```
  ! ----------------------------
  ! Surface structure definition
  ! ----------------------------
  !:tdoc+:
  TYPE :: CRTM_Surface_type
    ! Allocation indicator
    LOGICAL :: Is_Allocated = .TRUE.  ! Placeholder for future expansion
    ! Dimension values
    ! ...None yet
    ! Gross type of surface determined by coverage
    REAL(fp) :: Land_Coverage  = ZERO
    REAL(fp) :: Water_Coverage = ZERO
    REAL(fp) :: Snow_Coverage  = ZERO
    REAL(fp) :: Ice_Coverage   = ZERO
    ! Land surface type data
    INTEGER  :: Land_Type              = DEFAULT_LAND_TYPE
    REAL(fp) :: Land_Temperature       = DEFAULT_LAND_TEMPERATURE
    REAL(fp) :: Soil_Moisture_Content  = DEFAULT_SOIL_MOISTURE_CONTENT
    REAL(fp) :: Canopy_Water_Content   = DEFAULT_CANOPY_WATER_CONTENT
    REAL(fp) :: Vegetation_Fraction    = DEFAULT_VEGETATION_FRACTION
    REAL(fp) :: Soil_Temperature       = DEFAULT_SOIL_TEMPERATURE
    REAL(fp) :: LAI                    = DEFAULT_LAI
    INTEGER  :: Soil_Type              = DEFAULT_SOIL_TYPE
    INTEGER  :: Vegetation_Type        = DEFAULT_VEGETATION_TYPE
    ! Water type data
    INTEGER  :: Water_Type         = DEFAULT_WATER_TYPE
    REAL(fp) :: Water_Temperature  = DEFAULT_WATER_TEMPERATURE
    REAL(fp) :: Wind_Speed         = DEFAULT_WIND_SPEED
    REAL(fp) :: Wind_Direction     = DEFAULT_WIND_DIRECTION
    REAL(fp) :: Salinity           = DEFAULT_SALINITY
    ! Snow surface type data
    INTEGER  :: Snow_Type         = DEFAULT_SNOW_TYPE
    REAL(fp) :: Snow_Temperature  = DEFAULT_SNOW_TEMPERATURE
    REAL(fp) :: Snow_Depth        = DEFAULT_SNOW_DEPTH
    REAL(fp) :: Snow_Density      = DEFAULT_SNOW_DENSITY
    REAL(fp) :: Snow_Grain_Size   = DEFAULT_SNOW_GRAIN_SIZE
    ! Ice surface type data
    INTEGER  :: Ice_Type         = DEFAULT_ICE_TYPE
    REAL(fp) :: Ice_Temperature  = DEFAULT_ICE_TEMPERATURE
    REAL(fp) :: Ice_Thickness    = DEFAULT_ICE_THICKNESS
    REAL(fp) :: Ice_Density      = DEFAULT_ICE_DENSITY
    REAL(fp) :: Ice_Roughness    = DEFAULT_ICE_ROUGHNESS
    ! SensorData containing channel brightness temperatures
    TYPE(CRTM_SensorData_type) :: SensorData
  END TYPE CRTM_Surface_type
  !:tdoc-:
```

```
  FUNCTION Compute_MW_Snow_SfcOptics( &
    Surface     , &  ! Input
    GeometryInfo, &  ! Input
    SensorIndex , &  ! Input
    ChannelIndex, &  ! Input
    SfcOptics   ) &  ! Output
  RESULT( Error_Status )
    ! Arguments
    TYPE(CRTM_Surface_type),      INTENT(IN)     :: Surface
    TYPE(CRTM_GeometryInfo_type), INTENT(IN)     :: GeometryInfo
    INTEGER,                      INTENT(IN)     :: SensorIndex
    INTEGER,                      INTENT(IN)     :: ChannelIndex
    TYPE(CRTM_SfcOptics_type),    INTENT(IN OUT) :: SfcOptics
    ! Function result
    INTEGER :: Error_Status<dc3>
```

```
[ming.chen@rhw9105:1 libsrc.CRTM_CSEM]$ ls libsrc.CRTM
ACCoeff_Binary_IO.f90           CRTM_Options_Define.f90         ODAS_Binary_IO.f90
ACCoeff_Define.f90              CRTM_Parameters.f90             ODAS_Define.f90
ADA_Module.f90                  CRTM_Planck_Functions.f90       ODAS_Predictor_Define.f90
AerosolCoeff_Binary_IO.f90      CRTM_Predictor_Define.f90       ODAS_Predictor.f90
AerosolCoeff_Define.f90         CRTM_Predictor.f90              ODAS_TauCoeff.f90
AOvar_Define.f90                CRTM_RTSolution_Define.f90      ODPS_AtmAbsorption.f90
