SBDART (Santa Barbara DISORT Atmospheric Radiative Transfer) is a FORTRAN computer code designed for the analysis of a wide variety of radiative transfer problems encountered in satellite remote sensing and atmospheric energy budget studies. The program is based on a collection of highly developed and reliable physical models, which have been developed by the atmospheric science community over the past few decades. The following discussion is a brief introduction to the key components of the code and the models on which they are based.

The radiative transfer equation is numerically integrated with DISORT (DIScreet Ordinate Radiative Transfer, Stamnes et al, 1988). The discrete ordinate method provides a numerically stable algorithm to solve the equations of plane-parallel radiative transfer in a vertically inhomogeneous atmosphere. The intensity of both scattered and thermally emitted radiation can be computed at different heights and directions. SBDART is configured to allow up to 65 atmospheric layers and 40 radiation streams (40 zenith angles and 40 azimuthal modes).

Solutions for monochromatic upward and downward intensities expressed in terms of the monochromatic transmittance

$$T_\nu(\tau;\mu) = \exp(-\frac{\tau_\nu}{\mu})$$

$$\frac{dT_\nu(\tau;\mu)}{d\tau} = -\frac{1}{\mu}\exp(-\frac{\tau_\nu}{\mu})$$

$$I_\nu^\uparrow(\tau;\mu) = B_\nu(\tau^*)T_\nu(\tau^* - \tau;\mu) - \int_\tau^{\tau^*} B_\nu(\tau')\frac{dT_\nu(\tau'-\tau;\mu)}{d\tau'}d\tau'$$

$$I_\nu^\downarrow(\tau;-\mu) = \int_0^\tau B_\nu(\tau')\frac{dT_\nu(\tau-\tau';\mu)}{d\tau'}d\tau'$$

$$\frac{1}{c}\frac{\partial}{\partial t}I_\nu + \widehat{\Omega}\nabla I_\nu + \left(k_{\nu,s} + k_{\nu,a}\right)I_\nu = j_\nu + \frac{1}{4\pi}k_{\nu,s}\int_\Omega I_\nu d\Omega$$

Cloud model

Clouds are a major modulator of the earths climate, both by reflecting visible radiation back out to space and by intercepting part of the infrared radiation emitted by the Earth and re-radiating it back to the surface. The computation of radiative transfer within a cloudy atmosphere requires knowledge of the scattering efficiency, the single scattering albedo, which is the probability that a extinction event scatters rather than absorbs a photon, and the asymmetry factor, which indicates the strength of forward scattering. SBDART contains an internal database of these parameters for clouds composed of spherical water or ice droplets. This internal database was computed with a Mie scattering code and covers a range of particle size effective radius in the range 2 to 128μm. (The effective radius is the ratio of the third and second moments of the droplet radius distribution). By default, the angular distribution of scattered photons is based on the simple Henyey-Greenstein parameterization, but more detailed scattering functions may be input as desired. (The Henyey-Greenstein approximation has been shown to provide good accuracy when applied to radiative flux calculations (van de Hulst, 1968; Hansen, 1969).

Henyey-Greenstein scattering phase function

$$P_{HG}(\Theta) = \frac{1 - g^2}{(1 + g^2 - 2g\cos(\Theta))^{3/2}}$$

The scattering angle Θ is a function of the Sun and satellite viewing geometries

$\cos(\Theta) = \cos(\theta')\cos(\theta) + \sin(\theta')\sin(\theta)\cos(\phi' - \phi)$

NOTE: the incident direction $(\boldsymbol{\theta'}, \boldsymbol{\phi'})$ is the opposite direction from the Sun:

$\theta' = 180 - \theta_0 = 135^0$ and $\phi' = \phi_0 - 180 = 0^0$

$\cos(\Theta) = \cos(135)\cos(45) + \sin(135)\sin(45)\cos(0-90) = -0.5$

Thus $\Theta = 120^0$

$$I^{\uparrow}(0, \mu, \varphi) = \frac{\omega_0}{4\pi} F_0 P(\Theta) \frac{\tau^*}{\mu}$$

Standard Atmospheric Models

We have adopted six standard atmospheric profiles from the 5s atmospheric radiation code which are intended to model the following typical climatic conditions: tropical, midlatitude summer, midlatitude winter, subarctic summer, subarctic winter and US62. These model atmospheres (McClatchey et al, 1971) have been widely used in the atmospheric research community and provide standard vertical profiles of pressure, temperature, water vapor and ozone density. In addition, the user can specify their own model atmosphere based on, for example, a series of radiosonde profiles. The concentration of trace gases such as CO2 or CH4 are assumed to make up a fixed fraction (which may be specified by the user) of the total particle density.

Standard Aerosol Models

SBDART can compute the radiative effects of several common boundary layer and upper atmosphere aerosol types. In the boundary layer, the user can select either rural, urban, or maritime aerosols. These models differ from one another in the way their scattering efficiency, single scattering albedo and asymmetry factors vary with wavelength. The total vertical optical depth of boundary layer aerosols is derived from user specified horizontal meteorologic visibility at 0.55 um and an internal vertical distribution model. In the upper atmosphere up to 5 aerosol layers can be specified, with radiative characteristics that model fresh and aged volcanic, meteoric and the climitologic tropospheric background aerosols. The aerosol 3 models included in SBDART were derived from those provided in the 5s (Tanre, 1988) and LOWTRAN7 computer codes (Shettle and Fenn, 1975).

