

Atmospheric Correction

With

ATCOR

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ATCOR Exercises

Contents :

Top level menu

Pull-Down Modules

ATCOR flat terrain

Example imagery: Landsat, SPOT; airborne: HyMap

ATCOR rugged terrain

slope, aspect, skyview, topographic shadow

Example imagery : Landsat-7 ETM; airborne: HyMap

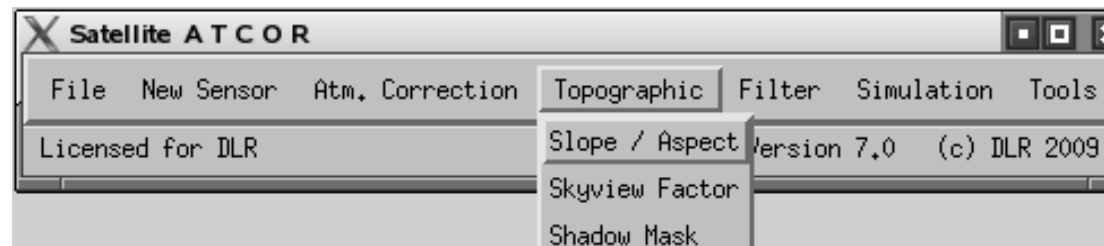
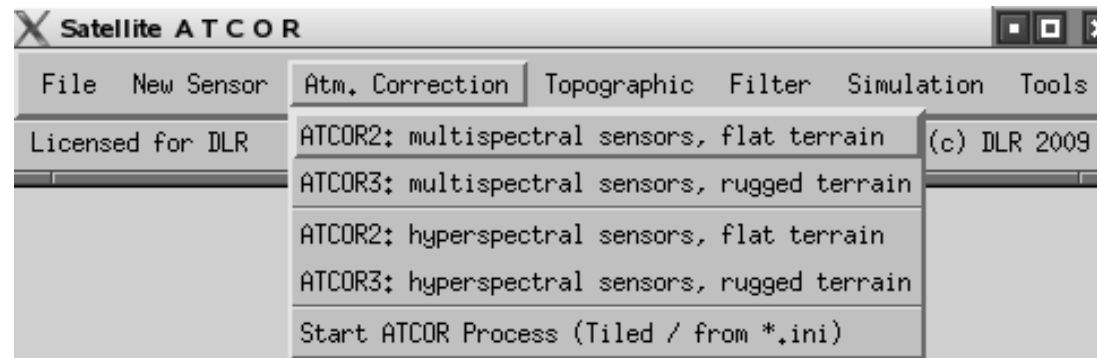
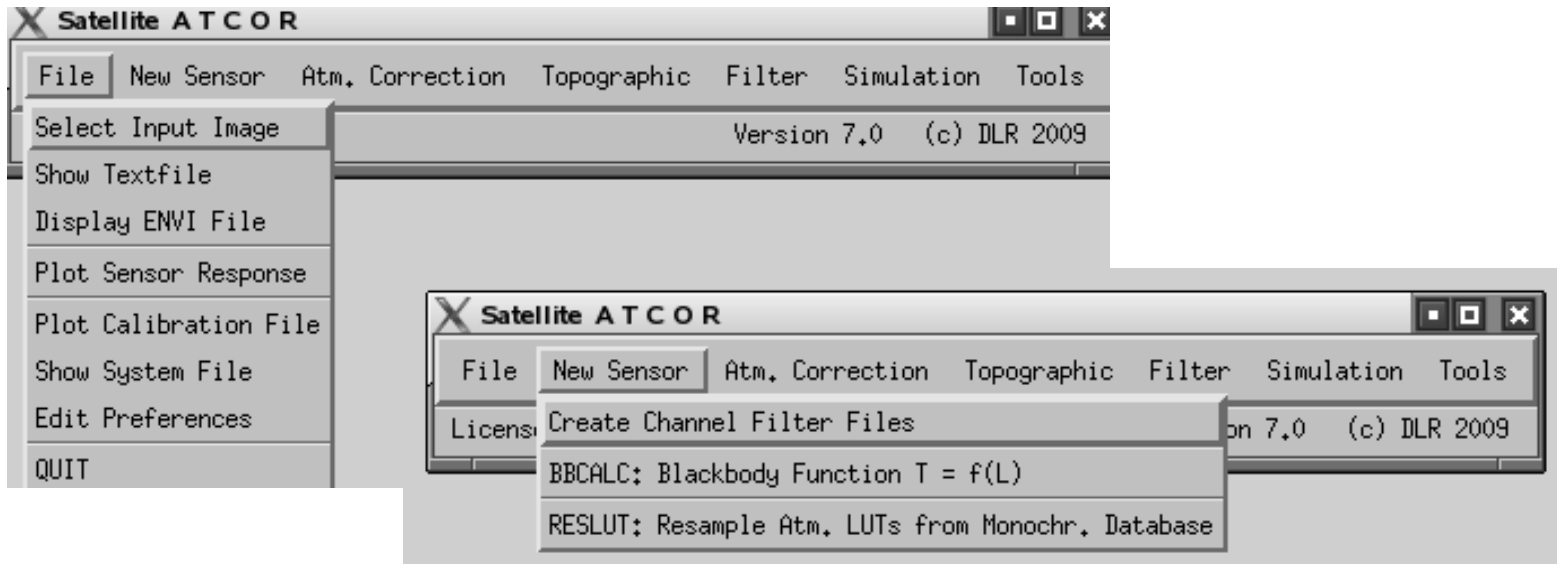
ATCOR hyperspectral (definition of a new sensor)

