



Supplement of

Ice content and interannual water storage changes of an active rock glacier in the dry Andes of Argentina

Christian Halla et al.

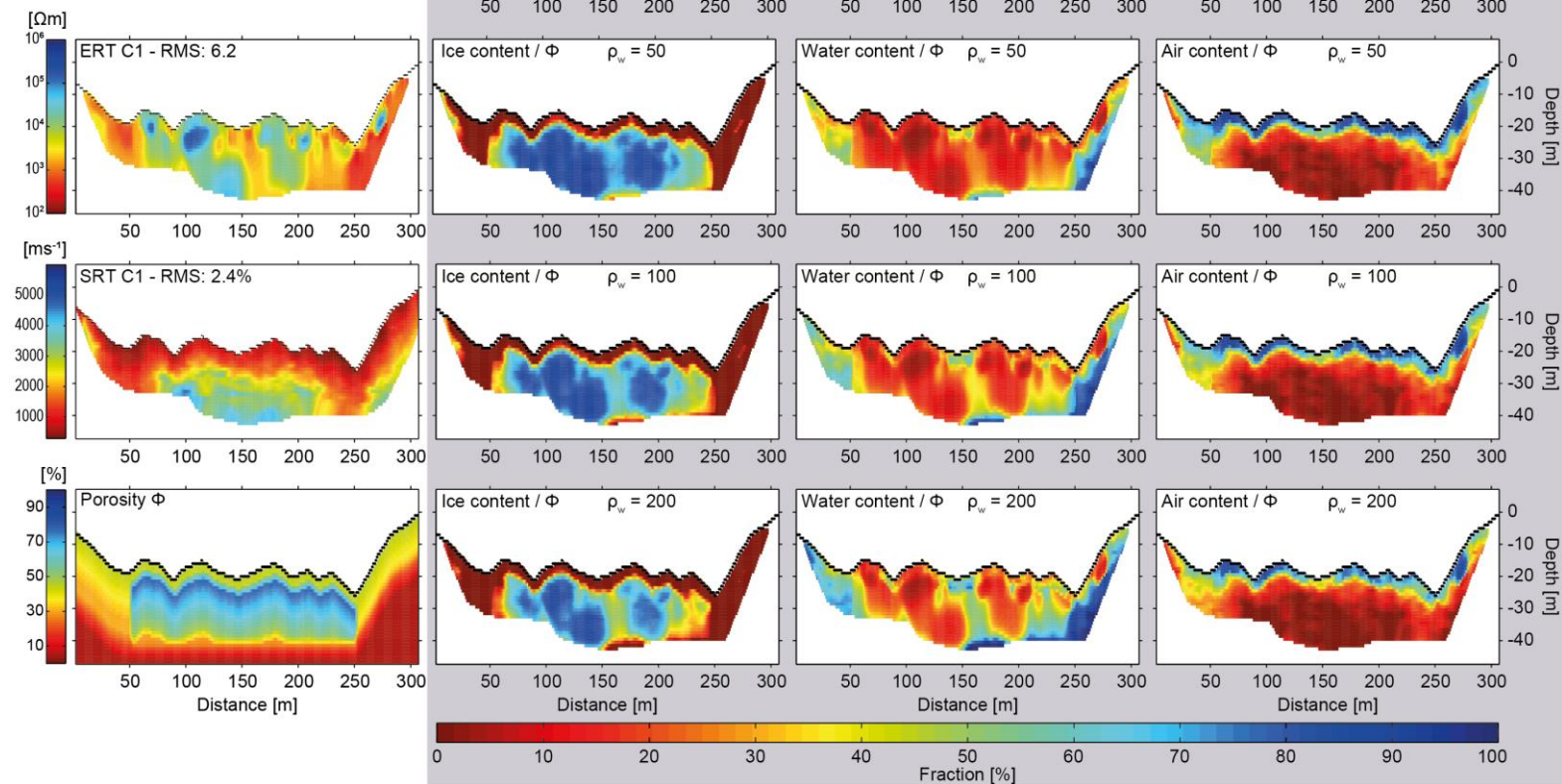
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S1 Four phase model (4PM) sceanarios of Dos Lenguas rock glacier

4PM Input Data

Field data Dos Linguas cross-profile C1:
 Electrical resistivity tomography (ERT), 23.02.2017
 Refraction seismic tomography (SRT), 24.02.2017
 0 m depth \approx 4470 m asl
 Used 4PM parameters:
 Mixed Φ , $\rho_w = 30, 50, 100 \text{ \Ωm}$
 $v_{sw} = 330 \text{ ms}^{-1}$, $v_{water} = 1500 \text{ ms}^{-1}$, $v_{ice} = 3500 \text{ ms}^{-1}$
 Archie's law: $a = 1$, $m = 2$, $n = 2$



10 Fig. S 1: 4PM results of cross-profile C1 for the mixed porosity model. Ice, water and air content per porosity (Φ) are given for four pore water resistivities ($\rho_w = 30, 50, 100, 200 \text{ \Ωm}$).

4PM Input Data

Field data Dos Lenguas cross-profile C1:
 Electrical resistivity tomography (ERT), 23.02.2017
 Refraction seismic tomography (SRT), 24.02.2017
 0 m depth \approx 4470 m asl
 Used 4PM parameters:
 $\Phi = 70\%$, $\rho_w = 30, 50, 100 \text{ \& } 200 \text{ \& } \Omega\text{m}$
 $v_{\text{air}} = 330 \text{ ms}^{-1}$, $v_{\text{water}} = 1500 \text{ ms}^{-1}$, $v_{\text{ice}} = 3500 \text{ ms}^{-1}$
 Archie's law: $a = 1$, $m = 2$, $n = 2$

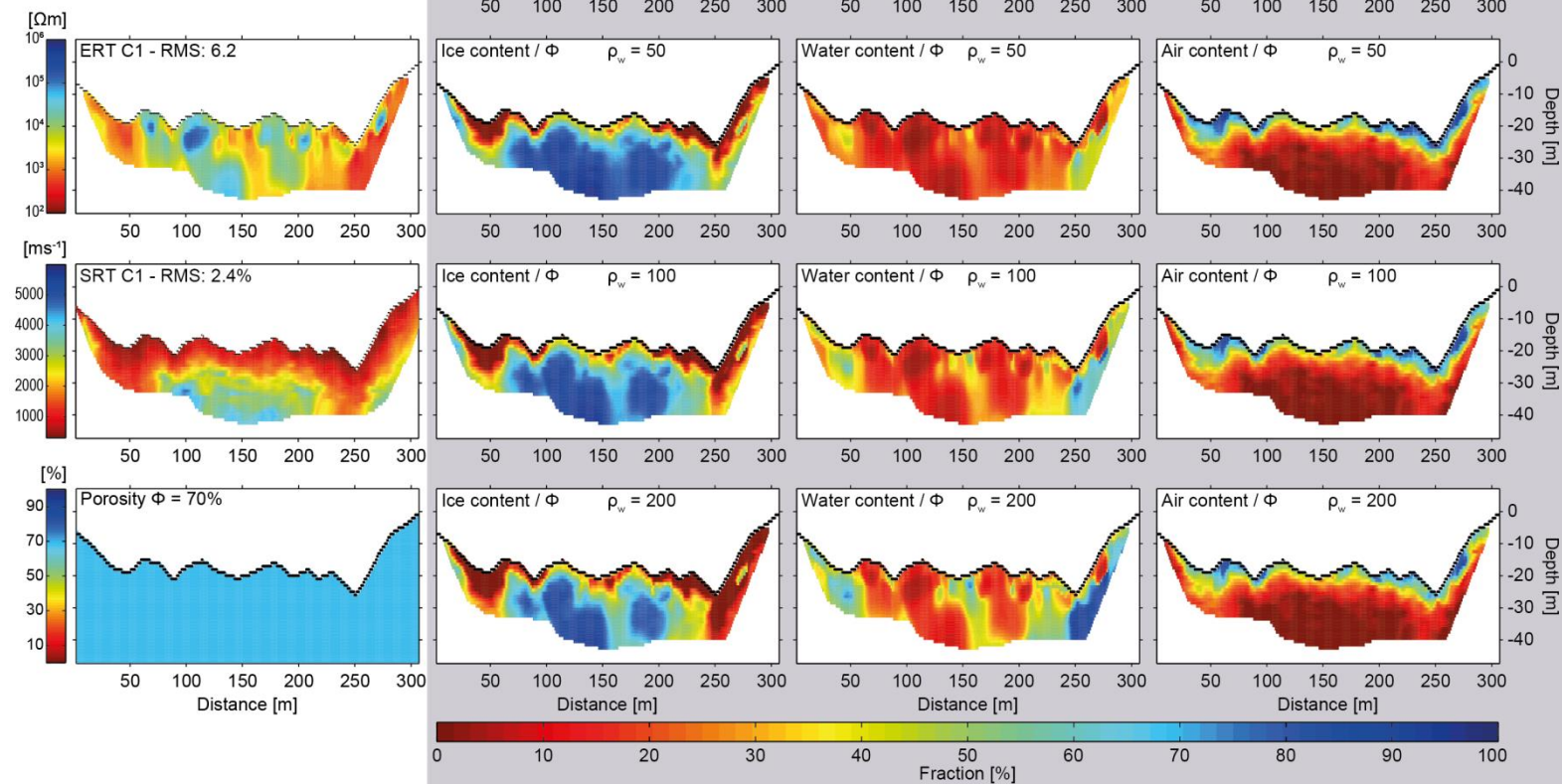


Fig. S 2: 4PM results of cross-profile C1 for the 70% porosity model. Ice, water and air content per porosity (Φ) are given for four pore water resistivities ($\rho_w = 30, 50, 100, 200 \text{ \& } \Omega\text{m}$).

