Description of the methane-centric wetland dataset, based on GIEMS

ESA project RECCAP2

Estellus

July 5, 2023

1 Introduction

The GIEMS2 database provides the monthly extent of the continental water surfaces, including lakes, rivers, wetlands, and rice paddies, from 1992 to 2015, as described in Prigent et al. [2020]. It is on a 0.25^ox0.25^o regular grid in latitude and longitude. It has recently been extended to 2020 within the RECCAP2 project.

For methane emission modeling, three water surface types are usually considered separately: the permanent water surfaces (such as lakes, rivers, and reservoirs), the rice paddies, and the wetlands (i.e., the remaining water surfaces). As a consequence, the possibility to separate these contributions within the GIEMS pixels is required. Here, the objective is to create a methane-centric GIEMS dataset, over the last decades, isolating the wetlands from the other surface waters, in order to facilitate the estimation of the wetland methane emissions. This corresponds to a need of the methane emission community. A parallel effort has been undertaken in the US with the Surface Water Microwave Product Series (SWAMPS) [Jensen and Mcdonald, 2019], to produce the Wetland Area and Dynamics for Methane Modeling (WAD2M) dataset [Zhang et al., 2021].

Several actions were taken to produce a methane-centric GIEMS dataset (1992-2020), for the RECCAP2 project:

- Adding the snow information
- Handling of the coastal areas
- Suppressing miss-classified water surfaces in urban areas
- Excluding the permanent open water surfaces (lakes, rivers, reservoirs)
- Subtracting the irrigated rice paddy contribution
- Adding peatland surfaces.

The different steps are described in the following sections. Some comparisons are provided between the initial GIEMS dataset, and the resulting methane-centric GIEMS dataset, along with some comparisons with SWAMPS and WAD2M.

2 Development of the methane-centric GIEMS

2.1 Adding the snow information

The passive microwave signal observed by satellite is the main source of information in the GIEMS processing and it is affected by the presence of snow. As a consequence, the surface water fraction cannot not be reliably quantified when snow is present in the pixel and the surface water detection scheme is not run on those pixels. The ECMWF snow information from ERA5 is adopted in the GIEMS processing to flag the pixels that are at least partly covered by snow [Prigent et al., 2020]. The surface water fraction is set to -999 when snow is present, to avoid confusion with pixels where no surface water has been detected (as in the initial GIEMS2 dataset).

2.2 The urban areas

It has been noticed that unexpectedly large water surfaces are detected by GIEMS2, in areas with high urban concentration. Paris is such an example, where highly reflecting surfaces are misinterpreted as water (predominance of zinc roofs in Paris). The ESA Climate Change Initiative (CCI) Land Cover map is adopted here to flag these pixels. The CCI Land Cover map provides 22 types at 300 m, including an urban class [CCI, 2017]. It is aggregated onto the 0.25^o regular grid. The grid cells with urban percentage above 40% are systematically excluded, to avoid any confusion between urban and water surfaces.

2.3 The coastal issues

GIEMS2 surface water estimate is primarily based on passive microwave observations that are very sensitive to the presence of water, including the ocean. Contamination can come from the presence of ocean within the pixel but also from the ocean nearby the pixel, due to the satellite antenna patterns especially at the lower microwave frequencies used in the retrieval (19 GHz). As a consequence, estimation of the surface water extent in coastal areas with instruments such as SSM/I is questionable and in the initial GIEMS2 methodology, the coasts are masked. To overcome this limitation, the Global Lakes and Wetlands Database (GLWD) at Lehner and Döll [2004] has been used to calculate the wetland fraction up to 50 km from the coast. All water surfaces from GLWD are added up, except lakes, rivers, and reservoirs. For GLWD wetland types that are providing percentage ranges, the mean surface fraction value in the range is adopted.

