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The EuroSDR network on Digital Camera Calibration and Validation

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110th EuroSDR Meetings

Rotterdam, May 23-25, 2007

Experimental Phase 2b data

#	Altitude [m]	GSD [m]	# strips long/cross	% overlap long/cross	# Images	Additional data
ADS Vaihingen/Enz, June 26, 2004						
low	1500	0.18	4 / 2	100 / 44	36	GPS/INS
high	2500	0.26	3 / 3	100 / 70	36	GPS/INS
DMC Fredrikstad, October 10, 2003						
low	**950**	**0.10**	**5**	**60 / 30**	**115**	**(GPS(/INS))**
high	**1800**	**0.18**	**3**	**60 / 30**	**34**	**(GPS(/INS))**
UltracamD Fredrikstad, September 16, 2004						
low	**1900**	**0.17**	**4 / 1**	**80 / 60**	**131**	**GPS(/INS)**
high	**3800**	**0.34**	**2**	**80 / 60**	**28**	**GPS(/INS)**

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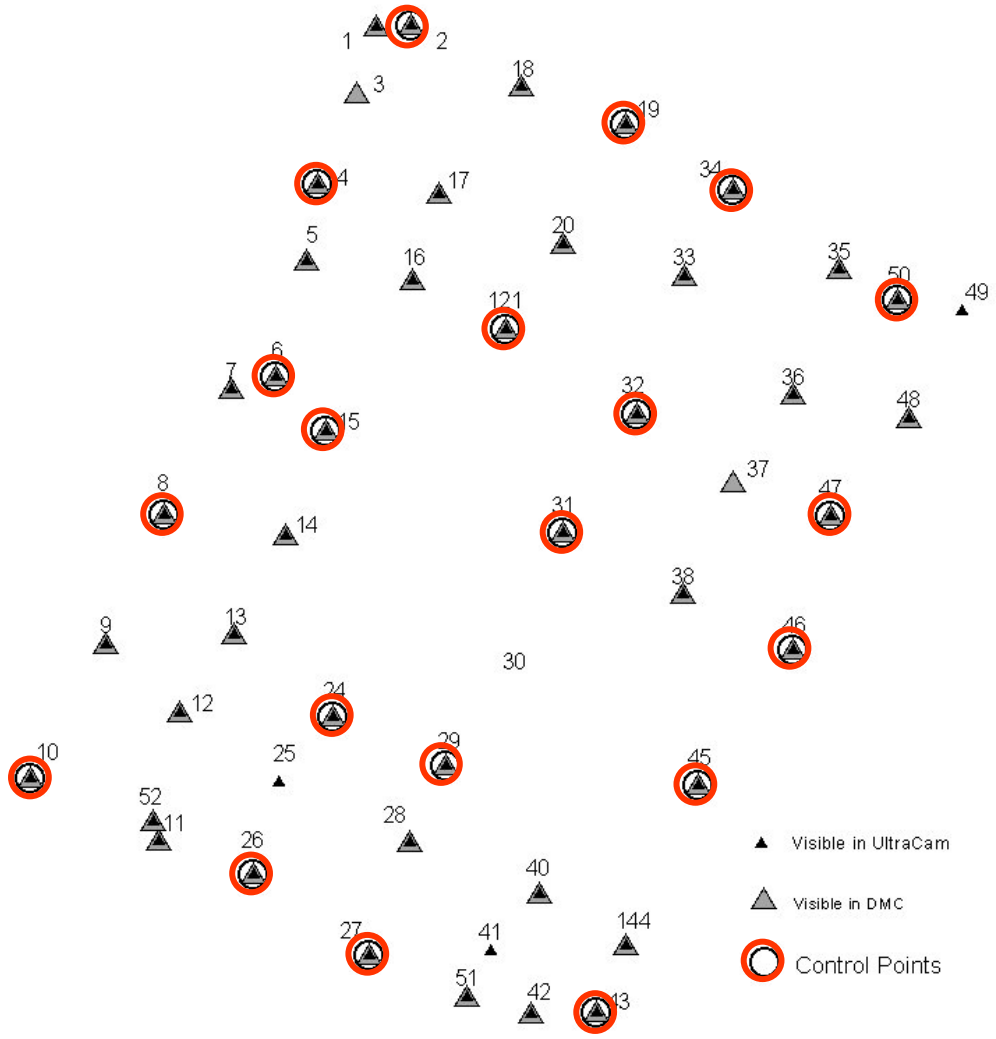
The Fredrikstad test range

DMC and UCD flights



object points

~ 20 control points

~ 25 check points

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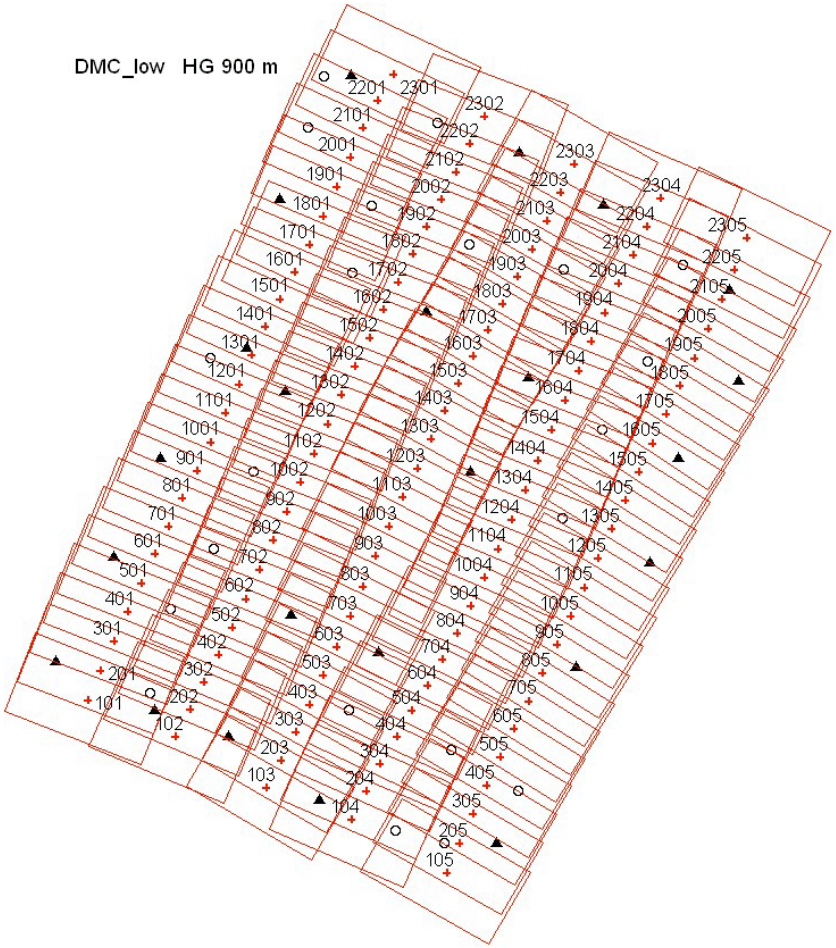
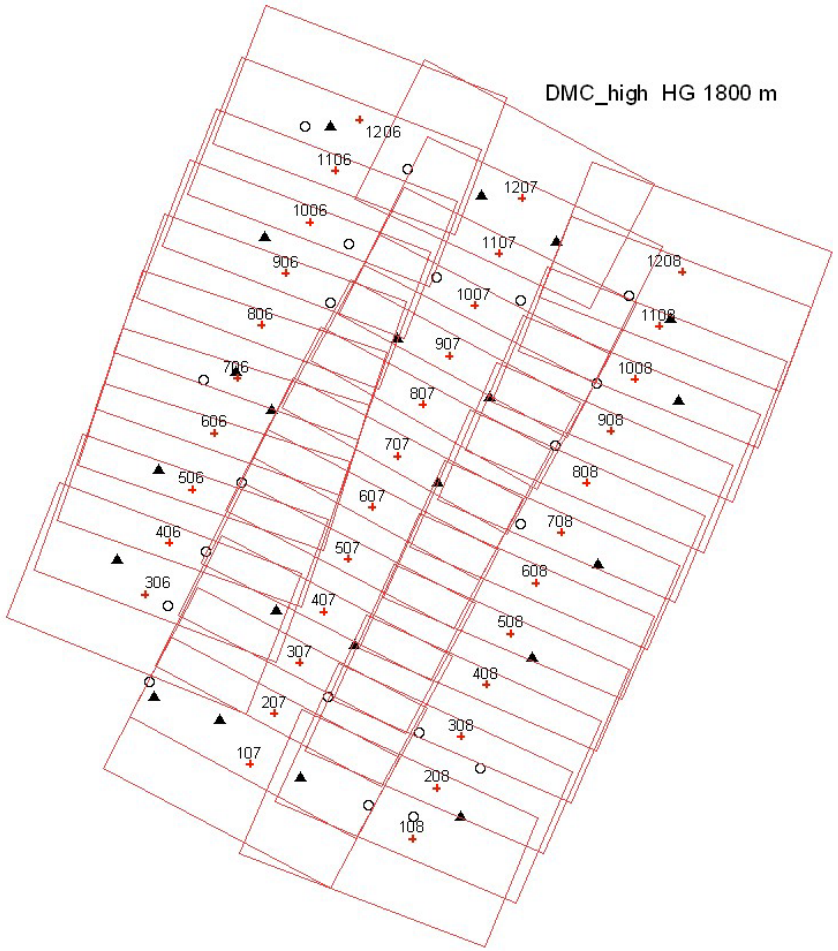
DMC image block geometry





Low (GSD 10cm, h=950m)

High (GSD 18cm, h=1800m)

