UČNI NAČRT PREDMETA / COURSE SYLLABUS	
Predmet:	Fizikalna oceanografija obalnih voda
Course title:	Physical Oceanography of Coastal Waters

Študijski program in stopnja Study programme and level	Študijska smer Study field	Letnik Academic year	Semester Semester
Senzorske tehnologije, 3. stopnja		1	1
Sensor Technologies, 3rd cycle		1	1

Vrsta predmeta / Course type Izbirni / Elective

Univerzitetna koda predmeta / University course code: ST3-891

Predavanja Lectures	Seminar Seminar	Sem. vaje Tutorial	Lab. vaje Laboratory work	Druge oblike	Samost. delo Individ. work	ECTS
15	**15**			**15**	**105**	**5**

**Navedena porazdelitev ur velja, če je vpisanih vsaj 15 študentov. Drugače se obseg izvedbe kontaktnih ur sorazmerno zmanjša in prenese v samostojno delo. / This distribution of hours is valid if at least 15 students are enrolled. Otherwise the contact hours are linearly reduced and transfered to individual work.*

Nosilec predmeta / Lecturer: Prof. dr. Vlado Malačič

Jeziki / Languages:		
	Predavanja / Lectures:	Slovenščina, angleščina / Slovenian, English
	Vaje / Tutorial:	

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:	**Prerequisits:**
Zaključena druga stopnja bolonjskega študija ali diploma univerzitetnega študijskega programa.	Completed Bologna second cycle study program or an equivalent pre-Bologna university study program.

Vsebina:	**Content (Syllabus outline):**
Osnove. Merila gibanja. Pomen rotacije koordinatnega sistema in stratifikacije tekočine. Vertikalna spremenljivost gostote v atmosferi in oceanu. Metoda končnih diferenc in navidezne frekvence gibanja. Coriolisova sila. Enačbe gibanja v rotirajočem koordinatnem sistemu. Nepomembnost centrifugalne sile pri geofizikalnih tekočinah. Inercialen tok. Geostrofičen tok. Gibanje tekočin v atmosferi in oceanih. Ohranitev mase soli in vlažnosti. Boussinesque aproksimacija, zapis gibalnih enačb in energije s pomočjo pretokov. Ekmanova plast. Ekmanova plast na prosti gladini in nad trdo podlago. Ekmanov transport,	Fundamentals. Scales of motion, scale analysis. Importance of rotation and of stratification. Vertical variation of density in atmosphere and ocean. Finite differences and aliasing. Coriolis force. Equations of motion in a rotating framework of reference. Unimportance of centrifugal force. Inertial flow. Geostrophic flow. Fluid motion in oceans and atmosphere. Salt and moisture budgets. Boussinesque approximation, flux formulation of equations of motion and energy. The Ekman layer. Ekman layer at the free surface and on a rigid surface (sea-floor). Ekman transport, upwelling and down-welling in coastal waters. Shallow water equations and normal modes in a continuously stratified fluids on a rotating Earth.

dvigovanje pridnene in spuščanje površinske vode v obalnem pasu. Gibalne enačbe za plitko vodo in lastna gibanja v stratificirani tekočini na rotirajoči Zemlji. Dolgi valovi na rotirajoči Zemlji. Kelvinovi, Poincaré-jevi in Rossby-evi valovi. Topografski Rossby-evi valovi. Disperzijske zveze. Stojni in zastojni val. Ohranitev potencialne vrtinčnosti v toku homogene in stratificirane tekočine. Gravitacijski tok. Obalni tokovi osladkane vodne mase. Plastoviti modeli. Interni Rossby-ev polmer deformacije. Lastna gibanja (seiche) v obalnih vodah in jezerih na rotirajoči Zemlji (vozelne točke). Barotropna in baroklinska lastna gibanja. Kvazi-geostrofska dinamika. Osnovne enačbe, dolžinsko in časovno merilo. Planetarni in topografski valovi v stratificirani tekočini. Nestabilnosti toka na rotirajoči Zemlji. Barotropne in baroklinske nestabilnosti. 2D turbulenca toka v rotirajočem koordinatnem sistemu. Kaskada enstrofije in energije. Geostrofska turbulenca. Podatkovna asimilacija v numeričnih simulacijah geofizikalnih tekočin. Potiskanje, optimalna interpolacija, Kalmanovo filtriranje in inverzne metode.	Long waves on a rotating Earth. Kelvin, Poincaré and Rossby waves. Topography Rossby waves. Dispersion relations. Standing and arrested waves. Potential vorticity conservation in a homogeneous and stratified flow. Gravity currents. Costal currents of freshwater. Layered model. Internal Rossby deformation radius. Eigen motions. Standing waves (seiches) in coastal seas and lakes on a rotating Earth (nodal points). Barotropic and baroclinic standing motions. Quasi-geostrophic dynamics. Governing equations, length and timescale. Planetary waves and topography waves in a stratified fluid. Instabilities on a rotating Earth. Barotropic and baroclinic instabilities. 2D turbulence of a flow in a rotating frame of reference. Enstrophy and energy cascade. Geostrophic turbulence. Data assimilation techniques in numerical simulations of geophysical flows. Nudging, optimal interpolation, Kalman filtering and inverse methods.

