Smoke in the Southern Hemisphere

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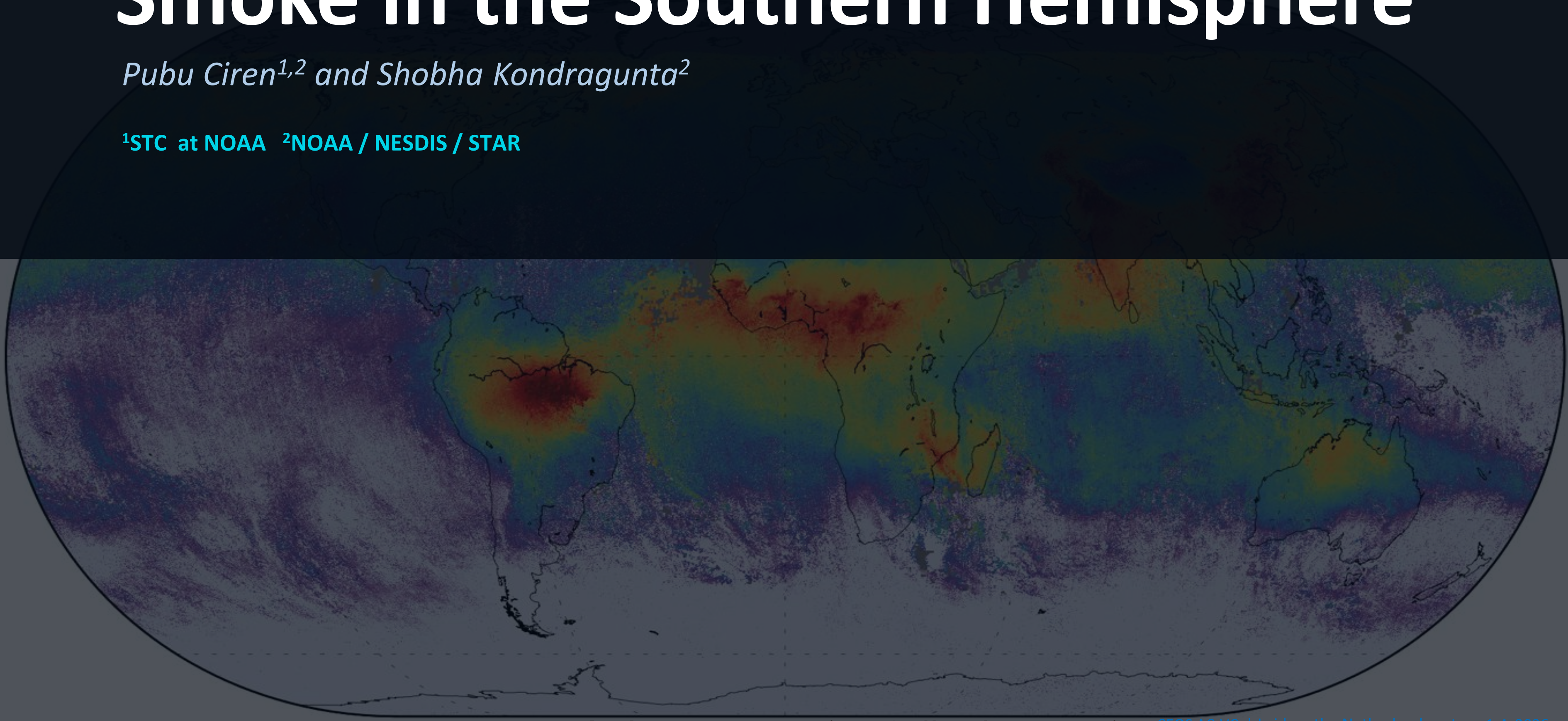


S5P/TROPOMI CO total column mixing ratio (Borsdorff et al., GRL 2018)

Smoke Statistics in the SH

~3M km²

Annual Burned Area
(Sub-Saharan Africa)

