Oceanographic conditions during the Wind and Salinity Experiment 2000 and 2001, NW Mediterranean Sea

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INTRODUCTION

Unlike other oceanographic parameters (temperature, ocean colour, sea surface height, surface winds) until now no space mission had been attempted to determine sea surface salinity, a key parameter to understand the global ocean circulation and the role of the ocean in the Earth's climate. This was due to the technological challenge in building and flying an instrument capable of doing so, in spite of the measurement principles being known for a long time. Sea surface salinity can be measured by passive microwave remote sensing at L-band: this reserved frequency band (1400-1427 MHz) is a compromise between the sensitivity of the brightness temperature to the salinity, small atmospheric perturbation, and reasonable pixel resolution [1]. To provide global coverage measurements of ocean surface salinity and soil moisture with a three-day revisit time the European Space Agency (ESA) selected in May 1999 the Earth Explorer Opportunity Mission SMOS (Soil Moisture and Ocean Salinity) to be launched in 2006 [2]. Its payload is MIRAS (Microwave Imaging Radiometer by Aperture Synthesis), a new polarimetric two-dimensional synthetic aperture radiometer based on the techniques used in radio-astronomy to obtain high angular resolution maps of the sky [3].

The radiometer measures the brightness temperature emitted by the Earth, the product of the physical temperature of the pixel being imaged and the surface emissivity that depends on the incidence angle, the polarisation of the wave, the sea surface salinity and temperature, and the surface roughness. MIRAS has a two-dimensional field of view and images pixels under a wide range of incidence angles: in SMOS from 0° at nadir to approximately 60°, which translates into a brightness temperature range over the ocean at vertical and horizontal polarisations from 50 to 150 K with a small dependence on sea salinity and wind speed.

The measurement of the sea surface salinity is then obtained indirectly from the measurement of the amount of noise power measured by the radiometer, provided the effect of the rest of parameters influencing the brightness temperature can be accounted for.

The scientific requirements of the sea surface salinity measurement for a number of oceanographic applications have been determined by an international scientific panel [4] and dedicated SMOS studies [5]. The wind-induced roughness and the sea foam coverage modify the brightness temperatures and are the major error sources in the sea surface salinity retrieval. The determination of the L-band brightness temperatures sensitivities to wind speed and their azimuthal variation have been addressed through an ESA-sponsored joint experimental campaign (WInd and Salinity Experiment, WISE) involving 6 research teams from Spain (UPC, ICM-CSIC, U. València), France (LODYC, CETP), and the USA (U. Massachusetts) in autumn 2000 and 2001 [6].

The WISE campaigns took place at the Casablanca oil rig (owned by Repsol-YPF), located at 40° 43' 4" N 1° 21' 34" E, 40 km offshore the Ebro river mouth, where the bottom depth is 165 m. The sea conditions there are representative of the NW Mediterranean shelf/slope region with periodic influence of the Ebro river fresh water plume. A polarimetric L-band AUtomatic RAdiometer (LAURA) built by the Polytechnic University of Catalonia (UPC, Barcelona), together with other infrared and microwave radiometers and video cameras, was imaging the sea surface from the oil platform at different incidence and azimuth angles, and under diverse environmental (temperature, salinity, wind, sea roughness) conditions. Four buoys moored around the platform were providing the oceanographic and meteorological information to describe the sea conditions. During WISE 2000, systematic measurements were acquired from 16 November to 18 December 2000 and continued during 9 to 15 January 2001, and during WISE 2001 from 23 October to 22 November 2001.

In this paper we present the main results of the oceanographic measurements made from the moored buoys and from instruments in the platform in support of the radiometer data acquisition.

OCEANOGRAPHIC MEASUREMENTS

The oceanographic and meteorological characterisation of the sea environment during WISE 2000 and 2001 was mainly provided by sensors located in 4 buoys moored over bottom depths from 145 to 175 m in an area restricted to navigation within 500 m around the oil platform and close to the radiometers field of view. These buoys were specifically deployed for the campaign. Additionally, some extra data were collected from the platform itself. The measured parameters were:

- Buoy 1. Water temperature and conductivity (to compute salinity) at 20 cm below sea level. In WISE 2001 an ultrasonic anemometer for precise wind measurement was added
- Buoy 2. Near-surface meteorological station (wind speed and direction, air temperature, relative humidity, solar radiation), significant wave height, wave period
- Buoy 3. Wave spectrum and derived parameters (2001)
- Buoy 4. Water temperature and conductivity at 20 cm below sea level
- Water temperature and conductivity at 5 m below sea level measured by an instrument hanging from the platform
- Wind speed and direction on top of the communications tower (69 m) of the platform
- Sae state (2D wave spectrum and foam coverage) from stereo-cameras (see Weill et al., same issue)

Within the WISE team the oceanographic data acquisition and analysis were performed by ICM-CSIC (buoy 1, buoy 2, instruments on platform, and sea operations) and LODYC (buoy 3 and buoy 4).

Buoy 1

The objective for buoy 1 was to collect conductivity and temperature data near the sea surface close to the radiometers field-of-view, and send them to a data logging station installed on the platform, using a real time link. The buoy was designed and built for WISE 2000 (Fig. 1) by EMS Environmental Monitoring Systems S.L., and modified for WISE 2001 mainly to host extra power batteries. It was a toroidal body with an inox steel structure to allocate the signalisation elements (flash, radar reflector, and satellite ARGOS beacon) and the measuring and transmitting instruments. The net buoyancy was near to 400 kg.