ASvar_Define.f90                CRTM_RTSolution.f90             ODPS_Binary_IO.f90
Binary_File_Utility.f90         CRTM_SensorData_Define.f90      ODPS_CoordinateMapping.f90
CloudCoeff_Binary_IO.f90        CRTM_SensorInfo.f90             ODPS_Define.f90
CloudCoeff_Define.f90           CRTM_SfcOptics_Define.f90       ODPS_Predictor_Define.f90
Common_RTSolution.f90           CRTM_SfcOptics.f90              ODPS_Predictor.f90
Compare_Float_Numbers.f90       CRTM_SpcCoeff.f90               ODPS_TauCoeff.f90
CRTM_Adjoint_Module.f90         CRTM_Surface_Define.f90         ODSSU_AtmAbsorption.f90
CRTM_AerosolCoeff.f90           CRTM_Tangent_Linear_Module.f90  ODSSU_Binary_IO.f90
CRTM_Aerosol_Define.f90         CRTM_TauCoeff.f90               ODSSU_Define.f90
CRTM_AerosolScatter.f90         CRTM_Utility.f90                ODSSU_TauCoeff.f90
CRTM_AncillaryInput_Define.f90  CRTM_Version.inc                ODZeeman_AtmAbsorption.f90
CRTM_AntennaCorrection.f90      CSvar_Define.f90                ODZeeman_Predictor.f90
CRTM_AOD_Module.f90             DateTime_Utility.f90            ODZeeman_TauCoeff.f90
CRTM_AtmAbsorption.f90          Date_Utility.f90                PAFV_Define.f90
CRTM_AtmOptics_Define.f90       Emission_Module.f90             Profile_Utility_Parameters.f90
CRTM_AtmOptics.f90              Endian_Utility.f90              RTV_Define.f90
CRTM_Atmosphere_Define.f90      File_Utility.f90                Search_Utility.f90
CRTM_Atmosphere.f90             FitCoeff_Define.f90             SensorInfo_Parameters.f90
CRTM_ChannelInfo_Define.f90     FitCoeff_Destroy.inc            SOI_Module.f90
CRTM_CloudCoeff.f90             FitCoeff_Equal.inc              Sort_Utility.f90
CRTM_CloudCover_Define.f90      FitCoeff_Info.inc               SpcCoeff_Binary_IO.f90
CRTM_Cloud_Define.f90           FitCoeff_ReadFile.inc           SpcCoeff_Define.f90
CRTM_CloudScatter.f90           FitCoeff_SetValue.inc           Spectral_Units_Conversion.f90
CRTM_Forward_Module.f90         FitCoeff_WriteFile.inc          SSU_Input_Define.f90
CRTM_Geometry_Define.f90        Fresnel.f90                     String_Utility.f90
CRTM_GeometryInfo_Define.f90    Fundamental_Constants.f90       Subset_Define.f90
CRTM_GeometryInfo.f90           iAtm_Define.f90                 TauCoeff_Define.f90
CRTM_Interpolation.f90          Message_Handler.f90             Timing_Utility.f90
CRTM_K_Matrix_Module.f90        NLTECoeff_Binary_IO.f90         Type_Kinds.f90
CRTM_LifeCycle.f90              NLTECoeff_Define.f90            UnitTest_Define.f90
CRTM_Model_Profiles.f90         NLTE_Parameters.f90             Zeeman_Input_Define.f90
CRTM_Module.fpp                 NLTE_Predictor_Define.f90       Zeeman_Utility.f90
CRTM_MoleculeScatter.f90        NLTE_Predictor_IO.f90
CRTM_NLTECorrection.f90         ODAS_AtmAbsorption.f90
```

```
[ming.chen@rhw9105:1 libsrc.CRTM_CSEM]$ ls libsrc.CSEM
Azimuth_Emissivity_F6_Module.f90  CRTM_VISiceCoeff.f90               NESDIS_AMSU_SICEEM_Module.f90
Azimuth_Emissivity_Module.f90     CRTM_VIS_Ice_SfcOptics.f90         NESDIS_AMSU_SnowEM_Module.f90
Compare_Float_Numbers.f90         CRTM_VISlandCoeff.f90              NESDIS_ATMS_SeaICE_LIB.f90
CRTM_Fastem1.f90                  CRTM_VIS_Land_SfcOptics.f90        NESDIS_ATMS_SeaICE_Module.f90
CRTM_FastemX.f90                  CRTM_VISsnowCoeff.f90              NESDIS_ATMS_SnowEM_Module.f90
