Online Appendix "Granular mortality modeling with temperature and epidemic shocks: a three-state regime-switching approach"

A Baseline model: calibrated parameters

Figure caption. The NUTS 2 region-specific parameters related to each of the six age groups ($\mathcal{X} = \{65\text{-}69, 70\text{-}74, 75\text{-}79, 80\text{-}84, 85\text{-}89, 90+\}$) as estimated by the baseline mortality model. Each figure below represents a different age group.

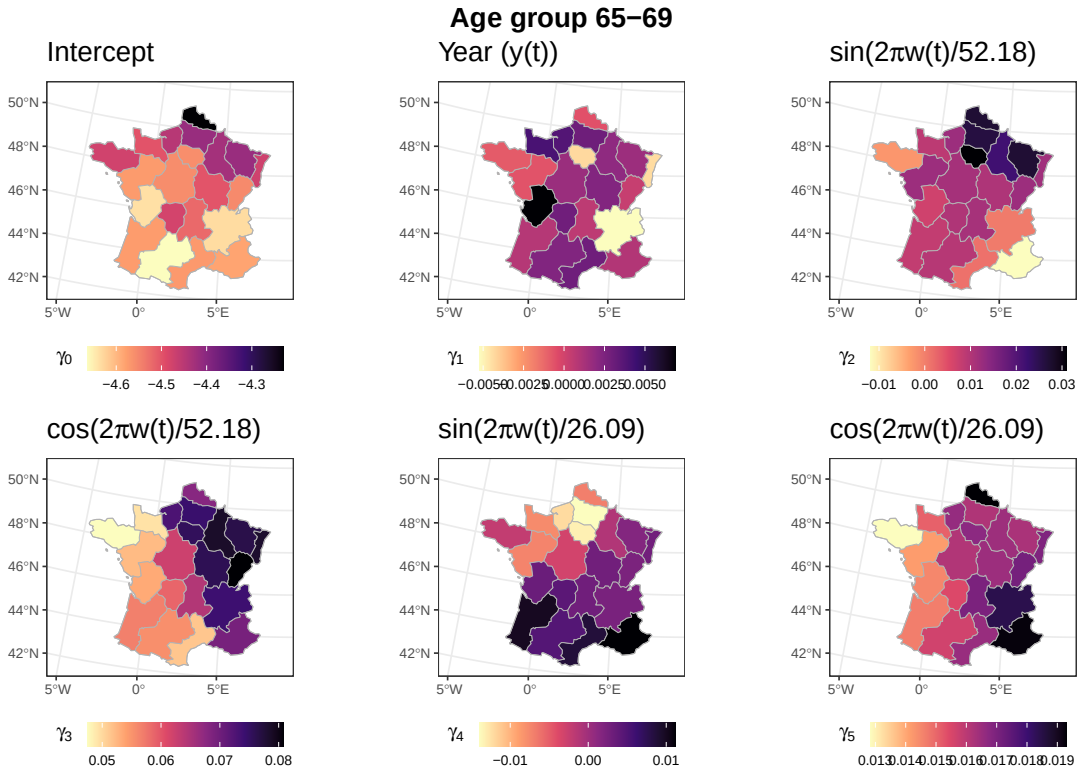

Figure A.1: Age group 65-69.

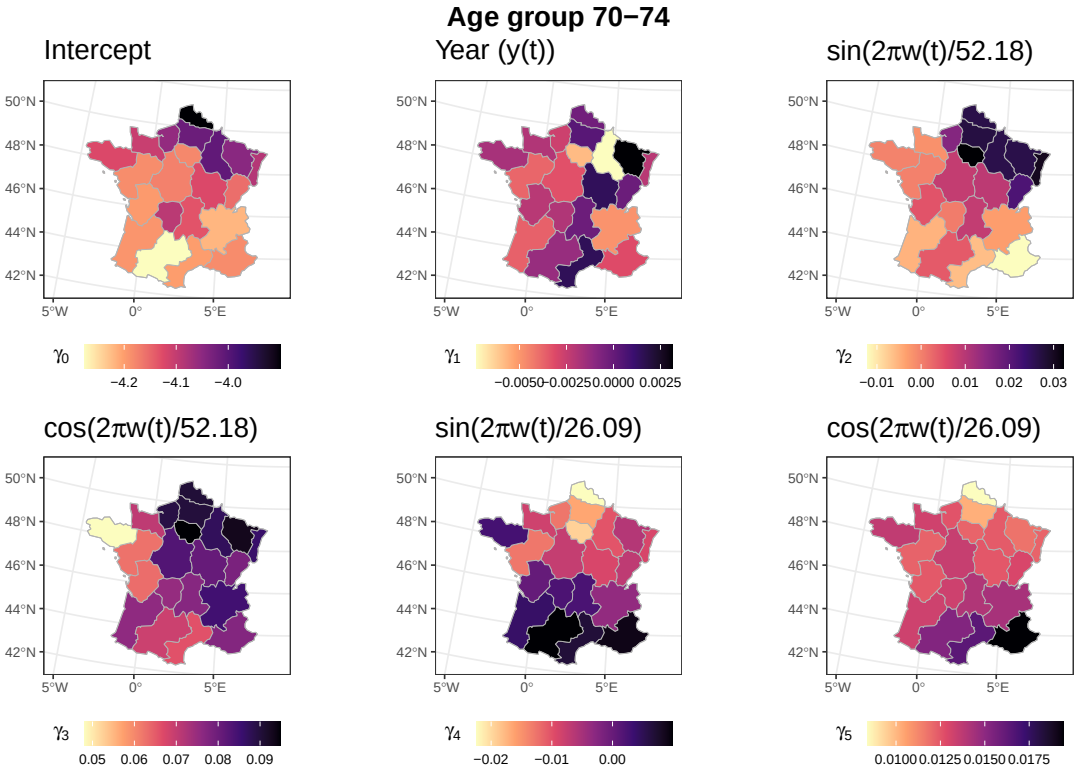

Figure A.2: Age group 70-74.

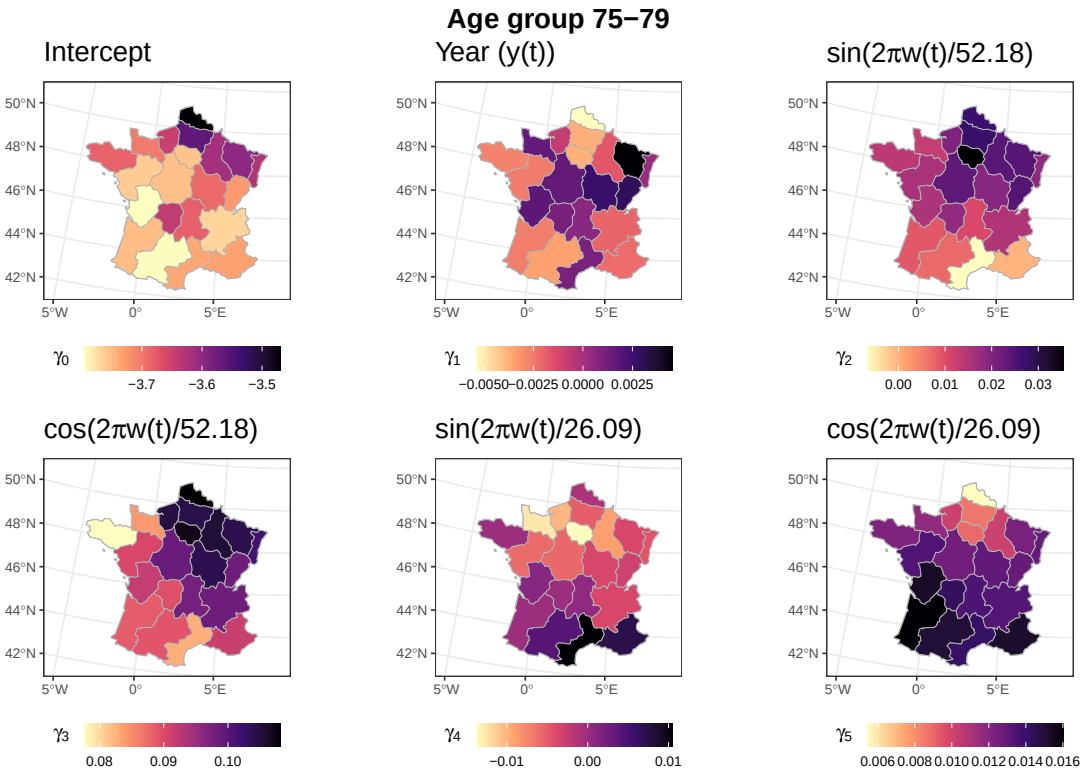

Figure A.3: Age group 75-79.

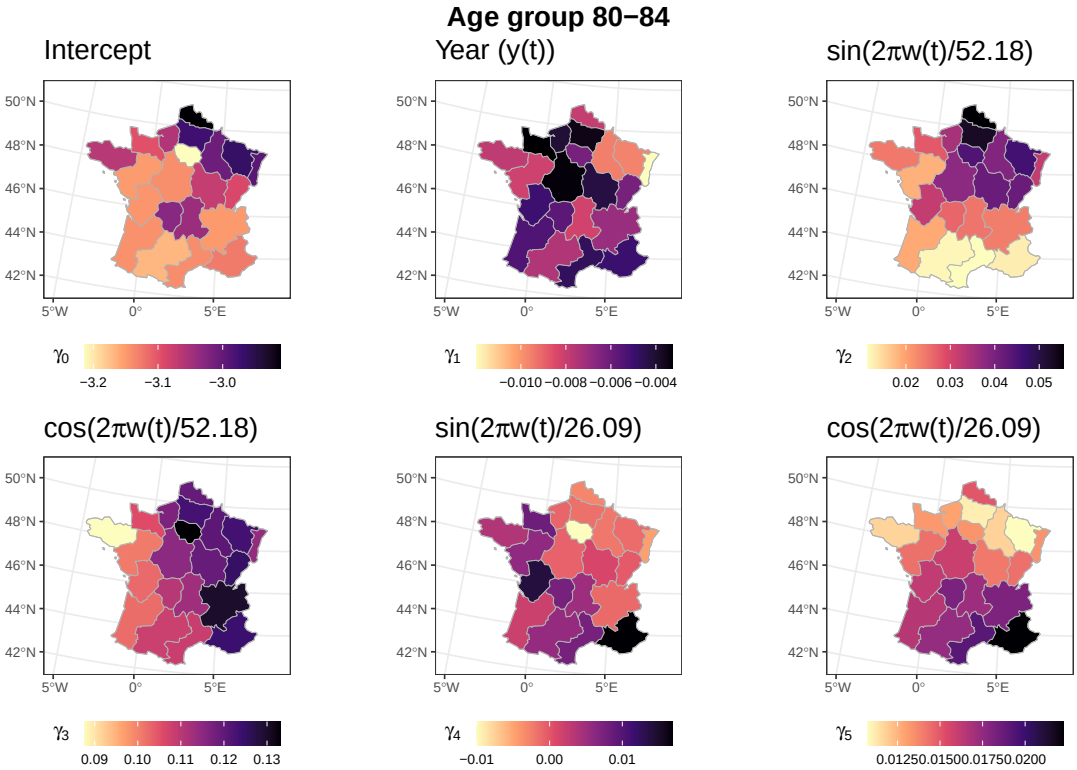

Figure A.4: Age group 80-84.

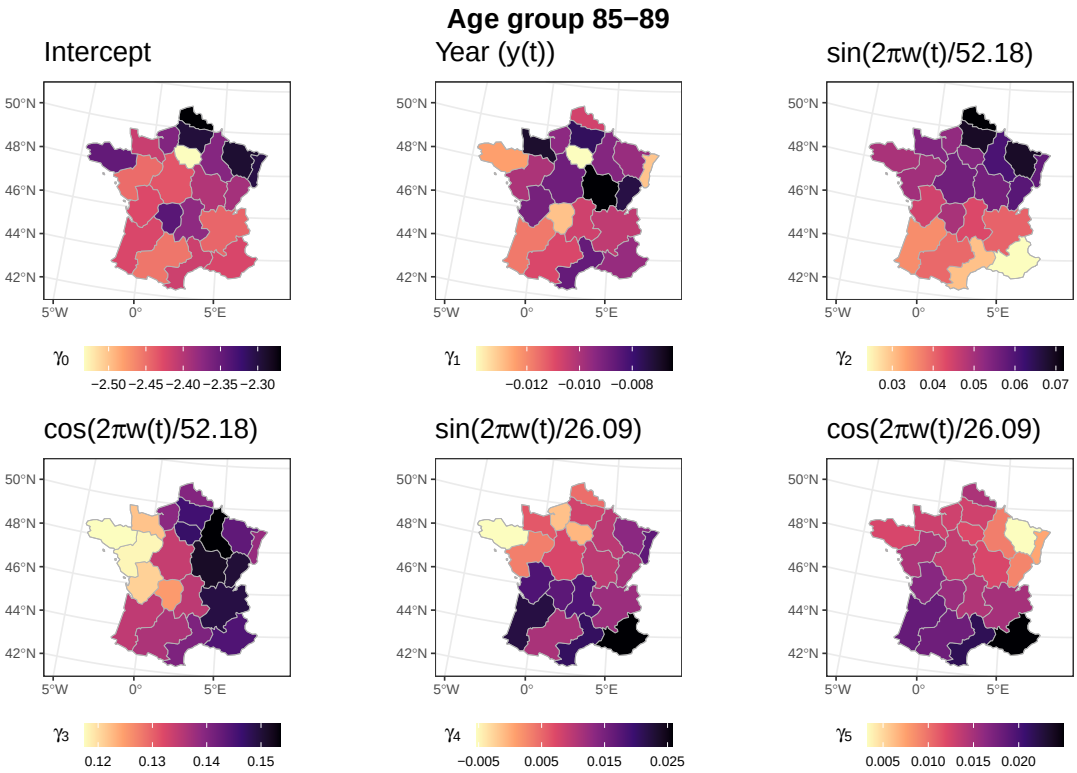

Figure A.5: Age group 85-89.

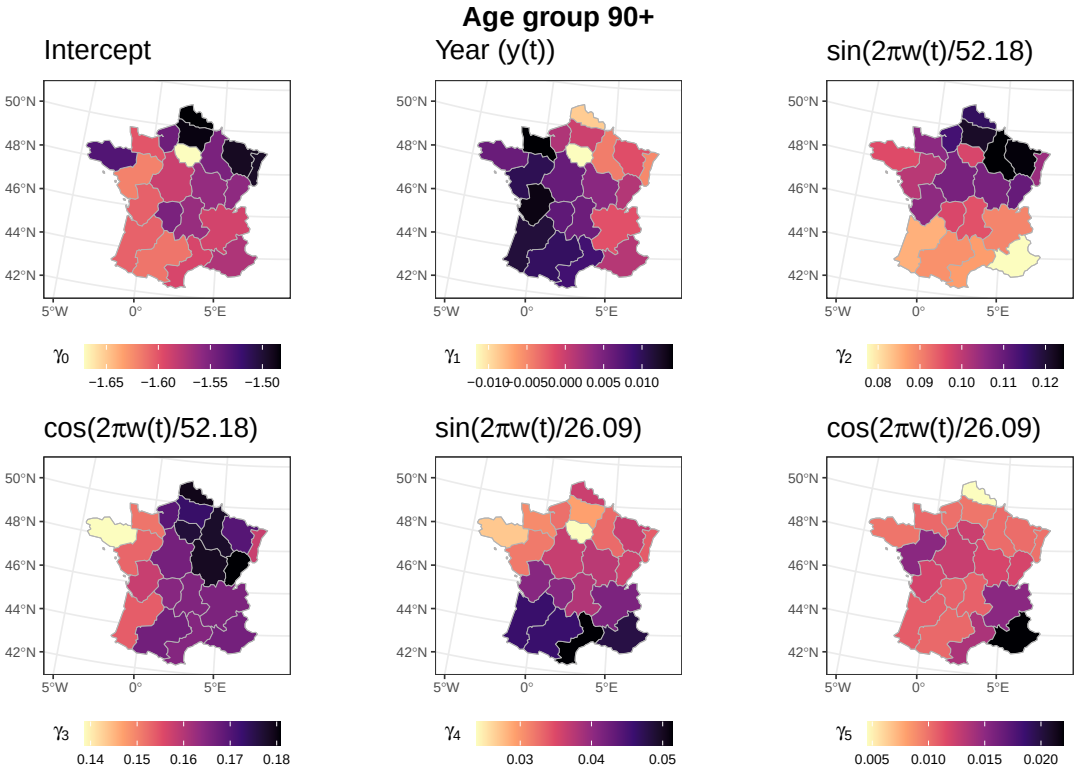

Figure A.6: Age group 90+.

B Best-estimate in-sample model fit

Figure caption. The grey line represents the observed death counts from the first ISO week of the year 2013 till the 26th ISO week of the year 2024. The red line visualizes the estimated baseline number of deaths, while the blue line visualizes the best-estimate prediction of the death counts resulting from the regime-switching model. At the bottom, we show the BE regime-switching trajectory. We show the results for the age groups 65-69, 70-74, 75-79 (top panels), and 80-84, 85-89, 90+ (bottom panels). Each figure corresponds to a different French NUTS 2 region.

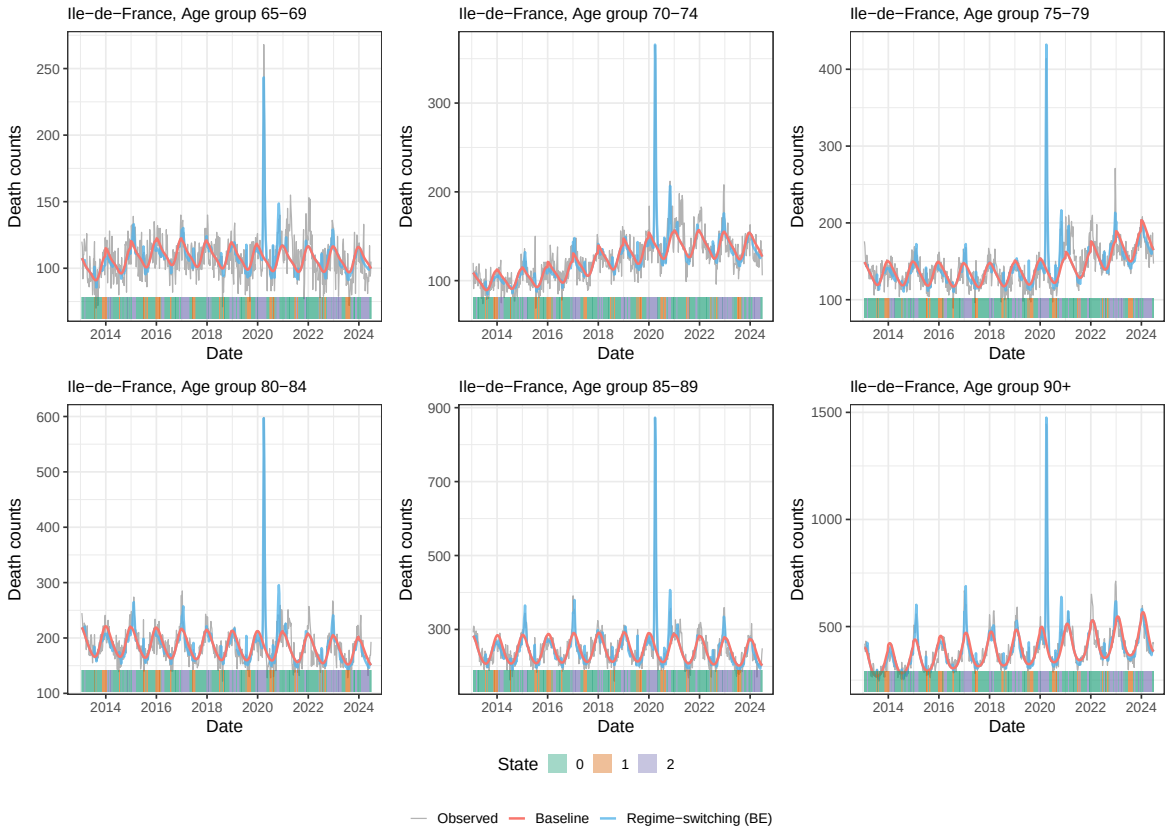

Figure B.1: Ile-de-France (FR10).

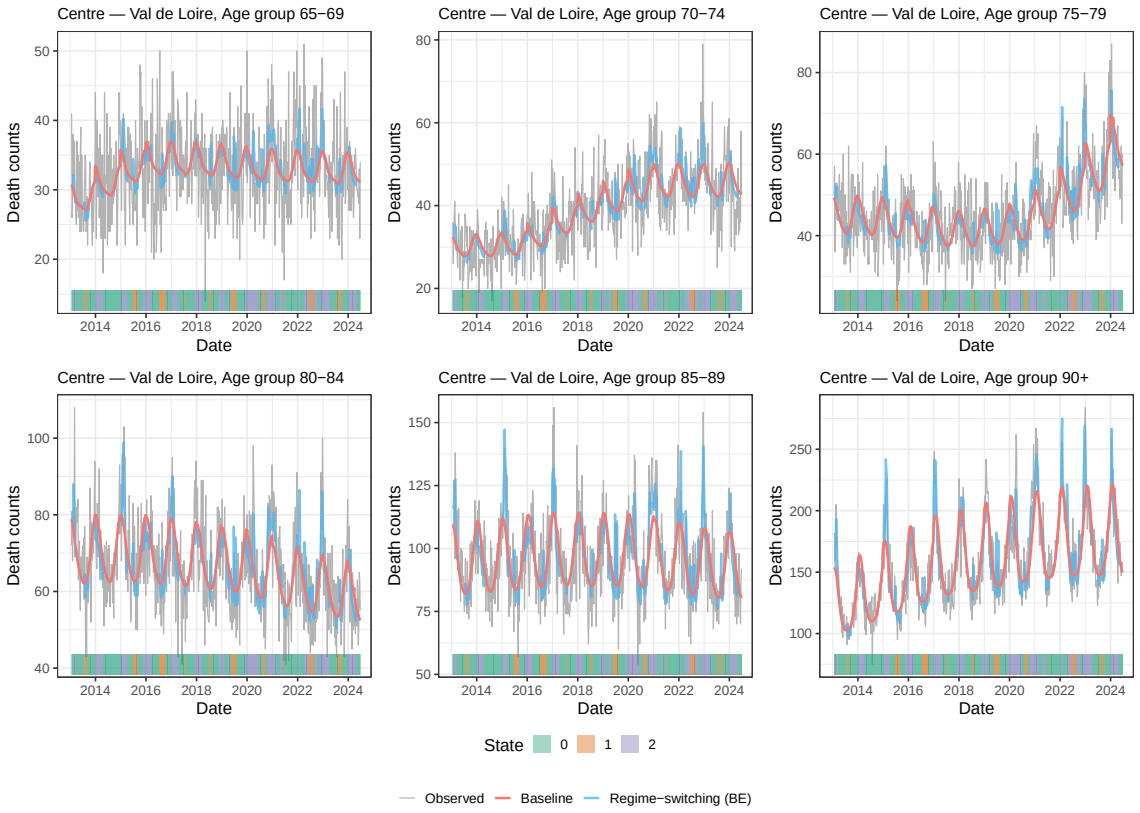

Figure B.2: Centre-Val de Loire (FRB0).

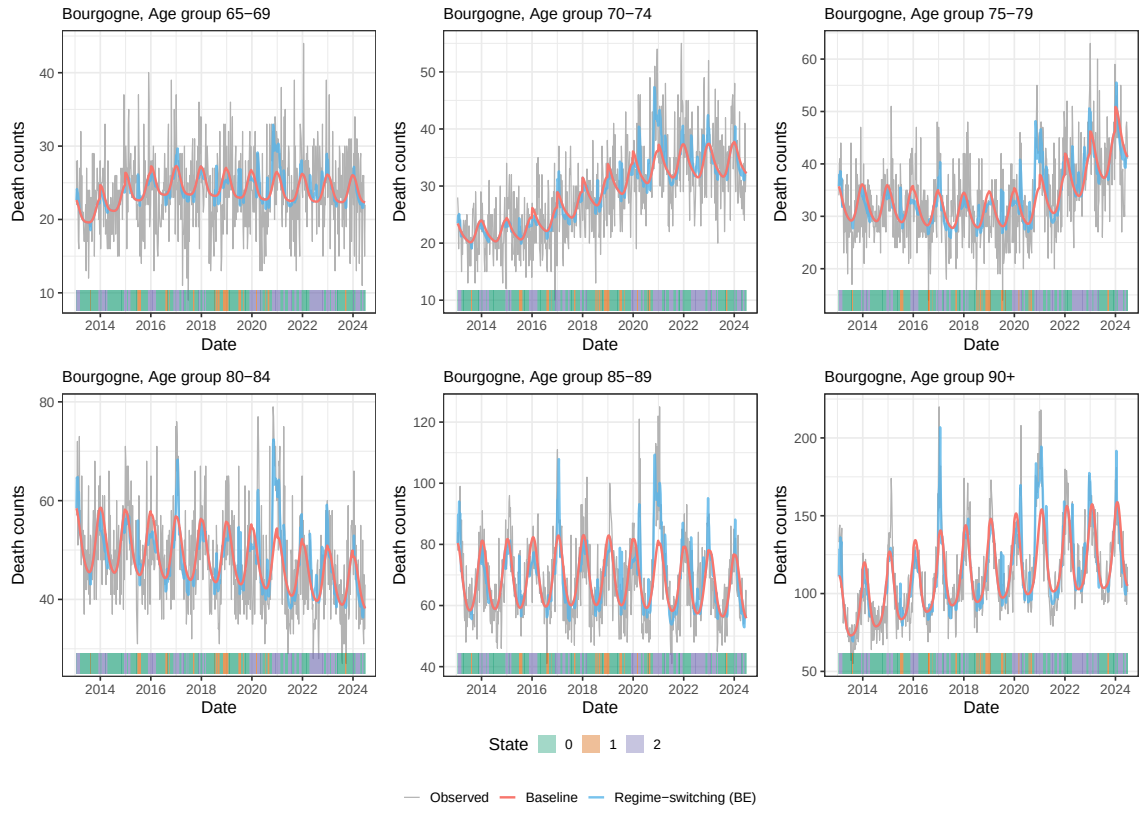

Figure B.3: Bourgogne (FRC1).

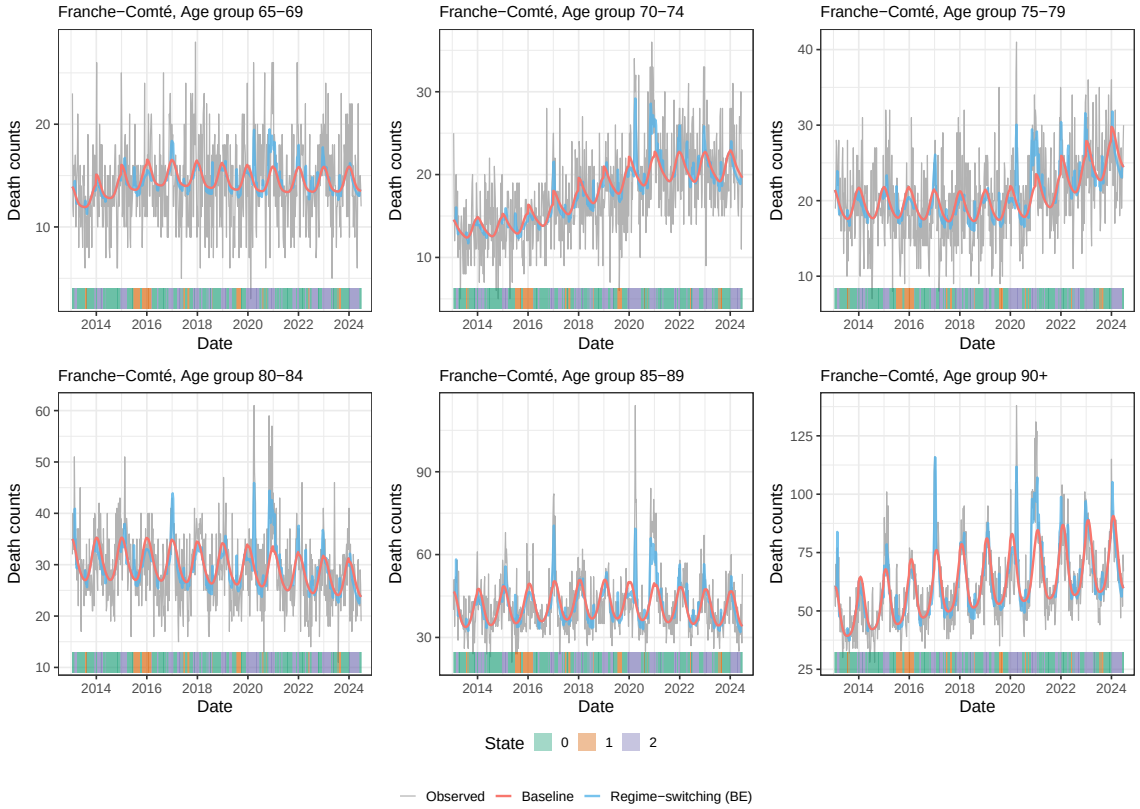

Figure B.4: Franche-Comté (FRC2).

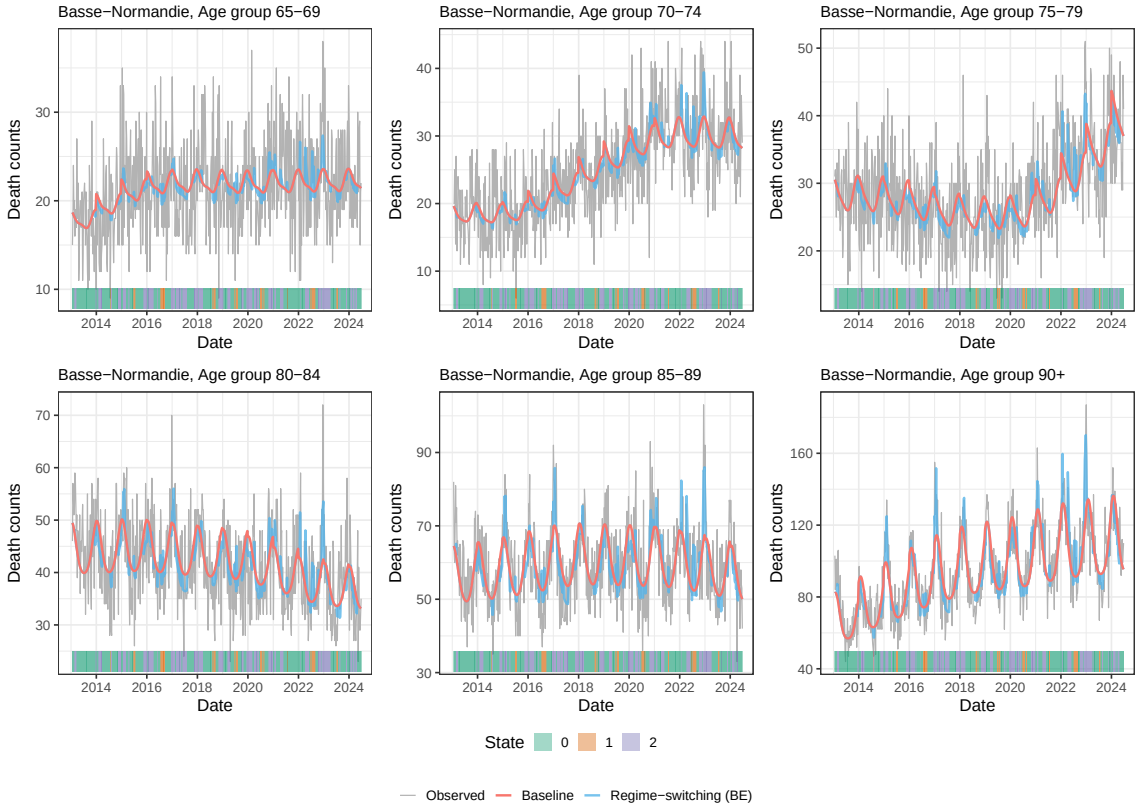

Figure B.5: Basse-Normandie (FRD1).

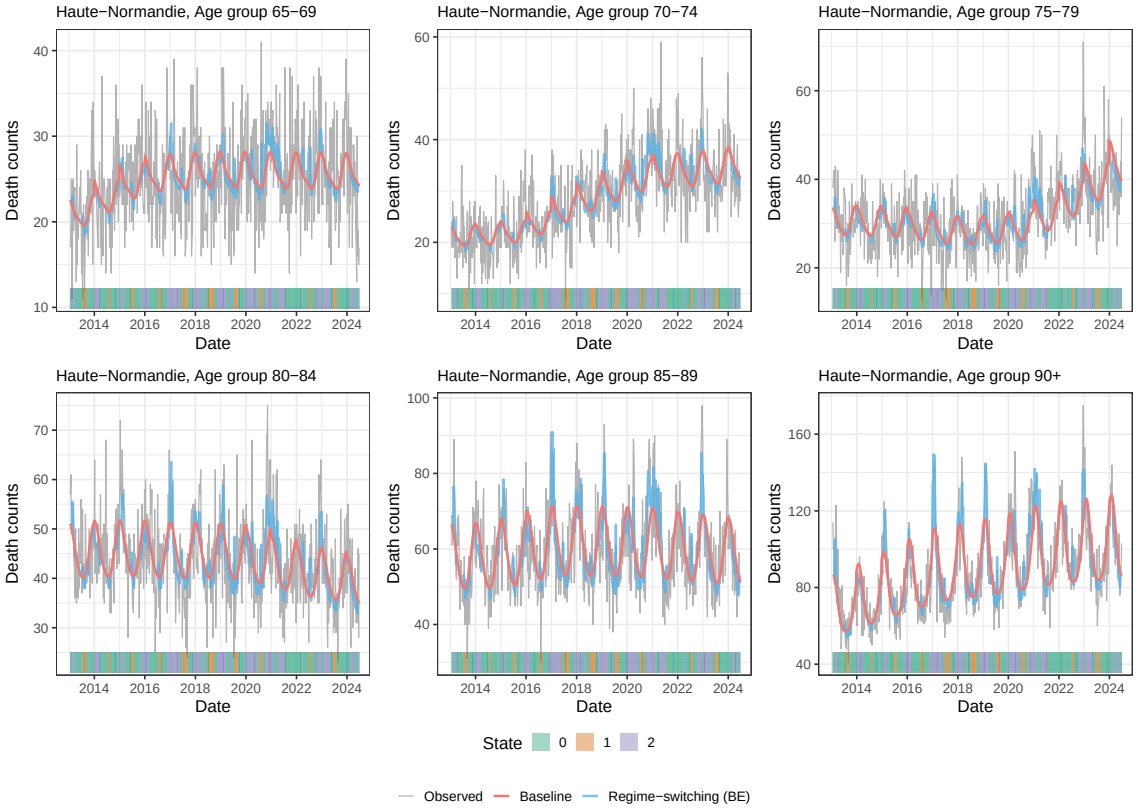

Figure B.6: Haute-Normandie (FRD2).

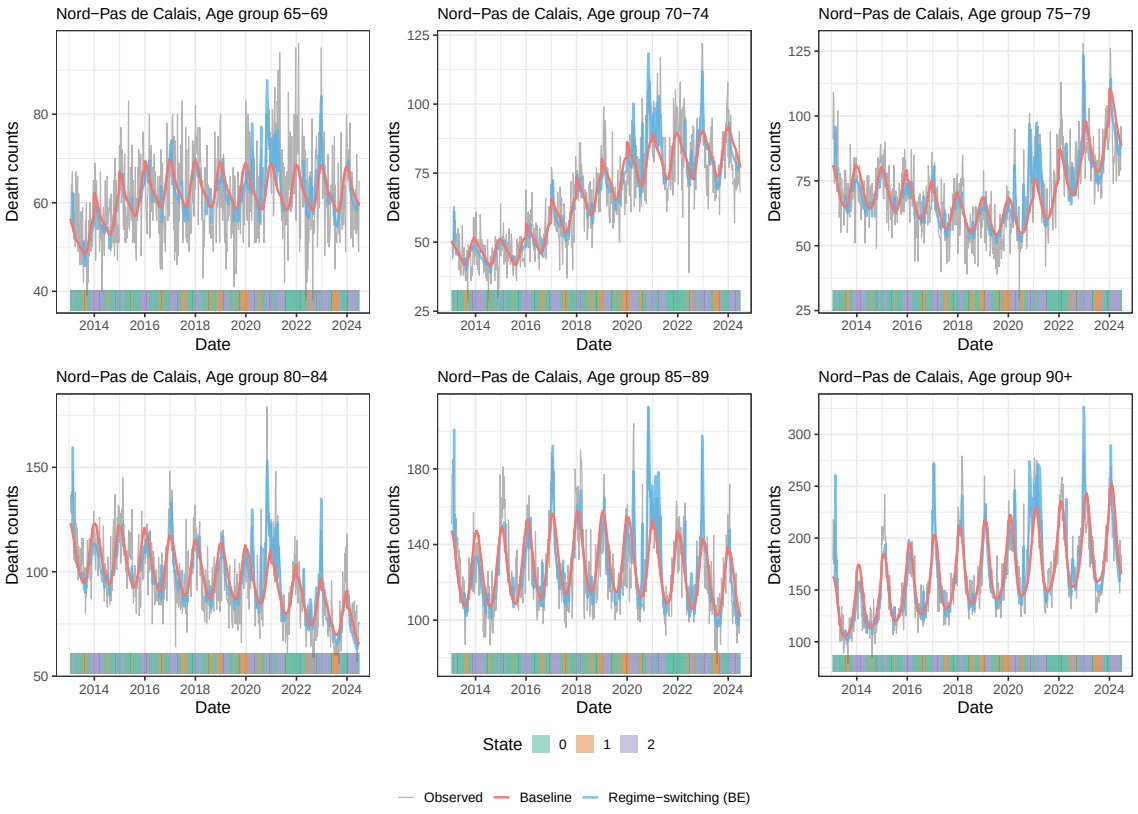

Figure B.7: Nord-Pas de Calais (FRE1).

