

Wrap up results

June 14, 2018

Highlights

Thank you for your comments! Based on those comments, I made the changes:

- Added the results with 10 clusters in each intervention arm.
- Added more values of missingness ICC: 0, 0.1, 0.3, 0.5, 0.7, 0.8, 0.9

Settings

Outcome model

The outcome Y_{ijl} is generated by:

$$\pi_{ijl} = \text{expit}(1 + 1.36 * i + x_{ijl} + \delta_{ij})$$

1. i is the treatment indicator. $i = 1$ treated; $i = 0$ control
2. x is the covariate. $x \sim N(0, 0.2)$ (The variance is 0.2. I choose a relatively small variance since I want to avoid non-convergence. However, this generated small differences between CRA and adjusted CRA.)
3. The variance of δ_{ij} changed based on different ICC (the ICC for the datasets):
 - ICC=0.05, $\delta_{ij} \sim N(0, 0.173)$ (the variance is 0.173)
 - ICC=0.1, $\delta_{ij} \sim N(0, 0.366)$ (the variance is 0.366)
 - ICC=0.2, $\delta_{ij} \sim N(0, 0.823)$ (the variance is 0.823)
4. Number of clusters: **10, or 50** clusters in each intervention arm
5. Cluster size: the cluster size is from a Poisson distribution, which is not fixed. cluster size $\sim POI(50)$

Missingness generation model

$$\text{logit}(R_{ijl} = 1 | Y_{ij}, X_{ij}) = \text{intercept} + i + X_{ijl} + \sigma_{ij}$$

1. The intercept is varied to make sure the missing percentage is around 30%
2. i is the treatment indicator. $i=1$ treated; $i=0$ control
3. x is the covariate. $x \sim N(0, 0.2)$ (The variance is 0.2)
4. The variance of σ_{ij} represents the cluster effects in missingness. It changed based on different missingness ICC:
 - $\sigma_{ij} = 0$, the missing ICC=0, there is no cluster effects
 - ICC=0.1, $\sigma_{ij} \sim N(0, 0.366)$ (the variance is 0.366)
 - ICC=0.3, $\sigma_{ij} \sim N(0, 1.410)$ (the variance is 1.410)
 - ICC=0.5, $\sigma_{ij} \sim N(0, 3.291)$ (the variance is 3.291)
 - ICC=0.7, $\sigma_{ij} \sim N(0, 7.678)$ (the variance is 7.678)
 - ICC=0.8, $\sigma_{ij} \sim N(0, 13.163)$ (the variance is 13.163)

- ICC=0.9, $\sigma_{ij} \sim N(0, 29.616)$ (the variance is 29.616)
5. 1000 replicates for each scenario

Missingness handling methods

1. Calculation of true value:

- Fit the GEE with the formula: $Y \sim \text{intervention arm}$ (without covariates). Estimate the coefficient of intervention arm.
- With full datasets without missing values
- Repeat for 1000 times and calculate the mean value.

2. UCRA: unadjusted complete record analysis

- Fit the GEE with the formula: $Y \sim \text{intervention arm}$ (without covariates). Estimate the coefficient of intervention arm.
- Delete the records with missing values in Y
- Repeat for 1000 times.

3. CRA: adjusted complete record analysis

- Fit the GEE with formula: $Y \sim \text{intervention-arm} + X$ (with covariates). Estimate the coefficient of intervention arm.
- Delete the records with missing values in Y
- Repeat for 1000 times.

4. IPW: inverse probability weighting

- Calculate the weights by fitting GLM: $\text{glm}(y \sim \text{arm} + x)$
- Fit the GEE with the formula: $Y \sim \text{intervention arm}$ (without covariates) with corresponding weights. Estimate the coefficient of intervention arm.
- Repeat for 1000 times.

5. IPWC: inverse probability weighting with cluster effects

- Calculate the weights by fitting generalized linear mixed effect model: $\text{glmer}(y \sim \text{arm} + x + \text{cluster effect})$
- Fit the GEE with the formula: $Y \sim \text{intervention arm}$ (without covariates) with corresponding weights. Estimate the coefficient of intervention arm.
- Repeat for 1000 times.

6. MMI: multilevel multiple imputation

- consider cluster effects in the imputation

Results 1

More number of clusters : I added the results for 10 clusters in each intervention arm in the tables. The results are showing below.

