Progress in MOD09 Development

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What is MOD09 ?

Atmospheric Correction Algorithm: Spectral Reflectances

Moving from Top of Atmosphere Reflectance to Surface Reflectance by removing the atmospheric component of the signal.

- atmospheric correction

Why ?

Improved products for environmental management in Near Real Time - FireWatch, Fire Scar Mapping, Change Detection, Pastures From Space, Vegetation Parameters

New Products - Air quality

MOD09 Development Under IMAPP

- IMAPP used operationally by DLI for L0 to L1B processing.
- IMAPP has been free of operational problems
- Well supported by Univ. Wisconsin-Madison SSEC
- Strong links to IMAPP development team through WASTAC and Curtin Uni

International MODIS/AIRS Processing Package

Goal:

Continue to provide freely available software for processing EOS direct broadcast data that is easy to install and operate.

What's New in 2003

- AIRS/AMSU/HSB Level 1 First Release (with JPL)
- MODIS Level 1 Update (Geolocation, Calibration)
- Updated MODIS Level 2 Science Products

What's Coming in 2004

- AMSR-E Level 1 First Release (with RSS)
- AIRS/AMSU/HSB Level 2 Science Products (with JPL)
- Additional MODIS Level 2 Science Products

IMAPP is funded until 2006

International MODIS/AIRS Processing Package

(from BAMS, Feb 2004, Huang et al.)

TABLE 1. Summary of current and planned IMAPP MODIS and AIRS product algorithms.

	MODIS	AIRS/AMSU/HSB
Current	Geo-location/navigation Cloud mask Cloud phase Cloud-top property Clear T/Q sounding Total precipitable water	Geo-location/navigation
Planned	Cloud particle size Cloud optical thickness Aerosol optical thickness Surface reflectance Sea surface temperature Snow detection Sea ice detection Scene classification (Clouds and land surface)	Clear/cloudy T/Q sounding Cloud detection Cloud clearing Cloud height/emissivity Surface skin temperature Cloud liquid water AMSU precipitation estimate
	MODIS/AIRS collocation	

MODIS Processing

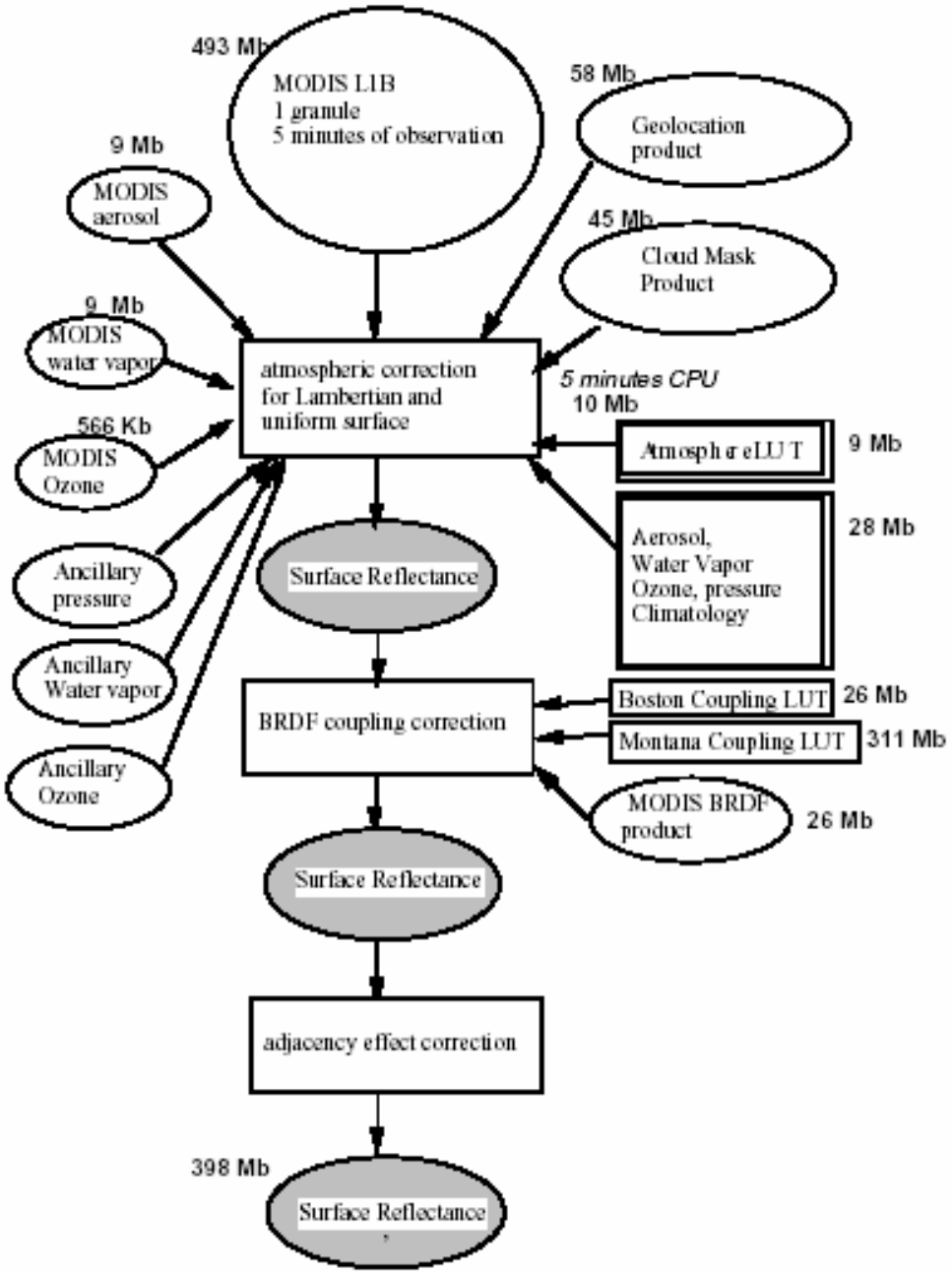
New MODIS Level 2 Products in 2004:

- Aerosol Optical Depth (MOD04)
- Land Surface Reflectance (MOD09) *WASTAC*
- Sea Surface Temperature (MOD28): *Beta Ready*
- Cloud Optical Properties (MOD06_OD)
- Snow and Sea Ice Detection (MOD10, MOD29)
- Scene Classification (Clouds and Land Surface)

New MODIS Utilities:

- Thermal Infrared Destriping
- Guide to converting IMAPP L1B format to DAAC format

MOD09 Algorithm



Taken from MOD090 ATBD
E.Vermote and A. Vermeulen (1999)

Required Input Data

MODIS Level 1B radiance files at 1000, 500, and 250 meter resolution (Terra or Aqua)

and

MODIS Level 1B geolocation file at 1000 meter resolution

IMAPP or DAAC L1B format may be used!