4PM Input Data

Field data Dos Lunguas cross-profile C1:
 Electrical resistivity tomography (ERT), 23.02.2017
 Refraction seismic tomography (SRT), 24.02.2017
 0 m depth \approx 4470 m asl
Used 4PM parameters:
 $\Phi = 50\%$, $\rho_w = 30, 50, 100 \text{ \& } 200 \text{ \& } \Omega\text{m}$
 $v_{\text{air}} = 330 \text{ ms}^{-1}$, $v_{\text{water}} = 1500 \text{ ms}^{-1}$, $v_{\text{ice}} = 3500 \text{ ms}^{-1}$
 Archie's law: $a = 1$, $m = 2$, $n = 2$

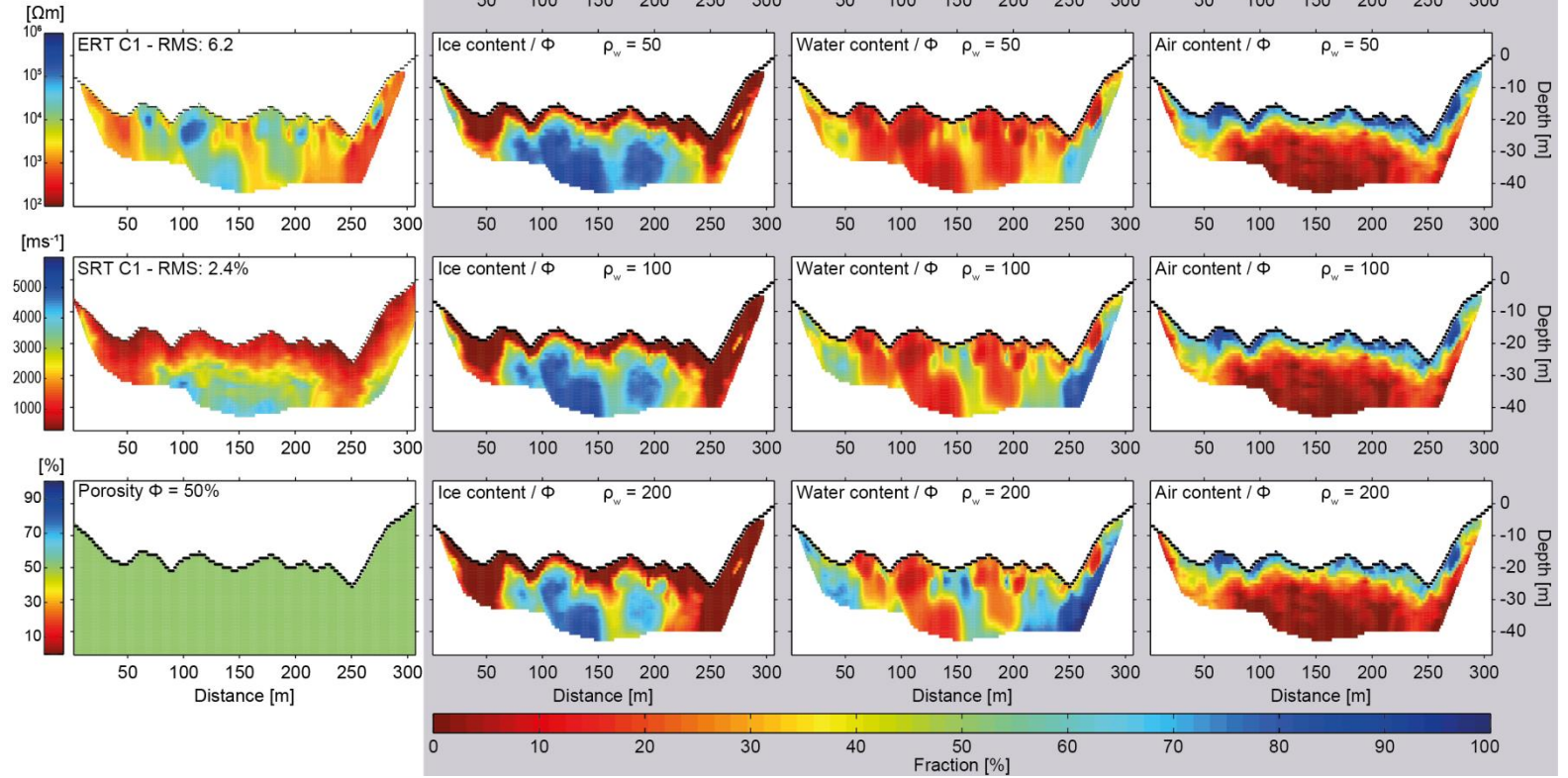


Fig. S 3: 4PM results of cross-profile C1 for the 50% porosity model. Ice, water and air content per porosity (Φ) are given for four pore water resistivities ($\rho_w = 30, 50, 100, 200 \text{ \& } \Omega\text{m}$).

4PM Input Data

Field data Dos Lunguas cross-profile C1:
 Electrical resistivity tomography (ERT), 23.02.2017
 Refraction seismic tomography (SRT), 24.02.2017
 0m depth \approx 4470 m asl
 Used 4PM parameters:
 $\Phi = 30\%$, $\rho_w = 30, 50, 100 \text{ \& } 200 \text{ \Omega m}$
 $v_{\text{air}} = 330 \text{ ms}^{-1}$, $v_{\text{water}} = 1500 \text{ ms}^{-1}$, $v_{\text{ice}} = 3500 \text{ ms}^{-1}$
 Archie's law: $a = 1$, $m = 2$, $n = 2$

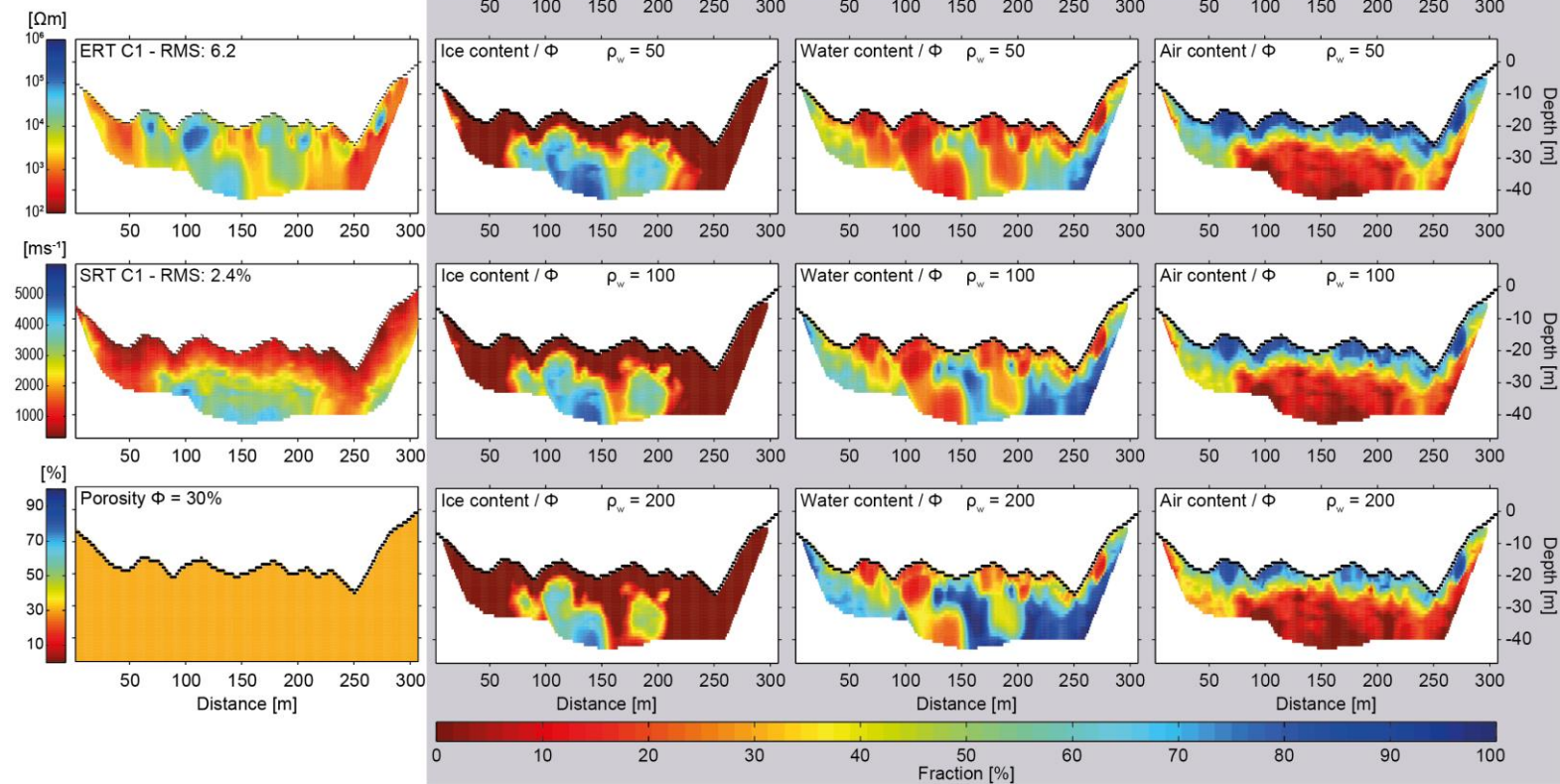


Fig. S 4: 4PM results of cross-profile C1 for the 30% porosity model. Ice, water and air content per porosity (Φ) are given for four pore water resistivities ($\rho_w = 30, 50, 100, 200 \text{ \Omega m}$).

