

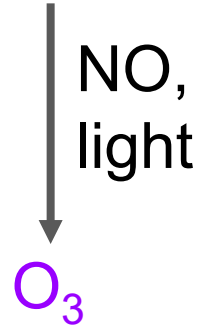
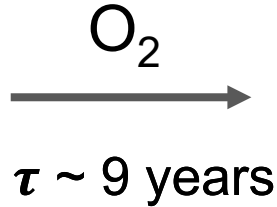
H₂ biogeochemical cycle: implications for H₂ climate impact

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John Patterson, Prof. Eric Saltzman University of California Irvine



H₂ is not a greenhouse gas but its oxidation perturbs the Earth's radiative budget



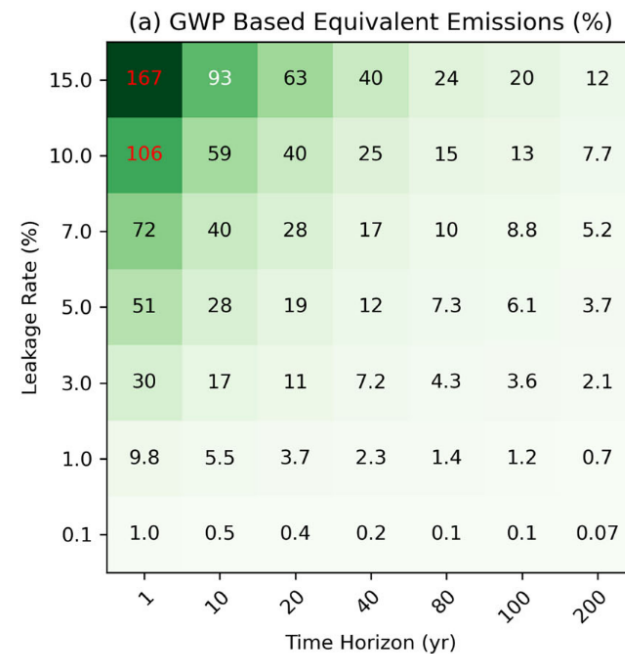
- H₂ oxidation increases CH₄ lifetime and produces stratospheric H₂O and O₃
- Chemistry is well understood (Derwent 2001)

Estimate of H₂ GWP100

| | |
|--|---|
| Derwent (2001, 2020, 2022) | 3.3 - 5.6 (no including stratospheric water) 8 +/- 2 |
| Hauglustaine (2022), Paulot (2021) | 12.8 |
| Warwick (2022,2023) | 10.9 |
| CICERO (multi-model) | 12.4 |

H₂ forcing is significant over ~ 20-year horizon

Green H₂

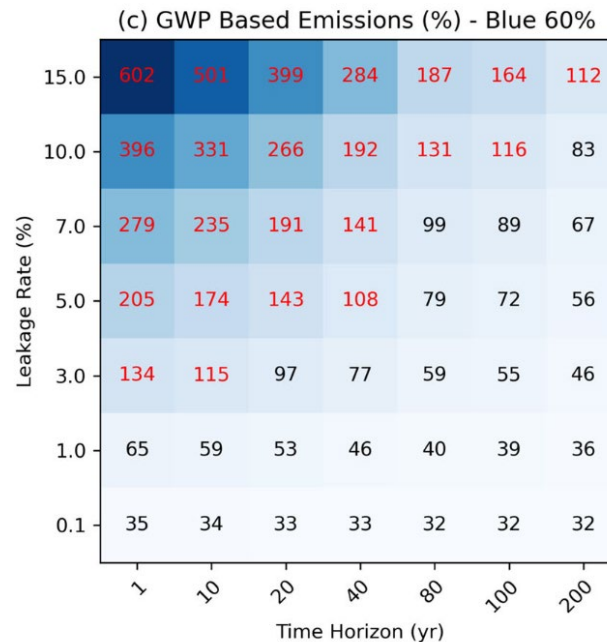


Hauglustaine
(2022)

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Green H₂ (40%) Blue H₂ (60%)

