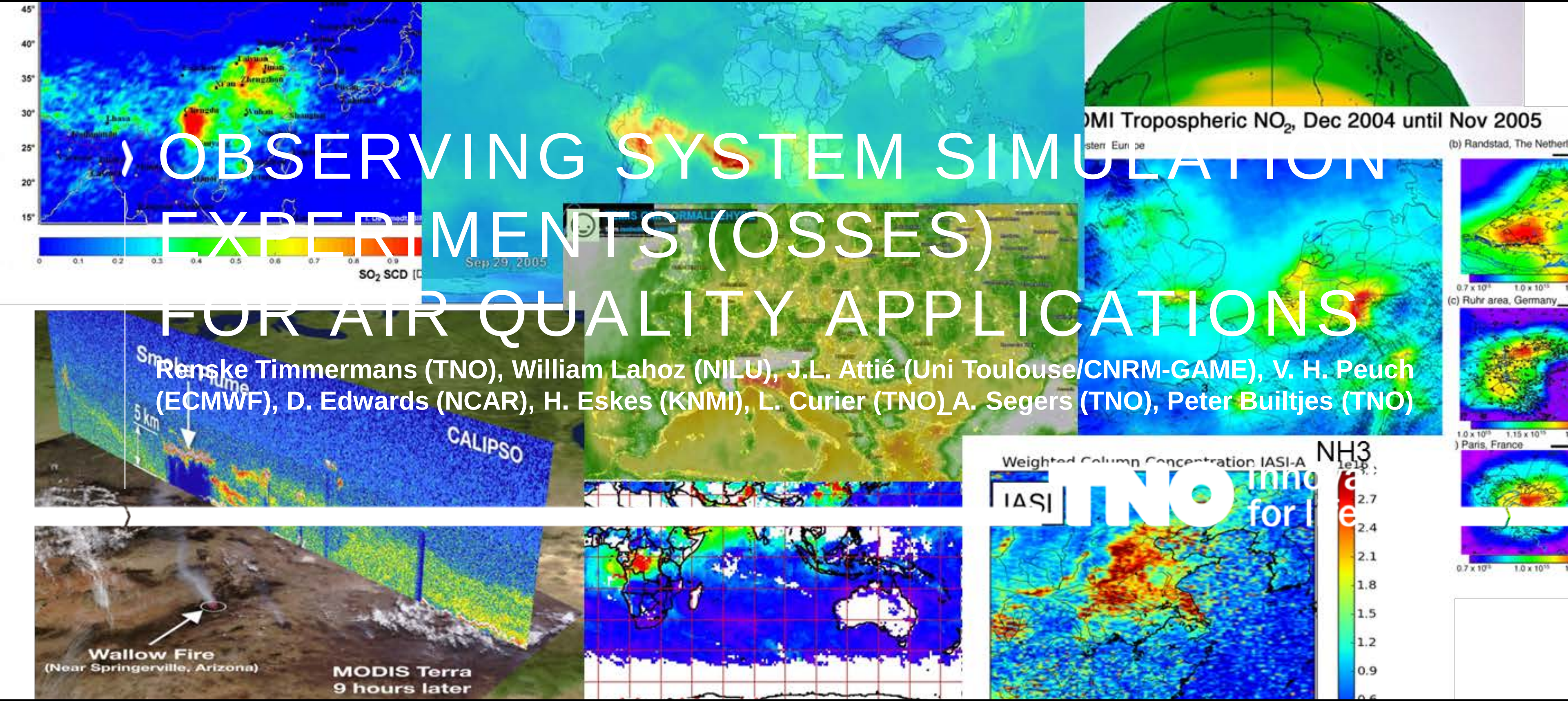
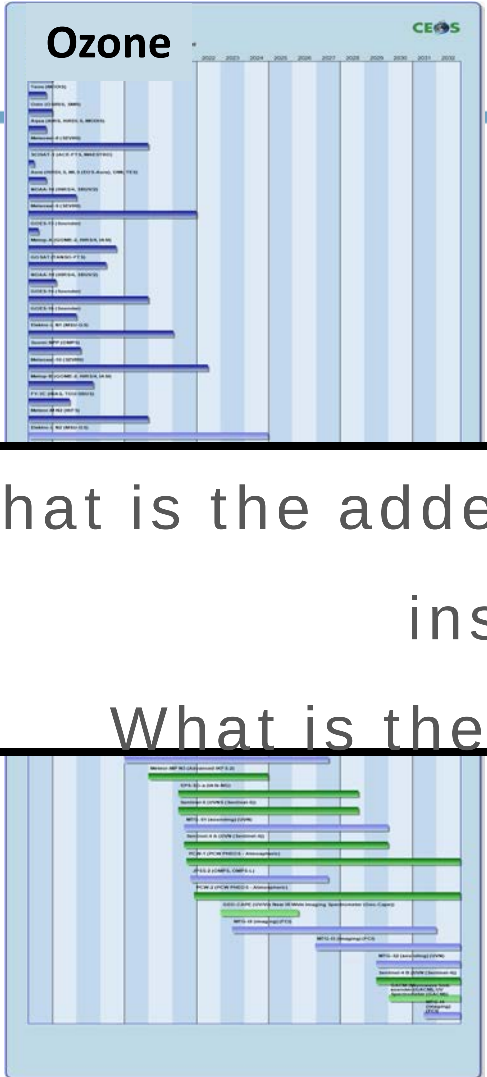
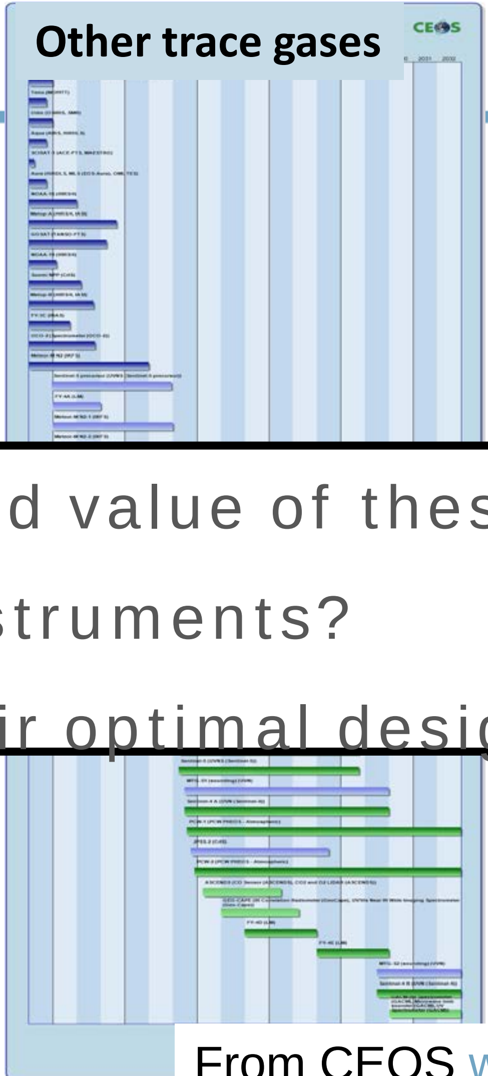


