Bibliography

Y. Achdou and O. Pironneau. *Computational Methods for Option Pricing*, Frontiers in Applied Mathematics 30. SIAM, 2005. doi:10.1137/1.9780898717495. (Cited on p. 264)

M. Ades and P.-J. van Leeuwen. The equivalent-weights particle filter in a high-dimensional system. *Quarterly Journal of the Royal Meteorological Society*, 141:484–503, 2015. (Cited on p. 103)

K. Aki and P. G. Richards. *Quantitative Seismology: Theory and Methods*. University Science Books, 2002. (Cited on pp. 245, 247)

H. Ammari, M. Asch, V. Jugnon, L. Guadarrama Bustos, and H. Kang. Transient imaging with limited-view data. *SIAM Journal on Imaging Sciences*, 4:1097–1121, 2011. (Cited on pp. 257, 259, 260)

H. Ammari, E. Bossy, J. Garnier, and L. L. Seppecher. Acousto-electromagnetic tomography. *SIAM Journal on Applied Mathematics*, 72:1592–1617, 2012. doi:10.1137/120863654. (Cited on p. 257)

H. Ammari, S. Boulmier, and P. Millien. A mathematical and numerical framework for magnetoacoustic tomography with magnetic induction. *Journal of Differential Equations*, 259:5379–5405, 2015. (Cited on p. 257)

B. D. O. Anderson and J. B. Moore. *Optimal Filtering*. Prentice-Hall, Inc., 1979. (Cited on pp. 90, 189)

J. L. Anderson. An ensemble adjustment Kalman filter for data assimilation. *Monthly Weather Review*, 129:2884–2903, 2001. (Cited on p. 174)

J. L. Anderson. An adaptive covariance inflation error correction algorithm for ensemble filters. *Tellus* A, 59:210–224, 2007. (Cited on p. 172)

J. L. Anderson and S. L. Anderson. A Monte Carlo implementation of the nonlinear filtering problem to produce ensemble assimilations and forecasts. *Monthly Weather Review*, 127:2741–2758, 1999. (Cited on p. 172)

J. L. Anderson and L. Lei. Empirical localization of observation impact in ensemble Kalman filters. *Monthly Weather Review*, 141:4140–4153, 2013. (Cited on p. 171)

A. Andrews. A square root formulation of the Kalman covariance equation. *AIAA Journal*, 6:1165–1168, 1968. (Cited on pp. 155, 167)

R. A. Anthes. Data assimilation and initialization of hurricane prediction models. *Journal of the Atmospheric Sciences*, 31:702–719, 1974. (Cited on pp. 121, 233)

G. Artana, A. Cammilleri, J. Carlier, and E. Memin. Strong and weak constraint variational assimilations for reduced order fluid flow modeling. *Journal of Computational Physics*, 231:3264–3288, 2012. (Cited on p. 139)

R. J. Arthern. Optimal estimation of changes in the mass of ice sheets. *Journal of Geophysical Research*, 108, 2003. (Cited on p. 224)

R. J. Arthern and G. H. Gudmundsson. Initialization of ice-sheet forecasts viewed as an inverse Robin problem. *Journal of Glaciology*, 56:527–533, 2010. (Cited on p. 224)

R. J. Arthern and R. C. A. Hindmarsh. Determining the contribution of Antarctica to sea-level rise using data assimilation methods. *Philosophical Transactions of the Royal Society* A: *Mathematical, Physical and Engineering Sciences*, 364:1841–1865, 2006. (Cited on p. 224)

M. Asch, J.-C. Le Gac, and Ph. Helluy. An adjoint method for geoacoustic inversions. In *2nd Conference on Inverse Problems, Control and Shape Optimization*, Carthage, 2002. (Cited on p. 257)

R. Aster, B. Borchers, and C. Thurber. *Parameter Estimation and Inverse Problems*. Academic Press, 2012. (Cited on p. 33)

J. Aubert and A. Fournier. Inferring internal properties of Earth's core dynamics and their evolution from surface observations and a numerical geodynamo model. *Nonlinear Processes in Geophysics*, 18:657–674, 2011. (Cited on p. 248)

L. Auger and A. V. Tangborn. A wavelet-based reduced rank Kalman filter for assimilation of stratospheric chemical tracer observations. *Monthly Weather Review*, 132:1220–1237, 2004. (Cited on p. 145)

D. Auroux. *Etude de différentes méthodes d'assimilation de données pour l'environnement*. PhD thesis, Université de Nice Sophia-Antipolis, 2003. (Cited on pp. 126, 127)

D. Auroux. The back and forth nudging algorithm applied to a shallow water model, comparison and hybridization with the 4D-VAR. *International Journal for Numerical Methods in Fluids*, 61:911–929, 2009. (Cited on p. 132)

D. Auroux and J. Blum. Back and forth nudging algorithm for data assimilation problems. *Comptes Rendus Mathematique*, 340:873–878, 2005. (Cited on pp. 122, 127, 128)

D. Auroux and J. Blum. A nudging-based data assimilation method: The back and forth nudging (BFN) algorithm. *Nonlinear Processes in Geophysics*, 15:305–319, 2008. (Cited on pp. 128, 129)

D. Auroux and M. Nodet. The back and forth nudging algorithm for data assimilation problems: Theoretical results on transport equations. *ESAIM: Control, Optimisation and Calculus of Variations*, 18:318–342, 2012. (Cited on p. 130)

D. Auroux, P. Bansart, and J. Blum. An evolution of the back and forth nudging for geophysical data assimilation: Application to Burgers equation and comparisons. *Inverse Problems in Science and Engineering*, 21:399–419, 2013. (Cited on p. 131)

R. N. Bannister. A review of forecast error covariance statistics in atmospheric variational data assimilation. II: Modelling the forecast error covariance statistics. *Quarterly Journal of the Royal Meteorological Society*, 134:1971–1996, 2008. (Cited on p. 140)

D. Barber. *Bayesian Reasoning and Machine Learning*. Cambridge University Press, 2012. (Cited on p. 74)

S. Barbier, A. Rapaport, and A. Rousseau. Modelling of biological decontamination of a water resource in natural environment and related feedback strategies. *Journal of Scientific Computing*, 68:1267–1280, 2016. (Cited on p. 227)

C. Bardos, J. Garnier, and G. Papanicolaou. Identification of Green's functions singularities by cross correlation of noisy signals. *Inverse Problems*, 24:015011, 2008. (Cited on p. 246)

G. K. Batchelor. *An Introduction to Fluid Dynamics*. Cambridge University Press, 2000. (Cited on p. 255)

P. Bauer, A. Thorpe, and G. Brunet. The quiet revolution of numerical weather prediction. *Nature*, 525:47–55, 2015. doi:10.1038/nature14956. (Cited on p. 238)

D. W. Behringer, M. Ji, and A. Leetmaa. An improved coupled model for ENSO prediction and implications for ocean initialization. Part I: The Ocean Data Assimilation System. *Monthly Weather Review*, 126:1013–1021, 1998. (Cited on p. 221)

B. M. Bell. The iterated Kalman smoother as a Gauss–Newton method. *SIAM Journal on Optimization*, 626–636, 1994. doi:10.1137/0804035. (Cited on p. 207)

M. J. Bell, M. J. Martin, and N. K. Nichols. Assimilation of data into an ocean model with systematic errors near the equator. *Quarterly Journal of the Royal Meteorological Society*, 130:873–893, 2004. (Cited on p. 221)

M. J. Bell, M. Lefebvre, P.-Y. Le Traon, N. Smith, and K. Wilmer-Becker. GODAE The Global Ocean Data Assimilation Experiment. *Oceanography*, 22:14–21, 2009. (Cited on p. 220)

A. F. Bennett. *Inverse Modeling of the Ocean and Atmosphere*. Cambridge University Press, 2004. (Cited on p. 33)

K. Bergemann and S. Reich. A mollified ensemble Kalman filter. *Quarterly Journal of the Royal Meteorological Society*, 136:1636–1643, 2010. doi:10.1002/qj.672. (Cited on pp. 176, 177)

L. Berre and G. Desroziers. Filtering of background error variances and correlations by local spatial averaging: A review. *Monthly Weather Review*, 138:3693–3720, 2010. (Cited on p. 202)

L. Berre, H. Varella, and G. Desroziers. Modelling of flow-dependent ensemble-based background-error correlations using a wavelet formulation in 4D-Var at Météo-France. *Quarterly Journal of the Royal Meteorological Society*, 141:2803–2812, 2015. (Cited on pp. 202, 203)

C. Bertoglio, P. Moireau, and J.-F. Gerbeau. Sequential parameter estimation for fluid-structure problems. Application to hemodynamics. *International Journal for Numerical Methods in Biomedical Engineering*, 28:434–455, 2012. doi:10.1002/cnm. 1476. (Cited on p. 251)

C. Bertoglio, D. Chapelle, M. A. Fernández, J.-F. Gerbeau, and P. Moireau. State observers of a vascular fluid-structure interaction model through measurements in the solid. *Computer Methods in Applied Mechanics and Engineering*, 256:149–168, 2013. doi:10.1016/j.cma.2012.12.010. (Cited on p. 251)

C. Bertoglio, D. Barber, N. Gaddum, I. Valverde, M. Rutten, P. Beerbaum, P. Moireau, R. Hose, and J.-F. Gerbeau. Identification of artery wall stiffness: In vitro validation and in vivo results of a data assimilation procedure applied to a 3D fluid-structure interaction model. *Journal of Biomechanics*, 47:1027–1034, 2014. doi: 10.1016/j.jbiomech.2013.12.029. (Cited on pp. 251, 252)

S. Beyou, A. Cuzol, S. Gorthi, and E. Mémin. Weighted ensemble transform kalman filter for image assimilation. *Tellus* A, 65:18803, 2013. ISSN 1600-0870. `http://www.tellusa.net/index.php/tellusa/article/view/18803`. (Cited on p. 256)

L. T. Biegler. *Nonlinear Programming: Concepts, Algorithms, and Applications to Chemical Processes*. MOS-SIAM Series on Optimization 10, SIAM, 2010. doi:10.1137/ 1.9780898719383. (Cited on p. 262)

L.T. Biegler. Efficient nonlinear programming algorithms for chemical process control and operations. In A. Korytowski, M. Szymkat, K. K Malanowski, and W. Mitkowski, editors, *System Modeling and Optimization*, pages 21–35. Springer, 2007. (Cited on p. 261)

R. Bintanja, R. S. W. van de Wal, and J. Oerlemans. A new method to estimate ice age temperatures. *Climate Dynamics*, 24:197–211, 2004. (Cited on p. 224)

C. H. Bishop, B. J. Etherton, and S. J. Majumdar. Adaptive sampling with the ensemble transform Kalman filter. Part I: Theoretical aspects. *Monthly Weather Review*, 129:420–436, 2001. (Cited on pp. 103, 163)

A. A. Bloom and M. Williams. Constraining ecosystem carbon dynamics in a data-limited world: Integrating ecological "common sense" in a model–data fusion framework. *Biogeosciences*, 12:1299–1315, 2015. (Cited on p. 230)

M Bocher, N. Coltice, A. Fournier, and P. J. Tackley. A sequential data assimilation approach for the joint reconstruction of mantle convection and surface tectonics. *Geophysical Journal International*, 204:200–214, 2016. (Cited on p. 249)

M. Bocquet. Ensemble Kalman filtering without the intrinsic need for inflation. *Nonlinear Processes in Geophysics*, 18:735–750, 2011. doi:10.5194/npg-18-735-2011. (Cited on pp. 172, 184, 185)

M. Bocquet. Parameter field estimation for atmospheric dispersion: Application to the Chernobyl accident using 4D-Var. *Quarterly Journal of the Royal Meteorological Society*, 138:664–681, 2012a. doi:10.1002/qj.961. (Cited on p. 50)

M. Bocquet. An introduction to inverse modelling and parameter estimation for atmosphere and ocean sciences. In É. Blayo, M. Bocquet, E. Cosme, and L. F. Cugliandolo, editors, *Advanced Data Assimilation for Geosciences*, pages 461–493, Les Houches School of Physics, 2012b. Oxford University Press. (Cited on p. 241)

M. Bocquet. Localization and the iterative ensemble Kalman smoother. *Quarterly Journal of the Royal Meteorological Society*, 142:1075–1089, 2016. (Cited on pp. 166, 205, 206, 207, 209, 215, 216)

M. Bocquet and P. Sakov. Combining inflation-free and iterative ensemble Kalman filters for strongly nonlinear systems. *Nonlinear Processes in Geophysics*, 19:383–399, 2012. doi:10.5194/npg-19-383-2012. (Cited on pp. 172, 186, 209)

M. Bocquet and P. Sakov. Joint state and parameter estimation with an iterative ensemble Kalman smoother. *Nonlinear Processes in Geophysics*, 20:803–818, 2013. doi:10.5194/npg-20-803-2013. (Cited on pp. 178, 180, 189, 210)

M. Bocquet and P. Sakov. An iterative ensemble Kalman smoother. *Quarterly Journal of the Royal Meteorological Society*, 140:1521–1535, 2014. doi:10.1002/qj.2236. (Cited on pp. 189, 205, 207, 209, 211, 213)

M. Bocquet, C. A. Pires, and L. Wu. Beyond Gaussian statistical modeling in geophysical data assimilation. *Monthly Weather Review*, 138:2997–3023, 2010. doi:10.1175/2010MWR3164.1. (Cited on p. 102)

M. Bocquet, P. N. Raanes, and A. Hannart. Expanding the validity of the ensemble Kalman filter without the intrinsic need for inflation. *Nonlinear Processes in Geophysics*, 22:645–662, 2015. doi:10.5194/npg-22-645-2015. (Cited on pp. 172, 177, 184, 185, 186, 199)

A. Boilley and J.-F. Mahfouf. Assimilation of low-level wind in a high-resolution mesoscale model using the back and forth nudging algorithm. *Tellus* A, 64:18697, 2012. (Cited on p. 132)

B. Bonan, M. Nodet, O. Ozenda, and C. Ritz. Data assimilation in glaciology. In É. Blayo, M. Bocquet, E. Cosme, and L. F. Cugliandolo, editors, *Advanced Data Assimilation for Geosciences*, pages 577–584. Oxford University Press, 2012. (Cited on p. 224)