PLUS

8 NCEP gridded WV and Ps
1 or 2 NCEP gridded ozone

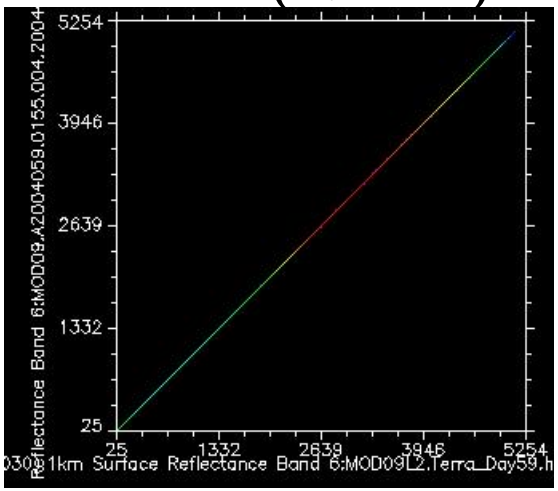
More Required Input Data

For each process, the following LUTs must be available:

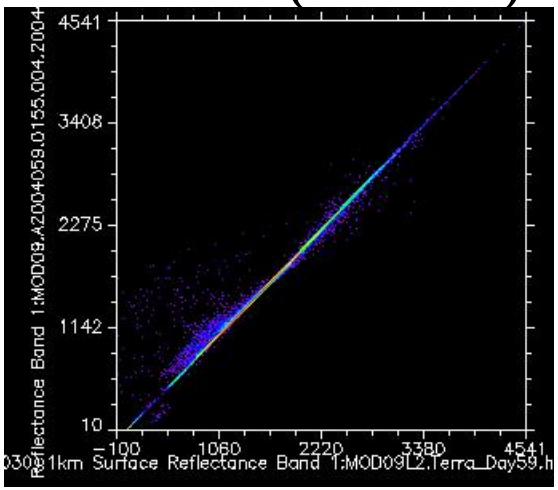
PCF LUN	File Name
209501	ANC_OORT_WV.CLIMATOLOGY
209504	1_km_z8.hdf
209505	landcov_8km.v1
209554	toms_10yr.anc
209520	Con_0664.V2.01
209521	Con_0875.V2.01
209522	Con_0469.V2.01
209523	Con_0547.V2.01
209524	Con_1240.V2.01
209525	Con_1640.V2.01
209526	Con_2142.V2.01
209527	AeroTrans.0664.V2.1
209528	AeroTrans.0875.V2.1
209529	AeroTrans.0469.V2.1
209530	AeroTrans.0547.V2.1
209531	AeroTrans.1240.V2.1
209532	AeroTrans.1640.V2.1
209533	AeroTrans.2142.V2.1
209534	SraTable.V2.01
209563	VALID_COORDS
209570	new_modis_pol_corr4.hdf
209571	rayleigh_modis_412_iqu2.hdf

