AIR QUALITY FORECASTING SYSTEM IN A DOLOMITIC VALLEY: PERFORMANCE COMPARISON BETWEEN EXPECTED AND MEASURED DATA

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Outline

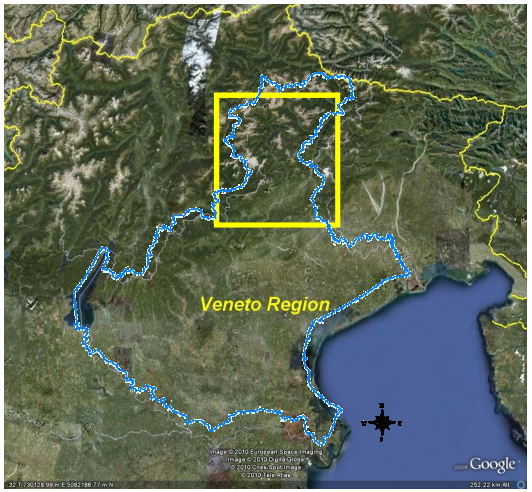
Topics

- *the scene*
- *atmospheric emission inventory*
- *modelling system characteristics*
- *results (AQFS performaces)*
- *the air quality forecasting bulletin*
- *conclusions*

The Scene – Belluno Valley



A new UNESCO heritage site

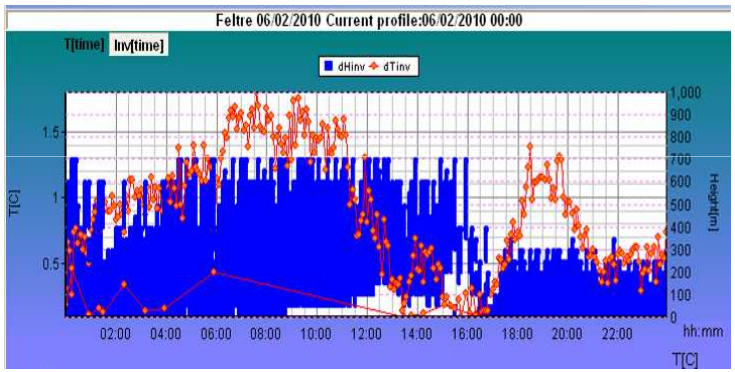


Belluno Valley and its basin

Belluno: 36,000 inhabitants

Feltre: 19,000 inhabitants

► few emission sources but……



Main aerological characteristics

► a very high frequency of air stagnation during the winter

► very low wind speed with fog episodes
(89% hs under 0.5 m/s at Feltre in winter)

► strong temperature inversion profile

many times the vertical dispersion is limited!!

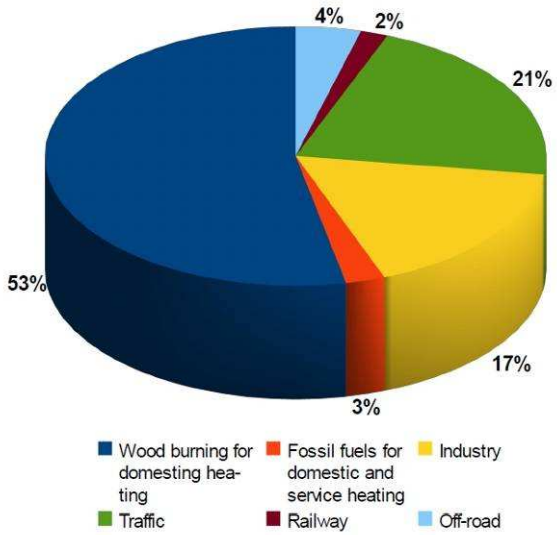
The Emission Inventory/1

- Essential tool to understand pressures acting in the domain
- It is a local inventory based on bottom–up approach

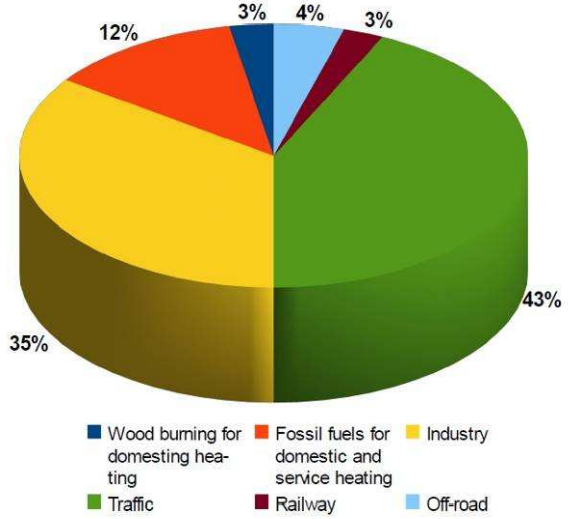
Industrial Processes	Traffic	Domestic Heating
►150 factories and 990 chimneys	►more than 60 roads included in the db	►wood combustion plays a dominant role
►first 20 activities performed ~ 90% TSP of the industrial sectors (M1,M3,M4,M5,M6 amount)	►emission calculated with TREFIC (using COPERT 3 methodology) starting from hourly traffic flows	►investigated through the use of >5000 questionnaires to population (covering 8% of the population in the Belluno Valley)
►data derived from chimney chemical analisys ($PM, NO_X, SO_X, CO, VOCs$)	►vehicle flows divided in 3 categories (C1= passangers cars + motorcycles; C2 = LDV; C3 = HDV)	►collected data about use of fuels and combustors