The main instrument in buoy 1 was a SeaBird MicroCAT system (model SBE37-SM). It allows recording in a RAM water temperature and conductivity for further salinity determination. An RS-232 interface allows real-time data transmission by an external UHF link. An additional submersible pump was added to ensure a constant water flow through the conductivity cell. The water inlet was situated at 20 cm below sea level in the central part of the toroid, to minimise the effect of waves (possibility for air bubbles being introduced into the measuring cell).

Temperature and conductivity sensor characteristics are:

- Measurement range T -5 to 35 °C, C 0 to 7 S/m
- Initial accuracy T 0.002°C, C 0.0003 S/m
- Typical stability (per month) T 0.0002 °C, C 0.0003 S/m
- Resolution T 0.0001 °C, C 0.0001 S/m

This allows computing salinity, according to established standards [7], with 0.003 psu/month stability, and 0.0002 psu resolution. It has to be noticed that the conductivity cell is equipped with a chemical poison device to avoid biofouling, and the corresponding degradation of the conductivity measurement.

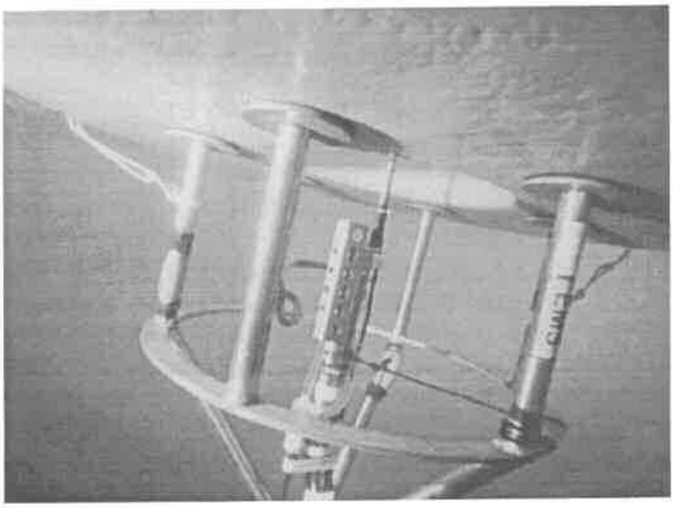

Fig. 1. underwater view of the CT recorder in buoy 1 to sample near-surface salinity

One of the conclusions from WISE 2000 (see below) was the need to increase the quality of wind speed measurements for use in emissivity models improvement. For WISE 2001 a Doppler ultrasonic anemometer model 5010-0005 from USONIC, UK was added to buoy 1. This instrument provides a better sensitivity to wind speed (especially at low speeds) than the traditional rotor anemometers and avoids their possible mechanical problems.

It measures wind speed every 0.3 second and transmits it in real time by a standard RS-232 interface. Wind direction measurements were not used, since the anemometer was installed on a moving platform (moored buoy) without any extra compass for absolute direction determination. The sensor characteristics are:

Measurement range	0 to 60 m/s
Initial accuracy	0.1 m/s (below 5 m/s) or <1.5% of measured value (above 5 m/s)
Resolution	0.05 m/s

A microprocessor received data from the anemometer every 10 s, collected this data stream together with the MicroCAT data received every 2 min., and sent the whole data set every 30 min., via a radio modem, to a receiver placed in the platform. Additionally, the microprocessor averaged the anemometer data every 30 s and stored them in a RAM.

Buoy 2

The objective was to characterise the sea surface state in the field-of-view during radiometer measurements. Buoy 2 was a standard Coastal Monitoring Buoy (CMB3280) from Aanderaa Instruments, Norway that includes a meteorological station, a significant wave height and period recorder (accelerometer), and an acoustic surface (1 m) current meter. The main floating body has a "wet" diameter of 90 cm and a total buoyancy of 345 kg. The buoy carries security elements (flash, radar reflector), is powered by solar panels, records data internally, and transmits them by VHF in real time.

A high sampling rate produces rapid power consumption and missfunctioning of the whole system after a few days. To avoid this, the current meter and the air pressure sensors (both not crucial and highly power consumers) were disconnected.

The remaining parameters recorded by the buoy were:

	accuracy	resolution
Wind speed	± 2%	0.075 m/s
Wind direction	± 5° mag.	0.4 °
Air temperature	± 0.1 °C	0.05 °C
Solar radiation	± 20 W/m^2	0.4 W/m^2
Relative humidity	± 2 %	0.1 %
Wave height	± 0.2 m, 10%	0.01m
Wave period	± 10%	0.03 s

Fig. 2, Buoys 2 and 4 moored near the Casablanca oil rig for WISE 2001

Buoy 3

A Spear-F Datawell waverider buoy was provided by LODYC to record the surface wave spectrum in 14 frequency bands every 3 h and transmit it via satellite (Argos system), following the procedure used by MétéoFrance. In addition it transmits the significant wave height and the dominant period of the waves. In WISE 2000 the buoy was damaged when trying to deploy it under rough seas, and could not further be used. In WISE 2001 it operated successfully during the entire campaign.

