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Air Pollutant Emissions in the SSP Scenarios

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TASK FORCE ON INTEGRATED ASSESSMENT MODELLING (TFIAM)

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Outline

- **Scenarios Background**
- **Representative Concentration Pathways (RCPs)**
  - ***Primarily designed as inputs for CMIP6***
- **Shared Socio-Economic Pathways (SSPs)**
  - ***Designed for many uses, including inputs for CMIP6***

TOOLS: Scenarios

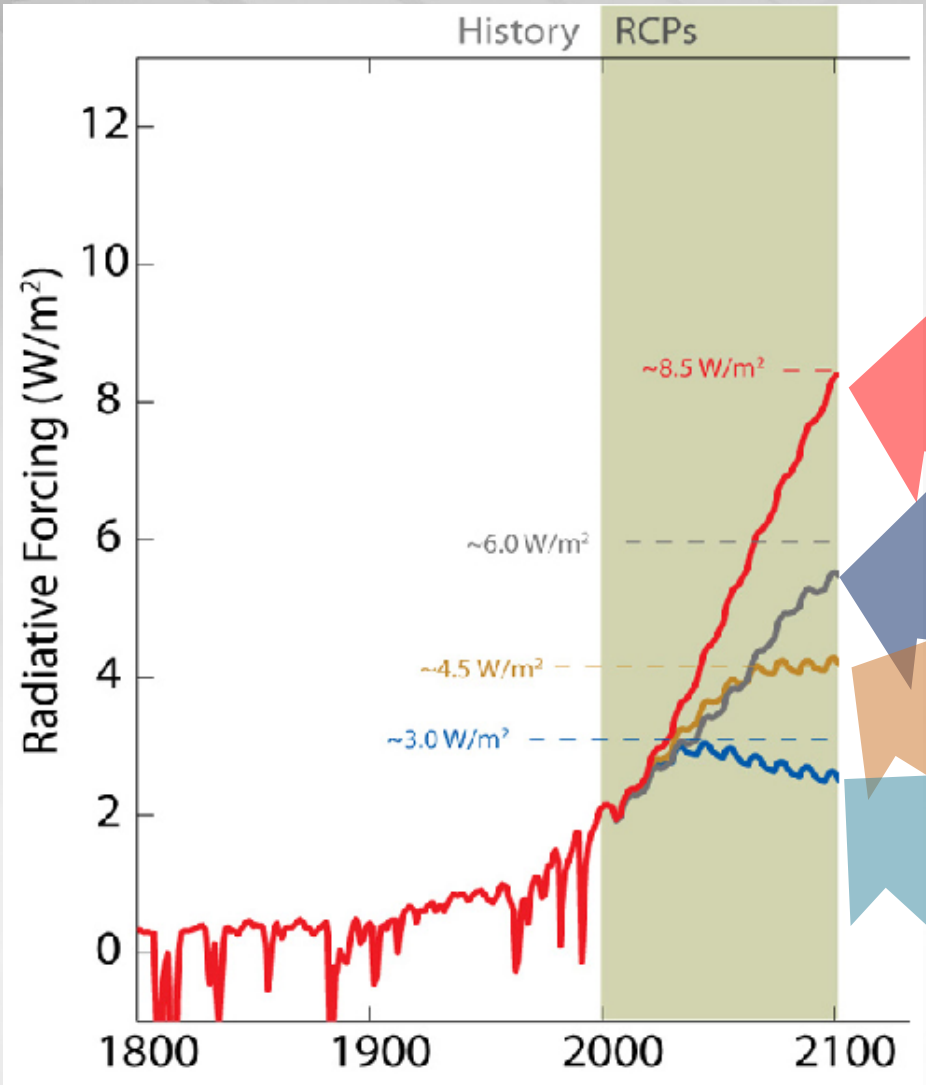
Scenarios are images of the future…. They are neither predictions nor forecasts. Rather, each scenario is one alternative image of how the future might unfold. A set of scenarios assists in the understanding of possible future developments of complex systems.

