Data assimilation of gas measurements in TCAM model simulations over Northern Italy

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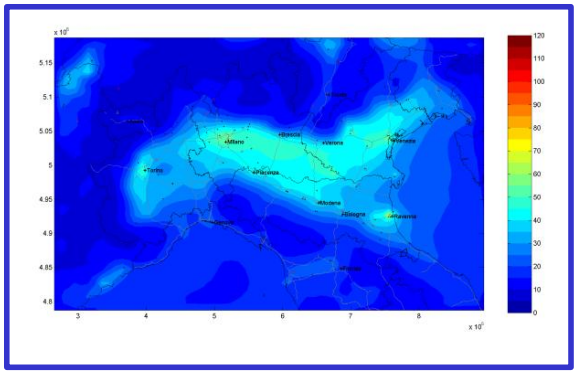
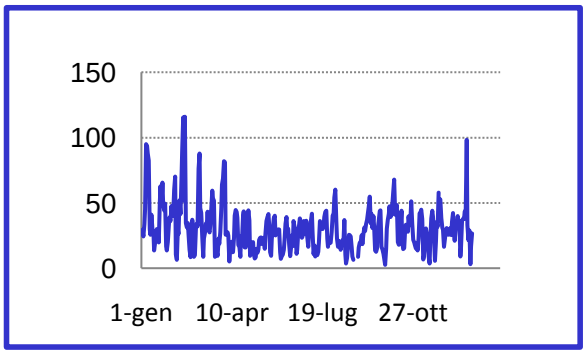
TFMM Meeting 13-14/05, Larnaca