Buoy 4

A redundant surface temperature and salinity measurement was obtained from a Clearwater SVP small float equipped with FSI temperature and conductivity sensors that were also transmitting data, measured once per hour, via satellite. The expected accuracy at sea is 0.1 psu and 0.1°C for salinity and temperature respectively. In WISE 2000 this float was moored separately, but was lost after one month of operation. In WISE 2001 it was attached to buoy 2 line with a 10 m long iron cable protected with a semi-rigid plastic cover. The buoy 4 satellite Argos beacon was then used as an extra security element for buoy 2.

Measures from the platform

To complement the oceanographic measurements made at the moored buoys, an extra instrument was deployed in the platform itself. A winch with a hydrographic cable is available in the southern side of the platform. The cable hangs from the structure of a gas torch at some 40 m above sea level, and allows deploying instruments at any depth.

Using this cable a second SeaBird MicroCAT (without additional pump) was located at 5 m below sea level. The purpose was to record temperature and conductivity at a depth that will be the standard for in situ data to be used for SMOS salinity data validation (e.g. Argo profiling floats). The comparison between the time series recorded by the two identical instruments can provide valuable information for the future SMOS data validation strategy. During WISE 2000 the winch was operated in several occasions to obtain vertical T, S profiles in the top 0-5 m. In 2001 this option was discarded as it resulted to be of poor use, the operation was not easy, and produced interruptions in the 5 m time series.

In 2000 an Aanderaa RCM9 Doppler currentmeter was also hung from the cable to record water velocity (plus temperature and conductivity) at 2 m below sea level, as substitution for the sensor that had to be disconnected in buoy 2. This information intended for air-sea flux computations resulted of no further use, and was not implemented in the 2001 campaign.

Extra wind speed and direction sensors, recording at 15 minutes intervals, were installed on top of the platform communications tower, at 69 m above sea level. Although redundant with data recorded on buoy 2 (and buoy 1 in 2001), they were considered as backup information and also useful to check for any wind direction distortions generated by the platform itself when the buoy was in the downwind side.

The sampling rate for the data acquisition system on buoys 1 and 2, and the MicroCAT hung from the platform, was set at 2 minutes. This was the minimum allowed to keep all the sensors working properly with enough power available for 2 months of operation. After calibration and cross-comparison of all the deployed instruments with water samples analysed on the laboratory, we can conclude that the recorded temperature and salinity values are correct within 0.02 °C and 0.02 psu, a sufficient quality for the WISE objectives. An exception to this is the conductivity sensor in buoy 4 that produced an underestimation of salinity of around 0.15 psu.

The deployment of buoys was difficult in 2000 due to limited availability of adequate ships, and mainly to bad weather conditions. In WISE 2000 only buoy 4 could be moored at the beginning of the experiment (15 November). The sensors at the platform could be installed on 29 November, and buoys 1 and 2 moored on 2 December, although part of buoy 2 sensors were not operational until 13 December due to a technical failure. Additionally, the wind speed sensor on buoy 2 did not work for 14 days during the second half of December. As previously said, buoy 3 could not be deployed. The wind sensors on the platform were operational from 14 November. Buoy 4 was lost by mid December, probably after being trawled by a ship. Buoys 1 and 2 were recovered on 20 January, while the instruments on the platform were disassembled on 14 and 15 January, after completion of the experiment.

In WISE 2001 the buoys deployment was made without problems on 4 October from the CSIC research vessel “García del Cid”, except buoy 1 that was not ready until 23 October, just at the beginning of the experiment. The instruments on the platform were installed on 24 October. On 15 November a violent Levant storm (easterly wind bursts higher than 120 Km/h) occurred on the Casablanca area with maximum waves over 12 m. It was the strongest storm ever recorded in the platform since it was installed in the early 80s, and produced serious damage to its structure. It partially destroyed buoy 2 (that ceased operating and lost stored data) and the anemometer on buoy 1. The link that attached buoy 4 to buoy 2 was broken, and the float drifted away until it could be rescued 230 km to the south. On 22 November the buoys were recovered and the instruments on the platform disassembled.

WISE 2000 RESULTS

The resolution, accuracy, and hence consistency, between all sensors were good enough to provide the required temperature and salinity data set and reconstruct time series to complement the radiometer measurements

The surface temperature temporal evolution was typical of the autumn season. November is usually the month when the erosion of the summer stratification is speed up by the occurrence of strong and cold winds: SST values that can be above 25°C at the end of the warm season (September) will drop to around 13°C after completion of the winter vertical mixing (February). During the first week of WISE 2000 the temperature decreased by more than 2.5 °C, then it recovered and the surface cooling continued regularly for the rest of the measurement period, with another strong drop around December 20, and even some short periods of small increase as around December 10. In total SST ranged from 17.5 to 14 °C. The sudden decrease detected by the sensor in buoy 4 near to the beginning of the series (Fig. 3, last page) was short in time but very strong. We don’t have a clear explanation for this, as it was not related to a remarkable signal on the salinity records but contemporaneous to quite strong and perhaps cold (no air temperature data available at that moment) northerly winds.

