

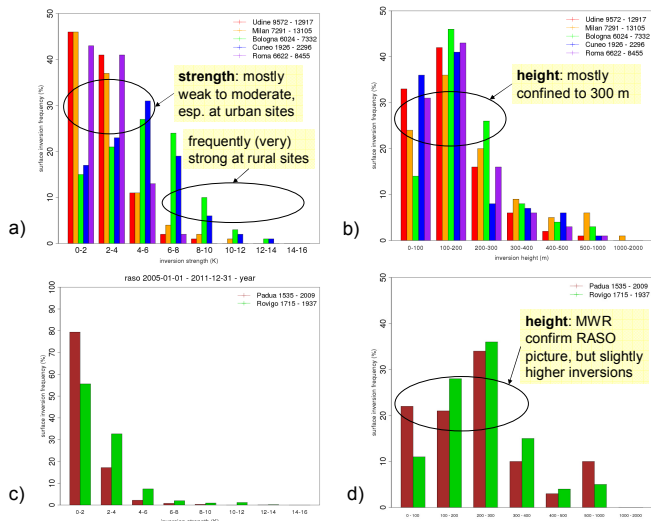
Climatology of the Static Stability of the Night-time Po Valley PBL from Radio Sondes and Passive Microwave Radiometers

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The Po Valley is well known for air quality issues due to scarce ventilation and frequent very stable conditions of the planetary boundary layer (PBL). In this study the static stability and the turbulence conditions of the near surface layer are evaluated based on the night-time radio soundings (00 UTC) for the period 1973-2011, as well as, for the thermal part, on two MTP5-HE microwave radiometers (MWR, profiles from 0 to 1000 m) installed by ARPA Veneto (ARPAV, Ferrario et al., 2006) in 2005. Five radio soundings are analyzed of which only three (Milan, Bologna, Cuneo) are in the Po Valley, while Udine is adjacent and Rome outside of the Po Valley. The resulting average conditions are then set in relation with the average cold season air quality in terms of particulate matter PM10.

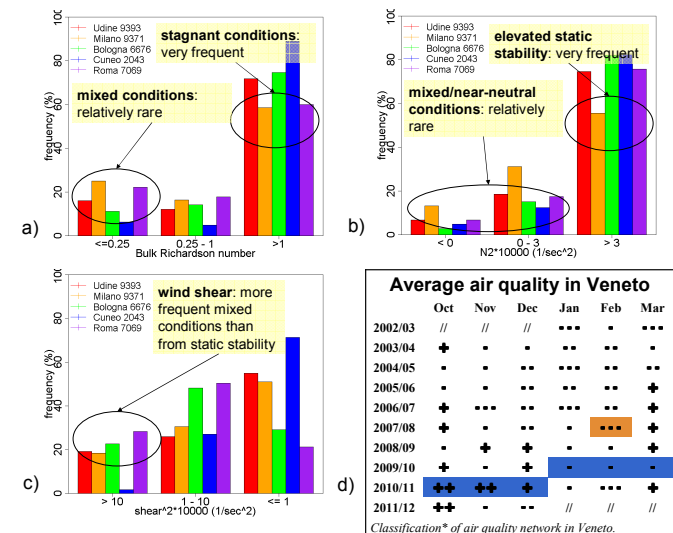
Night-time surface inversion climatology



Distribution of the surface based inversions as seen by the radio soundings in terms of intensity (K, panel a) and height (m above ground, panel b) for the period 1973-2011. Panel c) and d) respectively for the MWRs for the period 2005-2011 (numbers denote presence of surface inversions – available valid profiles).

- > very frequent surface inversions, mostly moderate/weak & confined to 300 m;
- > very pronounced for rural areas;
- > MWR: consistent, but slightly weaker and higher inversions (smoother profile).

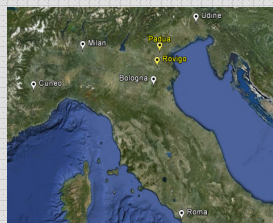
Average air quality explained!



Distribution of near-surface Bulk Richardson Number (1, panel a), static stability (10-4 s-2, panel b), and squared wind shear (10-4 s-2, panel c) as calculated from the radio soundings for the period 1973-2011 (numbers in legend denote available valid profiles). The three classes denote, from the left to the right of each panel, dispersive, potentially dispersive and stagnant conditions. Panel d) represents monthly averaged air quality (see descr.).

- > very frequent stable conditions (stronger than isothermal for values $N2 > 3$), but more frequent conditions of appreciable wind shear, sufficient for mixing;
- > average air quality conditions can be 'explained' by static stability (~70%) and Bulk Richardson Number (another ~20%).

