

# Evaluation of the impact of a IASI-NG-type observing system for tropospheric ozone analyses and forecasts

P. Dauphin (1), A. Coman (1), G. Dufour (1), P. Sellitto (1), G. Forêt (1), M. Eremenko (1), J. Cuesta (1), , B. Gaubert (1), M. Beekmann (1), V.-H. Peuch (2), J.-M. Flaud (1), C. Clerbaux (3, 4), C. Crevoisier (5)

- (1) Laboratoire Inter-universitaire des Systèmes Atmosphériques (LISA), UMR7583, Universités Paris-Est et Paris Diderot, CNRS, Créteil, France  
(2) European Centre for Medium-Range Weather Forecasts (ECMWF), Research Department, Shinfield Park, Reading, Berkshire, RG2 9AX, United Kingdom  
(3) UPMC Université Paris 06; Université Versailles St.-Quentin; CNRS/INSU, LATMOS-IPSL, Paris, France  
(4) Spectroscopie de l'Atmosphère, Service de Chimie Quantique et Photophysique, Université Libre de Bruxelles (U.L.B.), Brussels, Belgium  
(5) UPMC Université Paris 06; Ecole Polytechnique; CNRS UMR 8539, LMD-IPSL, Palaiseau, France  
**Contact: pierre.dauphin@lisa.u-pec.fr**

## 1. INTRODUCTION AND MOTIVATION OF THIS STUDY

Ozone can adversely impact human health and the ecosystem. Thus, monitoring and legislation are implemented to regulate its concentrations. Air quality (AQ) monitoring from space starts to be regarded as a useful tool to complement with in situ measurements and regional chemical transport models (CTM) to draw a more comprehensive picture of pollution processes. In the case of tropospheric ozone, important progresses in the field of atmospheric sounding from space have been accomplished during the last decade, especially with thermal infrared (TIR) space-borne instruments. It is now possible to observe accurately tropospheric ozone concentrations from space. However, limitations remain with the current observation systems in particular to observe ozone in the lowermost troposphere. Since resolving ozone concentrations at the lowest layers is not always assured with the present instruments, future missions are required to undergo a thorough design process to maximize the expected sensitivity to the lowermost troposphere. In order to quantify the benefit of future missions, Observing System Simulation Experiments (OSSEs) are powerful tools: it allows assessing the expected improvement of the analyses and forecasts when using these future observations. Different elements are necessary to conduct this:

- (1) one reference atmospheric state usually given by model simulations, called Nature Run (here defined by the MOCAGE CTM);
- (2) an optimized observation simulator (here based on the KOPRA radiative transfer model and the KOPRAFIT inversion module) ;
- (3) an assimilation system (here a Local Ensemble Kalman Filter applied to the CHIMERE CTM).

We conduct OSSEs for one of the possible configuration of IASI-NG (IASI-NG/IRS2), proposed to fly within the EPS-SG EUMETSAT program. The objective is to assess the capability of this new instrument to improve tropospheric ozone monitoring, especially over Europe. Indeed, the spectral resolution and the radiometric noise of IASI-NG/IRS2 are planned to be twice better than for IASI. In this poster, we present first analyses of a relative OSSE, by comparing IASI and IASI-NG/IRS2 instruments. The first step is the comparison between MOCAGE Nature Run and IASI, IASI-NG/IRS2 pseudo-observations. Here we compared the results of this OSSE. These comparisons are performed for the 19<sup>th</sup> of August 2009 because a pollution episode occurs this day. The aim of the comparisons is to present the performances of IASI and IASI-NG /IRS2 TIR nadir satellite instruments and to demonstrate the improvement of the new instrument and the feasibility of the OSSEs.

