SMBMIP
over the Greenland ice sheet

Intercomparion of 11 models
over 1980-2012 forced by ERA-Interim

*Photo: Swiss Camp, one of the longest SMB time series...*

1. List of models

Model Name	Model type				Reso. (km)	Modis Albedo	Institute (Country)		Contacts
	EBM	GCM	PDD	RCM					
BESSI	x				10		Bergen Univ.	NO	Zolles T.
BOX13 (MM5)				x	5		GEUS	DN	Box J.
CESM		x			~1 (100?)		Utrecht Univ.	NL	Kampenhout L., Lenaerts J., …
dEBM	x				1		AWI	DE	Krebs-Kanzow U.
HIRHAM				x	5	x	DMI	DN	Mottram R., Langen P., …
MAR (ISMIP6)				x	15		Liège Univ.	BE	Fettweis X.
MPI-ESM		x			~1 (150)		Max Planck Inst.	DE	Kapsch M.
PDD1km			x		1		Sheffield Univ.	UK	Wilton D., Hanna E.
PDD5km			x		5		Lincoln Univ.	UK	Hanna E., Huybrechts P.
RACMO				x	~1 (5)	x	Utrecht. Univ	NL	Noel B., van den Broeke M., van de Berg W.J., …
SNOWMODEL	x				5		Colorado Univ.	US	Liston G., Mernild S.

- All the models have been interpolated on the same ISMIP6 based 1km grid by using the downscaling technique of Franco et al. (2012), taking into account the sub-grid 1km topo.

- The comparison is done on the "common" ice sheet mask and common period (1980-2012).

- Except both GCMs, all the models use ERA-Interim as forcing.
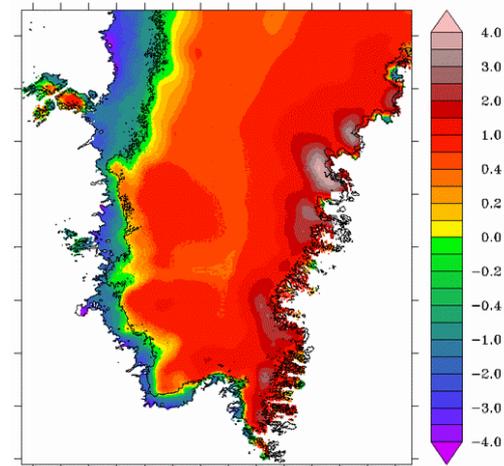
2. Mean 2000-2012 SMB

