Continuous
Mortality Investigation

Institute and Faculty of Actuaries

The new CMI projections model

Chief Actuaries' and Senior Life Actuaries' Workshop

Tim Gordon
Chair of the CMI Mortality Projections Committee

5 October 2016

CMI

CMI

- Wholly owned by Institute and Faculty of Actuaries
- Independent executive and management

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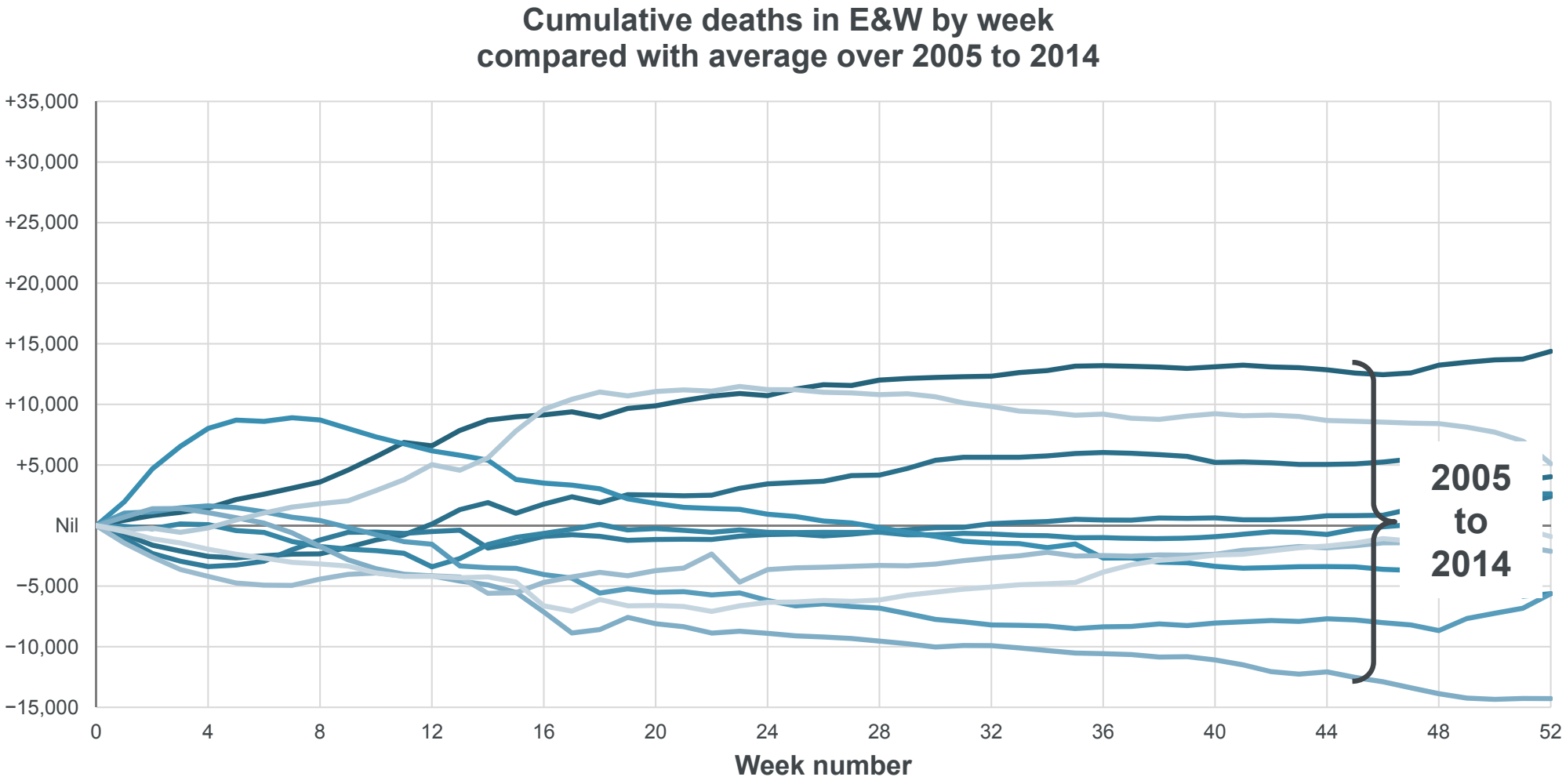
Mission

> *To produce high-quality impartial analysis, standard tables and models of mortality and morbidity for long-term insurance products and pension scheme liabilities on behalf of subscribers and, in doing so, to further actuarial understanding.*

Our vision is to be regarded across the world as setting the benchmark for the quality, depth and breadth of analysis of industry-wide insurance company and pension scheme experience studies

