

A taste of atmospheric chemistry in ORCHIDEE:

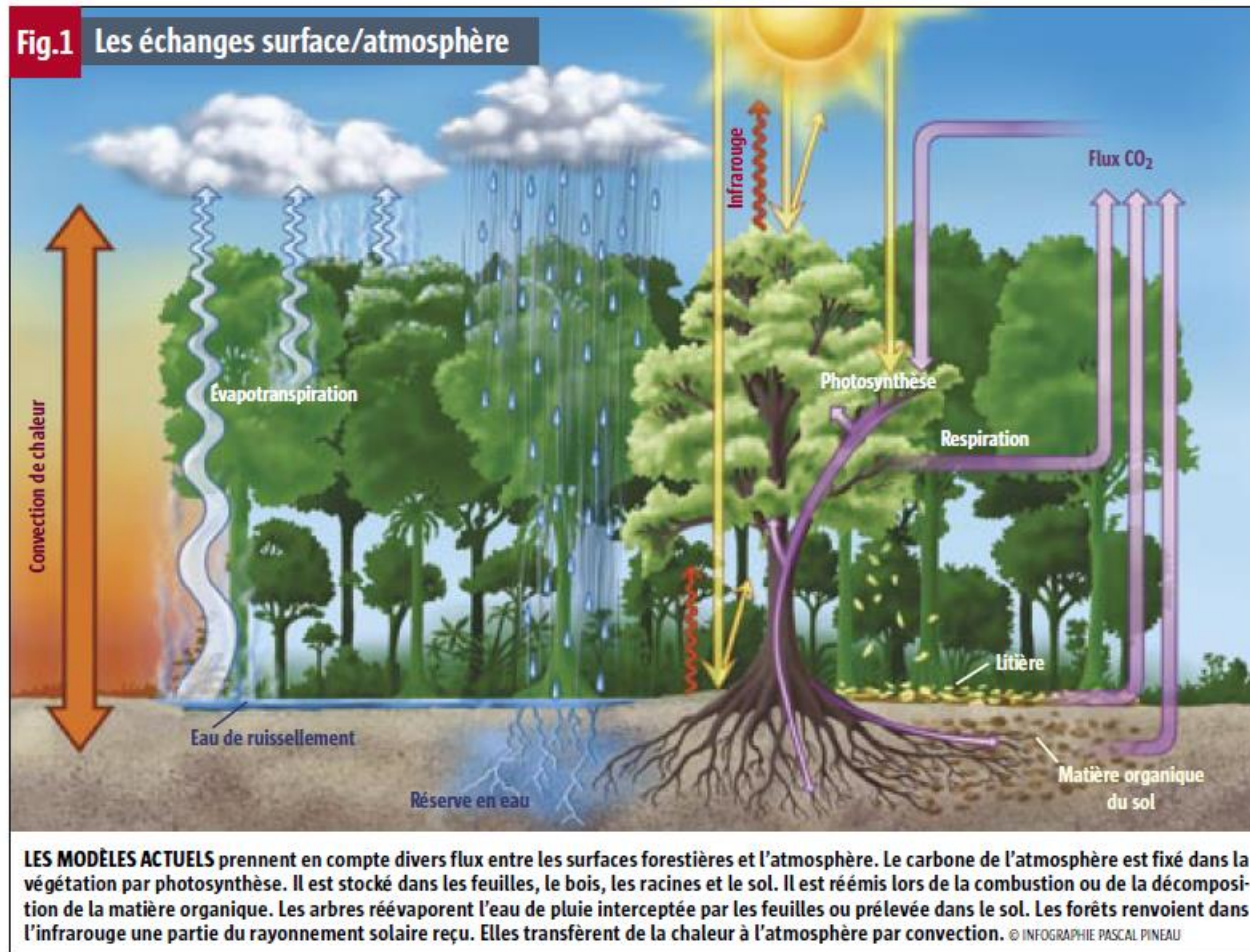
Importance of the terrestrial biosphere for surface-atmosphere chemical interactions.

Juliette Lathière and coworkers.

juliette.lathiere@lsce.ipsl.fr - CNRS Researcher LSCE

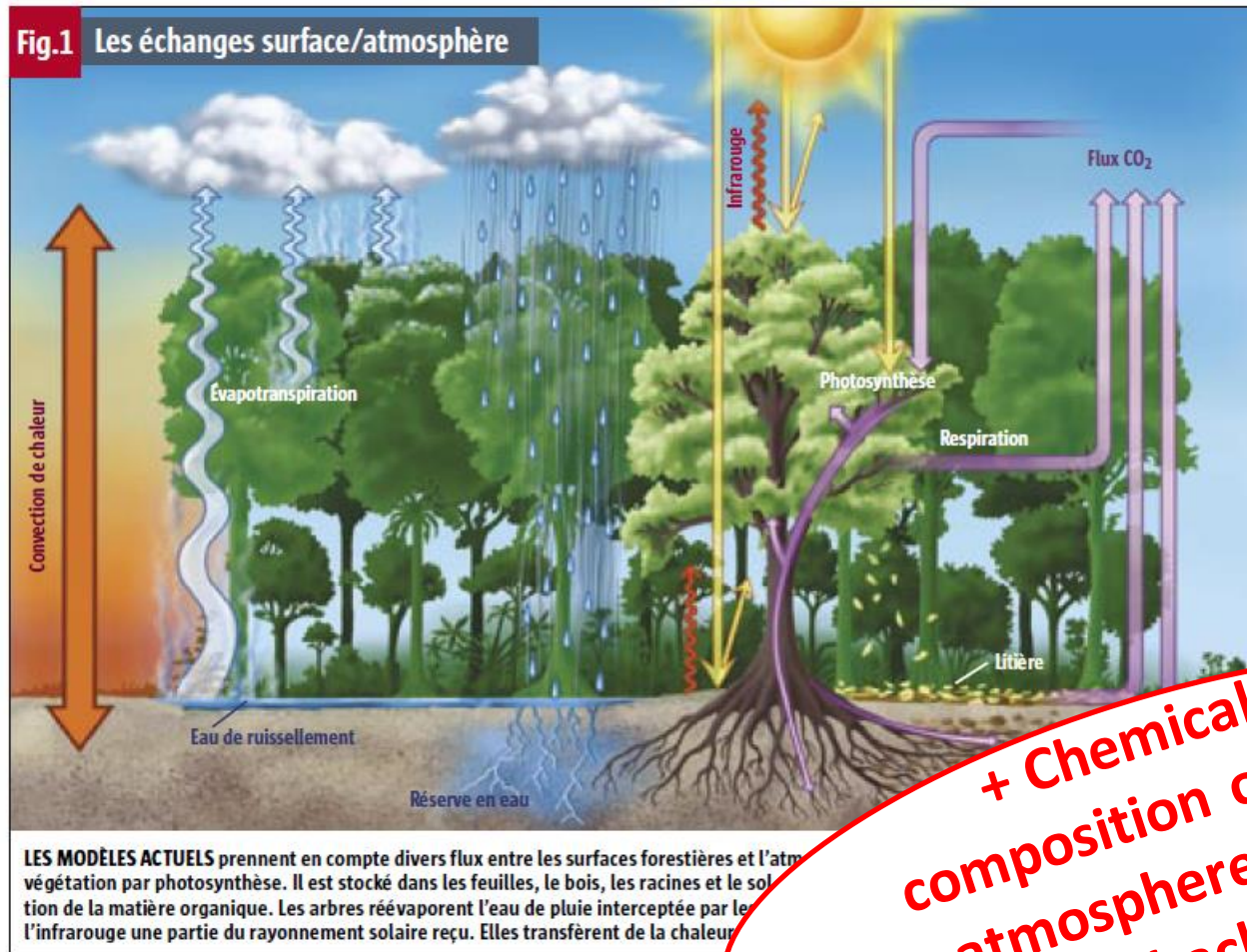


Context



- Biophysical cycles (energy transfer, surface albedo)
 - Biogeochemical cycles (water, carbon, nitrogen...)
- Importance for the ESM and climate evolution

