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!
! README for OMSO2e (OMI Daily L3e for OMSO2) Version 1.1.7
!
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! App Version: 1.1.7
!
! Date: 2017-01-27
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! OMSO2e High Level Overview:
!   This is an overview of the Version 1.1.7 OMI (Ozone Monitoring Instrument)
!   OMSO2e Application Plugin Package (APP).  The OMSO2e APP creates the OMSO2e
!   data product of the U.S. OMI Science Team, which is the daily 0.25-degree
!   by 0.25-degree Level 3e (L3e) column amount SO2 product based on the
!   "best pixel" approach.  The "e" in "OMSO2e" represents "expanded".
!
!   The OMSO2e APP creates a daily L3e gridded data product file from (as many
!   as) three consecutive OMSO2G daily Level 2G (L2G) gridded data product
!   files, where each OMSO2G file contains 24 consecutive UTC hours of OMSO2
!   orbital Level 2 (L2) swath data subsetted onto a 0.25-degree by 0.25-degree
!   grid in longitude and latitude.
!
!   A L3e day is defined as the ensemble of all L2 ground pixels with pixel
!   centers that have the same local calendar date on the ground.  There are
!   two reasons behind such a definition.  First, a L3e day provides complete
!   coverage of Earth, since every point on Earth (outside of polar night)
!   experiences daylight on each calendar date (in comparison, 24 consecutive
!   UTC hours of OMI observations do not completely cover Earth).  Second, the
!   L3e day puts the discontinuity (i.e., where the L2 observations within a
!   given day differ by almost 24 hours) at +/-180 degrees longitude, and, thus,
!   the discontinuity can be placed undistractingly along the extreme left and
!   right edges of several commonly used map projections.
!
!   The calendar date of the L3e day is the calendar date at Greenwich midway
!   through the L3e day, and is specified via the L3e day of year parameter in
!   the PCF (Process Control File) of the OMSO2e APP.  Note that some of the
!   L2 observations at the beginning of a L3e day will correspond to the
!   previous calendar date at Greenwich, and some of the L2 observations at
!   the end of a L3e day will correspond to the next calendar date at Greenwich.
!   Consequently, data from three consecutive OMI L2G files are required to
!   fully populate the L3e grid at all longitudes for any given L3e day.
!
!   The OMSO2e APP was developed for Dr. Nick Krotkov (NASA/GSFC), and is based
!   upon the TOMS Level 3 Gridded Software.  The latter was developed over a
!   period of many years by several people:  W. Byerly, D. Cao, E. Celarier,
!   Q. Choung, S. Huang, B. Irby, D. Lee, L. Liu, L. Moy, M. Peng, L. Phung,
!   B. Raines, C. Seftor, and, especially, C. Wellemeyer.
!
! Adopted OMSO2e Grid:
!   The adopted L3e grid is a 0.25-degree by 0.25-degree grid in longitude and
!   latitude.  The dimensions of the grid are 1440 by 720.  The center of the
!   first grid cell is located at longitude -179.875 and latitude -89.875.  The
!   center of the final grid cell is located at longitude 179.875 and latitude
!   89.875.  The center of the grid itself is located at longitude 0.0 and
!   latitude 0.0, and corresponds to the corners of four grid cells.
!
!   The grid format of the OMSO2e HDF-EOS 5 product files is consistent with
!   KNMI document number SD-OMIE-KNMI-443 entitled "Definition of OMI Grids
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!   for Level 3 and Level 4 Data Products" by J.P. Veefkind, J.F. De Hahn,
!   P.F. Levelt and R. Noordhoek.
!
!   The format of the OMSO2e HDF-EOS 5 product files is consistent with "A File
!   Format for Satellite Atmospheric Chemistry Data Based On Aura File Format
!   Guidelines" by C. Craig, P. Veefkind, P. Leonard, P. Wagner, C. Vuu and
!   D. Shepard.
!
! OMSO2e Gridding Algorithm:
!   Each grid cell in the L3e product contains the data for the L2 observation
!   that overlaps with the L3e grid cell which has the shortest path length
!   [path length = 1/cos(solar zenith angle) + 1/cos(viewing zenith angle)].
!
!   The overlap between an L2 observation and an L3e grid cell is determined
!   in a manner consistent with the document entitled "Total Ozone Mapping
!   Spectrometer (TOMS) Level-3 Data Products User's Guide" by R. McPeters,
!   P.K. Bhartia, A. Kruger, et al.
!
!   An L2 observation can be mapped onto more than one L3e grid cell, if the
!   L2 observation overlaps with and has the shortest path length for more
!   than one L3e grid cell.
!
!   The L2 observations are not averaged or weighted in any way in the L3e
!   product.
!
!   The L3e product currently excludes L2 data collected in OMI spatial and
!   spectral zoom modes.
!
!   Before the L2 observation with the shortest path length is selected, each
!   of the L2 observations that overlap with each L3e grid cell is considered,
!   and compared with several exclusion criteria.  These criteria are summarized
!   here in sequence.
!
!   Let l3_tnoon be the time at noon UTC for the L3e day, and let l2g_time
!   be the L2 observation time.
!
!   A1) As a rough first cut, L2 observations made outside of the 48-hour time
!       interval centered at l3_tnoon are excluded.  Thus, L2 observations with
!
!       l2g_time <  l3_tnoon - (24 hours - 15 minutes)
!
!       or
!
