Integrated Climate Change Analysis

Modeling Workgroup Quarterly Meeting – Dec 2016

Kyle Hinson[1], Andrew Sommerlot[2], Gopal Bhatt[3]

[1] Chesapeake Research Consortium, [2] University of Maryland Center for Environmental Science, [3] Penn State University

Presentation Outline

- Brief review of previous work

- Estimation of potential evapotranspiration

- Model simulation and results

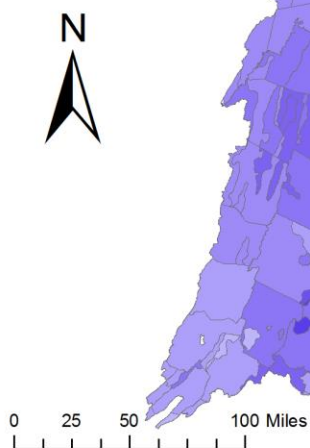- Next steps

2025 rainfall based on long term trends
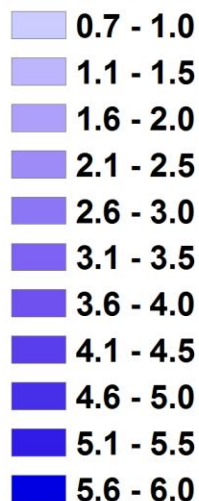
- *STAC has recommended use of long-term trends for estimating 2025 rainfall projections.*

- Monthly PRISM data is a reliable source of rainfall data.

- Aaron Mills (USGS) and Karen Rice (USGS) recommended using trends on annual PRISM data.

PRISM (red dots) and NLDAS (blue dots) data are shown
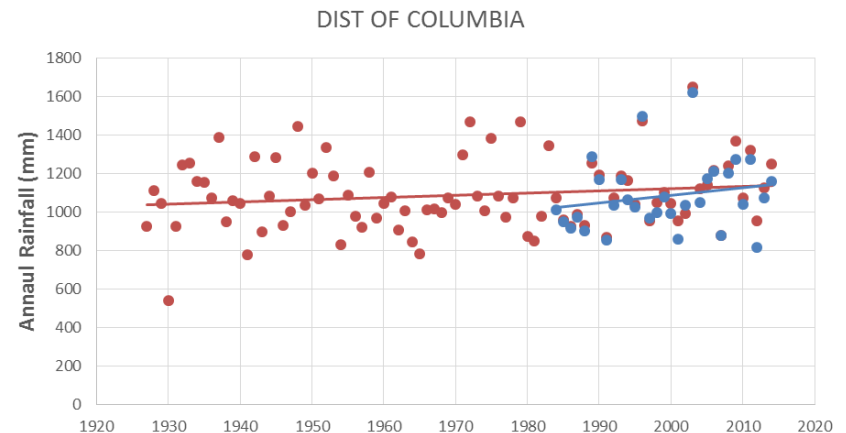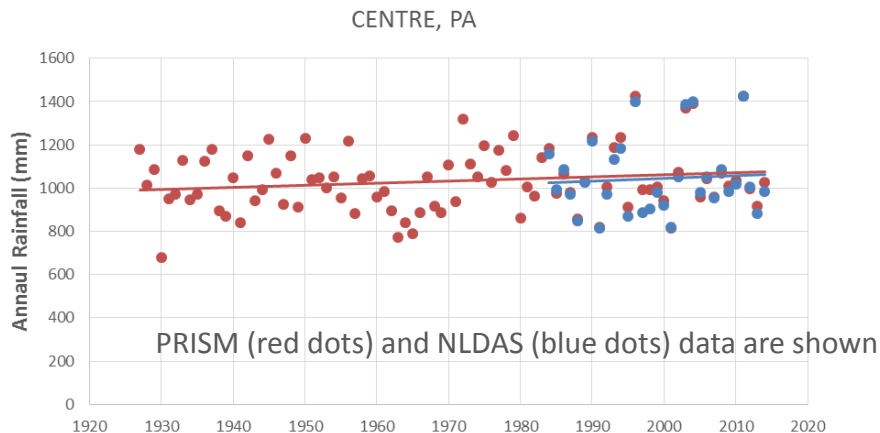
- 32 member ensemble (P50 median) was recommended for temperature projections.

Change in Rainfall using *Annual Trend in PRISM data (88 Years)*

2025 Rainfall Projection (percent change)

	0.7 - 1.0
	1.1 - 1.5
	1.6 - 2.0
	2.1 - 2.5
	2.6 - 3.0
	3.1 - 3.5
	3.6 - 4.0
	4.1 - 4.5
	4.6 - 5.0
	5.1 - 5.5
	5.6 - 6.0

N

0 25 50 100 Miles

Change in Rainfall Volume 2021-2030 vs. 1991-2000

Major Basins	PRISM Trend
Youghiogheny River	2.1%
Patuxent River Basin	3.3%
Western Shore	4.1%
Rappahannock River Basin	3.2%
York River Basin	2.6%
Eastern Shore	2.5%
James River Basin	2.2%
Potomac River Basin	2.8%
Susquehanna River Basin	3.7%
Chesapeake Bay Watershed	**3.1%**

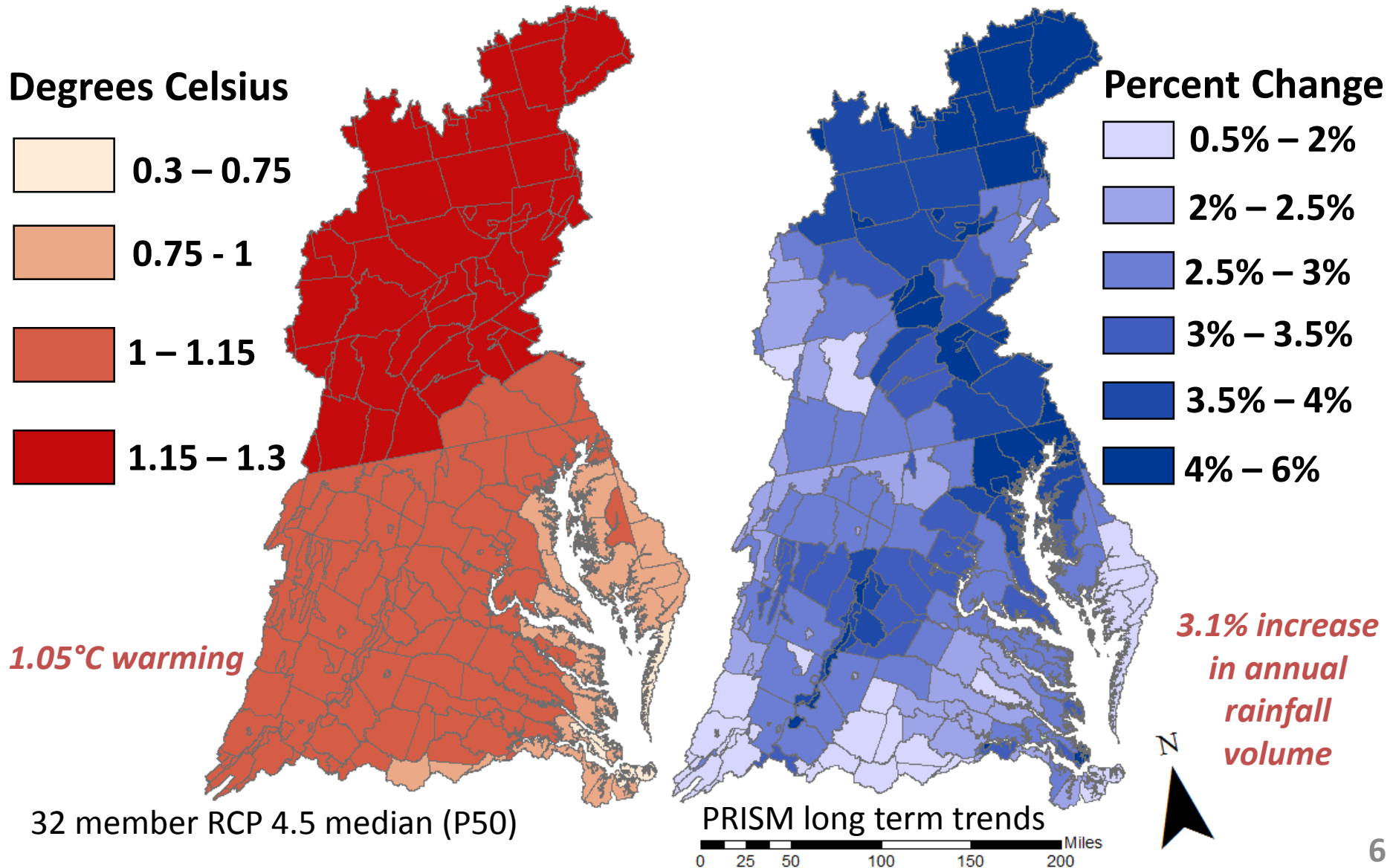# Change in Rainfall using *Multiple Model Ensemble of Downscaled GCMs (RCP 4.5)*

