Karlsruhe Institute of Technology

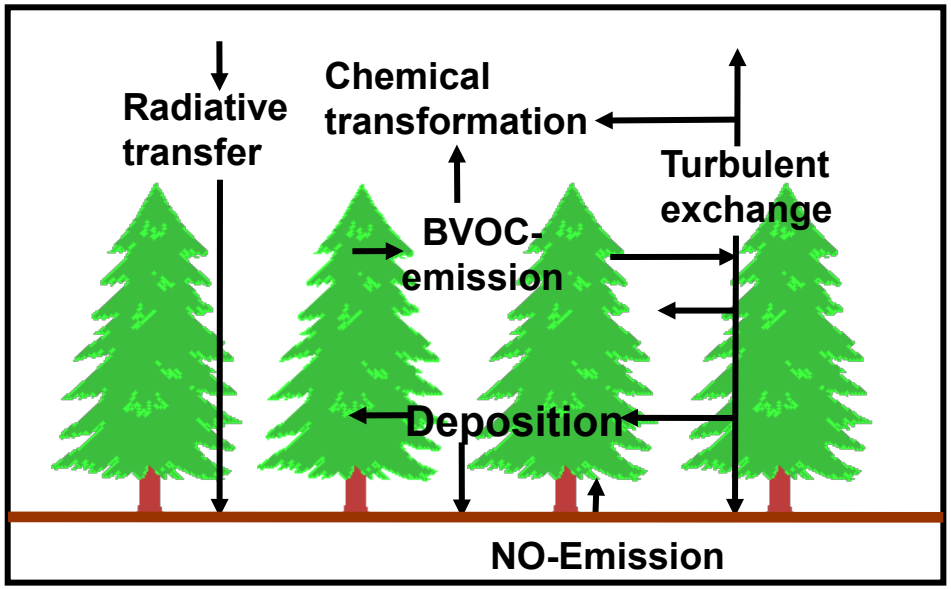
# Simulation of Biogenic VOC Conversion with CACHE

Renate Forkel (renate.forkel@kit.edu)

Karlsruher Institut für Technologie
Institut für Meteorologie und Klimaforschung
IMK-IFU
Kreuzeckbahnstr. 19
Garmisch-Partenkirchen
Germany

# CACHE: Canopy Atmospheric CHemistry Emission model

- How are BVOC emitted by trees processed within the forest canopy?
- What is the effect of in-canopy chemistry on fluxes above the canopy?




- **Prognostic** one-dimesional canopy-chemistry-PBL model
- Validated for different boreal and mediterranean forests



Renate Forkel, IMK-IFU Garmisch-Partenkirchen
renate.forkel@kit.edu

# CACHE's Origin

- Developed at IMK-IFU (Fraunhofer Institute für Atmosphärische Environmental Research at that time) within a project coordinated by Rainer Steinbrecher by myself with contributions by Bill Stockwell

**IMK-IFU** (~ 80 persons) is part of **KIT** (~ 8000 employees).
Research topics at IMK-IFU are
biogenic C and N cycles, hydrology, GHG trends, air quality

Besides my work with CACHE my current research topics are mostly related to regional air quality modelling with MCCM or WRF/Chem (working group 'Regional Coupling of Ecosystem-Atmosphere Processes', http://imk-ifu/air_quality.php, head P. Suppan).

- CACHE includes significant parts of CUPID by John Norman (http://www.soils.wisc.edu/~norman/cupid)
- As part of the working group's activities CACHE is currently implemented into **MoBiLE** (Modular Biosphere Simulation Environment - a framework to link 1-dimensional biosphere models)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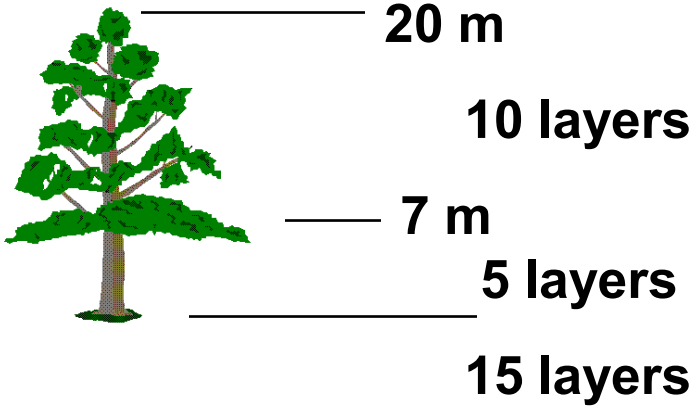
# Features of CACHE