IPCC Special Report on Emissions Scenarios (2000)

Scenarios (in a climate context) can consist of:

- Demographic, Social, and Economic Characteristics
- Technology Availability and Performance
- Emissions and Land-Use Changes
- Atmospheric Composition and Air Pollution
- Physical Climate Changes
- Climate Impacts

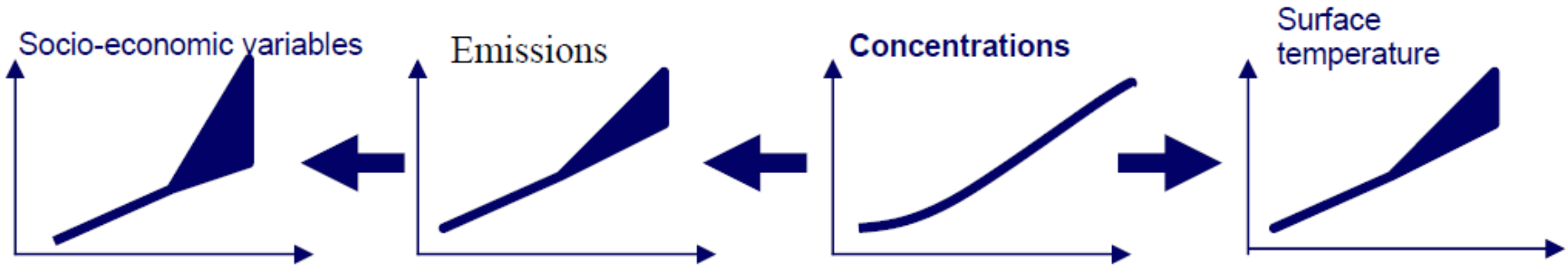
Representative Concentration Pathways (RCPs)



- The climate modeling community wanted 4 levels of radiative forcing that would span the emissions literature.

- 8.5 Wm^{-2} (RCP 8.5, *1350ppm CO_2-e*)
- 6.0 Wm^{-2} (RCP 6.0, *850ppm CO_2-e*)
- 4.5 Wm^{-2} (RCP 4.5, *650ppm CO_2-e*)
- 2.6 Wm^{-2} (RCP 2.6, *450ppm CO_2-e*)

Parallel Scenario Process



1) RCPs:

RCPs (Complete)

CMIP5 (Complete)

2) SSPs:

- Shared Socio-economic Pathways (Complete)

3) IAM quantification of SSPs:

- Emissions, Land-Use, … (Complete)

