PRISM/AVNIR-2 Cal/Val Results and Data Applications

ICC Kyoto

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- *Summary*

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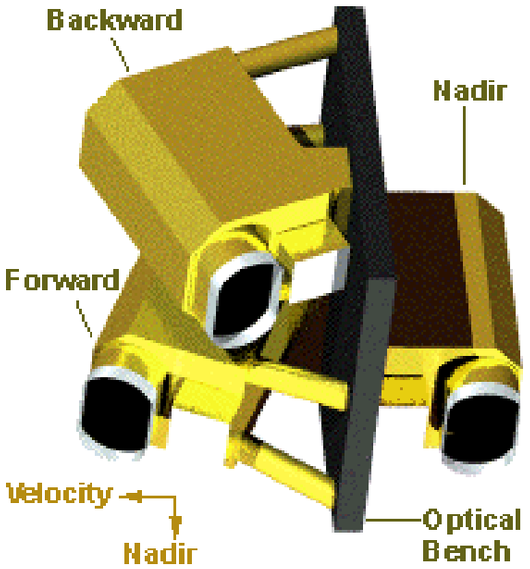
Ortho-rectified AVNIR-2 image over Kyoto acquired on Oct. 9, 2006

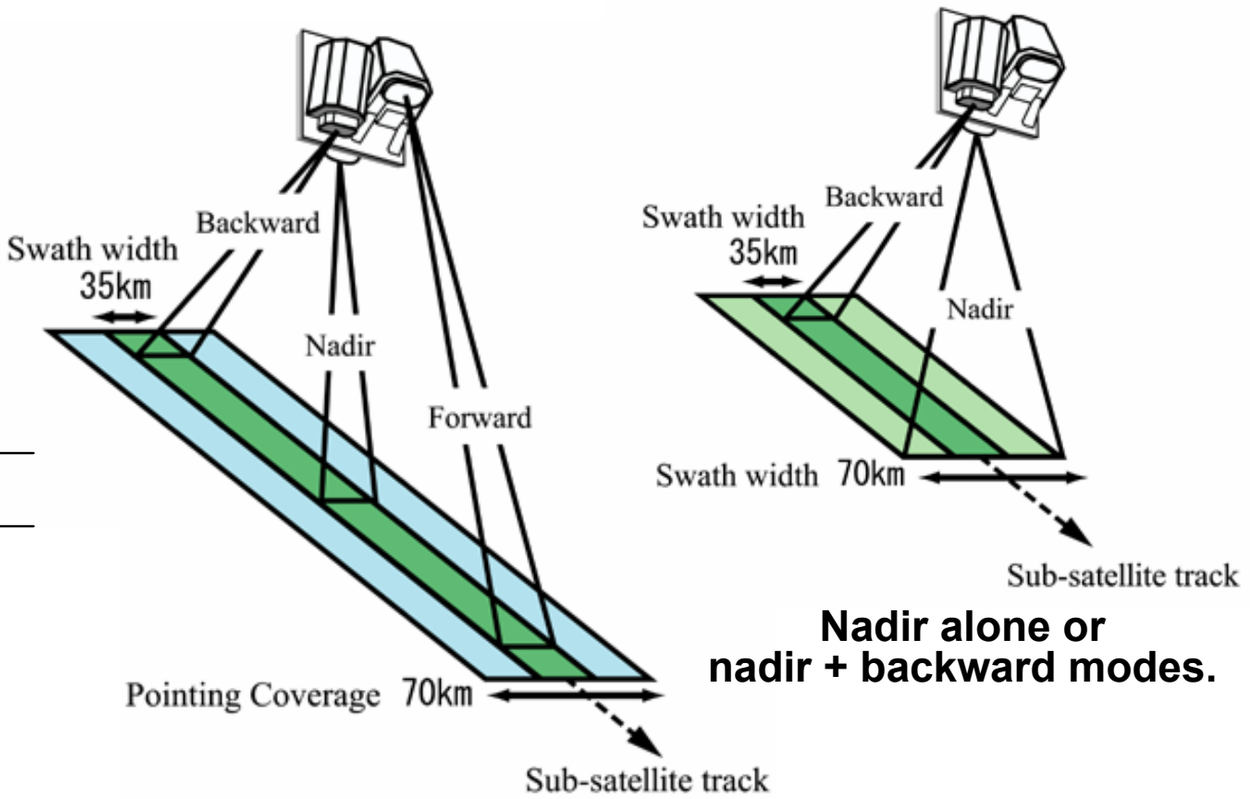
PRISM

Panchromatic Remote-sensing Instrument for Stereo Mapping
パンクロマティック立体視センサ



0.52-0.77 μ m

Number of Optics : 3, AT +/- 23.8 deg
(Nadir / Forward / Backward)
Base/Height ratio : 1.0 (F / B)
Spatial resolution : 2.5m at Nadir
Swath width : 35km at Triplet mode
70km at Nadir only
Pointing angle : +/- 1.5 deg.
S/N : >70, MTF : >0.20
Scanning method : Push broom
Quantization : 8 bits
Data compression : JPEG extension
Compression rate: 1/4.5 or 1/9



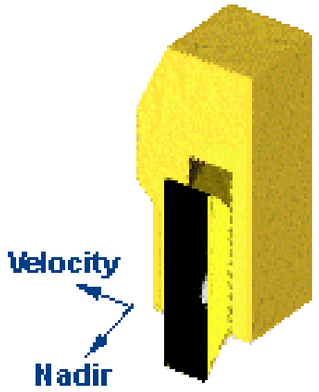
Nadir alone or nadir + backward modes.

Observing geometry of triplet mode.

✓Two observation (+/-1.20deg. pointing angle) per orbit are necessary for observing whole coverage by triplet mode except in high latitude areas.

