Supplemental Materials

Table 1
Mass, critical temperature, critical volume, and relative diffusion coefficients used for the investigated NMHC. D/DCO_2, Worton indicates the values used in Worton et al. (2012). The significant lengths of the reconstruction scenarios are also provided (in years before drill date).

Species	Ethane	Propane	*n*-Butane	*i*-Butane	*n*-Pentane	*i*-Pentane
Mass (g mol^{-1})	30.07	44.10	58.12	58.12	72.15	72.15
T_{crit} (K)	305.3	369.8	425.1	407.8	469.7	460.4
V_{crit}	146	200	255	259	311	306
D/DCO_2	0.905	0.702	0.584	0.583	0.505	0.511
D/DCO_2, Worton	0.910	0.723	0.615	0.615	0.544	0.544
Significant Length 2008 EU (years)	65.7	69.4	72.5	72.5	75.1	74.9
Significant Length 2008 US (years)	65.2	68.1	70.6	70.6	72.8	72.6
Significant Length 2009 Hole (years)	56.7	60.0	62.7	62.7	-	-

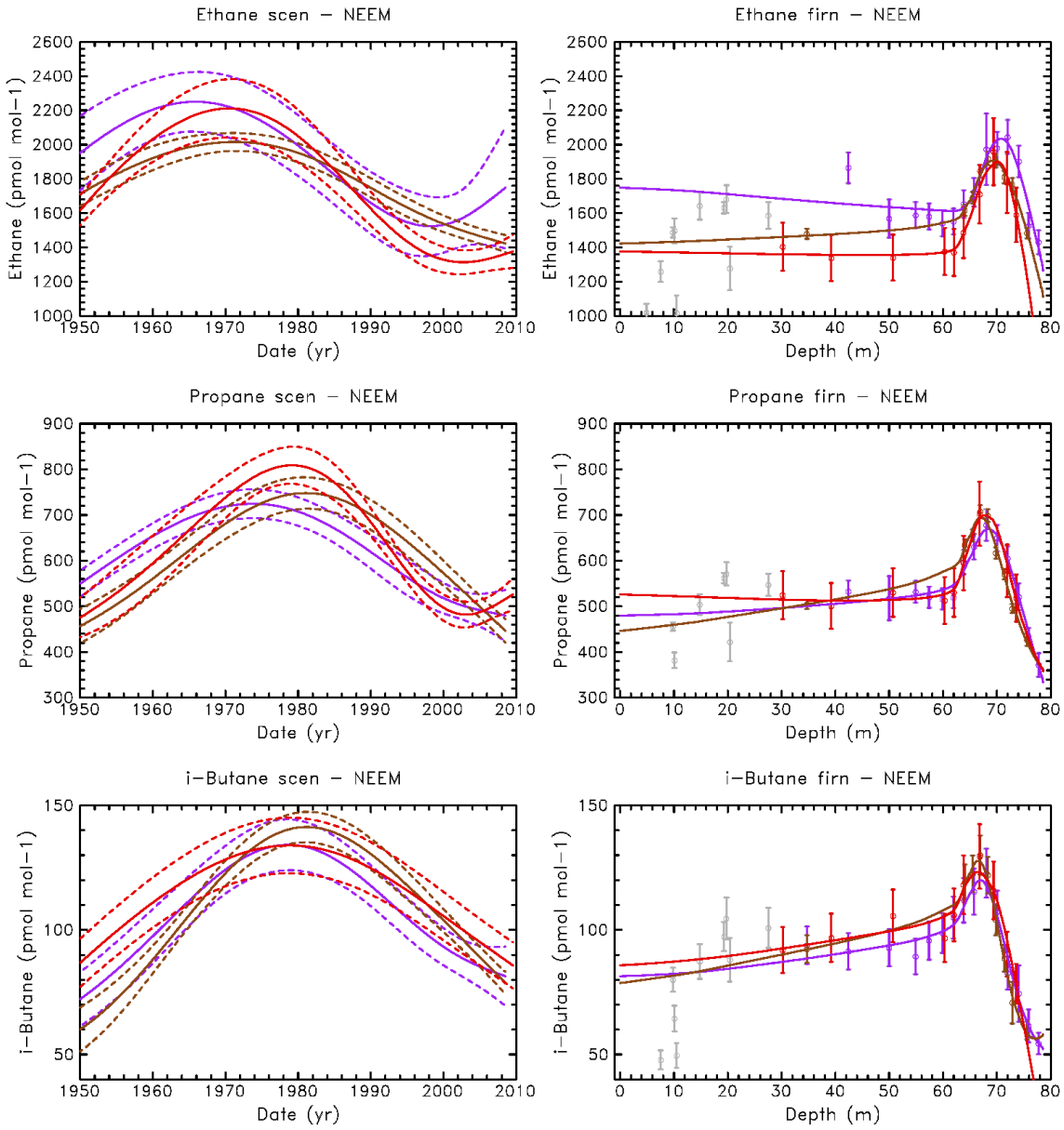

Figure S-1a.
Single site constrained firn profile (right) and atmospheric trend reconstruction (left) for C_2H_6, C_3H_8 and *n*-C_4H_{10}. Dashed lines represent the 2-σ confidence margins of the model calculations. Colors - NEEM-EU in purple, NEEM-US in brown and NEEM-09 in red. Data points not used for scenario reconstruction (affected by seasonality) are shown in grey. Error bars indicate the 2-σ uncertainty in the data.

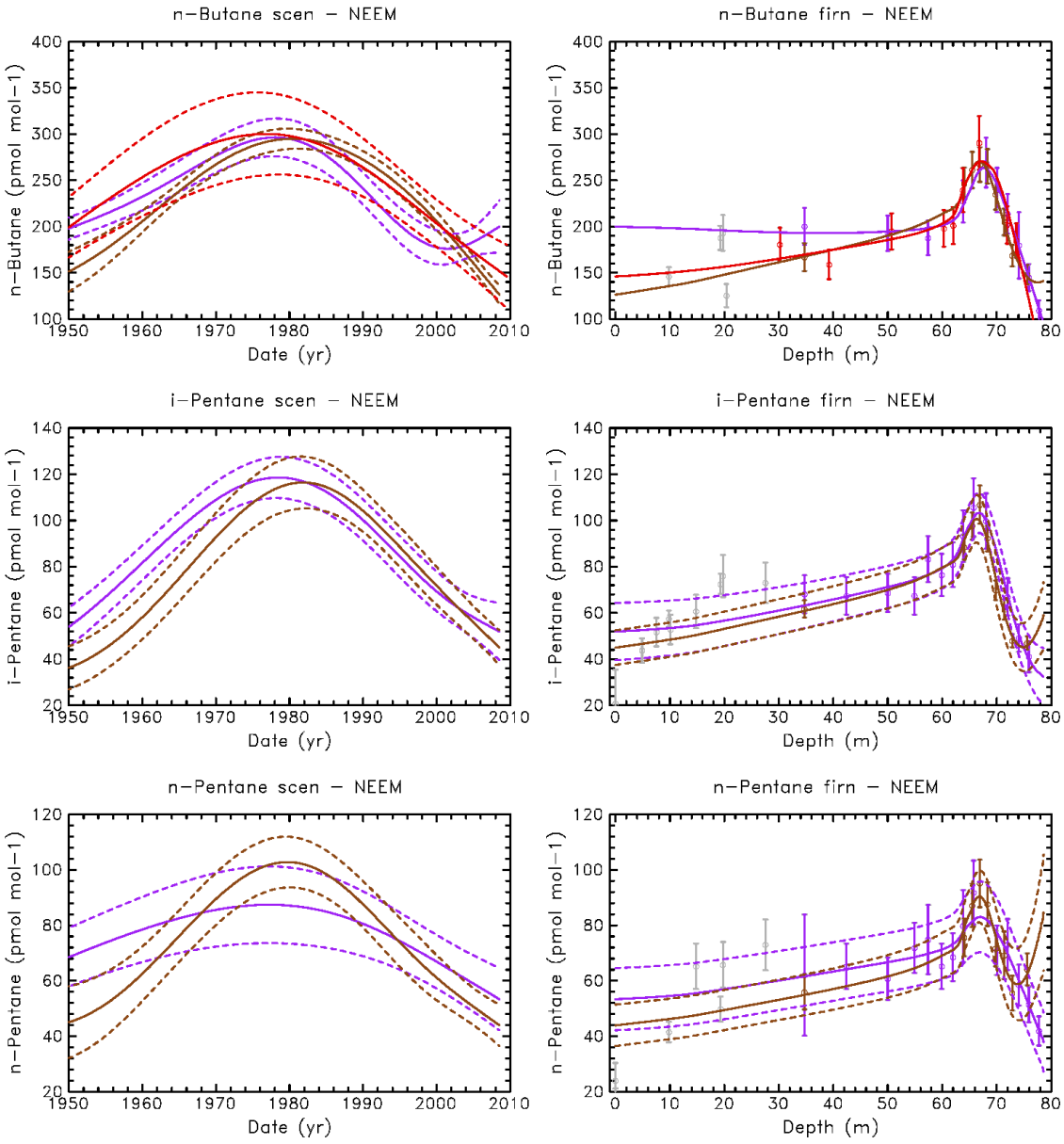

Figure S-1b.
Same as Fig. S-1a for *i*-C_4H_{10}, *n*-C_5H_{12} and *n*-C_5H_{12}.

