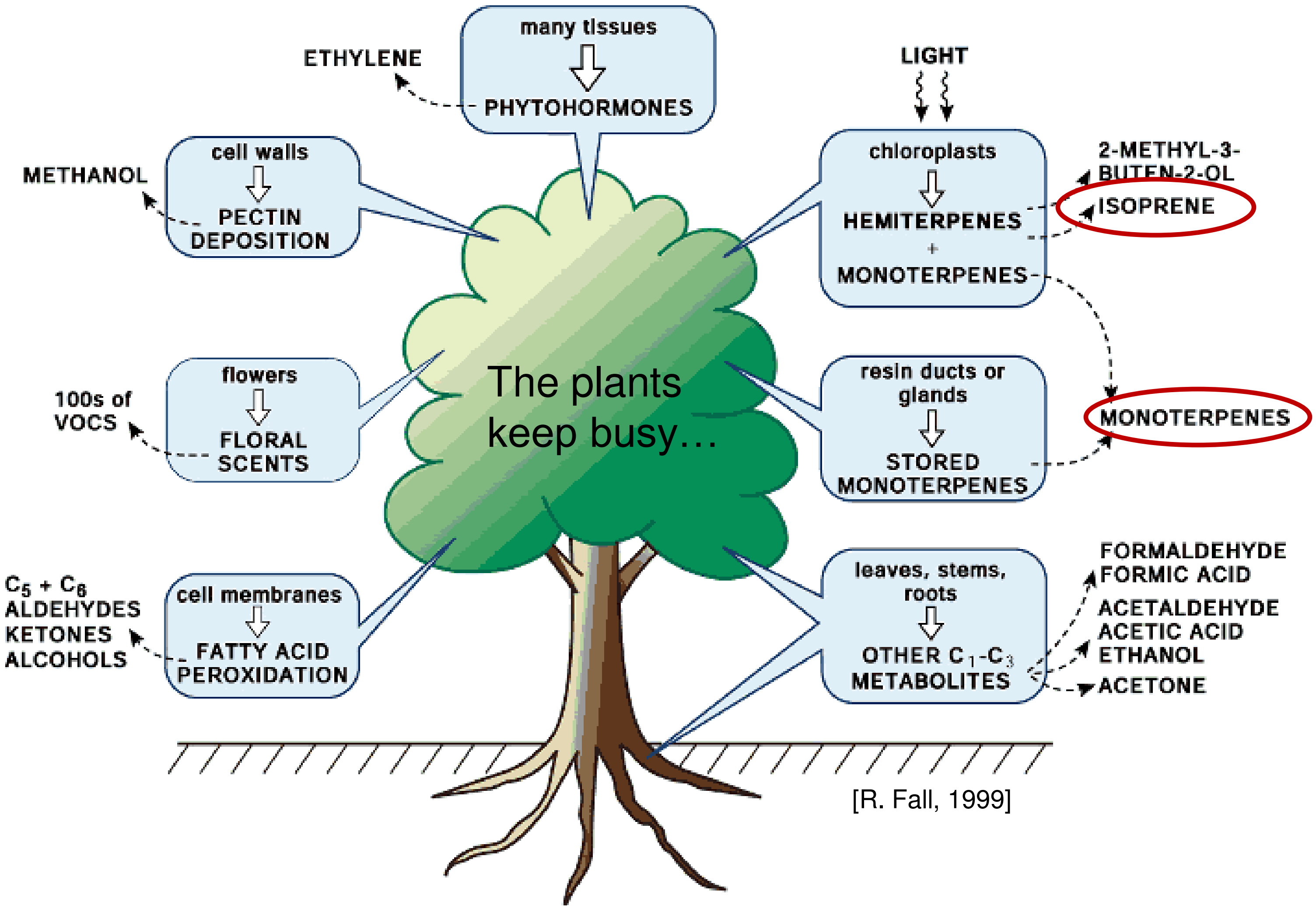
Biogenic emissions

Virpi Tarvainen (FMI), 19.2.2013

Foto: Timo Anttila



[R. Fall, 1999]

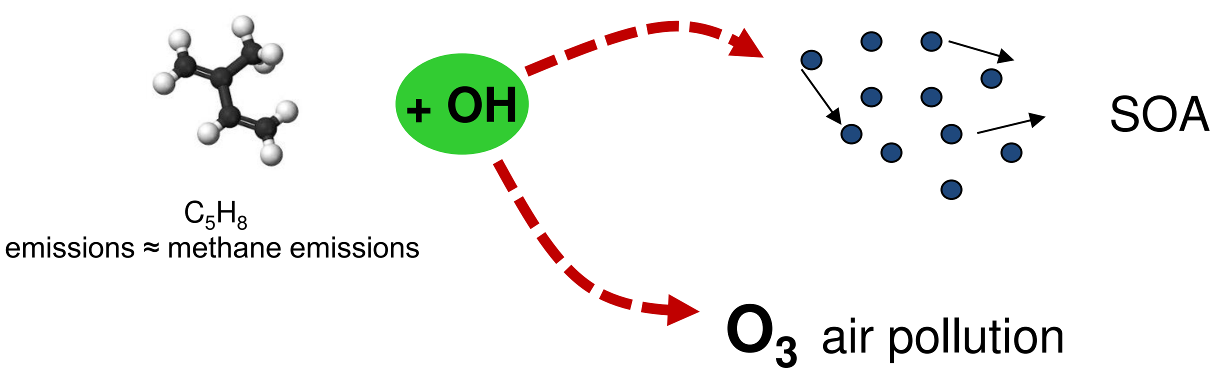
Biogenic volatile organic compound (BVOC) emissions