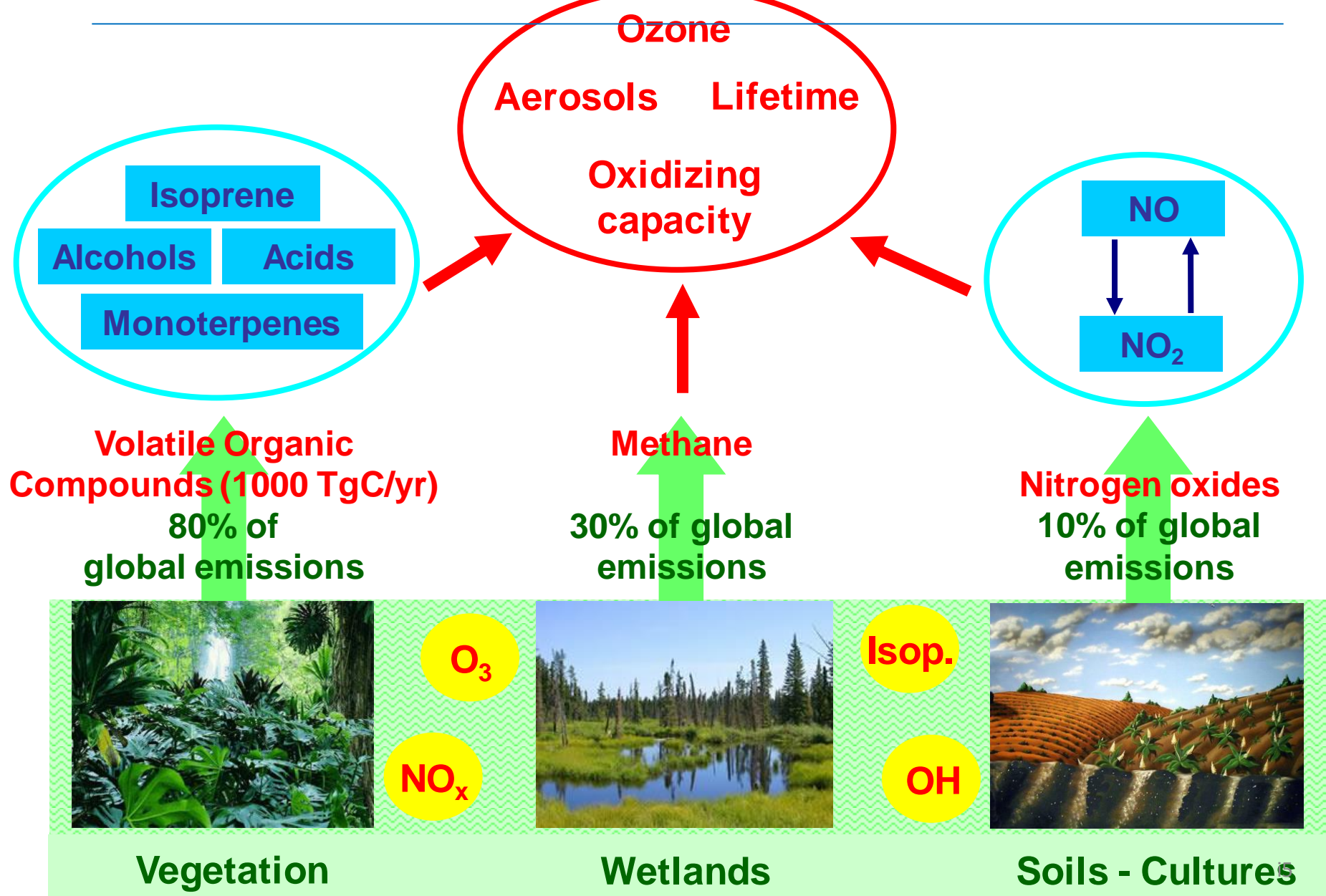
Context



- Biophysical cycles (energy transfer, surface fluxes...)
 - Biogeochemical cycles (water, carbon, nitrogen...)
- Importance for the ESM and climate evolution

+ Chemical composition of the atmosphere and feedbacks !

The terrestrial biosphere and atmospheric chemistry



Chemistry-vegetation retroactions

Atmospheric chemical composition

CO₂

Pollution: O₃, NO_x, SO₂ and particles

Deposition



Deposition



Deposition



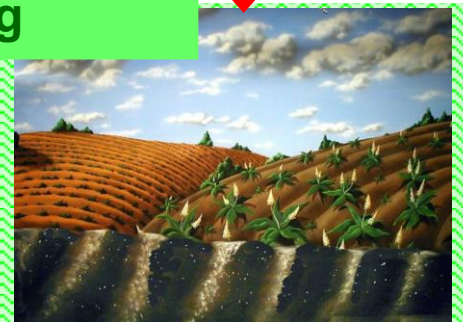
→ Growth, Distribution, Functioning



Vegetation



Wetlands



Soils - Cultures

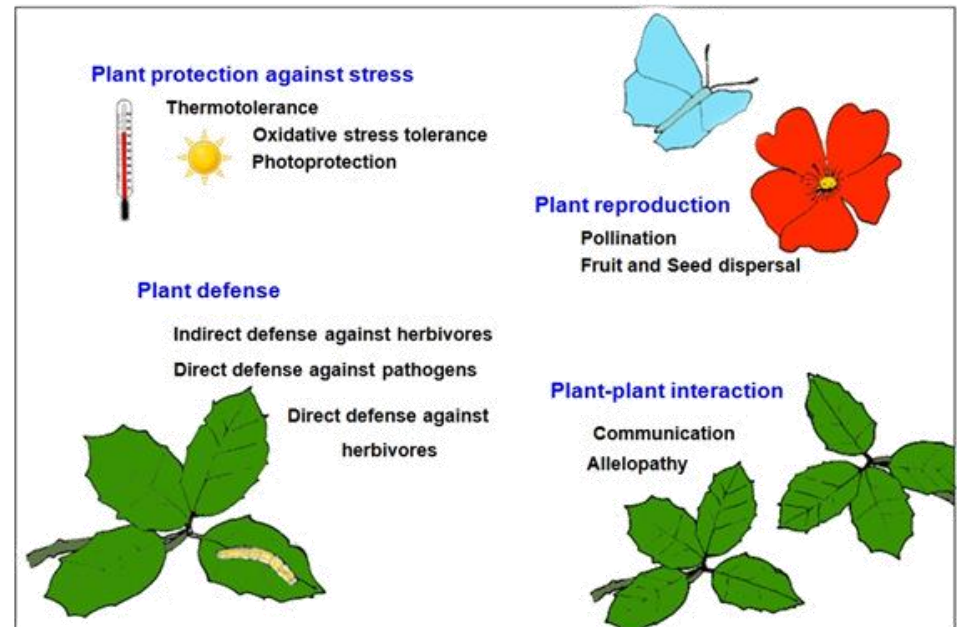
A few definitions...

➤ **Biogenic VOC (« biogénique » ou « biotique »)**: VOC emitted in the atmosphere from natural sources, marine or terrestrial. These emissions are related to soil microbial activity, volcanoes activity, natural gas leak, marine aerosols and marine and terrestrial biosphere.

