Addressing eddy covariance flux errors due to uncertainties in open path IRGA operation under harsh environmental conditions on the Tibetan Plateau

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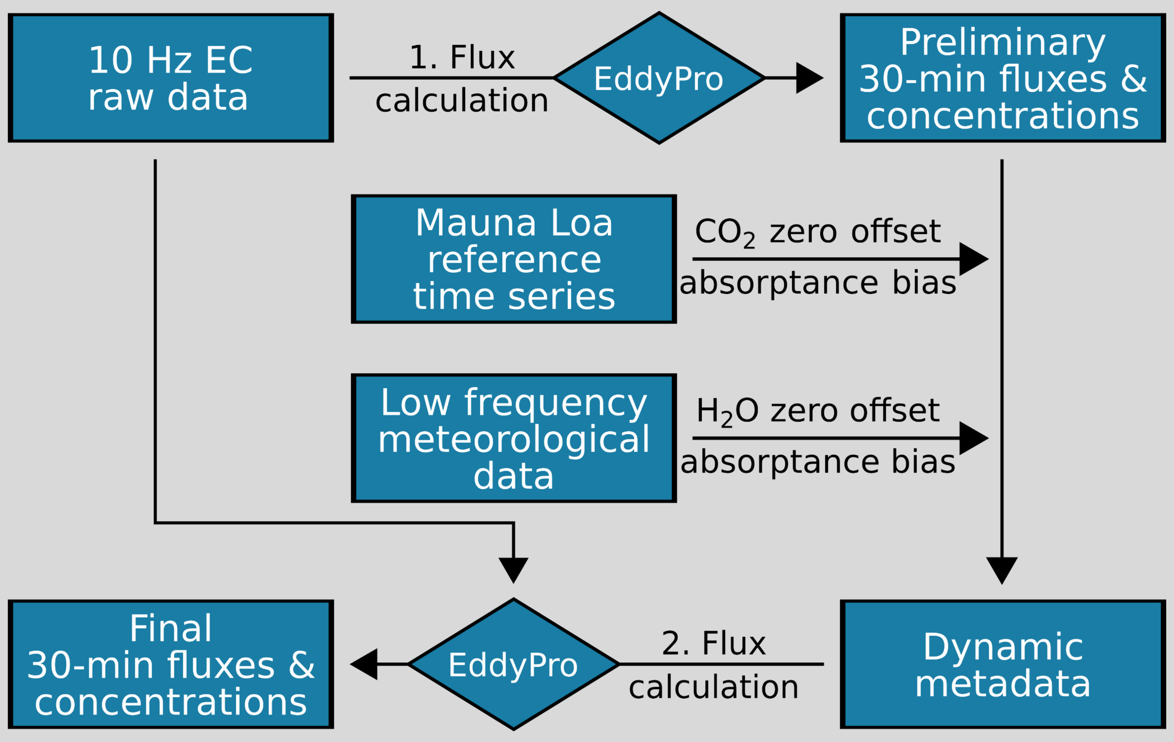
Drift correction in a nutshell

- **Problem**: EC station on the Tibetan Plateau (as many others) is unattended for most time of the year, maintenance and calibration irregular, harsh environmental conditions → CO_2 and H_2O concentrations show strong drift.
- **Correction**: Requires the instrument-specific calibration curve and reference time series for the gas concentrations [1]. In this study, the references used were:
  - **H_2O**: Humidity measurements of meteorological probe at the site
  - **CO_2**: Model based on Mauna Loa CO_2 concentration time series [2].
- **Procedure:** The initial 30-min mean concentrations are used to derive the offset from the reference (i.e. "real") concentration. This offset is then converted to absorptance and subtracted from all 10 Hz measurements during second raw data processing.



Background: IRGA operating principle

- The Li-7500 open path infrared gas analyzer (IRGA) is a so-called dual wavelength, single path sensor.
- Measures relative difference of absorptance at gas-absorbing wavelengths (CO_2 : 4.25 µm, H_2O : 2.59 µm) and non-absorbing reference wavelength (3.59 µm for both CO_2 and H_2O) within the same sample volume.
- Uses instrument specific curvilinear calibration to convert between absorptance and concentration.

