**home/lee/Desktop/rttov\_11.3/src/main/rttov\_fastem5.F90**

**home/lee/Desktop/rttov\_11.3/src/main/mod\_rttov\_fastem5\_coef.F90**

**1、fastem5的函数原型**

SUBROUTINE rttov\_fastem5( fastem\_version, & ! Input

Frequency , & ! Input

Zenith\_Angle, & ! Input

Temperature , & ! Input

Salinity , & ! Input

Wind\_Speed , & ! Input

Emissivity , & ! Output

Reflectivity, & ! Output

Transmittance,& ! Input, may not be used

Rel\_Azimuth ,& ! Input, may not be used

Supply\_Foam\_Fraction, & ! Optional input

Foam\_Fraction) ! Optional input

*! Description:*

*! To compute FASTEM-5 emissivities and reflectivities.*

*!*

*! Copyright:*

*! This software was developed within the context of*

*! the EUMETSAT Satellite Application Facility on*

*! Numerical Weather Prediction (NWP SAF), under the*

*! Cooperation Agreement dated 25 November 1998, between*

*! EUMETSAT and the Met Office, UK, by one or more partners*

*! within the NWP SAF. The partners in the NWP SAF are*

*! the Met Office, ECMWF, KNMI and MeteoFrance.*

*!*

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*!*

*! Method:*

*! An improved fast microwave sea surface emissivity model, FASTEM4*

*! Liu, Q., S. English, F. Weng, 2009: Report in prepare*

*!*

*! It is an extension of the FASTEM-3 English 2003.*

*! http://www.metoffice.com/research/interproj/nwpsaf/rtm/evalfastems.pdf*

*!*

*! Current Code Owner: SAF NWP*

*!*

*! History:*

*! Version Date Comment*

*! ------- ---- -------*

*! 1.0 27/08/2009 New F90 code (Q. Liu)*

*! 1.1 10-Feb-2014 Revised wind azimuth dependence (M. Kazumori)*

*! 1.2 05/06/2015 Allow foam\_fraction input (L-F Meunier)*

*!*

*! Code Description:*

*! Language: Fortran 90.*

*! Software Standards: "European Standards for Writing and*

*! Documenting Exchangeable Fortran 90 Code".*

*!*

*! Declarations:*

*! Modules used:*

!

**2、外部定义的数据类型**

USE mod\_rttov\_fastem5\_coef, ONLY : FresnelVariables\_type, PermittivityVariables\_type

USE mod\_rttov\_fastem5\_coef, ONLY: fp

USE parkind1, ONLY : jpim, jplm

USE parkind1, Only : fp => jprb

! Disable implicit typing

IMPLICIT NONE

INTEGER, PARAMETER :: JPIM = SELECTED\_INT\_KIND(9) !< Standard integer type

INTEGER, PARAMETER :: JPLM = KIND(.TRUE.) !< Standard logical type

TYPE :: FresnelVariables\_type

! PRIVATE

! The intermediate terms

COMPLEX(fp) :: z1, z2

! The real and imaginary components

REAL(fp) :: rzRv,izRv ! Vertical

REAL(fp) :: rzRh,izRh ! Horizontal

END TYPE FresnelVariables\_type

TYPE :: PermittivityVariables\_type

! PRIVATE

REAL(fp) :: t, t\_sq, t\_cu ! Temperature in degC

REAL(fp) :: f1, f2, del1, del2, tau1\_k, tau2\_k, es\_k, e1\_k

REAL(fp) :: ces, ctau1, ctau2, ce1, delta, beta, sigma, S

END TYPE PermittivityVariables\_type

**3、外部定义的常量**

USE mod\_rttov\_fastem5\_coef, ONLY : ZERO, ONE, TWO, PI, DEGREES\_TO\_RADIANS, transmittance\_limit\_lower,&

transmittance\_limit\_upper, e0\_4, e0\_5, min\_f, max\_f, min\_wind, max\_wind, A\_COEF, Lcoef4, Lcoef5,&

Scoef, t\_c4, t\_c5, b\_coef, FR\_COEFF, x, y, coef\_mk\_azi

! Environment setup

! -----------------

! Module use

! INTEGER, PUBLIC, PARAMETER :: fp = SELECTED\_REAL\_KIND(15)

