Test di sensibilità sulla simulazione ad alta risoluzione della qualità dell'aria in aree urbane

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(2) Centro di Eccellenza CETEMPS, Dipartimento di Scienze Fisiche e Chimiche, Università degli studi dell'Aquila, L'Aquila.

Center of Excellence CETEMPS
Telesensing of Environment and Model Prediction of Severe events

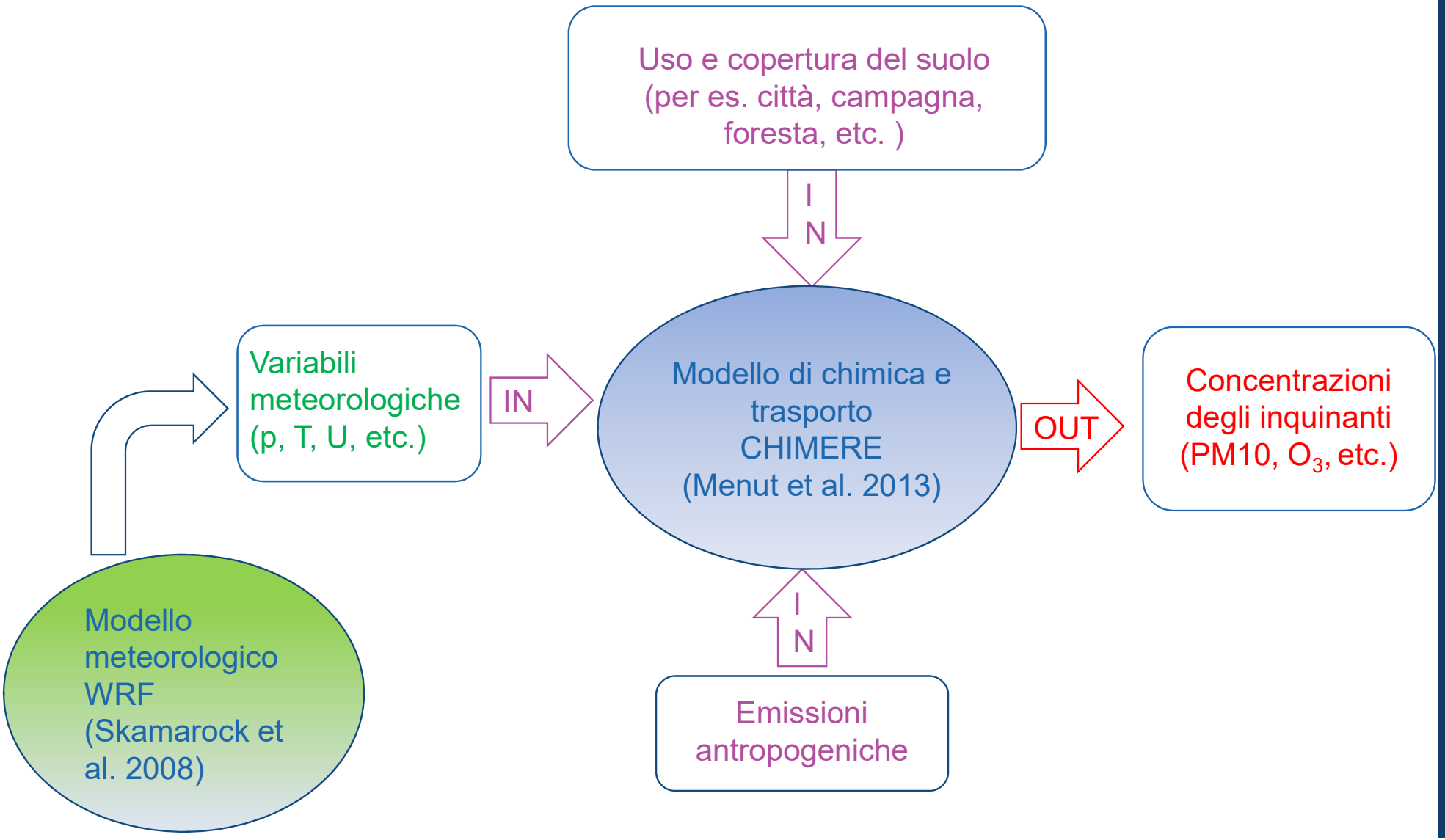
ARPA Lazio
Roma, 5 aprile 2018

Motivazione e Obiettivo dello studio

- ✓ Esigenze nella simulazione della qualità dell'aria in ambiente urbano:
  - studiare fenomeni meteorologici a scala dell'ordine del km
  - tenere conto della città (tessitura urbanistica, proprietà termiche dei materiali da costruzione, rugosità superficiale, etc)

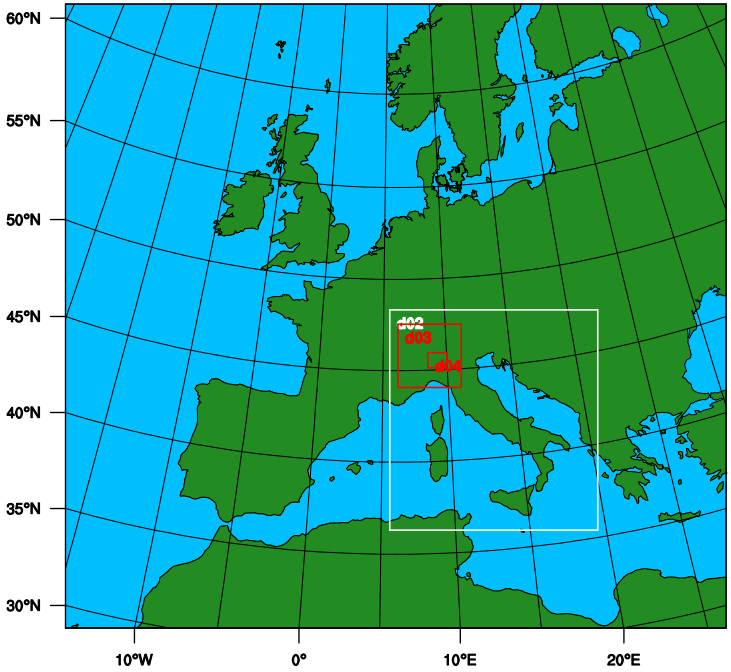
- ✓ Studiare la sensibilità della catena modellistica WRF-CHIMERE a:
  - aumento di risoluzione spaziale della griglia orizzontale
  - aumento della risoluzione spaziale delle emissioni antropiche
  - uso di schemi di parametrizzazione urbana con valori di default e modificati dei parametri morfologici e termici della città

