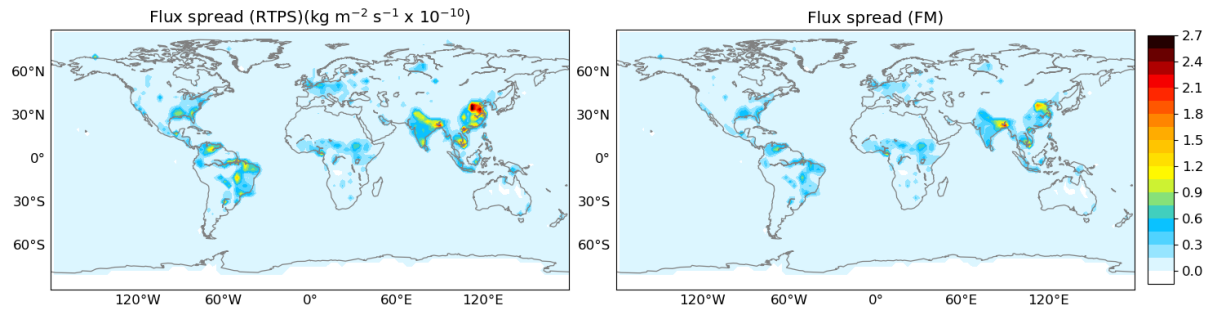Geoscientific
Model Development

Supplement of

Estimation of CH$_4$ emission based on an advanced 4D-LETKF assimilation system

Jagat S. H. Bisht et al.

Correspondence to: Jagat S. H. Bisht (jagatbisht@jamstec.go.jp, jshbisht@gmail.com)
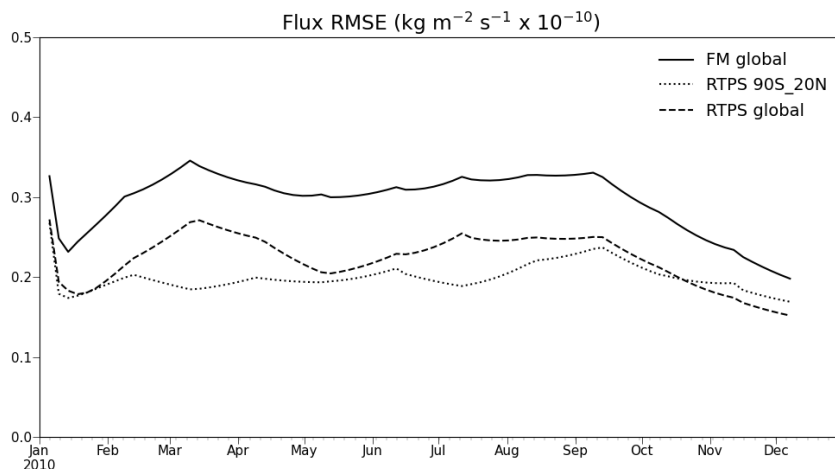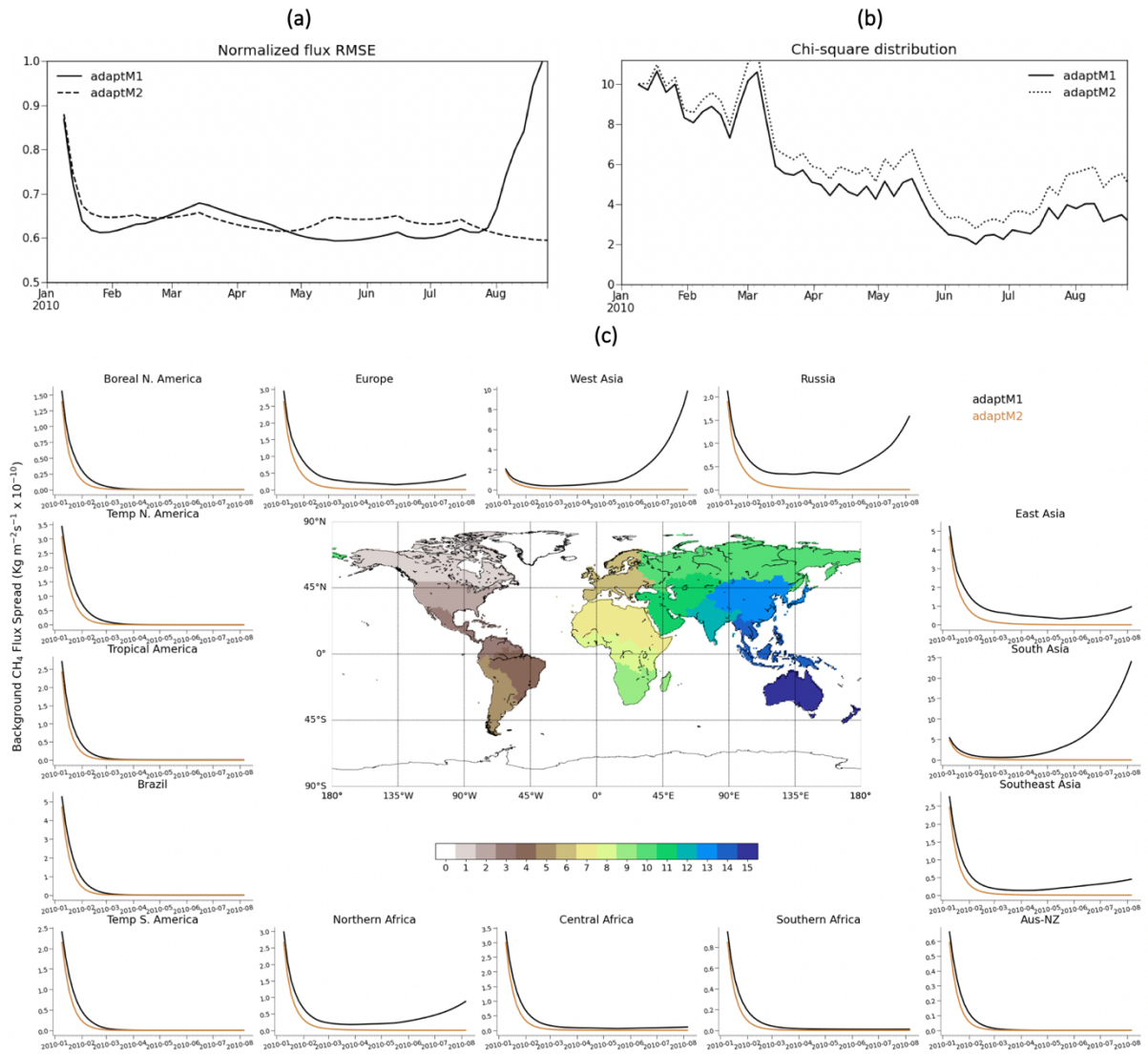
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2

