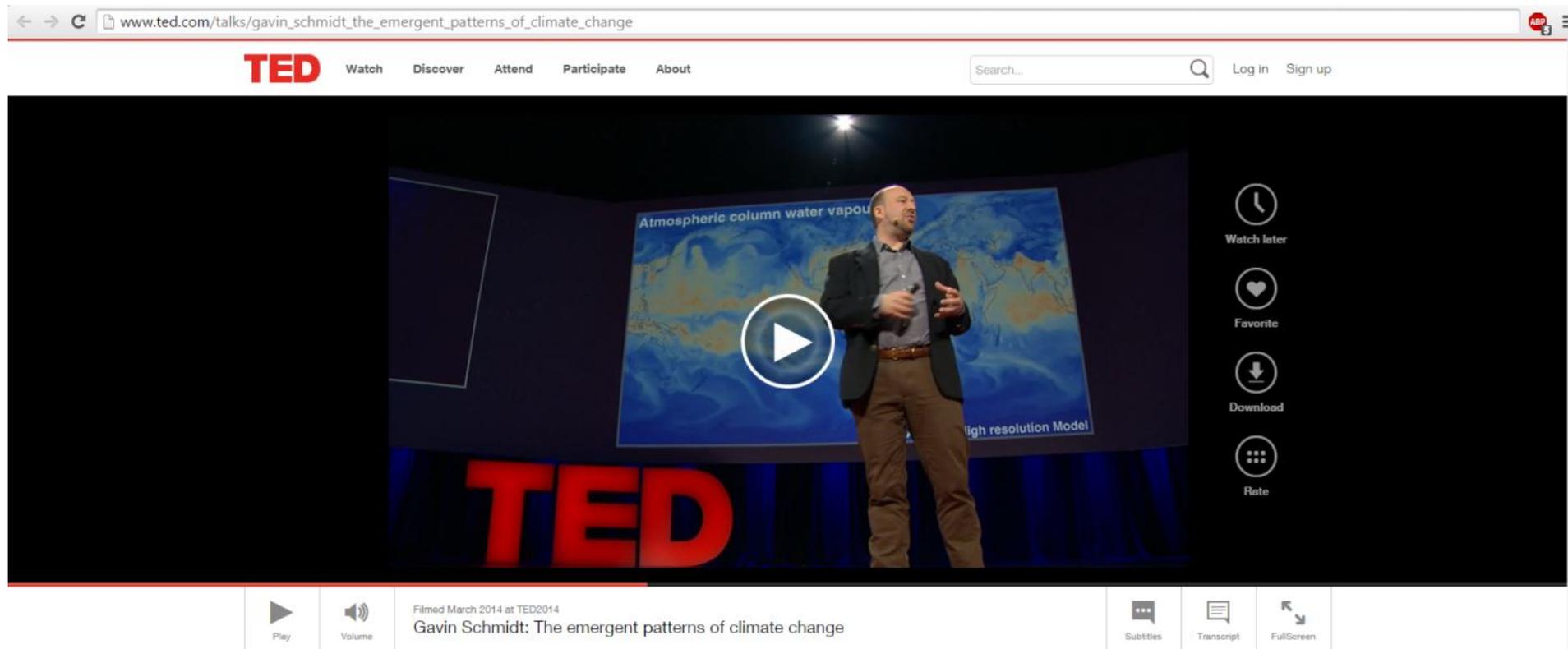
# Пространственный охват и временное разрешение



SSM/I F13

26.08.2005

# Моделирование



The image shows a screenshot of a TED talk video player. The URL in the browser address bar is [www.ted.com/talks/gavin\\_schmidt\\_the\\_emergent\\_patterns\\_of\\_climate\\_change](http://www.ted.com/talks/gavin_schmidt_the_emergent_patterns_of_climate_change). The TED logo is visible in the top left corner. The main video area shows a speaker, Gavin Schmidt, standing on a stage in front of a large screen displaying a map of the world with the text "Atmospheric column water vapour" and "High resolution Model". A large play button is overlaid on the video. On the right side of the video player, there are several interactive icons: "Watch later", "Favorite", "Download", and "Rate". At the bottom of the player, there are controls for "Play", "Volume", "Subtitles", "Transcript", and "Full Screen". The video title is "Gavin Schmidt: The emergent patterns of climate change" and it was filmed in March 2014 at TED2014.

“If we had observations of the future we obviously would trust them more than models, but unfortunately observations of the future are not available at this time”

Tom Knutson and Robert Tuleya

# Проблемы оперативного прогноза

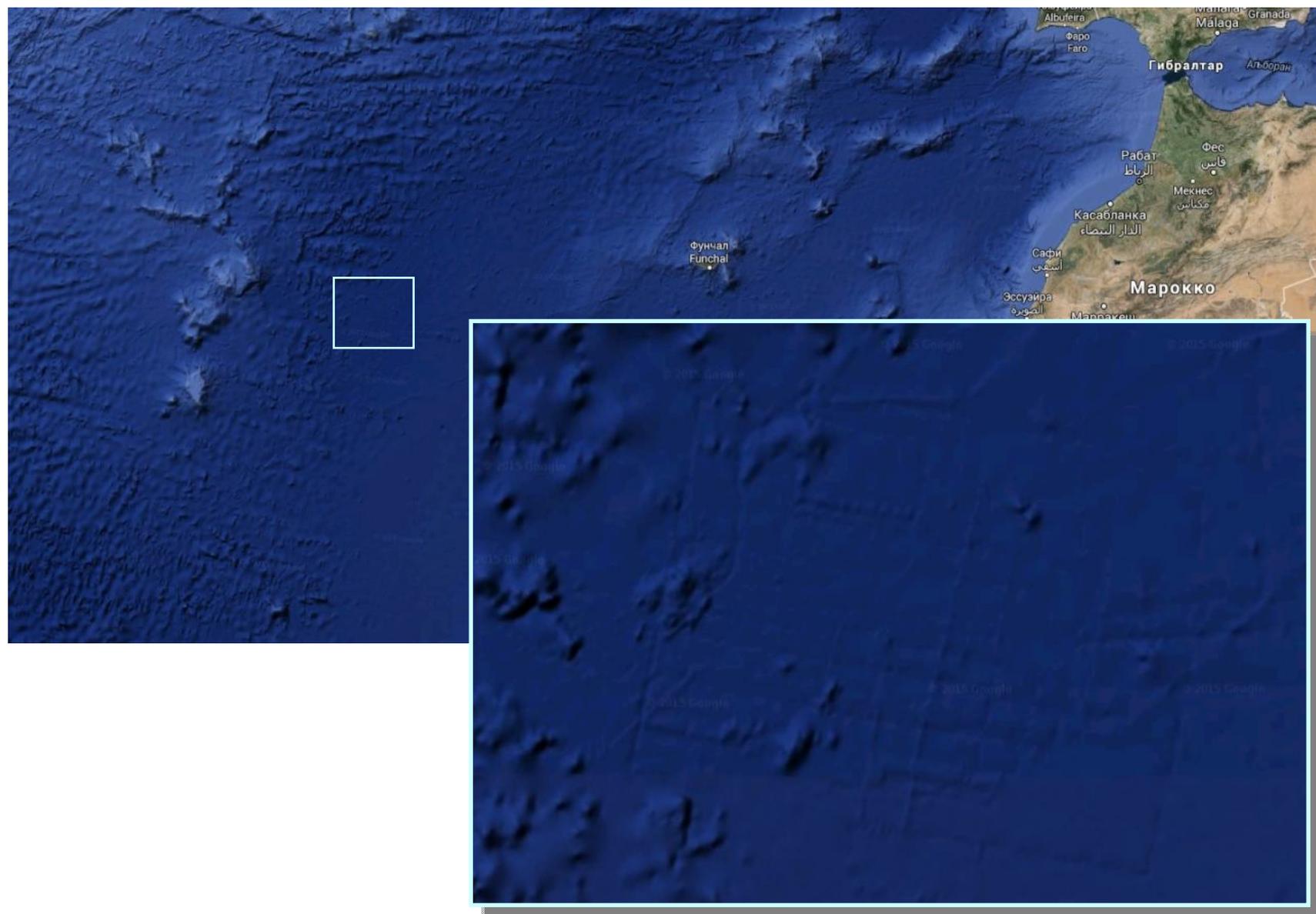
J. Kaplan, M. DeMaria, and J. Knaff, 2010. A revised tropical cyclone rapid intensification index for the Atlantic and Eastern North Pacific basins. *Wea. Forecasting*, **25**, 220-241

*“The relative importance of the individual rapid intensification predictors is shown to differ between the two basins (Atlantic and eastern North Pacific).*

*<...>*

*Specifically, the POD for the RII ranged from 15% to 59% (53% to 73%) while the FAR ranged from 71% to 85% (53% to 79%) in the Atlantic (eastern North Pacific) basins, respectively, for the three thresholds studied. Nevertheless, the modest probability of detection and relatively high false alarm ratio of the rapid intensity index and other intensity guidance demonstrate the difficulty of predicting RI, particularly in the Atlantic basin”*

# Проблемы «монопольных» моделей



# Возможности «быстрого» моделирования

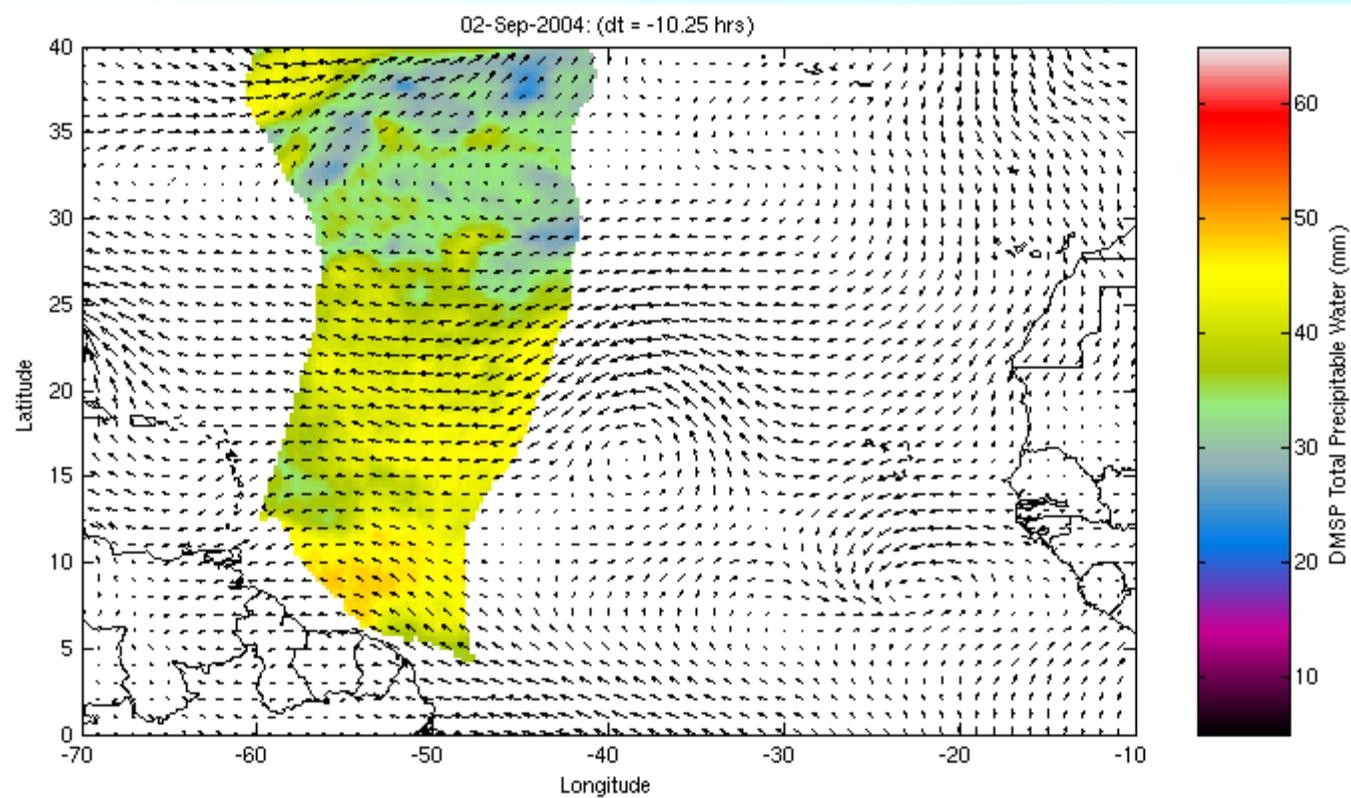
*Wimmers A.J., Velden C.S.* Seamless advective blending of total precipitable water retrievals from polar-orbiting satellites // J. Appl. Meteor. Climatol. 2011. Vol. 50. No.5 P. 1024-1036.

*Нерушев А.Ф., Крамчанинова Е.К.* Метод определения характеристик атмосферных движений по данным измерений метеорологических геостационарных спутников // Исследование Земли из космоса. 2011. № 1. С. 3-13.

*Ермаков Д.М., Чернушич А.П., Шарков Е.А., Шрамков Я.Н.* Возможности построения краткосрочных глобальных радиотепловых изображений системы океан-атмосфера на базе программной платформы Stream Handler // Современные проблемы дистанционного зондирования Земли из космоса. 2011. Т. 8. №3. С. 9–16.

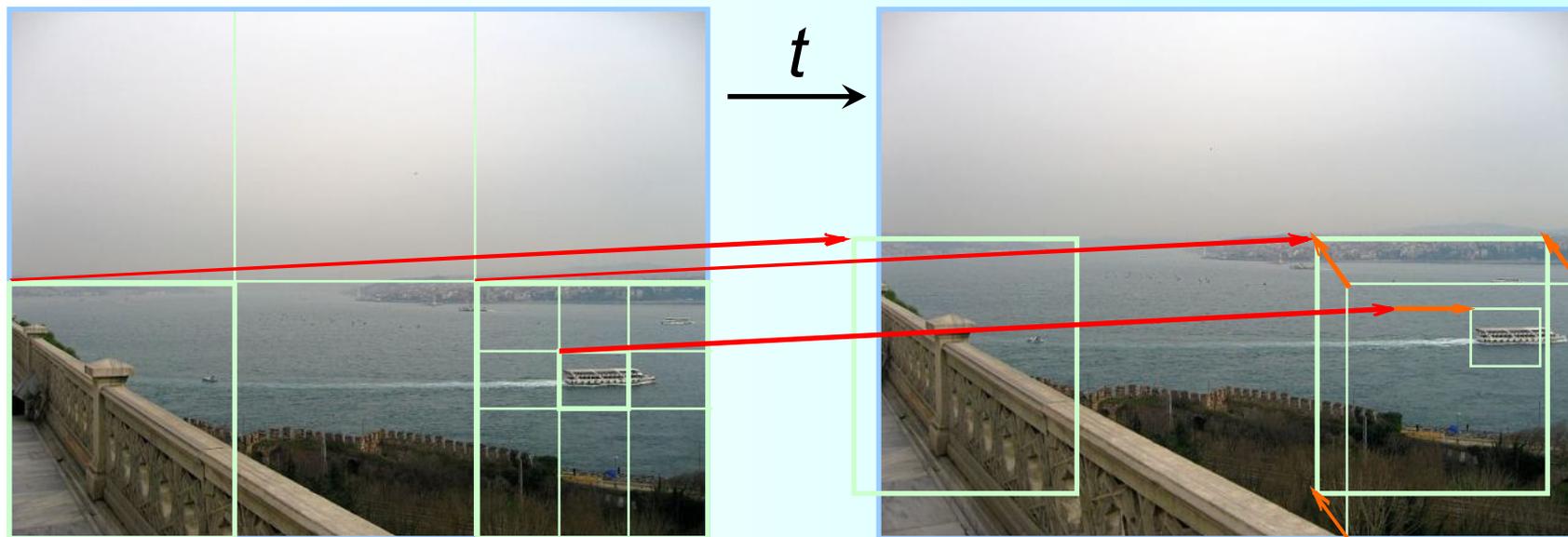
*(Ермаков Д.М., Чернушич А.П., Шарков Е.А., Шрамков Я.Н. Пространственно-временная интерполяция спутниковых радиометрических данных для исследования тропического циклогенеза / Тезисы докладов VIII Всероссийской открытой конференции «Современные проблемы дистанционного зондирования Земли из космоса». – ИКИ РАН, Москва, 2010. 15 – 19 ноября 2010. – С. 62.)*

# Wimmers, Velden: Seamless advective blending (2011)



- шаг расчетной сетки  $0,25^\circ$
- дискретизация по времени – произвольная
- временная интерполяция – неоднородная по сетке

# Оценка и компенсация движения



$M(x, y)$  – векторное поле смещений

$V(x, y) = M(x, y) / t$  – поле скоростей

# Построение опорных полей



# Сшивка лакун

$$x^j = (x + L + j - 1) \% L + 1 \quad y^k = y + k \quad w_{x,y} = -1 \quad w_{x^+,y} \geq 0 \quad w_{x^-,y} = -1, w_{x^j,y} \geq 0, j = 1..l-1$$

$$d = \lceil l/2 - 0,5 \rceil \cdot 2 + 5 \quad x_B = x^{-d} \quad y_B = y^{-\lceil d/2 - 0,5 \rceil}$$

$$S(B, N) = \sum_{j=0}^{d-1} \sum_{i=0}^{d-1} |s_{i,j}| \quad s_{i,j} = \begin{cases} W_{x_B^i, y_B^j} - W_{x_N^i, y_N^j}, & \text{при } w_{x_B^i, y_B^j} = -1, w_{x_N^i, y_N^j} = -1, \\ 0, & \text{при } w_{x_B^i, y_B^j} \geq 0 \text{ или } w_{x_N^i, y_N^j} \geq 0. \end{cases}$$

*Ермаков Д.М., Раев М.Д., Чернушич А.П., Шарков Е.А.* Алгоритм построения глобальных радиотепловых полей системы океан-атмосфера высокой пространственно-временной дискретизации по спутниковым микроволновым измерениям // Исследование Земли из космоса. 2013. № 4. С. 72-82.

$$W_{x^{i+m}, y^{j+n}} := \begin{cases} W_{x^{i+m}, y^{j+n}} + W_J \cdot \exp(-2 \cdot m/d), & \text{при } w_{x^{i+m}, y^{j+n}} \geq 0, \\ W_{x^{i+m}, y^{j+n}}, & \text{при } w_{x^{i+m}, y^{j+n}} = -1. \end{cases} \quad \vec{v} = (v_x; v_y) = (1; 2 \cdot (y_B - y_S)/d)$$

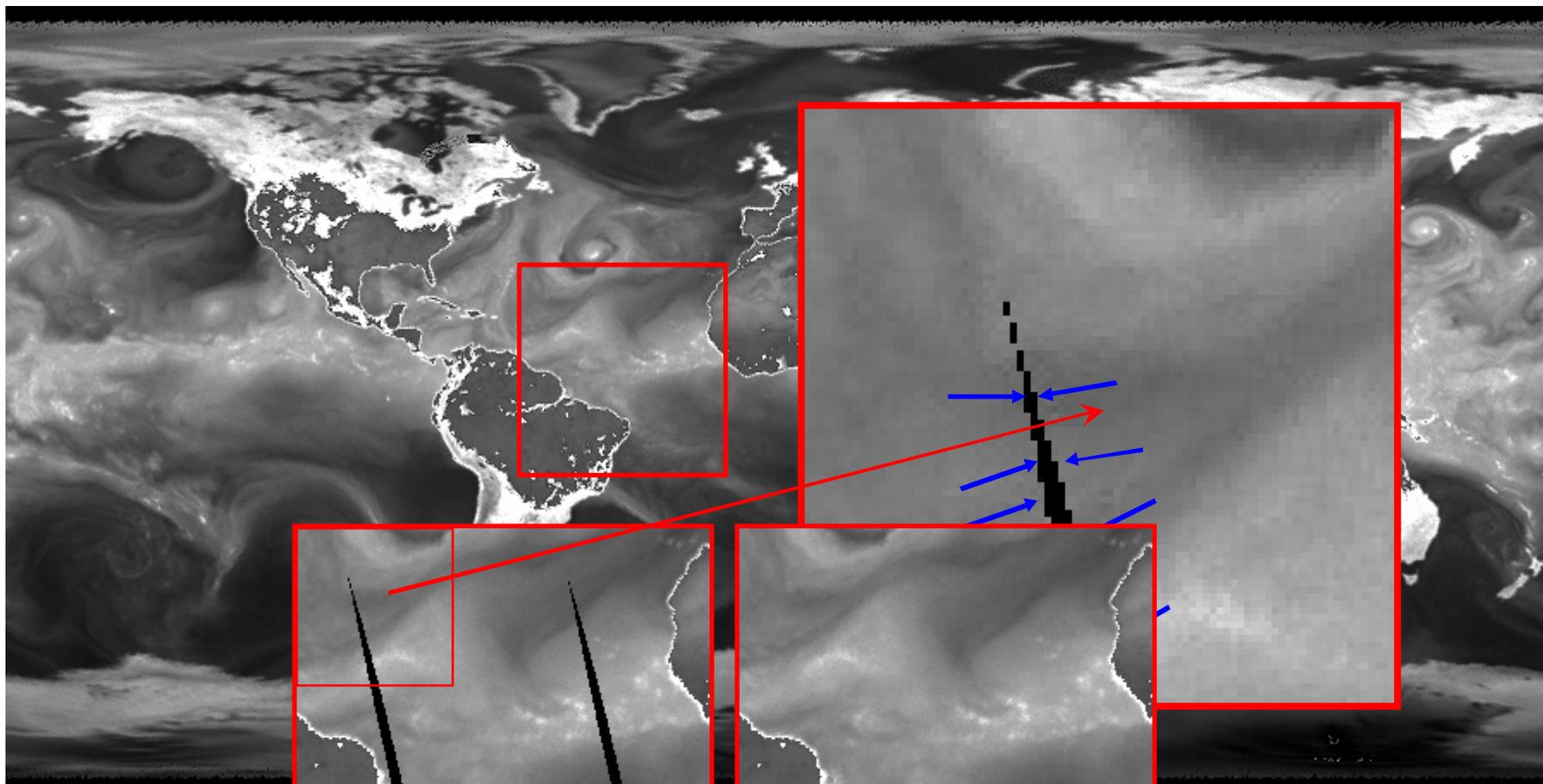
$$D = f \cdot d$$

$$w_{x^{i+m}, y^{j+n}} := \begin{cases} w_{x^{i+m}, y^{j+n}} + \exp(-2 \cdot m/d), & \text{при } w_{x^{i+m}, y^{j+n}} \geq 0, \\ -1, & \text{при } w_{x^{i+m}, y^{j+n}} = -1 \end{cases}$$

$$W_{x,y} := \begin{cases} W_{x,y} / w_{x,y}, & \text{при } w_{x,y} > 0, \\ W_{x,y}, & \text{при } w_{x,y} \leq 0. \end{cases}$$