Table 1.1: The Bias of each method with different ICCs, missingness ICCs, and an independent working correlation matrix

k	ICC	ICCM	UCRA	CRA	IPW	IPWC	MMI
10	0.05	0.0	0.031	0.041	0.000	0.001	0.008
		0.1	0.029	0.039	0.000	0.009	0.004
		0.3	0.017	0.041	0.006	0.024	0.007
		0.5	0.014	0.038	0.002	0.040	0.003
	0.10	0.0	0.033	0.037	0.003	0.003	0.006
		0.1	0.029	0.035	0.003	0.006	0.004
		0.3	0.015	0.040	0.005	0.027	0.008
		0.5	0.011	0.038	0.002	0.050	0.004
	0.20	0.0	0.033	0.030	0.005	0.006	0.006
		0.1	0.026	0.033	0.002	0.009	0.004
		0.3	0.013	0.037	0.005	0.041	0.005
		0.5	0.009	0.036	0.003	0.071	0.001
50	0.05	0.0	0.033	0.036	0.006	0.006	0.008
		0.1	0.030	0.035	0.004	0.003	0.005
		0.3	0.020	0.037	0.001	0.004	0.006
		0.5	0.012	0.039	0.001	0.011	0.006
	0.1	0.0	0.033	0.033	0.009	0.009	0.007
		0.1	0.030	0.032	0.006	0.005	0.004
		0.3	0.020	0.034	0.003	0.005	0.005
		0.5	0.013	0.035	0.001	0.014	0.005
	0.2	0.0	0.033	0.027	0.011	0.011	0.005
		0.1	0.028	0.028	0.008	0.007	0.004
		0.3	0.020	0.028	0.005	0.007	0.004
		0.5	0.013	0.030	0.003	0.017	0.005

- k: number of clusters in each arm
- ICC: dataset ICC
- ICCM: missingness ICC
- UCRA: unadjusted complete record analysis
- CRA: adjusted record analysis
- IPW: inverse probability weighting
- IPWC: inverse probability weighting with cluster effect
- MMI: multilevel multiple imputation
- BIAS = Absolute value of (estimate-true value)

When k=10, the results have the same pattern with k=50. However, the biases are larger when missingness ICC get bigger. When the missingness ICC < 0.5, IPW, IPWC, and MMI have better effects than CRA and UCRA. UCRA is more close to 0 than CRA, although the differences are not big. The differences may become obvious with a larger variance of x. I chose a small value since I want to avoid non-convergence.

Table 1.2: The Bias of each method with different ICCs, missingness ICCs, and an exchangeable working correlation matrix

k	ICC	ICCM	UCRA	CRA	IPW	IPWC	MMI
10	0.05	0.0	0.031	0.040	0.028	0.028	0.009
		0.1	0.030	0.037	0.024	0.029	0.004
		0.3	0.018	0.041	0.024	0.045	0.007
		0.5	0.014	0.039	0.015	0.060	0.003
	0.1	0.0	0.033	0.034	0.051	0.051	0.007
		0.1	0.032	0.031	0.044	0.052	0.003
		0.3	0.019	0.037	0.040	0.066	0.007
		0.5	0.014	0.037	0.026	0.097	0.003
	0.2	0.0	0.032	0.021	0.085	0.084	0.007
		0.1	0.030	0.023	0.077	0.081	0.004
		0.3	0.021	0.027	0.064	0.101	0.005
		0.5	0.017	0.028	0.044	0.118	0.001
50	0.05	0.0	0.033	0.036	0.027	0.027	0.008
		0.1	0.031	0.034	0.023	0.025	0.005
		0.3	0.023	0.035	0.016	0.020	0.006
		0.5	0.015	0.037	0.012	0.021	0.006
	0.1	0.0	0.033	0.030	0.055	0.055	0.007
		0.1	0.032	0.029	0.047	0.0	0.004
		0.3	0.025	0.030	0.033	0.038	0.005
		0.5	0.017	0.032	0.021	0.034	0.005
	0.2	0.0	0.032	0.019	0.106	0.106	0.005
		0.1	0.030	0.020	0.095	0.090	0.004
		0.3	0.025	0.021	0.069	0.073	0.004
		0.5	0.017	0.023	0.048	0.064	0.004

The results are very similar to the independent working correlation matrix

Table 1.3: The Standard Deviation of each method with different ICCs , missingness ICCs, and the independent working correlation matrix

k	ICC	ICCM	UCRA	CRA	IPW	IPWC	MMI
10	0.05	0.0	0.268	0.274	0.276	0.276	0.393
		0.1	0.267	0.272	0.274	0.283	0.395
		0.3	0.268	0.273	0.274	0.301	0.406
		0.5	0.270	0.275	0.274	0.313	0.419
	0.1	0.0	0.314	0.320	0.320	0.321	0.434
		0.1	0.315	0.321	0.320	0.333	0.437
		0.3	0.318	0.324	0.322	0.357	0.4
		0.5	0.321	0.327	0.324	0.373	0.464

k	ICC	ICCM	UCRA	CRA	IPW	IPWC	MMI
50	0.2	0.0	0.392	0.400	0.395	0.395	0.502
		0.1	0.398	0.406	0.401	0.417	0.512
		0.3	0.403	0.411	0.405	0.451	0.526
		0.5	0.408	0.416	0.409	0.472	0.542
	0.05	0.0	0.125	0.128	0.129	0.129	0.176
		0.1	0.126	0.129	0.129	0.141	0.176
		0.3	0.127	0.130	0.129	0.171	0.180
		0.5	0.129	0.131	0.130	0.198	0.185
	0.1	0.0	0.148	0.151	0.151	0.151	0.197
		0.1	0.149	0.152	0.151	0.165	0.199
		0.3	0.151	0.154	0.152	0.202	0.202
		0.5	0.153	0.156	0.154	0.235	0.209
	0.2	0.0	0.186	0.190	0.187	0.187	0.233
		0.1	0.188	0.192	0.189	0.207	0.236
		0.3	0.192	0.196	0.192	0.254	0.241
		0.5	0.196	0.200	0.195	0.297	0.249

