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INSTITUTE OF MONITORING
OF CLIMATIC AND ECOLOGICAL SYSTEM

SIBERIAN BRANCH OF THE RUSSIAN ACADEMY OF SCIENCE

Investigation in the changes of eddy and advective heat fluxes over the southeastern part of Western Siberia

Usova E.I., Kharyutkina E.V., Loginov S.V., **Martynova Yu.V.**

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Purpose: **Estimate of the dynamics of advective and eddy heat fluxes in Tomsk region at the end of XX and at the beginning XXI centuries**

Era-Interim Reanalysis

- Term: 00, 06, 12, 18 UTC;
- Spatial distribution: 1,25° * 1,25° and 0,125° * 0,125°;

Region

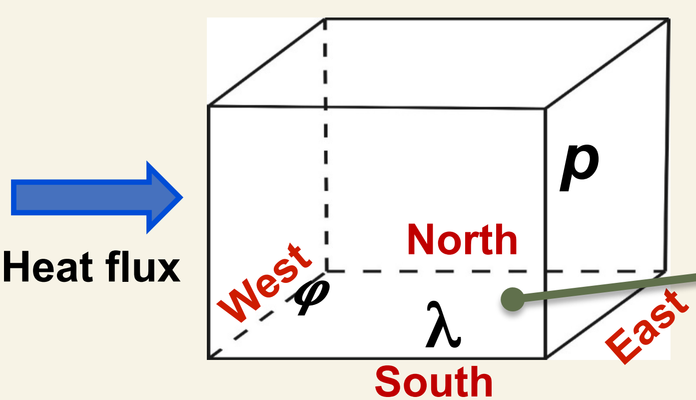
Tomsk region (55°- 62° N, 74°- 90° E)

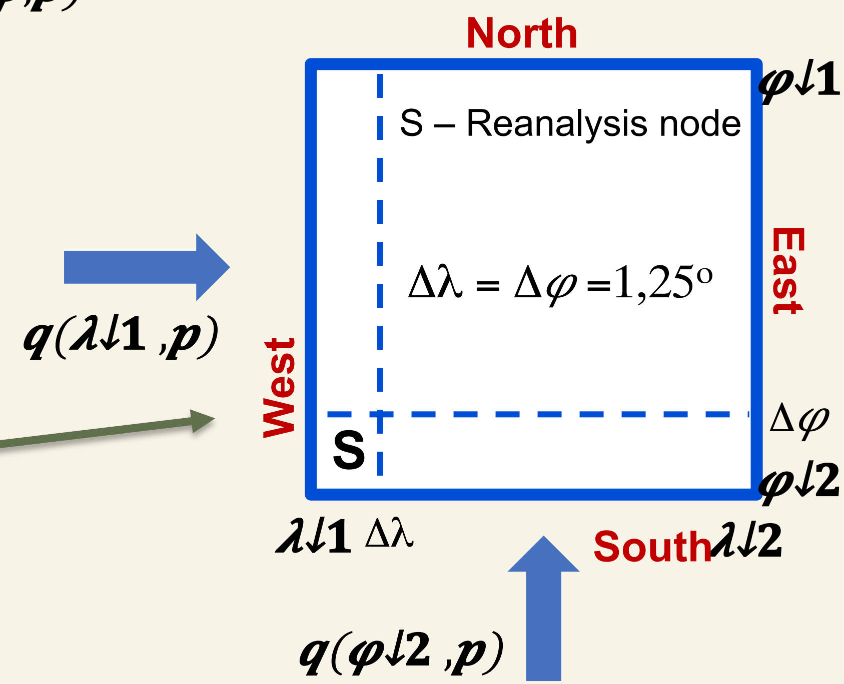
Calculation Method of Advective and Eddy Heat Fluxes

