Energy, water and carbon flux responses to meteorological and edaphic drivers in agricultural ecosystems of Australia and New Zealand

C. Vote[a], J. Cleverly[b], P. Isaac[c], C. Ewenz[d], S. Grover[e], E. van Gorsel[f], B. Teodosio[g], J. Beringer[h], D. Campbell[i], E. Daly[g], D. Eamus[b], J. Hunt[j], P. Grace[k], L. Hutley[l], J. Laubach[j], M. McCaskill[m], I. McHugh[n], D. Rowlings[k], S. Rutledge[i,o], C. Rüdiger[g], L. Schipper[i], I. Schroder[p], P. Ward[q], J. Walker[g] and J. Webb[r].

[a] Graham Centre for Agricultural Innovation, Charles Sturt University, Wagga Wagga, NSW 2678
[b]School of Life Sciences, University of Technology Sydney, Broadway, NSW 2007
[c]OzFlux Central Node, TERN-OzFlux, Melbourne, VIC 3159
[d]Airborne Research Australia, Flinders University, Po Box 335, Salisbury South, SA 5106
[e]AgriBio, Centre for Agribioscience, School of Life Sciences, Bundoora, VIC 3083
[f]Fenner School of Environment and Society, The Australian National University, Canberra, ACT 2601
[g]Department of Civil Engineering, Monash University, Clayton, VIC 3800
[h]The University of Western Australia, School of Agriculture and Environment, Crawley, WA 6020
[i]School of Science and Environmental Research Institute, University of Waikato, Hamilton, New Zealand
[j]Landcare Research, P.O. Box 69040, Lincoln 7640, New Zealand
[k]Institute for Future Environments and Science and Engineering Faculty, Queensland University of Technology, Brisbane, QLD 4000
[l]School of Environment, Research Institute for the Environment and Livelihoods, Charles Darwin University, NT 0909
[m]Department of Economic Development, Jobs, Transport and Resources, Hamilton, VIC 3300
[n]School of Earth, Atmosphere and Environment, Monash University, Clayton, VIC, 3800
[o]National Institute for Public Health and the Environment, Centre for Environmental Quality, PO Box 1, 3720 BA Bilthoven, The Netherlands
[p]International CCS & CO_2 CRC, Resources Division, Geoscience Australia, ACT 2601
[q]CSIRO Agriculture and Food, Private Bag No 5, Wembley, WA 6913
[r]Department of Ecology, Environment and Evolution, La Trobe University, Bundoora VIC 3083
Email: cvote@csu.edu.au

Abstract: Despite occupying one-third of the terrestrial surface and being highly sensitive to changes in hydrology, agricultural ecosystems are under-represented in flux studies of water and carbon cycles across the globe. Australia and New Zealand are no different, where only 16% of OzFlux sites are located in predominately agricultural landscapes. Consequently, the primary objective of this study was to investigate and compare the responses of agricultural fluxes of surface energy (sensible heat flux), water (evapotranspiration, ET) and carbon (net ecosystem exchange, NEE) to eight meteorological and edaphic drivers (net radiation, atmospheric specific humidity, vapour pressure deficit, net radiation, air temperature, ground heat flux, soil temperature and soil water content). Three levels of management intensity were considered, including minimal management (e.g. grazed rangelands); moderate management (e.g. dryland agriculture and pasturelands); and irrigated or other intensively managed agricultural systems (e.g. dense grazing in fertilised and irrigated paddocks). The responses of sensible heat flux, ET and NEE to meteorological and edaphic drivers were investigated on a daily timescale using a novel statistical approach based upon wavelet theory (wavelet-based canonical correlation analysis, wCCA). The approach consisted of (i) wavelet-based principal components analysis (wPCA) to reduce the number of driving variables and to separately identify dependencies amongst fluxes or drivers, followed by (ii) wavelet-based multiple linear regression (wMLR) to infer relationships between drivers and fluxes. We found that irrigation of crops released NEE and ET from dependence upon all meteorological and edaphic drivers, except in extreme conditions such as inundation (rice) or high heat (almonds). By contrast, moderate intensity agriculture and pasture (along with high intensity grazing in the energy-limited environments of NZ) were most closely coupled to these drivers, especially vapour pressure deficit, available energy and air temperature. Low intensity grazed rangelands were most strongly coupled to the large fluctuations in available energy and atmospheric humidity which characterise the summer wet season across northern and much of central Australia. Results from this study provide a consistent, detailed understanding of factors related to optimisation of water use and crop and forage production across a variety of conditions.

Keywords: *Agriculture, water, carbon, eddy covariance, wavelet statistics*