The Emission Inventory/2

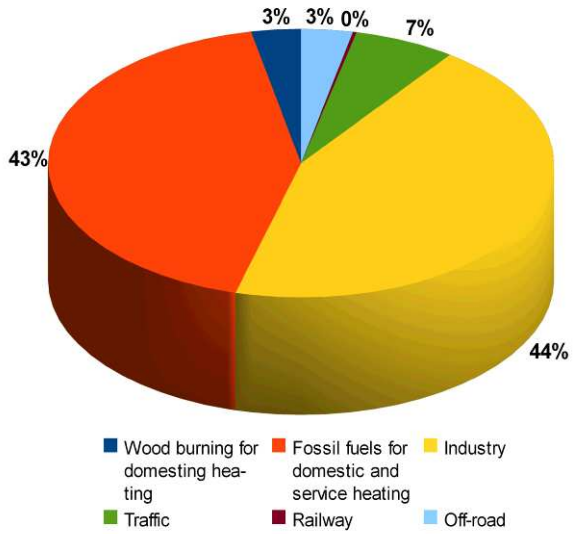
PM10



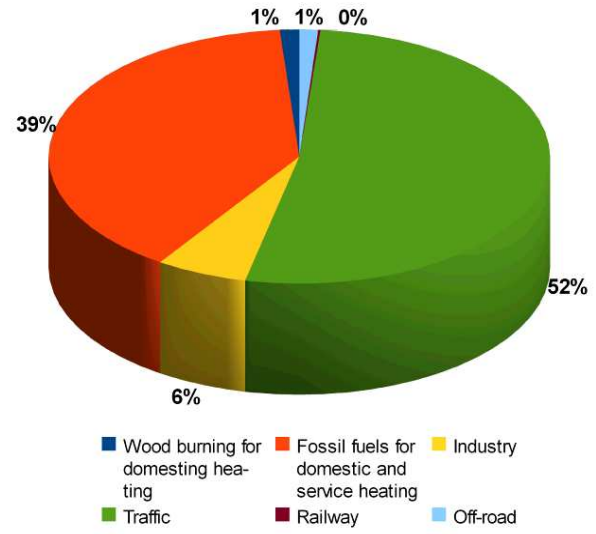
NO_2



SO_X



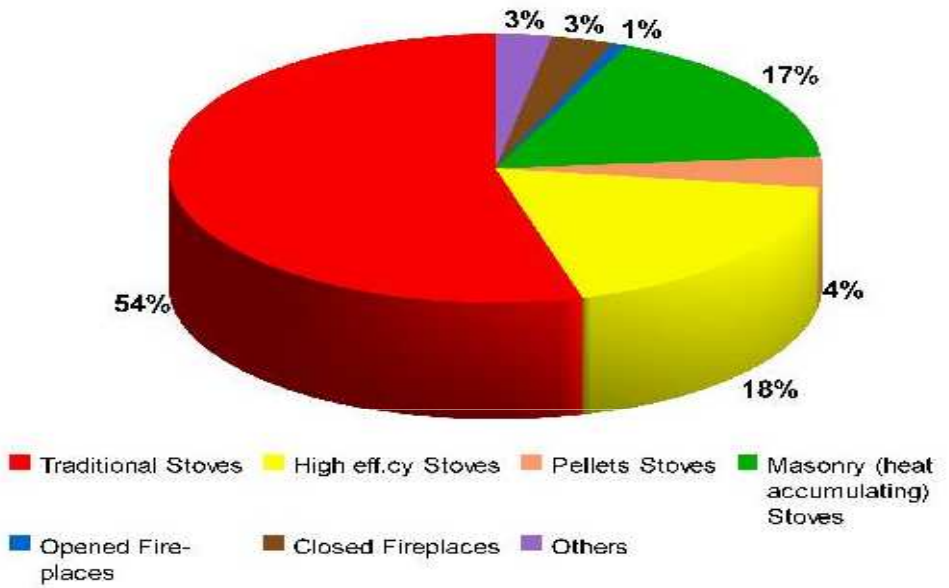
CO



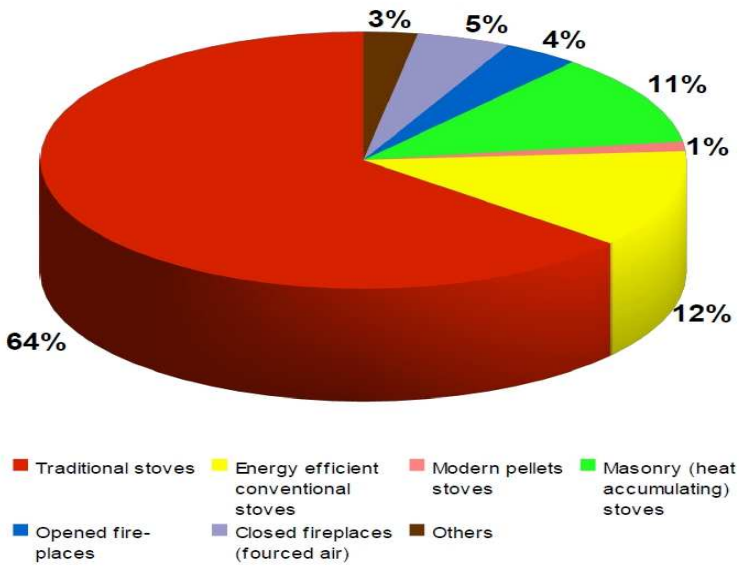
Biomass burning

►More than 80% of families use almost a stove for heating

Biomass burning – Primary use



PM10 emission (205.8 Mg/y) from biomass burning for domestic heating



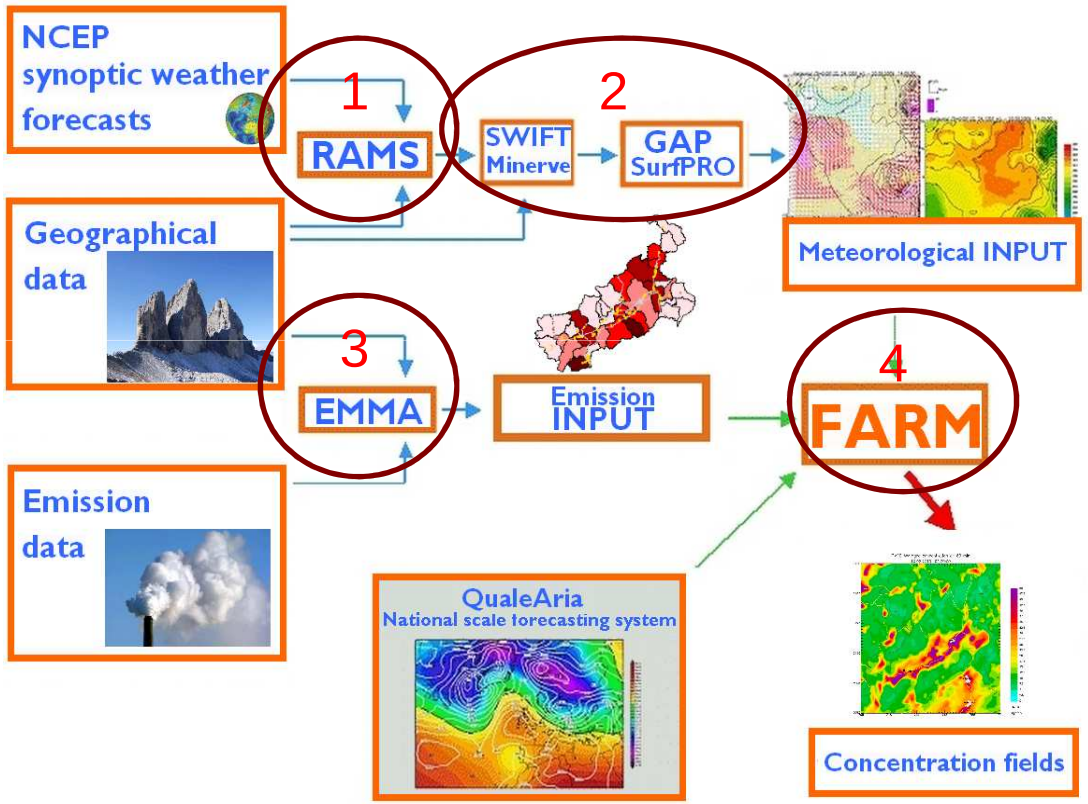
►PM10 Emission Factors (*) - g GJ^{-1}

Stoves				Fireplaces		
Traditional	High eff.cy	Pellets	Masonry (heat accumulating)	Closed (forced air)	Opened	Others
250	**150**	**70**	**150**	**250**	**500**	**250**

(*) according to: DIIAR, Politecnico di Milano (Italy), 2006

AQFS SKYNET – The architecture

- Built by 4 modules
- Operational since Jun. 09, stable configuration in Nov. 09
- AQFS aim: information on air pollution to support AQM and to be distribuited to the general public as required by AQ framework directive 2008/50 CE



AQFS – Modelling system characteristics

Mesoscale

grid 1 – 32 km horizontal resolution

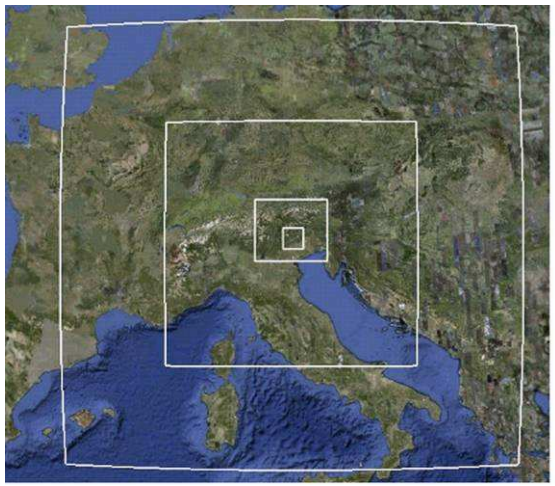
grid 2 – 16 km horizontal resolution

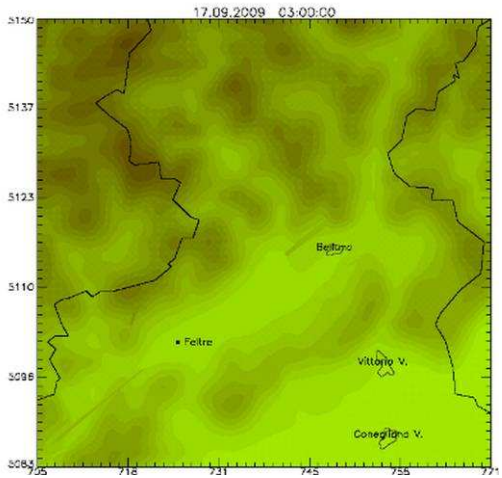
grid 3 – 4 km horizontal resolution

grid 4 – 1 km horizontal resolution

