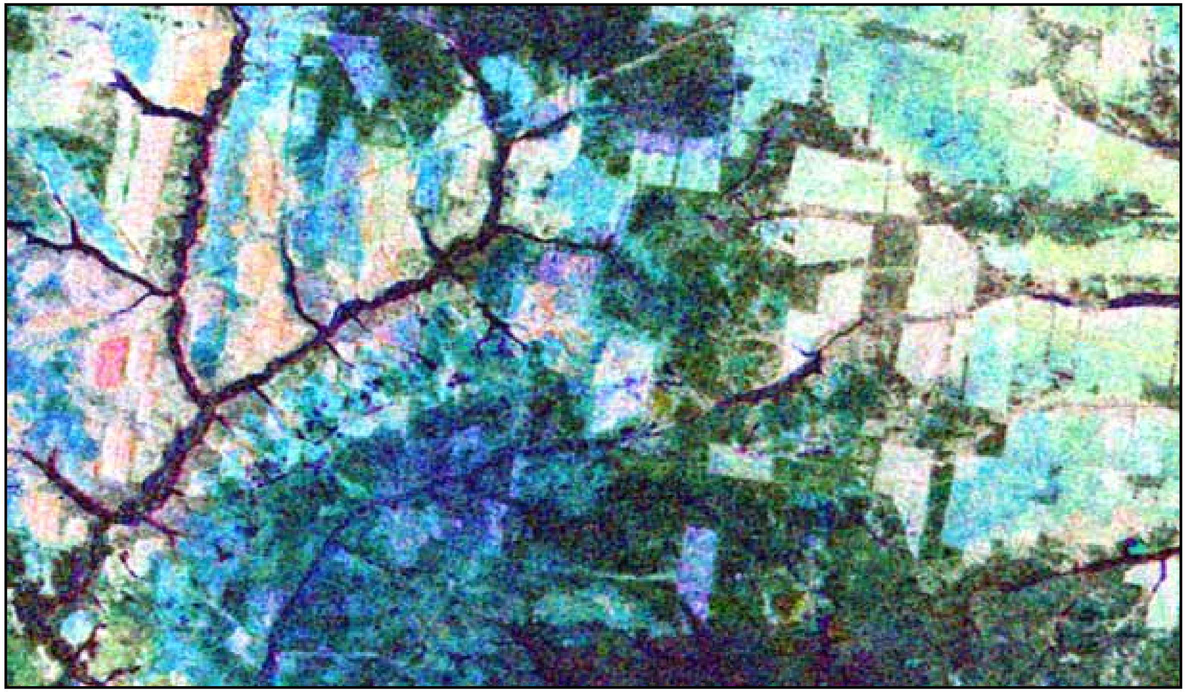
ALOS

K&C Initiative
An international science collaboration led by JAXA

Progress at Phase 2 – KC#12

Forestry Theme
Central Siberia



Friedrich-Schiller-University Jena, GAMMA Remote Sensing

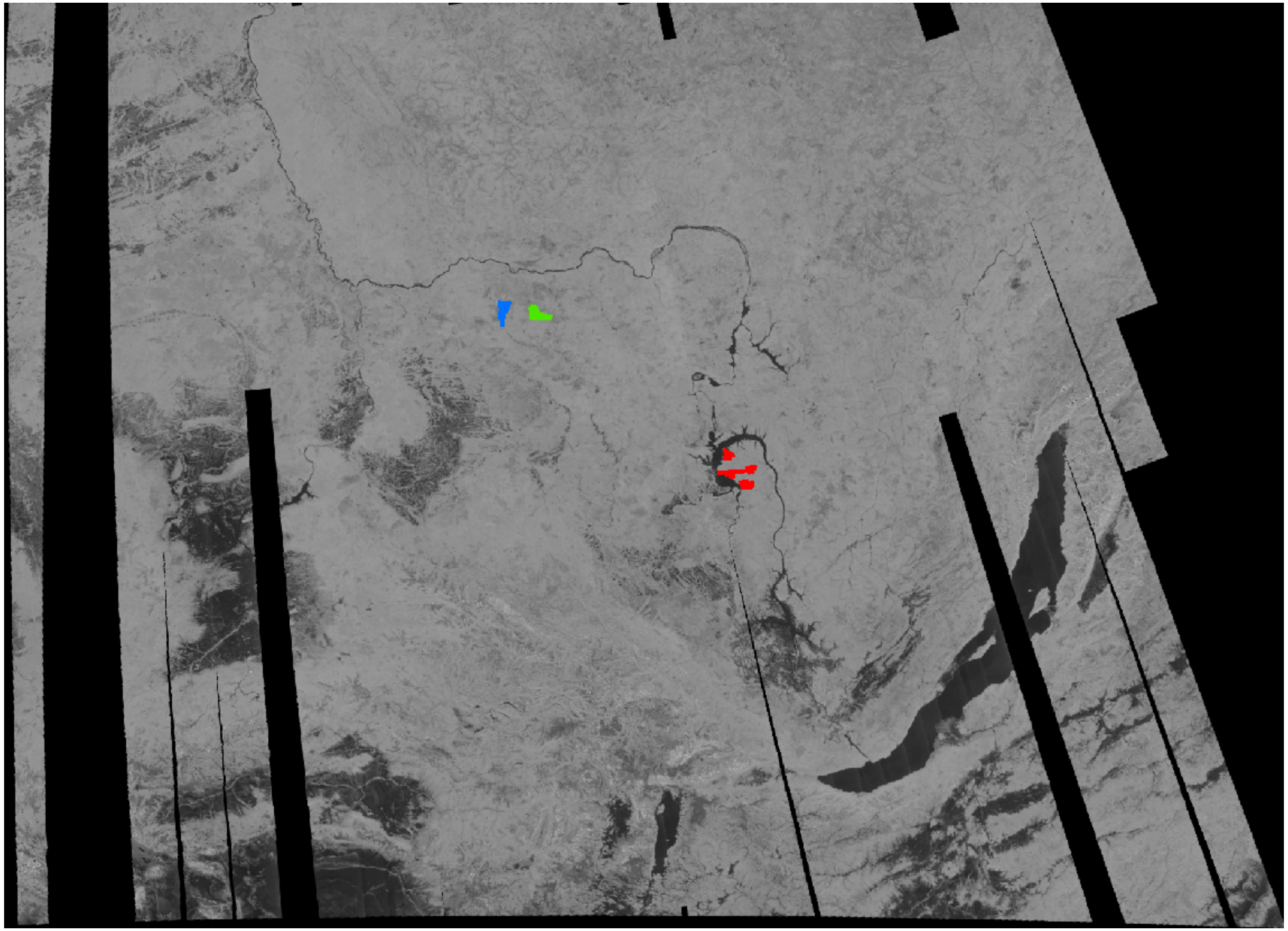
seit 1548

GAMMA REMOTE SENSING

Outline – Scientific Questions

- Test Sites, Data Pool, and Coherence Computation
- What can be expected from summer coherence images (regarding forestry related applications)?
- Does the HV coherence contain additional information (over HH coherence)?
- Is the computation of FBS-FBD coherence based on FBS (winter) and FBD (summer) images feasible and useful?
- How distinct is the correlation between coherence/backscatter and forest stem volume?

- **Test Sites in Siberia**



Chunsky N (T475/F1150)

Chunsky E (T473/F1150)

Primorsky (T466/F1110)

- **Ground data**

Problems with ground data:

- Data outdated (GIS data 10 years old, information within GIS data even older)
  → new clear-cuts, growth and regrowth of forest (SAR data from 2007/2008)
- Polygons inaccurate – deviation partly more than 100 m
- Partly high heterogeneity within forest stands, e.g. only partly logged
- Only trees with economic relevance are considered (e.g. stem diameter > 8 cm)

Handling of these problems

- Buffering polygon information (7x7 diversity filter on 12.5 m data)
- Minimum size of forest stand 256 pixels (12.5 m data)
- Applying maximum variance of coherence (sigma coh. < 0.1)
- Excluding forest stands which have been potentially logged during last 10 years (high coherence and high biomass) → list with obsolete stands has been created

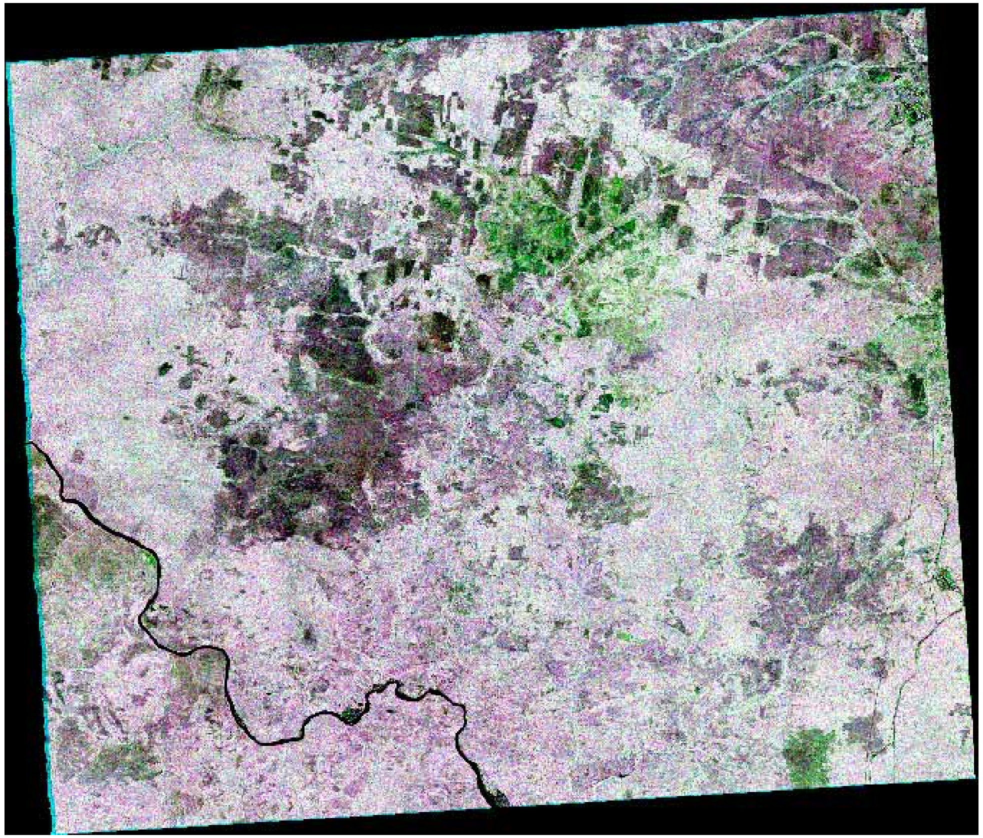
- **Data Pool**

Chunsky N (T475/F1150)		Chunsky E (T473/F1150)		Primorsky (T466/F1110)	
FBS	FBD	FBS	FBD	FBS	FBD
		30dec06		18jan07	
		14feb07		05mar07	
	20jun07		02jul07		21jul07
	05aug07		17aug07		05sep07
	20sep07		02oct07		21oct07
			17nov07		
05nov07					
21dec07					
05feb08		02jan08		21jan08	
22mar08		17feb08			
	07may08				
	22jun08		04jul08		
	07aug08		19aug08		
		04jan09			
		19feb09			

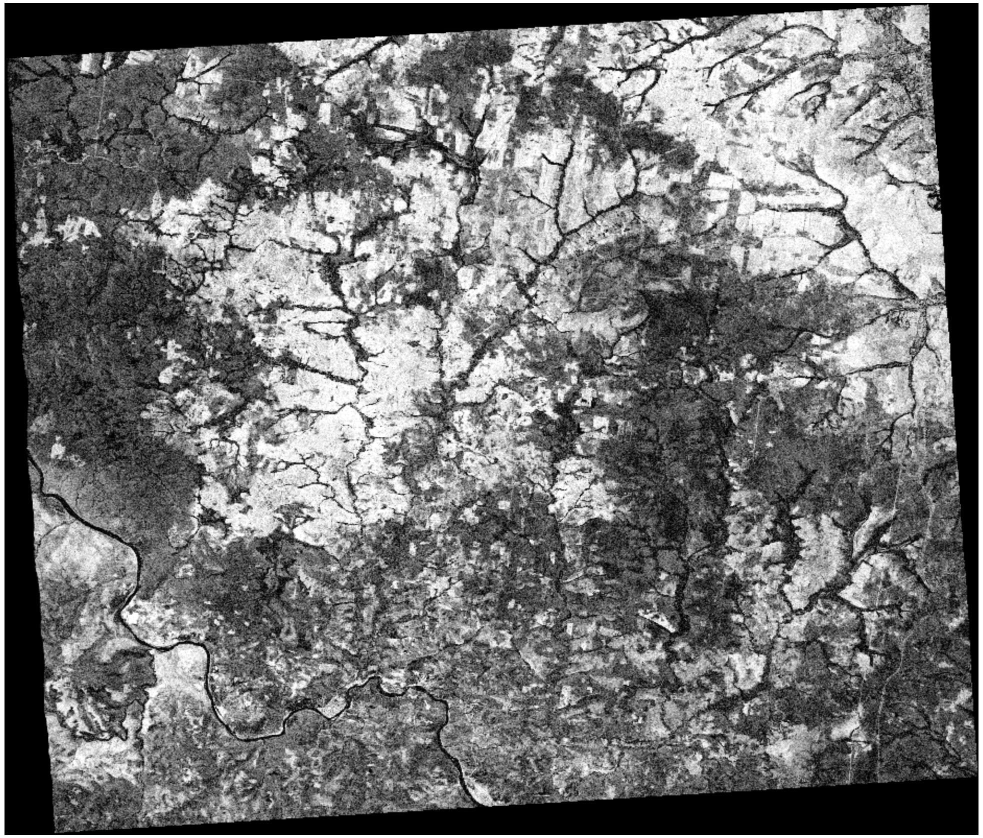
• Coherence Computation

- Standard Level 1.1 FBS and FBD were processed to coherence and backscatter
- Interferometric processing consisted of:
  - SLC data co-registration to sub-pixel level
  - Slope adaptive common-band filtering in range
  - Common-band filtering in azimuth
  - Image texture (stdev/mean, 15×15 window) was applied to reduce impact of strong scatterers during coherence estimation
  - Coherence derivation employs adaptive estimation (variable coherence estimation window sizes): small windows (3×3) at high coherence areas, larger windows (5×5) at low coherence areas
- Coherence orthorectified using SRTM elevation data
- Final pixel size: 12.5 m × 12.5 m (FBS-FBS, FBS-FBD); 25 m × 25 m (FBD-FBD)

- **Summer Coherence Images (Chunsky N)**

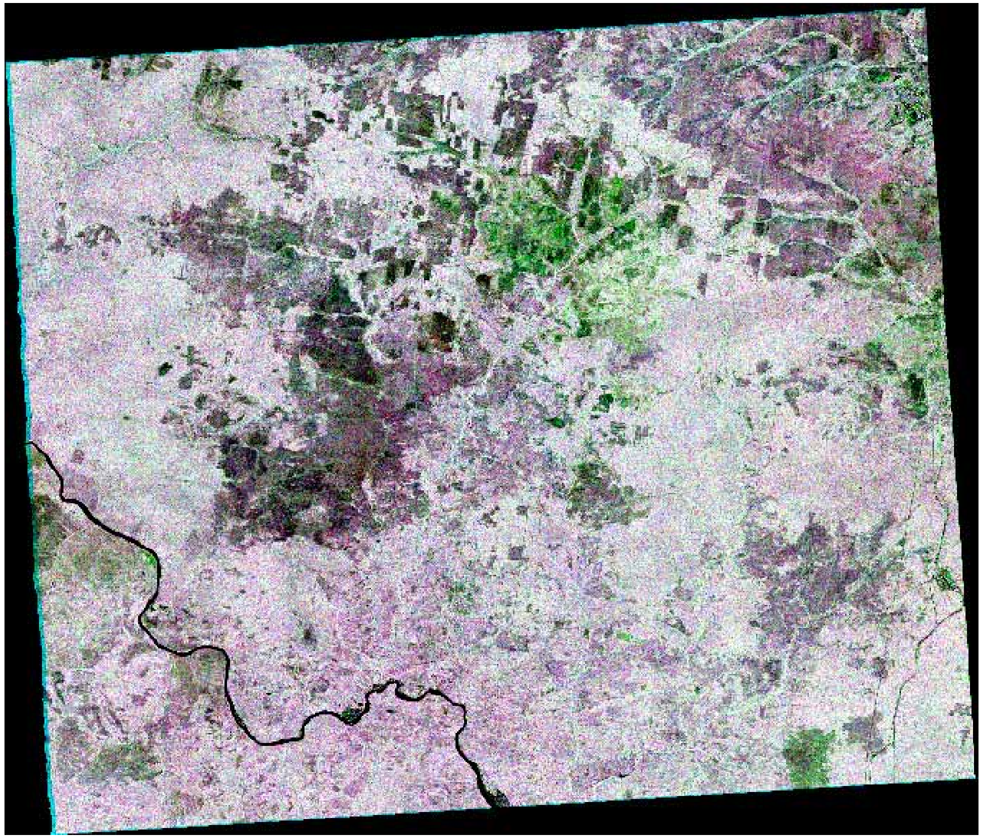


Sigma Zero HV (20jun07/ 05aug07/ 20sep07)

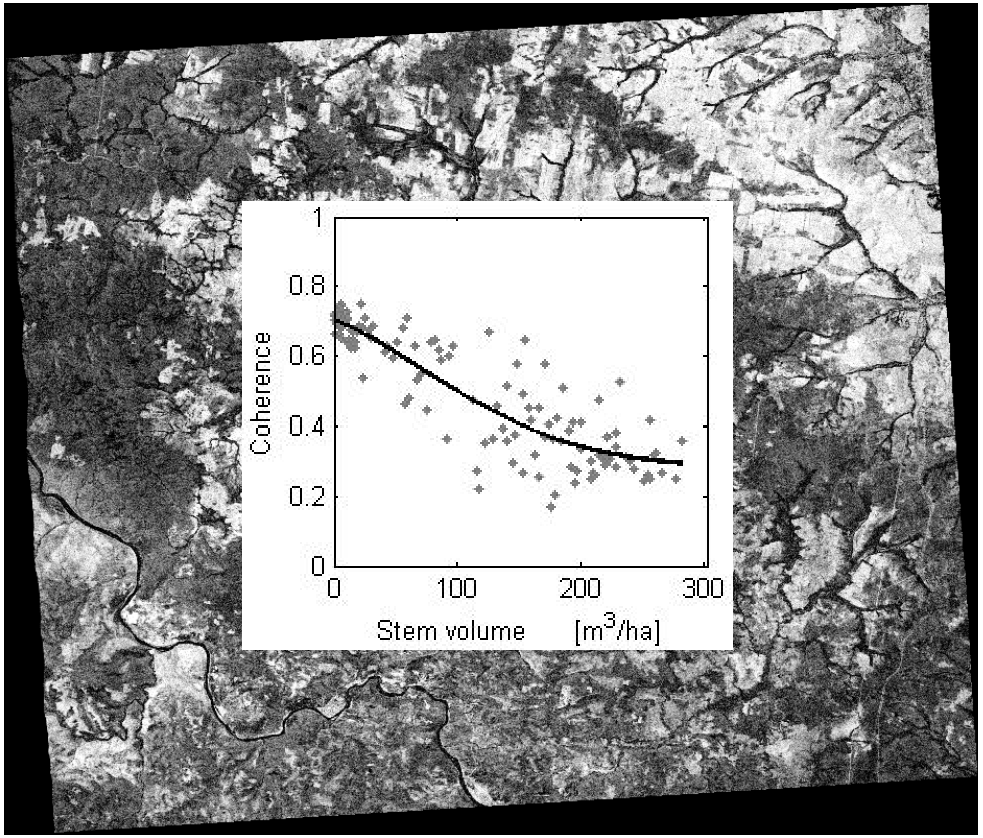


FBS Coherence HH (21dec07 X 05feb08)

- **Summer Coherence Images (Chunsky N)**

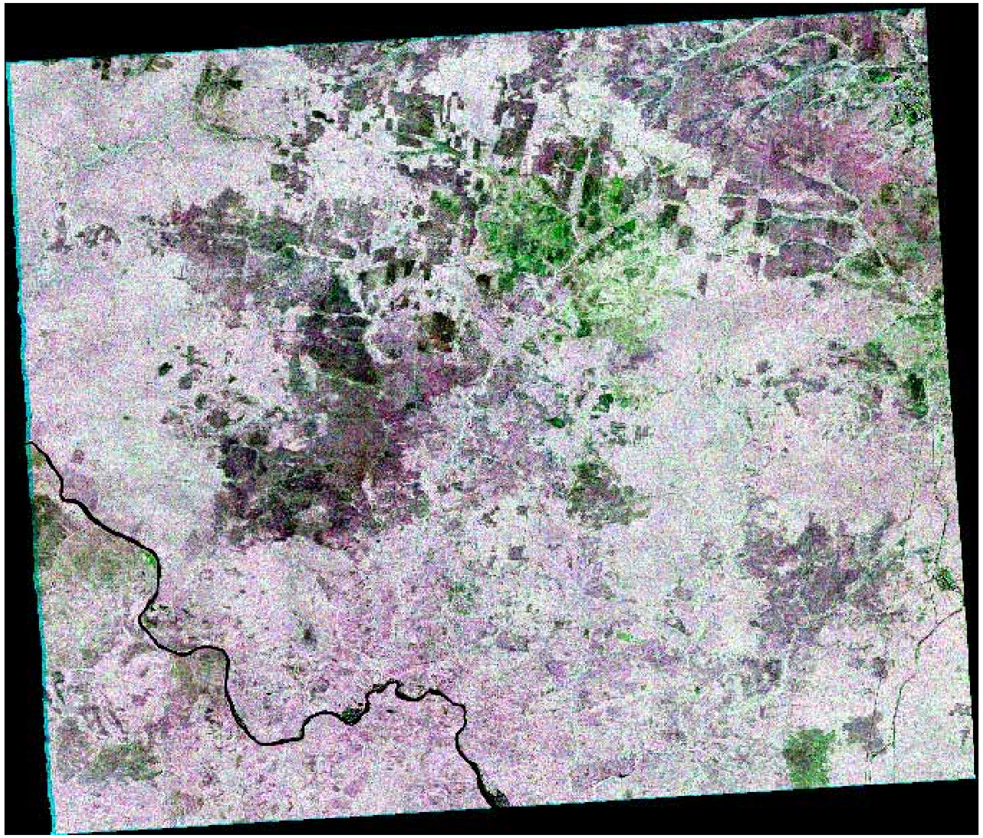


Sigma Zero HV (20jun07/ 05aug07/ 20sep07)