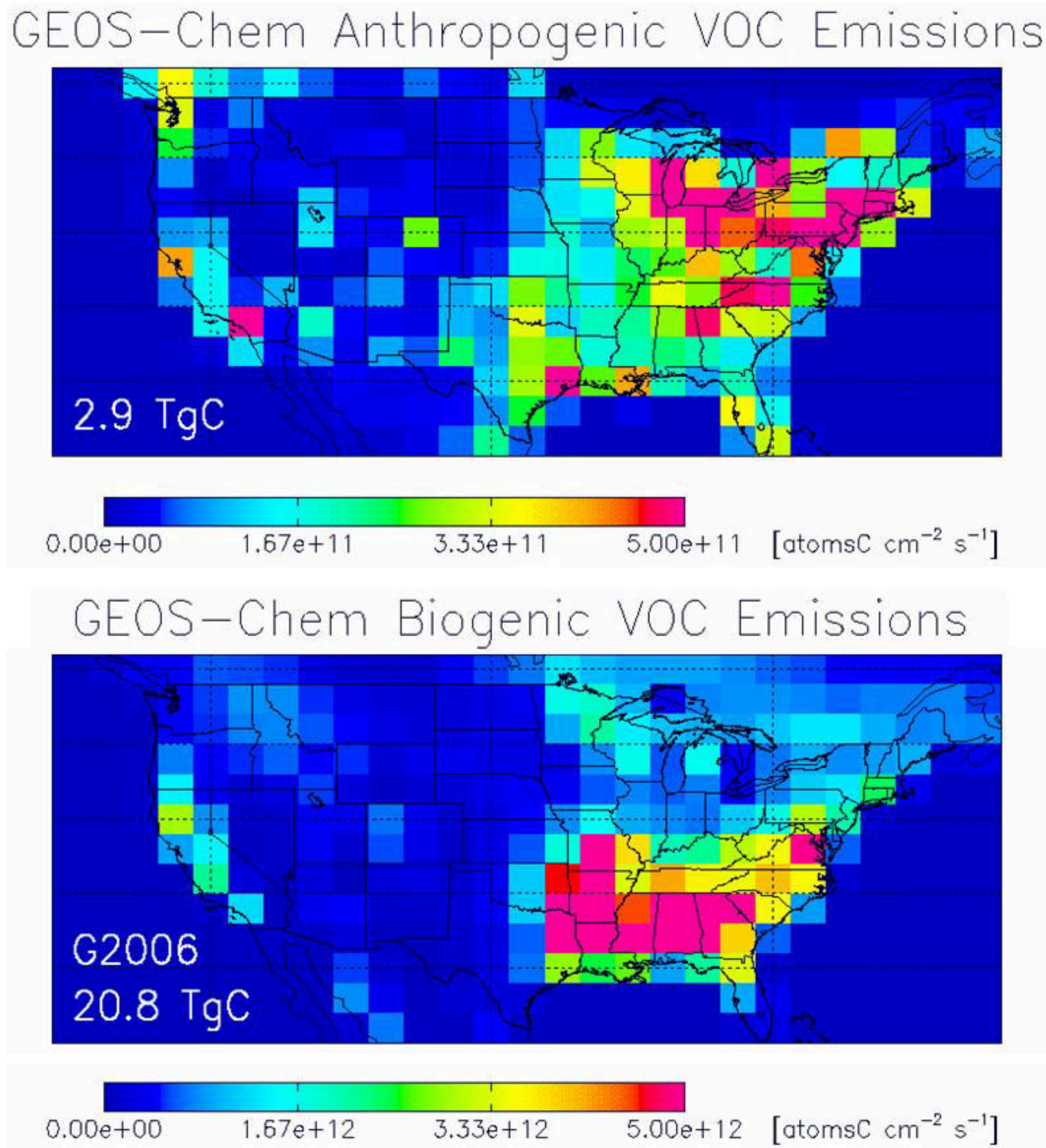
Biogenic volatile organic compound emissions

• terrestrial vegetation is **the dominant source** of volatile organic compounds (**BVOCs**) to the atmosphere

biosphere: 1150 Tg C a^{-1} ≈ 80% of the global total VOC (Guenther et al., 1995)

• the biogenic emissions play **an important role in atmospheric chemistry and climate** since they are often **highly reactive** and can **contribute to the processes that create ozone and particles** in the atmosphere