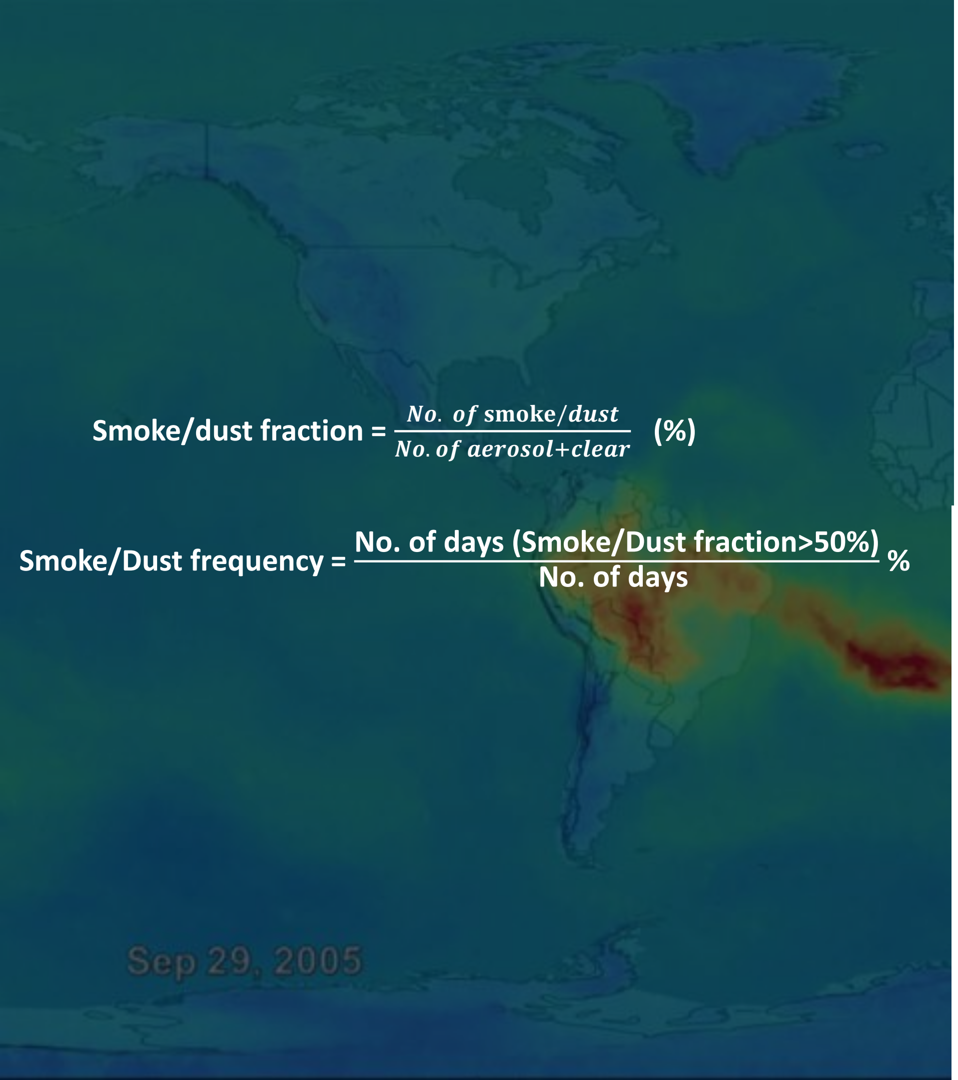
>70%

Global Biomass
Burning Emissions

6–8 days

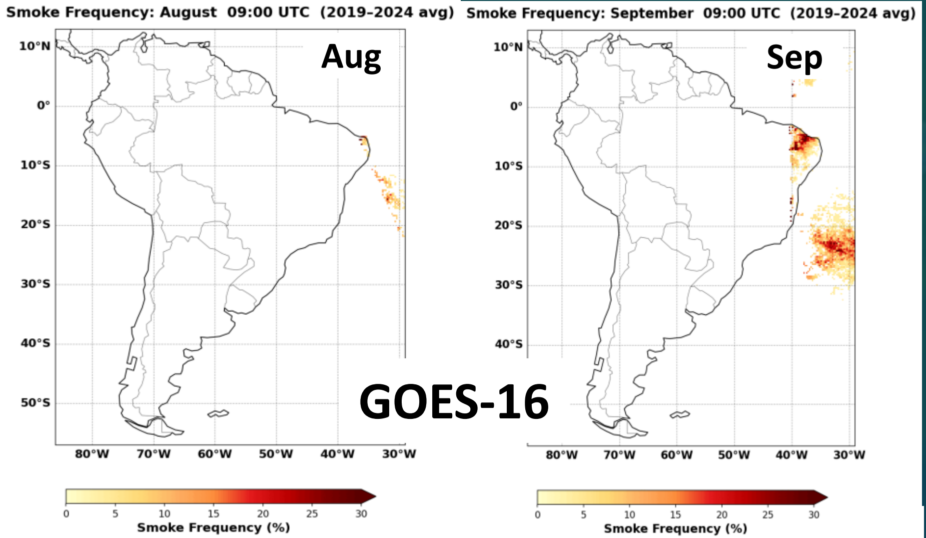
Mean Aerosol
Lifetime (smoke)

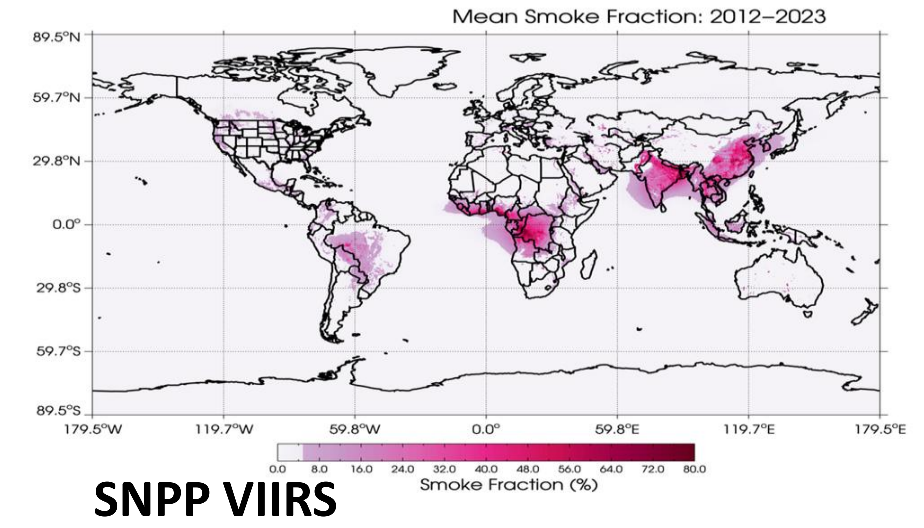
- **Scale of the source**
  - Southern hemisphere fires (Africa, South America, Australia) are the dominant global source of pyrogenic aerosols.
- **Climate and air quality**
  - Smoke plumes influence regional climate, air quality, and the radiation budget over the South Atlantic and Indian Oceans.
- **Algorithm challenge**
  - SH smoke frequently co-occurs with Saharan/Sahel dust outflow over the Atlantic
  - Accurate smoke characterization requires discrimination from co-located dust and cloud.
- **Data Gaps**
  - While fires, emissions, and smoke are monitored diurnally with GEO Imagers, atmospheric composition observations from satellites are only once a day with LEO sensors.