Mean snowline over 2000-2012 based on MODIS
(source: jonathan_ryan@brown.edu)
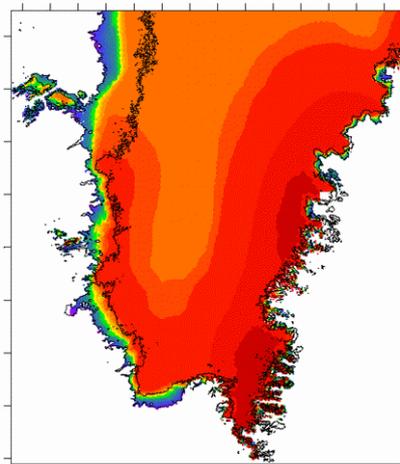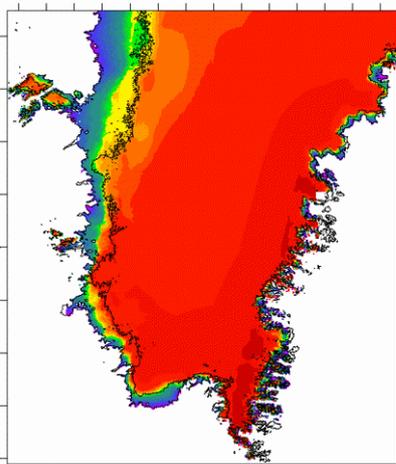
Units: m WE/yr
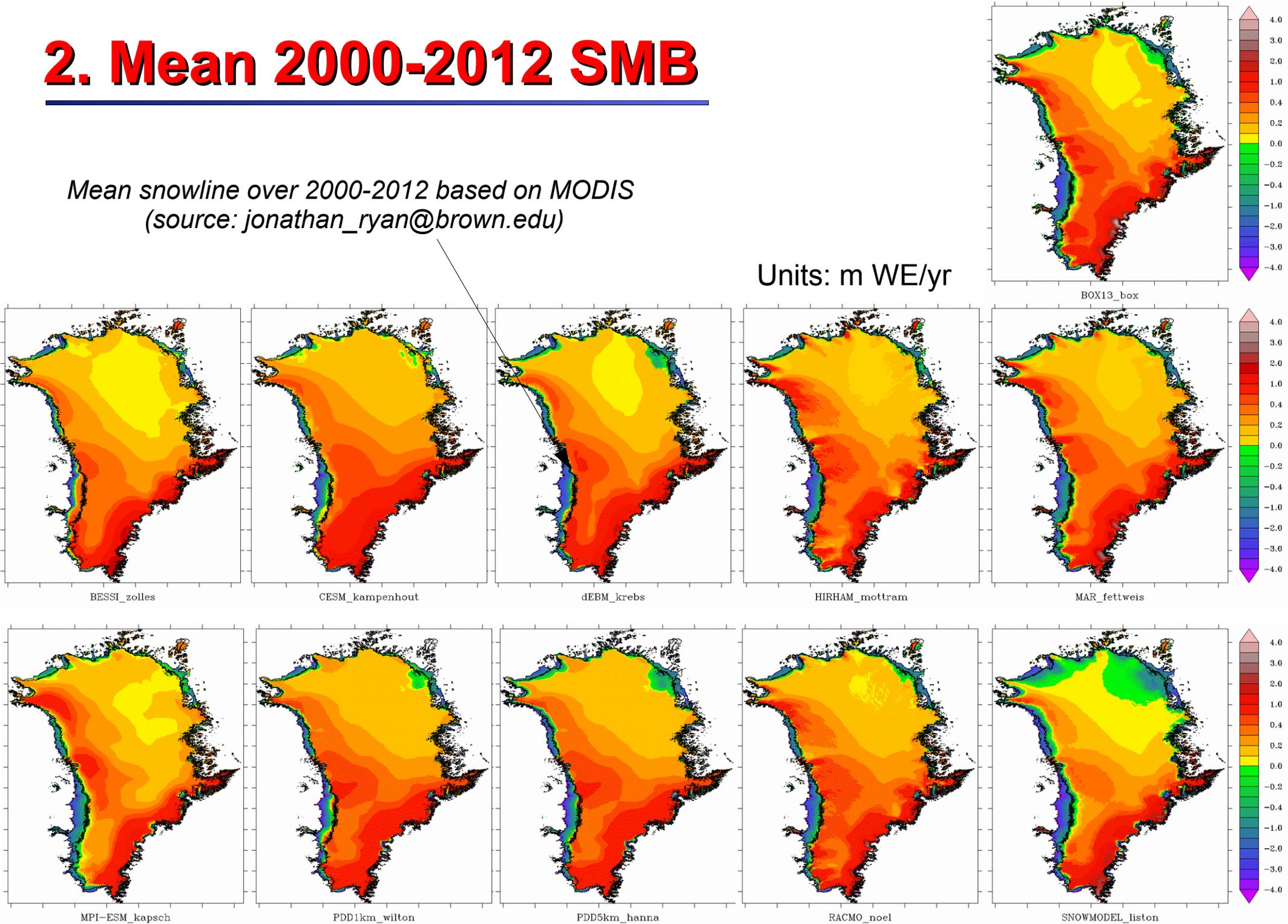
2. Mean 2000-2012 SMB

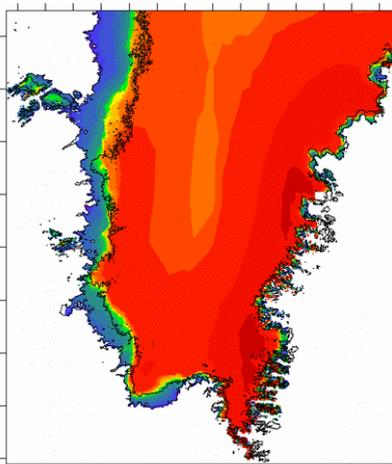*A priori, the mean snowline
should be in the ablation zone !!*
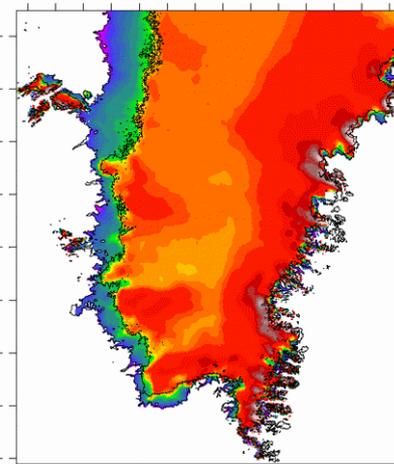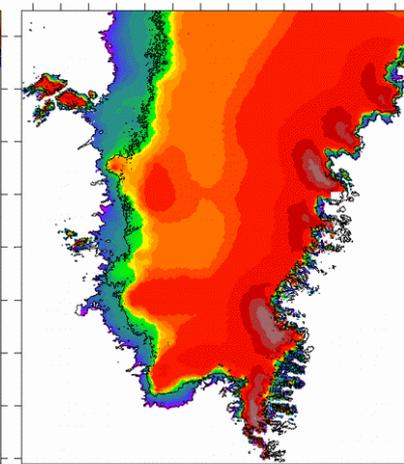
3. Ensemble mean

