



Charles University in Prague  
Faculty of Mathematics and Physics  
Dept. of Meteorology and Environment Protection  
V Holesovickach 2, Prague 8,  
Czech Republic



# VERIFICATION OF THE AIR QUALITY MODEL AGAINST FLIGHT MEASUREMENT OF SHIP PLUMES (CORRIDORS)

**Tomáš Halenka, Peter Huszár**

**<sup>1</sup> Regular associate of the Abdus Salam ICTP, Trieste, Italy**

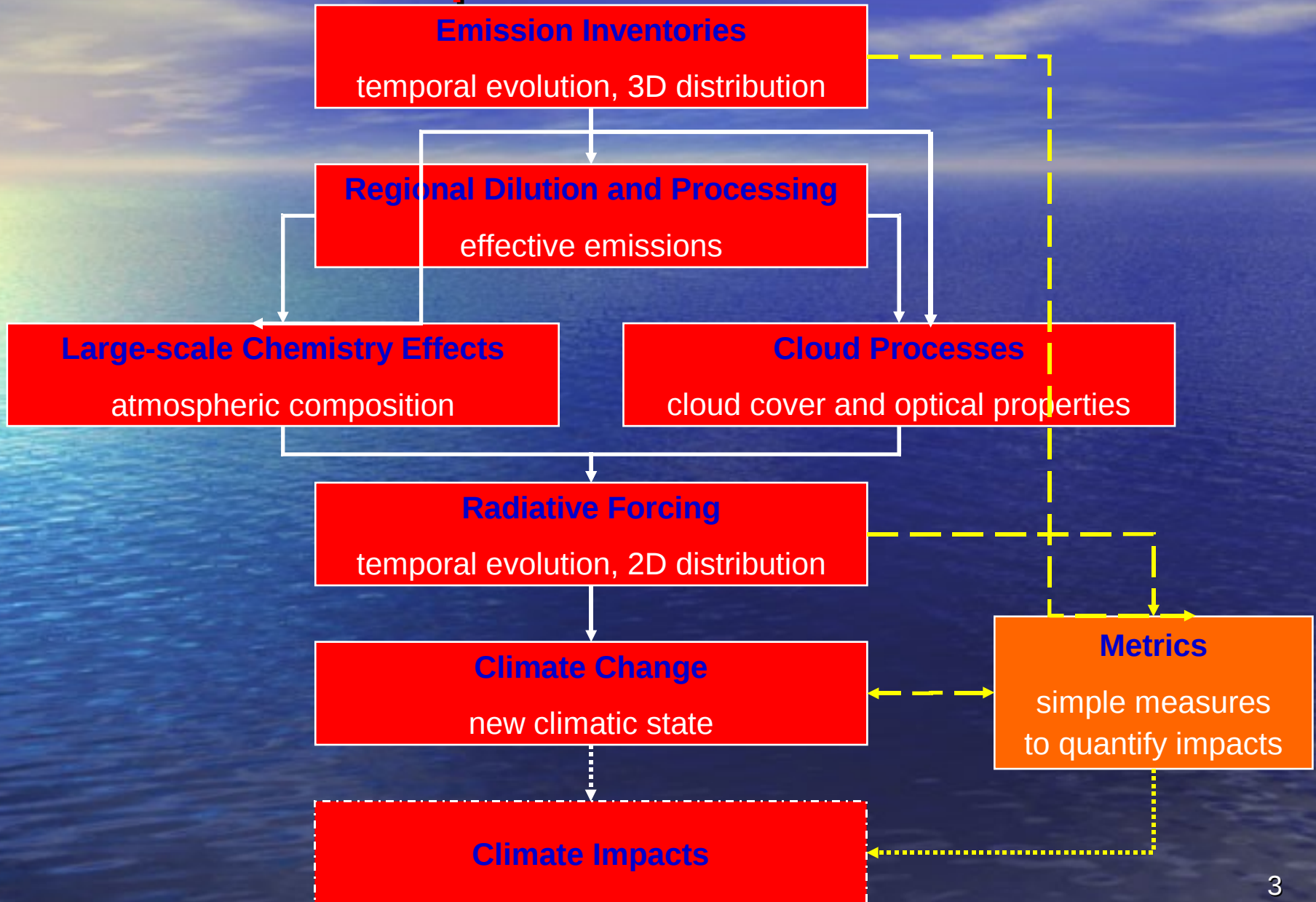
E-mail: [tomas.halenka@mff.cuni.cz](mailto:tomas.halenka@mff.cuni.cz)

# EC FP6 Integrated Project

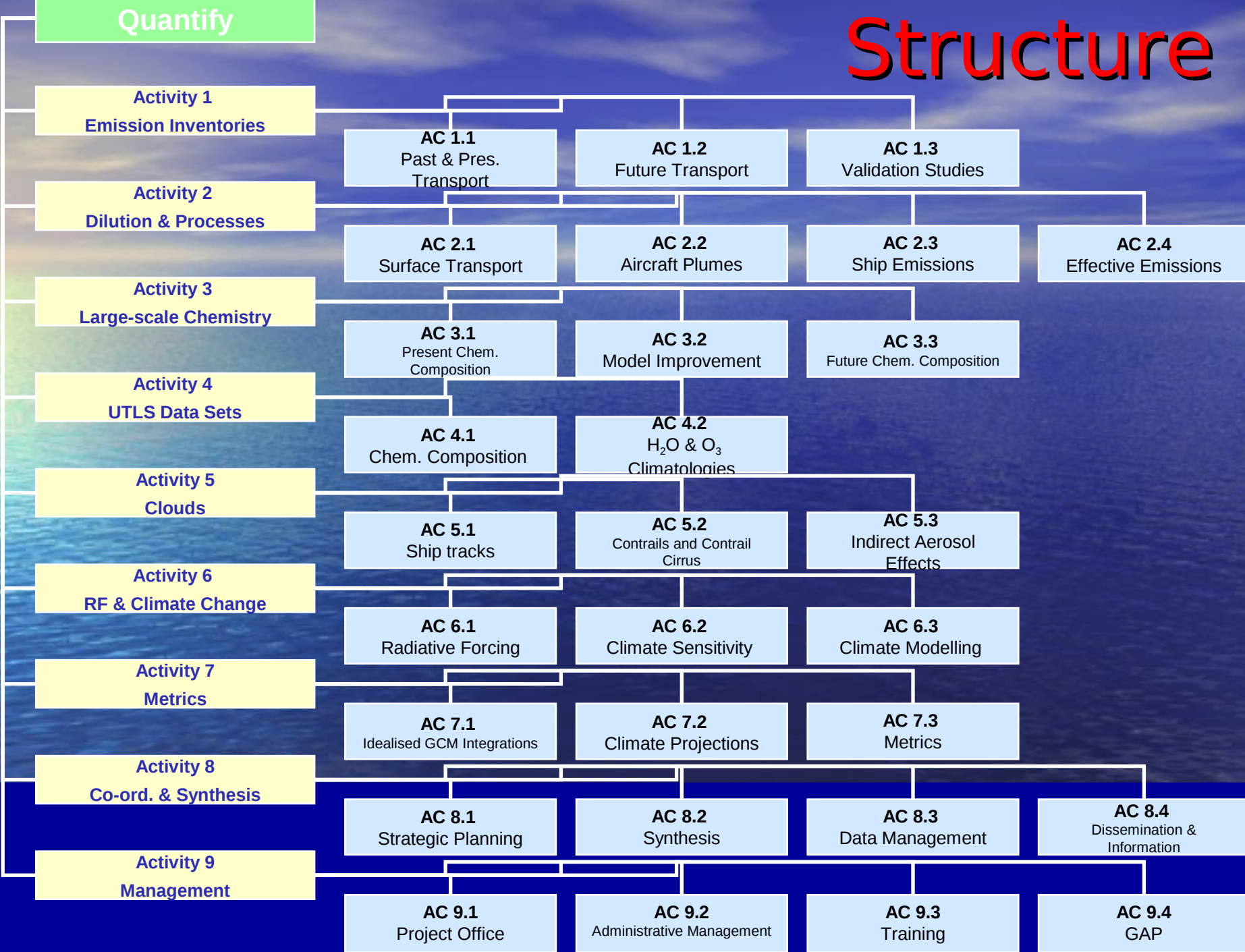


Coordinated by Robert Sausen  
DLR-Institut für Physik der Atmosphäre  
Oberpfaffenhofen, Germany  
<http://www.pa.op.dlr.de/quantify/>

