We illustrate this (Fig. 10) by constructing RDMs for one-timestep-ahead linear forecasts of sine waves with additive, uniformly distributed noise, E, of increasing amplitudes $X(t) = \sin(t) + E$. For a pure sine wave there is essentially zero error in a one-day-ahead prediction; the RDM is accordingly a flat line (Fig. 10 *A* and *B*). As the level of noise increases, measurement error increases, but as there is no nonlinearity, no relationship between the residuals and the lagged values of the time series (Fig. 10 *C*–*F*) becomes apparent. In contrast, RDMs constructed on linear forecasts of a nonlinear system contain clear structure. We demonstrate this with the logistic map (in the chaotic regime) (Fig. 10 *G* and *H*). In this case, RDMs return the logistic map itself. Thus, RDMs can not only indicate that a time series is nonlinear, but also give insight into the functional form of that nonlinearity.

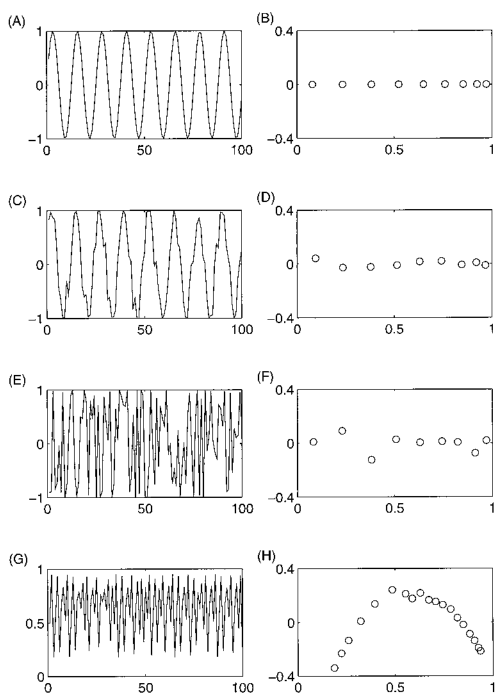

Fig. 10. (*A*) RDM(AR3) for a sine wave with no noise. Error from the one time step linear forecast is very small; the RDM is flat. (*B*) As in panel *A* but with a small amount noise added. The linear forecast has more error, but this error is not systematic; no structure is apparent in the residuals. (*C*) As in panel *B* but with a high noise amplitude. The errors continue to increase, but no structure emerges. (*D*) RDM(AR3) for the logistic map. The RDM returns the original nonlinear system. Bins of 100.

Table 2. Results from applying RDMs to adapt the ECMWF to provide local forecasts

		ECMWF Corrections			
		Mean error		Systematic error	
City name	Bin mean	Original	Corrected	Original	Corrected
Darwin	1006.9	1.38	1.09	1.08	−0.32
	1008.9	1.41	1.05	1.16	−0.11
	1010.1	1.39	1.08	1.10	−0.21
	1011.3	1.69	0.95	1.63	0.19
	1012.5	1.74	0.98	1.64	0.28
Townsville	1006.5	2.30	2.32	−0.83	−0.51
	1010.6	1.87	1.91	−0.47	−0.18
	1012.7	1.78	1.77	−0.57	−0.34
	1014.5	2.15	2.20	0.14	0.51
	1015.8	1.63	1.59	−0.60	−0.19
	1017.5	1.34	1.38	−0.07	0.42
Perth	1007.8	5.95	6.04	−4.98	−4.98
	1011.9	3.62	3.74	−1.01	−1.16
	1014.1	3.37	3.55	−0.07	−0.51
	1015.9	3.42	3.41	0.77	0.21
	1018.0	4.01	3.73	2.03	1.22
	1021.1	4.30	3.62	3.49	2.15
Sydney	1003.4	9.98	7.16	−9.46	−5.20
	1009.2	7.29	5.86	−5.80	−2.28
	1012.8	5.41	4.47	−3.40	−0.14
	1015.7	5.51	4.85	−1.91	0.73
	1018.6	4.22	4.48	0.10	2.16
	1021.1	3.63	3.79	0.90	2.32

Corrections were made out-of-sample; for each point in the series, other points from the same season/year were excluded from the calculation of the RDM and subsequent correction for that point. Improvement is given both in terms of mean error and systematic error, with the latter category as expected showing the greatest improvement in some situations. Both temperate locations show significant improvement at times of extreme pressures—high pressure for Perth and low pressure for Sydney, betraying the geographical component to the bias in the ECMWF. Results are expected to be less consistent in the tropics where the nonlinearity is largely absent; nevertheless, RDMs provide significant improvement at Darwin (but not at Townsville). Improvements in mean error in temperate latitudes exceed 30% in some pressure conditions.

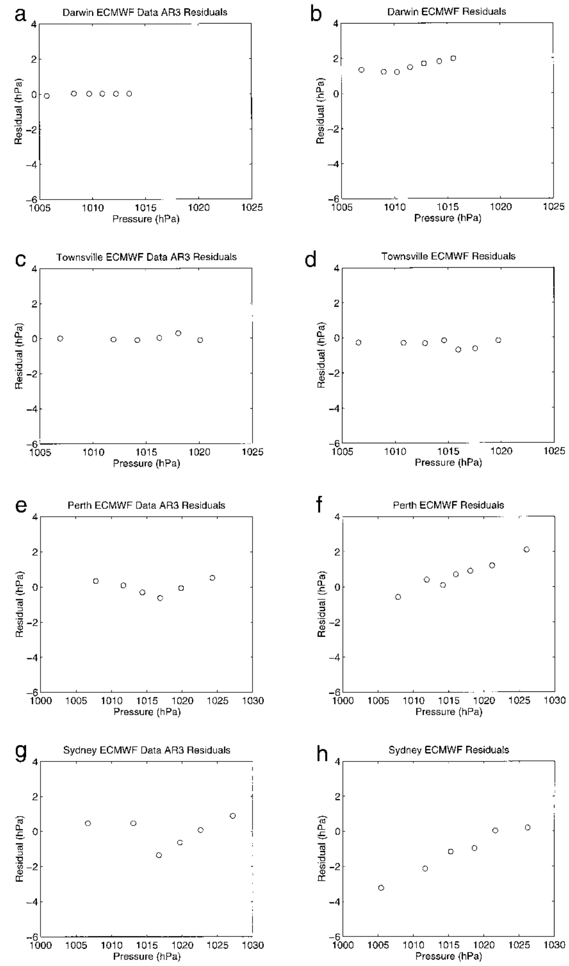

Fig. 11. RDM plots for numerical model forecast data (ECMWF) interpolated to the locations of the four cities in Fig. 3. (*a, c, e*, and *g*) Plot the RDM(AR3)s for this model as in Fig. 3. (*b, d, f*, and *h*) The RDM for the model forecasts where residuals are calculated from the raw observations, and plotted against raw observations [RDM(ECMWF)].