2025 Rainfall Projection (percent change)

	0.7 - 1.0
	1.1 - 1.5
	1.6 - 2.0
	2.1 - 2.5
	2.6 - 3.0
	3.1 - 3.5
	3.6 - 4.0
	4.1 - 4.5
	4.6 - 5.0
	5.1 - 5.5
	5.6 - 6.0
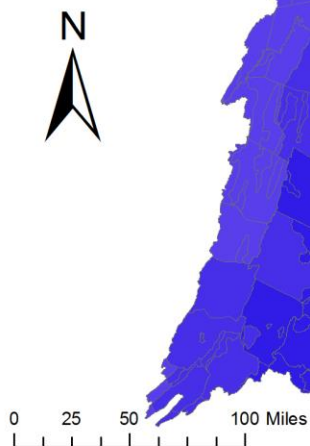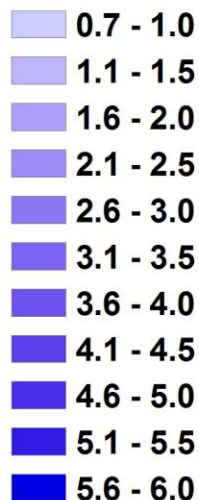
Change in Rainfall Volume 2021-2030 vs. 1991-2000

Major Basins	CMIP5
Youghiogheny River	4.1%
Patuxent River Basin	4.2%
Western Shore	4.2%
Rappahannock River Basin	4.9%
York River Basin	4.7%
Eastern Shore	3.7%
James River Basin	5.0%
Potomac River Basin	4.7%
Susquehanna River Basin	4.1%
Chesapeake Bay Watershed	**4.4%**

Year 2025: Changes in Temperature* and Precipitation

Degrees Celsius

- 0.3 – 0.75
- 0.75 - 1
- 1 – 1.15
- 1.15 – 1.3

1.05°C warming

32 member RCP 4.5 median (P50)

Percent Change

- 0.5% – 2%
- 2% – 2.5%
- 2.5% – 3%
- 3% – 3.5%
- 3.5% – 4%
- 4% – 6%

3.1% increase in annual rainfall volume

PRISM long term trends

N

Miles
0 25 50   100   150   200
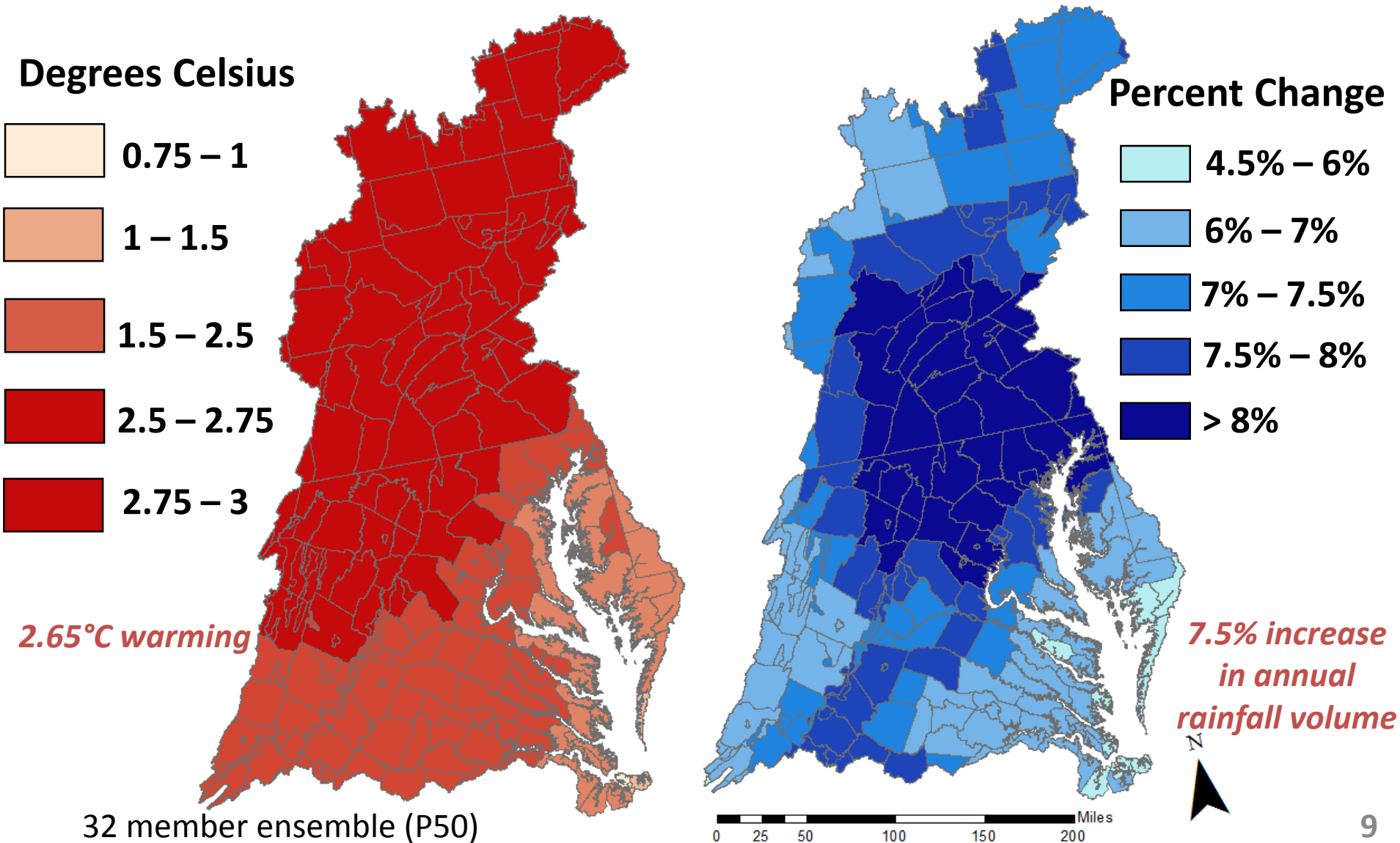
6

2050 rainfall and temperature projections

- *STAC has recommended the use of downscaled global climate models for rainfall and temperature projections.*

- The use of RCP 4.5 and 8.5 was recommended.
- For rainfall, **P50 (median), P90 and P10 (90 and 10% bounds)** were recommended.
- For temperature, P50 (median) was recommended.

- Following the recommendations, rainfall and temperature datasets were prepared using downscaled data from 32 GCMs (US Climate Resilience Toolkit).

