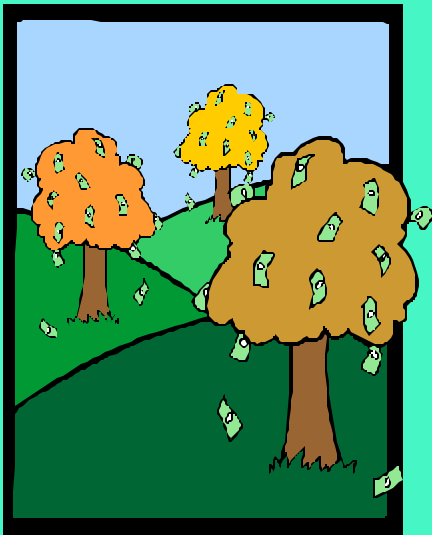


# Plant-Atmosphere Interactions: Biometeorology at UCB



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Biometeorology  
Ecosystem Science Division  
Department of Environmental  
Science, Policy and Management  
University of California, Berkeley

# What Is Biometeorology?



- It is a science that deals with the relationship between living things and atmospheric phenomena.

## Classic Applications of Biometeorology

- Irrigation Scheduling
- Insect + Pathogen Development Modeling (IPM)
- Spray + spore diffusion
- Windbreak Design
- Frost Protection
- Plant Production Modeling
- Weather and Climate Prediction
- Pollution Modeling
- Forest Physiological Functioning



# Goals of Biomet Research at UCB

Study the the physical, biological, and chemical process that control trace gas fluxes between the biosphere and atmosphere



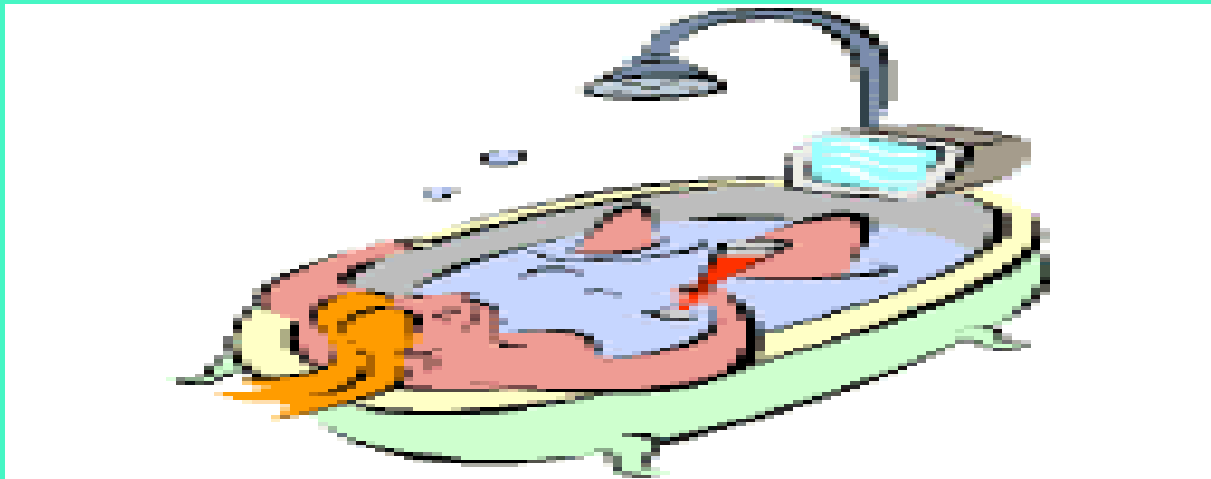
Utility of Biomet Research:  
Assess Biological Control and Feedbacks on  
Weather and Climate and Vice Versa



**To Characterize the Canopy Microclimate, We must Measure and Model Carbon Dioxide, Water Vapor and Energy Fluxes of across vegetation/atmosphere interface.**