Example imagery: Hyperion or CHRIS/Proba

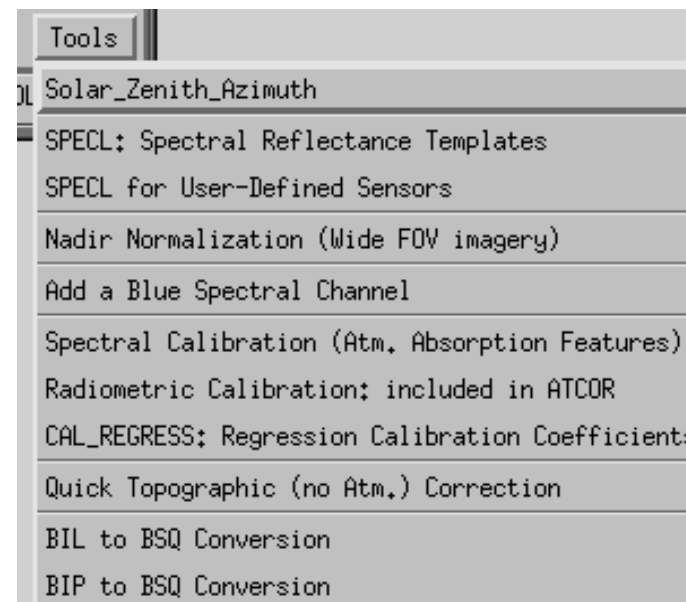
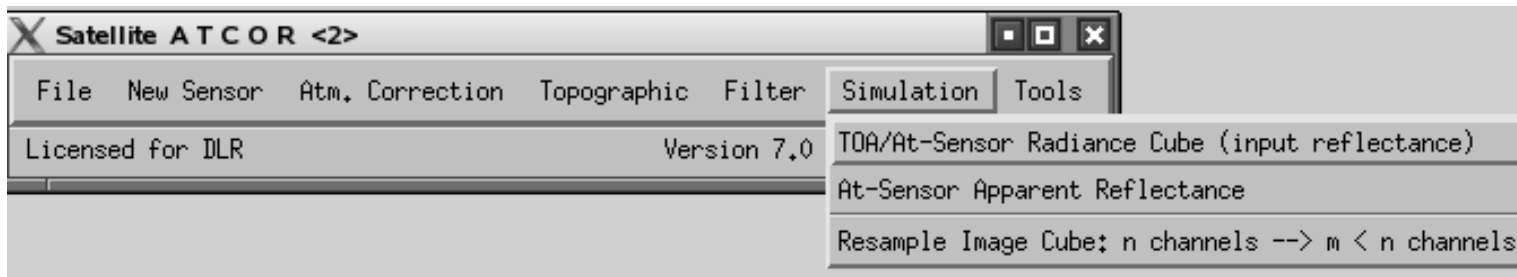
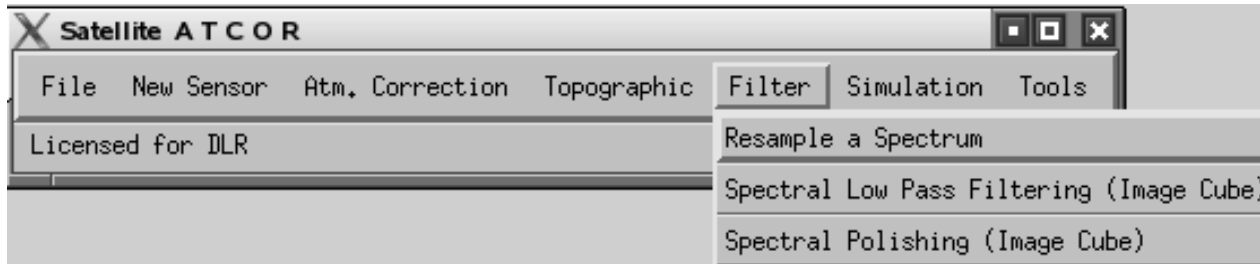
Automatic spectral classification (reflectance image)

Simulation of MS scene from HS scene (spectral resampling)

Top level & pull-down menus (1)



Top level & pull-down menus (2)





ATCOR Main Menu

ATCOR2: Satellite Sensors, Flat Terrain Imagery (BETA Version 7.0.0, 2009)

INPUT IMAGE FILE: Date (dd/mm/year) 20/08/1989

OUTPUT IMAGE FILE: OVERWRITE

Scale Factor =

Selected SENSOR = Pixel size [m] =

CALIBRATION FILE:

ATMOSPHERIC FILE: ATM. FILE for thermal band(s):

Adjacency range [km] = Zones =

Visibility [km] = Solar zenith [degree] = Ground elevation [km] =

MESSAGES:
Output file already exists; change name or press OVERWRITE !

ATCOR Processing Options

Blocked Options Are Not Available For The Selected Sensor
(Might also apply for a reduced set of bands)
(Either Haze or Cirrus Removal, not both)

Variable Visibility (aerosol optical thickness)	<input type="checkbox"/> Yes	<input type="checkbox"/> No
Variable Water Vapor	<input type="checkbox"/> Yes	<input type="checkbox"/> No
Haze Removal	<input type="checkbox"/> Yes	<input type="checkbox"/> No
Shadow Removal (Clouds/Buildings)	<input type="checkbox"/> Yes	<input type="checkbox"/> No
Value Added Products	<input type="checkbox"/> Yes	<input type="checkbox"/> No
Load Visibility Index Map	<input type="checkbox"/> Yes	<input type="checkbox"/> No
Cirrus Removal	<input type="checkbox"/> Yes	<input type="checkbox"/> No

Specify DEM Related Files

Update DEM Path Path =

Mandatory Files

Elevation = DEM height (z) unit : [m] [dm] [cm]

Slope [degree] =

Aspect [degree] =

Optional Files

Sky View Factor [%] =

Cast Shadow [0,1] =

Use pre-calculated shadow file (if existing)

Shadow map calculated "on the fly", requires more memory

--> Check "tm_blforest_ilu,bsq" for possible DEM-related artifacts.

Message

Cancel OK

Potential problem with elevation data : often coded as 16 bit integer

Height steps in integer may cause horizontal/vertical stripes in slope and aspect maps if standard topographic processing (kernel size 3×3 pixels) is employed.

Steps to improve slope / aspect maps:

1. float(elevation)
2. calculate slope / aspect with low pass filter (5×5 pixels)
3. resize factor 4 larger (bilinear)
4. low pass filter 7×7 pixels
5. resize factor 0.25 (nearest neighbor) to obtain original size

Potential problem with elevation data : often coded as 16 bit integer

Height steps in integer may cause horizontal/vertical stripes in slope and aspect maps if standard topographic processing (kernel size 3×3 pixels) is employed.