Local Scale

downscaling





Computational domain
(66x67 cells at 1 km of horizontal resolution)
and 10 vertical levels.

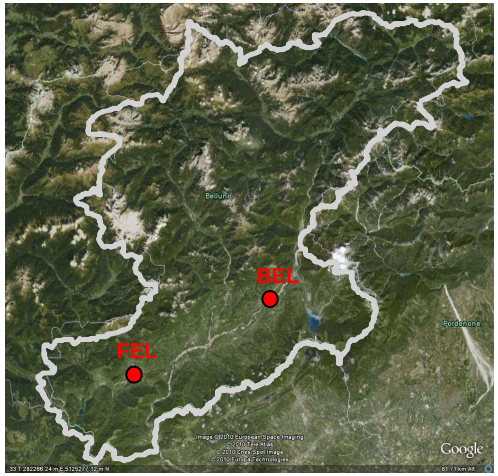
MODEL OUTPUTS

- Equipped with automatic procedures works as a calculation chain
- SKYNET runs on a daily basis to produce forecasts for current day (+24 hs) and the following one (+48hs)
- Hourly concentration fields submitted to post-processing tools

Things to remember

►It has been selected the time period Nov.09 – Feb.10 (4 months) for data analisys

Belluno (BEL) and Feltre (FEL)
Air Quality stations:
(2 Urban Background stations)



►2 pollutants considered for evaluation of forecast system: PM10 and NO_2

Results presented as:

- Statistical indicators
- Box plots
- Scatter plots
- Direct comparison of predicted vs measured concentrations
- Output maps

MB	$MB = \frac{1}{N}\sum_{i=1}^{N}(O_i - P_i)$
FB	$FB = \frac{(\overline{O} - \overline{P})}{(\overline{O} + \overline{P})/2}$
d	$d = 1 - \frac{\sum_{i}^{N} O_i - P_i}{\sum_{i=1}^{N} \lvert P_i - \overline{O} \rvert + \lvert O_i - \overline{O} \rvert}$
RMSE	$RMSE = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(O_i - P_i)^2}$
NSD	$NSD = \frac{\sigma_P}{\sigma_O}$
F2	$2.0 \geq F2 = \frac{1}{N}\sum_{i=1}^{N}\frac{P_i}{O_i} \geq 0.5$