4PM Input Data

Field data Dos Lunguas cross-profile C2:
 Electrical resistivity tomography (ERT), 02.03.2017
 Refraction seismic tomography (SRT), 02.03.2017
 0m depth \approx 4372 m asl
 Used 4PM parameters:
 mixed $\Phi = 70\%$, $\rho_w = 30, 50, 100 \text{ \& } 200 \text{ \& } \Omega\text{m}$
 $v_{\text{ice}} = 330 \text{ ms}^{-1}$, $v_{\text{water}} = 1500 \text{ ms}^{-1}$, $v_{\text{ice}} = 3500 \text{ ms}^{-1}$
 Archie's law: $a = 1$, $m = 2$, $n = 2$

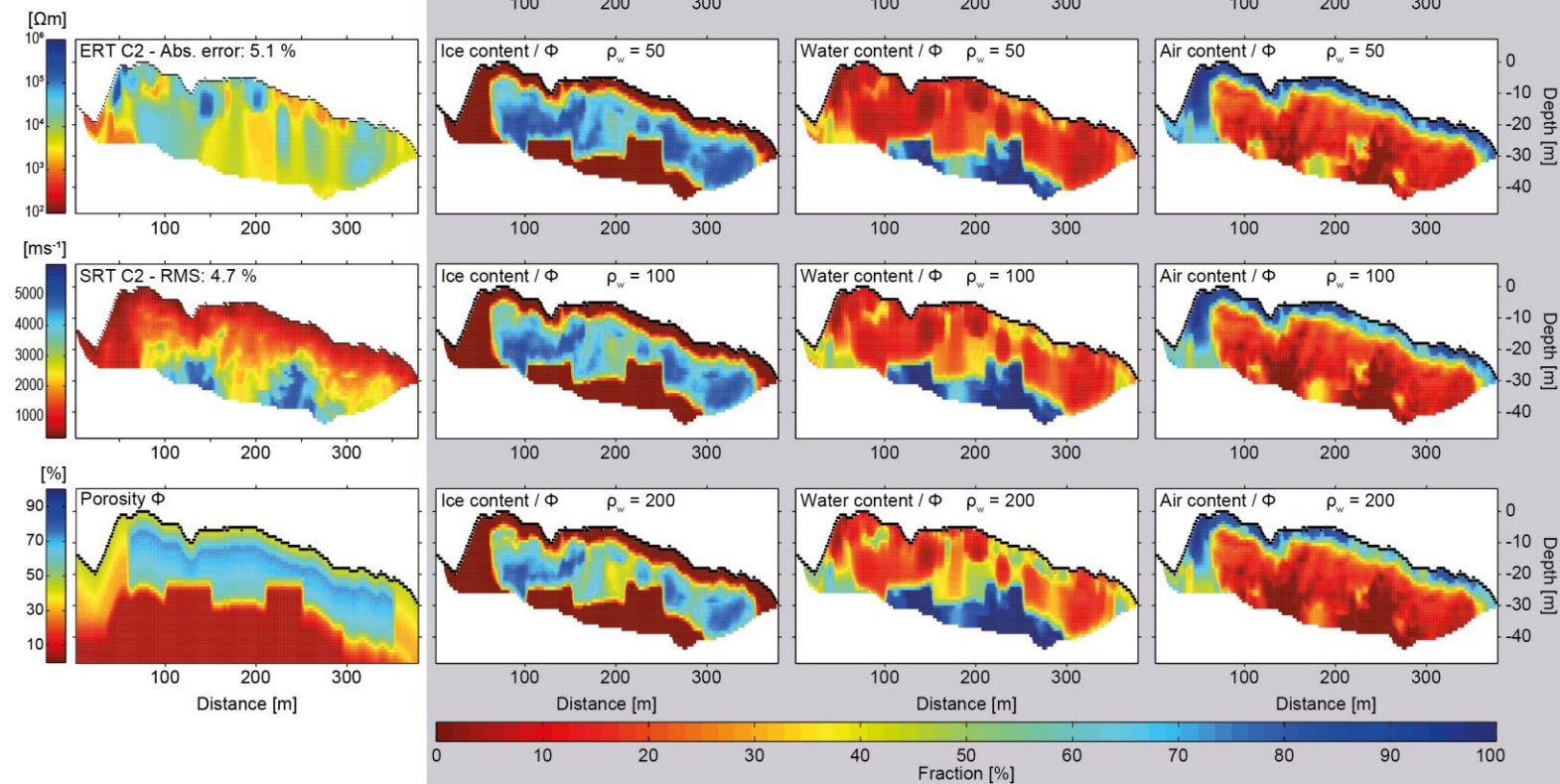


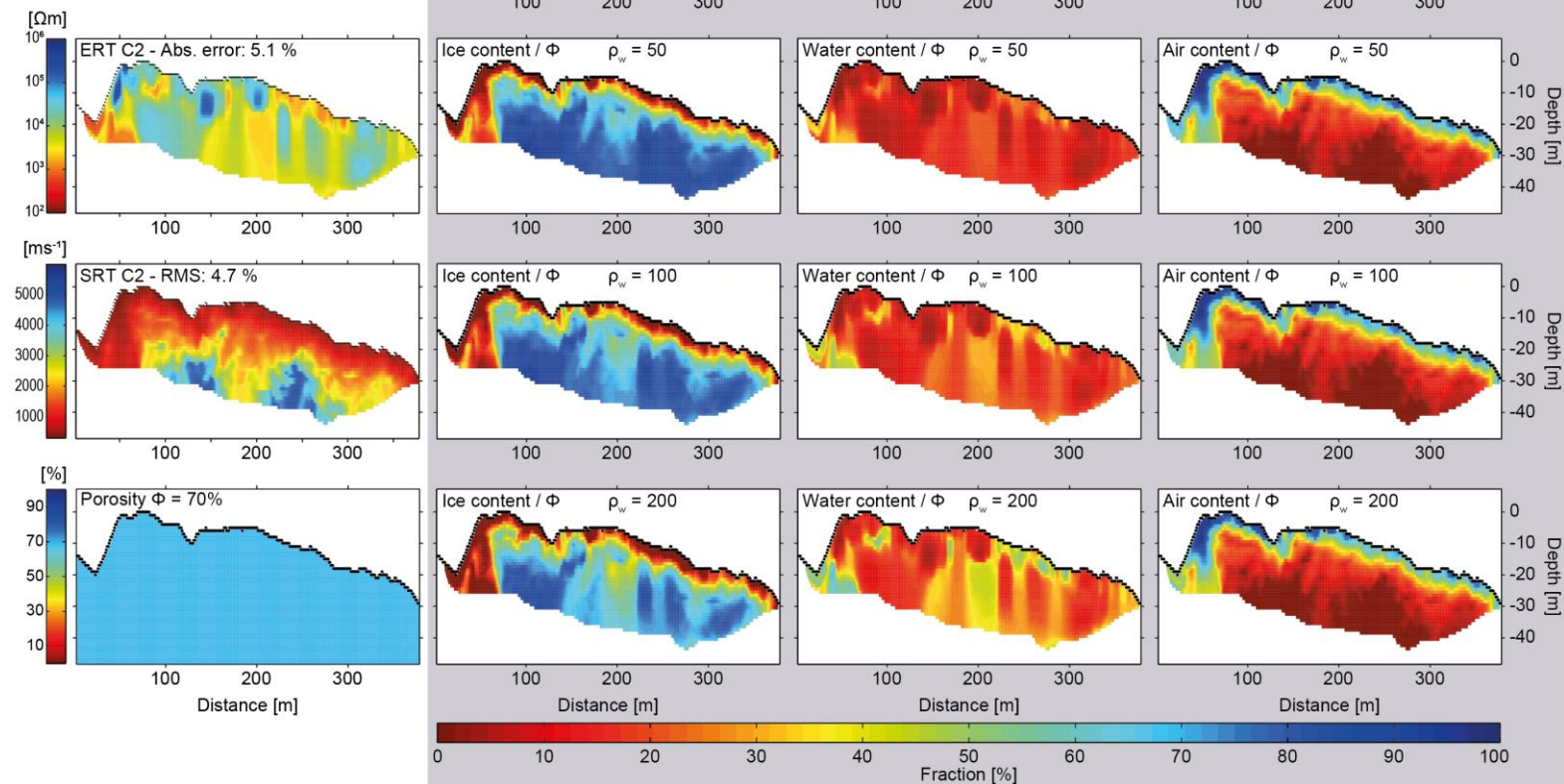
Fig. S 5: 4PM results of cross-profile C2 for the mixed porosity model. Ice, water and air content per porosity (Φ) are given for four pore water resistivities ($\rho_w = 30, 50, 100, 200 \text{ \& } \Omega\text{m}$).

4PM Input Data

Field data Dos Lenguas cross-profile C2:
Electrical resistivity tomography (ERT), 02.03.2017
Refraction seismic tomography (SRT), 02.03.2017
0m depth = 4372 m asl

Used 4PM parameters:

$\Phi = 70\%$, $\rho_w = 30, 50, 100 \text{ \& } 200 \text{ \& } \Omega\text{m}$
 $v_{\text{ice}} = 330 \text{ ms}^{-1}$, $v_{\text{water}} = 1500 \text{ ms}^{-1}$, $v_{\text{ice}} = 3500 \text{ ms}^{-1}$
Archies' law: $a = 1$, $m = 2$, $n = 2$



25 Fig. S 6: 4PM results of cross-profile C2 for the 70% porosity model. Ice, water and air content per porosity (Φ) are given for four pore water resistivities ($\rho_w = 30, 50, 100, 200 \text{ \& } \Omega\text{m}$).

4PM Input Data

Field data Dos Lenguas cross-profile C2:

Electrical resistivity tomography (ERT), 27.02.2017
Refraction seismic tomography (SRT), 28.02.2017
0m depth \approx 4372 m asl

Used 4PM parameters:

$\Phi = 50\%$, $\rho_w = 30, 50, 100 \text{ \& } 200 \text{ \& } \Omega\text{m}$
 $v_{\text{air}} = 330 \text{ ms}^{-1}$, $v_{\text{water}} = 1500 \text{ ms}^{-1}$, $v_{\text{ice}} = 3500 \text{ ms}^{-1}$
Archie's law: $a = 1$, $m = 2$, $n = 2$

