ECN

Energy research Centre of the Netherlands

# $^{222}$Rn vertical gradient measurements and its use for transport model calibration

Alex Vermeulen, Bart Verheggen, Wlodek Zahorowski

ECN

## Overview

- Measurement setup: Cabauw $^{222}Rn$ gradient system
- Measurement results
- Modeling setup: COMET
- Calibration of COMET vertical mixing
- $^{222}Rn$ and $CH_4$, $CO_2$
- Conclusions

# Cabauw super site height 213 AGL=ASL

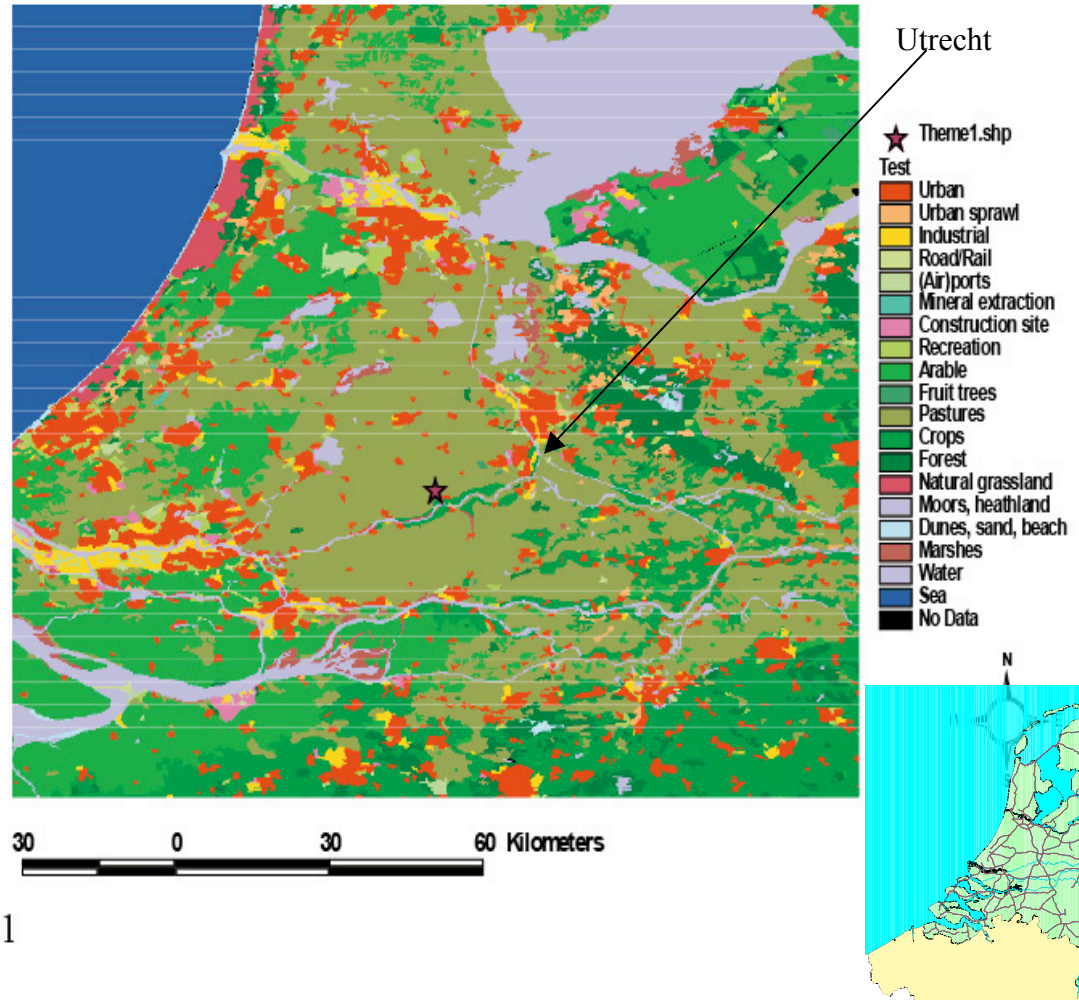
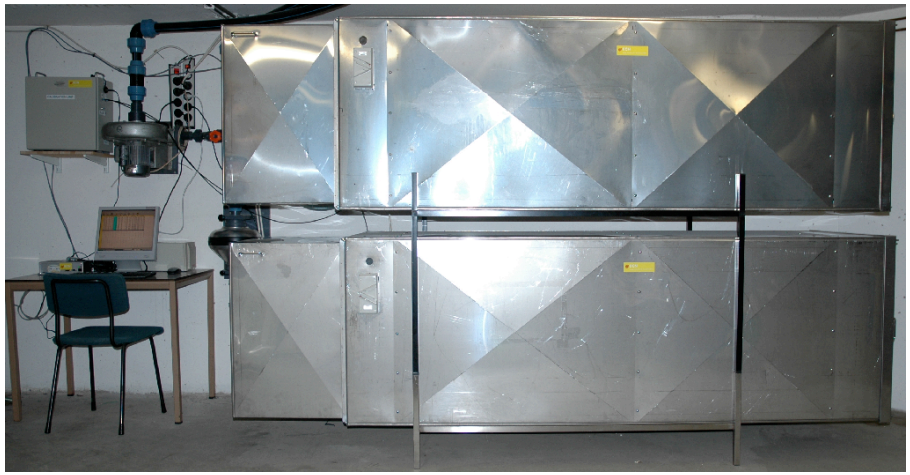
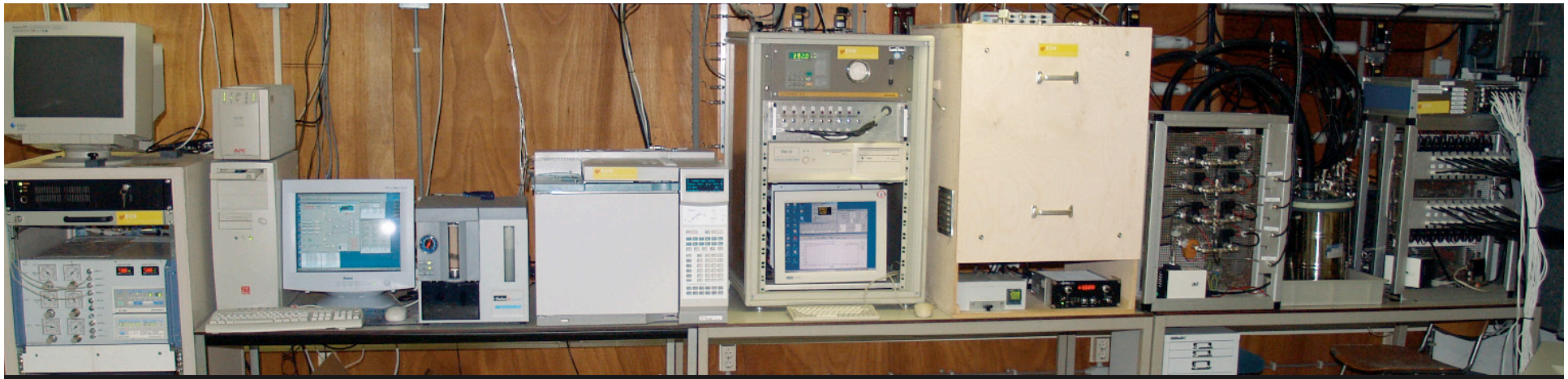