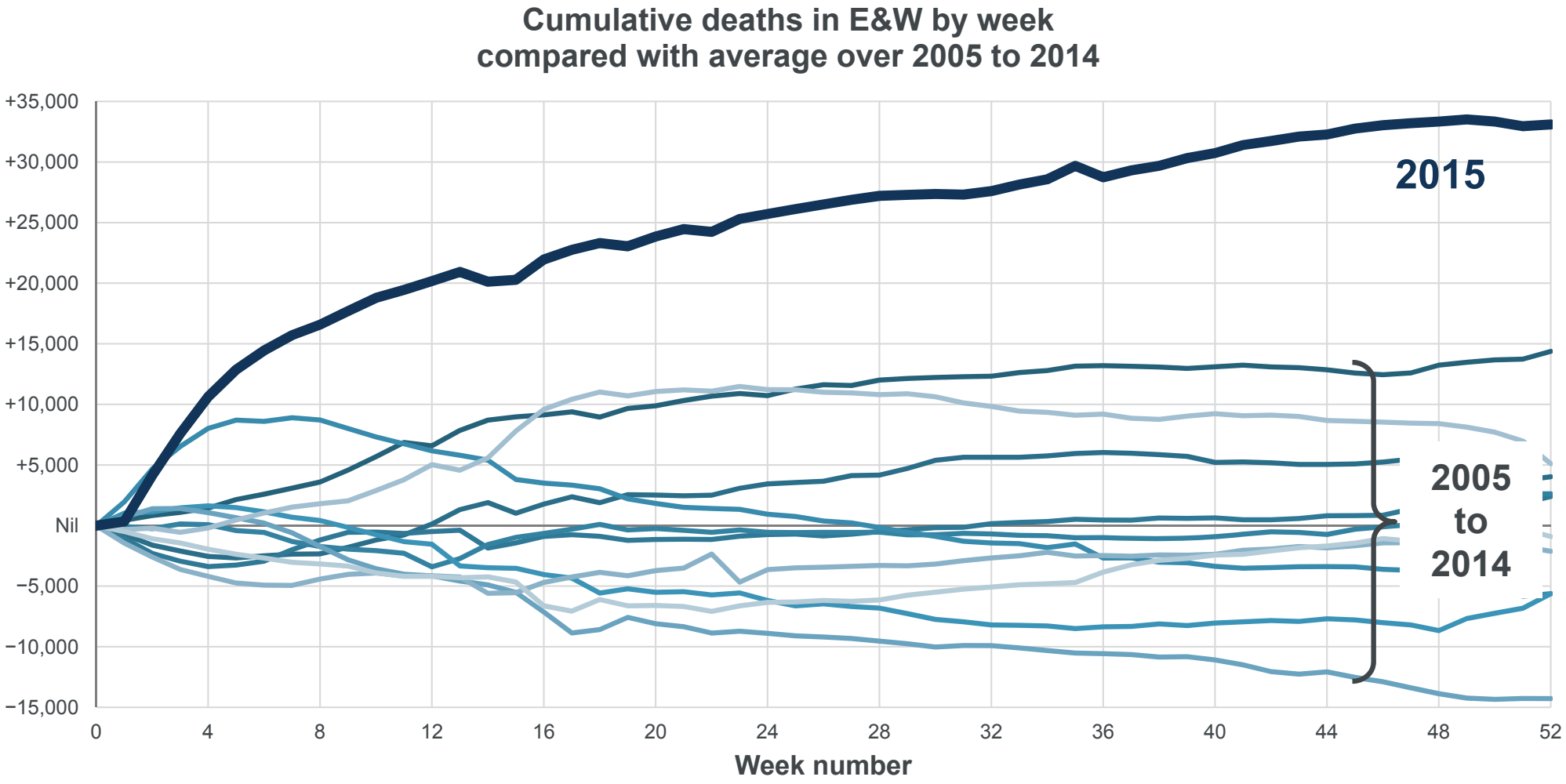
1. Recent mortality in England & Wales

Recent England & Wales deaths



Calculations by Aon Hewitt using ONS data

Recent England & Wales deaths



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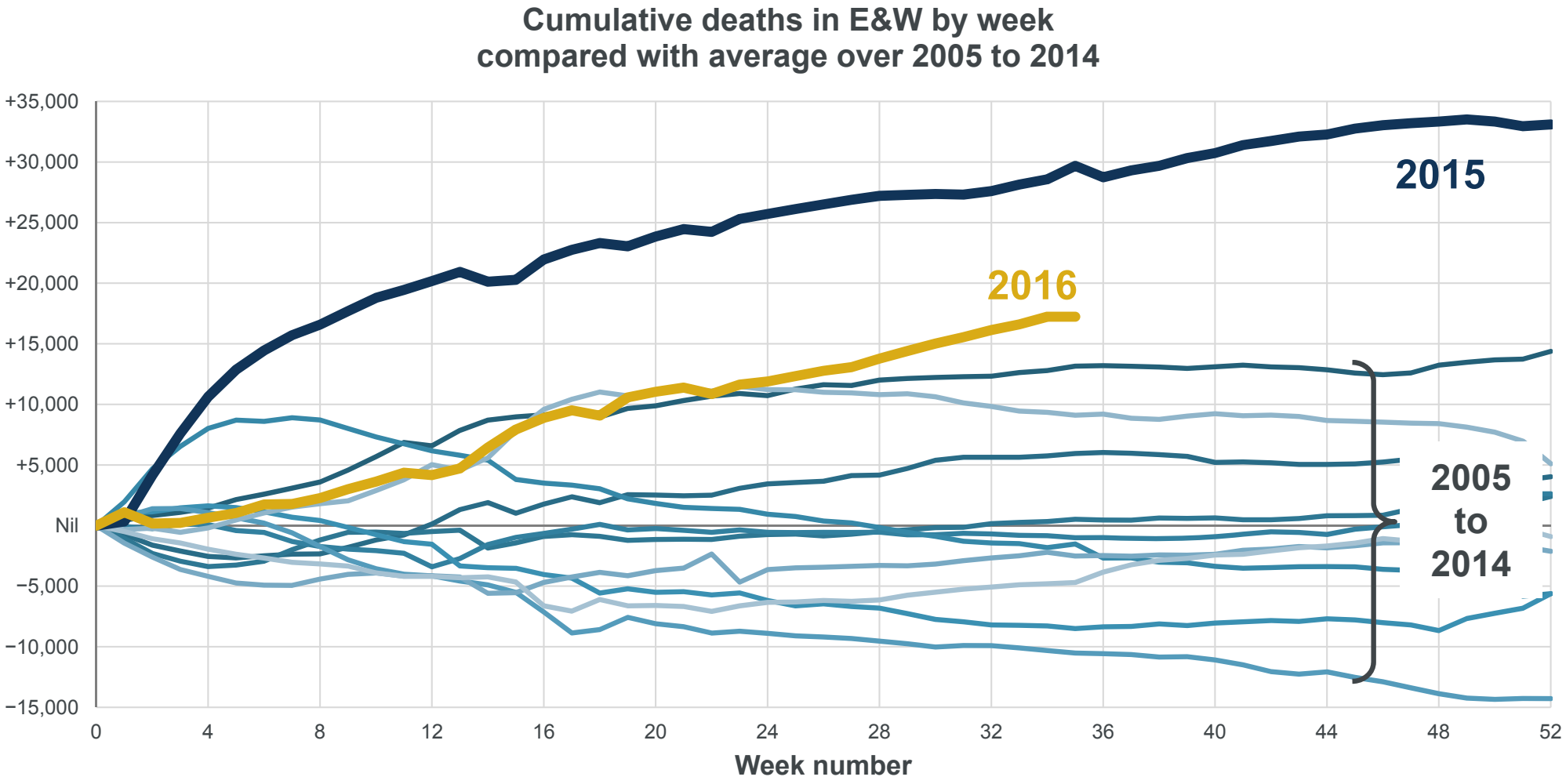
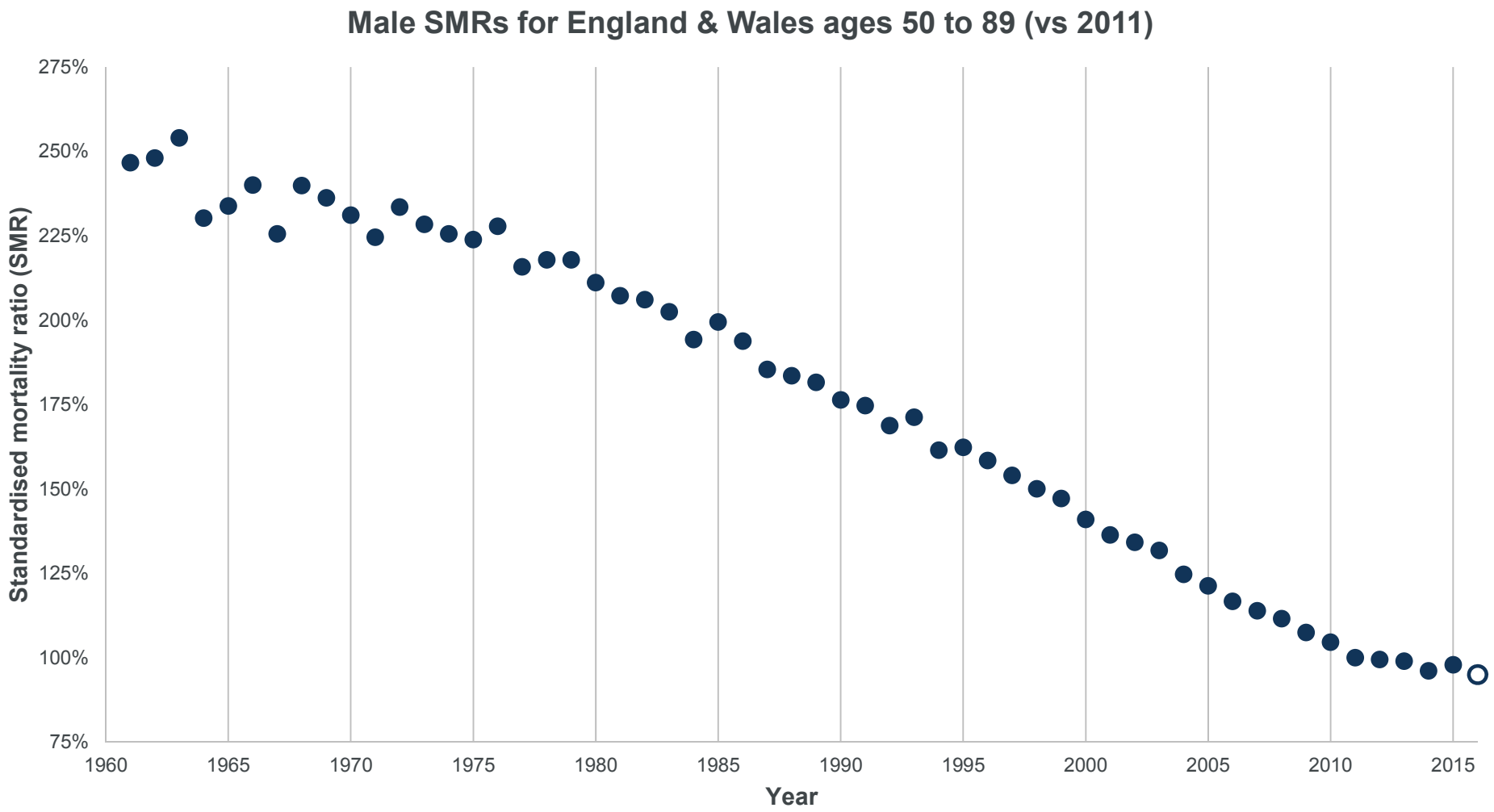
Recent England & Wales deaths



