

evolve.txt Notes on evolution of KRC code, after the first 17 years.  
Newest on top. Does not include all minor changes.

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2017feb23 V 3.4.3 Released. Correct effective azimuth of tilted surfaces by reversing diurnal Sun motion (TLATS).

2016sep05 V 3.4.2 Released as alpha. Correct the version 3 layer-doubling factor from 4 to 2. The convergence safety factor in code SCONVG and the input minimum CONVF are both the square of that described in the JGR article in section 3.2.3 . Replace use of R2R family of routines, which overloaded arguments so that the compiler could not check out-of-bounds, with FILLMV set of routines with a FILL and MoVe routine for each word type.

2016may20 V 3.4.1 Option to use flat-model result for the far-field of sloped models. Allow up to 3 binary files open at once. Major changes to TDISK and new routines TFAR (read a type -1, -2 (had been -1) , or -3 file) and CUBUTERP (cubic spline over uniformly spaced data). Modest changes to KRC, TSEAS, TLATS, TDAY. Minor changes to TCARD and to commons HATCOM, FILCOM, and UNITS. See the V34 USers Guide for documentation.

2016mar22 Version 3.3.1 Minor glitch fixes. LD18 is used to indicate when parameter and layer table were last printed; used to force their print if a numerical blowup happens.

2016mar07 Version 3.3.0 Released as alpha, later withdrawn. IB becomes IIB, flags made negative, and positive values represent geothermal heat flow in milliwatts/m<sup>2</sup>. Allow bond albedo function beyond Lambert. Option for zone table, major re-code of TDAY; new routine READZONE. Revision of time-doubling code. Printing the layer table moved from TPRINT to TDAY. Changes to KRCCOM and FILCOM. Start naming of source files with 2 digits of version number, e.g. tday33.f; include files are all ...vvc.f where vv is first 2 parts of version number. Soft links are used for routines and commons that had nill of minor revisions.

2015dec24++ Version 3.2.3 TDAY: First time-double layer not less than 4. FLAY now is the first physical layer. Real parameter 11 (ABRPHA) and 32 (FD32) become the Clausius-Clapeyron coefficients used in function CO2PT; labeled SatPrA and SatPrB in the input file. Values for CO2 (the prior hard-code) are 27.9546 and 3182.48, included in master323.inp; which is also updated to finer layers. Minor print changes.

2015jun1 Version 3.2.1 Released to ASU. Add TUN8 subroutine to write a fort.77 file when I15 is 100+. TUN8 has access to several of the commons: see the code to learn what the current version outputs; TUN8 would need to be modified by user for their special need. KRC calls TUN8 at the start of each case to write a

header. If I15=101, then TDAY calls TUN8 on the last day of each season being output to disk at each output hour. If I15=102, then TLATS calls TUN8 for every latitude for every season being output to disk. Change KRCCOM to move ALAT and ELEV earlier.

2014apr28 Version 2.4.1 Released to ASU. Fix blunder in the v2.x.x system when using the Viking lander pressure relation; in VLPRES update the base date for compatibility with the J2000 system. LAST SINGLE PRECISION VERSION.

2014mar28 Version 2.3.3 (not released)

Minor fixes to V2.3.2 routines noticed in the R\*8 development:

```
daycom.inc  BLAY(MAXN1) >> BLAY(MAXN1P) and increase NWDAY by 1
tday.f      DIFFI(MAXN1) >> DIFFI(MAXN1P)
"           HEAT >> HEATA  simply to make it unique
tdisk.f     INTEGER*4 HEADLEN /30/ >> INTEGER*4 HEADLEN /25/
tcard.f near 274 N1PIB.GT.MAXN1 >> N1PIB.GT.MAXN1P
```

2014mar23:28Code KRCN, A Crank-Nicholson solution version of the R\*8 version of TDAY8, only this file is modified, and it calls the new routine tridah8.f, which is a modification of the Numerical Recipes routine tridag. A parallel change is to remove all code related to time doubling, use of which would require changing the matrix size at nearly every time step.

2014mar10:16 V3.1.1 Code KRC8, a double-precision version, keeping the same algorithms. Major source files and routine names changed by adding a trailing 8: ---.f >> ---8.f . For a number of minor routines, kept the same name and grouped them into a file ksubs8.f . Order of arrays in KRCCOM modified. The files for all commons with any real variables renamed: ---com.inc >> ---c8m.f . 21 FORTRAN files modified. Untabify most source-code files. Makefile Make8 .