Very narrow ablation zone

Ablation zone or accumulation zone in the models

Average of the 1980-2012 SMB over the 11 models

"Dark zone" only in a few MODIS forced models

Large discrepancies in the precipitation

Standard deviation of the mean 1980-2012 SMB over the 11 models
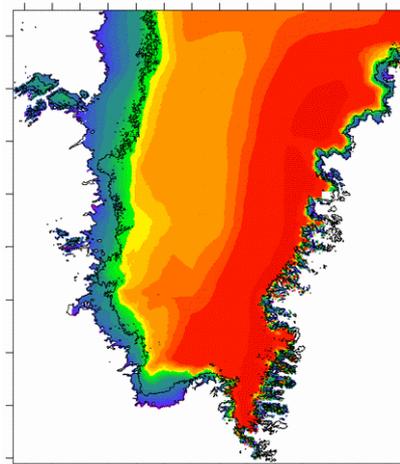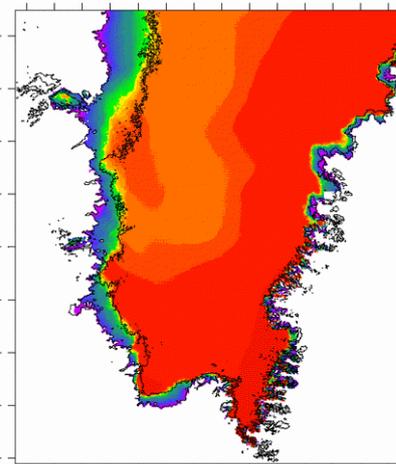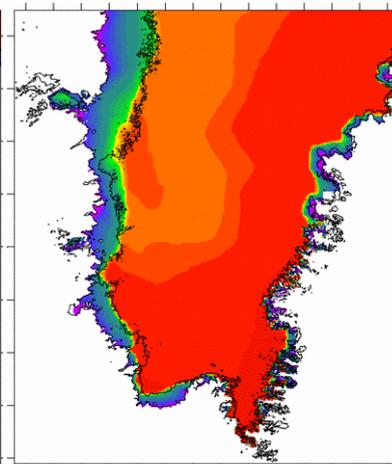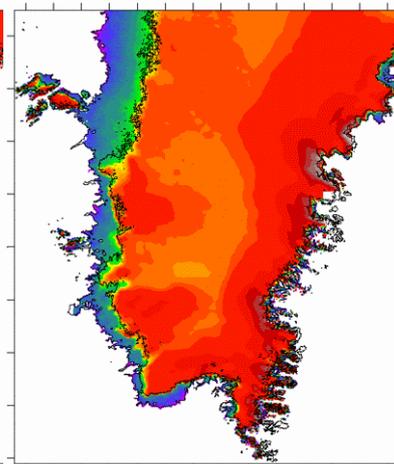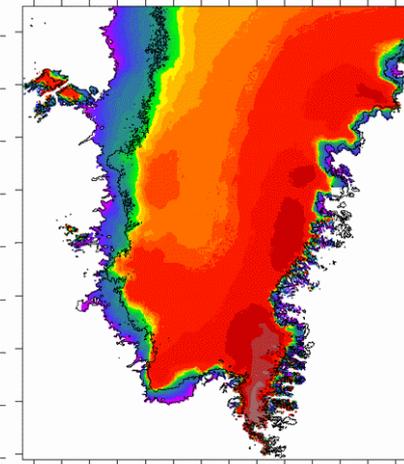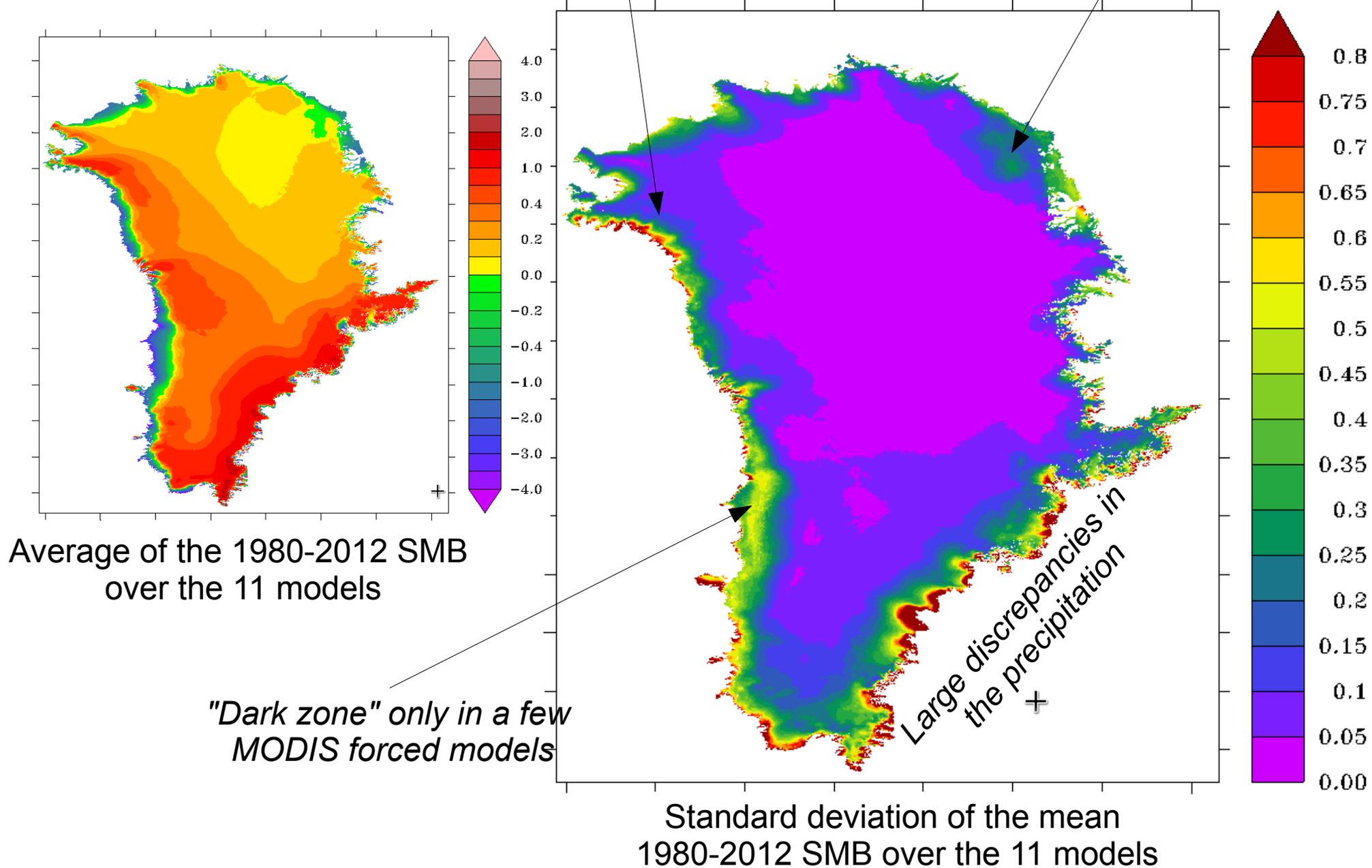
3. Ensemble mean

