Constraining uncertainties in observed methane inter-annual variability:

A proposal for multi-model decadal hindcast simulations

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And

???

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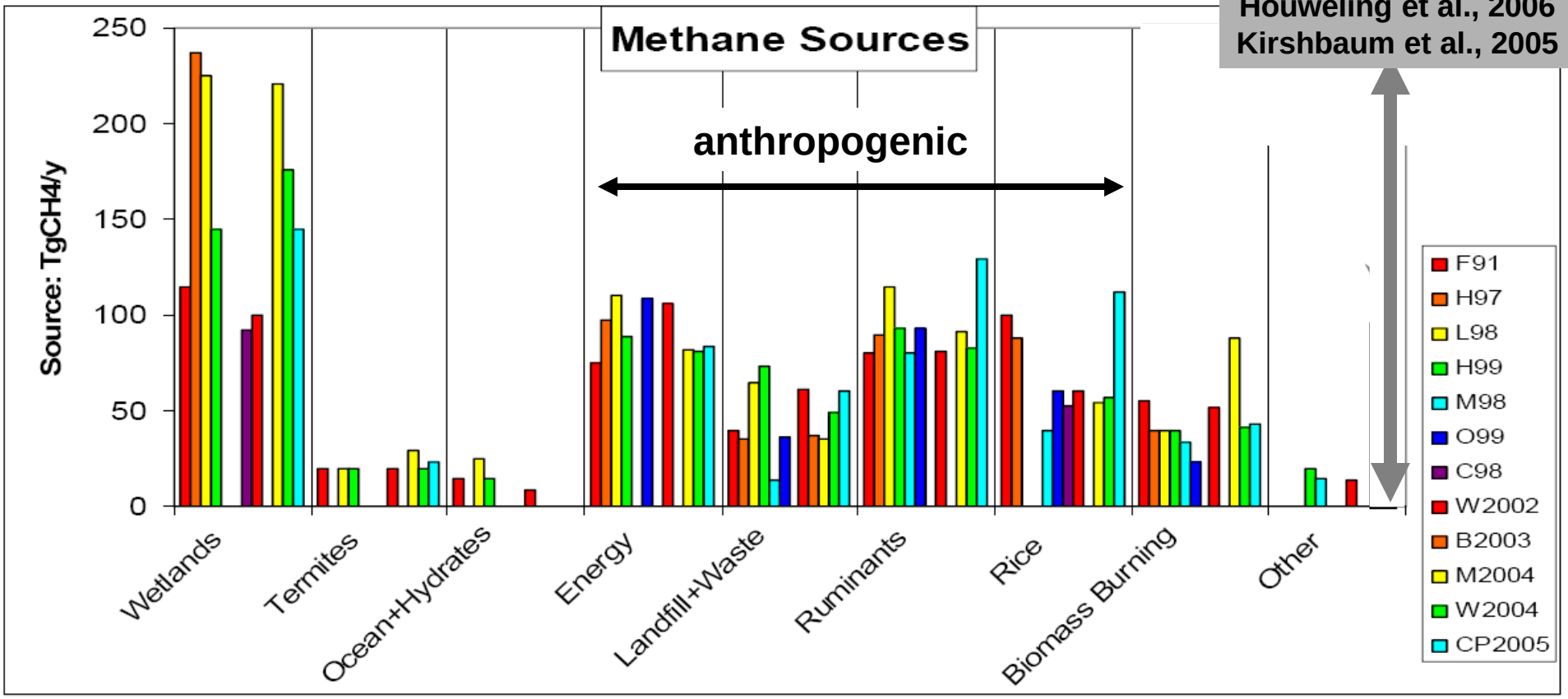
Estimates of current CH_4 emissions

Total CH_4 source ~600 Tg yr^{-1}, ~60% anthropogenic [*IPCC AR-4*]
>25% uncertainty in present-day CH_4 sources