B. Bonan, M. Nodet, C. Ritz, and V. Peyaud. An ETKF approach for initial state and parameter estimation in ice sheet modelling. *Nonlinear Processes in Geophysics*, 21:569–582, 2014. (Cited on pp. 193, 224)

M. Bonavita, L. Raynaud, and L. Isaksen. Estimating background-error variances with the ECMWF ensemble of data assimilation system: Some effects of ensemble size and day-to-day variability. *Quarterly Journal of the Royal Meteorological Society*, 137:423–434, 2011. (Cited on p. 202)

M. Bonavita, L. Isaksen, and E. Hólm. On the use of EDA background error variances in the ECMWF 4D-Var. *Quarterly Journal of the Royal Meteorological Society*, 138:1540–1559, 2012. (Cited on p. 202)

M. Bonnet and A. Constantinescu. Inverse problems in elasticity. *Inverse Problems*, 21:R1, 2005. http://stacks.iop.org/0266-5611/21/i=2/a=R01. (Cited on p. 261)

M. Boulakia, S. Cazeau, M. A. Fernández, J.-F. Gerbeau, and N. Zemzemi. Mathe-
    matical modeling of electrocardiograms: A numerical study. *Annals of Biomedical
    Engineering*, 38:1071–1097, 2010. doi:10.1007/s10439-009-9873-0. (Cited on p. 253)

F. Bouttier and P. Courtier. Data assimilation, concepts and methods. *Training course
    notes of ECMWF, European Centre for Medium-range Weather Forecasts*, 53, 1997.
    (Cited on p. 68)

J.-M. Brankart, E. Cosme, C.-E. Testut, P. Brasseur, and J. Verron. Efficient adaptive
    error parameterization for square root or ensemble Kalman filters: Application to
    the control of ocean mesoscale signals. *Monthly Weather Review*, 138:932–950, 2010.
    (Cited on p. 172)

P. Brasseur and J. Verron. The SEEK filter method for data assimilation in oceanogra-
    phy: A synthesis. *Ocean Dynamics*, 56:650–661, 2006. (Cited on pp. 142, 143)

P. Brasseur, P. Bahurel, L. Bertino, F. Birol, J.-M. Brankart, N. Ferry, S. Losa, E. Remy,
    J. Schröter, S. Skachko, C. E. Testut, B. Tranchant, P. J. van Leeuwen, and J. Verron.
    Data assimilation for marine monitoring and prediction: The MERCATOR oper-
    ational assimilation systems and the MERSEA developments. *Quarterly Journal of
    the Royal Meteorological Society*, 131:3561–3582, 2005. (Cited on p. 220)

P. Brasseur, N. Gruber, R. Barciela, K. Brander, M. Doron, A. El Moussaoui, A. Hob-
    day, M. Huret, A.-S. Kremeur, P. Lehodey, R. Matear, C. Moulin, R. Murtugudde,
    I. Senina, and E. Svendsen. Integrating biogeochemistry and ecology into ocean data
    assimilation systems. *Oceanography*, 22:206–215, 2009. (Cited on pp. 221, 227)

L. M. Brekhovskikh. *Waves in Layered Media*, second edition. Academic Press, 1980.
    (Cited on p. 245)

F. Brenguier, N. M. Shapiro, M. Campillo, A. Nercessian, and V. Ferrazzini. 3-D sur-
    face wave tomography of the Piton de la Fournaise volcano using seismic noise cor-
    relations. *Geophysical Research Letters*, 34:L02305, 2007. (Cited on p. 247)

F. Brenguier, N. Shapiro, M. Campillo, V. Ferrazzini, Z. Duputel, O. Coutant, and
    A. Nercessian. Towards forecasting volcanic eruptions using seismic noise. *Nature
    Geoscience*, 1:126–130, 2008. (Cited on p. 247)

D. Bresch, Th. Colin, E. Grenier, B. Ribba, and O. Saut. Computational modeling
    of solid tumor growth: The avascular stage. *SIAM Journal on Scientific Computing*,
    32:2321–2344, 2010. doi:10.1137/070708895. (Cited on p. 251)

N. Bret-Rouzaut and J.-P. Favennec. *Oil & Gas Exploration and Production: Reserves,
    Costs, Contracts*. Technip Editions, 2011. (Cited on p. 246)

P. Brousseau, L. Berre, F. Bouttier, and G. Desroziers. Background-error covariances
    for a convective-scale data-assimilation system: Arome–France 3D-VAR. *Quarterly
    Journal of the Royal Meteorological Society*, 137:409–422, 2011. (Cited on p. 140)

M. Buehner. Ensemble-derived stationary and flow-dependent background-error co-
    variances: Evaluation in a quasi-operational NWP setting. *Quarterly Journal of the
    Royal Meteorological Society*, 131:1013–1043, 2005. doi:10.1256/qj.04.15. (Cited on
    pp. 182, 199, 202)

M. Buehner, P. L. Houtekamer, C. Charette, H. L. Mitchell, and B. He. Intercomparison of variational data assimilation and the ensemble Kalman filter for global deterministic NWP. Part I: Description and single-observation experiments. *Monthly Weather Review*, 138:1550–1566, 2010a. (Cited on pp. 204, 205)

M. Buehner, P. L. Houtekamer, C. Charette, H. L. Mitchell, and B. He. Intercomparison of variational data assimilation and the ensemble Kalman filter for global deterministic NWP. Part II: One-month experiments with real observations. *Monthly Weather Review*, 138:1567–1586, 2010b. (Cited on p. 205)

M. Buehner, J. Morneau, and C. Charette. Four-dimensional ensemble-variational data assimilation for global deterministic weather prediction. *Nonlinear Processes in Geophysics*, 20:669–682, 2013. doi:10.5194/npg-20-669-2013. (Cited on p. 207)

M. Buehner, R. McTaggart-Cowan, A. Beaulne, C. Charette, L. Garand, S. Heilliette, E. Lapalme, S. Laroche, S. R. Macpherson, J. Morneau, and A. Zadra. Implementation of deterministic weather forecasting systems based on ensemble-variational data assimilation at Environment Canada. Part I: The global system. *Monthly Weather Review*, 143:2532–2559, 2015. (Cited on p. 207)

G. Burgers, P. J. van Leeuwen, and G. Evensen. Analysis scheme in the ensemble Kalman filter. *Monthly Weather Review*, 126:1719–1724, 1998. (Cited on p. 156)

M. Campillo, P. Roux, and N. M. Shapiro. Correlations of seismic ambient noise to image and to monitor the solid Earth, *Encyclopedia of Solid Earth Geophysics*, pages 1230–1235. Springer, 2011. (Cited on p. 246)

E. Canet, A. Fournier, and D. Jault. Forward and adjoint quasi-geostrophic models of the geomagnetic secular variation. *Journal of Geophysical Research: Solid Earth*, 114:B11101, 2009. doi:10.1029/2008JB006189. (Cited on p. 248)

C. Canudas De Wit, F. Morbidi, L. Leon Ojeda, A. Y. Kibangou, I. Bellicot, and P. Bellemain. Grenoble Traffic Lab: An experimental platform for advanced traffic monitoring and forecasting. *IEEE Control Systems*, 35:23–39, 2015. `https://hal.archives-ouvertes.fr/hal-01059126`. (Cited on p. 264)

Y. Cao, J. Zhu, Z. Luo, and I. M. Navon. Reduced-order modeling of the upper tropical Pacific ocean model using proper orthogonal decomposition. *Computers & Mathematics with Applications*, 52:1373–1386, 2006a. (Cited on p. 139)

Y. Cao, J. Zhu, I. M. Navon, and Z. Luo. A reduced-order approach to four-dimensional variational data assimilation using proper orthogonal decomposition. *Journal for Numerical Methods in Fluids*, 53:1511–1583, 2006b. (Cited on p. 139)

T. Capelle, P. Sturm, and A. Vidard. Formulating LUTI calibration as an optimisation problem: Example of Tranus shadow price estimation. *Procedia Engineering*, 115:12–20, 2015. doi:10.1016/j.proeng.2015.07.349. (Cited on p. 266)

V. Carmillet, J. M. Brankart, P. Brasseur, H. Drange, G. Evensen, and J. Verron. A singular evolutive extended Kalman filter to assimilate ocean color data in a coupled physical-biochemical model of the North Atlantic ocean. *Ocean Modelling*, 3:167–192, 2001. (Cited on p. 221)

A. Carrassi, S. Vannitsem, D. Zupanski, and M. Zupanski. The maximum likelihood ensemble filter performances in chaotic systems. *Tellus* A, 61:587–600, 2009. (Cited on p. 180)

S. Castellari, A. Griffa, T. M. Ozgokmen, and P. M. Poulain. Prediction of particle trajectories in the Adriatic Sea using Lagrangian data assimilation. *Journal of Marine Systems*, 29:33–50, 2001. (Cited on p. 220)

V. Chabot, M. Nodet, N. Papadakis, and A. Vidard. Accounting for observation errors in image data assimilation. *Tellus* A, 67:4117–19, 2015. (Cited on p. 221)

Y. Chao, Z. Li, J. Farrara, J. C. McWilliams, J. Bellingham, X. Capet, F. Chavez, J.-K. Choi, R. Davis, J. Doyle, D. M. Fratantoni, P. Li, P. Marchesiello, M. A. Moline, J. Paduan, and S. Ramp. Development, implementation and evaluation of a data-assimilative ocean forecasting system off the central California coast. *Deep Sea Research Part* II*: Topical Studies in Oceanography*, 56:100–126, 2009. (Cited on p. 220)

D. Chapelle, P. Moireau, and P. Le Tallec. Robust filtering for joint state-parameter estimation in distributed mechanical systems. *Discrete and Continuous Dynamical Systems*, (1-2):65–84, 2009. (Cited on p. 260)

F. Chevallier. Greenhouse gas flux inversion. In É. Blayo, M. Bocquet, E. Cosme, and L. F. Cugliandolo, editors, *Advanced Data Assimilation for Geosciences*, pages 497–505, Les Houches school of physics, 2012. Oxford University Press. (Cited on p. 241)

T. M. Chin and A. J. Mariano. Spatial regression and multiscale approximations for sequential data assimilation in ocean models. *Journal of Geophysical Research*, 104: 7991–8014, 1999. (Cited on p. 145)

C. K. Chui and G. Chen. Wavelet Kalman filtering. In *Kalman Filtering*, pages 164–177. Springer, 1999. (Cited on p. 145)

J. F. Claerbout. *Fundamentals of Geophysical Data Processing: With Applications to Petroleum Prospecting*. McGraw-Hill, 1976. (Cited on p. 245)

J. F. Claerbout. *Imaging the Earth's Interior*. Blackwell, 1985. (Cited on p. 245)

A. M. Clayton, A. C. Lorenc, and D. M. Barker. Operational implementation of a hybrid ensemble/4D-Var global data assimilation system at the Met Office. *Quarterly Journal of the Royal Meteorological Society*, 139:1445–1461, 2013. doi:10.1002/qj.2054. (Cited on p. 205)

S. E. Cohn and R. Todling. Approximate data assimilation schemes for stable and unstable dynamics. *Journal Meteorological Society of Japan Series* 2, 63–75, 1996. (Cited on pp. 141, 142)

S. E. Cohn, N. S. Sivakumaran, and R. Todling. A fixed-lag Kalman smoother for retrospective data assimilation. *Monthly Weather Review*, 122:2838–2867, 1994. (Cited on p. 189)

T. Colin, A. Iollo, J.-B. Lagaert, and O. Saut. An inverse problem for the recovery of the vascularization of a tumor. *Journal of Inverse and Ill-posed Problems*, 22:759–786, 2014. doi:10.1515/jip-2013-0009. (Cited on pp. 251, 252)

N. Coltice, T. Rolf, P. Tackley, and S. Labrosse. Dynamic causes of the relation between area and age of the ocean floor. *Science*, 336:335–338, 2012. (Cited on p. 249)

D. Colton and R. Kress. *Inverse Acoustic and Electromagnetic Scattering Theory*. Springer, 1998. (Cited on pp. 33, 257)

C. Corrado, J.-F. Gerbeau, and P. Moireau. Identification of weakly coupled multiphysics problems. Application to the inverse problem of electrocardiography. *Journal of Computational Physics*, 283:271–298, 2015. (Cited on p. 253)

E. Cosme, J.-M. Brankart, J. Verron, P. Brasseur, and M. Krysta. Implementation of a reduced-rank, square-root smoother for ocean data assimilation. *Ocean Modelling*, 33:87–100, 2010. (Cited on pp. 145, 189)

E. Cosme, J. Verron, P. Brasseur, J. Blum, and D. Auroux. Smoothing problems in a Bayesian framework and their linear Gaussian solutions. *Monthly Weather Review*, 140:683–695, 2012. (Cited on p. 189)

R. Courant and K. O. Friedrichs. *Supersonic Flow and Shock Waves*. Springer, 1976. (Cited on p. 255)

R. Courant and D. Hilbert. *Methods of Mathematical Physics*, volume 1. Wiley, 1989a. (Cited on pp. 23, 26, 28, 31)

R. Courant and D. Hilbert. *Methods of Mathematical Physics*, volume 2. Wiley, 1989b. (Cited on p. 245)

D. Courault, E. Kpemlie, R. Hadria, A. Bsaibes, A. Olioso, and O. Hagolle. Data assimilation: effect of agricultural land-use modifications on surface fluxes and microclimate. *iLEAPS Newsletter*, pages 1–2, 2014. (Cited on p. 230)

P. Courtier, J.-N. Thépaut, and A. Hollingsworth. A strategy for operational implementation of 4D-VAR, using an incremental approach. *Quarterly Journal of the Royal Meteorological Society*, 120:1367–1387, 1994. (Cited on p. 64)

M. Coustau, S. Ricci, V. Borrell-Estupina, C. Bouvier, and O. Thual. Benefits and limitations of data assimilation for discharge forecasting using an event-based rainfall–runoff model. *Natural Hazards and Earth System Science*, 13:583–596, 2013. (Cited on p. 233)

P. Cristini and D. Komatitsch. Some illustrative examples of the use of a spectral-element method in ocean acoustics. *Journal of the Acoustical Society of America*, 131:EL229–EL235, 2012. doi:10.1121/1.3682459. (Cited on p. 258)