Data set and availability



Code, altitude (m asl), start of operations, and managing institutions of the radio soundings (RASO) and microwave radiometers (MWR) used in this study.

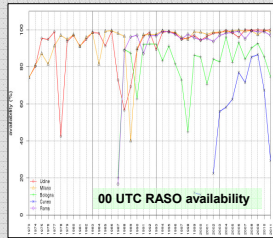
RASO	code	alt	from	Manager
Cuneo	16113	386	1999	ARPA Piemonte
Milan	16080	103	1973	Aeronautica Militare
Bologna	16144	11	1987	ARPA Emilia Romagna
Udine	16044	92	1973	Aeronautica Militare
Roma	16245	12	1987	Aeronautica Militare

MWR	code	alt	from	Manager
Padua	25	30	2005	ARPA Veneto
Rovigo	27	23	2005	ARPA Veneto

Frequency of occurrence of temperature inversions from radio soundings at (sfc) and detached from (up) the surface for less than 3000 m for the entire year (all) and the cold season (cold) for the period 1973-2011, MWRs for the period 2003-2011.

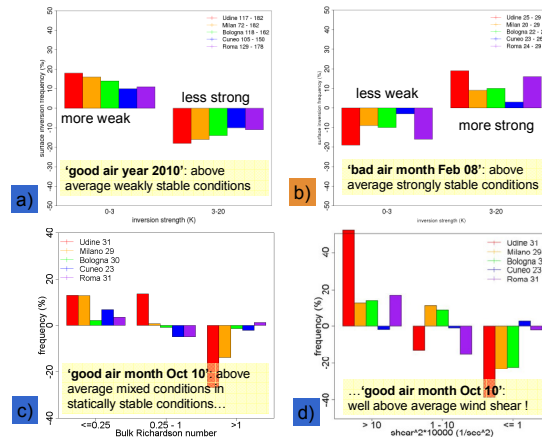
	Cuneo	Milan	Bologna	Udine	Roma
sfc all	82%	54%	81%	73%	77%
up all	9%	25%	14%	13%	14%
sfc cold	81%	57%	72%	73%	76%
up cold	11%	28%	23%	15%	15%

	Padua 25	Rovigo 27
sfc all	67%	79%
sfc cold	66%	71%



- > Radio soundings for station Milan (intra Po Valley, urban) and Udine (adjacent) exhibit good availability (>95% from the '90-ies), while more variable for Roma (extra Po Valley, urban), Bologna and Cuneo (intra, rural);
- > MWR in Padua (intra Po Valley, urban) and Rovigo (intra Po Valley, 'less' urban) robust with availability frequently well above 90% and up to 100%.

Good and bad air quality: illustrative cases



Distribution of the deviation of the surface based inversion strength from the climatology 1973-2011 for the cold season 2010 as seen by the radio soundings (K, panel a), and the partition of weak and strong inversions for the month February 2008 (K, panel b, numbers denote 'surface inversions' – available profiles). Panel c) shows the distribution of the near-surface Bulk Richardson Number for the month October 2009, while panel d) reveals unusually strong wind shear, which counteracted relatively strong static stability conditions (not shown).

- > periods with good/bad air quality feature below/above average stagnant conditions;
- > good air months with statically stagnant conditions often feature above average near-surface wind shear.

Summary of findings and conclusions

An almost 40-year climatology for the near surface night-time Po Valley PBL as derived from the 00 UTC radio soundings was presented, compared to MWR retrievals, and set in relation to average cold season air quality (AQ) conditions. The main findings are:

- > very frequent weak to moderate (0-4 K) surface temperature inversions confined to 300 m;
- > rural inversion strengths up to 14 K not unusual, less strong and less confined in urban areas (urban heat island?);
- > good correspondence with MWR retrievals, which yield slightly weaker and higher inversions (smoother profiles);
- > very frequent stable conditions which correlate well with the monthly averaged cold season AQ conditions.

The 00 UTC soundings seem to represent the average cold season air quality, so that is approach is a candidate method for AQ assessments for Climate Change scenarios. Future work comprises analysis of the 12 UTC radio soundings.

References
 Ferrario M.E., Pernigotti D., Rossa A.M. and Sansone M., 2006: Presentation and first assessment of a radiometer network in the Italian region Veneto. Proceedings of the 6th ICUC, International Conference on Urban Climate Göteborg, Sweden

* If the median of the station-averaged monthly distribution was >1.5 or within (1.25-1.5, 1.0-1.25), or (1.0-0.75, 0.5-0.25) times the EU limit of 50 µg/m3 the air quality was defined respectively as ('bad' (**), or 'poor' (→ or -), or 'good' (+ or ++)). All the 54 cold season months since 2003 (availability of air quality measurements) were so classified and related to the near-surface temperature and wind shear conditions (see extended abstract for details).