2.4 Excluding the permanent surface waters

Several permanent surface water masks are available. Studies are often based on the JRC Global Surface Water Mapping Layers v1.2 maps for 1984-2018 at 30 m resolution [Pekel et al., 2016]. One version is provided by the Floodability Index map [Nguyen and Aires, under review, 2022], including modification from MERIT hydro [Yamazaki et al., 2019]. Another version is processed by ECMWF (M. Choulga personal communication). The first version gives a total surface of $3.75\text{x}10^6\text{km}^2$, the second one $2.72\text{x}10^6\text{km}^2$, including differences in the handling of the coasts. GLWD provides another estimates that amounts to $3.039\text{x}10^6\text{km}^2$. For consistency with other information used in the production of this methane-centric dataset, the GLWD estimates are selected.

2.5 Subtracting irrigated rice paddies

The rice paddies emit methane. However, they are expected to have a methane emission behavior that is different from the other water surfaces. In the methane budget exercises, the methane emitted by the rice paddies is currently counted in the anthropogenic sources. As a consequence, the water surfaces detected by the satellites that are related to irrigated rice paddies have to be suppressed from the GIEMS water surfaces, to avoid double counting of the rice emissions. The MIRCA data set (circa 2000) [Portmann et al., 2010] provides the rice paddy seasonality and it is selected here.

2.6 Adding peatland

Peatlands have accumulated large stocks of organic carbon over time, and are estimated to contain a third of the global soil carbon. In peatland soils, thanks to their rich carbon content and specific hydrology, anaerobic respiration processes are efficiently producing methane. However, these peatlands are not always inundated and as a consequence will be missed by GIEMS. As a consequence, the GLWD peatland information, concentrated in the boreal region, is added to GIEMS.

3 The resulting methane-centric GIEMS dataset

The methane-centric GIEMS dataset consists in a NetCDF file (GIEMS_MethaneCentric_1992-2002_025deg.nc). The surface wetland fraction (between 0 and 1) is on a $0.25^o\text{x}0.25^o$ regular grid (720 x 1440 grid points), for monthly values from 1992 to 2020 (29 years x 12 months = 348 months).

Figure 1 compares the time series of the wetland surface extents from methane-centric GIEMS and initial GIEMS, for four latitude bands. The SWAMPS estimates and the methane-centric SWAMPS (named WAD2M) are also added. The static GLWD wetland surfaces are indicated as well. Large differences are observed between the GIEMS and the SWAMPS derived estimates, in terms of mean surfaces as well as in terms of temporal variability.

Figure 2 provides maps of the methane-centric GIEMS, and WAD2M at the mean yearly maximum (over the 2000 to 2020 that they have in common), along with the static GLWD wetland maps, over 5 climatologically different areas. For GLWD, all surface fractions from GLWD are added up, except lakes, rivers, and reservoirs, and for the wetland types that are providing percentage ranges, the mean surface fraction value in the range is adopted.

There are on going discussions in the community to tend to reduce the differences between the datasets. The new version of GLWD2 is very promising, to provide an updated and consistent characterization of the wetlands and permanent water. It will be used to improve the methane-centric GIEMS dataset in the future.

References

ESA Land Cover CCI. Product user guide version 2.0. *UCL-Geomatics: London, UK*, 2017.

Katherine Jensen and Kyle Mcdonald. Surface water microwave product series version 3: A near-real time and 25-year historical global inundated area fraction time series from active and passive microwave remote sensing. *IEEE Geoscience and remote sensing letters*, 16(9):1402–1406, 2019.

Bernhard Lehner and Petra Döll. Development and validation of a global database of lakes, reservoirs and wetlands. *Journal of hydrology*, 296(1-4):1–22, 2004.

Jean-François Pekel, Andrew Cottam, Noel Gorelick, and Alan S Belward. High-resolution mapping of global surface water and its long-term changes. *Nature*, 540(7633):418, 2016.

Felix T Portmann, Stefan Siebert, and Petra Döll. Mirca2000 global monthly irrigated and rainfed crop areas around the year 2000: A new high-resolution data set for agricultural and hydrological modeling. *Global Biogeochemical Cycles*, 24:1–24, 2010. ISSN 0886-6236. doi: 10.1029/2008GB003435.

Catherine Prigent, Carlos Jimenez, and Philippe Bousquet. Satellite-derived global surface water extent and dynamics over the last 25 years (giems-2). *Journal of Geophysical Research: Atmospheres*, 125(3): e2019JD030711, 2020.

