Supplementary material

Recent improvements of the melt pond albedo parametrization in HIRHAM-NAOSIM

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Parametrization 1 (autoregressive with ice categories)

4.2 Autoregressive with ice categories

Variables needed:

- Ice surface temperature $T[°C]$
- Ice thickness $[m]$

Melt ponds evolve differently on thick and thin ice (Box 3):

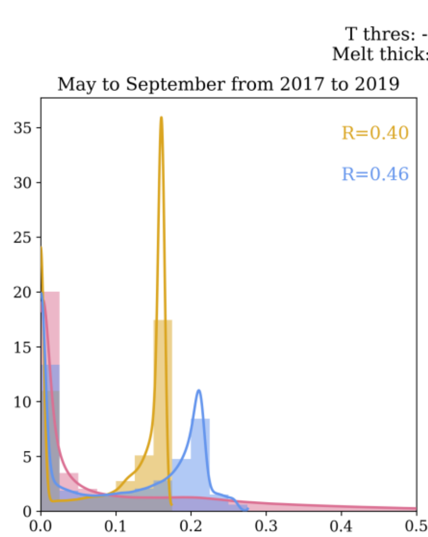
- Thin ice: young, low surface roughness, large but shallow ponds
- Thick ice: older, high surface roughness, small but deep ponds

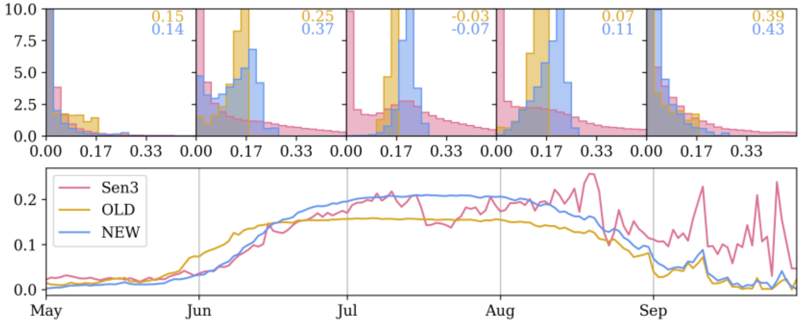
3 Cases

1: cold	2: warm, thin ice	3: warm, thick ice
- No melt - refreezing	- Melt - Fraction grows fast	- Melt - Fraction grows slow

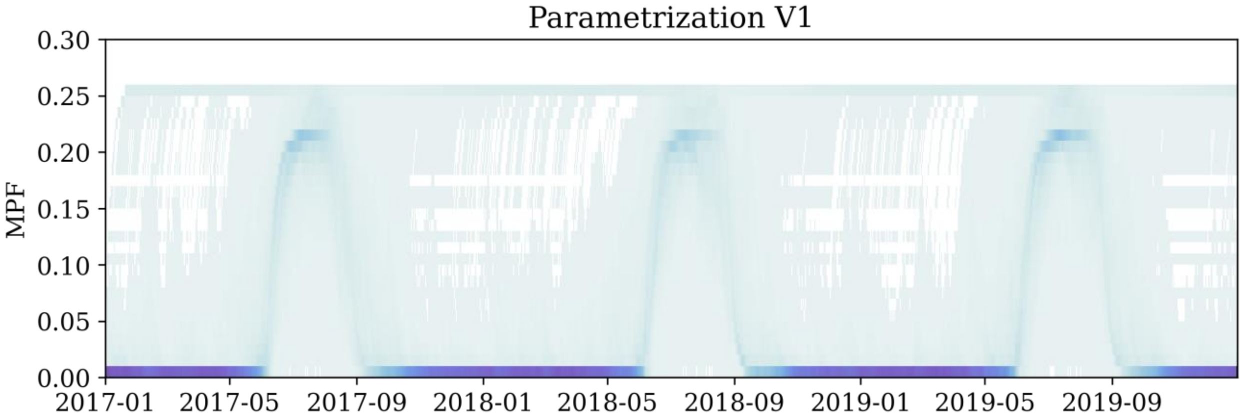
$$f_{p_t} = f_{p_{t-1}} \cdot memory + (1 - memory) \cdot \underbrace{Meltrate}_{} \cdot (T_t - T_{thres})$$