# Chain of Impacts



# Structure



# Motivation

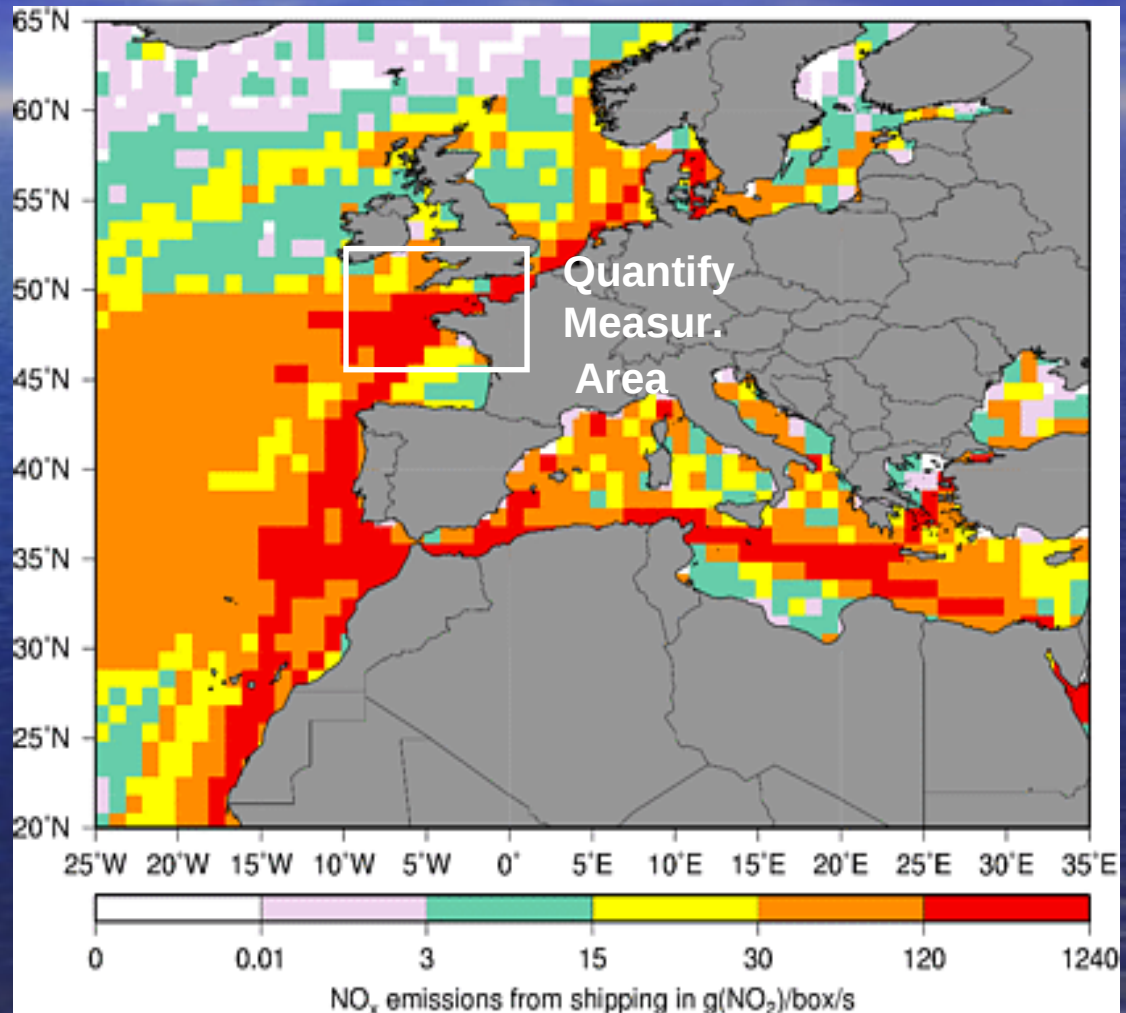
- **To identify, recognize and understand the processes and their role in transformation and transport of emission from transportation systems for bridging the gap between the scale of single sources and scale of global model grid**
- **To support measurement campaigns**

# Goals

- **To verify model system against measurement**
- **To analyse the sensitivity of the model system to emissions, processes, etc.**
- **To predict atmospheric condition for support the measurement campaign**
- **To use the model results for parameterization of effective emission indices**

# Measurement of Ship Emissions

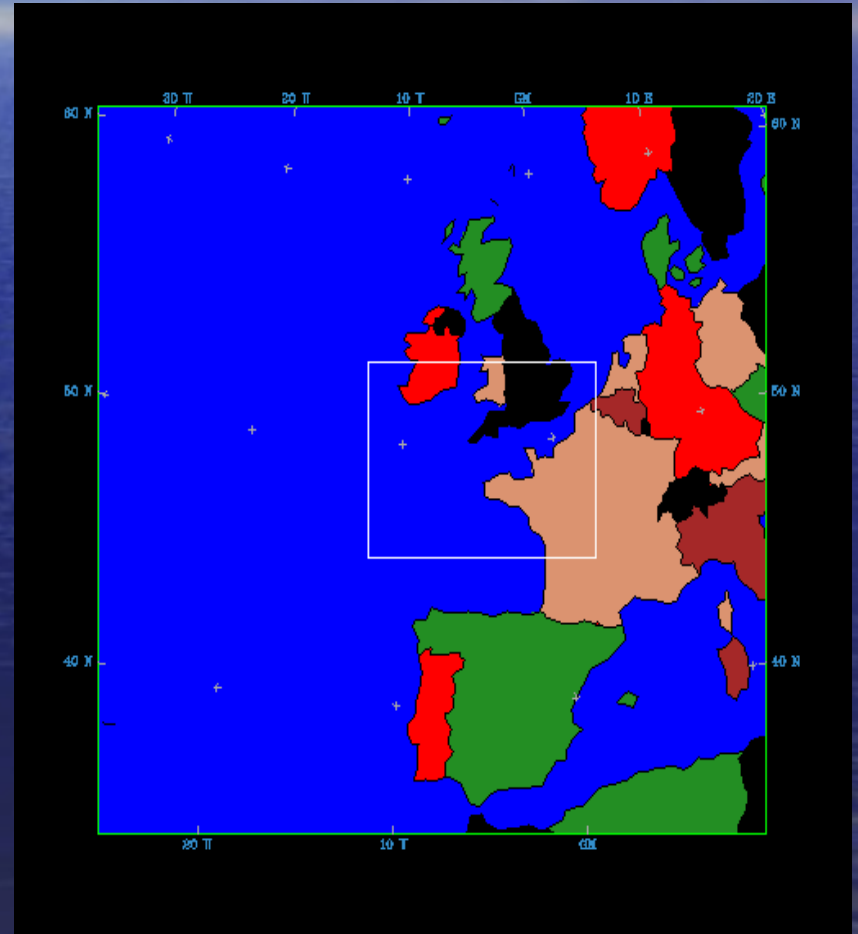
- WP 2.3.1
- WP 2.3.2
- WP 2.3.3



*Eyring et al., 2005*

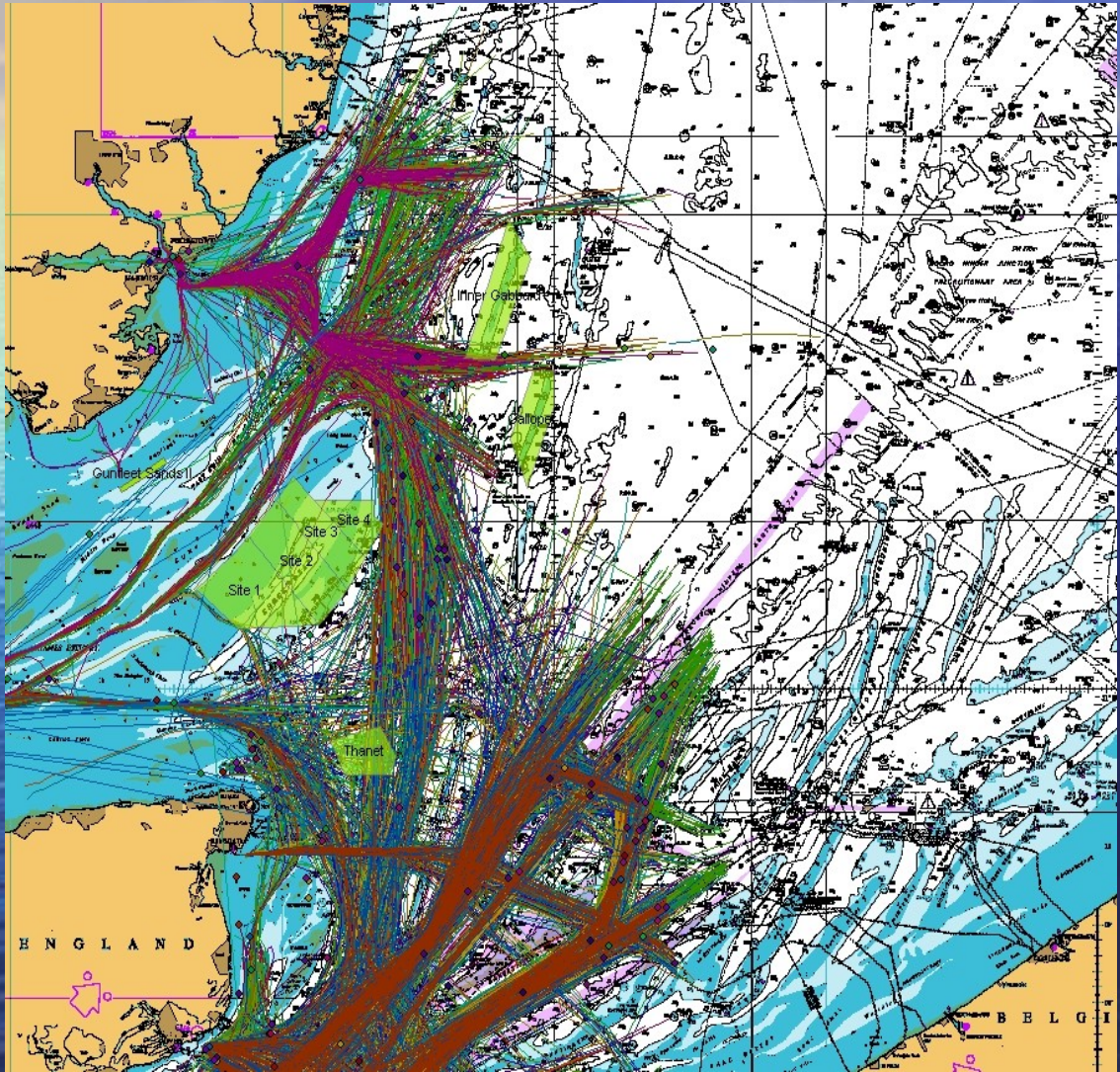
# Couple MM5 - CAMx

- double nesting (27 x 27 km, 9 x 9 km), one way
- EMEP 50 km emission inventory and UKAEA (United Kingdom Atmospheric Emission Inventory) used, interpolated,
- CBM-IV chemistry