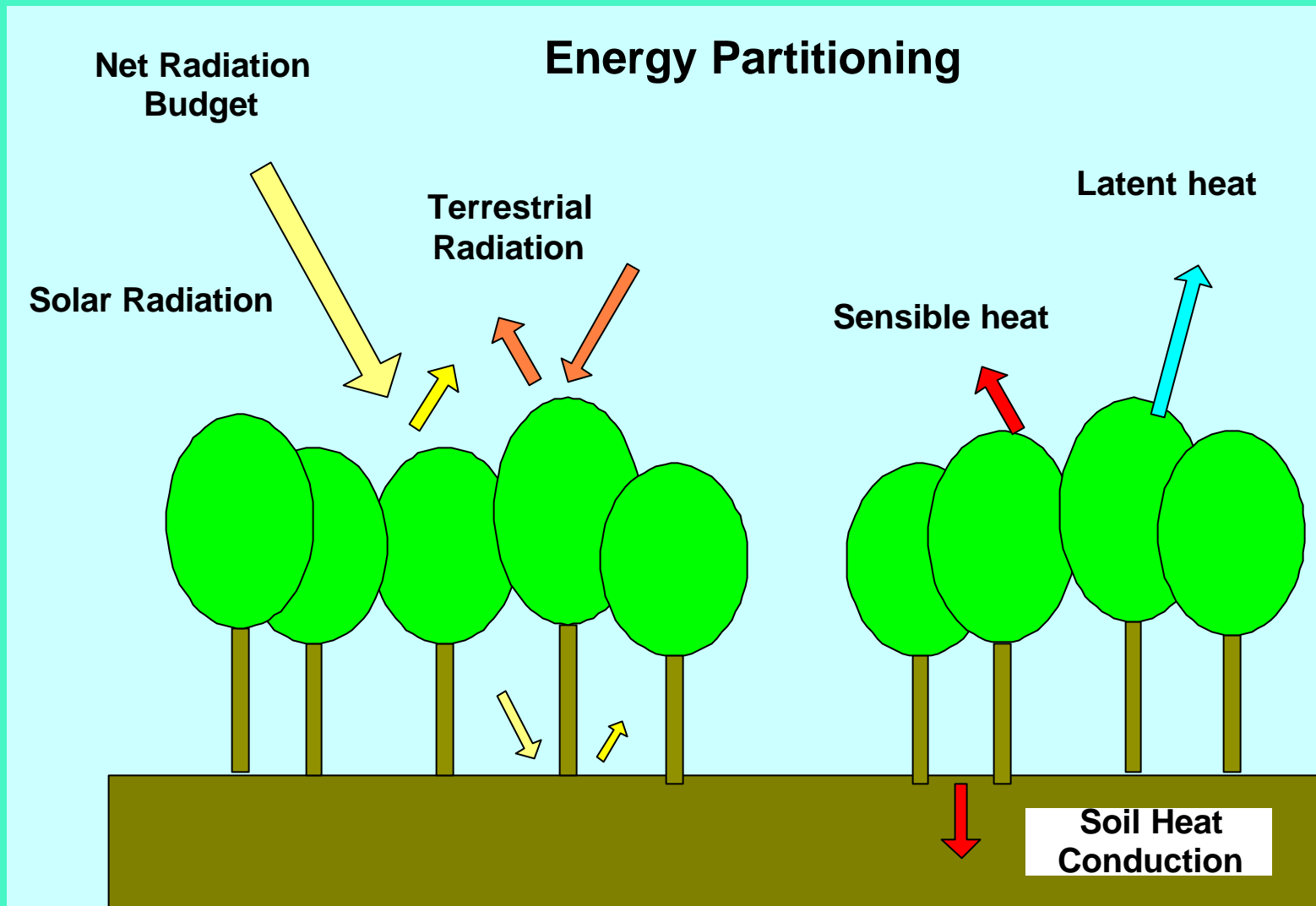


## Conservation of Mass: Solving the Bathtub Problem



