Atmospheric Correction

With

ATCOR

Rudolf.Richter@dlr.de

German Remote Sensing Data Center

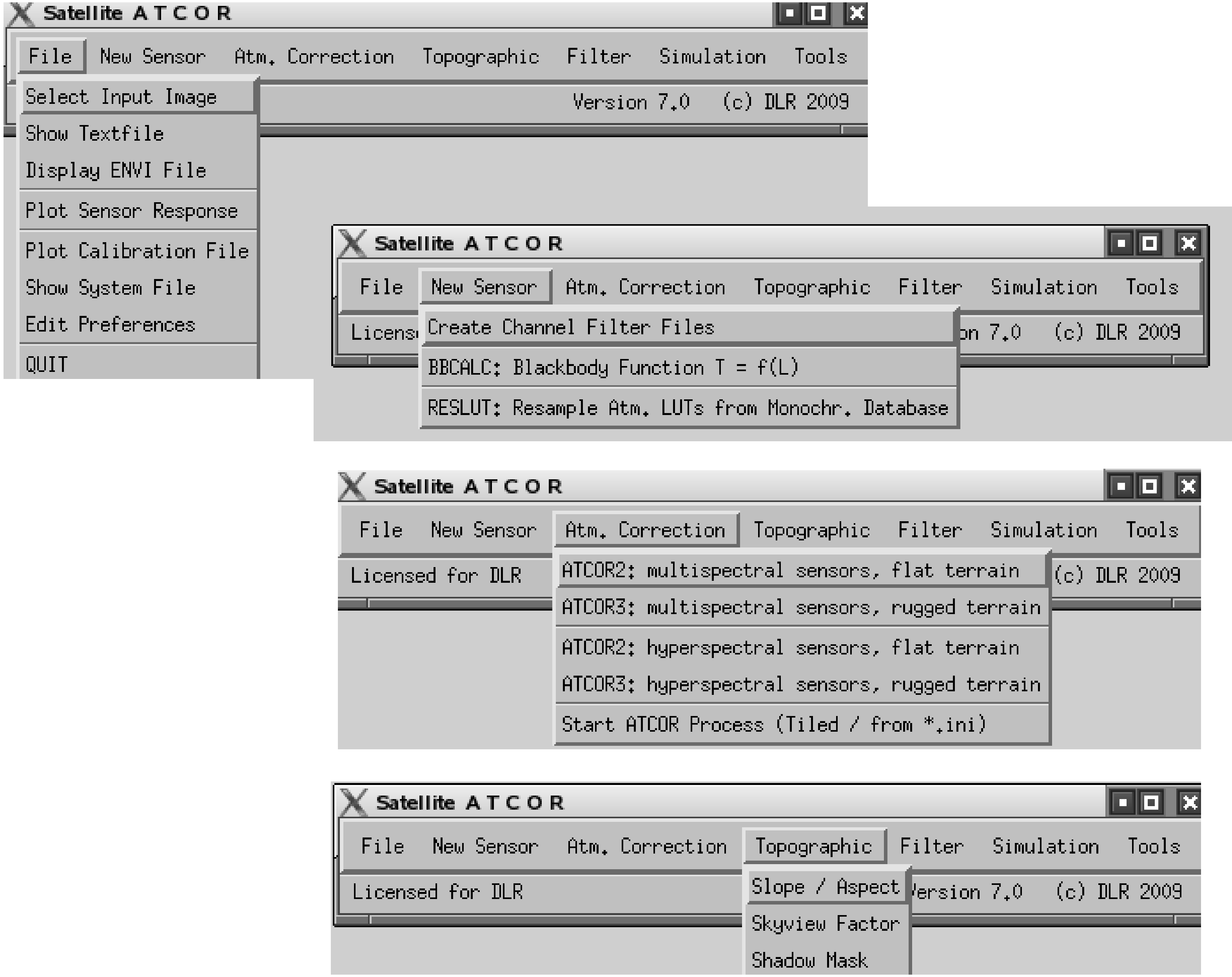
ATCOR Exercises

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)

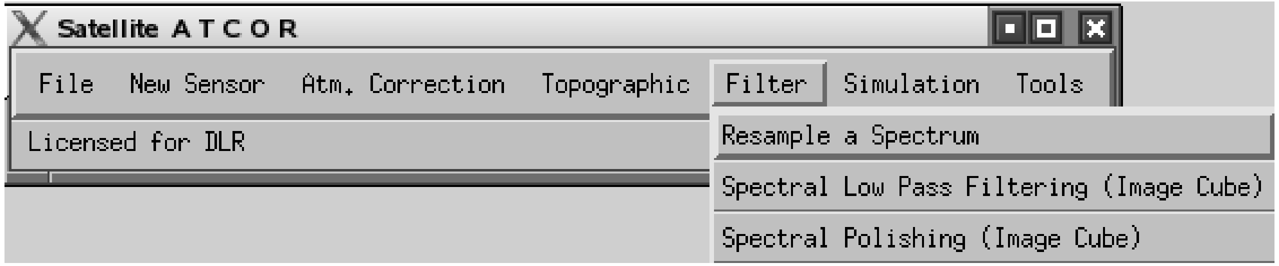
ATCOR Exercises

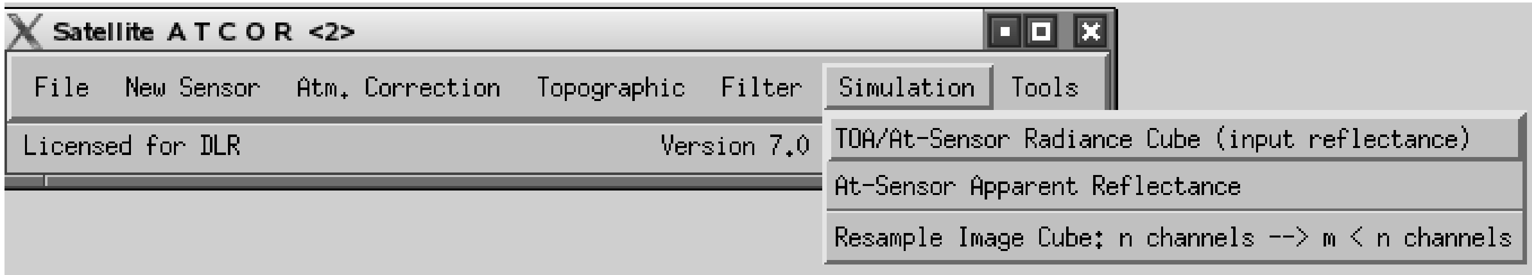
Top level & pull-down menus (1)

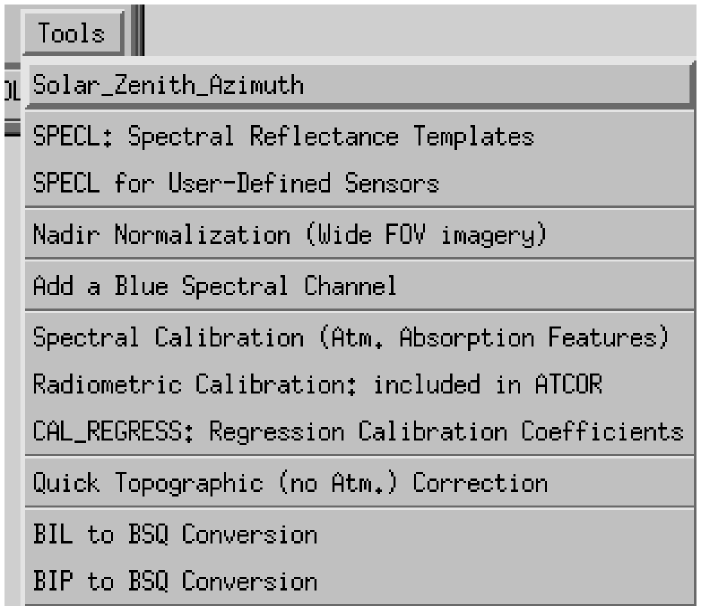


ATCOR Exercises

Top level & pull-down menus (2)

