

## References

- Adcroft, A. and J.-M. Campin, 2004: Rescaled height coordinates for accurate representation of free-surface flows in ocean circulation models. *Ocean Modell.*, **7**, 269–284.
- Agresti, A., 2002: *Categorical Data Analysis, 2nd ed.* New York: Wiley, 734pp.
- An, H. S., 1977: A Numerical Experiment of the M2 Tide in the Yellow Sea. *J. Oceanogr.*, **33**, 103–110.
- An, Soon-Il, 2008: Interannual variations of the tropical ocean instability wave and ENSO. *J. Climate*, **21**, 3680–3686.
- Anderson, J. L., 2001: An Ensemble Adjustment Kalman Filter for Data Assimilation. *Mon. Wea. Rev.*, **129**, 2884–2903.
- Andersson, E. and H. Järvinen, 1999: Variational Quality Control. *Quart. J. Roy. Meteor. Soc.*, **125**, 697–722.
- Aoki, Te., Ta. Aoki, M. Fukabori, and T. Takao, 2002: Characteristics of UV-B Irradiance at Syowa Station, Antarctica: Analyses of the Measurements and Comparison with Numerical Simulations. *J. Meteor. Soc. Japan*, **80**, 161–170.
- Arakawa, A., 1972: Design of the UCLA general circulation model. Numerical simulation weather and climate, Tech. Rep. 7, Dept. of Meteorology, University of California, Los Angeles. 116pp.
- Arakawa, A. and V. R. Lamb, 1977: Computational design of the basic dynamical processes of the UCLA general circulation model. *Methods in Computational Physics*, **17**, 174–265, Academic Press.
- Arakawa, A. and W. H. Schubert, 1974: Interaction of a cumulus cloud ensemble with the large-scale environment, Part I. *J. Atmos. Sci.*, **31**, 674–701.
- Aranami, K. and J. Ishida, 2004: Implementation of two dimensional decomposition for JMA non-hydrostatic model. *CAS/JSC WGNE Res. Activ. Atmos. Oceanic Modell.*, **34**, 03.01–03.02.
- Aranami, K., T. Hara, Y. Ikuta, K. Kawano, K. Matsubayashi, H. Kusabiraki, T. Ito, T. Egawa, K. Yamashita, Y. Ota, Y. Ishikawa, T. Fujita, and J. Ishida, 2015: A new operational regional model for convection-permitting numerical weather prediction at JMA. *CAS/JSC WGNE Res. Activ. Atmos. Oceanic Modell.*, **45**, 05.05–05.06.
- Baines, P. G. and T. N. Palmer, 1990: Rationale for a new physically-based parametrization of subgrid-scale orographic effects. 11.
- Barnes, R. T. H., R. Hide, A. A. White, and C. A. Wilson, 1983: Atmospheric angular momentum fluctuations, length-of-day change and polar motion. *Proc. R. Soc.*, **A387**, 31–73.
- Bartholomé, E. and A. S. Belward, 2005: GLC2000: a new approach to global land cover mapping from Earth observation data. *International Journal of Remote Sensing*, **26**, 1959–1977.
- Bechtold, P., M. Kohler, T. Jung, F. Doblas-Reyes, M. Leutbecher, M. J. Rodwell, F. Vitart, and G. Balsamo, 2008: Advances in simulating atmospheric variability with the ECMWF model: From synoptic to decadal time-scales. *Quart. J. Roy. Meteor. Soc.*, **134**, 1337–1351.
- Beljaars, A. C. M., 1995: The parameterization of surface fluxes in large-scale models under free convection. *Quart. J. Roy. Meteor. Soc.*, **121**, 255–270.
- Beljaars, A. C. M., A. R. Brown, and N. Wood, 2004: A new parametrization of turbulent orographic form drag. *Quart. J. Roy. Meteor. Soc.*, **130**, 1327–1347.
- Beljaars, A. C. M. and A. A. M. Holtslag, 1991: Flux parameterization over land surfaces for atmospheric models. *J. Appl. Meteor.*, **30**, 327–341.
- Berger, M. J. and J. Olinger, 1984: Adaptive mesh refinement for hyperbolic partial differential equations. *J. Comp. Phys.*, **53**, 484–512.
- Berner, J., G. J. Shutts, M. Leutbecher, and T. N. Palmer, 2009: A Spectral Stochastic Kinetic Energy Backscatter Scheme and Its Impact on Flow-Dependent Predictability in the ECMWF Ensemble Prediction System. *J. Atmos. Sci.*, **66**, 603–626.
- Best, M. J., A. C. M. Beljaars, J. Polcher, and P. Viterbo, 2004: A proposed structure for coupling tiled surfaces with the planetary boundary layer. *J. Hydr. Meteorol.*, **5**, 1271–1278.
- Bishop, C. H., B. J. Etherton, and S. J. Majumdar, 2001: Adaptive Sampling with the Ensemble Transform Kalman Filter. Part I: Theoretical Aspects. *Mon. Wea. Rev.*, **129**, 420–436.
- Blackadar, A. K., 1962: The vertical distribution of wind and turbulent exchange in a neutral atmosphere. *J.*

- Geophys. Res.*, **67**, 3095–3102.
- Bloom, S. C., L. L. Takacs, A. M. da Silva, and D. Ledvina, 1996: Data assimilation using incremental analysis updates. *Mon. Wea. Rev.*, **124**, 1256–1271.
- Bourke, W., 1974: A multi-level spectral model. I. Formulation and hemispheric integrations. *Mon. Wea. Rev.*, **102**, 687–701.
- Brasnett, B., 1999: A global analysis of snow depth for numerical weather prediction. *J. Appl. Meteor.*, **38**, 726–740.
- Braud, I., J. Noilhan, P. Bessemoulin, P. Mascart, R. Haverkamp, and M. Vauclin, 1993: Bare-ground surface heat and water exchanges under dry conditions: Observations and parameterization. *Bound.-Layer Meteor.*, **66**, 173–200.
- Briegleb, B. P., P. Minnis, V. Ramanathan, and E. Harrison, 1986: Comparison of Regional Clear-Sky Albedos Inferred from Satellite Observations and Model Computations. *Journal of Climate and Applied Meteorology*, **25**, 214–226.
- Bringi, V. N. and V. Chandrasekar, 2001: *Polarimetric Doppler Weather Radar: Principles and Applications*. Cambridge University Press.
- Brown, P. R. and P. N. Francis, 1995: Improved Measurements of the Ice Water Content in Cirrus Using a Total-Water Probe. *J. Atmos. and Oceanic Technol.*, **12**, 410–414.
- Broxton, P. D., X. Zeng, W. Scheftic, and P. A. Troch, 2014a: A MODIS-Based 1 km Maximum Green Vegetation Fraction Dataset. *J. Appl. Meteor. Climat.*, **53**, 1996–2004.
- Broxton, P. D., X. Zeng, W. Scheftic, and P. A. Troch, 2014b: A MODIS-Based 1 km Maximum Green Vegetation Fraction Dataset. *J. Appl. Meteor. Climat.*, **53**, 1996–2004.
- Buizza, R., 1998: Impact of Horizontal Diffusion on T21, T42, and T63 Singular Vectors. *J. Atmos. Sci.*, **55**, 1069–1083.
- Buizza, R., M. Miller, and T. N. Palmer, 1999: Stochastic representation of model uncertainties in the ECMWF Ensemble Prediction System. *Quart. J. Roy. Meteor. Soc.*, **125**, 2887–2908.
- Buizza, R. and T. N. Palmer, 1995: The Singular-Vector Structure of the Atmospheric Global Circulation. *J. Atmos. Sci.*, **52**, 1434–1456.
- Cameron, J. and W. Bell, 2018: The testing and implementation of variational bias correction (VarBC) in the Met Office global NWP system. *Weather Science Technical Report No: 631, Met Office*, 1–22.
- Caron, J. F., 2013: Mismatching perturbations at the lateral boundaries in limited-area ensemble forecasting: A case study. *Mon. Wea. Rev.*, **141**, 356–374.
- Carter, W.P.L., 2000: Documentation of the SAPRC-99 Chemical Mechanism for VOC reactivity assesment. Final report to california air resources board.
- Cats, G., Van T. Vu, and L. Wolters, 2008: Overlapping communications with calculations. *Hirlam newsletter*, **54**, 189–201.
- Caumont, O., V. Ducrocq, É. Wattrelot, G. Jaubert, and S. Pradier-vabre, 2010: 1D+3DVar assimilation of radar reflectivity data: a proof of concept. *Tellus*, **62A**, 173–187.
- Cavaleri, L. and P. M. Rizzoli, 1981: Wind wave prediction in shallow water: Theory and applications. *J. Geophys. Res.*, **86**, 10 961–10 973.
- Charnock, H., 1955: Wind stress on a water surface. *Quart. J. Roy. Meteor. Soc.*, **81**, 639–640.
- Chiba, J. and H. Kawai, 2021: Improved SST-shortwave radiation feedback using an updated stratocumulus parameterization. *WGNE blue book, Res. Activ. Earth Sys. Modell*, **51**, 4–03.
- Chikamoto, Y., H. Mukougawa, T. Kubota, H. Sato, A. Ito, and S. Maeda, 2007: Evidence of growing bred vector associated with the tropical intraseasonal oscillation. *Geophys. Res. Lett.*, **34**, L04 806.
- Chou, M.-D., M. J. Suarez, X.-Z. Liang, and M. M.-H. Yan, 2001: A thermal infrared radiation parameterization for atmospheric studies. *Technical report series on global modeling and data assimilation, Vol. 19, NASA Goddard Space Flight Center*, 56pp.
- Coakley, J. A., Jr., R. D. Cess, and F. B. Yurevich, 1983: The effect of tropospheric aerosols on the Earth's radiation budget: A parameterization for climate models. *J. Atmos. Sci.*, **40**, 116–138.
- Collins, W. D., 2001: Parameterization of generalized cloud overlap for radiative calculations in general circulation models. *J. Atmos. Sci.*, **58**, 3224–3242.