$$n = \lceil m \cdot v_y \rceil, m = 1..D$$

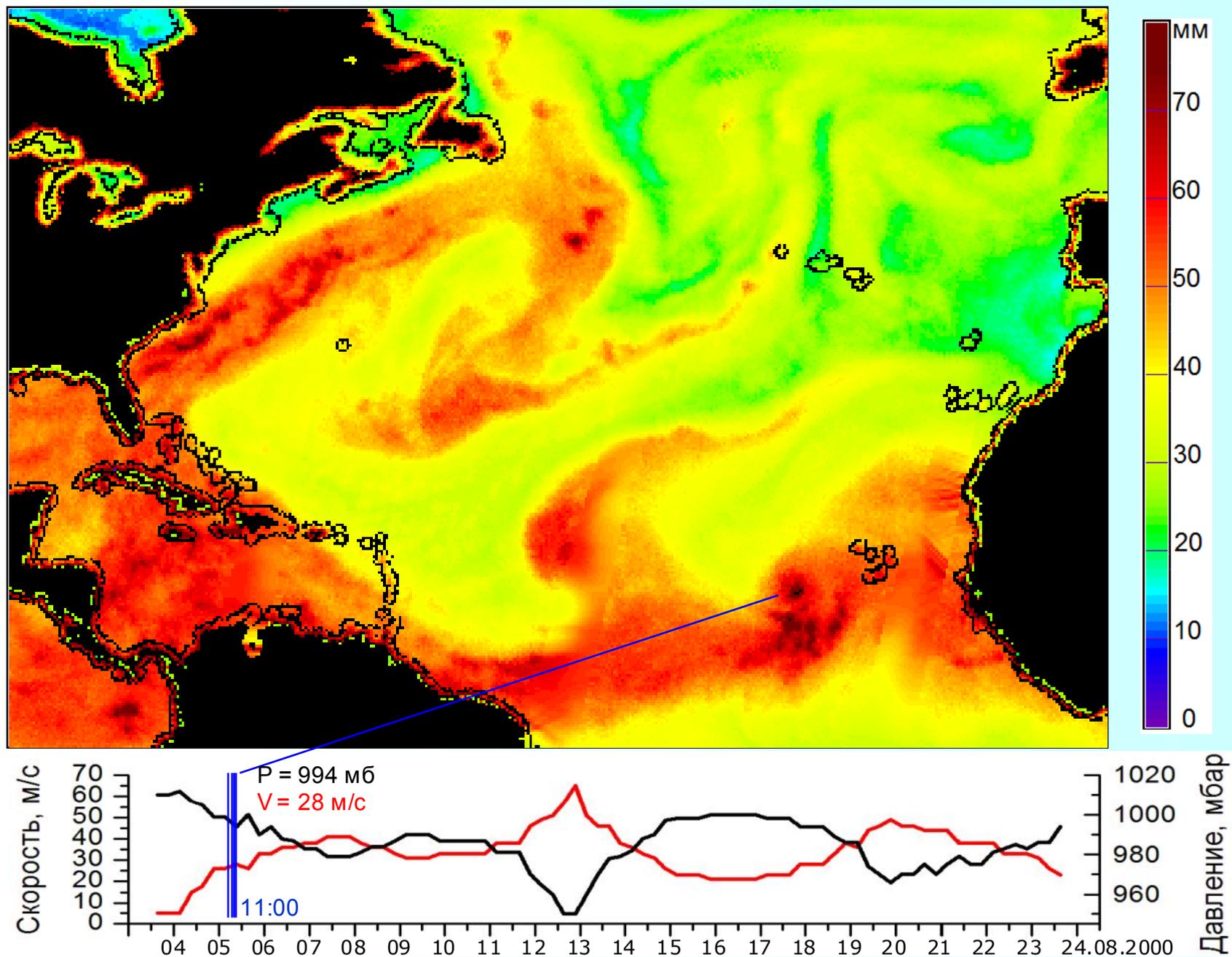
# Сшивка лакун: реализация



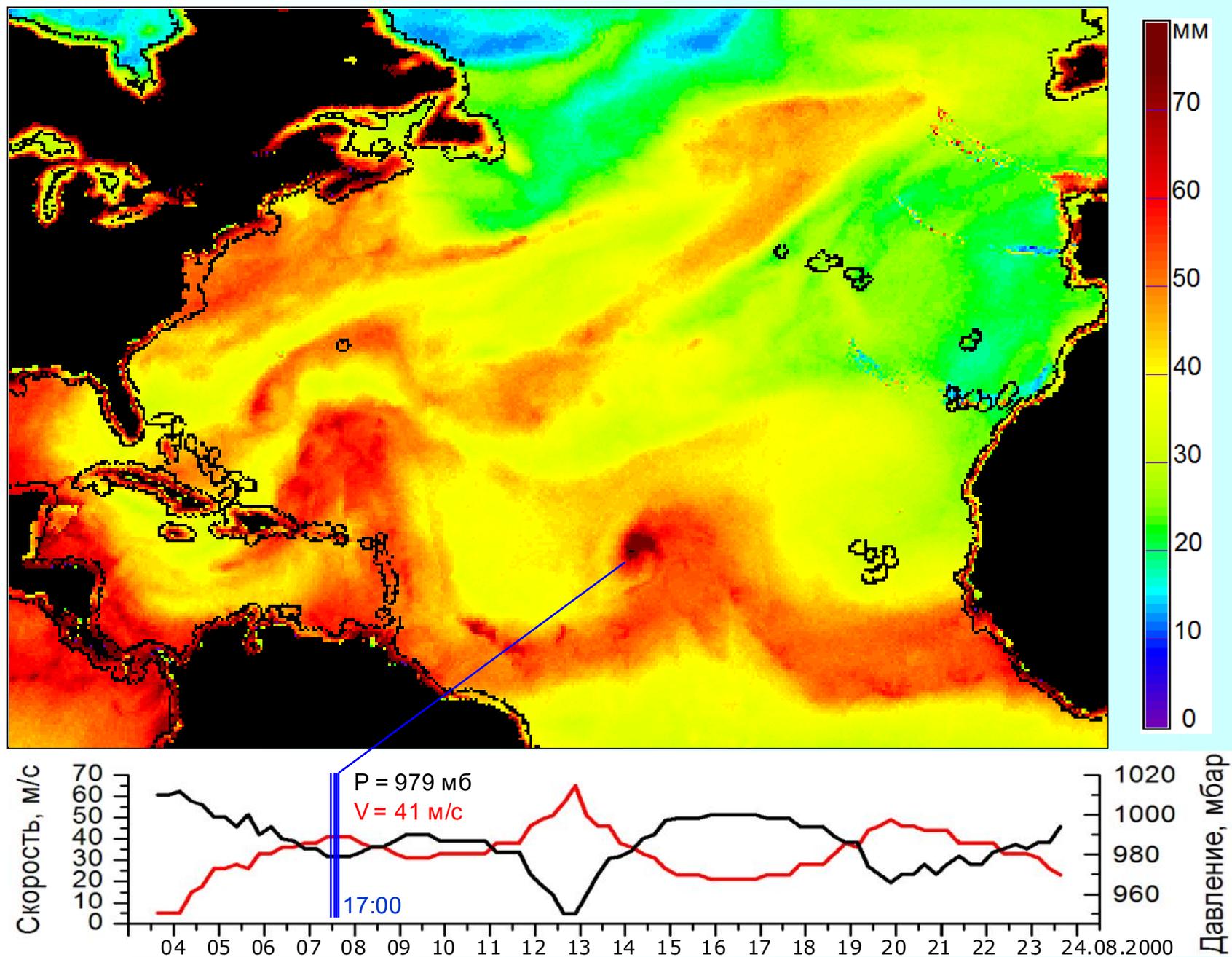
***F14A + F15A***

16/17 августа 2000 г.

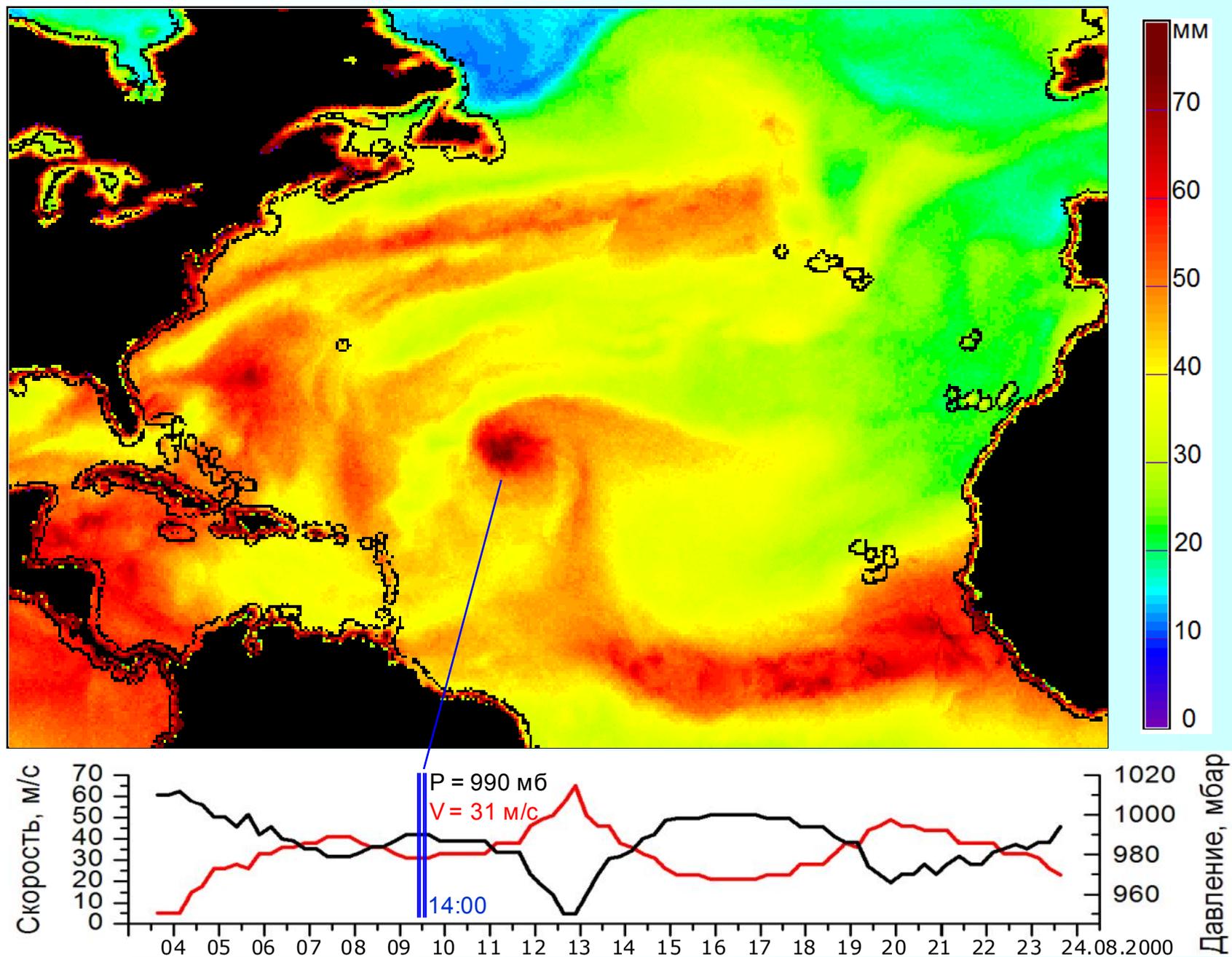
# Пространственно-временная интерполяция



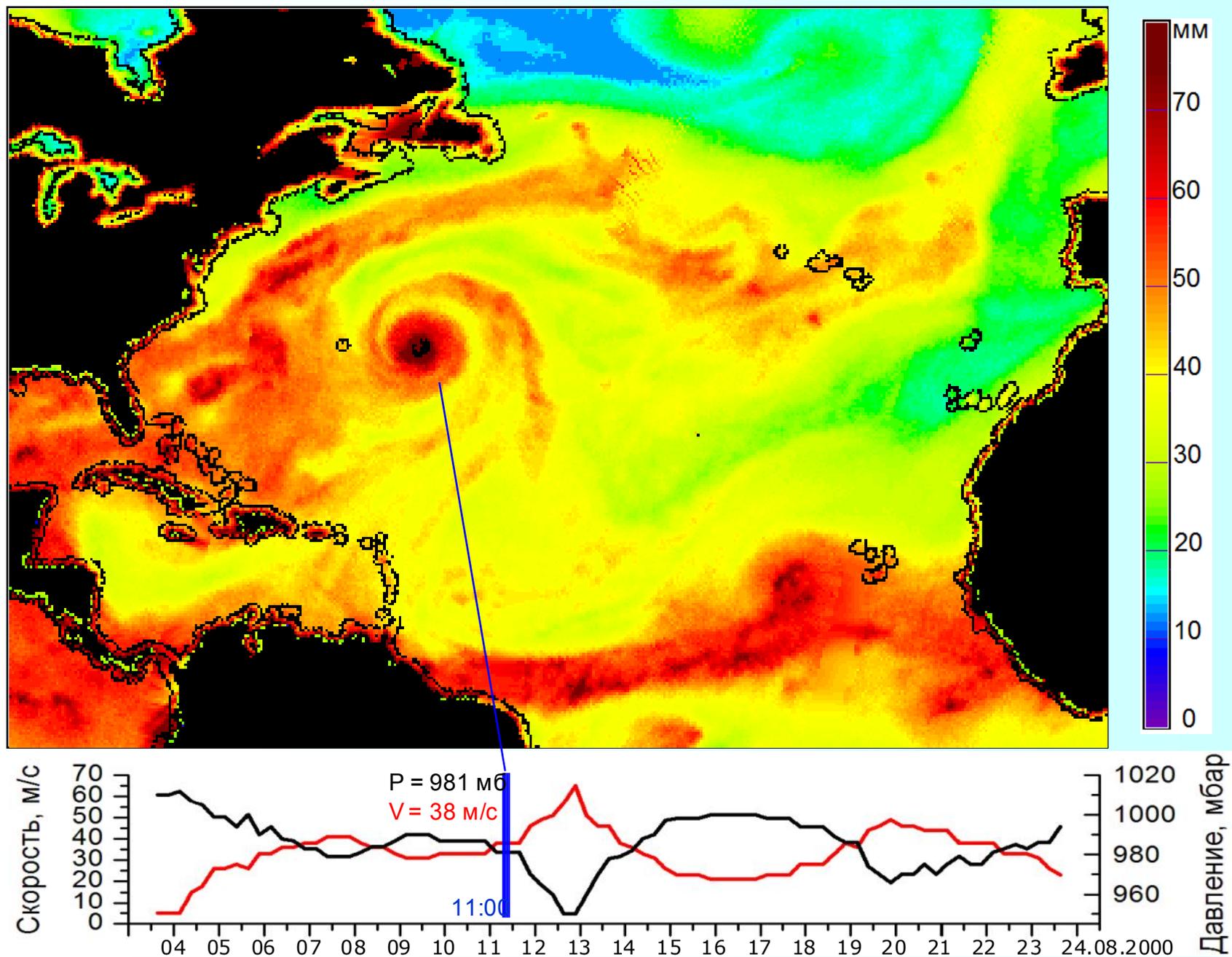
# Пространственно-временная интерполяция



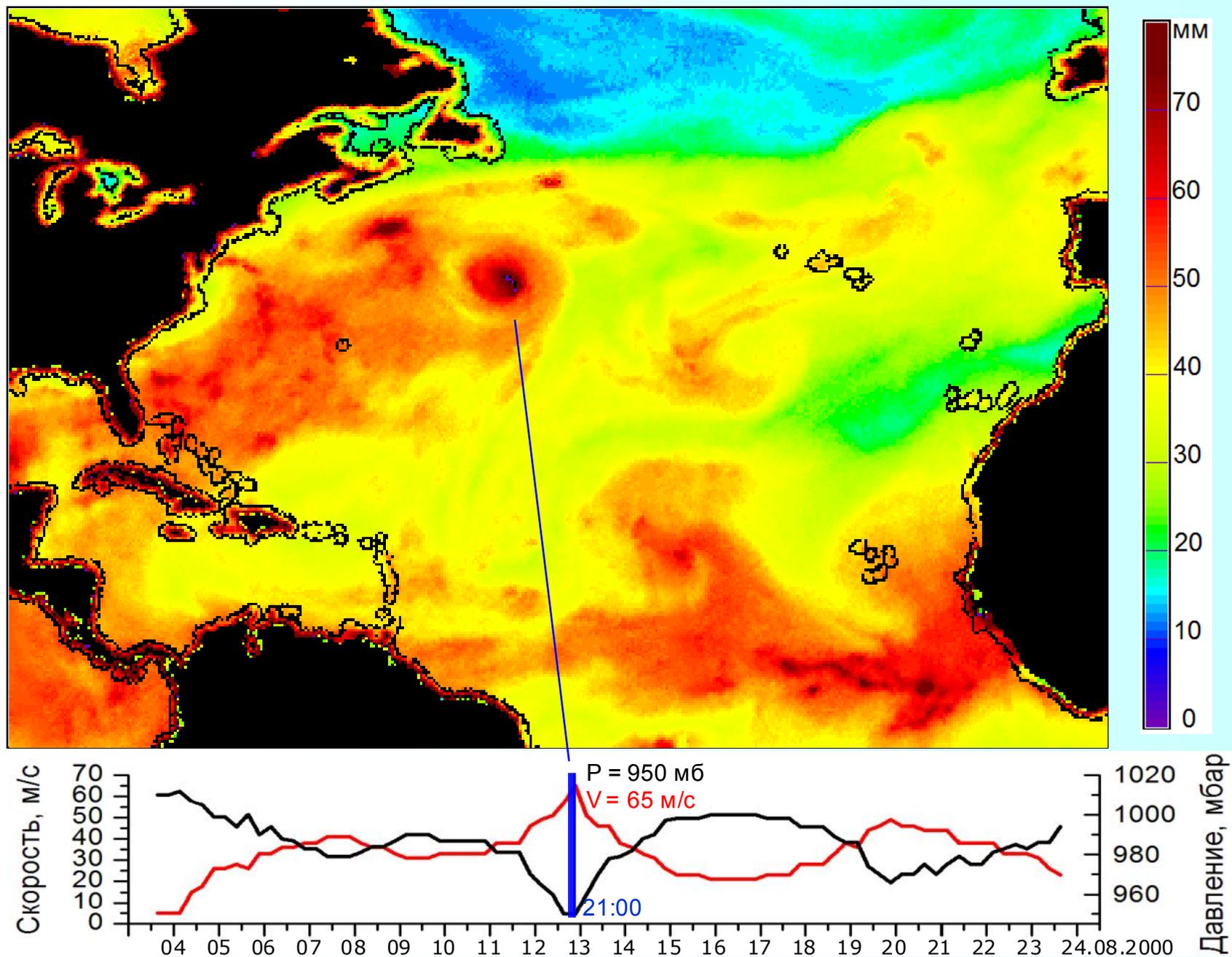
# Пространственно-временная интерполяция



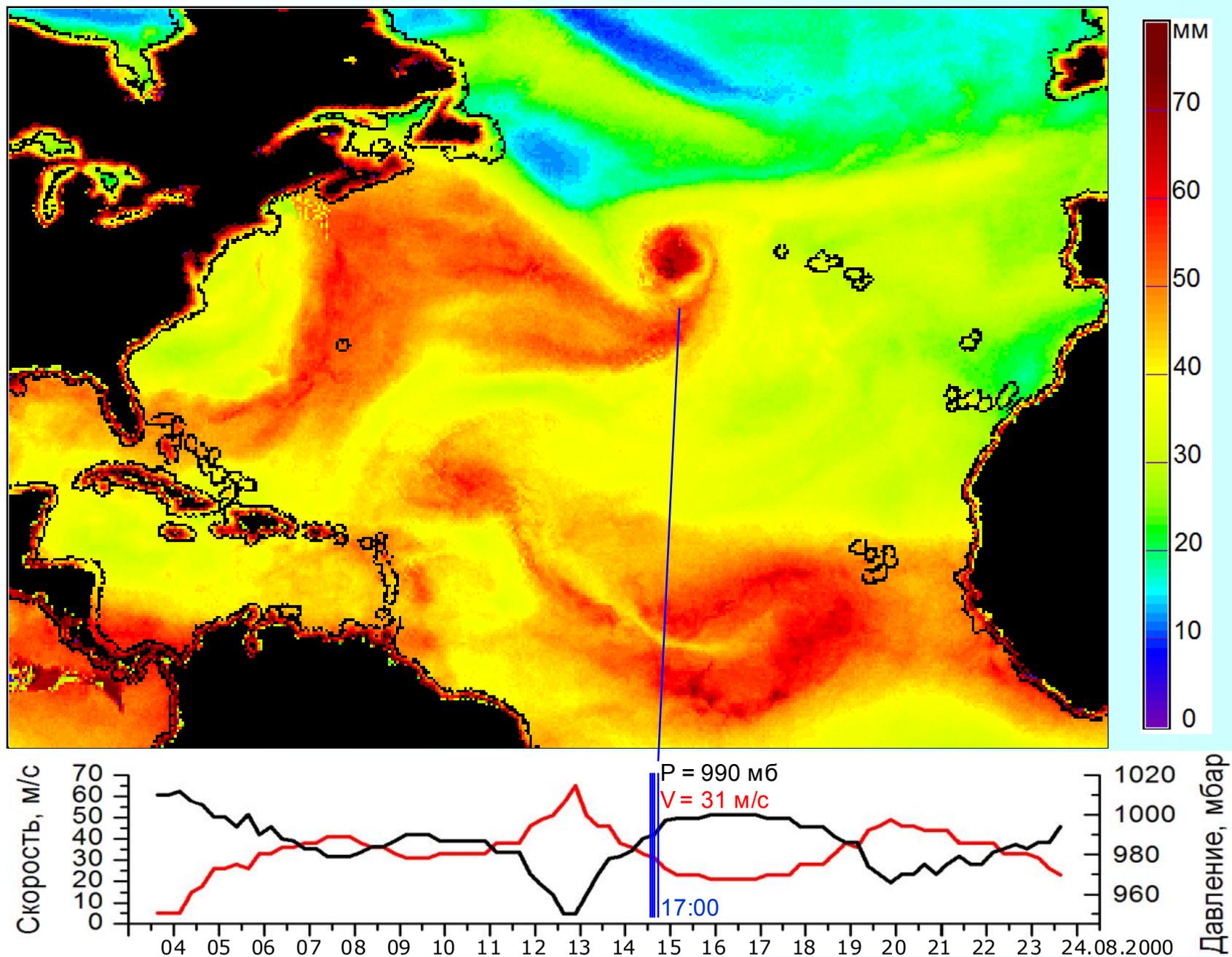
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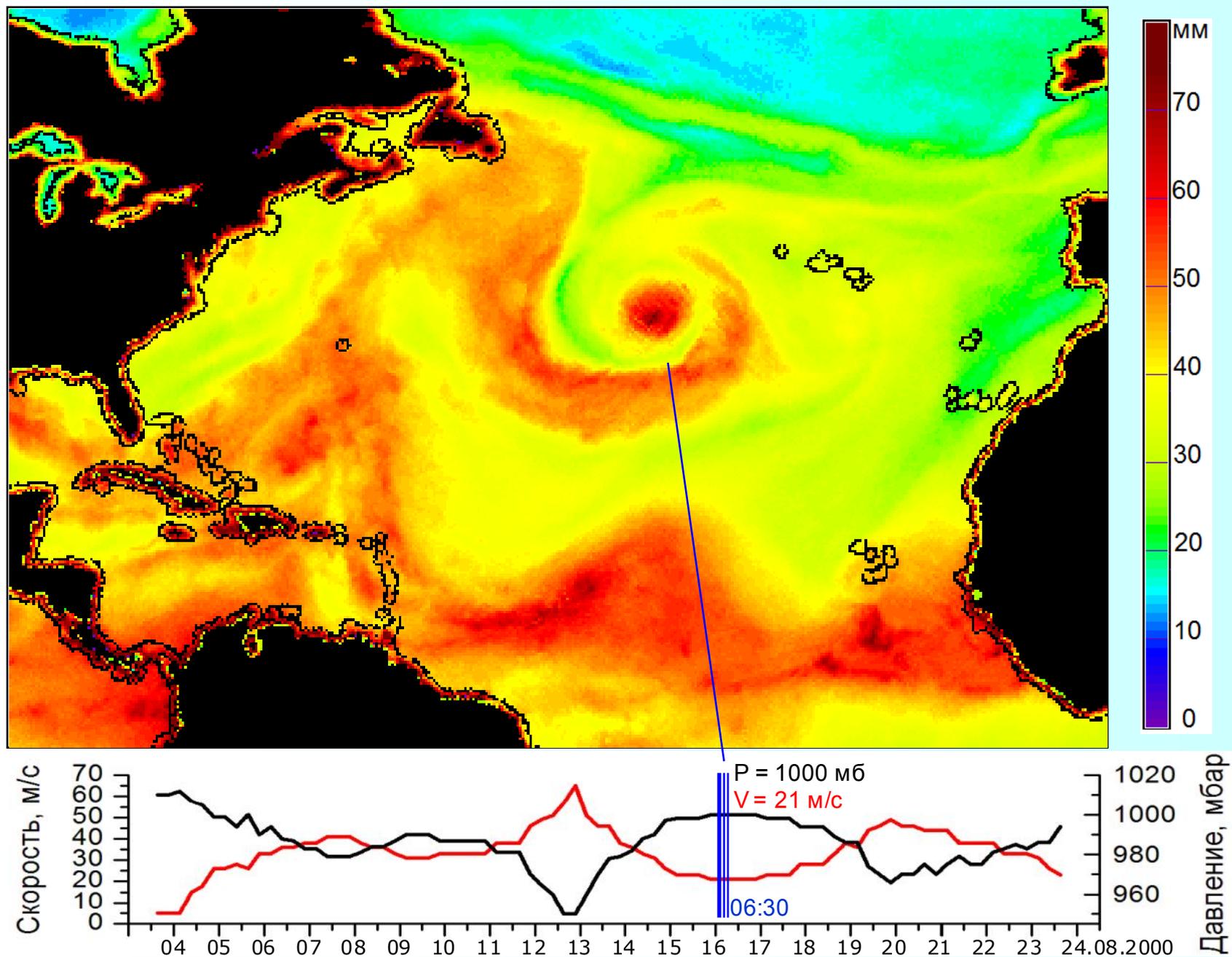
# Пространственно-временная интерполяция



