Retrospective Forecasting of the Onset Time of the March 24, 2017 Eruption at Kambalny Volcano (Kamchatka) Based on a Comparison of the Solar-daily Rhythm and its Parts of the Global and Regional Earthquakes

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C" pgy " vgej pks wg" qh" nqpi /vgtm " *qpg" {gct" cpf " o qtg+" cpf " nguu" vj cp" : " f c{u" hqtgecuvkpi " qh" i tgcv" gctvj s wcngu"y cu"f guetkdgf "kp"*Uj ktqmqx"gv'cn "4236="Uj ktqmqx"gv'cn "4237+0'Hqtgecuv"y gtg "dcugf "qp"vj g" ugkuo qmqi kecn" "vgej pks wgu"cpf "tgeqtf kpi u"qh"tgo qvg" rtgewtuqtu "wukpi "kpuvwo gpvcn'o gyj qf u0'Gctnkgt. "yj g" hqtgecuvu"cpf "tgncvkqpu"dgvy ggp"gctvj s wcngu"cpf "xqnecpke "gtwrvkqpu"y gtg "uvwf kgf "kp"*I qtgnej kk "gv"cn "3; ; 9= Hktuqx. "Uj ktqmqx. "4227="Uj ktqmqx. "3; 99.""3; 9: ."3; 7. "4223. "4232="Uj ktqmqx. "F wdtqxumc {c. "4232="Uj ktqmqx "X0C0. "Mw| m p{ " c0F 03; ; ; ="Uj ktqmqx. "Uvgr cpxz. "F {tqdumc{c. "4232 "cpf "qyj gt+0'Kp "yj ku"r cr gt "yj g "cwyj qtu" cwgo r ygf "vq "cr rn{"yj g "vgej pks wg"kp "qtf gt "vq "r tqxkf g "c "tgcn/ukm g "hqtgecuvkpi "qh "yj g "qpugv'qh "gtwrvkqpu"cv" Mco dcn p{"Xqnecpq"wukpi "tgvtqur gevkxg"f cvc "kp "vgto u"qh "gcgevkqp"qh"c""46/j qwt "kpvtxcn'cpf "ku"tcvkqpu"hqt" i nqdcn'cpf "nqecn'Mco ej cvmc "ugkum ke "gxgpvu0'Hktuv''uj go kuukqp'cv'Mco dcn p{"Xqnecpq"y gtg "dugtxgf "d{ "yj g" uekgpvkuvu"qh "MXGTV"qp "O ctej "46. "4239"cv'cdqwv'43*"r atqz{um o +"WVE"*I ktkpic"Q0C0.'gv'cn "4239+0'

Vj gtg "ctg "nq "tgeqtf u "qh"j kuvqtkecn'gtwrvkqpu "qh "Mco dcn p{0"N qv"kpenwf kpi " Mco dcn p{. "yj gtg "ctg "6 " xqnecpqgu"yj cv'eqo r tkugu"c "d gpug "i tqwr "qh 'xqnecpqgu"kp"yj g "uqwy " Mco ej cvmc< Mwuwf ej . '\ j gmqxm {. "K o {kpum {" cpf "Mquj gngx0'Cv'ngcuv'qpg "gtwrvkqp'j cu'dggp"tgeqtf gf "hqt "gcej "qh"yj gug "xqnecpqgu0'Vj gug "hkxg "xqnecpqgu"ng " cnqpi "c "ncttqy "tcpi g "qh"ncvkwf g "htqo " 73 5"vq "730 "P 0'Vj g "o quv'xkgi qtqwu"r atqz{um cp'gtwrvkqp"r tqf wegf "d{ " Mwuwf ej "y cu"f qewo gpvgf "qp "O ctej "4: .'3; 290'Vj g"xqnecpq"gtwrvgf "5 "mo "5 "qh'r tqf wevu"+'I uuej gpmq. "3; 9: _0'

Y g"uwi i guv"yj g"o gyj qf "hqt "eqpuvtwevkqp"qh"c"hqtgecuv'ewtxg "wukpi "uc r o ng"f cvc "htqo "yj g "ecvcnqi ug"qh" Mco ej cvmp"gctvj s wcngu"d{ "MD"HTE" TCU" *j wr <1[y y y 0go uf 0tw+"y kyj " gr kegpvtcn'f kuvcpegu "vq "67" mo " tgncvkxgn{"vq"yj g"uwo o kv'eqqtf kpcvgu'qh'Mco dcn p{"Xqnecpq"*73 6Ž6: :)'P 0"378 Å75)'G+0'

