9th International Conference on Harmonisation within Atmospheric Dispersion Modelling for Regulatory Purposes

SENSITIVITY OF CTM SIMULATIONS TO METEOROLOGICAL INPUT

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The sensitivity study

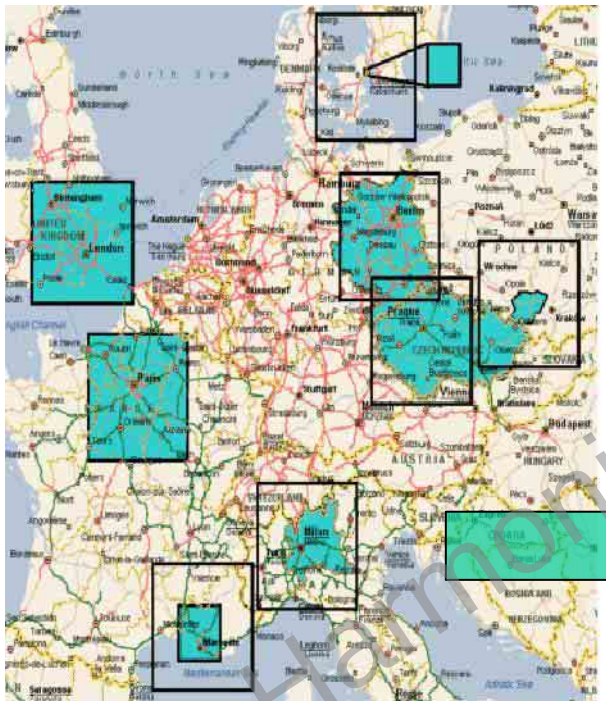
Objectives:

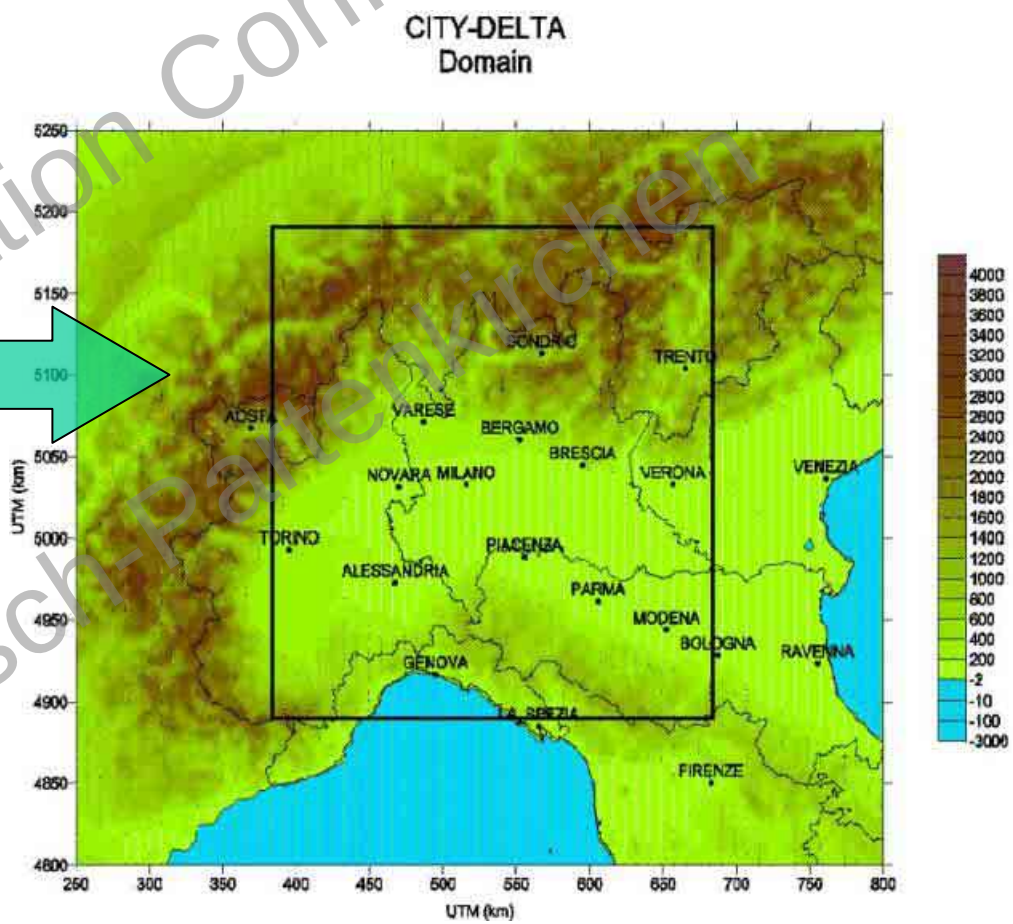
- Tuning the meteorological input for the long-term City-delta II simulations (Milan area, 5km resolution, O3 + PM10, 1 year of integration)
- Test model sensitivity to the formulation of wind field

Metodology:

