**Syllabus**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Discipline’s code | Discipline’s title |  | | | Number of ECTS | SWST  Self-work of student with teacher in hours |
| Lect. | Pract. | Lab. |
|  | Marine pollution, detection and mapping | 7 | 3 | 1 | 5 | 40 |

|  |  |
| --- | --- |
| Academic presentation of the course | **Aim of course:** …  **As a result of studying the discipline, students should be able to:**   1. Summarise pollution sources and types in marine environment 2. Summarise the concepts for deriving water quality variables using data acquired by active and passive sensors. 3. Produce geographic maps of water quality variables (including oil spill) from satellite imageries 4. Analyse data records of marine related essential climate variables |
| Prerequisites | Tertiary education in science, mathematics, technology and engineering  Basic skill in statistical analysis |
| Post requisites |  |
| Information resources | **literature**:   * Acker, J., Williams, R., Chiu, L., Ardanuy, P., Miller, S., Schueler, C., Vachon, P.W., Manore, M., 2014. Remote Sensing from Satellites☆, in: Reference Module in Earth Systems and Environmental Sciences. Elsevier. https://doi.org/10.1016/B978-0-12-409548-9.09440-9 * Androulakis, D.N., Banks, A.C., Dounas, C., Margaris, D.P., 2020. An Evaluation of Autonomous In Situ Temperature Loggers in a Coastal Region of the Eastern Mediterranean Sea for Use in the Validation of Near-Shore Satellite Sea Surface Temperature Measurements. Remote Sens. 12, 1140. https://doi.org/10.3390/rs12071140 * Ardhuin, F., Stopa, J.E., Chapron, B., Collard, F., Husson, R., Jensen, R.E., Johannessen, J., Mouche, A., Passaro, M., Quartly, G.D., Swail, V., Young, I., 2019. Observing Sea States. Front. Mar. Sci. 6. https://doi.org/10.3389/fmars.2019.00124 * Berger, M., Camps, A., Font, J., Kerr, Y., Miller, J., Johannessen, J., Boutin, J., Drinkwater, M.R., Skou, N., Floury, N., Rast, M., Rebhan, H., Attema, E., 2002. Measuring Ocean Salinity with ESA’s SMOS Mission 10. * Cane, M.A., 2005. The evolution of El Niño, past and future. Earth Planet. Sci. Lett. 230, 227–240. https://doi.org/10.1016/j.epsl.2004.12.003 * Carbon Dioxide Capture and Storage — IPCC, n.d. URL https://www.ipcc.ch/report/carbon-dioxide-capture-and-storage/ (accessed 5.25.21). * DeVries, T., 2014. The oceanic anthropogenic CO2 sink: Storage, air-sea fluxes, and transports over the industrial era. Glob. Biogeochem. Cycles 28, 631–647. https://doi.org/10.1002/2013GB004739 * DeVries, T., Holzer, M., Primeau, F., 2017. Recent increase in oceanic carbon uptake driven by weaker upper-ocean overturning. Nature 542, 215–218. https://doi.org/10.1038/nature21068 * DeVries, T., Quéré, C.L., Andrews, O., Berthet, S., Hauck, J., Ilyina, T., Landschützer, P., Lenton, A., Lima, I.D., Nowicki, M., Schwinger, J., Séférian, R., 2019. Decadal trends in the ocean carbon sink. Proc. Natl. Acad. Sci. 116, 11646–11651. https://doi.org/10.1073/pnas.1900371116 * Dodet, G., Piolle, J.-F., Quilfen, Y., Abdalla, S., Accensi, M., Ardhuin, F., Ash, E., Bidlot, J.-R., Gommenginger, C., Marechal, G., Passaro, M., Quartly, G., Stopa, J., Timmermans, B., Young, I., Cipollini, P., Donlon, C., 2020. The Sea State CCI dataset v1: towards a sea state climate data record based on satellite observations. Earth Syst. Sci. Data 12, 1929–1951. https://doi.org/10.5194/essd-12-1929-2020 * Edson, J.B., Jampana, V., Weller, R.A., Bigorre, S.P., Plueddemann, A.J., Fairall, C.W., Miller, S.D., Mahrt, L., Vickers, D., Hersbach, H., 2013. On the Exchange of Momentum over the Open Ocean. J. Phys. Oceanogr. 