Vj g"o gyj qf "qh"ewo wncvkxg "ewtxg "eqpuvtwevkqp "dcugf "qp "c "46/j qwt "rj {yj o " y cu"r tqr qugf "d{ "X0C0' Uj ktqmqx "kp "*Uj ktqmqx "gv'cn "4236+"cpf "hqt "yj g "hktuv'vko g "gxgtr "cr r nkgf "hqt "hqtgecuvkpi "yj g "O ctej "33. "4233" Vqj qmw"gctyj s wcng "*Lcr cp+"y kyj "O y "? ; . 20'Kp "yj ku'r cr gt "y g"wugf "7 "tgxgcngf "rj {yj o u "*Vcdng "3+0'Vj g" eqpukf gtgf "gctyj s wcngu'nqecvgf "'kp"yj g "ctgc "qh'Mco dcn p{'ceewttgf "cv'f gr yj u'htqo "37 "vq '342" /"422 "mo 0'

Table 1. Dcukc "r ctco gvgtu"qh"yj g"ugkuo ke "tgur qpug"hqt "ecrewncvkpi "yj g"ewo wncvkxg "ewtxgu0

Interval	M	H (km)	T (rhythm)	Δ Φ	N/m	P	n⁺/n⁻
2017							
*42 "/"45"+0250"	4097 "/"506"	2 "/"422"	46 "j qwt"	2045: "	: 12"	2022223"	713"
*35 "/"45+0250'	4097 "/"506"	2 "/"422"	7 "o kp"	20524"	914"	20226"	21; "
45*5<64+025 "ó 45*43<33+025 "	4097 "/"506"	2 "/"9"	407 "o kp"	2069; "	: 13"	2023"	216"
35*39<62+025 "ó" 45*9<5: "+025 "	4097 "/"506"	6 /422"	4 "o kp"	2062; "	; 12"	202225"	219"
35*6<37+025 "ó" 45*37<79"+025 "	4097 "/"506"	6 /422"	52 "uge"	204; 7"	3214"	202224"	514"

O cpvg"gctyj s wcngu"ceewttgf "pgct "yj g"uwrr qugf "xqnecpq)u"o cpvng"o ci o c "hggf kpi "ctgc0'Hqt "gcej "qh"hkxg " tj {yj o u"y g"kpf kecvcf "c "kko g "kpvgtxcn'cuuqekcvgf "y kyj "N"cpf "m"gxgpvu"yj cv'kx/qt 'f qp+/'kx/yj g"cevkxg "Δ F"y kyj " r j cug "kpvgtxcn0"

Rj cugu"qh "yj g "tj {yj o u"xct{ "htqo "2 "vq "3020'Vj g "rj {yj o "ku "eqpukf gtgf "uvcukukecn{ "uki pkhkecpv'kh"yj g"P " r tqdcdkrkv{ "qh"c "tcpf qo "gxgpf f kuttkdwkqp "qxgt "yj g "tj {yj o "r j cug "f qgu"pqv'gzeggf "20230'Vj g"P xcnwg "ku" ecrewncvgf "htqo "yj g"Dgtpqwnnk'hqto wc< P = C (N, m) • (ΔF)N • (1- Δ F)m. "y j gtg "C (N, m) "ku "yj g "pwo dgt "qh"

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Kpukwwg"qh"Xqnecpqnqi {"cpf "Ugkuo qnqi {"HGD'TCU. 'Rgvtqr cxnqxum/Mco ej cvm{. "Twukc. "42 yj /48 yj "Cwi wuv. "423: "

