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Climate impact on Earth rotation speed from CMIP6 model simulations

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About CMIP6

- The Coupled Model Intercomparison Project (CMIP) is an initiative of the World Climate Research Programme with the aim of understanding past and future climate changes due to natural variability or in response to changing radiative forcing. Research groups around the globe contribute climate simulations from various models adhering to a specified experiment design.
- Started in 1995, current phase CMIP6.
- Differences from previous phase CMIP5:
  - New generation of climate models, new start year for future scenarios (2006 vs. 2015)
  - Ensemble of CMIP-Endorsed MIPs –> ScenarioMIP.
  - New way of constructing future scenarios from a combination of new future pathways of societal development, the Shared Socioeconomic Pathways (SSPs – see App. A) and the previously used Representative Concentration Pathways RCPs (identified by radiative forcing levels of X.X W/m2 in 2100).

Trends in zonal means of zonal wind fields CMIP6 vs. CMIP5

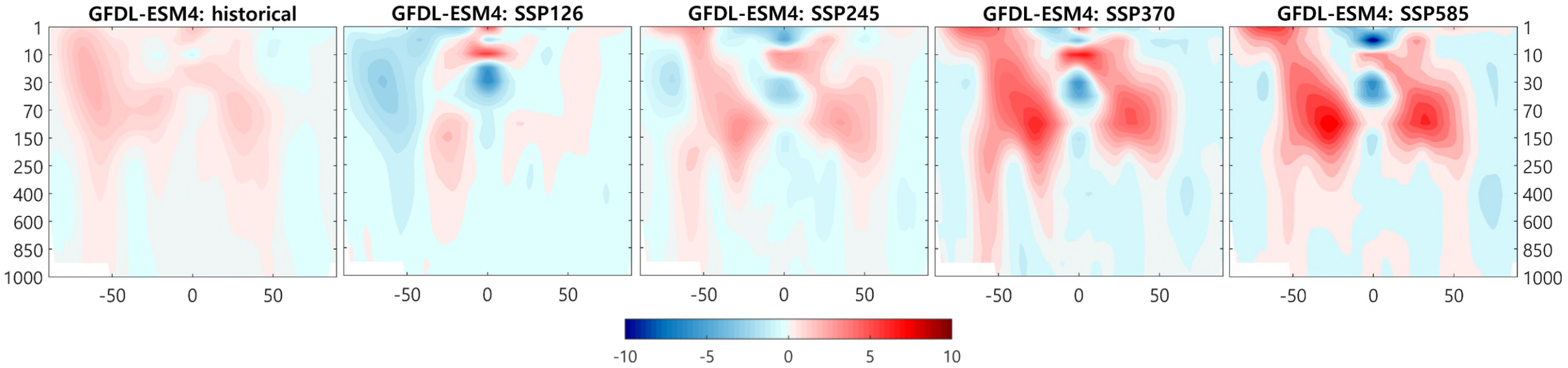


Figure 1 Trends in zonal means of zonal wind [m/s/century] from CMIP6 – ScenarioMIP, Model GFDL-ESM4 (John et al., 2018; Krasting et al., 2018), x-axis: latitude [°], y-axis: pressure [hPa].