OBSERVING SYSTEM SIMULATION EXPERIMENTS (OSSES) FOR AIR QUALITY APPLICATIONS

Renske Timmermans (TNO), William Lahoz (NILU), J.L. Attié (Uni Toulouse/CNRM-GAME), V. H. Peuch (ECMWF), D. Edwards (NCAR), H. Eskes (KNMI), L. Curier (TNO) A. Segers (TNO), Peter Builtjes (TNO)

current
approved
planned
considered





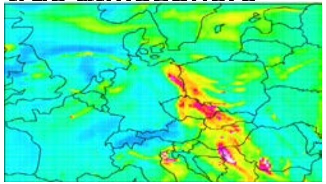
What is the added value of these future instruments?

What is their optimal design?

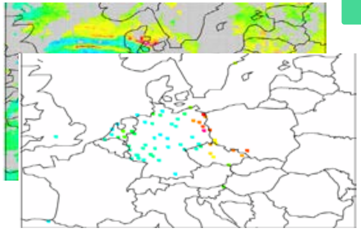
From CEOS www.eohandbook.com

OBSERVING SYSTEM SIMULATION EXPERIMENTS

Model forecast as “true atmosphere”

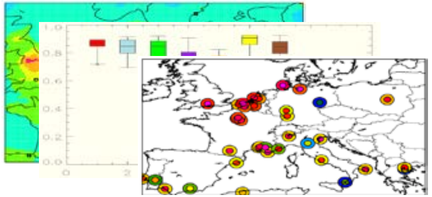


synthetic observation



Active assimilation of observations

Assessment



TALK'S OBJECTIVES

1. **Present the OSSE methodology**
2. **Formulate requirements using illustrative examples from existing air quality OSSEs**

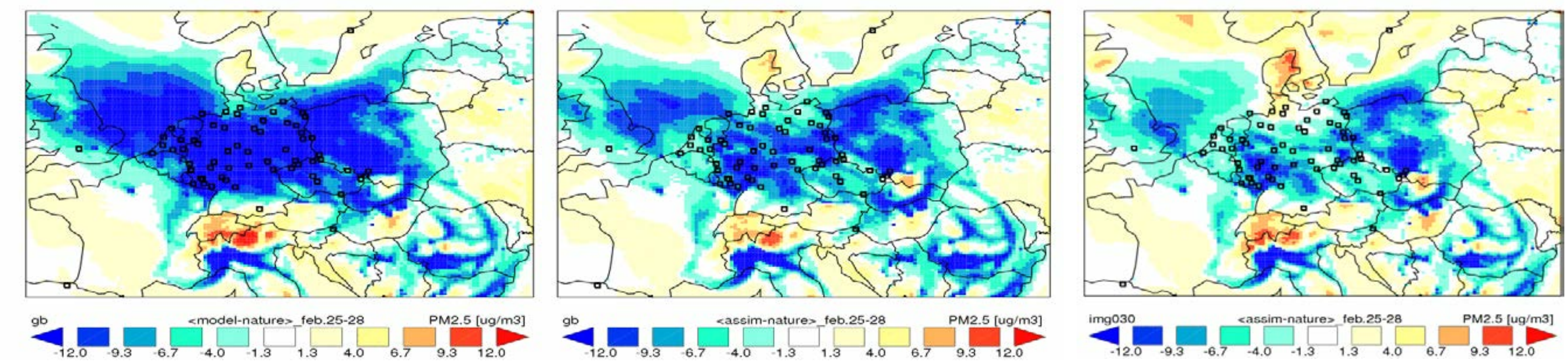
POTENTIAL OF OSSES

- Assess added value new planned instrument with respect to current observing system

