«Estimations of numerical experiments results with model WRF in polar regions»

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Non-hydrostatic regional model WRF

(The national centre of Atmospheric Researches),

Classic

Polar

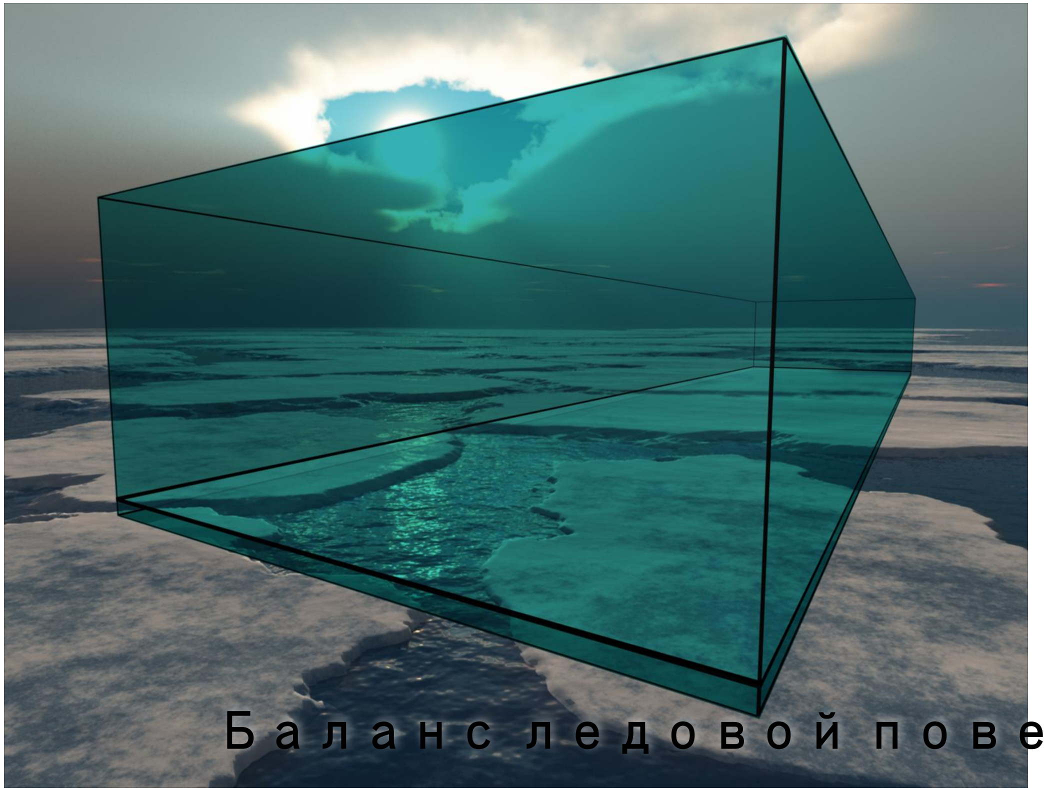
Features of the polar version

Albedo

Density

Heat conduction

Ice fraction



Thermometric conductivity

Water content

Roughness

Б а л а н с л е д о в о й п о в е р х н о с т и

Topic

Verification of model WRF on the basis of unique observations given from drifting stations the North Pole – 35 and the North Pole – 36.

An estimation sensible and latent fluxes from underlying surface.

о. Гренландия
о. Элсмир
м.Моррис-Джесуп
хребет Альфа
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Чукотское поднятие
Чукотское море
Берингове пролив
м. Барроу
м. Лисберн
7-OCT-2009
NP-37
open 7-SEN-2009
15-JAN-2009
1-JAN-2009
30-AUG-2009
NP-36
7-SEN-2008
хребет Менделеева
о.Врангеля
пр.Лонга
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Певек
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Ню-Олесунн
Баренцбург
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о. Белый
архипелаг Шпицберген
15-JUL-2008
котловина Нансена
85 °с.ш.
1-JAN-2008
котловина Амундсена
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хребет Гаккеля
котловина подводников
Восточно-Сибирское море
NP-35
21-SEN-2007
Нагурская
Земля Франца-Иосифа
о. Ушакова
о. Шмидта
м. Арктический
Северная Земля
м. Песчаный
о. Визе
80 °с.ш.
Баренцево море
Мурманск
Мыс Желания
Карское море
море Лаптевых
Новосибирские о-ва
о-ва Де-Лонга
пр.Санникова
пр.Дм.Лаптева
пр.Вилькицкого
м. Челюскин
м. Святой Нос
м. Канин Нос
Новая Земля
о.Колгуев
пр.Карские Ворота
о.Вайгач
п-ов Ямал
75 °с.ш.
Диксон
п-ов Таймыр
Хатанга
Тикси
шкала глубин (м)
масштаб
0 100 200 300 400 500 км
проекция Ламберта
4500 4000 3500 3000 2500 2000 1500 1000 500 200 100 0
NP-35 21/09/2007 - 15/07/2008
NP-36 07/09/2008-30/08/2009
HIGH LATITUDE ARCTIC EXPEDITON OF AARI, ROSHYDROMET

