Joint-Simulatorの紹介

Joint-Simulator利用ワークショップ
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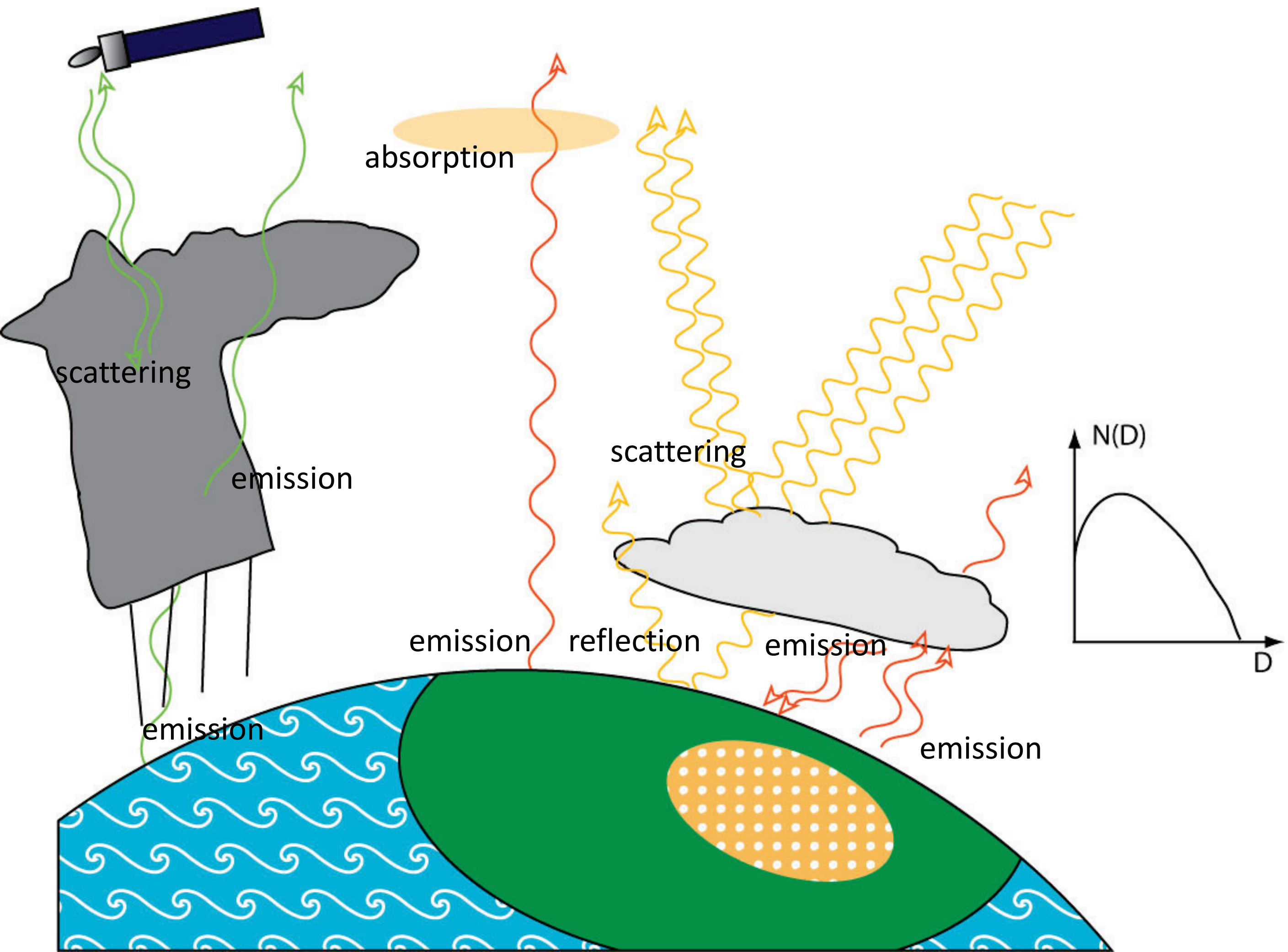
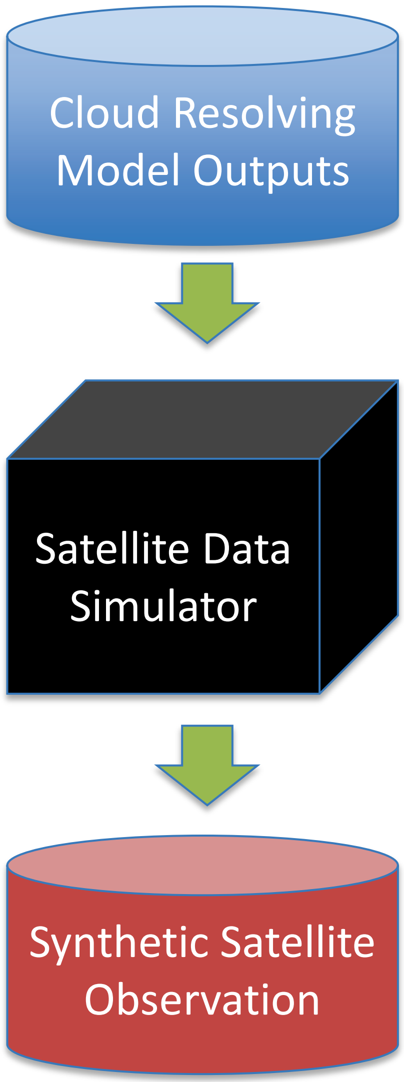
What is Joint-Simulator?

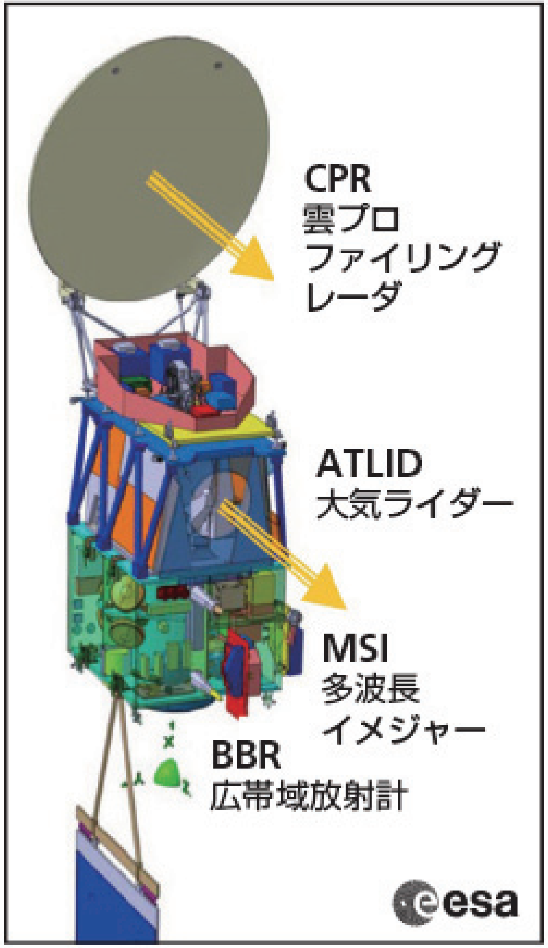
- Joint-Simulator solves the 1D radiative transfer problems given by a cloud resolving model in *a consistent way among the sensor simulators and with the model*.



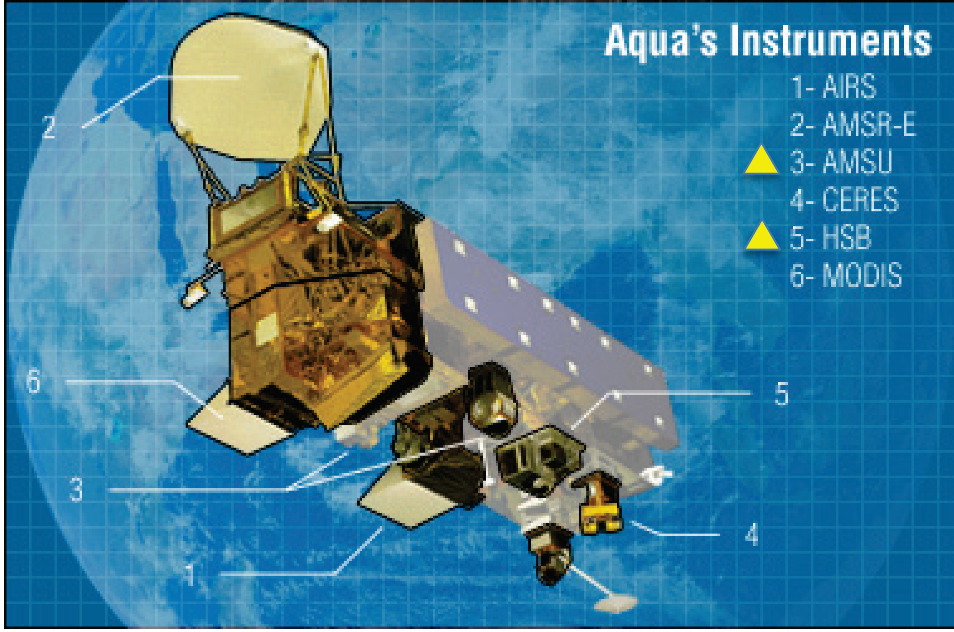


Applicable sensors: examples

EarthCARE



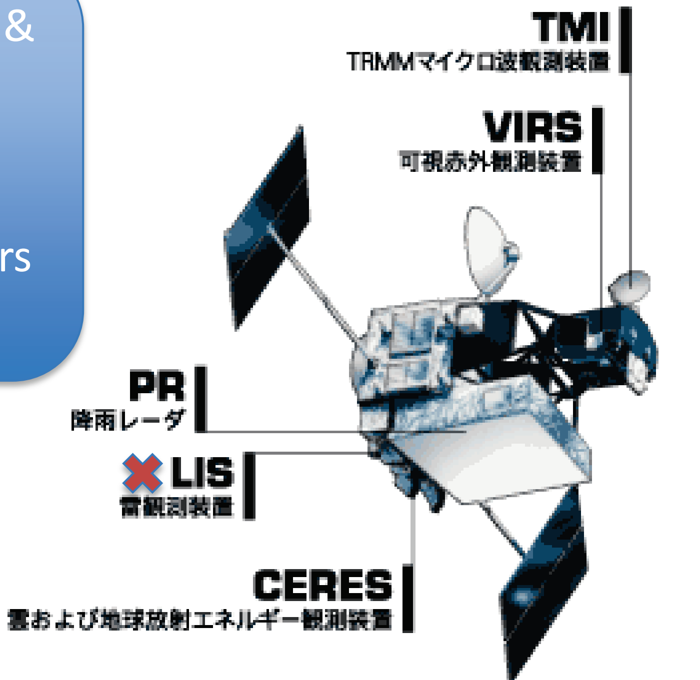
Pamphlet
http://www.jaxa.jp/projects/sat/earthcare/index_e.html



http://aqua.nasa.gov/about/instruments.php

- Microwave radiometers & sounders*
- Radars
- Lidars
- Visible & infrared imagers
- Broadband radiometers

