Description of products in University of Utah database

Chuntao Liu
9. 2006

1. Introduction to the structure of the database

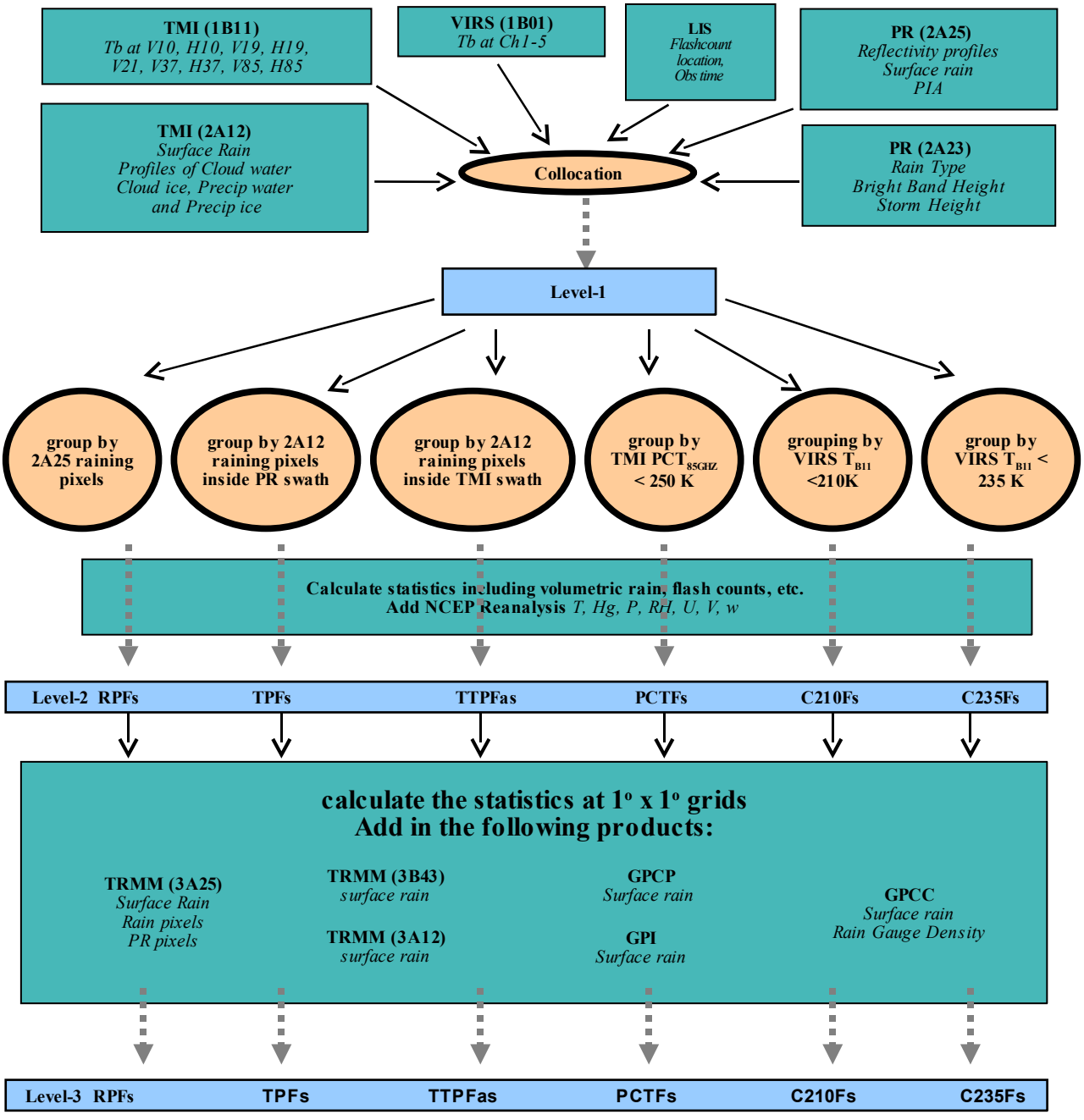
Using feature grouping concept to study tropical deep convection has been a tradition in Dr. Zipser's research group. From early works using SSM/I (Mohr and Zipser, 1996, Mohr et al., 1999, Toracintar and Zipser., 2001) to the works lately using TRMM (Nesbitt et al. 2000, 2003, 2004, Cecil et al. 2005, Nesbitt et al. 2006, Liu and Zipser 2005, Zipser et al. 2006, Liu et al., 2006), the features were either defined as cold brightness temperature from Microwave measurements or the raining area observed by TRMM precipitation radar. Since Dec 1997, the TRMM measurements have been collected, processed and stored in University of Utah. With the most recent upgrades, currently University of Utah TRMM feature database includes three levels of processing:

- Level 1
  Collocation of observations and retrievals from different instruments on board the TRMM satellite.
- Level 2
  Grouping the features based on the different definitions, then calculate the properties of measurements and retrievals inside these features, such as size, height of reflectivity, minimum brightness temperature from Microwave and IR channels, etc..
- Level 3
  Summarizing the level-2 feature properties on a 1x1 boxes globally. Also incorporate the GPI, GPCC, GPCP, TRMM 3A25, 3B43 precipitation estimates.

The products include:

- 1Z: orbitally saved original measurements and retrievals at pixels level.
- 2Z: Orbitally saved old definition (2A25 raining area+ 85 GHz PCT < 250 K) of precipitation features (Nesbitt et al. 2000) properties. Monthly combined files available too.
- 1NZ: orbitally saved original measurement and retrievals at nadir view only at pixel level.
- 1Z06PIX: saved total PR and TMI sampled pixels in a 1x1 degree boxes.
- 1Z06ORBIT: saved grouping information of all the features at pixels level.
- 2NZ06: properties of features vertically grouped at nadir cross section.
- 2Z06.C210F: properties of features grouped by CH4 Tb <=210K inside PR swath (Liu et al., 2006)
- 2Z06.C235F: properties of features grouped by CH4 Tb <=235K inside PR swath
- 2Z06.C273F: properties of features grouped by CH4 Tb <=273K inside PR swath
- 2Z06.LIS: properties of PR and TMI measurements at location of flashes inside PR swath
- 2Z06.PCTF: properties of features grouped by 85 GHz PCT <=250K inside PR swath
- 2Z06.RPF: properties of features grouped by PR 2A25 near surface raining pixels
- 2Z06.RPPF: properties of features grouped by PR 2A25 near surface raining pixels and the area of projected 20 dBZ pixels.
- 2Z06.TPF:properties of features grouped by TMI 2A12 surface raining pixels inside PR swath
- 2Z06.TPF:properties of features grouped by TMI 2A12 surface raining pixels inside TMI swath
- 3Z: monthly summarized 2Z parameters inside 1x1 boxes globally (36S-36N).

Note: Level-3 products for new definitions (2NZ06 and 2Z06.xxx) have not been implemented.



Flow chart of the University of Utah TRMM feature database

2. Parameters in each products

The different parameters were calculated for all features in the following groups.

- Parameters in PR swath features (RPF, RPPF, TPF, PCTF, C210F, C235F, C273F)

