SATELLITE WINDS CALCULATED AT INM AND ITS POTENTIAL USEFULNESS FOR THE OPERATIONAL FORECASTER

J. M. FERNÁNDEZ SERDÁN, F. MARTÍN LEÓN

Instituto Nacional de Meteorología (INM)
Apartado 285
28071 Madrid, Spain

ABSTRACT

Besides the Cloud Motion Winds calculated by Eumetsat and NOAA, and available through the GTS, winds of this kind are extracted at INM from Meteosat loops. providing much more winds in the area of interest (because from all 3 channels including WV tracers in clear air, and higher spatial resolution and frequency), even if not at the same high level of quality.

The basic procedure has been developed and improved, with increased automatic quality checking combining wind-by-wind criteria and local comparisons of winds of either channel.

This dataset with the adequate tools is used in operational forecast, as a help to the diagnosis, thus aleviating the scarceness of wind data, particularly over sea. Examples of the comparison with other sources of information (satellite imagery, conceptual models, NWP models, etc.), providing the forecaster with a better 4-dimensional atmospheric picture, are presented.

1. INTRODUCTION

The Satob winds from Meteosat images, currently generated by Eumetsat, following ESA methods and experience, and widely distributed via GTS, have been regularly improved and reach a high quality (often considered as the best Satob source).

In SAIDAS, basic McIDAS algorithms (developed by SSEC, University of Wisconsin) (Suomi, 1983; Hayden, 1988) are available; even if advanced at its beginnings, these have little evolved in the recent years, and objective quality of the winds is certainly not as good as for Satob (in the height asignment rather than in the wind itself). But it allows for specific developments; in our case, more winds (higher frequency, better spatial resolution, use of all channels, for even higher latitudes, and not limited to cloud tracers) are calculated for a limited area. Other developments include an improved final selection (deletion, corrections, flagging), and an *a posteriori* evaluation (comparisons, statistics), all the procedure being automatic. Furthermore, the interative tools already available in McIDAS have been improved and enhanced, allowing wider access to these and other similar data in a friendly manner.

2. PROCEDURE

A first adaptation of McIDAS algorithms has been running routinely since 1992, at the beginning basically for IR images. The complete procedure was in place in mid-1995; it is called VDI (Spanish acronym for Drift Winds from Images); its first part is similar and independent for each of 2 or 3 channels, using mainly the basic algorithms; a second part considers all channels at once (most of the new developments are in this last part).

2.1. BASIC ALGORITHMS AND OPTIONS

The tracers are squared boxes (20 to 26 pixels of side) of the initial image in a sequence of 3, inside each box a gradient of at least 10 brightness values in a 3-pixel distance must be found, brightnesses falling in a predefined range; otherwise, a new attempt is done at a distance half the side of the box. The level is calculated from interpolation to Spanish HIRLAM model output (Díaz-Pabón, 1996) of a significative temperature (from coldest class in a histogram of pixels, IR used if not the WV process); below 700hPa an average level (considering also warmest pixels) is taken. The tracking algorithm is a cross correlation; initial search centre is given by the forecast (second image), and the previously calculated wind (third image); final average of 2 succesive winds, representing an 1-hour interval, will be retained.

The complete procedure is run 8 times a day, with central images corresponding to the synoptic hour at each time for each channel. The area considered is most of the Meteosat B-format.

2.2. WINDS IN EACH CHANNEL

As stated, the first part of the procedure are independent processes for IR, VIS (diurnal), and WV.

The IR process is the basic one: any level or time, day and night. But it is not providing a high number of winds at each time, and a too low level is assigned to semitransparent cirrus.

VIS process starts from normalized images (Sun as at zenith; Binder, 1989), at the better resolution. Higher density of winds is so obtained, particularly at low levels. Problems are the effect of different sun angle, even if normalized images (e.g. shadows with low Sun), ground or landmarks considered as tracers, and the need to use IR channel (coarser resolution), for level assignment.