Applicable to CloudSat CPR & CALIPSO CALIOP

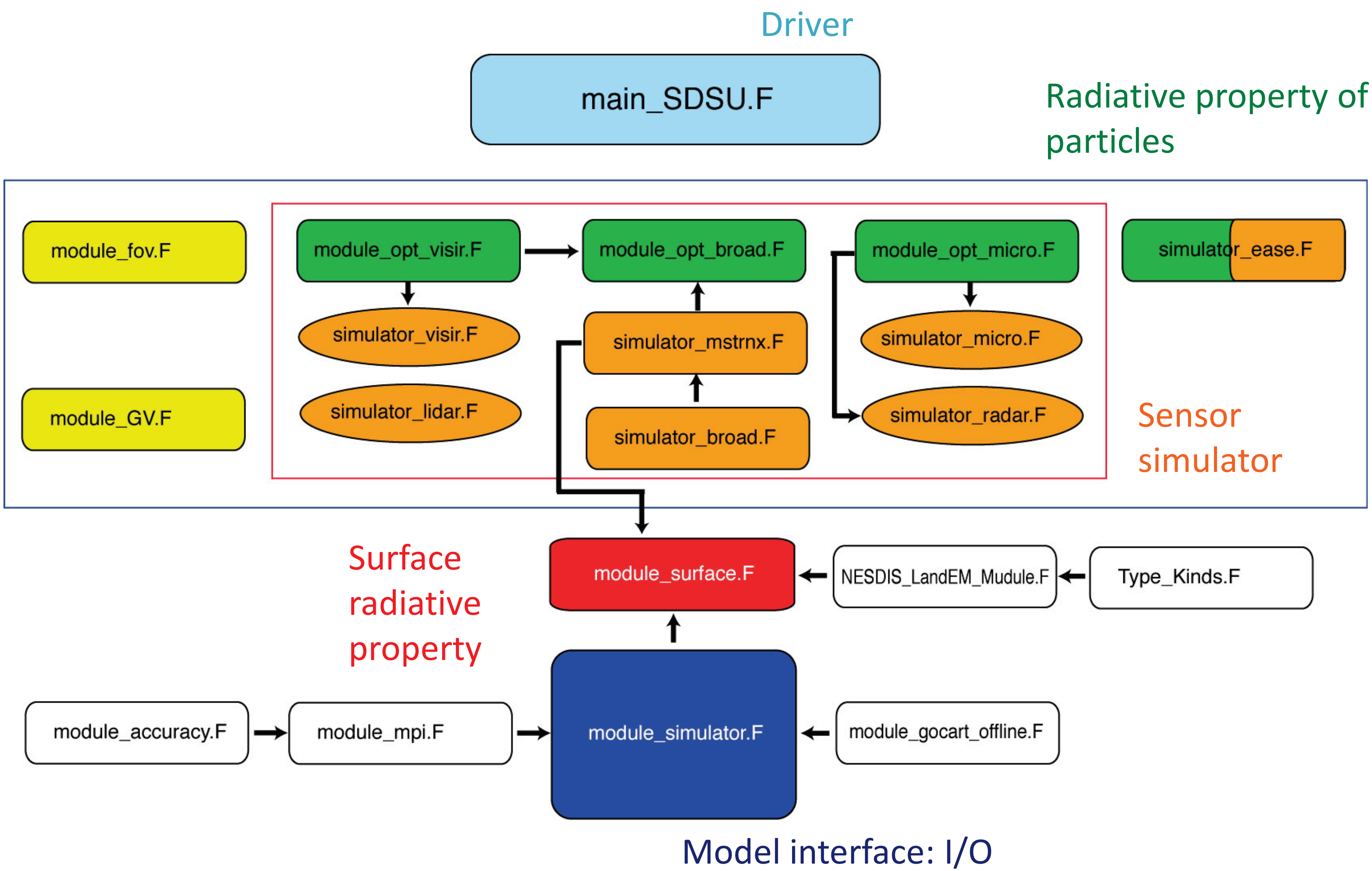


http://www.eorc.jaxa.jp/TRMM/about/mechanism/main_j.htm

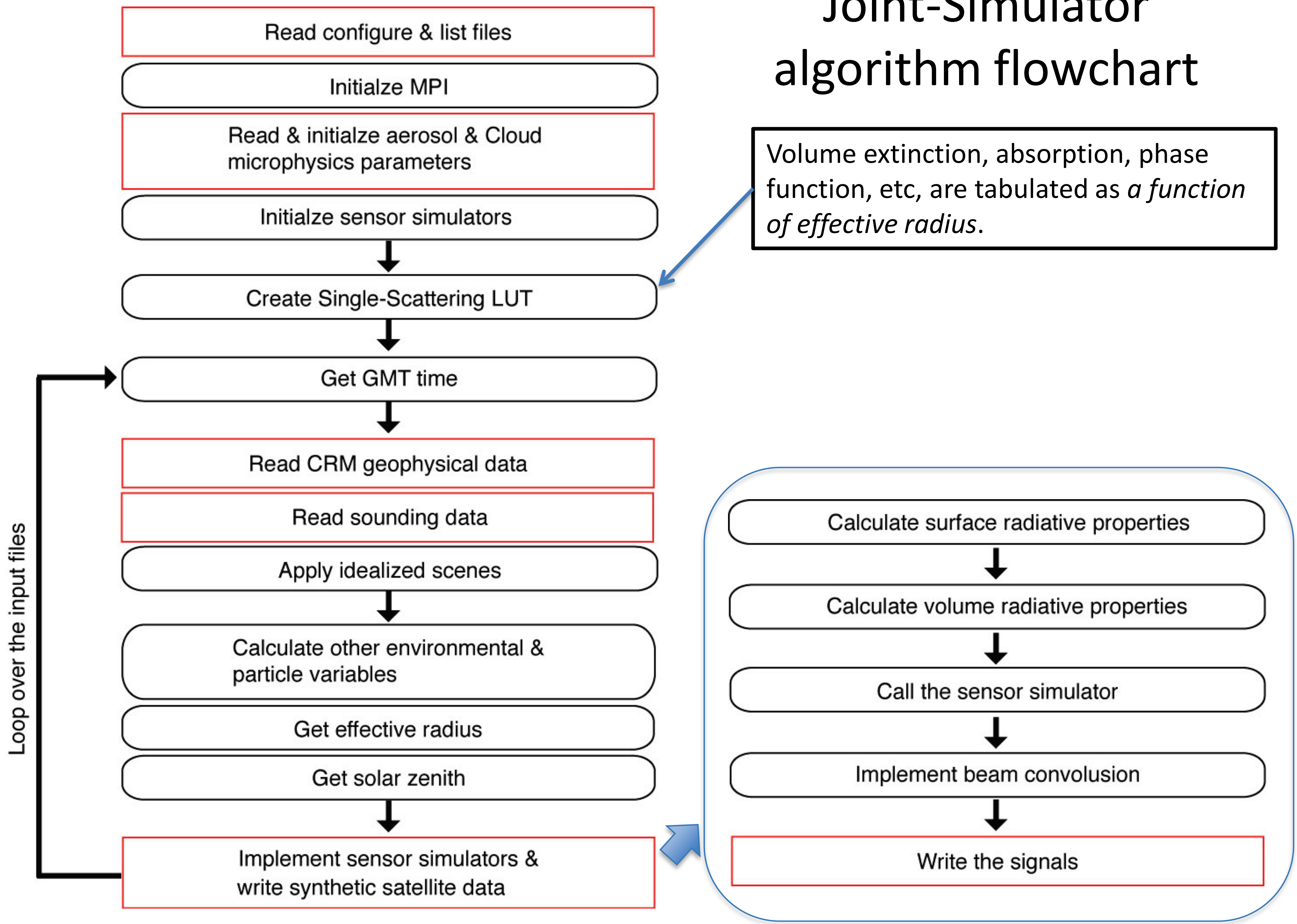
Sensor simulators

- Visible and infrared imager
  - RSTAR6b (Nakajima & Tanaka 1986, 1988)
    - Discrete-ordinate method/adding method
    - K-distribution table with HITRAN2004
- Microwave radiometer and sounder
  - Kummerow (1993)
    - Eddington approximation
- Radar
  - Masunaga & Kummerow (2005)
  - EASE (Okamoto et al. 2007, 2008; Nishizawa et al. 2008)
- Lidar
  - Matsui et al. (2009)
  - EASE
- Broadband radiometer
  - CLIRAD (Chou and Suarez 1994, 1999; Chou et al. 2001)
    - δελτα–Eddington approximation/adding method (two stream)
    - K-distribution method with HITRAN1996
    - 21 bands
  - MSTRN-X (Sekiguchi and Nakajima 2008)
    - Discrete-ordinate method/adding method (two stream)
    - Correlated-k distribution method with HITRAN2004
    - 18, 29, or 37 bands.

