Spatial Estimates for CH_4 and N_2O Emission at the Continental Scale Using a Direct Inversion Technique With Recursive Source Area Aggregation

Alexander T. Vermeulen[1]; , Gerben Pieterse[2]; Peter Bergamaschi[3]; Matteo Corraza[3]; Rob Rodink[1]; Elena Popa[2,1]; Pim van den Bulk[1]

[1] Air Quality & Climate Change, ECN, Petten, Netherlands [2] Utrecht University, Utrecht, Netherlands [3] JRC, IES, Ispra, Italy

ECN Energieonderzoek Centrum Nederland

Introduction

The recent extension of the European network of high precision continuous atmospheric observations of greenhouse gases allows to test and improve inversion techniques based on atmospheric transport modeling.
First we evaluate the model performance for CH_4 and CO_2 for several European stations.
Also we show the latest results of (spatial) high resolution inversions of the average emission fluxes for methane and nitrous oxide for the years 2006 and 2007 using the observations of the recently expanded network and sensitivity footprints delvered by the COMET model, used in a direct matrix inversion scheme that applies a recursive source area aggregation scheme.

COMET

Simple two layer Lagrangian trajectory model [1], describing concentrations in mixed layer and residual layer along trajectory path. COMET is driven by trajectory data calculated by the FLEXTRA model [2] using ECMWF analysed windfields.See fig 1.

COMET Inverse

The Source Receptor Matrices derived with COMET are used in a direct SVD inversion using a Iterative Source Aggregation Scheme (ISAS). In ISAS the SRM matrix is accumulated from the SRM's for multiple receptors, regularized by joining adjacent cells in blocks of 2x2, 4x4 etc, until all joined blocks have contributions of at least a given value relative to the maximum value in the initial SRM. In further steps blocks with uncertain derived emissions are removed, blocks that form dipoles are joined and blocks with associated small eigenvalues are removed from the equation. Removed blocks are assigned the prior emission [3]

Observations

Observations 2007: CHIOTTO/CE-IP network of tall towers, the RAMCES network (F), the UBA network (D), and the NOAA CMDL cooperative flask network. Where available the continuous data were used in hourly resolution.

Boundary conditions and priors

Methane and nitrous oxide global background data have been calculated using the TM5 model by JRC in 2x3 degree resolution [4,5]. CO_2 background data is from the EU Carbontracker system [6]. Emissions are used according to the NEU 6.2 protocol with a resolution of 1x1 degree, or EDGAR v4.1 at 0.1 degree resolution. The FACEM CO_2 NEE fluxes have been produced at a resolution of 0.1 degree [7].

Results

In forward mode the model explains up to 80% of observed variability depending on station and prior emissions field. The simulations show that tall towers receive a significant signal from regional sources and sinks of GHGs. The ISAS system determines automatically the regions and the resolution for which observations allow to resolve with a given precision the emissions in a direct inversion. The results depend on specific properties of the different greenhouse gases like the relative size, temporal variations and locations of the sources and sinks.
Further extension of the network with continuous observations and further increasing resolution and precision of the transport modelling is still needed.