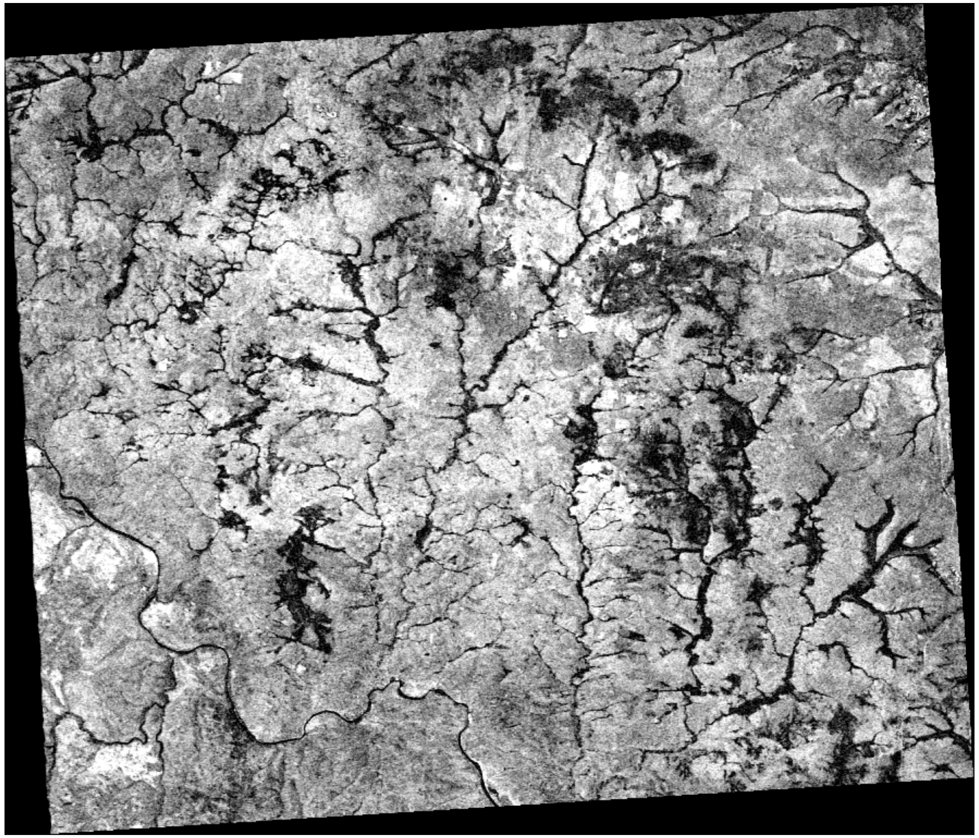


FBS Coherence HH (21dec07 X 05feb08)

- **Summer Coherence Images (Chunsky N)**

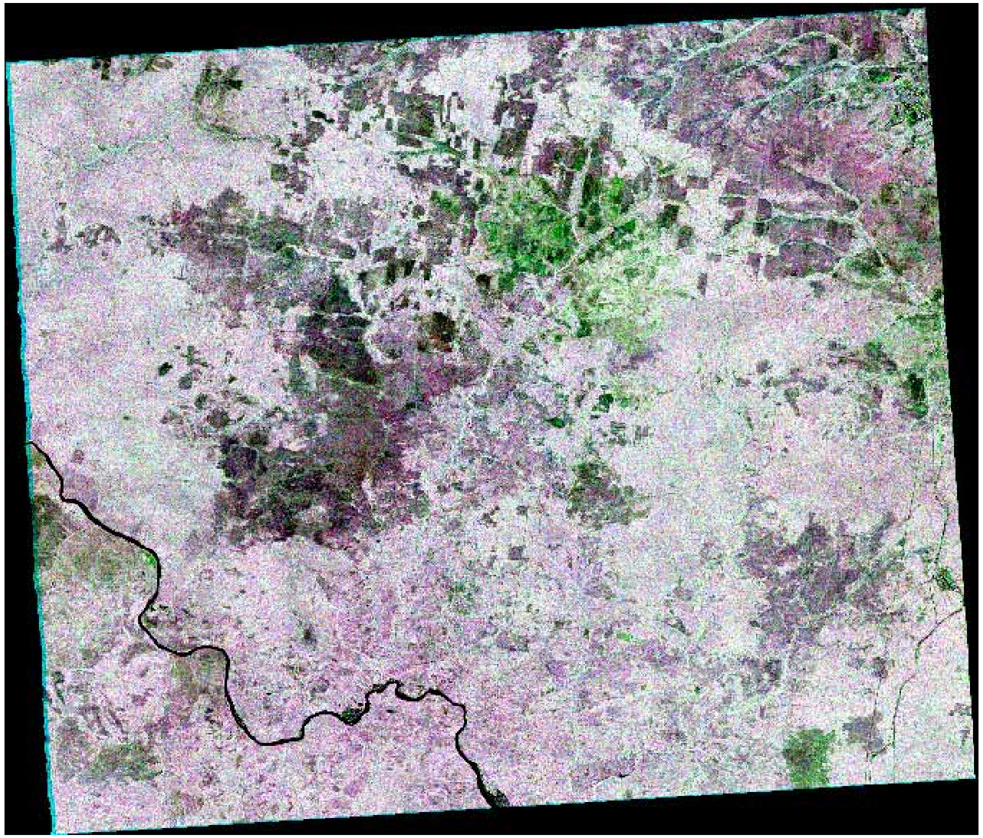


Sigma Zero HV (20jun07/ 05aug07/ 20sep07)

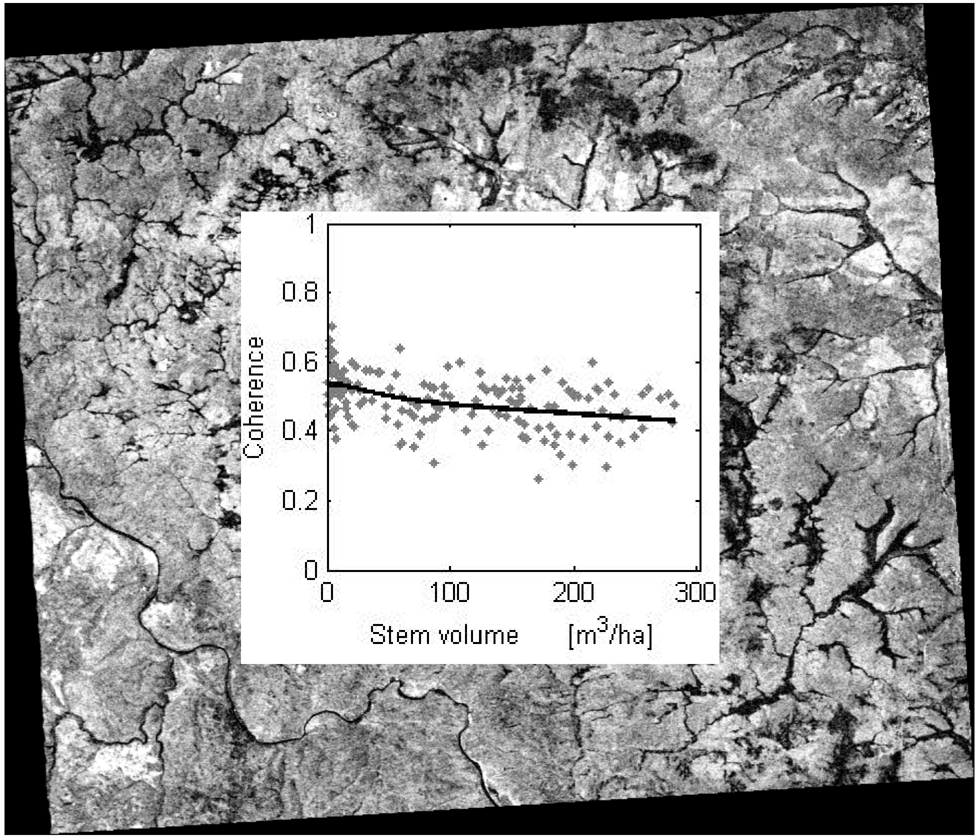


FBD Coherence HH (20jun07 X 05aug07)

- **Summer Coherence Images (Chunsky N)**

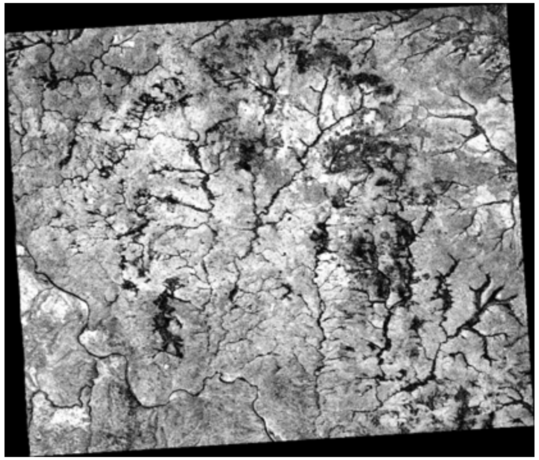


Sigma Zero HV (20jun07/ 05aug07/ 20sep07)

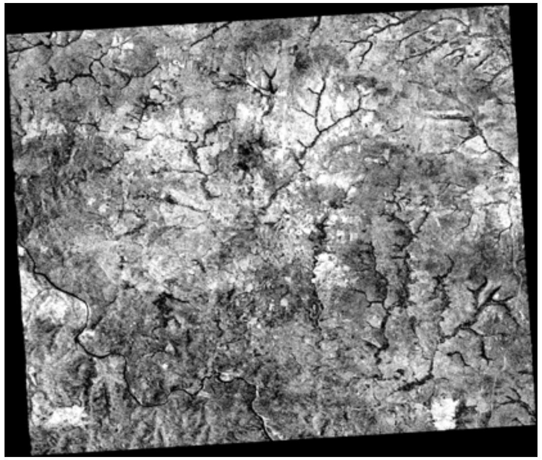


FBD Coherence HH (20jun07 X 05aug07)

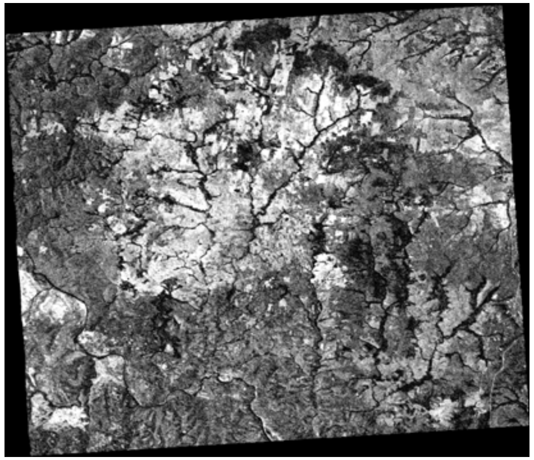
- **Summer Coherence Images (Chunsky N)**



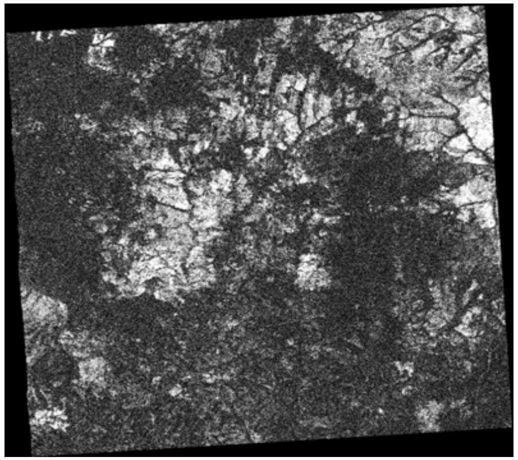
FBD Coherence HH (20jun07 X 05aug07)



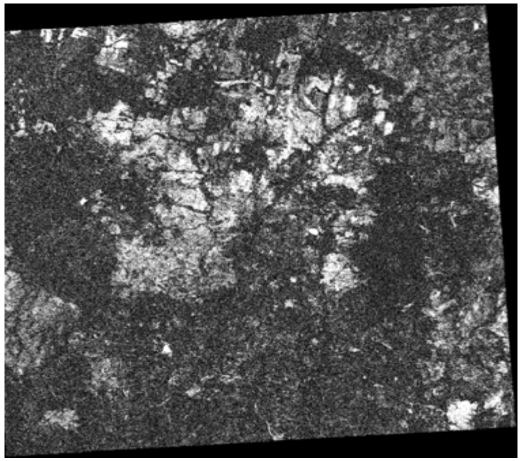
FBD Coherence HH (05aug07 X 20sep07)



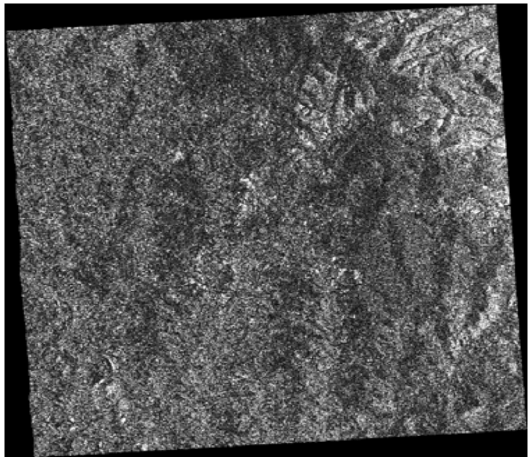
FBD Coherence HH (20jun07 X 20sep07)



FBD Coherence HH (07may08 X 22jun08)
B_{perp}: 3,750 m (B_c: ~ 6,500 m)

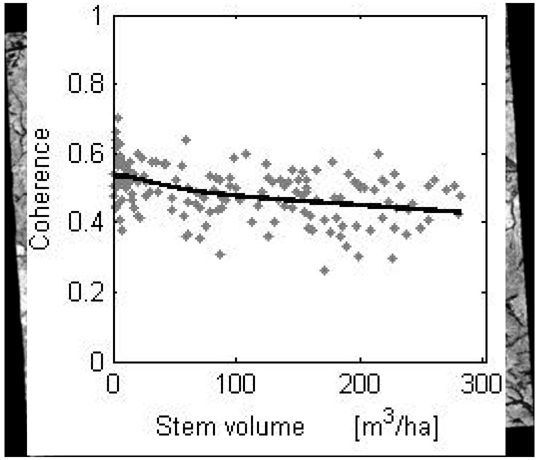


FBD Coherence HH (22jun08 X 07aug08)
B_{perp}: 4,060 m (B_c: ~ 6,500 m)

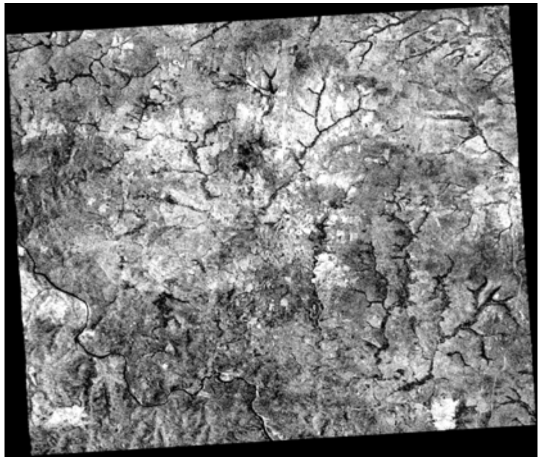


FBD Coherence HH (07may08 X 07aug08)
B_{perp}: 7,810 m (B_c: ~ 6,500 m)

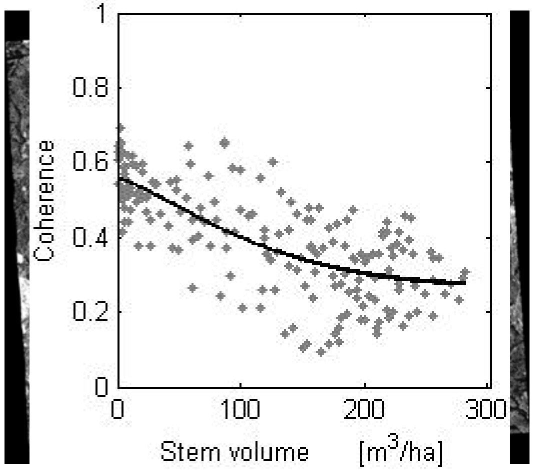
- **Summer Coherence Images (Chunsky N)**



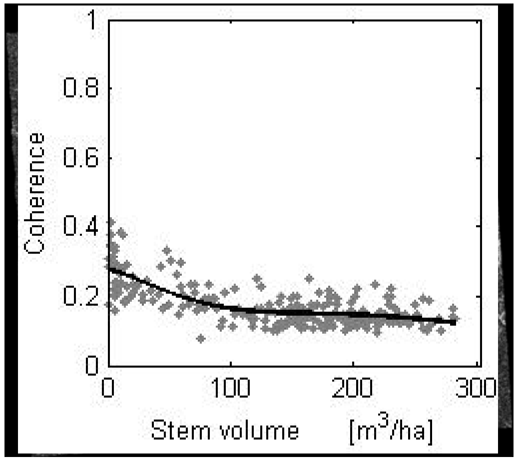
FBD Coherence HH (20jun07 X 05aug07)



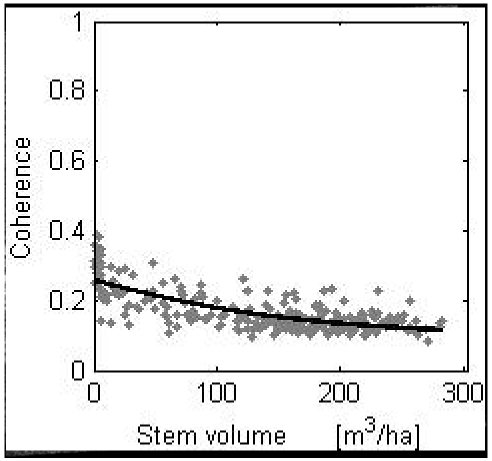
FBD Coherence HH (05aug07 X 20sep07)



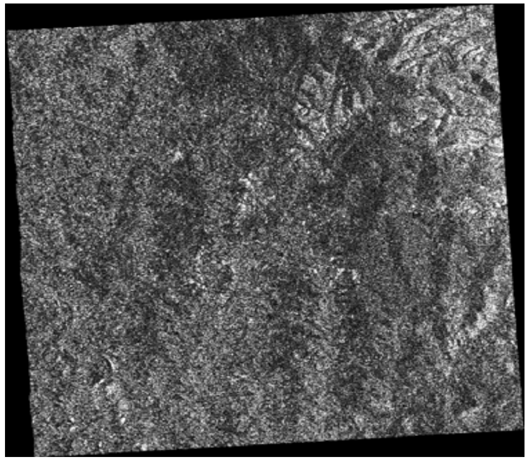
FBD Coherence HH (20jun07 X 20sep07)



FBD Coherence HH (07may08 X 22jun08)



FBD Coherence HH (22jun08 X 07aug08)

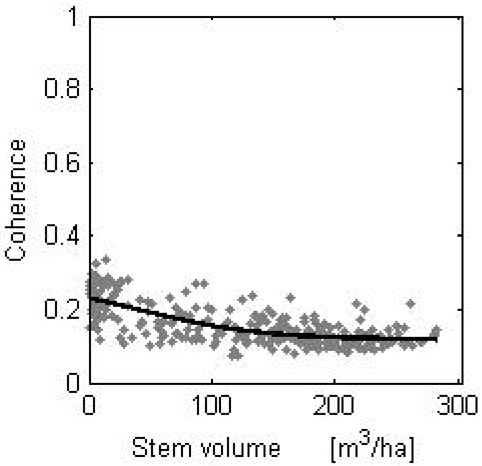


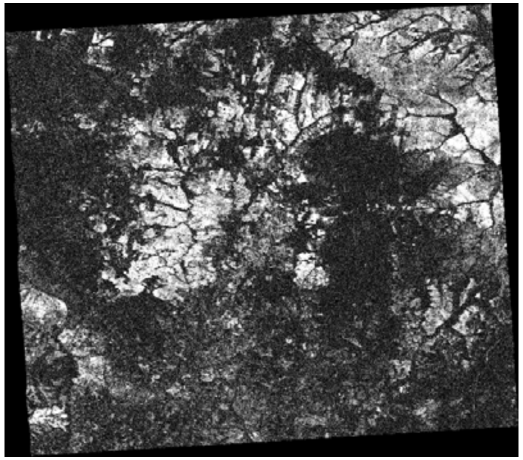
FBD Coherence HH (07may08 X 07aug08)

• Summer Coherence Images (Chunsky N)

FBD Coherence HH (20jun07 X 07may08)

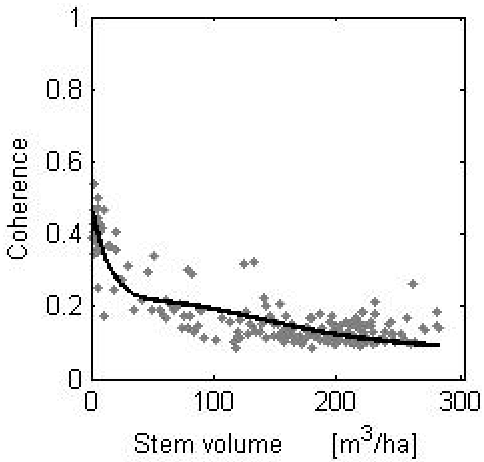
B_{perp}: 3,032 m (B_c: ~ 6,500 m)

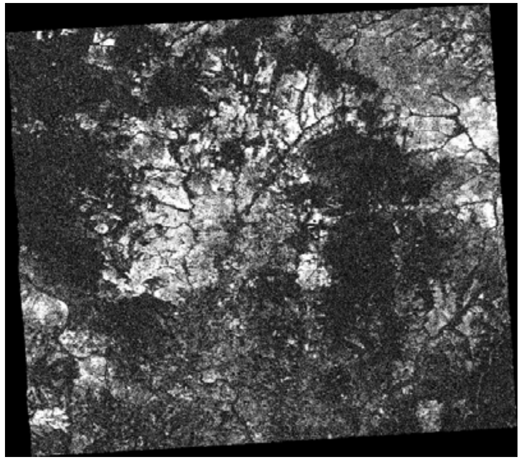




FBD Coherence HH (05aug07 X 07may08)

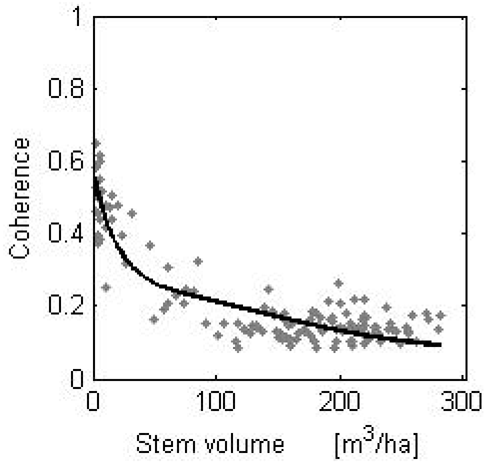
B_{perp}: 2,688 m (B_c: ~ 6,500 m)