- Collins, W. D., J. M. Lee-Taylor, D. P. Edwards, and G. L. Francis, 2006: Effects of increased near-infrared absorption by water vapor on the climate system. *J. Geophys. Res.*, **111**, D18 109.
- Courtier, P., J.-N. Thépaut, and A. Hollingsworth, 1994: A strategy for operational implementation of 4D-Var, using an incremental approach. *Quart. J. Roy. Meteor. Soc.*, **120**, 1367–1387.
- Culverwell, I. D., H. W. Lewis, D. Offiler, C. Marquardt, and C. P. Burrows, 2015: The Radio Occultation Processing Package, ROPP. *Atmos. Meas. Tech.*, **8**, 1887–1899.
- de Rosnay, P., M. Drusch, D. Vasiljevic, G. Balsamo, C. Albergel, and L. Isaksen, 2013: A simplified Extended Kalman Filter for the global operational soil moisture analysis at ECMWF. *Quart. J. Roy. Meteor. Soc.*, **139**, 1199–1213.
- Dee, D. P., 2004: Variational bias correction of radiance data in the ECMWF system. *Proceedings of the ECMWF workshop on assimilation of high spectral resolution sounders in NWP*, Reading, UK, 28 June - 1 July 2004, 97–112.
- DeFries, R. S., M. C. Hansen, J. R. G. Townshend, A. C. Janetos, and T. R. Loveland, 2000: A new global 1km data set of percent tree cover derived from remote sensing. *Global Chg. Biol.*, **6**, 247–254.
- Derber, J. and F. Bouttier, 1999: A reformulation of the background error covariance in the ECMWF global data assimilation system. *Tellus*, **51A**, 195–221.
- Derber, J. C. and W.-S. Wu, 1998: The use of TOVS cloud-cleared radiances in the NCEP SSI analysis system. *Mon. Wea. Rev.*, **126**, 2287–2299.
- Desroziers, G., L. Berre, B. Chapnik, and P. Poli, 2005: Diagnosis of observation, background and analysis-error statistics in observation space. *Quart. J. Roy. Meteor. Soc.*, **131**, 3385–3396.
- Deushi, M. and K. Shibata, 2011: Development of a Meteorological Research Institute chemistry-climate model version 2 for the study of tropospheric and stratospheric chemistry. *Pap. Meteor. Geophys.*, **62**, 1–46.
- Dobbie, J. S., J. Li, and P. Chýlek, 1999: Two- and four-stream optical properties for water clouds and solar wavelengths. *J. Geophys. Res.*, **104**, 2067–2079.
- Drusch, M. and P. Viterbo, 2007: Assimilation of screen-level variables in ECMWF's integrated forecast system: A study on the impact on the forecast quality and analyzed soil moisture. *Mon. Wea. Rev.*, **135**, 300–314.
- Ebert, E. E. and J. A. Curry, 1992: A parameterization of ice cloud optical properties for climate models. *J. Geophys. Res.*, **97**, 3831–3836.
- ECMWF, 2014: Part IV: Physical Process, Chapter 7 Clouds and large-scale precipitation. *IFS Documentation—Cy40r1*, 91–108.
- Egbert, G. D. and S. Y. Erofeeva, 2002: Efficient Inverse Modeling of Barotropic Ocean Tides. *J. Atmos. Oceanic Technol.*, **19**, 183–204.
- Ehrendorfer, M., R. M. Errico, and K. D. Raeder, 1999: Singular vector perturbation growth in a primitive equation model with moist physics. *J. Atmos. Sci.*, **56**, 1627–1648.
- Elliott, A. J., 1986: Shear diffusion and the spread of oil in the surface layers of the North Sea. *Dt. Hydrogr. Zeit.*, **39**, 113–137.
- Epifanio, C. C. and T. Qian, 2008: Wave–turbulence interactions in a breaking mountain wave. *J. Atmos. Sci.*, **65**, 3139–3158.
- Essery, R., J. Pomeroy, J. Parviainen, and P. Storck, 2003: Sublimation of Snow from Coniferous Forests in a Climate Model. *J. Climate*, **16**, 1855–1864.
- Eyre, J. R. and W. P. Menzel, 1989: Retrieval of Cloud Parameters from Satellite Sounder Data: A Simulation Study. *J. Appl. Meteor.*, **28**, 267–275.
- FAO, IIASA, ISRIC, ISSCAS, and JRC, 2012: Harmonized World Soil Database (version 1.2). 42pp., URL [http://webarchive.iiasa.ac.at/Research/LUC/External-World-soil-database/HWSD\\_Documentation.pdf](http://webarchive.iiasa.ac.at/Research/LUC/External-World-soil-database/HWSD_Documentation.pdf).
- Fécan, F., B. Marticorena, and G. Bergametti, 1998: Parametrization of the increase of the aeolian erosion threshold wind friction velocity due to soil moisture for arid and semi-arid areas. *Annales Geophysicae*, **17**, 149–157.
- Field, P. R., A. J. Heymsfield, and A. Bansemmer, 2007: Snow Size Distribution Parameterization for Midlatitude and Tropical Ice Clouds. *J. Atmos. Sci.*, **64**, 4346–4365.

- Fingas, M. F., 2010: OIL SPILL SCIENCE and TECHNOLOGY. *Gulf Professional Publishing*, 201–242.
- Folland, C. K. and D. E. Parker, 1995: Correction of instrumental biases in historical sea surface temperature data. *Quart. J. Roy. Meteor. Soc.*, **121**, 319–367.
- Frank, W. M., 1977: The structure and energetics of the tropical cyclone I. Storm structure. *Mon. Wea. Rev.*, **105**, 1119–1135.
- Frank, W. M., 1984: A composite analysis of the core of a mature hurricane. *Mon. Wea. Rev.*, **112**, 2401–2420.
- Freidenreich, S. M. and V. Ramaswamy, 1999: A new multiple-band solar radiative parameterization for general circulation models. *J. Geophys. Res.*, **104**, 31 389–31 409.
- Fu, Q. and K. N. Liou, 1992: On the correlated  $k$ -distribution method for radiative transfer in nonhomogeneous atmospheres. *J. Atmos. Sci.*, **49**, 2139–2156.
- Fujii, Y., 2005: Preconditioned Optimizing Utility for Large-dimensional analyses (POpULar). *J. Oceanogr.*, **61**, 655–662.
- Fujii, Y. and M. Kamachi, 2003a: A nonlinear preconditioned quasi-Newton method without inversion of a first-guess covariance matrix in variational analyses. *Tellus A*, **55**, 450–454.
- Fujii, Y. and M. Kamachi, 2003b: A reconstruction of observed profiles in the sea east of Japan using vertical coupled temperature-salinity EOF modes. *J. Oceanogr.*, **59**, 173–186.
- Fujii, Y., M. Kamachi, S. Matsumoto, and S. Ishizaki, 2012: Barrier layer and relevant variability of the salinity field in the equatorial Pacific estimated in an ocean reanalysis experiment. *Pure Appl. Geophys.*, **169**, 579–594.
- Fujii, Y., T. Yoshida, H. Sugimoto, I. Ishikawa, and S. Urakawa, 2023: Evaluation of a global ocean reanalysis generated by a global ocean data assimilation system based on a Four-Dimensional Variational (4DVAR) method. *Front. Clim.*, **4**, 1–20, doi:10.3389/fclim.2022.1019673.
- Fujita, T., 1952: Pressure Distribution within Typhoon. *Geophys. Mag.*, **23**, 437–451.
- Garratt, J. R. and R. J. Francey, 1978: Bulk characteristics of heat transfer in the unstable, baroclinic atmospheric boundary layer. *Bound.-Layer Meteor.*, **15**, 399–421.
- Gauthier, P. and J.-N. Thépaut, 2001: Impact of digital filter as a weak constraint in the preoperational 4DVAR assimilation system of Météo-France. *Mon. Wea. Rev.*, **129**, 2089–2102.
- Geer, A. J., F. Baordo, N. Bormann, and S. J. English, 2014: All-sky assimilation of microwave humidity sounders. *ECMWF Tech. Memo.*, **741**.
- Geer, A. J. and P. Bauer, 2011: Observation errors in all-sky data assimilation. *Quart. J. Roy. Meteor. Soc.*, **137**, 2024–2037.
- Geleyn, J.-F. and A. Hollingsworth, 1979: An economical analytical method for the computation of the interaction between scattering and line absorption of radiation. *Beitr. Phys. Atmos.*, **52**, 1–16.
- Gent, P. R. and J. C. McWilliams, 1990: Isopycnal mixing in ocean circulation models. *J. Phys. Oceanogr.*, **20**, 150–155.
- Gifford, F. A., 1982: Horizontal diffusion in the atmosphere: a Lagrangian-dynamical theory. *Atmos. Env.*, **16**, 505–512.
- Giglio, L., J. T. Randerson, van der G. R. Werf, P. S. Kasibhatla, G. J. Collatz, D. C. Morton, and R. S. DeFries, 2010: Assessing variability and long-term trends in burned area by merging multiple satellite fire products. *Biogeosciences*, **7**, 1171–1186.
- Godfrey, J. S. and A. C. M. Beljaars, 1991: On the turbulent fluxes of buoyancy, heat and moisture at the air-sea interface at low wind speeds. *J. Geophys. Res.-Oceans*, **96**, 22 043–22 048.
- Godske, C. L. et al., 1957: *Dynamic Meteorology and Weather Forecasting*, chap. 18. Amer. Met. Soc.
- Griffies, S. M. and R. W. Hallberg, 2000: Biharmonic friction with a Smagorinsky-like viscosity for use in large-scale eddy-permitting ocean models. *Mon. Wea. Rev.*, **128**, 2935–2946.
- Gryanik, V. M., C. Lüpkes, A. Grachev, and D. Sidorenko, 2020: New Modified and Extended Stability Functions for the Stable Boundary Layer based on SHEBA and Parametrizations of Bulk Transfer Coefficients for Climate Models. *J. Atmos. Sci.*, **77**, 2687–2716.
- Guenther, A., T. Karl, P. Harley, C. Wiedinmyer, P. I. Palmer, and C. Geron, 2006: Estimates of global terrestrial isoprene emissions using MEGAN (Model of Emissions of Gases and Aerosols from Nature). *Atmos. Chem. Phys.*, **6**, 3181–3210.

