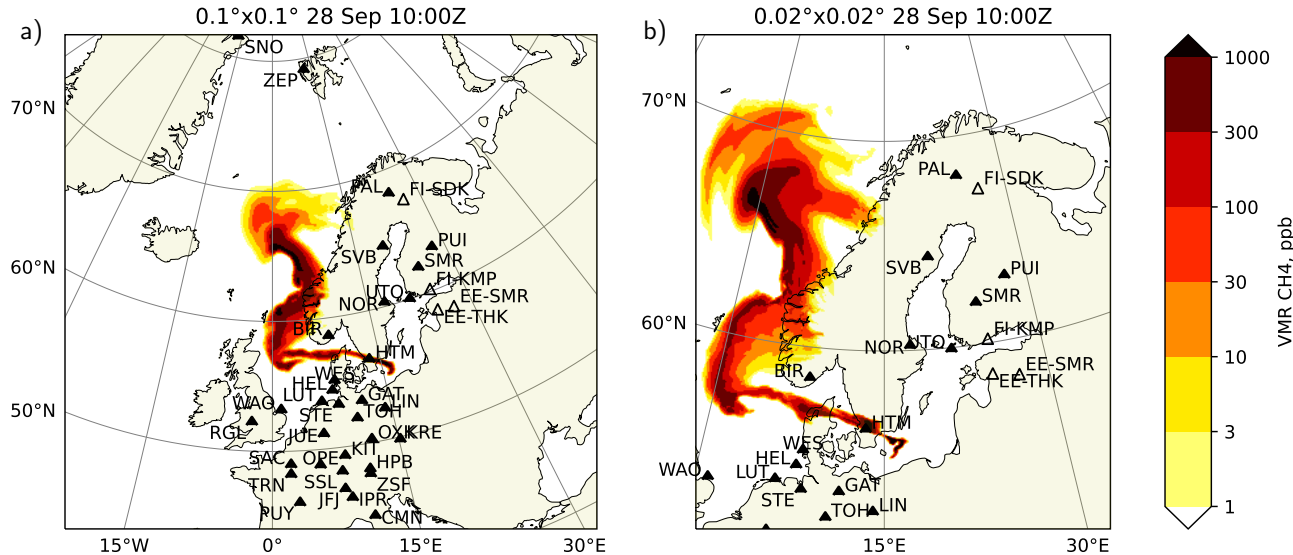


1 Simulation setup

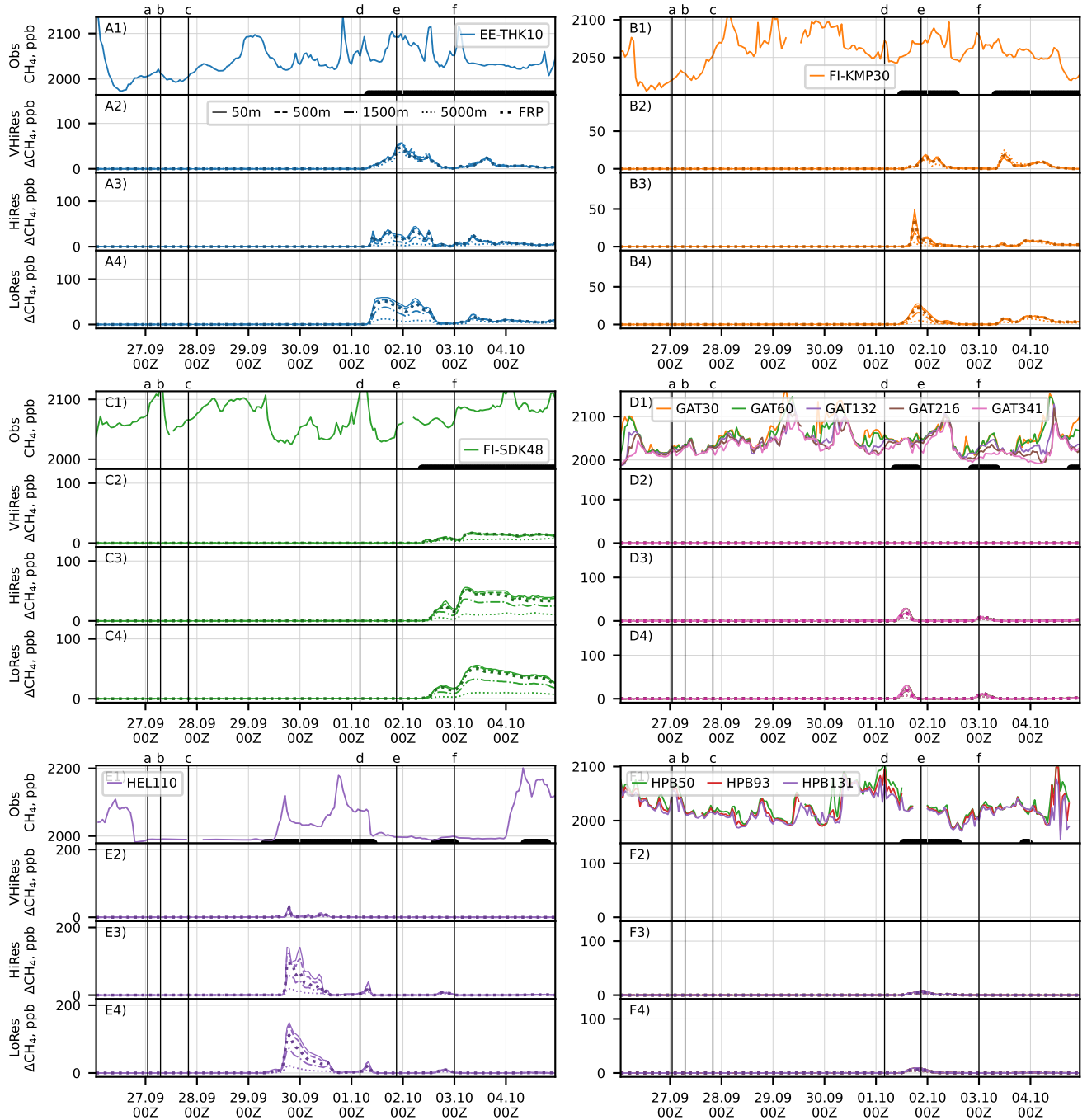


**Figure S1.** Simulation domains used for the study, and locations of the observation stations. ICOS stations shown with filled symbols.