V. Cristini and J. Lowengrub. *Multiscale Modeling of Cancer: An Integrated Experimental and Mathematical Modeling Approach*. Cambridge University Press, 2010. (Cited on p. 252)

N. Daget, A. Weaver, and M. A. Balmaseda. Ensemble estimation of background-error variances in a three-dimensional variational data assimilation system for the global ocean. *Quarterly Journal of the Royal Meteorological Society*, 135:1071–1094, 2009. (Cited on p. 142)

A. Dalcher and E. Kalnay. Error growth and predictability in operational ECMWF forecasts. *Tellus* A, 39:474–491, 1987. (Cited on p. 238)

DART toolbox, 2013. `http://www.image.ucar.edu/DAReS/DART`. (Cited on p. 87)

E. Daskalakis, C. Evangelidis, J. Garnier, N. Melis, G. Papanicolaou, and C. Tsogka. Robust seismic velocity change estimation using ambient noise recordings. *Geophysical Journal International*, 205:1926–1936, 2016. (Cited on p. 245)

F. Davidson, A. Allen, G. Brassington, Ø. Breivik, P. Daniel, M. Kamachi, S. Sato, B. King, F. Lefevre, and M. Sutton. Applications of GODAE ocean current forecasts to search and rescue and ship routing. *Oceanography*, 22:176–181, 2009. (Cited on p. 220)

H. C. Davies. A lateral boundary formulation for multi-level prediction models. *Quarterly Journal of the Royal Meteorological Society*, 102:405–418, 1976. (Cited on p. 125)

X. Davoine and M. Bocquet. Inverse modelling-based reconstruction of the Chernobyl source term available for long-range transport. *Atmospheric Chemistry and Physics*, 7:1549–1564, 2007. doi:10.5194/acp-7-1549-2007. (Cited on p. 241)

L. Debreu, E. Neveu, E. Simon, F.-X. Le Dimet, and A. Vidard. Multigrid solvers and multigrid preconditioners for the solution of variational data assimilation problems. *Quarterly Journal of the Royal Meteorological Society*, 142:515–528, 2015. (Cited on p. 150)

M. H. DeGroot and M. J. Schervisch. *Probability and Statistics*, fourth edition. Addison Wesley, 2012. (Cited on pp. 14, 23, 75)

S. Delahaies, L. Roulstone, and N. K. Nichols. *Regularization of a Carbon-Cycle Model-Data Fusion Problem*. Preprint, University of Reading, 2013. (Cited on p. 230)

M. C. Delfour and J.-P. Zolésio. *Shapes and Geometries: Analysis, Differential Calculus, and Optimization. Advances in Design and Control*, second edition, Advances in Design and Control 22, SIAM, 2011. doi:10.1137/1.9780898719826. (Cited on p. 256)

G. Desroziers, J.-T. Camino, and L. Berre. 4DEnVar: Link with 4D state formulation of variational assimilation and different possible implementations. *Quarterly Journal of the Royal Meteorological Society*, 140:2097–2110, 2014. doi:10.1002/qj.2325. (Cited on p. 207)

G. Desroziers, E. Arbogast, and L. Berre. Improving spatial localization in 4DEnVar. *Quarterly Journal of the Royal Meteorological Society*, 2016. Accepted for publication. doi:10.1002/qj.2898. (Cited on p. 206)

W. A. Dorigo, R. Zurita-Milla, A. J. W. de Wit, J. Brazile, R. Singh, and M. E. Schaepman. A review on reflective remote sensing and data assimilation techniques for enhanced agroecosystem modeling. *International Journal of Applied Earth Observation and Geoinformation*, 9:165–193, 2007. (Cited on p. 230)

S.E. Dosso and J. Dettmer. Bayesian matched-field geoacoustic inversion. *Inverse Problems*, 27:055009, 2011. (Cited on p. 257)

A. Doucet and A. M. Johansen. A tutorial on particle filtering and smoothing: 15 years later, In *Oxford Handbook of Nonlinear Filtering*, pages 656–704. Oxford University Press, 2011. (Cited on p. 99)

A. Doucet, N. de Freitas, and N. Gordon, editors. *Sequential Monte Carlo Methods in Practice*. Springer-Verlag, 2001. (Cited on p. 100)

M. Dowd. Bayesian statistical data assimilation for ecosystem models using Markov Chain Monte Carlo. *Journal of Marine Systems*, 68:439–456, 2007. (Cited on p. 227)

D. V. Droznin, N. M. Shapiro, S. Ya. Droznina, S. L. Senyukov, V. N. Chebrov, and E. I. Gordeev. Detecting and locating volcanic tremors on the Klyuchevskoy group of volcanoes (Kamchatka) based on correlations of continuous seismic records. *Geophysical Journal International*, 203:1001–1010, 2015. doi:10.1093/gji/ggv342. (Cited on p. 247)

M. Duembgen and L.C.G. Rogers. Estimate nothing. *Quantitative Finance*, 14:2065–2072, 2014. `arxiv:1401.5666`. (Cited on p. 264)

S. Dueri, B. Faugeras, and O. Maury. Modelling the skipjack tuna dynamics in the Indian Ocean with APECOSM-E—Part 1: Model formulation. *Ecological Modelling*, 245:41–54, 2012a. (Cited on pp. 226, 227)

S. Dueri, B. Faugeras, and O. Maury. Modelling the skipjack tuna dynamics in the Indian Ocean with APECOSM-E—Part 2: Parameter estimation and sensitivity analysis. *Ecological Modelling*, 245:55–64, 2012b. (Cited on p. 228)

S. Durbiano. *Vecteurs caractéristiques de modèles océaniques pour la réduction d'ordre en assimilation de données*. PhD thesis, Université de Grenoble, 2001. `http://www.theses.fr/2001GRE10228`. (Cited on p. 150)

H. Elbern, E. Friese, L. Nieradzik, and J. Schwinger. Data assimilation in atmospheric chemistry and air quality. In É. Blayo, M. Bocquet, E. Cosme, and L. F. Cugliandolo, editors, *Advanced Data Assimilation for Geosciences*, pages 507–533, Les Houches school of physics, 2012. Oxford University Press. (Cited on p. 241)

H. Engl and P. Kugler. Nonlinear inverse problems: Theoretical aspects and some industrial applications, In: Multidisciplinary Methods for Analysis Optimization and Control of Complex Systems Volume 6 of Mathematics in Industry, pages 3–47, Springer, 2005. (Cited on p. 261)

H. Engl, M. Hanke, and A. Neubauer. *Regularization of Inverse Problems*. Kluwer, 1996. (Cited on pp. 9, 35, 254)

H. W. Engl, C. Flamm, P. Kügler, J. Lu, S. Müller, and P. Peter Schuster. Inverse problems in systems biology. *Inverse Problems*, 35:123015, 2009. (Cited on p. 254)

D. Estep. *Duality, Adjoint Operators, and Uncertainty in a Complex World (Short Course)*. Colorado State University, 2004. `http://www.stat.colostate.edu/~estep/research/talks/montrealcourse.pdf`. (Cited on p. 35)

G. Evensen. Sequential data assimilation with a nonlinear quasi-geostrophic model using Monte Carlo methods to forecast error statistics. *Journal of Geophysical Research*, 99:10,143–10,162, 1994. (Cited on pp. 156, 159)

G. Evensen. The ensemble Kalman filter: Theoretical formulation and practical implementation. *Ocean Dynamics*, 53:343–367, 2003. (Cited on p. 167)

G. Evensen. *Data Assimilation: The Ensemble Kalman Filter*, second edition. Springer-Verlag, 2009. (Cited on pp. xvi, 66, 99, 156)

G. Evensen and P. J. van Leeuwen. An ensemble Kalman smoother for nonlinear dynamics. *Monthly Weather Review*, 128:1852–1867, 2000. (Cited on p. 189)

D. Fairbairn, S. R. Pring, A. C. Lorenc, and I. Roulstone. A comparison of 4DVar with ensemble data assimilation methods. *Quarterly Journal of the Royal Meteorological Society*, 140:281–294, 2014. (Cited on pp. 205, 207)

S. Fan, L.-Y. Oey, and P. Hamilton. Assimilation of drifter and satellite data in a model of the Northeastern Gulf of Mexico. *Continental Shelf Research*, 24:1001–1013, 2004. (Cited on p. 220)

B. F. Farrell and P. J. Ioannou. State estimation using a reduced-order Kalman filter. *Journal of the Atmospheric Sciences*, 58:3666–3680, 2001. (Cited on p. 139)

B. Faugeras and O. Maury. An advection-diffusion-reaction size-structured fish population dynamics model combined with a statistical parameter estimation procedure: Application to the Indian Ocean skipjack tuna fishery. *Mathematical Biosciences and Engineering*, 2:719–741, 2005. (Cited on p. 227)

B. Faugeras, M. Lévy, L. Mémery, J. Verron, J. Blum, and I. Charpentier. Can biogeochemical fluxes be recovered from nitrate and chlorophyll data? A case study assimilating data in the Northwestern Mediterranean Sea at the JGOFS-DYFAMED station. *Journal of Marine Systems*, 40/41:99–125, 2003. (Cited on p. 227)

B. Faugeras, O. Bernard, A. Sciandra, and M. Lévy. A mechanistic modelling and data assimilation approach to estimate the carbon/chlorophyll and carbon/nitrogen ratios in a coupled hydrodynamical-biological model. *Nonlinear Processes in Geophysics*, 11:515–533, 2004. (Cited on p. 227)

W. Feller. *An Introduction to Probability Theory and Its Applications*, volume 1, third edition. John Wiley and Sons, 1968. (Cited on p. 75)

J. Fernandez-Villaverde and J. F. Rubio-Ramirez. Estimating macroeconomic models: A likelihood approach. *Review of Economic Studies*, 74:1059–1087, 2007. (Cited on p. 264)

E. J. Fertig, J. Harlim, and B. R. Hunt. A comparative study of 4D-VAR and a 4D ensemble Kalman filter: Perfect model simulations with Lorenz-96. *Tellus* A, 59:96–100, 2007. (Cited on p. 205)

A. Fichtner. *Full Seismic Waveform Modelling and Inversion*. Springer, 2011. (Cited on pp. 245, 247)

A. Fichtner and A. Villasenor. Crust and upper mantle of the western Mediterranean—Constraints from full-waveform inversion. *Earth and Planetary Science Letters*, 428:52–62, 2015. (Cited on p. 247)

C. B. Field. *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation: Special Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press, 2012. (Cited on p. 232)

C. Fischer, T. Montmerle, L. Berre, L. Auger, and S. E. Stefanescu. An overview of the variational assimilation in the Aladin/France numerical weather-prediction system. *Quarterly Journal of the Royal Meteorological Society*, 131:3477–3492, 2005. (Cited on p. 140)

A. R. Fisher, A. J. Schissler, and J. C. Schotland. Photoacoustic effect of multiply scattered light. *Physical Review* E, 76:036604, 2007. (Cited on p. 259)

M. Fisher. Background error covariance modelling. In *Seminar on Recent Development in Data Assimilation ECMWF*, ECMWF, 2003. `http://www.ecmwf.int/en/learning/workshops-and-seminars/past-workshops/2003-annual-seminar` (Cited on pp. 66, 140, 142)

M. Fisher, Y. Trémolet, H. Auvinen, D. Tan, and P. Poli. *Weak-Constraint and Long-Window* 4D-Var. Technical Report 655, ECMWF, 2011. `http://old.ecmwf.int/publications/library/ecpublications/_pdf/tm/601-700/tm655.pdf`. (Cited on p. 207)

L. Formaggia, A. Quarteroni, and A. Veneziani, editors. *Cardiovascular Mathematics: Modeling and Simulation of the Circulatory System*. Springer-Verlag, 2009. (Cited on p. 252)

A. Fournier, G. Hulot, D. Jault, W. Kuang, A. Tangborn, N. Gillet, E. Canet, J. Aubert, and F. Lhuillier. An introduction to data assimilation and predictability in geomagnetism. *Space Science Reviews*, 155:247–291, 2010. doi:10.1007/s11214-010-9669-4. (Cited on p. 248)

A. Fournier, L. Nerger, and J. Aubert. An ensemble Kalman filter for the time-dependent analysis of the geomagnetic field. *Geochemistry, Geophysics, Geosystems*, 14:4035–4043, 2013. (Cited on pp. 193, 248)

W. B. Frank and N. M. Shapiro. Automatic detection of low-frequency earthquakes (LFEs) based on a beamformed network response. *Geophysical Journal International*, 197:1215–1223, 2014. doi:10.1093/gji/ggu058. (Cited on p. 246)

B. Friedland. *Control System Design—An Introduction to State-Space Methods*. McGraw-Hill, 1986. (Cited on pp. 18, 54, 75, 96)

P. Gajardo, J. Harmand, C. Ramírez, and A. Rapaport. Minimal time bioremediation of natural water resources. *Automatica*, 47:1764–1769, August 2011. (Cited on p. 227)

L. S. Gandin. Objective Analysis of Meteorological Fields. Gidrometeorologicheskoe Izdatelstvo (GIMIZ), Leningrad. (Israel Program for Scientific Translations, Jerusalem, 1965, 242 pp.) 1963. (Cited on p. 50)

P. Garthwaite, I. Jolliffe, and B. Jones. *Statistical Inference*. Oxford University Press, 2002. (Cited on pp. 78, 90)

G. Gaspari and S. E. Cohn. Construction of correlation functions in two and three dimensions. *Quarterly Journal of the Royal Meteorological Society*, 125:723–757, 1999. (Cited on p. 168)

A. Gelb. *Applied Optimal Estimation*. MIT Press, 1974. (Cited on pp. 18, 54, 96)

A. Gelman, J. B. Carlin, H. S. Stern, D. B. Dunson, A. Vehtari, and D. B. Rubin. *Bayesian Data Analysis*, third edition. Taylor & Francis, 2014. (Cited on p. 183)

M. B. Giles and M. C. Duta. Algorithm developments for discrete adjoint methods. *AIAA Journal*, 41:198–2005, 2003. (Cited on p. 254)

F. Gillet-Chaulet, O. Gagliardini, H. Seddik, M. Nodet, G. Durand, C. Ritz, T. Zwinger, R. Greve, and D. G. Vaughan. Greenland ice sheet contribution to sea-level rise from a new-generation ice-sheet model. *The Cryosphere*, 6:1561–1576, 2012. (Cited on pp. 224, 225)