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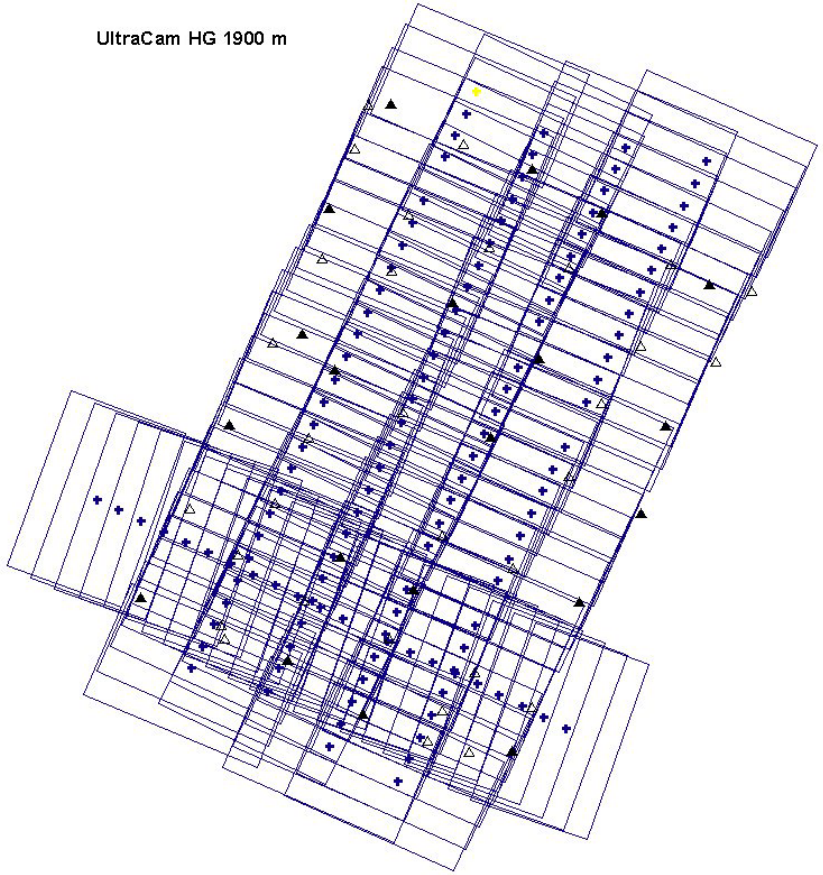
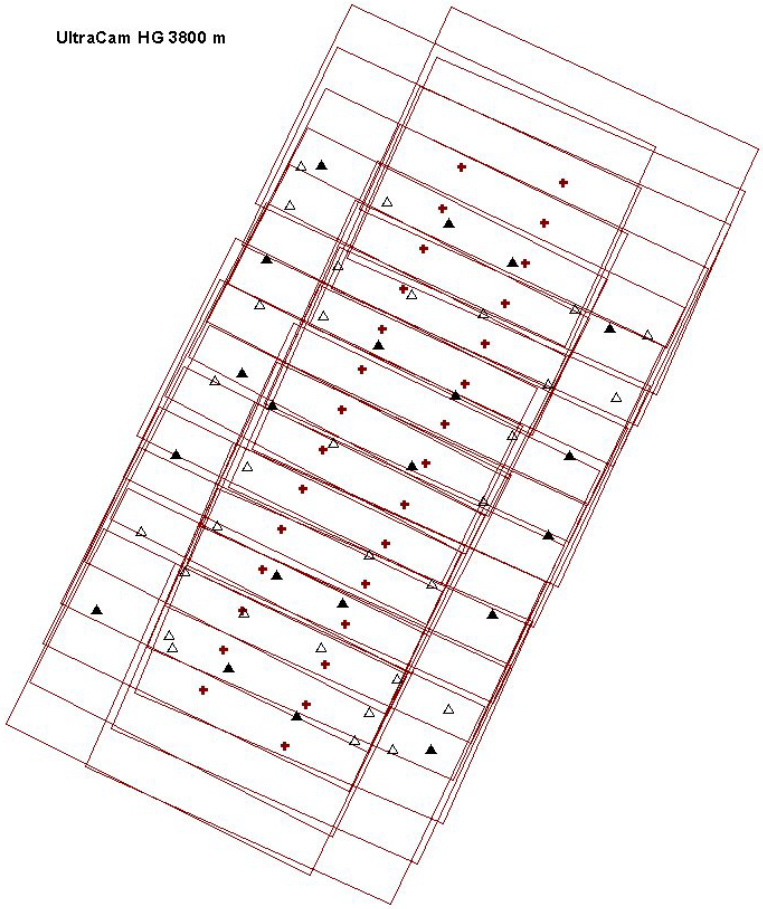
UCD image block geometry





Low (GSD 17cm, h=1900m)

High (GSD 34cm, h=3800m)

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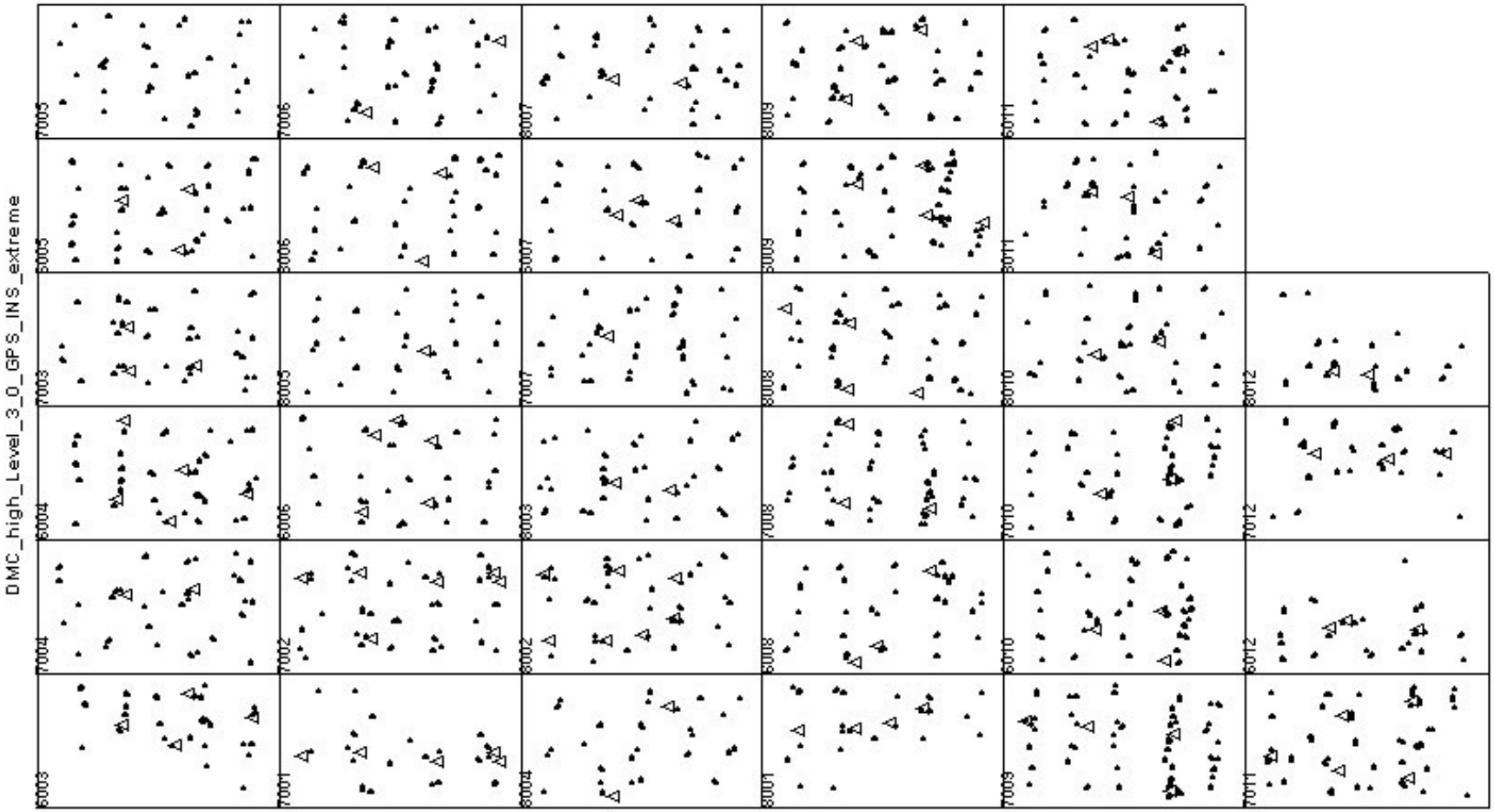
Image coordinates by Pilot Centre



Example DMC high measured points / image

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Phase 2 / 2 b

Active Participants

#	Code	Institutions
1	**ICC**	**Institute Cartographic Catalunya, Spain**
2	LM	Lantmatäriet, Gävle, Sweden
3	itacyl	ITACYL, Valladolid, Spain
4	inpho	inpho, Stuttgart, Germany
5	**CSIRO**	**CSIRO Information Sciences, Wembley, Australia**
6	DLR-B	DLR, Berlin, Germany
7	HfT	University of Applied Science, Stuttgart, Germany
8	**IPI**	**IPI, University of Hannover, Germany**
9	ETH, *ETH*	ETH Zürich, Switzerland
10	UoP	University of Pavia, Italy

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Phase 2 / 2 b
Active Participants

#	Code	Institutions
11	UoN	University of Nottingham, England
12	**Ingr.ZI**	**Intergraph ZI, Aalen, Germany**
13	*Vexcel*	*Vexcel, Graz, Austria*

normal	activities in phase 2
bold	activities in phase 2 and 2b
italic	activities in phase 2b

Phase 2b results data

- **DMC** phase 2b processings
  - **5 participants**
  - 21 versions for high, 20 versions for low flight
  - 5 versions for both flights
- **UCD** phase 2b processings
  - **4 participants**
  - 15 versions for low, 14 versions for high flight
  - 5 versions for both flights
- overall **80 different variants** evaluated in phase 2b