La catena modellistica WRF- CHIMERE

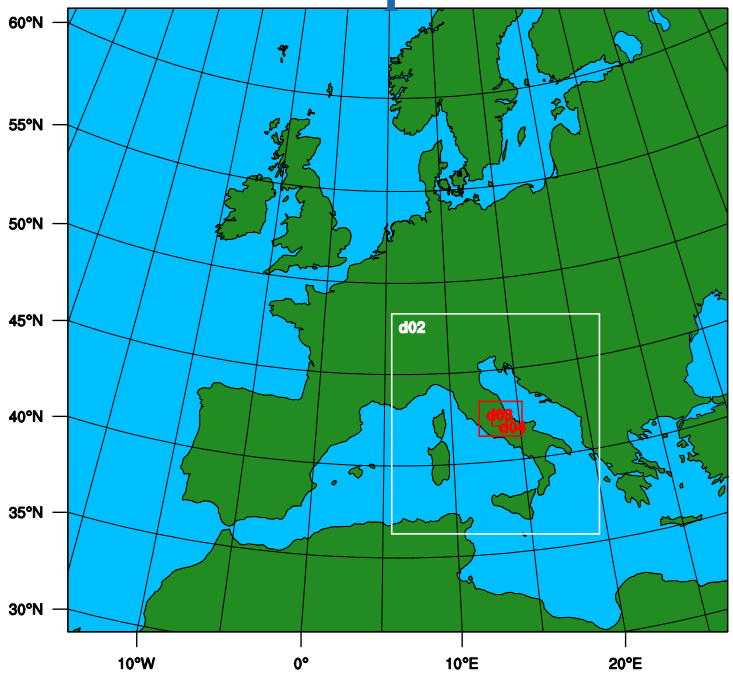


Aree geografiche

Milano



L'Aquila

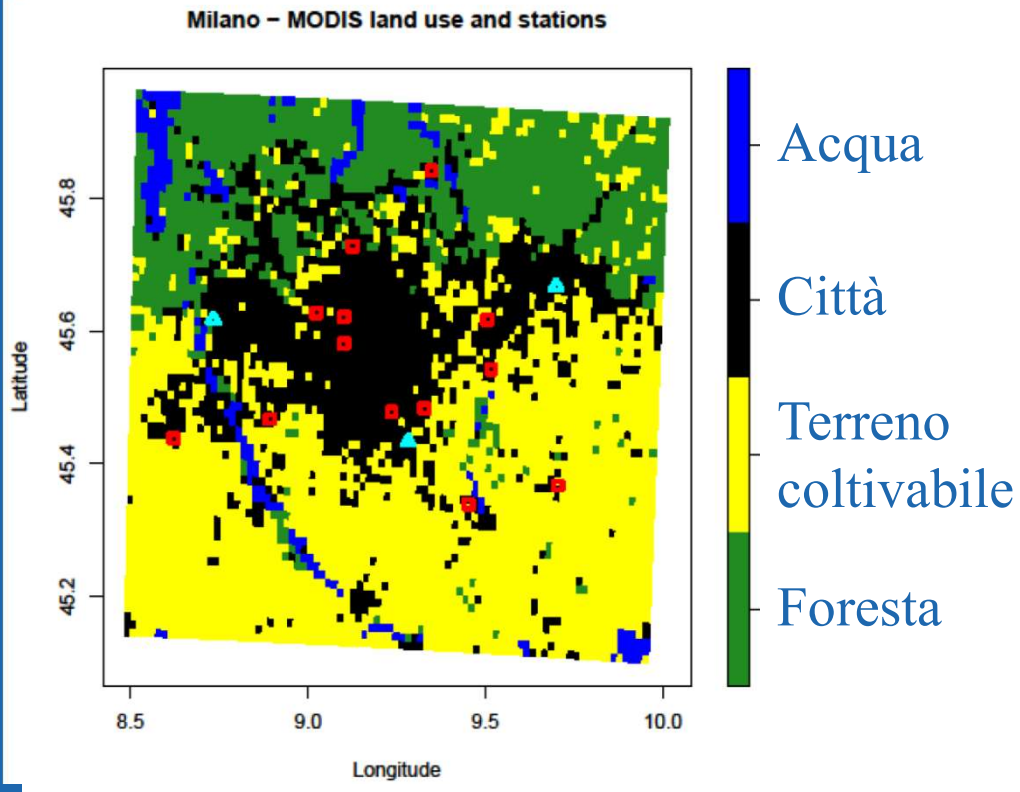


Dimensione della griglia orizzontale

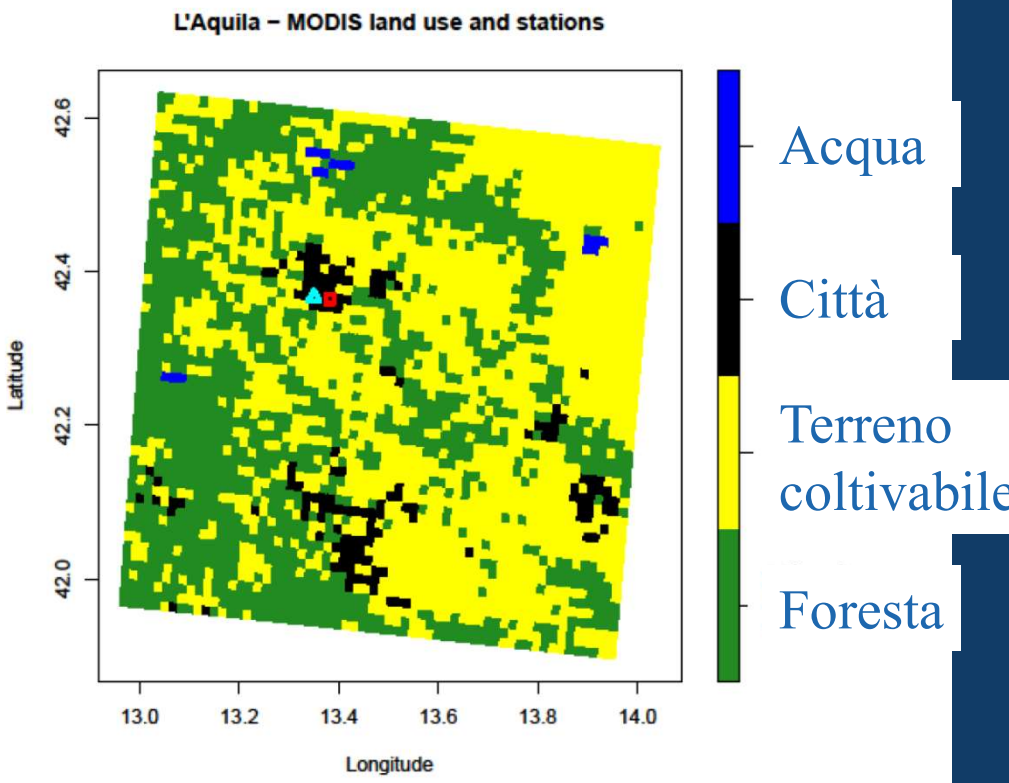
	dx = dy WRF (km)	dx = dy CHIMERE (°)
d01 (EUR)	36	0.5
d02 (ITA)	12	0.12
d03	4	0.04
d04 (Urban Area)	1.3	0.015

Stazioni meteo e chimiche

Milano



L'Aquila



- ✓ Triangoli (in ciano): stazioni meteo
- ✓ Quadrati (in rosso): stazioni chimiche - AirBase

Simulazioni

- ✓ Periodi:
  - Gennaio 2010
  - Luglio 2010

	Etichetta	Schema Urbano WRF	Parametri Urbani WRF	Redistribuzione delle emissioni
Caso di riferimento	**REF**	Bulk	-	No
Schemi urbani Complessità crescente	**UCM**	UCM	Default	No
	BEP	BEP	Default	No
	UCMt	UCM	Modificati	No
	BEPt	BEP	Modificati	No
Riallocazione spaziale	**GLOB**	Bulk	-	Sì