Preliminary estimations of model WRF

11.12.2007 - 19.12.2007

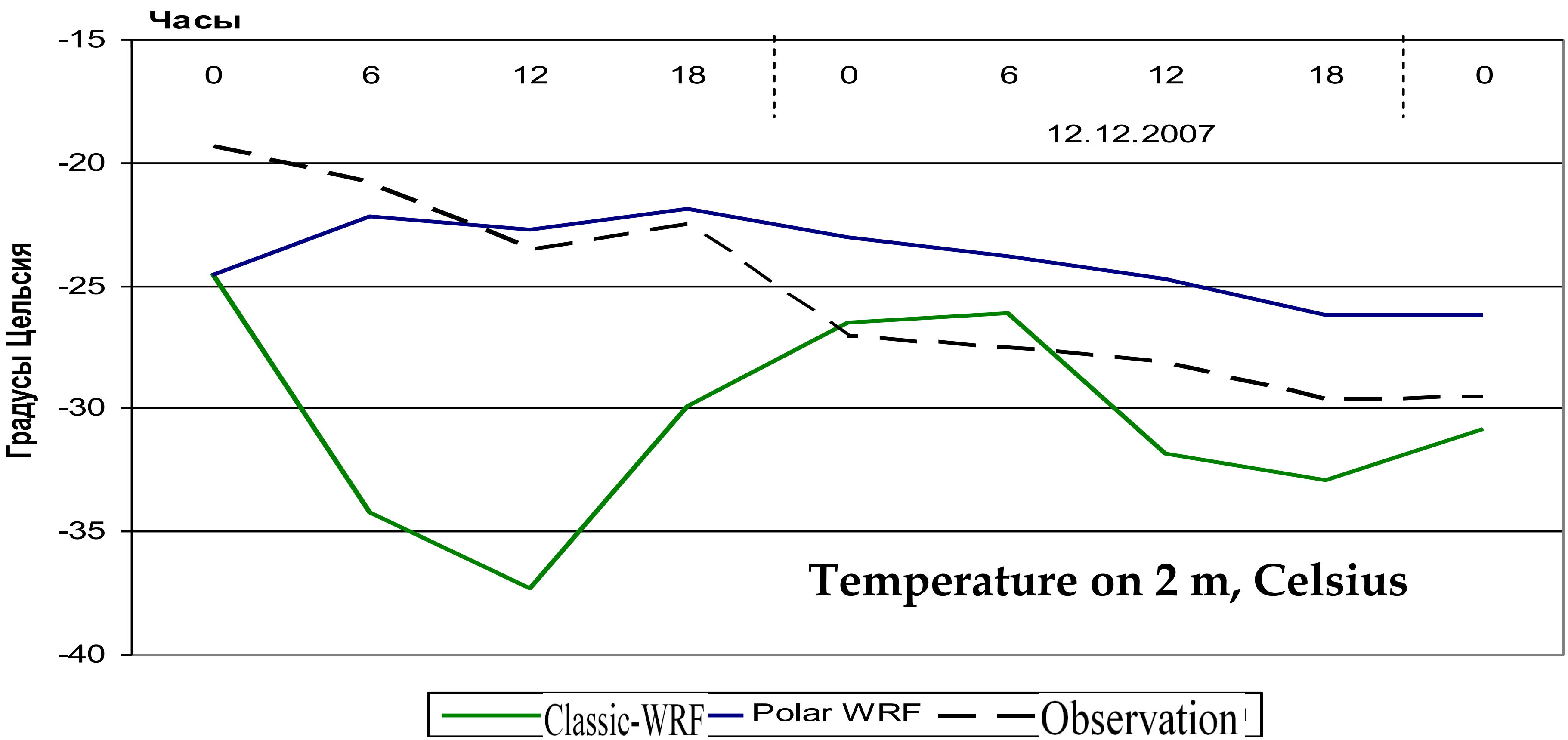
Spatial step - 2 км,
Length of forecast - 36 h.
Initial and boundary conditions - NCAR Finally Analysis

Estimation of initial fields, mean for 11.12.2007 - 19.12.2007

	Mean difference	Standard deviation
Temperature on 2м (C)	**4.7**	**2.9**
Humidity on 2м (%)	**8**	**3**
Wind speed on 10 м (м/с)	**2.4**	**3.1**

Estimations of forecasts, Polar and Classic versions of WRF, mean for 11.12.2007 - 19.12.2007.

	Polar version		Classic version	
	Mean difference	Standard deviation	Mean difference	Standard deviation
Temperature on 2м (C)	2.7	1.4	6.8	5.3
Humidity on 2м (%)	4	2	9	6
Wind speed on 10 м (м/с)	1.4	0.6	1.4	0.6



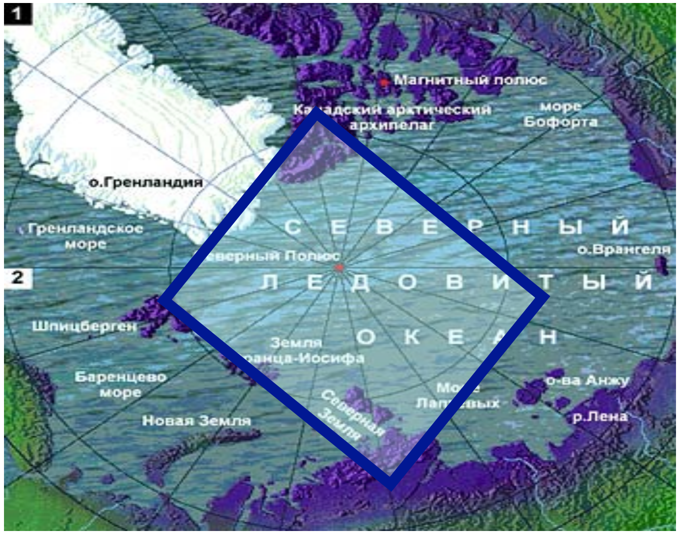
Mean estimations on a column of atmosphere from a surface to 100 hPa vertical profiles of temperature, relative humidity and wind speed for a cloudless interval and cloudy.

	Cloudlessly interval		Cloudly interval	
	Mean difference	Standard deviatiin	Mean difference	Standard deviatiin
Temperature on 2м (C)	2.1	1.7	1.9	1.6
Humidity on 2м (%)	8.5	7.3	10.9	11.3
Wind speed on 10 м (м/c)	1.8	1.3	1.7	1.4

Conclusions:

- Preliminary level of estimations which can improve further is received
- Calculations on the polar version of model WRF are closer to measurements than on the common version
- Initial fields produce the big Errors which influence on forecast quality
- More exact description of balance of a surface attracts considerable improvement quality of forecasts.