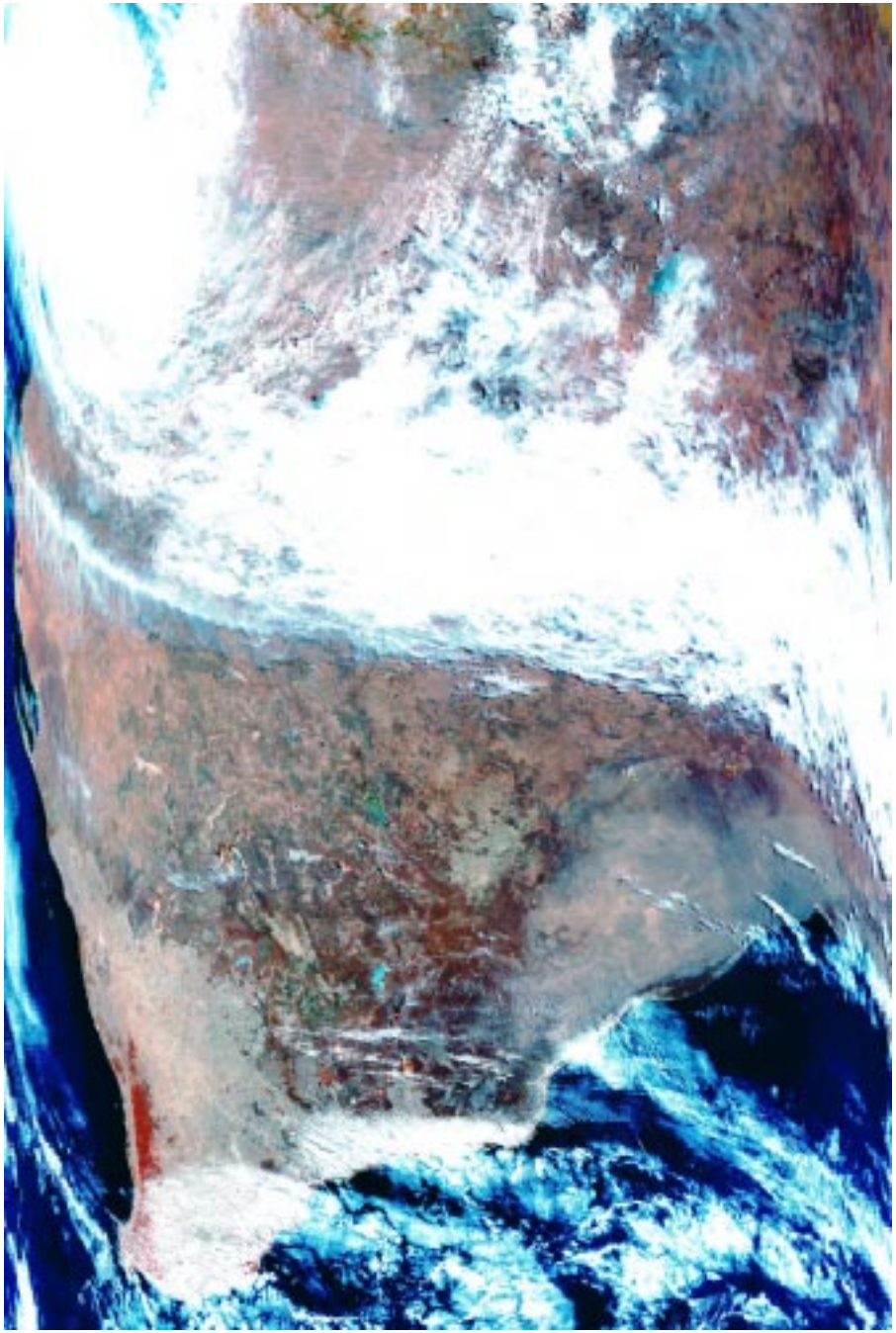
Local implementation of MOD09

Band 6 (1.6 um)



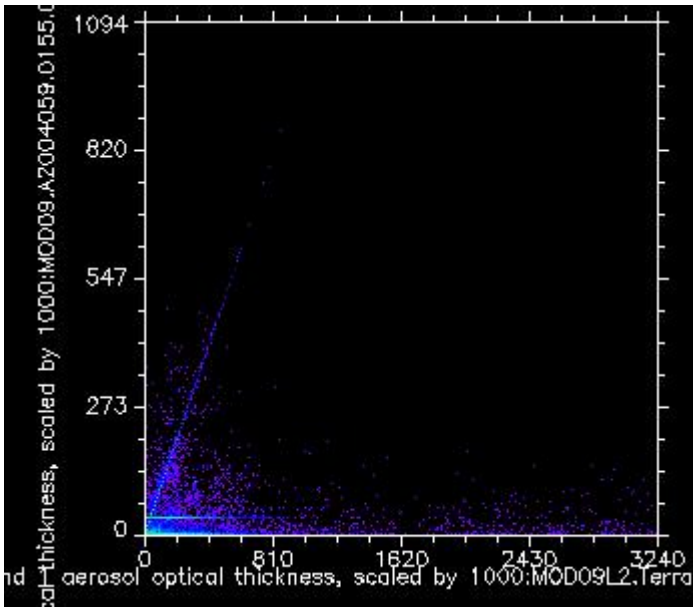
Band 1 (650 nm)