$$q(\lambda,\varphi,p) = -V(\lambda,\varphi,p) * \nabla Q(\lambda,\varphi,p)$$

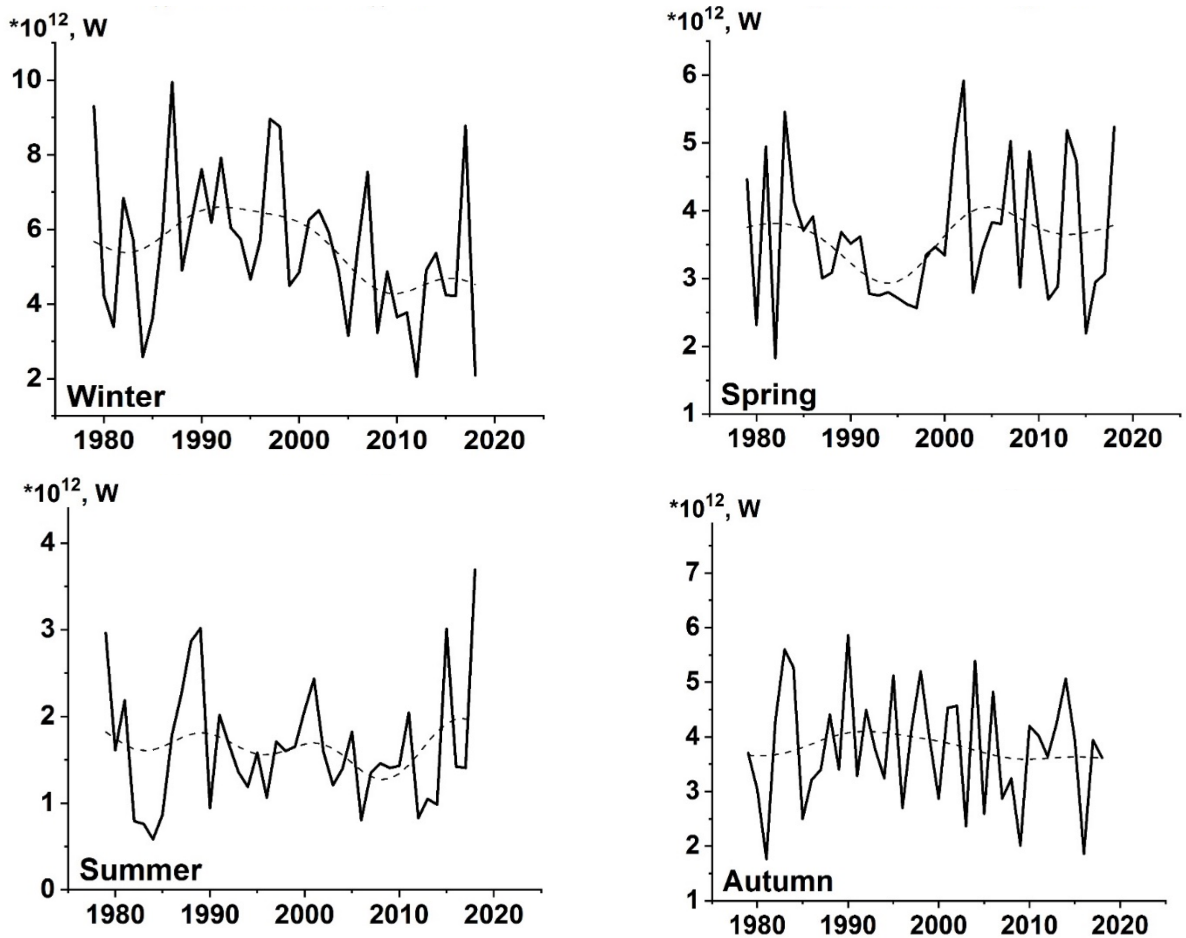
λ,ϕ,ρ – latitude, longitude and pressure at the isobaric height;

V – wind direction; ∇Q – air heat content gradient.