Выбор оптимальной конфигурации модели для полярных областей.



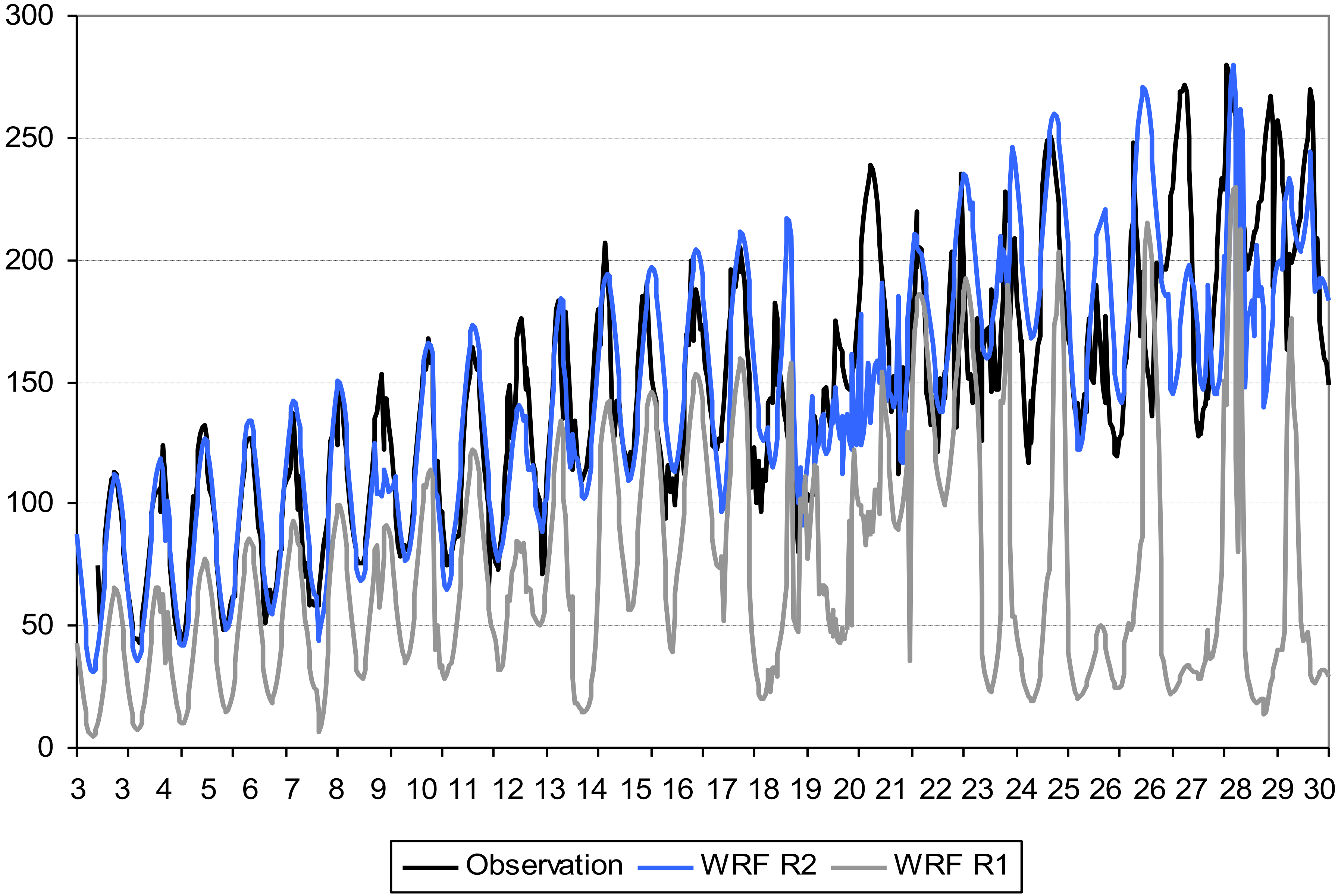
Parameterization of radiation
- R1 – Dudhia J scheme
- R2 – RRTMG Scheme

Parameterization of turbulence
- T1 – Monin-Obufhov scheme
- T2 – Monin-Obukhov (Janjic) scheme

