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The potential to detect wildfire-related species in the infrared

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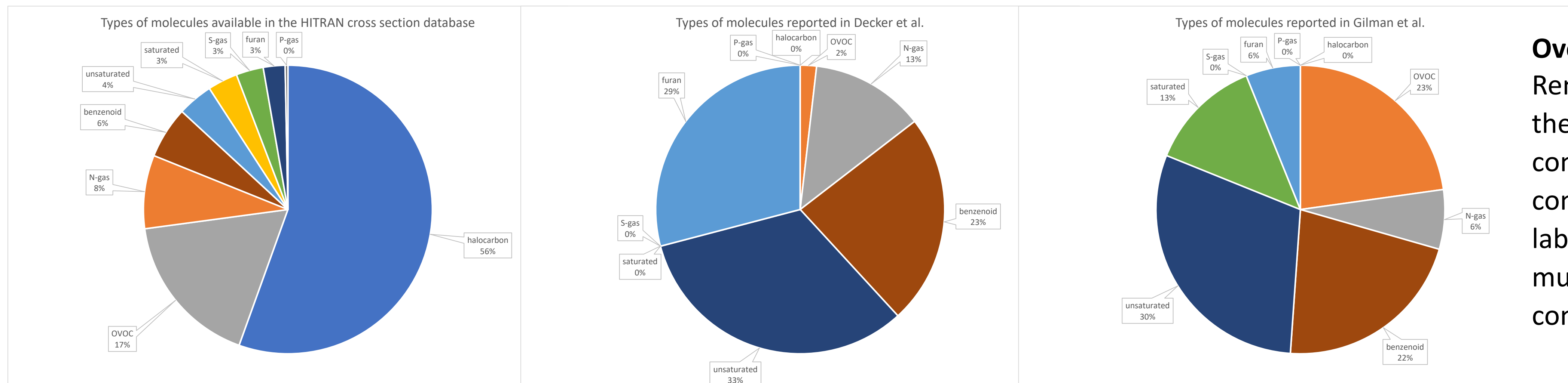


Introduction:

Wildfires are a cause for growing concern for air quality and the climate. They represent a large source of emissions of gas-phase and particulate species. As a consequence of global warming, the spatial extent, severity and duration of wildfires is likely to increase, with current indications suggesting that this may already be happening. Wildfires are a truly global phenomenon, with largescale occurrences on each continent besides Antarctica.

Wildfire plume composition:

Like all pyrolysis sources, as an emission source, wildfires are highly complex, with a large variety of primary and secondary particulates and gases. Particulates are not expected to be long-lived, and so have an important, yet mostly short-term impact on climate and air quality. Conversely the gas-phase species, which are composed of volatilized, pyrolyzed or partially oxidized molecules will exhibit a broad range of physical and chemical behaviours in the atmosphere.

