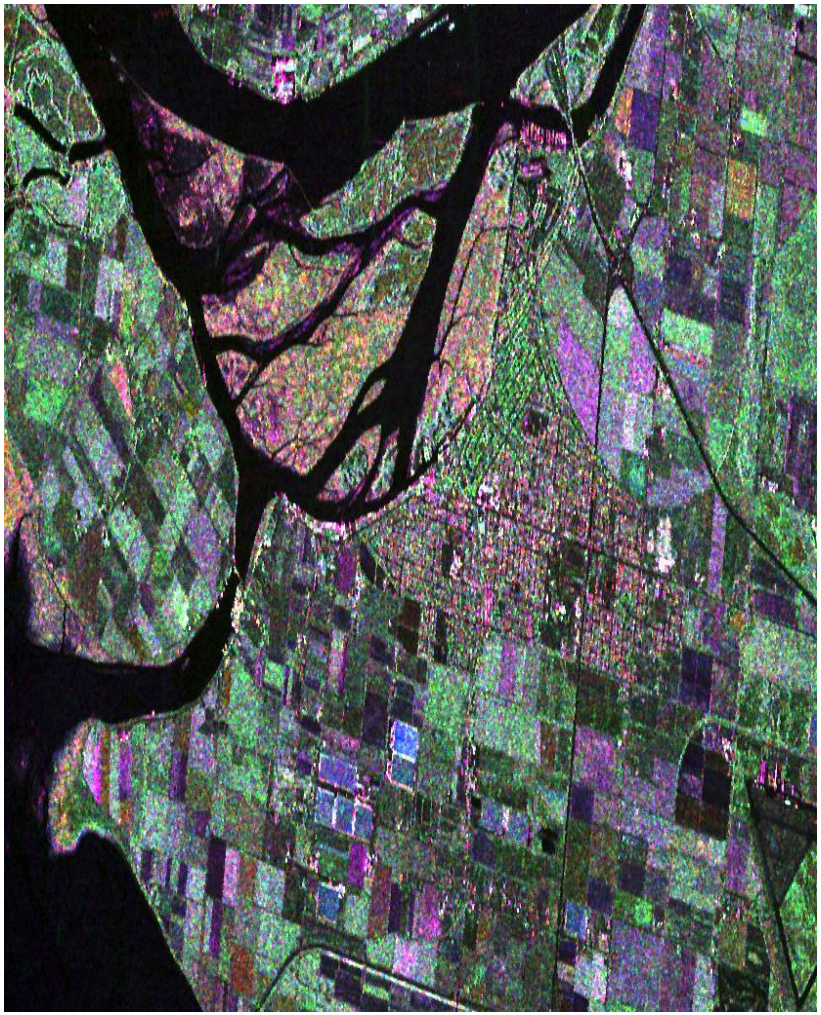
RADARSAT-2 and AgriSAR 2009



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Jeevan Padda, Andy Mah &
Gordon Davidson

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Richmond, BC, CANADA

gstaples@mda.ca

Outline

- RADARSAT-2 mission
- AgriSAR 2009 campaign
- Results to data
- Summary and future work

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RADARSAT-2 Mission Overview

- Co-funded by Canadian Space Agency (CSA) and MacDonald Dettwiler (MDA)
- MDA is the owner and operator of RADARSAT-2 and holds the the worldwide distribution rights for all products
- Data continuity from RADARSAT-1
  - all RADARSAT-1 imaging modes supported
- Mission optimizes to support long-term data supply through 2014
- Operational since April 25, 2008

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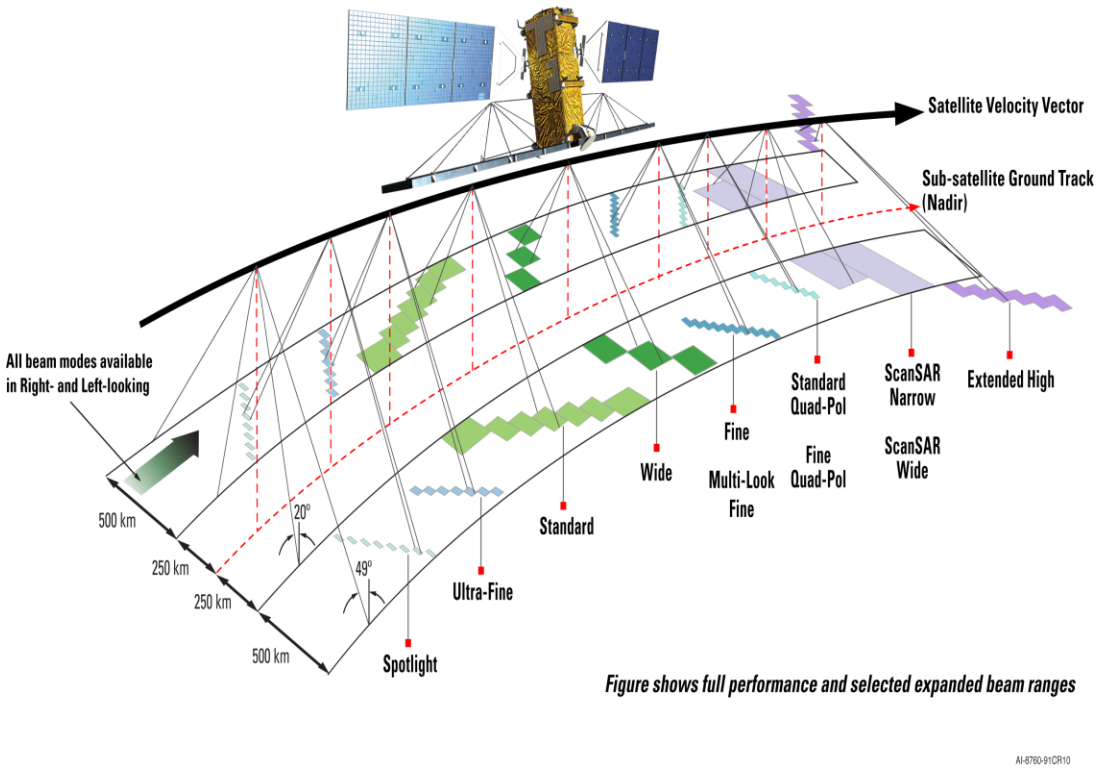
RADARSAT-2 Features

- High resolution:
  - 3 m
  - multi-look 10 m
  - SpotLight
- Polarimetric modes
  - single/dual polarization
  - quad-pol
- Right and left-looking capability
- Enhanced ground system providing:
  - efficient satellite tasking (12 - 24 hours routine)
  - faster data processing
  - data encryption
- Re-configurable:
  - new modes have been implemented



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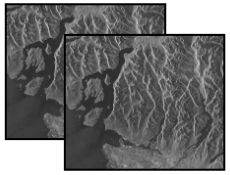
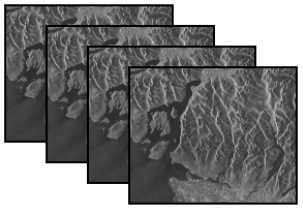
RADARSAT-2 Imaging Parameters



HH + HV
VV +VH



HH + VH + HV + VV

Beam Mode		Approximate Incidence Angle	Nominal Swath Width	Approximate Resolution Gnd Rg x Az	Number of looks Rg x Az
Selective Polarization transmit H or V receive H and / or V	Fine	30° - 49°	50 km	10 x 9 m	1 x 1
	Standard	20° - 49°	100 km	25 x 28 m	1 x 4
	Low Incidence	*10° - 23°*	*170 km*	*40 x 28 m*	*1 x 4*
	High Incidence	49° - 59°	70 km	20 x 28 m	1 x 4
	Wide	20° - 44°	150 km	25 x 28 m	1 x 4
	ScanSAR Narrow	20° - 46°	300 km	50 x 50 m	2 x 2
	ScanSAR Wide	20° - 49°	500 km	100 x 100 m	4 x 4
Polarimetric transmit H and V on alternate pulses receive H and V simultaneously	Fine Quad-Pol	20° - 41°	25 km	11 x 9 m	1 x 1
	Standard Quad-Pol	20° - 41°	25 km	25 x 28 m	1 x 4
Selective Single Polarization transmit H or V receive H or V	Ultra-fine	30° - 49°	20 km	3 x 3 m	1 x 1
	Multi-Look Fine	30° - 49°	50 km	11 x 9 m	2 x 2
	SpotLight	20° - 49°	8 x 20 km	2.2 x 0.7 m	1 x 1

HH or VV or HV or VH

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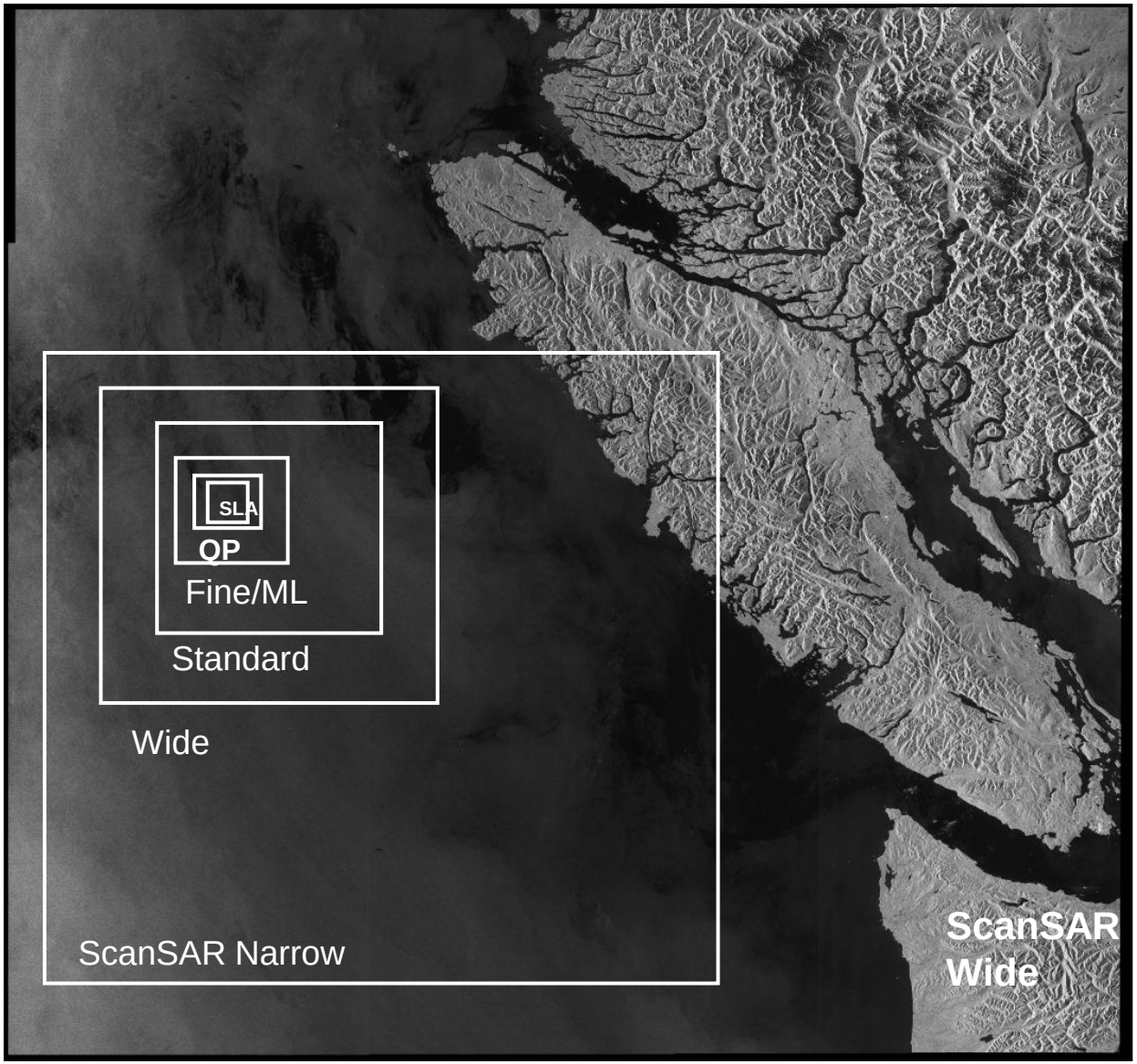
RADARSAT-2 Beam Mode Coverage



- ScanSAR Wide
  - 500 km x 500 km
  - 100 m res
- ScanSAR Narrow
  - 300 km x 300 km
  - 50 m res
- Wide
  - 140 km x 140 km
  - 30 m res
- Standard
  - 100 km x 100 km
  - 25 m res
- Fine/ML
  - 50 km x 50 km
  - 10 m res
- Quad Standard
  - 25 km x 25 km
  - 25 m res
- Quad Fine
  - 25 km x 25 km
  - 10 m (nom)
- SpotLight
  - 10 km x 20 km
  - .8m x 2.5 m res

(Nominal values)

© MDA

SpotLight

Spotlight 1:1
.8 m x 2.3 m
resolution
20 km swath width

Vancouver airport

© MDA

Red(HH)+Green(HV)+Blue(VV)

Fine QP 19
39° inc angle
9 m nominal res

Acquired Aug/08

© MDA

AgriSAR 2009 Campaign

- ESA-funded project to assess the pre-launch capability of the planned Sentinel-1 SAR for agriculture and land cover monitoring

- Objective is to use RADARSAT-2 quad-polarized data to simulate Sentinel-1 Interferometric Wide Swath High-Resolution mode (IW-HR):
  - IW-HR mode is dual polarized:(VV+VH) or (HH+HV)

- Sentinel-1/2 are dual-pol only, but follow-on mission may have quad-pol capability, so RADARSAT-2 data are used to assess the incremental benefit of quad-pol for agriculture and land cover monitoring

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AgriSAR Test Sites

- Test sites
  - Indian Head, Saskatchewan, Canada
  - Flevoland and Garderen, Netherlands
  - Barrax, Spain
- Spaceborne data
  - RADARSAT-2 quad-pol
  - RapidEye optical
- Ground sampling
  - Crop type & field area
  - Seeding and harvest dates
  - Weekly: photographs, LAI, growth index
  - Meteorological data: rain, temperature

Indian Head showing RADARSAT-2 acquisitions (red), RapidEye (yellow), and area-of-interest (green).

© MDA

RADARSAT-2 Acquisition Summary

- Acquisition plan:
  - Acquire all available Fine-Quad scenes over each test site:
  - 1 April and 30 September 2009
  - Right looking
  - Ascending and descending passes

- Acquisition results:

Test site	RADARSAT-2 Acquisition Summary			
	Planned	**Successful**	**Unsuccessful**	**Volume**
Barrax, ES	60	57 (95%)	3 (order error)	17.4 GB
Indian Head, SK	74	57 (77%)	17 (conflicts)	4.2 GB
Flevoland, NL	76	65 (85%)	11 (conflicts)	141.GB
Garderen, NL (Asc. FQ5 and FQ21 only)	15	14 (87%)	2 (conflicts)	14.9 GB
Total	**225**	**193 (85%)**	**33**	**50.6 GB**

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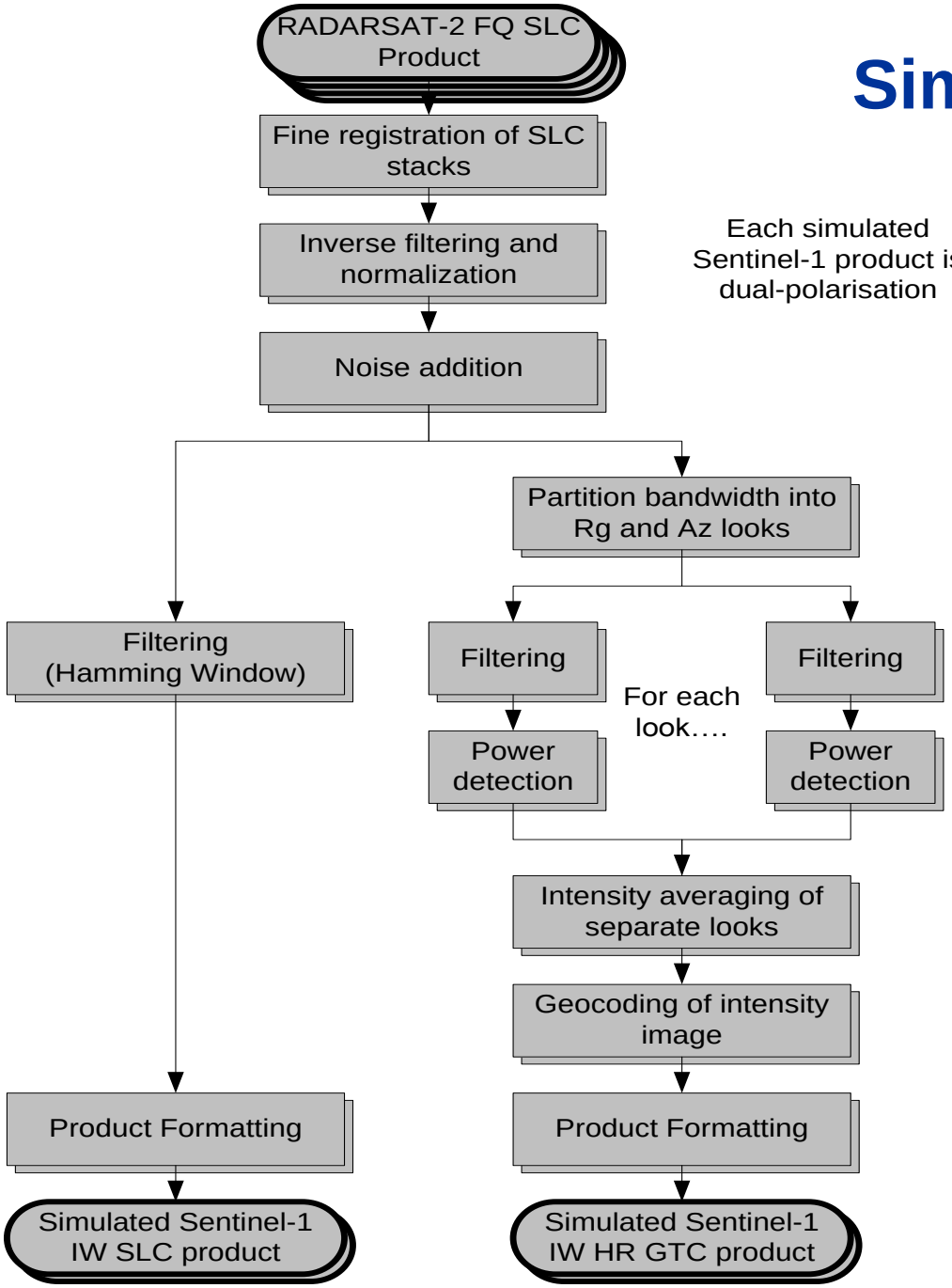
Simulation Process



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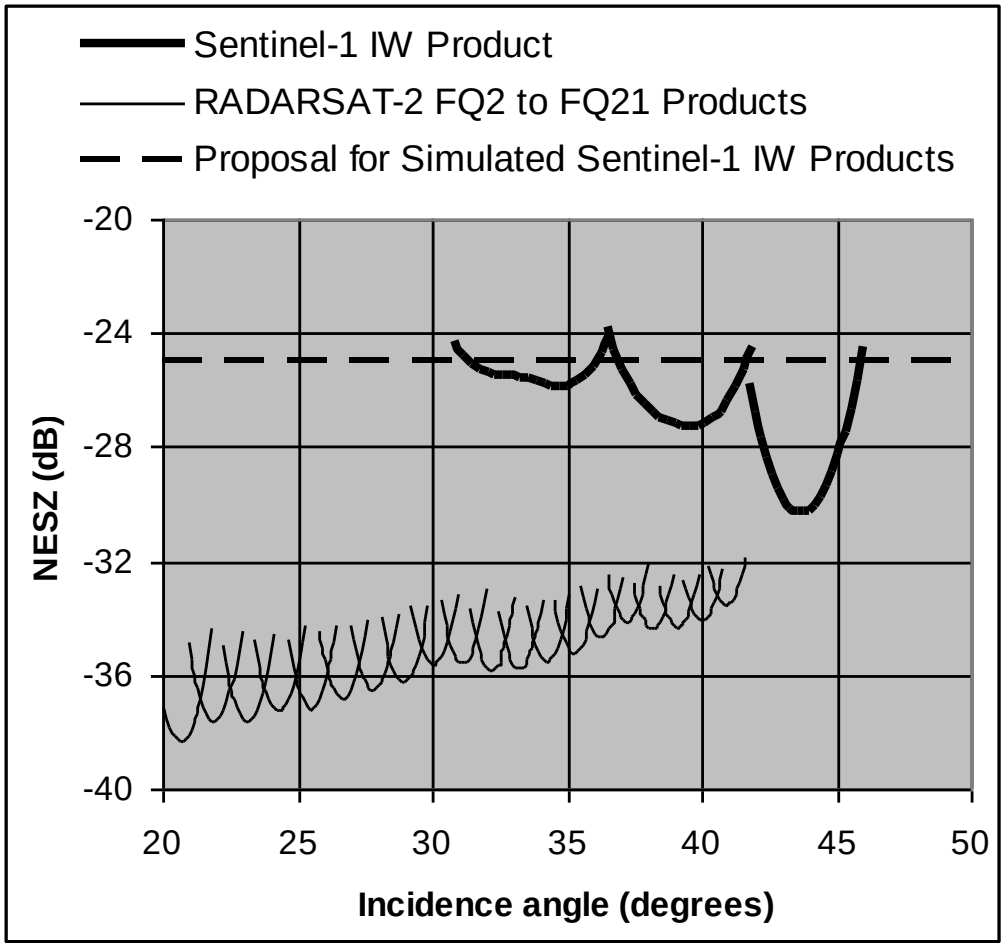
IW Simulation: Noise Level



- The RADARSAT-2 Fine-Quad mode has a very low noise level.
- For Sentinel-1 simulation the noise equivalent sigma zero is raised to -25 dB.
- Note, RADARSAT-2 FQ and Sentinel-1 IW cover different incidence angles.

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Sentinel-1 – Simulation Comparison

Parameter	Sentinel-1	Simulation	Impact on Crop Classification Performance
Nominal Resolution [m] (rg x az)	20 x 21	20 x 22	Insignificant
Equivalent Number of Looks	4.9	4.3 – 5.3	Insignificant
Noise level (dB)	< -23.7	- 25 dB	Insignificant
Polarization	Dual (HH+HV) or (VV+VH)	Dual (HH+HV) and (VV+VH)	None
Swath Width (km)	250	25	None
Nominal Incidence Angle (°)	30 - 46	20 - 41	Minor

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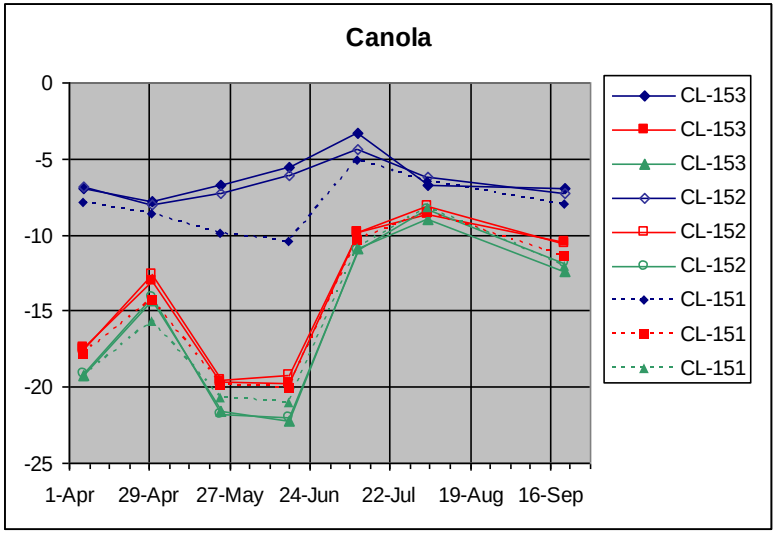
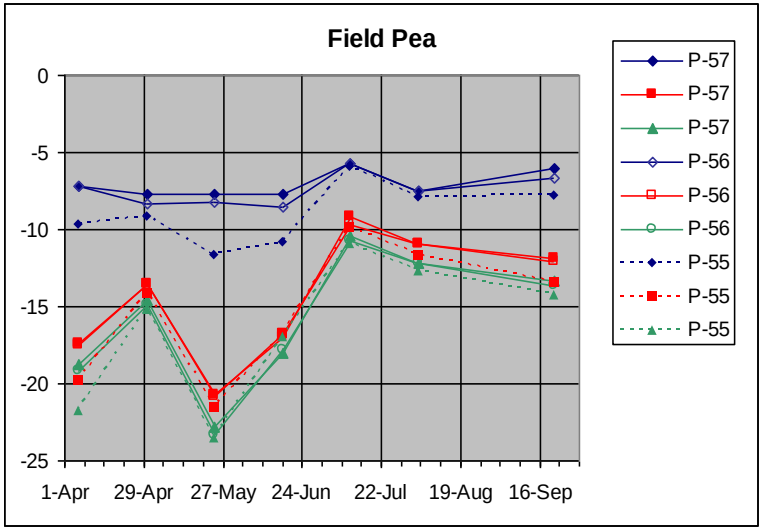
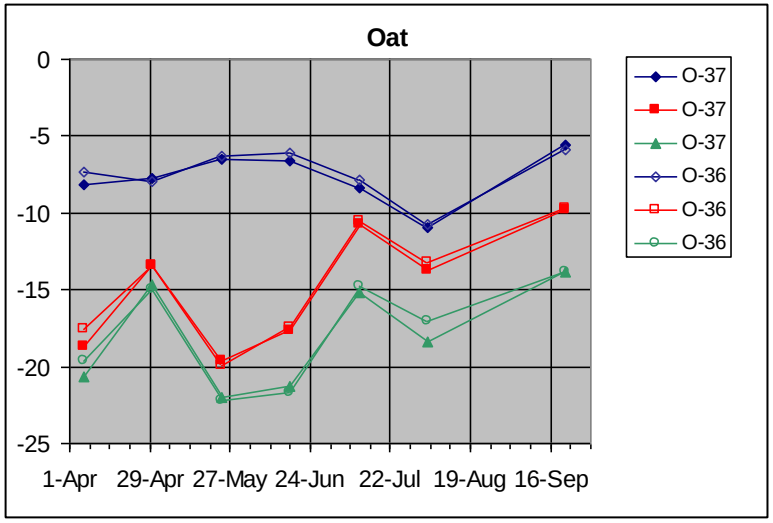
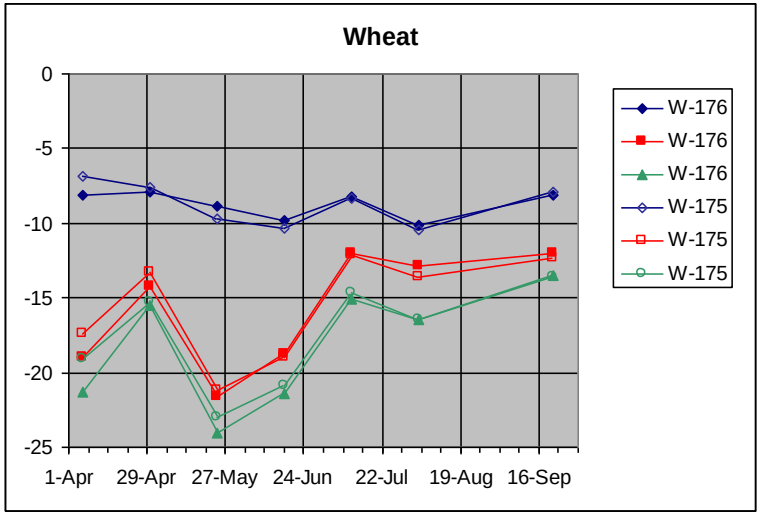
RADARSAT-2: Results to Date