CRTM_Interpolation.f90            CRTM_VIS_Snow_SfcOptics.f90        NESDIS_LandEM_Module.f90
CRTM_IRiceCoeff.f90               CRTM_VISwaterCoeff.f90             NESDIS_MHS_SICEEM_Module.f90
CRTM_IR_Ice_SfcOptics.f90         CRTM_VIS_Water_SfcOptics.f90       NESDIS_MHS_SnowEM_Module.f90
CRTM_IRlandCoeff.f90              DateTime_Utility.f90               NESDIS_SEAICE_PHYEM_MODULE.f90
CRTM_IR_Land_SfcOptics.f90        Ellison.f90                        NESDIS_SnowEM_ATMS_Parameters.f90
CRTM_IRsnowCoeff.f90              Foam_Utility_Module.f90            NESDIS_SnowEM_Parameters.f90
CRTM_IR_Snow_SfcOptics.f90        Fresnel.f90                        NESDIS_SSMI_Module.f90
CRTM_IRSSEM.f90                   Guillou.f90                        NESDIS_SSMI_SIceEM_Module.f90
CRTM_IRwaterCoeff.f90             Hyperbolic_Step.f90                NESDIS_SSMI_SnowEM_Module.f90
CRTM_IR_Water_SfcOptics.f90       IRwaterCoeff_Define.f90            NESDIS_SSMIS_SeaIceEM_Module.f90
CRTM_LowFrequency_MWSSEM.f90      Large_Scale_Correction_Module.f90  NESDIS_SSMIS_SnowEM_Module.f90
CRTM_MW_Ice_SfcOptics.f90         Liu.f90                            Reflection_Correction_Module.f90
CRTM_MW_Land_SfcOptics.f90        LSEatlas_Define.f90                SEcategory_Define.f90
CRTM_MW_Snow_SfcOptics.f90        MWwaterCoeff_Define.f90            Slope_Variance.f90
CRTM_MWwaterCoeff.f90             MWwaterLUT_Define.f90              Small_Scale_Correction_Module.f90
CRTM_MW_Water_SfcOptics.f90       NESDIS_AMSRE_SICEEM_Module.f90     String_Utility.f90
CRTM_SEcategory.f90               NESDIS_AMSRE_SNOWEM_Module.f90

[/home/Ming.Chen]ls
ann_mlpcoeff_define.mod           irssem_emiscoeff_define.mod        nesdis_waterir_brdf_module.mod
ann_mlp_module.mod                irssem_emiscoeff_reader.mod        nesdis_waterir_emiss_module.mod
ann_mwlandcoeff_reader.mod        large_scale_correction_module.mod  nesdis_waterir_phymodel.mod
azimuth_emissivity_f6_module.mod  liu.mod                            nesdis_watervis_phymodel.mod
azimuth_emissivity_module.mod     mod_brdf_atlas.mod                 npoess_lut_module.mod
cnrm_amsua_reader.mod             mod_rttov_brdf_atlas.mod           npoess_lut_reader.mod
cnrm_atlas_module.mod             mod_rttov_fastem5r1_coef.mod       parkind1.mod
compare_float_numbers.mod         mod_rttov_fastem6_coef.mod         reflection_correction_module.mod
crtm_fastem1.mod                  mw_canopy_optics.mod               rttov_coef_io_mod.mod
crtm_fastem_constants.mod         mw_leaf_optics.mod                 rttov_const.mod
crtm_fastem_module.mod            mw_soil_optics.mod                 rttov_fast_coef_utils_mod.mod
crtm_fastem_parameters.mod        mw_soil_permittivity.mod           rttov_fastem5r1_ad_module.mod
crtm_fastemxx.mod                 mw_soilwater_permittivity.mod      rttov_fastem5r1_module.mod
crtm_lowfrequency_mwssem.mod      nesdis_amsre_iceem_module.mod      rttov_fastem5r1_tl_module.mod
crtm_mwwatercoeff_define.mod      nesdis_amsre_snowem_module.mod     rttov_fastem6_ad_module.mod
crtm_mwwaterlut_define.mod        nesdis_amsu_iceem_module.mod       rttov_fastem6_module.mod
crtm_rttov_sensor_map.mod         nesdis_amsu_snowem_module.mod      rttov_fastem6_tl_module.mod
csem_exception_handler.mod        nesdis_ann_landem.mod              rttov_fastem_module.mod
csem_iceir_sfcoptics.mod          nesdis_atms_iceem_module.mod       rttov_global.mod