Aumento della risoluzione orizzontale

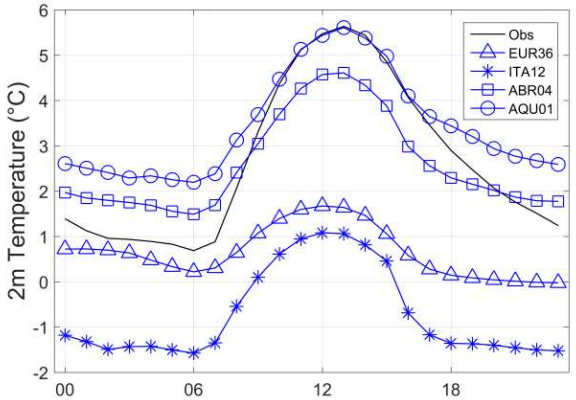
Temperatura a 2 m

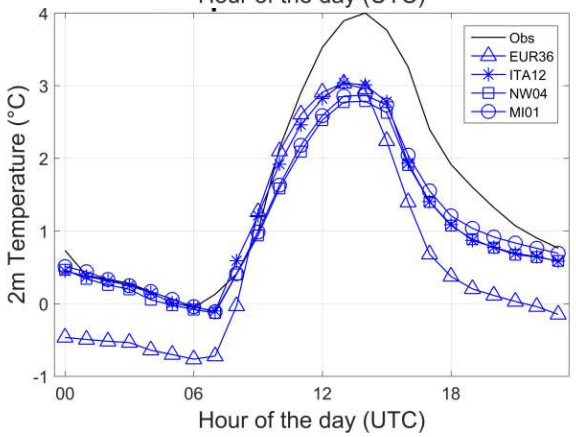
WRF RESULTS

L'Aquila

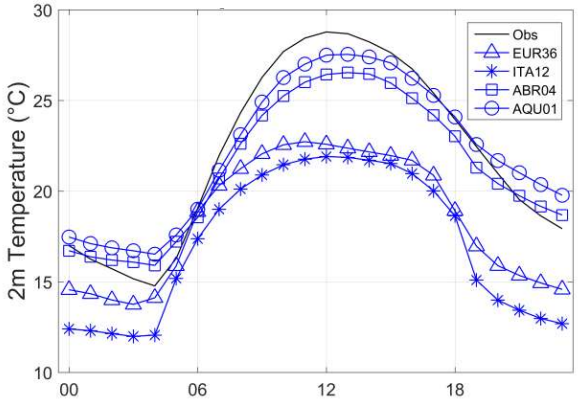
Milano

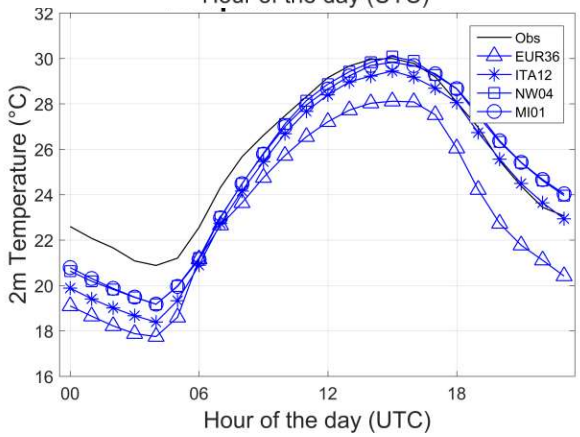
Gennaio 2010





Luglio 2010





OBS EUR36 ITA12 NW04 ABR04 MI01 AQU01

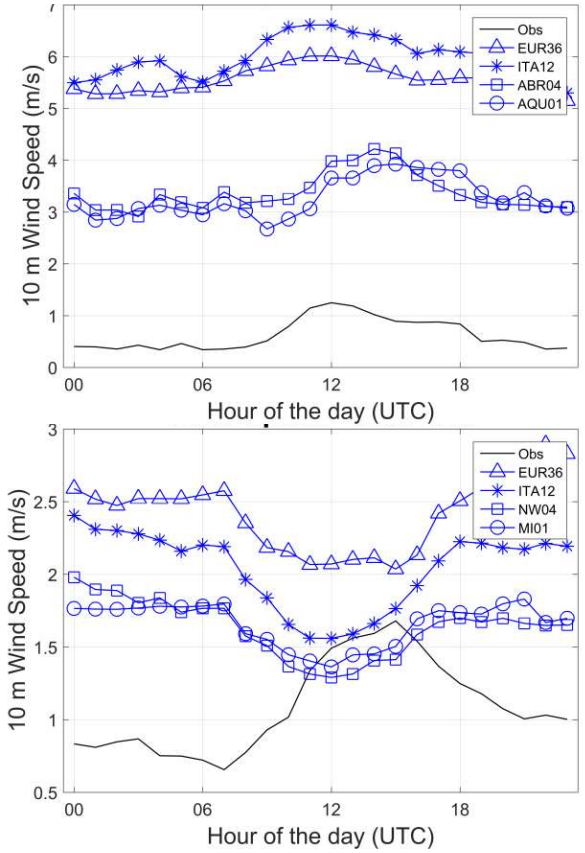
Aumento della risoluzione orizzontale

Velocità del vento a 10 m

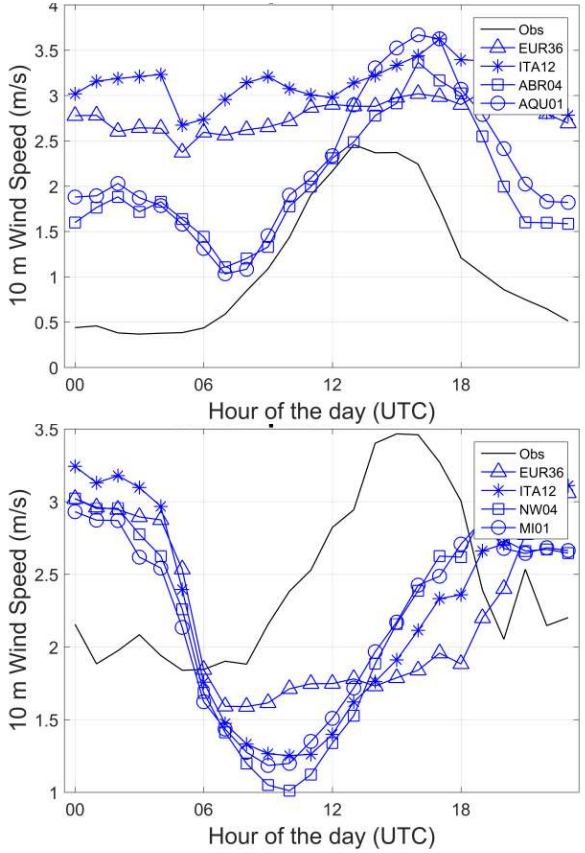
WRF RESULTS

L'Aquila Milano

Gennaio 2010



Luglio 2010



OBS EUR36 ITA12 NW04 ABR04 MI01 AQU01

Aumento della risoluzione orizzontale

