



A step further in the assimilation of IASI and CrIS radiances for O₃ and CO in operations

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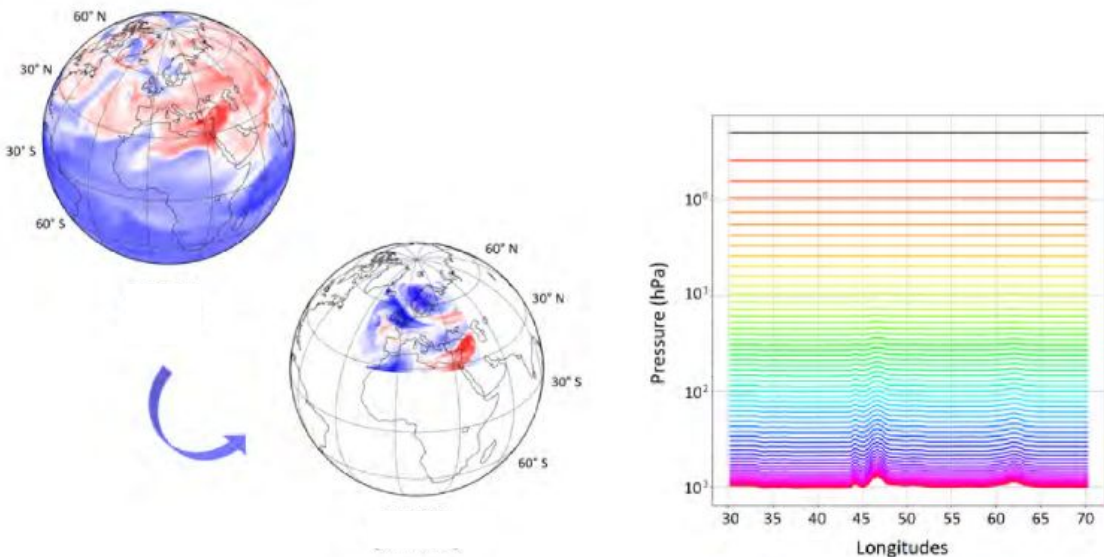


Illustration of the MOCAGE global model at 0.5° (GLOB05) and regional model at 0.1° (MACC01) and representation of the 60 hybrid pressure levels. [by Vittorioso, 2023]

MOCAGE CTM :

- Main processes
 - Sources
 - Transformations
 - Transport
 - Sinks

- Chemical schemes
 - REPROBUS (stratosphere) [Lefevre et al., 1994]
 - RACM (troposphere) [Stockwell et al., 1997]

- MOCAGE simulations
 - 118 gaseous species
 - 434 chemical reactions
 - primary aerosols
 - secondary inorganic aerosols

Modelling

- Improved horizontal and vertical resolution (0.5 degree on global domain, 60 vert. levels up to 0.1 hPa)
- Process improvement
- Use of new emission inventories

Data assimilation

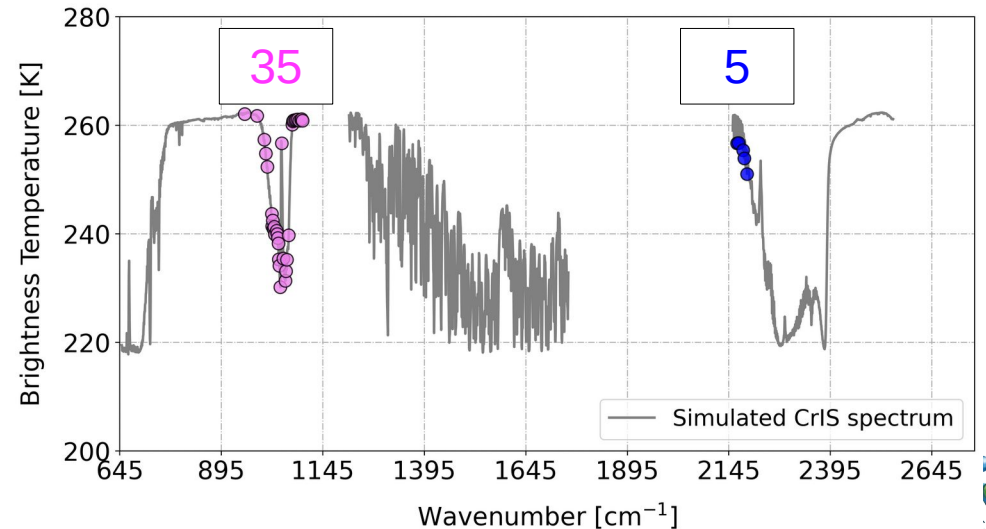
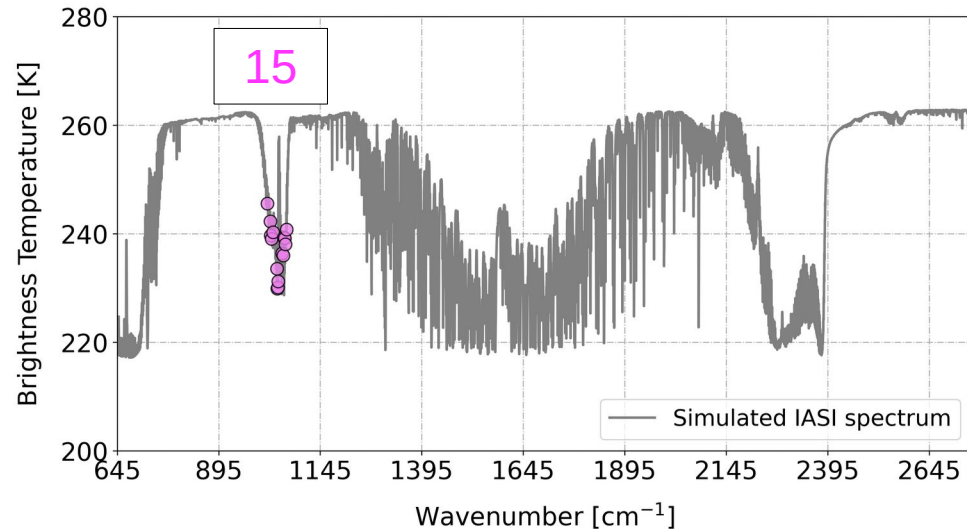
- Assimilation of conventional or remote sensing observations
- What does MOCAGE currently assimilate in the global domain?
 - AOD MODIS (L2)
 - AOD VIIRS (L2)
 - SO₂ TROPOMI (L2) + monitoring SO₂ IASI (L2)

Objective

- Assimilate IR radiances (L1) for ozone (O₃) and carbon monoxide (CO) field enhancement in MOCAGE CTM

IASI and CrIS are hyperspectral infrared sounders :