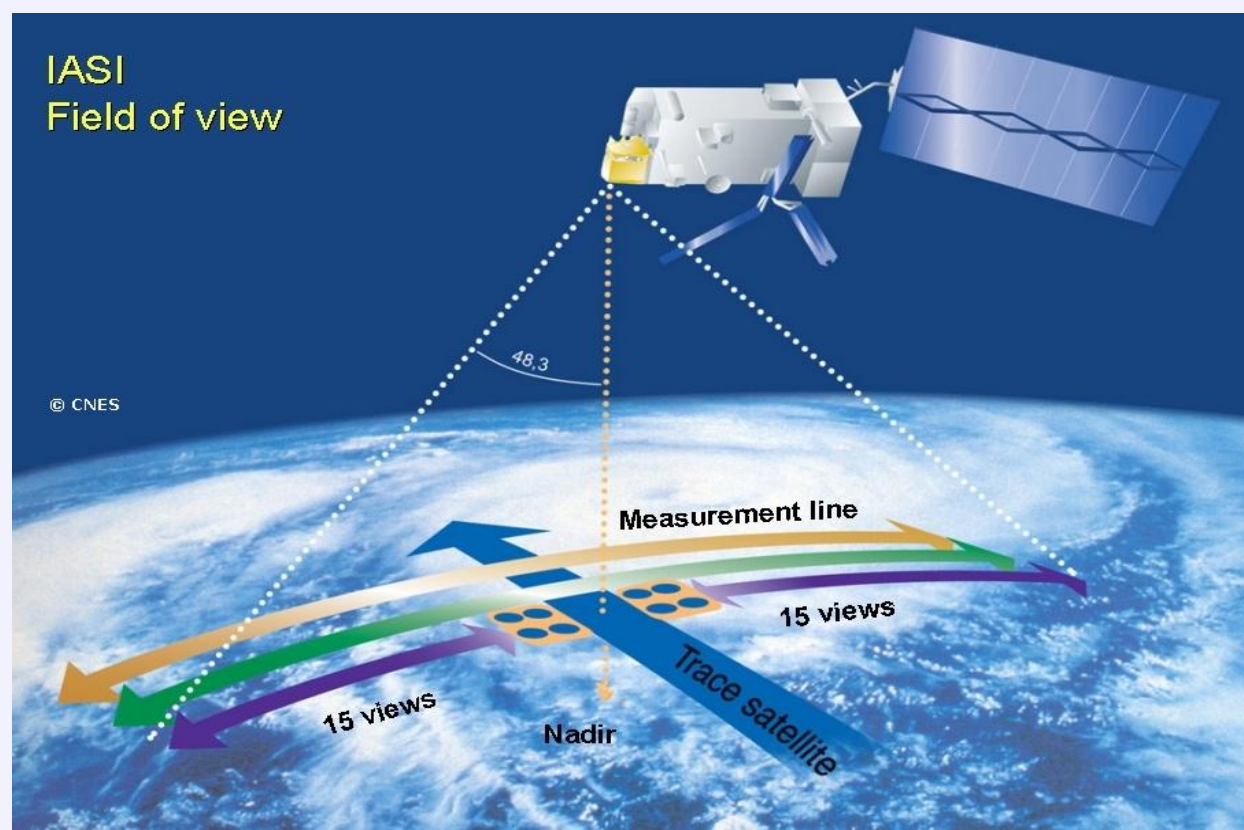
## 2. IASI, IASI-NG : Present and future

### Present instrument, IASI:

- FTIR
- Spectral resolution of 0.25 cm<sup>-1</sup>
- NESR=20 nW/cm<sup>2</sup>.sr.cm<sup>-1</sup>