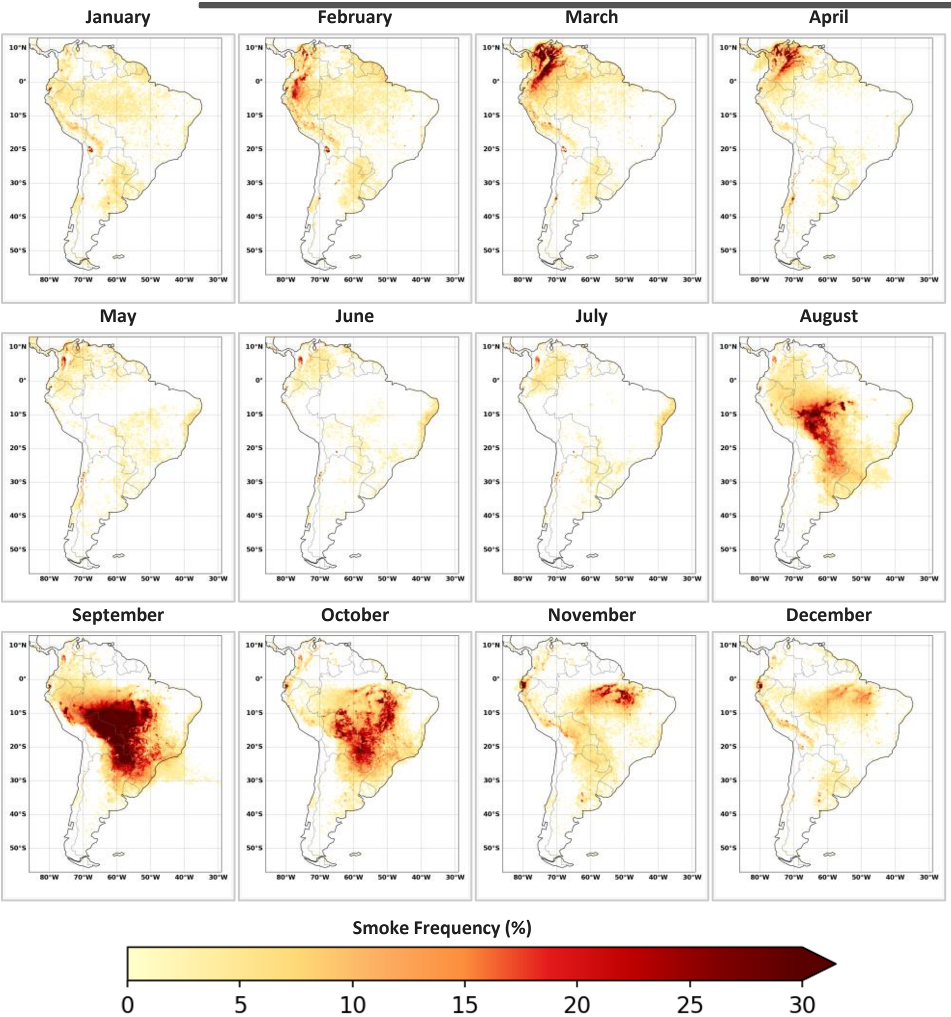
$$\text{Smoke/dust fraction} = \frac{No.\ of\ smoke/dust}{No.\ of\ aerosol+clear}\ (\%)$$

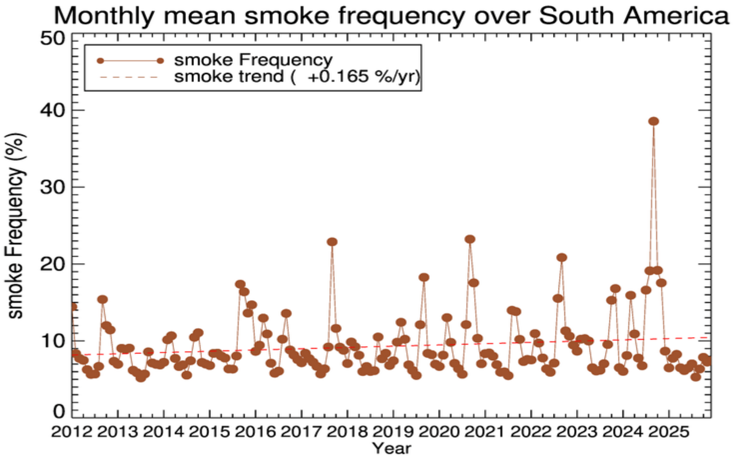
$$\text{Smoke/Dust frequency} = \frac{\text{No. of days (Smoke/Dust fraction>50\%)}}{\text{No. of days}}\ \%$$