Surface models

The ground surface cover is an important determinant of the overall radiation environment. In SBDART six basic surface types -- ocean water (Viollier, 1980), lake water (Kondratyev, 1969), vegetation (Manual of Remote Sensing), snow (Wiscombe and Warren, 1980) and sand (Staetter and Schroeder, 1978) -- are used to parameterize the spectral reflectivity of the surface. The spectral reflectivity of a large variety of surface conditions is well approximated by combinations of these basic types. For example, the fractions of vegetation, water and sand can be adjusted to generate a new spectral reflectivity representing new/old growth, or deciduous vs evergreen forest. Combining a small fraction of the spectral reflectivity of water with that of sand yields an overall spectral dependence close to wet soil.

SBDART model input parameters

SBDART radiative transfer model

- SBDART is a software tool that computes plane-parallel radiative transfer in clear and cloudy conditions within the Earth's atmosphere and at the surface.

- SBDART's main input file is called INPUT. This file contains a single NAMELIST input block also named INPUT.

SBDART configuration INPUT file

- SBDART is a software tool that computes plane-parallel radiative transfer in clear and cloudy conditions within the Earth's atmosphere and at the surface.

- SBDART's main input file is called INPUT. This file contains a single NAMELIST input block also named INPUT.

rt.doc

```
The default configuration of INPUT is as follows:

==========================================================================

 &INPUT
  idatm   =  4          ,  amix    =  0.0        ,  isat    =  0          ,
  wlinf   =  0.550      ,  wlsup   =  0.550      ,  wlinc   =  0.0        ,
  sza     =  0.0        ,  csza    =  -1.0       ,  solfac  =  1.0        ,
  nf      =  2          ,  iday    =  0          ,  time    =  16.0       ,
  alat    =  -64.7670   ,  alon    =  -64.0670   ,  zpres   =  -1.0       ,
  pbar    =  -1.0       ,  sclh2o  =  -1.0       ,  uw      =  -1.0       ,
  uo3     =  -1.0       ,  o3trp   =  -1.0       ,  ztrp    =  0.0        ,
  xrsc    =  1.0        ,  xn2     =  -1.0       ,  xo2     =  -1.0       ,
  xco2    =  -1.0       ,  xch4    =  -1.0       ,  xn2o    =  -1.0       ,
  xco     =  -1.0       ,  xno2    =  -1.0       ,  xso2    =  -1.0       ,
  xnh3    =  -1.0       ,  xno     =  -1.0       ,  xhno3   =  -1.0       ,
  xo4     =  1.0        ,  isalb   =  0          ,  albcon  =  0.0        ,
  sc      =  1.0,3*0.0  ,  zcloud  =  5*0.0      ,  tcloud  =  5*0.0      ,
  lwp     =  5*0.0      ,  nre     =  5*8.0      ,  rhcld   =  -1.0       ,
  krhclr  =  0          ,  jaer    =  5*0        ,  zaer    =  5*0.0      ,
  taerst  =  5*0.0      ,  iaer    =  0          ,  vis     =  23.0       ,
  rhaer   =  -1.0       ,  wlbaer  =  47*0.0     ,  tbaer   =  47*0.0     ,
  abaer   =  -1.0       ,  wbaer   =  47*0.950   ,  gbaer   =  47*0.70    ,
  pmaer   =  940*0.0    ,  zbaer   =  50*-1.0    ,  dbaer   =  50*-1.0    ,
  nothrm  =  -1         ,  nosct   =  0          ,  kdist   =  3          ,
  zgrid1  =  0.0        ,  zgrid2  =  30.0       ,  ngrid   =  50         ,
  zout    =  0.0,100.0  ,  iout    =  10         ,  deltam  =  t          ,
  lamber  =  t          ,  ibcnd   =  0          ,  saza    =  180.0      ,
  prnt    =  7*f        ,  ipth    =  1          ,  fisot   =  0.0        ,
  temis   =  0.0        ,  nstr    =  4          ,  nzen    =  0          ,
  uzen    =  20*-1.0    ,  vzen    = 20*90       ,  nphi    =  0          ,
  phi     =  20*-1.0    ,  imomc   =  3          ,  imoma   =  3          ,
  ttemp   =  -1.0       ,  btemp   =  -1.0       ,  spowder =  f          ,
  idb     =  20*0
 /

==========================================================================
```

SBDART configuration INPUT file

WLINF:

Lower wavelength limit when ISAT=0

WLSUP:

Upper wavelength limit when ISAT=0

- (WLINF > 0.250 microns)
- (WLSUP < 100.0 microns)

```
The default configuration of INPUT is as follows:

============================================================================

 &INPUT
  idatm    =  4          ,  amix     =  0.0        ,  isat     =  0          ,
  wlinf    =  0.550      ,  wlsup    =  0.550      ,  wlinc    =  0.0        ,
  sza      =  0.0        ,  csza     =  -1.0       ,  solfac   =  1.0        ,
  nf       =  2          ,  iday     =  0          ,  time     =  16.0       ,
  alat     =  -64.7670   ,  alon     =  -64.0670   ,  zpres    =  -1.0       ,
  pbar     =  -1.0       ,  sclh2o   =  -1.0       ,  uw       =  -1.0       ,
  uo3      =  -1.0       ,  o3trp    =  -1.0       ,  ztrp     =  0.0        ,
  xrsc     =  1.0        ,  xn2      =  -1.0       ,  xo2      =  -1.0       ,
  xco2     =  -1.0       ,  xch4     =  -1.0       ,  xn2o     =  -1.0       ,
  xco      =  -1.0       ,  xno2     =  -1.0       ,  xso2     =  -1.0       ,
  xnh3     =  -1.0       ,  xno      =  -1.0       ,  xhno3    =  -1.0       ,
  xo4      =  1.0        ,  isalb    =  0          ,  albcon   =  0.0        ,
  sc       =  1.0,3*0.0  ,  zcloud   =  5*0.0      ,  tcloud   =  5*0.0      ,
  lwp      =  5*0.0      ,  nre      =  5*8.0      ,  rhcld    =  -1.0       ,
  krhclr   =  0          ,  jaer     =  5*0        ,  zaer     =  5*0.0      ,
  taerst   =  5*0.0      ,  iaer     =  0          ,  vis      =  23.0       ,
  rhaer    =  -1.0       ,  wlbaer   =  47*0.0     ,  tbaer    =  47*0.0     ,
  abaer    =  -1.0       ,  wbaer    =  47*0.950   ,  gbaer    =  47*0.70    ,
  pmaer    =  940*0.0    ,  zbaer    =  50*-1.0    ,  dbaer    =  50*-1.0    ,
  nothrm   =  -1         ,  nosct    =  0          ,  kdist    =  3          ,
  zgrid1   =  0.0        ,  zgrid2   =  30.0       ,  ngrid    =  50         ,
  zout     =  0.0,100.0  ,  iout     =  10         ,  deltam   =  t          ,
  lamber   =  t          ,  ibcnd    =  0          ,  saza     =  180.0      ,
  prnt     =  7*f        ,  ipth     =  1          ,  fisot    =  0.0        ,
  temis    =  0.0        ,  nstr     =  4          ,  nzen     =  0          ,
  uzen     =  20*-1.0    ,  vzen     = 20*90       ,  nphi     =  0          ,
  phi      =  20*-1.0    ,  imomc    =  3          ,  imoma    =  3          ,
  ttemp    =  -1.0       ,  btemp    =  -1.0       ,  spowder  =  f          ,
  idb      =  20*0
 /

=========================================================================
```

SBDART configuration INPUT file

WLINC:
This parameter specifies the spectral resolution

- WLINC = 0 (the default) => wavelength increment is equal to 0.005 um or 1/10 the wavelength range, which ever is smaller. If the WLINF=WLSUP then WLINC=.001
- WLINC < 0 => wavelength increment is a constant fraction of the current wavelength.

```
The default configuration of INPUT is as follows:

=============================================================================

 &INPUT
  idatm    =  4          ,  amix     =  0.0        ,  isat     =  0          ,
  wlinf    =  0.550      ,  wlsup    =  0.550      ,  wlinc    =  0.0        ,
  sza      =  0.0        ,  csza     =  -1.0       ,  solfac   =  1.0        ,
  nf       =  2          ,  iday     =  0          ,  time     =  16.0       ,
  alat     =  -64.7670   ,  alon     =  -64.0670   ,  zpres    =  -1.0       ,
  pbar     =  -1.0       ,  sclh2o   =  -1.0       ,  uw       =  -1.0       ,
  uo3      =  -1.0       ,  o3trp    =  -1.0       ,  ztrp     =  0.0        ,
  xrsc     =  1.0        ,  xn2      =  -1.0       ,  xo2      =  -1.0       ,
  xco2     =  -1.0       ,  xch4     =  -1.0       ,  xn2o     =  -1.0       ,
  xco      =  -1.0       ,  xno2     =  -1.0       ,  xso2     =  -1.0       ,
  xnh3     =  -1.0       ,  xno      =  -1.0       ,  xhno3    =  -1.0       ,
  xo4      =  1.0        ,  isalb    =  0          ,  albcon   =  0.0        ,
  sc       =  1.0,3*0.0  ,  zcloud   =  5*0.0      ,  tcloud   =  5*0.0      ,
  lwp      =  5*0.0      ,  nre      =  5*8.0      ,  rhcld    =  -1.0       ,
  krhclr   =  0          ,  jaer     =  5*0        ,  zaer     =  5*0.0      ,
  taerst   =  5*0.0      ,  iaer     =  0          ,  vis      =  23.0       ,
  rhaer    =  -1.0       ,  wlbaer   =  47*0.0     ,  tbaer    =  47*0.0     ,
  abaer    =  -1.0       ,  wbaer    =  47*0.950   ,  gbaer    =  47*0.70    ,
  pmaer    =  940*0.0    ,  zbaer    =  50*-1.0    ,  dbaer    =  50*-1.0    ,
  nothrm   =  -1         ,  nosct    =  0          ,  kdist    =  3          ,
  zgrid1   =  0.0        ,  zgrid2   =  30.0       ,  ngrid    =  50         ,
  zout     =  0.0,100.0  ,  iout     =  10         ,  deltam   =  t          ,
  lamber   =  t          ,  ibcnd    =  0          ,  saza     =  180.0      ,
  prnt     =  7*f        ,  ipth     =  1          ,  fisot    =  0.0        ,
  temis    =  0.0        ,  nstr     =  4          ,  nzen     =  0          ,
  uzen     =  20*-1.0    ,  vzen     = 20*90       ,  nphi     =  0          ,
  phi      =  20*-1.0    ,  imomc    =  3          ,  imoma    =  3          ,
  ttemp    =  -1.0       ,  btemp    =  -1.0       ,  spowder  =  f          ,
  idb      =  20*0
 /

=========================================================================
```

SBDART configuration INPUT file

NF:

SOLAR SPECTRUM SELECTOR

- -2 = use TOA solar irradiance read from CKTAU file when kdist=-1. NF=-2 is not a valid input when kdist.ne.-1
- -1 = read from file solar.dat (user supplied) data file, "solar.dat"
- 0 = spectrally uniform
- 1 = 5s solar spectrum 0.005 micron resolution, .25 to 4 micron
- 2 = LOWTRAN_7 solar spectrum (default) 20 cm-1 resolution, 0. to 28780 cm-1 10 cm-1 resolution, 28780. to 57490 cm-1
- 3 = MODTRAN_3 solar spectrum 20 cm-1 resolution, 100 - 49960 cm-1

```
The default configuration of INPUT is as follows:

===========================================================================

 &INPUT
  idatm    =  4          ,  amix     =  0.0        ,  isat     =  0          ,
  wlinf    =  0.550      ,  wlsup    =  0.550      ,  wlinc    =  0.0        ,
  sza      =  0.0        ,  csza     =  -1.0       ,  solfac   =  1.0        ,
  nf       =  2          ,  iday     =  0          ,  time     =  16.0       ,
  alat     =  -64.7670   ,  alon     =  -64.0670   ,  zpres    =  -1.0       ,
  pbar     =  -1.0       ,  sclh2o   =  -1.0       ,  uw       =  -1.0       ,
  uo3      =  -1.0       ,  o3trp    =  -1.0       ,  ztrp     =  0.0        ,
  xrsc     =  1.0        ,  xn2      =  -1.0       ,  xo2      =  -1.0       ,
  xco2     =  -1.0       ,  xch4     =  -1.0       ,  xn2o     =  -1.0       ,
  xco      =  -1.0       ,  xno2     =  -1.0       ,  xso2     =  -1.0       ,
  xnh3     =  -1.0       ,  xno      =  -1.0       ,  xhno3    =  -1.0       ,
  xo4      =  1.0        ,  isalb    =  0          ,  albcon   =  0.0        ,
  sc       =  1.0,3*0.0  ,  zcloud   =  5*0.0      ,  tcloud   =  5*0.0      ,
  lwp      =  5*0.0      ,  nre      =  5*8.0      ,  rhcld    =  -1.0       ,
  krhclr   =  0          ,  jaer     =  5*0        ,  zaer     =  5*0.0      ,
  taerst   =  5*0.0      ,  iaer     =  0          ,  vis      =  23.0       ,
  rhaer    =  -1.0       ,  wlbaer   =  47*0.0     ,  tbaer    =  47*0.0     ,
  abaer    =  -1.0       ,  wbaer    =  47*0.950   ,  gbaer    =  47*0.70    ,
  pmaer    =  940*0.0    ,  zbaer    =  50*-1.0    ,  dbaer    =  50*-1.0    ,
  nothrm   =  -1         ,  nosct    =  0          ,  kdist    =  3          ,
  zgrid1   =  0.0        ,  zgrid2   =  30.0       ,  ngrid    =  50         ,
  zout     =  0.0,100.0  ,  iout     =  10         ,  deltam   =  t          ,
  lamber   =  t          ,  ibcnd    =  0          ,  saza     =  180.0      ,
  prnt     =  7*f        ,  ipth     =  1          ,  fisot    =  0.0        ,
  temis    =  0.0        ,  nstr     =  4          ,  nzen     =  0          ,
  uzen     =  20*-1.0    ,  vzen     = 20*90       ,  nphi     =  0          ,
  phi      =  20*-1.0    ,  imomc    = 3           ,  imoma    =  3          ,
  ttemp    =  -1.0       ,  btemp    =  -1.0       ,  spowder  =  f          ,
  idb      =  20*0
 /

===========================================================================
```

SBDART configuration INPUT file

IDATM:

ATMOSPHERIC

PROFILE:

- 0 User Specified
- 1 TROPICAL
- 2 MID-LATITUDE SUMMER
- 3 MID-LATITUDE WINTER
- 4 SUB-ARCTIC SUMMER
- 5 SUB-ARCTIC WINTER
- 6 US62

- If IDATM = 0 a user supplied atmospheric profile, "atms.dat", is read from the current working directory

```
The default configuration of INPUT is as follows:

===========================================================================

 &INPUT
  idatm   =  4          ,  amix    =  0.0        ,  isat    =  0          ,
  wlinf   =  0.550      ,  wlsup   =  0.550      ,  wlinc   =  0.0        ,
  sza     =  0.0        ,  csza    =  -1.0       ,  solfac  =  1.0        ,
  nf      =  2          ,  iday    =  0          ,  time    =  16.0       ,
  alat    =  -64.7670   ,  alon    =  -64.0670   ,  zpres   =  -1.0       ,
  pbar    =  -1.0       ,  sclh2o  =  -1.0       ,  uw      =  -1.0       ,
  uo3     =  -1.0       ,  o3trp   =  -1.0       ,  ztrp    =  0.0        ,
  xrsc    =  1.0        ,  xn2     =  -1.0       ,  xo2     =  -1.0       ,
  xco2    =  -1.0       ,  xch4    =  -1.0       ,  xn2o    =  -1.0       ,
  xco     =  -1.0       ,  xno2    =  -1.0       ,  xso2    =  -1.0       ,
  xnh3    =  -1.0       ,  xno     =  -1.0       ,  xhno3   =  -1.0       ,
  xo4     =  1.0        ,  isalb   =  0          ,  albcon  =  0.0        ,
  sc      =  1.0,3*0.0  ,  zcloud  =  5*0.0      ,  tcloud  =  5*0.0      ,
  lwp     =  5*0.0      ,  nre     =  5*8.0      ,  rhcld   =  -1.0       ,
  krhclr  =  0          ,  jaer    =  5*0        ,  zaer    =  5*0.0      ,
  taerst  =  5*0.0      ,  iaer    =  0          ,  vis     =  23.0       ,
  rhaer   =  -1.0       ,  wlbaer  =  47*0.0     ,  tbaer   =  47*0.0     ,
  abaer   =  -1.0       ,  wbaer   =  47*0.950   ,  gbaer   =  47*0.70    ,
  pmaer   =  940*0.0    ,  zbaer   =  50*-1.0    ,  dbaer   =  50*-1.0    ,
  nothrm  =  -1         ,  nosct   =  0          ,  kdist   =  3          ,
  zgrid1  =  0.0        ,  zgrid2  =  30.0       ,  ngrid   =  50         ,
  zout    =  0.0,100.0  ,  iout    =  10         ,  deltam  =  t          ,
  lamber  =  t          ,  ibcnd   =  0          ,  saza    =  180.0      ,
  prnt    =  7*f        ,  ipth    =  1          ,  fisot   =  0.0        ,
  temis   =  0.0        ,  nstr    =  4          ,  nzen    =  0          ,
  uzen    =  20*-1.0    ,  vzen    = 20*90       ,  nphi    =  0          ,
  phi     =  20*-1.0    ,  imomc   =  3          ,  imoma   =  3          ,
  ttemp   =  -1.0       ,  btemp   =  -1.0       ,  spowder =  f          ,
  idb     =  20*0
 /

========================================================================
```