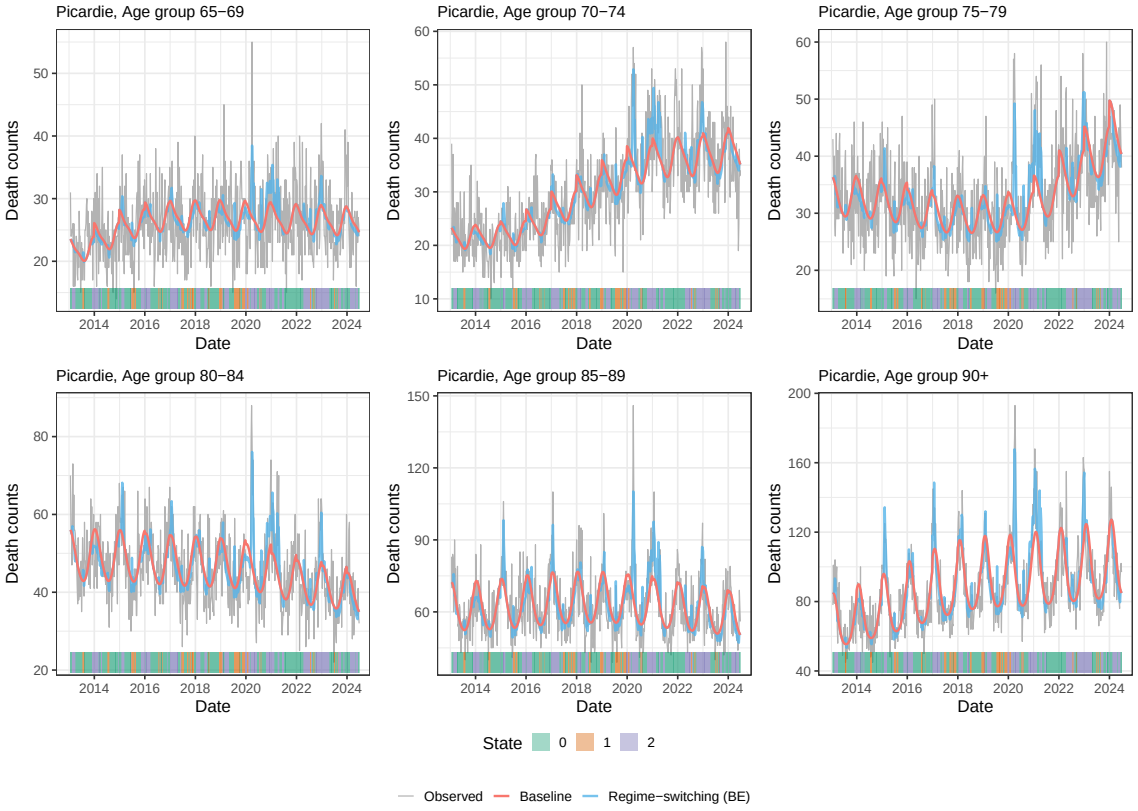

Figure B.8: Picardie (FRE2).

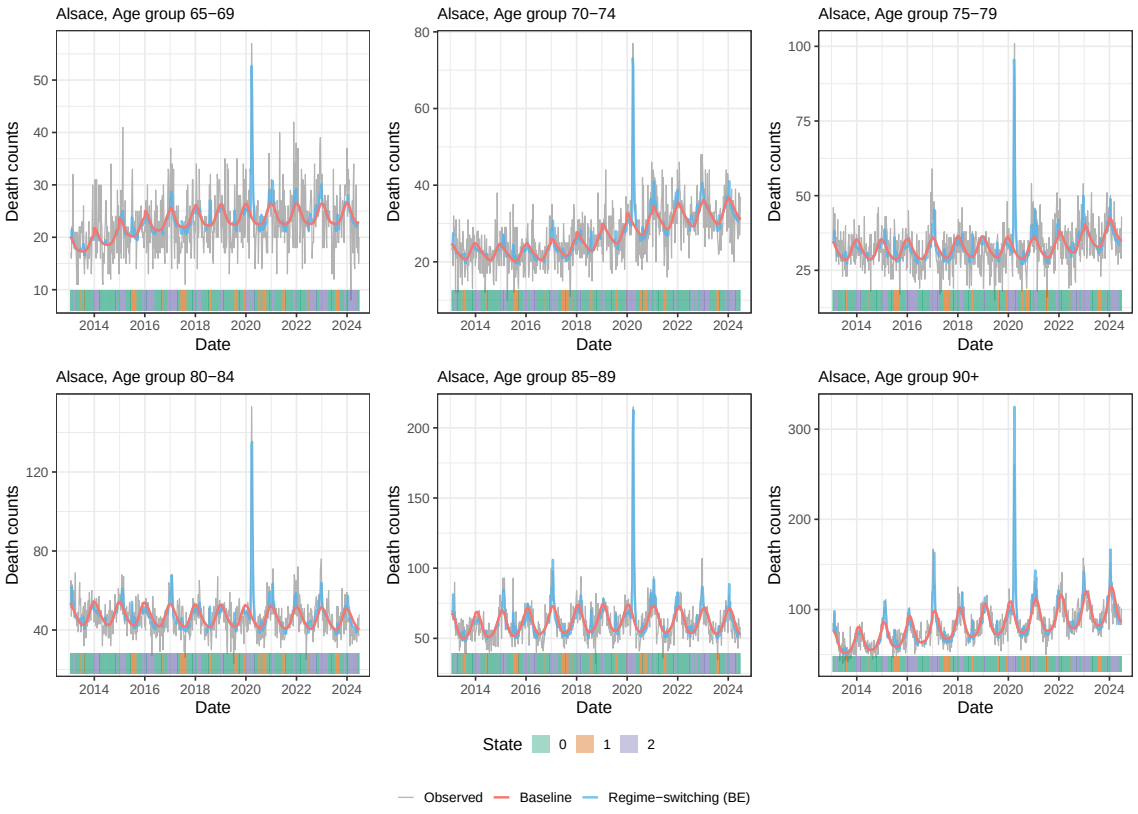

Figure B.9: Alsace (FRF1).

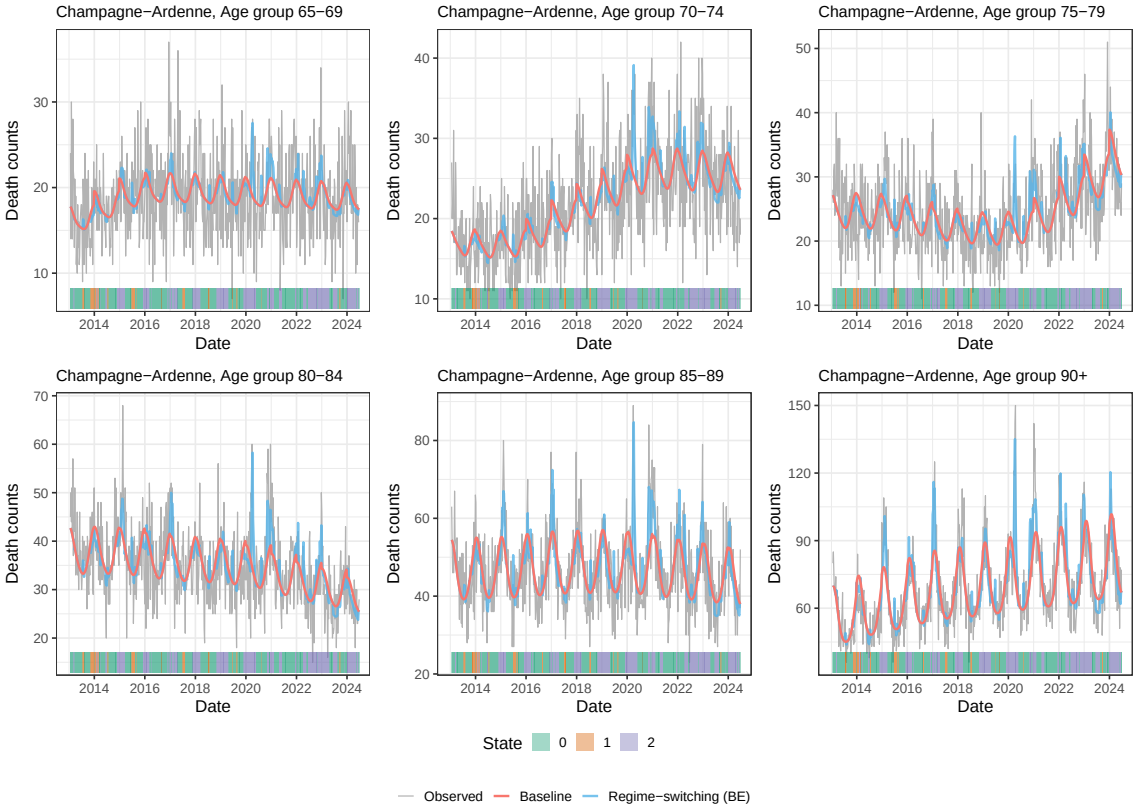

Figure B.10: Champagne-Ardenne (FRF2).

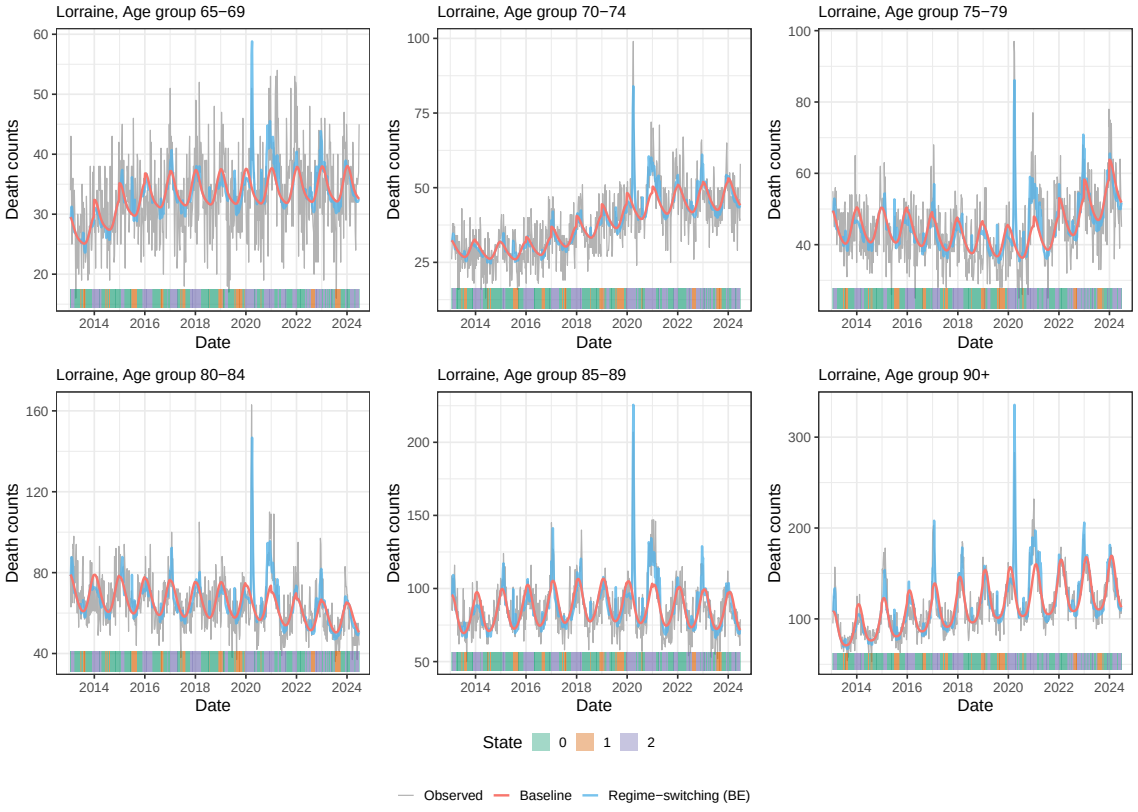

Figure B.11: Lorraine (FRF3).

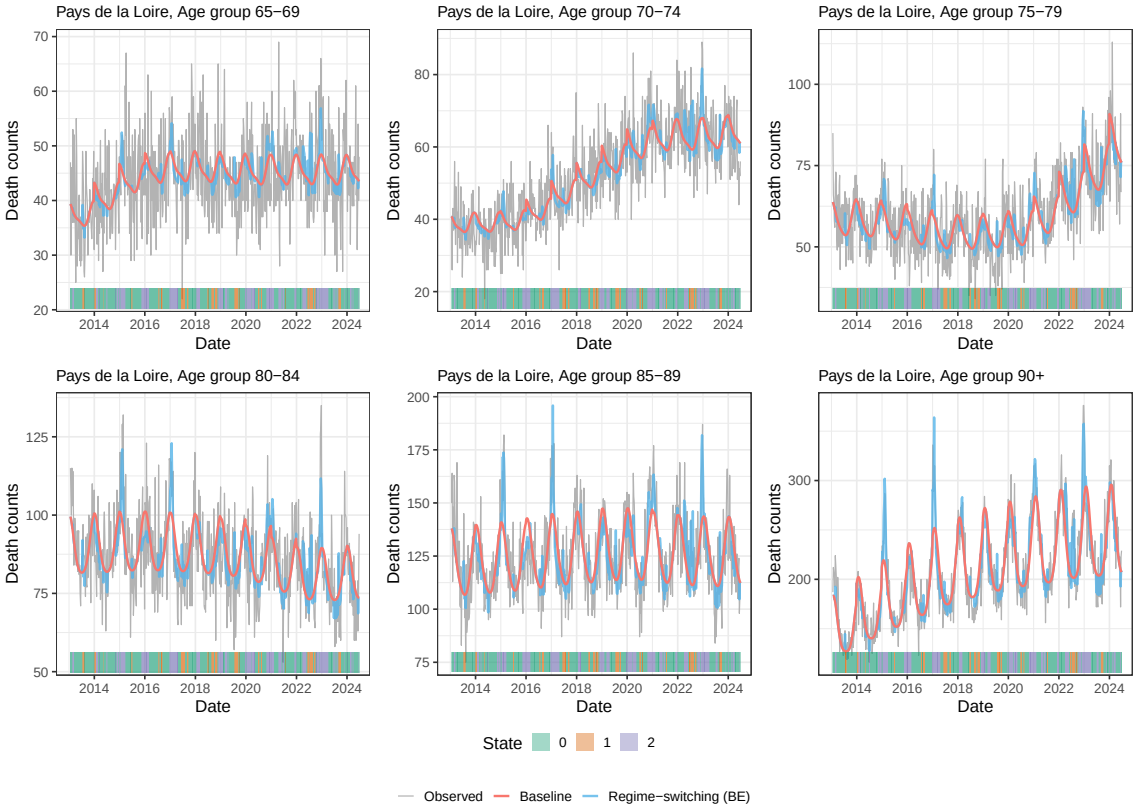

Figure B.12: Pays de la Loire (FRG0).

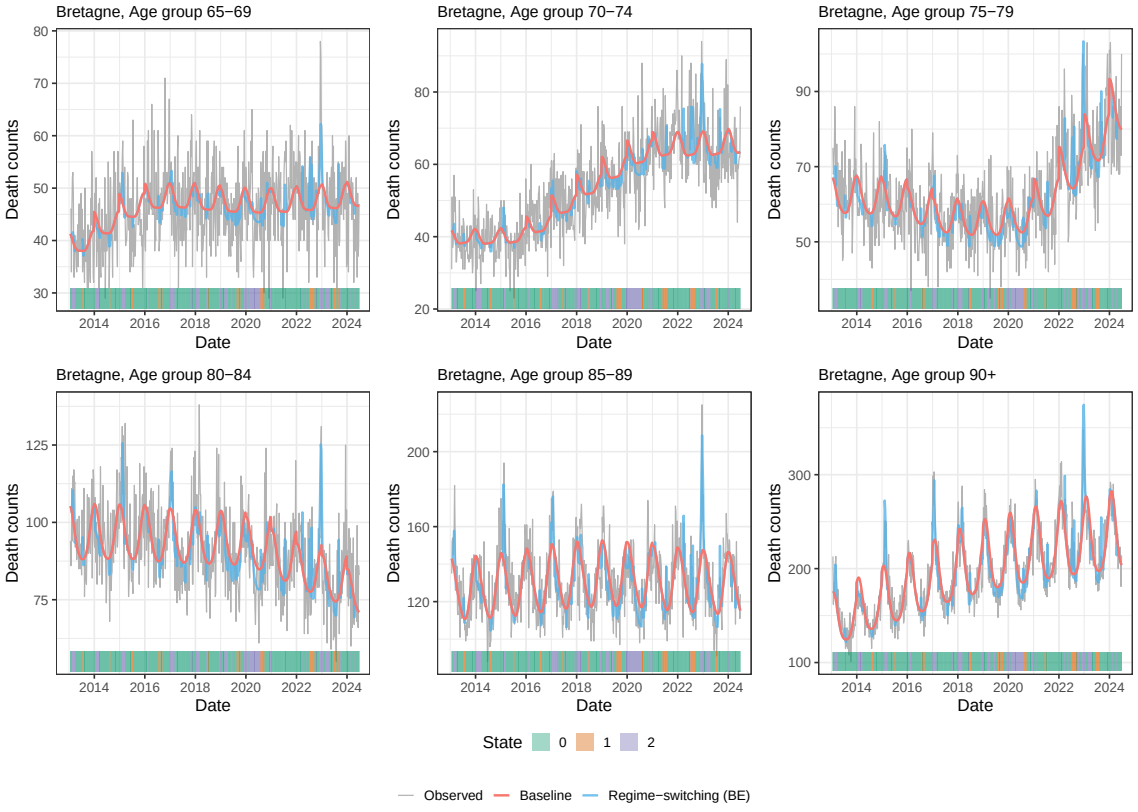

Figure B.13: Bretagne (FRH0).

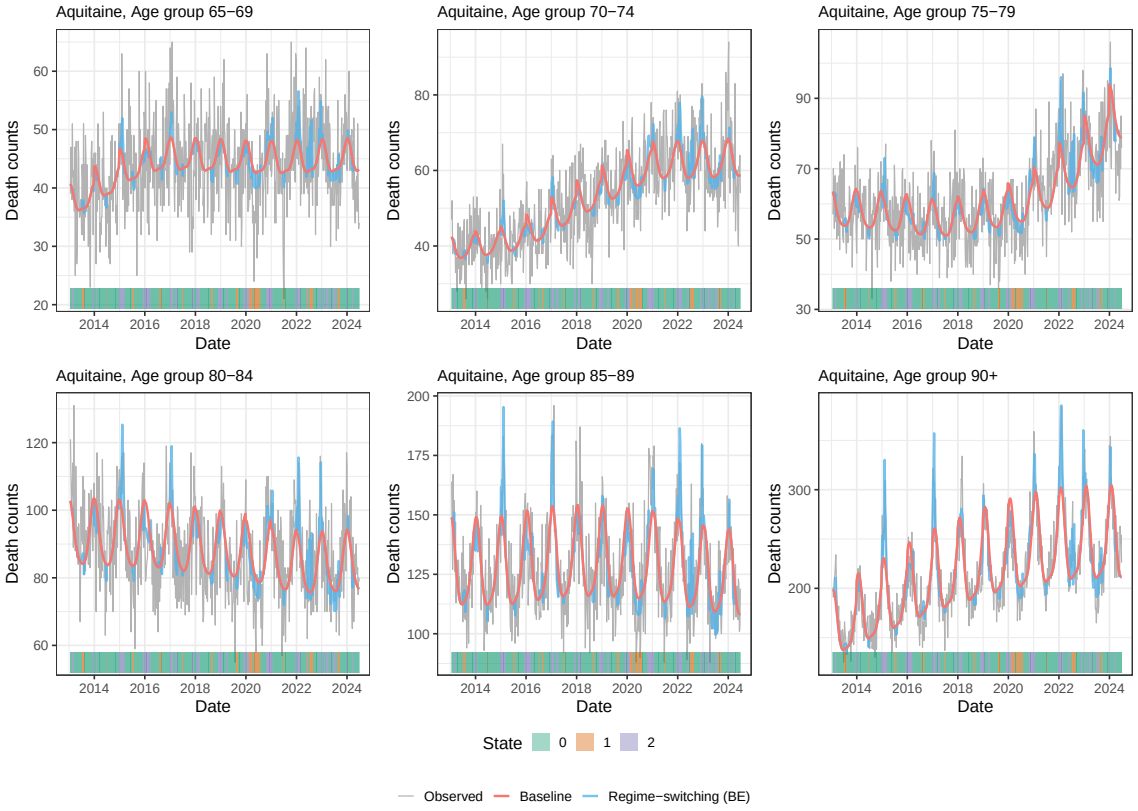

Figure B.14: Aquitaine (FRI1).

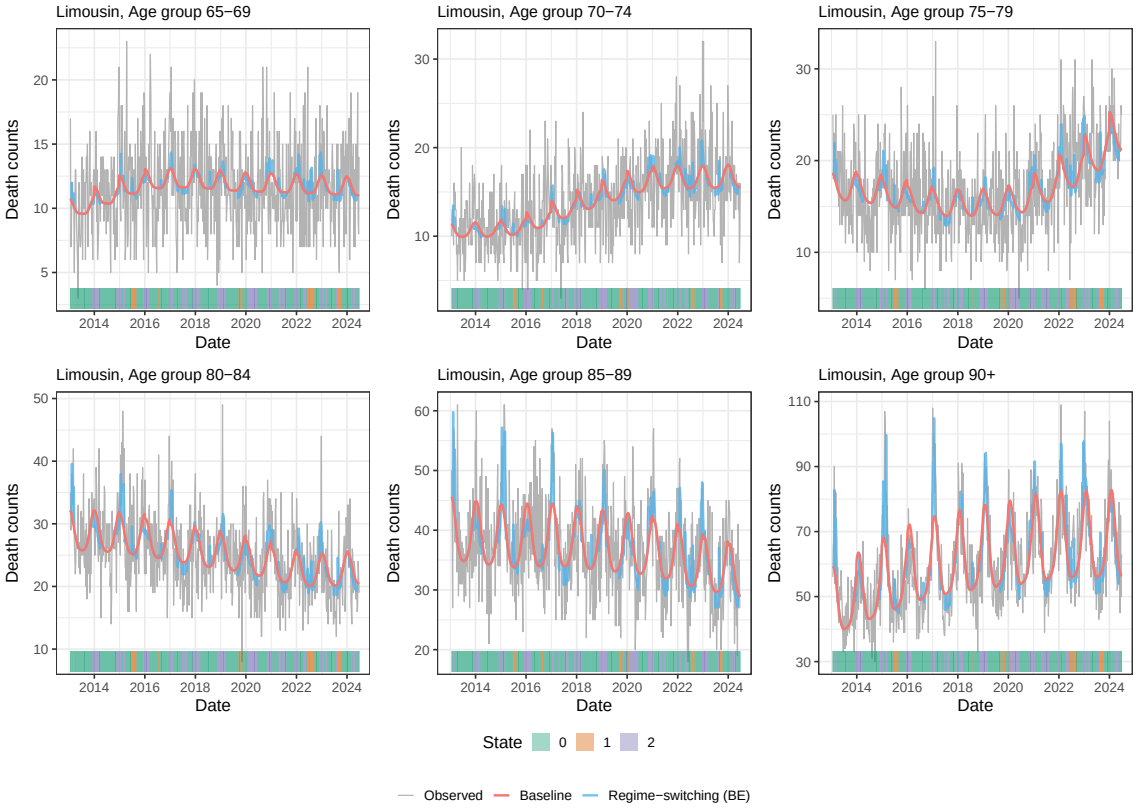

Figure B.15: Limousin (FRI2).

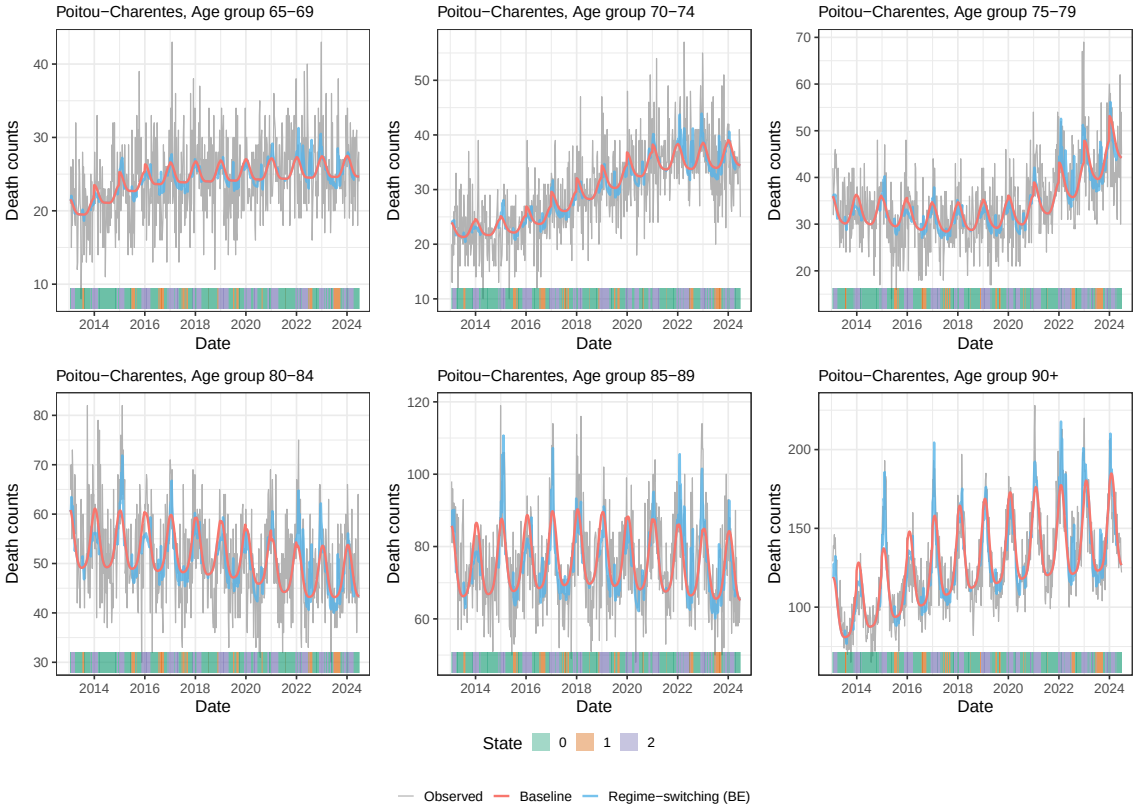

Figure B.16: Poitou-Charentes (FRI3).

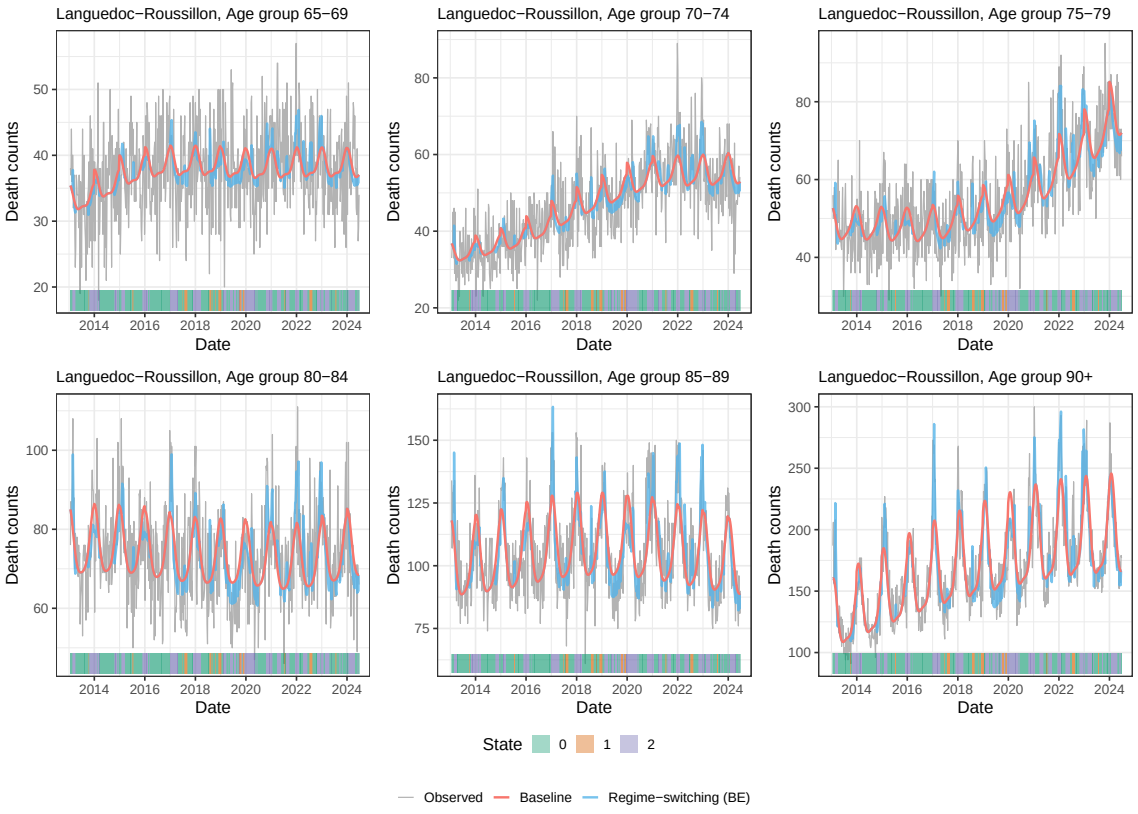

Figure B.17: Languedoc-Roussillon (FRJ1).

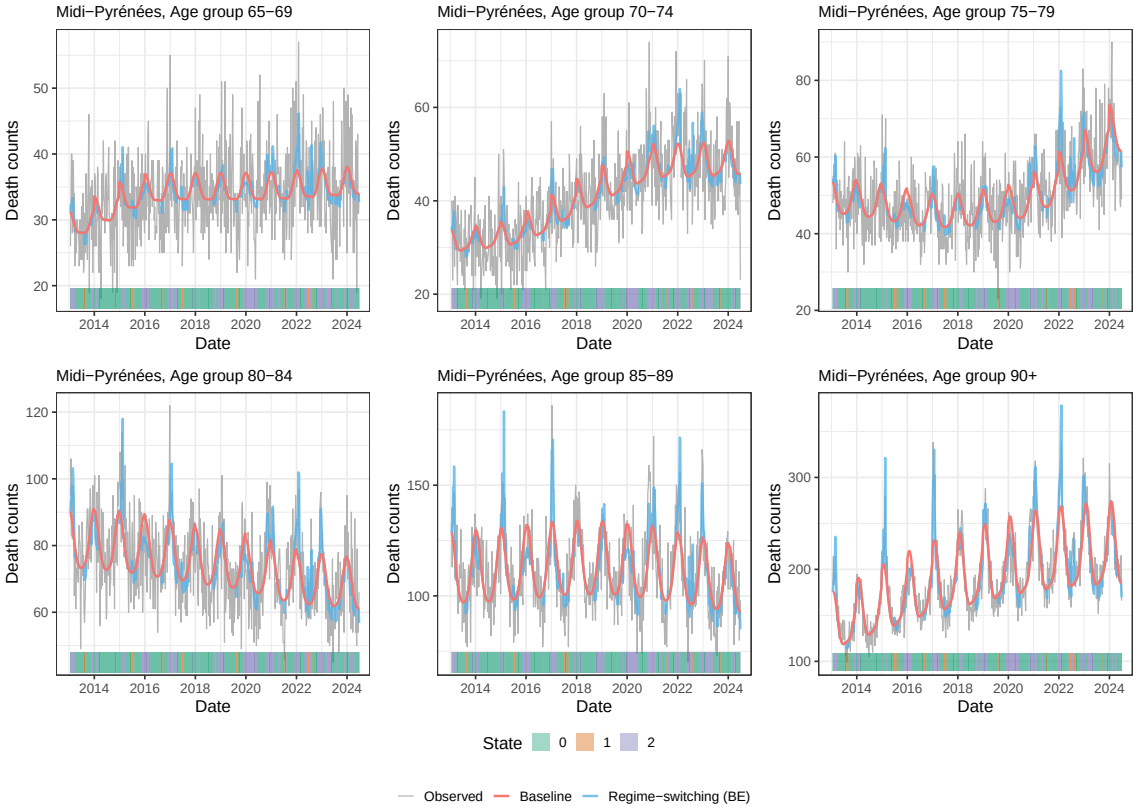

Figure B.18: Midi-Pyrénées (FRJ2).

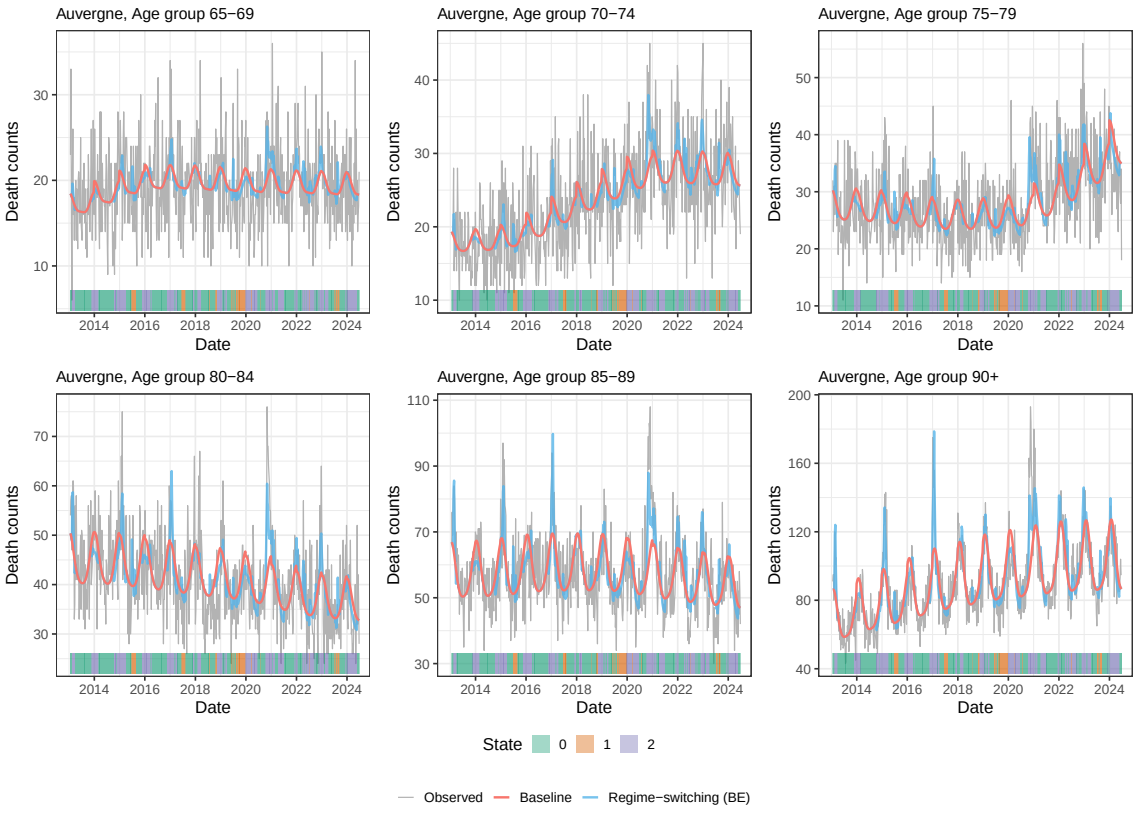

Figure B.19: Auvergne (FRK1).

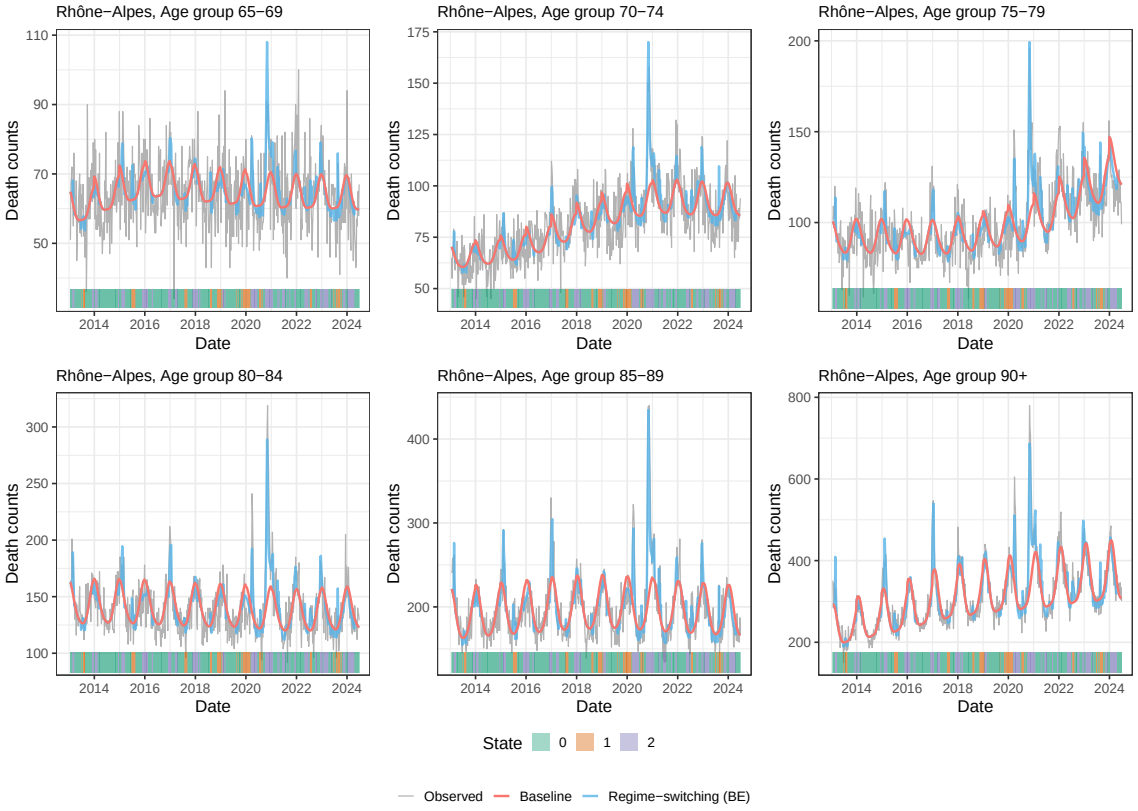

Figure B.20: Rhône-Alpes (FRK2).