2014feb28 Version 2.3.2 Released to ASU. Change Makefiles to use gfortran rather than g77, and simplify them. [Untabify and justify most .f files; many variables to set explicitly to REAL\*4]

2014jan27 Version 2.3.0 If fatal error, rather than terminating run, KRC will try the next case. Ensure disk files closed for unusual sequences. Use more accurate, and slower, models for the OnePoint mode.

2013nov13 Version 2.2.4 Sent to ASU but named krc222f there. This is the last of several variations on 2.2.2 that dealt only with the makefile, IDL routines, and tiny format changes. All calculations are the same in all variants of 2.2.2 and 2.2.4

2013aug30 Fix logic in tdisk when changing between file types.

2013aug26 Version 2.2.2 Revise PORB system to accommodate exoplanets and a format

for asteroids that allows cut-and-paste from the JPL small-bodies browser; most changes are in porbel.f . Add design and Users Guide documents for PORB. Included detailed documentation of Type 52 output file.

2013jun10:Aug05 v2.2.1 Fix bug in computing dates to match requested LS in OnePoint mode that was introduced in 2013jan changes. Major change to PORB system, reducing geometry matrix from 60 to 30 items; use new routines porbig.f, which computes the geometry matrix, and porbit.f which computes geometry for a specific time. These routines are generic for any orbit and spin axis. Mars values now agree closely with Allison and McEwen (2000), as described in ls.tex

2013jan30+ v2.1.2

Add version number to screen, print file , and type5x output. Defined in filcom Remove capability of taking input cards from terminal. Use IMPLICIT NONE throughout. Fix binf5 to detect CPU word order and write in .bin5 file Update PORB system to use dates from J2000.0, dates now 11545 less than older. Revise the orbit-element tables, using Standish for planet orbits. Change variable name: PHOXX to PHFXX , to match matrix.tex conventions.

2013jan25 Version 1 distributed for KRC workshop at ASU Jan 28-30. This is the version described in H. Kieffer, Thermal model for analysis of Mars infrared mapping, J. Geophys. Res.: Planets, v.118, 451-570 (2013).

2012jun02 Compute cosine of incidence on level and slopes using vector algebra. This removes the restriction that slope normals should not be tilted past the spin axis, and is exact for large slopes. A few new subroutines for vector algebra.

2012may11 Temporary calculation of magnitude of energy lost from system when Tatm falls below saturation but there is no cap to which to add the snowfall. Use FLOST in krcom and TTX4 in latcom. Then comment out code in TSEAS but leave the few statements in TDAY and TLATS

2012 Mar 3 06:07:45 Very scary, after many crashes (typical exceeding MAXN4) and debugs, added a print statement to TDISK and it ran. Removing the compiler option -fdefault-integer-8 seems to have fixed the problems.

2012 mar Develop no-atmosphere capability, which uses average annual insolation for initial temperature estimates; changes restricted to TLATS and TDAY. Write OBLIP and AVEYEAR. Discover many versions of porbcm.inc and some porb--.f; replace all current use except -/krc/porb/ with soft-links. No-atmosphere is triggered by PTOTAL of 1 [Pascal] or less. Include '|<debug' on D-lines. Incorporate CLIMTAU that allows read of zonal/seasonal dust and ice opacities

2011july Develop movie version, KRCm, to speed up Phils calculation of spinning thermal planet; achieved factor of 3800. Requires use of soft links to

multiple versions of some routines

2010sep04 In tday; remove the 0.9 pad on N3 limit of DELJUL/PERIOD

2010apr21 Update 3 routines that deal with the 4 input lines related to temperature-dependent properties: tprint, tcard, tday , giving the extension .f2 and the older versions extension .f1. Make soft links of .f to the .f2 version Also make soft link for krccom.inc to krccom2.inc . As of this date, the base version of KRC has the temperature-dependent option, invoked by setting LKOFT. Add option of 3rd integer on first input line. If not 0, then will read a card of 6 debug flags, IDB1 to IDB6, which are contained in units.inc and all are initialized as 0 in TCARD(1)

2010jan11 Go to IMPLICIT NONE in all major routines

Change names in krccom PI>>PIVAL RAD>>RADC to improve search uniqueness

Move TINT call from tlats to tseas so as to remove 1-season delay in SUMF

Add D-line writes to FORTRAN units for study of KofT differences.