Model

Model + in-situ PM2.5

Model + in-situ PM2.5 + sat AOD

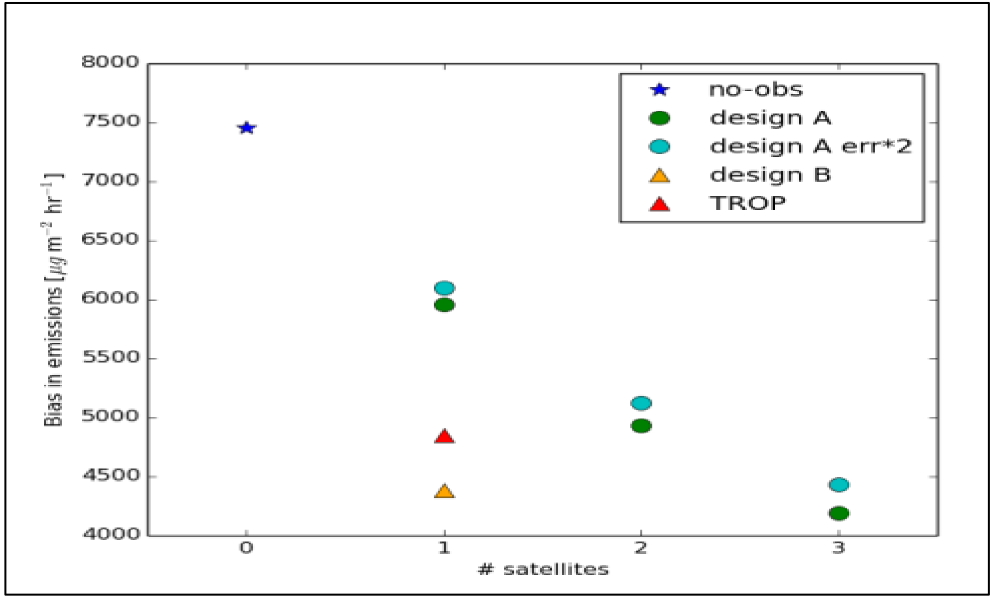


Absolute difference in PM2.5 concentrations between “true”state of the atmosphere and assimilation runs

From Timmermans et al., 2009, IEEE-JSTARS

POTENTIAL OF OSSES

- Assess added value new planned instrument
- Compare instrument designs or operations



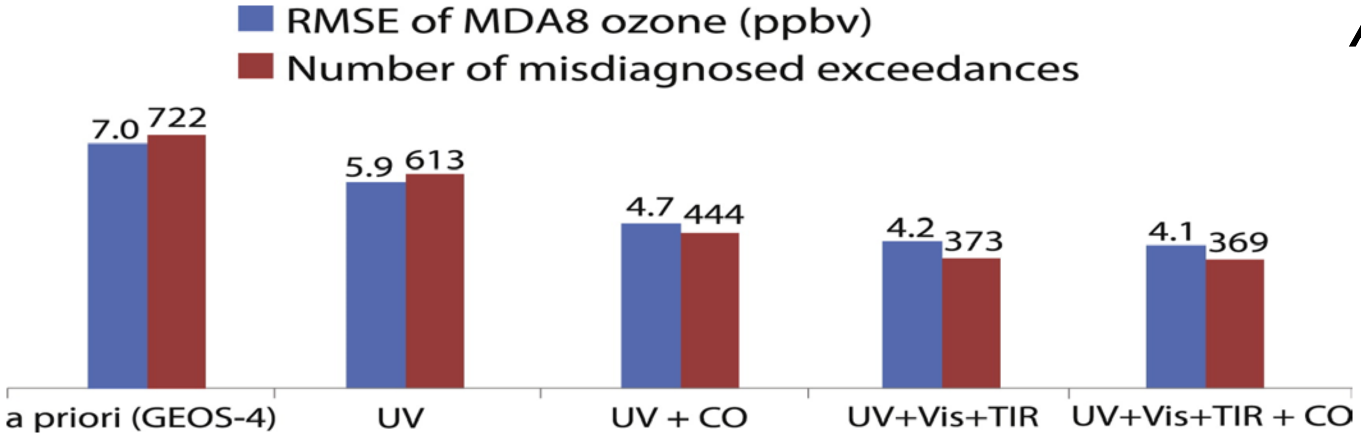
What is the value of two designs of a small NO2 instrument compared to a conventional large NO2 instrument

