Note on day 3 : Modelling session

**Maarten Krol – COS-OCS project overview**

Project initially focused on two parts:

1. Contribution of COS to stratospheric sulfate aerosol layer and the Junger Layer?
2. Reconciliation of the CO2-COS budget

Part I : Nagori et al., 2021

1D model representing the isotopic composition of COS in the stratosphere was built.

Aim: Constrain the isotopic fractionation of the photolysis

A chemical loss of 40 GgS/yr was prescribed: decay of COS in the stratosphere through photolysis. COS fractionated during the photolysis (enriched in S34). The transport of Sulfate is deduced.

Performed sensitivity studies to the isotopic signature of the emissions

Results:

* Model able to reproduce the Junge Layer
* COS important precursor of the Junge Layer
* Fit one isotope measurement by tuning the oceanic emission
* Isotopic measurments inform on the transport processes in the stratosphere

Need more isotopic measurements to confirm the modeled isotopic composition

Part II

Ma et al., 2021:

* Atmospheric inversion of COS surface mixing ratio using TM5
* By starting from a prior biosphere flux with a constant atmospheric COS concentration (1000 GgS/y), the inversion tends to decrease the biosphere sink in the tropics
* Importance of implementing a first order processes for the interaction between the vegetation flux and the atmospheric surface concentration of COS: decrease the plant sink over the tropical lands and in the America (Mid West)

Cho et al., 2022:

* Optimization of the CA temperature response at two sites, Harvard and Hyttyala
* Fit parameter -> new alpha
* Fit better the evolution of the plant uptake as function of temperature
* Need plant specific values for alpha

Comparison of two optimized fluxes: Ma et al., 2021 and Remaud et al., 2022

* Both are in good agreement with independent observations (MIPAS, HIPPO)
* Close COS budget for the two fluxes
* Same phase
* Ma et al., 2021 fluxes have a stronger seasonal cycle than the one from Remaud et al., 2022, which is due to transport processes. There is a stronger vertical mixing in TM5 than in LMDz.
* Models with less vertical mixing are in better agreement with the observed vertical gradient in Northern America

Isotope modelling in TM5:

* COS model fractions quite well reproduced
* No skills in simulating isotope at Jerusalem and Harvard
* Isotope values poorly reproduced: Imply variability in source signature and fractionation factors
* Need to compare measurements technics, difference in the measurement technics?

**Marine Remaud: Simulation of atmospheric COS mixing ratio: Evaluating the impact of transport and emission distribution on COS tropospheric variability using ground-based and aircraft data**

TRANSCOM experiment for COS:

* Intercomparison of COS values simulated by 7 transport models.
* Focus on the seasonal cycle and interhemispheric gradient.
* Evaluate the role of transport errors versus emission distribution

Difference between models on these two aspects mainly explained by the strength of vertical mixing in the models

Two groups of models: strong versus weak vertical mixing

Transport errors can be important in summer over areas of strong surface fluxes: it reaches 70 ppt at BRW for instance

Interhemispheric gradient poorly reproduced: All models agree there is a missing source in the tropics, and an overestimated source / underestimated sink in the high northern latiudes.

Seasonal cycle has a two months lag at BRW which is contributed by oceanic emissions -> Oceanic emissions too high in the high latitudes?

Seasonal cycle too weak over land - > Biosphere fluxes are underestimated

Diurnal effect for the biosphere flux small

Roisin: The mosses in the high latitudes can also contribuate to the late uptake of COS in August/September in the high latitudes.

**Jin Ma – Combined assimilation of COS from MIPAS and NOAA surface observations with TM5-4DVAR**

Use of MIPAS retrievals and NOAA surface measurements to better constrain mixing ratio in troposphere and also the surface fluxes

Biais correction reconciles the fitting at the surface and at the troposphere

Biosphere flux gets reduced in all inversion

In agreement with Stinecipher : MIPAS tends to favor low GPP

Co-assimilation of NOAA+MIPAS data improves the fit strongly

**Stelios Myriokefalitakis – The global COS budget in TM5**

Low photolysis rate in the model - > increase the photolysis rate to match the HPMTF observations (from Veres et al. )

Ma et al., 2021: The tropical missing source has no seasonality

OCS can potentially be produced in the tropical clouds in the low atmosphere but HPFTM oxydation in the droplets needs to be tested experimentally

Sauveur Belviso: Is there a COS production through photolysis in droplets because bacteria in aerosols?

**Philippe Peylin – Evaluation of CMIP6/TRENDY model gross primary productivity using atmospheric COS and CO2 data**

Focusing on the seasonal cycle, COS atmospheric measurements are used to isolate the GPP bias from the respiration bias in several Land surface models

Use of the state of the art surface fluxes except for the ocean: use of optimized oceanic flux from Remaud et al., 2022

Less model spread in CMIP6 than CMP5

Analysis reveals that the majority of LSModels suffer from GPP biais

The uncertainty in transport does not completely change the results

LRU need to be higher

**Camille Abadie – Modelling ecosystem COS fluxes in the ORCHIDEE land surface model**

Use COS to constraint GPP and evaluate the impact stomatal diffusion, plant transpiration

COS assimilated at one site to optimize the parameters implicated in the COS and CO2 fluxes

Use of observations of soil and vegetation fluxes at Hyttyala

Optimisation of 10 parameters linked to plant uptake of COS/CO2

3 optimization scenarios:

- Assimilation of COS fluxes

- Assimimaton of COS fluxes and GPP

- A ssimilation of GPP

Assimilating COS only degrades the seasonal GPP

COS data-> increase of internal conductance

Assimilation of the GPP : Vcmax needs to be increased!

After optimization with the COS fluxes and the GPP : WUE is Higher and closer to observations

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Comparison of the latitudinal variations of the COS abundance simulated by several transport models using the **Ctl** surface flux dataset (colored dots) with the observations (black line) for February (left), August (right) over the years 2012-2018. The simulated COS abundances have been shifted such that the means are the same as the mean of the observations (~500 ppt). The time series of COS mixing ratio have been detrended and filtered to remove the synoptic variability beforehand. In August, the value at site GIF simulated by the TOMCAT ATM was removed as it was an outlier (value above 800 ppt). For the same reason, the COS values at site GIF simulated by TOMCAT (800 ppt) and LMDz (around 700 ppt) have been removed in February. We removed the site KUM, which is co-located in longitude and latitude with site MLO, for the sake of simplicity.