- Calmet pre-processor was used to produce 3 sets of meteorological data
- A "representative" 14 days test period was selected (including different synoptic conditions and the main ozone episode).
First 3 days excluded from analysis, to let the model forget I.C.
- A Chemical Transport Model (CAMx) was run on the test period with the 3 different meteorologies, leaving all other input (emissions, BC) and setups unchanged

CityDelta Milan Domain





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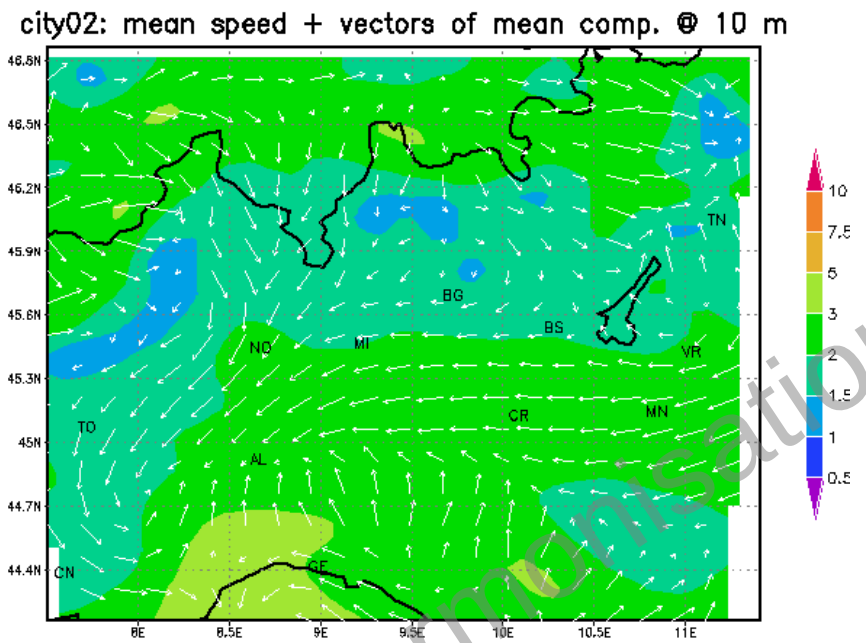
The meteorological datasets (formulation)

Calmet pre-processor

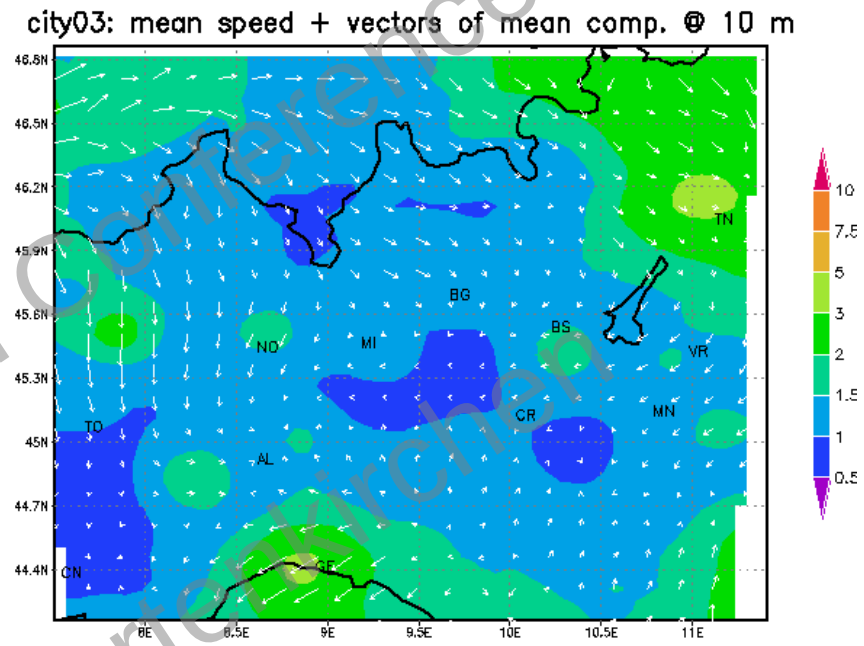
- Reconstructs 3D fields of wind and temperature, starting from a first guess and local observations
- Uses parametric schemes to estimate mixingh heigth and turbulence fields

	"Aladin" input	"ECMWF" input	"Base" input
Horizontal wind	Aladin wind field interpolated on CAMx grid	ECMWF as first guess + surf. observations + Temp	Aladin wind field + surface obs.
Vertical wind	Diagnosed from horizontal wind and orography		
Temperature	Surface observations + Temp		
Radiative forcing	Surface cloud cover observations (Synop)		
Turbulence, Kz	Calmet parameterisations		
Humidity, rain water	Aladin fields		

The meteorological datasets (analysis)



"Aladin" 10 m wind, 1 year average



"ECMWF" 10 m wind, 1 year average

"Aladin" wind is:

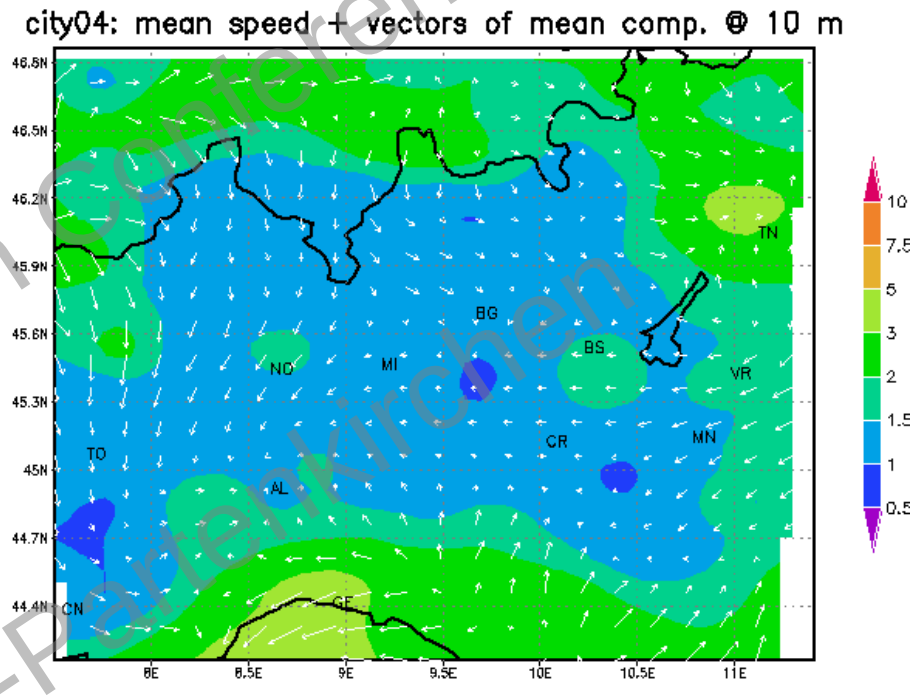
- stronger at all layers below 2000 m (difference is about 1-2 m/s, but in lowest levels this corresponds to 50%)
- more regular in time and space (advection should be more effective)
- more linked to orography (also in upper layers)

<u>Differences in E and SW boundaries !!</u>

The meteorological datasets (analysis)

“Base” wind:

- similar to “ECMWF” in lower levels in Po valley (dominated by observations)
- similar to “Aladin” elsewhere



“Base” 10 m wind, 1 year average

The meteorological datasets (validation)

Verification against 7 stations not used by Calmet; 6 months statistics

Wind speed (m/s)	Aladin	ECM	Base		Wind dir (degrees)	Aladin	ECM	Base
BIAS	+0.7	-0.2	0.0		**BIAS**	-2	+3	+1
RMSE	1.5	1.1	1.1		**RMSE**	79	71	67

- "Aladin" overestimates wind speed, "ECM" slightly underestimates it
- "Base" has slightly better scores

Summary:

- All dataset look "reasonable" and contain the main regional-scale structures (eastern flow in Po valley, southerly winds in Appenines, mountain breeze)
- "Aladin" wind is more regular and self-consistent
- "Base" and "ECMWF" surface winds are closer to observations