Outline

Data assimilation

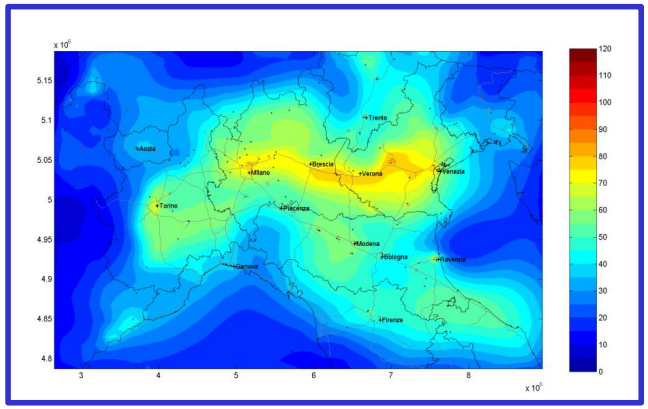
INPUT



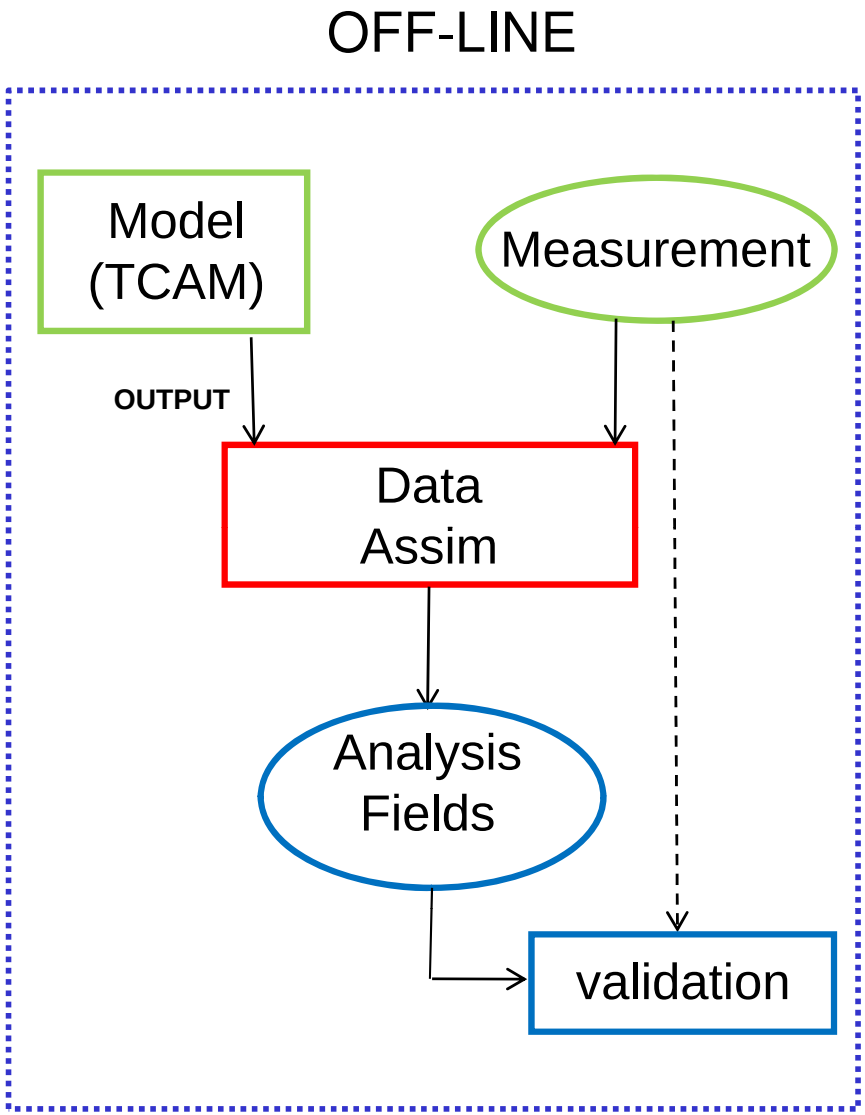


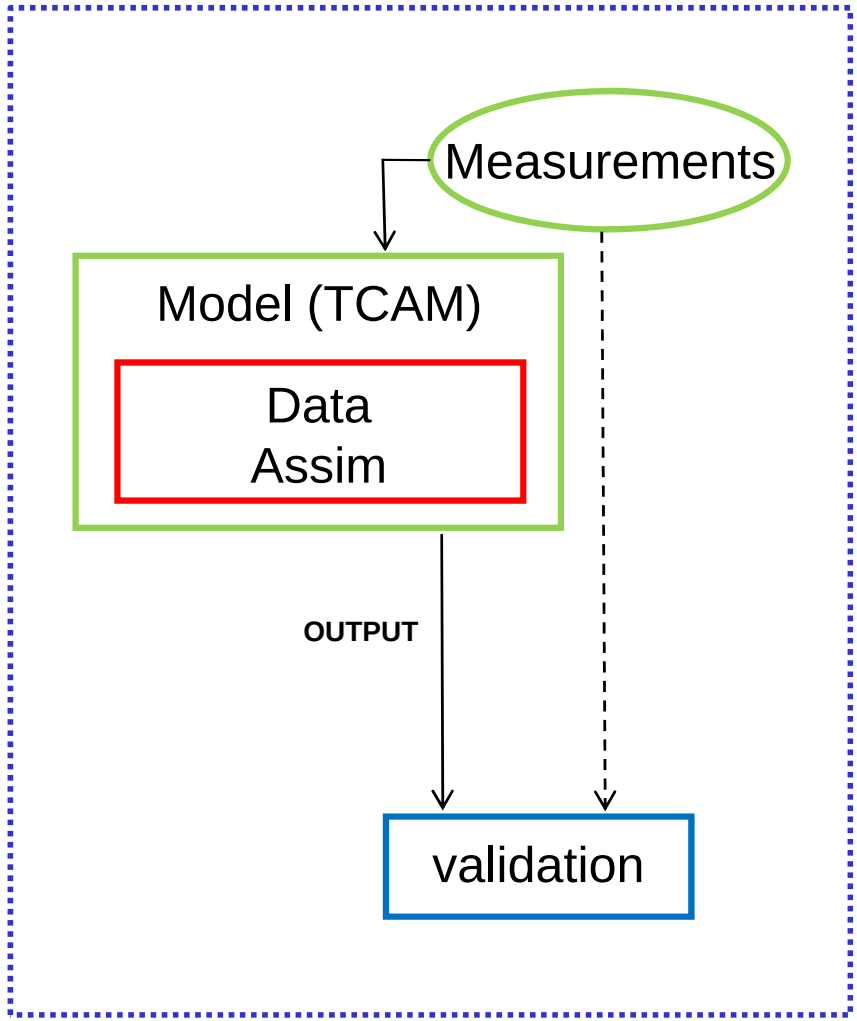
Data Assimilation

OUTPUT



On line VS Off line





Data Assimilation Techniques

- Residual Inverse Distance Weighting;
- Residual Co-Kriging;
- Optimal Interpolation;
- Ensemble Kalman Filter;
- 4D var.

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Optimal Interpolation

Foundamental equations

$$x_a = x_b + K(y - Hx_b)$$

$$K = BH^T(HBH^T + R)^{-1}$$

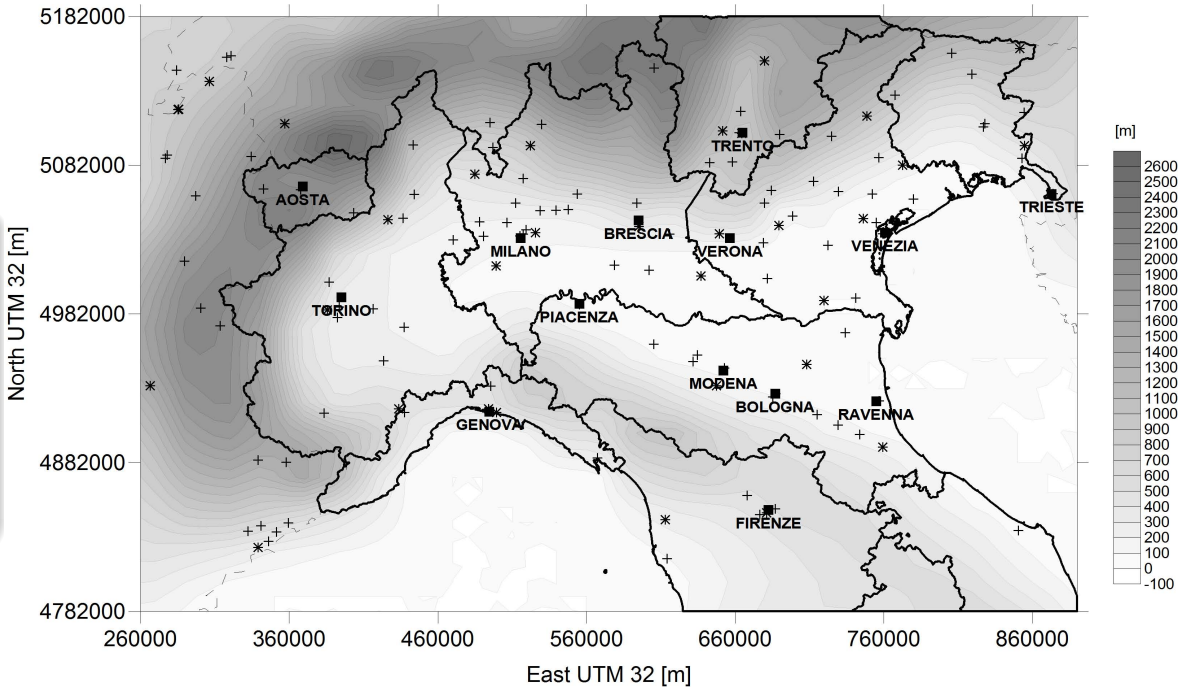
x_a: analysed field
x_b: background field
y: measurements (ground/lidar/satellites)
H: output operator
K: OI gain