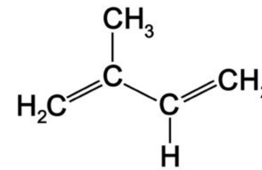




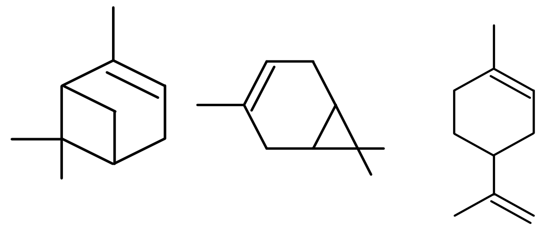
Total (24-h average) anthropogenic and biogenic VOC emissions for June-August 2006 – NOTE scales! [Millet et al. JGR 2008].

BVOC emissions – important compounds?

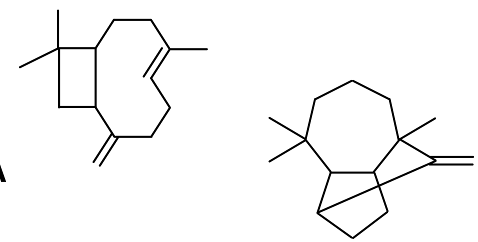
Principal compound: isoprene C_5H_8
Global emissions 440-660 TgC a^{-1}
Highly reactive, lifetime against OH < 1 h, source of O_3 and SOA



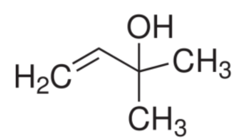
Monoterpenes $C_{10}H_{16}$ (many)
Global emissions 127 TgC a^{-1}



Sesquiterpenes $C_{15}H_{24}$ (many)
Varies, X0-Y0 % of MT emissions (T-dependent)
Highly reactive, probably important source of SOA



Other (e.g. MBO $C_5H_{10}O$ (2-methyl-3-buten-2-ol))
Increase ozone, HOx? Regional importance.



Compounds are emitted **for different purposes**

defensive, attractive, communicative, competitive, stress relief …

Emission modeling

emission of **compound X** from a region with N land use classes or **vegetation types**

Regional Emission Rate of compound X

land Area of each **vegetation type**

Foliar Density of each vegetation type

$$ER_X = \sum_{j=1}^{N} [A_j FD_j EP_{Xj} CF_{Xj}]$$

effect of **environmental variables** on emission of X from each vegetation type

Emission Potential of compound X from each vegetation type

light **temperature**

Other factors: **leaf age, soil moisture, … ?**

Emission modeling

•Emission potentials of the plant species ↔ measurements of plants and/or different soil types (e.g. wetland) in actual environmental conditions

=> **emissions data base for plants/soils**

•Land use information: main forest classes, other ecosystems (e.g. open fens) ↔ satellite observations

=> **land use/biomass data base**.

•Environmental conditions, variation (temperature, solar radiation)

=> **meteorological data base**.

• **A way to connect plant emission and the environmental conditions** of the growth environment

=> **emission algorithm(s)…**

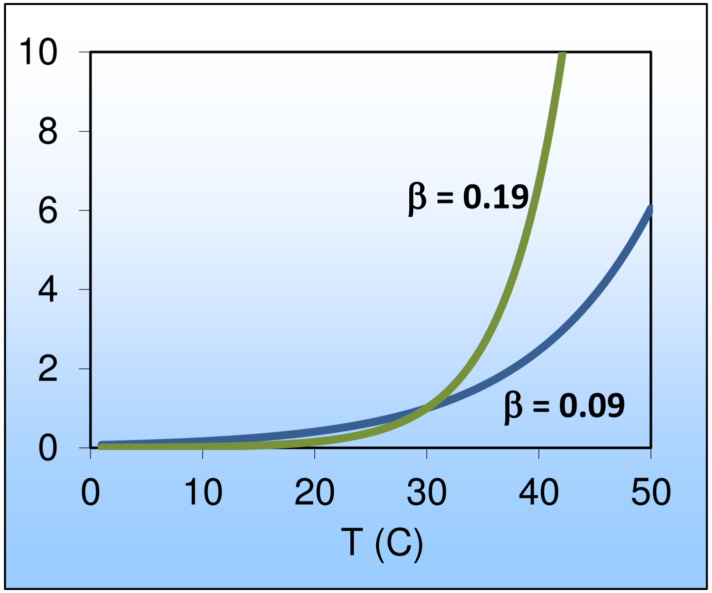
Influence of temperature on emission from storage pools

- Temperature dependent
- Monoterpenes
- Sesquiterpenes

$$ER(T) = E_S \cdot \gamma$$

E_S = emission rate at standard conditions <=> 30 C

$$\gamma(\text{pool}) = e^{\beta(T - T_S)}$$



$\beta = 0.09\,C^{-1}$, experimental constant

T = leaf temperature (C)

T_S = leaf temperature at standard conditions (30 C)