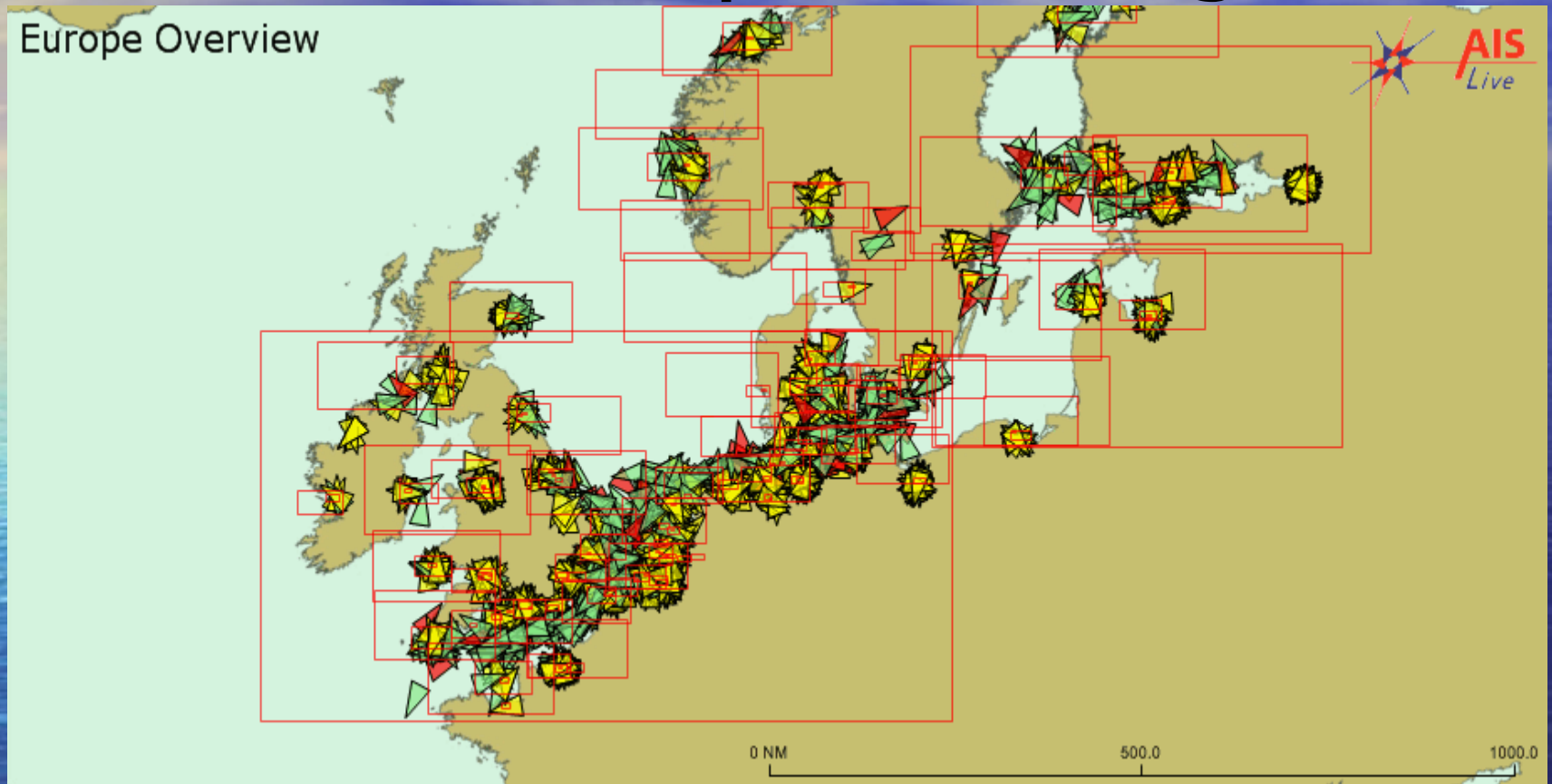


# Ship corridor data



- UK Maritime and Coastguard Agency radar data of ship corridors for estuary of Thames river. 9

# Individual ship tracking



<http://aisfree.aislive.com/Influx.aspx?Map=Europe%20Overv>

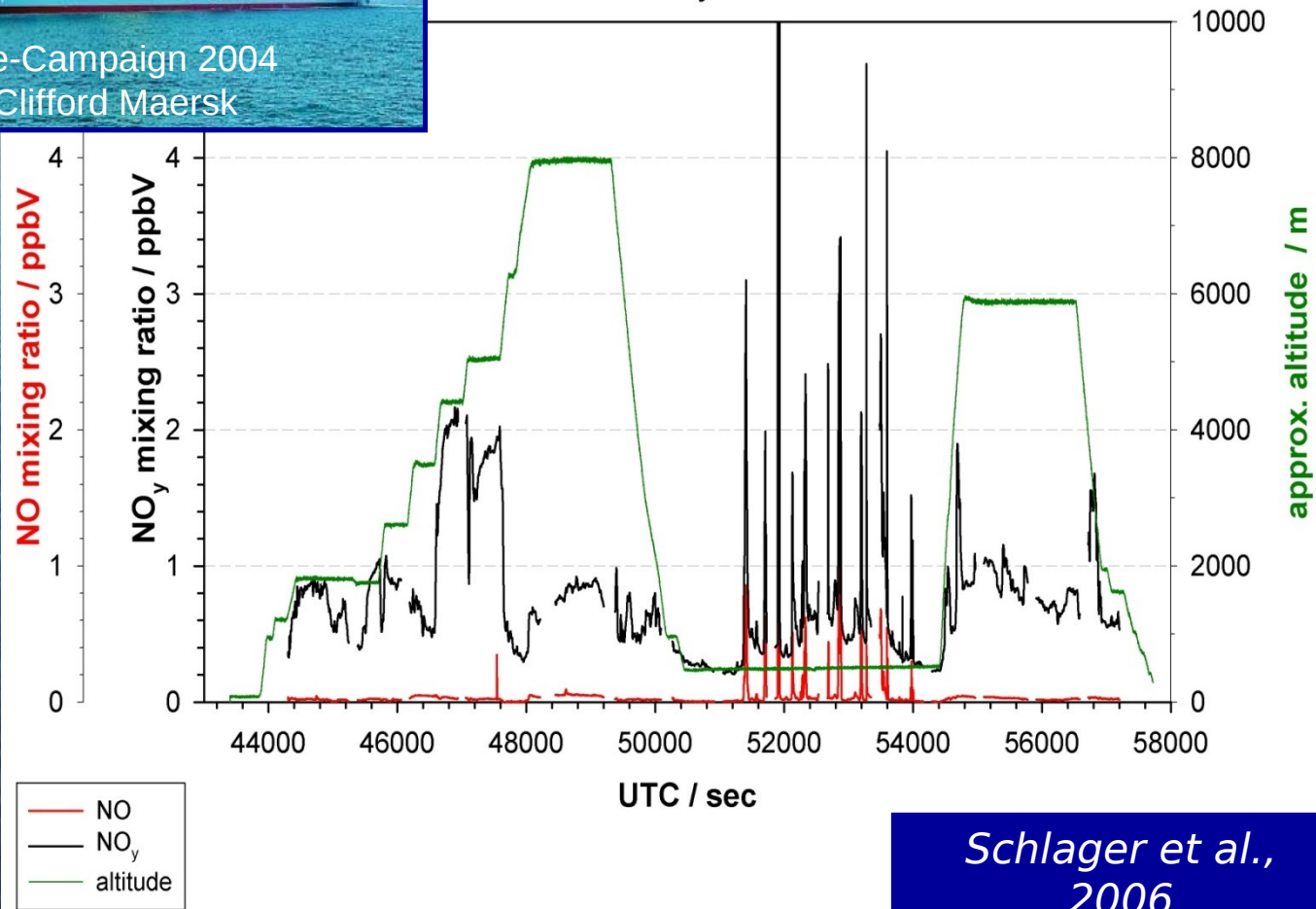
<http://ais.gps.nl/AISLivePortal/DesktopDefault.aspx>

# Airborne measurements of ship emissions



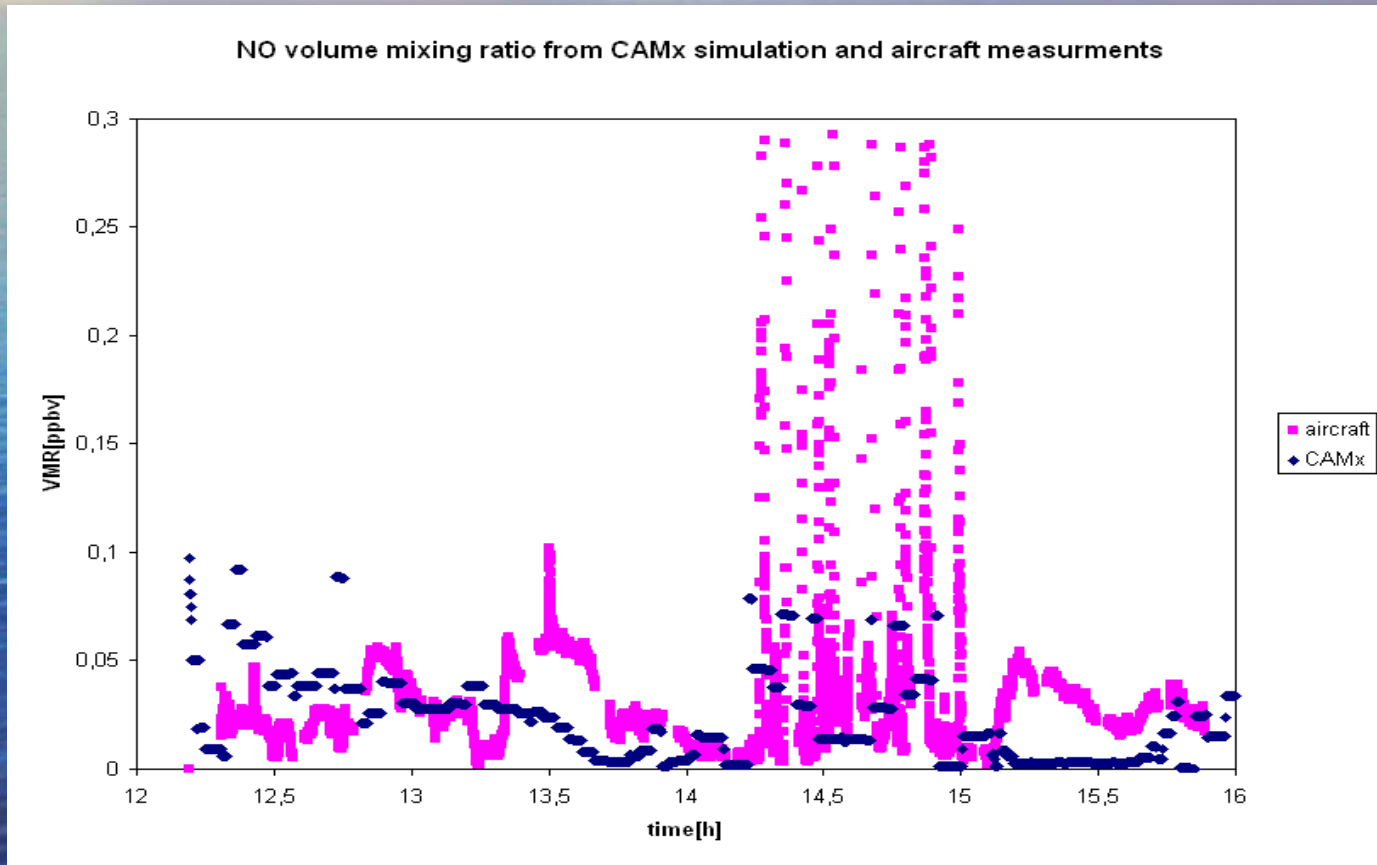
ITOP 2004 - F040723  
NO, NO<sub>y</sub>