As ICC and ICCM get larger, the SD also get larger. The IPWC and MMI have larger SD than other methods. And the k=10 scenarios have larger SD than k=50 scenarios

Table 1.4: The Standard Deviation of each method with different ICCs, missingness ICCs, and an exchangeable working correlation matrix

k	ICC	ICCM	UCRA	CRA	IPW	IPWC	MMI
10	0.05	0.0	0.268	0.274	0.286	0.286	0.393
		0.1	0.266	0.272	0.282	0.291	0.395
		0.3	0.268	0.273	0.280	0.313	0.406
		0.5	0.269	0.275	0.279	0.336	0.419
	0.1	0.0	0.313	0.322	0.341	0.342	0.434
		0.1	0.313	0.323	0.337	0.349	0.437
		0.3	0.316	0.325	0.335	0.384	0.4
		0.5	0.318	0.327	0.332	0.405	0.463
	0.2	0.0	0.390	0.404	0.442	0.442	0.502
		0.1	0.395	0.4	0.438	0.465	0.511
		0.3	0.399	0.413	0.431	0.513	0.526
		0.5	0.402	0.416	0.425	0.529	0.542
	0.05	0.0	0.125	0.128	0.134	0.134	0.175
		0.1	0.126	0.129	0.133	0.145	0.176
		0.3	0.127	0.129	0.132	0.177	0.180
		0.5	0.128	0.131	0.131	0.209	0.184
	0.1	0.0	0.147	0.151	0.160	0.160	0.196
		0.1	0.148	0.152	0.158	0.174	0.198
		0.3	0.149	0.153	0.156	0.217	0.202

k	ICC	ICCM	UCRA	CRA	IPW	IPWC	MMI
		0.5	0.151	0.155	0.156	0.257	0.208
	0.2	0.0	0.185	0.190	0.207	0.207	0.232
		0.1	0.186	0.191	0.204	0.230	0.235
		0.3	0.188	0.193	0.200	0.292	0.241
		0.5	0.190	0.195	0.197	0.346	0.248

It has similar results as the independent working correlation matrix. However, the SDs are larger than the independent scenario.

Table 1.5: The MCSD of each method with different ICCs , missingness ICCs, and an independent working correlation matrix

k	ICC	ICCM	UCRA	CRA	IPW	IPWC	MMI
10	0.05	0.0	0.291	0.298	0.299	0.299	0.294
		0.1	0.283	0.291	0.289	0.316	0.287
		0.3	0.292	0.301	0.296	0.388	0.297
		0.5	0.291	0.299	0.295	0.457	0.296
	0.1	0.0	0.344	0.353	0.348	0.348	0.348
		0.1	0.337	0.345	0.343	0.376	0.337
		0.3	0.345	0.354	0.348	0.465	0.347
		0.5	0.349	0.358	0.352	0.549	0.349
	0.2	0.0	0.431	0.441	0.432	0.433	0.435
		0.1	0.436	0.447	0.438	0.482	0.435
		0.3	0.448	0.459	0.446	0.599	0.440
		0.5	0.455	0.466	0.454	0.7	0.442
	0.05	0.0	0.125	0.127	0.128	0.128	0.126
		0.1	0.131	0.134	0.135	0.1	0.131
		0.3	0.135	0.137	0.137	0.190	0.135
		0.5	0.136	0.138	0.138	0.227	0.135
	0.1	0.0	0.147	0.1	0.149	0.149	0.148
		0.1	0.153	0.156	0.156	0.173	0.152
		0.3	0.157	0.161	0.159	0.221	0.156
		0.5	0.159	0.162	0.160	0.266	0.156
	0.2	0.0	0.184	0.187	0.183	0.183	0.185
		0.1	0.193	0.197	0.193	0.216	0.191
		0.3	0.198	0.203	0.198	0.281	0.194
		0.5	0.203	0.207	0.202	0.342	0.196

Do not have big differences with the SD results.

