

M > 51.463.8

< l. G: g^j_1 \. X. > \h j g b d k \. :. J y [q _ g , d X P i _ e \ ^ 1 , D = K f b j g h \ ^ 3 , 2013

¹ K \ _ j A n Z i Z ^ g h _ m i j Z \ e _ g b _ i h] b ^ j h f _ l _ h j h e h] b b b f h g ^ u l h j k Z g d l l _ h j [m j] Z x s _

² K Z g d l _ l _ j [m j] k d b c r B o g e k t Z e m l Z h d _ Z g h e h] b b b f l l R b j r h \ Z J : G

³ = h k m ^ Z j k l \ _ g g u c h d _ Z g h] j Z n b q _ k d b c b g k Z g d l l _ b j [m j] K G h A _ m i j h ^ Z e _ g b _
antony.spb@bk.ru

<HKIJHBA<?>?GB?RLHJ	FH<UOG:=HGH<<G?<K	DHC=M; ?
G:HKGHLDFGHC	FHEBBDMEEB	
MIKEHBOF:GBJ	H:GBX:LHJFB	
DHFEDK:A:SBLGUOK	HMM@GBC	

Lj_of_jgZy]b^jh^bgZfbq_kdZy fh^_evk l G g^khdh q Z]kl]bu Nzb gkdh]h
 eb\Z bkihevah\ZgZ ^ey \hkijhba_^_gby rlhjf]h[u]o_g_Zg]hgh \\
 j_^_dZ[j_] dh]^Z ^ey ij_^h l \ j Z s _ g b y l _ g Z] [h m g] _ g b y l \] K Z g
 [h\Zehkv aZdjulb_ kl\hjh\ Dhfie_dkZ aZsblguo khhj m`_gbc
 jZkq_lh\ k ^Zggufb baf_j_gby mjh\gy \h^u gZ]b^jh f _ l _ h j h
 ©DjhgrlZ^b ©=hjguc bgklblm^a b kdhjklb l_q_gbc gZ Z\lf
 klZgpbb m fZydZ ©Lhe[mobg^a ihdZaZeh qlh fh^_evvZ^_d\Z
 guo]b^jh f _ l _ h j h e h] b q _ k d b o m k e h \ b y o

Dexq_u_ ~~kl~~ rlhjf]h_u_gZ]hgu fh^_ebjh\ZgZ sbl]o_kk]b]e]m]g]b]c KZgd l
 l_l_j[m.j]Z

< gZklhys__ \j_fy \ N = ; A V Z i @ K g h _ j M = F K ^ a \ _ ^ m l k y j Z [h l u i
 pbb b \g_ ^j_gbx \ hi_jZl b \ gh _ bkihevah \ Zgb _ dhfie_dkZ]b^
 ^ey ijh]ghaZ]b^jheh]bq_kdh]h b wdheh]bq_kdh]h khk]hygby
 aZeb\Z b G _ \kdhc]m[u >ey h[_ki_q_gby gZ^`ghc b wnn_c
 aZsblguo khj m`_gbc -K Z l g d l [m j] Z h l g Z \ h ^ g _ g b c D A K j Z a j Z [h l Z
 g b j m k d k l _ f i z h] g h a z ^ t _ f z h ^ u K I I < d h l h j Z y \ j _ ` b f _ j _ Z e v g h] l
 h [_ k i _ q b \ Z b l l f h b g g] b i j h] g h a m j h \ g y \ h ^ u k i _ j _ ^ Z q _ c i h e g h c
 \ k b k l _ f i m ^ ^ _ j ` d j b g y l b j r _ g b c K I I J i h m i j Z \ e _ g b x D A K K I I <
 d Z d d h f i e _ d k \ a Z b f h ^ _ c k l \ m x s b o] b ^ j h ^ b g Z f b q _ k d b o f h ^ _ e _ c
 h [t _ f g Z [e x ^ _ g b c h k h k l h j g b u \ h Z g h c k n _ j u g Z ^ g _ c H k g h \ g h
 g b _ K I I < h i _ j Z l b \ g Z y \ u ^ Z q Z i j h] g h k l b q _ k d b o i j h ^ m d l h \ \ > e y \\
 guo j _ d h f _ g ^ Z p b c i j _ ^ m k f Z l j b \ Z _ l k y j Z k q _ l i h g Z [h j m \ h a f h `\
 j _ Z e v g u o k b l m Z p b c G Z j y ^ m k K I I < l Z Z v g b j m g l k y b j Z a j Z i j h Z d l b
 b g n h j f Z p b h g b m l x f w d h e h] b q _ k d k l] h y g b y B K W K d h l h j Z y \ [m ^ _ l
 e y l v M i j Z \ e _ g b x D A K b ^ j m] b f x j b ^ b q _ k d b f e b p Z f b g n h j f Z p b x
 k l h y g b b G _ \ k d h c] m [u b \ h k l h q g h c q Z k l b N b g k d h] h a Z e b \ Z
 Y ^ j h f h [_ b o _ k b K I I < b B K W K \ e y _ l h y f i e _ d f h j k d b f c h ^ _ e _ c
 D F F < g Z k l h y s _ _ \ j _ f y k m s _ k l \ m x l ^ \ _ g Z p b h g Z e v g u _ f h ^ _
 k d h] h f h j y b N b g k d h] h a Z e b \ Z d h l h j u _ f h] m l k h k l Z \ b l v h k g h \\
 - f h ^ _ e v g u o _ C A R D I N A L (C o a s t a l A r e a D y n a m i c s I n v e s t i g a t i o n A l g o r i t h m) [1] ;
 - d h f i e _ d k f h ^ _ e _ c ^ e y h i _ j Z l b \ g h] h i j h] g h a Z k h k l h y g b y
 j Z [h g u d k h j m ^ g b d Z f b J = = F M K I [M I P P + F G X b
 < i h k e _ ^ g b c d h f i e _ d k \ d e x q _ g u Z l f h k n _ j g Z y N h b ^ g k e d h] f h F
 a Z e b G U L F O O S (t h e G U L f o f F i n l a n d O p e r a t i o n a l O c e a n o g r a p h i c S y s t e m > @ f h ^ _ e v

