Energy research Centre of the Netherlands

Verifying the Emissions of non-CO_2 GHG of NW Europe Using the European Network of Tall Towers

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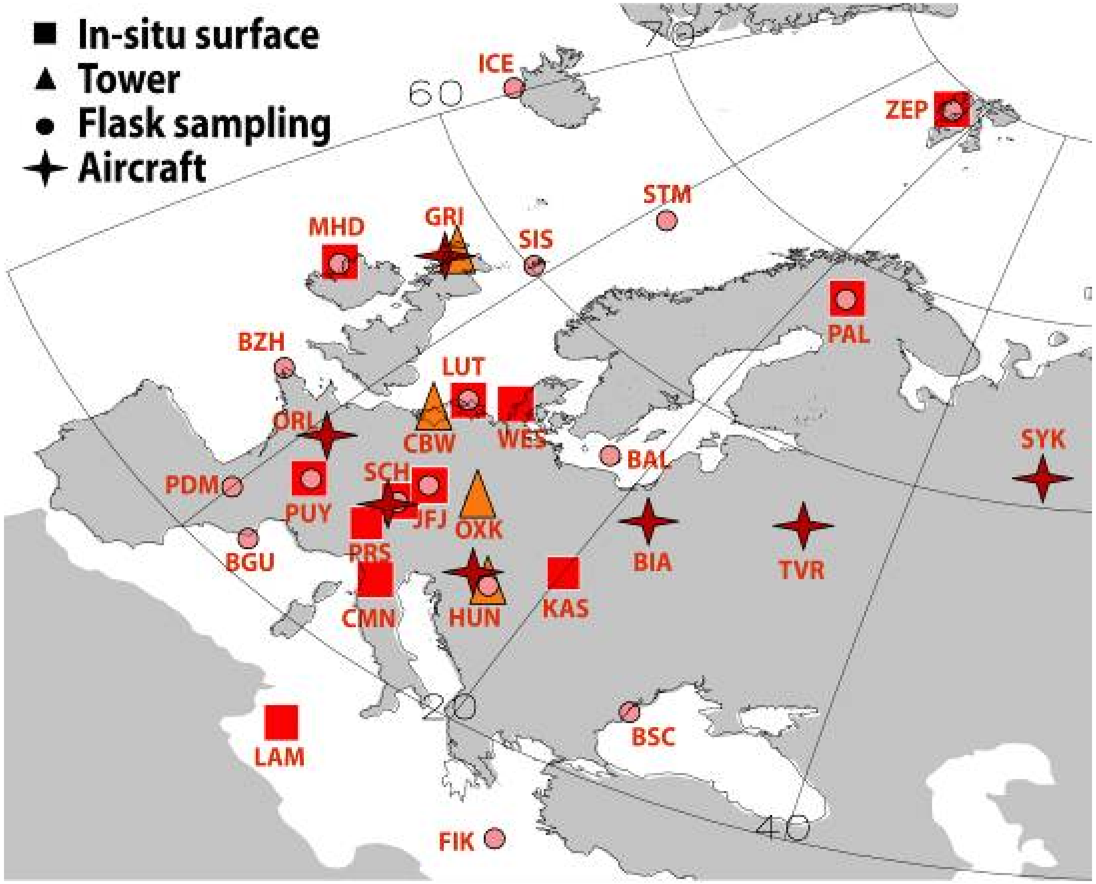
[1] ECN [2] JRC ISPRA [3] LSCE [4] MPI-BGC [5] CIO-RUG [6] UEDIN [7] HMS [3] UK Mettoffice

Outline

- Expansion of the surface network in Europe
- Measurement results
- Model setup (NEU 6.2)
- Model results: emissions of methane
- Challenges & Outlook

The European Atmospheric Network Present status



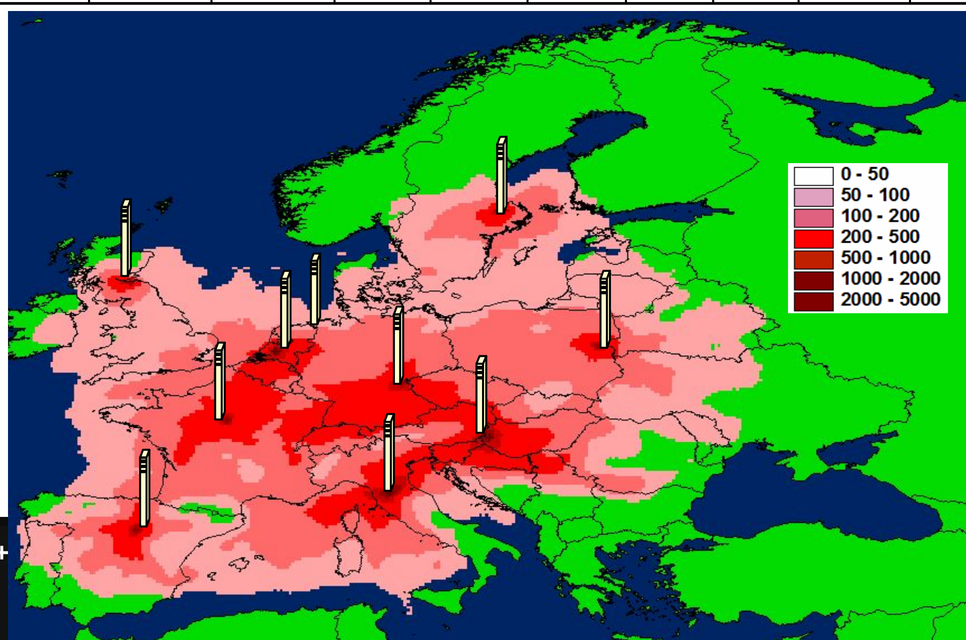
- 3 laboratories for air sample analysis
- Background CO_2 observing sites around the world
- Regionaly dense stations network in Western Europe
- Transect of aircraft sites across Eurasia
- New network of tall towers

The tall tower network (CHIOTTO)