Model Description

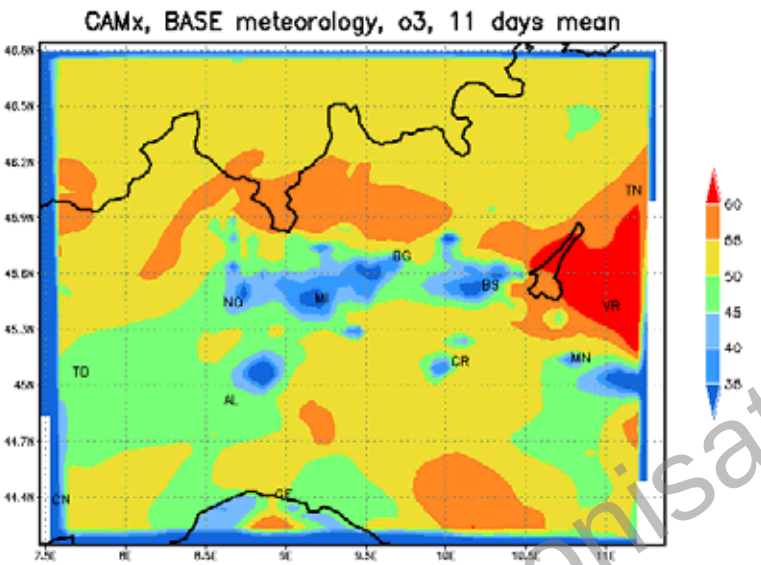
CAMx

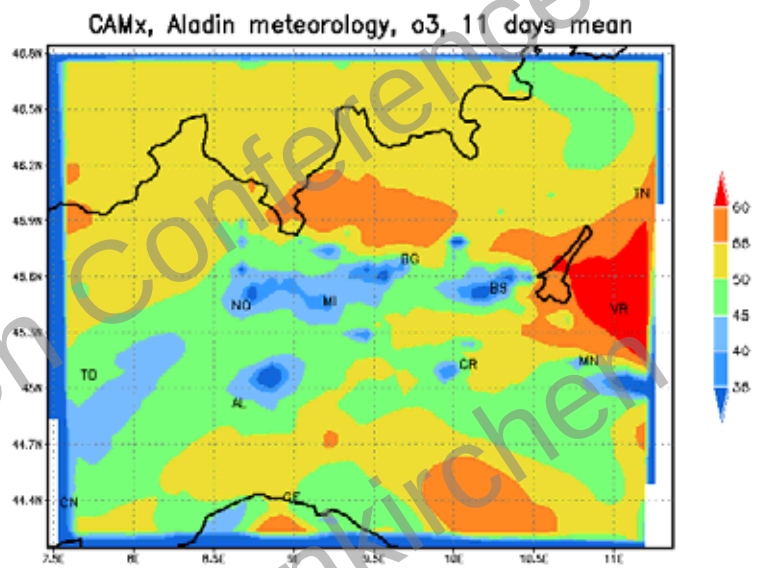
- Eulerian photochemical transport and dispersion model, with aerosol module
- Modules for horizontal and vertical advection/diffusion (Bott Scheme)
- Resistance Based Dry Deposition
- Wet Deposition
- Photolysis rates adjusted as a function of cloud cover, total ozone column and turbidity
- Chemistry
    - Mechanism: SAPRC99 and CBIV99
    - Solver: CMC and IEH

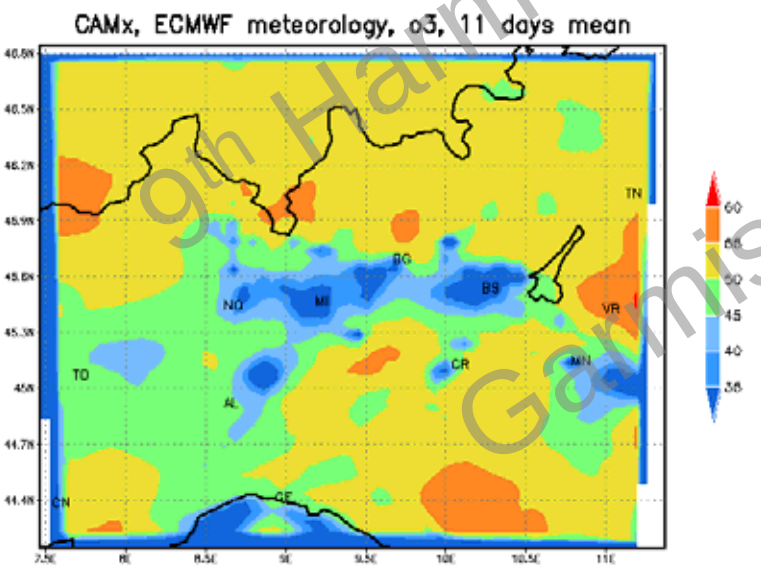
Configuration (CityDelta phase II)

- 11 vertical layers (up to 3,900 m a.g.l.)
- 300 x 300 km^2 model domain
- 5 km resolution
- O3 / NO2... + PM