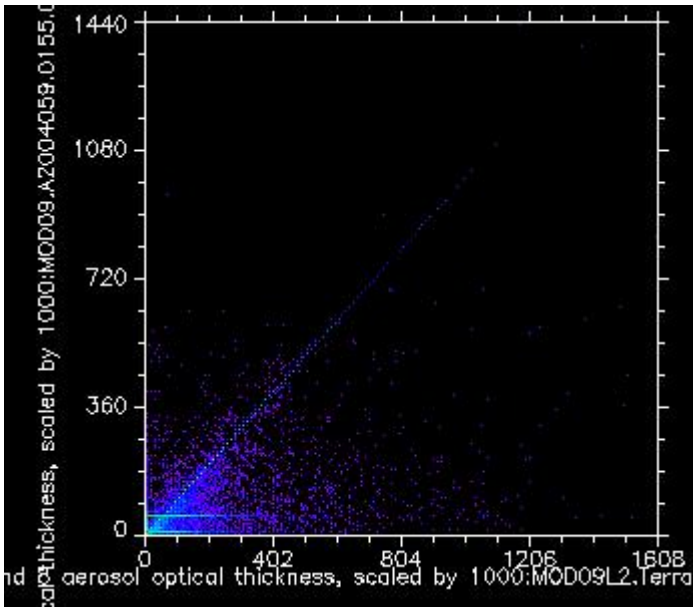


AOD discrepancies

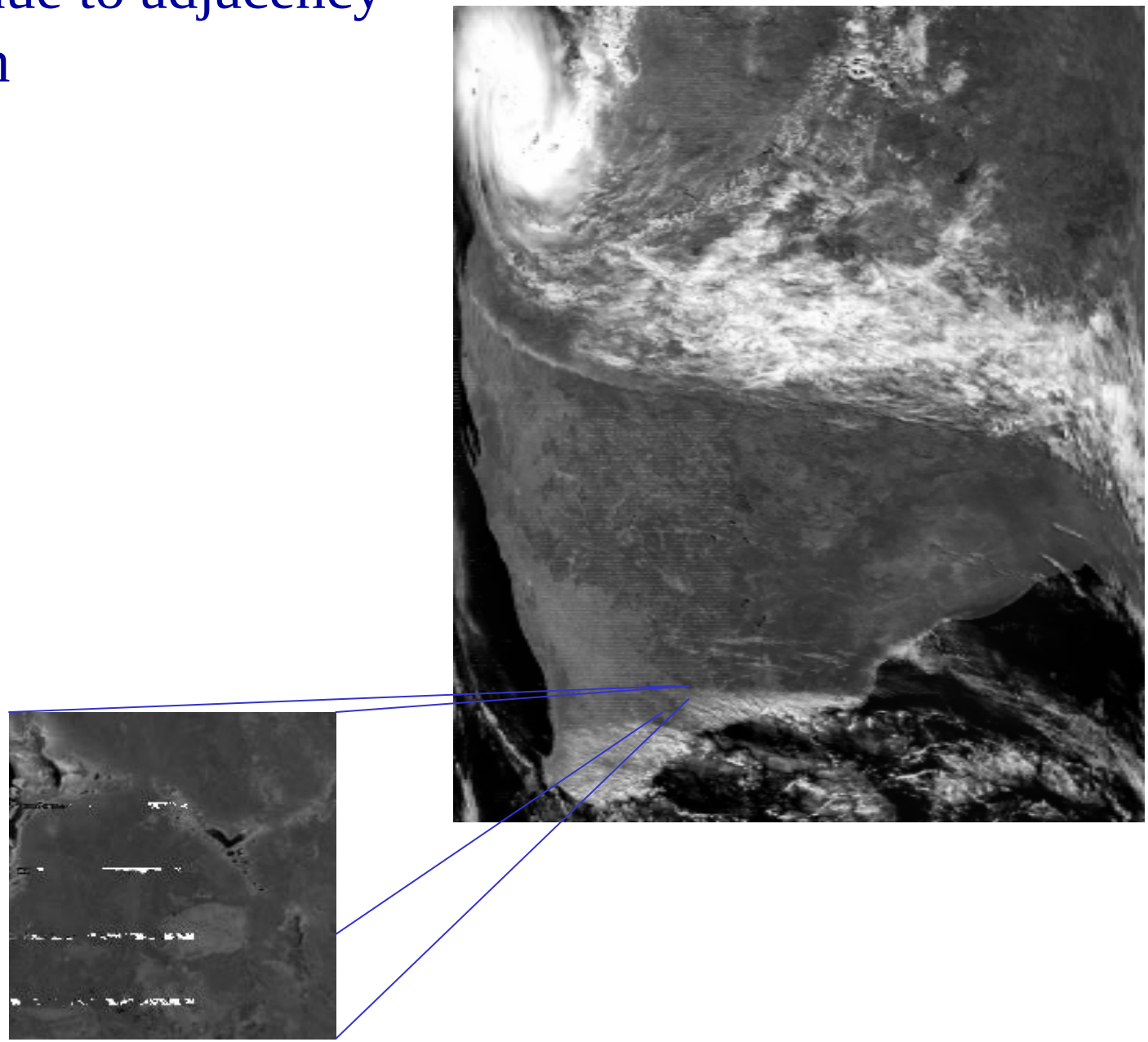
Band 1



Band 8

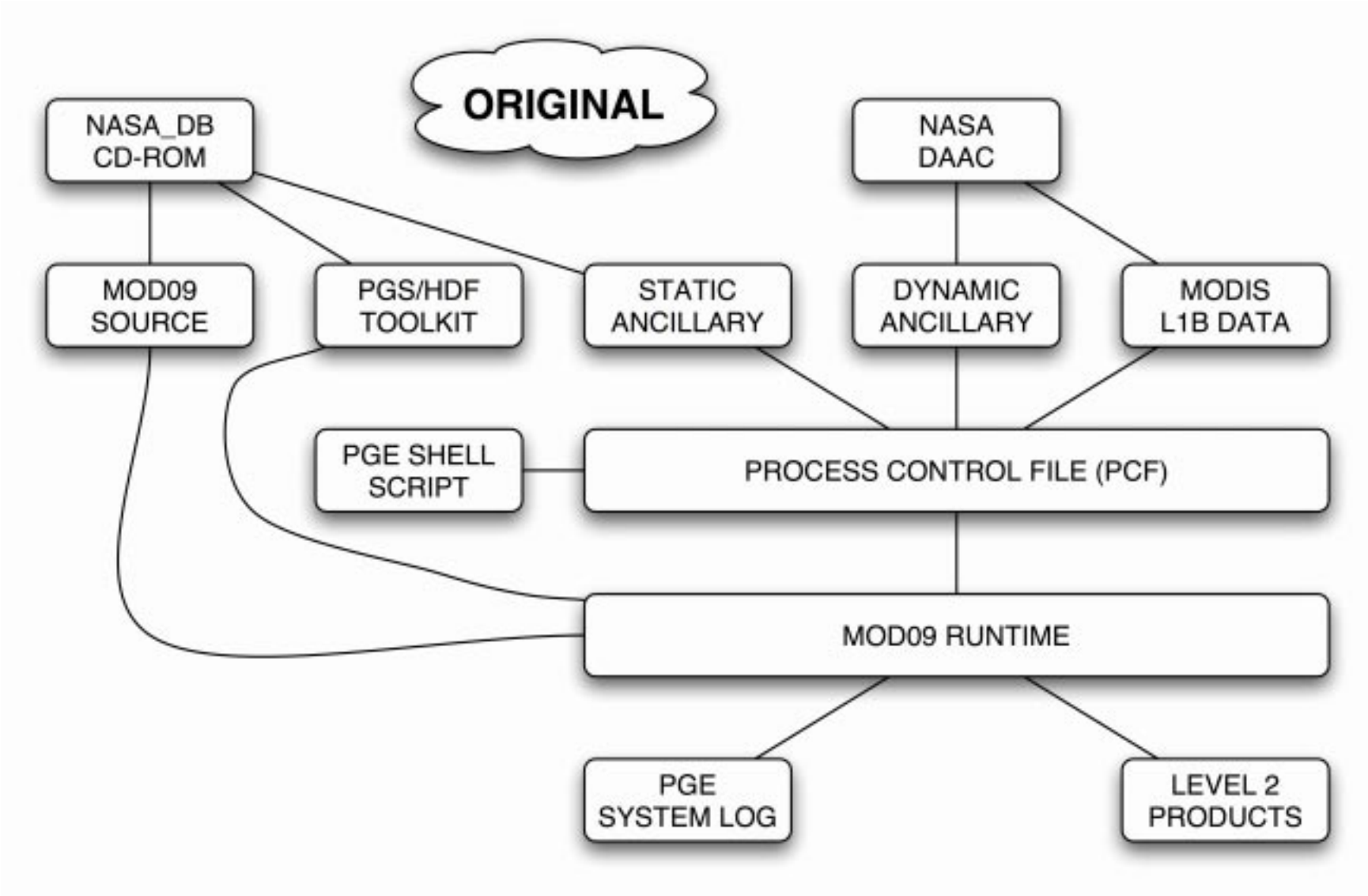


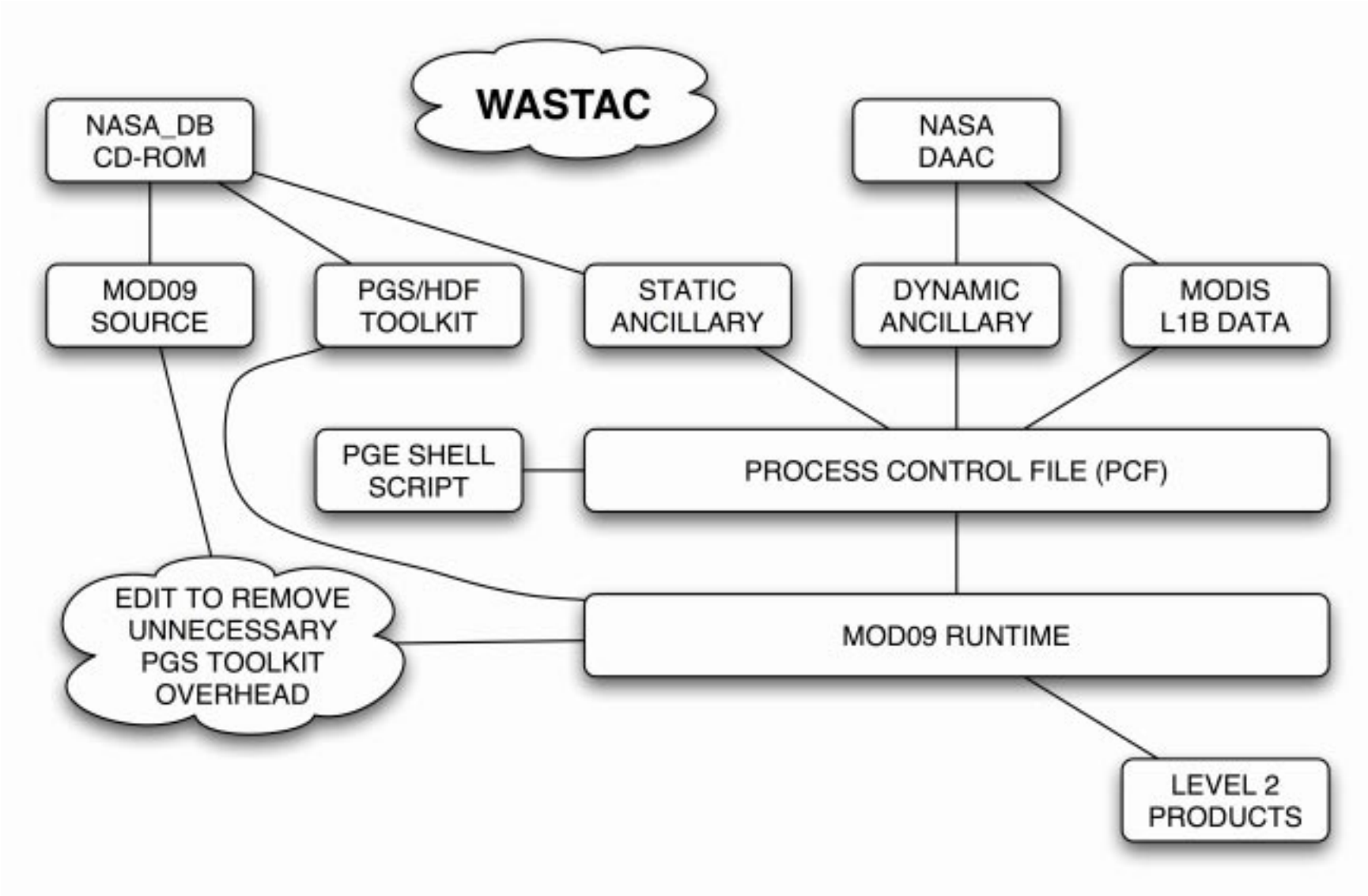
Striping due to adjacency correction

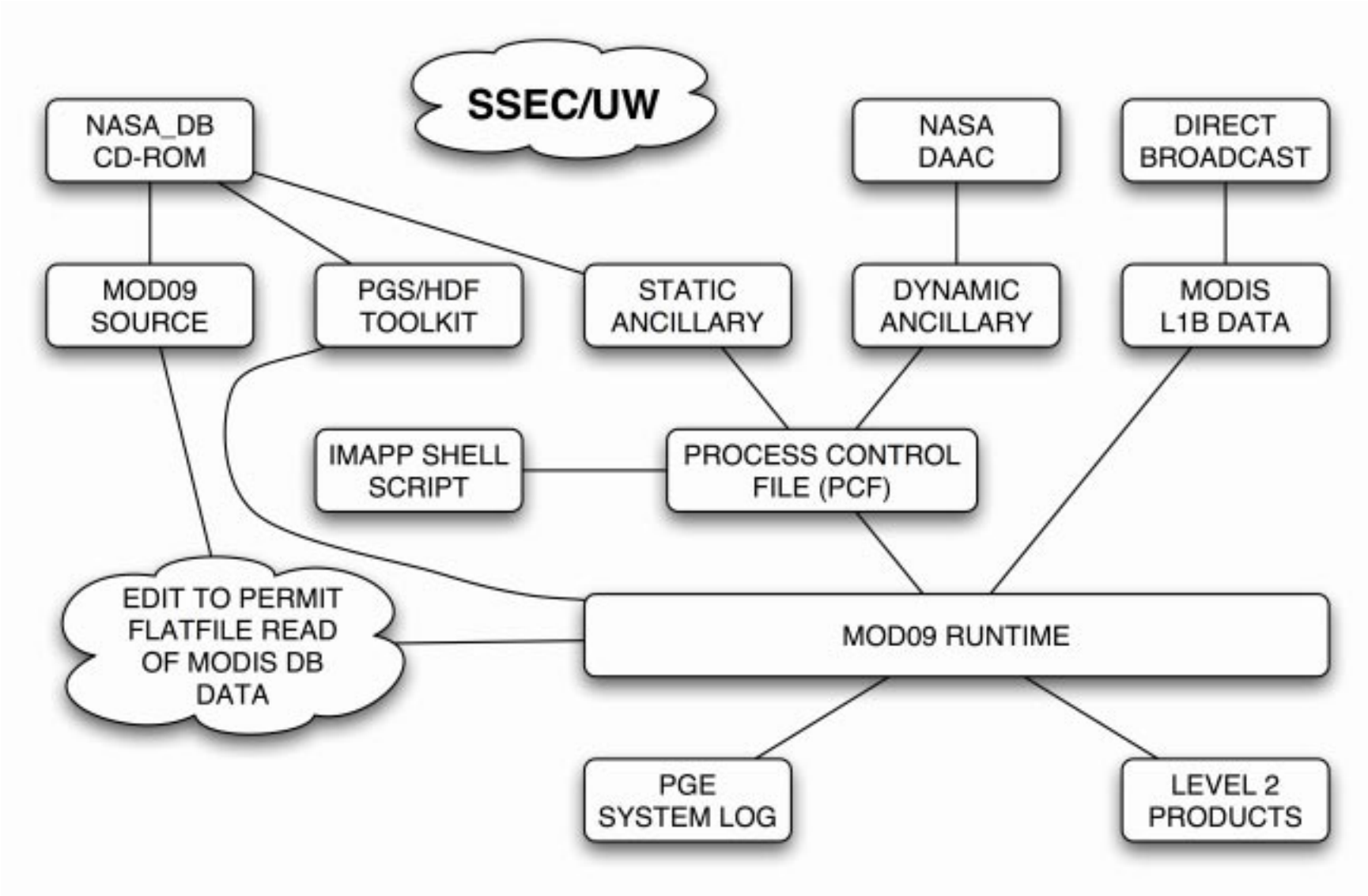


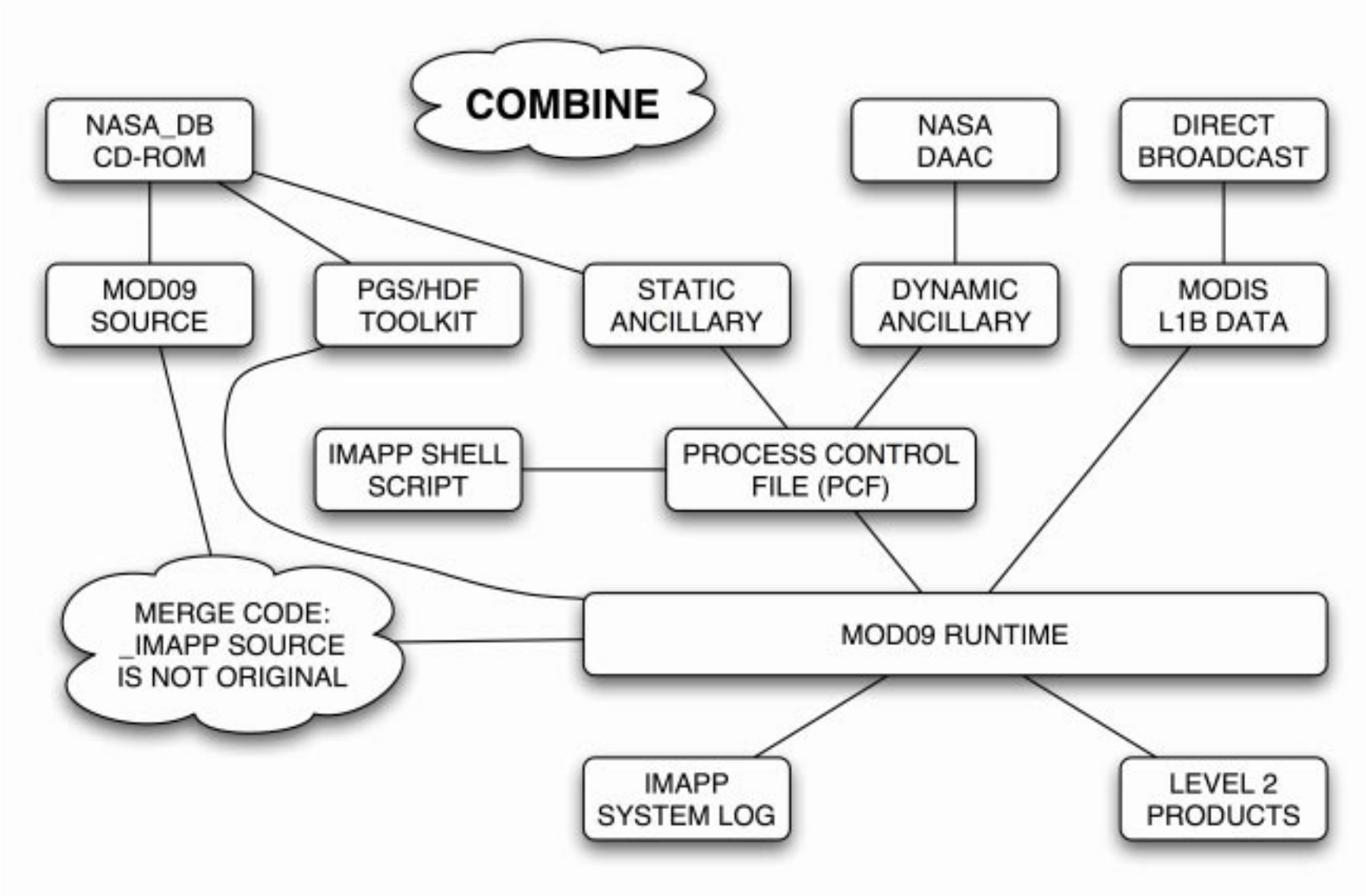
Rationale For MOD09 Development Route

• Given that the IMAPP route has been chosen for the development of an operational Direct Broadcast (DB) version of the MODIS surface reflectance algorithm (MOD09), modification of the existing NASA DB code requires a large amount of work, particularly on the I/O which is bound to PGS library routines in the NASA DB code.
• A major concern has always been the amount of ongoing maintenance of the IMAPP code which will be needed as updates to the NASA DB code occur from the DAAC.
• We have taken the view that ongoing maintenance is inevitable, although we are unable to guess how frequently the DAAC will issue updates to its code to the DB community.
• Given that maintenance will be ongoing, we believe the best approach is to replace existing I/O with equivalent IMAPP based routines. We believe that for the MODIS satellite data inputs, this can be done on a scanline by scanline basis in the routines found in source file modis_srefl.c
