MOSAiC Carbon Dioxide and Methane, Version 1, ReadMe

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What is this?

University of Colorado operated two Picarro G2311-f greenhouse gas (GHG) flux analyzers during MOSAiC – one sampling air from the ship bow mast, and one sampling from the 10m flux tower at Met City. This product is a QC-filtered version of these data sets, averaged to 10-sec and 1-minute from the original 10Hz measurements. Both analyzers were new (purchased in 2019) and factory calibrated prior to the field deployment. The primary standard for our CO_2 and CH_4 concentrations will be the NOAA Global Monitoring Lab flask samples. When these analyses are available we expect to make a small adjustment to both analyzer calibrations to bring them into agreement the the NOAA reference measurements. We conducted a relative check on calibration stability with tank standards on several occasions during the cruise, but did not adjust the analyzer calibrations. We note a small bias in concentrations between the two analyzers and this remained consistent over the course of the project.

Gas sampling inlet lines for both analyzers were heated and insulated 1/2" OD teflon. For the ship, the inlet was maintained at ~25°C. At MetCity the inlet was maintained 10-15°C above the ambient temperature. See Figures 1 and 2 for illustrations of the installation.

Preliminary data files are available to the MOSAiC user community from our project folder on the shared workspace drive:

`/isibhv/projects-dmz/mosaic/Teams_Tasks/02_Atmos/Trace_Gas_Flux_CU_Bigelow/`

What parameters are included?

Data files are supplied in both MATLAB table format and ASCII text. Both 10-sec and 1-min files contain the same variables:

Figure 1: Lab installations for the Picarro analyzers. a) forward E-deck container lab. b) Met City instrument hut (Legs 1-3).

`datenum`: MATLAB datenum UTC timestamp - a serial date number representing the whole and fractional number of days from a fixed, preset date (January 0, 0000) in the proleptic ISO calendar.

`yr`/**`mon`**/**`day`**/**`hr`**/**`min`**/**`sec`**: other UTC timestamp variables.

`Pc_torr`: Picarro analyzer cavity pressure (torr).

`Tc_C`: Picarro analyzer cavity temperature (°C)

`ch4w_ppm`: raw 'wet' methane mole ratio, ppm.

`ch4d_ppm`: raw 'dry' methane mole ratio, ppm. This is a correction to the measured 'wet' concentration, computed by the Picarro analyzer software, based on the measured water vapor concentration.

`co2w_ppm`: raw 'wet' carbon dioxide mole ratio, ppm.

`co2d_ppm`: raw 'dry' carbon dioxide mole ratio, ppm.

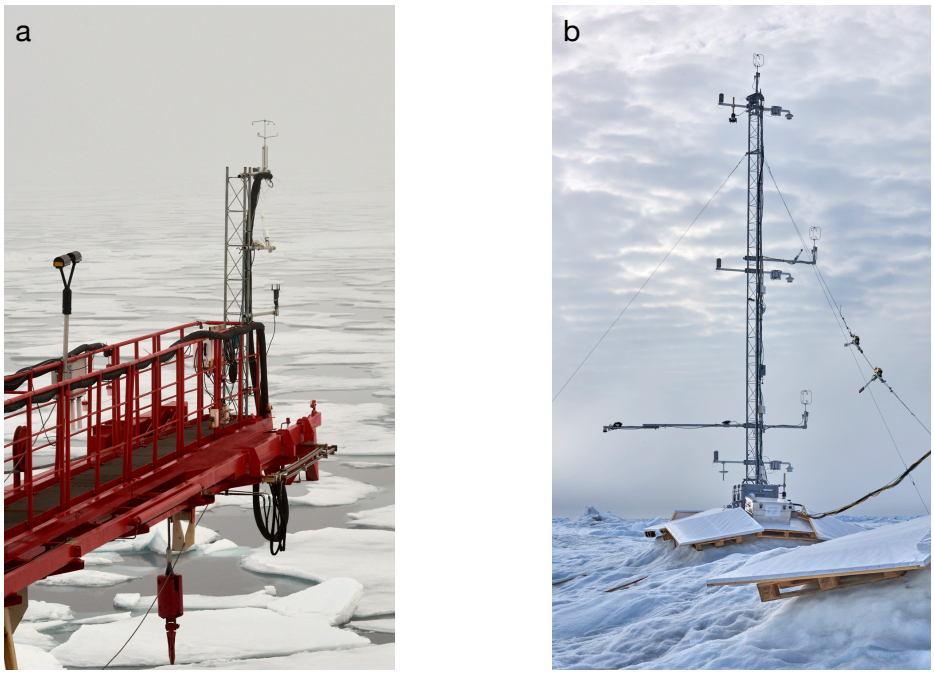

Figure 2: a) Ship bow met tower (Legs 4-5). The flux inlet for CO_2/CH_4 sampling is the heated and insulated black bundle extending up to the base of the sonic anemometer at the top of the tower. b) The MetCity 10-meter flux tower with the black heated inlet line extending to the base of the anemometer at the top of the tower.