43, 1589–1610. https://doi.org/10.1175/JPO-D-12-0173.1 * ESA - Climate from Space [WWW Document], n.d. URL https://cfs.climate.esa.int (accessed 4.21.21). * Garbe, C.S., Rutgersson, A., Boutin, J., de Leeuw, G., Delille, B., Fairall, C.W., Gruber, N., Hare, J., Ho, D.T., Johnson, M.T., Nightingale, P.D., Pettersson, H., Piskozub, J., Sahlée, E., Tsai, W., Ward, B., Woolf, D.K., Zappa, C.J., 2014. Transfer Across the Air-Sea Interface, in: Liss, P.S., Johnson, M.T. (Eds.), Ocean-Atmosphere Interactions of Gases and Particles, Springer Earth System Sciences. Springer, Berlin, Heidelberg, pp. 55–112. https://doi.org/10.1007/978-3-642-25643-1\_2 * GCOS | WMO [WWW Document], n.d. URL https://gcos.wmo.int/en/essential-climate-variables (accessed 4.21.21). * Gimeno, L., Nieto, R., Drumond, A., Durán-Quesada, A.M., 2012. Ocean Evaporation and Precipitation, in: Meyers, R.A. (Ed.), Encyclopedia of Sustainability Science and Technology. Springer, New York, NY, pp. 7244–7263. https://doi.org/10.1007/978-1-4419-0851-3\_734 * Gregory, J.M., Griffies, S.M., Hughes, C.W., Lowe, J.A., Church, J.A., Fukimori, I., Gomez, N., Kopp, R.E., Landerer, F., Cozannet, G.L., Ponte, R.M., Stammer, D., Tamisiea, M.E., van de Wal, R.S.W., 2019. Concepts and Terminology for Sea Level: Mean, Variability and Change, Both Local and Global. Surv. Geophys. 40, 1251–1289. https://doi.org/10.1007/s10712-019-09525-z * Introducing GOCE [WWW Document], n.d. URL http://www.esa.int/Applications/Observing\_the\_Earth/GOCE/Introducing\_GOCE (accessed 5.4.21). * Kara, A.B., Rochford, P.A., Hurlburt, H.E., 2000. An optimal definition for ocean mixed layer depth. J. Geophys. Res. Oceans 105, 16803–16821. https://doi.org/10.1029/2000JC900072 * Kirk, J.T.O., 1994. Light and Photosynthesis in Aquatic Ecosystems, 2nd ed. Cambridge University Press, Cambridge. https://doi.org/10.1017/CBO9780511623370 * Kulk, G., Platt, T., Dingle, J., Jackson, T., Jönsson, B.F., Bouman, H.A., Babin, M., Brewin, R.J.W., Doblin, M., Estrada, M., Figueiras, F.G., Furuya, K., González-Benítez, N., Gudfinnsson, H.G., Gudmundsson, K., Huang, B., Isada, T., Kovač, Ž., Lutz, V.A., Marañón, E., Raman, M., Richardson, K., Rozema, P.D., Poll, W.H. van de, Segura, V., Tilstone, G.H., Uitz, J., Dongen-Vogels, V. van, Yoshikawa, T., Sathyendranath, S., 2020. Primary Production, an Index of Climate Change in the Ocean: Satellite-Based Estimates over Two Decades. Remote Sens. 12, 826. https://doi.org/10.3390/rs12050826 * Lambeck, K., 1997. GEOIDGeoid, in: Encyclopedia of Planetary Science, Encyclopedia of Earth Science. Springer Netherlands, Dordrecht, pp. 268–269. https://doi.org/10.1007/1-4020-4520-4\_152 * Mashayek, A., Salehipour, H., Bouffard, D., Caulfield, C.P., Ferrari, R., Nikurashin, M., Peltier, W.R., Smyth, W.D., 2017. Efficiency of turbulent mixing in the abyssal ocean circulation. Geophys. Res. Lett. 44, 6296–6306. https://doi.org/10.1002/2016GL072452 * McPhaden, M.J., Zebiak, S.E., Glantz, M.H., 2006. ENSO as an Integrating Concept in Earth Science. Science 314, 1740–1745. https://doi.org/10.1126/science.1132588 * Merchant, C.J., Embury, O., Bulgin, C.E., Block, T., Corlett, G.K., Fiedler, E., Good, S.A., Mittaz, J., Rayner, N.A., Berry, D., Eastwood, S., Taylor, M., Tsushima, Y., Waterfall, A., Wilson, R., Donlon, C., 2019. Satellite-based time-series of sea-surface temperature since 1981 for climate