### Future instrument, IASI-NG/IRS2:

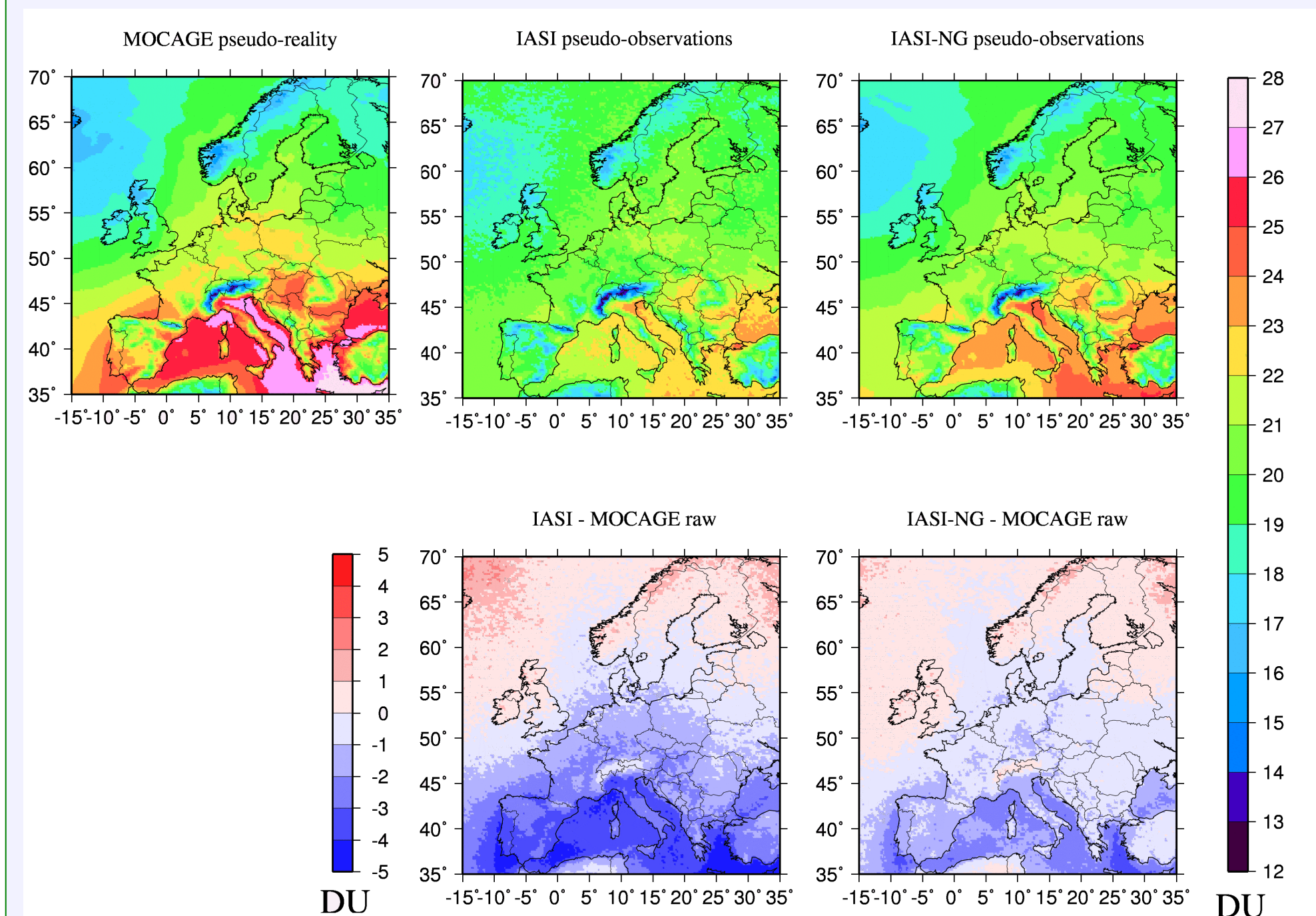
- FTIR
- Spectral resolution of 0.125 cm<sup>-1</sup>
- NESR=10nW/cm<sup>2</sup>.sr.cm<sup>-1</sup>