Slope map from SRTM elevation data
Standard processing with kernel 3×3 pixels



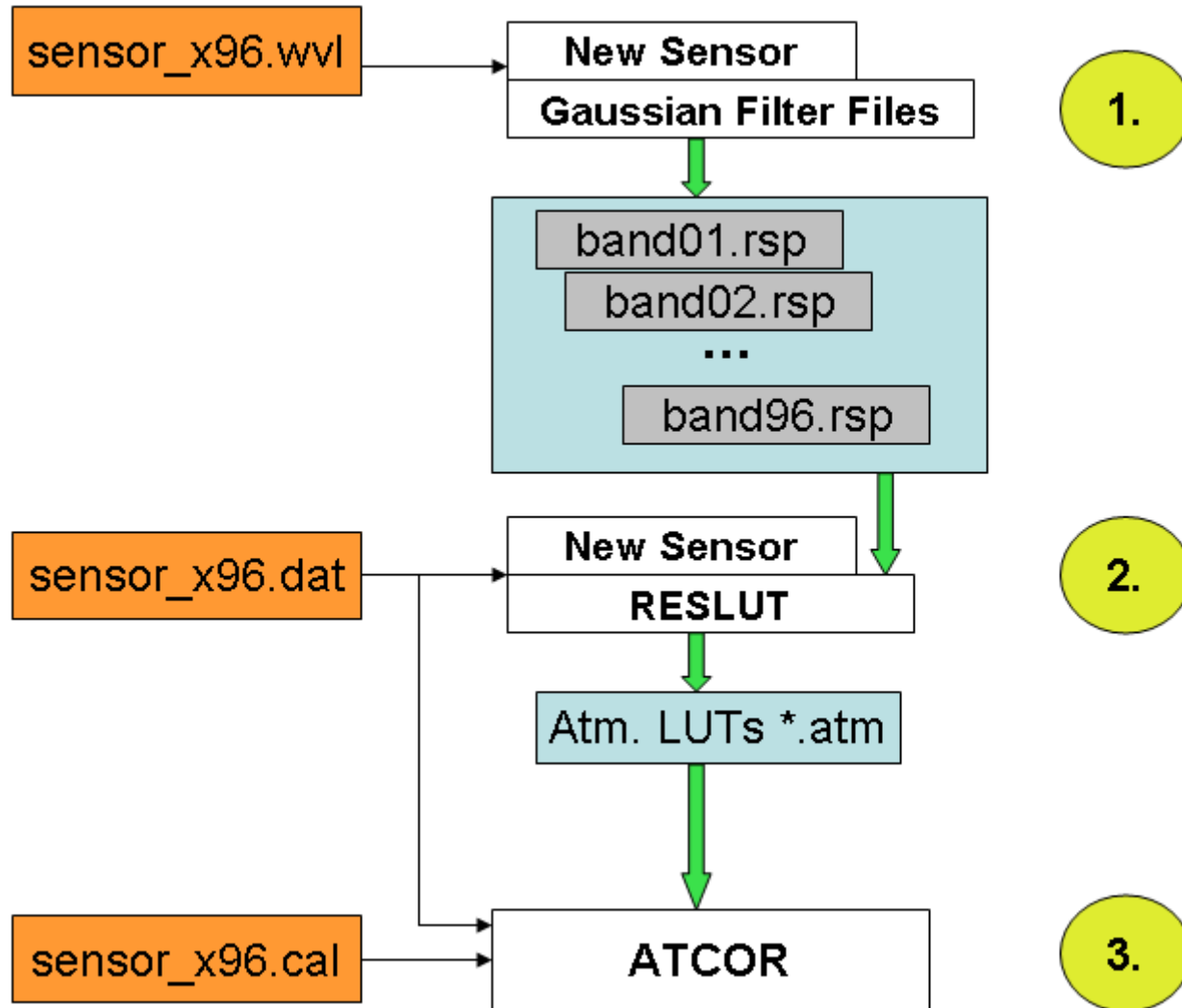
Improved processing: mean slope = 11.2°
Standard processing: mean slope = 11.3°

User Defines New Sensor (1)

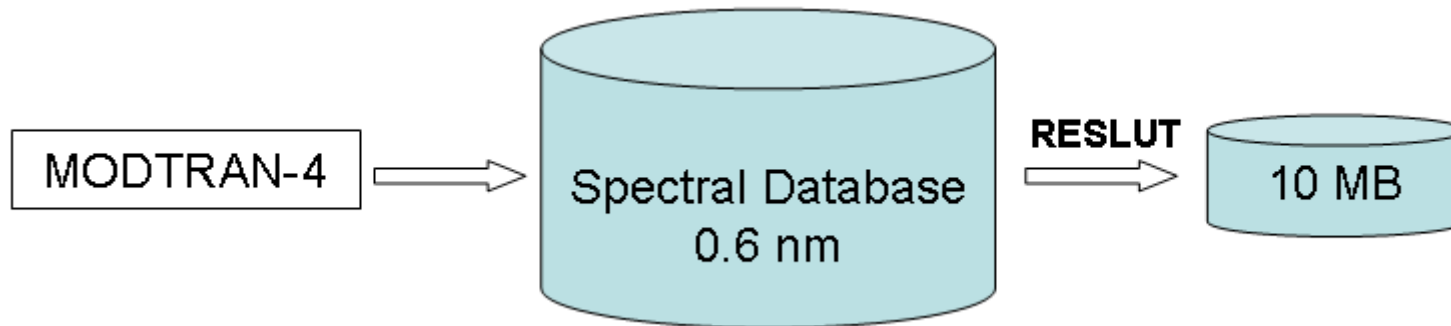
Needs a sensor name (e.g. x96) :

- Make new folder : *../atcor/sensor/x96/*
- ASCII file with 3 columns (*sensor/x96/x96.wvl*) :
band number, center wavelength, bandwidth (μm or nm)
- Sensor definition file (*../atcor/sensor/hyper2/sensor_x96.dat*)
(*copy one of the existing sensor.dat files*)
- Radiometric calibration file (3 column ASCII file, *x96.cal*)
 - (a) band number, c_0 , c_1 ($\text{mW cm}^{-2} \text{sr}^{-1} \mu\text{m}^{-1}$)
 - (b) λ , c_0 , c_1 (center wavelength λ in nm or μm)
- Calculate sensor-specific LUTs for atmospheric correction:
resample monochromatic database

User Defines New Sensor (2)



User Defines New Sensor (3)



Satellite ATCOR

File | **New Sensor** | Atm. Correction | Topographic | Filter | Simulation

Licens: Create Channel Filter Files | on 7.0 (c) D

BBCALC: Blackbody Function $T = f(L)$

RESLUT: Resample Atm. LUTs from Monochr. Database

◆ Reflective Region ◆ Thermal Region

Selected SENSOR =

Select ATM files

*** RUN ***

Resampling from high spectral resolution database:
 /export/data/data7/atcor2+3/atm_database/
 To sensor-specific atmospheric library:
 /export/data/data7/atcor2+3/atm_lib/chris_mode1h/

Select aerosol types (solar region)

rural urban maritime desert

The name h99000 symbolizes a satellite altitude
 The string "wv10" in the filename indicates a water vapor column 1.0 [g/cm², or cm]
 "wv20" indicates a water vapor column of 2.0 [g/cm², or cm] , etc.

