IL NUOVO CIMENTO Vol. 36 C, N. 4 Luglio-Agosto 2013
DOI 10.1393/ncc/i2013-11548-8

Communications: SIF Congress 2012

Water flow in the inlets of the Marano-Grado lagoon system (NE Italy)

I. Mancero-Mosquera(*)
Istituto Nazionale di Oceanografia e di Geofisica Sperimentale - Trieste, Italy

ricevuto il 25 Febbraio 2013

Summary. — Water flow in the inlets of Grado and Lignano of the Marano-Grado Lagoon system was measured between July 2010 and September 2011, to study the water exchange between the lagoon and the Adriatic Sea. The average magnitude of the flow is about 500 mm/s in Grado and 400 mm/s in Lignano. The tidal forcing accounts for about 90% of the variability, with the semi-diurnal M2 and S2 contributing over 75%. They behave almost in phase with Lignano leading Grado by about 20 seconds. K1, the strongest diurnal constituent, contributes 7.4% to the energy, and shows a phase difference of about 10 minutes with the Grado response leading Lignano. Adriatic Seiches are found with periodicities of 21.14, 10.92, 7.04, 5.24, 4.29 and 3.59 hours, accounting for most of the non-tidal energy.

PACS 92.10.-c – Physical oceanography.
PACS 92.10.Sx – Coastal, estuarine, and near shore processes.
PACS 91.50.Cw – Beach and coastal processes.
PACS 92.10.A- – Circulation and currents.

1. – Introduction

The Marano-Grado Lagoon system is located in the northern shore of the Adriatic Sea (fig. 1). It is about 5 km wide and 20 km long, separated from the open sea by a shoreline consisting of islands and elongated sand bars running parallel to the mainland. It is connected to the sea through several inlets, the most important being: Grado (390 m wide/10 m deep), Porto Buso (430 m) and Lignano (310 m/11 m). The Marano Lagoon corresponds to the western part extending from Lignano until Porto Buso inlet, while Grado Lagoon is in the eastern part; both forming a system with the double toponym

(*) On behalf of V. Kovačević[1], M. Lipizer[2], R. Villalta[3], F. Arena[1], A. Triches[2], G. Fontolan[4]
[1] *Istituto Nazionale di Oceanografia e di Geofisica Sperimentale - Trieste, Italy*
[2] *Regione Autonoma Friuli Venezia Giulia, Trieste, Italy*
[3] *Consulta d'Ambito Territoriale Ottimale Interregionale del Lemene, San Vito al Tagliamento (PN), Italy*
[4] *Dipartimento di Matematica e Geoscienze, Università degli Studi di Trieste, Italy.*

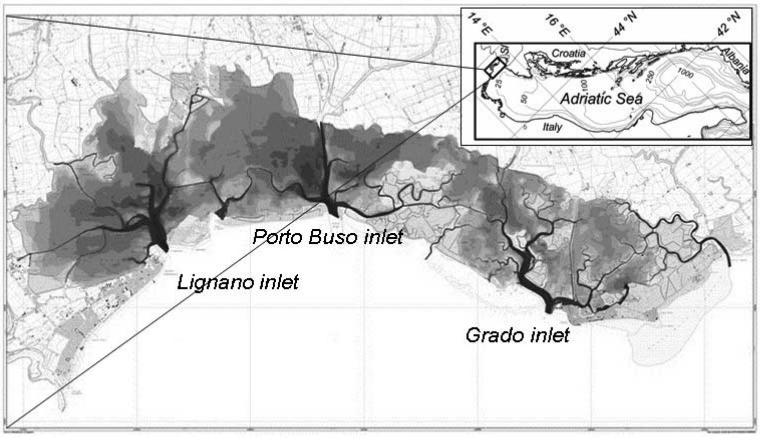

Fig. 1. – Bathymetric map of the Marano-Grado Lagoon as reported in [1]. ADCPs were placed in the bottom of Grado and Lignano inlets.

being attributable to the historical period when Grado belonged to the Austro-Hungarian Empire while Marano was part of Italy. The whole area extends for $160\,\mathrm{km}^2$ [1] amounting to the second biggest lagoon of the Adriatic Sea (after the Venetian Lagoon). It has been important for human development since the times of the Venetian Republic, when it was integral part of the *Litoranea Veneta* waterway network. Currently, the recent urban expansion (1950), the creation of natural reserves of Valle Canal Novo, Foci dello Stella and Val Cavanata (1996) and the presence of endemic as well as migratory fauna species, make the lagoon of great interest from the scientific and social point of view.