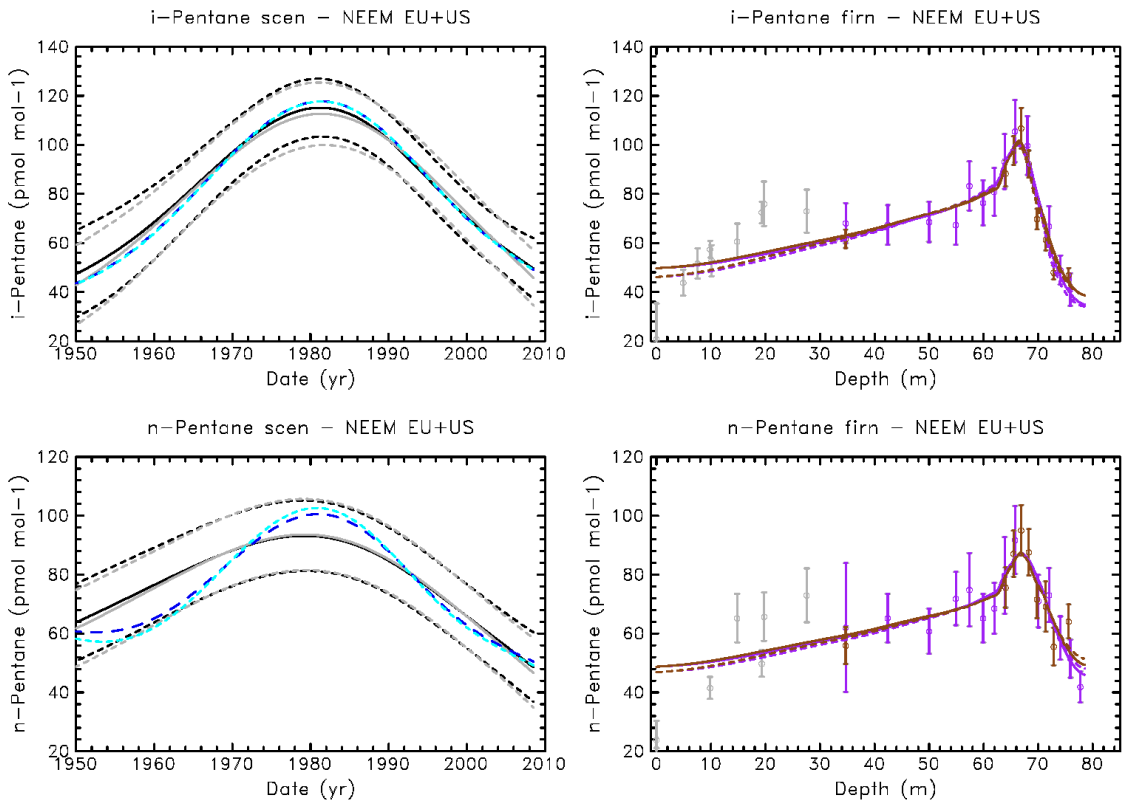

Figure S-2.
Multi-hole constrained atmospheric trend reconstruction for n-C_5H_{12} and i-C_5H_{12} with INSTAAR model Green's functions. Equal weight for all sites: black lines on left panel and continuous lines on right panel. Weighting using single site optimal RMSD: grey lines on left panel and dashed lines on right panel. Colors for firn results: NEEM-EU in purple, NEEM-US in brown. Scenarios calculated with LGGE-GIPSA model Green's functions are shown in blue for comparison - dark blue: equal weight for all sites, clear blue: weighting using single site optimal RMSD.

Note about Figure S-2:
Results obtained with the INSTAAR model Green's functions for n-C_5H_{12} and i-C_5H_{12} are consistent with the LGGE results within their uncertainty limits. They are nearly identical for *i*-C_5H_{12} with the INSTAAR model Green's functions producing a smoother scenario than the LGGE-GIPSA model Green's function. This difference can be better understood by comparing the right panels of Figure S-2 and Figure 5b of the main paper. The LGGE-GIPSA model Green's functions produce a slightly narrower *n*-C_5H_{12} peak in the firn with a slightly better match of the firn data at 60-64 m depth and a more complex shape of the deep firn profile (below 70 m depth). These differences are not significant in comparison with the uncertainties on the data (which are comparable to the scenario uncertainty envelope).