Show Selected Files

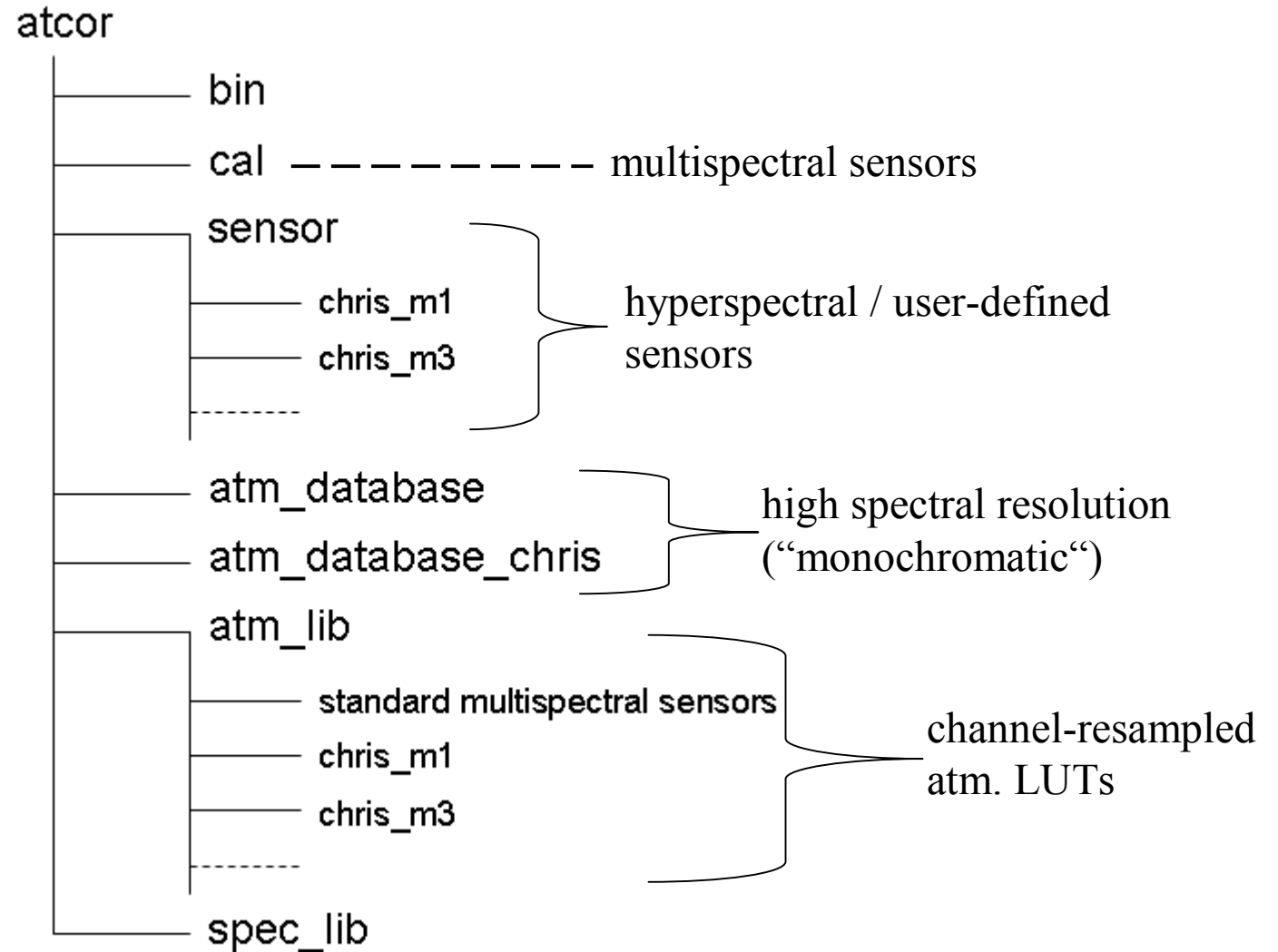
```

      ../atm_database/h99000_wv04_rura,bp7
      ../atm_database/h99000_wv10_rura,bp7
      ../atm_database/h99000_wv20_rura,bp7
      ../atm_database/h99000_wv29_rura,bp7
    
```

Cancel OK

User Defines New Sensor (4)

Directory Structure

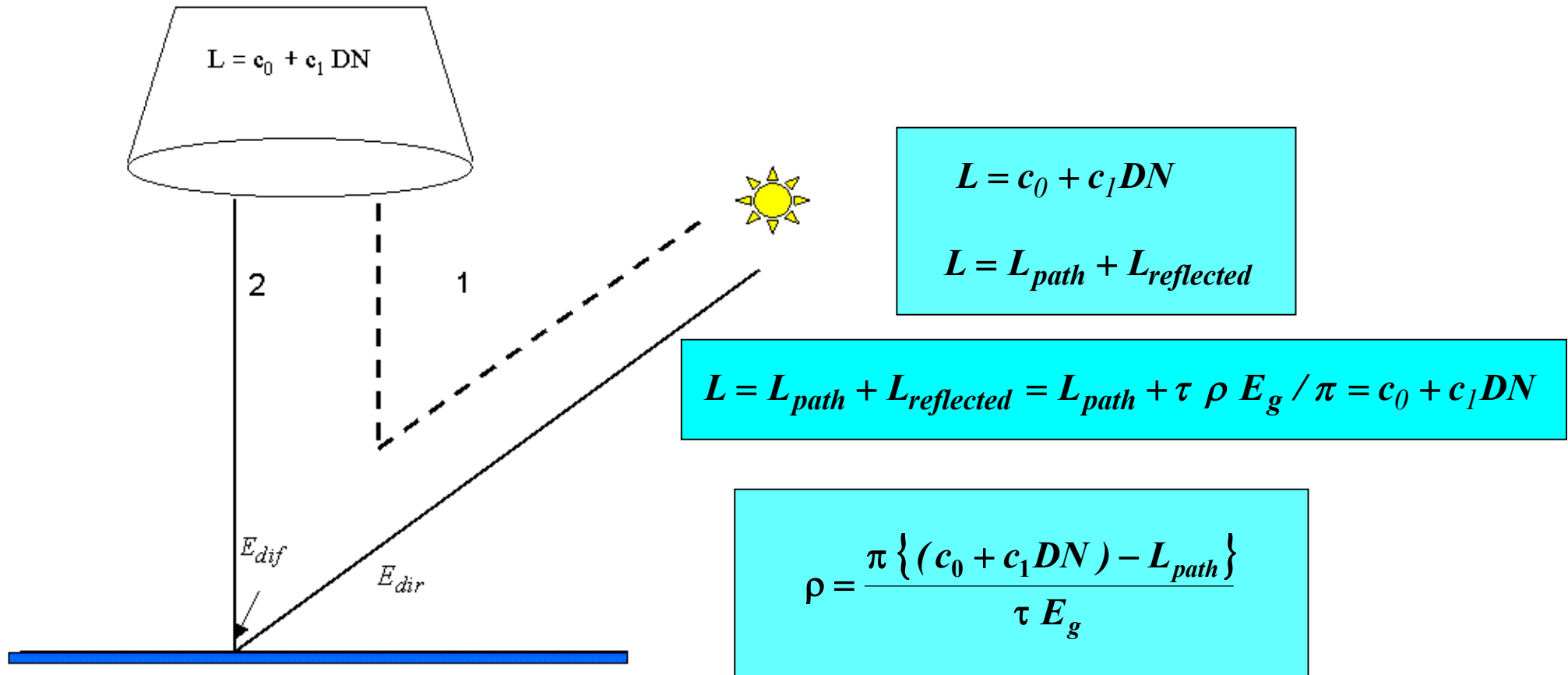


Critical Parameters During Correction (1)