REAL(fp), PUBLIC, PARAMETER :: ZERO = 0.0\_fp

REAL(fp), PUBLIC, PARAMETER :: POINT\_5 = 0.5\_fp

REAL(fp), PUBLIC, PARAMETER :: ONE = 1.0\_fp

REAL(fp), PUBLIC, PARAMETER :: TWO = 2.0\_fp

REAL(fp), PUBLIC, PARAMETER :: THREE = 3.0\_fp

REAL(fp), PUBLIC, PARAMETER :: PI = 3.141592653589793238462643383279\_fp

REAL(fp), PUBLIC, PARAMETER :: DEGREES\_TO\_RADIANS = PI/180.0\_fp

REAL(fp), PUBLIC, PARAMETER :: transmittance\_limit\_lower = 0.00001\_fp

REAL(fp), PUBLIC, PARAMETER :: transmittance\_limit\_upper = 0.9999\_fp

!

REAL(fp), PUBLIC, PARAMETER :: e0\_4 = 0.0088419\_fp ! Value used in FASTEM-4

REAL(fp), PUBLIC, PARAMETER :: e0\_5 = 0.00885418781762\_fp ! from Paul van Delst (used in FASTEM-5)

! minimum and maximum frequency

REAL( fp ), PUBLIC, PARAMETER :: min\_f = 1.4\_fp

REAL( fp ), PUBLIC, PARAMETER :: max\_f = 200.0\_fp

! minimum and maximum wind speed

REAL( fp ), PUBLIC, PARAMETER :: min\_wind = 0.3\_fp

REAL( fp ), PUBLIC, PARAMETER :: max\_wind = 35.0\_fp

! The fitting coefficients for the JCSDA permittivity model

! see the ref. (An Improved Fast Microwave Sea Surface Emissivity Model, FASTEM4,

! Technical Report, UK Met. Office)

REAL(fp), PUBLIC, PARAMETER :: A\_COEF(0:38) = (/ 3.8\_fp, 0.0248033\_fp, 87.9181727\_fp, &

-0.4031592248\_fp, 0.0009493088010\_fp, -0.1930858348E-05\_fp, -0.002697\_fp, &

-7.3E-06\_fp, -8.9E-06\_fp, 5.723\_fp, 0.022379\_fp, &

-0.00071237\_fp, -6.28908E-03\_fp, 1.76032E-04\_fp, -9.22144E-05\_fp, &

0.1124465\_fp, -0.0039815727\_fp, 0.00008113381\_fp, -0.00000071824242\_fp,&

-2.39357E-03\_fp, 3.1353E-05\_fp, -2.52477E-07\_fp, 0.003049979018\_fp, &

-3.010041629E-05\_fp, 0.4811910733E-05\_fp, -0.4259775841E-07\_fp, 0.149\_fp, &

-8.8E-04\_fp, -1.05E-04\_fp, 2.033E-02\_fp, 1.266E-04\_fp, &

2.464E-06\_fp, -1.849E-05\_fp, 2.551E-07\_fp, -2.551E-08\_fp, &

0.182521\_fp, -1.46192E-03\_fp, 2.09324E-05\_fp, -1.28205E-07\_fp/)

! fitting coefficients for the large-scale correction - FASTEM-5

REAL(fp), PUBLIC, PARAMETER :: Lcoef5(36) = (/ &

-5.994667E-02\_fp, 9.341346E-04\_fp,-9.566110E-07\_fp, 8.360313E-02\_fp,-1.085991E-03\_fp, &

6.735338E-07\_fp,-2.617296E-02\_fp, 2.864495E-04\_fp,-1.429979E-07\_fp,-5.265879E-04\_fp, &

6.880275E-05\_fp,-2.916657E-07\_fp,-1.671574E-05\_fp, 1.086405E-06\_fp,-3.632227E-09\_fp, &

1.161940E-04\_fp,-6.349418E-05\_fp, 2.466556E-07\_fp,-2.431811E-02\_fp,-1.031810E-03\_fp, &

4.519513E-06\_fp, 2.868236E-02\_fp, 1.186478E-03\_fp,-5.257096E-06\_fp,-7.933390E-03\_fp, &

-2.422303E-04\_fp, 1.089605E-06\_fp,-1.083452E-03\_fp,-1.788509E-05\_fp, 5.464239E-09\_fp, &

