Image products from the new hyperspectral sensor DESIS

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Forth Worth, Texas, USA

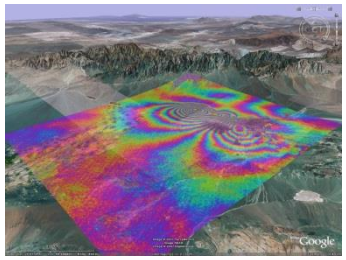
1 DLR – Earth Observation Center

2 DLR – Optical Systems

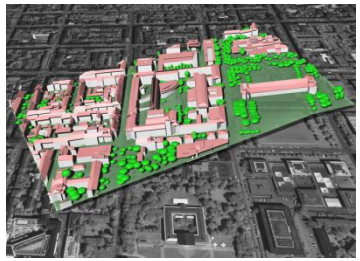
DLR

Deutsches Zentrum für Luft- und Raumfahrt
German Aerospace Agency

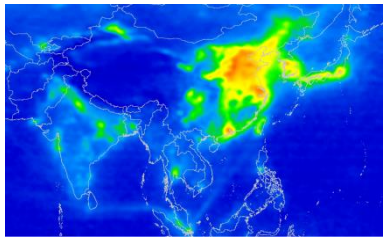
- Aeronautics, Space, Transportation, Energy and Security
- 16 sites in Germany, ~8000 employees
- 45 Institutes
  - Optical Space Systems (Berlin)
  - Earth Observation Center (Oberpfaffenhofen)



Radar



Optical

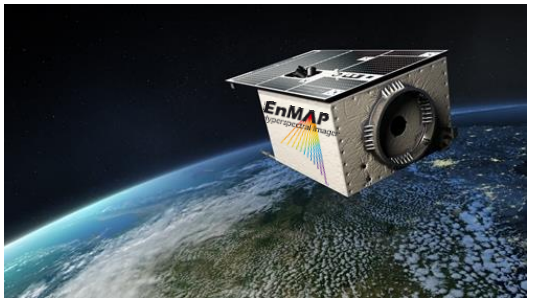


Atmosphere

Washington DC, Brussels, Tokyo, Paris

Competences: Hyperspectral Image Processing

- Spaceborne:
  - The Environmental Mapping and Analysis Program (EnMAP)
  - Biodiversity, climate & ecoystem change, natural resources



- Airborne:
  - HySpex (VNIR&SWIR, operated by DLR)
  - Calibrated & characterised at DLR

- Micro aerial vehicles:
  - Cubert 450-950nm (Frame camera, ~0.5kg)

Consortium: DLR & TBE Data Processing

TBE

Raw image data + auxiliary data

Tasking

Teledyne Mission Control

Request Data

DLR-GS

DLR Requester

DLR DESIS Data Management System

Data Transcription

Data Storage DESIS data + Auxilary data

Data download (Polling)