Institute of Atmospheric Physics  
Schlager, Roiger, Lichtenstern, Uhlemann

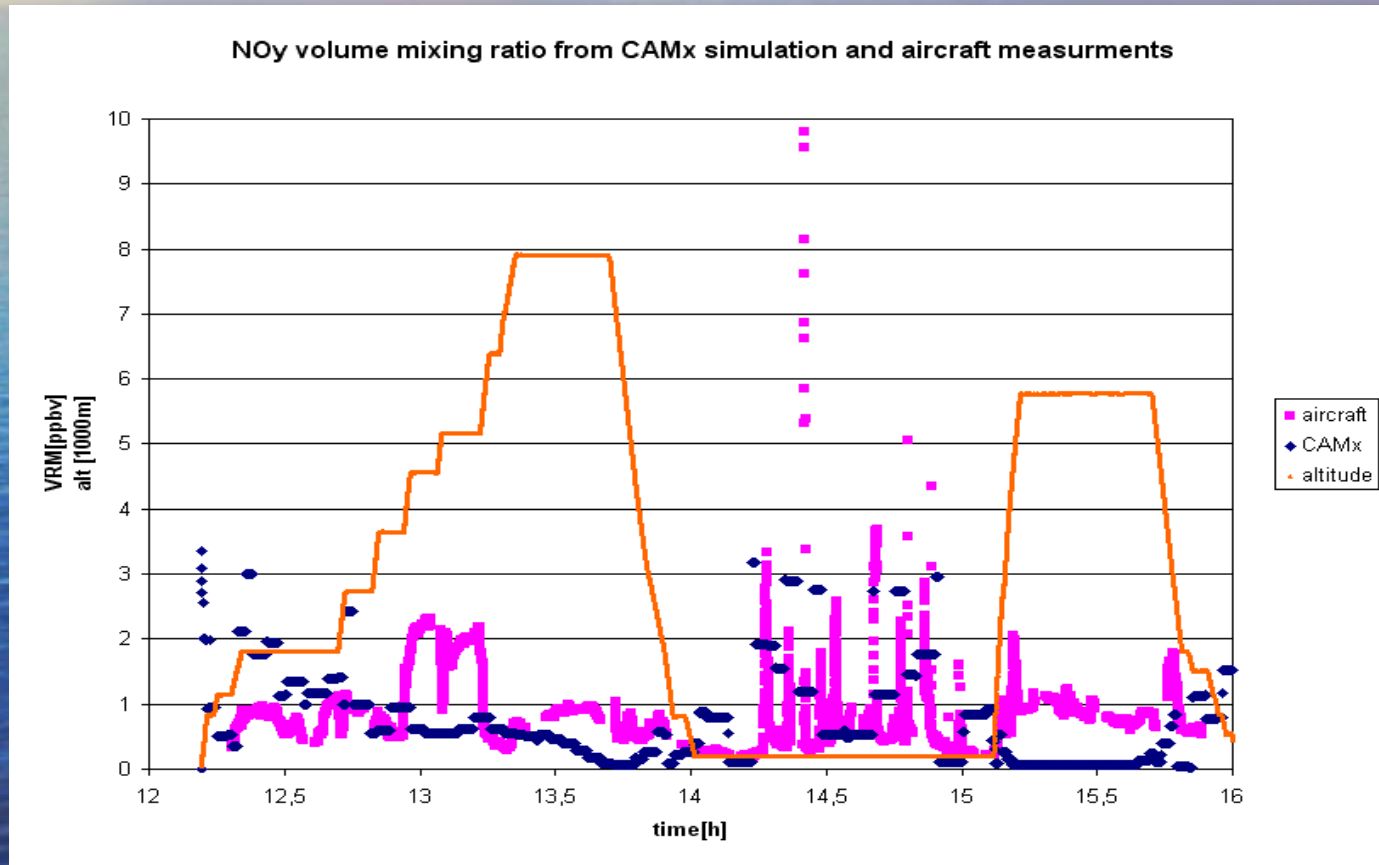


Schlager et al.,  
2006

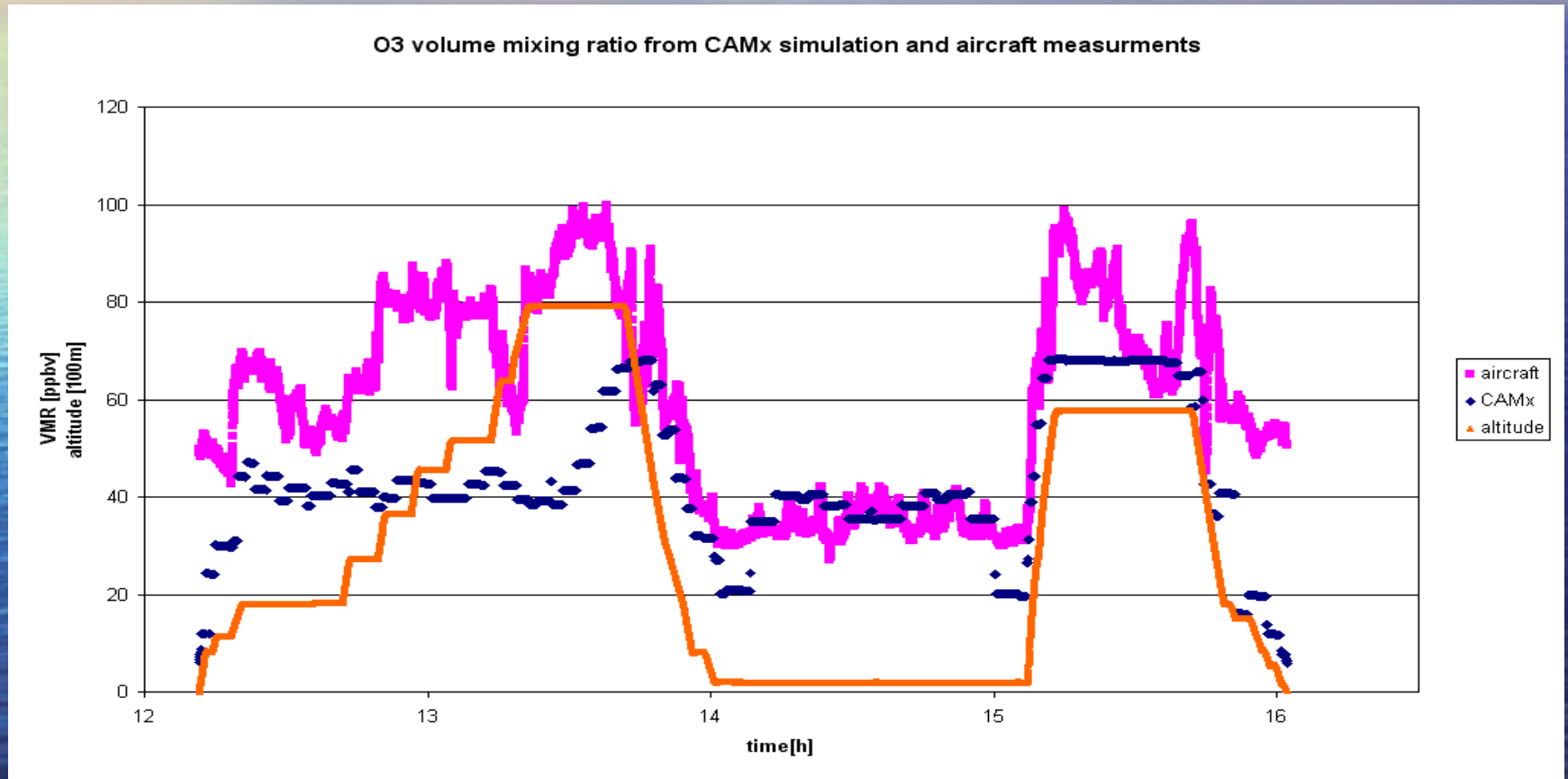
# Pre-project measurement and modelling



# Pre-project measurement and modelling

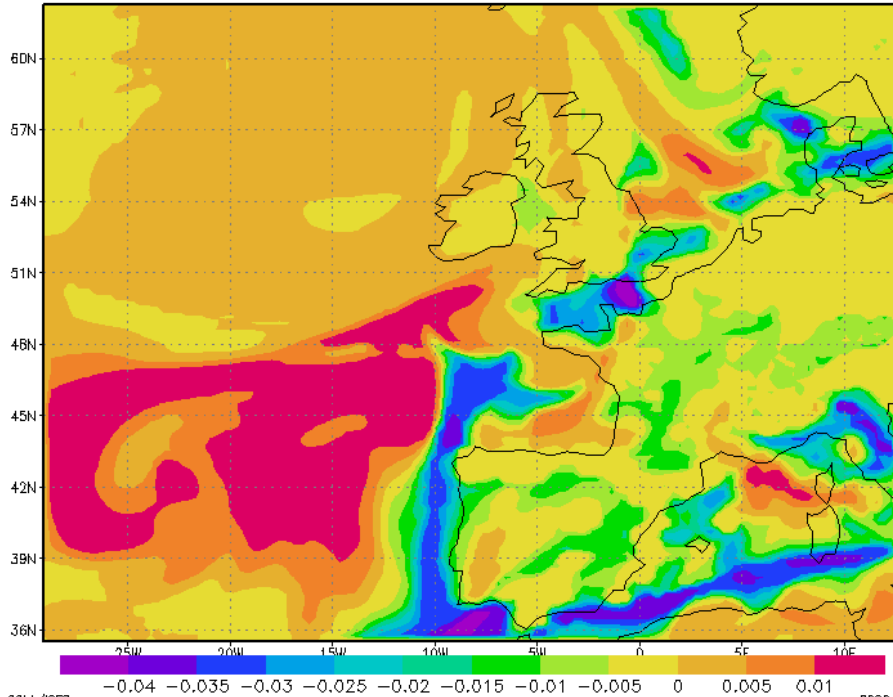