SPECTRA module of ATCOR

1. Radiometric Calibration
2. Aerosol Type
3. Visibility (AOT at 550 nm)
4. Water Vapor (only hyperspectral)

Critical Parameters During Correction (2)



Dark target: visibility low \implies L_{path} high \implies ρ negative

Calibration problems: c_0 , c_1 influence on ρ

Units for Radiometric Calibration

$$\mathbf{L = c_0 + c_1 DN} \quad \mathbf{OR :} \quad \mathbf{DN = A * L}$$

Radiance unit in ATCOR : c_0, c_1 ($\text{mW cm}^{-2} \text{sr}^{-1} \mu\text{m}^{-1}$)

SPOT meta file : A ($\text{m}^2 \text{sr} \mu\text{m W}^{-1}$) $c_1 = 0.1/A$
(ATCOR converts A into c_1)

Landsat-TM/ ETM meta file: $\text{W m}^{-2} \text{sr}^{-1} \mu\text{m}^{-1}$

Multiply with factor 0.1 to get ATCOR radiance unit

Ikonos : $\text{cm}^2 \text{sr}^1 (\text{mW})^{-1}$ (channel-integrated)

Quickbird: $\text{W cm}^{-2} \text{sr}^{-1}$ (absCalFactor in .IMD File)

IRS-P6 Liss3 : Bias = Lmin and Gain = Lmax ($\text{mW cm}^{-2} \text{sr}^{-1} \mu\text{m}^{-1}$)

$$c_0 = \text{Bias}, \quad c_1 = (\text{Lmax} - \text{Lmin}) / 255$$

DIMAP FORMAT (SPOT)

(SPOT) DIMAP-Format : band sequence in TIFF File is 3,2,1,4

DIMAP is also used for Formosat and Kompsat

But:

Meta file contains calibration parameters in ascending band sequence

e.g. XS1 <PHYSICAL_GAIN>1.829 holds for band 1

- ATCOR requires the normal band sequence 1, 2, 3, 4
- Convert TIFF band order (e.g. with ENVI)
- offer a TIFF (max. 9 bands) oder ENVI-BSQ to ATCOR

ATCOR Preference File

Edit Preference Parameters File = /users/richt_r/.idl/rese/atcor3/preference_parameters.dat

Water Vapor Option for Water Pixels
◆ 0 = keep values, do not replace ◆ 1 = use land-average ◆ 2 = use line average of land pixels

Water Vapor Map over Land
◆ 0 = no smoothing ◆ 1 = smooth with 100m box

◆ 0 = no band interpolation in 760 nm region ◆ 1 = interpolate bands in 760 nm oxygen region
◆ 0 = no band interpolation in 725/ 825 nm region ◆ 1 = interpolate bands in 725 and 825 nm water vapor region
◆ 0 = no band interpolation in 940/1130 nm region ◆ 1 = interpolate bands in 940 and 1130 nm water vapor region
◆ 0 = no band interpolation in 1400/1900 nm region ◆ 1 = interpolate bands in 1400 and 1900 nm water vapor region
◆ 0 = do not write "_out_hcw" file (haze/cloud/water/land) ◆ 1 = write "_out_hcw" file

Cloud reflectance threshold (%) in the blue-green region (cloud mask) =

Water reflectance threshold (%) in the NIR region (water mask) =

Water reflectance threshold (%) in the 1600 nm region (water mask) =

Maximum surface reflectance (%) cut-off limit =

Water vapor threshold to switch off cirrus algorithm [cm] =

Define saturation: $DN(\text{saturated}) > b \cdot DN(\text{max})$ with $b=0,9$ to $1,0$, b =

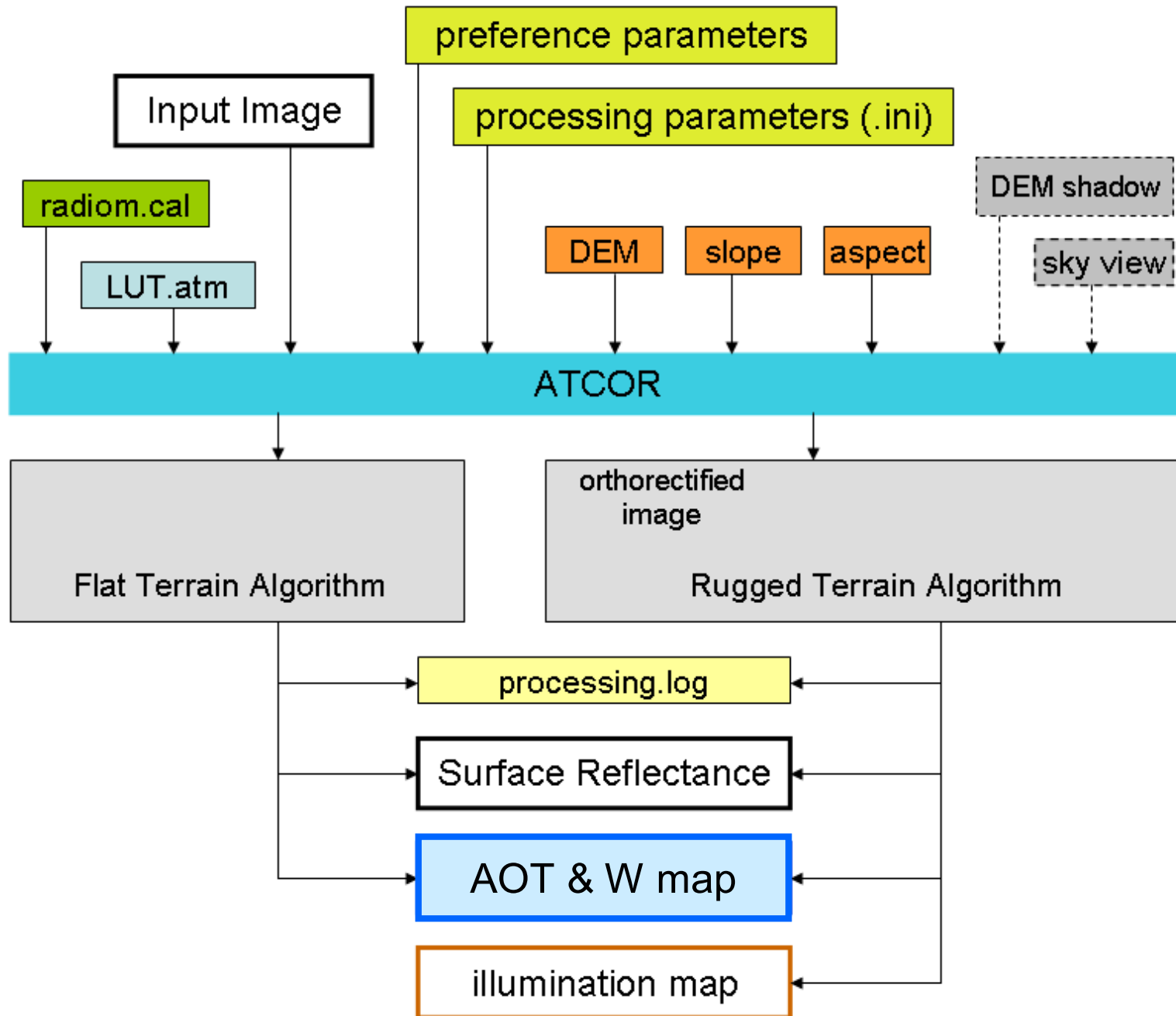
Message :