Models vs ensemble mean

Units: m WE/yr

4. Evaluation

Ice cores (Bales et al., ...)

Mean **1980-2012** SMB from MAR – 15km (mmWE/yr)
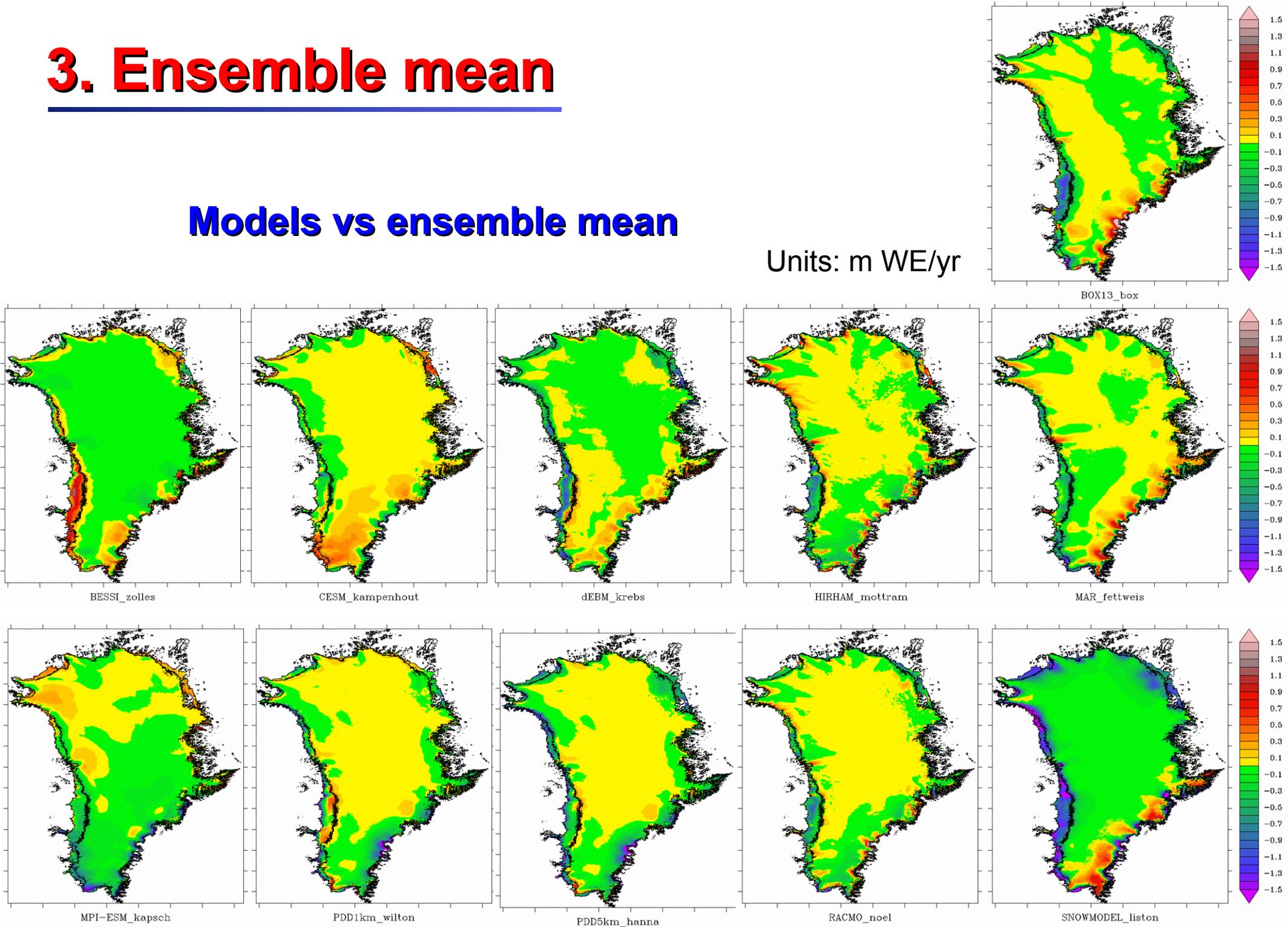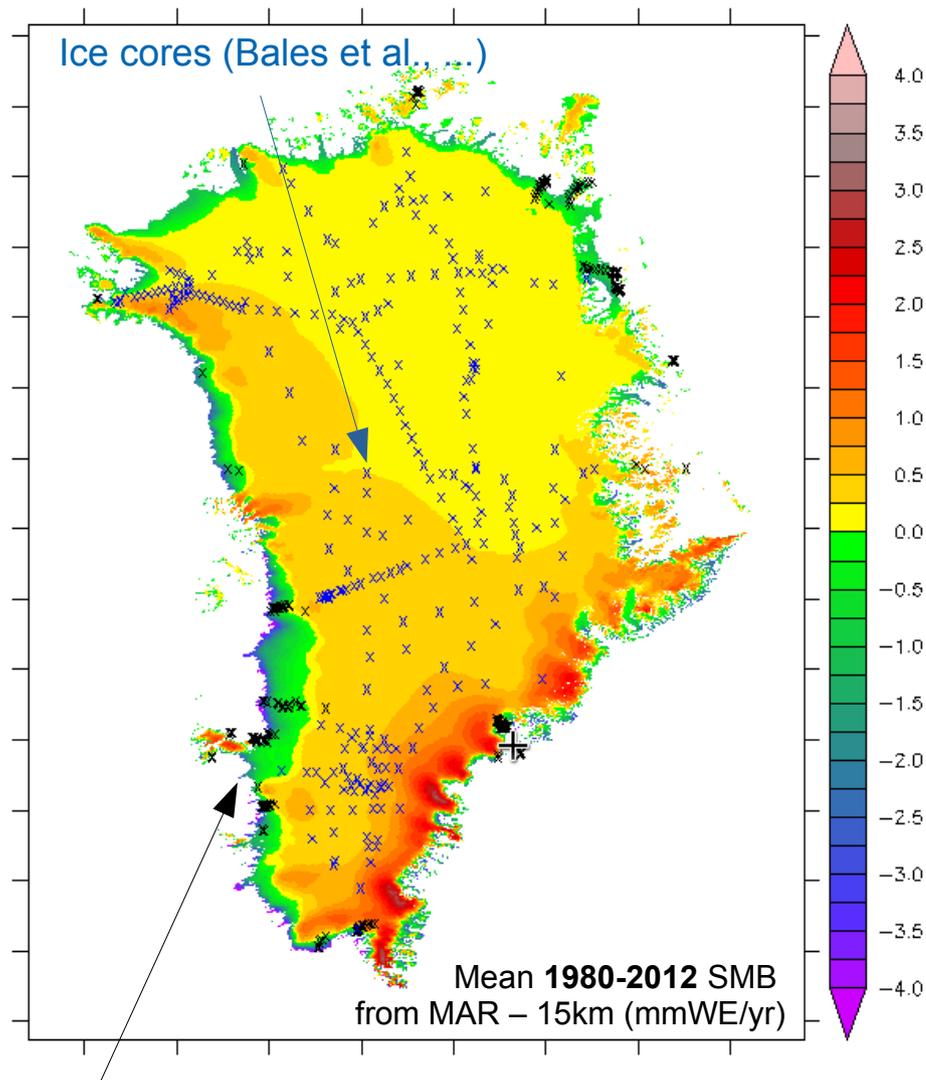
PROMICE SMB data base (Machguth et al., 2016)