Total Advective Heat Flux Incoming to Tomsk Region



1. In the beginning of the XXI century over the whole region a decrease in advective transfer was observed in Autumn and in Winter, and an increase - in Spring and in Summer;

2. ***<u>Winter</u>*** is characterized by the maximum value of **advective heat transfer**;

3. For **eddy heat fluxes** the temporal tendencies is quiet similar, in general. But, the maximum eddy heat fluxes were observed ***in spring.***

Advective Heat Flux

Flux direction	Season	Total flux, 10^{12} ,W	West, %	East, %	North, %	South, %
Incoming flux	**Winter**	**5,52**	18	0	2	**80**
	Spring	3,6	19	0	31	**50**
	Summer	1,65	15	2	**50**	33
	Autumn	3,8	18	0	5	**77**
Outcoming flux	**Winter**	**4,23**	0	37	**61**	1
	Spring	2,43	0	28	**54**	17
	Summer	1,5	3	18	22	**57**
	Autumn	2,37	0	35	**60**	5

Eddy Heat Flux

Flux direction	Season	Total flux, 10^{12} ,W	West, %	East, %	North, %	South, %
Incoming flux	Winter	0,74	17	2	8	**73**
	Spring	**1,12**	15	0	34	**51**
	Summer	0,67	15	5	**57**	23
	Autumn	0,81	14	1	13	**72**
Outcoming flux	Winter	0,79	1	42	**52**	5
	Spring	**1,05**	0	26	**44**	30
	Summer	0,58	5	15	34	**46**
	Autumn	0,73	1	41	**48**	10

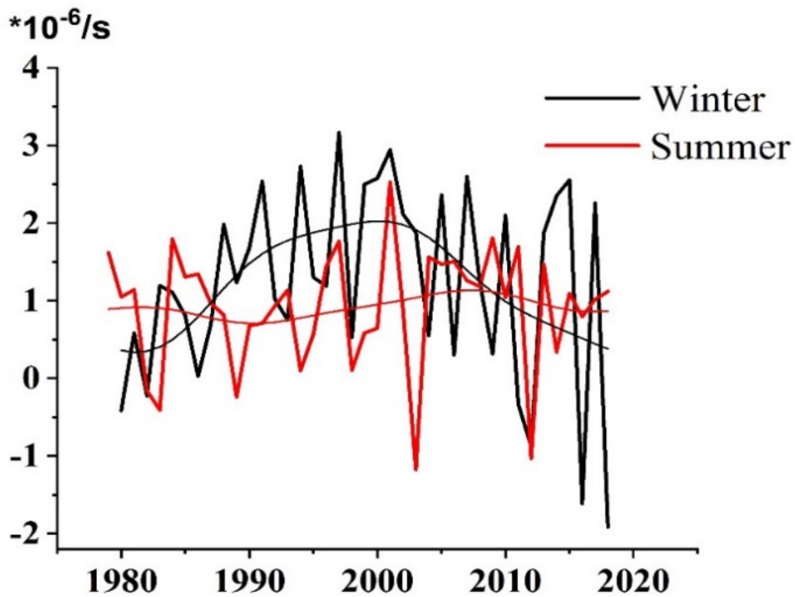
1. Distribution of advective and eddy heat transfer across the borders in Tomsk region is quiet similar, in general;

2. In Winter and Autumn, heat flux, incoming to the region from the southern border dominated (up to 80 %). In Spring, its value was reduced down to 50 % due to the growth of the heat flux, incoming from the northern border. In Summer, the opposite situation is observed: heat, incoming from the northern border – 50 %; incoming from southern border – 30 %;