3 **Figure S1.** Initial analysis ensemble flux spread with RTPS and fixed multiplicative (FM) covariance
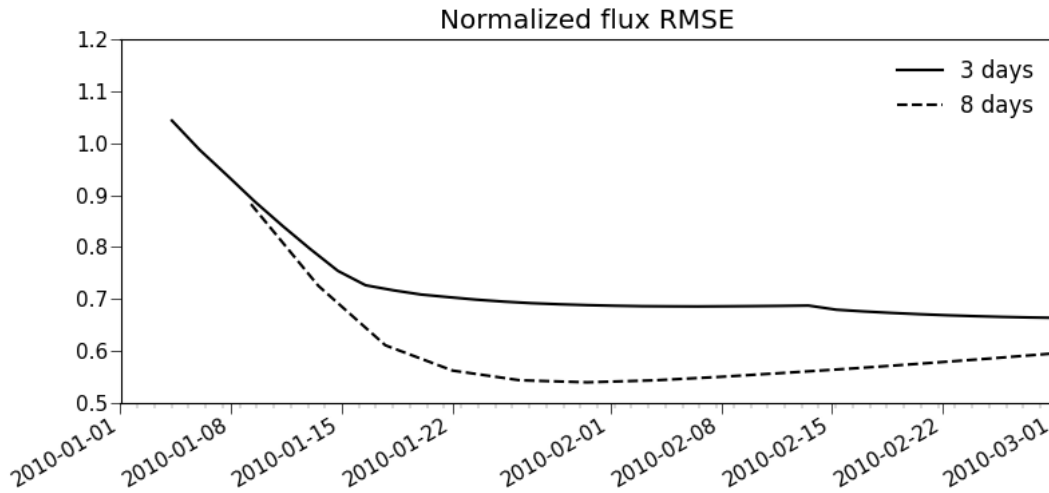4 inflation methods.

5

6 **Figure S2.** Time series of RMSE of surface CH4 flux analysis, for 1 year of data assimilation at every
7 grid using fixed multiplicative inflation and RTPS inflation methods over global landmass region.

