

UNIVERSIDAD DE CANTABRIA

**DEPARTAMENTO DE CIENCIAS Y TÉCNICAS
DEL AGUA Y DEL MEDIO AMBIENTE**

TESIS DOCTORAL

**ESTUDIO DE LA VARIABILIDAD CLIMÁTICA DE VALORES
EXTREMOS DE OLEAJE**

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BIBLIOGRAFÍA

Aghedo, A.M., S. Rast and M.G. Schultz (2010). Sensitivity of tracer transport to model resolution, prescribed meteorology and tracer lifetime in the general circulation model ECHAM5. *Atmospheric Chemistry and Physics*, 10, 3385-3396.

Allan, J.C. and P.D. Komar (2000). Are ocean wave heights increasing in eastern North Pacific? *Eos Transactions*. AGU, 81, 561-566.

Alves, J.H.G.M. and I.R. Young (2004). On estimating extreme wave heights using combined Geosat, Topex/Poseidon and ERS-1 altimeter data. *Applied Ocean Research*, 25, 167-186.

Alves, J.H.G.M. (2006). Numerical modeling of ocean swell contributions to the global wind-wave climate. *Ocean Modeling*, 11, 98-122.

Barry R.G. and A.H. Perry (1973). *Synoptic climatology: methods and applications*. Harper & Row.

Baldwin M.P., L.J. Gray, T.J. Dunkerton, K. Hamilton, P.H. Haynes, W.J. Randel, J.R. Holton, M.J. Alexander, I. Hirota, T. Horinouchi, D.B.A. Jones, J.S. Kinnersley, C. Marquardt, K. Sato and M. Takahashi (2001). The quasi-biennial oscillation. *Reviews of Geophysics*, 39, 179-229.

Barnston, A. G. and R. E. Livezey, (1987). Classification, seasonality and persistence of low-frequency atmospheric circulation patterns. *Monthly Weather Review*, 115, 1083-1126.

Beran, M.A. and M.K. Nozdryn-Plotnicki (1977). Estimation of low return period floods. *Bulletin of the International Association of Hydrologic Sciences*, 2, 275-282.

Bertotti, L., and L. Cavalieri (2008). Analysis of the Voyager storm, *Ocean Engineering*, 35, 1-5.

Booij, N., R. C. Ris and L.H. Holthuijsen (1999). A third-generation wave model for coastal regions. Part I: model description and validation. *Journal of Geophysical Research*, 104 (C4), 7649-7666.

Bortkiewicz, L., von (1992). Variationsbreite und mittlerer Fehler, *Sitzungsber. Berlin Maths. Ges*, 21, 3-11.

Brands, S. S. Herrera, D. San Martín and J.M. Gutiérrez (2010). Performance of the ENSEMBLES Global Climate Models over the Iberian Peninsula from a statistical downscaling perspective. Enviado a *Climate Research*.

Browne, M., B. Castelle, D. Strauss, R. Tomlinson, M. Blumenstein and C. Lane (2007). Nearshore swell estimation from a global wind-wave model: Spectral process, linear and artificial neural network models. *Coastal Engineering*, 54, 445-460.

Caires, S. and A. Sterl (2003). Validation of ocean wind and wave data using triple collocation. *Journal of Geophysical Research*, 108(C3), 3098.

Caires, S. and Sterl A. (2005). 100-year return value estimates for ocean wind speed and significant wave height from the ERA-40 data. *Journal of Climate*, 18, 1032-1048.

Caires, S., V. Swail and X.L. Wang (2006). Projection and Analysis of Extreme Wave Climate. *Journal of Climate*, 19(21), 5581-5605.

Camus, P. (2009). *Metodología para la definición del clima marítimo en aguas profundas y someras: aplicaciones en el corto, medio y largo plazo*. Tesis Doctoral. Universidad de Cantabria.

Camus, P., F.J. Méndez, R. Medina and A.S., Cofiño (2010). Analysis of clustering and selection algorithms for the study of multivariate wave climate. Enviado a *Coastal Engineering*.

