CEOS WGCV IVOS 31, Perth

"TIMELINE"AVHRR Re-Processing

DLR German Aerospace Center
EOC Earth Observation Center & OS Optical Sensor Systems

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DLR-EOC

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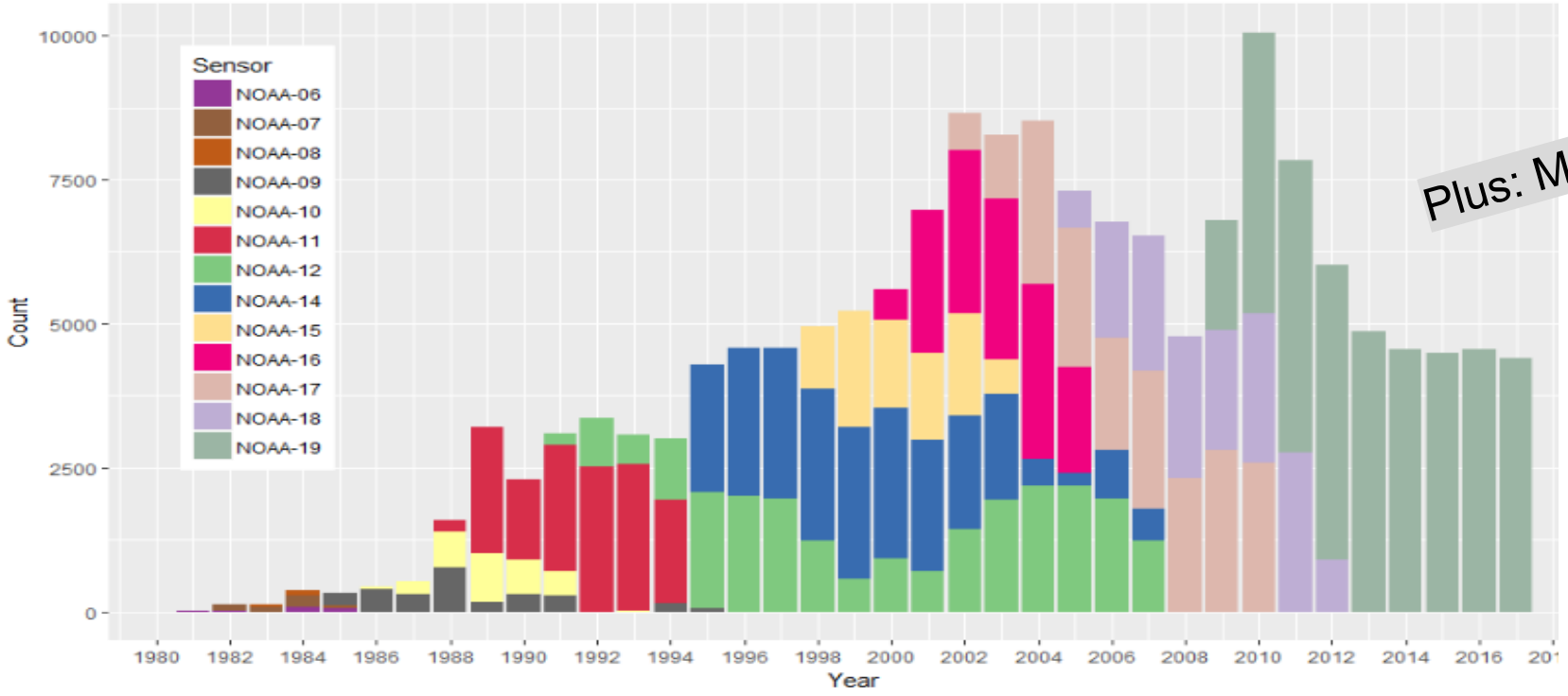
AVHRR L1B Data volume @ DLR's DIMS archive (by Jan. 2019)

– HRPT-Data for Europe & North Africa @ 1 km nadir GSD
  – **~174.000** L1B Products **~70 TByte**

– GAC-Data global @ 4 km nadir GSD
  – **~289.000** L1B Products **~25 TByte**



Plus: MetOp A & B

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TIMELINE Products

In Orbit-Geometry (Level-1b & Level- 2)	Gridded composites (Level-3)
Top-of-Atmosphere Reflectances	
Cloud mask, Cloud products	Cloud products
Water mask	
BOA Reflectances, incl. BRDF correction	
Snow & Ice	Snow & Ice
Hot Spot	Hot Spot
	Burnt Area
Albedo	Albedo
Land Surface Temperature	Land Surface Temperature
NDVI	NDVI
	FAPAR
	LAI