L1a processor

Data Storage DESIS data + Auxilary data

ToA

Orthoimage

Reflectance

TELEDYNE BROWN ENGINEERING Everywhereyoulook™

Share Calibration
Share Validation

ToA

Orthoimage

Reflectance

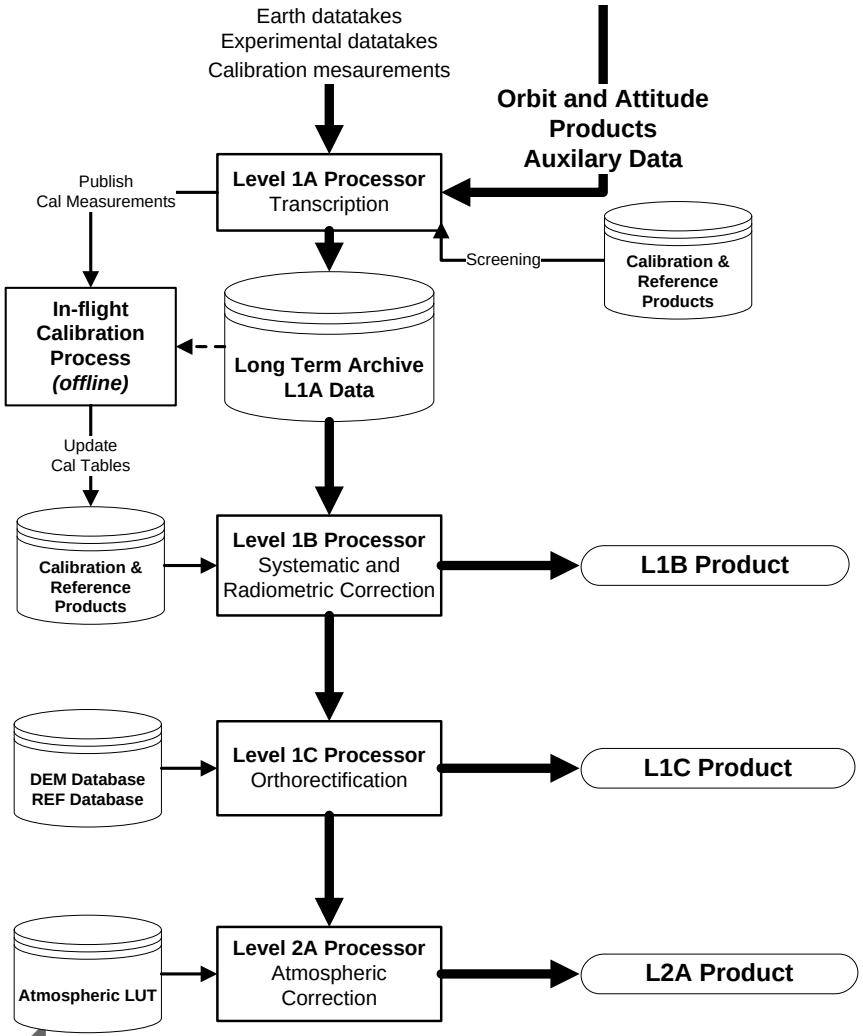
DLR

Commercial Partners

Scientific Partners

DLR

Processing Chain



L1A

- Data from different data streams: Image data, calibration data, AOCS, prepared for long term data storage.
- Not delivered to the user.

L1B

- L1A data + applied systematic and radiometric corrections (housekeeping and AOCS data appended).
- TOA radiance.