Year 2050: Changes in Temperature and Precipitation – RCP 4.5
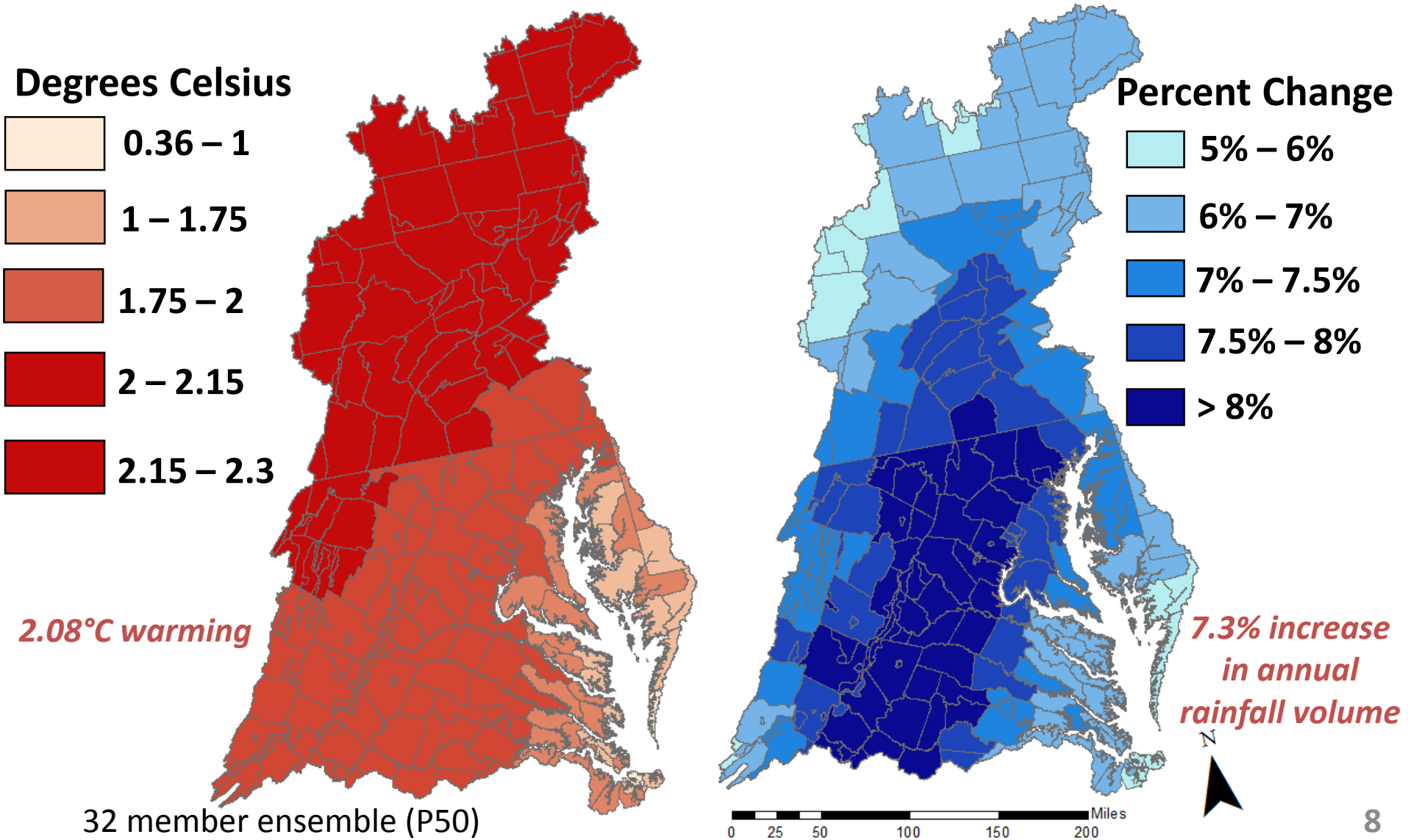
Degrees Celsius

- 0.36 – 1
- 1 – 1.75
- 1.75 – 2
- 2 – 2.15
- 2.15 – 2.3

2.08°C warming

32 member ensemble (P50)

Percent Change

- 5% – 6%
- 6% – 7%
- 7% – 7.5%
- 7.5% – 8%
- > 8%

7.3% increase in annual rainfall volume

N

Miles
0 25 50 100 150 200

8

Year 2050: Changes in Temperature and Precipitation – RCP 8.5

Degrees Celsius

- 0.75 – 1
- 1 – 1.5
- 1.5 – 2.5
- 2.5 – 2.75
- 2.75 – 3

2.65°C warming

32 member ensemble (P50)

Percent Change

- 4.5% – 6%
- 6% – 7%
- 7% – 7.5%
- 7.5% – 8%
- > 8%

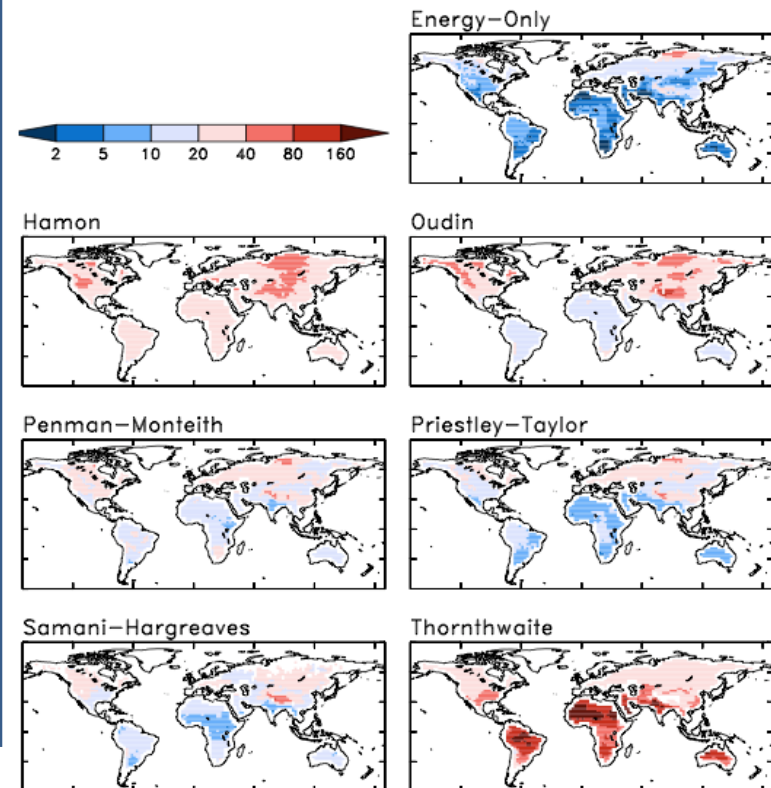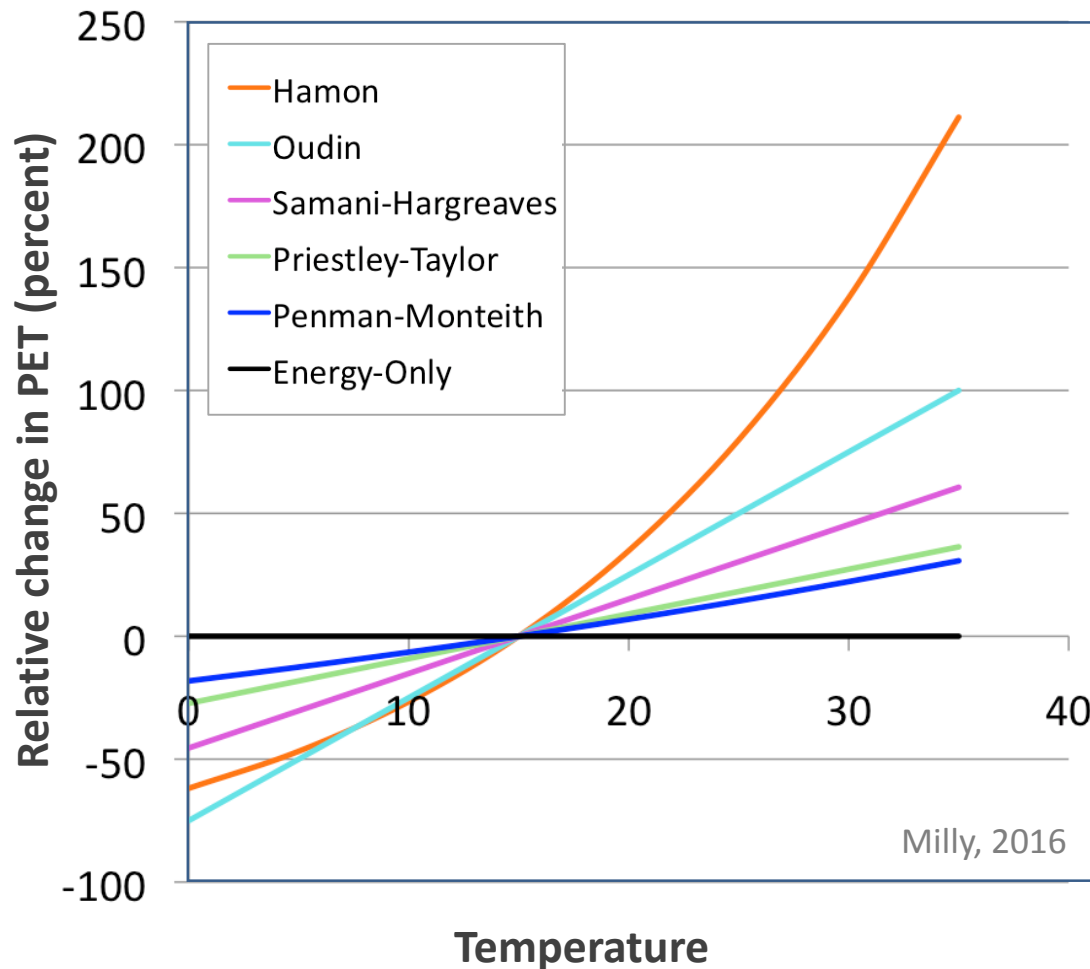*7.5% increase in annual rainfall volume*