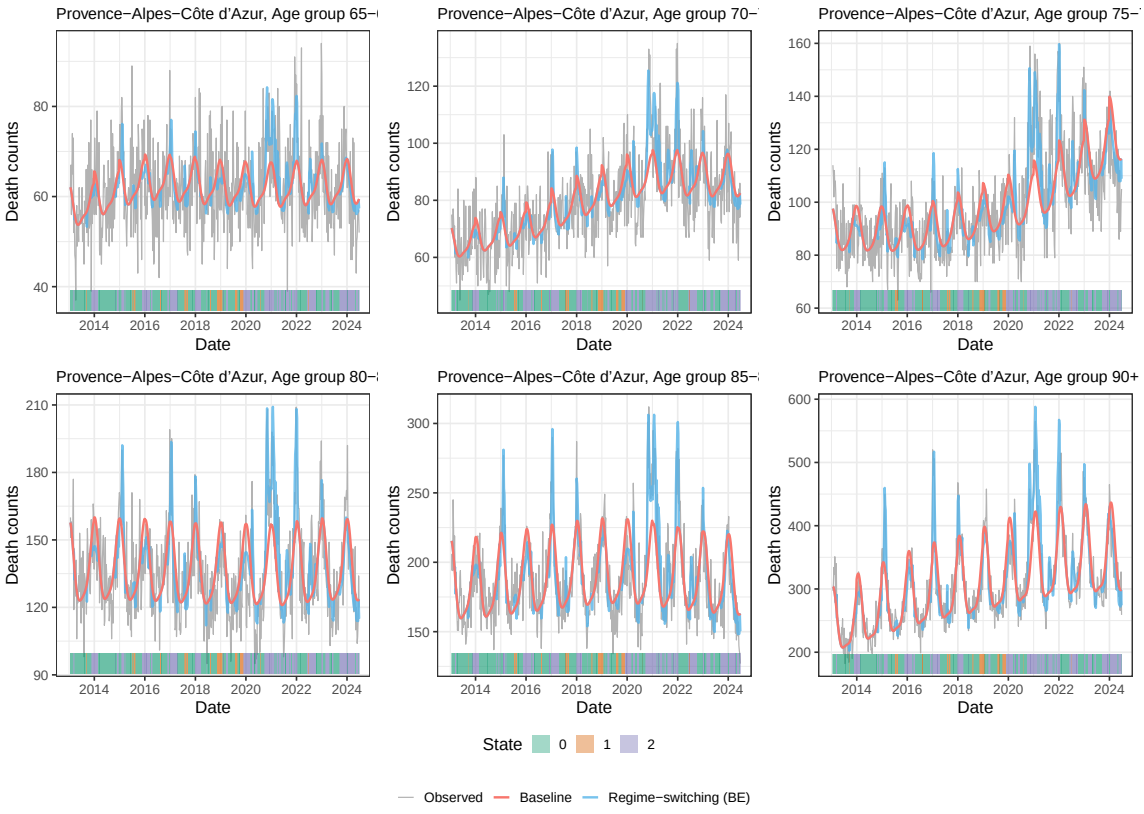

Figure B.21: Provence-Alpes-Côte d'Azur (FRL0).

C Uncertainty in in-sample predictions

Figure caption. We present 95% confidence intervals for the weekly death counts in every NUTS 2 region for the age groups 65-69, 70-74, 75-79 (top panels), and 80-84, 85-89, 90+ (bottom panels), from the first ISO week of 2013 till the 26th ISO week of 2024. The intervals represent different sources of uncertainty: state uncertainty only (red), state, parameter, and spatial uncertainty (green), and state, parameter, spatial, and Poisson uncertainty (blue). Each figure below corresponds to a different French NUTS 2 region.

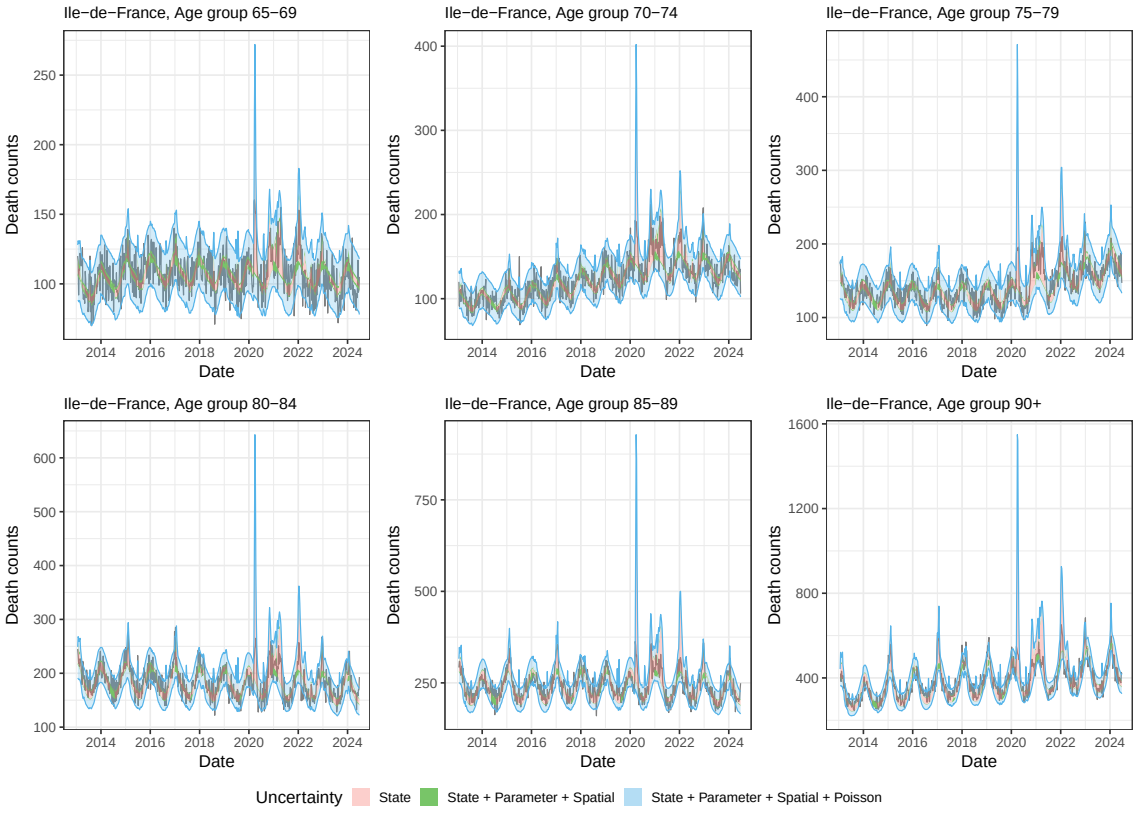

Figure C.1: Ile-de-France (FR10).

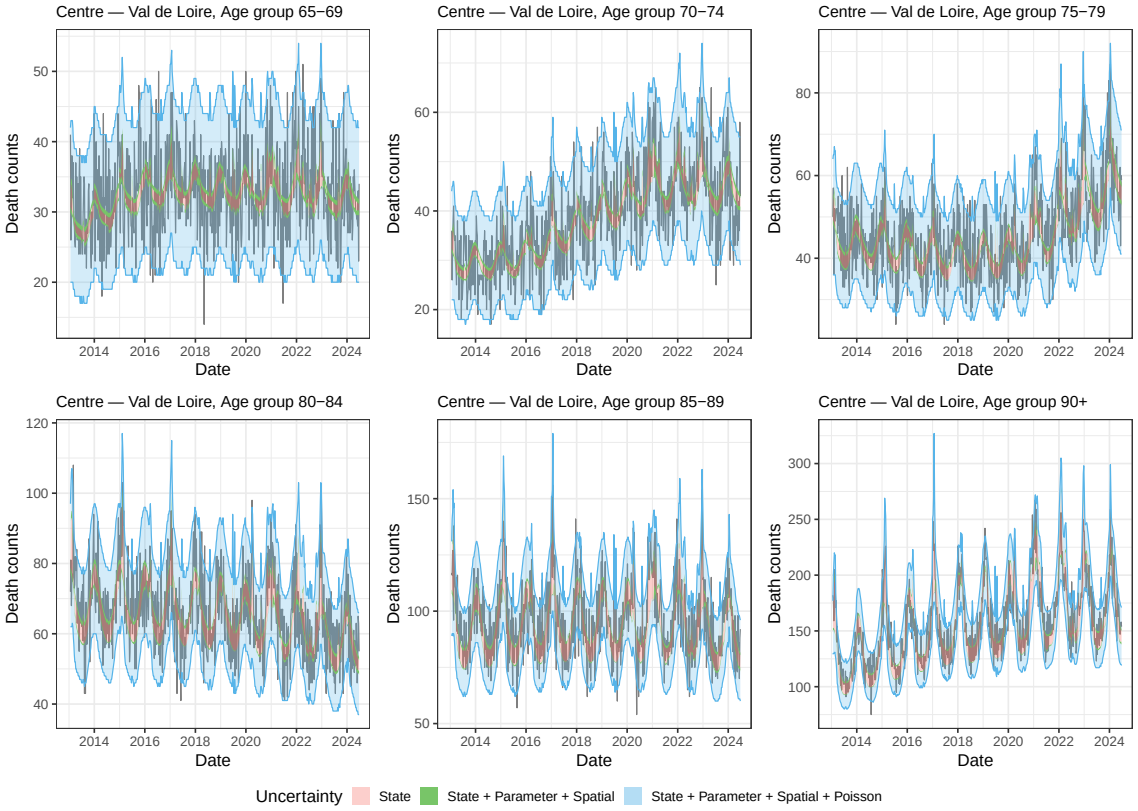

Figure C.2: Centre — Val de Loire (FRB0).

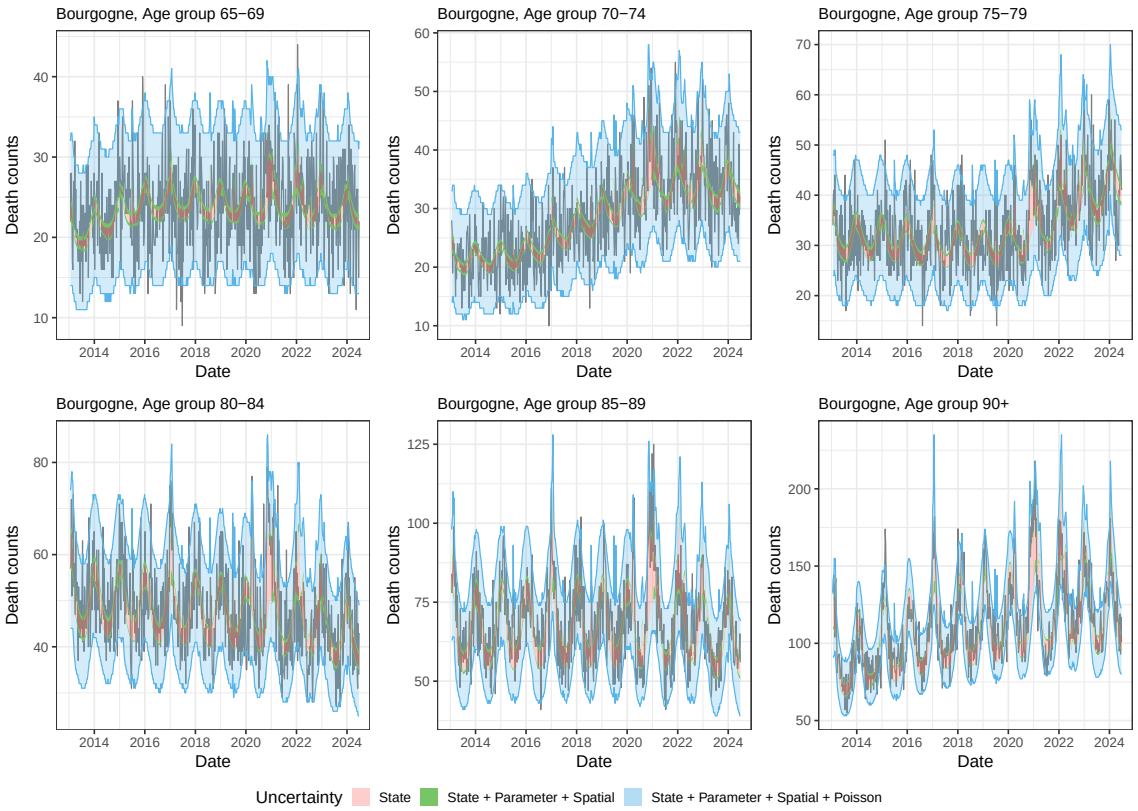

Figure C.3: Bourgogne (FRC1).

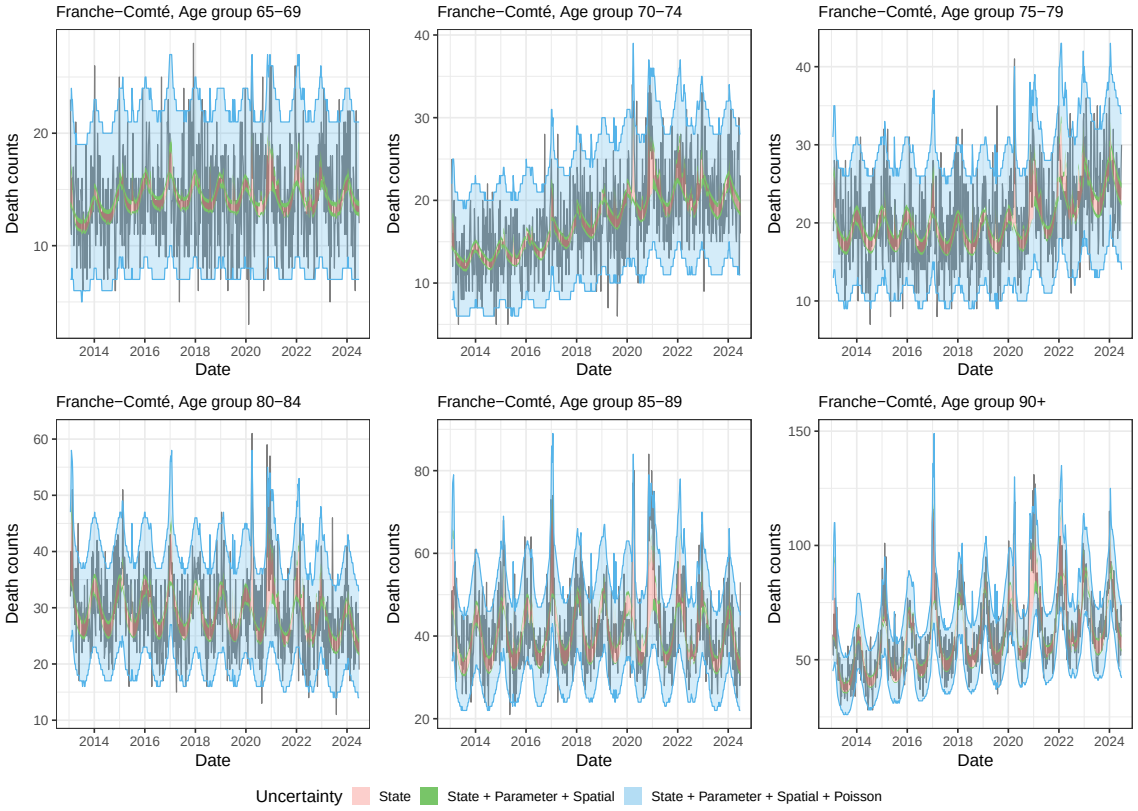

Figure C.4: Franche-Comté (FRC2).

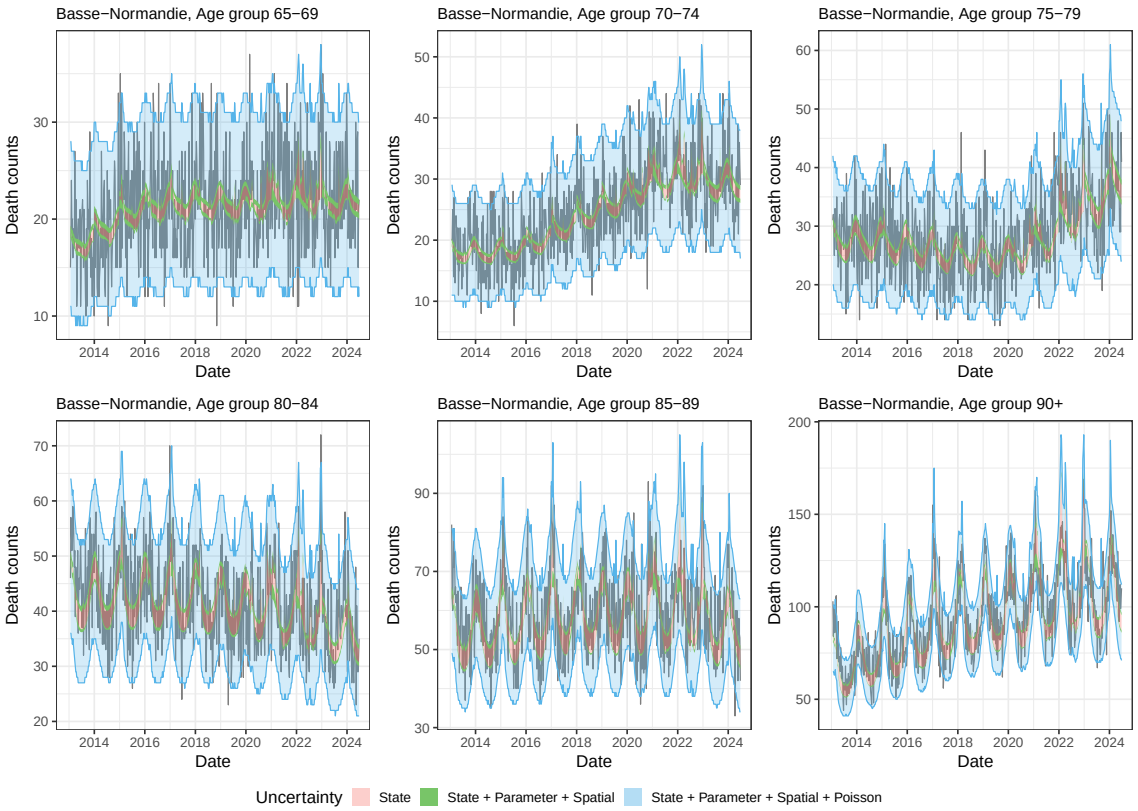

Figure C.5: Basse-Normandie (FRD1).

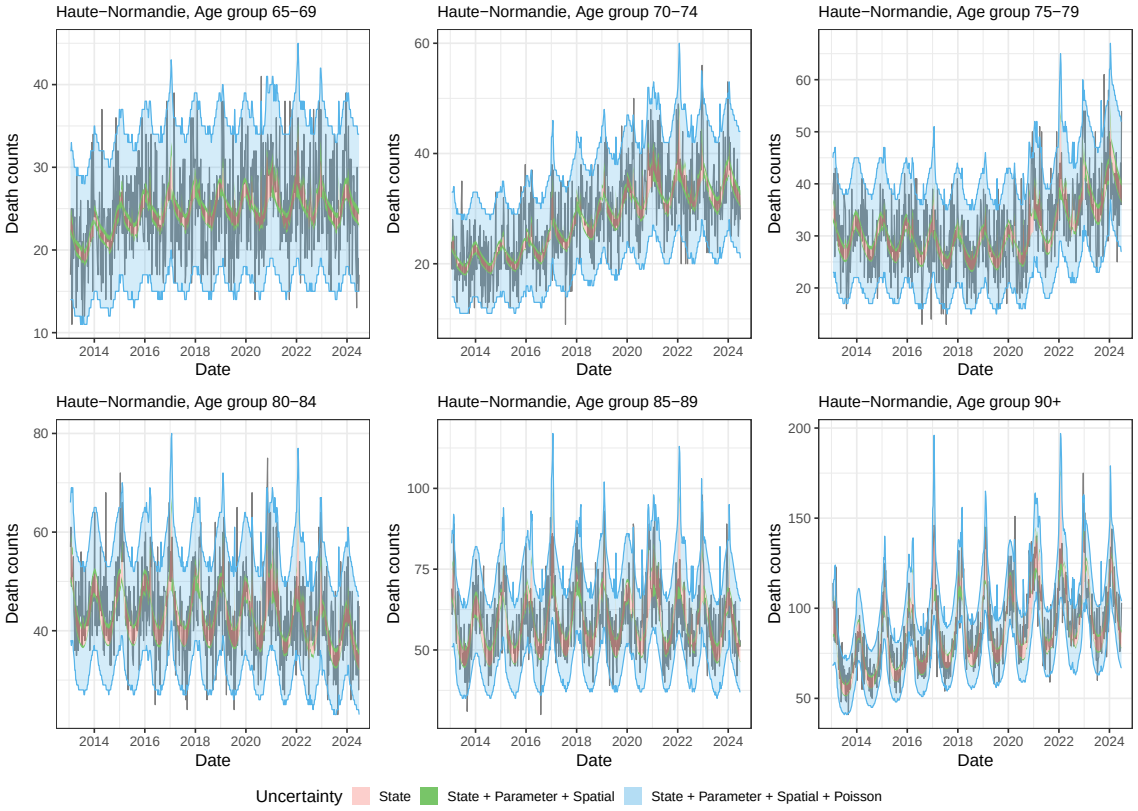

Figure C.6: Haute-Normandie (FRD2).

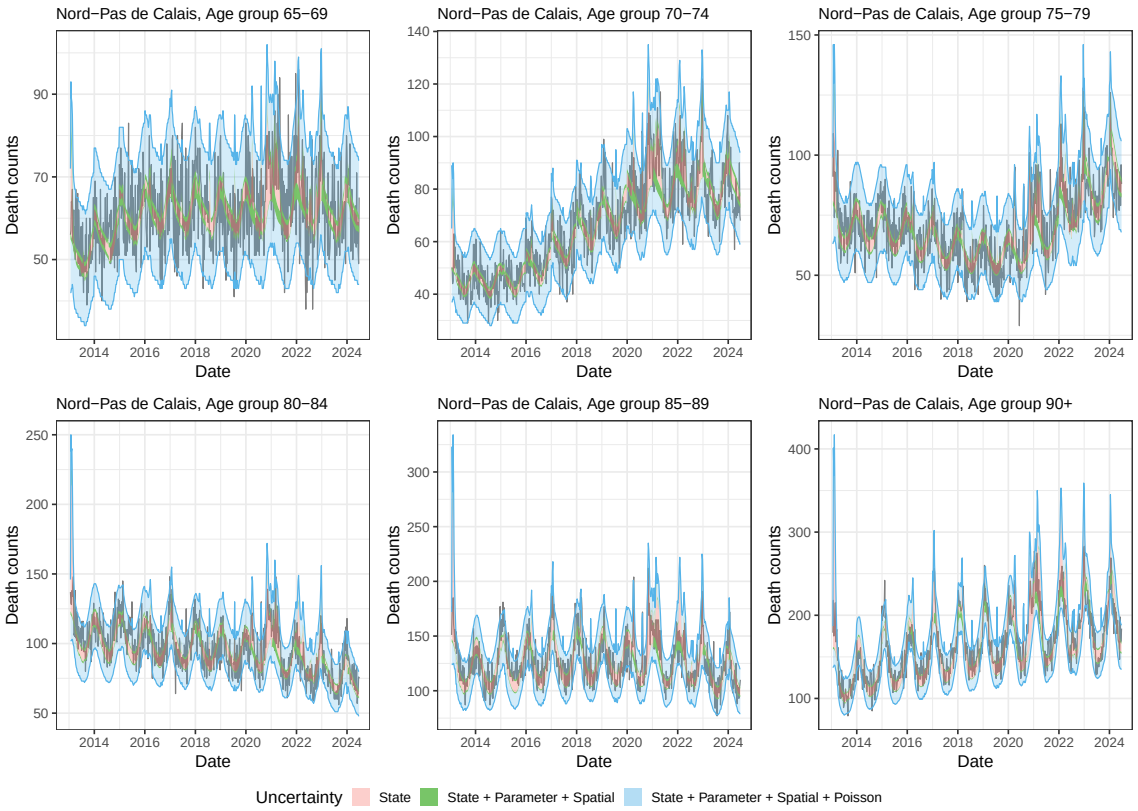

Figure C.7: Nord-Pas de Calais (FRE1).

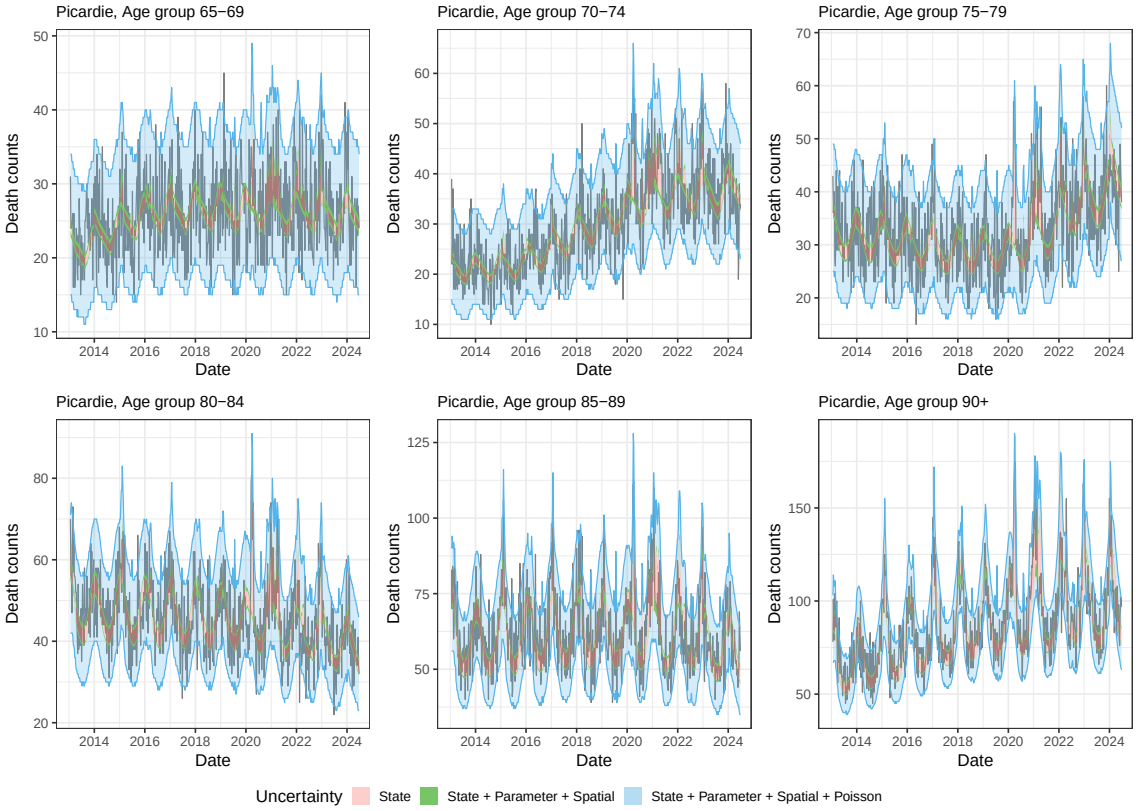

Figure C.8: Picardie (FRE2).

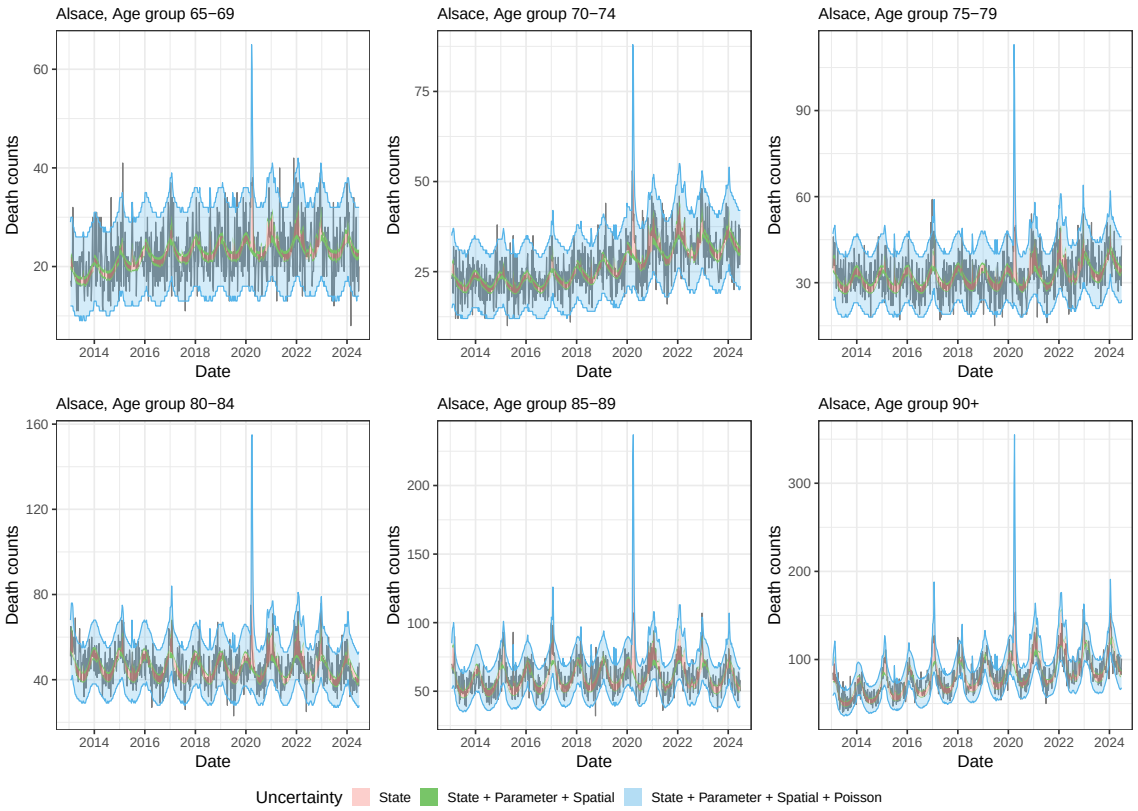

Figure C.9: Alsace (FRF1).

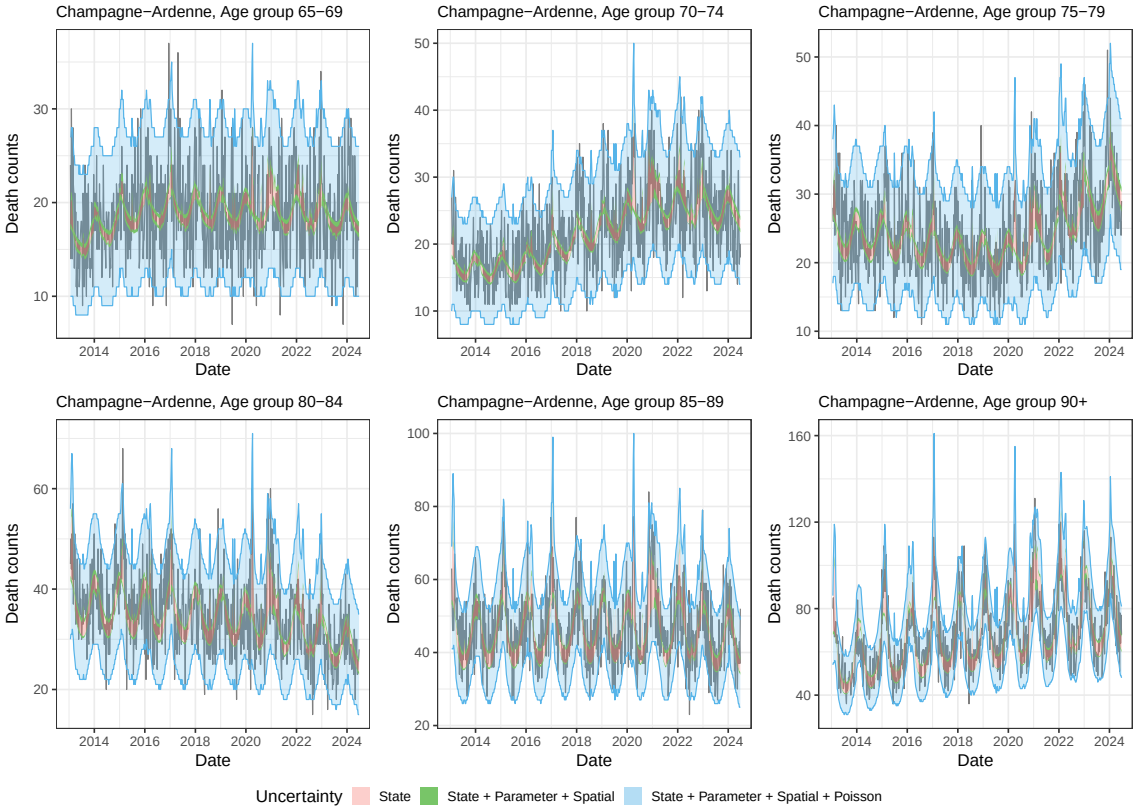

Figure C.10: Champagne-Ardenne (FRF2).

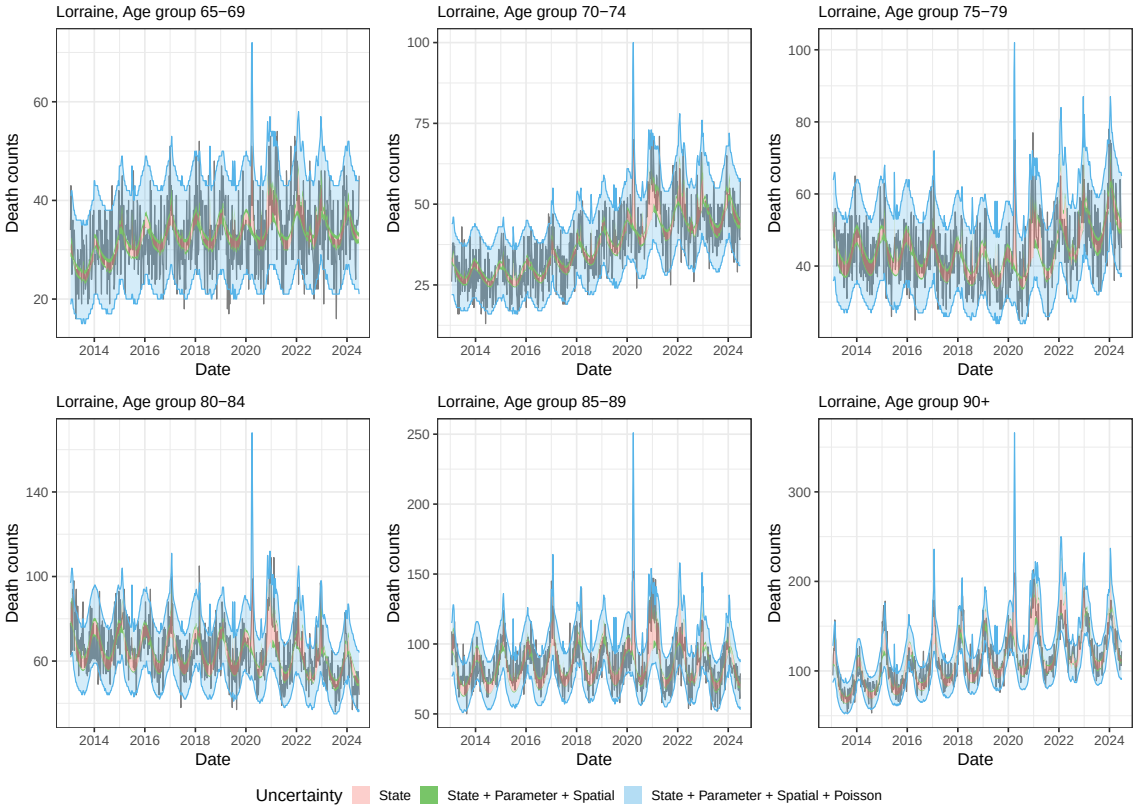

Figure C.11: Lorraine (FRF3).

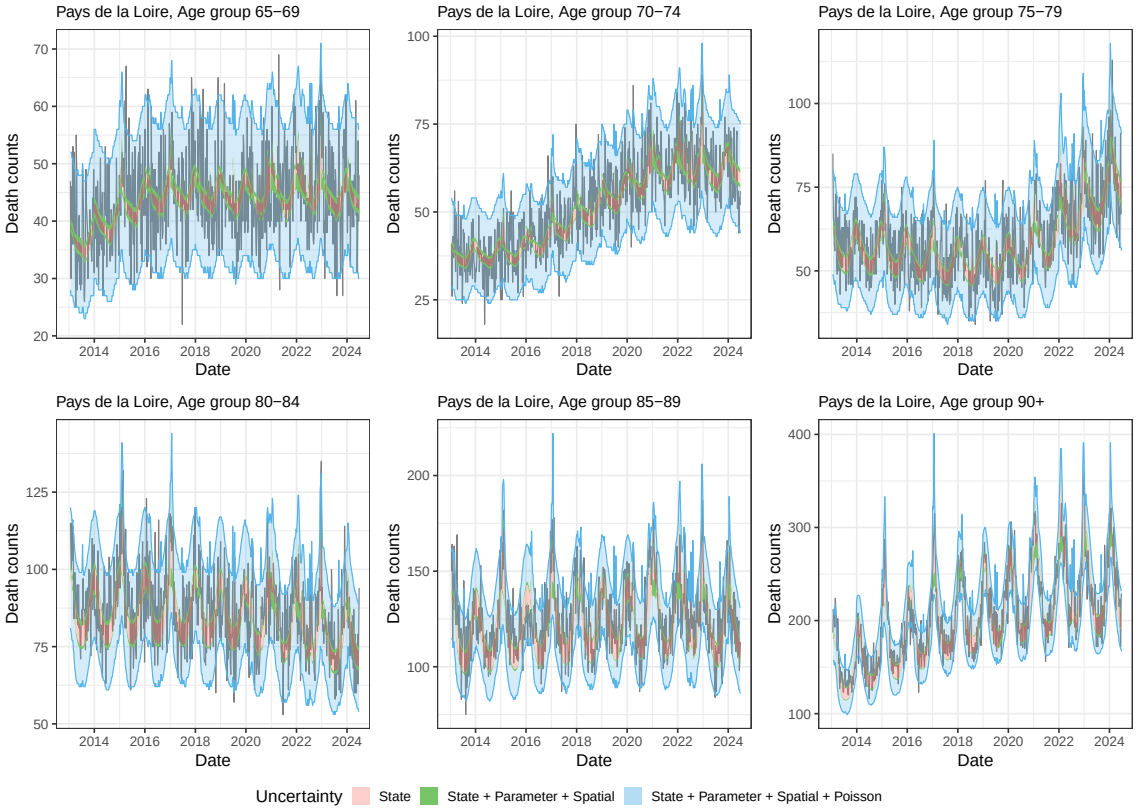

Figure C.12: Pays de la Loire (FRG0).