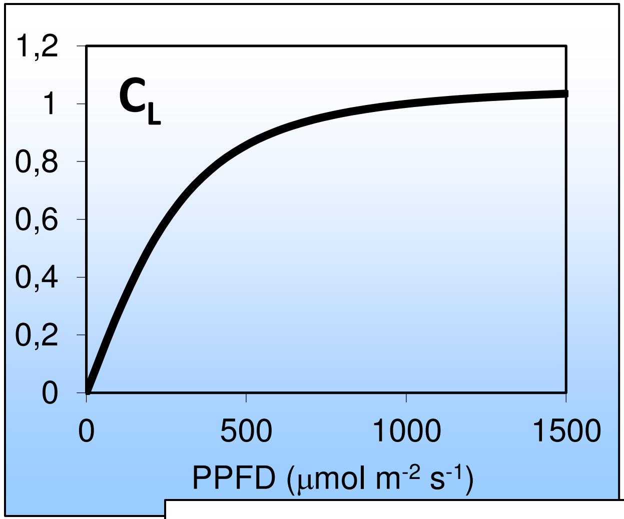
Tingey et al., 1980; Guenther et al.,1993

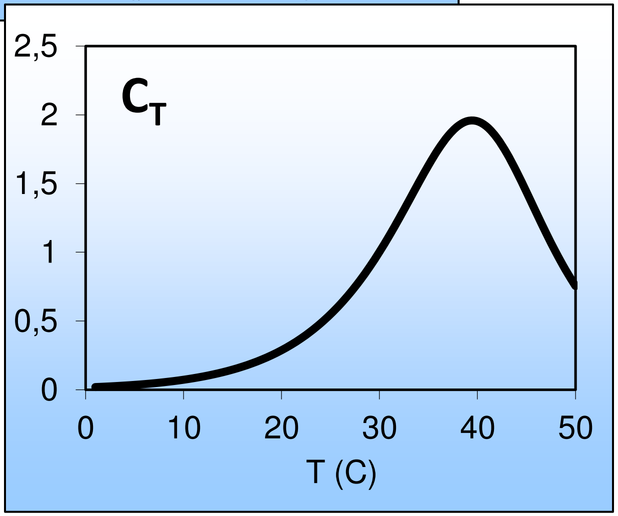
Influence of light and temperature on emission from *de novo* synthesis

- Temperature and light dependent
- Isoprene
- (some monoterpenes, MBO, Cineol…?)

$ER(L,T) = E_S \cdot \gamma$

Standard <=> 30 C, 1000 μmol m^{-2} s^{-1}





$$\gamma(\text{synthesis}) = C_L C_T$$

$$= \frac{\alpha C_{L1} L}{\sqrt{1+\alpha^2 L^2}} \frac{\exp([C_{T1}(T-T_S)]/RT_S T)}{C_{T3}+\exp([C_{T2}(T-T_M)]/RT_S T)}$$

Light coefficient — Temperature coefficient

$L =$ photosynthetically active photon flux density (PPFD)

$T =$ leaf temperature (K)

$\alpha = 0.0027, C_{L1} = 1.066, C_{T1} = 95000 \text{ J mol}^{-1}, C_{T2} = 230000 \text{ J mol}^{-1},$

$C_{T3} = 0.961, T_M = 314$ K, experimental constants

Guenther et al.,1993; Guenther 1997

Globally, the biosphere is by far the largest source of reactive VOCs and an accurate representation of the emissions in atmospheric chemistry models is therefore critically important.




Scots pine, 50% Norway spruce, 30% Downy birch, 12% Silver birch, 4%



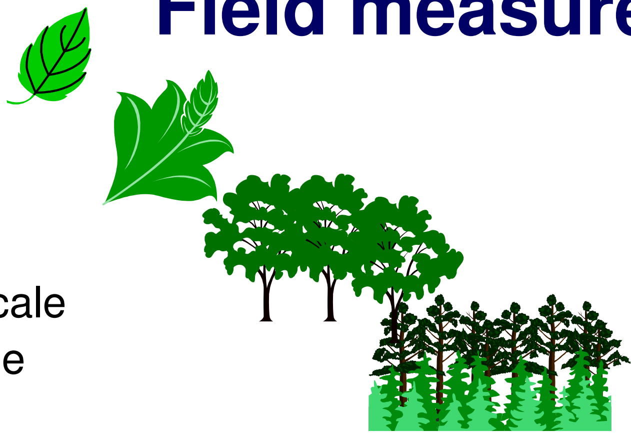

Source: Statistics of the Finnish Forest Research Insitute, 2008; illustrations © PuuProffa (www.puuproffa.fi)

To measure emissions (FMI)

- enclosure technique
- dynamic flow-through
- sampling at inlet & outlet
- **simultaneous measurement of light and temperature**
- sample storage until analysis
- analysis in laboratory, GC/MS