For improving NOx emission estimates

POTENTIAL OF OSSES

- Assess added value new planned instrument
- Compare instrument designs or operations
- Assess new data assimilation methodologies (e.g. combined data assimilation)

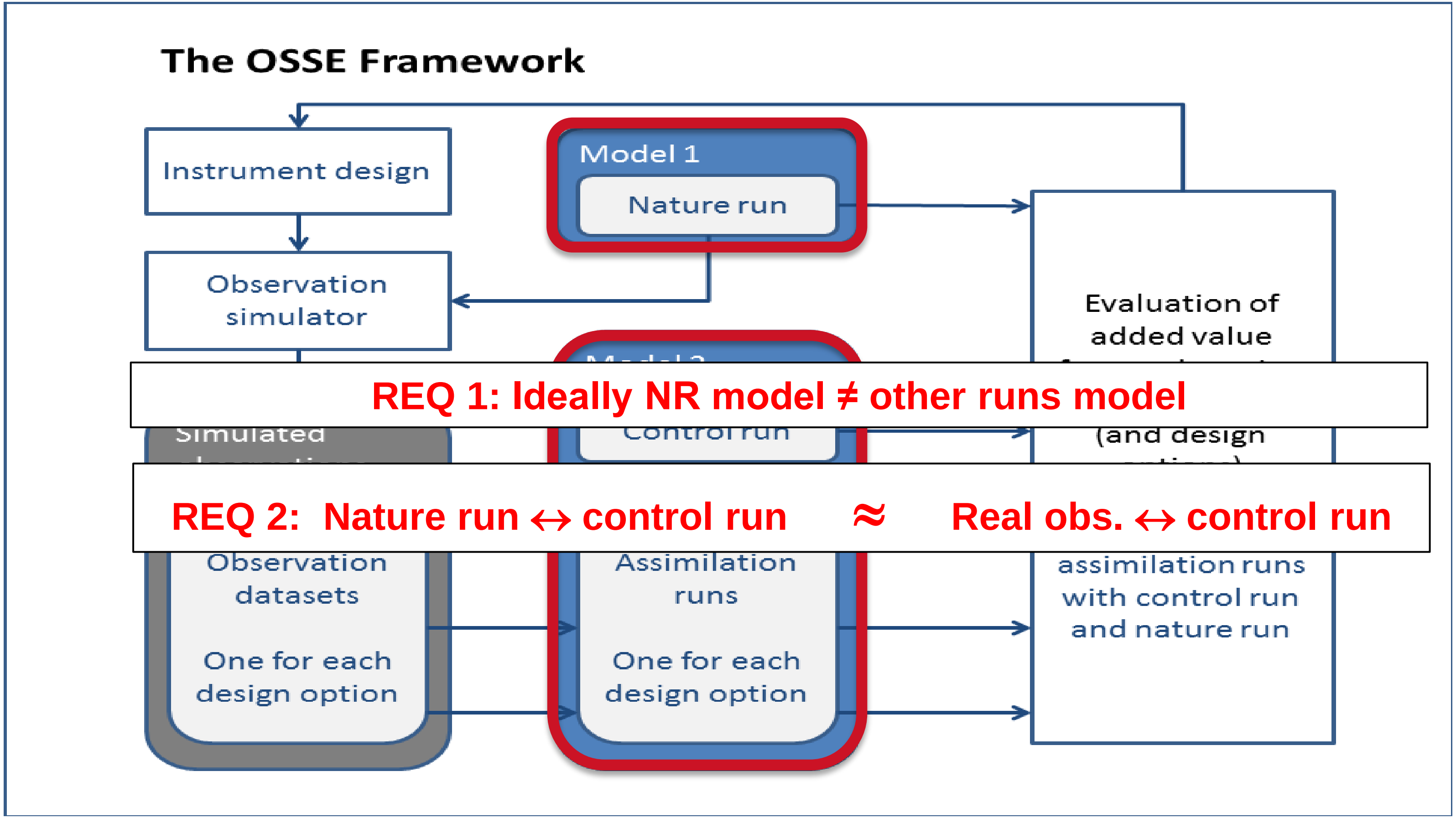
Impact of O3 and CO satellite observations on



