Interpretation and Analysis of Projected Ice Sheet Contributions from a Structured Expert Judgement

Or….How can you get 2 m by 2100?

Jonathan Bamber, Michael Oppenheimer, Bob Kopp,
Roger Cooke, Willy Aspinall

Attributing global sea level rise to its component parts

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What are the options?

- **Deterministic ice sheet models:** critical unknown boundary/initial conditions, poorly understood processes, v. short observational record…..
- **Probabilistic approach** (e.g. Little, C. M. et al (2013), Probabilistic framework for assessing the ice sheet contribution to sea level change, *PNAS, 110(9), 3264-3269.)*
- **Plausibility approach** (e.g. Pfeffer, W. T., et al (2008), Kinematic constraints on glacier contributions to 21st-century sea-level rise, *Science, 321(5894), 1340-1343.)*
- **Structured Expert Judgement approach** (e.g. Bamber, J. L., Oppenheimer, M., Kopp, R. E., Aspinall, W. P. & Cooke, R. M. Ice sheet contributions to future sea-level rise from structured expert judgment. *Proc. Nat. Acad. Sci.* 116, 11195-11200, doi:10.1073/pnas.1817205116 (2019).

Why Structured Expert Judgement?

- Statistical theory and psychology demonstrates that:

  i) the brain is capable of complex Bayesian analysis,

  ii) a pooled, virtual expert has greater skill,

  iii) capture the influence of the known unknowns & unknown unknowns

- SEJ is an approach that can identify uncertainties and quantify them. It is not a substitute for basic research.

What is it?

Uses calibrated (weighted) expert judgements, providing a formal (and reproducable) approach for estimating uncertain quantities based on current scientific understanding.

Particularly effective at identifying experts who are able to quantify their uncertainties with high statistical accuracy rather than, e.g., experts with restricted domains of knowledge, or high scientific reputation….

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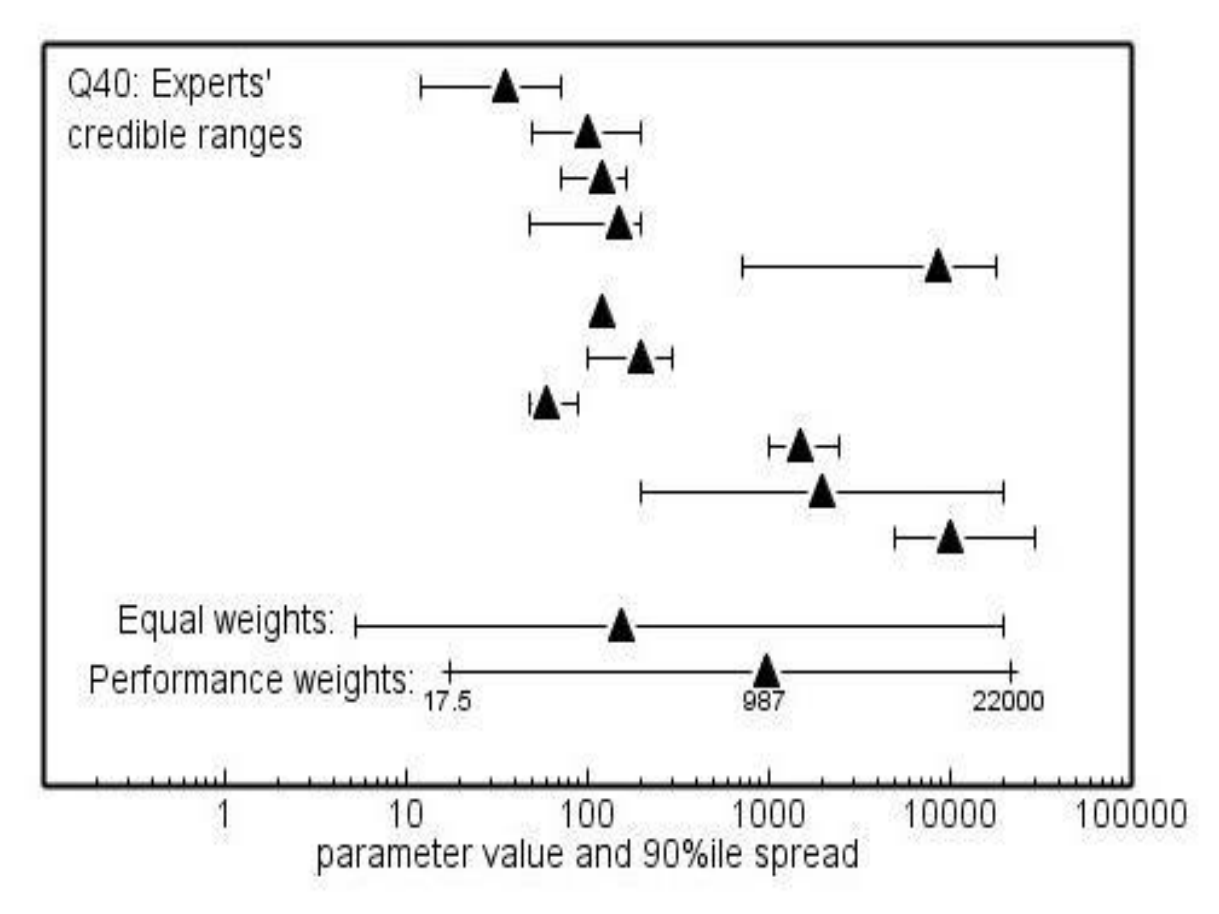
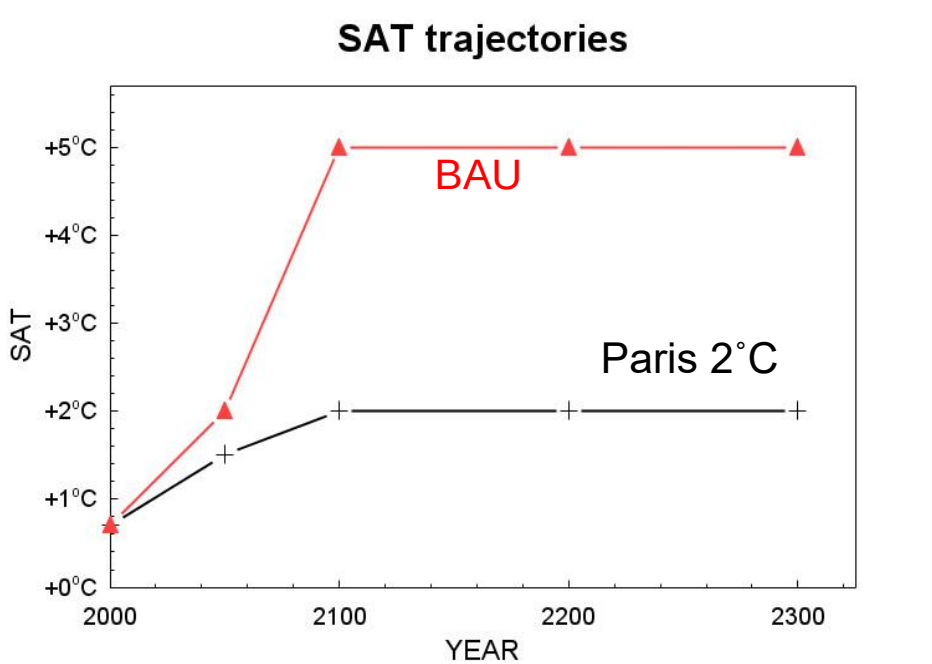
Two workshops in 2018, one in DC, one in London:

Elicit 5, 50 and 95th %ile and from these produce Prob Density Function (PDF)



Scenarios, time periods and processes:



Three processes that control the mass balance of the ice sheets

A positive accumulation change will results in a negative sea level contribution.

SLR = "mm global-mean sea-level equivalent" = Runoff+ Discharge - Accumulation

Three distinct and ascending values are required for each question, please.

Greenland

2050

Greenland, for a global mean SAT rise of **1.5`°C** by **2050** WRT pre-industrial what will be the **integrated contribution,** in **mm SLR** relative to 2000-2010 of the following:

Accumulation	**5%**	**50%**	**95%**
Runoff	**5%**	**50%**	**95%**
Discharge (grounding line flux)	**5%**	**50%**	**95%**

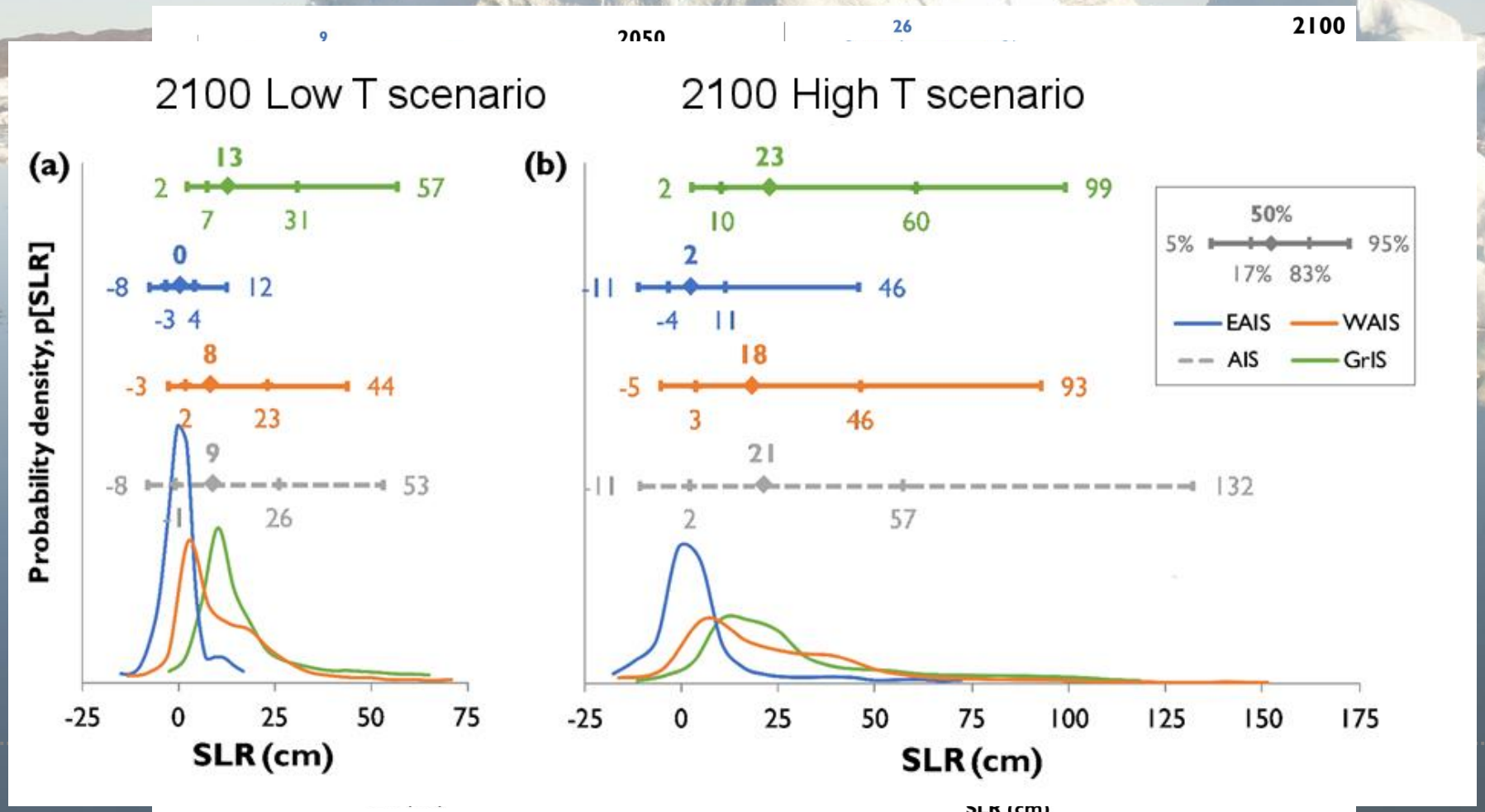
Idem, 2°C by 2050

Accumulation	**5%**	**50%**	**95%**
Runoff	**5%**	**50%**	**95%**
Discharge (grounding line flux)	**5%**	**50%**	**95%**