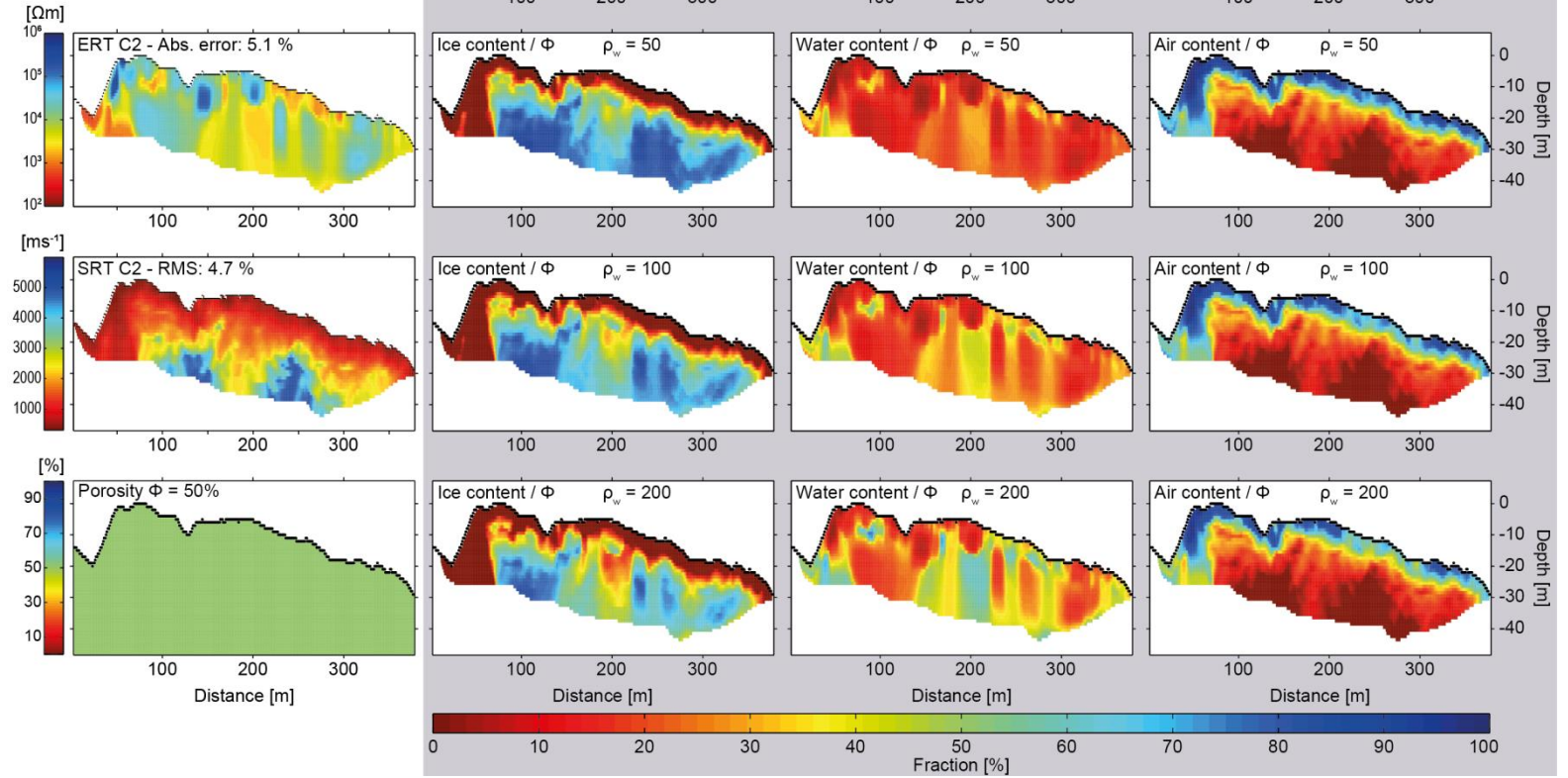
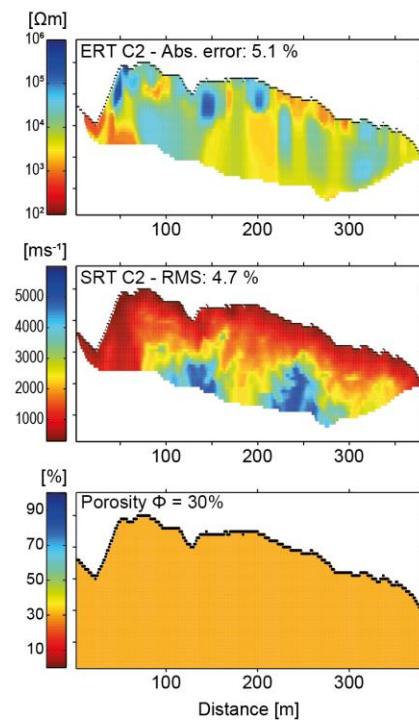


Fig. S 7: 4PM results of cross-profile C2 for the 50% porosity model. Ice, water and air content per porosity (Φ) are given for four pore water resistivities ($\rho_w = 30, 50, 100, 200 \text{ \& } \Omega\text{m}$).

4PM Input Data

Field data Dos Linguas cross-profile C2:
 Electrical resistivity tomography (ERT), 27.02.2017
 Refraction seismic tomography (SRT), 28.02.2017
 0m depth \approx 4372 m asl
 Used 4PM parameters:
 $\Phi = 30\%$, $\rho_w = 30, 50, 100 \text{ \& } 200 \text{ \& } \Omega\text{m}$
 $v_{\text{air}} = 330 \text{ ms}^{-1}$, $v_{\text{water}} = 1500 \text{ ms}^{-1}$, $v_{\text{ice}} = 3500 \text{ ms}^{-1}$
 Archie's law: $a = 1$, $m = 2$, $n = 2$



Results 4PM Dos Linguas C2: Fractions per porosity $\Phi = 30\%$ and $\rho_w = 30, 50, 100 \text{ \& } 200 \text{ \& } \Omega\text{m}$

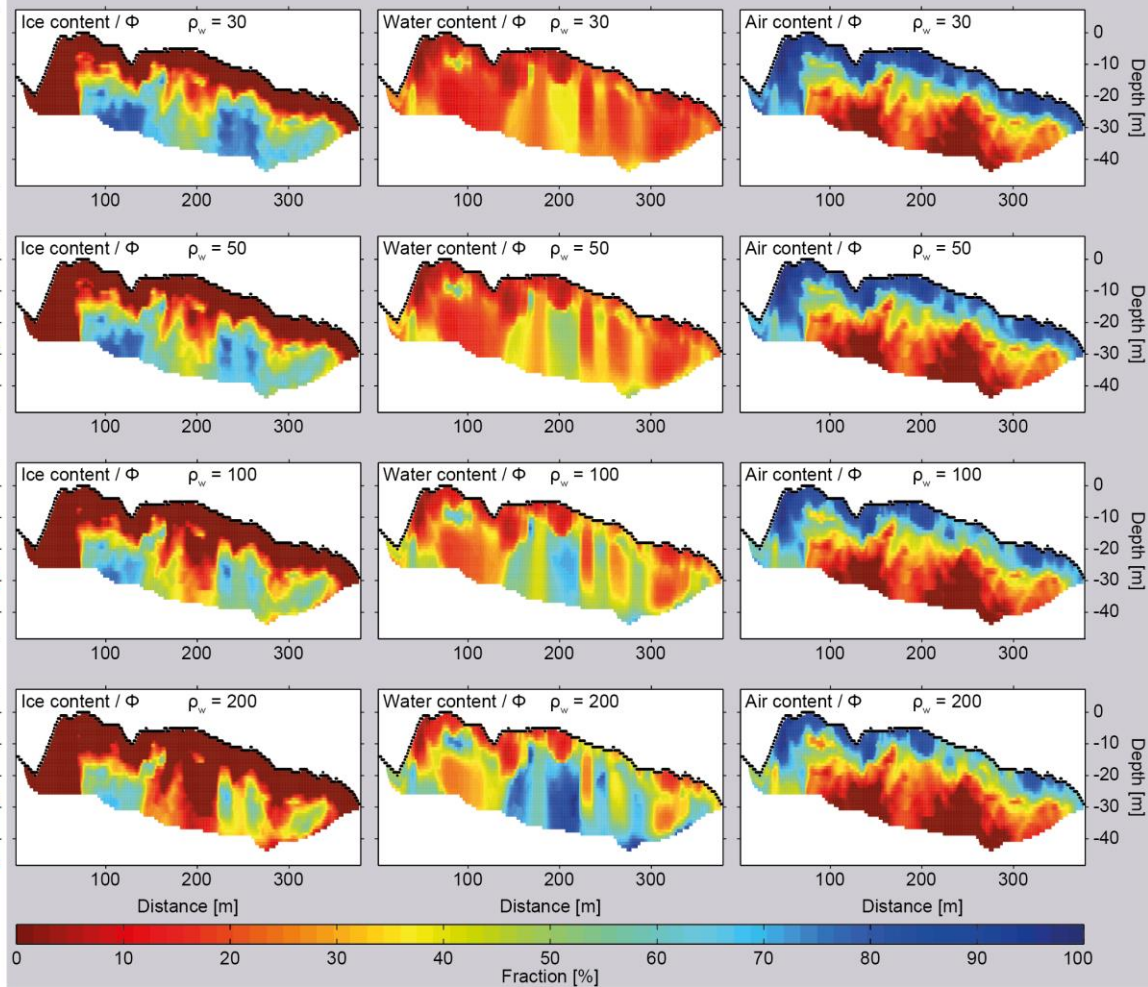


Fig. S 8: 4PM results of cross-profile C2 for the 30% porosity model. Ice, water and air content per porosity (Φ) are given for four pore water resistivities ($\rho_w = 30, 50, 100, 200 \text{ \& } \Omega\text{m}$).

4PM Input Data

Field data Dos Linguas profile L1:
 Electrical resistivity tomography (ERT), 02.03.2017
 Seismic refraction tomography (SRT), 02.03.2017
 0m depth = 4367 m asl
Used 4PM parameters:
 mixed Φ , $\rho_w = 30, 50, 100 \text{ \& } 200 \text{ \& } \Omega\text{m}$
 $v_{\text{air}} = 330 \text{ ms}^{-1}$, $v_{\text{water}} = 1500 \text{ ms}^{-1}$, $v_{\text{ice}} = 3500 \text{ ms}^{-1}$
 Archie's law: $a = 1$, $m = 2$, $n = 2$