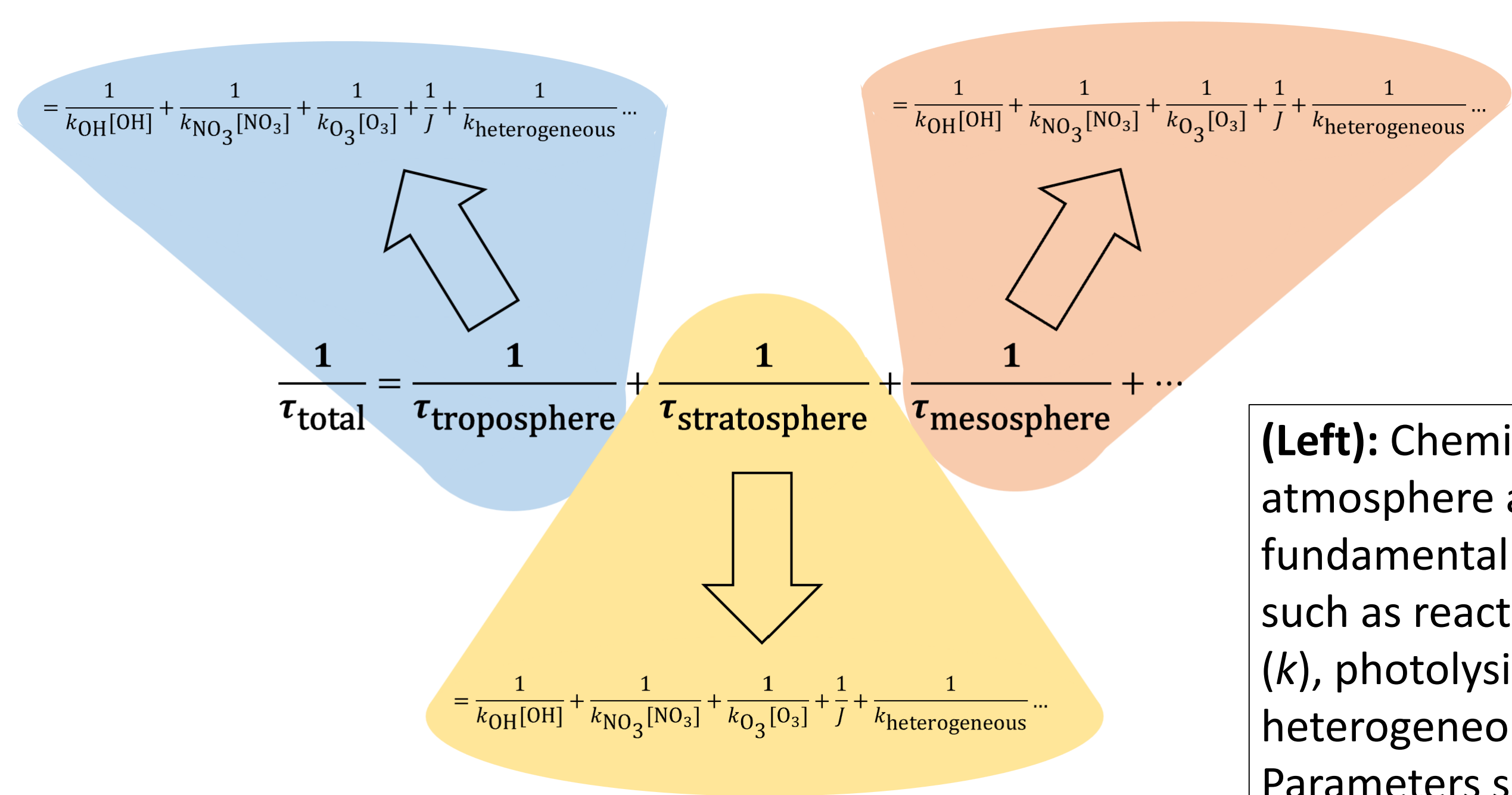


Overlap between HITRAN and wildfire measurements:

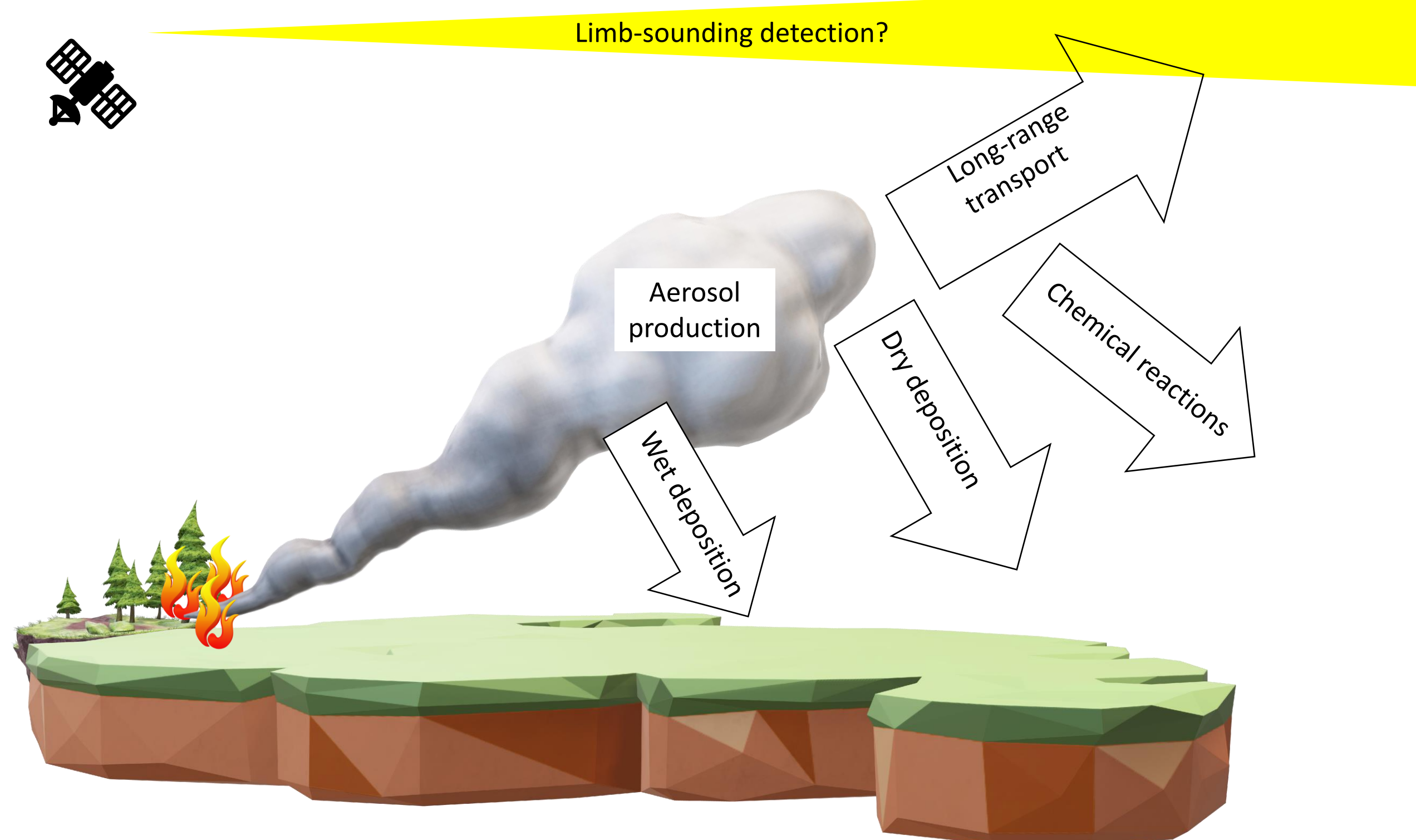
Remote sensing of wildfire components will depend upon the availability of spectroscopic data. If the current contents of the HITRAN database of cross sections is compared with measurements of wildfire plumes and fire lab experiments, major differences are observed, including much larger numbers of unsaturated, benzenoid and furan compounds in wildfire scenarios.

Lifetimes in the atmosphere:

Not all wildfire chemicals will survive transport, many of these components will be very short-lived such as furans, polyenes and other unsaturated species, which possess lifetimes of less than a day. Others could be long-lived, such as hydrogen cyanide (HCN), isocyanic acid (HNCO) and acetonitrile (CH₃CN), which can persist for several years. Some species, such as the peroxyacyl nitrates, possess short lifetimes in the boundary layer, but may become long-lived as they are lofted. The main factors that govern the persistence of these chemicals are their reaction rates with atmospheric oxidants, their photolysis rates and their wet deposition rates.