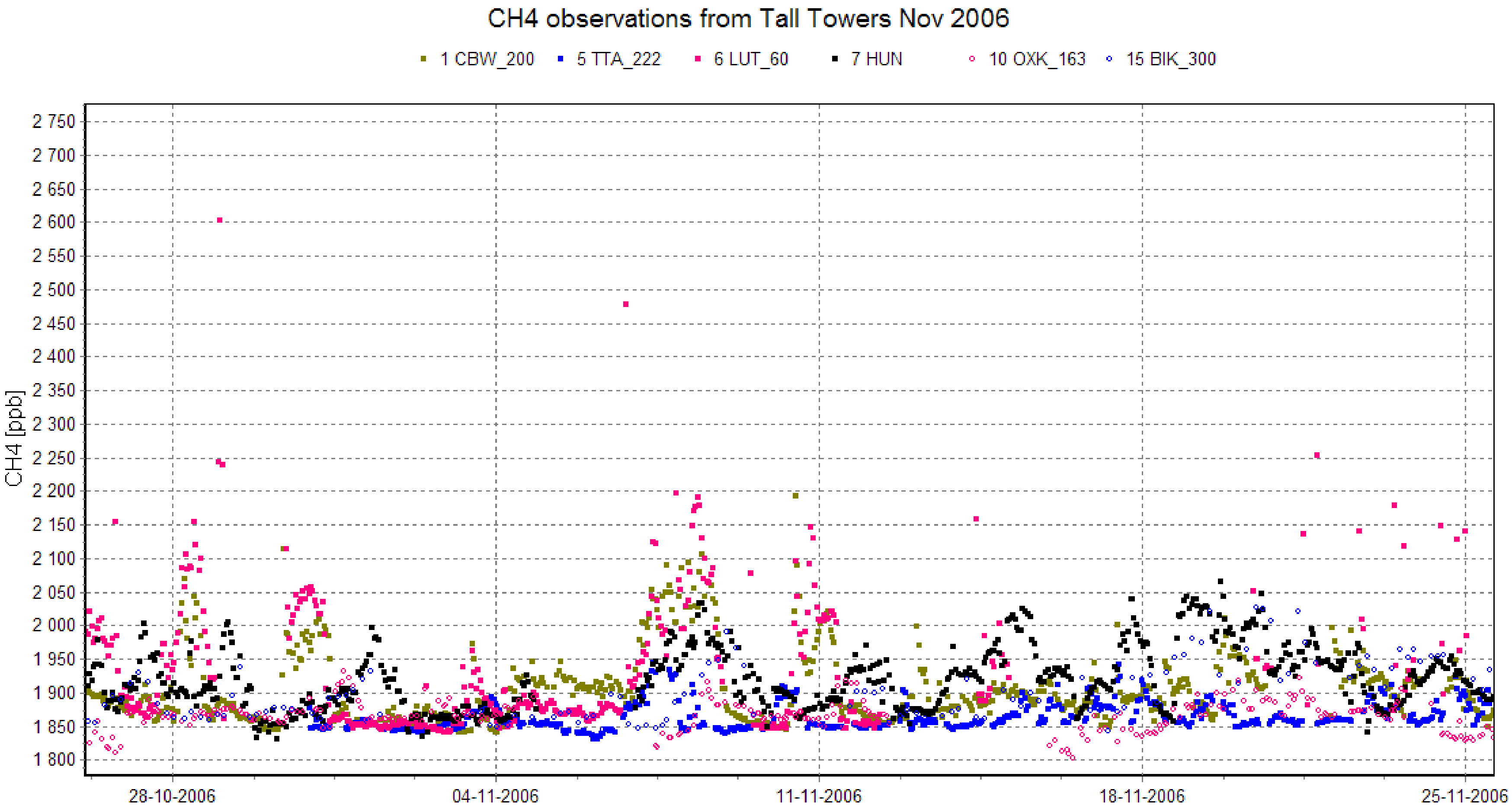
- 8 continuous monitoring stations
- 4 new stations, 4 upgraded
- High precision CO_2, CH_4, SF_6, N_2O
- Tall towers (>100 m AGL)
- Common equipment set
- Common sample treatment (drying etc)
- Common scale, calibration gases, archive standards
- Vertical gradient where possible
- Ancillary tracers: CO, ^{222}Rn, H_2, FTIR
- Flask observations
- Intercomparisons

The observational (tall) tower network

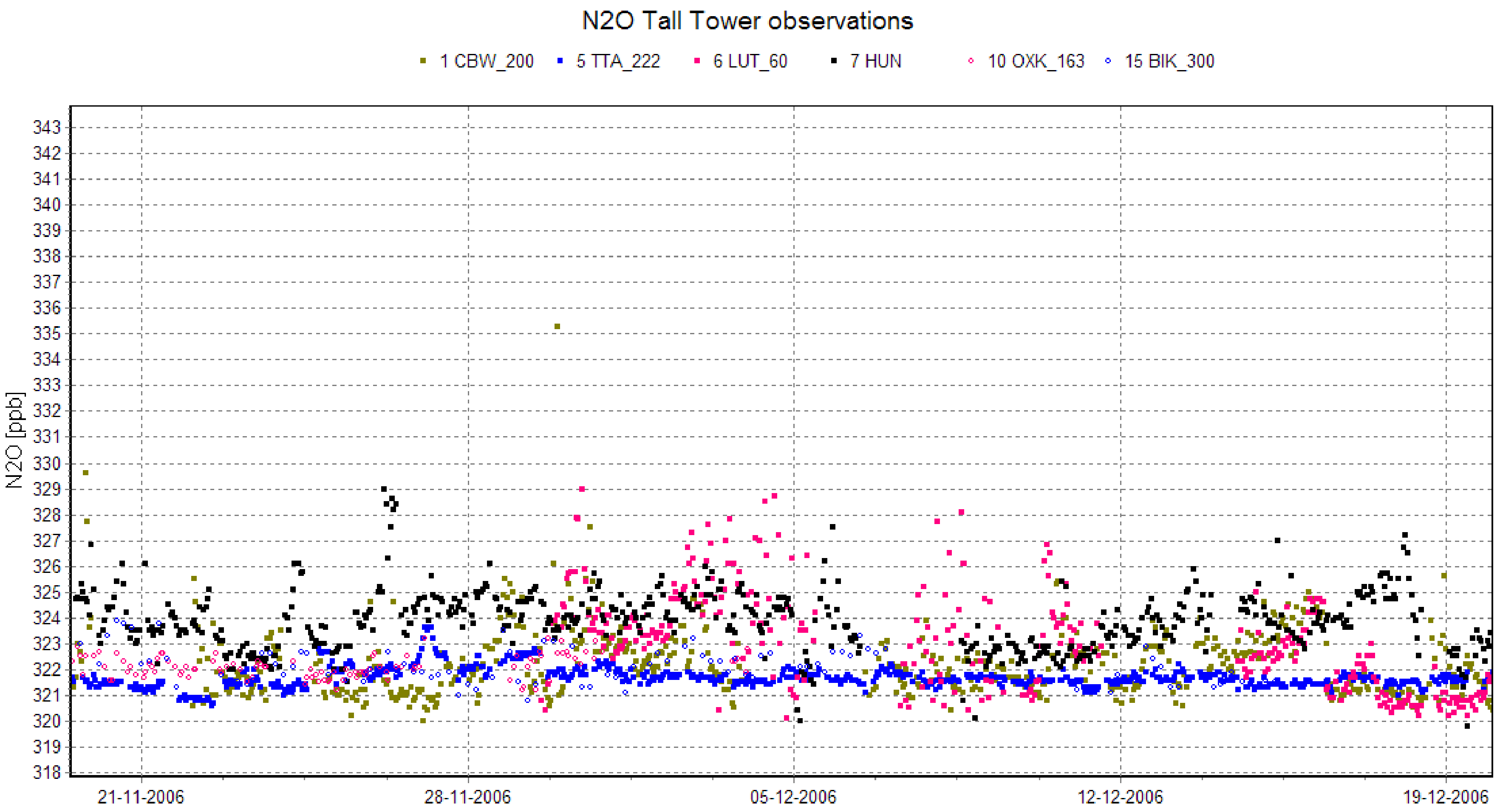
		Hght	Position		Concentration measurement (levels)							Flux meas		
Name		(m)	Lon	Lat	CO_2	CH_4	N_2O	SF_6	CO	^{222}Rn	Flasks	CO_2	CH_4	Operator
Cabauw	NL	200	04°56’	51°58’	4	4	4	4	4	1	✓	2		ECN
Griffin/Angus	UK	232	-2°59'	56°33’	1	1	1	1		1				UEDIN
Hegyhatsal	H	117	16°39’	46°57'	4	1	1	1	1		✓	2		ELTE
Orleans/Trainou	F	131	2°07’	46°58’	3	3	3	3	3	1	✓			LSCE
Norunda	S	102	17°28’	60°05’	4	2						2	2	LUPG
Florence	I	245	11°16’	43°49’	1	1	1	1	1					UNITUS
Ochsenkopf	D	163	11°49’	50°03’	3	3	3	3			✓			MPIBGC
Bialystok	PL	300	22°45’	52°15’	5	5	5	5	5		✓			MPIBGC
Lutjewad	NL	60	6°21’	53°24’	2	2	2	2	2	1	✓	2		CIO-RUG
La Muela	ES	84	1°06’	41°35’	1						✓	1		PCB