• We are presently writing (or converting existing) IMAPP modules which will provide the file I/O support. We are also intercepting the PGS_SMF calls and redirecting to the IMAPP messaging routine.
• We believe this is the 'simplest' approach and allows the science code 'structure' of the existing NASA code to remain relatively intact. In some respects this will benefit future modifications to the code such as updates to the NASA DB science code issued by the DAAC, but may also take longer to modify such updates to work with the revised I/O structure.
• However, as noted earlier, ongoing maintenance of the IMAPP DB code is inevitable, and as such, our chosen approach does not add much extra work, but does have the benefit of a shorter lead time to an operational version of MOD09 under the IMAPP processing structure.
• The approach we have decided to take will also facilitate the inclusion of our own science modules at later stages of the development process, which will become an integral part of the overall project as we seek to include localized version of global algorithms for example. The ability to do this though will come from a greater understanding of the NASA DB code structure rather than from the simple IMAPP wrapper used for the SST code.


ORIGINAL
NASA_DB
CD-ROM
NASA
DAAC
MOD09
SOURCE
PGS/HDF
TOOLKIT
STATIC
ANCILLARY
DYNAMIC
ANCILLARY
MODIS
L1B DATA
PGE SHELL
SCRIPT
PROCESS CONTROL FILE (PCF)
MOD09 RUNTIME
PGE
SYSTEM LOG
LEVEL 2
PRODUCTS


WASTAC
NASA_DB
CD-ROM
NASA
DAAC
MOD09
SOURCE
PGS/HDF
TOOLKIT
STATIC
ANCILLARY
DYNAMIC
ANCILLARY
MODIS
L1B DATA
PGE SHELL
SCRIPT
PROCESS CONTROL FILE (PCF)
EDIT TO REMOVE
UNNECESSARY
PGS TOOLKIT
OVERHEAD
MOD09 RUNTIME
LEVEL 2
PRODUCTS


SSEC/UW
NASA_DB
CD-ROM
NASA
DAAC
DIRECT
BROADCAST
MOD09
SOURCE
PGS/HDF
TOOLKIT
STATIC
ANCILLARY
DYNAMIC
ANCILLARY
MODIS
L1B DATA
IMAPP SHELL
SCRIPT
PROCESS CONTROL
FILE (PCF)
EDIT TO PERMIT
FLATFILE READ
OF MODIS DB
DATA
MOD09 RUNTIME
PGE
SYSTEM LOG
LEVEL 2
PRODUCTS


COMBINE
NASA_DB
CD-ROM
NASA
DAAC
DIRECT
BROADCAST
MOD09
SOURCE
PGS/HDF
TOOLKIT
STATIC
ANCILLARY
DYNAMIC
ANCILLARY
MODIS
L1B DATA
IMAPP SHELL
SCRIPT
PROCESS CONTROL
FILE (PCF)
MERGE CODE:
_IMAPP SOURCE
IS NOT ORIGINAL
MOD09 RUNTIME
IMAPP
SYSTEM LOG
LEVEL 2
PRODUCTS

IMAPP/SST as template

```
[davies@dlimodis src]$ pwd

/home/davies/IMAPP/MODIS_SREFL/srefl/src


[davies@dlimodis src]$ ls

big_endian.f                db_mod28_Get_Metadata.f       makefile
bright_m.f                  db_mod28_get_rp.f             makefile.debug
brite_m.f                   db_mod28_initialize_output.f  message.f
db_mod09_file_close.f       db_mod28_write_products.f     modis_bright.f
db_mod09_file_open.f        db_read_flat_file.f           modis_srefl.csh