August 2006
US

From Zoogman et al. , Atm. Env., 84, 2014

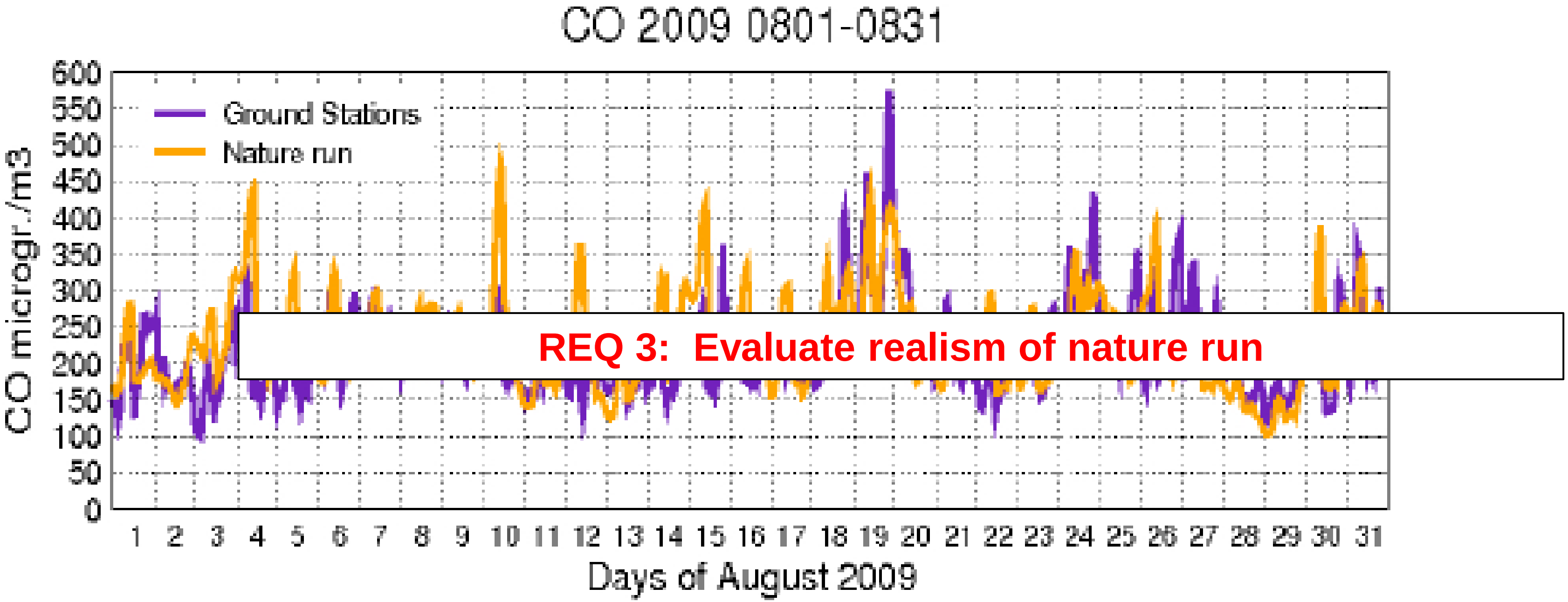
OSSE METHODOLOGY



REQ 1: Ideally NR model ≠ other runs model

REQ 2: Nature run ↔ control run ≈ Real obs. ↔ control run

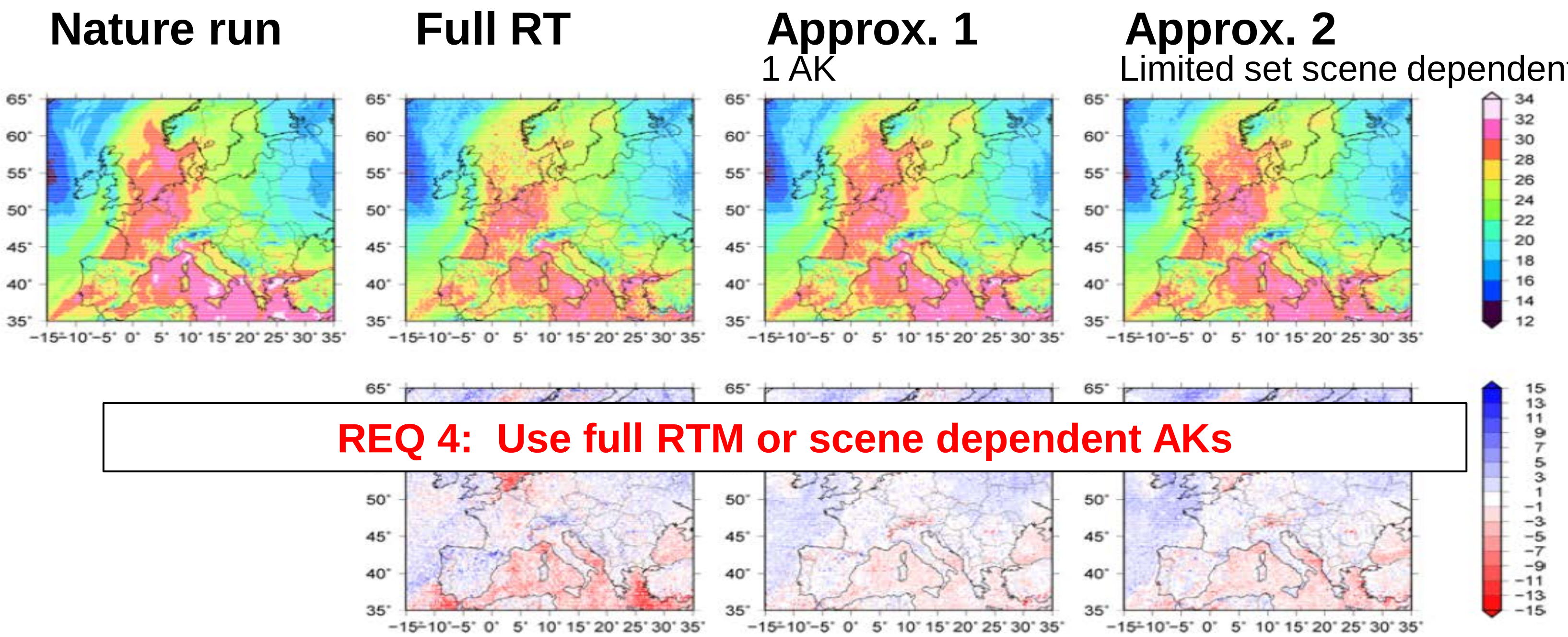
EVALUATION OF NATURE RUN



From Claeyman et al. , Atmos. Meas. Tech., 4, 2011

IMPACT USING SIMPLIFICATIONS

Simulated lower tropospheric O3



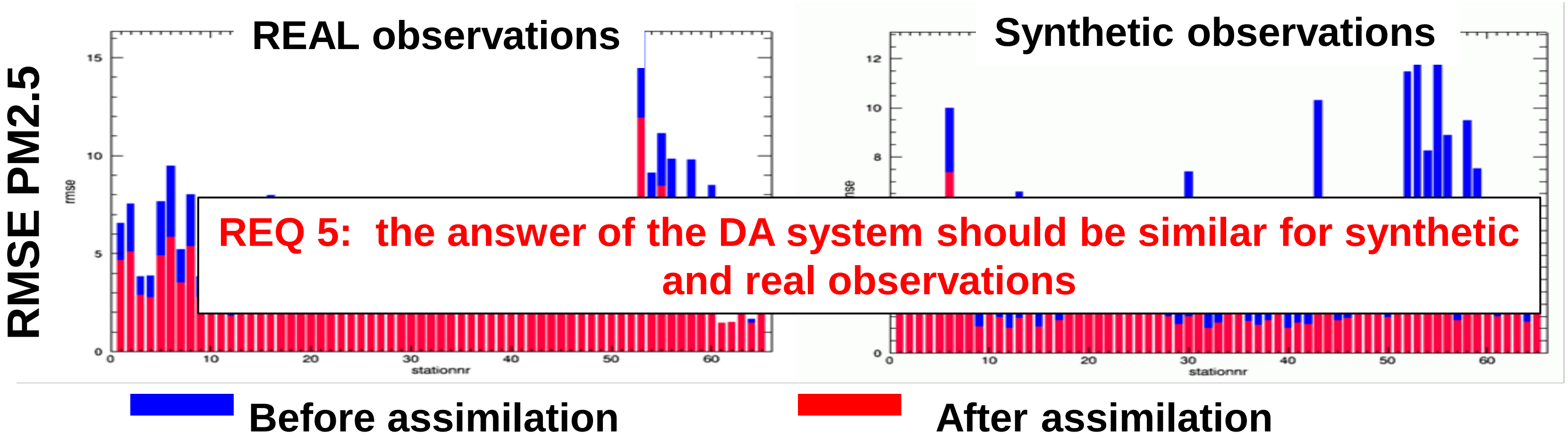
REQ 4: Use full RTM or scene dependent AKs