Two dimensions: SSP

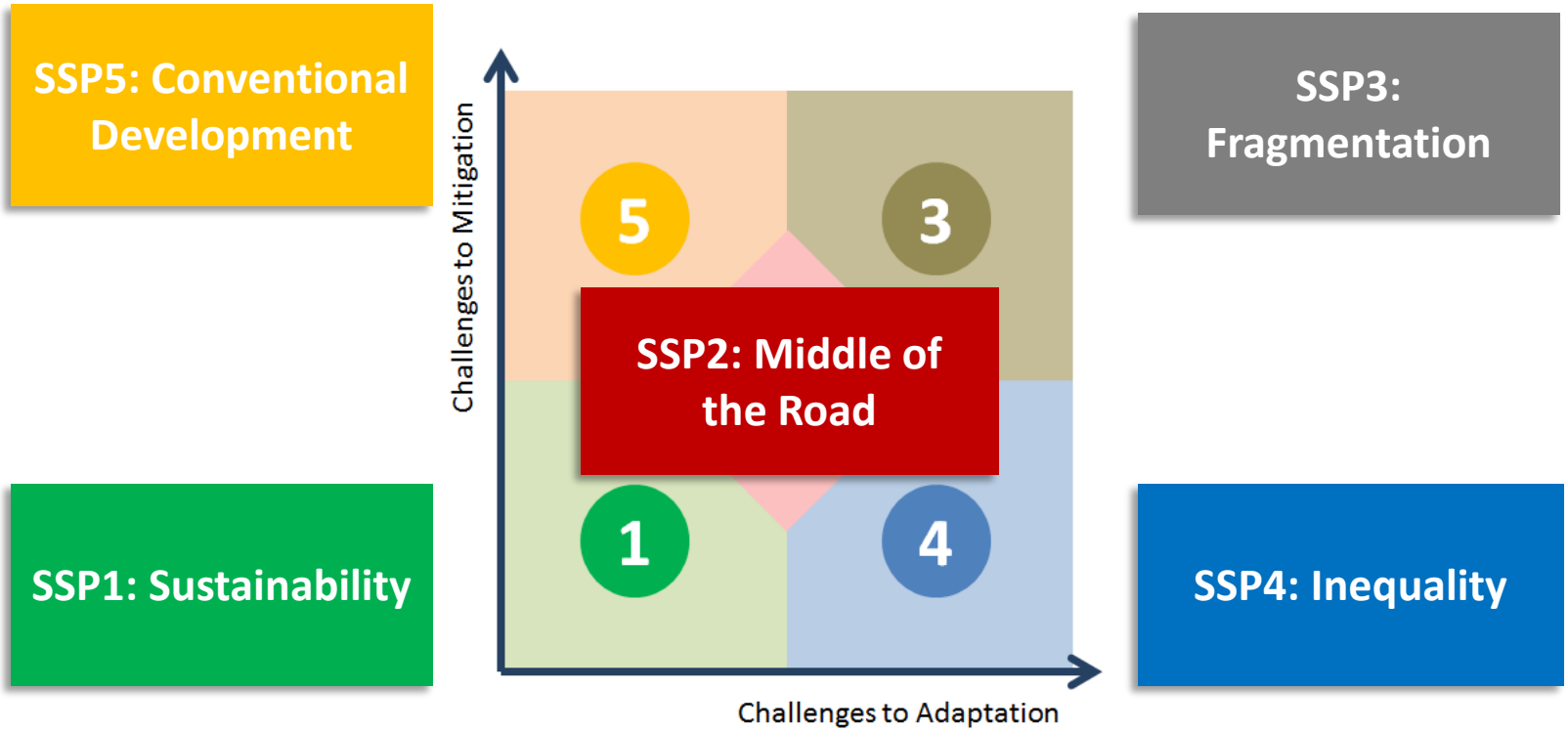
RCP level

4) Harmonized & gridded SSPs emissions and land-use:

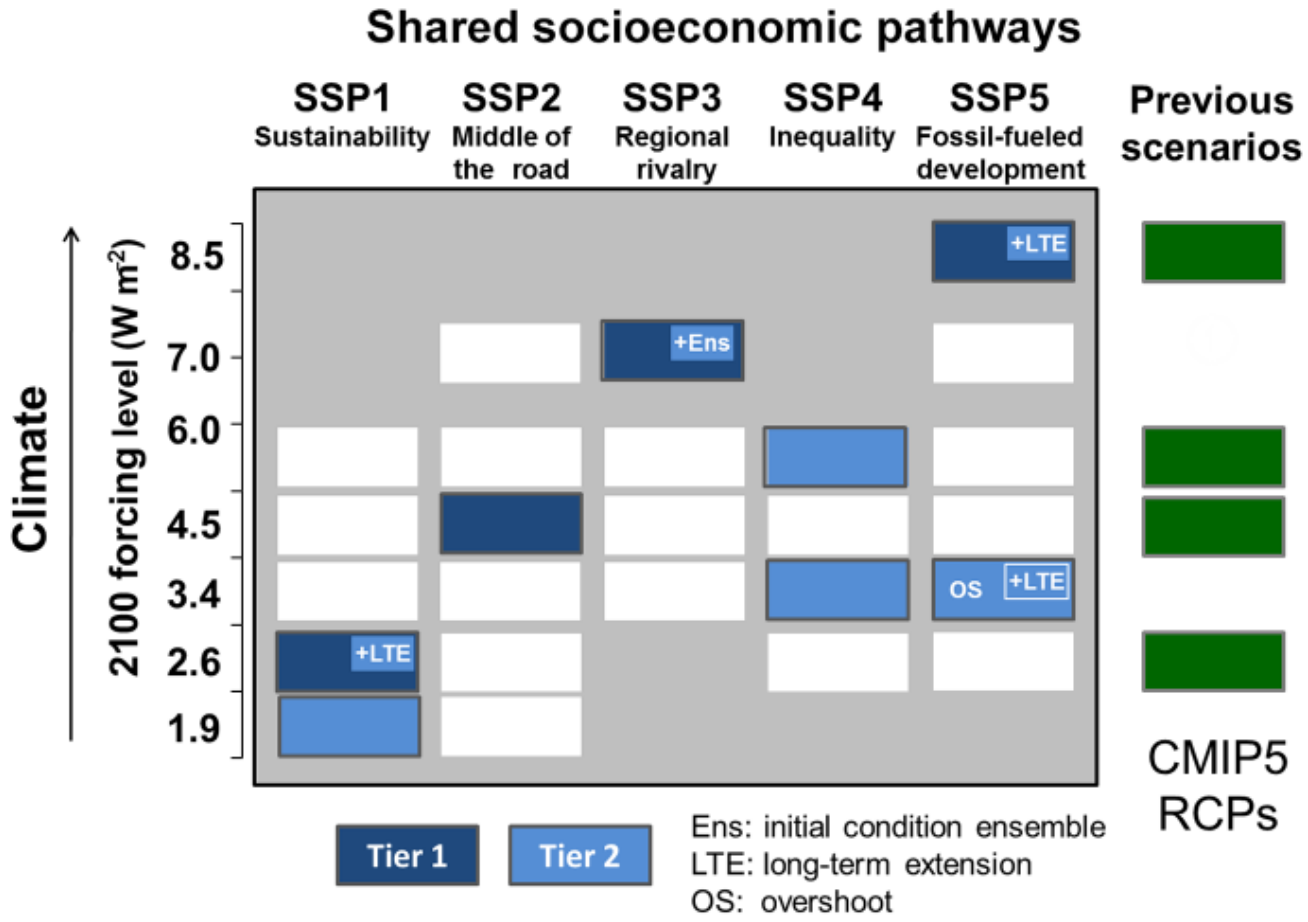
- Harmonize to common starting point for emissions, land-use, …
- Map information to spatial grid for use in models (climate, carbon, chemistry, etc.)