N

Miles
0   25   50   100   150   200

9

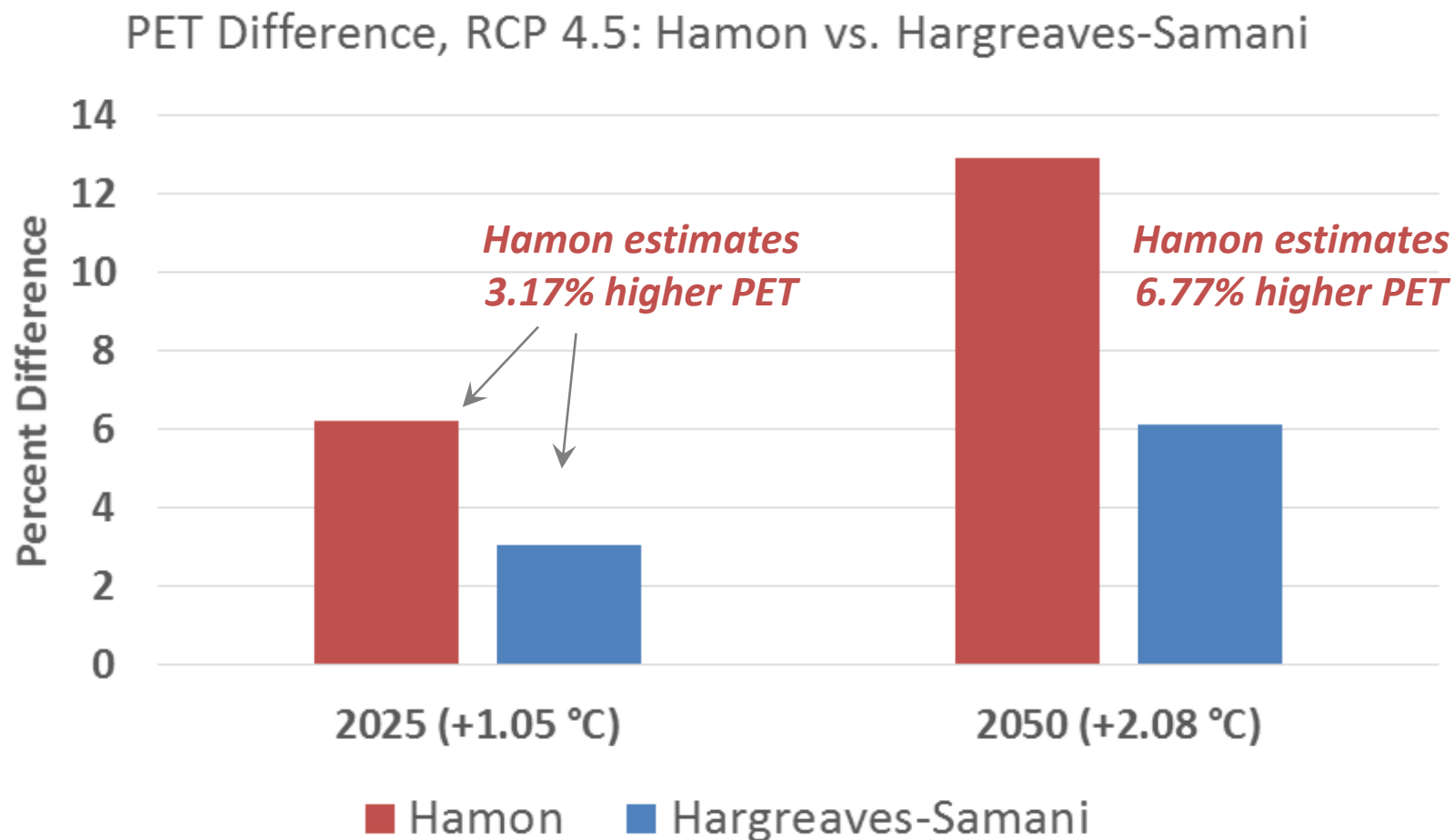# Simulation of climate change scenarios

- Phase 6 Beta 3 model was used for the simulation of climate change scenarios.

- Changes in flow and sediment were simulated using *process-based* simulation of hydrology and sediment transport in Phase 6.

- A deterministic simulation of nutrients was based on *Phase 6 sensitivities*:
  - For phosphorus, sensitives from APLE are applied to changes in flow and sediment.
  - For nitrogen, sensitivities for flow were estimated from Butcher et al. 2013, EPA/600/R12/058A.