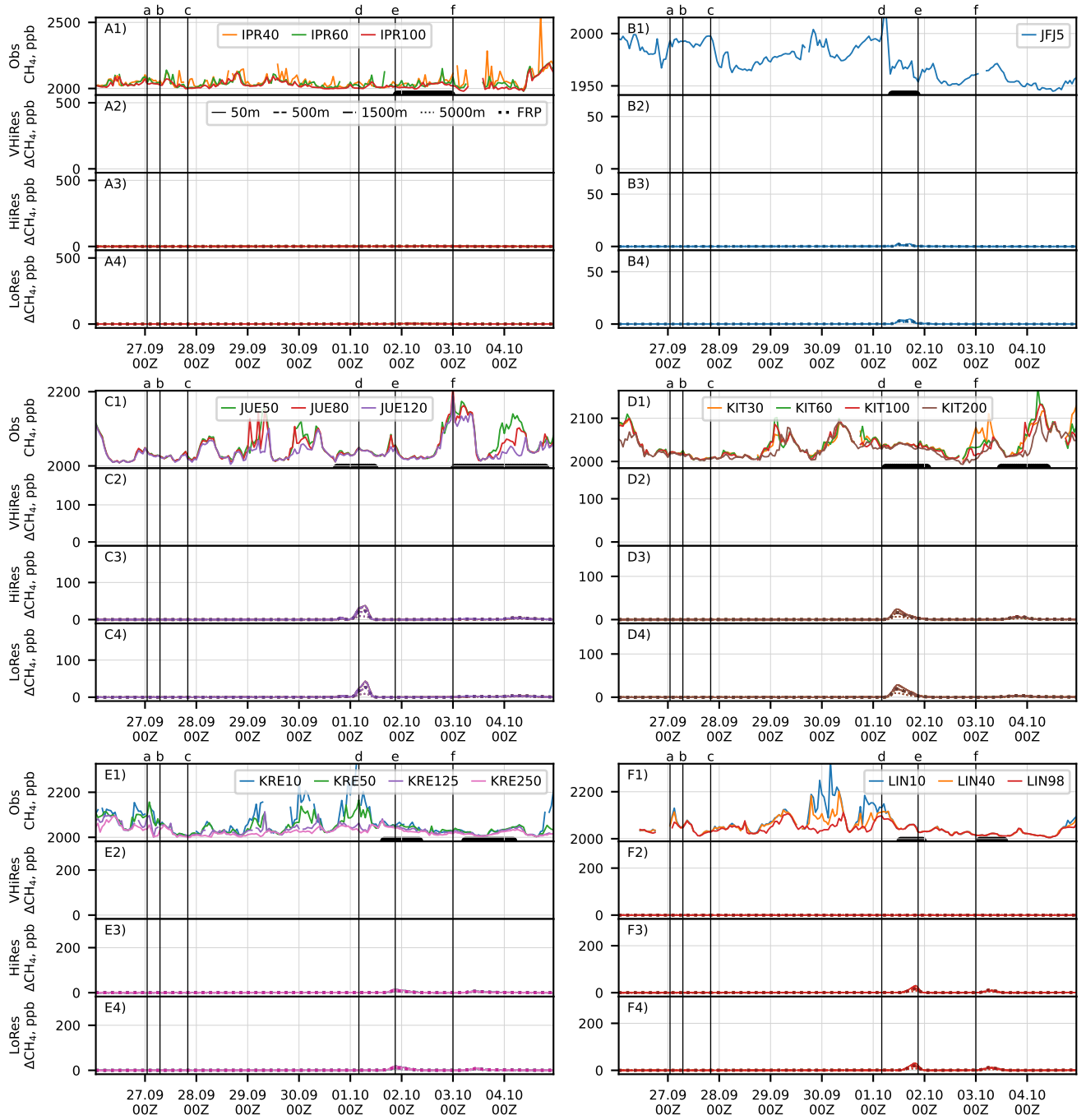
The simulations were performed with Silam model on two domains shown in Fig. S1. The larger domain was simulated at 0.1-deg and 0.4-deg resolution (Fig. S1a) driven with the same set of operational ECMWF forecasts, The smaller domain was simulated at 0.02-deg resolution (Fig. S1b), with MEPS unperturbed-member forecasts with 2.5-km resolution.