Ozone: mean concentrations

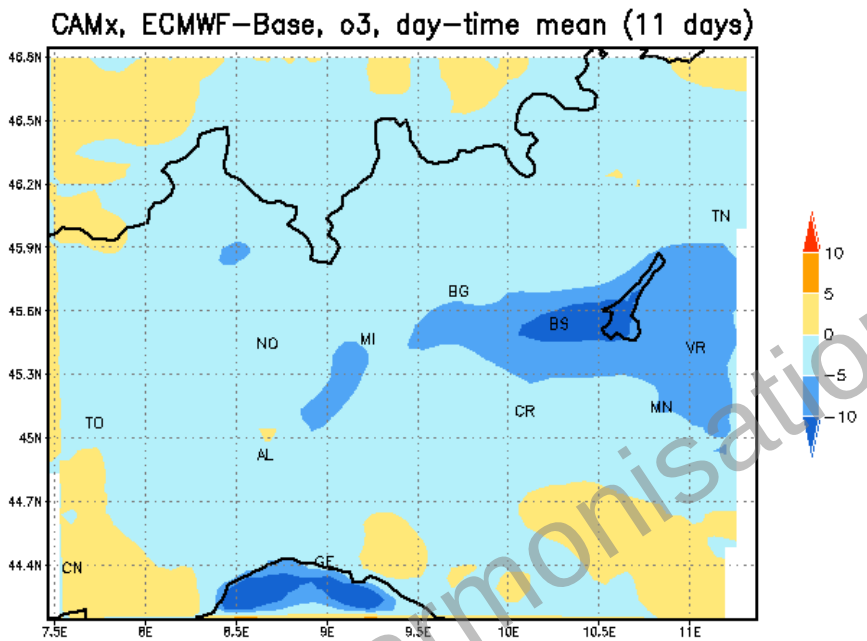




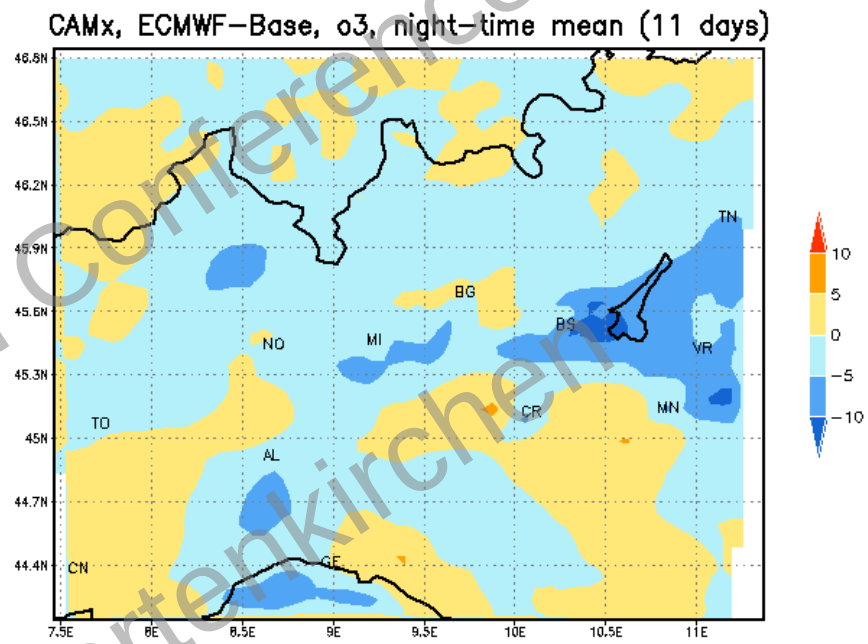


- Spatial distribution is rather similar
- "ECMWF" has lower values everywhere: on average, 5 ppb ≈ 10%)
- "Aladin" has higher values in Milan area
- Larger differences near boundaries E and SW (up to 25%); may be linked to inconsitenciy between Aladin and wind used to create BC

Ozone: ECMWF vs Base



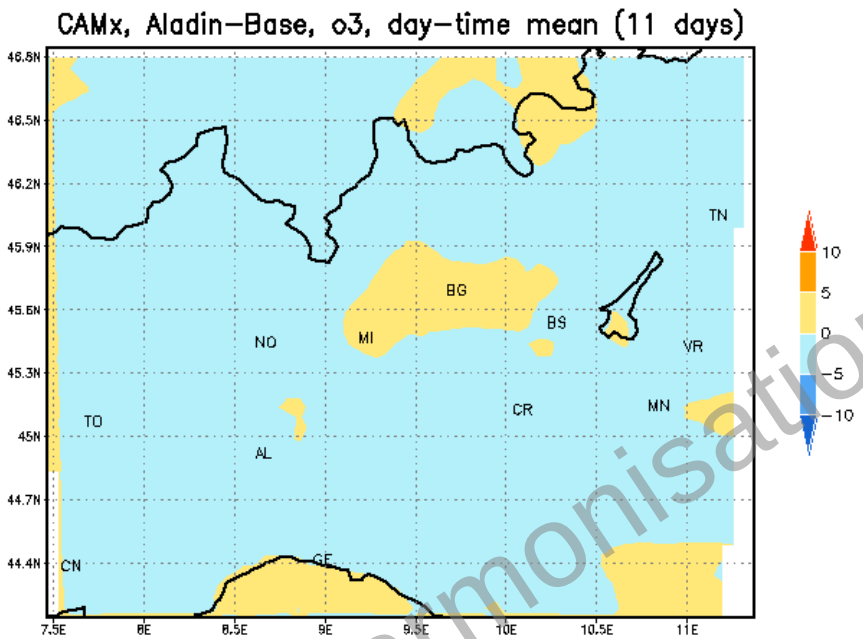
O3 difference: day (ppb)



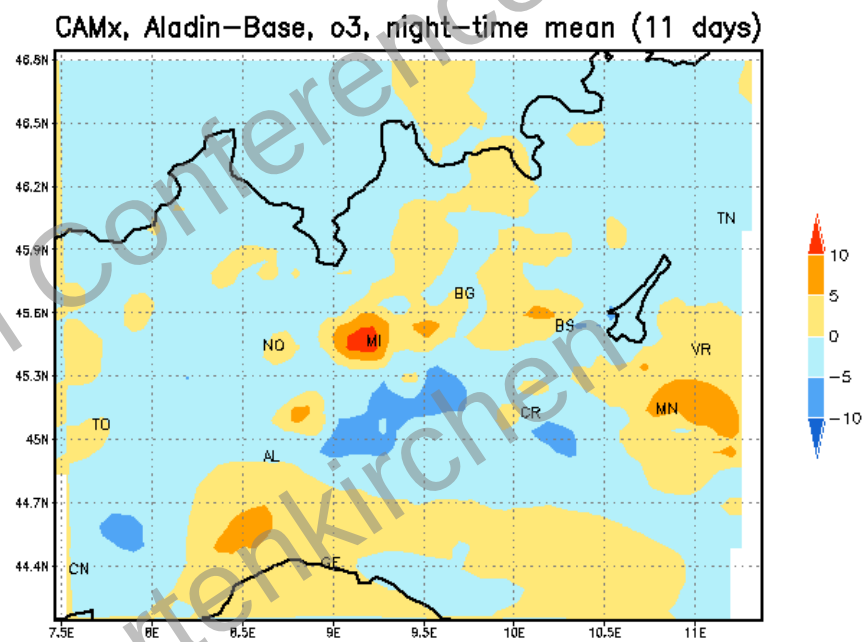
O3 difference: night (ppb)