- Vertical Extension typically –2 to 3000 m, variable number of model layers
- Vertical transport of heat, moisture, and chemical compounds in
- Gas phase chemical transformations (RACM or RACM-MIM)
- Leaf and surface energy balance
- BVOC emission (currently emission factors for 8 plant species)
- Simple NO emission from soil
- Deposition
- Soil temperature and moisture
- External forcings (e.g. clouds)

**Example for typical setup**




Reference: Forkel et al, 2006: Trace gas exchange and gas phase chemistry in a Norway spruce forest: A study with a coupled 1-dimensional canopy atmospheric chemistry emission model, Atmos. Environ., 40, S1, S28-S42.



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# CACHE Input

- **Canopy information**
  - LAI
  - Height dependence of incremental LAI
  - Canopy height, trunk space height
  - Plant species (if tree is already implemented)
  - If plant is not yet implemented: BVOC emission factors
- **Meteorological, geographical, and soil information**
  - Solar radiation at canopy to
    (or alternatively latitude, longitude, julian day plus cloud information)
  - Initial profiles for atmospheric temperature, humidity, wind
  - Soil temperature and moisture
- **Chemistry information**
  - Initial concentration profiles (as many compounds as available
- **Information about advection**
  - Source term



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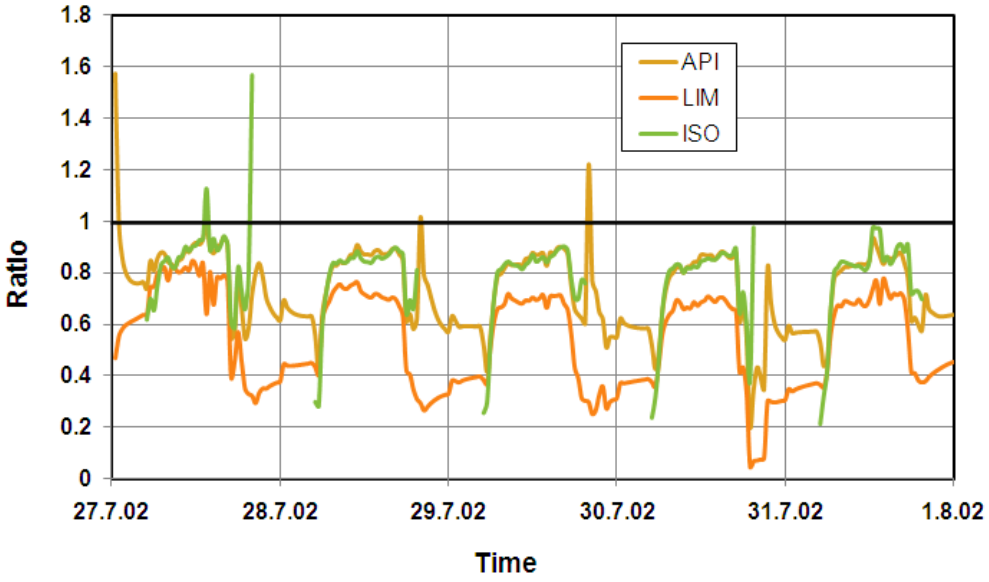
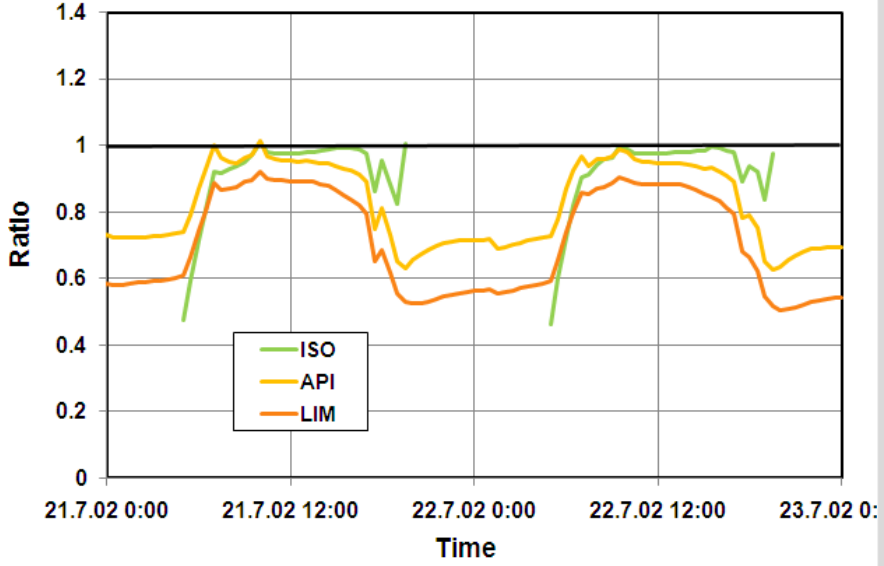
# CACHE application

