CAMAERA

TOWARDS A REPRESENTATION OF FUNGAL SPORES IN IFS-COMPO

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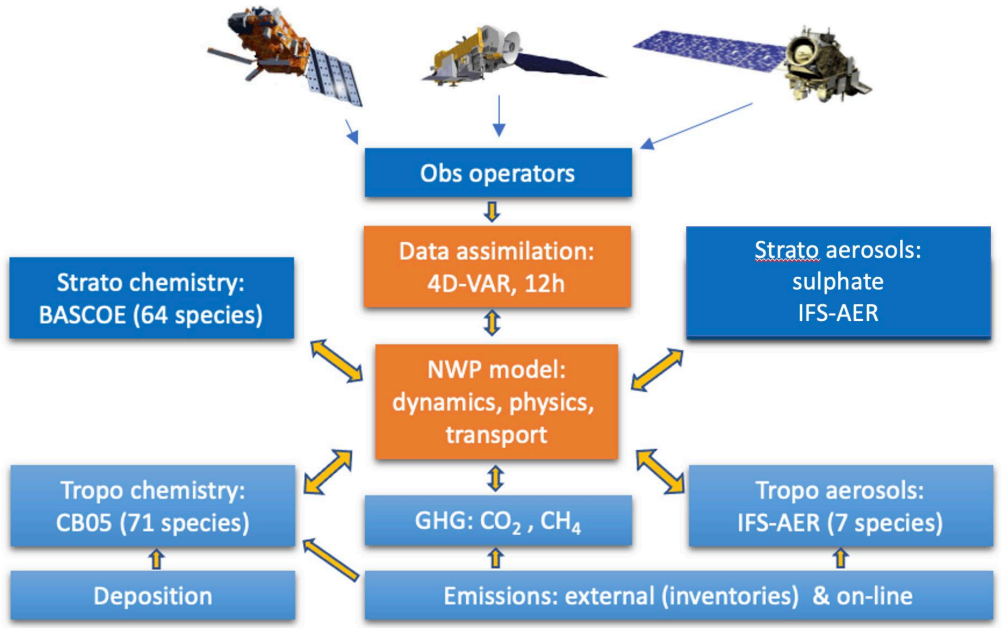
Whare fungal spores?

- Fungal spores are microscopic biological particles that allow fungi to be reproduced, serving a similar purpose to that of seeds in the plant world,
- Many fungal spores contain allergens which can trigger a range of respiratory symptoms in those susceptible,
- It is estimated that around 3-4% of the general population get allergy symptoms from fungal spores, including the majority of asthma sufferers,
- Fungi come in a wide range of types and sizes. Fungal spores are all microscopic. Most fungi require warmth and humidity to grow, reproduce and release their spores into the environment,
- In summer time and in affected places, fungal spores represent a significant fraction of observed PM10

Fungal spores. Coloured scanning electron micrograph (SEM) of the spores of a fungus. Steve Gschmeissner/Science photo library

IFS-COMPO in CAMS

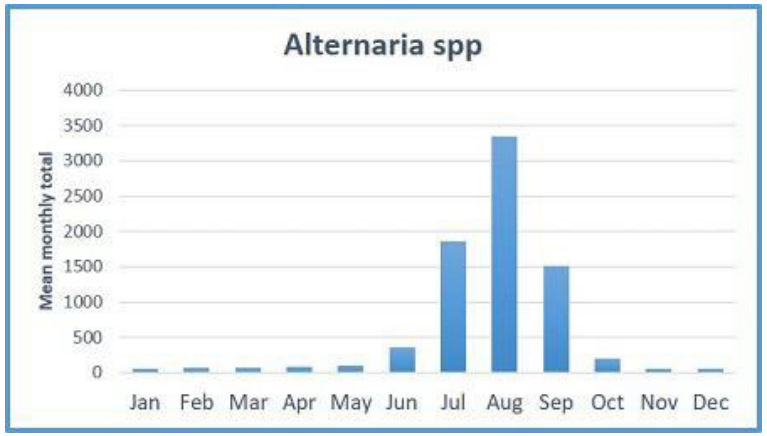
- IFS : Integrated Forecasting System from ECMWF
- IFS – COMPO : IFS with atmospheric composition extension, used operationally for CAMS forecasts
- For aerosols, a « Bulk-bin » approach :
  - 3 bins for SS and DU
  - Single tracer for other species
- Cycle 49R1 implemented operationally on 12/11/2024

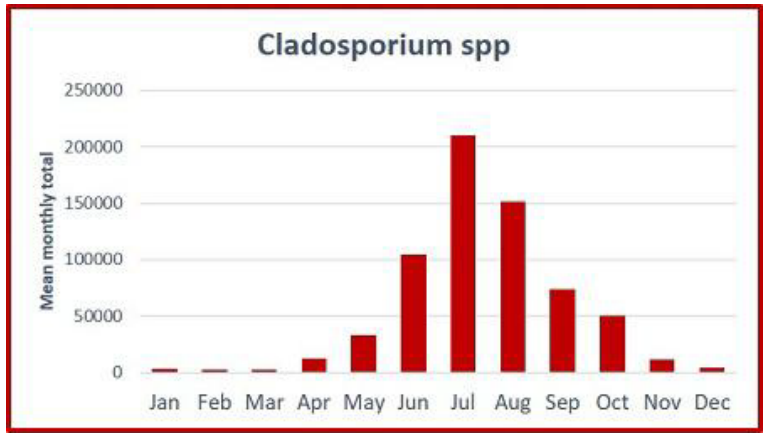


IFS-COMPO schematic

Implementation of fungal spores in IFS-COMPO

- Single tracer that represents all fungal spores : lumped approach which is a very big simplification
- Assumed mean diameter of 3 micron, density of 1000 kg/m3
- Three emission schemes as a function of temperature, humidity, wind speed and leaf area index (LAI) are being tested





Mean monthly counts of fungal spores from different species at Worcester (UK), as collected by the University of Worcester

Emissions of fungal spores in IFS-COMPO

- For all emissions scheme, no fungal spores emission occur if snow is present on the ground, and for temperatures below 5°c – from results of Janssen et al (2021)
- Emission schemes tested:
  - Heald and Spracklen (2009)