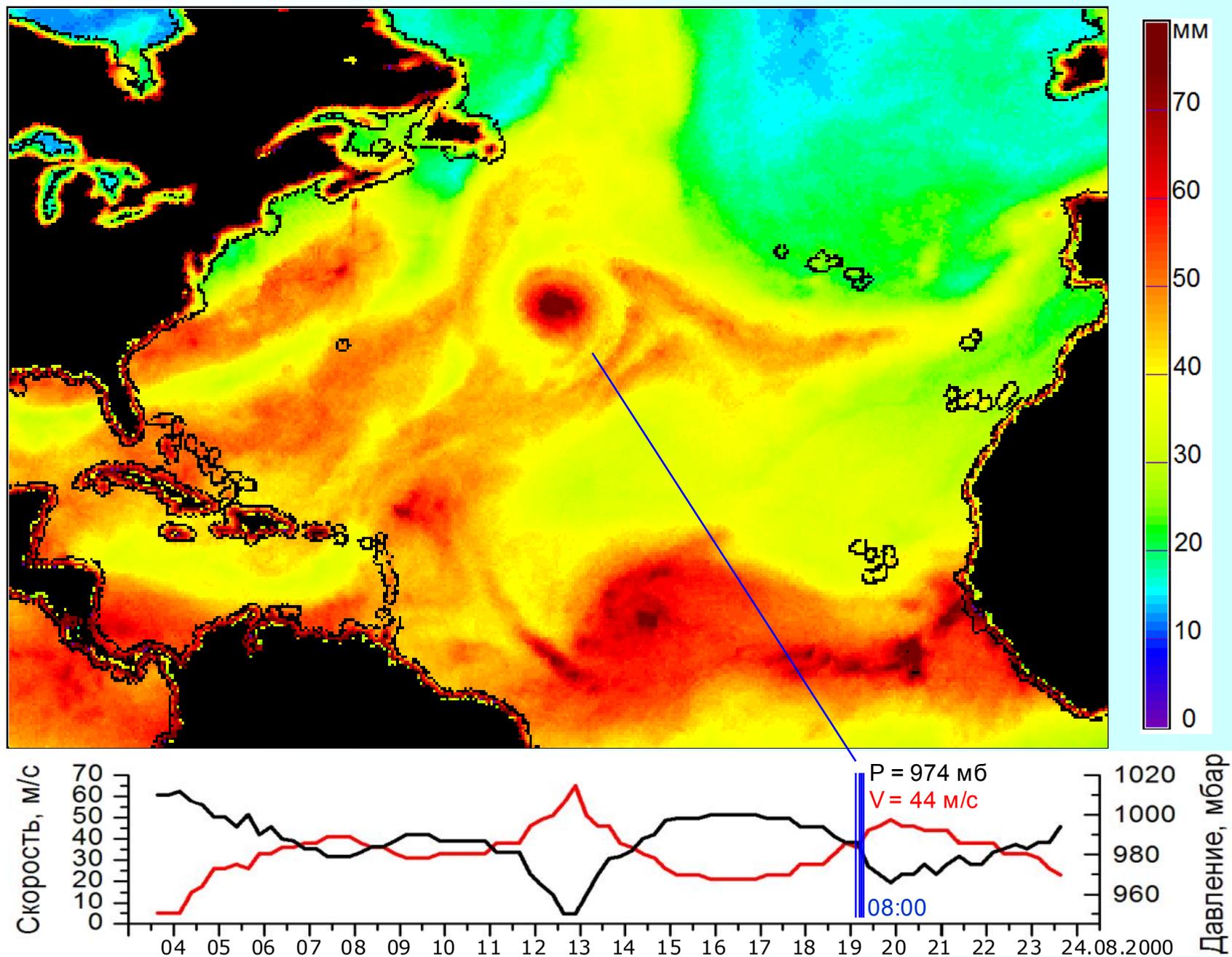
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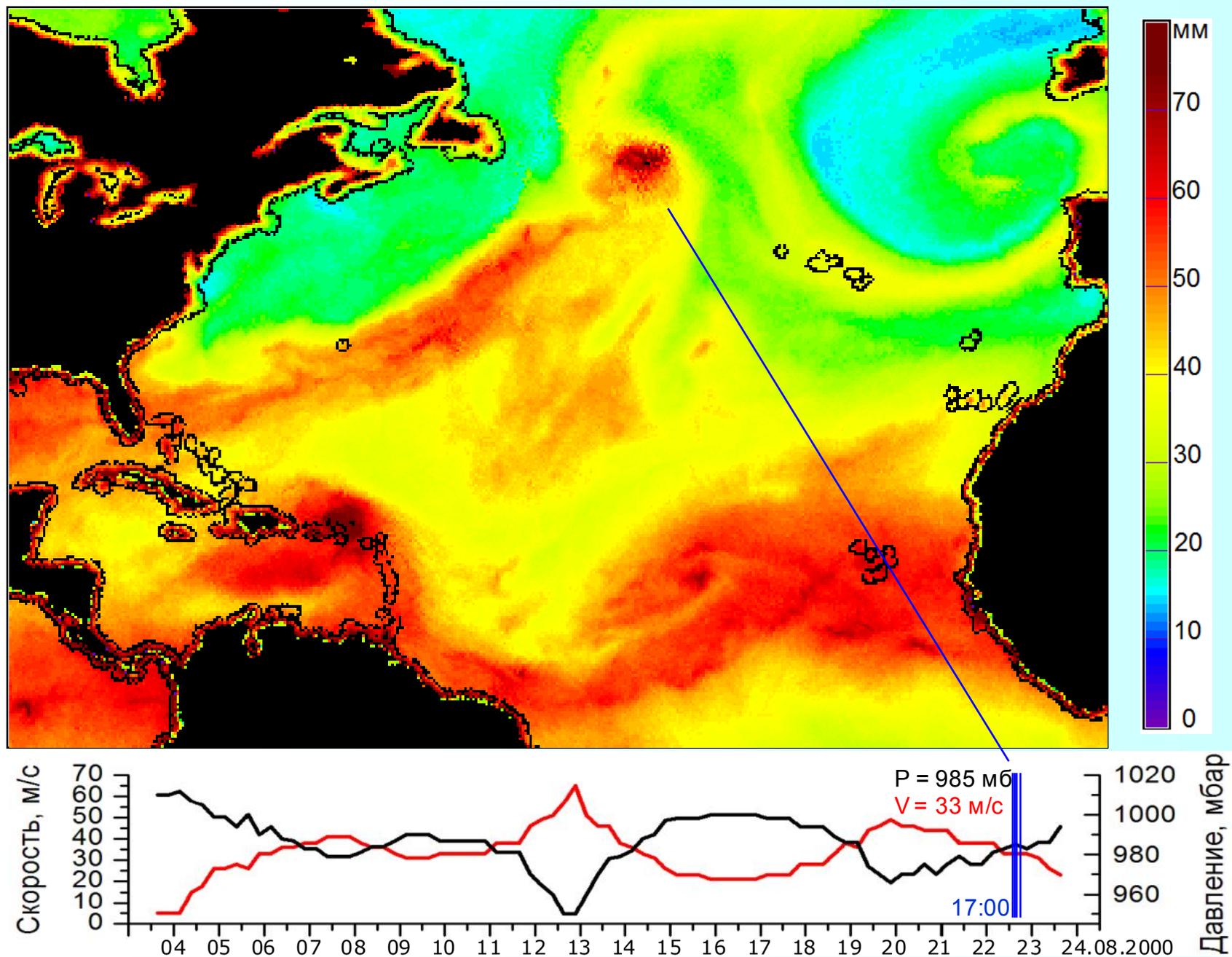
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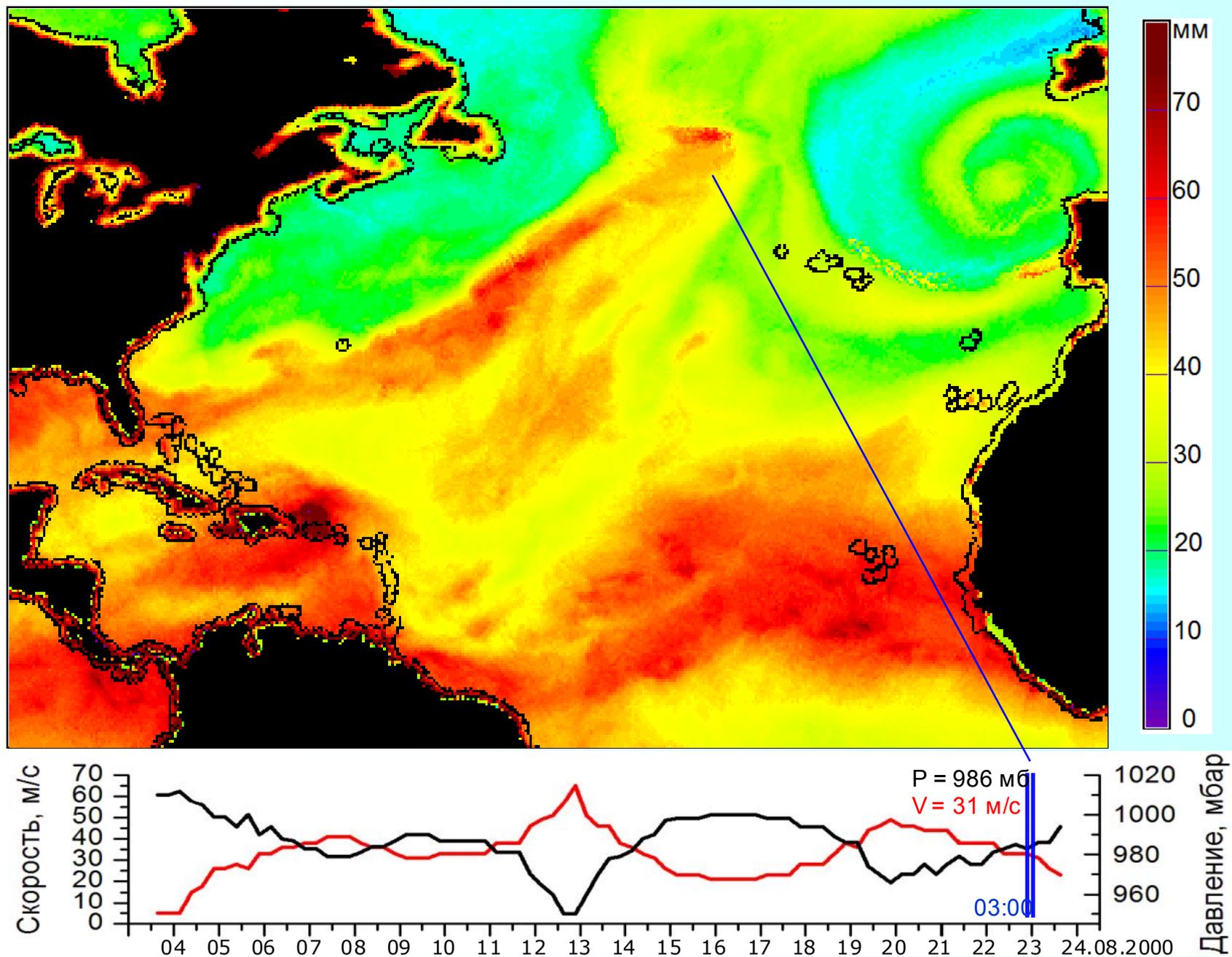
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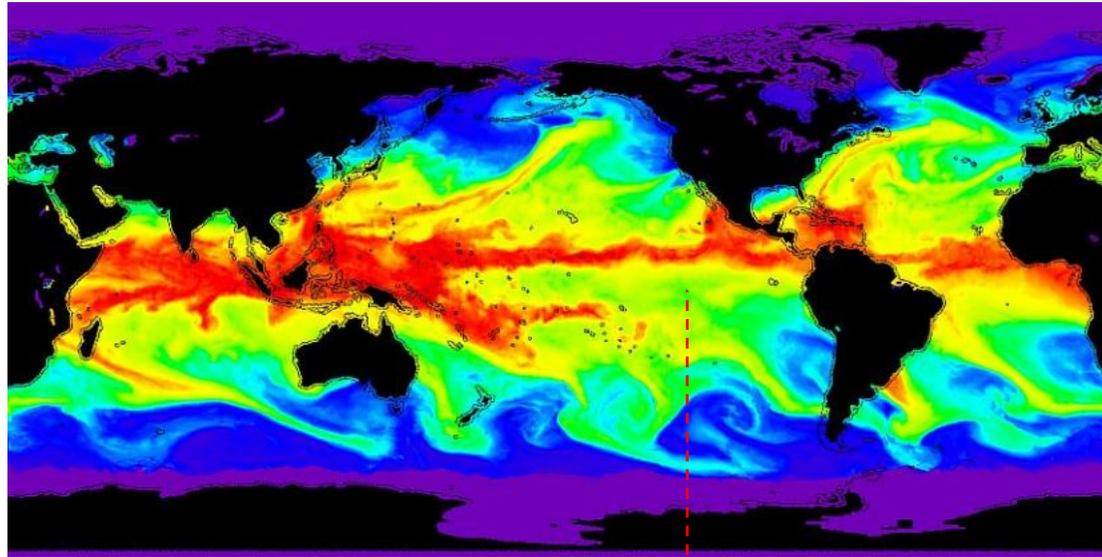
# Пространственно-временная интерполяция



# Пространственно-временная интерполяция

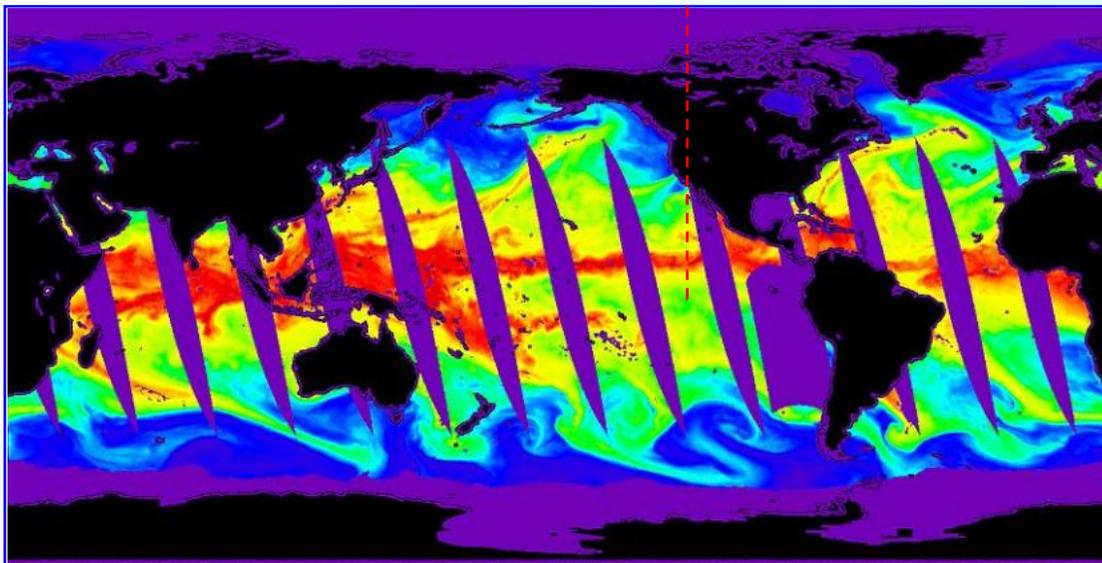
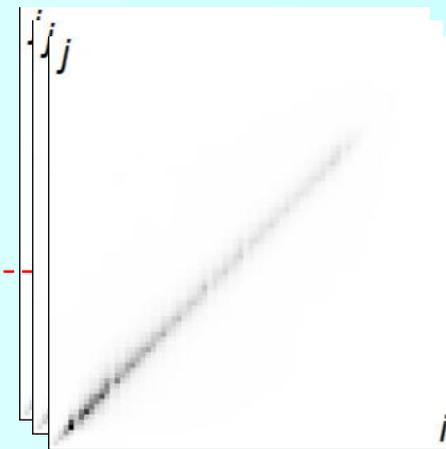


# Оценка точности интерполяции: методика



SSMIS F16 (*i*)

$$\Delta t = +000000$$

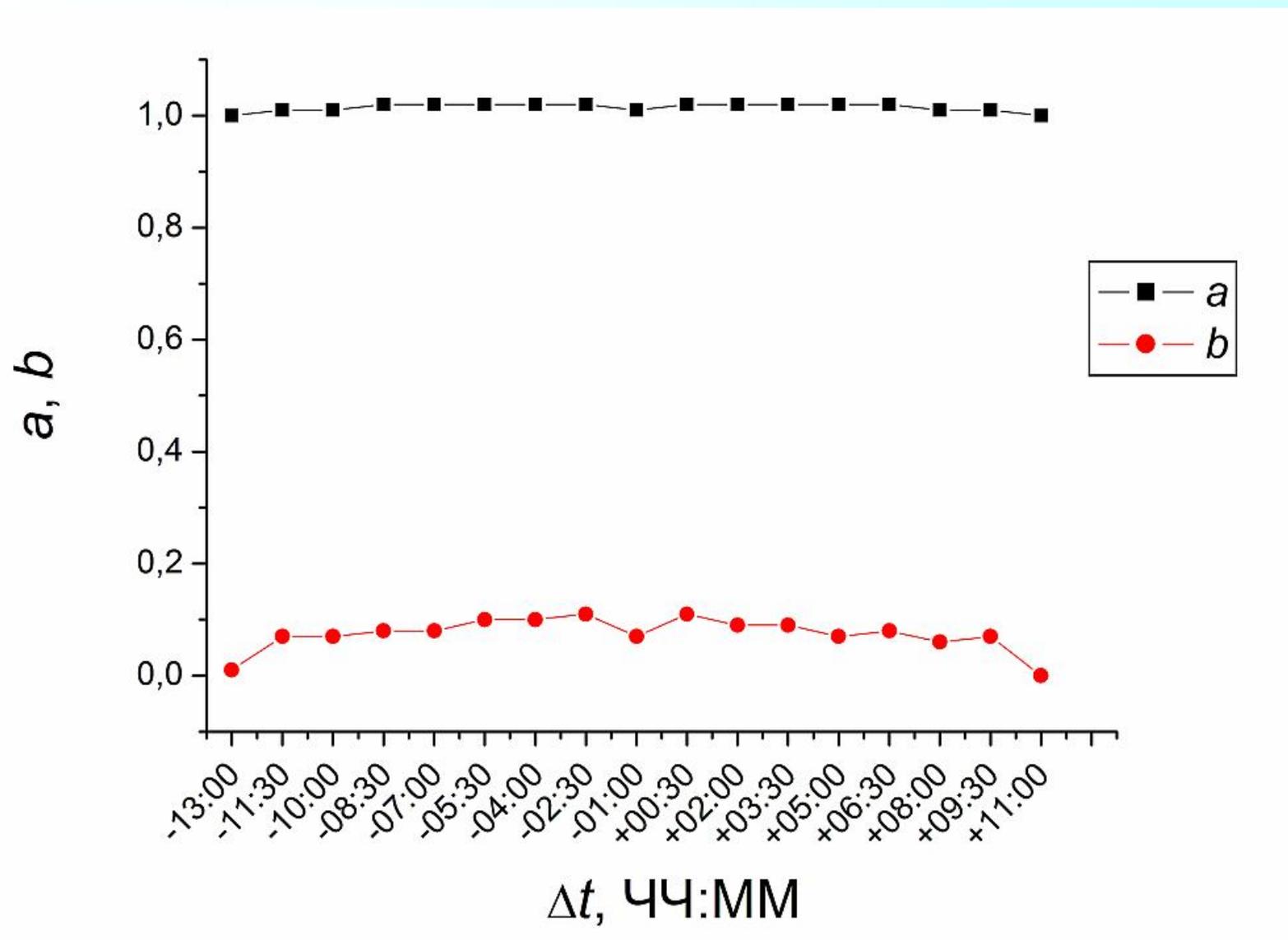


SSMIS F17 (*j*)

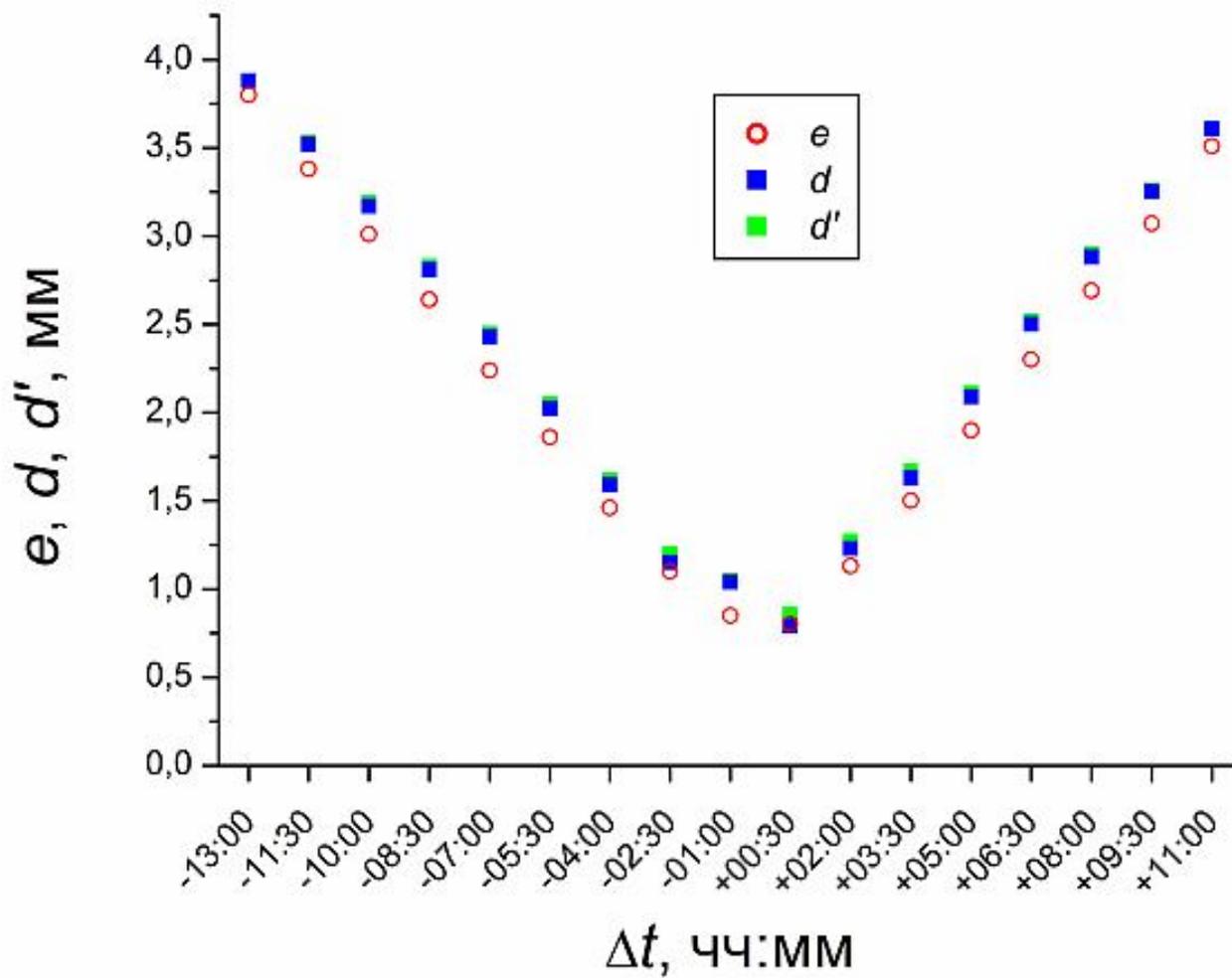
# Оценка точности интерполяции: критерии



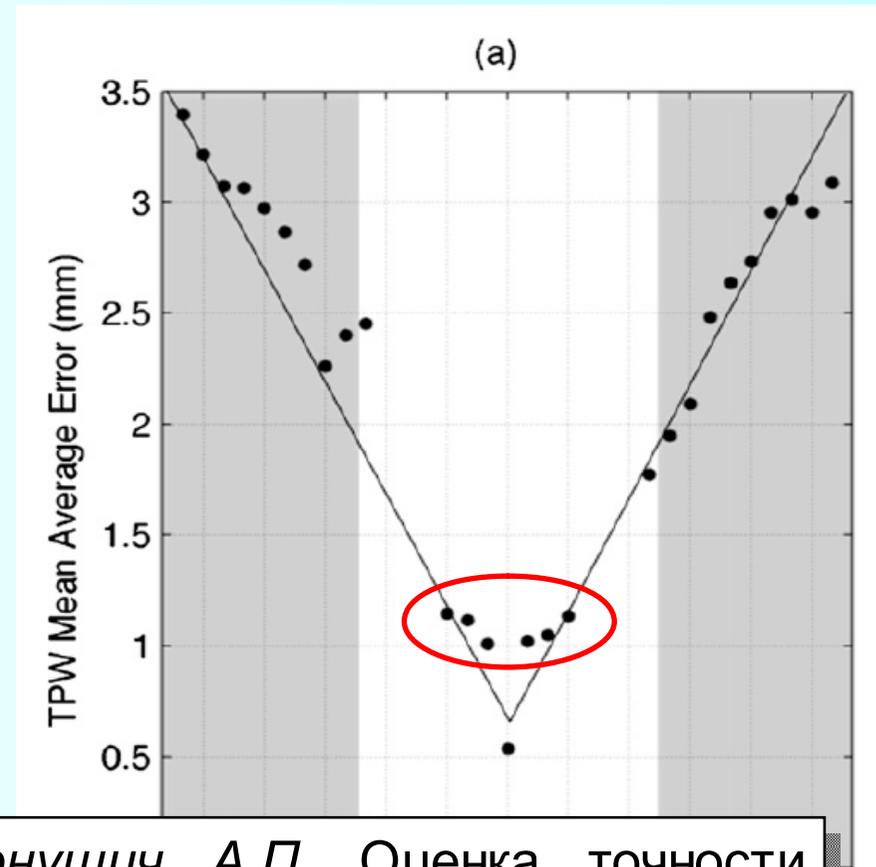
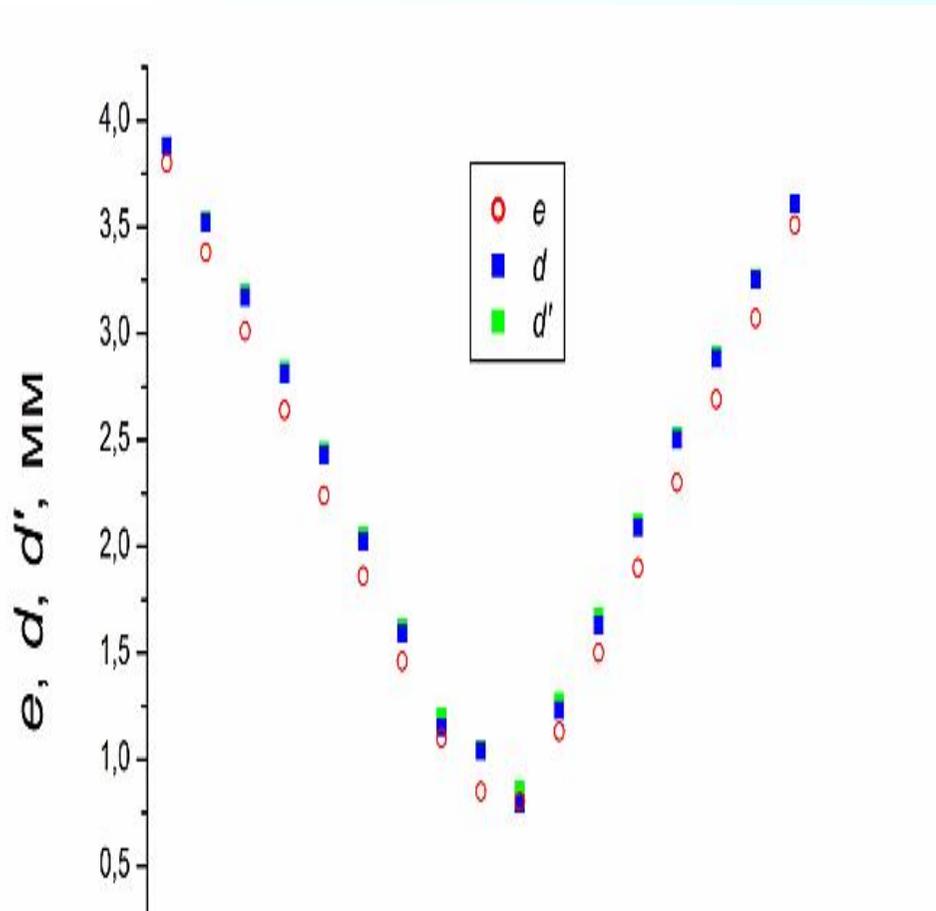
# Оценка точности интерполяции: результаты