GRPNUM	'feature number in the orbit data'
ORBIT	'Orbit number'
BOOST	'0: before boost, 1: after boost'
LAT	'Geographical center latitude '
LON	'Geographical center longitude '
ALTRK	'number of pixels along track'
ACTRK	'number of pixels across track'
ELEV	'ground elevation (km)'
YEAR	'UTC year'
MONTH	'UTC month'
DAY	'UTC day'
HOUR	'UTC hour'
NPIXELS_PR	'number of pr pixels inside feature'
NPIXELS_20DBZ	'number of pr pixels inside feature with 20dBZ'
NPIXELS_TMI	'number of tmi pixels inside feature'
NRAINPIXELS_2A25	'number of pr raining pixels'
NRAINPIXELS_2A12	'number of tmi raining pixels'
VOLRAIN_2A25	'volumetric rain from 2a25 (mm/hr*km^2)'
VOLRAIN_20DBZ	'volumetric rain from 2a25 for 20dBZ pixels (mm/hr*km^2)'
VOLRAIN_2A12	'volumetric rain from 2a12 (mm/hr*km^2)'
MIN85PCT	'minimum 85GHz PCT (K)'
MIN37PCT	'minimum 37GHz PCT (K)'
NLT275	'number of PR pixels with 85GHz PCT < 275 K'
NLT250	'number of PR pixels with 85GHz PCT < 250 K'
NLT225	'number of PR pixels with 85GHz PCT < 225 K'
NLT200	'number of PR pixels with 85GHz PCT < 200 K'
NLT175	'number of PR pixels with 85GHz PCT < 175 K'
NLT150	'number of PR pixels with 85GHz PCT < 150 K'
NLT125	'number of PR pixels with 85GHz PCT < 125 K'
NLT100	'number of PR pixels with 85GHz PCT < 100 K'
MINIR	'minimum 10.8 um Tb (K)'
MAXNSZ	'maximum near surface reflectivity (dBZ)'
MAXDBZ	'maximum 1km reflectivity at 0.5-20km by 0.5km interval (dBZ)'
N20DBZ	'number of pr pixels greater or equal to 20 dBZ at 1-16 km by 1 km interval'
MAXHT	'maximum height of the feature from 2A23 storm height (km)'
MAXHT15	'maximum height reached by the feature with 15 dBZ (km)'
MAXHT20	'maximum height reached by the feature with 20 dBZ (km)'
MAXHT30	'maximum height reached by the feature with 30 dBZ (km)'
MAXHT40	'maximum height reached by the feature with 40 dBZ (km)'
NCH4LE210	'number of pr pixels with 10.8 um TB <= 210 K'
NCH4LE235	'number of pr pixels with 10.8 um TB <= 235 K'
NCH4LT273	'number of pr pixels with 10.8 um TB < 273 K'
NCH4GE273	'number of pr pixels with 10.8 um TB >= 273 K'
LANDOCEAN	'0: over ocean 1:over land'

NSTRAT_2A25 'number of pr pixels with stratiform rain'
NCONV_2A25 'number of pr pixels with convective form rain'
RAINSTRAT_2A25 'stratiform volumetric rain (mm/hr*km^2)'
RAINCONV_2A25 'convective form volumetric rain (mm/hr*km^2)'
NRPF 'number of radar precipitation features inside'
R_LON 'center longitude of the ellipses'
R_LAT 'center latitude of the ellipses'
R_MAJOR 'major axle (km)'
R_MINOR 'minor axle (km)'
R_ORIENTATION ' orientation angle (degree)'
R_SOLID ' percent filled '
FLASHCOUNT 'flash counts (#)'
VIEWTIME 'flash view time '
MEDCH1 'median value of Tb at VIRs ch1 (K)'
MEDCH2 'median value of Tb at VIRs ch2 (K)'
MEDCH3 'median value of Tb at VIRs ch3 (K)'
MEDREFCH1 'median value of reflectance at 0.63 micron for ch4 < 210K'
MEDREFCH2 'median value of reflectance at 1.6 micron for ch4 <210K'
MEDREFCH3 'median value of reflectance at 3.75 micron for ch4 <210K'
MEDREF210235CH1 'median value of reflectance at 0.63 micron for ch4 >210 and '...
MEDREF210235CH2 'median value of reflectance at 1.6 micron for ch4 >210 and <235K'
MEDREF210235CH3 'median value of reflectance at 3.75 micron for ch4 >210 and < 235K'
MEDCH4 'median value of Tb at VIRs ch4 (K)'
MEDCH5 'median value of Tb at VIRs ch5 (K)'
MED20DBZ10KMCH1 'median value of 10 km 20dbz pixels Tb at VIRs ch1 (K)'
MED20DBZ10KMCH2 'median value of 10 km 20dbz pixels Tb at VIRs ch2 (K)'
MED20DBZ10KMCH3 'median value of 10 km 20dbz pixels Tb at VIRs ch3 (K)'
MEDREF20DBZ10KMCH1 'median of 10 km 20dbz pixels ch1 reflectance for ch4<210 K'
MEDREF20DBZ10KMCH2 'median of 10 km 20dbz pixels ch2 reflectance for ch4<210 K'
MEDREF20DBZ10KMCH3 'median of 10 km 20dbz pixels ch3 reflectance for ch4<210 K'
MED20DBZ10KMCH4 'median value of 10 km 20dbz pixels Tb at VIRs ch4 (K)'
MED20DBZ10KMCH5 'median value of 10 km 20dbz pixels Tb at VIRs ch5 (K)'
MED20DBZ14KMCH1 'median value of 14 km 20dbz pixels Tb at VIRs ch1 (K)'
MED20DBZ14KMCH2 'median value of 14 km 20dbz pixels Tb at VIRs ch2 (K)'
MED20DBZ14KMCH3 'median value of 14 km 20dbz pixels Tb at VIRs ch3 (K)'
MEDREF20DBZ14KMCH1 'median of 14 km 20dbz pixels ch1 reflectance for ch4<210 K'
MEDREF20DBZ14KMCH2 'median of 14 km 20dbz pixels ch2 reflectance for ch4<210 K'
MEDREF20DBZ14KMCH3 'median of 14 km 20dbz pixels ch3 reflectance for ch4<210 K'
MED20DBZ14KMCH4 'median value of 14 km 20dbz pixels Tb at VIRs ch4 (K)'
MED20DBZ14KMCH5 'median value of 14 km 20dbz pixels Tb at VIRs ch5 (K)'