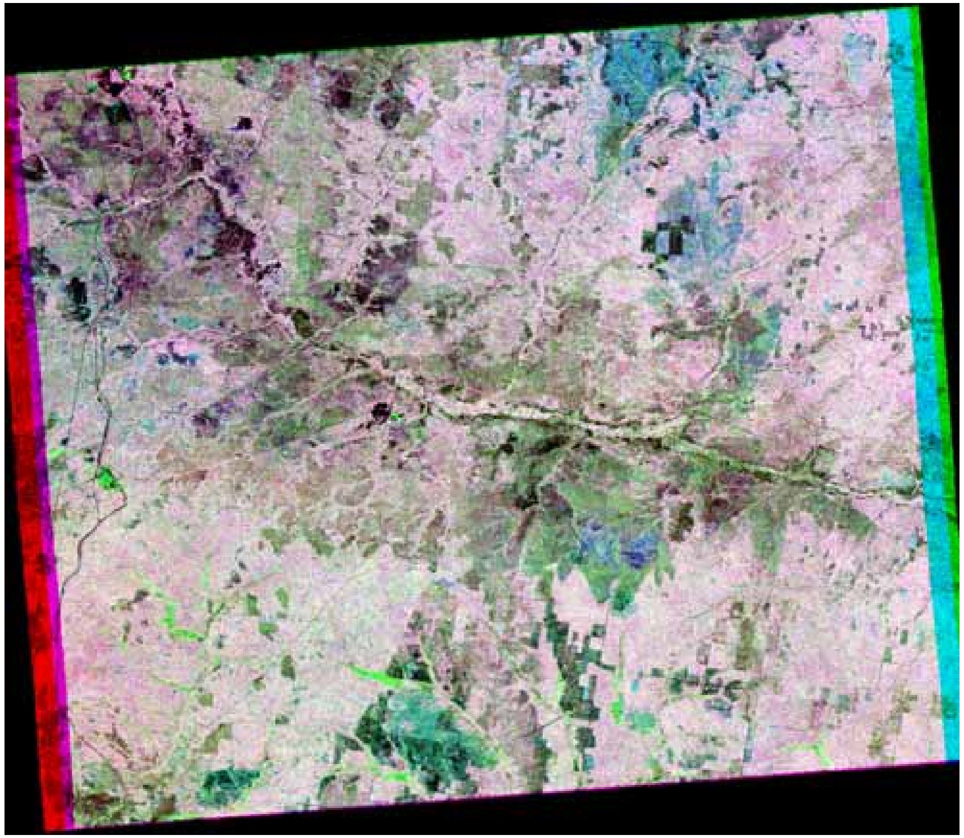


FBD Coherence HH (20sep07 X 07may08)

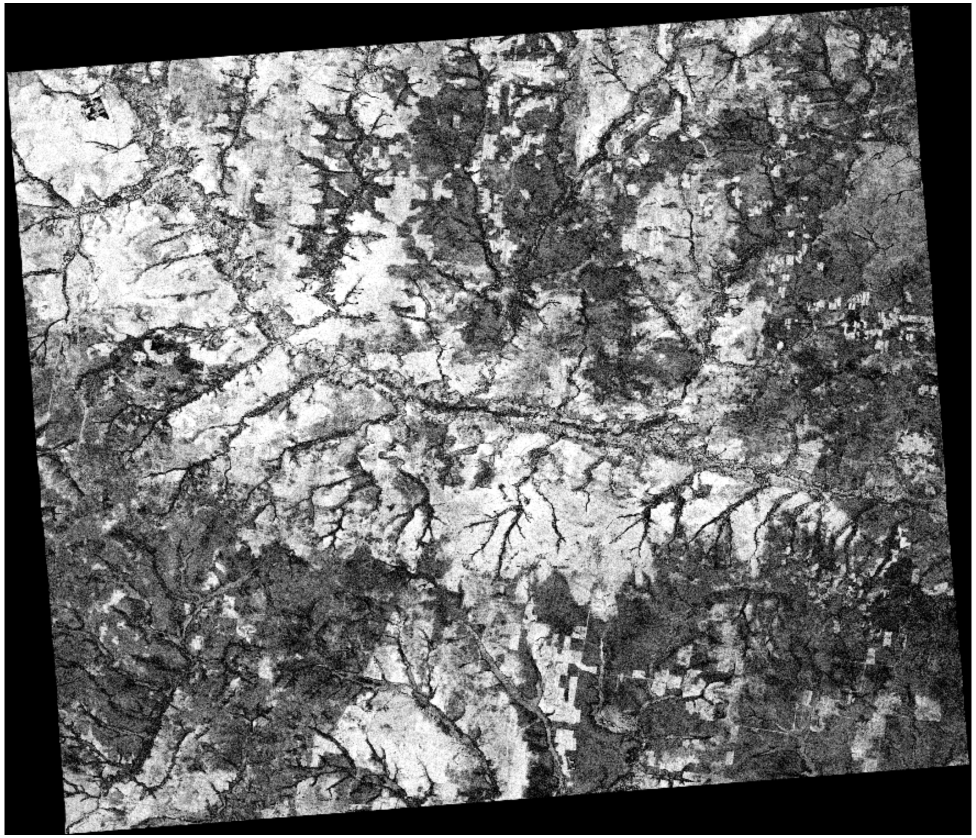
B_{perp}: 2,601 m (B_c: ~ 6,500 m)



- **Summer Coherence Images (Chunsky E)**

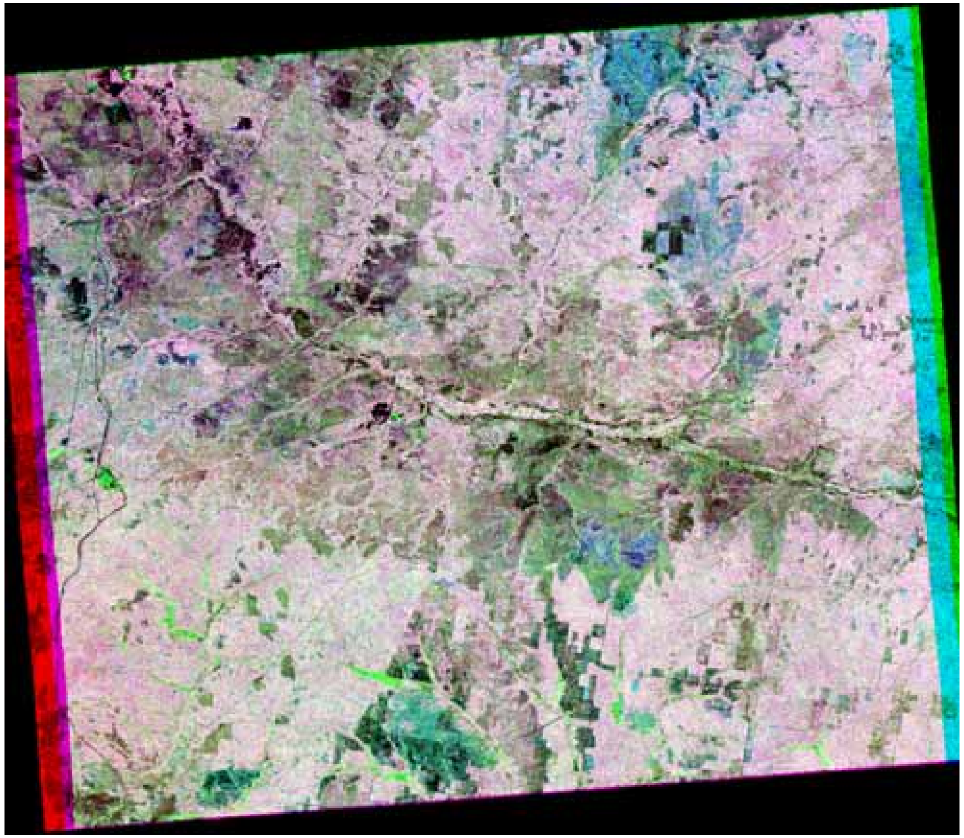


Sigma Zero HV (02jul07/ 17aug07/ 17nov07)

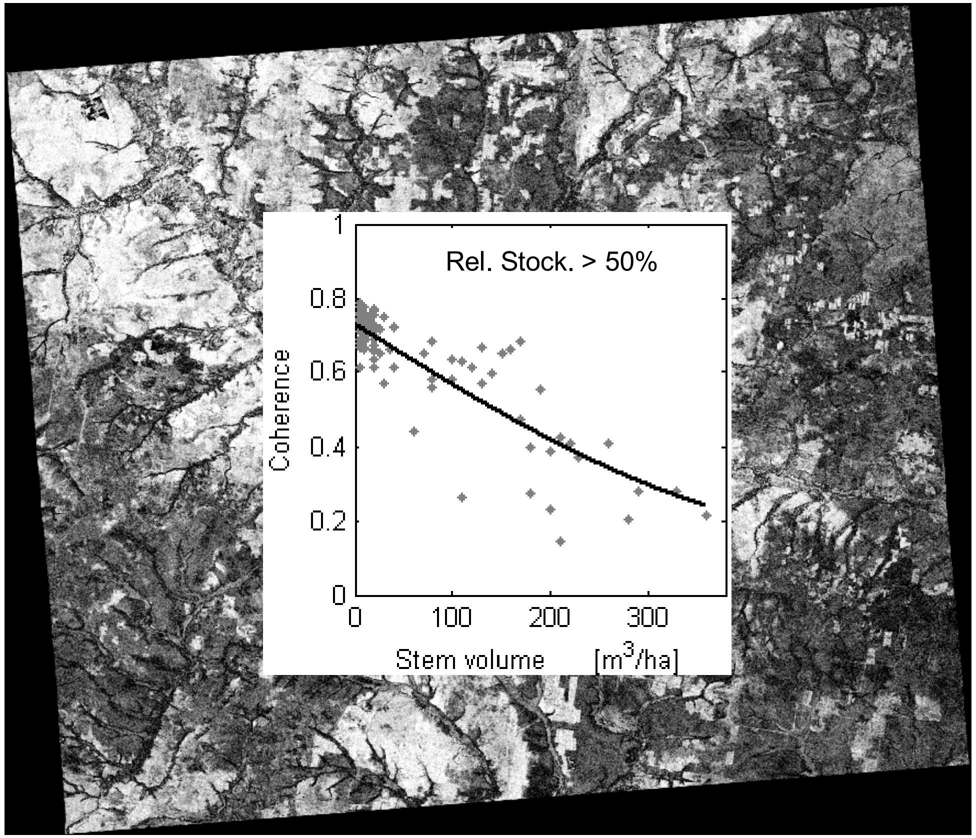


FBS Coherence HH (02jan08 X 17feb08)

- **Summer Coherence Images (Chunsky E)**

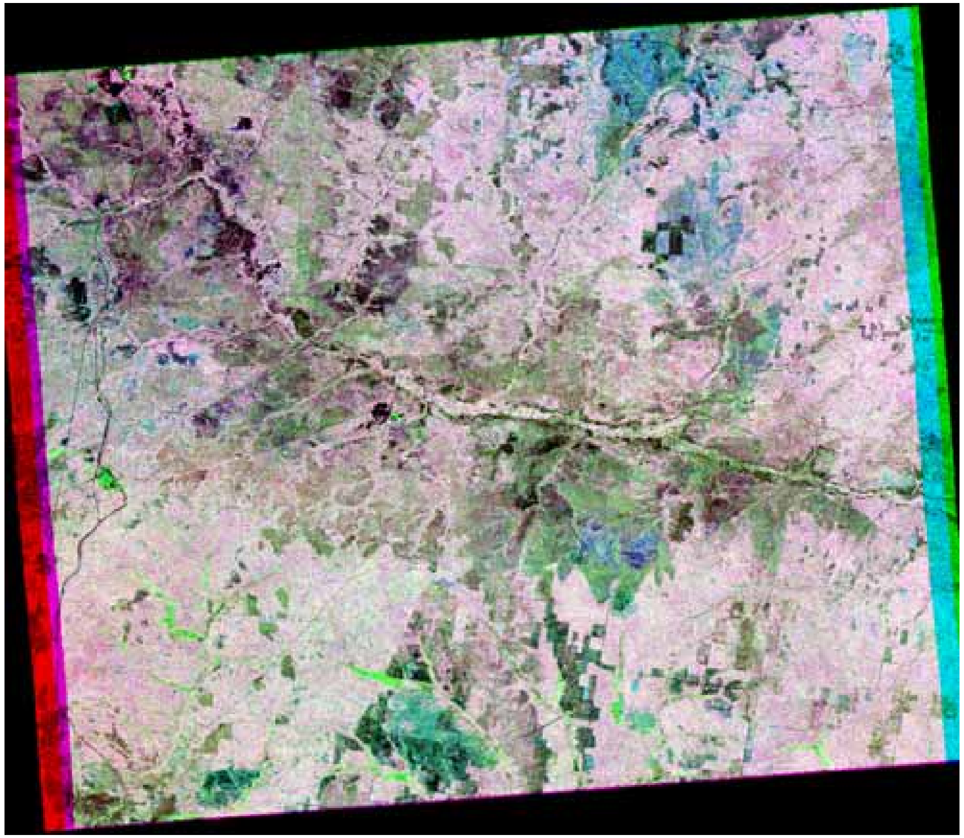


Sigma Zero HV (02jul07/ 17aug07/ 17nov07)

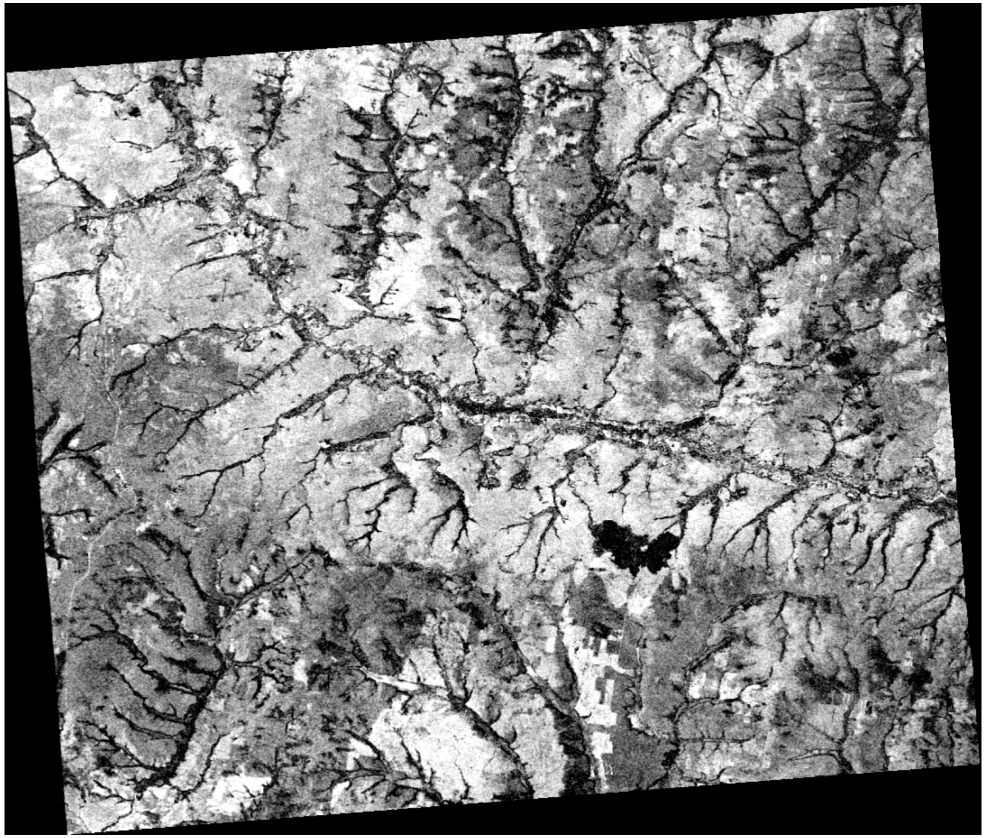


FBS Coherence HH (02jan08 X 17feb08)

- **Summer Coherence Images (Chunsky E)**

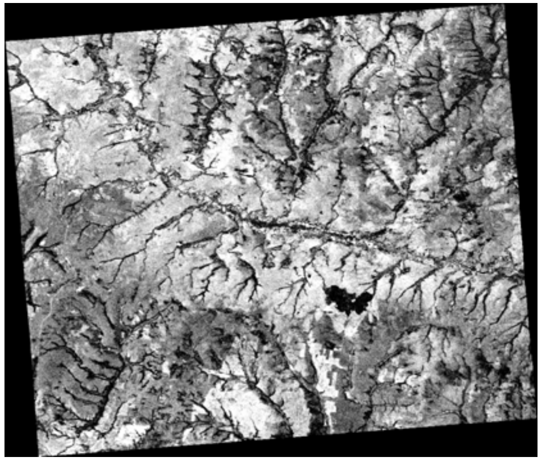


Sigma Zero HV (02jul07/ 17aug07/ 17nov07)

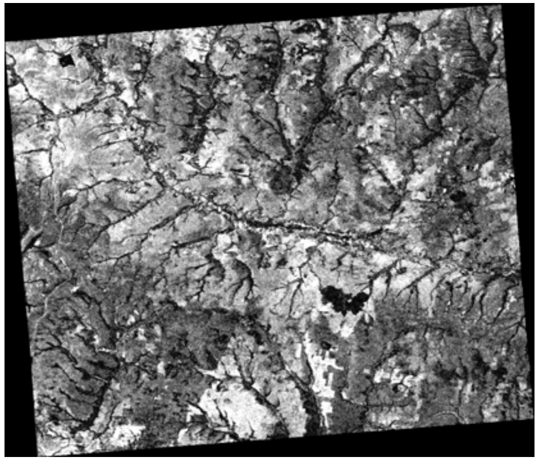


FBD Coherence HH (02jul07 X 17aug07)

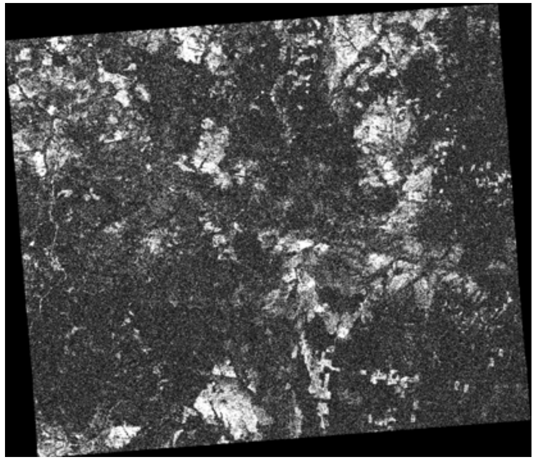
- **Summer Coherence Images (Chunsky E)**



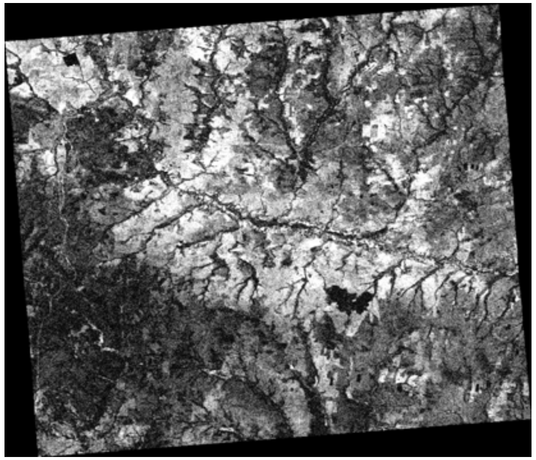
FBD Coherence HH (02jul07 X 17aug07)



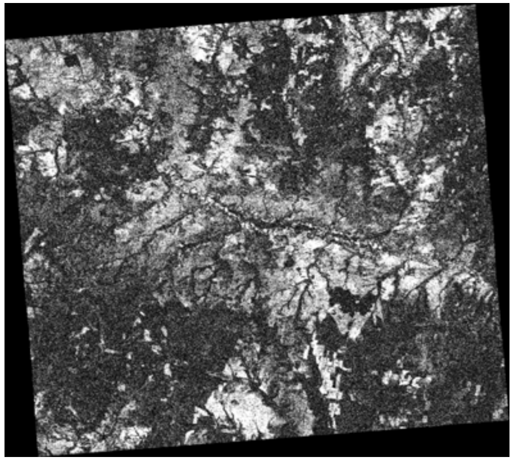
FBD Coherence HH (02jul07 X 02oct07)



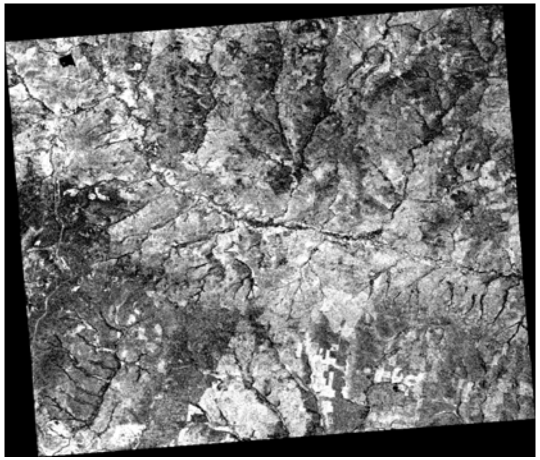
FBD Coherence HH (02jul07 X 17nov07)



FBD Coherence HH (02jul07 X 04jul08)

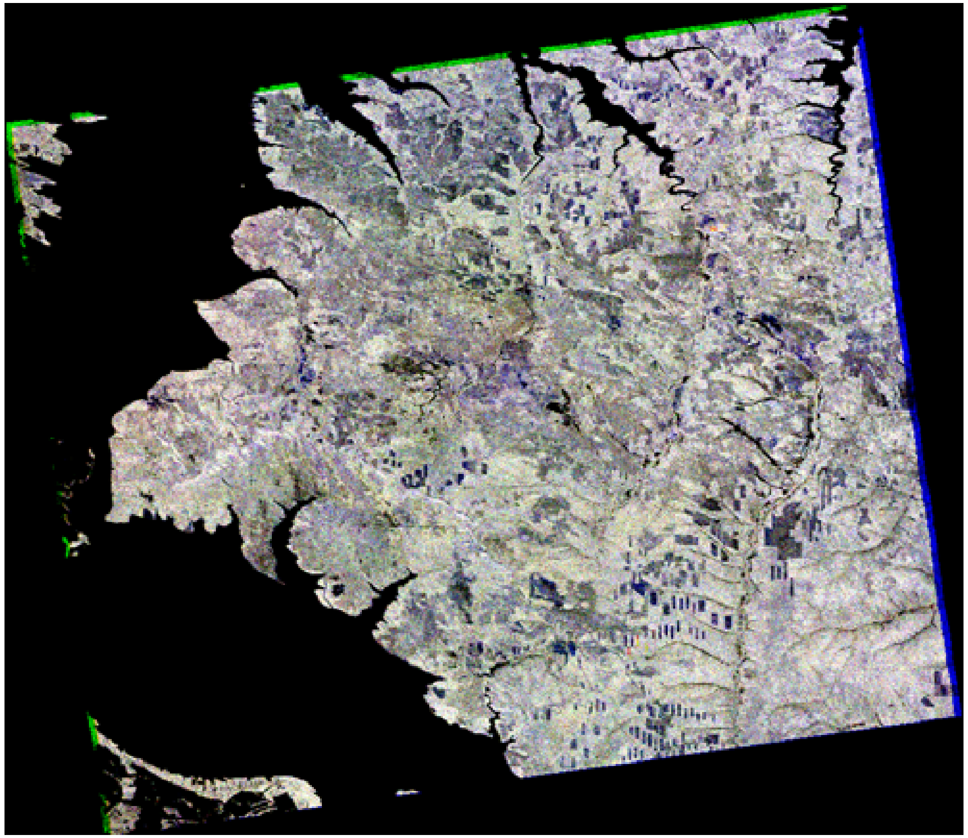


FBD Coherence HH (02jul07 X 19aug08)