db_mod09_file_open.o        db_write_flat_file.f          srefl.cfg
db_mod09_get_data.f         hdrgetkeydbl.f                sst.f
db_mod28_chk_input.f        hdrgetkeyint.f                strcompress.f
db_mod28_compute_products.f hdrgetkeystr.f                string_length.f


[davies@dlimodis src]$ ls ../include

db_mod09uw_data.inc   fundamental_constants.inc  srefl.inc
db_mod09uw_debug.inc  platform_name.inc
```

Main I/O routines

in main()

```
scan_status=get_a_scan_imapp(&allfiles, &allgeoloc, iline_rd_1km,
                             cloud_mask_valid_pieces, lhdf_cmask,
                             bands, locator500, locator250, &modwv,
                             daynightflag, smchFT, smchP, smchEX, &clouds, 2,
                             &commands, &modozone, nline_1km, processversion,
                             metadata[BUILDBUFFER], &scalefac, foundlines_1km,
                             centerpix, &modis_cloud_avail[1]);
```

in get_a_scan_imapp()

```
    int l1b_1km_unit, l1b_hkm_unit, l1b_qkm_unit, geo_1km_unit, debug_unit,
    mod09_unit, mod09_hdr_unit;
    char *imapp_config_file="srefl.cfg";

    db_mod09_file_open(imapp_config_file,&l1b_1km_neles,&l1b_1km_lun,&l1b_hkm_lun,
                              &l1b_qkm_lun,&geo_1km_lun,&mod09_lun,&hdr_lun,&debug_lun);
```

write_scan() ---> write_scan_imapp()

WriteAot() ---> WriteAot_imapp()