Five SSPs

- 5 SSPs are being used to develop **NEW SCENARIOS** to explore a range of future societal circumstances that exhibit a wide range of
  - **Challenges to adaptation**, and
  - **Challenges to mitigation**.



The SSP Scenario Matrix Architecture



There is also a third "SPA" dimension related to climate policy.

- IAM models produced quantifications for multiple scenarios. One set of model realizations is selected as the set of "marker" scenarios for that SSP (column in figure).
  - Depending on the purpose of any specific analysis, consistent SSP quantifications with a specific IAM are available in many cases.
  - Only the marker SSP5 reference scenario reaches 8.5

Air Pollutant Emissions in the SSPs

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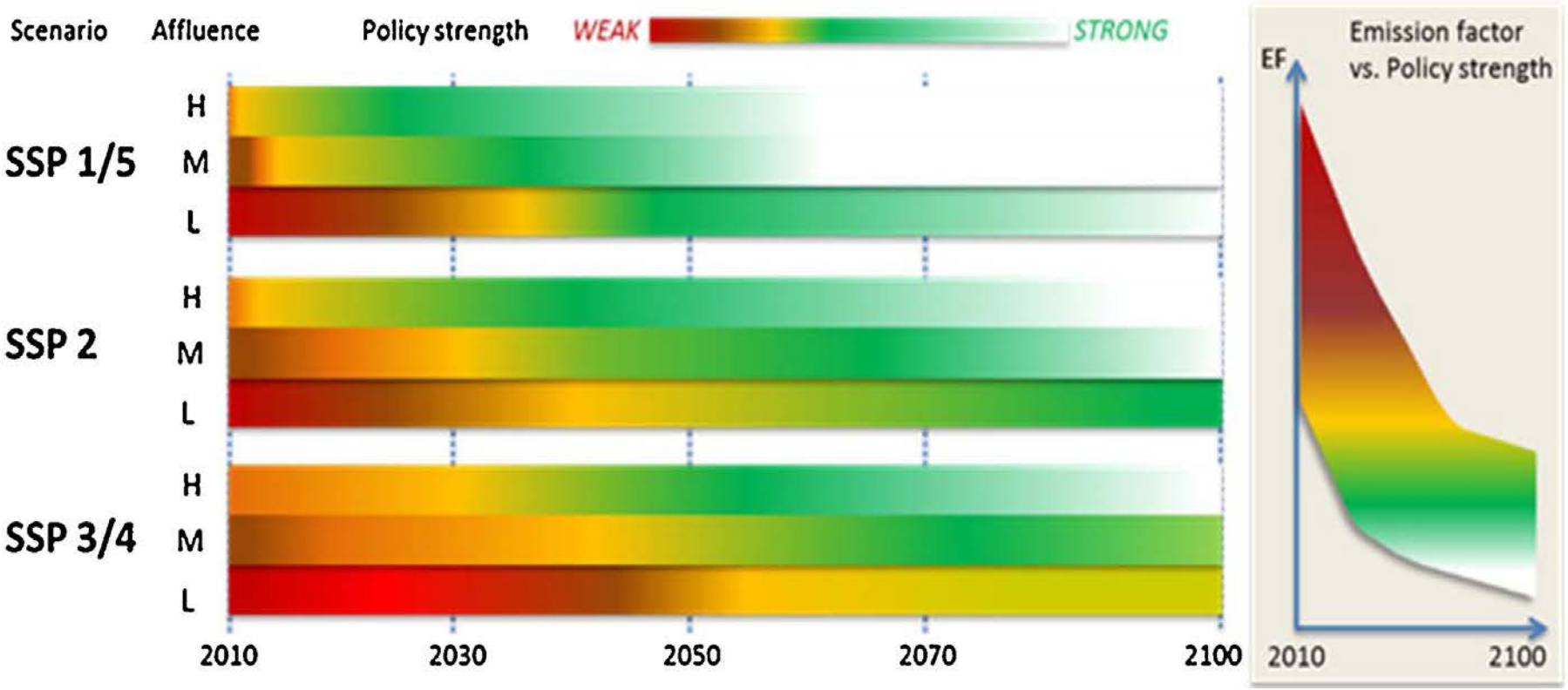
Air pollutant emission controls in the SSPs follow one of three stylized pathways grouped to be broadly consistent with the SSP storylines.