WV process uses linearly enhanced (in brigthness) images, for a better contrast; tracers and winds are related both to high (and even medium) cloudiness, and clear air at medium or high levels (water vapor tracers): the former are giving good winds and level assignment; the later are less frequent and less quality in both aspects: the tracer has actually a thickness, with variable contribution of several layers); but are of the great interest in areas without clouds at high or medium level (level is assigned from the WV brigthness temperature).

2.3. FINAL SELECTION

Each tracer provides 2 succesive winds (then averaged), if maxima of correlation are obtained in 2nd and 3rd image; then are deleted those with: difference too high between the 2 winds (more than 10m/s in either component); calm or very weak wind over land (excluding the plains), below 500hPa; temperatures not coping with the forecast profile; very poor (or too fine) correlation, these criteria being more stringent if cases when the difference between succesive winds was significant (5 to 10m/s in either component).

Each wind selected is then compared to anyone close enough (.75 degrees in latitude and longitude), considering as criteria whether is there a significant difference in succesive winds, and the correlation value. A final flag is assigned, varying from 0 (wind better than someone close, similar, with successive winds a1so similar), to 5 (significant difference between succesive, and could not be compared in the vicinity). Only when being the worst in any comparison, or almost coincident with a better one, are the winds rejected in this phase.

WV winds are only compared to IR or VIS above a level (currently 350hPa), where the tracer is probably high cloud. In this case if the winds are not very different, the WV level if clearly higher is adopted by both (the tracer being certainly the same, composed of semitransparent cirrus). The threshold, chosen empirically, has been giving good results, but is nevertheless subject to further revision.

2.4. OBJECTIVE EVALUATION OF RESULTS

Included in the procedure, is two-fold; on one hand, the results are compared each 6 hours to the interpolated analysis of LAM-INM, and statististics (Willmott, 1985) are computed separately over 2 large areas, the first over the Atlantic (where more and better winds are obtained), the second rather continental (where the observational coverage, and hence the analysis, is better).

On the other hand, comparisons with upper air observations are performed and stored: winds at the closest main level in the case of radiosoundings, or at a level different in less than 150hPa if measured from aircrafts, the vicinity criterion being .5 degree in latitude and longitude. The statistical evaluation of these comparisons is done monthly, seasonal (totals, and 3 intervals of level), and will be done for the year (intervals of level, and level and speed).

2.5. INTERACTIVE ACCESS TO THE DATASET

With tools adapted from McIDAS or newly developed in SAIDAS a good and quick access to this data is allowed: display, grid generation (optionally with filters, or a guess), local listing of wind and auxiliar information, comparisons with a reference, and other. These are generally used in combination with Meteosat images, and with other wind data -Satob included- also accessed by these tools.

3. CONSIDERATIONS ON RESULTS

The procedure is generally able to get good coverage and consistent results in most areas with potential difficulty: very close winds at fairly different levels (2 systems of cloudiness, or clear air above low clouds), or from different channels. Results are sometimes not so good: erroneous level for some semitransparent cirrus (IR winds), some doubtful tracers and winds near the ground. Some zones remain poorly covered: because of little contrast, not very defined contours, or changes in the tracer, no winds are found (this is particular where only relying on water vapor features in WV channel).

3.1. STATISTICAL RESULTS

The comparisons with observations of reference could easily be accesed on SAIDAS, and could help to estimate the local validity of recently calculated winds. They are also providing statistics, and hereafter are presented some significative monthly and seasonal results for the comparison with radiosoundings at 12z:

MONTH	N. cases	Mean spd(ref) (m/s)	BIAS (m/s)	RMS vect (m/s)	RMS spd (m/s)	Corr. regr	Err. dir (deg)
August/95	291	10.5	-1.0	6.4	4.9	.83	26.9
Mars/96	269	11.2	-1.2	6.6	4.7	.82	29.5

No important difference from a given month to another is observed (and is partly due to differences in wind speed). Globally the winds result slightly weaker than those of reference (negative *bias*).

