Validation of one-year LAMI model re-analysis on the Po-Valley, northern Italy
Comparison to CALMET output on the sub-area of Veneto

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Introduction

This work began as part of the CTN–ACE, year 2004, Task 09.01.04: models observatory with two application on Mediterranean Area (Italy) held by dr. Marco Deserti of ARPA-Meteorological Service of Emilia Romagna (SIM). The Task had the aim to prepare input data (emissions inventory, boundary conditions and meteorology) for an inter-comparison exercise between Quality Air Models and to test a possible operative chain in order to run daily an air quality model for the two areas of Italy: Padan-Adriatic (BPA) and Mediterranean (MED). In this framework SIM made a 1 year LAMI reanalysis, from March 2003 to April 2004. The aim of this work is to verify the quality of the surface wind field output of this reanalysis and to compare it with the one of the CALMET meteorological diagnostic model, currently in use in the ARPA-Veneto Meteorological Centre of Teolo (CMT).

Short description of the LAMI 3.9 reanalysis

Lokal Modell (LM) is a state-of-the-art non-hydrostatic meteorological model; its development started at DWD, and it is now carried on by the Weather Services of Germany, Switzerland, Italy and Greece through the COSMO consortium. The LAMI (Limited Area Model Italy) project is based on an agreement among UGM, ARPA- SIM to produce a numerical forecast based on Lokal Model on Italy; it run twice a day at 7 km horizontal resolution and 35 vertical levels.

This 1 year re-analysis used slightly different settings:

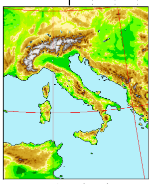
•Initial conditions: the run is a composite of 732 runs, each 12hours long. For each run the upper initial conditions are given by the previous LAMI run whilst the surface condition are given by interpolation of the ECMWF analysis.

•Boundary condition: one way nesting by Davies relaxation scheme; every 6 hours ECMWF analysis on 60 vertical levels and horizontal resolution 0.5°;

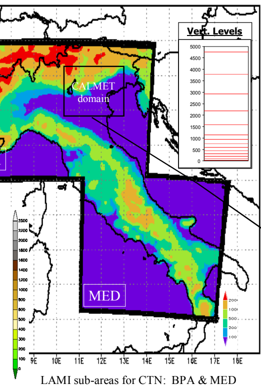
•Data assimilation: nudging of observation (GTS data coming from UCEA for horizontal wind vector, potential temperature, relative humidity, 'near-surface' pressure) in a continuous cycle, with identical analysis increments used during 6 advection time steps. Data are analysed vertically first, and then spread laterally along horizontal surfaces. The balance is achieved between hydrostatic temperature and geostrophic wind increments and 'near-surface' pressure analysis increments.

•Platform: cluster Linux with 12 processors. Total run-time 40 CPU days.

•Resolution: 7km in horizontal, 16 vertical levels.



LAMI domain

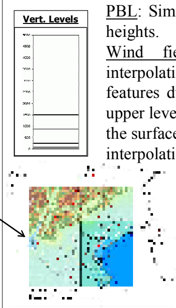


LAMI sub-areas for CTN: BPA & MED

CALMET wind treatment

PBL: Similarity Theory is used to calculate mixing heights.

Wind field: surface field is calculated by interpolating the data, plus taking into account some features due to orography like slope flows. For the upper levels a blend is made with the extrapolation of the surface wind field up to the mixing height and the interpolation of the upper data.



CALMET domain

50x42 grid points Δx=Δy=4km
10 vertical levels up to 3km

CALMET settings at CMT:

Input land stations: 24 CMT, 1 EZI (Industrial site station) and 9 Meteotrentino (red squares), 9 Synop (red diamonds);

Input sea station: off-shore Venice Municipality station (red circle).

