ROADIDEA

FOG PILOT

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The combined Fog Monitoring System over the Veneto Region – Italy

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The FP7 project **ROADIDEA** studies the innovation potential of the European ITS sector. In this framework the **Fog Pilot**, is aimed to construct and test a fog monitoring system combining real-time satellite images and surface reports; a verification of the final products was performed, obtaining the first issues with the data of the winter 2009-2010.

Fog in the Po Valley

The presence of fog is a frequent phenomenon in the Po Valley (up to 80-120 days per year), with consequent strong impact on road, air, ship and railway traffic, by dangerous reduction of visibility.

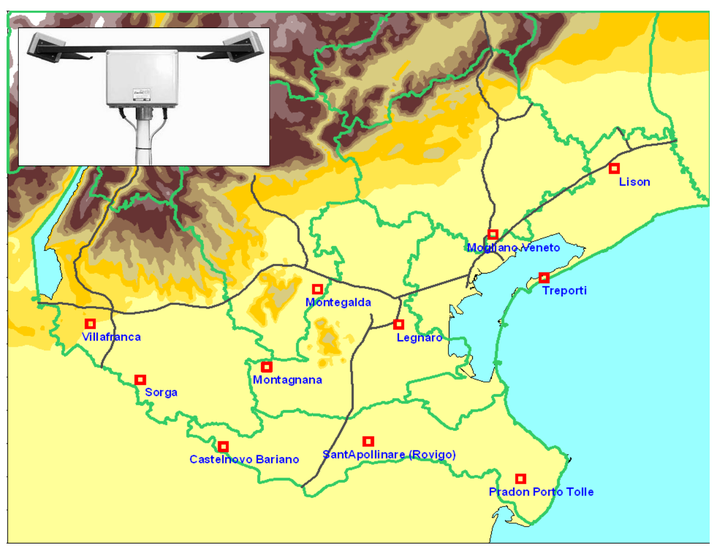
Objectives of the ROADIDEA Fog Pilot

The main objectives of the ARPAV Fog Pilot in ROADIDEA are:

- to set up a cost effective, areal fog monitoring system for diagnosing reduced visibility conditions over an extended geographical region as alter-native to the expensive only in situ monitoring;
- set up a network of direct visibility sensors, working in real time, and relatively dense in comparison to SYNOP and METAR;
- set up of an information model to merge direct and indirect visibility information derived from satellite and meteorological surface stations;
- maintain open architecture to allow integration of complementary and innovative data sources for visibility (reports, intelligent cars, webcams, etc.).

The network of visibility sensors

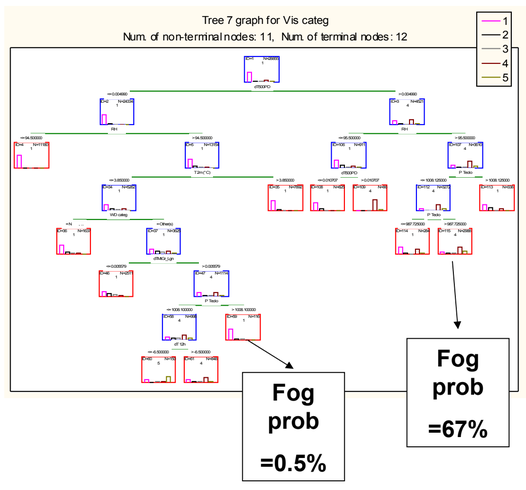
For the ROADIDEA Fog Pilot a network of 10 visibilimeters was installed. The siting is limited to the Veneto plain, most prone to intense and persistent fog. Visibilimeters provide direct visibility measures which then are converted in a probability of fog (reduced visibility conditions) for merging with other data sources.



Visibility sensors (red boxes) used in the visibilimeter network for the Veneto Fog Pilot.