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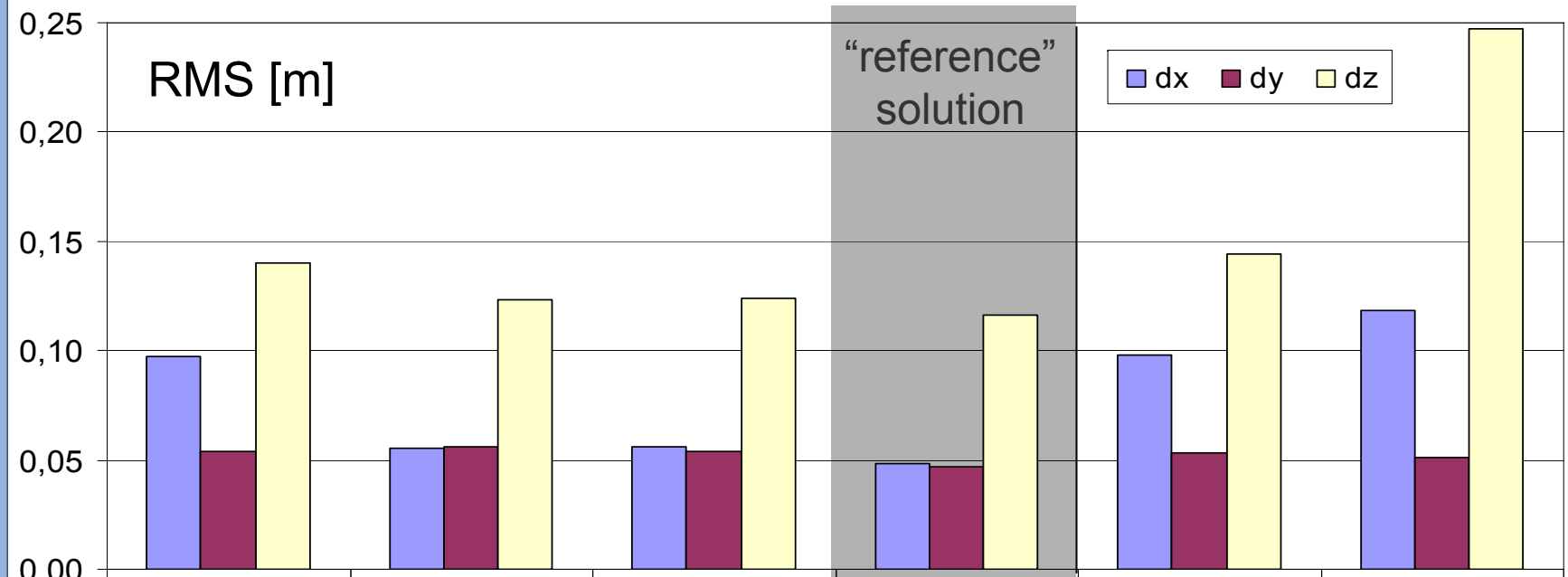
Phase 2b – DMC high, GSD 18cm

ifp solutions



	ifp no dgap	ifp p44 dgap	ifp p44 sign dgap	ifp p44 all cp dgap	ifp no patb	ifp no patb
STD [m] GCPs.	0.02	0.02	0.02	0.02	0.02	0.01
	0.02	0.02	0.02	0.02	0.02	0.01
STD [um] Image pts.	3	3	3	3	3	3,6
	3	3	3	3	3	1,2

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Phase 2b
ifp "reference" solutions

Flight	H [m]	GSD [m]	RMS		
			X [m]	Y [m]	Z [m]
DMC	950	0.10	0.040	0.048	0.132
DMC	1800	0.18	0.048	0.047	0.116
UCD	1900	0.17	0.076	0.060	0.059
UCD	3800	0.34	0.048	0.068	0.103

- RMS values from check point differences
- in all cases 44 significant Gruen parameters introduced, from all available ground points (GCPs and ChPs)
- Input std.dev. used for weighting:
  - image points 3um
  - GCPs 2cm

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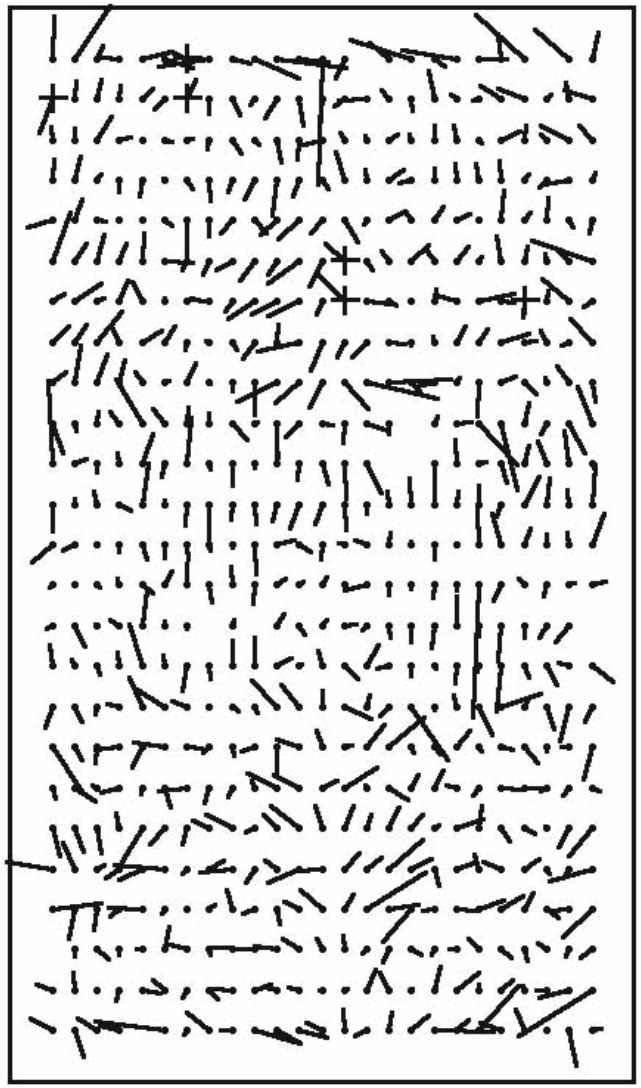
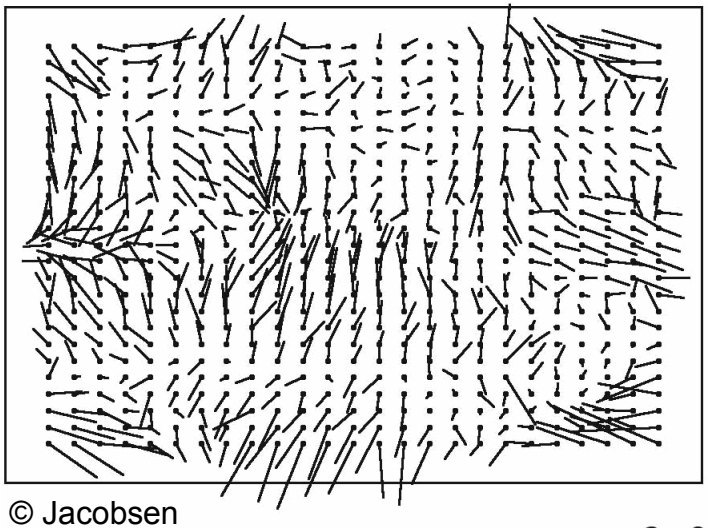
Image coordinate residuals
AT without add. params

DMC



© Jacobsen

3.0



© Jacobsen

UCD 3.0

Overlay of residuals from both flying heights (low & high)

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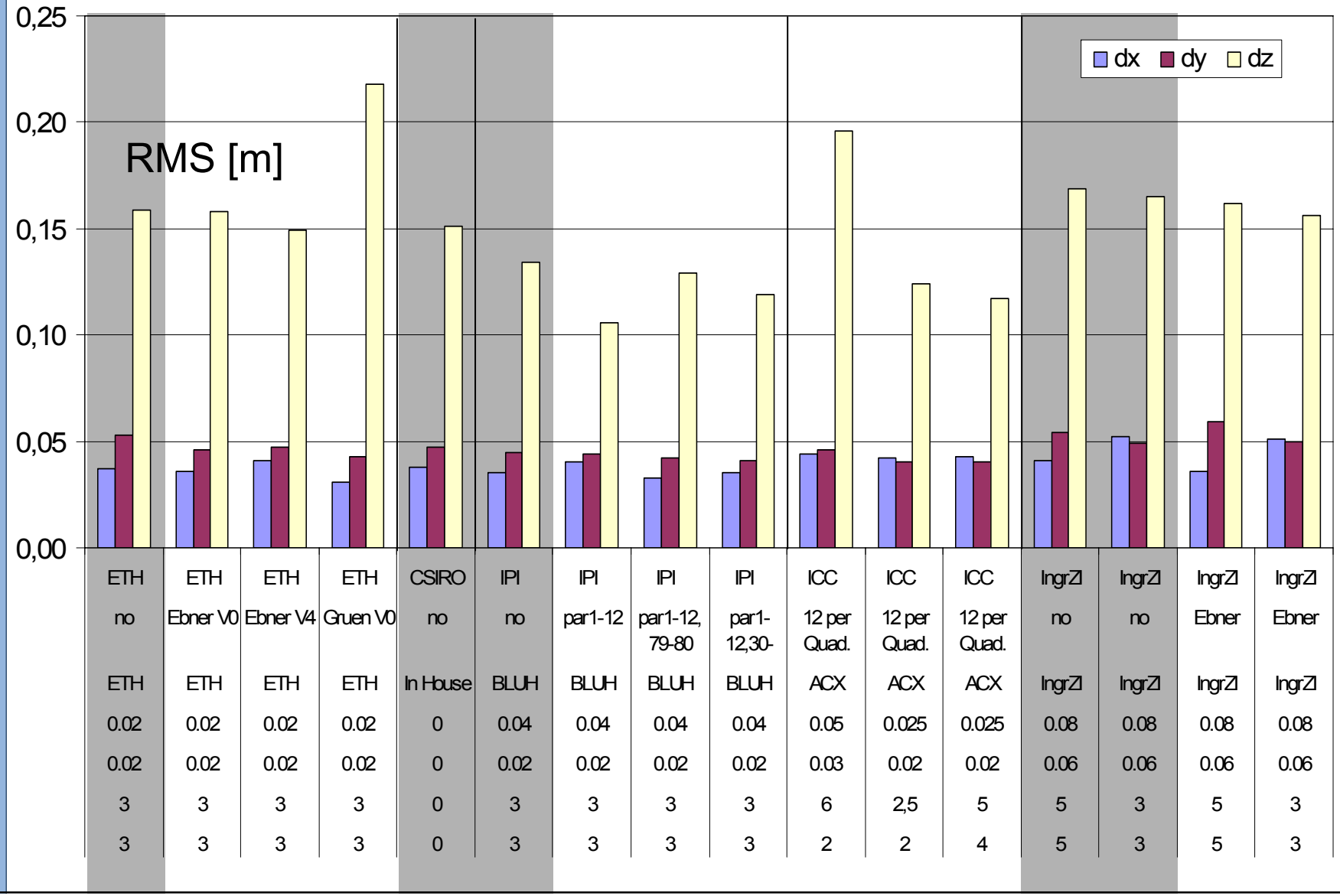
Phase 2b – DMC low

GSD 10cm, hg 950m

No SC



ETH	ETH	ETH	ETH	CSIRO	IPI	IPI	IPI	IPI	ICC	ICC	ICC	IngrZI	IngrZI	IngrZI	IngrZI
no	Ebner V0	Ebner V4	Gruen V0	no	no	par1-12	par1-12, 79-80	par1-12,30-	12 per Quad.	12 per Quad.	12 per Quad.	no	no	Ebner	Ebner
ETH	ETH	ETH	ETH	In House	BLUH	BLUH	BLUH	BLUH	ACX	ACX	ACX	IngrZI	IngrZI	IngrZI	IngrZI
0.02	0.02	0.02	0.02	0	0.04	0.04	0.04	0.04	0.05	0.025	0.025	0.08	0.08	0.08	0.08
0.02	0.02	0.02	0.02	0	0.02	0.02	0.02	0.02	0.03	0.02	0.02	0.06	0.06	0.06	0.06
3	3	3	3	0	3	3	3	3	6	2,5	5	5	3	5	3
3	3	3	3	0	3	3	3	3	2	2	4	5	3	5	3