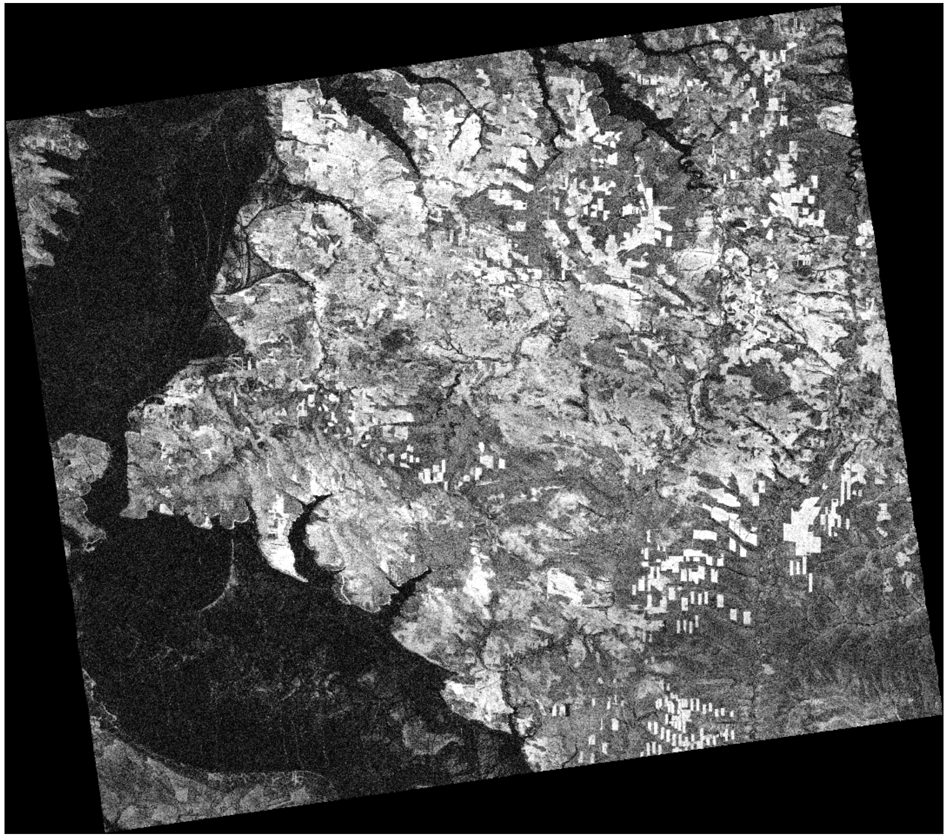


FBD Coherence HH (17aug07 X 02oct07)

- **Summer Coherence Images (Primorsky)**

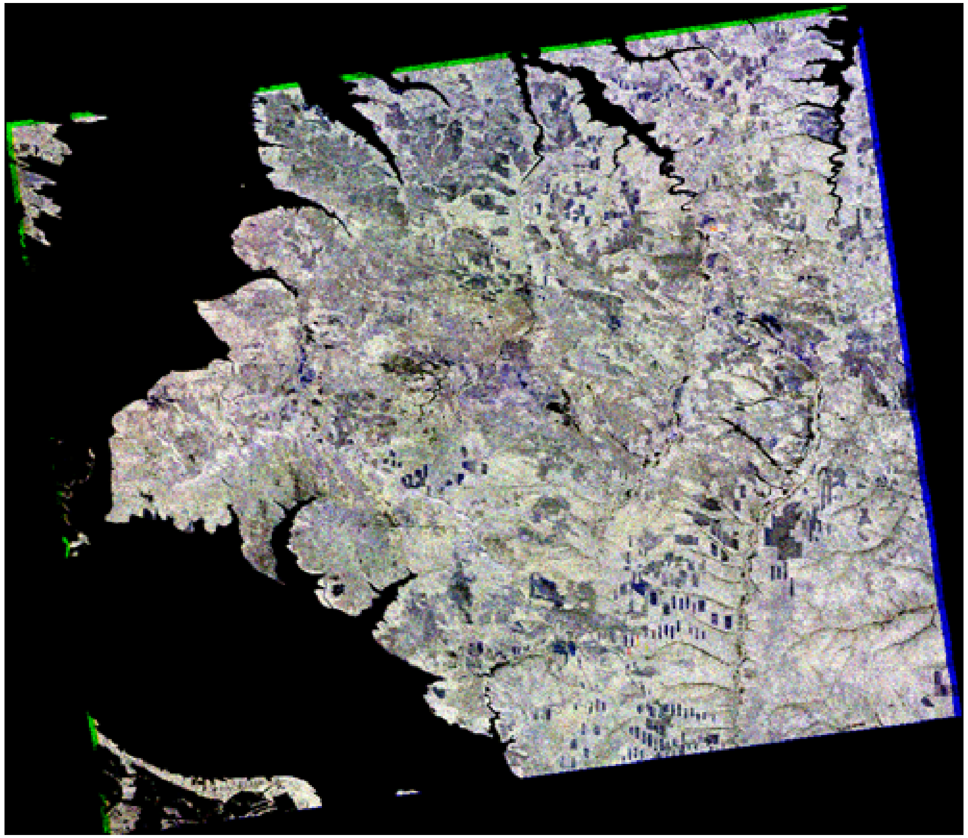


Sigma Zero HV (21jul07/ 05sep07/ 21oct07)

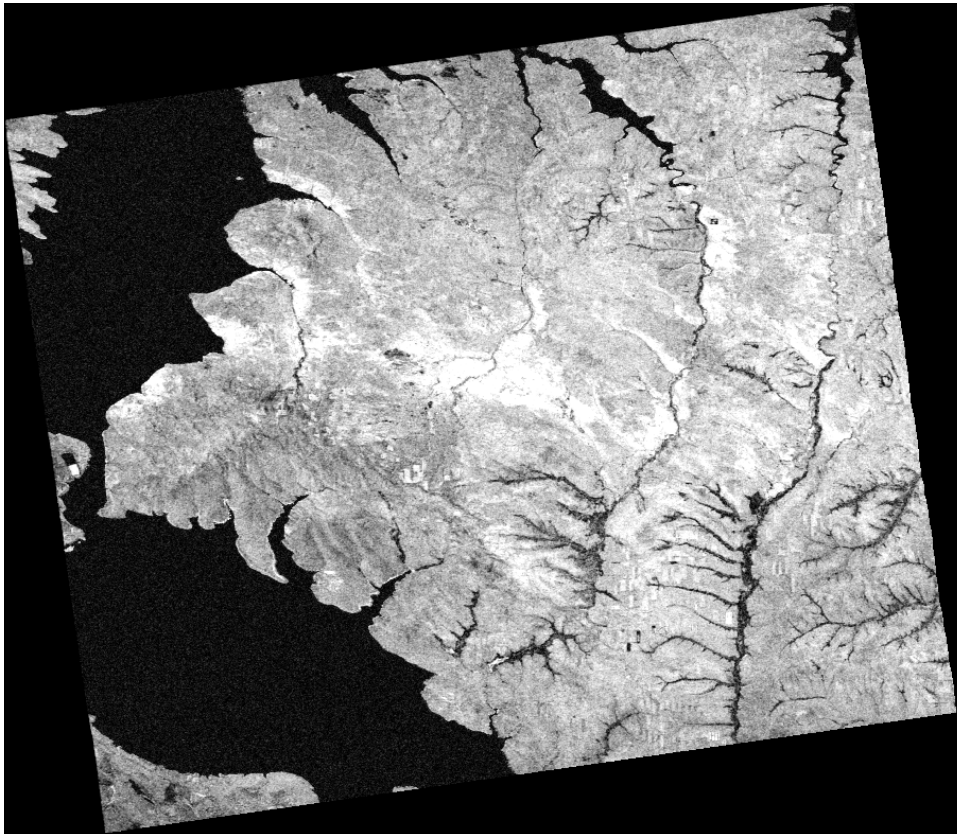


FBS Coherence HH (18jan07 X 05mar07)

- **Summer Coherence Images (Primorsky)**

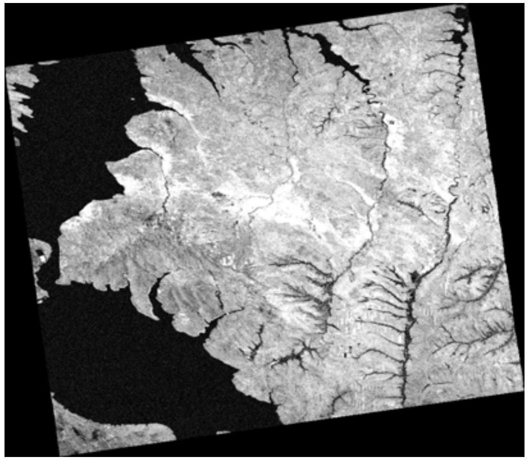


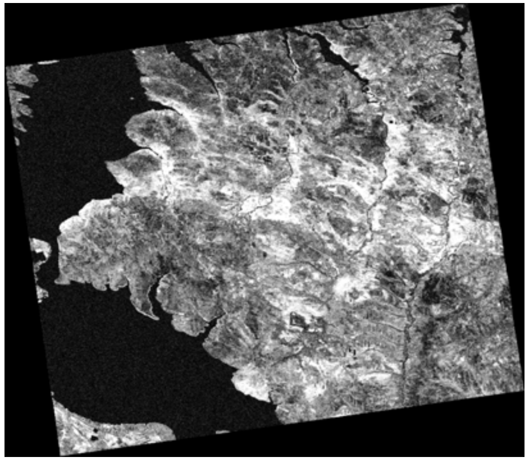
Sigma Zero HV (21jul07/ 05sep07/ 21oct07)

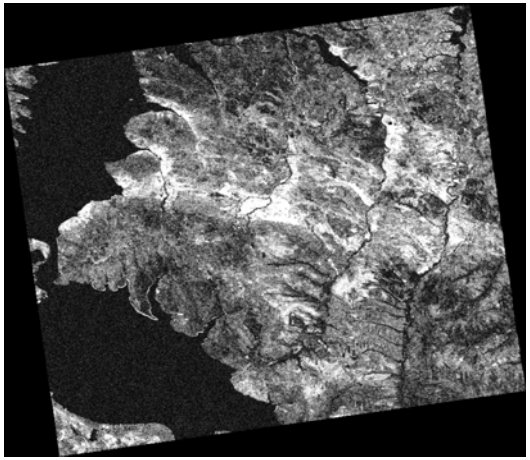


FBD Coherence HH (21jul07 X 05sep07)

- **Summer Coherence Images (Primorsky)**


FBD Coherence HH (21jul07 X 05sep07)


FBD Coherence HH (05sep07 X 21oct07)


FBD Coherence HH (21jul07 X 21oct07)

Summer Coherence Images – Preliminary Conclusions

- Generally high overall coherence for short temporal baselines if both images are acquired at midsummer
- High coherence also for high stem volume forest stands – much greater than in winter!
- Weak to no correlation with forest stem volume
- Decorrelation appears at patches with (presumably) temporal soil moisture variations (e.g. headwaters, bogs, floodplains)
- Overall decorrelation increases with increasing temporal baseline, decorrelation is higher at high forest biomass areas → correlation with stem volume increases with temporal baseline
- Heavy decorrelation, if one of the images is out of season (midsummer)
- Intra-annual summer coherence can contain valuable information
- Summer coherence is much less suited for forest stem volume estimation than winter coherence

Summer Coherence Images – Preliminary Conclusions

- Generally high overall coherence for short temporal baselines if both images are acquired at midsummer
- High coherence also for high stem volume forest stands – much greater than in winter!
- Weak to no correlation with forest stem volume
- Decorrelation appears at patches with (presumably) temporal soil moisture variations (e.g. headwaters, bogs, floodplains)
- Overall decorrelation increases with increasing temporal baseline, decorrelation is higher at high forest biomass areas → correlation with stem volume increases with temporal baseline
- Heavy decorrelation, if one of the images is out of season (midsummer)
- Intra-annual summer coherence can contain valuable information
- Summer coherence is much less suited for forest stem volume estimation than winter coherence

- Question to be discussed: Why is summer coherence greater for high stem volume forest than winter coherence?

Outline – Scientific Questions

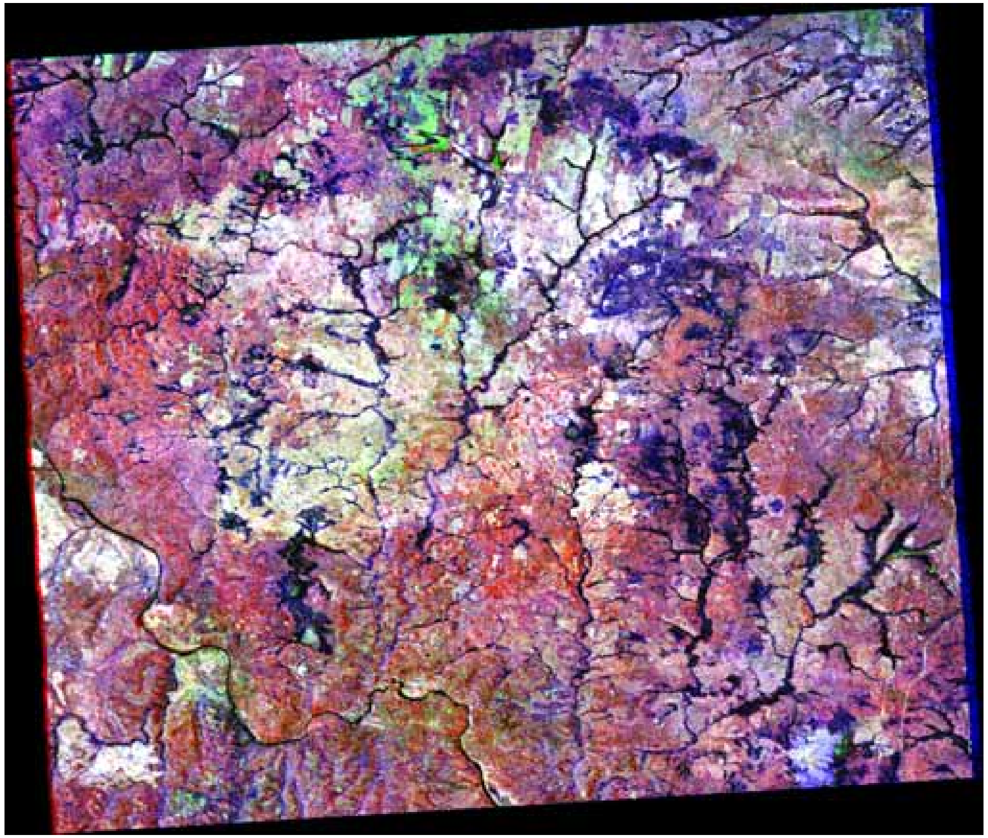
- Test Sites, Data Pool, and Coherence Computation
- What can be expected from summer coherence images (regarding forestry related applications)?
- Does the HV coherence contain additional information (regarding HH coherence)?
- Is the computation of coherence based on FBS (winter) and FBD (summer) images feasible and useful?
- How distinct is the correlation between coherence/backscatter and forest stem volume?

- **HV coherence vs. HH coherence**

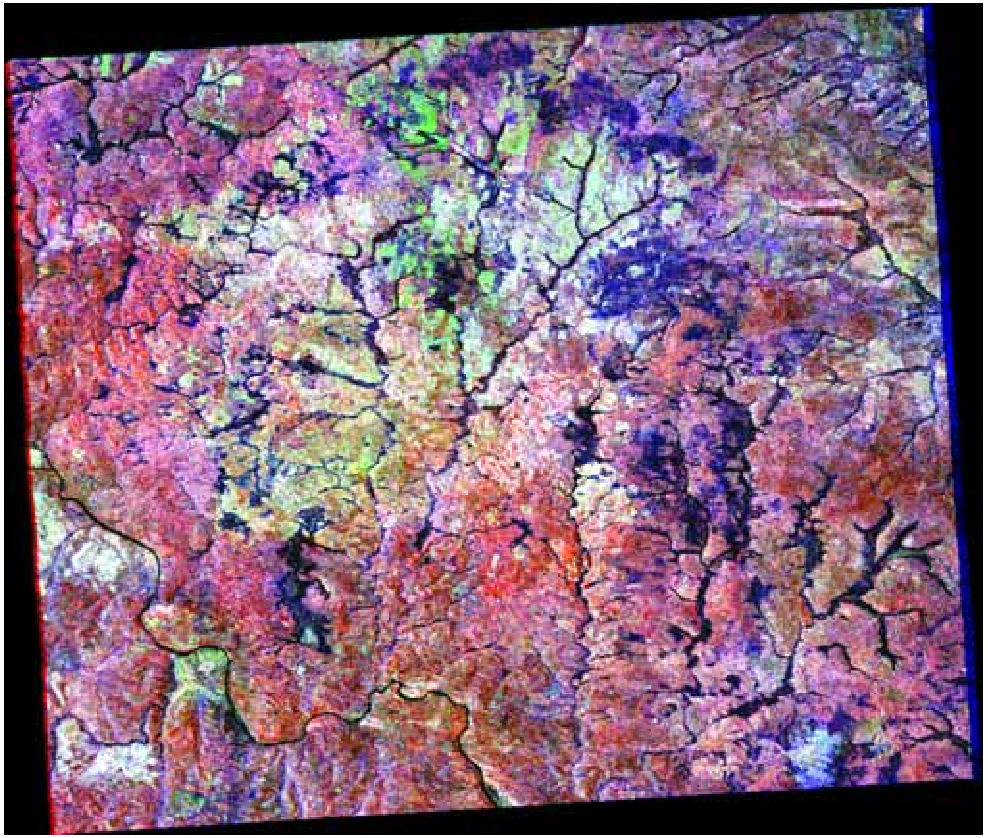
Preliminary Considerations:

1. Scattering of EM wave is a deterministic process
2. Scattering mechanism determines depolarisation of EM wave and thus phase and magnitude of all polarisation states (e.g. HH and HV channel)
3. Phase and magnitude of HH and HV are not independent of each other
4. Maximum interferometric coherence appears only if phase and magnitude remain stable at both acquisitions, this means the scattering mechanism needs to remain stable
5. Due to 1-4 HH and HV coherence should contain similar information

- **HV coherence vs. HH coherence (Chunsky N)**



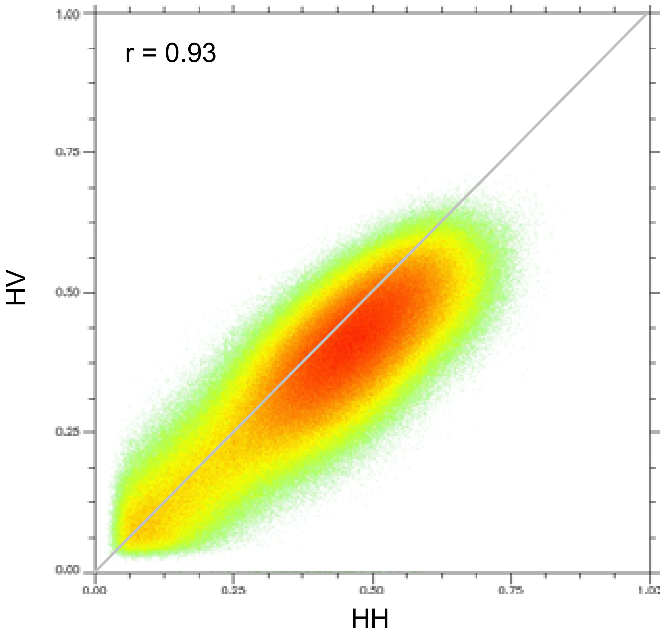
FBD Coherence HH (20jun07 X 05aug07 / 20jun07 X 20sep07 / 05aug07 X 20sep07)



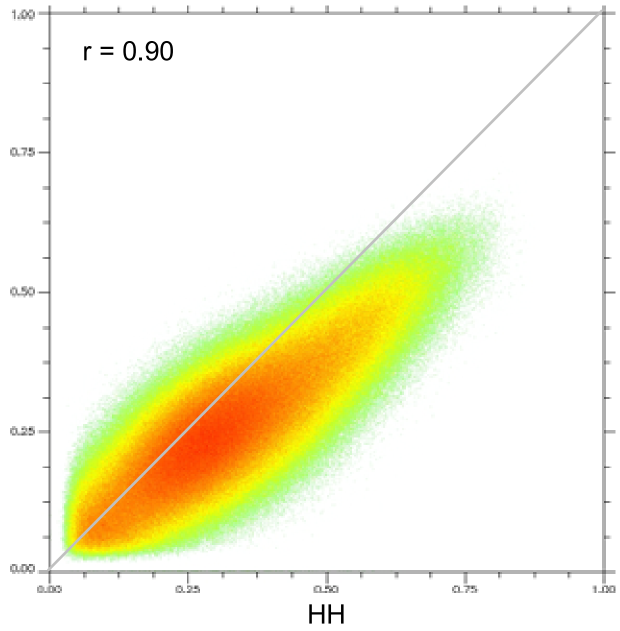
FBD Coherence HV (20jun07 X 05aug07 / 20jun07 X 20sep07 / 05aug07 X 20sep07)