Structure of Joint-Simulator



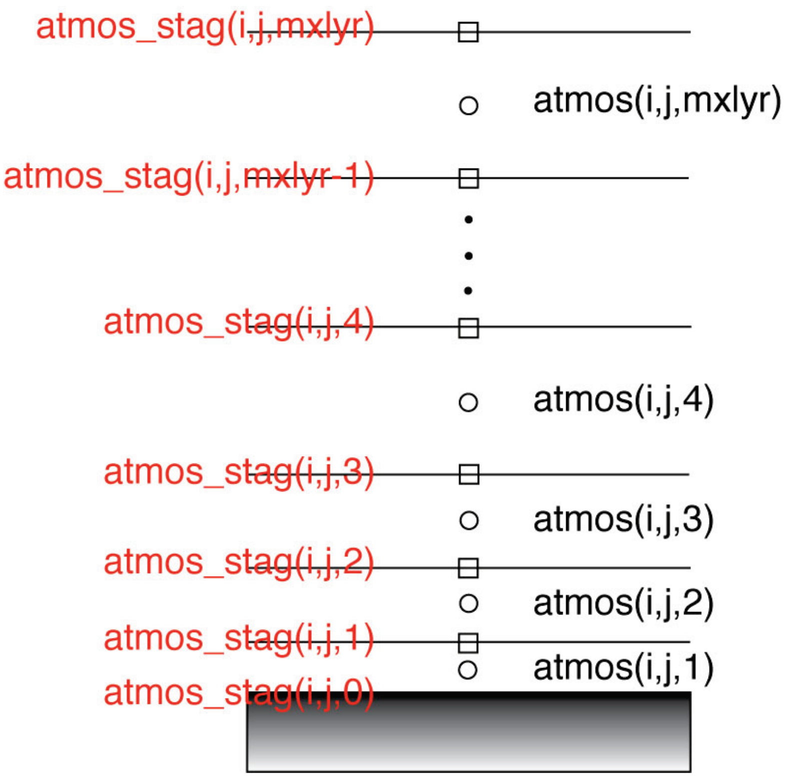
Joint-Simulator algorithm flowchart



How easy to implement Joint-simulator?

- Registration
  - Go to Joint-Simulator webpage (https://sites.google.com/site/jointsimulator/) and click “Contact & Registration”
  - Then, you can get a package from a ftp site.
- Requirement
  - A C-preprocessor, a Fortran compiler, and netcdf library
- Preparation of input
  - Put your model output (winds, thermodynamics, aerosol-cloud variables) in a single netcdf file.
    - Spherical (lat-lon) or rectangular grid system if the beam convolution is necessary.
  - Edit the configure file, Configure_SDSU.F, for your experiments and model assumptions.

Preparing input data



- Grid information
  - ✓ Latitude, longitude
  - ✓ height
- Dynamical variables
  - ✓ Vertical wind (3D)
  - ✓ 10-m horizontal winds
- Thermodynamical variables
  - ✓ Air temperature
  - ✓ Total pressure or moist air density
  - ✓ Vapor mixing ratio or relative humidity
- Surface variables (example)
  - ✓ Land-cover type
  - ✓ Soil moisture content
- Cloud microphysical variables
  - ✓ Bulk: mass (and number) concentration for each category
  - ✓ Bin: mass concentration for each bin
- Aerosol microphysical variables
  - ✓ Bulk: same as the above
  - ✓ Internal mixture and hygroscopic growth of a particle

Editing the Configure_SDSU.F

hashino@gcrm3:~/J-SIM/SAMPLE/outputs/NICAM/East_Asia_AP/EASE

```
! ##############################################################################
! #####################  Configure PSD options ##########################
! ##############################################################################

$psdinfo_options
! NOTE this namelist is turned on by setting cloud_microphysics == GENERAL
!
! For Grabowski98   (Grabowski 1998, JAS)
! ---- beginning of G98 setup ----
! name of the cloud microphysical scheme
!   This is used for the LUT file name.
  gnl_cmic_name = 'G98',
! type of the cloud microphysical scheme
!   BIN for bin models
!   BULK for bulk schemes
  gnl_cmic_type = 'BULK',
! number of bins for liquid
  nbin_liq_in = 1,
! number of categories for liquid
  ncat_liq_in = 2,
! number of bins for ice
  nbin_ice_in = 1,
! number of categories for ice
  ncat_ice_in = 2,
! input units for particles
!   false: use the default naming of particles
!   true : use the user-defined naming of particles given by vname_m_liq & vname_m_ice
  vname_gnl_in = .true.,
! if hydrometeors are in terms of specific variables [kg/kg] or [1/kg], set it to 'Q'
!                    [g/m^3] or [1/m^3], set it to 'M'
  vunit_liq = 'Q',
  vunit_ice = 'Q',

! flags for reading parameters from netcdf.
!              distribution #, name of categories, psd parameters, md parameters
  lflg_rdncd_gnl = .false., .false., .false., .false.,

! NOTE: the followings are necessary to make LUT, but once LUT is bult,
!       these can be read from the netcdf file.

! category name
  cname_liq_in(1) = 'cloud',
!
! variable name for mass concentration variable as appear in netcdf file.
  vname_m_liq(1) = 'QC',
!
! variable name for number concentration variable as appear in netcdf file.
  vname_n_liq(1) = 'CC',
!
! diagnosis scheme for effective radius
!   hydrometers: 0 : no use,  1 : Heymsfield & Platt 1984 scheme
  dschm_liq_gnl(1) = 0,
                                                                    756,1         78
```

All the microphysical assumptions are set in the configure file.

The parameters are defined for each category.

Editing the Configure_SDSU.F

hashino@gcrm3:~/J-SIM/SAMPLE/outputs/NICAM/East_Asia_AP/EASE

```
!
! distribution number for bulk microphysical scheme
!   0: uniform distribution
!   1: gamma distribution
!   2: lognormal distribution
  PSDINFO_LIQ_IN(1)%DISNO    =          0,
!
! parameters of the PSD function in CGS unit
!
!   uniform (mono-disperse) distribution:
!      N(D)=N_T*delta(D-D_m)
!     1: N_T (number concentration),  2: Dm (diameter),
!     3: D_2/D_1 (ratio of the upper and lower limits to define a finite diameter width of the distribution)
!     4: not used.
!
!   generalized gamma distribution:
!      N(D)=N_0 * D^(nu*(1+alpha)-1) * exp( -(lambda * D)^nu)
!     1: lambda (slope parameter),   2: N_0 (intercept parameter),  3: alpha (shape parameter)
!     4: nu (shape parameter)
!
!   lognormal distribution:
!      N(D)=N_T/(D*sigma*sqrt(2*PI)) * exp{-(log(D)-log(D_n))^2/(2.0*sigma^2)}
!     1: N_T (number concentration), 2: D_n (log(D_n) is equal to mean of log(D)),
!     3: sigma (standard deviation of log(D))
!
  PSDINFO_LIQ_IN(1)%PSD_PAR =   -999.0e0    ,  16.0e-4,  1.25992e+0   , 0.0e+0,
!
! parameters for mass-dimensional relationship in CGS unit
!    m=a_m*D^a_m
!    md_par(1) -> a_m
!    md_par(2) -> b_m
  PSDINFO_LIQ_IN(1)%MD_PAR  =   0.5235988e+0, 3.0e+0,
!
! terminal velocity relationship in CGS unit
!    v(D)=a_v*D^b_v
!    vtmpar_liq_gnl(1,:) -> a_v
!    vtmpar_liq_gnl(2,:) -> b_v
  vtmpar_liq_in(:,1) = 0.0e+0,  1.0e+0,

  cname_liq_in(2) = 'rain',
  vname_m_liq(2) = 'QR',
  vname_n_liq(2) = 'CR',
  dschm_liq_gnl(2) = 0,
  PSDINFO_LIQ_IN(2)%DISNO    =          1,
  PSDINFO_LIQ_IN(2)%PSD_PAR =   -999.0e0 ,   0.10e0    ,    0.0e+0        , 1.0e+0,
  PSDINFO_LIQ_IN(2)%MD_PAR  =   0.5235988e+0, 3.0e+0,
  vtmpar_liq_in(:,2) = 1.3e+3,  0.5e+0,

                                                                757,1          84
```

Three mathematical functions to choose from:

- Mono-disperse distribution
- Generalized gamma distribution
- Lognormal distribution

Number of predicted moments are diagnosed.

Editing the Configure_SDSU.F

```
hashino@gcrm3:~/J-SIM/SAMPLE/outputs/NICAM/East_Asia_AP/EASE

  cname_ice_in(1) = 'ice',
  vname_m_ice(1) = 'QI',
  vname_n_ice(1) = 'CI',
  dschm_ice_gnl(1) = 0,
  PSDINFO_ICE_IN(1)%DISNO   =            0,
  PSDINFO_ICE_IN(1)%PSD_PAR =  -999.0e0 ,   80.0e-4     ,    1.25992e+0,   1.0e+0,
  PSDINFO_ICE_IN(1)%MD_PAR  =  110.8e-3, 2.91,
  vtmpar_ice_in(:,1) = 0.0e+0,  0.5e+0,

  cname_ice_in(2) = 'snow',
  vname_m_ice(2) = 'QS',
  vname_n_ice(2) = 'CS',
  dschm_ice_gnl(2) = 0,
  PSDINFO_ICE_IN(2)%DISNO   =            1,
  PSDINFO_ICE_IN(2)%PSD_PAR =  -999.0e0 ,   0.10e+0   ,    0.0e+0,   1.0e+0        ,
  PSDINFO_ICE_IN(2)%MD_PAR  =  0.0025, 2.0e+0,
  vtmpar_ice_in(:,2) = 126.491106406735,  0.25e+0,
! ---- end of G98 setup ----


! ---- beginning of SPRINTARS setup ----
!   This is used for the LUT file name.
  gnl_amic_name = 'SPR',
! type of the aerosol microphysical scheme
!   BIN for bin models
!   BULK for bulk schemes
  gnl_amic_type = 'BULK',
! number of bins for aerosol particles
  nbin_aer_in = 1,
! number of categories for aerosol particles
  ncat_aer_in = 4,

  ! if hydrometeors are in terms of specific variables [kg/kg] or [1/kg], set it to 'Q'
  !                      [g/m^3] or [1/m^3], set it to 'M'
  vunit_aer = 'M',

  ! NOTE: the followings are necessary to make LUT, but once LUT is bult,
  !       these can be read from the netcdf file.
!
! category name, used for name of lookup tables
  cname_aer_in(1) = 'dust',
!
! variable name for mass concentration variable as appear in netcdf file.
  vname_m_aer(1) = 'QDUST',
! diagnosis scheme for effective radius
!   aerosol: 0 : no use,  1 : SPRINTARS
  dschm_aer_gnl(1) = 0,
                                                        804,0-1       89
```

Sensitivity tests can be easily conducted without compiling.

Setting up the aerosol microphysics scheme is similar to the cloud microphysics scheme.