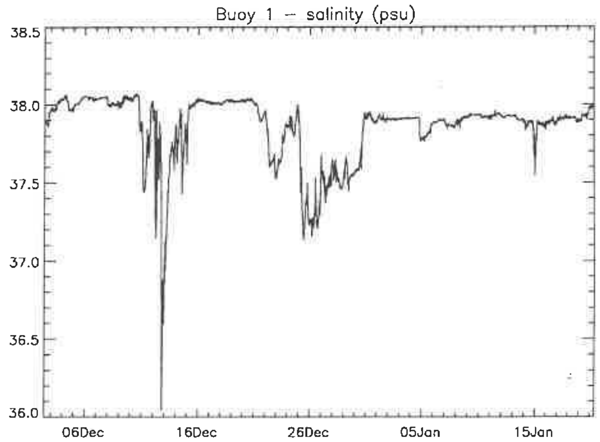

Fig. 4. Salinity at 20 cm recorded by buoy 1 during WISE 2000 near the Casablanca platform

Sea Surface Salinity remained always near 38 psu (Fig. 4), a value typical of the Mediterranean open sea waters that, unlike temperature, do not display a clear seasonal salinity signal. This means that the WISE area was usually out of the direct influence of the Ebro river discharge. The salinity time series shows the occurrence of some low SSS events that typically had a duration of 5-6 days. These events, especially the one around December 12 (strongest SSS drop), are associated to similar SST decreases, a possible indication of the river plume reaching the Casablanca area, as continental waters are not only fresher but also colder than ambient water. This interpretation has been confirmed by the sequence of satellite infrared images that display the evolution of the cold-water tongue from the river mouth to this offshore location.

The usual situation presents an alongslope current from the NE that keeps the river plume close to shore and continental waters flowing to the SW, away from the platform. Occasionally current reversals, strong southerly winds, or a significant increase of the river discharge, allow these lower salinity waters to reach our experiment area (Fig. 5, last page). The two main events detected in WISE 2000 resulted in recorded SSS values 2 psu (December 12) and almost 1 psu (December 25) lower than the regular 37.9-38 psu observed all around the experiment.

An important issue related to salinity remote sensing is the possible presence of a vertical salinity gradient. A microwave radiometer will only measure the very surface values, which is not the case of in situ sampling, where sensors have to be completely immerged in seawater. Validation of SMOS salinity determinations will strongly rely on in situ measurements made from standard moored or drifting buoys, or even hydrographic casts or underway measurements from research or opportunity vessels. In all theses cases temperature, and especially conductivity, sensors are not operated close to the surface to avoid interference from air bubbles and even to protect them from possible sources of dirt. A present standard value for near surface salinity measurement is 5 m below sea level. In some cases, especially after strong rainfall when the wind speed is low, salinity at this depth can be significantly different from SSS and then errors can be introduced by comparing both values.

The difference between salinity close to the surface (-20 cm, buoy 1) and at 5 m was monitored during WISE by deploying a second instrument at this depth.

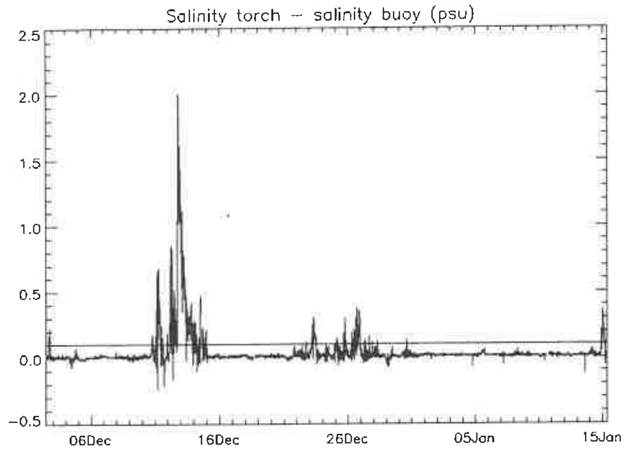

Fig. 6. Salinity difference between sensors located at –5 m and –0.2 m

Most of the time the difference between both time series is below 0.1 psu (Fig. 6), a value that can be considered a threshold for SSS satellite remote sensing resolution. It is only remarkable during the reported low salinity events, especially that of December 10-15 when the difference reached up to 2.0 psu. The latter is another confirmation that this event was due to an intrusion of the river plume, a near-surface phenomenon, since at 20 cm the salinity drop from ambient water was almost 2.1 psu while at 5 m it was only 0.8 psu maximum.

To increase the knowledge on the vertical resolution of the salinity gradient the sensor at -5 m was manually raised to -2 m, -1 m and to the surface in several occasions. The resulting profiles, with typically a duration of about one hour and a half, display very small salinity variations (usually less than 0.01) except those on December 12 and 14 (low salinity event) and January 10 at surface (probably effect of air bubbles) that can reach up to 0.3 psu. In these specific cases it is remarkable the high temporal variability of the salinity values, which reflects the dynamic character of the event. This was also observed in the SSS time series, where changes of the order of 2 psu can be recorded in very few hours. This poses an additional problem to the satellite SSS validation that has to be analysed in the framework of the general cal/val strategy and considering the decorrelation scales at open oceans.

Wind data, from both buoy 2 and the Casablanca tower, were mapped to 10 m for standard analysis. The hypotheses of neutral stability was checked for the periods where air temperature was available. In general the atmosphere appeared to be slightly unstable.

