

A Long Term Data Record from AVHRR, MODIS and VIIRS

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Long Term Land Data Record

- Develop and produce a global long term coarse spatial resolution (0.05deg) data record from AVHRR, MODIS and VIIRS for use in global change and climate studies.
- Use a MODIS-like operational production approach including an operational QA team.
- Set up an advisory process.
- Make intermediate versions of the data sets available to the community through a web interface and solicit input from users.
- Hold community workshops for outreach and feedback.
- Prototype the development and production of a climate quality data record.

LTDR Products

AVHRR, MODIS, VIIRS:

Surface reflectance

Vegetation Indices

Surface temperature and emissivity

Snow

LAI/FPAR

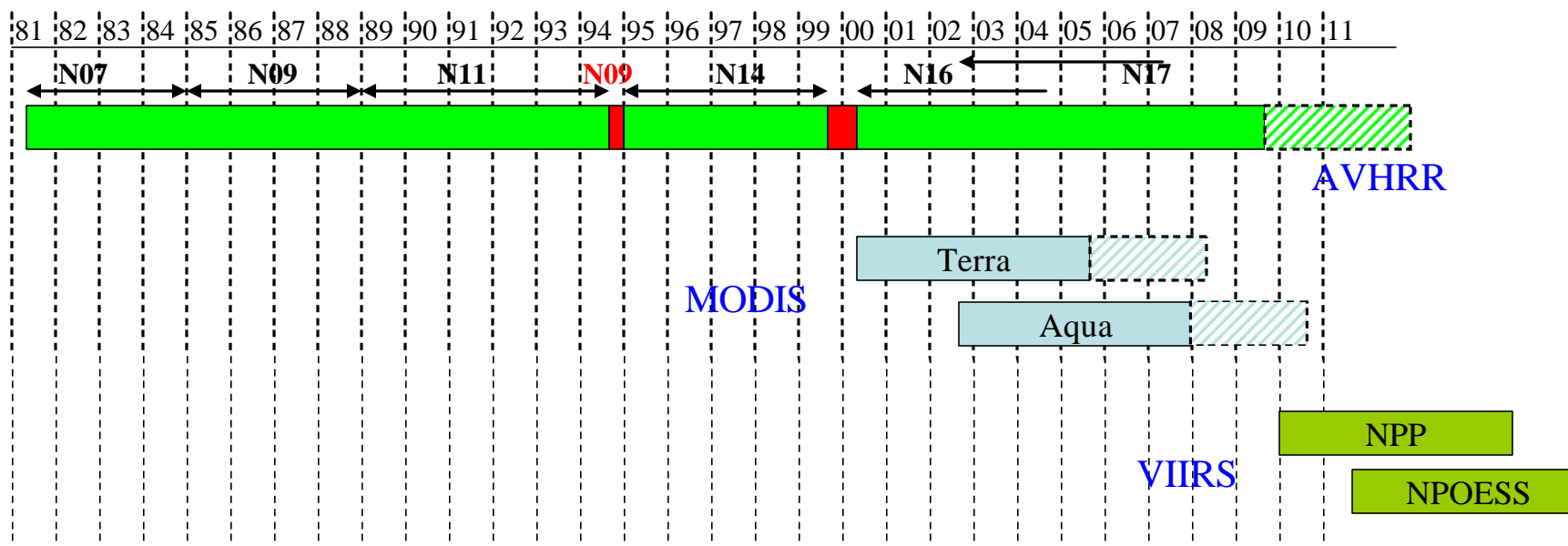
BRDF/Albedo

Aerosols

Burned area

Products and formats will be modified based on feedback from the User Community Workshops.

Data Sources



Existing Production Systems

AVHRR:

-Pathfinder AVHRR Land (PAL) data set produced and distributed by GSFC DAAC.

-NOAA (GVI).

-Others: e.g. GIMMS.

Differences in these products due to different processing approaches.

The most widely used is the PAL data set. However, it uses a suboptimal radiometric degradation assumption and includes partial atmospheric correction.

MODIS Terra and Aqua:

-Level 1 produced and distributed by GSFC DAAC.

-Land Level 2 and higher products are generated in MODAPS at GSFC-Code 614.5 (Ed Masuoka) and distributed from the ECS DAACs.

-Products created in this system are validated to stage 2 and have published accuracies.