Surface scattering

Dihedral scattering

Volume scattering

© MDA

Crop Response: Oats

1 June 2009 (PF_09)

10 June 2009 (PF_09)

17 June 2009 (PF_09)

24 June 2009 (PF_09)

8 July 2009 (PF_09)

15 July 2009 (PF_09)

30 July 2009 (sample)

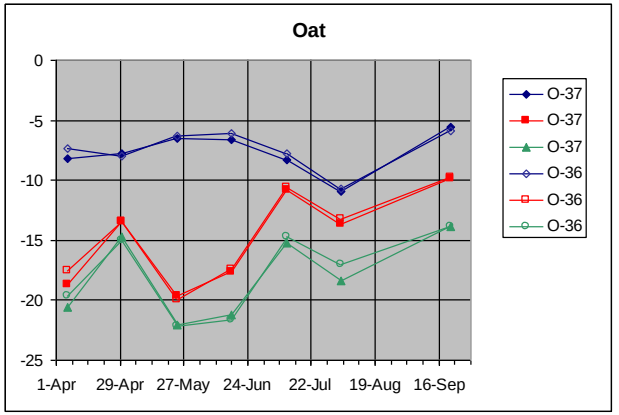
6 August 2009 (sample)

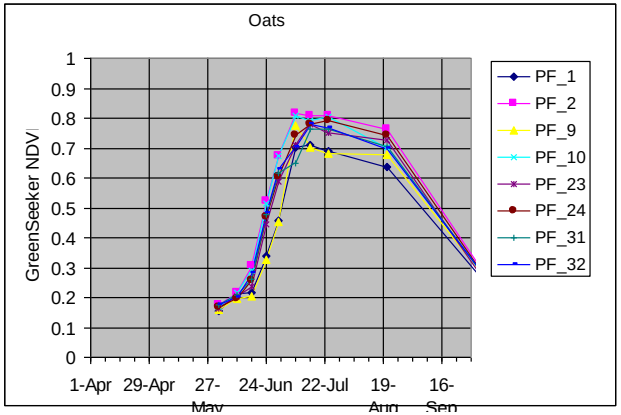
13 August 2009 (sample)

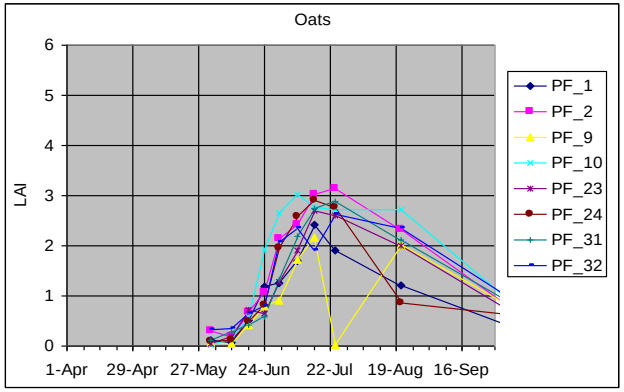
21 August 2009 (PF_09)

27 August 2009 (sample)

20 October 2009 (PF_09)







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Summary and Future Work

- Summary
  - Extensive dataset for developing SAR-based agriculture information products covering the entire growing season
  - Three diverse agriculture test sites
  - Quad-pol SAR data and derived simulations
  - Ground truth data
  - Near co-incident optical time series

- Future work
  - SAR-based crop classification using supervised classification
  - Evaluate dual-pol data and incremental benefit of quad-pol data

- Operational applications
  - Operational agriculture and land-cover information products more viable with recent development of RADARSAT-2 Wide-Swath Quad-Pol mode (50 km swath width versus 25 km)

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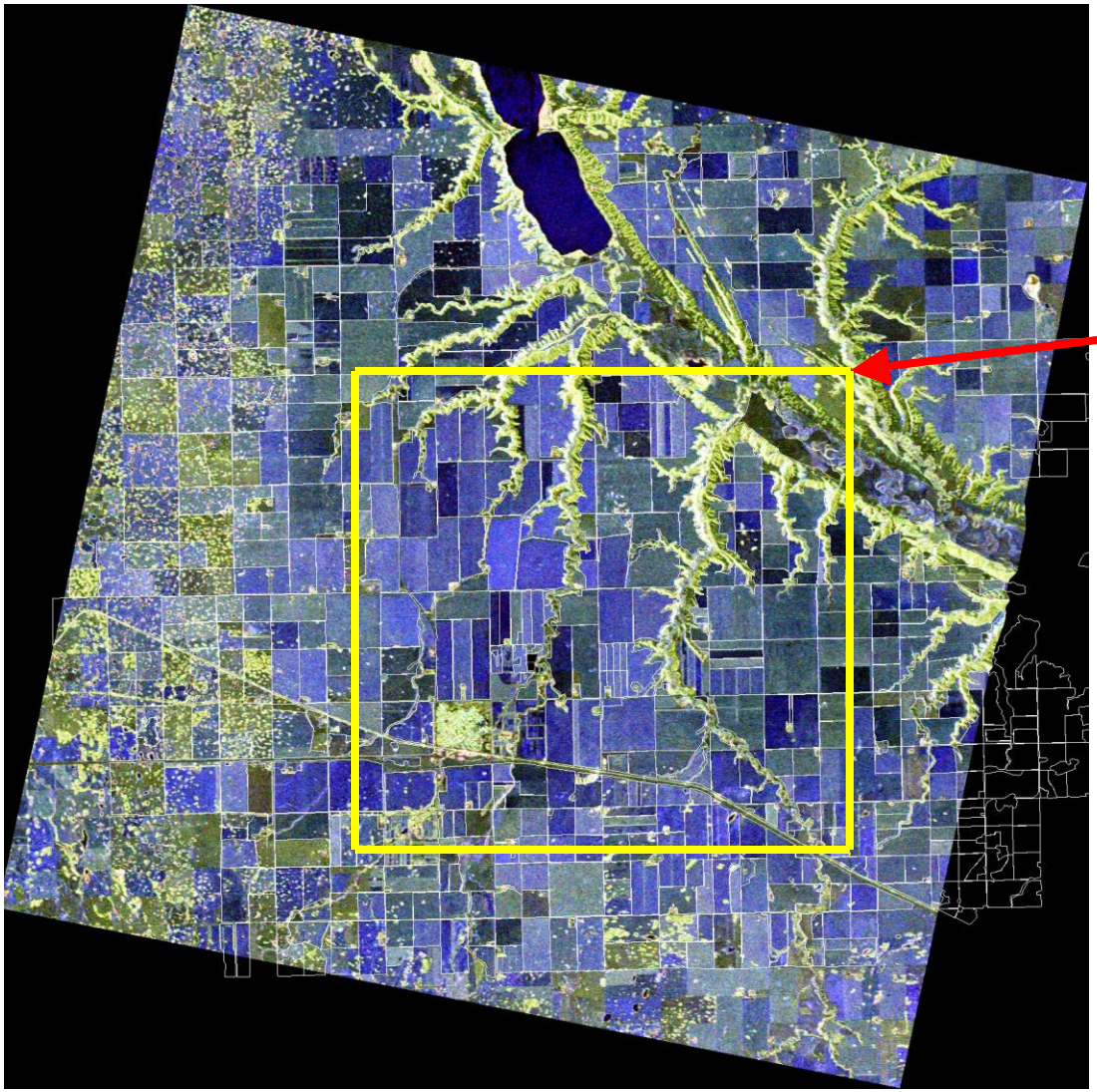
Indian Head Descending-Ascending Image Comparison



Area of Interest

Surface Scattering - $|HH+VV|^2$

Dihedral Scattering - $|HH-VV|^2$

Volume Scattering - $|HV|^2$

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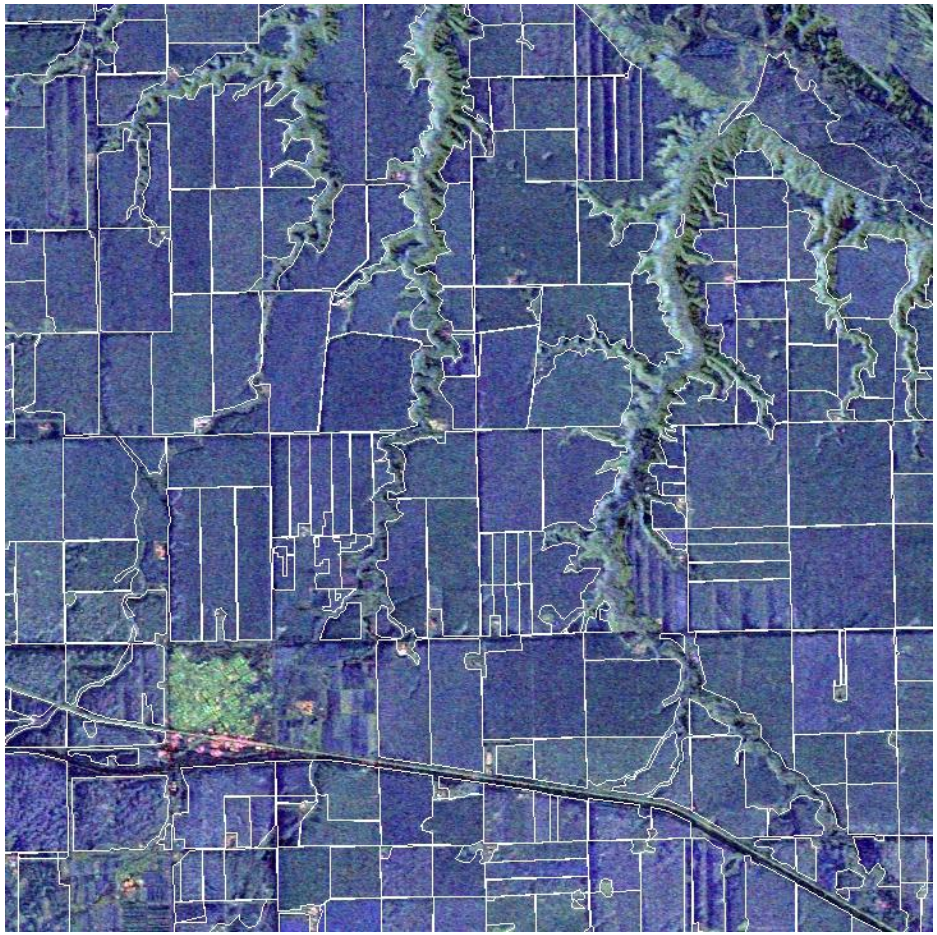
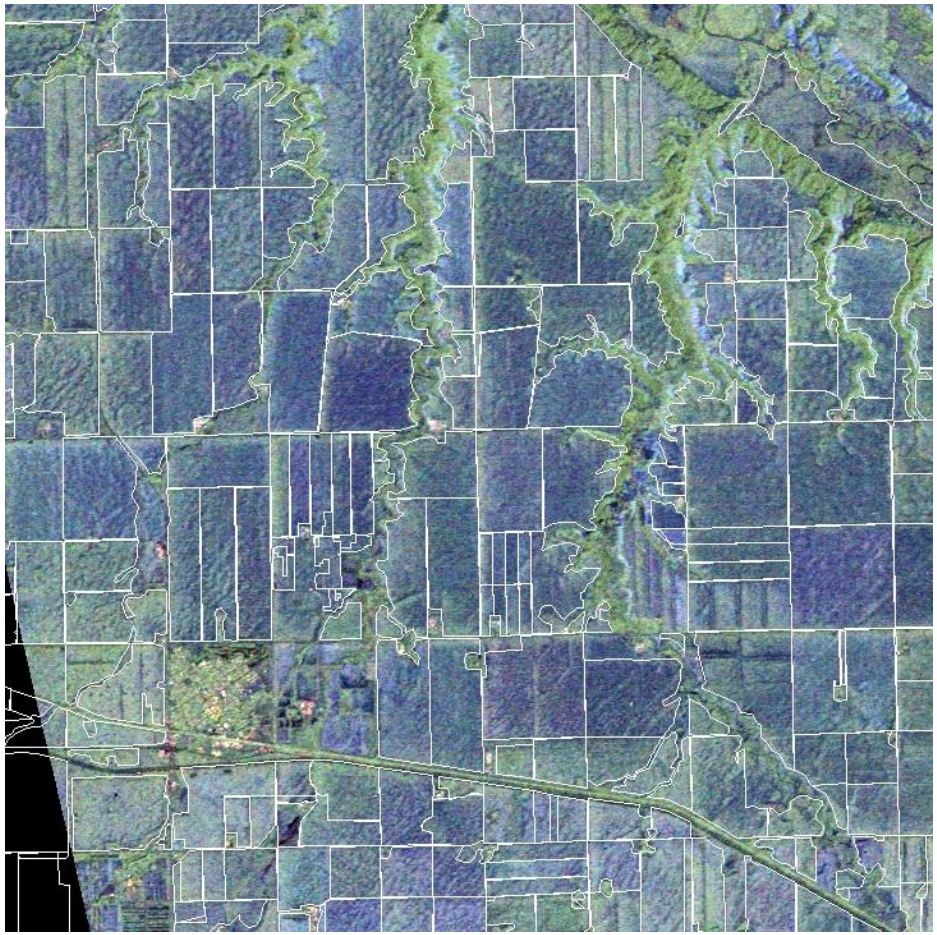
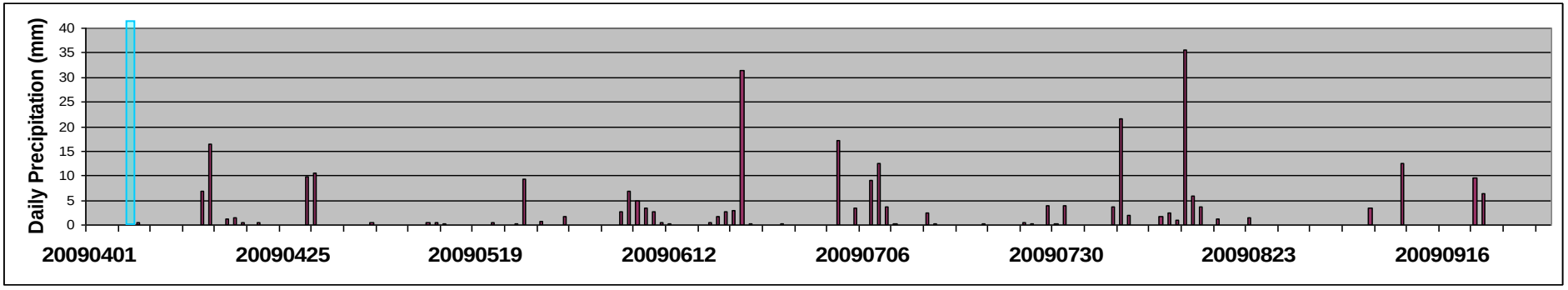
April 06, 2009	
Dsc FQ10	Asc FQ11