A monitoring programme started in 2010, to set up measurements that would enable estimating the water volume and mass exchange through some of the inlets. For that reason, bottom-mounted Acoustic Doppler Current Profilers (ADCP) were deployed in the two lagoon inlets, Grado and Lignano, on 6th and 7th July 2010, respectively, with the scope to provide a long-term series of horizontal currents; complemented by vessel-mounted ADCP surveys; water profiling and water sampling on a monthly basis. The latter enabled determination of the solid sediment concentration in the water column to be intended for the solid transport estimation. The purpose of the present work, however, focuses on the analysis of the current flow regime through the inlets connecting the lagoon and the open sea.

2. – Experimental setup, data and methods

The position of the instruments was chosen after preliminary surveys, aimed at estimating the best possible linear relation between the data from the bottom-mounted instrument and those from the cross-sectional measurements. Bottom-mounted ADCPs were configured to take measurements (pings) every 10 seconds, while an average of 60 pings is recorded every ten minutes, in the total of 46 cells along the water column. Spatial resolution is $0.25\,\mathrm{m}$, corresponding to the height of a monitored cell along the vertical profile. The total number of cells with good data thus depends on the depth of the inlets, which is about 10 meters for Grado and $11\,\mathrm{m}$ for Lignano. The period considered in the present work spans roughly 13 months, form July 2010 to September 2011 (table I). After the initial quality control, spikes and other errors were removed.

TABLE I. – *Position and duration of the ADCP measurements in the inlets of Grado and Lignano.*

Inlet	Latitude (°N)	Longitude (°E)	Start time	Hour (UTC)	End time	Hour (UTC)	Depth (m)	Cells #
Grado	45.681316	13.370616	6 July 2010	16h00	1 September 2011	00h00	10	30
Lignano	45.704516	13.152433	7 July 2010	16h00	23 September 2011	15h00	11	34

Time series were separated in a cell-by-cell basis for both inlets; hourly series were produced by averaging 13 ten-minute values of the horizontal velocity centred on the whole hour and the velocity expressed in geographical coordinates (East and North components). As expected, the velocity vectors are scattered prevalently along the longitudinal axes of the inlets, that is, they are aligned with the orientation of the channels. The Principal-Component Analysis [2] shows that about 99% of the total energy is due to the along-channel velocity component referred to as the major Principal Component PC1. A perpendicular minor principal component, PC2, or cross-channel component, is, therefore, neglected, and the PC1 is regarded as representative of the inlet flow. Instrument calibration and vector representation has been chosen to yield a positive sign for currents flowing out of the lagoon into the Adriatic Sea and vice versa. The Empirical Orthogonal Analysis [2] shows that the flow is almost homogeneous along the water column, and this vertically uniform component accounts for about 98% of the energy. Only during the slack water interval, that is, approximately every six hours, the vertical distribution of the velocity is more inhomogeneous due to the gradual direction change. Hence, the following analysis has been performed on the PC1 of the vertically averaged time series of both inlets.

The Harmonic Analysis was applied in order to study the variability due to tidal forcing. This method performs a least-square fit of a sum of sinusoidal terms to the data, terms containing the well-known astronomical frequencies related to tides [3], thus allowing the estimation of amplitudes, phases and explained variance at each frequency. Tidal oscillations account for 92% of the total variability at Grado and 93% at Lignano. Information on various parameters is detailed in table II. Non-tidal variability is obtained by subtracting the synthetic harmonic series (the ones including all resolved astronomical tidal terms) from the total series. The result is expected to contain other high- and low-frequency variability such as seiches, inertial flow, surges and meteorologically driven flow.