- **HV coherence vs. HH coherence (Chunsky N)**

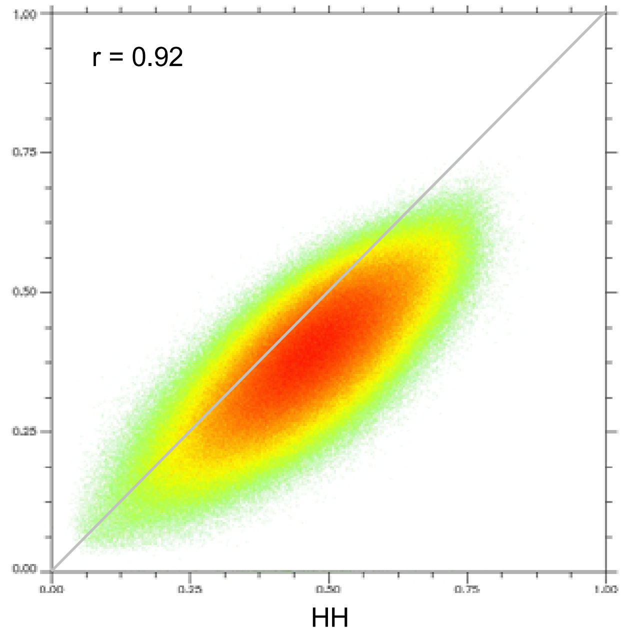
20jun07 X 05aug07



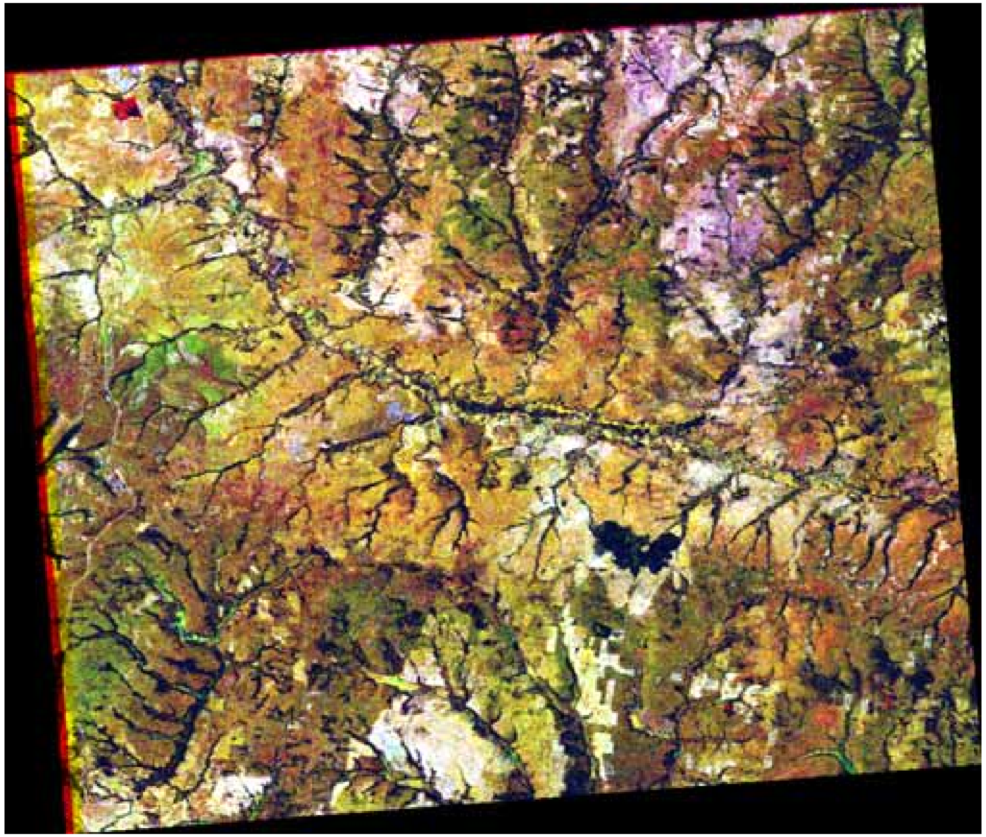
20jun07 X 20sep07



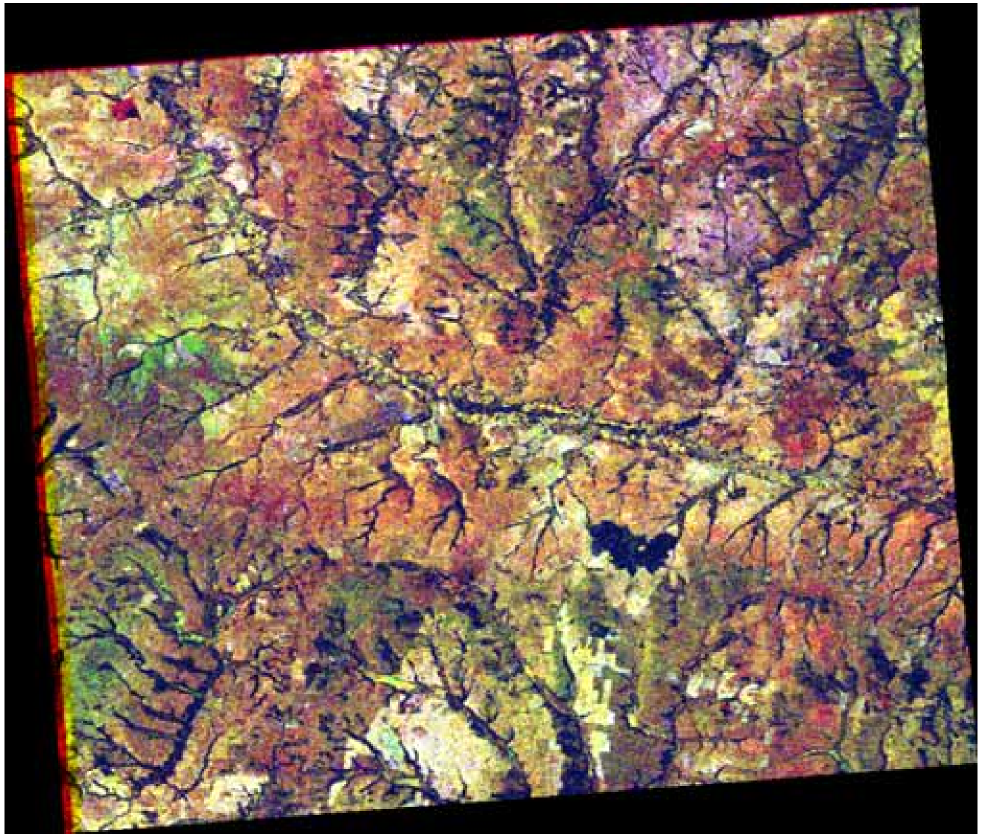
05aug07 X 20sep07



- **HV coherence vs. HH coherence (Chunsky E)**

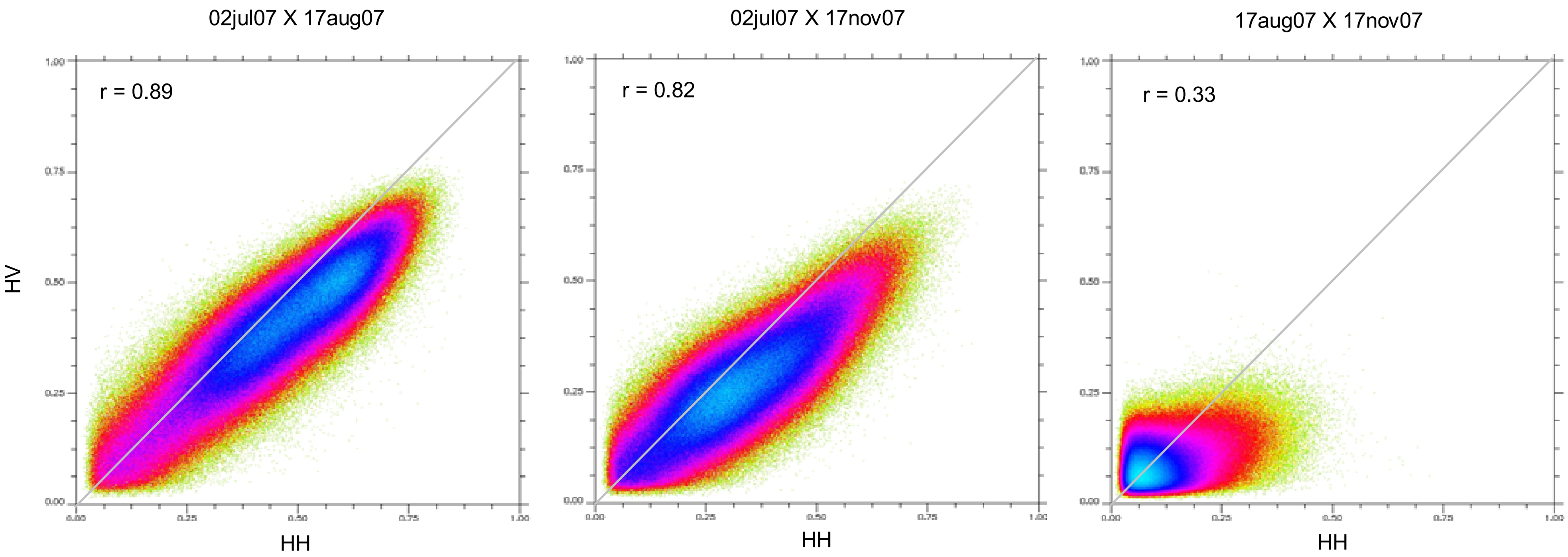


FBD Coherence HH (02jul07 X 17aug07 / 02jul07 X 17nov07 / 17aug07 X 17nov07)

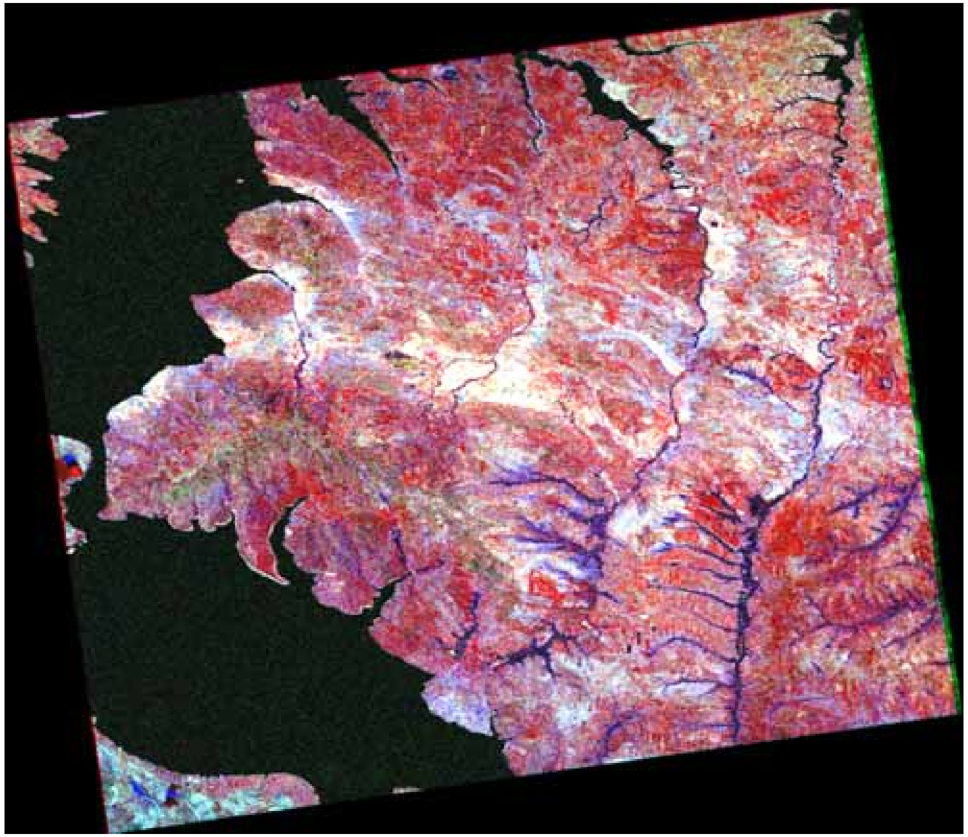


FBD Coherence HV (02jul07 X 17aug07 / 02jul07 X 17nov07 / 17aug07 X 17nov07)

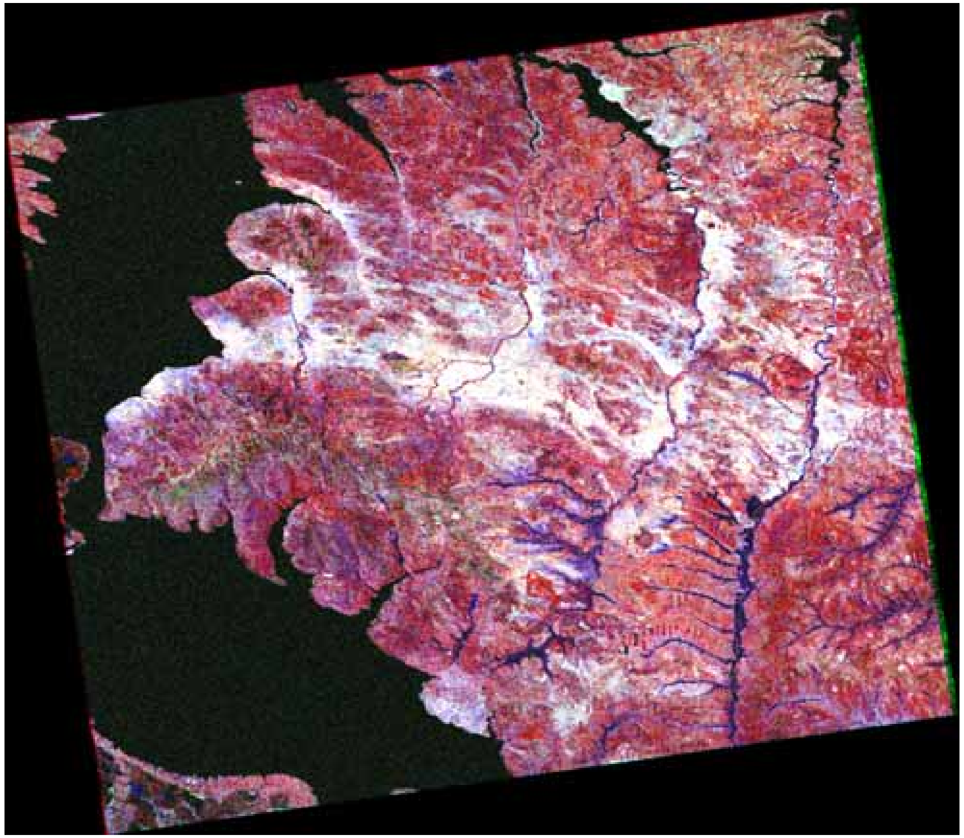
- **HV coherence vs. HH coherence (Chunsky E)**



- **HV coherence vs. HH coherence (Primorsky)**

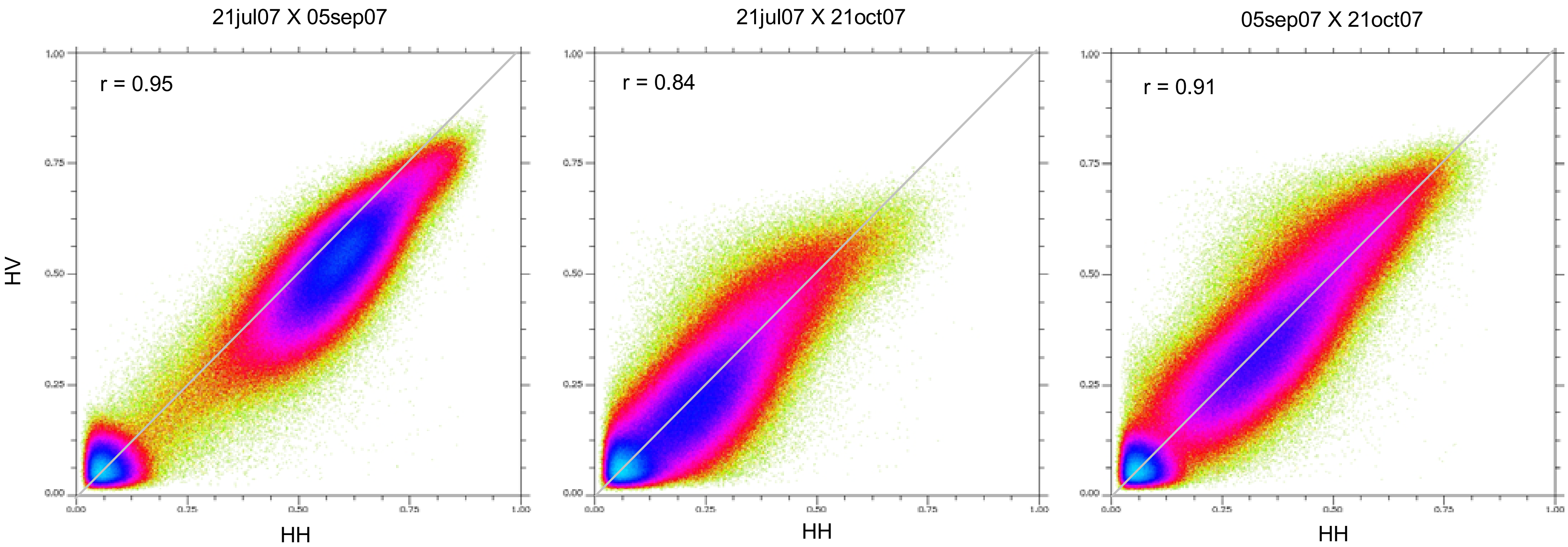


FBD Coherence HH (21jul07 X 05sep07 / 21jul07 X 21oct07 / 05sep07 X 21oct07)

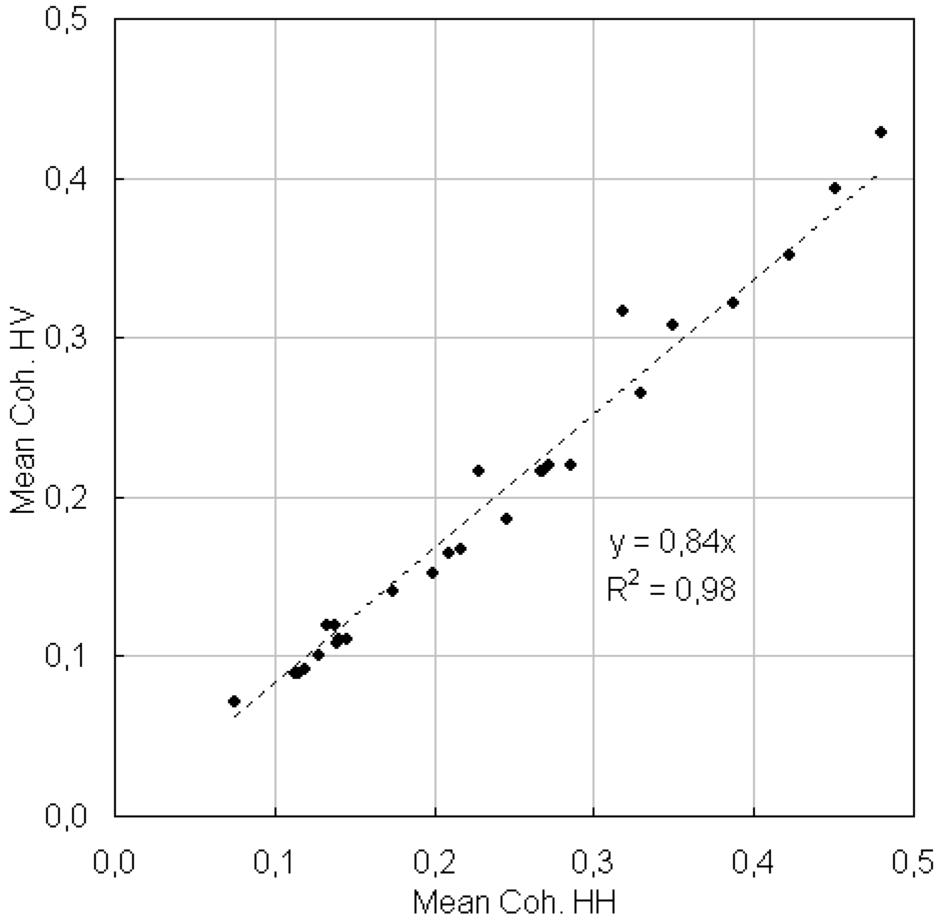


FBD Coherence HV (21jul07 X 05sep07 / 21jul07 X 21oct07 / 05sep07 X 21oct07)

- **HV coherence vs. HH coherence (Primorsky)**

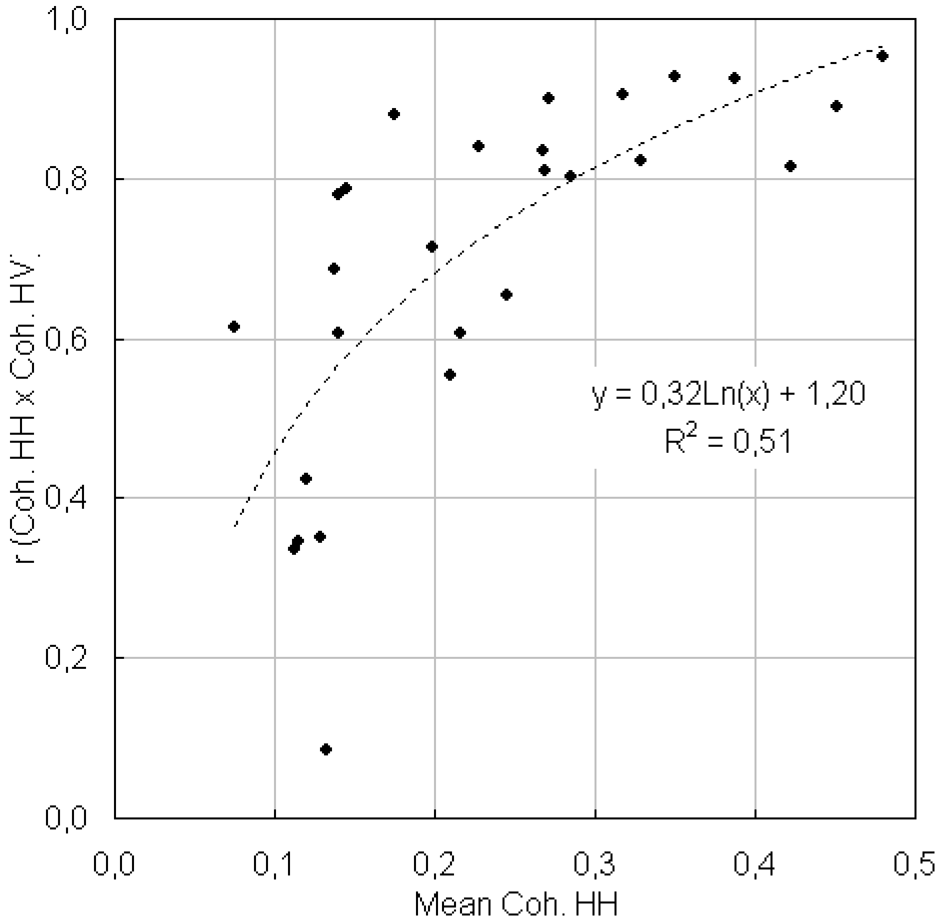


• HV coherence vs. HH coherence



- Computation of overall coherence (average per scene)
- Computation for 27 pairs (all 3 sites, diverse temporal baselines – almost all possible image combinations)
- Comparison of mean HH and HV coherence

- **HV coherence vs. HH coherence**



- Computation of pixel based correlation r between HH and HV coherence (scatterplots)
- Computation for 27 pairs (all 3 sites, diverse temporal baselines – almost all possible image combinations)
- Comparison of mean HH coherence vs. r
- → Decreasing overall scene coherence results in decreasing correlation r between HH and HV coherence (noise)

- **HV coherence vs. HH coherence – Preliminary Conclusions**

  - Preliminary considerations have been approved
  - In general, HH coherence slightly exceeds HV coherence
  - In case of very low overall coherence, pixels based correlation r between HH and HV coherence is very low

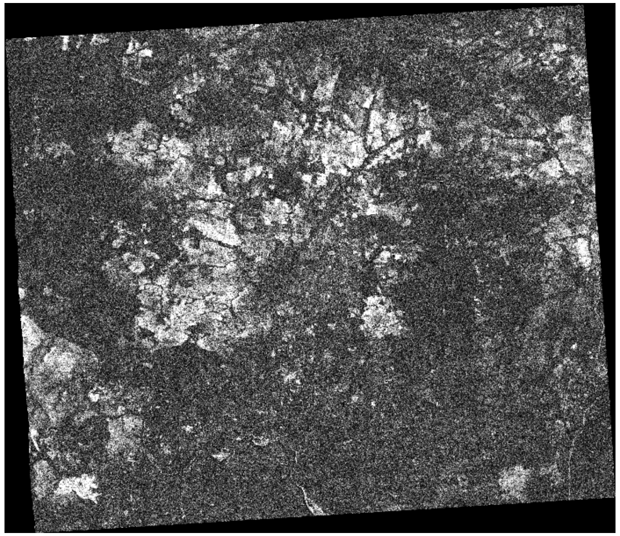
Outline – Scientific Questions

- Test Sites, Data Pool, and Coherence Computation
- What can be expected from summer coherence images (regarding forestry related applications)?
- Does the HV coherence contain additional information (regarding HH coherence)?
- Is the computation of coherence based on FBS (winter) and FBD (summer) images feasible and useful?
- How distinct is the correlation between coherence/backscatter and forest stem volume?