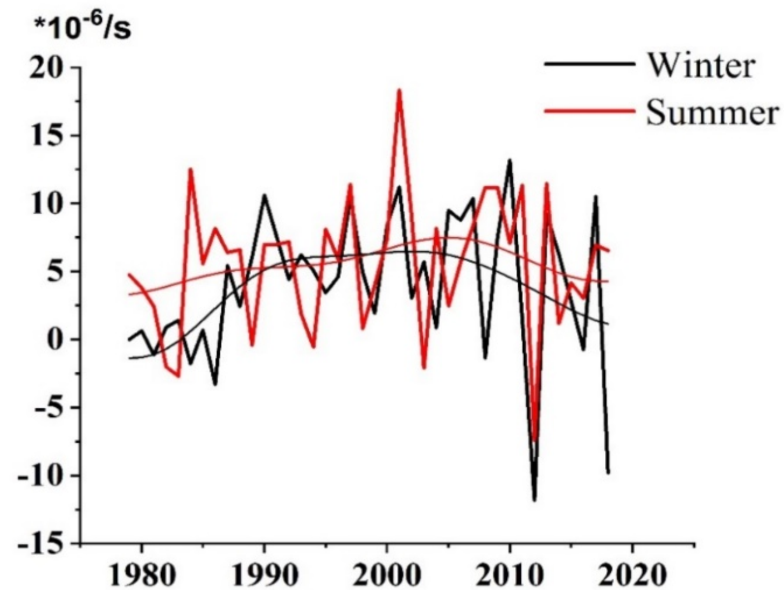
3. Heat fluxes, incoming to the region from the **southern border**, play a regulating role in revealed changes

Relative Vorticity

1000 hPa



500 hPa



1. There was a great fluctuation of the relative vorticity value at the beginning XXI centuries. However, in general, the tendency to negative values appearance was observed;
2. This indicates a decrease in cyclonic activity and an increase in the anticyclonic circulation type.

Investigation in the Changes of Eddy and Advective Heat Fluxes over the Southeastern Part of Western Siberia

Usova E.I., Loginov S.V., Kharyutkina E.V., Martynova Yu.V.

Institute of monitoring of climatic and ecological systems SB RAS, 634055, Tomsk, 10/3 Academichesky ave., e-mail: kh_ev@imces.ru

Purpose: Estimate of the dynamics of advective and eddy heat fluxes in Tomsk region at the end of XX and at the beginning XXI centuries

Era-Interim Reanalysis Data

- Term: 00, 06, 12, 18 UTC;
- Spatial distribution:
  - 1,25° * 1,25°
  - 0,125° * 0,125°

Region

- Tomsk region (55°- 62° N, 74°- 90° E)

Atmospheric Layer

- 1000 – 850 hPa

Time Intervals

- 1979 – 2018
- 1979 – 1998
- 1999 – 2018

Characteristics

- Advective heat flux
- Eddy heat flux
- Relative vorticity

Calculation Method of Advective and Eddy Heat Fluxes*

$$q(\lambda,\varphi,p) = -\vec{V}(\lambda,\varphi,p)\cdot\vec{\nabla}Q(\lambda,\varphi,p)$$

Western and eastern borders

$$q(\lambda,p) = \int_{\varphi_2}^{\varphi_1} q(\lambda,\varphi,p)\,d\varphi$$

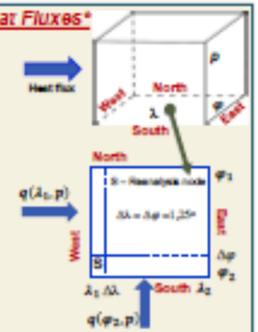
Northern and southern borders

$$q(\varphi,p) = \int_{\lambda_1}^{\lambda_2} q(\lambda,\varphi,p)\,d\lambda$$

An Example of calculation for the western border

Heat flux, incoming to the region	Heat flux, out coming to the region
$q(\lambda,p)^{in}_{total} = \int_{\varphi_2,\ u>0,\ \vec{V}_n\nabla Q>0}^{\varphi_1} q(\lambda,\varphi,p)d\varphi$	$q(\lambda,p)^{out}_{total} = \int_{\varphi_2,\ u<0,\ \vec{V}_n\nabla Q>0}^{\varphi_1} q(\lambda,\varphi,p)d\varphi$

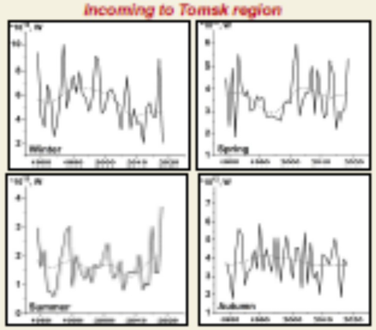
λ,φ,p – latitude, longitude and pressure at the isobaric height;
$\vec{V}$ – wind direction; ∇Q – air heat content gradient.