	Model	Bias (mWE)	RMSE	Correl.
Ice cores (#260)	BESSI_zolles	-0.07	0.11	0.87
	BOX13_box	0.02	0.13	0.83
	CESM_kampenhout	0.05	0.14	0.80
	dEBM_krebs	-0.01	0.08	0.89
	HIRHAM_mottram	0.02	0.13	0.82
	MAR_fettweis	0.01	0.08	0.93
	MPI-ESM_kapsch	0.01	0.12	0.76
	PDD1km_wilton	-0.01	0.04	**0.97**
	PDD5km_hanna	-0.01	0.04	**0.96**
	RACMO_noel	-0.02	0.08	0.88
	SNOWMODEL_liston	-0.05	0.12	0.87
Full PROMICE SMB data Base (#1694)	BESSI_zolles	0.37	0.87	0.79
	BOX13_box	-0.01	0.61	0.88
	CESM_kampenhout	0.11	0.66	0.86
	dEBM_krebs	0.03	0.70	0.84
	HIRHAM_mottram	0.13	0.58	0.90
	MAR_fettweis	0.10	0.49	0.93
	MPI-ESM_kapsch	-0.06	0.75	0.81
	RACMO_noel	-0.07	0.61	0.89
	SNOWMODEL_liston	-0.30	0.67	0.89
Only main ice sheet SMB data base (#1439)	BESSI_zolles	0.45	0.89	0.81
	BOX13_box	-0.01	0.58	0.90
	CESM_kampenhout	0.11	0.61	0.89
	dEBM_krebs	0.05	0.76	0.82
	HIRHAM_mottram	0.09	0.57	0.91
	MAR_fettweis	0.10	0.48	0.93
	MPI-ESM_kapsch	-0.05	0.69	0.85
	PDD1km_wilton	-0.18	0.69	0.89
	PDD5km_hanna	-0.17	0.72	0.86
	RACMO_noel	-0.05	0.62	0.90
	SNOWMODEL_liston	-0.31	0.61	0.92

Observations are not representative of the whole ice sheet !!