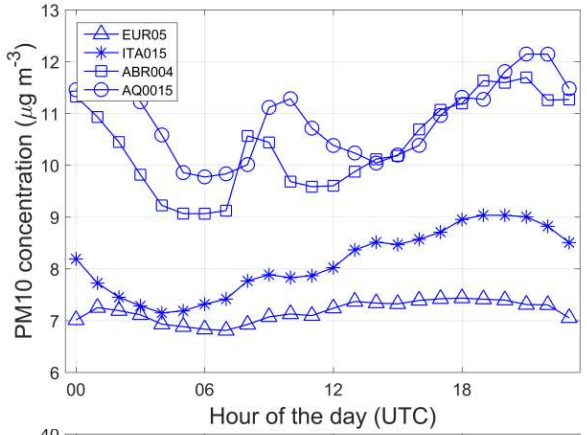
PM10 – gennaio 2010

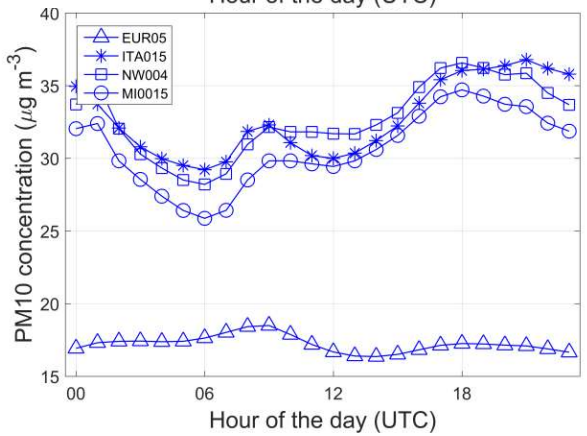
L'Aquila

Milano

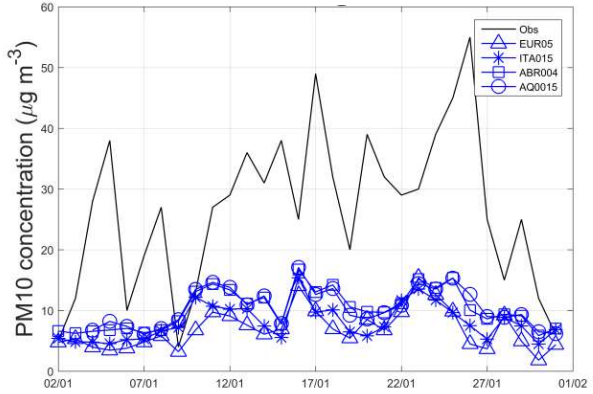
CHIMERE RESULTS

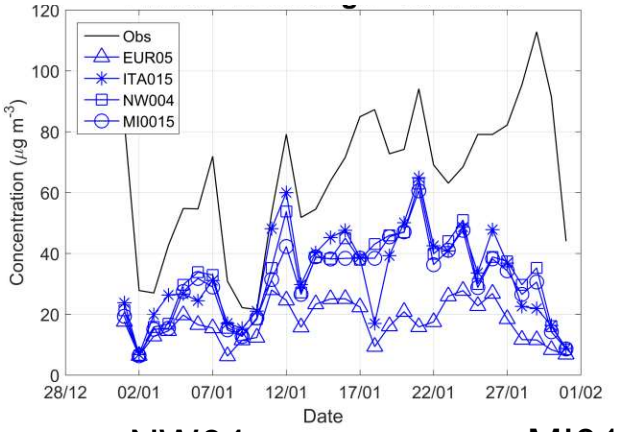
Valori orari





Valori giornalieri





OBS EUR36 ITA12 NW04 ABR04 MI01 AQU01

Aumento della risoluzione orizzontale

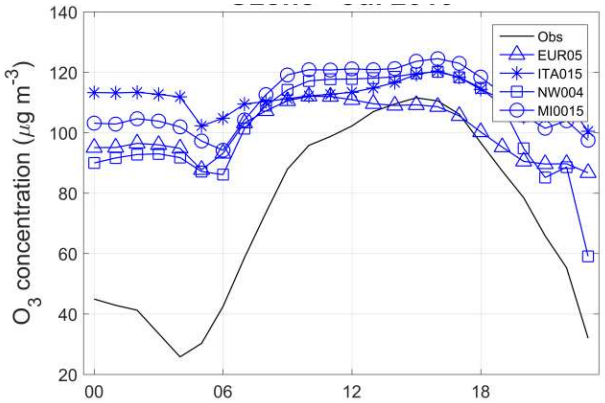
Ozono – luglio 2010

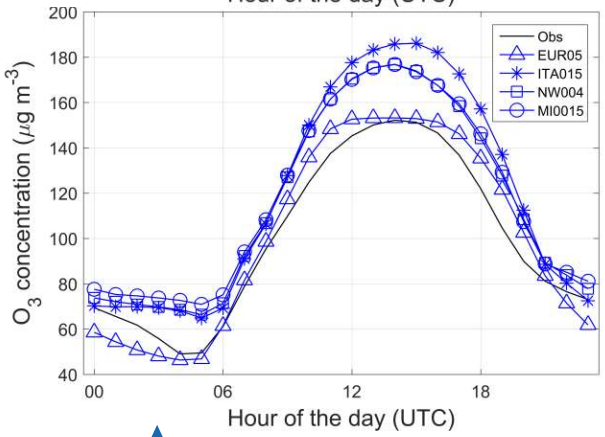
CHIMERE RESULTS

L'Aquila

Milano

Valori orari





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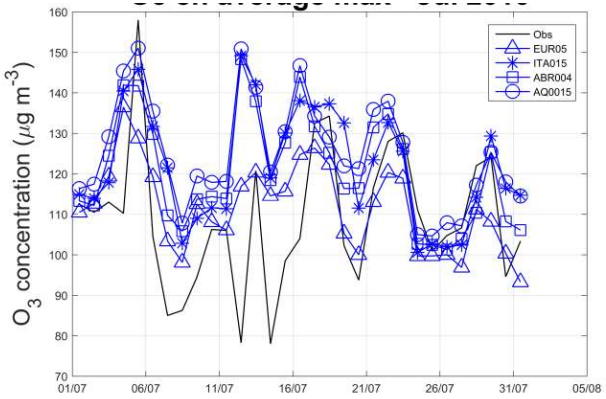
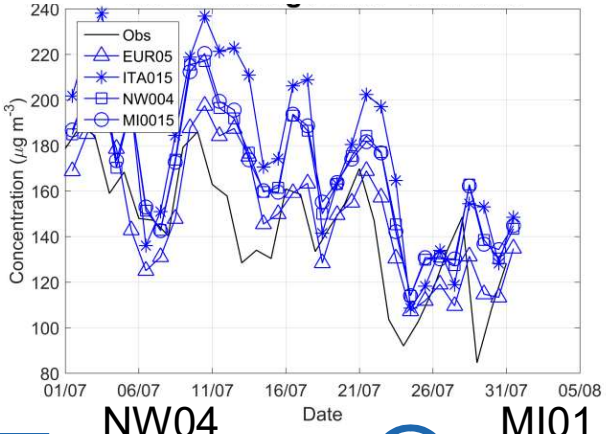