2100

Greenland, for a global mean SAT rise of **2°C** by **2100** WRT pre-industrial what will be the **integrated contribution,** in **mm SLR** relative to 2000-2010 of the following:

The findings. SLR PDFs



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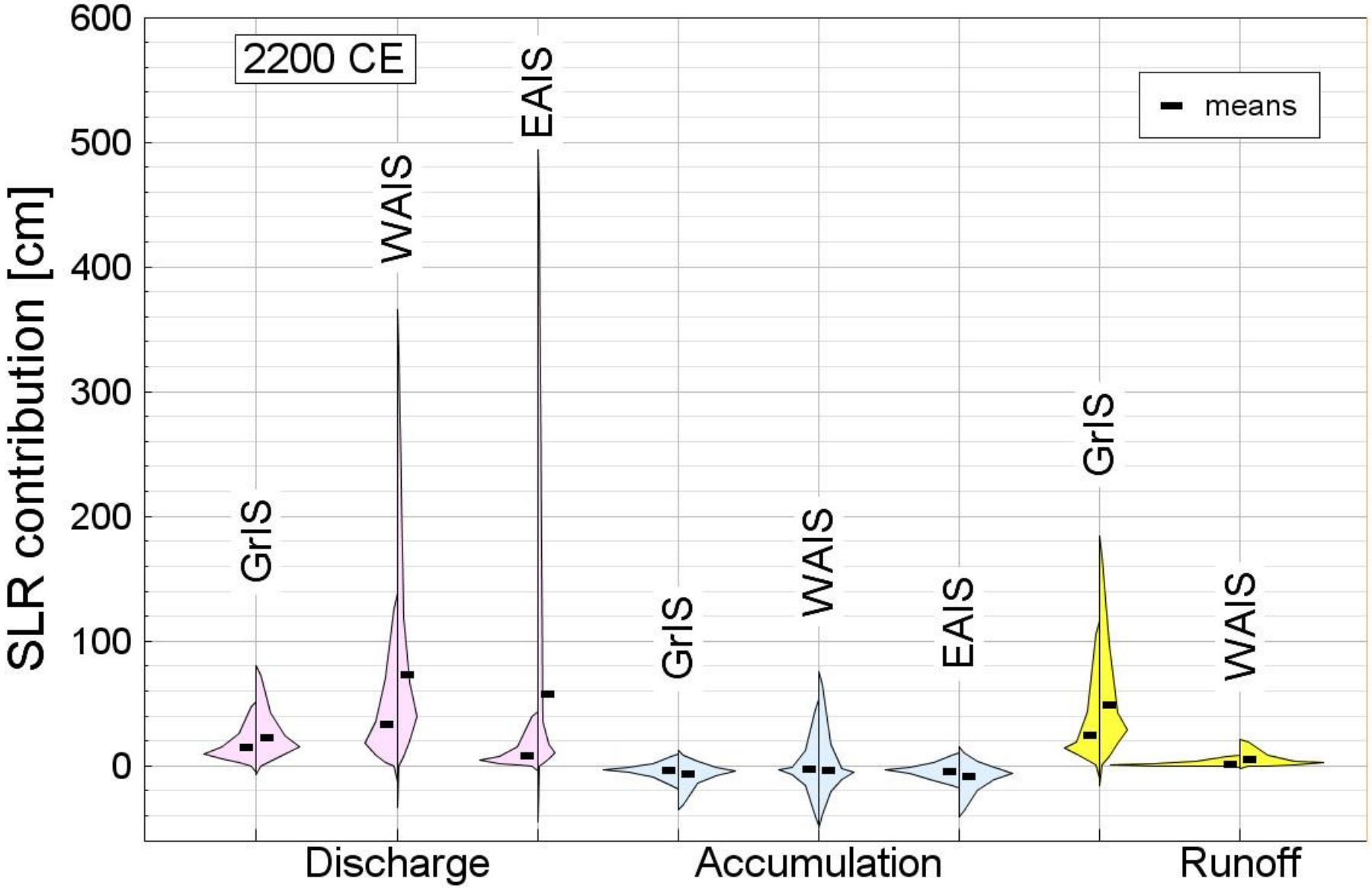