L. Gilquin, T. Capelle, E. Arnaud, and C. Prieur. *Sensitivity Analysis and Optimisation of a Land Use and Transport Integrated Model*. Submitted preprint, 2016. `https://hal.inria.fr/hal-01291774`. (Cited on p. 266)

G. H. Golub and C. F. van Loan. *Matrix Computations*, fourth edition. The Johns Hopkins University Press, 2013. (Cited on pp. 23, 54, 66, 134, 135, 149, 178, 199)

N. J. Gordon, D. J. Salmond, and A. F. M. Smith. Novel approach to nonlinear/non-Gaussian Bayesian state estimation. *IEE Proceedings F (Radar and Signal Processing)*, 140:107–113, 1993. (Cited on p. 100)

D. Grana and E. Della Rossa. Probabilistic petrophysical-properties estimation integrating statistical rock physics with seismic inversion. *Geophysics*, 75:O21–O37, 2010. (Cited on p. 246)

M. Gray, C. Petit, S. Rodionov, M. Bocquet, L. Bertino, M. Ferrari, and T. Fusco. Local ensemble transform Kalman filter, a fast non-stationary control law for adaptive optics on ELTs: Theoretical aspects and first simulation results. *Optics Express*, 22:20894–20913, 2014. doi:10.1364/OE.22.020894. (Cited on pp. 171, 193)

W. W. Gregg. Assimilation of SeaWiFS ocean chlorophyll data into a three-dimensional global ocean model. *Journal of Marine Systems*, 69:205–225, 2008. (Cited on p. 221)

M. S. Grewal and A. P. Andrews. *Kalman Filtering: Theory and Practice Using MATLAB*, second edition. John Wiley & Sons, 2001. (Cited on p. 97)

S. J. Greybush, E. Kalnay, T. Miyoshi, K. Ide, and B. R. Hunt. Balance and ensemble Kalman filter localization techniques. *Monthly Weather Review*, 129:511–522, 2011. (Cited on p. 171)

A. Griewank. *Evaluating derivatives: Principles and Techniques of Automatic Differentiation*, second edition, SIAM, 2000. doi:10.1137/1.9780898717761. (Cited on p. 49)

A. Griewank and A. Walther. Revolve: An implementation of checkpointing for the reverse or adjoint mode of computational differentiation. *ACM Transactions on Mathematical Software*, 26:19–45, 2000. (Cited on p. 49)

A. K. Griffith and N. K. Nichols. Adjoint methods in data assimilation for estimating model error. *Flow, Turbulence and Combustion*, 65:469–488, 2000. (Cited on p. 67)

W. Gropp, E. Lusk, and A. Skjellum. *Using MPI: Portable Parallel Programming with the Message-Passing Interface*. MIT Press, 2014. (Cited on p. 99)

J. Guckenheimer and P. Holmes. *Nonlinear Oscillations, Dynamical Systems, and Bifurcations of Vector Fields*. Springer-Verlag, 1983. (Cited on p. 10)

N. Gustafsson, J. Bojarova, and O. Vignes. A hybrid variational ensemble data assimilation for the HIgh Resolution Limited Area Model (HIRLAM). *Nonlinear Processes in Geophysics*, 21:303–323, 2014. doi:10.5194/npg-21-303-2014. (Cited on p. 207)

A. Gyulai. The application of joint inversion in geophysical exploration. *International Journal of Geosciences*, 04:283–289, 2013. (Cited on p. 246)

E. Haber, D. W. Oldenburg, and R. Shekhtman. Inversion of time domain three-dimensional electromagnetic data. *Geophysical Journal International*, 171:550–564, 2007. doi:10.1111/j.1365-246X.2007.03365.x. (Cited on p. 246)

J. Habert, S. Ricci, A. Piacentini, G. Jonville, E. Le Pape, O. Thual, N. Goutal, F. Zaoui, and R. Ata. Estimation of lateral inflows using data assimilation in the context of real-time flood forecasting for the Marne Catchment in France. In *Advances in Hydroinformatics*, pages 93–105. Springer, 2014. (Cited on p. 233)

J. Hadamard. *Lectures on the Cauchy Problem in Linear Partial Differential Equations*. Yale University Press, 1923. (Cited on p. 6)

N. Halko, P.-G. Martinsson, and J. A. Tropp. Finding structure with randomness: Probabilistic algorithms for constructing approximate matrix decompositions. *SIAM Review*, 53:217–288, 2011. doi:10.1137/090771806. (Cited on p. 199)

T. M. Hamill and C. Snyder. A hybrid ensemble Kalman filter-3D variational analysis scheme. *Monthly Weather Review*, 128:2905–2919, 2000. (Cited on pp. 198, 201, 202, 205)

T. M. Hamill, J. S. Whitaker, and C. Snyder. Distance-dependent filtering of background error covariance estimates in an ensemble Kalman filter. *Monthly Weather Review*, 129:2776–2790, 2001. (Cited on p. 167)

R. G. Hanea, G. J. M. Velders, and A. W. Heemink. Data assimilation of ground-level ozone in Europe with a Kalman filter and chemistry transport model. *Journal of Geophysical Research*, 109:D10302, 2004. (Cited on p. 156)

A. Hannachi, I. T. Jolliffe, and D. B. Stephenson. Empirical orthogonal functions and related techniques in atmospheric science: A review. *International Journal of Climatology*, 27:1119–1152, 2007. (Cited on p. 137)

A. Hannart, A. Carrassi, M. Bocquet, M. Ghil, P. Naveau, M. Pulido, J. Ruiz, and P. Tandeo. DADA: Data assimilation for the detection and attribution of weather- and climate-related events. *Climate Change*, 136:155–174, 2016. doi:10.1007/S10584-016-1595-3. (Cited on p. 193)

P. C. Hansen. *Discrete Inverse Problems: Insight and Algorithms*. Fundamentals of Algorithms 7, SIAM, 2010. doi:10.1137/9780898718836. (Cited on pp. xv, 52)

E. Harader, V. Borrell-Estupina, S. Ricci, M. Coustau, O. Thual, A. Piacentini, and C. Bouvier. Correcting the radar rainfall forcing of a hydrological model with data assimilation: Application to flood forecasting in the Lez catchment in Southern France. *Hydrology & Earth System Sciences*, 16:4247–4264, 2012. (Cited on p. 233)

L. Hascoet. Adjoints by automatic differentiation. In E. Blayo, M. Bocquet, E. Cosme, and L. F. Cugliandolo, editors, *Advanced Data Assimilation for Geosciences*. Lecture Notes of the Les Houches School of Physics: Special Issue, June 2012. Oxford University Press, 2012. (Cited on p. 49)

J.-M. Haussaire and M. Bocquet. A low-order coupled chemistry meteorology model for testing online and offline data assimilation schemes: L95-grs (v1.0). *Geoscientific Model Development*, 9:393–412, 2016. doi:10.5194/gmd-9-393-2016. (Cited on p. 210)

T. Hayase. Numerical simulation of real-world flows. *Fluid Dynamics Research*, 47:051201, 2015. (Cited on p. 255)

P. Heimbach and V. Bugnion. Greenland ice-sheet volume sensitivity to basal, surface and initial conditions derived from an adjoint model. *Annals of Glaciology*, 50:67–80, 2009. (Cited on p. 224)

J. P. Hermand, M. Meyer, M. Asch, and M. Berrada. Adjoint-based acoustic inversion for the physical characterization of a shallow water environment. *Journal of the Acoustical Society of America*, 119:3860–3871, 2006. `http://link.aip.org/link/?JAS/119/3860/1`. (Cited on p. 257)

J. C. Herrera, D. B. Work, R. Herring, X. J. Ban, Q. Jacobson, and A. M. Bayen. Evaluation of traffic data obtained via GPS-enabled mobile phones: The mobile century field experiment. *Transportation Research Part C: Emerging Technologies*, 18:568–583, 2010. (Cited on p. 265)

M. J. Hoffman, S. J. Greybush, R. J. Wilson, G. Gyarmati, R. N. Hoffman, E. Kalnay, K. Ide, E. J. Kostelich, T. Miyoshi, and I. Szunyogh. An ensemble Kalman filter data assimilation system for the martian atmosphere: Implementation and simulation experiments. *Icarus*, 209:470–481, 2010. doi:10.1016/j.icarus.2010.03.034. (Cited on pp. 171, 193)

R. V. Hogg, J. McKean, and A. T. Craig. *Introduction to Mathematical Statistics*. Pearson, 2013. (Cited on p. 90)

J. E. Hoke and R. A. Anthes. The initialization of numerical models by a dynamic-initialization technique. *Monthly Weather Review*, 104:1551–1556, 1976. (Cited on p. 121)

R. A. Horn and C. R. Johnson. *Matrix Analysis*. Cambridge University Press, 2012. (Cited on p. 169)

I. Hoteit and A. Köhl. Efficiency of reduced-order, time-dependent adjoint data assimilation approaches. *Journal of Oceanography*, 62:539–550, 2006. (Cited on p. 151)

P. L. Houtekamer and H. L. Mitchell. Data assimilation using an ensemble Kalman filter technique. *Monthly Weather Review*, 126:796–811, 1998. (Cited on pp. 156, 159)

P. L. Houtekamer and H. L. Mitchell. A sequential ensemble Kalman filter for atmospheric data assimilation. *Monthly Weather Review*, 129:123–137, 2001. (Cited on pp. 167, 171)

P. L. Houtekamer and H. L. Mitchell. Ensemble Kalman filtering. *Quarterly Journal of the Royal Meteorological Society*, 131:3269–3289, 2005. doi:10.1256/qj.05.135. (Cited on p. 238)

M. R. Huddleston, M. J. Bell, M. J. Martin, and N. K. Nichols. Assessment of wind-stress errors using bias corrected ocean data assimilation. *Quarterly Journal of the Royal Meteorological Society*, 598:853–871, 2004. (Cited on p. 221)

T. J. R. Hughes. *The Finite Element Method: Linear, Static, and Dynamic Finite Element Analysis*. Prentice-Hall, 1987. (Cited on pp. 13, 23)

G. Hulot, T. J. Sabaka, N. Olsen, and A. Fournier. The present and future geomagnetic field. In *Treatise on Geophysics,* volume 5*: Geomagnetism*, pages 33–78. Elsevier Science, 2015. (Cited on p. 248)

B. R. Hunt, E. Kalnay, E. J. Kostelich, E. Ott, D. J. Patil, T. Sauer, I. Szunyogh, J. A. Yorke, and A. V. Zimin. Four-dimensional ensemble Kalman filtering. *Tellus* A, 56:273–277, 2004. (Cited on pp. 205, 210)

B. R. Hunt, E. J. Kostelich, and I. Szunyogh. Efficient data assimilation for spatiotemporal chaos: A local ensemble transform Kalman filter. *Physica* D, 230:112–126, 2007. (Cited on pp. 163, 164, 168, 179, 185, 208)

K. Ide, P. Courtier, M. Ghil, and A. C. Lorenc. Unified notation for data assimilation: Operational, sequential and variational. *Journal of the Meteorological Society of Japan*, 75:181–189, 1997. (Cited on p. 12)

A. Imperiale, Al. Routier, S. Durrleman, and P. Moireau. Improving efficiency of data assimilation procedure for a biomechanical heart model by representing surfaces as currents. In Sébastien Ourselin, Daniel Rueckert, and Nic Smith, editors, *FIMH— 7th International Conference on Functional Imaging and Modeling of the Heart*—2013, volume 7945 of Lecture Notes in Computer Science, pages 342–351, Springer, 2013. doi:10.1007/978-3-642-38899-6. (Cited on p. 261)

K. Ito and S. S. Ravindran. A reduced basis method for control problems governed by PDEs. In *Control and Estimation of Distributed Parameter Systems*, pages 153–168. Birkhäuser, 1998. (Cited on p. 138)

A. Jameson. Aerodynamic design via control theory. *Journal of Scientific Computing*, 3:233–260, 1988. (Cited on p. 254)

A. Jameson. Advances in aerodynamic shape optimization, *Frontiers of Computational Fluid Dynamics* 2006, pages 49–79. World Scientific, 2006. (Cited on pp. 255, 256)

M. Jay-Allemand, F. Gillet-Chaulet, J. J. Fürst, and M. Nodet. Investigating changes in basal conditions of Variegated Glacier prior to and during its 1982–1983 surge. *The Cryosphere*, 5:659–672, 2011. (Cited on p. 224)

E. T. Jaynes. *Probability Theory, the Logic of Science*. Cambridge University Press, 2003. (Cited on pp. 75, 81)

F. B. Jensen, W. A. Kuperman, M. B. Porter, and H. Schmidt. *Computational Ocean Acoustics*, second edition. Springer-Verlag, 2011. (Cited on p. 257)

T. Jordan. The interference spiral of earthquake system science. In *The William F. Brace Memorial Lecture Series*, MIT, 2015. (Cited on pp. 4, 5)

A. Jordi, M. I. Ferrer, G. Vizoso, A. Orfila, G. Basterretxea, B. Casas, A. Álvarez, D. Roig, B. Garau, M. Martínez, V. Fernández, A. Fornés, M. Ruiz, J. J. Fornós, P. Balaguer, C. M. Duarte, I. Rodríguez, E. Alvarez, R. Onken, P. Orfila, and J. Tintoré. Scientific management of Mediterranean coastal zone: A hybrid ocean forecasting system for oil spill and search and rescue operations. *Marine Pollution Bulletin*, 53:361–368, 2006. (Cited on p. 220)

J. P. Kaipio and E. Somersalo. *Statistical and Computational Inverse Problems*. Springer, 2005. (Cited on pp. xvi, 257)

R. E. Kalman. A new approach to linear filtering and prediction problems. *Transactions of the ASME Journal of Basic Engineering Series D*, 82:35–45, 1960. (Cited on pp. 16, 75, 90)

E. Kalnay. *Atmospheric Modeling, Data Assimilation and Predictability*. Cambridge University Press, 2003. (Cited on p. 64)

E. Kalnay, H. Li, T. Miyoshi, S.-C. Yang, and J. Ballabrera-Poy. 4D-Var or ensemble Kalman filter? *Tellus* A, 59A:758–773, 2007. (Cited on pp. 195, 197)