Results/ Statistical Indexes

► AQFS performaces; +24 and +48 are considered distinctly

		MB	FB	d	RMSE	NSD	F2
Belluno	PM10+24	10.35	0.33	0.47	18.55	0.52	0.84
	PM10+48	9.66	0.32	0.46	17.88	0.60	0.85
Feltre	PM10+24	18.35	0.53	0.44	25.13	0.47	0.68
	PM10+48	18.47	0.57	0.50	25.29	0.45	0.70

		MB	FB	d	RMSE	NSD	F2
Belluno	NO_2+24	1.60	0.04	0.75	17.61	1.30	0.98
	NO_2+48	1.41	0.04	0.75	17.78	1.31	0.99
Feltre	NO_2+24	-2.52	-0.08	0.55	20.86	1.42	1.28
	NO_2+48	-2.14	-0.07	0.56	20.70	1.40	1.27

Considerations

► very similarity between +24 and +48 runs = good agreement of predictions

► PM10= BEL has high values of *d* and *F2* and low for *RMSE*.

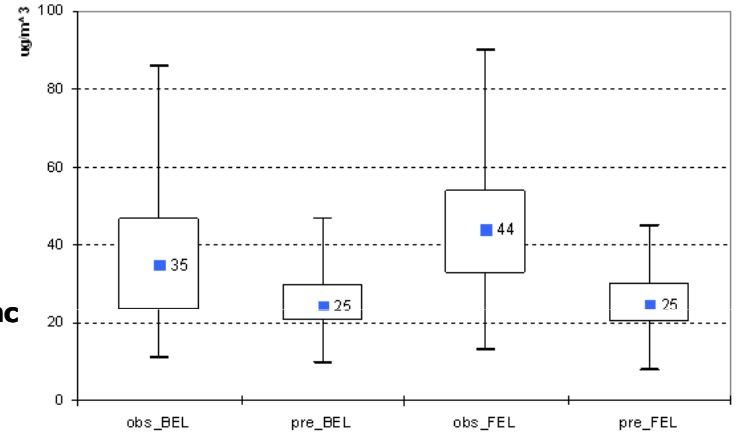
► model simulates NO_2 in a better way = good *d* and *FB* (close to 0), low *MB* values

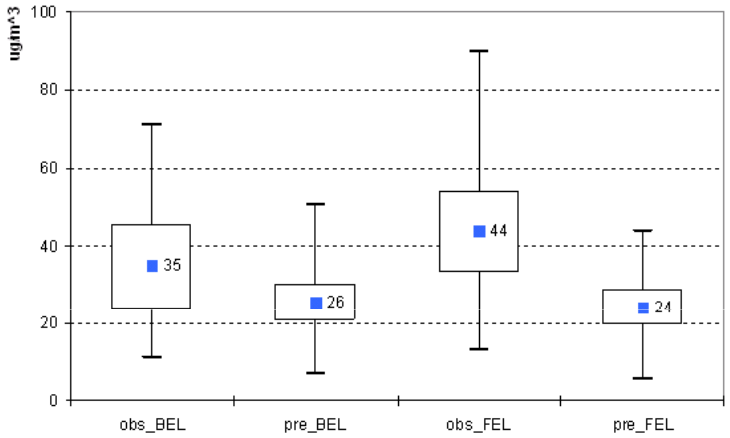
Results/Box Plots

- Comparisons between PM10 and NO_2 obs. data and pre. data in BEL and FEL stations
- AQFS tends to understimate PM10 in FEL; good agreement for NO_2

PM10
(+24 on the left
+48 on the right)

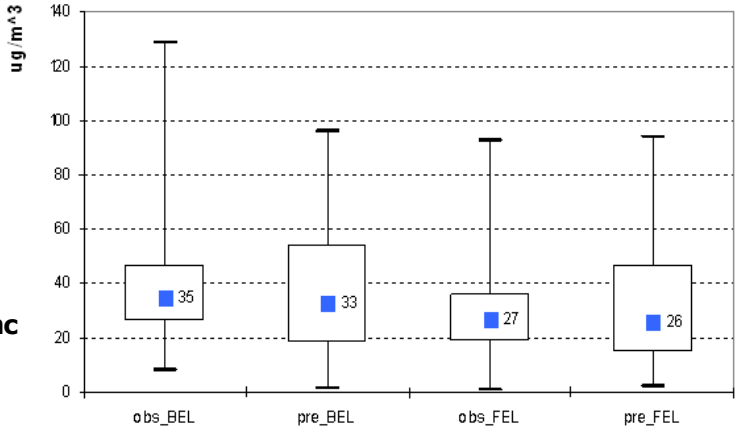
PM10 daily averages conc

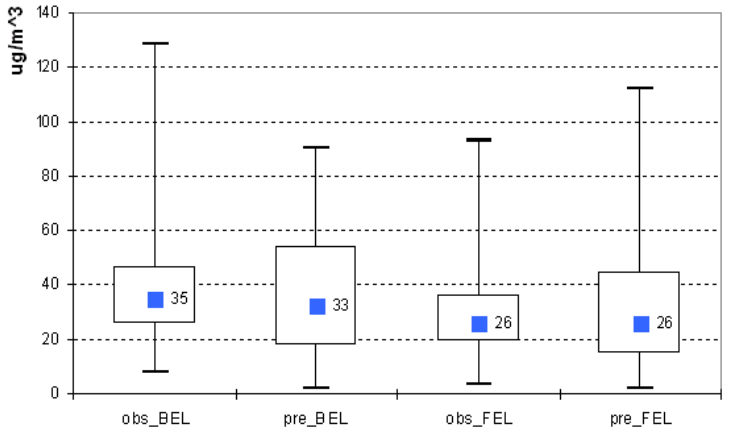




NO_2
(+24 on the left
+48 on the right)