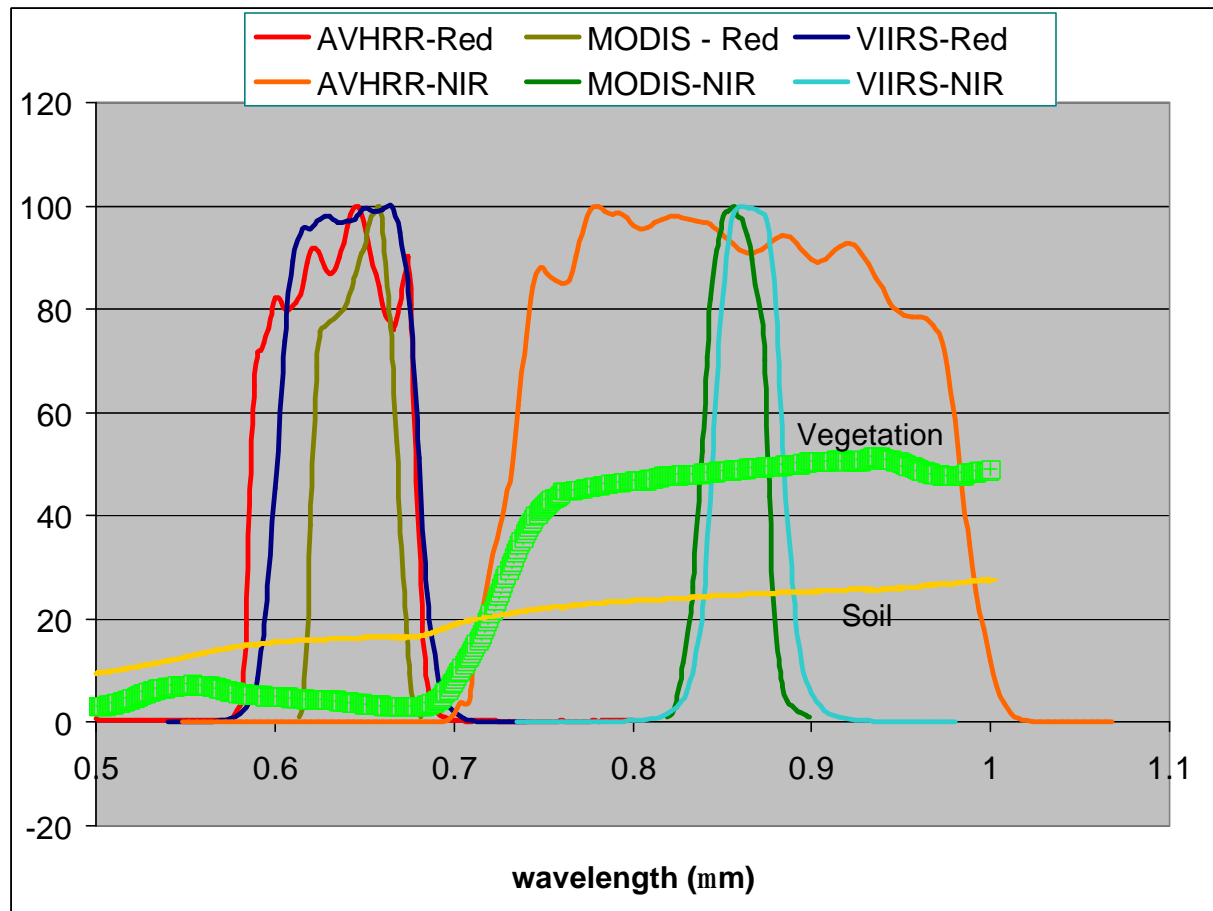
NPP/NPOESS:

under development.

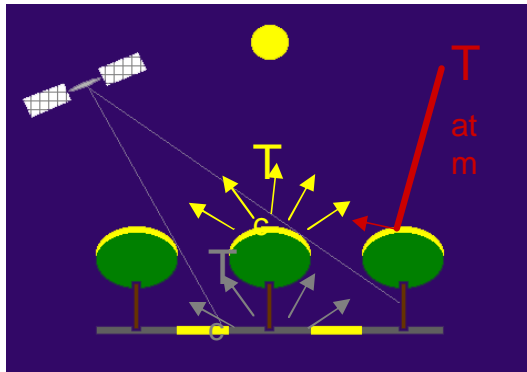
Input Data Characteristics

- Different over pass time
- Different illumination and viewing geometries
- Different spatial resolution : AVHRR (1km, 4 km),
MODIS (250m, 500m, 1km), VIIRS (
- Available spectral bands: AVHRR (1 Red, 1 NIR, 3 IR),
MODIS (36 bands Blue -> IR), VIIRS (22 bands Blue -> IR)
- Onboard VIS/NIR calibration (AVHRR: No, MODIS: Yes, VIIRS: Yes)

Relative Spectral Response



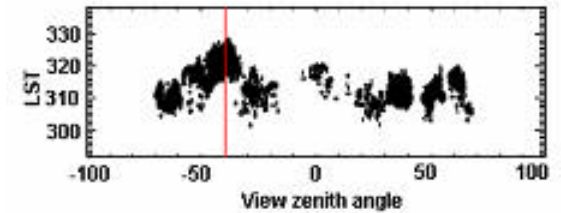
Variable geometry impacts land surface temperature retrievals