Biogenic VOCs : Importance for Ecology

- **Isoprene** : 0.5% to 2% of carbon assimilated and even more when stress occurs, up to 10% when accounting for every BVOCs
 - Antioxydant
 - Antibacterial protection
 - Blossom hormon
 - Keeping herbivorous away
 - Thermotolerance:
Protecting against short high temperature episodes

BVOCs functions in plants



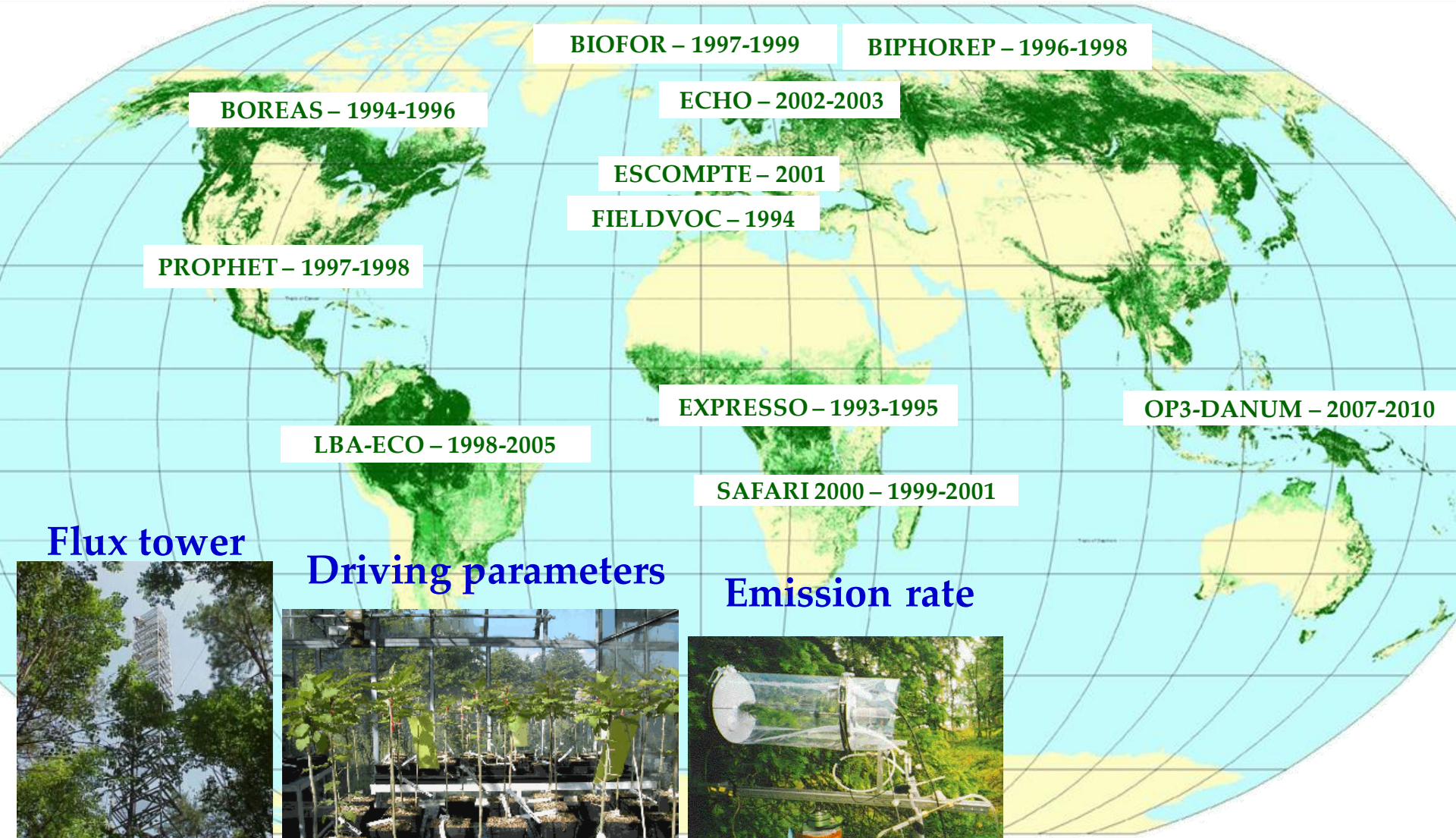
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- **Monoterpenes and other VOCs (essential oils)**
 - Keeping herbivorous away
 - Antiseptic
 - Communication between plants
 - ...

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 - Communication between plants
 - ...
- **Still many uncertainties: ecologic role, synthesis, ER, emission variation, compounds (difficulty to study and measure)...**