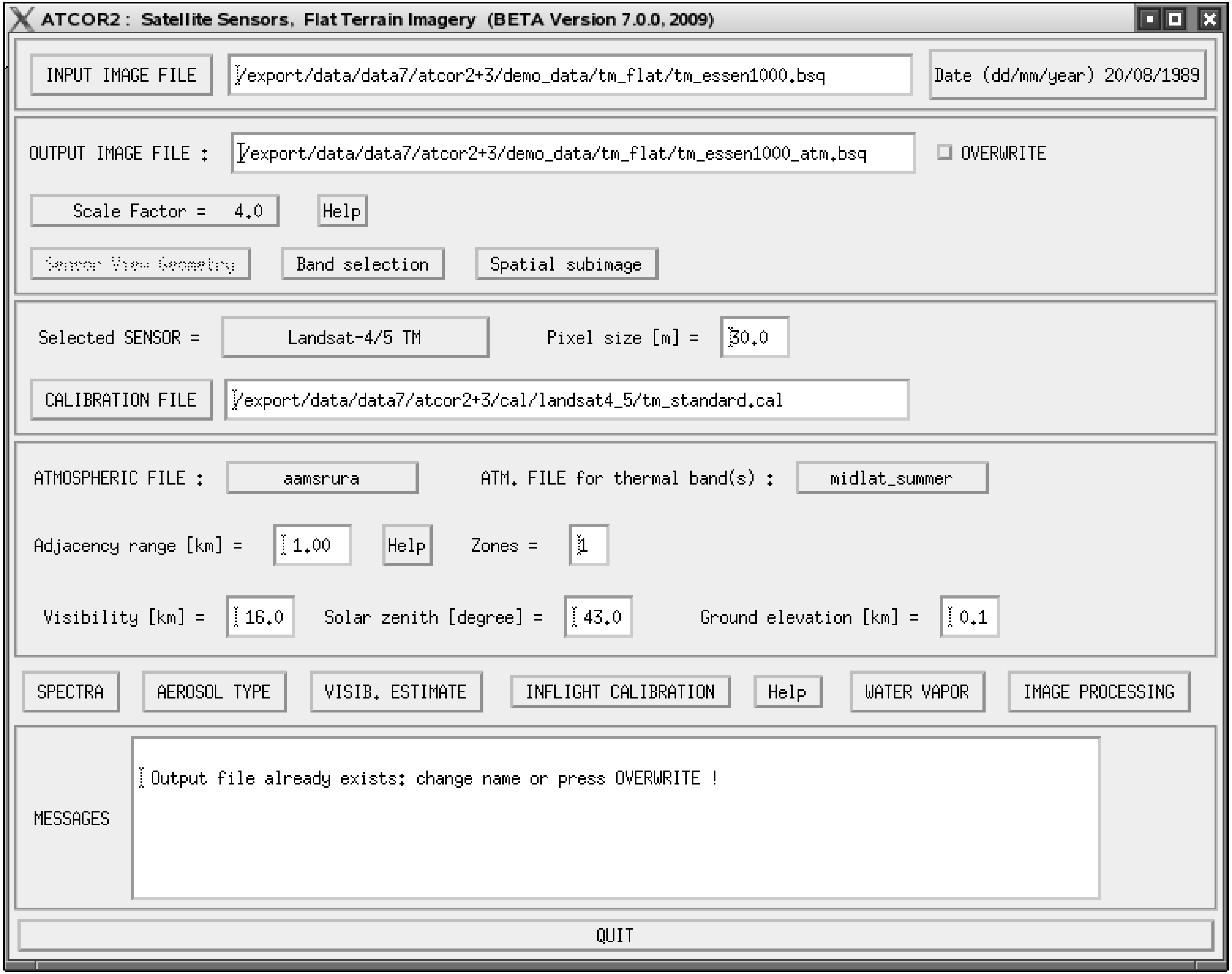






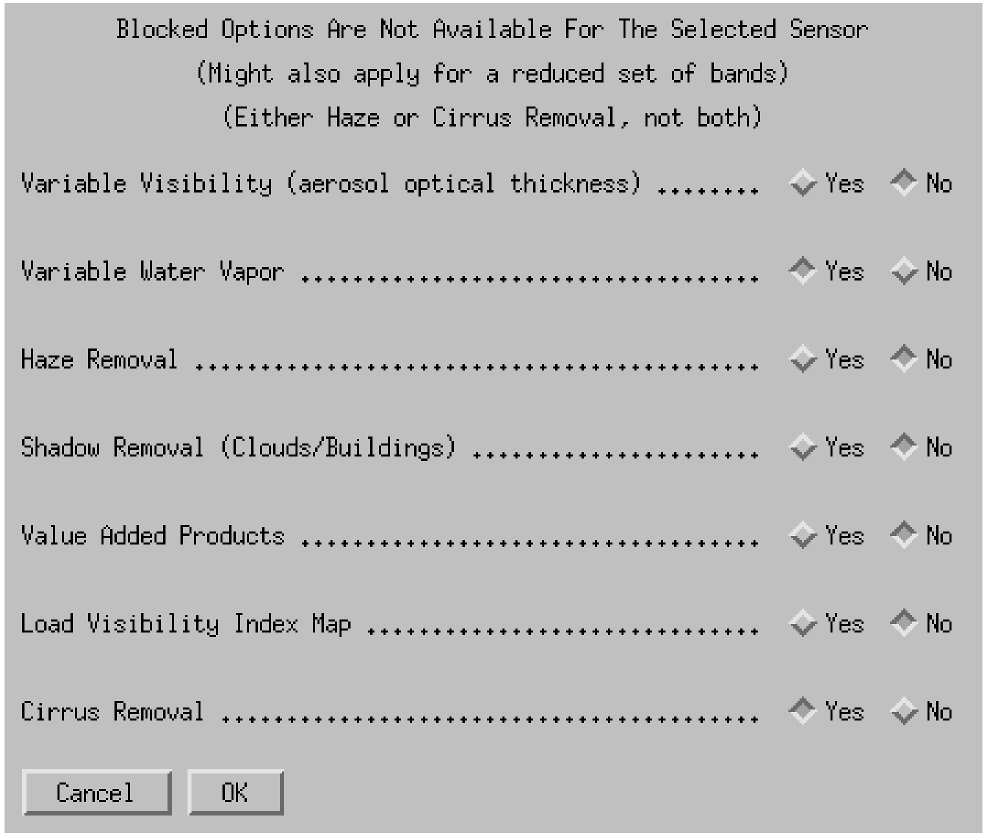
DLR

ATCOR Main Menu

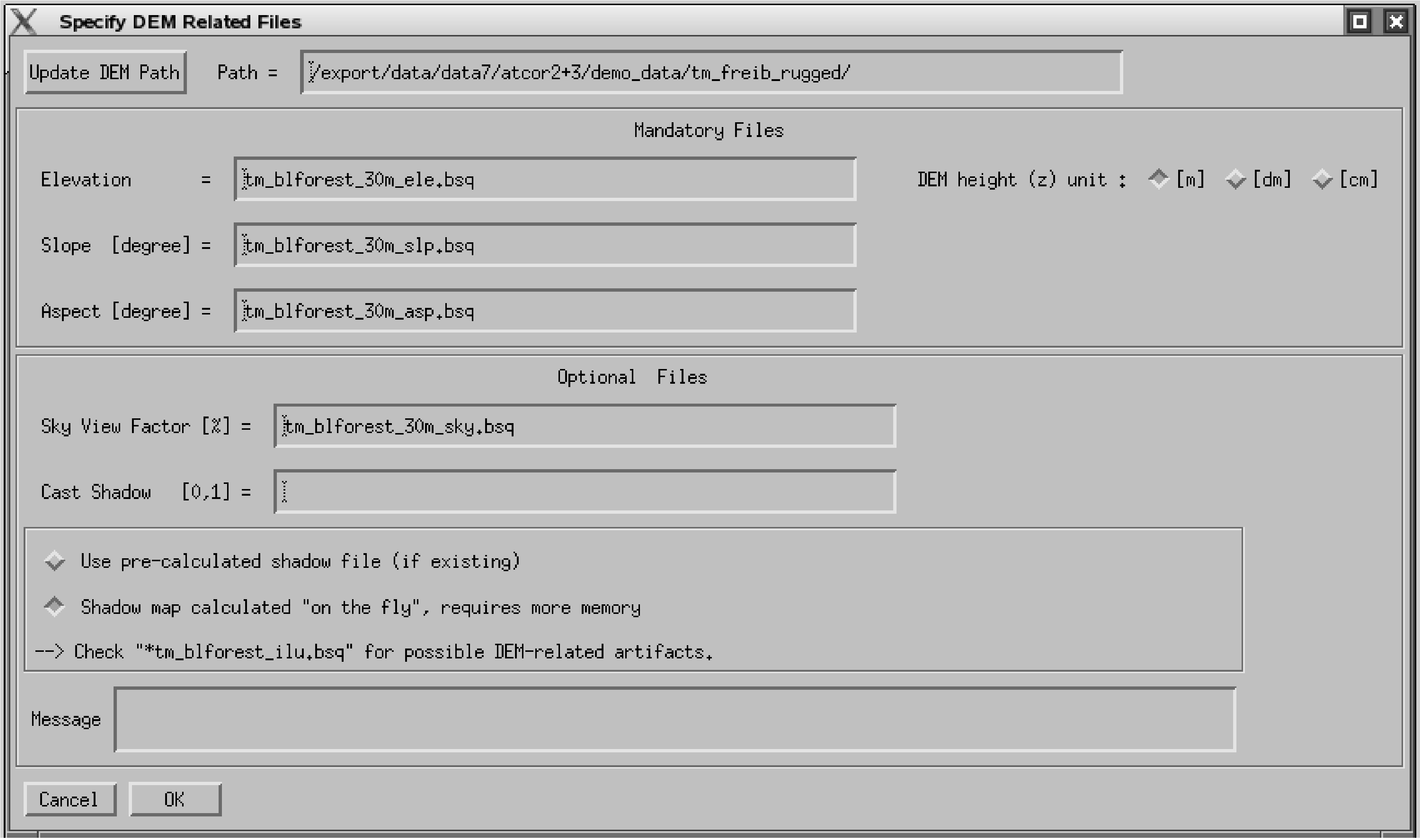


German Remote Sensing Data Center

ATCOR Processing Options



ATCOR DEM Files



Slope / Aspect Maps (1)

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:

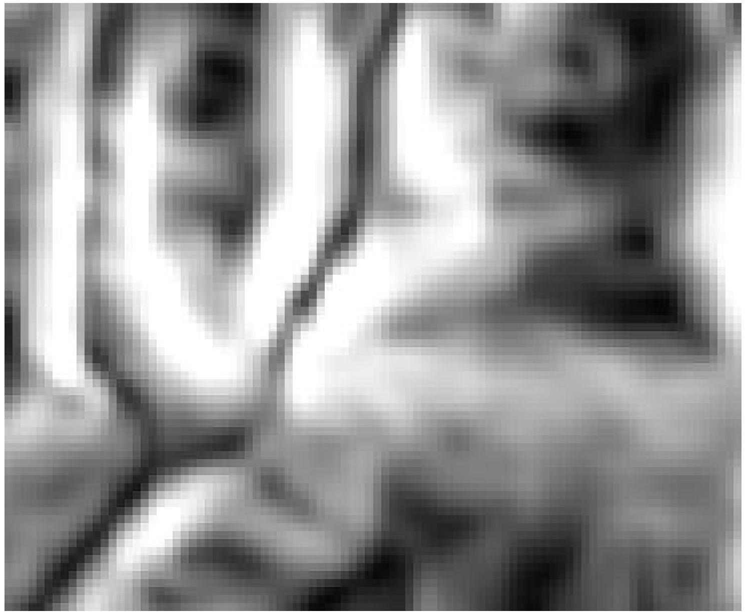
1. float(elevation)
2. calculate slope / aspect with low pass filter (5×5 pixels)
3. resize factor 4 larger (bilinear)