# Pre-project measurement and modelling

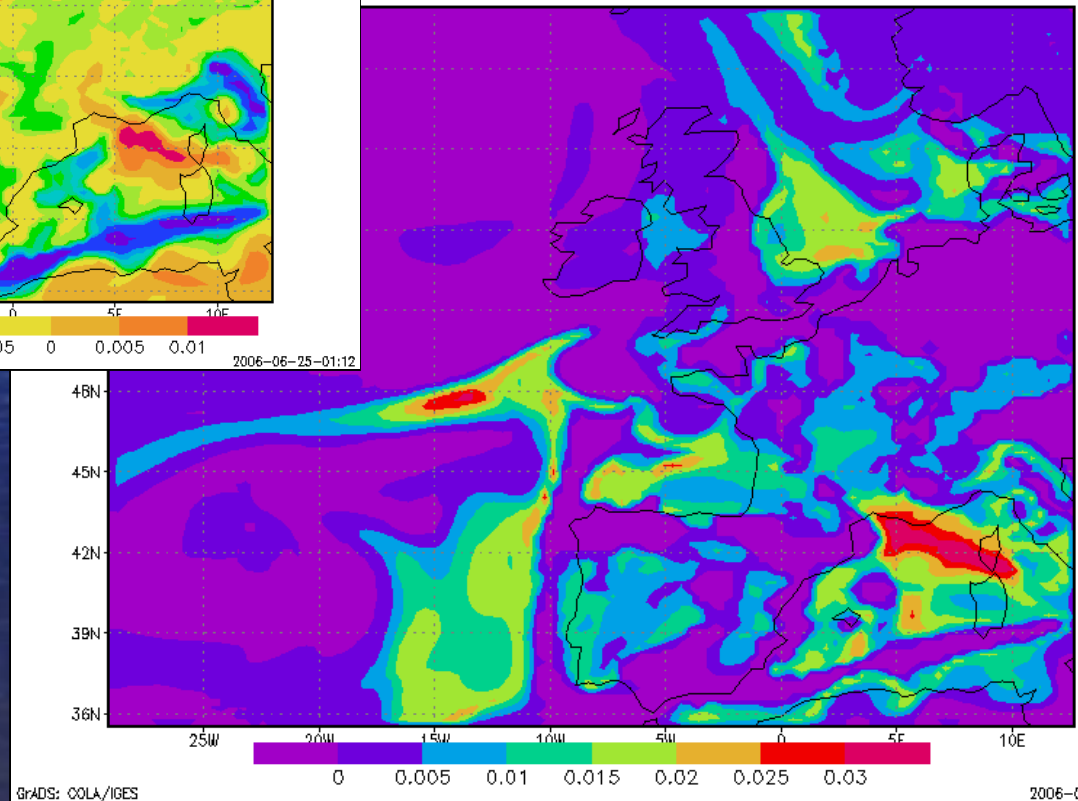


# Sensitivity study

O<sub>3</sub> change [ppm] with no ships traffic

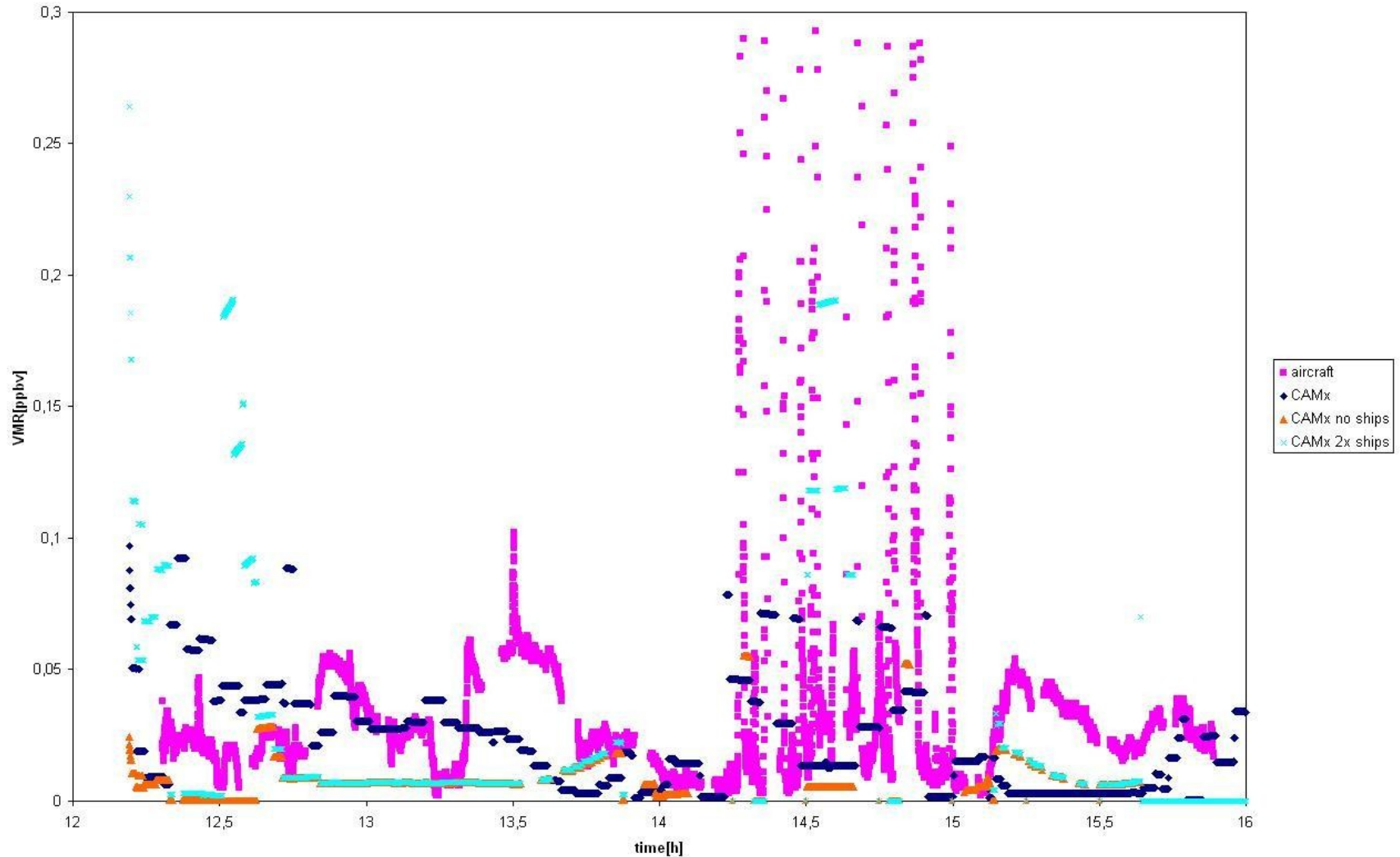


of O<sub>3</sub> [ppm] with 2x ships emissions



# Sensitivity study - NO

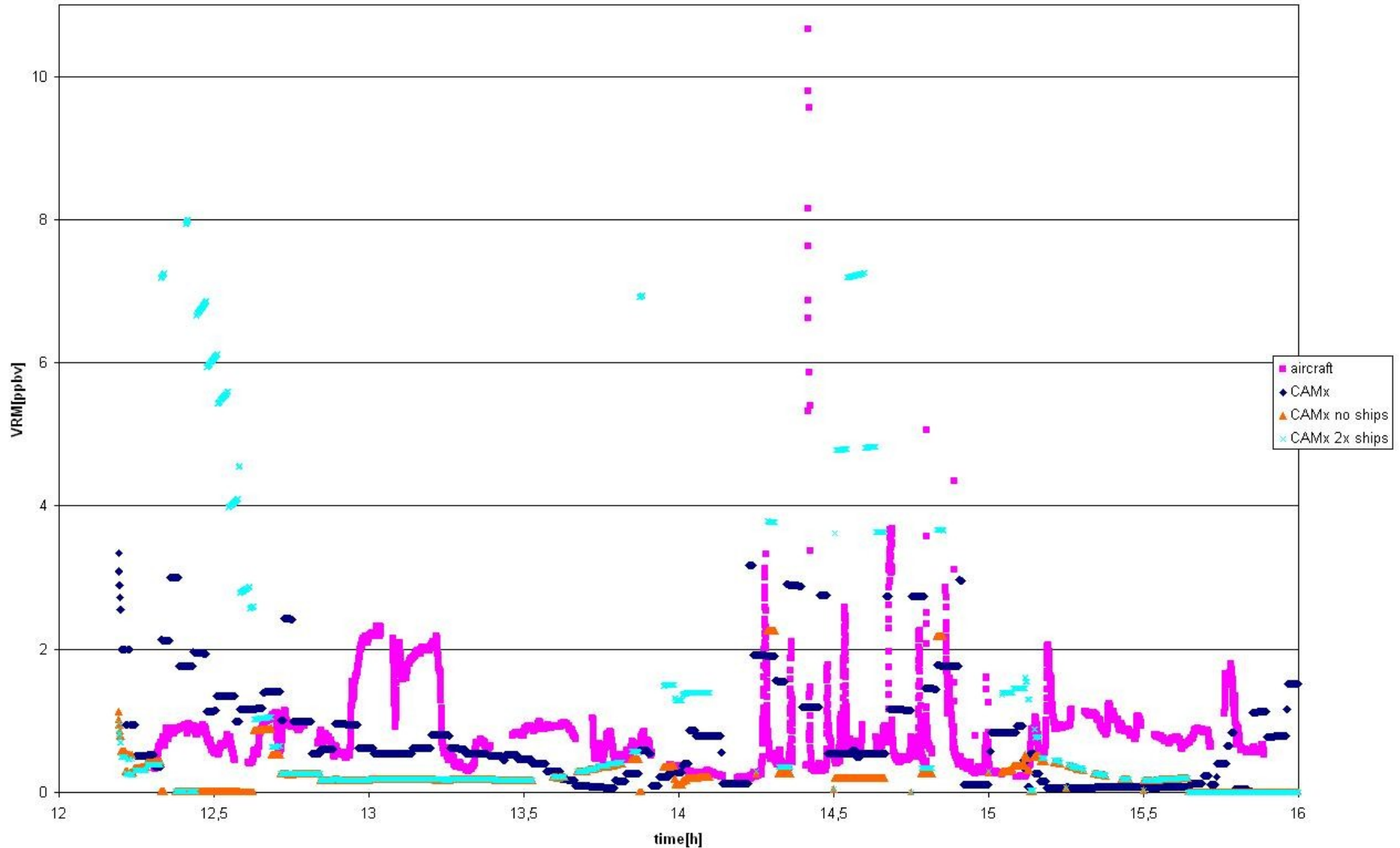
NO volume mixing ratio from CAMx simulation and aircraft measurements