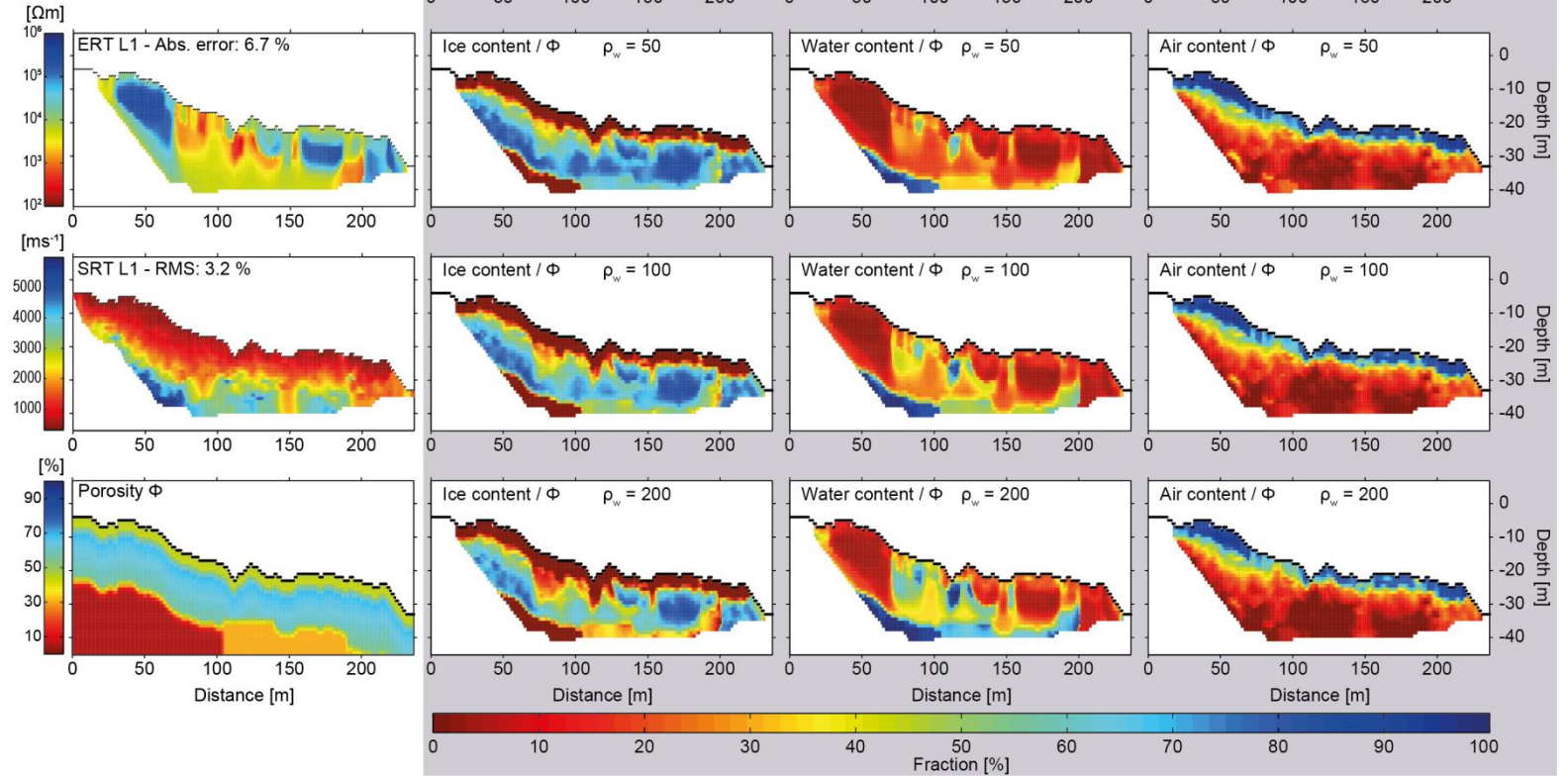


Fig. S 9: 4PM results of cross-profile L1 for the mixed porosity model. Ice, water and air content per porosity (Φ) are given for four pore water resistivities ($\rho_w = 30, 50, 100, 200 \text{ \& } \Omega\text{m}$).

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4PM Input Data

Field data Dos Lenguas profile L1:

Electrical resistivity tomography (ERT), 02.03.2017
Seismic refraction tomography (SRT), 02.03.2017
0m depth = 4367 m asl

Used 4PM parameters:

$\Phi = 70\%$, $\rho_w = 30, 50, 100 \text{ \& } 200 \text{ \& } \Omega\text{m}$
 $v_{\text{air}} = 330 \text{ ms}^{-1}$, $v_{\text{water}} = 1500 \text{ ms}^{-1}$, $v_{\text{ice}} = 3500 \text{ ms}^{-1}$
Archie's law: $a = 1$, $m = 2$, $n = 2$

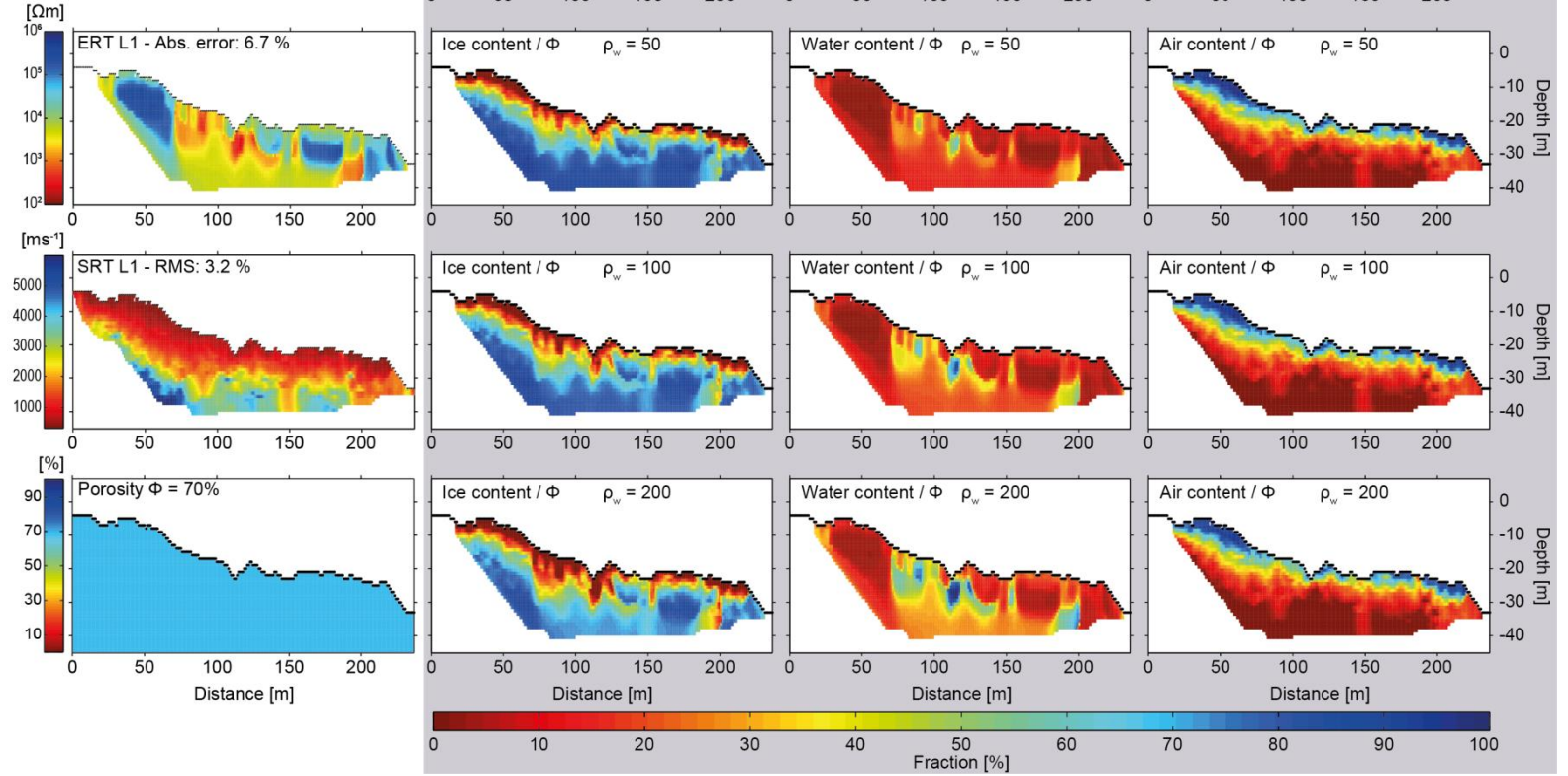
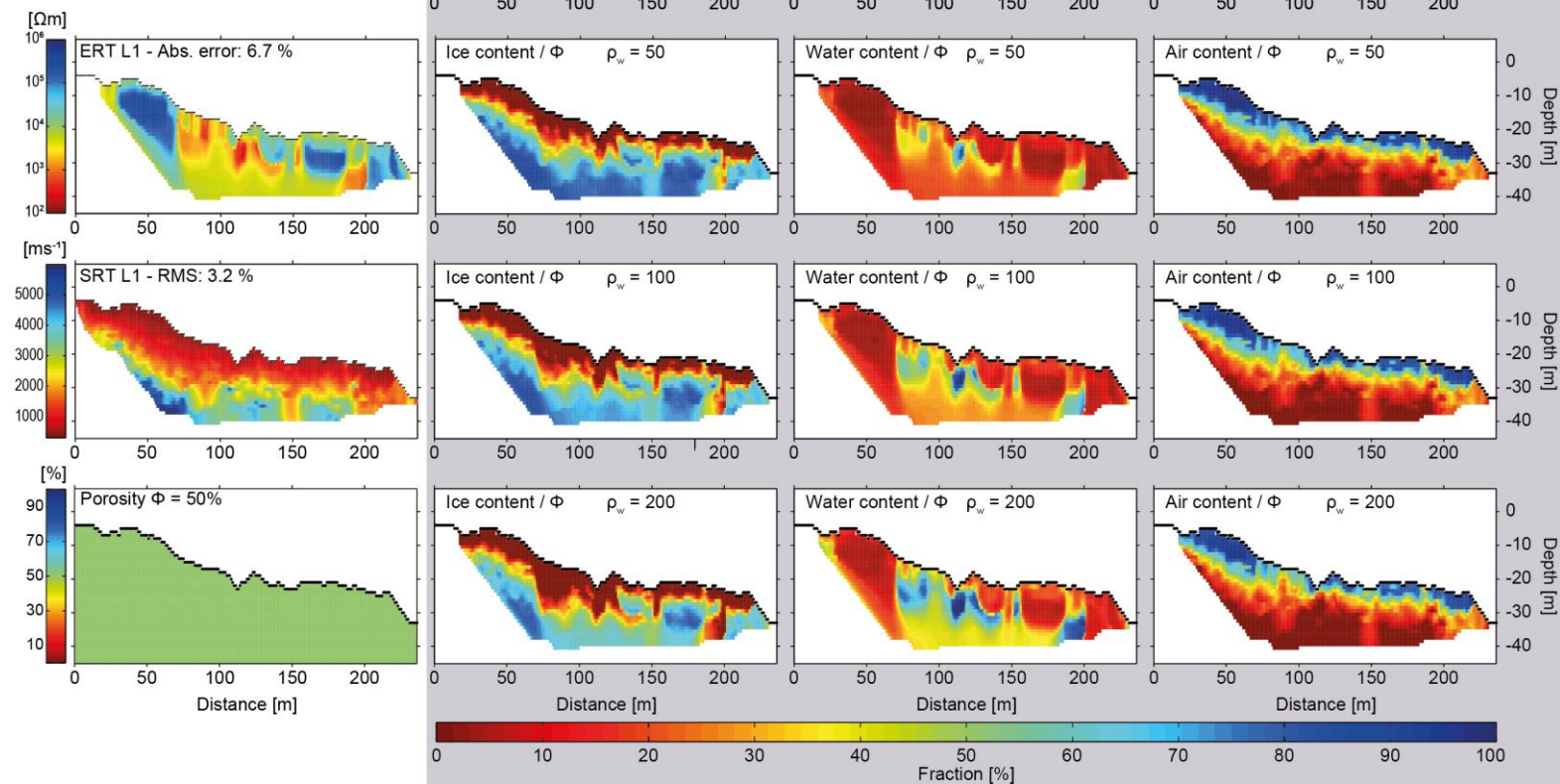