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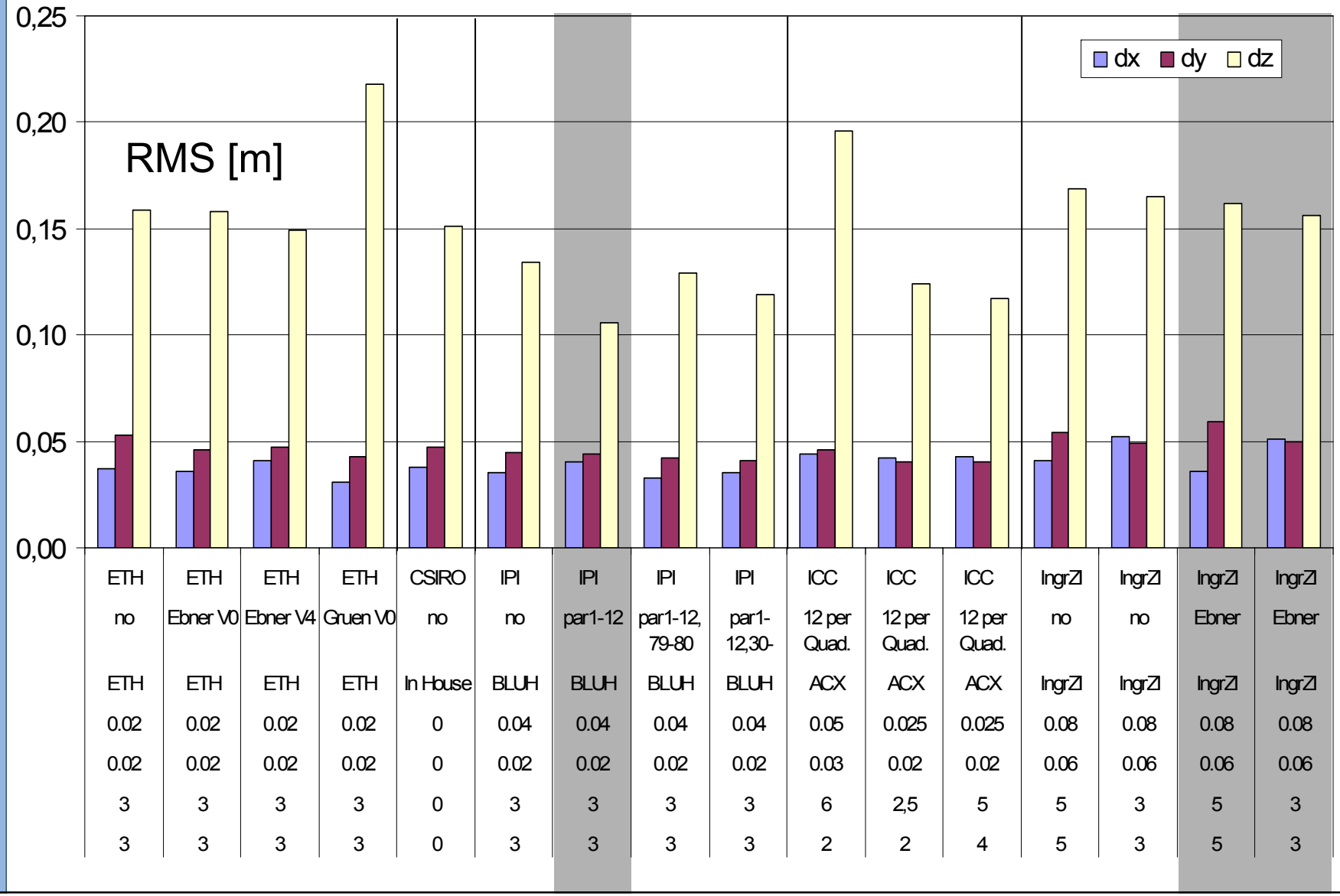
Phase 2b – DMC low

GSD 10cm, hg 950m

Standard params



	ETH	ETH	ETH	ETH	CSIRO	IPI	IPI	IPI	IPI	ICC	ICC	ICC	IngrZI	IngrZI	IngrZI	IngrZI
	no	Ebner V0	Ebner V4	Gruen V0	no	no	par1-12	par1-12, 79-80	par1-12,30-	12 per Quad.	12 per Quad.	12 per Quad.	no	no	Ebner	Ebner
	ETH	ETH	ETH	ETH	In House	BLUH	BLUH	BLUH	BLUH	ACX	ACX	ACX	IngrZI	IngrZI	IngrZI	IngrZI
	0.02	0.02	0.02	0.02	0	0.04	0.04	0.04	0.04	0.05	0.025	0.025	0.08	0.08	0.08	0.08
	0.02	0.02	0.02	0.02	0	0.02	0.02	0.02	0.02	0.03	0.02	0.02	0.06	0.06	0.06	0.06
	3	3	3	3	0	3	3	3	3	6	2,5	5	5	3	5	3
	3	3	3	3	0	3	3	3	3	2	2	4	5	3	5	3

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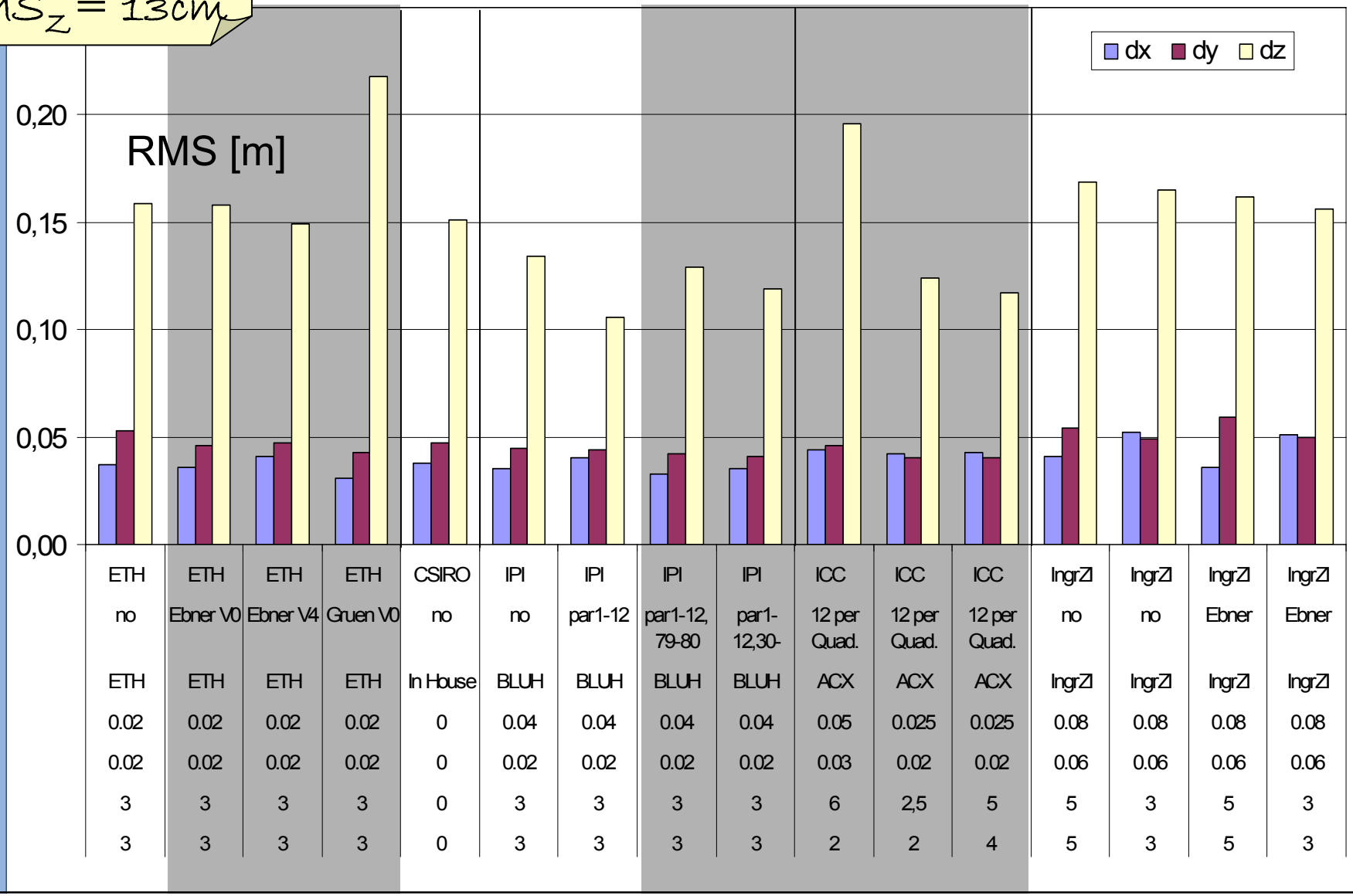
Phase 2b – DMC low

GSD 10cm, hg 950m

DMC specific

ifp „reference“
$RMS_X = 4cm$
$RMS_Y = 5cm$
$RMS_Z = 13cm$



	ETH	ETH	ETH	ETH	CSIRO	IPI	IPI	IPI	IPI	ICC	ICC	ICC	IngrZI	IngrZI	IngrZI	IngrZI
	no	Ebner V0	Ebner V4	Gruen V0	no	no	par1-12	par1-12, 79-80	par1-12,30-	12 per Quad.	12 per Quad.	12 per Quad.	no	no	Ebner	Ebner
	ETH	ETH	ETH	ETH	In House	BLUH	BLUH	BLUH	BLUH	ACX	ACX	ACX	IngrZI	IngrZI	IngrZI	IngrZI
	0.02	0.02	0.02	0.02	0	0.04	0.04	0.04	0.04	0.05	0.025	0.025	0.08	0.08	0.08	0.08
	0.02	0.02	0.02	0.02	0	0.02	0.02	0.02	0.02	0.03	0.02	0.02	0.06	0.06	0.06	0.06
	3	3	3	3	0	3	3	3	3	6	2,5	5	5	3	5	3
	3	3	3	3	0	3	3	3	3	2	2	4	5	3	5	3