Settings of preference file may influence masking

Calculation of masks (1-4):

1. water : $\rho(\text{NIR}) < T1$, $\rho(1.6\mu\text{m}) < T2$, surf. ρ)
2. cloud: $\rho^*(\text{blue}) > 0.30$ (default, TOA ρ^*)
3. haze, cirrus, shadow masks (optional)
4. saturated pixels (blue band)
5. haze, cirrus removal, de-shadowing (optional)
6. AOT retrieval
7. Water vapor retrieval
8. Surface reflectance retrieval

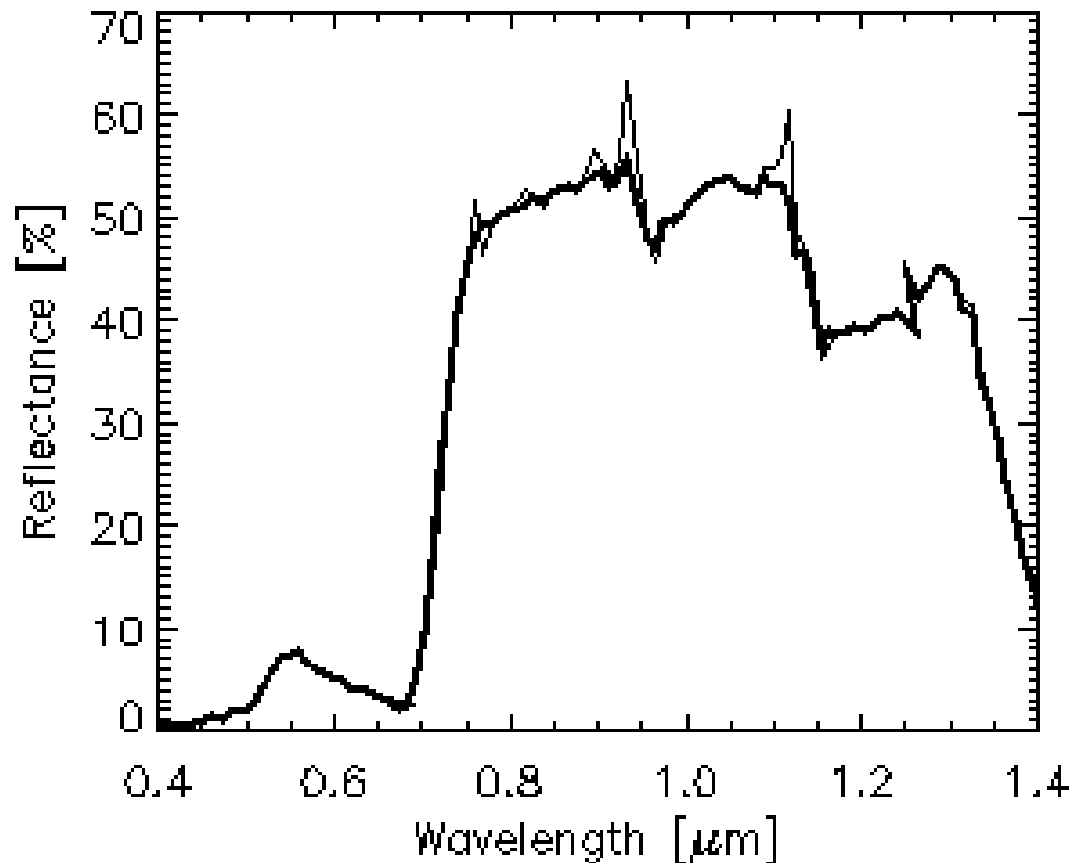
ATCOR I/O Files



Use atmospheric absorption features $\chi^2 = \sum_{i=1}^N \left[\rho_i(\delta) - \rho_i^{smooth} \right]^2 = 0$

Shift channel center wavelengths until reflectance spectrum shows minimum deviations with respect to smoothed spectrum