## Ratio of effective to potential fluxes at canopy top

### Low isoprene (spruce), low $NO_x$




### High isoprene (oak), low $NO_x$




**Ratio depends on**
**a) BVOC reactivity, b) residence time, c) chemical conditions**



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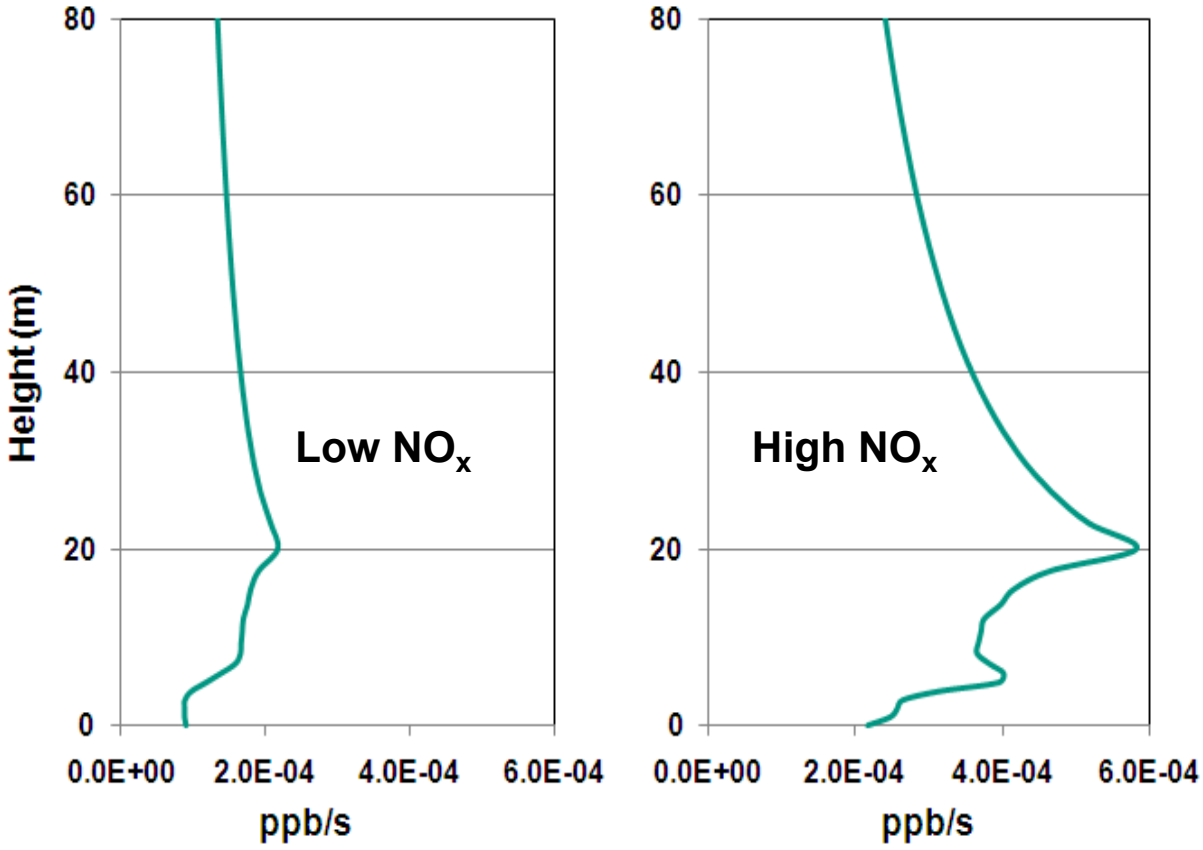
# CACHE application