From Sellitto et al. , Atmos. Meas. Tech., 6, 2013

DATA ASSIMILATION SYSTEM

TNO innovation for life

- an established data assimilation system in the context of air quality forecasts and analyses;
- Compare response of assimilation system to simulated and real observations of existing observation systems



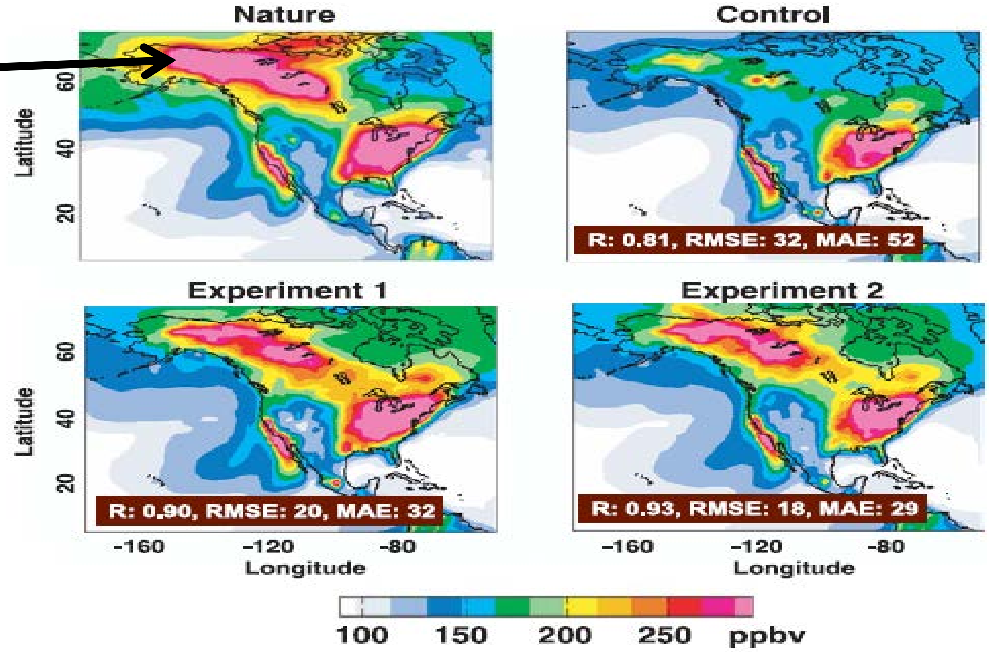
REQ 5: the answer of the DA system should be similar for synthetic and real observations

EVALUATION OSSE RESULTS

Example of Mean surface CO distribution for 6–31 July 2004 in ppbv.