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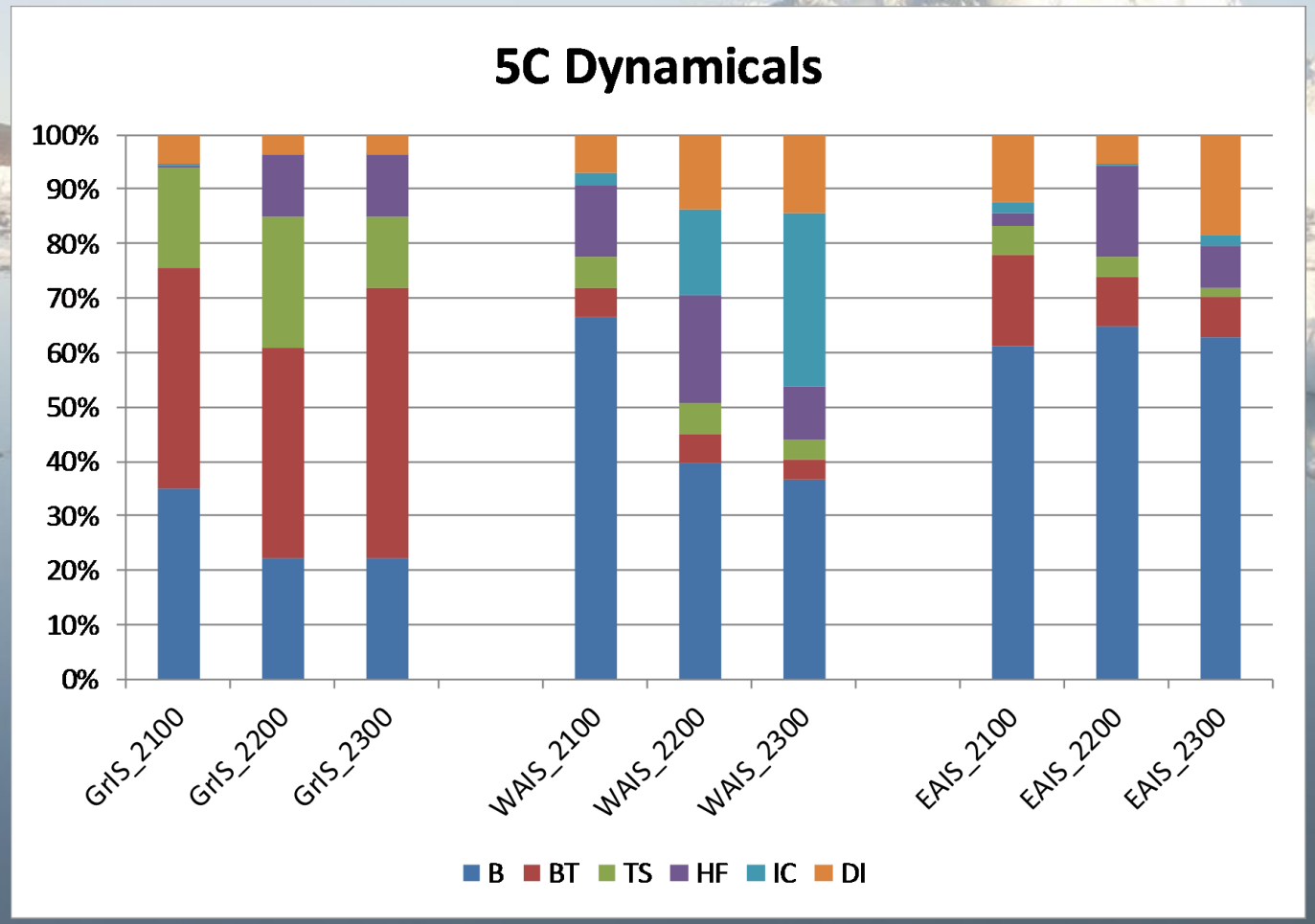
Relative importance of different processes for ice dynamics



B=buttressing

BT=basal traction

TS=transverse stresses

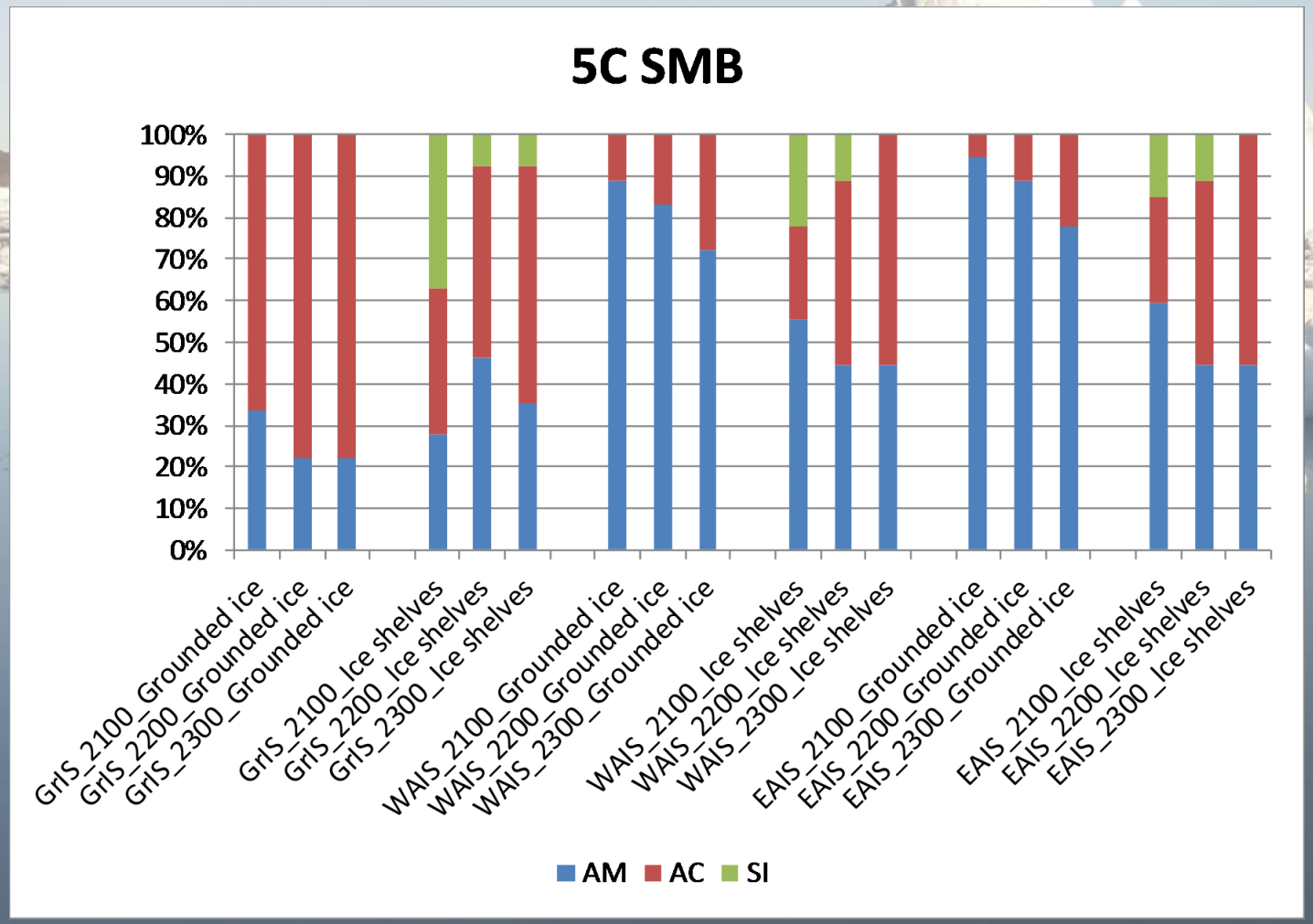
HF= hydrofracture

IC=ice cliff

DI=dissipation of icebergs

Also considered self gravitation and vertical land motion effects on stability (not considered 1st order).