Fig. S 10: 4PM results of cross-profile L1 for the 70% porosity model. Ice, water and air content per porosity (Φ) are given for four pore water resistivities ($\rho_w = 30, 50, 100, 200 \text{ \& } \Omega\text{m}$).

4PM Input Data

Field data Dos Linguas profile L1:
 Electrical resistivity tomography (ERT), 02.03.2017
 Seismic refraction tomography (SRT), 02.03.2017
 0m depth \approx 4367 m asl
Used 4PM parameters:
 $\Phi = 50\%$, $\rho_w = 30, 50, 100 \text{ \& } 200 \text{ \Omega m}$
 $v_{\text{ice}} = 330 \text{ ms}^{-1}$, $v_{\text{water}} = 1500 \text{ ms}^{-1}$, $v_{\text{ice}} = 3500 \text{ ms}^{-1}$
 Archie's law: $a = 1$, $m = 2$, $n = 2$



40 Fig. S 11: 4PM results of cross-profile L1 for the 50% porosity model. Ice, water and air content per porosity (Φ) are given for four pore water resistivities ($\rho_w = 30, 50, 100, 200 \text{ \Omega m}$).

4PM Input Data

Field data Dos Lunegas profile L1:

Electrical resistivity tomography (ERT), 02.03.2017
Seismic refraction tomography (SRT), 02.03.2017
0m depth \approx 4367 m asl

Used 4PM parameters:

$\Phi = 30\%$, $\rho_w = 30, 50, 100 \text{ \& } 200 \text{ \& } \Omega\text{m}$
 $v_{\text{ice}} = 330 \text{ ms}^{-1}$, $v_{\text{water}} = 1500 \text{ ms}^{-1}$, $v_{\text{ice}} = 3500 \text{ ms}^{-1}$
Archie's law: $a = 1$, $m = 2$, $n = 2$

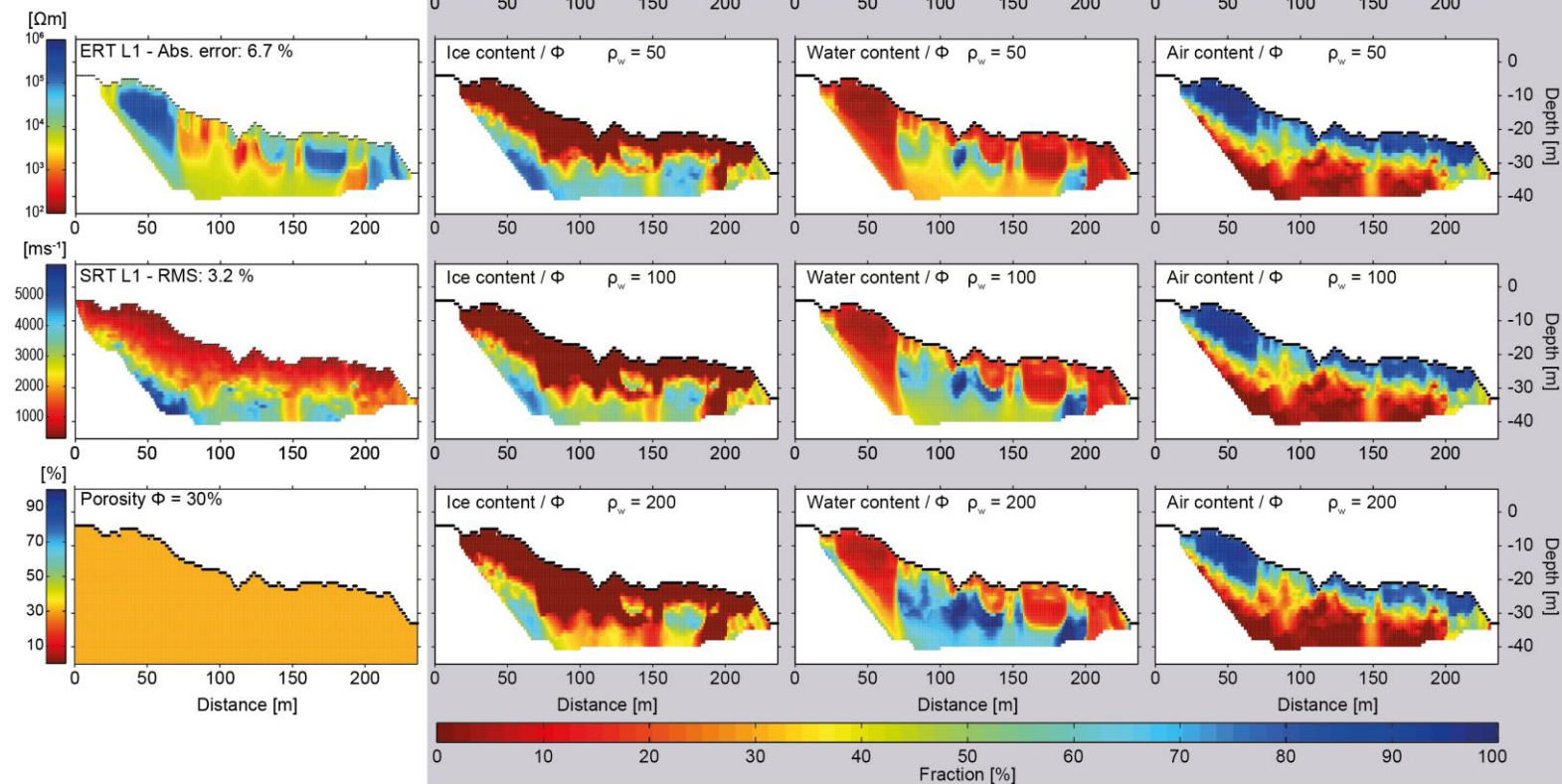


Fig. S 12: 4PM results of cross-profile L1 for the 30% porosity model. Ice, water and air content per porosity (Φ) are given for four pore water resistivities ($\rho_w = 30, 50, 100, 200 \text{ \& } \Omega\text{m}$).

4PM Input Data

Field data Dos Linguas profile L2:
 Electrical resistivity tomography (ERT), 01.03.2018
 Seismic refraction tomography (SRT), 02.03.2018
 0m depth = 4370 m asl
Used 4PM parameters:
 mixed Φ , $\rho_w = 30, 50, 100 \text{ \& } 200 \text{ \& } \Omega\text{m}$
 $v_{\text{air}} = 330 \text{ ms}^{-1}$, $v_{\text{water}} = 1500 \text{ ms}^{-1}$, $v_{\text{ice}} = 3500 \text{ ms}^{-1}$
 Archie's law: $a = 1$, $m = 2$, $n = 2$