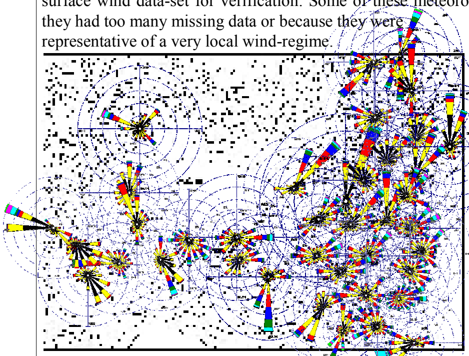
For this application:

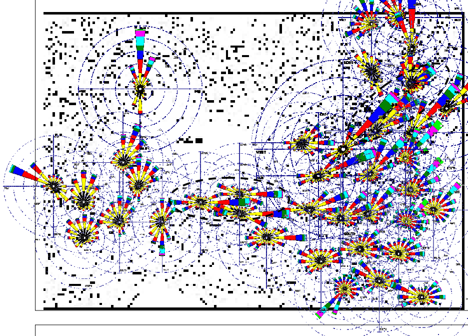
Input data stations: 9 Synop (red diamonds);

Input upper air (radio soundings): 16080 (Milano) and 16044 (Udine).

Data set for verification

The CTN group collected data from different Italian Regional Meteorological Services in order to build a surface wind data-set for verification. Some of these meteorological stations have been rejected because they had too many missing data or because they were representative of a very local wind-regime.



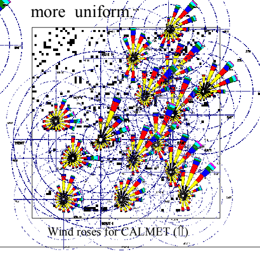


Wind roses for surface stations (⇑) and for LAMI (⇓)

In the left figure most of the selected stations are shown (in Veneto region they are too many to be all shown): the wind rose display allows to reject station with strange behaviour. The Piemonte (PIE) stations are in the WEST, Emilia-Romagna (EMR) in the CENTER and SOUTH, Veneto (VEN) in the NORTH-EAST and are at 10 and 5m (the last are in mountainous regions).

From the bottom left figure is possible to recognise that the LAMI model overestimates the strength of the north-estern wind (Bora) on the EAST-side of the Po-valley (in particular south of the Alps, marked with eastern oval) and also the eastern wind on the northern part of the Appennins (central oval).

As expected the wind field of the CALMET model is much more uniform.



Wind roses for CALMET (⇑)

LAMI and CALMET statistical verification

To evaluate the performance of the LAMI and CALMET wind field we calculated the statistical parameters reported below, where wvc(s,t) is the wind velocity calculated on the station s at the time t (one instantaneous value every hour), wvo(s,t) is the relative observed wind velocity (one hour-average on scalars value), ntot(s) is the total number of observations on station s, σc(s), σo(s) are the standard deviations.

For the wind direction we consider the following statistical indices: %30° and %60° (% cases with wind direction in agreement within 30° and 60°, respectively), also coupled with wind intensity range success (within 0.5 or 1 m/s) as in the Table on the left , last two rows.

DIST takes into account both wind intensity and direction (u(t,s) and v(t,s) being the wind vector components).

Definition of statistics

$$\mathrm{BIAS}(s)=\frac{\sum_t (wv_c(s,t)-wv_o(s,t))}{ntot(s)}$$

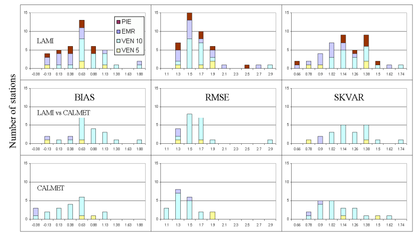
$$\mathrm{RMSE}(s)=\frac{\sqrt{\sum_t (wv_c(s,t)-wv_o(s,t))^2}}{\sqrt{(ntot(s)-1)}}$$

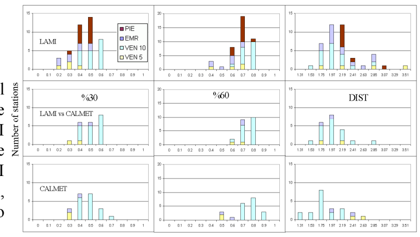
$$\mathrm{SKILL-VAR}(s)=\frac{\sigma_c(s)}{\sigma_o(s)}$$

$$\mathrm{DIST}(s)=\frac{\sum_t \sqrt{((u_c(t,s)-u_o(t,s))^2+(v_c(t,s)-v_o(t,s))^2)}}{ntot(s)}$$