**The spectral and radiometric characteristics of the IASI-NG/IRS2 are twice better than IASI.**

## 4. Nature Run vs. Pseudo-observations: the performances of the instruments<sup>[2]</sup>

### Cartography of mean TOC 0-6km for August 2009:



Underestimation of both instruments for southern Europe  
IASI: ~10%  
IASI-NG/IRS2: ~ 4.5%

Overestimation of both instruments for northern Europe  
Same magnitude between IASI and IASI-NG/IRS2 ~2%

RMSE for entire Europe  
IASI: ~13.5%  
IASI-NG/IRS2: ~9.7%

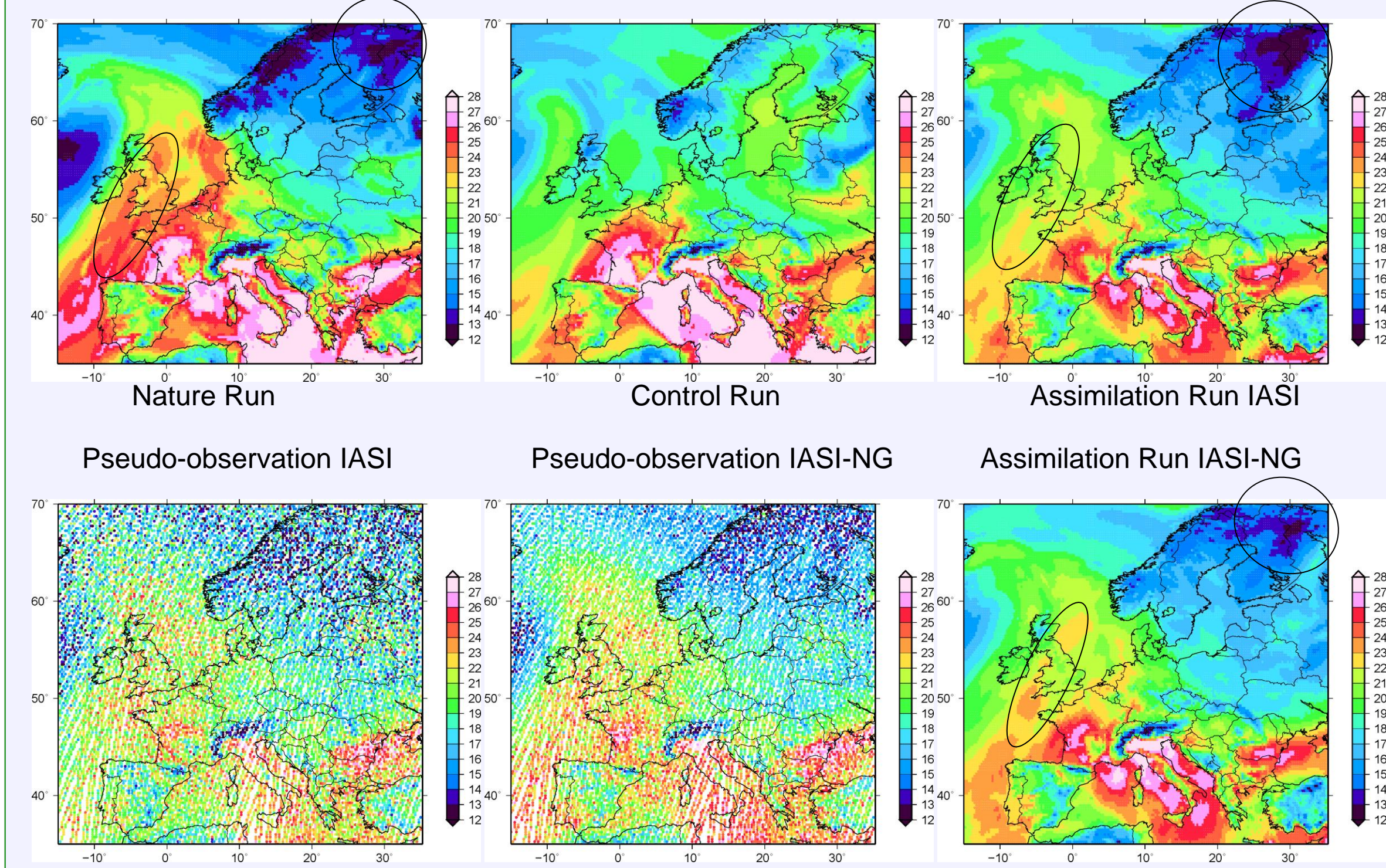
Bias for entire Europe  
IASI: ~- 4.66%  
IASI-NG/IRS2: ~ -1.77%