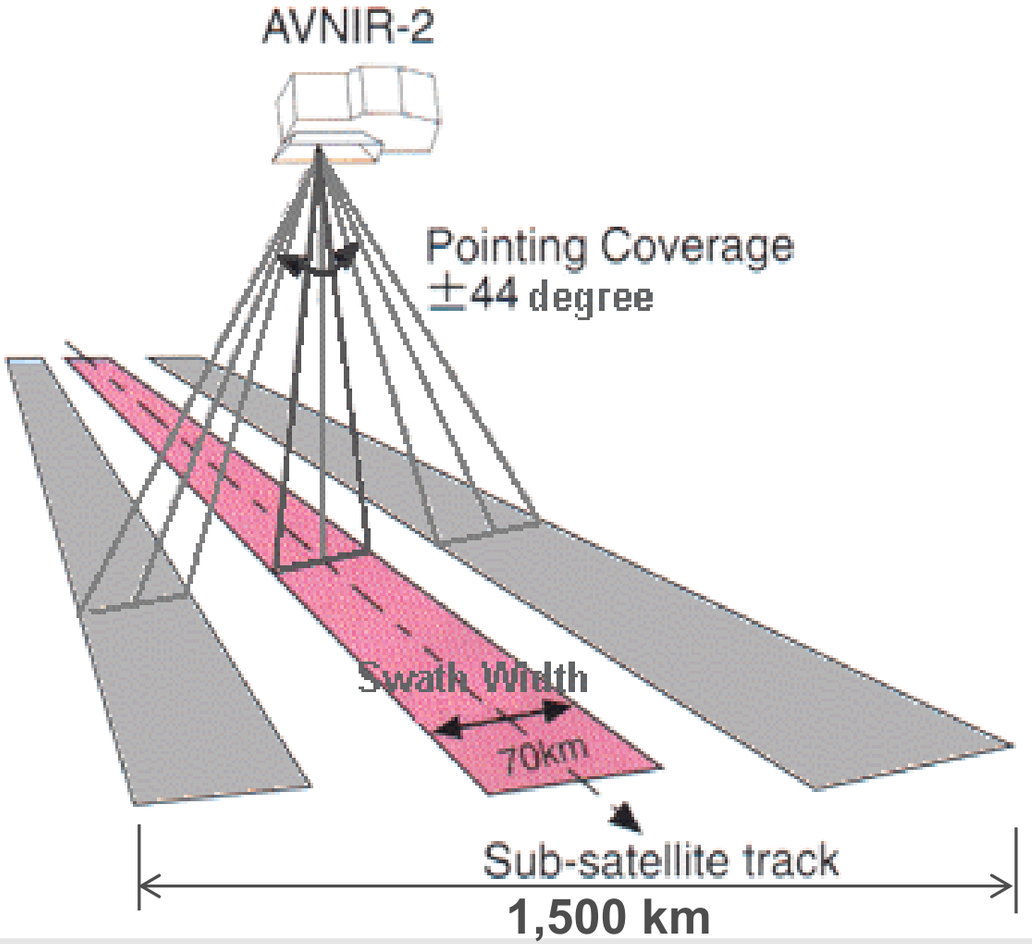
AVNIR-2

Advanced Visible and Near Infrared Radiometer type 2
高性能可視近赤外放射計2型



Band 1 : 0.42-0.50 μ m
Band 2 : 0.52-0.60 μ m
Band 3 : 0.61-0.69 μ m
Band 4 : 0.76-0.89 μ m

Field of view : 5.8 deg.
Swath width : 70km at Nadir
Instantaneous FOV : 14.28 μ rad
Spatial resolution : 10m at Nadir
Number of detectors : 7000 /band
Pointing angle : +/- 44 deg.
S/N : >200, MTF : >0.25 (1-3), >0.20 (4)
Scanning method : Push broom
Quantization : 8 bits



Improvements in AVNIR-2 from AVNIR
- ✓Resolution : 10m < 16m
- ✓Pointing angle : +/-44 deg < +/-40 deg
- ✓Calibration system : lamp 2 < lamp 1, Solar 1

Cal/Val History & Status

- **History**
  - ✓ **Jan. 24, 2006: ALOS was launched**
  - ✓ Jan. 28, 2006: Critical Phase completed: Successful deployments and normal control
  - ✓ **Feb. 14-17, 2006: First images acquisition**
  - ✓ **May 15, 2006: Initial Check-out Phase completed**
  - ✓ **Oct. 23, 2006: Initial Cal/Val Phase completed; Operational Phase started**
    - All bus & mission systems operational and in good conditions
- **Orbit and Attitude Determinations**
  - ✓ Precision Orbit Determination by GUTS: From March 27, 2006
    - Very well, about **10cm orbit determined**
  - ✓ Large geometric error (about 7-8km in AT direction; 5km in XT direction of Nadir)
    - **1 second time error** > Onboard firmware updated on Sep. 22, 2006
  - ✓ Onboard Precise Attitude Determination (ATT3)
    - 0.1 sec time error > Corrected on Sep. 29, 2006
  - ✓ Off-line Precise Position and Geolocation Determination System (PPDS)
    - Started on July 9, 2006: Precise Attitude Determination (PAD, “Onsite Precision”)
- **PRISM & AVNIR-2**
  - ✓ PRISM Brighter noise (Blooming) > No idea to correction
  - ✓ AVNIR-2’s mirror drive degrades pointing stability of PRISM > Checking at EOC
  - ✓ Block noise by JPEG compression > **under investigating to develop filter**
  - ✓ **Absolute geometric accuracy > still evaluating as operational calibration**

Cal/Val & Science Team (CVST) for Optical

As of March 8, 2007

JAXA	PI, Collaborators and Data nodes
• EORC Research & Analysis Group Masanobu Shimada (Leader, PALSAR), Takeo Tadono (PRISM/AVNIR-2), Hiroshi Murakami (Radiometry), Kazuo Ohta, Ken Matsubayashi, Mitsuyo Kakimoto (Program coordination) • Remote Sensing Technology Center (RESTEC) Akira Mukaida, Sachi Kawamoto, Junko Yamashita, Narotoshi Imoto (Calibration), Fumi Ohgushi (Obs. plannning), Junichi Takaku, Noriko Futamura (DSM, Ortho products and validation) • EORC Ground System Development Shinichi Suzuki etc. • ALOS Project Team Yuji Osawa, Hidenori Watarai, Akihiro Matsumoto (PRISM/AVNIR-2), Takanori Iwata (AOCS/PPDS), etc.	• Geographical Survey Institute of Japan Dr. Hiroshi Masaharu, Dr. Izumi Kamiya, Dr. Hiroyuki Hasegawa, Dr. Yoshiyuki Mizuta • University of Tokyo, Japan Prof. Ryosuke Shibasaki • Kouchi University, Japan Dr. Masayuki Matsuoka • ETH Zurich, Switzerland Prof. Armin Gruen • University College of London, UK Prof. Ian Dowman • Geoscience Australia Dr. Craig Smith • ESA Dr. Philippe Goryl • ASF • GISTDA Dr. Boonchoob Boongthong with co-principal investigators

Activity of Cal/Val & Science Team (CVST)

Reflection of Activities

- Update processor at EORC, JAXA : 1A → 1B1, 1B2 → High level products
  - ✓ Parameter table update, evaluations of sensor characteristics and models
  - ✓ Comparison of standard products processed at **EORC** and **EOC**
- A goal is improved the image quality and absolute accuracies of standard products, and altitude accuracy of generated DSM for PRISM.