Callaghan, D.P., P. Nielsen, A. Short and R. Ranasinghe (2008). Statistical simulation of wave climate and extreme beach erosion. *Coastal Engineering*, 55, 375-390.

Casson E. and S. Coles (2000). Simulation and extremal analysis of hurricane events. *Applied Statistics*, 49(2), 227-245.

Castillo, E., A.S. Hadi, N. Balakrishnan and J.M. Sarabia (2005). Extreme Value and Related Models with Applications in Engineering and Science. Wiley-Interscience. New Jersey.

Chen G., S.W. Bi and R. Ezraty (2004). Global structure of extreme wind and wave climate derived from TOPEX altimeter data. *International Journal of Remote Sensing*, 25(5), 1005-1018.

Coles, S.G. (2001). *An introduction to statistical modeling of extreme values*. London, Springer, 208 pp.

Duan, Q., S. Sorooshian, V. Gupta (1992). Effective and efficient global optimization for conceptual rainfall–runoff models. *Water Resources Research*, 28, 1015-1031.

Easterling, D.R., J.L. Evans, P.Y. Groisman, T.R. Karl, K.E. Kunkel, and P. Ambenje (2000a). Observed variability and trends in extreme climate events: A brief review. *Bulletin of the American Meteorological Society*, 81(3), 417-425.

Easterling, D.R., S. Chagnon, T.R. Karl, J. Meehl, and C. Parmesan (2000b). Climate extremes: observations, modeling, and impacts. *Science*, 289(5487), 2068-2074.

Fisher, R. A. and L.H.C. Tippett (1928). Limiting forms of the frequency distribution of the largest or smallest member of a sample. *Mathematical Proceedings of the Cambridge Philosophical Society*, 24, 180-190.

Franke, R. (1982). Scattered data interpolation: test of some methods. *Mathematics of Computation*, 38, 181-200.

Fréchet, M. (1927). Sur la loi de probabilité de l'écart maximum. *Annales de la Societe Polonaise de Mathematique Cracovie* 6, 93-116.

Galambos, J. (1987). *The Asymptotic Theory of Extreme Order Statistics*, Robert E. Krieger. Malabar, Florida. 2nd ed.

Gnedenko, B. (1943). Sur la distribution limite du terme maximum d'une série aléatoire. Translated and reprinted in: *Breakthroughs in Statistics*, I, 1992, Springer-Verlag, 195-225.

Grabemann I. and R. Weisse (2008). Climate change impact on extreme wave conditions in the North Sea: an ensemble study. *Ocean Dynamics*, 58, 199-212.

Graham, N.E. and H.F. Diaz (2001). Evidence for intensification of North Pacific winter cyclones since 1948. *Bulletin of the American Meteorological Society*, 82, 1869-1893

Groeneweg, J., M. Van Ledden and M. Zijlema (2006). Wave transformation in front of the Dutch Coast in: J.M. Smith (Ed.), Proc. 30th International Conference on Coastal Engineering, San Diego, USA, 552-564.

Guedes Soares, C. and M.G. Scotto (2004). Application of the r-largest-order statistics for long-term predictions of significant wave height. *Coastal Engineering*, 51, 387-394.

Gulev, S. K. and V. Grigorjeva (2004). Last century changes in ocean wind wave height from global visual wave data. *Geophysical Research Letters*, 31, L24302.

Gulev, S.K. and V. Grigorjeva (2006). Variability of the winter wind waves and swell in the North Atlantic and North Pacific as revealed by the voluntary observing ship data, *Journal of Climate*, 19, 5667-5685

Gumbel, E.J. (1958). *Statistics of Extremes*, Columbia University Press.

Harley, M.D., I.L. Turner, A.D. Short and R. Ranasinghe (2009). Interannual variability and controls of the Sydney wave climate. *International Journal of Climatology*, 30(9), 1322-1335.

Hemer, M.A., J.A. Church and J.R. Hunter (2007). *A wave climatology for the Australian Region*. CSIRO Marine and Atmospheric Research report prepared for the Australian Greenhouse Office, Department of Environment and Water Resources, Australia. 77pp.