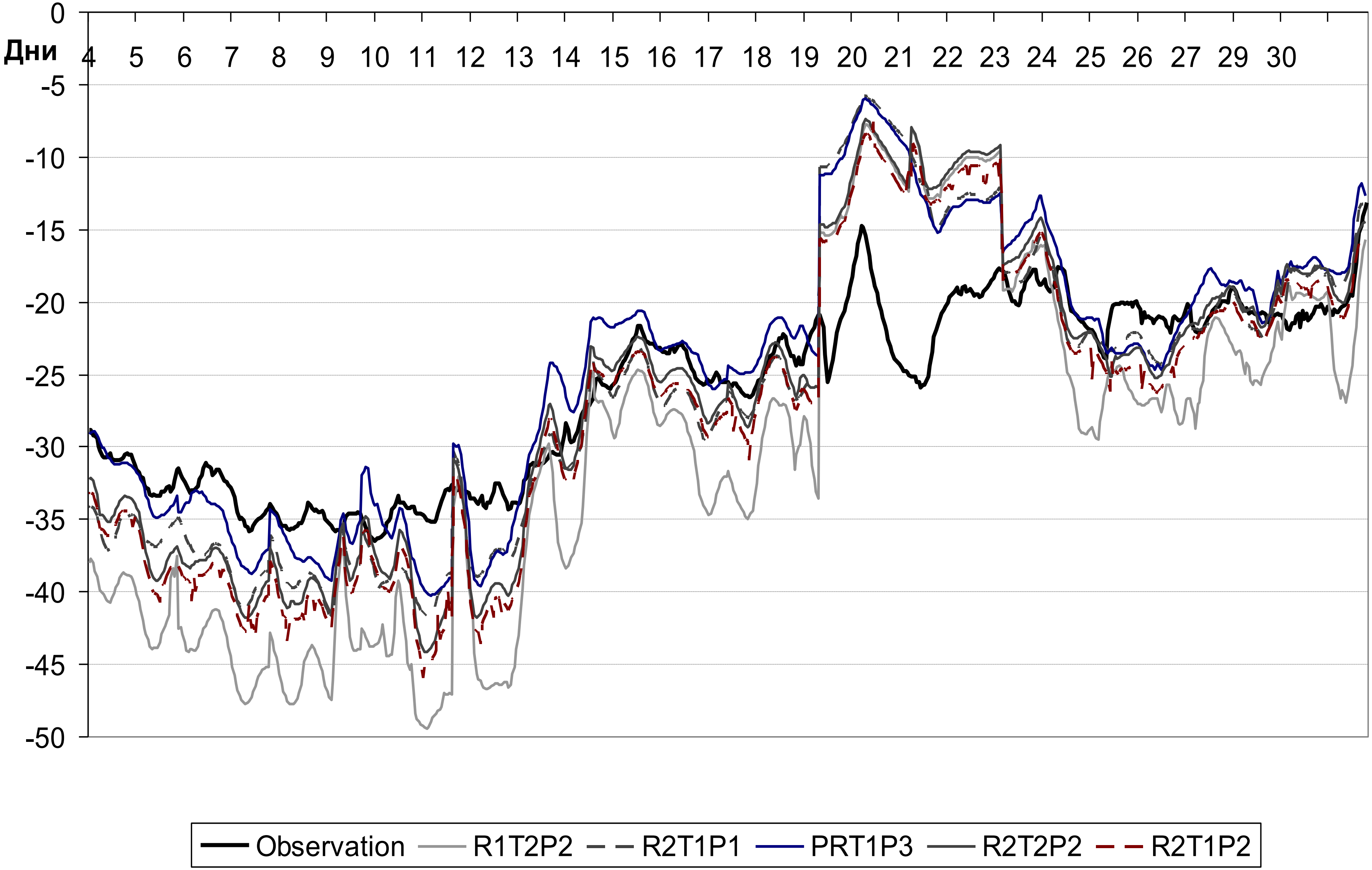
Parameterization of boundary layer
- P1 – Mellor-Yamada-Janjic TKE scheme
- P2 – Mellor-Yamada-Janjic 3rd level TKE scheme
- P3 – Modified Bougeault and Lacarrere scheme

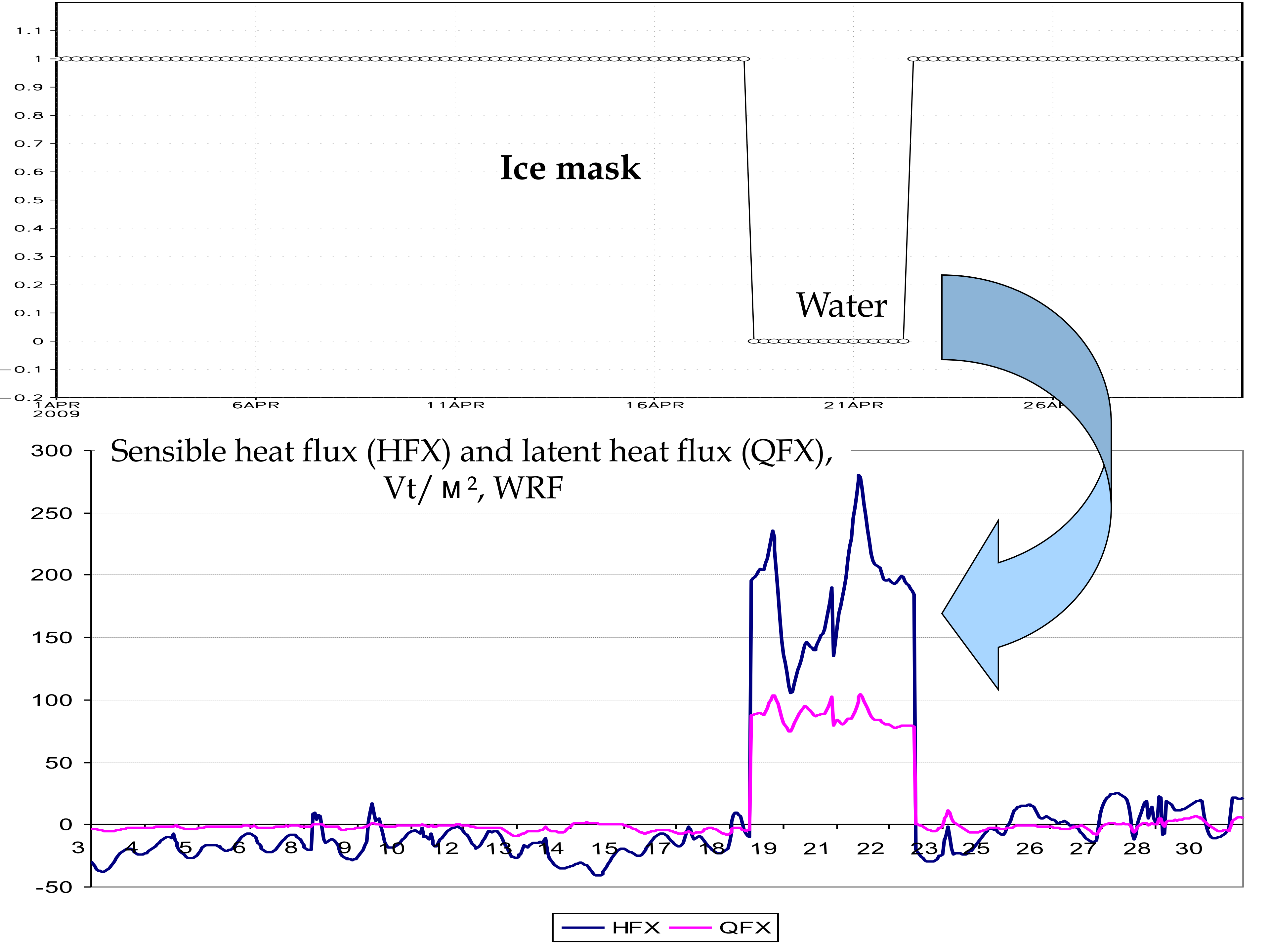
Experiment	T2 (°C)		T8 (°C)		Q2 (g/kg)		Q8 (g/kg)		W10 (м/с)	
	Δ	D	Δ	D	Δ	D	Δ	D	Δ	D
Fnl	5.4	10.3	-	-	-	-	-	-	2.7	3.2
R1T2P2	7.0	14.8	6.3	14.6	0.14	0.04	0.14	0.04	1.4	1.9
R2T1P1	3.8	11.9	3.4	8.2	0.21	0.14	0.18	0.13	1.4	1.5
R2T1P3	3.1	11.4	3.0	8.1	0.16	0.05	0.17	0.04	2.4	2.1
R2T2P2	4.0	11.7	3.4	8.4	0.25	0.11	0.24	0.14	1.6	2.2
R2T1P2	3.9	11.5	3.5	8.5	0.28	0.12	0.27	0.14	1.9	2.2
HirHam	5.2	2.5	-	-	-	-	-	-	1.9	1.6