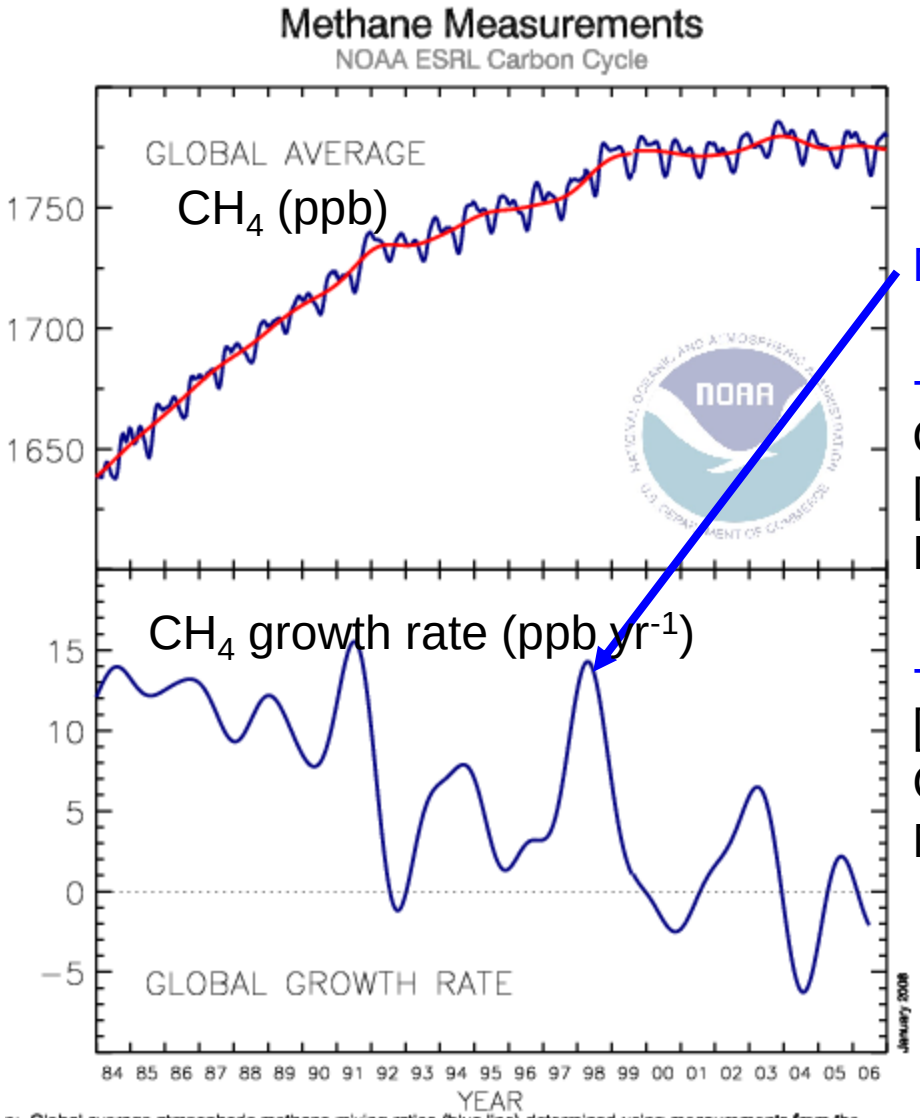
Plants?
Keppler et al., 2006
Ferreti et al., 2006
Houweling et al., 2006
Kirshbaum et al., 2005



c/o Michael Raupach, CSIRO, Australia; studies cited in IPCC TAR, AR-4

Methane sink (OH) also ~30% uncertain [*Stevenson et al.*, 2006]

Why have methane concentrations leveled off? How well do we understand inter-annual variability?



p: Global average atmospheric methane mixing ratios (blue line) determined using measurements from the rbon Cycle cooperative air sampling network. The red line represents the long-term trend. Bottom: Global rage growth rate for methane. Contact: Dr. Ed Dlugokencky, NOAA ESRL Carbon Cycle, Boulder, Colorado, 03) 497-6228, ed.dlugokencky@noaa.gov, http://www.esrl.noaa.gov/gmd/ccgg/.

Major driver for 97-98 anomaly?