Hemer, M.A., J.A. Church and J.R. Hunter (2010). Variability and trends in the directional wave climate of the Southern Hemisphere. *International Journal of Climatology*, 30, 475-491

Herman, A., R. Kaiser and H.D. Niemeyer (2009). Wind-wave variability in shallow tidal sea – Spectral modeling combined with neural network methods. *Coastal Engineering*, 56, 759-772.

Hewitson, B.C. and R.G. Crane (2002). Self-organizing maps: applications to synoptic climatology. *Climate Research*, 22(1), 13-26.

Hurrell, J. W. (1995). Decadal trends in the North Atlantic Oscillation: Regional temperatures and precipitation. *Science*, 269, 676–679.

IH Cantabria (2009). SEAWIND: Multi-Reanalysis and Multi-Physics High-Resolution WRF dynamical downscaling of Surface Wind on the Atlantic and the Mediterranean European basins. Hindcast vs. Climatic integration [Fita, L., J. Fernandez, J.M. Gutiérrez and A. S. Cofiño] Santander Meteorology Group. Dep. Applied Mathematics and Computer Science Instituto de Física de Cantabria (CSIC-UC) Universidad de Cantabria (UC), Santander, Spain.

IPCC (Intergovernmental Panel on Climate Change), (2007). *Climate Change 2007: The Physical Science Basis*. Contribution of Working Group I to the Fourth Assessment Report (AR4) of the Intergovernmental Panel on Climate Change [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, UK, and New York. <http://www.ipcc.ch>.

Jones, P. D., T. Jónsson, and D. Wheeler (1997), Extension to the North Atlantic Oscillation using early instrumental pressure observations from Gibraltar and southwest Iceland, *International Journal of Climatology*, 17, 1433–1450.

Kako S. and M. Kubota (2006). Relationship between and El Niño event and the interannual variability of significant wave heights in the North Pacific. *Canadian Meteorological and Oceanographic Society. Atmosphere-Ocean*, 44(4), 377-395.

Kalnay E., M. Kanamitsu, R. Kistler, W. Collins, D. Deaven, L. Gandin, M. Iredell, S. Saha, G. White, J. Woollen, Y. Zhu, M. Chelliah, W. Ebisuzaki, W. Higgins, J. Janowiak, K. C. Mo, C. Ropelewski, J. Wang, A. Leetmaa, R. Reynolds, R. Jenne and D. Joseph (1996). The NCEP/NCAR 40-Year Reanalysis Project. *Bulletin of the American Meteorological Society*, 77 (3), 437–471

Kalra, R., M.C. Deo, R. Kumar and V.K. Agarwal (2005). Artificial neural network to translate offshore satellite wave to data to coastal locations. *Ocean Engineering*, 32, 1917-1932.

Katz, R.W., M.B. Parlange and P. Naveau (2002). Statistics of extremes in hydrology. *Advances in Water Resources*, 25, 1287-1304.

Kennard, R.W. and L.A. Stone (1969). Computer aided design experiments. *Technometrics*, 11, 137-148.

Kohonen, T. (2000). *Self-Organizing Maps*. Springer-Verlag, Berlin, 3rd ed.

Komen, G. J., L. Cavalieri, M. Donelan, K. Hasselmann, S. Hasselmann and P. A. E. M. Janssen (1994). *Dynamics and Modelling of Ocean Waves*. Cambridge University Press, 532 pp.

Leadbetter, M.R., G. Lindgrem, H. Rootzén (1983). *Extremes and Related Properties of Random Sequences and Series*. Springer-Verlag, New York-Heidelberg-Berlin, 336 pp.

Lettenmaier, D.P. and Burges, S.J. (1982). Gumbel's extreme value I distribution, a new look. *Journal of Hydraulics Division-ASCE* 108, 502-504.

Lionello, P. and A. Sanna (2005). Mediterranean wave climate variability and its link with NAO and Indian Monsoon. *Climate Dynamics*, 25, 611-623.