Team Activities

- ✓ Collection and share GCP, reference DSM and ground truth data
- ✓ Setting the Cal/Val test sites
- ✓ Observation requests for Cal/Val, and provide the ALOS data to the members
- ✓ Objective evaluations, comparison of the results between the members and JAXA

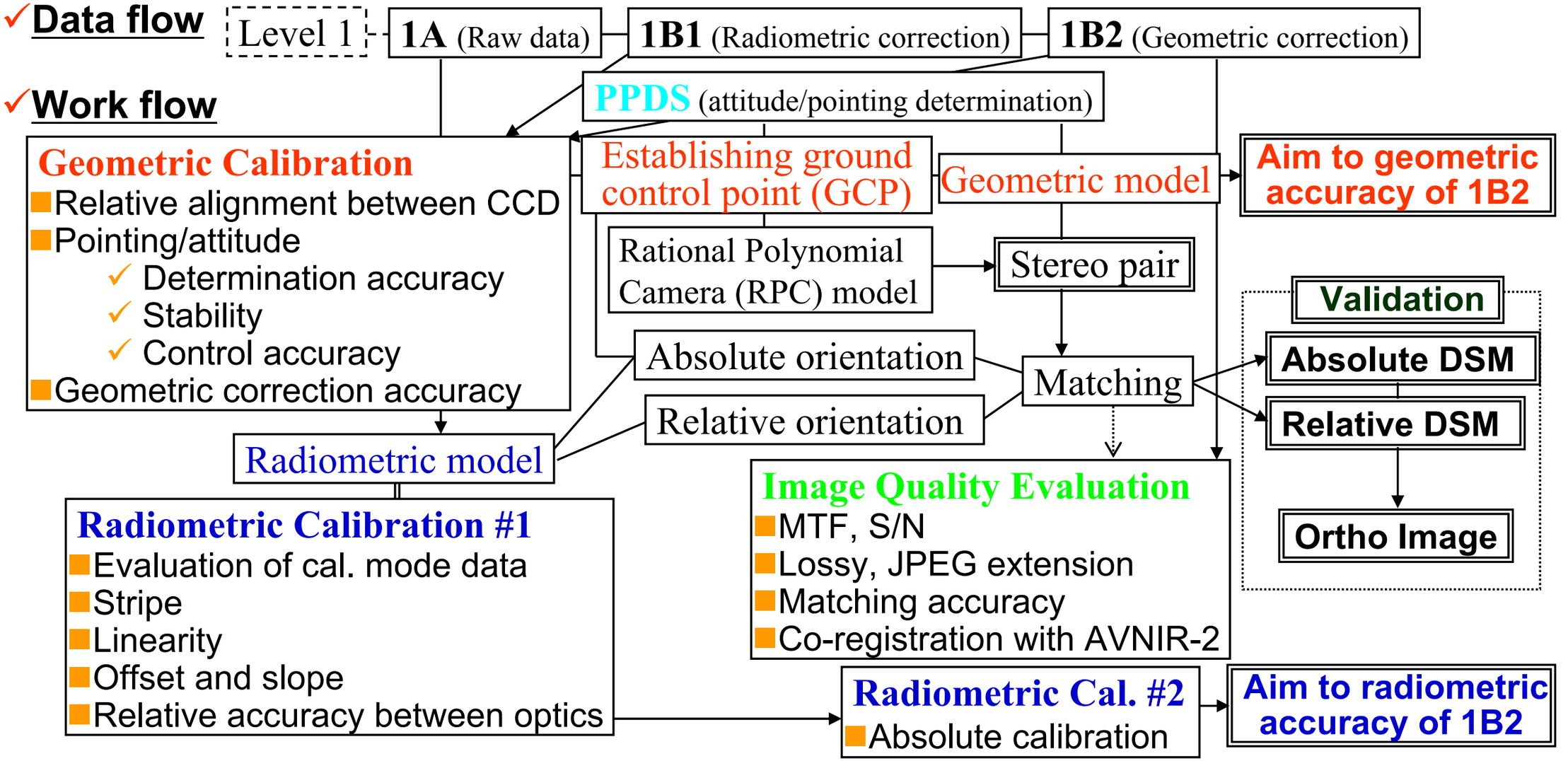
Schedule

January 24, 2006: ALOS Launch

- CVST #4 Jun. 28-29, 2006 : Launch results and preliminary Cal/Val results are presenting, information exchange to go forward.
- CVST #5 Oct. 16-17, 2006 : Recommendation and backup to move operational phase from Oct. 24 , 2006
- CVST #6 Mar. 8-9, 2007 : Confirming the accuracy of high-level products *i.e.*, PRISM/DSM, and ortho-rectified images. Calibration is still active.