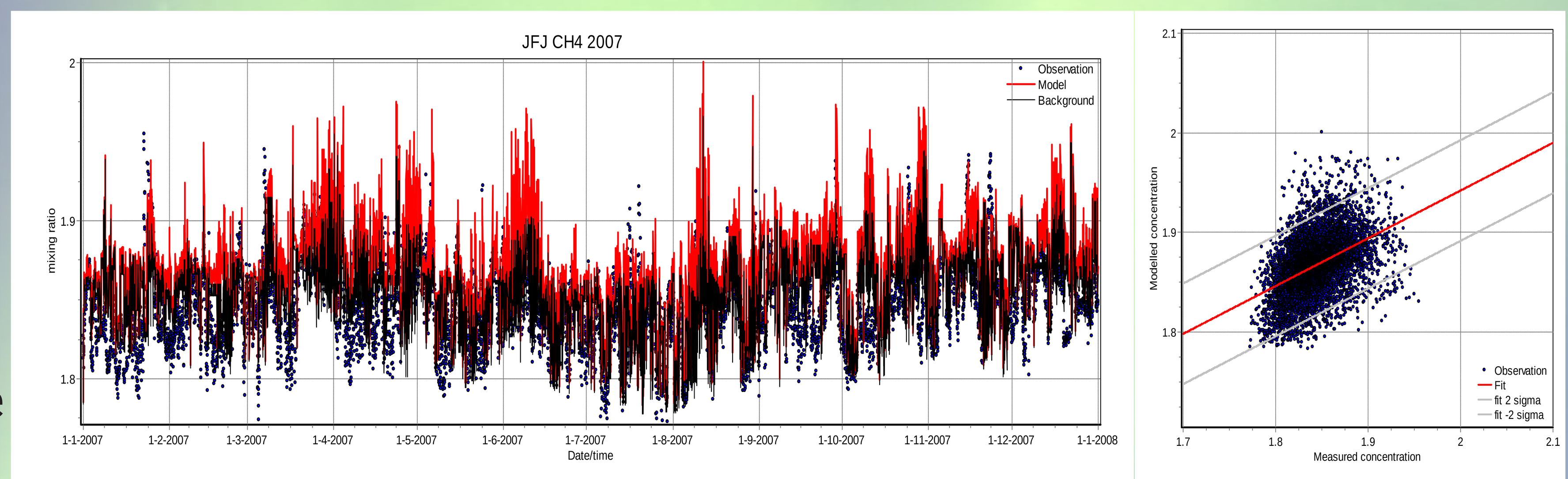

Fig 3 (a) Forward simulation and measured mixing ratios of CH_4 [ppm] at station Junkfraujoch in 2007 and (b) corresponding scatterplot of modeled versus measured mixing ratios [ppm]; see table 1