4. low pass filter 7×7 pixels
5. resize factor 0.25 (nearest neighbor) to obtain original size

Slope / Aspect Maps (2)

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/*

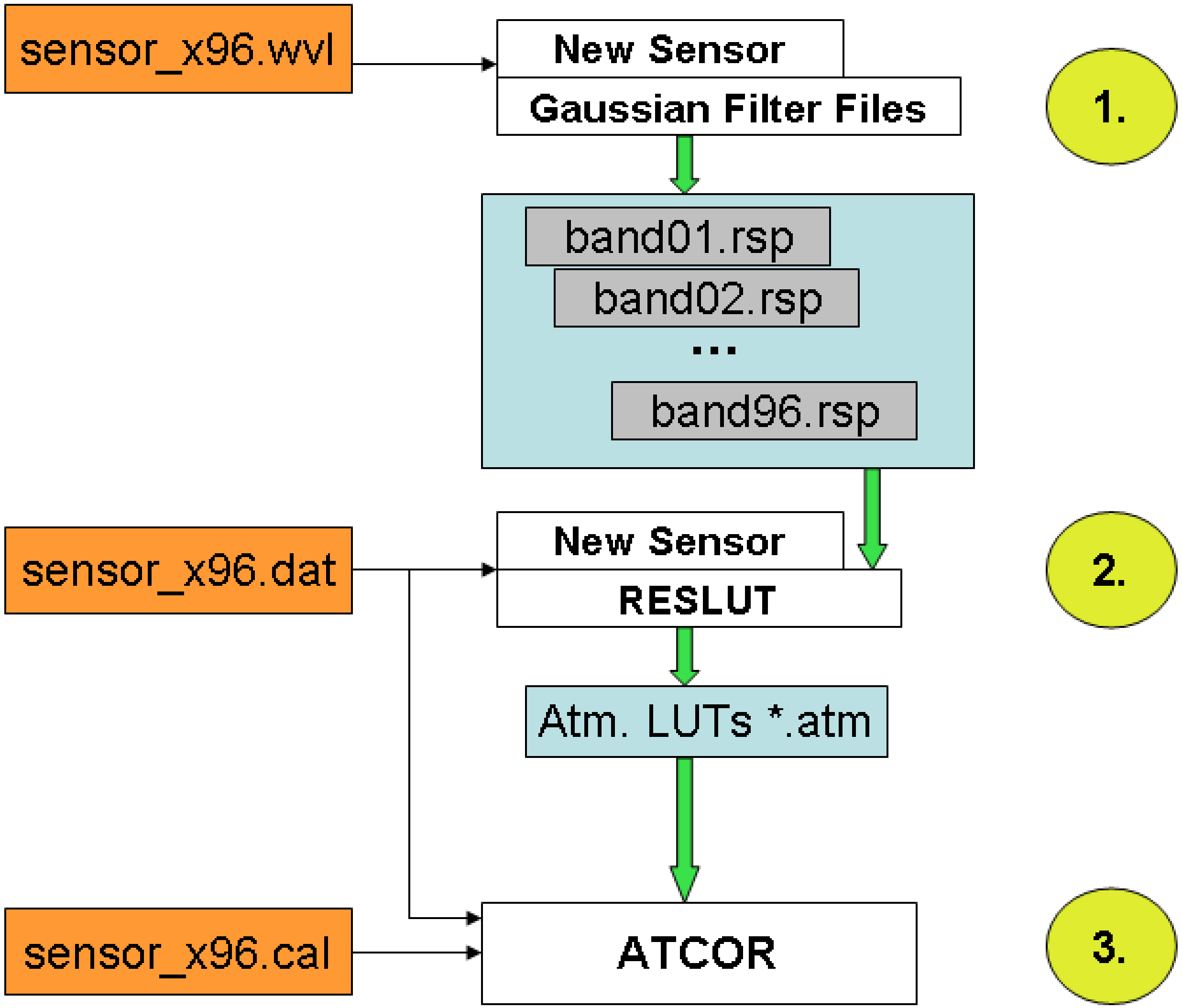
- ASCII file with 3 columns (*sensor/x96/x96.wvl*) :
  band number, center wavelength, bandwidth (µm or nm)

- 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, c0, c1 (mW cm^{-2} sr^{-1} μm^{-1})
  (b) λ, c0, c1 (center wavelength λ in nm or µm)