Surface data statistics

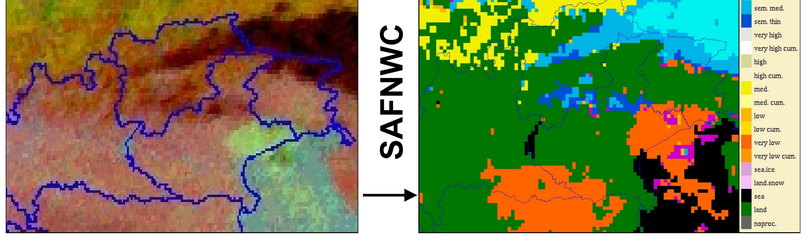
The data obtained from the automatic surface meteorological stations network yields another, indirect probability estimate for fog occurrence based on current meteorological conditions by applying a statistical decision tree methodology (CART).



The decision tree obtained with the CART analysis allows us to derive a fog probability depending on the meteorological conditions (temperature, wind, humidity etc.) recorded by the ground stations. The fact that this method very rarely gives high fog probabilities limits its value in comparison to the other methods used in the Fog Pilot.

SAFNWC Cloud Type

The METEOSAT satellite images have the potential to provide areal fog information and were used to aid the spatial interpolation of the direct visibility measurements. The satellite information was processed by cloud classification algorithm of the Satellite Application Facility Nowcasting (SAFNWC), a software system developed over the last 13 years by a consortium of European national weather services.



METEOSAT Satellite image.

Cloud Type product derived by the SAFNWC software package.

The cloud classification obtained by SAFNWC provides and information that can be divided into 3 classes: clear sky, overcast (medium-high coverage), low or very low clouds. To each class a value of probability of reduced visibility (under 500 m) was empirically assigned. The probability values were verified only a posteriori; for example a probability of 70% to have reduced visibility was assigned, in case of low or very low clouds estimated by SAFNWC Cloud Type product; verification reveals an overestimate of the fog probability. This empirical choice will be substituted by more complete statistical analysis once an sufficiently long data set (few year) will have be collected.

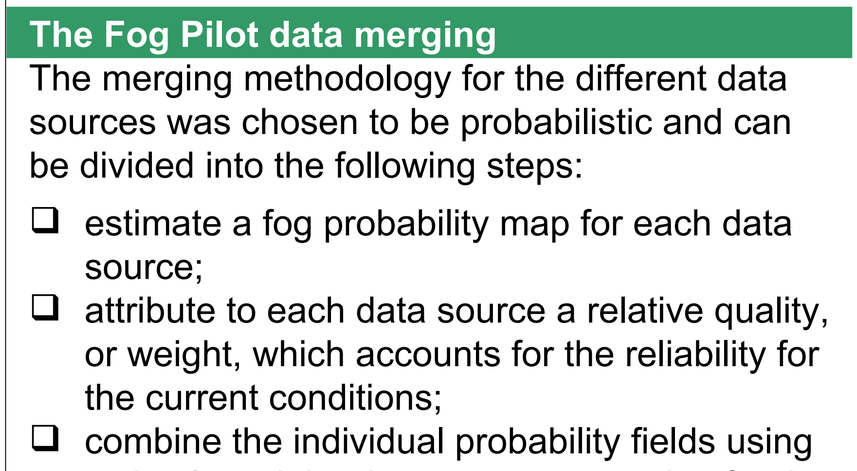
The Fog Pilot data merging

The merging methodology for the different data sources was chosen to be probabilistic and can be divided into the following steps:

- estimate a fog probability map for each data source;
- attribute to each data source a relative quality, or weight, which accounts for the reliability for the current conditions;
- combine the individual probability fields using a simple weighted average, accounting for the relative data quality of each field :

$$P(x,y) = \frac{\sigma_{sat} \cdot w_{sat}(x,y) \cdot P_{sat}(x,y) + \sigma_{vis} \cdot w_{vis}(x,y) \cdot P_{vis}(x,y) + \sigma_{cart} \cdot w_{cart}(x,y) \cdot P_{cart}(x,y)}{\sigma_{sat} \cdot w_{sat}(x,y) + \sigma_{vis} \cdot w_{vis}(x,y) + \sigma_{cart} \cdot w_{cart}(x,y)}$$

***The final product** consists in a probability map of reduced visibility, which can yield fog alerts based on selected thresholds (e.g. 40%).*