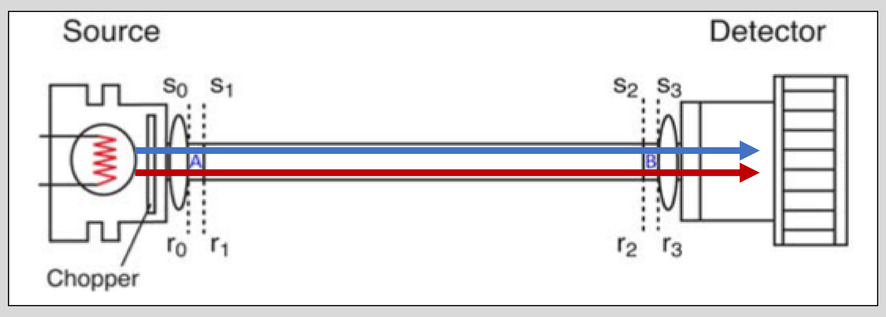


Fig. 4: Operating principle of an IRGA with gas-absorbing wavelength and reference wavelength [1]

Fig. 5: A Li-7500 IRGA [3]

- Contaminant deposition within the optical path influences shorter wavelengths stronger than longer wavelengths, thus leading to:
  - ➢ Overestimation of H_2O concentration.
  - ➢ Underestimation of CO_2 concentration.
  - ➢ The effect on fluxes calculated from these concentrations depends on the magnitude of the raw CO_2 and H_2O fluxes and the magnitude of the WPL correction, i.e. also on the sensible heat flux and is thus specific to the study site [4].