-- Biomass burning (CH_4 emission, OH suppression via CO)
[e.g.Butler et al., 2005; Duncan et al., 2003; Bousquet et al., 2006;Langenfelds et al., 2002]

-- Wetlands
[e.g. Dlugokencky et al. 2001; Cunnold et al., 2002; Wang et al., 2004, Mikaloff Fletcher 2004, Chen and Prinn, 2006]

Model studies indicate different drivers for observed decadal trends

Study	Period	Approach	Major driver of trends / *IAV**
Law and Nisbet, 1996	1980-1994	2D CTM	1991 on FSU emis decline
Bekki & Law, 1997	*1980-1992*	*2D CTM*	*wetlands & OH*
Dlugokencky et al, 2003	1984-2002	Obs. analysis	approach to steady state?
Karlsdottir and Isaksen, 2000	1980-1996	3D CTM (met fixed)	OH (+anthrop SE Asian emis, -strat. o3)
Johnson et al, 2002	*20 years*	*3D CTM (emis fixed)*	*OH (water vapor)*
Warwick et al, 2002	*1980-1998*	*3D CTM (OH fixed)*	*transport*
Dentener et al, 2003ab	1979-1993	semi-inverse 3D CTM	OH (mainly water vapor)
Wang et al, 2004	1988-1997	3D CTM	anthrop emis & OH (-strat O_3)
Dalsoren and Isaksen, 2006	1990-2001	3D CTM (only emis. vary)	OH (+anthrop. CO, NOx, NMVOC emissions)
Fiore et al, 2006	1990-2004	3D CTM (only met. varies)	OH (lightning NO_x) + T
Bousquet et al, 2006	1984-2003	inverse 3D CTM (OH from CH_3Cl inversion)	anthrop emis; post-1998 +anthrop - wetlands
Khalil et al, 2007	23 years	Obs. analysis	constant emis. and lifetime
Drevet et al., 2008	1990-2005	3D CTM	Anthrop. emis + OH

** Many of these studies also identify a large role for wetlands and BB on IAV*

Atmospheric Chemistry and Climate (AC&C):
Effort focused on representation of chemistry-climate interactions in earth system models

Activity #1: CHEMICAL HINDCASTS

Objective: Use observations of trends and variability in atmospheric composition over recent decades to test models used to project future atmospheric chemistry and climate and to derive and quantify objective measures of uncertainty.

Each hindcast experiment defined by:

-- a multi-year series (post-1980) of measurements of atmospheric trace species.

-- a clear objective grading criteria for evaluating model success.

-- a set of required diagnostics to facilitate model comparison and evaluation.

-- multi-year external forcings (e.g., emissions) needed to drive the simulations.