PGS toolkit

```
Setting environment flags that control toolkit compilation
----------------------------------------------------------

The -pg flag turns on profiler output when main program is
executed at which time output is written to file gmon.out

[davies@dlimodis src]$ env | grep FLAG
ADD_IFLAGS=
F77FLAGS=-g -fno-second-underscore
CFLAGS=-g -pg
CFHFLAGS=-g -Df2cFortran
ADD_LFLAGS=
[davies@dlimodis src]$ export CFLAGS="-g -pg"
[davies@dlimodis src]$ export CFHFLAGS="-g -Df2cFortran -pg"
[davies@dlimodis src]$ export F77FLAGS="-g -fno-second-underscore -pg"


Making the PGS toolkit
----------------------

[davies@dlimodis src]$ pwd
/home/davies/NASA_DB/src/toolkit/v5/src

[davies@dlimodis src]$ ls
AA   CSC  DEM          EPH  IO        makefile.cpp_ofunix  MET  SMF  TSF
CBP  CUC  ecs.options  GCT  makefile  MEM                  PC   TD

[davies@dlimodis src]$ make cleano

[davies@dlimodis src]$ make
```

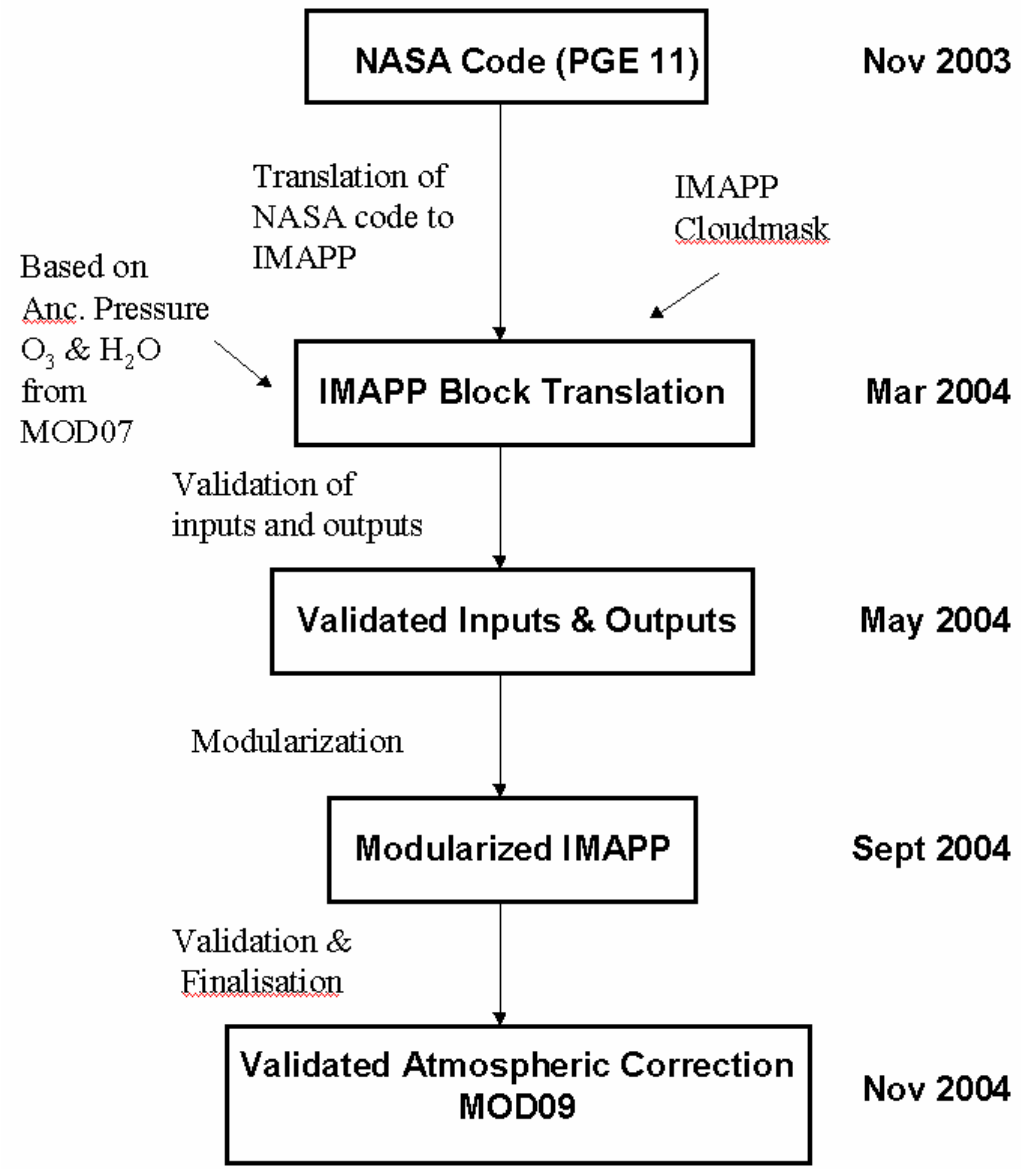
Trace

```
main
   -   bfunk1
   -   modsmf
   -   AllocMem
   -   get_params
   -   -   lun_description_lut
   -   set_processing_flags
   -   AllocMem
   -   CAllocMem
   -   bfunk2
   -   modsmf
   -   ECSmet_init
   -   -   AllocMem
   -   -   CAllocMem
   -   -   AllocMem
   -   get_L1B_format
   -   -   readECSmetadata_string
   -   -   format_to_int32
   -   modsmf
   -   get_ESDT_names
   -   init_height_pressure
   -   getECSmetadata
   -   -   readECSmetadata_string
   -   -   modsmf
   -   -   readECSmetadata_string
   -   -   readECSmetadata_numerical
.
.
.
```

Preliminary conclusions

- MOD09 as distributed comprises over 55,000 lines of code.
- Converting to IMAPP format is not a trivial task.
- Continuing to remove calls to the PGS library as we believe there is much overhead involved here which is unnecessary for DB users.
- Continuing to migrate code to read MODIS data staged in the IMAPP manner.
- Intermediate goal is a system which has same IMAPP front-end but with additional logic in script to stage ancillary data via PCF file - a merge of the two code branches above.
- Are we on track?

Timeline for MOD09 Development



Future Requirements

The Need for Ancillary Data

Currently the MOD09 code needs GDAS, TOVS and surface pressure inputs.

MODIS-derived H_2O and O_3 products will be integrated but the need for surface pressure data will remain.

The Need for Validation Data

Data sources for the validation of;

1) input MODIS-derived H_2O and O_3 products
2) surface reflectance and aerosol optical depth products