`h2o_pct`: raw water vapor mole ratio, percent. Note, that for Legs 1-3, until April 16, the ship Picarro analyzer was sampling undried ambient air. After April 16 on Leg 3 the ship system used a Nafion air drier, installed at the analyzer sample inlet. The measured water vapor concentrations after that date are dried air and do not reflect ambient variability. For the Met City analyzer all measurements from Legs 1-3 are undried and Legs 4 and 5 are using an air drier. The long sample inlet lines act as a low-pass filter for variability in the ambient water vapor concentration due to adsorption on the tubing walls. Furthermore, when snow or ice crystals are present in the air or when rime on the inlet breaks off and enters the heated inlet lines, the observed water vapor concentration shows significant spikes. This does not seem to affect the measured CO_2 and CH_4 concentrations adversely.

`ch4w_ppm_decorr` / **`ch4d_ppm_decorr`** / **`co2w_ppm_decorr`** / **`co2d_ppm_decorr`**: raw concentrations decorrelated with respect to cavity temperature. See notes on filtering methods below.

Filtering methods.

For the ship measurements, a relative wind sector of ± 130 degrees with respect to the ship's bow is the criterion for removing most contamination from sources on the ship. Gas concentration data for relative wind directions beyond this range is excluded. For the Met City measurements, true wind direction within 10° of the compass bearing from the tower to the ship is similarly excluded (Figure 3).

For Version 1 of this data set the filtering process involves 3 steps:

1) A rough elimination of all periods of known bad or suspect data, which includes bad wind direction, known malfunctions of the analyzer, periods when the ship inlet is in back-flush mode (i.e. not sampling ambient air), and periods of sustained, gross pollution from local sources (e.g. helicopter flights).

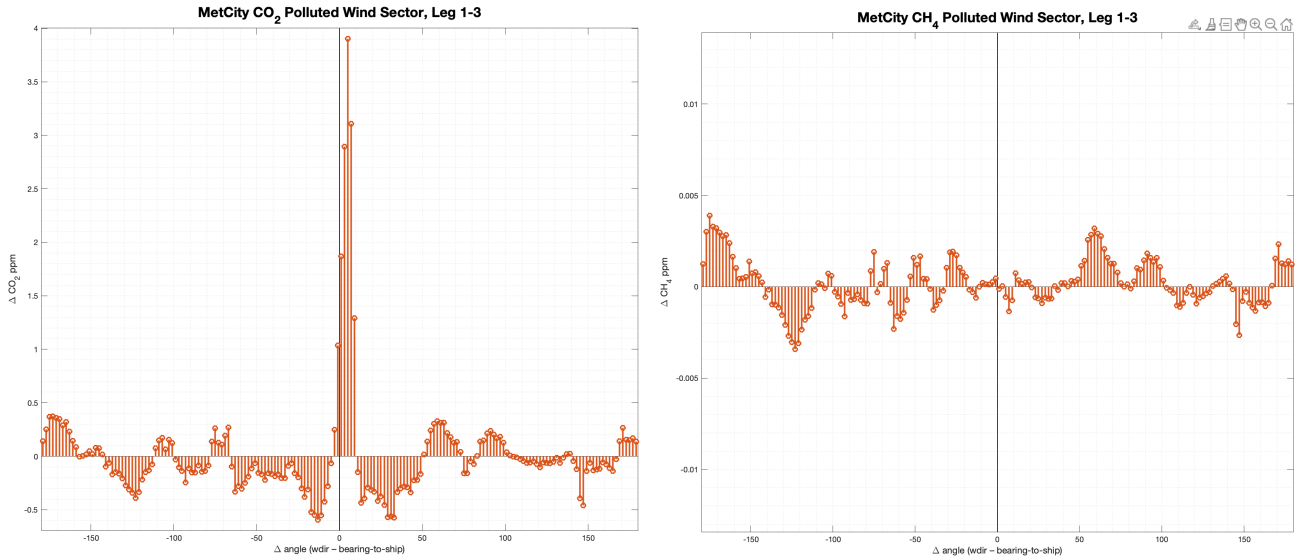

Figure 3: *Analysis of pollution spikes at the Met City tower as a function of wind direction and compass bearing to the ship. The y-axis is the difference between 1-min concentrations and the daily mean concentration of each gas. The x-axis is the difference between true wind direction and tower-to-ship compass bearing. For CO_2 there is a clear indication of ship pollution spikes for winds within ±10° of the ship bearing. There is no apparent CH_4 pollution from the ship, at least at Met City. The ship-tower distance varied from 350-500m during Legs 1-3. Results for Legs 4 and 5 are similar.*