Calculations by Aon Hewitt using ONS data

Male SMR



Calculations by Aon Hewitt using ONS data

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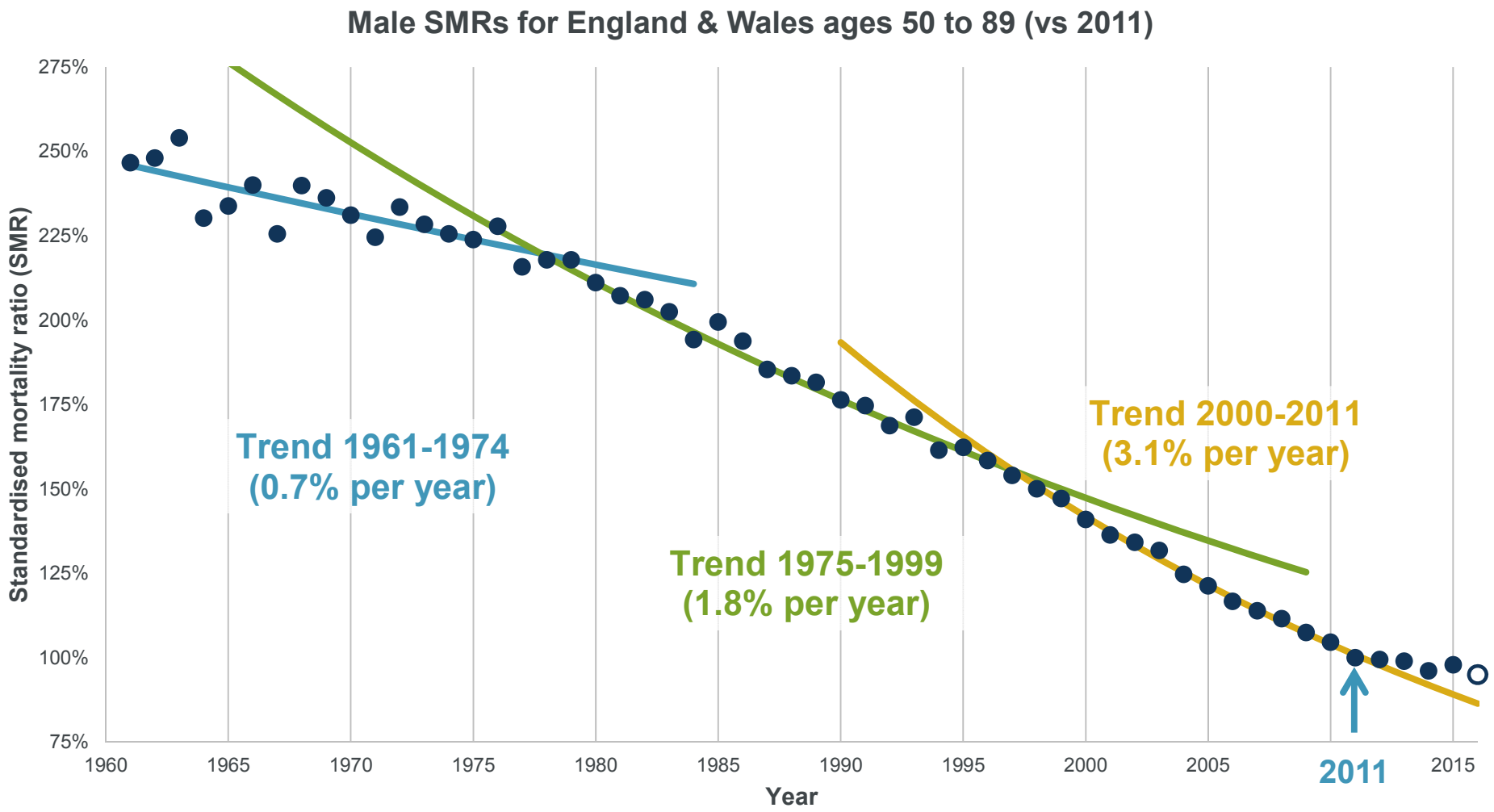
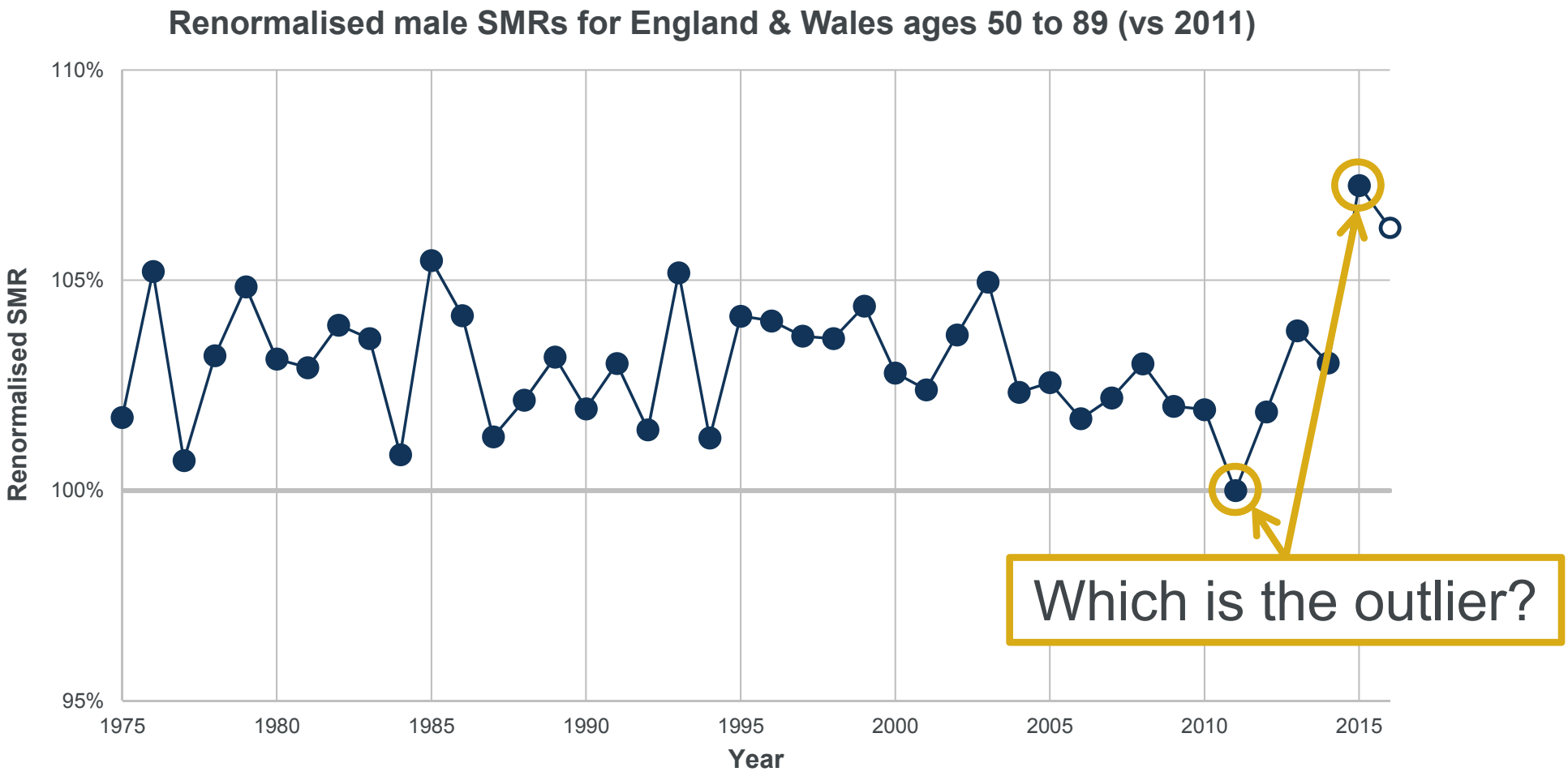


Calculations by Aon Hewitt using ONS data

Male SMR renormalised by smoothed improvements (from proposed model)



Calculations by Aon Hewitt using ONS data and the proposed CMI projection model calibrated to data to end 2015

2. Proposed CMI Projection Model

Consultation process

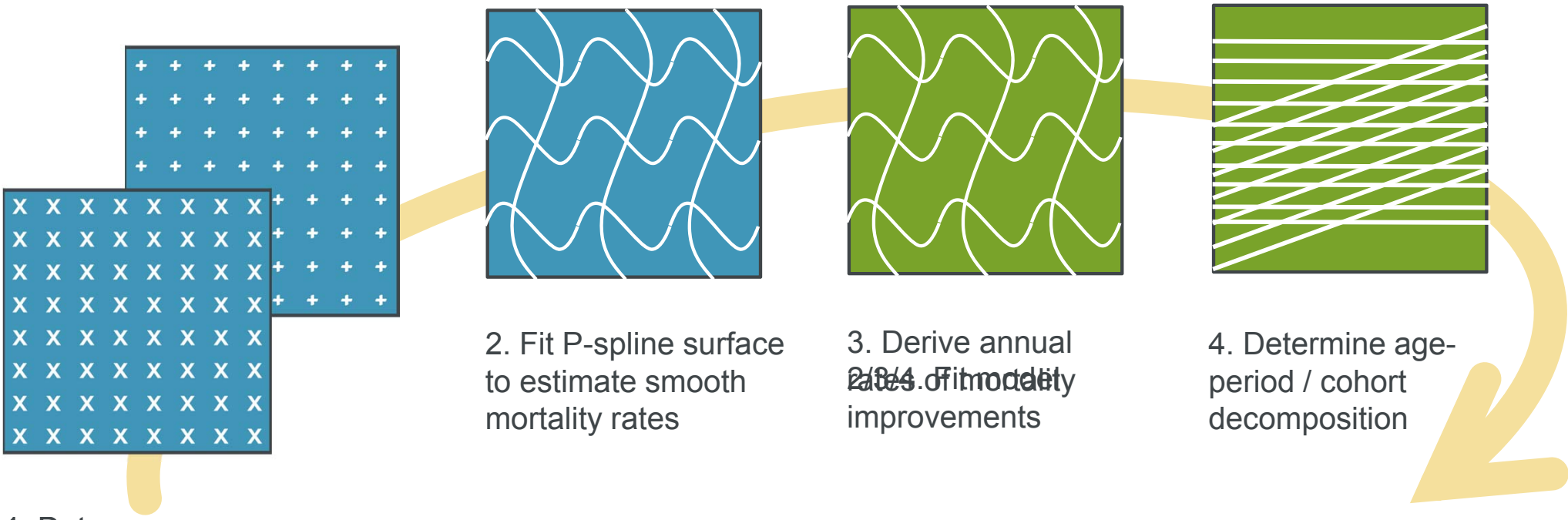
Date	Item
22 June 2016	Working Paper 90 published
29 June 2016	Edinburgh consultation meeting
11 July 2016	London consultation meeting
31 August 2016	Working Paper 91 published and model software released
30 September 2016	**Responses to consultation due**
November 2016	Working paper summarising responses and revisions
March 2017	Publish CMI_2016 (based on data to 31 December 2016)

Current CMI Model – very high level overview

In the short-term, the best guide to the likely pace of mortality improvement is the most recently observed experience(?)

The forces driving mortality change are themselves subject to change over time. Inform assumption choice less by analysis, more by subjective judgement.

What's changed – big picture



2. Fit P-spline surface to estimate smooth mortality rates

3. Derive annual rates of mortality improvements

2/3/4. Fit model

4. Determine age-period / cohort decomposition

1. Data
(a) Raw death and population data for ~~England~~ UK & Wales
(b) Population data at high ages constructed by CMI (using ONS methodology)
(c) CMI caps unlikely data points using a simpler method

5. Projection
~~(a) Step back two years for initial rates~~
~~(b)~~ Sum separate projections of age-period and cohort components

3. Proposed CMI Projection Model – initial improvements

Age-Period-Cohort Improvement model

- Definition of the model:

$$\log m_{xt} = \alpha_x + \beta_x(t - \bar{t}) + \kappa_t + \gamma_{t-x}$$

  where:

  - x and t are age and calendar year
  - α_x and β_x are sets of parameters indexed by age
  - κ_t is a set of parameters indexed by calendar year (period)
  - γ_{t-x} is a set of parameters indexed by birth year (cohort)
  - $\bar{t}$ is the midpoint of the period used to calibrate the model

- Mortality improvement is *not* q_{xt}-based, but $\log m_{xt}$-based:

$$MI_{xt} = -\left(\log m_{xt} - \log m_{x,t-1}\right)$$

Age-Period-Cohort Improvement model

- Definition of the model:

$$\log m_{xt} = \alpha_x + \beta_x(t - \bar{t}) + \kappa_t + \gamma_{t-x}$$

- Mortality improvement (reduction in $\log m_{xt}$) is:

$$MI_{xt} = \underbrace{-\beta_x}_{\text{Age}} + \underbrace{(\kappa_{t-1} - \kappa_t)}_{\text{Period}} + \underbrace{(\gamma_{t-x-1} - \gamma_{t-x})}_{\text{Cohort}}$$