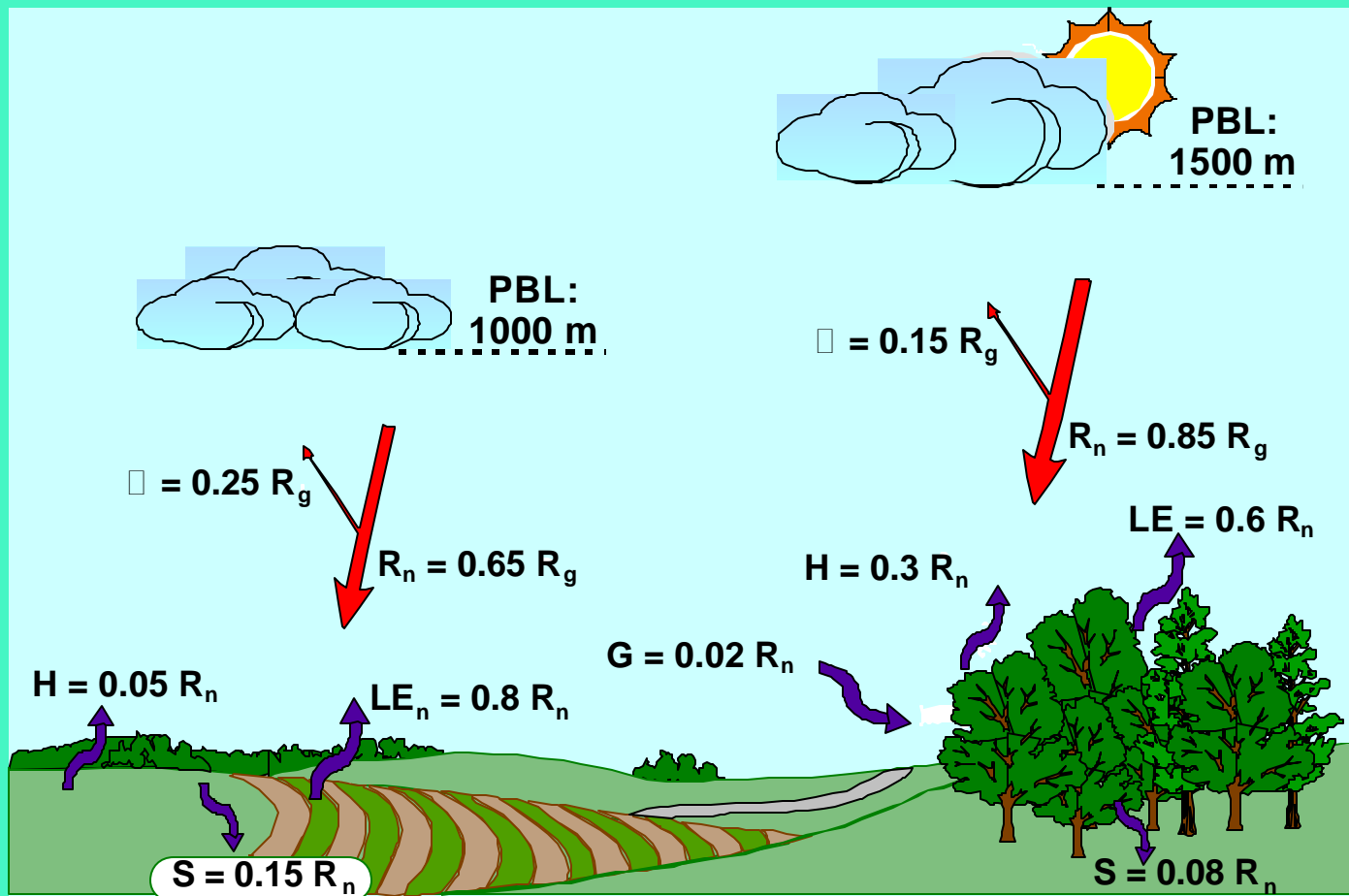
The 'Level' in a Tub is Constant if:  
the Flow In Equals the Flow Out