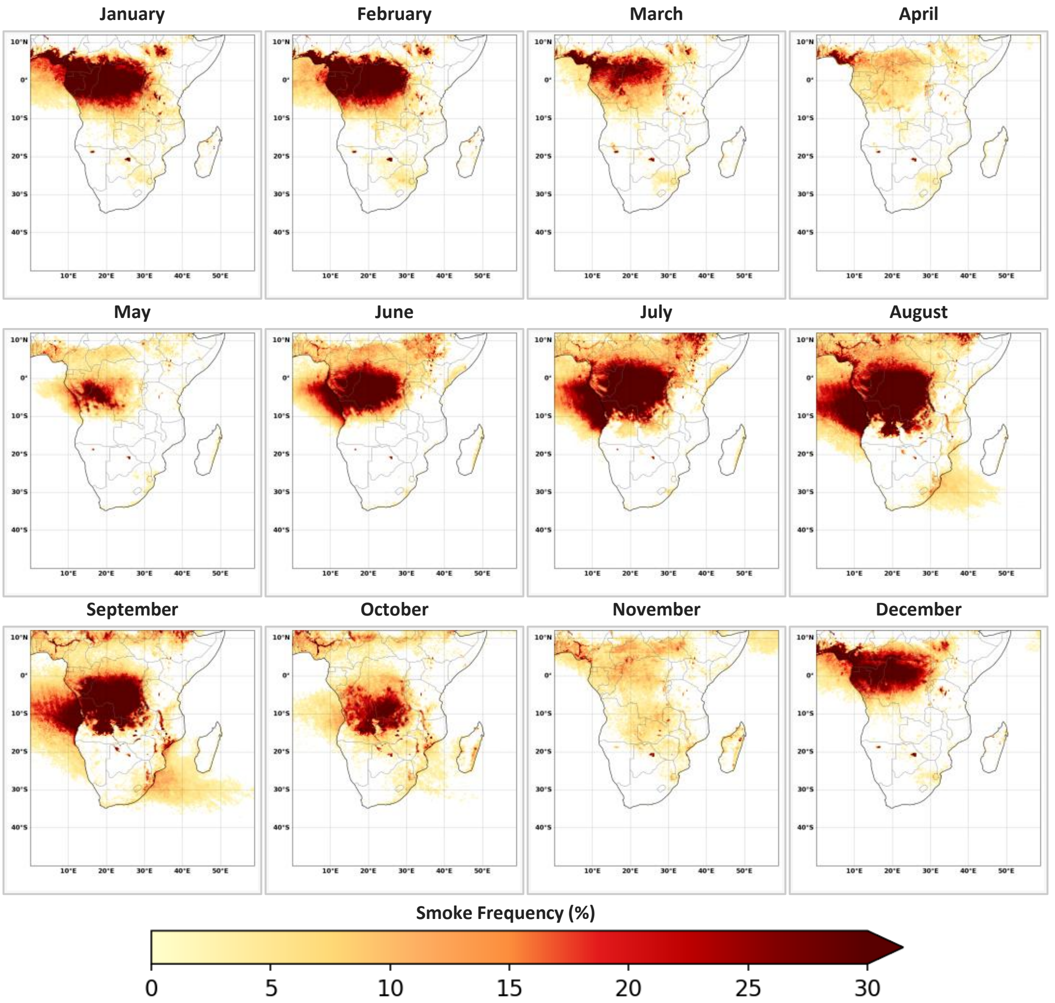
Suomi NPP VIIRS— Smoke Frequency Monthly Climatology (2012–2025): South America