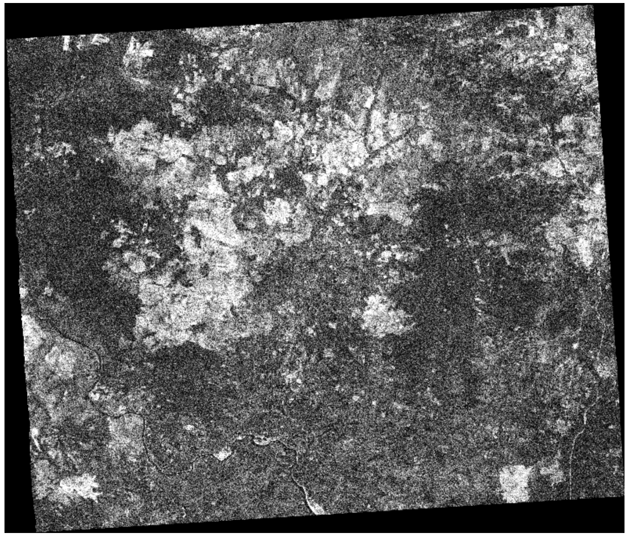
- **FBS (winter) FBD (summer) coherence**

  - After resampling of FBD image to FBS pixel spacing coherence computation was applied as described above

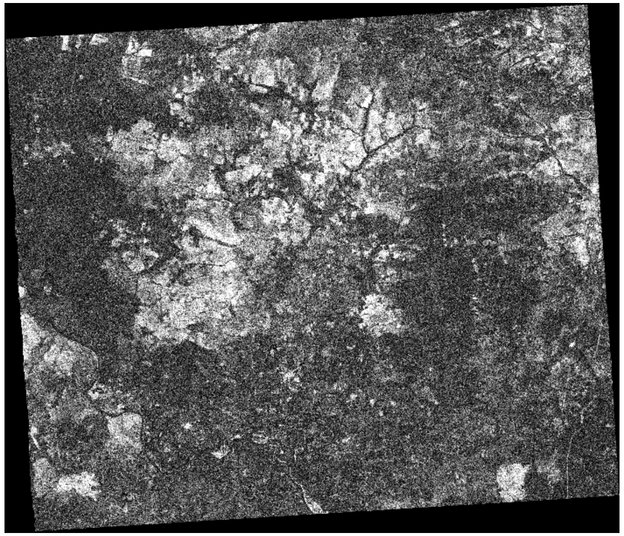
- **FBS (winter) FBD (summer) coherence (Chunsky N)**



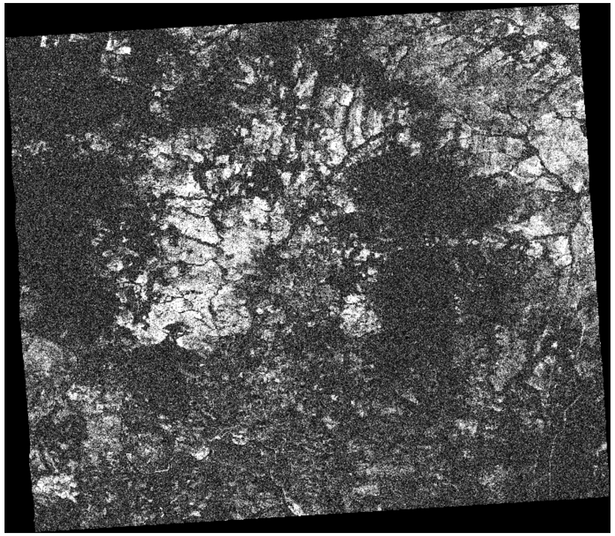
05nov07 X 20jun07



05nov07 X 05aug07

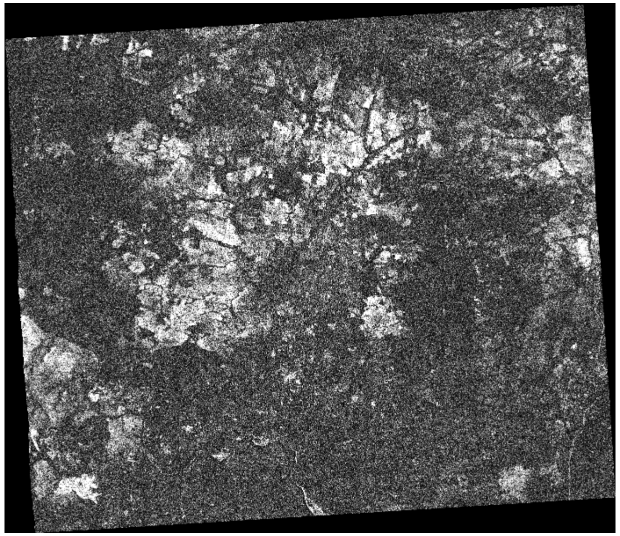


05nov07 X 20sep07

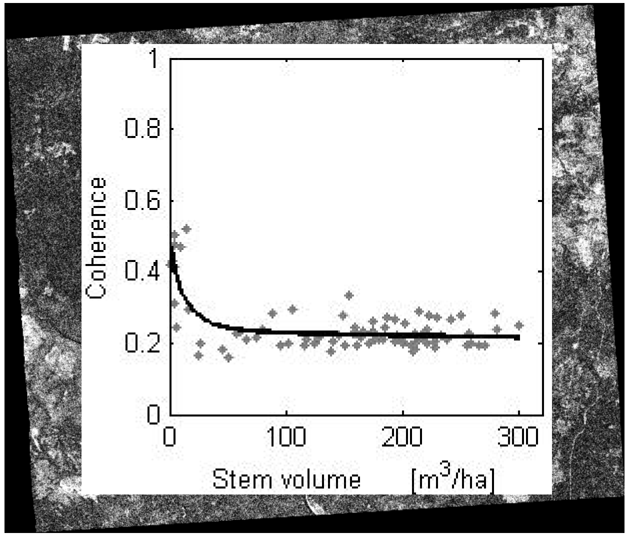


05nov07 X 07may08

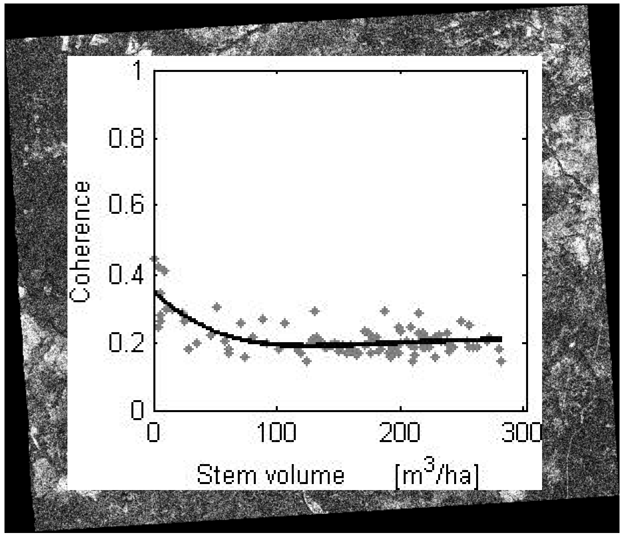
- **FBS (winter) FBD (summer) coherence (Chunsky N)**



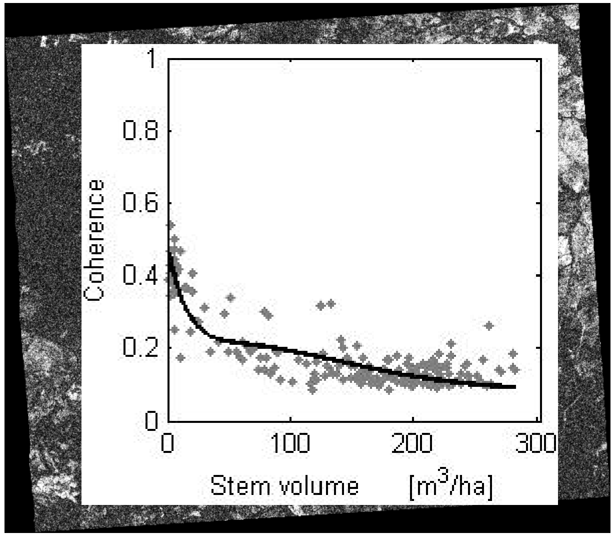
05nov07 X 20jun07



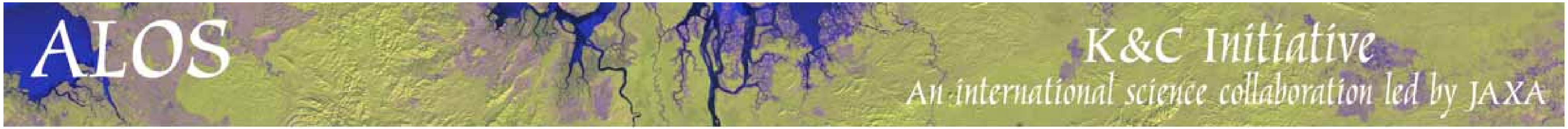
05nov07 X 05aug07



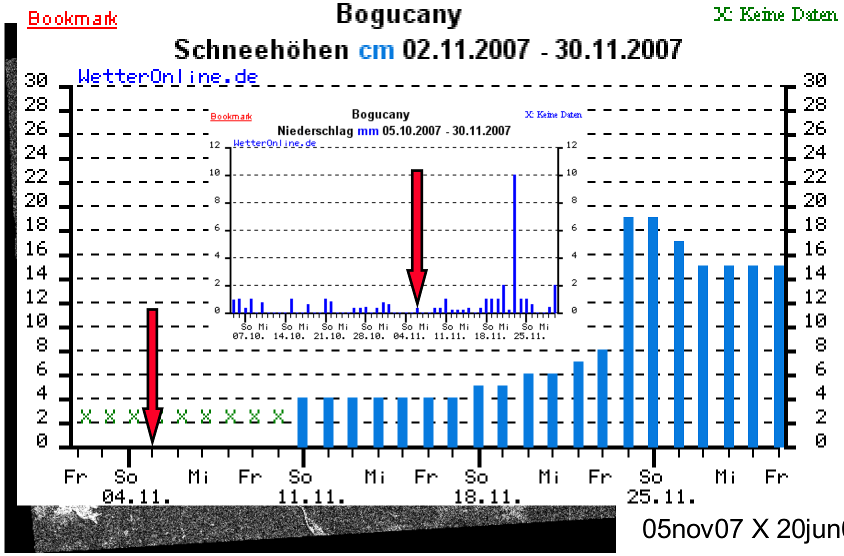
05nov07 X 20sep07



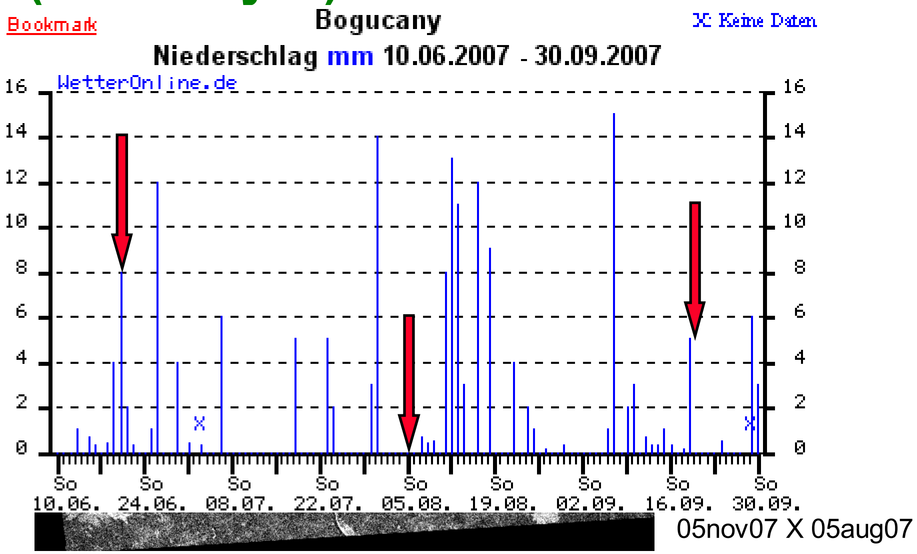
05nov07 X 07may08



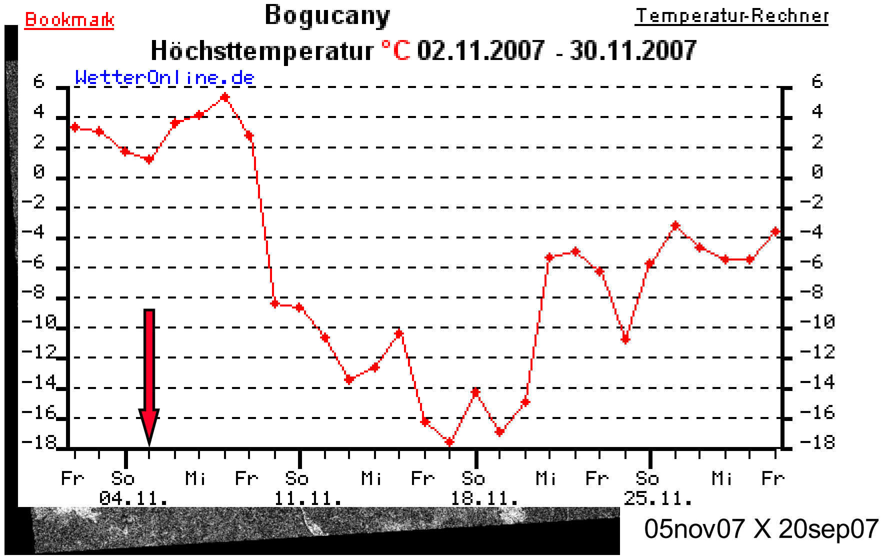
• FBS (winter) FBD (summer) coherence (Chunsky N)



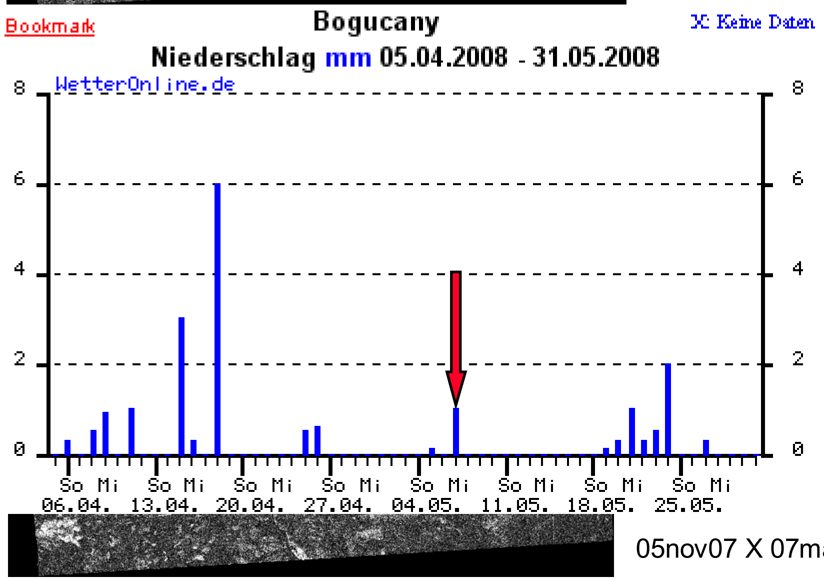
05nov07 X 20jun07



05nov07 X 05aug07

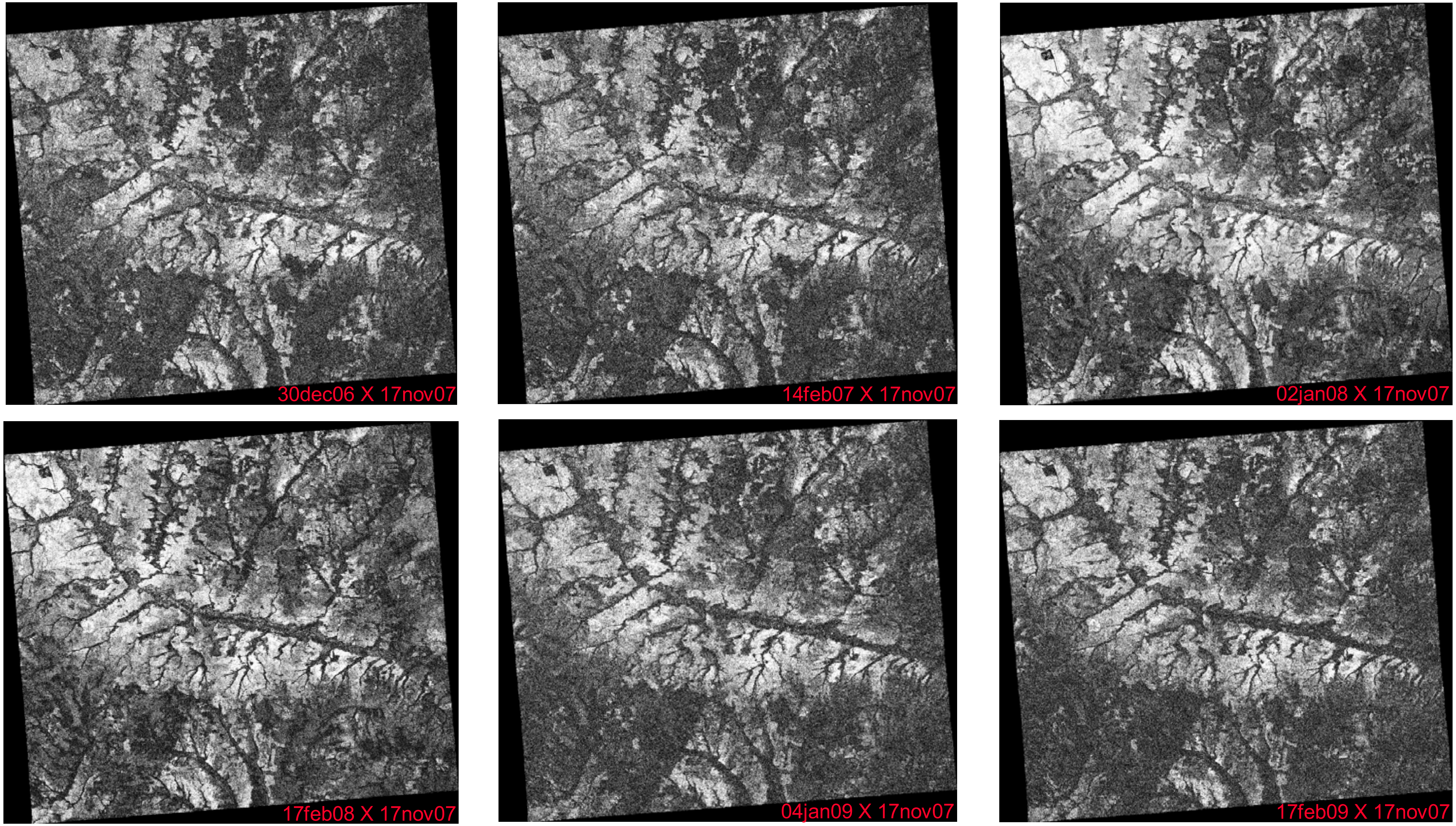


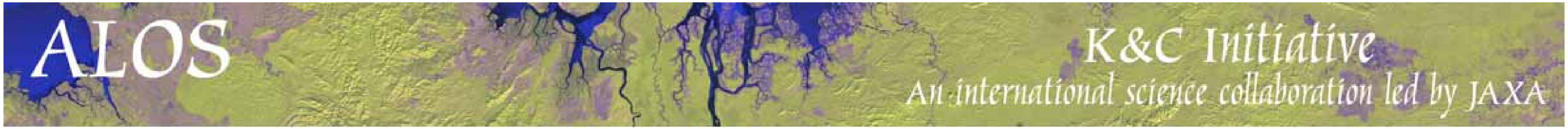
05nov07 X 20sep07



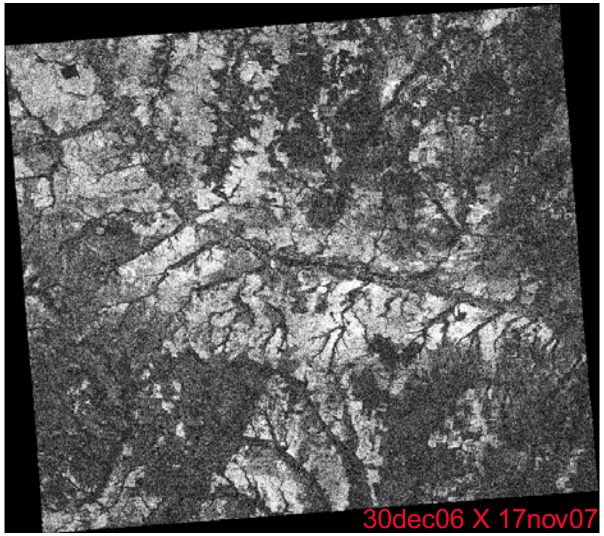
05nov07 X 07may08

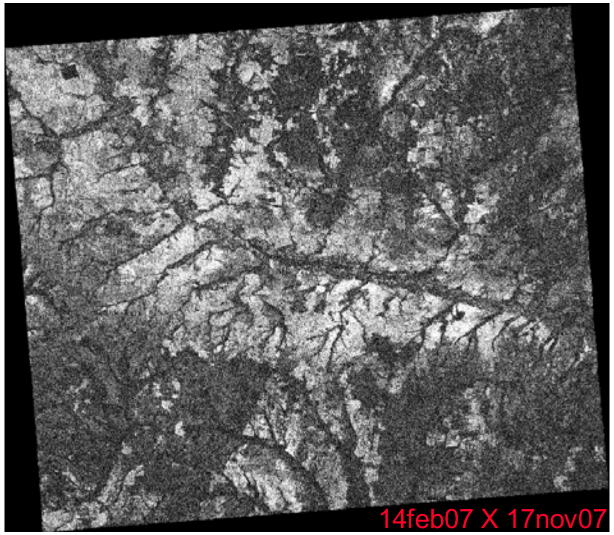
- **FBS (winter) FBD (early winter) coherence (Chunsky E)**