The wind speed averaged during the whole period is 6.8 m/s. Wind speed higher than 15 m/s were observed on November 17, 24 and 26, on December 15, 28, 29, 30 and 31 and on January 5, 6 and 8. Unfortunately the strongest winds were observed during the Christmas/New Year period during which the radiometer manned experiments were not operating. Wind direction was mainly from the W and NW, with few events from open sea (SE, E or NE). The strongest speeds correspond always to northwesterlies.

We compared the data gathered by the two instruments, mapped to 10 m height, during the period of common measurements. For the comparison to be meaningful we averaged the measurements during one hour. Fig. 7 (last page) shows data from the meteorological station on the platform against simultaneous data from buoy 2. The regression lines are orthogonal (same weight given to the two types of measurements, minimize the distance perpendicular to the fit). We fitted the measurements in the range 3 - 15 m/s (most commonly observed wind speed range and optimal range for instruments) and in the whole data range.

In the range 3-15 m/s the equation of the fit is: $U_M = 1.09\ U_B + 0.07$ with an explained variance of 92%, in the whole range it is $U_M = 1.17\ U_B - 0.20$ with an explained variance of 96%. The mean difference between the instruments is $\langle U_B - U_M \rangle = -0.92$ m/s with a standard deviation of 1.83 m/s. In the most commonly observed range the instruments differ by about 10%, the standard deviation of the difference being rather high. We checked that the measurements are nevertheless usable for checking emissivity models. This discrepancy might be due to several factors:

- different instruments
- different height: the mapping to 10 m is not perfect and from 69 m it is a large correction (we tried to correct for the stability, but it did not improve the result), the platform is likely to disturb the air flow less at the top than at low altitude.

To compare with the future SMOS situation, when wind data will be needed from other sources, we have also analysed spaceborne wind information. Measurements of the QuikSCAT satellite scatterometer (nudge algorithm) were co-located with the platform using a radius of 0.27° latitude and 0.37° longitude: 196 measurements were found for the duration of the campaign. Since the scatterometer cannot approach closer than 50 km from coast no measurement was coincident with the platform: all of them were east and south. These data were averaged for each satellite pass and the resulting average was compared with one-hour average of the in-situ measurements. The QuikSCAT data have been compared to the meteorological station measurements at 10 m height. The equation of the fit in the range 3-15 m/s is: $U_Q =$

$0.97\ U_M + 0.68$ with an explained variance of 74%; the mean difference between the instruments $\langle U_M - U_Q \rangle$ is 0.44 m/s with a standard deviation of 2.8 m/s. The points are rather dispersed, probably due to the imperfect co-location, but they compare rather well. The three wind speed data series (buoy 1, tower station and QuikSCAT) are presented in Fig. 8 (last page).

During the five weeks when significant wave height (average of the highest third of the waves) could be recorded, data ranged from 0.1 to 4.0 m, with an average of 0.9 m. Wave periods ranged from 1.6 to 7.5 s, with an average of 3.2 s. Most of the time wave height is correlated to wind stress. This means that waves are mainly due to local wind and hence wind speed values, with the adequate correction for the presence of foam, can be used as a parameter for the determination of surface roughness in the models of sea surface emissivity. However, as seen in Fig. 9, some times during WISE 2000 considerable wave heights were recorded without simultaneous high wind (records around number 30000, 43000 and 61000 in the figure). This is an indication that the wave field at the Casablanca site was at that moment not originated by local winds, but arrived there from external areas (swell). This is also an important issue to be solved for SMOS salinity retrieval if wind speed information has to be used in the computation.

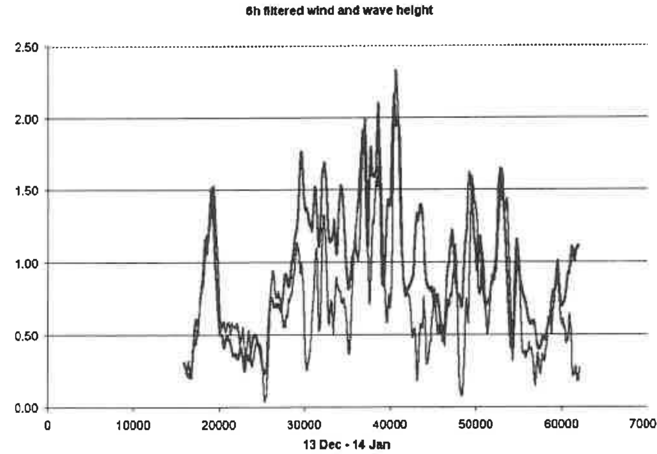

Fig. 9. Low passed (6h filter) wave height (thick, m) and wind speed (thin, 10 m/s) for the period December 13 to January 14

WISE 2001 RESULTS

The 2001 campaign took place also in autumn, but almost one month in advance with respect to the previous year. As previously said, and after the experience gained with WISE 2000, the buoys deployment was made more efficiently using a research vessel, and all the buoys were in place before the beginning of the radiometer measurements. The data intercomparison and analysis was made following the same procedure described for WISE 2000.

At the beginning of the period the temperature (Fig. 10) was still slightly above 22, and did not initiate a clear decrease until early November. A cold event (a drop of almost 2 °C) occurred on 4 November, but after two days the temperature recovered and continued the slow decreasing trend. After the storm the decrease was accentuated and by the end of the campaign the temperature was quite stable around 16 °C, practically the same value observed the previous year at that date.