The terrestrial biosphere and VOCs



Flux tower



Driving parameters

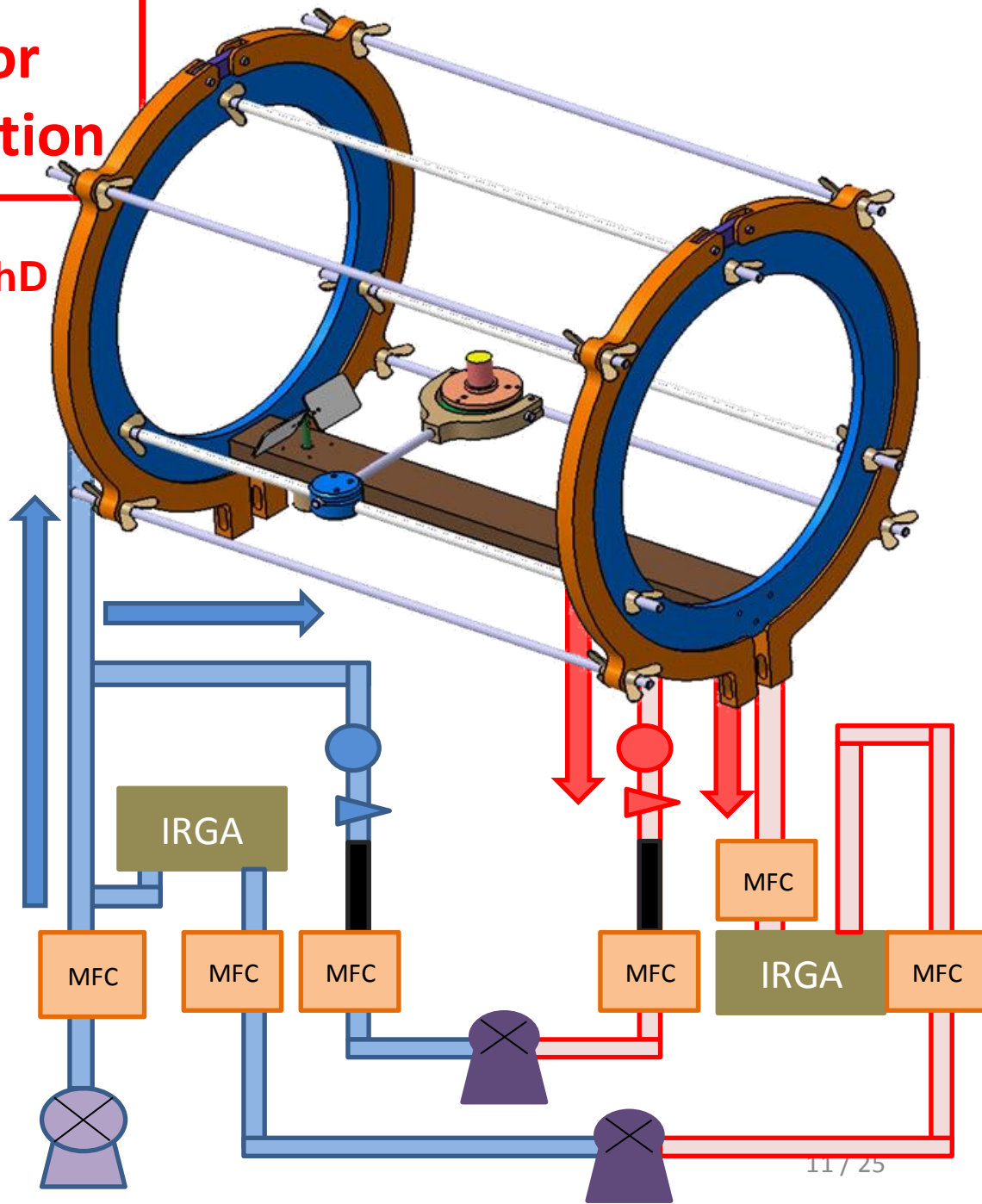


Emission rate



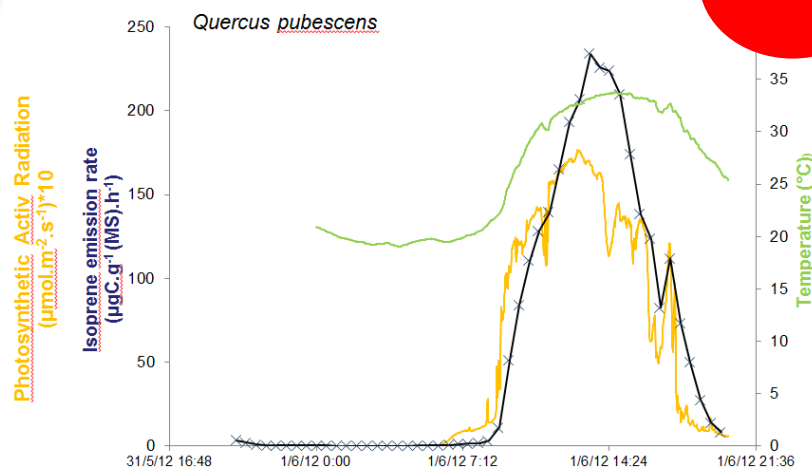
Dynamic enclosure for Emission Rate investigation