* Usova E.I., Loginov S.V., Kharyutkina E.V. The influence of heat fluxes in the Barents Sea on the temperature regime of West Siberia in winter season. // Optika Atmosfery i Okeana. 2018. V. 31. No. 06. P. 452-459 (in Russian)

Total advective heat flux

Incoming to Tomsk region



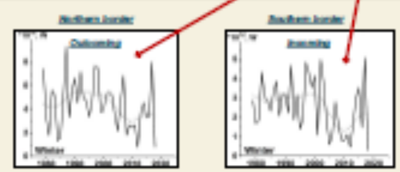
1. In the beginning of the XX century over the whole region a decrease in advective transfer was observed in Autumn and in Winter, and an increase - in Spring and in Summer;
2. **Winter** is characterized by the maximum value of **advective heat transfer**;
3. For **eddy heat fluxes** the temporal tendencies is quiet similar, in general. But, the maximum eddy heat fluxes were observed **in spring**;
4. In Winter and Autumn, heat flux, incoming to the region from the southern border dominated (up to 80 %). In Spring, its value was reduced down to 50 % due to the growth of the heat flux, incoming from the northern border. In Summer, the opposite situation is observed: heat, incoming from the northern border – 50 %; incoming from southern border – 30 %;
5. Heat fluxes, incoming to the region from **the southern border**, play a regulating role in revealed changes.

Distribution of heat transfer

across the borders in Tomsk region over 1979 - 2018

Advective flux

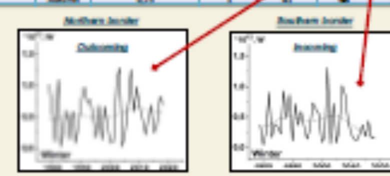
Flux direction	Season	Total flux, 10^{13} W	West, %	East, %	North, %	South, %
Incoming flux	Winter	3,52	18	0	2	80
	Spring	3,6	18	0	31	50
	Summer	1,48	18	2	50	30
	Autumn	3,6	18	0	8	77
Outcoming flux	Winter	4,23	0	37	61	1
	Spring	2,45	0	26	56	17
	Summer	1,6	5	18	21	57
	Autumn	2,37	0	38	60	0



The temporal variability of the advective heat flux in winter

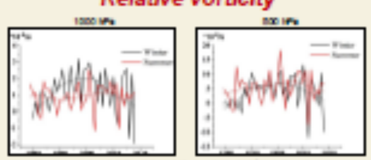
Eddy flux

Flux direction	Season	Total flux, 10^{13} W	West, %	East, %	North, %	South, %
Incoming flux	Winter	0,74	17	3	4	78
	Spring	1,12	18	0	34	51
	Summer	0,67	18	8	57	20
	Autumn	0,61	14	1	13	72
Outcoming flux	Winter	0,70	1	43	52	0
	Spring	1,20	0	26	46	30
	Summer	0,56	8	[illegible]	34	49
	Autumn	0,75	1	41	48	10



The temporal variability of the eddy heat flux in Tomsk region in winter

Relative vorticity



The temporal variability of the relative vorticity (*10⁻⁶/s) in Tomsk region

1. There was a great fluctuation of the relative vorticity value at the beginning XXI centuries. However, in general, the tendency to negative values appearance was observed;
2. This indicates a decrease in cyclonic activity and an increase in the anticyclonic circulation type.

For Discussion

Weather and climatic conditions were formed not only due to the processes of large-scale atmospheric circulation. Probably, the influence of local factors prevailed: the formation of local forms of circulation (cyclones and anticyclones) will contribute to the intensification of convective processes. And, as a result, to the associated weather conditions. Therefore, investigating in regional climate change problem, it is very important to take into account local scale circulation processes variability.

Acknowledgments
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