**Better representation of ozone distribution in the lower troposphere with IASI-NG/IRS2.**

## 5. Preliminary results of the OSSE for August 19<sup>th</sup>, 2009:

### Improvement of ozone structures:

#### Surface – 6 km partial columns of ozone



Differences in the ozone patterns are observed between NR and CR, mainly due to differences in the dynamical structures of the models. **The PO are already sufficient** to better represent these structures using data assimilation. **The PONG slightly improve** the comparison ARs vs. NR.

- Nature Run (NR): Pseudo-reality

- Pseudo-observation IASI and IASI-NG type (PO and PONG): simulated observations of IASI and IASI-NG/IRS2 instruments

- Control Run: reference CTM

- Assimilation Runs (DA and Dang): the CTM (CR) after assimilation of the pseudo-observations

## 3. Description of an OSSE

### • MOCAGE CTM : Nature Run

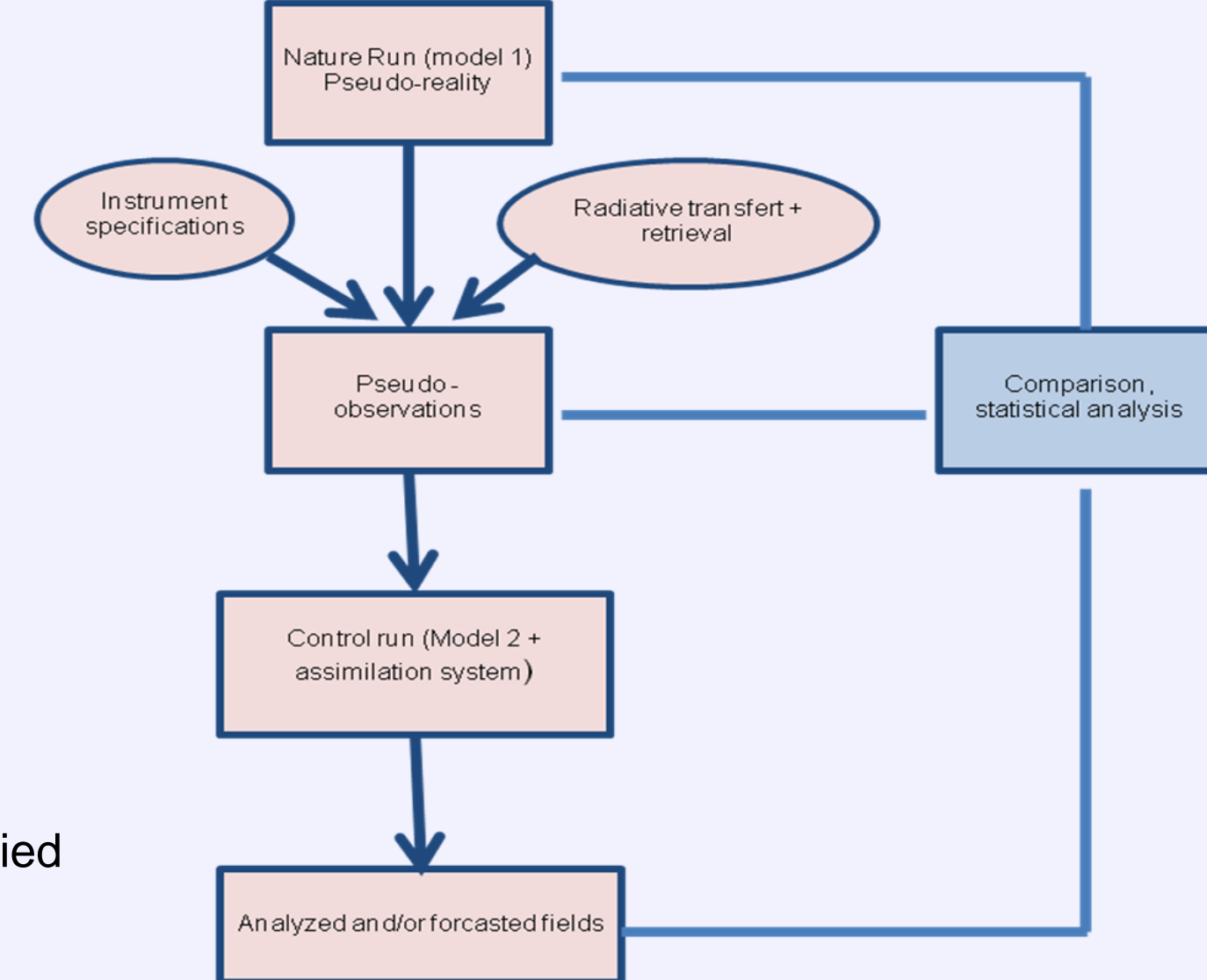
- global model, nested to Europe
- Surface-35km
- Meteo: ARPEGE