Results – concentrations

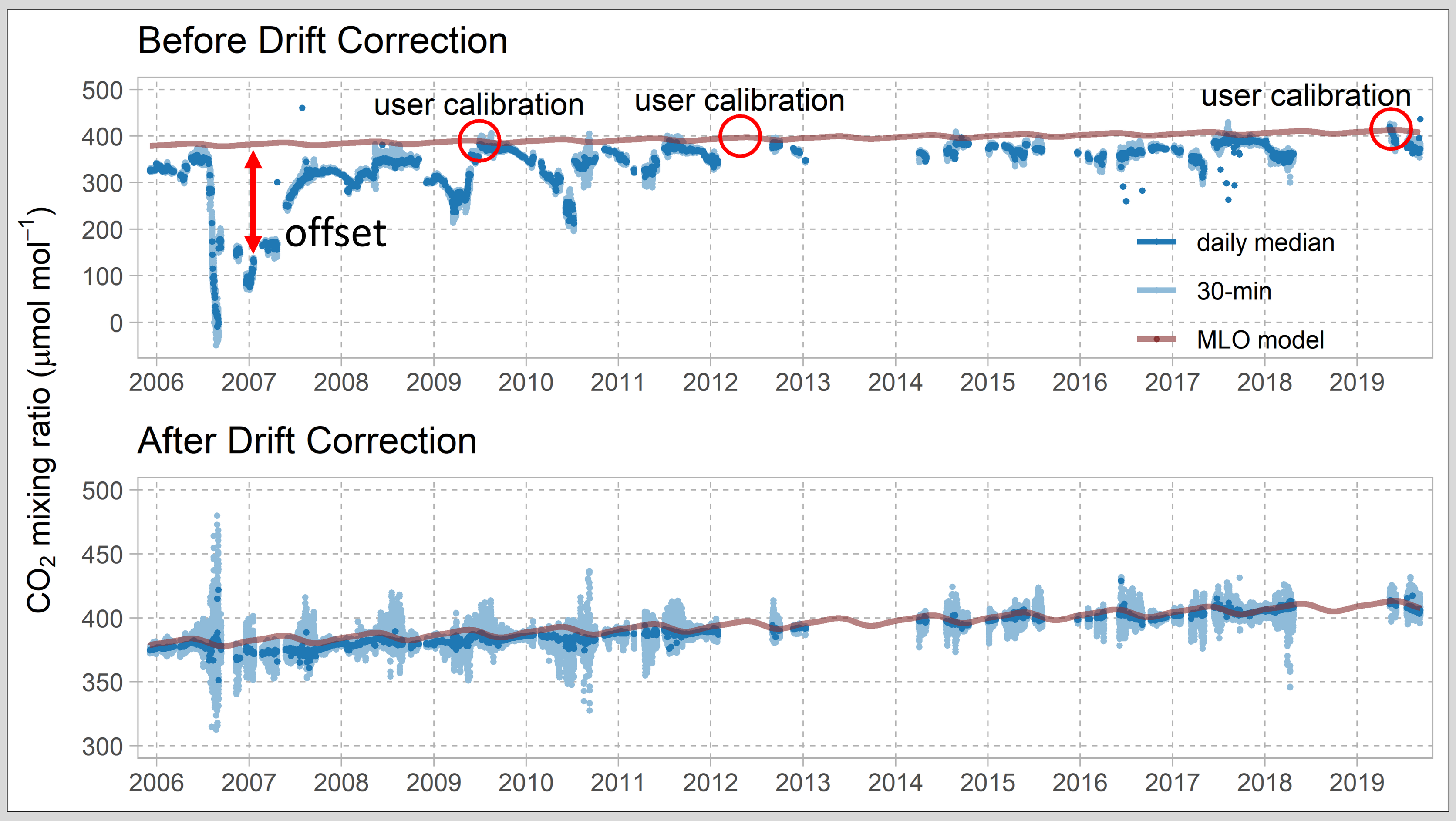


Fig. 2: Daily median and 30-min CO_2 dry air mixing ratios before and after drift correction. Please note the different y-axis scales.