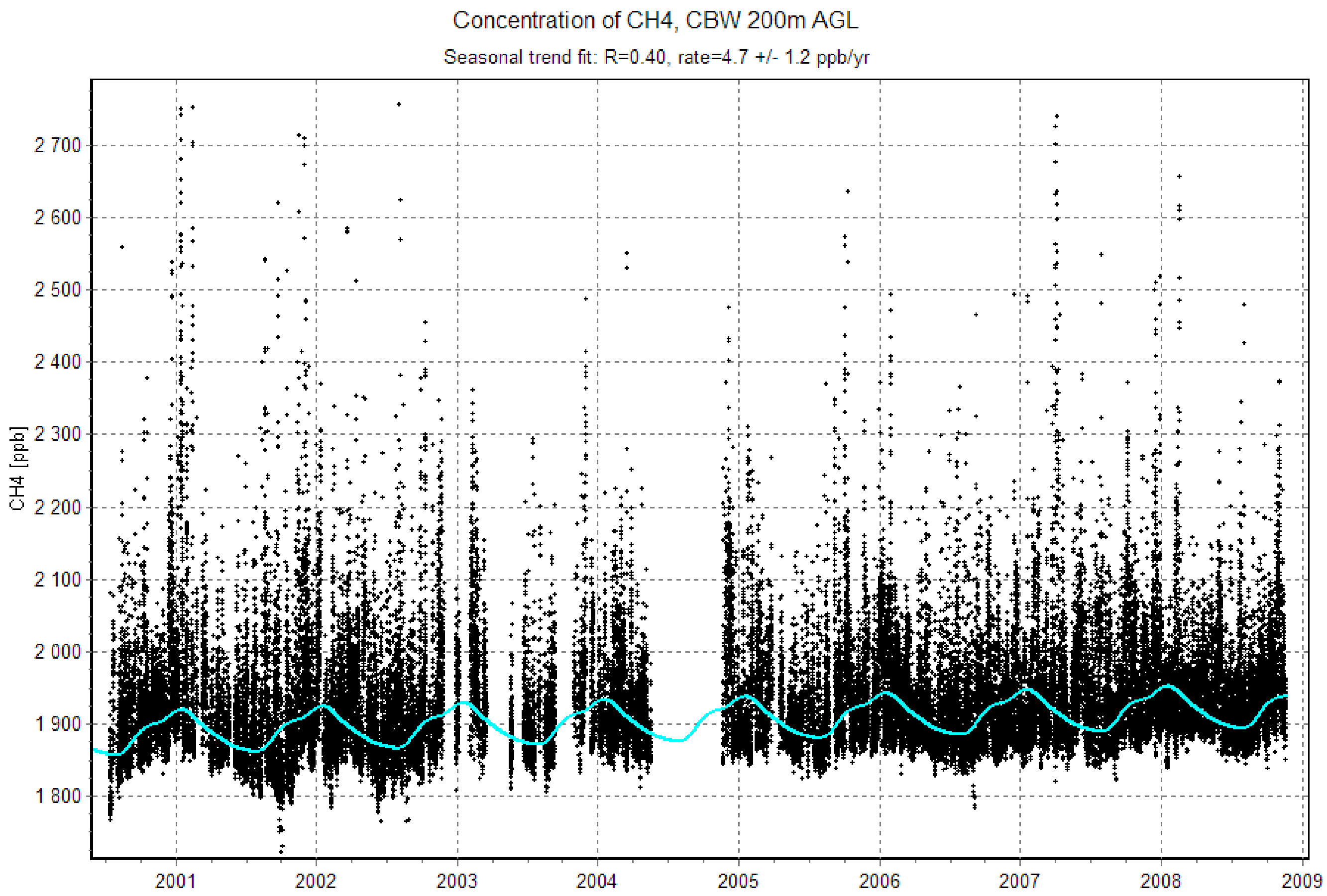
Measurement results: CH_4 in the network



Measurement results: N_2O



Measurement results: CH_4 emission trend CBW

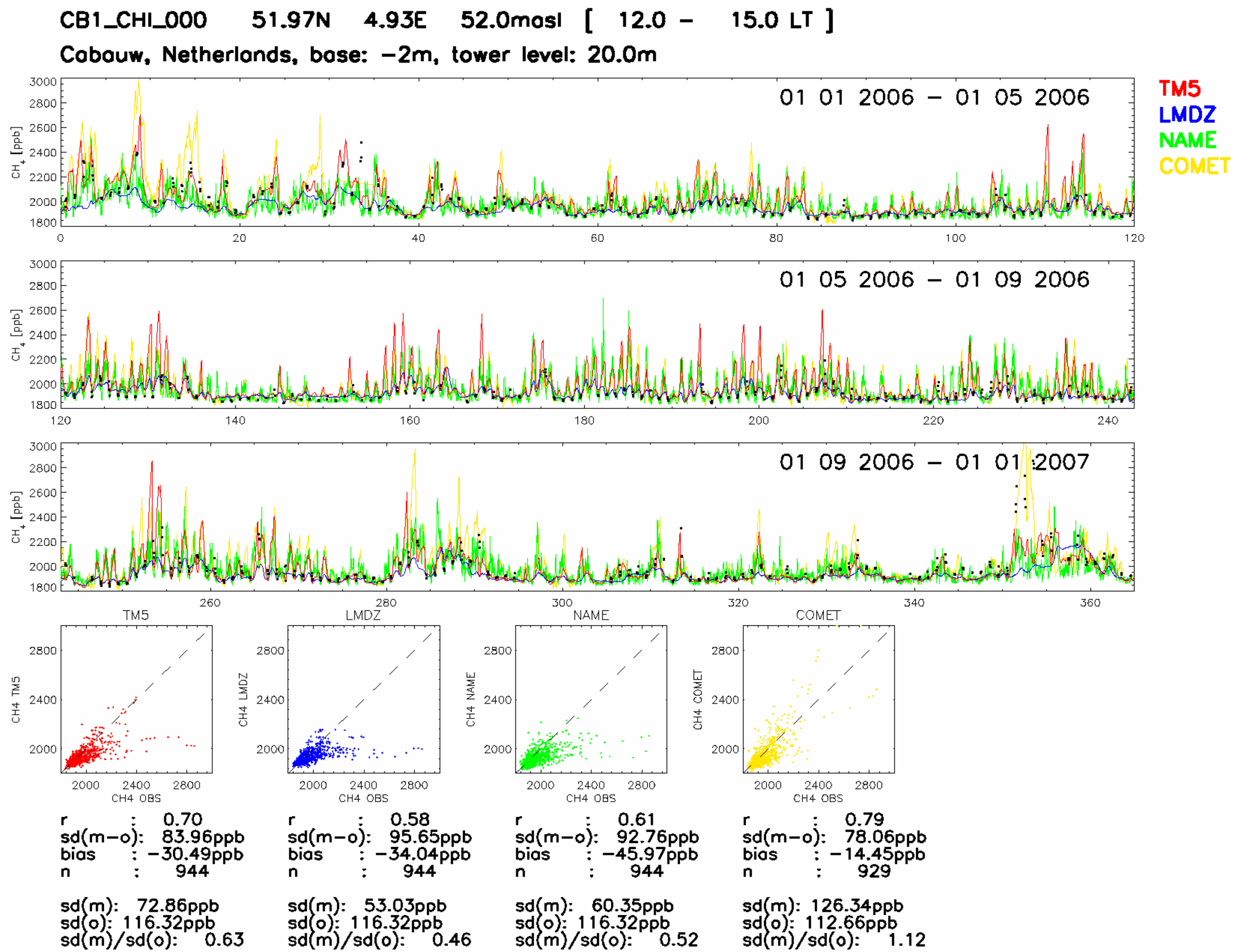


- Seasonal trend fit 1993-2008: 0.8 +/- 0.6 ppb/yr
- 2000-2008: 4.7 +/- 1.2 ppb/yr