B: background error covariance matrix
R: measurement error covariance matrix

Test case setup

Domain Info

- Dimension: $640x430km^2$;
- Horiz. Resolution: $10km$;
- Ground station OI: $+$;
- Ground station validation: $*$;



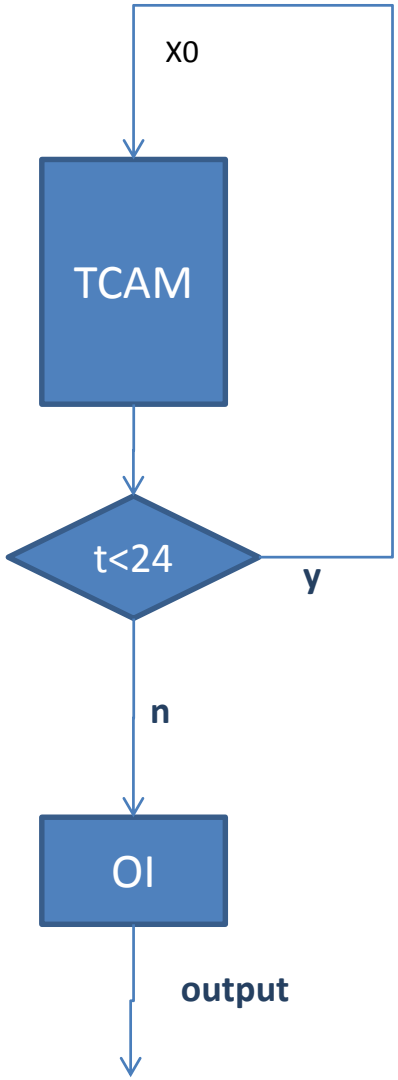
TCAM model

- 3D Eulerian Model;
- Horizontal Transport: Chapeau function + Forester filter;
- Vertical Transport: Crank-Nicholson;
- Dry deposition: resistance-based approac;
- Wet deposition: scavenging approac;
- Gas chemical mechanism: SAPRC97 (modified);
- Kinetic Gas solver: LSODE.

Test case 1: Off line DA

Test features

- Period: 2004/01/01-2004/12/31
- DA measurements: ground O3 max8h;
- DA output: O3 max8h;
- Assimilation interval: Day.



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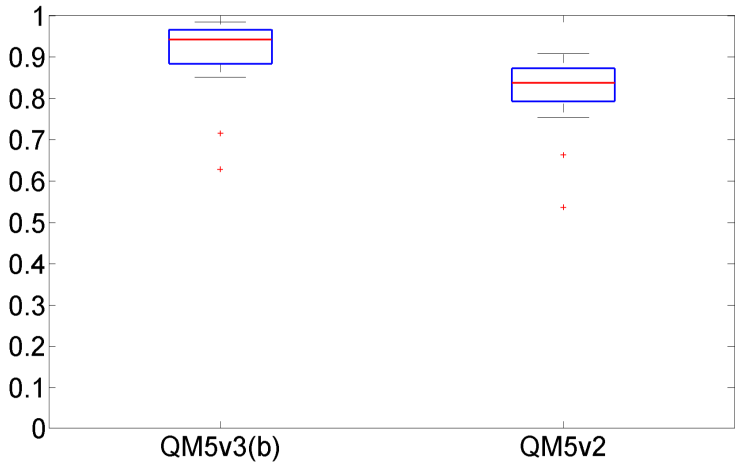
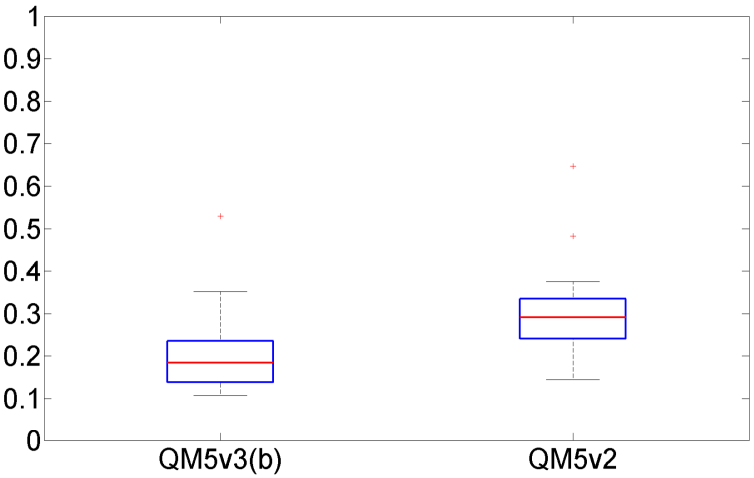
Correlation (Max8h)