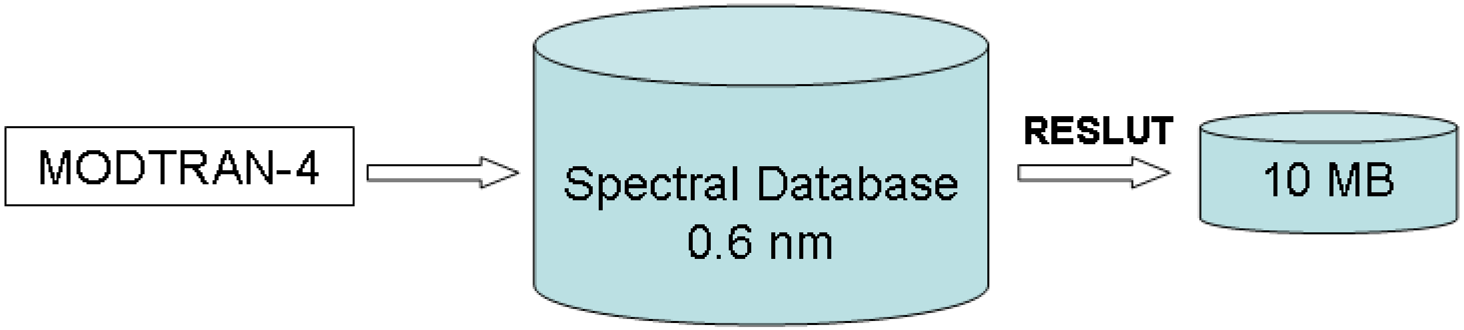
- Calculate sensor-specific LUTs for atmospheric correction:
  resample monochromatic database

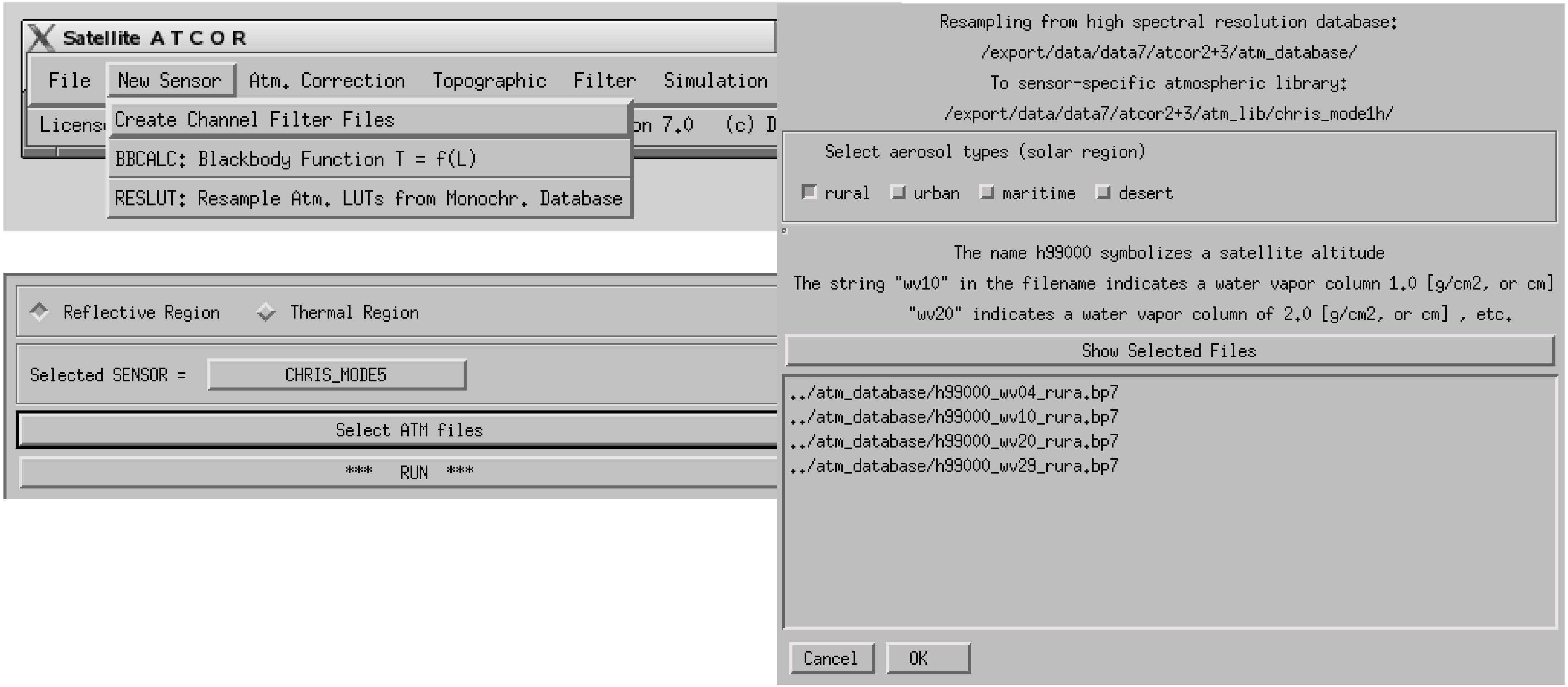
User Defines New Sensor (2)



ATCOR Hyperspectral

User Defines New Sensor (3)

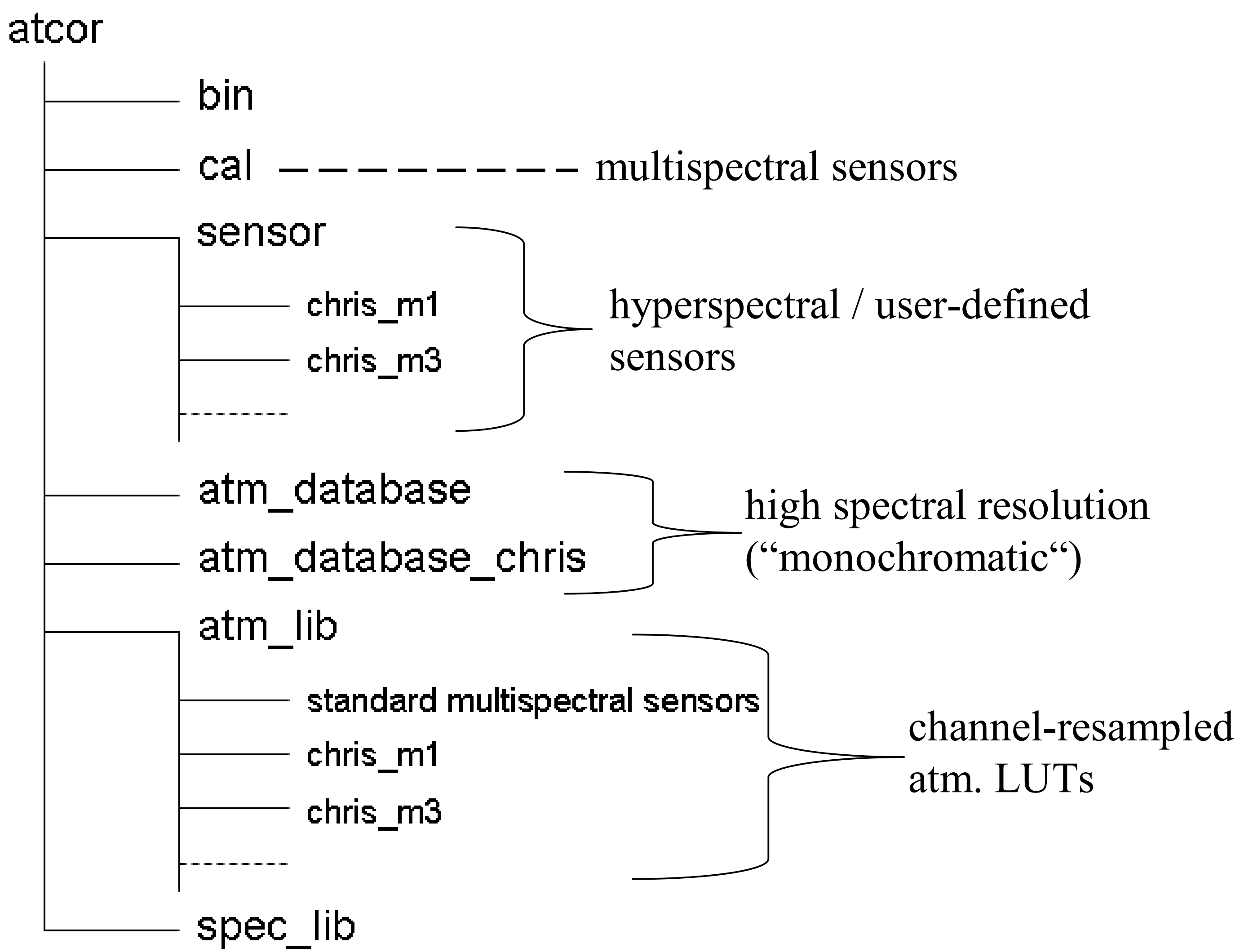




German Remote Sensing Data Center

User Defines New Sensor (4)