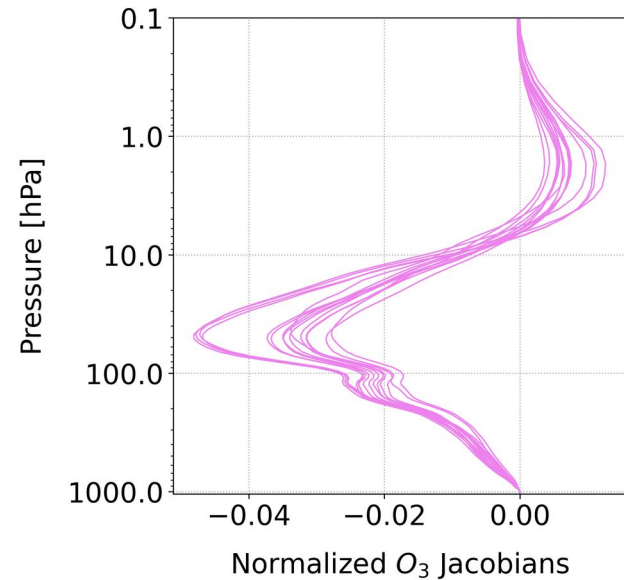
- IASI and CrIS are respectively on board the polar satellites (Metop-B and C) and (NOAA-20 and 21)
- IASI is sensitive in the infrared between 645 and 2760 cm^{-1} (8461 channels) with a spectral resolution of 0.5 cm^{-1}
- CrIS-FSR is sensitive in the infrared between 650–1095, 1210–1750 and 2155–2550 cm^{-1} (2211 channels) with a spectral resolution of 0.625 cm^{-1}



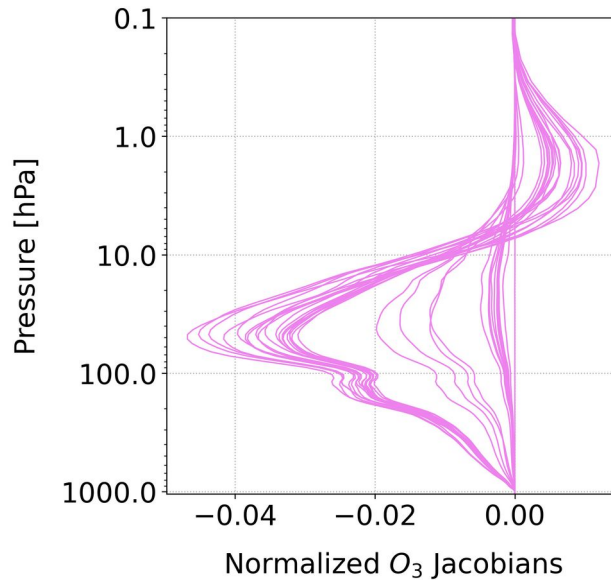
Jacobians

- Represents the sensitivity of observations to a geophysical parameter in the atmosphere, here O₃ and CO
- Normalized Jacobians = Jacobians * 10 % of the O₃ or CO concentration (unit is K)

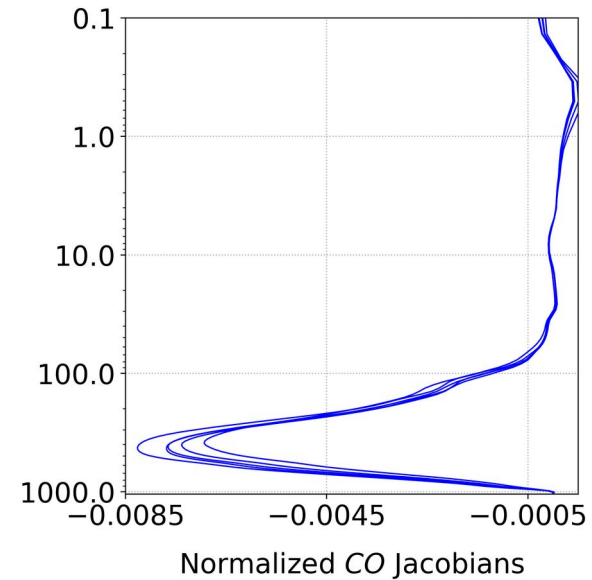
IASI O₃ (15)

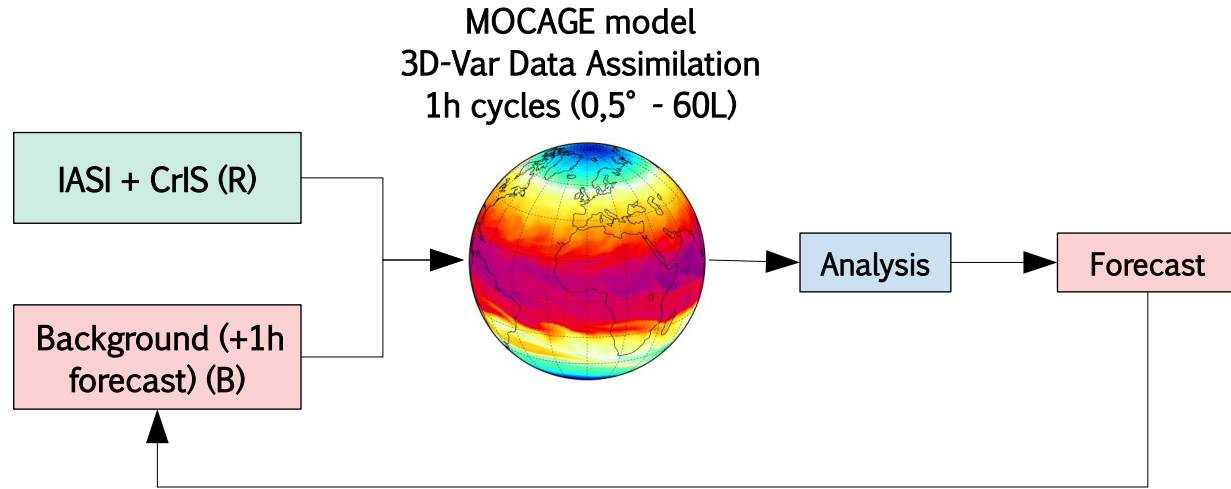


CrIS O₃ (35)



CrIS CO (5)