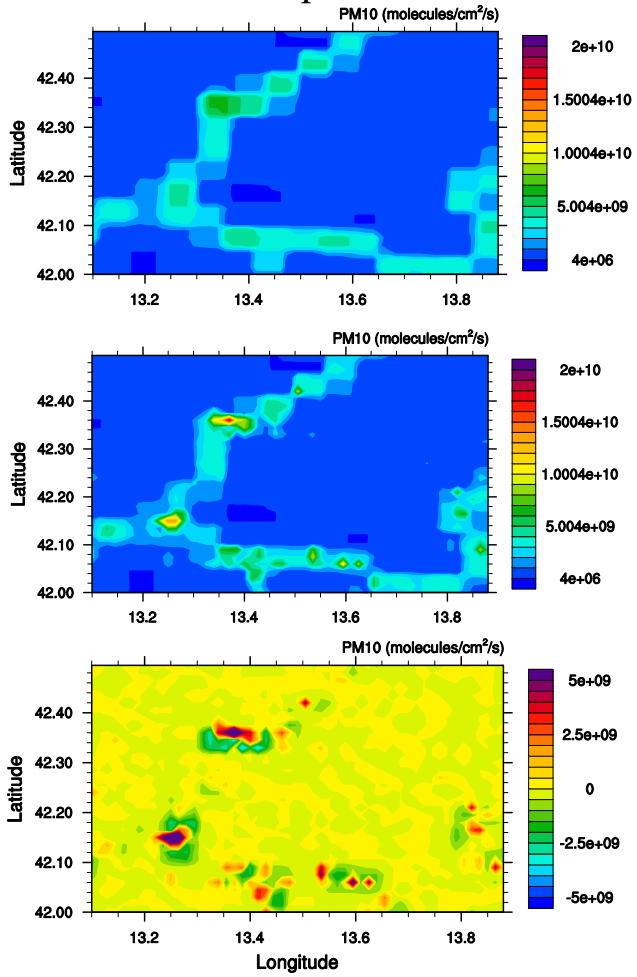


OBS EUR36 ITA12 NW04 ABR04 MI01 AQU01

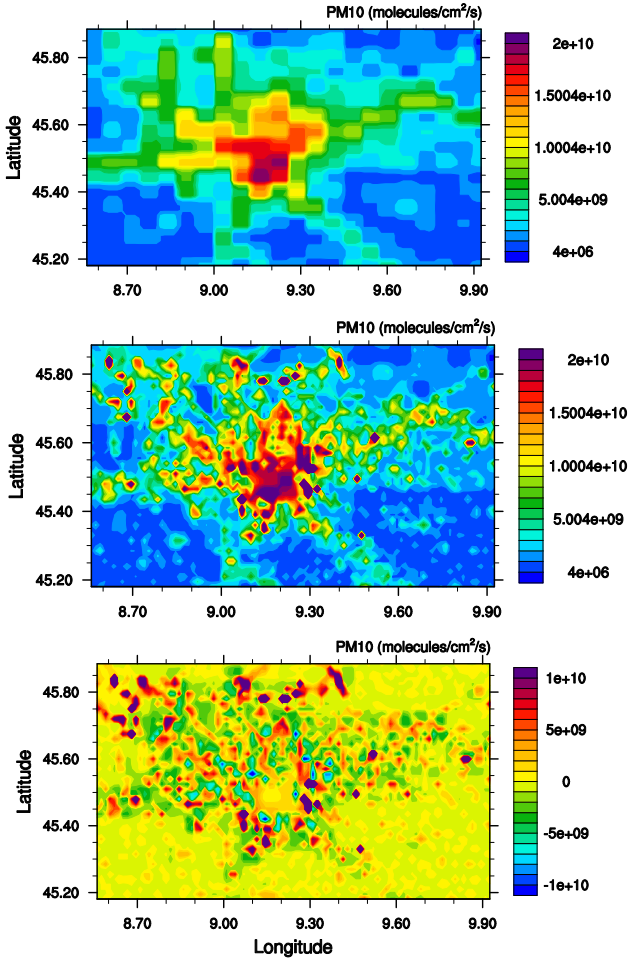
Aumento della risoluzione orizzontale delle emissioni antropiche

Flusso emissivo di PM10 alle 12:00 UTC nel gennaio 2010

L'Aquila



Milano



Inventario di emissioni: CTN (5 x 5 km)

Inventario di emissioni: CTN (5 x 5 km)

+

GlobCover Land Use dataset

Differenza

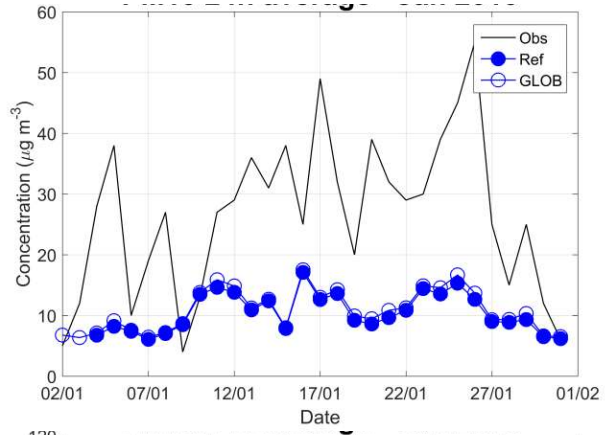
Aumento della risoluzione orizzontale delle emissioni antropiche