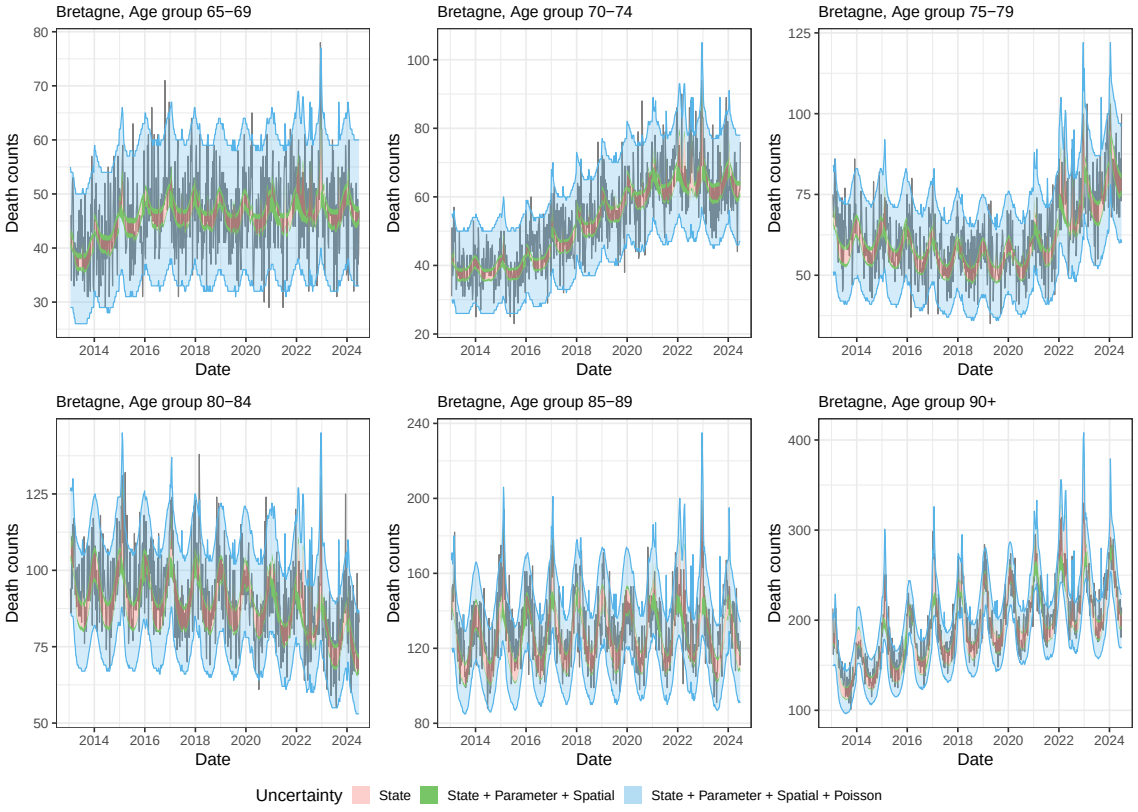

Figure C.13: Bretagne (FRH0).

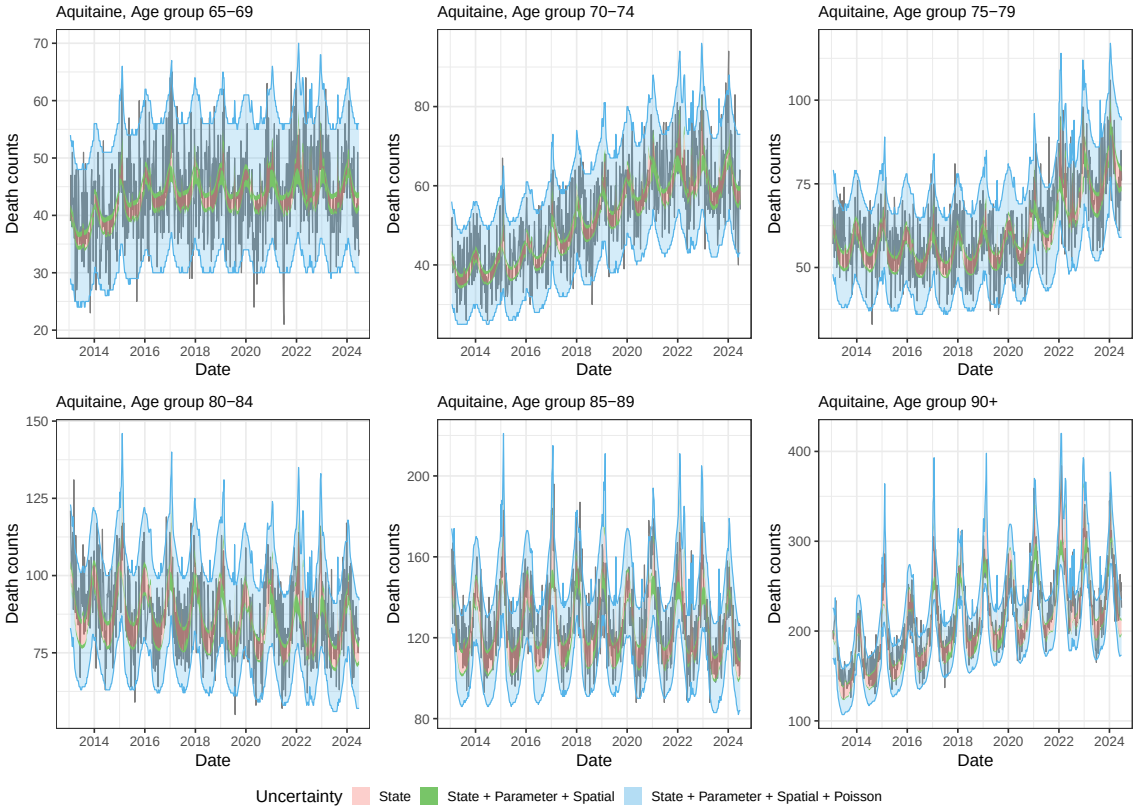

Figure C.14: Aquitaine (FRI1).

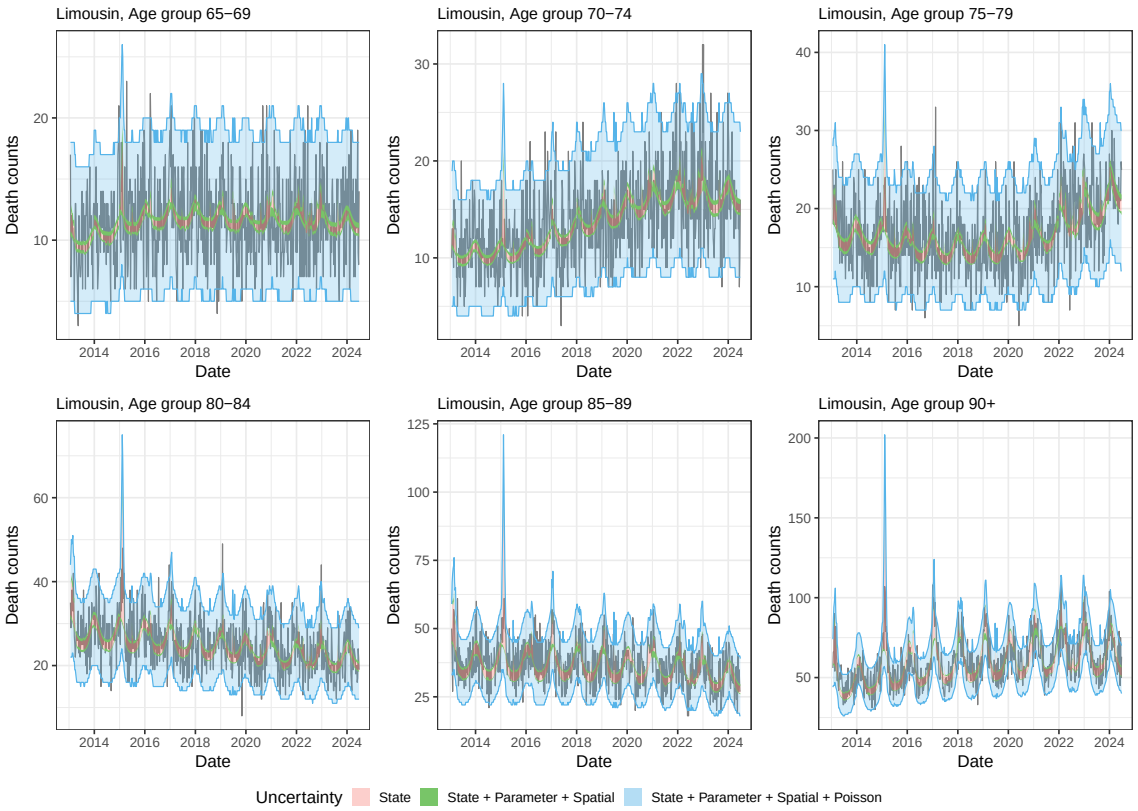

Figure C.15: Limousin (FRI2).

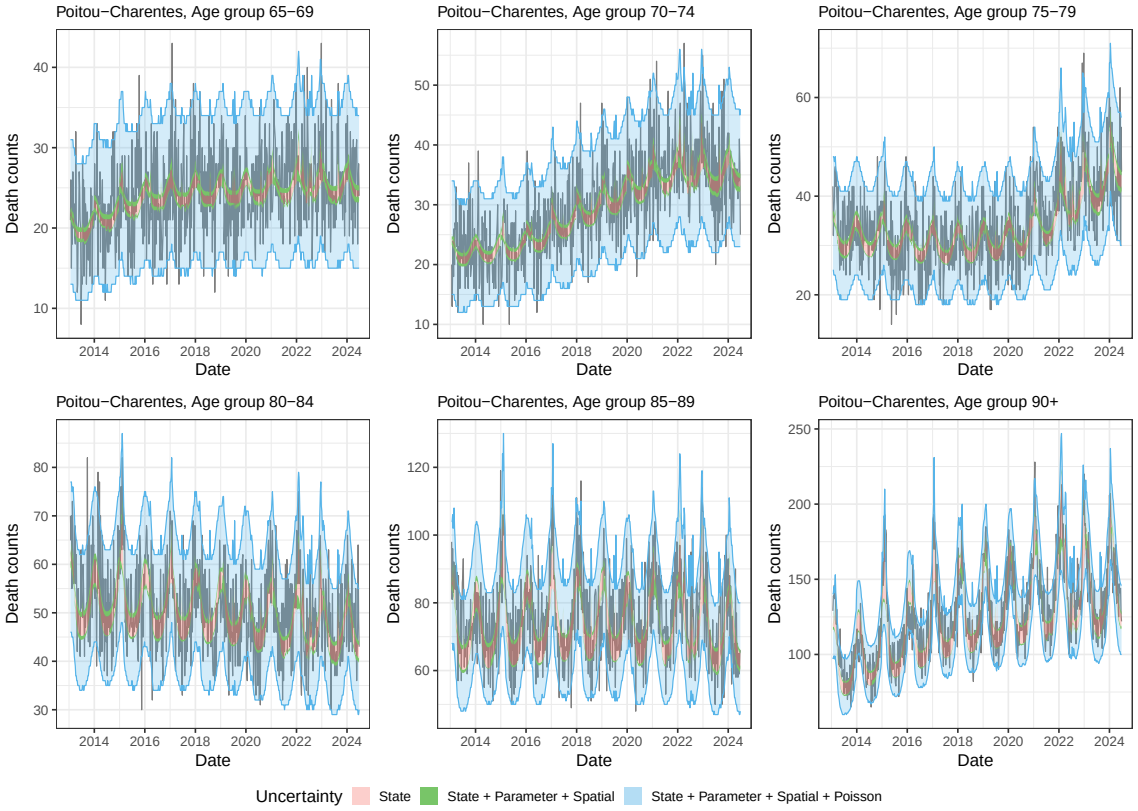

Figure C.16: Poitou-Charentes (FRI3).

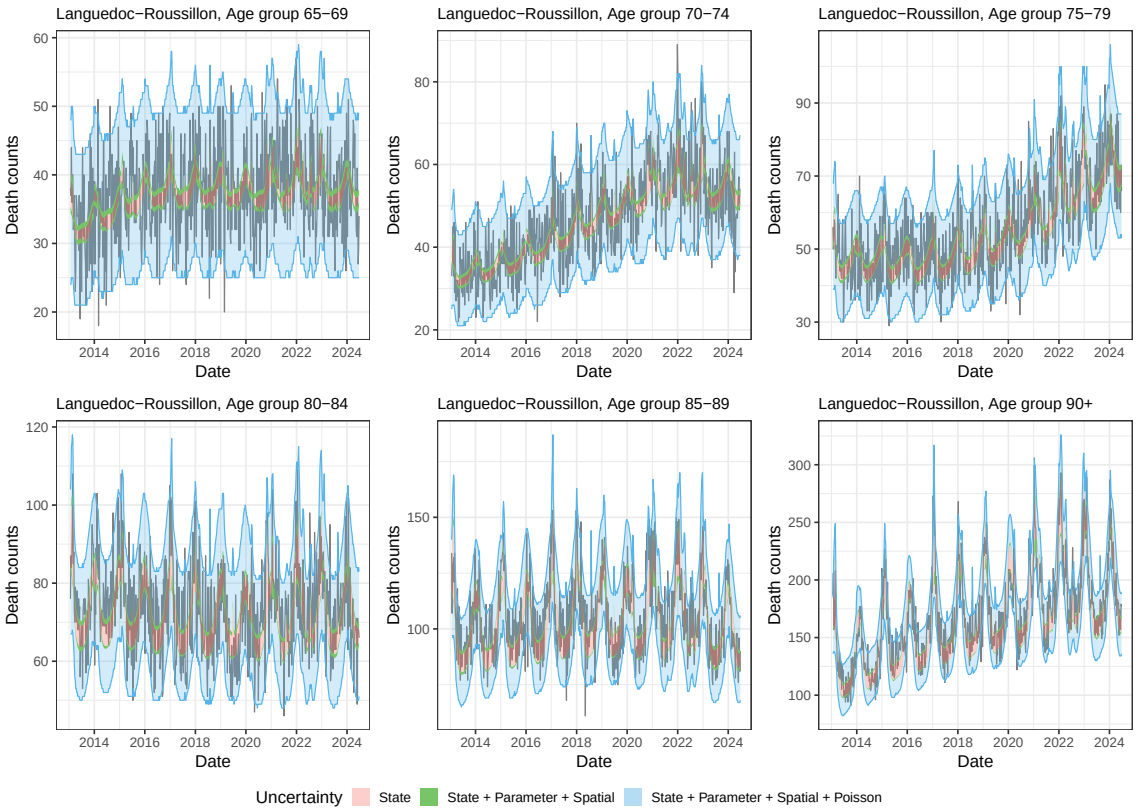

Figure C.17: Languedoc-Roussillon (FRJ1).

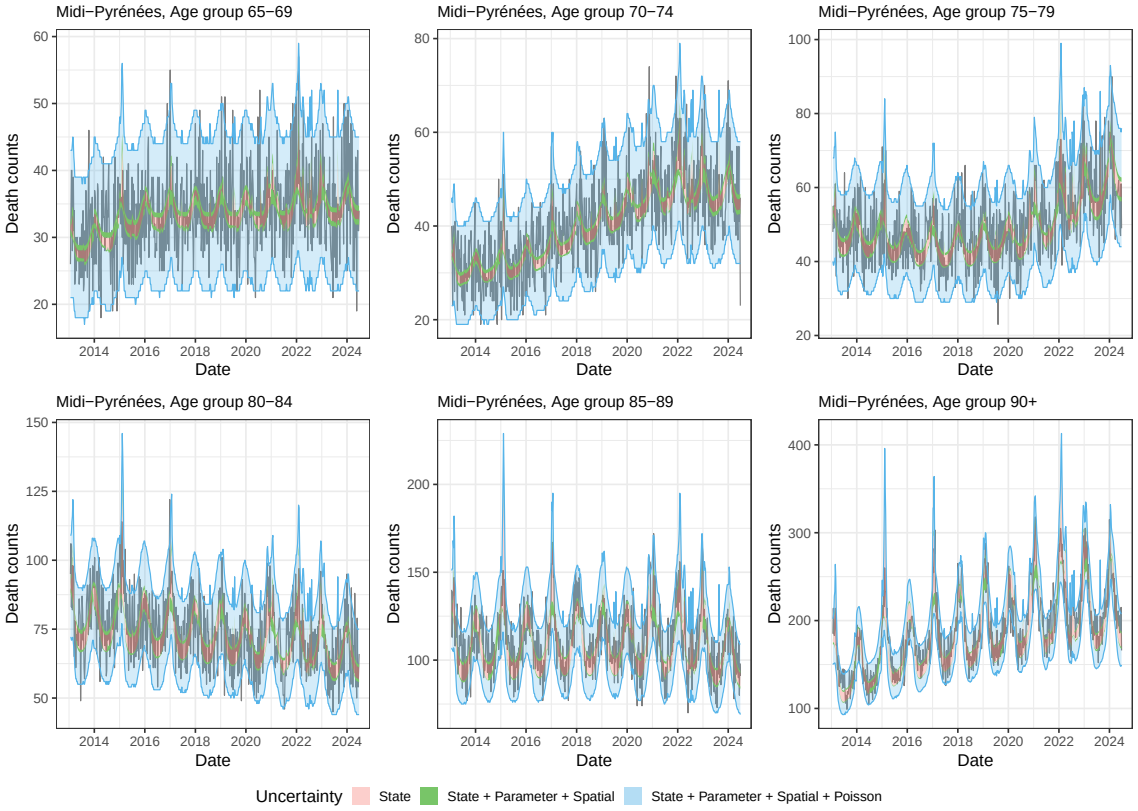

Figure C.18: Midi-Pyrénées (FRJ2).

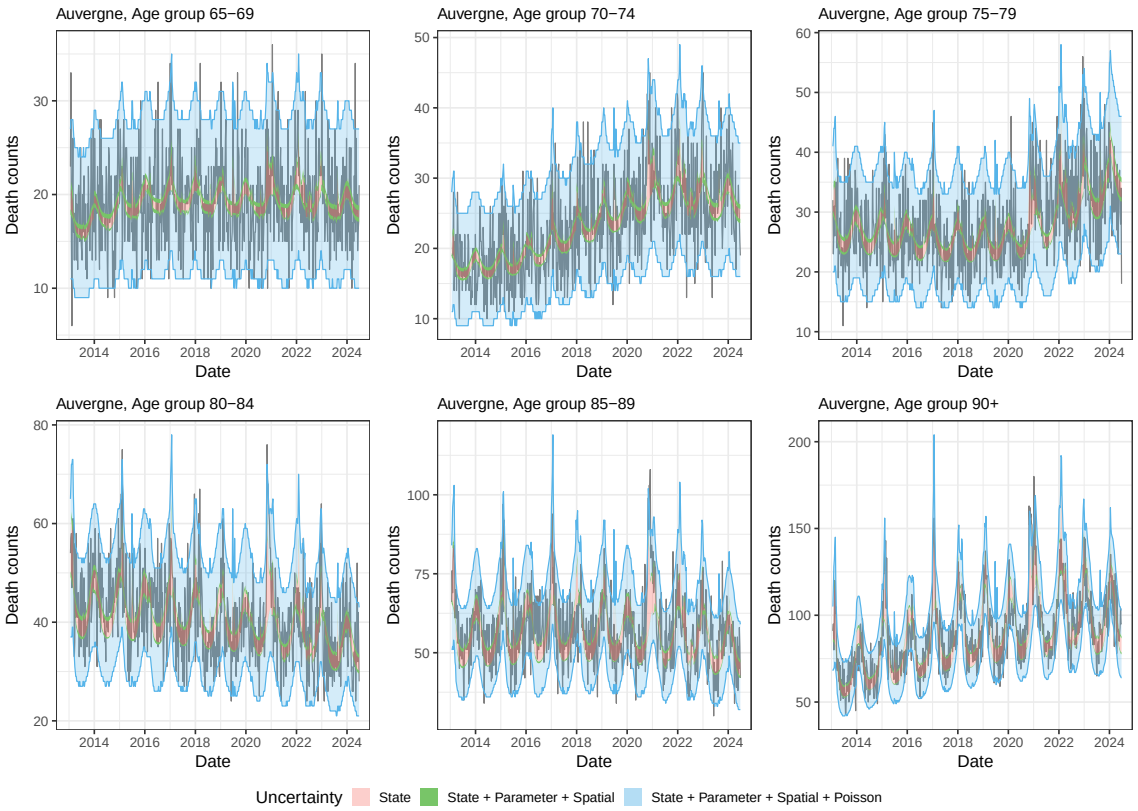

Figure C.19: Auvergne (FRK1).

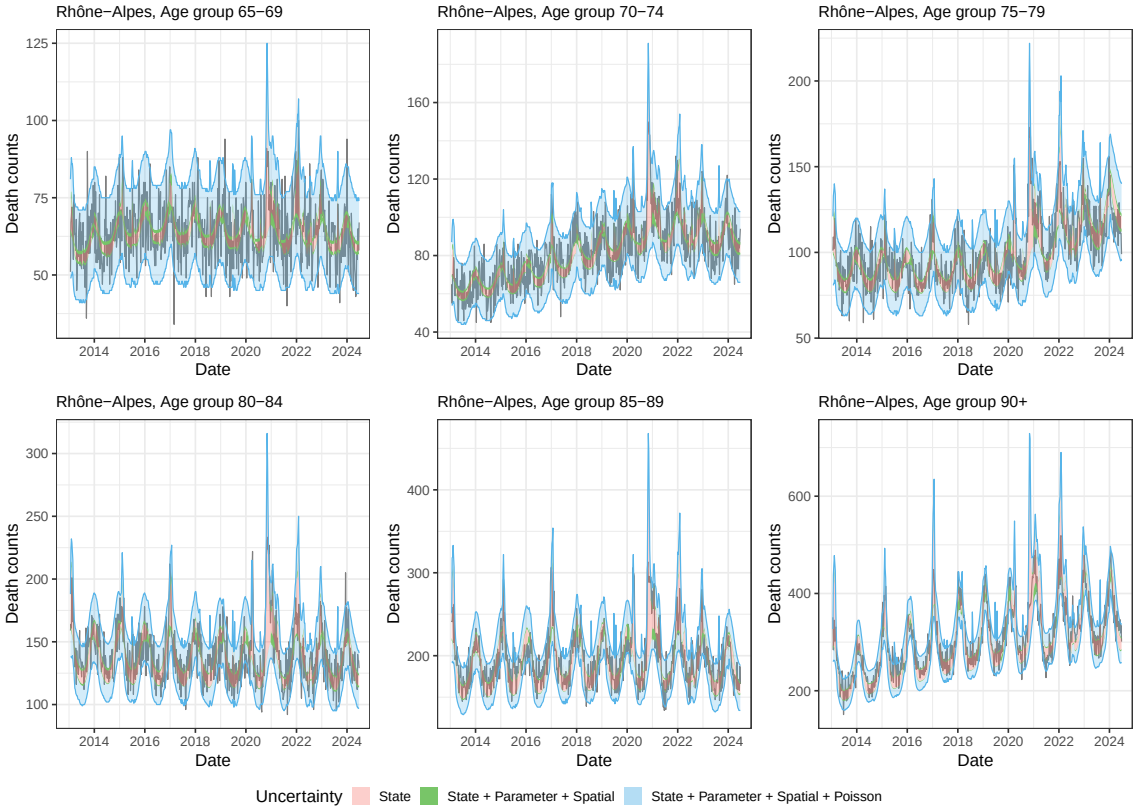

Figure C.20: Rhône-Alpes (FRK2).

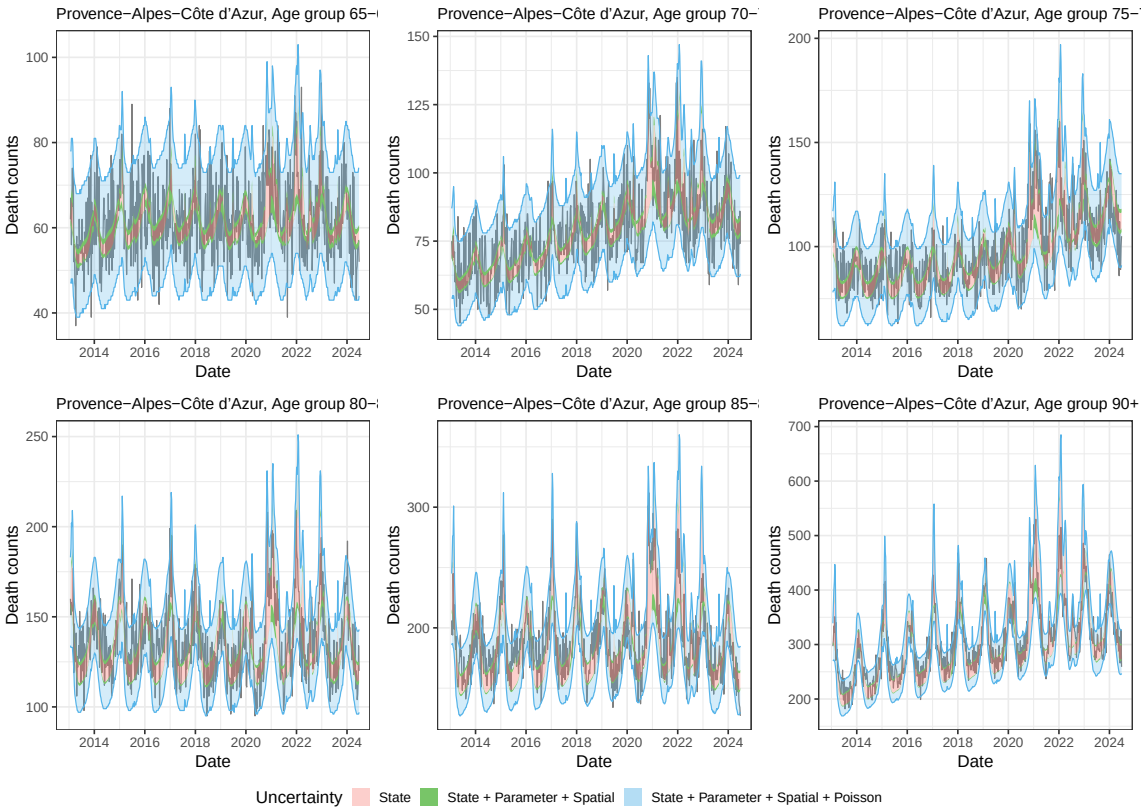

Figure C.21: Provence-Alpes-Côte d'Azur (FRL0).

D Out-of-sample back-testing

Figure caption. We present the 95% out-of-sample prediction intervals for the weekly death counts in the NUTS 2 regions of France for the age groups 65-69, 70-74, 75-79 (top panels), and 80-84, 85-89, 90+ (bottom panels), from the 27th ISO-week of 2022 till the 26th ISO-week of 2024. The intervals take into account the parameter, spatial, state, and Poisson uncertainty and are based on 25 000 bootstrap samples. The blue lines show the 2.5%, 50%, and 97.5% quantile, the red line visualizes the estimated baseline number of deaths, and the black line visualizes the observed death counts. Each figure below corresponds to a different French NUTS 2 region.

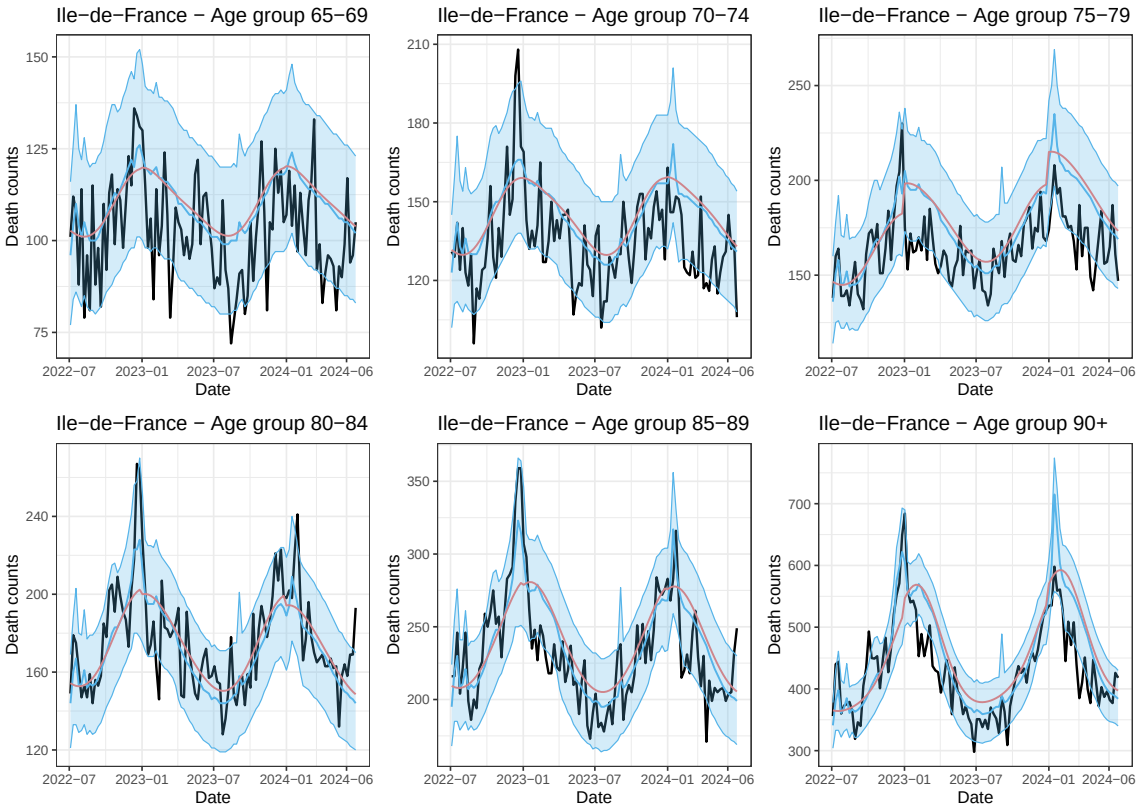

Figure D.1: Ile-de-France (FR10).

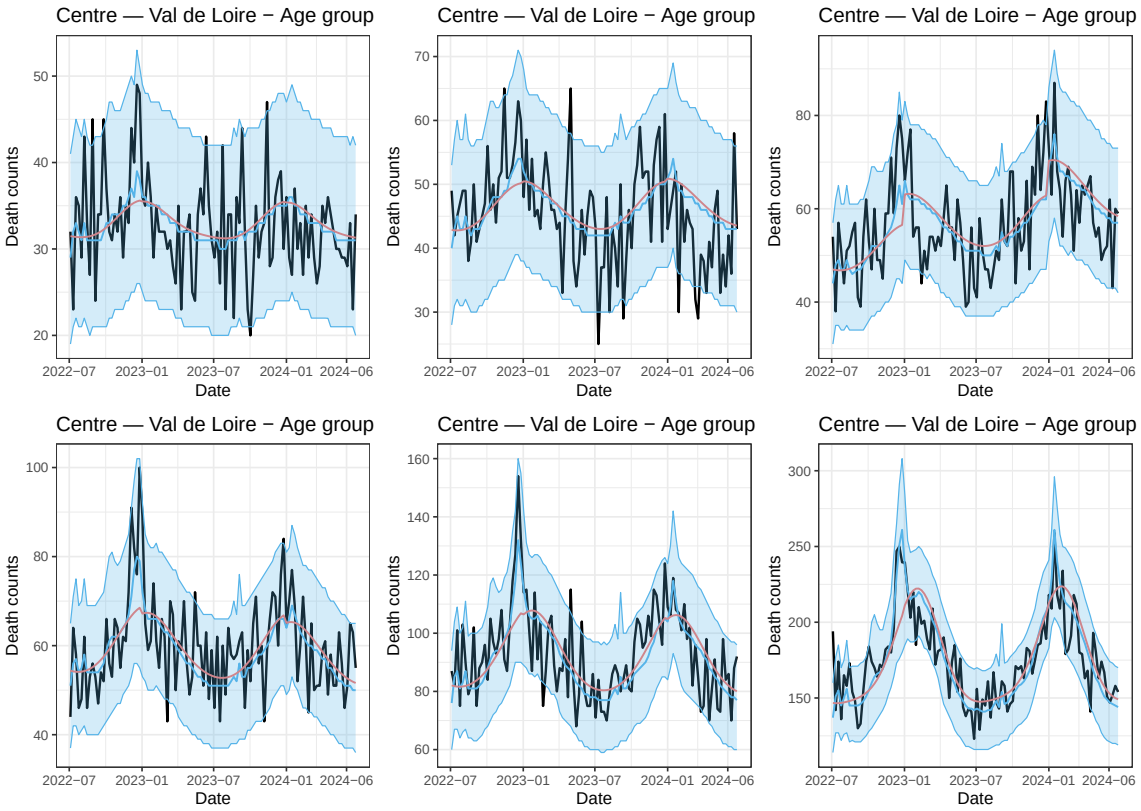

Figure D.2: Centre — Val de Loire (FRB0).

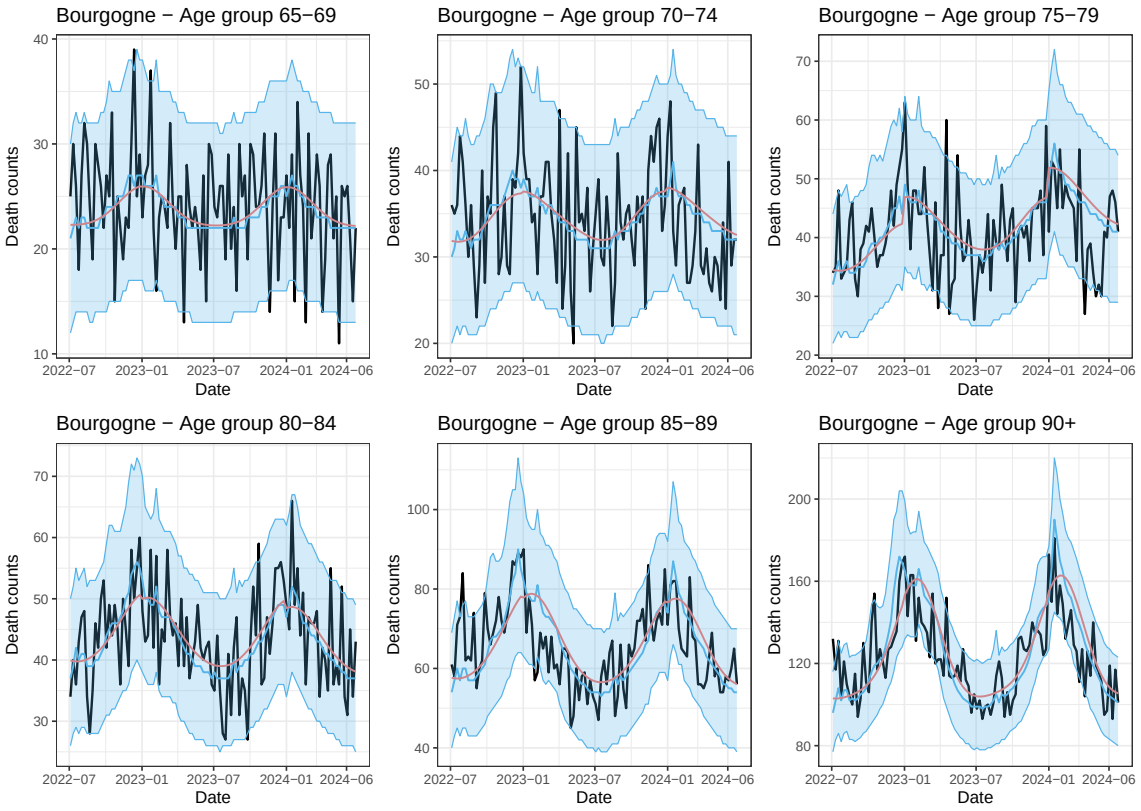

Figure D.3: Bourgogne (FRC1).

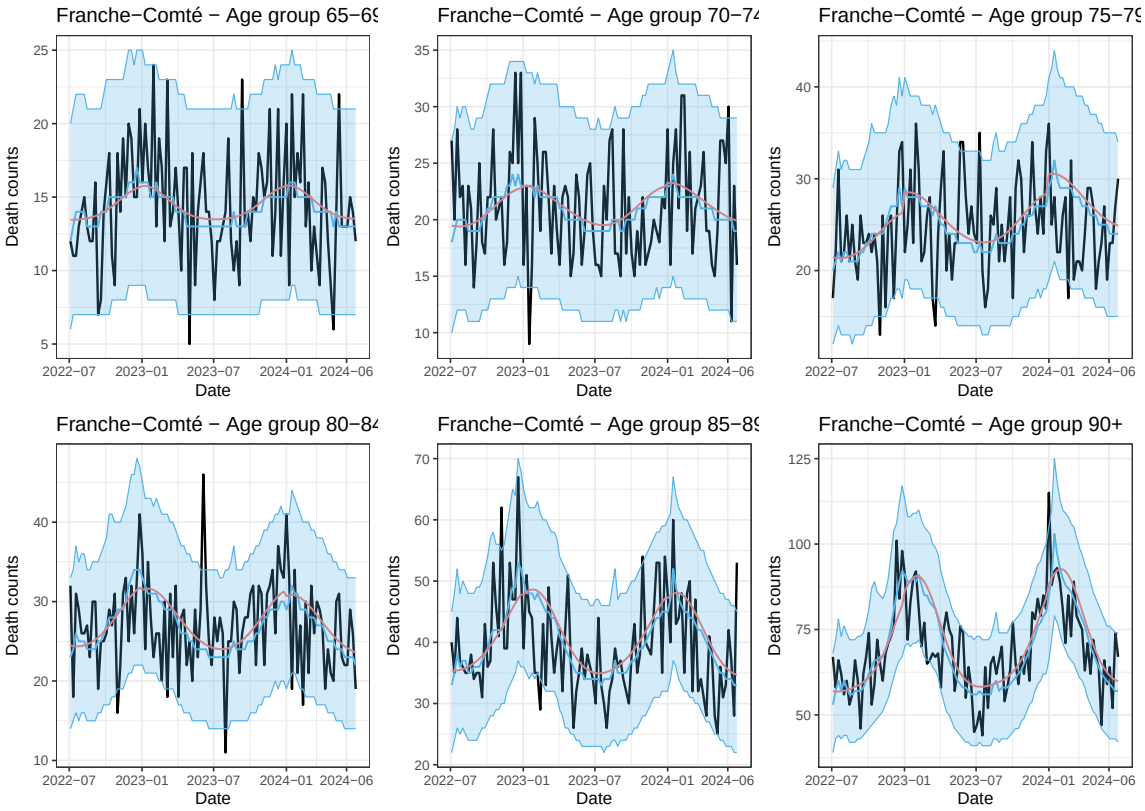

Figure D.4: Franche-Comté (FRC2).