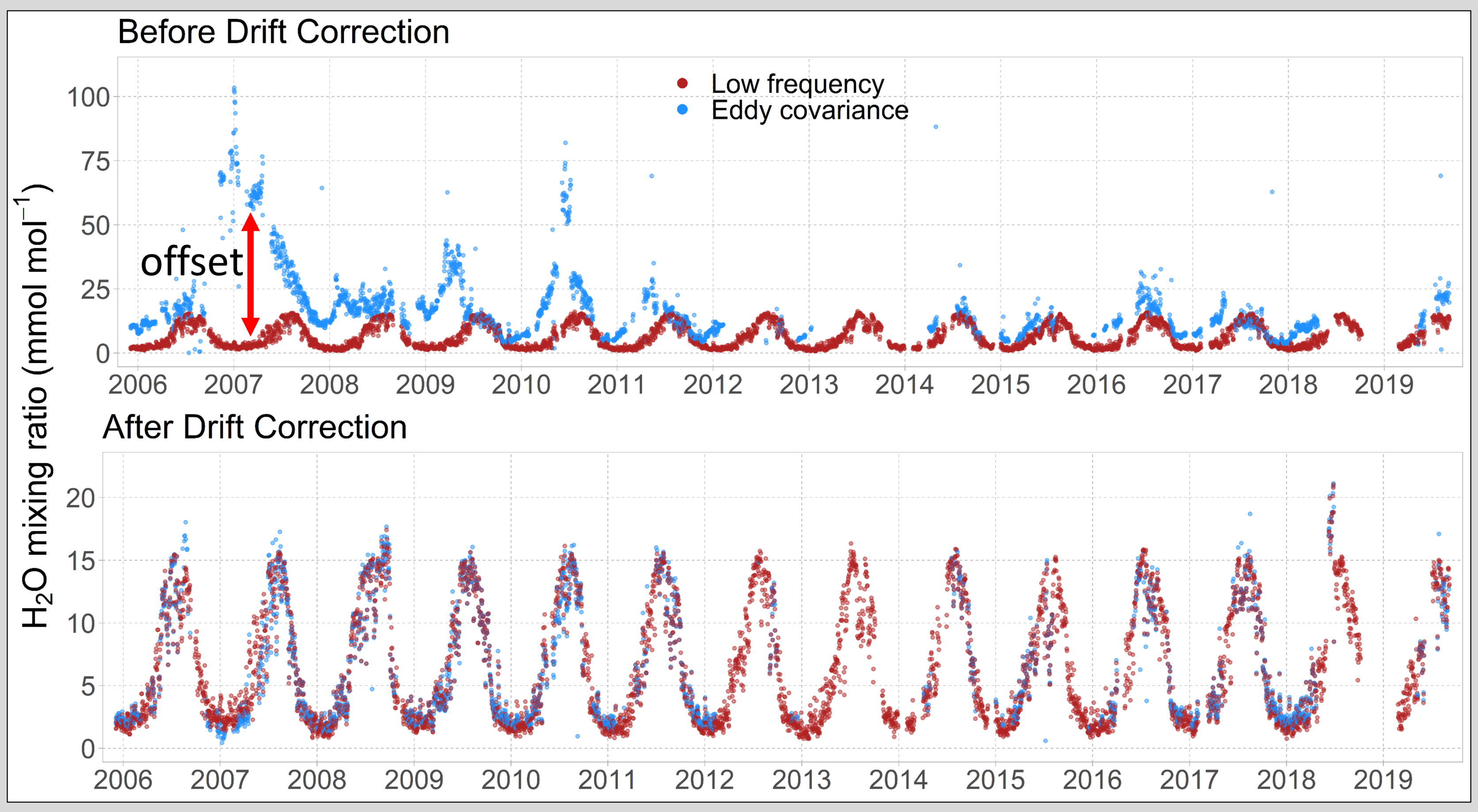


Fig. 3: Daily mean H_2O dry air mixing ratios before and after drift correction. Please note the different y-axis scales.