Specific humidity [kg/kg]

Leaf-area index [m^2/m^2]

$$F_{\mathrm{H\&S}} = c \times \frac{q}{7.5 \cdot 10^{-2}} \times \mathrm{LAI}\,, \quad c = \begin{cases} 2315\ \mathrm{m^{-2}\ s^{-1}} & d = 3\ \mu\mathrm{m} \quad [\mathrm{Ref.\ 2}] \\ 500\ \mathrm{m^{-2}\ s^{-1}} & d = 5\ \mu\mathrm{m} \quad [\mathrm{Ref.\ 3}] \end{cases}$$

Temperature [°C]

  - Hummel et al (2015): $F_{\mathrm{Hm}} = 20.426 \times (T - 275.82) + 3.93 \times 10^4 \times q \times \mathrm{LAI} \quad [\mathrm{Ref.\ 4}]$
  - Statistical model from Janssen et al (2021) : $F_{\mathrm{stat}} = b_0 + b_1 \cdot q_{2\,\mathrm{m}} + b_2 \cdot \mathrm{LAI} + b_3 \cdot u^*,$

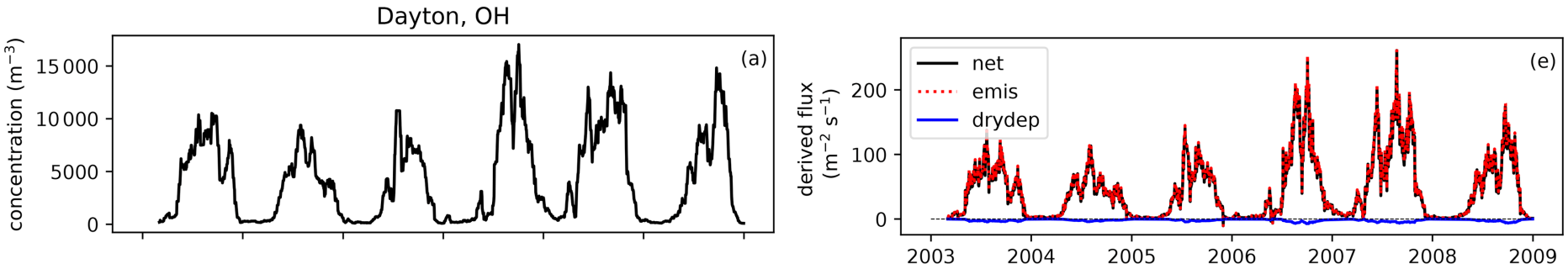
Heald, C. L., and D. V. Spracklen*: Atmospheric budget of primary biological aerosol particles from fungal spores, Geophys. Res. Lett., 36, 2009*

Hummel et al *: Regional-scale simulations of fungal spore aerosols using an emission parameterization adapted to local measurements of fluorescent biological aerosol particles, Atmos. Chem. Phys., 15, 6127–6146, https://doi.org/10.5194/acp-15-6127-2015, 2015.*

Janssen et al*: Drivers of the fungal spore bioaerosol budget: observational analysis and global modeling, Atmos. Chem. Phys., 21, 4381–4401, 2021.*

Evaluation strategy

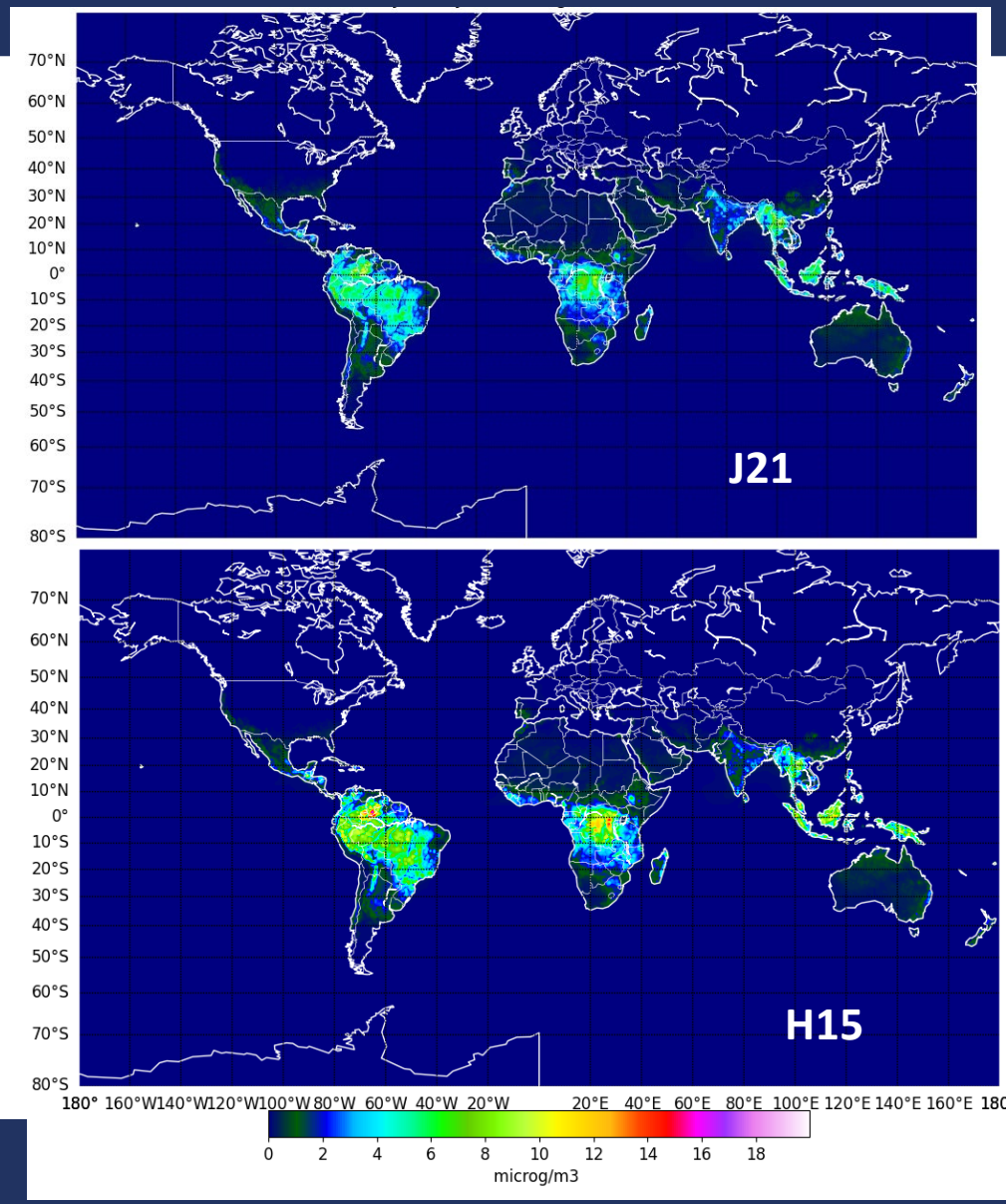
- Fungal spores (and pollen) observations are often not open/free
- PM10 has been used to evaluate the impact of fungal spores over Europe, US, East Asia and Brazil
- A large dataset of observational datasets has been gathered for validation:
  - Arabitol/Mannitol concentration over France/Switzerland from IGE/IRD – polyols are a good proxy for fungal spores
  - Fungal spores emissions derived from ground observations of spores counts over the U.S. from Janssen et al (2021)
  - Fungal spores counts over Hyy
  - DNA abundance of fungal spores over 47 stations worldwide
  - In the future, possibly, fungal spores counts from the European Aeroallergen Network (EAN)