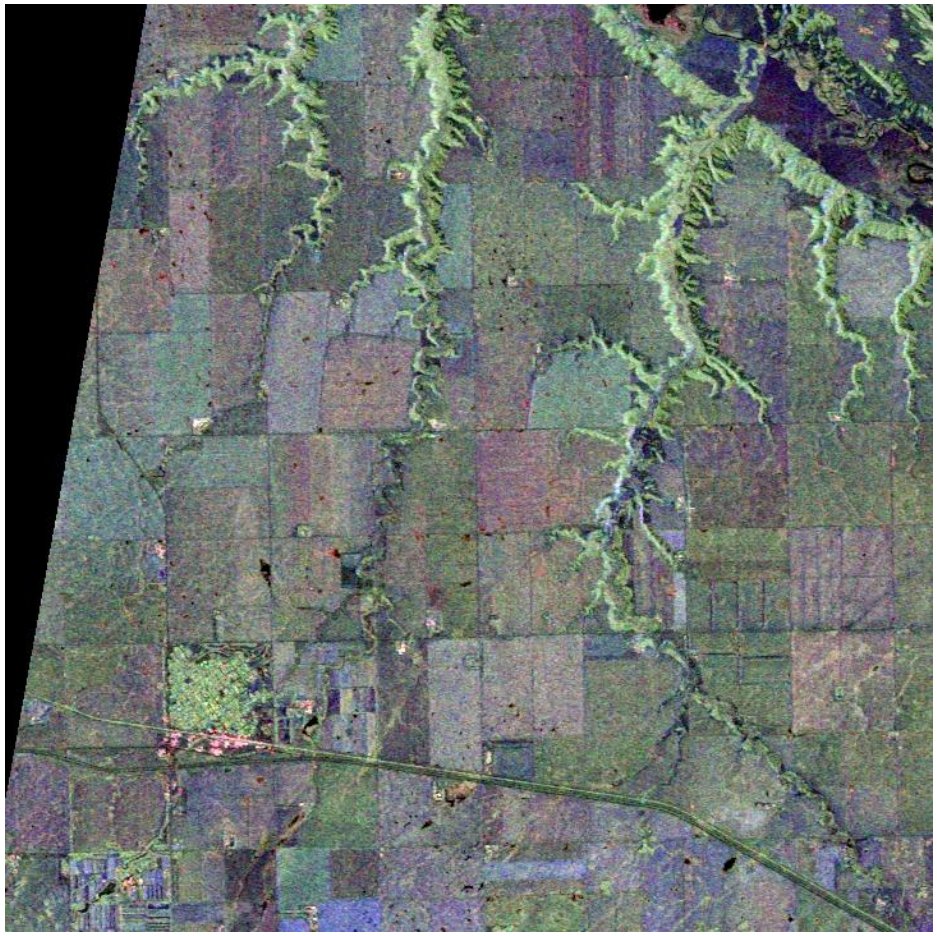
*Snow on Ground: 14 cm

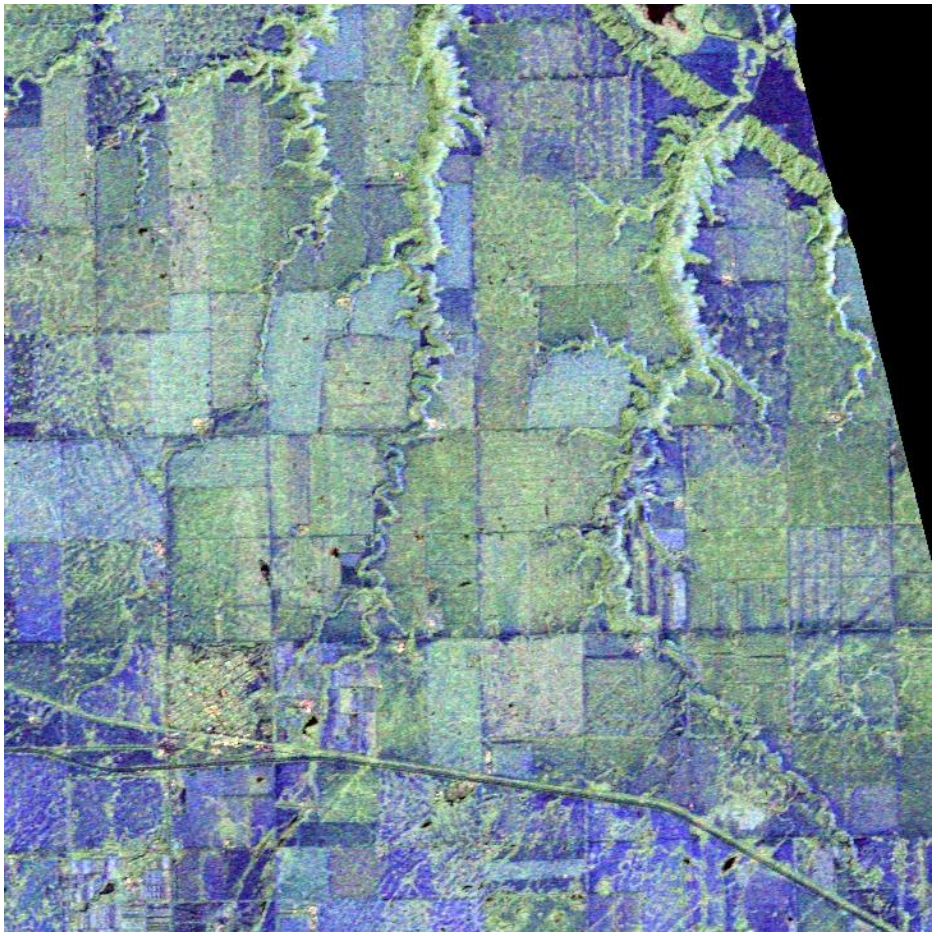


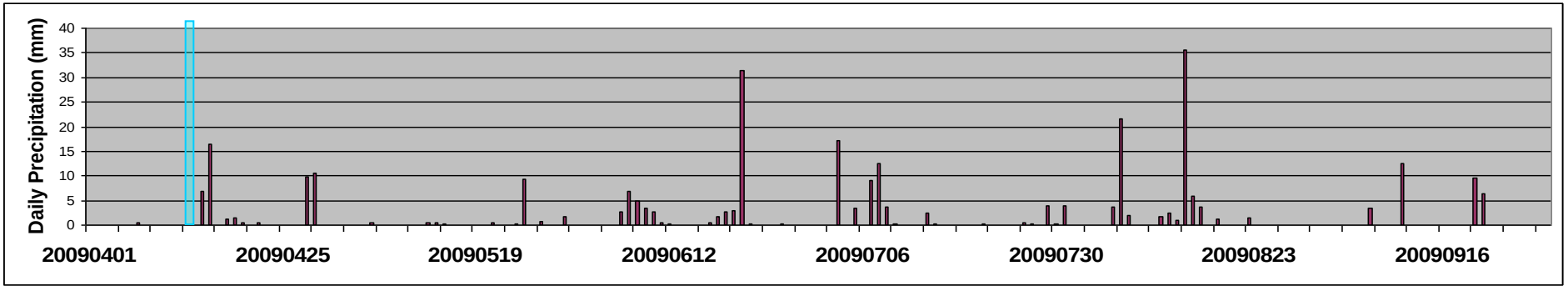




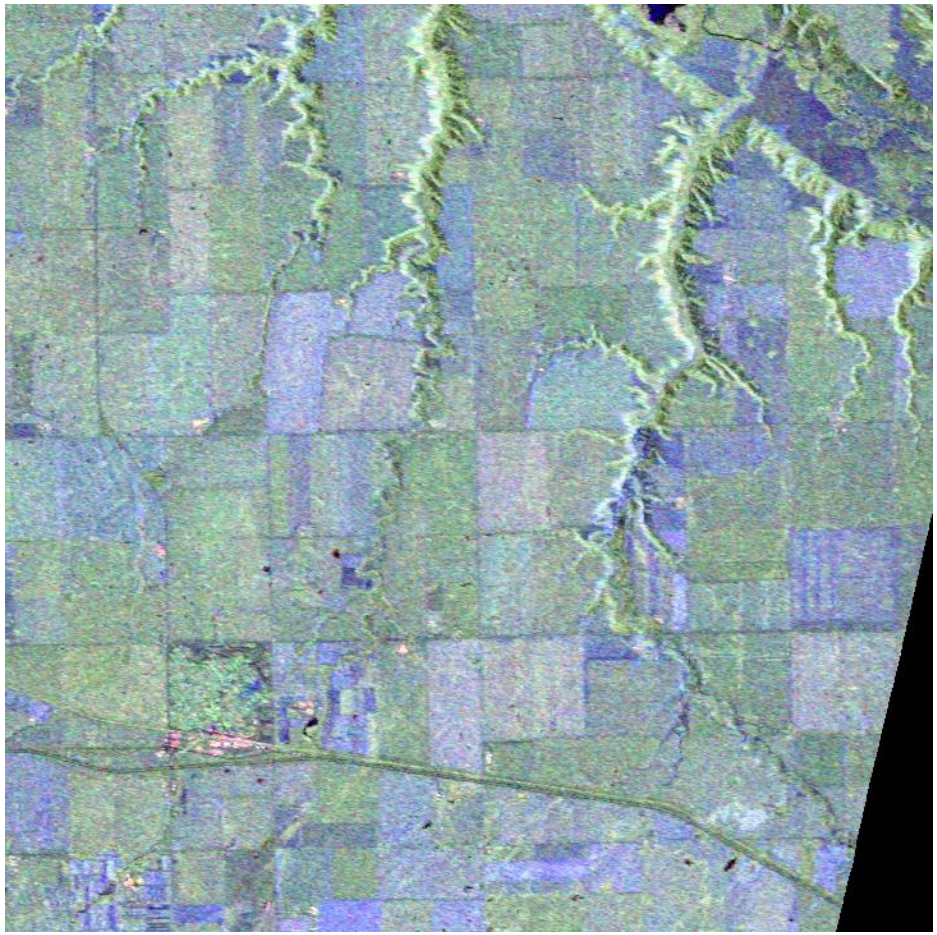
April 13, 2009	
Dsc FQ14	Asc FQ06

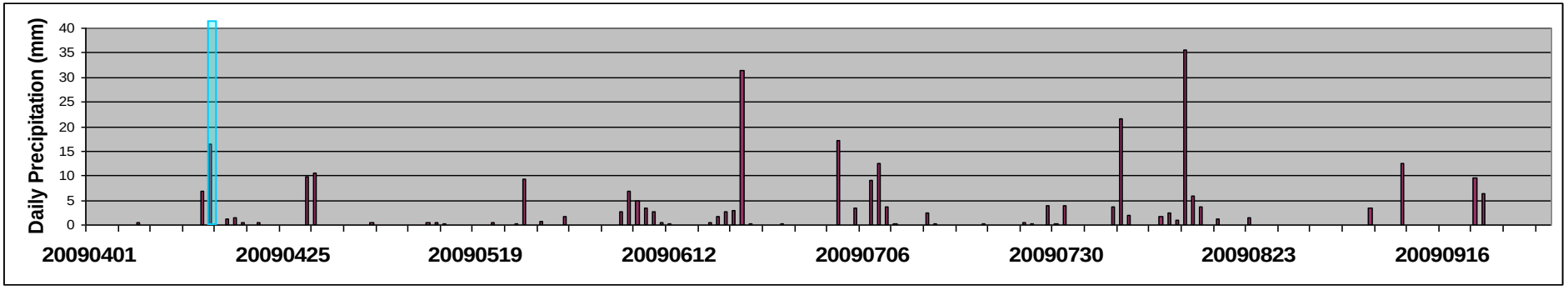




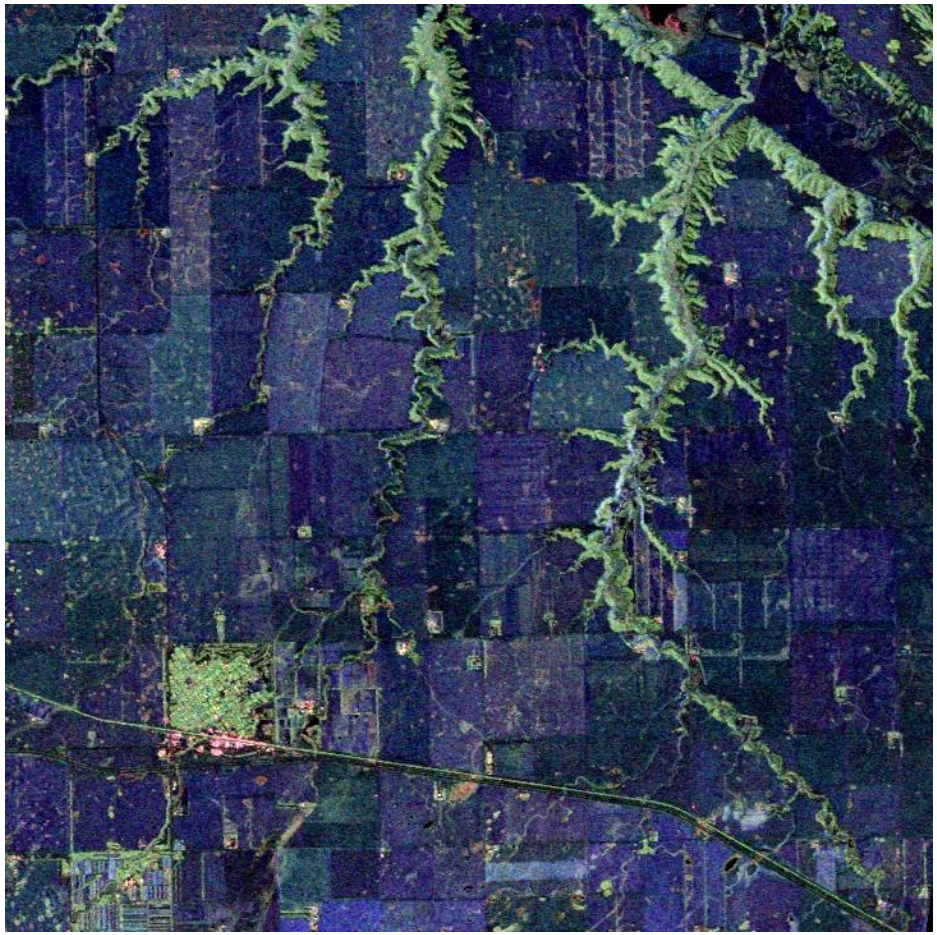


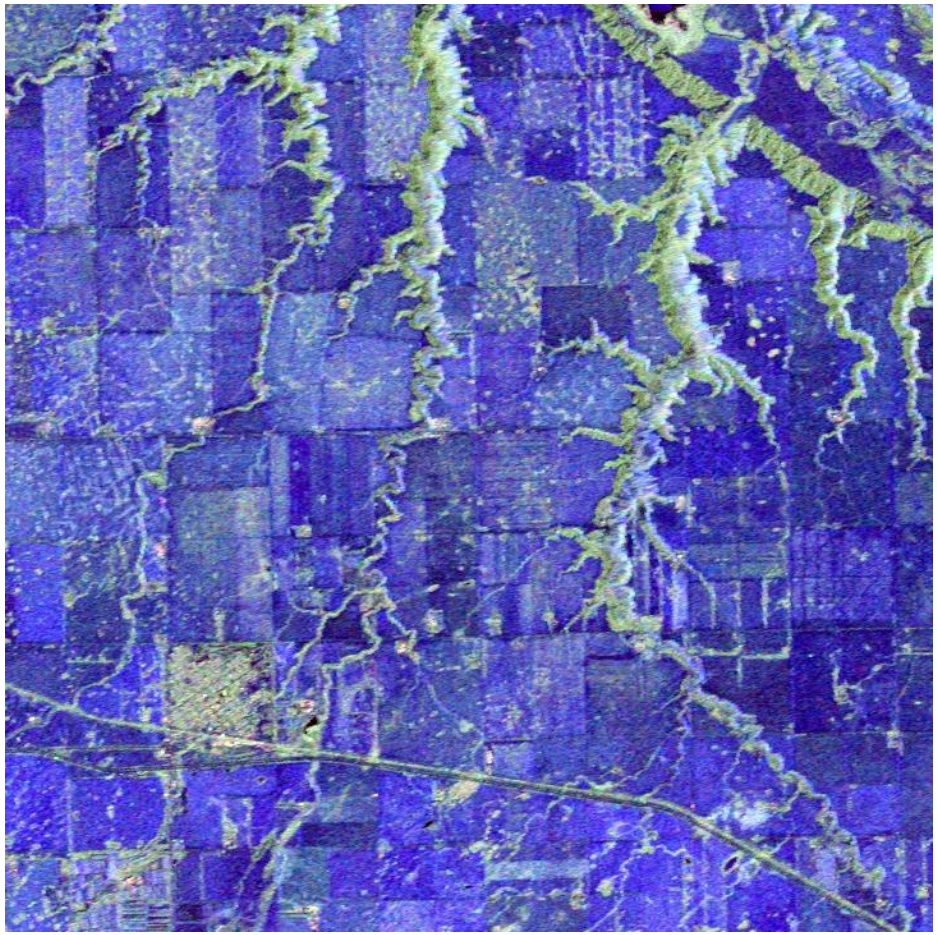
April 16, 2009	
Dsc FQ02	Asc FQ19

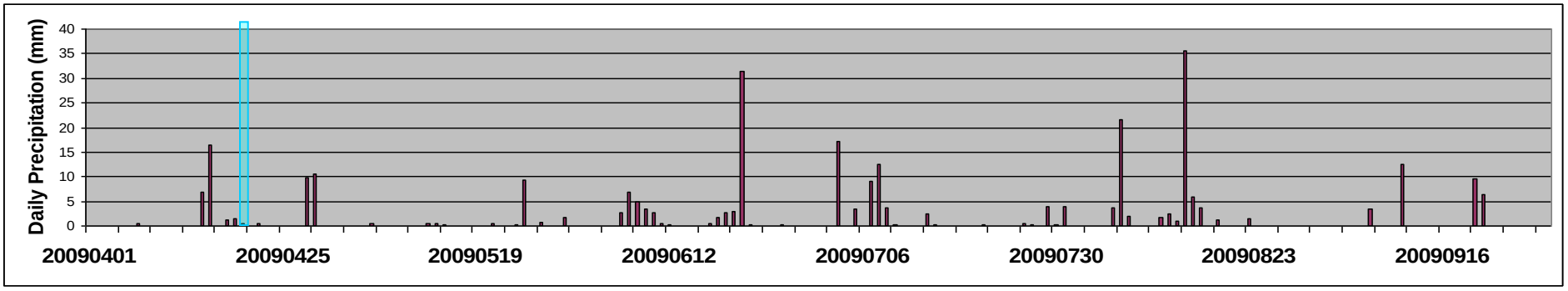




April 20, 2009	
Dsc FQ19	Asc FQ02

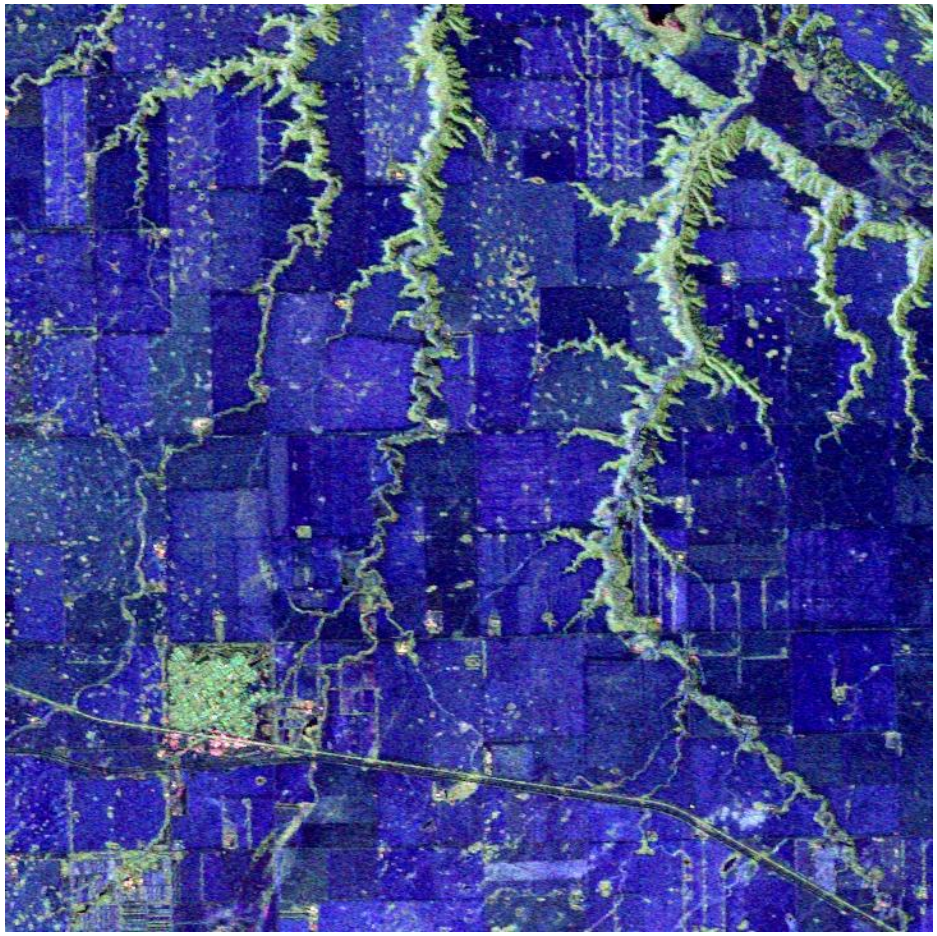


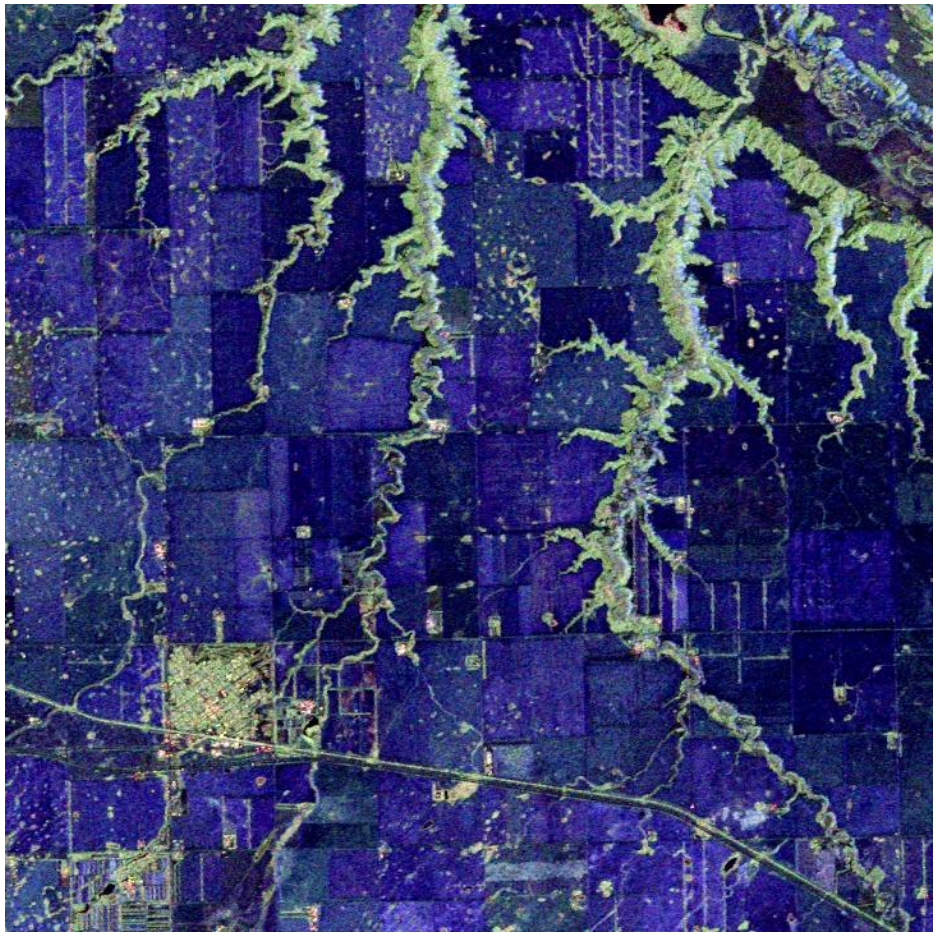


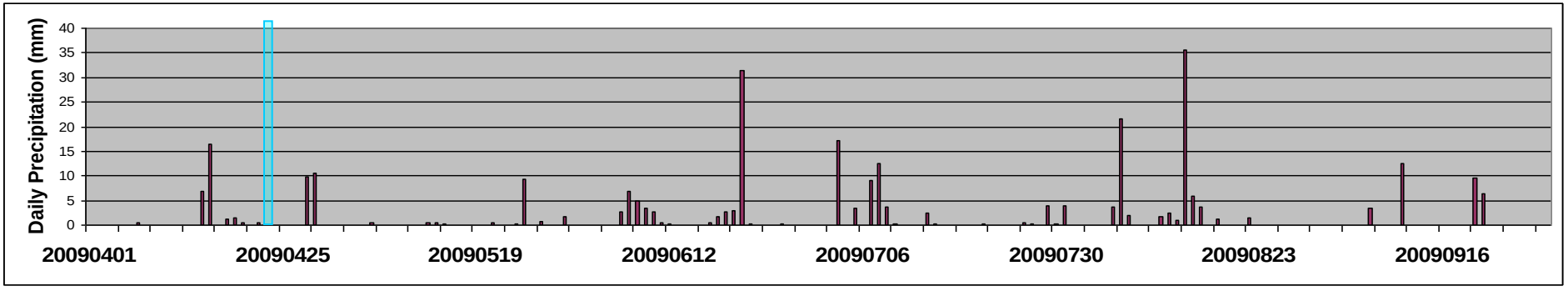


April 23, 2009	
Dsc FQ06	Asc FQ15

*Snow on Ground: 2 cm

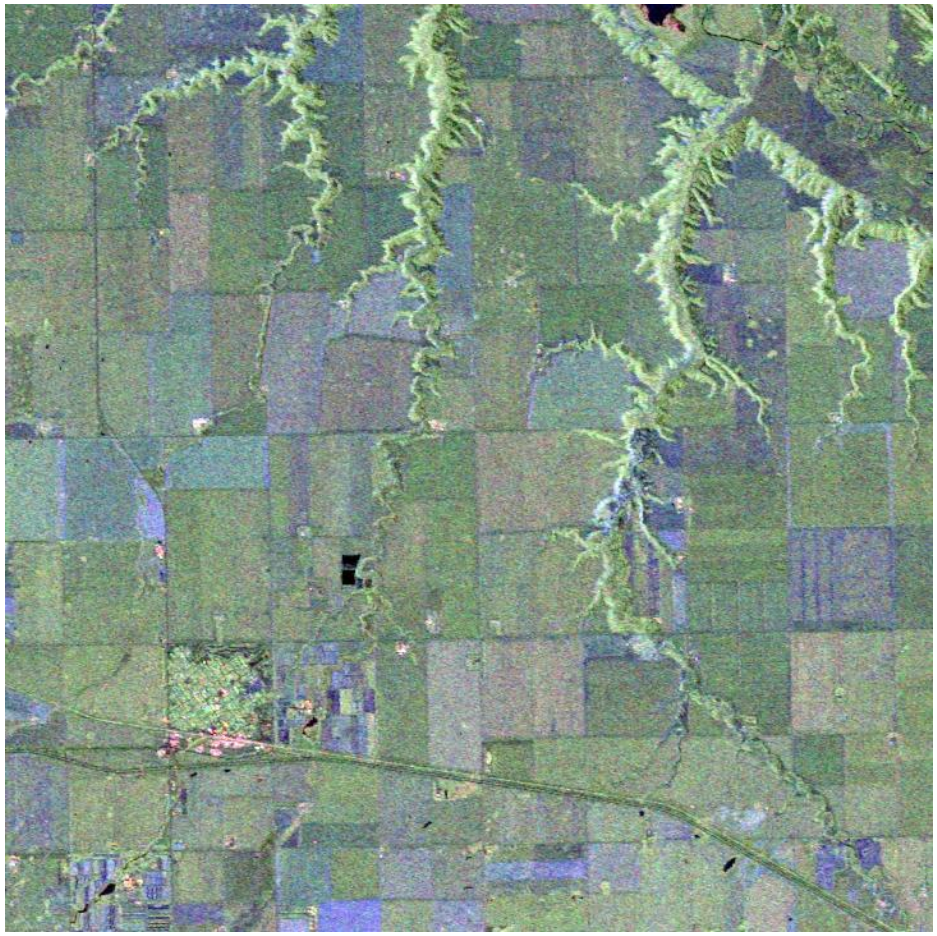


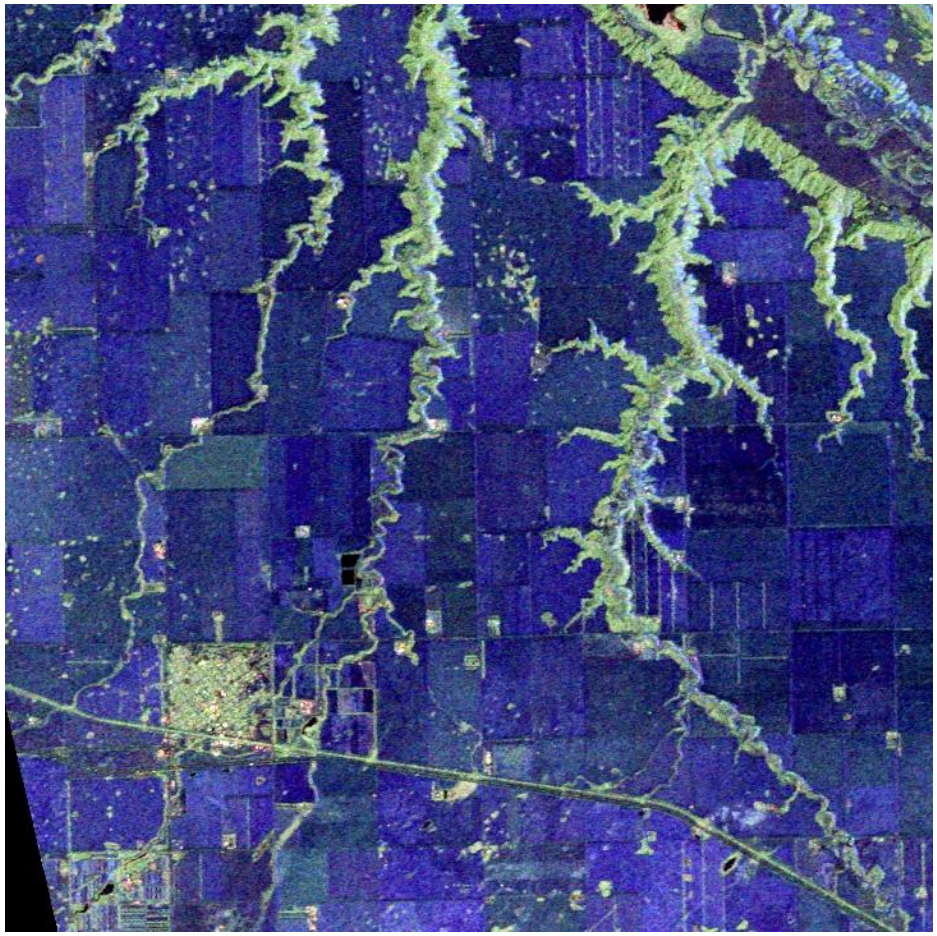