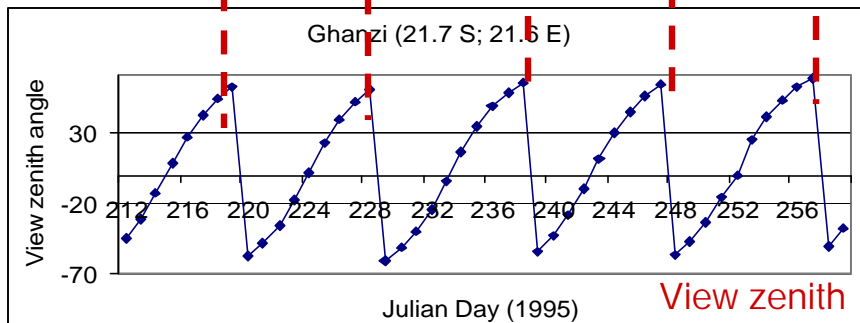
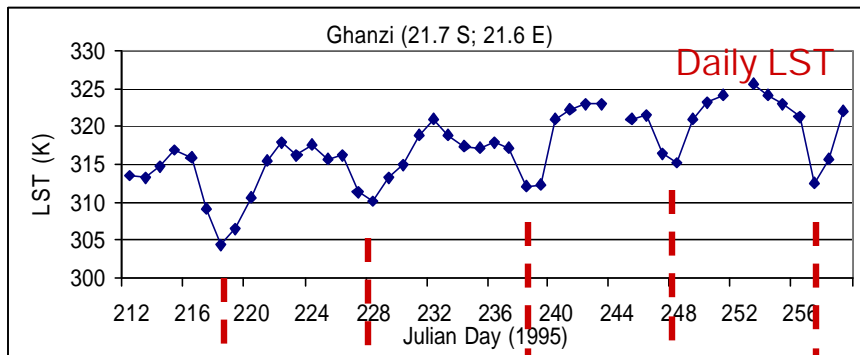
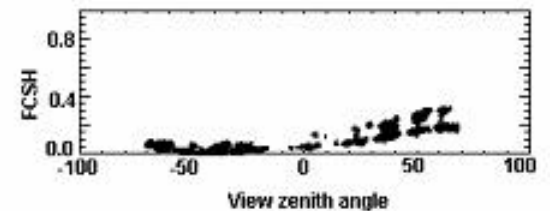
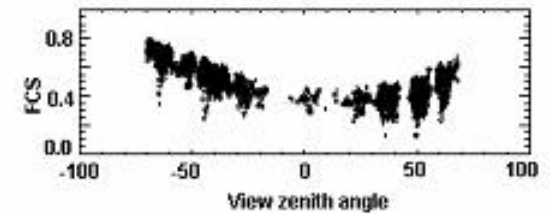
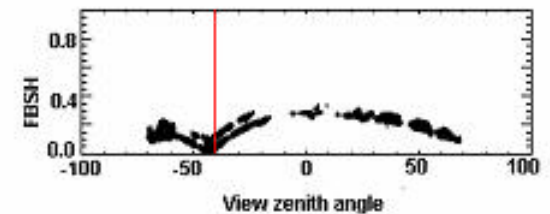
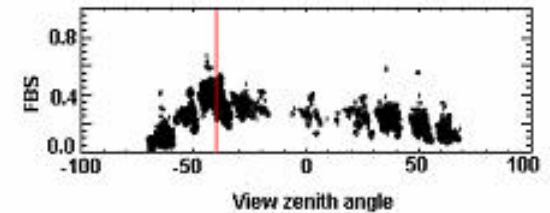
Combined effect of:

- Vegetation structure (3D)
- Orbital characteristics
- AVHRR sensor characteristics