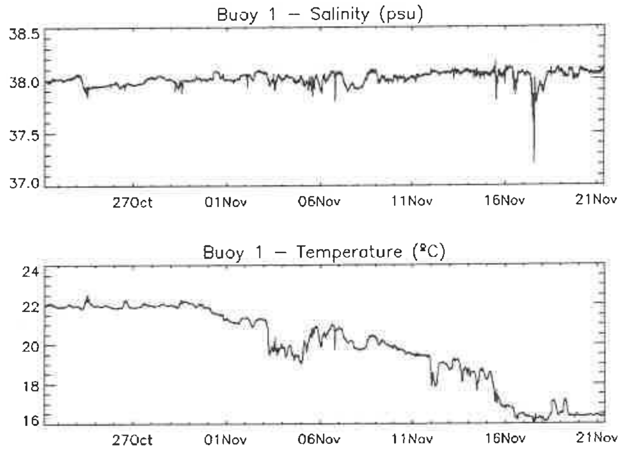

Fig. 10. Surface salinity and temperature recorded by buoy 1 during WISE 2001

Salinity was very constant around 38.0 psu (Fig. 10). Only in 8 short occasions (usually few minutes) during the 30 days period the values differed from this mean by more than 0.1 psu, the expected threshold for salinity detection by SMOS. And just twice the difference was above 0.2 psu, the most remarkable on 18 November (down to 37.2 psu) after an intense rain event.

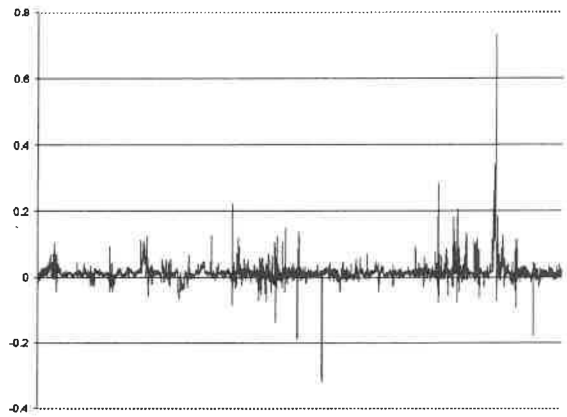

Fig. 11. Difference in psu between salinity recorded at 5 m below sea level (platform) and at 20 cm (buoy 1) from 23 October until 22 November 2001

The vertical structure of salinity near the surface is still more homogeneous than in WISE 2000 (Fig. 6 and 11). The difference between the values measured by the sensor situated at – 5 m and the sensor close to surface overpasses 0.1 psu in few occasions and always during few minutes. Only once, during the rain event mentioned in the previous paragraph, a significant difference persisted for 4 h and reached a maximum of 0.7 psu.

The same wind data analysis as performed in WISE 2000 was applied to the 2001 records. We expected to have better quality data with the ultrasonic Doppler anemometer added to buoy 1, but unfortunately several technical problems reduced the usable information to only two short series. It was due mainly to missfuntioning of the microprocessor that controlled the anemometer data acquisition and transmission just 2 days after deployment. And when this problem could be definitively fixed, the violent storm destroyed the instrument after 6 days of correct operation.

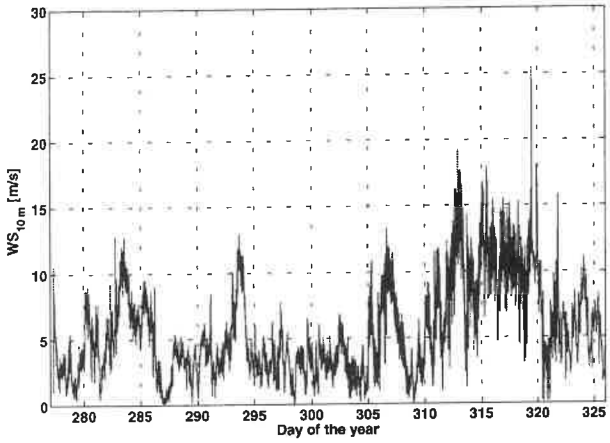

Fig. 12. Complete wind speed series (mapped to 10 m) measured during WISE 2001

In Fig. 12 we present the reconstructed wind speed data series from the different instruments from 4 October (buoys deployment) until 22 November (end of the experiment). The direction was very variable until early November, with two events of strong winds from NE and one from SW. After that, while increasing notably the speed, it was usually from the N and NW with storms (more than 20 m/s) every two days from 9 to 15 November, and all of them from NW except the "big one" that was from E. After a last minor storm on the 17, the tendency was to lower the speed until the end of the experiment.

Unlike what happened in 2000, during WISE 2001 we had the opportunity to measure with the radiometer under really intense wind and rough sea conditions. Especially remarkable were the two severe storms that occurred on 11 and 15 November. As previously said, the second one produced serious damage to the buoys and to the Casablanca platform structure. Although it was not possible to keep the radiometer working continuously during the storms, data could be recorded under very rough seas.