# Оценка точности интерполяции: результаты



# Оценка точности интерполяции: результаты

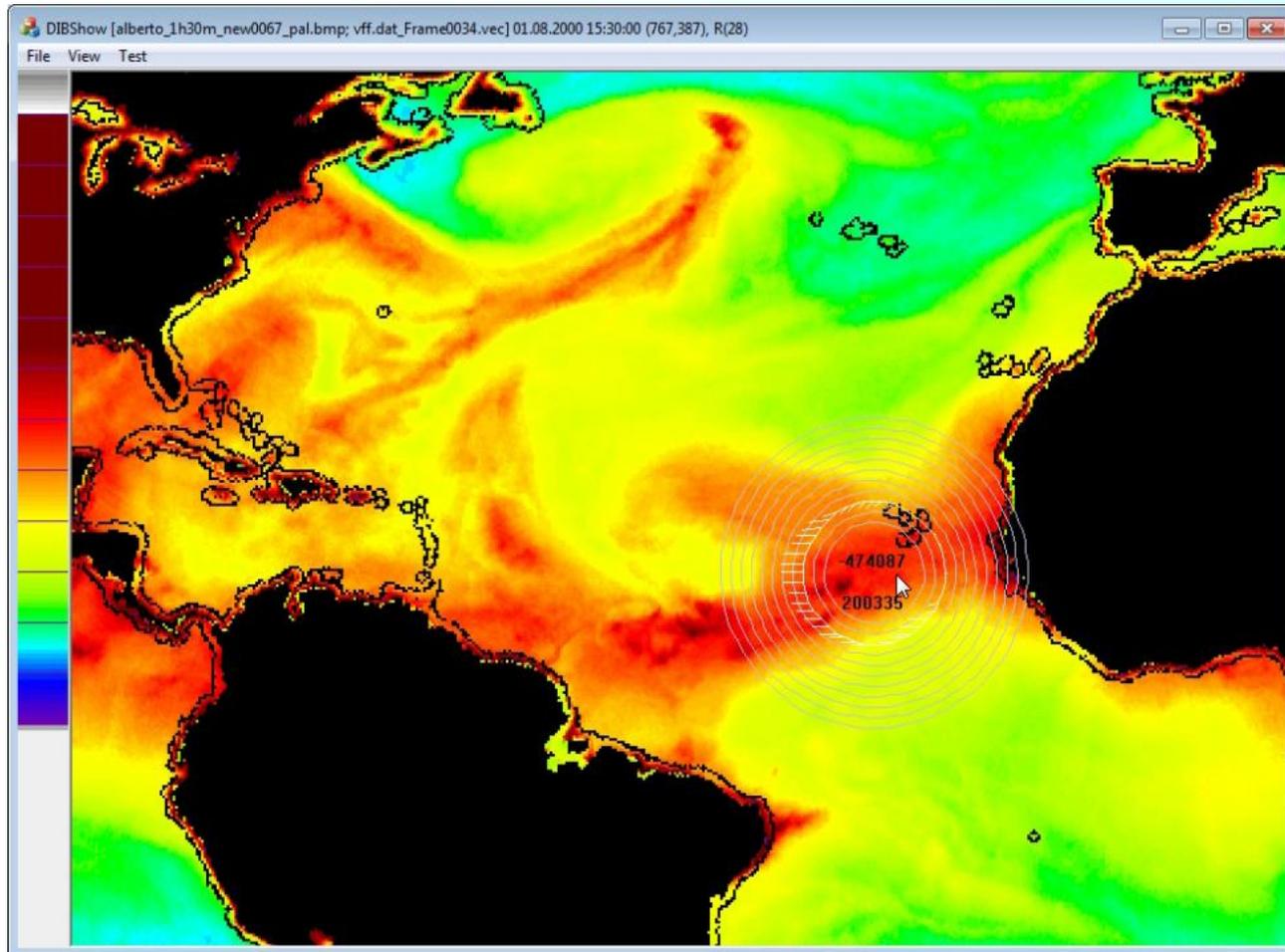


Ермаков Д.М., Шарков Е.А., Чернушич А.П. Оценка точности интерполяционной схемы спутникового радиотепловидения // Современные проблемы дистанционного зондирования Земли из космоса. 2015. Т. 12. №2. С. 77-88.

Погрешность 0,8 мм

Погрешность 0,5 (?) - 2,0 мм

# Оценки потоков. Адвекция скрытого тепла



V-поле

x

M-поле  $\vec{v}$

Потоки через  
произвольные  
контуры!

Ермаков Д.М., Шарков Е.А., Чернушич А.П. Оценка тропосферных адвективных потоков скрытого тепла над океаном при анимационном анализе радиотепловых данных спутникового мониторинга // Исследование Земли из космоса. 2014. № 4. С. 32-38.

H. Zhao, D. Tang, Y. Wang, 2008. Comparison of phytoplankton blooms triggered by two typhoons with different intensities and translation speeds in the South China Sea. *Mar. Ecol. Prog. Ser.*, 365, 57-65

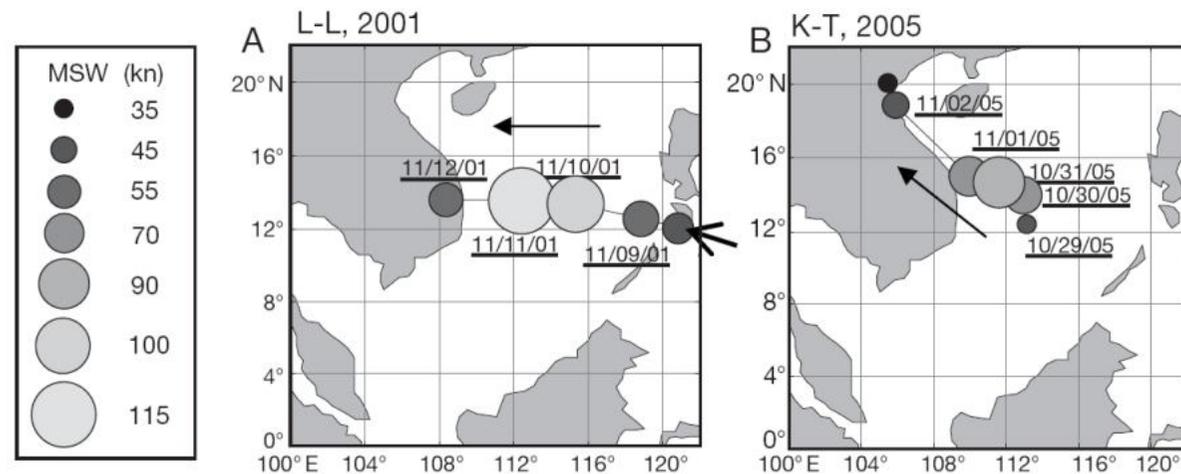
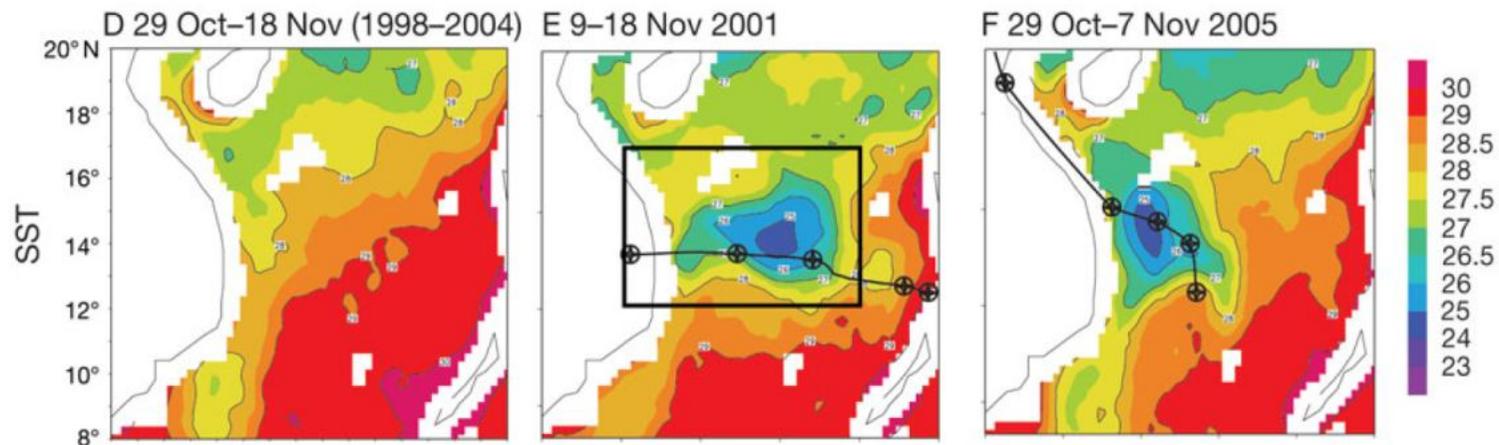


Fig. 2. (A) Track and intensity of typhoons Ling-Ling (L-L) (2001) and Kai-Tak (K-T) (2005) in the South China Sea (SCS). MSW: maximum sustained wind (in knots,  $1 \text{ kn} = 0.514 \text{ m s}^{-1}$ ). Dates are given as mm/dd/yy



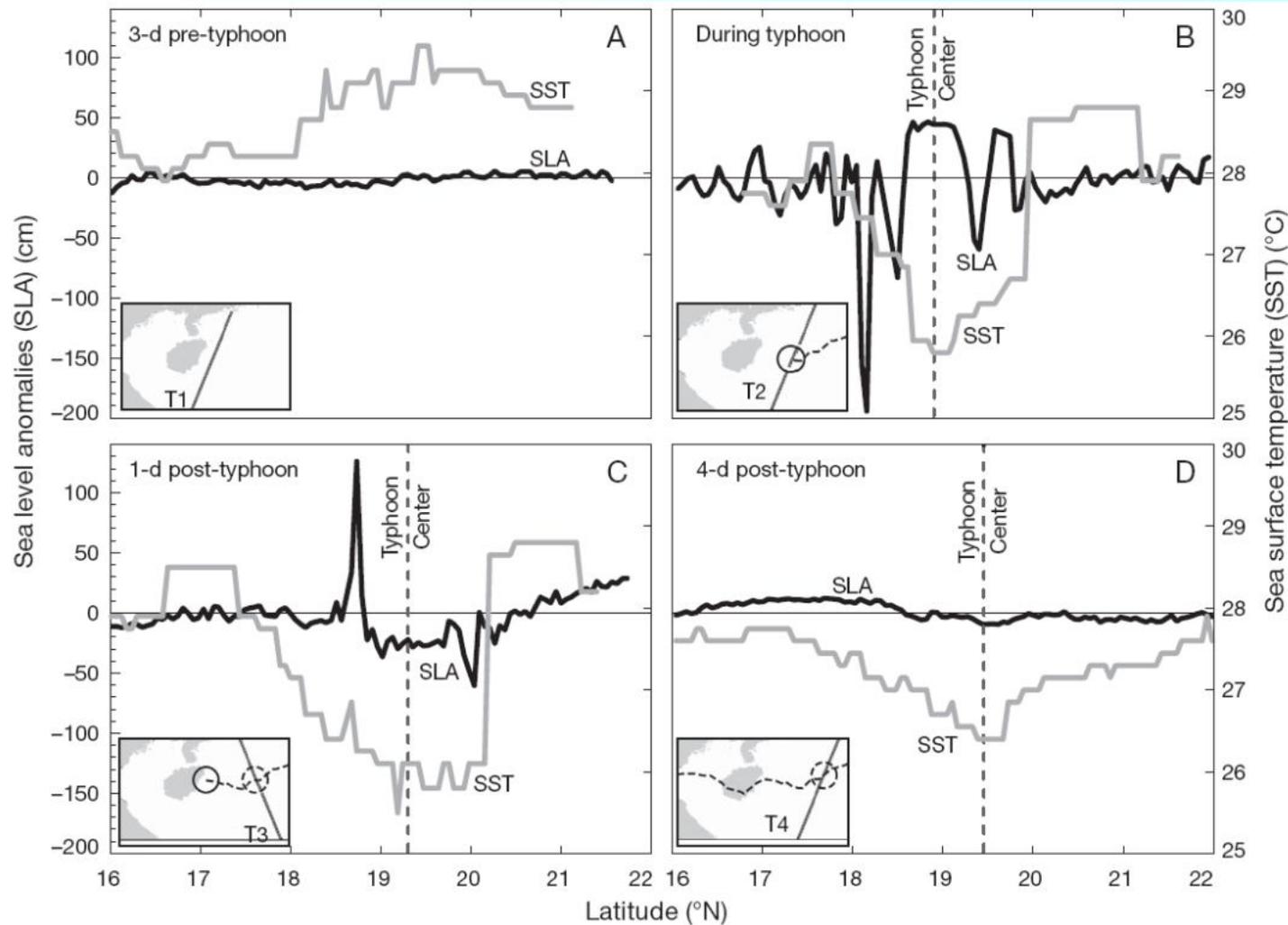


Fig. 6. GFO SLA (Geosat Follow-On, sea-level anomaly) transects measured (A) 3 d before, (B) during, (C) 1 d after, and (D) 4 d after typhoon. TMI-AMSRE SST data measured along the same transect and on the same day (not precisely the same time) with SLA are overlaid. SLAs in the typhoon centers were high during the typhoon and low 1 d after the typhoon. Low SLA matched low SST in the track of the typhoon. Insets: GFO transects and location of present typhoon center (solid circle) and past center (dashed circle); see Fig. 1 for overview.

C. Gentemann, D. Smith and F. Wentz, 2000. Microwave SST correlation with cyclone intensity. *24th Conference on Hurricanes and Tropical Meteorology*

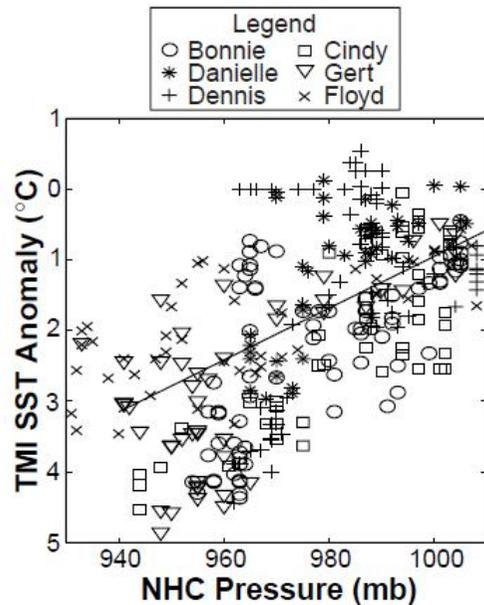


Figure 2. Relationship between hurricane storm induced SST anomalies and storm minimum pressure.

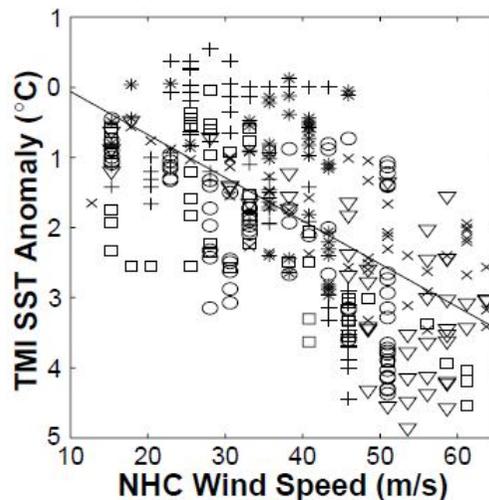


Figure 3. Relationship between hurricane storm induced SST anomalies and maximum sustained wind speed.

upwelling is generally to the right of the storm track, this 5 day time series of SST anomalies was calculated at several positions to the right of the track location. To find the location of the maximum upwelling at each position, the SST anomalies were temporally averaged. At the position with the largest temporally averaged anomaly, the maximum SST anomaly was identified. This value was then used to examine the relationship between maximum sustained wind speed and SST anomalies (Fig. 2) and minimum central pressure and SST anomalies (Fig. 3).

A weak linear relationship is seen in both Figure 2 and Figure 3. Stronger storms resulted in larger anomalies. The correlation is  $-0.62$  and  $0.57$ , respectively. Some of the scatter and the relatively weak correlation may be attributed to differences in the upper ocean thermodynamic structure between the Equatorial Atlantic and the North Atlantic and varying forward storm velocity, which effects development of vertical mixing. These results are obviously regionally dependent due to variations in the upper ocean structure.

#### 4. REFERENCES

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- Wentz, F. J., C. L. Gentemann, D. K. Smith, and D. B. Chelton: Satellite measurements of sea-surface

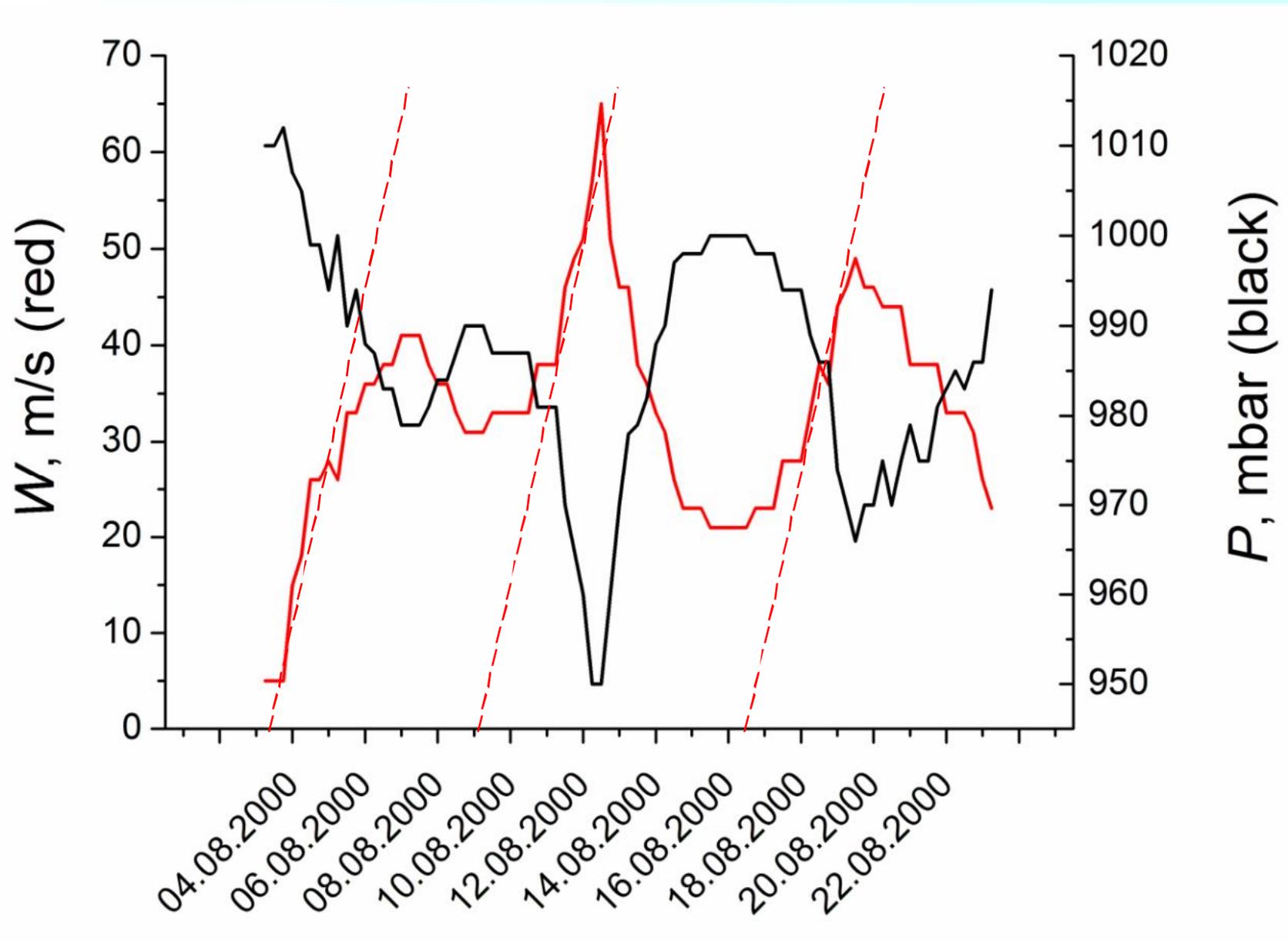
М.С. Пермяков, 2007, автореферат дисс. д.ф.-м.н.