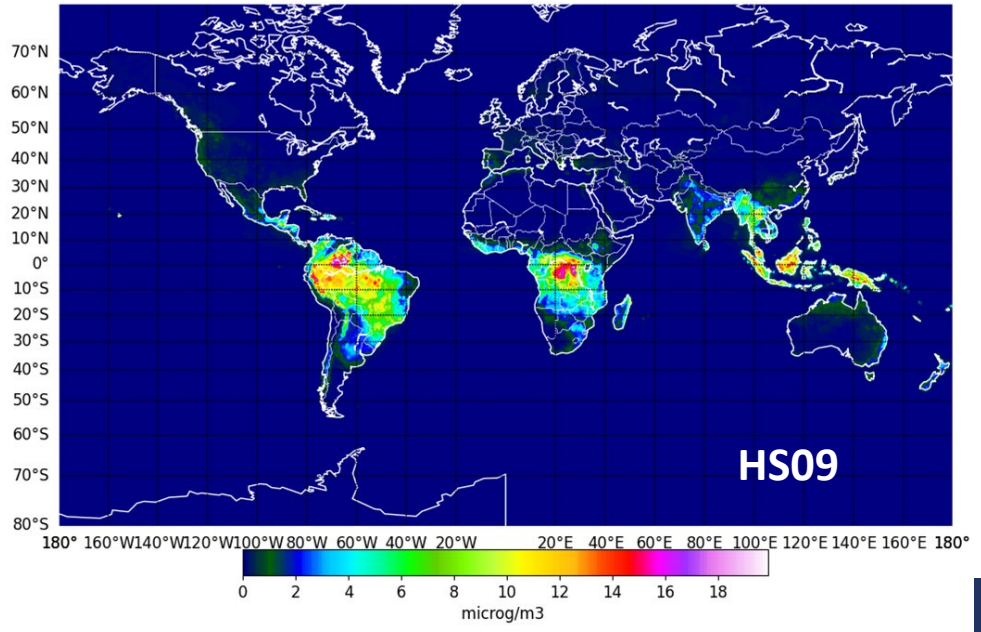


From Janssen et al (ACP, 2021) : left, observed spore counts at Dayton (OH, USA); right, derived fungal spores emission and dry deposition fluxes.

Simulated fungal spores surface concentration

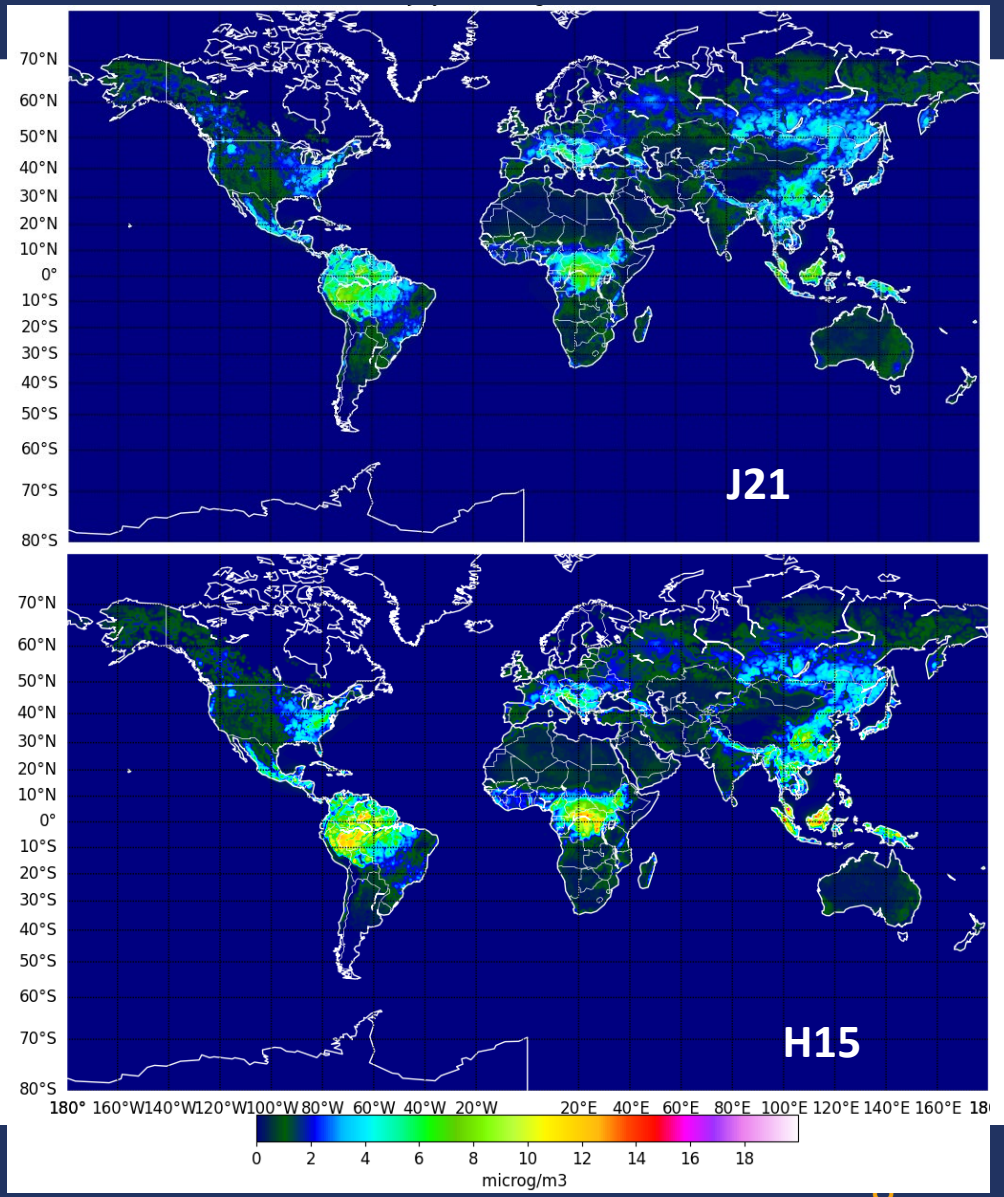
IFS-COMPO simulation without data assimilation,
January 2019 average