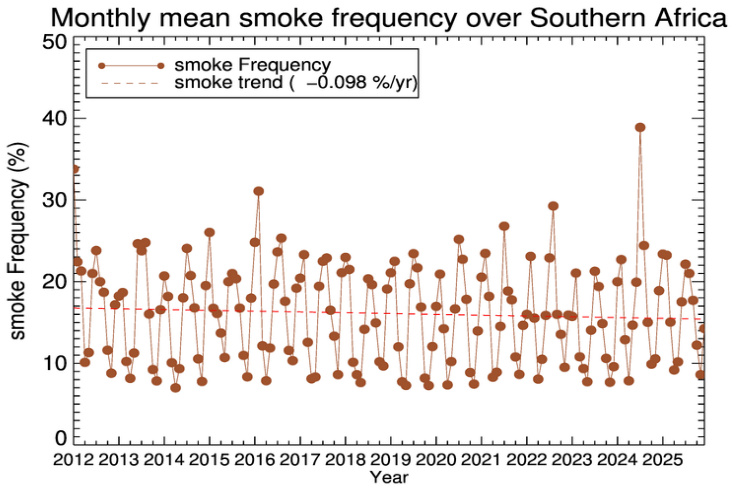




- **Aug–Oct peak season**: smoke frequency >25% over Amazon, driven by Southern Hemisphere dry-season fires
- **Significant upward trend (+0.165 %/yr, 2012–2025)**: intensifying fire activity linked to deforestation and ENSO-driven drought
- **2024 record fire season**: largest monthly smoke frequency in the 2012–2025 record, exceeding all previous years including the 2019–2020 Amazon fires.

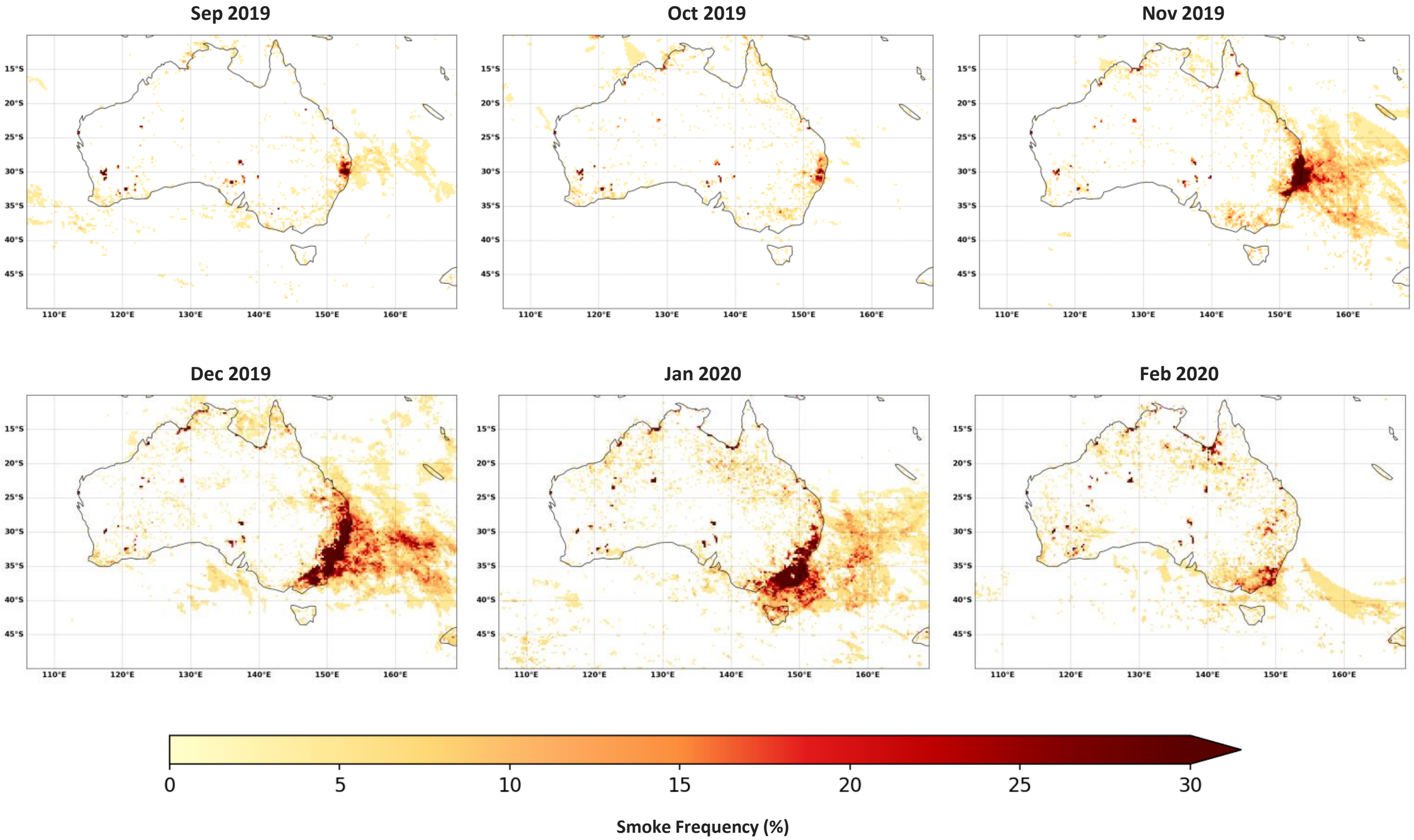
Suomi NPP VIIRS— Smoke Frequency Monthly Climatology (2012–2025): Southern Africa