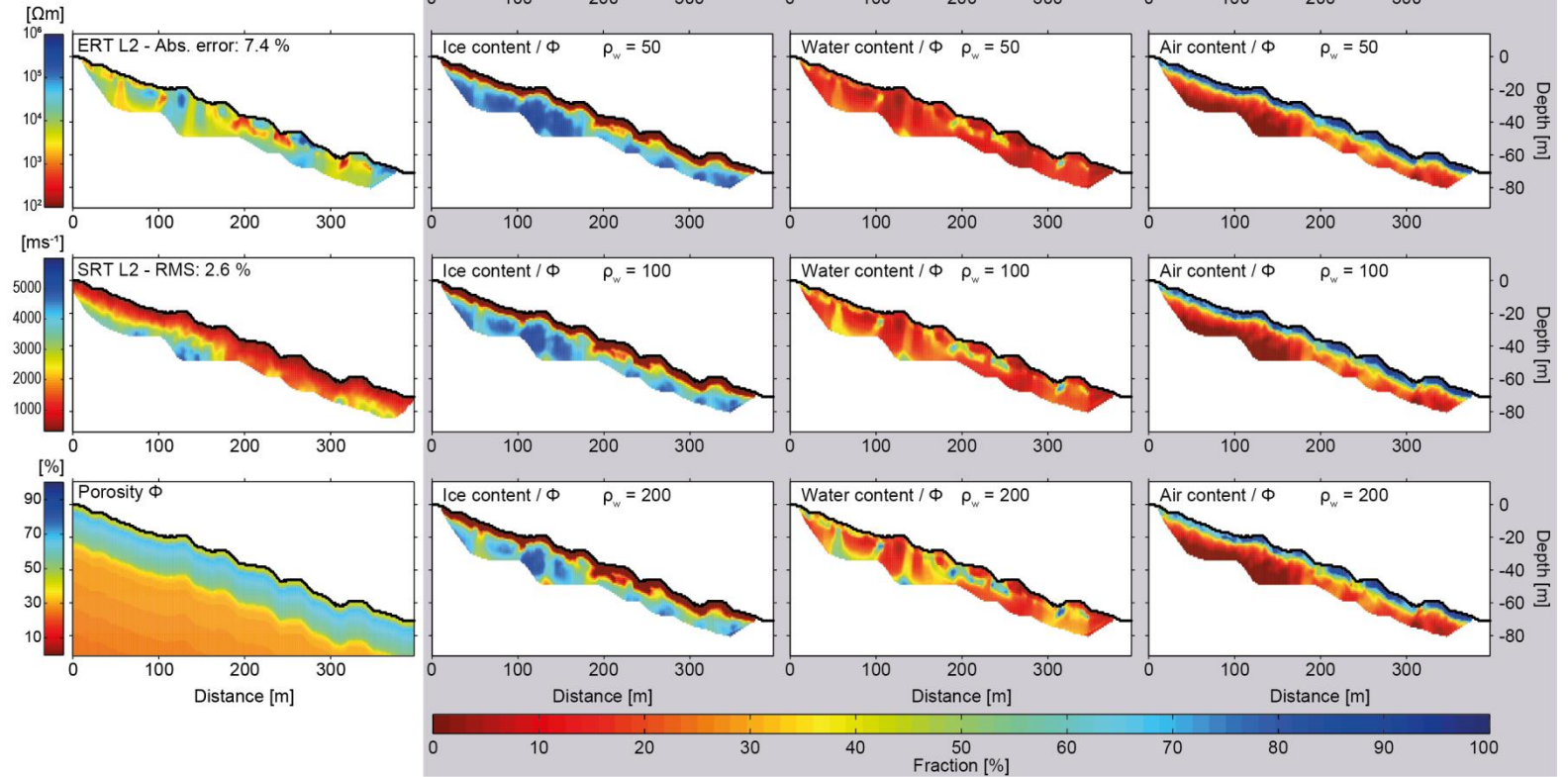


Fig. S 13: 4PM results of cross-profile L2 for the mixed porosity model. Ice, water and air content per porosity (Φ) are given for four pore water resistivities ($\rho_w = 30, 50, 100, 200 \text{ \& } \Omega\text{m}$).

4PM Input Data

Field data Dos Lunegas profile L2:
 Electrical resistivity tomography (ERT), 01.03.2018
 Seismic refraction tomography (SRT), 02.03.2018
 0m depth = 4370 m asl
 Used 4PM parameters:
 $\Phi = 70\%$, $\rho_w = 30, 50, 100 \text{ \& } 200 \text{ \& } \Omega\text{m}$
 $v_{\text{air}} = 330 \text{ ms}^{-1}$, $v_{\text{water}} = 1500 \text{ ms}^{-1}$, $v_{\text{ice}} = 3500 \text{ ms}^{-1}$
 Archie's law: $a = 1$, $m = 2$, $n = 2$

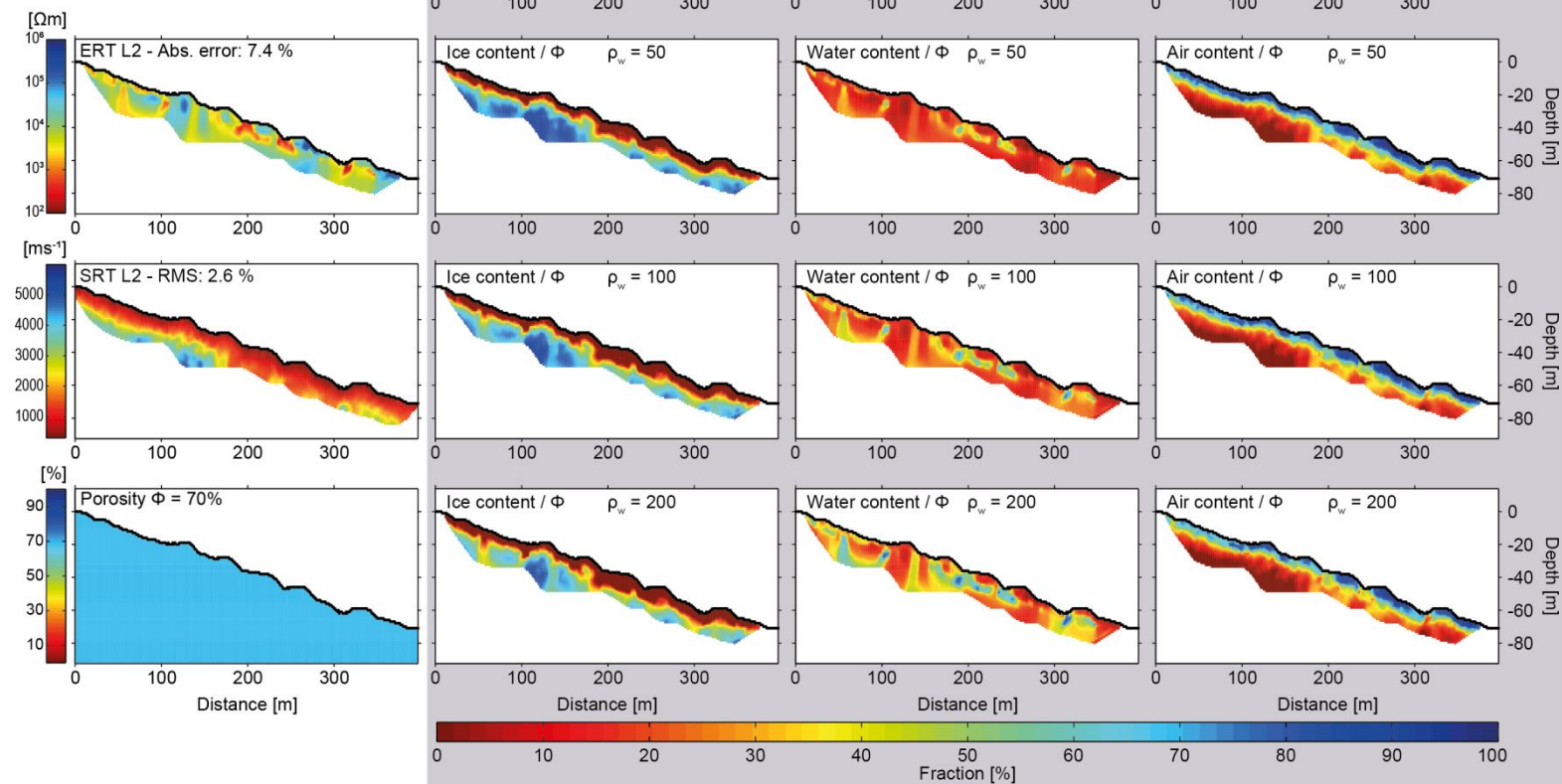


Fig. S 14: 4PM results of cross-profile L2 for the 70% porosity model. Ice, water and air content per porosity (Φ) are given for four pore water resistivities ($\rho_w = 30, 50, 100, 200 \text{ \& } \Omega\text{m}$).

4PM Input Data

Field data Dos Linguas profile L2:
 Electrical resistivity tomography (ERT), 01.03.2018
 Seismic refraction tomography (SRT), 02.03.2018
 0m depth = 4370 m asl
 Used 4PM parameters:
 $\Phi = 50\%$, $\rho_w = 30, 50, 100 \text{ \& } 200 \text{ \& } \Omega\text{m}$
 $v_w = 330 \text{ ms}^{-1}$, $v_{\text{water}} = 1500 \text{ ms}^{-1}$, $v_{\text{ice}} = 3500 \text{ ms}^{-1}$
 Archie's law: $a = 1$, $m = 2$, $n = 2$

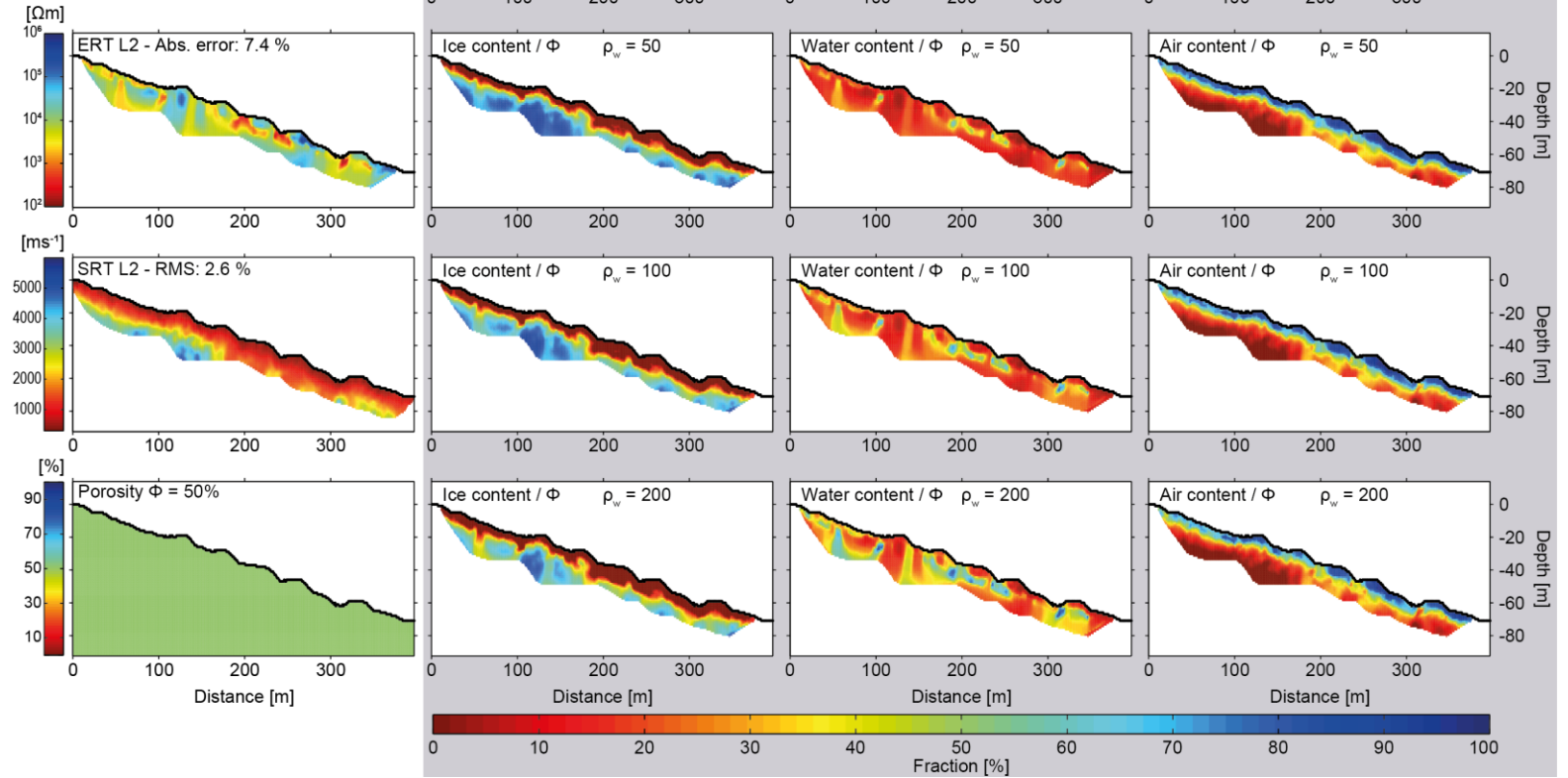


Fig. S 15: 4PM results of cross-profile L2 for the 50% porosity model. Ice, water and air content per porosity (Φ) are given for four pore water resistivities ($\rho_w = 30, 50, 100, 200 \text{ \& } \Omega\text{m}$).

