SPECTROSCOPY AND ATMOSPHERE: PARALLEL ROADS?

OF COURSE NOT!

→ A LOT OF INTERSECTIONS (INTERACTIONS)

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V. Catoire, C. Robert, et al. (>20 persons during 25 years)

→ Flying IR lasers spectrometers: SPIRALE, SPIRIT, SPECIES
SPIRALE: SPectromètre InfraRouge d’Absorption à 6 diodes Lasers Embarquées under balloon for upper troposphere & stratosphere studies

Gondola characteristics

Weight = 500 kg
Height = 3.6 m (+ 3.5 m)
Horizontal width = 2.5 m

Balloon : V = 150 000 m³
diameter ~ 70 m
aerostat total length ~ 100 m

9 scientific flights (2001-2011) at different latitudes:
68°N: Kiruna (Sweden)
44°N: Aire/l'Adour or Gap (France)
5°S: Teresina (Brazil)

Built for satellite validations and ozone layer issue

Herriot cell:
300-500m optical path
6 channels measuring absorption spectra every second: 2 to 5 m vertical resolution → Each laser emits in a micro-domain (~0.5 cm⁻¹) containing absorption lines of the molecules with ultra-high spectral resolution (0.0001 cm⁻¹)
Performances of SPIRALE instrument: vertical profiles

Exemple: Aire/l'Adour (France), 2 Oct 2002 (7h15-10h45)

Dynamic effect (air mass transport)

Profiles not shown of

- CO₂
- NO
- H₂O₂
- HOCI
- COF₂

Volume mixing ratio (ppb)

O₃
descent

CH₄
ascent
68°N: Kiruna (Sweden)

Launch

Landing
5°S: Teresina (Brazil)
Multi-reflections Robert cell (optical path: 151 m)

Next generation
→ First: try in the lab!
SPIRIT: SPectromètre InfraRouge In siTu

optical bench → aircraft certified rack
100 kg
3 QCLs
pathlength: 151 m
FP7-European Project

Sampling tube for external air

SPIRIT Live Control onboard
Command-Control software for SPIRIT
19 November 2011 · SPIRIT

SPIRIT:
- CO out of convective cloud
- CO in the convective cloud
- Altitude

\[ f = \frac{[\text{CO}]_{\text{UT}_{\text{CONV}}} - [\text{CO}]_{\text{UT}}}{[\text{CO}]_{\text{surface}} - [\text{CO}]_{\text{UT}}} \]

⇒ ~30% of upper tropospheric air comes from polluted surface

South China Sea
Borneo Island

CO volume mixing ratio (ppb)

>100 ppbv

96
93
90
87
84
81
78
75
72
69
66
63
07/07/16: Tanker/Oil Refinery and Biomass Burning emissions in West Africa
Next Generation → under development: SPECIES: SPEClromètre Infrarouge à lasErs in Situ

→ Principle & mechanical design

- Modular design: 3 to 4 racks (19") : resonant optical cavities
- Each module can measure 1 to 2 gaseous species every 2 seconds

OF-CEAS

Ultra-high resolution: 0.005 cm\(^{-1}\) → 104 resonant modes: 0.52 cm\(^{-1}\)

Ring-Down: 17µs → 10km optical pathlength
AIRCRAFT RACK + Cooling for balloon

SPECIES: SPECtromètre Infrarouge à lasErs in Situ

Aircraft & Balloon Measurements from surface to upper stratosphere

SPECIES BALLON

### Table

<table>
<thead>
<tr>
<th>Species</th>
<th>Wavelength (µm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CH₄, CO</td>
<td>2.325</td>
</tr>
<tr>
<td>CH₄, HCHO</td>
<td>3.418</td>
</tr>
<tr>
<td>NO, CO₂</td>
<td>5.262</td>
</tr>
<tr>
<td>N₂O, ^13^CO₂</td>
<td>2.863</td>
</tr>
</tbody>
</table>
ANTICIPATING: can a molecule we are interested in be detected, from the surface (boundary layer) to the upper stratosphere? → Using the home-made software ‘Base2020.exe’, with the database HITRAN2020 and a standard atmosphere (1976: less polluted than now)

Unzip the folder « base_2020_executable_specatmos »
Click on the directory "programme" and then on "base2020.exe" , click to continue
Choose the icones on the left "HITRAN2020", "raies moléculaires" : "toutes" or a particular molecule and the "Interval spectral"
Click on the icone "recherche" in the upper left, then choose in the left "altitude", "chemin optique", "pression de mesure"
Click on "spectres" (jour or nuit) in the upper part, then on "zoom" in the lower left part and a new window appears on which you can use your mouse to click right or left

\[ c = \lambda \nu = \nu / \tilde{\nu} \]
\[ \text{wavenumber } \sigma = \tilde{\nu} \]
\[ \nu = c \tilde{\nu} \]