- Gives us mortality rates / improvements and APC split *in one step*
- Fit by minimising
  - deviance (aka $-2 \times \log \text{likehood}$) for goodness-of-fit, plus
  - multiples of squared 3rd differences of α_x, β_x and γ_{t-x}, plus
  - multiple of squared 2nd differences of κ_t – tends to flatten MI_{xt},

  and applying identifiability

4. Proposed CMI Projection Model – projection

Apparent direction of travel

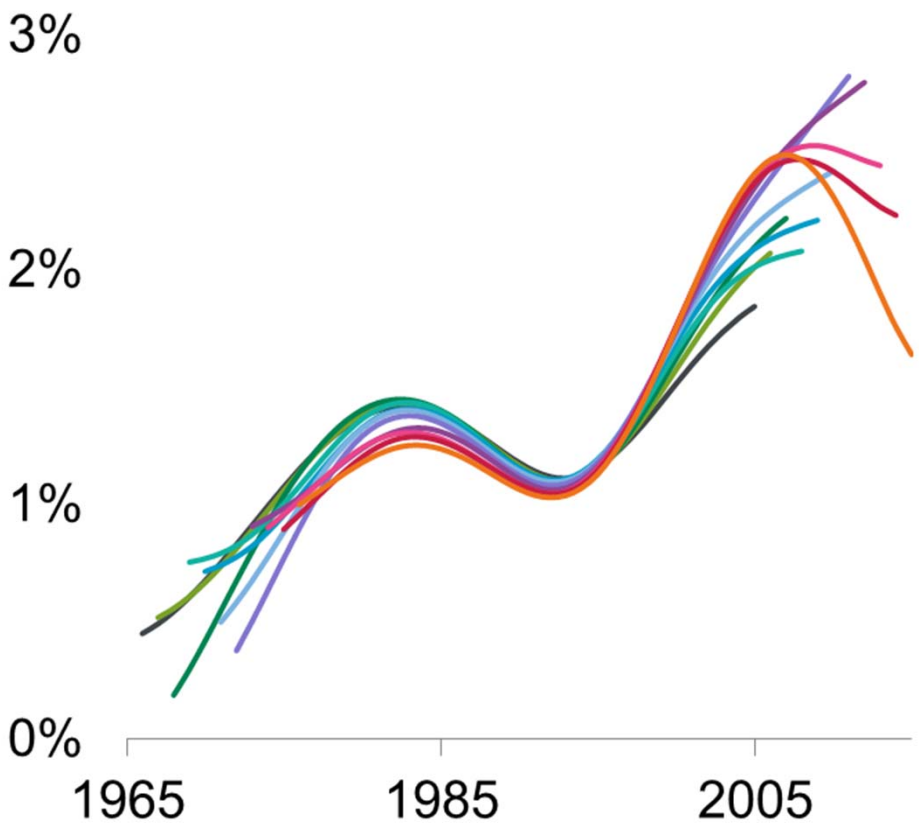
Lesson:

Apparent direction of travel from period component is uncertain

CMI proposed approach

- Core assumption to remain as nil allowance for direction of travel
- Give users option to specify direction of travel
- Model to output direction of travel

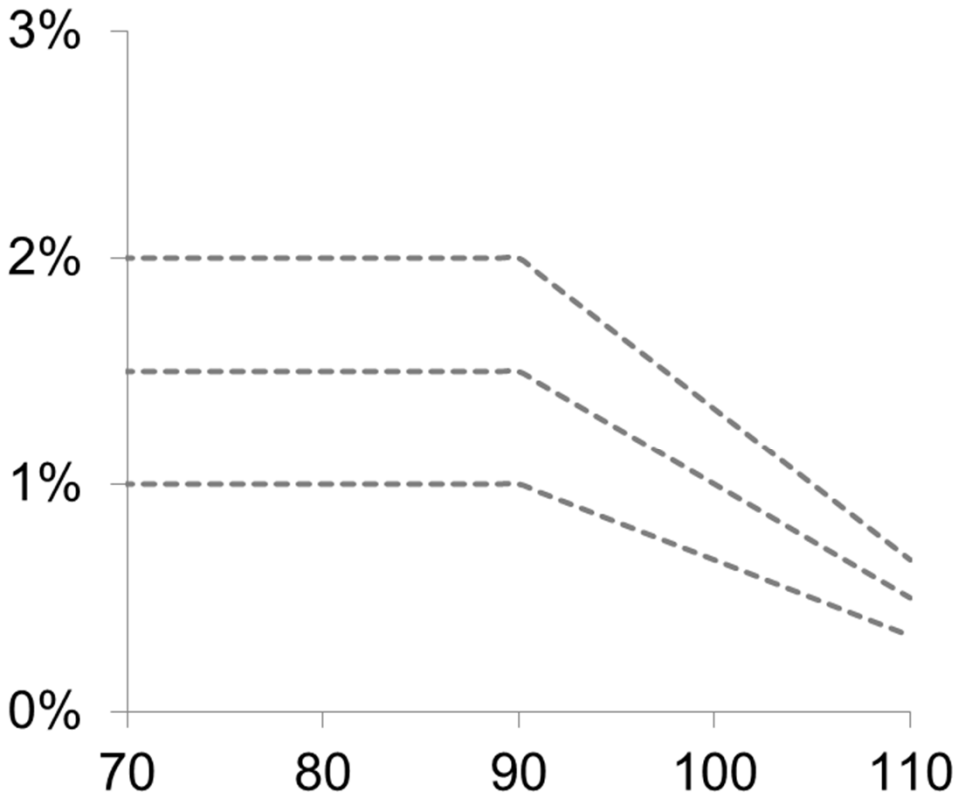
Periods ending in 2005 to 2015



Current shape of long-term rate (LTR)

- Under the current Core assumption, the LTR applies up to age 90, and tapers to zero at 120

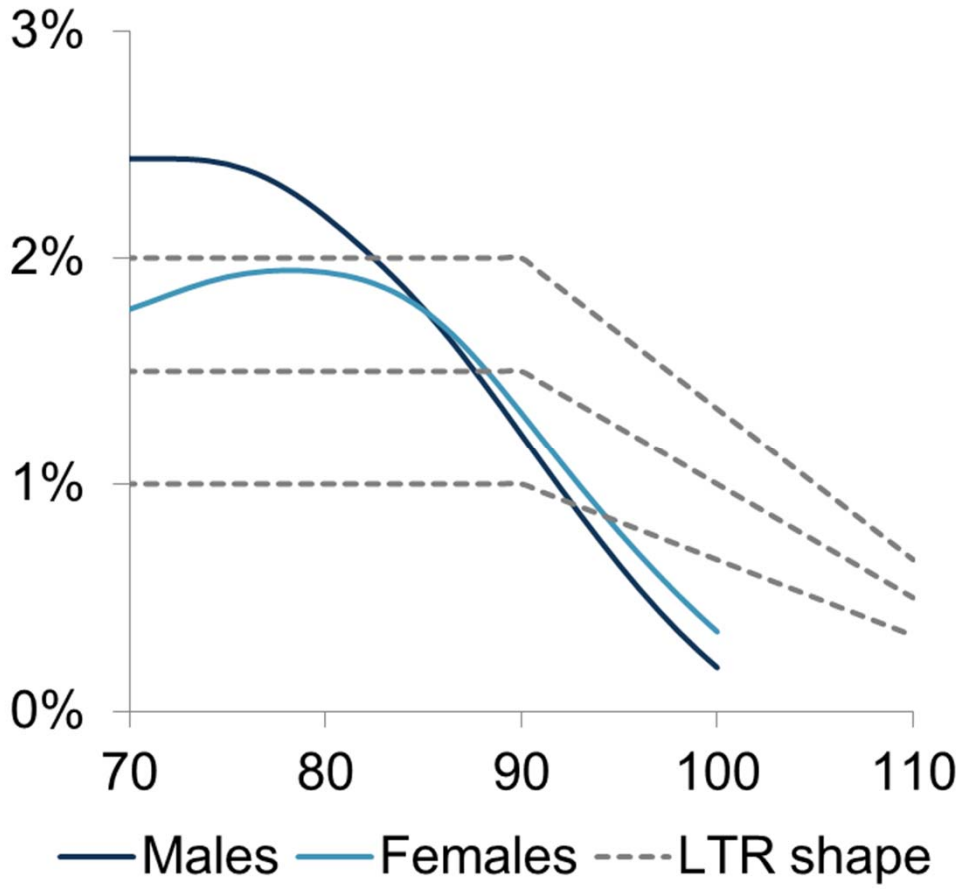
Shape of LTR by age



Current shape of long-term rate (LTR)

- Under the current Core assumption, the LTR applies up to age 90, and tapers to zero at 120
- This implies a sharp rise in improvements for centenarians in future, which is out of line with past experience