Luceño, A., M. Menéndez, and F.J. Méndez (2006). The effect of temporal dependence on the estimation of the frequency of extreme ocean climate events. *Proceedings of the Royal Society of London, Series A*, 462, 1683-1697.

Martín-Vide, J., and J. A. López-Bustins (2006). The western Mediterranean Oscillation and Iberian peninsula rainfall. *International Journal of Climatology*, 26 (11), 1455-1475.

Méndez, F.J., M. Menéndez, A. Luceño, and I.J. Losada (2006). Estimation of the long-term variability of extreme significant wave height using a time-dependent POT model. *Journal of Geophysical Research*, 111, C07024.

Menéndez M. (2008). *Metodología para el análisis estadístico no estacionario de valores extremos de variables geofísicas*. Tesis doctoral. Universidad de Cantabria.

Menéndez, M., F.J. Méndez, I.J. Losada and N.E. Graham (2008). Variability of extreme wave heights in the northeast Pacific Ocean based on buoy measurements. *Geophysical Research Letters*, 35, L22607.

Menéndez M., F.J. Méndez, C. Izaguirre, A. Luceño and I.J. Losada (2009a). The influence of seasonality on estimating return values of significant wave height. *Coastal Engineering*, 56(3), 211-219

Menéndez, M., F.J. Méndez, I.J. Losada (2009b). Forecasting seasonal to interannual variability in extreme sea levels. *ICES Journal of Marine Science*, 66, 1490-1496.

Mises, R. von (1936). La distribution de la plus grande de n valeurs. Reproduced in Selected Papers of Richard von Mises, II (1954). *American Mathematical Society* 271-294.

Morton, I.D., J. Bowers and G. Mould (1997). Estimating return period wave heights and wind speeds using a seasonal point process model. *Coastal Engineering*, 31, 305-326.

Nakicenovic, N., and R. Stewart (2000). *Emissions Scenarios: Special Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press, London.

Panchang, V., L. Zhao and Z. Demirbilek (1999). Estimation of extreme wave heights using GEOSAT measurements. *Ocean Engineering*, 26, 205-225.

Pickands, J. (1975). Statistical inference using extreme order statistics. *Annals of Statistics*, 3, 119-131.

Polinsky, A., R.D. Feinstein, S. Shi and A. Kuki (1996). Librain: Software for automated design of exploratory and targeted combinatorial libraries. In: Molecular Diversity and Combinatorial Chemistry: Libraries and Drug Discovery (I.M. Chaiken and K.D. Janda, eds.) *American Chemical Society*, Washington, D.C., pp. 219-232.

Ponce de León, S., and C. Guedes Soares (2008). Sensitivity of wave model predictions to wind fields in the western Mediterranean Sea, *Coastal Engineering*, 55(11), 920-929.

Queffeulou, P. (2005). Wave height variability over the Mediterranean Sea, using altimeter data. Proceedings of the 5th International Symposium on Ocean Wave Measurements and Analysis (Madrid, Spain), Paper 21,

Rasmusson E.M. and T.H. Carpenter (1981). Variations in tropical sea surface temperature and surface wind fields associated with the Southern Oscillation/El Niño. *Monthly Weather Review*, 110, 354-384.

Rice, S.O. (1939). The distribution of the maxima of a random curve. *American Journal of Mathematics* 61, 409-416.

Rice, J. (1994). *Mathematical Statistics and Data Analysis*. 2nd ed. Duxbury.

Rippa, S. (1999). An algorithm for selecting a good value for the parameter c in radial basis function interpolation. *Advances in Computational Mathematics*, 11, 193-210.

Rogers, W.E., J.M. Kaihatu, N. Booij and L.H. Holthuijsen (1999). Improving the Numerics of the Third-Generation Wave Action Model. *Naval Research Laboratory*, Report Number 7320-99-9695.

Ruggiero, P., G.M. Kaminsky, P.D. Komar and W.G. McDougal (1997). Extreme waves and coastal erosion in the Pacific Northwest. *Ocean Wave Measurement and Analysis*, Proceedings of the 3rd International Symposium, Waves '97, 947-961.