4. Evaluation

Mean SMB vs Bare ice area

Comparison of the mean 2000-2012 bare ice area from MODIS with respect to the mean 2000-2012 SMB from models.
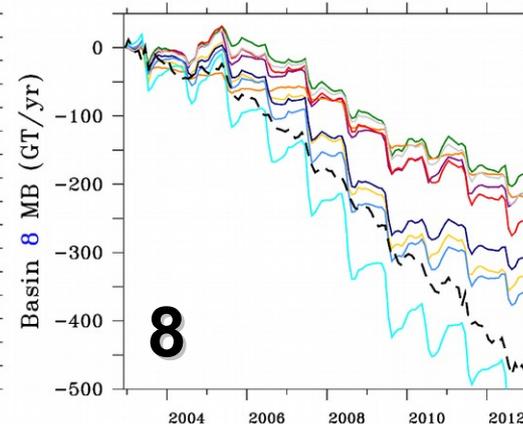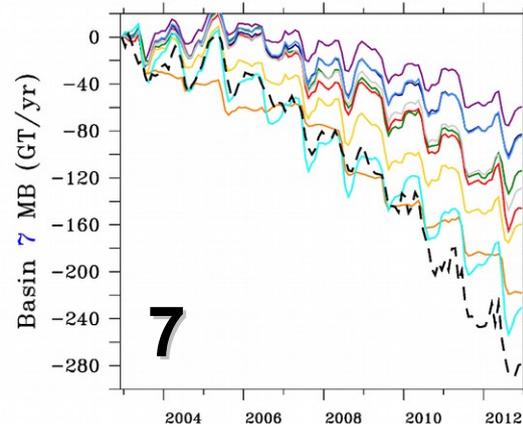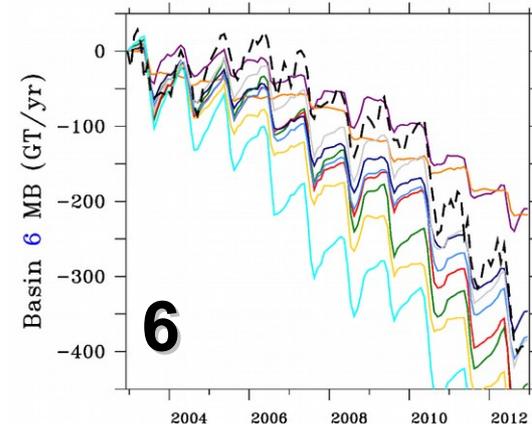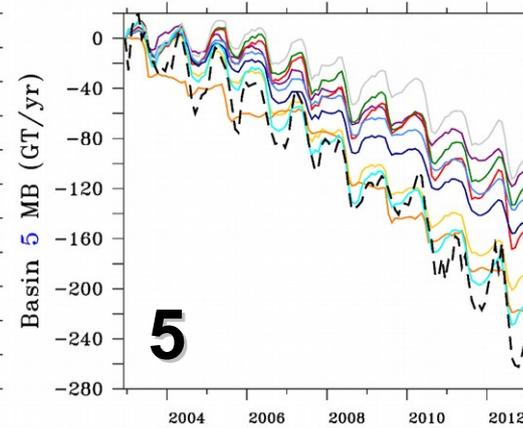
	Percentage of the main ice sheet		
	SMB > 200mm/yr and bare ice in MODIS	SMB < -200mm/yr and no bare ice in MODIS	Total Error
BOX13_box	1.0	2.3	3.3
dEBM_krebs	1.6	2.8	4.4
MAR_fettweis	0.5	2.5	2.9
CESM_kampenhout	1.5	0.9	2.4
BESSI_zolles	3.3	0.8	4.1
PDD1km_wilton	1.6	1.7	3.3
PDD5km_hanna	1.2	4.2	5.4
RACMO_noel	0.9	2.1	3.0
SNOWMODEL_liston	0.4	9.7	10.1
HIRHAM_mottram	0.9	1.6	2.5
MPI-ESM_kapsch	0.6	1.5	2.1

In the bare ice area, SMB should be negative!

SMB can be negative even if bare ice is not detected by MODIS

Source GRACE:
andreas.groh@tu-dresden.de

on the common
ice sheet mask

2003 - 2012

5. SMB vs GRACE

Source GRACE:
andreas.groh@tu-dresden.de

GrIS	Trend.	R^2	RMSE
BESSI	-143.8	0.98	86.9
BOX13	-83.6	0.98	79.7
CESM	-188.1	0.98	94.9
dEBM	-41.2	0.98	79.1
HIRHAM	-81.1	0.99	51.9
MAR	-73.6	0.99	48.4
MPI-ESM	-177.2	0.93	186.5
PDD1km	-91.4	0.98	82.6
PDD5km	-80.5	0.98	74.6
RACMO	-85.8	0.99	51.8
SNOWMODEL	44.2	0.98	90

Units: GT/yr

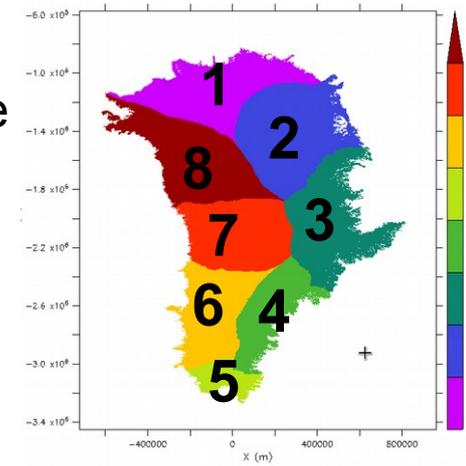| Basin 2	Trend.	R^2	RMSE
BESSI	1.3	0.72	8.4
BOX13	2.8	0.77	7.4
CESM	3.5	0.6	10.2
dEBM	13.3	0.63	12.3
HIRHAM	17.4	0.63	9.9
MAR	5.4	0.77	7.4
MPI-ESM	-0.5	0.29	13.3
PDD1km	5.2	0.71	8.8
PDD5km	8.1	0.69	10.8
RACMO	7.7	0.74	7.8
SNOWMODEL	25.5	0.5	21.9

Basin 5	Trend.	R^2	RMSE
BESSI	-11.1	0.94	16.2
BOX13	-9.9	0.97	12.2
CESM	-17	0.96	14.2
dEBM	-2.6	0.95	14.3
HIRHAM	-2.9	0.93	17.4
MAR	-8	0.98	9.9
MPI-ESM	-10.8	0.92	19.6
PDD1km	-6.7	0.95	14.7
PDD5km	-8.8	0.95	14.4
RACMO	-13.1	0.97	11.2
SNOWMODEL	-0.1	0.97	11.5