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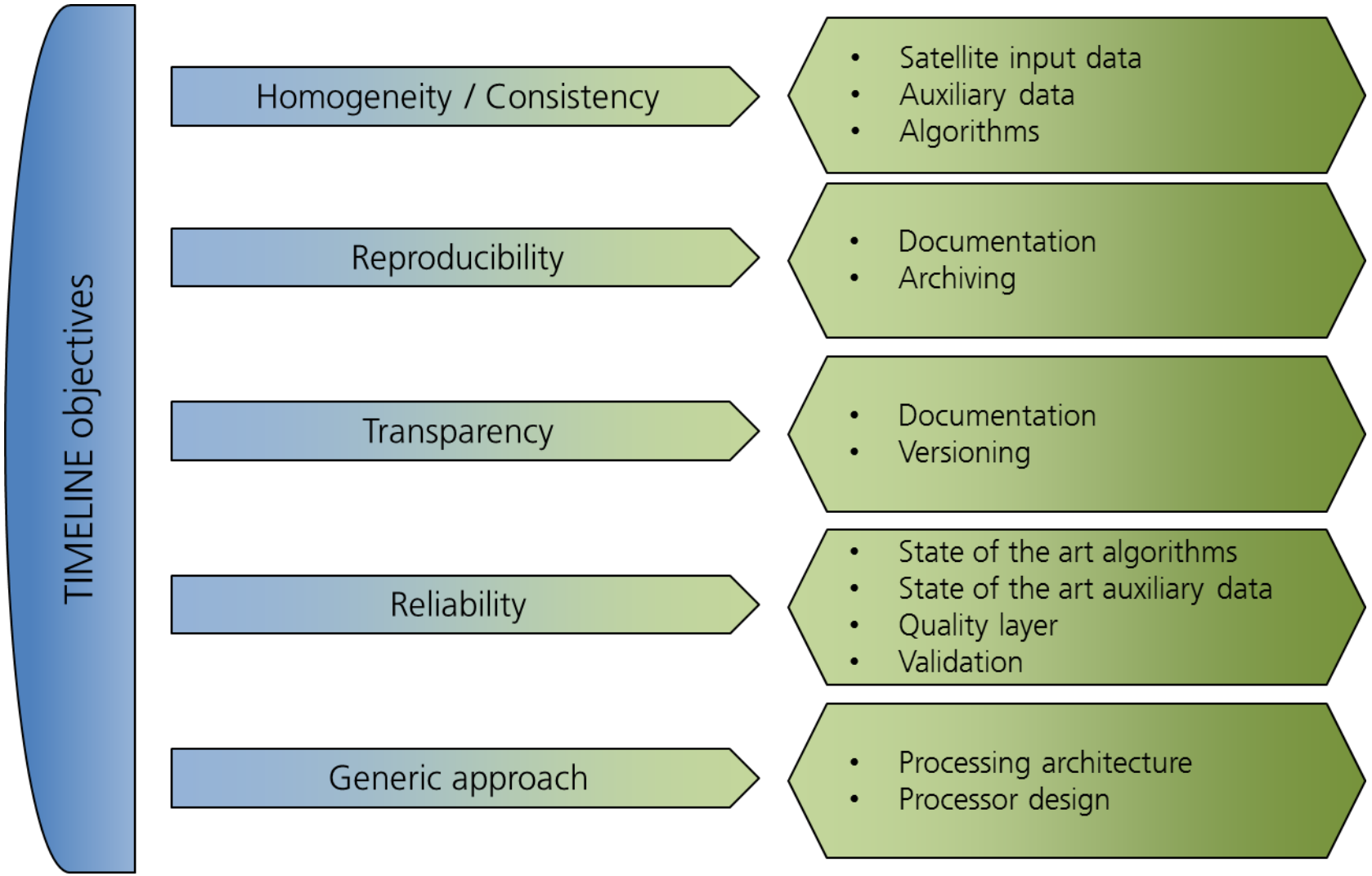
Translation of objectives into requirements