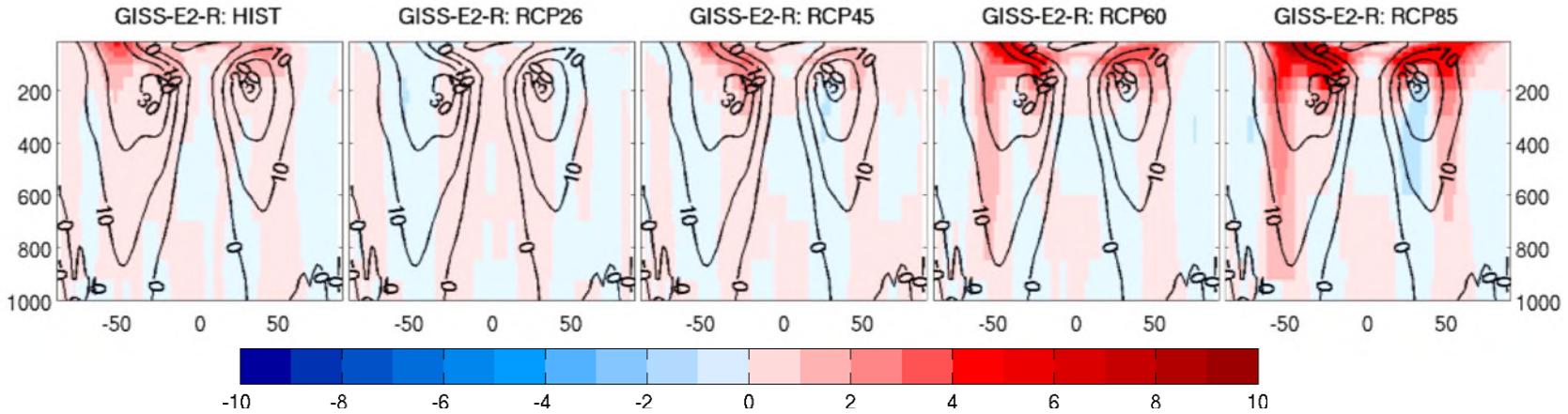


Figure 2 Trends in zonal means of zonal wind [m/s/century] from CMIP5, Model GISS-E2-R (Salstein et al., 2012).

Historical and simulated trends in surface temperature CMIP6

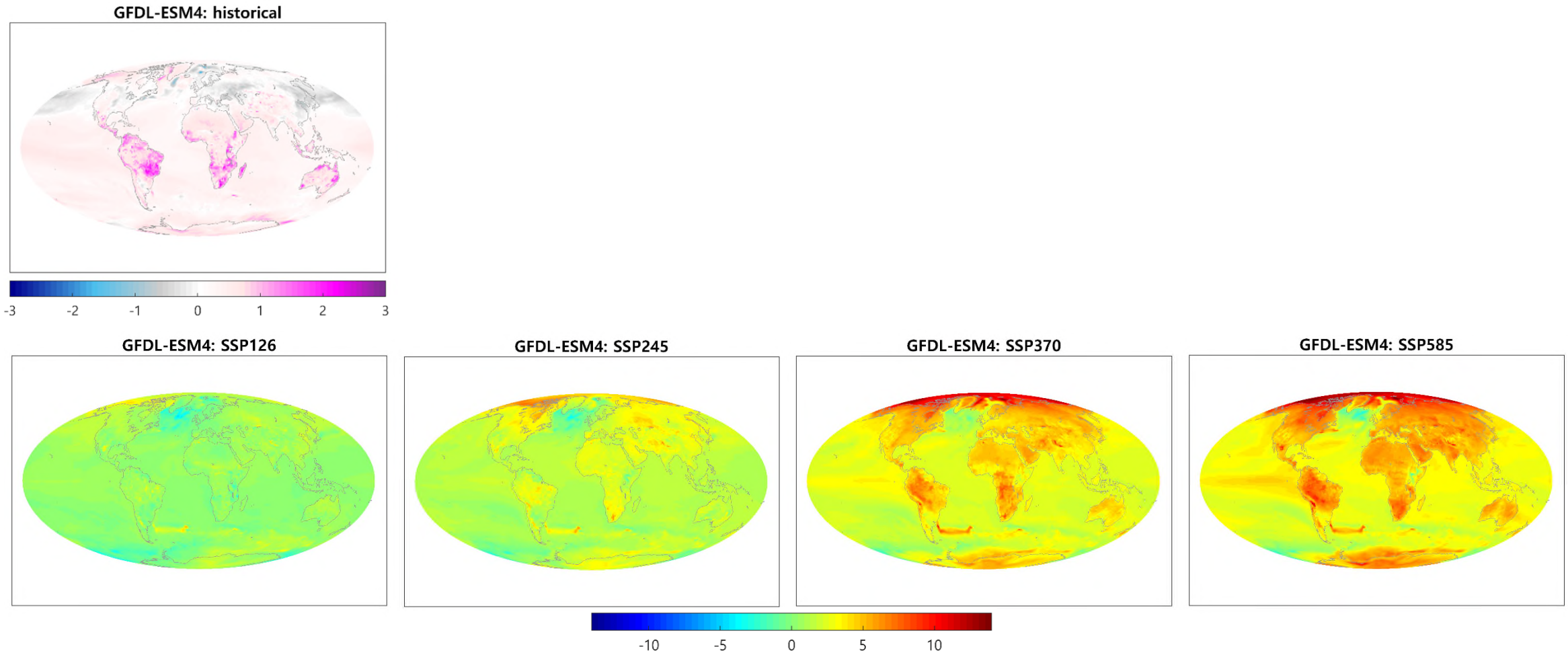
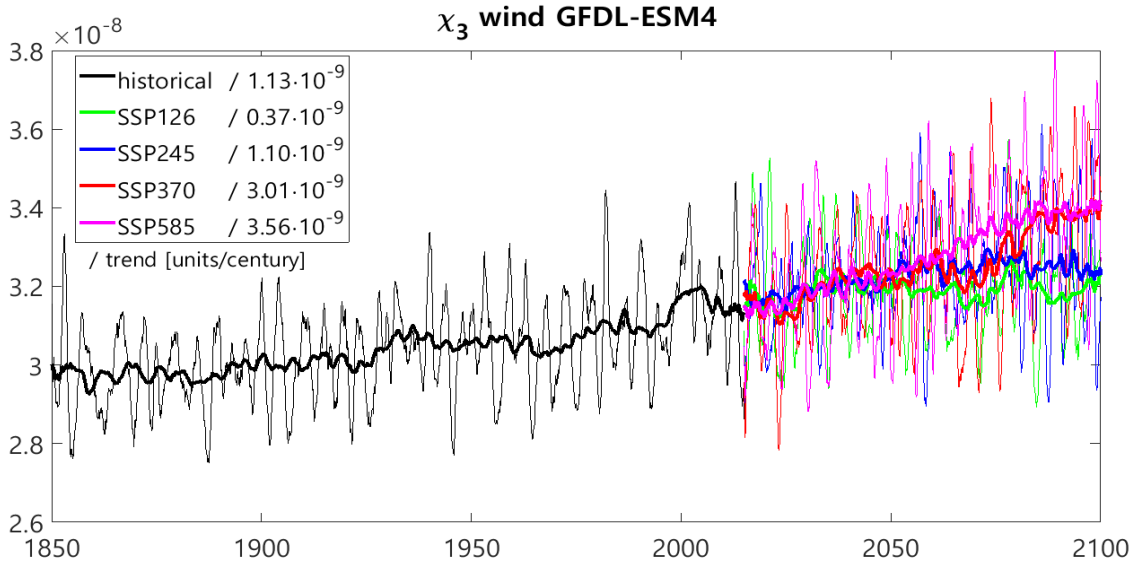