> Confirm the updated accuracies as of March 8, 2007 and future work

PRISM Calibration & Validation Plan

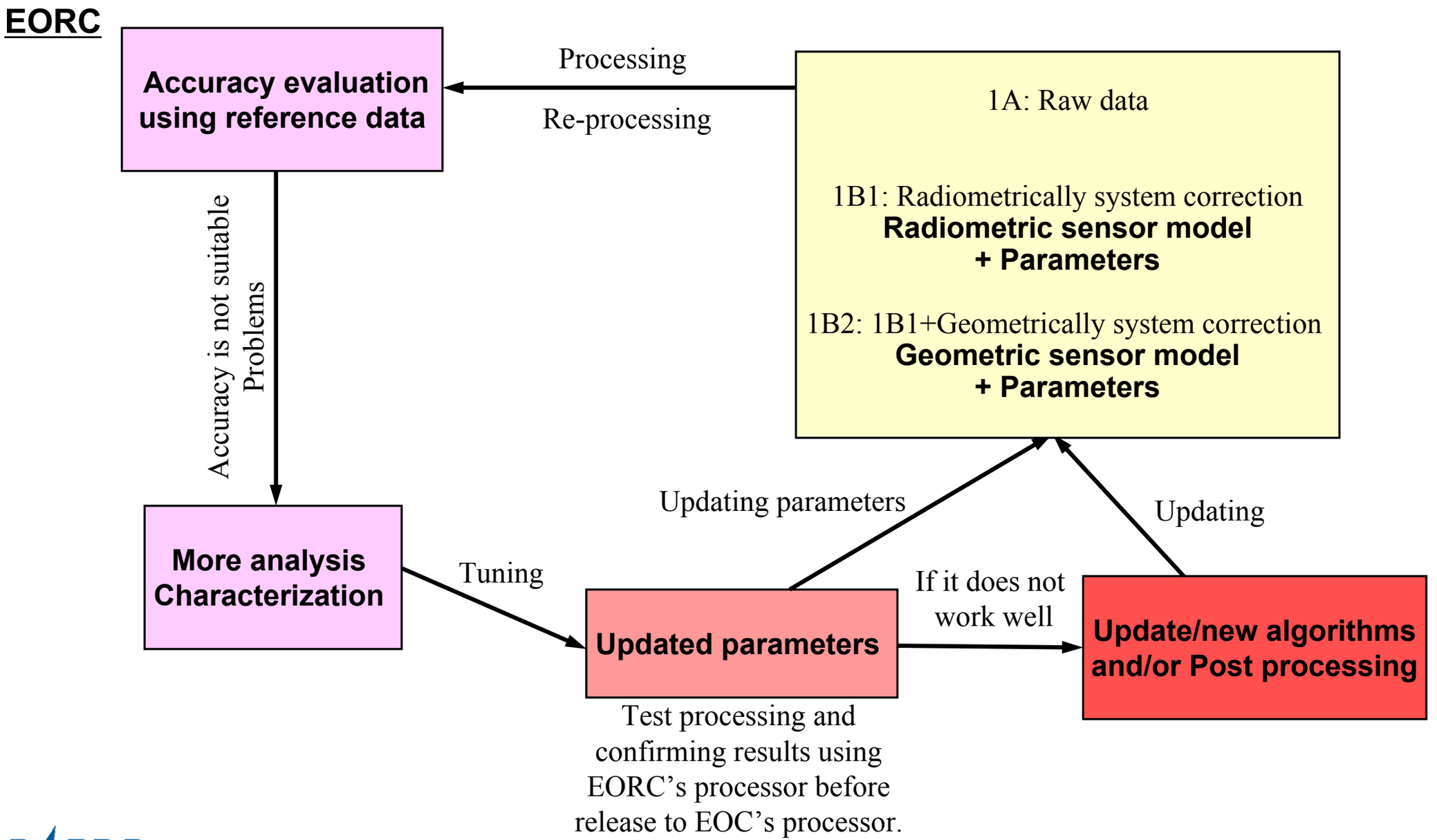


Cooperation with;

- **AVNIR-2 for radiometric calibration and geometric calibration at nadir, and**
- **Precision Pointing and Geolocation Determination System (PPDS) for satellite position and attitude evaluations : GPSR, STT, IRU, and ADS**

Calibration Structure in JAXA

- Procedure of calibration result reflections in the case of PRISM/AVNIR-2

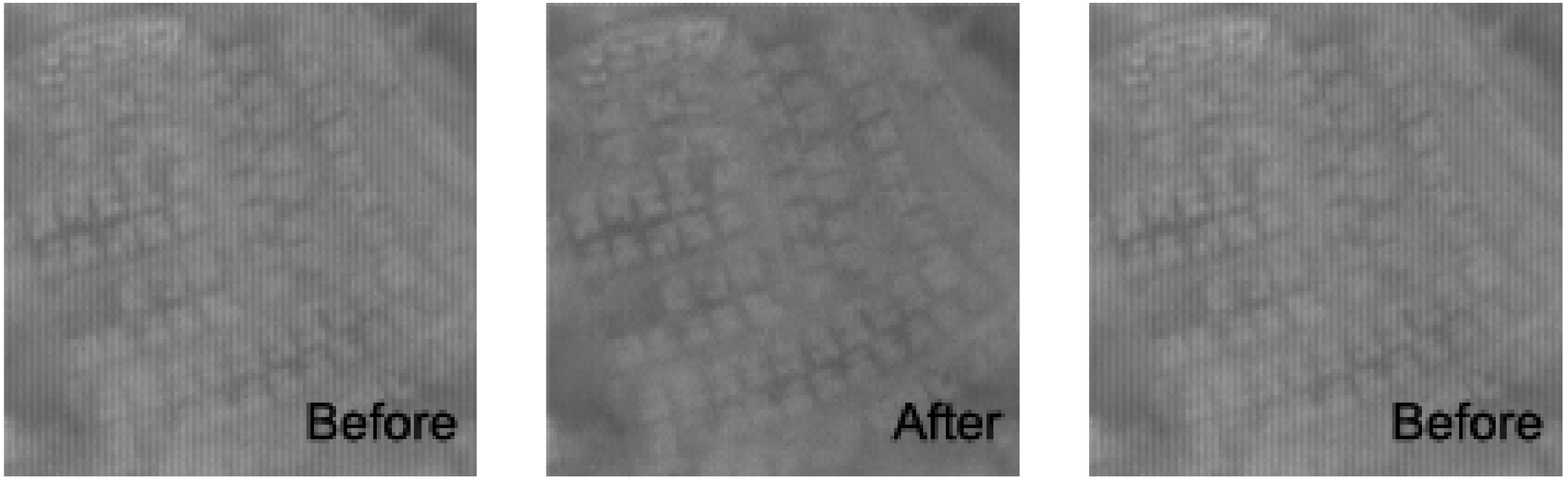


Results of PRISM/AVNIR-2 Cal (as of Sep. 29, 2007)

Standard Product	Target Accuracy	Results as of Sep. 29, 2007
PRISM 1B2	Radiometry Relative Accuracy 5% (1σ) Absolute Accuracy 10% (1σ) Geometry Absolute Accuracy (without GCP) 2.0m (1σ) for Nadir-looking radiometer with the Precise Pointing Geolocation Determination System (PPDS)	Radiometry (RMS) Relative Accuracy less than 0.4% (1DN) →**Strip noise reduction is applied from Oct. 19** Absolute Accuracy less than 4.6% Geometry Absolute Accuracy: using 1,390 GCPs in the world →**Pointing alignment evaluation** Pixel (X) / Line (Y) / Distance (RMS) Nadir **6.5m** / **7.3m** / **9.8m** Forward 8.0m / 14.7m / 16.7m Backward 7.4m / 16.6m / 18.1m Relative Accuracy (1σ) 3 radiometers 1.9m / 2.3m / 3.0m
AVNIR-2 1B2	Radiometry Relative Accuracy 5% (1σ) Absolute Accuracy 10% (1σ) Geometry Absolute Accuracy without GCP 94.6m (1σ) Relative Accuracy with GCP 2.6m (1σ) at 0 degree pointing angle	Radiometry (RMS) Relative Accuracy less than 0.4% (1DN) Absolute Accuracy 3.8% (B1), 4.6% (B2), 2.2%(B3), 15.6% (B4) < 50% contributes by water vapor Geometry (-41.5 to +41.5 deg.. pointing) Pixel (X) / Line (Y) / Distance Absolute Accuracy (RMS) **106m** / **19m** / **108m** Relative Accuracy (1σ) 4m / 4m / 6m

*** Latest ALOS calibration result can be find at**
http://www.eorc.jaxa.jp/hatoyama/satellite/data_tekyo_setsumei/alos_hyouka_e.html in English
http://www.eorc.jaxa.jp/hatoyama/satellite/data_tekyo_setsumei/alos_hyouka.html in Japanese