Anne Cyrielle Genard-Zielinski PhD
2014 IMBE-LSCE
Christophe Boissard, LSCE

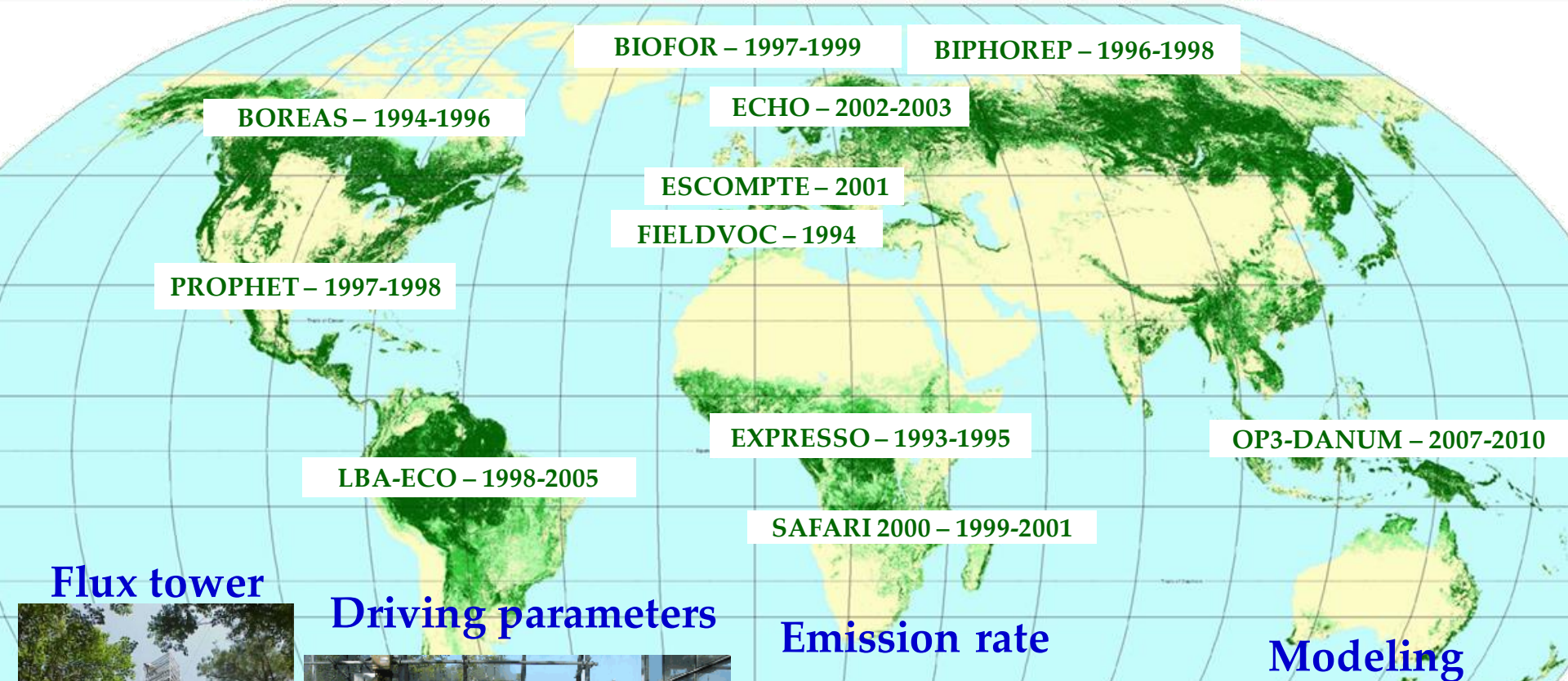


Dynamic enclosure for Emission Rate investigation

Field campaign in Haute Provence – O3HP



The terrestrial biosphere and VOCs



Flux tower



Driving parameters



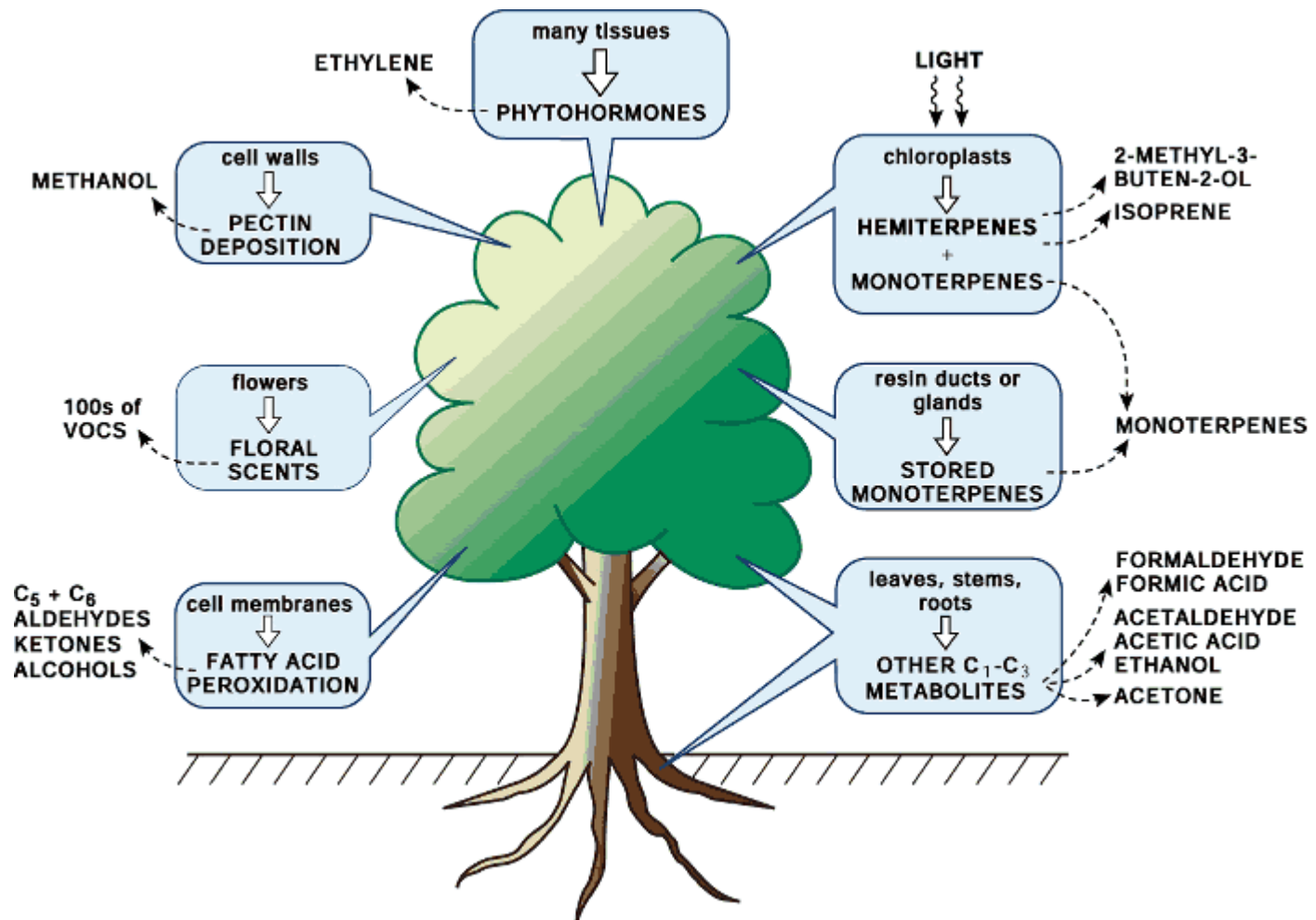
Emission rate



Modeling

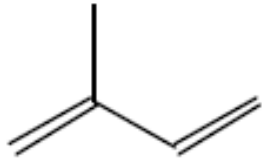


BVOC : a great diversity of compounds



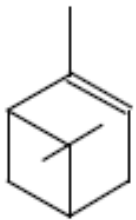
« BVOC tree »