2009apr22

Begin ability to forecast deep layers based on storage of midnight values.

Scheme 1. [Coded, but not refined. Mostly a stub] Store at integral years prior to forecast season index. If have 3 or more values, use EPREAD; should be safe to use on all layers. Because of possible jump perturbation on the first day, best to not have that be one of the stored dates. Does nothing if IDISK2=0. [To remove, delete TMN4Y from hatcom, delete call to TYEARP in TSEAS, remove tyearp.o from sources in Makefile]

Scheme 2.[Not implemented] Rolling storage of all seasons for the past year. At forecast season; evaluate thermal delay to surface and make [complicated] forecast.

2008nov11-2009feb MAJOR CHANGE. Add temperature-dependent conduction option

Use L10 as logical variable for k-of-T

Lengthen KRCCOM and move some inputs around  
recode tday to have constant and T-dependent options

Update IDL routines that deal with KRCCOM

Remove max # seasons restriction.

2008oct02-25

Found error in calculation of planetary temperature; was using

hemispheric integral 1-BETA instead of  $\exp(-\text{Tau\_IR})$ ; so in effect using tau that was too large by factor of  $\text{tau\_eff}/\text{Tau\_IR}$ .

Modify: krc.f tseas.f tlats.f tday.f tdisk.f tprint.f tcard.f  
krccom.inc daycom.inc

Use slope azimuth as a flag for a pit of slope SLOPE.

Put in proper SKYFAC for conical pit.

Allow for Snow formation in cold atmosphere and fall to surface.

Move MAXBOT from daycom.inc to krccom.inc.  
Replace ID22(1) and (2) with KVALB and KVTAU.  
Move AMW fixed value in tlats.f into krccom in place of ABRAMP  
move other physical and hardware-dependent constants into krc and krccom.  
Add output file type 56 in tdisk.  
Replace dual use of GGT by using new DTMAX for daily convergence.  
Major modification of output Type 52.  
Use IDOWN as season index at which to read some changes

2006sep09 Allow seasonally variable albedo and TauD.

three new routines: seasalb, seastau, readtxt360;

and changes in tseas and tcard and filcom.inc

2006sep09 tcard Correct error: REAL\*4 LSUBS should have been ALSUBS

2006apr30 tdisk Add TTB4 to type 54 output

2006apr22 tdisk Allow flexible number of cases for output file type 52 and 54

2006apr12 tdisk Change file style 54 to have both 1 am and 1 pm surface Temp.

2006jan25 tlats Modify SKYFAC from linear with slope to  $(1+\cos s)/2$

2005dec28 tlats Fix bug using ZENLIM. Additional comments

2005nov19 tprint Add print of depth to top of 2nd layer

2005nov18 tlats Add optional solar zenith angle limit

2004sep30-Oct5 tday.f tdisk.f Add storage of surface downward fluxes every hour on last day. Revise file style 52 to include them (and a spare variable).

2004sep28 tlats.f Add tests to avoid round-off to negative fluxes at night so code would run at ASU

2004sep28 porb.f Change name of called routine ROTATE to ROTVEC to avoid library conflicts

2004jul06 tdisk Add file style 54 Add the Common HATCOM

2002nov01 tseas.f Have DJU5 increment by current DELJUL for each season

2002aug04 tdisk.f Add output file type 53=(combo at 1 lat, 2+80 seasons, 10 cases). Recode logic

2002jul12-17 Incorporate Delta-Eddington atmosphere. Found that double precision

is required within deding2.f

2002mar07 krc.f tcards.f Major change. Add option for "one-point" rapid runs for Surface T

2002mar07 alsubs.f Created. Adopted from l\_sub.s.pro

1999dec krc.f tcards.f Add option to continue from current condition

98sep01-07 Add section to TDISK for output of bin5 files type 51 and 52. Minor code cleanup, avoiding divide-by-zero if atmosphere parameters were zero Make KRC/moon version of TLATS and TDAY by removing all atmosphere code, and including eclipse section in TLATS; commons left the same even though atmosphere results not calculated.

1997sep idlkrc.f Build this IDL interface to call KRC.