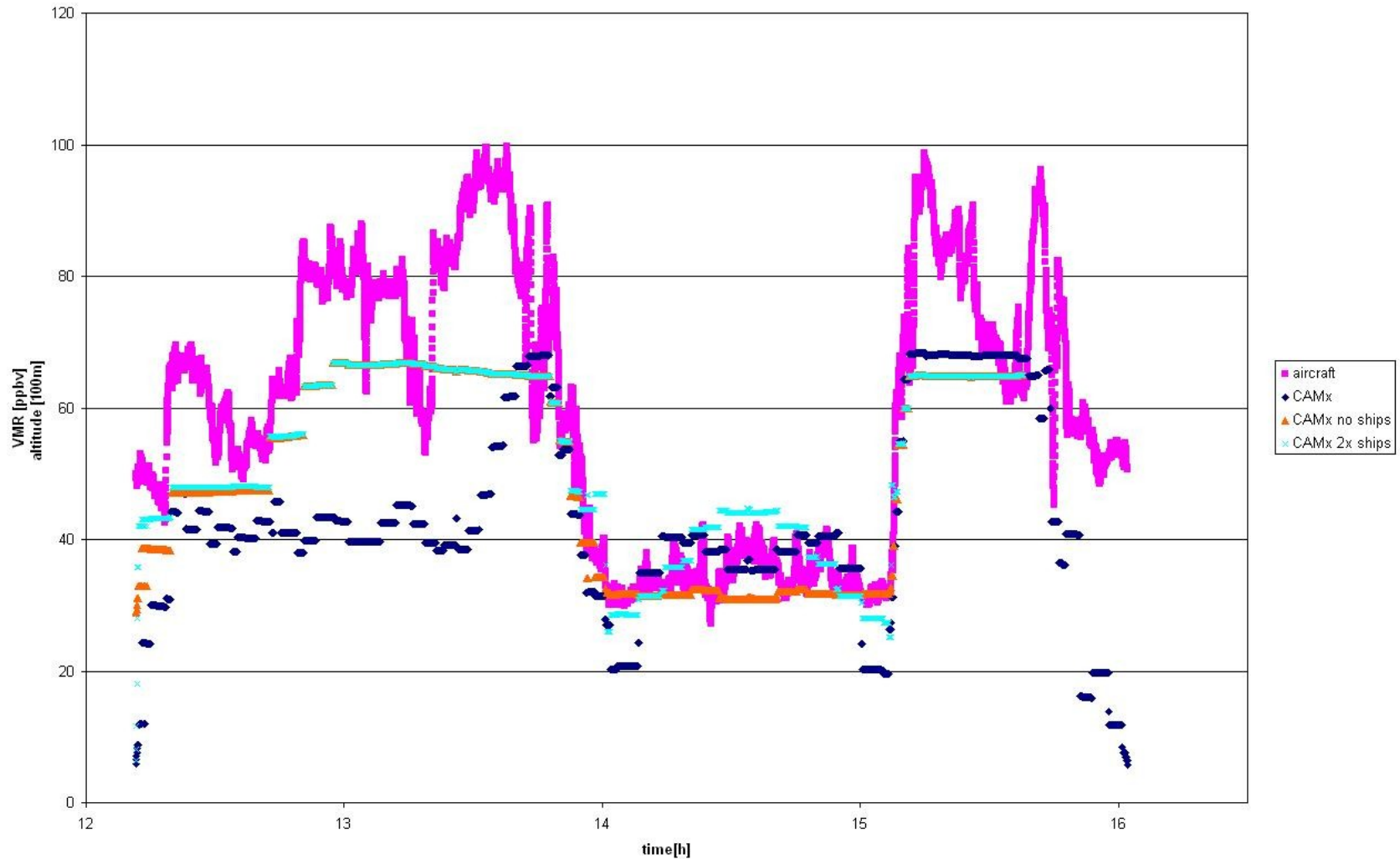
# Sensitivity study - $\text{NO}_y$

$\text{NO}_y$  volume mixing ratio from CAMx simulation and aircraft measurements



# Sensitivity study - O<sub>3</sub>

O<sub>3</sub> volume mixing ratio from CAMx simulation and aircraft measurements



# AC2: QUANTIFY Measurement Campaign on Ship Emissions

Hans Schlager, Andreas Petzold, Ally Lewis, Frank Arnold, Nikolay Sitnikov,  
Jana Moldanova, Eric Friedel, Thomas Halenka  
& campaign team



# Type of flights and Objectives

## A) Sampling in the exhaust plume of a dedicated source ship (ACL)

- ▶ To determine the dilution of ship emissions in exhaust trails
- ▶ To analyse chemical transformations in exhaust plumes
- ▶ To analyse aerosol processing in exhaust plumes
- ▶ To infer emission factors, in particular of secondary emissions
- ▶ To provide validation data for plume dispersion and plume chemistry box models

## B) Sampling in major ship corridors

- ▶ To analyse shipping-related trace species on regional scale
- ▶ To sample "background" data for air mixed with the ship plumes
- ▶ To provide validation data for regional chemistry-transport models
- ▶ To validate ship emission inventories

# Falcon Measurements

Instrument	Partner	PI
NO / NO <sub>y</sub>	DLR-IPA	Schlager
CO	DLR IPA	
CO <sub>2</sub>	DLR-IPA	
HCHO	DLR-IPA	
O <sub>3</sub>	DLR-IPA	
HNO <sub>3</sub> + SO <sub>2</sub>	MPI - K	Arnold
NO <sub>2</sub>	CAO	Sitnikov
HC	Uni York	Lewis
aerosol number + size (CPC + DS)	DLR-IPA	Petzold
aerosol size (DMA)	DLR-IPA	
aerosol size (OPC)	DLR-IPA	
volatility	DLR-IPA	
black carbon	DLR-IPA	
RH, temp, wind	DLR-FB	Giez