J.-S. Kang, E. Kalnay, T. Miyoshi, J. Liu, and I. Fung. Estimation of surface carbon fluxes with an advanced data assimilation methodology. *Journal of Geophysical Research*, 117:D24101, 2012. doi:10.1029/2012JD018259. (Cited on p. 193)

J. B. Keller. Inverse problems. *American Mathematical Monthly*, 73:1–23, 1966. (Cited on pp. 3, 23)

J. D. Kepert. Covariance localisation and balance in an ensemble Kalman filter. *Quarterly Journal of the Royal Meteorological Society*, 135:1157–1176, 2009. doi:10.1002/qj.443. (Cited on p. 171)

S. P. Khare, J. L. Anderson, T. J. Hoar, and D. Nychka. An investigation into the application of an ensemble Kalman smoother to high-dimensional geophysical systems. *Tellus* A, 60:97–112, 2008. (Cited on p. 189)

S. Kim, N. Shephard, and S. Chib. Stochastic volatility: Likelihood inference and comparison with ARCH models. *Review of Economic Studies*, 65:361–393, 1998. (Cited on p. 264)

A. Kirsch. *An Introduction to the Mathematical Theory of Inverse Problems*. Springer-Verlag, 1996. (Cited on pp. xvi, 7, 23)

R. Kleeman, A. M. Moore, and N. R. Smith. Assimilation of subsurface thermal data into a simple ocean model for the initialization of an intermediate tropical coupled ocean-atmosphere forecast model. *Monthly Weather Review*, 123:3103–3113, 1995. (Cited on p. 221)

D. T. Kleist and K. Ide. An OSSE-based evaluation of hybrid variational-ensemble data assimilation for the NCEP GFS, Part I: System description and 3D-hybrid results. *Monthly Weather Review*, 143:433–451, 2015. doi:10.1175/MWR-D-13-00351.1. (Cited on p. 207)

D. Komatitsch and R. Martin. An unsplit convolutional Perfectly Matched Layer improved at grazing incidence for the seismic wave equation. *Geophysics*, 72:SM155–SM167, 2007. doi:10.1190/1.2757586. (Cited on p. 247)

A. Kong, J. S. Liu, and W. H. Wong. Sequential imputations and Bayesian missing data problems. *Journal of the American Statistical Association*, 89:278–288, 1994. (Cited on p. 101)

E. Kreyszig. *Introductory Functional Analysis with Applications*. John Wiley & Sons, 1978. (Cited on pp. 23, 25, 33)

M. Krysta, E. Blayo, E. Cosme, and J. Verron. A consistent hybrid variational-smoothing data assimilation method: Application to a simple shallow-water model of the turbulent midlatitude ocean. *Monthly Weather Review*, 139:3333–3347, 2011. (Cited on p. 152)

W. Kuang and A. Tangborn. Interpretation of core field models, in geomagnetic observations and models. In M. Mandea and M. Korte, editors, *IAGA Special Sopron Book Series*, volume 5, pages 295–309. Springer, 2011. doi:10.1007/978-90-481-9858-0_12. (Cited on p. 248)

W. Kuang, A. Tangborn, W. Jiang, J. Bloxham, and Z. Wei. MoSST DAS: The first generation geomagnetic data assimilation framework. *Communications in Computational Physics*, 3:85–108, 2008. (Cited on p. 248)

P. K. Kundu and I. M. Cohen. *Fluid Mechanics*, second edition. Academic Press, 2002. (Cited on p. 255)

L. Kuznetsov, K. Ide, K. Jones, and C. K. R. T. Jones. A method for assimilation of Lagrangian data. *Monthly Weather Review*, 131:2247–2260, 2003. (Cited on p. 220)

H. Kwakernaak and R. Sivan. *Linear Optimal Control Systems*. John Wiley & Sons, 1972. (Cited on pp. 18, 54)

L. D. Landau and E.M. Lifschitz. *Theory of Elasticity*. Pergamon Press, 1975. (Cited on p. 247)

E. Larose, L. Stehly, and M. Campillo. Imaging the solid Earth with seismic noise. In *Proceedings of the Second Helas International Conference: Helioseismology, Asteroseismology and MHRD Connections*, volume 118 of *Journal of Physics Conference Series*, page 12003, 2008. (Cited on p. 245)

E. Larour. Rheology of the Ronne Ice Shelf, Antarctica, inferred from satellite radar interferometry data using an inverse control method. *Geophysical Research Letters*, 32:L05103, 2005. (Cited on p. 224)

C. Lauvernet, F. X. Le Dimet, F. Baret, H. Deboissezon, J. C. Favard, R. Vintila, C. Lazar, A. Badea, and F.-X. Le. Assimilation of high temporal frequency spot data to describe canopy functioning—The case of wheat crops in the ADAM experiment in Romania. In *First International Symposium on Recent Advances in Quantitative Remote Sensing*, pages 16–20. University of Valencia, 2002. (Cited on p. 230)

C. Lauvernet, F. Baret, L. Hascoet, S. Buis, and F.-X. Le Dimet. Multitemporal-patch ensemble inversion of coupled surface–atmosphere radiative transfer models for land surface characterization. *Remote Sensing of Environment*, 112:851–861, 2008. (Cited on p. 230)

C. Lauvernet, F. X. Le Dimet, and F. Baret. Prise en compte de structures spatiales pour assimilation variationnelle de données de télédétection. Exemple sur un modèle simple de croissance de végétation. In *EGC* 2014 – *14èmes journées Francophones "Extraction et Gestion des Connaissances,"* volume 1, pages 27–39, Rennes, France, 2014. (Cited on pp. 231, 232)

K. Law, A. Stuart, and K. Zygalakis. *Data Assimilation. A Mathematical Introduction*. Springer, 2015. doi:10.1007/978-3-319-20325-6. (Cited on p. xvi)

A. S. Lawless. DARC Data Assimilation Research Centre, 2002. `http://www.met.reading.ac.uk/~darc/`. (Cited on p. 68)

A. S. Lawless, N. K. Nichols, C. Boess, and A. Bunse-Gerstner. Using model reduction methods within incremental four-dimensional variational data assimilation. *Monthly Weather Review*, 136:1511–1522, 2008. (Cited on p. 147)

L. M. Lawson, Y. H. Spitz, E. E. Hofmann, and R. B. Long. A data assimilation technique applied to a predator-prey model. *Bulletin of Mathematical Biology*, 57:593–617, July 1995. (Cited on p. 226)

P. D. Lax. *Hyperbolic Systems of Conservation Laws and the Mathematical Theory of Shock Waves*. CBMS-NSF Regional Conference Series in Applied Mathematics 11, SIAM, 1973. doi:10.1137/1.9781611970562. (Cited on p. 43)

F.-X. Le Dimet and O. Talagrand. Variational algorithms for analysis and assimilation of meteorological observations: Theoretical aspects. *Tellus*, 38A:97–110, 1986. (Cited on p. 51)

F. Le Gland, V. Monbet, and V.-D. Tran. Large sample asymptotics for the ensemble Kalman filter. In D. Crisan and B. Rosovskii, editors, *The Oxford Handbook of Nonlinear Filtering*, pages 598–631. Oxford University Press, 2011. (Cited on p. 157)

O. Le Maitre and O. M. Knio. *Spectral Methods for Uncertainty Quantification*. Springer, 2010. (Cited on p. 6)

B. Legras and R. Vautard. A guide to Liapunov vectors. In *Proceedings of the* 1995 *ECMWF Seminar on Predictability*, volume 1, pages 143–156, ECMWF, 1996. (Cited on p. 136)

B. Lemieux-Dudon, F. Parrenin, and E. Blayo. A probabilistic method to construct a common and optimal chronology for an ice core. *Physics of Ice Core Records*, 68:233–245, 2008. (Cited on p. 224)

B. Lemieux-Dudon, E. Blayo, J.-R. Petit, C. Waelbroeck, A. Svensson, C. Ritz, J.-M. Barnola, B. M. Narcisi, and F. Parrenin. Consistent dating for Antarctic and Greenland ice cores. *Quaternary Science Reviews*, 29:8–20, 2010. (Cited on p. 224)

K. Leoviriyakit and A. Jameson. Aero-structural wing planform optimization. AIAA paper 2004-0029. In *42nd AIAA Aerospace Sciences Meeting & Exhibit*, 2004. `aero-comlab.stanford.edu/kasidit/publications/aes.pdf`. (Cited on p. 255)

J. M. Lewis, S. Lakshmivarahan, and S. K. Dhall. *Dynamic Data Assimilation: A Least Squares Approach*. Cambridge University Press, 2006. (Cited on pp. xv, xvi)

H. Li, E. Kalnay, and T. Miyoshi. Simultaneous estimation of covariance inflation and observation errors within an ensemble Kalman filter. *Quarterly Journal of the Royal Meteorological Society*, 135:523–533, 2009. (Cited on p. 172)

S. Li and L. Petzold. Adjoint sensitivity analysis for time-dependent partial differential equations with adaptive mesh refinement. *Journal of Computational Physics*, 198:310–325, 2004. (Cited on p. 50)

X. Liang, X. Zheng, S. Zhang, G. Wu, Y. Dai, and Y. Li. Maximum likelihood estimation of inflation factors on error covariance matrices for ensemble Kalman filter assimilation. *Quarterly Journal of the Royal Meteorological Society*, 138:263–273, 2012. (Cited on p. 172)

F.-C. Lin, M. P. Moschetti, and M. H. Ritzwoller. Surface wave tomography of the western United States from ambient seismic noise: Rayleigh and Love wave phase velocity maps. *Geophysical Journal International*, 173:281–298, 2008. (Cited on p. 246)

M. A. Lindquist, J. M. Loh, L. Y. Atlas, and T. D. Wager. Modeling the hemodynamic response function in fMRI: Efficiency, bias and mis-modeling. *Neuroimage*, 45(1 Suppl):S187–S198, 2008. `http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3318970/`. (Cited on p. 252)

J.-L. Lions. Exact controllability, stabilization and perturbations for distributed systems. *SIAM Review*, 30:1–68, 1988. doi:10.1137/1030001. (Cited on p. 51)

C. Liu and Z. Hu. Reliable and efficient approach of BOLD signal with dual Kalman filtering. *Computational and Mathematical Methods in Medicine*, 2012:961967, 2012. doi:10.1155/2012/961967. (Cited on p. 253)

C. Liu, Q. Xiao, and B. Wang. An ensemble-based four-dimensional variational data assimilation scheme. Part I: Technical formulation and preliminary test. *Monthly Weather Review*, 136:3363–3373, 2008. (Cited on p. 203)

C. Liu, Q. Xiao, and B. Wang. An ensemble-based four-dimensional variational data assimilation scheme. Part II: Observing system simulation experiments with advanced research WRF (ARW). *Monthly Weather Review*, 137:1687–1704, 2009. (Cited on p. 204)

G.-D. Liu, L.-L. Zhang, and L.-Y. Zhu. Seismic prospecting for oil and gas on the complex geological bodies. *Progress in Geophysics*, 3, 2006. (Cited on p. 246)

D. M. Livings, S. L. Dance, and N. K. Nichols. Unbiased ensemble square root filters. *Physica* D, 237:1021–1028, 2008. (Cited on p. 165)

O. I. Lobkis and R. L. Weaver. On the emergence of the Green's function in the correlations of a diffuse field. *Journal of the Acoustical Society of America*, 110:3011–3017, 2001. `http://link.aip.org/link/?JAS/110/3011/1`. (Cited on p. 246)

D. Lombardi, T. Colin, A. Iollo, O. Saut, F. Bonichon, and J. Palussière. Some models for the prediction of tumor growth: General framework and applications to metastases in the lung. In *Computational Surgery and Dual Training*, Chapter 19, pages 289–314. Springer, 2012. `https://hal.archives-ouvertes.fr/hal-00664725`. (Cited on p. 252)

A. C. Lorenc. The potential of the ensemble Kalman filter for NWP—A comparison with 4D-Var. *Quarterly Journal of the Royal Meteorological Society*, 118:3183–3203, 2003. doi:10.1256/qj.02.132. (Cited on pp. 51, 182, 195, 199, 202)

A. C. Lorenc, N. E. Bowler, A. M. Clayton, S. R. Pring, and D. Fairbarn. Comparison of hybrid-4DEnVar and hybrid-4DVar data assimilation methods for global NWP. *Monthly Weather Review*, 143:2012–229, 2015. doi:10.1175/MWR-D-14-00195.1. (Cited on pp. 205, 207)

E. N. Lorenz. Deterministic nonperiodic flow. *Journal of the Atmospheric Sciences*, 20:130–141, 1963. (Cited on pp. 23, 67, 187)

E. N. Lorenz. A study of the predictability of a 28-variable atmospheric model. *Tellus*, 17:321–333, 1965. (Cited on p. 238)

E. N. Lorenz. Atmospheric predictability experiments with a large numerical model. *Tellus*, 34:505–513, 1982. (Cited on p. 238)

E. N. Lorenz and K. A. Emmanuel. Optimal sites for supplementary weather observations: Simulation with a small model. *Journal of the Atmospheric Sciences*, 55:399–414, 1998. (Cited on pp. 102, 172)

D. Luenberger. Observers for multivariable systems. *IEEE Transactions on Automatic Control*, 11:190–197, 1966. (Cited on p. 122)

Y. Luo, K. Ogle, C. Tucker, S. Fei, and C. Gao. Ecological forecasting and data assimilation in a data-rich era. *Ecological Applications*, 21:1429–1442, 2011. (Cited on p. 227)

P. Lynch. The origins of computer weather prediction and climate modeling. *Journal of Computational Physics*, 227:3431–3444, 2008. (Cited on p. 50)

D. R. MacAyeal. The basal stress distribution of Ice Stream E, Antarctica, inferred by control methods. *Journal of Geophysical Research*, 97:595–603, 1992. (Cited on p. 224)

D. J. C. MacKay. *Information Theory, Inference and Learning Algorithms*. Cambridge University Press, 2003. (Cited on p. 102)

L. Magnusson and E. Källén. Factors influencing skill improvements in the ECMWF forecasting system. *Monthly Weather Review*, 141:3142–3153, 2013. doi:10.1175/MWR-D-12-00318.1. (Cited on p. 240)