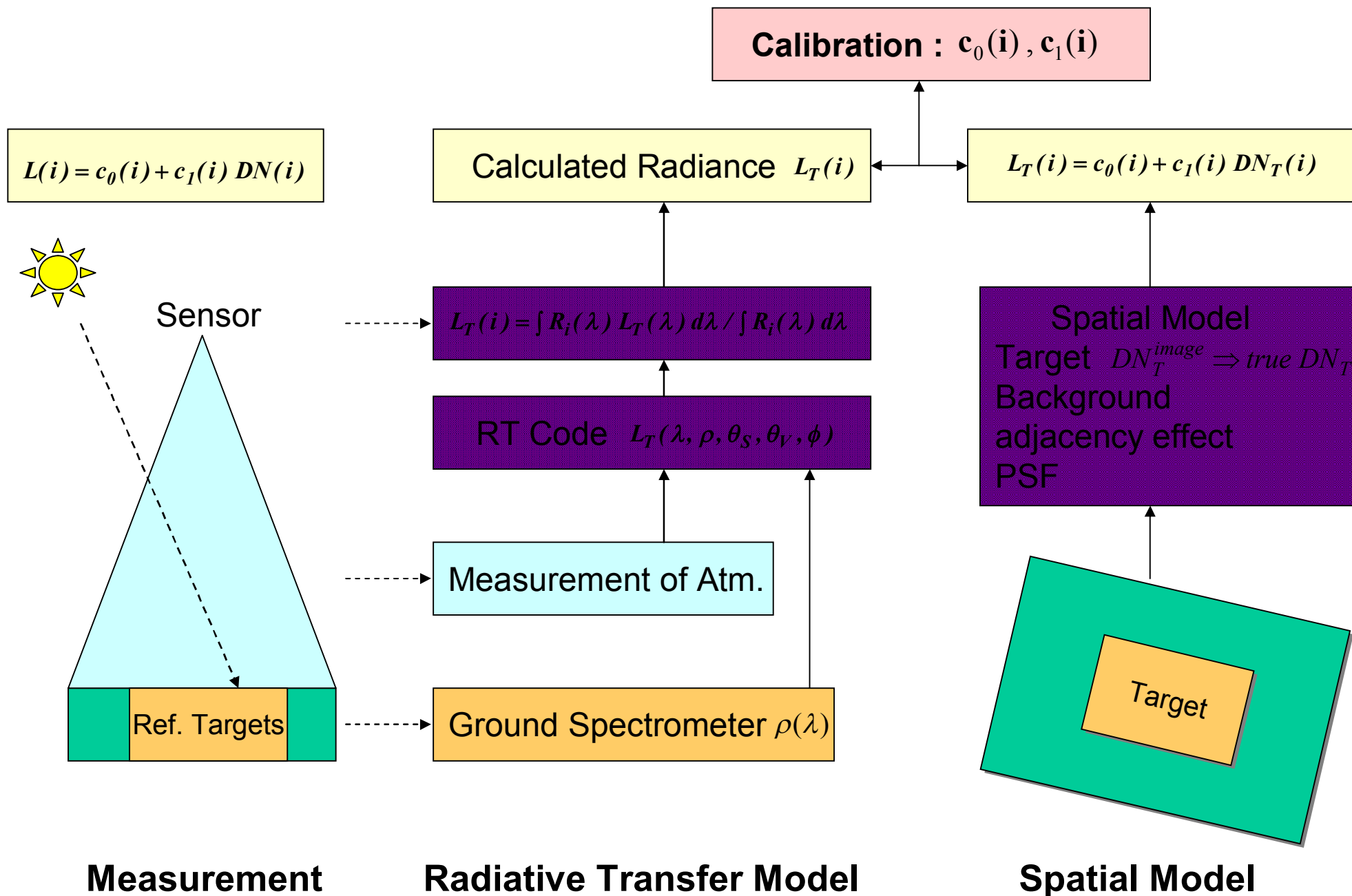
Guanter, L., Richter, R., and Moreno, J., "Spectral calibration of hyperspectral imagery using atmospheric absorption features", Applied Optics 45:2360-2370 (2006).

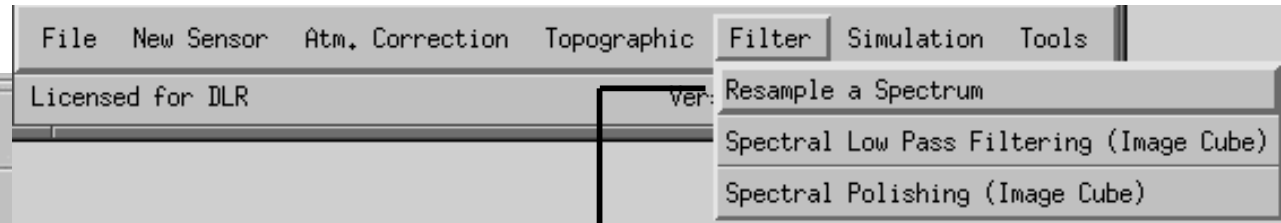


thin: before spectral calibration

thick: after calibration

AVIRIS spectrum





Mode of Calculation c1 c0 & c1

Number of calibration targets = 1

Target 1: box = Ground reflectance file

Target 2: box = Ground reflectance file

Results of calibration:

File =

Definition of target center coordinates :

Click targets in zoom window Specify x/y coordinates

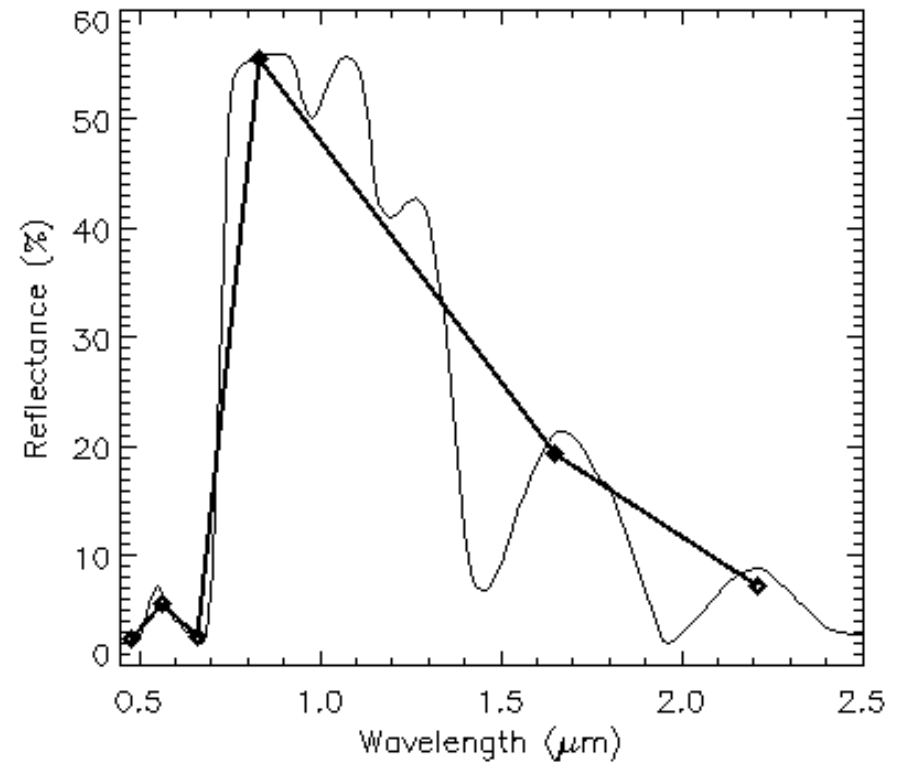
Target 1 : mouse button 1 (left)

Target 2 : mouse button 2 (center)

Target 1 : column = row =

Target 2 : column = row =

Message:



Mode of Calculation c1 c0 & c1

Number of calibration targets = 1

Target 1: box = Ground reflectance file

Target 2: box = Ground reflectance file

Results of calibration:

File =

Definition of target center coordinates :

Click targets in zoom window Specify x/y coordinates

Target 1 : mouse button 1 (left)

Target 2 : mouse button 2 (center)

Target 1 : column = row =

Target 2 : column = row =

Message:

Multiple Targets (n > 2)

Use names like:

target1.cal

target2.cal etc

(for calibration regression analysis)

Program creates files

target1.rdn

target2.rdn etc

rdn = radiance – digital number

example:

	wvl	radiance	DN1c	stdev(DN1)	x/y =	box =
	0.4856	7.94044	97.4	1.2	419/ 511	5
	0.5702	7.53249	44.0	0.8		
	0.6610	7.59662	51.4	1.0		
	0.8384	5.55482	50.6	1.0		
	1.6759	1.46875	81.1	3.3		
	2.2160	0.50376	45.2	1.8		

Inflight Radiometric Calibration (4)

calibration regression analysis:

Use program “cal_regress“ on ATCOR’s IDL command line, e.g.