Rao et al. 2016. "Future Air Pollution in the Shared Socio-Economic Pathways." *Global Environmental Change* 42 (2017) 346–358.
http://dx.doi.org/10.1016/j.gloenvcha.2016.05.009

Air Pollutant Emissions in the SSPs

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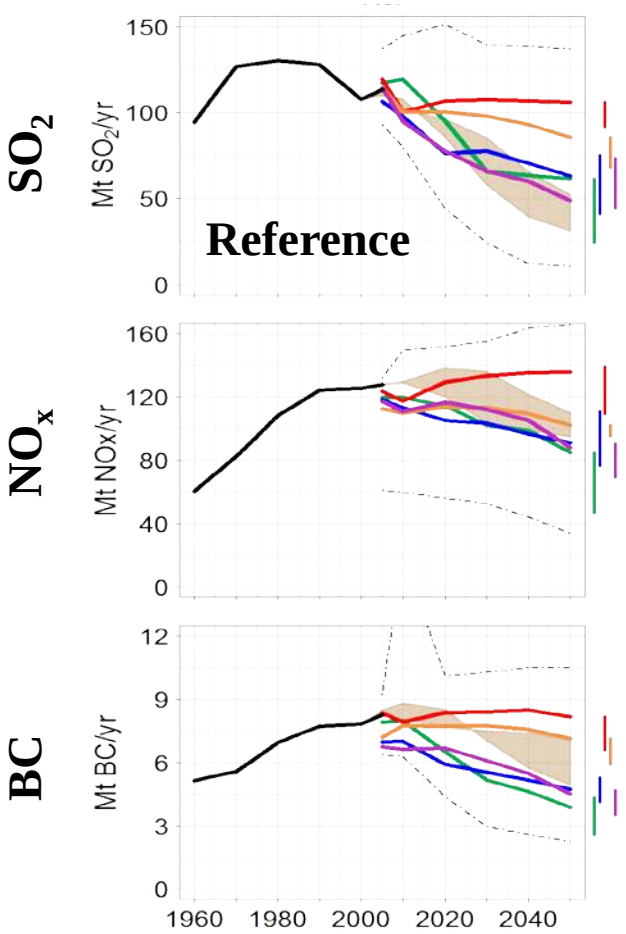
Implementations of the Shared Socio-economic Pathways (SSPs) published fall 2016



- Wider range of reference case air pollutant emission pathways.
- Note that reference case trajectory is critical to co-benefits results.
  - These are trajectories generated by long-term IAMs.
  - Models not all calibrated to same historical data.