SBDART configuration INPUT file

ISAT:

FILTER FUNCTION TYPES

- -4 Guassian filter, WLINF-2*WLSUP to WLINF+2*WLSUP
- -3 Trianglar filter, WLINF-WLSUP to WLINF+WLSUP
- -2 Flat filter, WLINF-.5*WLSUP to WLINF+.5*WLSUP
- -1 USER DEFINED, read from filter.dat
- 0 WLINF TO WLSUP WITH FILTER FUNCTION = 1 (default)

ISAT > 0, corresponds to different satellites

```
The default configuration of INPUT is as follows:

============================================================================

 &INPUT
  idatm    =  4          ,  amix     =  0.0        ,  isat     =  0          ,
  wlinf    =  0.550      ,  wlsup    =  0.550      ,  wlinc    =  0.0        ,
  sza      =  0.0        ,  csza     =  -1.0       ,  solfac   =  1.0        ,
  nf       =  2          ,  iday     =  0          ,  time     =  16.0       ,
  alat     =  -64.7670   ,  alon     =  -64.0670   ,  zpres    =  -1.0       ,
  pbar     =  -1.0       ,  sclh2o   =  -1.0       ,  uw       =  -1.0       ,
  uo3      =  -1.0       ,  o3trp    =  -1.0       ,  ztrp     =  0.0        ,
  xrsc     =  1.0        ,  xn2      =  -1.0       ,  xo2      =  -1.0       ,
  xco2     =  -1.0       ,  xch4     =  -1.0       ,  xn2o     =  -1.0       ,
  xco      =  -1.0       ,  xno2     =  -1.0       ,  xso2     =  -1.0       ,
  xnh3     =  -1.0       ,  xno      =  -1.0       ,  xhno3    =  -1.0       ,
  xo4      =  1.0        ,  isalb    =  0          ,  albcon   =  0.0        ,
  sc       =  1.0,3*0.0  ,  zcloud   =  5*0.0      ,  tcloud   =  5*0.0      ,
  lwp      =  5*0.0      ,  nre      =  5*8.0      ,  rhcld    =  -1.0       ,
  krhclr   =  0          ,  jaer     =  5*0        ,  zaer     =  5*0.0      ,
  taerst   =  5*0.0      ,  iaer     =  0          ,  vis      =  23.0       ,
  rhaer    =  -1.0       ,  wlbaer   =  47*0.0     ,  tbaer    =  47*0.0     ,
  abaer    =  -1.0       ,  wbaer    =  47*0.950   ,  gbaer    =  47*0.70    ,
  pmaer    =  940*0.0    ,  zbaer    =  50*-1.0    ,  dbaer    =  50*-1.0    ,
  nothrm   =  -1         ,  nosct    =  0          ,  kdist    =  3          ,
  zgrid1   =  0.0        ,  zgrid2   =  30.0       ,  ngrid    =  50         ,
  zout     =  0.0,100.0  ,  iout     =  10         ,  deltam   =  t          ,
  lamber   =  t          ,  ibcnd    =  0          ,  saza     =  180.0      ,
  prnt     =  7*f        ,  ipth     =  1          ,  fisot    =  0.0        ,
  temis    =  0.0        ,  nstr     =  4          ,  nzen     =  0          ,
  uzen     =  20*-1.0    ,  vzen     = 20*90       ,  nphi     =  0          ,
  phi      =  20*-1.0    ,  imomc    =  3          ,  imoma    =  3          ,
  ttemp    =  -1.0       ,  btemp    =  -1.0       ,  spowder  =  f          ,
  idb      =  20*0
 /

============================================================================
```

SBDART configuration INPUT file

IOUT:

STANDARD OUTPUT SELECTOR

- 0. no standard output is produced
- 1. one output record for each wavelength,
  - WL = wavelength (microns)
  - FFV = filter function value
  - TOPDN = total downward flux at ZOUT(2) km (w/m2/micron)
  - TOPUP = total upward flux at ZOUT(2) km (w/m2/micron)
  - TOPDIR= direct downward flux at ZOUT(2) km (w/m2/micron)
  - BOTDN = total downward flux at ZOUT(1) km (w/m2/micron)
  - BOTUP = total upward flux at ZOUT(1) km (w/m2/micron)
  - BOTDIR= direct downward flux at ZOUT(1) km (w/m2/micron)