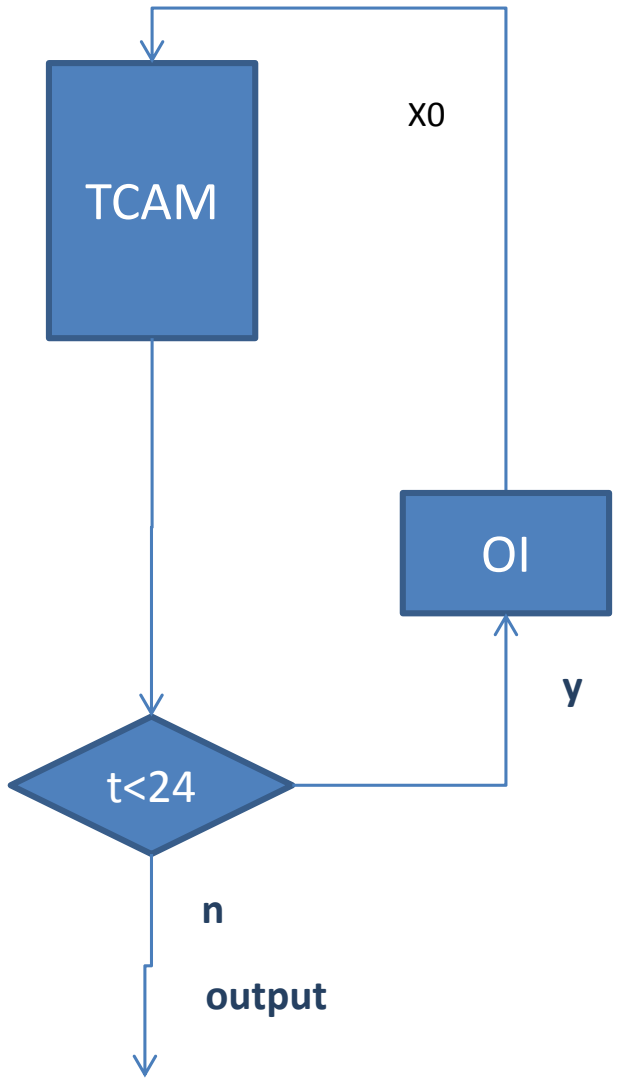
NMAE (Max8h)



Test case 2: On line DA

Test features

- Period: 2004/07/15-2004/07/31
- DA measurements: ground O3;
- DA output: O3 hourly mean;
- Assimilation interval: Hour;



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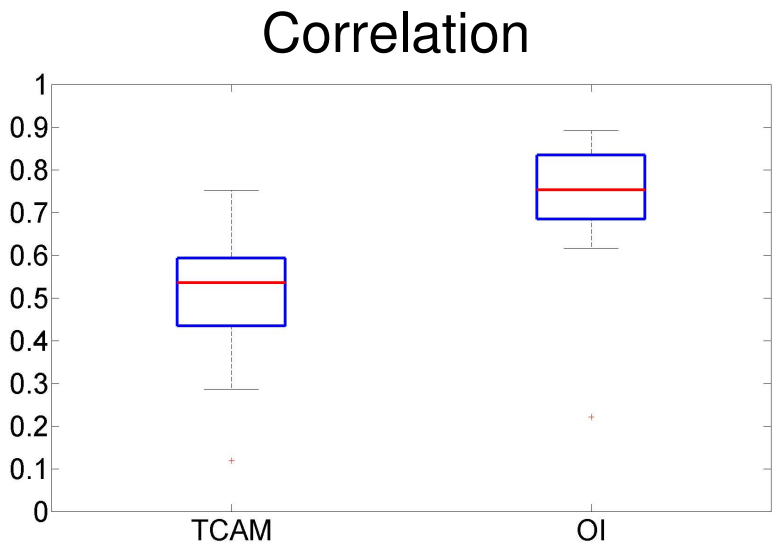