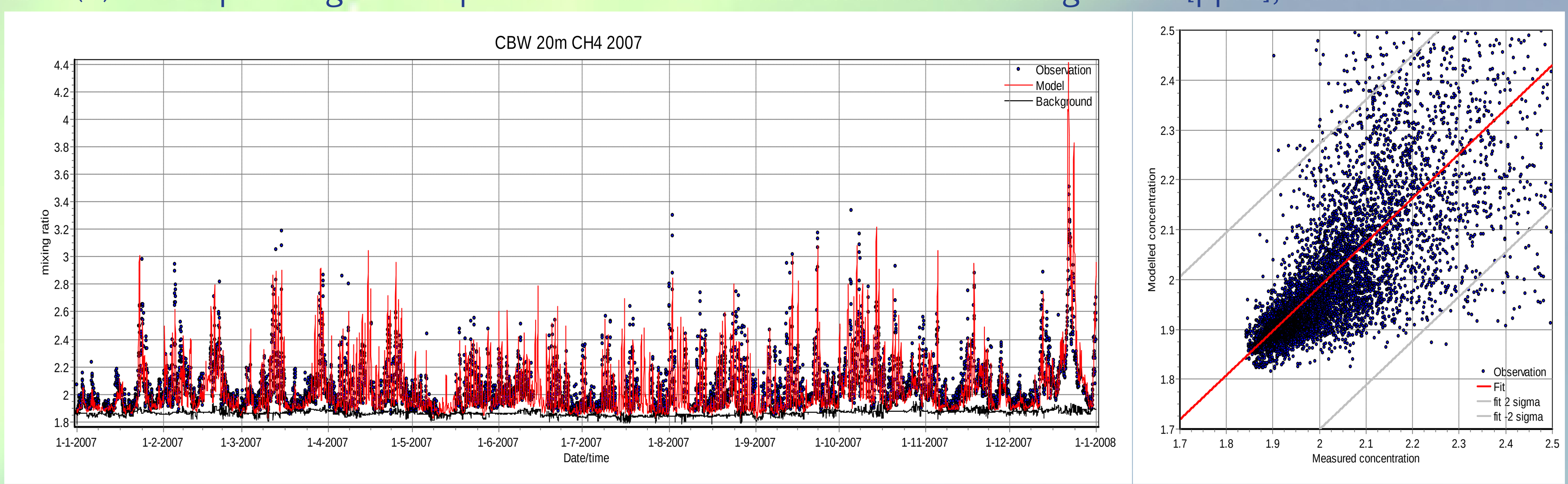

Fig 4 (a) Forward simulation and measured mixing ratios of CH_4 [ppm] at station Cabauw in 2007 and (b) corresponding scatterplot of modeled versus measured mixing ratios [ppm]; see table 1

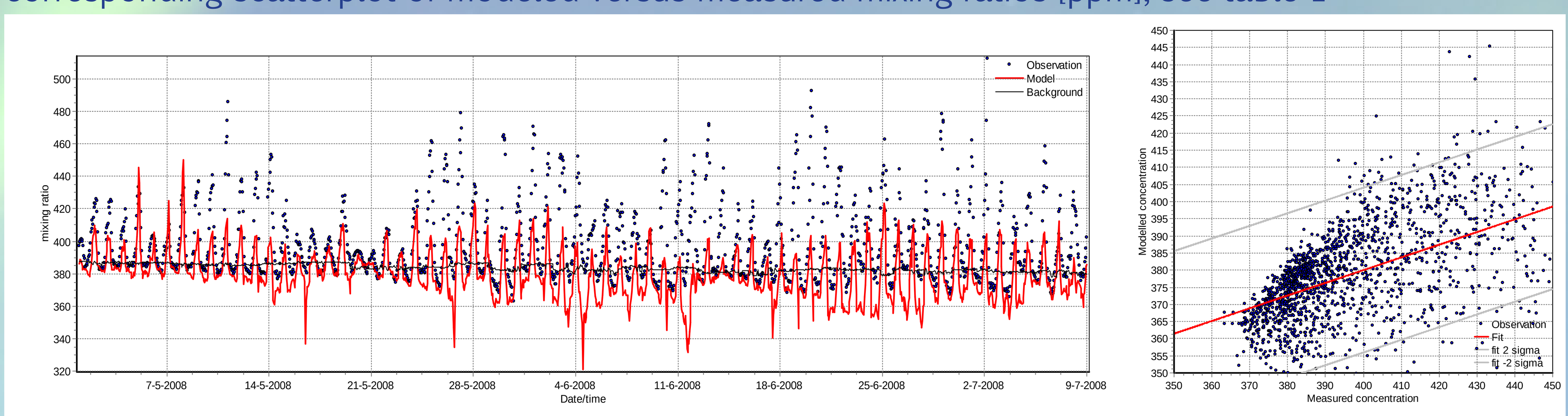

Fig 5 (a) Forward simulation and measured mixing ratios of CO_2 [ppm] at station Hegyhatsal (HU) in summer 2008 and (b) corresponding scatterplot of modeled versus measured mixing ratios [ppm]; see table 1