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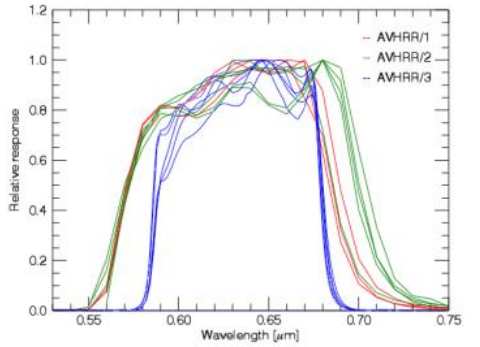
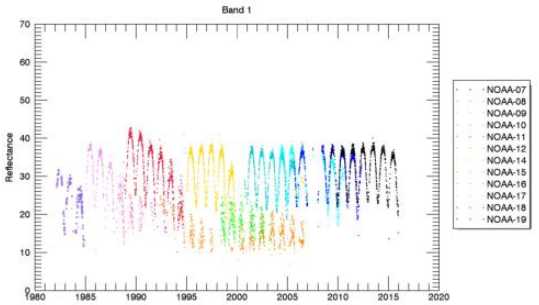
Challenges & Improvements

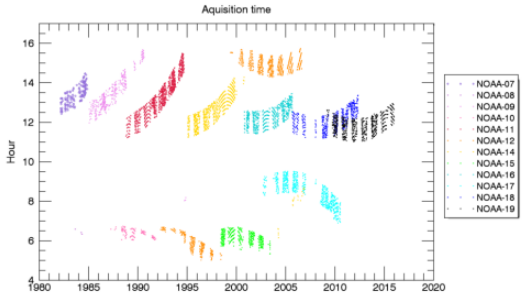
- Multiple sensors with slightly different SRFs
  - ➢ Spectral normalization (empirical model using HYPERION data)
- (Slight) inconsistency in radiometry when using NOAA OSPO calibration factors
  - ➢ Radiometric harmonization using PICs sites
- Drifting orbits
  - ➢ BRDF correction, parametrization from data using ± 1 months window
- Errors and „noise" in data
  - ➢ Provision of data quality measures and typical uncertainties



Spectral response functions (SRF) of AVHRR sensors on NOAA-7 untill NOAA-19, band 1



Lybia 4 time series (tech. Albedo)



Lybia 4 time series acquisition times

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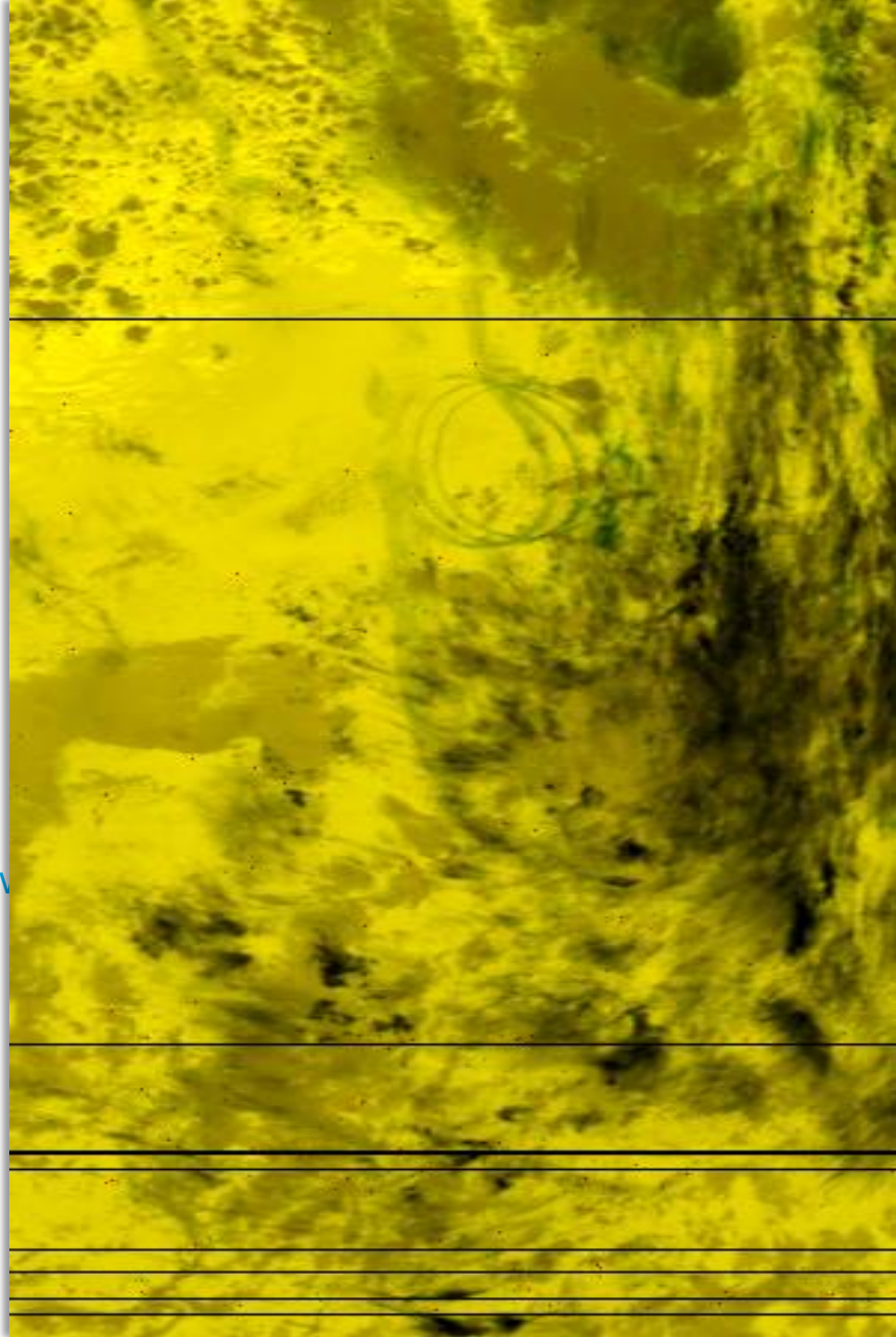