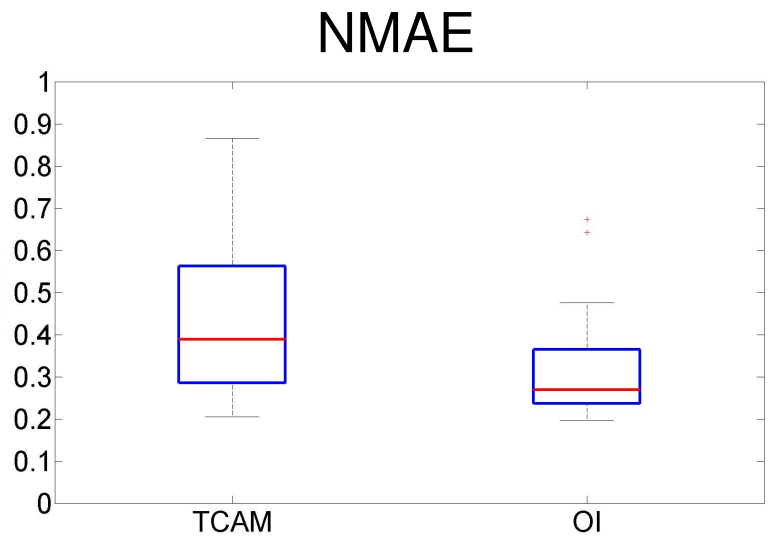

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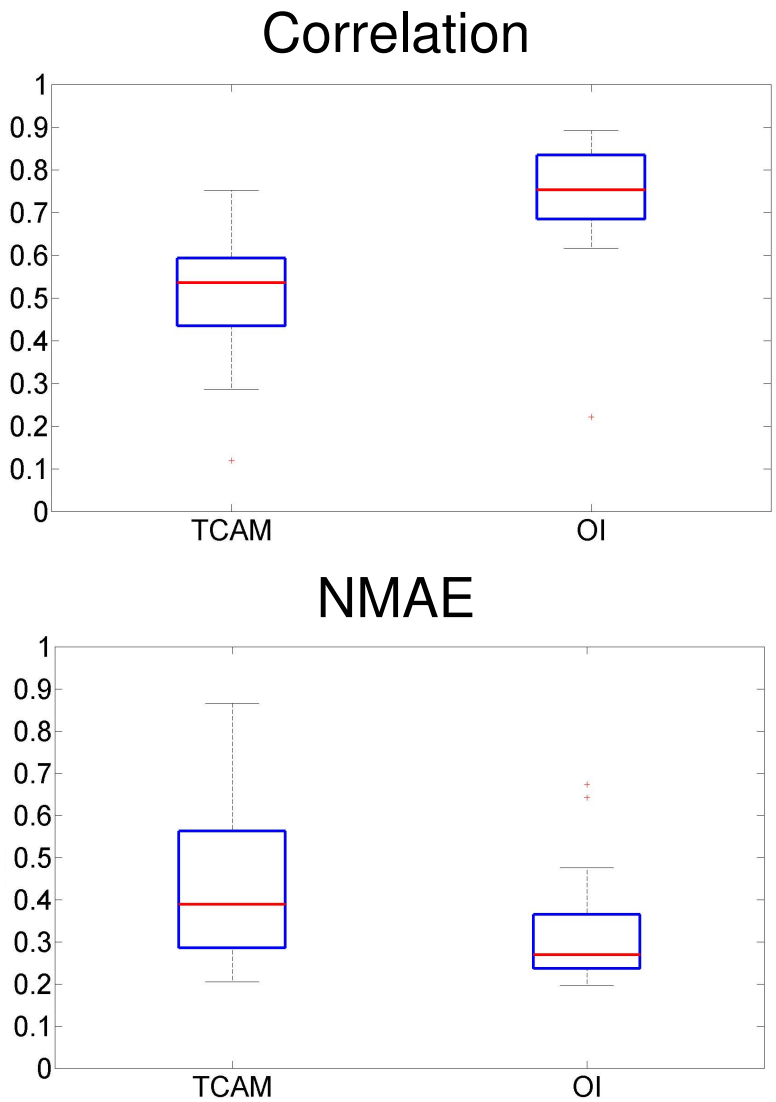
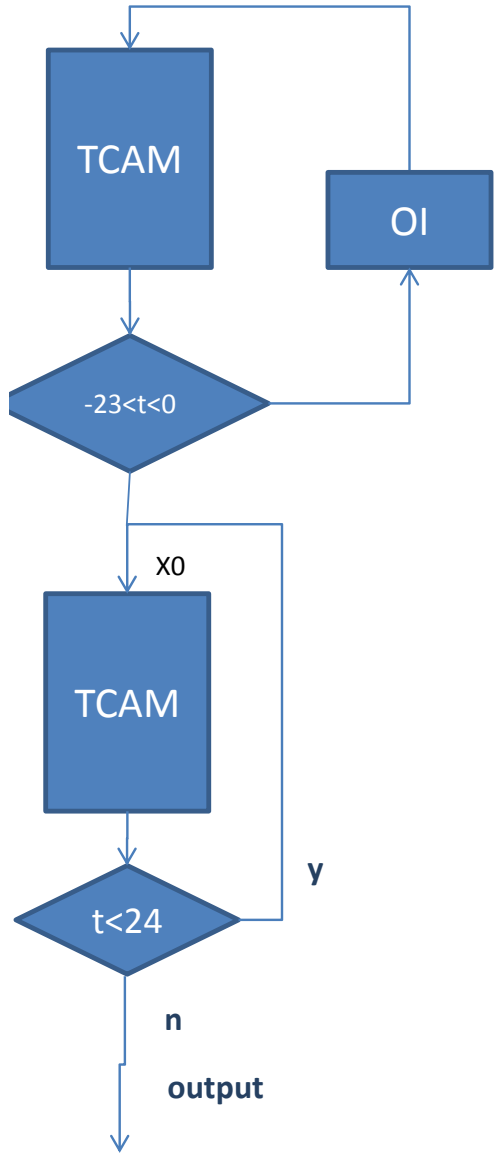
unrealistic



Test case 3: Realistic On line DA

Test features

- Period: 2004/07/15-2004/07/31
- DA variable: O3 hourly mean;
- DA measurements: ground O3;
- DA output: O3 hourly mean;
- Assimilation interval: 24-hour day $d - 1$.