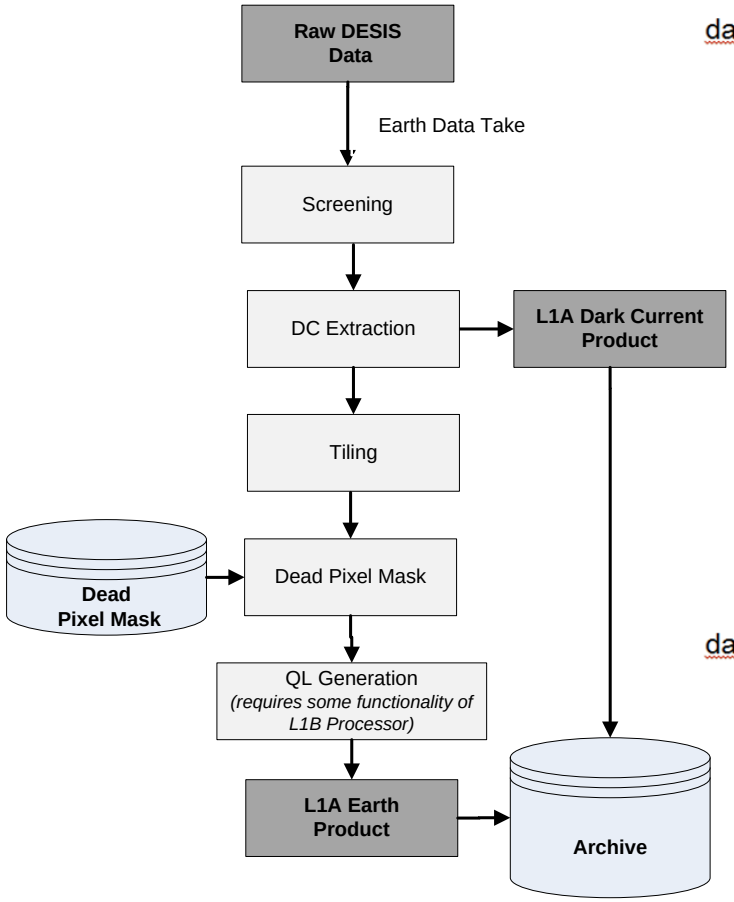
L1C

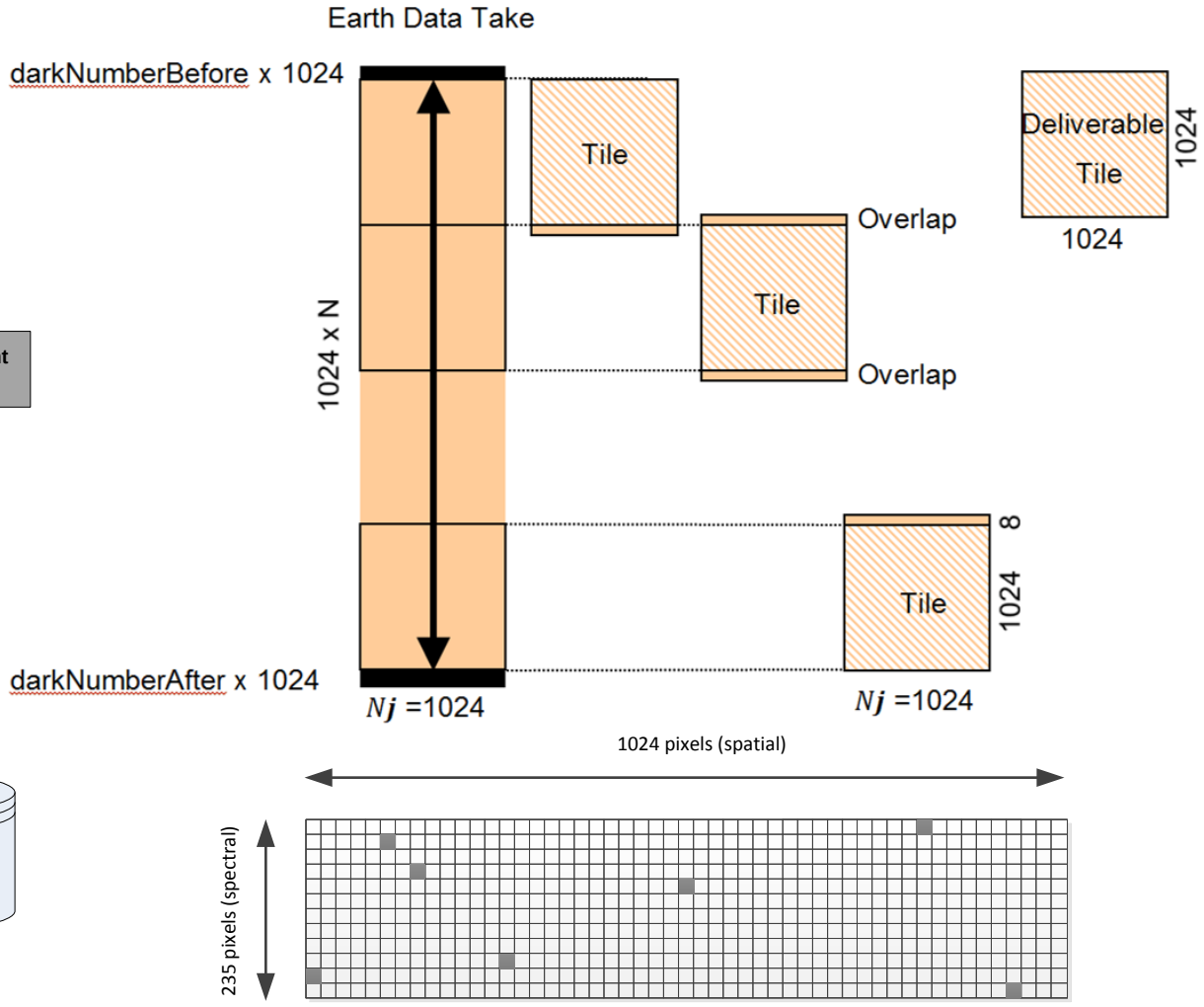
- Orthorectified and resampled L1B data
- Direct georeferencing, DEM.