Directory Structure

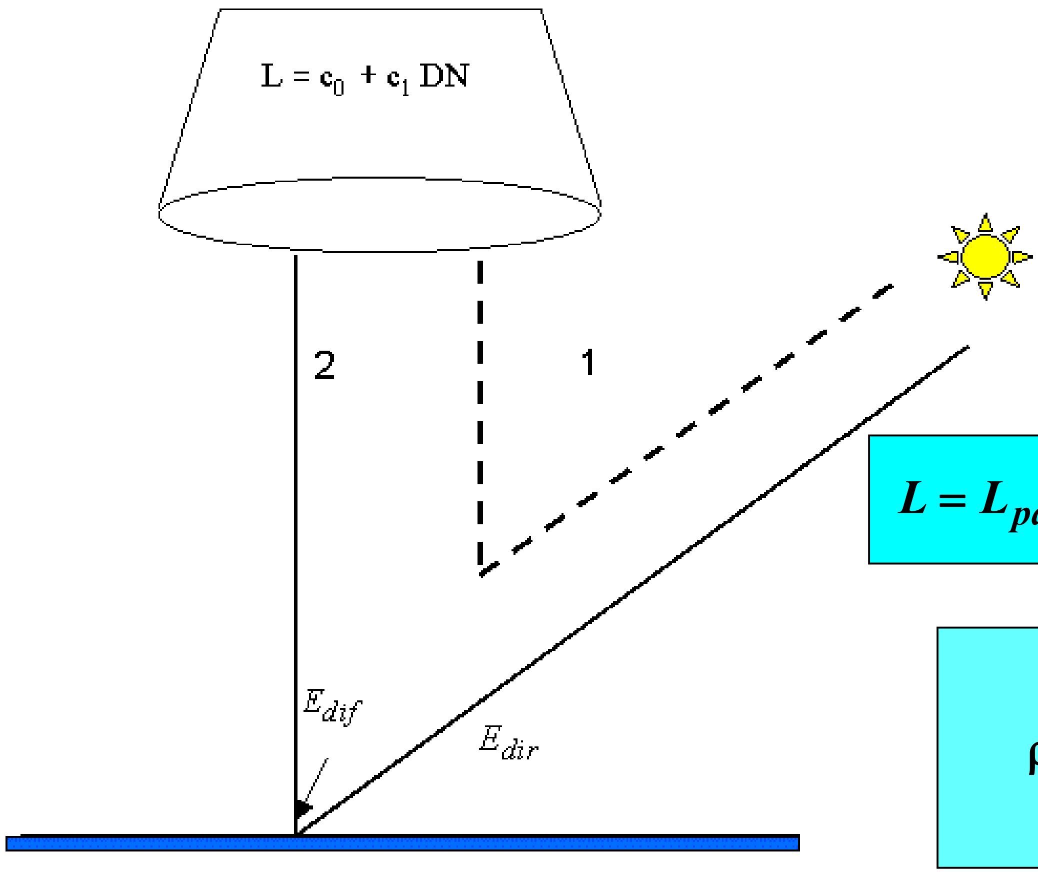


Critical Parameters During Correction (1)

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)



$$L = c_0 + c_1 DN$$

$$L = L_{path} + L_{reflected}$$

$$L = L_{path} + L_{reflected} = L_{path} + \tau\ \rho\ E_g / \pi = c_0 + c_1 DN$$

$$\rho = \frac{\pi \{ (c_0 + c_1 DN) - L_{path} \}}{\tau\ E_g}$$

Dark target: visibility low ==> L(path) high ==> ρ negative

Calibration problems: c_0 , c_1 influence on ρ

Units for Radiometric Calibration

$$L = c_0 + c_1 DN \qquad \text{OR :} \qquad DN = A * L$$

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

SPOT meta file : A ($m^2\ sr\ \mu m\ W^{-1}$) $c_1 = 0.1/A$
(ATCOR converts A into c1)

Landsat-TM/ ETM meta file: $W\ m^{-2}\ sr^{-1}\ \mu m^{-1}$
Multiply with factor 0.1 to get ATCOR radiance unit

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

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

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

c_0 = Bias, c_1 = (Lmax – 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

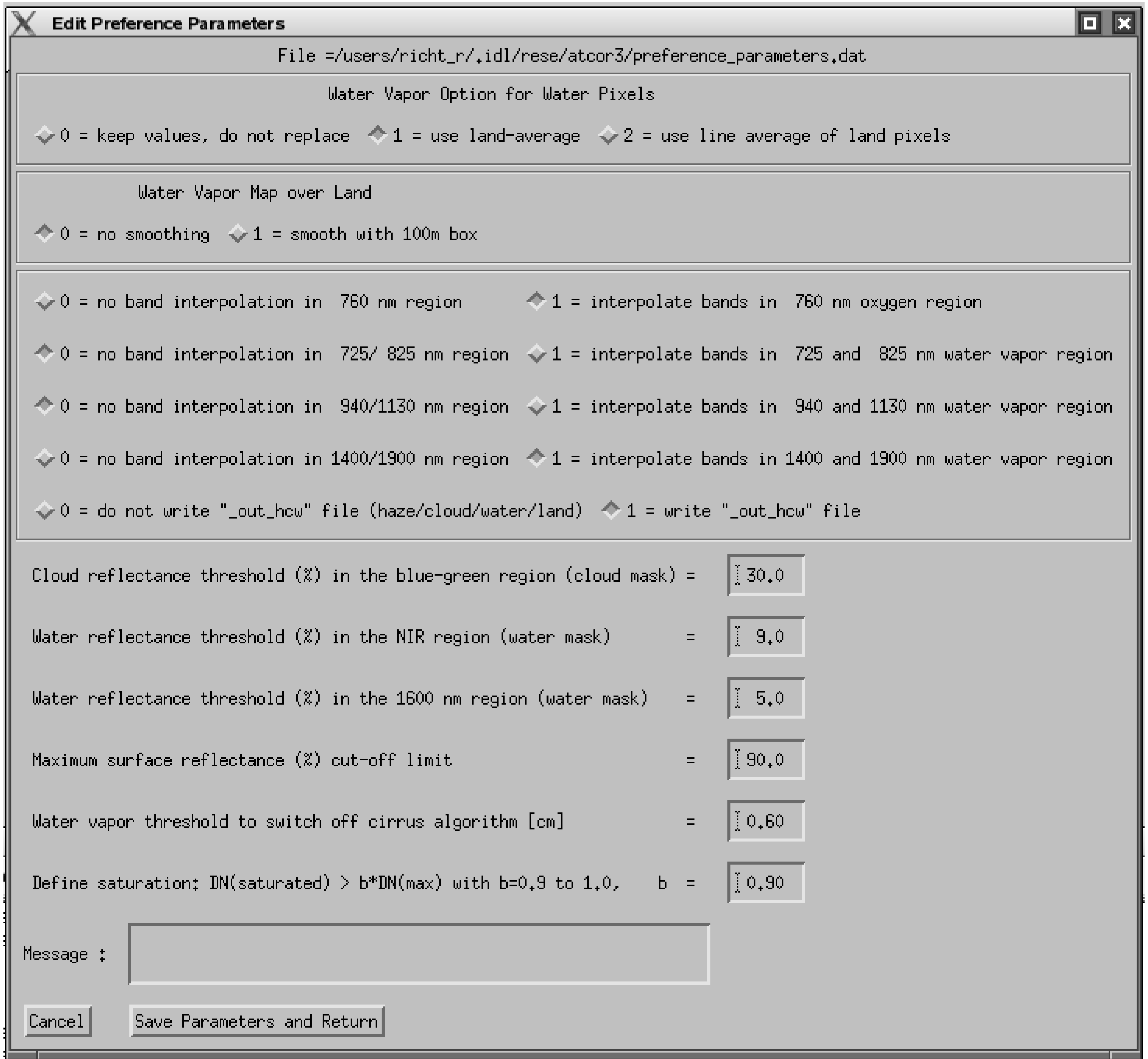
But:

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



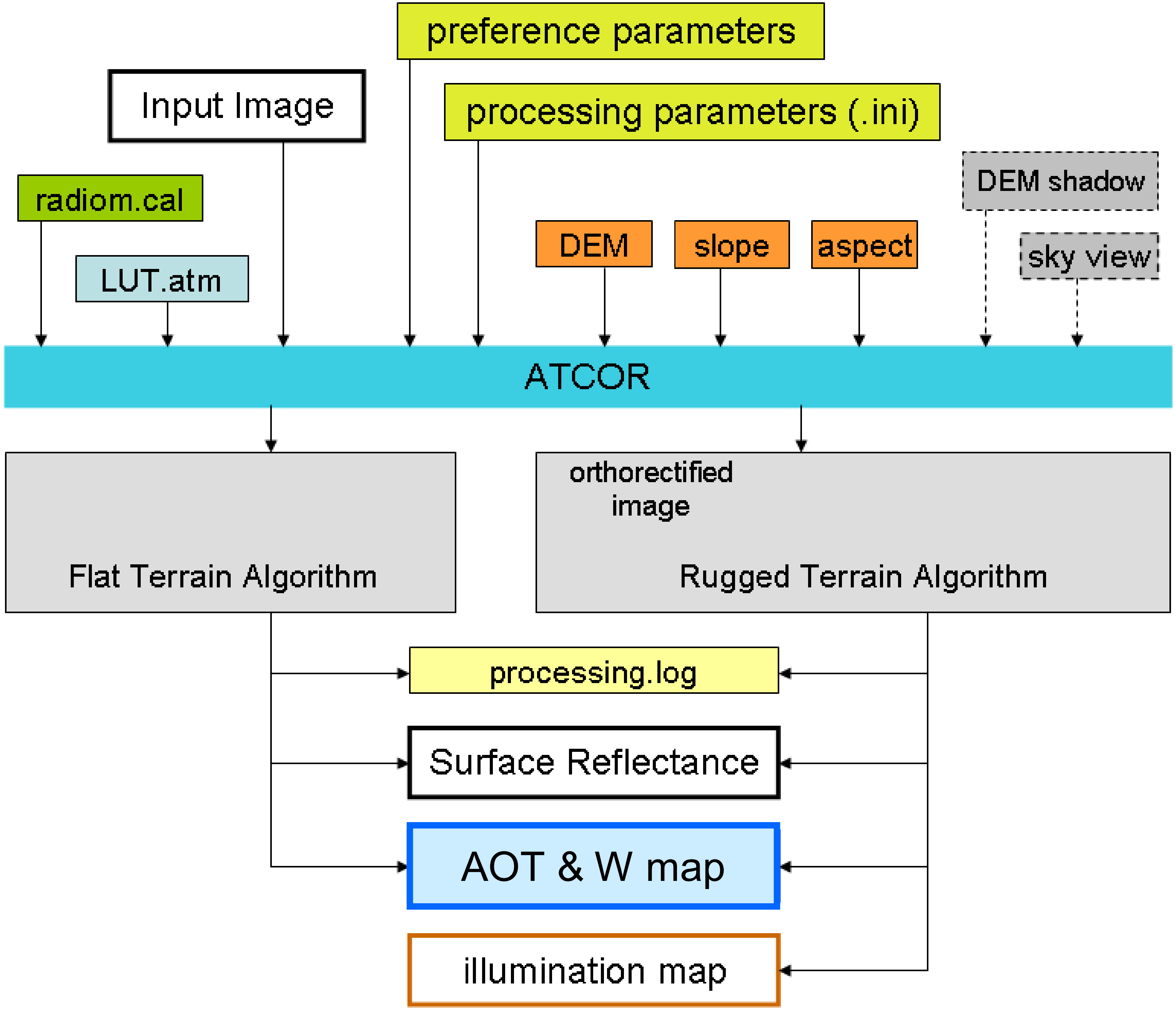
ATCOR Processing Steps

Settings of preference file may influence masking

Calculation of masks (1-4):

1. water : ρ(NIR) < T1, ρ(1.6μm) < T2 , surf. ρ)
2. cloud: ρ^*(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



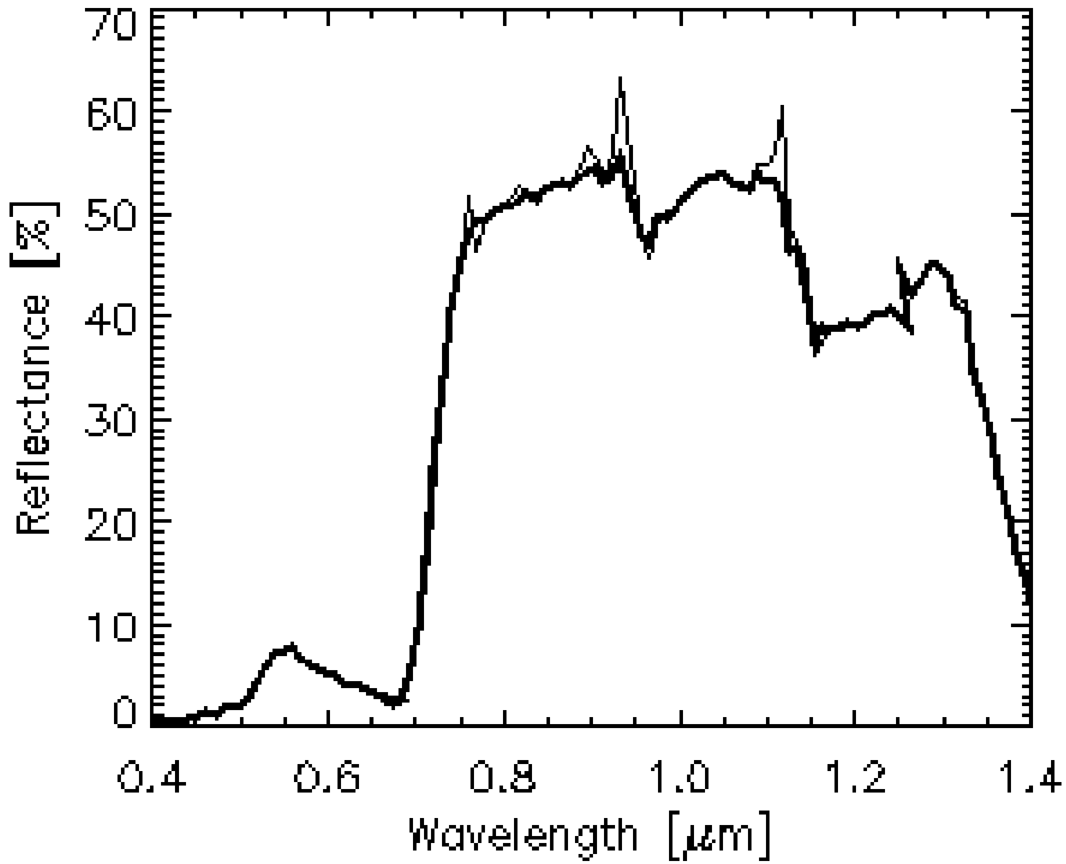
Spectral Calibration

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).