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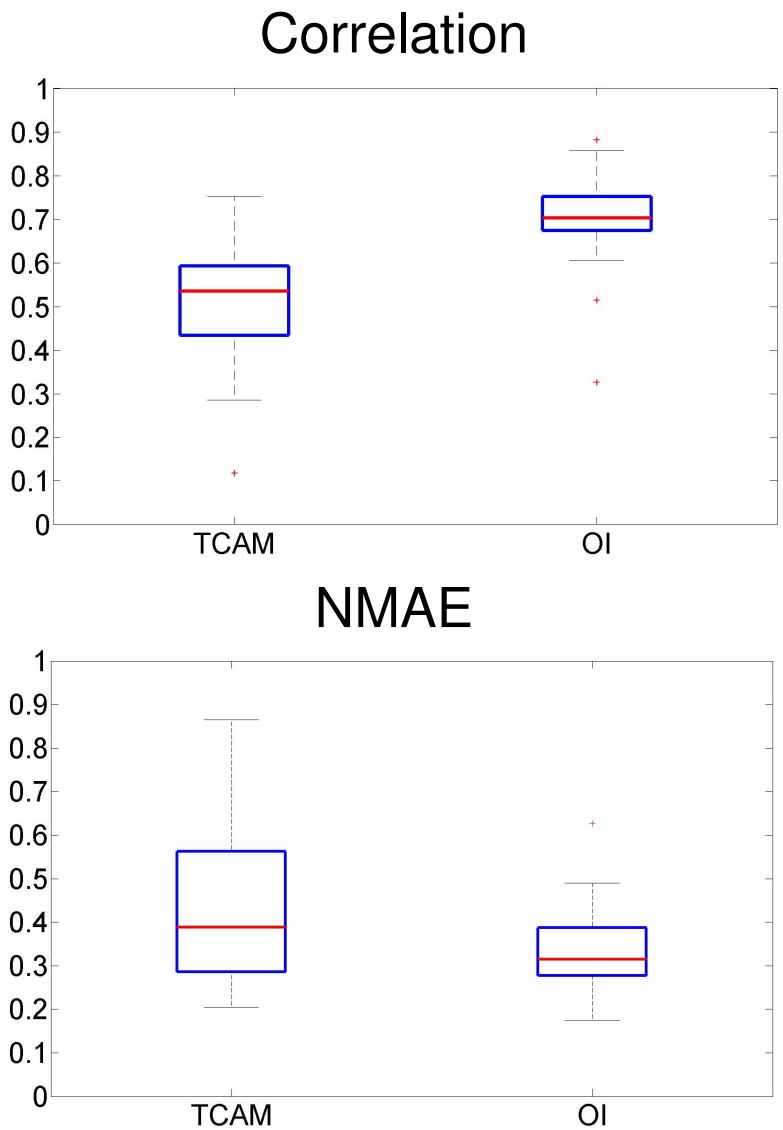