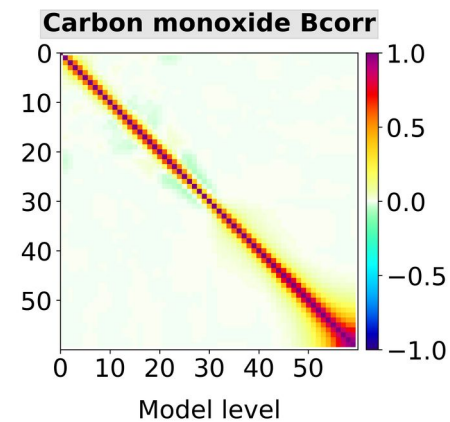
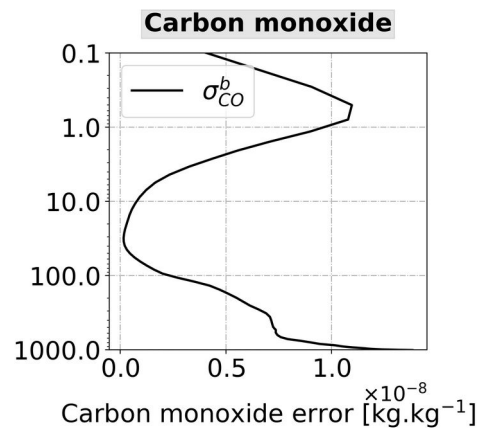
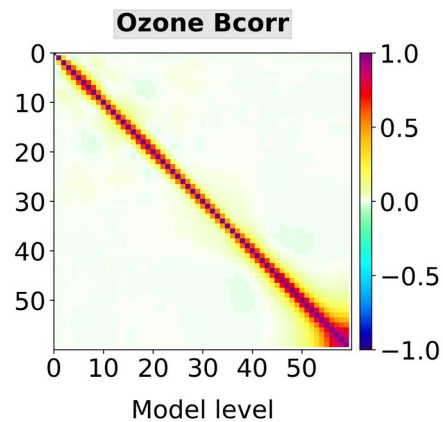
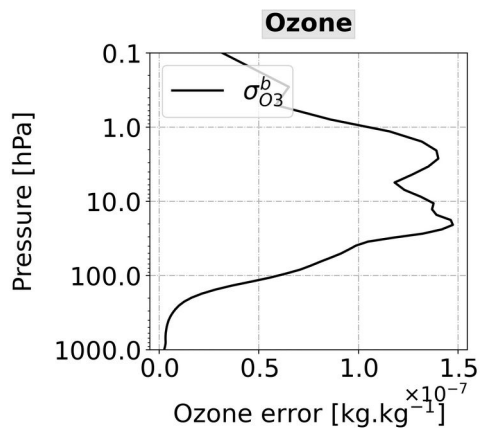




Period	Model	Instruments	Channels	Bias correction	Control variable	Tskin retrieved	B errors	R errors	Thinning
May 23 ▽ Apr 24	MOCAGE Global (0,5°)	IASI + CrIS	IASI O ₃ (15) IASI T _{skin} (1) CrIS O ₃ (35) CrIS CO (5) CrIS T _{skin} (1)	NO	O ₃ CO T _{skin}	YES	Estimated background error covariance matrix	Diagnosed observation error covariance matrix	0.5 deg Sea Clear sky

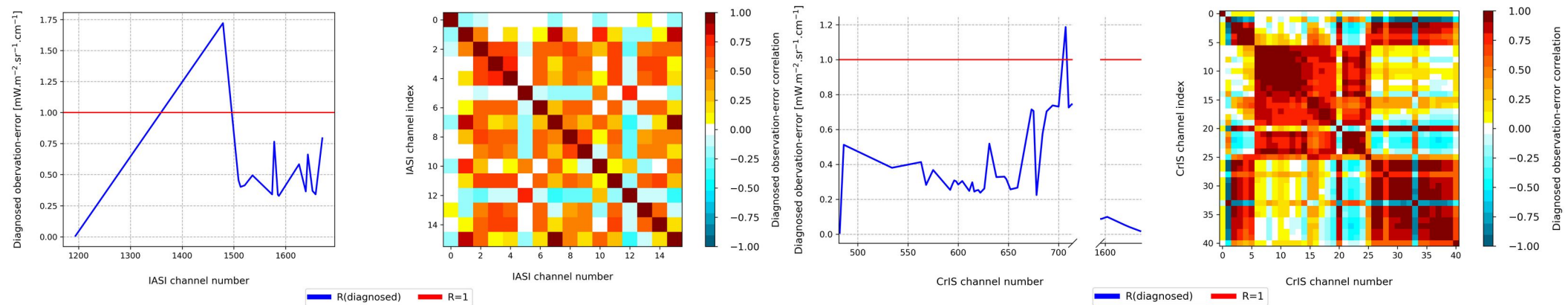
Improvement in the background error description

- Previously: error standard deviations estimated from 30% of each model profile (O₃ and CO)
- Now: Calculation of the background error covariance matrix (including error correlations) using the NMC method (forecast difference 36h-12h over one year of data)



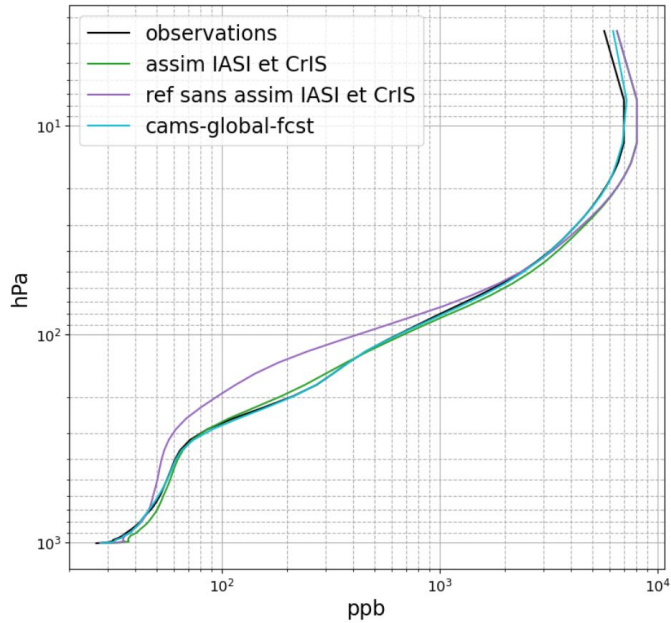
Two-step method

- First round of assimilation using unitary matrix ($R = 1$) or estimated error variances (std O-B)
- Calculation of the observation error covariance matrix (including error correlations) diagnosed using the method of [Desroziers et al., 2005]