Fig 1

# ECN greenhouse gas and $^{222}Rn$ observations, starting 1992

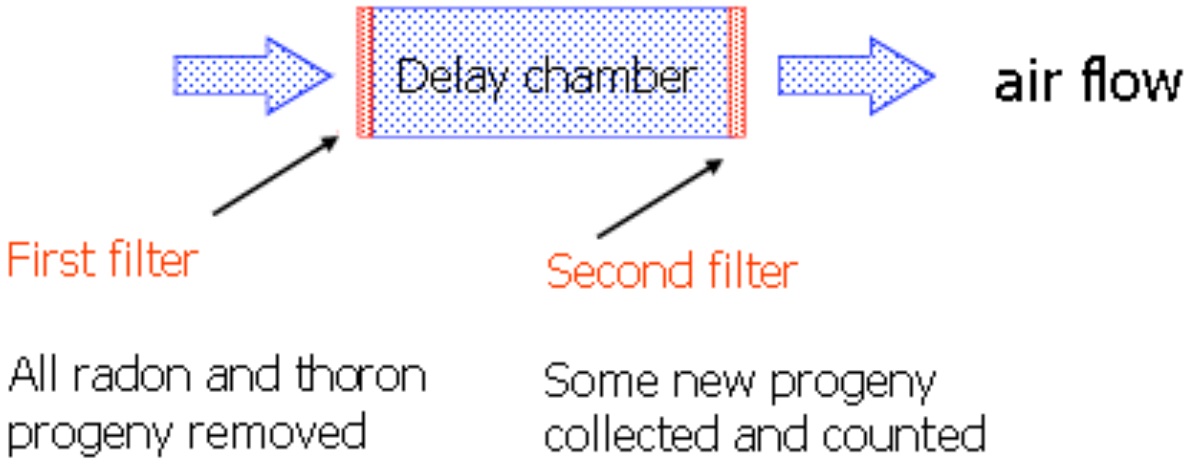


| Gas | Method | Operational | Precision |
|---|---|---|---|
| $CO_2$ | LICOR 7000 | Nov-04 | 0.05 ppm |
| Flask sampler | CIO | Nov-04 | |
| $^{222}Rn$ | ANSTO | Nov-05 200m<br>Feb-06 20m | 50 $mBq.m^{-3}$ |
| $CH_4$ | GC-FID | Nov-04 | 2 ppb |
| CO | GC-FID | | 1 ppb |
| $N_2O$ | GC-ECD | | 0.4 ppb |
| $SF_6$ | GC-ECD | | 0.2 ppt |

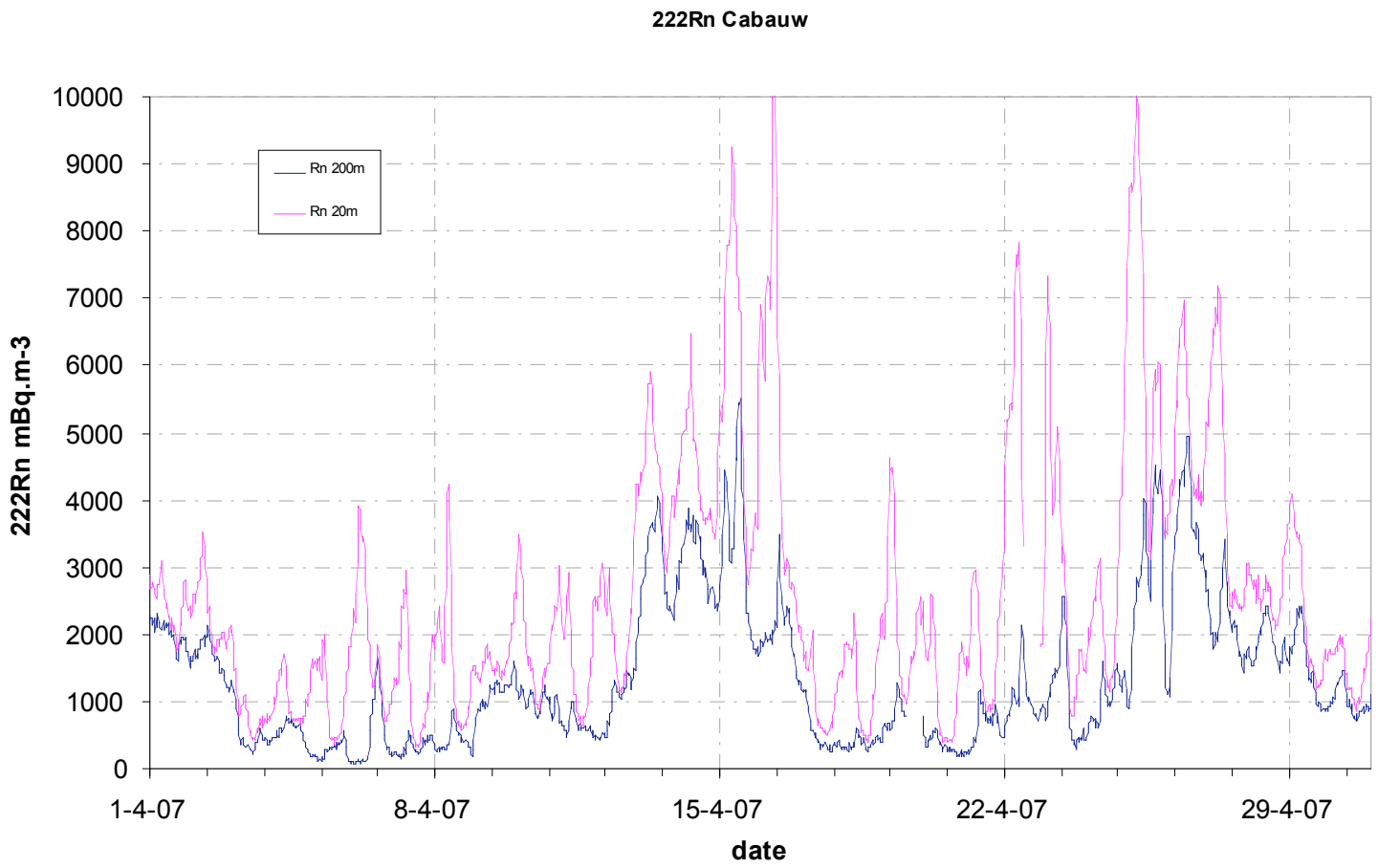


# $^{222}$Rn measurement principle

Principle of operation
of the two filter radon detector



# Cabauw $^{222}$Rn concentration gradient



# Observations

Fig. 1 Diurnal mean radon concentrantions Cabauw
NH Spring 2007; all observations