Temeljni literatura in viri / Readings:

Izbrana poglavja iz naslednjih knjig: / Selected chapters from the following books:

- B. Cushman-Roisin and J. M. Beckers. Introduction to Geophysical Fluiod Dynamics, Physical and Numerical Aspects, 2nd Ed. 2011, Academic Press, ISBN: 978-0-12-088759-0.
- G. T. Csanady, Circulation in the Coastal Ocean, 1982. D. reidel Publishing Company, ISBN 90-277-1400-2.
- A. E. Gill, Atmosphere-Ocean Dynamics. 1982. Academic Press, ISBN 0-12-283520-4.
- R. E. Thomson and W. J. Emery, Data Analysis Methods in Physical Oceanography, 3rd Ed., 2014. Elsevier, ISBN 978-0-12-387782-6.
- C. HJ. Hearn. The Dynamics of Coastal Models, 2008. Cambridge University Press, ISBN 978-0-521-80740-1

- Izbrani znanstveni članki

Cilji in kompetence:	**Objectives and competences:**
Cilj predmeta je posredovati študentom obstoječa znanja iz fizikalne oceanografije obalnih voda. Študentje bodo spoznali osnove gibanja tekočin v rotirajočem koordinatnem sistemu. Spoznali bodo dolge valove, ki so pomembni za obalno cirkulacijo,	The objective of the course is to deliver to the students the existing knowledge of physical oceanography of coastal waters. Students will be acquainted with fundaments of flows in a rotating Earth. They will learn about long

in tudi ostale ključne ohranitvene zakone, ki so pomembni za opis gibanja tekočine v rotirajočem koordinatnem sistemu. Razvili bodo sposobnost samostojnega raziskovalnega in razvojnega dela na področju fizikalne oceanografije obalnih voda, ki vključuje tako analitične rešitve kot numerične metode reševanja zapletenejših problemov.	waves that play a role in a coastal circulation. They will learn about key conservation properties that matter in a description of geophysical flows. Students will develop the ability to solve independent research and development tasks in the field of physical oceanography of coastal waters, from analytical solutions to numerical approaches to resolve more complex flows.

Predvideni študijski rezultati:	**Intended learning outcomes:**
Znanje in razumevanje: Študenti bodo z uspešno opravljenimi obveznostmi tega predmeta pridobili: • osnovno znanje in razumevanje fizikalne oceanografije, • analitične in numerične metode za reševanje problemov obalnega morja, • osnove za nadaljevanje raziskovalnega dela s področja geofizikalnih tekočin.	Knowledge and understanding: Students, successfully completing this course will acquire: • basic knowledge and understanding of physical oceanography, • analytical and numerical tools to solve problems in coastal waters, • fundamental knowledge for the research in geophysical fluid dynamics.

Metode poučevanja in učenja:	**Learning and teaching methods:**
predavanja, seminarji, konzultacije, individualno delo	lectures, seminars, consultancy, individual work

Načini ocenjevanja:	Delež (v %) / Weight (in %)	**Assessment:**
Seminarska naloga	50 %	Seminar work
Ustni zagovor seminarske naloge	50 %	Oral defense of seminar work

Reference nosilca / Lecturer's references:

- QUERIN, Stefano, BENSI, M., CARDIN, Vanessa, SOLIDORO, Cosimo, BACER, S., MARIOTTI, Laura, STEL, Fulvio, MALAČIČ, Vlado. Saw-tooth modulation of the deep-water thermohaline properties in the southern Adriatic Sea. Journal of geophysical research, ISSN 0148-0227, 2016, 121, 7, 4585-4600, doi: 10.1002/2015JC011522. [COBISS.SI-ID 3913039]
- GENOV, Tilen, ANGELINI, Valeria, HACE, Ana, PALMISANO, Giuseppe, PETELIN, Boris, MALAČIČ, Vlado, PARI, Sauro, MAZZARIOL, Sandro. Mid-distance re-sighting of a common bottlenose dolphin in the northern Adriatic Sea: insight into regional movement patterns. Journal of the Marine Biological Association of the United Kingdom, ISSN 0025-3154, 2016, l96, 4, 909-914, doi: 10.1017/S0025315415001241. [COBISS.SI-ID 3559759]
- LIČER, Matjaž, SMERKOL, Peter, FETTICH, Anja, RAVDAS, Michalis, PAPAPOSTOLOU, Alexandros, MANTZIAFOU, Anneta, STRAJNAR, Benedikt, CEDILNIK, Jure, JEROMEL, Maja, JERMAN, Jure, PETAN, Sašo, MALAČIČ, Vlado, SOFIANOS, Sarantis. Modeling the ocean and atmosphere during an extreme bora event in northern Adriatic using one-way and two-way atmosphere-ocean coupling. Ocean Science, ISSN 1812-0784, 2016, 12, 71-86, doi: 10.5194/os-12-71-2016. [COBISS.SI-ID 3702095].
- FALCIERI, Francesco Marcello, KANTHA, Lakshmi, BENETAZZO, Alvise, BERGAMASCO, Andrea, BONALDO, Davide, BARBARIOL, Francesco, MALAČIČ, Vlado, SCLAVO, Mauro, CARNIEL, Sandro. Turbulence observations in the Gulf of Trieste under moderate wind forcing and different water column stratification. Ocean Science, ISSN 1812-0784, 2016, 12, 433-449, doi: 10.5194/os-12-433-2016. [COBISS.SI-ID 3806543]

- PETELIN, Boris, KONONENKO, Igor, MALAČIČ, Vlado, KUKAR, Matjaž. Dynamic fuzzy paths and cycles in multi-level directed graphs. Engineering applications of artificial intelligence, , 2014, 37, 194-206, doi: 10.1016/j.engappai.2014.09.012. [COBISS.SI-ID 3224655].