8

Figure S3 CH$_4$ LETKF flux estimation time series for; (a) normalized RMSE estimated using
adaptive multiplicative inflation method in two sensitivity experiments (adaptM1; 50% initial
inflation, adaptM2; 40% initial inflation), (b) chi-square distribution comparison for adaptive
multiplicative sensitivity experiments (c) background error spread evolution for adaptive
multiplicative inflation experiments.

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15 **Figure S4.** Time series of normalized RMSE estimated using 3 days and 8 days assimilation window

16 for CH_4 LETKF data assimilation (inflation method: RTPS).

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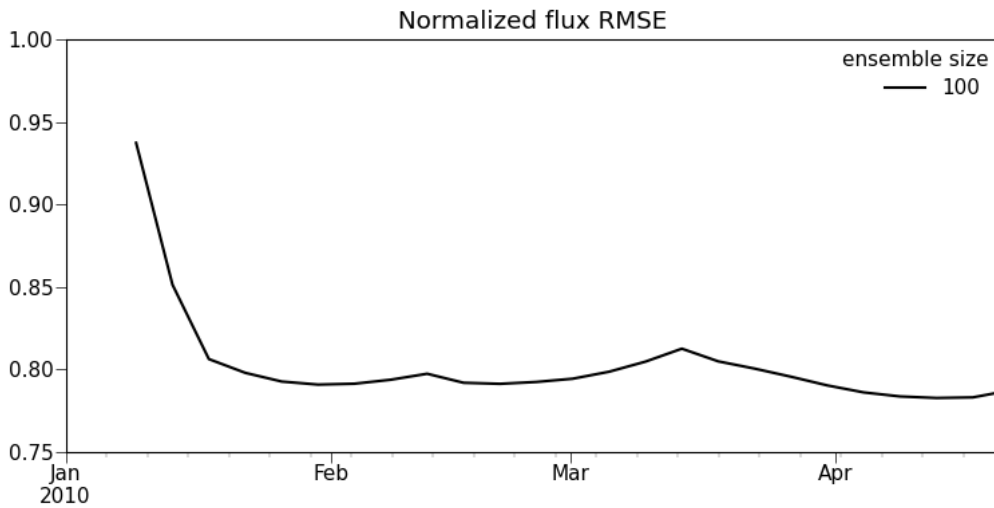
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20 **Figure S5.** Time series of normalized RMSE of surface CH_4 flux analysis after assimilating GOSAT

21 synthetic CH_4 observations shown for the period of 4 months using initial spread that is generated by

22 considering the initial perturbation at each model grid by considering horizontal spatial error

23 correlation between grid points among ensemble members, with a global mean correlation of 20%.

24
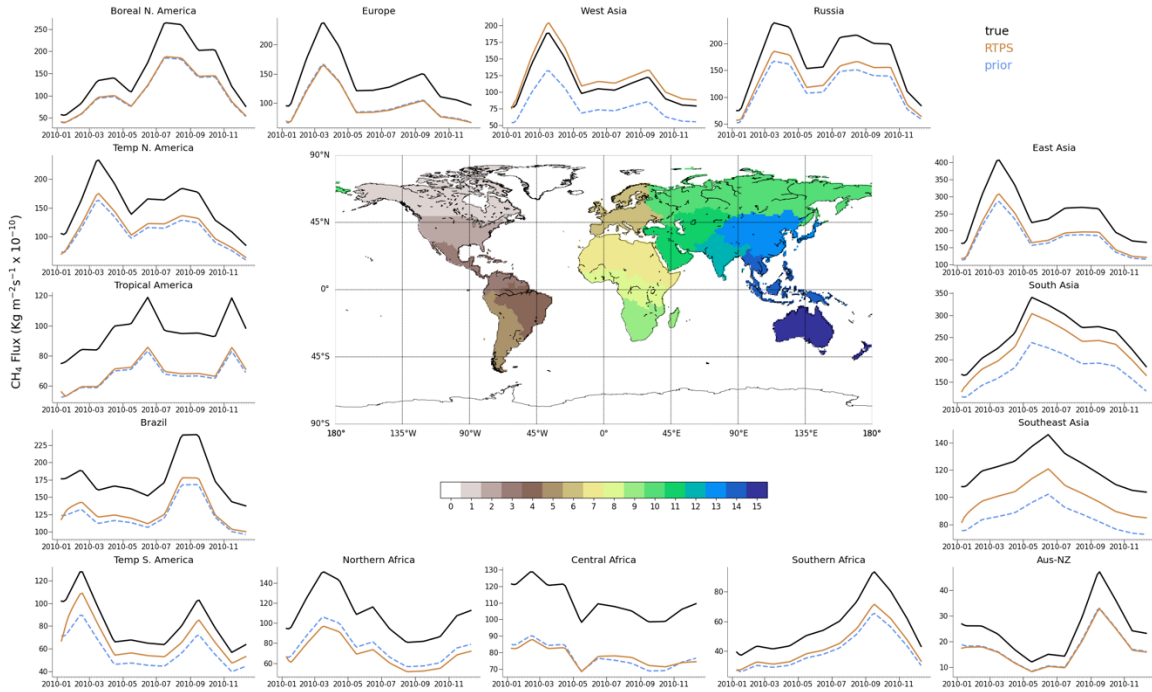
Figure S6. The 1-year CH4 total flux seasonal cycles of true (black), prior (gray), and estimated from
the LETKF (blue) in 15 regions using FM inflation method after assimilating synthetic GOSAT CH$_4$
observations (Fig. 6).