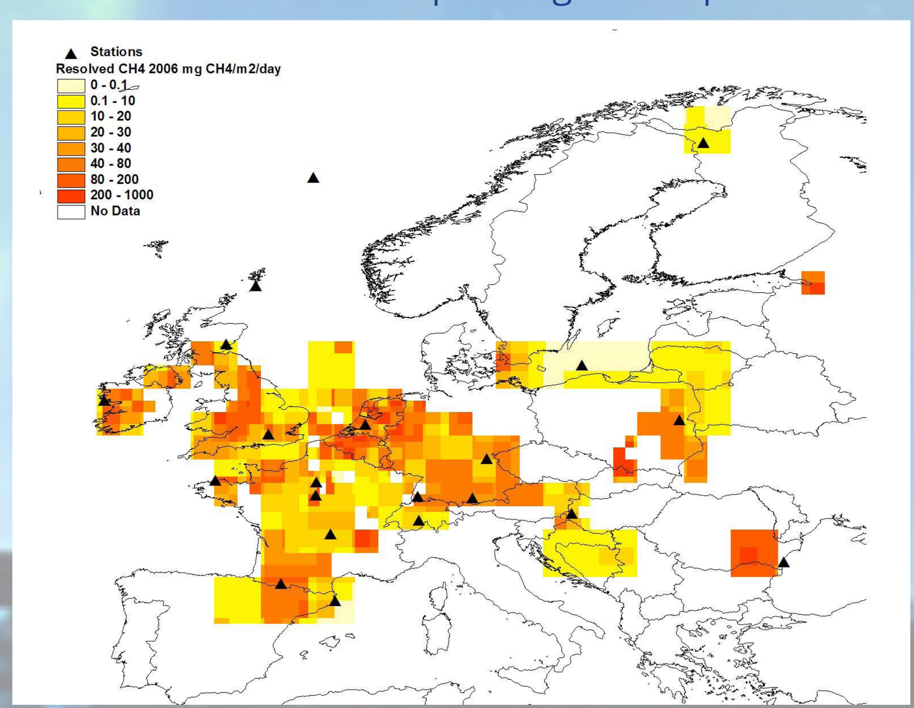

Fig 6 Posterior CH_4 emissions resolved from the observations in 2006 (at black triangles) using the COMET source area aggregation inversion system

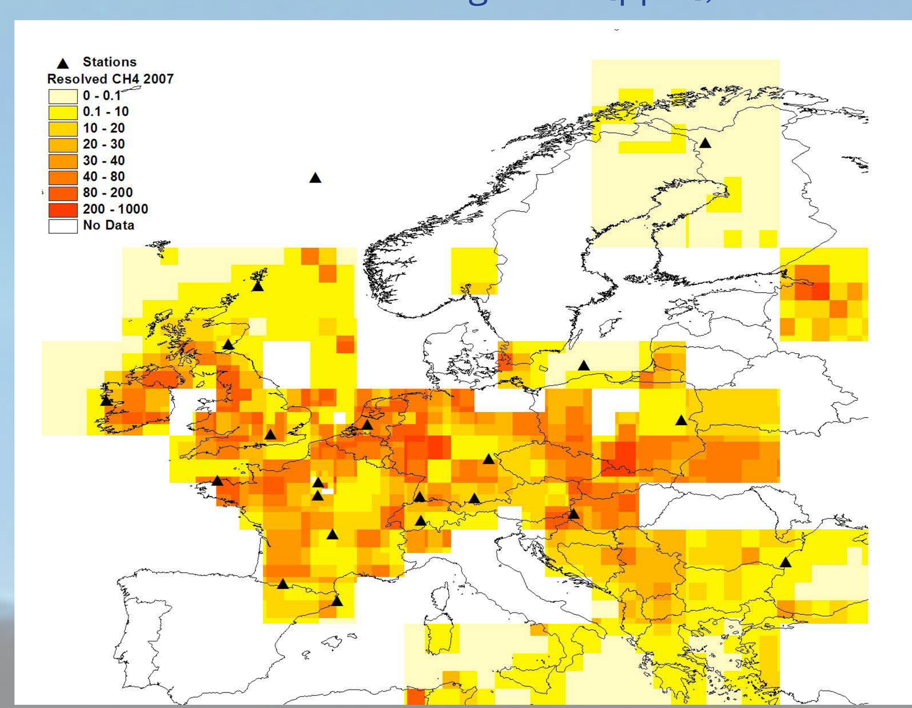

Fig 7 Posterior CH_4 emissions resolved from the observations in 2007 (at black triangles) using the COMET source area aggregation inversion system