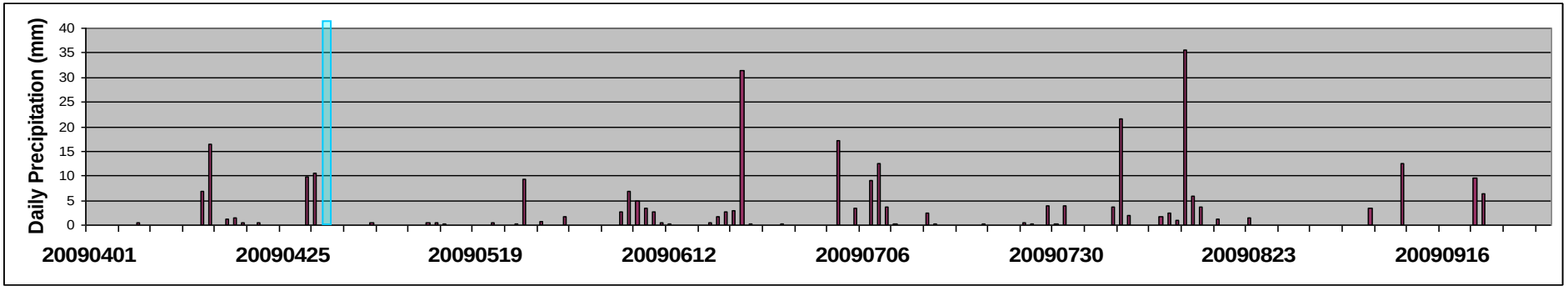


April 30, 2009	
Dsc FQ10	Asc FQ11

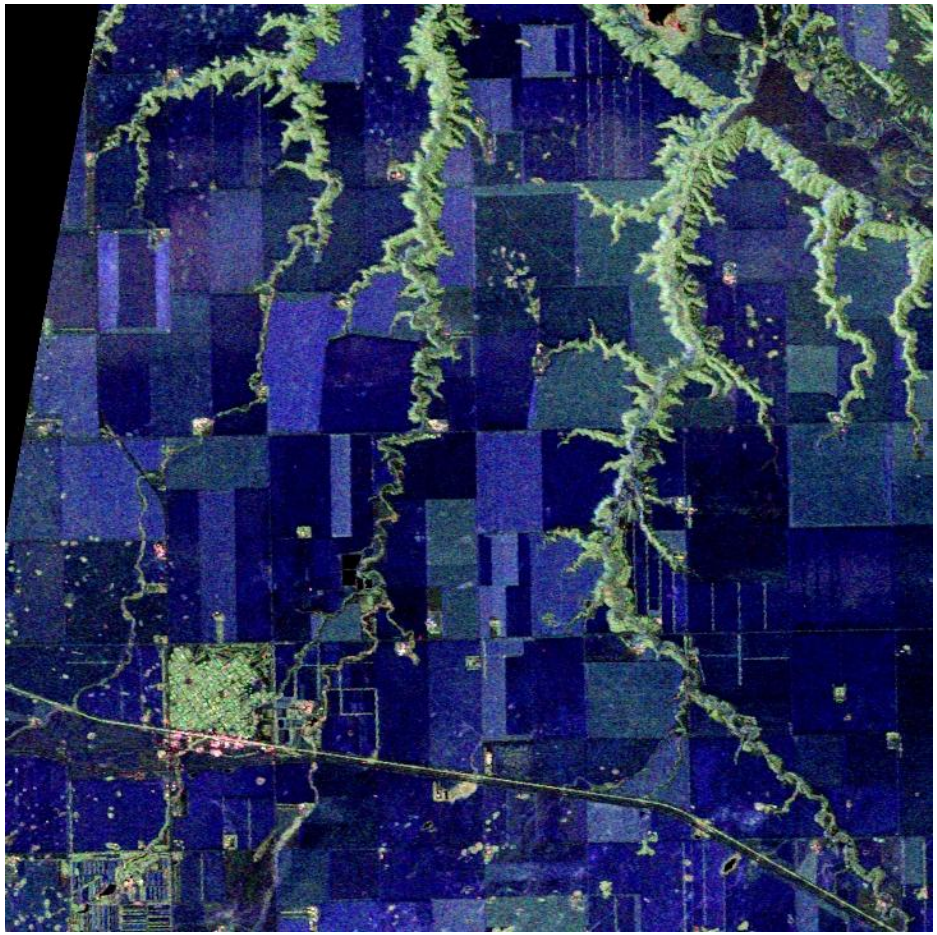
*Snow on Ground: 1 cm

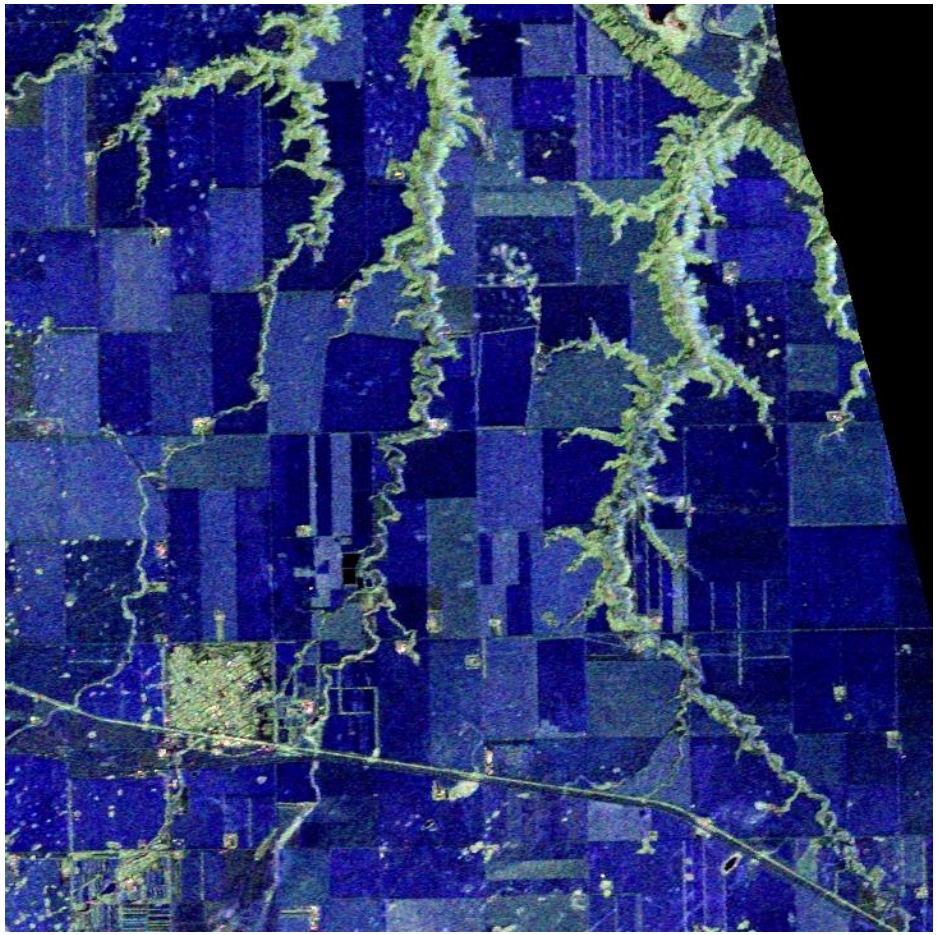


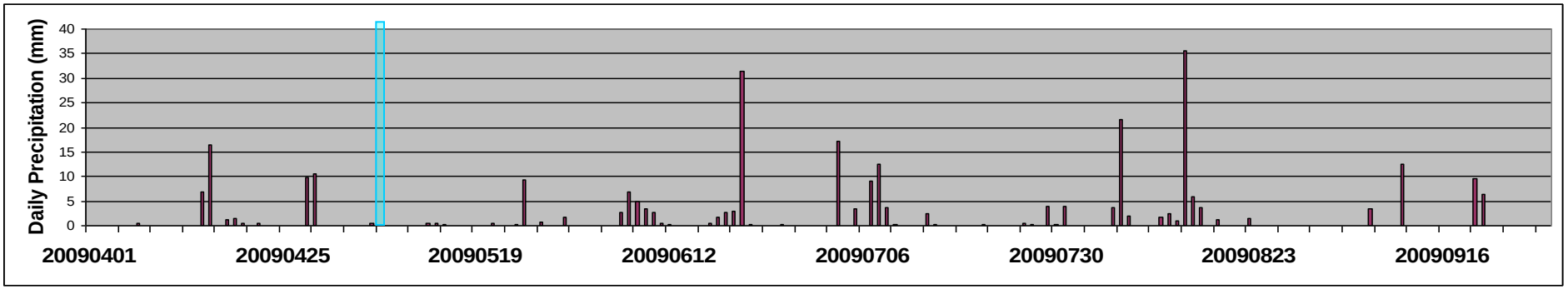




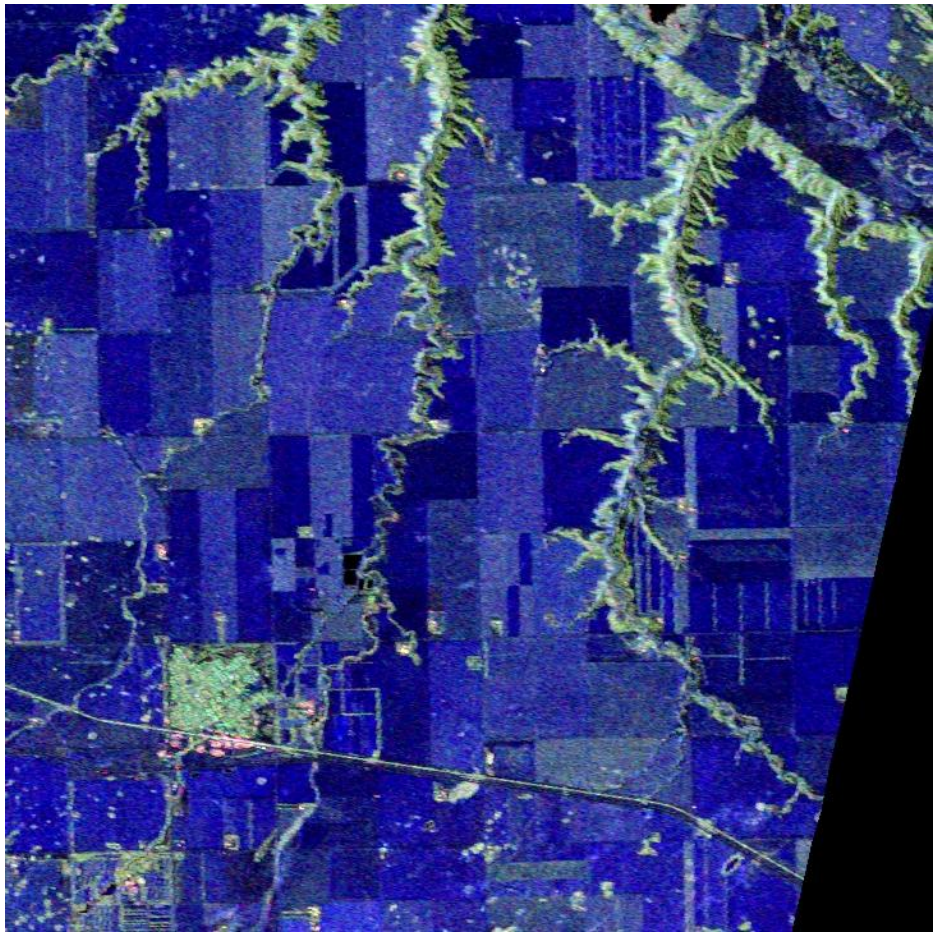
May 07, 2009	
Dsc FQ14	Asc FQ06

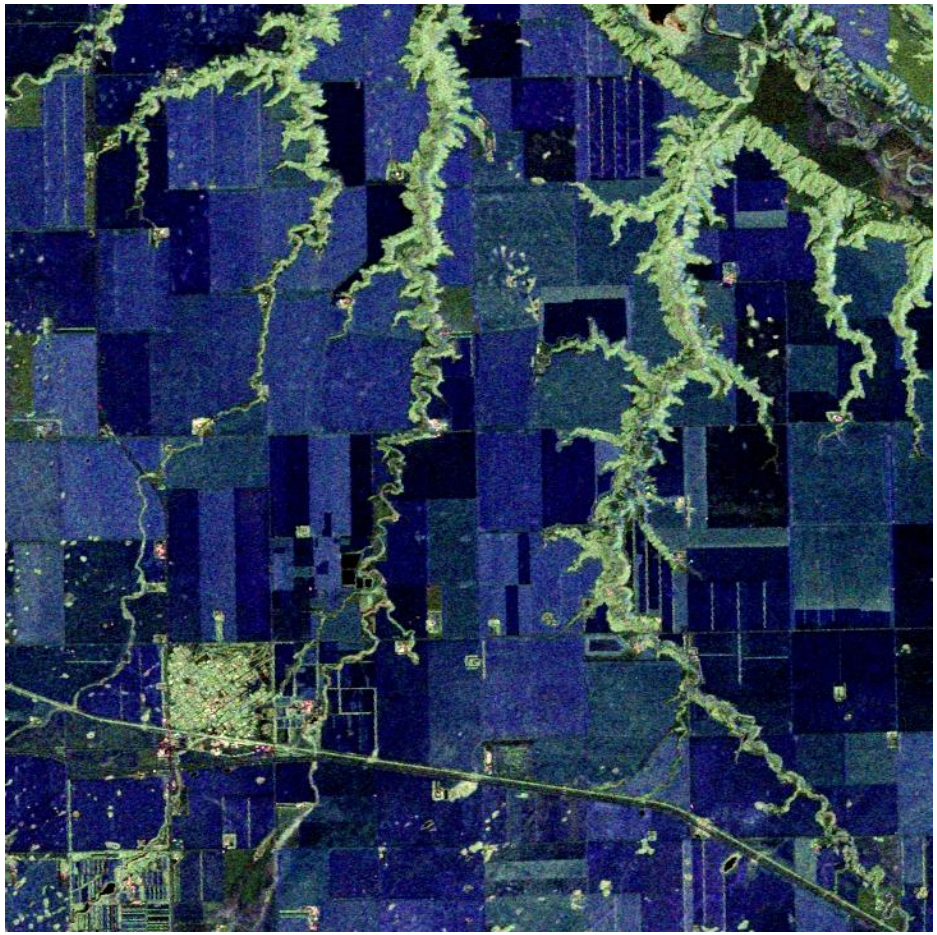


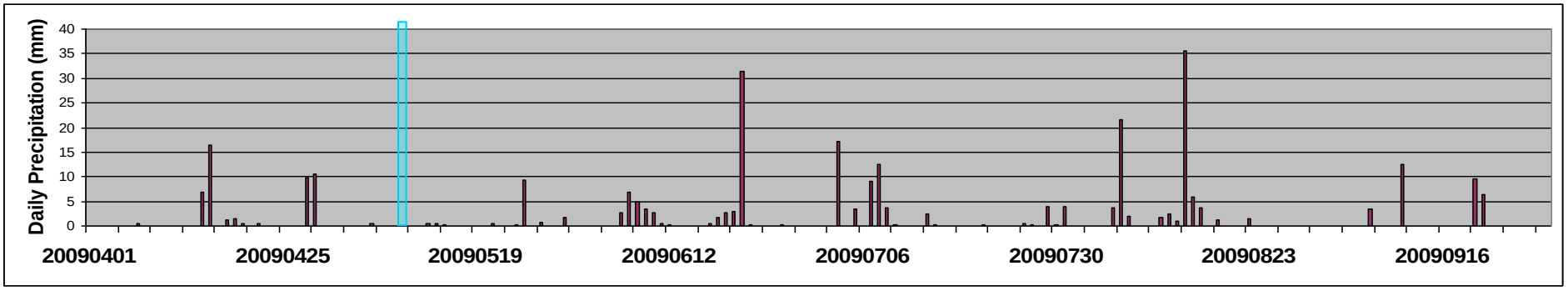




May 10, 2009	
Dsc FQ02	Asc FQ19

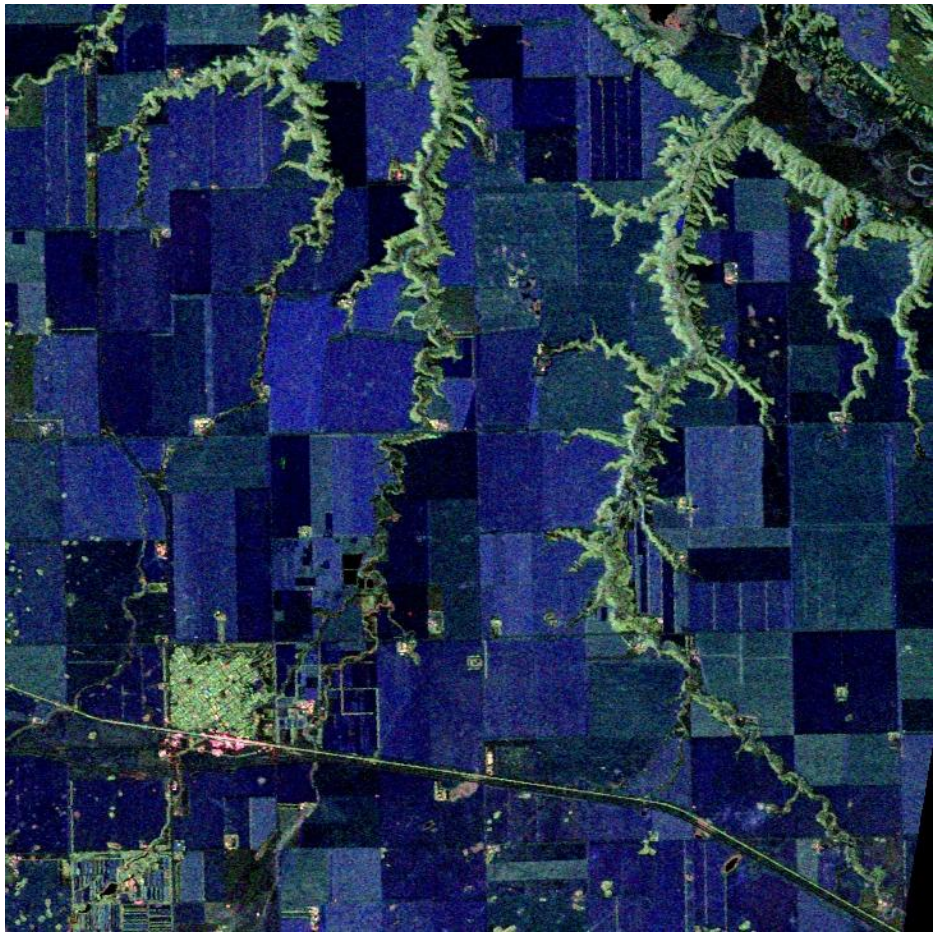


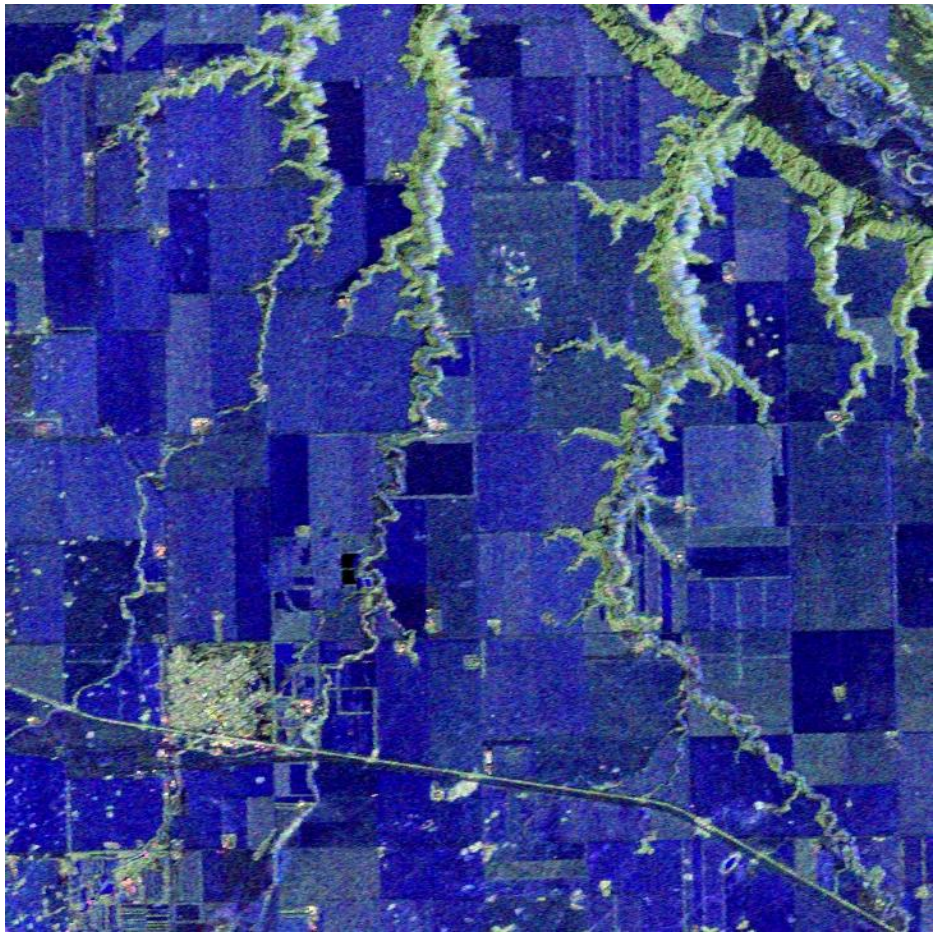


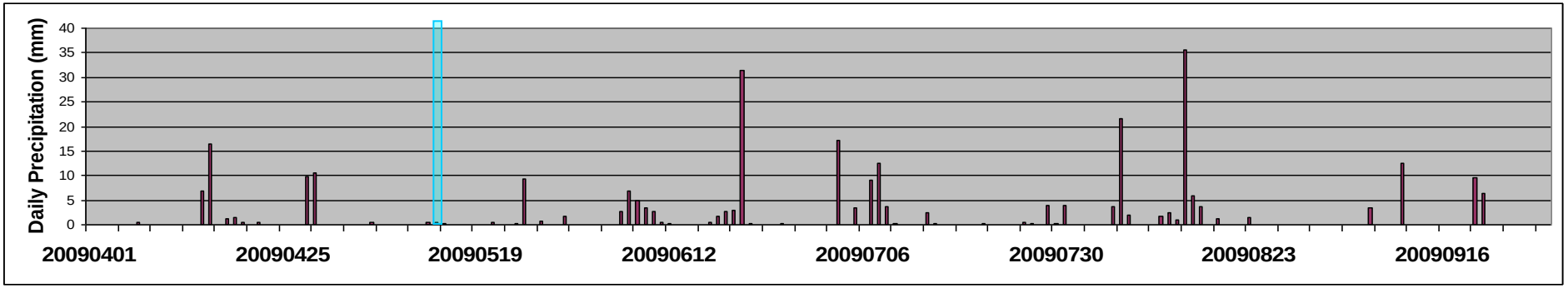


May 14, 2009	
Dsc FQ19	Asc FQ02

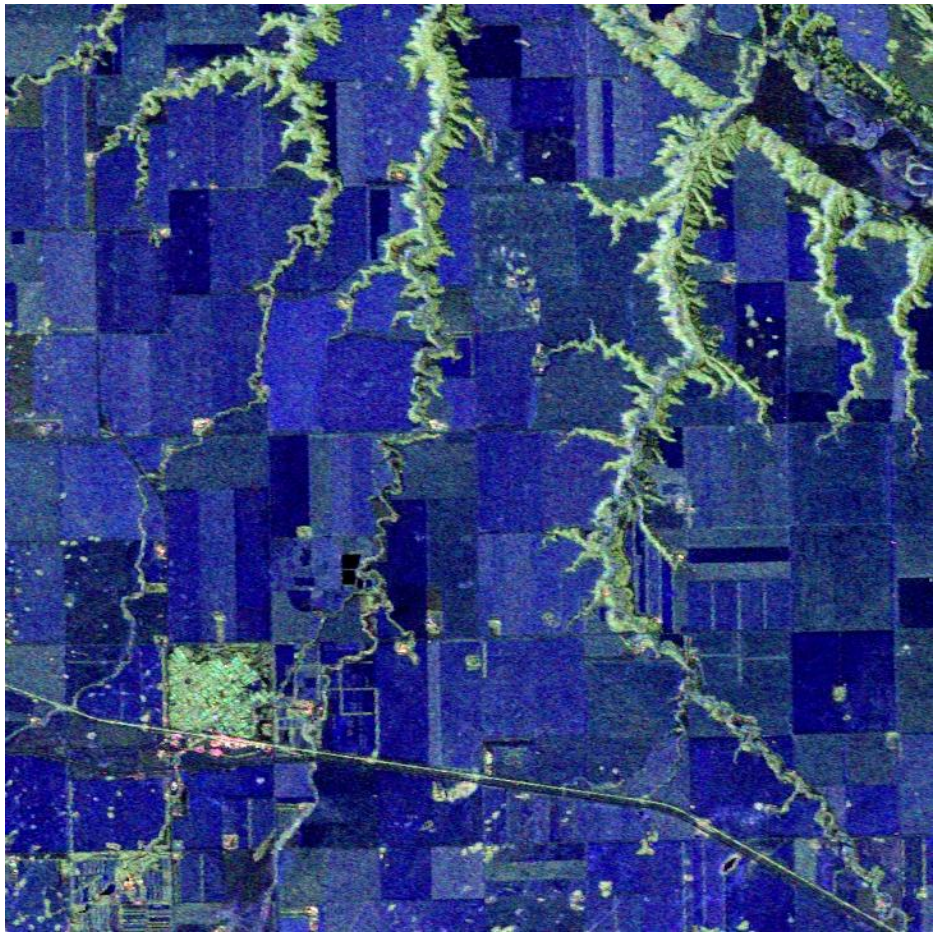
*Snow on Ground: 3 cm

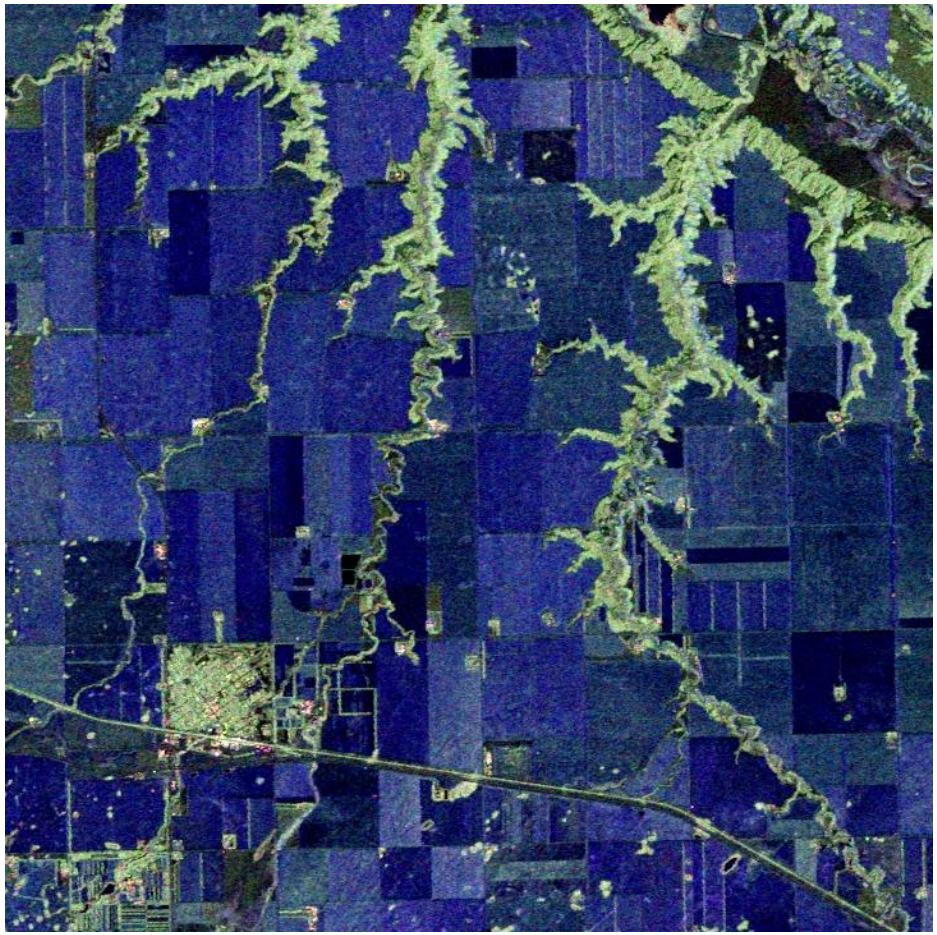


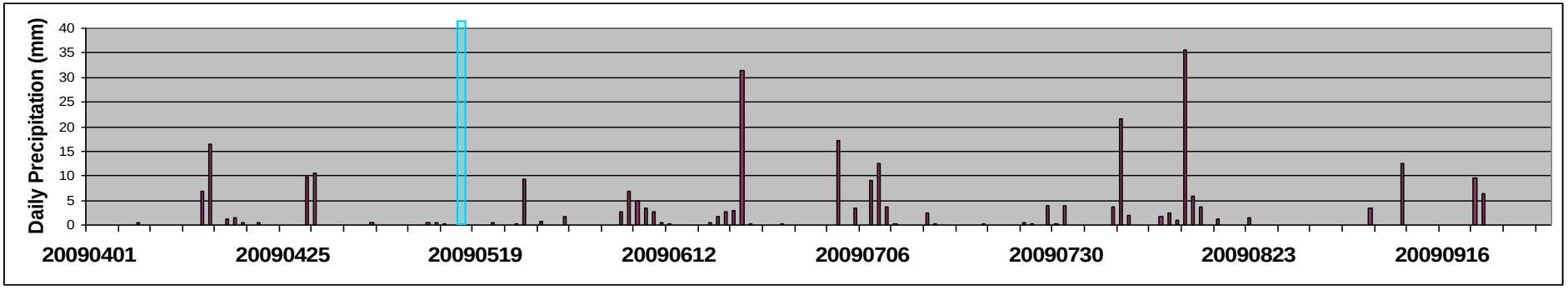