G_ \kdhc NEVAM (NEVA Model) fh^_ev _ljh\h]h SWAN (Simulating Waves Nearshore > @ -KZlg d[mj]kdZy fh^_ev w\ljhnbDZpbpb ;Zelbckd SPBEM (St.Petersburg Baltic Eutrophication Model > @ < dhfie_dk lZd`_ \oh^yl ^Zgguo gZ[ex^_gbc [ehdb f`_fh^_evgh]h h[f_gZ bgnZjfZpb_c h pbb b Zjob\Zpbpb j_amevlZlh\ >ey aZ^Zgby Zlfhkn_jgbo \ha^_ck \bc gZ hldjulhc]jZgbp_ fhjy bkihev`gmx_lkfh^_\eba Zjfkn_jgZy HIRLAM (HIgh Resolution Local Area Model > @ b fh HIRLAM (HIgh Resolution Operational Model for the Baltic Sea) [8].

< gZklhys_c kIZlv_ jZkk hZlfjh\Zh_kky bkihevah\Zgbyv\gmljb fh^ gh]h dhfie_dkZ lj_ofh_jghc [b^jhb^bgZfbq_kdhc NEVAM edZd bgkljmfh_gIz i a\heyxs_]h mlhqqblv b ^_lZebabh\Zlv ijh]gha]b^jh^bgZfbq_kdh Ihqghc qZklb Nbgkdh]h aZeb\Z Z hkh[_ggh \ G_ \kdhc]m[_ b hdj >ey _jbnbdZpbpb NEVAM gZjy^m k ^Zjghh_hjhheh]bq_kdibo i klh\ lZd`_ ijb\ e_dZ_lky Zjob\ baf_j_gguo]b^jheh]bq_kdibo oZjZguc \ j_amevlZI_fhjZjh^a Z\lhfZlbq_kdhc]b^jhf_l_hjhheh]bq_kdhc F:=FK ©DjhgrIZ^I^a F:=FK ©DjhgrIZ^I^a [ueZ mklZgh\ e_g l_l_j[mj]kdbf PJ= FgZ]em[b_g_ \ lhqd_ k dhhj^bgZIZfb f •k f •\ ^ gZoh^y sklkkygqiz jZdf d x]m hl fZydZ ©Lhe[mobg^ M Zjob\ kh^_j^bl ^Zggu_ h iZjZf_ljZo \heg_gby mjh\g_ ih\joghkIb q_gbc ijb^hgguo khe_gZkljb lZfkljhj_gghf dbkehjahZ_b fmlghklb jbh^ k ghy[jy ih ^_dZ[jy]

HibkZgb_fh^eb NEVAM. Fh^_NEVAM y\ey_lky mkh_jr_gkljh\Zgghc _ kb_c lj_of_jghc]b^jh^bgZfbq_kdhc fh^_eb G_ \kdhc]m[u b \hkIhc aZeb\Z > @ b gZkgh\ZfgZghc fh^_eb h[s_c pbjdmeypbh hd_ZgZ lj mgb_jkb Princeton Ocean Model, POM > @ bkihevams_c \ dZq_kl\ _j ghc-dhhj^bgZlm Hlebqbl_evghc qe_jhbj^bgZehc_kley_lky]eZ^dh ij^klZ\ e_gb_lh[h]jZnbb_kgZqbWZlhl re[mqr__ ih kjZ\g_gbx k mjh\ b bahibdgbq_kdbfb fh^_eyfb hibkZgb_ ^bgZfbdb l_q_gbc \ ijb^ keh_ >hkIZlhqghf b h jhth hibku\Zxl lZd`_ l_jfh^bgZfbqmkdb_ wnn_ keh\ e_ggu_ g_ebg_cgghklvx mjZ\g_gbyl b h k h y e b yo h j h w h h i m ^ o h ^ y l ^ey fh^_ebjh\Zgby l_q_gbc \ r_evnh\hc ahg_ hd_Zgh\ f_edh\h \gmlj_ggbo fhjyo b wklmZjbyo j_d >hihegbl_evg h_ ij_bfms_kl\h kdh]h mgb_jkb_lZ khklhbl \ hibkZgbb _jlbDZe [rg b] l g l g h j h j bahgl i_j_ghkZ gZ hkgh_ bkiulZgguo b gZ^_`guolkiZjZfghj b Fa_ZebqZk bhl\ YfZ^u > @ ZfZjdbgkdh]h > @