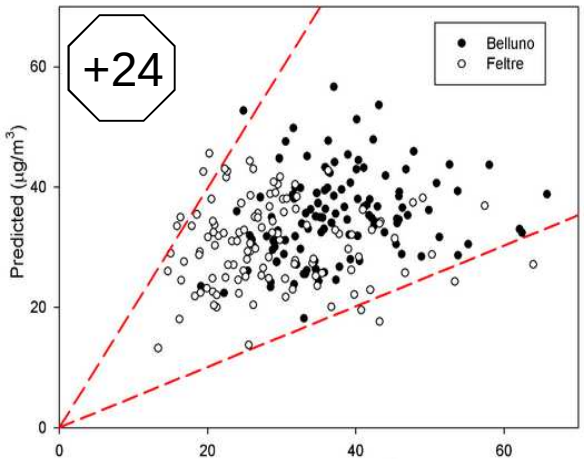
NO_2 hourly averages conc

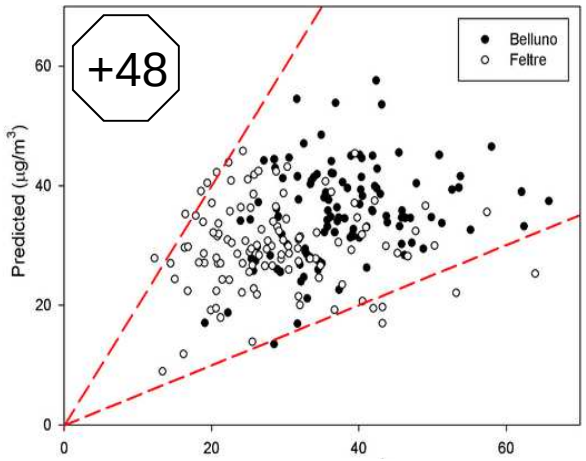




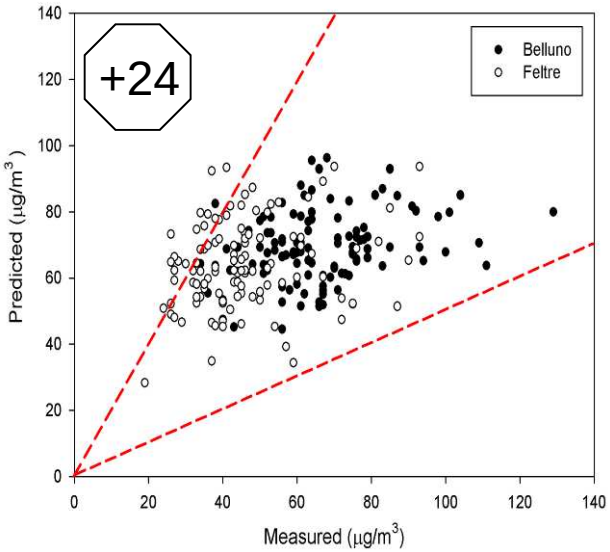
Results/Scatter Plots

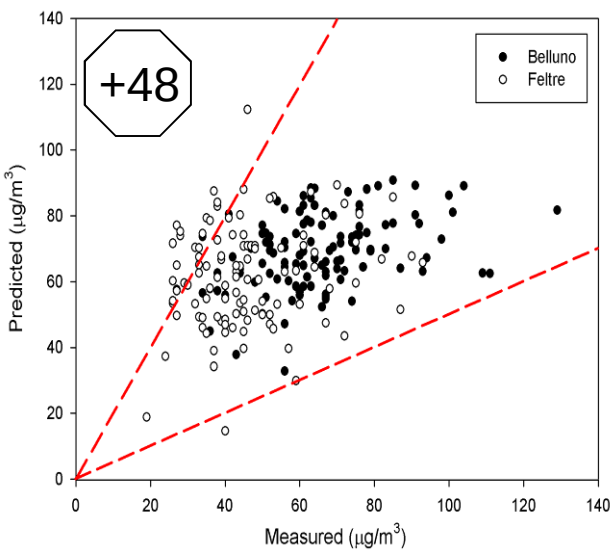
NO_2 daily averages





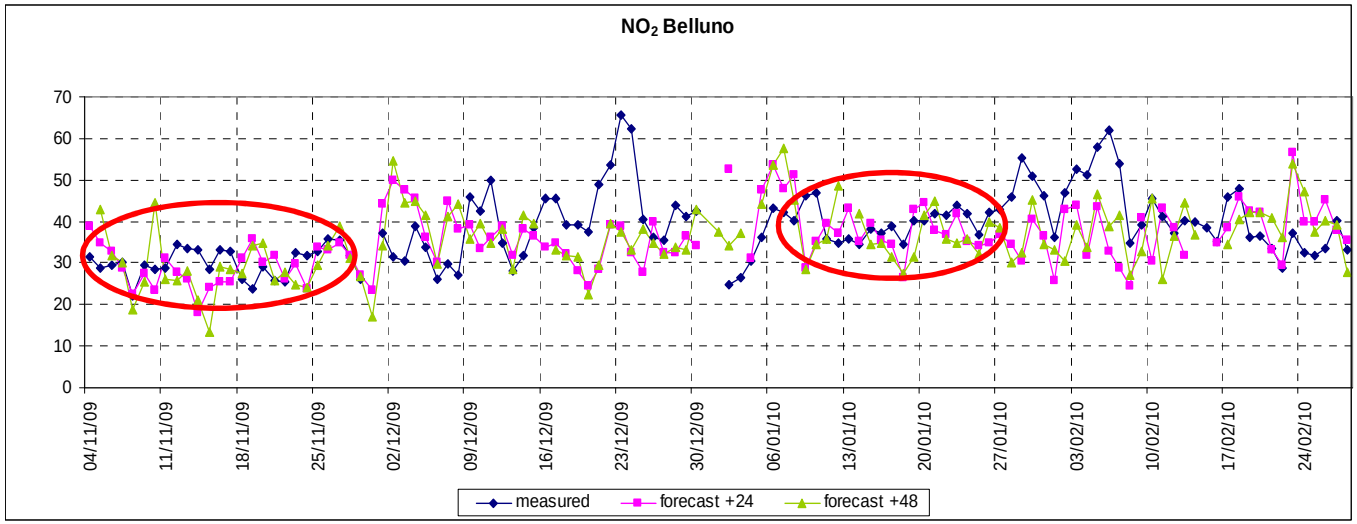
NO_2 maximum daily 1-hour mean conc

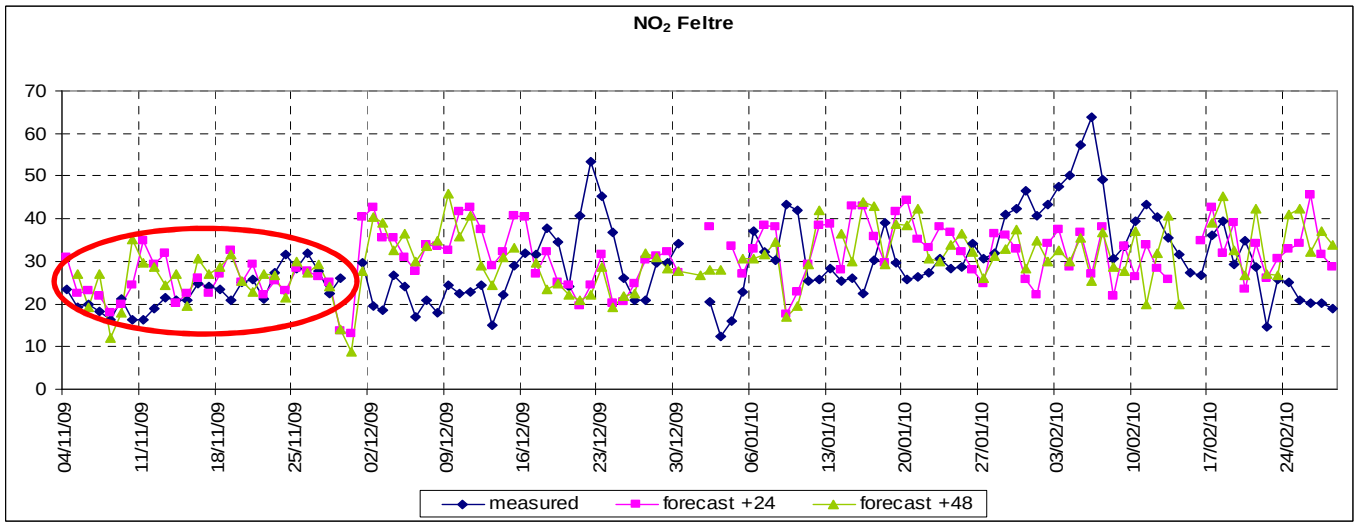




Results/Direct comparison of predicted vs measured concentrations

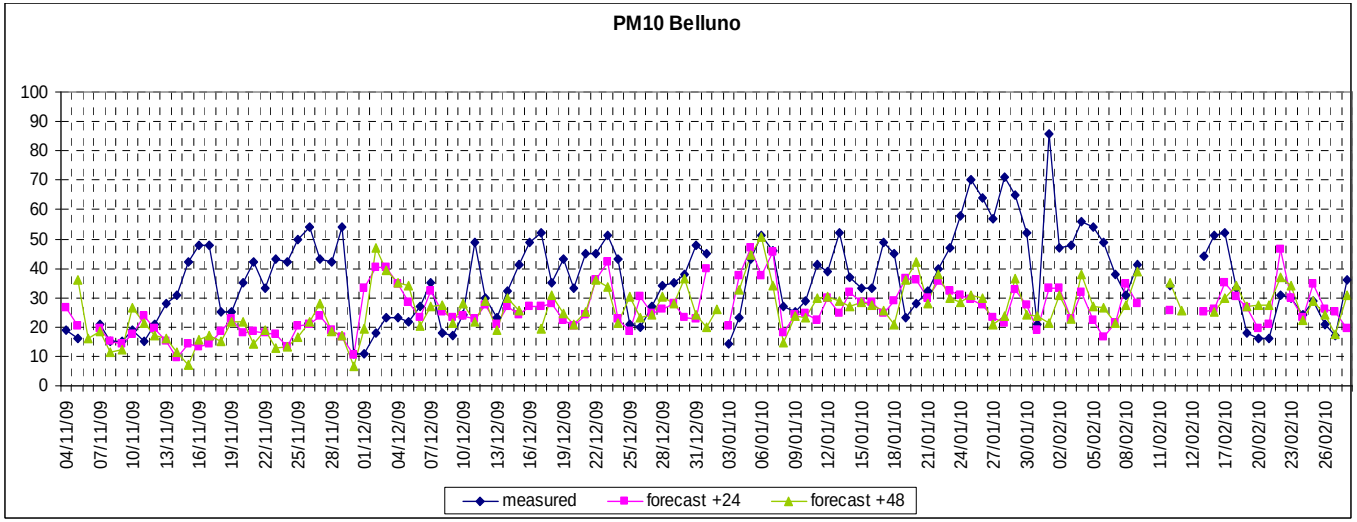
NOV 09 – FEB 10: NO_2

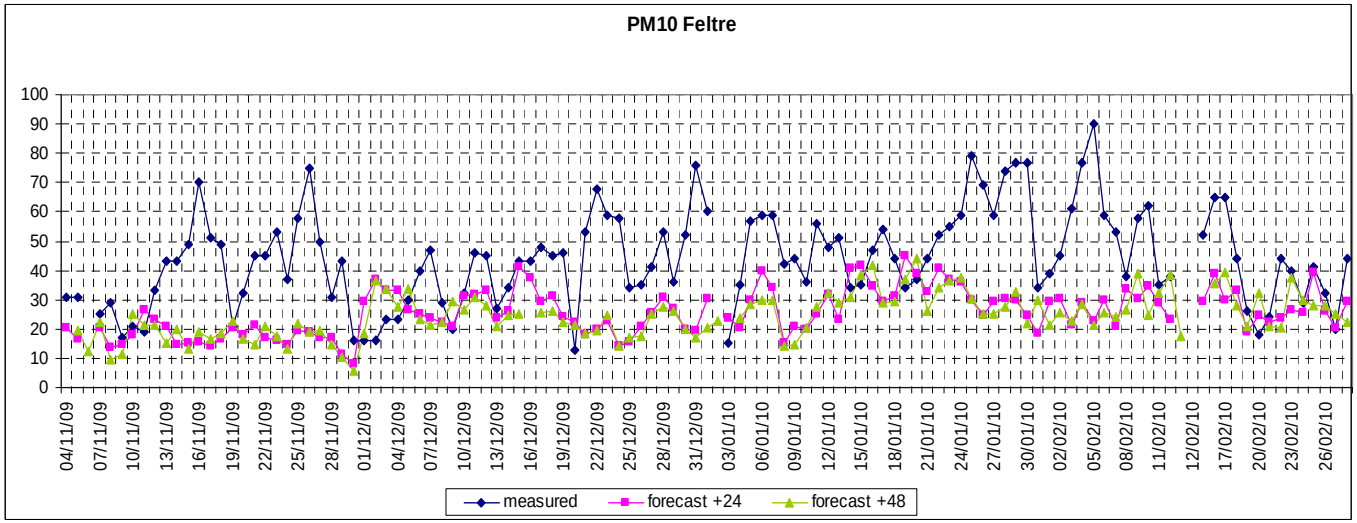




Results/Direct comparison of predicted vs measured concentrations

NOV 09 – FEB 10: PM10

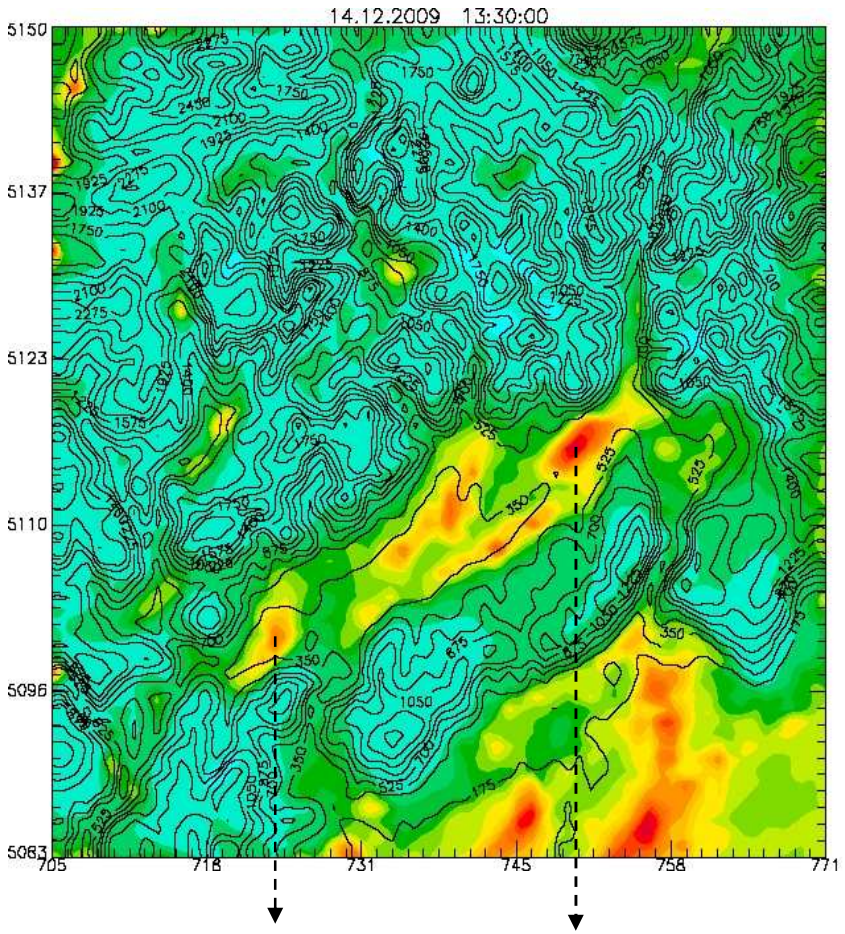