Non-tidal variability is further analysed by using classical Fourier analysis as well as the Wavelet Transform [4]. The latter is based on the inner product of a function f with a wavelet function $\psi_{\tau,\mathrm{s}}$

$$W_{\mathrm{f}}(s,\tau) = \langle f, \psi_{\tau,s} \rangle = \int_{-\infty}^{+\infty} f(t)\psi^{*}_{\tau,s}\mathrm{d}t, \tag{1}$$

where $\psi_{\tau,\mathrm{s}}$ is the translation and scaling of a fundamental mother wavelet ψ:

$$\psi_{\tau,\mathrm{s}} = \left(1/\sqrt{s}\right)\psi\left((t-\tau)/s\right).$$

TABLE II. – *Parameters from the harmonic analysis of vertically averaged data, including frequency (F) in cycles per hour (cph), amplitudes of the semi-major axis (M), semi-minor axis (m), and their respective errors (eM, em) in millimetres per second (mm/s); phase (P) and error of the phase (eP) in degrees; and explained variance (EV) in percentage with respect to total variance in the records.*

Grado

Tide	F (cph)	M (mm/s)	eM (mm/s)	m (mm/s)	em (mm/s)	P (°)	eP (°)	EV (%)
M2	0.0805114	620.3	9.8	−0.4	1.6	2.9	0.9	56.8
S2	0.0833333	375.9	9.8	−2.5	1.6	14.2	1.3	20.9
K1	0.0417807	224.3	13.7	−1.5	1.3	163.1	3.5	7.4
K2	0.0835615	122.0	10.4	2.0	1.5	10.4	4.8	2.2
N2	0.0789992	102.3	9.9	0.9	1.5	7.5	5.1	1.5
O1	0.0387307	68.5	14.4	4.8	1.4	156.6	12.6	0.7
P1	0.0415526	66.6	13.4	0.2	1.4	158.8	14.4	0.7
							Total:	90.2

Lignano

Tide	F (cph)	M (mm/s)	eM (mm/s)	m (mm/s)	em (mm/s)	P (°)	eP (°)	EV (%)
M2	0.0805114	507.1	9.1	−8.5	2.0	2.8	1.1	55.1
S2	0.0833333	323.4	9.0	−6.4	2.0	13.9	1.9	22.4
K1	0.0417807	186.3	13.3	−5.0	1.9	165.5	3.9	7.4
K2	0.0835615	104.3	9.8	−3.9	1.9	10.6	5.3	2.3
N2	0.0789992	89.2	9.6	−1.6	1.9	7.8	6.0	1.7
P1	0.0415526	56.8	12.9	−1.8	1.9	168.6	14.5	0.7
O1	0.0387307	51.6	11.7	−7.2	2.2	153.0	14.2	0.6
							Total:	90.19

Unlike the sinusoids of the Fourier transform, ψ is a short-lived oscillation. The translation parameter τ allows the scanning of variability along the time axis, while the scaling parameter s changes the frequency response of ψ. The praxis with time series is made via associated wavelet filters, for the integral (1) is a convolution as well. The link between the Wavelet transform and digital filtering has been amply studied and criteria to choose a suitable filter are found in the scientific literature [4-6]. In the present work, the Symmlet-4 wavelet filter is chosen for its compact support (8 coefficients) that allows a better estimation of the variance at different time scales. Likewise, the Morlet wavelet is used to assess how the variance changes in time (stationarity), due to its better resolution [4] of the time-scale plane.

Finally, an error analysis is conducted by finding the propagation of the first two statistical moments of a random vector $\mathbf{x} = (x_1, x_2, \dots x_n)$ through a functional $y = f(\mathbf{x})$, via approximating f with Taylor polynomials around the mean vector $\mu_{\mathbf{x}}$ [7]. If the vector standard deviation is $\sigma_{\mathbf{x}}$, then eqs. (2) and (3) hold true, where the partial derivatives

TABLE III. – *Phase Differences (Diff) based on the longest possible common period between Grado and Lignano i.e. starting 7 July 2010 16h00 and extending for 10089 hours (420.38 days). Positive sign indicates Grado leading Lignano.*