Figure 3 Trends in surface temperature [°C/century] from CMIP6 – ScenarioMIP, Model GFDL-ESM4.

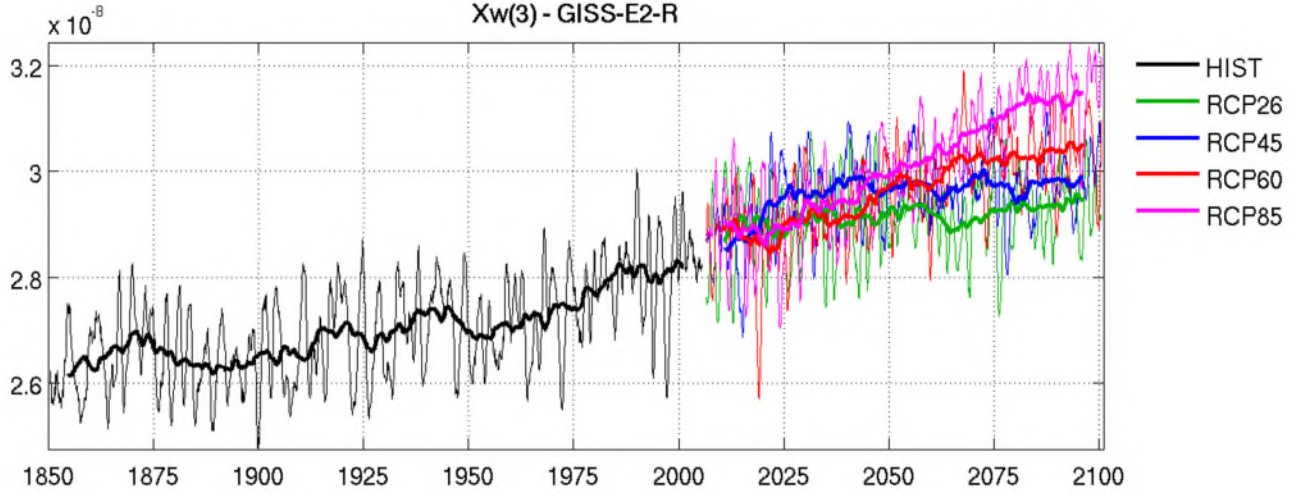
Variability and trends in axial AAMF CMIP6 vs. CMIP5

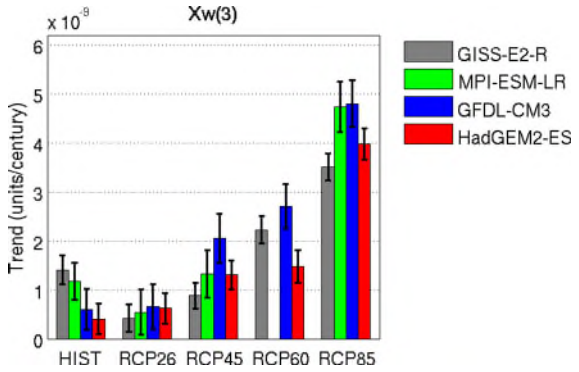


Corresponding scenarios

CMIP5	CMIP6
RCP26	SSP126
RCP45	SSP245
RCP85	SSP585

Figure 4 Atmospheric Angular momentum functions (AAMF) χ_3 from CMIP6 (this study) and CMIP5 (Salstein et al., 2012).