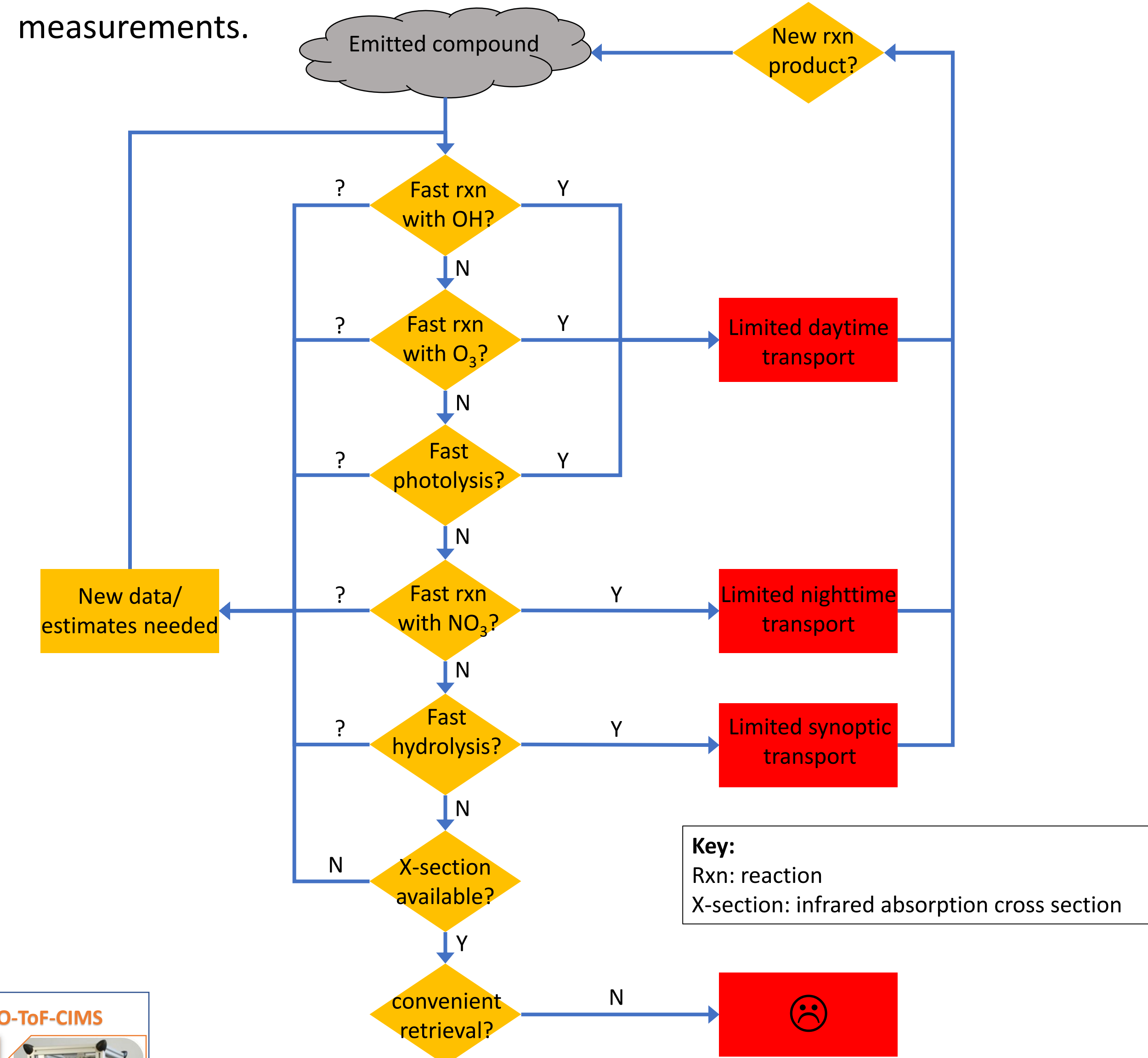


(Left): Chemical lifetimes in the atmosphere are controlled by fundamental kinetic parameters, such as reaction rate coefficients (k), photolysis rates (J) and heterogeneous deposition rates. Parameters such as these can be determined in laboratory experiments, or through estimation.



Potential screening approach and workflow for assessing candidate molecules for remote sensing:

With existing measurement databases and estimation techniques, it is possible to assess which types of chemical components are likely to survive transport and have the potential for long-term climatic effects as well as being amenable to limb-sounding detection. Such an approach would also identify which types of species are poorly understood and require new measurements.