- Haimberger, L., C. Tavalato, and S. Sperka, 2008: Toward elimination of the warm bias in historic radiosonde temperature records—Some new results from a comprehensive intercomparison of upper-air data. *J. Climate*, **21**, 4587–4606.
- Haimberger, L., C. Tavalato, and S. Sperka, 2012: Homogenization of the global radiosonde temperature dataset through combined comparison with reanalysis background series and neighboring stations. *J. Climate*, **25**, 8108–8131.
- Hamrud, M., M. Bonavita, and L. Isaksen, 2015: EnKF and hybrid gain ensemble data assimilation part I: EnKF implementation. *Mon. Wea. Rev.*, **143**, 4847–4864.
- Han, J. and H.-L. Pan, 2011: Revision of Convection and Vertical Diffusion Schemes in the NCEP Global Forecast System. *Weather and Forecasting*, **26**, 520–533.
- Hara, T., 2015: Necessity of parameterizations for convective initiation in high resolution cloud-permitting models. *CAS/JSC WGNE Res. Activ. Atmos. Oceanic Modell.*, **45**, 04.06–04.07.
- Hara, T., K. Kawano, K. Aranami, Y. Kitamura, M. Sakamoto, H. Kusabiraki, C. Muroi, and J. Ishida, 2012: Development of Physics Library and its application to ASUCA. *CAS/JSC WGNE Res. Activ. Atmos. Oceanic Modell.*, **42**, 05.05–05.06.
- Hasegawa, H., N. Kohno, M. Higaki, and M. Itoh, 2017: Upgrade of JMA’s Storm Surge Prediction for the WMO Storm Surge Watch Scheme (SSWS). *RSMC Tokyo-Typhoon Center Technical Review*, **19**, 26–34.
- Hasegawa, Y., A. Sugai, Yo. Hayashi, Yu. Hayashi, S. Saito, and T. Shimbori, 2015: Improvements of volcanic ash fall forecasts issued by the Japan Meteorological Agency. *J. Appl. Volcanol.*, **4**, 2.
- Hasselmann, K., T. P. Barnett, E. Bouws, H. Carlson, D. E. Cartwright, K. Enke, J. A. Ewing, H. Gienapp, D. E. Hasselmann, P. Kruseman, A. Meerburg, P. Muller, D. J. Olbers, K. Richter, W. Sell, and H. Walden, 1973: Measurements of wind-wave growth and swell decay during the Joint North Sea Wave Project (JONSWAP). *Dtsch. Hydrogr. Z.*
- Hasselmann, S., K. Hasselmann, J. H. Allender, and T. P. Barnett, 1985: Computations and parameterizations of the nonlinear energy transfer in a gravity-wave spectrum. Part II: Parameterizations of the nonlinear energy transfer for application in wave models. *J. Phys. Oceanogr.*, **15**, 1378–1391.
- Hasumi, H., 2006: CCSR Ocean Component Model (COCO) Version 4.0. CCSR Report 25, Center for Climate System Research, The University of Tokyo. 103pp.
- Hess, R., 2001: Assimilation of screen-level observations by variational soil moisture analysis. *Meteor. Atmos. Phys.*, **77**, 145–154.
- Higaki, M., H. Hayashibara, and F. Nozaki, 2009: Outline of the storm surge prediction model at the Japan Meteorological Agency. *RSMC Tokyo-Typhoon Center Technical Review*, **11**, 25–38.
- Hirahara, S., M. Ishii, and Y. Fukuda, 2014: Centennial-scale sea surface temperature analysis and its uncertainty. *J. Climate*, **27**, 57–75.
- Hirahara, S., Y. Kubo, T. Yoshida, T. Komori, J. Chiba, T. Takakura, T. Kanehama, R. Sekiguchi, K. Ochi, H. Sugimoto, Y. Adachi, I. Ishikawa, and Y. Fujii, 2023: Japan Meteorological Agency/Meteorological Research Institute Coupled Prediction System version 3 (JMA/MRI-CPS3). *J. Meteor. Soc. Japan*, accepted.
- Hirai, M., K. Miyaoka, H. Sato, H. Sugimoto, A. Minami, and C. Matsukawa, 2014: March 2014 upgrade of JMA’s One-month Ensemble Prediction System. *CAS/JSC WGNE Res. Activ. Atmos. Oceanic Modell.*, **44**, 6.09–6.10.
- Hirose, N., N. Usui, K. Sakamoto, H. Tsujino, G. Yamanaka, H. Nakano, S. Urakawa, T. Toyoda, Y. Fujii, and N. Kohno, 2019: Development of a new operational system for monitoring and forecasting coastal and open-ocean states around Japan. *Ocean Dyn.*, **69**, 1333–1357.
- Hoffman, R. N. and E. Kalnay, 1983: Lagged average forecasting, an alternative to Monte Carlo forecasting. *Tellus A: Dynamic Meteorology and Oceanography*, **35**, 100–118.
- Hogan, R. J. and A. Bozzo, 2015: Mitigating errors in surface temperature forecasts using approximate radiation updates. *J. Adv. Model. Earth Syst.*, **7**, 836–853.
- Hogan, R. J. and S. Hirahara, 2016: Effect of solar zenith angle specification in models on mean shortwave fluxes and stratospheric temperatures. *Geophys. Res. Lett.*, **43**, 482–488.
- Holmlund, K., 1998: The utilization of statistical properties of satellite-derived atmospheric motion vectors to derive quality indicators. *Wea. Forecasting*, **13**, 1093–1104.

- Holtzlag, A. A. M. and B. A. Boville, 1993: Local versus nonlocal boundary-layer diffusion in a global climate model. *J. Climate*, **6**, 1825–1842.
- Honda, Y., M. Nishijima, K. Koizumi, Y. Ohta, K. Tamiya, T. Kawabata, and T. Tsuyuki, 2005: A pre-operational variational data assimilation system for a non-hydrostatic model at the Japan Meteorological Agency: Formulation and preliminary results. *Quart. J. Roy. Meteor. Soc.*, **131**, 3465–3475.
- Hortal, M., 2002: The development and testing of a new two-time-level semi-Lagrangian scheme (SETTLS) in the ECMWF forecast model. *Quart. J. Roy. Meteor. Soc.*, **128**, 1671–1687.
- Hoskins, B. J. and A. J. Simmons, 1975: A multi-layer spectral model and the semi-implicit method. *Quart. J. Roy. Meteor. Soc.*, **101**, 637–655.
- Hotta, D. and Y. Ota, 2019: Statistical generation of SST perturbations with spatio-temporally coherent growing patterns. *Quart. J. Roy. Meteor. Soc.*, **145**, 1660–1673.
- Hu, Y. X. and K. Stamnes, 1993: An accurate parameterization of the radiative properties of water clouds suitable for use in climate models. *J. Climate*, **6**, 728–742.
- Hunke, E. C. and W. H. Lipscomb, 2006: CICE. *The Los Alamos Sea Ice Model Documentation and Software User's Manual*, accessed 6 August 2021, <https://github.com/CICE-Consortium/CICE/wiki>.
- Hunt, B. R., E. J. Kostelich, and I. Szunyogh, 2007: Efficient data assimilation for spatiotemporal chaos: A local ensemble transform Kalman filter. *Physica D*, **230**, 112–126.
- ICAO, 2018: *Annex 3 - Meteorological Service for International Air Navigation*. 20th ed., International Civil Aviation Organization, 224 pp.
- Ikawa, M. and K. Saito, 1991: Description of a nonhydrostatic model developed at the Forecast Research Department of the MRI. *Tech. Rep. MRI*, **28**, 238pp.
- Ikuta, Y., T. Fujita, Y. Ota, and Y. Honda, 2021: Variational data assimilation system for operational regional models at Japan Meteorological Agency. *J. Meteor. Soc. Japan*, **99**.
- Ikuta, Y. and Y. Honda, 2011: Development of 1D+4DVAR data assimilation of radar reflectivity in JNoVA. *CAS/JSC WGNE Res. Activ. Atmos. Oceanic Modell.*, **41**, 01.09–01.10.
- Ikuta, Y., H. Kusabiraki, K. Kawano, T. Anzai, M. Sawada, M. Ujiie S. Nishimoto, Y. Ota, and M. Narita, 2020: A New Data assimilation System and Upgrading of Physical Processes in JMA's Meso-scale NWP System. *CAS/JSC WGNE Res. Activ. Atmos. Oceanic Modell.*, **50**, 01.07–01.08.
- Imai, T. and R. Yoshida, 2016: Algorithm Theoretical Basis for Himawari-8 Cloud Mask Product. *Meteorological Satellite Center Technical Note*, **61**, 1–17.
- Ishida, J., 2007: Development of a hybrid terrain-following vertical coordinate for JMA Non-hydrostatic Model. *CAS/JSC WGNE Res. Activ. Atmos. Oceanic Modell.*, **37**, 03.09–03.10.
- Ishida, J., K. Aranami, K. Kawano, K. Matsubayashi, Y. Kitamura, and C. Muroi, 2022: ASUCA: the JMA operational non-hydrostatic model. *J. Meteor. Soc. Japan*, in press.
- Ishida, J., C. Muroi, and Y. Aikawa, 2009: Development of a new dynamical core for the nonhydrostatic model. *CAS/JSC WGNE Res. Activ. Atmos. Oceanic Modell.*, **39**, 05.09–05.10.
- Ishida, J., C. Muroi, K. Kawano, and Y. Kitamura, 2010: Development of a new nonhydrostatic model “ASUCA” at JMA. *CAS/JSC WGNE Res. Activ. Atmos. Oceanic Modell.*, **40**, 05.11–05.12.
- Ishihara, M., Y. Kato, T. Abo, K. Kobayashi, and Y. Izumikawa, 2006: Characteristics and Performance of the Operational Wind Profiler Network of the Japan Meteorological Agency. *J. Meteor. Soc. Japan*, **84**, 1085–1096.
- Ishii, K., T. Shimbori, R. Kai, Y. Hasegawa, Y. Hayashi, and H. Tsuchiyama, 2021: Improvement of volcanic ash cloud prediction in the Tokyo Volcanic Ash Advisory Center. *WGNE Res. Activ. Earth Sys. Modell.*, **51**, 05.03–05.04.
- Ishii, M., A. Shouji, S. Sugimoto, and T. Matsumoto, 2005: Objective Analyses of Sea-Surface Temperature and Marine Meteorological Variables for the 20th Century using ICOADS and the Kobe Collection. *Int. J. Climatol.*, **25**, 865–879.
- Ishikawa, Y., 2010: Data assimilation of GPS precipitable water vapor into the JMA mesoscale numerical weather prediction model. *CAS/JSC WGNE Res. Activ. Atmos. Oceanic Modell.*, **40**, 1–13.
- Ishikawa, Y. and K. Koizumi, 2002: Meso-scale analysis. *Outline of the operational numerical weather prediction at the Japan Meteorological Agency. Appendix to WMO Technical Progress Report on the Global*

- Data-processing and Forecasting System*, Tokyo, Japan, Japan Meteorological Agency, 26–31.
- Iwamura, K. and H. Kitagawa, 2008: An upgrade of the JMA Operational Global NWP Model. *CAS/JSC WGNE Res. Activ. Atmos. Oceanic Modell.*, **38**, 06.3–06.4.
- Iwasaki, T., T. Maki, and K. Katayama, 1998: Tracer transport model at Japan Meteorological Agency and its application to the ETEX data. *Atmos. Env.*, **32**, 4285–4295.
- Iwasaki, T., S. Yamada, and K. Tada, 1989: A parameterization scheme of orographic gravity wave drag with two different vertical partitionings, Part I: Impacts on medium-range forecasts. *J. Meteor. Soc. Japan*, **67**, 11–27.
- Jakob, C. and A. P. Siebesma, 2003: A new subcloud model for mass-flux convection schemes: Influence on triggering, updraft properties, and model climate. *Mon. Wea. Rev.*, **131**, 2765–2778.
- Janssen, P., 2004: *The Interaction of Ocean Waves and Wind*. Cambridge Univ. Press, 308pp.
- Japan Meteorological Agency, 2006: Characteristics of Global Sea Surface Temperature Analysis Data (COBE-SST) for Climate Use. *Monthly Report on Climate System Separated Volume*, **12**, 116pp.
- JMA, 1997: Objective Interpretation of NWP Products. *Outline of the operational numerical weather prediction at the Japan Meteorological Agency. Appendix to WMO Technical Progress Report on the Global Data-processing and Forecasting System*, Japan Meteorological Agency, Tokyo, Japan, 123–124.
- JMA, 2002: *Outline of the operational numerical weather prediction at the Japan Meteorological Agency. Appendix to WMO Technical Progress Report on the Global Data-processing and Forecasting System*. Japan Meteorological Agency, Tokyo, Japan.
- JMA, 2007: *Outline of the operational numerical weather prediction at the Japan Meteorological Agency. Appendix to WMO Technical Progress Report on the Global Data-processing and Forecasting System and Numerical Weather Prediction Research*. Japan Meteorological Agency, Tokyo, Japan.
- JMA, 2013: *Outline of the operational numerical weather prediction at the Japan Meteorological Agency, Appendix to WMO Technical Progress Report on the Global Data-processing and Forecasting System (GDPFS) and Numerical Weather Prediction (NWP) Research*. Japan Meteorological Agency, Tokyo, Japan.
- JMA, 2017: Joint WMO Technical Progress Report on the Global Data Processing and Forecasting System and Numerical Weather Prediction Research Activities for 2016. 31–32.
- JMA, 2018: *Outline of the operational numerical weather prediction at the Japan Meteorological Agency. Appendix to WMO Technical Progress Report on the Global Data-processing and Forecasting System*. Japan Meteorological Agency, Tokyo, Japan.
- JMA, 2019: *Outline of the operational numerical weather prediction at the Japan Meteorological Agency. Appendix to WMO Technical Progress Report on the Global Data-processing and Forecasting System and Numerical Weather Prediction*.
- Jolliffe, I. T. and D. B. Stephenson, 2003: *Forecast Verification: A Practitioner's Guide in Atmospheric Science*. Wiley, 254pp.
- Joseph, J. H., W. J. Wiscombe, and J. A. Weinman, 1976: The delta-Eddington approximation for radiative flux transfer. *J. Atmos. Sci.*, **33**, 2452–2459.
- Juang, H.-M. H., 2004: A Reduced Spectral Transform for the NCEP Seasonal Forecast Global Spectral Atmospheric Model. *Mon. Wea. Rev.*, **132**, 1019–1035.
- Kadowaki, T., 2005: A 4-dimensional variational assimilation system for the JMA Global Spectrum Model. *CAS/JSC WGNE Res. Activ. Atmos. Oceanic Modell.*, **35**, 01.17–01.18.
- Kadowaki, T., Y. Ota, and S. Yokota, 2020: Introduction of a new hybrid data assimilation system for the JMA Global Spectral Model. *WGNE Res. Activ. Earth System Modell.*, **50**, 01.09–01.10.
- Kadowaki, T. and K. Yoshimoto, 2012: A new inner model with a higher horizontal resolution (TL319) in JMA's Global 4D-Var data assimilation system. *CAS/JSC WGNE Res. Activ. Atmos. Oceanic Modell.*, 01.09–01.10.
- Kain, J. S., 2004: The Kain-Fritsch convective parameterization: An update. *J. Appl. Meteor.*, **43**, 170–181.
- Kain, J. S. and J. M. Fritsch, 1990: A one-dimensional entraining/detraining plume model and its application in convective parameterization. *J. Atmos. Sci.*, **47**, 2784–2802.
- Kajino, M., M. Deushi, T. T. Sekiyama, N. Oshima, K. Yumimoto, T. Y. Tanaka, J. Ching, A. Hashimoto, T. Yamamoto, M. Ikegami, A. Kamada, M. Miyashita, Y. Inomata, S. Shima, A. Takami, A. Shimizu,