Illustrations © Heidi Hellén, Virpi Tarvainen

Field measurements



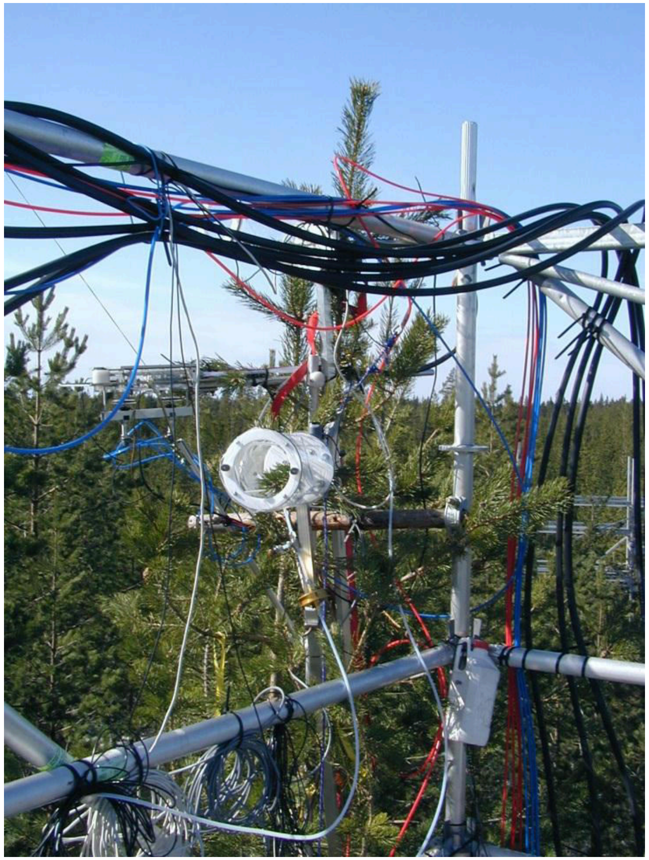
<u>Different scales</u>

- Leaf level
- Branch level
- Ecosystem scale
- Regional scale

- Variable environmental conditions

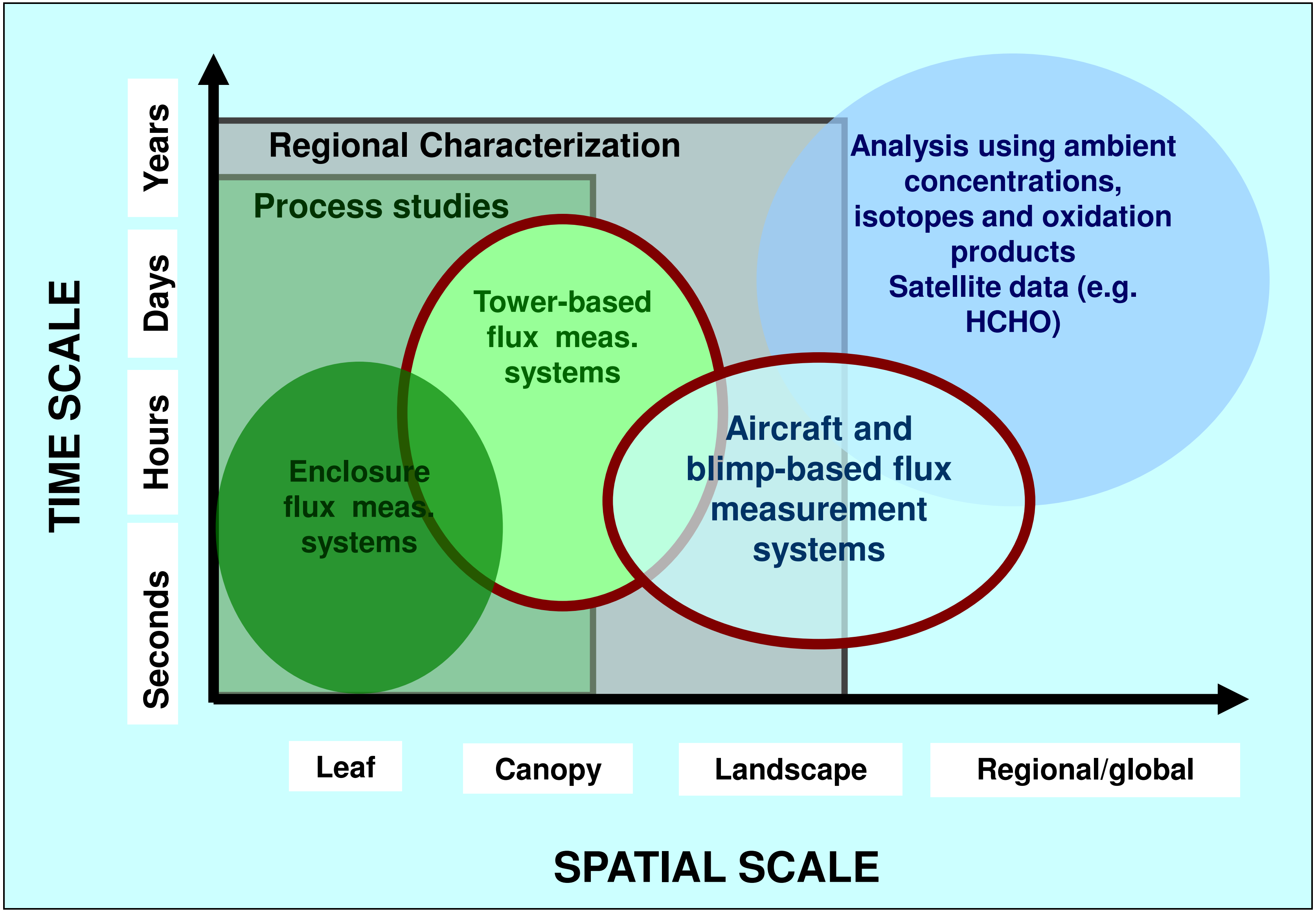
<u>Needed for</u>