Tide	Period (h)	Grado $P(°)$	Lignano $P(°)$	Diff. (°)	(h)	Time lag
M2	12.4206	2.88	2.7	−0.1800	−0.0062	−22 s
S2	12.0000	14.19	13.99	−0.2000	−0.0067	−24 s
K1	23.9345	163.11	165.57	2.4600	+0.1636	+9.8 min.
K2	11.9672	10.48	10.94	0.4600	+0.0153	+55 s
N2	12.6584	7.63	7.59	−0.0400	−0.0014	−5 s
O1	25.8193	156.39	153.24	−3.1500	−0.2259	−13.6 min
P1	24.0659	158.72	168.34	9.6200	+0.6431	+38.6 min

are evaluated in $\mu_{\mathbf{x}}$:

$$\mu_y = E(y) = f(\mu_{\mathbf{x}}), \tag{2}$$

$$\sigma_y^2 = E[(y-\mu_y)^2] = \sum_{i=1}^{N}\left[\frac{\partial f}{\partial x_i}\right]^2 \sigma_i^2 + \sum_{i=1}^{N}\sum_{\substack{j=1\\ j\neq i}}^{N}\left(\frac{\partial f}{\partial x_i}\right)\left(\frac{\partial f}{\partial x_j}\right)\sigma_{ij}. \tag{3}$$

3. – Result and discussion

Axial currents show a long-term average value of 14 mm/s (outflowing) and about 400 mm/s average magnitudes. The total variance estimated from the record is $3.345082\times 10^5 (\mathrm{mm/s})^2$ in Grado and $2.417755\times 10^5 (\mathrm{mm/s})^2$ in Lignano. The maximum outflowing currents recorded were of 1.36×10^3 mm/s in Grado and 1.42×10^3 mm/s in Lignano, while the inflow extreme values were -1.46×10^3 mm/s in Grado and -1.37×10^3 mm/s in Lignano. The variance is further analysed given the tidal character of the inlets.

3˙1. *Tidal signal.* – The seven typical tidal constituents (K1, O1, P1, K2, M2, N2, S2) of the Adriatic Sea level [8], are also representative of the tidal flow, summing up to the 90% of the total flow variance in both inlets (table II). The strongest one is M2 with an amplitude of 620 mm/s in the Grado inlet, and 507 mm/s in the Lignano inlet, explaining more than 55% of total variance in both channels. The second strongest one is S2, explaining more than 20% of total variability, with amplitudes of 375 mm/s in Grado and 323 mm/s in Lignano. The diurnal K1 is the third strongest accounting for 7.4% of the total variance in both records. The remaining three constituents, N2, O1 and P1, account for about 3% of the total variance. The phase differences between tidal signals in the two inlets were calculated taking into account the series for a common time interval, starting on 7 July at 16h00UTC and extending for 420 days. Results were computed for the seven strongest constituents and presented in table III. The semi-diurnal group shows up almost simultaneously in both inlets, *i.e.* the differences are within 60 seconds. Thus, M2 and S2 accounting for over 76% of the total variability in both inlets show a difference of about 22–24 seconds. The phase differences are 55 seconds for K2 and 5 seconds for N2. On the other hand, the diurnal group has differences reaching about 40 minutes. The strongest among them, K1, shows almost 10-minute difference, with Grado leading Lignano. Similarly, Grado leads Lignano by 38 minutes regarding P1, but lags belind by 13 minutes in O1. However, the contribution of O1 and P1 to the total