- S. Hatakeyama, Y. Sadanaga, H. Irie, K. Adachi, Y. Zaizen, Y. Igarashi, H. Ueda, T. Maki, and M. Mikami, 2019: NHM-Chem, the Japan Meteorological Agency's Regional Meteorology — Chemistry Model: Model Evaluations toward the Consistent Predictions of the Chemical, Physical, and Optical Properties of Aerosols. *Journal of the Meteorological Society of Japan. Ser. II*, **97**, 337–374.
- Takehata, K., M. Kunii, K. Kawano, and H. Kawada, 2021: Upgrades of JMA's Mesoscale Ensemble Prediction System. *CAS/JSC WGNE Res. Activ. Atmos. Oceanic Modell.*, **51**, 5.05–5.06.
- Kanda, M., T. Kawai, M. Kanega, R. Moriwaki, K. Narita, and A. Hagishima, 2005: A Simple Energy Balance Model for Regular Building Arrays. *Bound.-Layer Meteor.*, **116**, 423–443.
- Kannari, A., Y. Tonooka, T. Baba, and K. Murano, 2007: Development of multiple-species 1km × 1km resolution hourly basis emissions inventory for Japan. *Atmospheric Environment*, **41**, 3428–3439.
- Kawai, H., 2002: Forecast of sulfur dioxide flow from Miyake volcano with a high resolution regional transport model. *CAS/JSC WGNE Res. Activ. Atmos. Oceanic Modell.*, **32**, 05.24–05.25.
- Kawai, H., 2005: Improvement of a cloud ice fall scheme in GCM. *CAS/JSC WGNE Res. Activ. Atmos. Oceanic Modell.*, **35**, 04.11–04.12.
- Kawai, H. and T. Inoue, 2006: A simple parameterization scheme for subtropical marine stratocumulus. *SOLA*, **2**, 17–20.
- Kawai, H., T. Koshiro, and M. J. Webb, 2017: Interpretation of factors controlling low cloud cover and low cloud feedback using a unified predictive index. *J. Climate*, **30**, 9119–9131.
- Kawai, H., H. Yonehara, and M. Ujiie, 2013: Vertical Layer Placement in Eta Coordinate for Models with a High Model Top. *CAS/JSC WGNE Res. Activ. Atmos. Oceanic Modell.*, **43**, 03.3–03.4.
- Kessler, E., 1969: *On the distribution and continuity of water substance in atmospheric circulation*. Meteorol. Monogr., American Meteorol. Soc., Boston, MA, 84pp.
- Kikuchi, M., H. Murakami, K. Suzuki, T. M. Nagao, and A. Higurashi, 2018: Improved Hourly Estimates of Aerosol Optical Thickness Using Spatiotemporal Variability Derived From Himawari-8 Geostationary Satellite. *IEEE Transactions on Geoscience and Remote Sensing*, **56**, 3442–3455.
- Kim, H., 2017: Global Soil Wetness Project Phase 3 Atmospheric Boundary Conditions (Experiment 1) [Data set]. *Data Integration and Analysis System (DIAS)*, URL <https://doi.org/10.20783/DIAS.501>.
- Kitada, T., 1994: Modelling of transport, reaction and deposition of acid rain. *Kishou Kenkyu Note*, **182**, 95–117, (in Japanese).
- Kitada, T., G. R. Carmichael, and L. K. Peters, 1986: Effects of dry deposition on the concentration-distributions of atmospheric pollutants within land- and sea-breeze circulations. *Atmos. Env.*, **20**, 1999–2010.
- Kitamura, Y. and J. Ito, 2016: Revisiting the bulk relation for heat flux in the free convection limit. *Bound.-Layer Meteor.*, **158**, 93–103.
- Klemp, J. B., W. C. Skamarock, and J. Dudhia, 2007: Conservative split-explicit time integration methods for the compressible nonhydrostatic equations. *Mon. Wea. Rev.*, **135**, 2897–2913.
- Kobayashi, S., Y. Kosaka, J. Chiba, T. Tokuyoshi, Y. Harada, C. Kobayashi, and H. Naoe, 2021: JRA-3Q: Japanese reanalysis for three quarters of a century. *WCRP-WWRP Symposium on Data Assimilation and Reanalysis/ECMWF annual seminar 2021, WMO/WCRP, O4–2*, accessed 6 July 2022, <https://symp-bonn2021.sciencesconf.org/data/355900.pdf>.
- Kobayashi, S., Y. Ota, Y. Harada, A. Ebata, M. Moriya, H. Onoda, K. Onogi, H. Kamahori, C. Kobayashi, H. Endo, K. Miyaoka, and K. Takahashi, 2015: The JRA-55 Reanalysis: General specifications and basic characteristics. *J. Meteor. Soc. Japan*, **93**, 5–48.
- Kohno, N., D. Miura, and K. Yoshita, 2012: The development of JMA wave data assimilation system. *Proceedings of the 12th International Workshop on Wave Hindcasting and Forecasting and Coastal Hazards Symposium*, Kohala Coast, Hawaii, 30 October - 4 November 2011, H2, (<http://www.waveworkshop.org>).
- Kohno, N., K. Murotani, H. Minematsu, and D. Miura, 2009: The improvement of JMA operational wave forecasting system. *Proceedings of the 11th International Workshop on Wave Hindcasting and Forecasting and Coastal Hazards Symposium*, Halifax, Canada, 18 - 23 October 2009, R3, (<http://www.waveworkshop.org>).
- Koizumi, K., Y. Ishikawa, and T. Tsuyuki, 2005: Assimilation of precipitation data to the JMA mesoscale model with a four-dimensional variational method and its impact on precipitation forecasts. *SOLA*, **1**, 45–



48.

- Komori, T., S. Hirahara, and R. Sekiguchi, 2020: Improved representation of convective moistening in JMA's next-generation coupled seasonal prediction system. *WGNE blue book, Res. Activ. Earth Sys. Modell*, **50**, 4–05.
- Konishi, T., 1995: An experimental storm surge prediction for the western part of the Inland Sea with application to Typhoon 9119. *Pap. Meteor. Geophys.*, **46**, 9–17.
- Koren, B., 1993: A robust upwind discretization method for advection, diffusion and source terms. *CWI Technical Report NM-R 9308*, 1–22, URL <http://oai.cwi.nl/oai/asset/5293/05293D.pdf>.
- Koyaguchi, T., 2008: *Modeling of Volcanic Phenomena*. Univ. Tokyo Press, 637 pp.
- Kudo, A., 2011: Development of JMA's new turbulence index. *15th Conference on Aviation, Range, and Aerospace Meteorology*, Amer. Met. Soc., Los Angeles, CA, 1 - 4 August 2011.
- Kuragano, T., Y. Fujii, T. Toyoda, N. Usui, K. Ogawa, and M. Kamachi, 2014: Seasonal barotropic sea surface height fluctuation in relation to regional ocean mass variation. *J. Oceanogr.*, **70**, 45–62.
- Kuragano, T. and M. Kamachi, 2000: Global statistical space-time scales of oceanic variability estimated from the TOPEX/POSEIDON altimeter data. *J. Geophys. Res.*, **105**, 955–974.
- Kurihara, Y., Murakami H., and M. Kachi, 2016: Sea surface temperature from the new Japanese geostationary meteorological Himawari-8 satellite. *Geophys. Res. Lett.*, **43**, 1234–1240.
- Kurihara, Y., T. Sakurai, and T. Kuragano, 2006: Global daily sea surface temperature analysis using data from satellite microwave radiometer, satellite infrared radiometer and in-situ observations. *Weather Bulletin, JMA*, **73**, s1–s18.
- Kyouda, M. and M. Higaki, 2015: Upgrade of JMA's Typhoon Ensemble Prediction System. *RSMC Tokyo-Typhoon Center Technical Review*, **17**, 1–13.
- Lalauette, F., 2003: Early detection of abnormal weather conditions using a probabilistic extreme forecast index. *Q. J. R. Meteorol. Soc.*, **129**, 3037–3057.
- Lee, T. J. and R. A. Pielke, 1992: Estimating the soil surface specific humidity. *J. Appl. Meteor.*, **31**, 480–484.
- Leonard, B. P., 1979: A stable and accurate convective modelling procedure based on quadratic upstream interpolation. *Computer Methods in Applied Mechanics and Engineering*, **19**, 59–98, URL <https://www.sciencedirect.com/science/article/pii/0045782579900343>.
- Li, J., 2002: Accounting for unresolved clouds in a 1D infrared radiative transfer model. Part I: Solution for radiative transfer, including cloud scattering and overlap. *J. Atmos. Sci.*, **59**, 3302–3320.
- Li, J. and H. W. Barker, 2005: A radiation algorithm with correlated-*k* distribution. Part I: Local thermal equilibrium. *J. Atmos. Sci.*, **62**, 286–309.
- Lin, Y.-L., R. D. Farley, and H. D. Orville, 1983: Bulk Parameterization of the Snow Field in a Cloud Model. *J. Climate Appl. Meteor.*, **22**, 1065–1092.
- Lindner, T. H. and J. Li, 2000: Parameterization of the optical properties for water clouds in the infrared. *J. Climate*, **13**, 1797–1805.
- Liu, D. C. and J. Nocedal, 1989: On the limited memory BFGS method for large scale optimization. *Math. Programming*, **45**, 503–528.
- Locarnini, R. A., A. V. Mishonov, O. K. Baranova, T. P. Boyer, M. M. Zweng, H. E. Garcia, J. R. Reagan, D. Seidov, K. Weathers, C. R. Paver, and I. Smolyar, 2018: *World Ocean Atlas 2018, Volume 1: Temperature*. NOAA Atlas NESDIS 81, 52 pp.
- Lord, S. J. and A. Arakawa, 1980: Interaction of a cumulus cloud ensemble with the large-scale environment. Part II. *J. Atmos. Sci.*, **37**, 2677–2692.
- Lorenc, A. C., 2003: The potential of the ensemble Kalman filter for NWP: a comparison with 4D-Var. *Quart. J. Roy. Meteor. Soc.*, **129**, 3183–3203.
- Lorenc, A. C. and F. Rawlins, 2005: Why does 4D-Var beat 3D-Var? *Quart. J. Roy. Meteor. Soc.*, **131**, 3247–3257.
- Lott, F. and M. J. Miller, 1997: A New Subgrid Orographic Drag Parameterization : Its Formulatin and Testing. *Quart. J. Roy. Meteor. Soc.*, **123**, 101–127.
- Louis, J.-F., M. Tiedtke, and J.-F. Geleyn, 1982: A short history of the operational PBL-parameterization at ECMWF. *Workshop on Planetary Boundary Layer Parameterization*, Reading, United Kingdom, 25 - 27