-3.855673E-05\_fp, 9.360072E-07\_fp,-2.639362E-09\_fp, 1.101309E-03\_fp, 3.599147E-05\_fp, &

-1.043146E-07\_fp /)

! fitting coefficients for the large-scale correction - FASTEM-4

REAL(fp), PUBLIC, PARAMETER :: Lcoef4(36) = (/ &

-9.197134E-02\_fp, 8.310678E-04\_fp,-6.065411E-07\_fp, 1.350073E-01\_fp,-1.032096E-03\_fp, &

4.259935E-07\_fp,-4.373322E-02\_fp, 2.545863E-04\_fp, 9.835554E-08\_fp,-1.199751E-03\_fp, &

1.360423E-05\_fp,-2.088404E-08\_fp,-2.201640E-05\_fp, 1.951581E-07\_fp,-2.599185E-10\_fp, &

4.477322E-04\_fp,-2.986217E-05\_fp, 9.406466E-08\_fp,-7.103127E-02\_fp,-4.713113E-05\_fp, &

1.754742E-06\_fp, 9.720859E-02\_fp, 1.374668E-04\_fp,-2.591771E-06\_fp,-2.687455E-02\_fp, &

-3.677779E-05\_fp, 7.548377E-07\_fp,-3.049506E-03\_fp,-5.412826E-05\_fp, 2.285387E-07\_fp, &

-2.201640E-05\_fp, 1.951581E-07\_fp,-2.599185E-10\_fp, 2.297488E-03\_fp, 3.787032E-05\_fp, &

-1.553581E-07\_fp /)

! fitting coefficients for the small-scale correction

REAL(fp), PUBLIC, PARAMETER :: Scoef(8) = (/ &

-5.0208480E-06\_fp, 2.3297951E-08\_fp, 4.6625726E-08\_fp, -1.9765665E-09\_fp, &

-7.0469823E-04\_fp, 7.5061193E-04\_fp, 9.8103876E-04\_fp, 1.5489504E-04\_fp /)

! August 3, 2011

! 0.5

! fitting coefficients for the downward radiation using transmittance - FASTEM-5

REAL(fp), PUBLIC, PARAMETER :: t\_c5(45) = (/ &

0.199277E+00\_fp, 0.166155E+00\_fp, 0.153272E-01\_fp, 0.399234E+01\_fp,-0.130968E+01\_fp, &

-0.874716E+00\_fp,-0.169403E+01\_fp,-0.260998E-01\_fp, 0.540443E+00\_fp,-0.282483E+00\_fp, &

-0.219994E+00\_fp,-0.203438E-01\_fp, 0.351731E+00\_fp, 0.208641E+01\_fp,-0.693299E+00\_fp, &

0.867861E-01\_fp, 0.619020E-01\_fp, 0.595251E-02\_fp,-0.475191E+01\_fp,-0.430134E-01\_fp, &

0.248524E+01\_fp, 0.388242E-01\_fp, 0.194901E+00\_fp,-0.425093E-01\_fp, 0.607698E+01\_fp, &

-0.313861E+01\_fp,-0.103383E+01\_fp,-0.377867E+01\_fp, 0.180284E+01\_fp, 0.699556E+00\_fp, &

-0.506455E-01\_fp,-0.262822E+00\_fp, 0.703056E-01\_fp, 0.362055E+01\_fp,-0.120318E+01\_fp, &

-0.124971E+01\_fp, 0.154014E-01\_fp, 0.759848E-01\_fp,-0.268604E-01\_fp,-0.802073E+01\_fp, &

0.324658E+01\_fp, 0.304165E+01\_fp, 0.100000E+01\_fp, 0.200000E-01\_fp, 0.300000E+00\_fp /)

! fitting coefficients for the downward radiation using transmittance - FASTEM-4

REAL(fp), PUBLIC, PARAMETER :: t\_c4(45) = (/ &

-0.675700E-01\_fp, 0.214600E+00\_fp,-0.363000E-02\_fp, 0.636730E+01\_fp, 0.900610E+00\_fp, &

-0.524880E+00\_fp,-0.370920E+01\_fp,-0.143310E+01\_fp, 0.397450E+00\_fp, 0.823100E-01\_fp, &