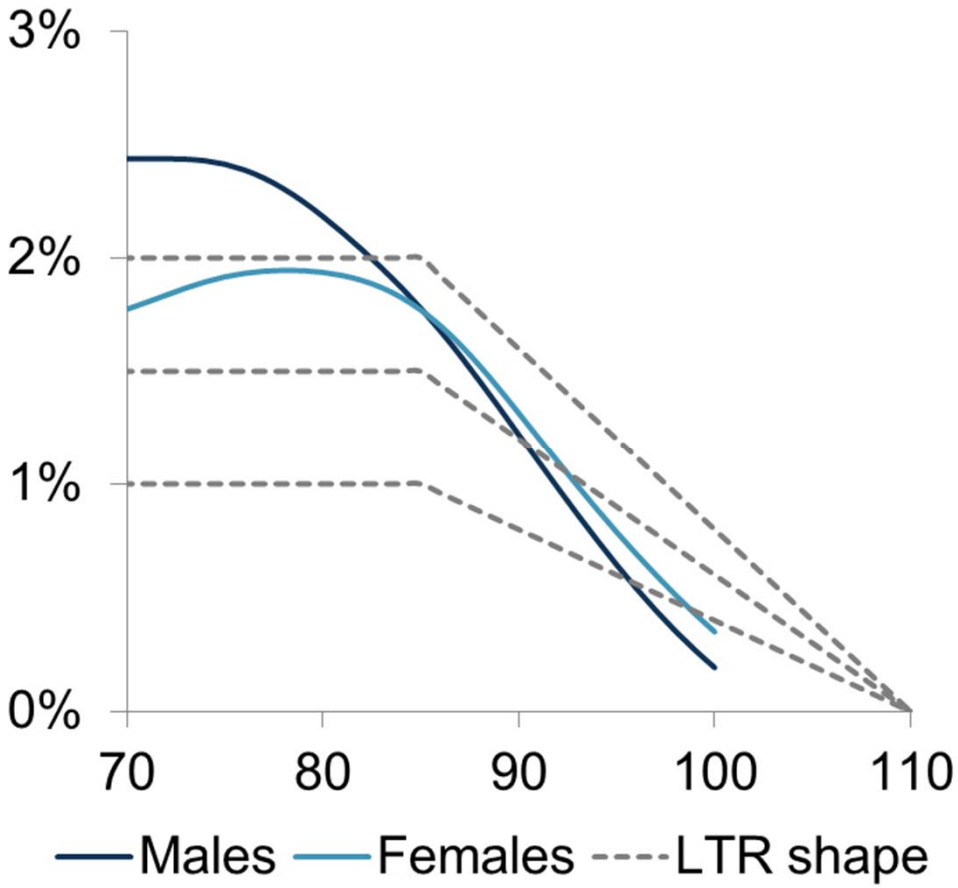
Mortality improvements by age
APCI age component and LTR shapes



Proposed shape of long-term rate (LTR)

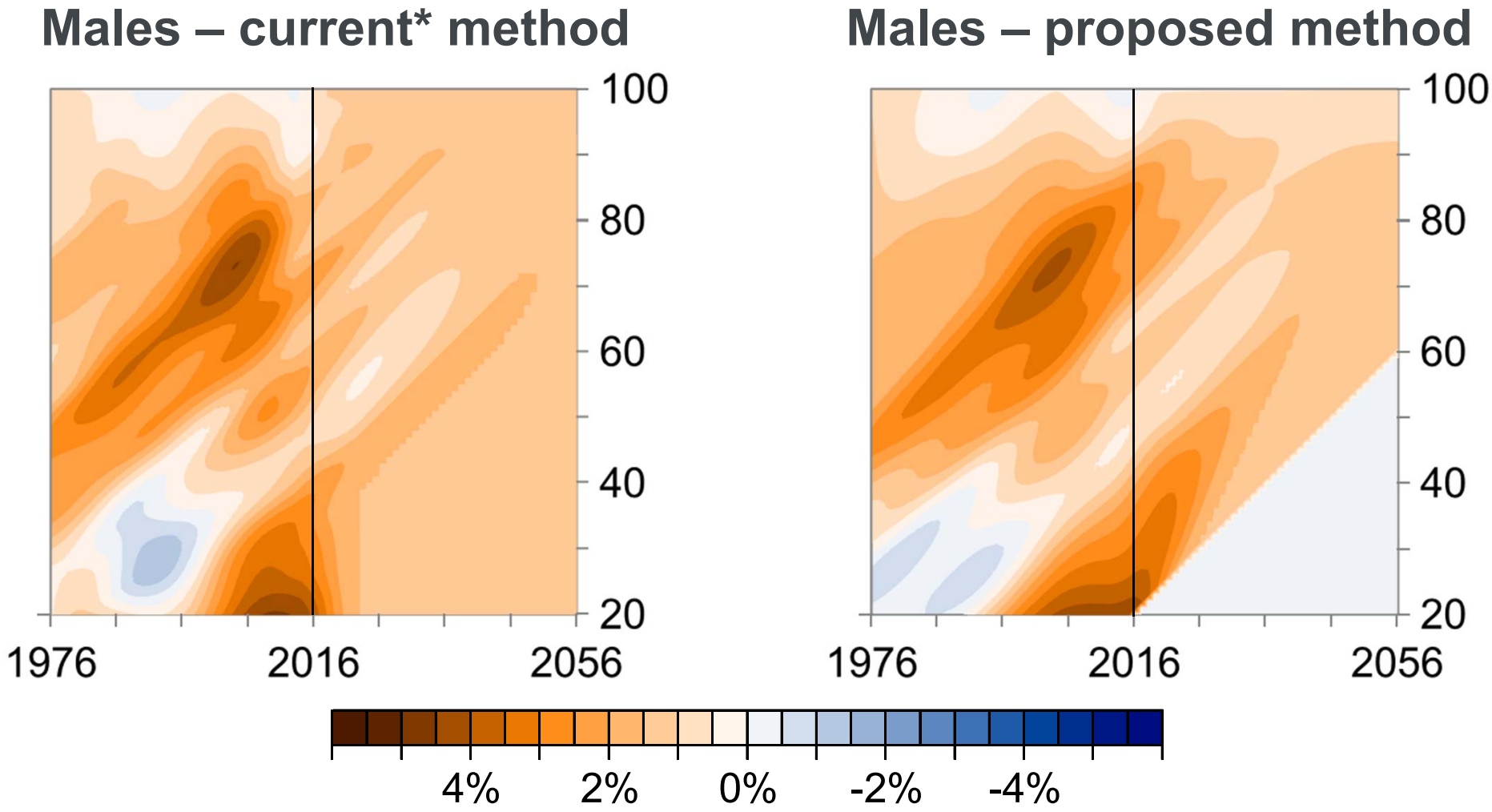
- We propose that the LTR applies up to age **85**, and tapers to zero at age **110**
- This implies a more modest rise in improvements for centenarians

Mortality improvements by age
APCI age component and LTR shapes



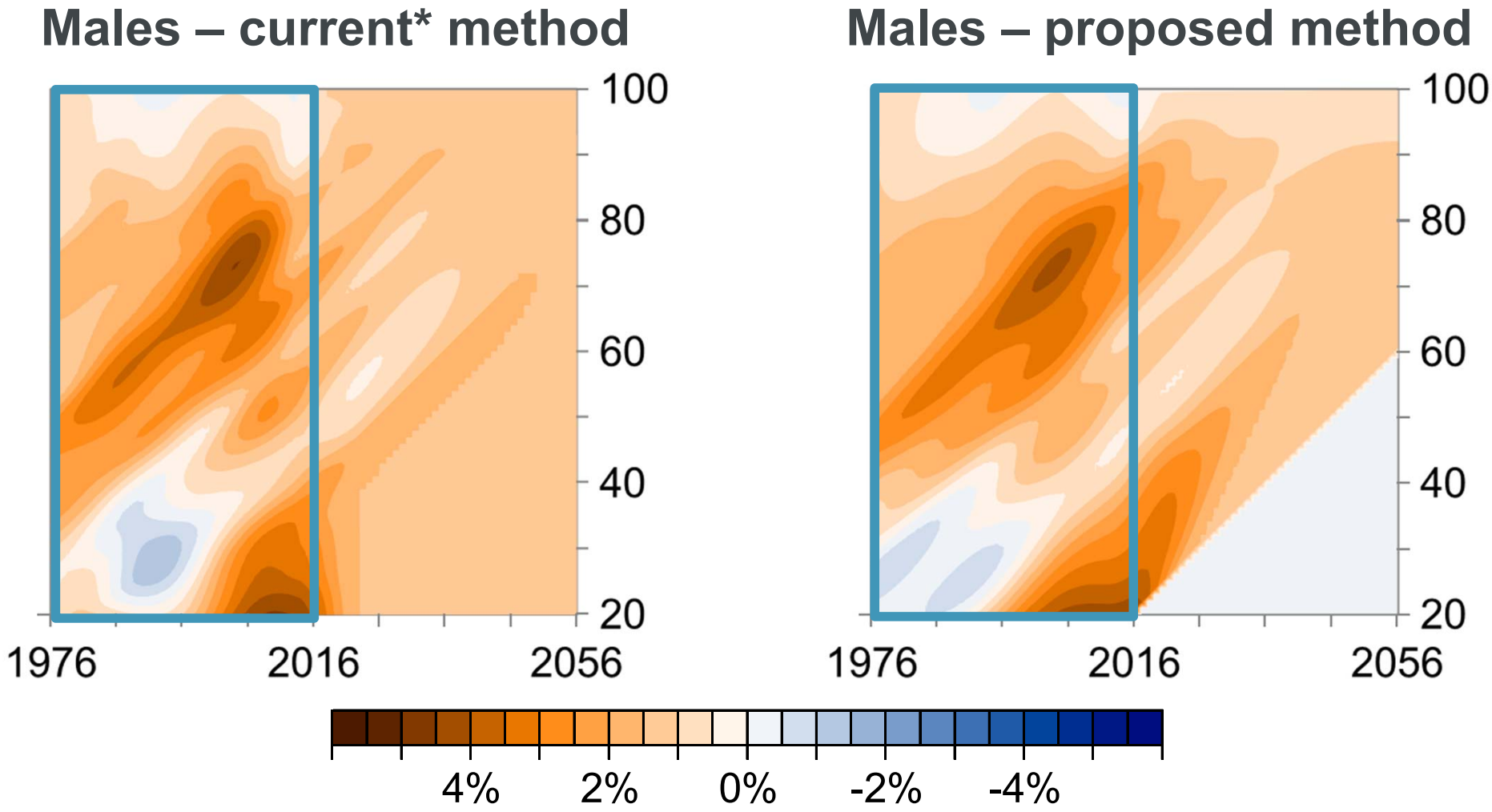
5. Proposed CMI Projection Model – impact

