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# A Community Emissions Data System: More Timely Emissions Data With Uncertainty

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*An idea that grew out of our experience producing historical emissions for the RCP/CMIP5 process several years ago.*

## Background

Motivation

Goals

## Flexible, Community Data System

Overview/Approach

CMIP6 Timing

Summary

## **Goals:**

***Emissions with the same standards of timeliness, openness, and uncertainty quantification as other key model inputs.***

Gridded emissions of aerosol (BC, OC) and aerosol precursor compounds (SO<sub>2</sub>, NO<sub>x</sub>, NH<sub>3</sub>, CH<sub>4</sub>, CO, NMVOC) are key inputs for aerosol research and Earth System Models

- Needed for historical and future simulations, validation/comparisons with observations, historical attribution, and uncertainty quantification

The current historical dataset used by GCMs/ESMs (Lamarque et al. 2010) was a major advance in terms of consistency and completeness. This data, however, has a number of shortcomings.

- Only extends to 2000 with coarse temporal resolution (10-years)
- Time series for many of the species formed by combining different data sets leading to inconsistencies
- No comprehensive uncertainty analysis provided (available only for SO<sub>2</sub> – Smith et al. 2011 and earlier BC/OC datasets – Bond et al. 2007)
- Underlying driver data not made available with emissions data set
- Methodology not consistent across emission species
- Process was not designed to be repeatable and easily updated

## Scientific Research Support

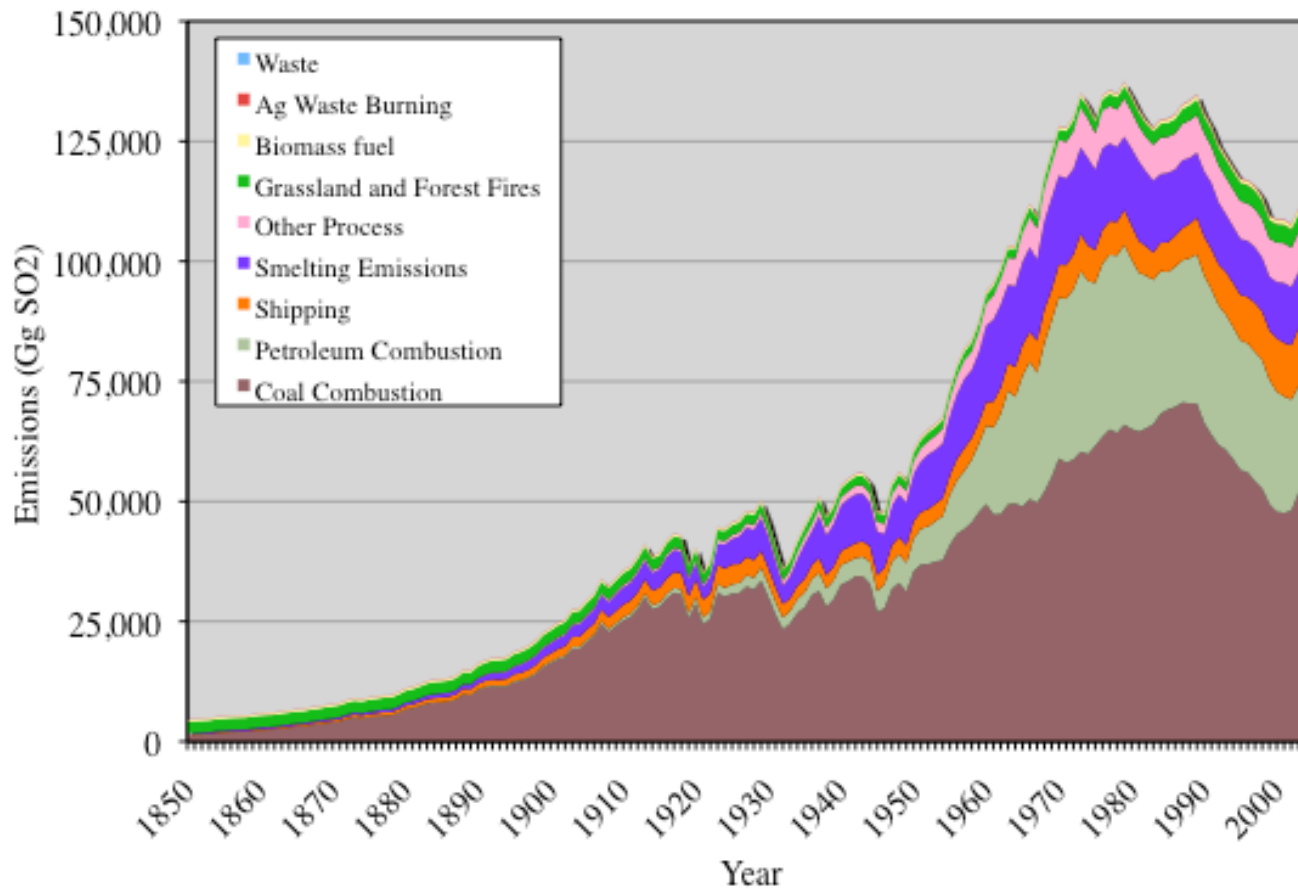
- Regular updates of anthropogenic emissions (SO<sub>2</sub>, BC, NO<sub>x</sub>, CH<sub>4</sub>, etc.)
- Consistent extrapolation over time (prevent spurious discontinuities)
- Consistent with country-level inventories (where desired/appropriate)
- Annual resolution with regular updates
- Facilitate greater temporal (seasonal) and spatial (e.g. US, China, Russia, sub-country) detail
- Transparent emission results (drivers + assumptions -> emissions)
- Facilitate cross-country comparison (EF consistency, trends)