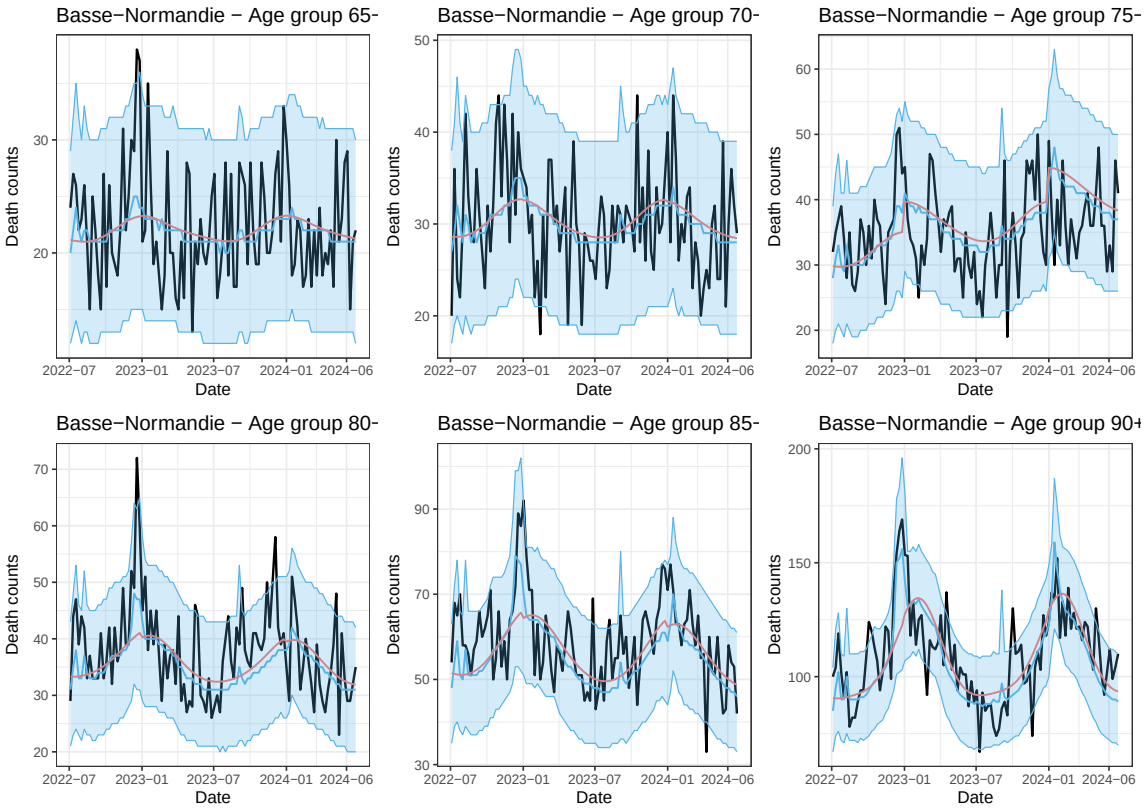

Figure D.5: Basse-Normandie (FRD1).

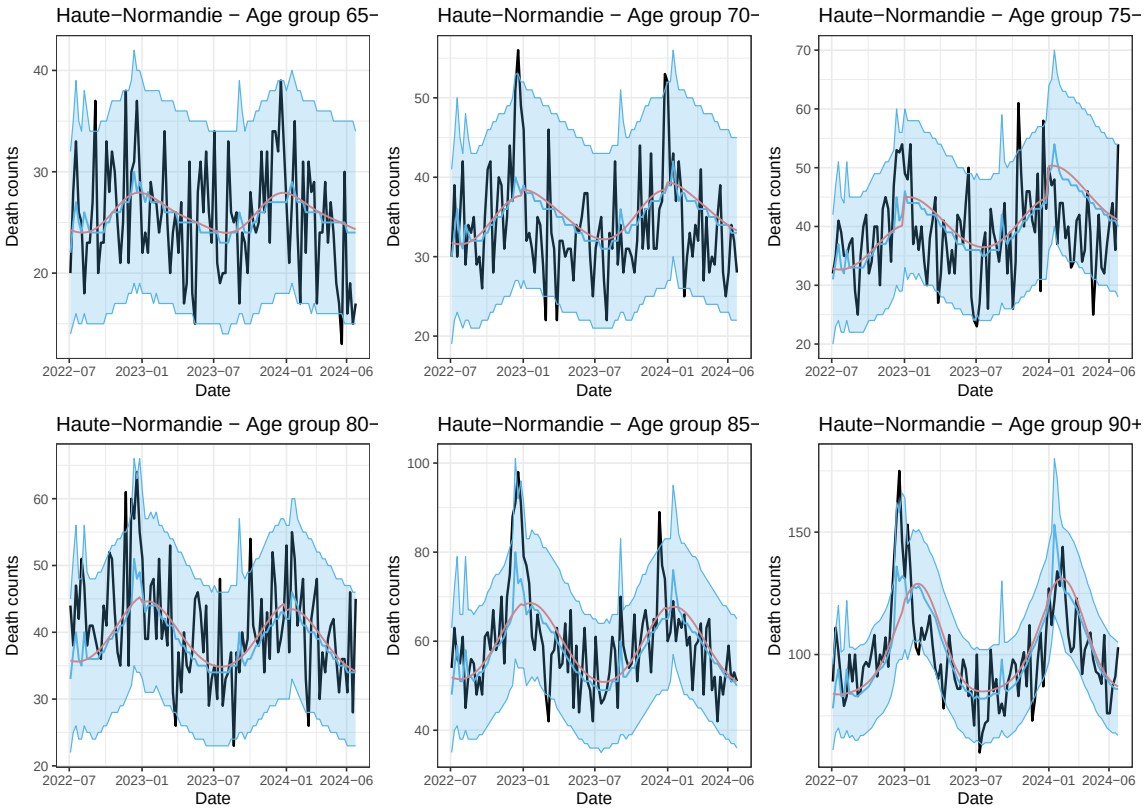

Figure D.6: Haute-Normandie (FRD2).

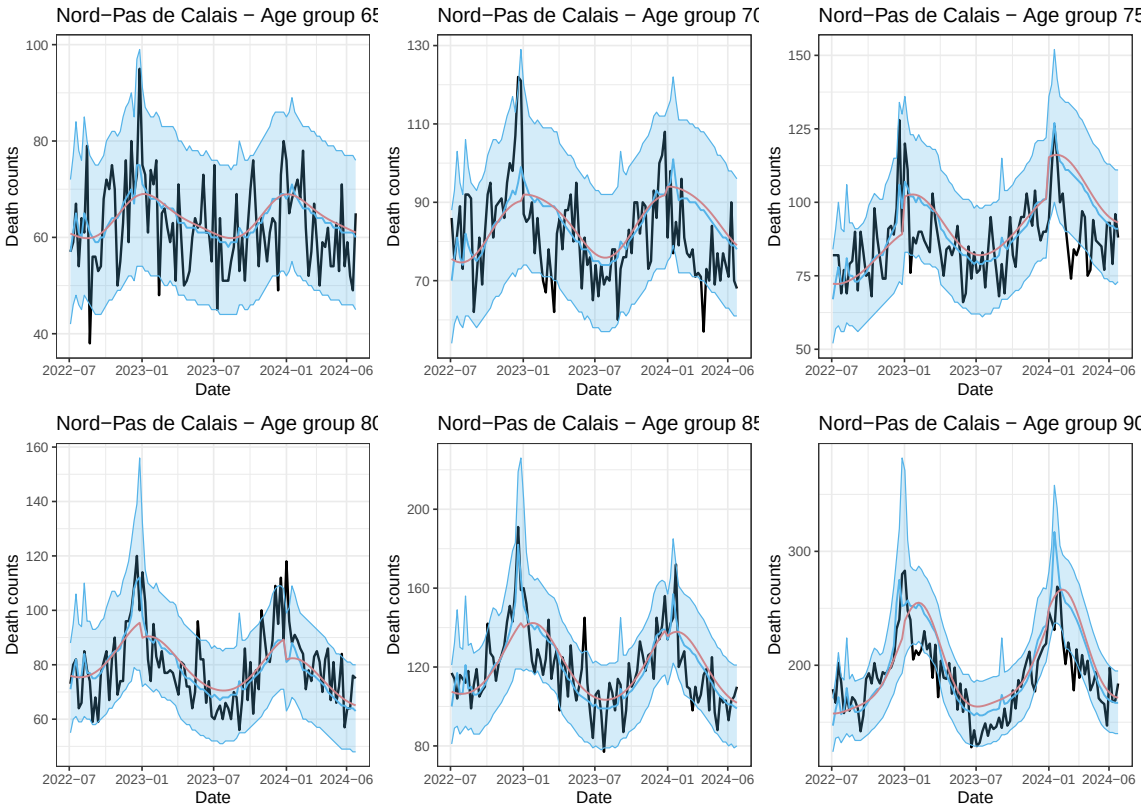

Figure D.7: Nord-Pas de Calais (FRE1).

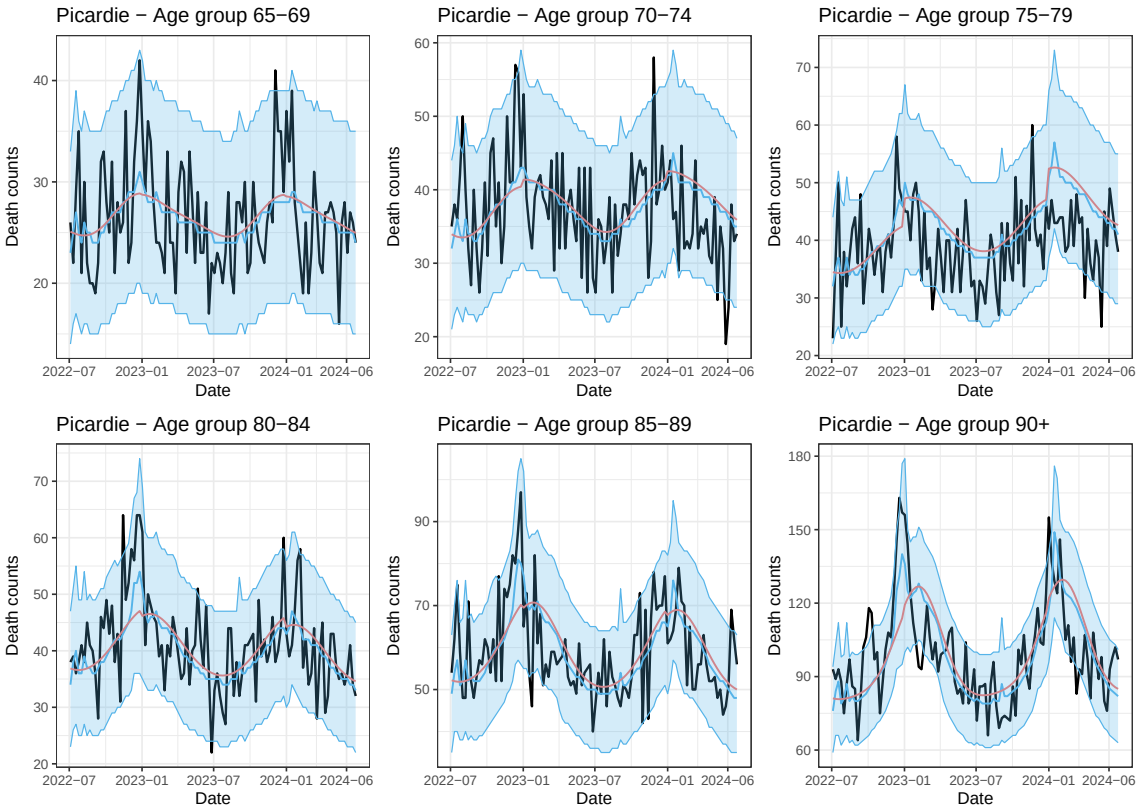

Figure D.8: Picardie (FRE2).

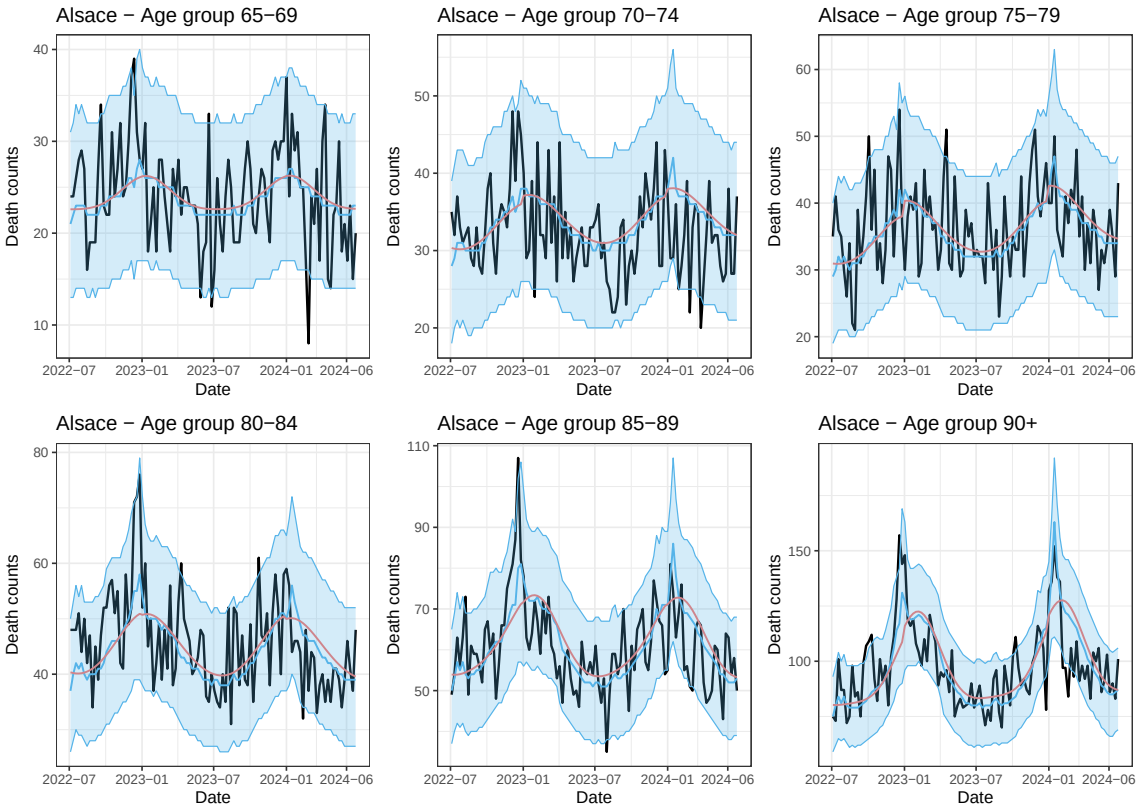

Figure D.9: Alsace (FRF1).

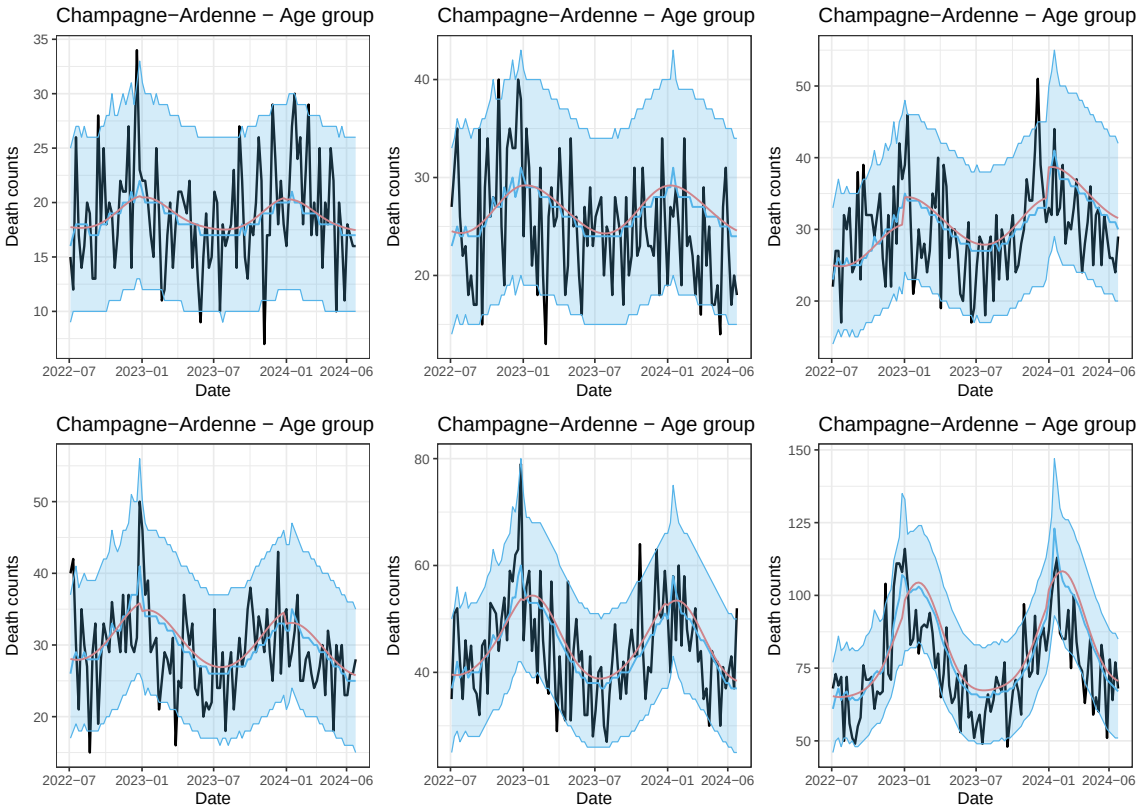

Figure D.10: Champagne-Ardenne (FRF2).

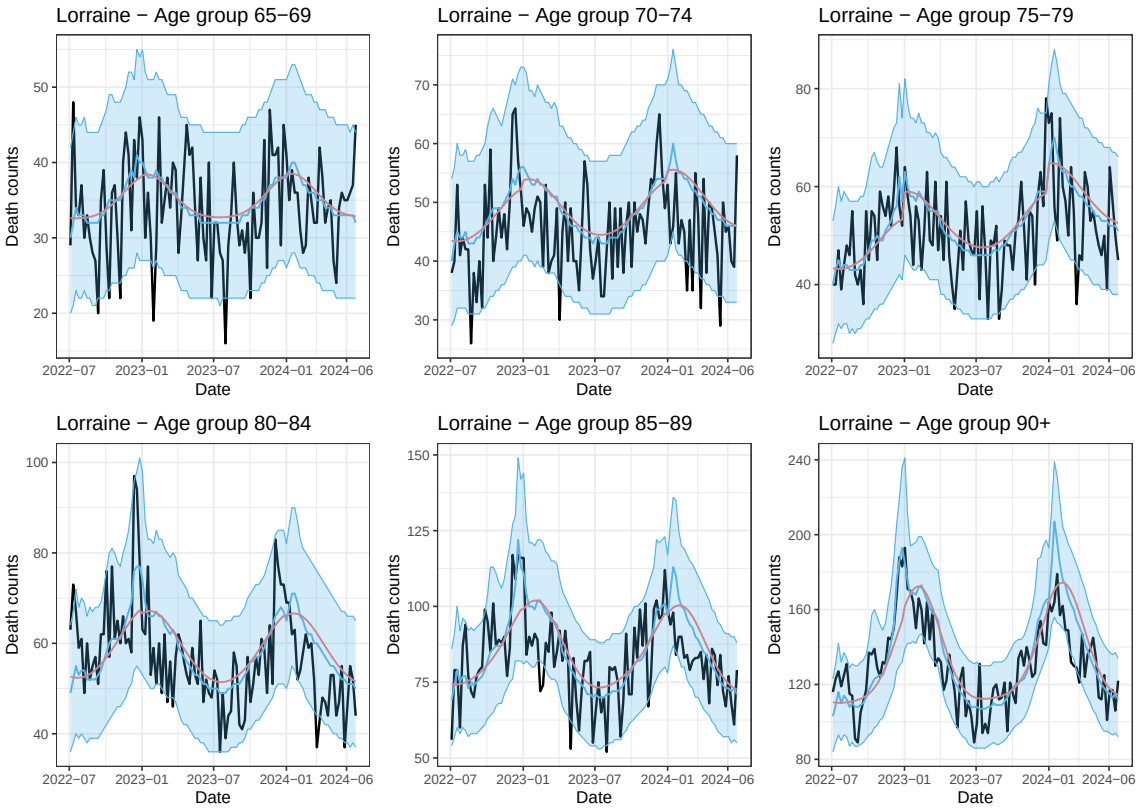

Figure D.11: Lorraine (FRF3).

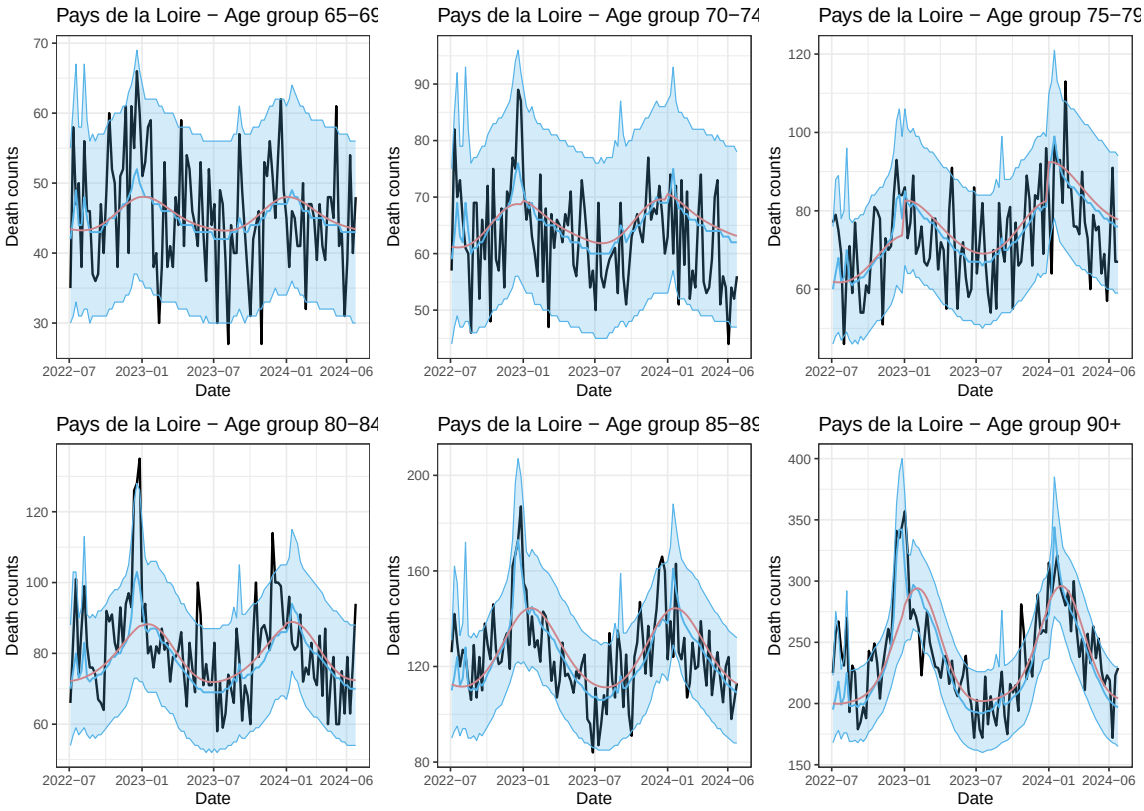

Figure D.12: Pays de la Loire (FRG0).

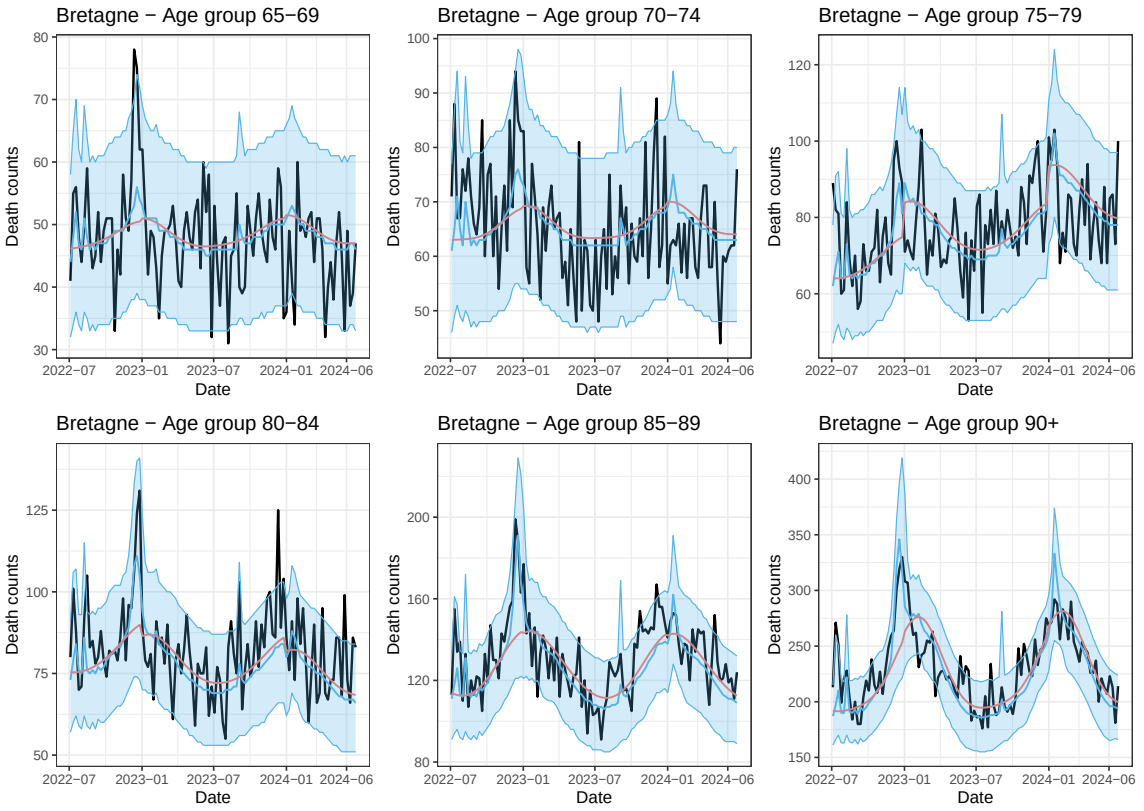

Figure D.13: Bretagne (FRH0).

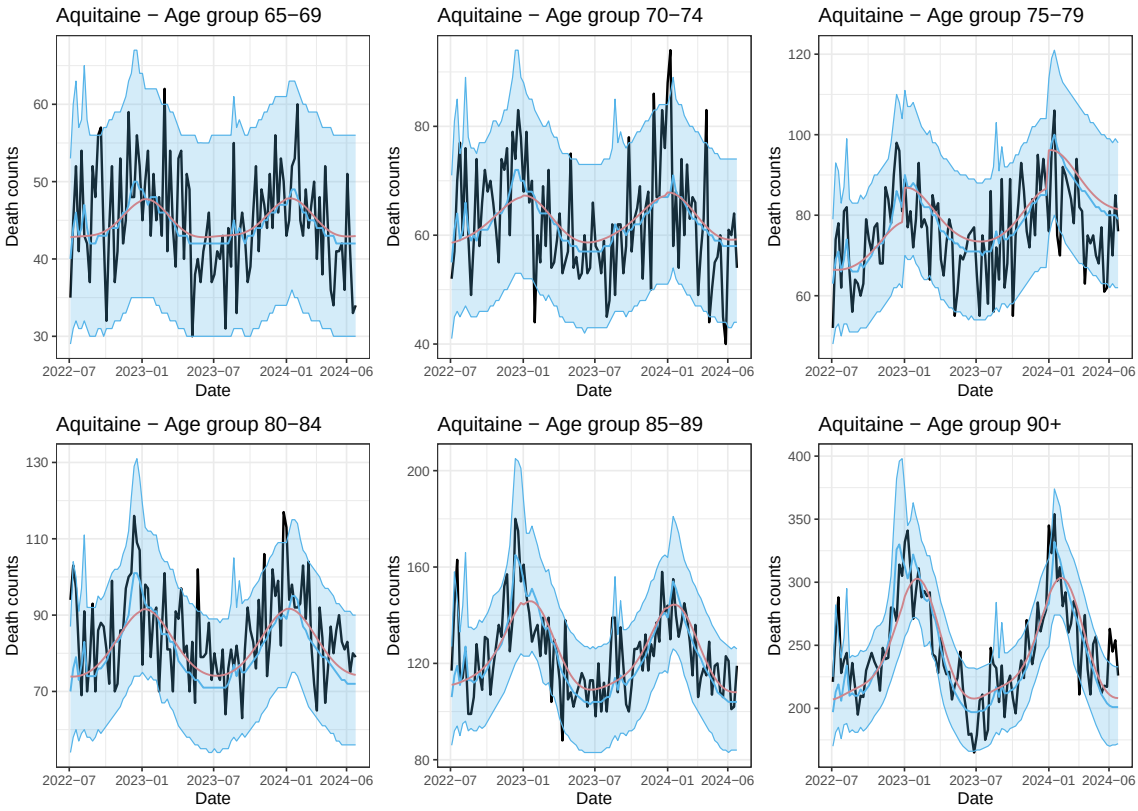

Figure D.14: Aquitaine (FRI1).

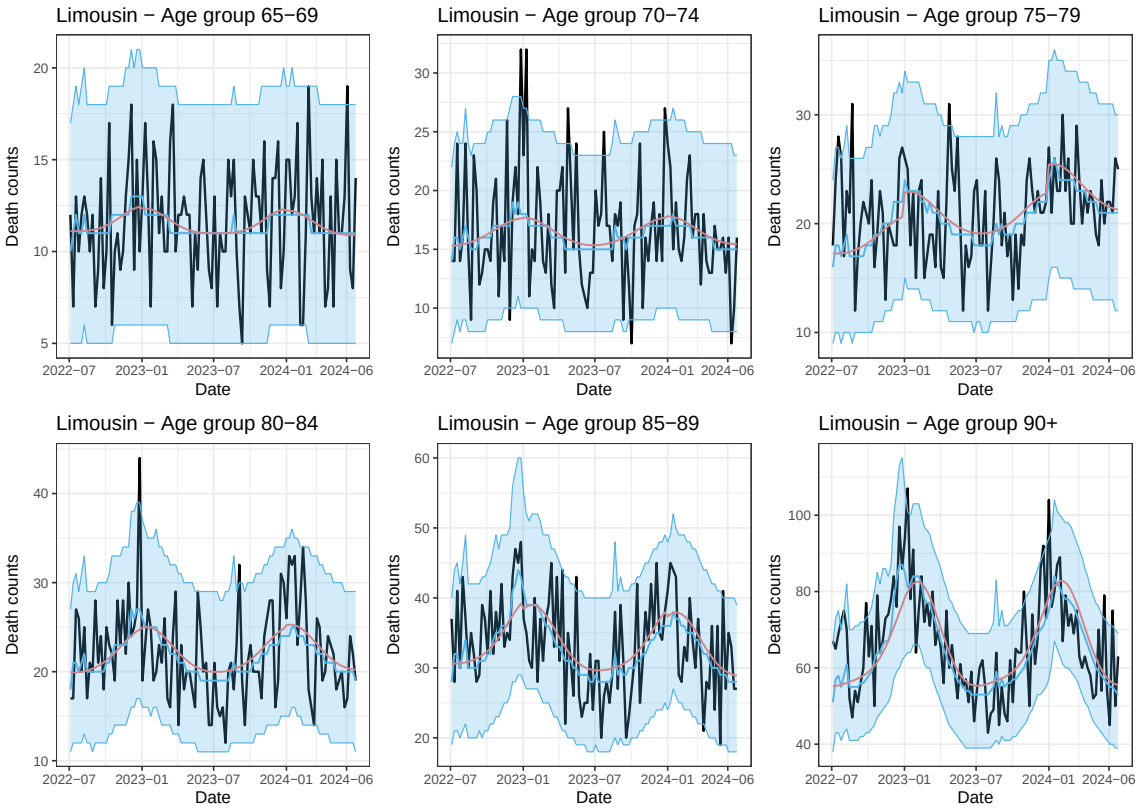

Figure D.15: Limousin (FRI2).

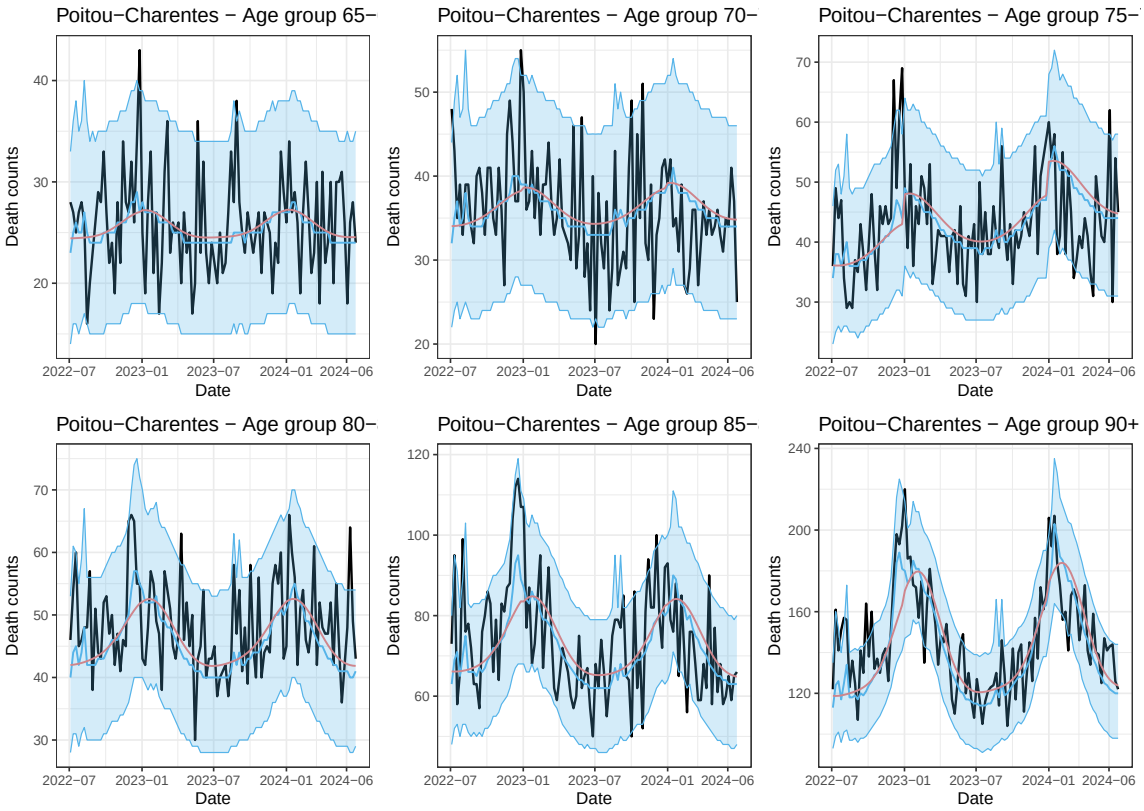

Figure D.16: Poitou-Charentes (FRI3).

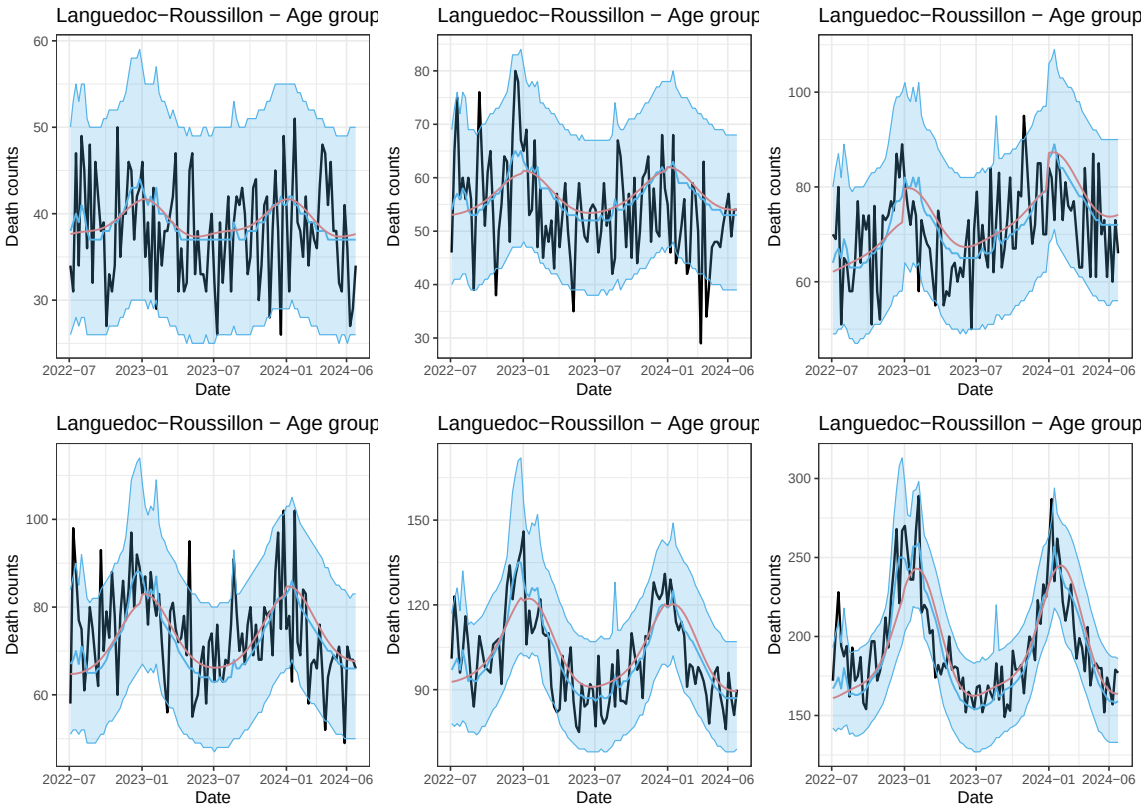

Figure D.17: Languedoc-Roussillon (FRJ1).