eqo. dkpcvkqpu"qh'*N*"y kyj "*m.*'y j gtg"*N*"ku'vj g"pwo dgt"qh gxgpvu"kp'vj g"cevcvxg"r j cug."*m /*"qwukf g"qh"kv'*I o wto cp."
3; 94+0'Chvgt"gcej "vko g"kpvgtxcn'hqt"y j kej "vj g"eqttgur qpf kpi "tj {vj o "y cu'f gvgevgf ."vj gtg"qeewttgf "*n ++'
gxgpvu'kpcnwf gf "kpvq"cevcvxg"r j cug"cpf "*n-+'gxgpvu'gzenwf gf "qh'kv'*Vcdng"3+0"Vj g"gpvktg"ecvcnqi "eqpvckpu"72"
ecugu'n{kpi "y kyj kp"vj g"cevcvxg"r j cug"kpvgtxcn'cpf "4: "ecugu'n{kpi "qw'qh'vj g"cevcvxg"r j cug"kpvgtxcn0'Vj g"tcvkq"ku"
721'4: ? 309: 0'Vq"ecncwncvg"vj g"r tgf kevkvg"hwpevkqp"qh'ko g"*ewo wncvkxg"ewtxg"kv'ku'r tqr qugf "vq"wug"4'v{r gu"qh"
ugkuo ke"tgur qpug"]Uj ktqmqv"gv0cn0'4236.4237_0'V{r g"K*"n +"ku"cuuki pgf "c"xcnwg"n?30'Hqt "v{r g"KK*"t +"gcej "
tgur qpug'ecug"j cu'c'xcnwg"qh'*∑n/∑r)=N/R"y kyj "c"o kpwu'uki p0'Kp"vj ku'ecug. "vj g"ewo wncvkxg"ewtxg."cv'vj g"ko g"
qh'vj g"r tgf kevkqp"qh'vj g"gtwr vkqp."y km'vcmg"c"| gtq"xcnwg. "dgecwug"N – R • (∑n/∑r) = N – R • (N/R) = 00'Vj g"
eqpenwukqp"cdqw'vj g"hqtgecuv'qh'vj g"gtwr vkqp"ku'i kxgp"kh'vj g"ewtxg"swkemn{"cr r tqcej gu'vj g"o kpko wo "*Hki wtg"
3+0'Hki 0'3"uj qy u'vj g"ewtxg"o czko wo "cpf "ku'uj cr r f genkpg0'Cv'vj g"xgt{"gpf "qh'O ctej "45. "y g"eqwnf "hqtgecuv'
vj cv'vj g"gtwr vkqp"qh'vj xqnecpq"eqwnf "dg"gzr gevgf "y kyj kp"y q"qt'vj tgg"f c{u0"

Uko knct "ewo wncvkxg"ewtxgu"y gtg "ecnewncvgf "wukpi "vj g"ecvcnqi wg"qh"Mco ej cvmcp"gctvj swcmgu"
y kyj "vj g"342/422"mo "j {r qegpvgtu'f gr vj u."qecevgf "y kyj kp"vj g"ncvkwf g."cuuqekcvgf "y kyj "hkxg"cevkxg"
xqnecpqgu"qh'Uqwj "Mco ej cvmc "*73Å2)'P "/"73Å)0'Y g"cnuq "ecnewncvgf "ewo wncvkxg"ewtxgu'hqt"vj g"
y qrf "rkj qur j gtke"gxgpvu"y kyj "J "?"2/322"mo "cpf "O y ×80 "*j wt u<1gctj swcmg0wui u0 qx1+'qxgt"vj g"
r gtkqf "qh'htqo "O c'3; ."4238'vkm'vj g"gtwr vkqp"qh'Mco dcrp{"Xqnecpq0'Vj g"eqo r ctkqp"qh'vj tgg"
ewo wncvkxg"ewtxgu'qh'c"uko knct'mkpf "cnqy "eqpenwf kpi "vj cv'r ncpgct{'rkj qur j gtke'ugkuo kekv{"cv'f gr vj u"
qh'wr "vq"322"mo "*Hki wtg"4+'ku'vj g"o quv'ko r qtvpv'dwknf /wr "gtwr vkxg"hcevqt. "tguwngf "kp"c"uwy cam "qh"
xqnecpke/vgevqpke"gctj swcmgu"qh'Mco dcrp{"Xqnecpq"cpf "ku'gtwr vkqp'Vj g"r tqr qugf "cr r tqcej "ecp "dg"
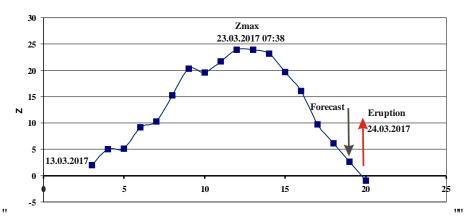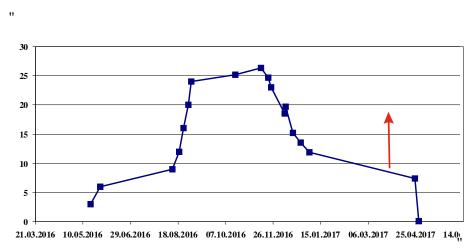wugf "vq"vguv'ku'ghhgevkxgpguu'qp"vj g"gzco r ng"qh'qvj gt "xqnecpke"gtwr vkqpu0'

Fig. 1. Vj g"ewo wncvkxg"""ewtxg"qh"7"kpvcvf c"tj {vj o u"htqo "vj g"f cvc"qh'gctj swcmgu'vj cv'qeewttgf "dghqtg"vj g"
gtwr vkqp"kp"Mco dcrpc{c"cv'cp"gr kegpvtcn'f kuvcpeg"qh'6606"mo "htqo "ku'r gcm'htqo "O ctej "35"vq"46. "42370'
Us wctg"eqttgur qpf u'vq'cp"gctj swcmg0'