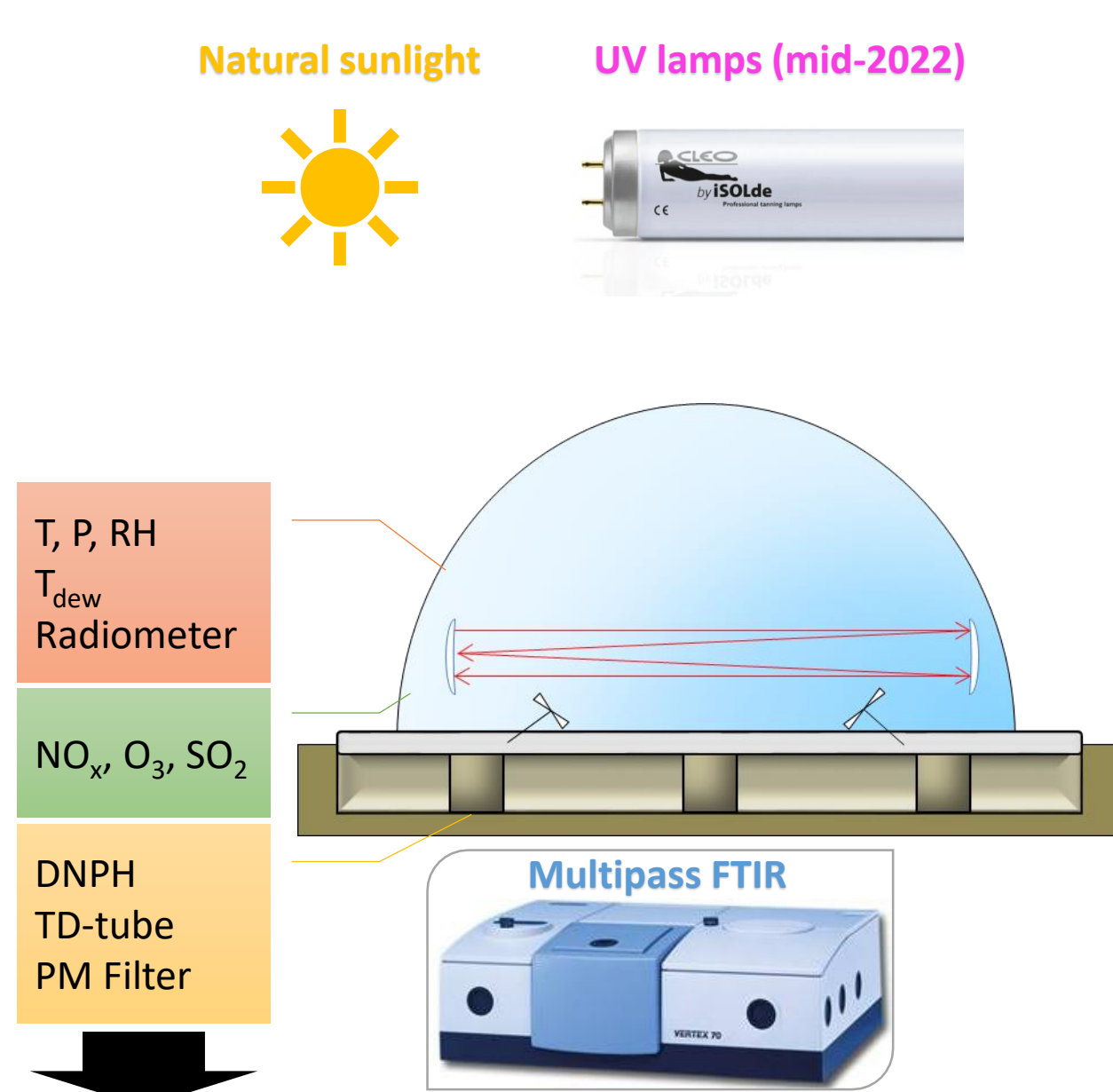
(Above): There are many possible loss processes in the atmosphere, but also 1000s of different wildfire emissions, we can therefore expect that many chemicals survive long-range transport. Chemicals containing nitrogen, sulphur and phosphorus are of particular interest since these are likely to have large impacts on the environment.

Making new measurements:

New measurements will be necessary in many cases, to improve our understanding of the long-range transport and possible transformation products of important wildfire chemical components. For this purpose, the laboratory facilities at CNRS-Orléans together with ACTRIS national platform, HELIOS, will be available to understand these processes further.