< kh\j_f_gghc NEVAM b kke_^m_fZy h[eZklv \u[jZgZ lZd qIh[u Z hibkZlv ijhp_kku \ G_ \kdhc]m[gZbli DAK h f m a l e m x qZklv \g_rg_] lmZjby j G_\Z hl h Dhlebg ijbf_jgh ^h f_jb^bZgZ R_i_e_\kdh]h]jZgbpZ kl\hj G_\u ijhoh^bl iZ f_ j b ^ b Z g r i Z i g Z f y _ j b ^ b Z g m ž • • \ ^ Djb\hebg_cgZy d\Zabhjlm]h g zelZgZyf k [jZzhkl qlh[u h[_ki_qblv fZdkbfZevgh_jZaj_r_gb_ \ G_ \kdhc]m[_ \ ij^_eZo ^h DAK Qbkeh maeOdhk j^bgZih_ k aZiZ^Z gZ500hkl h d jZ\gh dhhj^bgZI_ k x]Z-gZ8 k qbkeh jZ\ghf_jgh jZ b i h r h \ g g u >jm]b_ iZjZf_lju k_l db ^Zgu \ lZ[e



Jbk Ko_fZ Dhfie_dkZ aZsblguo-ikHhj[m]i]zbbkGZg_d^g_gbc DAK
 < < < < ±h^kijhimkdgu_ \hjhZ DAKk^kijbimkdgu_ dZgZeu
 D1 D11 ±qZklb ^Zf[u

LZ pZ

IZjZf_lju jZkq_lghc k_ldb fh^_eb G_\kdhc]m[u

IZjZf_lju	Fbgbfmf	FZdkbfmf
RZ] ihdhj^bgZI_	47.4	368.5
RZ] ihdhj^bgZI_	38.6	556.9
=em[bgZ \h^h_fZ	0.2	34.0

LZ[ebpZ

IZjZf_lju hl_jklbc DAK kh\j_f_ggh_ khklhygb_

HI_jklb_	RbjbgZf	=em[bgZ	Qbkeh rZ]h\NRVAb
K	200	16.0	4
K	110	7.0	2
<	336	2.5	5
<	280	5.0	4
<	280	2.5	2
<	280	5.0	2
<	280	5.0	2
<	336	2.5	2

Kh\j_f_gggZy dhgnb]mjZpby DAK ihdZaZgZ gZ jbkI < IZ
 \mxsbo \h^hijhimkdgu_ hbm kkguo khhj m`_gbc DAK ih khklhy
 e_IZ] Fh^_evgh_ ij_^klZ\e_gb_ \h^hijhimkdguo b km^
 khhlk]m_l wlfm khklhygbx Fh^_ev iha\hey_l hidju\Zlv b a
 ijhp_kk_ jZkq_lh\

Fh^_ev pbjdmeyptG_ \k^h]m[_ h[t^bg_gZZk_f]h]d]h^c
 evx fhjkdh]h ev^Z + (<Ow]bc @h^_eb e_^ ^_b b gk]ggZ_dZI_]hjb
 g_^_nhjfbjh\Zgguc b ^_nhjfbjh\Zgguc e_^ < k\hxgguc_je^v g
 ^_eblky gZ g_kdhev dh ih^dZI_]ZjggucZgZ_ h]h]f]b]k luc th gZke
 _gguc GZkeh_gguc e_^ kms_kl]m_l ijb lhe k b g Z Zdeg Z Z u\Z_gfv