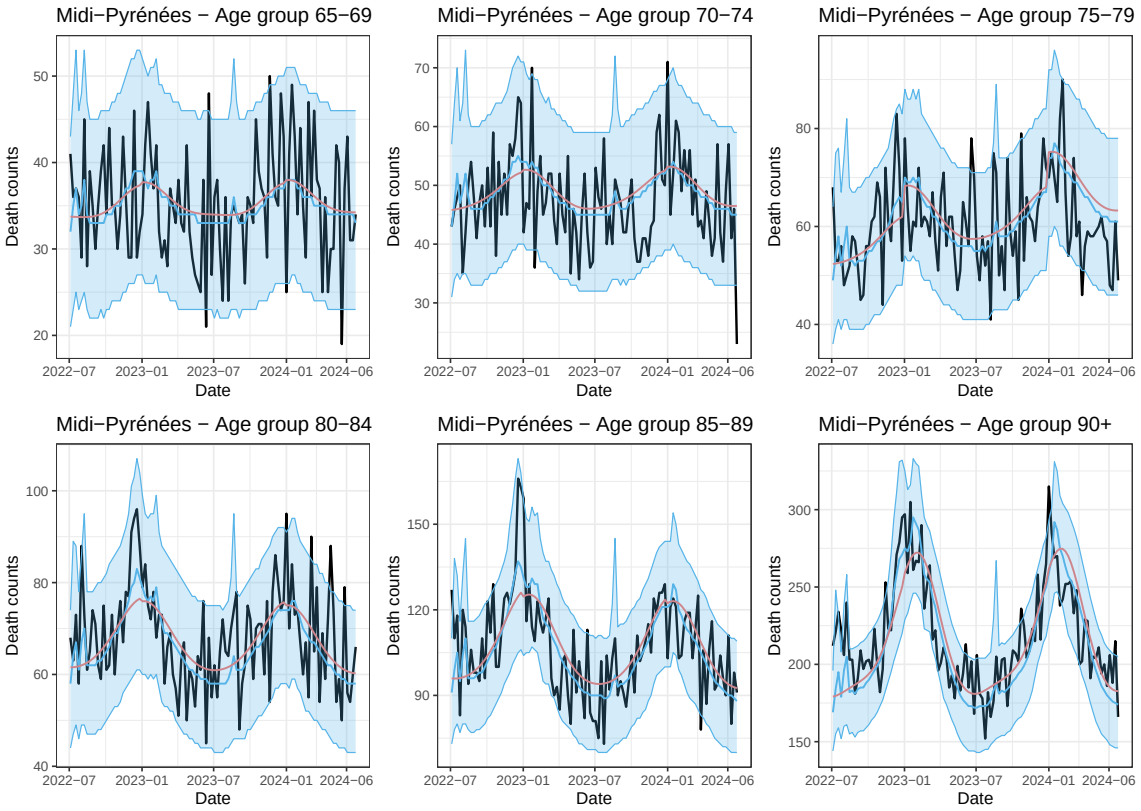

Figure D.18: Midi-Pyrénées (FRJ2).

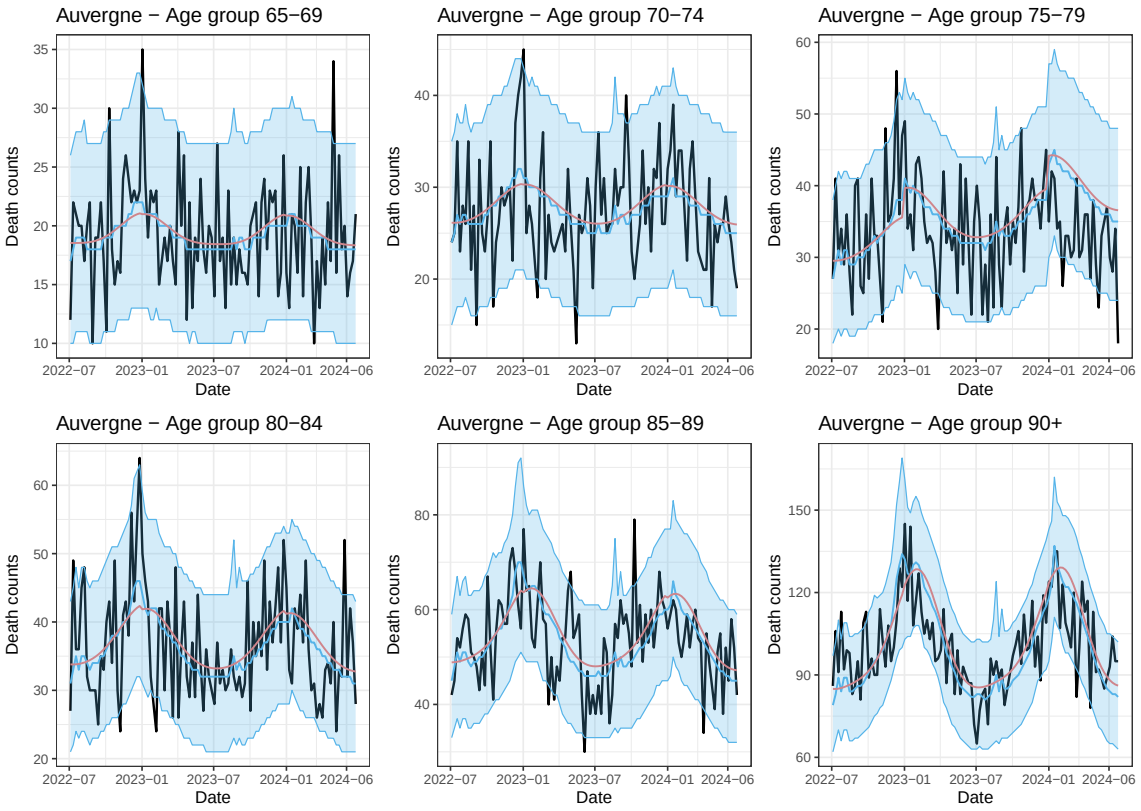

Figure D.19: Auvergne (FRK1).

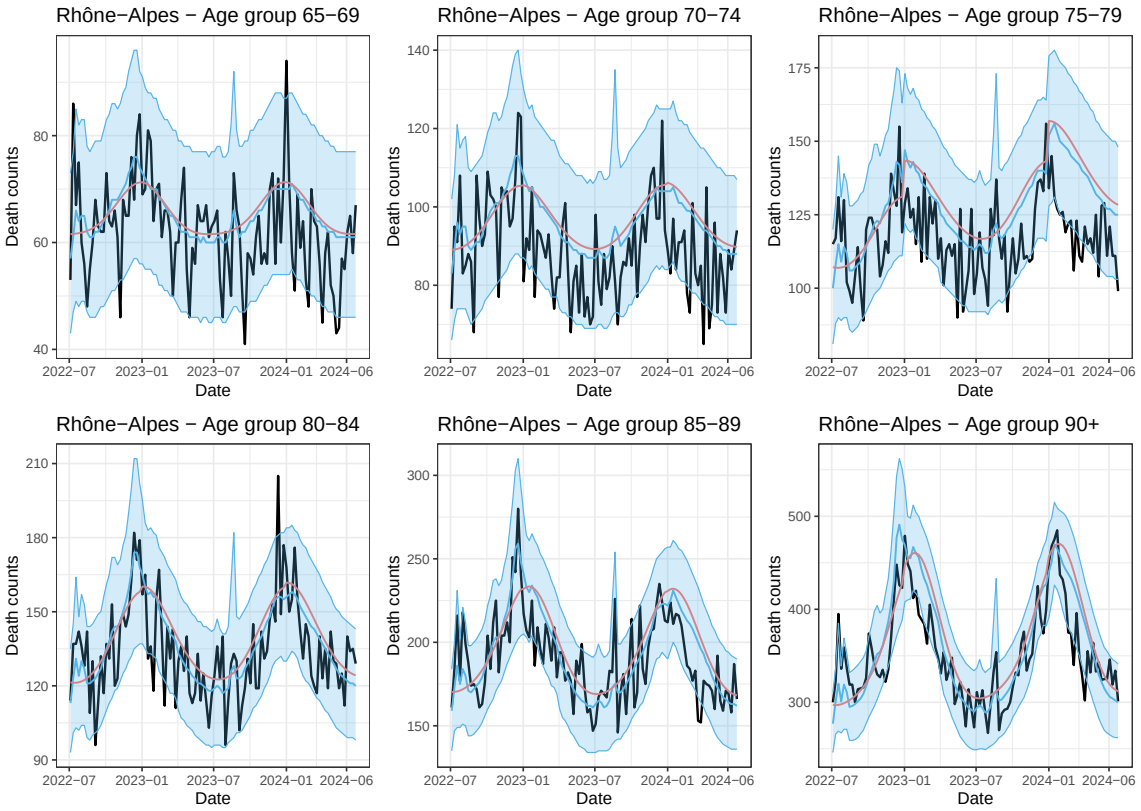

Figure D.20: Rhône-Alpes (FRK2).

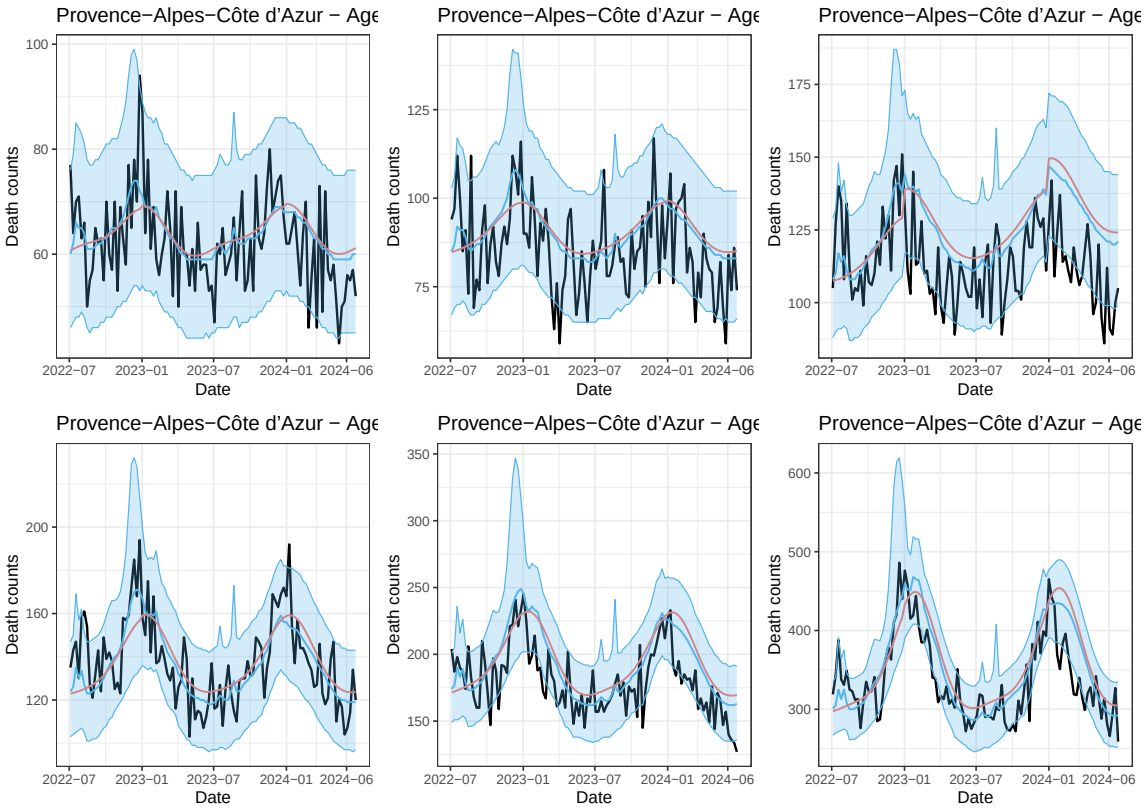

Figure D.21: Provence-Alpes-Côte d'Azur (FRL0).

E Temperature and influenza scenarios

Figure caption. Projections for the daily average temperature based on the RCP 4.5, and RCP 8.5 scenarios (left panel), and for the weekly influenza activity per 100 inhabitants based on the proposed Bayesian stochastic SIRS model (right panel). We provide a moderate and severe incidence scenario for influenza activity using the point-wise 50% and 95% quantiles of the posterior predictive samples, respectively. Each figure below corresponds to a different French NUTS 2 region.

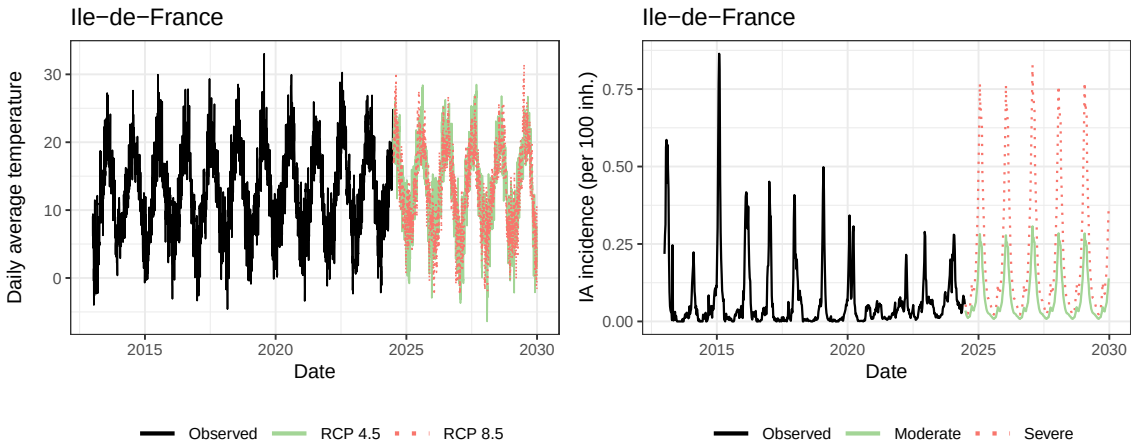

Figure E.1: Ile-de-France (FR10).

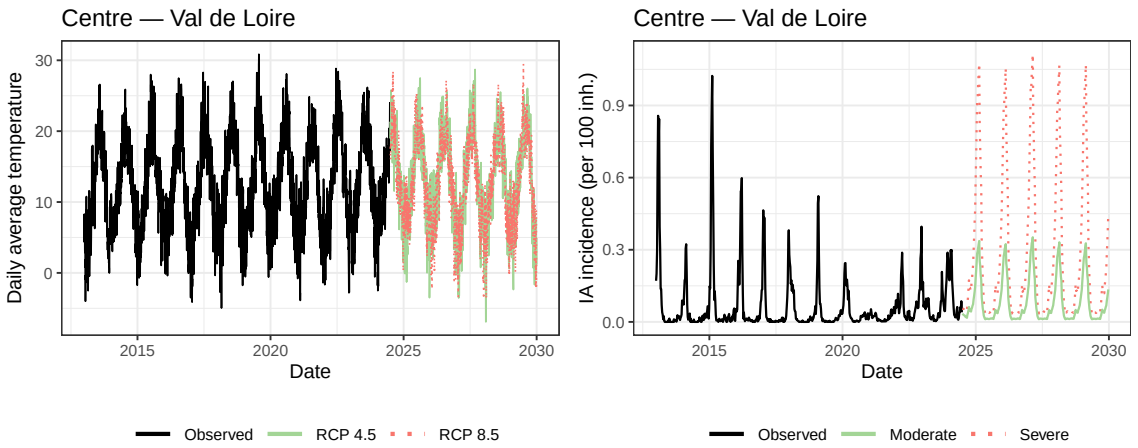

Figure E.2: Centre — Val de Loire (FRB0).

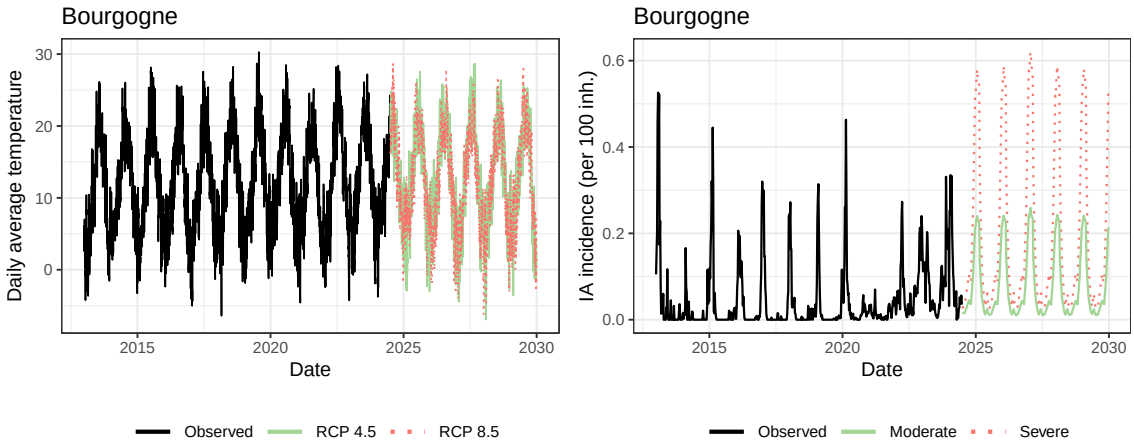

Figure E.3: Bourgogne (FRC1).

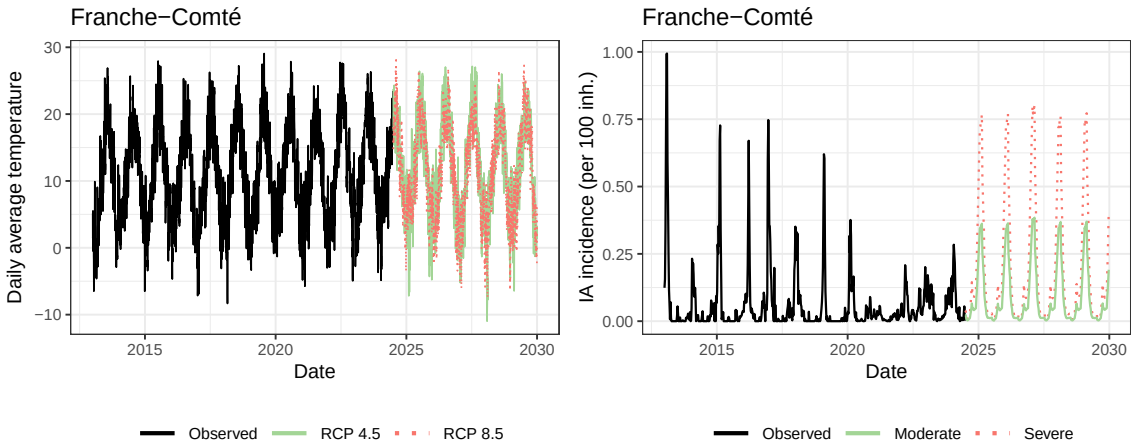

Figure E.4: Franche-Comté (FRC2).

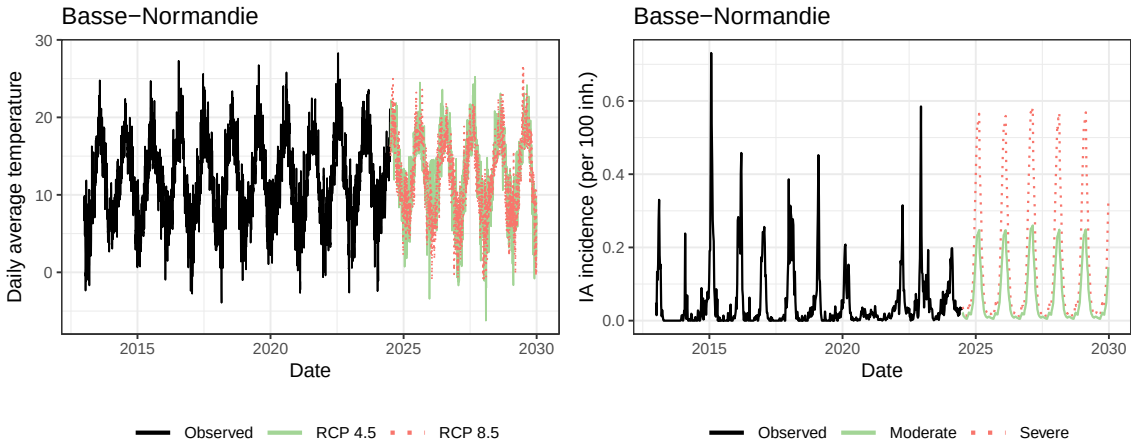

Figure E.5: Basse-Normandie (FRD1).

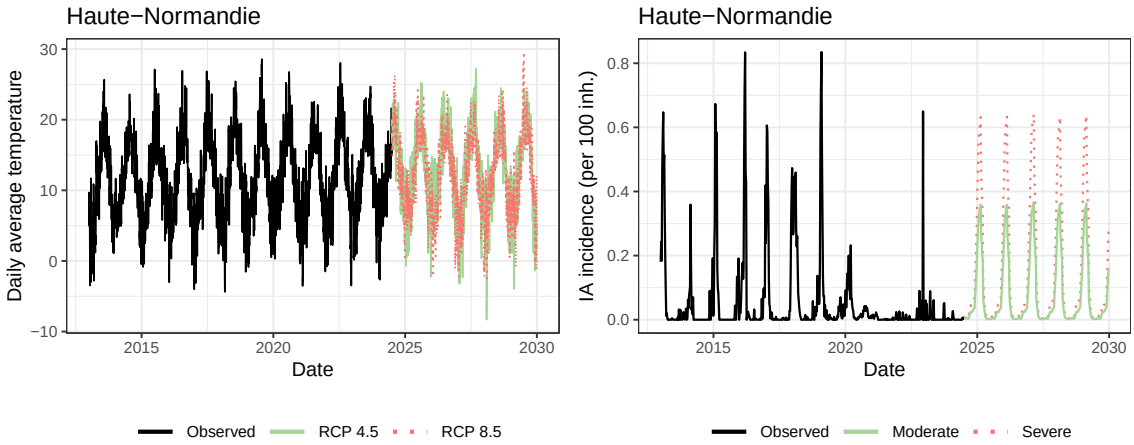

Figure E.6: Haute-Normandie (FRD2).

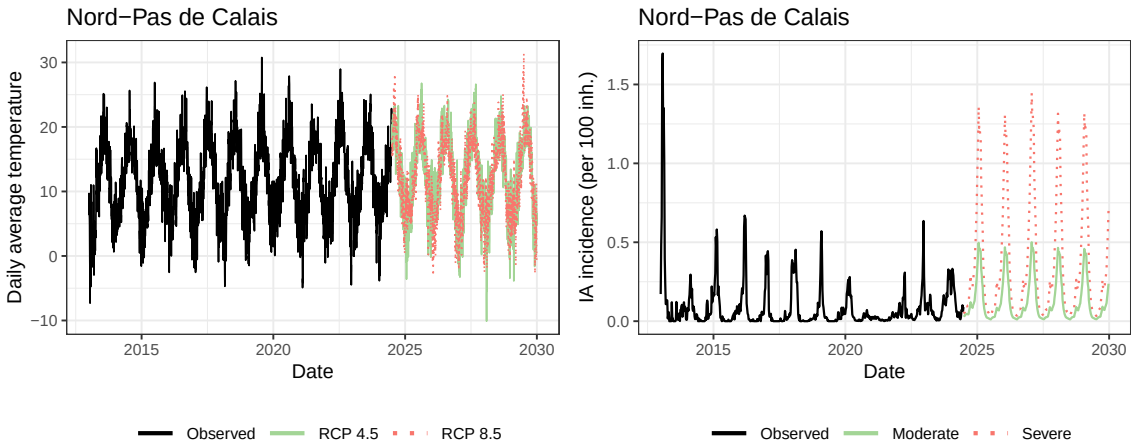

Figure E.7: Nord-Pas de Calais (FRE1).

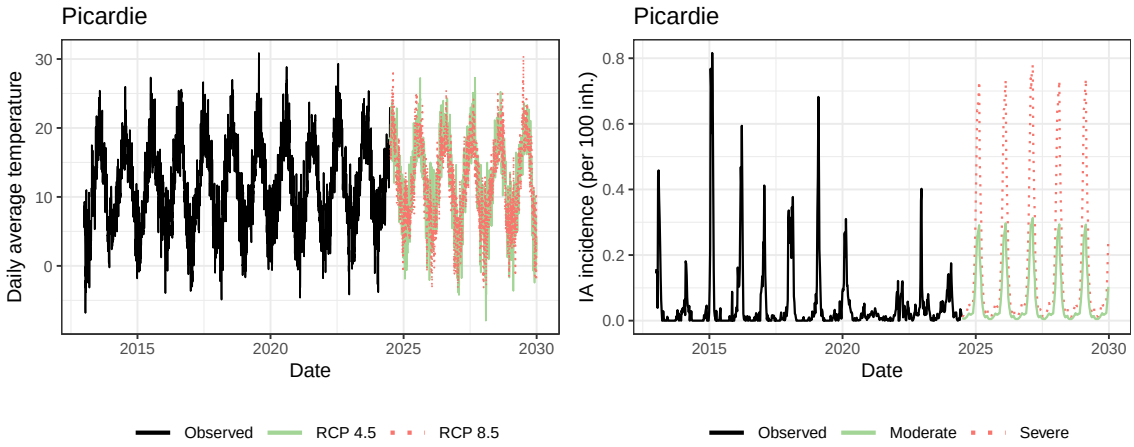

Figure E.8: Picardie (FRE2).

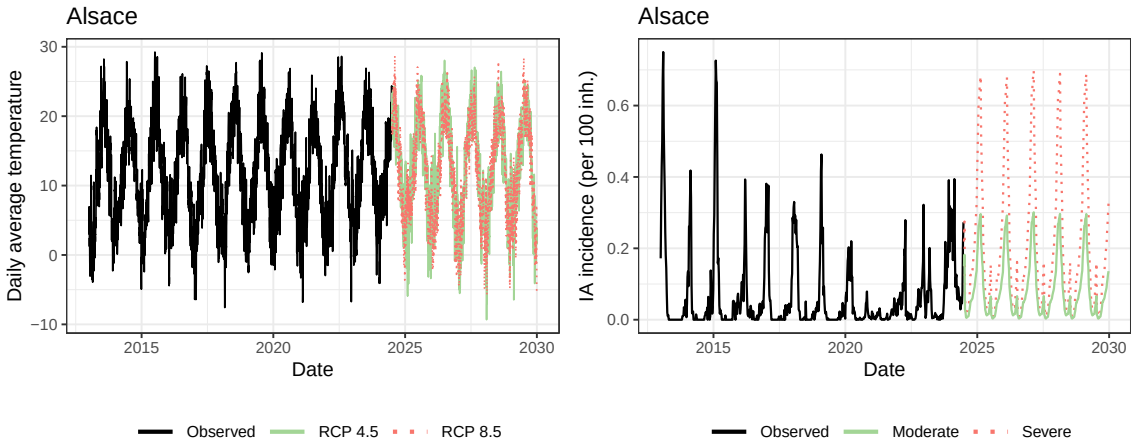

Figure E.9: Alsace (FRF1).

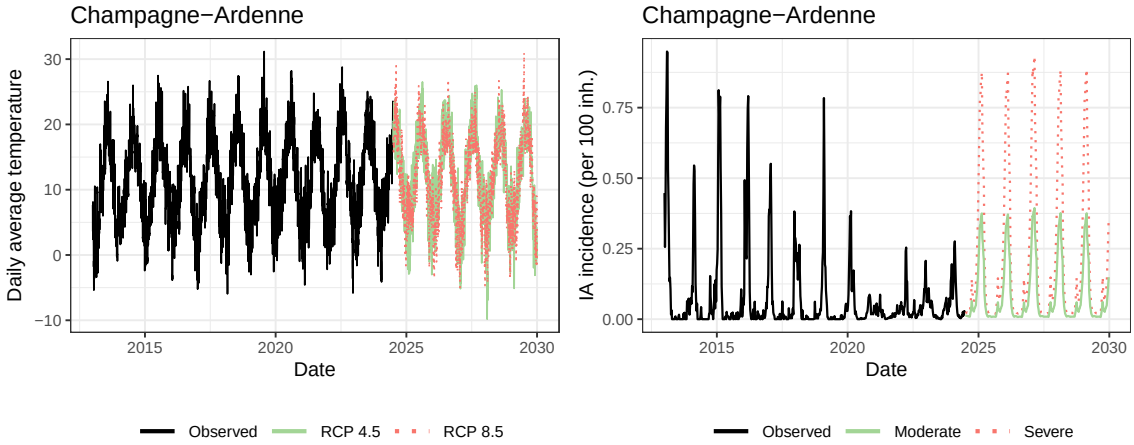

Figure E.10: Champagne-Ardenne (FRF2).

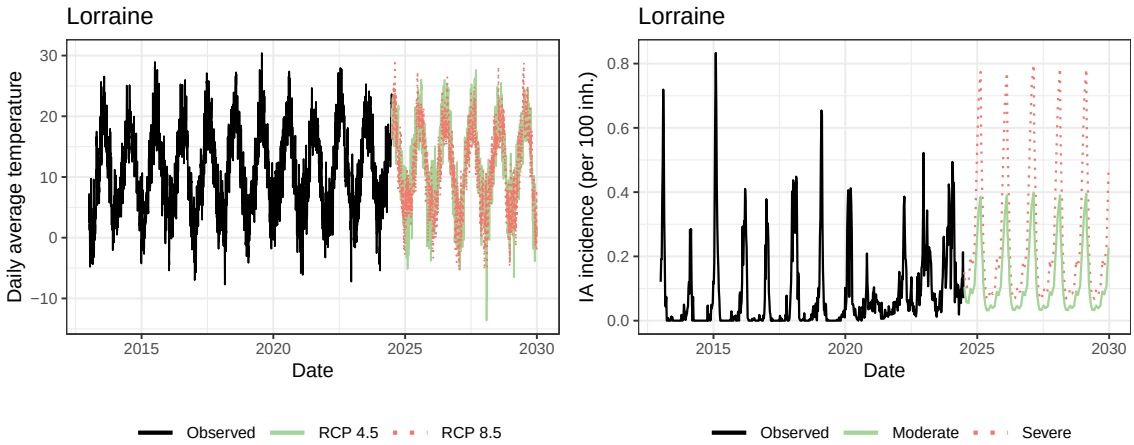

Figure E.11: Lorraine (FRF3).

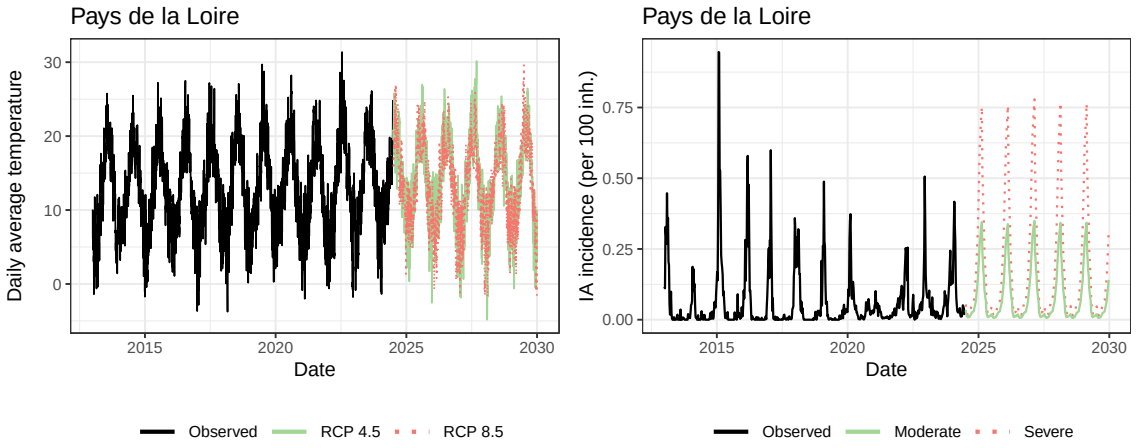

Figure E.12: Pays de la Loire (FRG0).

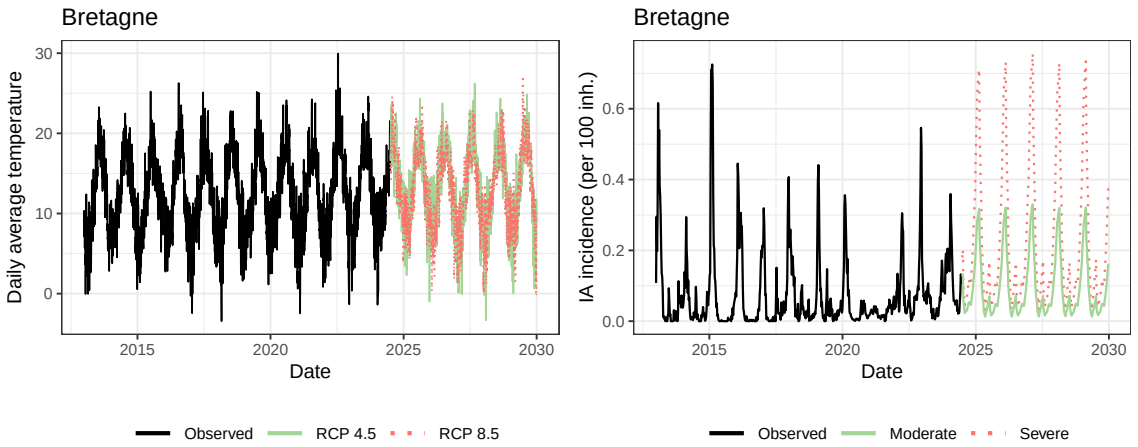

Figure E.13: Bretagne (FRH0).

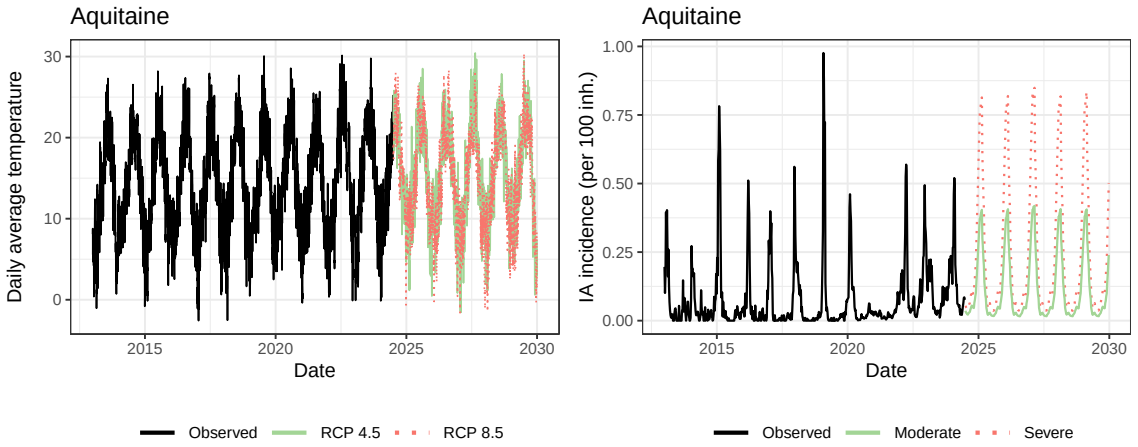

Figure E.14: Aquitaine (FRI1).

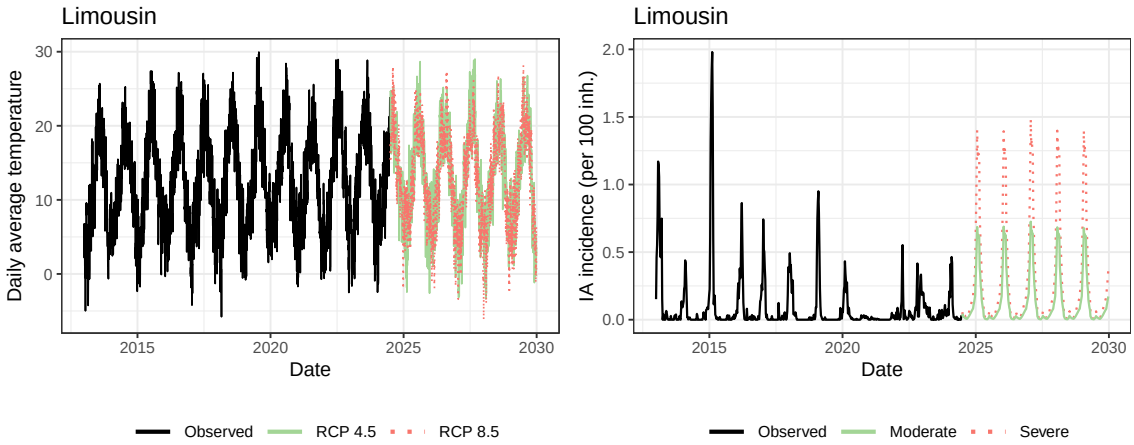

Figure E.15: Limousin (FRI2).

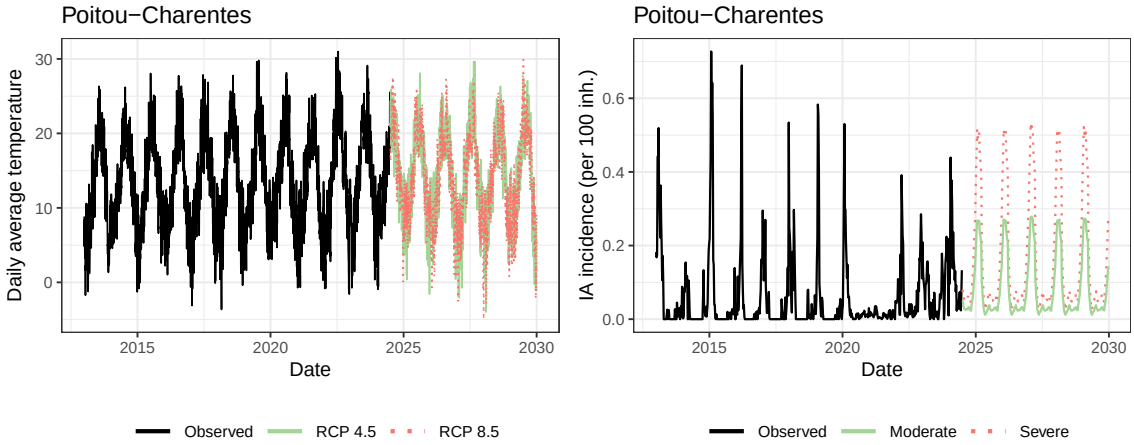

Figure E.16: Poitou-Charentes (FRI3).

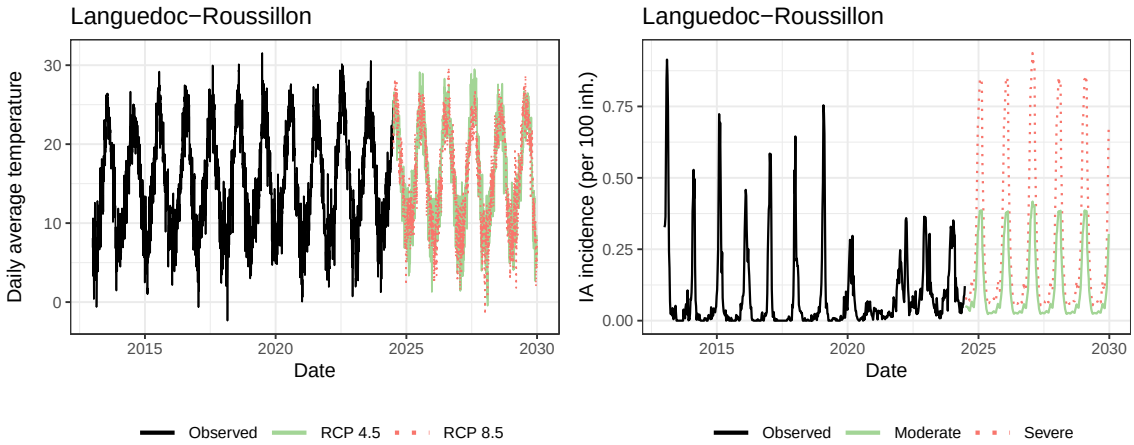

Figure E.17: Languedoc-Roussillon (FRJ1).