**MACR production rate at noon**

**Oak ridge forest (height 20 m)**



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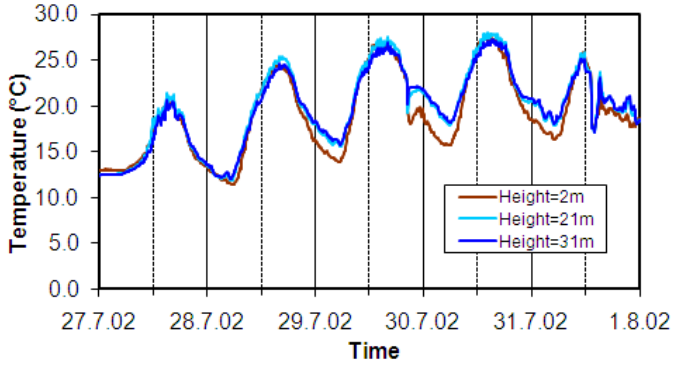
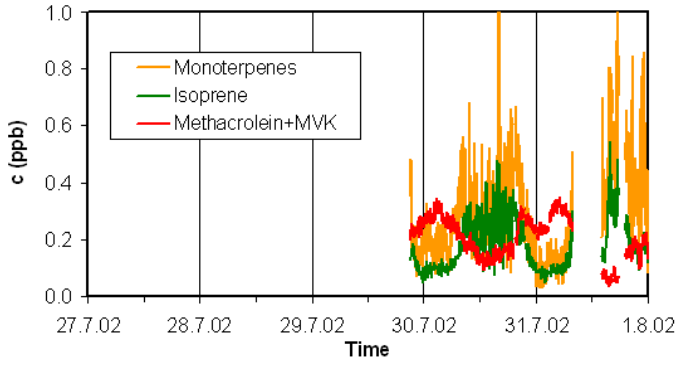
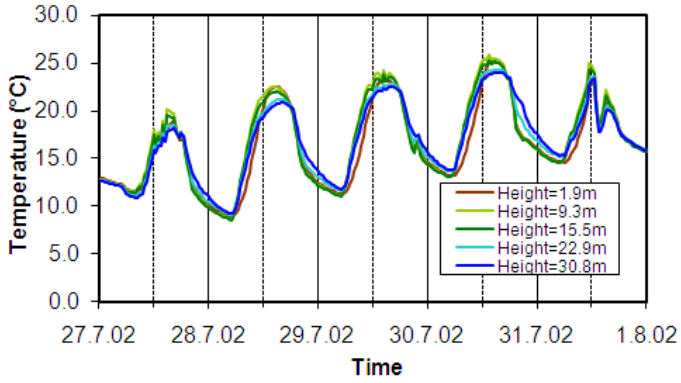
# CACHE Evaluation

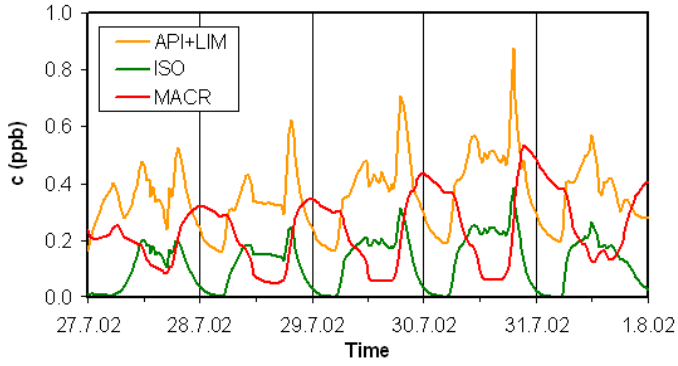
- BVOC fluxes
- Temporal courses and profiles of temperature and humidity
- Temporal courses and profiles of chemical compounds

**Waldstein, spruce forest**



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# Outlook

- Application of CACHE within CANOPEE
  - Adaptation of CACHE to OHP site
  - CANOPEE case studies
  - Further development (include particulate matter)
- Finalize implementation into MoBiLE




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