### • CHIMERE CTM : Control Run

- regional model
- Surface-12km
- Meteo: ECMWF
- Chemical forcing: MOZART

- KOPRA-KOPRAFIT<sup>[1]</sup>: radiative transfer and ozone retrieval

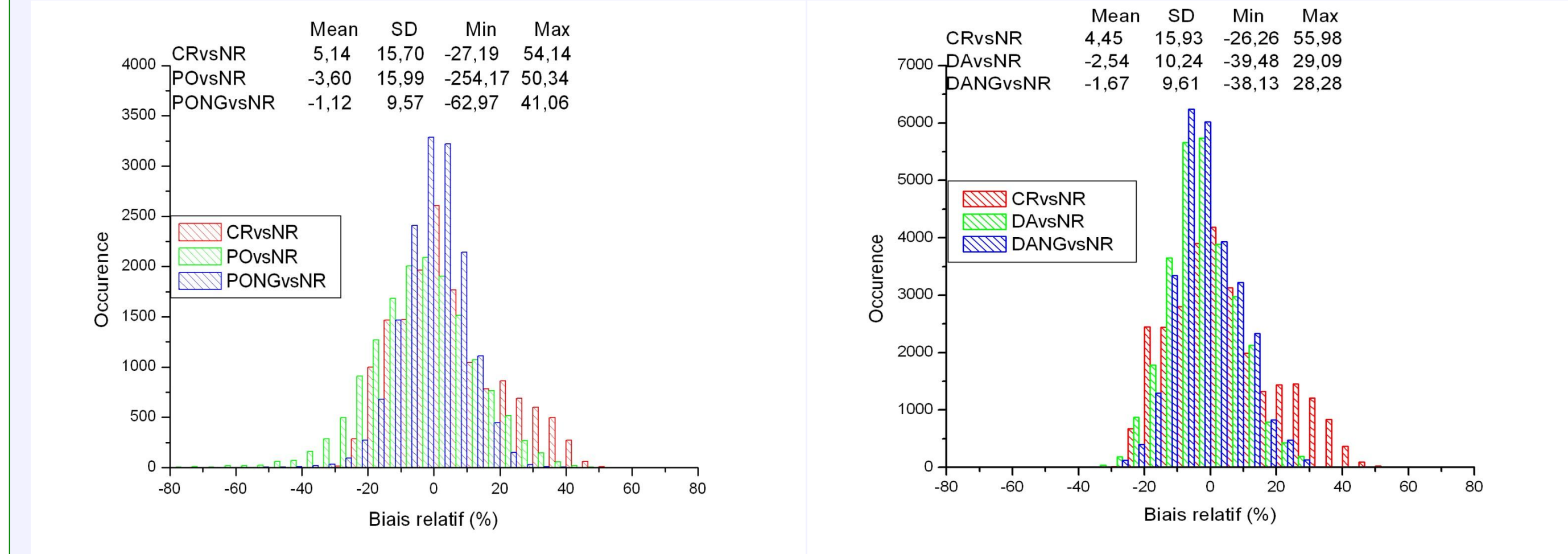
- Assimilation System<sup>[3]</sup>: Local Ensemble Kalman Filter applied to the CHIMERE CTM.



