

References

- Abel, S. J. and I. A. Boutle, 2012: An improved representation of the raindrop size distribution for single-moment microphysics schemes. *Quart. J. Roy. Meteor. Soc.*, **138**, 2151–2162.
- Abel, S. J. and B. J. Shipway, 2007: A comparison of cloud-resolving model simulations of trade wind cumulus with aircraft observations taken during RICO. *Quart. J. Roy. Meteor. Soc.*, **133**, 781–794.
- 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.
- 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.
- 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.
- 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. 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. Oliger, 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.

- Briegleb, B. P., 1992: Delta-Eddington Approximation for Solar Radiation in the NCAR Community Climate Model. *J. Geophys. Res.*, **97**, 7603–7612.
- 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.
- 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, 2014: 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.
- 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.
- 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**, L04806.
- 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.
- Deardorff, J. W., 1978: Efficient prediction of ground surface temperature and moisture, with inclusion of a layer of vegetation. *J. Geophys. Res.*, **83**, 1889–1903.
- Deardorff, J. W., 1980: Stratocumulus-capped mixed layers derived from a three-dimensional model. *Bound.-Layer Meteor.*, **18**, 495–527.
- 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. Meteorol. 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.
- 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.
- 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.
- Fairall, C. W., E. F. Bradley, J. E. Hare, A. A. Grachev, and J. B. Edson, 2003: Bulk parameterization of air-sea fluxes: Updates and verification for the COARE algorithm. *J. Clim.*, **16**, 571–591.
- 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.
- Field, P. R., A. J. Heymsfield, and A. Bansemer, 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.
- Foster, D. J. and R. D. Davy, 1988: Global Snow Depth Climatology. Tech. Rep. USAF-ETAC/TN-88/006, Scott Air Force Base, Illinois. 48pp.
- 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. and M. Kamachi, 2003: 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.
- Fujita, T., 1952: Pressure Distribution within Typhoon. *Geophys. Mag.*, **23**, 437–451.
- 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.
- 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.
- 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.
- 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. Tavolato, 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. Tavolato, 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 fo 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.
- Hibler, W. D., 1979: A dynamic thermodynamic sea ice model. *J. Phys. Oceanogr.*, **9**, 815–846.
- 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.
- 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.
- Holmlund, K., 1998: The utilization of statistical properties of satellite-derived atmospheric motion vectors to derive quality indicators. *Wea. Forecasting*, **13**, 1093–1104.
- Holtslag, 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.
- Hunke, E. C. and J. K. Dukowicz, 1997: An elastic-viscous-plastic model for sea ice dynamics. *J. Phys. Oceanogr.*, **27**, 1849–1867.
- Hunke, E. C. and W. H. Lipscomb, 2006: CICE. *The Los Alamos Sea Ice Model Documentation and Software User's Manual*, URL <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*. International Civil Aviation Organization.
- 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. 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.
- 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., 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, 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. 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 Maritime Safety Agency, (Ed.) , 1983: *Nihonkinkai Kairyu Tokeizu (Statistical charts of ocean currents around Japan)*. Japan Maritime Safety Agency, (in Japanese).
- 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.
- 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. 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., Y. Inomata, K. Sato, H. Ueda, Z. Han, J. An, G. Katata, M. Deushi, T. Maki, N. Oshima, J. Kurokawa, T. Ohara, A. Takami, and S. Hatakeyama, 2012: Development of the RAQM2 aerosol chemical transport model and predictions of the Northeast Asian aerosol mass, size, chemistry and the mixing type. *Atmos. Chem. Phys.*, **12**, 11 833–11 856.
- 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., 2013: Improvement of a stratocumulus scheme for mid-latitude marine low clouds. *CAS/JSC WGNE Res. Act. Atmos. Ocean Model/WMO*, **42**, 4.03–04.
- Kawai, H. and T. Inoue, 2006: A Simple Parameterization Scheme for Subtropical Marine Stratocumulus. *SOLA*, **2**, 17–20.
- Kessler, E., 1969: *On the distribution and continuity of water substance in atmospheric circulation.* Meteorol. Monogr., American Meteorol. Soc., Boston, MA, 84pp.
- 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. Ota, Y. Harada, A. Ebita, 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.
- Kondo, J., 1975: Air-sea bulk transfer coefficients in diabatic conditions. *Bound.-Layer Meteor.*, **9**, 91–112.
- 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>.
- 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., 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 JMAs Typhoon Ensemble Prediction System. *17*, 1–13.
- Lalaurette, F., 2003: Early detection of abnormal weather conditions using a probabilistic extreme forecast index. *Q. J. R. Meteorol. Soc.*, **129**, 3037–3057.
- 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.
- 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. and F. Rawlins, 2005: Why does 4D-Var beat 3D-Var? *Q. J. R. Meteorol. Soc.*, **131**, 3247–3257.
- 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.
- Luo, J.-J., S. Masson, E. Roeckner, G. Madec, and T. Yamagata, 2005: Reducing climatology bias in an ocean-atmosphere CGCM with improved coupling physics. *J. Clim.*, **18**, 2344–2360.
- 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.