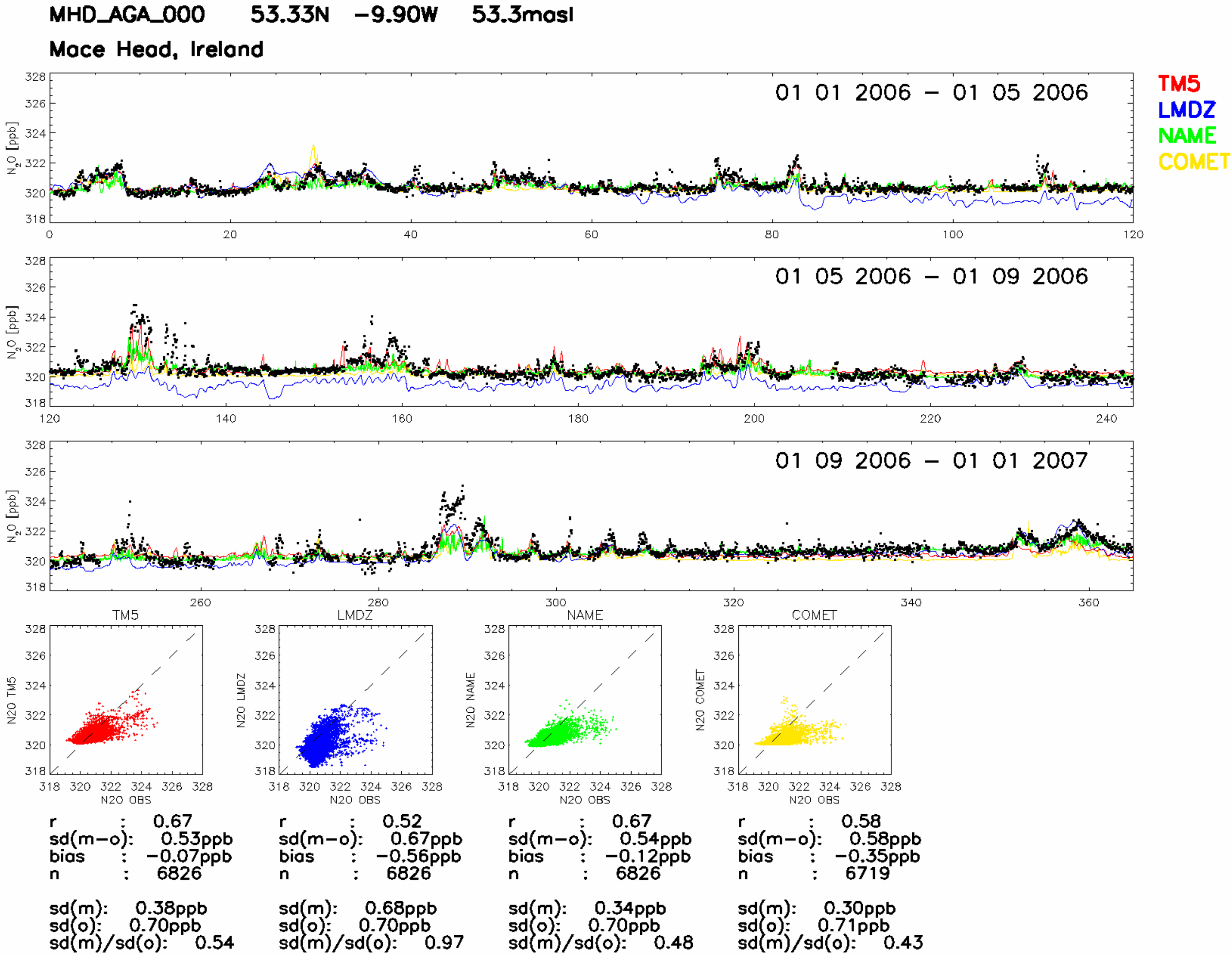
NitroEurope model and inversion exp. setup

partner	model	short description
JRC	TM5-4DVAR model	Eulerian two-way nested zoom model [*Krol et al.*, 2005]; 4DVAR optimization (individual grid cells) [*Bergamaschi et al., 2007; Meirink et al., 2008*]
MPI	TM3-STILT	TM3: global Eulerian model [*Heimann and Koerner, 2003*] STILT: nested regional model (0.25x0.25)
CEA	LMDZ model	Eulerian model with flexible grid size, high resolution over Europe [*Bousquet et al, 2007*] 4DVAR multi-species optimization (individual grid cells)
ECN	COMET WRF/FLEXPART	Lagrangian trajectory model [Vermeulenm 2006, 2007] Lagrangian particle dispersion model [*Stohl*, 1998] Recursive source area aggregation Inversion technique
UKM	NAME model	Lagrangian particle dispersion model [*Manning et al., 2003, Manning, 2007*] Baseline detection and Simulated annealing inversion technique