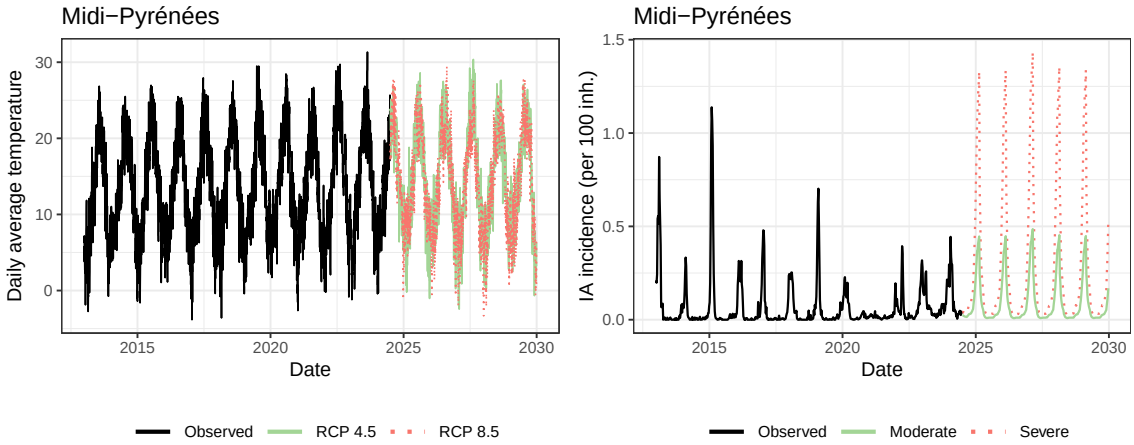

Figure E.18: Midi-Pyrénées (FRJ2).

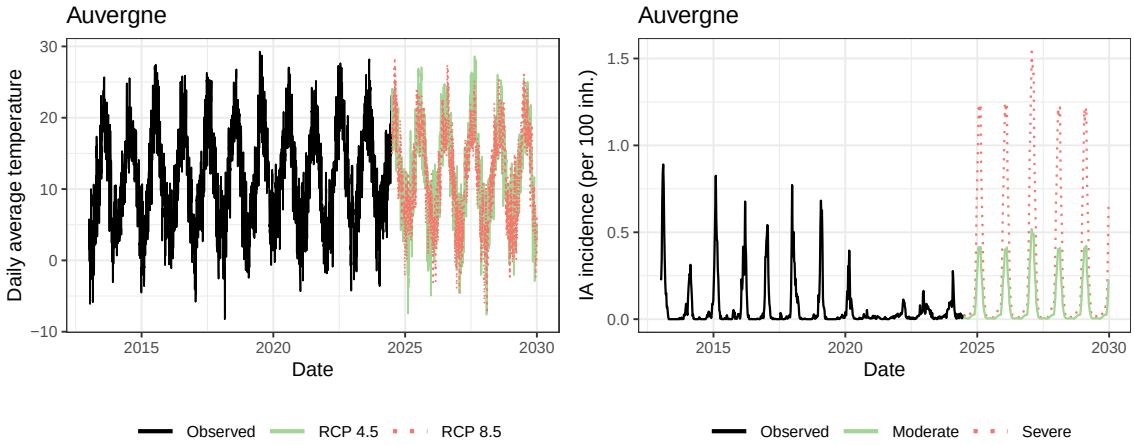

Figure E.19: Auvergne (FRK1).

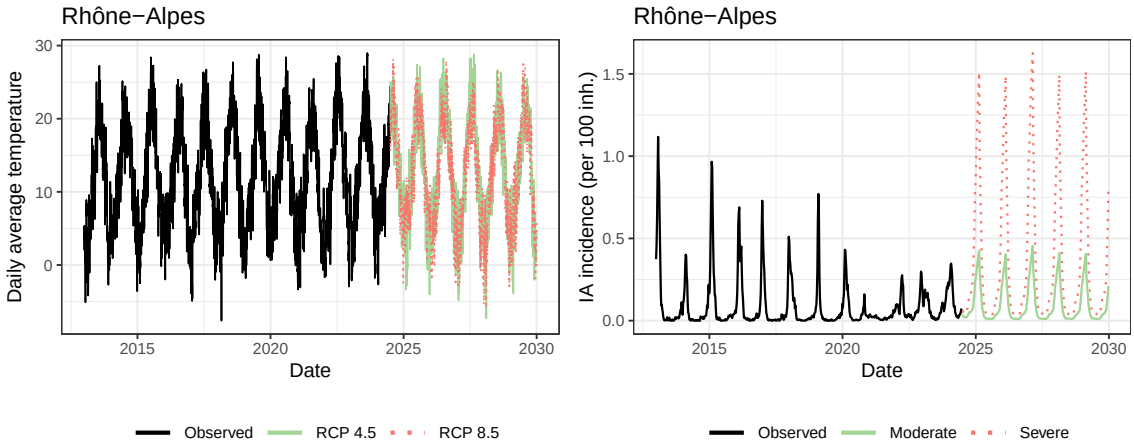

Figure E.20: Rhône-Alpes (FRK2).

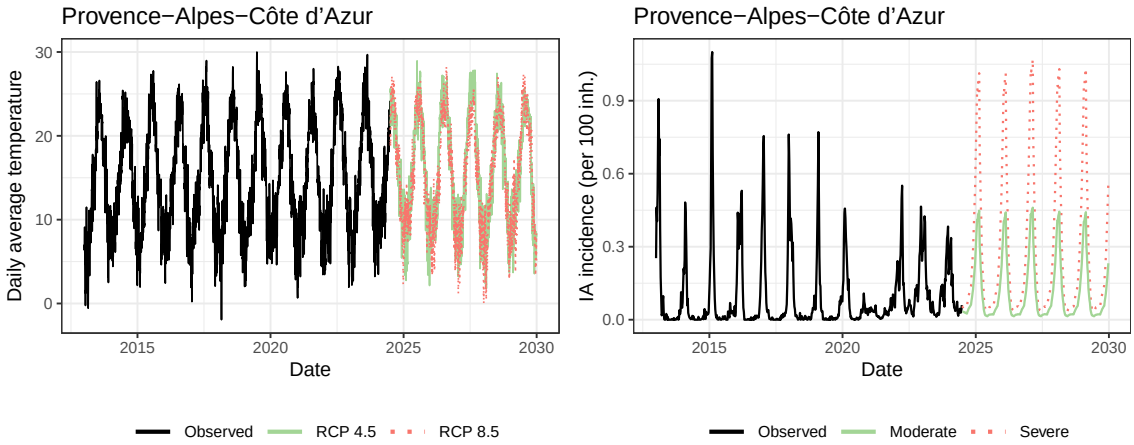

Figure E.21: Provence-Alpes-Côte d'Azur (FRL0).

F Scenario-based mortality forecasts

Figure caption. Based on the moderate influenza / RCP 4.5 and the severe influenza / RCP 4.5 scenario, we present 95% prediction intervals for the weekly death rates per 1 000 person-years in the French NUTS 2 regions for the age groups 65-69, 70-74, 75-79 (top panels), and 80-84, 85-89, and 90+ (top panels). The predictions range from the 27th ISO week of 2024 to the 52nd ISO week of 2029. The intervals take into account parameter, spatial, state and Poisson uncertainty based on 25 000 bootstrap samples. The black line depicts the observed death rates per 1 000 person-years, from the first ISO week of 2013 to the 26th ISO week of 2024. Each figure below corresponds to a different French NUTS 2 region.

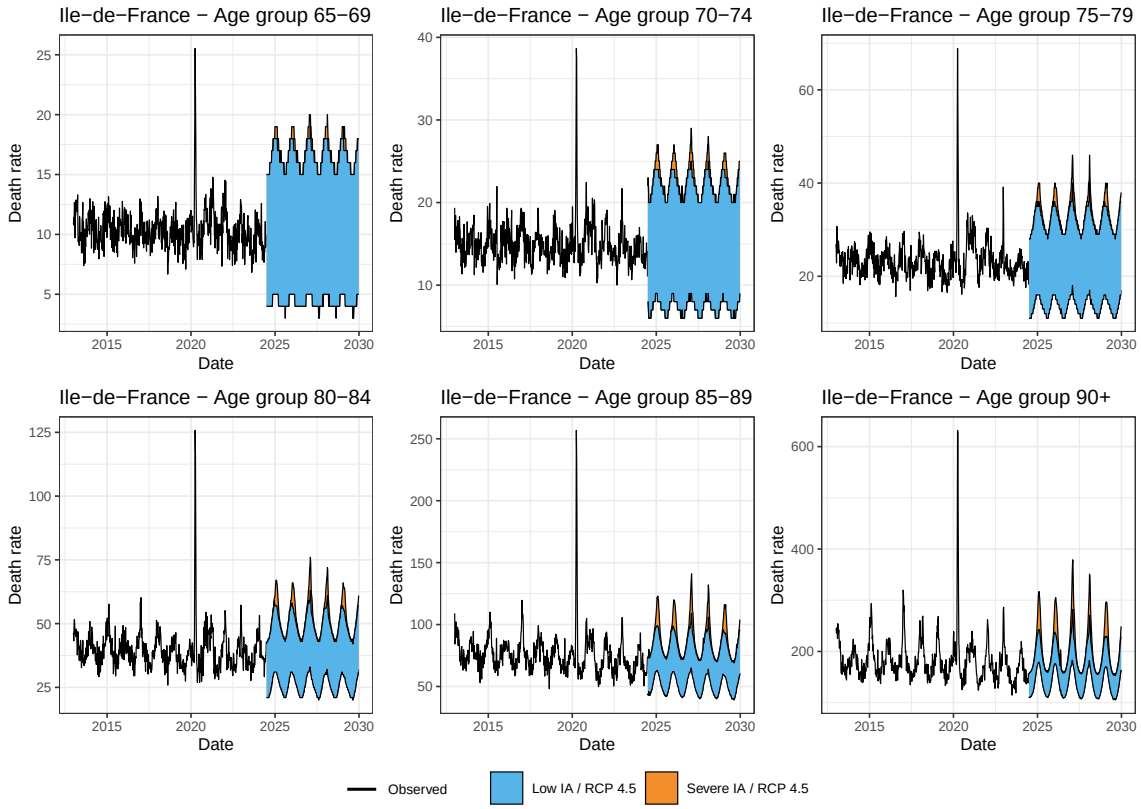

Figure F.1: Ile-de-France (FR10).

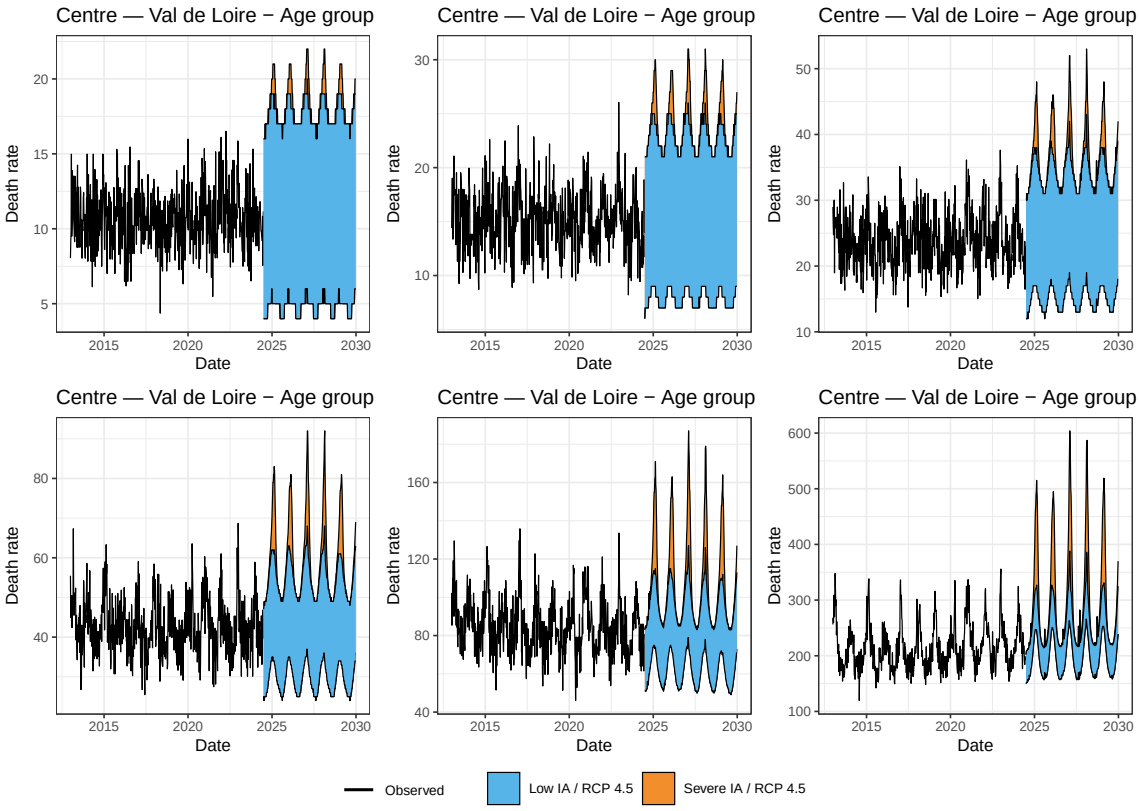

Figure F.2: Centre — Val de Loire (FRB0).

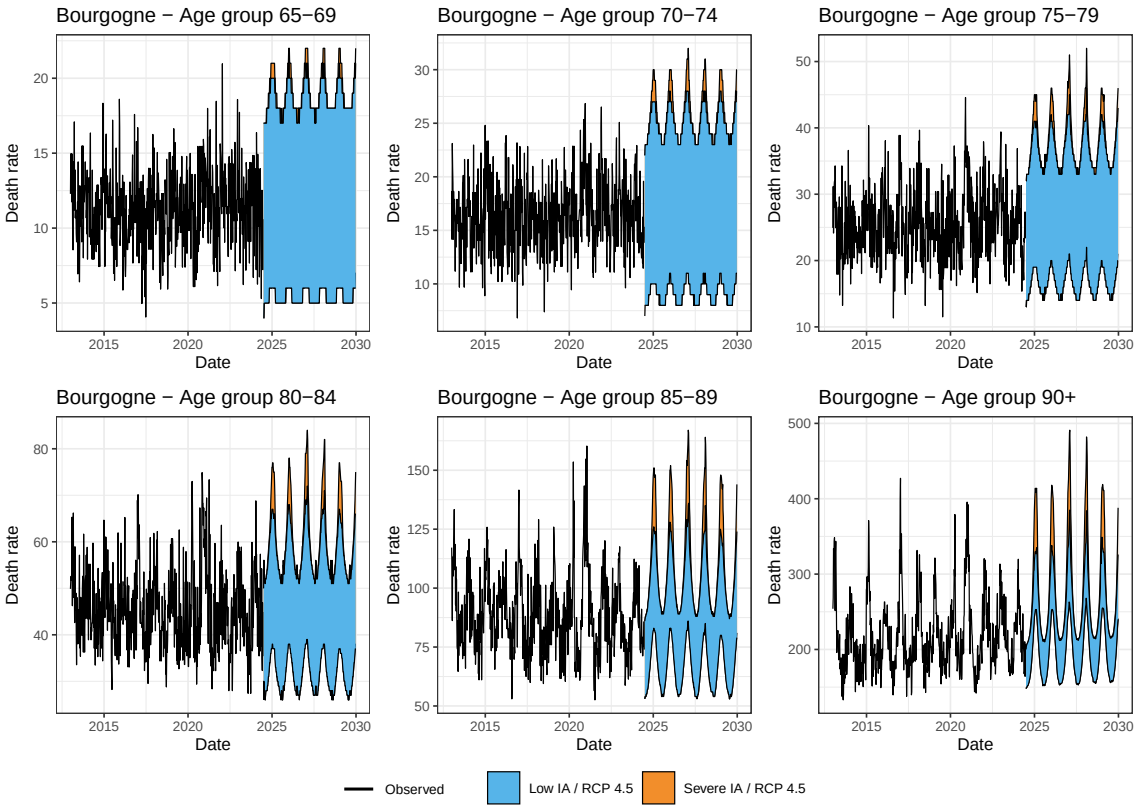

Figure F.3: Bourgogne (FRC1).

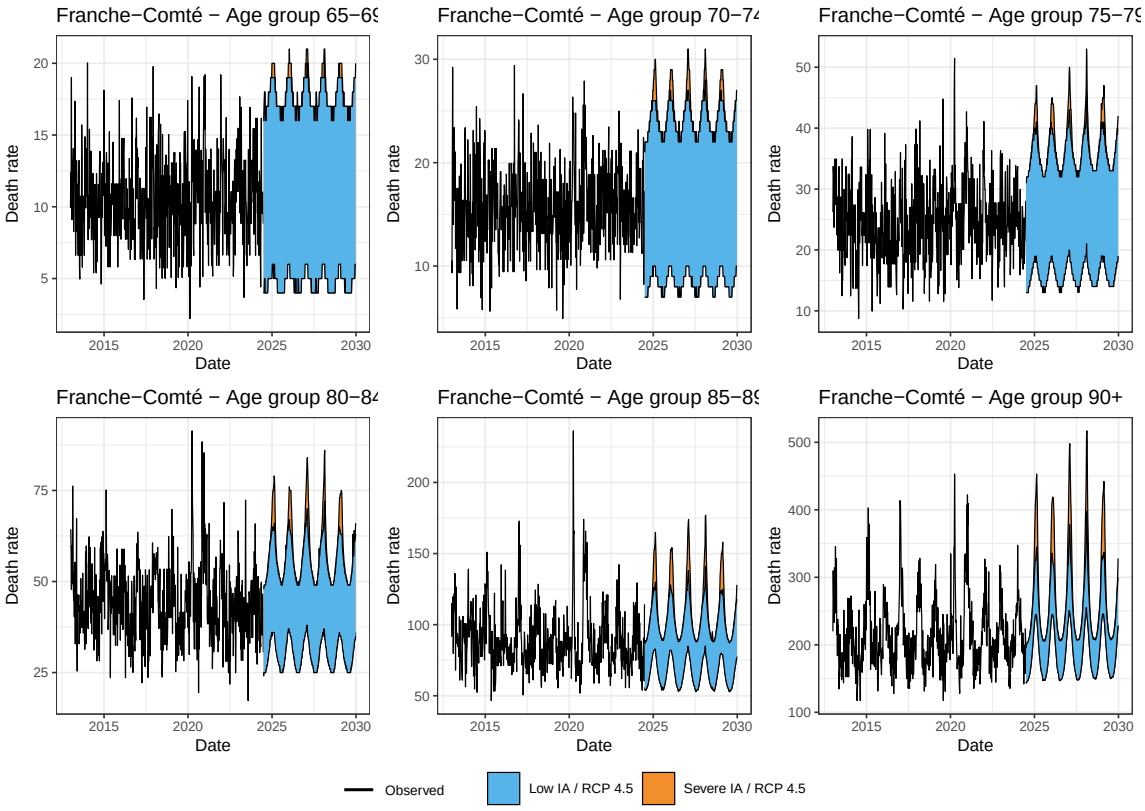

Figure F.4: Franche-Comté (FRC2).

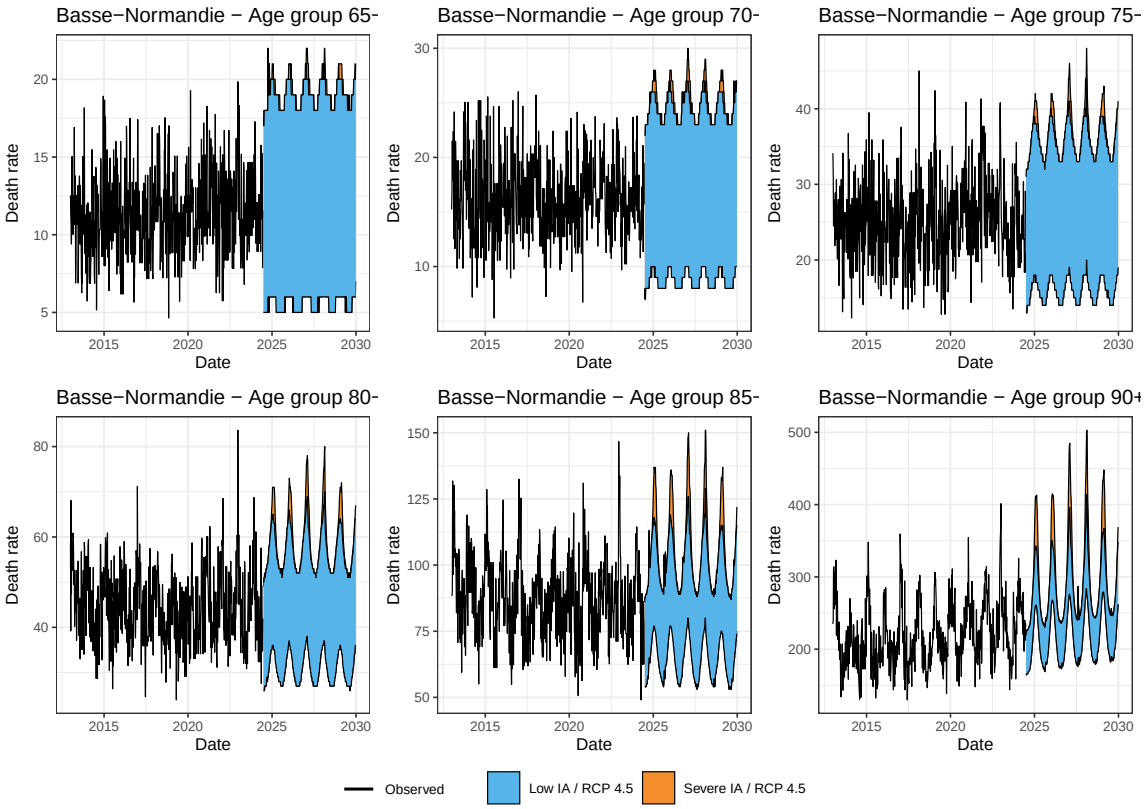

Figure F.5: Basse-Normandie (FRD1).

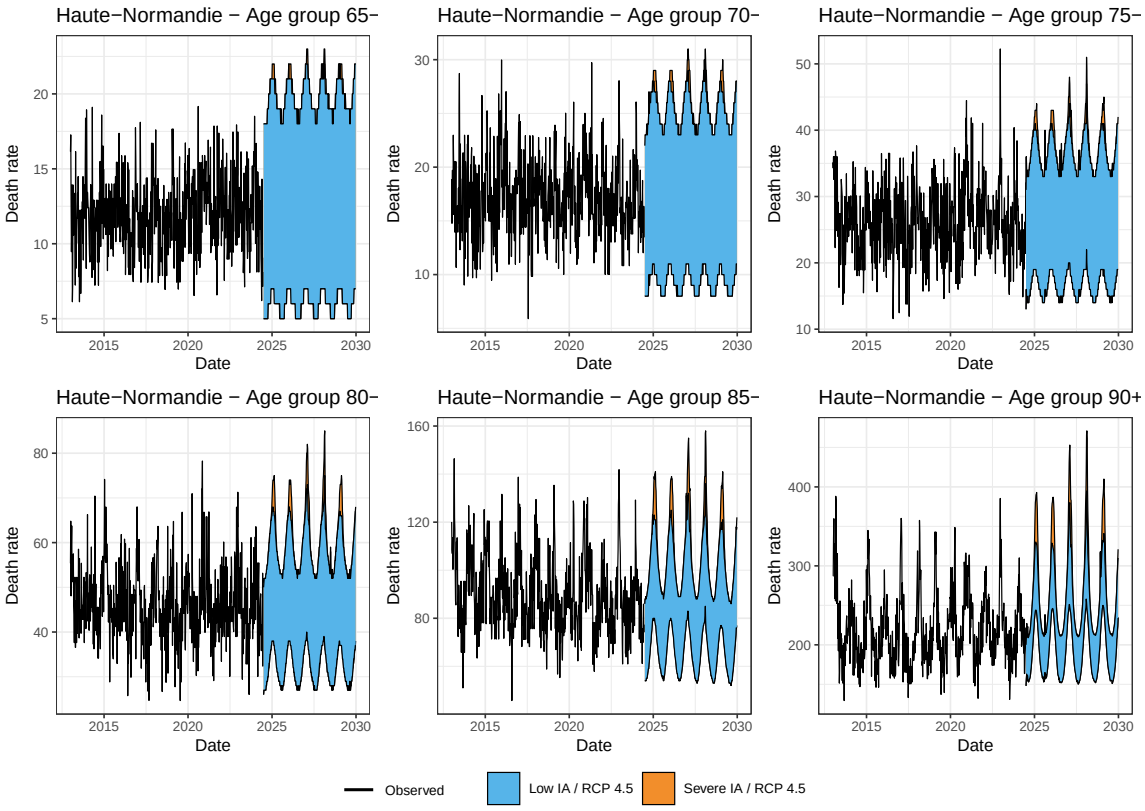

Figure F.6: Haute-Normandie (FRD2).

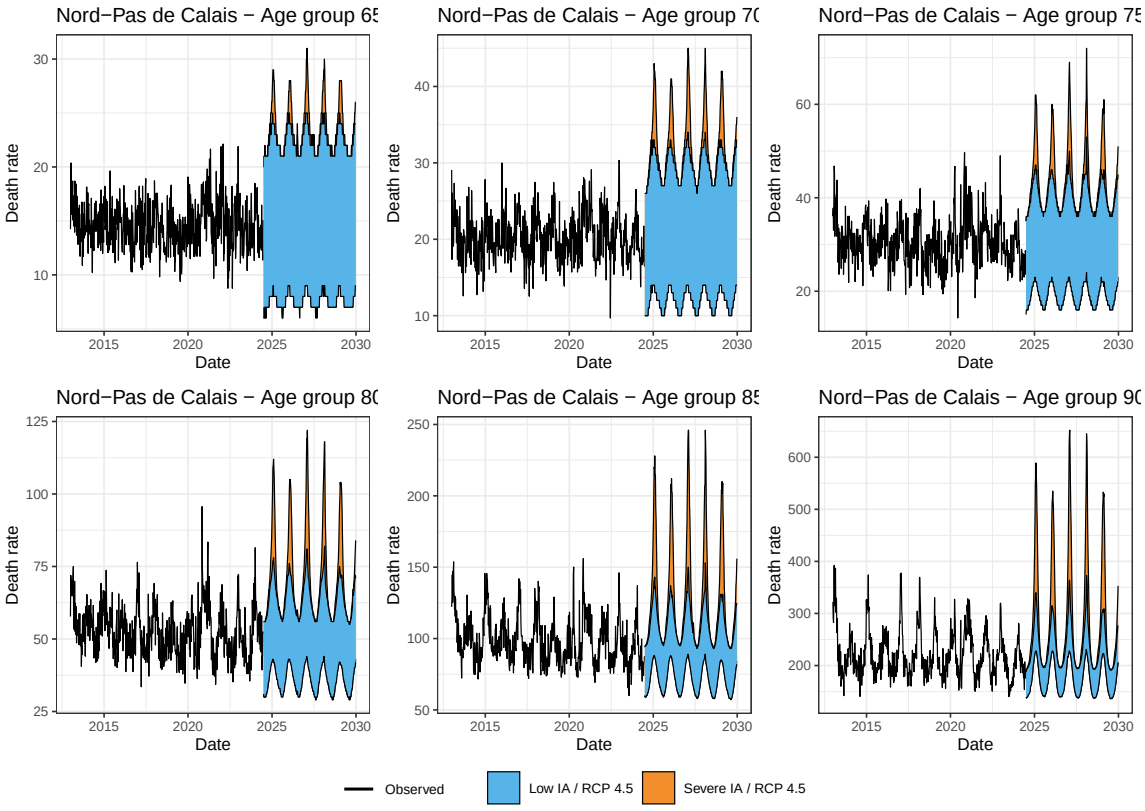

Figure F.7: Nord-Pas de Calais (FRE1).

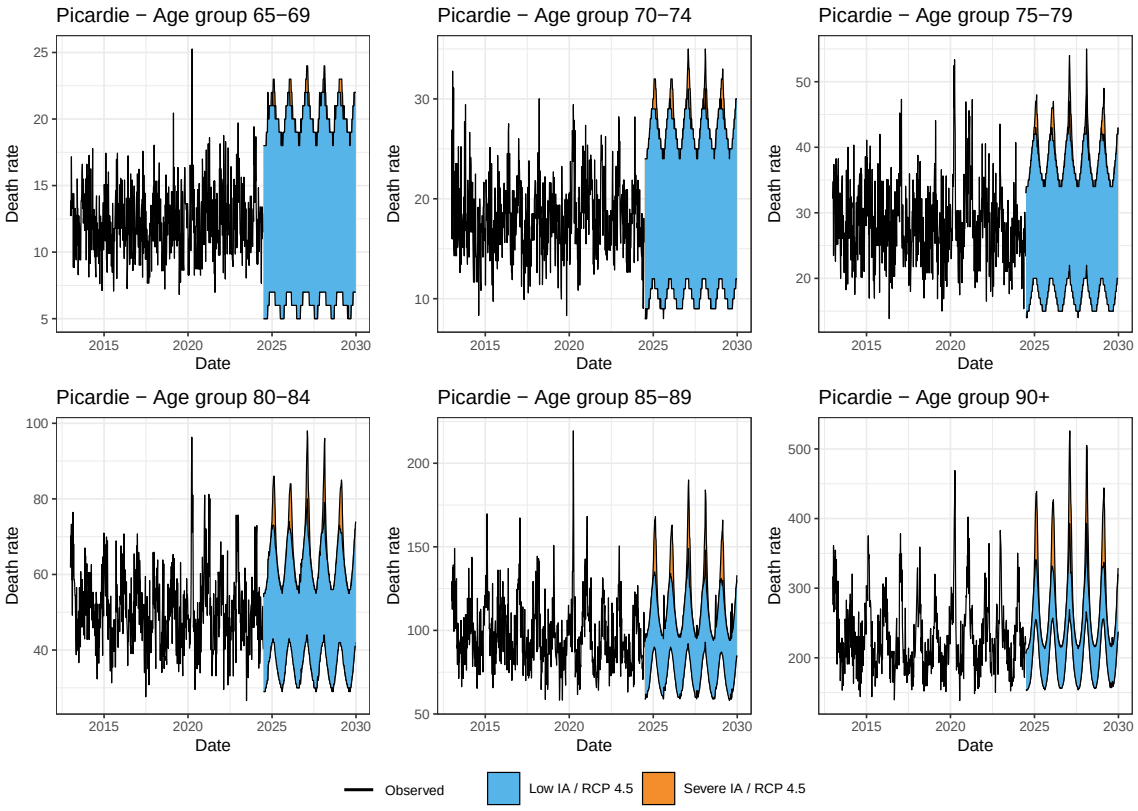

Figure F.8: Picardie (FRE2).

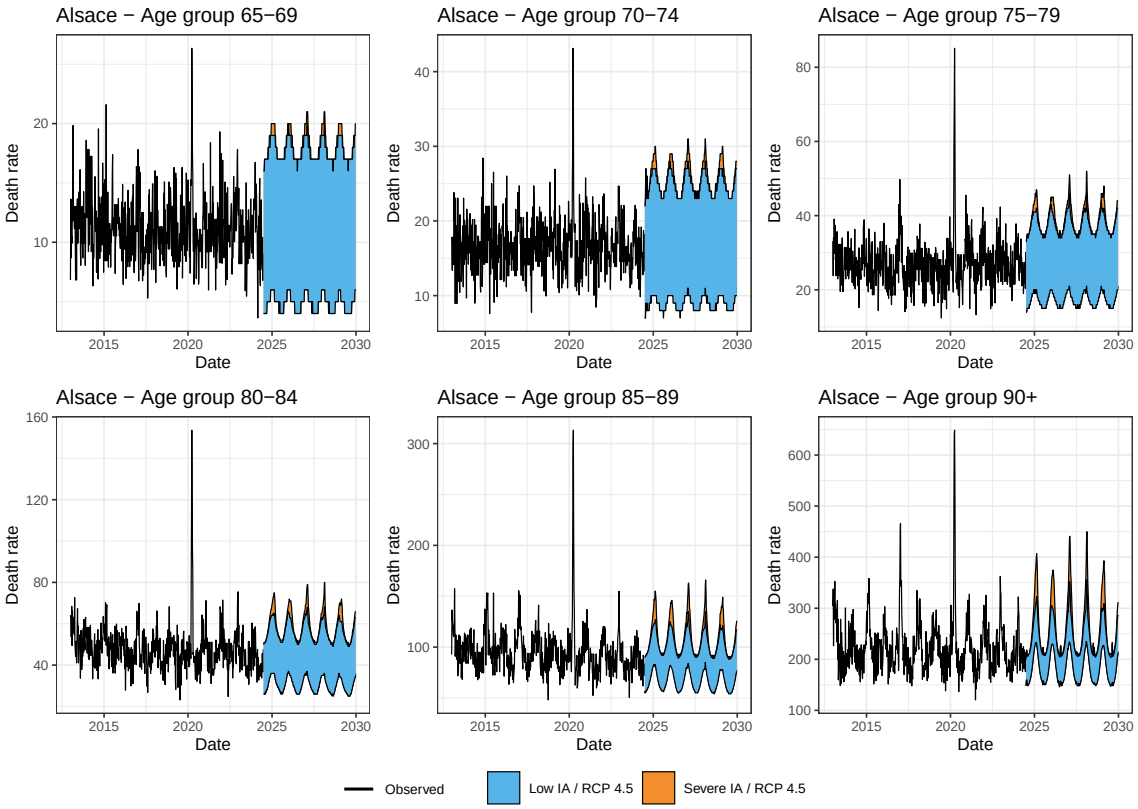

Figure F.9: Alsace (FRF1).

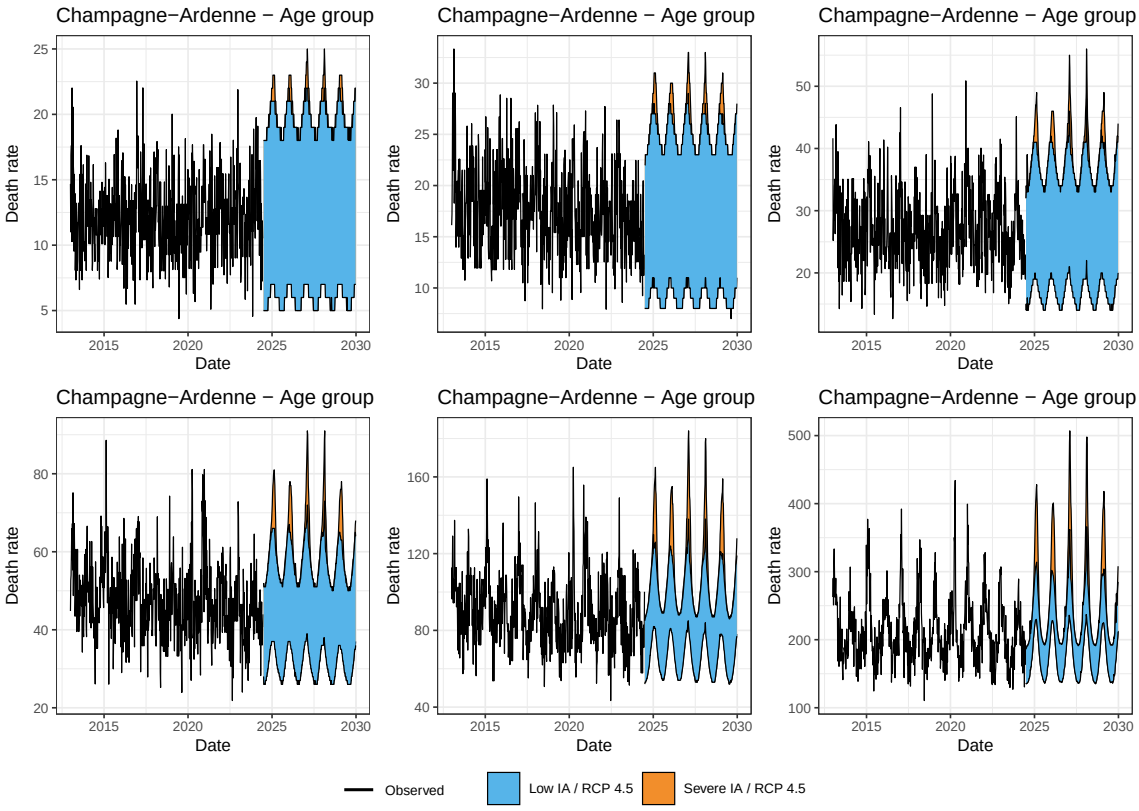

Figure F.10: Champagne-Ardenne (FRF2).

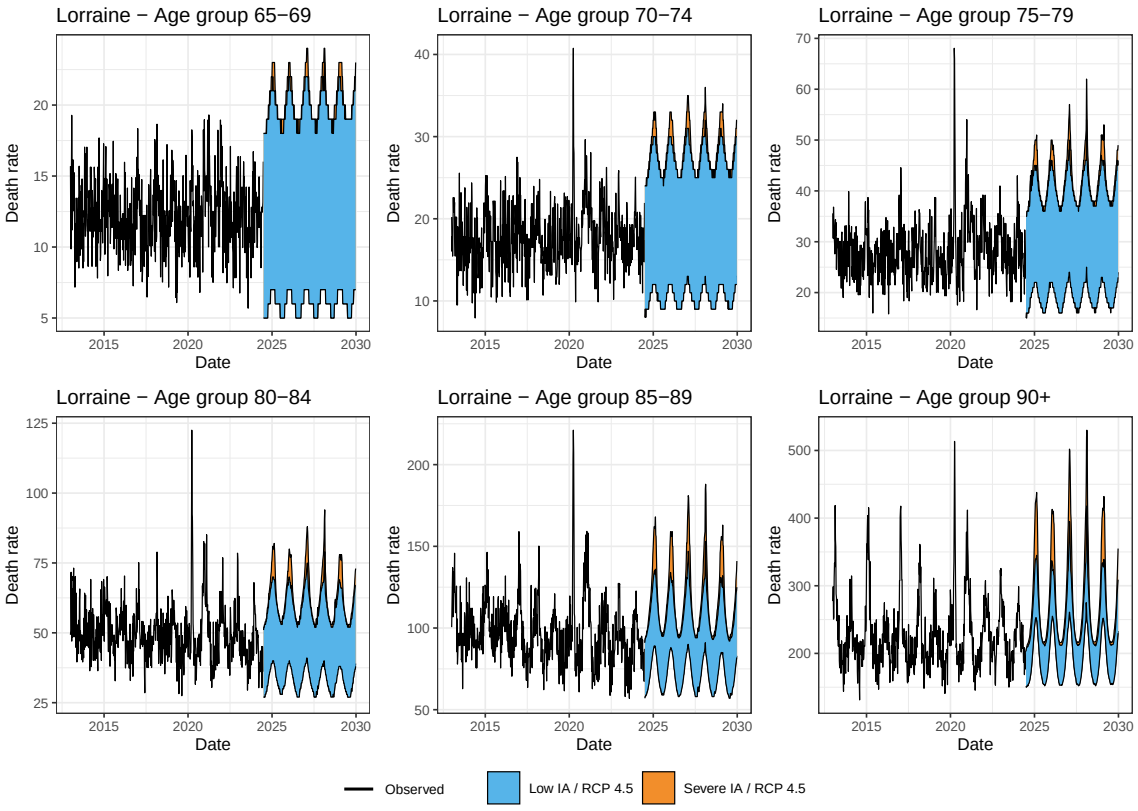

Figure F.11: Lorraine (FRF3).