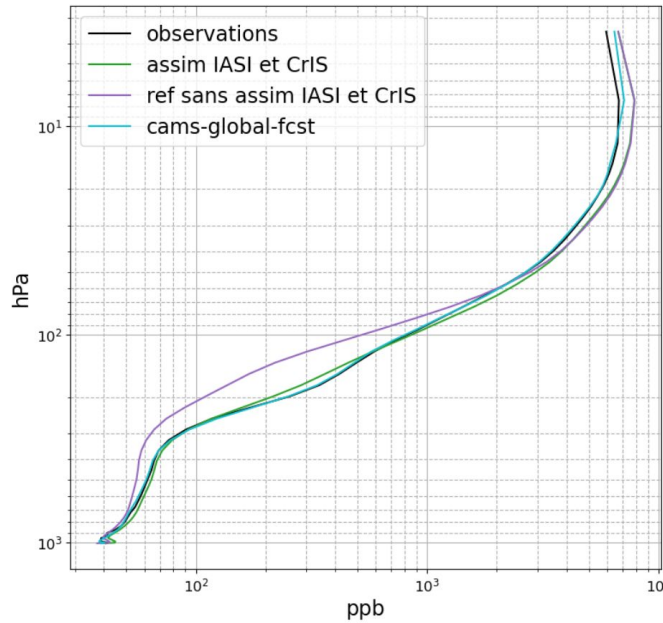


Average profiles O₃ – May 2023 → April 2024

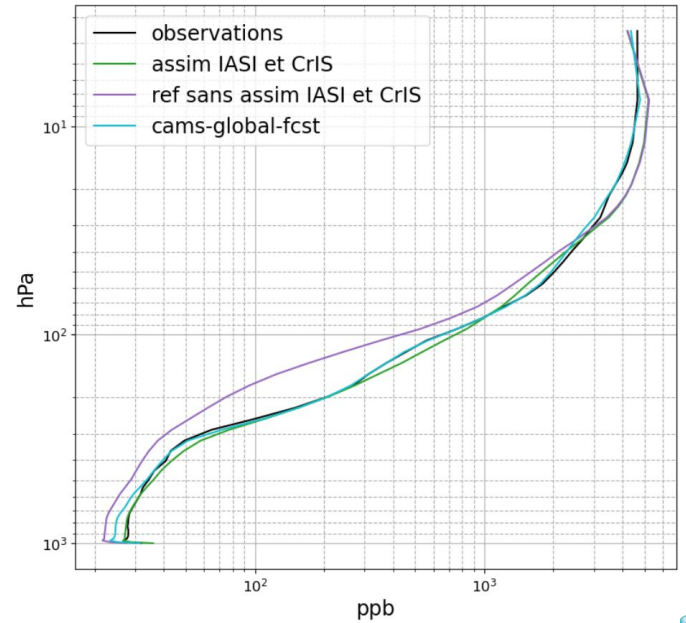
Globe



Europe

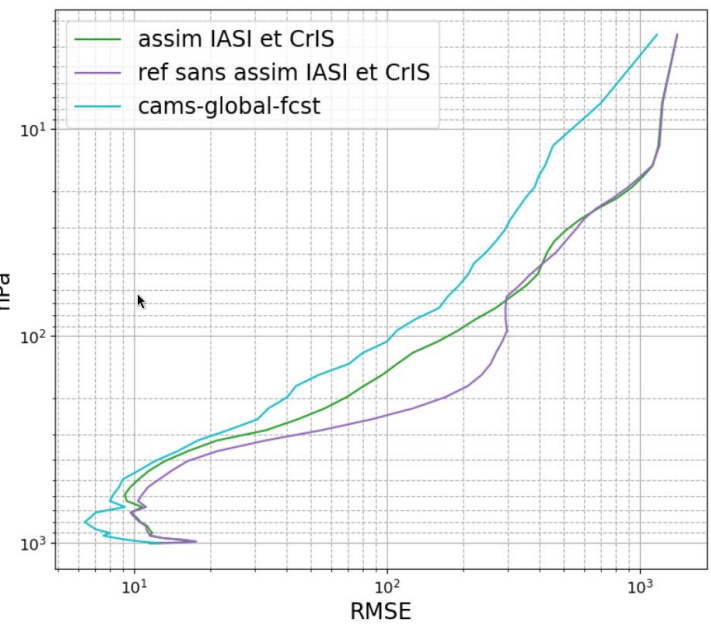


South Pole