Fig. 13 shows the recorded wave height (four times the variance of the wave slopes), that overpassed 6 m during several hours in both storms, and the peak wave period recorded by the waverider buoy during the whole duration of WISE 2001. It has to be recalled that the spectral wave height (3 h average) recorded by buoy 3 is by definition square root of 2 higher than the significant wave height recorded (every 2 minutes) by buoy 2.

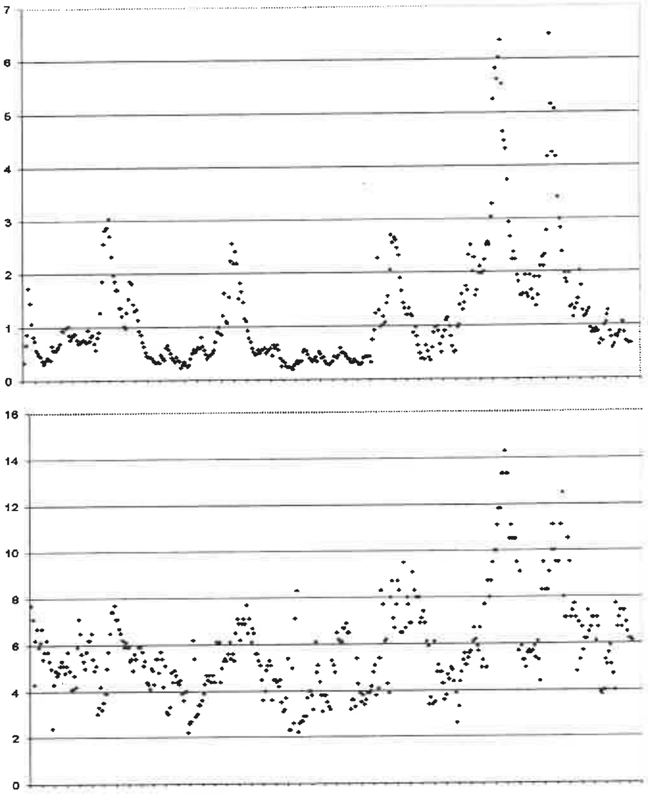

Fig. 13. Three hours average wave height (top, m) and peak wave period (bottom, s) recorded by buoy 3 during WISE 2001, from 4 October to 22 November

Fig. 14 (last page) shows the different characteristics of the wave spectra measured by buoy 3 in two 24 h periods. During the 15 November storm the SWH variance increases and the wavelength is shifted to longer wavelength.

CONCLUSIONS

The full sets of in situ and satellite data recorded during the WISE campaigns give the following conclusions on the oceanographic and meteorological conditions during the 2000 and 2001 experiments:

- The sea surface temperature is evolving according to seasonality, with the continuous decrease typical of the autumn process of stratification destruction
- Salinity is very homogeneous, both in time and in vertical in the top layer. It is only affected in few occasions by the incidence of the river plume (2000) or intense rainfall (2001)
- The obtained measurements include a large range of wind conditions, even violent storms. Their analysis, together with radiometric data, will improve the modelisation of the effect of sea surface roughness on L-band emissivity

- The achieved accuracy in wind speed data is not as good as it would be desirable, since the near-surface (buoy) and 69 m records, when mapped to 10 m, differ by about 10%. Only few data could be obtained with the higher quality ultrasonic anemometer
- The recorded wave data are complete enough to allow investigating the usefulness of considering directly the sea surface spectrum instead of parameterising it through wind speed in the correction for surface roughness in emissivity models

Further analysis of these data is in progress in the framework of different studies funded by ESA and national agencies. We expect they will contribute significantly to the science definition studies for the adequate retrieval of Sea Surface Salinity by the SMOS space mission.

ACKNOWLEDGEMENTS

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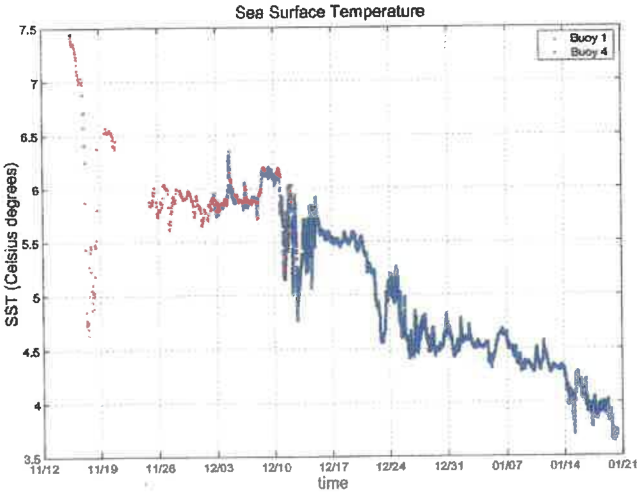