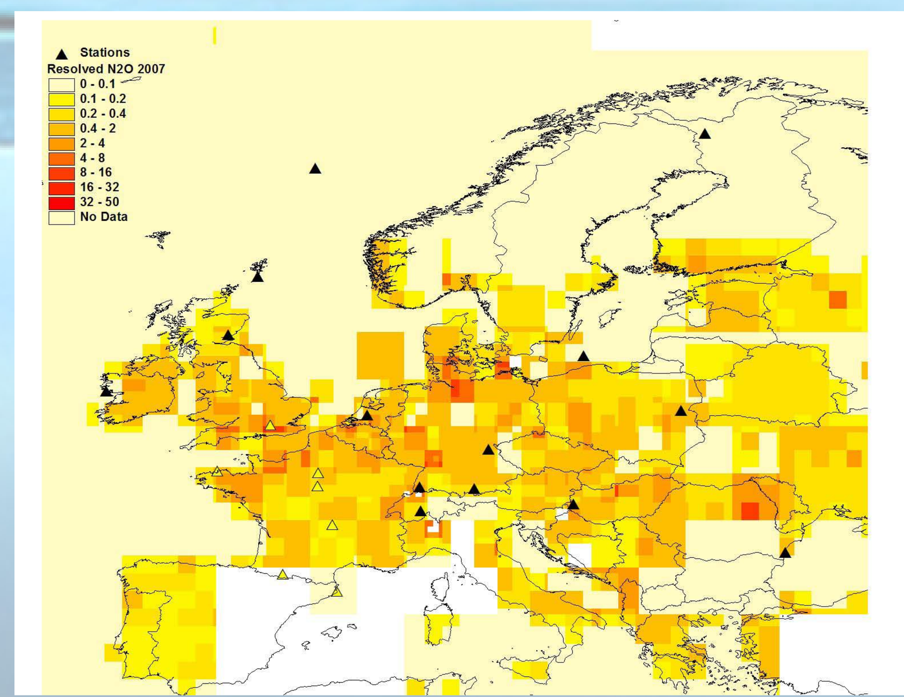

Fig 7 Posterior N_2O emissions resolved from the observations in 2007 (at black triangles) using the COMET source area aggregation inversion system

Table 1, Performance of forward simulated concentrations of CH_4 and CO_2 for different stations and prior emission estimates

Gas	CH_4					CO_2		
Station	JFJ	CBW				HUN		
Obs Height	2500	20			200	20		
RMSE	0.025	0.143	0.111	0.172	0.039	18.7	12.0	3.6
BIAS	0.022	-0.020	-0.084	-0.019	-0.028	-8.1	-18.6	-12.0
Slope	0.480	0.888	0.581	0.786	0.292	0.802	0.370	0.040
R	0.4450	0.7528	0.6936	0.6440	0.4791	0.6105	0.5696	0.2428
R^2	0.1981	0.5668	0.4811	0.4148	0.2295	0.3727	0.3245	0.0589