csem_icemw_sfcoptics.mod          nesdis_atms_seaice_lib.mod         rttov_hdf_coefs.mod
csem_icevis_sfcoptics.mod         nesdis_atms_snowem_module.mod      rttov_hdf_mod.mod
csem_interpolation.mod            nesdis_iceir_phymodel.mod          rttov_hdf_rttov_coef_io.mod
csem_landir_sfcoptics.mod         nesdis_icemw_phymodel.mod          rttov_hdf_rttov_coef_pcc1_io.mod
csem_landmw_sfcoptics.mod         nesdis_icevis_phymodel.mod         rttov_hdf_rttov_coef_pcc2_io.mod
csem_landvis_sfcoptics.mod        nesdis_landem_module.mod           rttov_hdf_rttov_coef_pcc_io.mod
csem_lifecycle.mod                nesdis_landir_phymodel.mod         rttov_hdf_rttov_fast_coef_io.mod
csem_model_manager.mod            nesdis_landmw_phymodel.mod         rttov_hdf_rttov_nlte_coef_io.mod
csem_rttov_reader.mod             nesdis_landvis_phymodel.mod        rttov_irssem_module.mod
csem_rttov_visnir_brdf.mod        nesdis_mhs_iceem_module.mod        rttov_solar_refl_mod.mod
csem_snowir_sfcoptics.mod         nesdis_mhs_snowem_module.mod       rttov_tessem_mod.mod
csem_snowmw_sfcoptics.mod         nesdis_mw_iceemiss_util.mod        rttov_types.mod
csem_snowvis_sfcoptics.mod        nesdis_mw_iceem_lut.mod            search_utility.mod
csem_struct_define.mod            nesdis_mw_snowemiss_util.mod       slope_variance.mod
csem_type_kinds.mod               nesdis_mw_snowem_lut.mod           small_scale_correction_module.mod
csem_waterir_sfcoptics.mod        nesdis_sensors_icemw_modules.mod   snowmw_optical_model.mod
csem_watermw_sfcoptics.mod        nesdis_sensors_snowmw_modules.mod  soilmw_dsm_module.mod
csem_watervis_sfcoptics.mod       nesdis_snowem_atms_parameters.mod  soilmw_roughness_correction.mod
ellison.mod                       nesdis_snowem_parameters.mod       string_utility.mod
fastem_coeff_reader.mod           nesdis_snowir_phymodel.mod         telsem2_atlas_module.mod
fitcoeff_define.mod               nesdis_snowmw_phymodel.mod         telsem2_atlas_reader.mod
foam_utility_module.mod           nesdis_snowvis_phymodel.mod        telsem_atlas_module.mod
fresnel.mod                       nesdis_ssmi_iceem_module.mod       telsem_atlas_reader.mod
fresnel_refl_trans.mod            nesdis_ssmis_iceem_module.mod      uwir_atlas_module.mod
guillou.mod                       nesdis_ssmi_snowem_module.mod      uwir_atlas_reader.mod
hyperbolic_step.mod               nesdis_ssmis_snowem_module.mod     yomhook.mod
```

Stand-along package:

```
[ming.chen@rhw9105:1 CSEM]$ ls
Build  doc  fix  interfacing  LICENSE  README.md  src  TEST-EXAMPLE
```

./configure –prefix=CSEM_Installation_Path

make & make install

Integrated CRTM-CSEM Package

```
[ming.chen@rhw9105:1 REL-2.3.0]$ ls
autogen.sh    configure     crtm_release_notes.txt  install-sh  make_crtm_lib.sh  README
config-setup  configure.ac  fix                     libsrc      Makefile.in       README.NCO
```

./configure –prefix=lib_installation_path

make & make install

crtm_v2.3.0/lib : libcrtm.a

FL_FLAGS = -L$(CRTM_DIR)/lib -lcrtm

```
[ming.chen@rhw9105:1 REL-3.0.0]$ ls
autogen.sh    configure     csem_v1.0.0  install-sh  Makefile.in  README.NCO
config-setup  configure.ac  fix          libsrc      README
```

./configure –prefix=lib_installation_path

make & make install

crtm_v3.0.0/lib : libcrtm.a libcsem.a

FL_FLAGS = -L$(CRTM_DIR)/lib -lcrtm –lcsem