-0.255980E+00\_fp, 0.552000E-02\_fp, 0.208000E+01\_fp, 0.244920E+01\_fp,-0.456420E+00\_fp, &

-0.224900E-01\_fp, 0.616900E-01\_fp,-0.344000E-02\_fp,-0.507570E+01\_fp,-0.360670E+01\_fp, &

0.118750E+01\_fp, 0.124950E+00\_fp, 0.121270E+00\_fp, 0.714000E-02\_fp, 0.736620E+01\_fp, &

-0.114060E+00\_fp,-0.272910E+00\_fp,-0.504350E+01\_fp,-0.336450E+00\_fp, 0.161260E+00\_fp, &

-0.154290E+00\_fp,-0.141070E+00\_fp,-0.809000E-02\_fp, 0.395290E+01\_fp, 0.958580E+00\_fp, &

-0.159080E+00\_fp, 0.368500E-01\_fp, 0.307100E-01\_fp, 0.810000E-03\_fp,-0.619960E+01\_fp, &

-0.172580E+01\_fp, 0.641360E+00\_fp, 0.100000E+01\_fp, 0.200000E-01\_fp, 0.300000E+00\_fp /)

! fitting coefficients for the azimuth dependence, S1 and S4 trained by

REAL(fp), PUBLIC, PARAMETER :: b\_coef(120) = (/ &

3.307255E-04\_fp,-2.901276E-06\_fp,-1.475497E-04\_fp, 1.288152E-06\_fp, 1.004010E-04\_fp, &

-2.671158E-07\_fp, 4.363154E-06\_fp,-9.817795E-09\_fp,-4.777876E-05\_fp, 3.051852E-08\_fp, &

1.369383E-03\_fp,-2.215847E-05\_fp,-8.099833E-04\_fp, 1.767702E-05\_fp,-5.977649E-06\_fp, &

-1.784656E-07\_fp,-9.355531E-07\_fp, 5.495131E-08\_fp,-3.479300E-05\_fp,-3.751652E-07\_fp, &

2.673536E-04\_fp,-1.378890E-06\_fp,-8.660113E-05\_fp, 2.871488E-07\_fp, 1.361118E-05\_fp, &

-1.622586E-08\_fp,-1.232439E-07\_fp,-3.067416E-09\_fp,-1.835366E-06\_fp, 8.098728E-09\_fp, &

1.255415E-04\_fp,-5.145201E-07\_fp,-8.832514E-06\_fp,-5.105879E-09\_fp, 2.734041E-05\_fp, &

-3.398604E-07\_fp, 3.417435E-06\_fp,-7.043251E-09\_fp, 1.497222E-05\_fp,-6.832110E-09\_fp, &

-2.315959E-03\_fp,-1.023585E-06\_fp, 5.154471E-05\_fp, 9.534546E-06\_fp,-6.306568E-05\_fp, &

-4.378498E-07\_fp,-2.132017E-06\_fp, 1.612415E-08\_fp,-1.929693E-06\_fp,-6.217311E-09\_fp, &

-1.656672E-04\_fp, 6.385099E-07\_fp, 2.290074E-06\_fp, 1.103787E-07\_fp,-5.548757E-06\_fp, &

5.275966E-08\_fp,-4.653774E-07\_fp, 1.427566E-09\_fp,-3.197232E-06\_fp,-4.048557E-09\_fp, &

-1.909801E-04\_fp,-3.387963E-07\_fp, 4.641319E-05\_fp, 4.502372E-07\_fp,-5.055813E-05\_fp, &

2.104201E-07\_fp,-4.121861E-06\_fp,-1.633057E-08\_fp,-2.469888E-05\_fp, 4.492103E-08\_fp, &

-4.582853E-03\_fp,-5.373940E-06\_fp, 9.713047E-04\_fp, 1.783009E-05\_fp,-4.539091E-04\_fp, &

7.652954E-07\_fp,-6.708905E-06\_fp, 2.148401E-08\_fp, 8.054350E-05\_fp, 3.069258E-07\_fp, &

-6.405746E-05\_fp,-9.694284E-08\_fp, 1.914498E-05\_fp, 1.336975E-07\_fp,-4.561696E-06\_fp, &

3.769169E-08\_fp,-6.105244E-07\_fp, 2.433761E-10\_fp,-3.961735E-06\_fp, 1.995636E-08\_fp, &