Table 1.6: The MCSD of each method with different ICCs, missingness ICCs, and an exchangeable working correlation matrix

k	ICC	ICCM	UCRA	CRA	IPW	IPWC	MMI
10	0.05	0.0	0.290	0.297	0.309	0.309	0.293
		0.1	0.283	0.293	0.302	0.328	0.287
		0.3	0.292	0.303	0.308	0.403	0.297
		0.5	0.290	0.300	0.303	0.485	0.296
	0.1	0.0	0.342	0.352	0.370	0.370	0.346
		0.1	0.336	0.349	0.367	0.401	0.336
		0.3	0.342	0.355	0.365	0.505	0.346
		0.5	0.345	0.357	0.360	0.587	0.348
	0.2	0.0	0.428	0.442	0.479	0.479	0.433
		0.1	0.432	0.448	0.489	0.531	0.434
		0.3	0.437	0.454	0.479	0.660	0.438
		0.5	0.439	0.457	0.468	0.771	0.441
50	0.05	0.0	0.124	0.126	0.133	0.133	0.126
		0.1	0.130	0.132	0.138	0.154	0.130
		0.3	0.133	0.136	0.140	0.197	0.134
		0.5	0.134	0.137	0.139	0.241	0.134
	0.1	0.0	0.145	0.148	0.159	0.159	0.146
		0.1	0.1	0.154	0.163	0.183	0.151
		0.3	0.154	0.158	0.163	0.239	0.154
		0.5	0.155	0.159	0.162	0.290	0.155
	0.2	0.0	0.181	0.186	0.207	0.207	0.183
		0.1	0.187	0.193	0.212	0.241	0.189
		0.3	0.191	0.197	0.209	0.323	0.192
		0.5	0.194	0.200	0.206	0.402	0.194

Do not have big differences with the SD results.

Table 1.7: The Coverage of each method with different ICCs, missingness ICCs, and an independent working correlation matrix

k	ICC	ICCM	UCRA	CRA	IPW	IPWC	MMI
10	0.05	0.0	0.898	0.917	0.915	0.915	0.991
		0.1	0.918	0.922	0.928	0.898	0.991
		0.3	0.9	0.909	0.916	0.857	0.984
		0.5	0.917	0.918	0.915	0.776	0.990
	0.1	0.0	0.9	0.916	0.913	0.911	0.982
		0.1	0.906	0.913	0.915	0.887	0.987
		0.3	0.914	0.913	0.913	0.839	0.983
		0.5	0.914	0.909	0.915	0.764	0.986
	0.2	0.0	0.913	0.912	0.916	0.917	0.971
		0.1	0.904	0.904	0.909	0.885	0.975
		0.3	0.903	0.906	0.911	0.841	0.973
		0.5	0.902	0.907	0.906	0.752	0.978

k	ICC	ICCM	UCRA	CRA	IPW	IPWC	MMI
50	0.05	0.0	0.934	0.936	0.949	0.949	0.992
		0.1	0.935	0.933	0.944	0.930	0.988
		0.3	0.930	0.938	0.944	0.915	0.989
		0.5	0.935	0.928	0.941	0.901	0.992
	0.1	0.0	0.938	0.944	0.944	0.945	0.988
		0.1	0.935	0.939	0.937	0.942	0.986
		0.3	0.932	0.943	0.9	0.917	0.992
		0.5	0.934	0.938	0.945	0.906	0.990
	0.2	0.0	0.943	0.953	0.947	0.947	0.984
		0.1	0.934	0.952	0.944	0.936	0.979
		0.3	0.942	0.940	0.948	0.922	0.989
		0.5	0.942	0.938	0.941	0.905	0.986

- with small ICCM, the IPW and IPWC have good coverage rates.
- MMI gets over-coverage. (since it has a larger SD?)
- When ICCM is big (ICCM=0.5), the IPW with k=10 meets the non-convergence problem and gets bad coverage, while the IPW with k=50 has acceptable results I think. (acceptable or not?)

Table 1.8: The Coverage of each method with different ICCs , missingness ICCs, and an exchangeable working correlation matrix

k	ICC	ICCM	UCRA	CRA	IPW	IPWC	MMI
10	0.05	0.0	0.899	0.919	0.908	0.909	0.990
		0.1	0.921	0.919	0.915	0.890	0.992
		0.3	0.907	0.9	0.906	0.786	0.983
		0.5	0.918	0.918	0.917	0.678	0.990
	0.1	0.0	0.915	0.914	0.907	0.908	0.983
		0.1	0.911	0.9	0.900	0.858	0.987
		0.3	0.911	0.9	0.908	0.812	0.983
		0.5	0.918	0.913	0.912	0.697	0.990
	0.2	0.0	0.9	0.920	0.869	0.869	0.970
		0.1	0.908	0.917	0.855	0.828	0.973
		0.3	0.916	0.913	0.880	0.786	0.976
		0.5	0.908	0.902	0.893	0.695	0.978
50	0.05	0.0	0.937	0.940	0.951	0.949	0.992
		0.1	0.935	0.934	0.938	0.927	0.989
		0.3	0.930	0.942	0.939	0.909	0.988
		0.5	0.933	0.932	0.940	0.894	0.990
	0.1	0.0	0.939	0.952	0.943	0.943	0.988
		0.1	0.939	0.945	0.945	0.935	0.989
		0.3	0.939	0.947	0.939	0.905	0.992
		0.5	0.942	0.947	0.941	0.875	0.990

k	ICC	ICCM	UCRA	CRA	IPW	IPWC	MMI
	0.2	0.0	0.946	0.953	0.924	0.923	0.983
		0.1	0.942	0.951	0.930	0.914	0.982
		0.3	0.946	0.948	0.928	0.891	0.988
		0.5	0.941	0.948	0.938	0.858	0.988