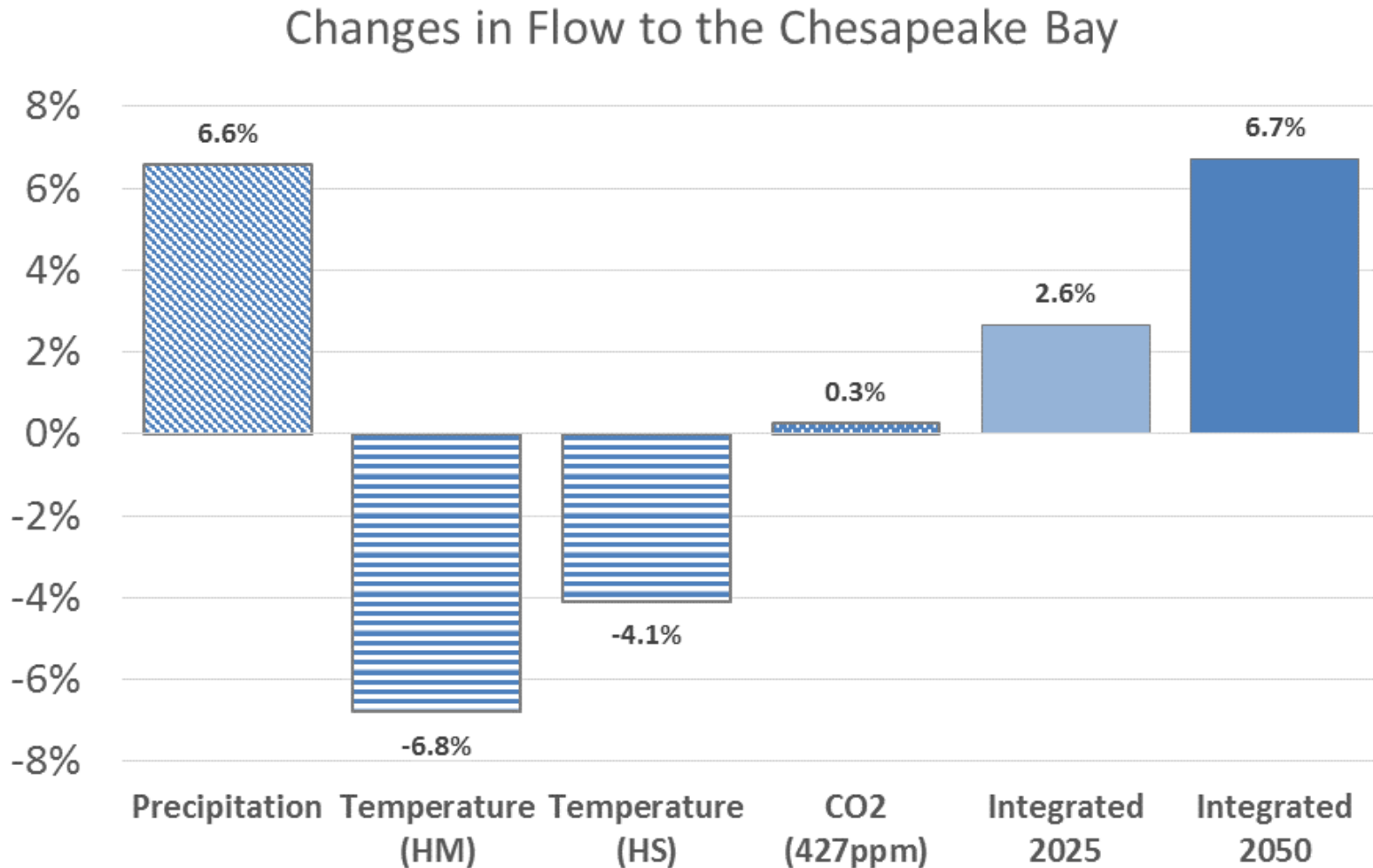# Estimation of potential evapotranspiration

Milly PCD (USGS) at STAC Workshop, 2016: *Runoff in a Changing