- Lower Ozone in “ECMWF” (with respect to “Base”) is mainly due to day-time maxima
- The difference near boundaries exists on both day and night

Ozone: Aladin vs Base



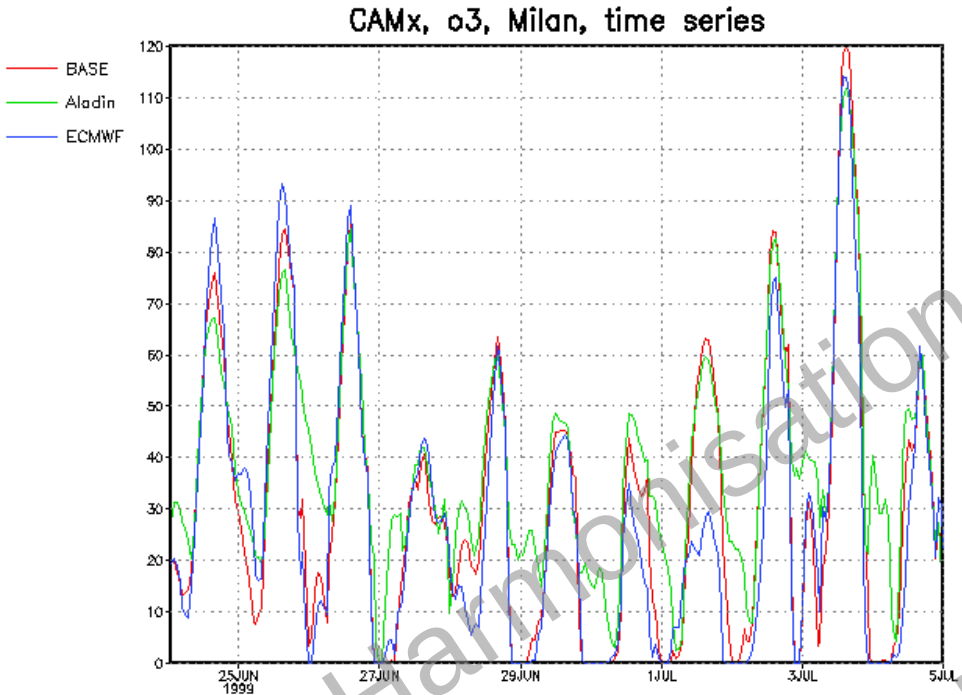
O3 difference: day (ppb)

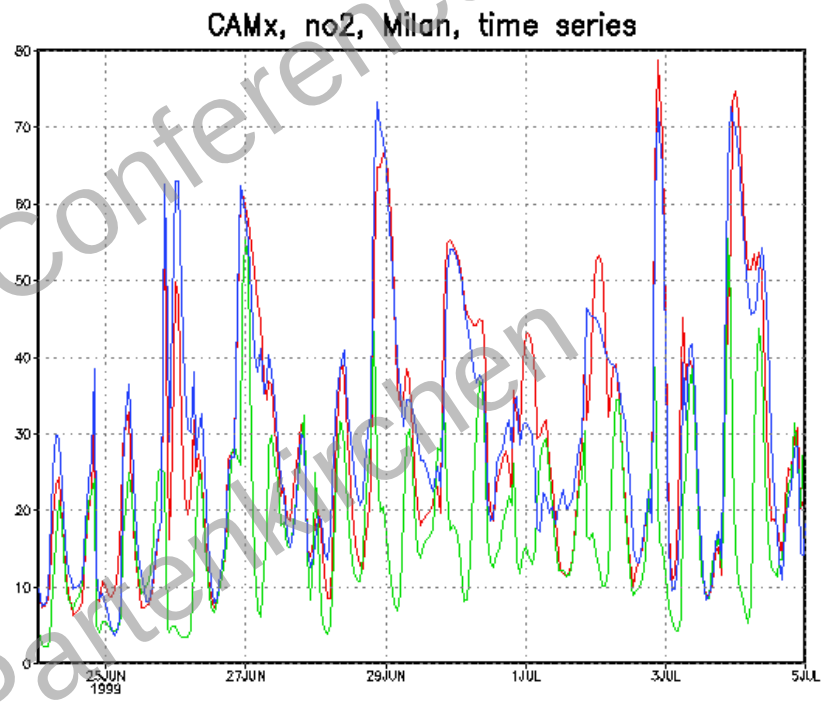


O3 difference: night (ppb)

- During day hours “Aladin” has slightly lower O3 values in rural areas
- Higher Ozone in “Aladin” in urban areas is mainly due to nigh-time values
- Since CAMx underestimate night-time urban Ozone, “Aladin” simulation is closer to observations

Urban diurnal cycle (O3 and NO2)





In Milan urban area during night, “Aladin” O3 is higher, while NO2 is lower (and its diurnal cycle is less regular)