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Spectral normalization

Hyperspectral database:

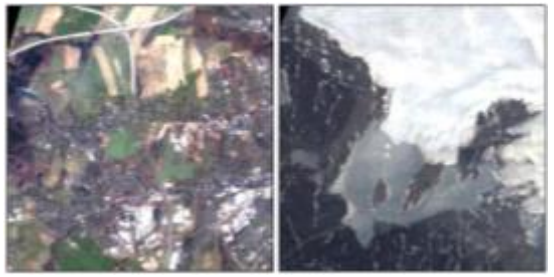
– 10 HYPERION 1GsT products (TOA-rad and BOA-ref (ATCOR))
  – data from Greenland to North Africa
  – diversity in biomes and land cover classes
  – diversity in seasonality

Advantages:

– over 11 mio. spectral samples
– well-known stability (VNIR shifts <1.5 nm, GREEN et al., 2003)
– uncertainty in L2 & L3 products resulting from spectral stability can be estimated

Approach similar to STEVEN et al., 2003, 2007

– Least-square fitting to reference sensor (NOAA 19), linear model (polynominal & sigmoid tested)

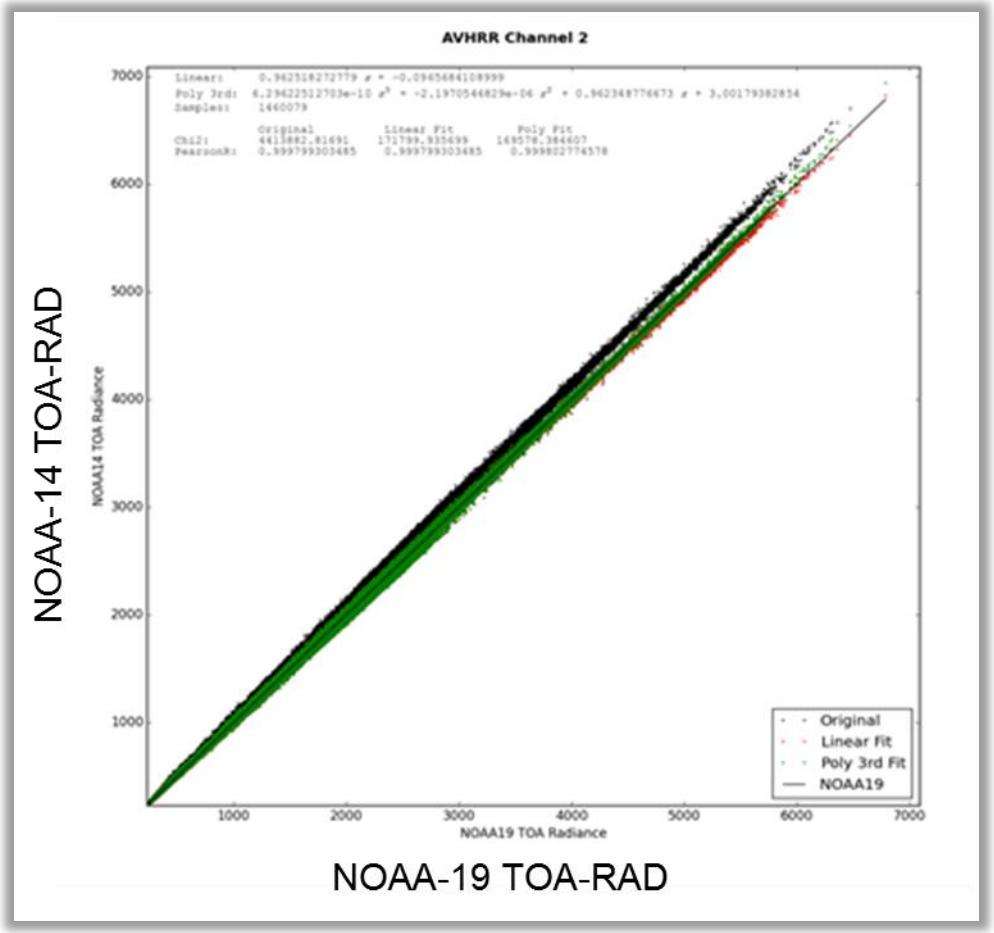


Spectral normalization

Approach similar to STEVEN et al., 2003, 2007

- Least-square fitting to reference sensor (NOAA 19)
- Exclude critical bands & pixels (well-known HYPERION defects)