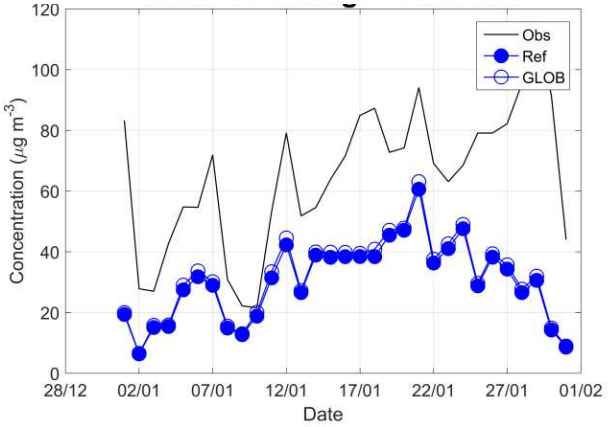
Valori giornalieri di PM10 e ozono

L'Aquila

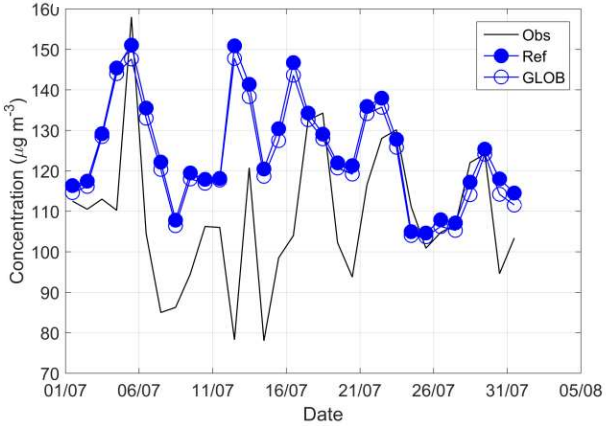
Milano

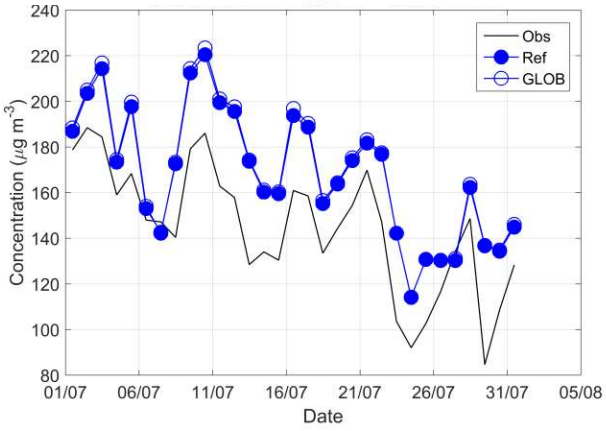
PM10





Ozono





OBS Ref GLOB

Uso degli schemi urbani in WRF

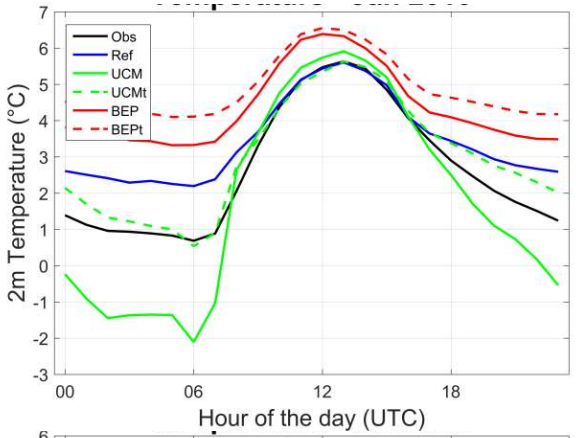
Temperatura a 2 m

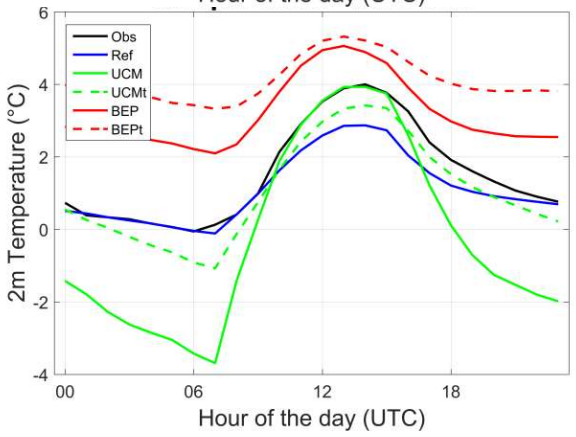
WRF RESULTS

L'Aquila

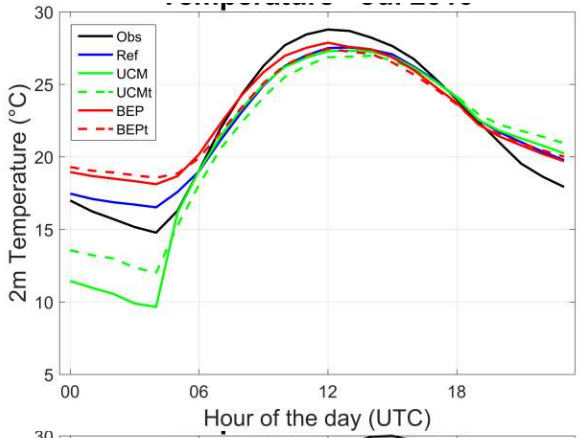
Milano

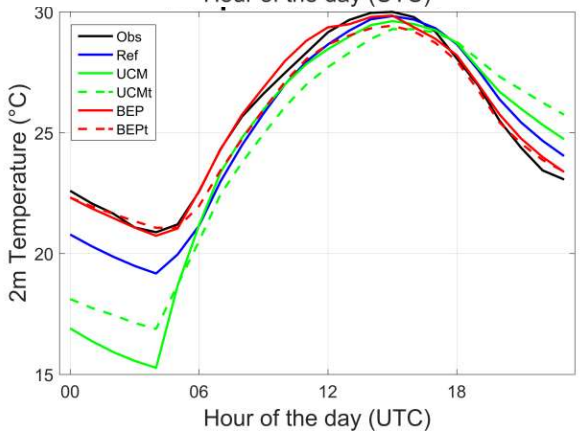
Gennaio 2010





Luglio 2010





OBS Ref UCM UCMt BEP BEPt

Uso degli schemi urbani in WRF

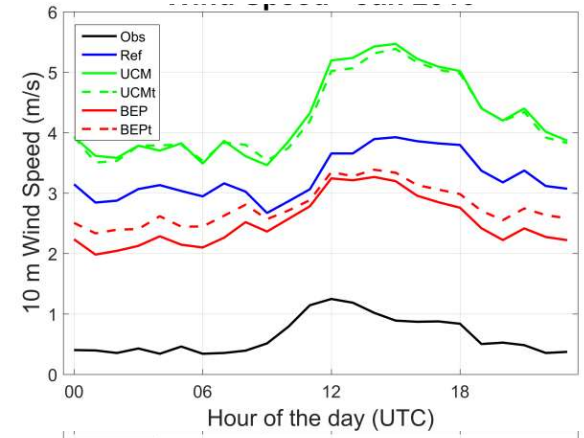
Velocità del vento a 10 m

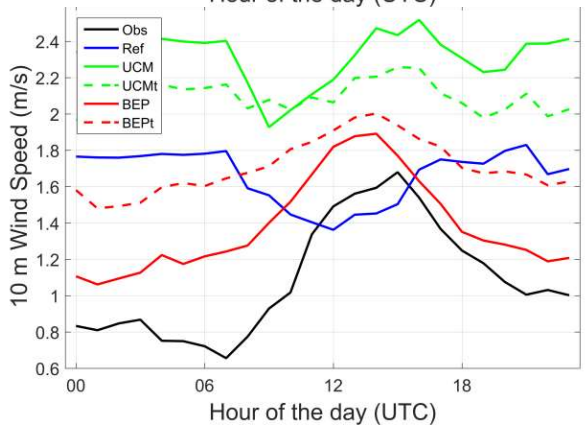
WRF RESULTS

L'Aquila

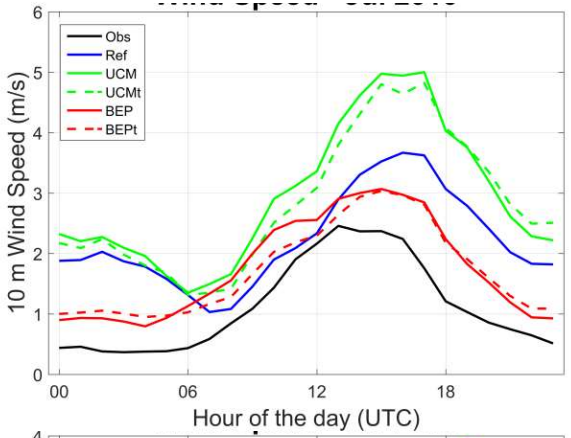