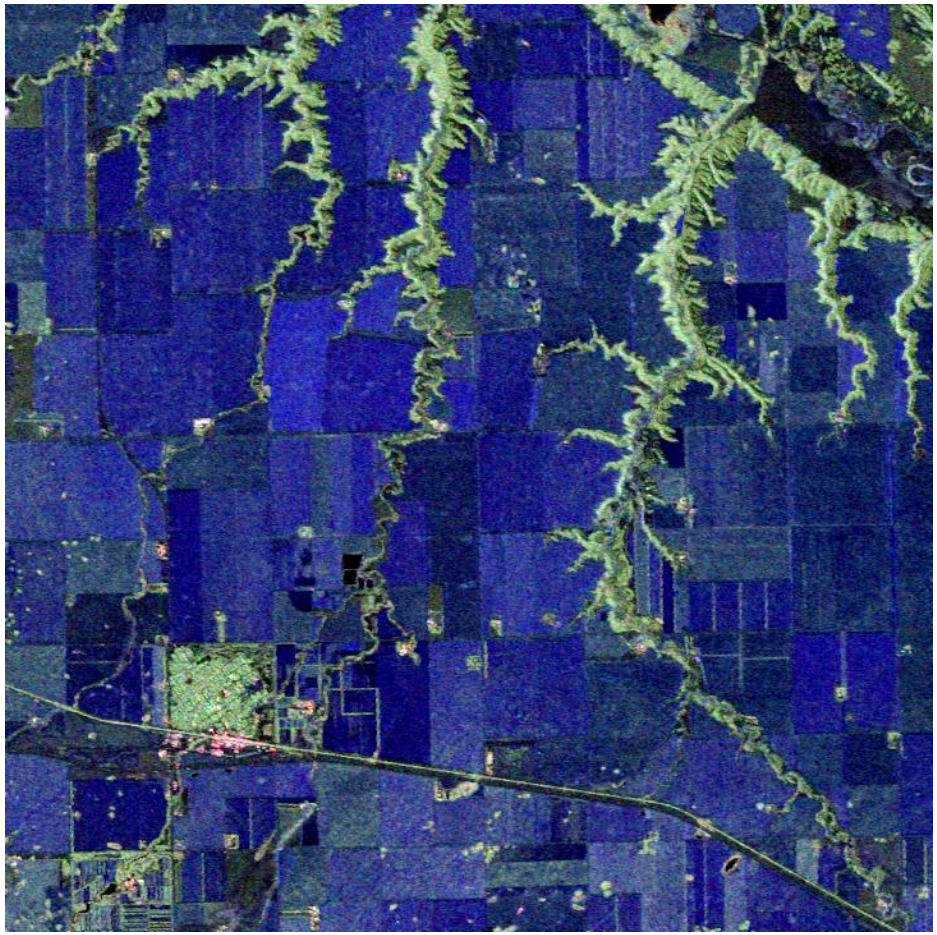
May 17, 2009	
Dsc FQ06	Asc FQ15

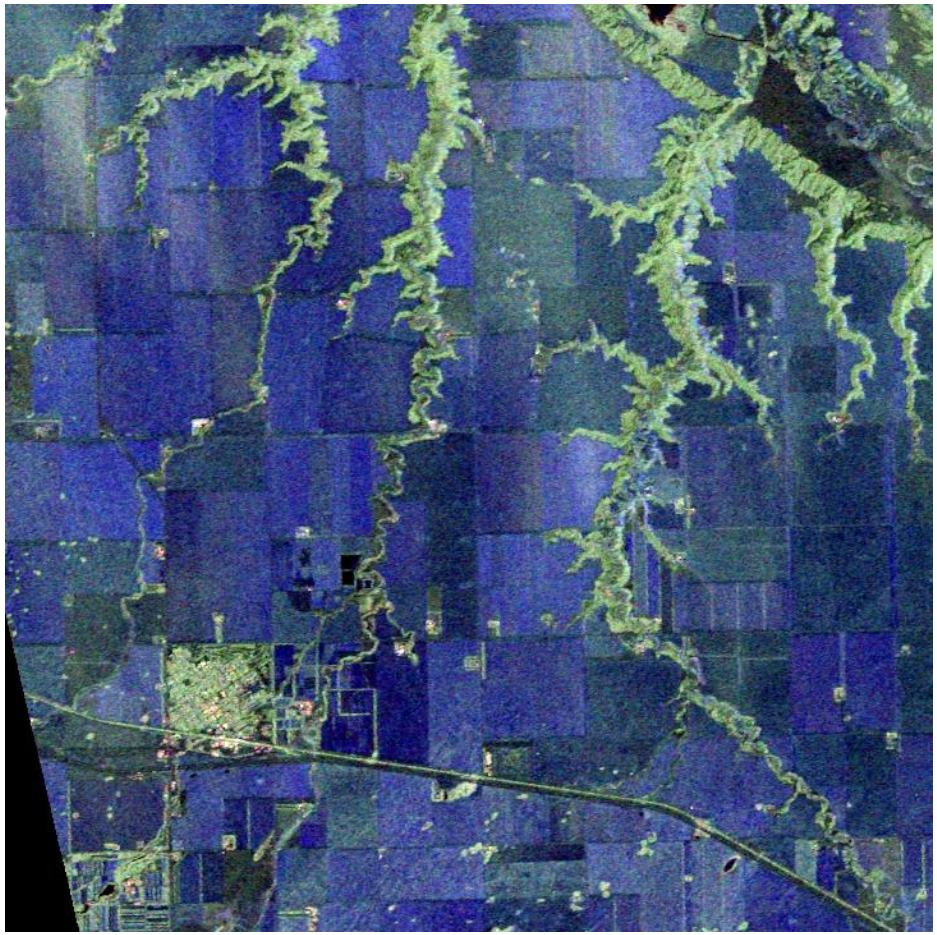


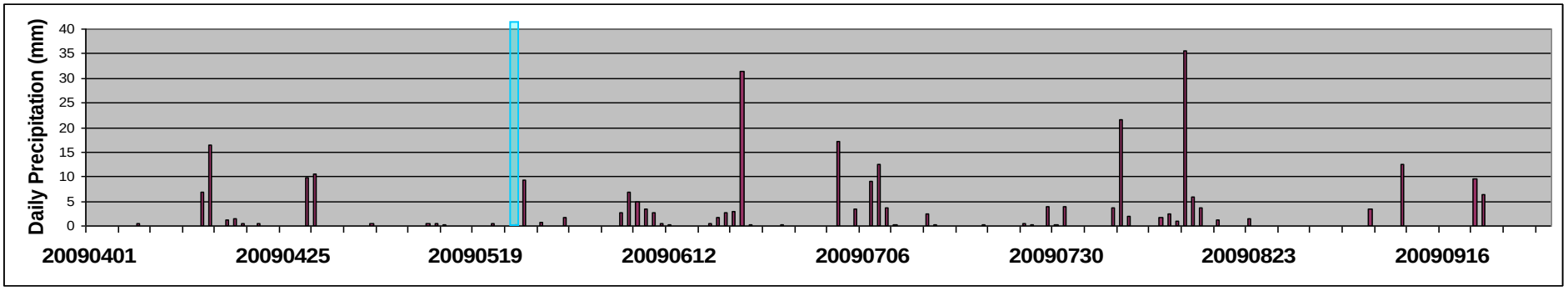




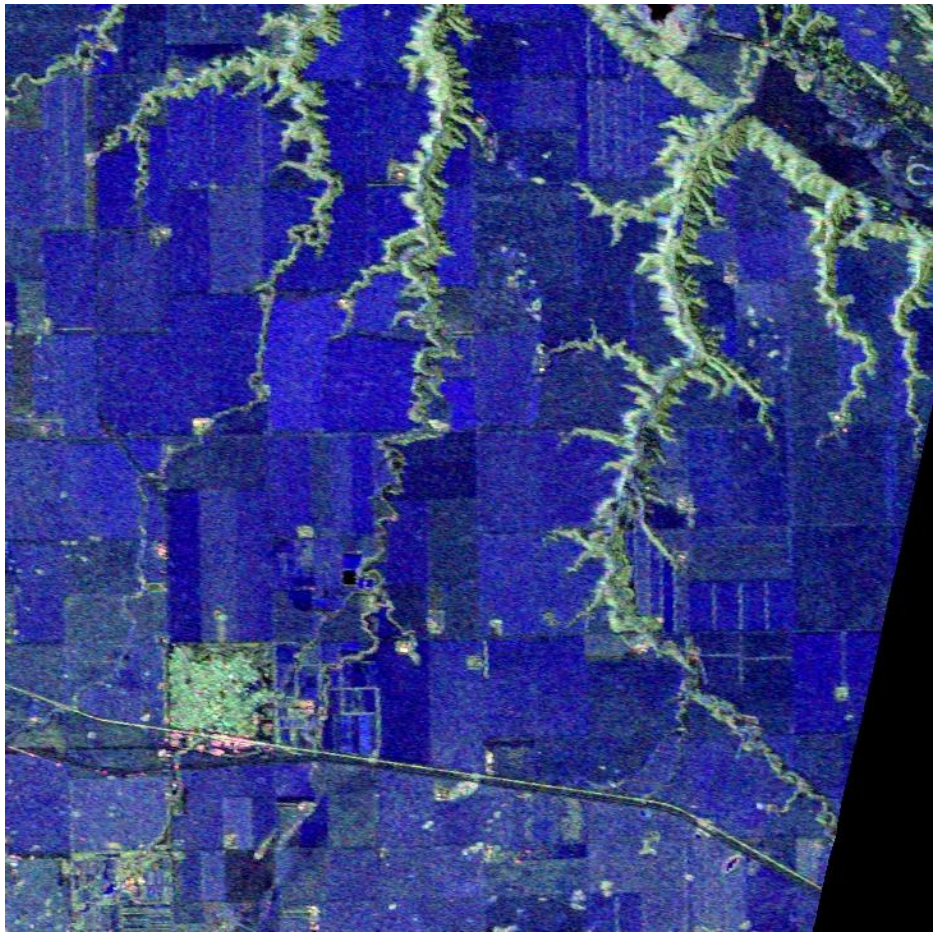
May 24, 2009	
Dsc FQ10	Asc FQ11

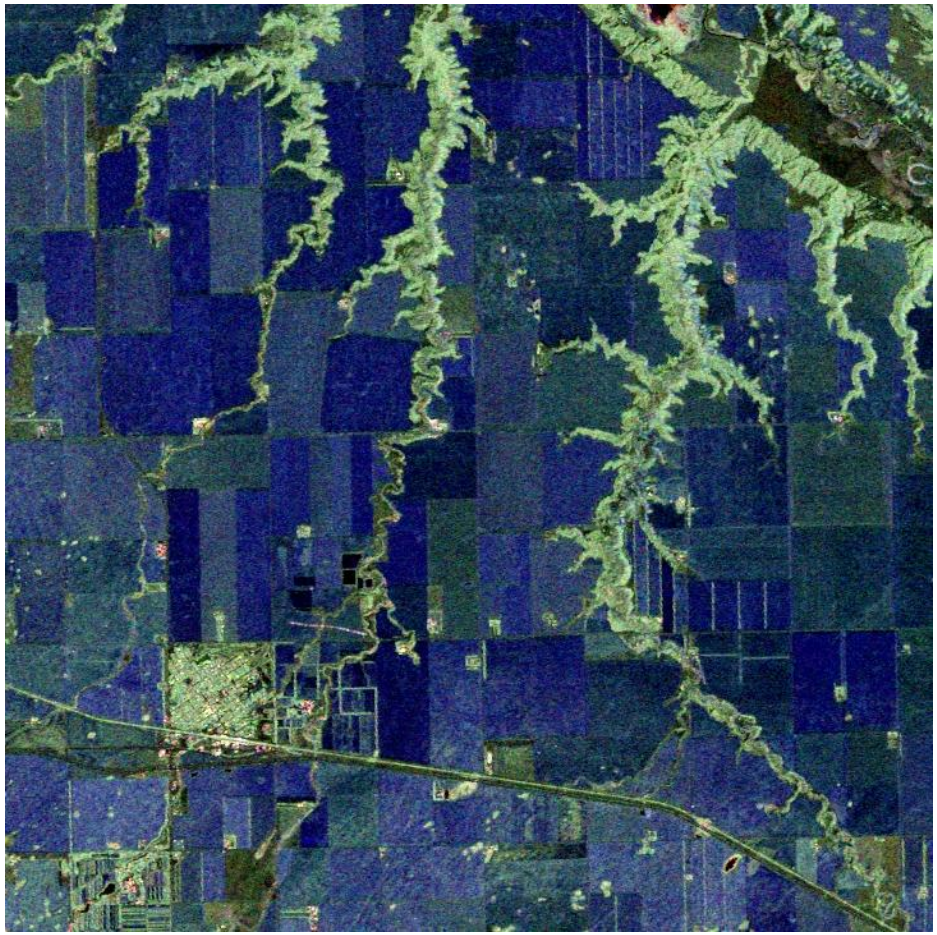


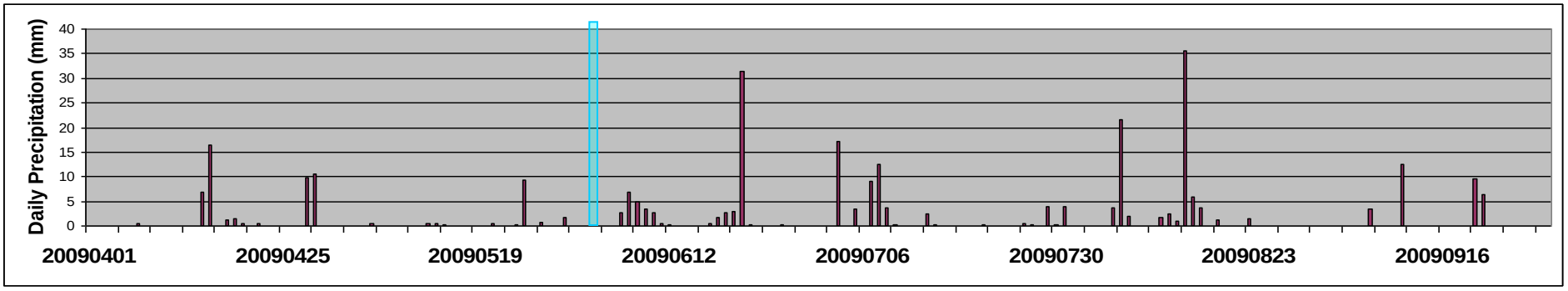




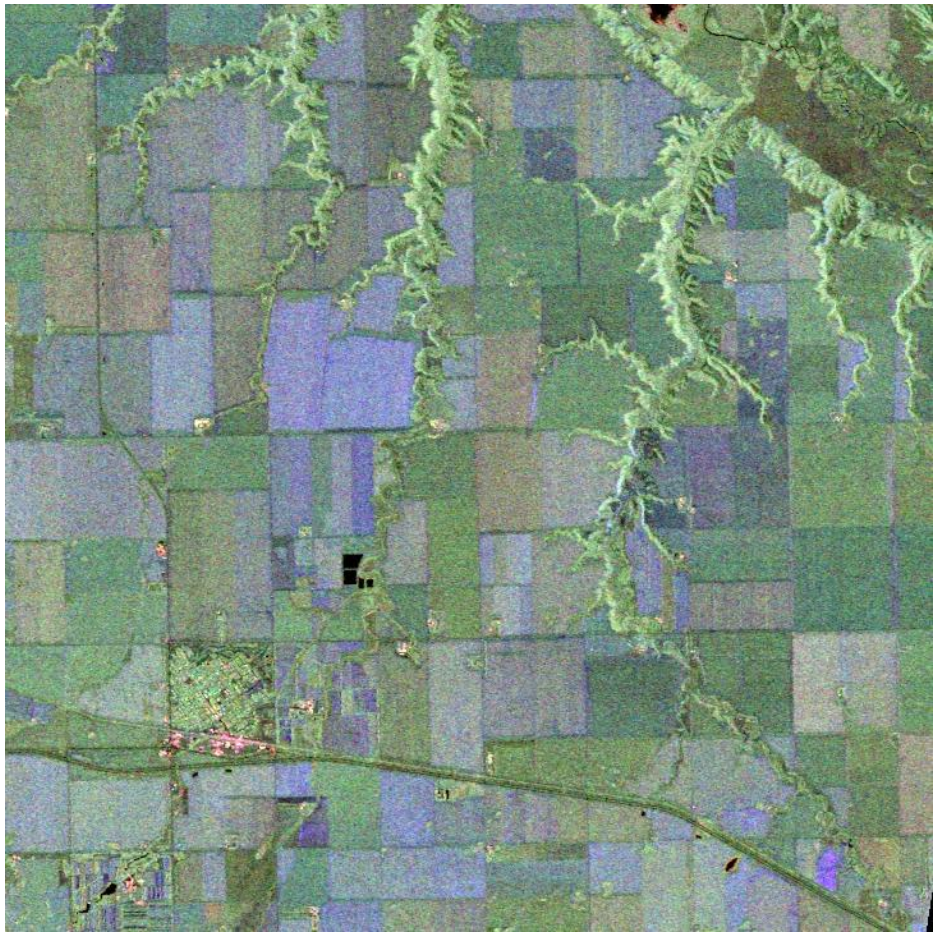
June 03, 2009	
Dsc FQ02	Asc FQ19

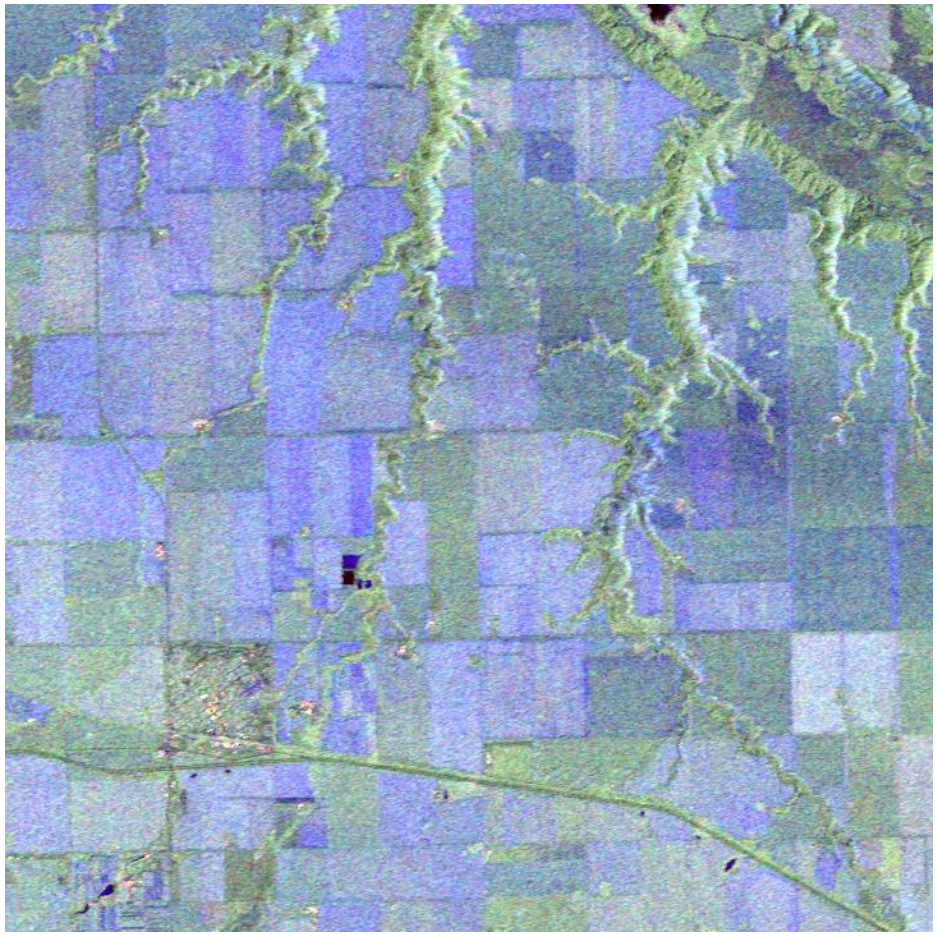


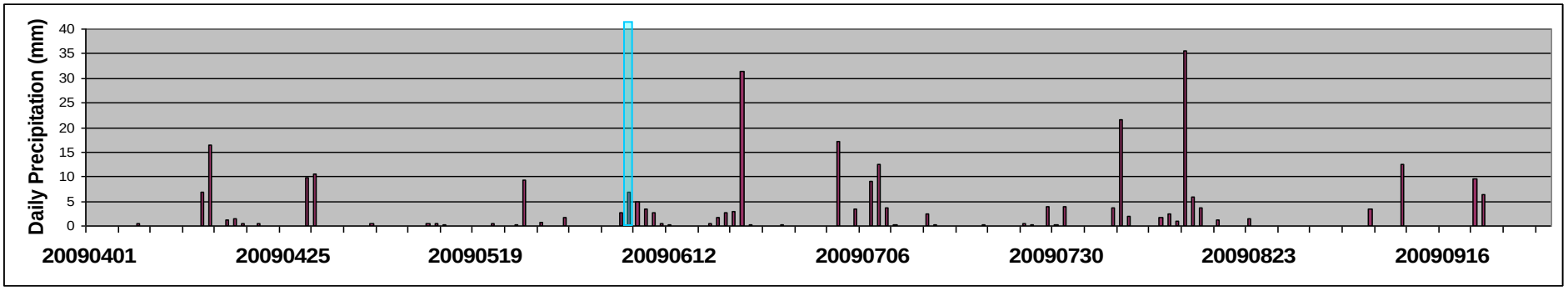




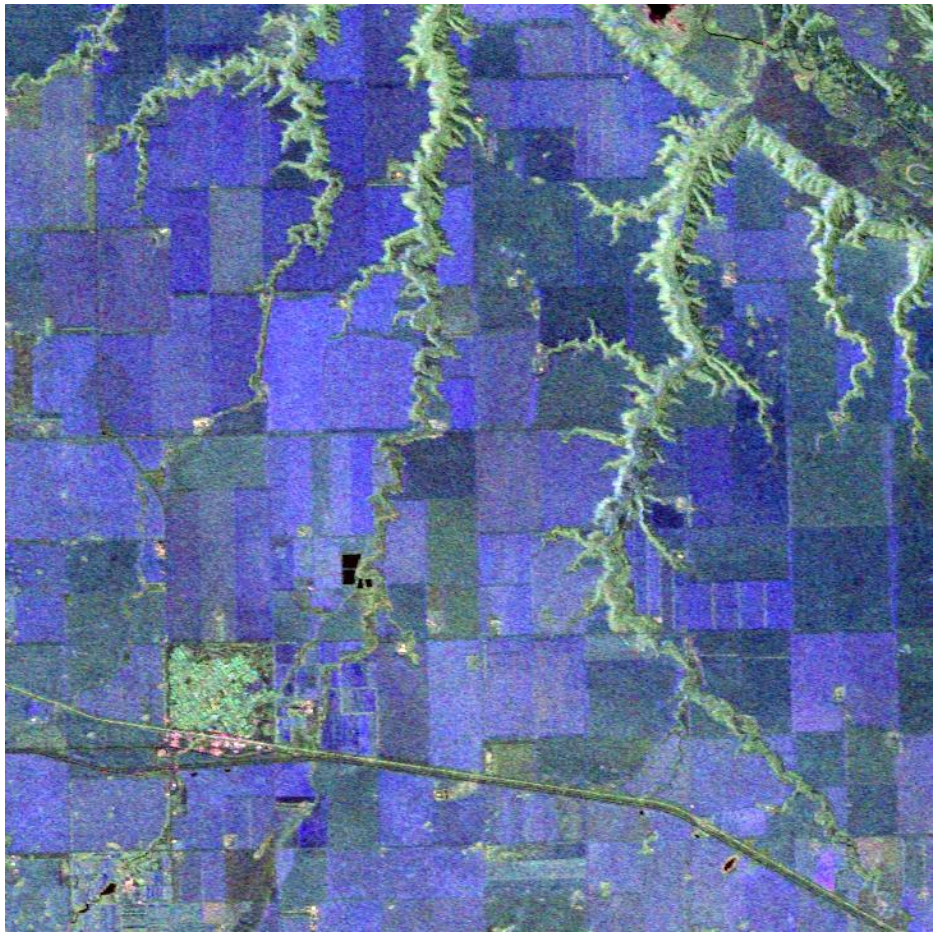
June 07, 2009	
Dsc FQ19	Asc FQ02

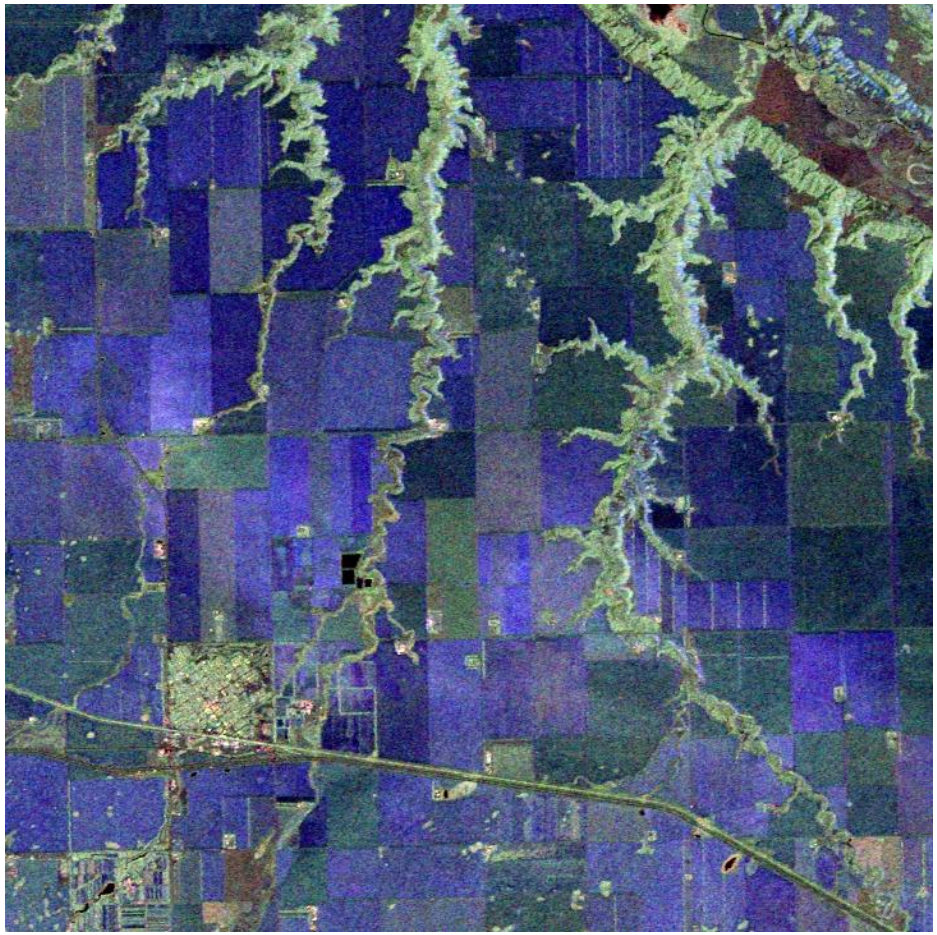


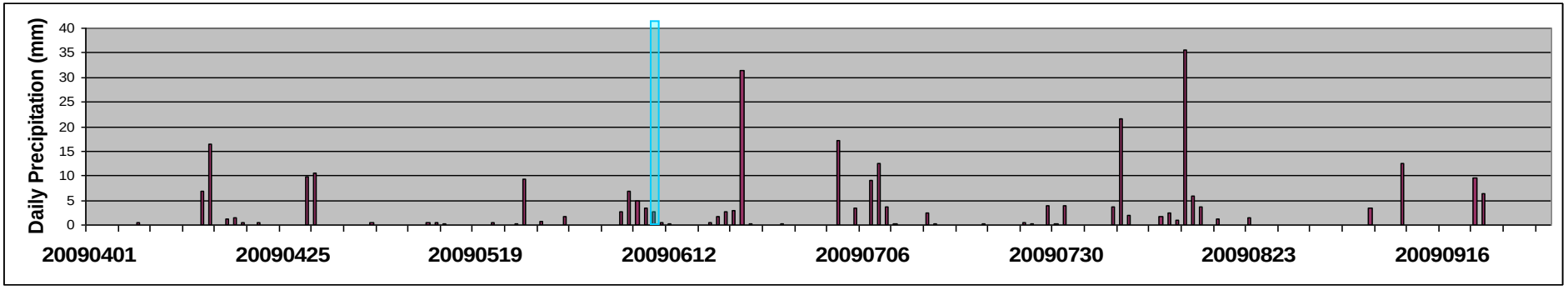




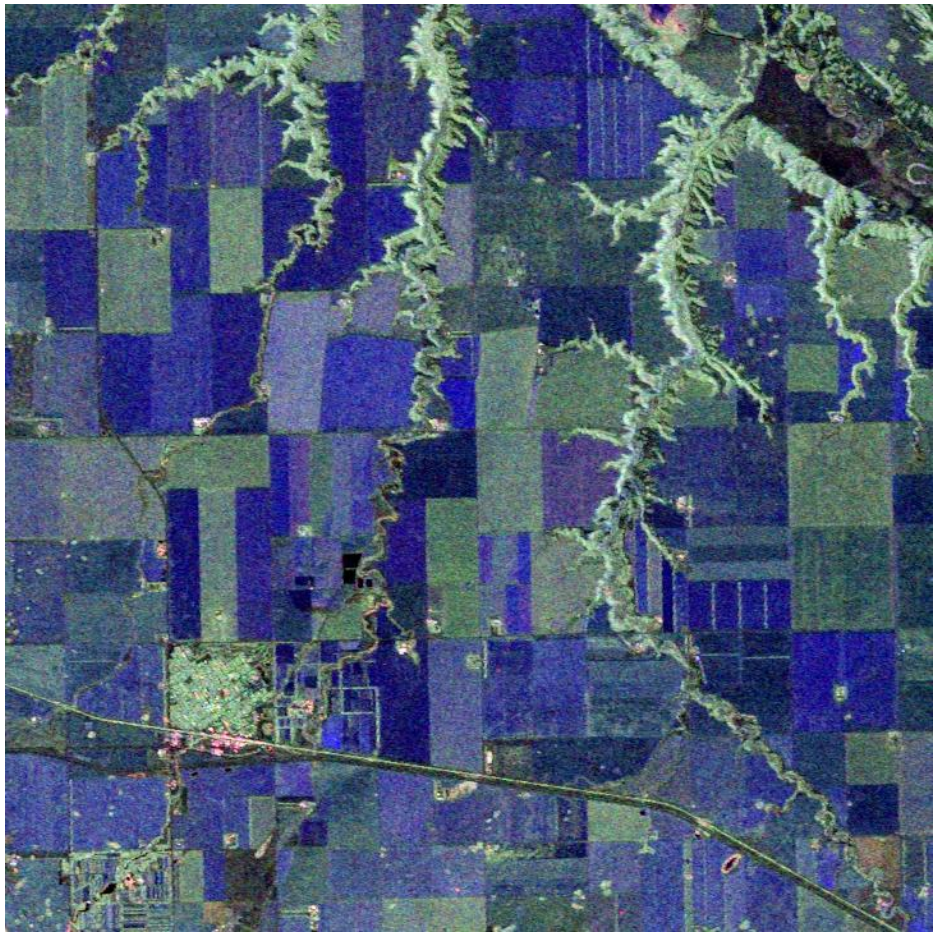
June 10, 2009	
Dsc FQ06	Asc FQ15