RCP
SSP1
SSP2
SSP3
SSP4
SSP5
Historical
IPCC 5TH Assessment Range

Rao S, et al. (2016) "Future Air Pollution in the Shared Socio-Economic Pathways." *Global Environmental Change*. http://dx.doi.org/10.1016/j.gloenvcha.2016.05.009

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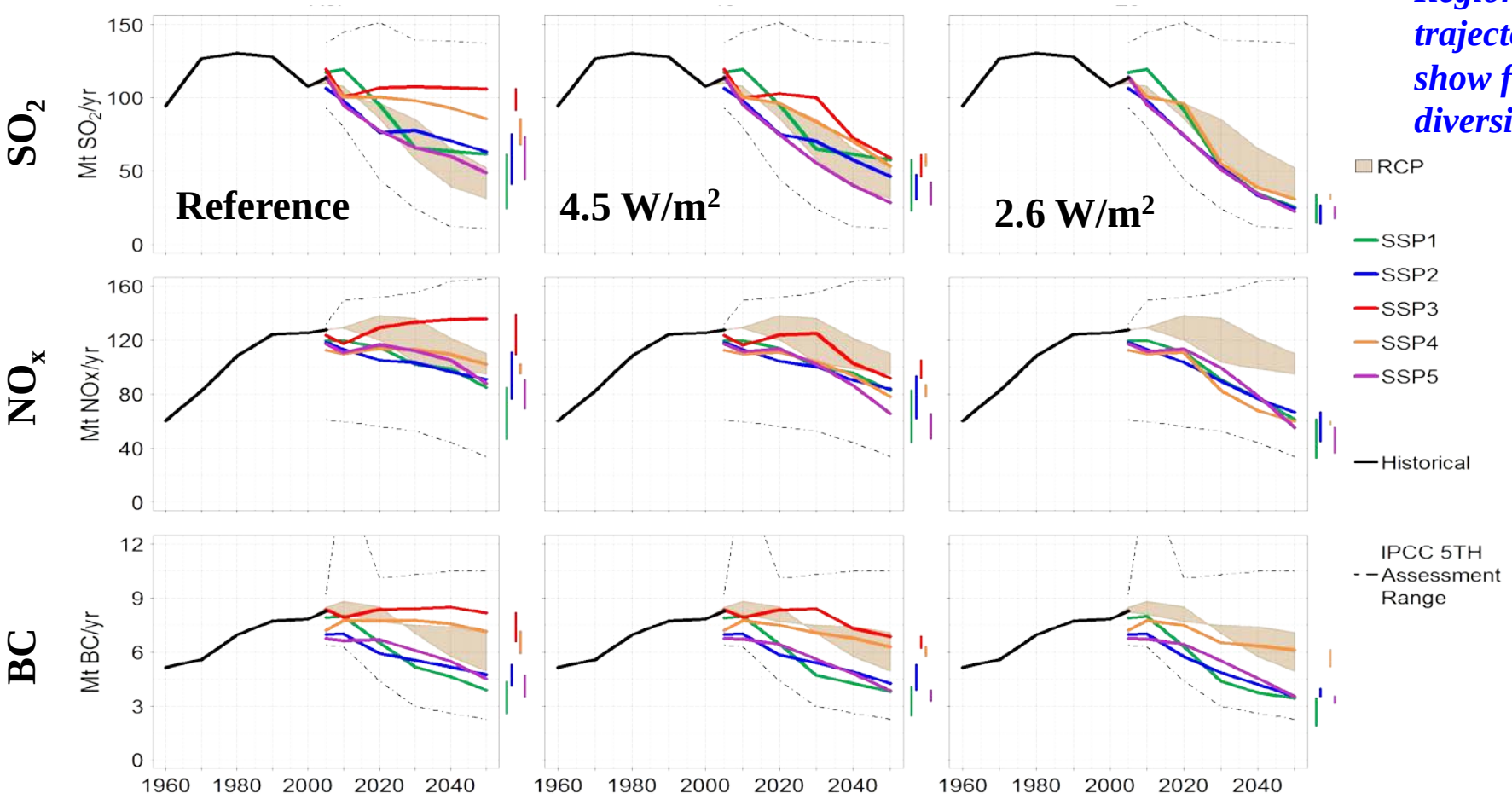
- Feature a wider range of reference case air pollutant emission pathways.
- Range naturally narrows as GHG emissions are reduced.