PRISM - Update Radiometric Correction Algorithm

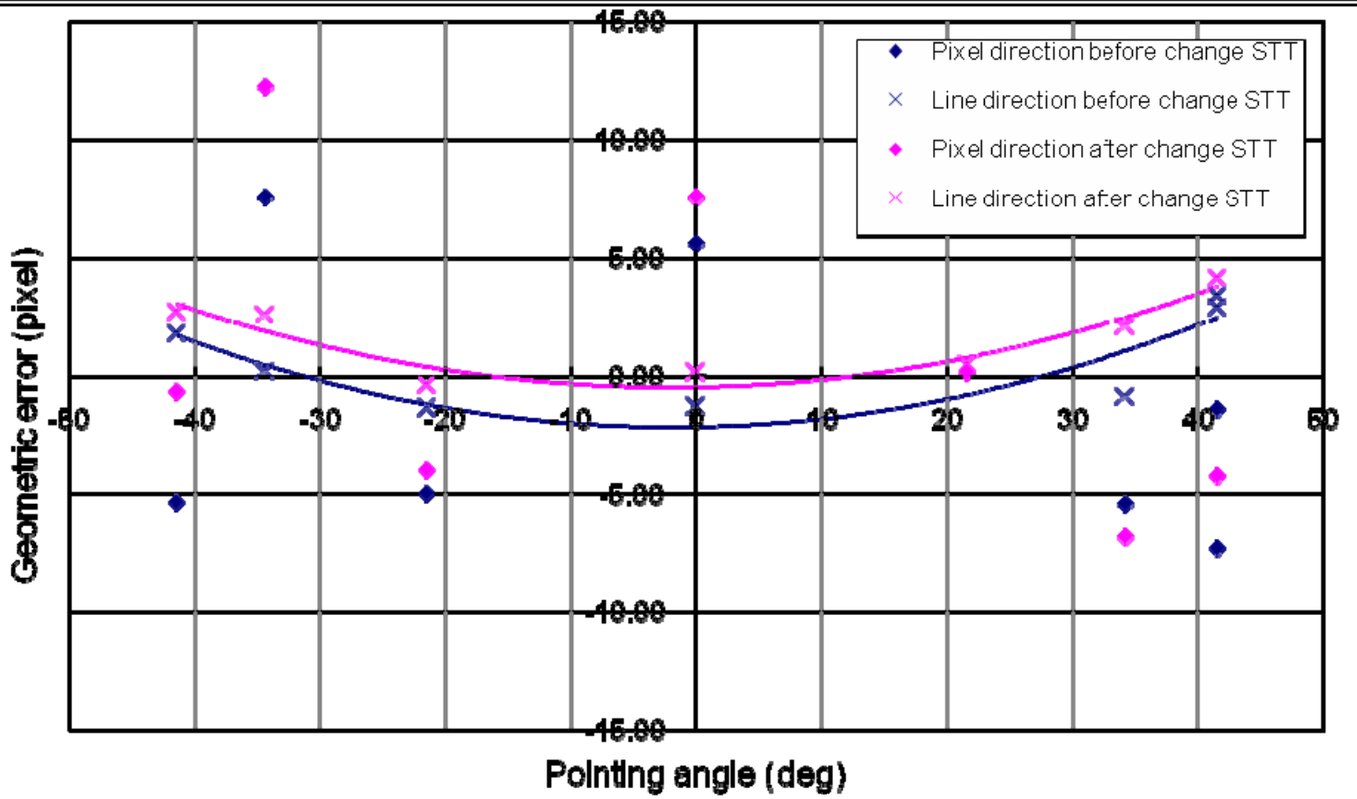


Example of Image comparison between before and after updating radiometric correction algorithm.

PRISM radiometric system correction algorithm was updated on October 19, 2007.

- ✓ Sometime stripe noises are appear especially in homogeneous target.
- ✓ Stability of “Optical Black” (OB), which is used in radiometric sensor model as the reference, but one OB in each 22 seconds.
- ✓ Two filters (averaged and iFFT) have been developed however it did not work well.
- ✓ Re-evaluation / confirmation using more images.
- ✓ Threshold values are carefully determined in processing of sensitivity variation between CCDs (CCD gaps) as well as between odd/even detectors.
  > JPEG block noises may be highly visible as the result.