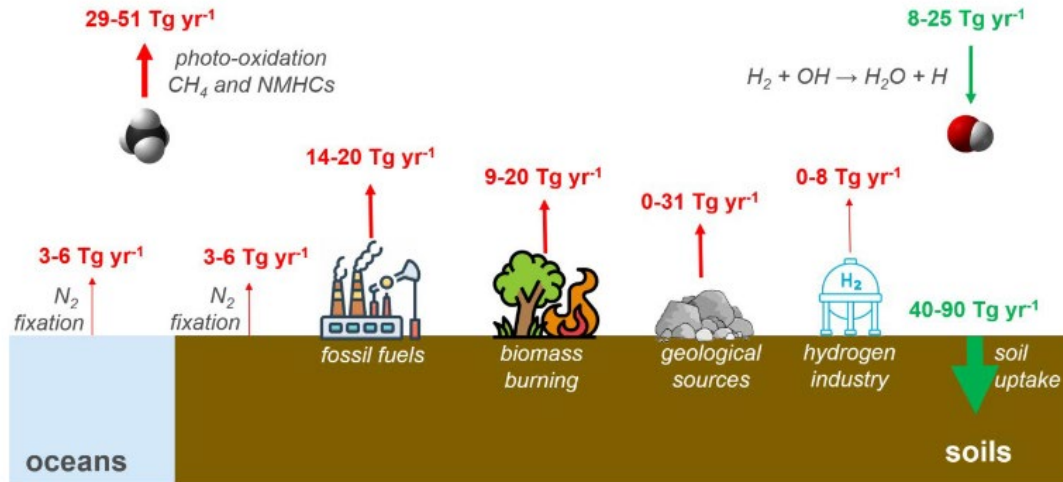


CH₄ leakage may cancel most H₂ benefits

Hauglustaine
(2022)

H₂ budget remains poorly constrained

Figure 1. Global hydrogen budget



Source: JRC (2022) adapted from the figures presented by Sand, Paulot, and Stevenson

- Soil sink reduces the climate impact of H₂
- 100% uncertainty on individual sources
- Underconstrained with current observational setup (~11 monitoring stations, ~10 soil sink measurements)

Leverage & expand existing NOAA/US universities modeling and observing capabilities to constrain H₂ biogeochemical cycling

GFDL Earth System Model

Ability to run historical and future simulations with dynamic soil H₂ model

Fabien Paulot (NOAA GFDL)

H₂ soil model

Mechanistic H₂ soil model (hydrology, microbiology) constrained by observations

A. Porporato, X. Zhang (Princeton University)

Polar firn air observation/model (1850-...)

historical trends, changes in hemispheric gradient

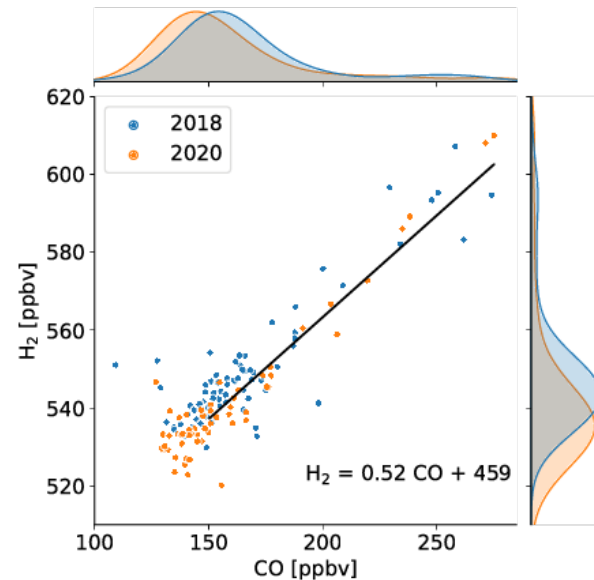
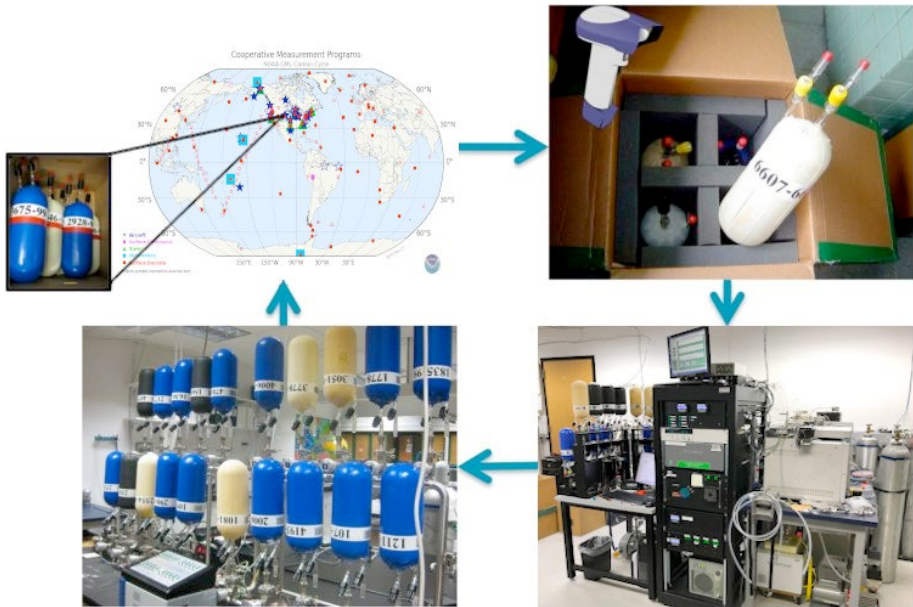
E. Saltzman (UCI)