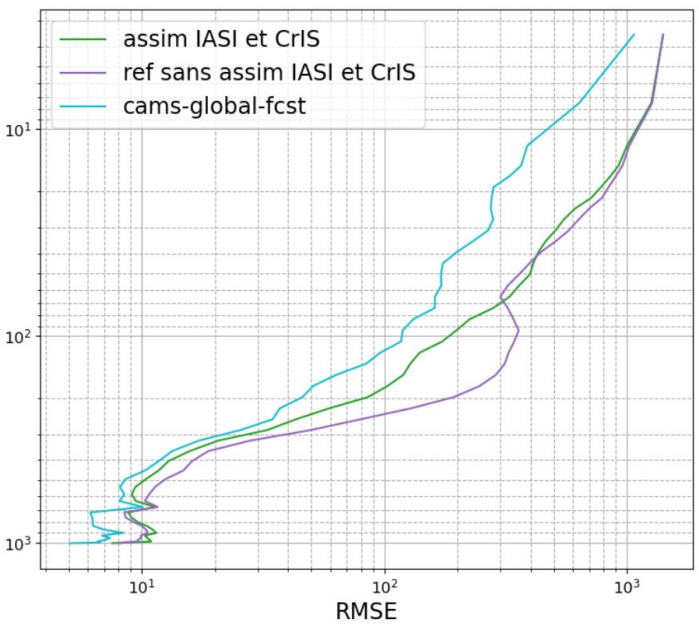


RMSE profiles O₃ – May 2023 → April 2024

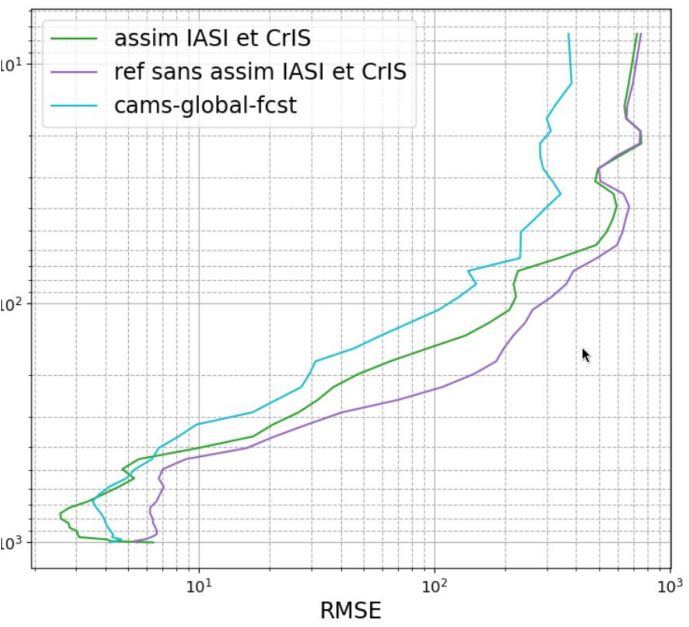
Globe



Europe

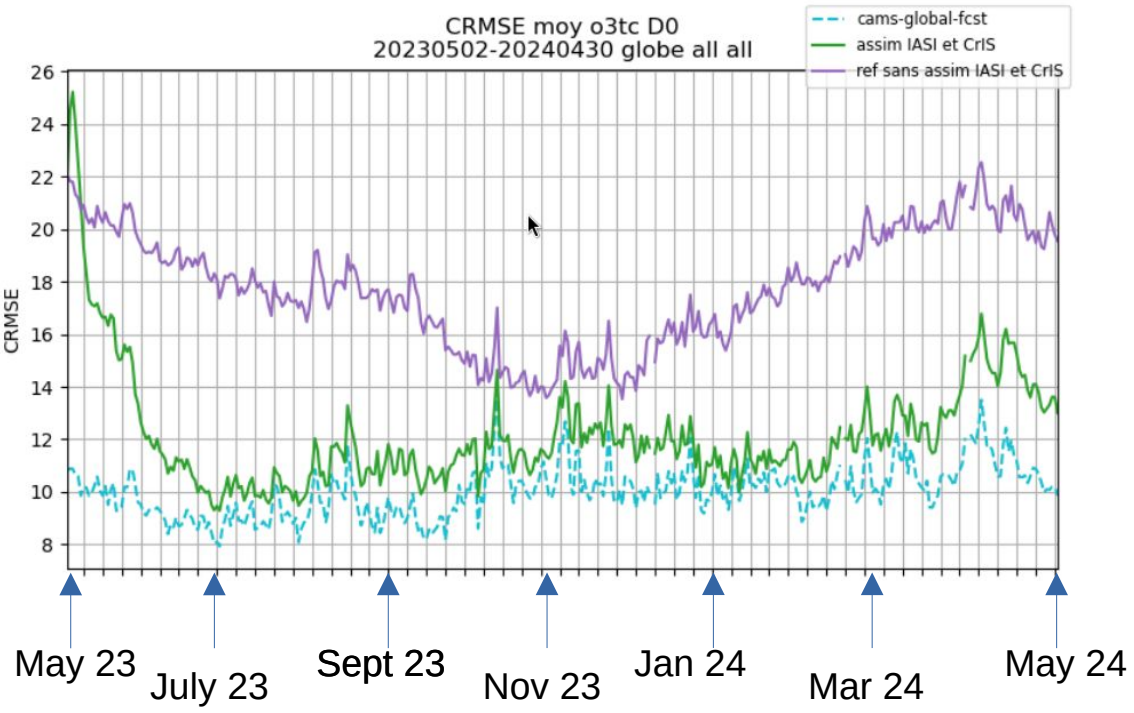
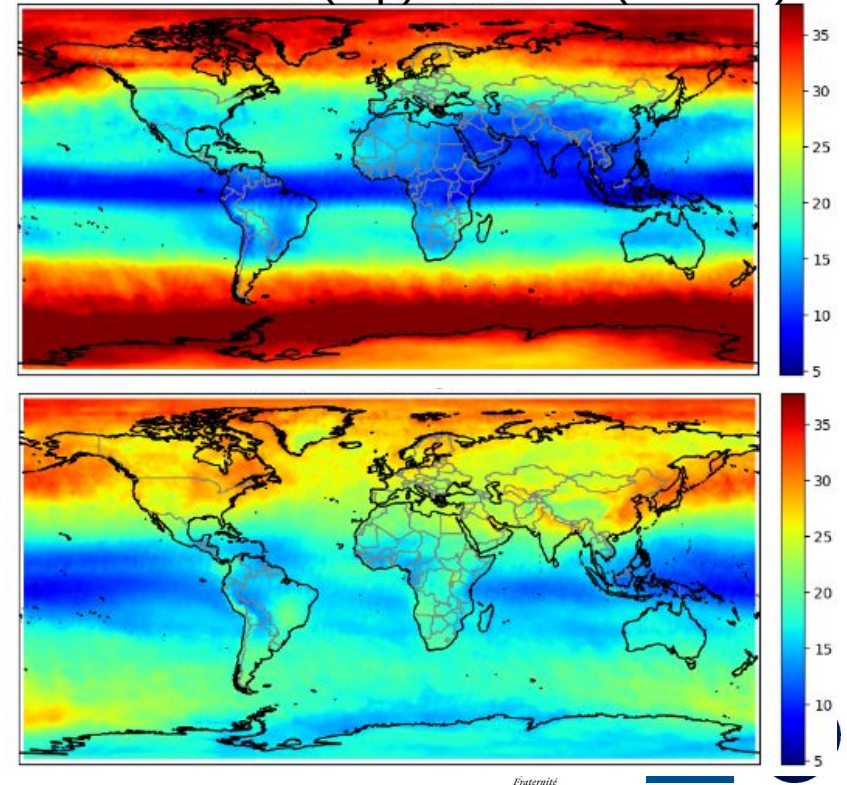