- November 1981, ECMWF, 59–79.
- Loveland, T. R., B. C. Reed, J. F. Brown, D. O. Ohlen, Z. Zhu, L. Youing, and J. W. Merchant, 2000: Development of a global land cover characteristics database and IGBP DISCover from 1km AVHRR data. *Int. J. Remote Sensing*, 1303–1330.
- Lyard, F., F. Lefèvre, T. Letellier, and O. Francis, 2006: Modelling the global ocean tides: Modern insights from FES2004. *Ocean Dyn.*, **56**, 394–415.
- Lynch, P., 1997: The Dolph-Chebyshev Window: A Simple Optimal Filter. *Mon. Wea. Rev.*, **125**, 655–660.
- Machenhauer, B., 1977: On the dynamics of gravity oscillations in a shallow water model, with application to normal mode initialization. *Contrib. Atmos. Phys.*, **50**, 253–271.
- Mahfouf, J.-F., 1999: Influence of physical process on the tangent-linear approximation. *Tellus*, **51A**, 147–166.
- Makihara, Y., 2000: Algorithms for precipitation nowcasting focused on detailed analysis using radar and raingauge data. *Technical Reports of the Meteorological Research Institute*, **39**, 63–111.
- Martin, G. M., D. W. Johnson, and A. Spice, 1994: The measurement and parameterization of effective radius of droplets in warm stratocumulus clouds. *J. Atmos. Sci.*, **51**, 1823–1842.
- Matsumoto, K., T. Takanezawa, and M. Ooe, 2000: Ocean Tide Models Developed by Assimilating TOPEX/POSEIDON Altimeter Data into Hydrodynamical Model: A Global Model and a Regional Model around Japan. *J. Oceanogr.*, **56**, 567–581.
- Matsumoto, T., M. Ishii, Y. Fukuda, and S. Hirahara, 2006: Sea Ice Data Derived from Microwave Radiometer for Climate Monitoring. *14th Conference on Satellite Meteorology and Oceanography, Amer. Meteor. Soc.*, P2.21.
- McLandress, C. and J. F. Scinocca, 2005: The GCM response to current parameterizations of nonorographic gravity wave drag. *J. Atmos. Sci.*, **62**, 2394–2413.
- Meador, W. E. and W. R. Weaver, 1980: Two-stream approximations to radiative transfer in planetary atmospheres: A unified description of existing methods and a new improvement. *J. Atmos. Sci.*, **37**, 630–643.
- Mellor, G. L., 1977: The Gaussian cloud model relations. *J. Atmos. Sci.*, **34**, 356–358.
- Mellor, G. L. and L. Kantha, 1989: An ice-ocean coupled model. *J. Geophys. Res.*, **94**, 10937–10954.
- Mellor, G. L. and T. Yamada, 1974: A hierarchy of turbulence closure models for planetary boundary layers. *J. Atmos. Sci.*, **31**, 1791–1806.
- Mellor, G. L. and T. Yamada, 1982: Development of a turbulence closure model for geophysical fluid problems. *Rev. Geophys. Space Phys.*, **20**, 851–875.
- Mitsuyasu, H. and T. Honda, 1982: Wind-induced growth of water waves. *J. Fluid Mech.*, **123**, 425–442.
- Miyamoto, K., 2006: Introduction of the Reduced Gaussian Grid into the Operational Global NWP Model at JMA. *CAS/JSC WGNE Res. Activ. Atmos. Oceanic Modell.*, **36**, 06.09–06.10.
- Mizuta, R., H. Yoshimura, H. Murakami, M. Matsueda, H. Endo, T. Ose, K. Kamiguchi, M. Hosaka, M. Sugi, S. Yukimoto, S. Kusunoki, and A. Kitoh, 2012: Climate simulations using MRI-AGCM3.2 with 20-km grid. *J. Meteor. Soc. Japan*, **90A**, 233–258.
- Moorthi, S. and M. J. Suarez, 1992: Relaxed Arakawa-Schubert: A parameterization of moist convection for general circulation models. *Mon. Wea. Rev.*, **120**, 978–1002.
- Munk, W. H. and D. E. Cartwright, 1966: Tidal Spectroscopy and Prediction. *Phil. Trans. Roy. Soc. A*, **259**, 533–581.
- Murphy, A. H., 1973: A New Vector Partition of the Probability Score. *J. Appl. Meteor.*, **12**, 595–600.
- Murray, Ross J., 1996: Explicit generation of orthogonal grids for ocean models. *Journal of Computational Physics*, **126**, 251–273.
- Myneni, Knyazikhin Y. Park T., R., 2015: MOD15A2H MODIS/Terra Leaf Area Index/FPAR 8-Day L4 Global 500m SIN Grid V006 [Data set]. NASA EOSDIS Land Processes DAAC, Accessed 2022-07-20 from <https://doi.org/10.5067/MODIS/MOD15A2H.006>.
- Myneni, R. B., S. Hoffman, Y. Knyazikhin, J. L. Privette, J. Glassy, Y. Tian, Y. Wang, X. Song, Y. Zhang, G. R. Smith, A. Lotsch, M. Friedl, J. T. Morisette, P. Votava, R. R. Nemani, and S. W. Running, 2002: Global products of vegetation leaf area and fraction absorbed PAR from year one of MODIS data. *Remote Sens. Environ.*, **83**, 214–231.

- Nagasawa, R., 2012: The problem of cloud overlap in the radiation process of JMA's global NWP model. *CAS/JSC WGNE Res. Activ. Atmos. Oceanic Modell.*, **42**, 4.15–4.16.
- Naito, I. and N. Kikuchi, 1992: Atmospheric contributions to non-seasonal variations in the length of day. *Geophys. Res. Lett.*, **19**, 1843–1846.
- Nakagawa, M., 2009: Outline of the High Resolution Global Model at the Japan Meteorological Agency. *RSMC Tokyo-Typhoon Center Technical Review*, **11**, 1–13.
- Nakanishi, M., 2001: Improvement of the Mellor-Yamada turbulence closure model based on large-eddy simulation data. *Bound.-Layer Meteor.*, **99**, 349–378.
- Nakanishi, M. and H. Niino, 2004: An improved Mellor-Yamada level-3 model with condensation physics: Its design and verification. *Bound.-Layer Meteor.*, **112**, 1–31.
- Nakanishi, M. and H. Niino, 2006: An improved Mellor-Yamada level-3 model: Its numerical stability and application to a regional prediction of advection fog. *Bound.-Layer Meteor.*, **119**, 397–407.
- Nakanishi, M. and H. Niino, 2009: Development of an Improved Turbulence Closure Model for the Atmospheric Boundary Layer. *J. Meteor. Soc. Japan*, **87**, 895–912.
- Nakano, H. and N. Sugimoto, 2002: Effects of bottom boundary layer parameterization on reproducing deep and bottom waters in a world ocean model. *J. Phys. Oceanogr.*, **32**, 1209–1227.
- Narui, A., 2006: Changing the Resolution of the Inner Loop of Global 4D-Var at JMA. *CAS/JSC WGNE Res. Activ. Atmos. Oceanic Modell.*, **36**, 01.23–01.24.
- Nishizawa, S. and Y. Kitamura, 2018: A Surface Flux Scheme Based on the Monin-Obukhov Similarity for Finite Volume Models. *J. Adv. Model. Earth Syst.*, **10**, 3159–3175.
- Niwa, Y. and Y. Fujii, 2020: A conjugate BFGS method for accurate estimation of a posterior error covariance matrix in a linear inverse problem. *Quart. J. Roy. Meteor. Soc.*, **146**, 3118–3143.
- Nocedal, J. and S. J. Wright, 2006: *Numerical Optimization*. 2d ed., Springer, 664pp.
- Noh, Y. and H. J. Kim, 1999: Simulations of temperature and turbulence structure of the oceanic boundary layer with the improved near-surface process. *J. Geophys. Res.*, **104**, 15 621–15 634.
- Noilhan, J. and P. Lacarrère, 1995: GCM Grid-Scale Evaporation from Mesoscale Modeling. *J. Climate*, **8**, 206–223.
- Noilhan, J. and J.-F. Mahfouf, 1996: The ISBA land surface parameterisation scheme. *Glob. Planet. Chang.*, **13**, 145–159.
- Noilhan, J. and S. Planton, 1989: A Simple Parameterization of Land Surface Processes for Meteorological Models. *Mon. Wea. Rev.*, **117**, 536–549.
- Ohara, T., H. Akimoto, J. Kurokawa, N. Horii, K. Yamaji, X. Yan, and T. Hayasaka, 2007: An Asian emission inventory of anthropogenic emission sources for the period 1980–2020. *Atmos. Chem. Phys.*, **7**, 4419–4444.
- Oleson, K. W., D. M. Lawrence, G. B. Bonan, M. G. Flanner, E. Kluzek, P. J. Lawrence, S. Levis, S. C. Swenson, P. E. Thornton, A. Dai, M. Decker, R. Dickinson, J. Feddema, C. L. Heald, F. Hoffman, J.-F. Lamarque, N. Mahowald, G.-Y. Niu, T. Qian, J. Randerson, S. Running, K. Sakaguchi, A. Slater, R. Stöckli, A. Wang, Z.-L. Yang, Xiaodong Zeng, and Xubin Zeng, 2010: Technical Description of version 4.0 of the Community Land Model (CLM). NCAR Technical Note 478, NCAR. 257pp.
- Olson, J. B., J. S. Kenyon, W. M. Angevine, J. M. Brown, M. Pagowski, and K. Sušelj, 2019: A description of the MYNN-EDMF scheme And the Coupling to Other Components in WRF-ARW. *NOAA Tech. Memo. OAR GSD*, **61**, 37pp.
- Ono, K., M. Kunii, and Y. Honda, 2021: The regional model-based Mesoscale Ensemble Prediction System, MEPS, at the Japan Meteorological Agency. *Quart. J. Roy. Meteor. Soc.*, **147**, 465–484.
- Onogi, K., 1998: A Data Quality Control Method Using Forecasted Horizontal Gradient and Tendency in a NWP System: Dynamic QC. *J. Meteor. Soc. Japan*, **76**, 497–516.
- Onogi, K., J. Tsutsui, H. Koide, M. Sakamoto, S. Kobayashi, H. Hatsushika, T. Matsumoto, N. Yamazaki, H. Kamahori, K. Takahashi, S. Kadokura, K. Wada, K. Kato, R. Oyama, T. Ose, N. Mannoji, and R. Taira, 2007: The JRA-25 reanalysis. *J. Meteor. Soc. Japan*, **85**, 369–432.
- Ota, Y., M. Ikegami, and H. Yamaguchi, 2019: Upgrade of initial perturbations made using the Local Ensemble Transform Kalman Filter in JMA's Global EPS. *CAS/JSC WGNE Res. Activ. Atmos. Oceanic Modell.*, **49**, 6.11–6.12.