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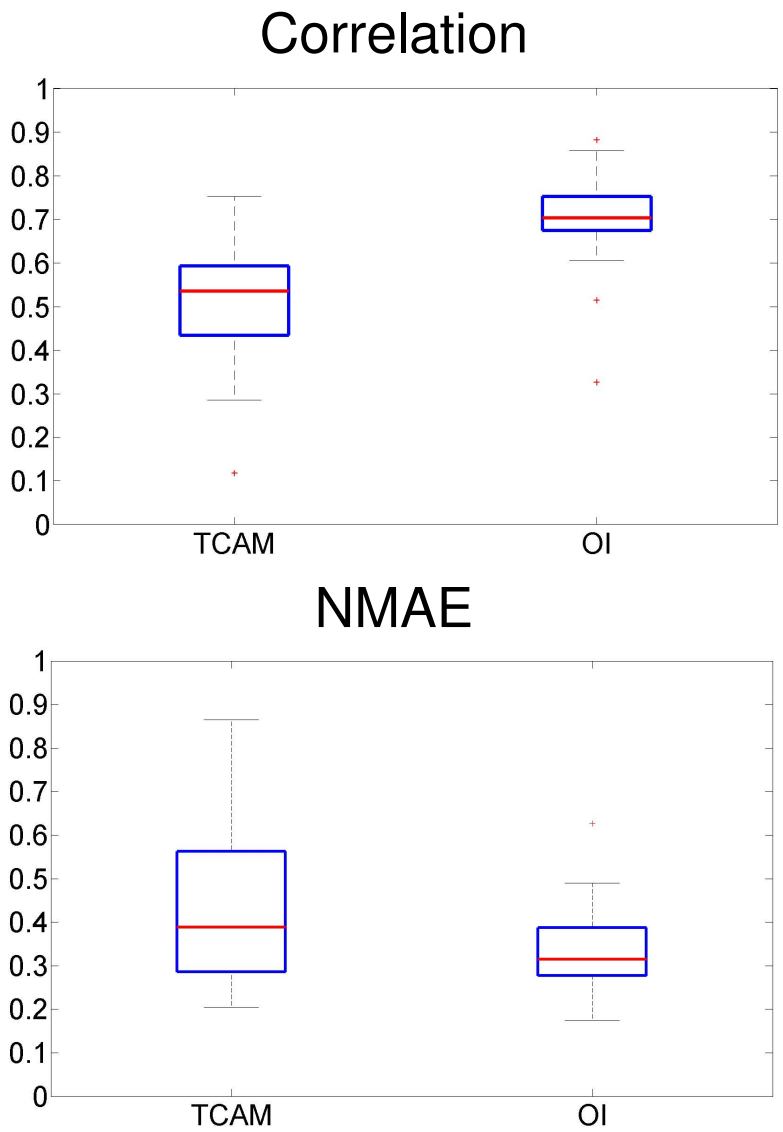
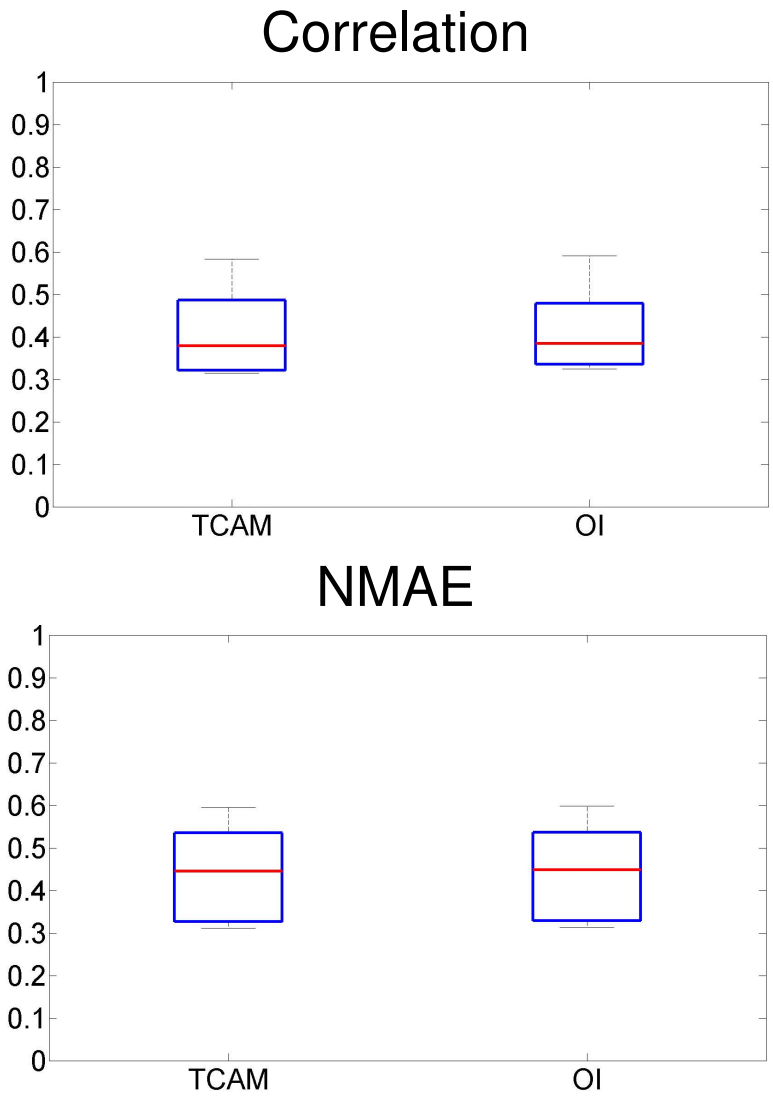
more realistic



Test case 4: On line DA of Sat. Data

Test features

- Period: 2007/05/15-2005/07/31
- DA variable: NO2 hourly mean;
- DA measurements: OMI NO2;
- DA output: O3 hourly mean;
- Assimilation interval: ...;