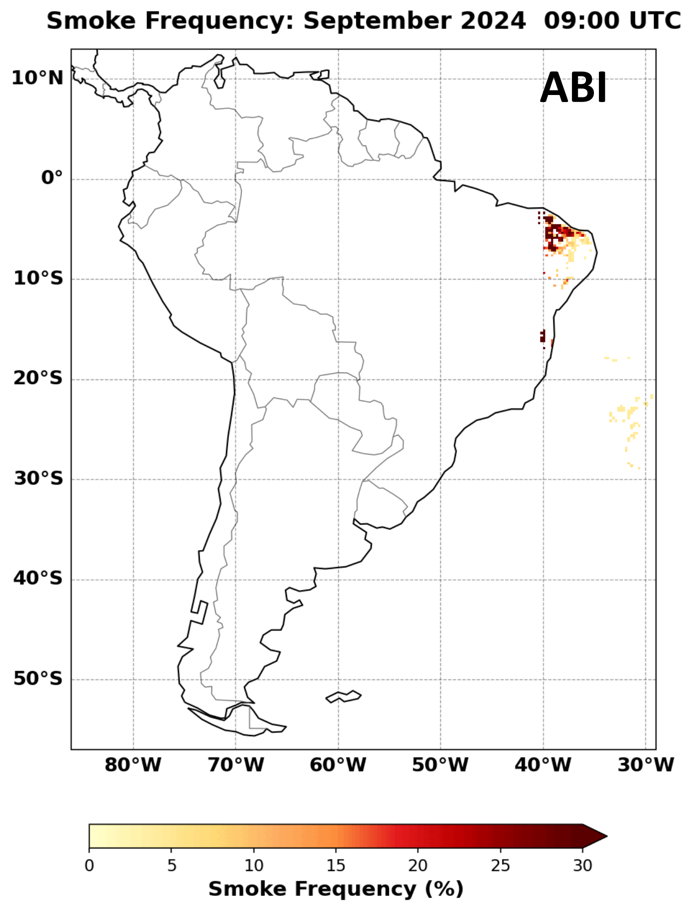
- **Seasonal southward shift**: fire activity progresses from Congo/Angola basin (Jun–Aug) southward into Zambia, Zimbabwe, and Mozambique (Sep–Nov), following the retreating dry season
- **Jun–Oct peak season**: smoke frequency >25–30% over central Africa, with July–August showing the most intense and spatially extensive burning
- **Slight downward trend (–0.098 %/yr, 2012–2025)**: modest decline contrasting with the increasing trend over South America, with lower interannual variability reflecting a more stable seasonal fire cycle