The results are similar to independent working correlation matrix

Table 1.9: The non-convergence of each method with different ICCs , missingness ICCs, and an independent working correlation matrix

k	ICC	ICCM	UCRA	CRA	IPW	IPWC	MMI
10	0.05	0.0	0	0	0	0	0
		0.1	0	0	0	0	0
		0.3	0	0	0	0	0
		0.5	0	0	0	18	0
	0.1	0.0	0	0	0	0	0
		0.1	0	0	0	0	0
		0.3	0	0	0	0	0
		0.5	0	0	0	24	0
	0.2	0.0	0	0	0	0	0
		0.1	0	0	0	0	0
		0.3	0	0	0	0	0
		0.5	0	0	0	25	0
50	0.05	0.0	0	0	0	0	0
		0.1	0	0	0	0	0
		0.3	0	0	0	0	0
		0.5	0	0	0	0	0
	0.1	0.0	0	0	0	0	0
		0.1	0	0	0	0	0
		0.3	0	0	0	0	0
		0.5	0	0	0	0	0
	0.2	0.0	0	0	0	0	0
		0.1	0	0	0	0	0
		0.3	0	0	0	0	0
		0.5	0	0	0	0	0

With independent working correlation matrix, most of the scenairos do not have non-convergence problem. The only non-convergences happened on scenarios with k=10 and ICCM=0.5.

Table 1.10: The non-convergence of each method with different ICCs, missingness ICCs, and an exchangeable working correlation matrix

k	ICC	ICCM	UCRA	CRA	IPW	IPWC	MMI
10	0.05	0.0	0	0	7	7	0
		0.1	0	0	5	13	0
		0.3	0	0	4	72	0
		0.5	0	0	1	151	0
	0.1	0.0	0	0	16	16	0
		0.1	0	0	13	31	0
		0.3	0	0	6	47	0
		0.5	0	0	5	117	0
	0.2	0.0	0	0	58	57	0
		0.1	0	0	57	69	0
		0.3	0	0	38	63	0
		0.5	0	1	24	109	0
	0.05	0.0	0	0	0	0	0
		0.1	0	0	0	0	0
		0.3	0	0	0	6	0
		0.5	0	0	0		0
	0.1	0.0	0	0	1	1	0
		0.1	0	0	0	1	0
		0.3	0	0	0	18	0
		0.5	0	0	0	26	0
	0.2	0.0	0	0	3	3	0
		0.1	0	0	1	12	0
		0.3	0	0	2	23	0
		0.5	0	0	0	43	0

With exchangeable working correlation matrix, some of the IPW methods have non-convergence problem, especially the k=10, ICCM=0.5. The k=50 scenarios are better than the k=10 scenarios.

Results 2

Here are also more results for scenario k=50. I tried more missingness ICC values: 0, 0.1, 0.3, 0.5, 0.7, 0.8, 0.9 (previous we tried ICC = 0, 0.1, 0.3, 0.8, which followed Caille's chosen values)

Table 2.1: The Bias of each method with different ICCs and missingness ICCs, an independent working correlation matrix

ICC	ICCM	UCRA	CRA	IPW	IPWC	MMI
0.05	0.0	0.033	0.036	0.006	0.006	0.008
	0.1	0.030	0.035	0.004	0.003	0.005
	0.3	0.020	0.037	0.001	0.004	0.006
	0.5	0.012	0.039	0.001	0.011	0.006
	0.7	0.006	0.038	0.001	0.027	0.005
	0.8	0.004	0.038	0.001	0.093	0.002
	0.9	0.001	0.037	0.001	0.336	0.001

ICC	ICCM	UCRA	CRA	IPW	IPWC	MMI
0.1	0.0	0.033	0.033	0.009	0.009	0.007
	0.1	0.030	0.032	0.006	0.005	0.004
	0.3	0.020	0.034	0.003	0.005	0.005
	0.5	0.013	0.035	0.001	0.014	0.005
	0.7	0.007	0.035	0.001	0.032	0.002
	0.8	0.004	0.036	0.000	0.105	0.002
	0.9	0.002	0.035	0.000	0.395	0.001
0.2	0.0	0.033	0.027	0.011	0.011	0.005
	0.1	0.028	0.028	0.008	0.007	0.004
	0.3	0.020	0.028	0.005	0.007	0.004
	0.5	0.013	0.030	0.003	0.017	0.005
	0.7	0.008	0.029	0.003	0.040	0.001
	0.8	0.005	0.030	0.002	0.123	0.002
	0.9	0.004	0.028	0.003	0.370	0.002