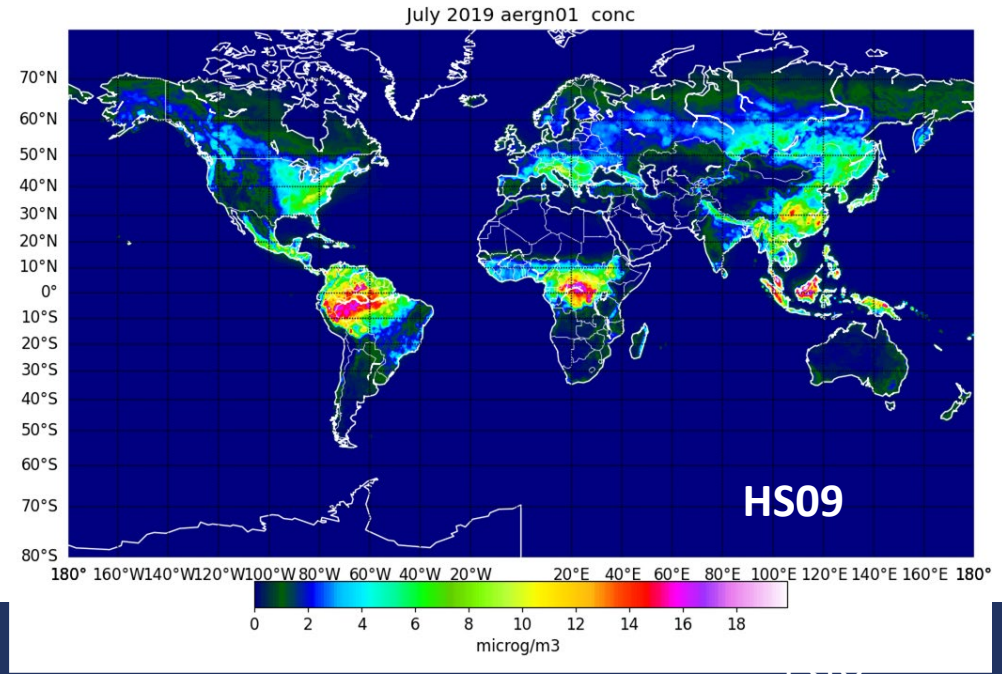




Simulated fungal spores surface concentration

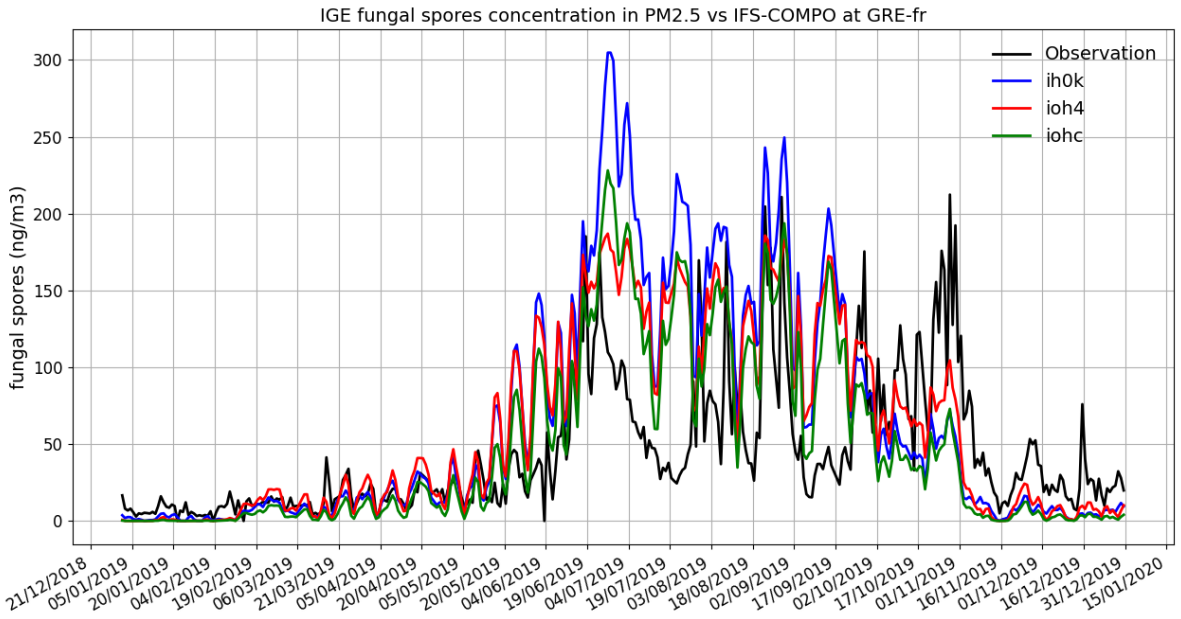
IFS-COMPO simulation without data assimilation, July 2019 average