lhesbgZ i_j_[jhkdb ijb [hevrbo lhesbgZo e_^ hlgkkl]lky d dZl
W\hexpby dZ`^hc dZl_]hjbb ev^Z hibku\Zd hgy m jZg gby ebs^ey
^b b fZkku ev^Z ijbq_f wlb mjZ\g_gby j_rZxlky \ eZjZg`_hf i
gu ev^Z < dZ`^hc dZl_]hjbb ijbq_f lky \ j_amevlZl_ Z^_dpjb ^_nhjfZ
fh^bgZfbq_kdbo ijhp_kkh\ lj_^iheZ]Z_lky qlh ijb[ieZlglye e_^ km
]^_]em[bgZ \h^h_fZ f_gvr_ aZ^Zggh]h djblbq_kdh]h agZq_gby
imevkZ l_ieZ b \eZ]b gZ]jZg\hpaZmgZha h^ZiZejZf m jkka lZd
`_ dZd \ > @
lehsZ^v \h^hh[f_gZ f_`^m G_\kdhc]m[hc b Nbgkdbkf aZeb\hf
_jghc qZkl_c DAK khklZ\ey_l khhl\blkl\fggZdbf h[jZahf ie
sZ^v \h^hh[f_gZ ^ey k_jghc qZklb ^Zf[u aZf_lgh f_gvr_ hdheh
fZjgh]h \h^hh[f_gZ q_f iehsZ^v \h^hh[f_gZ __ x`ghc qZklb D
qbkeZ]h\ k_ldb ijbh^ys__ky gZ hl_jklby ^Zf[u ^dZdqiljZ\beh g
iha\hey_l ^hklZlhqgh ohjhrh hibku\Zlv l_q_gby \ hl_jklbyo \h^h
b h hijhimkdguo dZgZeZo DAK
IhklZghdZqbke_ggh]hwdki_jbf_glZ >ey bkiulZgby NEVAME pue u
[jZg i_jbh^ \j_f_gb k wdklj_fZevgufb]b^jhf_l_hjheh]bZ_kdbfb m
\beh lZdb_ mkeh\b]m[_G\h\kgfZxl hk_gvx b \ gZqZe_ abfu
< ghy[j_f_dZ[j_] gZ[ex^Zebkv ljb rihjfh\uo gZ]hm gZ \h^u \
[_ dh]^Z ^ey ij_gby\jZs\h^g_gbyl \lKjZgd]_ ihlj_[h\Zehkv aZdjulb
kl\hj\ DAK l_j\uc gZ]hg ijhbgahy]je Kl\hju khhjm`_gbc [ueb aZ
lu k q fhkdh\kdh]h \j_f_gb ghy[jy ^h q ghy[jy <lhjhc
ijhke_^h\Zeb \ klyad_ h^bg aZ_dZ]jybfjb ijhoh`_^_gbb b[rbjgh]h p
dehgZ Kl\hju khhjm`_gbc [ueb aZdjulu k q ^h q ^_dZ[jy
khhjm`_gbc [ueb aZdjulu k q ^h q ^_dZ[jy LZdbf h[jZa
fhf i_jbh^_ [ueb hlf_q_gu ljbZgZ\GkgfZoblybfZevgufb mjh\gyfb \
^u ih]b^jheh]bq_kdhfm ihklm =hjguc bgklblml g b kf \
rlZ^lkdh]h nmlrlhdZ
K mq_lhf]b^jhf_l_hjheh]bq_kdhc h[klZgh\db \ mdZaZgguc ijh
lZd`_ \ i_jbh^ gZdhie_gguo ^Zgguc gZ limj giuh hgZ [NEVAMB
[ue \uiheg_g j_ljhki_dlb\gudk m kq_ggyZjy ih ^_dZ[jy]
< dZq_kl_ gZqZevguo mkeh\bc [ueb \aylu ihey l_gi_jZlmju b
guf fh^_eb +,520% > @ GZ hldjuluo [hdh\uo]jZgghZj aZ^Z\Zeb
gbp__`_qZkgu_ agZq_gby mjh\gy l_fi_jZlmju b khe_ghklb ih ^Z
\hklhqqghc]jZghkl_hyggZy \h \j_f_gb l_fiKjZd mjZkij_^_e_gguc ih
jmdZ\Zf k k d u >ey]hZkq_QZ bkihevah\ZeZkv wfaZ]b b b kklZly
k\yau\Zx@Zy^3f k k mjh\g_f \h^u \ EZ^h`kdhf ha_j_

$$Q = 0.6321 \eta^2 + 39.86 \eta + 1138.4, \tag{1}$$

]^_n - mjh_gv \hKfu \imgdl_ l_ljhdj_ihklv \ bklhd_ G_\u
GZ]jZggbk Zlfhkn_jhc [ueb aZ^Zgu _`_qZkgu_ ihey hkgh\guo
kdbo iZjZf_ljh\ ^Z\`e_gb_ l_fi_jZlmjZ hlgkbl_evgy \eZ`ghklv
e_gb_ _ljZ h[eZqghklv dhebq_kl\h hkZ^dhHIRLAKK]qblZgg_u ih
J_amevlZlu jZkq_lh\b kjZg_ gb_k Zggufb gZ[ex^gbc Hkh[uc bgl_j_k
ij_^klZ\ey_l \hkijhba_`_gb_ fh^_evx]b^jheh]bq_kdbb iZjZf_ljh\
q_kdbo ihklh\ DjhgrlZ^l b =hjguc bgklblml \ jZchg_ fZydZ Lhe[r
]h gZ jZkklhygbb df d aZiZ^m hl DAFK = Fkq @Z jhgrlZg^h d Z
lZd`_ g_ikhj_^kl_ggh hdheh kl\hj\ DAK