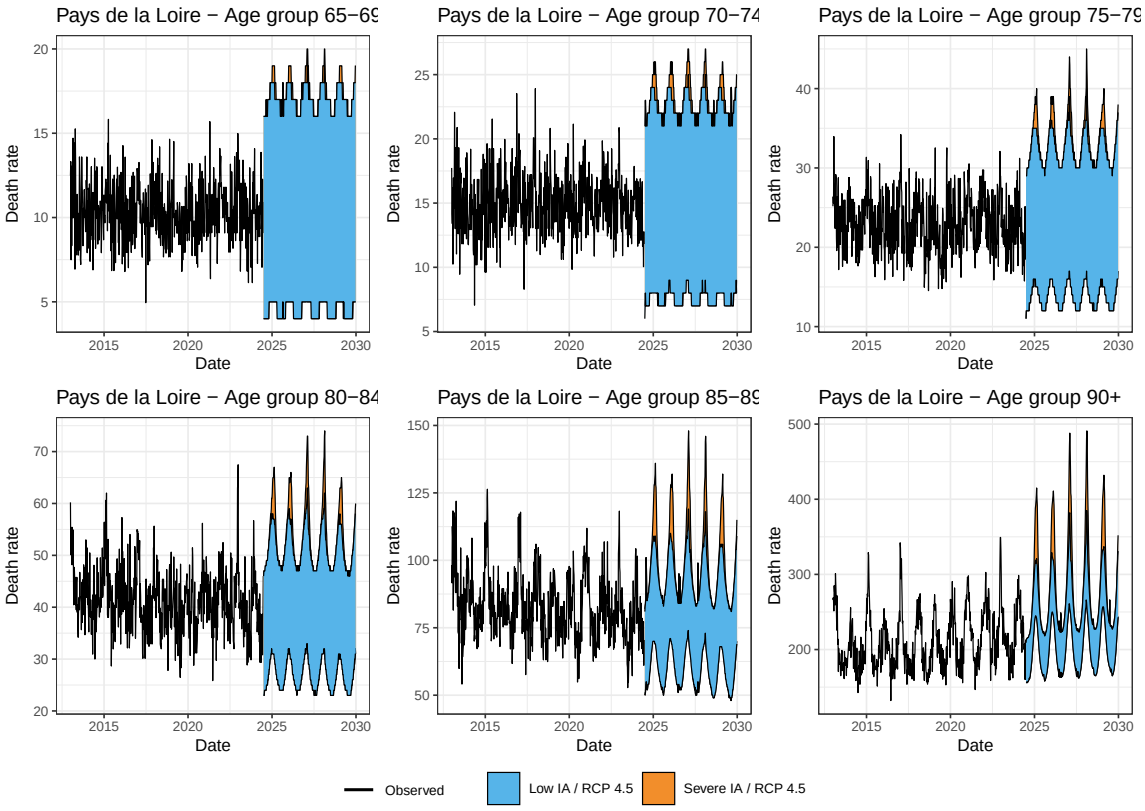

Figure F.12: Pays de la Loire (FRG0).

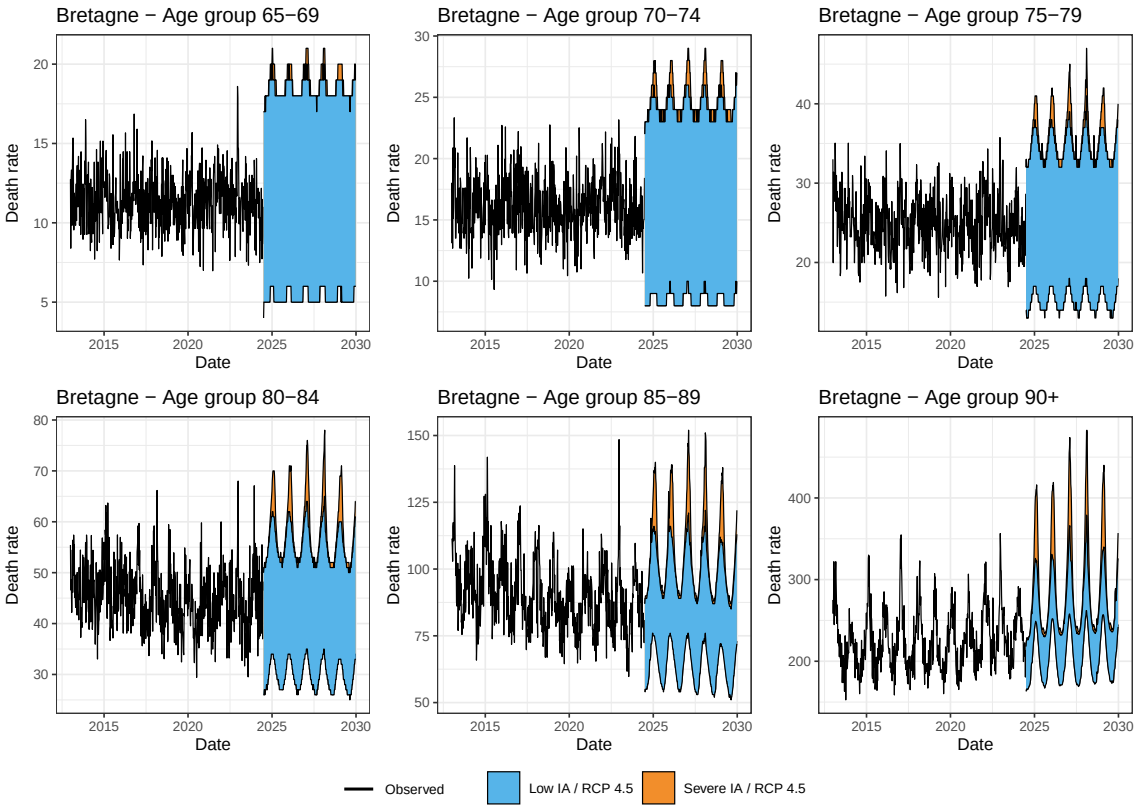

Figure F.13: Bretagne (FRH0).

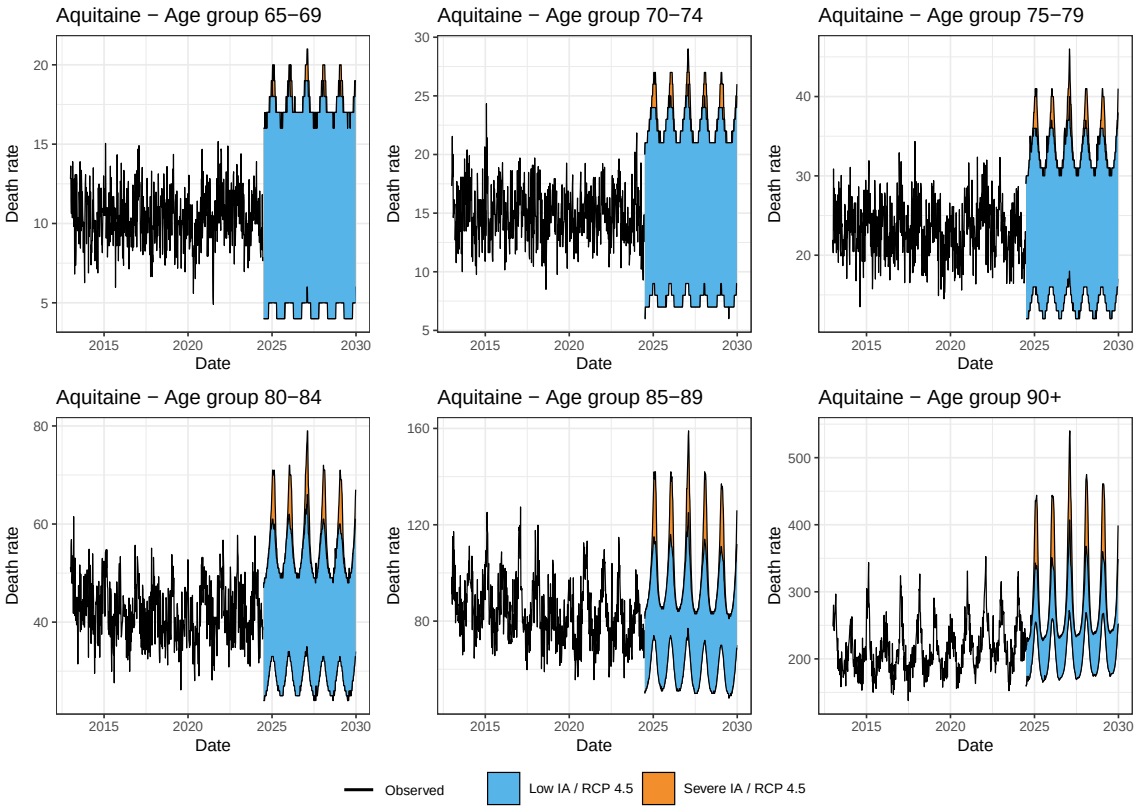

Figure F.14: Aquitaine (FRI1).

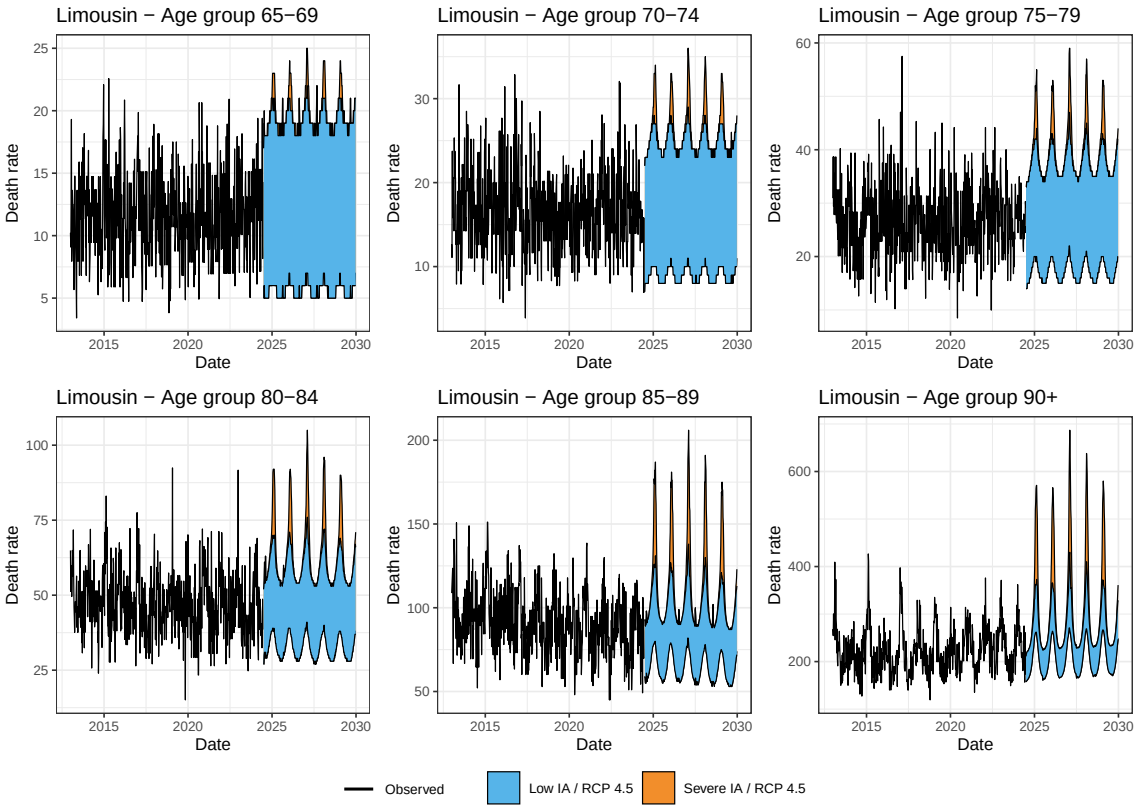

Figure F.15: Limousin (FRI2).

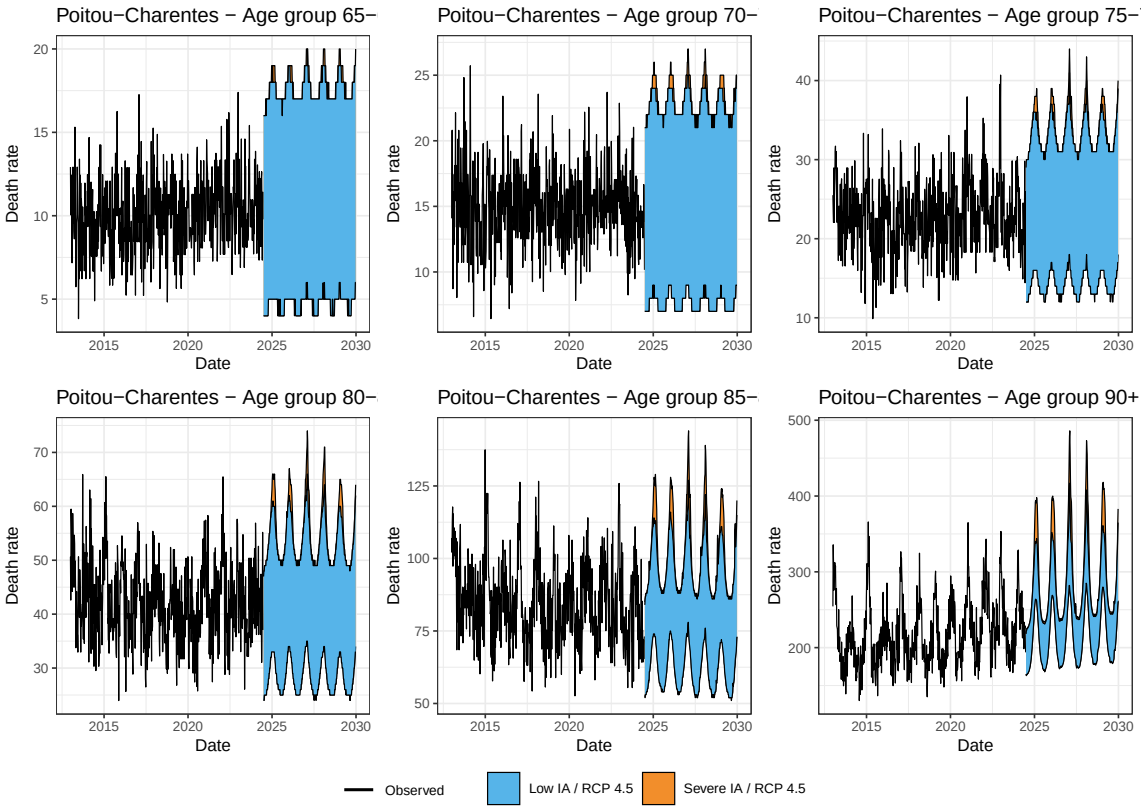

Figure F.16: Poitou-Charentes (FRI3).

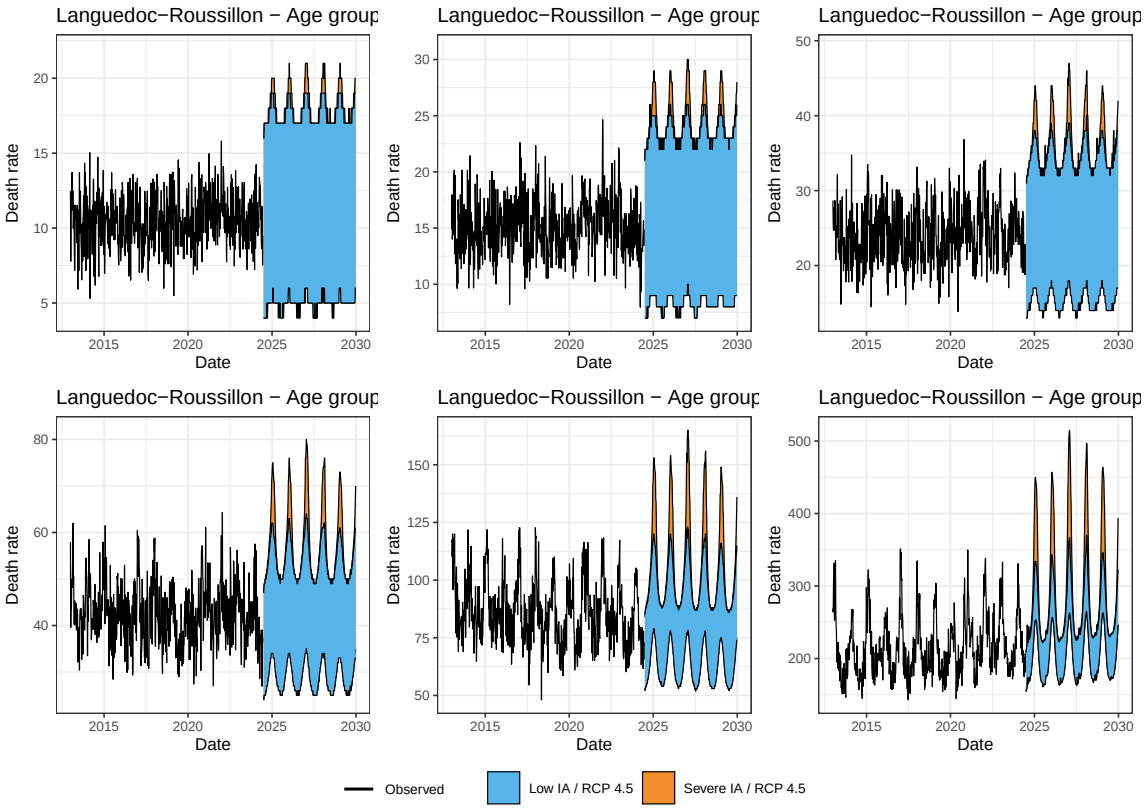

Figure F.17: Languedoc-Roussillon (FRJ1).

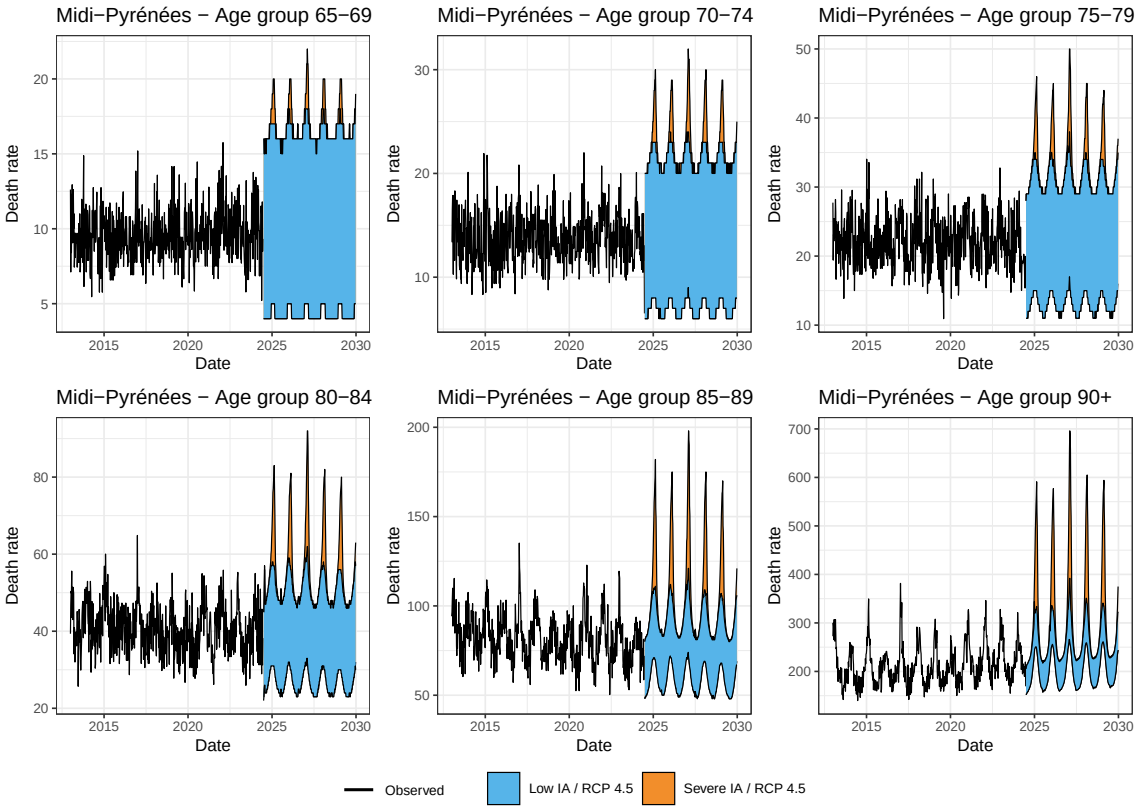

Figure F.18: Midi-Pyrénées (FRJ2).

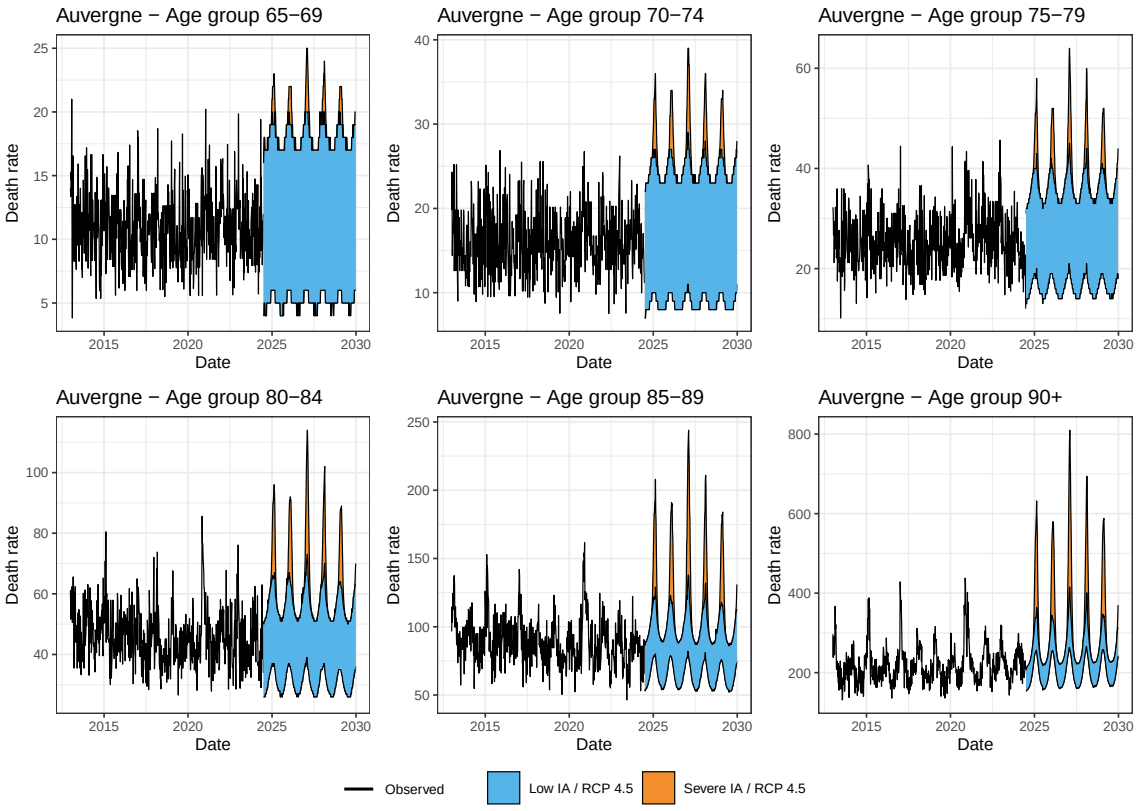

Figure F.19: Auvergne (FRK1).

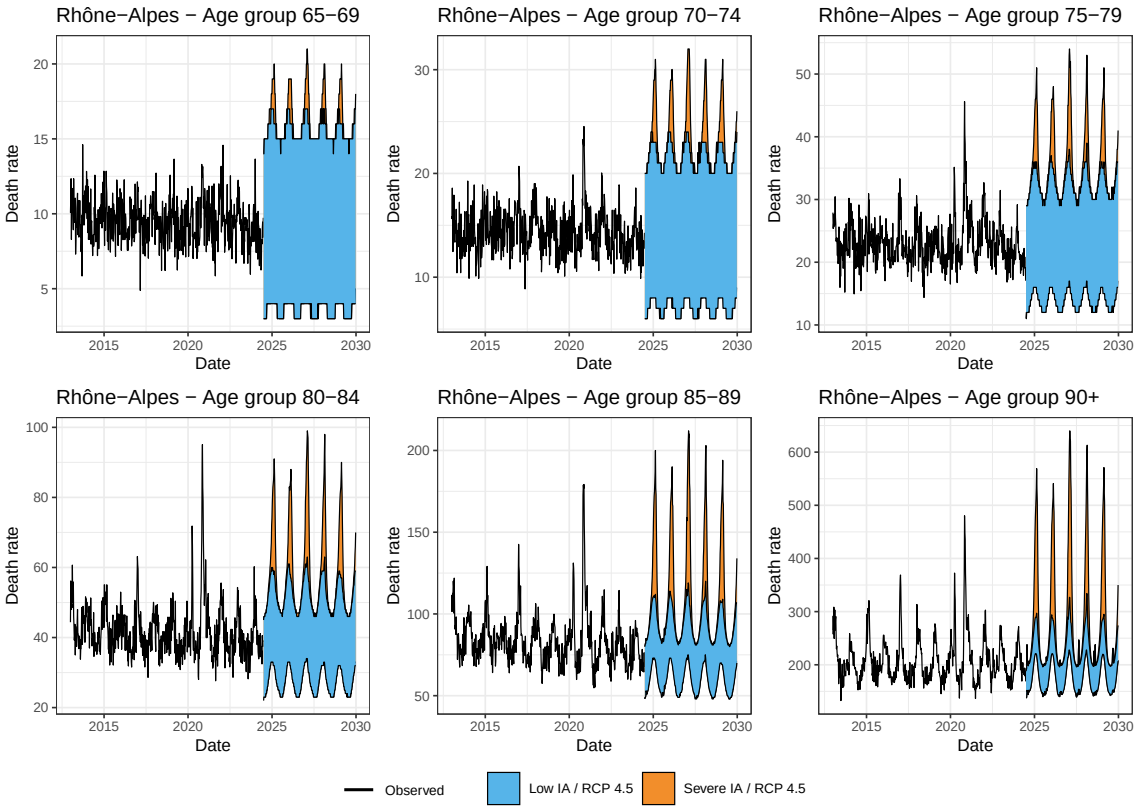

Figure F.20: Rhône-Alpes (FRK2).

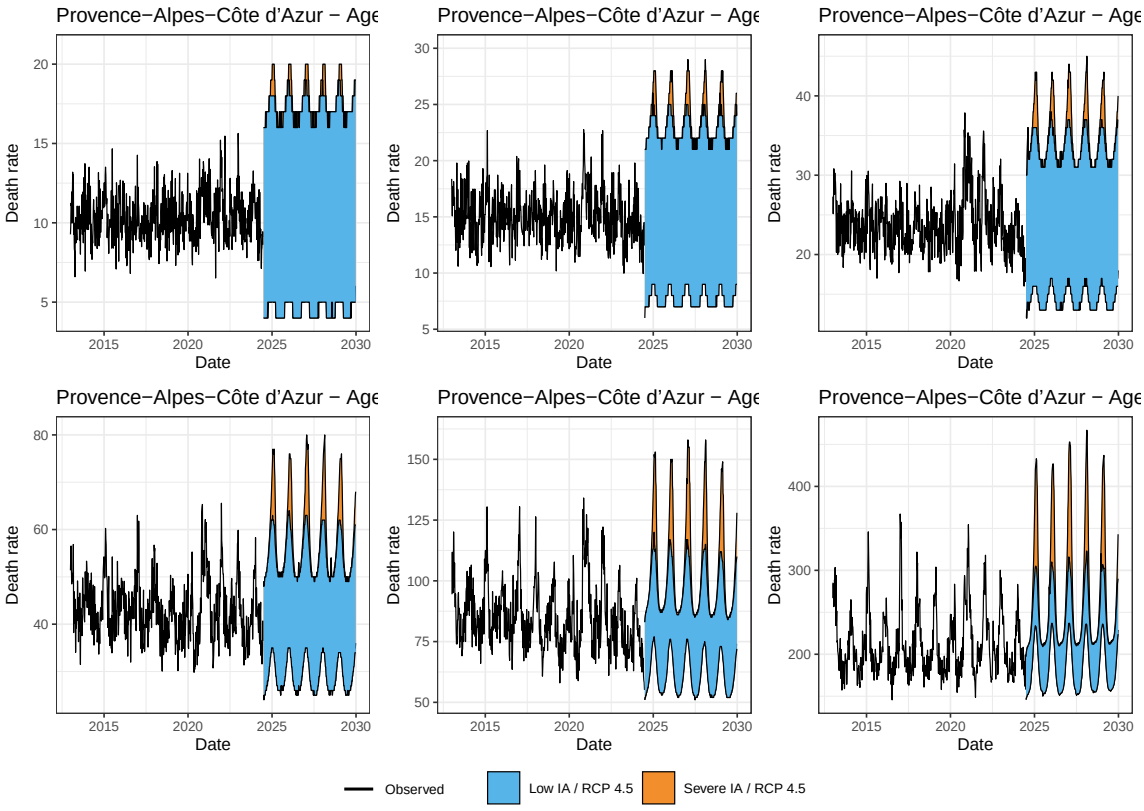

Figure F.21: Provence-Alpes-Côte d'Azur (FRL0).

G Scenario-based mortality forecasts: excess deaths

Figure caption. We present the relative excess deaths compared to the baseline mortality model in the French NUTS 2 regions under the moderate influenza / RCP 4.5 scenario and the severe influenza / RCP 4.5 scenario. Each figure below corresponds to a different age group

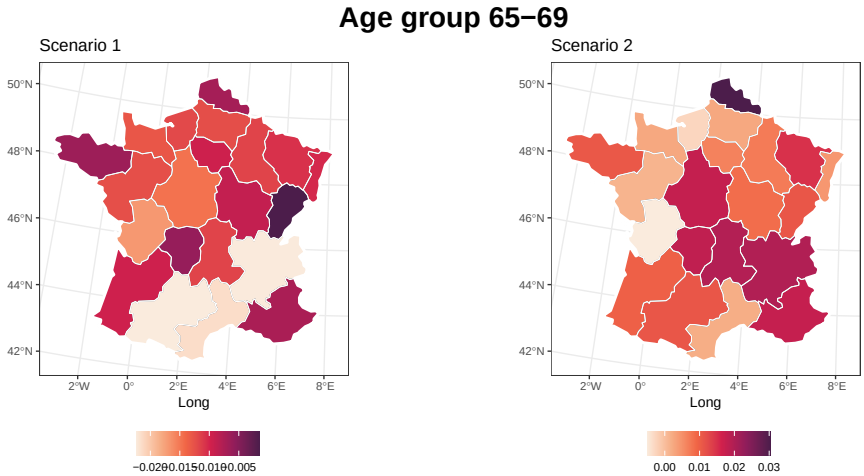

Figure G.1: Age group 65-69.

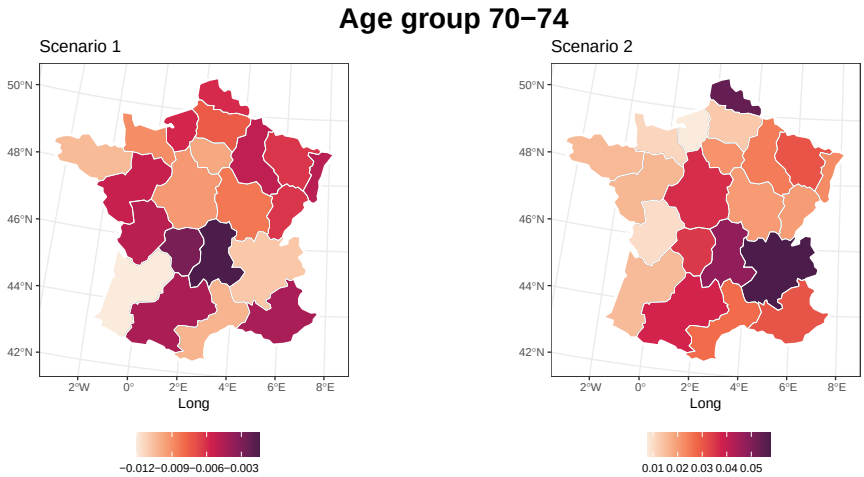

Figure G.2: Age group 70-74.

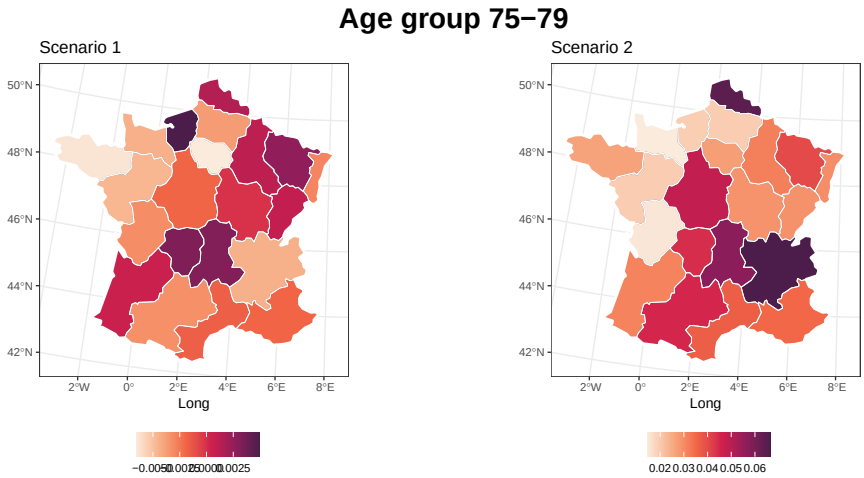

Figure G.3: Age group 75-79.

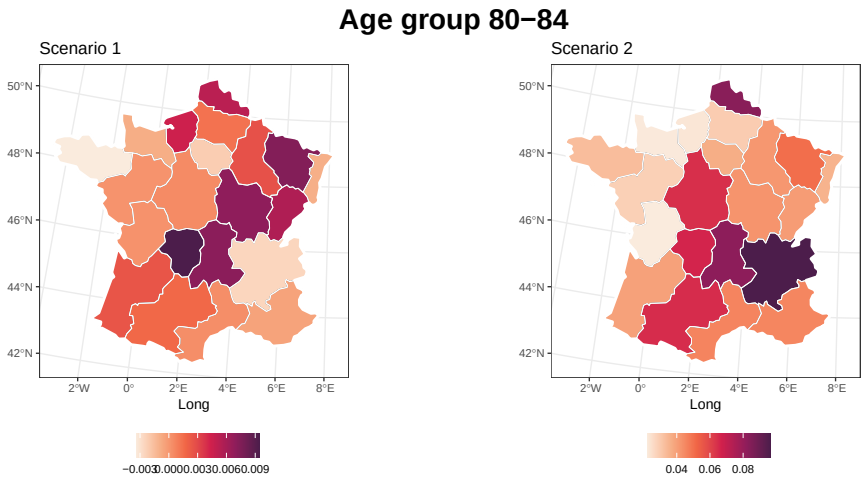

Figure G.4: Age group 80-84.

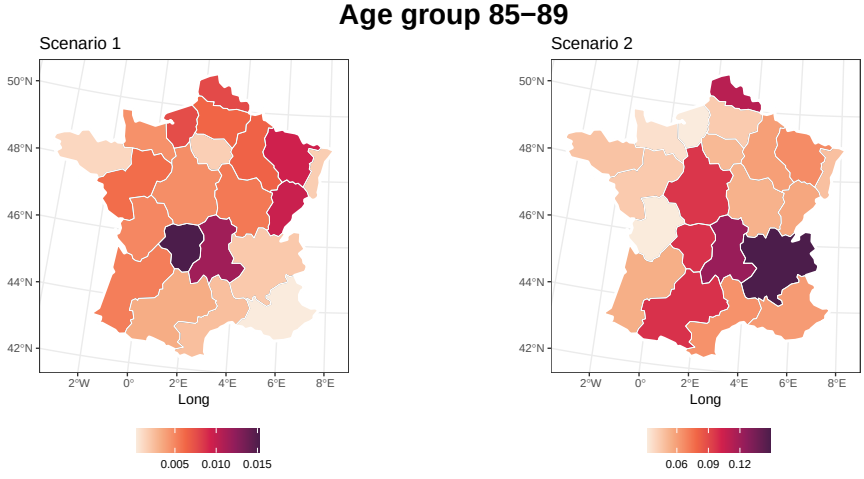

Figure G.5: Age group 85-89.

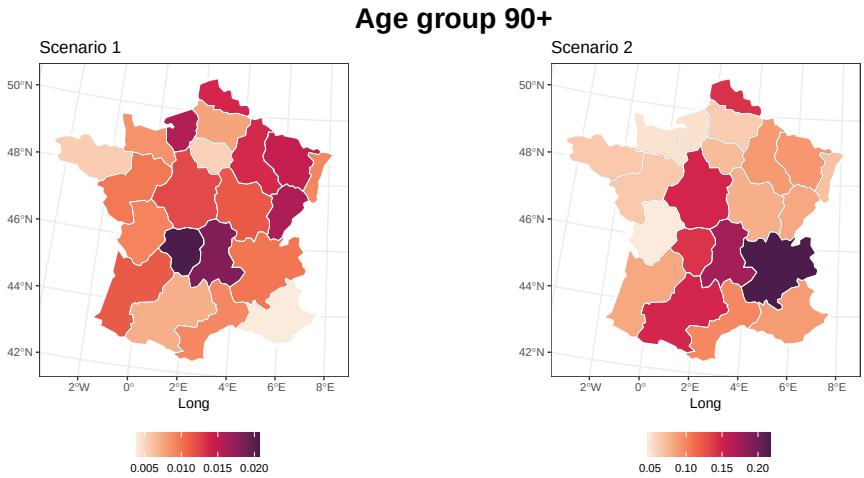

Figure G.6: Age group 90+.