- Parameters in TMI swath features (TTPF)

ORBIT 'Orbit number'
GRPNUM 'feature number in the orbit data'
BOOST '0: before boost, 1: after boost'
LAT 'Geographical center latitude '
LON 'Geographical center longitude '
ALTRK 'number of pixels along track'
ACTRK 'number of pixels across track'

ELEV 'ground elevation (km)'
YEAR 'UTC year'
MONTH 'UTC month'
DAY 'UTC day'
HOUR 'UTC hour'
NPIXELS_PR 'number of pr pixels inside feature'
NPIXELS_20DBZ 'number of pr pixels inside feature with 20dBZ'
NPIXELS_TMI 'number of tmi pixels inside feature'
NRAINPIXELS_2A25 'number of pr raining pixels'
NRAINPIXELS_2A12 'number of tmi raining pixels'
VOLRAIN_2A25 'volumetric rain from 2a25 (mm/hr*km^2)'
VOLRAIN_20DBZ 'volumetric rain from 2a25 for 20dBZ pixels (mm/hr*km^2)'
VOLRAIN_2A12 'volumetric rain from 2a12 (mm/hr*km^2)'
MIN85PCT 'minimum 85GHz PCT (K)'
MIN37PCT 'minimum 37GHz PCT (K)'
NLT275 'number of TMI pixels with 85GHz PCT < 275 K'
NLT250 'number of TMI pixels with 85GHz PCT < 250 K'
NLT225 'number of TMI pixels with 85GHz PCT < 225 K'
NLT200 'number of TMI pixels with 85GHz PCT < 200 K'
NLT175 'number of TMI pixels with 85GHz PCT < 175 K'
NLT150 'number of TMI pixels with 85GHz PCT < 150 K'
NLT125 'number of TMI pixels with 85GHz PCT < 125 K'
NLT100 'number of TMI pixels with 85GHz PCT < 100 K'
MINIR 'minimum 10.8 micron Tb (K)'
MAXNSZ 'maximum near surface reflectivity (dBZ)'
MAXHT 'maximum height of the feature from 2A23 storm height (km)'
MAXHT15 'maximum height reached by the feature with 15 dBZ (km)'
MAXHT20 'maximum height reached by the feature with 20 dBZ (km)'
MAXHT30 'maximum height reached by the feature with 30 dBZ (km)'
MAXHT40 'maximum height reached by the feature with 40 dBZ (km)'
NCH4LE210 'number of pr pixels with 10.8 um TB <= 210 K'
NCH4LE235 'number of pr pixels with 10.8 um TB <= 235 K'
NCH4LT273 'number of pr pixels with 10.8 um TB < 273 K'
NCH4GE273 'number of pr pixels with 10.8 um TB >= 273 K'
LANDOCEAN '0: over ocean 1:over land'
FLASHCOUNT 'flash counts inside TMI swath(#)'
VIEWTIME 'flash view time inside TMI swath'