!       l2g_time >= l3_tnoon + (24 hours - 15 minutes)
!
!       are excluded.
!
!   At any given moment, all points on Earth between the longitude of midnight
!   and the dateline that are on the same side of the dateline have the same
!   calendar date.  The calendar dates on opposite sides of the dateline differ
!   by one day, except at the instant when the longitude of midnight and the
!   dateline coincide, in which case the date is the same everywhere on Earth.
!
!   Let l2_lom be the longitude of midnight at l2g_time, and let l2g_lon be the
!   longitude at the center of the L2 observation.  The dateline is assumed to
!   lie strictly at a longitude of +/-180 degrees for the sake of simplicity,
!   which ignores the zigs and zags of the actual dateline.
!
!   A2) L2 observations with local calendar dates on the ground that correspond
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!       to the day before the L3e day are excluded.  This has been
!       implemented as L2 observations with
!
!       l2g_time <  l3_tnoon - 15 minutes
!
!       and
!
!       -180 degrees <= l2g_lon < l2_lom
!
!       are excluded.
!
!   A3) L2 observations with local calendar dates on the ground that correspond
!       to the day after the L3e day are excluded.  This has been
!       implemented as L2 observations with
!
!       l2g_time >= l3_tnoon + 15 minutes
!
!       and
!
!       l2_lom <= l2g_lon < 180 degrees
!
!       are excluded.
!
!   Let bit5 be "bit 5" (the 6th bit) of the "ground pixel quality flag" of the
!   L2 observation.  This is the solar eclipse possibility flag.
!
!   A4) L2 observations with the solar eclipse possibility flag set are
!       excluded.  Thus, L2 observations with
!
!       bit5 /= 0
!
!       are excluded.
!
!   Let bit11 be "bit 11" (the 12th bit) of the "quality flags" of the L2
!   observation.  This is the row anomaly flag.
!
!   A5) L2 observations with the row anomaly flag set are excluded.  Thus, L2
!       observations with
!
!       bit11 /= 0
!
!       are excluded.
!
! OMSO2e Gridding Algorithm for PBL SO2:
!   The PBL (Planetary Boundary Layer) SO2 estimates come from the OMSO2 L2 code
!   that uses the PCA (Principal Component Analysis) algorithm.
!
!   There are several criteria in addition to A1 through A5 (above) for
!   excluding L2 observations from the L3e grid for the PBL observations.
!
!   C6) L2 observations with a radiative cloud fraction greater than 0.2 or less
!       than 0.0 are excluded.  Thus, L2 observations with
!
!       l2g_rcf > 0.2
!
!       or
!
!       l2g_rcf < 0.0
!
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!       are excluded
!
!   C7) L2 observations with a solar zenith angle greater than 70.0 degrees are
!       excluded.  Thus, L2 observations with
!
!       l2g_sza > 70.0
!
!       are excluded.
!
!   C8) L2 observations with a 1-based scene number (cross-track position number)
!       greater than 58 or less than 3 are excluded.  Thus, L2 observations with
!
!       l2g_scene > 58
!
!       or
!
!       l2g_scene < 3
!
!       are excluded (i.e. included scenes must satisfy  2 < l2g_scene < 59)
!
!   C9) No L2 observations are excluded based on terrain height in Version 1.1.7
!       of the OMSO2e APP.
!
! OMSO2e Adjustment for PBL SO2:
!
!   C10) A Pacific Sector Correction (PSC) is not applied in Version 1.1.7 of
!        the OMSO2e APP, and the PacificSectorCorrection diagnostic field has
!        been replaced by the PacificSectorAverage diagnostic field.
!
!   The PBL SO2 is scaled by the clear sky (globally fixed) Air Mass Factor
!   (AMF).  This step also generates a new L3e data field, SlantColumnAmountSO2,
!   which is the original PBL SO2 column amount multiplied by a factor of 0.36.
!   The "new" PBL SO2 column amount is then computed from the slant column
!   amount SO2 and the local monthly AMF from the GEOS-CHEM model.
!
!   C11) Let l3_caspbl be the column amount SO2 PBL.  The slant column amount
!        SO2 for each grid cell, l3_scaso2, is simply
!
!        l3_scaso2 = l3_caspbl * 0.36
!
!   C12) Let l3_amfclr be the empirical mean clear sky AMF for the month of
!        observation (derived using the approach described in "Retrieval of
!        vertical columns of sulfur dioxide from SCIAMACHY and OMI: Air mass
!        factor algorithm development, validation, and error analysis" by
!        C. Lee, R. V. Martin, A. van Donkelaar, et al.), and let l3_scaso2 be
!        the slant column amount SO2.  The scaled PBL SO2 is then
!
!        l3_caspbl = l3_scaso2 / l3_amfclr
!
!        The result (of C11 and C12) is equivalent to
!
!        l3_caspbl = l3_caspbl * 0.36 / l3_amfclr
!
! South Atlantic Anomaly Mask for PBL SO2:
!
!   C13) Finally, the PBL and slant column SO2 are set to fill values in grid
!        cells that fall within the South Atlantic Anomaly (i.e. SAA) region.
!
!        A smaller SAA mask has been implemented in Version 1.1.7 of the OMSO2e
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!        APP.  The new mask has been empirically derived from monthly maps of
!        the PBL SO2 column amount for June and July 2005, and covers the very
!        noisiest parts of the SAA.
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