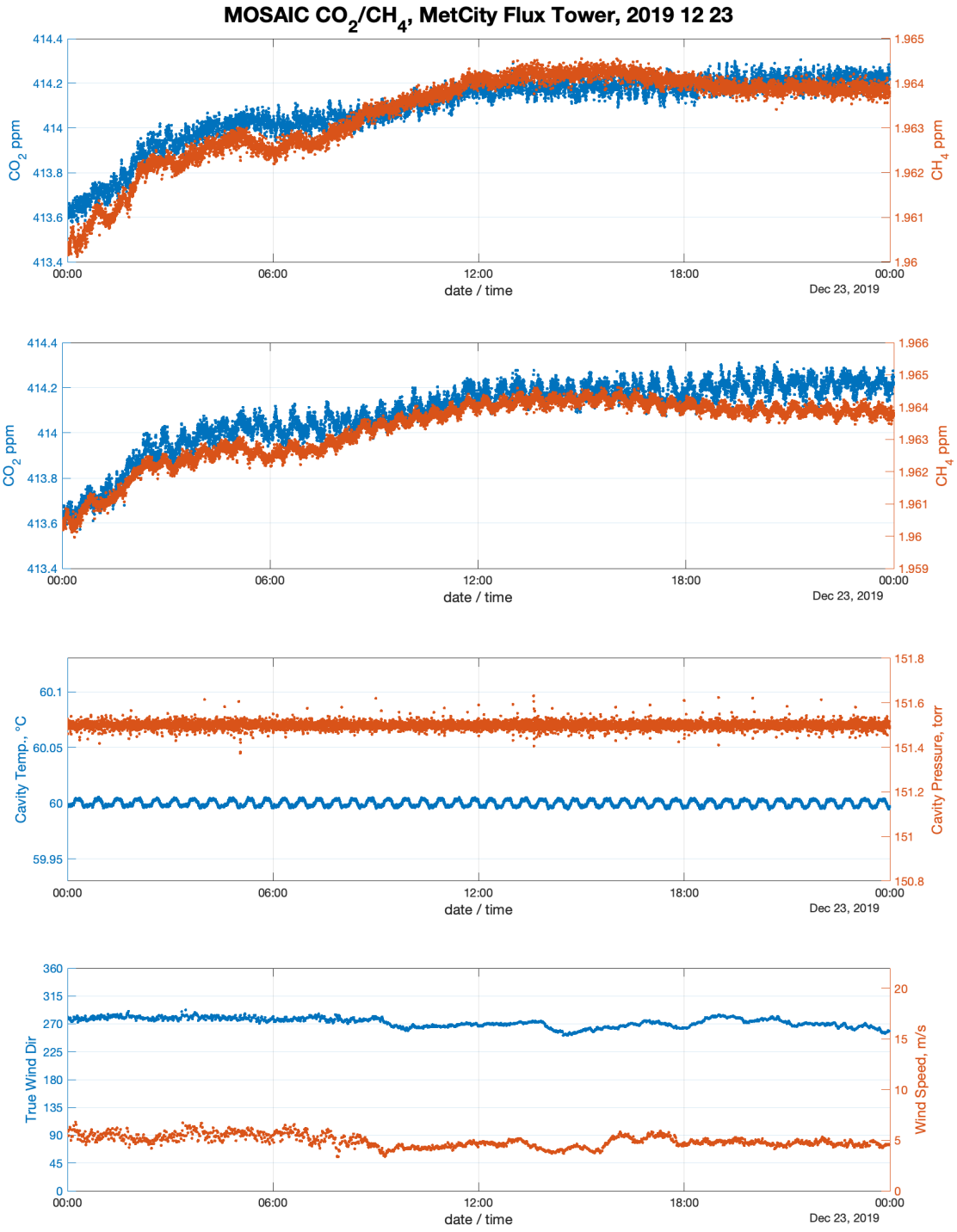

Figure 4: 10-sec data from the Met City Picarro analyzer. The oscillation in cavity temperature is illustrated in the third panel. Concentrations in the upper panel have been decorrelated with respect to the cavity temperature. The second panel shows the raw signal prior to decorrelation.

2) Use of a de-spike filter to remove momentary spikes due to local emissions or other measurement glitches.

3) Decorrelation of the raw concentrations with respect to the cavity temperature. This was necessary for the Met City instrument because of a periodic instability in the cavity temperature, creating small oscillations in the computed concentration.