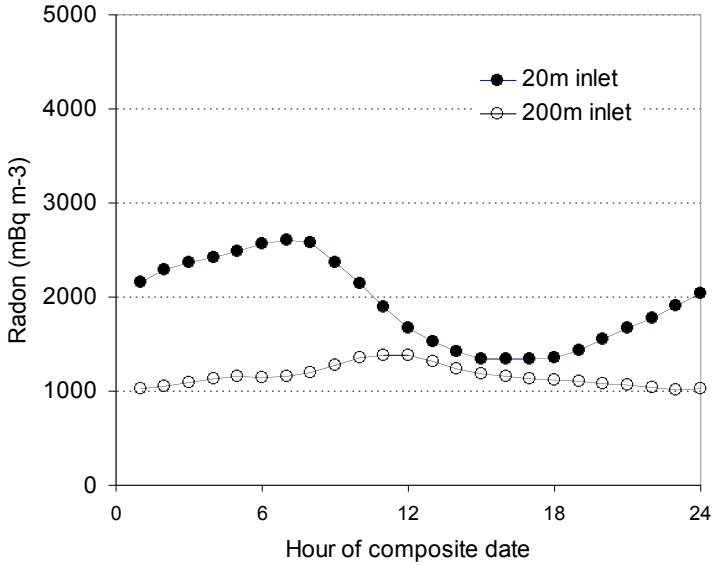
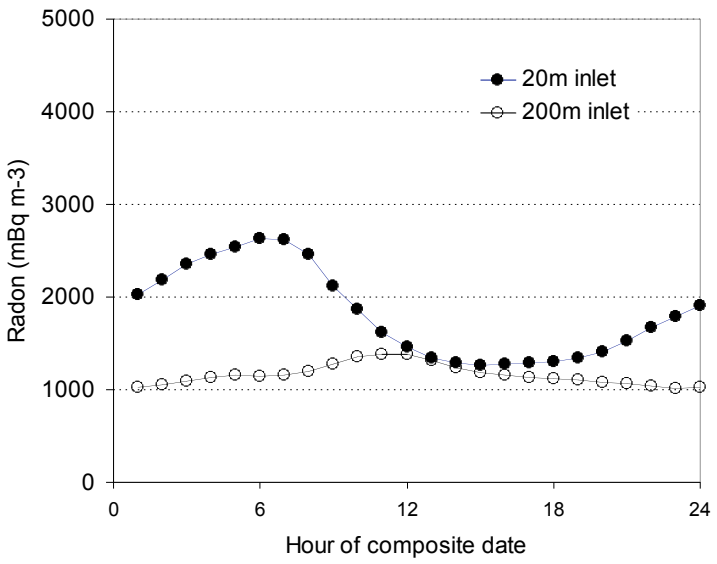



Fig. 2 Diurnal mean radon concentrantions Cabauw
NH Summer 2007, all observations



# Observations low/high windspeeds

Fig. 4 Diurnal mean radon concentrations Cabauw
NH Summer 2007, wind speed smaller than 3m/s

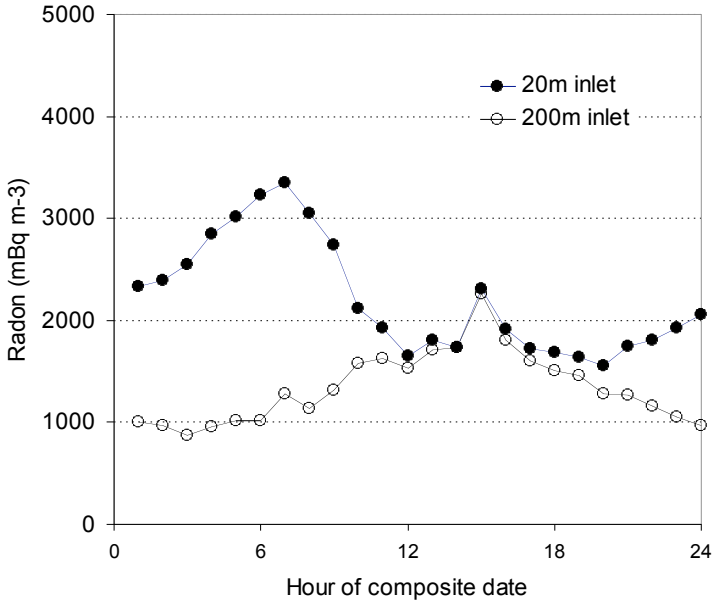
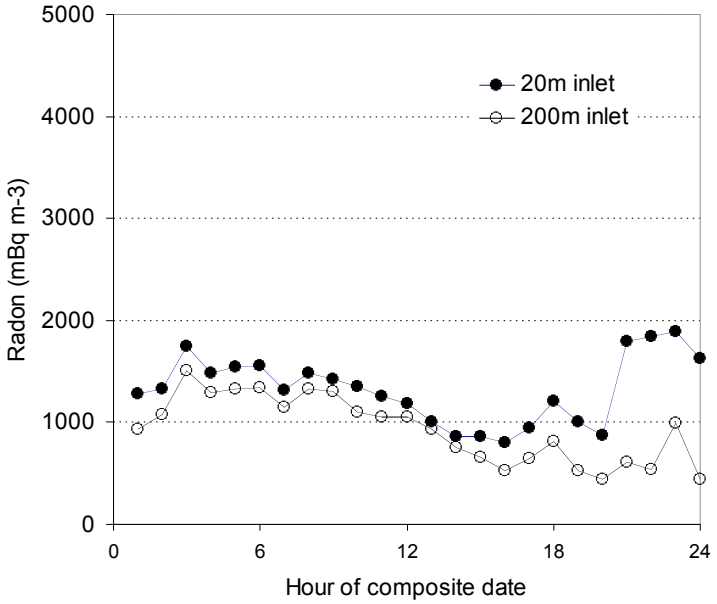