L2A

- Atmospheric corrections

Level 1A Processor



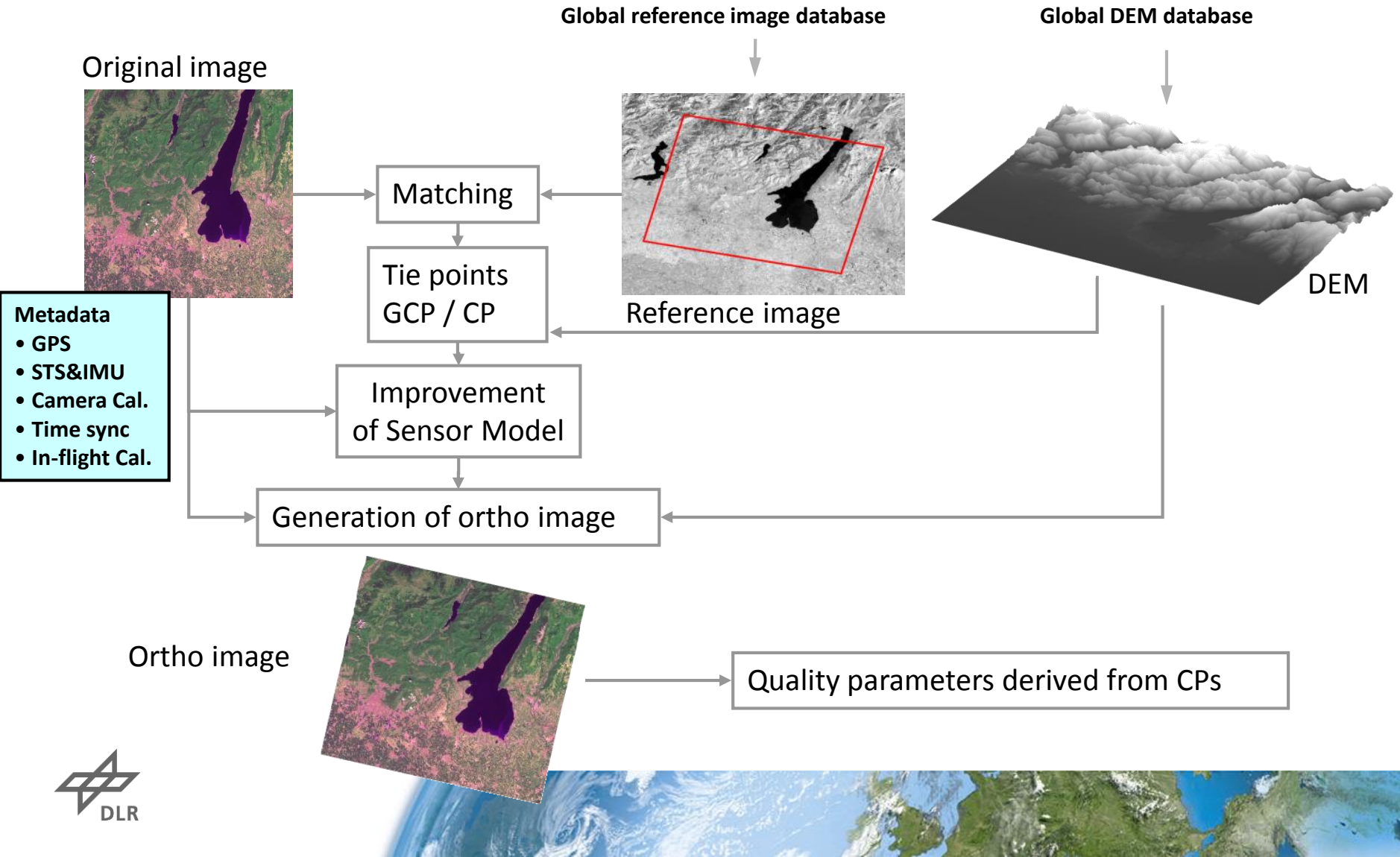


Geometric Correction Processor L1C: Overview

Geometric Correction of L1B Product for sensor, satellite motion and terrain related geometric distortions:

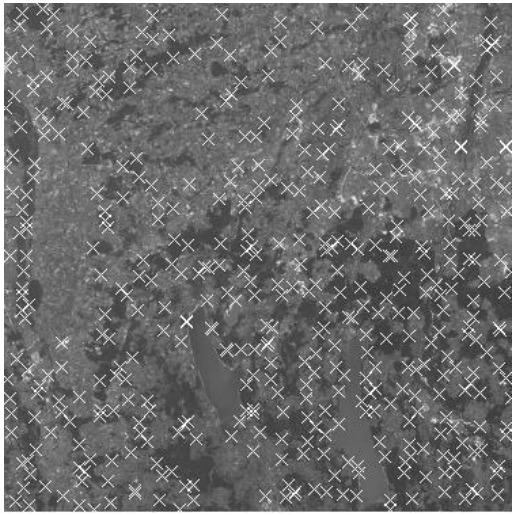
- Sensor Model (including laboratory calibration & in-flight boresight angles)
- Sensor Model refinement by automatic GCP extraction from references
  - Different image matching methods
  - Several outlier detection and removal mechanisms
- Resampling by accounting for the rolling shutter
- Geometric performance targets
  - 0.5 pixel (15 m) w.r.t. Landsat-8 orthos (linear RMSE)
  - 95% achievement