Comparison of male mortality improvements



* Note that “current” is not the same as CMI_2015

1. Historical fit is broadly similar



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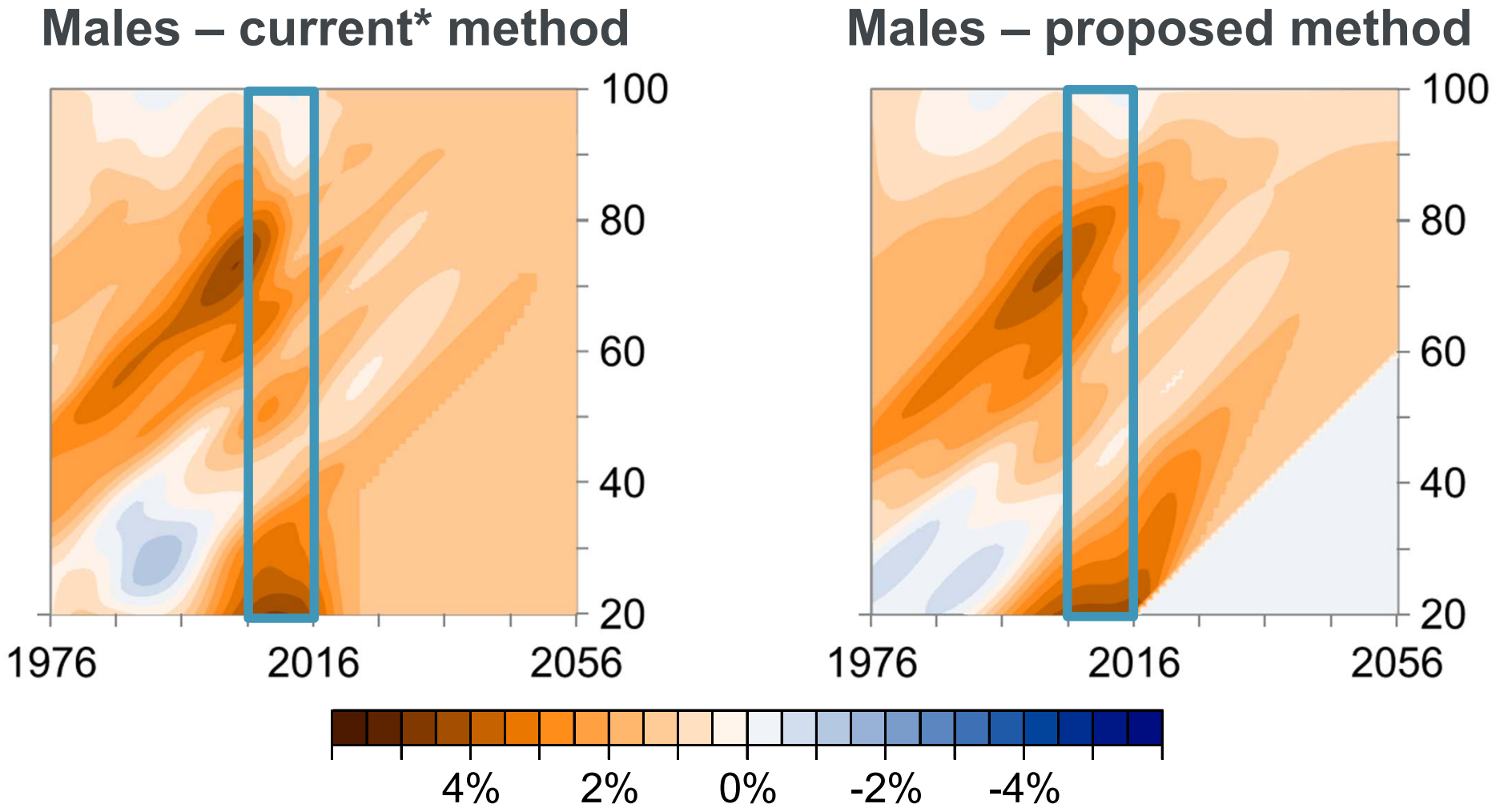
2. Recent improvements are higher



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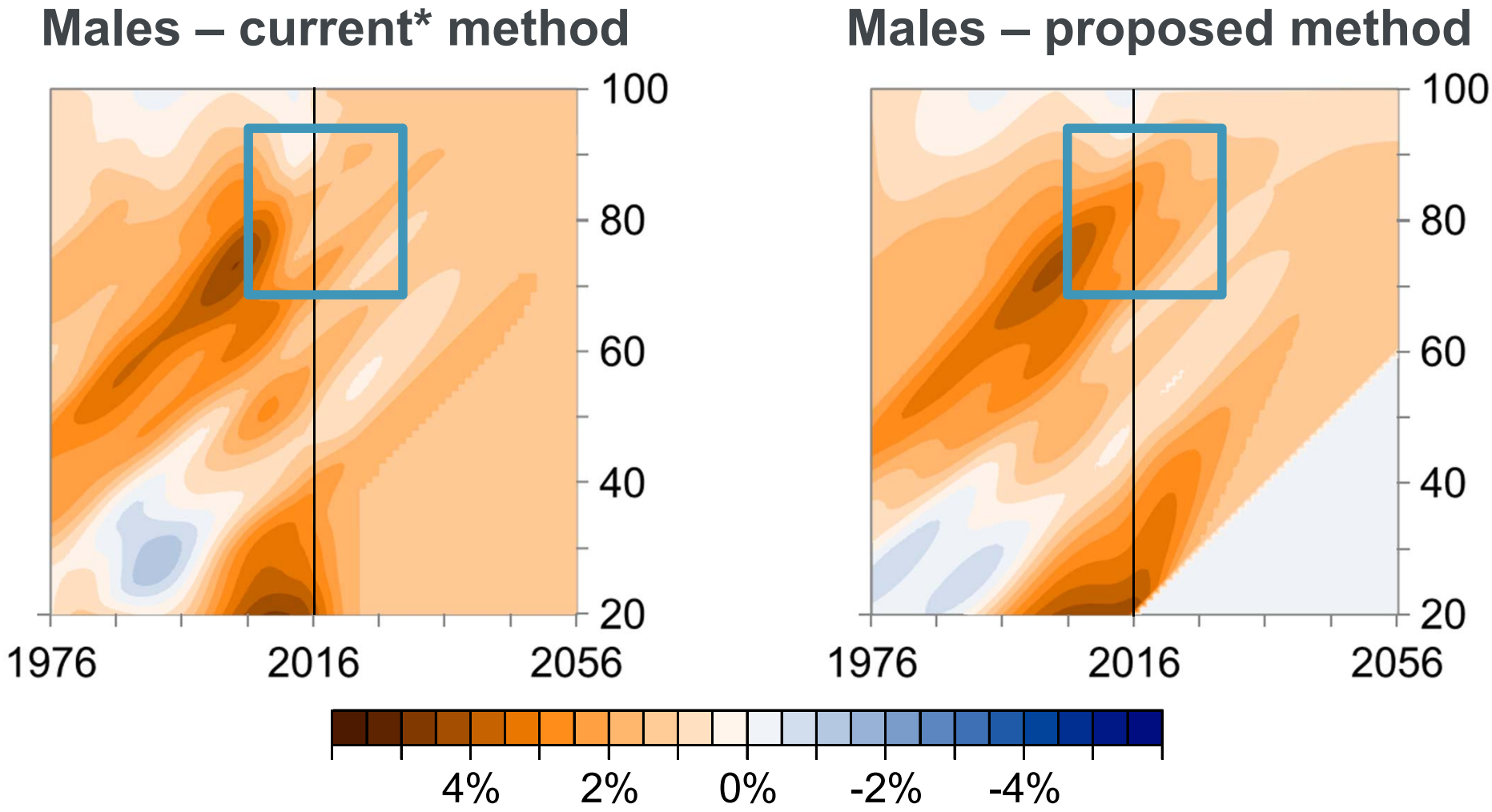
3. Lower long-term old-age improvements