AVNIR-2 - Alignment Change

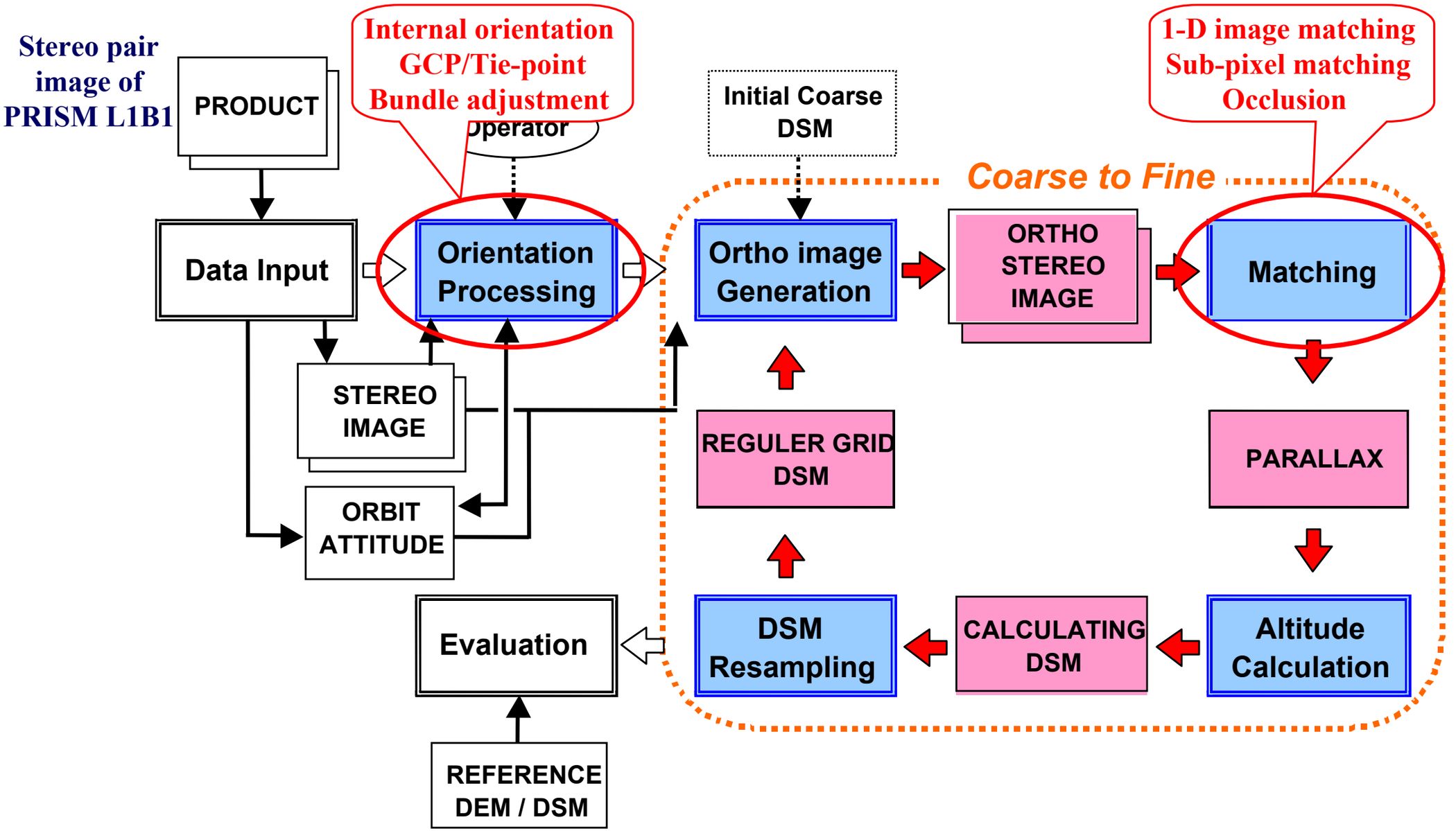


Comparison of geometric accuracy between before and after attitude coordinate origin change.

Sensor alignment of AVNIR-2 looks like change due to attitude coordinate origin change.

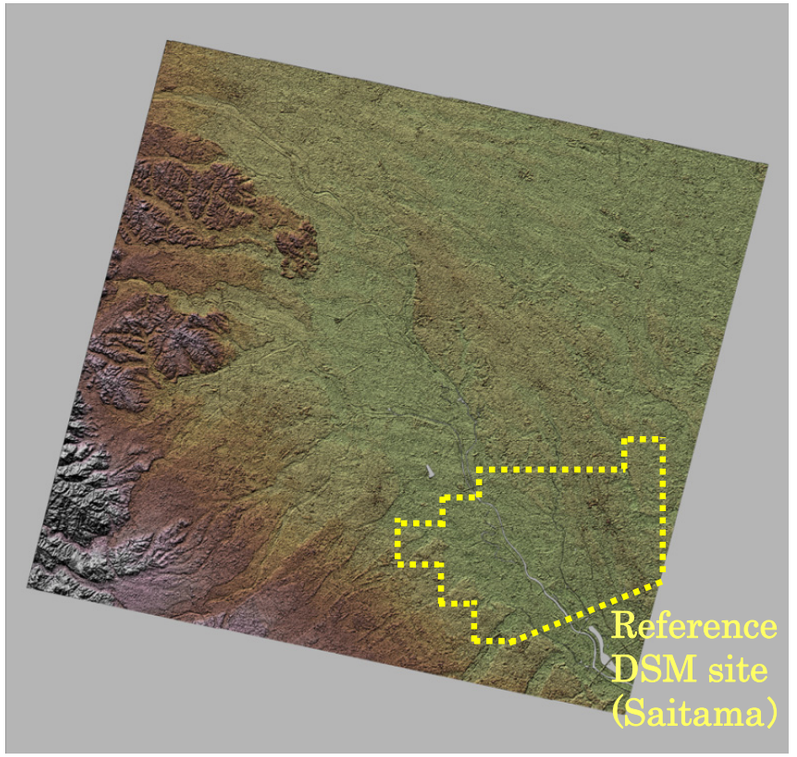
- ✓ Satellite attitude is defined at Star Tracker (STT) coordinate.
- ✓ Due to moving STT coordinate during recurrent of the ALOS, STT coordinate origin changed on March 22, 2007, which is using attitude “Onsite Precision”. PRISM’s alignment is adjusting.
- ✓ This is caused by 20m gap in line direction of geometric accuracy of AVNIR-2.
- ✓ Normally, AVNIR-2 is operating as 0deg. pointing angle.
  > We are considering that it should be corrected or not.

PRISM DSM and Ortho Image Generation Software (DOGS)

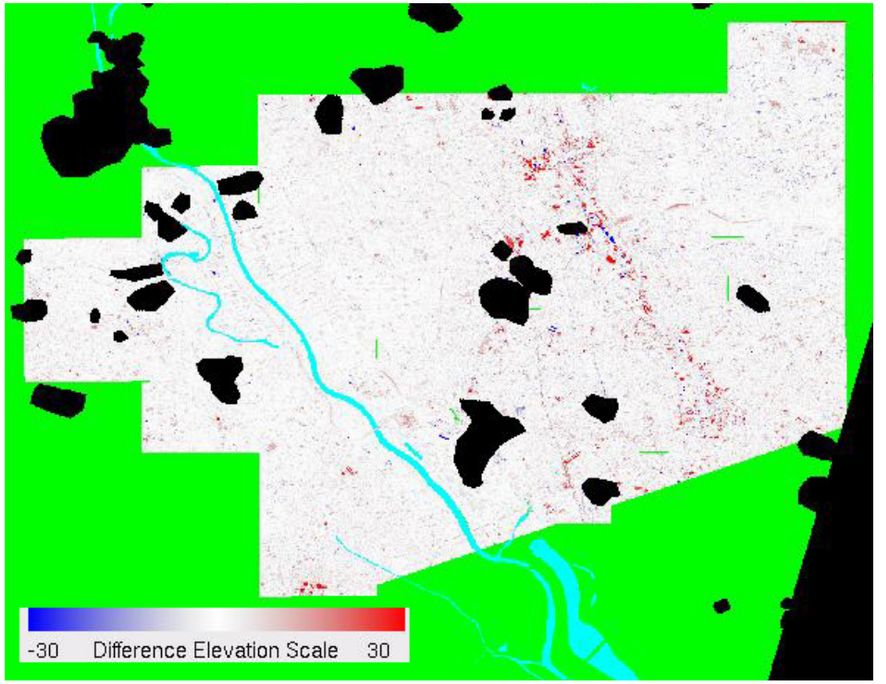


Processing flowchart of PRISM DSM generating software.