Editing the Configure_SDS U.F

hashino@gcrm3:~/J-SIM/SAMPLE/outputs/NICAM/East_Asia_AP/EASE

```
! distribution number for bulk microphysical scheme
!   0: uniform distribution
!   1: gamma distribution
!   2: lognormal distribution
!   3: lognormal volume distribution
  PSDINFO_aer_IN(1)%DISNO   =            3,
! parameters of the PSD function in CGS unit
!
!   uniform (mono-disperse) distribution:
!      N(D)=N_T*delta(D-D_m)
!     1: N_T (number concentration),  2: Dm (diameter),
!     3: D_2/D_1 (ratio of the upper and lower limits to define a finite diameter width of the distribution)
!     4: not used.
!
!   generalized gamma distribution:
!      N(D)=N_0 * D^(nu*(1+alpha)-1) * exp( -(lambda * D)^nu)
!     1: lambda (slope parameter),   2: N_0 (intercept parameter),  3: alpha (shape parameter)
!     4: nu (shape parameter)
!
!   lognormal distribution:
!      N(D)=N_T/(D*sigma*sqrt(2*PI)) * exp{-(log(D)-log(D_n))^2/(2.0*sigma^2)}
!     1: N_T (number concentration), 2: D_n (log(D_n) is equal to mean of log(D)),
!     3: sigma (standard deviation of log(D))
!
!   lognormal volume distribution:
!      V(D)=V_T/(D*sigma*sqrt(2*PI)) * exp{-(log(D)-log(D_n))^2/(2.0*log(sigma)^2)}
!      N(D)=6/pi*D^{-3}}*V(D)
!     1: V_T (volume concentration), 2: D_n (log(D_n) is equal to mean of log(D)),
!     3: sigma (log(sigma) is equal to standard deviation of log(D))
!
  PSDINFO_aer_IN(1)%PSD_PAR =   -999.0e0 ,   2.54e-4   ,    2.5e+0  , 0.0e+0,
!
! parameters for mass-dimensional relationship in CGS unit
!    m=a_m*D^a_m
!    md_par(1) -> a_m
!    md_par(2) -> b_m
  PSDINFO_aer_IN(1)%MD_PAR  =   1.30899693899575, 3.0e+0,
! number of internally mixed components
  aerinfo_in(1)%nmix = 1,
! name of internally mixed aersosol components
  aerinfo_in(1)%cname_im = 'dust',
! mass fraction of aerosol components for internal mixture
  aerinfo_in(1)%mf = 1.0e+0,
! radius boundary for integration of PSD [cm]
  aerinfo_in(1)%rbnd = 0.1e-4, 10.0e-4
! overriding option for aerosol refractive index
  rfi_ov_flag(1) = .false.,
! overriding option for aerosol extinction coefficient
  cextp_ov_flag(1) = .false.,

                                                                    901,0-1         95
```

Lognormal volume distribution can be chosen for aerosol particles

Editing the Configure_SDSU.F

hashino@gcrm3:~/J-SIM/SAMPLE/outputs/NICAM/East_Asia_AP/EASE

```
  cname_aer_in(2) = 'sslt',
  vname_m_aer(2) = 'QSSLT',
  dschm_aer_gnl(2) = 0,
  PSDINFO_aer_IN(2)%DISNO   =           3,
  PSDINFO_aer_IN(2)%PSD_PAR =   -999.0e0 ,   2.0e-4    ,    2.51e+0    , 0.0e+0,
  PSDINFO_aer_IN(2)%MD_PAR  =  1.17809724509617, 3.0e+0,
  aerinfo_in(2)%nmix = 1,
  aerinfo_in(2)%cname_im = 'sslt',
  aerinfo_in(2)%mf = 1.0e+0,
  aerinfo_in(2)%rbnd = 0.1e-4, 10.0e-4
  rfi_ov_flag(2) = .false.,
  cextp_ov_flag(2) = .false.,

  cname_aer_in(3) = 'slft',
  vname_m_aer(3) = 'QSLFT',
  dschm_aer_gnl(3) = 0,
  PSDINFO_aer_IN(3)%DISNO   =           3,
  PSDINFO_aer_IN(3)%PSD_PAR =   -999.0e0 ,   0.14e-4    ,    2.03e+0   , 0.0e+0,
  PSDINFO_aer_IN(3)%MD_PAR  =   0.92624623403391, 3.0e+0,
  aerinfo_in(3)%nmix = 1,
  aerinfo_in(3)%cname_im = 'slft',
  aerinfo_in(3)%mf = 1.0e+0,
  aerinfo_in(3)%rbnd = 0.01e-4, 1.0e-4
  rfi_ov_flag(3) = .false.,
  cextp_ov_flag(3) = .false.,

  cname_aer_in(4) = 'crbn',
  vname_m_aer(4) = 'QCRBN',
  dschm_aer_gnl(4) = 0,
  PSDINFO_aer_IN(4)%DISNO   =           3,
  PSDINFO_aer_IN(4)%PSD_PAR =   -999.0e0 ,   0.2e-4    ,    1.80e+0   , 0.0e+0,
  PSDINFO_aer_IN(4)%MD_PAR  =   0.768744258321166, 3.0e+0,
  aerinfo_in(4)%nmix = 2,
  aerinfo_in(4)%cname_im = 'bcbn','ocbn',
  aerinfo_in(4)%mf = 1.0e+0, 3.33e+0,
  aerinfo_in(4)%rbnd = 0.01e-4, 1.0e-4
  rfi_ov_flag(4) = .false.,
  cextp_ov_flag(4) = .false.,
! ---- end of SPRINTARS setup ----

$end
"Configure_SDSU.F" 943L, 47469C written                         941,0-1       99
```

The refractive index defined in RSTAR6b is used by specifying “cname_im”.

The mass fraction and size range for integration can be specified.

The refractive index and extinction coefficient can be overridden.

Editing the Configure_SDSU.F

hashino@gcrm3:~/J-SIM/SAMPLE/outputs/NICAM/East_Asia_AP/EASE

```
! ##############################################################################
! #####################  Configure Simulator Switch  ##########################
! ##############################################################################

$simulator_switch
  micro  = .false.      ! microwave simulator switch; on when .true. (logical)
  radar  = .false.      ! radar simulator switch; on  when .true.  (logical)
  visir  = .false.      ! visble/IR simulator switch; on when .true. (logical)
  lidar  = .false.      ! Lidar simulator switch; on when .true. (logical)
  isccp  = .false.      ! ISCCP-like simulator switch; on when .true. (logical)
  broad  = .false.      ! Lidar simulator switch; on when .true. (logical)
  GV     = .false.       ! GV simulator switch; on when .true. (logical)
  ease   = .true.      ! Earthcare Active-Sensor (EASE) simulator switch; on when .true. (logical)
$end

! ##############################################################################
! ##################  Configure Input-Output Options ##########################
! ##############################################################################

$io_options
  sdsu_dir_sslut= '/home/hashino/SVN_update/J-simulator/SSLUT/'  ! directory for the single-scattering LUTs (character)
  sdsu_dir_data = '/home/hashino/SVN_update/J-simulator/DATAFILES/'        ! directory for various datafiles needed for simulator (character)
  sdsu_io_name  = 'inpfile'      ! name of model-input-list file  (character)
  verbose_SDSU  = .true.             ! if true, print out more comments during run. (logical)
  write_surface = .false.             ! if true, write out surface single scattering properties (logical)
  write_opt     = .false.             ! if true, write out single scattering properties (logical)
  write_CRM3D   = .false.             ! if true, write out CRM 3D input file in GrADS format (logical)
  write_CRM2D   = .false.             ! if true, write out CRM 2D input file in GrADS format (logical)
  output_suffix = '.bin'              ! suffix of output name (character)
$end
                                                                                      48,3          1
```

Editing the Configure_SDSU.F

s1

```
$visir_options

  visir_sensor = 'MODIS'    !sensor name
  znth_slr = 0.e0     ! solar zenith angle [deg] (if -999. coszen depends on model time.)
  znth_obs = 12.13    ! veiwing zenith angle [deg]
  azmth    = 40.      ! azimuth angle between the sun and sensor [deg]
  mxwavel = 4         !The number of channels
  wavel = 0.659, 1.380, 3.750, 11.030 !Channel wavelengths  [micron]
  nch_wavel = '0.659micron', '1.380micron','3.75micron','11.03micron' !lut charactere consistent to wavel
  fov_ct_visir =  1., 1., 1., 1.                 !Spatial resolution for cross-track FOV
  fov_dt_visir =  1., 1., 1., 1.                 !Spatial resolution for down-track FOV
```