South Pole

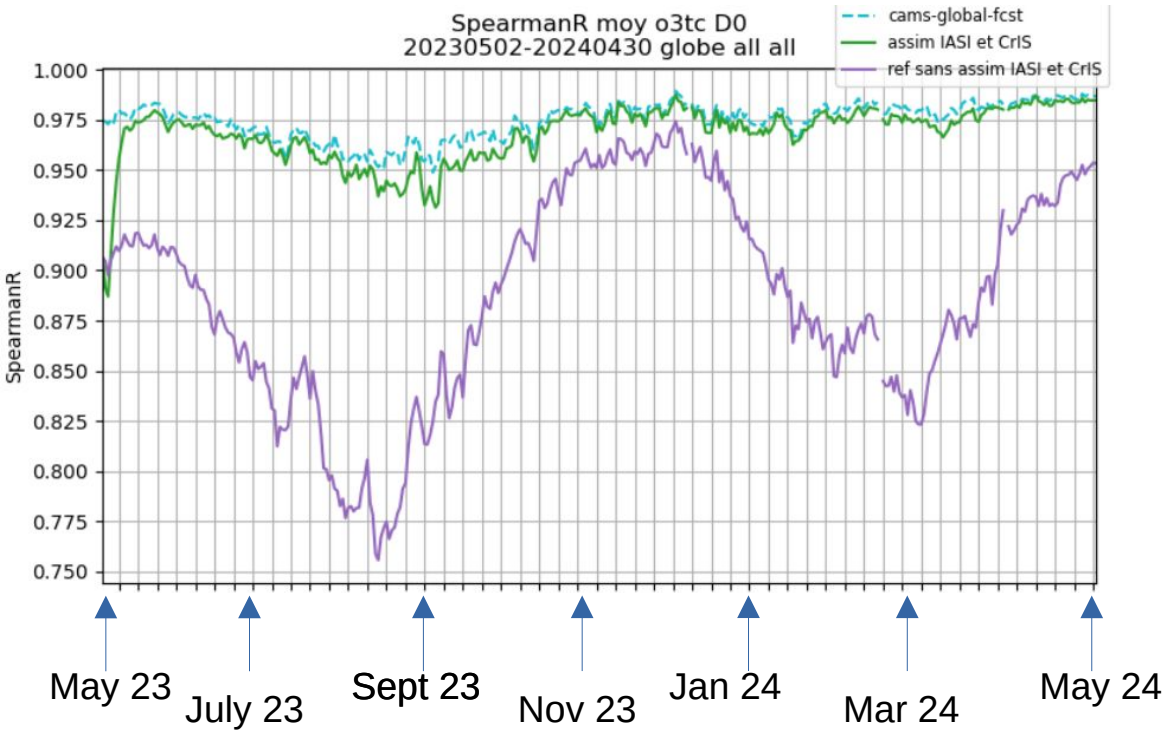


RMSE and CRMSE O₃tc (DU) – May 2023 → April 2024

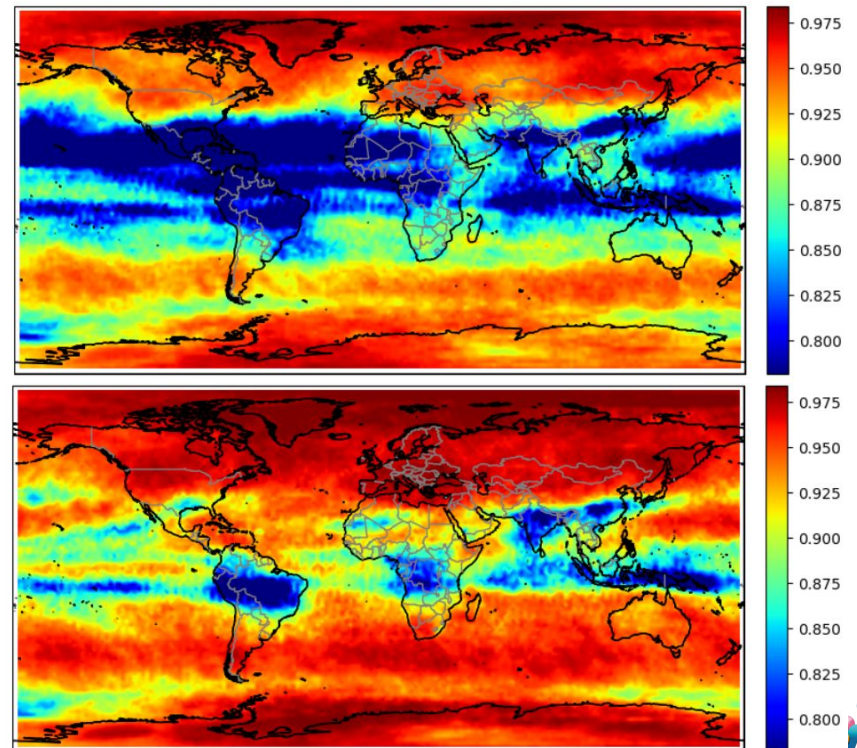
RMSE – Ref (top) – Assim (bottom)



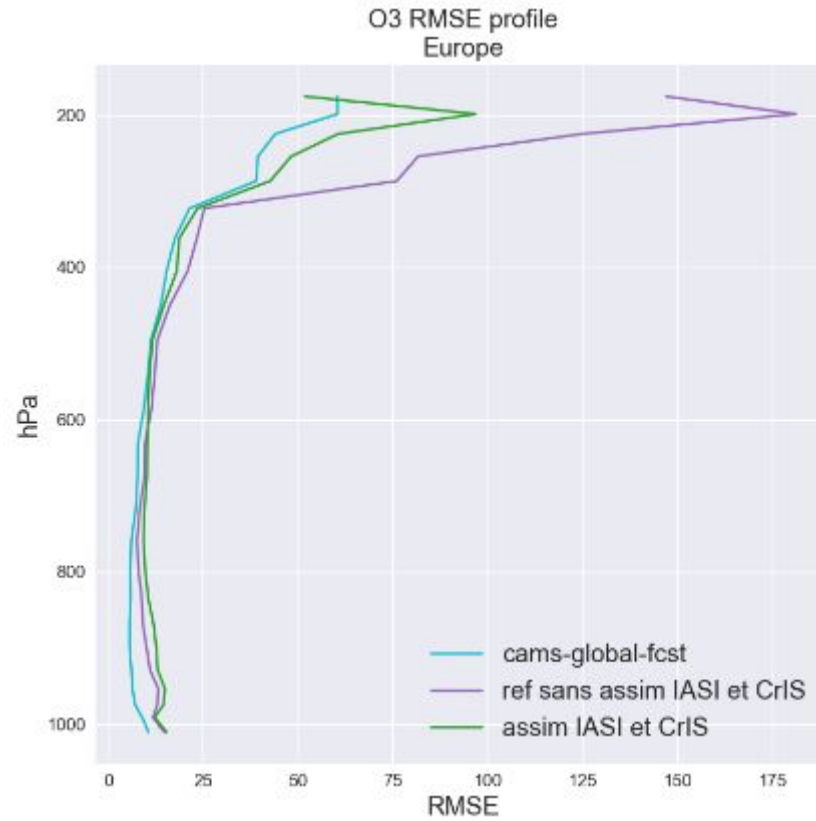
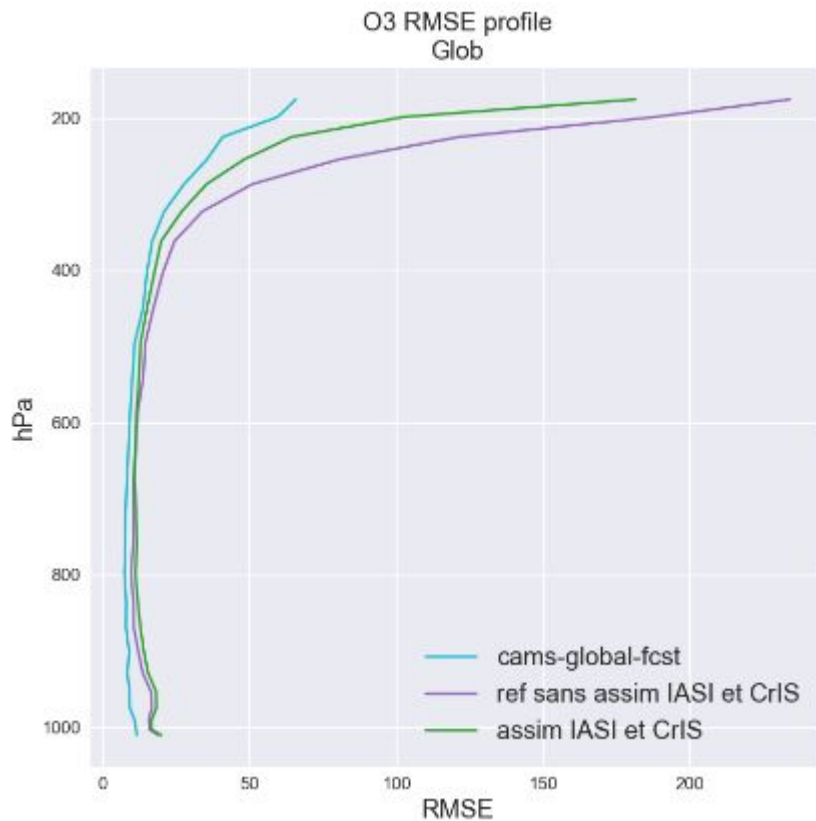
Correlation O₃tc (DU) – May 2023 → April 2024