Daily AVHRR LST over a woodland site



projected fractions

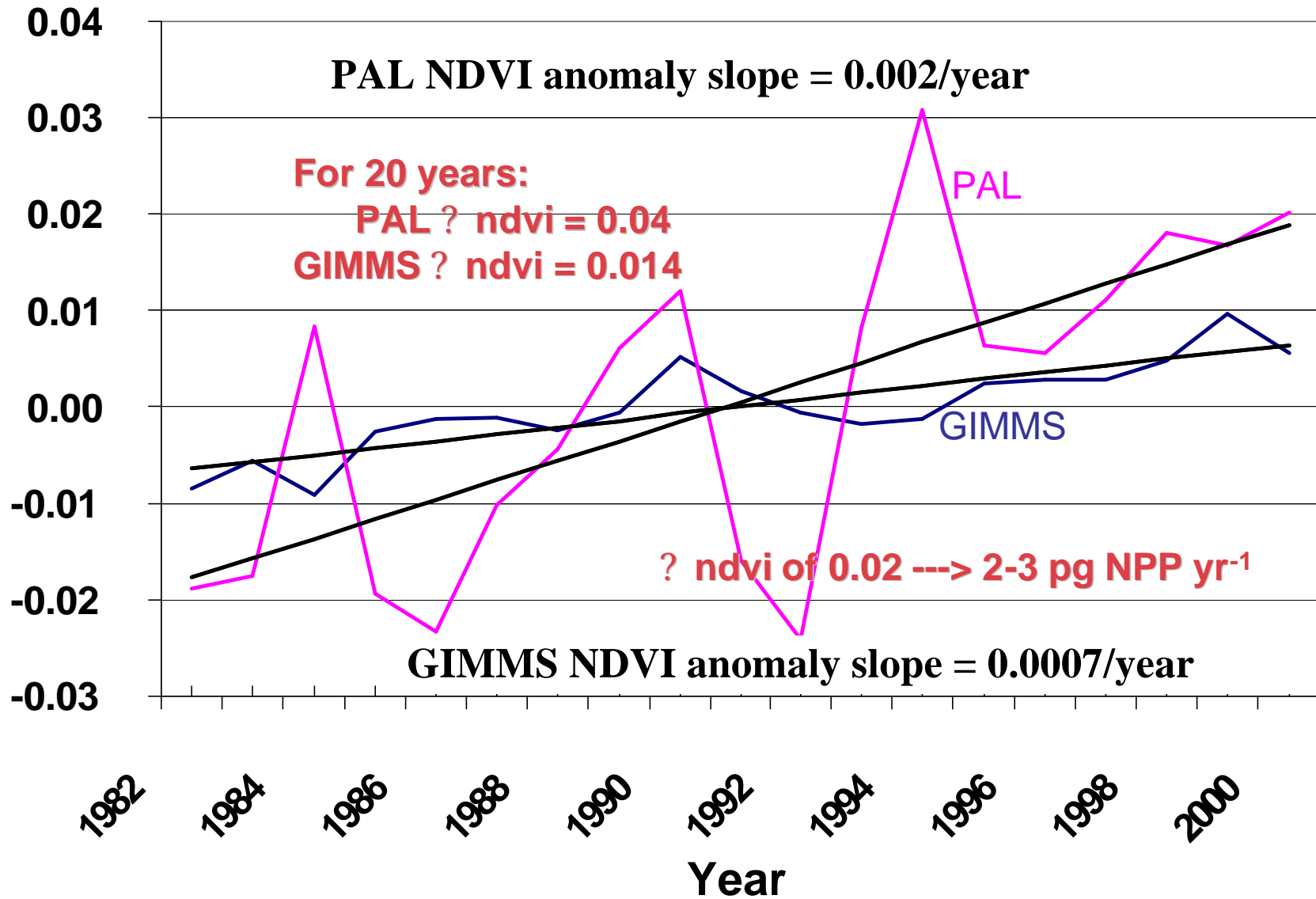


AVHRR 9-day periodicity over a shrubland

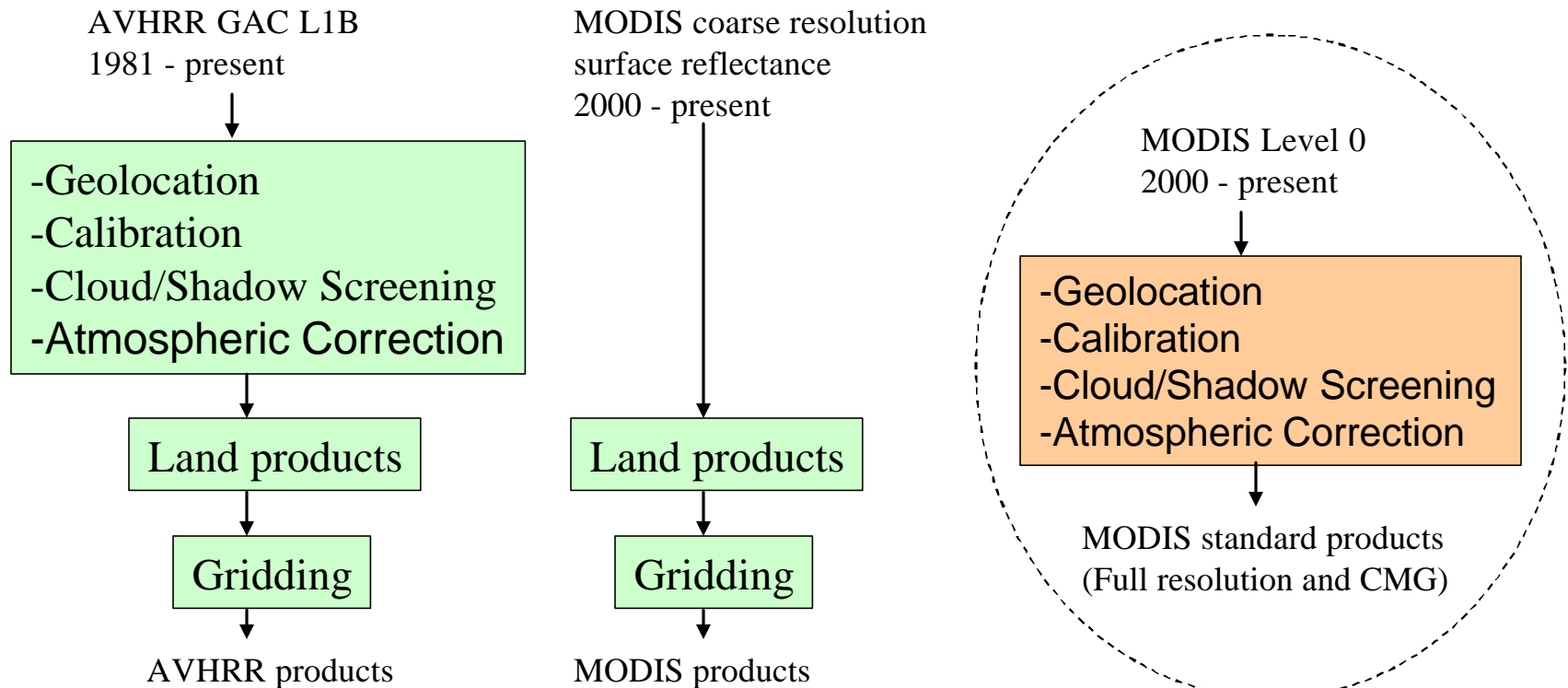
- Hot-spot effect (where no shadows are observed): 9 K average temperature difference