Fig. 2. Rtqi pquvke"ewtxg"hqt"y qrf "gctj swcmgu'htqo "3: 02704238"vq"4: 026042370'y kyj "O y ×"80 ."J "?"2/322"
mo 0'

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Kpuvkwg"qh'Xqrecpqri {"cpf "Ugkuo qi {"HGD'TCU. 'Rgvtqr cxnqxum/Mco ej cvmc{. 'Twukc. "42 yj /48 yj "Cwi wuv. '423: "

"

Tghgtgpegu"

I ktkpc"Q0C0"O grpknqx"F0K0"O cpgxkej "C0I 0"P w|j fcgx"C0C0'Gtwrvkqp"qh'Mco dcmp{"Xqrecqq"kp"
42390' *Vtcpuvgf " htqo " Twuukcp+llUqxvrgo gpp{g" rtqdrgo {" fkuvcp| kqppqi q" |qpfktqxcpk{c" \ go rk" k| "
mquo quc042390'V0360P0'4.'rr0485/4890'

I wuej gpmq"KKO'Vj g"xqrecpke"gtwrvkqpu"qh'j g"Y qtrf0'Ecvcrqi 0O quqy 0Pcwnc03; 9; 0'697'rr0'

I qtgrej km" Uj ktqmqx." Hktuvqx." Ej wbctqxc0' Uj kxgnxej " Xqrecpq<' Fggr" uvtwewtg" cpf " hqtgecuvkpi "
gtwrvkqpu"*Mco ej cvnc+'Lqwrpcn'qh'Xqrecpqrq0'Cpf 'I gqvj gto cn'Tgugctej 09: "*3; ; 9+.'rr0343/3540"

Hktuvqx"R0R0'cpf "Uj ktqmqx"X0C0'F {pco ku'qh'o qpgewrcuj {ftqi gp"cpf "ku'tgncvkqp"vq'fghqto cvkqpcr'
rtqeguugu"cv'vj g"Rgvtqr cxrqxum/Mco ej cvm{'i gqf {pco ke'vguv'ukvg<'Gxkf gpeg'htqo "qdugtxcvkqpu"kp'3; ; ; 64225."
I gqej go 0'Kpv0'4227.xqr0'650P033.'rr03278/32860'

I o wto cp'I 0U0'Vj gqt{'cpf "O cyj go cvkecr'Uvcvkuvkeu.'O queqy <'X{uuj 0uj mqnc.'3; 94.'389'r 0'

Uj ktqmqx" X0C0' Vj g" kphnwgpeg" qh"qwgt/ur cec" hcevqtu"qp "i gqf {pco kecr'ugvwkpi " cpf "vj g"qpgi /vgto "
rtgf kevkqp"qh'vj ku'ugvwkpi "hqt"vj g"pqtvj y guvgtp"Rcekhke"vgevqpke"| qpg."Xqrecpkuo "cpf "I gqf {pco ku."O queqy <'
P cwnc."3; 99.'rr0325/3370'

Uj ktqmqx."X0C0'C "ecug"uvwf {"qh"uj qtv/vgto "hqtecuv'qh'vj g"vko g.'r nceg"cpf "o ci pkwf g"qh'gctj s wcmgu"
y kj "O "?"8690 "qeewttgf "kp"Mco ej cvm'kp"vj g"r gtkqf "qh'3; ; 8/4200."dcugf "qp"vj g"eqo r ngz "qh'ugkuo qrqi kecr'
f cvc."I qef {pco ku'cpf "Xqrecpkuo "qh'vj g"Mwtkn/Mco ej cvm"Kuncpf "Cte"U{uvgo +."Rgvtqr cxrqxum."Mco ej cvm<'
KKI I ."4223.'rr0; 9/3380'

Uj ktqmqx"X0C0'Uqo g"r tqegf wtcn'cur gevu"qh'eqo r ngz "r tgf kevkqp"qh'hcpm'gtwrvkqpu"cv'Mnwej gxumq{"
xqrecpq."Mco ej cvm0'Xqrecp0'cpf "Ugkuo qr03; ; 70P09.'rr0; 43/; 640'

Uj ktqmqx"X0C0'Tgcrkqpuj kr "dgwy ggp"xqrecpke"gtwrvkqpu"kp"Mco ej cvm"cpf "gctj s wcmgu"kp"vj g"wr r gt "
o cpvng"ll'Dwnn0xwmcpqn0ncp| kk0CP "UUT0'O0P cwnc03; 9: .'rr05/: 0'