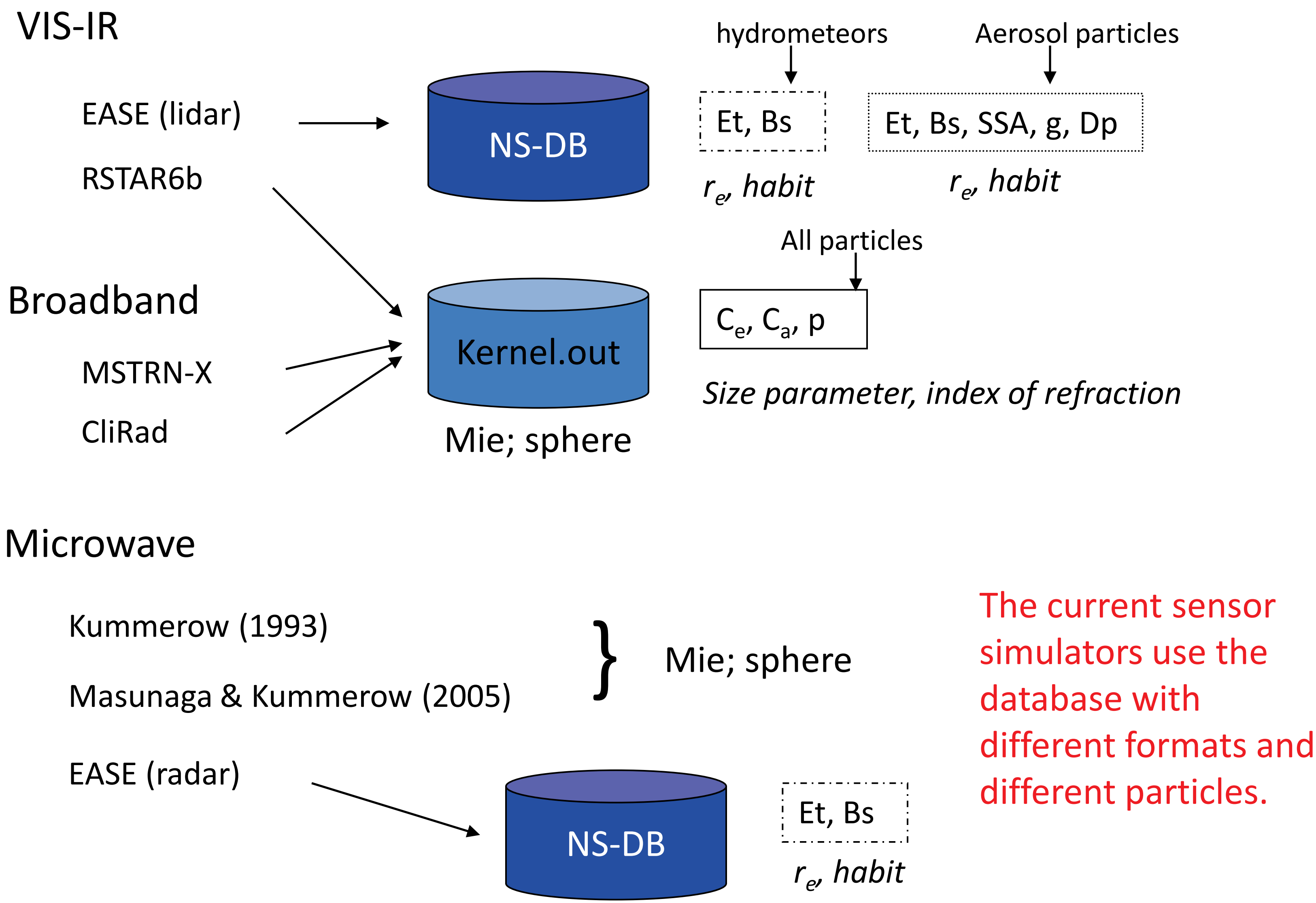
s1

```
! ##########################  Configure Radar Sensor  ##########################
! ##############################################################################

$radar_options

  radar_sensor = 'CPR'  !sensor name (Cloud Profile Radar or CloudSat)
  attenuation  = .true.       !true - attenuating radar reflectivity dBZ  false-non-attenuating
  ground_radar = .false.      !=.true. for ground-based sensor; =.false. for satellite-based sensor
  mxfreq_radar = 1            !The number of channels
  min_echo = -28.             !minimal_detactable echo [dBZ]
  view_angle_radar = 0.16        !viewing angle [deg]
  k2 = 0.75  !dielectric constant |k^2| defaults (if not known -> -999.)
  freq_radar = 94.15 !Channel frequencies [GHz]
  nch_radar = '94.15G '  !lut character that is consistent to freq_radar
  fov_ct_radar =  1.4        ! Spatial resolution for cross-track FOV
  fov_dt_radar =  2.5        ! Spatial resolution for down-track FOV


!  radar_sensor = 'PR'        !sensor name (TRMM Precipitation Radar) (character*20)
!  attenuation  = .false.     !true - take account for attenuation (logical)
!  ground_radar = .false.     !=.true. for ground-based sensor; =.false. for satellite-based sensor (logical
)
```

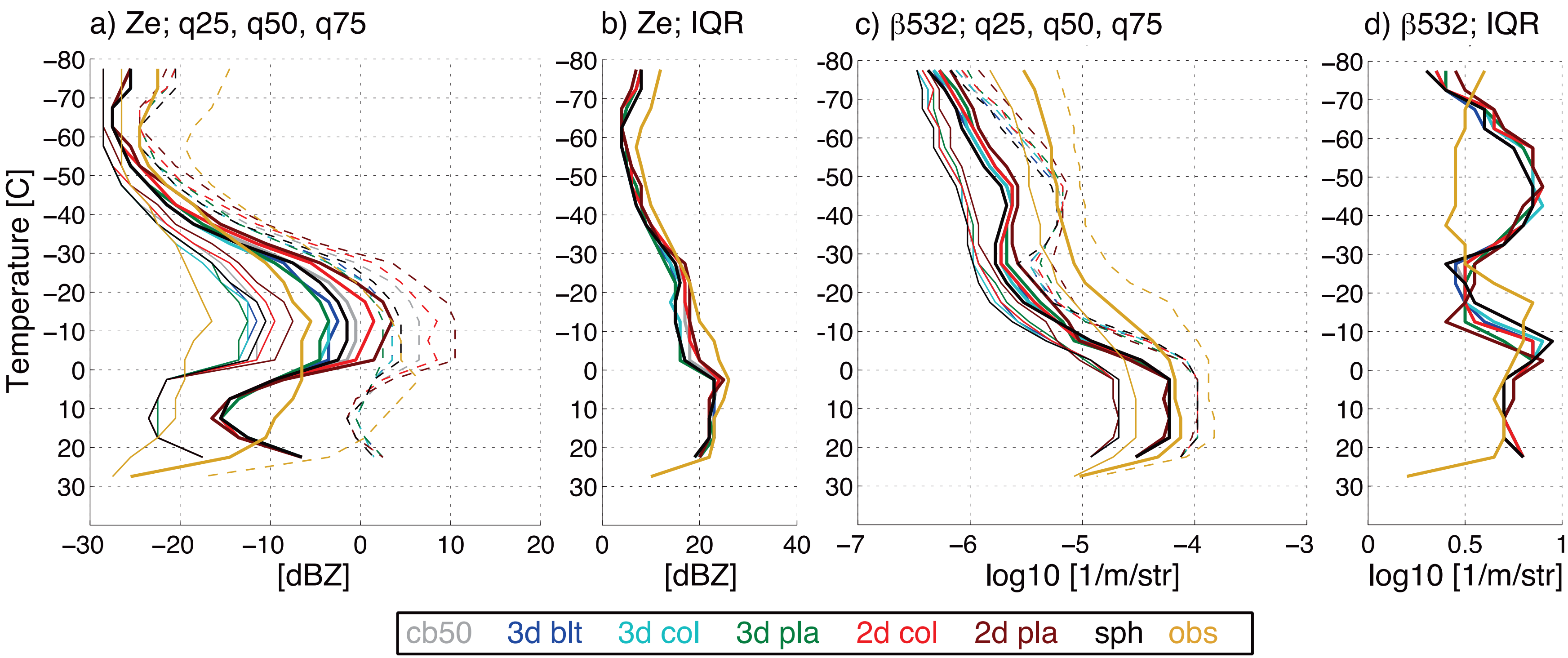
Editing the Configure_SDSU.F

```
s1

! ##############################################################################
! ################  Configure EASE simulator options   #####################
! ##############################################################################

$ease_options

 updown_switch   = 1  ! 0:Upward (MIRAI) 1:Downward (CALIPSO/CLOUDSAT) 2:Downward (EarthCARE)

 analysis_switch = 1  ! nalysis switch : 1 ~ 4 (integer)
                      ! 1- normal, 2- water cloud Req < 50 um, 3- Ice cloud 2-4, 4- Ice cloud 5-7

 alt_start = 120.0e0   ! start altitude [m] (real)

 dhgt_resa = 240.0e0   ! radar lidar range bin size [m] (real)

 number_alt = 83     ! number for altitude bins (integer)

 icmicout_flag = 1   ! flag for atmos & cloud outputs 0) do not write out 1) write out

 sounding_index = 'US'   ! sounding (climatolgy) index for initialization for stratosphere atmos profile.
                         ! 'HS' - High-latitude summer, 'HW' - High-latitude winter
                         ! 'MS' - Mid-latitude summer , 'MW' - Mid-latitude winter
                         ! 'TR' - Tropics             , 'US' - US standard

 ease_slut_c = 1    ! flag for singler scattering look-up table
                    !  These options are available for 95 GHz radar and 532 nm lidar.
                    !  0 (default): CB50 (mixture of 50% of 2D column and 50% of 3D bullet-rosette model)
                    !  1: sphere
                    !  2: 3d bullet
                    !  3: 3d column
                    !  4: 3d plate
                    !  5: 2d column
                    !  6: 2d plate
```

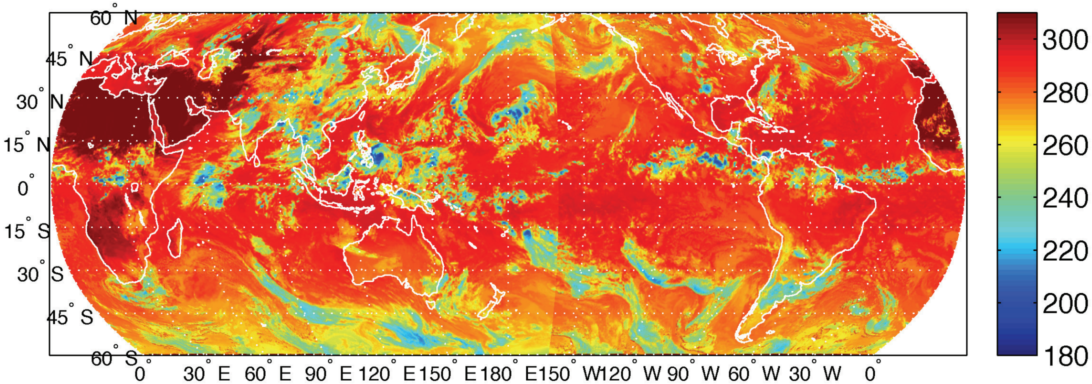
Current status of single scattering library in Joint-simulator



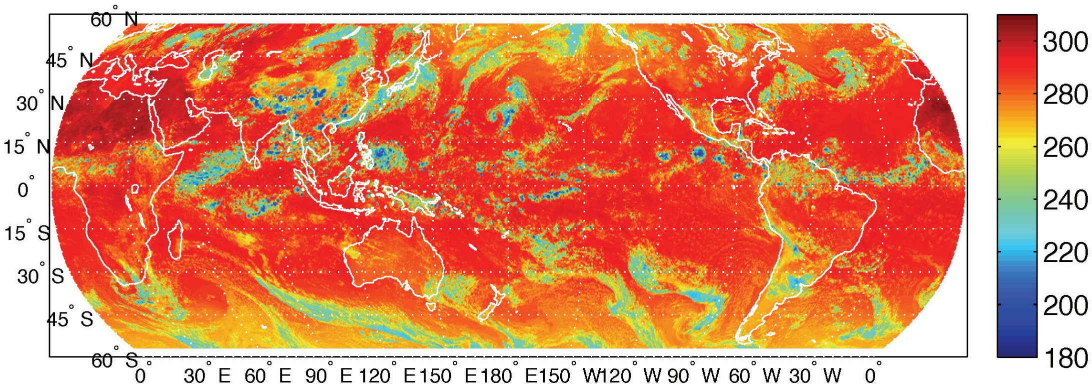
Uncertainty due to non-spherical ice scattering in CFEDs