NOAA GML observation network (2008-)

recent trends, geographic distribution, seasonal cycle

Many sites at DOE stations
G. Petron (NOAA GML)

GML: Build infrastructure to monitor H₂



Observed H₂/CO relationship in NY/PHL region

NOAA GML observation network (2008-)

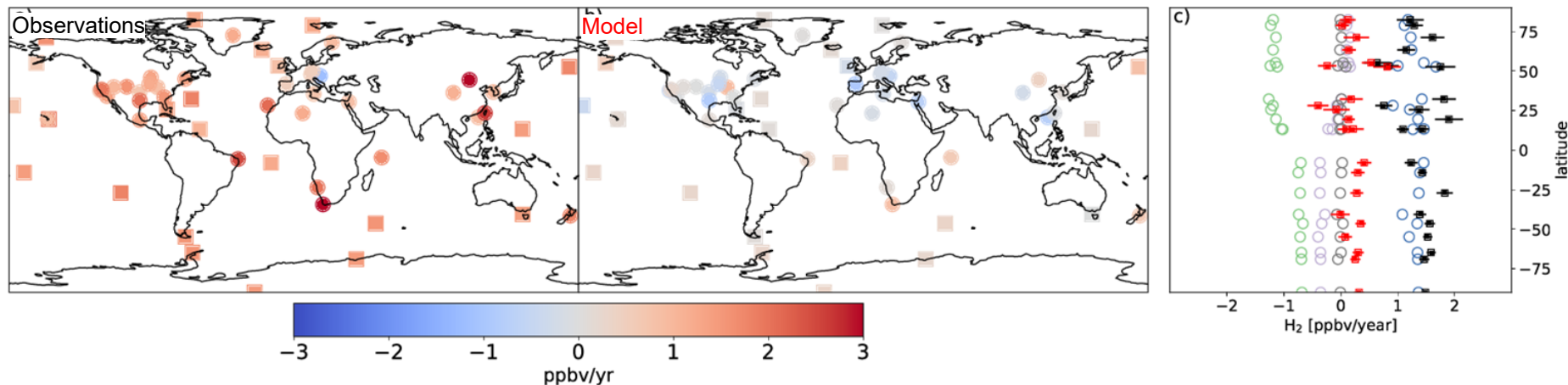
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Many sites at DOE stations

G. Petron (NOAA GML)

- High-precision H₂ measurements are challenging
- Need for improved calibration and data collection (cylinder) to increase the efficiency, reliability and quality of the NOAA short term and long term atmospheric H₂ measurement program

Identify drivers of contemporary trends in atmospheric H₂



More information on H₂ Leakage/Detection Strategies, see SCS021 NREL Hydrogen Sensor Testing Laboratory presentation by Bill Buttner.