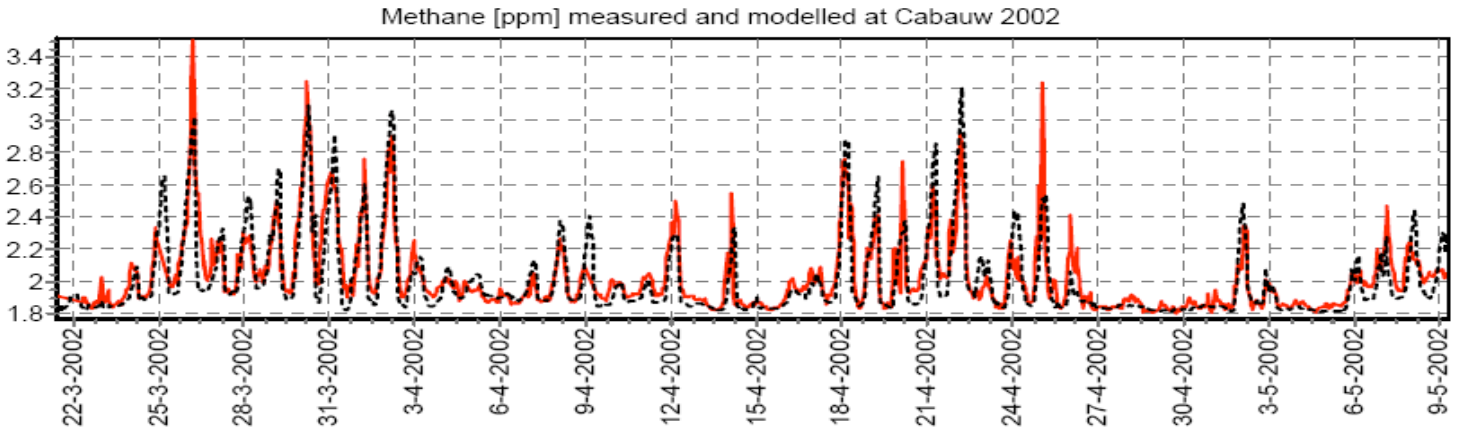

Fig. 6 Diurnal mean radon concentrations Cabauw
NH Summer 2007, wind speed bigger than 7m/s



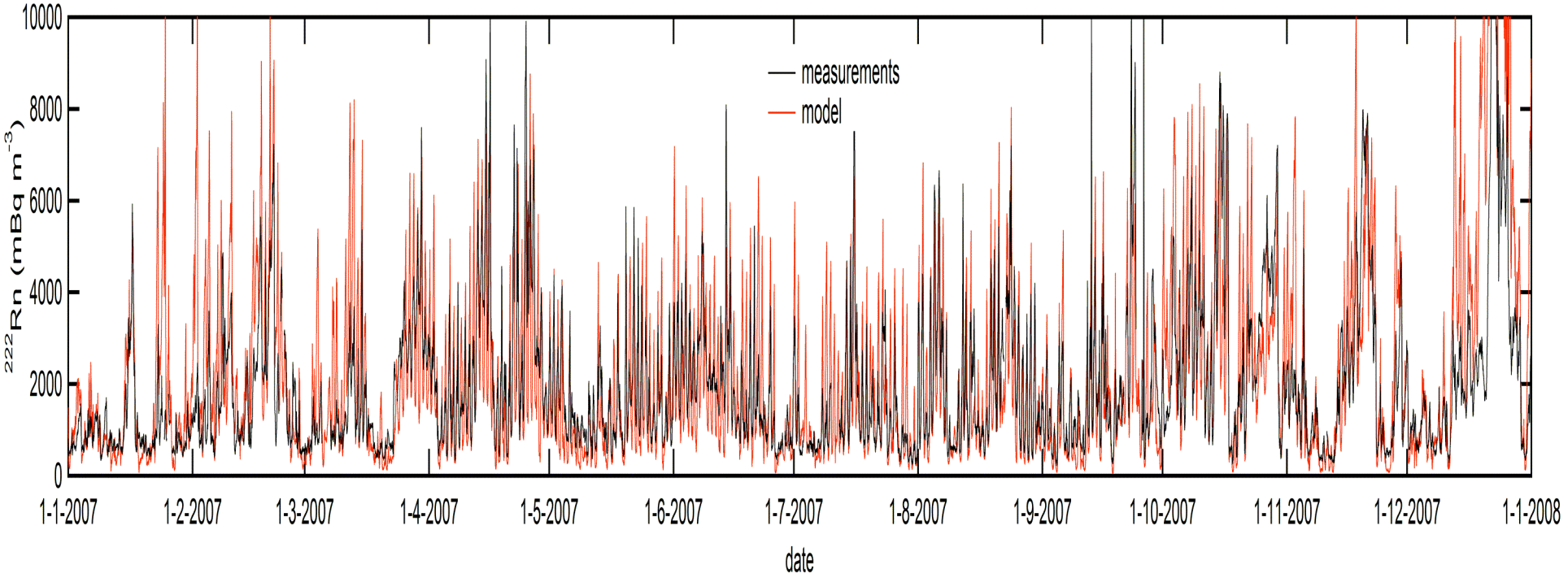
## Model setup

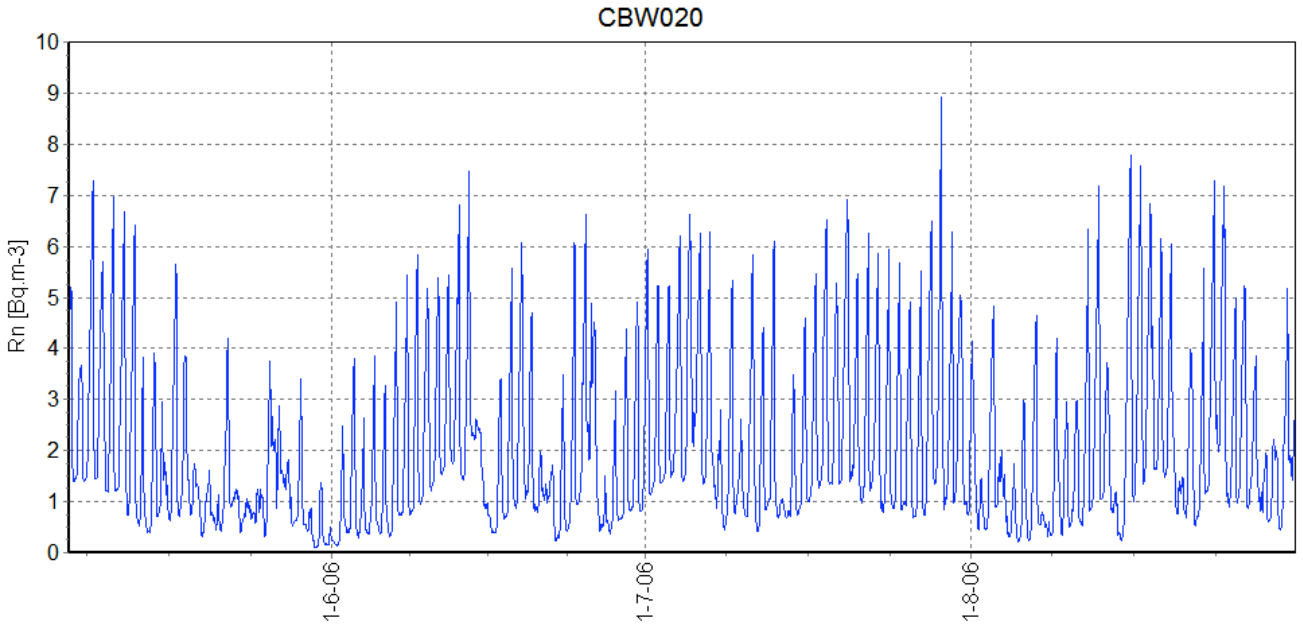
Lagrangian single trajectory model, limited domain
Moving two layered box: mixed PBL+reservoir layer
Hourly trajectories (Flextra)
ECMWF meteorology, max 0.2 degrees res,3 hourly fields
PBL analysed by ECMWF or crit. Richardson number (0.25) method
Transcom Rn flux field, NO global background field