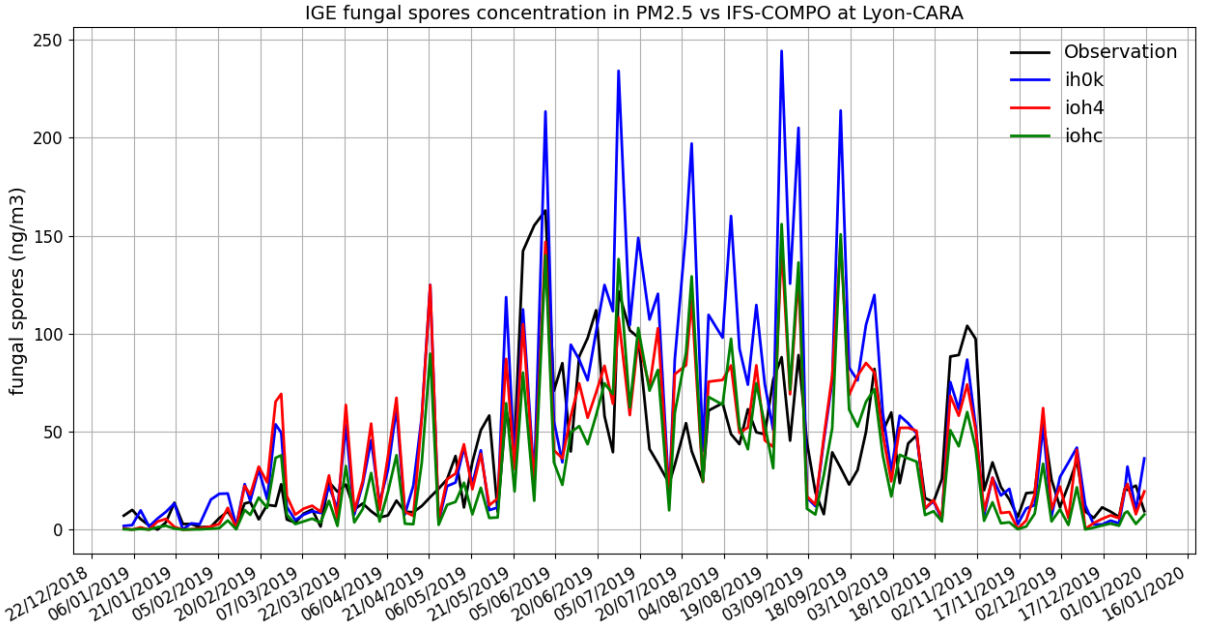




Evaluation versus observational datasets

- Comparison against fungal spores concentration derived from polyol observations from IGE-IRD
- The seasonal cycle is relatively well represented with some exceptions