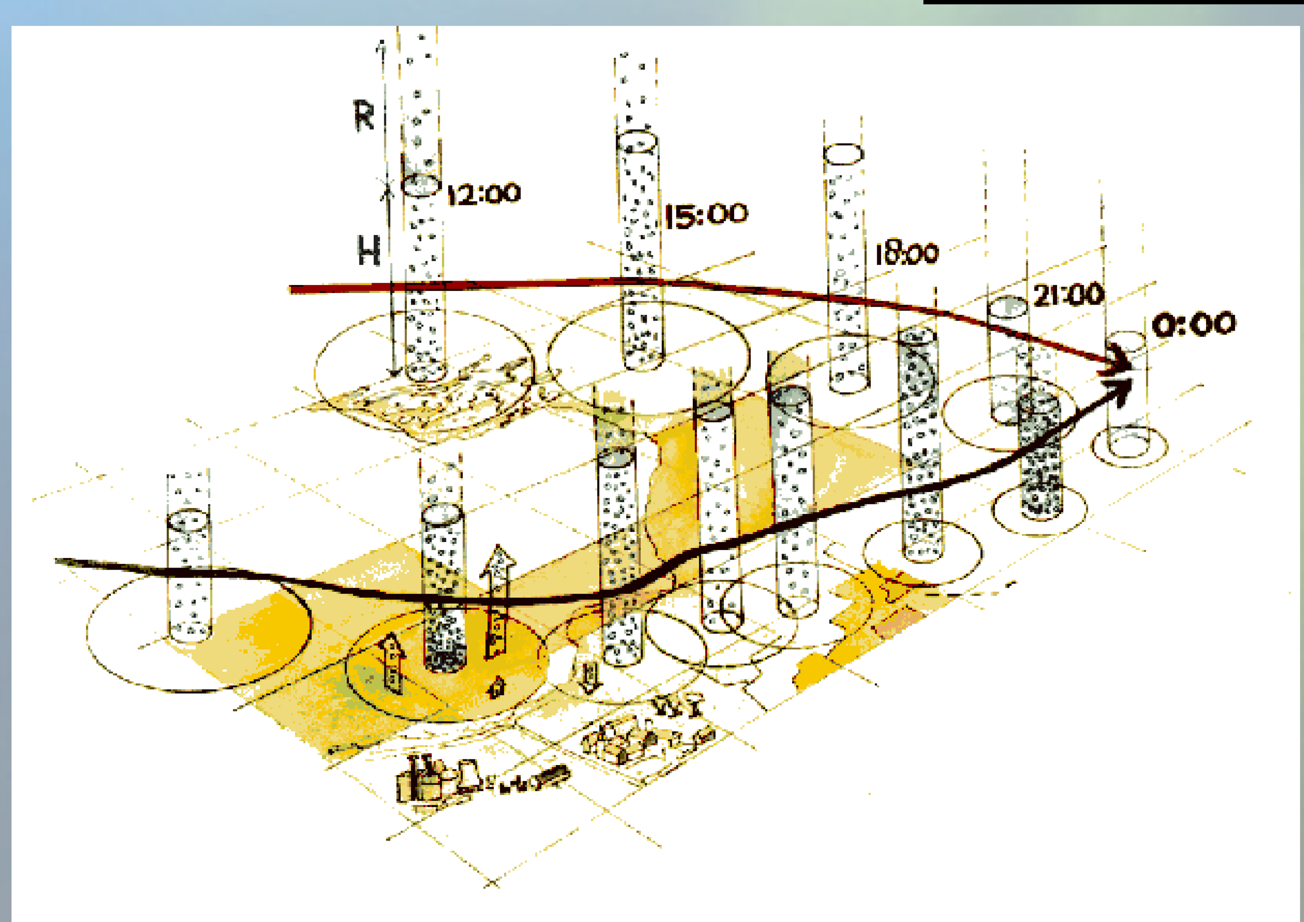

Fig 2. Artist impression of the COMET trajectory model (AH)

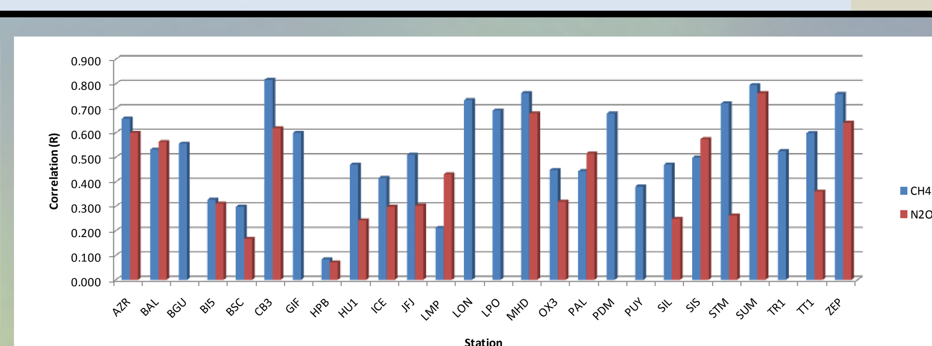

Fig 2. Correlation at 26 stations in Europe of COMET predicted concentrations of CH_4 and N_2O with observations using the prior emission data

Acknowledgements

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References

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