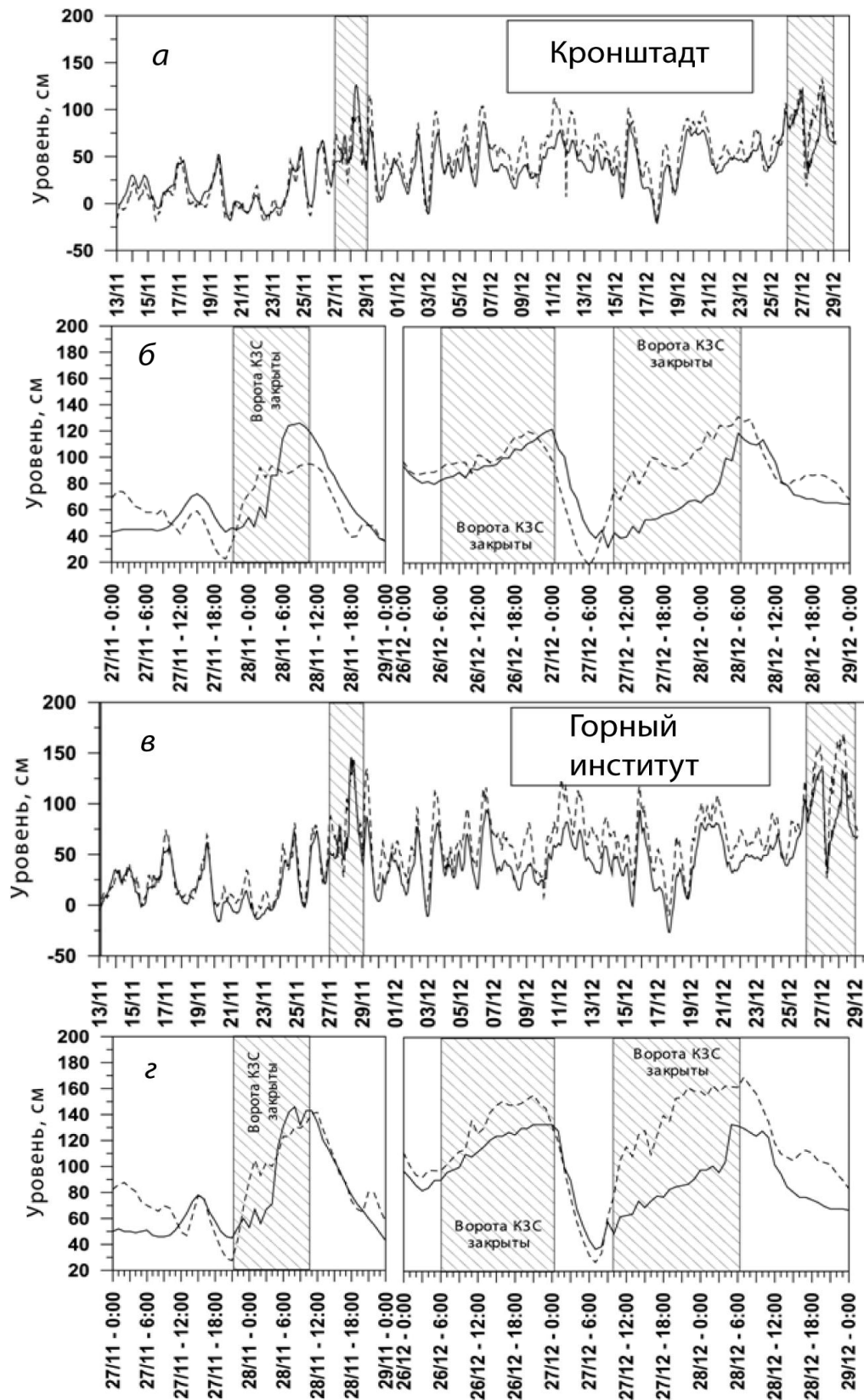
GZ jbk kf p\ \de ic d m k l Z \e_gu ijhkljZgkl\ _ggu_ jZkij_ ^_e_g
kdhjhkl_c l_q_gbc ^ey kemqZy aZdjuluo b hldjuluo kl\hjZo
\hjhlZ\ mkeh\byo rihjfh\hgjZu ghZ lfq_gmkbe_gb_ l_q_gbc ^h
^hev ^Zf[u kh klhjhg Nbgkdh]h aZeb\Z Z lZd`_kfh\mrk gb
_jghc qZklb ^Zf[~~Z~~ ljbkihgb`_grjbg\ygZ aZiZ^ghc jZg bpo b hlc
\hjhlZba[ulhqguc h[t_f \h^u gZdh\ledhg u]m[_G mklj_fey_lky q
^hijhimkdgu_B4-Bh l Z [jZlgh \ aZeb\ \ gZijZ\ e_gbb ijhlb\hiheh
e_gbx \(\j b Z D ljb wihf bgl_gkb\ghklv l_q_gbc \ G_kdhc]m[
\Z_l Ke_^m_l hlf_lblv- qlh_dZ[jy f_gy]ekyZde Zh kbe_ ZZd b i
ijZ\ e_gbx