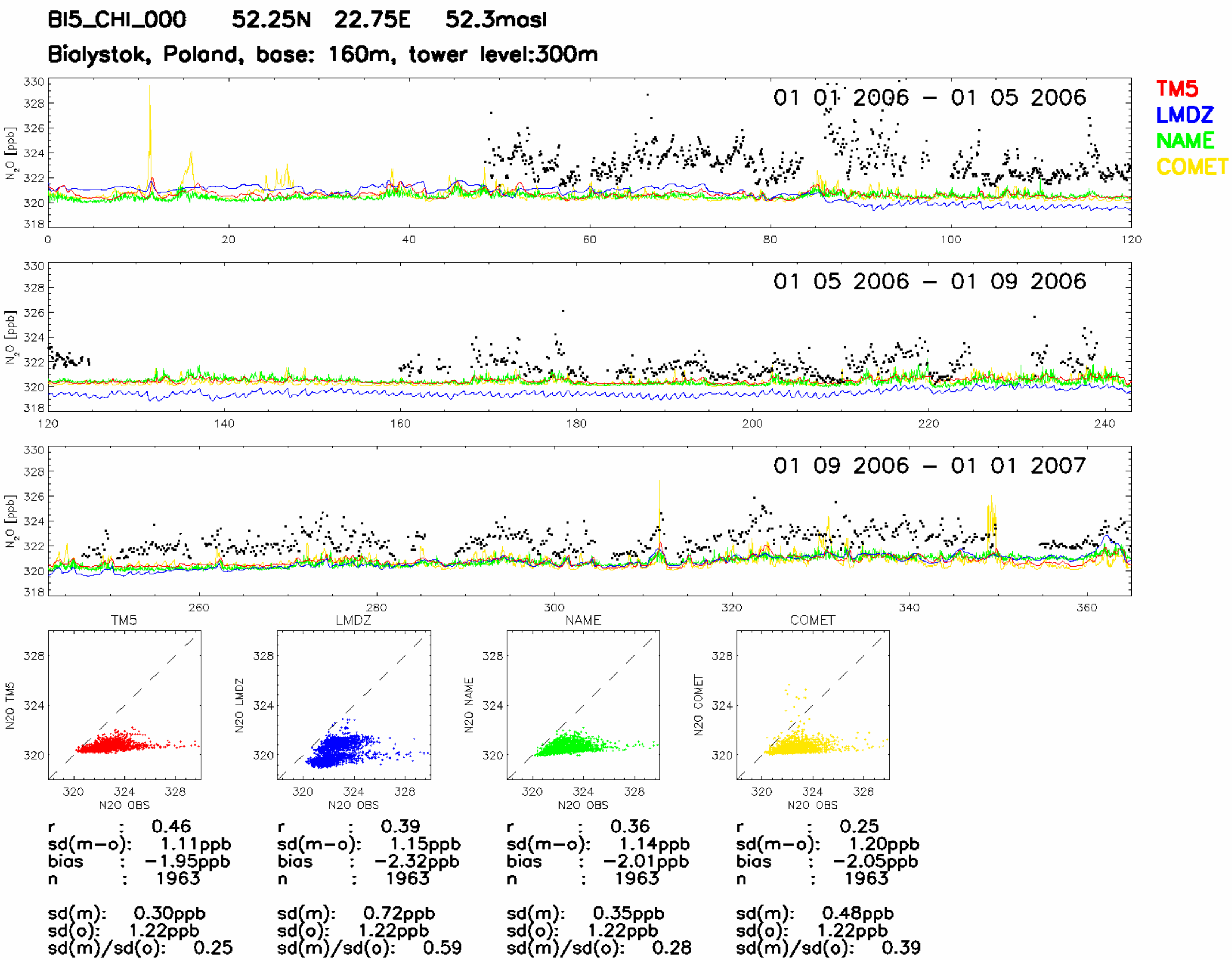
ECN CH_4 forward results: CBW



N_2O forward results: MHD

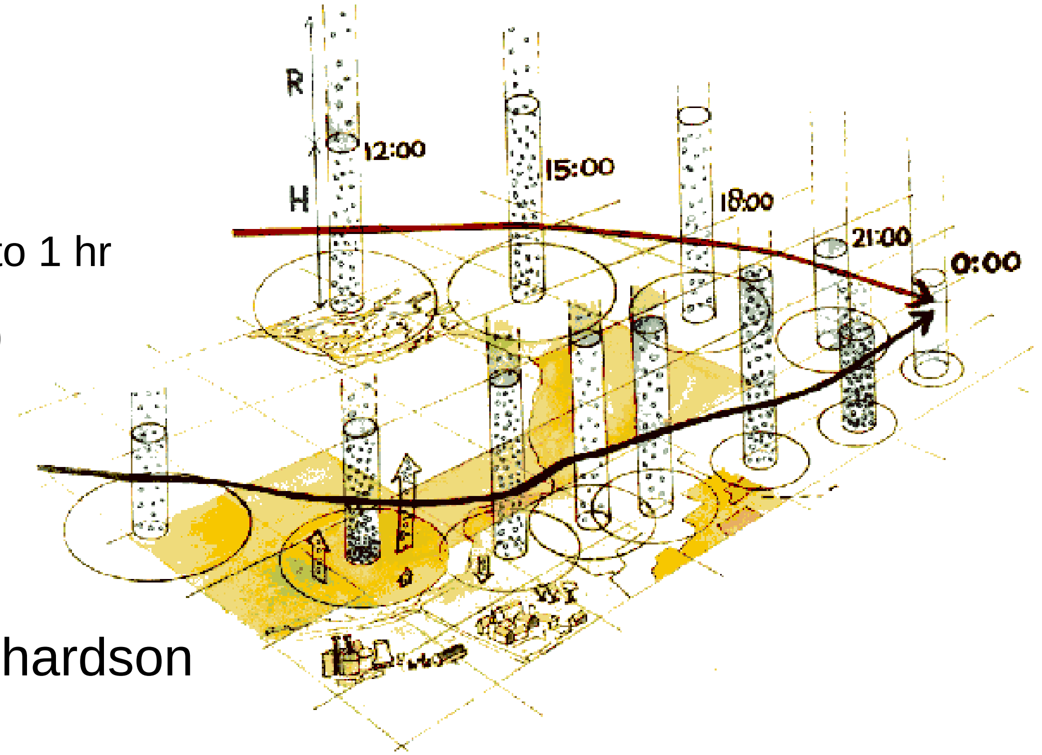


N_2O Forward results: BIK

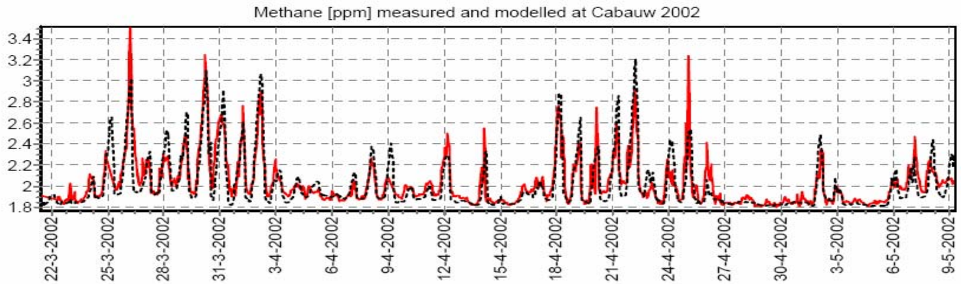


Transport model COMET

- Lagrangian model
- ECMWF meteorology
  - 2° to 0.2° resolution
  - timestep 3 hr, interpolated into 1 hr
- Hourly trajectories (FLEXTRA)
- Moving two layered box :
  - Mixing layer
  - Reservoir layer
- Mixing layer height: critical Richardson number