Fig. 3. Surface temperature recorded by buoys 1 and 4 during WISE 2000

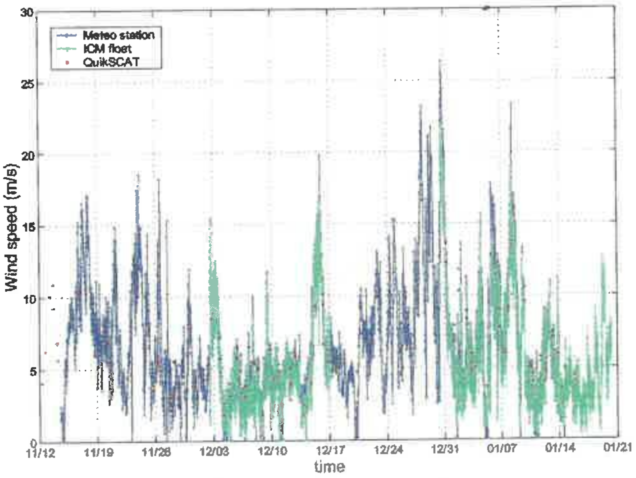


Fig. 8. Integration of the three wind speed data sets obtained for WISE 2000

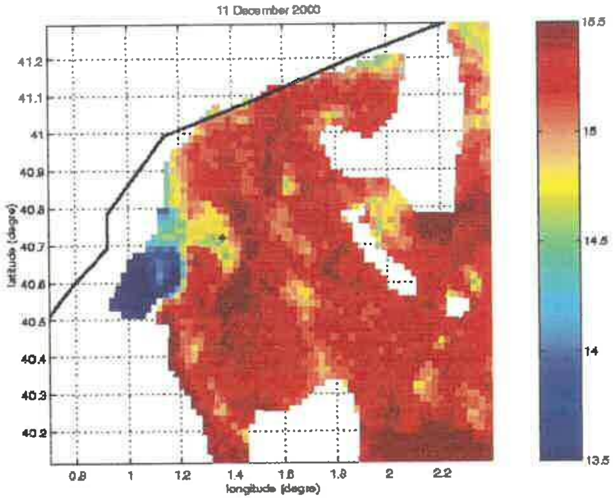
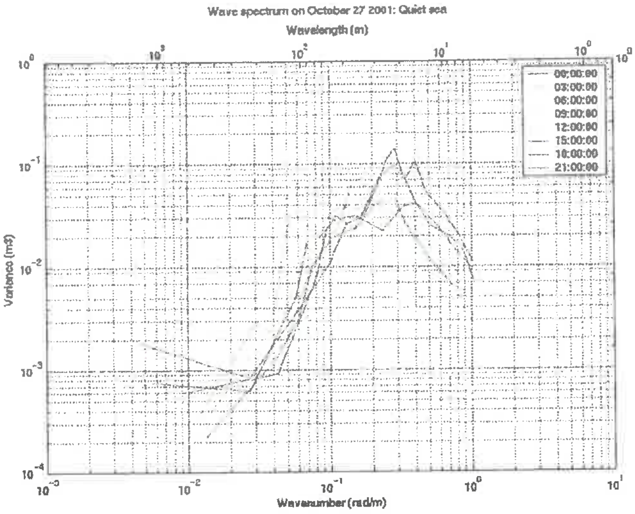


Fig. 5. AVHRR SST image on 11 December 2000, with the cold water plume reaching the Casablanca location (+)



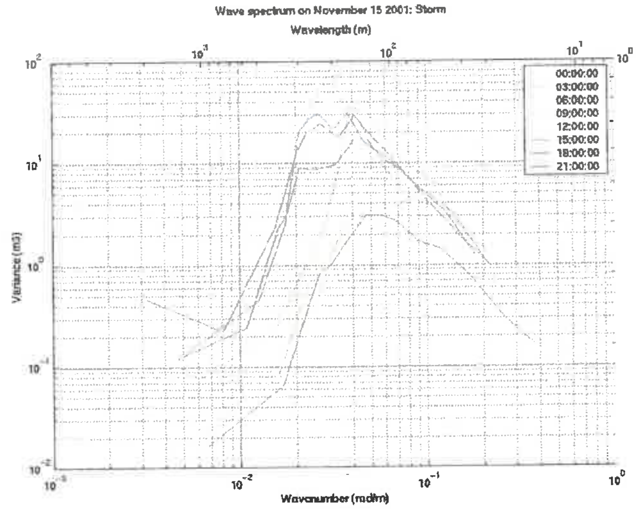


Fig. 14. WISE 2001 sea surface spectra recorded by buoy 3 in a quiet day (27 October, top) and in a stormy day (15 November, bottom)

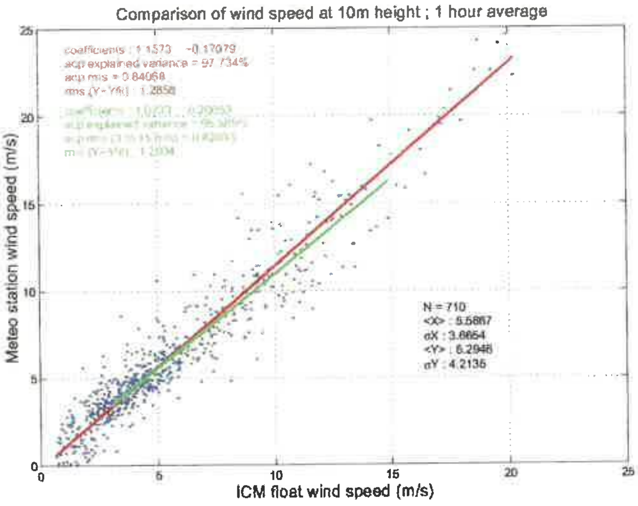


Fig. 7. Wind speed (at 10 m) comparison for the two in situ data sources during WISE 2000