5 2 Timeseries for Stations

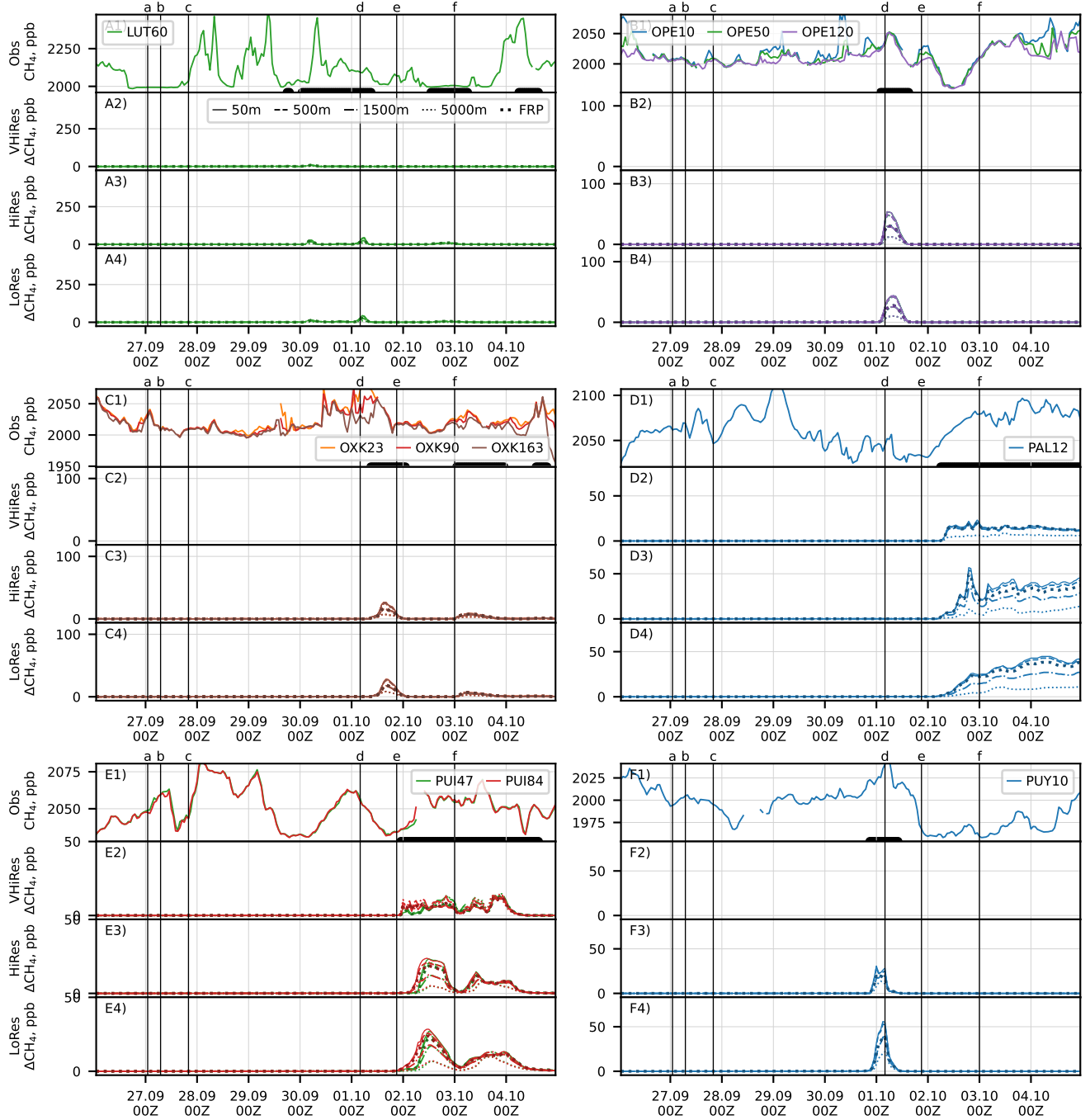
This section shows simulated and observed timeseries for the stations that did not fit to the main paper and Taylor diagrams for them.



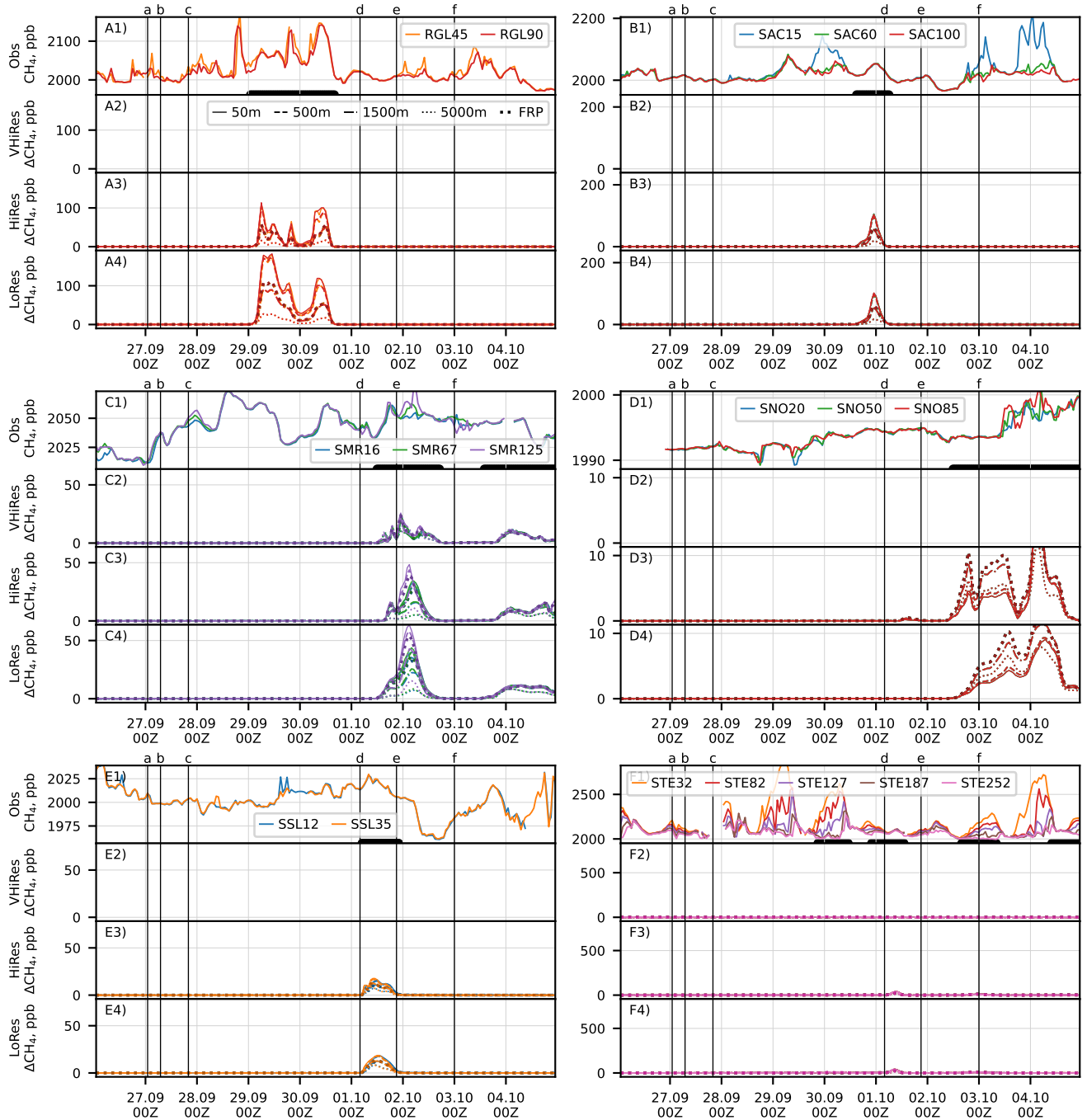
**Figure S2.** Timeseries of methane mixing ratio observed at EE-THK, FI-KMP, FI-SDK, GAT, HEL and HPB stations after the pipeline rupture, and corresponding timeseries simulated with three different resolutions for several vertical profiles of the release. Each group of panels corresponds to a station. The panels in each group are (top down) for observations, and model with 0.02-deg, 0.1-deg, 0.4-deg resolution. Measurement heights are coded with colors, and emission heights with line styles. Vertical lines mark the moments shown in maps of the main paper