Comparison of assimilation results with results from nature run and control run to see the added impact of the future observations

Wild fires

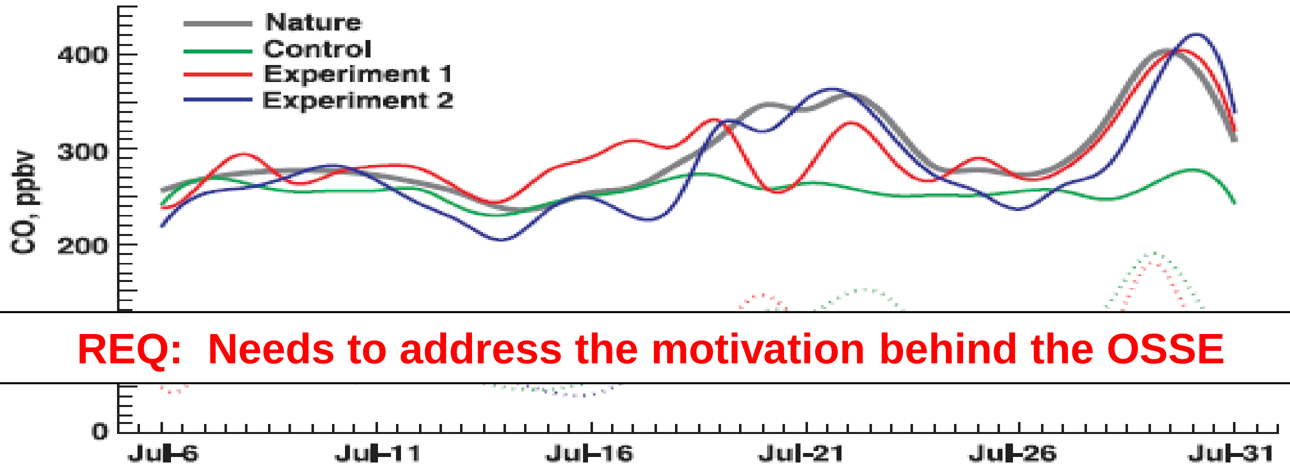


Experiment 1:
S1 (TIR/LEO)

Experiment 2:
S1 (TIR/LEO)
S2 (NIR+TIR/GEO)

From Edwards et al., 2009, J. Geophys. Res., 114, added value for char. variability of surface CO

Example of Surface CO



REQ: Needs to address the motivation behind the OSSE

Figure 8. Daily mean surface CO sampled from the models at the locations of 1000 USEPA air quality sites. Dashed lines correspond to RMSE of modeled CO relative to the NR truth.

From Edwards et al., 2009, J. Geophys. Res., 114

MAIN CONCLUSIONS

- OSSEs performed hitherto provide evidence of their value for assessing the benefit of future instruments, and/or find optimum instrument characteristics

- To ensure realistic evaluation of the benefit (more) attention should be paid to:
  - realism of nature run (check differences with control run)
  - realistic error estimates,
  - scene dependent AKs or full RTM,
  - driving motivation behind the OSSE

- To minimize dependency on shortcomings of individual OSSE elements we suggest comparing at least two instruments/designs

MAIN CONCLUSIONS

- OSSEs expensive (100-400k) but only fraction of instrument costs (2-100M)
- We recommend the continued use of OSSEs by space agencies to assess the usefulness of the observations also in terms of societal benefit, legislation and economic costs.

Presentations based on:

Observing System Simulation Experiments for air quality by R.M.A. Timmermans[1,*], W.A. Lahoz[2], J.-L. Attié[3], V.-H. Peuch[4], R.L. Curier[1], D.P. Edwards[5], H.J. Eskes[6], P.J.H. Builtjes[1,7]


THANK YOU FOR
YOUR ATTENTION
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TNO innovation for life