- Resample from ~11 to 5 nm FWHM, convolve to AVHRR pre-launch SRF

- Results:
  - Linear model sufficient (polynomial & sigmoid also tested)
  - Residual error is non-Gaussian
  - Statistical dependency between residual error and NDVI, weak for AVHRR band 1 (Pearson R^2 ~0.2), not negligible for AVHRR band 2 (R^2 ~0.5)
  - Splitting of samples into NDVI classes before regression shows only marginal improvement
  - SWINNEN & VEROUSTRAETE (2008) describe these errors as regionally variable and depending on biomass, i.e., BRDF effects



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Spectral normalization

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    AVHRR band 2 (R^2 ~0.
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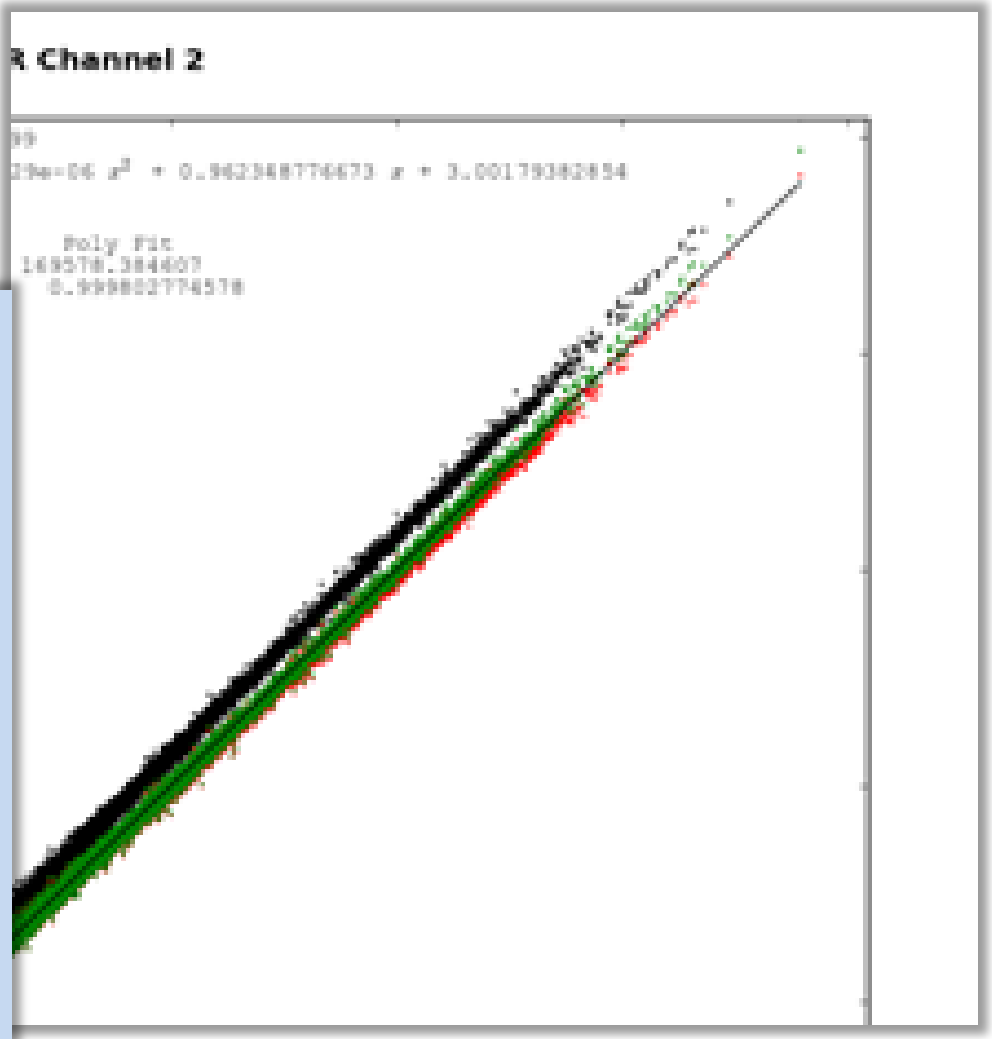
Depicted:
scatter plot of channel 2,
NOAA-14 Vs. NOAA-19
for clarity: 1.4 Mio out of 11 Mio data samples