- Validation of emission algorithms
- Assessment of experimental parameters in emission algorithms
- Development of ecosystem and regional level emission potentials
- …



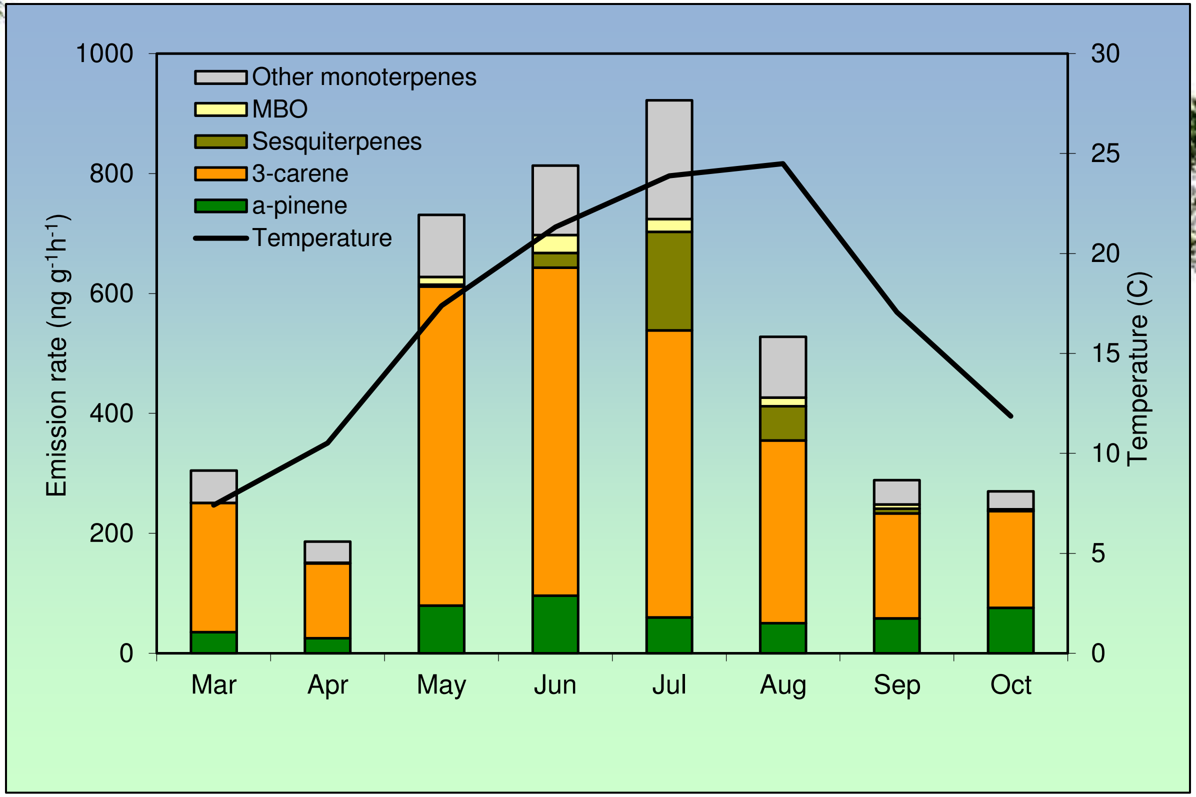
Branch level measurements from a tree growing in a natural environment
(Hyytiälä 2004, photo Heidi Hellén)