1.350148E-06\_fp, 3.678149E-07\_fp, 1.261701E-05\_fp,-2.011440E-07\_fp,-2.361347E-05\_fp, &

2.943147E-08\_fp,-1.304551E-07\_fp,-1.119368E-09\_fp, 8.469458E-06\_fp,-2.292171E-09\_fp, &

1.419156E-03\_fp,-3.838338E-06\_fp, 8.222562E-05\_fp,-1.106098E-06\_fp,-5.482327E-05\_fp, &

3.083137E-07\_fp, 4.418828E-06\_fp,-1.302562E-08\_fp, 3.768883E-05\_fp,-5.012753E-08\_fp, &

-9.396649E-06\_fp, 2.764698E-07\_fp, 1.745336E-05\_fp,-1.427031E-07\_fp,-3.879930E-06\_fp, &

-1.117458E-08\_fp, 5.688281E-08\_fp, 1.513582E-09\_fp, 6.778764E-06\_fp,-7.691286E-09\_fp /)

! Frequency-dependent azimuth correction

REAL(fp), PUBLIC, PARAMETER :: x(9) = (/ 0.0\_fp, 1.4\_fp, 6.8\_fp, 10.7\_fp, 19.35\_fp, &

37.\_fp, 89.\_fp, 150.\_fp, 200.\_fp/)

REAL(fp), PUBLIC, PARAMETER :: y(9) = (/ 0.0\_fp, 0.1\_fp, 0.6\_fp, 0.9\_fp, 1.\_fp, &

1.0\_fp, 0.4\_fp, 0.2\_fp, 0.0\_fp/)

! Coefficients for M.Kazumori azimuth model function (FASTEM-6)

REAL(fp), PUBLIC, PARAMETER :: coef\_mk\_azi(6,6,2) = RESHAPE( (/ &

4.401E-02, -1.636E+01, 1.478E+00, -4.800E-02, 3.202E-06, -6.002E-05,& ! 06V OK

4.379E-02, -1.633E+01, 1.453E+00, -4.176E-02, 5.561E-06, -4.644E-05,& ! 10V OK

5.009E-02, -1.638E+01, 1.520E+00, -3.994E-02, 1.330E-05, 1.113E-05,& ! 19V OK

5.165E-02, -1.638E+01, 1.543E+00, -4.066E-02, 1.494E-05, 1.010E-05,& ! 23V interpolated

5.553E-02, -1.638E+01, 1.602E+00, -4.246E-02, 1.903E-05, 7.524E-06,& ! 37V OK

-9.131E-05, 1.251E+00, 6.769E-01, -2.913E-02, 1.092E+00, -1.806E-04,& ! 89V OK revised

-1.234E-07, -8.179E-03, -1.040E+01, 4.477E-01, 0.000E+00, 3.390E-05,& ! 06H OK

-1.938E-05, -8.007E-03, -1.039E+01, 4.610E-01, 0.000E+00, 4.419E-05,& ! 10H OK

1.362E-04, -1.013E-03, -9.235E+00, 3.844E-01, 0.000E+00, 2.891E-04,& ! 19H OK

1.519E-04, -7.865E-04, -9.234E+00, 3.884E-01, 0.000E+00, 6.856E-04,& ! 23H Interpolated

1.910E-04, -2.224E-04, -9.232E+00, 3.982E-01, 0.000E+00, 1.673E-03,& ! 37H OK

3.554E-04, 5.226E-04, 9.816E-01, -7.783E-03, 0.000E+00, 2.437E+01 /), &! 89H OK revised

(/6,6,2/))

! --------------------------------------

! Structure definition to hold forward

! variables across FWD, TL, and AD calls

! --------------------------------------

! =============================================================

! Routine for forward model foam reflectivity

! Function dependence is on zenith angle only

! so no TL or AD routine.

! See Eqns(18.44a) (18.44b) in

! Ulaby, F.T. et al. (1986) Microwave Remote Sensing, Active

! and Passive, vol.3, From Theory to Applications, pp1457.

! =============================================================

REAL(fp), PUBLIC, PARAMETER :: FR\_COEFF(5) = &

(/ 0.07\_fp, -1.748e-3\_fp, -7.336e-5\_fp, 1.044e-7\_fp, -0.93\_fp /)