Coming short-wave radiation (Vt/m²). Observation and experiments with WRF with two various parameterizations of radiation.



Temperature on 2 m (°C). Observation and experiments with different parameterizations, April 2009.




Ice mask
Water
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
1APR
2009
6APR
11APR
16APR
21APR
Sensible heat flux (HFX) and latent heat flux (QFX),
Vt/ м², WRF
300
250
200
150
100
50
0
-50
3
4
5
6
8
9
10
12
13
14
15
17
18
19
21
22
23
25
26
27
28
30
HFX
QFX

Estimations of forecast

spatial step 10 кm

Experiment	T2 (°C)		T8 (°C)		W10 (м/с)	
	Δ	**D**	**Δ**	**D**	**Δ**	**D**
R1 T 2P2	5.4	7.8	6.3	7.6	1.2	1.7
R2 T 1P1	2.6	2.9	2.4	3.2	1.2	1.4
R2 T 1P3	2.1	2.4	2.2	2.4	2.2	1.9
R2 T 2P2	3.0	3.2	3.4	3.4	1.3	2.0
R2 T 1P2	2.9	3.3	2.5	3.5	1.7	2.0

spatial step 2 кm

Experiment	T2 (°C)		T8 (°C)		Q2 (g/kg)		Q8 (q/kg)		W10 (м/с)	
	Δ	**D**	**Δ**	**D**	**Δ**	**D**	**Δ**	**D**	**Δ**	**D**
R2 T 1P3	**1.8**	**2.2**	1.8	2.3	0.1	0.02	0.1	0.02	1.3	1.9

Calculation of turbulence fluxes

$$Ri = 0$$

Indifferent stratification

$$\Delta U = \frac{U_*}{\chi} \ln \frac{z_2}{z_1}$$

$$\Delta \theta = \theta_* \ln \frac{z_2}{z_1}$$

$$\Delta q = q_* \ln \frac{z_2}{z_1}$$

$$Ri \geq 0.2$$

Strongly unstable stratification

$$U_* = \frac{\chi \Delta U + \chi N (z_2 - z_1)}{(\ln \frac{z_2}{z_2} + \beta_u \frac{z_2 - z_1}{L})}$$

$$\theta_* = \frac{\chi \Delta \theta}{(\ln \frac{z_8}{z_2} + C_o \frac{z_2 - z_1}{L} + C_o C_N \frac{Fr^3 (z_2 - z_1)}{L})}$$

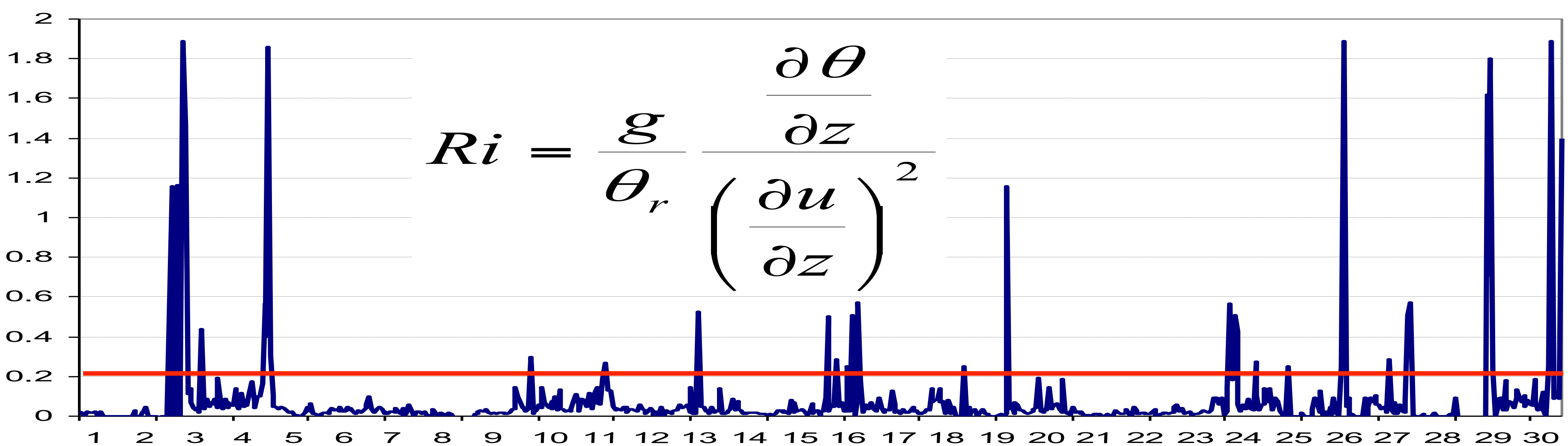
$$0.2 > Ri > 0$$

Stable stratification

$$\Delta U = \frac{U_*}{\chi} (\ln \frac{z_2}{z_1} + \beta_u \frac{z_2 - z_1}{L})$$