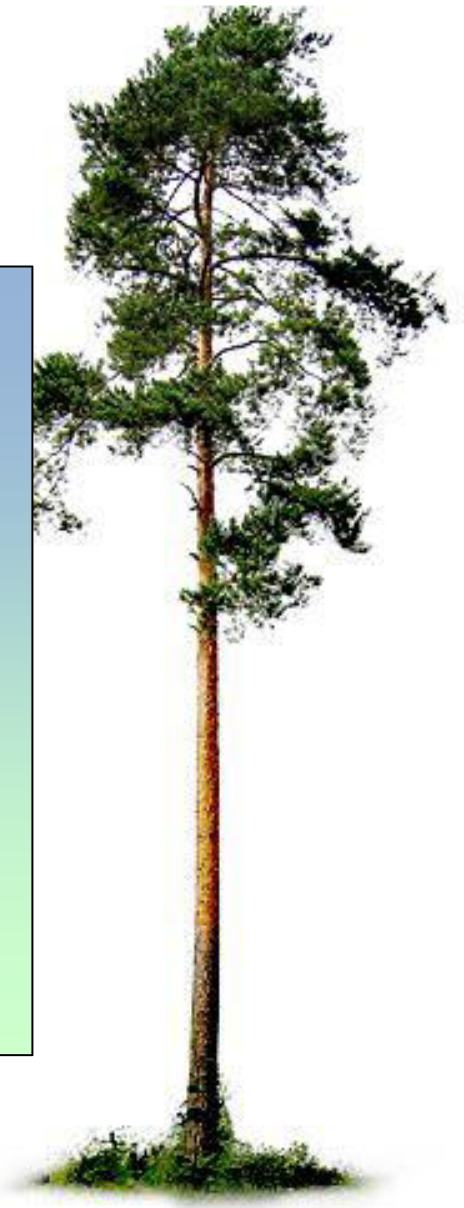
TOOLS FOR INVESTIGATING TRACE GAS FLUXES



Christine Wiedinmyer, NCAR

Emissions of Scots pine





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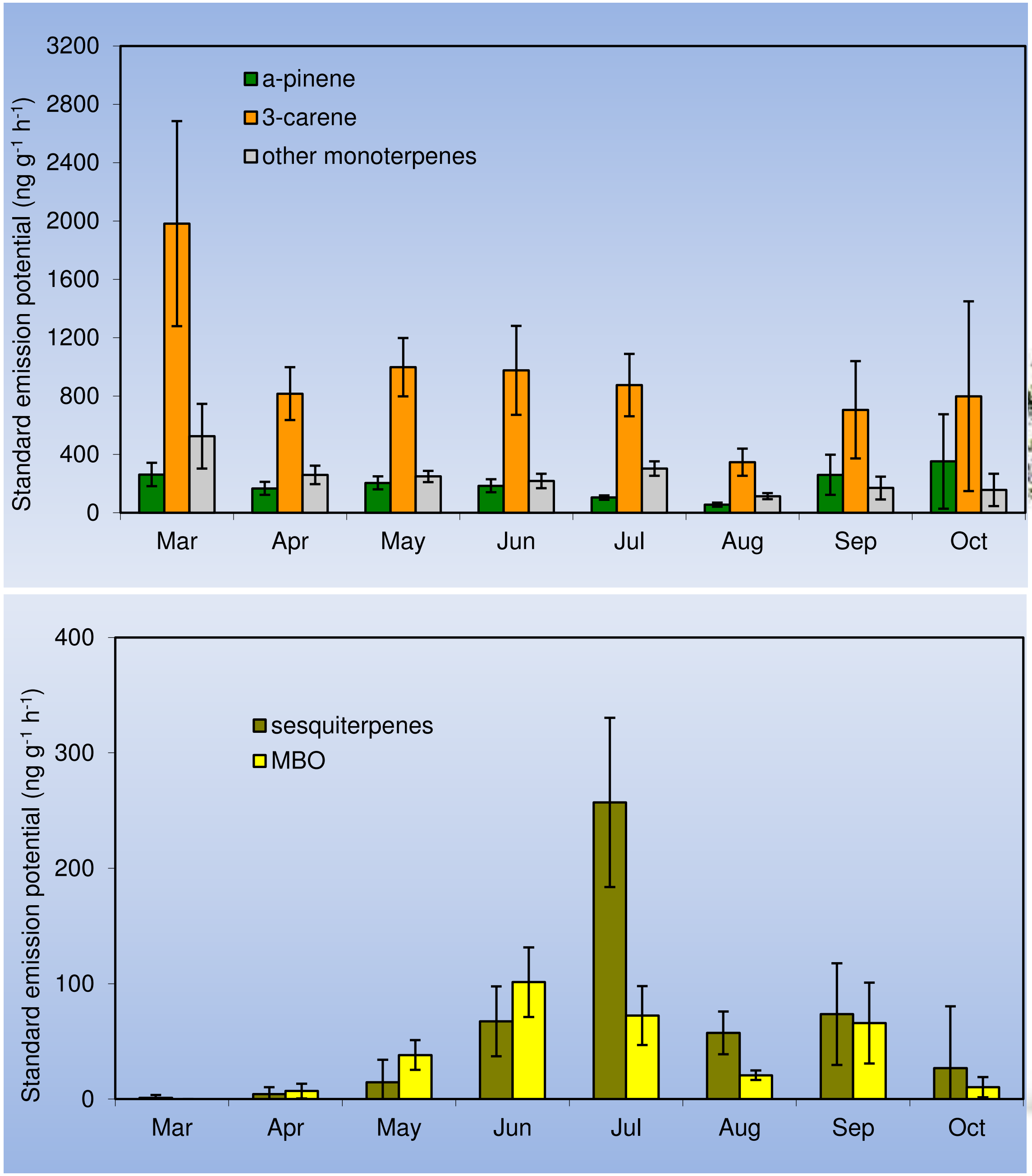
Emission Potential