It has more than 10 ways to show results !!!

```
The default configuration of INPUT is as follows:

==============================================================

 &INPUT
  idatm    =  4           ,  amix     =  0.0         ,  isat    =
  wlinf    =  0.550       ,  wlsup    =  0.550       ,  wlinc   =
  sza      =  0.0         ,  csza     =  -1.0        ,  solfac  =
  nf       =  2           ,  iday     =  0           ,  time    =
  alat     =  -64.7670    ,  alon     =  -64.0670    ,  zpres   =
  pbar     =  -1.0        ,  sclh2o   =  -1.0        ,  uw      =
  uo3      =  -1.0        ,  o3trp    =  -1.0        ,  ztrp    =
  xrsc     =  1.0         ,  xn2      =  -1.0        ,  xo2     =
  xco2     =  -1.0        ,  xch4     =  -1.0        ,  xn2o    =
  xco      =  -1.0        ,  xno2     =  -1.0        ,  xso2    =
  xnh3     =  -1.0        ,  xno      =  -1.0        ,  xhno3   =
  xo4      =  1.0         ,  isalb    =  0           ,  albcon  =
  sc       =  1.0,3*0.0   ,  zcloud   =  5*0.0       ,  tcloud  =
  lwp      =  5*0.0       ,  nre      =  5*8.0       ,  rhcld   =
  krhclr   =  0           ,  jaer     =  5*0         ,  zaer    =
  taerst   =  5*0.0       ,  iaer     =  0           ,  vis     =
  rhaer    =  -1.0        ,  wlbaer   =  47*0.0      ,  tbaer   =
  abaer    =  -1.0        ,  wbaer    =  47*0.950    ,  gbaer   =
  pmaer    =  940*0.0     ,  zbaer    =  50*-1.0     ,  dbaer   =
  nothrm   =  -1          ,  nosct    =  0           ,  kdist   =
  zgrid1   =  0.0         ,  zgrid2   =  30.0        ,  ngrid   =
  zout     =  0.0,100.0   ,  iout     =  10          ,  deltam  =
  lamber   =  t           ,  ibcnd    =  0           ,  saza    =
  prnt     =  7*f         ,  ipth     =  1           ,  fisot   =
  temis    =  0.0         ,  nstr     =  4           ,  nzen    =
  uzen     =  20*-1.0     ,  vzen     = 20*90        ,  nphi    =
  phi      =  20*-1.0     ,  imomc    =  3           ,  imoma   =
  ttemp    =  -1.0        ,  btemp    =  -1.0        ,  spowder =
  idb      =  20*0
 /

==============================================================
```

Example 1

- Computing the spectral surface irradiance from 0.25 to 1.0 µm for a sub-arctic summer atmosphere

Example 1

- Computing the spectral surface irradiance from 0.25 to 1.0 μm for a sub-arctic summer atmosphere

INPUT file should look like..

```
$input
   idatm=4,   isat=0, wlinf=.25, wlsup=1.0, wlinc=.005, iout=1,
$end
```

Example 1

- Computing the spectral surface irradiance from 0.25 to 1.0 µm for a sub-arctic summer atmosphere

INPUT file should look like..

```
$input
   idatm=4,   isat=0, wlinf=.25, wlsup=1.0, wlinc=.005, iout=1,
$end
```

- Then the file sbchk.1 contains the sbdart output:

```
"tbf
            151
  0.25000000  1.00000  7.4070E+01  5.0984E-02  7.4070E+01  0.0000E+00  0.0000E+00  0.0000E+00
  0.25500000  1.00000  5.4452E+01  3.3486E-02  5.4452E+01  0.0000E+00  0.0000E+00  0.0000E+00
  0.26000000  1.00000  5.3256E+01  3.2182E-02  5.3256E+01  0.0000E+00  0.0000E+00  0.0000E+00
  0.26500000  1.00000  2.0639E+02  1.2590E-01  2.0639E+02  0.0000E+00  0.0000E+00  0.0000E+00
  0.27000000  1.00000  3.0863E+02  2.0426E-01  3.0863E+02  0.0000E+00  0.0000E+00  0.0000E+00
  0.27500000  1.00000  1.1356E+02  8.9083E-02  1.1356E+02  0.0000E+00  0.0000E+00  0.0000E+00
  0.28000000  1.00000  7.9266E+01  7.8461E-02  7.9266E+01  0.0000E+00  0.0000E+00  0.0000E+00
  0.28500000  1.00000  1.2142E+02  1.6311E-01  1.2142E+02  0.0000E+00  0.0000E+00  0.0000E+00
  0.29000000  1.00000  6.8750E+02  1.3405E+00  6.8750E+02  0.0000E+00  0.0000E+00  0.0000E+00
  0.29500000  1.00000  4.8547E+02  1.5028E+00  4.8547E+02  2.3948E-01  3.4061E-17  1.4968E-01
  0.30000000  1.00000  3.6541E+02  2.1882E+00  3.6541E+02  6.2628E+00  7.0230E-16  3.7695E+00
  0.30500000  1.00000  7.2336E+02  1.2597E+01  7.2336E+02  7.5756E+01  1.9159E-14  4.4719E+01
  0.31000000  1.00000  4.2497E+02  2.3933E+01  4.2497E+02  1.1206E+02 -1.0439E-14  6.5903E+01
  0.31500000  1.00000  8.3180E+02  1.0219E+02  8.3180E+02  3.5355E+02  4.5802E-14  2.0978E+02
  0.32000000  1.00000  8.5170E+02  1.3231E+02  8.5170E+02  4.2528E+02  1.0464E-13  2.5904E+02
  0.32500000  1.00000  8.0958E+02  1.6936E+02  8.0958E+02  4.8163E+02  1.3705E-13  2.9970E+02
```