## Enable Scientific Advances

- Uncertainty analysis (X 3!)
- Short-Lived Climate Forcer Research
- GCM Validation and Uncertainty Quantification
- Near-term climate prediction and analysis

# SO<sub>2</sub> Emissions

## Global SO<sub>2</sub> Emissions



*Annual estimates at country level from 1850-2005 using updated inventories, mass-balance, and driver data.*

*Gridded emissions every 10-years for RCP scenarios.*

*Smith et al (2011)*

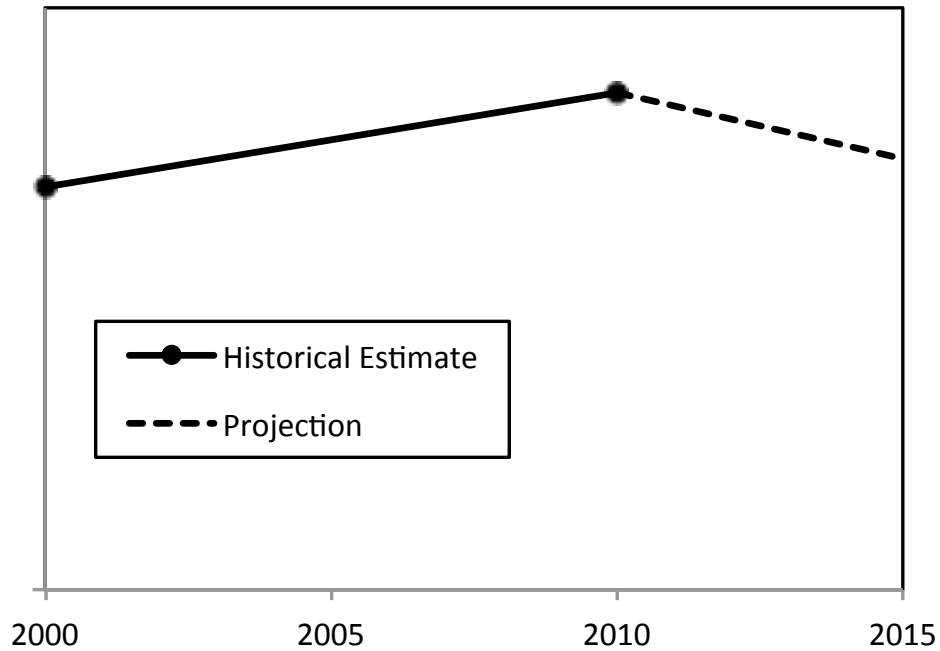
Fairly monotonic increase from 1950-1970