- Parameters in LIS

ORBIT 'orbit number '
YEAR 'UTC year'
MONTH 'UTC month'
DAY 'UTC day'
HOUR 'UTC hour '
MINUTE 'UTC minute'
LON 'Longitude '
LAT 'Latitude '
NEARSURFRAIN '2A25 Near surface rain (mm/hr)'
NEARSURFZ 'Near surface reflectivity (dBZ)'
VIRSCH4 '10.8 micron Tb (K)'

VIRSCH3 '3.75 micron Tb (K)'
PCT85 '85 GHZ PCT (K)'
RAIN_2A12 '2A12 surface rain (mm/hr) '
STORMH '2A23 Storm height (m)'
RAINTYPE '2A23 rain type'
MAXHT15 'height of 15 dBZ (km)'
MAXHT20 'Height of 20 dBZ (km)'
MAXHT30 'Height of 30 dBZ (km)'
MAXHT40 'Height of 40 dBZ (km)'

- Parameters in 2NZ

ORBIT 'orbit number'
GRPNUM 'group number'
BOOST 'boost: 0 before, 1 after'
YEAR 'UTC year'
MONTH 'UTC month'
DAY 'UTC day'
HOUR 'UTC hour'
LON 'Longitude'
LAT 'Latitude'
NPIX 'number of pixels '
NPIX_20DBZ 'number of pixels with 20 dBZ'
NPIX_30DBZ 'number of pixels with 30 dBZ'
NPIX_40DBZ 'number of pixels with 40 dBZ'
NPIX_ANVIL 'number of anvil pixels'
NPIX_ANVIL_HORIZON 'number of anvil pixels at horizon'
NPIX_HORIZONTAL 'number of pixels at horizon'
NPIXRAIN_2A25 'number of 2a25 raining pixels at horizon'
NPIXRAIN_2A12 'number of 2a12 raining pixels at horizon'
NPIX_STRAT 'number of 2a25 stratiform raining pixels at horizon'
NPIX_CONV 'number of 2a25 convective raining pixels at horizon'
MIN85PCT 'minimum 85 GHz PCT (K)'
MIN37PCT 'minimum 37 GHz PCT (K)'
MINCH4 'minimum 10.8 micro Tb (K)'
MAXHT20 'maximum height of 20dBZ (km)'
MAXHT 'maximum storm height (km)'
MAXHT30 'maximum height of 30dBZ (km)'
MAXHT40 'maximum height of 40dBZ (km)'
MAXDBZ 'maximum reflectivity (dBZ)'
MEANZANVIL 'mean anvil center height (km)'
MEANZANVIL_TOP 'mean anvil top height (km)'
MEANZANVIL_BOT 'mean anvil bottom height (km)'
RAIN_2A25 '2A25 Volumetric rain (mm/hr*km^2)'
RAIN_2A12 '2A12 Volumetric rain (mm/hr*km^2)'
RAIN_STRAT '2A25 stratiform Volumetric rain (mm/hr*km^2)'
RAIN_CONV '2A25 convective Volumetric rain (mm/hr*km^2)'
MAXNSZ 'maximum near surface reflectivity (dBZ)'

3. Softwares to read the products

All the products are saved in "HDF4" format. An IDL program "read_pf_level1_hdf.pro" is used to read the level-1 orbital data. Another IDL program "hdf_2_struct.pro" is provided to read all the level-2 and level-3 products.

Example:

```
IDL> hdf_2_struct,'pf_200006.HDF',f,labels=d
IDL> help,f,/str
        ...     show the data structure
IDL> help,d,/str
        ...     The description of the parameters will be shown
```