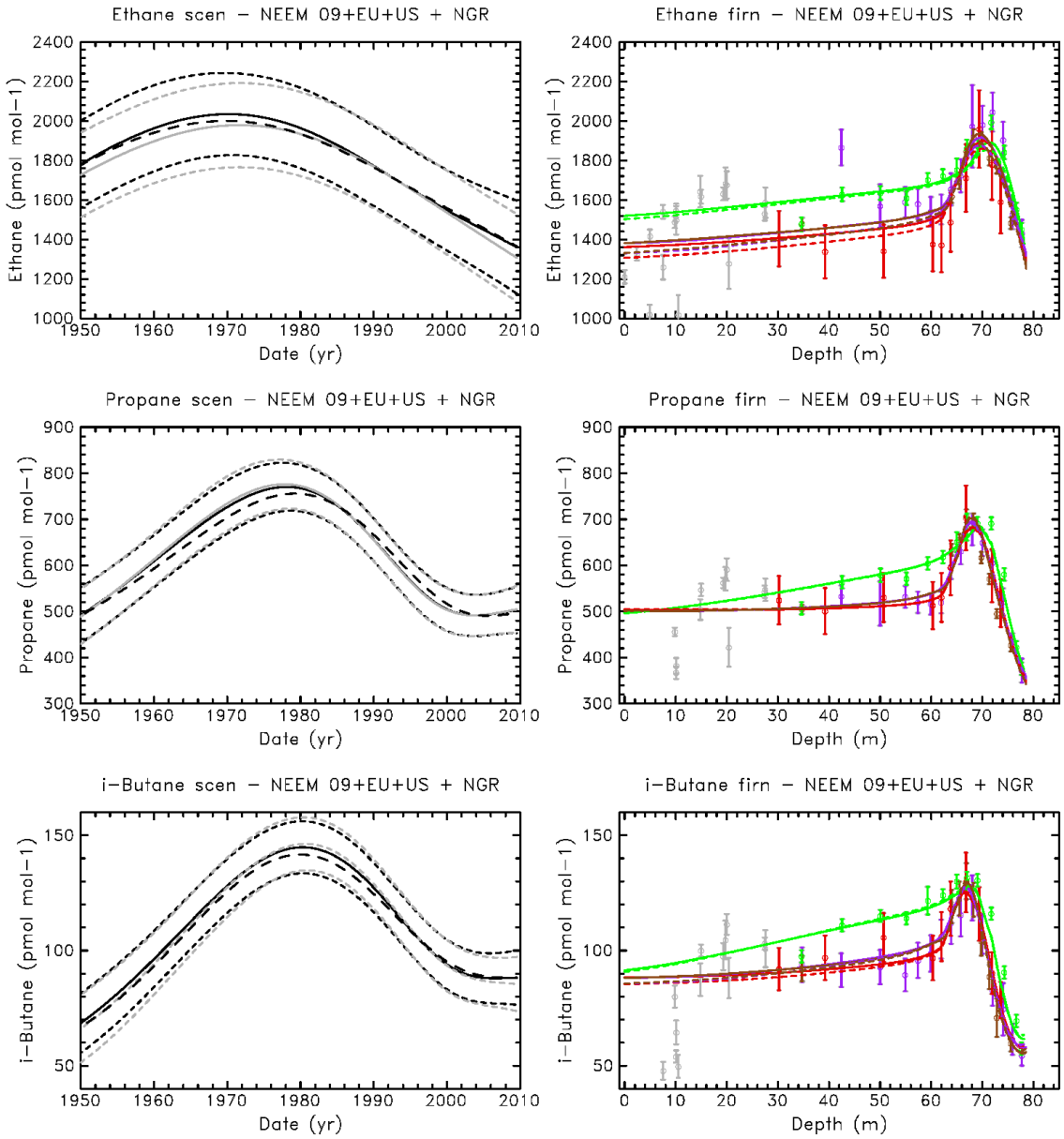

Figure S-3a.

Multi-site constrained atmospheric trend reconstruction with North GRIP and NEEM for C_2H_6, C_3H_8 and *i*-C_4H_{10}. Equal weight for all boreholes: black lines on left panel and continuous lines on right panel. NEEM only scenario with equal weight for all boreholes: black long dashed lines in left panels. NEEM + NGRIP constrained simulations with weighting using single borehole optimal RMSD: grey lines in left panels and dashed lines in right panels. Colors for firn results: North GRIP - green, NEEM-EU - purple, NEEM-US - brown, NEEM 2009 - red.