- ICC: dataset ICC
- ICCM: missingness ICC
- UCRA: unadjusted complete record analysis
- CRA: adjusted record analysis
- IPW: inverse probability weighting
- IPWC: inverse probability weighting with cluster effect
- MMI: multilevel multiple imputation
- BIAS = Absolute value of (estimate-true value)

IPW, IPWC, and MMI have better effects than CRA and UCRA when missingness ICC is not big (ICCM < 0.5). UCRA is more close to 0 than CRA, although the differences are not big. The differences may become obvious with a larger variance of x.

Table 2.2: The Bias of each method with different ICCs and missingness ICCs, an exchangeable working correlation matrix

ICC	ICCM	UCRA	CRA	IPW	IPWC	MMI
0.05	0.0	0.033	0.036	0.027	0.027	0.008
	0.1	0.031	0.034	0.023	0.025	0.005
	0.3	0.023	0.035	0.016	0.020	0.006
	0.5	0.015	0.037	0.012	0.021	0.006
	0.7	0.008	0.037	0.006	0.034	0.004
	0.8	0.006	0.036	0.003	0.105	0.002
	0.9	0.002	0.036	0.001	0.364	0.001
0.1	0.0	0.033	0.030	0.055	0.055	0.007
	0.1	0.032	0.029	0.047	0.050	0.004
	0.3	0.025	0.030	0.033	0.038	0.005
	0.5	0.017	0.032	0.021	0.034	0.005
	0.7	0.011	0.030	0.010	0.048	0.001

ICC	ICCM	UCRA	CRA	IPW	IPWC	MMI
	0.8	0.007	0.031	0.005	0.129	0.002
	0.9	0.004	0.031	0.001	0.418	0.002
	0.0	0.032	0.019	0.106	0.106	0.005
0.2	0.1	0.030	0.020	0.095	0.090	0.004
	0.3	0.025	0.021	0.069	0.073	0.004
	0.5	0.017	0.023	0.048	0.064	0.004
	0.7	0.013	0.020	0.023	0.079	0.000
	0.8	0.009	0.019	0.011	0.165	0.001
	0.9	0.006	0.017	0.002	0.324	0.002

The results are very similar to the independent working correlation matrix

Table 2.3: The Standard Deviation of each method with different ICCs and missingness ICCs, the independent working correlation matrix

ICC	ICCM	UCRA	CRA	IPW	IPWC	MMI
0.05	0.0	0.125	0.128	0.129	0.129	0.176
	0.1	0.126	0.129	0.129	0.141	0.176
	0.3	0.127	0.130	0.129	0.171	0.180
	0.5	0.129	0.131	0.130	0.198	0.185
	0.7	0.130	0.133	0.131	0.212	0.189
	0.8	0.131	0.133	0.131	0.217	0.192
	0.9	0.132	0.135	0.132	0.217	0.197
0.1	0.0	0.148	0.151	0.151	0.151	0.197
	0.1	0.149	0.152	0.151	0.165	0.199
	0.3	0.151	0.154	0.152	0.202	0.202
	0.5	0.153	0.156	0.154	0.235	0.209
	0.7	0.156	0.159	0.156	0.251	0.215
	0.8	0.157	0.161	0.157	0.255	0.219
	0.9	0.160	0.163	0.160	0.239	0.226
0.2	0.0	0.186	0.190	0.187	0.187	0.233
	0.1	0.188	0.192	0.189	0.207	0.236
	0.3	0.192	0.196	0.192	0.254	0.241
	0.5	0.196	0.200	0.195	0.297	0.249
	0.7	0.200	0.204	0.199	0.316	0.258
	0.8	0.203	0.207	0.202	0.318	0.265
	0.9	0.207	0.211	0.206	0.256	0.276

As ICC and ICCM get larger, the SD also get larger. The IPWC and MMI have larger SD than other methods.

