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Emissions-MIP (or, what is important about emissions)

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Dimensions of Emission Data Uncertainty

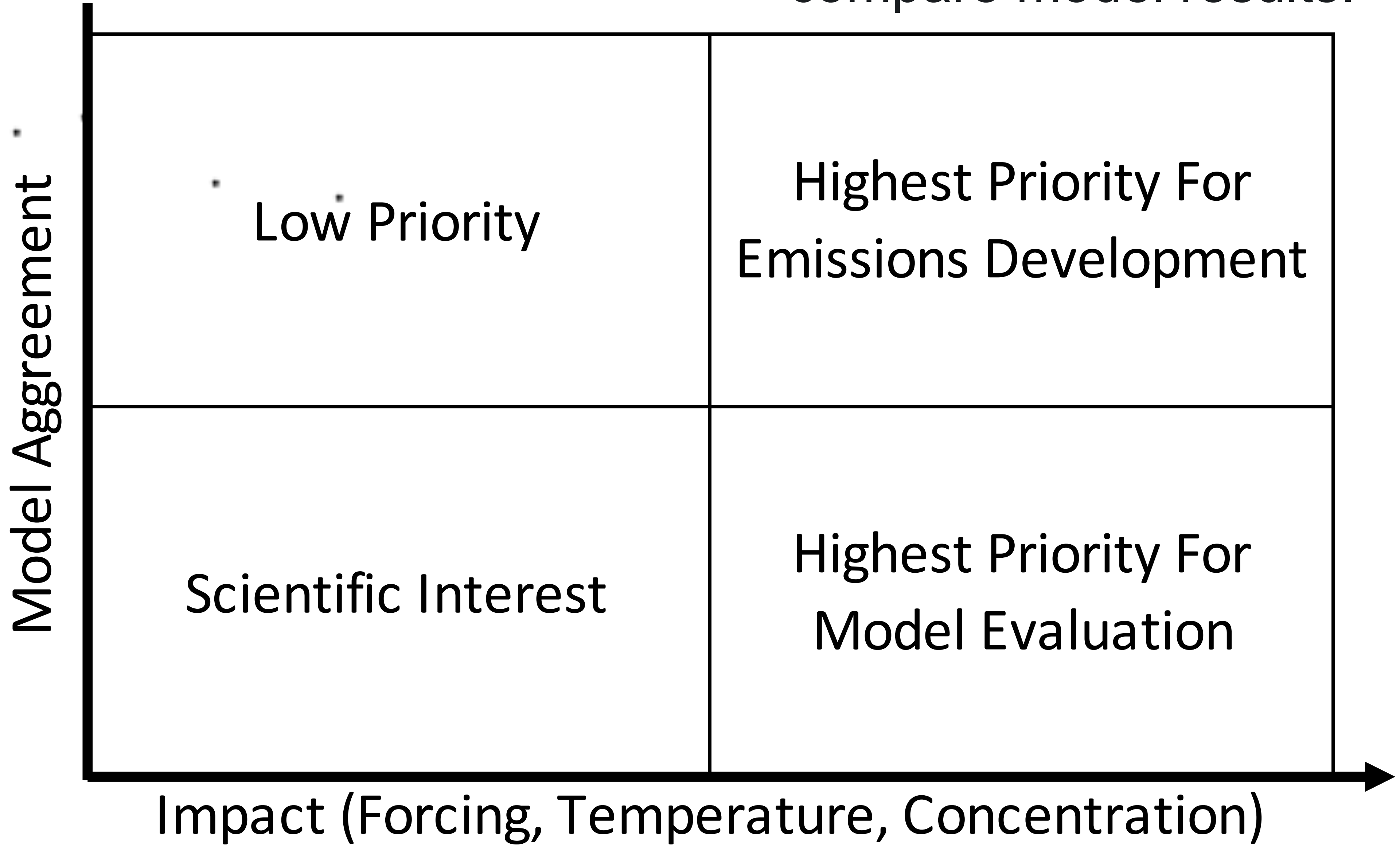
In addition to global annual emission rates and long-term trends, other characteristics of emissions will impact results, but these impacts are not well quantified:

- **Temporal Distribution: Seasonality, Diurnal & Weekly Patterns**
  - Impacts aerosol formation and transport, chemical reaction rates
- **Injection Height and Characteristics**
  - Effective Injection Height = stack height + plume rise (v, T, W)
  - Plume processing (e.g. fraction of SO_2 injected as SO_4)
- **Spatial Distribution (and changes over time)**
  - Shifts within US emissions over 20th century (China, Canada, Russia?)
  - Atlantic vs Pacific distribution of 20th century International Shipping SO_2

- Some of this information is in regional datasets, but requires work to incorporate into long-term global data.
- Other uncertainties could be substantially reduced, but also requires effort

Emissions Sensitivity Model Inter-comparison (Emissions-MIP)

Conduct specific emission perturbations (perturbation – reference) across models and compare model results.



- *We will learn what aspects of emissions data are important for global models*
- *We will also learn something scientifically useful about the models (where they agree/disagree)*

Emissions-MIP: Project Structure

Philosophy: Probe model behavior with climatically relevant aerosol/precursor emission perturbations, as realistically “as possible”.

Phase 1

Suite ~decadal length, atmosphere-only (proscribed ocean & sea-ice) model runs

- Includes CTMs as well as atmospheric components of GCMs

First order evaluation of inter-model differences, and magnitude of effects on radiative forcing and concentrations

Phase 2

Ensembles of fully coupled model experiments over longer periods (20-50 years) to test sensitivity in the interactive system for cases found to be important in Phase I.