«По судовым гидрологическим данным показано, что «след» тайфуна в океане может быть теплым. На масштабах полигонов при прохождении тайфунов теплообмен возрастает не более чем в два раза, но потоки энергии ветра на поверхности могут превышать более чем на порядок их фоновые значения. Изменения теплосодержания и потенциальной энергии, соизмеримые с полной теплоотдачей и энергией ветра на поверхности за время воздействия тайфуна, прослеживаются только в верхнем перемешанном слое»

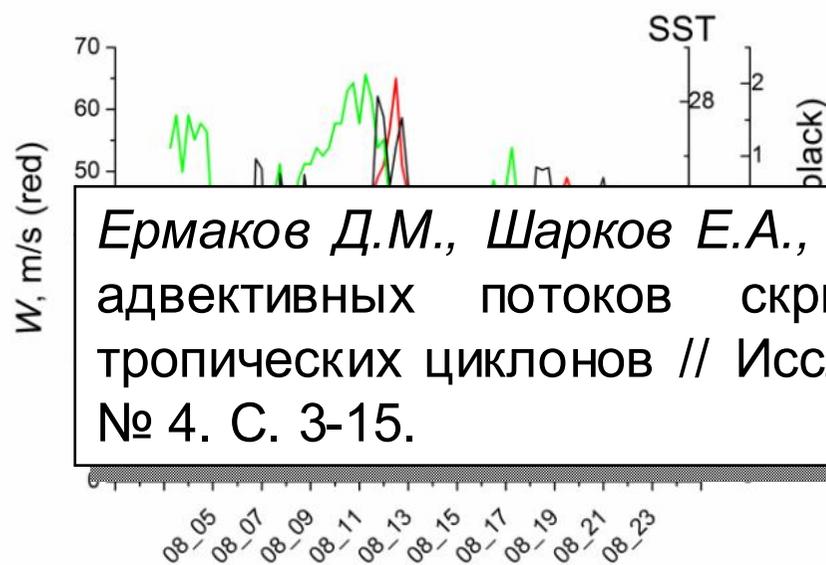
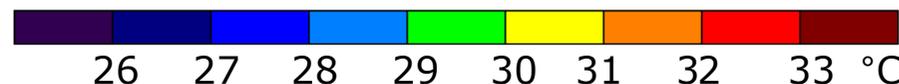
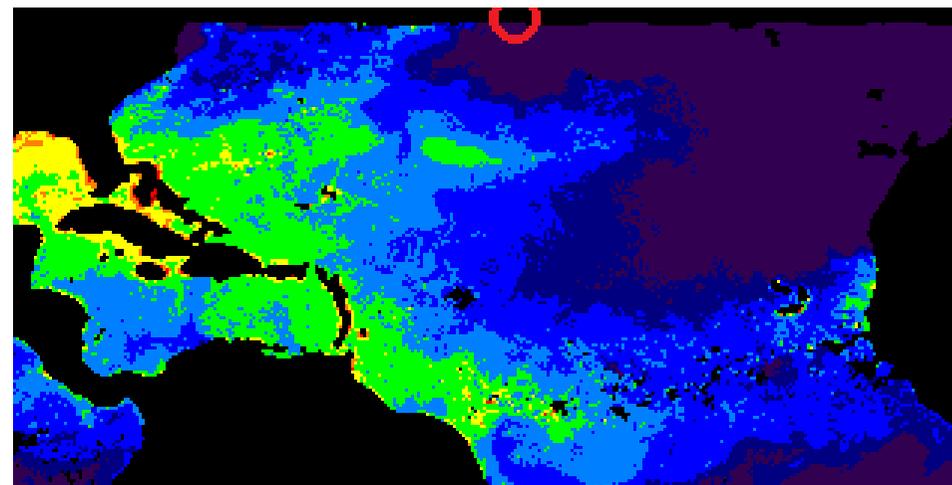
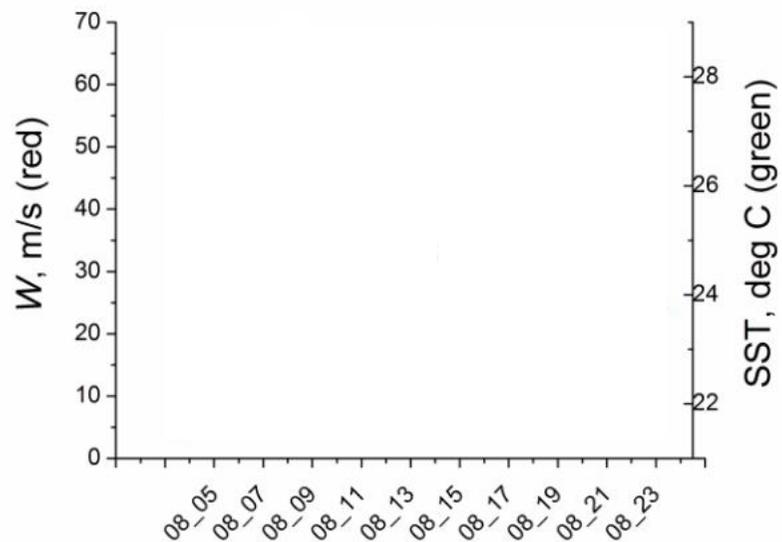
Э. Пальмен, Ч. Ньютон, 1973. Циркуляционные системы атмосферы

«...важнейшим источником полной энергии является боковой приток водяного пара во влажном приземном слое, но <...> дополнительный приток скрытого и ощутимого тепла от морской поверхности в области ядра также представляет источник тепла, которым пренебрегать нельзя»

# Эволюция ТЦ Алберто: метеопараметры



# Эволюция ТЦ Alberto: радиотепловидение

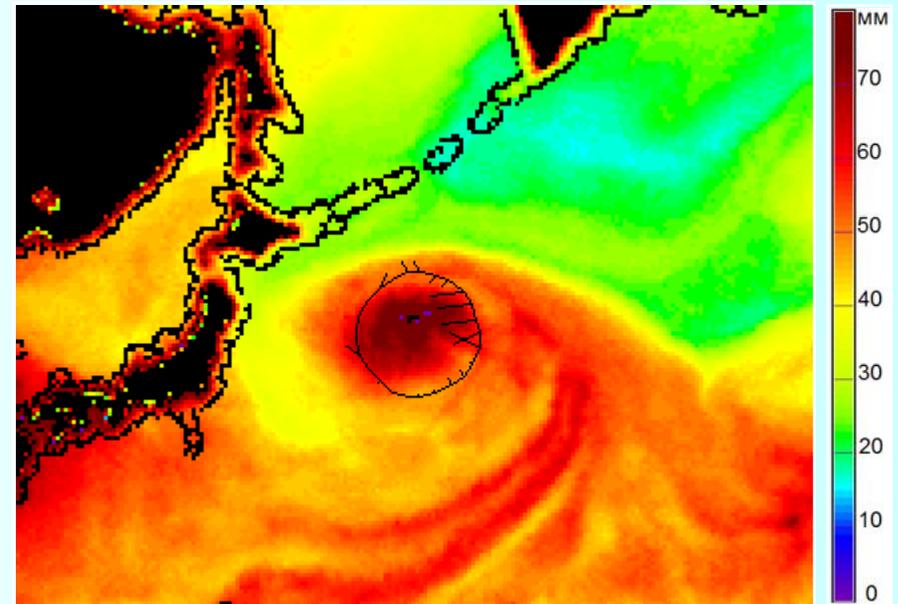
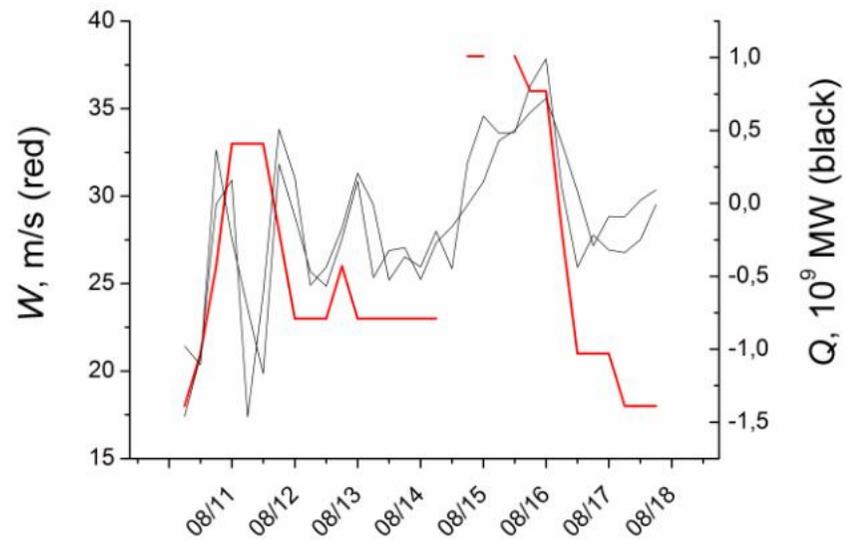
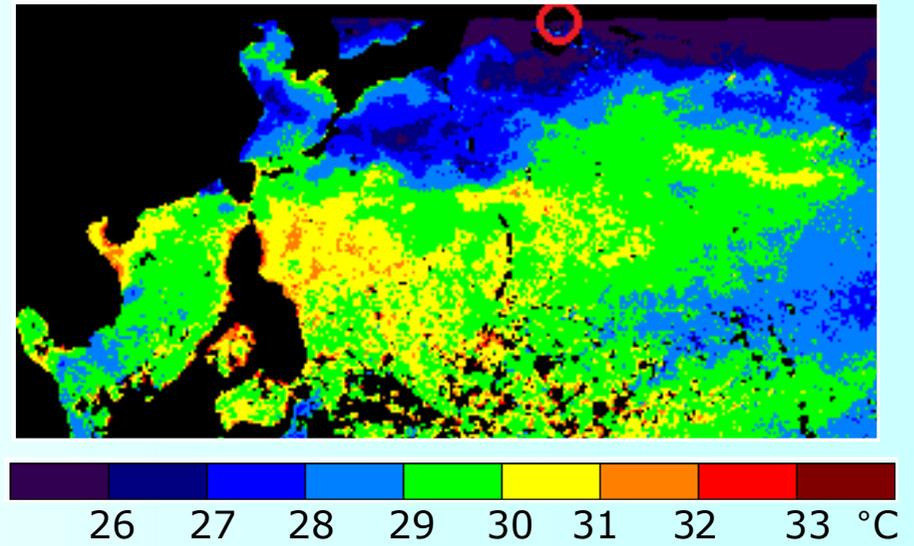
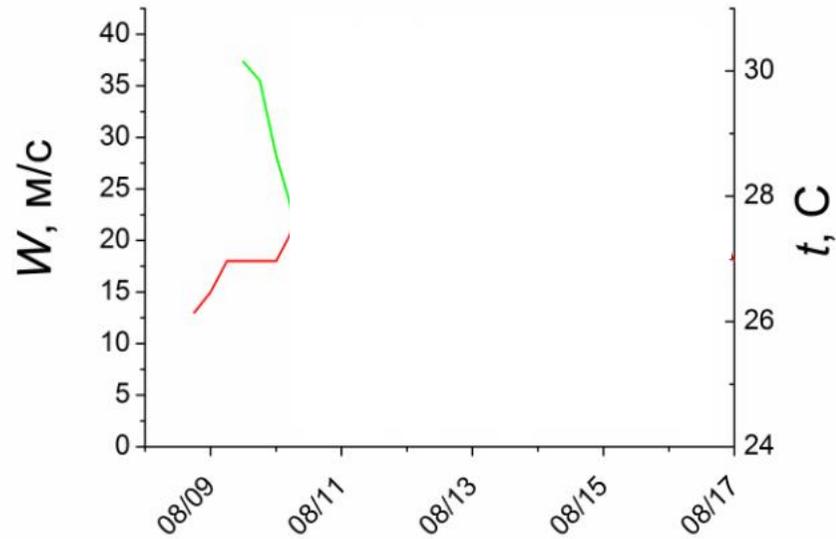


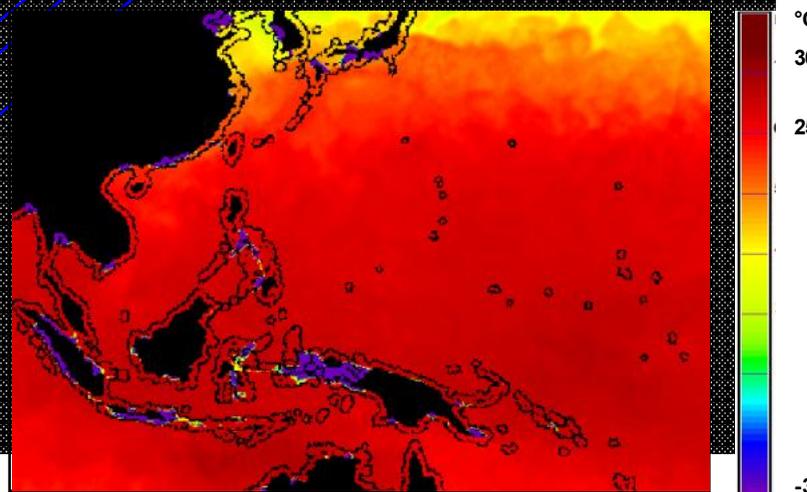
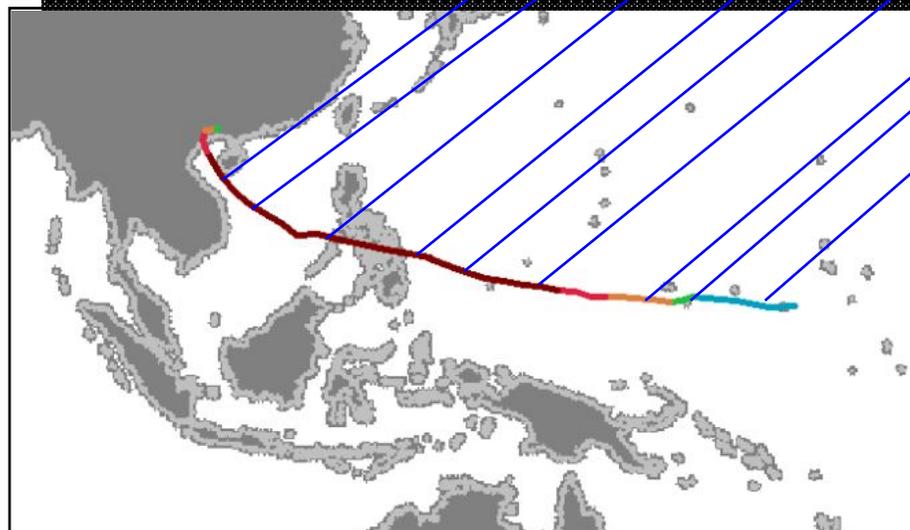
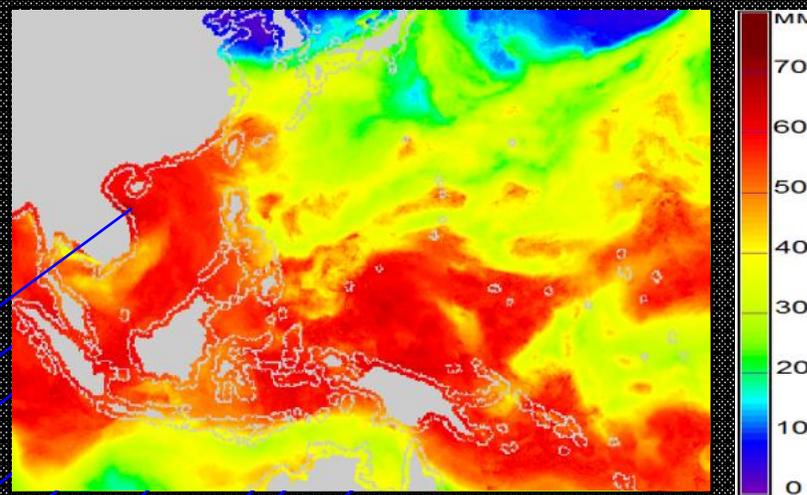
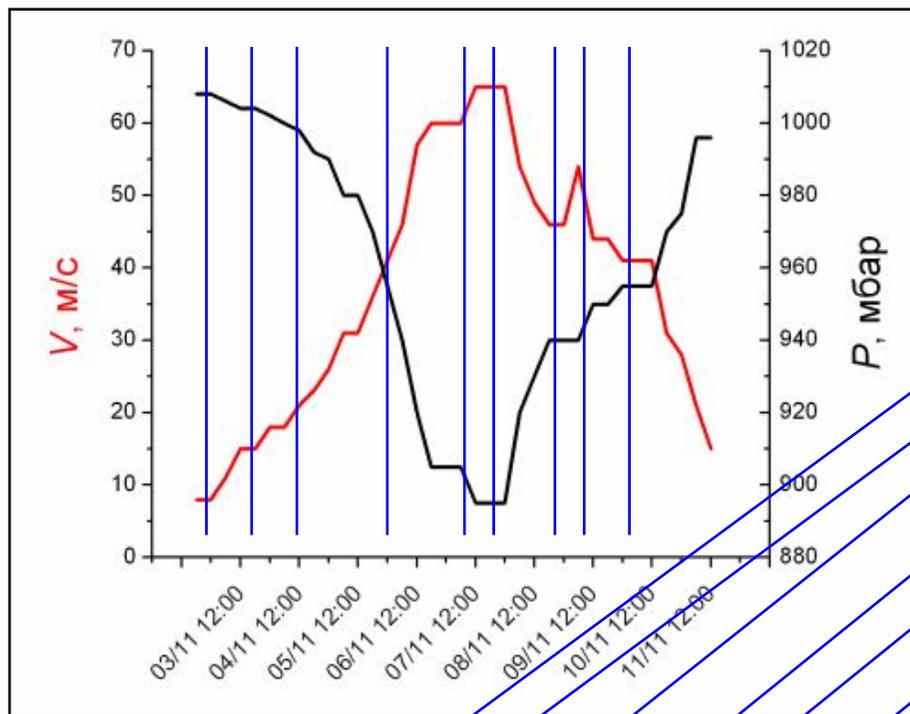
Ермаков Д.М., Шарков Е.А., Чернушич А.П. Роль тропосферных адвективных потоков скрытого тепла в интенсификации тропических циклонов // Исследование Земли из космоса. 2014. № 4. С. 3-15.

## Тропические циклоны в августе 2000 г.

<b>N</b>	<b>ТЦ</b>	<b>Бассейн</b>	<b>Даты</b>
1	Alberto	Северная Атлантика (NA)	03 – 23 августа 2000
2	Debby	Северная Атлантика (NA)	16 – 25 августа 2000
3	Bilis	Северо-запад Тихого океана (NWP)	15 – 24 августа 2000
4	Ewiniar	Северо-запад Тихого океана (NWP)	11 – 18 августа 2000
5	Jelawat	Северо-запад Тихого океана (NWP)	01 – 12 августа 2000
6	Giema	Северо-восток Тихого океана (NEP)	04 – 11 августа 2000
7	Hector	Северо-восток Тихого океана (NEP)	08 – 20 августа 2000

# Эволюция ТЦ Ewiniar: радиотепловидение





SST: (по композитам RSS)

## 'Category-6' Supertyphoon Haiyan in

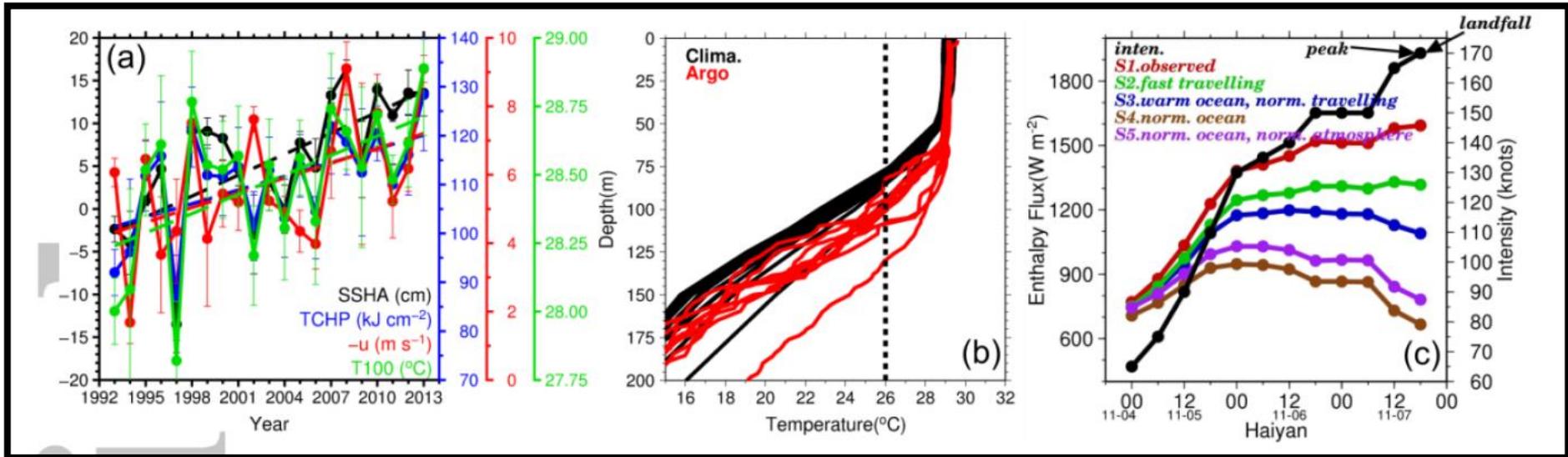
### Global Warming Hiatus: Contribution from Subsurface Ocean

#### Warming

I.-I. Lin\*, Iam-Fei Pun, and Chun-Chi Lien

*Department of Atmospheric Sciences, National Taiwan University, Taipei, Taiwan.*

With the extra-ordinary intensity of 170 kts, super-typhoon Haiyan devastated the Philippines in November 2013. This intensity is among the highest ever observed for tropical cyclones (TCs) globally, 35 kts well above the threshold of the existing highest category of 5. Though there is speculation to associate global warming with such intensity, existing research indicate that we have been in a warming *hiatus* period, with the *hiatus* attributed to the La Niña-like multi-decadal phenomenon. It is thus intriguing to understand why Haiyan can occur during *hiatus*. It is suggested that as the western Pacific manifestation of the La Niña-like phenomenon is to pile up warm subsurface water to the west, the western North Pacific experienced evident subsurface warming and created a very favorable ocean pre-condition for Haiyan. Together with its fast travelling speed, the air-sea flux supply was 158% as compared to normal for intensification.



<b>Genesis position</b>	177°E 7°N	178.6°E 3.8°N	145°E 12.7°N	164.2°E 5.6°N
<b>Distance from genesis to peak [km]</b>	5446	3452	2425	4202
<b>Distance-integrated Flux [<math>\text{Wm}^{-2} \times \text{km}</math>]</b>	2,373,964	1,918,134	2,318,047	4,307,407

1,6 KBT /  $\text{M}^2$



# Hurricane Research Division

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## Frequently Asked Questions

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### Subject: D7) How much energy does a hurricane release?

*Contributed by Chris Landsea (NHC)*

Hurricanes can be thought of, to a first approximation, as a heat engine; obtaining its heat input from the warm, humid air over the tropical ocean, and releasing this heat through the condensation of water vapor into water droplets in deep thunderstorms of the eyewall and rainbands, then giving off a cold exhaust in the upper levels of the troposphere (~12 km/8 mi up).

One can look at the energetics of a hurricane in two ways:

1. the total amount of energy released by the condensation of water droplets or ...
2. the amount of kinetic energy generated to maintain the strong swirling winds of the hurricane ([Emanuel 1999](#)).

It turns out that the vast majority of the heat released in the condensation process is used to cause rising motions in the thunderstorms and only a small portion drives the storm's horizontal winds.

#### • Method 1) - Total energy released through cloud/rain formation:

An average hurricane produces 1.5 cm/day (0.6 inches/day) of rain inside a circle of radius 665 km (360 n.mi) (Gray 1981). (More rain falls in the inner portion of hurricane around the eyewall, less in the outer rainbands.) Converting this to a volume of rain gives  $2.1 \times 10^{16}$  cm<sup>3</sup>/day. A cubic cm of rain weighs 1 gm. Using the latent heat of condensation, this amount of rain produced gives

$$5.2 \times 10^{19} \text{ Joules/day or}$$

$$6.0 \times 10^{14} \text{ Watts.}$$

This is equivalent to 200 times the world-wide electrical generating capacity - an incredible amount of energy produced!

#### TC FAQ

- [Basic Definitions](#)
- [Cyclone Names](#)
- [Cyclone Myths](#)
- [Cyclone Winds](#)
- [Cyclone Records](#)
- [Cyclone Forecasting](#)
- [Cyclone Climatology](#)
- [Cyclone Observation](#)
- [Real Time Info](#)
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- [Cyclone Prep](#)
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# Мощность ТЦ по Kerry Emanuel

## The power of a hurricane: An example of reckless driving on the information superhighway

Kerry A. Emanuel  
Massachusetts Institute of Technology

One of the more problematic tasks of the research scientist is to convey to the public in an accurate but stimulating way the power and beauty of natural phenomena. The World Wide Web provides a new means to do this, and increasingly is used as a resource for scientific information by everyone from school children to professional scientists. How accurate is the information that is available on the Web? Is most of the information traceable to its source? As a very small experiment designed to address these issues, the author asked students in his tropical meteorology class to investigate how the power of a hurricane is being conveyed to the public via the Web. This article describes the surprising result.

### Of bombs and storms

A quick search turned up nine sites that refer to the power or energy of a hurricane. Of these, five state that a single hurricane over the course of one day releases an amount of energy equivalent to 400 20-megaton bombs. (A sixth states that this amount of energy is released in one *minute*. Presumably, this is a misquotation of another source.) As one megaton is equivalent to  $4.2 \times 10^{15}$  joules, the quoted power amounts to about  $4 \times 10^{14}$  watts. Only one of these five sites quotes a source – a popular book on hurricanes (Lee 1993). The sites range from the Web page of a high-school science teacher to the home page of a former director of the US National Hurricane Center. Two further sites, one from a small college and the other from an advanced placement high-school physics course, quote a power output of  $2 \times 10^{13}$  watts, but do not give sources. A final site states that the energy content of a hurricane is about  $10^{15}$  joules, but does not define what that pertains to.

### A simple estimate

In a popular textbook, Anthes *et al.* (1978) estimate that the latent-heat release in an average hurricane amounts to  $10^{14}$  watts. This is not perhaps a meaningful quantity, however, since most of the latent heat is used to raise the potential energy of air. (For example, the flow of moist, stable air over a mountain actually requires work to be done on the air, but large quantities of latent heat are released.) A more meaningful quantity is the rate of generation of kinetic energy, which in a steady hurricane also equals the rate of dissipation of kinetic energy. Bister and Emanuel (1998) showed that in a hurricane dissipation occurs mostly in the atmospheric surface layer, and that the corresponding dissipation rate per unit area,  $D$ , is given by:

$$D = \rho C_D V^3,$$

where  $\rho$  is the air density,  $V$  is a characteristic wind speed at low levels and  $C_D$  is the surface drag coefficient. Thus, integrated over the surface area covered by a circularly symmetric hurricane, the total power dissipated by the storm,  $P$ , is:

$$P = 2\pi \int_0^{r_0} \rho C_D V^3 r dr, \quad (1)$$

where  $r$  is the radius and  $r_0$  is some characteristic outer radius encompassing the storm. To evaluate Eq. (1) I shall assume that the velocity varies linearly with radius inside the radius of maximum winds,  $r_m$ , and that it has a profile outside of  $r_m$  similar to those used by Holland (1980) and Emanuel (1986). I also take the average sea-level air density to be  $1 \text{ kg m}^{-3}$  and use a drag coefficient of  $2 \times 10^{-3}$ . With these values, an average Atlantic hurricane with maximum winds of  $50 \text{ m s}^{-1}$  and a radius of maximum winds of  $30 \text{ km}$  dissipates  $3 \times 10^{12}$  watts. At the extreme end, a Pacific super-typhoon with a maximum wind speed of  $80 \text{ m s}^{-1}$  and a radius of maximum winds of  $50 \text{ km}$  dissipates  $3 \times 10^{13}$  watts. Thus the values quoted by most of the World Wide Web sites are too high by one to two orders of magnitude. Values quoted by two educational institutions

were consistent with power dissipated in large Pacific super-typhoons.