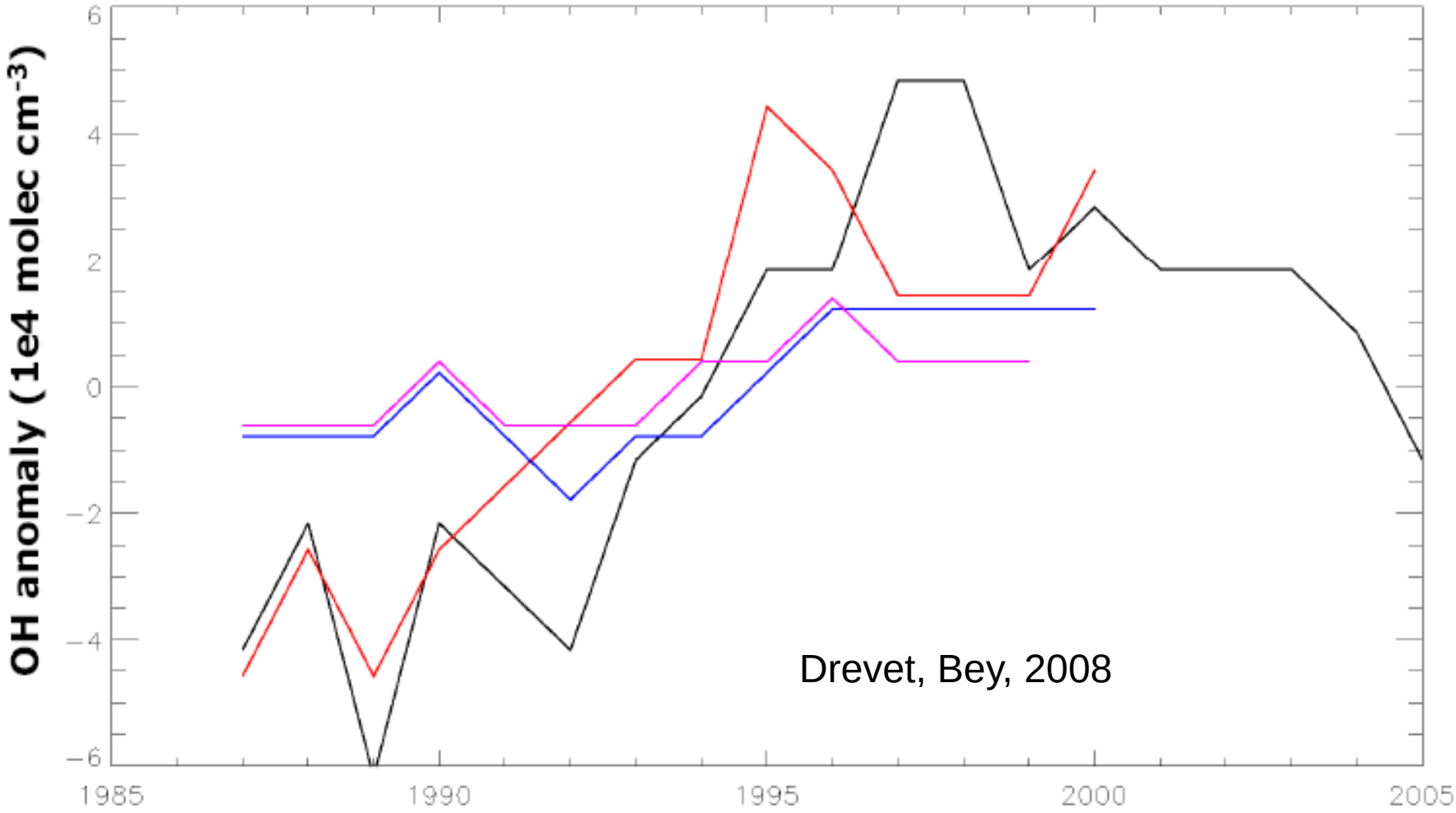
-- guidelines on the types of chemical models and meteorological fields that can usefully participate.

***Chemical Hindcasts Proposed*:**

1. Simple tracers (CFCs and N2O)
2. Aerosols
3. ***Ozone Variability (including simulations of OH)***
4. ***Methane Variability.***

Model intercomparison of OH interannual variability

GEOS-Chem (CTM driven by GEOS-4 re-analysis)
TM4 (CTM driven by ERA-40 ECMWF, RETRO emissions, T. van Noije)
ECHAM5-MOZECH (GCM nudged to ECMWF, RETRO emissions, S. Rast & M. Schultz)
LMDzINCA (GCM nudged to ECMWF, RETRO emissions, S. Szopa & D. Hauglustain



Joint AC&C and TRANSCOM Activity to examine methane variability?

Can we begin to reconcile conclusions from top-down and bottom-up approaches?

Forward model hindcast, including sources of OH variability: 1980-present

-- ozone (and aerosol) precursor emissions (anth., biomass burning, biogenic, lightning)
-- methane specified to observed values (lower boundary or fixed abundances)
-- stratospheric ozone columns
-- meteorology (reanalysis and/or GCM driven by observed SSTs)

Forward model output available for input to methane inversions:

-- Interannually varying monthly mean OH fields (ensemble mean; uncertainty)
-- Archived methane loss by tropospheric OH (also to stratosphere / soils)
= implied global emissions, may help with a priori error estimates

Multi-year inversion modeling for methane:

-- Interannually varying monthly mean OH fields (forward model ensemble mean)
-- Constant OH (multi-year forward model ensemble mean?)
-- Coordinate with HYMN (Hydrogen, Methane and Nitrous oxide: Trend variability, budgets and interactions with the biosphere)

Possible Time Line

- 2008: define activity as a community, gauge participant interest
  Initial feedback from Transcom community (last week)
  - working document available (frank.dentener@jrc.it)

- 2009: prepare input datasets for forward model hindcast simulations; begin forward model simulations; assemble a priori methane emissions, observations for inversions

- 2010: forward model simulations complete, prepare archived OH fields + methane loss rates for inversions; begin inversion studies; analysis of forward model results for OH/CH_4

- 2011: complete inverse studies + analysis