Case1: $Meltrate_1 = 0$
Case2: $Meltrate_2 > 0$
Case3: $Meltrate_3 > 0$

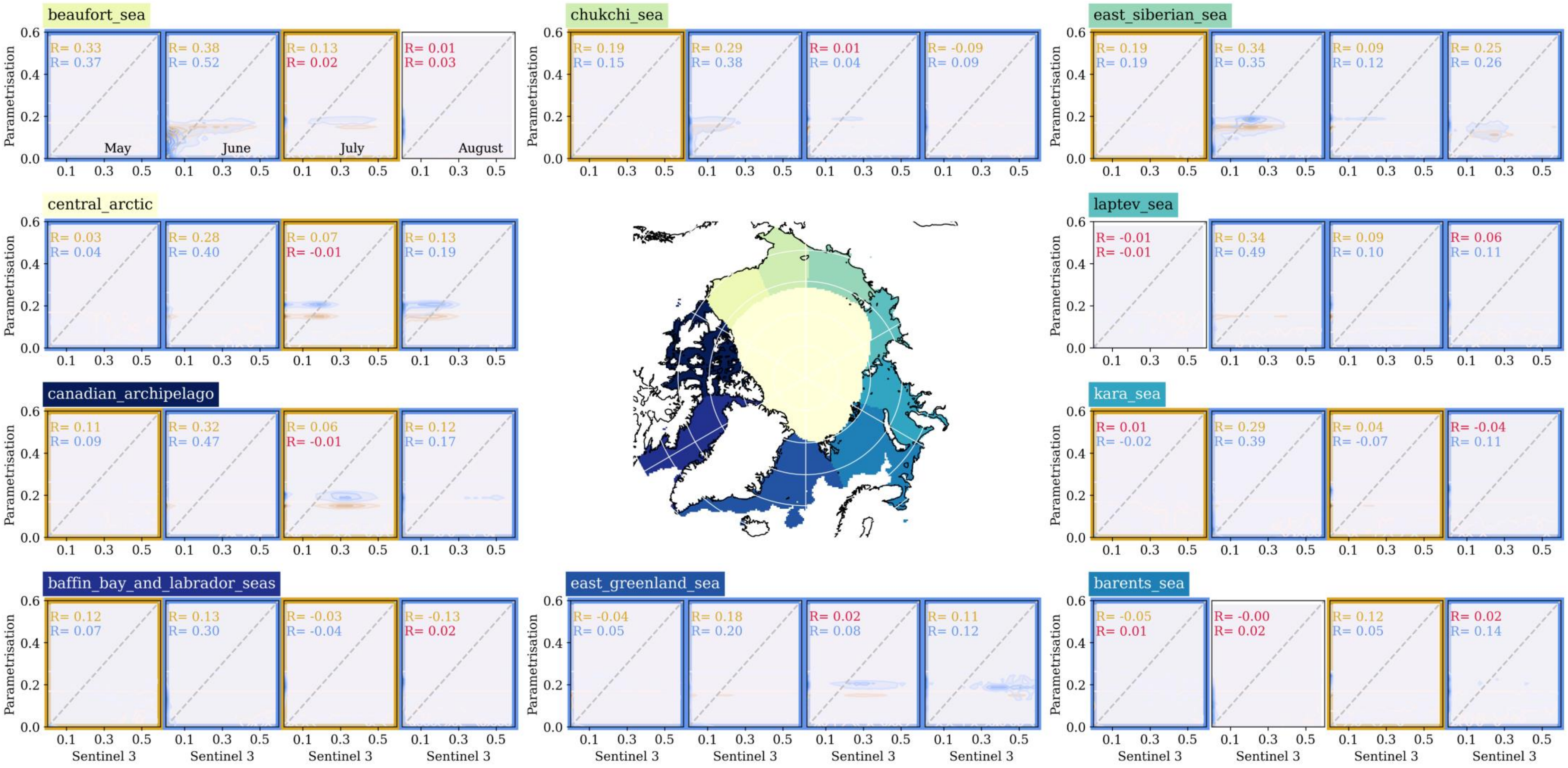




	μ	σ	May: μ | σ	Jun: μ | σ	Jul: μ | σ	Aug: μ | σ	Sep: μ | σ
Sen3	**0.11**	0.15	**0.02** | 0.06	**0.11** | 0.15	**0.18** | 0.16	**0.19** | 0.20	**0.11** | 0.15
OLD	**0.10**	0.07	**0.02** | 0.04	**0.13** | 0.04	**0.16** | 0.01	**0.14** | 0.03	**0.03** | 0.05
NEW	**0.11**	0.09	**0.01** | 0.04	**0.12** | 0.07	**0.21** | 0.02	**0.18** | 0.05	**0.04** | 0.05