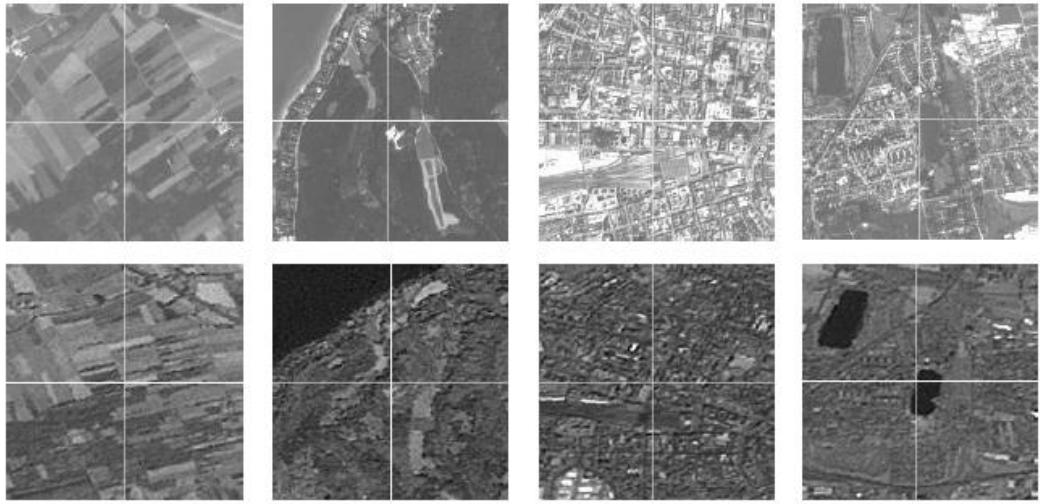
How to improve the geometric accuracy? *within an operational environment*



DLR

Tie points generation





(c) agriculture area (d) woodland (e) urban zone (f) lakeshore

Outliers: detect and remove

- By quality parameters of matching process
- By selection of only „best matches“ in a cell
- By consistency with Sensor Model

Level 1C Processor: ALOS/PRISM Example

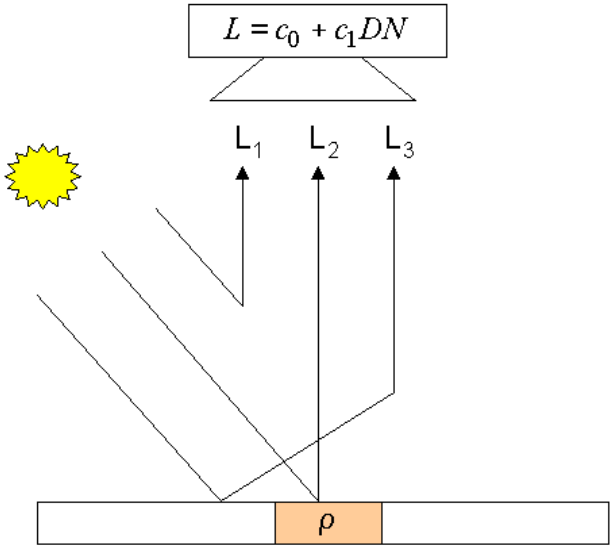
- L1B image product: applied systematic and radiometric corrections
- TOA radiance