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

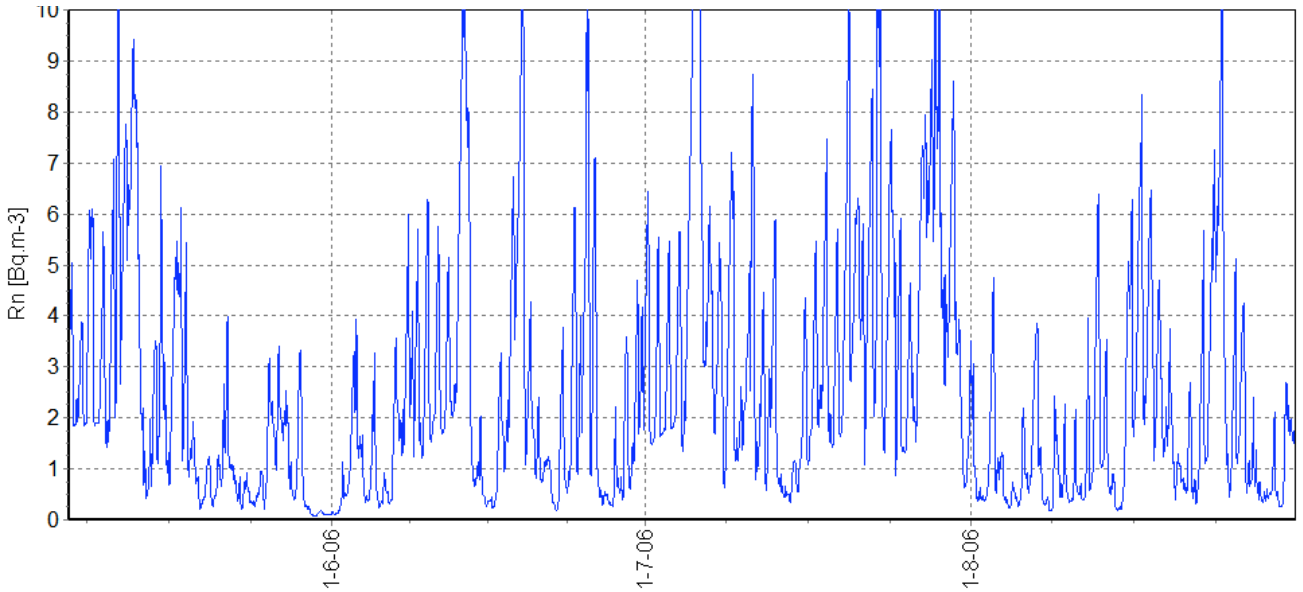


# COMET model results vs observations



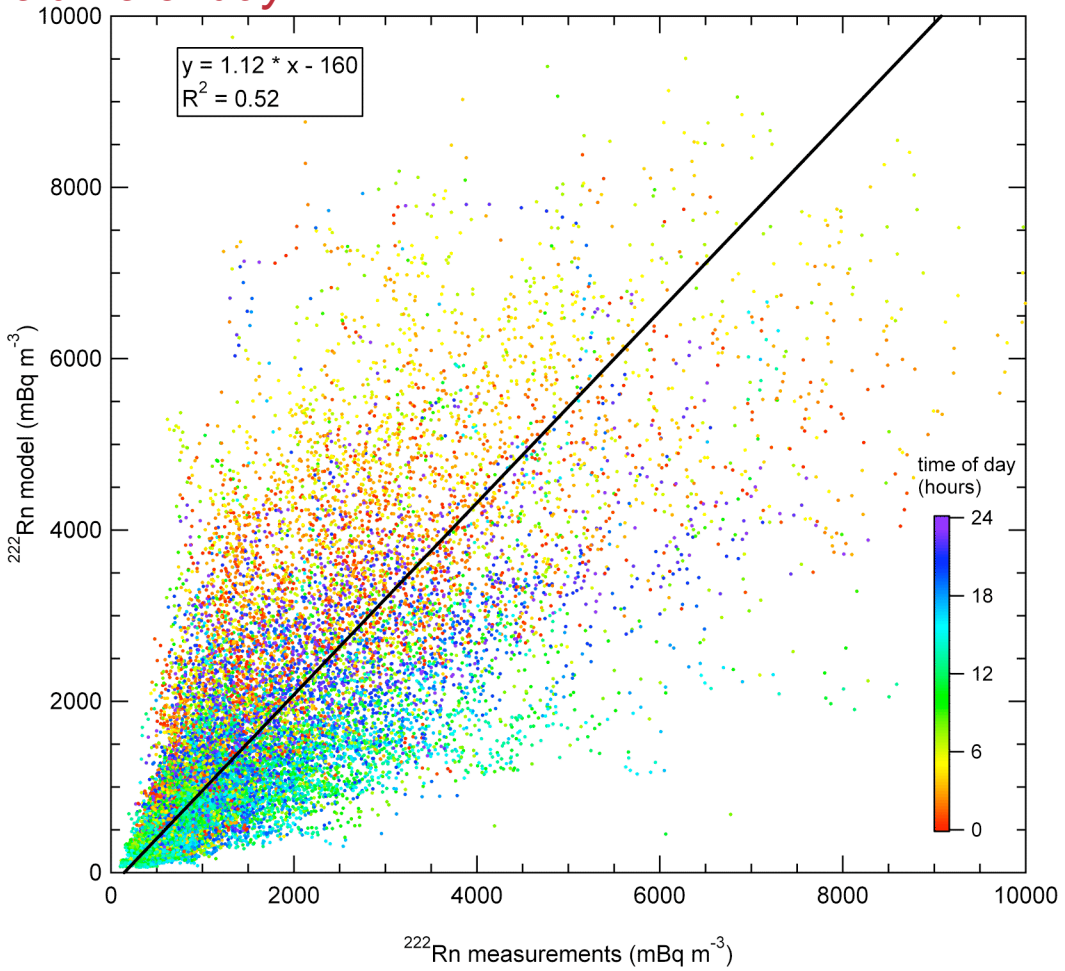



0.2 degree resol.