KjZ\g_gb_ jZkkqblZgguo b baf_j_gguo G Z gjZ d _g_bjc ^nk j Z \ey g
gZ[ex^Z_fu_ b jZkkqblZggu_ ih fh^_eb agZq_gby mjhl\ghy \[eb
DjhgrlZ^l b =hjguc bgklblml Ke_^m_l hlf_jl bal me q ll Z l d h d h jhrghu
]eZkmxiky ih nZa_ k ^Zggufb gZlmjguo gZ[ex^_gbc \ l_q_gb_
jbh^Z ghy[\y_dZ[jy] Z \ ghy[j_ kms_kl\m_l g_hieho_h_
exlguf agZq_gbyf mjh\gy H^gZdh \ ^_dZ[j_ ih g e u f g h b g h d k Z a Z
l_evgh gZ[ex^_gguo ijbq_f g_^hhp_gdb \ h[hbo imgdlZo ijb
k\b^_l_evkl\m_l h aZgb`_gguo agZq_gbyo mjh\gy gZ hldjulho
aZ^Z\Zebkv gZ hkgh\Zgbb j_amevl ZHIROMZ kq_lh\ ih fh^_eb

< p_ehf fh^h_eZ aZeZ ohjhrmx kh]eZkh\Zgghklv fh^_evgh]
mjh\g_c \ kblmZpbb gZ\h^g_gbc ijb aZdjulby kl^hjhZ [DyAKlf < l
qZ_lky aZgb`_gb_ fh^_evgh]h mjh\gy ijb lj_lv_f rihjfh\hf gZ
dehg_gb_ khklZ\beh b kjfh d Z h e h \ FKjD \ img
guc bgklblml Ke_^m_l hlf_lblv qlh bgnhjZpby h \j_f_gb aZ
i_jbh^ g_lhqgZ NZah\uc k^b] \ gZqZe_]kr k d h d _ ^k d]Z[jly[mj b
e_g g_lhqguf aZ^Zgb_f g h f a Z Z j u] b y_kl\hj\ DAK \ fh^_evghf j

H dZq_kl\ _ jZkq_lZ mjh\gy ihj b \ h e y g l k k Z i b k l b q_kdb_ oZjZ
jbklbdb lZ[e DZd \b^gh ba lZ[ebpu nZdlbq_kdb_ b ijh]gh
\h^u ohjhrh dhjj_ebjmxl ^jm] k ^m g d h Z o l H [h j b p Zil_evghk agZq
l_fZl b q_kdhc hrb[db]h\hjbl h lhf qlh fh^_ev \ kj_Ygy_f aZgb`

KjZ\g_gb_ jZkkqblZgguo b baf_j_gguo kdhjhkl_c lqg_gbc
rIZ^l^a >ey ZgZebaZ kdhjhkl_c l_q_gbc bkihevah\Zgwo\j_b_f_gg
f_j_gguo b jZkkqblZgguo agZq_gbc kdhjhklb l_qgrg Z e l^ l h q c
GZ j b k k f p \ \ d e i c d m ^ _ g u] j Z n b d b k h i h k l Z \ e y] h g b o y h ^ Z _ f f h g g e y
gZijZ\ e_gby jZkkqblZgg hc b gZ[ex^Z_f F c ` k d h j h k l b k m s _ g _ b \ m x
aZf_lgu_e h Z b y dZd ih fh^mex lZd b ih gZijZ\ e_gbx ;he__ ij
gb_ h kl_i_gb khhl_lkl\by jZkkqblZgguo b gZ[ex^Z_f Z i o k d h
l b k b q _ k d b _ h p _ g d b \ _ j h y l g h k l g u o o Z j Z d l _ j b k l b d ^ Z g g u o g Z [j Z k q _ l Z
jZkq_lZ kh]eZkghZ d h g h j f u f j g h k l b b a f _ g q b \ h k l b g Z l m j g u o b f l
g u o ^ h \ h e v g h [e b a d b L Z d i j b \ k f p g g u d e g e d h g k l b j Z k i j _ ^ _ e
g b y (V , 3 f k d h j h k l b l v _ q h g ^ Z y g g u f b a f _ j _ g b c b j Z k q _ l Z i h d Z a u \
k h \ i Z ^ _ g b _ i h g Z i j Z \ e _ g b x e f l Z g h k k f l r a f h d h i l y i j b w i h f a g Z a _ g b y
f _ j _ g g h c k d h j h k l b ^ e y \ k _ o f Z d k b f m f h \ j Z k i j _ i j _ e u r g z o y l _ a Z Z q
g b y f h ^ m e y j Z k k q b j l h Z g g h c k d



Jbk GZ[ex^_ggu_ b jZkkqblZggu_ agZq_gby mjh\gy \ imgdIZo Djhgr
 k ghy[jy ih ^_dZ[j\ ^ejy kemqZ_gZ\h^g_ b dcyk ih g
 b k ih ^_dZ[j\].]
 KiehrGZy e b j g t a y m e v l Z l g Z [e x ^ _ g b c ± j Z k q b m a z y