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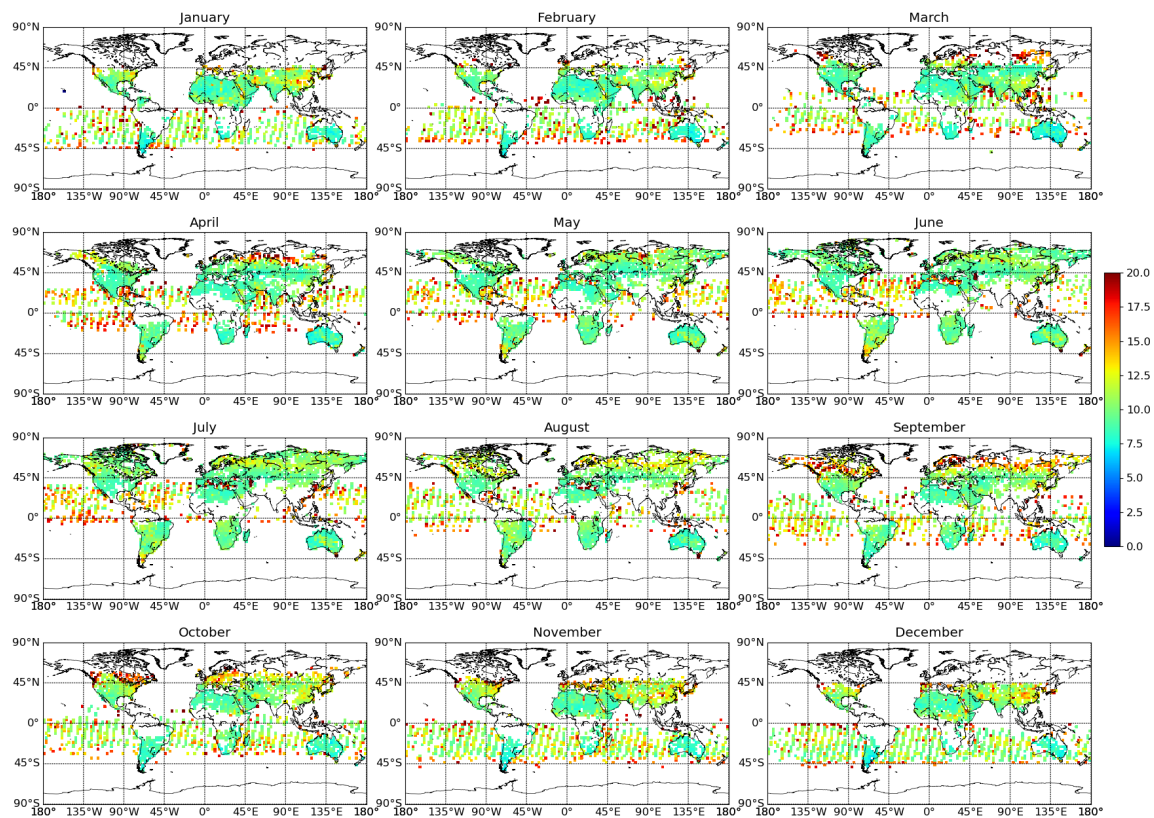
Figure S7. Monthly mean of real GOSAT observations retrieval error during the year 2010.

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