Regional trajectories show further diversity



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Because the SSP implementations were generated before the CMIP6 historical emissions were complete, they are being harmonized to

NEW HISTORICAL EMISSIONS

TOOLS: Historical Emissions–Community Emissions Data System (CEDS)

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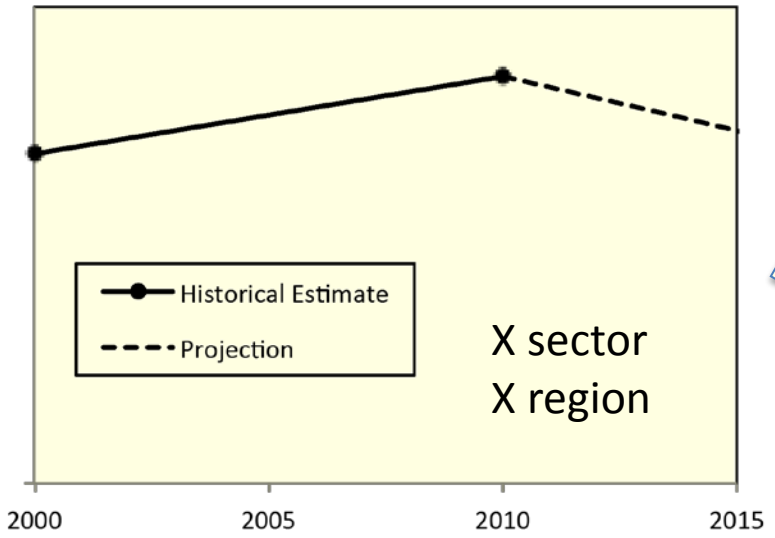
Timely estimates for emissions of aerosol (BC, OC) and aerosol precursor compounds (SO_2, NO_x, NH_3, CH_4, CO, NMVOC) are key inputs for aerosol research and Earth System Models

Needed for historical simulations, validation/comparisons with observations, historical attribution, uncertainty quantification, IAM calibration and validation, and economic/policy analysis.

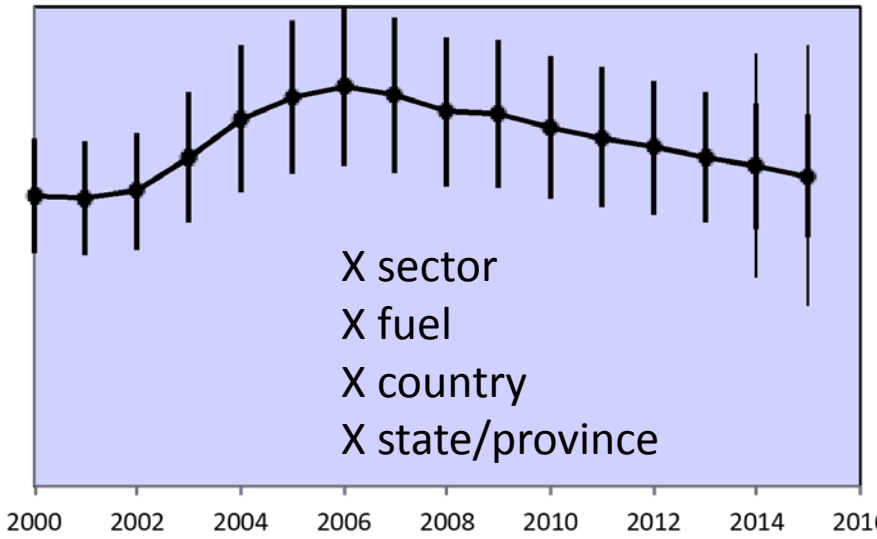
Instead of this



Produced using an open-source data system to increase data transparency and facilitate research advancements.