BVOCs : molecular structure

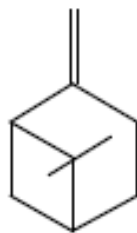


Isoprene

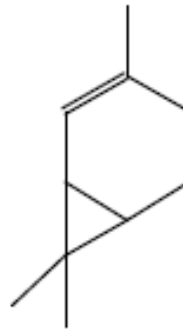
Molécule d'isoprène



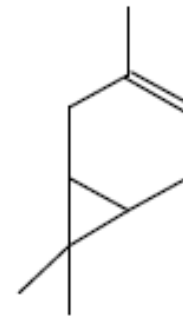
α- Pinène



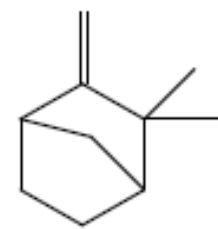
β-Pinène



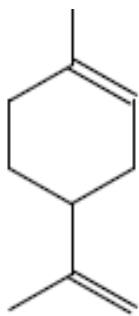
2-Carène



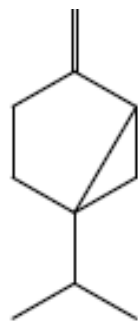
3-Carène



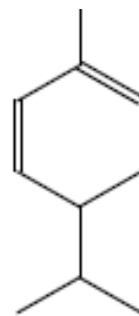
Camphène



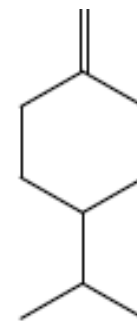
Limonène



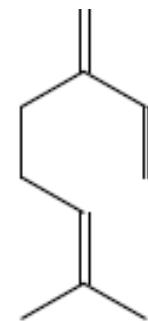
Sabinène



α-Phellandrène



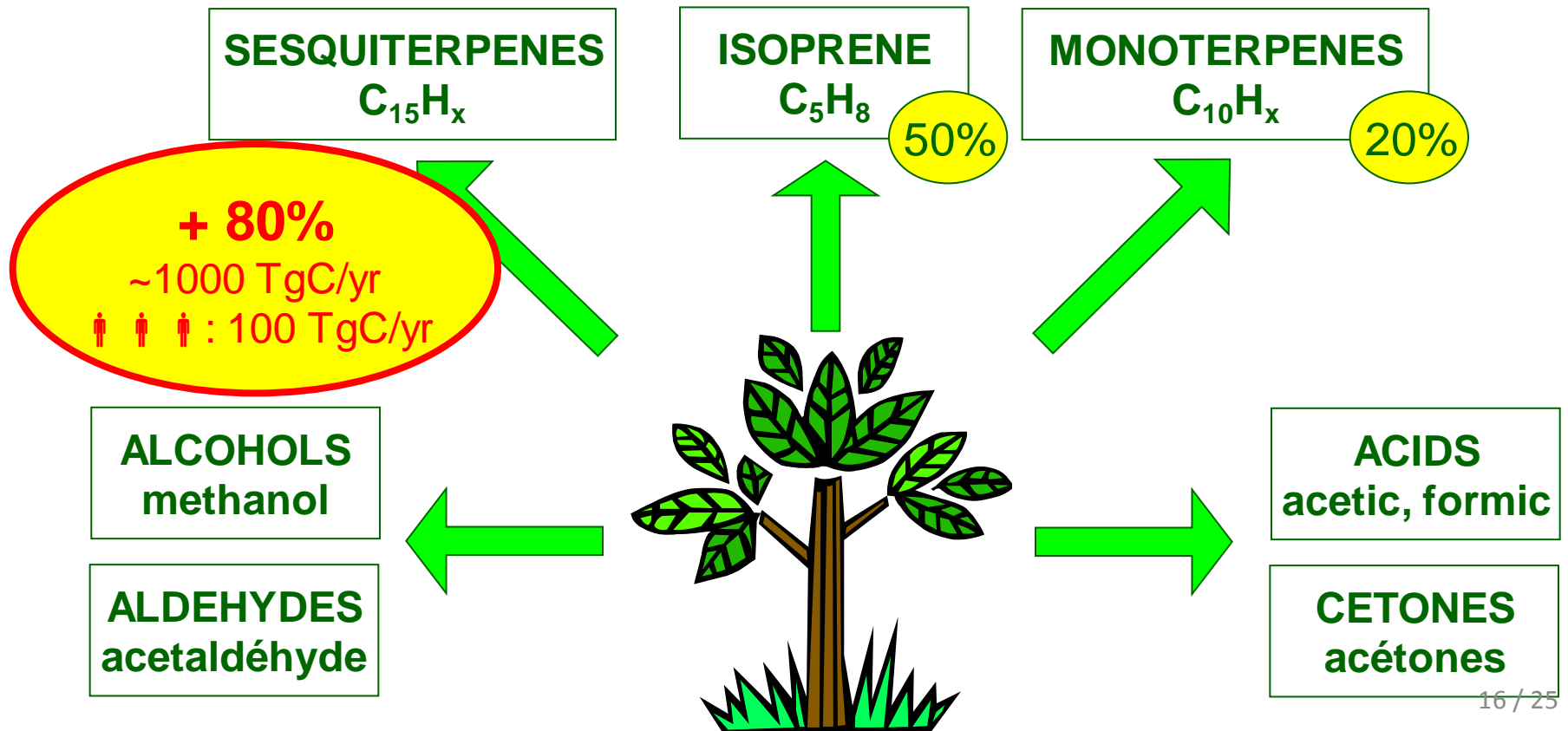
β-Phellandrène



Myrcène

Main monoterpenes emitted by vegetation

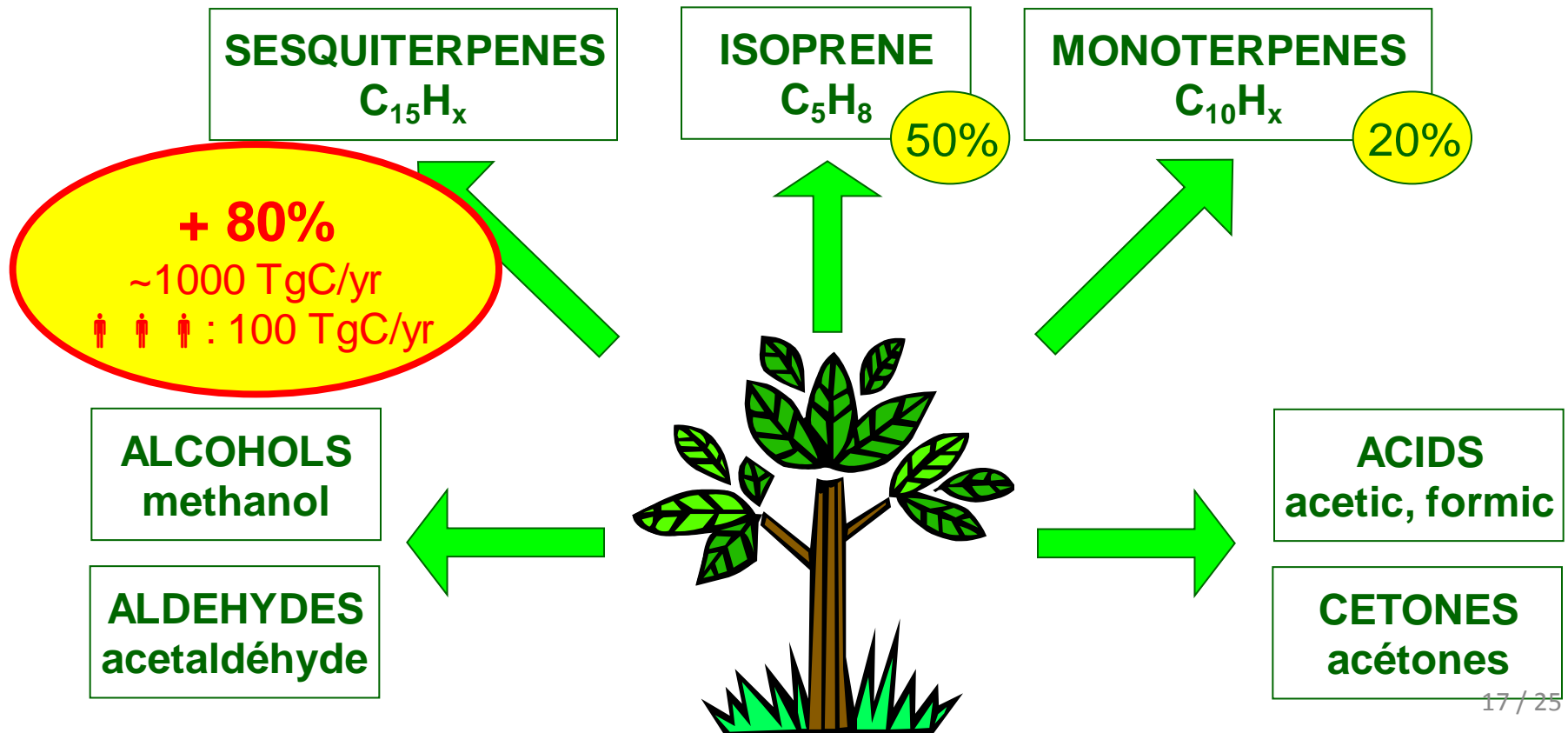
BVOC : a great diversity of compounds



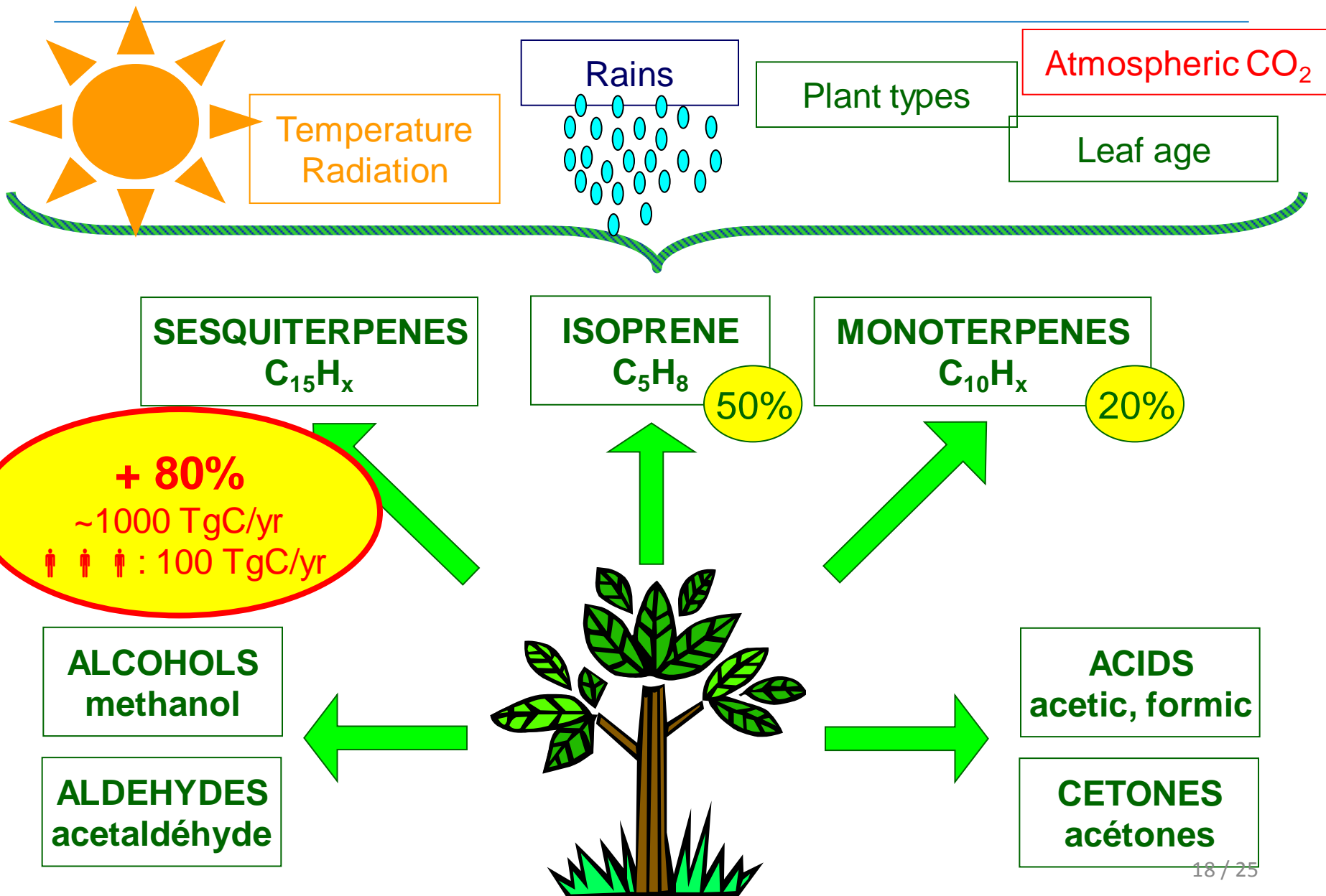
BVOC : a great diversity of compounds

- **Other natural VOC sources:** Sharks (squalene), seaweed (cholesterol), living and human beings, oceanic biosphere, etc.