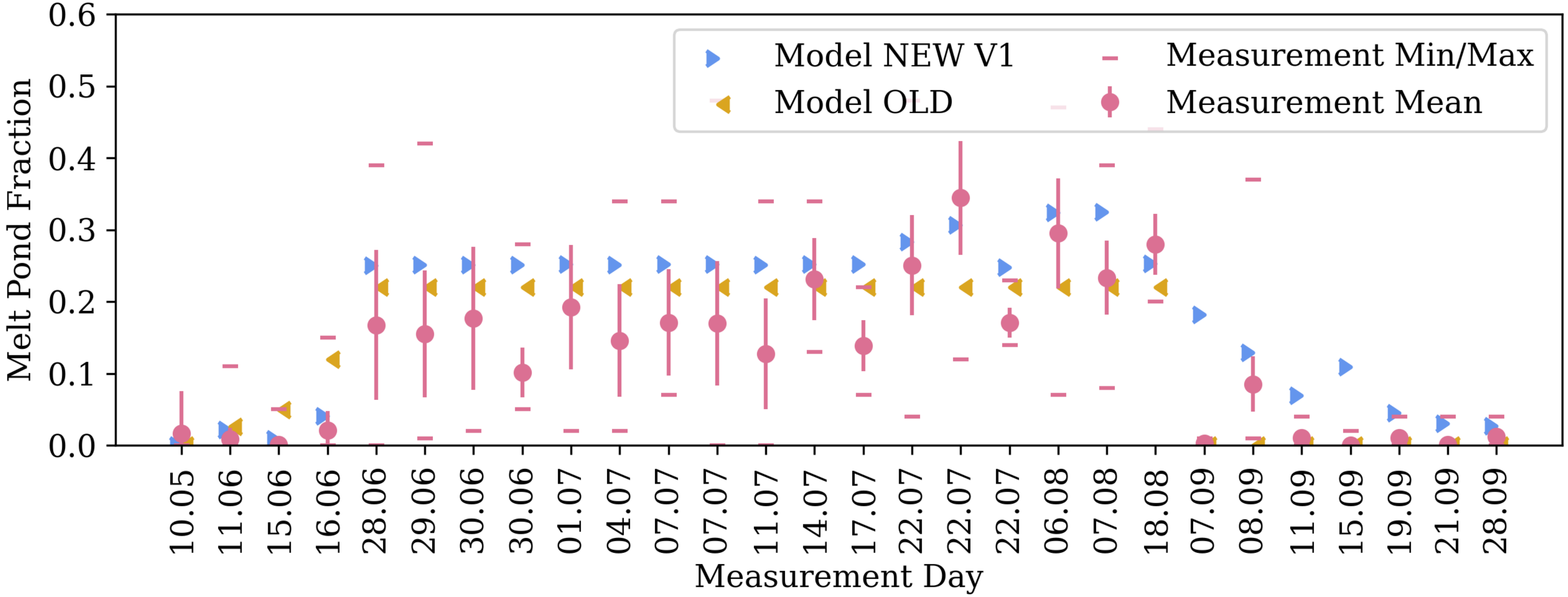


Parametrization 1 – 2D-histograms for different regions



Comparison to helicopter observations from MOSAIC

- Melt pond fraction observations: Sperzel et al. Scientific Data, 10(1) (2023)
- Simulation with Parametrization 1
- Simulation with old (linear) Parametrization



Parametrization 2 (accumulated melt volume)

4.3. Accumulated Melt Volume

Variables needed:

- Ice surface temperature $T[°C]$
- Ice thickness $[m]$
- Heat flux for melting ice $F[\frac{W}{m^2}]$

Parametrizing the melt volume per unit area for each timestep:

$$V_t = V_{t-1} \cdot (1 - loss) + \ gain \cdot \Delta t$$

The meltwater gain is calculated from the residual flux for melting ice (F) and the enthalpy of fusion (H): $gain = F/(H \cdot \rho_{H_2O})$