Saji, N.H., B.N. Goswami, P.N. Vinayachandran and T. Yamagata (1999). A dipole mode in the tropical Indian Ocean. *Nature* 401, 360-363

Sasaki, W. and T. Hibiya (2007). Interannual variability of summertime significant wave heights in the western north Pacific, *Journal of Oceanography*, Vol. 63, pp. 203 to 213.

Smith, R.L. (1986). Extreme value theory based on the r-largest annual events. *Journal of Hydrology* 86, 27-43.

Stansby, P., J. Zhou, C. Kuang, M. Walkden, J. Hall and M. Dickson (2006). Long-term prediction of nearshore wave climate with an application to cliff erosion. Proc. 30th International Conference on Coastal Engineering, San Diego, USA, 616-627.

Thompson, D. W. J. and J. M. Wallace (1998). The Arctic Oscillation signature in the wintertime geopotential height and temperature fields. *Geophysical Research Letters*, 25, 1297-1300.

Thompson, D. W. J. and J. M. Wallace (2000). Annular modes in the extratropical circulation. Part I: Month to month variability. *Journal of Climate*, 13, 1000–1016.

Tolman, H. L. (1989). The numerical model WAVEWATCH: a third generation model for the hindcasting of wind waves on tides in shelf seas. *Communications on Hydraulic and Geotechnical Engineering*, Delft Univ. of Techn., ISSN 0169-6548, Rep. no. 89-2, 72 pp.

Tolman , H. L (1997). *User manual and system documentation of WAVEWATCH-III version 1.15*. NOAA / NWS / NCEP / OMB Technical Note 151, 97 pp.

Tolman, H.L. (1999). *User manual and system documentation of WAVEWATCH III version 1.18*. NOAA/NWS/NCEP/OMB Technical Note 166, 110 pp.

Tomás, A., F.J. Méndez and I.J. Losada (2008). A method for spatial calibration of wave hindcast data bases. *Continental Shelf Research*, 28, 391-398.

Tomás, A. (2009). *Metodologías de calibración de bases de datos de reanálisis de clima marítimo*. Tesis doctoral. Universidad de Cantabria.

U.K. Climate Projections (2009). *Marine & Coastal Projections*. ISBN 978-1-906360-03-0.

U.S. Climate Change Science Program (2008). *Weather and Climate Extremes in a Changing Climate. Regions of Focus: North America, Hawaii, Caribbean and U.S. Pacific Islands*, Synthesis and Assessment Product 3.3.

Vidal, C., R. Medina and P. Lomónaco (2006). Wave height parameter for damage description of rubble-mound breakwaters. *Coastal Engineering*, 53, 711-722.

Wallace, J.M., and D.S. Gutzler (1981). Teleconnections in the geopotential height field during the Northern Hemisphere winter. *Monthly Weather Review*, 109, 784-812

WAMDIG (1988). The WAM model - A third generation ocean wave prediction model. *Journal of Physical Oceanography*. 18, 1775-1810.

Wang, X.L. and V.R. Swail (2001). Changes of extreme wave heights in Northern Hemisphere oceans and related atmospheric circulation regimes. *Journal of Climate*, 14, 2204-2221.

Wang, X.L., F.W. Zwiers and V.R. Swail (2004). North Atlantic ocean wave climate change scenarios for the twenty-first century. *Journal of Climate*, 17, 2368-2383.

Wang, X. L. and V. Swail (2006). Climate change signal and uncertainty in projections of ocean wave height. *Climate Dynamics*, 26, 109-126.

Wang J. and X. Zang (2008). Downscaling and projection of winter extreme daily precipitation over North America. *Journal of Climate*, pp 923-937.

Willet, P. (1996). Molecular diversity techniques for chemical databases. *Information Research*, Vol. 2, No 3.

Woolf D.K., P.G. Challenor and P.D. Cotton (2002). Variability and predictability of the North Atlantic wave climate. *Journal of Geophysical Research*, 107(C10), 3145.

Young, I.R. (1999). Seasonal variability of the global ocean wind and wave climate. *Int. Journal of Climatology*, 19, 931-950.