- Ou, S. and K.-N. Liou, 1995: Ice microphysics and climatic temperature feedback. *Atmos. Res.*, **35**, 127–138.
- Oyama, R., 2010: Upgrade of atmospheric motion vector derivation algorithms at JMA/MSC. Meteorological Satellite Center Technical Note 54, Japan Meteorological Agency, Tokyo, Japan. 1–32. (<https://www.data.jma.go.jp/mscweb/en/product/library/note/index.html>).
- Palmer, T. N., G. J. Shutts, and R. Swinbank, 1986: Alleviation of a systematic westerly bias in general circulation and numerical weather prediction models through an orographic gravity wave drag parameterization. *Quart. J. Roy. Meteor. Soc.*, **112**, 1001–1039.
- Parrish, D. and J. C. Derber, 1992: The National Meteorological Center's spectral statistical-interpolation analysis system. *Mon. Wea. Rev.*, **120**, 1747–1763.
- Persson, A. O., 1991: Kalman Filtering - A new approach to adaptive statistical interpretation of numerical meteorological forecasts. *WMO Technical Document*, **421**, XX27–XX32.
- Phillips, D. S., 1984: Analytical surface pressure and drag for linear hydrostatic flow over three-dimensional elliptical mountains. *J. Atmos. Sci.*, **41**, 1073–1084.
- Plant, W. J., 1982: A relationship between wind stress and wave slope. *J. Geophys. Res.*, **87**, 1961–1967.
- Prather, M. J., 1986: Numerical advection by conservation of second-order moments. *J. Geophys. Res.*, **91**, 6671–6681.
- Price, J. F., J. D. Weller, and R. Pinkel, 1986: Diurnal cycling: Observations and models of the upper ocean response to diurnal heating, cooling, and wind mixing. *J. Geophys. Res.*, **91**, 8411–8427.
- Purser, R. J., W. S. Wu, D. F. Parrish, and N. M. Roberts, 2003: Numerical aspects of the application of recursive filters to variational statistical analysis. Part I: Spatially homogeneous and isotropic Gaussian covariances. *Mon. Wea. Rev.*, **131**, 1524–1535.
- Ramankutty, N., A. T. Evan, C. Monfreda, and J. A. Foley, 2008: Farming the planet: 1. Geographic distribution of global agricultural lands in the year 2000. *Global Biogeochemical Cycles*, **22**, GB1003.
- Randall, D. and D.-M. Pan, 1993: Implementation of the Arakawa-Schubert cumulus parameterization with a prognostic closure. *The representation of cumulus convection in numerical models, AMS Meteorological Monograph Series*, **46**, 137–144.
- Randel, W. J., F. Wu, J. M. Russell III, A. Roche, and J. W. Waters, 1998: Seasonal cycles and QBO variations in stratospheric CH<sub>4</sub> and H<sub>2</sub>O observed in UARS HALOE data. *J. Atmos. Sci.*, **55**, 163–185.
- Ray, R. D., 1999: A Global Ocean Tide Model From TOPEX/POSEIDON Altimetry: GOT99.2. Technical Memorandum NASA/TM-1999-209478, Goddard Space Flight Center. 58pp.
- Redelsperger, J.-L., F. Guichard, and S. Mondon, 2000: A parameterization of mesoscale enhancement of surface fluxes for large-scale models. *J. Climate*, **13**, 402–421.
- Redi, M. H., 1982: Oceanic isopycnal mixing by coordinate rotation. *J. Phys. Oceanogr.*, 1154–1158.
- Reed, M., 1989: The physical fates component of the natural resource damage assessment model system. *Oil and Chemical Pollution*, **5**, 99–123.
- Reynolds, R. W., 1987: A real-time global sea surface temperature analysis. *J. Climate*, **1**, 75–86.
- Roberts, N. M. and H. W. Lean, 2008: Scale-Selective Verification of Rainfall Accumulations from High-Resolution Forecasts of Convective Events. *Mon. Wea. Rev.*, **136**, 78–97.
- Rothman, L. S., A. Barbe, D. C. Benner, L. R. Brown, C. Camy-Peyret, M. R. Carleer, K. Chance, C. Clerbaux, V. Dana, V. M. Devi, A. Fayt, J.-M. Flaud, R. R. Gamache, A. Goldman, D. Jacquemart, K. W. Jucks, W. J. Lafferty, J.-Y. Mandin, S. T. Massie, V. Nemtchinov, D. A. Newnham, A. Perrin, C. P. Rinsland, J. Schroeder, K. M. Smith, M. A. H. Smith, K. Tang, R. A. Toth, J. Vander Auwera, P. Varanasi, and K. Yoshino, 2003: The HITRAN molecular spectroscopic database: edition of 2000 including updates through 2001. *J. Quant. Spectrosc. Radiat. Transfer*, **82**, 5–44.
- Saito, K., J. Ishida, K. Aranami, T. Hara, T. Segawa, M. Narita, and Y. Honda, 2007: Nonhydrostatic Atmospheric Models and Operational Development at JMA. *J. Meteor. Soc. Japan*, **85B**, 271–304.
- Saito, K., T. Fujita, Y. Yamada, J. Ishida, Y. Kumagai, K. Aranami, S. Ohmori, R. Nagasawa, S. Kumagai, C. Muroi, T. Kato, H. Eito, and Y. Yamazaki, 2006: The Operational JMA Nonhydrostatic Mesoscale Model. *Mon. Wea. Rev.*, **134**, 1266–1298.
- Sakamoto, K., H. Tsujino, H. Nakano, S. Urakawa, T. Toyoda, N. Hirose, N. Usui, and G. Yamanaka, 2019: Development of a 2-km resolution ocean model covering the coastal seas around Japan for operational

- application. *Ocean Dyn.*, **69**, 1181–1202.
- Sato, N., P. J. Sellers, D. A. Randall, E. K. Schneider, J. Shukla, J. L. Kinter III, Y-T Hou, and E. Albertazzi, 1989: Effects of implementing the simple biosphere model in a general circulation model. *J. Atmos. Sci.*, **46**, 2757–2782.
- Saunders, R., J. Hocking, P. Rayer, M. Matricardi, A. Geer, N. Bormann, P. Brunel, F. Karbou, and F. Aires, 2012: RTTOV-10 science and validation report. Tech. rep., EUMETSAT, 31 pp. ([https://nwp-saf.eumetsat.int/oldsite/deliverables/rtm/docs\\_rttov10/rttov10\\_svr\\_1.11.pdf](https://nwp-saf.eumetsat.int/oldsite/deliverables/rtm/docs_rttov10/rttov10_svr_1.11.pdf)).
- Schaaf, C. B., F. Gao, A. H. Strahler, W. Lucht, X. Li, T. Tsang, N. C. Strugnell, X. Zhang, Y. Jin, J. P. Muller, P. Lewis, M. Barnsley, P. Hobson, M. Disney, G. Roberts, M. Dunderdale, C. Doll, R. P. d’Entremont, B. Hu, S. Liang, J. L. Privette, and D. P. Roy, 2002: First operational BRDF, albedo nadir reflectance products from MODIS. *Remote Sens. Environ.*, **83**, 135–148.
- Schaefer, J. T., 1990: The critical success index as an indicator of warning skill. *Wea. Forecasting*, **5**, 570–575.
- Scinocca, J. F., 2003: An accurate spectral nonorographic gravity wave drag parameterization for general circulation models. *J. Atmos. Sci.*, **60**, 667–682.
- Sekiguchi, R., Y. Ichikawa, K. Ochi, and T. Takakura, 2022: Hindcast verification of JMA’s GEPS for one-month prediction. *WGNE Res. Activ. Earth Sys. Modell.*, **52**, 6.3–6.4.
- Sellers, P. J., Y. Mintz, Y. C. Sud, and A. Dalcher, 1986: A simple biosphere model (SiB) for use within general circulation models. *J. Atmos. Sci.*, **43**, 505–531.
- Selwood, P., 2012: The Met Office Unified Model I/O Server. *ENES Workshop: Scalable IO in climate models*, available at: [https://verc.enes.org/computing/hpc-collaborations/parallel-io/workshop-scalable-io-in-climate-models/presentations/Unified\\_Model\\_IO\\_Server\\_Paul\\_Selwood.ppt/view](https://verc.enes.org/computing/hpc-collaborations/parallel-io/workshop-scalable-io-in-climate-models/presentations/Unified_Model_IO_Server_Paul_Selwood.ppt/view).
- Shao, Y. and L. M. Leslie, 1997: Wind erosion prediction over the Australian continent. *Journal of Geophysical Research: Atmospheres*.
- Shao, Y. and H. Lu, 2000: A simple expression for wind erosion threshold friction velocity. *Journal of Geophysical Research: Atmospheres*.
- Shimbori, T., Y. Aikawa, and N. Seino, 2009: Operational implementation of the tephra fall forecast with the JMA mesoscale tracer transport model. *CAS/JSC WGNE Res. Activ. Atmos. Oceanic Modell.*, **39**, 5.29–5.30.
- Shimbori, T. and K. Ishii, 2021: Design of the Japan Meteorological Agency atmospheric transport model. *Tech. Rep. MRI*, **84**, 146pp.
- Shimokobe, A., 2012: Improvement of the Stratocumulus Parameterization Scheme in JMA’s Operational Global Spectral Model. *CAS/JSC WGNE Res. Activ. Atmos. Oceanic Modell.*, 4.17–4.18.
- Shoji, Y., K. Sato, M. Yabuki, and T. Tsuda, 2017: Comparison of shipborne GNSS-derived precipitable water vapor with radiosonde in the western North Pacific and in the seas adjacent to Japan. *Earth, Planets and Space*, **69(1)**, 1–13.
- Simmons, A. J. and D. M. Burridge, 1981: An energy and angular-momentum conserving vertical finite-difference scheme and hybrid vertical coordinates. *Mon. Wea. Rev.*, **109**, 758–766.
- Simonsen, C., 1991: Self adaptive model output statistics based on Kalman filtering. *WMO Technical Document*, **421**, XX33–XX37.
- Slingo, A., 1989: A GCM parameterization for the shortwave radiative properties of water clouds. *J. Atmos. Sci.*, **46**, 1419–1427.
- Smagorinsky, J., 1963: General circulation experiments with the primitive equations I. The basic experiment. *Mon. Wea. Rev.*, **91**, 99–164.
- Smith, R. N. B., 1990: A scheme for predicting layer clouds and their water content in a general circulation model. *Quart. J. Roy. Meteor. Soc.*, **116**, 435–460.
- Smith, S. D. and E. G. Banke, 1975: Variation of the sea surface drag coefficient with wind speed. *Quart. J. Roy. Meteor. Soc.*, **101**, 665–673.
- Sommeria, G. and J. W. Deardorff, 1977: Subgrid-scale condensation in models of nonprecipitating clouds. *J. Atmos. Sci.*, **34**, 344–355.
- Stanski, L. J. Wilson, H. R. and W. R. Burrows, 1989: Survey of common verification methods in meteorology. *Research Rep.*, **89-5**, Forecast Research Division, Atmospheric Environment Service, Environment Canada, 114pp.