# Measurements on board the Atlantic Conveyor



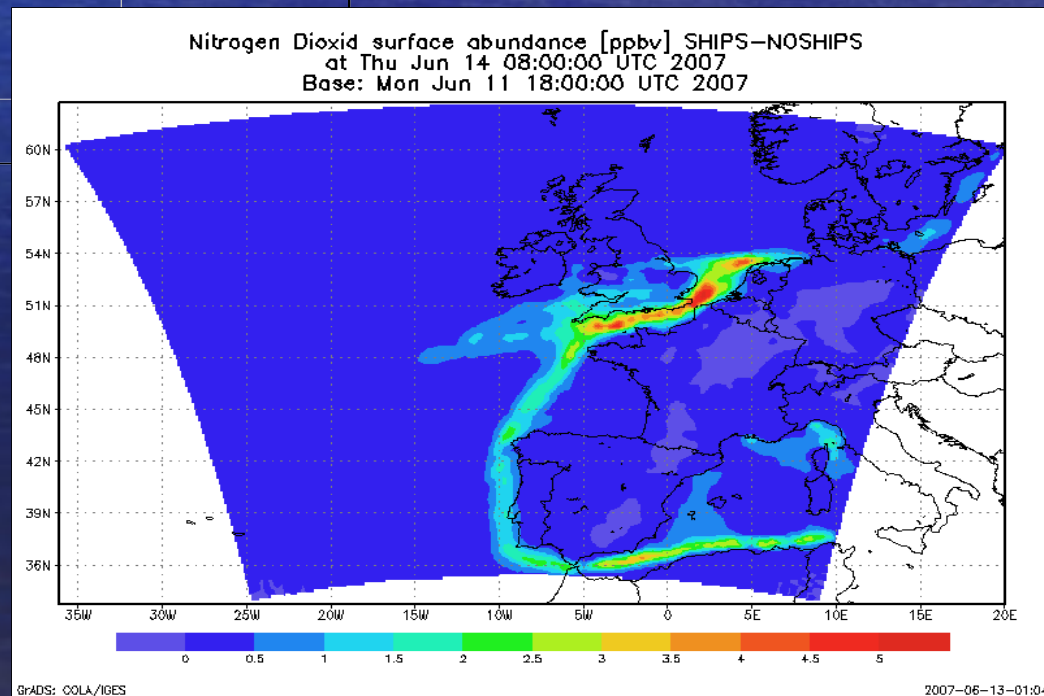
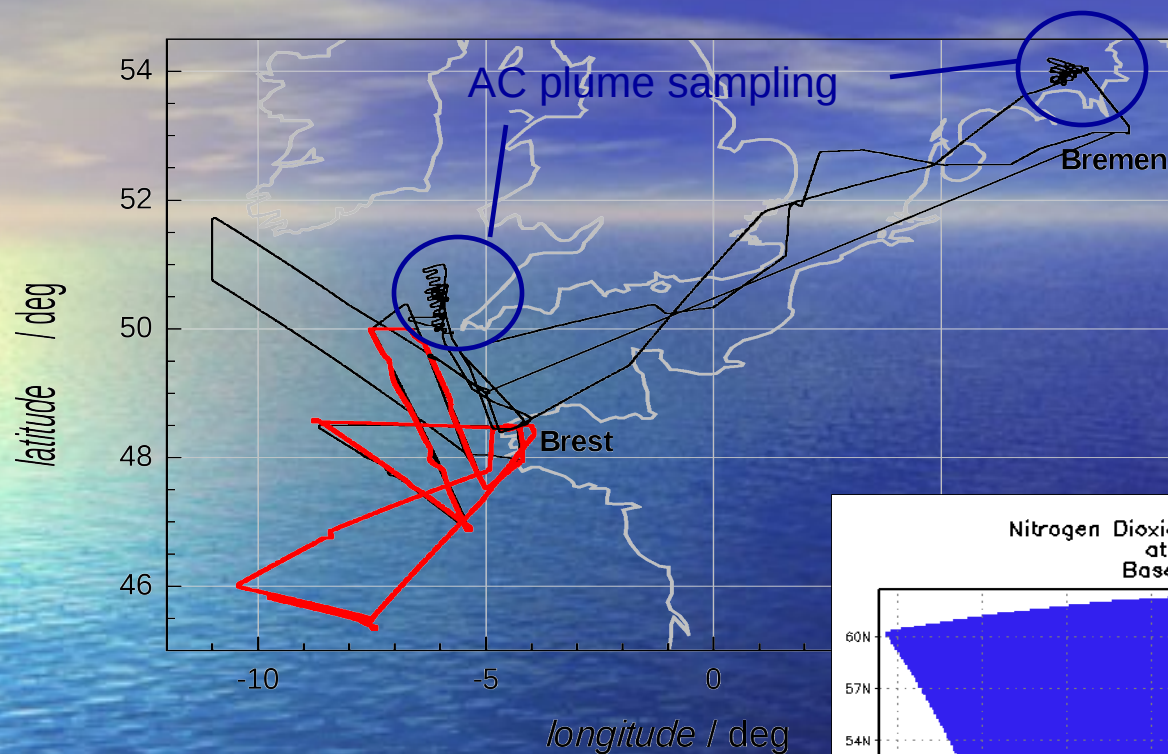
Species	Technique
NO <sub>x</sub>	CL
CO <sub>2</sub>	IR
CO	IR
HC	FID
O <sub>2</sub>	
SO <sub>2</sub>	IR
Benzene	carbopack
PM	filter
CN	CPC

IVL- Swedish Environmental Research Institute (Jana Moldanova, Eric Fridell)

# Near-field measurements of Atlantic Conveyor



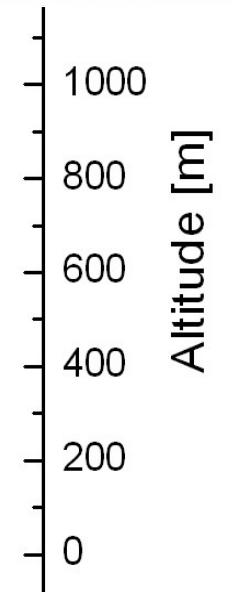
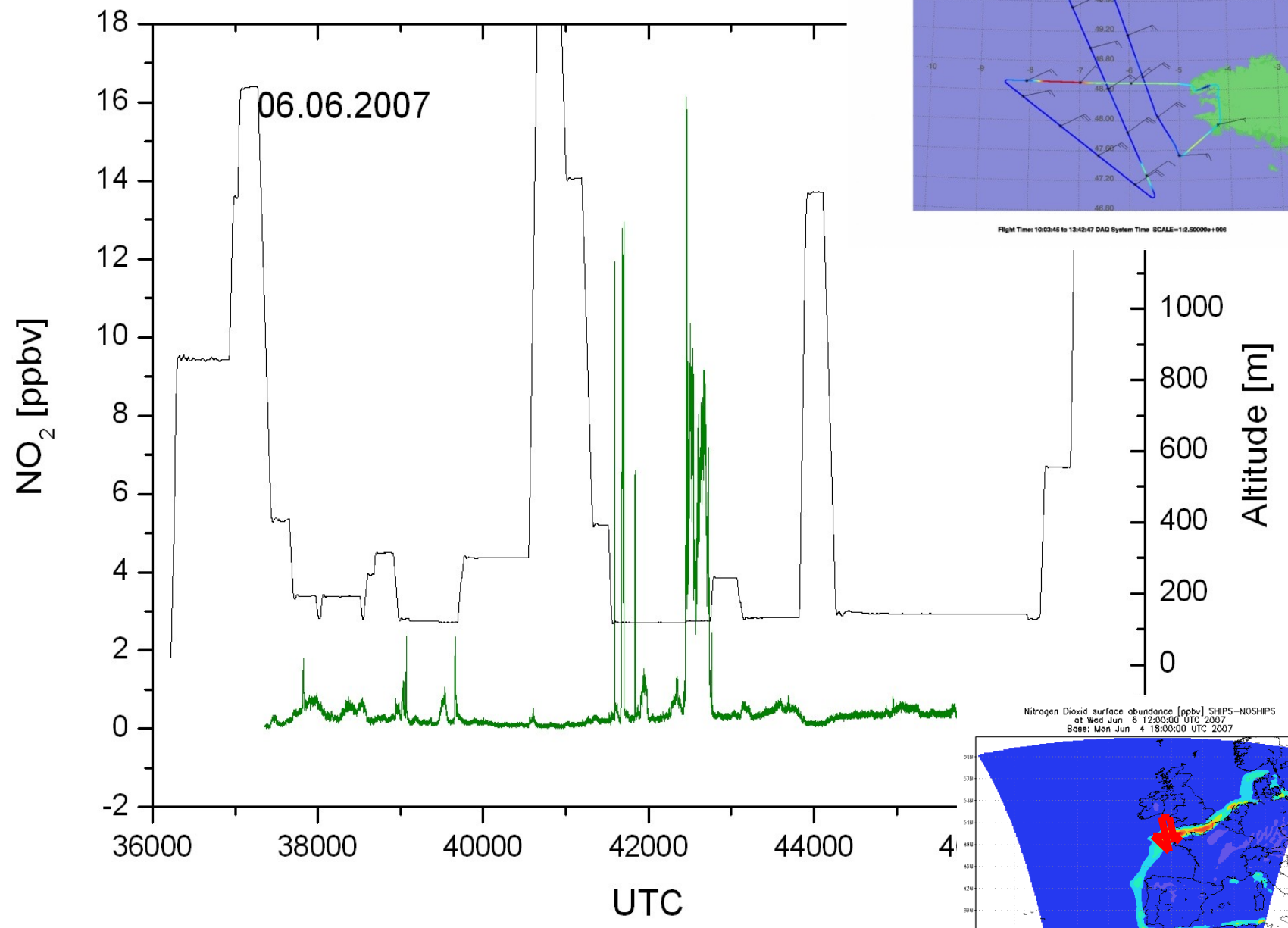
# Falcon Flight Pattern