- L1C image product: Geometric correction

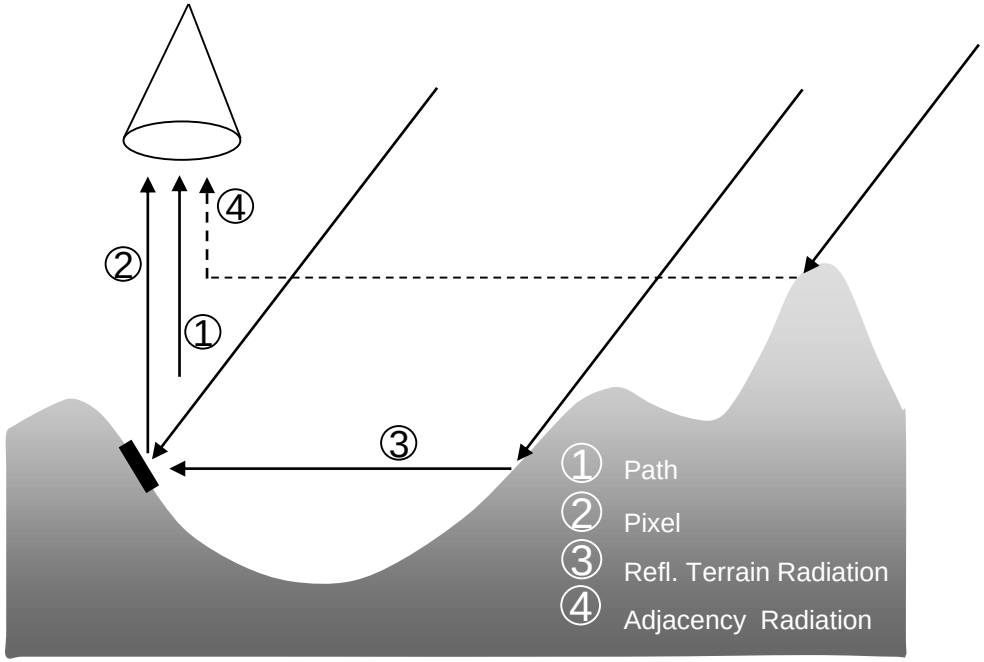
L2A Processor

- ATCOR – atmospheric correction accounting for elevation model

Radiation components flat terrain



Radiation components rugged terrain



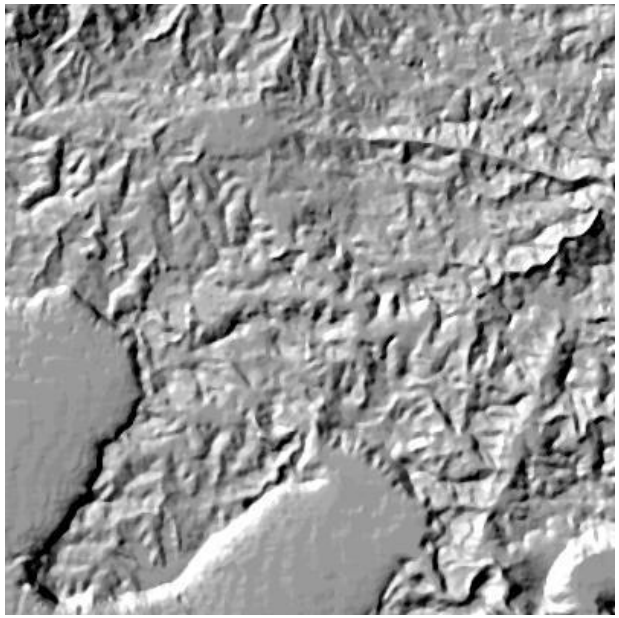
Surface reflectance

$$\rho = \frac{\pi (L - L_1)}{\tau (E_{dir} \cos\theta_s + E_{dif})}$$

L2A Processor

- ATCOR – atmospheric correction accounting for elevation model
- High geometric accuracy needed for topographic correction