Relative importance of different processes for SMB



Importance of changes in:

AM=atmos. moisture/circulation

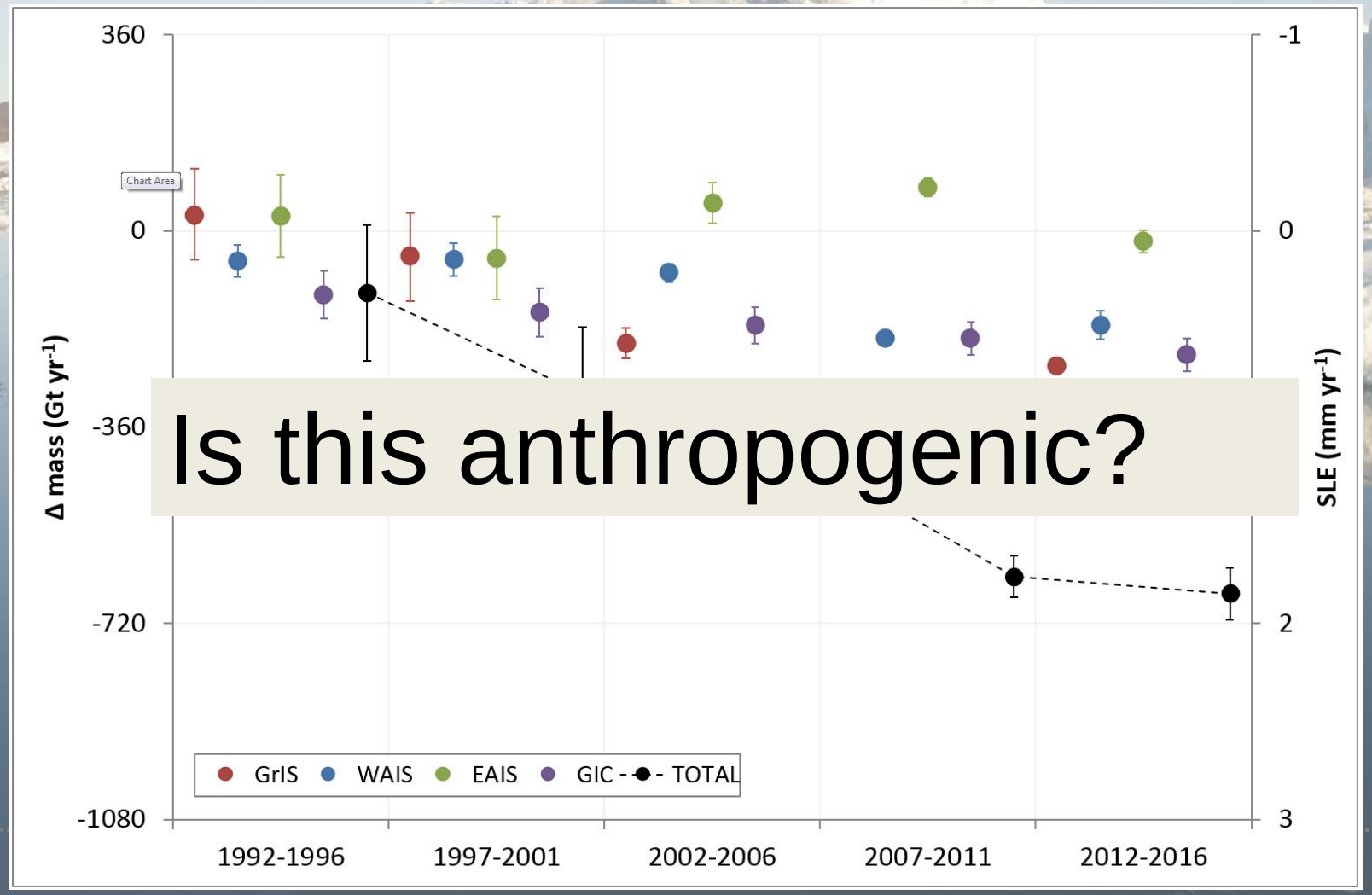
AC=albedo

SI=sea ice

Take home messages

- IPCC AR5 (6...?) way too conservative using likely range
- SLR > 2m by 2100 plausible
- Could impact > 600 m people (1/10th of world population)
- Uncertainties fn. of ΔT and Δtime
  - ➢ buttressing, basal traction and albedo key players
- Bamber, J.L., et al. (2019); Ice sheet contributions to future sea level rise from a structured expert judgement approach, *PNAS,* for more details (**Open Access**)
- Follow up paper on its way (slowly)

The land ice contribution to SLR during the satellite era:



Is this anthropogenic?