Median of histograms

median value	LAMI				CALMET
	PIE	EMR	VEN	CAL_DOM	
# DATA	8687	8358.5	8746.5	8758	8747.5
MODEL_MEAN	2.15	2.49	2.69	2.61	2.18
STATIONS MEAN	1.71	2.17	1.92	1.92	1.92
MODEL DEV	1.48	1.56	1.70	1.68	1.46
STATIONS DEV	1.21	1.56	1.37	1.44	1.44
BIAS (m/s)	0.52	0.31	0.74	0.69	0.31
FBIAS	0.27	0.13	0.32	0.31	0.14
RMSE (m/s)	1.60	1.44	1.63	1.58	1.40
NMSE	0.68	0.42	0.59	0.51	0.49
SKVAR	1.32	1.02	1.24	1.17	1.03
% SUCC 30°	0.31	0.43	0.42	0.44	0.42
% SUCC 60°	0.52	0.66	0.70	0.70	0.70
R	0.39	0.62	0.65	0.65	0.66
DIST (m/s)	2.13	2.07	2.04	2.00	1.79
% 0.5m/s & 30°	0.16	0.21	0.19	0.20	0.23
% 1m/s & 60°	0.36	0.44	0.41	0.43	0.51

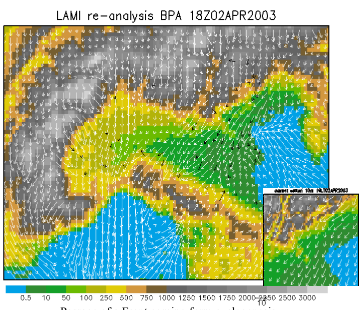




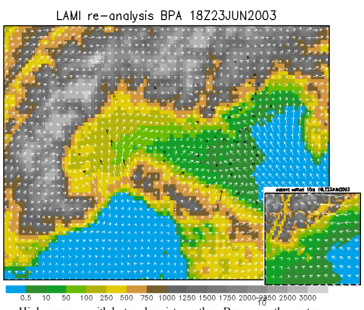
The histograms report the statistical parameter on verification stations: the first set of rows of figures refer to LAMI model, BPA domain (42 stations); the second set of rows refer to LAMI evaluated just on the CALMET domain, to be compared to the third, which refer to CALMET model (21 stations).

Case studies

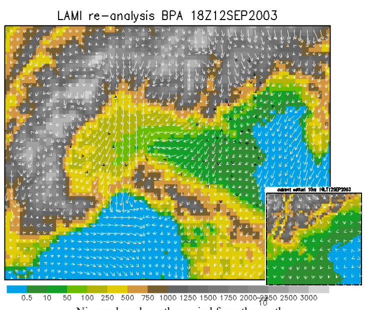
White arrow for model output, black for surface verification stations.



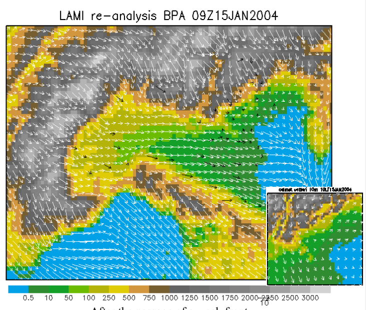
Passage of a Front coming form cyclogenesis on the Ligurian Gulf. Diffuse showers.



High pressure with hot and moist weather. Breeze on the eastern cost and thunderstorms on the north planes.



Nice and cool weather, wind form the north.



After the passage of a weak front, north-westerly winds at all levels.

Conclusions

LAMI model overestimates systematically the wind intensity, especially in the Veneto and Piemonte regions; CALMET performs slightly better on the Veneto region but is still overestimating the wind. This could mean that the surface data set used in both models are not enough representative of the area wind regime, for example they do not describe properly the decay of Bora-wind in the hinterland. The fact that LAMI overestimate the wind more than CALMET, as can be seen by looking at the areas marked with ovals in the LAMI windrose plot, could mean that there is something to be adjusted in the dynamic interaction between wind and sea or orography, or in the boundary conditions. It has to be noted that on Piemonte the correlation (R) and the rates of success (%30 and %60) are particularly poor.