Example 1

- Computing the spectral surface irradiance from 0.25 to 1.0 µm for a sub-arctic summer atmosphere

INPUT file should look like..

```
$input
   idatm=4,    isat=0, wlinf=.25, wlsup=1.0, wlinc=.005, iout=1,
$end
```

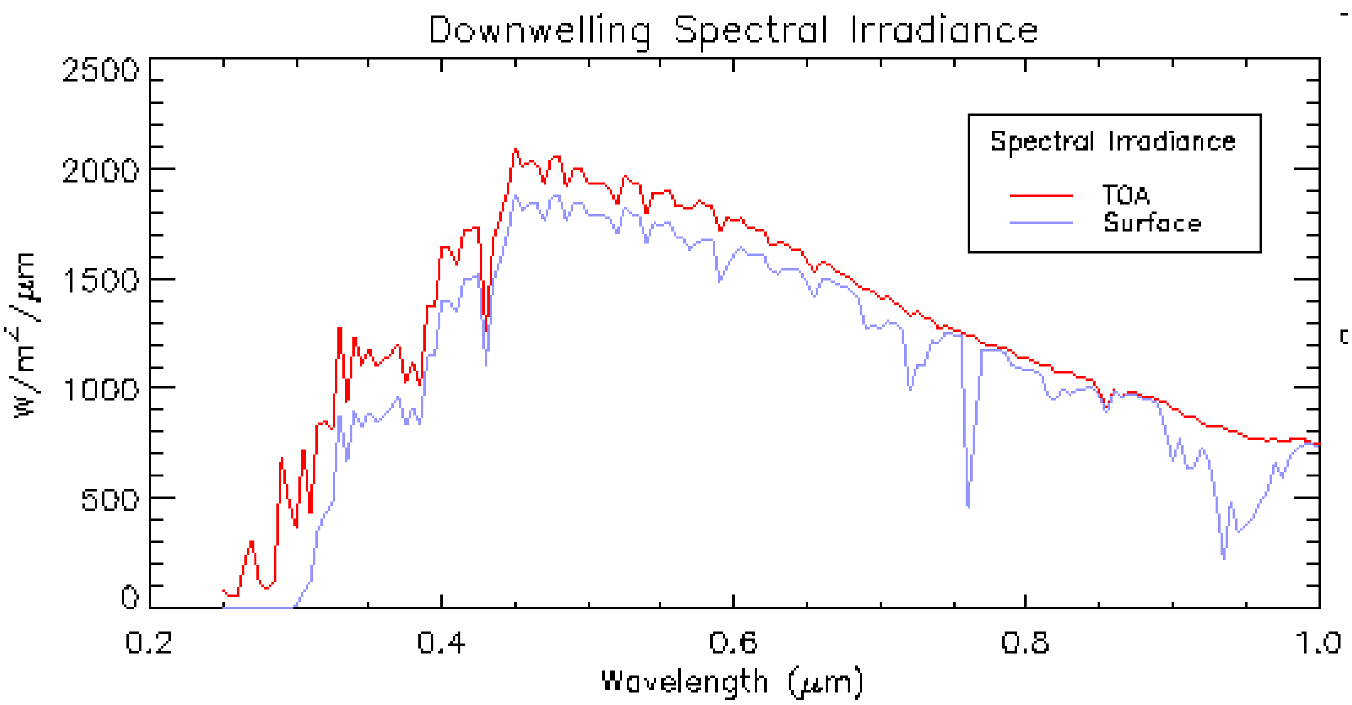
- Then the file sbchk.1 contains the sbdart output:

```
"tbf
            151
  0.25000000  1.00000  7.4070E+01  5.0984E-02  7.4070E+01  0.0000E+00  0.0000E+00  0.0000E+00
  0.25500000  1.00000  5.4452E+01  3.3486E-02  5.4452E+01  0.0000E+00  0.0000E+00  0.0000E+00
  0.26000000  1.00000  5.3256E+01  3.2182E-02  5.3256E+01  0.0000E+00  0.0000E+00  0.0000E+00
  0.26500000  1.00000  2.0639E+02  1.2590E-01  2.0639E+02  0.0000E+00  0.0000E+00  0.0000E+00
  0.27000000  1.00000  3.0863E+02  2.0426E-01  3.0863E+02  0.0000E+00  0.0000E+00  0.0000E+00
  0.27500000  1.00000  1.1356E+02  8.9083E-02  1.1356E+02  0.0000E+00  0.0000E+00  0.0000E+00
```

- Each output record corresponds to a single wavelength.
  - the wavelength (um),
  - filter value (unity in this example),
  - the downwelling solar flux at the top of the atmosphere (TOA, W m^{-2} μm^{-1}),
  - the TOA upwelling radiant flux,
  - the TOA direct solar flux,
  - the downwelling radiant flux at the surface,
  - the upwelling radiant flux at the surface
  - the direct solar flux at the surface

Example 1

- Computing the spectral surface irradiance from 0.25 to 1.0 µm for a sub-arctic summer atmosphere



SBDART configuration INPUT file

- You can also modify some other properties:
  - SOLAR GEOMETRY
  - SURFACE REFLECTANCE PROPERTIES
  - MODEL ATMOSPHERES
  - CLOUD PARAMETERS
  - STRATOSPHERIC AEROSOLS
  - BOUNDARY LAYER AEROSOLS
  - And some other variables regarding to a particular model (Cloud, gas absorption, source spectra, atmospheric and aerosol)