Table 2.4: The Standard Deviation of each method with different ICCs and missingness ICCs, an exchangeable working correlation matrix

ICC	ICCM	UCRA	CRA	IPW	IPWC	MMI
0.05	0.0	0.125	0.128	0.134	0.134	0.175
	0.1	0.126	0.129	0.133	0.145	0.176
	0.3	0.127	0.129	0.132	0.177	0.180
	0.5	0.128	0.131	0.131	0.209	0.184
	0.7	0.129	0.132	0.131	0.225	0.189
	0.8	0.130	0.133	0.131	0.232	0.191
	0.9	0.131	0.134	0.132	0.212	0.197
0.1	0.0	0.147	0.151	0.160	0.160	0.196
	0.1	0.148	0.152	0.158	0.174	0.198
	0.3	0.149	0.153	0.156	0.217	0.202
	0.5	0.151	0.155	0.156	0.257	0.208
	0.7	0.153	0.157	0.156	0.278	0.214
	0.8	0.155	0.159	0.156	0.283	0.218
	0.9	0.157	0.162	0.158	0.239	0.225
0.2	0.0	0.185	0.190	0.207	0.207	0.232
	0.1	0.186	0.191	0.204	0.230	0.235
	0.3	0.188	0.193	0.200	0.292	0.241
	0.5	0.190	0.195	0.197	0.346	0.248
	0.7	0.193	0.199	0.197	0.371	0.257
	0.8	0.196	0.202	0.198	0.373	0.264
	0.9	0.200	0.206	0.201	0.304	0.275

Similar with indepentent working corelation matrix's results

Table 2.5: The MCSD of each method with different ICCs and missingness ICCs, an independent working correlation matrix

ICC	ICCM	UCRA	CRA	IPW	IPWC	MMI
0.05	0.0	0.125	0.127	0.128	0.128	0.126
	0.1	0.131	0.134	0.135	0.150	0.131
	0.3	0.135	0.137	0.137	0.190	0.135
	0.5	0.136	0.138	0.138	0.227	0.135
	0.7	0.138	0.140	0.139	0.238	0.137
	0.8	0.139	0.142	0.140	0.237	0.138
	0.9	0.141	0.143	0.141	NA	0.141
0.1	0.0	0.147	0.150	0.149	0.149	0.148
	0.1	0.153	0.156	0.156	0.173	0.152
	0.3	0.157	0.161	0.159	0.221	0.156
	0.5	0.159	0.162	0.160	0.266	0.156
	0.7	0.162	0.165	0.162	0.287	0.158
	0.8	0.164	0.168	0.164	0.280	0.161
	0.9	0.167	0.170	0.167	0.414	0.167
0.2	0.0	0.184	0.187	0.183	0.183	0.185
	0.1	0.193	0.197	0.193	0.216	0.191
	0.3	0.198	0.203	0.198	0.281	0.194
	0.5	0.203	0.207	0.202	0.342	0.196

ICC	ICCM	UCRA	CRA	IPW	IPWC	MMI
	0.7	0.206	0.211	0.206	0.367	0.197
	0.8	0.210	0.215	0.209	0.352	0.201
	0.9	0.214	0.218	0.214	0.141	0.208

Do not have big differences with the SD results.

Table 2.6: The MCSD of each method with different ICCs and missingness ICCs, an exchangeable working correlation matrix

ICC	ICCM	UCRA	CRA	IPW	IPWC	MMI
0.05	0.0	0.124	0.126	0.133	0.133	0.126
	0.1	0.130	0.132	0.138	0.154	0.130
	0.3	0.133	0.136	0.140	0.197	0.134
	0.5	0.134	0.137	0.139	0.241	0.134
	0.7	0.136	0.139	0.139	0.253	0.137
	0.8	0.138	0.141	0.139	0.254	0.137
	0.9	0.140	0.142	0.141	NA	0.140
0.1	0.0	0.145	0.148	0.159	0.159	0.146
	0.1	0.150	0.154	0.163	0.183	0.151
	0.3	0.154	0.158	0.163	0.239	0.154
	0.5	0.155	0.159	0.162	0.290	0.155
	0.7	0.157	0.161	0.161	0.318	0.157
	0.8	0.160	0.164	0.162	0.309	0.160
	0.9	0.165	0.169	0.166	0.441	0.165
0.2	0.0	0.181	0.186	0.207	0.207	0.183
	0.1	0.187	0.193	0.212	0.241	0.189
	0.3	0.191	0.197	0.209	0.323	0.192
	0.5	0.194	0.200	0.206	0.402	0.194
	0.7	0.196	0.202	0.203	0.429	0.195
	0.8	0.199	0.206	0.203	0.409	0.199
	0.9	0.207	0.213	0.209	0.031	0.207

Do not have big differences with the SD results.

Table 2.7: The Coverage of each method with different ICCs and missingness ICCs, an independent working correlation matrix

ICC	ICCM	UCRA	CRA	IPW	IPWC	MMI
0.05	0.0	0.934	0.936	0.949	0.949	0.992
	0.1	0.935	0.933	0.944	0.930	0.988
	0.3	0.930	0.938	0.944	0.915	0.989
	0.5	0.935	0.928	0.941	0.901	0.992
	0.7	0.932	0.916	0.944	0.790	0.994
	0.8	0.925	0.927	0.931	0.235	0.992
	0.9	0.933	0.921	0.931	0.001	0.994