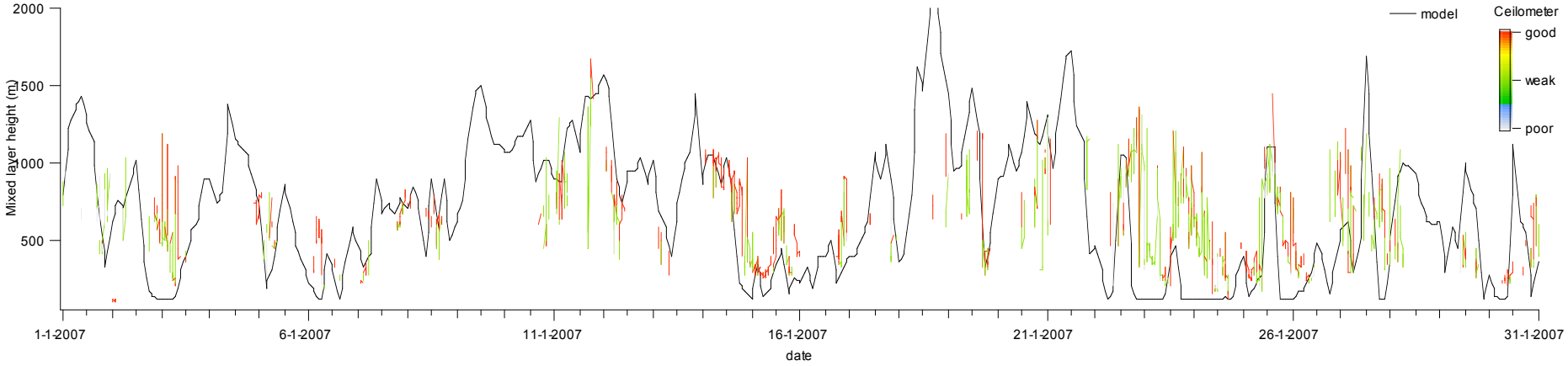



2.0 degree resol.

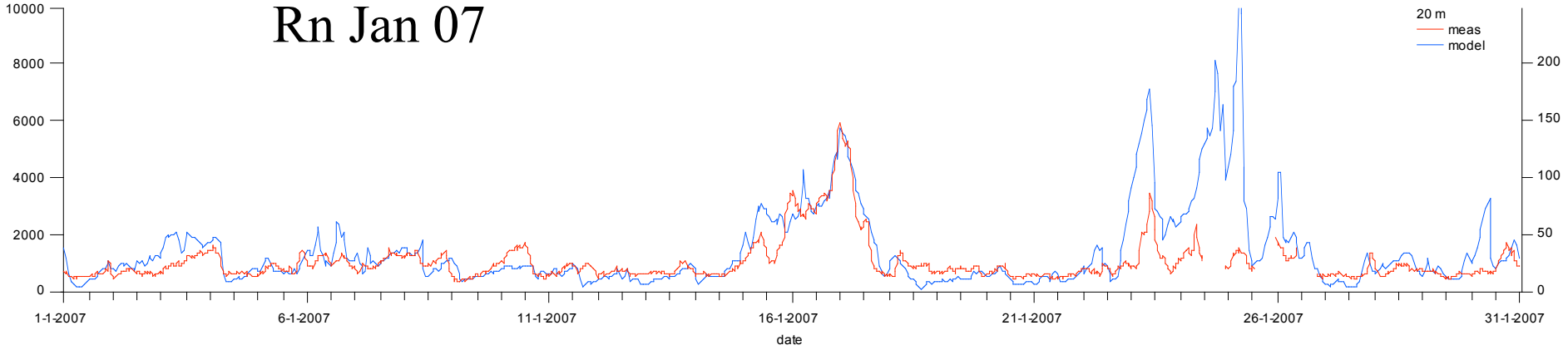
*Fig 5. Scatterplots of modeled versus measured 222Rn concentrations (30 minute values). Orthogonal linear fit is given. Symbol colour denotes the time of day.*