S. Mallat. A theory for multiresolution signal decomposition: The wavelet representation. *IEEE Transactions on Pattern Analysis and Machine Intelligence*, 11:674–693, 1989. (Cited on p. 138)

S. Mallat. *A Wavelet Tour of Signal Processing: The Sparse Way*. Academic Press, 2008. (Cited on p. 138)

J. Mandel, L. S. Bennethum, J. D. Beezley, and J. L. Coen. A wildland fire model with data assimilation. *Mathematics and Computers in Simulation*, 79:584–606, 2008. (Cited on p. 233)

J. Mandel, L. Cobb, and J. D. Beezley. On the convergence of the ensemble Kalman filter. *Applications of Mathematics*, 56:533–541, 2011. (Cited on p. 157)

J. Mandel, E. Bergou, S. Gürol, and S. Gratton. Hybrid Levenberg-Marquardt and weak constraint ensemble Kalman smoother method. *Nonlinear Processes in Geophysics Discussions*, 2:865–902, 2015. doi:10.5194/npgd-2-865-2015. (Cited on p. 209)

J. Martin, L. C. Wilcox, C. Burstedde, and O. Ghattas. A stochastic Newton MCMC method for large-scale statistical inverse problems with application to seismic inversion. *SIAM Journal on Scientific Computing*, 34:A1460–A1487, 2012. doi:10.1137/110845598. (Cited on p. 246)

A. Marzuoli. Toy models in physics and the reasonable effectiveness of mathematics, *Deduction, Computation, Experiment: Exploring the Effectiveness of Proof*, pages 49–64. Springer, 2008. doi:10.1007/978-88-470-0784-0_3. (Cited on p. 23)

P. S. Maybeck. *Stochastic Models, Estimation, and Control*. Academic Press, 1979. (Cited on pp. 90, 96)

D. J. McGillicuddy, D. R. Lynch, A. M. Moore, W. C. Gentleman, C. S. Davis, and C. J. Meise. An adjoint data assimilation approach to diagnosis of physical and biological controls on Pseudocalanus spp. in the Gulf of Maine-Georges Bank region. *Fisheries Oceanography*, 7:205–218, 1998. (Cited on p. 226)

G. McPherson. *Applying and Interpreting Statistics: A Comprehensive Guide*. Springer, 2001. (Cited on pp. 3, 75)

B. Ménétrier, T. Montmerle, Y. Michel, and L. Berre. Linear filtering of sample covariances for ensemble-based data assimilation. Part I: Optimality criteria and application to variance filtering and covariance localization. *Monthly Weather Review*, 143:1622–1643, 2015a. (Cited on p. 171)

B. Ménétrier, T. Montmerle, Y. Michel, and L. Berre. Linear filtering of sample covariances for ensemble-based data assimilation. Part II: Application to a convective-scale NWP model. *Monthly Weather Review*, 143:1644–1664, 2015b. (Cited on p. 171)

J. Merger, A. Borzì, and R. Herzog. Optimal control of a system of reaction–diffusion equations modeling the wine fermentation process. *Optimal Control Applications and Methods*, 2016. doi:10.1002/oca.2246. (Cited on pp. 261, 262)

M. Meyer, J.-P. Hermand, M. Asch, and J.-C. Le Gac. An iterative multiple frequency adjoint-based inversion algorithm for parabolic-type approximations in ocean acoustics. *Inverse Problems in Science and Engineering*, 14:245–265, 2006. (Cited on p. 257)

A. M. Michalak, A. Hirsch, L. Bruhwiler, K. R. Gurney, W. Peters, and P. P. Tans. Maximum likelihood estimation of covariance parameters for Bayesian atmospheric trace gas surface flux inversions. *Journal of Geophysical Research*, 110:D24107, 2005. doi:10.1029/2005JD005970. (Cited on p. 241)

G. Miguez-Macho. Spectral nudging to eliminate the effects of domain position and geometry in regional climate model simulations. *Journal of Geophysical Research*, 109:D13104, 2004. (Cited on p. 125)

R. N. Miller and M. A. Cane. A Kalman filter analysis of sea level height in the tropical Pacific. *Journal of Physical Oceanography*, 19:773–790, 1989. (Cited on p. 139)

T. Miyoshi. The Gaussian approach to adaptive covariance inflation and its implementation with the local ensemble transform Kalman filter. *Monthly Weather Review*, 139:1519–1535, 2011. (Cited on p. 172)

B. Mohammadi and O. Pironneau. *Applied Shape Optimization for Fluids*, second edition. Oxford University Press, 2009. (Cited on p. 256)

P. Moireau, D. Chapelle, and P. Le Tallec. Joint state and parameter estimation for distributed mechanical systems. *Computer Methods in Applied Mechanics and Engineering*, 197:659–677, 2008. doi:10.1016/j.cma.2007.08.021. (Cited on p. 260)

V. Monteiller, S. Chevrot, D. Komatitsch, and Y. Wang. Three-dimensional full waveform inversion of short-period teleseismic wavefields based upon the SEM–DSM hybrid method. *Geophysical Journal International*, 202:811–827, 2015. doi:10.1093/gji/ggv189. (Cited on p. 247)

A. Mordret, D. Rivet, M. Landès, and N. M. Shapiro. Three-dimensional shear velocity anisotropic model of Piton de la Fournaise Volcano (La Réunion Island) from ambient seismic noise. *Journal of Geophysical Research Solid Earth*, 120:406–427, 2015. doi:10.1002/2014JB011654. (Cited on p. 247)

M. Morlighem, E. Rignot, H. Seroussi, E. Larour, H. Ben Dhia, and D. Aubry. Spatial patterns of basal drag inferred using control methods from a full-Stokes and simpler models for Pine Island Glacier, West Antarctica. *Geophysical Research Letters*, 37:L14502, 2010. (Cited on p. 224)

M. Morzfeld, X. Tu, E. Atkins, and A. J. Chorin. A random map implementation of implicit filters. *Journal of Computational Physics*, 231:2049–2066, 2012. (Cited on p. 102)

M. Mu. Nonlinear singular vectors and nonlinear singular values. *Science in China Series* D*: Earth Sciences*, 43:375–385, 2000. (Cited on p. 136)

I. Myrseth and H. Omre. Hierarchical ensemble Kalman filter. *SPE Journal*, 15:569–580, 2010. (Cited on p. 188)

L. J. Natvik and G. Evensen. Assimilation of ocean colour data into a biochemical model of the North Atlantic. *Journal of Marine Systems*, 40/41:127–153, 2003. (Cited on p. 221)

L. Nerger, S. Schulte, and A. Bunse-Gerstner. On the influence of model nonlinearity and localization on ensemble Kalman smoothing. *Quarterly Journal of the Royal Meteorological Society*, 140:2249–2259, 2014. doi:10.1002/qj.2293. (Cited on p. 189)

E. Neveu. *Application des méthodes multigrilles à l'assimilation variationnelle de données en géophysique*. PhD thesis, Université Joseph Fourier, 2011. (Cited on pp. 148, 150)

G. A. Newman and M. Commer. New advances in three dimensional transient electromagnetic inversion. *Geophysical Journal International*, 160:5–32, 2005. doi:10.1111/j.1365-246X.2004.02468.x. (Cited on p. 246)

G.-H. C. Ng, D. McLaughlin, D. Entekhabi, and A. Ahanin. The role of model dynamics in ensemble Kalman filter performance for chaotic systems. *Tellus* A, 63:958–977, 2011. (Cited on p. 177)

E. D. Nino Ruiz and A. Sandu. A derivative-free trust region framework for variational data assimilation. *Journal of Computational and Applied Mathematics*, 293:164–179, 2016. (Cited on p. 209)

J. Nocedal and S. J. Wright. *Numerical Optimization*. Springer Series in Operations Research. Springer, 2006. (Cited on pp. 23, 25, 26, 35, 38, 58, 179, 262)

M. Nodet. Variational assimilation of Lagrangian data in oceanography. *Inverse Problems*, 22:245–263, 2006. (Cited on p. 220)

A. Obermann, T. Planès, E. Larose, and M. Campillo. Imaging preeruptive and coeruptive structural and mechanical changes of a volcano with ambient seismic noise. *Journal of Geophysical Research: Solid Earth*, 118:6285–6294, 2013. doi: 10.1002/2013JB010399. (Cited on p. 247)

B. Oksendal. *Stochastic Differential Equations. An Introduction with Applications*, sixth edition. Springer, 2003. doi:10.1007/978-3-642-14394-6. (Cited on pp. 92, 263)

E. Ott, B. R. Hunt, I. Szunyogh, A. V. Zimin, E. J. Kostelich, M. Corazza, E. Kalnay, D. J. Patil, and A. Yorke. A local ensemble Kalman filter for atmospheric data assimilation. *Tellus* A, 56:415–428, 2004. (Cited on pp. 165, 167)

H. Owhadi, C. Scovel, T. J. Sullivan, M. McKerns, and M. Ortiz. Optimal uncertainty quantification. *SIAM Review*, 55:271–345, 2013. doi:10.1137/10080782X. (Cited on p. 6)

L. Palatella and A. Trevisan. Interaction of Lyapunov vectors in the formulation of the nonlinear extension of the Kalman filter. *Physical Review* E, 91:042905, 2015. doi: 10.1103/PhysRevE.91.042905. (Cited on p. 177)

L. Palatella, A. Carrassi, and A. Trevisan. Lyapunov vectors and assimilation in the unstable subspace: Theory and applications. *Journal of Physics A: Mathematical and Theoretical*, 46:254020, 2013. (Cited on p. 177)

S. Pant, B. Fabrèges, J.-F. Gerbeau, and I. Vignon-Clementel. A methodological paradigm for patient-specific multi-scale CFD simulations: From clinical measurements to parameter estimates for individual analysis. *International Journal for Numerical Methods in Biomedical Engineering*, 30:1614–1648, 2014. doi:10.1002/cnm.2692. (Cited on p. 251)

E. Parzen. *Stochastic Processes*. Classics in Applied Mathematics 24, SIAM, 1999. doi: 10.1137/1.9781611971125. (Cited on p. 90)

J. Pellenq and G. Boulet. A methodology to test the pertinence of remote-sensing data assimilation into vegetation models for water and energy exchange at the land surface. *Agronomie*, 24:197–204, 2004. (Cited on p. 230)

S. G. Penny. The hybrid local ensemble transform Kalman filter. *Monthly Weather Review*, 142:2139–2149, 2014. doi:10.1175/MWR-D-13-00131.1. (Cited on p. 199)

M. Perego, A. Veneziani, and C. Vergara. A variational approach for estimating the compliance of the cardiovascular tissue: An inverse fluid-structure interaction problem. *SIAM Journal on Scientific Computing*, 33:1181–1211, 2011. doi:10.1137/100808277. (Cited on p. 251)

D. Peter, D. Komatitsch, Y. Luo, R. Martin, N. Le Goff, E. Casarotti, P. Le Loher, F. Magnoni, Q. Liu, C. Blitz, T. Nissen-Meyer, P. Basini, and J. Tromp. Forward and adjoint simulations of seismic wave propagation on fully unstructured hexahedral meshes. *Geophysical Journal International*, 186:721–739, 2011. doi:10.1111/j.1365-246X.2011.05044.x. (Cited on p. 247)

K. B. Petersen and M. S. Pedersen. *The Matrix Cookbook*, 2012. `https://archive.org/details/K_B_Petersen_and_M_S_Peders__The_Matrix_Cookbook`. (Cited on p. 94)

N. Petra, H. Zhu, G. Stadler, T. J. R. Hughes, and O. Ghattas. An inexact Gauss–Newton method for inversion of basal sliding and rheology parameters in a nonlinear Stokes ice sheet model. *Journal of Glaciology*, 58:889–903, 2012. (Cited on p. 224)

D. T. Pham. Stochastic methods for sequential data assimilation in strongly nonlinear systems. *Monthly Weather Review*, 129:1194–1207, 2001. (Cited on pp. 145, 154, 156)

D. T. Pham, J. Verron, and M. C. Roubaud. A singular evolutive extended Kalman filter for data assimilation in oceanography. *Journal of Marine Systems*, 16:323–340, 1998. (Cited on pp. 142, 145, 154, 156, 172)

C. Pires, R. Vautard, and O. Talagrand. On extending the limits of variational assimilation in nonlinear chaotic systems. *Tellus* A, 48:96–121, 1996. (Cited on p. 211)

O. Pironneau. On optimum design in fluid mechanics. *Journal of Fluid Mechanics*, 64:97–110, 1974. (Cited on p. 254)

M. K. Pitt and N. Shephard. Filtering via simulation: Auxiliary particle filters. *Journal of the American Statistical Association*, 94:590–599, 1999. (Cited on p. 264)

A. Platania and L. C. G. Rogers. *Particle Filtering in High-Frequency Data*. Preprint available at `http://www.statslab.cam.ac.uk/~chris/papers/particle_paper.pdf`, 2004. (Cited on p. 264)

J. Poterjoy. A localized particle filter for high-dimensional nonlinear systems. *Monthly Weather Review*, 144:59–76, 2016. (Cited on p. 103)

J. Poterjoy and F. Zhang. Systematic comparison of four-dimensional data assimilation methods with and without the tangent linear model using hybrid background error covariance: E4DVar versus 4DEnVar. *Monthly Weather Review*, 143:1601–1621, 2015. (Cited on p. 207)

W. H. Press, S. A. Teukolsky, W. T. Vetterling, and B. P. Flannery. *Numerical Recipes. The Art of Scientific Computing*, third edition. Cambridge University Press, 2007. (Cited on pp. 23, 35, 262)

A. Pulkkinen, B. T. Cox, S. R. Arridge, J. P. Kaipio, and T. Tarvainen. A Bayesian approach to spectral quantitative photoacoustic tomography. *Inverse Problems*, 30:065012, 2014. (Cited on p. 257)

A. Quarteroni, R. Sacco, and F. Saleri. *Numerical Mathematics*, second edition. Springer-Verlag, 2007. (Cited on pp. 9, 23, 38, 48, 58)

F. Rabier, H. Järvinen, E. Klinker, J.-F. Mahfouf, and A. Simmons. The ECMWF operational implementation of four-dimensional variational assimilation. I: Experimental results with simplified physics. *Quarterly Journal of the Royal Meteorological Society*, 126:1143–1170, 2000. (Cited on p. 238)