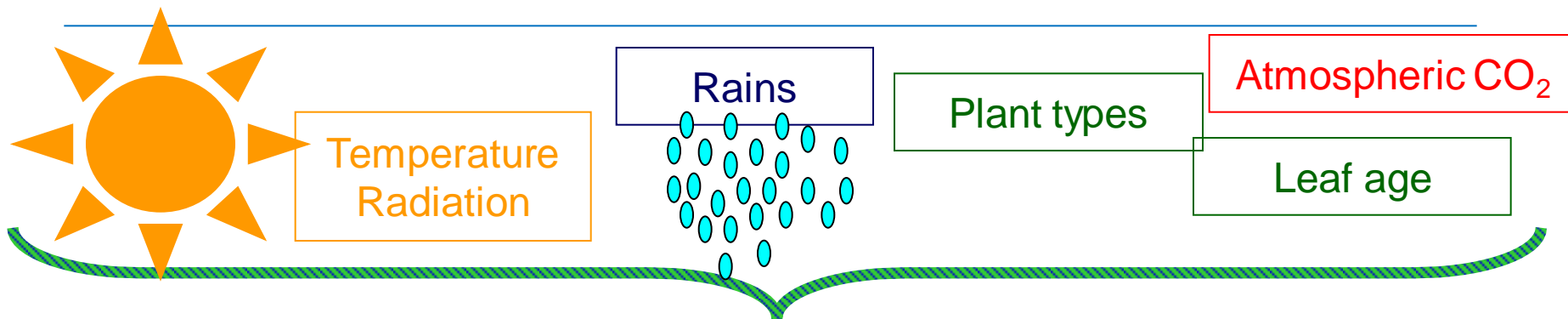
→ High diversity and emission rate typical of the terrestrial biosphere



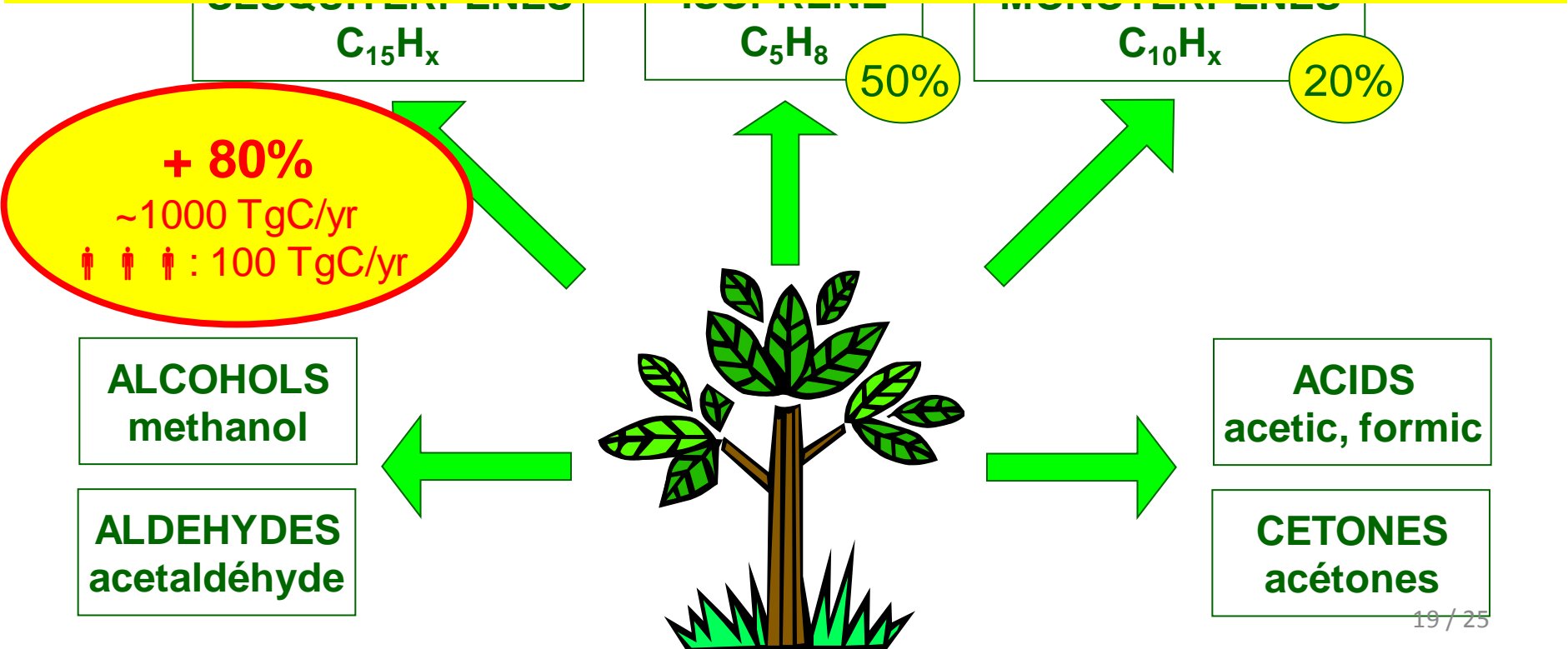
BVOC : a great diversity of compounds



BVOC : a great diversity of compounds



→ Implementation in models (regional, global; vegetation, chemistry)