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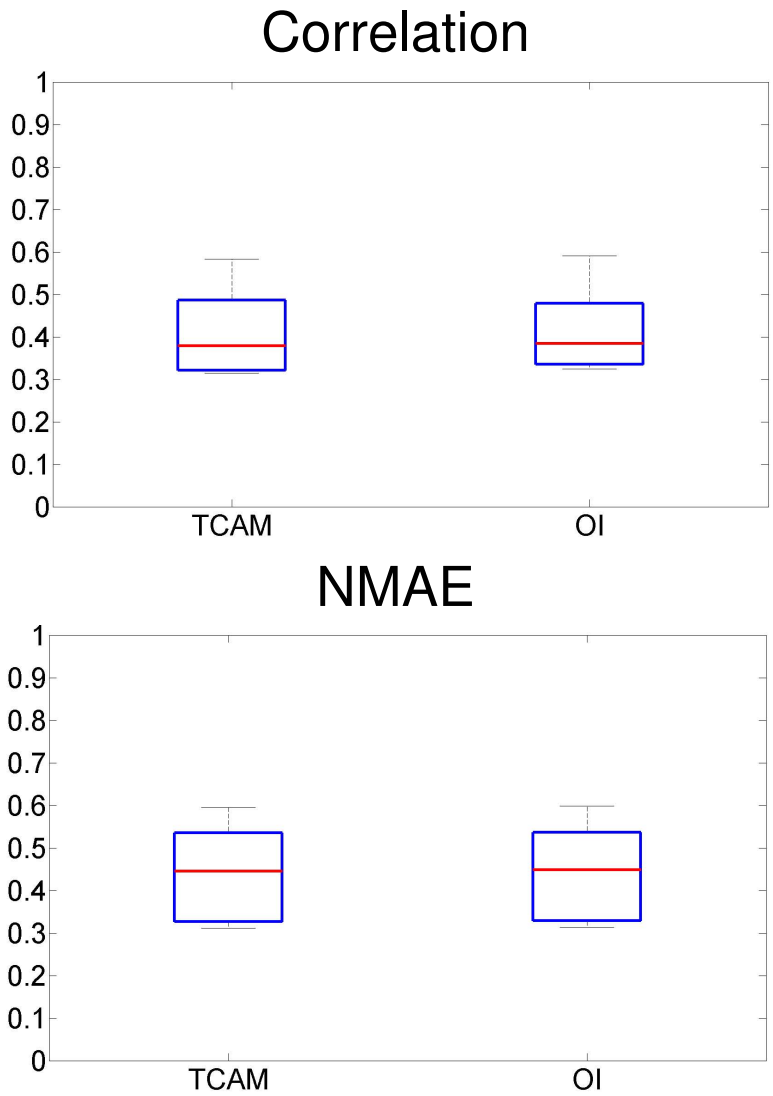
Too spot data!!!

... up to now...



Conclusions (?)

Off line DA

- Very high impact (expected);
- Increasing of performance even if the model performance are already good.

On line DA

- ground measurements: relatively high impact;
- satellite measurements: difficult to evaluate (too few spot data!)... Larger dataset of measurements/model results needed.

Future works

Dream(?)

Merge Online & Offline DA techniques for better forecast
(Very) difficult, but...

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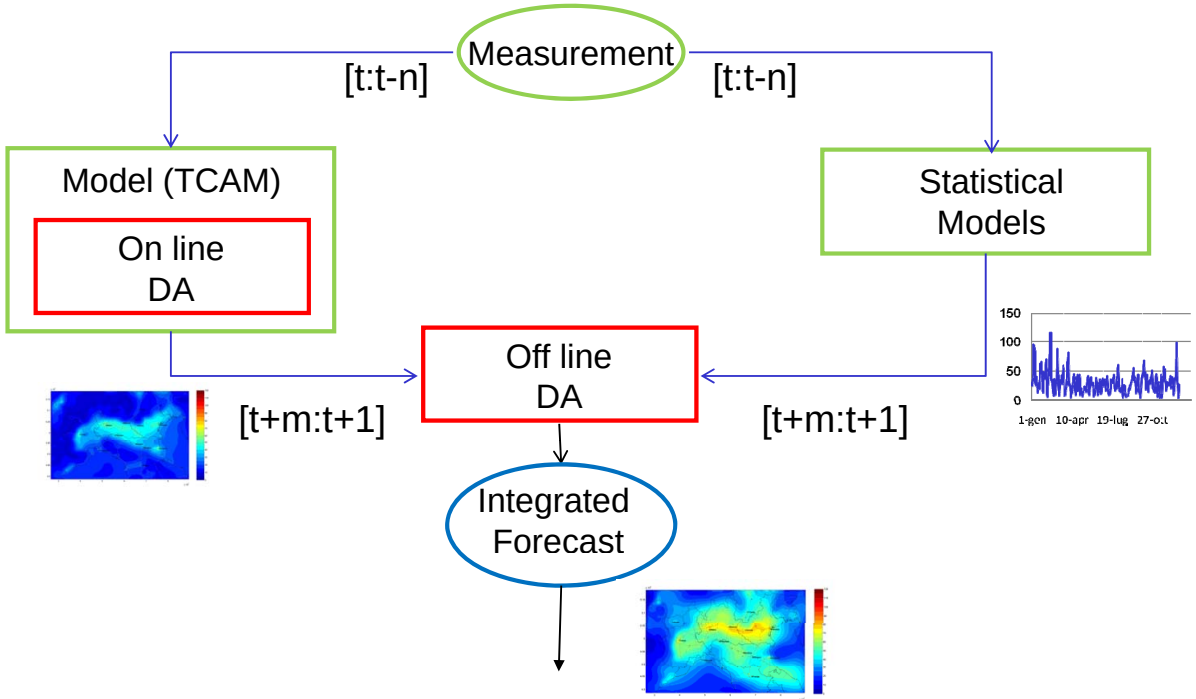

TO BE CONTINUED...

Optimal Interpolation

$$x_a = x_b + K(y - Hx_b)$$

HP:

- $B = [b_{i,j}] = \exp(-\frac{d_{i,j}^2}{2L_h^2})v = D(i,j)v$
- $R = rI$

$$\begin{aligned} K &= D(i,j)vH^T(v(HD(i,j)H^T + \frac{r}{v}I))^{-1} \\ &= D(i,j)H^T(HD(i,j)H^T + \sigma I)^{-1} \end{aligned}$$

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