Bamber, J. L., R. M. Westaway, B. Marzeion, and B. Wouters (2018), The land ice contribution to sea level during the satellite era, *Env. Res. Lett., 13(6), 063008.*

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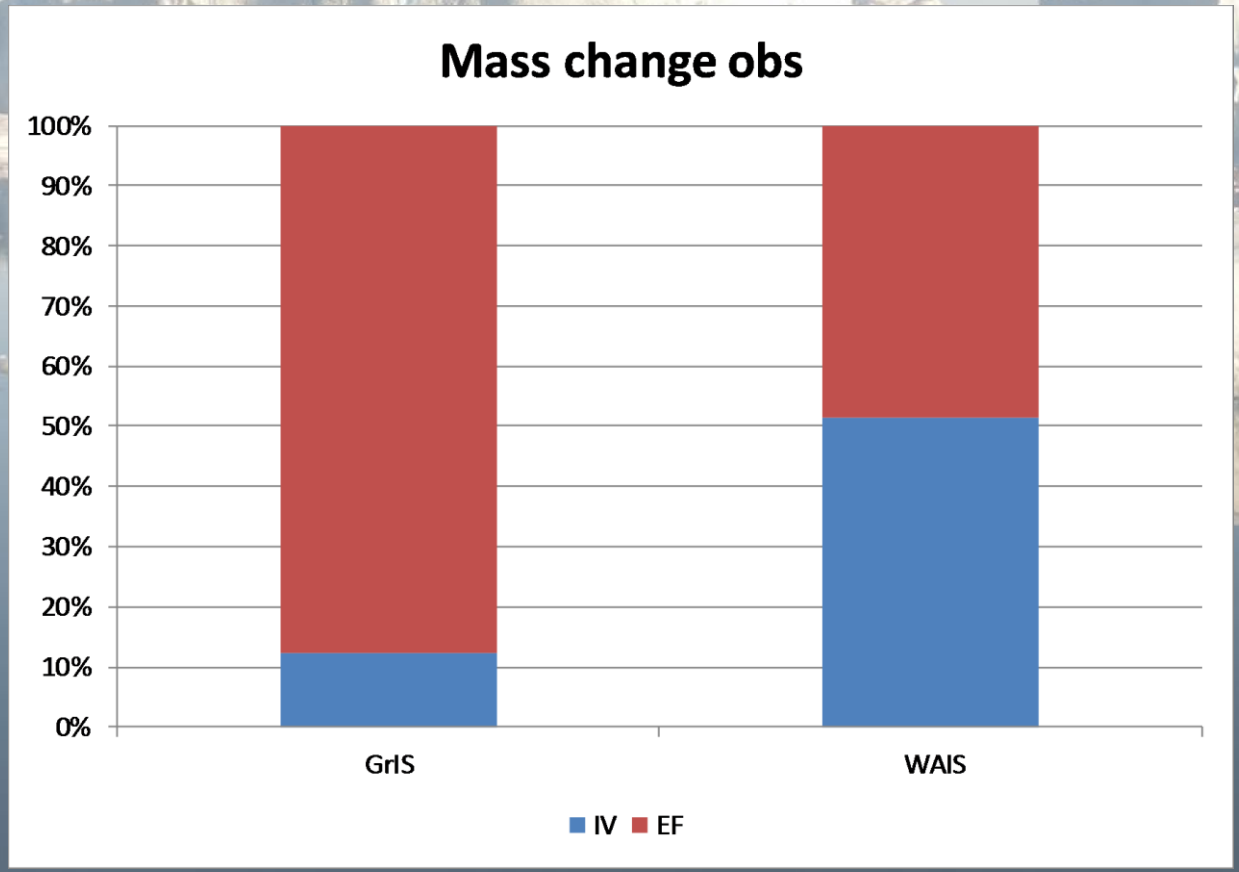
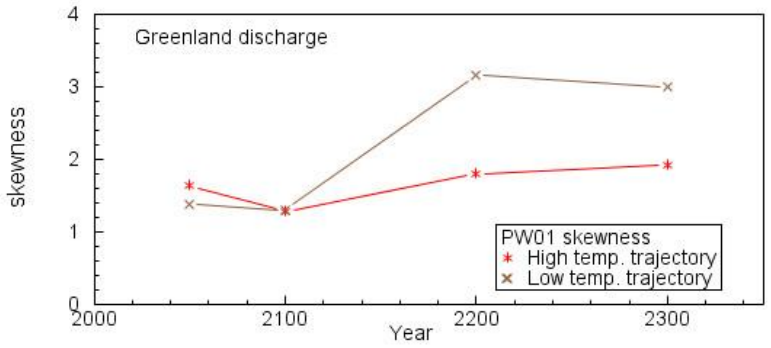
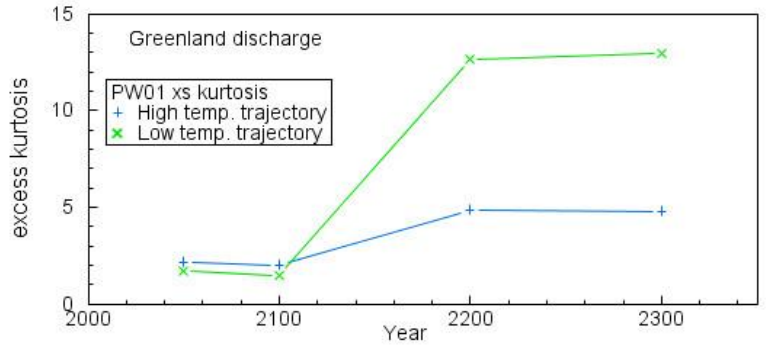
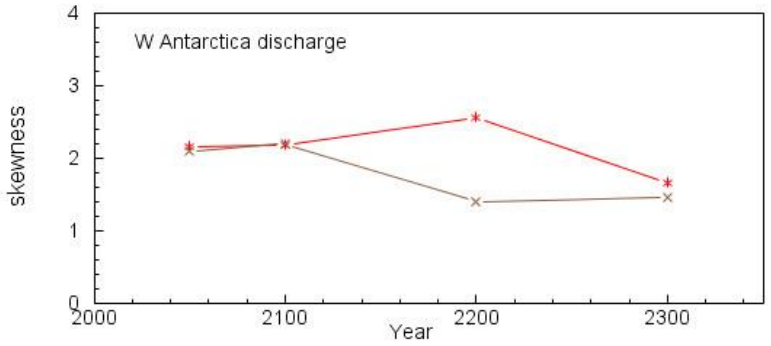
Internal Variability (IV) vs. External Forcing (EF)?