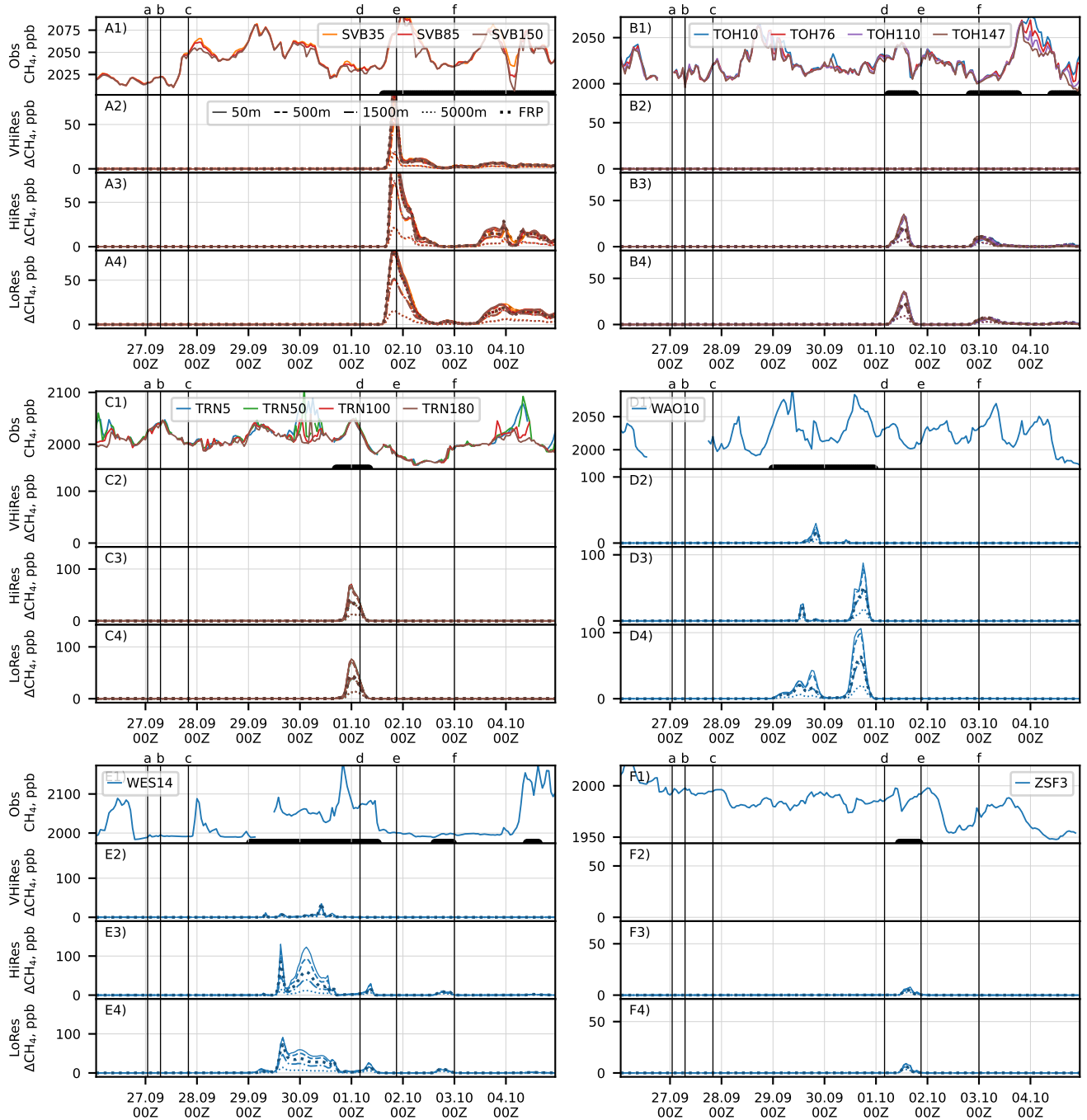
**Figure S3.** Timeseries of methane mixing ratio observed at IPR, JFJ, JUE, KIT, KRE, and LIN stations after the pipeline rupture, and corresponding timeseries simulated with three different resolutions for several vertical profiles of the release. Each group of panels corresponds to a station. The panels in each group are (top down) for observations, and model with 0.02-deg, 0.1-deg, 0.4-deg resolution. Measurement heights are coded with colors, and emission heights with line styles. Vertical lines mark the moments shown in maps of the main paper