black dots: uncorrected
black line: linear regression model
(offset: -0.094; gain: 0.963)
red dots: linear correction applied
green dots: 3rd order polynomial fit applied



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Harmonization workflow

– For Lybia4:
  1. TOA-Tech. Albedo => TOA-Rad => BOA-Ref
  2. TAC atm. correction using standard atmosphere (AOD climatology), dev. in cooperation with Brockmann
  3. Correction for spectral response functions, normalization to NOAA19
  4. Generation of time series, excluding erroneous & cloudy data
  5. Correction for BRDF
     a) Snyder Parameters as provided by Patrice Henry **=> thank you for your support !**
     b) Roujean fitted from AVHRR data
  6. Generation of harmonization factors based on BOA-Ref time series
  7. Convertion of harmonization factors back to TOA-Rad

– Check for validity by applying harmonization factors to Algeria3, La Crau & Demmin time series

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Harmonization database

- L1B processor „bypass" in order to derive
  - small image subsets (~15^2 to ~100^2 pixels) over CEOS sites Algeria3, Lybia4, La Crau, Demmin
  - data calibrated to NOAA OSPO, in units of „technical albedo"
  - all metadata from hrpt file available (instrument temperatures, deep space readings etc.)
  - all bands, Lat/Lon grids, view & sun grids, plus cloud masks available

```
ch1_ramp_cal.ascii  ch2_space.bin       ch3_space.hdr       ch4_space.bin   ch5_ramp_cal.ascii  ch5_target.hdr     sitedata_algeria3      sitedata_lacrau
ch1_space.bin       ch2_space.hdr       ch3_target.bin      ch4_space.hdr   ch5_space.bin       Min_Max_Stats.txt  sitedata_algeria3.hdr  sitedata_lacrau.hdr
ch1_space.hdr       ch3_ramp_cal.ascii  ch3_target.hdr      ch4_target.bin  ch5_space.hdr       prt.bin            sitedata_demmin        terascanlog.log
ch2_ramp_cal.ascii  ch3_space.bin       ch4_ramp_cal.ascii  ch4_target.hdr  ch5_target.bin      prt.hdr            sitedata_demmin.hdr
```

- Number of tiles:
  - La Crau: 12.107 datasets
  - Lybia4: 11.635
  - Algeria3: 13.305
  - Demmin: 11.207
- Generation of database (IDL .sav & .csv) for each site
  - Structure:

Data can be made available !