Climate: Climate-Model Choice Matters, and So Does PET Choice*
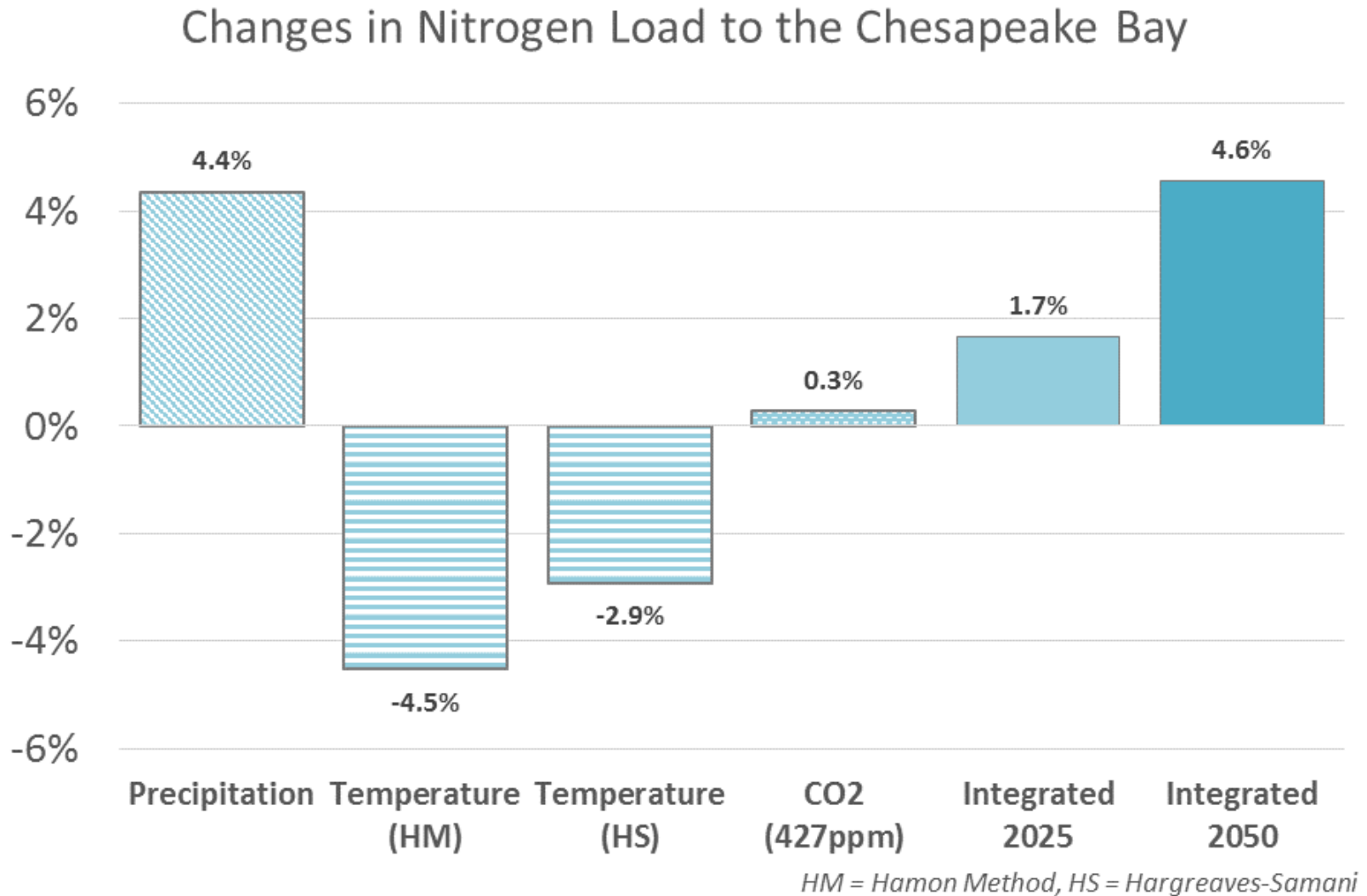
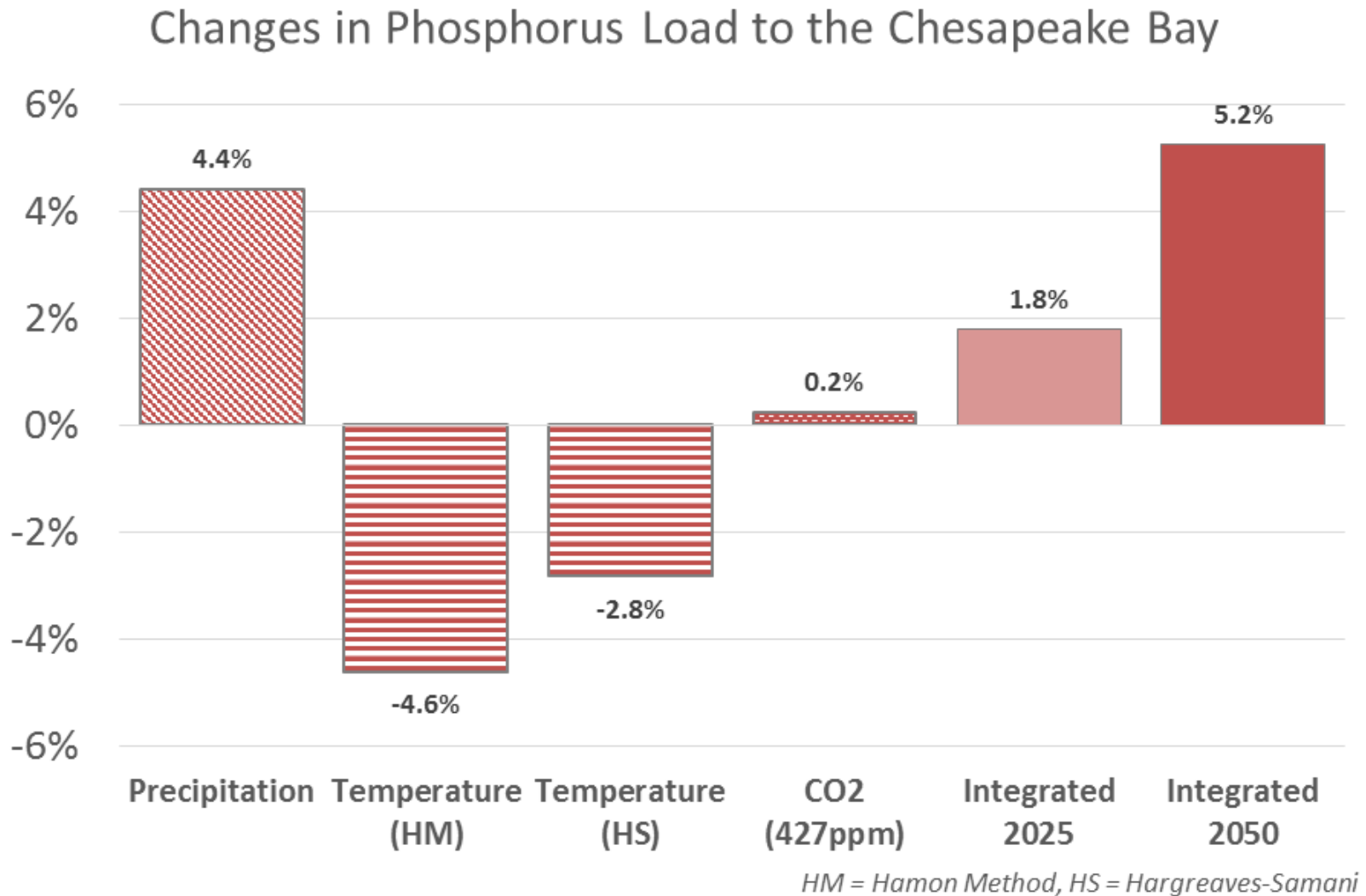