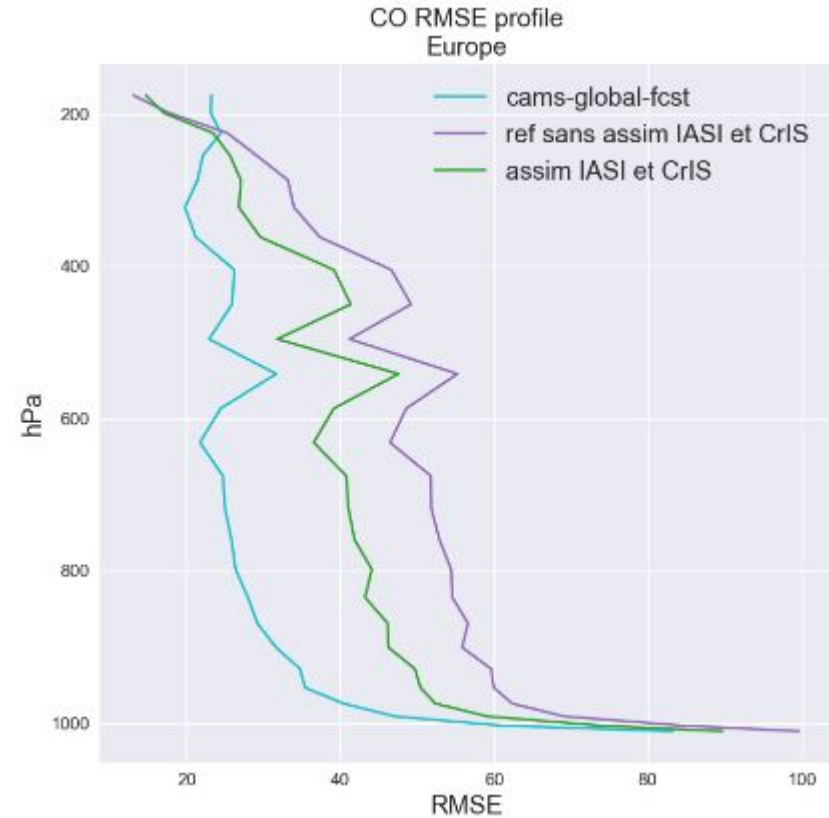
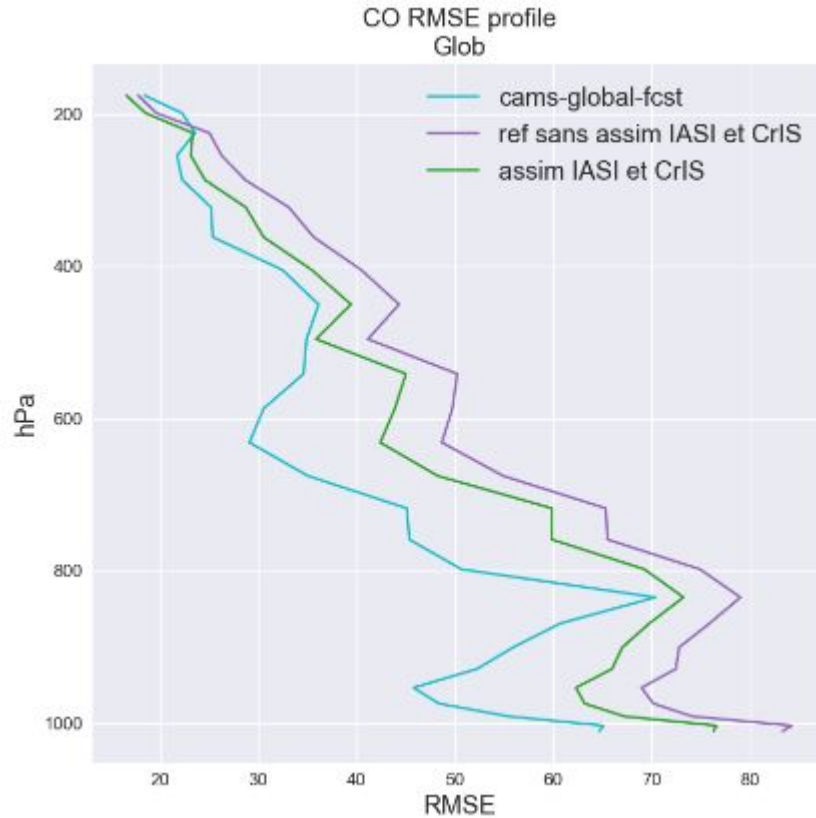
Correlation – Ref (top) – Assim (bottom)