Previous results for CH_4: R=0.9, bias =0 ppb



Vermeulen et al., Env. Sci. & Pol., 2, 1999
Vermeulen et al., ACPD, 6, 2006

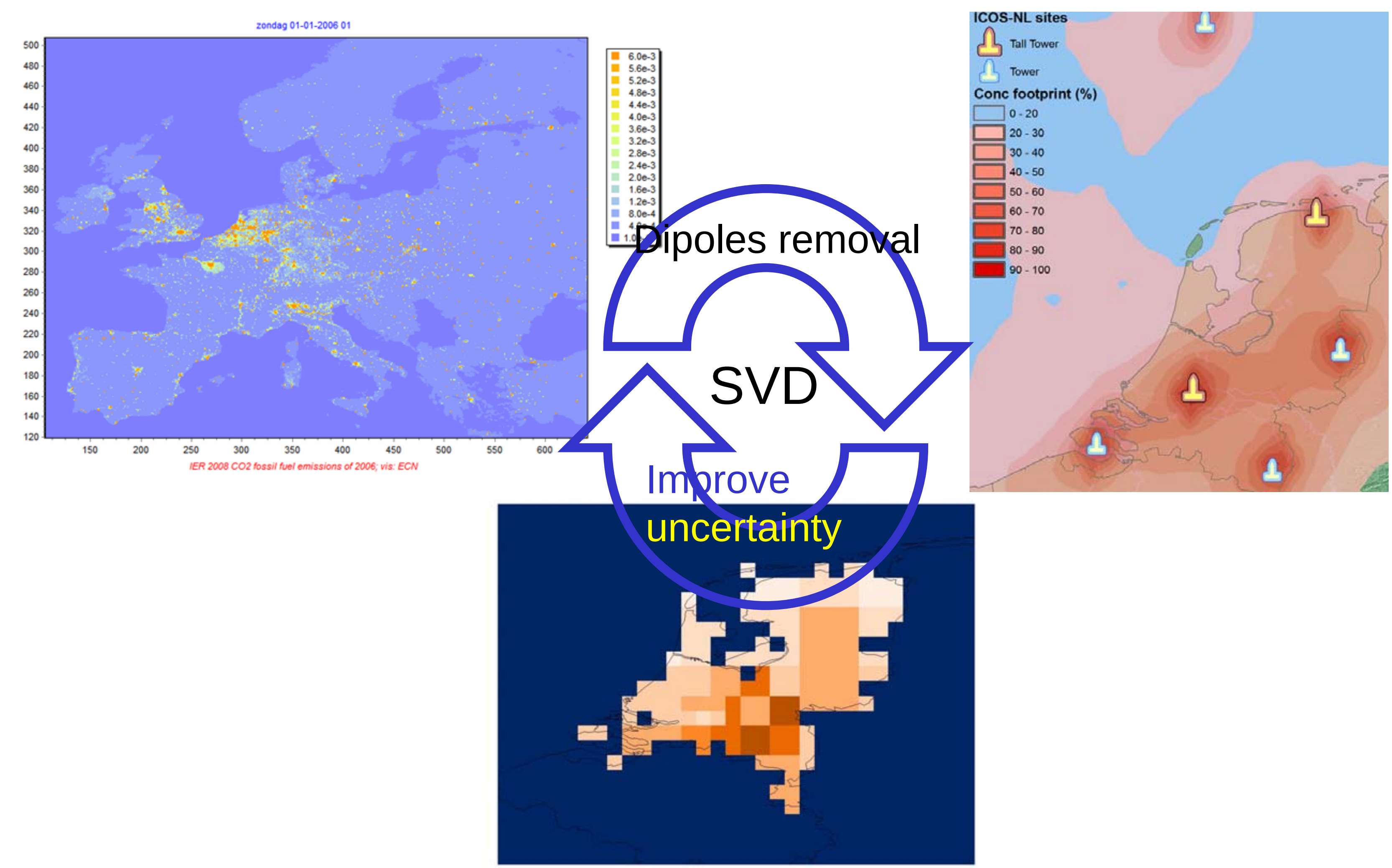
(Inverse) Model setup

- Source receptor matrix resol. 6 minutes (0.1°)
- Domain: Western Europe
- Matrix inversion using weighted SVD
- Linear system, SRM produced using COMET
- SRM is regularized based on maximum contributions by joining adjacent gridboxes 2 by 2
- Method allows emission determination for about 200 gridboxes
- Uses full hourly concentration data
- Dipole removal
- Variance criterium (30-50%).
- TM5 background concentrations
- Prior emissions: METDAT, Edgar 3.2/4, NEU

SVD inversion + recursive Source area aggregation

High res emissionmap

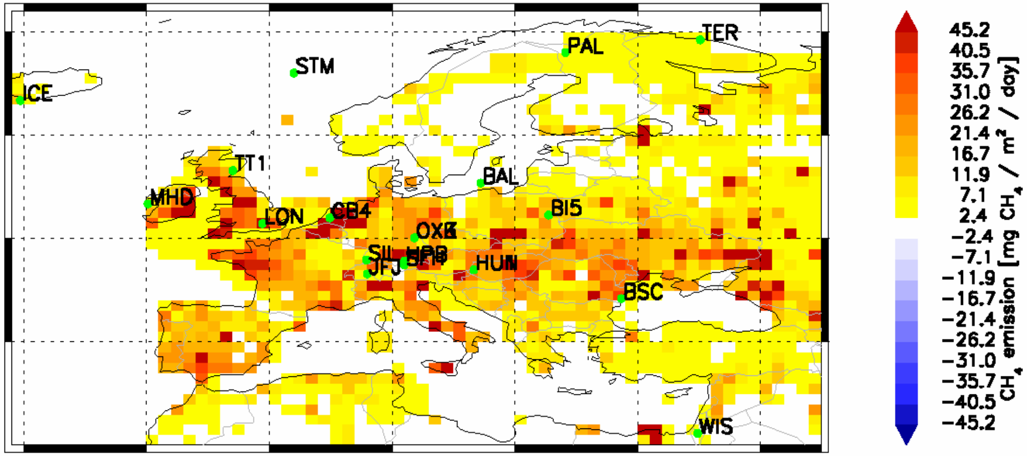
High res SRM = emission sensitivity



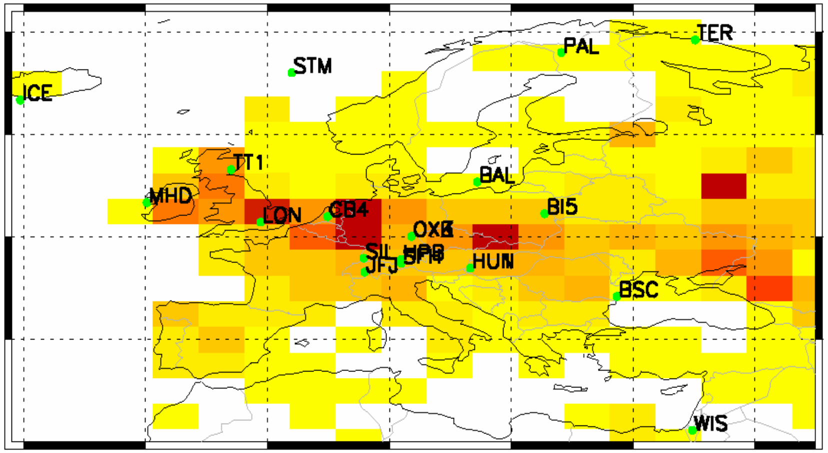
Medium resol. aggregated emission

CH_4 Inversion 2006 (prelim.!)