Milly, 2016

Comparison of PET estimates

PET Difference, RCP 4.5: Hamon vs. Hargreaves-Samani

Hamon estimates 3.17% higher PET

Hamon estimates 6.77% higher PET

Beta 3 Model results - *Flow*

Changes in Flow to the Chesapeake Bay

HM = Hamon Method, HS = Hargreaves-Samani

Beta 3 Model results – *Nitrogen*

Changes in Nitrogen Load to the Chesapeake Bay

HM = Hamon Method, HS = Hargreaves-Samani

Beta 3 Model results – *Phosphorus*

Changes in Phosphorus Load to the Chesapeake Bay

HM = Hamon Method, HS = Hargreaves-Samani

Beta 3 Model results - *Sediment*
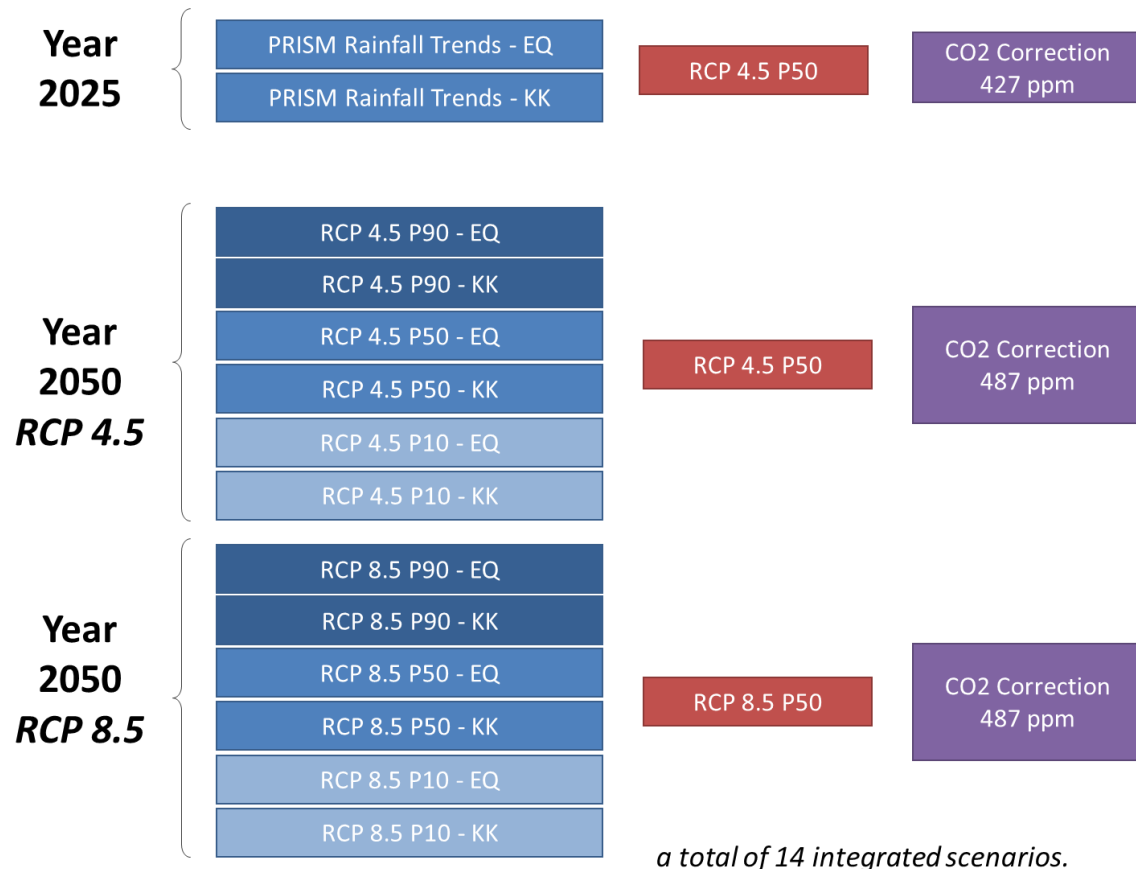

Changes in Sediment Load to the Chesapeake Bay
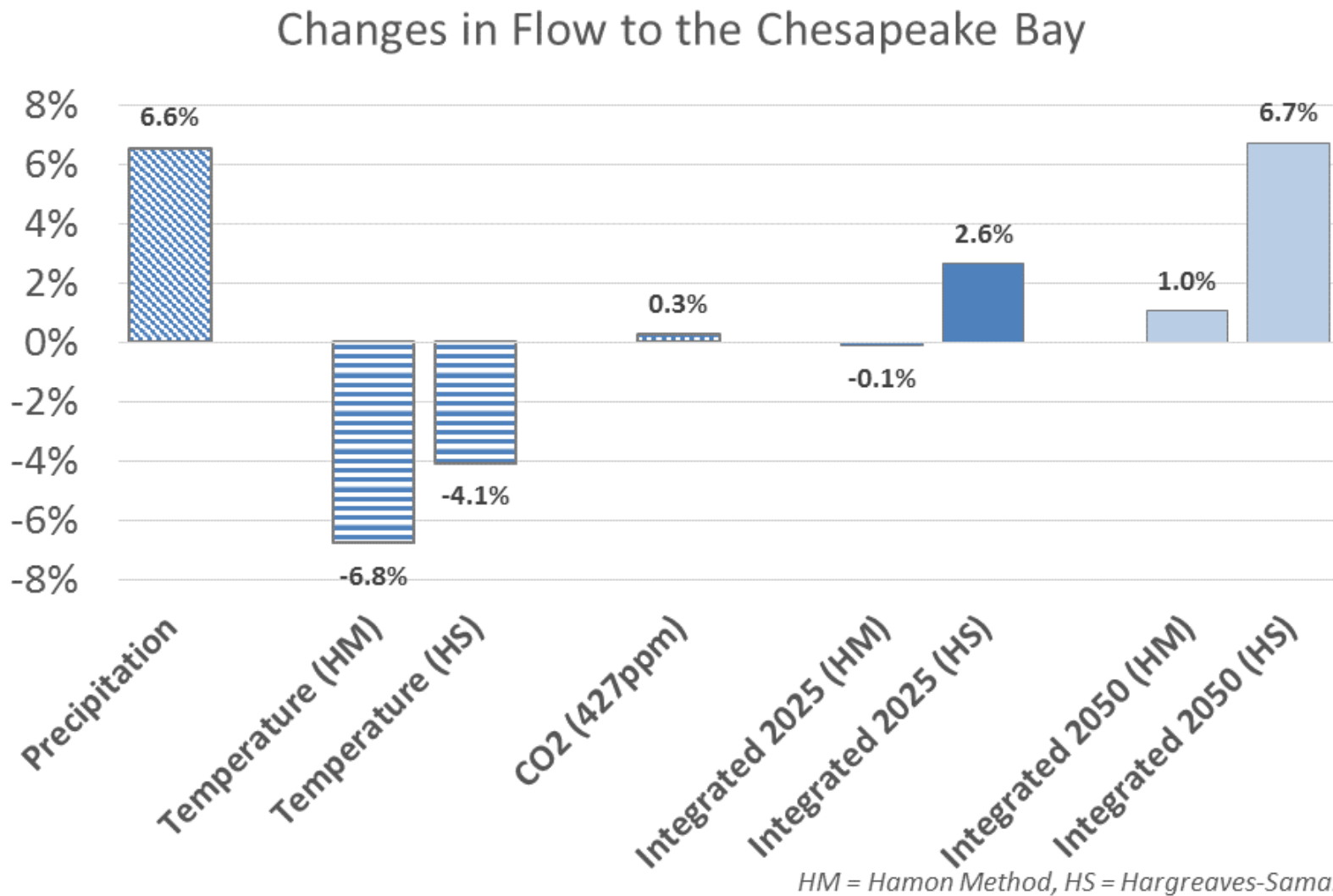
HM = Hamon Method, HS = Hargreaves-Samani
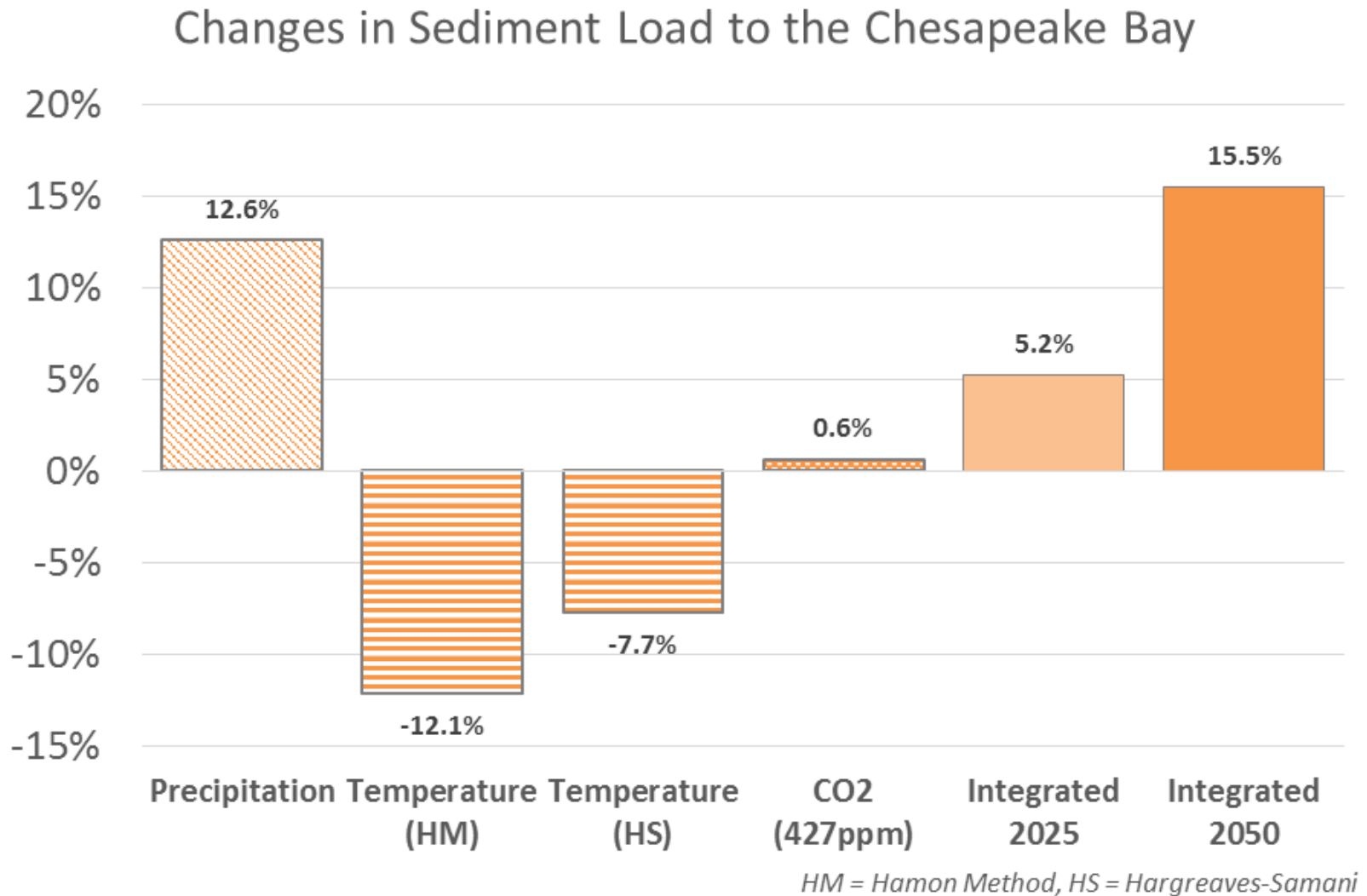
Next steps...