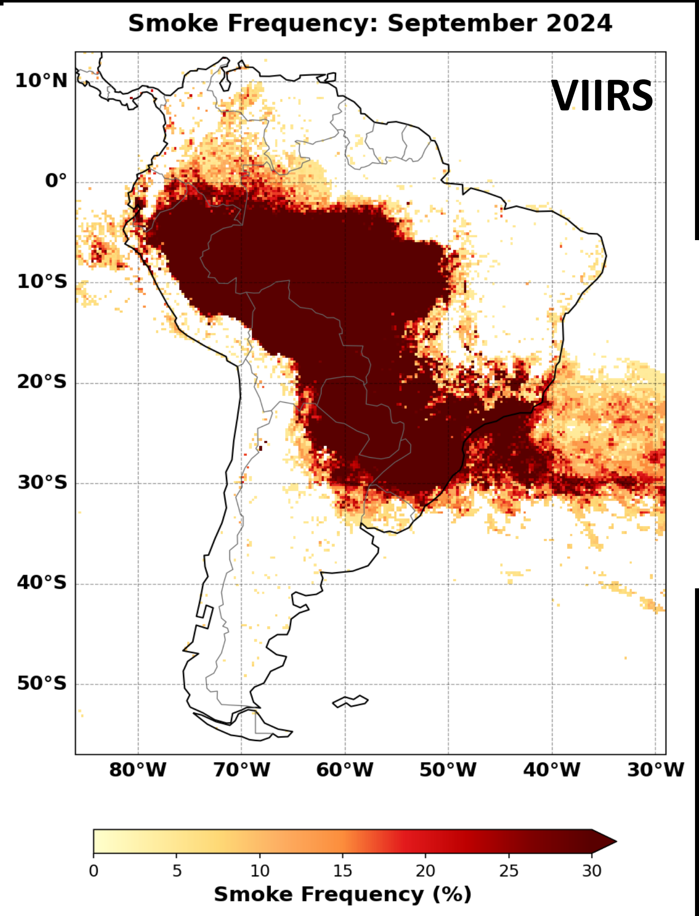
Suomi NPP VIIRS— 2019–2020 Australian Bushfire Season: Monthly Smoke Frequency

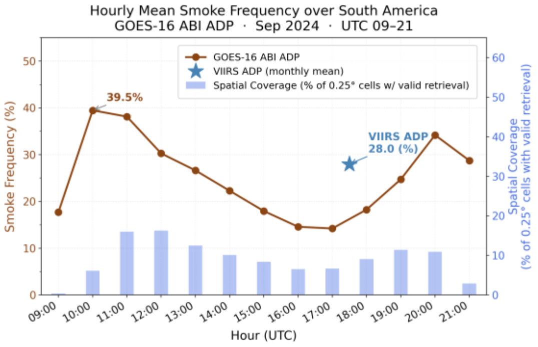


Black Summer 2019–2020: peak Dec–Jan smoke frequency >30% across southeastern Australia — unprecedented extent and intensity in the 2012–2025 record

GEO vs LEO


Smoke Frequency: September 2024 09:00 UTC
ABI
10°N
0°
10°S
20°S
30°S
40°S
50°S
80°W 70°W 60°W 50°W 40°W 30°W
0 5 10 15 20 25 30
Smoke Frequency (%)


Smoke Frequency: September 2024
VIIRS
10°N
0°
10°S
20°S
30°S
40°S
50°S
80°W 70°W 60°W 50°W 40°W 30°W
0 5 10 15 20 25 30
Smoke Frequency (%)


Hourly Mean Smoke Frequency over South America
GOES-16 ABI ADP · Sep 2024 · UTC 09–21
GOES-16 ABI ADP
VIIRS ADP (monthly mean)
Spatial Coverage (% of 0.25° cells w/ valid retrieval)
39.5%
VIIRS ADP
28.0 (%)
Smoke Frequency (%)
Spatial Coverage
(% of 0.25° cells with valid retrieval)
Hour (UTC)
09:00 10:00 11:00 12:00 13:00 14:00 15:00 16:00 17:00 18:00 19:00 20:00 21:00

Summary

Using smoke from fires as an example, we show the significance of having geostationary satellites in the southern hemisphere. GOES imagers capture the full diurnal cycle of smoke, especially the mid morning peak intensity. To monitor pollution from natural sources as well as anthropogenic sources, we need sensors that observe trace gases, that are not only pollutants by themselves but also lead to secondary ozone and fine particle formation.