Example 2

- Investigate how surface irradiance depends on the combined effects of cloud optical depth and surface albedo

Example 2

- Investigate how surface irradiance depends on the combined effects of cloud optical depth and surface albedo

You can use a shell bash script to repeatedly execute SBDART to give a range of different solutions. Sensibility analysis

```
#!/local/gnu/bin/bash
############################################################
# shell script for Example 2
# vary optical depth and surface albedo
############################################################
#

rm -f sbchk.2

for albcon in 0 .2 .4 .6 .8 1    ; do
for tcloud in 0 1 2 4 8 16 32 64 ; do
echo "
 &INPUT
 tcloud=$tcloud
 albcon=$albcon
 idatm=4
 isat=0
 wlinf=.55
 wlsup=.55
 isalb=0
 iout=10
 sza=30
 /" > INPUT
sbdart >> sbchk.2
done
done
```

Example 2

You can use a shell bash script to repeatedly execute SBDART to give a range of different solutions. Sensibility analysis

- Investigate how surface irradiance depends on the combined effects of cloud optical depth and surface albedo

TCLOUD:
Optical thickness of cloud layer

```
#!/local/gnu/bin/bash
############################################################
# shell script for Example 2
# vary optical depth and surface albedo
############################################################
#

rm -f sbchk.2

for albcon in 0 .2 .4 .6 .8 1    ; do
for tcloud in 0 1 2 4 8 16 32 64 ; do
echo "
 &INPUT
 tcloud=$tcloud
 albcon=$albcon
 idatm=4
 isat=0
 wlinf=.55
 wlsup=.55
 isalb=0
 iout=10
 sza=30
 /" > INPUT
sbdart >> sbchk.2
done
done
```

Example 2

- Investigate how surface irradiance depends on the combined effects of cloud optical depth and surface albedo

TCLOUD:
Optical thickness of cloud layer

You can use a shell bash script to repeatedly execute SBDART to give a range of different solutions. Sensibility analysis

```
#!/local/gnu/bin/bash
############################################################
# shell script for Example 2
# vary optical depth and surface albedo
############################################################
#

rm -f sbchk.2

for albcon in 0 .2 .4 .6 .8 1    ; do
for tcloud in 0 1 2 4 8 16 32 64 ; do
echo "
 &INPUT
 tcloud=$tcloud
 albcon=$albcon
 idatm=4
 isat=0
 wlinf=.55
 wlsup=.55
 isalb=0
 iout=10
 sza=30
 /" > INPUT
sbdart >> sbchk.2
done
done
```

ISALB:
SURFACE ALBEDO FEATURE

- -1 -spectral surface albedo read from "albedo.dat"
- 0 -user specified, spectrally uniform albedo set with ALBCON
- 1 -snow
- 2 -clear water
- 3 -lake water
- 4 -sea water
- 5 -sand (data range 0.4 - 2.3um)
- 6 -vegetation (data range 0.4 - 2.6um)

Example 2

You can use a shell bash script to repeatedly execute SBDART to give a range of different solutions. Sensibility analysis

- Investigate how surface irradiance depends on the combined effects of cloud optical depth and surface albedo

```
#!/local/gnu/bin/bash
################################################################
# shell script for Example 2
# vary optical depth and surface albedo
################################################################
#

rm -f sbchk.2

for albcon in 0 .2 .4 .6 .8 1    ; do
for tcloud in 0 1 2 4 8 16 32 64 ; do
echo "
 &INPUT
 tcloud=$tcloud
 albcon=$albcon
 idatm=4
 isat=0
 wlinf=.55
 wlsup=.55
 isalb=0
 iout=10
 sza=30
 /" > INPUT
sbdart >> sbchk.2
done
done
```

TCLOUD:
Optical thickness of cloud layer

ALBCON:
A spectrally uniform, surface albedo

ISALB:
SURFACE ALBEDO FEATURE

- -1 -spectral surface albedo read from "albedo.dat"
- 0 -user specified, spectrally uniform albedo set with ALBCON
- 1 -snow
- 2 -clear water
- 3 -lake water
- 4 -sea water
- 5 -sand (data range 0.4 - 2.3um)
- 6 -vegetation (data range 0.4 - 2.6um)

Example 2

You can use a shell bash script to repeatedly execute SBDART to give a range of different solutions. Sensibility analysis

- Investigate how surface irradiance depends on the combined effects of cloud optical depth and surface albedo

```
#!/local/gnu/bin/bash
##############################################################
# shell script for Example 2
# vary optical depth and surface albedo
##############################################################
#

rm -f sbchk.2

for albcon in 0 .2 .4 .6 .8 1    ; do
for tcloud in 0 1 2 4 8 16 32 64 ; do
echo "
 &INPUT
 tcloud=$tcloud
 albcon=$albcon
 idatm=4
 isat=0
 wlinf=.55
 wlsup=.55
 isalb=0
 iout=10
 sza=30
 /" > INPUT
sbdart >> sbchk.2
done
done
```

TCLOUD:
Optical thickness of cloud layer

ALBCON:
A spectrally uniform, surface albedo

ISALB:
SURFACE ALBEDO FEATURE

IOUT:
Standard output selector

- 10. one output record per run, integrated over wavelength.
  - WLINF = lower wavelength limit (microns)
  - WLSUP = upper wavelength limit (microns)
  - TOPDN = total downward flux at ZOUT(2) km (w/m2)
  - TOPUP = total upward flux at ZOUT(2) km (w/m2)
  - TOPDIR= direct downward flux at ZOUT(2) km (w/m2)

Example 2

- Investigate how surface irradiance depends on the combined effects of cloud optical depth and surface albedo