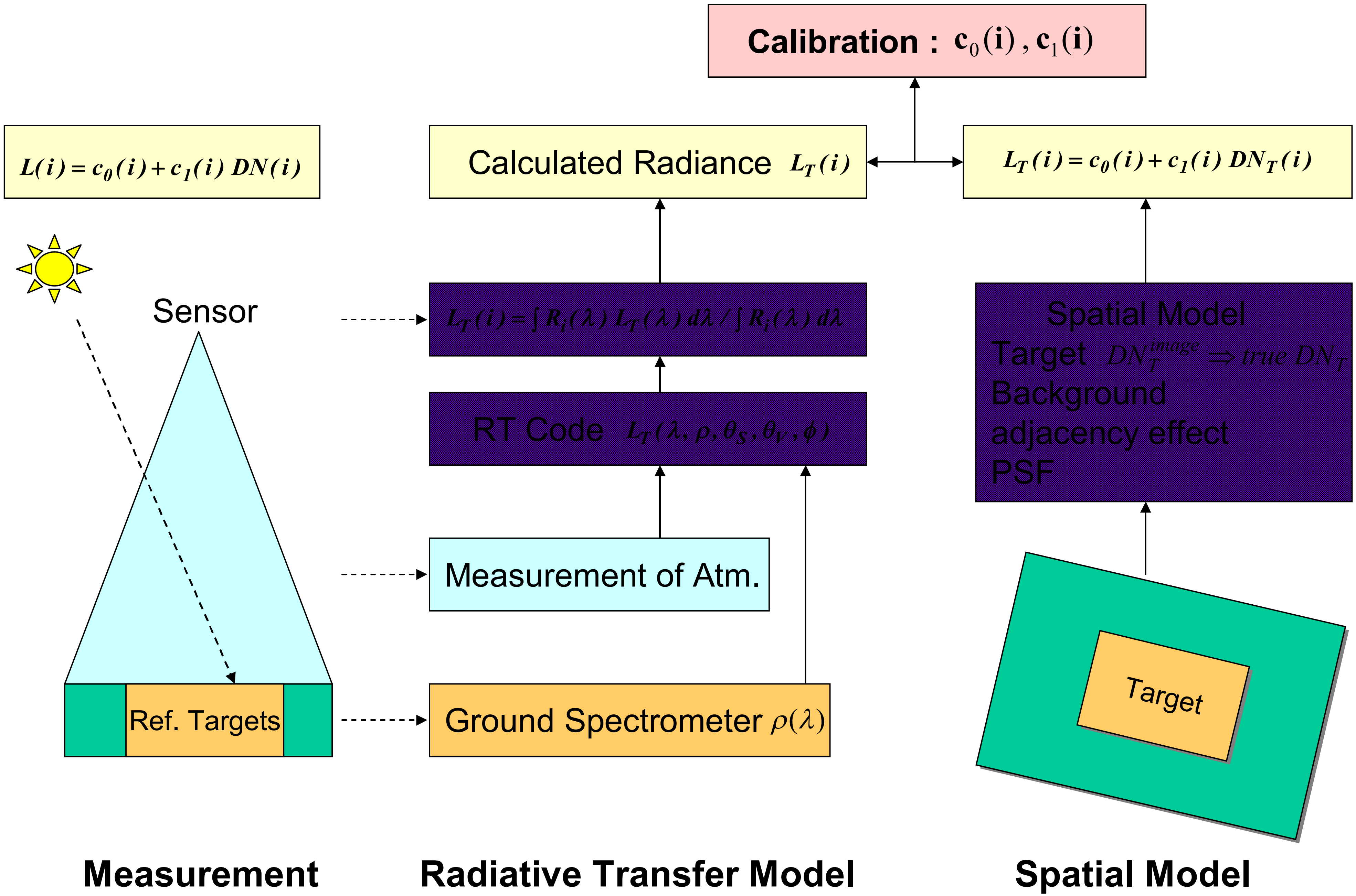


thin: before spectral calibration

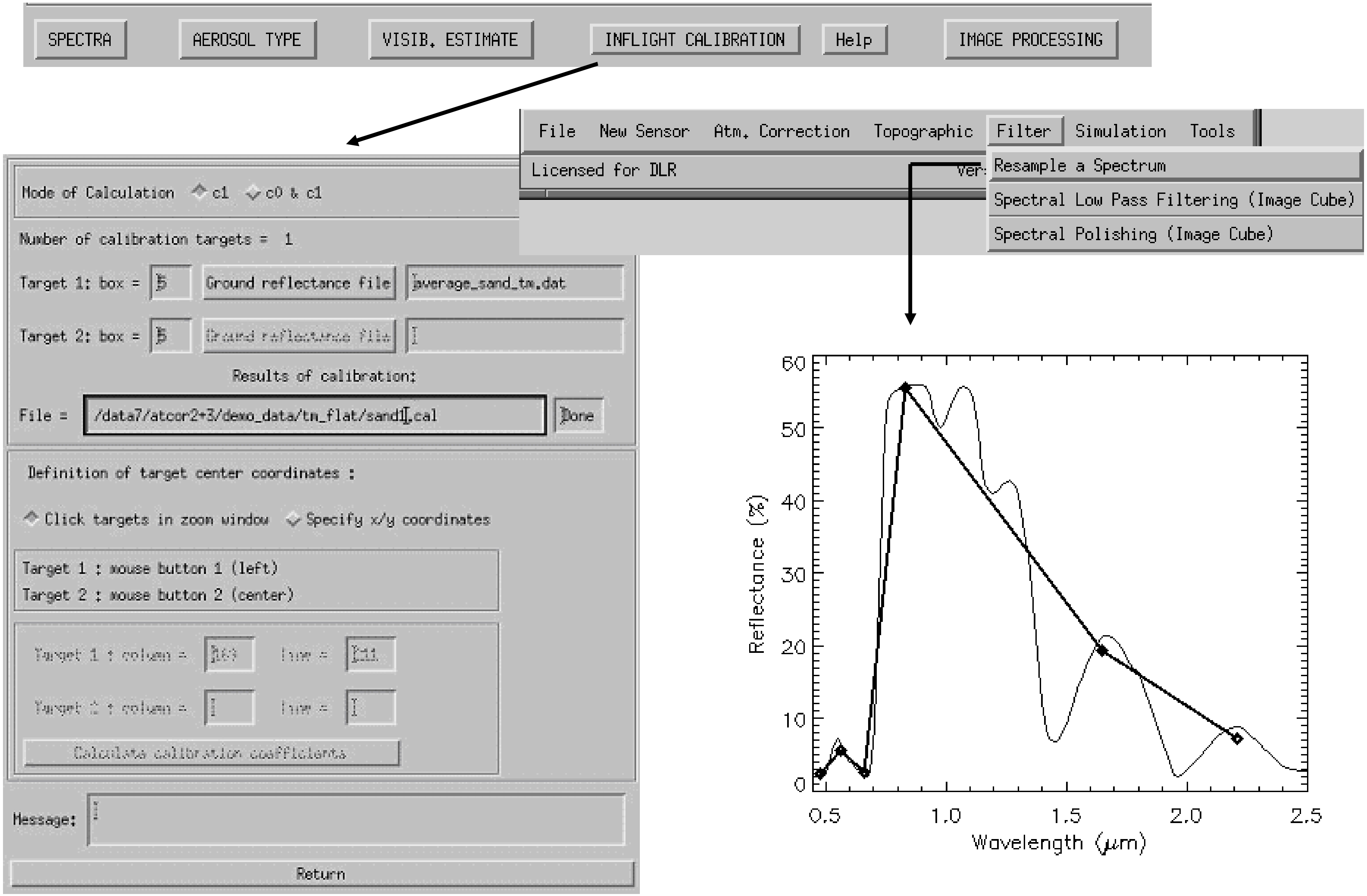
thick: after calibration

AVIRIS spectrum

Inflight Radiometric Calibration (1)