The complete source code of the reading program "hdf_2_struct.pro" is listed following:

```
 pro hdf_2_struct,filename,fdata,tag_label=tag_label,labels=labels
; GENERIC PROGRAM TO READ SDS ARRAYS FROM AN HDF FILE
; ALL OF THE ARRAYS ARE PUT INTO AN OUTPUT STRUCTURE, fdata

; KEYWORD tag_label: SET THIS IN ORDER FOR THE OUTPUT
;                 STRUCTURE TO USE THE SDS LABEL WHEN
;                 CREATING STRUCTURE TAG NAMES.
;                 DEFAULT IS TO USE SDS NAME.
; Modified by Chuntao in 2006 to restore structure from tagnames with "__"
;
fdata = {filename: filename}
labels= {filename:filename}
sdsfileid = hdf_sd_start(filename,/read)
hdf_sd_fileinfo,sdsfileid,numsds,ngatt
for i = 0, numsds - 1 do begin
  sds_id = hdf_sd_select(sdsfileid, i )
  hdf_sd_getinfo, sds_id, name = na, ndim = nd,type= typ, label=label
  hdf_sd_getdata, sds_id, data
  if keyword_set(tag_label) and strlen(label) gt 0 then na=label
;
  if(strpos(na,'__') lt 0) then begin
    fdata=create_struct(fdata, na, data)
    labels=create_struct(labels, na, label)
    hdf_sd_endaccess,sds_id
  endif
  if(strpos(na,'__') gt 0) then begin
   sname=strmid(na,0,strpos(na,'__'))
   subname=strmid(na,strpos(na,'__')+2,strlen(na)-strpos(na,'__')-2)
;    print,na,'=',sname,'+',subname
    tmp=create_struct(subname,data)
    labeltmp=create_struct(subname,label)
    hdf_sd_endaccess,sds_id
    newsname=sname
    while (newsname eq sname and i+1 le numsds - 1) do begin
```

```
      sds_id = hdf_sd_select(sdsfileid, i+1)
      hdf_sd_getinfo, sds_id, name = na, ndim = nd,type= typ, label=label
      hdf_sd_getdata, sds_id, data
      if keyword_set(tag_label) and strlen(label) gt 0 then na=label
     if(strpos(na,'__') gt 0) then begin
      newsname=strmid(na,0,strpos(na,'__'))
      newsubname=strmid(na,strpos(na,'__')+2,strlen(na)-strpos(na,'__')-2)
      if(newsname eq sname) then begin
       tmp=create_struct(tmp,newsubname,data)
       labeltmp=create_struct(labeltmp,newsubname,label)
       i=i+1
      endif
     endif
     if(strpos(na,'__') lt 0) then newsname=''
      hdf_sd_endaccess,sds_id
     endwhile
    fdata=create_struct(fdata, sname,tmp)
    labels=create_struct(labels, sname,labeltmp)
  endif
endfor
hdf_sd_end,sdsfileid
end
```

4. Product sizes

All level-1 data are compressed to save space. Compressed HDF level-1 orbital file have size about 20M. It will grow up to 200 M after uncompressed. The level-2 products are combined monthly and by parameters from Dec 1997 to Jun 2006. The product sizes are summarized as following:

Product name	Size
Level-1 orbital compressed (total from Dec 97 – Jul 2006)	900 G
Level-2 orbital compressed (old definition, total from Dec 97 – Jul 2006)	9.6 G
1NZ orbital (total from Dec 97 – Jun 2006)	55 G
1Z06ORBIT orbital compressed (total from Dec 97 – Jun 2006)	75 G
1Z06PIX orbital (total from Dec 97 – Jun 2006)	5 G
2NZ06 orbital (total from Dec 97 – Jun 2006)	1.7 G
2Z06.C210F orbital (total from Dec 97 – Jun 2006)	2.7 G
2Z06.C235F orbital (total from Dec 97 – Jun 2006)	9.0 G
2Z06.C273F orbital (total from Dec 97 – Jun 2006)	28.8 G
2Z06.LIS orbital (total from Dec 97 – Jun 2006)	0.72 G
2Z06.PCTF orbital (total from Dec 97 – Jun 2006)	4.1 G
2Z06.RPF orbital (total from Dec 97 – Jun 2006)	29.4 G
2Z06.RPPF orbital (total from Dec 97 – Jun 2006)	26 G