97fall-98summer Incorporate one-layer atmosphere with many parameters that can be tuned to mimic Haberle-Jakosky model. First-order treatment of scattering of solar radiation. Diurnal temperature is modeled as sinusoidal with phase shift. Wrote LaTeX description. Build TES look-up code for computation of thermal inertia from TES observations; this interfaces with Mike Mellon model set.

97jul Go from cal-cm units to all SI except for use of days

88sep08 .MARS]TDAY: Test moving layer T limit tests and metamorph. from N24 into each time loop; so that they are done 1536 instead of 40 times per "day". Negligible effect; <.01 degree in T<sub>META</sub>.

87nov22 TCARD: Add report if input integers are reset into valid range.  
NMHA no longer constrained.  
TPRINT: redo some formats.  
TDAY: Add error report if convergence is unstable.  
KRC: set IOERR=IOPM rather than IOSP.  
Force parameter print through call to TPRINT(2) if TDAY(1) error occurs.  
.MARS]TLATS: now includes variance tests.

87nov22 .YEAR] versions of DAYCOM and LATCOM with larger MAXN24 and MAXN2 meant for use with TYEAR.  
Most routines compiled into .YEAR] with the these.  
Will need to redo TDISK if it is to be used.

87oct01 ALL Separate the use of NMHA for storage and N24 for printout.  
TLATS: replace CFSOLAR with AVEDAY.

87sep11 .MARS] TDAY & TLATS: Special versions for metamorphism.  
Use ZLAT(17:19) for input of metamorphism and sublimation constants.  
Use TT(J,MAXN3) to transfer metamorphism rate.  
TYEAR: version of TLATS which averages daily insolation and includes  
PORB in the insolation calculation. Uses AVEDAY.

87jun30 TDAY: Avoid /0 if DTMJ(JJJ)=0 at "done" test.

87mar29 Remove incorporation of albedo in the solar incident flux ASOL.  
Add ADGDIF (diffuse solar flux) to KRCCOM.INC.  
Recompile TLATS,TDAY, Link.

86oct Paul finds erroneous factor of PI in computing coma diffuse radiance;  
change made to source code only, not linked.

85oct14 Add COMMON FILCOM of file names; print these in TPRINT.  
Change meaning of FROST4 and AFRO4 for comet.  
Minor changes in printout sequence.  
Change TYPE to WRITE(IOPM in TDISK.

85sep05-07 Combine the comet and mars versions into single routines which use  
the larger LATCOM. Only external change is reversing the meaning of  
LD18. Major restructuring of TLATS and TDAY to accommodate both comet  
and Mars; use LD20 .TRUE. if Mars, .FALSE. if comet. Other routines  
needed no changes.  
Revise HELPLIST.  
Create directory KRC.COM] for the comet-particular stuff. Move older  
routines for .KRC] to .KRC.COM]. Move all the routines which support  
both comet and mars from .KRC.MARS] to .KRC].  
Delete plot routines dating from 1984 which used the smaller LATCOM.

85May~10-14. Dave Paige visits Flagstaff. We create new directory  
[hkiefner.krc.mars] in which MARS version of code is put. MARS version  
has larger LATCOM (JLAT changed to real\*4). HELPLIST revised.  
After Dave left, found that TDISK had not had JLAT change,  
hence was not writing LATCOM to disk.  
Made new plot version, starting with 84jun comet version, but with  
almost entire revision using NCAR\_1 routines, including new  
MCURVE1, CONREC1 and GO1. Never got all the bugs out.

85Jun24-28 Paul Weissman visit. Found error in COMA2, otherwise no changes  
from Jun 84 comet version. Linked and ran and duplicated older runs.

circa 1980. Comet Version. See: P.R. Weissman and H.H. Kieffer, Thermal  
modeling of cometary nuclei, Icarus, v. 47,pp 302-311 (1981). Includes model for  
opacity, scattering, and emission of dust coma based on mass of ice sublimated

in last season. Computes non-gravitational acceleration terms. Moving numerical grid to keep it in fixed relation to surface which is subliming or condensing.

circa 1968. Original code: Used for analysis of Mariner 6, 7, 9 and for planning and analysis of the Viking missions. Described in: H.H. Kieffer et al., Thermal and albedo mapping of Mars During the Viking primary mission, J. Geophys. Res.,v. 82, 4249-4291 (1977)