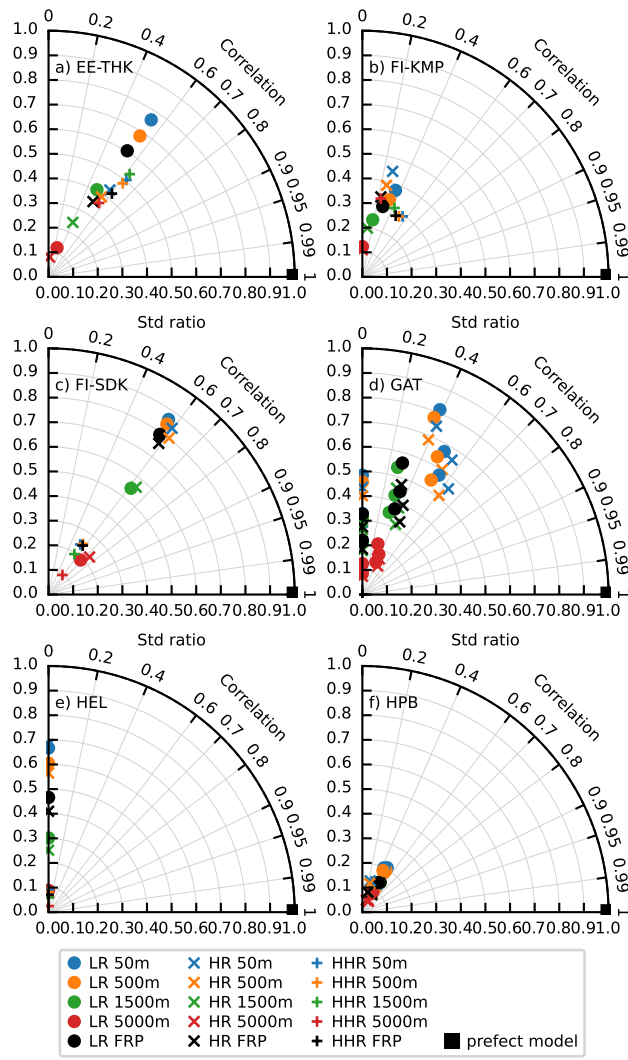
**Figure S4.** Timeseries of methane mixing ratio observed at LUT, OPE, OXK, PAL, PUI, and PUY stations after the pipeline rupture, and corresponding timeseries simulated with three different resolutions for several vertical profiles of the release. Each group of panels corresponds to a station. The panels in each group are (top down) for observations, and model with 0.02-deg, 0.1-deg, 0.4-deg resolution. Measurement heights are coded with colors, and emission heights with line styles. Vertical lines mark the moments shown in maps of the main paper



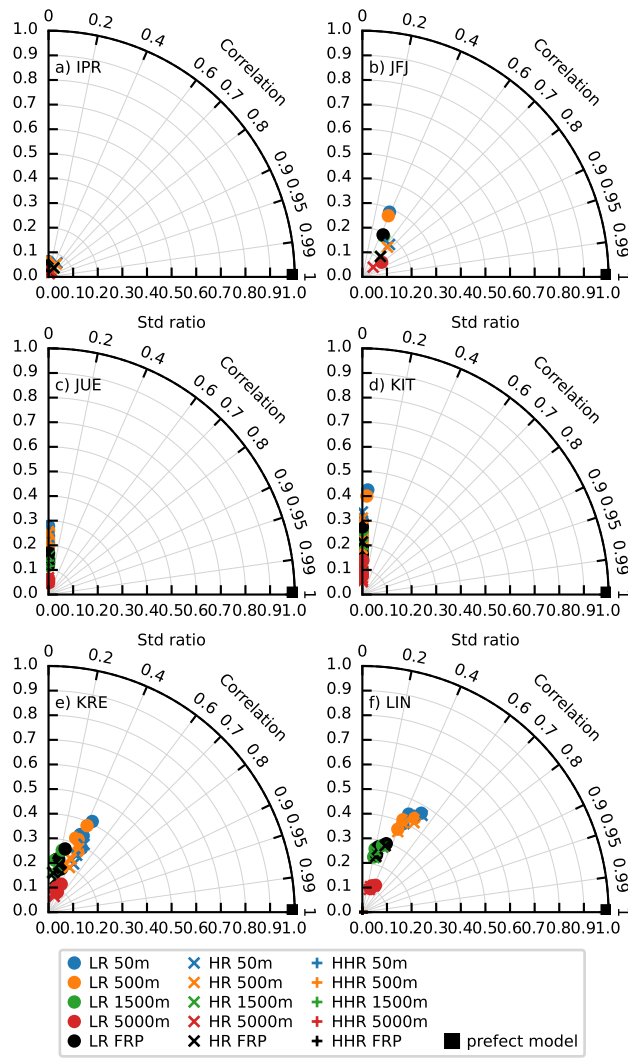
**Figure S5.** Timeseries of methane mixing ratio observed at RGL, SAC, SMR, SNO, SSL, and STE stations after the pipeline rupture, and corresponding timeseries simulated with three different resolutions for several vertical profiles of the release. Each group of panels corresponds to a station. The panels in each group are (top down) for observations, and model with 0.02-deg, 0.1-deg, 0.4-deg resolution. Measurement heights are coded with colors, and emission heights with line styles. Vertical lines mark the moments shown in maps of the main paper



**Figure S6.** Timeseries of methane mixing ratio observed at SVB, TOH, TRN, WAO, WES, and ZSF stations after the pipeline rupture, and corresponding timeseries simulated with three different resolutions for several vertical profiles of the release. Each group of panels corresponds to a station. The panels in each group are (top down) for observations, and model with 0.02-deg, 0.1-deg, 0.4-deg resolution. Measurement heights are coded with colors, and emission heights with line styles. Vertical lines mark the moments shown in maps of the main paper