### Summary

While the World Wide Web can serve as a valuable source of information, it is clearly susceptible to the rapid propagation of misinformation, as demonstrated by this very small example. Problems of the kind illustrated here would be mitigated by careful referencing to source material, as is standard practice in printed publications. While a realistic estimate of power dissipation in an average hurricane is two orders of magnitude less than most values found on the Web, it is still an impressive quantity, equivalent to the world-wide electrical generation capacity as of 1 January 1996, as reported by the US Department of Energy.

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- Emanuel, K. A. (1986) An air–sea interaction theory for tropical cyclones. Part I. *J. Atmos. Sci.*, **42**, pp. 1062–1071.
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Correspondence to: Prof. Kerry A. Emanuel, Program in Atmospheres, Oceans and Climate, Massachusetts Institute of Technology, Cambridge, MA 02139 USA.

# Пальмен, Ньютон. Циркуляционные системы атмосферы

## 15. Тропические циклоны, тайфуны, ураганы

### 15.6. Приходо-расход энергии

«Внутри круга радиусом  $1^\circ$  широты суммарная генерация энергии составляла до  $0,52 \cdot 10^{10}$  кДж/с. <...> Источник тепла для этой части равен  $36,5 \cdot 10^{10}$  кДж/с; следовательно, <...> лишь около 1,4% указанного количества преобразовывалась в механическую энергию»

«...для «среднего урагана» <...> генерация кинетической энергии в области радиусом  $6^\circ$  широты составляет  $1,5 \cdot 10^{10}$  кДж/с. <...>

Приведение данных ... к соответствующим единицам дает величину источника тепла для всего циклона около  $63 \cdot 10^{10}$  кДж/с»

	УУ, $2^\circ$	Дези, $1^\circ$	Элен, $1^\circ$
Приток скрытого тепла (адвекция)	0,55 ПВт	0,37 ПВт	0,37 ПВт
Дополнительный источник тепла (от моря)	0,01 ПВт	0,03 ПВт	0,06 ПВт

# Kerry Emanuel, 1998, Weather

Power of a hurricane: an example of reckless driving on the information superhighway

Диссипация кинетической энергии:

$$R = 30 \text{ км}, V = 50 \text{ м/с} \rightarrow 0,003 \text{ ПВт}$$

$$R = 50 \text{ км}, V = 80 \text{ м/с} \rightarrow 0,030 \text{ ПВт}$$

Вертикальный поток полного тепла:

$$R = 100 \text{ км}, V = 85 \text{ м/с} \rightarrow 0,050 \text{ ПВт}$$

$$R = 50 \text{ км}, V = 85 \text{ м/с} \rightarrow 0,013 \text{ ПВт}$$



RESEARCH LETTER

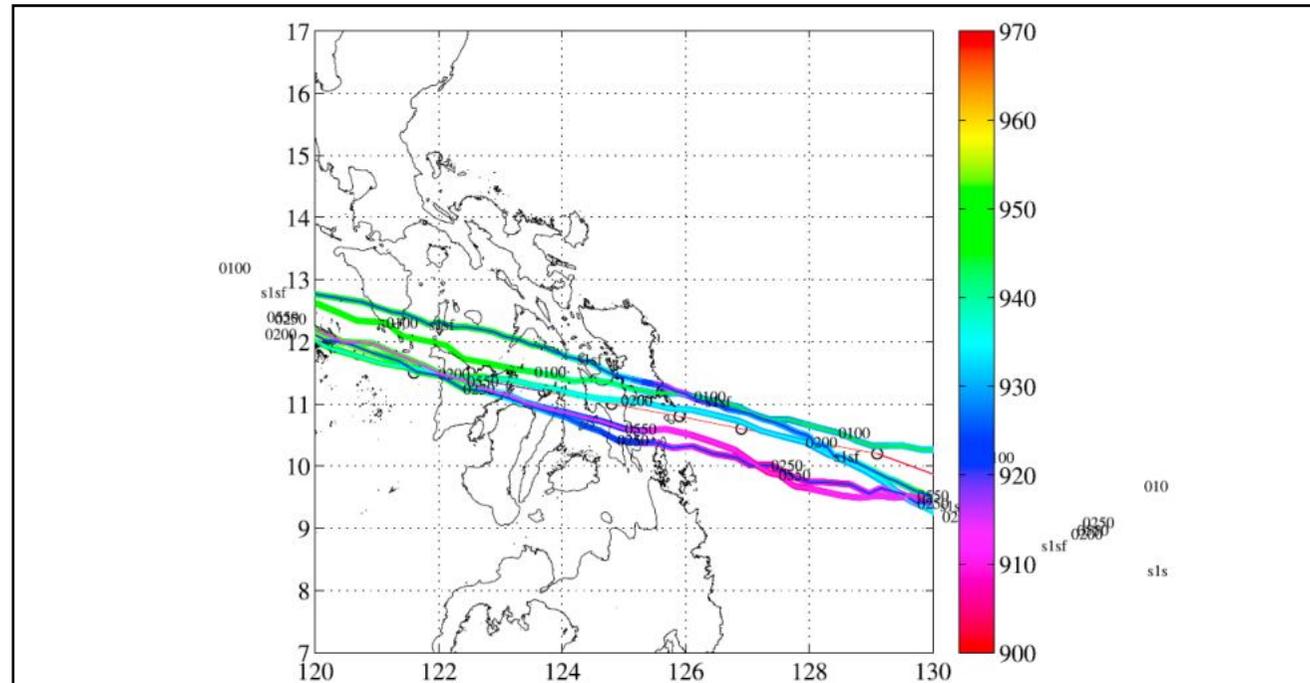
10.1002/2014GL060689

Key Points:

- Hindcast of typhoon Haiyan
- Local amplification of storm surge in the Leyte bay
- Seiche oscillation due to steep bathymetry by Philippines trench

Local amplification of storm surge by Super Typhoon Haiyan in Leyte Gulf

Nobuhito Mori<sup>1</sup>, Masaya Kato<sup>2</sup>, Sooyoul Kim<sup>3</sup>, Hajime Mase<sup>1</sup>, Yoko Shibutani<sup>1</sup>, Tetsuya Takemi<sup>1</sup>, Kazuhisa Tsuboki<sup>2</sup>, and Tomohiro Yasuda<sup>1</sup>



**Figure 1.** Track and minimum central pressure of Typhoon Haiyan (o: satellite data, numbers correspond to Weather Research and Forecasting/Cloud Resolving Storm Simulator (WRF/CRESS) simulations as abbreviated in Table A1). (a) East Visayas and (b) Tacloban and surrounding area with survey data (circles: measured inundation height).

(Figure A4). However, the initial growth of  $U_{10}$ ,  $P_{min}$ , and water surface elevation were qualitatively well simulated by the numerical models. The typhoon radius  $R_{max}$  was 50–100 km, equivalent in size to San Pedro

# Энергетический бюджет ТЦ

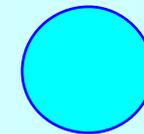
1 ПВт =  
 $10^9$  МВт



$$W = 50 \text{ кг/м}^2, v = 5 \text{ м/с}, r = 8 \cdot 10^5 \text{ м.}$$

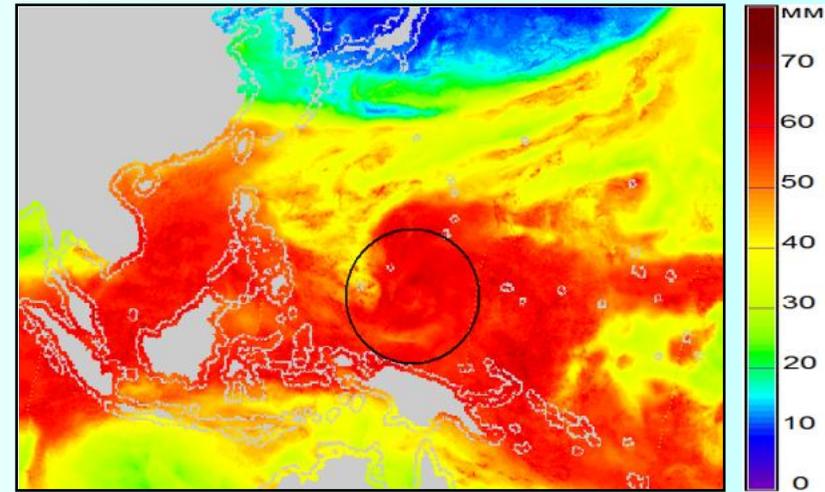
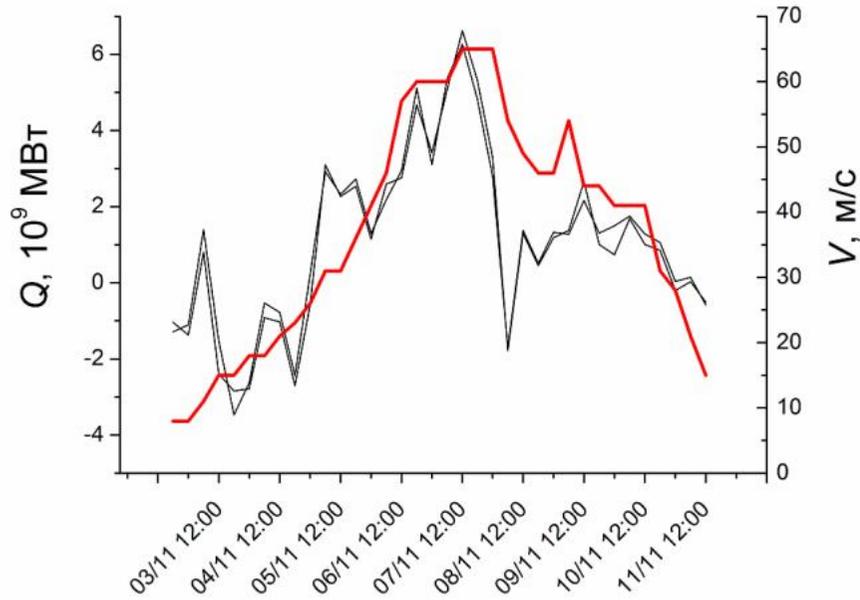
Тогда

$$Q = q \cdot W \cdot 2\pi \cdot r \cdot v = 2.9 \text{ ПВт}$$

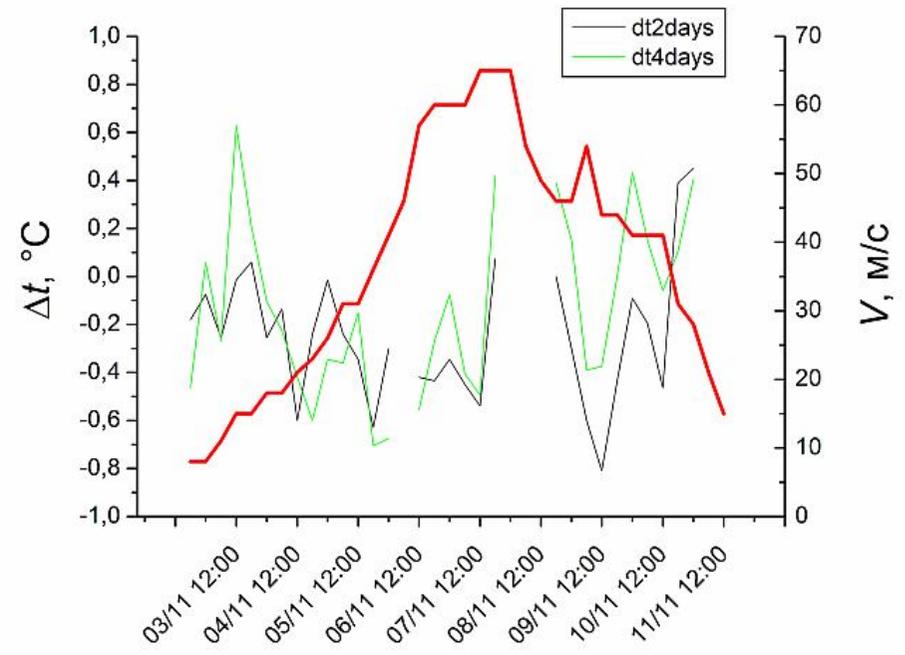
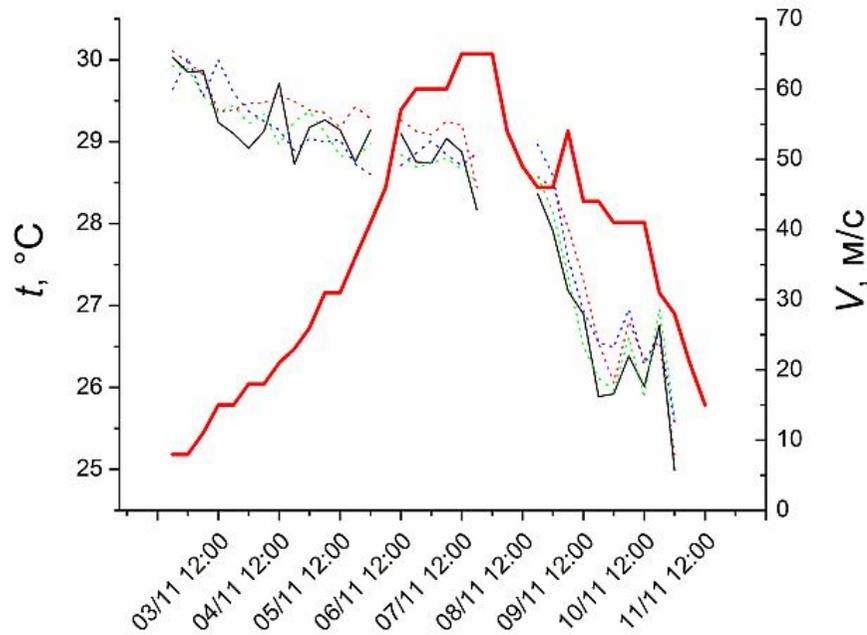


0,05 ПВт

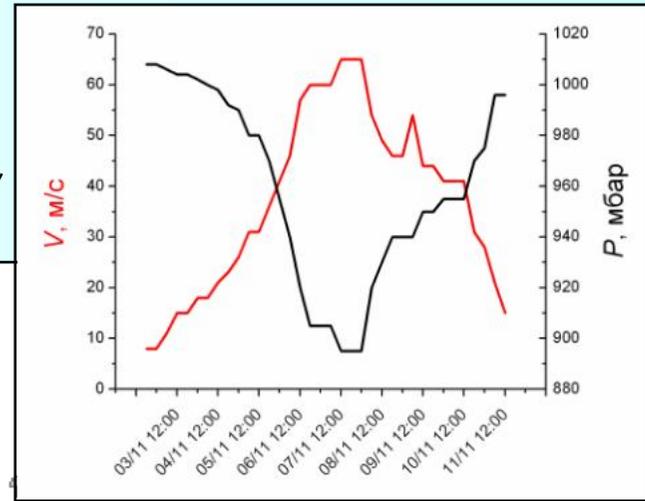
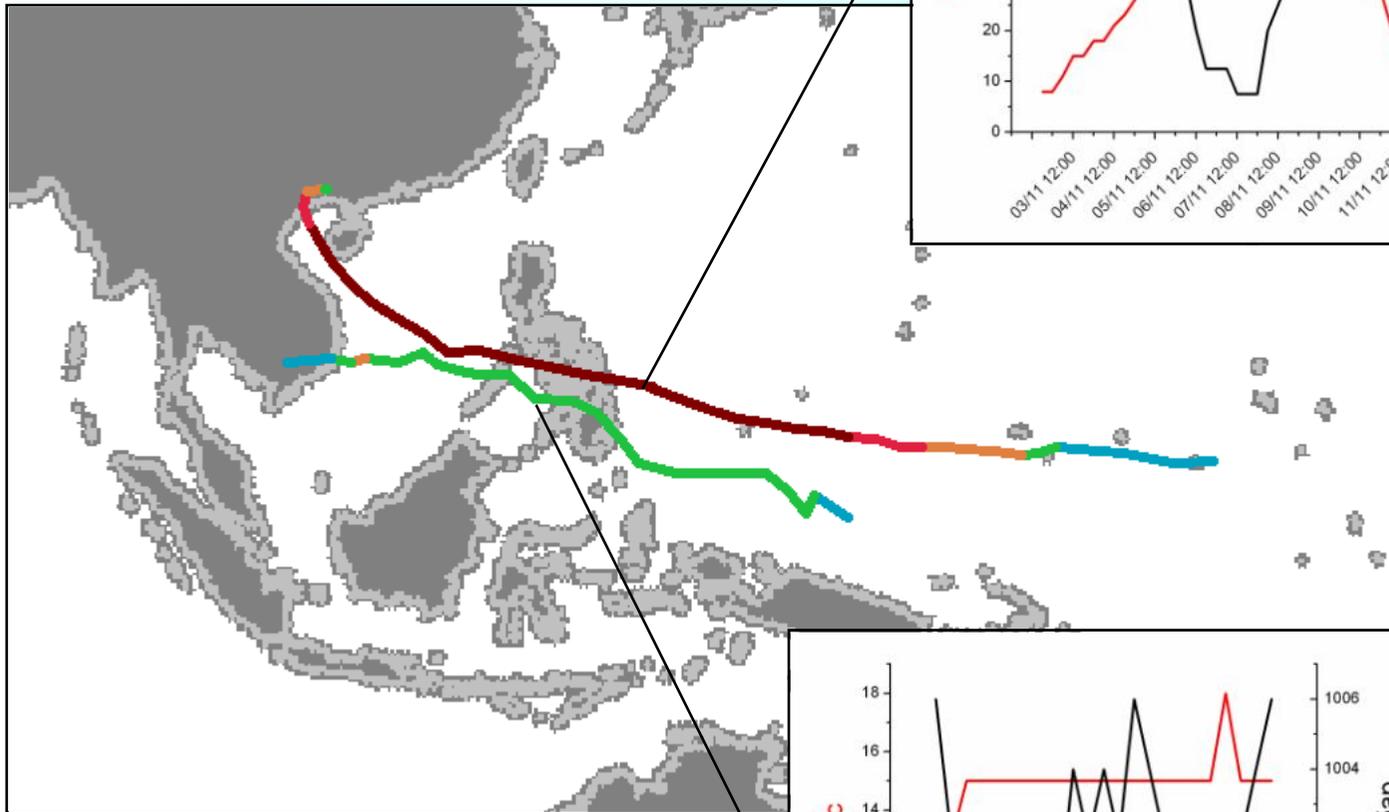
# Haiyan (NWP) 03 – 11 ноября 2013



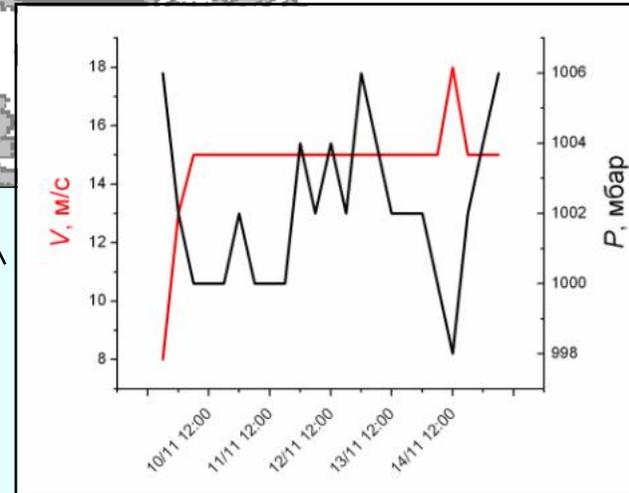
TPW, 05.11.2013



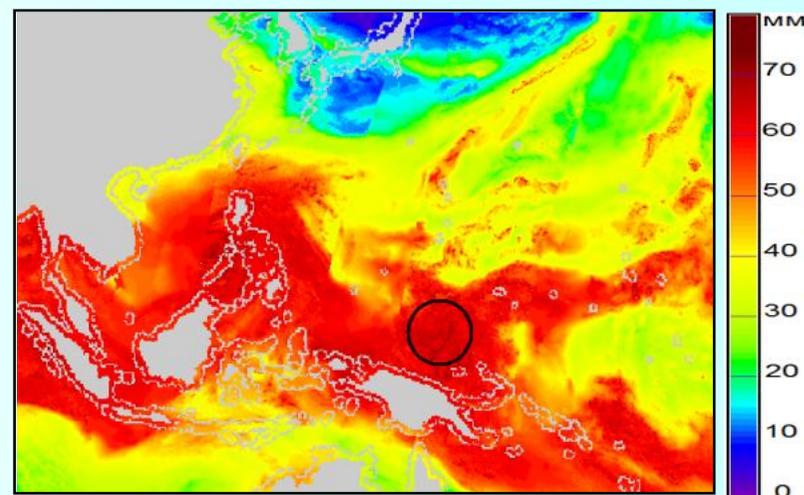
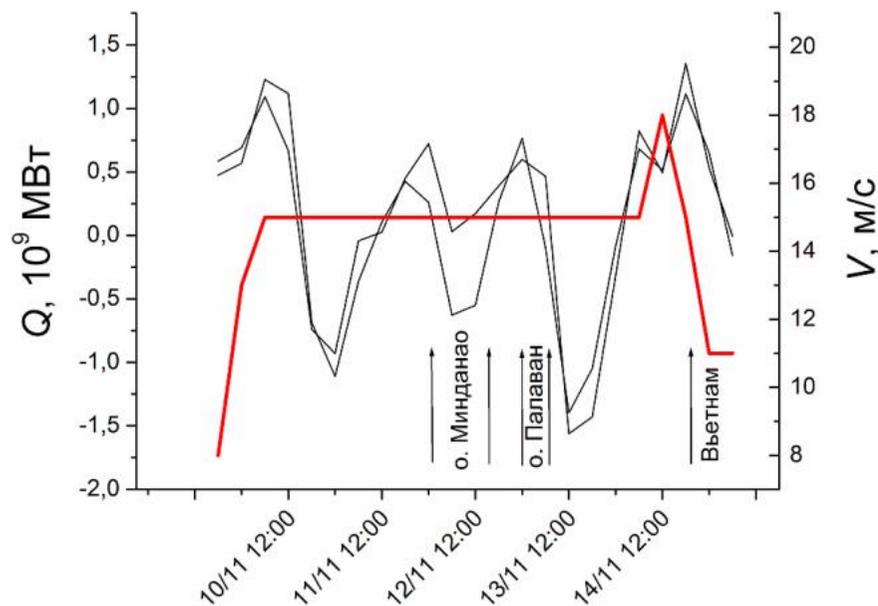
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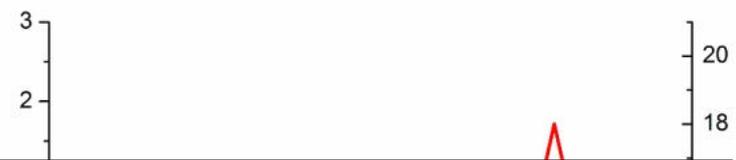
# Podul