Validation – PRISM/DSM Test Generation

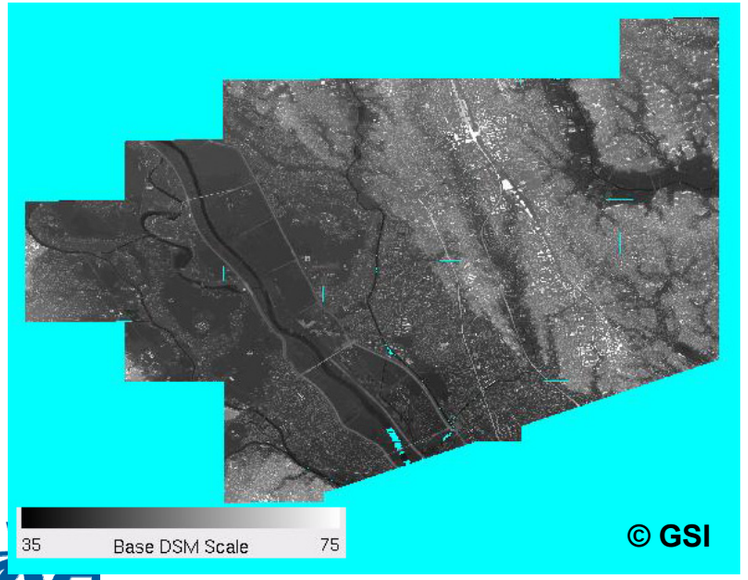


Example of generated DSM by PRISM Triplet (OB1).



Height differences between PRISM/DSM - Lidar/DSM.

as of November 19, 2007



Reference Lidar/DSM by GSI.

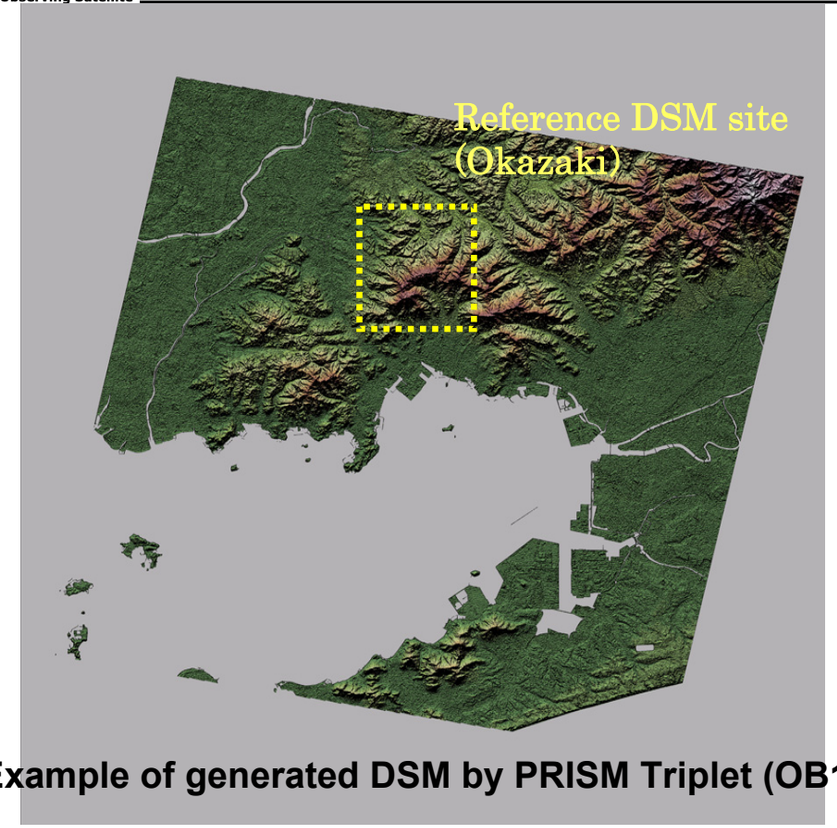
Test generation of PRISM/DSM using stereo pair image acquired in Saitama Pref. Japan on April 30 ("Cal/Val Dataset").

- ✓ Corrected CCD alignment images
- ✓ Compared the results with Lidar/DSM by GSI
- ✓ Averaged error= **1.47m**, STDEV= **4.88m** /1505512

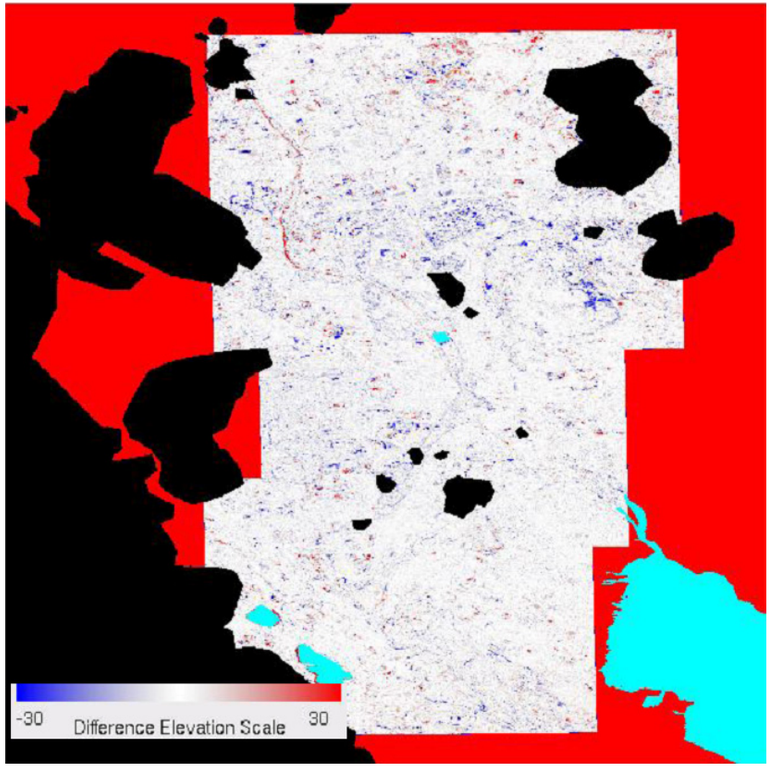
▼

- ✓ Large errors were identified due to new buildings
- ✓ Filtering and tuning of matching processing

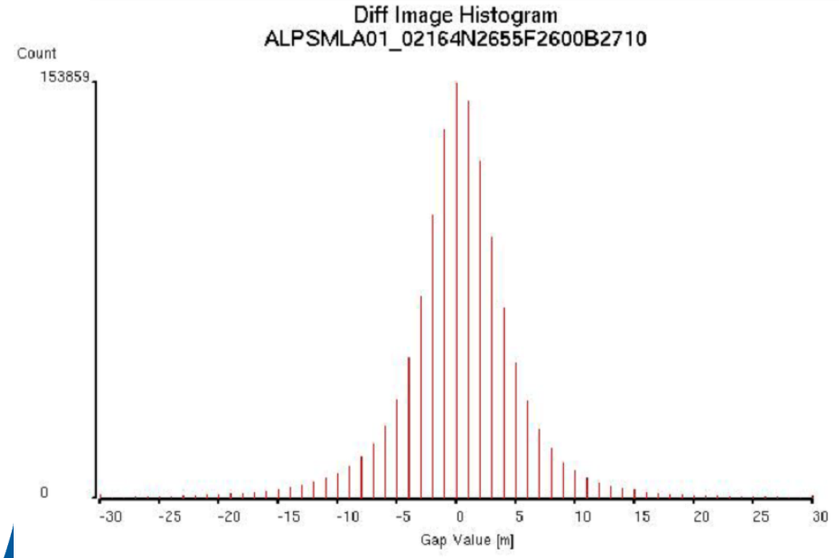
Validation – PRISM/DSM Test Generation



Example of generated DSM by PRISM Triplet (OB1).