"Uj ktqmqx."X0C0"F dtqxqrum{c."KM0'Qp"vj g"r ngpgct "ugkuo q/vgevqpke"pcwtg"qh'uy cm u"qh'xqrecpke"
gctj s wcmgu'tgncvgf "vq'vj g"r tgr ctcvkqp"qh'vj g"422: "Mqt{cmm{"xqrecq"gtwrvkqp0'll'Rtqeggf kpi u"qh'vj g"Ugeqpf "
uekgpvkhke/vgej pkecn'eqphgtgpeg" ëRtqdrgo u"qh'eqo r ngz "i gqr j {ukecr'o qpkqtkpi " kp" vj g" Hct" Gcuv." Twuukc"
    033/39'Qmqdgt."422; 0'Ej gh0'Gfkqtu0X0P Œj gdtqx0'Rgvtqr cxrqxum/Mco ej cvm{0'I U'TCU04232.'"
rr046; /4750""

"Uj ktqmqx"X0C0"Mw|o kp"[c0'F0'Qp"vj g"fckn{"r gtkqfkekv{"qh'xqrecpke"gctj s wcmgu"kp"vj g"Mwtkng/
Mco ej cvm"| qpg0'Xqrecp0'cpf "Ugkuo qr03; ; : 0P07.'rr0: 34/: 460'

Uj ktqmqx." X0C0' Vguvkpi " vj g" I NQDCU" vgej pks wg" hqt" vj g" tgcr' vko g" hqtecuvkpi " qh" uvtqpi " y qtrf "
gctj s wcmgu"kp"vj g"r gtkqf "qh'Lcpwct{"422: óQevqdgt"4232."Rtqeggf kpi u"qh'vj g"Ugeqpf "Tgi kqpcn'Uekgpvkhke"cpf "
Vgej pkecn' Eqphgtgpeg")Rtqdrgo u" qh" Eqo r ngz " I gqr j {ukecr' O qpkqtkpi " kp" vj g" Twuukcp" Hct" Gcuv."
Rgvtqr cxrqxum/Mco ej cvm{."Twuukc."422; ."Ej gdtqx"X0P 0"Gf 0"Rgvtqr cxrqxum/Mco ej cvm{<'I U'TCP ."4232."
rr0466/46: 0'

Uj ktqmqx" X0C0" Hktuvqx" R0R0" O cmctqx" G0Q0' Eqo qr j {uke" tj {j o u" kp" vj g" y qtrf " cpf " tgi kqpcr'
ugkuo kekv{." vj g" nqpi /vgto " hqtgecuv' hqt" O y ?: 05" Uko wuj ktumc{c" " gctj s wcmg" " 37083042280' " Uekgpvkhke"
Eqphgtgpeg048/52'O c{'42370Wj j pq/Ucj j crkpum"Twuukc0'Fcrpcvmcr0'Xncf kxquvqm"4237.'rr0455/45: 0"

Uj ktqmqx"X0C0'Hktuvqx"R0R0'O cmctqx"G0Q0'Ugt cpcx"KKO"Ugr cpcx"X0K0'Cp"Cr r tqcej "vq'vj g"Uj qtv"
cpf "Nqpi /Vgto "Hqtgecuvkpi "uvtqpi "Gctj s wcmgu<'C"Ecug"Uwf {"qh'O y ?: 02"Vqj qm"Gctj s wcmg."Lcr cp."
O ctej "42330'KUUP "2969/; 45; ."Ugkuo ke'Kpuvtwo gpvu."4237."Xqr0730P05.'rr044; /4630'

Uj ktqmqx"X0C0"Mw|o kp"[c0'F0'Qp"vj g"fckn{"r gtkqfkekv{"qh'xqrecpke"gctj s wcmgu"kp"vj g"Mwtkng/
Mco ej cvm"| qpg0'Xqrecp0'cpf "Ugkuo qr03; ; : 0P07.'rr0: 34/: 460'

Uj ktqmqx."X0C0"Ugr cpcx."KKO"cpf "F wdtqxqrum{c."KM0'Uwf {kpi "vj g"ugkuo ke'tgur qpug"qh'Mqt{cmm{"
cpf "Mn{wej gxumq{"cevkxg"xqrecpqgu."Mco ej cvm."cv'vj g"hkpcn'uvci g"qh'r tgr ctcvkqp"qh'uvtqpi "y qtrf "vgevqpke"
gctj s wcmgu."dcugf "qp"vj g"qdugtxcvkqpu"kp"422: ó4422; ."MPCWP VU0'Uekgpvkhke"ug"qh'Gctj pcwm'\ go ng."4232."
P 036.'rr033: /34; 0'

""