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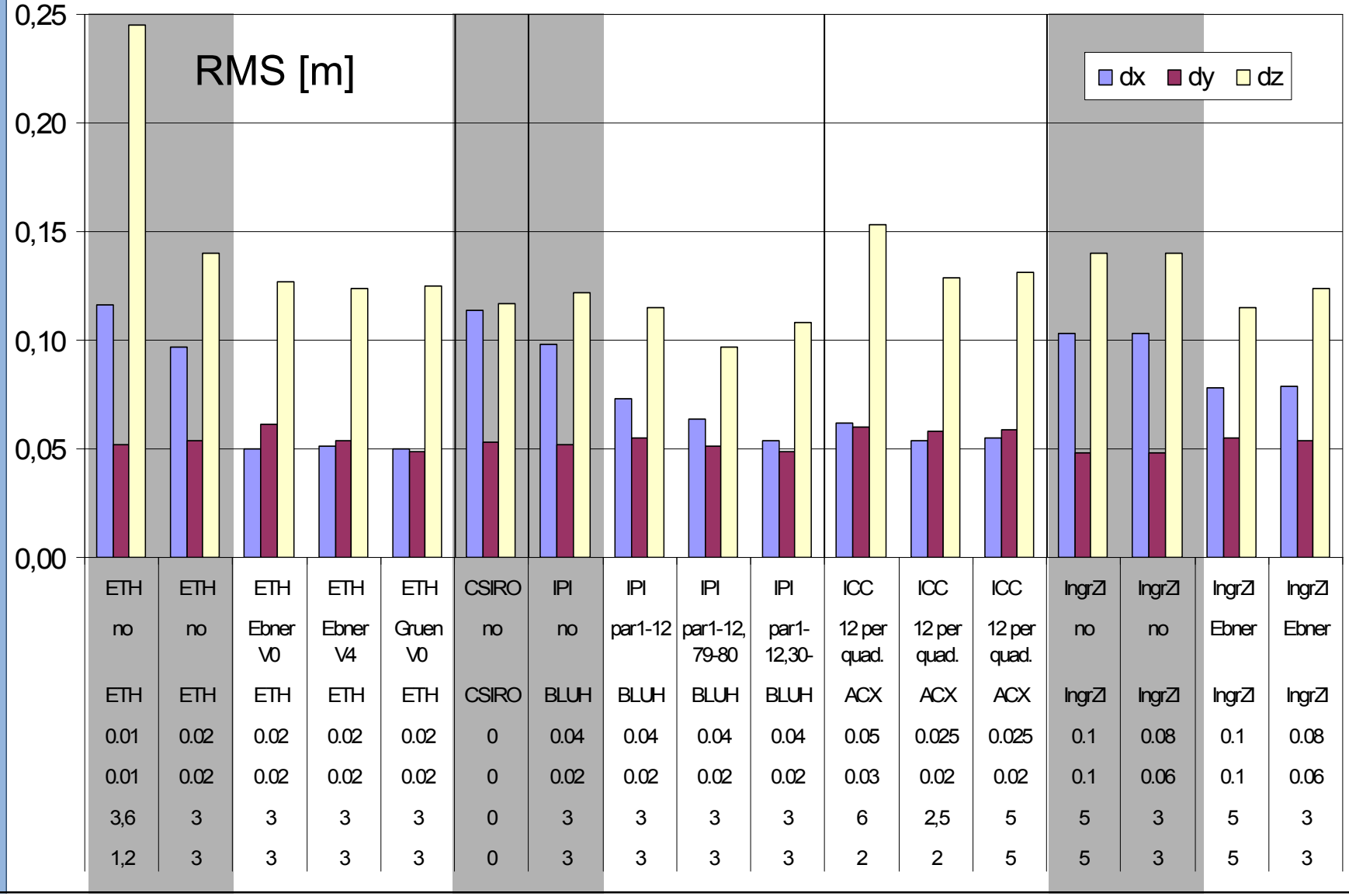
Phase 2b – DMC high

GSD 18cm, hg 1800m

No SC



ETH	ETH	ETH	ETH	ETH	CSIRO	IPI	IPI	IPI	IPI	ICC	ICC	ICC	IngrZI	IngrZI	IngrZI	IngrZI
no	no	Ebner V0	Ebner V4	Gruen V0	no	no	par1-12	par1-12, 79-80	par1-12,30-	12 per quad.	12 per quad.	12 per quad.	no	no	Ebner	Ebner
ETH	ETH	ETH	ETH	ETH	CSIRO	BLUH	BLUH	BLUH	BLUH	ACX	ACX	ACX	IngrZI	IngrZI	IngrZI	IngrZI
0.01	0.02	0.02	0.02	0.02	0	0.04	0.04	0.04	0.04	0.05	0.025	0.025	0.1	0.08	0.1	0.08
0.01	0.02	0.02	0.02	0.02	0	0.02	0.02	0.02	0.02	0.03	0.02	0.02	0.1	0.06	0.1	0.06
3,6	3	3	3	3	0	3	3	3	3	6	2,5	5	5	3	5	3
1,2	3	3	3	3	0	3	3	3	3	2	2	5	5	3	5	3

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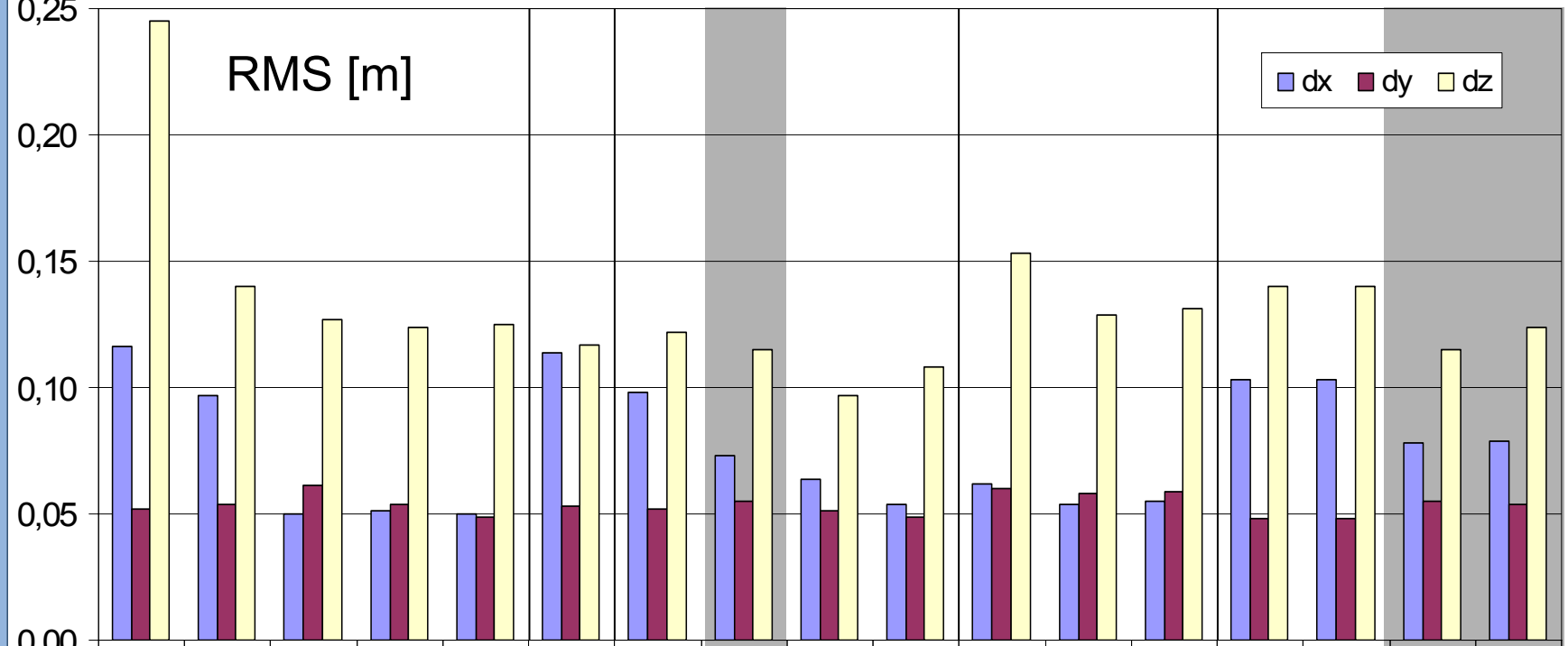
Phase 2b – DMC high

GSD 18cm, hg 1800m

Standard params



ETH	ETH	ETH	ETH	ETH	CSIRO	IPI	IPI	IPI	IPI	ICC	ICC	ICC	IngrZI	IngrZI	IngrZI	IngrZI
no	no	Ebner V0	Ebner V4	Gruen V0	no	no	par1-12	par1-12, 79-80	par1-12,30-	12 per quad.	12 per quad.	12 per quad.	no	no	Ebner	Ebner
ETH	ETH	ETH	ETH	ETH	CSIRO	BLUH	BLUH	BLUH	BLUH	ACX	ACX	ACX	IngrZI	IngrZI	IngrZI	IngrZI
0.01	0.02	0.02	0.02	0.02	0	0.04	0.04	0.04	0.04	0.05	0.025	0.025	0.1	0.08	0.1	0.08
0.01	0.02	0.02	0.02	0.02	0	0.02	0.02	0.02	0.02	0.03	0.02	0.02	0.1	0.06	0.1	0.06
3,6	3	3	3	3	0	3	3	3	3	6	2,5	5	5	3	5	3
1,2	3	3	3	3	0	3	3	3	3	2	2	5	5	3	5	3