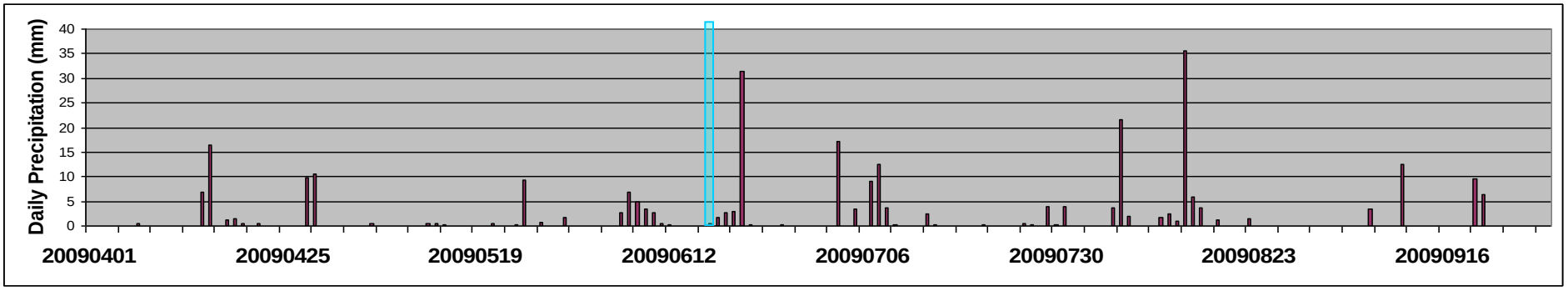




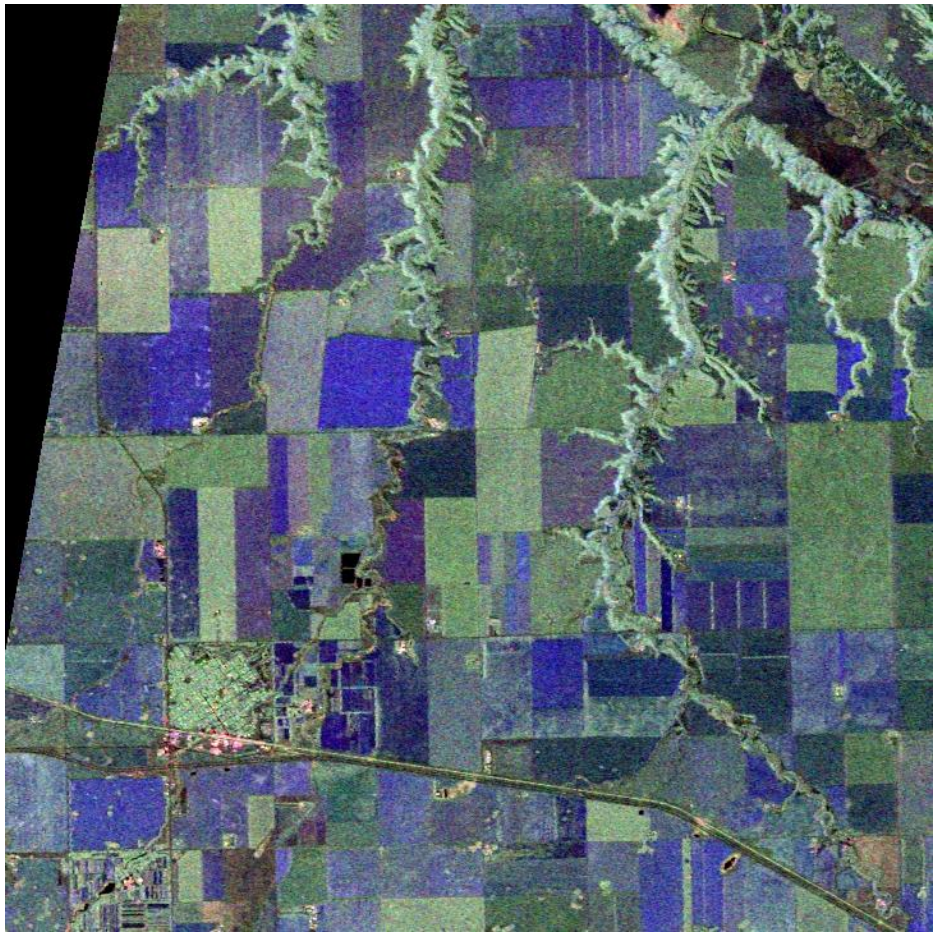


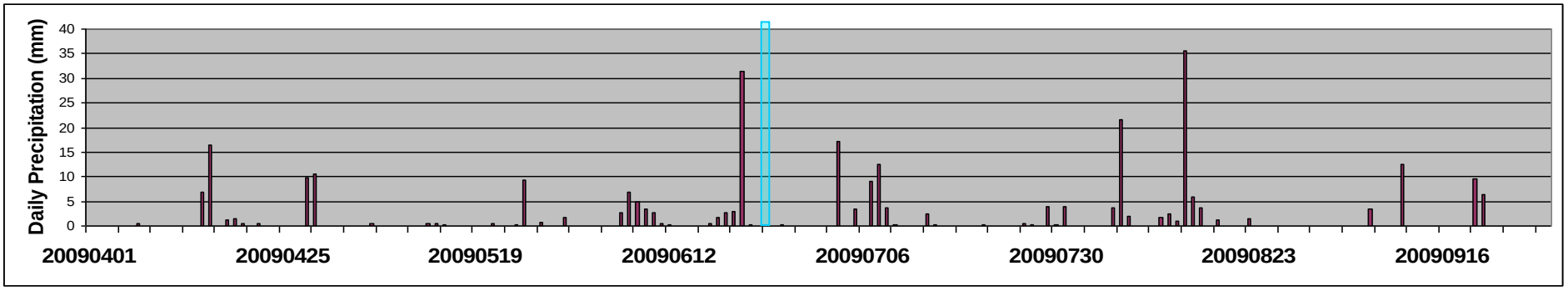
June 17, 2009	
Dsc FQ10	



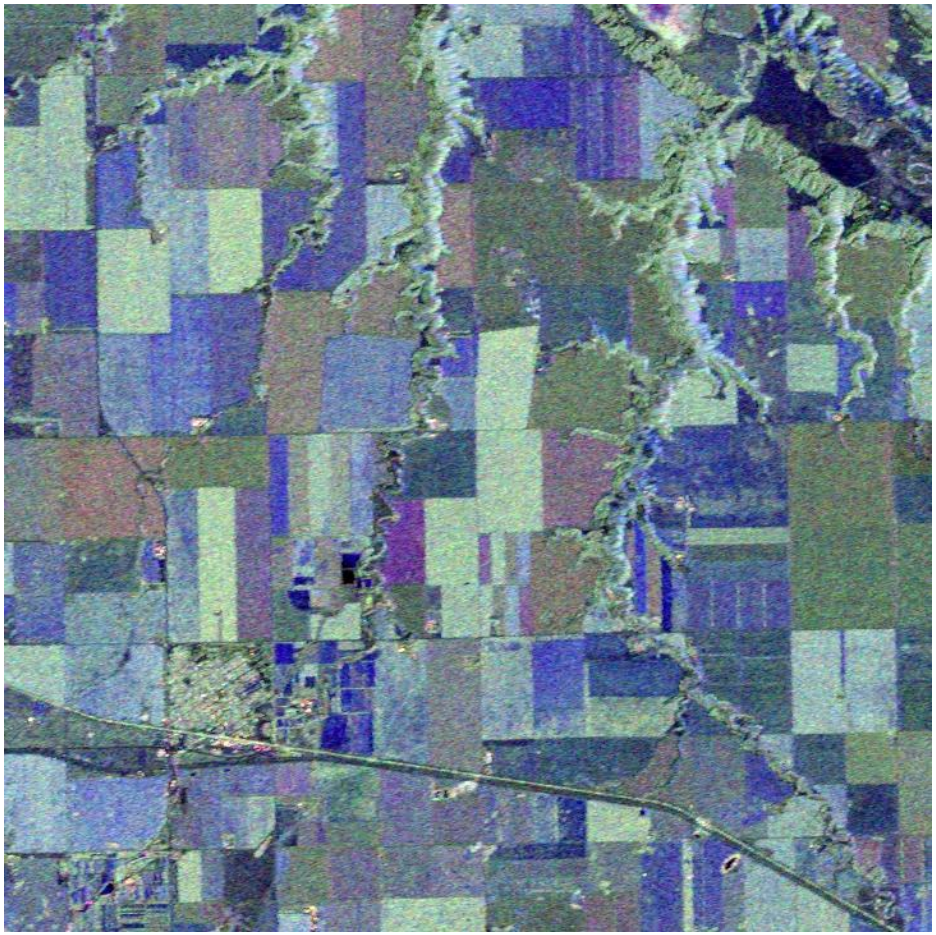


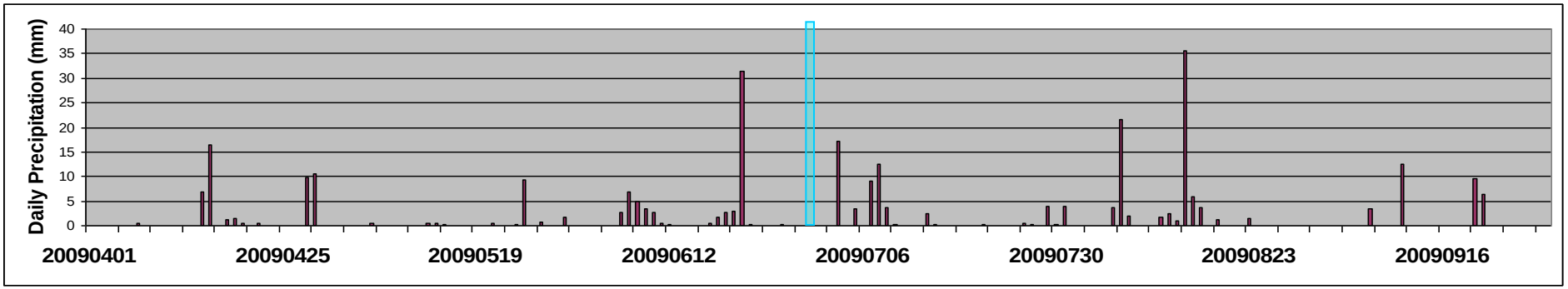
June 24, 2009	
Dsc FQ14	



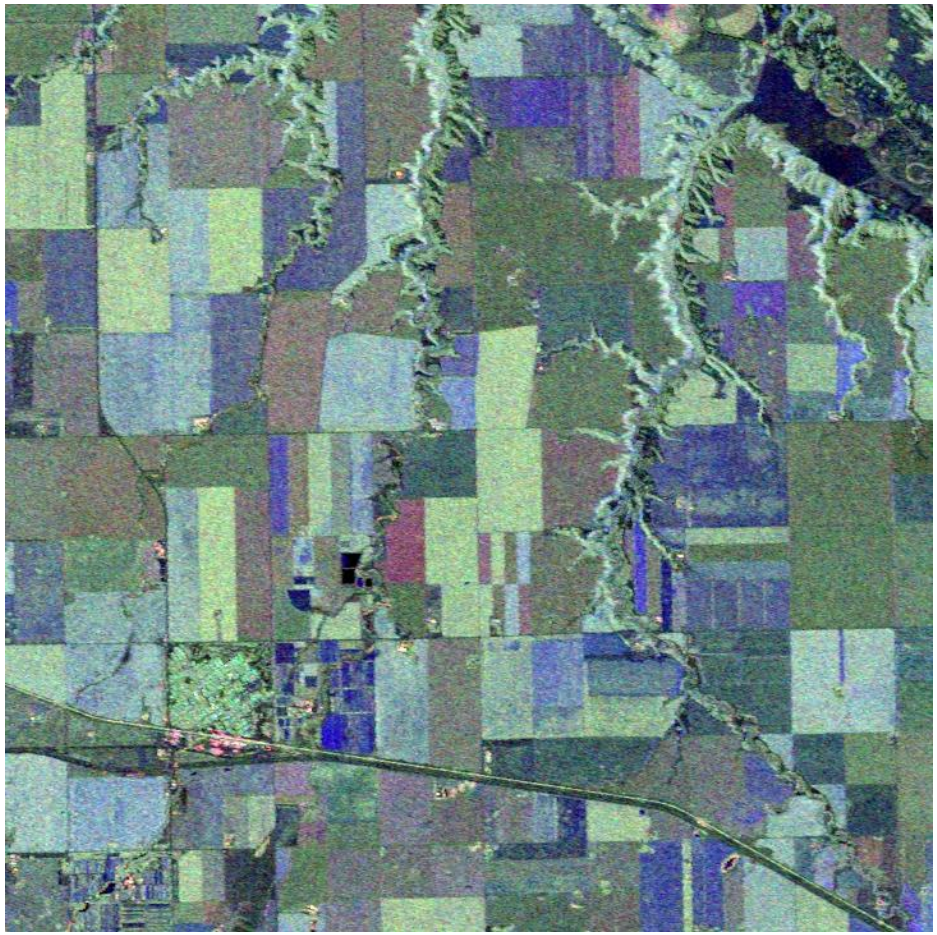


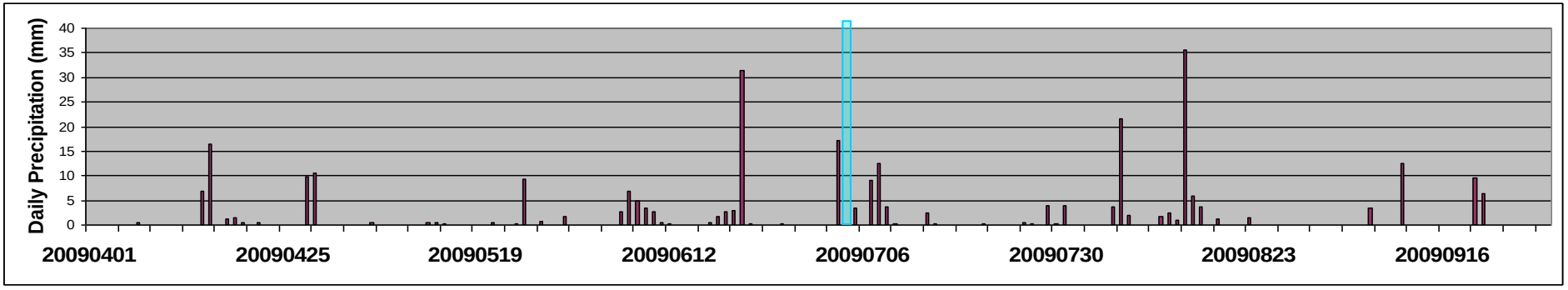
July 01, 2009	
Dsc FQ19	Asc FQ02



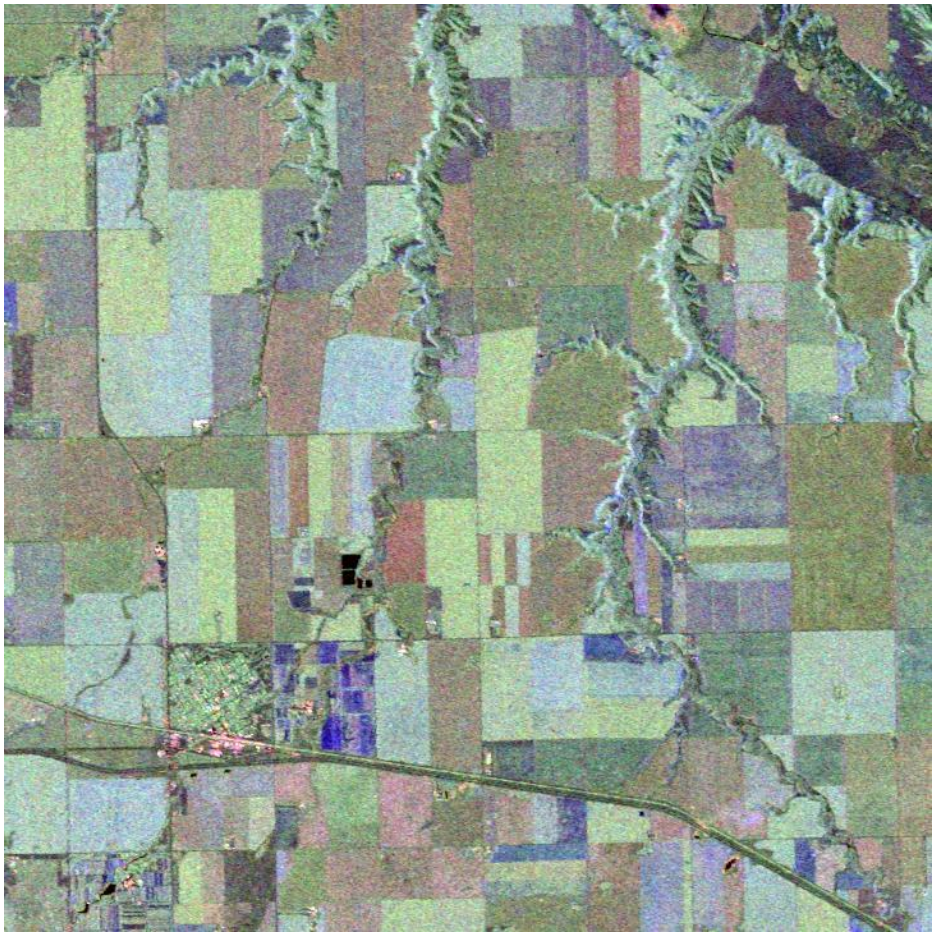


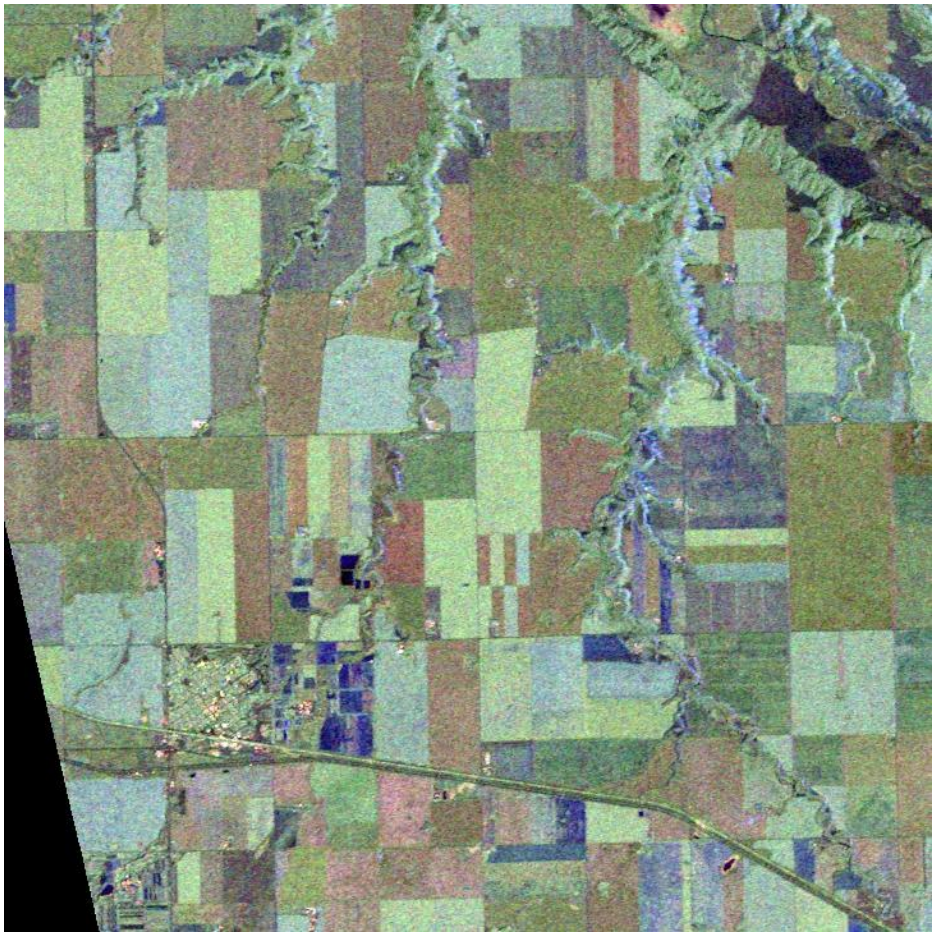
July 04, 2009	
Dsc FQ06	

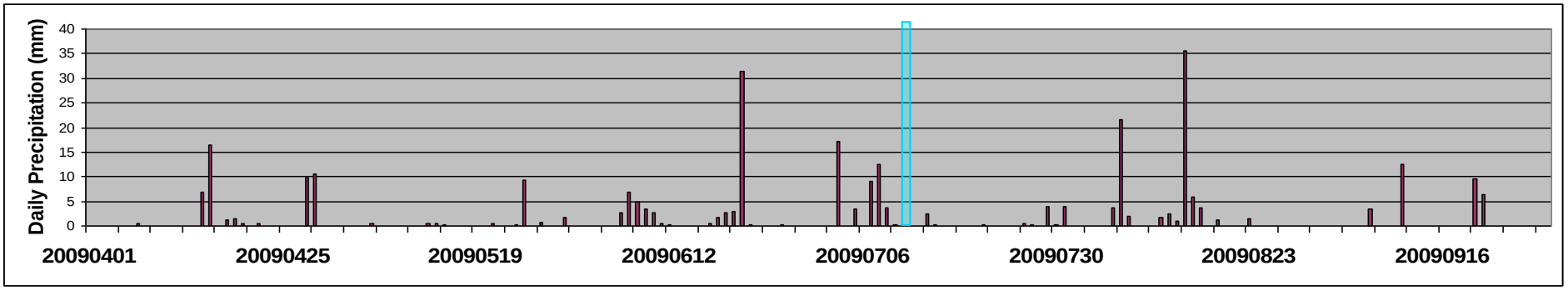




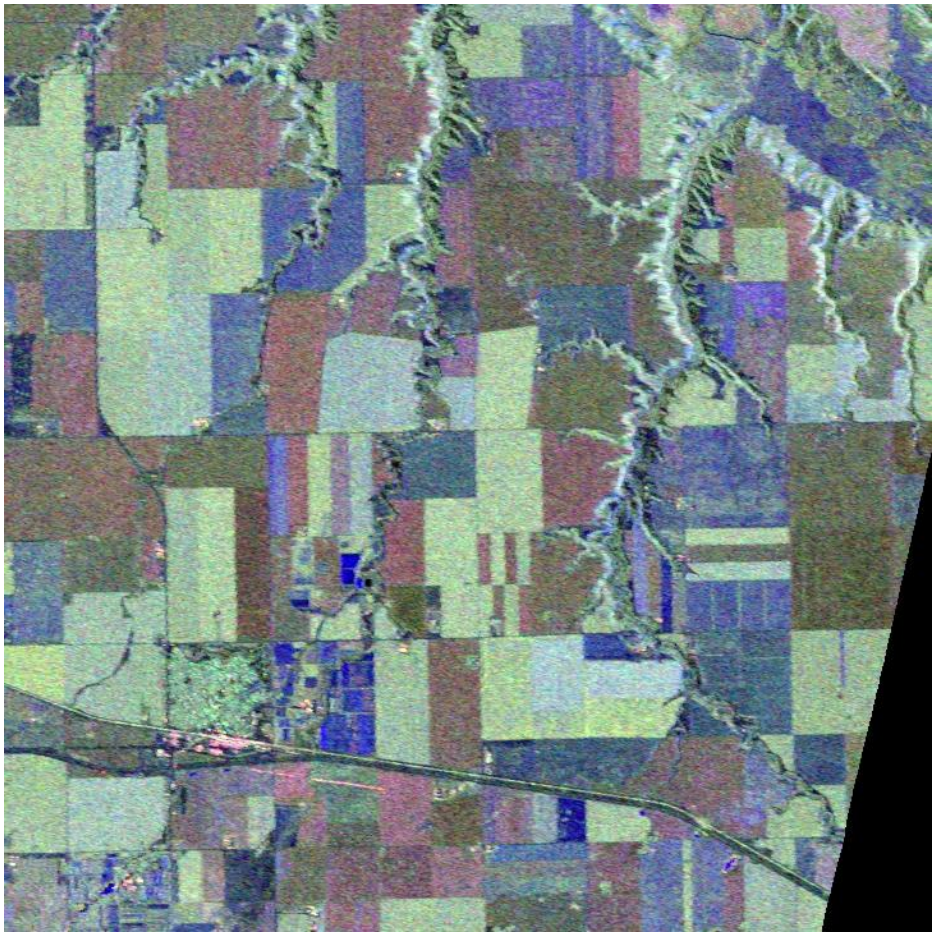
July 11, 2009	
Dsc FQ10	Asc FQ11

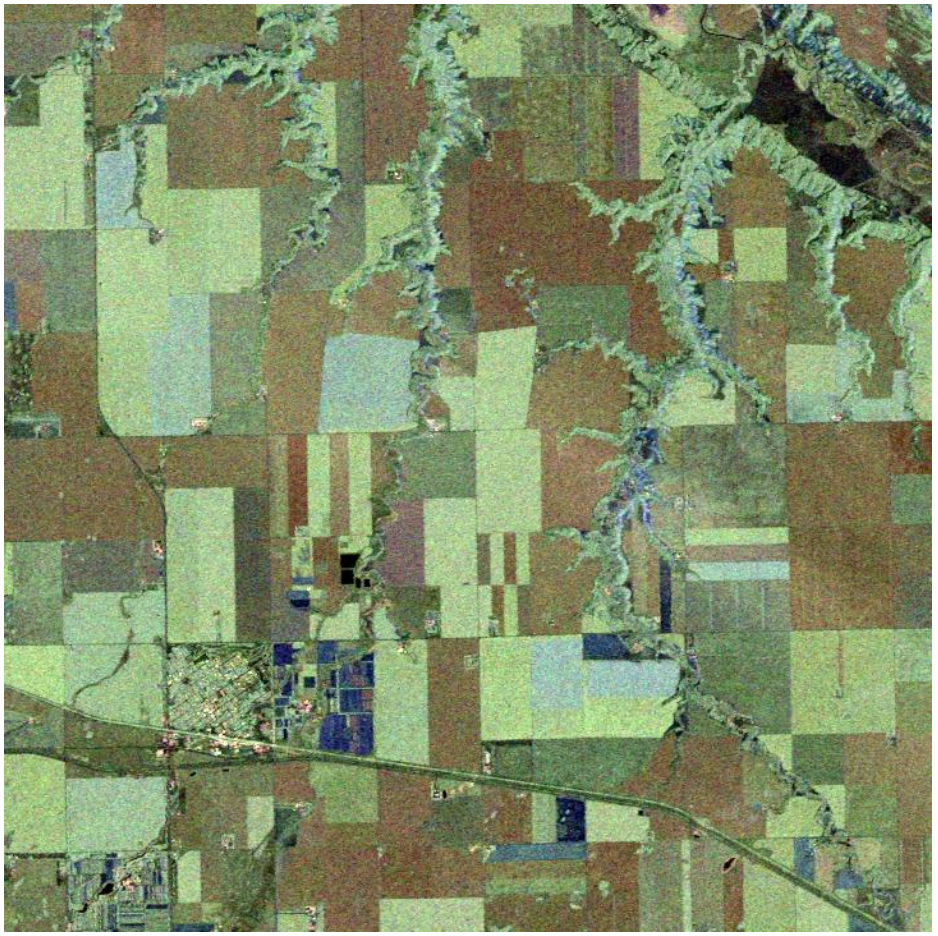


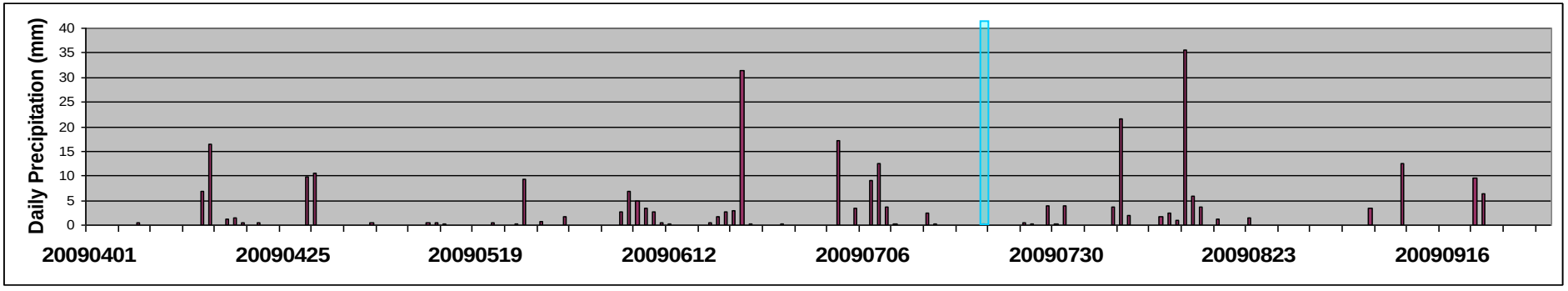




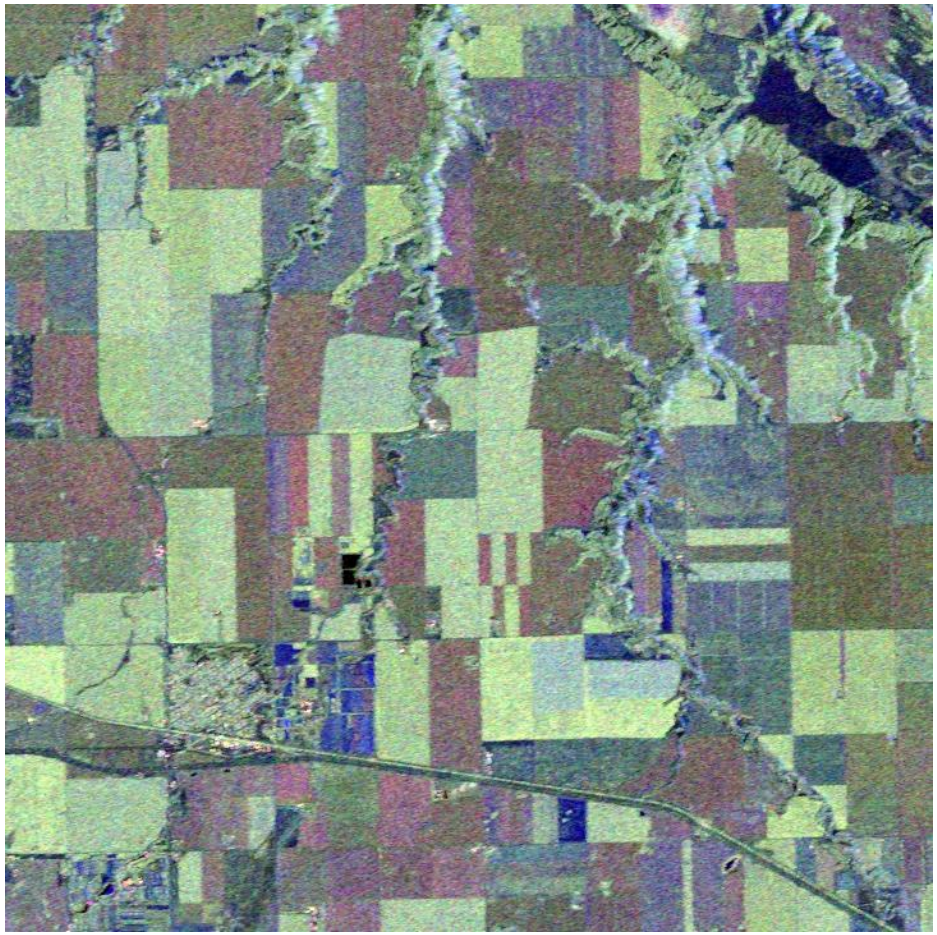
July 21, 2009	