- Effects more pronounced over sparse canopies (<60% tree cover).

Different Preprocessing : PAL vs GIMMS



AVHRR and MODIS Production Systems



List of potential products:
 Surface Reflectance, VI,
 Surface Temperature and emissivity,
 Snow, LAI/FPAR, BRDF/Albedo,
 Aerosols, burned area

Format:
 HDF-EOS
 Geographic projection 1/20 deg resolution
 Daily, multi-day, monthly

AVHRR data set

- AVHRR offers the longest record.
- Lacks onboard calibration.
- Limited set of spectral bands reduces the accuracy of atmospheric parameters retrieval and correction (water vapor and aerosols).
- Broad spectral bands lead to contamination by the atmosphere.
- Orbital drift leads to substantial variation in the solar geometry throughout the mission.

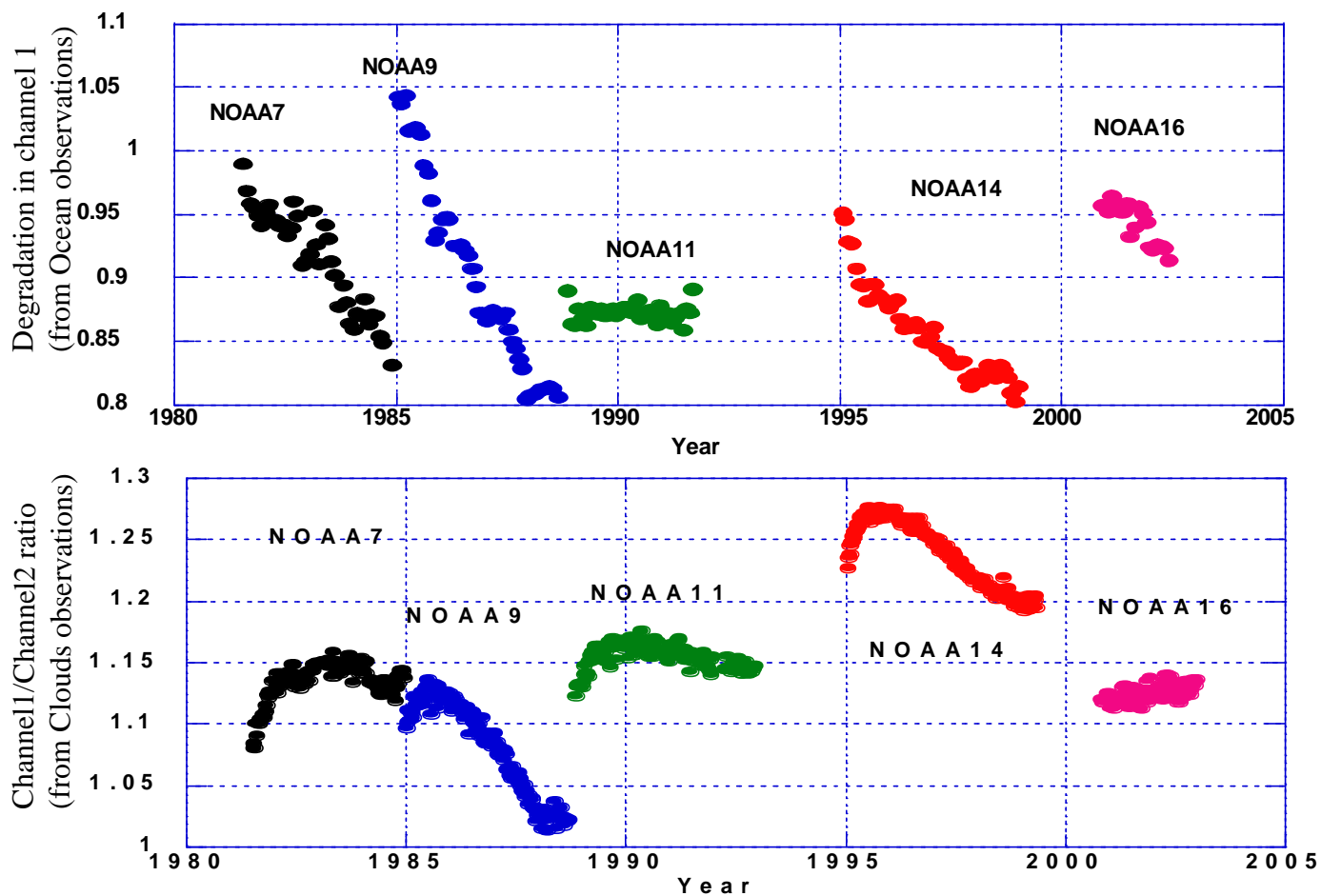
Generating Improved AVHRR products

Goal to make the AVHRR data set temporally consistent and consistent with MODIS by using:

- Reliable and consistent calibration across the different NOAA platforms.
- Apply MODIS algorithms to AVHRR where possible, e.g.: the MODIS aerosol retrieval and atmospheric correction approach.
- BRDF correction to address differences in the solar and viewing geometry.
- Coincident AVHRR/MODIS to evaluate and improve AVHRR products and quantify accuracy.

Consistent AVHRR calibration across platforms

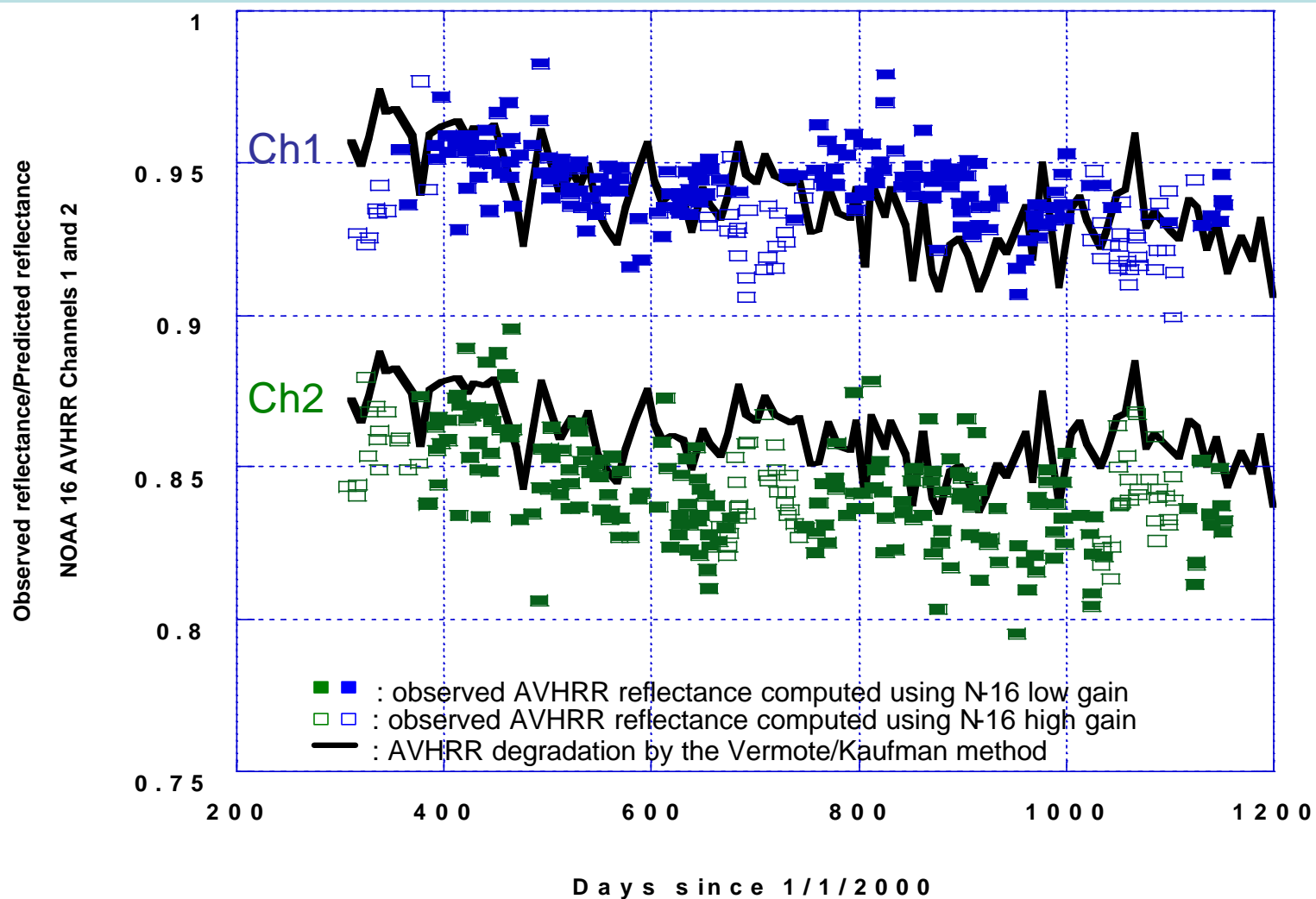
- Use the Vermote/Kaufman calibration approach (1995)