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Soil sink

GFDL Earth System Model

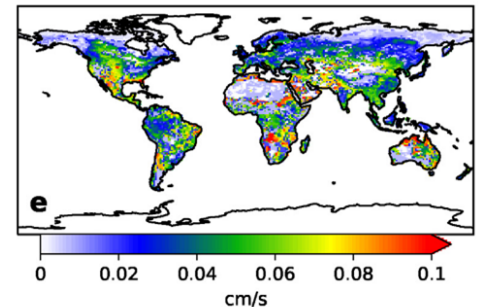
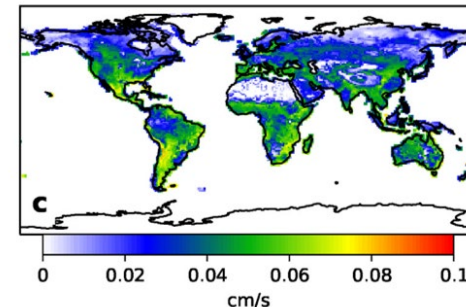
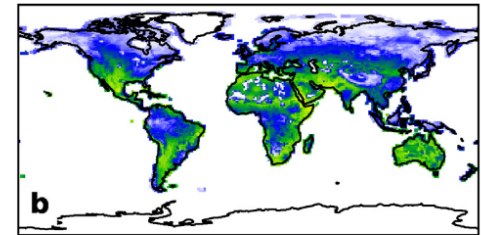
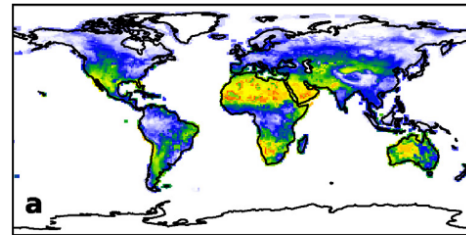
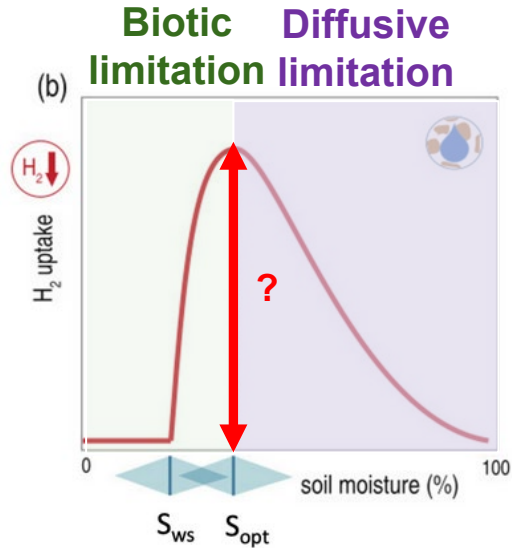
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H₂ soil model

Mechanistic H₂ soil model (hydrology, microbiology) constrained by observations

A. Porporato, X. Zhang (Princeton University)



What is the distribution/activity of H₂ consuming bacteria? How stable is the H₂ soil sink?

UCI/GML/GFDL

constraints on magnitude & stability of H₂ drivers

GFDL Earth System Model

Ability to run historical and future simulations with dynamic soil H₂ model

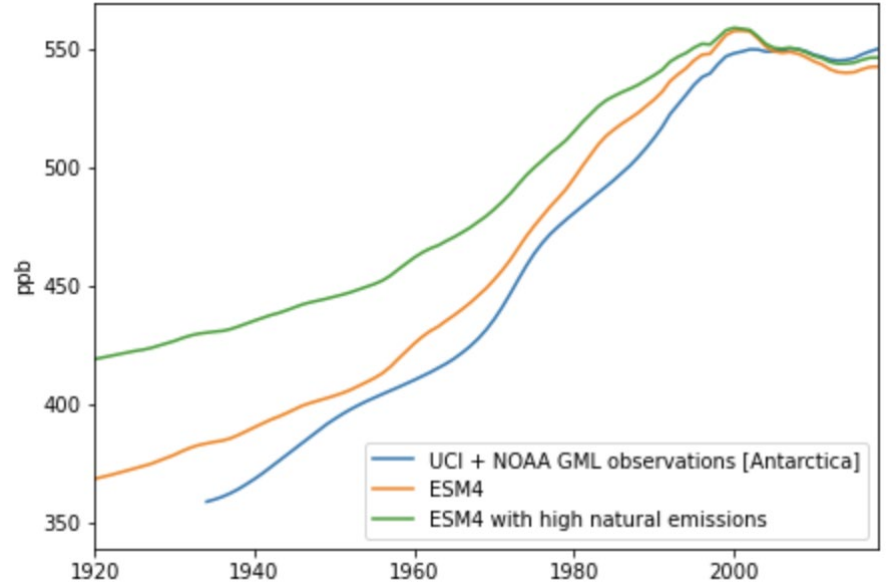
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NOAA GML calibration

Polar firn air observation/model (1850-...)

historical trends,
changes in hemispheric gradient

PI: E. Saltzman (UCI)



← NOAA GML

Develop record for Northern Hemisphere

Outlook

GFDL Earth System Model

Ability to run historical and future simulations with dynamic

soil H₂ model

Fabien Paulot (NOAA GFDL)

H₂ soil model

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G. Petron (NOAA GML)

- Leverage and advance existing capabilities to improve the understanding of H₂ biogeochemical cycling
- Build robust understanding of the response of H₂ to future changes (emissions, climate change, ...) and its climate implications