Dsc FQ02	Asc FQ19

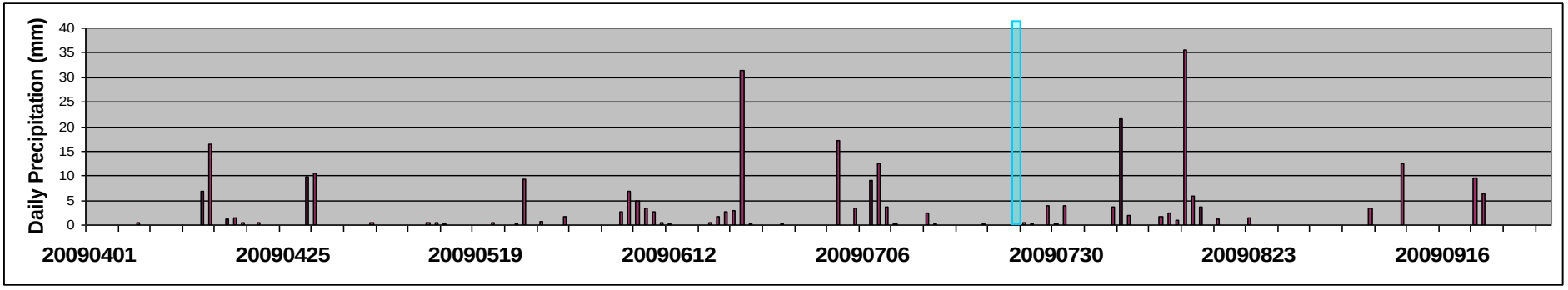




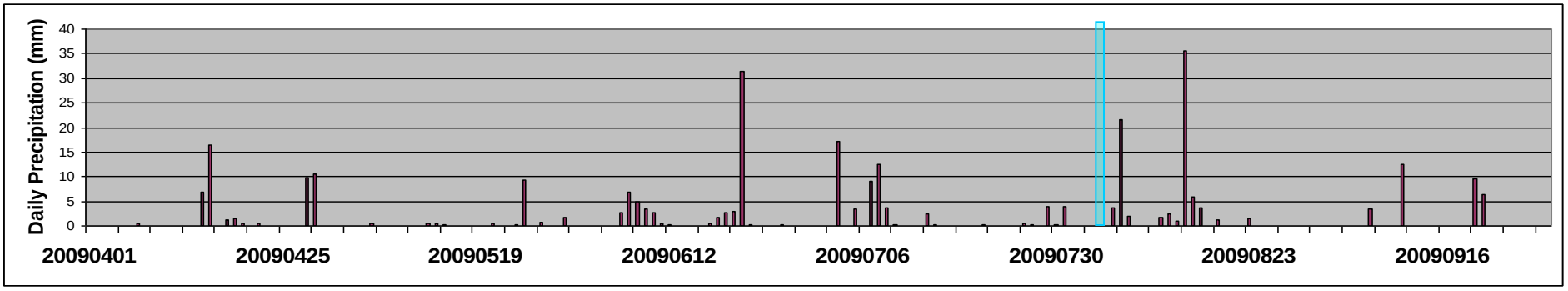


July 25, 2009	
	Asc FQ02

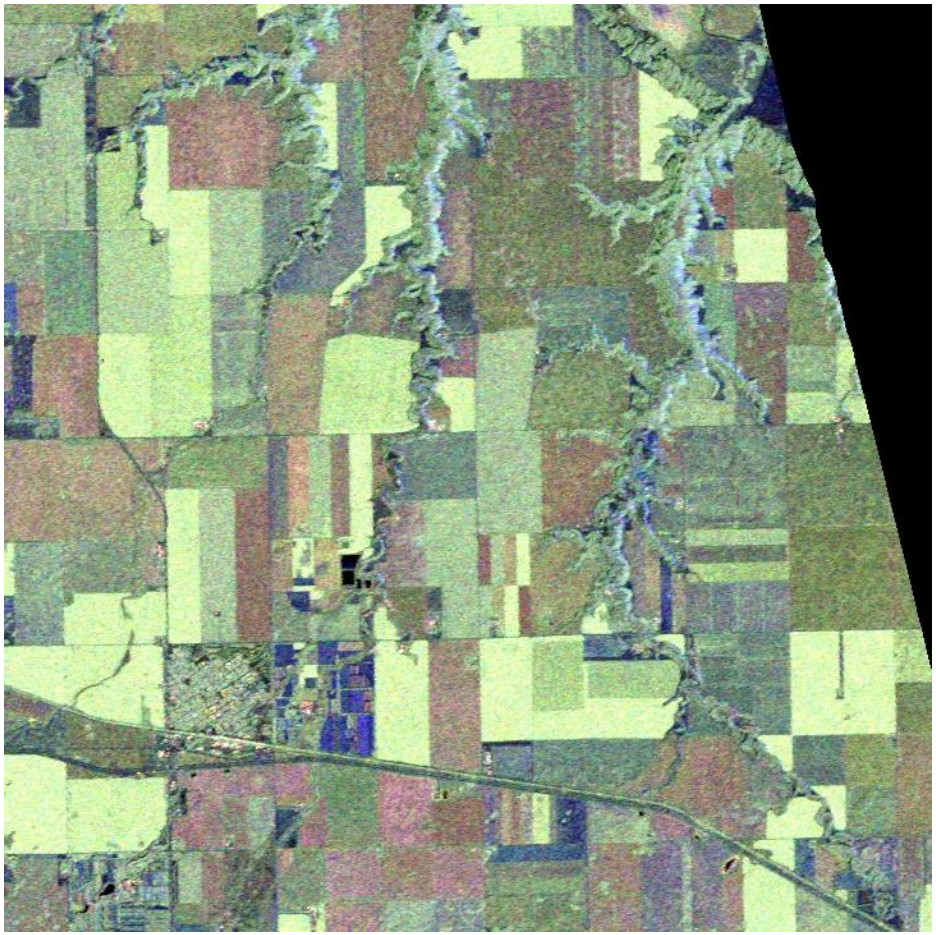


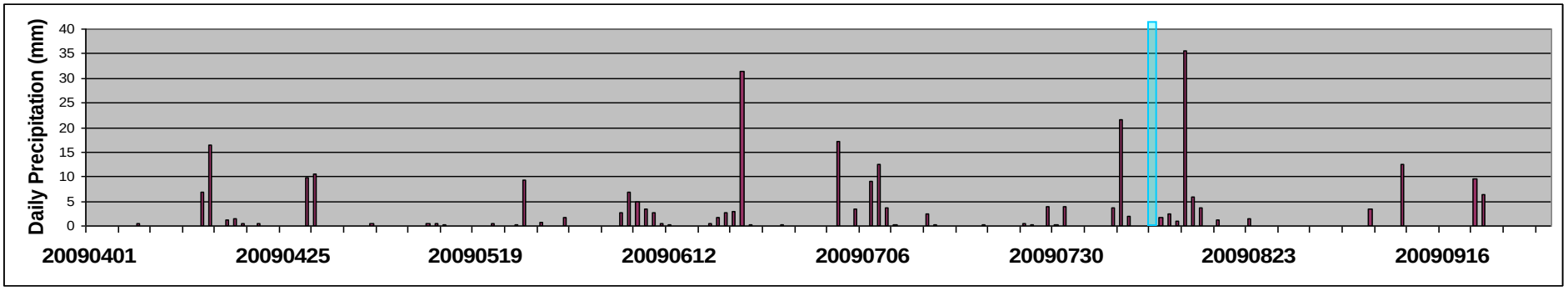


August 04, 2009	
Dsc FQ10	

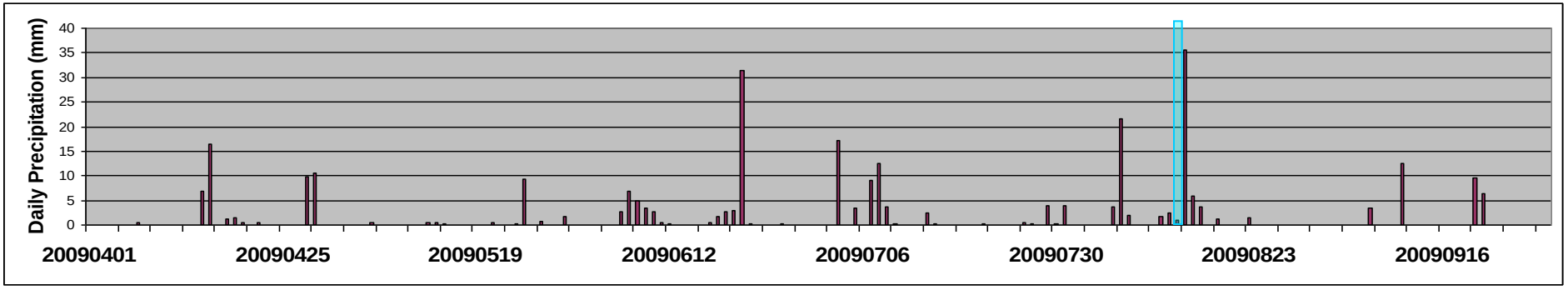


August 11, 2009	
Dsc FQ14	Asc FQ06

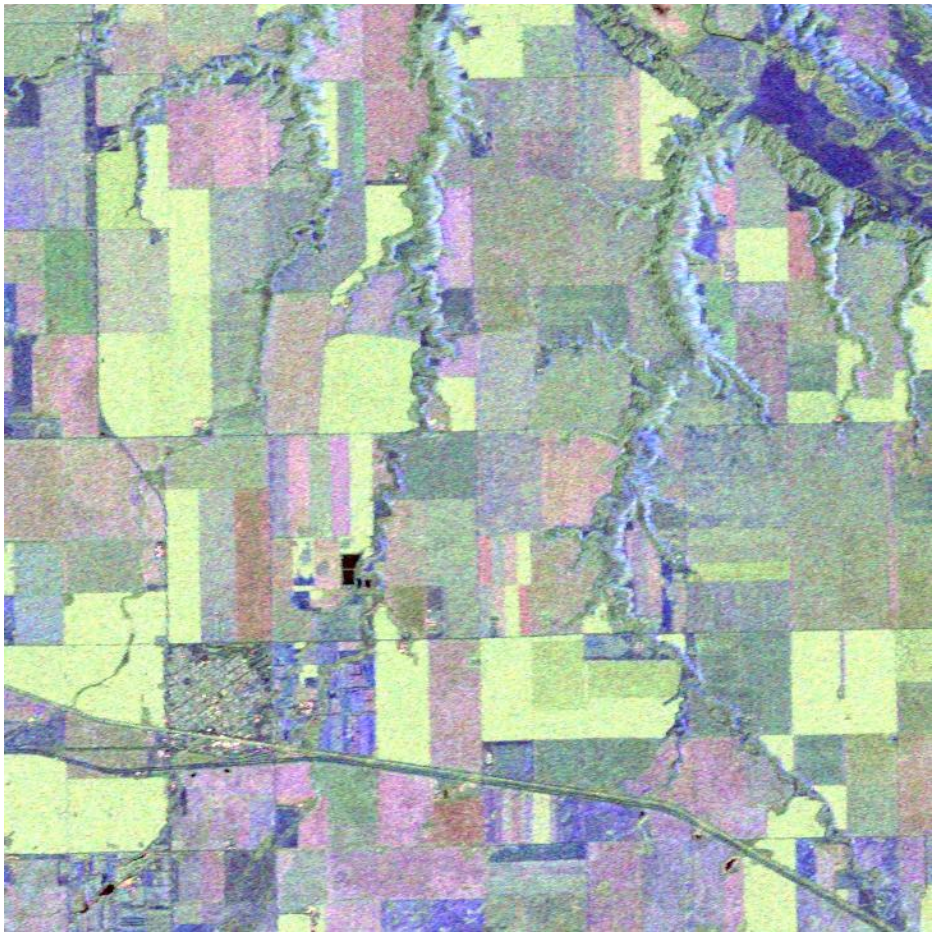


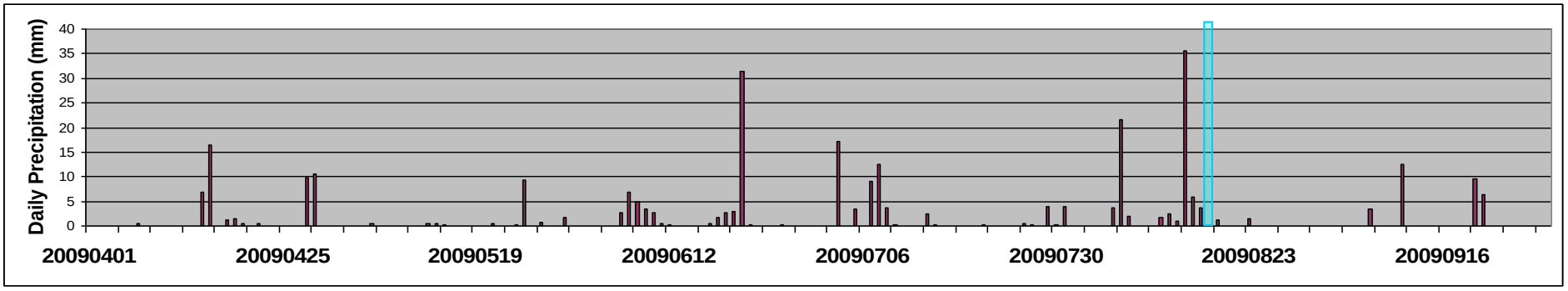


August 14, 2009	
	Asc FQ19

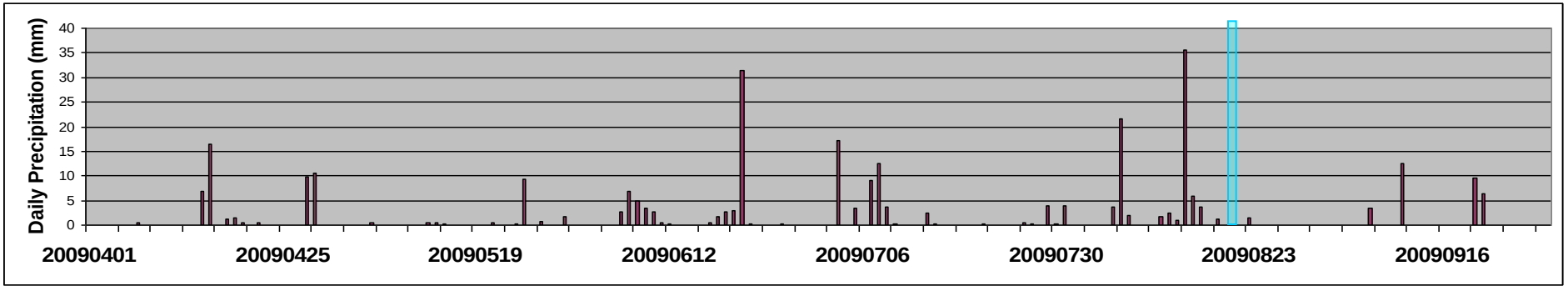


August 18, 2009	
Dsc FQ19	Asc FQ02

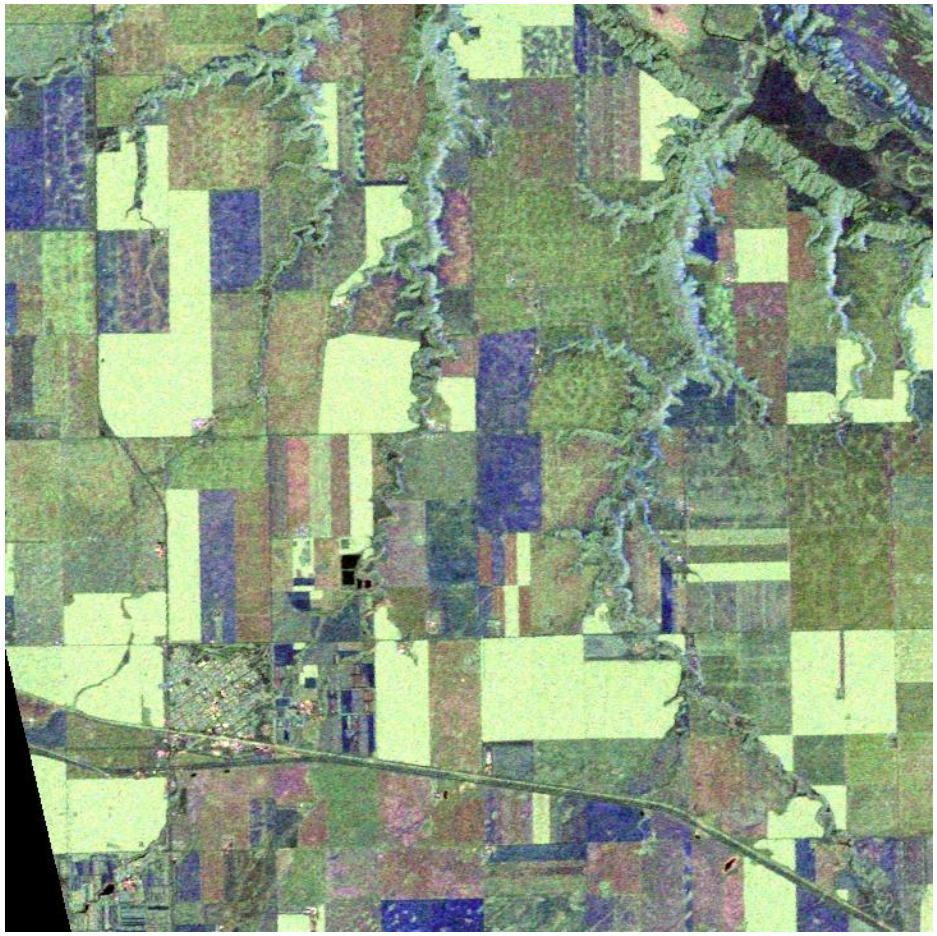


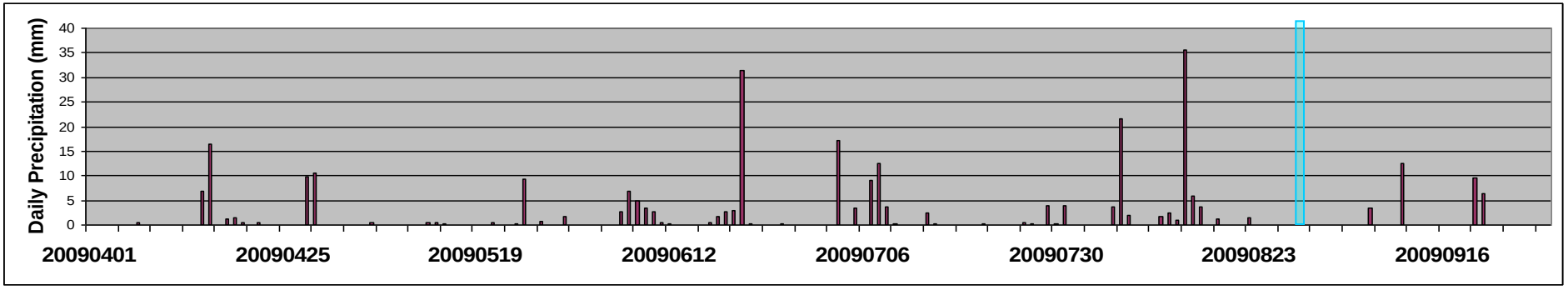


August 21, 2009	
	Asc FQ15

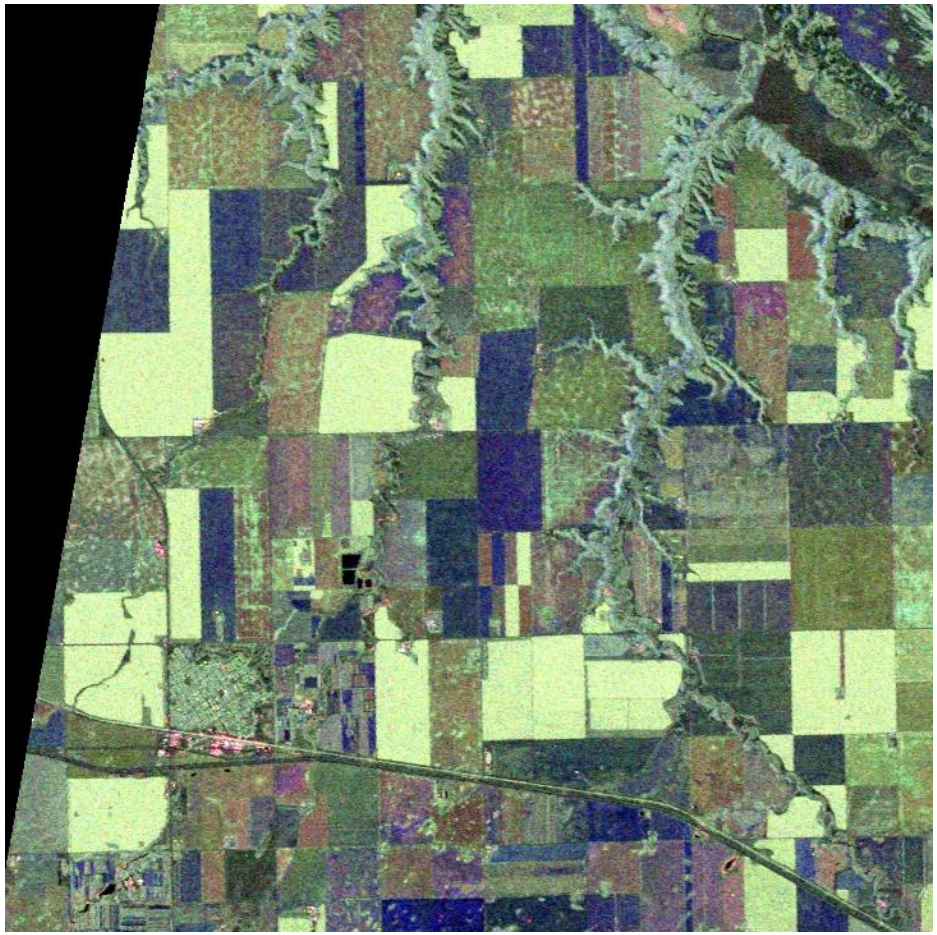


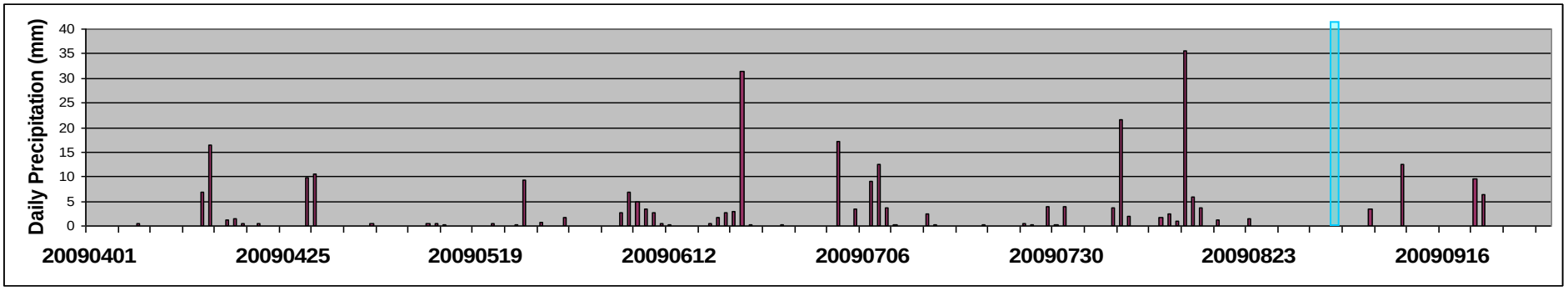
August 28, 2009	
	Asc FQ11