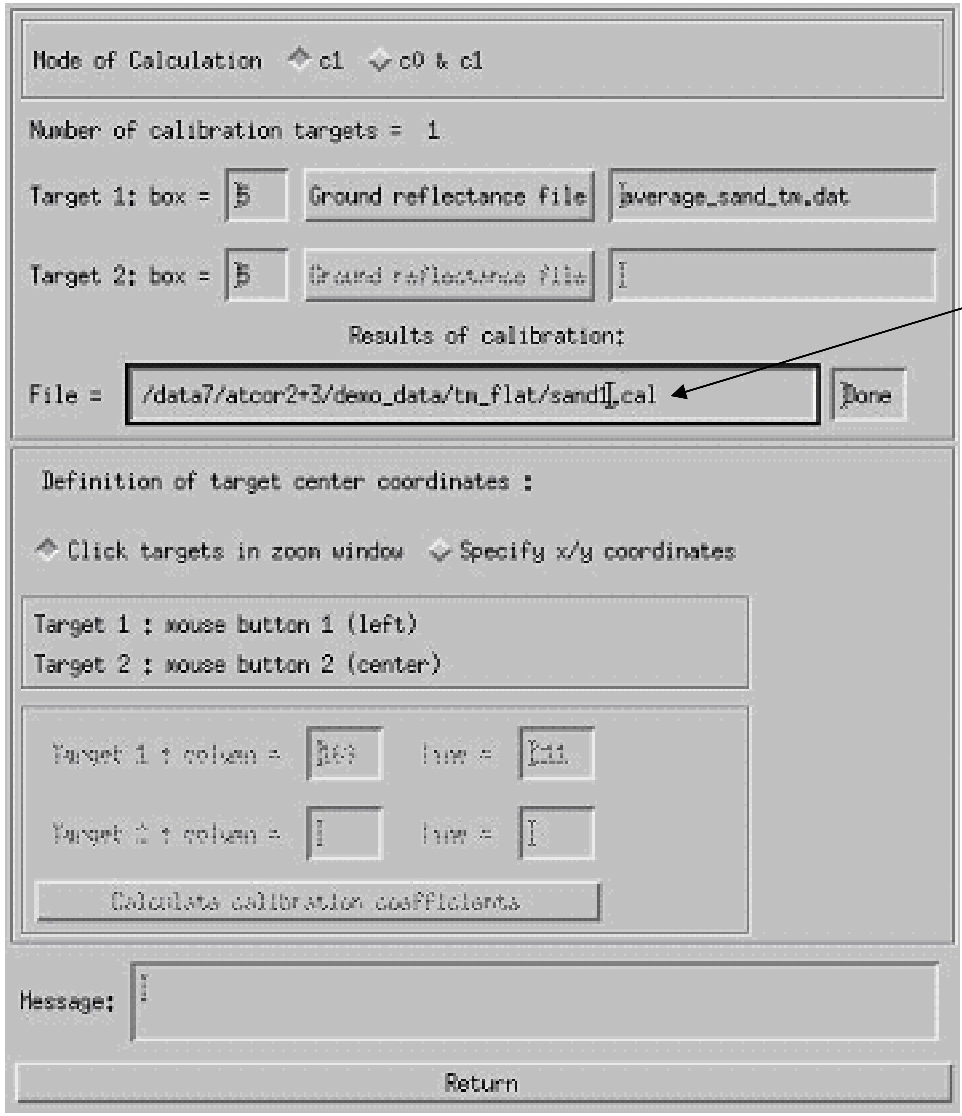


Inflight Radiometric Calibration (2)



German Remote Sensing Data Center

Inflight Radiometric Calibration (3)



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 = 419/ 511	box = 5
0.4856	7.94044	97.4	1.2		
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		

German Remote Sensing Data Center

Inflight Radiometric Calibration (4)

calibration regression analysis:

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

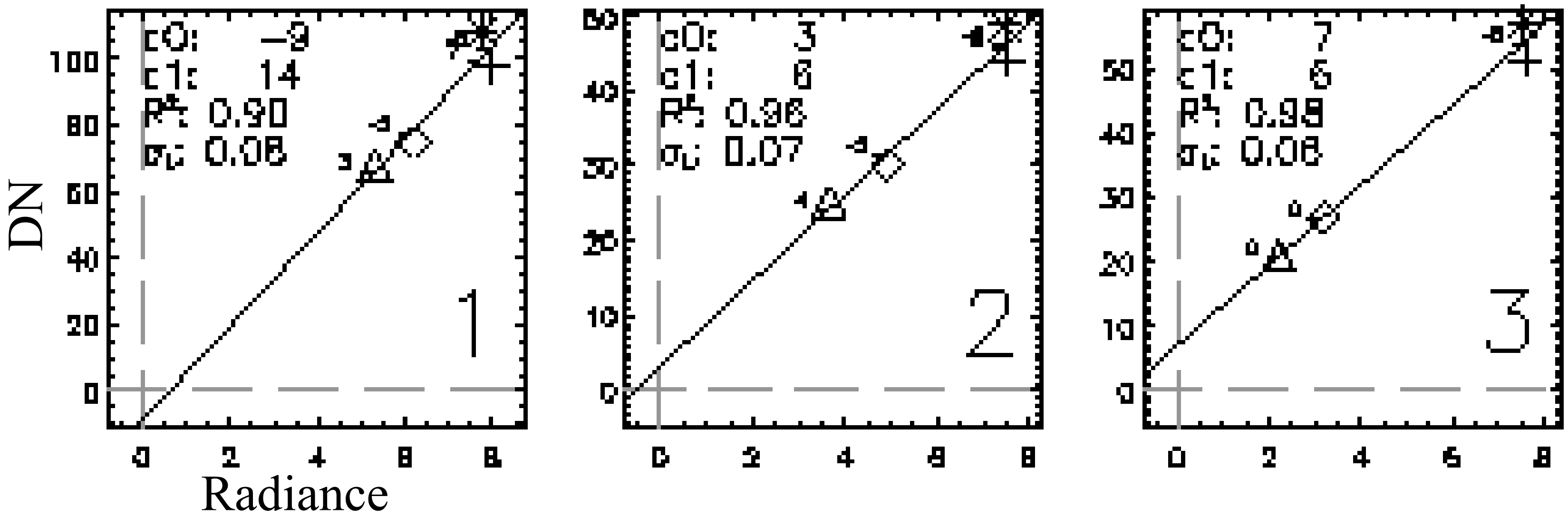
> cal_regress, ntargets=4, outfile=‘regress4‘

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)

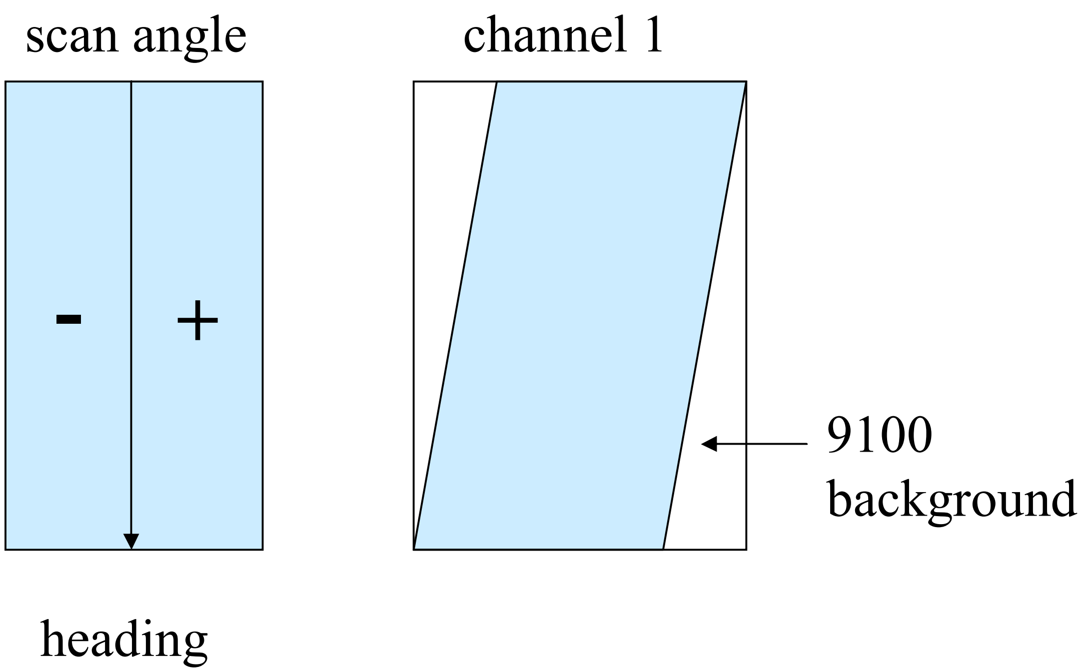
Geocoding with ORTHO or PARGE (http://www.rese.ch) :

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



Airborne ATCOR: scan angle (2)

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

α = - i*(FOV/n) where i=off-nadir pixel number (right of heading)

α = + i*(FOV/n) where i=off-nadir pixel number (left of heading)