-> Nocturnal ozone removal is less efficient in “Aladin”

-> This could be linked to stronger winds and enhanced mixing in “Aladin”
(O3 behaviour is “less urban”)

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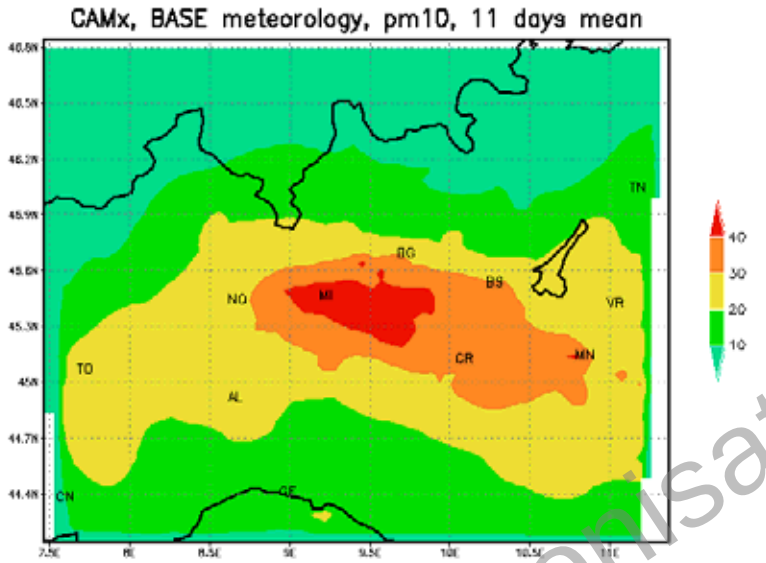
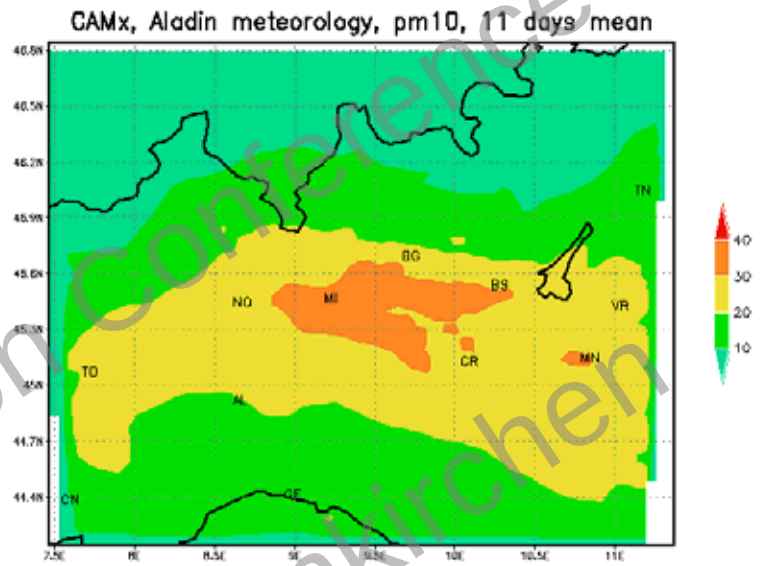
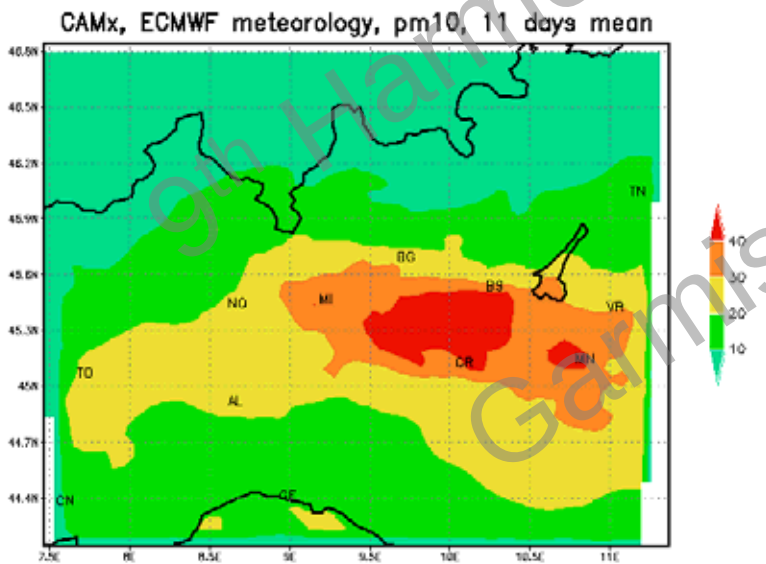
PM10: mean concentrations