- Machenauer, 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.
- McFarquhar, G. M., S. Iacobellis, and R. C. J. Somerville, 2003: SCM Simulations of Tropical Ice Clouds Using Observationally Based Parameterizations of Microphysics. *J. Climate*, **16**, 1643–1664.
- 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**, 10 937–10 954.
- 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.
- Morton, B. R., G. Taylor, and J. S. Turner, 1956: Turbulent gravitational convection from maintained and instantaneous sources. *Proc. Roy. Soc. (London) A*, **234**, 1–23.
- 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.
- Myeni, 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 global NWP model. *CAS/JSC WGNE Res. Act. Atmos. Ocea. Model/WMO*, **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.
- Nakamura, H., 1978: Dynamical effects of mountains on the general circulation of the atmosphere: I. Development of finite-difference schemes suitable for incorporating mountains. *J. Meteor. Soc. Japan*, **56**, 317–340.
- 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. Sugino, 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.
- 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.
- 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. Kluzeck, 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.
- 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. Manojoji, and R. Taira, 2007: The JRA-25 Reanalysis. *J. Meteor. Soc. Japan*, **85**, 369–432.
- 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. Schutts, 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.
- 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.
- 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.
- Räisänen, P., 1998: Effective longwave cloud fraction and Maximum-Random overlap of clouds: A problem and a solution. *Mon. Wea. Rev.*, **126**, 3336–3340.
- 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 CH₄ and H₂O 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.
- 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.
- 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.
- 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 (SiB) 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. (http://research.metoffice.gov.uk/research/interproj/nwpsaf/rttm/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.
- Scinocca, J. F., 2003: An accurate spectral nonorographic gravity wave drag parameterization for general circulation models. *J. Atmos. Sci.*, **60**, 667–682.
- 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.
- Semtner, A. J., 1976: A model for the thermodynamic growth of sea ice in numerical investigation of climate. *J. Phys. Oceanogr.*, **6**, 379–389.
- 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.
- 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.
- 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.
- 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.
- Sugi, M., R. Kawamura, and N. Sato, 1997: A study of SST-forced variability and potential predictability of

- seasonal mean fields using the JMA global model. *J. Meteor. Soc. Japan*, **75**, 717–736.
- 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.
- 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., J.-R. Bidlot, A. Beljaars, and P. A. E. M. Janssen, 2010: Refinements to a prognostic scheme of skin sea surface temperature. *Geophys. Res. Lett.*, **115**, C06009.
- Takaya, Y., S. Hirahara, T. Yasuda, S. Matsueda, T. Toyoda, Y. Fujii, H. Sugimoto, C. Matsukawa, I. Ishikawa, H. Mori, R. Nagasawa, Y. Kubo, N. Adachi, G. Yamanaka, T. Kuragano, A. Shimpo, S. Maeda, and T. Ose, 2018: Japan Meteorological Agency/Meteorological Research Institute-Coupled Prediction System version 2 (JMA/MRI-CPS2): atmosphere–land–ocean–sea ice coupled prediction system for operational seasonal forecasting. *Clim. Dyn.*, **50**, 751–765.
- 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.
- Toth, Z. and E. Kalnay, 1993: Ensemble Forecasting at NMC: The Generation of Perturbations. *Bull. Amer. Meteor. Soc.*, **74**, 2317–2330.
- Toth, Z. and E. Kalnay, 1997: Ensemble Forecasting at NCEP and the Breeding Method. *Mon. Wea. Rev.*, **125**, 3297–3319.
- 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.
- 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/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. (http://www.mri-jma.go.jp/Publish/Technical/DATA/VOL_80/index_en.html).
- Udin, I. and A. Ullerstig, 1976: A numerical model for forecasting the ice motion in the Bay and Sea of Bosnia. *SMHI MMK*, **6**, 1–40.
- 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>).
- 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.
- 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, 648pp.
- WMO, 1993: *Guide on the Global Data-processing System*. WMO-No.305, World Meteorological Organization.
- WMO, 2010: Standardized Verification System (SVS) for Long-Range Forecasts (LRF), Attachment II-8. *Manual on the Global Data-processing and Forecasting System Volume I - Global Aspects, Updated in 2012*, World Meteorological Organization.
- WMO, 2017: *Manual on the Global Data-processing and Forecasting System: Annex IV to the WMO Technical Regulations, 2017 edition*. World Meteorological Organization.
- Wurtele, M. G., R. D. Sharman, and T. L. Keller, 1987: Analysis and simulations of a troposphere-stratosphere gravity wave model. Part I. *J. Atmos. Sci.*, **44**, 3269–3281.
- 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**, 14 983–14 996.
- 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. *CAS/JSC WGNE Res. Activ. Atmos. Oceanic Modell.*, **47**, 4.15–4.16.
- 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, 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.
- 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).
- Yonehara, H. and M. Ujiie, 2011: A stochastic physics scheme for model uncertainties in the JMA one-week ensemble prediction system. *CAS/JSC WGNE Res. Act. Atmos. Ocean Model/WMO*, **41**, 6.09–6.10.
- 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. Tokuhiro, 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. Kadokawa, S. Yabu, K. Yamada, M. Nakagawa, and T. Tokuhiro, 2018: Upgrade of JMA's operational global NWP system. *CAS/JSC WGNE Res. Activ. Atmos. Oceanic Modell.*, 6.15–6.16.
- 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, Meteorological Research Institute, 83 pp.
- 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.
- 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.

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Outline of the Operational Numerical Weather Prediction at the Japan Meteorological Agency

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