Date	Platform	Sat zenith	Sat azi.	Sun zenith	Sun azi.	Mean Band 1	Mean Band 2	Mean Band 3	Mean Band 3a	Mean Band 4	Mean Band 5	Stdev Band 1	Stdev Band 2	Stdev Band 3	Stdev Band 3a	Stdev Band 4	Stdev Band 5

Current status

Processing:

- L1B: done
- L2A Atm. Correction: done for 1988-2014
- L2A BRDF (fitted from the data): in progress

Harmonization factors:

- 1st set of factors derived, validation ongoing (waiting for L2A processing to be finished)

Upcoming:

- 1st batch of thematic products: cloud products using APOLLO NG, snow mask, water mask, NDVI
- Re-processing of L1B when improved TIR calibration from FIDUCEO will be made available

TIMELINE

www.timeline.dlr.de

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FireBird sensors on TET-1 & BIROS Satellites

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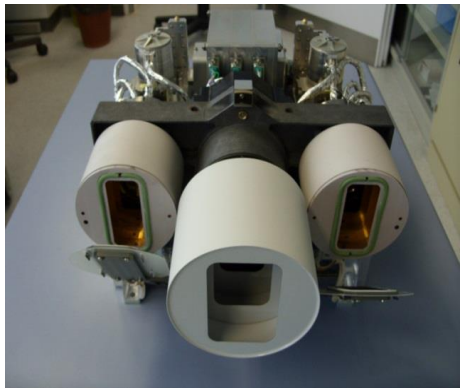
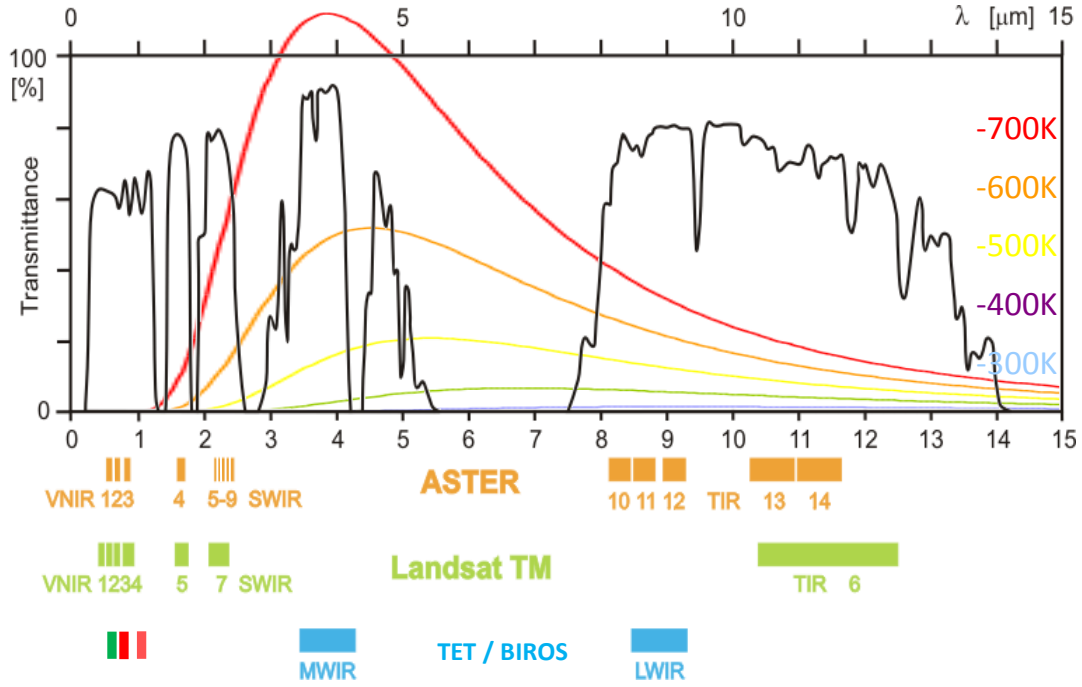
FireBird Instrument Design





	3 line-Camera (3 line FPA)	2 Infrared- Cameras
Wave length	460 - 560 nm 565 - 725 nm 790 - 930 nm	MWIR: 3,4 - 4,2 µm LWIR: 8,5-9,3 µm
Focal length	90,9 mm	46,39 mm
FOV	19,6°	19°
F-Number	3,8	2,0
Detector	CCD- Zeile	CdHgTe Arrays
Detector cooling	Passive, 20 ° C	Stirling, 80 - 100 K
Pixel size	7 µm x 7 µm	30 µm x 30 µm
Number of Pixel	3 x 5164	2 x 512 staggered
Quantization	14 bit	14 bit
Ground Resolution	42,4 m	356 m
GSD	42,4 m	178 m
Swath width	211 km km	178 km
Data rate	max 44 MBit/	0,35 MBit/s
Accuracy	100m on ground	100m on ground

In orbit since
2012 / 2016

Products – In-Orbit Validation