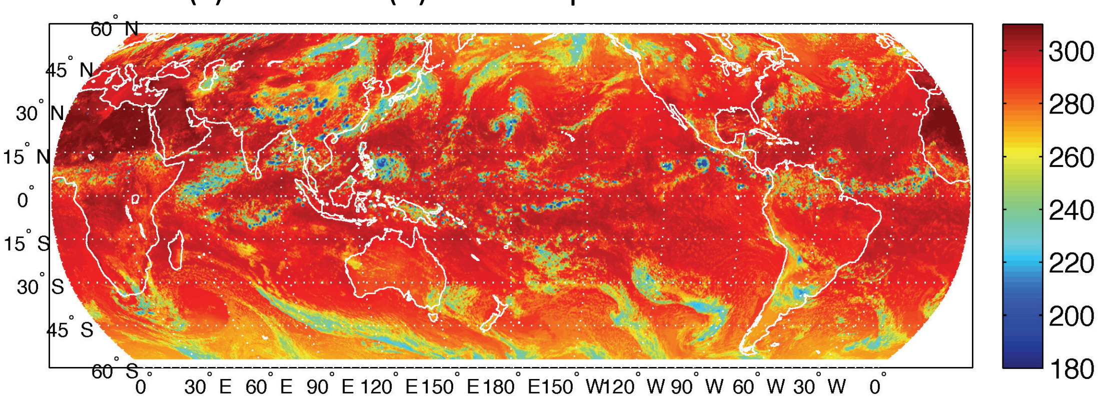
(a) Global IR (K) : 20080619.12



(b) NICAM IR (K): without response function



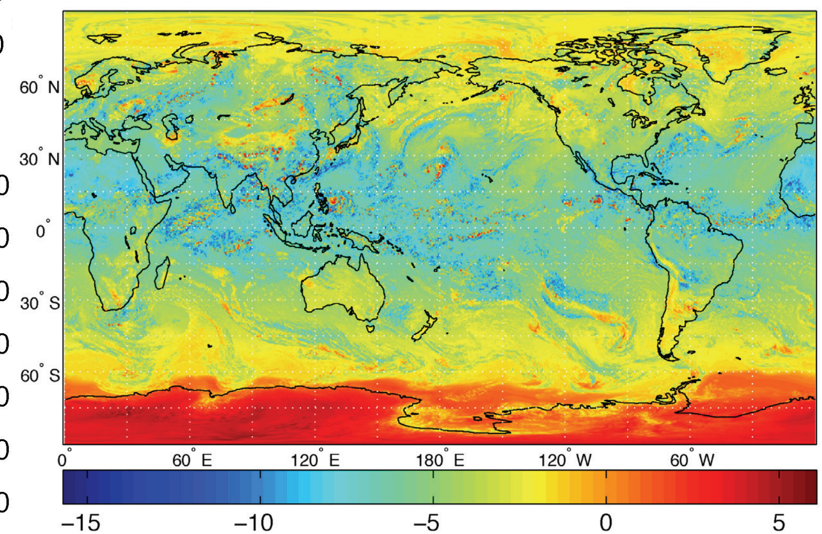
(c) NICAM IR (K): with response function



Adding an option for response function

- A better agreement between observation and NICAM can be seen over Saharan desert.
- In general, monochromatic simulation underestimates Tb. But, it overestimates Tb for high deep clouds.

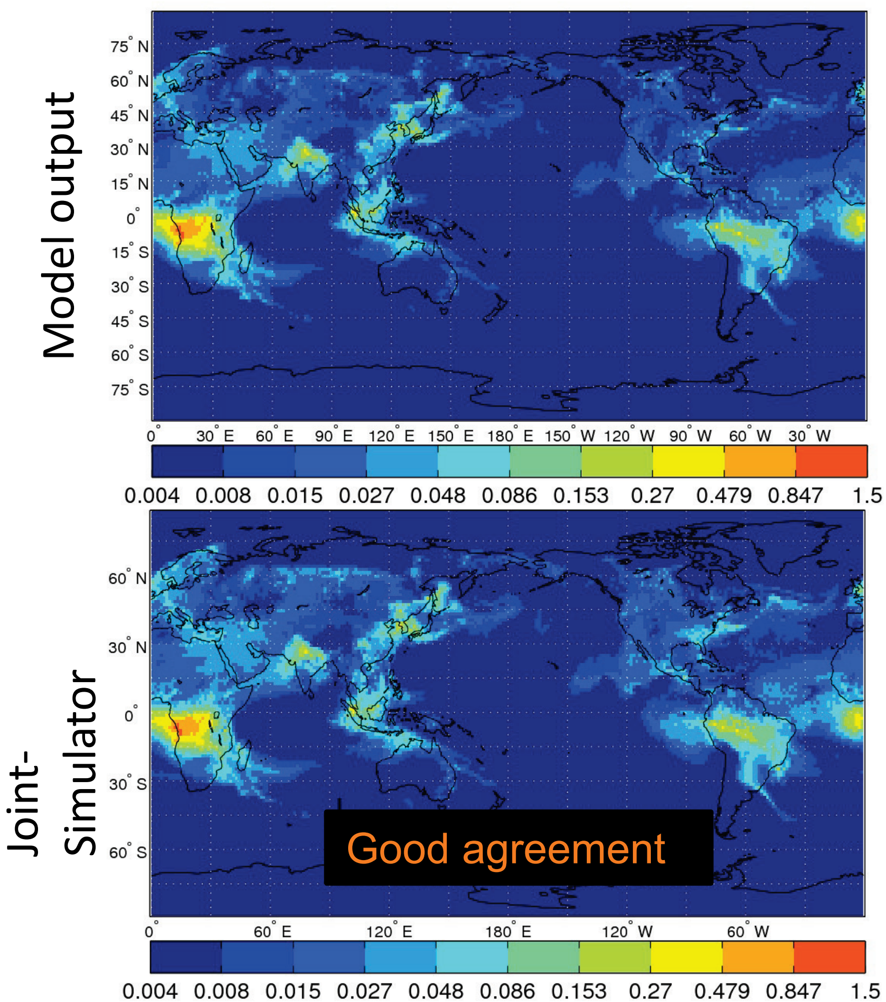
Difference: b-c (K)



Validation of simulated AOD (0.55 μm)

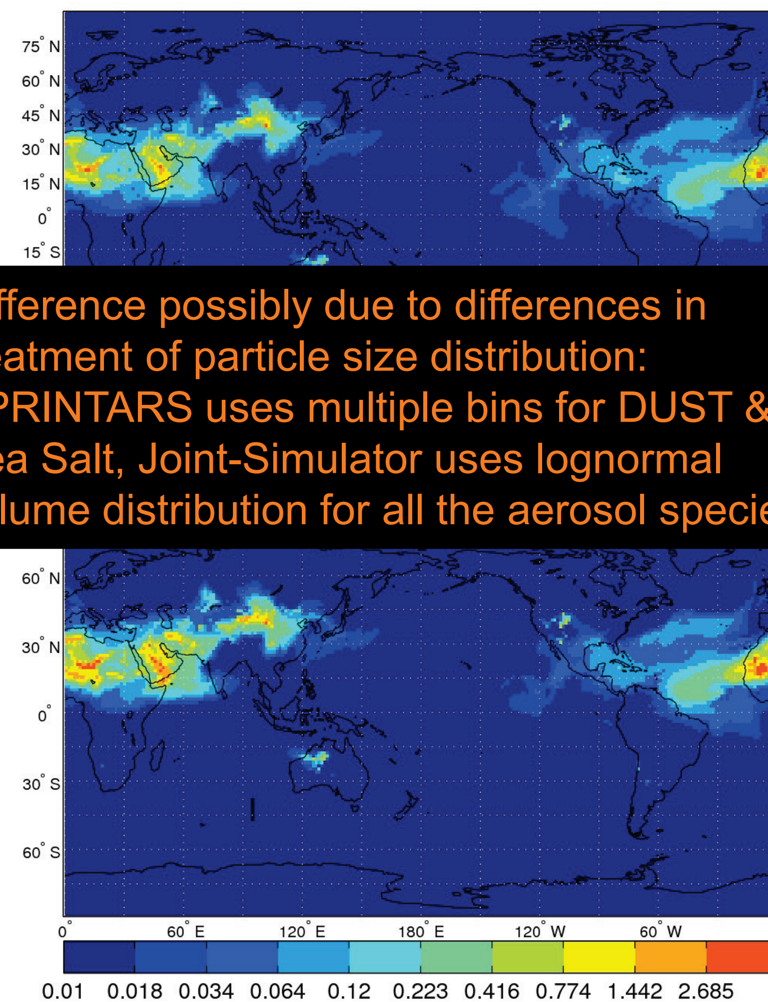
- NICAM-SPRINTARS global simulation provided by Dr. K. Suzuki@JPL with help of Dr. D. Goto.
- Aerosol Optical Depth (AOD) estimated with Joint-Simulator is compared against the outputs from SPRINTARS