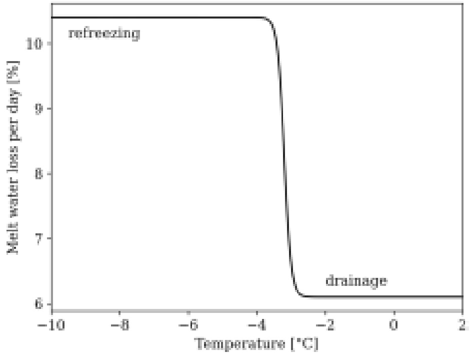


Fig. 6: Meltwater loss due to drainage and refreezing

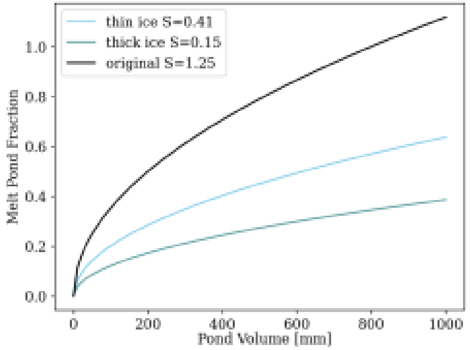
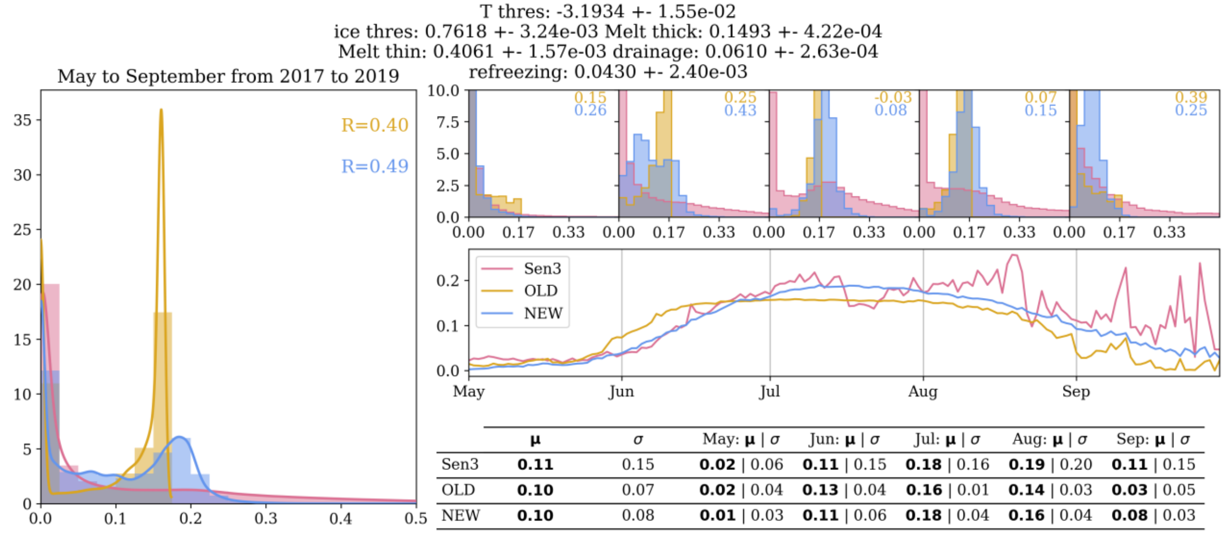


Fig. 7: Scaling of pond Volume and fraction with $f = \sqrt{V \cdot S}$



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<tr><th></th><th>μ</th><th>σ</th><th>May: μ | σ</th><th>Jun: μ | σ</th><th>Jul: μ | σ</th><th>Aug: μ | σ</th><th>Sep: μ | σ</th></tr>
<tr><td>Sen3</td><td>0.11</td><td>0.15</td><td>0.02 | 0.06</td><td>0.11 | 0.15</td><td>0.18 | 0.16</td><td>0.19 | 0.20</td><td>0.11 | 0.15</td></tr>
<tr><td>OLD</td><td>0.10</td><td>0.07</td><td>0.02 | 0.04</td><td>0.13 | 0.04</td><td>0.16 | 0.01</td><td>0.14 | 0.03</td><td>0.03 | 0.05</td></tr>
<tr><td>NEW</td><td>0.10</td><td>0.08</td><td>0.01 | 0.03</td><td>0.11 | 0.06</td><td>0.18 | 0.04</td><td>0.16 | 0.04</td><td>0.08 | 0.03</td></tr>
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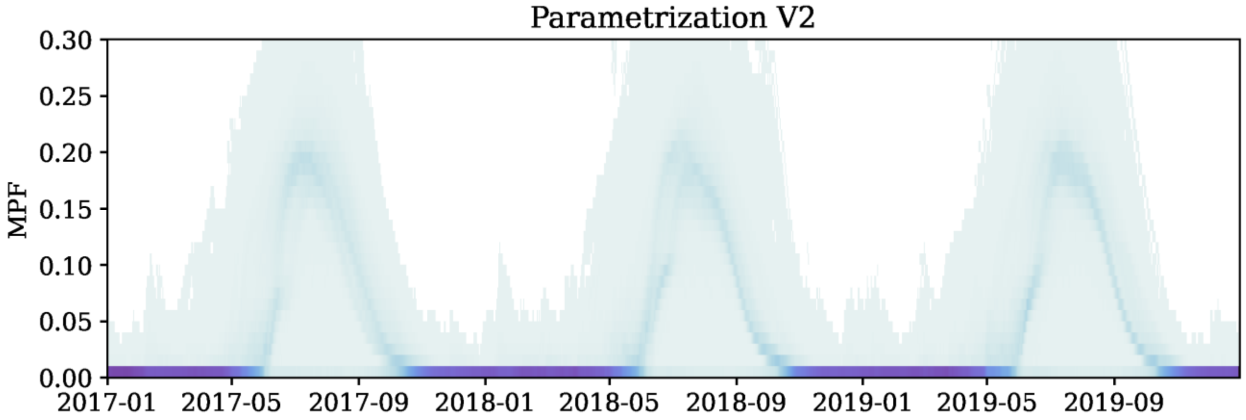

Parametrization 2 – 2D-histograms for different regions