Milano

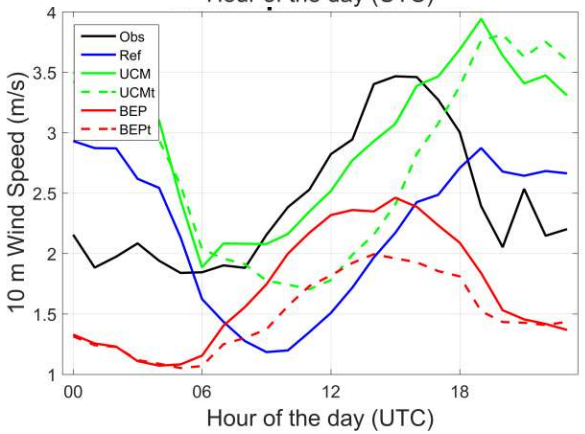
Gennaio 2010





Luglio 2010





OBS Ref UCM UCMt BEP BEPt

Uso degli schemi urbani in WRF

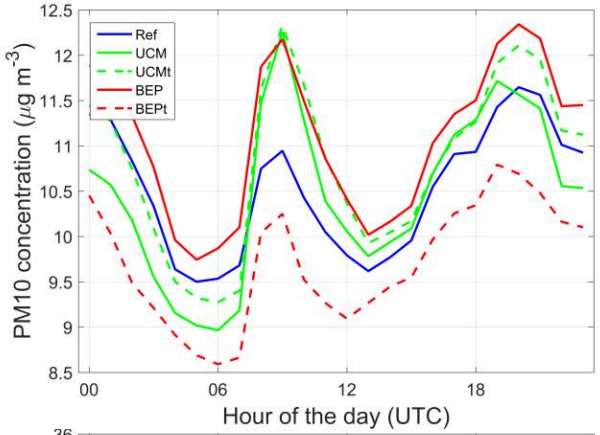
PM10 – gennaio 2010

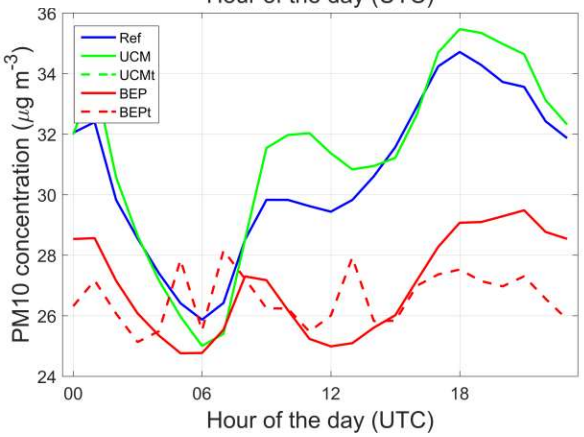
CHIMERE RESULTS

L'Aquila

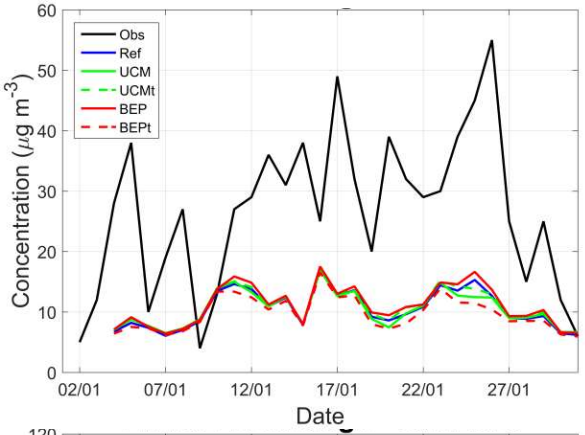
Milano

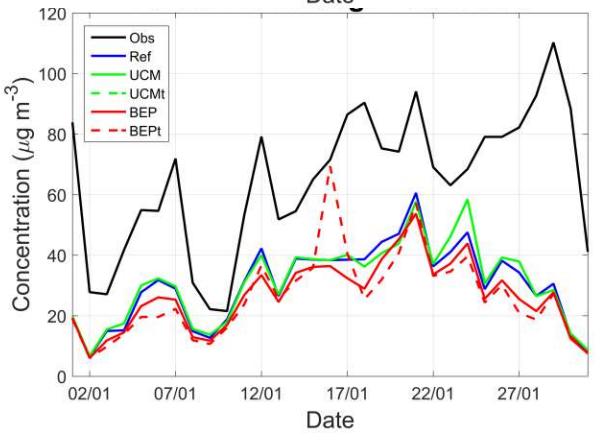
Valori orari





Valori giornalieri





OBS Ref UCM UCMt BEP BEPt

Uso degli schemi urbani in WRF

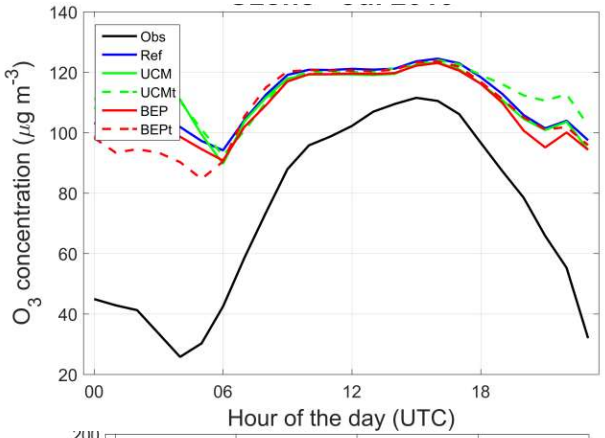
Ozono – luglio 2010

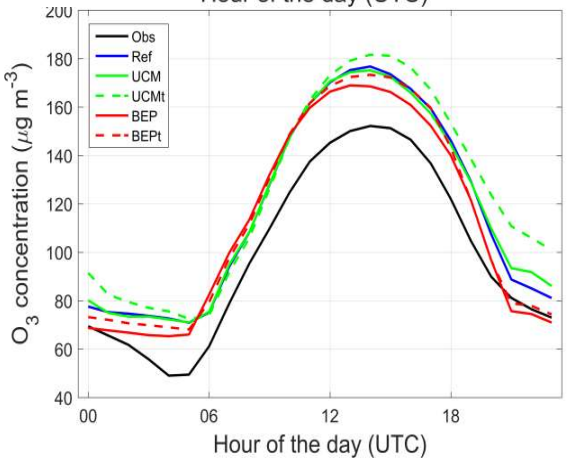
CHIMERE RESULTS

L'Aquila

Milano

Valori orari





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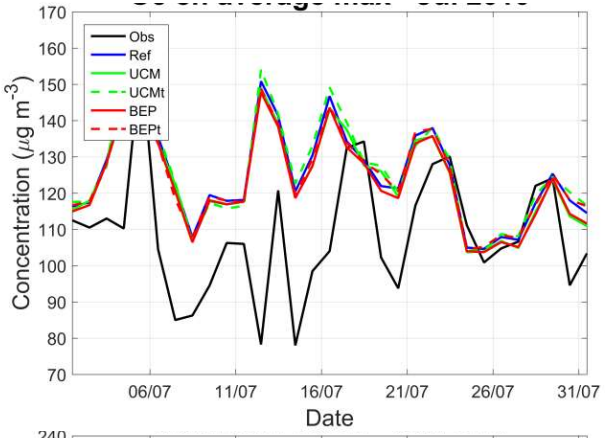