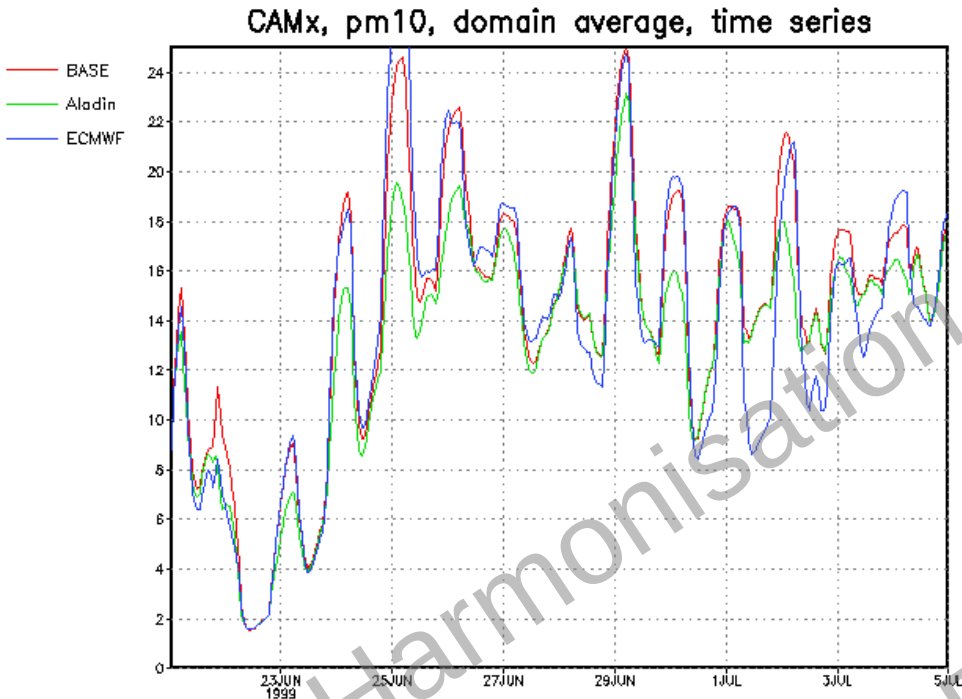


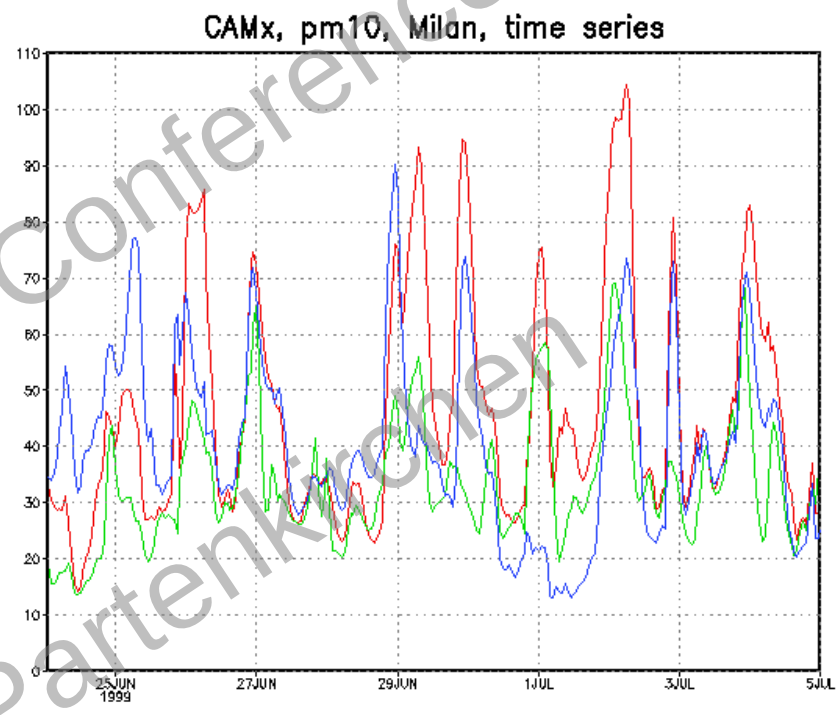




- Pattern is relatively smooth (compared to O3)
- "ECMWF": values similar to "Base", but pattern shifted to east (slower winds in upper PBL?)
- "Aladin": pattern similar to "Base", but lower values (difference ≈ 25%)
- CAMx strongly underestimate PM in Milan Area, so "Base" run preforms better

PM10: time series





- "Aladin" lower values are due to lower nocturnal maxima

  -> This (again) could be linked to stronger winds and enhanced mixing

- *"Aladin" has much smaller variations in Milan area*

Conclusions

The effects of horizontal wind reconstruction on a 2 weeks O3 and PM simulation has been tested:

Direct output of an high resolution LAM ("Aladin" dataset):

- near surface winds are stronger and more constant
- enhanced night-time mixing -> higher Ozone and lower PM10 in urban areas

Low resolution wind field corrected with observations ("ECMWF" dataset):

- lower O3 concentrations (10%, mainly due to daytime maxima)
- *The production of high ozone values ("Aladin" and "Base" runs) could be linked with stronger advection in upper PBL. A 6 month simulation with a different model (Calgrid, CityDelta1) produced similar results, with a much larger sensitivity (up to 40% difference)*

Correcting LAM wind with observation ("Base" dataset) seems sligtly benefical to model performance

In a nested simulation, inconsistency in wind may affect Ozone concentrations (in this experiment, this effect propagates up to 100 km inside the domain)