Dai Yamazaki, Daiki Ikeshima, Jeison Sosa, Paul D Bates, George H Allen, and Tamlin M Pavelsky. Merit hydro: A high-resolution global hydrography map based on latest topography dataset. *Water Resources Research*, 55(6):5053–5073, 2019.

Zhen Zhang, Etienne Fluet-Chouinard, Katherine Jensen, Kyle McDonald, Gustaf Hugelius, Thomas Gumbricht, Mark Carroll, Catherine Prigent, Annett Bartsch, and Benjamin Poulter. Development of the global dataset of wetland area and dynamics for methane modeling (wad2m). *Earth System Science Data*, 13(5):2001–2023, 2021.

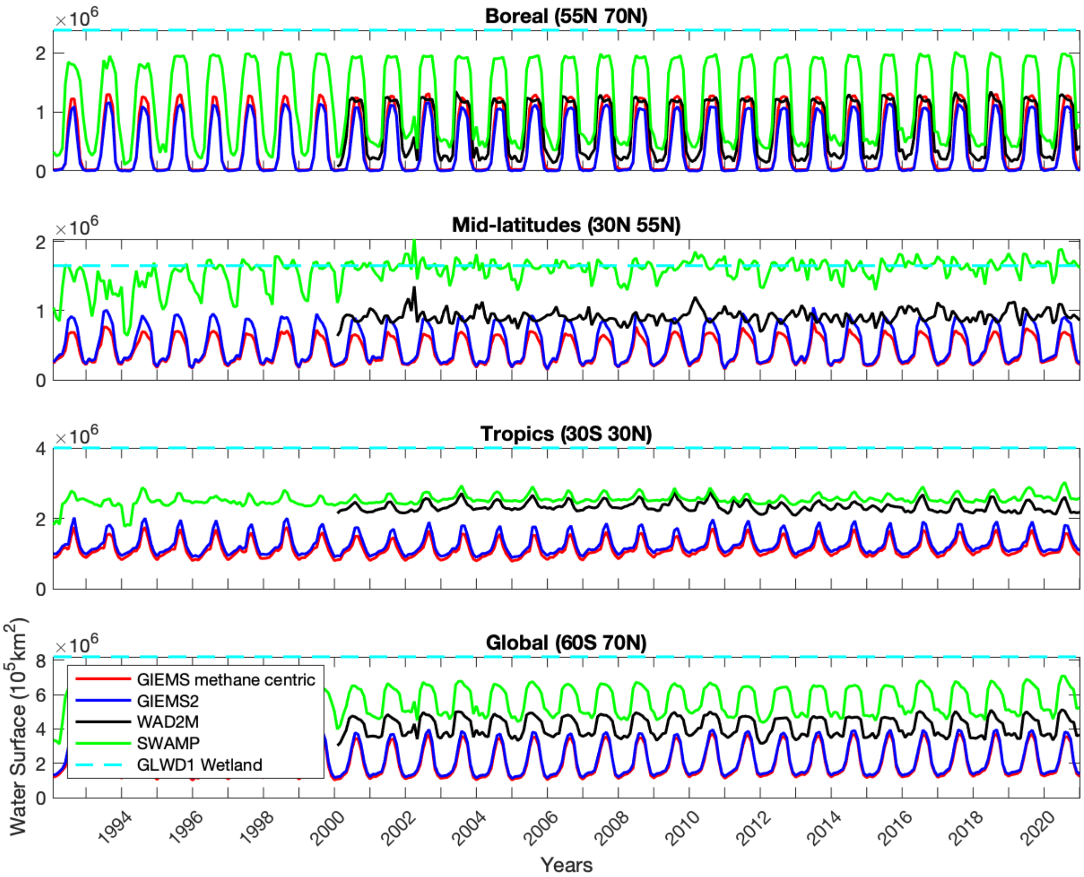

Figure 1: For four latitude bands, time series of the methane-centric GIEMS, initial GIEMS, SWAMPS, and WAD2M. The static GLWD wetland surfaces are also indicated.