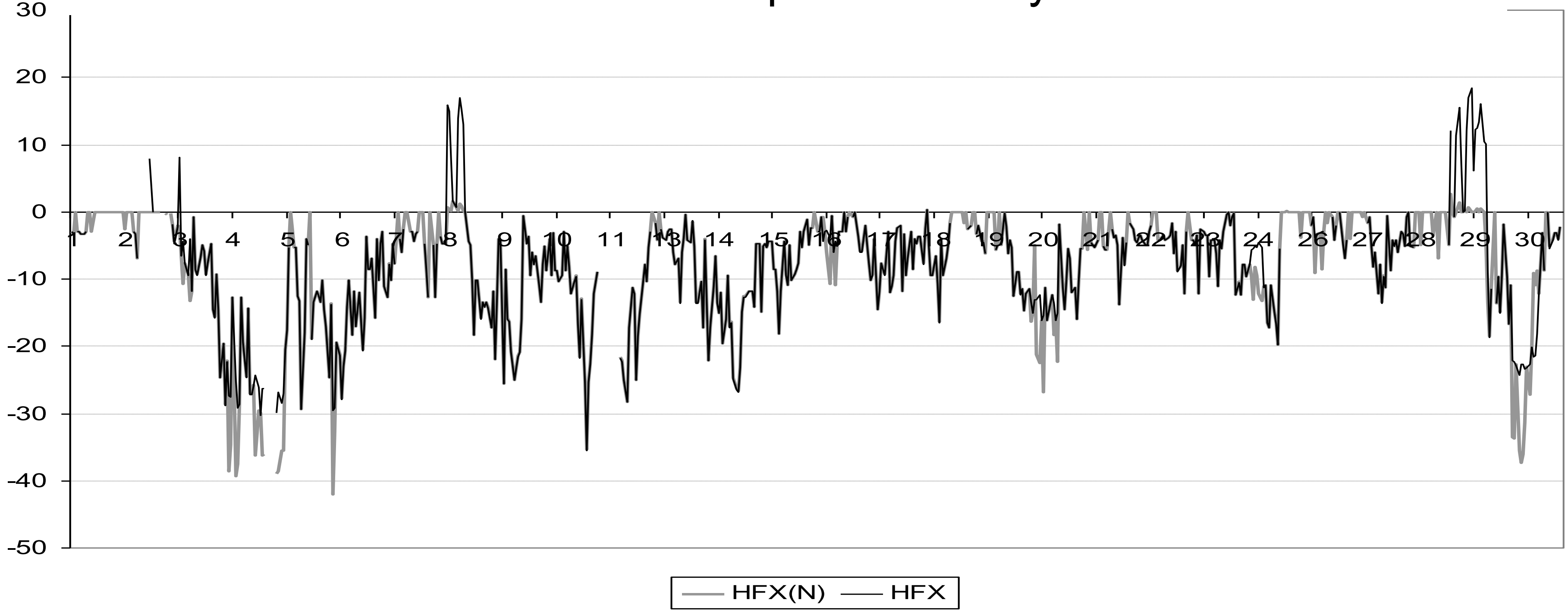
$$\Delta \theta = \theta_* (\ln \frac{z_2}{z_1} + \beta_\theta \frac{z_2 - z_1}{L})$$

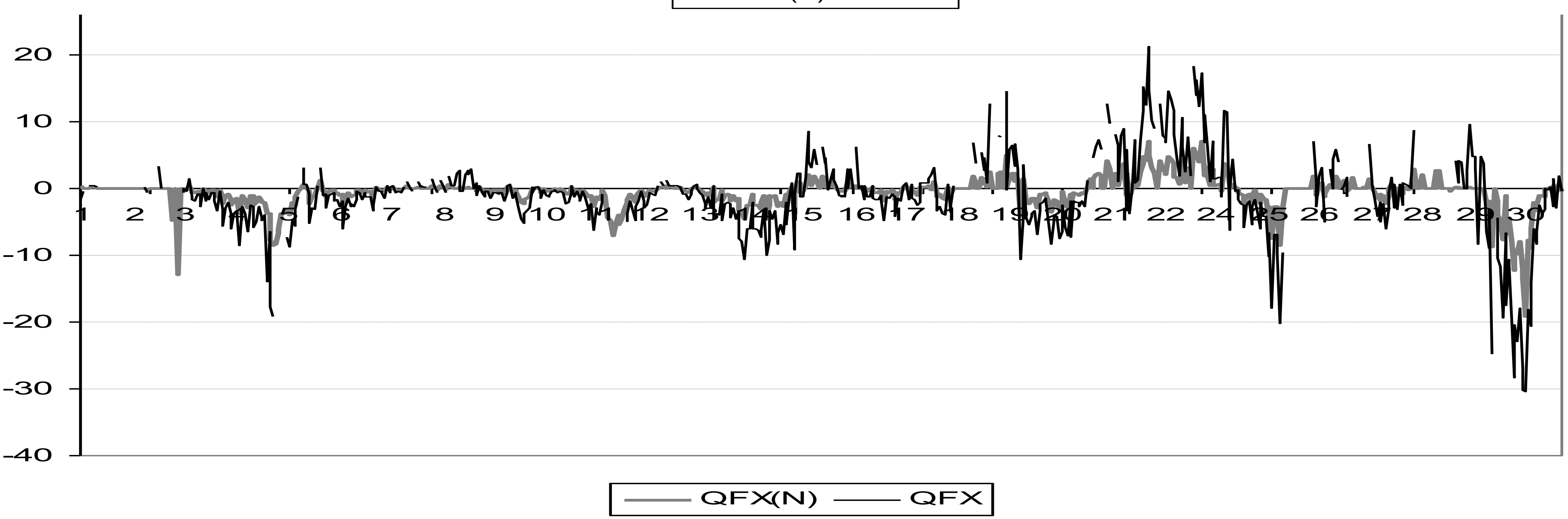
$$\Delta q = q_* (\ln \frac{z_2}{z_1} + \beta_\theta \frac{z_2 - z_1}{L})$$