# Podul (NWP) 10 – 15 ноября 2013



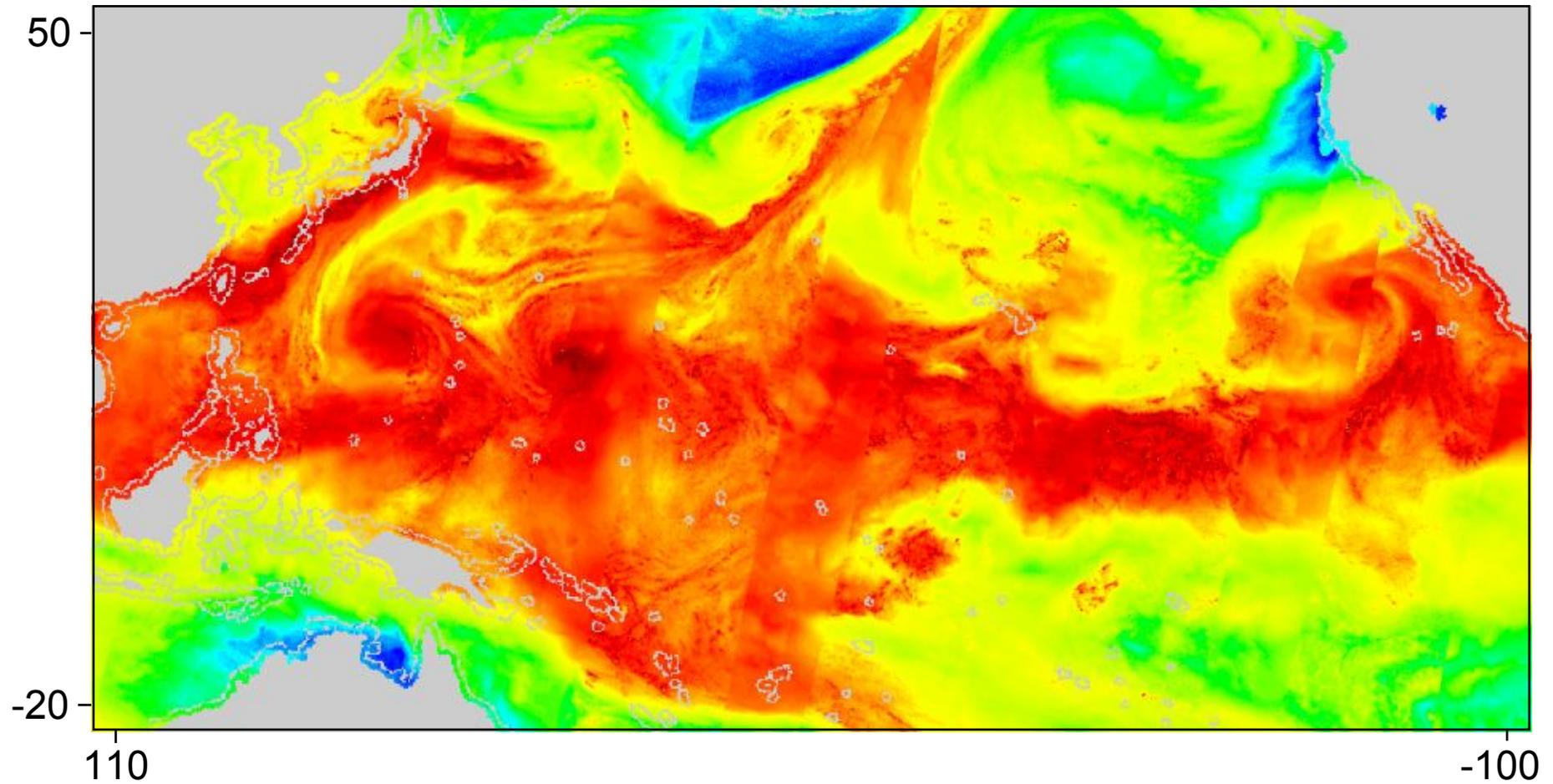
TPW, 10.11.2013



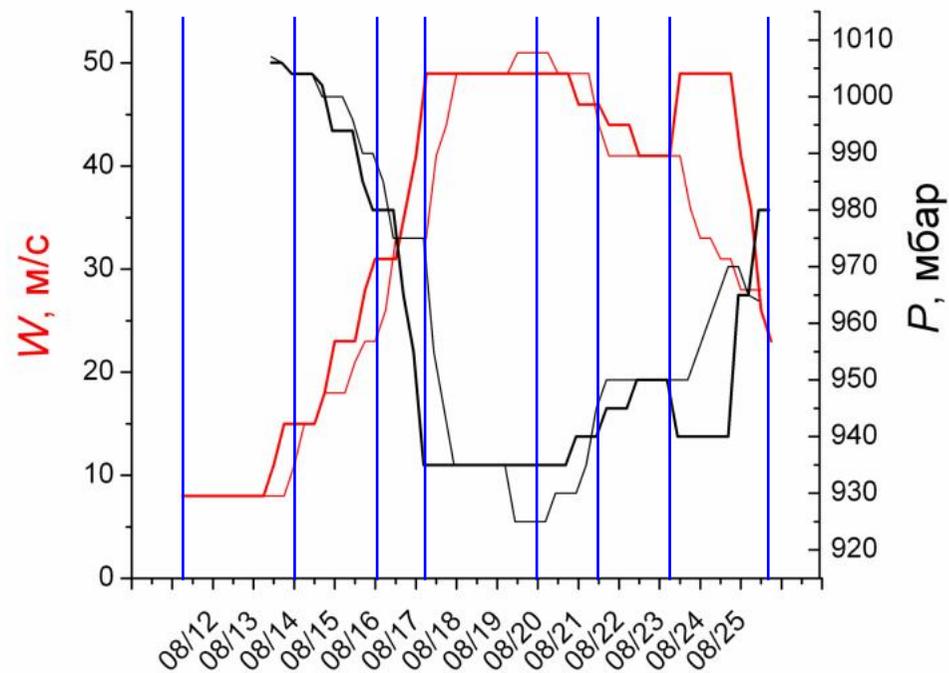
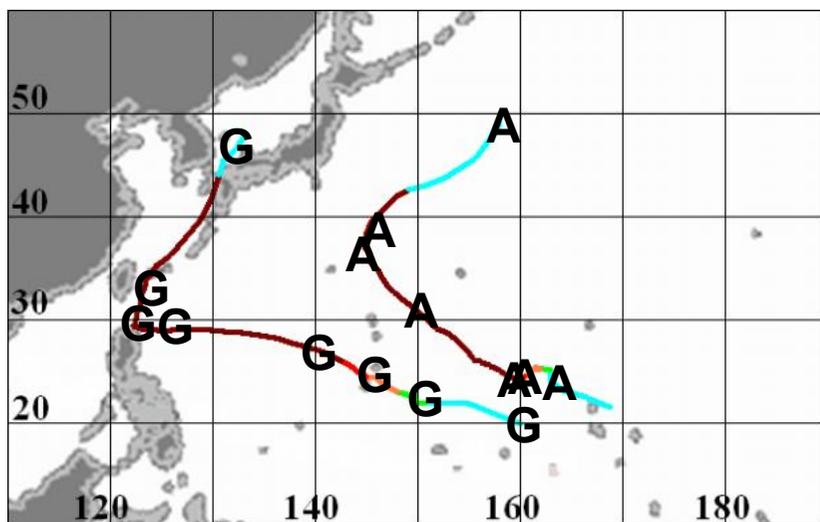
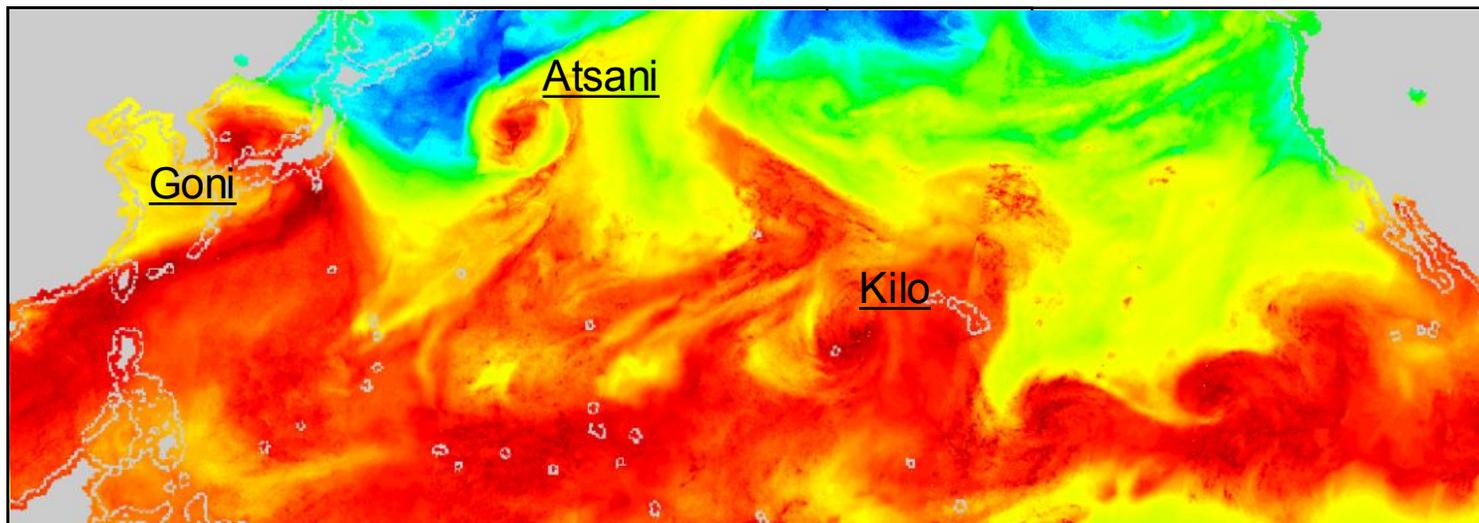
*Ermakov D.M., Sharkov E.A., Chernushich A.P.* Satellite radiothermovision of atmospheric mesoscale processes: case study of tropical cyclones // The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, Volume XL-7/W3, 2015 36th International Symposium on Remote Sensing of Environment, 11–15 May 2015, Berlin, Germany, pp. 179 – 186, doi:10.5194/isprsarchives-XL-7-W3-179-2015.

V, M/C

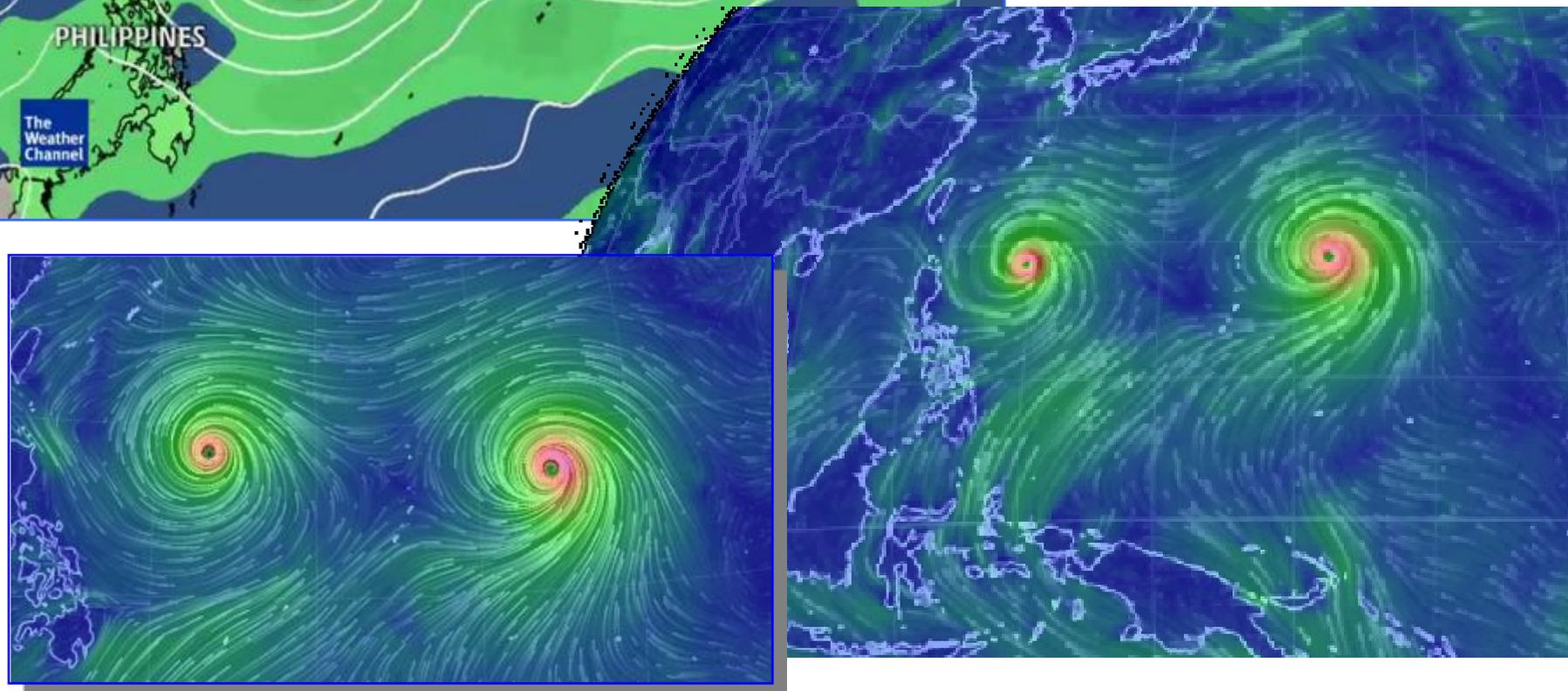
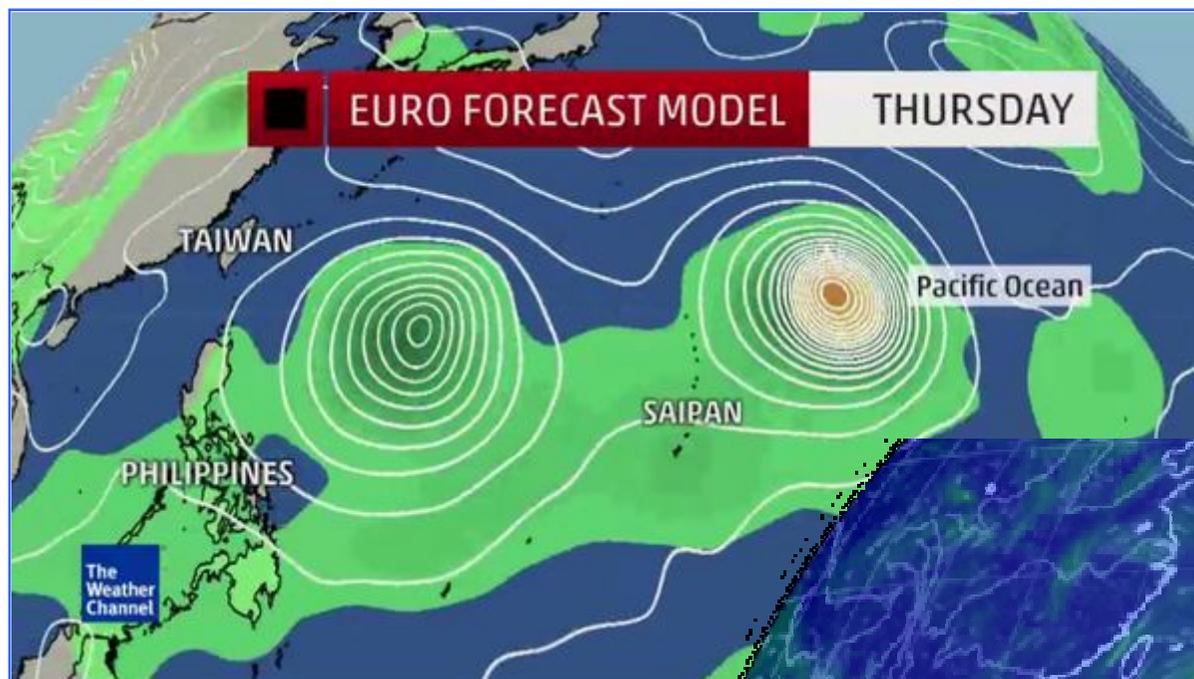
# Совмещение SSMIS и AMSR-2



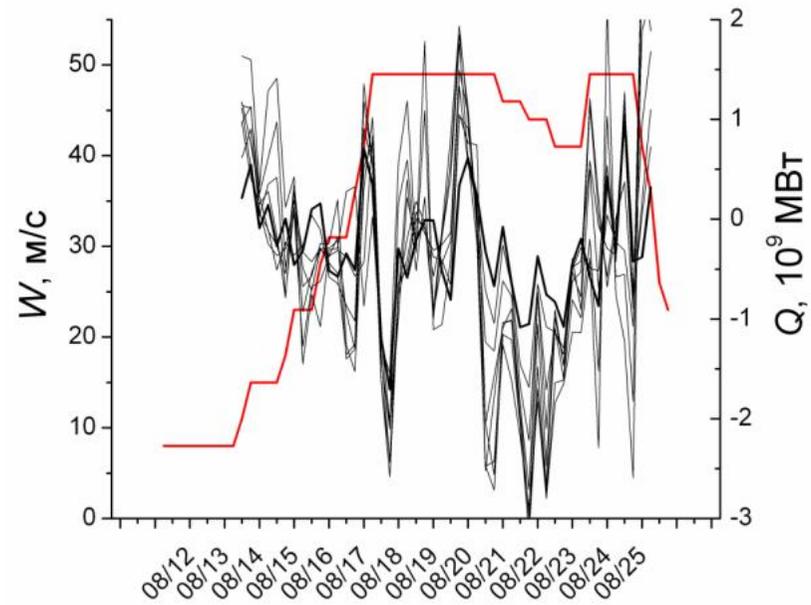
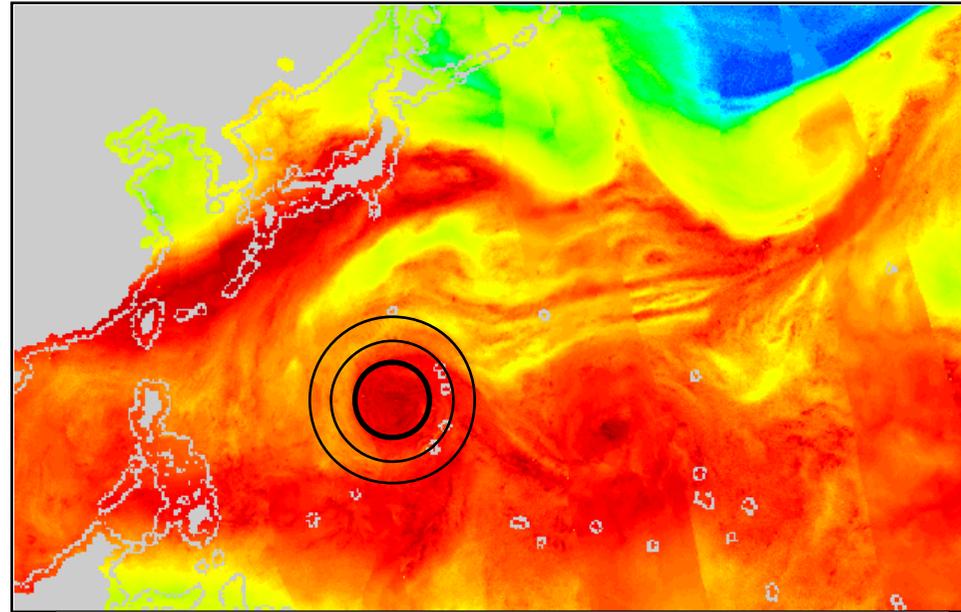
# Goni + Atsani, 12 – 25 августа 2015



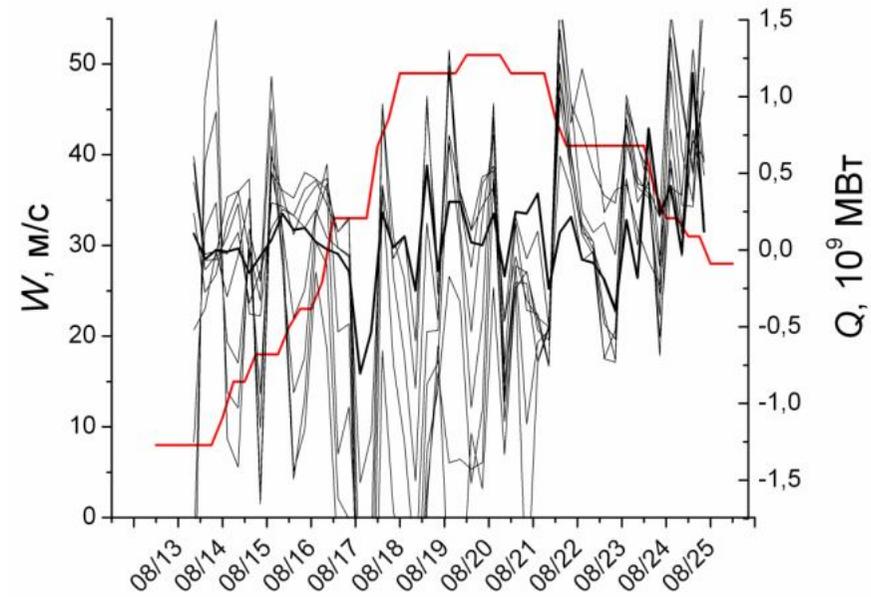
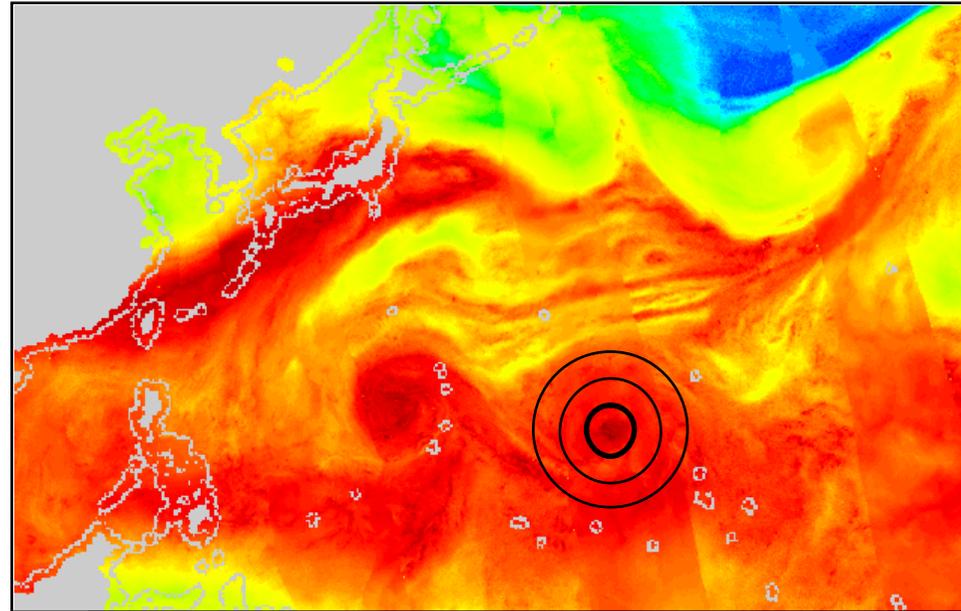
# Goni + Atsani: система взаимодействующих ТЦ



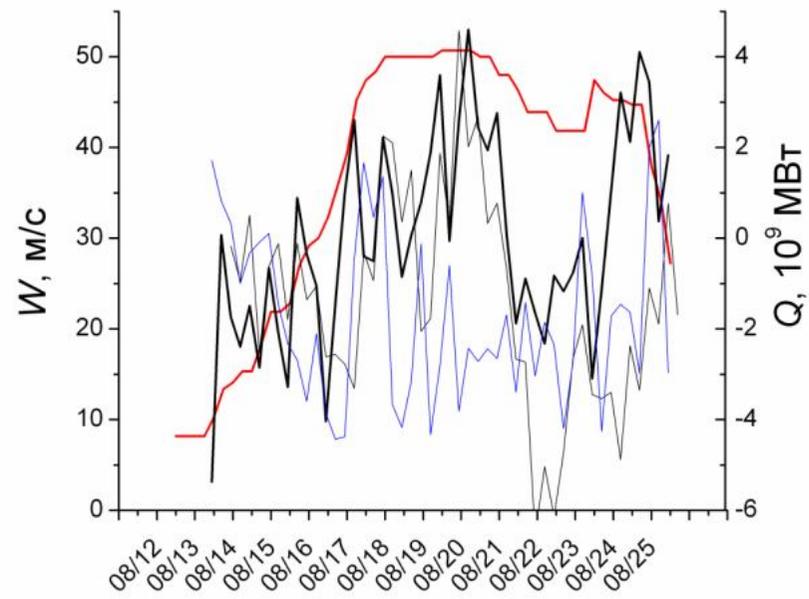
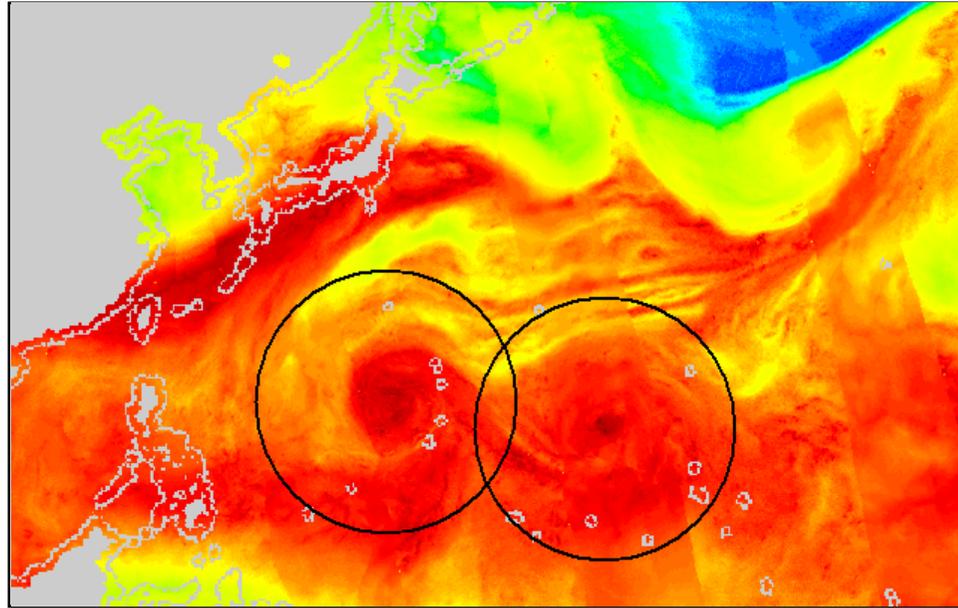
# Goni, потоки при малых $R$



# Atsani, потоки при малых $R$



# Goni + Atsani, потоки, общая граница



# От мезомасштабных к синоптическим процессам

SSMIS F16	01	02	03	04	05	06	07	08	09	10	11	12
2003										v7	v7	v7
2004	v7											
2005	v7		v7	v7	v7	v7						
2006	v7											
2007	v7											
2008	v7											
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2012	v7											
2013	v7		v7	v7								
2014	v7											
2015	v7											