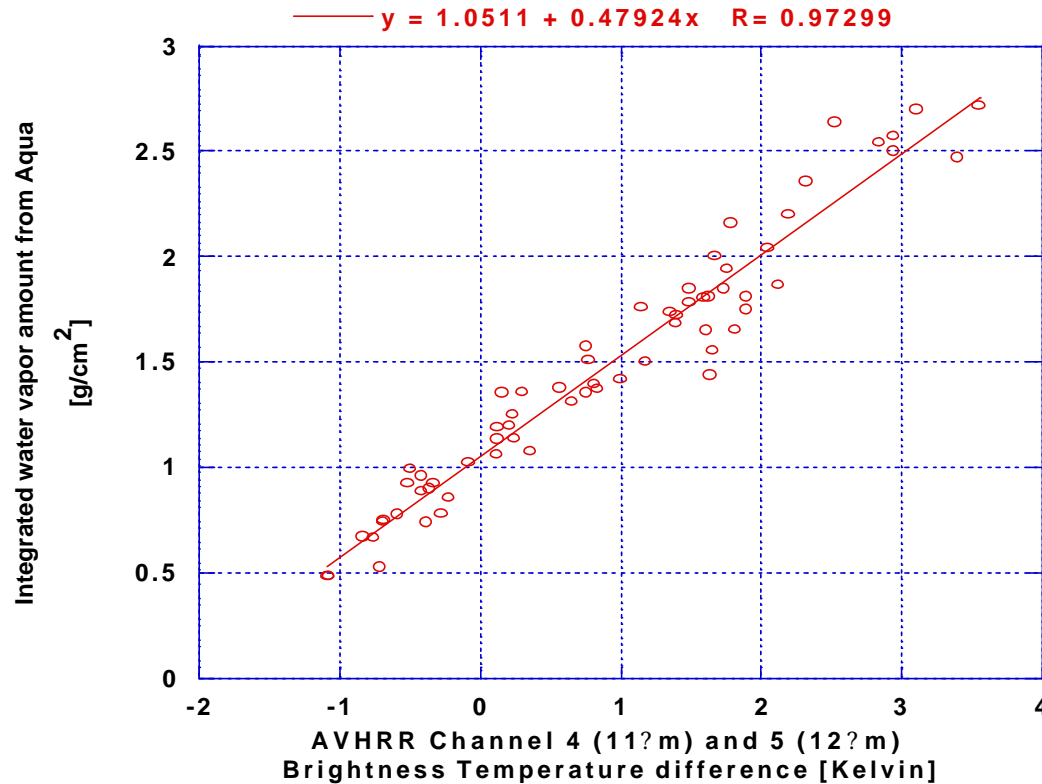
Approach used to validate N16 calibration with MODIS

- Select a stable calibration site.
- Characterize the reflectance spectral variation using MODIS narrow bands.
- Use 2 years of data to characterize the site BRDF using the simple linear kernel model used in the MODIS BRDF product.
 - Rigorous cloud screening is applied to the data.
 - Exclude observations within 15deg of backscattering conditions to avoid the hot spot.
 - Exclude off-nadir observations (viewing zenith angle > 50 deg) where the pixel size variation makes it difficult to select coincident observations.

Evaluating AVHRR calibration using MODIS



Use of MODIS to improve AVHRR atmospheric corrections



Use coincident MODIS/AVHRR data to develop an approach for water vapor retrieval from AVHRR.

Error Budget: MODIS surface reflectance and NDVI summary

Parameter	Accuracy
Calibration	2% absolute, 1% band to band
Pressure	±10 mbars
Water vapor	0.2 g.cm ⁻² (Differential absorption approach)
Ozone	±20 Dobson (EP-TOMS)
SWIR/VIS relation	± 0.005 reflectance units
Aerosol type	Smoke low/high absorption, urban polluted