- Sundqvist, H., 1978: A parameterization scheme for non-convective condensation including prediction of cloud water content. *Quart. J. Roy. Meteor. Soc.*, **104**, 677–690.
- Sundqvist, H., E. Berge, and J. E. Kristjánsson, 1989: Condensation and cloud parameterization studies with a mesoscale numerical weather prediction model. *Mon. Wea. Rev.*, **117**, 1641–1657.
- Suzuki, T., 1983: A theoretical model for dispersion of tephra. *Arc Volcanism: Physics and Tectonics*, Shimozuru, D. and I. Yokoyama, Eds., TERRAPUB, Tokyo, 95–113.
- Takakura, T. and T. Komori, 2020: Two-tiered sea surface temperature approach implemented to JMA's Global Ensemble Prediction System. *WGNE Res. Activ. Earth Sys. Modell.*, **50**, 6.15–6.16.
- Takasa, S., M. Chikasawa, and H. Mori, 2011: A new method of tide prediction along the Japanese coastline and its accuracy. *Weather Bulletin, JMA*, **78**, S33–S42, (in Japanese).
- Takaya, Y., T. Yasuda, Y. Fujii, S. Matsumoto, T. Soga, H. Mori, M. Hirai, I. Ishikawa, H. Sato, A. Shimpo, M. Kamachi, and T. Ose, 2017: Japan Meteorological Agency/Meteorological Research Institute-Coupled Prediction System version1 (JMA/MRI-CPS1) for operational seasonal forecasting. *Clim, Dyn*, **48**, 313–333.
- Takeuchi, Y. and T. Kurino, 1997: Document of algorithm to derive rain rate and precipitation with SSM/I and AMSR. *Algorithm description of PIs for SSM/I and ADEOS-II/AMSR, 2nd AMSR Workshop*, Tokyo, Japan, 61.1–61.9.
- Takeuchi, Y. and T. Tsuyuki, 2002: The operational 3D-Var assimilation system of JMA for the Global Spectrum Model and the Typhoon Model. *CAS/JSC WGNE Res. Activ. Atmos. Oceanic Modell.*, **32**, 1.59–1.60.
- Tanaka, T. Y., K. Orito, T. T. Sekiyama, K. Shibata, and M. Chiba, 2003: MASINGAR, a global tropospheric aerosol chemical transport model coupled with MRI/JMA98 GCM: Model description. *Pap. Meteorol. Geophys.*, **53** (4), 119–138.
- Tanguay, M., E. Yakimiw, H. Ritchie, and A. Robert, 1992: Advantage of spatial averaging in semi-implicit semi-Lagrangian schemes. *Mon. Wea. Rev.*, **120**, 113–123.
- The WAMDI Group, 1988: The WAM model—A third generation ocean wave prediction model. *J. Phys. Oceanogr.*, **18**, 1775–1810.
- Tiedtke, M., 1993: Representation of clouds in large-scale models. *Mon. Wea. Rev.*, **121**, 3040–3061.
- Tokioka, T., K. Yamazaki, A. Kitoh, and T. Ose, 1988: The equatorial 30–60 day oscillation and the Arakawa-Schubert penetrative cumulus parameterization. *J. Meteor. Soc. Japan*, **66**, 883–901.
- Toyoda, T., Y. Fujii, T. Yasuda, N. Usui, T. Iwao, T. Kuragano, and T. Kamachi, 2013: Improved analysis of the seasonal interannual fields by a global ocean data assimilation system. *Theoretical and Applied Mechanics Japan*, **61**, 31–48.
- Toyoda, T., Y. Fujii, T. Yasuda, N. Usui, K. Ogawa, T. Kuragano, H. Tsujino, and M. Kamachi, 2016: Data assimilation of sea ice concentration into a global ocean-sea ice model with corrections for atmospheric forcing and ocean temperature fields. *J. Oceanogr.*, **72**, 235–262.
- Toyoda, T., T. Awaji, N. Sugiura, S. Masuda, H. Igarashi, Y. Sasaki, Y. Hiyoshi, Y. Ishikawa, T. Mochizuki, T. Sakamoto, H. Tatebe, Y. Komuro, T. Suzuki, T. Nishimura, M. Mori, Y. Chikamoto, S. Yasunaka, Y. Imada, M. Arai, M. Watanabe, H. Shiogama, T. Nozawa, A. Hasegawa, M. Ishii, and M. Kimoto, 2011: Impact of the assimilation of sea ice concentration data on an atmosphere-ocean-sea ice coupled simulation of the arctic ocean climate. *SOLA*, **7**, 37–40.
- Trémolet, Y., 2008: Computation of observation sensitivity and observation impact in incremental variational data assimilation. *Tellus*, **60**.
- Tsujino, H., T. Motoi, I. Ishikawa, M. Hirabara, H. Nakano, G. Yamanaka, T. Yasuda, and H. Ishizaki, 2010: Reference Manual for the Meteorological Research Institute Community Ocean Model (MRI.COM) Version 3. Technical Reports of the Meteorological Research Institute 59, Meteorological Research Institute of Japan Meteorological Agency, Ibaraki, Japan. 241pp. ([http://www.mri-jma.go.jp/Publish/Technical/DATA/VOL\\_59/59\\_en.html](http://www.mri-jma.go.jp/Publish/Technical/DATA/VOL_59/59_en.html)).
- Tsujino, H., H. Nakano, K. Sakamoto, S. Urakawa, M. Hirabara, H. Ishizaki, and G. Yamanaka, 2017: Reference manual for the Meteorological Research Institute Community Ocean Model version 4 (MRI.COMv4). Technical Reports of the Meteorological Research Institute 80, Meteorological Research Institute of Japan Meteorological Agency, Ibaraki, Japan. 284pp. ([https://www.mri-jma.go.jp/Publish/Technical/DATA/VOL\\_80/index\\_en.html](https://www.mri-jma.go.jp/Publish/Technical/DATA/VOL_80/index_en.html)).

- Tsujino, H., S. Urakawa, H. Nakano, R. J. Small, W. M. Kim, S. G. Yeager, G. Danabasoglu, T. Suzuki, J. L. Bamber, M. Bentsen, C. W. Boning, A. Bozec, E. P. Chassignet, E. Curchitser, F. Boeira Dias, P. J. Durack, S. M. Griffies, Y. Harada, M. Ilicak, S. A. Josey, C. Kobayashi, S. Kobayashi, Y. Komuro, W. G. Large, J. Le Sommer, S. J. Marsland, S. Masina, M. Scheinert, H. Tomita, M. Valdivieso, and D. Yamazaki, 2018: JRA-55 based surface dataset for driving ocean-sea-ice models (JRA55-do). *Ocean Modelling*, **130**, 79–139, URL <https://www.sciencedirect.com/science/article/pii/S146350031830235X>.
- Ueno, K., 1998: An energy dissipation term in a numerical prediction wave model. *Sokkou-Jihou*, **65**, S181–S187, (in Japanese).
- Ueno, K., 2004: The development of the third generation wave model MRI-III for operational use. *Proceedings of the 8th International Workshop on Wave Hindcasting and Forecasting*, North Shore, Oahu, Hawaii, 14 - 19 November 2004, G2, (<http://www.waveworkshop.org>).
- Ujiie, M., M. Higuchi, T. Kadowaki, Y. Kuroki, K. Miyaoka, M. Oda, K. Ochi, R. Sekiguchi, H. Shimizu, S. Yokota, and H. Yonehara, 2021: Upgrade of JMA's operational global NWP system. *Res. Activ. Earth. Sys. Modell.*, 6.9–6.10.
- Umlauf, L. and H. Burchard, 2003: A generic length-scale equation for geophysical turbulence models. *JMR*, **61**, 235–265.
- Usui, N., Y. Fujii, K. Sakamoto, and M. Kamachi, 2015: Development of a four-dimensional variational assimilation system toward coastal data assimilation around Japan. *Mon. Wea. Rev.*, **143**, 3874–3892.
- Usui, N., S. Ishizaki, Y. Fujii, H. Tsujino, T. Yasuda, and M. Kamachi, 2006: Meteorological Research Institute multivariate ocean variational estimation (MOVE) system: Some early results. *Adv. Space Res.*, **37**, 806–822.
- van de Berg, L., J. Gustafsson, and A. Yildirim, 2002: Reprocessing of atmospheric motion vectors from Meteosat image data. ECMWF ERA-40 Project Report Series 3, European Centre for Medium-Range Weather Forecasts, Reading, UK. 159–168. (<https://www.ecmwf.int/en/publications>).
- Van Vuuren, D. P., J. Edmonds, M. Kainuma, K. Riahi, A. Thomson, K. Hibbard, G. C. Hurtt, T. Kram, V. Krey, J.-F. Lamarque, T. Masui, M. Meinshausen, N. Nakicenovic, S. J. Smith, and S. K. Rose, 2011: The representative concentration pathways: an overview. *Climatic Change*, **109**, 5–31.
- Veersé, F., D. Auroux, and M. Fisher, 2000: Limited-memory BFGS diagonal preconditioners for a data assimilation problem in meteorology. *Optimization and Engineering*, **1**, 323–339.
- Vialard, J., C. Menkes, J.-P. Boulanger, P. Delecluse, E. Guilyardi, M. J. McPhaden, and G. Madec, 2001: A model study of oceanic mechanisms affecting equatorial Pacific Sea surface temperature during the 1997-98 El Niño. *J. Phys. Oceanogr.*, **31**, 1649–1675.
- Vosper, S. B., 2015: Mountain waves and wakes generated by South Georgia: Implications for drag parametrization. *Quart. J. Roy. Meteor. Soc.*, **141**, 2813–2827.
- Wee, T. K. and Y. H. Kuo, 2004: Impact of a digital filter as a weak constraint in MM5 4DVAR: An observing system simulation experiment. *Mon. Wea. Rev.*, **132**, 543–559.
- Westerink, J. J., R. A. Luettich, and J. C. Feyen, 2008: A Basin-to Channel-Scale Unstructured Grid Hurricane Storm Surge Model Applied to Southern Louisiana. *Mon. Wea. Rev.*, **136**, 833–864.
- Wicker, L. J. and W. C. Skamarock, 2002: Time-splitting methods for elastic models using forward time schemes. *Mon. Wea. Rev.*, **130**, 2088–2097.
- Wilks, D. S., 2006: *Statistical Methods in the Atmospheric Sciences, Second Edition*, International Geophysics Series, Vol. 91. Academic Press, 627pp.
- Wilson, D. R. and S. P. Ballard, 1999: A microphysically based precipitation scheme for the UK meteorological office unified model. **125**, 1607–1636.
- WMO, 1993: *Guide on the Global Data-processing System*. WMO-No.305, World Meteorological Organization.
- WMO, 2019: *Manual on the Global Data-processing and Forecasting System. Annex IV to the WMO Technical Regulations*, World Meteorological Organization, Geneva, Switzerland.
- Woodruff, S.D., H.F. Diaz, J.D. Elms, and S.J. Worley, 1998: COADS release 2 data and metadata enhancements for improvements of marine surface flux fields. *Physics and Chemistry of the Earth*, **23**, 517–526.
- Woodruff, S.D., S.J. Worley, S.J. Lubker, Z. Ji, J.E. Freeman, D.I. Berry, P. Brohan, E.C. Kent, R.W. Reynolds, S.R. Smith, and C. Wilkinson, 2011: ICOADS release 2.5: Extensions and enhancements to the surface