ICC	ICCM	UCRA	CRA	IPW	IPWC	MMI
0.1	0.0	0.938	0.944	0.944	0.945	0.988
	0.1	0.935	0.939	0.937	0.942	0.986
	0.3	0.932	0.943	0.950	0.917	0.992
	0.5	0.934	0.938	0.945	0.906	0.990
	0.7	0.936	0.932	0.932	0.772	0.990
	0.8	0.933	0.926	0.930	0.241	0.992
	0.9	0.935	0.932	0.936	0.001	0.991
0.2	0.0	0.943	0.953	0.947	0.947	0.984
	0.1	0.934	0.952	0.944	0.936	0.979
	0.3	0.942	0.940	0.948	0.922	0.989
	0.5	0.942	0.938	0.941	0.905	0.986
	0.7	0.942	0.941	0.939	0.764	0.992
	0.8	0.940	0.938	0.940	0.267	0.990
	0.9	0.937	0.938	0.938	0.002	0.987

- with small ICCM, the IPW and IPWC have good coverage rates.
- MMI gets over-coverage. (since it has a larger SD?)
- When ICCM is big (ICCM > 0.5) the IPW meets the non-convergence problem and gets bad coverage.

Table 8: The Coverage of each method with different ICCs and missingness ICCs, an exchangeable working correlation matrix

ICC	ICCM	UCRA	CRA	IPW	IPWC	MMI
0.05	0.0	0.937	0.940	0.951	0.949	0.992
	0.1	0.935	0.934	0.938	0.927	0.989
	0.3	0.930	0.942	0.939	0.909	0.988
	0.5	0.933	0.932	0.940	0.894	0.990
	0.7	0.940	0.932	0.946	0.786	0.995
	0.8	0.935	0.927	0.937	0.234	0.992
	0.9	0.933	0.926	0.936	0.001	0.992
0.1	0.0	0.939	0.952	0.943	0.943	0.988
	0.1	0.939	0.945	0.945	0.935	0.989
	0.3	0.939	0.947	0.939	0.905	0.992
	0.5	0.942	0.947	0.941	0.875	0.990
	0.7	0.939	0.946	0.940	0.749	0.990
	0.8	0.940	0.935	0.944	0.235	0.994
	0.9	0.938	0.936	0.935	0.001	0.992
0.2	0.0	0.946	0.953	0.924	0.923	0.983
	0.1	0.942	0.951	0.930	0.914	0.982
	0.3	0.946	0.948	0.928	0.891	0.988
	0.5	0.941	0.948	0.938	0.858	0.988
	0.7	0.947	0.945	0.941	0.747	0.992
	0.8	0.937	0.945	0.940	0.260	0.990
	0.9	0.942	0.947	0.944	0.002	0.989

The results are similar to independent working correlation matrix

Table 9: The non-convergence of each method with different ICCs and missingness ICCs, an independent working correlation matrix

ICC	ICCM	UCRA	CRA	IPW	IPWC	MMI
0.05	0	0	0	0	0	0
	0.1	0	0	0	0	0
	0.3	0	0	0	0	0
	0.5	0	0	0	0	0
	0.7	0	0	0	129	0
	0.8	0	0	0	731	0
	0.9	0	0	0	999	0
0.1	0	0	0	0	0	0
	0.1	0	0	0	0	0
	0.3	0	0	0	0	0
	0.5	0	0	0	0	0
	0.7	0	0	0	141	0
	0.8	0	0	0	730	0
	0.9	0	0	0	998	0
0.2	0	0	0	0	0	0
	0.1	0	0	0	0	0
	0.3	0	0	0	0	0
	0.5	0	0	0	0	0
	0.7	0	0	0	138	0
	0.8	0	0	0	697	0
	0.9	0	0	0	998	0

Table 10: The non-convergence of each method with different ICCs and missingness ICCs, an exchangeable working correlation matrix

ICC	ICCM	UCRA	CRA	IPW	IPWC	MMI
0.05	0	0	0	0	0	0
	0.1	0	0	0	0	0
	0.3	0	0	0	6	0
	0.5	0	0	0	10	0
	0.7	0	0	0	133	0
	0.8	0	0	0	732	0
	0.9	0	0	0	999	0
0.1	0	0	0	1	1	0
	0.1	0	0	0	1	0
	0.3	0	0	0	18	0
	0.5	0	0	0	26	0
	0.7	0	0	0	162	0
	0.8	0	0	0	734	0
	0.9	0	0	0	998	0

ICC	ICCM	UCRA	CRA	IPW	IPWC	MMI
0.2	0	0	0	3	3	0
	0.1	0	0	1	12	0
	0.3	0	0	2	23	0
	0.5	0	0	0	43	0
	0.7	0	0	0	164	0
	0.8	0	0	0	708	0
	0.9	0	0	0	998	0

Summary

The observed problem:

- mmi always over-coverage.
- package CRTgeeDR, not work well when the data has a large ICC (from previous results)
- package geopack does not work well when the data has a large missingness ICC, i.e. $ICC > 0.5$ in the results.