W. Ramirez and J. Maciejowski. Optimal beer fermentation. *Journal of the Institute of Brewing*, 113:325–333, 2007. doi:10.1002/j.2050-0416.2007.tb00292.x. (Cited on p. 261)

F. Rawlins, S. P. Ballard, K. J. Bovis, A. M. Clayton, D. Li, G. W. Inverarity, A. C. Lorenc, and T. J. Payne. The Met Office global four-dimensional variational data assimilation scheme. *Quarterly Journal of the Royal Meteorological Society*, 133:347–362, 2007. (Cited on p. 140)

L. Raynaud, L. Berre, and G. Desroziers. Objective filtering of ensemble-based background-error variances. *Quarterly Journal of the Royal Meteorological Society*, 135:1177–1199, 2009. (Cited on p. 202)

D. A. Reed and J. Dongarra. Exascale computing and big data. *Communications of the ACM*, 58:56–68, 2015. doi:10.1145/2699414. (Cited on p. 89)

M. Reed and B. Simon. *Methods of Modern Mathematical Physics: Functional Analysis*. Academic Press, 1980. (Cited on pp. 23, 25)

S. Reich. A nonparametric ensemble transform method for Bayesian inference. *SIAM Journal on Scientific Computing*, 35:A2013–A2024, 2013. doi:10.1137/130907367. (Cited on p. 103)

S. Reich and C. Cotter. *Probabilistic Forecasting and Bayesian Data Assimilation*. Cambridge University Press, 2015. (Cited on p. xvi)

E. Ribbens, J. A. Silander Jr, and S. W. Pacala. Seedling recruitment in forests: Calibrating models to predict patterns of tree seedling dispersion. *Ecology*, 75:1794–1806, 1994. (Cited on p. 230)

S. Ricci, A. Piacentini, O. Thual, E. Le Pape, and G. Jonville. Correction of upstream flow and hydraulic state with data assimilation in the context of flood forecasting. *Hydrology & Earth System Sciences*, 15:3555–3575, 2011. (Cited on p. 233)

D. Rivet, M. Campillo, F. Sanchez-Sesma, N. M. Shapiro, and S. K. Singh. Identification of surface wave higher modes using a methodology based on seismic noise and coda waves. *Geophysical Journal International*, 203:856–868, 2015. doi:10.1093/gji/ggv339. (Cited on p. 246)

C. Robert, S. Durbiano, E. Blayo, J. Verron, J. Blum, and F. X. Le Dimet. A reduced-order strategy for 4D-Var data assimilation. *Journal of Marine Systems*, 57:70–82, 2005. (Cited on pp. 141, 150, 204)

C. Robert, E. Blayo, and J. Verron. Reduced-order 4D-Var: A preconditioner for the Incremental 4D-Var data assimilation method. *Geophysical Research Letters*, 33:L18609–4, 2006a. (Cited on pp. 151, 204)

C. Robert, E. Blayo, and J. Verron. Comparison of reduced-order, sequential and variational data assimilation methods in the tropical Pacific Ocean. *Ocean Dynamics*, 56:624–633, 2006b. (Cited on p. 151)

M. C. Rochoux, S. Ricci, D. Lucor, B. Cuenot, and A. Trouvé. Towards predictive data-driven simulations of wildfire spread—Part I: Reduced-cost Ensemble Kalman Filter based on a Polynomial Chaos surrogate model for parameter estimation. *Natural Hazards and Earth System Science*, 14:2951–2973, 2014. (Cited on pp. 233, 234)

M. C. Rochoux, C. Emery, S. Ricci, B. Cuenot, and A. Trouvé. Towards predictive data-driven simulations of wildfire spread—Part II: Ensemble Kalman Filter for the state estimation of a front-tracking simulator of wildfire spread. *Natural Hazards and Earth System Science*, 15:1721–1739, 2015. (Cited on pp. 233, 234, 235)

ROMS, `www.myroms.org`. (Cited on p. 220)

S. M. Ross. *Introduction to Probability Models*. Academic Press, 1997. (Cited on pp. 75, 90)

S. M. Ross. *Introduction to Probability and Statistics for Engineers and Scientists*, fifth edition, Elsevier Academic Press, 2014. (Cited on p. 90)

D. Rozier, F. Birol, E. Cosme, P. Brasseur, J. M. Brankart, and J. Verron. A reduced-order Kalman filter for data assimilation in physical oceanography. *SIAM Review*, 49:449–465, 2007. doi:10.1137/050635717. (Cited on p. 142)

G. A. Ruggiero, Y. Ourmières, E. Cosme, J. Blum, D. Auroux, and J. Verron. Data assimilation experiments using diffusive back-and-forth nudging for the NEMO ocean model. *Nonlinear Processes in Geophysics*, 22:233–248, 2015. (Cited on p. 132)

W. Sacher and P. Bartello. Sampling errors in ensemble Kalman filtering. Part I: Theory. *Monthly Weather Review*, 136:3035–3049, 2008. doi:10.1175/2007MWR2323.1. (Cited on p. 185)

P. Sakov and L. Bertino. Relation between two common localisation methods for the EnKF. *Computational Geosciences*, 15:225–237, 2011. (Cited on pp. 166, 169, 171, 199)

P. Sakov and P. R. Oke. A deterministic formulation of the ensemble Kalman filter: An alternative to ensemble square root filters. *Tellus* A, 60:361–371, 2008a. (Cited on p. 165)

P. Sakov and P. R. Oke. Implications of the form of the ensemble transformation in the ensemble square root filters. *Monthly Weather Review*, 136:1042–1053, 2008b. (Cited on pp. 175, 176)

P. Sakov, G. Evensen, and L. Bertino. Asynchronous data assimilation with the EnKF. *Tellus* A, 62:24–29, 2010. (Cited on p. 192)

P. Sakov, D. S. Oliver, and L. Bertino. An iterative EnKF for strongly nonlinear systems. *Monthly Weather Review*, 140:1988–2004, 2012. (Cited on pp. 179, 180, 207, 208, 209)

O. Saunier, A. Mathieu, D. Didier, M. Tombette, D. Quélo, V. Winiarek, and M. Bocquet. An inverse modeling method to assess the source term of the Fukushima nuclear power plant accident using gamma dose rate observations. *Atmospheric Chemistry and Physics*, 13:11403–11421, 2013. doi:10.5194/acpd-13-15567-2013. (Cited on p. 241)

A. H. Sayed. *Fundamentals of Adaptive Filtering*. John Wiley & Sons, 2003. (Cited on p. 82)

S. Schmidt. *Efficient Large Scale Aerodynamic Design Based on Shape Calculus*. PhD thesis, University of Trier, 2010. `http://ubt.opus.hbz-nrw.de/frontdoor.php?source_opus=569&la=en`. (Cited on p. 256)

S. Schmidt, C. Ilic, N. Gauger, and V. Schulz. *Shape Gradients and Their Smoothness for Practical Aerodynamic Design Optimization*. Technical Report Preprint-Nr.: SPP1253-10-03, DFG-SPP 1253, 2008. `http://www.am.uni-erlangen.de/home/spp1253/wiki/images/3/39/Preprint-spp1253-10-03.pdf`. Submitted (OPTE). (Cited on p. 256)

A. Segers, A. Heemink, M. Verlaan, and M. van Loon. A modified RRSQRT-filter for assimilating data in atmospheric chemistry models. *Environmental Modelling & Software*, 15:663–671, 2000. (Cited on p. 154)

A. J. Segers. *Data Assimilation in Atmospheric Chemistry Models Using Kalman Filtering*. PhD thesis, Delft University, 2002. (Cited on p. 156)

J. H. Seinfeld and S. N. Pandis. *Atmospheric Chemistry and Physics: From Air Pollution to Climate Change*, third edition. John Wiley & Sons, 2016. (Cited on p. 240)

N. M. Shapiro, M. Campillo, L. Stehly, and M. Ritzwoller. High resolution surface wave tomography from ambient seismic noise. *Science*, 307:1615–1618, 2005. (Cited on pp. 245, 246)

N. Silver. *The Signal and the Noise—The Art and Science of Prediction*. Penguin, 2012. (Cited on pp. 71, 72)

A. J. Simmons and A. Hollingsworth. Some aspects of the improvement in skill of numerical weather prediction. *Quarterly Journal of the Royal Meteorological Society*, 128:647–677, 2002. doi:10.1256/003590002321042135. (Cited on p. 240)

D. Simon. *Optimal State Estimation: Kalman, H Infinity, and Nonlinear Approaches*. John Wiley & Sons, 2006. (Cited on p. 177)

L. Slivinski, E. Spiller, A. Apte, and B. Sandstede. A hybrid particle-ensemble Kalman filter for Lagrangian data assimilation. *Monthly Weather Review*, 143:195–211, 2015. (Cited on p. 102)

N. R. Smith. The global ocean data assimilation experiment. *Advances in Space Research*, 25:1089–1098, 2000. (Cited on p. 220)

P. J. Smith, S. L. Dance, M. J. Baines, N. K. Nichols, and T. R. Scott. Variational data assimilation for parameter estimation: Application to a simple morphodynamic model. *Ocean Dynamics*, 59:697–708, 2009. (Cited on p. 220)

C. Snyder, T. Bengtsson, P. Bickel, and J. L. Anderson. Obstacles to high-dimensional particle filtering. *Monthly Weather Review*, 136:4629–4640, 2008. (Cited on p. 102)

C. Snyder, T. Bengtsson, and T. Morzfeld. Performance bounds for particle filters using the optimal proposal. *Monthly Weather Review*, 143:4750–4761, 2015. (Cited on p. 102)

D. Stammer. Estimating air-sea fluxes of heat, freshwater, and momentum through global ocean data assimilation. *Journal of Geophysical Research*, 109:C05023, 2004. (Cited on p. 220)

D. R. Stauffer and J. W. Bao. Optimal determination of nudging coefficients using the adjoint equations. *Tellus* A, 45:358–369, 1993. (Cited on p. 124)

L. Stehly, B. Fry, M. Campillo, N. M. Shapiro, J. Guilbert, L. Boschi, and D. Giardini. Tomography of the Alpine region from observations of seismic ambient noise. *Geophysical Journal International*, 178:338–350, 2009. (Cited on p. 246)

A. Stohl, P. Seibert, G. Wotawa, D. Arnold, J. F. Burkhart, S. Eckhardt, A. Vargas, and T. J. Yasunari. Xenon-133 and caesium-137 releases into the atmosphere from the Fukushima Dai-ichi nuclear power plant: Determination of the source term, atmospheric dispersion. *Atmospheric Chemistry and Physics*, 12:2313–2343, 2012. (Cited on p. 241)

J. C. Strikwerda. *Finite Difference Schemes and Partial Differential Equations*, second edition. SIAM, 2004. (Cited on pp. 13, 23, 62)

T. Suzuki. Special issue on data assimilation in fluid dynamics. *Fluid Dynamics Research*, 47:050001, 2015. (Cited on p. 255)

O. Talagrand. 4D-Var: Four-dimensional variational assimilation. In E. Blayo, M. Bocquet, E. Cosme, and L. F. Cugliandolo, editors, *Advanced Data Assimilation for Geosciences*, pages 3–30. Oxford University Press, 2012. Lecture Notes of the Les Houches School of Physics: Special Issue, 2012. doi:10.1093/acprof:oso/9780198723844.003.0001. (Cited on pp. 51, 52, 56)

A. Tangborn. Wavelet approximation of error covariance propagation in data assimilation. *Tellus* A, 56:16–28, 2004. (Cited on p. 145)

A. Tangborn and S. Q. Zhang. Wavelet transform adapted to an approximate Kalman filter system. *Applied Numerical Mathematics*, 33:307–316, May 2000. (Cited on pp. 140, 145)

C. Tape, Q. Liu, A. Maggi, and J. Tromp. Adjoint tomography of the southern California crust. *Science*, 325:988–992, 2009. (Cited on p. 247)

A. Tarantola. *Inverse Problem Theory and Methods for Model Parameter Estimation*. SIAM, 2005. (Cited on p. 245)

M. I. Taroudakis and G. N. Makrakis, editors. *Inverse Problems in Underwater Acoustics*. Springer-Verlag, 2001. (Cited on p. 258)

M. K. Tippett, J. L. Anderson, C. H. Bishop, T. M. Hamill, and J. S. Whitaker. Ensemble square root filters. *Monthly Weather Review*, 131:1485–1490, 2003. (Cited on p. 162)

R. D. Torn and G. J. Hakim. Ensemble data assimilation applied to RAINEX observations of Hurricane Katrina (2005). *Monthly Weather Review*, 137:2817–2829, September 2009. (Cited on p. 234)

Z. Toth and E. Kalnay. *Ensemble Forecasting at NMC and the Breeding Method*. Technical report, National Meteorological Center (U.S.), 1995. (Cited on p. 136)

Y. Tremolet. Incremental 4D-Var convergence study. *Tellus*, 59A:706–718, 2007a. (Cited on pp. 64, 148)

Y. Tremolet. Model-error estimation in 4D-Var. *Quarterly Journal of the Royal Meteorological Society*, 133:1267–1280, 2007b. (Cited on p. 67)

Y. Tremolet. Accounting for an imperfect model in 4D-Var. *Quarterly Journal of the Royal Meteorological Society*, 132:2483–2504, 2007c. (Cited on p. 67)

A. Trevisan and L. Palatella. On the Kalman filter error covariance collapse into the unstable subspace. *Nonlinear Processes in Geophysics*, 18:243–250, 2011. doi:10.5194/npg-18-243-2011. (Cited on p. 177)

F. Tröltzsch. *Optimal Control of Partial Differential Equations: Theory, Methods and Applications*. American Mathematical Society, 2010. (Cited on pp. 18, 35, 51)

M. Tsyrulnikov and A. Rakitkoa. A hierarchical Bayes ensemble Kalman filter. *Physica* D, 2016. Accepted for publication. doi:10.1016/j.physd.2016.07.009. (Cited on p. 189)

T. Van de Voorde, B. Verbeiren, Y. Cornet, M. Binard, J. van der Kwast, G. Engelen, F. Canters, and O. Batelaan. Mapping and modelling urban growth and its impact on the hydrology of urban watersheds with satellite imagery. *Earthzine IEEE, Earth Observation, Featured Article, Water*, July 9, 2013. (Cited on p. 265)