2Z06.TPF orbital (total from Dec 97 – Jun 2006)	7.1 G
2Z06.TTPF orbital (total from Dec 97 – Jun 2006)	6.7 G
1ZPIX combined monthly (total from Dec 97 – Jun 2006)	22 M
2NZ06 combined monthly (total from Dec 97 – Jun 2006)	0.95G M
2Z06.C210F combined monthly (total from Dec 97 – Jun 2006)	0.98 G
2Z06.C235F combined monthly (total from Dec 97 – Jun 2006)	7.1 G
2Z06.C273F combined monthly (total from Dec 97 – Jun 2006)	27 G
2Z06.LIS combined monthly (total from Dec 97 – Jun 2006)	271 M
2Z06.PCTF combined monthly (total from Dec 97 – Jun 2006)	2.2 G
2Z06.TPF combined monthly (total from Dec 97 – Jun 2006)	5.2 G
2Z06.RPF combined monthly (total from Dec 97 – Jun 2006)	27.5 G
2Z06.RPPF combined monthly (total from Dec 97 – Jun 2006)	24.1 G
2Z06.TTPF combined monthly (total from Dec 97 – Jun 2006)	5.5 G
RPF 4 pixels added NCEP sounding (total from Dec 97 – Jun 2006)	14 G
RPPF 4 pixels added NCEP sounding (total from Dec 97 – Jun 2006)	13.5 G
C210F 4 pixels added NCEP sounding (total from Dec 97 – Jun 2006)	0.78 G
TPF 4 pixels added NCEP sounding (total from Dec 97 – Jun 2006)	7 G

Note: Some of the monthly combined data have sizes much smaller than the orbital data. This is due to the disk block wasting for very small size orbital files.

References

Cecil, D. J., E. J. Zipser, and S. W. Nesbitt, 2002: Reflectivity, ice scattering, and lightning characteristics of hurricane eyewalls and rainbands. Part I: Quantitative description. *Mon. Wea. Rev.*, **130**, 769-784.

Cecil, D. J., S. J. Goodman, D. J. Boccippio, E. J. Zipser, and S. W. Nesbitt, 2005: Three years of TRMM precipitation features. Part I: Radar, radiometric, and lightning characteristics. *Mon. Wea. Rev.*, **133**, 543-566.

Liu, C., E. J. Zipser, 2005: Global distribution of convection panetrating tropical tropopause, *J. Geophys. Res.*, dio:10.1029/2005JD006063

Liu, C., E. J. Zipser, and S. W. Nesbitt, 2006: Global distribution of tropical deep convection: Different perspectives using infrared and radar as the primary data source. *J. Climate*, accepted.

Mohr, K.I., and E.J. Zipser, 1996b: Mesoscale convective systems defined by their 85 GHz ice scattering signature: Size and intensity comparison over tropical oceans and continents. Mon. Wea. Rev., 124, 2417-2437

Mohr, K.I., J.S. Famiglietti, and E.J. Zipser, 1999: The contribution to tropical rainfall with respect to convective system type, size, and intensity estimated from the ice scattering signature. J. Appl. Meteor., 38, 596-606.

Nesbitt, S. W., E. J. Zipser, and D. J. Cecil, 2000: A census of precipitation features in the Tropics using TRMM: Radar, ice scattering, and lightning observations. *J. Climate*, **13**, 4087-4106.

Nesbitt, S. W., and E. J. Zipser, 2003: The diurnal cycle of rainfall and convective intensity according to

three years of TRMM measurements. *J. Climate*, **16**, 1456-1475.
Nesbitt, S. W., E. J. Zipser, and C. D. Kummerow, 2004: An examination of version 5 rainfall estimates from the TRMM microwave imager, precipitation radar, and rain gauges on global, regional and storm scales. *J. Appl. Meteor.*, **43**, 1016-1036.
Nesbitt, S. W., R. Cifelli, and S. A. Rutledge, 2006: Storm morphology and rainfall characteristics of TRMM precipitation features. *Mon. Wea. Rev.*, accepted.
Toracinta, E.R., and E. J. Zipser, 2001: Lightning and SSM/I ice scattering MCSs in the global tropics. J. Appl. Meteor., 40, 983-1002.
Toracinta E. R., D. J. Cecil, E. J. Zipser, and S. W. Nesbitt, 2002: Radar, passive microwave, and lightning characteristics of precipitating systems in the Tropics. *Mon. Wea. Rev.*, **130**, 802-824.
Zipser, E. J., D. J. Cecil, C. Liu, S. W. Nesbitt, and D. P. Yorty, 2006, Where are the most intense thunderstorms on earth? *Bull. Amer. Meteor. Soc.*, **87**, 1057-1071.