A number of global and regional features

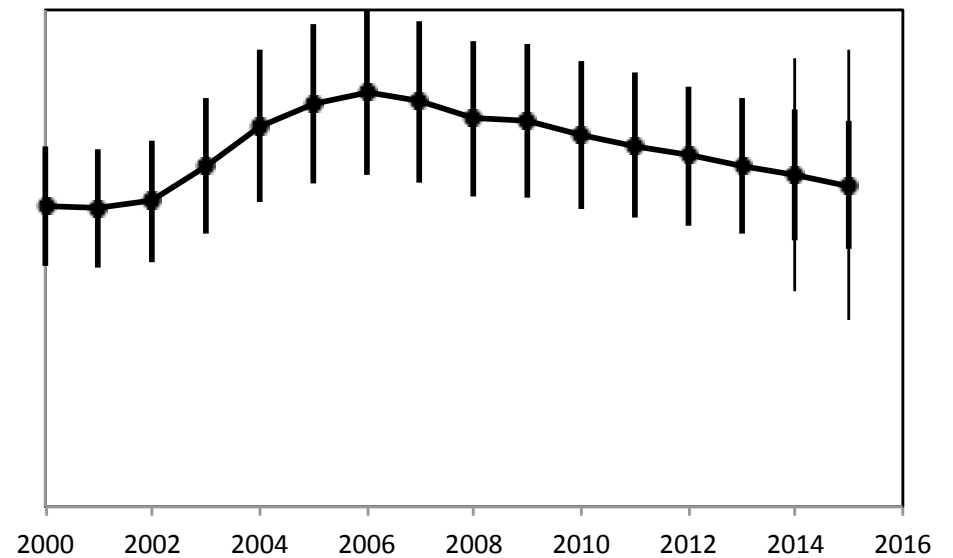
World wars, great depression, collapse of FSU, recent trends in China

# Goals of a New Emissions Data System

## Instead of this



## Produce This





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# A COMMUNITY EMISSIONS DATA SYSTEM

# Providing Data for Modelers

## Key Characteristics

- Annual data: can therefore provide more up-to-date information
- Country, sector, fuel (to extent possible), season, gridded
- Provide uncertainty estimates as automatic part of process!

## What is Possible?

- Preliminary OECD country estimates available from 2 years prior (additional uncertainty of ~10-20%).
- Lag for developing country estimates is larger (up to ~5 years or more)
- Preliminary estimates up to previous full year (Klimont et al 2013)
  - Using preliminary, not-sectoral, energy data
  - Extrapolation of emissions factor trends
  - These most recent years will generally be more uncertain than estimates from 5-10 years before present



# Emissions Data System Overview

## Overview

- Complementary to existing efforts
  - Bring together and extend existing information
- Open source code and (where possible) input data
- Annual updates of emissions
- Tool useful for emissions research more broadly (uncertainty, regional emissions, etc.)

## Approach

- Develop in the R open-source platform
- Focused on anthropogenic emissions (not open burning)
- Methodologies from Smith et al. (2011) & Klimont et al. (2013)