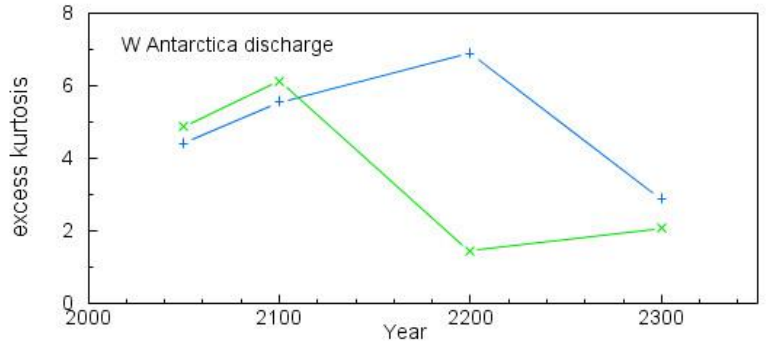


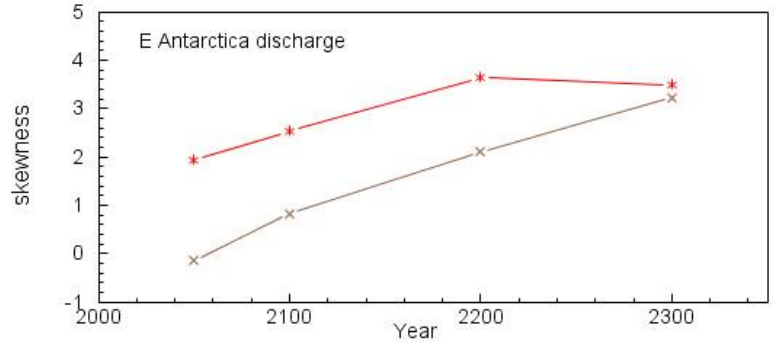
Process kurtosis and skewness

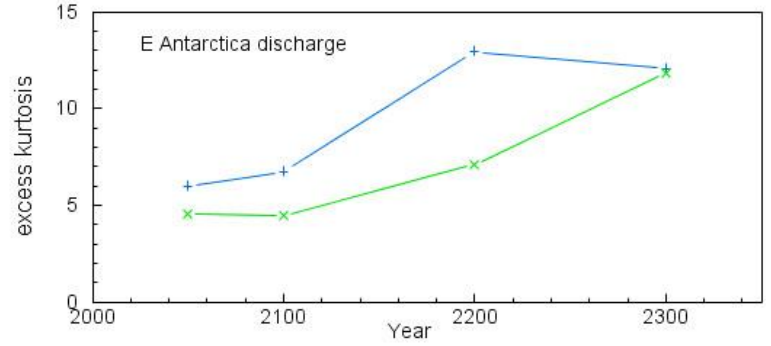












Kurtosis => tailedness

Skewness => non symmetry

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Change in rel importance of a process between 2 degs and 5 degs

Ice dynamic processes

Dynamicals	B	BT	TS	HF	IC	DI
GrIS_2100	0.13	-0.04	-0.04	-0.03	-0.03	0.02
GrIS_2200	0.02	-0.15	0.04	0.10	-0.02	0.02
GrIS_2300	0.03	0.08	-0.07	-0.02	-0.02	-0.01
WAIS_2100	-0.17	0.00	0.00	0.11	0.00	0.05
WAIS_2200	-0.33	0.00	0.00	0.07	0.14	0.12
WAIS_2300	-0.28	0.00	0.00	0.10	0.10	0.09
EAIS_2100	-0.02	-0.02	-0.02	-0.02	-0.02	0.09
EAIS_2200	-0.06	-0.17	0.00	0.17	0.00	0.05
EAIS_2300	-0.07	-0.08	-0.02	0.08	0.02	0.07

B=buttressing; BT=basal traction;
TS=transverse stresses; HF= hydrofracture
IC=ice cliff; DI=dissipation of bergs

SMB processes

SMB	AM	AC	SI
GrIS_2100_Grounded ice	0.00	0.00	0.00
GrIS_2200_Grounded ice	-0.11	0.11	0.00
GrIS_2300_Grounded ice	0.00	0.00	0.00
WAIS_2100_Grounded ice	0.06	-0.06	0.00
WAIS_2200_Grounded ice	-0.11	0.11	0.00
WAIS_2300_Grounded ice	-0.28	0.28	0.00
WAIS_2100_Ice shelves	0.02	-0.04	0.02
WAIS_2200_Ice shelves	-0.06	0.11	-0.06
WAIS_2300_Ice shelves	-0.06	0.11	-0.06
EAIS_2100_Grounded ice	0.00	0.00	0.00
EAIS_2200_Grounded ice	-0.11	0.11	0.00
EAIS_2300_Grounded ice	-0.22	0.22	0.00
EAIS_2100_Ice shelves	0.00	0.00	0.00
EAIS_2200_Ice shelves	-0.11	0.11	0.00
EAIS_2300_Ice shelves	-0.11	0.11	0.00

AM=atmos. moisture/circulation
AC=albedo; SI=sea ice

Ocean processes

Ocean processes	CDW	AMOC
GrIS_2100	-0.06	0.06
GrIS_2200	0.06	-0.06
GrIS_2300	0.00	0.00
WAIS_2100	0.00	0.00
WAIS_2200	0.06	-0.06
WAIS_2300	0.00	0.00
EAIS_2100	0.00	0.00
EAIS_2200	0.06	-0.06
EAIS_2300	-0.06	0.06

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What problems can SEJ address?

- Good for low probability/high impact processes/events
- E.g. earthquakes, volcanic eruptions, pandemics, tipping elements in the Earth System...