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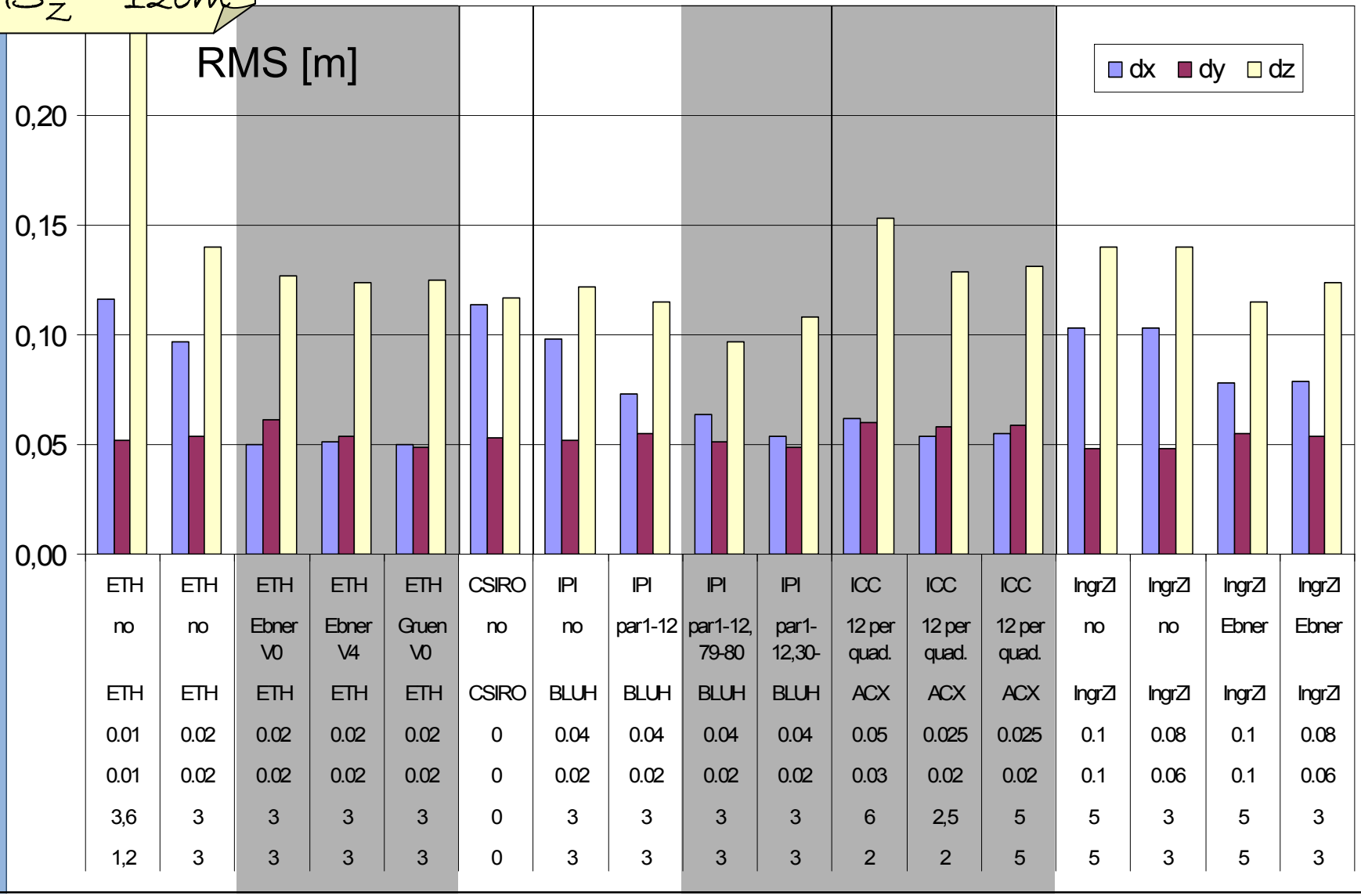
Phase 2b – DMC high

GSD 18cm, hg 1800m

DMC params

ifp „reference“
$RMS_X = 5cm$
$RMS_Y = 5cm$
$RMS_Z = 12cm$



ETH	ETH	ETH	ETH	ETH	CSIRO	IPI	IPI	IPI	IPI	ICC	ICC	ICC	IngrZI	IngrZI	IngrZI	IngrZI
no	no	Ebner V0	Ebner V4	Gruen V0	no	no	par1-12	par1-12, 79-80	par1-12,30-	12 per quad.	12 per quad.	12 per quad.	no	no	Ebner	Ebner
ETH	ETH	ETH	ETH	ETH	CSIRO	BLUH	BLUH	BLUH	BLUH	ACX	ACX	ACX	IngrZI	IngrZI	IngrZI	IngrZI
0.01	0.02	0.02	0.02	0.02	0	0.04	0.04	0.04	0.04	0.05	0.025	0.025	0.1	0.08	0.1	0.08
0.01	0.02	0.02	0.02	0.02	0	0.02	0.02	0.02	0.02	0.03	0.02	0.02	0.1	0.06	0.1	0.06
3,6	3	3	3	3	0	3	3	3	3	6	2,5	5	5	3	5	3
1,2	3	3	3	3	0	3	3	3	3	2	2	5	5	3	5	3

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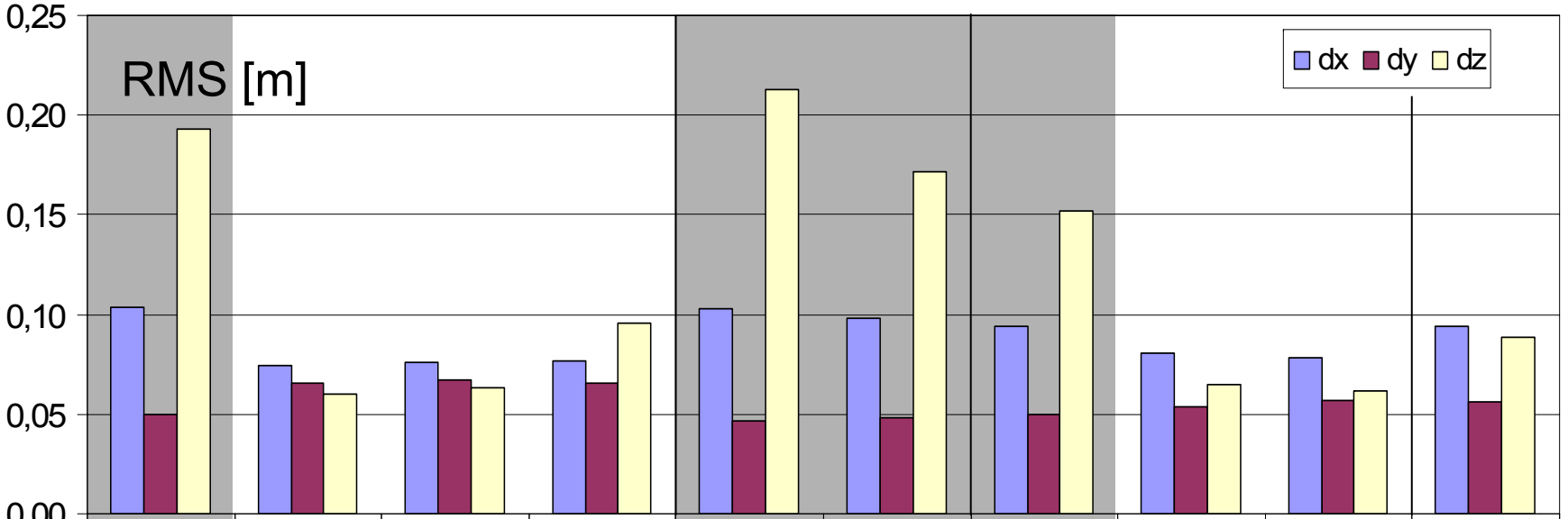
Phase 2b – UCD low

GSD 17cm, hg 1900m

No SC



ETH	ETH	ETH	ETH	CSIRO	CSIRO	IPI	IPI	IPI	Vexcel
no	gruen	ebner v0	gruen v0	Conf.B	Conf.C	no	par1-12	par1-	0
ETH	ETH	ETH	ETH	In House	In House	BLUH	BLUH	BLUH	BINGO
0.02	0.02	0.02	0.02	0	0	0.02	0.02	0.02	0
0.02	0.02	0.02	0.02	0	0	0.02	0.02	0.02	0
3	3	3	3	0	0	2	2	2	0
3	3	3	3	0	0	2	2	2	0

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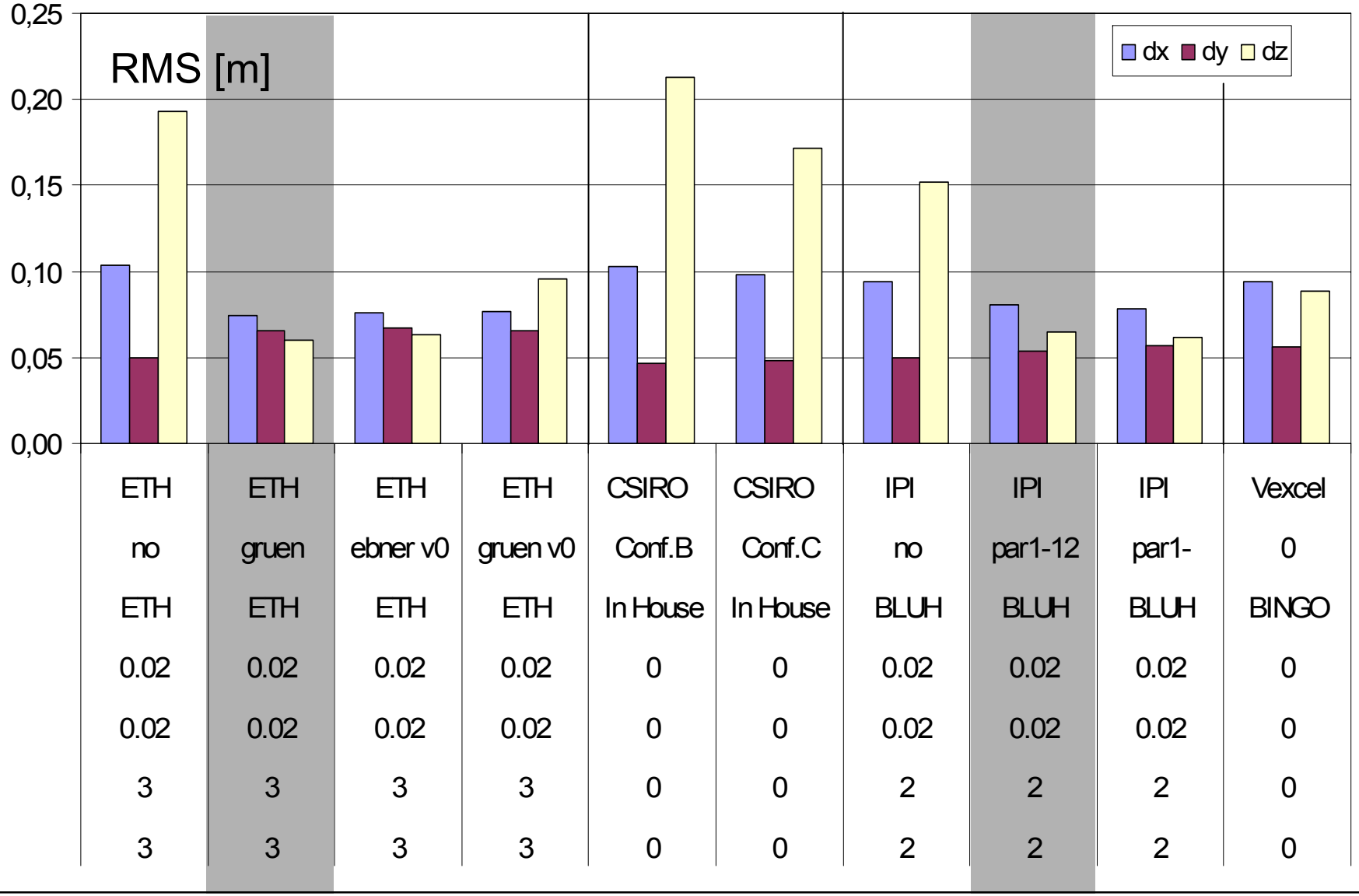
Phase 2b – UCD low