The final decorrelation step is an optional treatment to remove crosstalk variability between cavity temperature and concentration. The Met City analyzer exhibited significant oscillations

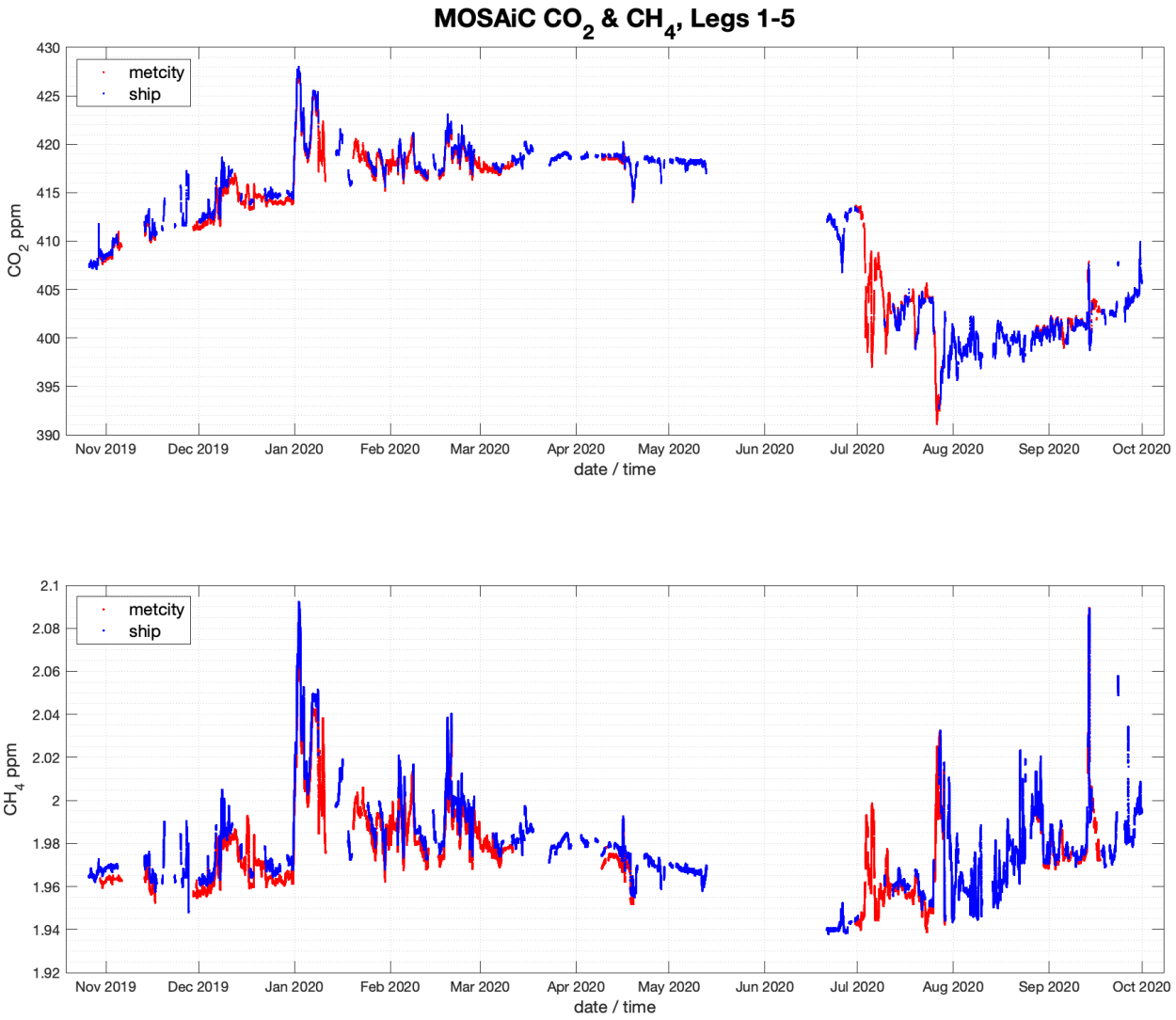

Figure 5: Time series of carbon dioxide and methane concentrations for the MOSAiC project from the ship and Met City flux analyzers. In the next version of this product, recalibration with respect to NOAA GML flask samples will correct the small offset in concentrations between the two systems.

in cavity temperature during Legs 1-3, and these largely disappeared during Legs 4 and 5. We do not know why. Figure 4 illustrates the effect of the decorrelation step on data from December 23. The data files provide both raw and decorrelated concentrations.

A plot of the filtered 1-minute CO2 and CH4 concentrations over the entire project is shown in Figure 5.

Future refinements to Version 2…

When results are available for the weekly NOAA GML flask samples we will recalibrate the two datasets.

If you notice any issues or have questions, feel free to contact me: byron.blomquist@colorado.edu.