Results – fluxes

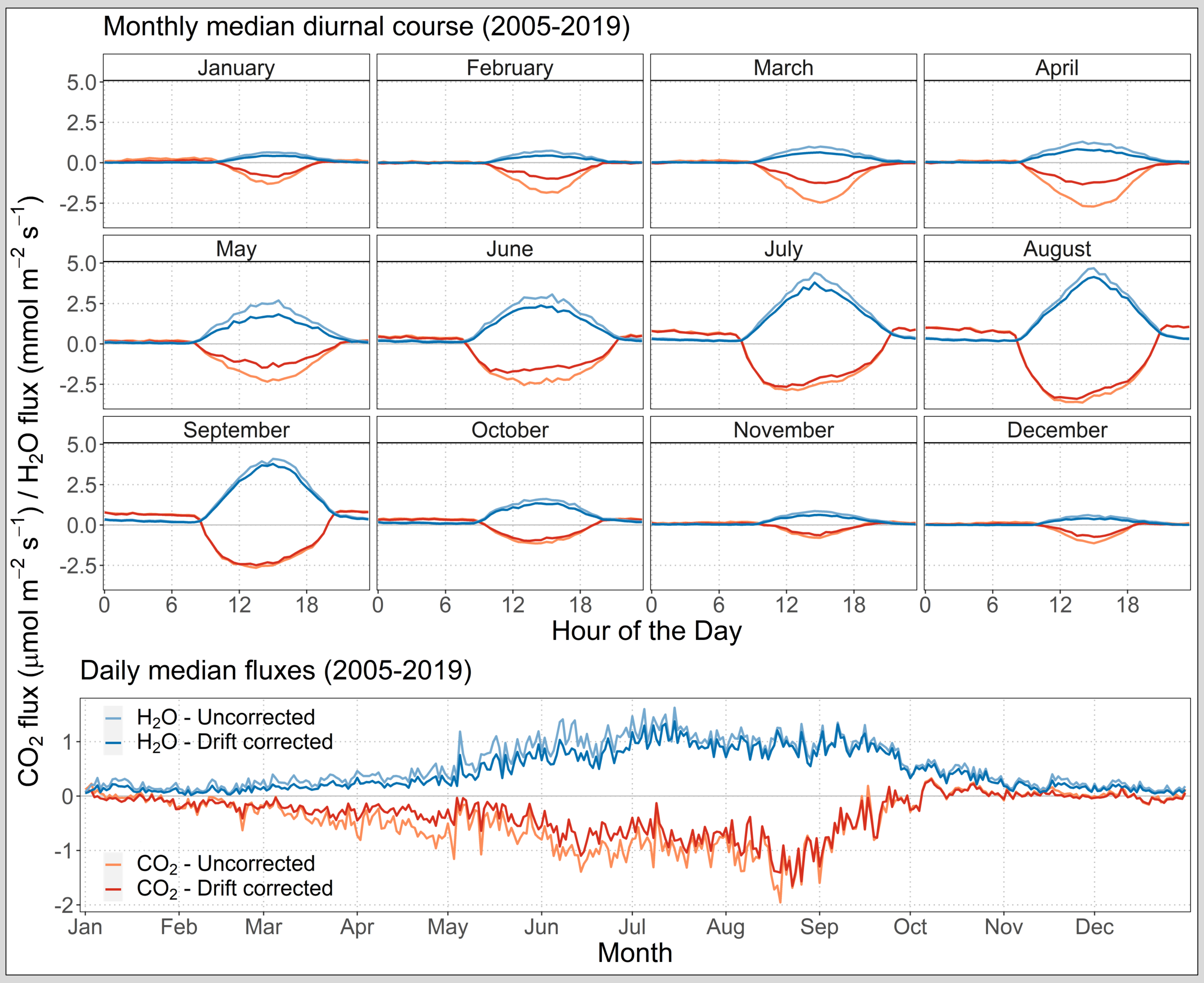


Fig. 6: Monthly median diurnal course of CO_2 and H_2O fluxes before and after drift correction and full processing (including correction for spectral attenuation, WPL correction and quality control).

Conclusions

- ➢ A drift in mean concentration estimates due to improper sensor management was efficiently removed.
- ➢ The magnitude of CO_2 and H_2O fluxes calculated after drift correction is smaller than the magnitude of uncorrected fluxes.
- ➢ For CO_2 flux, the WPL correction leads to a strong overestimation of CO_2 uptake during times with high sensible heat flux, e.g. during spring, before the onset of the summer monsoon, when solar radiation is high while moisture availability remains low.

[1] Fratini, G., McDermitt, D. K., and Papale, D.: Eddy-covariance flux errors due to biases in gas concentration measurements: origins, quantification and correction, Biogeosciences, 11, 1037–1051, https://doi.org/10.5194/bg-11-1037-2014, 2014.
[2] NOAA ESRL Global Monitoring Division. 2018, updated annually. Atmospheric Carbon Dioxide Dry Air Mole Fractions from quasi-continuous measurements at Mauna Loa, Hawaii, Barrow, Alaska, American Samoa and South Pole. Compiled by K.W. Thoning, D.R. Kitzis, and A. Crotwell. National Oceanic and Atmospheric Administration (NOAA), Earth System Research Laboratory (ESRL), Global Monitoring Division (GMD): Boulder, Colorado, USA. Version 2019-07 at https://doi.org/10.15138/yaf1-bk21
[3] LI-COR: LI-7500 Instruction Manual: Open Path CO2/H2O Gas Analyzer, 2004.
[4] Serrano-Ortiz, P., Kowalski, A. S., Domingo, F., Ruiz, B., and Alados-Arboledas, L.: Consequences of Uncertainties in CO2 Density for Estimating Net Ecosystem CO2 Exchange by Open-path Eddy Covariance, Boundary-Layer Meteorology, 126, 209–218, https://doi.org/10.1007/s10546-007-9234-1, 2008.

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