# Energy Exchange

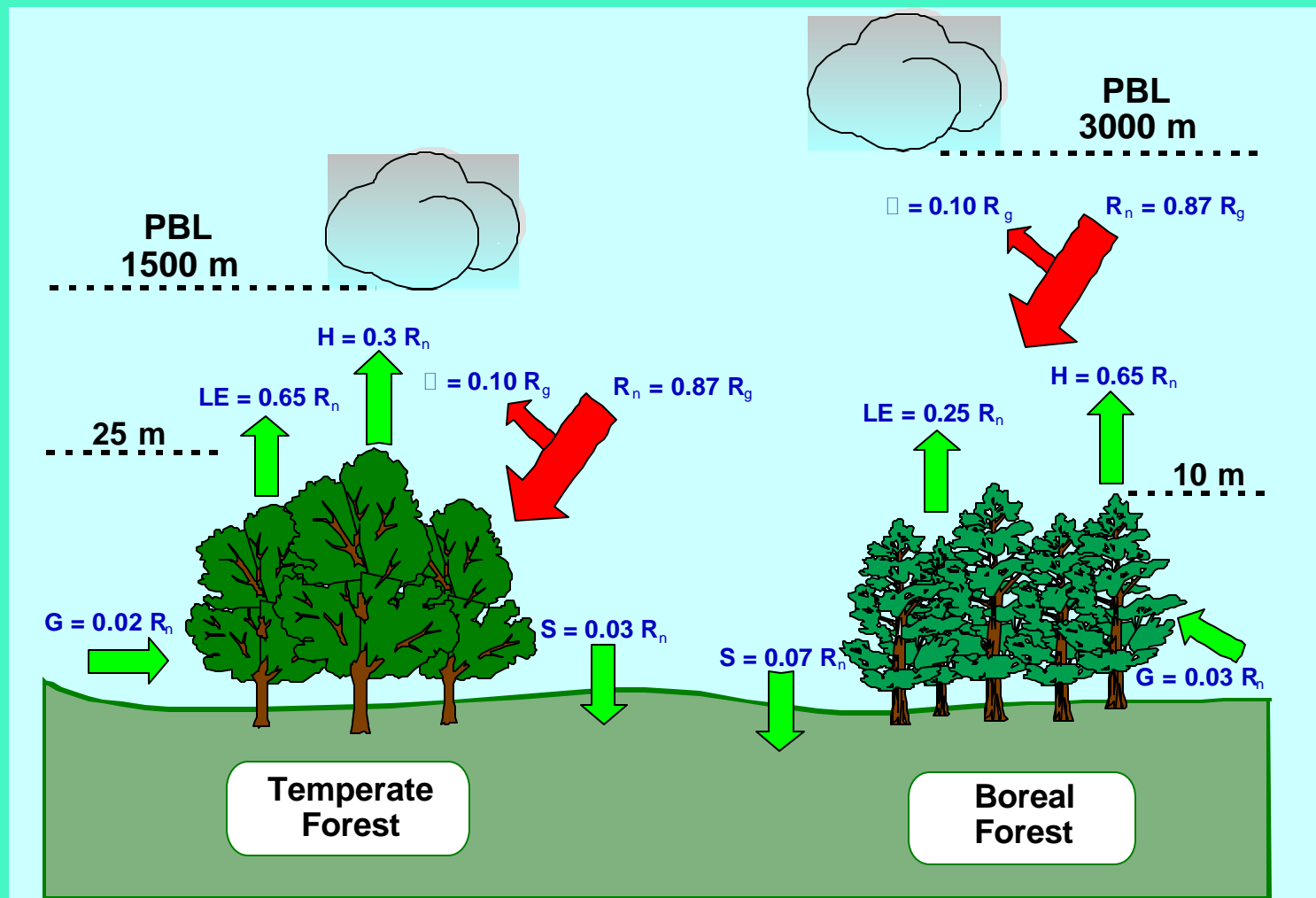




# Energy Balance Partitioning: Crops vs Forests



# Energy Balance Partitioning: Needle vs Broadleaved Forests

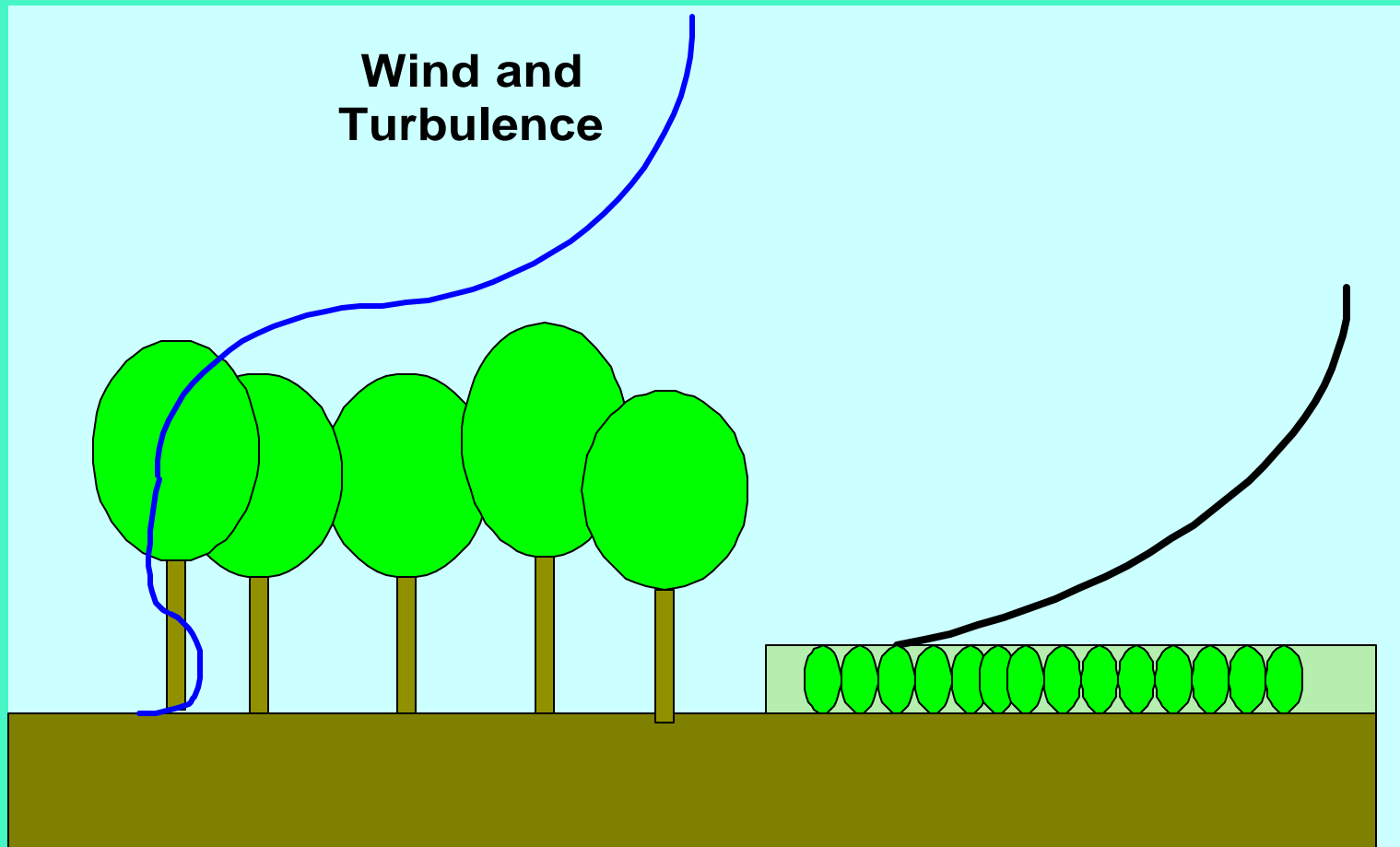


# Canopy Micrometeorology

- Measure and model turbulence and radiation statistics
- Across the vegetation-atmosphere interface
- In the stem space of forest canopies
- At the soil/atmosphere interface and