GSD 17cm, hg 1900m

Standard params



ETH	ETH	ETH	ETH	CSIRO	CSIRO	IPI	IPI	IPI	Vexcel
no	gruen	ebner v0	gruen v0	Conf.B	Conf.C	no	par1-12	par1-	0
ETH	ETH	ETH	ETH	In House	In House	BLUH	BLUH	BLUH	BINGO
0.02	0.02	0.02	0.02	0	0	0.02	0.02	0.02	0
0.02	0.02	0.02	0.02	0	0	0.02	0.02	0.02	0
3	3	3	3	0	0	2	2	2	0
3	3	3	3	0	0	2	2	2	0

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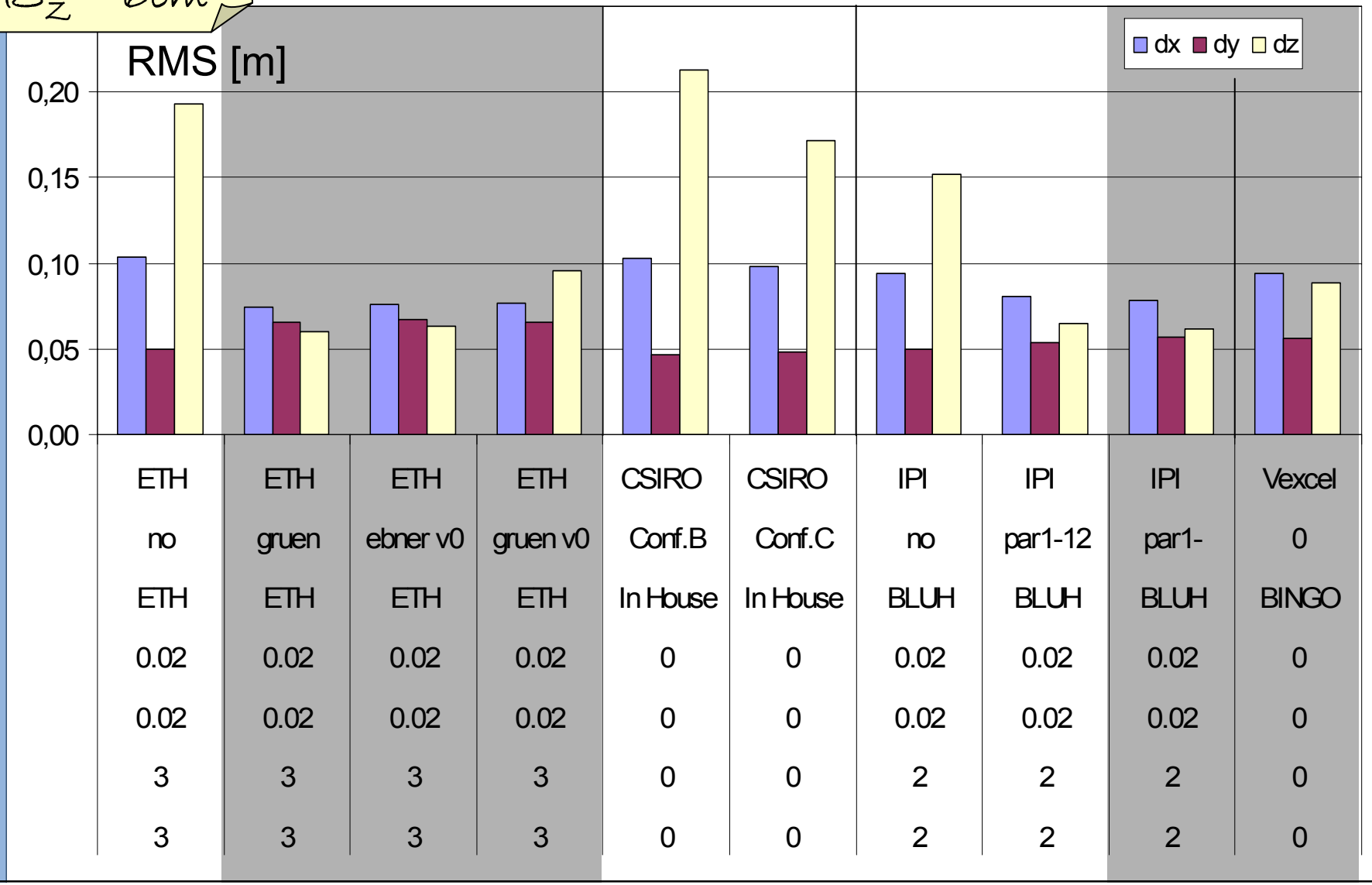
Phase 2b – UCD low

GSD 17cm, hg 1900m

UCD params

ifp „reference“
RMS_X = 8cm
RMS_Y = 6cm
RMS_Z = 6cm



	ETH	ETH	ETH	ETH	CSIRO	CSIRO	IPI	IPI	IPI	Vexcel
	no	gruen	ebner v0	gruen v0	Conf.B	Conf.C	no	par1-12	par1-	0
	ETH	ETH	ETH	ETH	In House	In House	BLUH	BLUH	BLUH	BINGO
	0.02	0.02	0.02	0.02	0	0	0.02	0.02	0.02	0
	0.02	0.02	0.02	0.02	0	0	0.02	0.02	0.02	0
	3	3	3	3	0	0	2	2	2	0
	3	3	3	3	0	0	2	2	2	0

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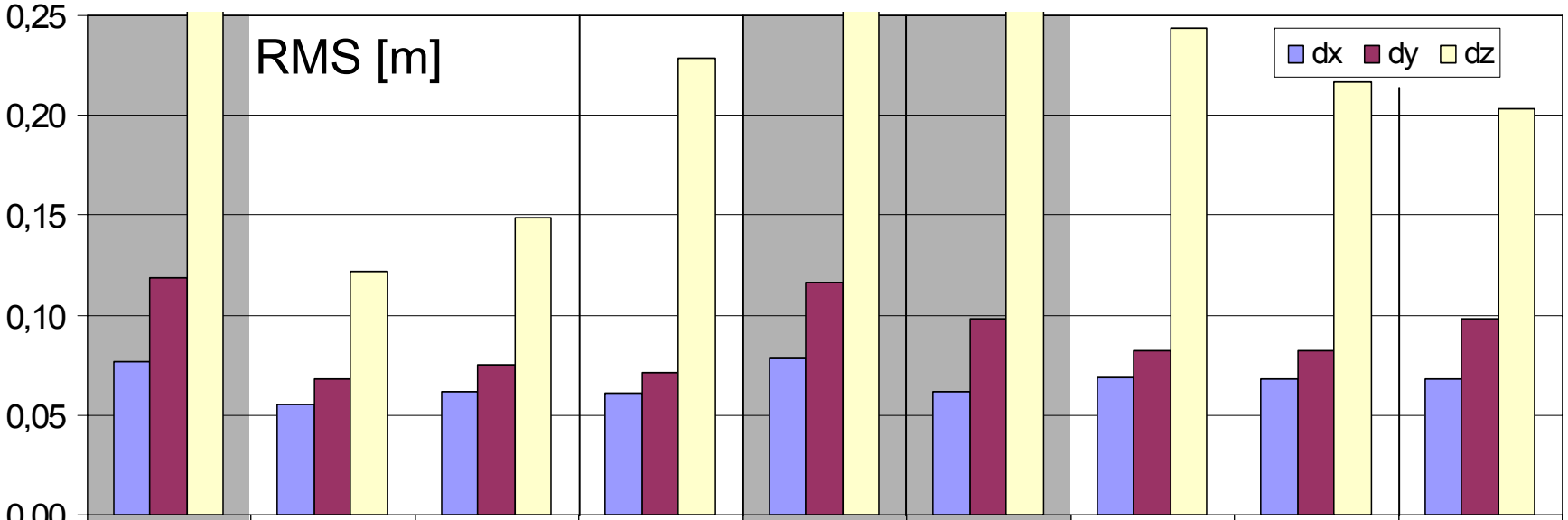
Phase 2b – UCD high

GSD 34cm, hg 3800m

No SC



ETH	ETH	ETH	ETH	CSIRO	IPI	IPI	IPI	Vexcel
no	gruen	ebner v0	gruen v0	no	no	par1-12	par1-12,42-	0
ETH	ETH	ETH	ETH	In House	BLUH	BLUH	BLUH	BINGO
0.02	0.02	0.02	0.02	0	0.02	0.02	0.02	0
0.02	0.02	0.02	0.02	0	0.02	0.02	0.02	0
3	3	3	3	0	2	2	2	0
3	3	3	3	0	2	2	2	0