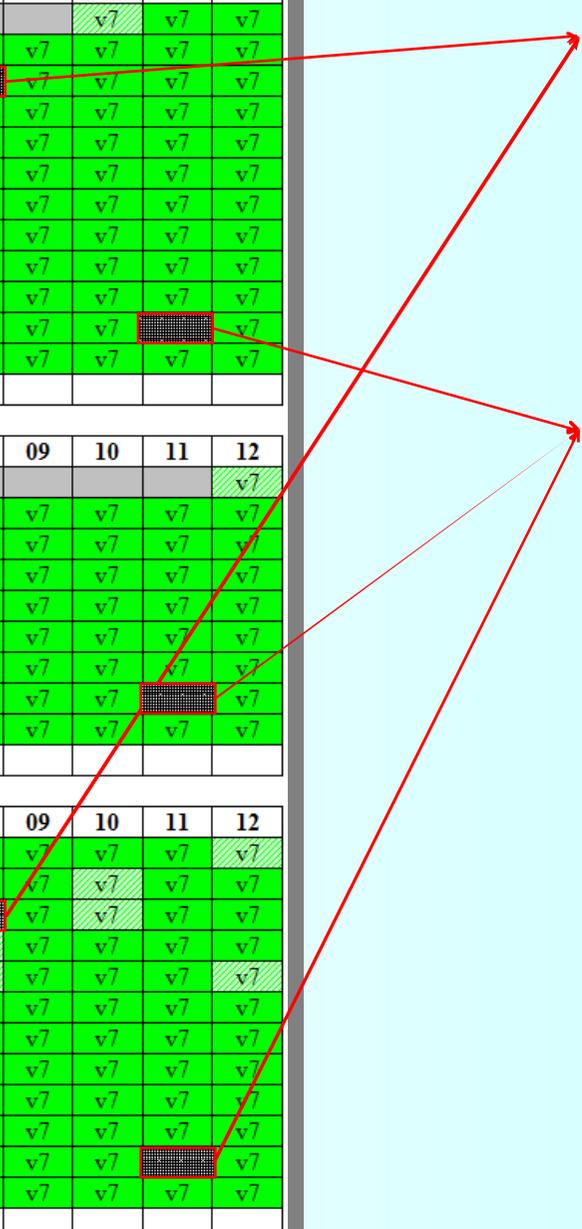
SSMIS F17	01	02	03	04	05	06	07	08	09	10	11	12
2006												v7
2007	v7											
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2013	v7		v7	v7								
2014	v7											
2015	v7											

WindSat	01	02	03	04	05	06	07	08	09	10	11	12
2003		v7										
2004	v7											
2005	v7	v7				v7	v7		v7	v7	v7	v7
2006	v7											
2007	v7	v7	v7	v7	v7	v7		v7	v7	v7	v7	v7
2008	v7											
2009	v7											
2010	v7											
2011	v7											
2012	v7											
2013	v7		v7	v7								
2014	v7											
2015	v7	v7	v7	v7	v7	v7						

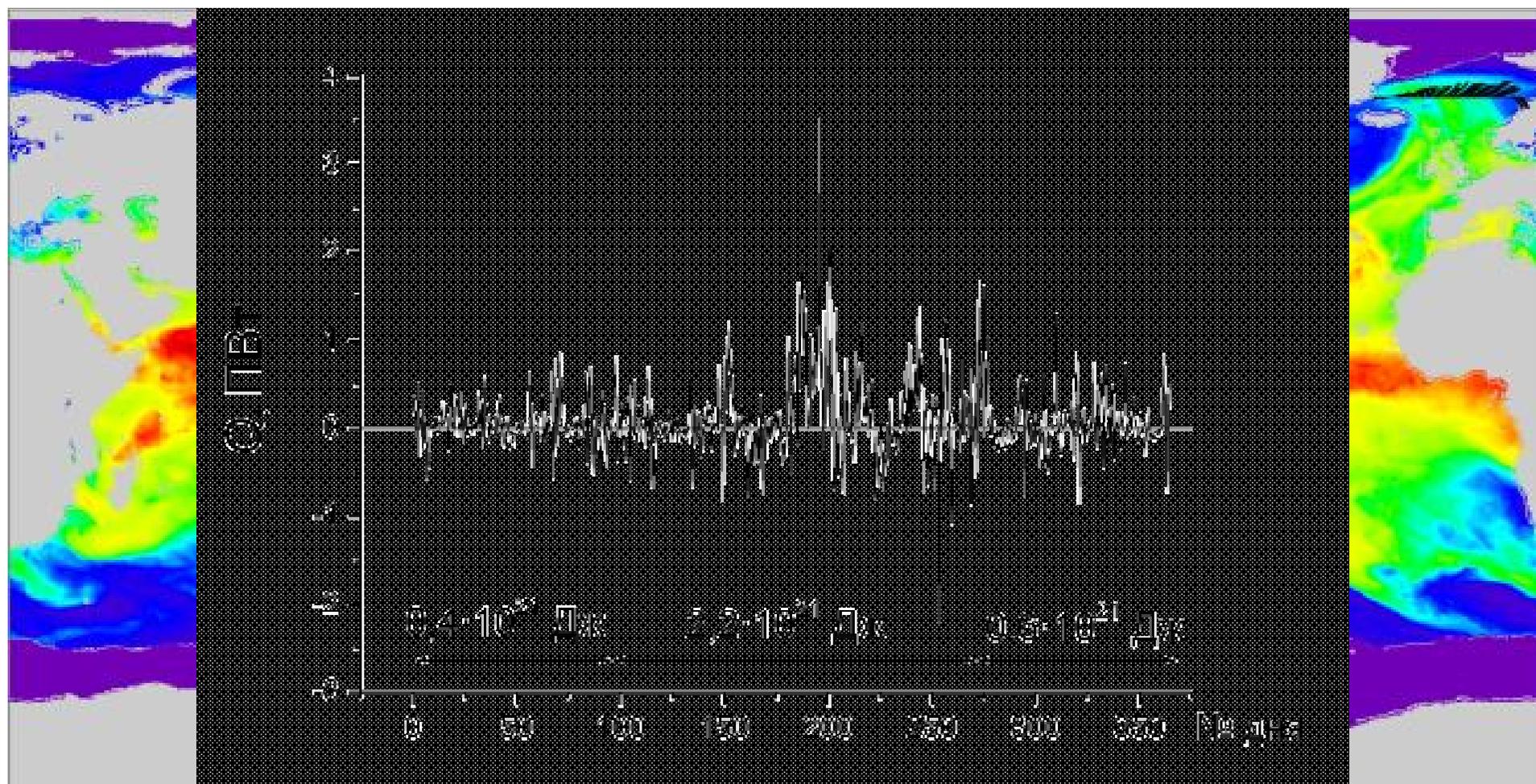
ТЦ Katrina

ТЦ Haiyan

ТЦ Podul



# Меридиональный поток скрытого тепла



# Геопортал спутникового радиотепловидения

← → ↻ fire.fryazino.net/tpw/Default.aspx

**СПУТНИКОВОЕ РАДИОТЕПЛОВИДЕНИЕ:**  
**ДИНАМИКА ГЕОФИЗИЧЕСКИХ ПОЛЕЙ**

Анимация Поля Методика Публикации Новости Контакты

2015 Параметер: TPW

**АНИМИРОВАННЫЕ ГЕОФИЗИЧЕСКИЕ ПОЛЯ**  
Динамика поля геофизического параметра атмосферы над акваториями Мирового океана: интегральное влагосодержание атмосферы (TPW) и водозапас облаков (CLW). Шаг по времени – 3 часа. Шаг сетки – 0,25°. Цветовая шкала значений в мм приведена справа.

Качество отображения анимированных полей зависит от пропускной способности сетевого соединения.  
Для получения полей в исходном виде откройте вкладку "Поля"

<http://fire.fryazino.net/tpw/Default.aspx>

# Заказ и получение данных

← → ↻ fire.fryazino.net/tpw/Fields.aspx

 **СПУТНИКОВОЕ РАДИОТЕПЛОВИДЕНИЕ:**  
**ДИНАМИКА ГЕОФИЗИЧЕСКИХ ПОЛЕЙ**

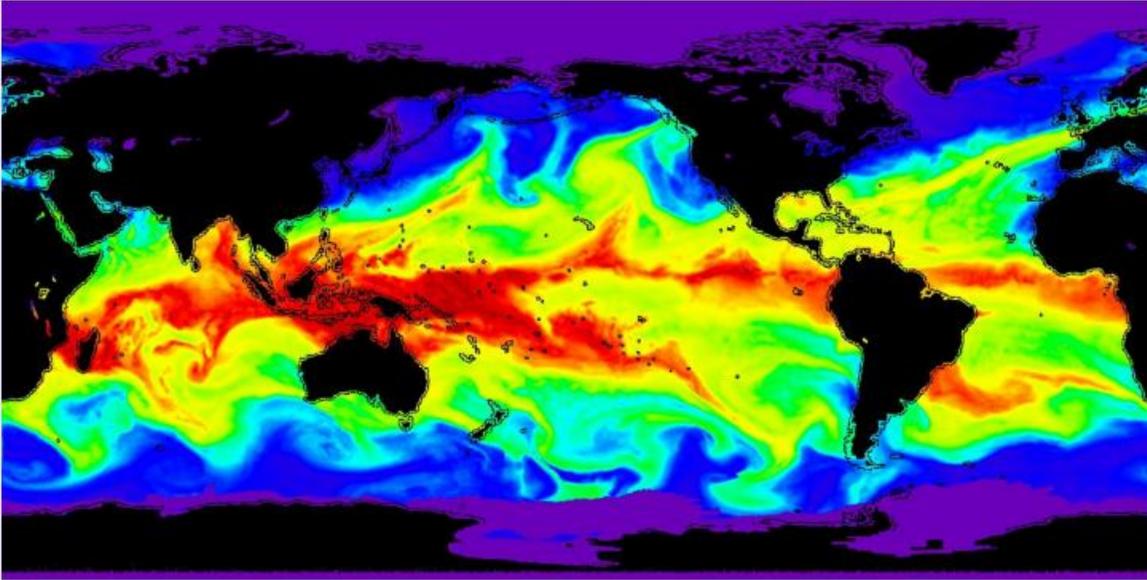
  

Анимация Поля Методика Публикации Новости Контакты

### ЗАКАЗ ПОЛЕЙ ИНТЕГРАЛЬНОГО ВЛАГОСОДЕРЖАНИЯ АТМОСФЕРЫ

Введите дату в формате год-месяц-день (YYYY-MM-DD) и время в формате часы-минуты(НН:ММ). Для выполнения расчета на заданное время нажмите на кнопку "Loc", "Ltw" или "Utc" справа от окна изображения. Для получения информации о типе поля, которое будет рассчитано, удерживайте курсор мыши над выбранной кнопкой (см. также примечание к пункту «Привязка по времени» раздела «Методика»). Рассчитанное поле будет показано в окне изображения. Для сохранения поля на свой компьютер нажмите кнопку "Save" под изображением.

Дата и время (2004-2015 гг.):



Loc  
Ltw  
Utc

Save

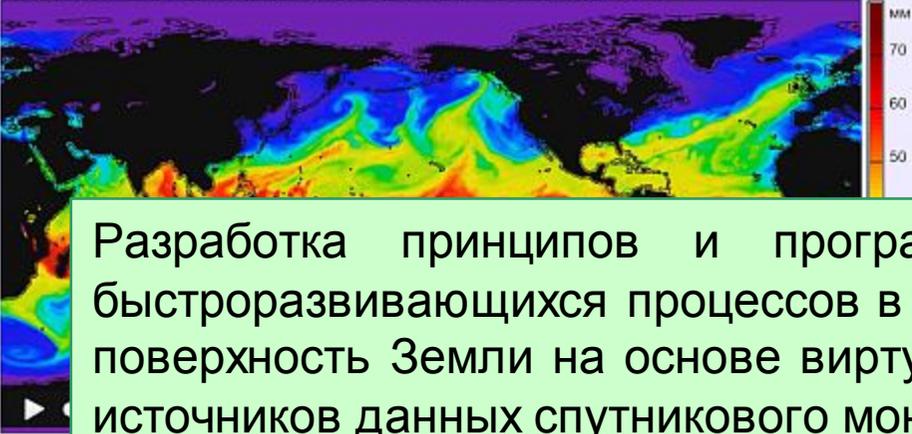
# Интерактивный Калькулятор для Атмосферных Расчетов

Спутниковое радиотепловидение:  
ДИНАМИКА ГЕОФИЗИЧЕСКИХ ПОЛЕЙ

Анимация Поля Методика Публикации Новости Контакты

2015 Параметр: TPW

АНИМИРОВАННЫЕ ГЕОФИЗИЧЕСКИЕ ПОЛЯ  
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Качество изображения: Для получения лучшего качества изображения нажмите на значок воспроизведения.

$R[x,y=240..480,t]=100*\text{del}(\text{tpw}[x,y,t], \text{sst}[x,y,t])*\sin(\text{latr}(y))$

$\text{del}(A,B)=(A-5,07)/0,38 - (B-27)/4$

$\text{latr}(y)=(90-0,25*y)*3,14159/180$

Разработка принципов и программных средств экспресс-анализа быстроразвивающихся процессов в системе атмосфера - подстилающая поверхность Земли на основе виртуальной интеграции распределённых источников данных спутникового мониторинга

Грант РФФИ № 15-07-04422 (2015 – 2017 гг.)

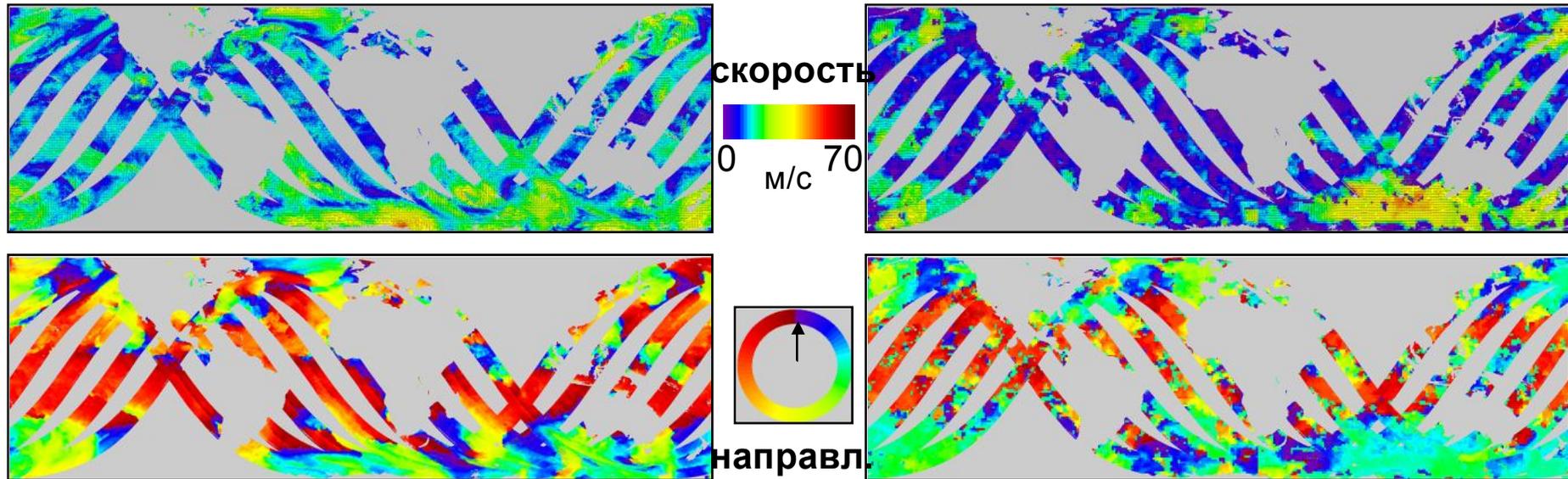
- Простой синтаксис
- Расширяемость
- Виртуальная интеграция
- Распределенные вычисления

# Адвекция и поля ветра

RapidScat (МКС)

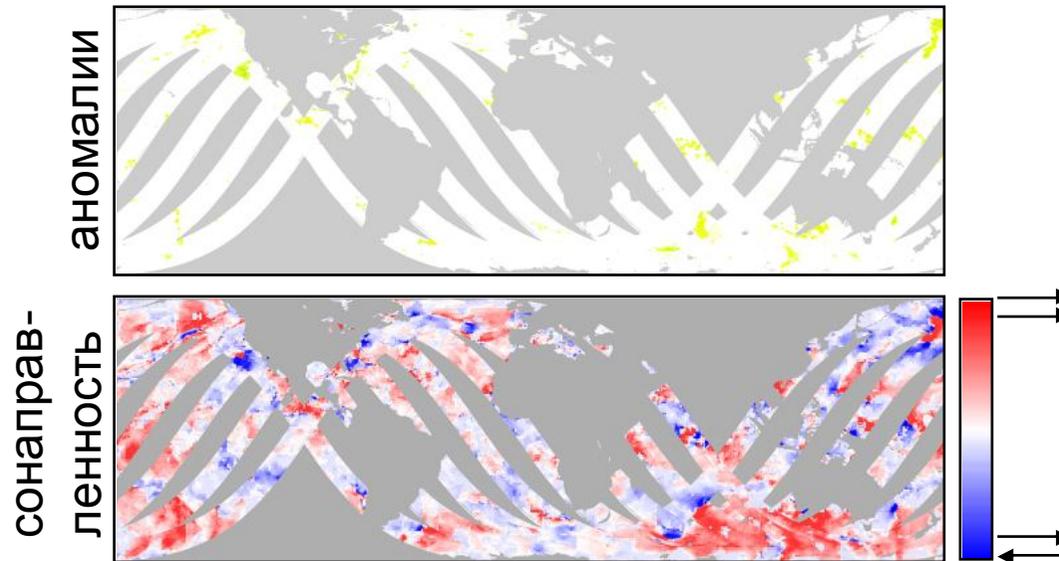
04 окт 2014, UTC < 12:00

Радиотепловидение

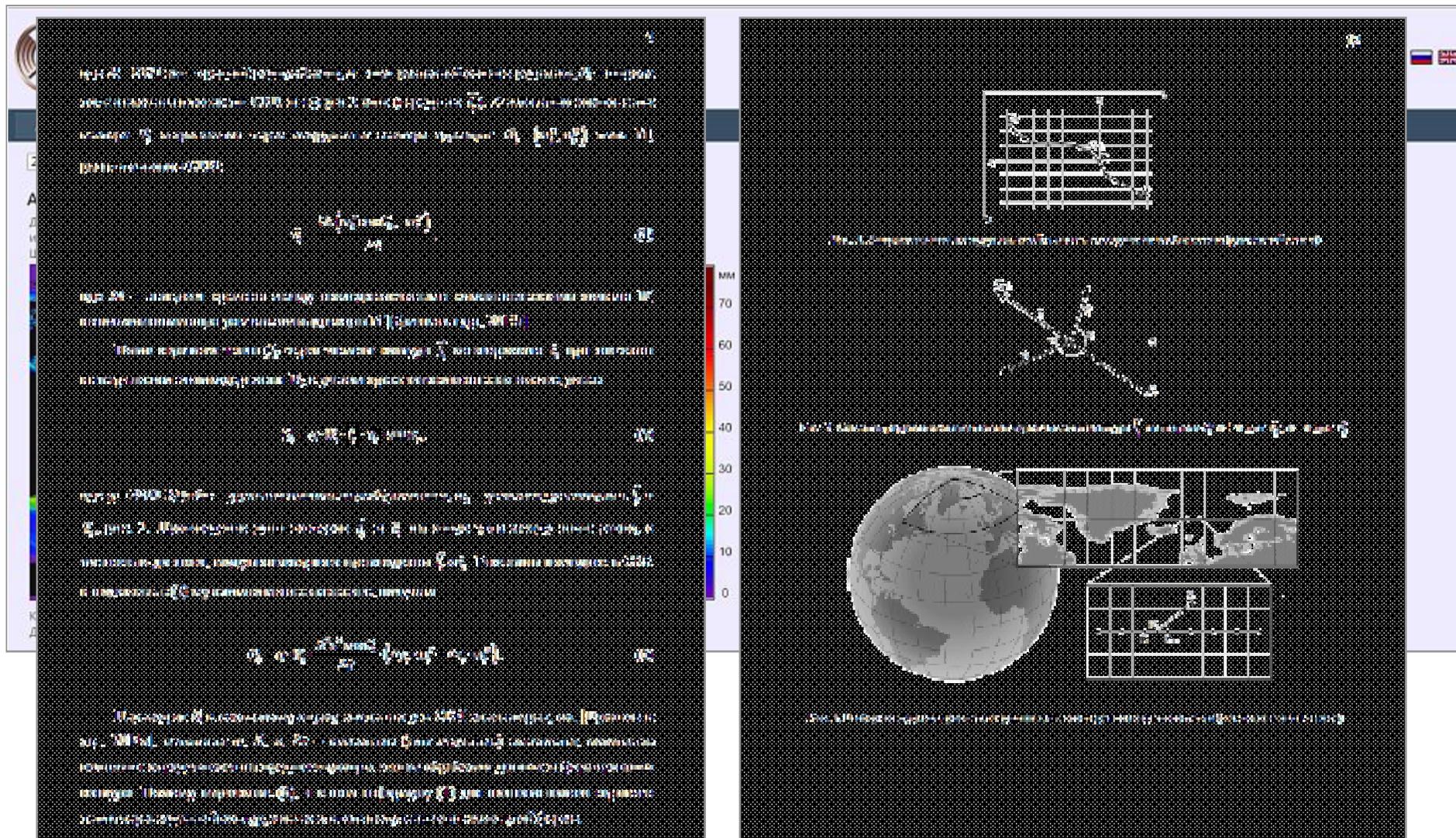


$$\vec{v} = k\vec{w} + \vec{\varepsilon}$$

$$k \approx \frac{(\vec{v} \cdot \vec{w})}{\vec{w}^2}$$

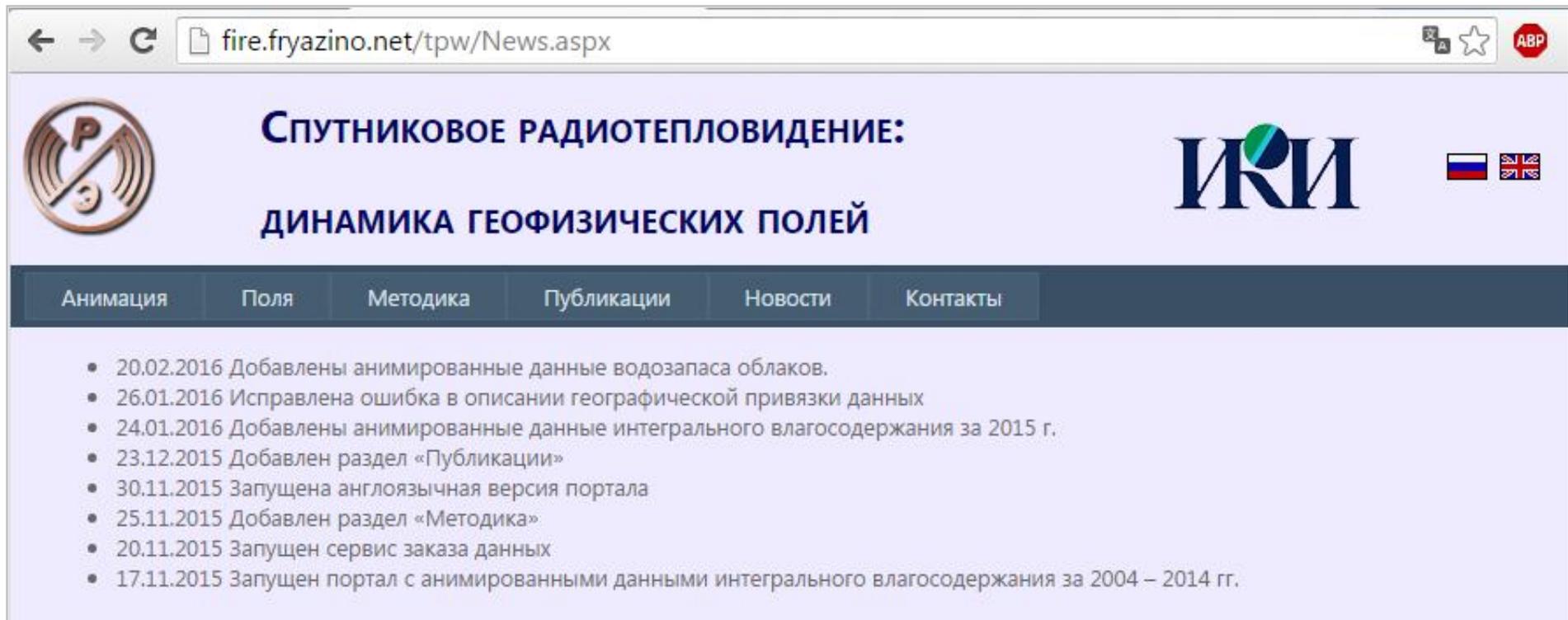


# Интерактивное спутниковое радиотепловидение



Ермаков Д.М., Шарков Е.А., Чернушич А.П. Спутниковое радиотепловидение на синоптических и климатически значимых масштабах // Исслед. Земли из космоса, 2016, 6.

# Обновления геопортала



← → ↻ fire.fryazino.net/tpw/News.aspx

 **СПУТНИКОВОЕ РАДИОТЕПЛОВИДЕНИЕ:**  
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Анимация Поля Методика Публикации Новости Контакты

- 20.02.2016 Добавлены анимированные данные водозапаса облаков.
- 26.01.2016 Исправлена ошибка в описании географической привязки данных
- 24.01.2016 Добавлены анимированные данные интегрального влагосодержания за 2015 г.
- 23.12.2015 Добавлен раздел «Публикации»
- 30.11.2015 Запущена англоязычная версия портала
- 25.11.2015 Добавлен раздел «Методика»
- 20.11.2015 Запущен сервис заказа данных
- 17.11.2015 Запущен портал с анимированными данными интегрального влагосодержания за 2004 – 2014 гг.

dima@ire.rssi.ru