Biogenic VOCs in ORCHIDEE

Estimating VOC emissions from vegetation

Atmos. Chem. Phys., 16, 14169–14202, 2016
www.atmos-chem-phys.net/16/14169/2016/
doi:10.5194/acp-16-14169-2016
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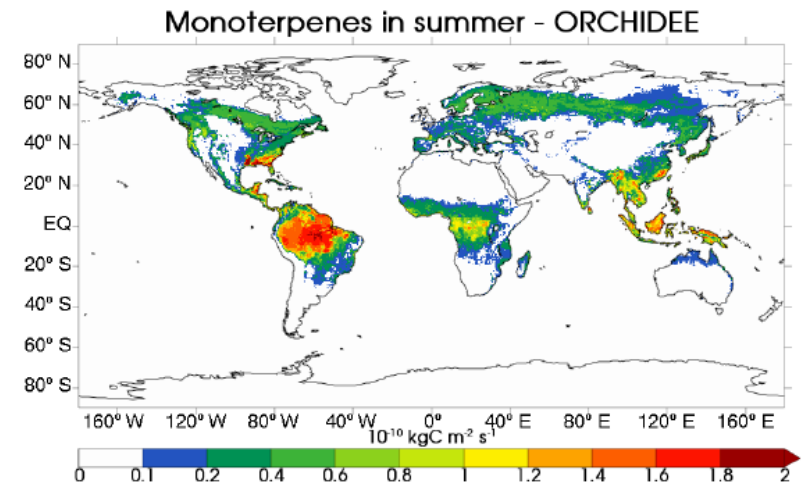
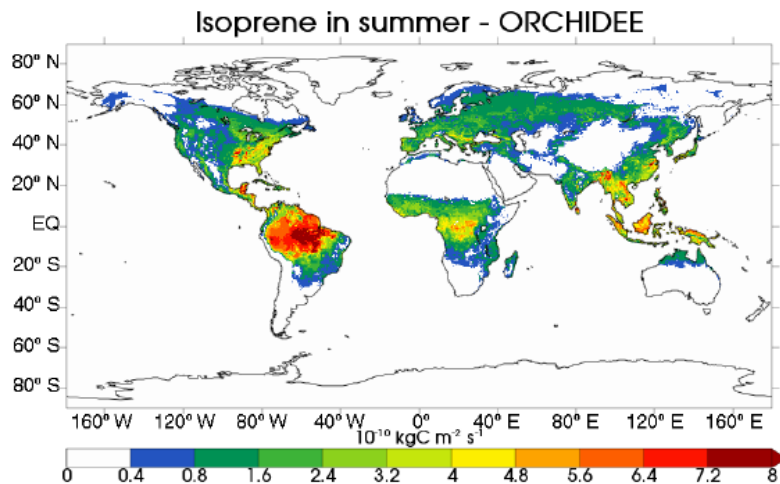
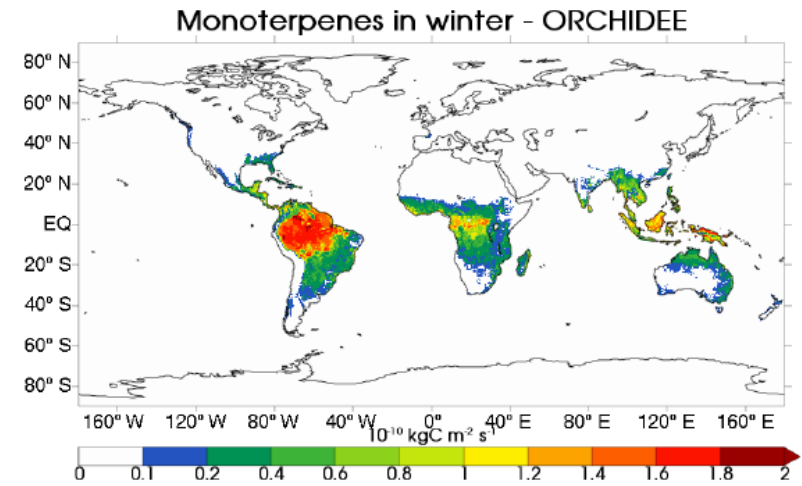
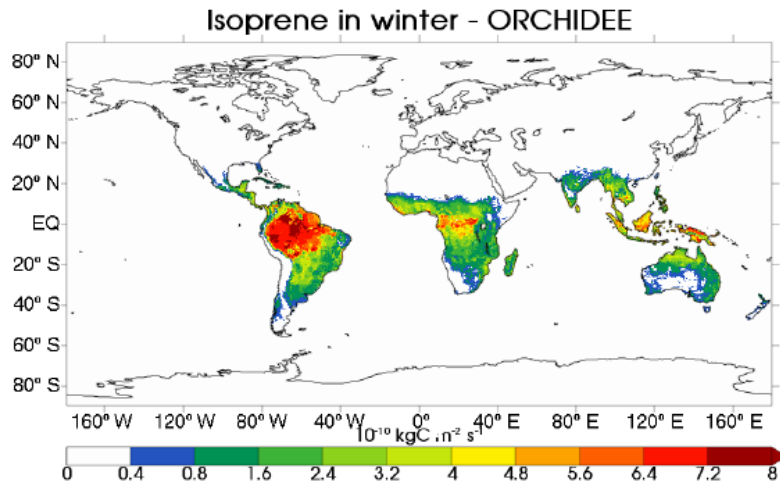
Atmospheric
Chemistry
and Physics
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Global biogenic volatile organic compound emissions in the ORCHIDEE and MEGAN models and sensitivity to key parameters

Palmira Messina¹, Juliette Lathière¹, Katerina Sindelarova^{2,3}, Nicolas Vuichard¹, Claire Granier^{2,4,5,6}, Josefine Ghattas⁷, Anne Cozic¹, and Didier A. Hauglustaine¹

$$F_{c,i}(l) = \underbrace{\text{LAI}_i(l)}_{\text{ORCHIDEE}} \cdot \text{SLW}_i \cdot \underbrace{\text{EF}_{c,i}}_{\text{Prescribed}} \cdot \text{CTL}_c(l) \cdot L_c$$

Estimating VOC emissions from vegetation



In the ORCHIDEE code – Trunk version

```
p24lath@curie70:/ccc/work/cont003/dsm/p24lath/ORCHIDEE_CODE_VERSIONS/ORCHIDEE_TRUNK_22112016/modipsl/modeles/ORCHIDEE/src_sechiba> ls -l
total 2312
-rw-r--r--. 1 p24lath dsm 5625 Nov 22 15:29 AA_make
-rw-r--r--. 1 p24lath dsm 787 Nov 22 15:29 AA_make.ldef
-rw-r--r--. 1 p24lath dsm 5817 Nov 22 15:30 Makefile
-rw-r--r--. 1 p24lath dsm 101048 Nov 22 15:19 chemistry.f90
-rw-r--r--. 1 p24lath dsm 90496 Nov 22 15:29 condveg.f90
-rw-r--r--. 1 p24lath dsm 144305 Nov 22 15:29 diffuco.f90
-rw-r--r--. 1 p24lath dsm 96275 Nov 22 15:29 enerbil.f90
-rw-r--r--. 1 p24lath dsm 72364 Nov 22 15:29 explicitSnow.f90
-rw-r--r--. 1 p24lath dsm 341731 Nov 22 15:29 hydroL.f90
-rw-r--r--. 1 p24lath dsm 202155 Nov 22 15:29 hydroLc.f90
-rw-r--r--. 1 p24lath dsm 100717 Nov 22 15:29 intersurf.f90
-rw-r--r--. 1 p24lath dsm 192963 Nov 22 15:29 ioipslctrl.f90
-rw-r--r--. 1 p24lath dsm 41759 Nov 22 15:29 qsat_moisture.f90
-rw-r--r--. 1 p24lath dsm 381337 Nov 22 15:29 routing.f90
-rw-r--r--. 1 p24lath dsm 108424 Nov 22 15:29 sechiba.f90
-rw-r--r--. 1 p24lath dsm 17340 Nov 22 15:29 sechiba_io.f90
-rwxr-xr-x. 1 p24lath dsm 19636 Nov 22 15:29 sechiba_io_p.f90
-rw-r--r--. 1 p24lath dsm 183124 Nov 22 15:29 slowproc.f90
-rw-r--r--. 1 p24lath dsm 103633 Nov 22 15:29 thermosoil.f90
-rw-r--r--. 1 p24lath dsm 107013 Nov 22 15:29 thermosoilc.f90
```

chemistry.f90

✓ **SUBROUTINE chemistry_bvoc**

In the ORCHIDEE code – Trunk version

❑ **Flags to add in run.def and activate** for BVOC emissions (and NOx):

```
CALL getin_p('CHEMISTRY_BVOC', ok_bvoc)  
WRITE(numout,*) 'Biogenic emissions: ', ok_bvoc
```

```
IF ( ok_bvoc ) THEN
```

```
  ok_leafage      = .TRUE.  
  ok_radcanopy   = .TRUE.  
  ok_multilayer  = .TRUE.  
  ok_pulse_NOx   = .TRUE.  
  ok_bbgfertil_NOx = .TRUE.  
  ok_cropsfertil_NOx = .TRUE.
```



All flags set to
FALSE by default

❑ **Forcings used to add in sechiba.card in ListNonDel** for NOx emissions:

Located in /ccc/work/cont003/dsm/p86ips1/IGCM/SRF/chemistry/:

orchidee_bbg_clim.nc: Biomass burning

orchidee_fertilizer_1995.nc: Fertilizer use

CAUTION WITH NOx RESULTS !!!!
IN DEVELOPMENT AND TESTS !

Other developments in progress in ORCHIDEE

- **Ozone Impact on vegetation:**
 - Thomas Verbeke PhD 2015 (D. Hauglustaine, N. Viovy, S. Szopa, J. Lathière), ORCHIDEE branch
- **Nitrogen cycle and Nitrogen Compounds in ORCHIDEE:**
 - Nicolas Vuichard
- **Coupling with atmospheric chemistry:**
 - 2-way exchanges between ORCHIDEE and LMDzINCA (Anne Cozic, INCA group)