LZ[ebpZ

KlZlbbklbq_kdb_ oZjZdl_jbklbdb mjh\gy \h^u
 imgdllgZxb cDjhrllgucbk blml

O ZjZdl_jbk	=hjguc bgklblm	DjhgrlZ^l
(G _i ±G _n)min	-74.6	-53.4
(G _i ±G _n)max	19.2	49.0
δ̂	-15.3	-6.4
δ	16.6	12.4
σ	20.6	15.6
r	0.93	0.91
N	1026	1058

Ijbf_qZgb_Hrb[db ijh]ghakZ_ %gyy Z[kheixhZy^gyy d\Z^jZlδq±kjd_ZgyynZjb
 f_lbq_kdZy kbkl_fZl_bq_hkchZyppb_gl dhjj_eypbb f_`^m ijh]ghklbq_kdbfb
 agZq_gbyfb _pZagpukjh]ghklbq_bdhZdlbq_kdh]h agZq_nmb efbgbfZezg
 (G_i ±G_n)max ±fZdkbfZzWg±jZaf_j \u[hjdb

LZ[ebpZ

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 jWguifh@

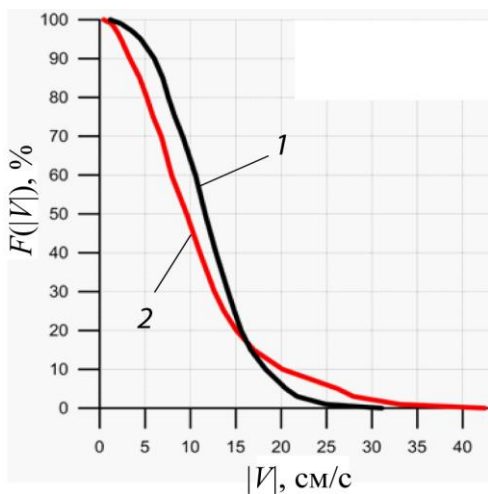
Bklhqqg ^Zgguc	Kj_^gb_ agZc				V fzo	Kj_^g_dZZbqgu_ hldehg_g					r ^{baf}
	V ₁	V ₂	V	3		I ₁	1	2	\$. f	
	kf k					kf k					
Fh^_ev	3.58	1.10	3.8	17	42.4	12.4	9.6	7.8	0.806	91	3.3
GZ[ex^_	5.32	5.29	7.5	45	31.1	10.4	8.6	5.9	0.682	129	1.4

Ijbf_qZgb_ V₁ bV₂ ±ijh_dpbb _dlhjZ kdhjhZyfbgjb^bZg b iZkZle_ekl\vggh_3
 ±fh^mev b gZijZ\le_gb_ kdhjhZkbfZlbbZegbh_agZq_gb_ fh^mey kdhjhklb l_
 d\Z^jZlguc dhj_gv ba fZl_fZl_bq_kZhy]ghh^h^jZobay_kdgby p_gljdhjhZgguo
 ZgZebabjm_fhc kdhjhklb l_q_gby ebφ_cgukpbkpbZjZgldpbc _dlhjZ kdhjh
 l_q_gpελ₂/λ₁ ±m]he ih\hjHZ hij_^_eyZpbx]hevrhc hkb weebikiZ±^bki_jh
 dhwnnbpb_gl baf_gqb\hklb

DZd \b^gh bajlZ[geb_ agZq_gb_ ykdZpZdl_d]hjZ kdhjhklb l_q_
 fh^_evguf ^Zgguf aZf_lgh f_gvr_ q_f ih ^Zgguf baf_h_gbc
 jhklb l_q_gby [hevr_ ^ey fh^_evguo ^Zgguo WeebikiKDH w
 ke_^gfbog_ \ulygml q_f ^ey_jZgguo]brafkemqZ_ _]h [hevrZy
 hjb_glbjh\ZgZ k \hklhdZ gZ aZiZ^ Ih]^Z dZd-\kke]hokZlhd^Zgg
 gZ k_aZhiZ^

GZ jbkjb_^_gu]jZnbdb nmgdpεbgjZykih^mey kdhjhklb fh^
 b gZlmjguo ^Zgguo <b^ghg_qlhkf ^kbZiZlajy_fhklv fh^_evguo ^
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 klvx ^Zgguo baf_j_gbc