applications. Sci. Data 6, 223. https://doi.org/10.1038/s41597-019-0236-x * MIMURA, N., 2013. Sea-level rise caused by climate change and its implications for society. Proc. Jpn. Acad. Ser. B Phys. Biol. Sci. 89, 281–301. https://doi.org/10.2183/pjab.89.281 * Mobley, C.D., 1994. Light and Water: Radiative Transfer in Natural Waters. Academic Press, San Diego. * Montégut, C. de B., Madec, G., Fischer, A.S., Lazar, A., Iudicone, D., 2004. Mixed layer depth over the global ocean: An examination of profile data and a profile-based climatology. J. Geophys. Res. Oceans 109. https://doi.org/10.1029/2004JC002378 * Mor, Z., Assouline, S., Tanny, J., Lensky, I.M., Lensky, N.G., 2018. Effect of Water Surface Salinity on Evaporation: The Case of a Diluted Buoyant Plume Over the Dead Sea. Water Resour. Res. 54, 1460–1475. https://doi.org/10.1002/2017WR021995 * Robinson, I.S., 2004. Measuring the Oceans from Space: The principles and methods of satellite oceanography, Geophysical Sciences. Springer-Verlag, Berlin Heidelberg. * Thomson, J., 2001. Great rivers of the ocean. Nature news010111-6. https://doi.org/10.1038/news010111-6 * Tippett, M.K., L’Heureux, M.L., 2020. Low-dimensional representations of Niño 3.4 evolution and the spring persistence barrier. Npj Clim. Atmospheric Sci. 3, 1–11. https://doi.org/10.1038/s41612-020-0128-y * Wallace, W.J. (Ed.), 1974. Chapter 6 Constant Proportionality of Constituents, in: Elsevier Oceanography Series, The Development of The Chlorinity/Salinity Concept in Oceanography. Elsevier, pp. 87–103. https://doi.org/10.1016/S0422-9894(08)70979-6 * Watson, A.J., Schuster, U., Shutler, J.D., Holding, T., Ashton, I.G.C., Landschützer, P., Woolf, D.K., Goddijn-Murphy, L., 2020. Revised estimates of ocean-atmosphere CO 2 flux are consistent with ocean carbon inventory. Nat. Commun. 11, 4422. https://doi.org/10.1038/s41467-020-18203-3 * Webb, P., n.d. Introduction to Oceanography. RWU. * Widlansky, M.J., Long, X., Schloesser, F., 2020. Increase in sea level variability with ocean warming associated with the nonlinear thermal expansion of seawater. Commun. Earth Environ. 1, 1–12. https://doi.org/10.1038/s43247-020-0008-8   **Internet-resources:**  Principles of Remote Sensing  <https://webapps.itc.utwente.nl/librarywww/papers_2009/general/principlesremotesensing.pdf>  Ocean optics  <https://www.oceanopticsbook.info>  Essential climate variables  <https://climate.esa.int/en/evidence/role-eo-understanding-climate-change/> |

Calendar (schedule) the implementation of the course content**:**

|  |  |  |  |
| --- | --- | --- | --- |
| Week / date | Topic title (lectures, practical classes, Independent work of students, IWS) | Number of hours | Maximum score |
| 1 | Lecture 1. Basics of remote sensing above water | 1 |  |
| Practical class 1. Accessing Data of the Copernicus Marine Service (CMEMS) | 2 |  |
| 1 | Lecture 2. Data retrieval and handling | 1 |  |
| Practical class 2. Data retrieval and handling | 8 |  |
| 2 | Lecture 3. Marin pollution  Lecture 4. Light and water  Lecture 5. Deriving water quality variables from remote sensing data | 3 |  |
| Practical class 3 Deriving water quality variables from remote sensing data | 8 |  |
| 3 | Lecture 6. Oil spill detection | 1 |  |
| Practical class 3 Oil spill detection | 8 |  |
| 3 | Lecture 7.Climate change and the seas | 3 |  |
| 4 | Self-work of student with teacher: SWST.  Analyse data records of marine related essential climate variables: a case study from the Caspian sea | 40 |  |