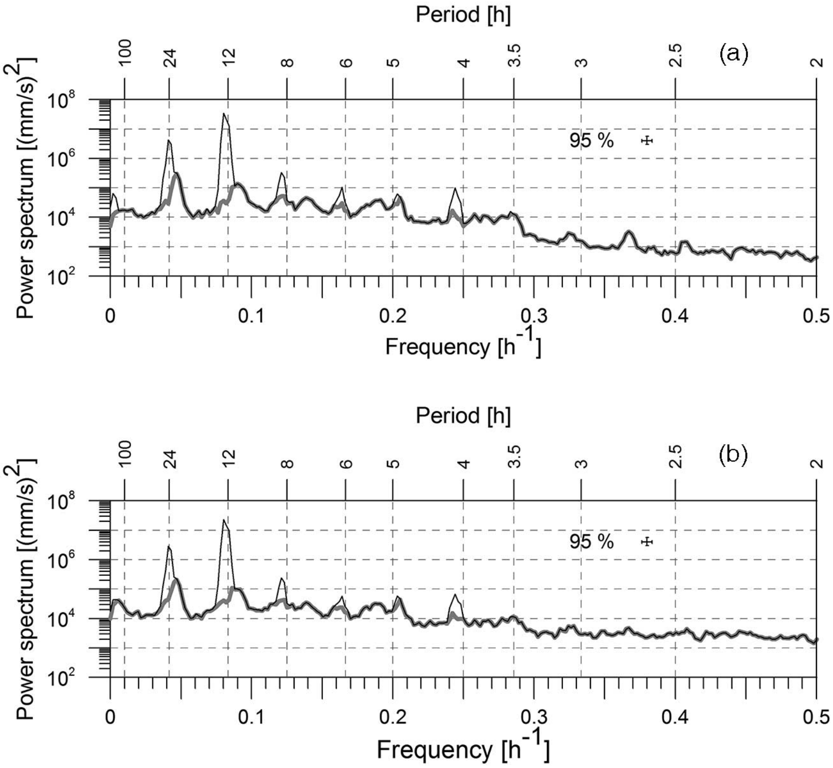

Fig. 2. – Power spectra of the total (thin black line) and non-tidal (thick grey line) flow for Grado (a) and Lignano (b). The highest peaks correspond to the diurnal group (24 hours) and the semi-diurnal one (12 h). Higher harmonics, typical of shallow waters, also appear.

variance is only about 1.7% in both inlets. These results are compared to the numerical study for the North Adriatic sea level [9], where the diurnal group is modelled as a topographic wave propagating across the basin from the Croatian coast toward Italy; while the semi-diurnal tide is explained as a set of Kelvin waves (incident and reflected) with the incoming wave progressing along the Croatian coast, and the partially reflected wave returning along the Italian coast. The constituents K1 and P1 seem to conform to this pattern for the Grado response leads Lignano. On the other hand, the semi-diurnal group shows a departure from the numerical study with M2, S2 and N2 signals in Lignano leading those at Grado. However, the phase differences (table III) are of the order of minutes in the diurnal group and of seconds in the semi-diurnal group.

3·2. *Non-tidal variability.* – Fourier spectra of the non-tidal times series (fig. 2) reveal two peaks of relatively high energy corresponding to the main frequencies of the Adriatic seiches. Periodicities of these maxima are about 21.3 hours and 11 hours in both records, corresponding to the seiche oscillations of the Adriatic Sea level [10]. The maximum cross-correlation between non-tidal series occurs at zero-lag with the value of 0.7 (not shown here). The Fourier cross-spectrum was computed and the coherence and phase obtained (fig. 3). The coherence maxima were computed with a spectral peak estimator [11] and found at periodicities of 21.14 hours (0.93 high peak), 10.92 hours (0.84 high), and at 7.04, 5.24, 4.29 and 3.59 hours with significant coherence as well. Phase lags corresponding to these peaks are about 10 minutes. These values are consistent with previous studies