Discussion

- We can confirm a clear relationship between the rise in global temperature and its geographic distribution and the wind speed and increase in axial AAM (equivalent to an increase in length of day). More intense greenhouse gas emission scenarios would lead to slower terrestrial rotation.
- The most important layers in terms of excitation of length of day are located in the upper atmosphere (~100 hPa), in tropical to subtropical latitudes. Mean trends in zonal means of zonal wind are very similar from CMIP5 and CMIP6 in this respect.
- The course of the AAMF over the 21st century from CMIP6 is somewhat different from that of CMIP5, whereas the overall trends and results in 2100 are again similar.
- Global atmospheric angular momentum units increase from around 3.1×10^{-8} (in excitation units) now to around 3.4×10^{-8} units in the year 2100 in the highest scenarios runs, this corresponds approximately to a 10 percent increase in overall relative axial angular momentum of the atmosphere.
- The wind terms from CMIP6 show an offset with respect to the CMIP5 estimates, which is likely due (at least in part) to differences in the vertical integration limits, but needs to be further investigated.
- This work has already been presented in a poster at the Journees 2019 in Paris and is summarized in a corresponding proceedings paper by Böhm and Salstein (to be published 2020). The original intention for EGU 2020 was to extend this study to oceanic excitation and a larger ensemble of CMIP6 models. Due to the unexpected limitations related to the COVID-19 pandemic these plans had to be postponed.

References & Acknowledgements

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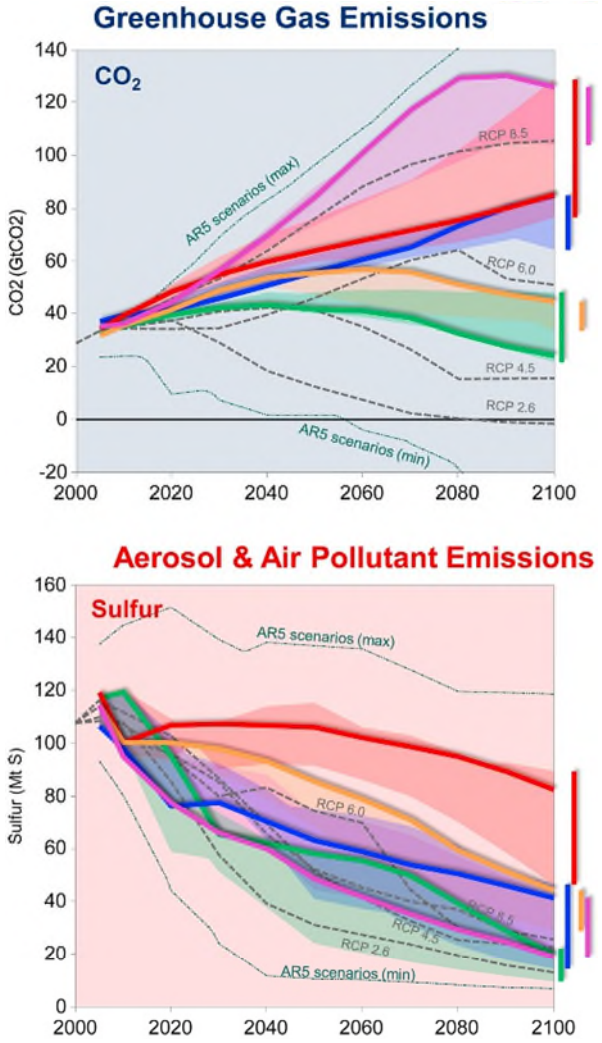
Appendix: Shared Socioeconomic Pathways (SSPs)

SSP1-2.6 Sustainability – Taking the Green Road: multi-model mean of ≪ 2˚C warming by 2100 expected, substantial land use change (increased global forest cover), low forcing.

SSP2-4.5 Middle of the Road: combines intermediate societal vulnerability with intermediate forcing level.

SSP3-7.0 Regional Rivalry – A Rocky Road: new in CMIP6, substantial land use change (decreased global forest cover), high NTCF (Near-Term Climate Forcers) emission.

SSP5-8.5 Fossil-fueled Development – Taking the Highway: strong economic and social developments, exploitation of abundant fossil fuel resources, adoption of resource and energy intensive lifestyles.



Source: Riahi et al. (2017)