Reflectance/ NDVI	Forest				Savanna				Semi-arid			
	value	Aerosol Optical Depth			value	Aerosol Optical Depth			value	Aerosol Optical Depth		
		clear	avg	hazy		clear	avg	hazy		clear	avg	hazy
?3 (470 nm)	0.012	0.0052	0.0051	0.0052	0.04	0.0052	0.0052	0.0053	0.07	0.0051	0.0053	0.0055
?4 (550 nm)	0.0375	0.0049	0.0055	0.0064	0.0636	0.0052	0.0058	0.0064	0.1246	0.0051	0.007	0.0085
?1 (645 nm)	0.024	0.0052	0.0059	0.0065	0.08	0.0053	0.0062	0.0067	0.14	0.0057	0.0074	0.0085
?2 (870 nm)	0.2931	0.004	0.0152	0.0246	0.2226	0.0035	0.0103	0.0164	0.2324	0.0041	0.0095	0.0146
?5 (1240 nm)	0.3083	0.0038	0.011	0.0179	0.288	0.0038	0.0097	0.0158	0.2929	0.0045	0.0093	0.0148
?6 (1650 nm)	0.1591	0.0029	0.0052	0.0084	0.2483	0.0035	0.0066	0.0104	0.3085	0.0055	0.0081	0.0125
?7 (2130 nm)	0.048	0.0041	0.0028	0.0042	0.16	0.004	0.0036	0.0053	0.28	0.0056	0.006	0.0087
NDVI	0.849	0.03	0.034	0.04	0.471	0.022	0.028	0.033	0.248	0.011	0.015	0.019

Error Budget: AVHRR surface reflectance and NDVI summary

	AVHRR Pathfinder-like processing	With LTDR improvements
Calibration	10% absolute, 4% band to band	4% absolute, 2% band to band
Pressure	±10 mbars	±10 mbars
Water vapor	0.7 g.cm ⁻² (NCEP or None)	0.3 g.cm ⁻² (split window)
Ozone	±30 Dobson (LONDON)	±10 Dobson (EP-TOMS)
Aerosols	No Correction	0.01 error in predicting red refl. from 3.75 ? m

Reflectance/ NDVI	Forest				Savanna				Semi-arid			
	value	Aerosol Optical Depth			value	Aerosol Optical Depth			value	Aerosol Optical Depth		
		clear	avg	hazy		clear	avg	hazy		clear	avg	hazy
? Ch1 (VIS)	0.0448	0.0056	0.051	0.0803	0.086	0.009	0.0457	0.073	0.143	0.0149	0.039	0.0628
? Ch2 (NIR)	0.237	0.020	0.0217	0.0338	0.196	0.0164	0.0225	0.037	0.217	0.0179	0.02	0.0349
? Ch3 (MIR)	0.045	0.002	0.0026	0.0031	0.086	0.0042	0.0044	0.0046	0.143	0.0073	0.0074	0.0074
NDVI	0.682	0.033	0.195	0.266	0.392	0.042	0.124	0.168	0.206	0.046	0.068	0.090
? Ch1 (VIS)	0.0448	0.0101	0.01	0.01	0.086	0.0101	0.0101	0.01	0.143	0.0106	0.0104	0.0104
? Ch2 (NIR)	0.237	0.0085	0.0133	0.0196	0.196	0.0075	0.0101	0.0141	0.217	0.0081	0.0097	0.0132
? Ch3 (MIR)	0.045	0.0014	0.0015	0.0025	0.086	0.0020	0.0022	0.0026	0.143	0.003	0.0033	0.0037
NDVI	0.682	0.056	0.058	0.064	0.392	0.043	0.047	0.054	0.206	0.03	0.033	0.038

Production and Distribution

- Use a MODAPS-like environment for production.
- Benefit from the MODIS production experience.
- Data products will be kept online and distributed by ftp and through a web page.
- Make intermediate data sets available for evaluators.
- Transition the data sets to the DAAC later in the project when the datasets are validated.

Community Outreach

- **Request users input through the project's web site.**
- **Workshops/Sessions held throughout the project to refine requirements and provide feedback on products.**
- **Publish team's evaluation of existing and intermediate datasets on the web and request input and comments from users.**
- **Participation in scientific conferences and peer reviewed publications.**

Status of the Beta data set production

- A Beta AVHRR data set is being produced for years 1981 – present from NOAA-7, NOAA-9, NOAA-11, NOAA-14 and NOAA-16:
 - Vicarious calibration.
 - Cloud screening using CLAVR.
 - Atmospheric correction:
 - NCEP Reanalysis ancillary data (surface pressure, water vapor, wind speed).
 - TOMS ozone concentration.
 - NOAA TBASE DEM to refine surface pressure.
 - Binned into a global 1/20 degree resolution grid.
 - Daily products.

Summary

- The creation of a Long Term Land Surface Data record with documented and comparable accuracy across instruments is feasible.
- The long term trend observed with precursor AVHRR datasets needs to be verified.
- The beta version of the AVHRR reflectance and NDVI data set will become available for evaluation in Early 2006.
- The user community involved in the definition and evaluation of the data sets (Pathfinder approach).
- Incremental release of the products (Beta => Provisional => Validated) as they are generated (MODIS approach).
- Updates on the project's website :
<http://ltdr.nascom.nasa.gov/ltdr.html>
nazmi.saleous@gsfc.nasa.gov