We compare Nature Run, Control Run, Assimilation Run and pseudo-observation.

## 6. Statistical Results:

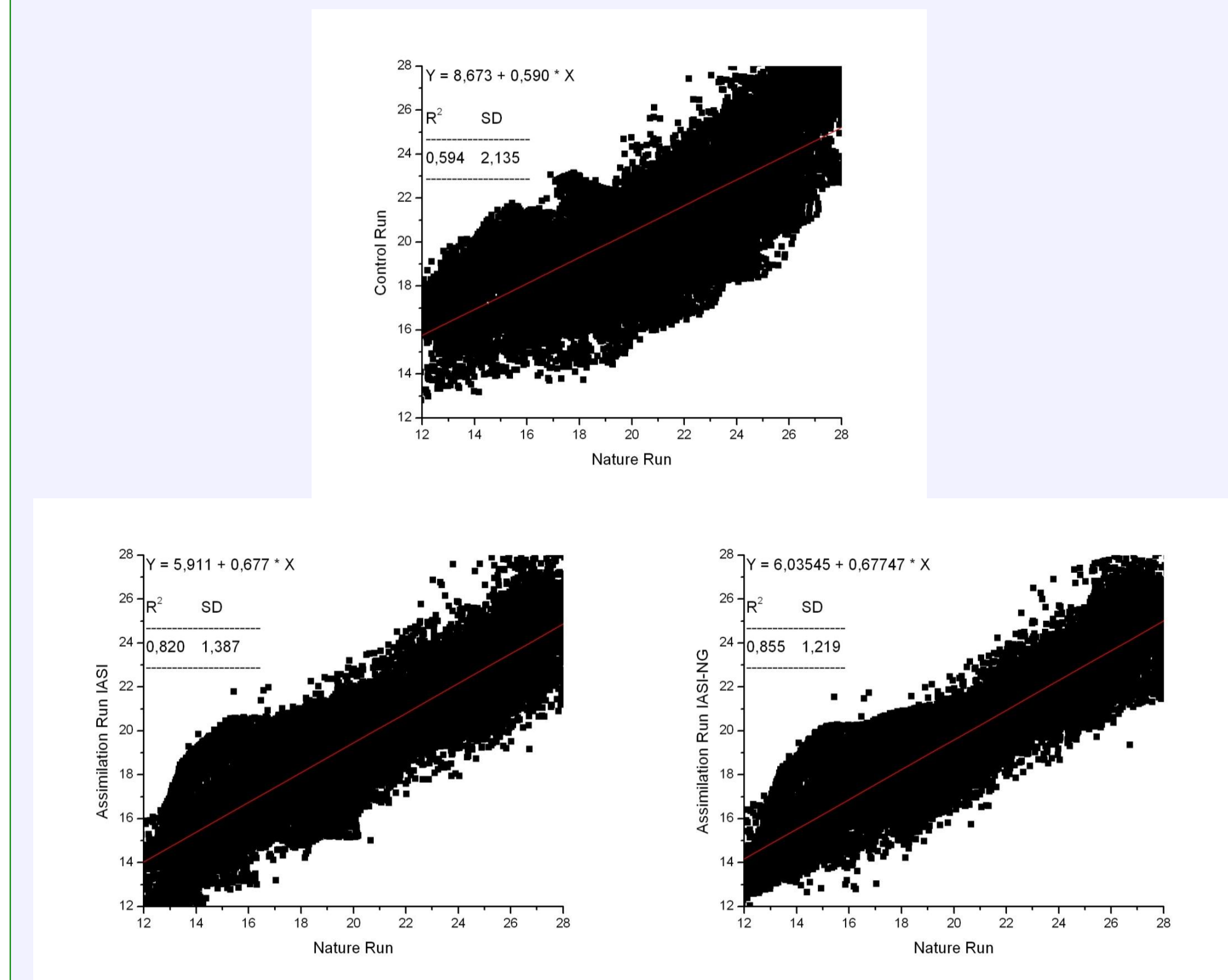
### Bias reduction:



The CR is positively biased on average compared to the NR (~+5%). The PO and PONG are negatively biased on average compared to the NR, PONG being closer to NR than PO. This is in agreement with the global analysis over August 2009 (section 4 and Sellitto *et al*)  
The score of the model after the assimilation of PO and PONG are improved: **the RMSE are significantly improved. The bias is also reduced but becomes negative.**

### Improvement of correlation and dispersion:

#### Scatter plots of the CR and the ARs with the NR.



The correlation coefficients between NR and ARs are improved compared to those between NR and CR:  
• ~+38% for IASI  
• ~+44% for IASI-NG/IRS2.

The dispersion of the scatter plots is also improved when pseudo-observations are assimilated. This is visible in the RMSE (SD) of the linear regression :  
• ~ +54% for IASI  
• ~ +75% for IASI-NG/IRS2.

The improvement of the correlation and dispersion reflects that the assimilation of the pseudo-observations IASI and IASI-NG allows the model to better represent the ozone patterns given in the pseudo-reality. **The PO IASI-NG improved the correlation and the dispersion compared to IASI of ~+4% and ~+14% respectively.**

## 7. Conclusion and Future work:

Preliminary results on one day (08/19/2009) show that the assimilation of the pseudo-observation IASI and IASI-NG improved the representation of the large O3 patterns, mainly representative of dynamical processes. The assimilation of PONG allows a larger reduction of the bias and the RMSE and a better improvement of the correlation between the NR and the CR than the PO. For a robust quantification of the gain of IASI-NG compared to IASI for the analysis and the forecast of ozone, the OSSE has to be analyzed on a longer period (one month) and to be better calibrated especially against real IASI observations.

## REFERENCES

- [1] Eremenko M., Dufour G., Foret G., Keim C., Orphal J., Beekmann M., Bergametti G., and Flaud J.-M.: Tropospheric ozone distributions over Europe during the heat wave in July 2007 observed from infrared nadir spectra recorded by IASI; Geophysical Research Letters, 35, L18 805; doi:10.1029/2008GL034803, 2008.
- [2] Sellitto P., Dufour G., Eremenko M., Cuesta J., Dauphin P., Forêt G., Gaubert B., Beekmann M., Peuch V.-H. and Flaud J.-M. : Potential of future thermal infrared space-borne sensor IASI-NG to monitor lower tropospheric ozone; Atmos. Meas. Tech. Discuss., 5, 7025-7065, 2012, doi:10.5194/amtd-5-7025-2012
- [3] Coman A., Foret G., Beekmann M., Eremenko M., Dufour G., Gaubert B., Ung A., Schmechtig C., Flaud J.-M., and Bergametti G.: Assimilation of IASI partial tropospheric columns with an Ensemble Kalman Filter over Europe ; Atmos. Chem. Phys., 12, 2513–2532, 2012, doi:10.5194/acp-12-2513-2012