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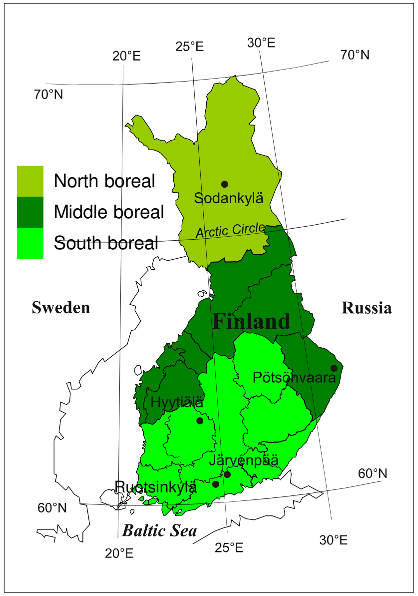
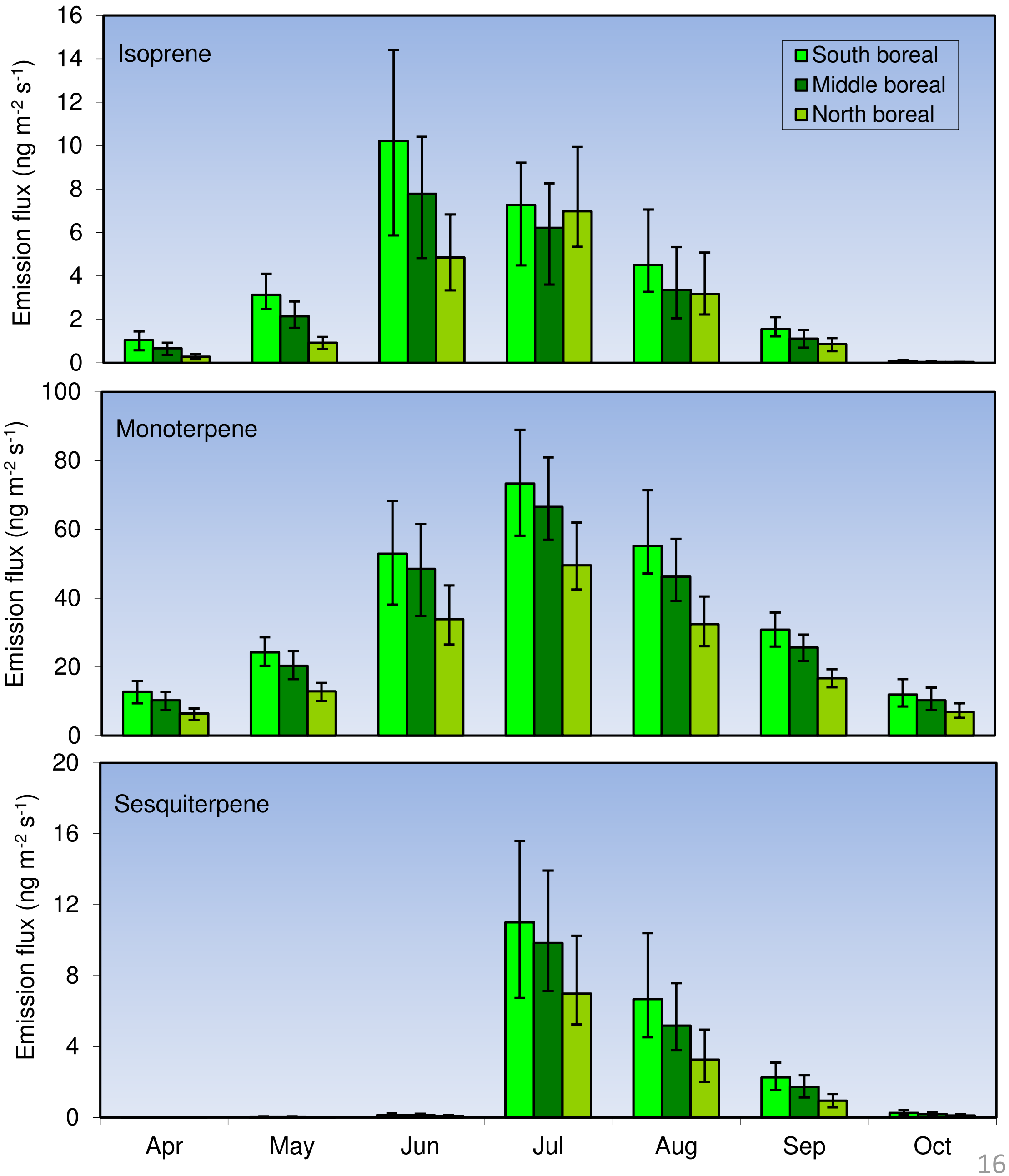


Average emissions



Terrestrial biomes classified by vegetation