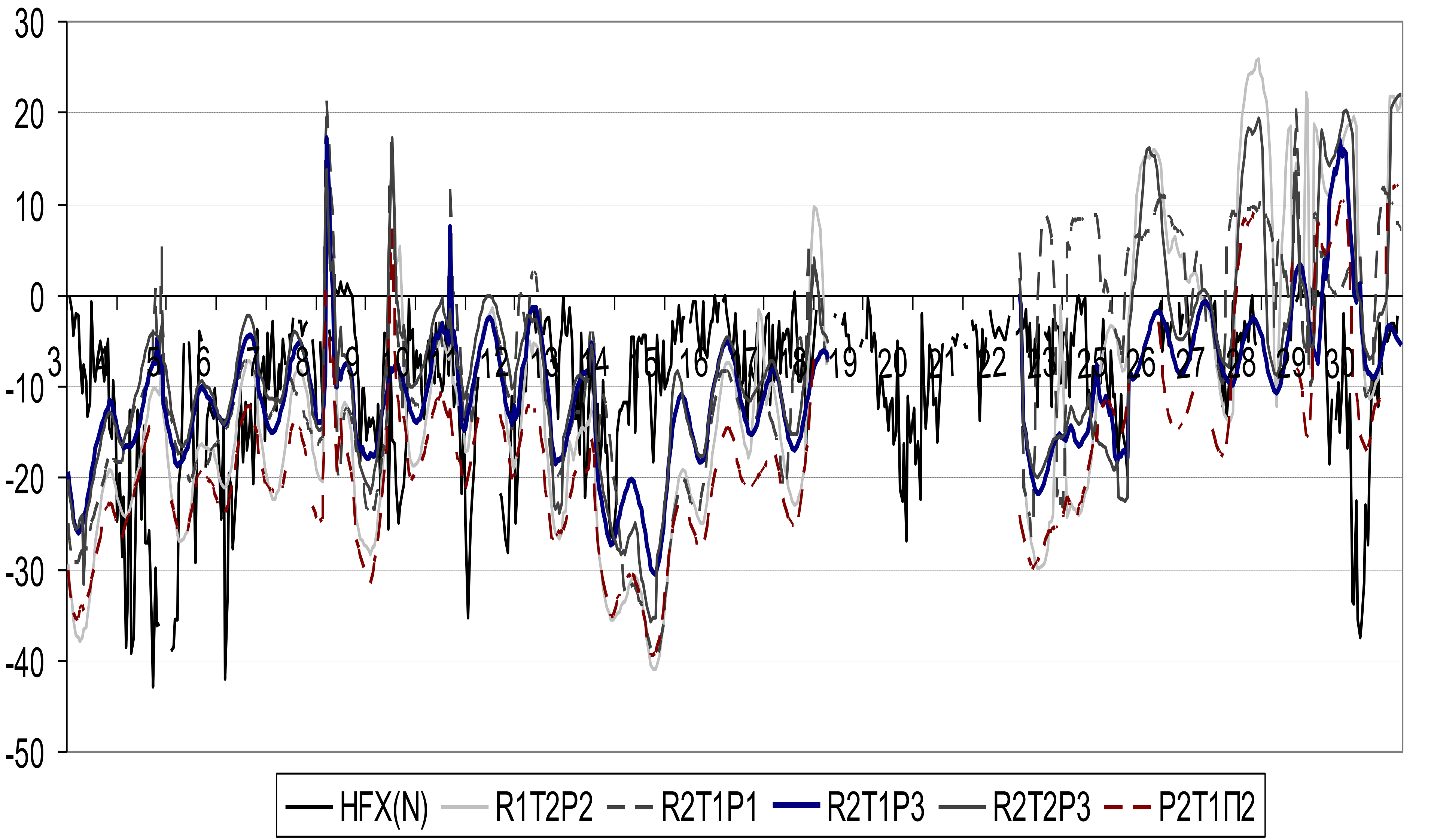
$$Ri = \frac{g}{\theta_r} \frac{\frac{\partial \theta}{\partial z}}{\left(\frac{\partial u}{\partial z} \right)^2}$$

Turbulent fluxes of the sensible (HFX) and latent (QFX) heat, calculated under the empirical data by 2 methods.





Sensible heat fluxes (Vt/m²), calculated by observation and experiments with model WRF with various parameterization.



Errors of turbulent flux of sensible and latent heat flux (experiments with WRF-model with different parameterization)

spatial step 10 км

Experiment	HFX (Вт/м²)		QFX (Вт/м²)	
	Δ	D	Δ	D
R1T2P2	13,2	80,0	2,8	7,3
R2T1P1	9,0	57,0	2,6	8,6
R2T1P3	8,4	48,0	2,8	11,1
R2T2P2	13,0	65,0	2,7	11,1
R2T1P2	11,6	61,0	3,1	8,2
HirHam	14,6	110,0	4,2	19,0

spatial step 2 км

Experiment	HFX (Вт/м²)		QFX (Вт/м²)	
	Δ	D	Δ	D
R2T1P3	7.6	36	2.7	9.7

Conclusions

•Validation of regional mesoscale model WRF by the drifting stations "North Poles“ data was done for the first time. Base level of estimations of forecasts of the basic meteorological values in Arctic regions is received. It is shown that for forecasting of weather in Arctic regions it is closer to measurements using the polar version of model WRF.