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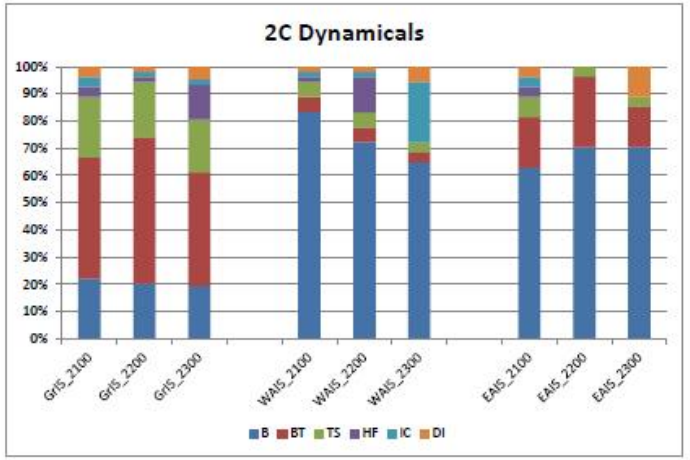

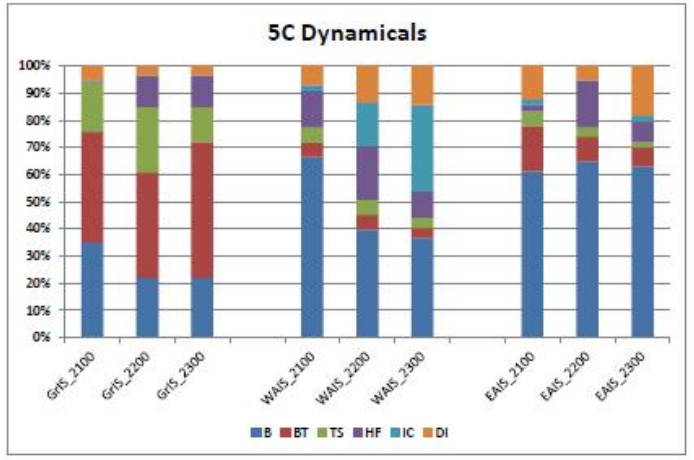

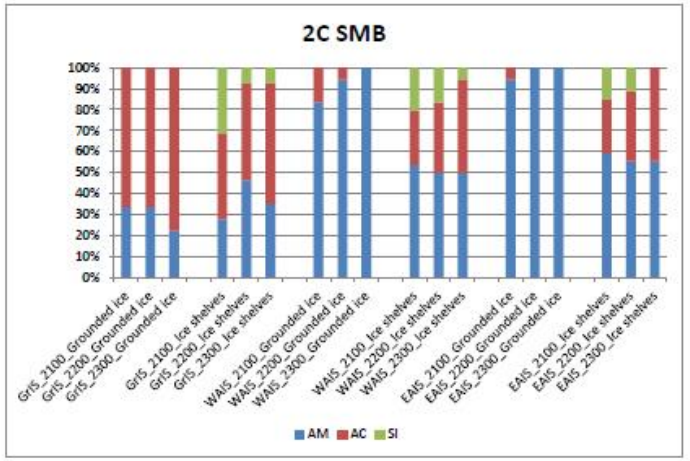

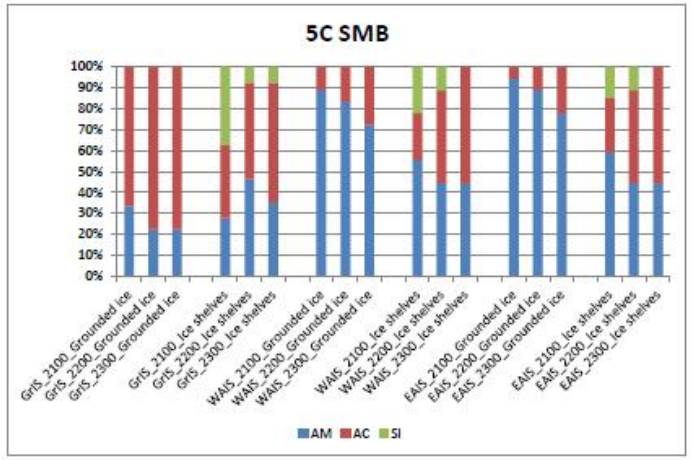

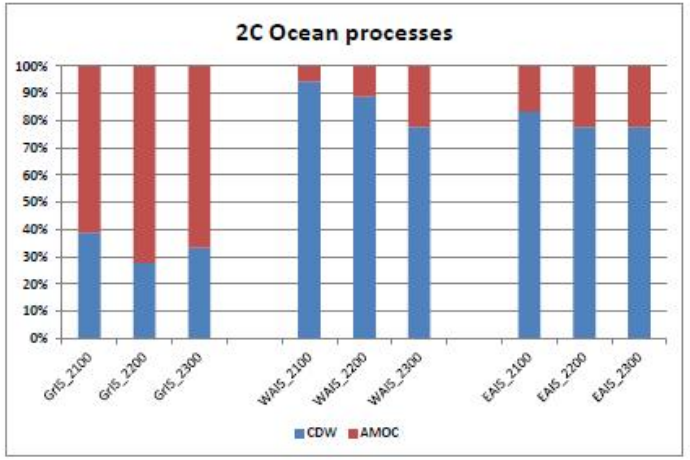

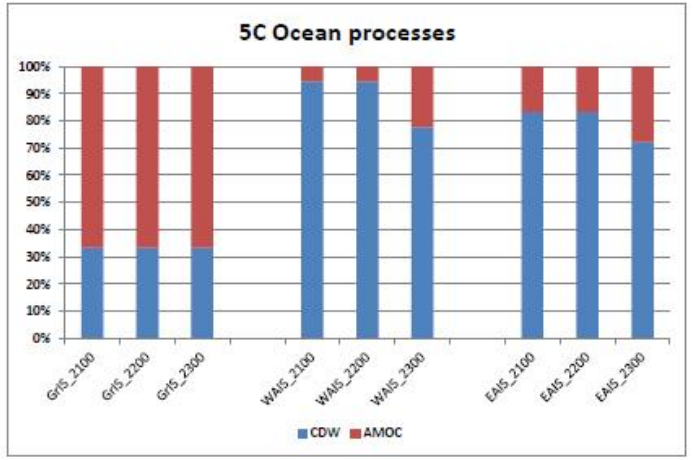

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