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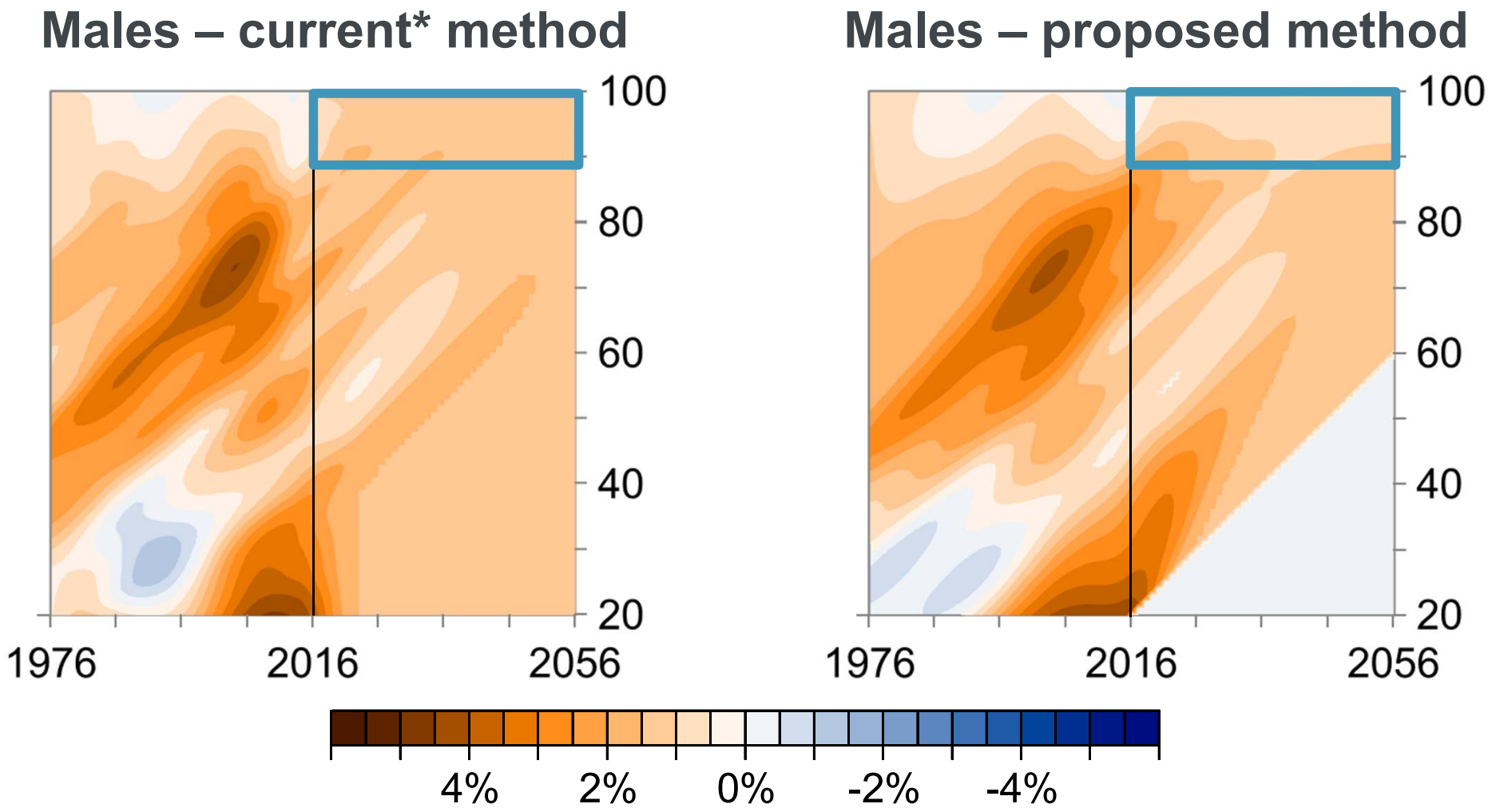
3. Lower long-term old-age improvements



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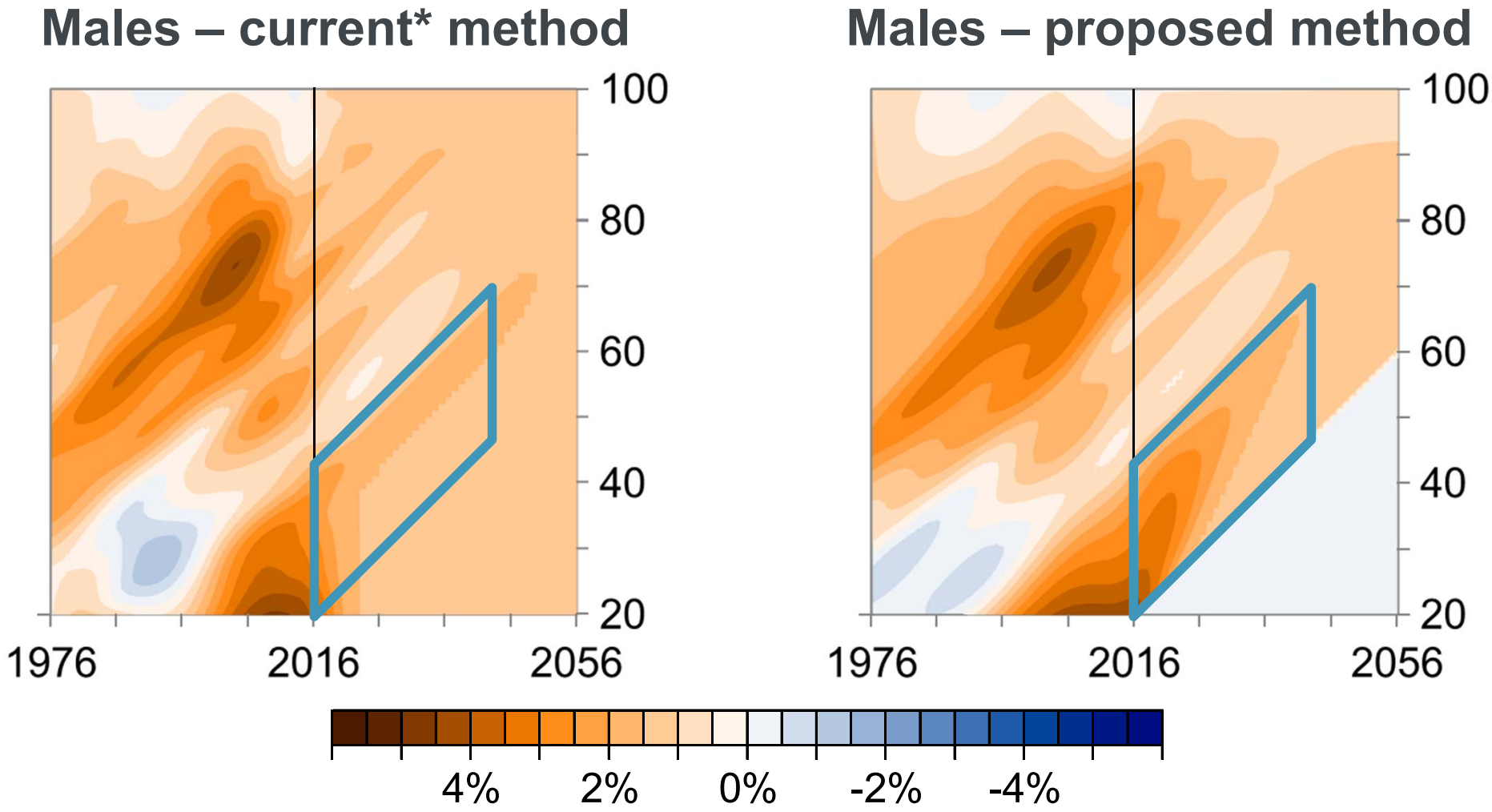
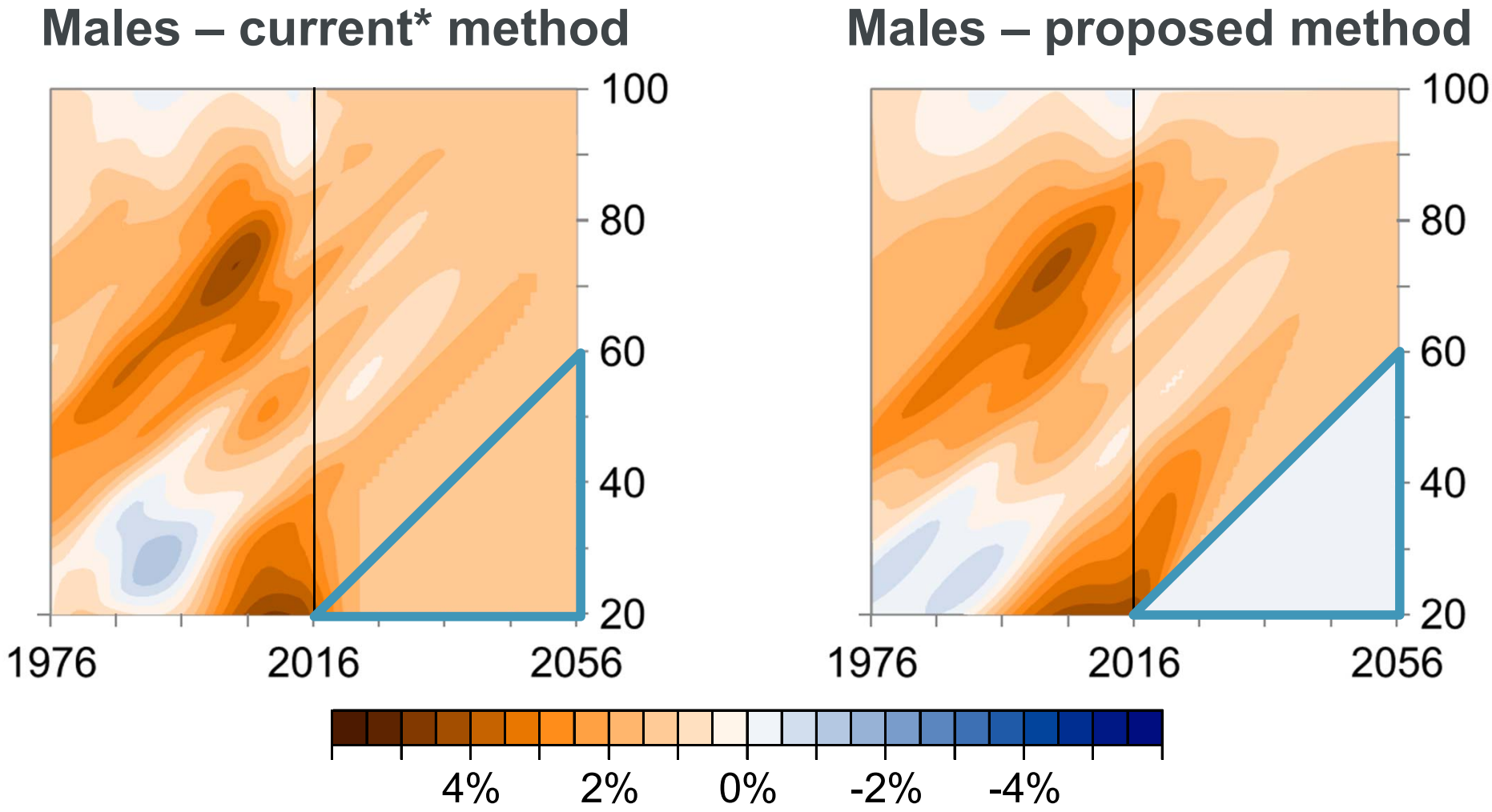
4. Young-age cohort improvements