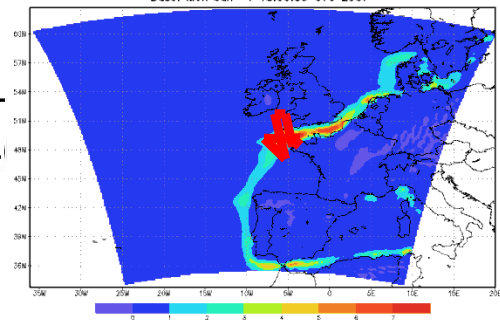




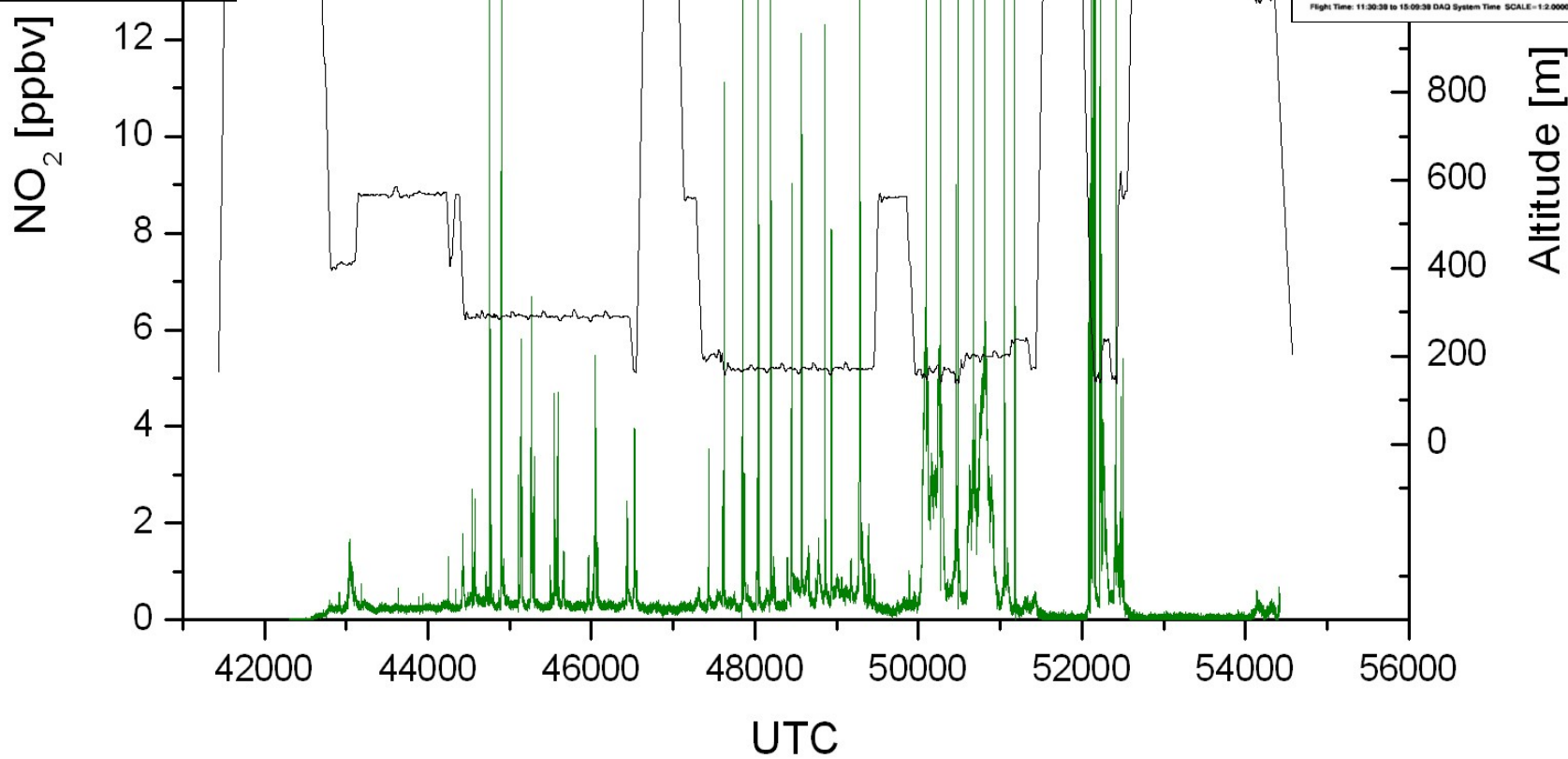
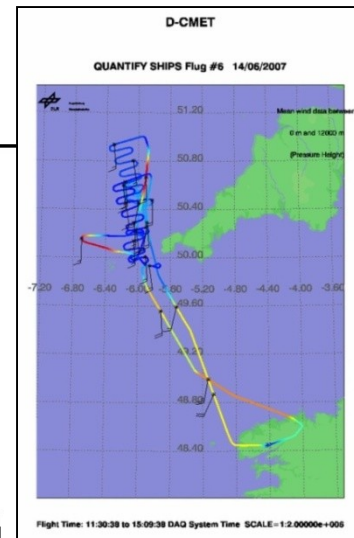
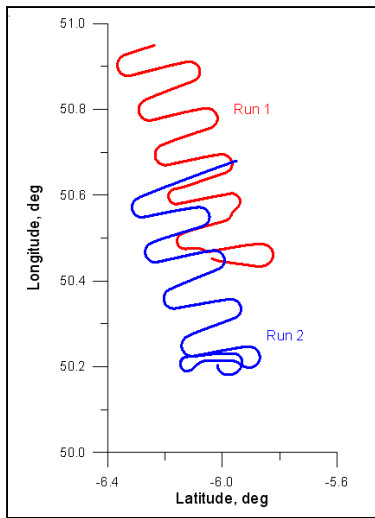
Flight Time: 10:03:46 to 13:42:47 DAG System Time SCALE=1:2,500,000e+006



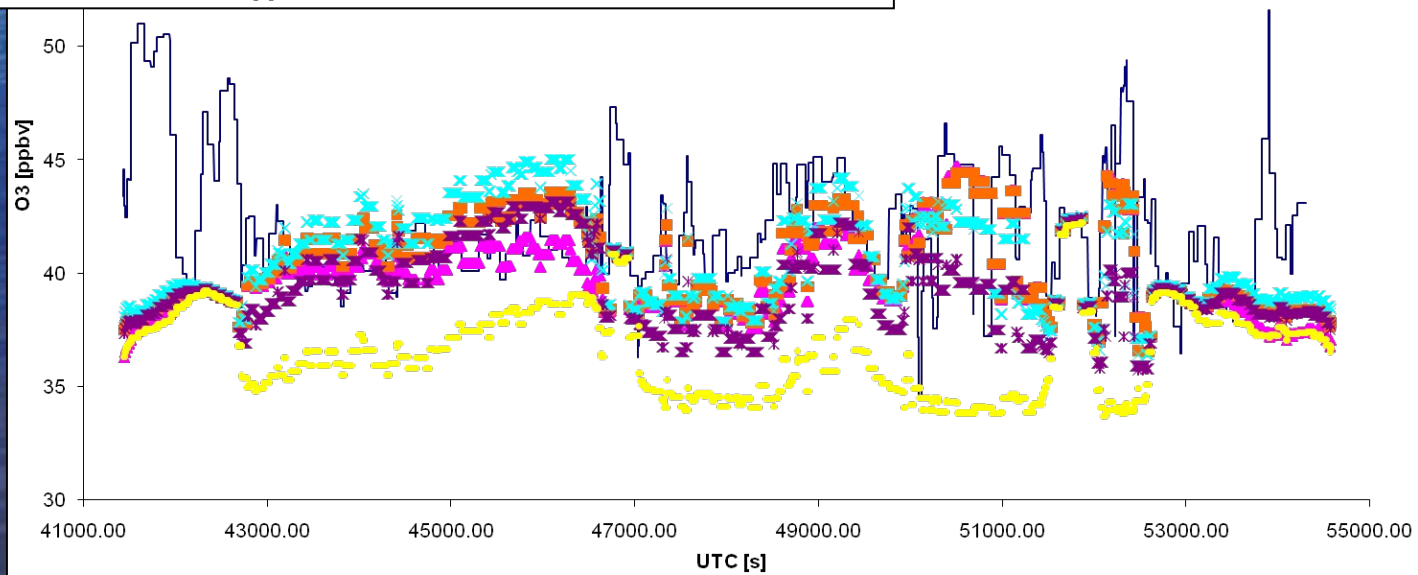
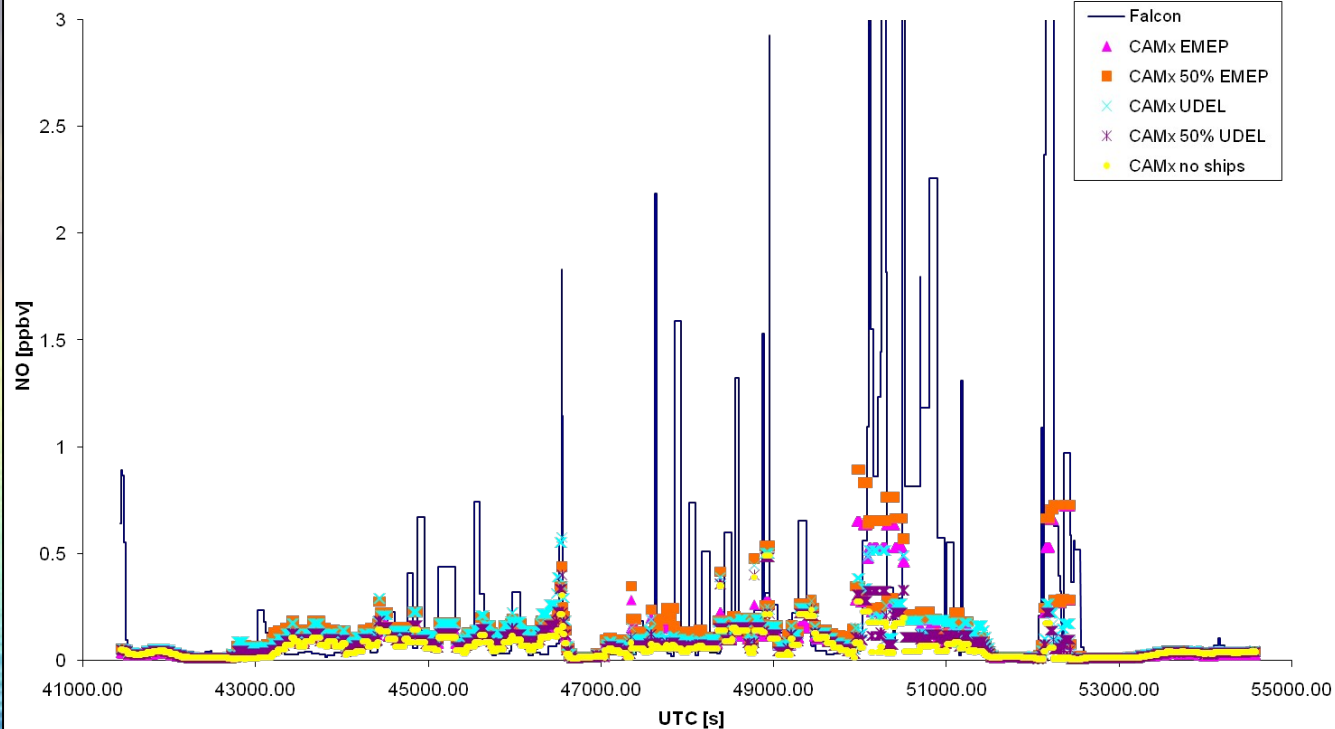
Nitrogen Dioxide surface abundance [ppbv] SHIPS-NOSHIPS at Wed Jun 6 12:00:00 UTC 2007 Base: Mon Jun 4 18:00:00 UTC 2007



# 14.06.2007 Atlantic Conveyor flight



NO Falcon vs. CAMx  
14/06/2007



# Conclusions

- Reasonable agreement of simulation in shipping corridor with pre-project flight measurement
- Quite robust results, there is sensitivity to the emissions changes
- Verification for main campaign still in progress

# Outlooks

- Tests of improvements of chemistry for heterogeneous processes in ship plumes
- Looking for possibilities of emission resolution increase
- Individual ship plume study – PiG option in CAMx
- Application of effective emission indices in validation for measurement campaign

# Acknowledgement

All the work performed under support  
by project EC FP6 Integrated Project  
QUANTIFY

THANKS FOR YOUR ATTENTION