Results/Output maps

- example of the output maps (daily averages): 14 december 2009

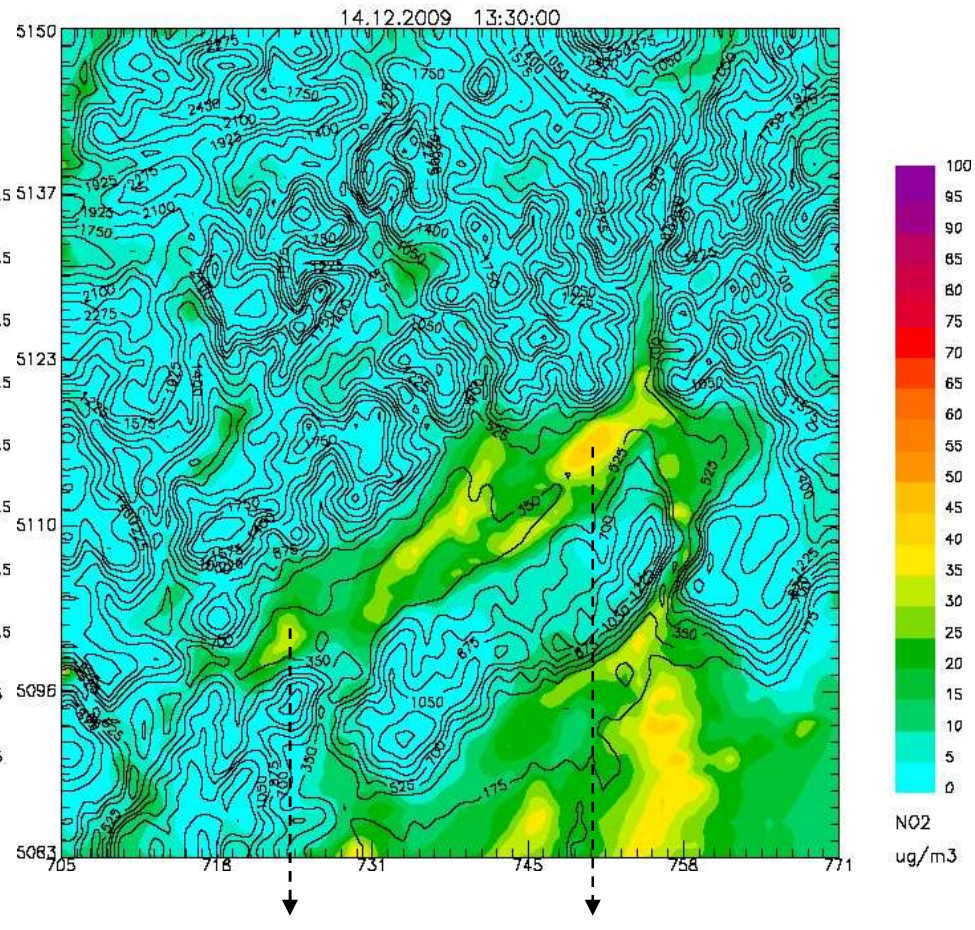
PM10



Meas_Fel: 34 µg/m³
Pred_Fel: 26 µg/m3

Meas_Bel: 32 µg/m³
Pred_Bel: 27 µg/m3

NO_2

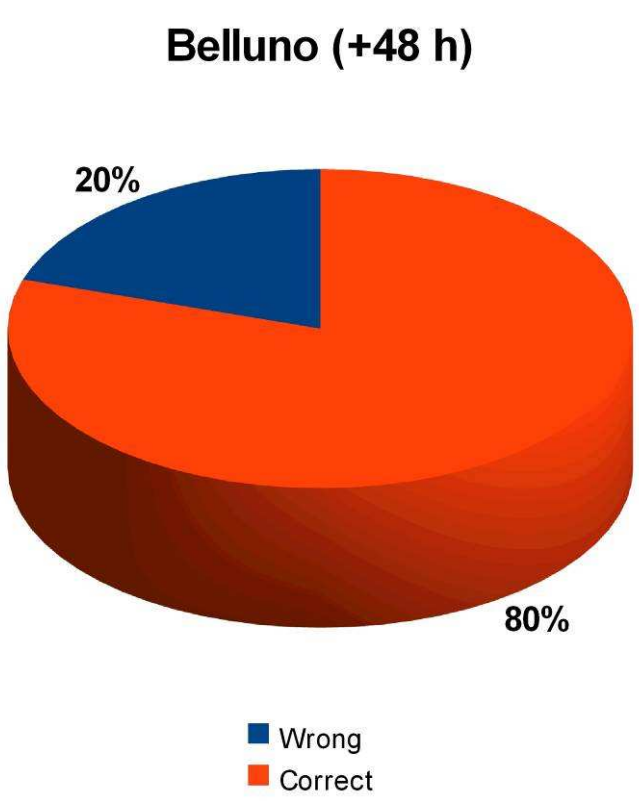


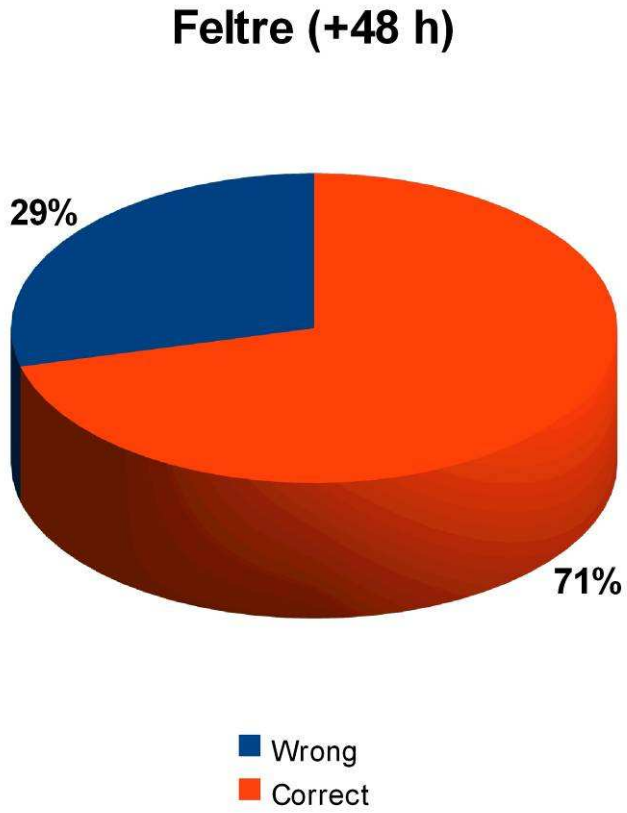
Meas_Fel: 24 µg/m³
Pred_Fel: 32 µg/m3

Meas_Fel: 32 µg/m³
Pred_Fel: 38 µg/m3

The air quality forecasting bulletin:PM10

- ►An experimental air quality forecasting bulletin has been produced for 2 winter months
- ►Used data from sodar and radiometer sited in Feltre and others systems acting on national scale
- ►Good results; 80% cases with a correct forecast for following day in BEL; 71% in FEL.
- ►The most critical episodes to forecast are snowy phenomena: NO uniform behavior
- ►Planned a bulletin in the summer period for O_3





Conclusions

► SKYNET has proved to be an useful tool to increase the knowledge of the dynamics acting in the Belluno Valley

►in the valley meteorological and orographical factors play a determinant rule in the air quality.

►absence of wind associated with a considerable orographic complexity create some criticalities to the model expecially when wind speeds go under 0.3 m/s

►however all the main AQ indicators demonstrate a good performance of modelling predictions in particular fo NO_2

►in particular there is a good agreement between meas. and pred. data in the Belluno station while model reveals the tendency to under-predict PM10 values in Feltre zone

►model and others tools data allowed us to create an experimental air quality forecasting bulletin which gave reliable predictions in the area.

Still going on.....

► Needs more studies for a correct reproduction of major air pollution episodes in the winter

► the implementation of SKYNET is linked to the improvement of accuracy of the meteorological modelling and dispersion parameterisation

► improving our knowledge about snowy episodes, phenomena not so rare in an alpine valley as it is ours.

Thank you for your attention!!

Picture by Federico Costa