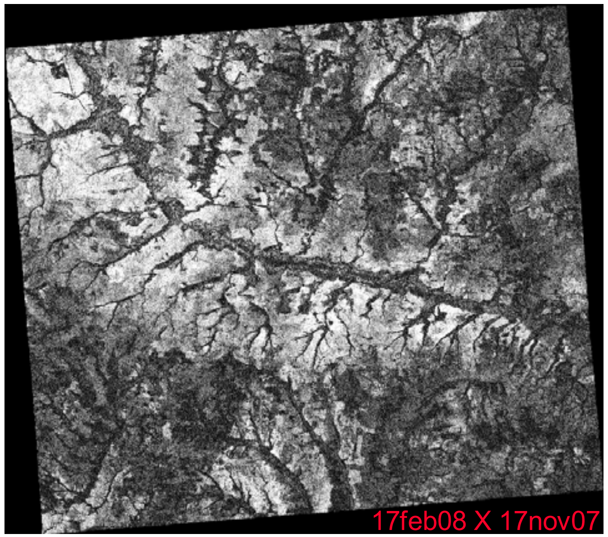


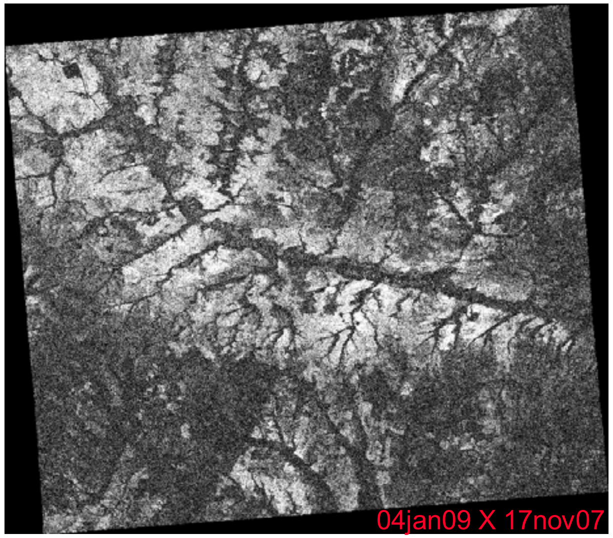


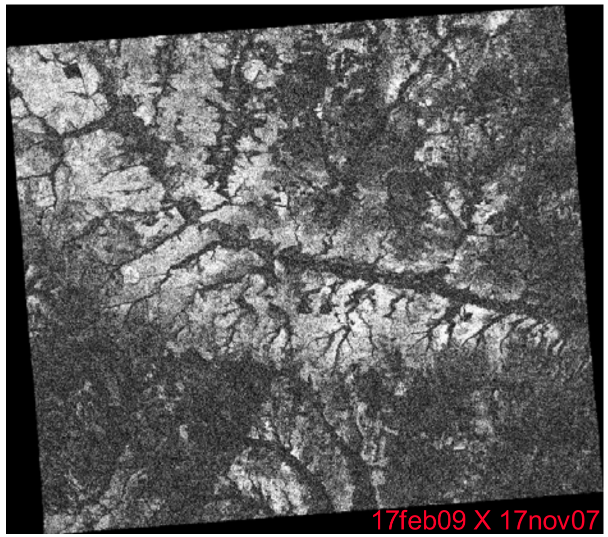
- **FBS (winter) FBD (early winter) coherence (Chunsky E)**



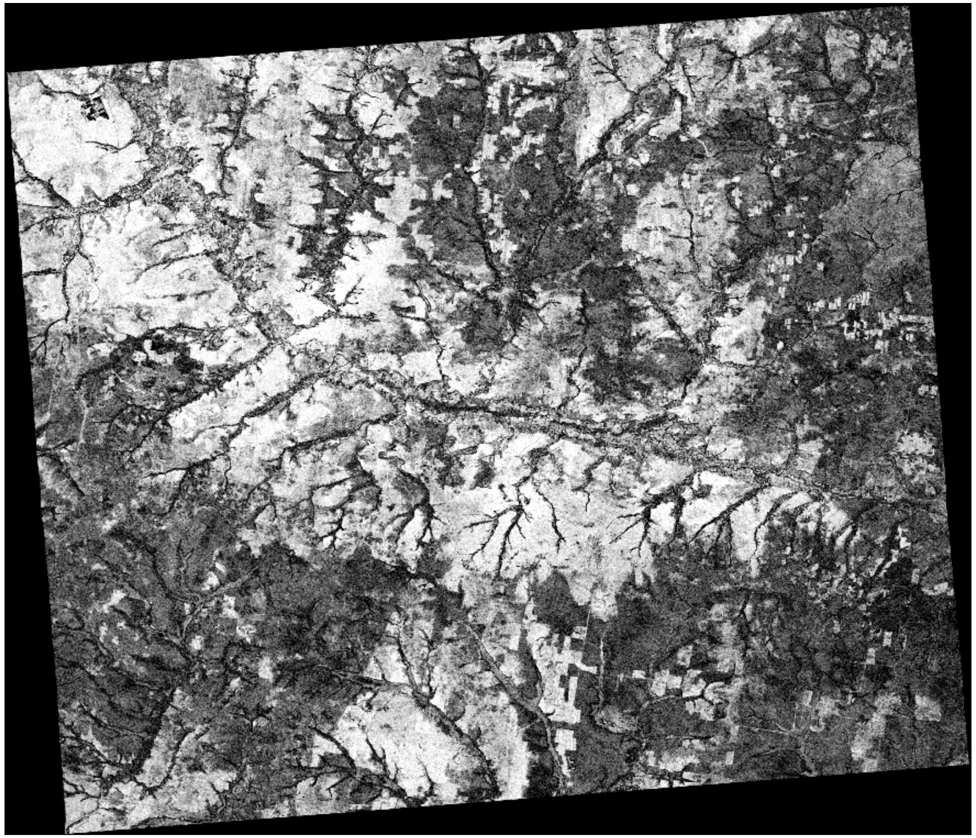




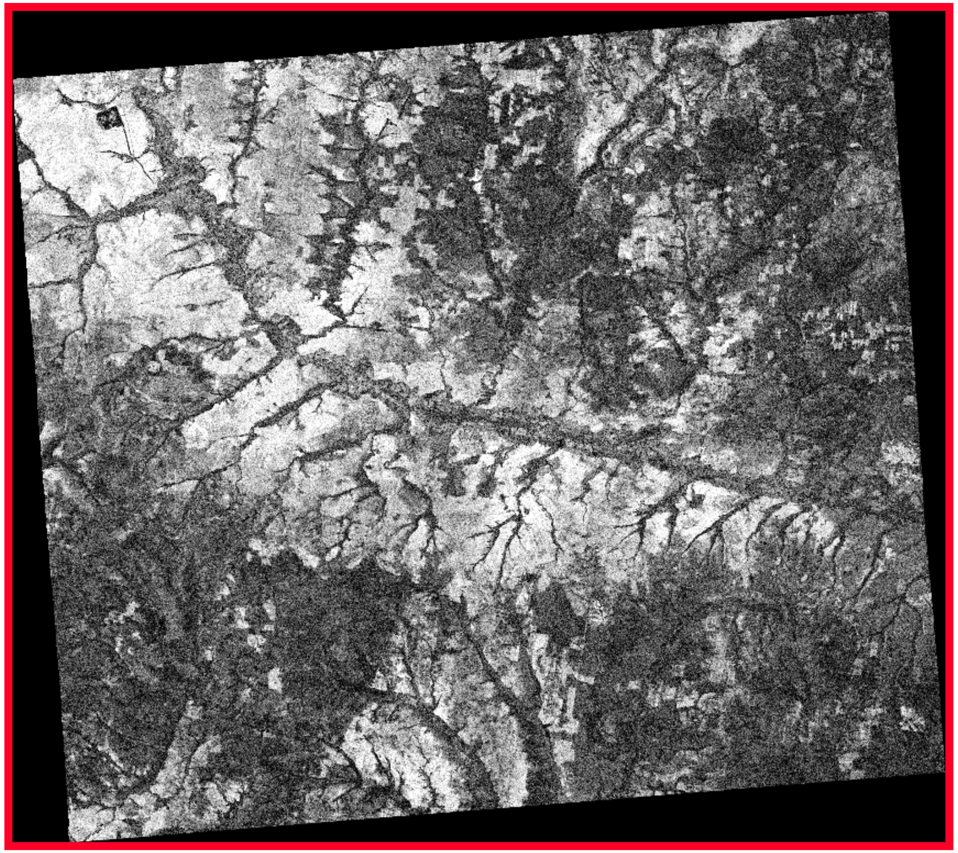




- **FBS (winter) FBD (early winter) coherence (Chunsky E)**

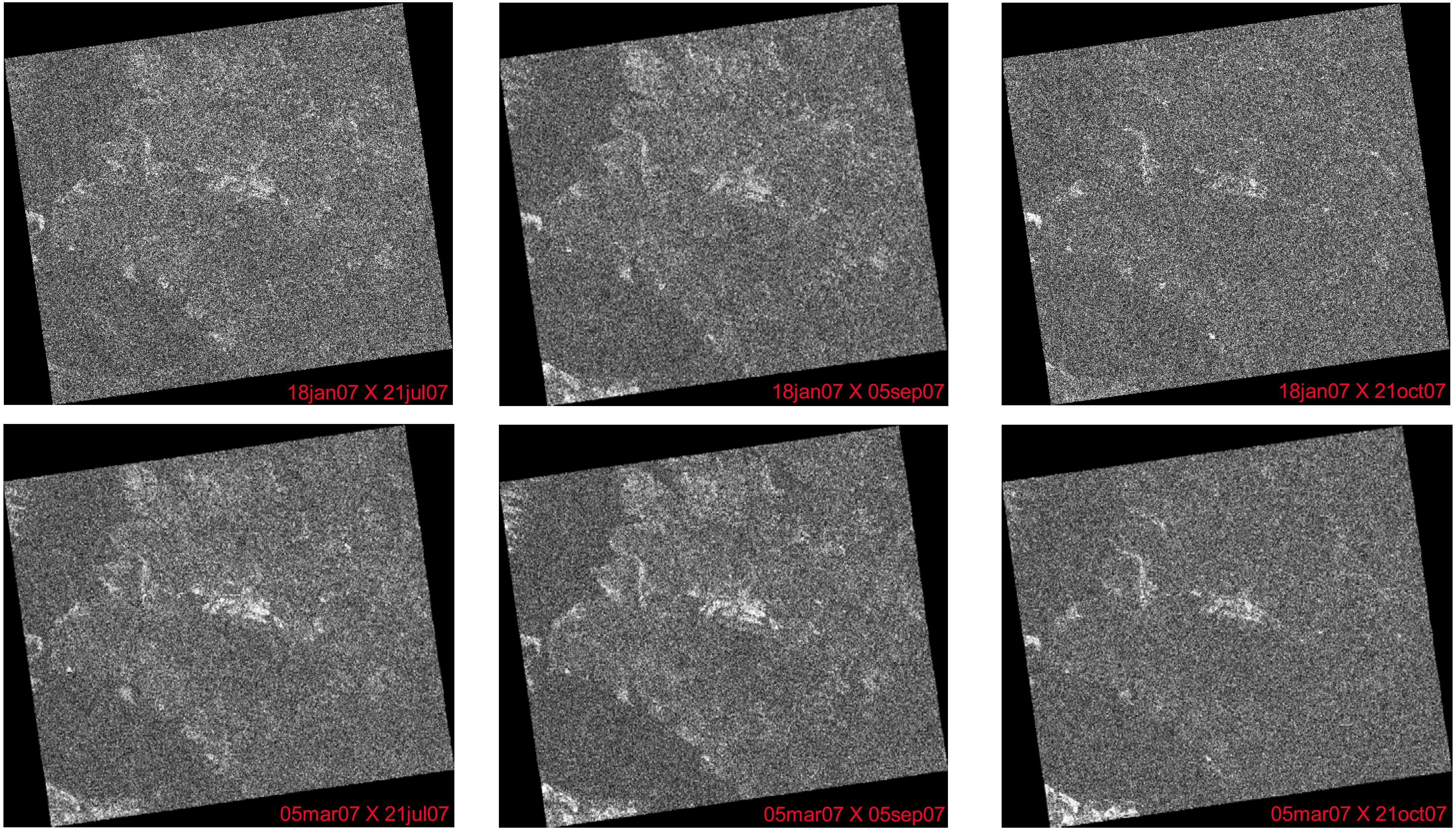


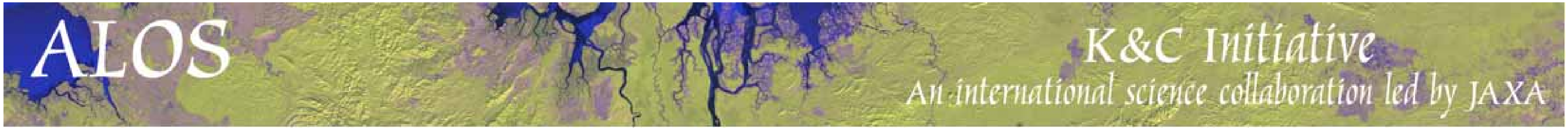
FBS Coherence HH (02jan08 X 17feb08)



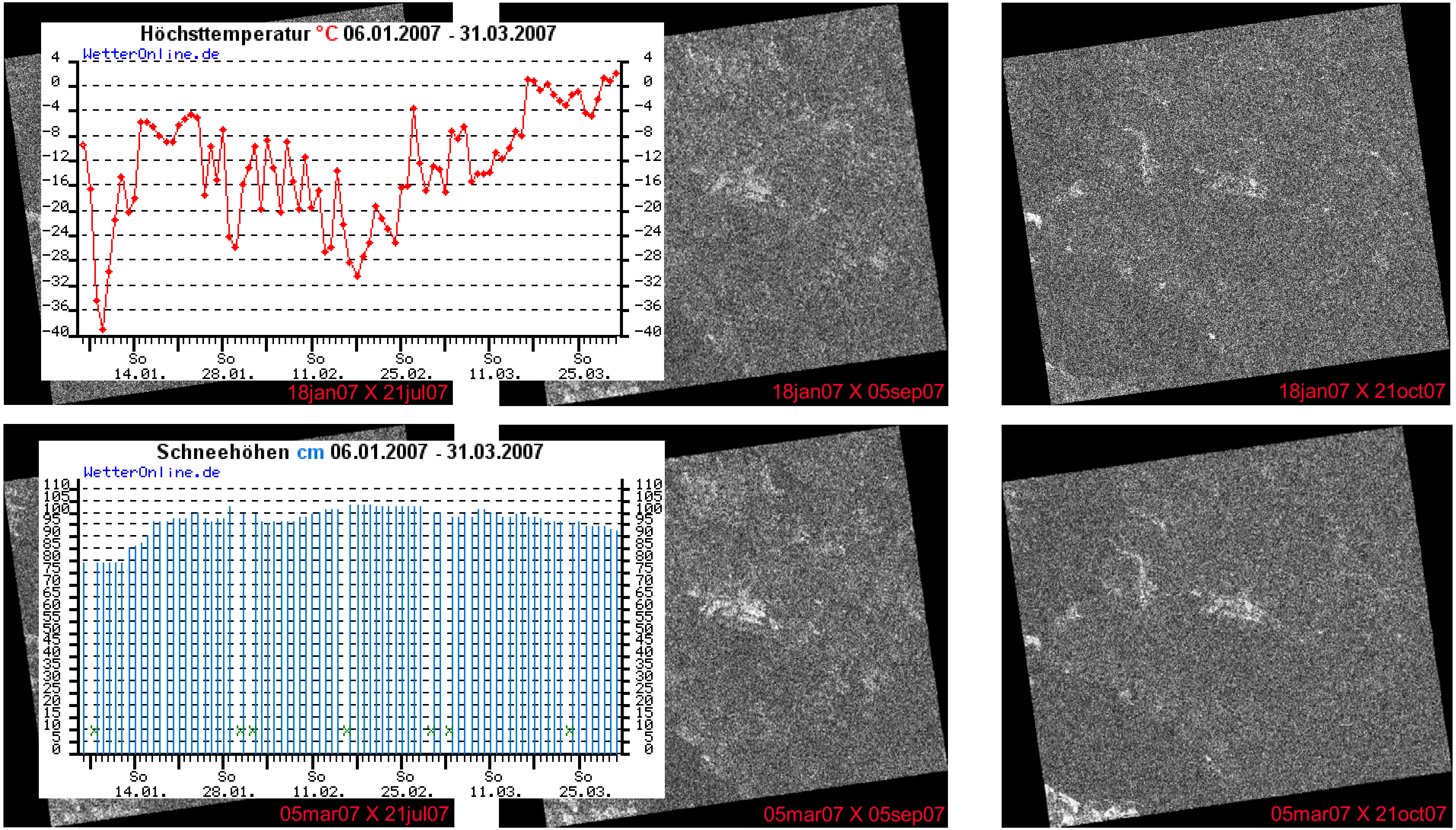
FBS/FBD Coherence HH (02jan08 X 17nov07)

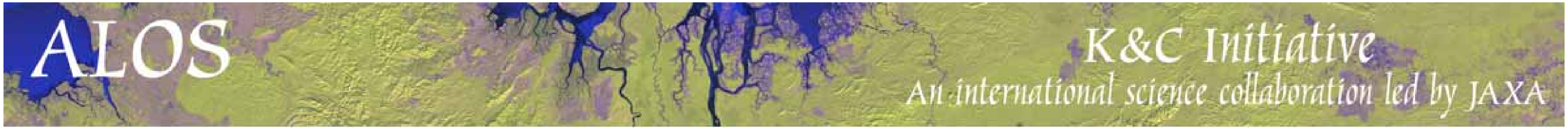
- **FBS (winter) FBD (summer) coherence (Primorsky)**



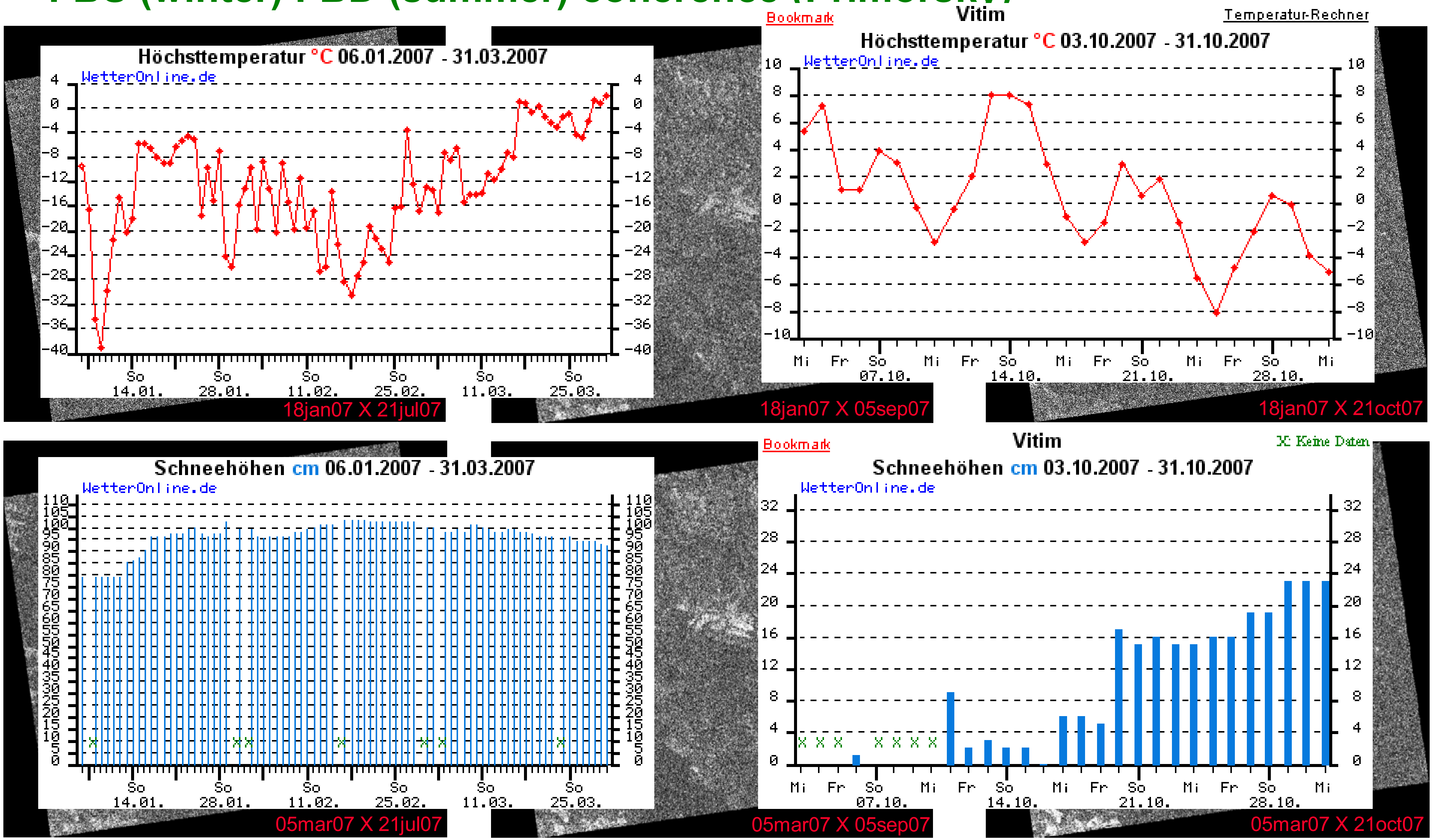


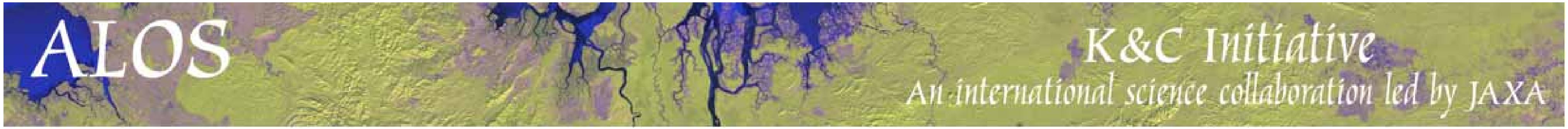
- **FBS (winter) FBD (summer) coherence (Primorsky)**