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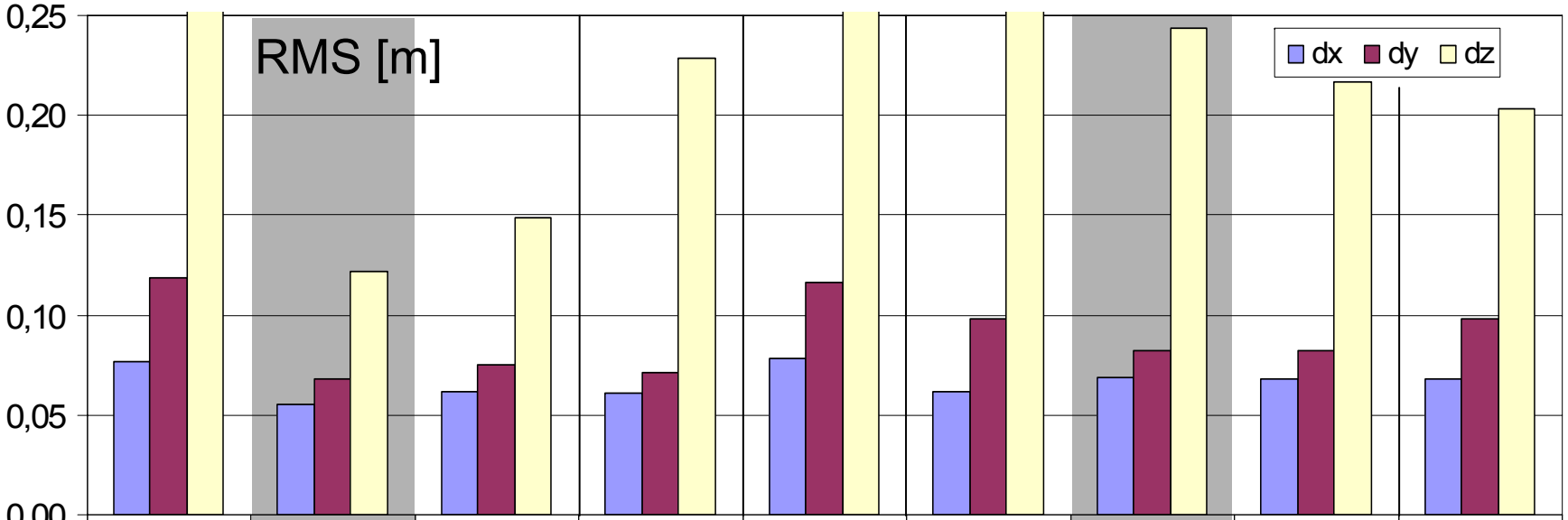
Phase 2b – UCD high

GSD 34cm, hg 3800m

Standard params



ETH	ETH	ETH	ETH	CSIRO	IPI	IPI	IPI	Vexcel
no	gruen	ebner v0	gruen v0	no	no	par1-12	par1-12,42-	0
ETH	ETH	ETH	ETH	In House	BLUH	BLUH	BLUH	BINGO
0.02	0.02	0.02	0.02	0	0.02	0.02	0.02	0
0.02	0.02	0.02	0.02	0	0.02	0.02	0.02	0
3	3	3	3	0	2	2	2	0
3	3	3	3	0	2	2	2	0

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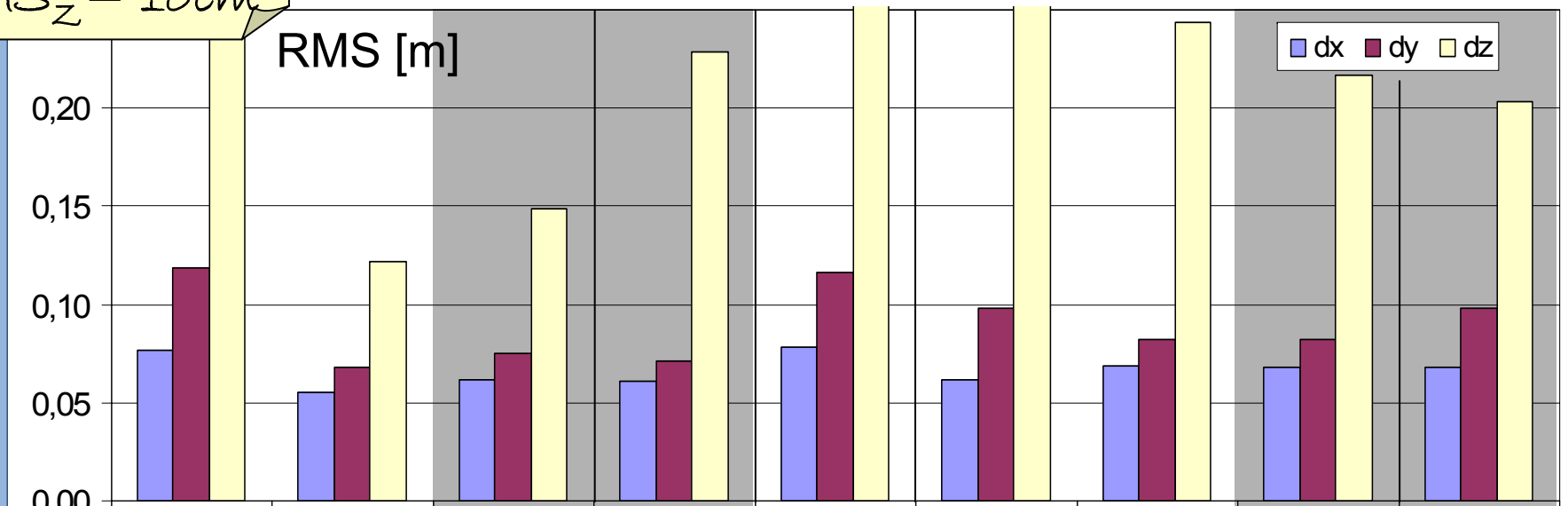
Phase 2b – UCD high

GSD 34cm, hg 3800m

UCD params

ifp „reference“
$RMS_X = 5cm$
$RMS_Y = 7cm$
$RMS_Z = 10cm$



	ETH	ETH	ETH	ETH	CSIRO	IPI	IPI	IPI	Vexcel
	no	gruen	ebner v0	gruen v0	no	no	par1-12	par1-12,42-	0
	ETH	ETH	ETH	ETH	In House	BLUH	BLUH	BLUH	BINGO
	0.02	0.02	0.02	0.02	0	0.02	0.02	0.02	0
	0.02	0.02	0.02	0.02	0	0.02	0.02	0.02	0
	3	3	3	3	0	2	2	2	0
	3	3	3	3	0	2	2	2	0

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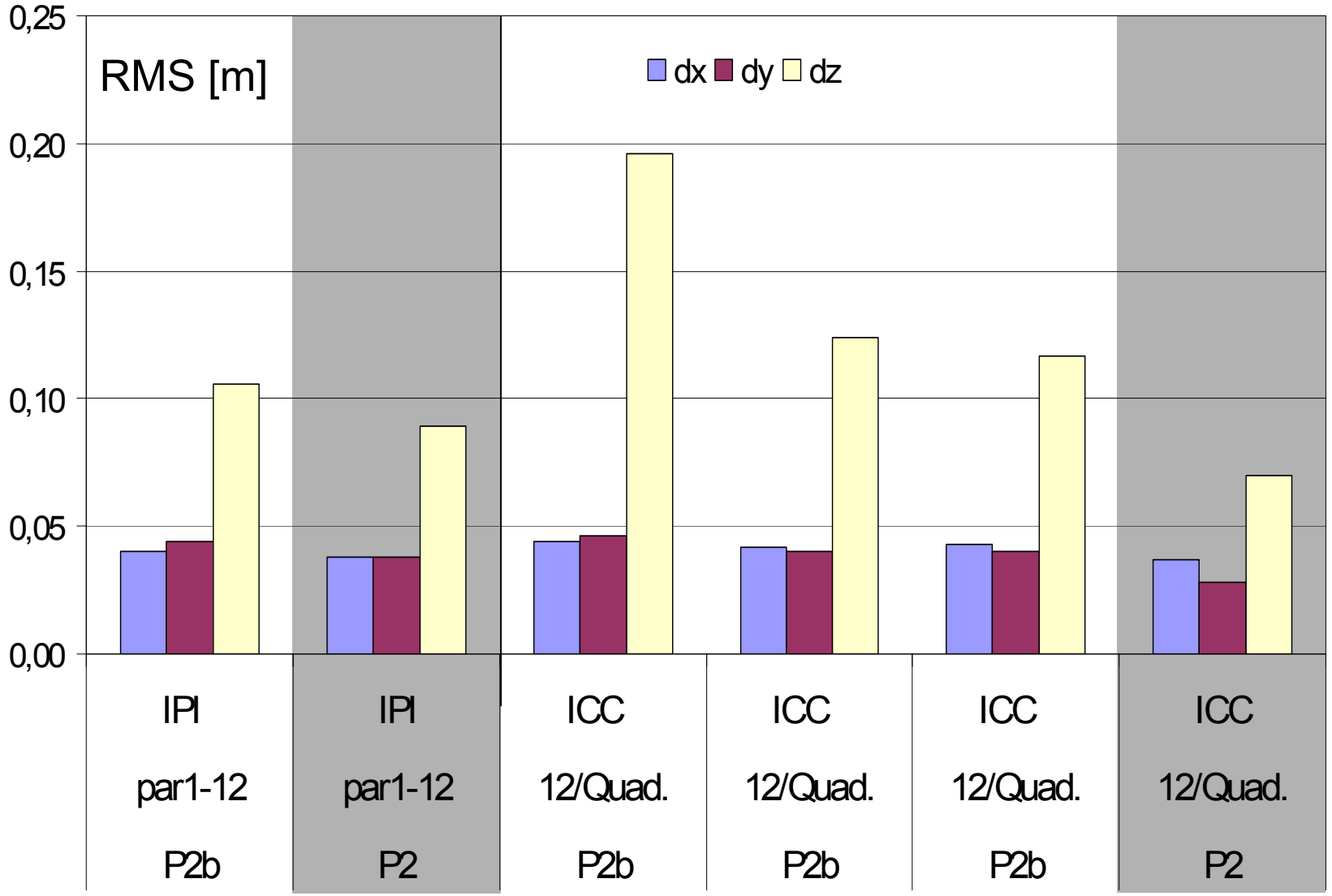
Phase 2b vs. Phase 2

DMC low block



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Summary
Results from Phase 2b

- **self-calibration is necessary in all cases to achieve optimal result**
- a priori weightings are also of influence, in some cases choice of weighting factors exceeds effect of additional parameter set
- in some cases special parameter sets adopted to sensor geometry seem to be necessary, although standard sets like Ebner or Gruen already compensate large portion of systematic error budget, i.e.
  - for UCD flights Gruen 44 params perform very well, same accuracy or even better than UC specific correction terms
  - for DMC low flight 12 standard BLUH params are mostly sufficient, amended by two additional DMC params for high flight
- a priori **recommendation of optimal additional parameter set is difficult** or even not possible

Summary
Project Camera Calibration

- **Phase 2b analyses now finalize project activities!**
- Final report to be compiled in fall 2007 (should be part of EuroSDR publication #53).
- Presentation / publication of project results
  - European DMC user meeting Gävle, Sweden (Jan 2007)
  - ISPRS workshop Hannover, Germany (May 2007)
  - Photogrammetric Week, Stuttgart, Germany (September 2007)
  - RSPoc annual meeting, Newcastle, UK (September 2007)
  - Journal publication
- Compilation of EduServ 2008 module, which is mostly based on project data, experiences and results