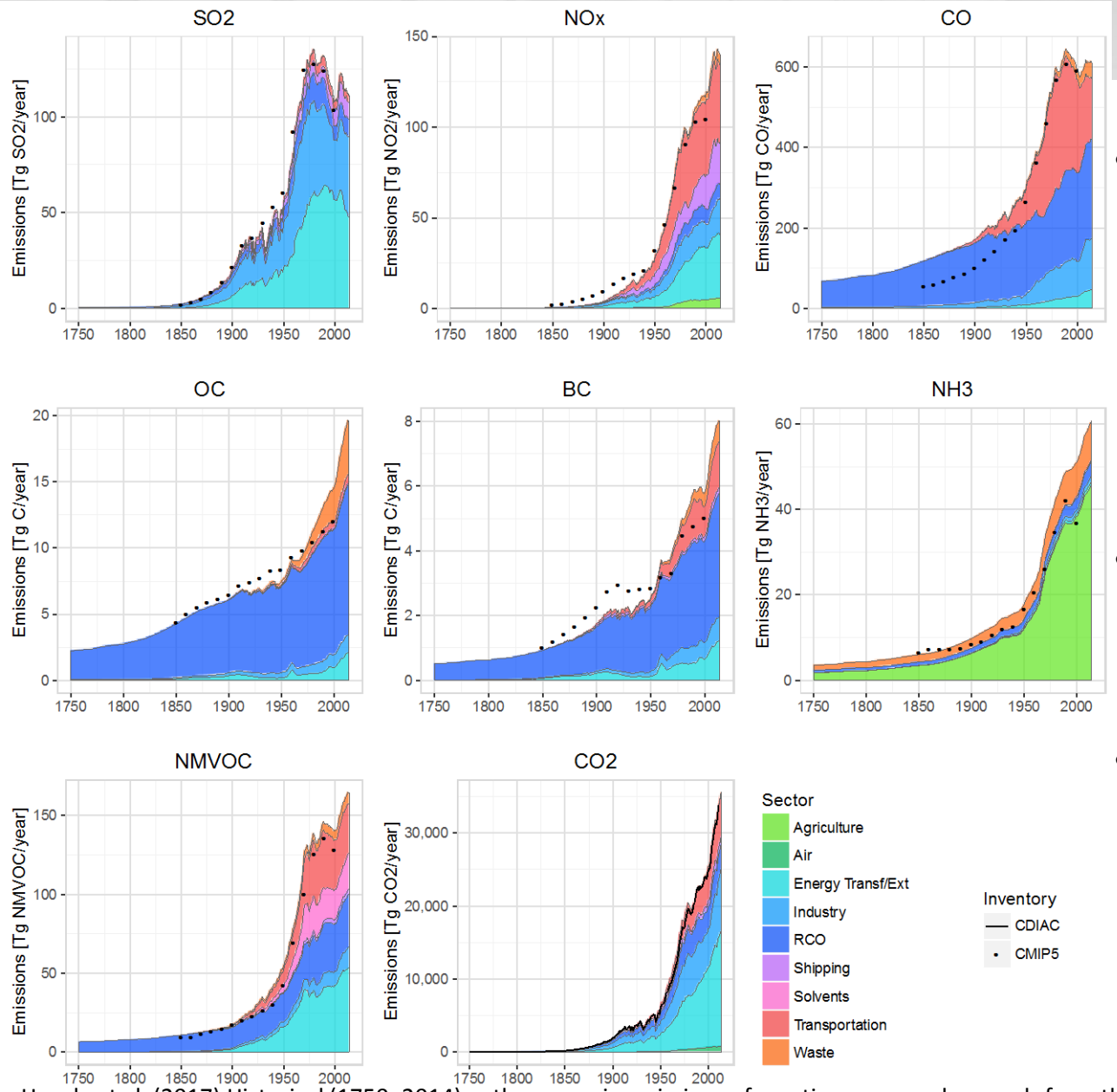
Uncertainty essential if extended to more recent years.

Produce



For anthropogenic emission sectors.

Global CMIP6 Emissions Compared to CMIP5



- Residential biomass are the dominant emissions in early years 1850. (Except NH3, where manure emissions are dominant, and NO_X, which is relatively small at this point.)
- Residential biomass has large contribution to BC and CO even to current day
- Transportation sector has large contribution to recent trends for NO_X and CO

Like with like comparison does not include aviation or agricultural waste burning.
** CO2 comparison includes aviation*

Hoesly et al. (2017) Historical (1750–2014) anthropogenic emissions of reactive gases and aerosols from the Community Emission Data System (CEDS), Geosci. Model Dev. Discuss., doi:10.5194/gmd-2017-43.

SSP Emissions Harmonization

In one of the final steps for production of gridded SSP emissions for use in CMIP6 models, emissions are being harmonized to the CMIP6 historical datasets:

Anthropogenic Emissions: CEDS (Hosley et al. 2017)

Open Burning Emissions: VUA (van Marle et al. 2017)

Harmonization Procedure:

1) Harmonize IAM emissions to match CEDS emissions extended to 2015 (2015 values will be identical in all scenarios).
   - Note, 2015 is a projected, and sometimes interpolated, year in the IAMs.
   - 2015 harmonization offset is propagated forward to smooth out discontinuities
2) Downscale emissions from IAM native regions to country level (e.g. van Vuuren et al. 2007)
3) Use same proxies and methods as used in CEDS system to map emissions to the grid level
   - Emissions distributions within countries, for each gridding sector, is constant over time.

THE END