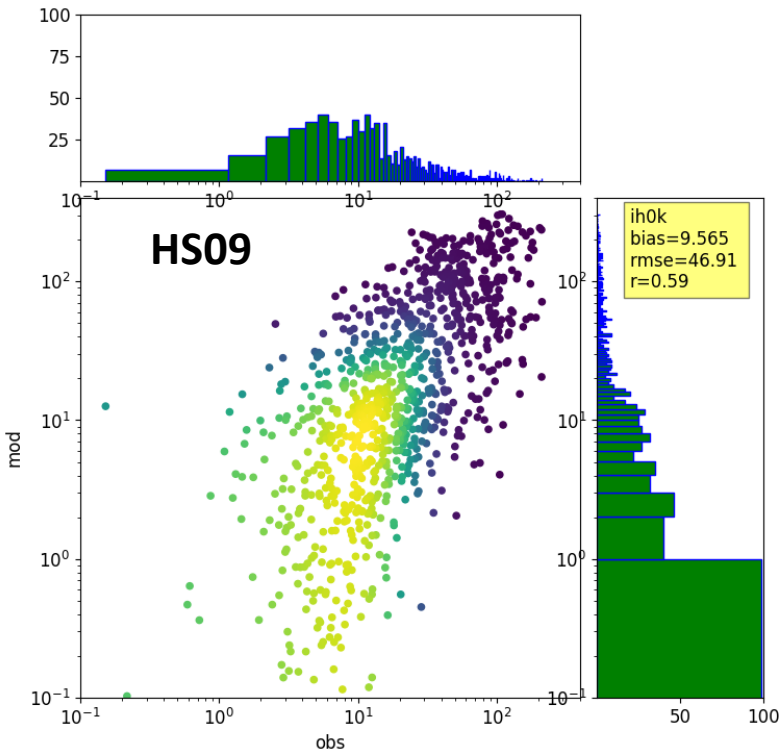


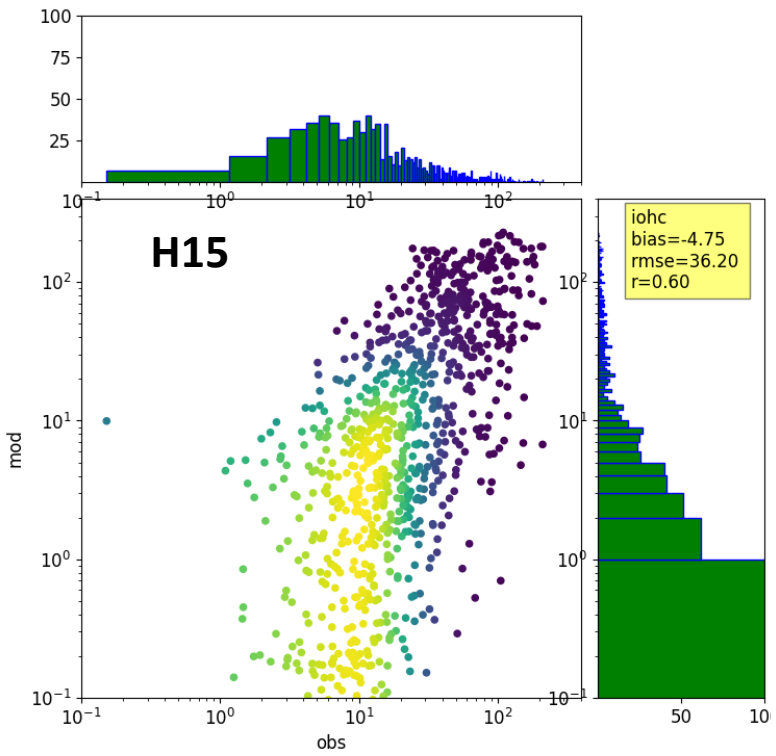


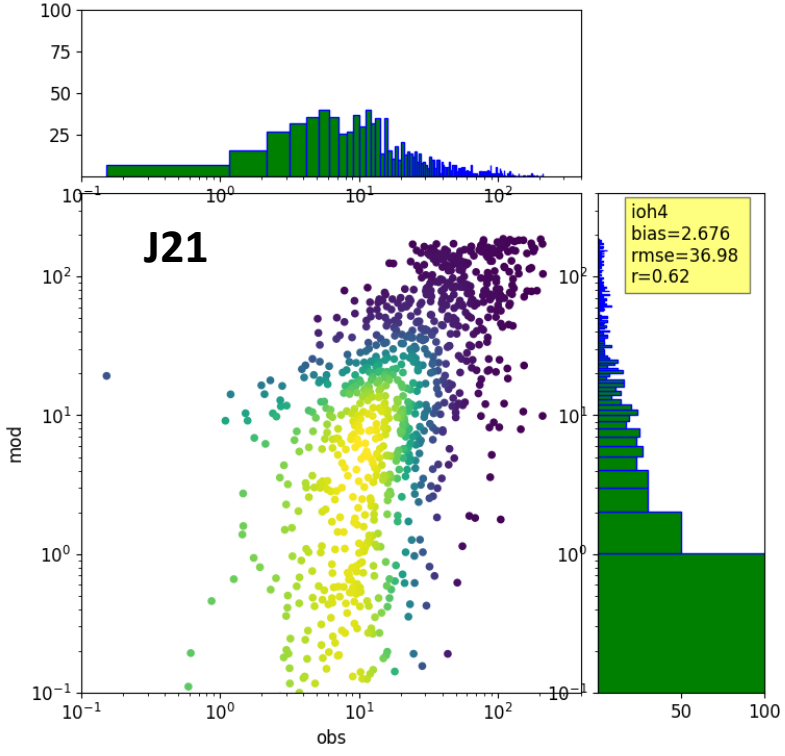
*Observed (**black**) and simulated (**blue=HS09**, **green=H15**, **red=J21**) surface concentration of fungal spores at Grenoble (left) and Lyon (right)*

Evaluation versus observational datasets

- Comparison against fungal spores concentration derived from polyol observations from IGE-IRD – all observed/simulated pairs in 2019
- Simulated values often too low