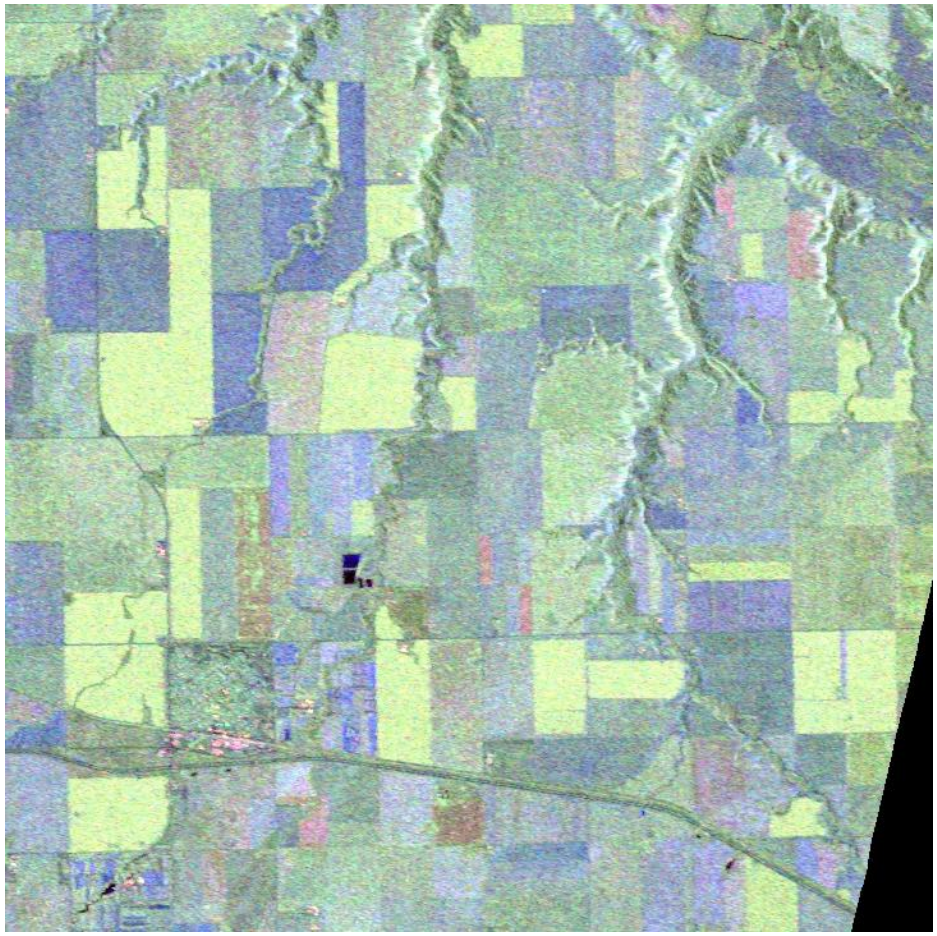


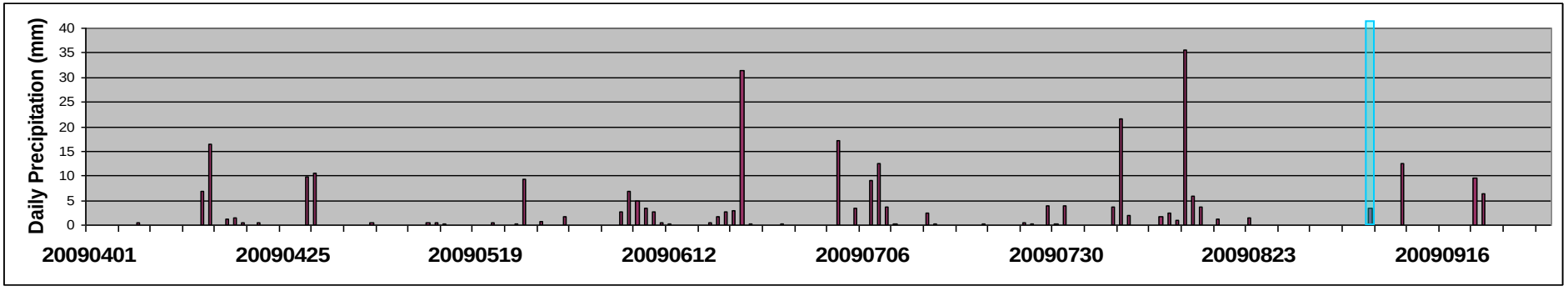
September 04, 2009	
Dsc FQ14	



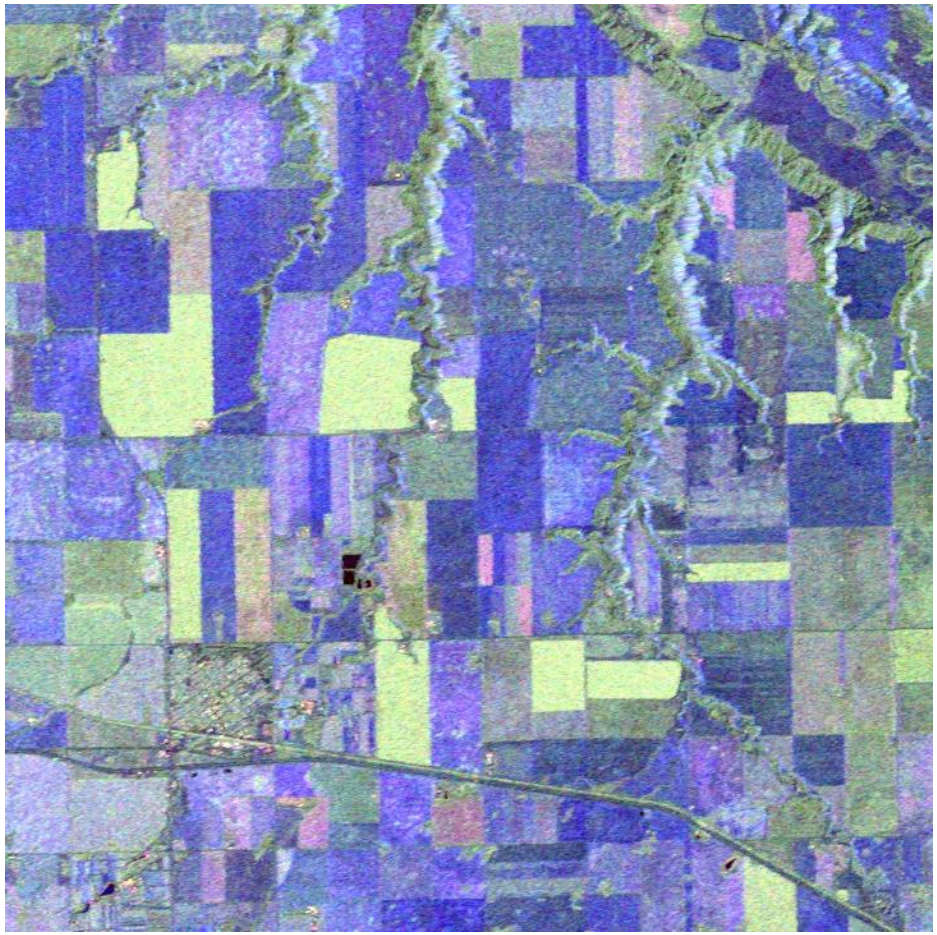


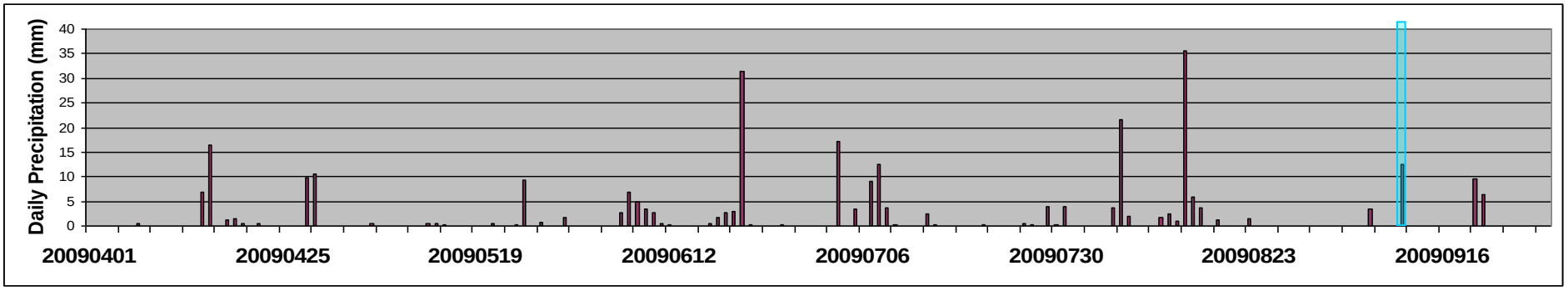
September 07, 2009	
Dsc FQ02	Asc FQ19



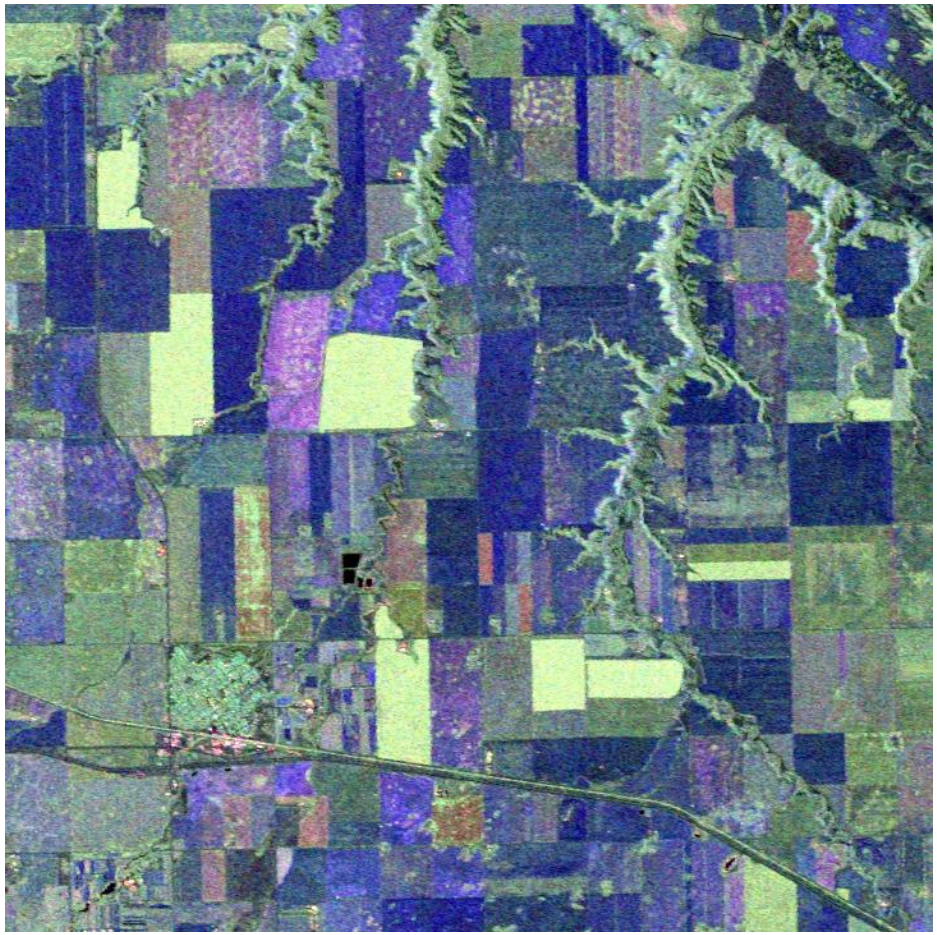


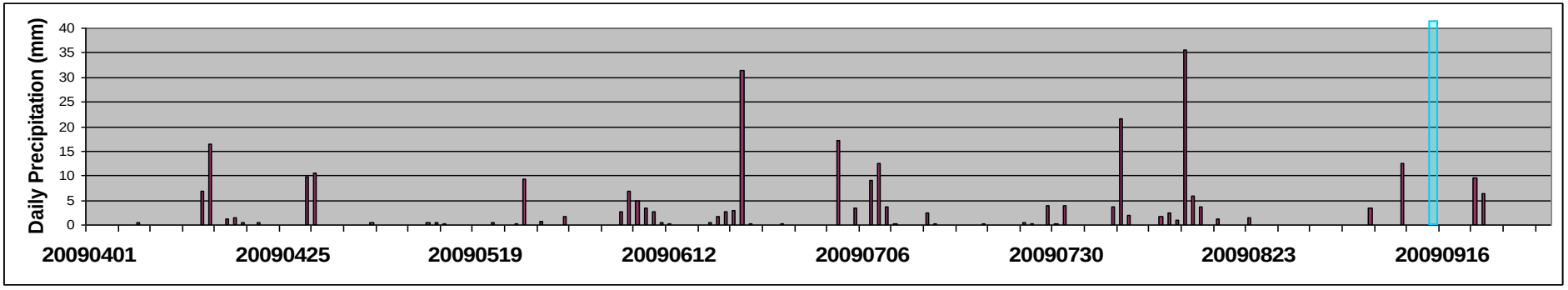
September 11, 2009	
Dsc FQ19	Asc FQ02



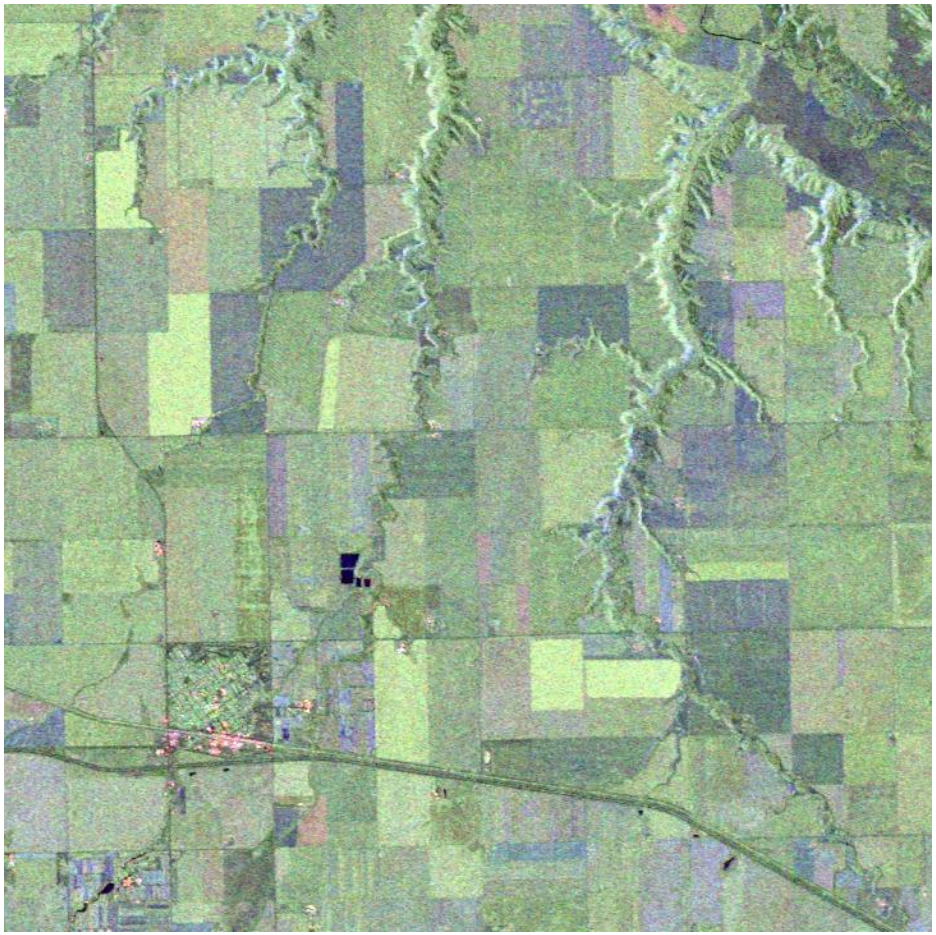


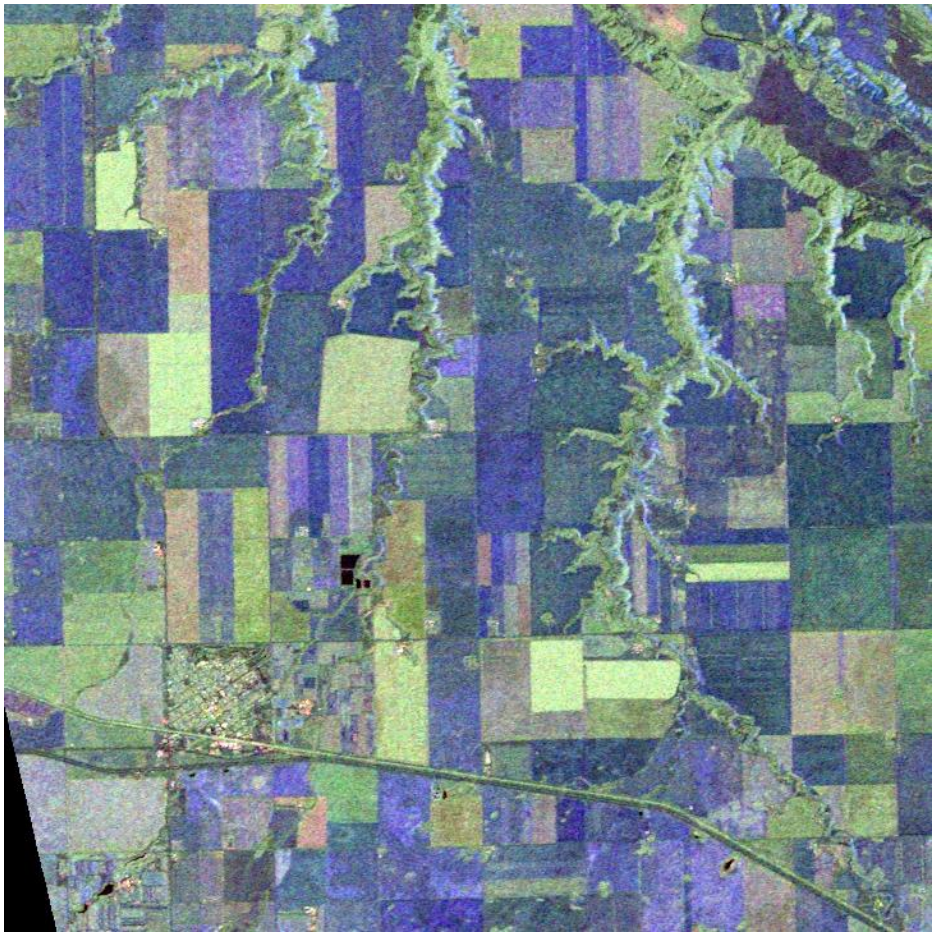
September 14, 2009	
Dsc FQ06	Asc FQ15

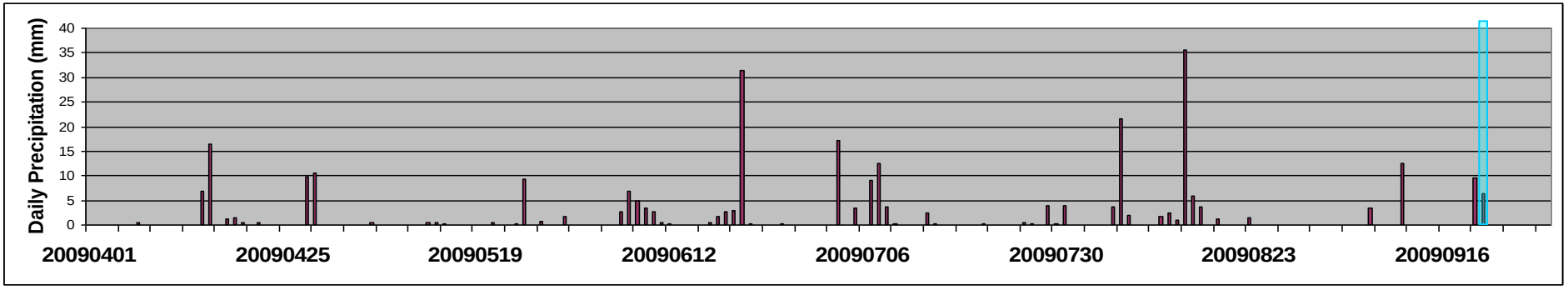
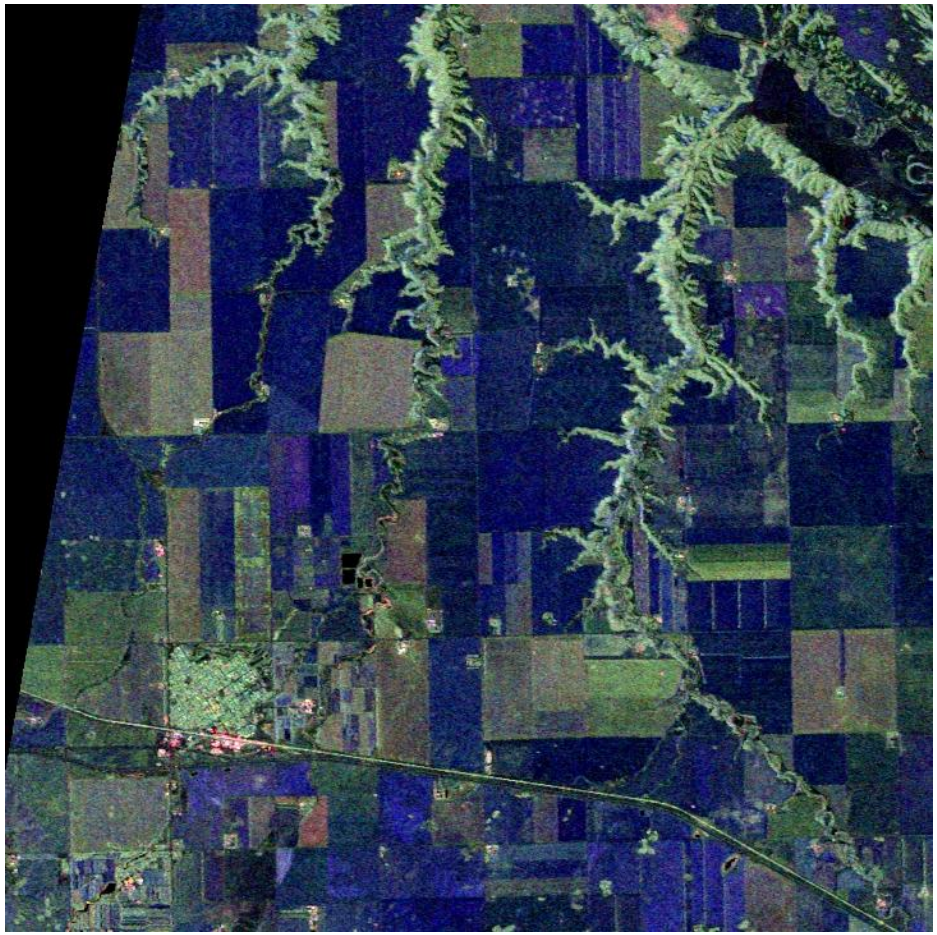
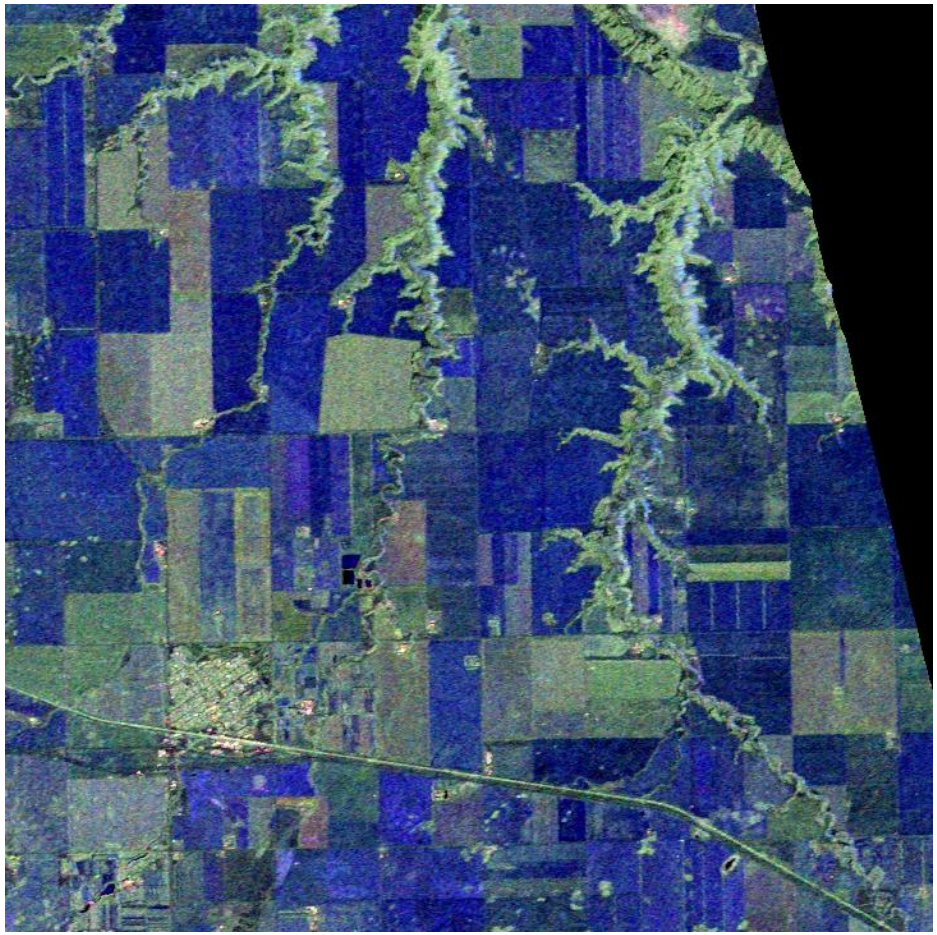
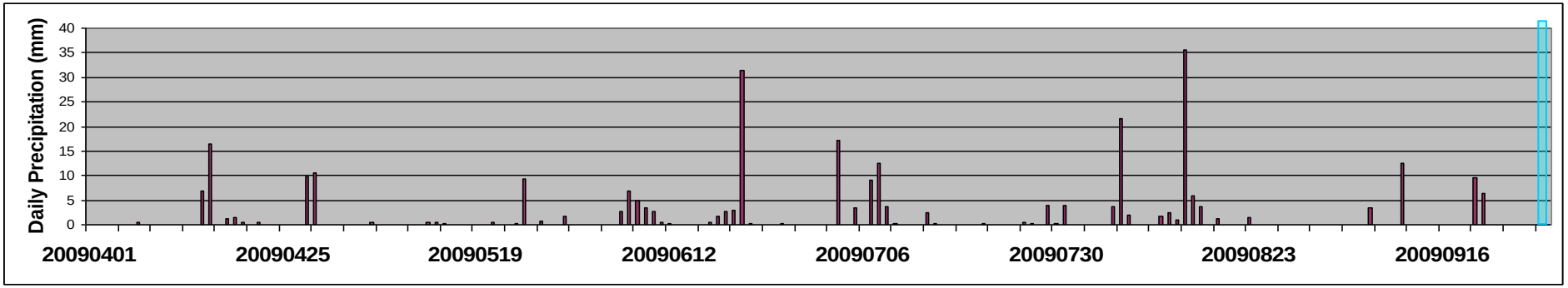




September 21, 2009	
Dsc FQ10	Asc FQ11







September 28, 2009	
Dsc FQ14	Asc FQ06