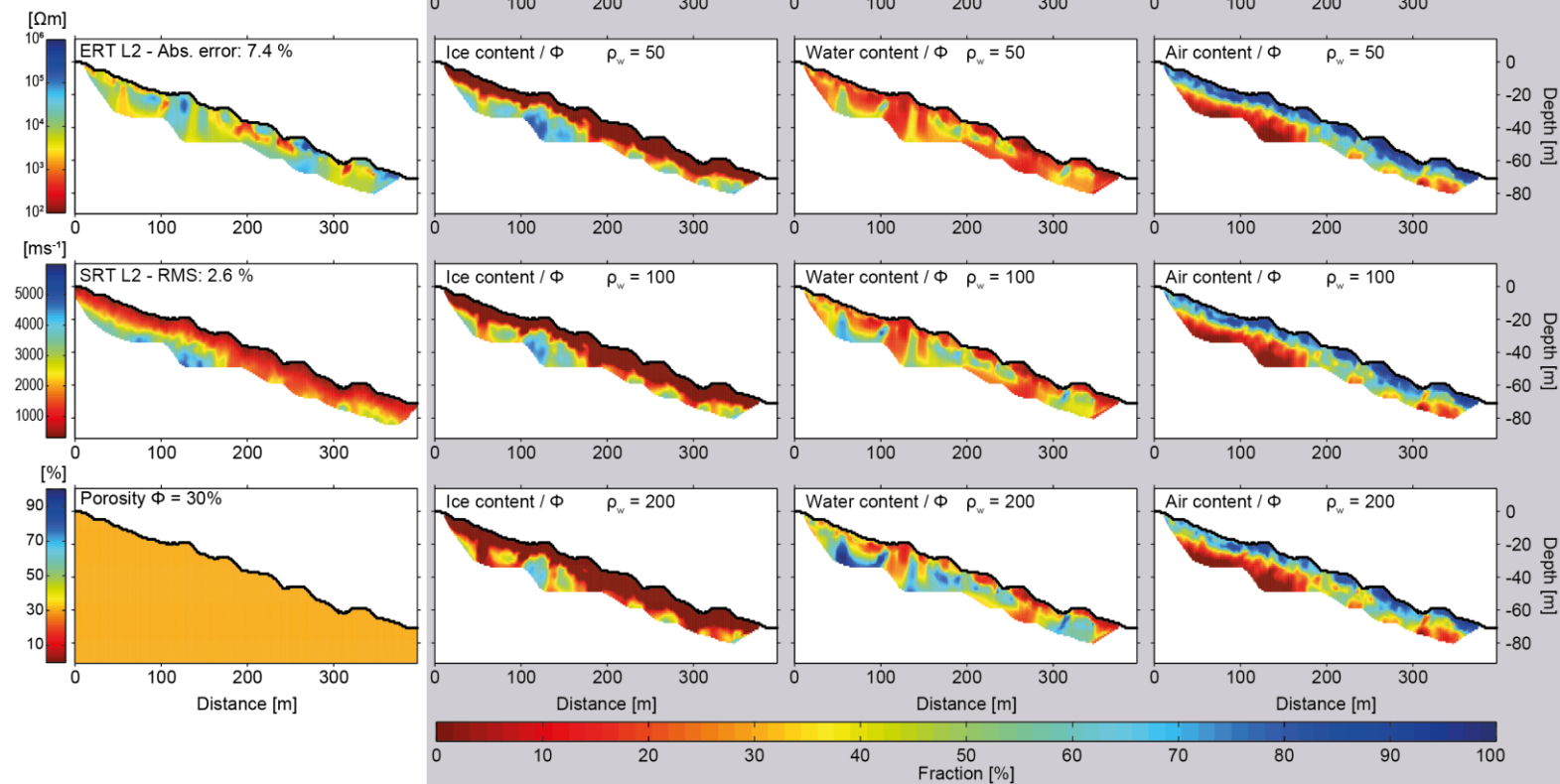
4PM Input Data

Field data Dos Linguas profile L2:

Electrical resistivity tomography (ERT), 01.03.2018
Seismic refraction tomography (SRT), 02.03.2018
0m depth = 4370 m asl

Used 4PM parameters:

$\Phi = 30\%$, $\rho_w = 30, 50, 100 \text{ \& } 200 \text{ \& } \Omega\text{m}$
 $v_w = 330 \text{ ms}^{-1}$, $v_{\text{water}} = 1500 \text{ ms}^{-1}$, $v_{\text{ice}} = 3500 \text{ ms}^{-1}$
Archies' law: $a = 1$, $m = 2$, $n = 2$



55 Fig. S 16: 4PM results of cross-profile L2 for the 30% porosity model. Ice, water and air content per porosity (Φ) are given for four pore water resistivities ($\rho_w = 30, 50, 100, 200 \text{ \& } \Omega\text{m}$).

S2 Ground surface temperatures of Dos Lunguas rock glacier

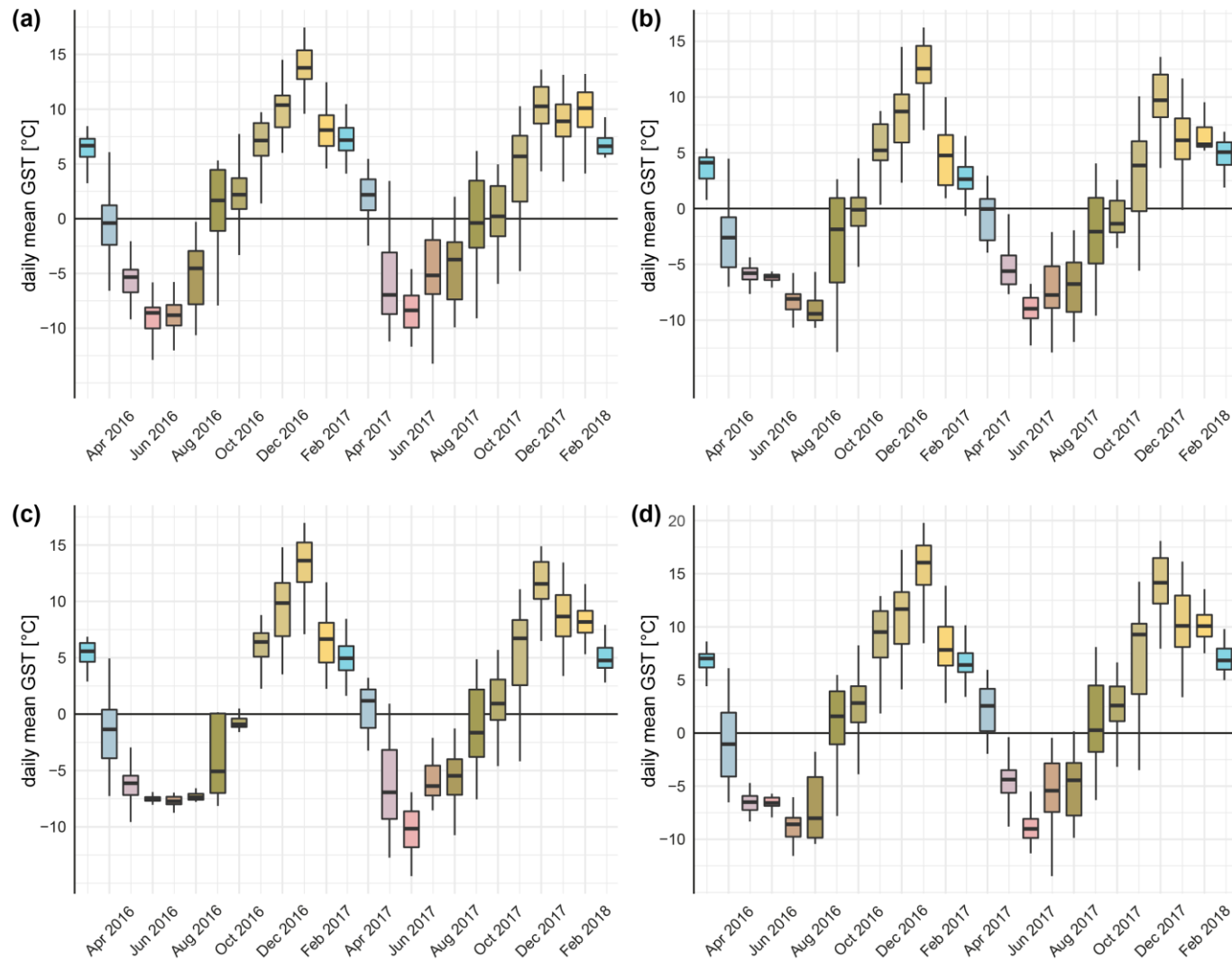


Fig. S 17: Boxplots of daily mean ground surface temperatures (GST) from Mar 2016 to Mar 2018 measured with iButtons in three hour intervals at four different locations of Dos Lunguas rock glacier ((a), (b), (c), and (d)). The ground surface temperature regime during the ablation period between Sep 2016 and Mar 2017 shows an earlier and warmer spring (Sep 2016) and a later and higher temperature maximum during summer (Jan 2107) compared to the ablation period 2017-18.