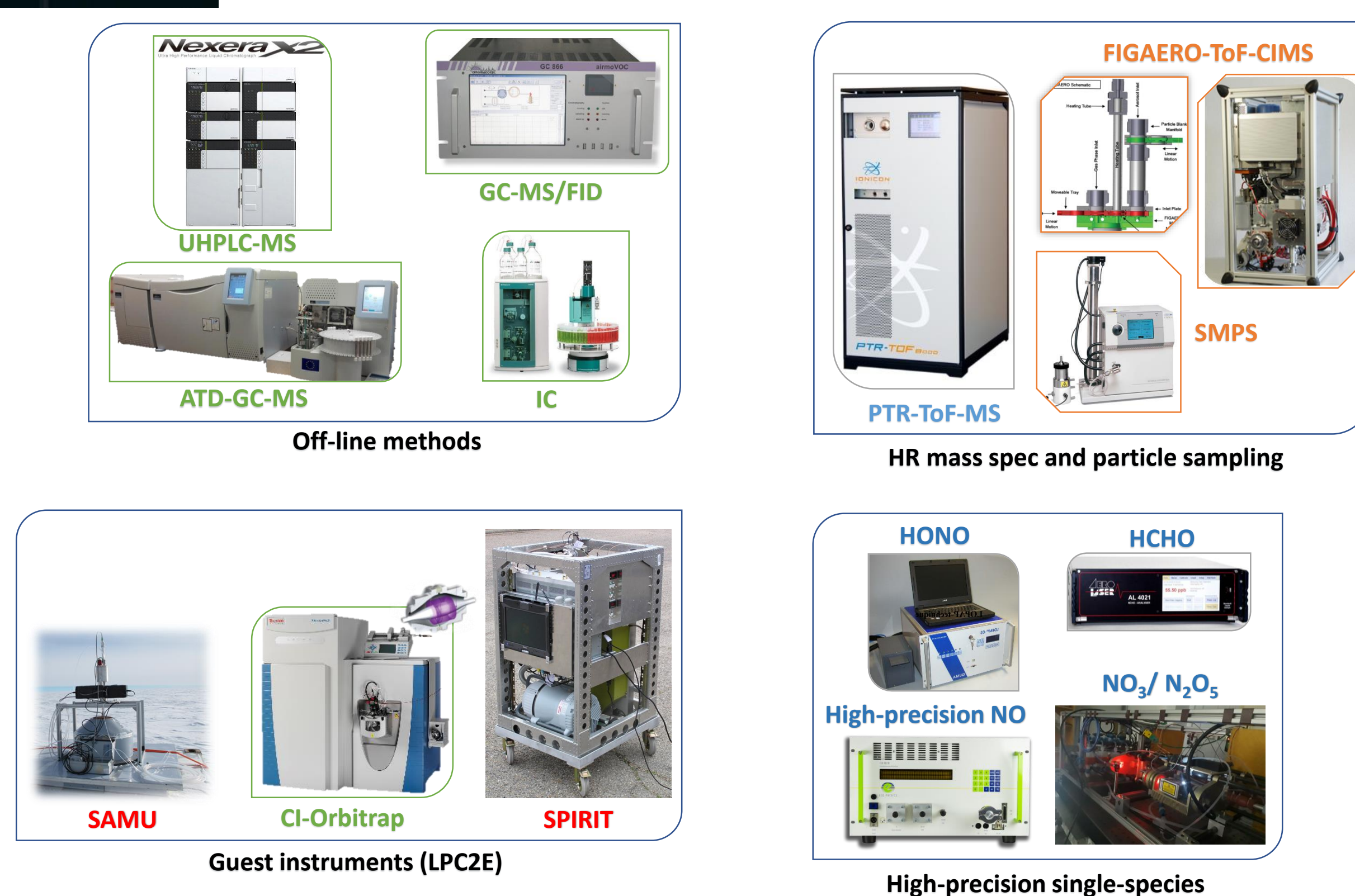


HELIOS instrumentation



HELIOS platform:

Situated in Central France, HELIOS is the largest outdoor chamber in France, and the third largest in Europe. It is equipped with a broad range of instrumentation, including many on-line and off-line mass spectrometric methods, open-path spectroscopic methods and various wet-chemical approaches. This allows us to cover much of the complex parameter-space encountered in real-world emissions such as wildfire plumes. This includes rate coefficients, reaction mechanisms and absorption cross sections.



References:

Decker et al., 2019, Environ. Sci. Technol., 53, 2529–2538
 Gilman et al., 2015, Atmos. Chem. Phys., 15, 13915–13938
 The HITRAN database:
<https://hitran.org/suppl/xsec/Table%20S2.%20Molecules.html>