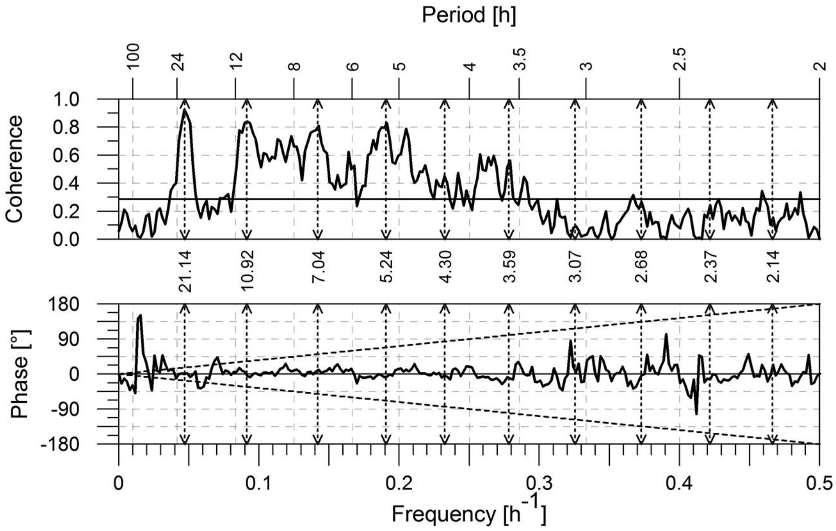

Fig. 3. – Coherence and phase between Grado and Lignano non-tidal flow. Arrows indicate the main Adriatic seiche modes as estimated from data. The first six ones show significant coherence (over 0.4). The corresponding phase is presented too, with the triangular limit (dashed line) indicating the one-hour time lag for each frequency. High coherence is thus accompanied by small phase lags.

on Adriatic seiche periodicities. The harmonic modes reported in [10] are 21.4, 10.8, 7.2, 5.3 and 4.7 hours.

Application of wavelet methodology to the non-tidal time series follows closely the research experience carried out on the Venetian Lagoon [12]. Given the sensibility of the method to missing data, a cross-interpolation scheme is devised with a simple model $Y = aX + b$, to predict the missing value "Y" in one inlet series by using the simultaneous measurement "X" in the other inlet. Hence, gaps were filled by profiting on the strong linear correlation (0.7) found between the non-tidal series (fig. 4). The Symmlet

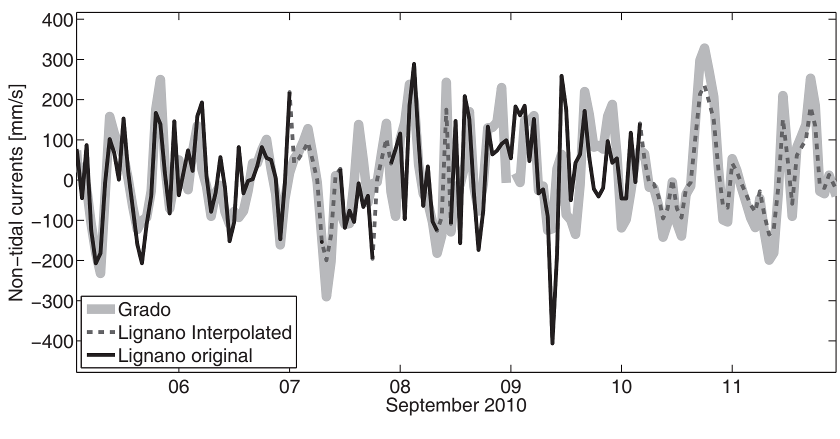

Fig. 4. – The strong correlation between non-tidal variability is used to interpolate missing data. This example shows a Lignano gap filled in by using Grado time series (see text for details).

TABLE IV. – *Wavelet variance distribution for different time scales.*

Time scales (hours)	Grado $(\mathrm{mm/s})^2$	Lignano $(\mathrm{mm/s})^2$
1024–2048 h	7.931	42.834
512–1024 h	17.812	71.382
256–512 h	58.548	173.665
128–256 h	124.842	297.651
64–128 h	279.404	325.063
32–64 h	502.599	531.329
16–32 h	3966.905	3374.291
8–16 h	5336.777	4687.521
4–8 h	4885.323	4410.807
2–4 h	1554.621	2231.537
Sum	16734.7622	16146.0797
Total	16708.3300	16099.6400
Relative error	0.1582%	0.2885%

wavelet filter allows the decomposing of variance in discrete time scales with no correlation between them, so their sum across scales equals the total variance of the series under analysis. Results are described in table IV. The most energetic scales are the ones enclosing the Seiche signals within the intervals of 16–32 hours, 8–16 hours and 4–8 hours. These time scales account for 84% of the non-tidal energy in Grado and 77% in Lignano; hence, the Seiche contribution is about 8% with respect to the total variance.