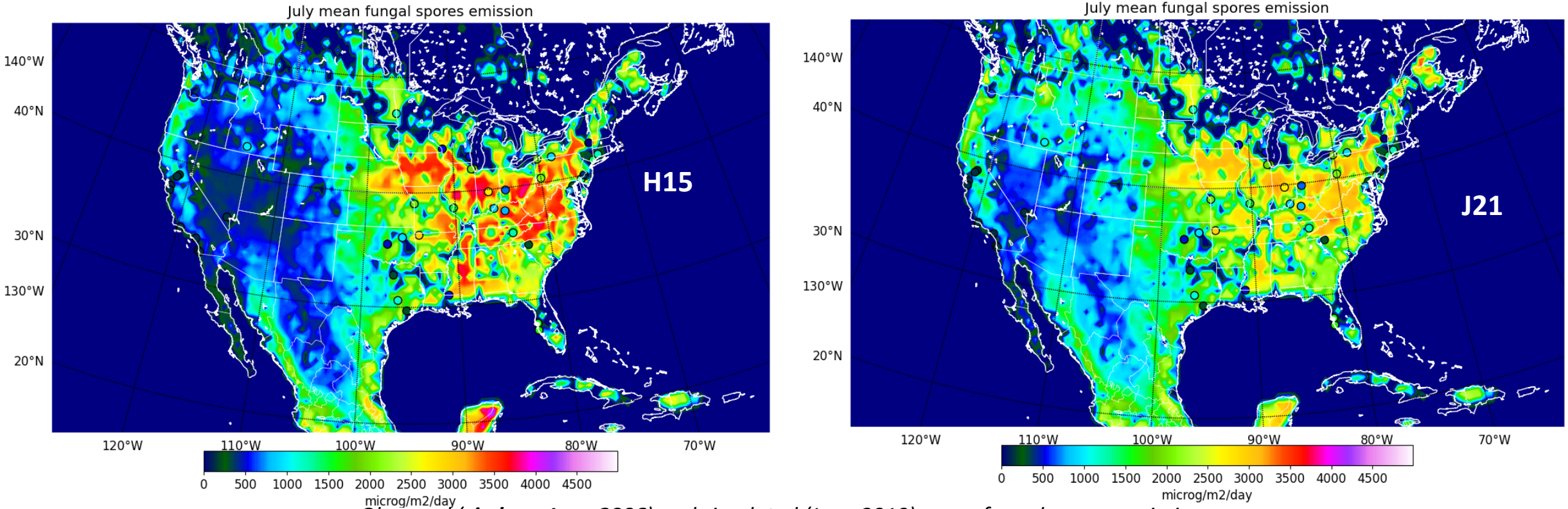






Evaluation versus observational datasets

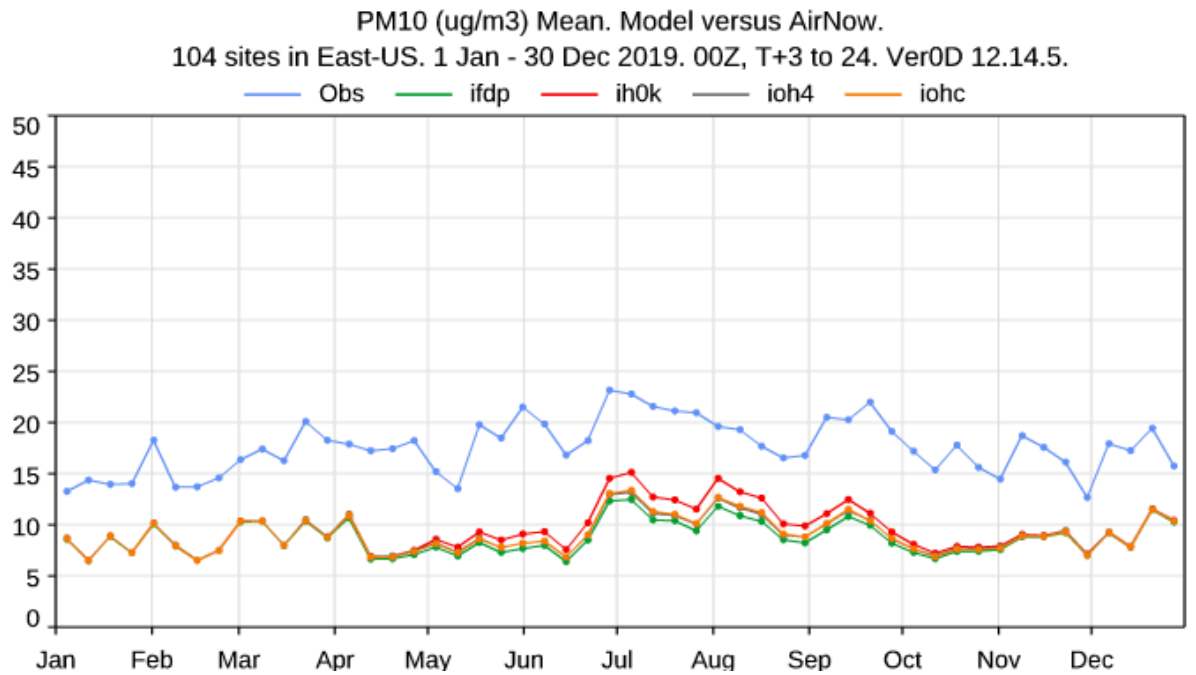
- Comparison against fungal spores emissions derived from surface concentration observations from Janssen et al (2021)
- Simulated values often too high with H15 and HS09