Carbonaceous AP



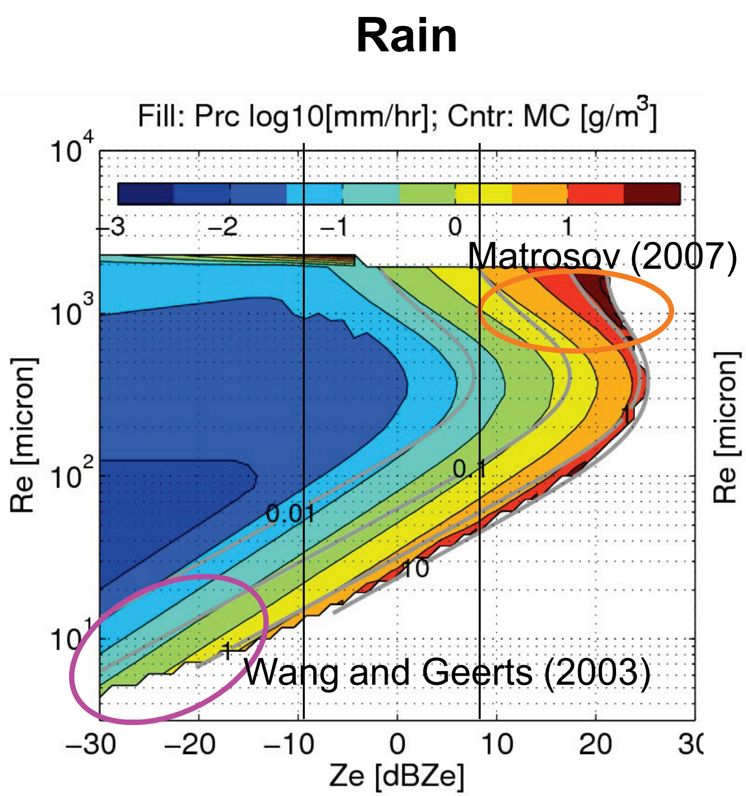
Good agreement

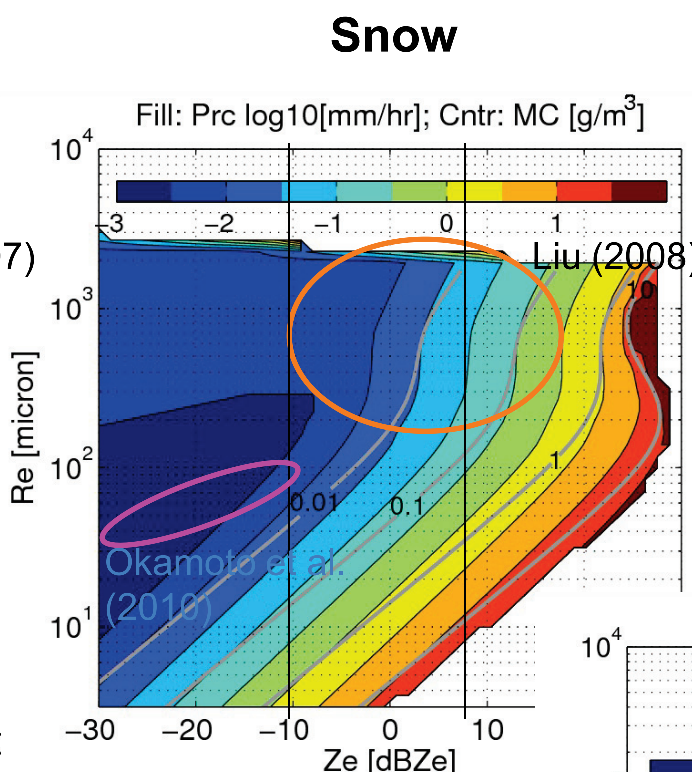
Dust



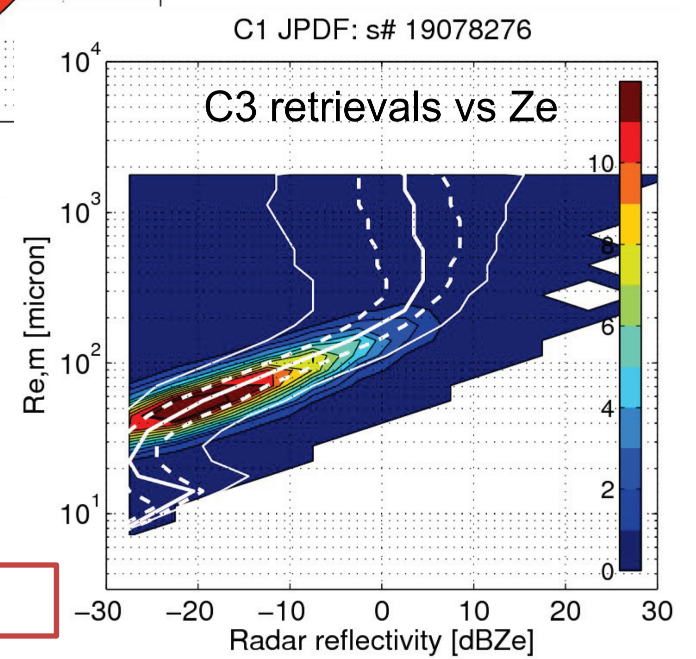
Difference possibly due to differences in treatment of particle size distribution: SPRINTARS uses multiple bins for DUST & Sea Salt, Joint-Simulator uses lognormal volume distribution for all the aerosol species.

Precipitation rate and Ze





Assume inverse-exponential distribution, varied mass and # of a hydrometeor category, and calculated 94GHz radar reflectivity. Only one layer (240m) of a cloud is assumed above the surface.



Rain: At -10 dBZe, Re>20 μm means precip rate<1 mm/hr
At 8 dBZe, precip rate>0.18 mm/hr

Snow: At -10 dBZe, Re>100 μm means precip rate<0.01 mm/hr
At 8 dBZe, precip rate>0.1 mm/hr

Attenuation is not included, leading to overestimation of Ze.

How fast does it run?

CPU: Intel Xeon(L5520) 2.26Ghz (4 cores)

Memory: 4x6 GB

- 32 CPUs
- 2560x1280x40 grid points
  - EASE: 26 min
  - RSTAR6b (one frequency): 40 min
  - MSTRNX: 13 min

Summary

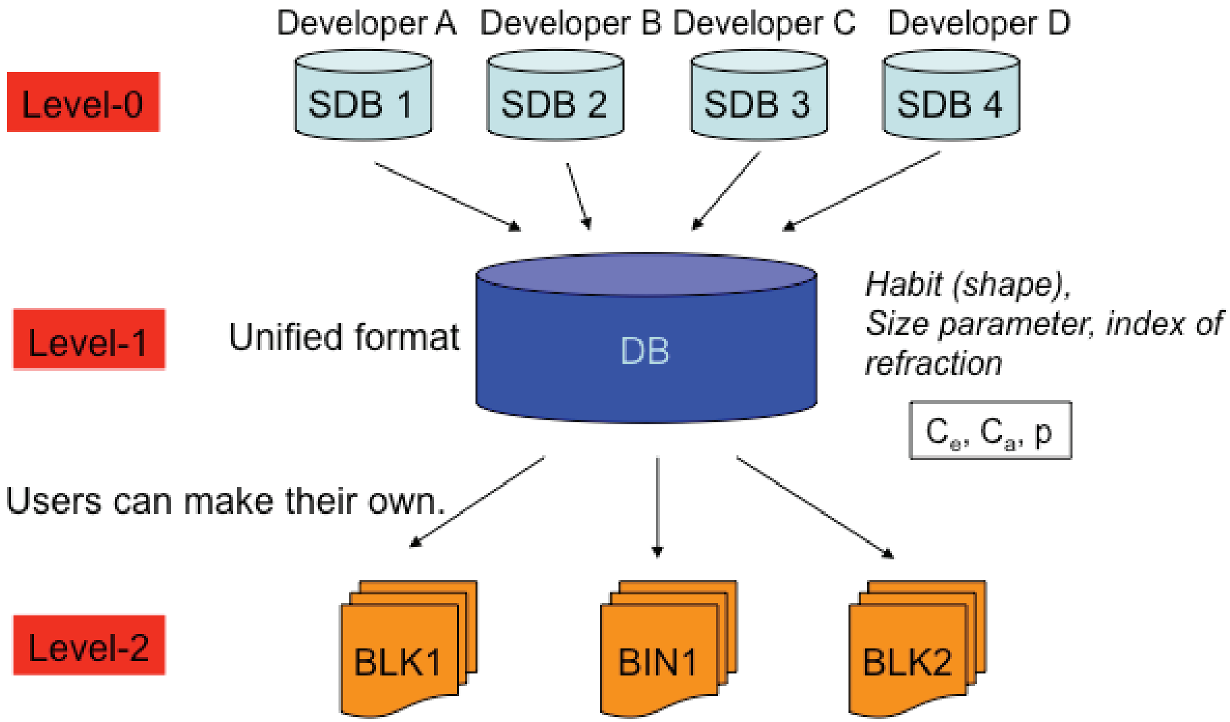
- Sensor simulators include radar, lidar, and broadband simulators that are not in SDSU.
- Universal interface that can be applied for various aerosol & cloud microphysical outputs
  - ✓ Atmospheric models: NICAM, JMA-NHM, & WRF
  - ✓ Aerosol microphysical models: SPRINTARS & GOCART
  - ✓ Cloud microphysical models: NICAM single, double-moment bulk scheme, Hebrai University spectral bin model, and WRF microphysical schemes (Lin scheme)
  - ✓ Particle size distribution, mass-dimensional relationship, and fall velocity are easily specified with a namelist.
- Parallel-computation option (Message Passing Interface) is available.
- The response function can be applied in the visible-IR simulator.
- Write out data necessary for off-line implementation of 3D RTM.
- Can be useful for retrieval algorithm development as well.

Future works

- netcdf output & multiple snapshots
- Construction of non-spherical scattering database
- GCM interface
- Add interfaces for 3D RTMs

Non-spherical scattering database (web-based)

Consolidate the efforts made by individual developers and can be used for testing their parameterization with RTMs easily.



Main collaborators

Prof. Nakajima's group at Tokai University
Prof. Okamoto's group at Kyusyu University
Dr. Ishimoto at Meteorological Research Institute.