EXTRA SLIDES

OBJECTIVE

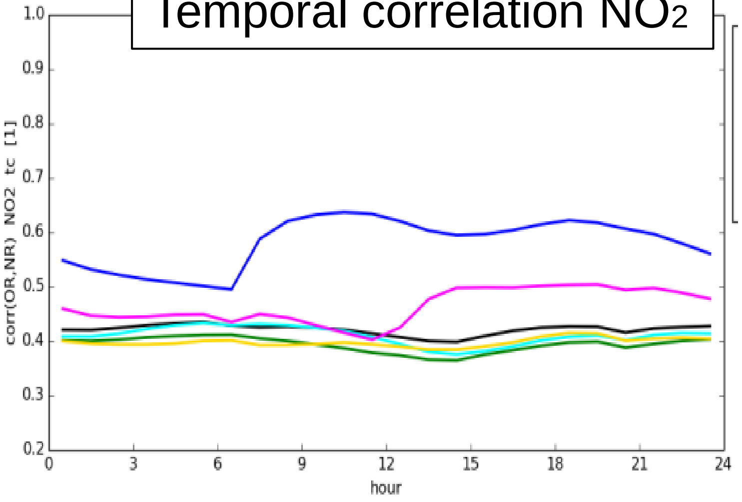
Using illustrative examples from existing air quality OSSEs:

- **Show potential of OSSEs**
- **Present methodology**
- **Present requirements for each OSSE element**
- **Show the value of air quality OSSEs**

POTENTIAL OSSES

- Added value new planned instrument
- Compare instrument designs or operations

Temporal correlation NO_2



No observations

S4 geostationary NO2 satellite obs.

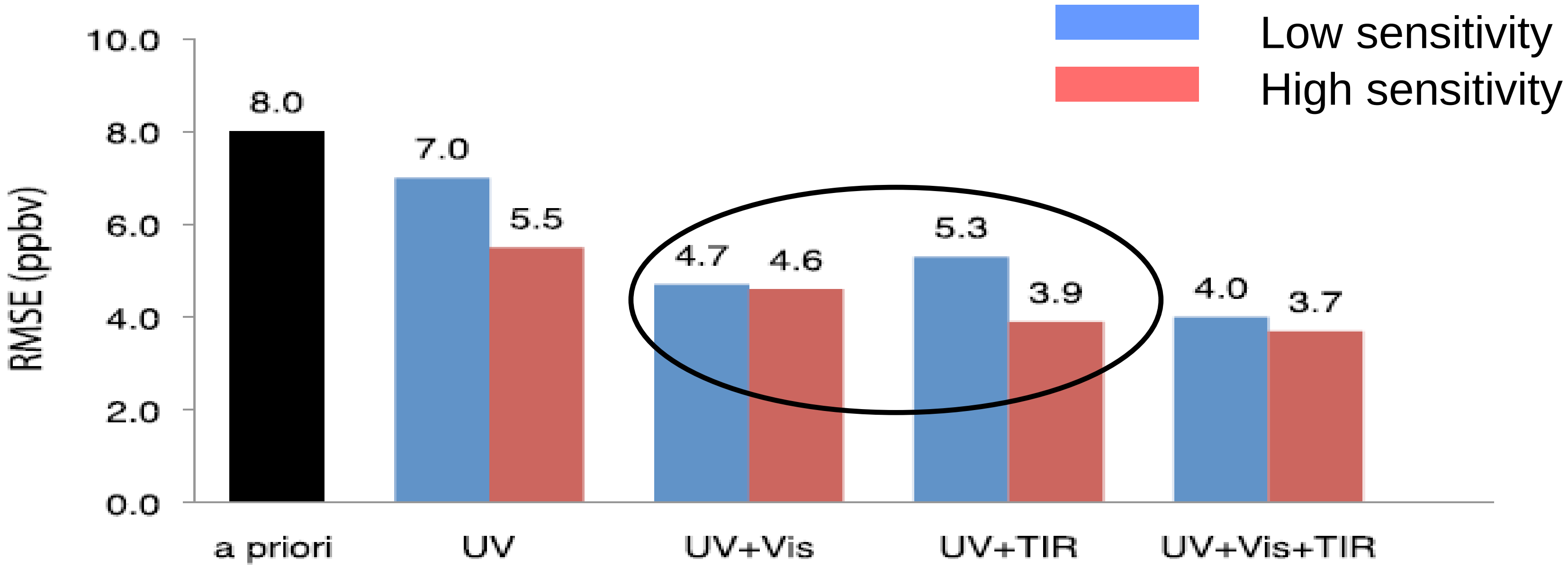
S5 LEO satellite NO2 obs

ISOTROP project

MAIN REQUIREMENTS NATURE RUN

- A high performance state-of-the-art air quality model;
- Spatio-temporal resolution ≥ resolution control run and target observations
- The NR model should be significantly different from the assimilation model; Ideally two different models.
- The differences between the NR and the CR output should approximate the differences between the CR output and real observations;
- The NR should cover an extended time period, ideally covering different seasons, and perhaps one or more years;
- The NR should cover an extended geographical region, as well as different chemical regimes.
- Nature run needs to be evaluated

IMPORTANCE OF OBSERVATION SIMULATOR



RMSE of 8-h maximum daily average ozone over continental US in July 2001 relative to the “true” state

From Zoogman et al., Atmospheric Environment 45, 2011

MAIN REQUIREMENTS OBSERVATION SIMULATOR

- Full radiative transfer computations or scene dependent avering kernels
- Full instrument description, including resolution, coverage, wavelength bands and spectral resolution, signal to noise ratio
- Realistic errors and error covariance matrix – crucial for data assimilation system
- Cloud information for identifying cloudy scenes