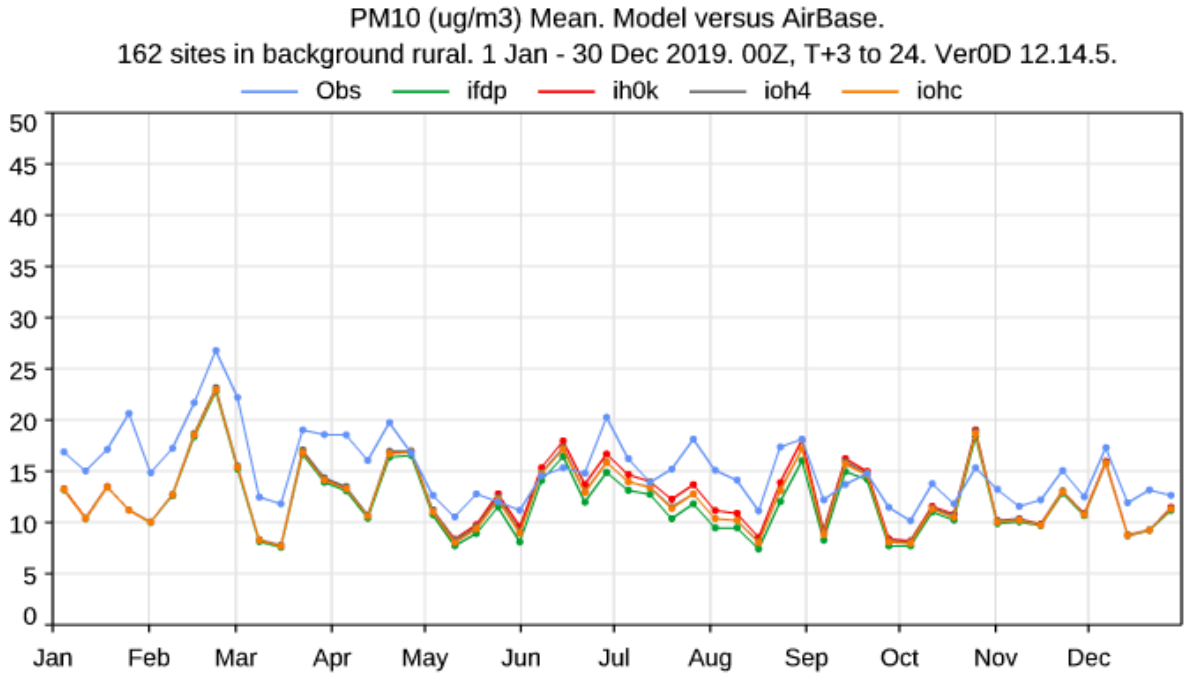


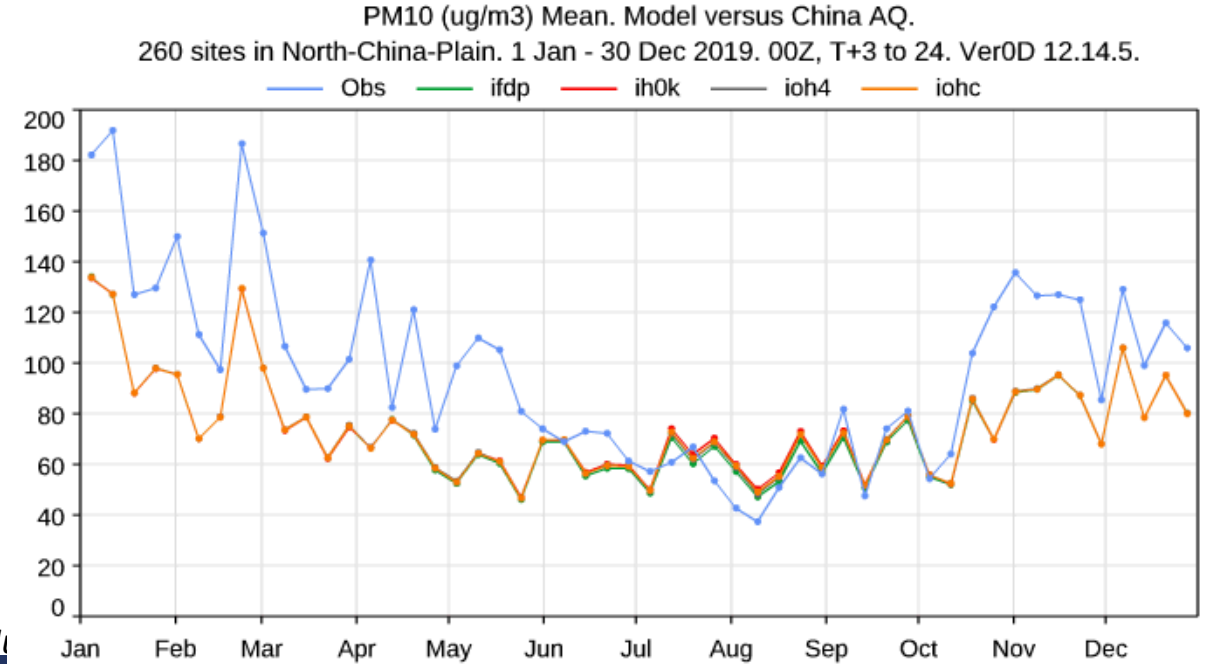
*Observed (**circles – June 2006**) and simulated (June 2019) mean fungal spores emissions*

Impact on simulated PM10

- Comparison of weekly observed and simulated PM10



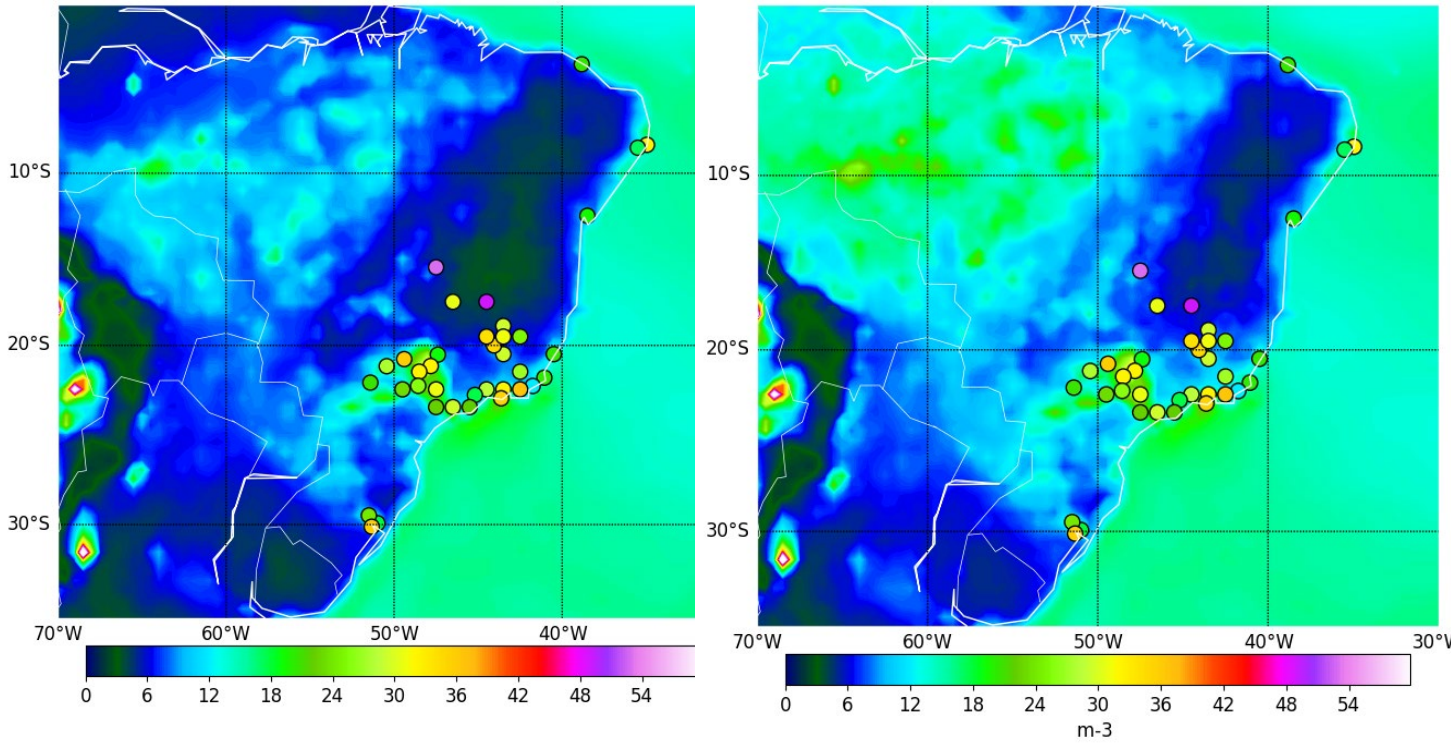




*Observed (**blue**) and simulated (**green=no fungal spores**, **red=HS09**, **orange=H15**, **gray=J21**) PM10 over different regions*

Conclusions

- A first implementation of fungal spores in IFS-COMPO have been carried out, with different emission schemes, using a simplified approach.
- Direct evaluation is hard because of sparse observations – at first order, the seasonal cycle and general features of fungal spores surface concentration seem to be broadly represented.
- The impact on simulated PM10 is generally positive in summertime



2017 mean observed (circles) and simulated PM10; left, without fungal spores, right, with fungal spores (HS2019 emissions)