Evolution in time of the variance is studied with the Morlet function, which has better resolution of the *t*-*s* plane, at the cost of introducing a small correlation between scales [13]. The $\log_{10}$-energy spectra are shown in fig. 5. The values are compared with a noise model in order to assess significance [13], so that values shown with white contouring are over the 95% of confidence limit. As observed, energy in the bands enclosing the seiche periodicities is reinforced recurrently but not regularly in both inlets, particularly at the onset of winter in December 2010. At longer time scales, Lignano shows a prominent feature in March 2011 with high energy at the scales between 256 and 512 hours (15 days estimated). Minor features can be observed in Grado as well.

3·3. *Error propagation.* – The Workhorse Sentinel ADCPs used in the inlets were set up to work at 600 kHz (Grado) and 1200 kHz (Lignano) with vertical resolution of 0.25 m. The starting errors in this analysis (σ), associated to these configurations (single-ping standard deviation), are 240 mm/s and 182 mm/s, respectively. Measurements are obtained every ten-minutes by averaging 60 pings, yielding an error $\sigma_s = \sigma/\sqrt{60}$, according to Central Limit Theorem. Posteriorly, six ten-minutes data are averaged to yield one hourly velocity value V_h, expressed as $V_\mathrm{h} = (1/6)\Sigma x_i$, $i = 1, 2, \ldots 6$. Since errors from ping to ping are uncorrelated, the assumption of uncorrelated errors in ten-minutes data is justified, thus the standard error of hourly values, σ_h, is obtained from (2) and (3) as

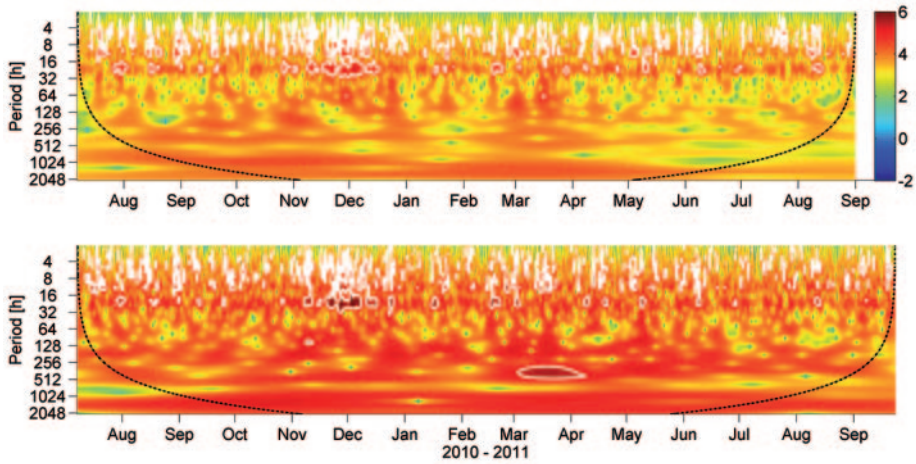

Fig. 5. – (Colour on-line) Wavelet spectra of non-tidal variability at Grado (top) and Lignano (bottom). The shading scale is logarithmic, between 10^{-2} and 10^{6} $[\mathrm{mm/s}]^2$. White solid lines delimit significant energy. Errors introduced by filtering are substantial under the dashed black line.

$\sigma_\mathrm{h} = \sigma_\mathrm{s}/\sqrt{6}$. Finally, vertically averaged velocity, W, is computed by summing hourly values along the water column and dividing by the number of cells N_c. However, there is 15% correlation between adjacent bins according to the manufacturer company, thus, if the covariance in (2) is decomposed as $\sigma_{ij} = \rho\sigma_i\sigma_j$, where ρ is the correlation, eq. (3) becomes $\sigma_w^2 \cong (1+2\rho)\sigma_\mathrm{h}^2/N_\mathrm{c}$. The instrumental error is thus about 2.5 mm/s and 1.9 mm/s for Grado and Lignano velocity, at the end of the hourly and vertical averaging.