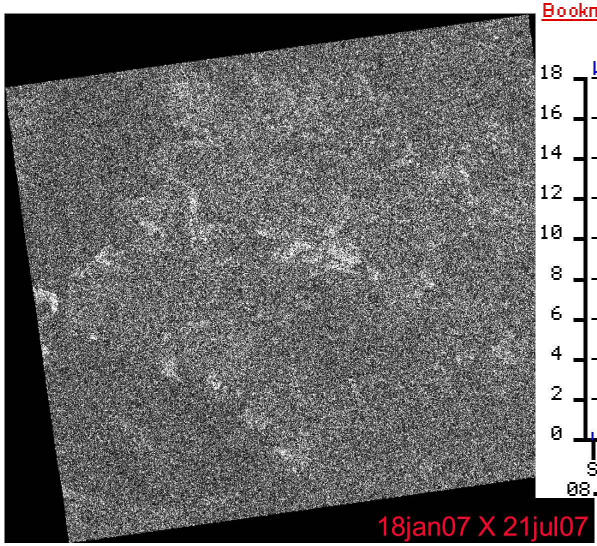


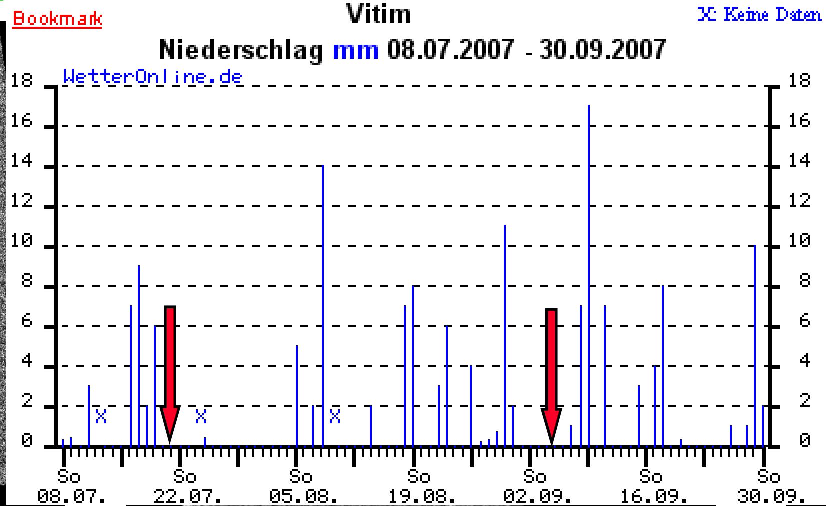
- **FBS (winter) FBD (summer) coherence (Primorsky)**



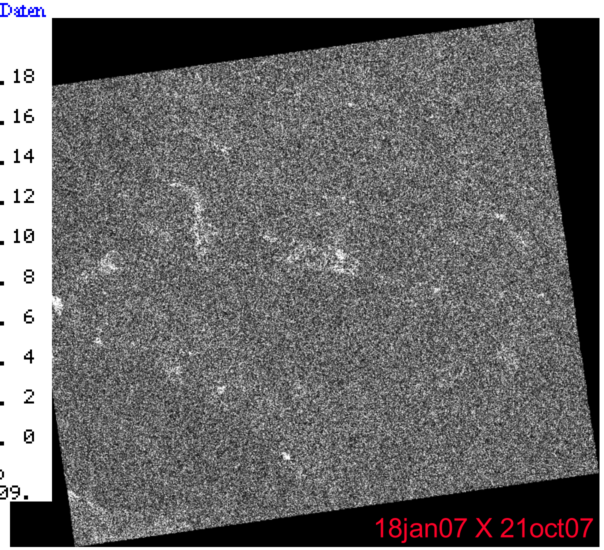


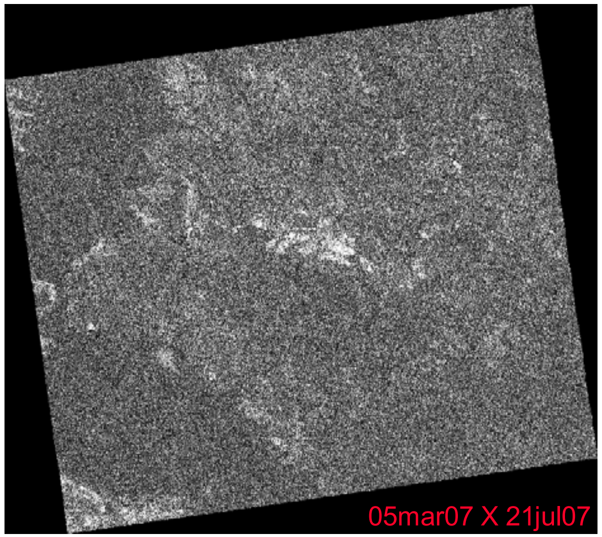
- **FBS (winter) FBD (summer) coherence (Primorsky)**

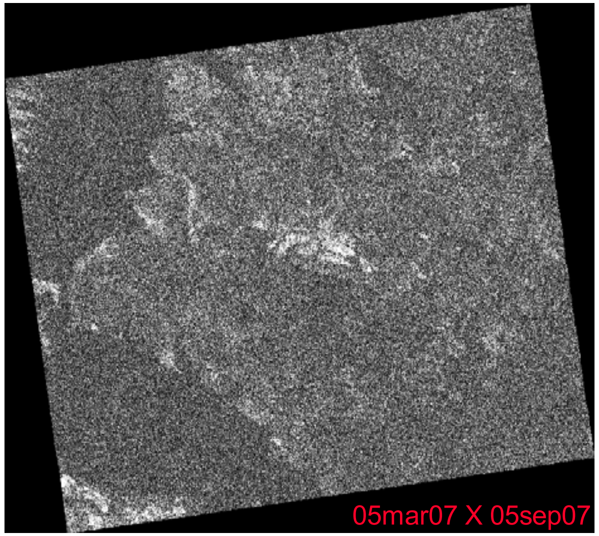

18jan07 X 21jul07

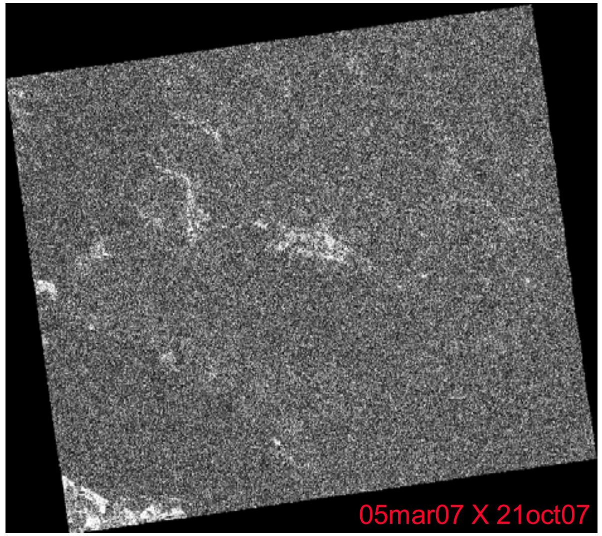



18jan07 X 05sep07


18jan07 X 21oct07


05mar07 X 21jul07


05mar07 X 05sep07


05mar07 X 21oct07

- **FBS (winter) FBD (summer) coherence – Preliminary Conclusions**

  - FBS-FBD coherence estimation technically possible
  - If both acquisitions are conducted at the same season (e.g. winter), FBS-FBD coherence is comparable to FBS-FBS coherence (except resolution)
  - If both images are not acquired at the same season (common case due to acquisition plan), overall coherence is very low. Forest covered areas are completely decorrelated – some remaining coherence appears only at forest free patches

Outline – Scientific Questions

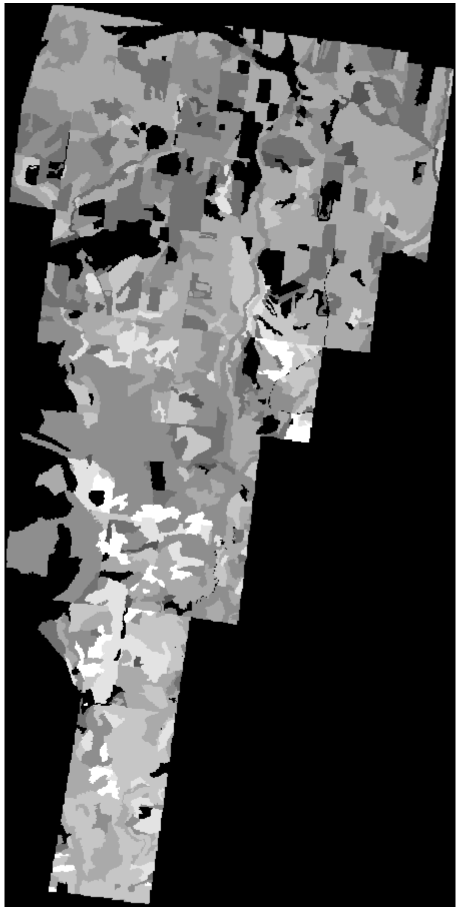
- Test Sites, Data Pool, and Coherence Computation
- What can be expected from summer coherence images (regarding forestry related applications)?
- Does the HV coherence contain additional information (regarding HH coherence)?
- Is the computation of coherence based on FBS (winter) and FBD (summer) images feasible and useful?
- How distinct is the correlation between coherence/backscatter and forest stem volume?

- **Correlation between coherence/backscatter and forest stem volume**

Chunsky North – Ground data

Stand ID

Stem Volume

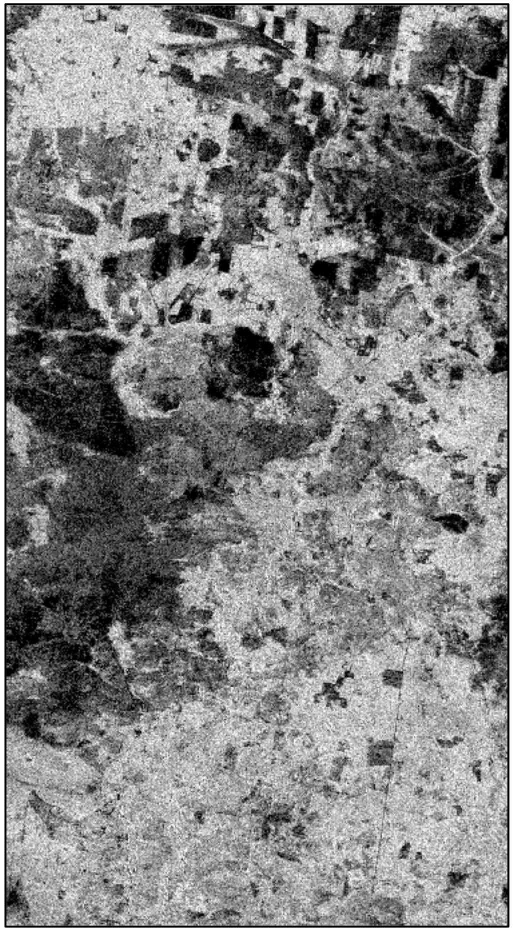


Rel. Stocking

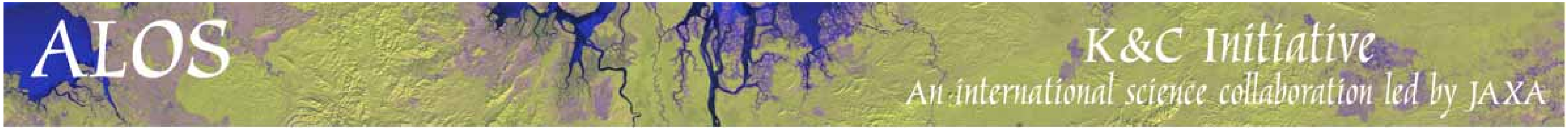
- **Correlation between coherence/backscatter and forest stem volume**

Chunsky North – SAR data

Coherence (05feb2008-22mar2008)



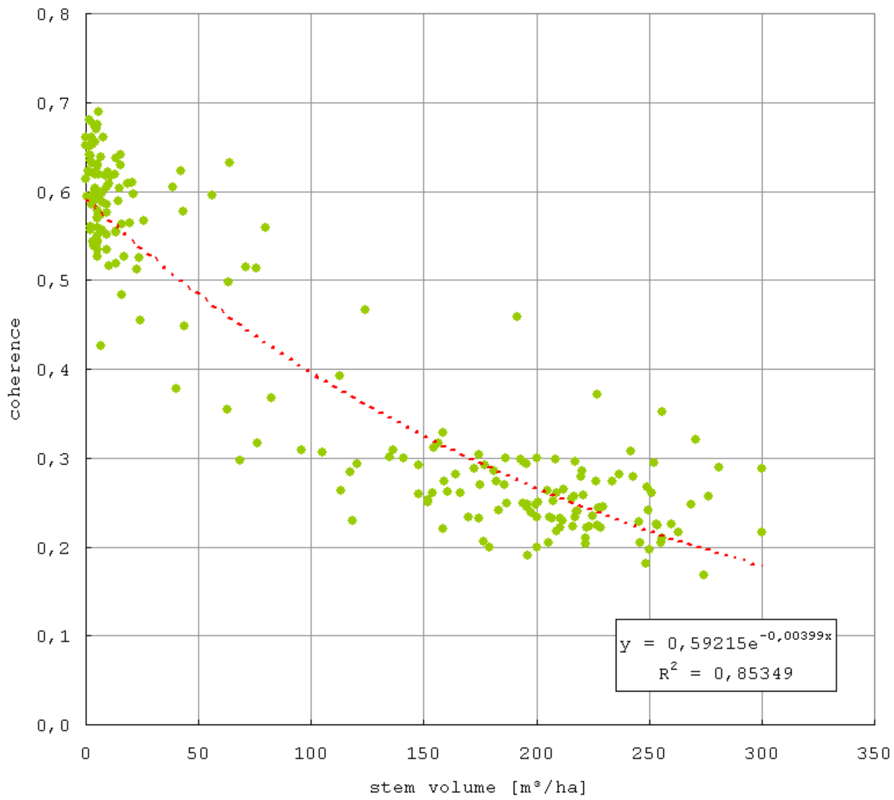
Backscatter (HV) (05aug2007)



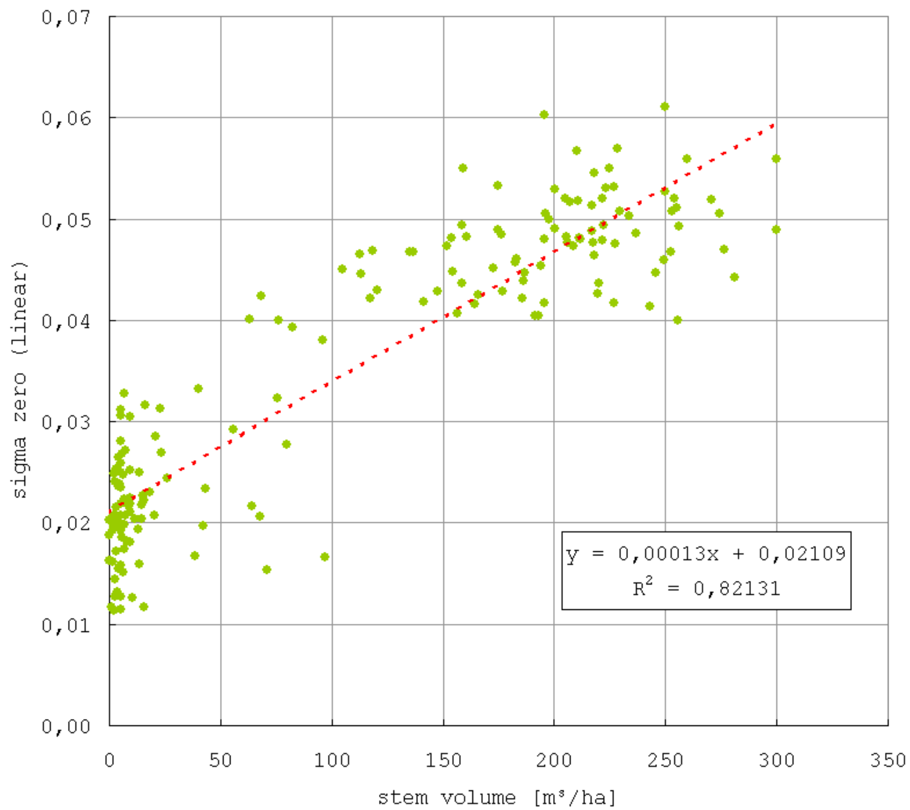
- **Correlation between coherence/backscatter and forest stem volume**

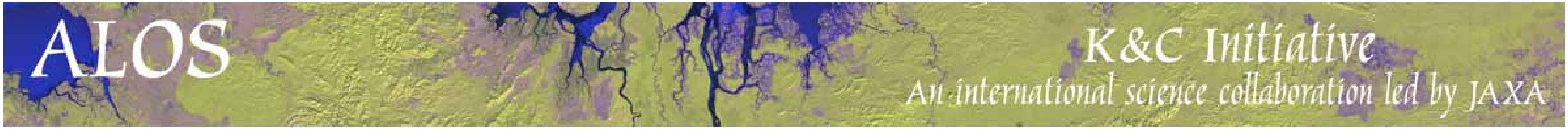
Chunsky North – Regression Analysis

Stem volume vs. Coherence (05feb2008-22mar2008)



Stem volume vs. backscatter (HV) (05aug2007)

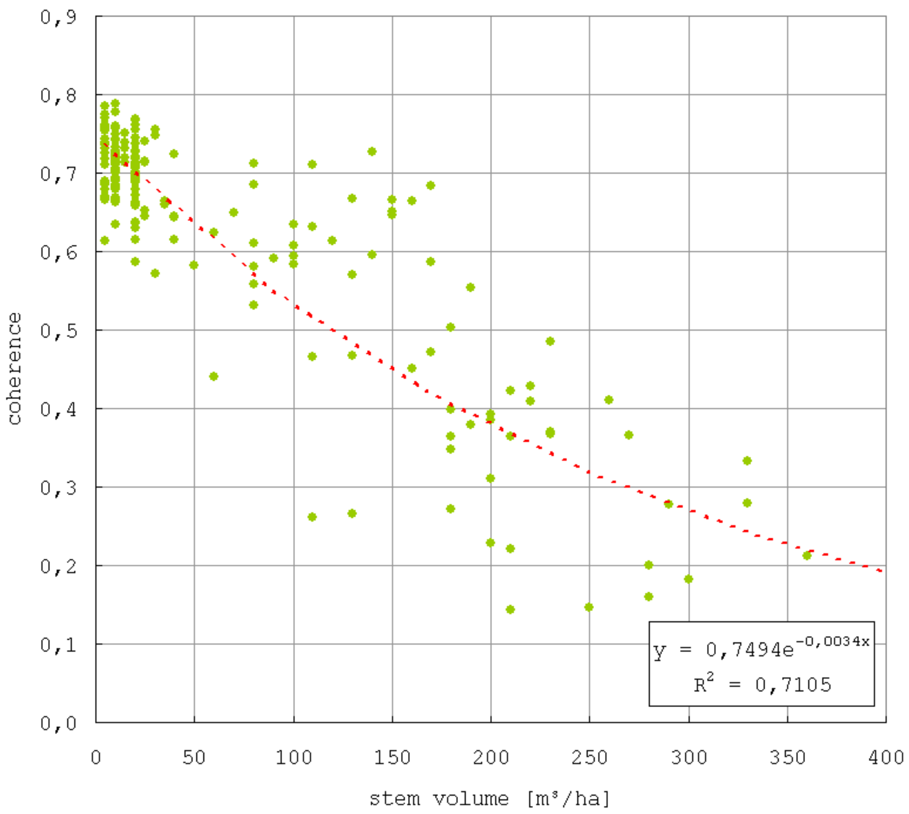




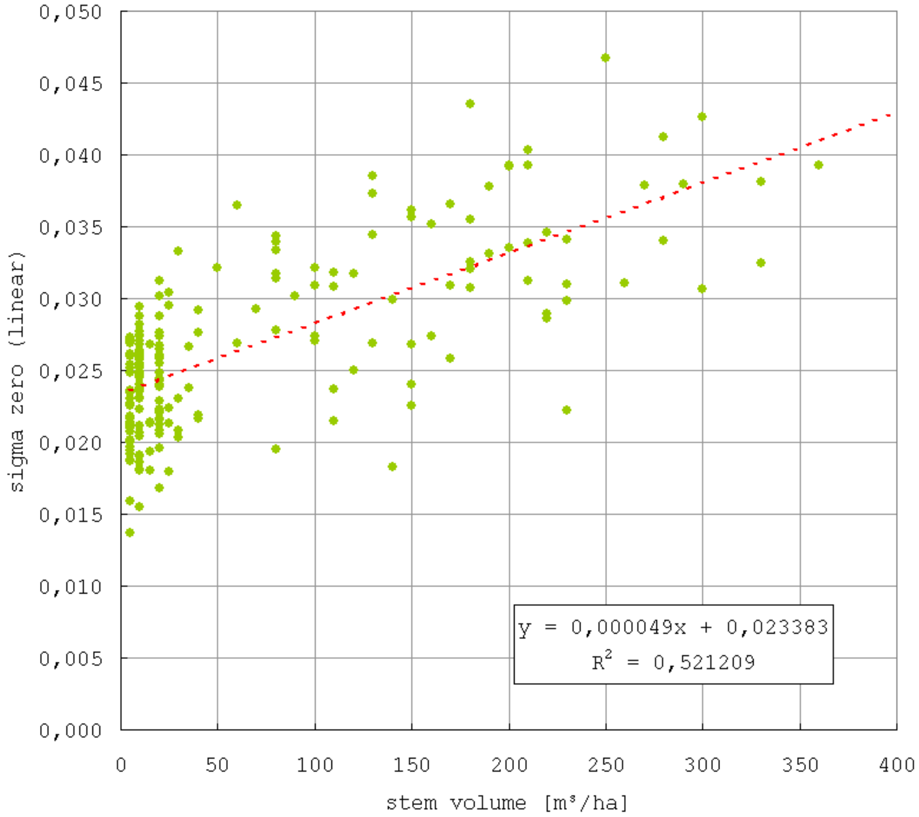
- **Correlation between coherence/backscatter and forest stem volume**

Chunsky East – Regression Analysis

Stem volume vs. Coherence (02jan2008-17feb2008)



Stem volume vs. backscatter (HV) (07jul2008)



- **Correlation between coherence/backscatter and forest stem volume – Preliminary Conclusions**

  - Significant correlation between coherence/backscatter and forest stem volume
  - Correlation between coherence and forest stem volume is highest in midwinter
  - Correlation between backscatter and forest stem volume is highest in midsummer
  - More sites and dates will be investigated
  - Improvement by means of multitemporal data assimilation will be investigated
  - Implementation of Interferometric Water Cloud Model is aspired – first results are promising

- **Overall Conclusions**

  - ALOS PALSAR data have high potential for forest stem volume estimation in Siberia
  - Midwinter FBS coherence provides the most powerful measure
  - Summer FBD coherence can provide additional information (e.g. for forest cover mapping), however, temporal baseline must be enlarged to increase temporal decorrelation; → This approach is very susceptible to variable environmental conditions
  - Computation of coherence based on FBS (winter) and FBD (summer) images is technically feasible but not very useful; it might be used to support forest cover mapping

- Thank you