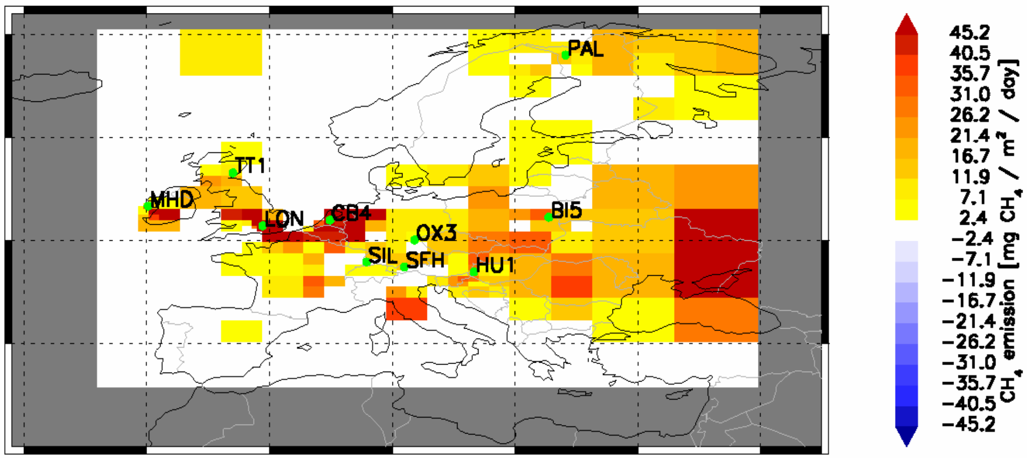
TM5−4DVAR



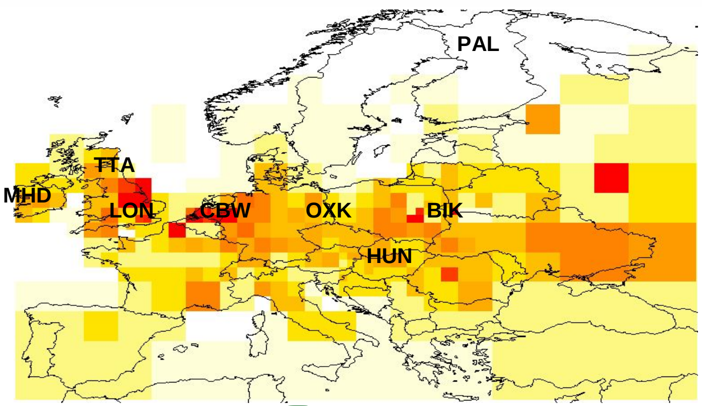
LMDZ



NAME



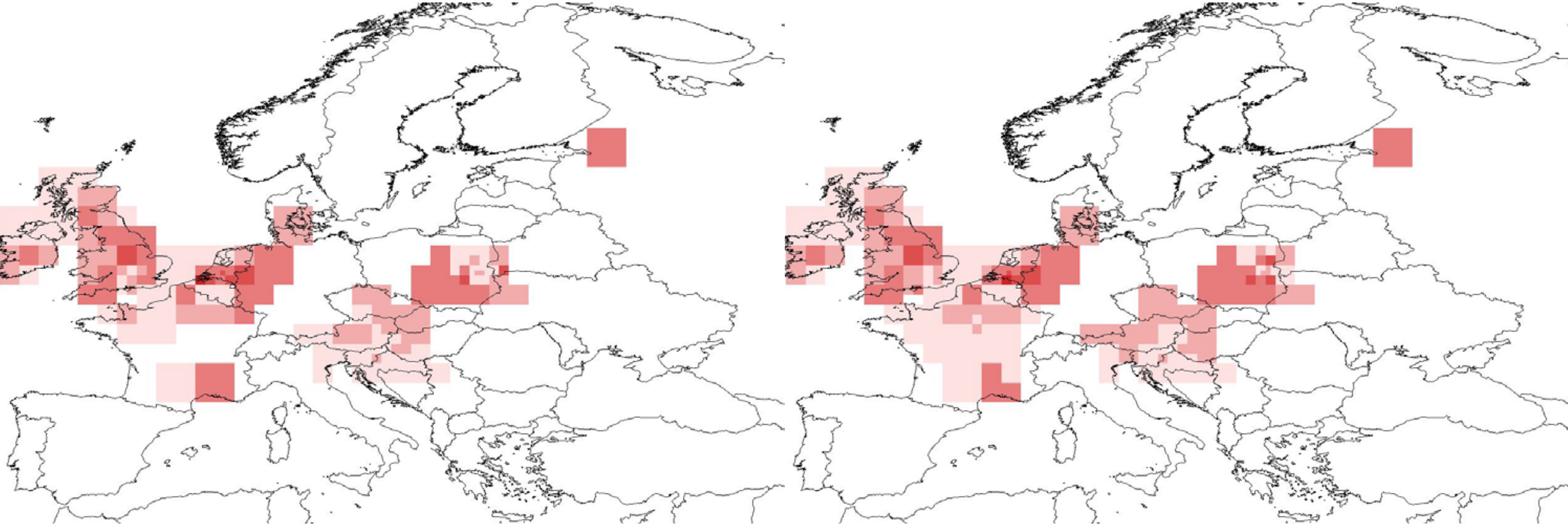
COMET



NitroEurope IP

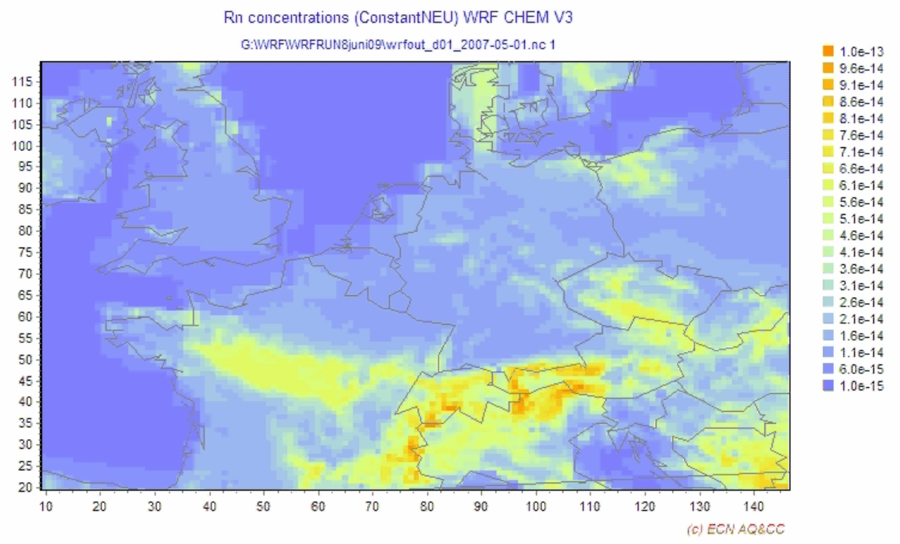
One station can make a difference

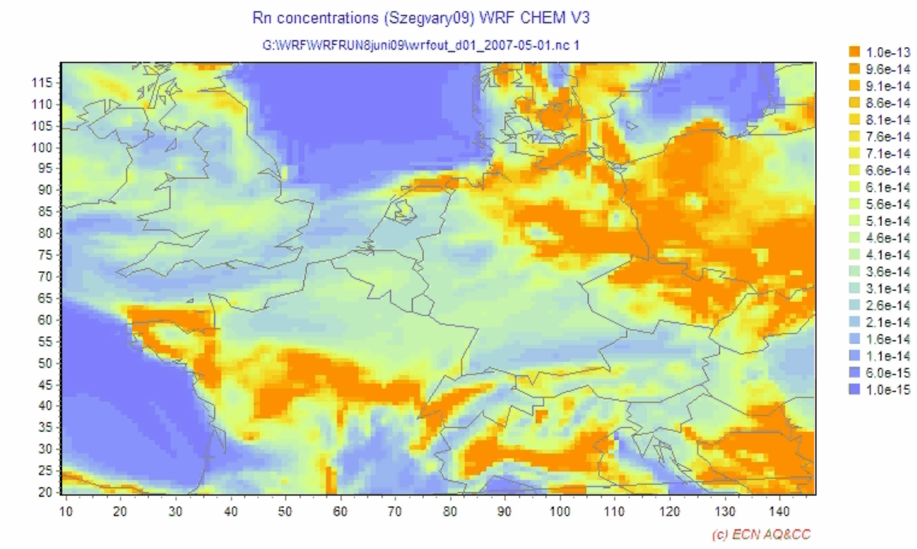
- Inversion is robust, adding TRN (3 months 2006) allows to resolve France better