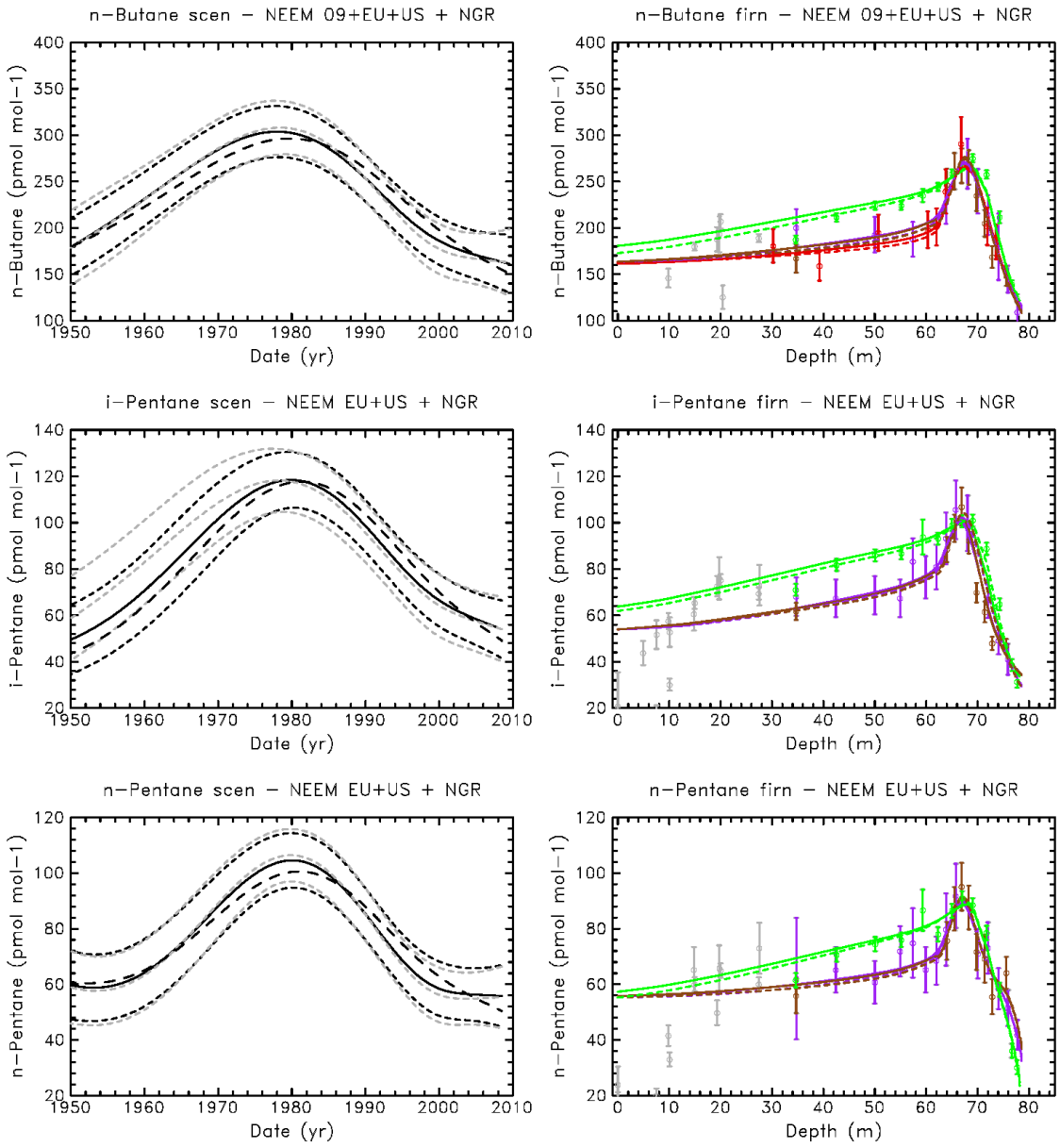

Figure S-3b
Same as Fig. S-3a for *n*-C_4H_{10}, *i*-C_5H_{12} and *n*-C_5H_{12}

Note about Figure S-3:
The NGRIP and NEEM data are not fully consistent in terms of calibration scale and methodology for uncertainty evaluation. However NGRIP brings a new constraint to the model with respect to NEEM because it was drilled 7-8 years earlier (2001). Directly comparing the North GRIP and NEEM firn data, the most striking difference lies in the slope and concentration levels in the upper firn (30 m to 60 m range), which reflects this difference in drill dates. The NEEM only and NEEM + NGRIP constrained scenarios are consistent (within uncertainty limits of one another) and no strong increase in the widths of the scenario uncertainty envelopes is observed, indicating a good consistency of the NEEM and NGRIP data.