J. van der Kwast, F. Canters, D. Karssenberg, G. Engelen, T. van de Voorde, I. Uljee, and K. de Jong. Remote sensing data assimilation in modeling urban dynamics: Objectives and methodology. *Procedia Environmental Sciences*, 7:140–145, 2011. doi:10.1016/j.proenv.2011.07.025. Spatial Statistics 2011: Mapping Global Change. (Cited on p. 266)

P. J. van Leeuwen. Particle filtering in geophysical systems. *Monthly Weather Review*, 137:4089–4114, 2009. (Cited on p. 102)

H. Varella, M. Guérif, S. Buis, and N. Beaudoin. Soil properties estimation by inversion of a crop model and observations on crops improves the prediction of agroenvironmental variables. *European Journal of Agronomy*, 33:139–147, 2010. (Cited on p. 230)

J. C. Vassberg and A. Jameson. Aerodynamic shape optimization of a Reno race plane. *International Journal of Vehicle Design*, 28:318–338, 2002. (Cited on p. 255)

F. Veersé and J. N. Thepaut. Multiple-truncation incremental approach for four-dimensional variational data assimilation. *Quarterly Journal of the Royal Meteorological Society*, 124:1889–1908, July 1998. (Cited on p. 147)

F. Veersé, D.-T. Pham, and J. Verron. *4D-Var/SEEK: A Consistent Hybrid Variational-Smoothing Data Assimilation Method*. Technical report, INRIA, 2000. (Cited on p. 152)

J. Verbeke, L. Boschi, L. Stehly, E. Kissling, and A. Michelini. High resolution tomography of central Europe derived from dense ambient-noise database of Rayleigh waves. *Geophysical Journal International*, 188:1173–1187, 2012. doi:10.1111/j.1365-246X.2011.05308.x. (Cited on p. 245)

M. Verlaan and A. W. Heemink. Tidal flow forecasting using reduced rank square root filters. *Stochastic Hydrology and Hydraulics*, 11:349–368, 1997. (Cited on pp. 142, 145, 154, 156)

M. Verlaan and A. W. Heemink. Nonlinearity in data assimilation applications: A practical method for analysis. *Monthly Weather Review*, 129:1578–1589, 2001. (Cited on pp. 154, 156)

J. Verron, L. Gourdeau, D. T. Pham, R. Murtugudde, and A. J. Busalacchi. An extended Kalman filter to assimilate satellite altimeter data into a nonlinear numerical model of the tropical Pacific Ocean: Method and validation. *Journal of Geophysical Research: Oceans* (1978–2012), 104:5441–5458, 1999. (Cited on p. 143)

J. A. Verstegen, D. Karssenberg, F. van der Hilst, and A. P. C. Faaij. Detecting systemic change in a land use system by Bayesian data assimilation. *Environmental Modelling & Software*, 75:424–438, 2016. doi:10.1016/j.envsoft.2015.02.013. (Cited on p. 266)

A. Vidard, F.-X. Le Dimet, and A. Piacentini. Determination of optimal nudging coefficients. *Tellus* A, 55:1–15, 2003. (Cited on p. 124)

A. Vidard, A. Piacentini, and F.-X. Le Dimet. Variational data analysis with control of the forecast bias. *Tellus* A, 56:1–12, 2004. (Cited on p. 67)

A. Vidard, M. Balmaseda, and D. Anderson. Assimilation of altimeter data in the ECMWF ocean analysis system 3. *Monthly Weather Review*, 137:1393–1408, 2009. (Cited on pp. 221, 222)

A. Vieli, A. J. Payne, A. Shepherd, and Z. Du. Causes of pre-collapse changes of the Larsen B ice shelf: Numerical modelling and assimilation of satellite observations. *Earth and Planetary Science Letters*, 259:297–306, 2007. (Cited on p. 224)

J. Virieux and S. Operto. An overview of full-waveform inversion in exploration geophysics. *Geophysics*, 74:WCC1–WCC26, 2009. (Cited on p. 247)

C. R. Vogel. *Computational Methods for Inverse Problems*. Frontiers in Applied Mathematics 23, SIAM, 2002. doi:10.1137/1.9780898717570. (Cited on pp. xv, 9, 35, 52, 82, 257)

H. von Storch and H. Langenberg. A spectral nudging technique for dynamical downscaling purposes. *Monthly Weather Review*, 128:3664–3673, 2000. (Cited on p. 125)

K. M. Waldron, J. Paegle, and J. D. Horel. Sensitivity of a spectrally filtered and nudged limited-area model to outer model options. *Monthly Weather Review*, 124:529–547, 1996. (Cited on p. 125)

X. Wang and C. H. Bishop. A comparison of breeding and ensemble transform Kalman filter ensemble forecast schemes. *Journal of the Atmospheric Sciences*, 60:1140–1158, 2003. (Cited on p. 172)

X. Wang, C. H. Bishop, and S. J. Julier. Which is better, an ensemble of positive-negative pairs or a centered spherical simplex ensemble? *Monthly Weather Review*, 132:1590–1605, 2004. (Cited on p. 165)

X. Wang, C. Snyder, and T. M. Hamill. On the theoretical equivalence of differently proposed ensemble-3DVAR hybrid analysis schemes. *Monthly Weather Review*, 135:222–227, 2007. (Cited on pp. 182, 198, 200, 201)

X. Wang, D. M. Barber, C. Snyder, and T. M. Hamill. A hybrid ETKF-3DVAR data assimilation scheme for the WRF model. Part I: Observing system simulation experiment. *Monthly Weather Review*, 136:5116–5131, 2008. (Cited on p. 198)

A. Weaver and P. Courtier. Correlation modelling on the sphere using a generalized diffusion equation. *Quarterly Journal of the Royal Meteorological Society*, 127:1815–1846, 2001. (Cited on p. 140)

J. S. Whitaker and T. M. Hamill. Ensemble data assimilation without perturbed observations. *Monthly Weather Review*, 130:1913–1924, 2002. (Cited on pp. 163, 167)

J. S. Whitaker and T. M. Hamill. Evaluating methods to account for system errors in ensemble data assimilation. *Monthly Weather Review*, 140:3078–3089, 2012. (Cited on p. 172)

Wikipedia. *Reservoir modeling*—Wikipedia, The Free Encyclopedia, 2014. `https://en.wikipedia.org/w/index.php?title=Reservoir_modeling& oldid=609742841` [accessed 15-January-2016]. (Cited on p. 246)

Wikipedia. *Allan McLeod Cormack*—Wikipedia, The Free Encyclopedia, 2015a. `https://en.wikipedia.org/w/index.php?title=Allan_McLeod_Cormack& oldid=697625372` [accessed 4-January-2016]. (Cited on p. 257)

Wikipedia. *Dynamo theory*—Wikipedia, The Free Encyclopedia, 2015b. `https: //en.wikipedia.org/w/index.php?title=Dynamo_theory&oldid=691795405` [accessed 9-January-2016]. (Cited on p. 248)

Wikipedia. *Rolle's theorem*—Wikipedia, The Free Encyclopedia, 2015c. `https://en. wikipedia.org/w/index.php?title=Rolle's_theorem&oldid=693962181` [accessed 27-December-2015]. (Cited on p. 27)

Wikipedia. *Convex function*—Wikipedia, The Free Encyclopedia, 2015d. `https:// en.wikipedia.org/w/index.php?title=Convex_function&oldid=693475217` [accessed 27-December-2015]. (Cited on p. 27)

Wikipedia. 2016 *North Korean nuclear test*—Wikipedia, The Free Encyclopedia, 2016a. `https://en.wikipedia.org/w/index.php?title=2016_North_ Korean_nuclear_test&oldid=700044434` [accessed 17-January-2016]. (Cited on p. 246)

Wikipedia. *Black-Scholes model*—Wikipedia, The Free Encyclopedia, 2016b. `https://en.wikipedia.org/w/index.php?title=Black-Scholes_model& oldid=713401147` [accessed 9-April-2016]. (Cited on p. 264)

Wikipedia. *Michaelis-Menten kinetics*—Wikipedia, The Free Encyclopedia, 2016c. `https://en.wikipedia.org/w/index.php?title=Michaelis-Menten_ kinetics&oldid=711205220` [accessed 10-April-2016]. (Cited on p. 254)

M. Williams, P. A. Schwarz, B. E. Law, J. Irvine, and M. R. Kurpius. An improved analysis of forest carbon dynamics using data assimilation. *Global Change Biology*, 11:89–105, 2005. (Cited on p. 230)

V. Winiarek, M. Bocquet, O. Saunier, and A. Mathieu. Estimation of errors in the inverse modeling of accidental release of atmospheric pollutant: Application to the reconstruction of the cesium-137 and iodine-131 source terms from the Fukushima Daiichi power plant. *Journal of Geophysical Research*, 117:D05122, 2012. doi:10.1029/2011JD016932. (Cited on p. 241)

V. Winiarek, M. Bocquet, N. Duhanyan, Y Roustan, O. Saunier, and A. Mathieu. Estimation of the caesium-137 source term from the Fukushima Daiichi nuclear power plant using a consistent joint assimilation of air concentration and deposition observations. *Atmospheric Environment*, 82:268–279, 2014. doi:10.1016/j.atmosenv.2013.10.017. (Cited on pp. 241, 242, 243)

D. B. Work, O.-P. Tossavainen, S. Blandin, A. M. Bayen, T. Iwuchukwu, and K. Tracton. An ensemble Kalman filtering approach to highway traffic estimation using GPS enabled mobile devices. In 47*th IEEE Conference on Decision and Control*, 2008. *CDC* 2008, pages 5062–5068. IEEE, 2008. (Cited on p. 265)

D. B Work, S. Blandin, O.-P. Tossavainen, B. Piccoli, and A. M. Bayen. A traffic model for velocity data assimilation. *Applied Mathematics Research eXpress*, 2010:1–35, 2010. (Cited on pp. 264, 265)

L. Wu, V. Mallet, M. Bocquet, and B. Sportisse. A comparison study of data assimilation algorithms for ozone forecasts. *Journal of Geophysical Research*, 113:D20310, 2008. doi:10.1029/2008JD009991. (Cited on pp. 156, 193)

L. Wu, F.-X. Le Dimet, P. De Reffye, B.-G. Hu, P.-H. Cournède, and M.-Z. Kang. An optimal control methodology for plant growth—Case study of a water supply problem of sunflower. *Mathematics and Computers in Simulation*, 82:909–923, 2012. (Cited on p. 229)

C. Wunsch. *Discrete Inverse and State Estimation Problems. With Geophysical Fluid Applications.* Cambridge University Press, 2006. (Cited on p. 123)

C. Wunsch and P. Heimbach. Practical global oceanic state estimation. *Physica* D*: Nonlinear Phenomena*, 230:197–208, June 2007. (Cited on p. 220)

Q. Xiao, X. Zou, and B. Wang. Initialization and simulation of a landfalling hurricane using a variational bogus data assimilation scheme. *Monthly Weather Review*, 128:2252–2269, 2000. (Cited on p. 234)

Z. Xie, D. Komatitsch, R. Martin, and R. Matzen. Improved forward wave propagation and adjoint-based sensitivity kernel calculations using a numerically stable finite-element PML. *Geophysical Journal International*, 198:1714–1747, 2014. (Cited on p. 247)

Y. Yang, C. Robinson, D. Heitz, and E Mémin. Enhanced ensemble-based 4DVar scheme for data assimilation. *Computers & Fluids*, 115:201–210, 2015. doi:10.1016/j.compfluid.2015.03.025. (Cited on p. 256)

H. Yao, P. Gouédard, J. A. Collins, J. J. McGuire, and R. D. van der Hilst. Structure of Young East Pacific Rise lithosphere from ambient noise correlation analysis of fundamental- and higher-mode Scholte-Rayleigh waves. *Comptes Rendus Geoscience*, 43:571–583, 2011. (Cited on p. 246)

Y. Ying and F. Zhang. An adaptive covariance relaxation method for ensemble data assimilation. *Quarterly Journal of the Royal Meteorological Society*, 141:2898–2906, 2015. ISSN 1477-870X. doi:10.1002/qj.2576. (Cited on p. 172)

Z. Yong and S. Wu, editors. *State-Space Models. Applications in Economics and Finance*. Springer, 2013. (Cited on p. 264)

M. Zhang and F. Zhang. E4DVar: Coupling an ensemble Kalman filter with four-dimensional variational data assimilation in a limited-area weather prediction model. *Monthly Weather Review*, 140:587–600, 2012. (Cited on p. 205)

R. Zhang, C. Czado, and K. Sigloch. Bayesian spatial modelling for high dimensional seismic inverse problems. *Journal of the Royal Statistical Society: Series* C *(Applied Statistics)*, 65:187–213, 2016. doi:10.1111/rssc.12118. (Cited on p. 246)

X. G. Zheng. An adaptive estimation of forecast error covariance parameters for Kalman filtering data assimilation. *Advances in Atmospheric Sciences*, 26:154–160, 2009. (Cited on p. 172)

Y. Zhu, R. Todling, J. Guo, S. E. Cohn, I. M. Navon, and Y. Yang. The GEOS-3 retrospective data assimilation system: The 6-hour lag case. *Monthly Weather Review*, 131:2129–2150, 2003. (Cited on p. 189)

O. C. Zienkiewicz and R. L. Taylor. *The Finite Element Method*, volume 1*: The Basics*, fifth edition. Butterworth-Heinemann, 2000. (Cited on p. 23)

D. Zigone, Y. Ben-Zion, M. Campillo, and P. Roux. Seismic tomography of the Southern California plate boundary region from noise based Rayleigh and Love Waves. *Pure and Applied Geophysics*, 172:1007–1032, 2015. (Cited on p. 245)

X. Zou, I. M. Navon, and F.-X. Le Dimet. An optimal nudging data assimilation scheme using parameter estimation. *Quarterly Journal of the Royal Meteorological Society*, 118:1163–1186, 1992. (Cited on p. 124)

M. Zupanski. Maximum likelihood ensemble filter: Theoretical aspects. *Monthly Weather Review*, 133:1710–1726, 2005. (Cited on pp. 178, 180, 210)

Index