- Atm + Topo corrected
- Geom. Acc. < 1 pixel

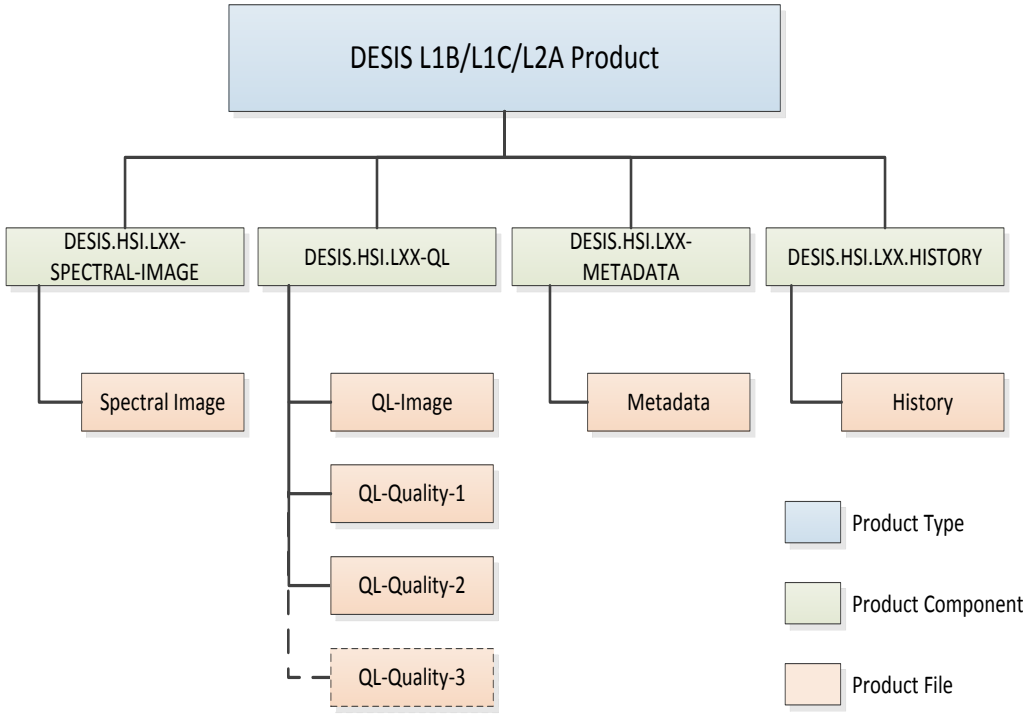


- Illumination map
- cos(local SZA)

- atm + topo corrected
- 3 pixel shift →

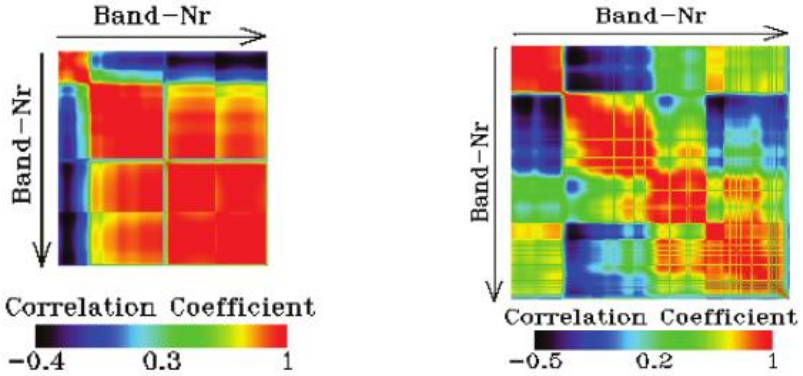
Products

- Data Products:
  - L1A Earth
  - L1A Calibration
  - L1A Dark Current (DC)
  - L1A Experimental
  - **L1B, L1C, L2A Products**
- Calibration:
  - Pre-launch and onboard measurements
  - Geometric
- Reference Products:
  - Dark current
  - Dead pixels
  - Etc.