4. – Conclusions

Data analysis confirms the tidal character of the inlets. There is a vertically homogeneous flow regime at the inlets, and a strong polarization along the channel axis. The astronomical tidal forcing is responsible for about 90% of the flow variability in both Grado and Lignano inlets. The semi-diurnal group is the most important one, with M2, S2, K2 and N2 contributing with about 79% of the total energy. The diurnal group (K1, O1 and P1) add up to about 9% of the variability. Phase differences are smaller in the semi-diurnal group (less than one minute) than in the diurnal one (10 minutes for K1). The non-tidal portion of the series contains about 10% of the energy, most of which is associated to Adriatic Seiche signals. The fundamental Seiche mode is found at 21.14 hours, while the higher modes are consistent with previous studies in the Adriatic Sea. Wavelet methods have proved useful in the study of variance of the non-tidal flow at the inlets. The non-stationary character of the Seiches has been assessed: they show recurrently along the entire period of analysis but not with constant energy; reinforcements appear at the onset of winter in both inlets. Likewise, an increase of energy, unrelated to the Adriatic Seiches, is found in Lignano at the beginning of the Spring 2011, with periodicities between 256 and 512 hours (about 15 days). Possible causes considered include river runoff, precipitation, surges and meteorological effects. Further research is needed to assess the origin of this feature.

* * *

The measurements were conducted in collaboration among the former regional authority "*Autorità di Bacino Regionale del Friuli Venezia-Giulia*", University of Trieste (*Dipartimento di Geoscienze*) and National Institute of Oceanography and Experimental Geophysics - OGS, as a part of the monitoring programme "Measurements of the volume and solid transport in the tidal inlets of the Marano-Grado Lagoon System", formalized by the "Atto n. 108/2010 OGS del 22/06/2010" and by the Contract CIG No. 14462760B6. I. Mancero-Mosquera participated in the work with the support of the "Programme for Training and Research in Italian Laboratories (TRIL)" of the Abdus Salam International Centre for Theoretical Physics, Trieste, Italy.

REFERENCES

[1] Triches A., Pillon S., Bezzi A., Lipizer M. and Gordini E., in *Carta batimetrica della Laguna di Marano e Grado: Note illustrative* (Arti Grafiche Friulane/Imoco Spa, Udine) 2011, pp. 15-21.
[2] Preisendorfer R. W., in *Principal component analysis in meteorology and oceanography*, edited by Mobley C. D. (Elsevier Science Publisher, Amsterdam, Oxford, New York, Tokyo) 1988.
[3] Pawlowicz R., Beardsley B. and Lentz S., *Comput. Geosci.*, **28** (2002) 929, http://dx.doi.org/10.1016/S0098-3004(02)00013-4.
[4] Mallat S., in *A Wavelet Tour of Signal Processing* (Academic Press, London) 1999.
[5] Percival D., *Biometrika*, **82** (1995) 619, http://dx.doi.org/10.1093/biomet/82.3.619.
[6] Percival D. and Mofjeld H., *J. Am. Stat. Assoc.*, **92** (1997) 439, 868, http://dx.doi.org/10.1080/01621459.1997.10474042.
[7] Arras K. O., EPFL-ASL-TR-98-01 R3 technical report EPFL (1998).
[8] Cushman-Roisin B., Malačič V. and Gačić M., in *Tides, seiches, and low-frequency oscillations*, edited by Gačić M., Poulain P.-M. and Artegiani A. (Kluwer Academic Publishing, Dordrecht) 2001, pp. 217–240.
[9] Malačič V., Viezzoli D. and Cushman-Roisin B., *J. Geophys. Res.*, **105** (2000) 26265, http://dx.doi.org/10.1029/2000JC900123.
[10] Mosetti F. and Purga N., *Boll. Ocean. Teor. Appl.*, **I**, N. 4 (1983) 277.
[11] Smith III, J.O., in *Spectral Audio Signal Processing* (W3K Publishing, Stanford, CA) 2011.
[12] Mancero-Mosquera I., Gačić M. and Mazzoldi A., *Cont. Shelf Res.*, **30** (2010) 915, http://dx.doi.org/10.1016/j.csr.2010.02.011.
[13] Torrence C. and Compo G. P., *Bull. Am. Meteorol. Soc.*, **79**, N. 1 (1998) 78, http://dx.doi.org/10.1175/1520-0477(1998)079<0061:APGTWA>2.0.CO;2.