Basin 6	Trend.	R^2	RMSE
BESSI	-10.5	0.89	36
BOX13	13.5	0.95	24.8
CESM	-11.8	0.87	39.6
dEBM	17.8	0.93	27.9
HIRHAM	-11.8	0.79	49.6
MAR	9.8	0.97	18.9
MPI-ESM	-10.9	0.65	66.3
PDD1km	1.5	0.92	31.9
PDD5km	4.5	0.92	30.5
RACMO	2.9	0.97	18.3
SNOWMODEL	27.6	0.92	29.7

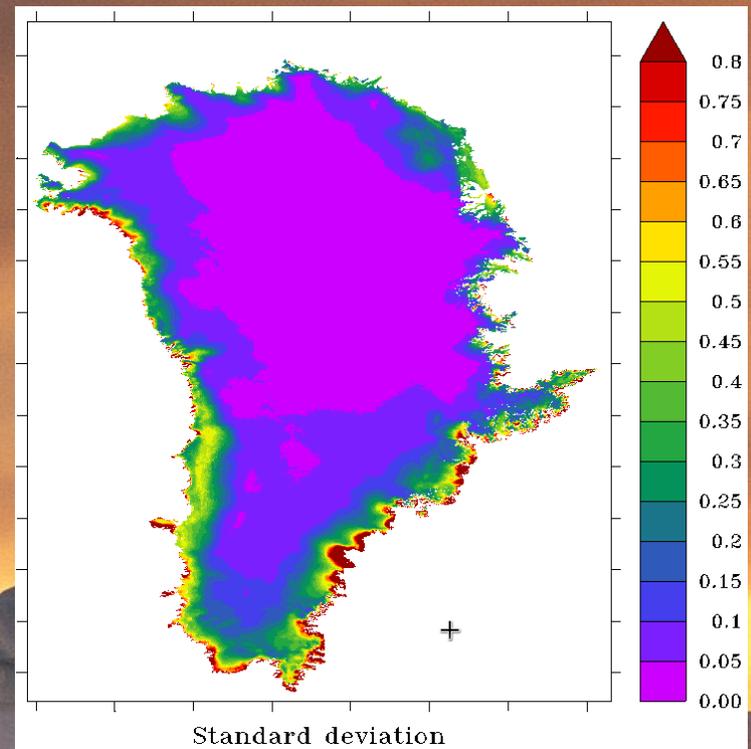*Trend of the GRACE - SMB
i.e. "trend" of the ice dynamics*
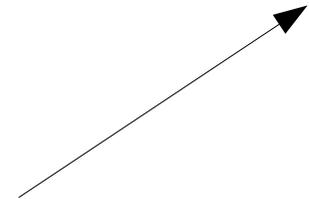
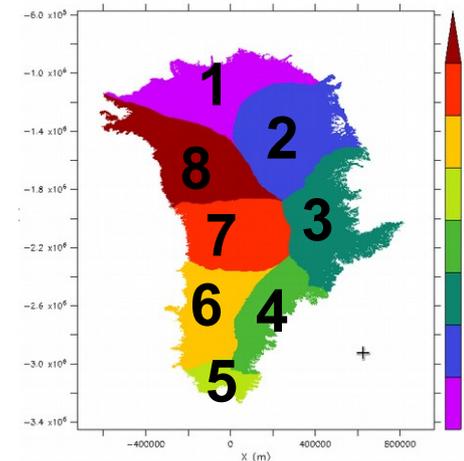*RMSE if we add this trend to SMB*

Next steps:

- Comparison with ~ 200 snow pits from Jason Box.

- Comparison with ICEsat ?

- Comparison with other SMB products you have ?

- Addition of the ensemble mean in the comparison.

Standard deviation

Next SMB measurements would be done in the "red" areas ;-)

Thanks for your attention!

x. Mean SMB

Mean SMB over 1980-2012 (GT/yr)

	GrIS	B 1	B 2	B 3	B 4	B 5	B 6	B 7	B 8
BESSI	386	14	18	74	109	42	45	53	32
BOX13	425	12	15	84	151	32	6	63	61
CESM	419	19	43	82	108	34	36	56	40
dEBM	387	10	14	81	115	37	28	58	44
HIRHAM	391	23	25	67	114	26	4	65	67
MAR	369	8	21	89	119	20	5	56	51
MPI-ESM	283	24	27	63	82	9	-25	46	57
PDD1km	329	26	26	62	65	28	13	65	43
PDD5km	282	12	15	63	66	28	4	62	30
RACMO	352	9	21	67	104	24	5	65	56
SNOWMODEL	90	-45	-28	51	90	36	-26	24	-11
Mean	*337.5*	*10*	*18*	*71*	*102*	*29*	*9*	*56*	*43*