RMSE O₃ profiles – May 2023 → April 2024



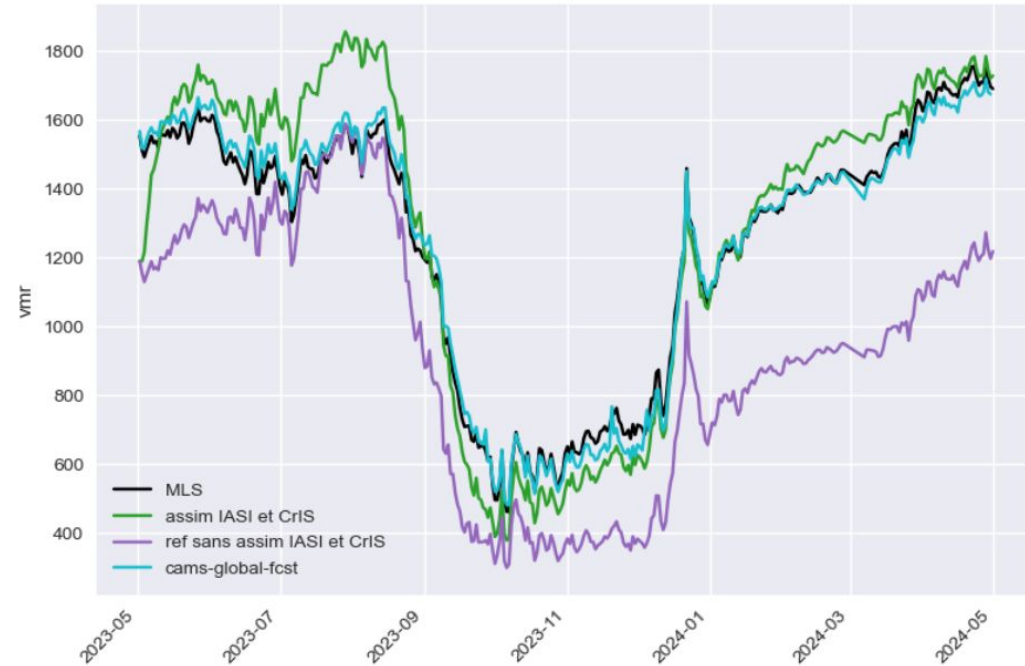
RMSE CO profiles – May 2023 → April 2024



Timeseries O₃ South Pole – May 2023 → April 2024

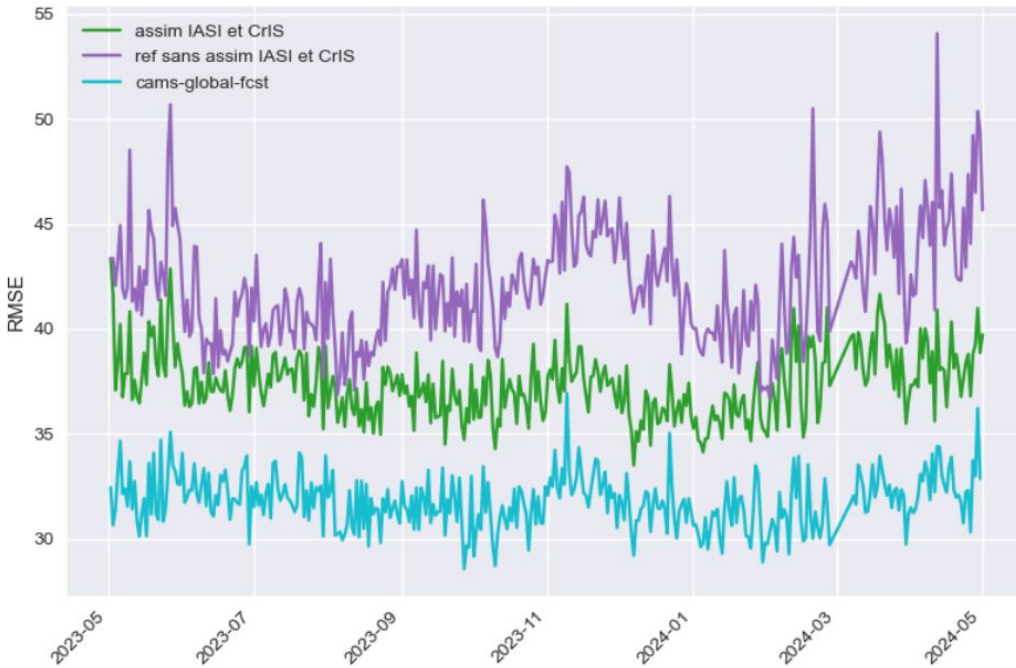
215 hPa

82 hPa

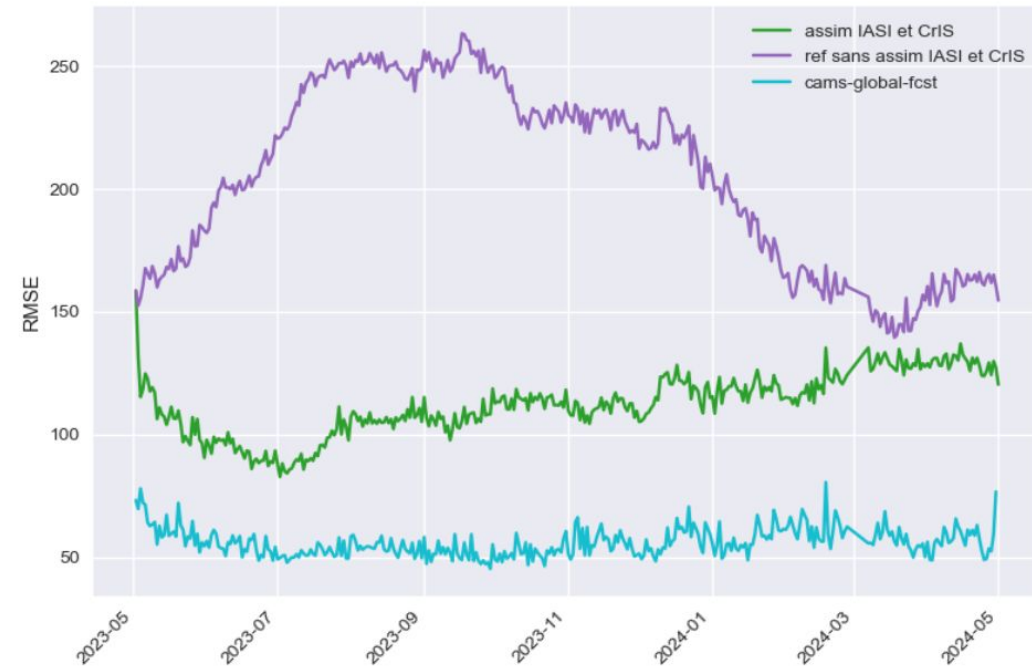


RMSE O₃ Tropics – May 2023 → April 2024

215 hPa



82 hPa



Conclusions :

- Assimilation of IASI and CrIS in MOCAGE with full **R** and **B** matrices
- Significant improvement in ozone and CO fields (despite only 5 assimilated channels fro CO)
- This configuration will be transferred to operations in November 2024

Future prospects :

- Request for a broader list of O₃ and CO channels for IASI and CrIS for operational use
- Add variational bias correction of observations in 3D-Var MOCAGE
- Extend the assimilation to the regional domain over Europe
- Explore the combined assimilation of radiance and geophysical products (UV and visible)