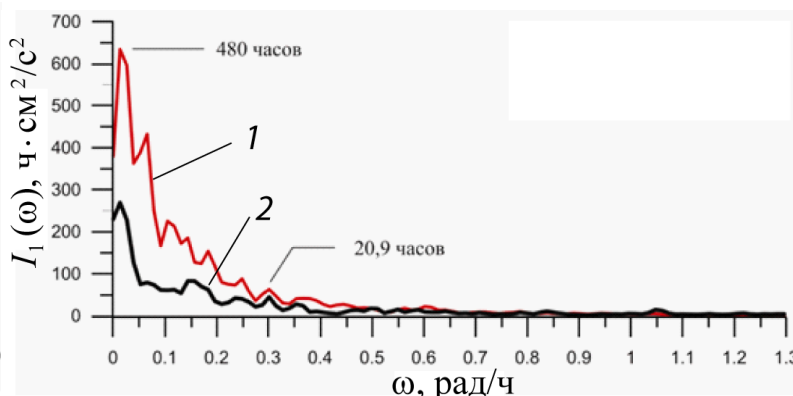
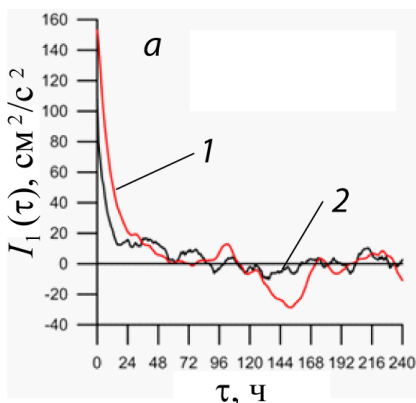
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 fh^_evghc kdhjhklb l_q_gpε ihZhuaggghc bgl_gkb\ghklb fh^_
 dhe_[Zgbc kdhjhklb kljmdlmjZ ijhp_kkZ ijb[ebabl_evgh h^b
 lmjguo ^Zgguo gZ[ex^Zxlky \ukhdhqZklhgu_ dhe_[Zghy fZe
 ju_ iheghklvx hlkmlkl\mxi \ kemqZ_ jZ^_benkg udhjj_Zegypub \ h
 kemqZyo ijbj_jgh, hdbZZdgb adhi_jbh^bq_kdhc khklZ\eyxs_c
 g_kdhevdh \ur_ ^ey fh^_evguo ^Zgguo



Jbk Nmgdpby jZkij_m_ey kdhjhklb l_q_gbc \\f_db F:=FK ©DjhgrIZ^Ia ih baf_j_gbcgbyb fh^_evg^AZgguf e)gby

=jZnbdb ebg_cgh]h bg\ZjbZglZ l_g ki_dljZevghc ien(ghkjl)k ihZauZ xl qlh baf_j_ggu_ b fh^_evgu_ ^Zggu ^_j`ZI [hevrhc gZ[hj dhe_[Zgbc jZaeb pbdebqghklb ba dhlhjuo lhqgh kh\iz lhevdh ^j\Z qZkl�.013 jZ^q i_jbh^ hdhehkmbeb & b jZ^ i_jbh^ hdheh q ljb wlhf \kx^m bngl_gkb\ghk ^_evguo dhe_[Zgbc \ur_ q_f ^AZgguo b gbc aZebq_gb_f dhe_[Zgby k i_jbh^hf (& jZ^ dhlhjh_ \ fh^_evghf jy kmkl\m_l iheghklvx

K^_eZggu_ \u\h^u h dZq_kl\ \hkijhl ^_gby ihey kdhjhklb l_q_gbcg ghkyl h]jZ guc oZjZdl_j ih ke^mxsbf -ijbqbgZf i_j\uo klZgpby baf_j_gbc kdhjhklb l_q_kh\iz^Z_l k maehf k_bdb\hfhj^ueb ^Zggu_ baf_j_hgbcZk fgh]h ijhimkdh\ jZaebqghc ijh^he`bl_evghklbZ \k_]h d [hld_ ijb]h^gh _`qZkguohlkq_lh\ ij jZ ijb h[s_c ^ebg_ jy^Z q



Jbk Ebg_cguc bg\ZjbZgl dhjj_eZp bh gh dhj ZevghcZieh ghklb kd l_q_gby \ f_kl_Zghkl)db F:=FK ©DjhgrIZ^Ia ih fh^_evguf ^AZgguf ebg b ih gZf baf_j_gbc2)ebgby




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kh\iZ^_gb_ ih gZijZ\e_gbx fZdkbfmfh\ iehlgkklb jZkij_^_e_ ohly ijb wlhf agZq_gby fh^mey baf_j_gghc kdhjhklb ^ey \k_c gby gZ kf k ij_\urZxl agZq_gby fh^mey jZkkqblZggghc kdhjhkl

JZ[hZ\i heg_gZjZfdZoijh_dIZJNNB

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E b l _ j Z l m j Z

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14.  b ^j<hkijhba_^_gb_ debfZlbq_kdbo baf_g_gb_ccg_:jgZbqkghhf fh^_eb pbjdmeyppb hd_ZgZ b ev^Z [_a ijb\yadb d debfZlbq_kdhc khe Lj ::GBTB Bkk eZgh_ baf_g_gZc h e i f i p_kkh\ \aZbfh^_ckl\by hd_ZgZ b \ iheyjguo h[eZklye^hk\[_hba^Zl -82. K
15.  <_jhylghklguc ZgZeba fhjkdbo l_qhgbc E b a ^ Z l F

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