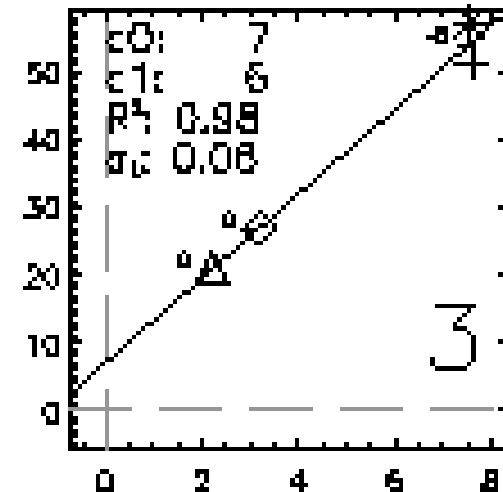
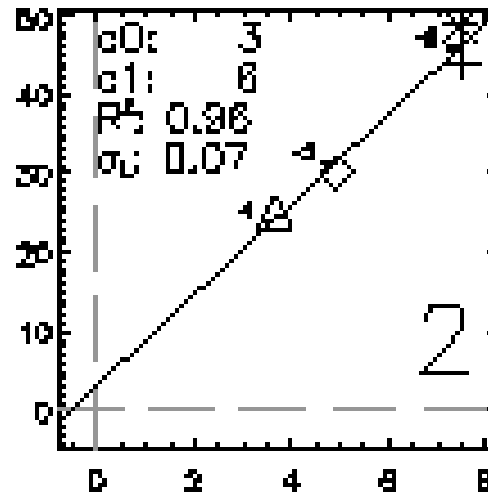
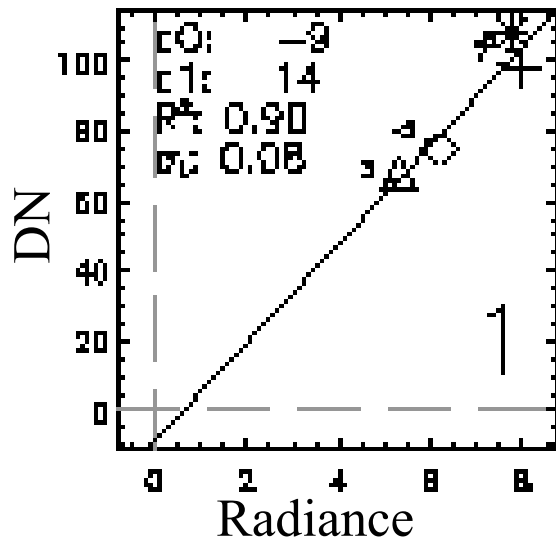
```
> cal_regress, ntargets=4, outfile='regress4'
```

A pickfile menu pops up asking for each of the (4) file names of the .rdn

Then the regression is calculated:

Output: ‘regress4.cal’ and ‘regress4_ifc_rep_A4.ps’

(inflight calibration report A4 format, postscript)

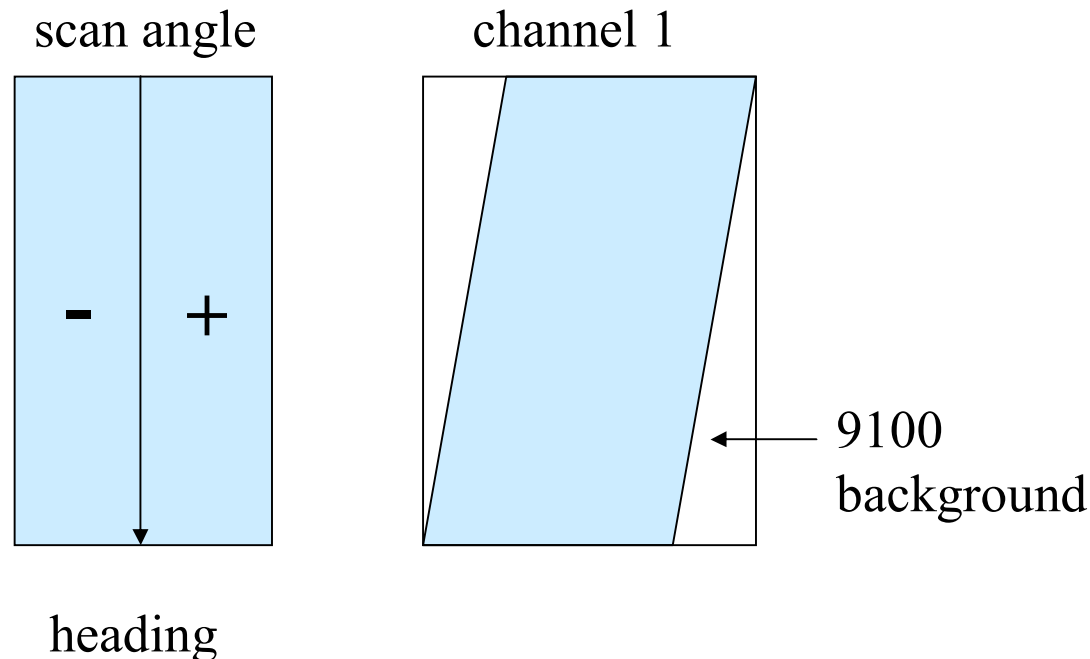


Airborne ATCOR: scan angle (1)

Geocoding with ORTHO or PARGE (<http://www.rese.ch>) :

Scan angle file (image_sca.bsq) with 2 or 3 channels:

- channel 1 : scan angle map (degree*100), background=9100
sign convention: negative right of nadir
- channel 2 : azimuth angle map (degree*10)
- channel 3 : range aircraft-to-terrain pixel (meters), optional



Original sensor geometry : sca file not required, calculated with information in “sensor_XXX.dat“ (pixels per line=n and FOV) neglecting aircraft movements:

$$\alpha = - i * (\text{FOV}/n) \text{ where } i = \text{off-nadir pixel number (right of heading)}$$

$$\alpha = + i * (\text{FOV}/n) \text{ where } i = \text{off-nadir pixel number (left of heading)}$$