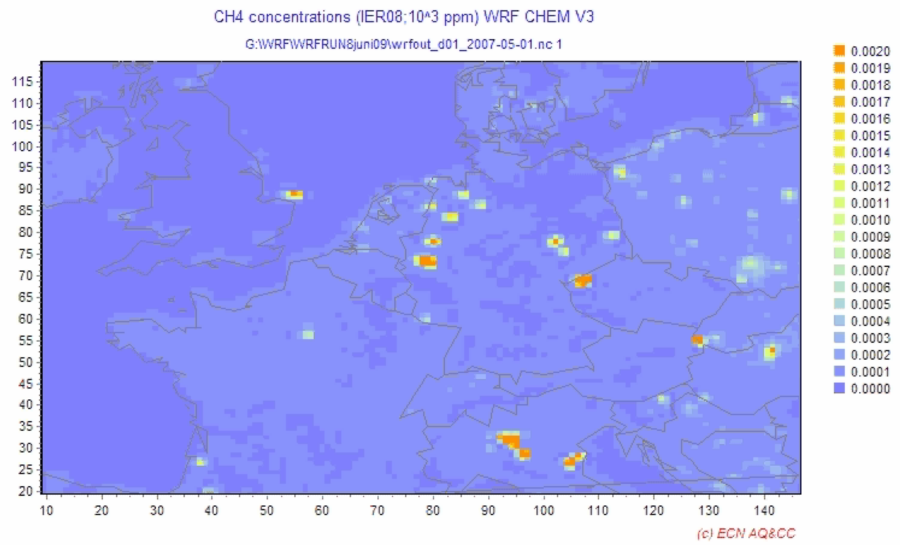


Excl. TRN obs Incl. TRN obs

Increasing model emissions+resolution

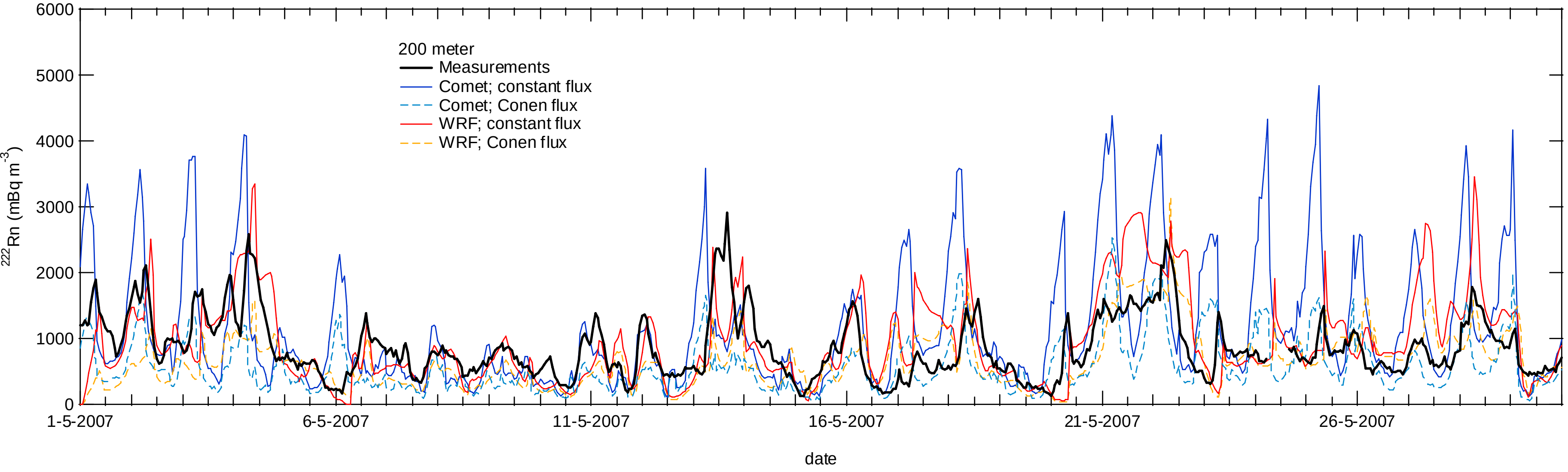


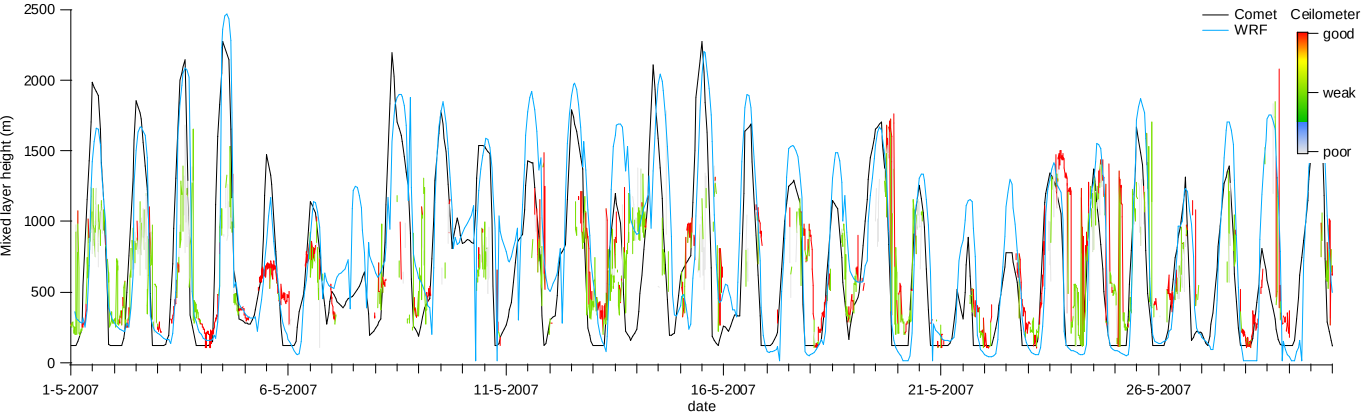




- WRF V3 mesoscale
- Resolution 15+5 km
- Passive tracers
- ECMWF 0.2 meteo
    - Constant Rn
    - Szegvary Rn
    - 5 km res CH4 IER

High resolution forward model results





R=correlation coefficients
Rn observed/modelled:

Comet_20_cnst	0.74
Comet_20_Conen	0.72
Comet_200_cnst	0.74
Comet_200_Conen	0.36
WRF_10_cnst	0.63
WRF_10_szeg	0.66
WRF_40_cnst	0.59
WRF_40_szeg	0.61
WRF_190_cnst	0.63
WRF_190_szeg	0.48

Conclusions, outlook

- Network is working, delivering data (still)
- Measurement are consistent, but more intercomparions are needed
- Continuous data looks noisy at first sight, but is full of valuable information
- Potential can be exploited using high resol. models
- First regional inversions on basis of data promising and consistent
- Measurements are now under severe threat
- **Support for infrastructure is critical!**

Outlook:

- Inversion for emissions CH4 2007 (NEU)
- Inversions for emissions N2O (NEU)
- Including Edgar V4 prior emissions at 0.1° res.
- Implement SVD inversions based on WRF SRM's (2 km res)

ECN

Acknowledgements

- EU FP5/6:
  - CHIOTTO
  - CarboEurope-IP
  - NitroEurope-IP
  - IMECC
  - Geomon
- Klimaat voor Ruimte:
  - ME-2

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