By season, statistics by intervals of level are also available:

	N. cases	Mean spd(ref)	BIAS	RMS vect	RMS spd	Corr. regr	Err. dir
Summer 1995:							
1000-700hPa	461	6.7	-0.1	6.3	5.0	.52	37.8
699-400hPa	96	13.3	-1.8	6.3	4.9	.79	17.6
399-100hPa	272	16.6	-1.7	7.2	5.7	.84	17.4
Winter 1995-96:							
1000-700hPa	333	8.4	-1.2	6.2	4.7	.65	32.2
699-400hPa	181	13.9	-1.8	7.3	5.9	.75	20.6
399-100hPa	236	21.0	-2.1	8.2	6.5	.86	16.0

The tendency to calculated winds slower than observed is evident at high and medium levels; this is a known fact (Woick, 1991), but here perhaps more important, in particular at medium levels, where certainly a too low level is often assigned to water vapor tracers. It is consistent that the error (RMS) increases for high level, while the absolute error in direction is higher at low level (particularly in summer), with weaker (and more variable) winds. The error seems in any case generally acceptable.

The statistics of the comparison with the analysis of the Spanish HIRLAM model are presented here with an example for the 22th May 1996 at 0z and 12z:

AREA	N. cases	Mean spd(ref)	BIAS	RMS vect	RMS spd	Corr. regr	Err. dir
Analysis 0z:							
N. Atlantic	118	15.4	1.1	5.8	4.6	.87	14.8
Europe&Med	117	18.3	0.0	8.7	6.9	.77	22.0
Analysis 12z:							
N. Atlantic	265	12.8	0.5	5.2	3.8	.89	19.6
Europa&Med	173	11.1	-0.1	6.4	5.1	.80	20.3

At 0z, the small positive bias over the Atlantic (not the usual tendency), seems indication of Model analysis giving winds slightly slower than real; while the bigger error in the European and Mediterranean zone reflects not only the expected worse global quality of VDI winds there, but also the higher mean speed. At 12z, the error (and the mean strength of wind) decreased, more comparisons being available from the contribution of the VIS (mainly at low and medium levels and over sea); despite a maybe too high error for the VDI winds over land, and a small *bias* of analyzed winds over sea, the 2 datasets are globally not very different, good indication for both.

4. APPLICATION TO DIAGNOSTICS: EXAMPLES

High level (above 400hPa, in black in the figures), and also medium level winds (400 to 700hPa, in white), are been used in operational diagnostic of the atmosphere in close connection with other data available, and WV imagery:

4.1. SUPPORT TO WV IMAGE INTERPRETATION

In the middle of 2 active systems (a cold front with important cold air mass on the Atlantic, and a cut-off low in the vicinity of Africa), a band of cloudiness and humidity is located. Before the analYsis of LAM is available, the VDI winds could confirm the existence of a wind shear with not very strong winds (30-40kt), associated to this band.