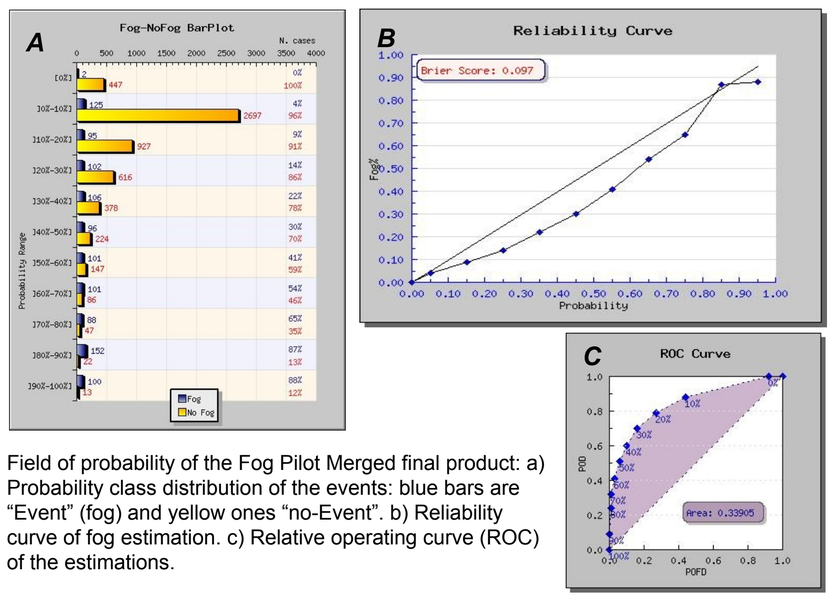
The output product of the Fog Pilot: on the left side the three products derived from single monitoring methods, while the large frame represents the merged final product. In each map the fog information is represented by the probability of having visibility under 500 meters.

Real time images are available at the address: http://85.42.129.76/ROADIDEA/

Verification of fog probability product

In order to verify the skill of the system in detect fog, in particular in area away from visibility meters, a cross validation on the product and a comparison with direct observations were performed, for the period 09/2009 - 02/2010. The following statistical indices and methods were used:

- reliability diagram: compares the probability estimates with the effectively observed fog frequency given the probability estimate;
- probability of Detection (POD), probability of False Detection (POFD, i.e. false alarms) and ROC curve diagram (ROC area);
- "TOTAL COST" (lower is better), or the directly derived "Economic Value" (higher is better), here calculated for a c/L ratio of 0.2.



Field of probability of the Fog Pilot Merged final product: a) Probability class distribution of the events: blue bars are "Event" (fog) and yellow ones "no-Event". b) Reliability curve of fog estimation. c) Relative operating curve (ROC) of the estimations.

	never	always	CART	SAF	VIS	MERGED	VENICE
BEST POD	0	1	0.52	0.43	0.76	0.73	0.76
BEST POFD	0	1	0.23	0.008	0.22	0.18	0.05
COST (L)	1	1.2	0.8254	0.74	0.6229	0.6049	0.4544
economic value	0	-20%	17%	26%	38%	40%	55%

Comparative table of the performance indices between the individual components and the merged Fog Pilot product; the reference values are the absence of action (never protect) and the maximum of the security (always protect). Last column "Venice" is referred to the value of the merged product with reference to the webcam observation in Venice city.

Conclusions

The main results of the ROADIDEA Fog Pilot can be summarized as follows:

- a probabilistic areal fog monitoring system has been built using a limited number of visibility sensors, a satellite cloud classification system and a meteorological surface station network;
- probabilistic verification of the Fog Pilot shows good performance with a probability of detection of about 75%, probability of false detection of about 10%;
- most value to the final product is brought by the direct visibility measurements, whereas the satellite information brings added value for the spatial interpolation; the contribution of the meteorological stations has yet to be established more rigorously;
- to the knowledge of the authors, the Fog Pilot constitutes the first attempt of an areal combined fog monitoring system, at least for road transport purposes, and has the potential to give a significant support for accident prevention and traffic management.

ARPAV (Regional Agency for Environmental Prevention and Protection of Veneto) is the regional meteorological service of the north-eastern Italian region Veneto. ARPAV is a partner of ROADIDEA Project (www.roadidea.eu)

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