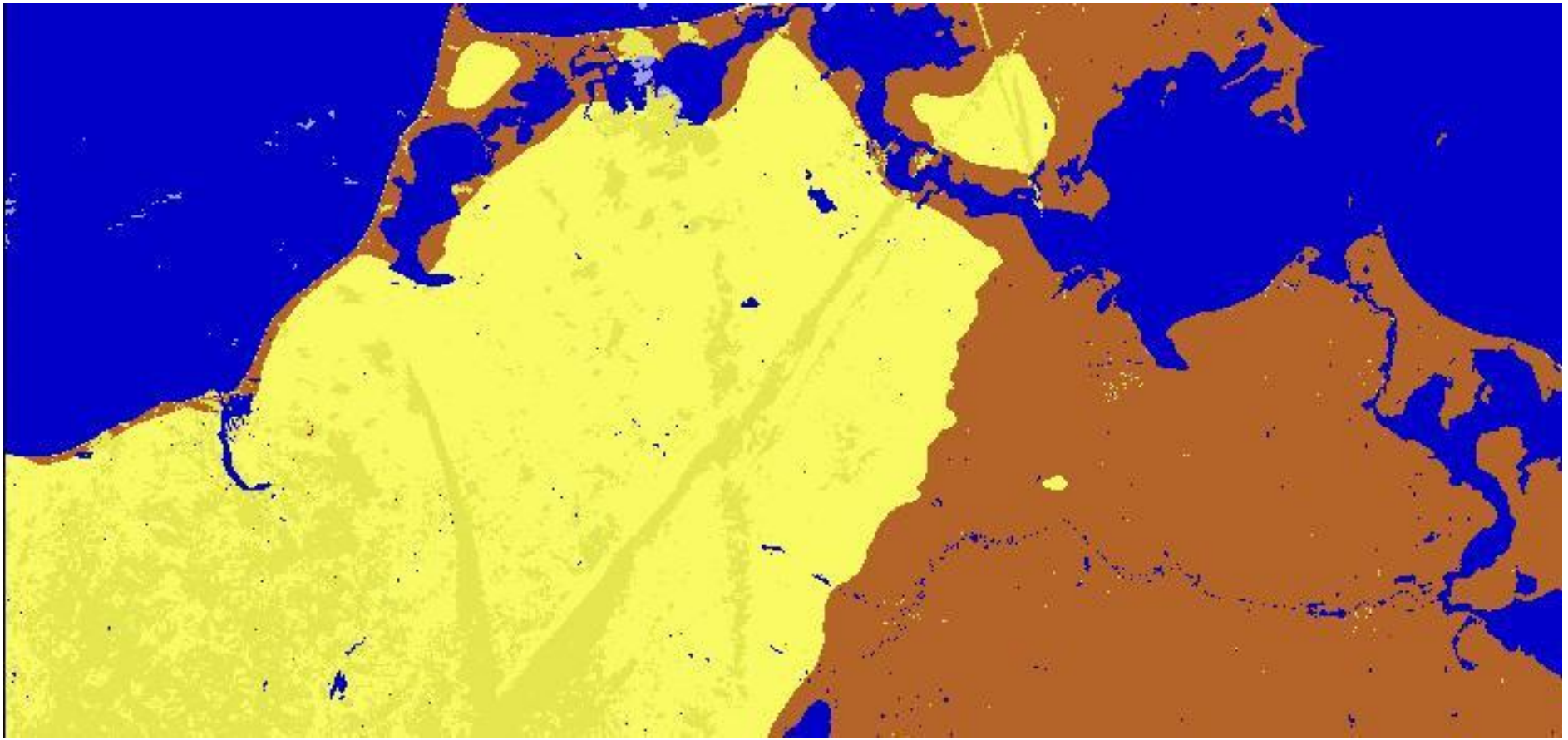
Quality Quicklooks

Quality Layer (Geotiff)	L1B	L1C	L2A
Dead pixels	X	X	X
Abnormal pixels	X	X	X
Too high radiance level	X	X	X
Too low radiance level	X	X	X
Shadow			X
Land			X
Water			X
Haze over land			X
Haze over water			X
Cloud over land			X
Cloud over water			X
Aerosol optical thickness			X
Perceptible water vapour			X
Band cross-correlation	X	X	X
Bad columns	X		
Bad lines	X		



Band-cross-correlation matrix

Quality Quicklooks



Haze / Cloud / Water / Land

Processor Performance Estimation

Parameter	Time/Size estimations
Average. datatake/day	5.5 minutes or 2400 km (40 GBytes /day)
Tile size	30 × 30 km (482 Mbytes/tile)
Max.L1A image tiles / day	100
Processing time DESIS_HSI_L1A / tile	20 minutes
DESIS_HSI_L1A processing time / day	33.3 hours
Max. L2A tile orders / day	200 (assuming 1 order/tile) GS-DLR Requirement
DESIS_HSI_L1B / tile	10 minutes
DESIS_HSI_L1C / tile	20-40 minutes
DESIS_HSI_L2A / tile	15 minutes
Processing time DESIS_HSI_L2A / tile	45-65 minutes

The calculations are based on the following software (SW): CentOS 5.9, x86_64, 2.6.18-348.4.1.el5 and hardware (HW): AMD Opteron 63xx (8 cores). Time estimations for processing one tile are calculated using one core.

DLR

Conclusions

- Processors support
  - L1B, L1C, L2A product generation
  - Product with 4 different binnings
  - Earth data mode, and experimental modes: BRDF, continuous
  - On demand processing

- Same processors at TBE and DLR → Same product delivered to the users

- Close cooperation on outcomes of calibration and validation activities

Subsequent Presentations

Ray Perkins, Chief Engineer, MUSES Ground Segment, Teledyne Brown Engineering
"Teledyne's Multi-User System for Earth Sensing (MUSES)""

Janja Avbelj, PhD, DLR Remote Sensing Technology Institute
"Image products from the new hyperspectral sensor DESIS"

Lewis Graham, President & CTO, GeoCue Group
"Building High Performance Processing Systems in Amazon Web Services"

Ray Perkins, Chief Engineer, MUSES Ground Segment, Teledyne Brown Engineering
"Imaging Spectroscopy Applications Using the DESIS Hyperspectral Instrument on MUSES"