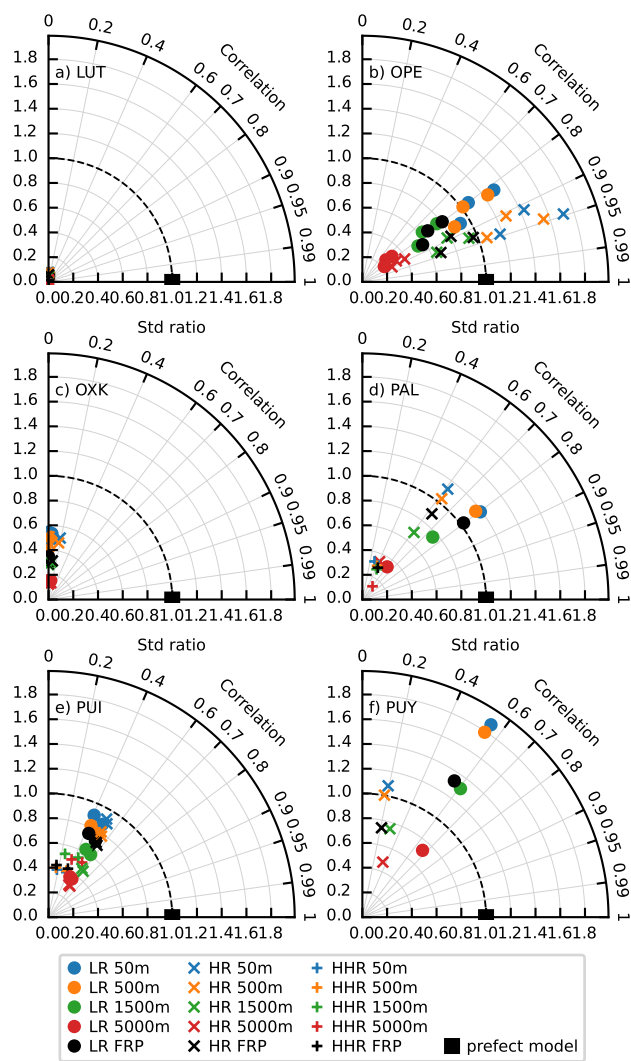


**Figure S7.** Taylor diagrams of model performance on the timeseries shown in Fig. S2

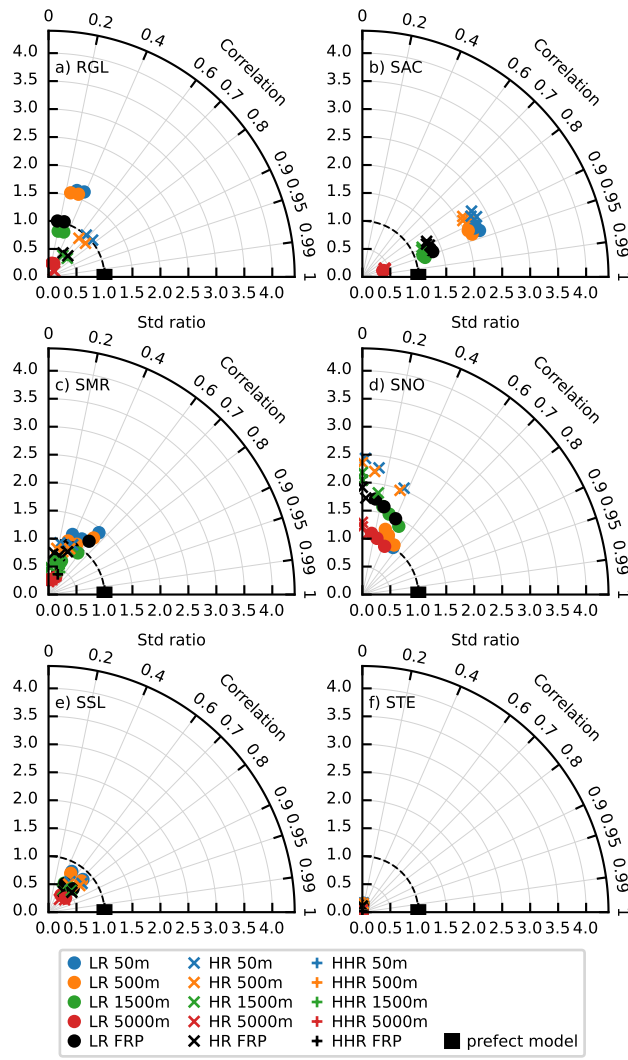


**Figure S8.** Taylor diagrams of model performance on the timeseries shown in Fig. S3

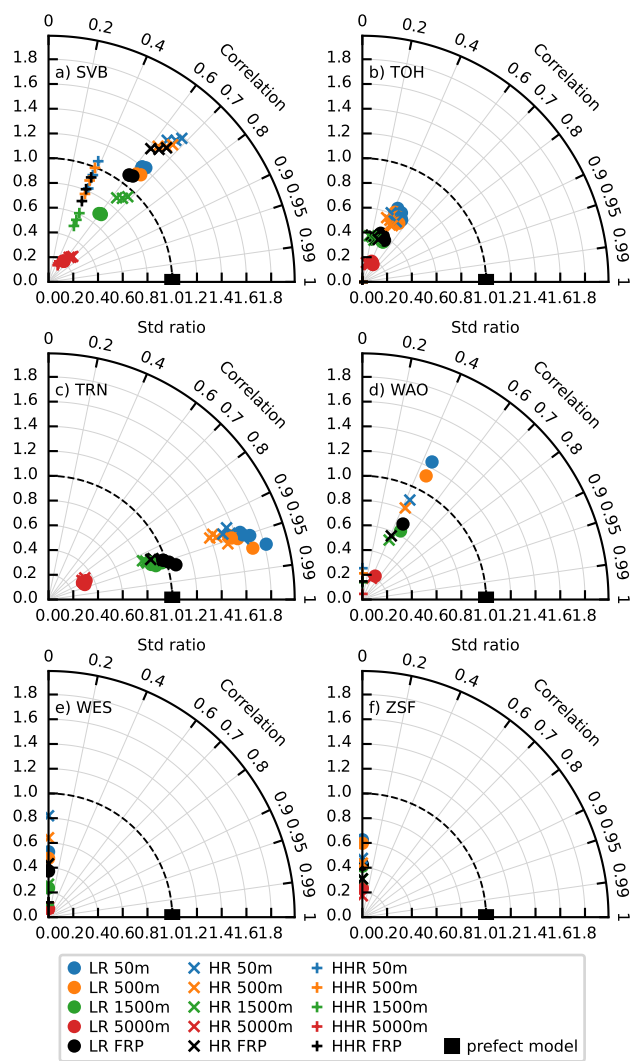




**Figure S9.** Taylor diagrams of model performance on the timeseries shown in Fig. S4

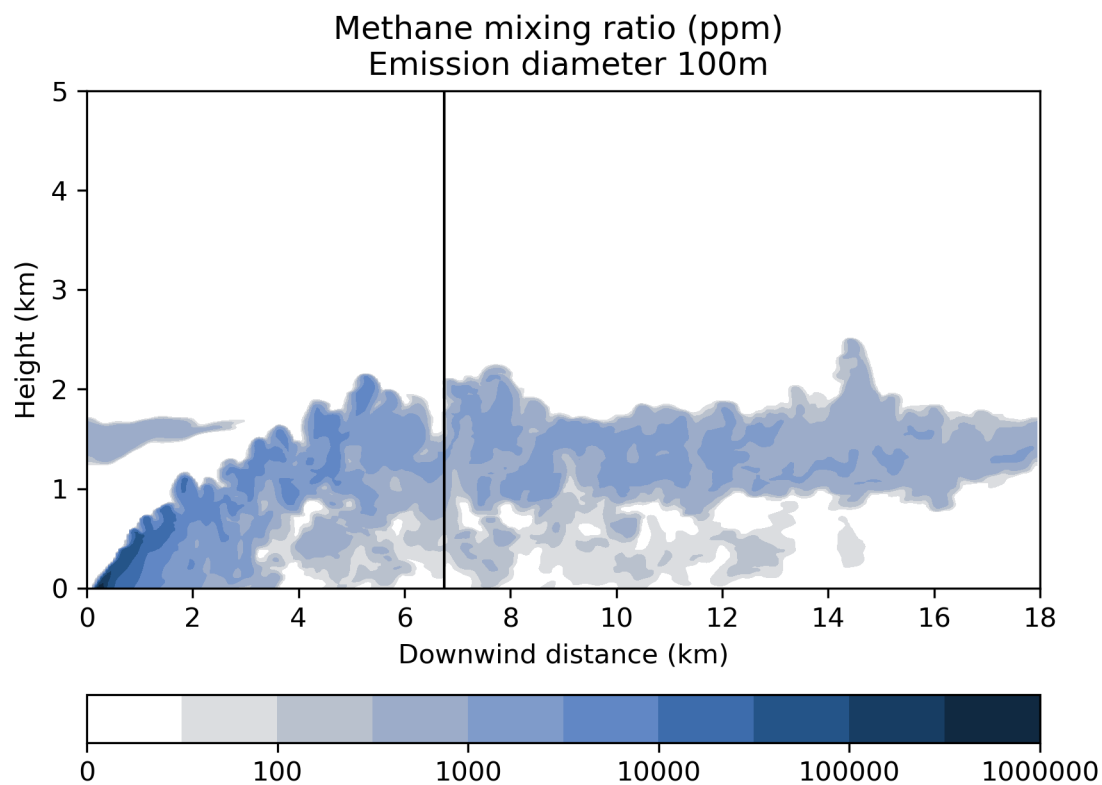


**Figure S10.** Taylor diagrams of model performance on the timeseries shown in Fig. S5

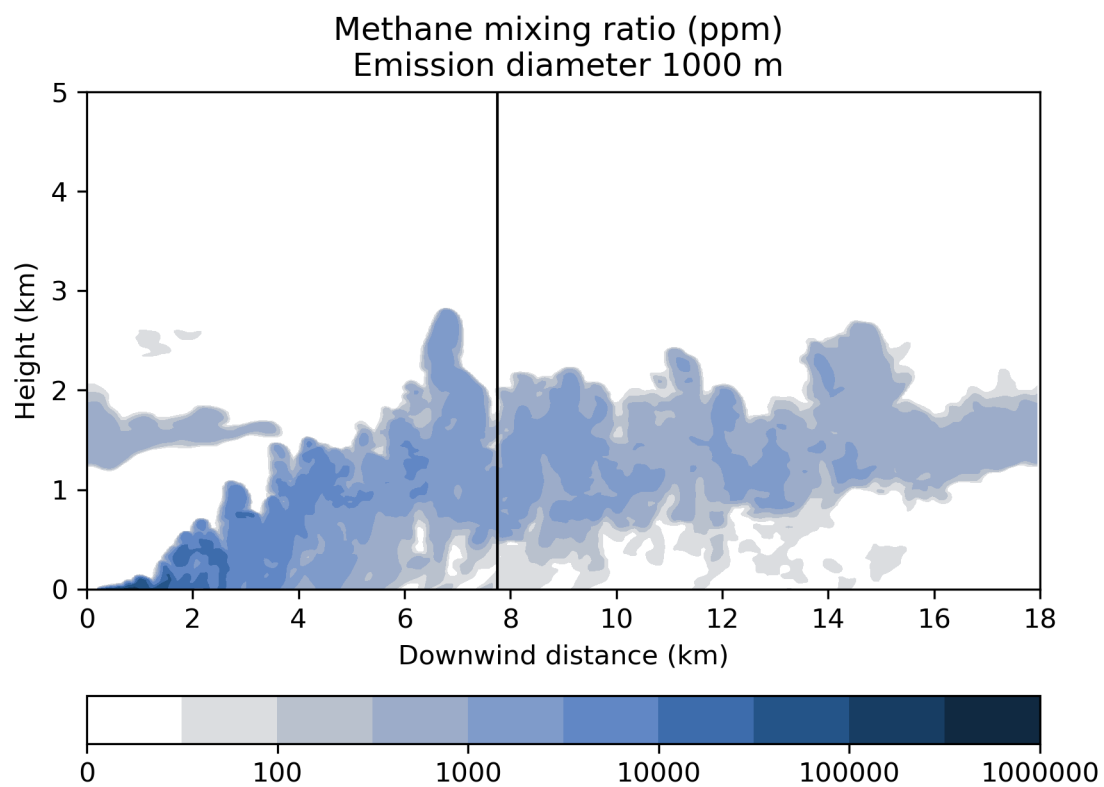


**Figure S11.** Taylor diagrams of model performance on the timeseries shown in Fig. S6

### 3 LES sensitivity simulations



**Figure S12.** Methane mixing ratio in the central line of the LES simulated plume for the maximum methane release from a circle with 100 m diameter. The vertical line indicates the point where the plume rise has finished.



**Figure S13.** LES simulated plume for the maximum methane release from a circle with 1000 m diameter.

## 4 Acknowledgments for ICOS data

- 10 The ICOS data usage policy (<https://www.icos-cp.eu/data-services/about-data-portal/data-license>, accessed 30.11.2022) requires each publication to have a reference for each of the time series used for a study, and the references are different for each measurement height at each station. The table below is intended to fulfill this requirement:

Code	References
BIR	Lund Myhre, C., Platt, S. M., Lunder, C., and Hermansen, O.: ICOS ATC NRT CH <sub>4</sub> growing time series, Birkenes (10.0m), 2022-03-01–2022-10-16, <a href="https://hdl.handle.net/11676/a-OqGFe7Aga6-k7Chen39EyQ">https://hdl.handle.net/11676/a-OqGFe7Aga6-k7Chen39EyQ</a> , 2022 Lund Myhre, C., Platt, S. M., Lunder, C., and Hermansen, O.: ICOS ATC NRT CH <sub>4</sub> growing time series, Birkenes (50.0m), 2022-03-01–2022-10-16, <a href="https://hdl.handle.net/11676/QhtU7Bpi3hW63r_P_YRETTsU">https://hdl.handle.net/11676/QhtU7Bpi3hW63r_P_YRETTsU</a> , 2022 Lund Myhre, C., Platt, S. M., Lunder, C., and Hermansen, O.: ICOS ATC NRT CH <sub>4</sub> growing time series, Birkenes (75.0m), 2022-03-01–2022-10-16, <a href="https://hdl.handle.net/11676/M1WVYeDMY6UtPnSvF6KKmq_L">https://hdl.handle.net/11676/M1WVYeDMY6UtPnSvF6KKmq_L</a> , 2022
GAT	Kubistin, D., Plaß-Dülmer, C., Kneuer, T., Lindauer, M., and Müller-Williams, J.: ICOS ATC NRT CH <sub>4</sub> growing time series, Gartow (30.0m), 2022-03-01–2022-10-16, <a href="https://hdl.handle.net/11676/V9y--C-FvYXiZfojwVq3bw42">https://hdl.handle.net/11676/V9y--C-FvYXiZfojwVq3bw42</a> , 2022 Kubistin, D., Plaß-Dülmer, C., Kneuer, T., Lindauer, M., and Müller-Williams, J.: ICOS ATC NRT CH <sub>4</sub> growing time series, Gartow (60.0m), 2022-03-01–2022-10-16, <a href="https://hdl.handle.net/11676/Yk1xCKJYJSz_GWeATpDA3Rjt">https://hdl.handle.net/11676/Yk1xCKJYJSz_GWeATpDA3Rjt</a> , 2022 Kubistin, D., Plaß-Dülmer, C., Kneuer, T., Lindauer, M., and Müller-Williams, J.: ICOS ATC NRT CH <sub>4</sub> growing time series, Gartow (132.0m), 2022-03-01–2022-10-16, <a href="https://hdl.handle.net/11676/Rt04d54lFTra9RYcYIGPQN5H">https://hdl.handle.net/11676/Rt04d54lFTra9RYcYIGPQN5H</a> , 2022 Kubistin, D., Plaß-Dülmer, C., Kneuer, T., Lindauer, M., and Müller-Williams, J.: ICOS ATC NRT CH <sub>4</sub> growing time series, Gartow (216.0m), 2022-03-01–2022-10-16, <a href="https://hdl.handle.net/11676/_qPTkWsLArD9RYD1s8gorAM0">https://hdl.handle.net/11676/_qPTkWsLArD9RYD1s8gorAM0</a> , 2022 Kubistin, D., Plaß-Dülmer, C., Kneuer, T., Lindauer, M., and Müller-Williams, J.: ICOS ATC NRT CH <sub>4</sub> growing time series, Gartow (341.0m), 2022-03-01–2022-10-16, <a href="https://hdl.handle.net/11676/K5H4gA-BlsJEyT2g8NsCnW9x">https://hdl.handle.net/11676/K5H4gA-BlsJEyT2g8NsCnW9x</a> , 2022
HEL	Kubistin, D., Plaß-Dülmer, C., Kneuer, T., Lindauer, M., and Müller-Williams, J.: ICOS ATC NRT CH <sub>4</sub> growing time series, Helgoland (110.0m), 2022-03-01–2022-10-16, <a href="https://hdl.handle.net/11676/_NblFnzvy2GGTPpdD0_SpKn-">https://hdl.handle.net/11676/_NblFnzvy2GGTPpdD0_SpKn-</a> , 2022
HPB	Kubistin, D., Plaß-Dülmer, C., Kneuer, T., Lindauer, M., and Müller-Williams, J.: ICOS ATC NRT CH <sub>4</sub> growing time series, Hohenpeissenberg (50.0m), 2022-03-01–2022-10-16, <a href="https://hdl.handle.net/11676/tpDePhqI3v9_aql5xksIrf8S">https://hdl.handle.net/11676/tpDePhqI3v9_aql5xksIrf8S</a> , 2022 Kubistin, D., Plaß-Dülmer, C., Kneuer, T., Lindauer, M., and Müller-Williams, J.: ICOS ATC NRT CH <sub>4</sub> growing time series, Hohenpeissenberg (93.0m), 2022-03-01–2022-10-16, <a href="https://hdl.handle.net/11676/nXNqErmYi8m2wemDaJz_Z9Dr">https://hdl.handle.net/11676/nXNqErmYi8m2wemDaJz_Z9Dr</a> , 2022 Kubistin, D., Plaß-Dülmer, C., Kneuer, T., Lindauer, M., and Müller-Williams, J.: ICOS ATC NRT CH <sub>4</sub> growing time series, Hohenpeissenberg (131.0m), 2022-03-01–2022-10-16, <a href="https://hdl.handle.net/11676/GabqfaCOTkNLQnnjz_IMn_6l">https://hdl.handle.net/11676/GabqfaCOTkNLQnnjz_IMn_6l</a> , 2022
HTM	Heliasz, M. and Biermann, T.: ICOS ATC NRT CH <sub>4</sub> growing time series, Hyltemossa (30.0m), 2022-03-01–2022-10-16, <a href="https://hdl.handle.net/11676/l9QSNswCe3fqCzL0iTwLU8la">https://hdl.handle.net/11676/l9QSNswCe3fqCzL0iTwLU8la</a> , 2022 Heliasz, M. and Biermann, T.: ICOS ATC NRT CH <sub>4</sub> growing time series, Hyltemossa (70.0m), 2022-03-01–2022-10-16, <a href="https://hdl.handle.net/11676/lV2WF-vf84LsT73z6kWFJgV4">https://hdl.handle.net/11676/lV2WF-vf84LsT73z6kWFJgV4</a> , 2022 Heliasz, M. and Biermann, T.: ICOS ATC NRT CH <sub>4</sub> growing time series, Hyltemossa (150.0m), 2022-03-01–2022-10-16, <a href="https://hdl.handle.net/11676/-uYDRenkp8mfYPJLhekmx9Ko">https://hdl.handle.net/11676/-uYDRenkp8mfYPJLhekmx9Ko</a> , 2022

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