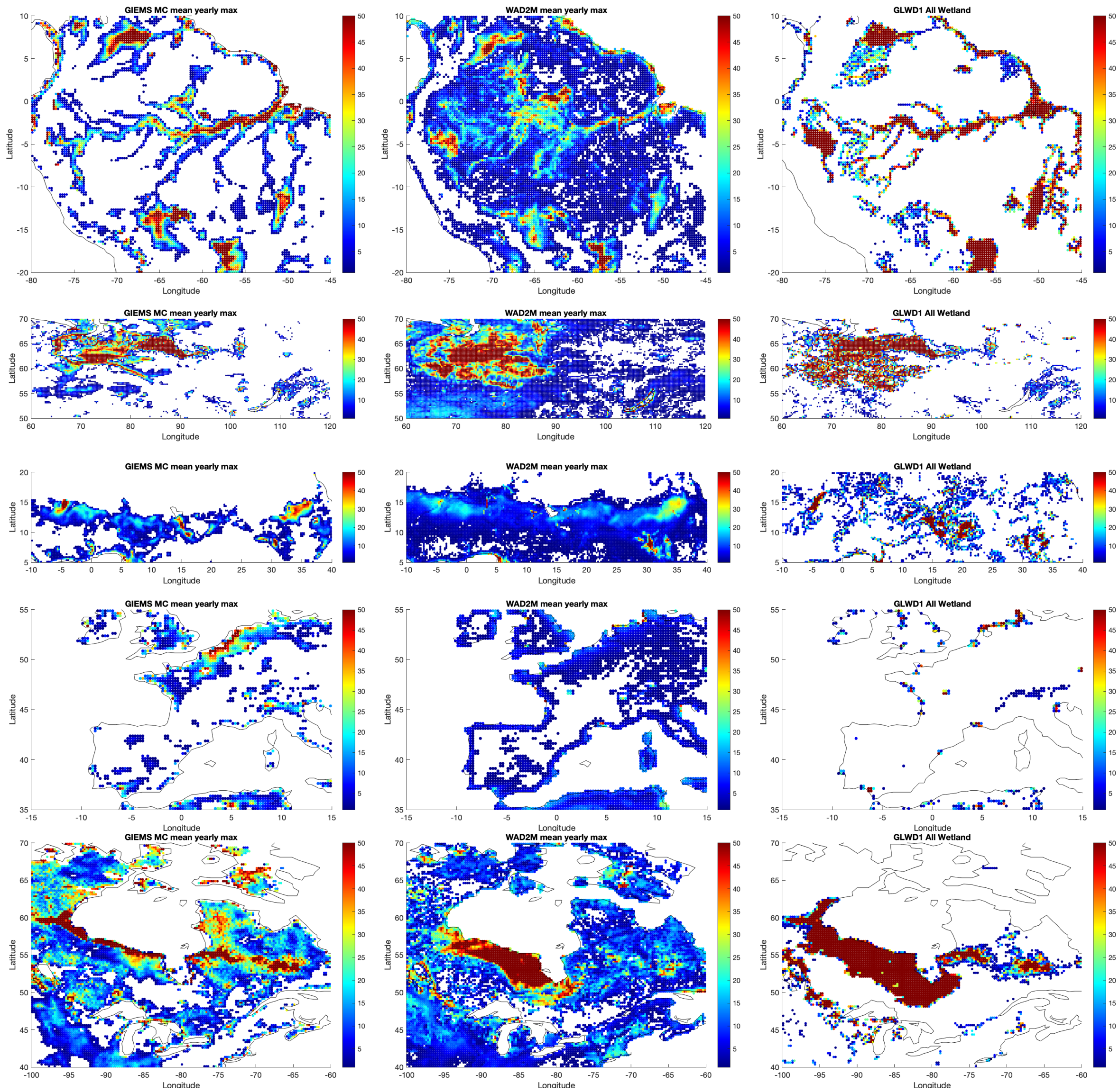

Figure 2: Maps of the mean yearly maximum wetland fraction (in %) for methane-centric GIEMS (left) and WAD2M (middle), along with GLWD total wetland fraction (right). From top to bottom: parts of South America, Russia, Sahel, Europe, and Canada.