Height differences between PRISM/DSM – Photogrametry/DSM.
as of November 19, 2007



Histogram of height difference.

=

Test generation of PRISM/DSM using stereo pair image acquired in Thun, Switzerland on June 21, 2006.

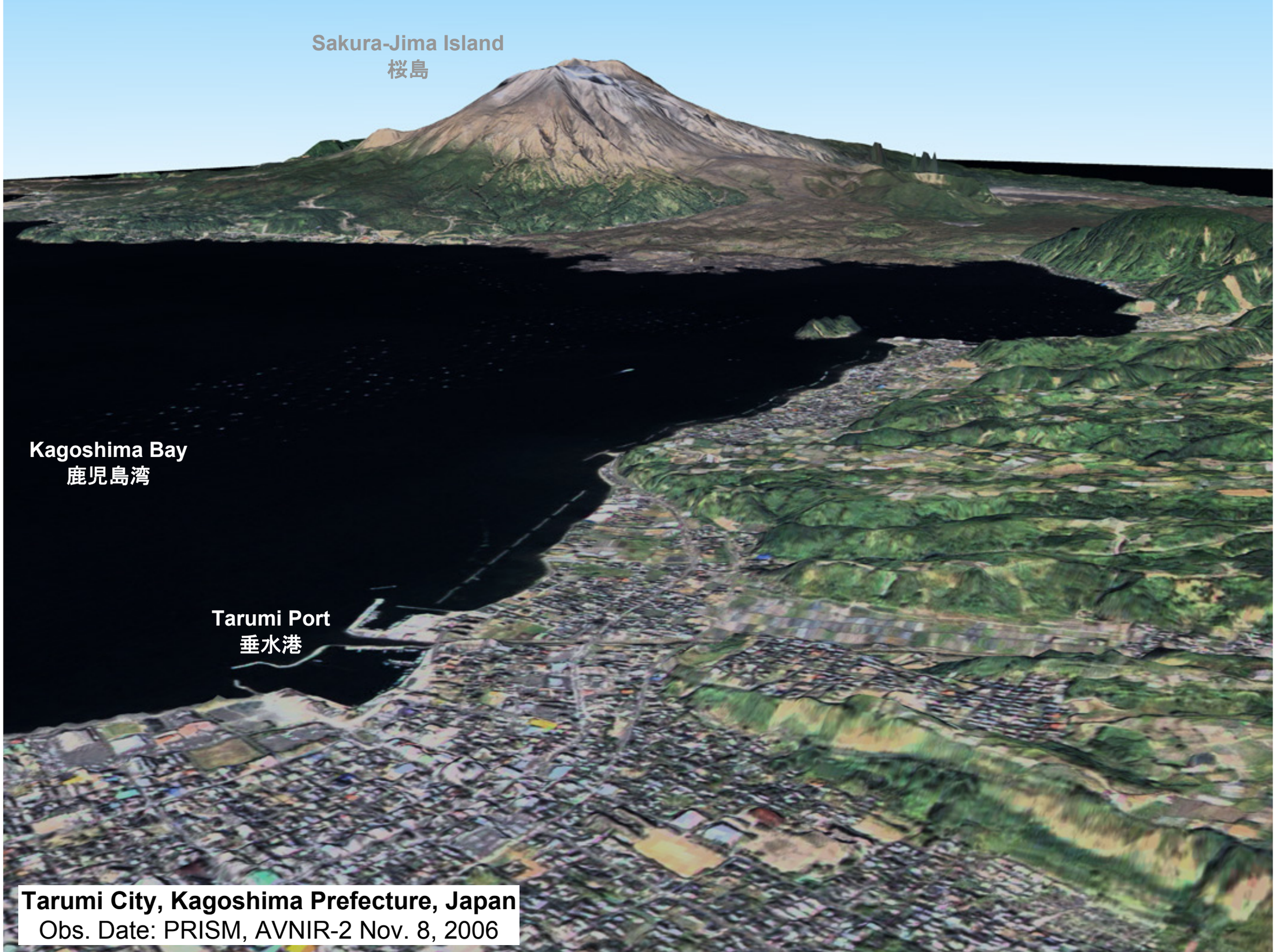
- ✓ Compared the results with DSM by aerial photo
- ✓ Averaged error= **0.27m**, STDEV= **5.82m** / 548352

▼

- ✓ Differences of observed year and date
- ✓ Large errors were identified due to edges of forest area
- ✓ Filtering and tuning of matching processing

Nara City, Nara Prefecture, Japan

Obs. Date: PRISM Nov. 10, 2006, AVNIR-2 Oct. 9, 2006



Tarumi City, Kagoshima Prefecture, Japan
Obs. Date: PRISM, AVNIR-2 Nov. 8, 2006

Uozu City, Toyama Prefecture, Japan
Obs. Date: PRISM, AVNIR-2 Feb. 22, 2007

Bird's-eye View of AVNIR-2 Image

Advanced Land Observing Satellite

Mt. Tsurugi-Dake, Toyama Pref., Japan

Obs. Date: AVNIR-2 Feb. 22, 2007

JAXA
宇宙航空研究開発機構
Japan Aerospace Exploration Agency

Summary

I introduced results of initial calibration and validation of PRISM and AVNIR-2, in particular,

1) Cal/Val plan and summary of initial calibration,
2) latest calibration results,
   - Updated radiometric correction algorithm of PRISM,
   - Geometric cal of AVNIR-2 > it will be decided update or not,
   - JPEG noises reduction of PRISM > it is under investigating, and
   - Update radiometric correction parameters of AVNIR-2
     > found some radiometric degradation.

Accuracy evaluations are continuously carrying out as operational calibration. Parameters update and algorithm tuning will be done to keep absolute accuracies when their degradations are found.

More details will be presented in Cal/Val session, this afternoon.

We, JAXA wish to thank our colleagues of CVST members for their many collaboration efforts in activities related to Cal/Val for ALOS.