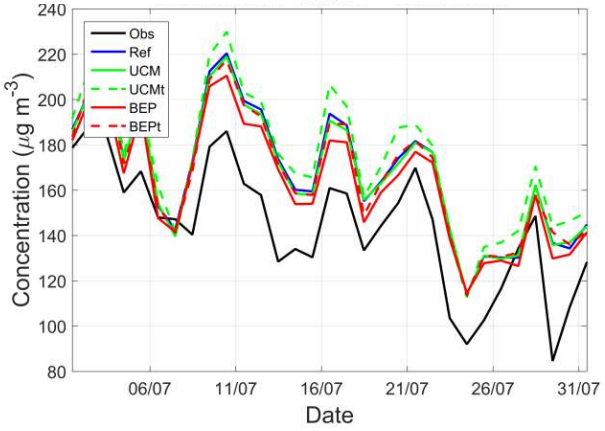

OBS Ref UCM UCMt BEP BEPt

Conclusioni

- ✓ Per le variabili meteo si osserva una generale miglioramento delle prestazioni del modello dalla bassa all'alta risoluzione
- ✓ Per le concentrazioni di inquinanti si ha un beneficio dell'aumento di risoluzione fino a 4 km
- ✓ L'aumento di risoluzione spaziale delle emissioni antropiche non ha un effetto significativo sulle prestazioni del modello
- ✓ L'uso di schemi di parametrizzazione urbana richiede una messa a punto nell'area di interesse
- ✓ Lo schema BEP corregge la forma della curva della velocità del vento, ma causa un'eccessiva diluizione degli inquinanti poiché sovrastima l'altezza del PBL

Futuri sviluppi e Ringraziamenti

Futuri sviluppi:

- usare informazioni più dettagliate sull'uso del suolo nelle aree urbane (aree residenziali con diversa densità, commerciali) e sulle caratteristiche morfologiche delle città

Ringraziamenti

- This work was partly supported by Italian Ministry of the Economic Development in the framework of the "Smart Clean Air City L'Aquila" project [code n. M/0007/03/X23] and partly carried out in the framework of the collaboration with the regional environmental agency of Abruzzo (ARTA).
- The computational resources were provided by CINECA in the framework of Iscra-C projects NMTFEPRA, PANCIA and ALTARIS7 and by the Gran Sasso National Laboratories (LNGS) in the framework of project ARIAPROBA.

WRF configuration

SUPPLEMENTARY MATERIAL

Physics Category (namelist.input option)	Scheme (namelist.input option)
Shortwave radiation (ra_sw_physics)	RRTMG (4)
Longwave radiation (ra_lw_physics)	RRTMG (4)
microphysics (mp_physics)	WSM6 (6)
Surface layer (sf_sfclay_physics)	Revised MM5 Monin-Obukhov (1)
Planetary Boundary Layer (bl_pbl_physics)	Bougeault and Lacarrere (BouLac) (8)
Land Surface (sf_surface_physics)	Unified Noah land-surface model (2)

- 33 eta vertical levels with 11 levels below 1000 m, the lowest one at about 23 m and the top at 50 hPa
- Initial and global boundary conditions: Global Forecasting System (GFS) operational analyses from the National Center for Environmental Prediction (NCEP), at a spatial resolution of 1° x 1° and a temporal resolution of 6 h
- Simulations in 30-hours blocks, starting at 18 UTC of each day, and discarding the first 6 hours as model spin-up

SUPPLEMENTARY MATERIAL

WRF configuration

Parameter for UCM and BEP Urban Canopy Models	Default	Kusaka et al. (2001)	Kim et al. (2013)	This work
Building height (m)	7.5	15	12	7.5
Roof width (m)	9.4	-	3.75	9.4
Road width (m)	9.4	-	11.25	9.4
Anthropogenic heat ($W\ m^{-2}$)	50	-	70	50
Anthropogenic latent heat ($W\ m^{-2}$)	25	-		25
Fraction of the urban landscape with no natural vegetation	0.9	1	0.95	0.9
Heat capacity of roof, building walls, road ($J\ m^{-3}\ K^{-1}$)	$1.0x\ 10^6$	$2.1x\ 10^6$	2.1x 106	2.1x 106
Thermal conductivity of roof, building walls ($W\ m^{-1}\ K^{-1}$)	0.67	2.28	2.28	2.28
Thermal conductivity of road ($W\ m^{-1}\ K^{-1}$)	0.4004	2.28	2.28	0.7
Surface albedo of roof, building walls, road	0.2	0.2	0.2	0.2
Surface emissivity of roof and building wall	0.90	0.97	0.97	0.97
Surface emissivity of road	0.95	0.97	0.97	0.97

CHIMERE options

Category (namelist variable)	chimere.par option
Biogenic emissions	MEGAN
Boundary conditions for gaseous species	LMDz4-INCA3
Boundary conditions for aerosol	LMDz4-INCA3
Chemistry mechanism	reduced MELCHIOR

- The number of vertical sigma levels is 12 with the top pressure at 500 hPa, 7 levels below 1000 m, and the first level of about 25 m height.
- Vertical diffusion coefficients are re-calculated based on the boundary layer height using the parameterization by Troen and Mahrt (1986) without counter-gradient term (Menut et al. 2013).
- Anthropogenic emissions: from the European Monitoring and Evaluation Programme (resolution of 0.5° x 0.5°) for the European domain, from the National Thematic Center for Atmosphere, Climate, Emissions (CTN-ACE, Deserti et al. 2008), at by a resolution of 5 km x 5 km and used for the inner domains.

SUPPLEMENTARY MATERIAL

SUPPLEMENTARY MATERIAL

WRF configuration

Urban area	Network	International code	Name	Latitude	Longitude	Type
Milan	NOAA-NCDC	160660	Malpensa	45.617	8.733	-
Milan	NOAA-NCDC	160760	Orio al Serio	45.667	9.700	-
Milan	NOAA-NCDC	160800	Linate	45.433	9.283	-
L'Aquila	CETEMPS	-	-	42.367	13.984	-
Milan	AirBase	IT0524A	Cassano d'Adda	45.542	9.516	Background
Milan	AirBase	IT0706A	Limito	45.483	9.328	Background
Milan	AirBase	IT0839A	Crema – Via XI febbraio	45.367	9.705	Background
Milan	AirBase	IT1010A	Magenta	45.467	8.893	Background
Milan	AirBase	IT1418A	Montanaso	45.335	9.453	Background
Milan	AirBase	IT1463A	Osio sotto	45.621	9.102	Background
Milan	AirBase	IT1466A	Trezzo d'Adda	45.617	9.506	Background
Milan	AirBase	IT1518A	NO - Verdi	45.438	8.621	Background
Milan	AirBase	IT1648A	Cantù	45.727	9.126	Background
Milan	AirBase	IT1650A	Saronno	45.627	9.024	Background
Milan	AirBase	IT1692A	MI - Pascal	45.478	9.236	Background
Milan	AirBase	IT1734A	Valmadrera	45.841	9.349	Background
Milan	AirBase	IT1743A	Monza - Machiavelli	45.581	9.102	Background
L'Aquila	AirBase	IT1856A	Amiternum	42.364	13.382	Traffic

Simulazioni

- ✓ Periodi:
  - Gennaio 2010
  - Luglio 2010

- ✓ Aumento della risoluzione spaziale della griglia orizzontale di WRF e CHIMERE

  Nel dominio a risoluzione più alta centrato sull'area metropolitana

- ✓ Aumento della risoluzione spaziale delle emissioni antropogeniche in CHIMERE

- ✓ Uso degli schemi di parametrizzazione urbana in WRF