- Aim to branch from CMIP6 DECK/historical runs

Data Logistics

- Use CMIP6 input and output data format specifications
- Public data and protocols to allow for replication and extension

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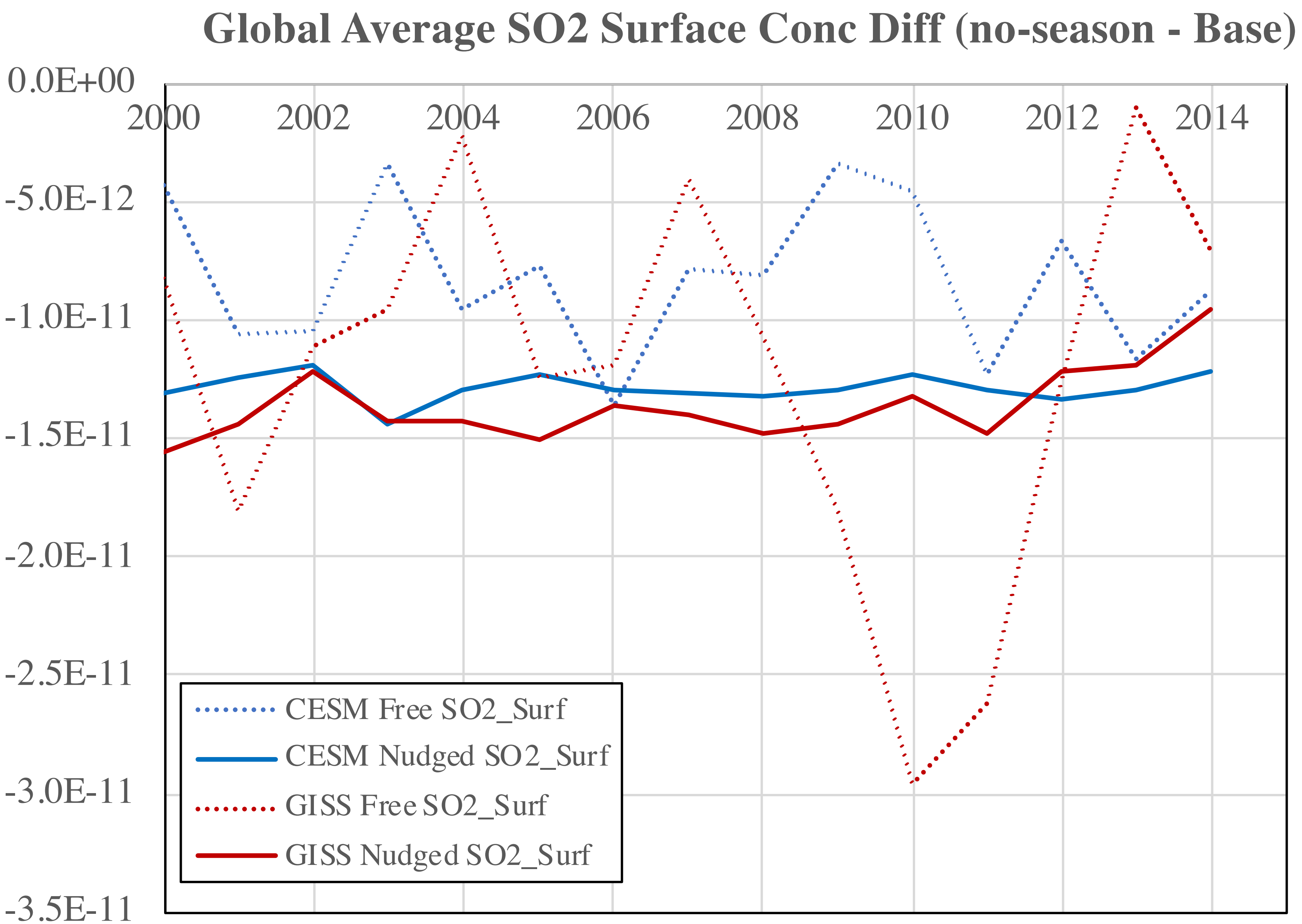
Proposed Experiments: Phase 1

Proposed Suite of Phase 1 Sensitivity Experiments

Property	Reference State	Contrast Case
SO_2 Emission Height	Surface Emissions	Emissions at a specified height
SO_2 Seasonality	CMIP6 (CEDS) seasonality	No seasonality
BC Seasonality	CMIP6 (CEDS) seasonality	No seasonality
International Ship SO_2 Emission - 1950	CMIP6 distribution	CMIP5 distribution
International Ship SO_2 Emission - 1920	CMIP6 distribution	CMIP5 distribution
% SO_2 emitted as SO_4	x% as SO_4	0%, 2%, 4%, 8% as SO_4
Regional SO_2 Emissions Sensitivity	Latest Europe and N American CEDS 1950s emissions	Emissions adjusted up or down by max estimated uncertainty

Sensitivity to SO_2 Emissions Seasonality



Removing seasonality from the SO_2 emissions data results in a small global decrease (~3%) in surface SO_2 concentrations

- When nudged winds are used, difference is similar between these two models.
- Without nudging noise is much larger, and results can differ in magnitude (but not sign) from nudged results.
- Larger differences expected regionally

* HadSST Ocean Temperatures