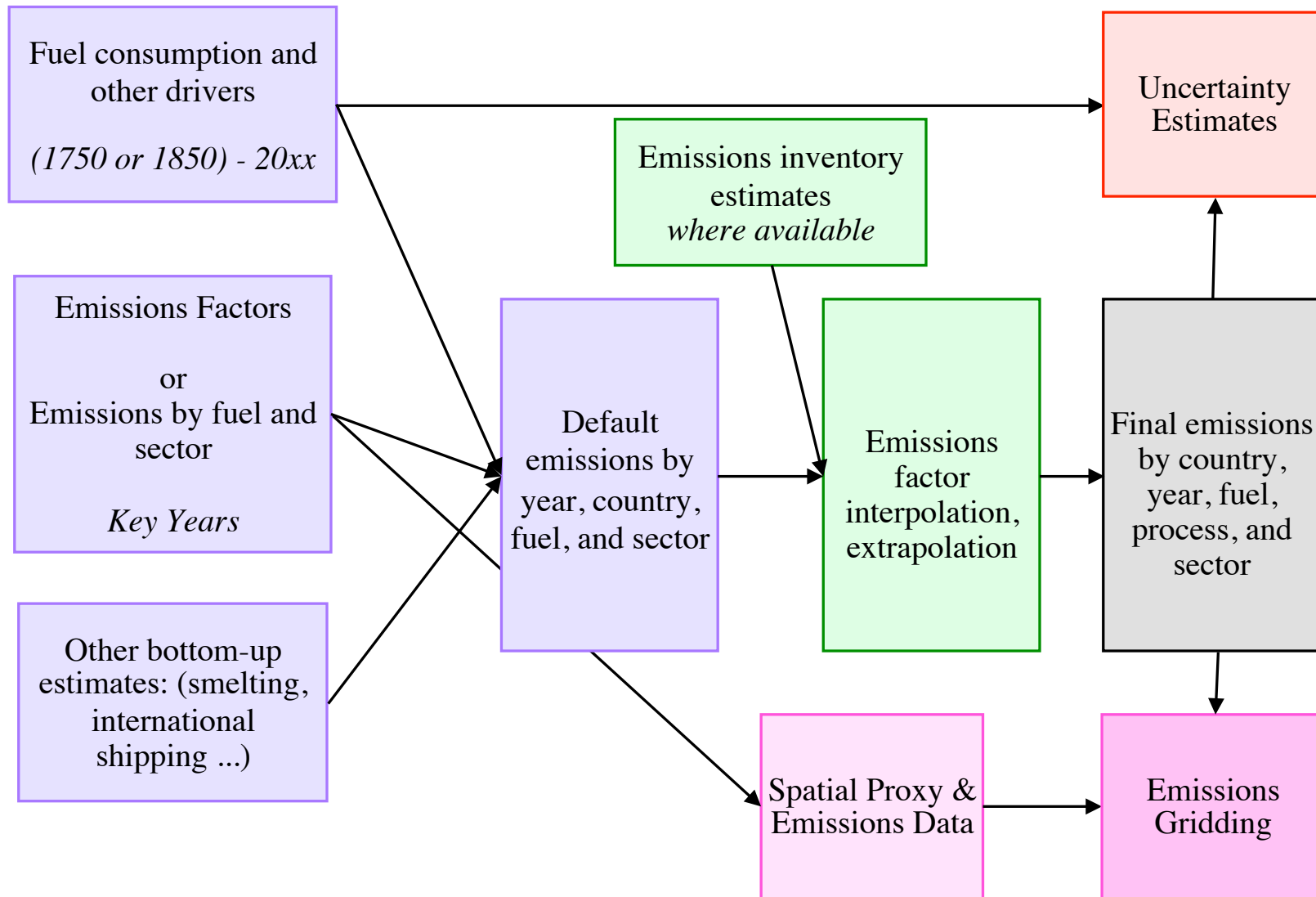
## Overall Approach

- All bottom-up emission uncertainty estimates contain a substantial element of expert judgment
- Guide assumptions with literature & comparisons between inventories
- Reduce dimensionality by a “tiered” approach to group assumptions  
*Otherwise: ~10 sectors X 200+ countries X 5 fuels X ~10 emissions*
- Consider correlations across sectors and countries
- Result: consistent uncertainty across emissions