- Assessment of impacts of change on the Bay water quality
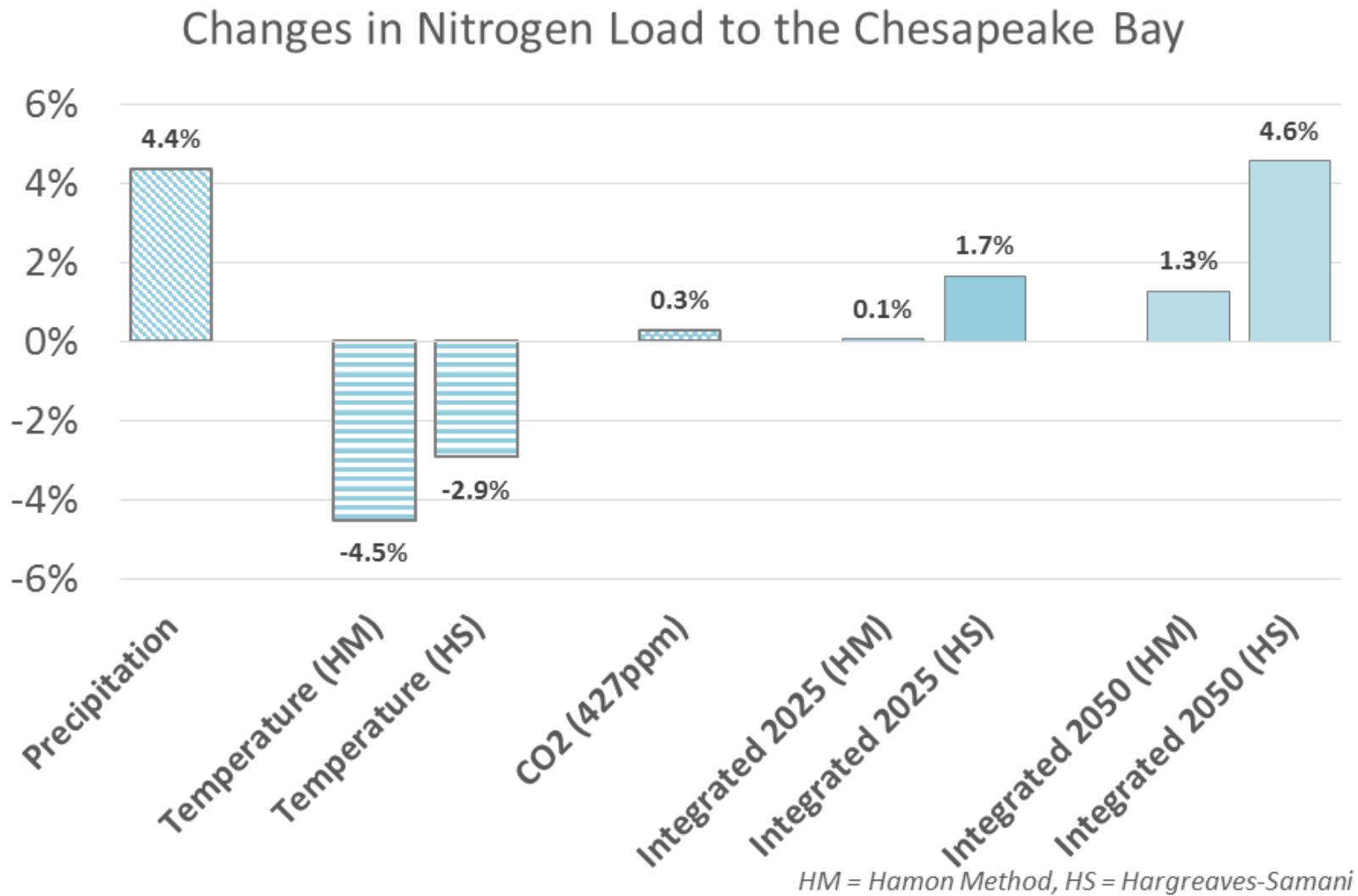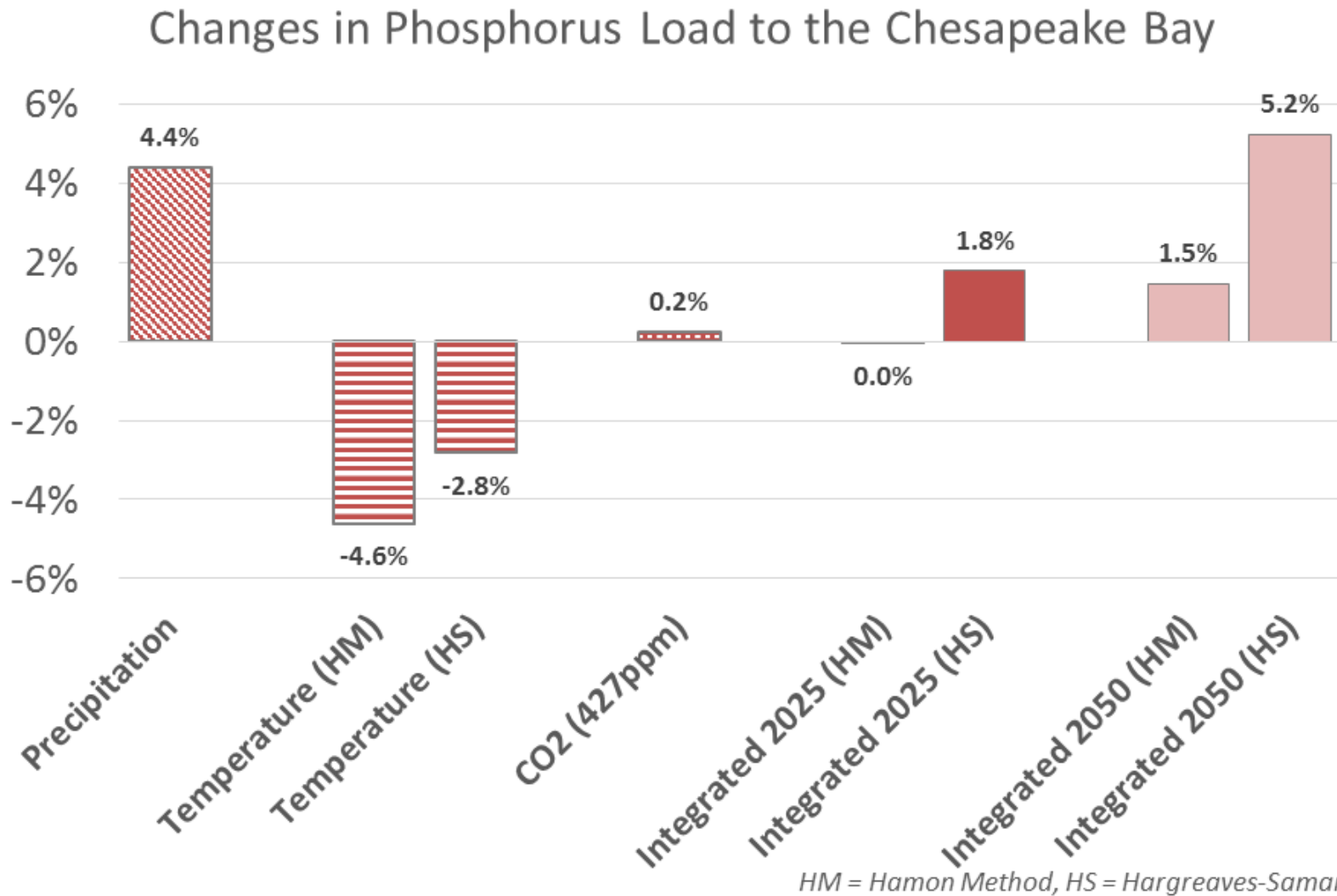- Additional climate change scenarios to quantify uncertainty

a total of 14 integrated scenarios.

Beta 3 Model results - *Flow*

Changes in Flow to the Chesapeake Bay

HM = Hamon Method, HS = Hargreaves-Samani

Beta 3 Model results – *Nitrogen*

Changes in Nitrogen Load to the Chesapeake Bay

HM = Hamon Method, HS = Hargreaves-Samani

Beta 3 Model results – *Phosphorus*

Changes in Phosphorus Load to the Chesapeake Bay

HM = Hamon Method, HS = Hargreaves-Samani

Beta 3 Model results - *Sediment*

Changes in Sediment Load to the Chesapeake Bay

HM = Hamon Method, HS = Hargreaves-Samani