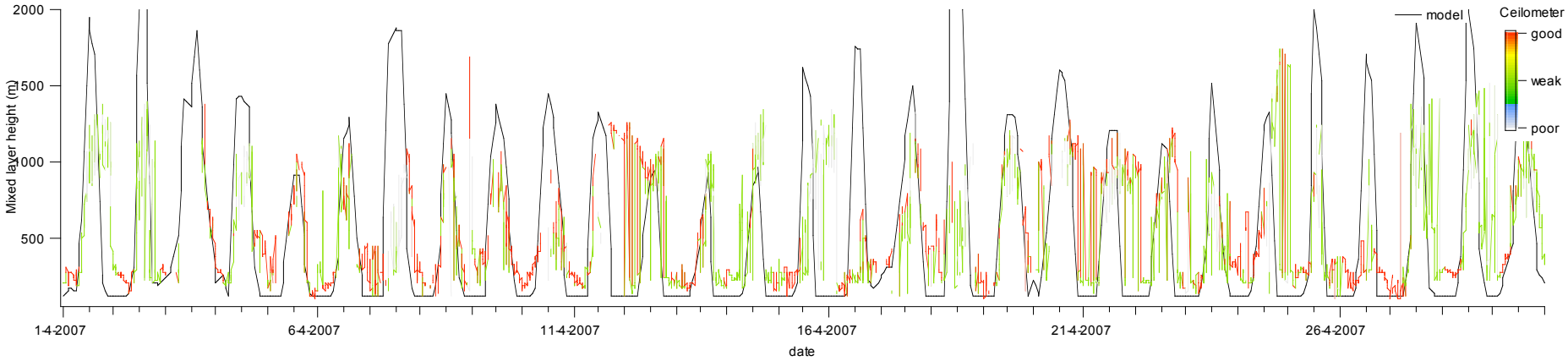
# PBL Jan 07



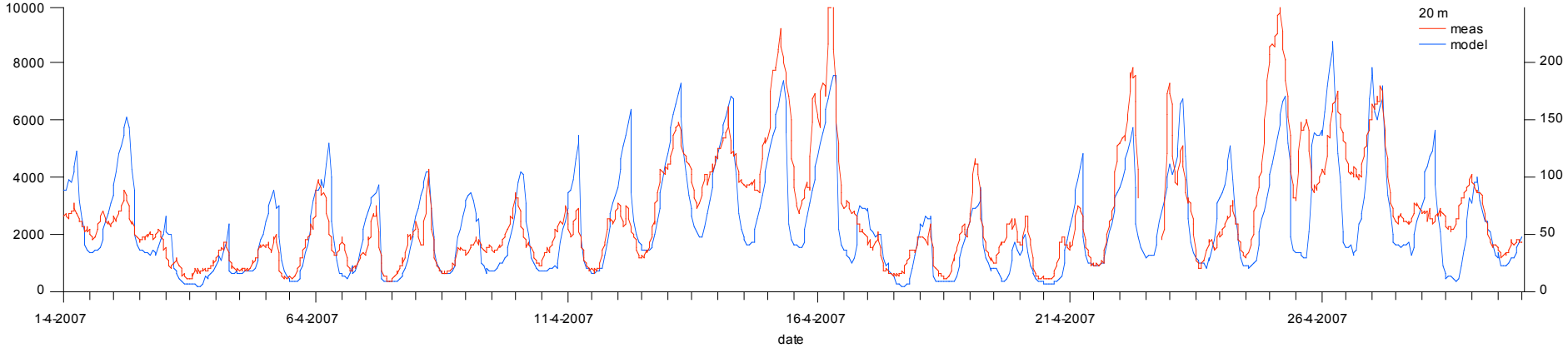

# Rn Jan 07



# PBL Apr 07




# Rn Apr 07



## Calibration of minimum PBL depth; entrainment

| | Resol. | Min. PBL | Entrainm. | R | RMSE | %stdev |
|---|---|---|---|---|---|---|
| | 2 | 120 | 0 | 0.69 | 3.04 | 150 |
| TC submission → | 1 | 120 | 0 | 0.69 | 2.08 | 94 |
| | **1** | **50** | 0 | **0.59** | **3.22** | **160** |
| | 0.2 | 50 | 0 | 0.60 | 3.28 | 156 |
| | 0.2 | 80 | 0 | 0.65 | 2.68 | 123 |
| | 0.2 | 100 | 0 | 0.66 | 2.40 | 108 |
| Optimal → | **0.2** | **120** | 0 | **0.67** | **2.21** | **98** |
| | 0.2 | 150 | 0 | 0.67 | 2.03 | 87 |
| | 0.2 | 200 | 0 | 0.67 | 1.83 | 74 |
| | 0.2 | 300 | 0 | 0.66 | 1.66 | 60 |
| | 0.2 | 120 | 2 | 0.67 | 2.03 | 89 |
| | 0.2 | 120 | 5 | 0.67 | 1.85 | 79 |
| | 0.2 | 120 | 10 | 0.67 | 1.67 | 68 |

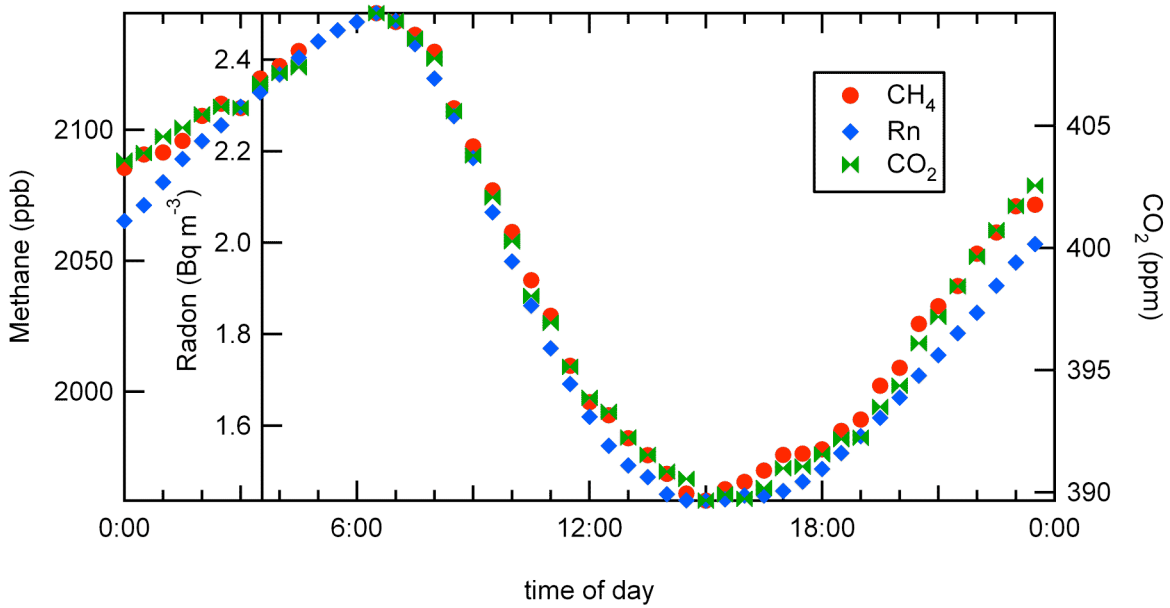
## Other points improved in COMET

- Parametrisation of gradient above PBL for tall towers
- Improved handling of mountain stations
- Boundary conditions from global transport model