•The optimum configuration of the model WRF for polar regions is found.

•Two methods of turbulent fluxes calculation under the empirical data are analysed. Monin-Obukhov method of calculation including components containing information on stratification of atmosphere is accepted.

•On the basis of the calculated values under the empirical data of fluxes heat and latent heat in models WRF and HIRHAM have been estimated. It was that the forecast quality of turbulent fluxes depends on stratification.

Thank you
for attention!

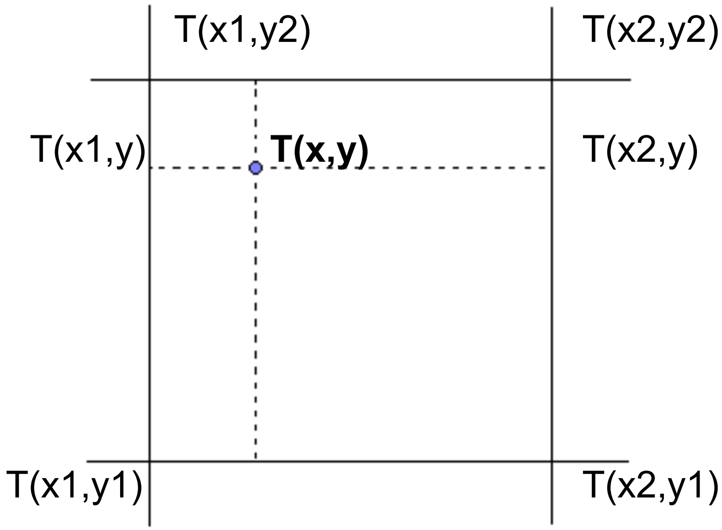
$$H = -\theta_* \chi c_P \rho U_*$$

$$LE = -\rho L q_* U_*$$

$$N^2 = \left(B \frac{\partial \theta}{\partial z} + 0.61 g \frac{\partial \theta}{\partial z} \right)$$

$$B = \frac{g}{T}$$

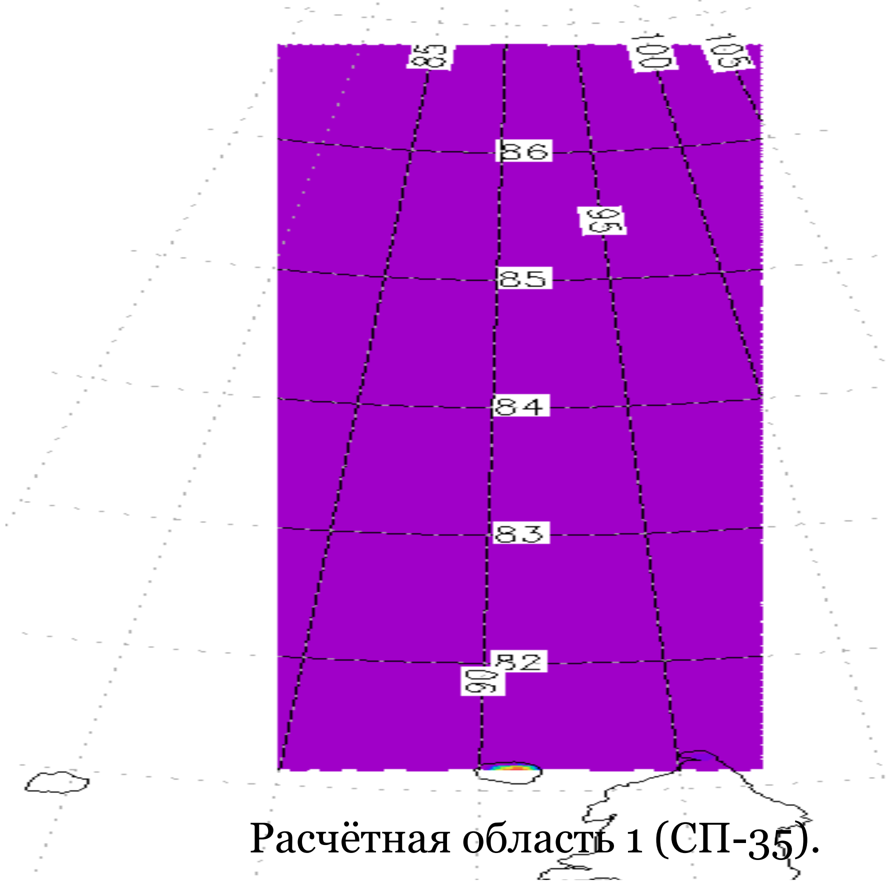
$$Fr = \frac{LN}{U^*}$$



$$T(x1,y) = T(x1,y2)\left(\frac{y - y1}{y2 - y1}\right) + T(x1,y1)\left(\frac{y2 - y}{y2 - y1}\right)$$

$$T(x2,y) = T(x2,y2)\left(\frac{y - y1}{y2 - y1}\right) + T(x2,y1)\left(\frac{y2 - y}{y2 - y1}\right)$$

$$T(x,y) = T(x1,y)\left(\frac{x2 - x}{x2 - x1}\right) + T(x2,y)\left(\frac{x - x1}{x2 - x1}\right)$$



Расчётная область 1 (СП-35).

облачно –с 19.01.2008 по 24.01.2008

безоблачно – с 11.12.2007 по 19.12.2007

Ri (0.2), разделение стратификации по числу

Skamarock W. C. et al. A description of the Advanced Research WRF version 2. NCAR Tech. Note No.468, June 2005 (last revision January 2007), 88 pp.

Расчёт турбулентных потоков.

Zilitinkevich, S. S., Perov, V. L., and King, J. C.: Near-surface tur-bulent fluxes in stable stratification: calculation techniques foruse in general circulation models, Quart. J. Roy. Met. Soc., 128, 1571–1587, 2002.