## Uncertainty For Most Recent Years

- **It is critical that emissions for recent years are coupled with uncertainty estimates**
- The additional uncertainty in the most recent years can be rigorously assessed by applying the extension methodologies to past data  
*Although “past uncertainty does not guarantee future uncertainty”*

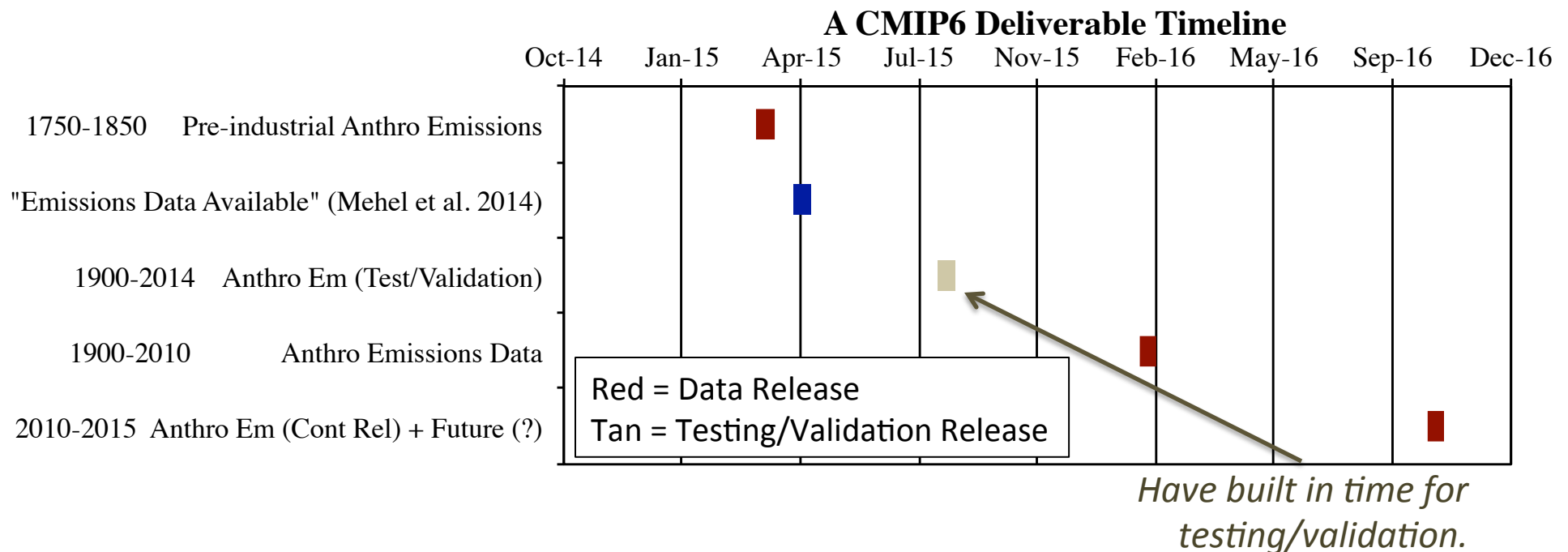
# Emissions Estimation System



# CMIP5 Timing

New (higher resolution & seasonal) pre-industrial emissions could be made available by Spring 2015.

A tested, gridded data set for the industrial era could be made available Spring 2016.



We propose an open-source emissions data system that can:

- Produce up-to-date anthropogenic aerosol and aerosol precursor emissions estimates
- Open data processes for community buy-in and verification
- Annual (& monthly) emission estimates in order to 1) capture timing of regional trends and 2) to provide as up-to-date estimates as possible
- Provide the uncertainty estimates needed for optimal use of data and for climate model UQ research
- Build on existing efforts (GAINS, EDGAR, REAS, country-level inventories) to provide data products and analysis needed for: modeling & climate/air quality work, and advance emissions estimation science.
- Publish methodology and results in peer-reviewed literature
- As an open source system, other groups can add/modify code and data



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**END**