* Note that “current” is not the same as CMI_2015

5. ‘New’ cohorts not projected



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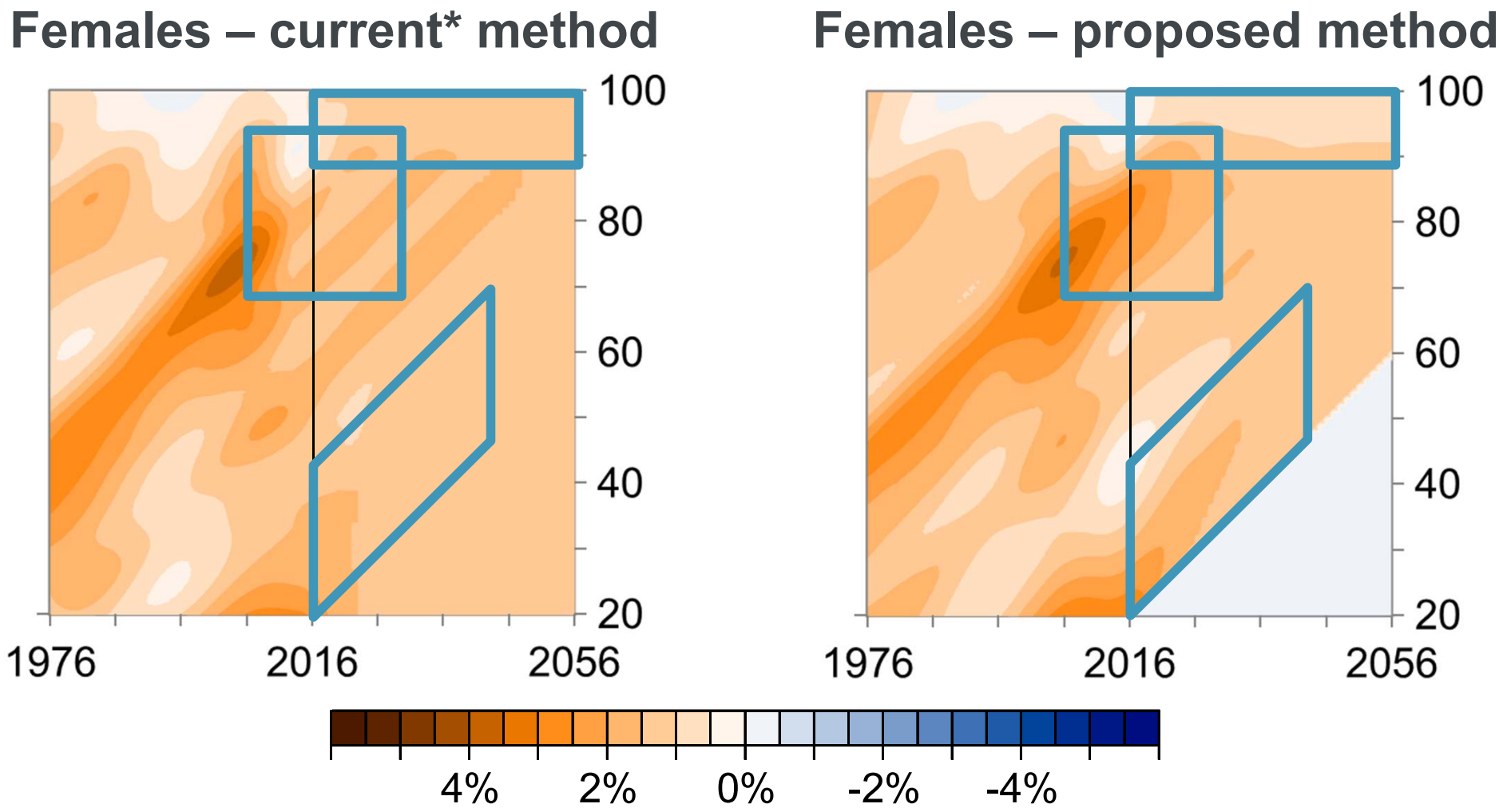
Comparison of female improvements



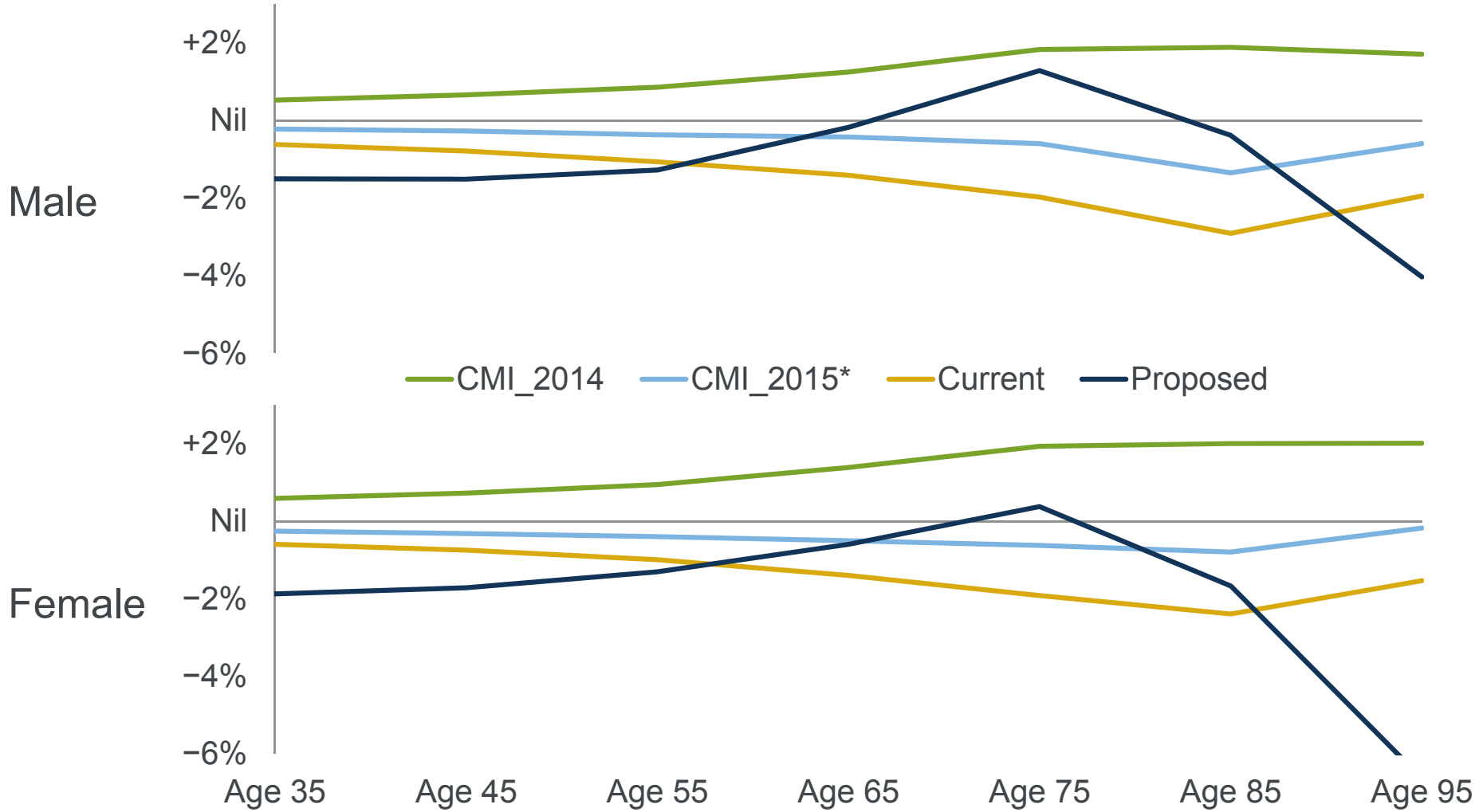
* Note that “current” is not the same as CMI_2015

Life expectancy at end 2015 vs CMI_2015

- CMI_2014 = actual data to 30 September 2014 + initial year 2011
- CMI_2015 = actual data to 31 July 2015 + initial year 2012
- CMI_2015* = CMI_2015 + data to end 2015 (still initial year 2012)
- 'Current' = CMI_2015* + initial year 2013
- 'Proposed' = data to end 2015 (no step-back applicable)

Sex	Method	Age 35	Age 45	Age 55	Age 65	Age 75	Age 85	Age 95
Male	CMI_2014	+0.53%	+0.67%	+0.87%	+1.26%	+1.84%	+1.90%	+1.72%
	CMI_2015*	−0.21%	−0.26%	−0.36%	−0.42%	−0.59%	−1.34%	−0.59%
	Current	−0.61%	−0.78%	−1.06%	−1.41%	−1.97%	−2.91%	−1.94%
	Proposed	−1.50%	−1.51%	−1.27%	−0.17%	+1.29%	−0.38%	−4.03%
Female	CMI_2014	+0.60%	+0.73%	+0.95%	+1.39%	+1.94%	+2.01%	+2.02%
	CMI_2015*	−0.25%	−0.31%	−0.39%	−0.50%	−0.62%	−0.79%	−0.17%
	Current	−0.59%	−0.74%	−0.99%	−1.39%	−1.91%	−2.39%	−1.53%
	Proposed	−1.87%	−1.71%	−1.30%	−0.59%	+0.38%	−1.66%	−6.63%

Life expectancy at end 2015 vs CMI_2015



Questions

Comments

The views expressed in this presentation are those of the presenter.

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