Editing the Configure_SDSU.F 2

hashino@gcrm3:~/J-SIM/SAMPLE/outputs/NICAM/East_Asia_AP/EASE

```
! ##########################################################################
! ####################  Configure Input Model options #########################
! ##########################################################################

$crm_options

  sim_case  = 'GENERAL'  ! Weatether Research & Forecasting Model (character*10)
  sdsu_dir_input = '/home/hashino/J-SIM/SAMPLE/CRM/NICAM/East_Asia_AP/'
  sdsu_dir_output = '/home/hashino/J-SIM/SAMPLE/outputs/NICAM/East_Asia_AP/EASE/'   ! output directory (character*200)
  mxgridx   = 256    ! max grid # in horizontal x direction  (integer)
  mxgridy   = 128      ! max grid # in horizontal y direction (integer)
  mxlyr     = 40     ! max grid # in vertical direction  (integer) Toshi- check this lator
  gridsize  = 3.5e0   ! horizontal grid spacings [km] (real)

!  sim_case = 'GCE' !Goddard Cumulus Ensemble Model (uniform_surface must be .true. for GCE)
!  sdsu_dir_input  = './../INPUTS/GCE/SCSMEX/RAMS1/'
!  sdsu_dir_output = './../OUTPUTS/GCE/SCSMEX/RAMS1/'
!  mxgridx = 256    !max grid # in horizontal x direction
!  mxgridy = 256    !max grid # in horizontal y direction
!  mxlyr   = 41     !max grid # in vertical direction
!  gridsize = 1.    !horizontal grid spacings [km]

!  sim_case = 'GCE2D' !Goddard Cumulus Ensemble Model 2D version (uniform_surface must be .true. for GCE)
!  sdsu_dir_input  = './../INPUTS/GCE/'
   sdsu_dir_output = './../OUTPUTS/GCE/'
                                                                                            74,1
```

Editing the Configure_SDSU.F 4

hashino@gcrm3:~/J-SIM/SAMPLE/outputs/NICAM/East_Asia_AP/EASE

```
! ###########################################################################
! ################  Configure Single-Scattering LUTs Options ###################
! ###########################################################################

$single_scatter_options


  lut_micro    = .true.    ! Particle single-scattering LUT options for micro/radar simulator (logical).
                            !.true.  : Use LUTs for microwave opt. Very Fast.
                            !.false. : Full solution of Mie routine. Slow, but accurate.
                            ! (This must be .false. for HUCM_SBM case.)

  lut_visir    = .true.     ! Particle single-scattering LUT option for visir simulator (logical)
                            !.true.  : Use LUTs for microwave opt. Very fast.
                            !.false. : Full solution of Mie routine Slow, but accurate.
                            ! (This must be .false. for HUCM_SBM case.

  lut_replace = .true.     ! Replace existing LUT, if you modify single-scattering routines (logical).
                            !.true.  : Replace single-scattering LUTs.
                            !.false. : Use existing Mie LUTs data.

  ice_refraction_func = 1 ! Effective refraction functions for frozen particles for Microwave/Radar simulator (integer)
                          ! 1: Oblique Maxwell-Garnett function that assumes ice inclusion within air matrix.
                          ! 2: Oblique Maxwell-Garnett function that assumes air inclusion within ice matrix.
                          ! 3: Effective-Medium function that assumes homogeneous mixing.

  melt_opt = 0    ! Effective refraction functions for melting particles for Microwave/Radar simulator (integer)
                  ! 0: Does not account melting particle
                  ! 1: Oblique Maxwell-Garnett function that assumes ice inclusion within water matrix.
                  ! 2: Oblique Maxwell-Garnett function that assumes water inclusion within ice matrix.
                  ! 3: Oblique Maxwell-Garnett function averaging option 1 and 2 --> RECOMMENDED
                  ! 4: Effective-Medium function that assumes homogeneous mixing.

$end
                                                                          342,4          33
```

Comparison of 1D and 3D RTM (Preliminary results)

High resolution simulation of marine stratocumulus
- provided by Mr. Y. Sato (Prof. Nakajima group)
- horizontal resolution: 500x500m

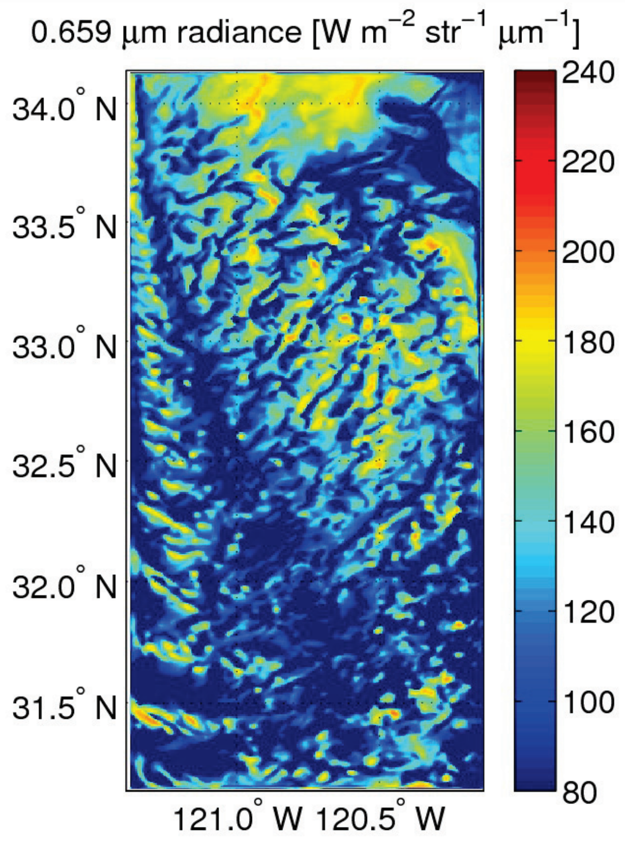
Can be useful for retrieval algorithm development

Experiment design

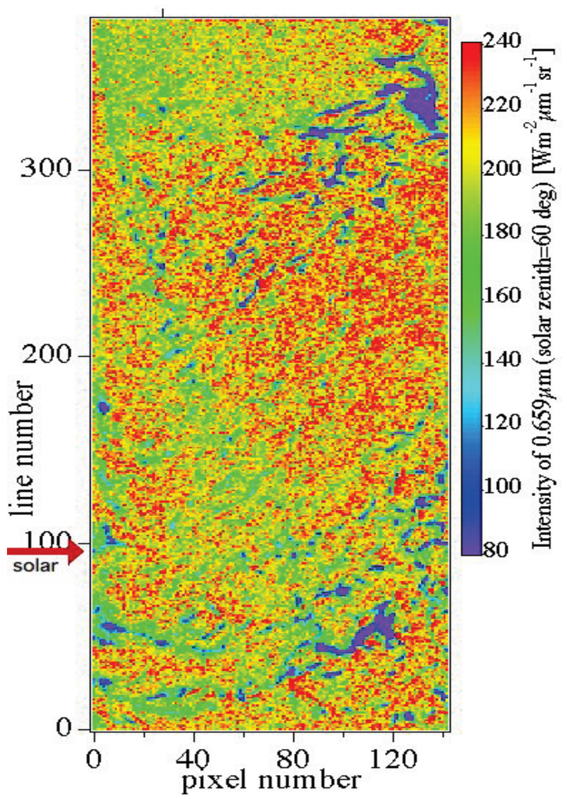
- solar zenith angle: 60°
- viewing zenith angle: 14.3°
- difference between solar azimuth angle and viewing azimuth angle:0°
- no surface reflection (RSTAR not changed yet)

RSTAR: lower radiance between clouds.

1D RTM: RSTAR6b



3D RTM: MCARaTS (Dr. Ishida)



Editing the Configure_SDSU.F 3

hashino@gcrm3:~/J-SIM/SAMPLE/outputs/NICAM/East_Asia_AP/EASE

```
 cloud_microphysics = 'GENERAL'  ! Cloud Microphyiscs Type (character*20)
                                ! GOD: Goddard bulk 1-mmt scheme [Tao et al. 2003]
                                ! GOD10: Goddard bulk 1-mmt scheme 2010 [Lang et al. 2010]
                                ! LIN: LIN bulk 1-mmt scheme  [Lin et al. ]
                                ! NSW: NICAM bulk 1-mmt scheme [Tomita 2008] ! 2010/09/02 T. Hashino added
                                ! WSM: WRF-Single-Moment 6-Class Scheme [Hong et al. 2004]
                                ! RAMS1: RAMS 1-mmt scheme [Walko et al., 1995]
                                ! RAMS2: RAMS 2-mmt scheme [Meyers et al., 1997]
                                ! HUCM_SBM: HUCM spectra-bin microphysics scheme [Khain et al. ]


 clear_sky_scene = .false.   ! if .true., zero out all condensates to create clear sky.



 uniform_surface = .false.            ! When it is true, this option assigns spatially uniform
                                      ! surface characters over the entire domain.
                                      ! (When sim_case='GCE', this must be always .true., because GCE input
                                      !  does not have these surface parameters.)

 idealized_surface%lat       =  20.5e0 ! latitude [deg]
 idealized_surface%lon       = 117.e0  ! lon      [deg]
 idealized_surface%frac_veg  =   0.e0  ! vegetation fraction [%] (optional for WRF)
 idealized_surface%albedo    =   0.05  ! surface SW albedo [-]
 idealized_surface%h2o_snow  =   0.e0  ! snow water equivalent [kg m-2]
 idealized_surface%h2o_soil  =   0.3e0 ! soil moisture fraction [0-1]
 idealized_surface%elev      =   0.e0  ! surface elevation [m]
 idealized_surface%dhgt_snow =   0.e0  ! snow depth [m]
 idealized_surface%iland     =   1     ! 1-land,  2-water
 idealized_surface%igbp_typ  =   5     ! IGBP land-cover type (dominant vegetation type )
                                       !--------------IGBP LULC type--------------
                                       ! water body =                   0
                                       ! evergreen needleleaf forest =  1
                                       ! evergreen broadleaf forest =   2
                                       ! deciduous needleleaf forest =  3
                                       ! deciduous broadleaf forest =   4
                                       ! mixed forests =                5
                                       ! closed shrubland =             6
                                       ! open shrublands =              7
                                       ! woody savannas =               8
                                       ! savannas =                     9
                                       ! grasslands =                  10
                                       ! permanent wetlands =          11
                                       ! croplands =                   12
                                       ! urban and built-up =          13
                                       ! cropland/natural vegetation mosaic =  14
                                       ! snow and ice =                15
                                       ! barren or sparsely vegetated = 16
                                       !------------------------------------------


 account_aerosol   = .true.   ! if true, account aerosol particles (logical)
 aerosol_microphysics = 'GENERAL'  ! Cloud Microphyiscs Type (character*20)

 nudge_gocart_on   = .false.   ! if true, read GLOBAL GOCART aerosl (you must prepare input separately)
                               ! defalt is .false.

$end
                                                                       119,0-1        13
```

Uncertainty due to non-spherical ice scattering in BETTER