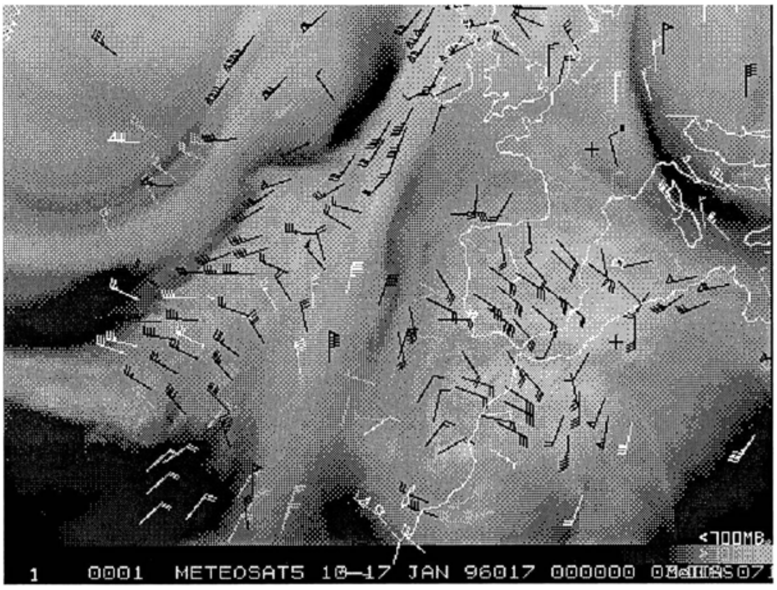
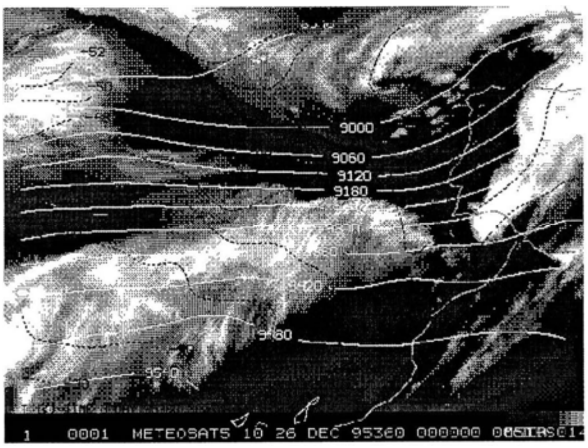
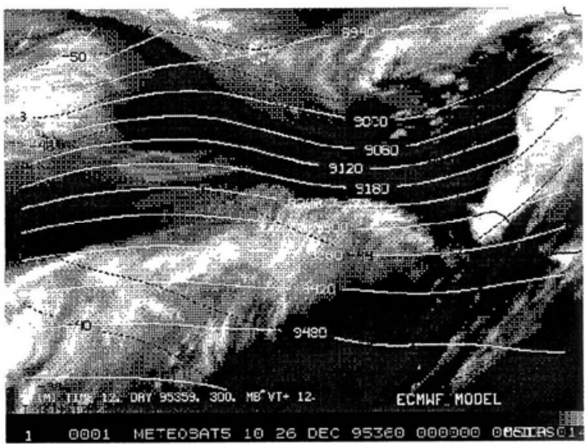


Fig. 1: VDI winds, WV image, 17-Jan-96/0z

4.2. VALIDATION AND ASSESSMENT OF MODEL OUTPUT





Figs. 2 and 3: LAM analysis; forecast ECMWF (+12h), 300hPa. Image WV, 26-Dec-95/0z.

In the 2 last weeks of 1995, the presence of strong zonal circulation over the Atlantic produced, when interacting with a polar low at the NW of the Iberian Peninsula, repeated episodes of persistent and intense rains over its west half. These situations (where both polar and subtropical circulations were involved), have not been satisfactorily resolved by the Models. In the example, the ECMWF (+12h) only reflects intense circulation at 300hPa, with an advective jet which could result in a deepening of the trough W of the Peninsula; while the LAM-INM analysis shows a more complex structure and a more channelled polar circulation.

Figs. 4 and 5: VDI winds on 0z WV image; WV image at 3z. 26-Dec-95.

The distribution of VDI winds was in the way of confirming LAM analysis, and cou1d be qua1itetive1y used to accomodate in mind a conceptua1 model; 3 hours later, the system apparently traslated without deepening only suggested by ECMWF forecast.