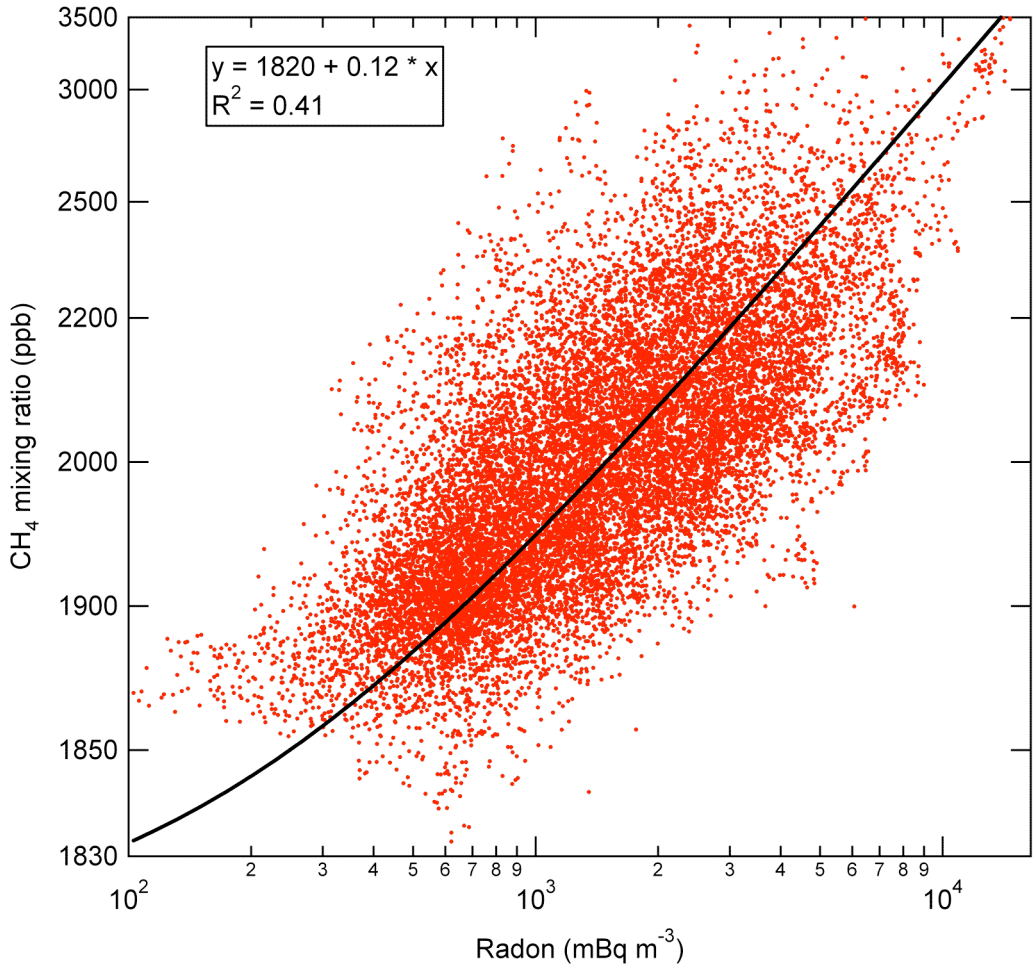
## Other developments

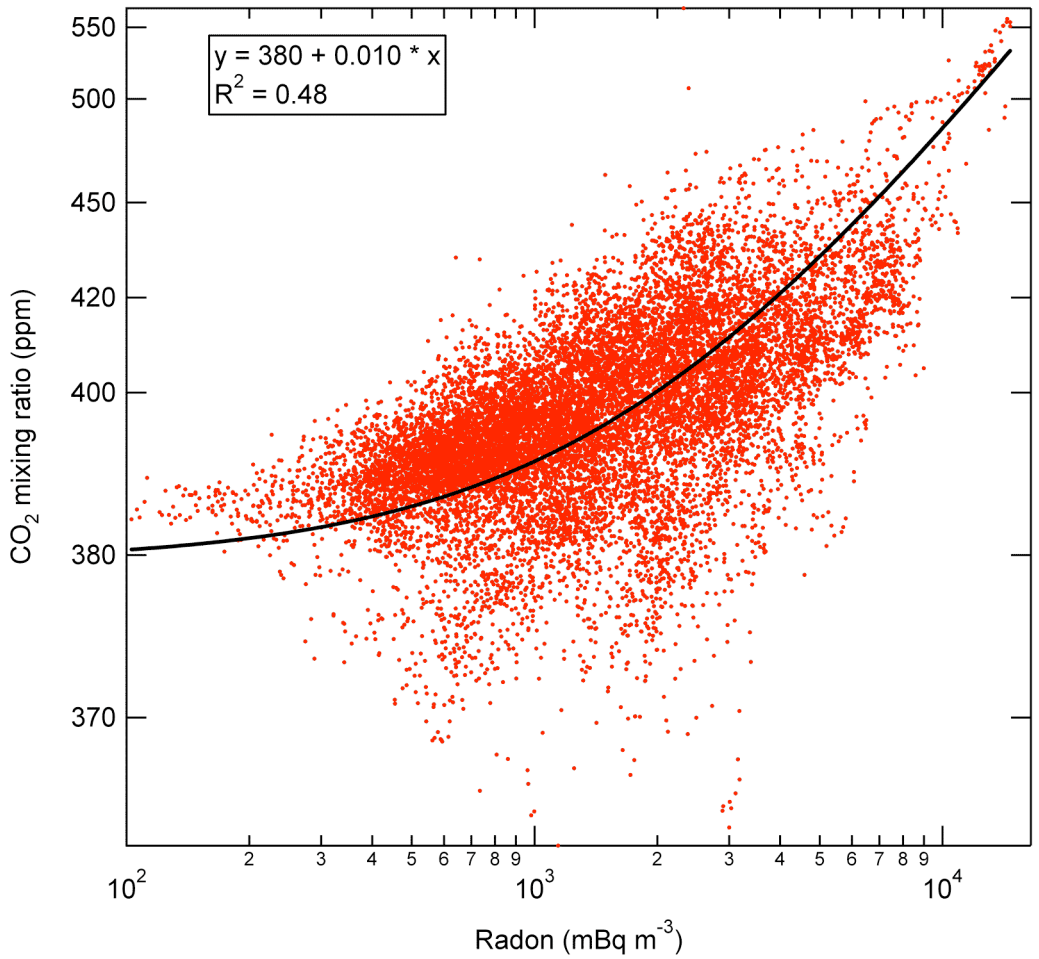
- WRF V3 and tracer modelling at high resolution (10 km)
- WRF-Flexpart/Flextra coupling
- MLBC CO2 biogenic fluxes at high resolution using high res landcover maps

# Average diurnal patterns of CH4, CO2, Rn strikingly similar



# But overall correlation is low




y = 380 + 0.010 * x
R2 = 0.48
550
500
450
420
400
380
370
CO2 mixing ratio (ppm)
2 3 4 5 6 7 8 9
10^2
10^3
2 3 4 5 6 7 8 9
10^4
Radon (mBq m-3)

## Conclusions

IF we believe the constant Rn emission flux field then:

-Calibration of the model allows for modest improvements in variability, RMSE

-Main factor improved is minimum PBL height

-Adding a simple (constant) entrainment above the standard due to PBL height changes does not improve performance

-Explained variability depends more on resolution of meteorology and emission field

-Errors in PBL height explain large part of forward model errors

-Current EPS (ECMWF), despite higher resolution, results in lower performance compared to previous versions

-Correlation of Rn with $CO_2$ and $CH_4$ too low for 'model-free' flux estimation

-Calibration needs to be checked with results for $CO_2$, $CH_4$ and for other obs. points…


The End