- marine meteorological archive. *Int. J. Climatol.*, **31**, 951–967.
- Wyser, K., 1998: The effective radius in ice clouds. *J. Climate*, **11**, 1793–1802.
- Xie, S. C., and M. H. Zhang, 2000: Impact of the convection triggering function on single-column model simulations. *J. Geophys. Res.*, **105**, 14983–14996.
- Yabu, S., 2013: Development of longwave radiation scheme with consideration of scattering by clouds in JMA global model. *CAS/JSC WGNE Res. Activ. Atmos. Oceanic Modell.*, **43**, 4.07–4.08.
- Yabu, S., T. Y. Tanaka, and N. Oshima, 2017: Development of a multi-species aerosol-radiation scheme in JMA's global model. *WGNE blue book, Res. Activ. Atmos. Oceanic Modell.*, **47**, 4–15.
- Yamaguchi, H., M. Higaki, and M. Kyouda, 2014: Upgrade of JMA's One-Week Ensemble Prediction System. *CAS/JSC WGNE Res. Activ. Atmos. Oceanic Modell.*, **44**, 6.17–6.18.
- Yamaguchi, H., M. Ikegami, T. Iwahira, K. Ochi, R. Sekiguchi, and T. Takakura, 2021: Upgrade of JMA's Global Ensemble Prediction System. *WGNE Res. Activ. Earth Sys. Modell.*, **51**, 6.13–6.14.
- Yamaguchi, H., M. Ikegami, K. Ochi, Y. Ota, R. Sekiguchi, and T. Takakura, 2020: Upgrade of JMA's Global Ensemble Prediction System. *WGNE Res. Activ. Earth Sys. Modell.*, **50**, 6.17–6.18.
- Yamaguchi, H., Y. Adachi, S. Hirahara, Y. Ichikawa, T. Iwahira, Y. Kuroki, C. Matsukawa, R. Nagasawa, K. Ochi, R. Sekiguchi, T. Takakura, M. Ujiie, and H. Yonehara, 2022: Upgrade of JMA's Global Ensemble Prediction System. *WGNE Res. Activ. Earth Sys. Modell.*, **52**, 6.9–6.10.
- Yamaguchi, M., R. Sakai, M. Kyoda, T. Komori, and T. Kadowaki, 2009: Typhoon Ensemble Prediction System developed at the Japan Meteorological Agency. *Mon. Wea. Rev.*, **137**, 2592–2604.
- Yamashita, K., 2016: ASSIMILATION OF HIMAWARI-8 ATMOSPHERIC MOTION VECTORS INTO THE NUMERICAL WEATHER PREDICTION SYSTEMS OF JAPAN METEOROLOGICAL AGENCY. *Proceedings for the 13th International Winds Workshop*, Monterey, California, USA, 27 June - 1 July 2016.
- Yanagino, K. and S. Takada, 1995: Quantitative Analysis and Application to Weather Prediction by Neural Networks. *Technical Report of IEICE*, **NC95-37**, 63–70, (in Japanese).
- Yano, S, Johan C. Winterwerp, A Tai, and T. Saita, 2010: Numerical Experiments on Features of Nonlinear Tide and Its Influences on Sediment Transport in the Ariake Sea and the Yatsushiro Sea. *J. of JSCE, Ser. B2 (Coastal Engineering)*, **66**, 341–345, (in Japanese).
- Yokota, S., T. Banno, M. Oigawa, G. Akimoto, K. Kawano, and Y. Ikuta, 2022: Implementation of hybrid 3DVar in JMA's local analysis. *CAS/JSC WGNE Res. Activ. Atmos. Oceanic Modell.*, **52**, 01.19–01.20.
- Yokota, S., T. Kadowaki, M. Oda, and Y. Ota, 2021: Improving ensemble-based background error covariances of the hybrid 4DVar in JMA's global analysis. *WGNE Res. Activ. Earth System Modell.*, **51**, 01.27–01.28.
- Yonehara, H. and M. Ujiie, 2011: A stochastic physics scheme for model uncertainties in the JMA one-week ensemble prediction system. *WGNE blue book, Res. Activ. Atmos. Oceanic Modell.*, **41**, 6–9.
- Yonehara, H., M. Ujiie, T. Kanehama, R. Sekiguchi, and Y. Hayashi, 2014: Upgrade of JMA's Operational NWP Global Model. *CAS/JSC WGNE Res. Activ. Atmos. Oceanic Modell.*, 6.19–6.20.
- Yonehara, H., T. Tokuhiko, R. Nagasawa, M. Ujiie, A. Shimokobe, M. Nakagawa, R. Sekiguchi, T. Kanehama, H. Sato, and K. Saitou, 2017: Upgrade of parameterization schemes in JMA's operational global NWP model. *CAS/JSC WGNE Res. Activ. Atmos. Oceanic Modell.*, 4.17–4.18.
- Yonehara, H., R. Sekiguchi, T. Kanehama, K. Saitou, T. Kinami, A. Shimokobe, D. Hotta, R. Nagasawa, H. Sato, M. Ujiie, T. Kadowaki, S. Yabu, K. Yamada, M. Nakagawa, and T. Tokuhiko, 2018: Upgrade of JMA's operational global NWP system. *CAS/JSC WGNE Res. Activ. Atmos. Oceanic Modell.*, 6.15–6.16.
- Yonehara, H., C. Matsukawa, T. Nabetani, T. Kanehama, T. Tokuhiko, K. Yamada, R. Nagasawa, Y. Adachi, and R. Sekiguchi, 2020: Upgrade of JMA's operational global model. *WGNE blue book, Res. Activ. Earth Sys. Modell.*, **50**, 6–19.
- Yoshida, M., M. Kikuchi, T. M. Nagao, H. Murakami, T. Nomaki, and A. Higurashi, 2018: Common Retrieval of Aerosol Properties for Imaging Satellite Sensors. *Journal of the Meteorological Society of Japan. Ser. II*, **96B**, 193–209.
- Yoshida, M., K. Yumimoto, T. M. Nagao, T. Y. Tanaka, M. Kikuchi, and H. Murakami, 2021: Satellite retrieval of aerosol combined with assimilated forecast. *Atmospheric Chemistry and Physics*, **21**, 1797–1813.
- Yoshimura, H., 2002: Development of a Semi-Implicit Semi-Lagrangian Global Model using Double Fourier Series. *The 4th International Workshop on Next Generation Climate Models for Advanced High Performance*



- Computing Facilities., NCAR, Boulder, Colorado, 12 - 14 March 2002.
- Yoshimura, H. and T. Matsumura, 2003: A Semi-Lagrangian Scheme Conservative in the Vertical Direction. *CAS/JSC WGNE Res. Activ. Atmos. Oceanic Modell.*, **33**, 03.19–03.20.
- Yoshimura, H. and T. Matsumura, 2004: Semi-Lagrangian Toitsu model. *Report of Numerical Prediction Division (Suuchiyouhouka Houkoku Bessatsu Houkoku)*, **50**, 51–60, (in Japanese).
- Yoshimura, H. and S. Yukimoto, 2008: Development of a Simple Coupler (Scup) for Earth System Modeling. *Pap. Meteor. Geophys.*, **59**, 19–29.
- Yukimoto, S., H. Yoshimura, M. Hosaka, T. Sakami, H. Tsujino, M. Hirabara, T. Y. Tanaka, M. Deushi, A. Obata, H. Nakano, Y. Adachi, E. Shindo, S. Yabu, T. Ose, and A. Kitoh, 2011: Meteorological Research Institute-Earth System Model Version 1 (MRI-ESM1) –Model Description–. *Technical Reports of the Meteorological Research Institute*, **64**, 1–96, doi: 10.11483/mritechrepo.64.
- Yukimoto, S., H. Kawai, T. Koshiro, N. Oshima, K. Yoshida, S. Urakawa, H. Tsujino, M. Deushi, T. Tanaka, M. Hosaka, S. Yabu, H. Yoshimura, E. Shindo, R. Mizuta, A. Obata, Y. Adachi, and M. Ishii, 2019: The Meteorological Research Institute Earth System Model Version 2.0, MRI-ESM2.0: Description and Basic Evaluation of the Physical Component. *Journal of the Meteorological Society of Japan. Ser. II*, **97**, 931–965.
- Yumimoto, K., T. Y. Tanaka, N. Oshima, and T. Maki, 2017: JRAero: the Japanese Reanalysis for Aerosol v1.0. *Geoscientific Model Development*, **10**, 3225–3253.
- Yumimoto, K., T. Y. Tanaka, M. Yoshida, M. Kikuchi, T. M. Nagao, H. Murakami, and T. Maki, 2018: Assimilation and Forecasting Experiment for Heavy Siberian Wildfire Smoke in May 2016 with Himawari-8 Aerosol Optical Thickness. *Journal of the Meteorological Society of Japan. Ser. II*, **96B**, 133–149.
- Zeng, X. and A. Beljaars, 2005: A prognostic scheme of sea surface skin temperature for modeling and data assimilation. *Geophys. Res. Lett.*, **32**, L14 605.
- Zeng, X. and A. Wang, 2007: Consistent Parameterization of Roughness Length and Displacement Height for Sparse and Dense Canopies in Land Models. *J. Hydrometeorol.*, **8**, 730–737.
- Zeng, X., M. Zhao, and R. E. Dickinson, 1998: Intercomparison of Bulk Aerodynamic Algorithms for the Computation of Sea Surface Fluxes Using TOGA COARE and TAO Data. *J. Climate*, **11**, 2628–2644.
- Zhang, H., T. Nakajima, G. Shi, T. Suzuki, and R. Imasu, 2003: An optimal approach to overlapping bands with correlated  $k$  distribution method and its application to radiative calculations. *J. Geophys. Res.*, **108**, D20, 4641.
- Zhong, W. and J. D. Haigh, 1995: Improved broadband emissivity parameterization for water vapor cooling rate calculations. *J. Atmos. Sci.*, **52**, 124–138.
- Zsótér, E., 2006: Recent developments in extreme weather forecasting. *ECMWF Newsletter*, **107**, 8–17.
- Zweng, M. M., J. R. Reagan, D. Seidov, T. P. Boyer, R. A. Locarnini, H. E. Garcia, A. V. Mishonov, O. K. Baranova, K. Weathers, C. R. Paver, and I. Smolyar, 2018: *World Ocean Atlas 2018, Volume 2: Salinity*. NOAA Atlas NESDIS 82, 50 pp.

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**Outline of the Operational Numerical Weather Prediction  
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