4.3. LIMITATIONS IN THE APPLICATION

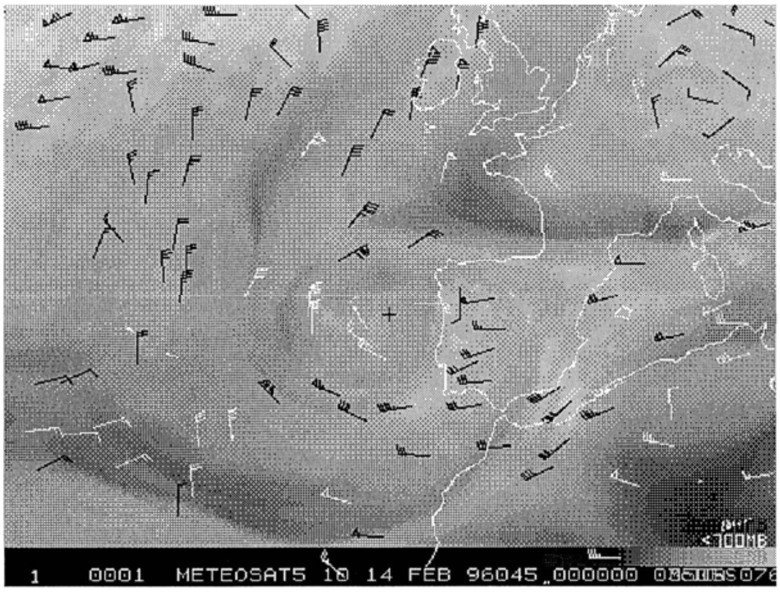


Fig 6: VDI winds on WV image. 14-Feb-1996/0z

In this case, the WV image shows, downstream the axis of the ridge over the Atlantic, an elongated maximum of vorticity by wind shear; the winds do not give a good information of this, partly because there are scarce data in the zone, due to difficulties for identification and tracking of water vapor structures (there is no high or medium level associated cloudiness). The Model did not provide a good identification (position and shape) of this maxima, either.

5. CONCLUSIONS

The VDI winds constitute a dataset of interest for diagnostics, at medium and high levels; a most complete and regular coverage would be of interest. Development of applications of low level winds in this context has to be undertaken, and should also be studied the possibilities offered in the future by Meteosat: winds from high resolution VIS and multichannel capability. The use of these winds in the Spanish HIRLAM Model assimilation is also been developed.

The results are globally of acceptable quality, still with a reduced number of suspect or at least partially erroneous winds; these should be deleted or modified, this is not possible in the current fully automatic procedure. An automatic semitransparency correction could also be considered to correct some of these.

The procedure adds information to that from Satob and other wind data; it could certainly be still useful in the future, with reasonable evolution taking into account all that is, or will be, available: well proven operational algorithms, next satellites, improved Satob follow-on information. Is also needed a deeper knowledge on what will be required or of interest from the users' point of view (applications, mainly in the field of diagnostic and nowcasting).

6. BIBLIOGRAPHIC REFERENCES

BINDER, P.,1989. A Normalization Procedure for METEOSAT Visible Channel Data. J. Atm. Ocea. Tec., Vol. 6, Feb. 1989, pp. 67-75.

DÍAZ-PABÓN, R., Limited Area Model at Spanish Meteorological Institute (I.N.M.). LAM Newsletter. European Working Group on Limited Area Modelling (EWGLAM), Num. 25, May 1996.

HAYDEN, C.M., AND MERRILL, R.T., 1988. Recent NESDIS research in wind estimation from geostationary satellite images, 1988 ECMWF Seminar Proceedings, Vol. II, pp 273-293.

SOUMI, V.E., FOX, R., LIMAYE, S.S., and SMITH, W.L.,1983. McIDAS III: A Modern Interactive Data Access and Analysis System, J. Clim. Appl. Met., Vol. 22, 5, pp 766-778.

WILLMOTT, C.J., ACKLESON, S.G., DAVIS, R.E., FEDDMA, J.J., KLINK, K.M., LEGATES, D.R., O'DONNELL, J., and ROWE, C.M., 1985. Statistics for the evaluation and comparison of models, J. Geoph. Research, Vol. 90, 5 pp 8995-9005.

WOICK, H., 1991. Verification of cloud motion winds. 1991 Wind Workshop Proceedings, pp 127-131.