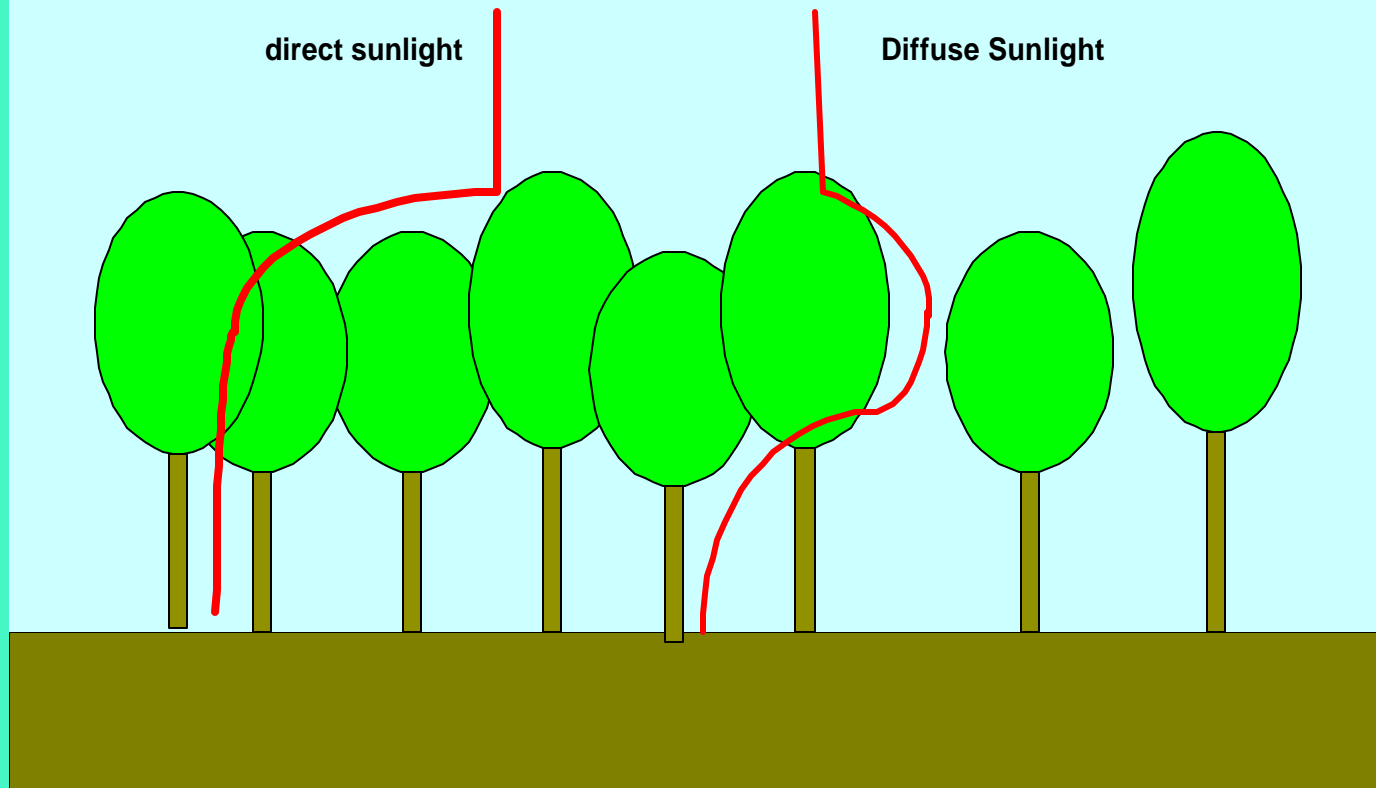


# Vertical Structure of Wind: Impact of Canopy Roughness

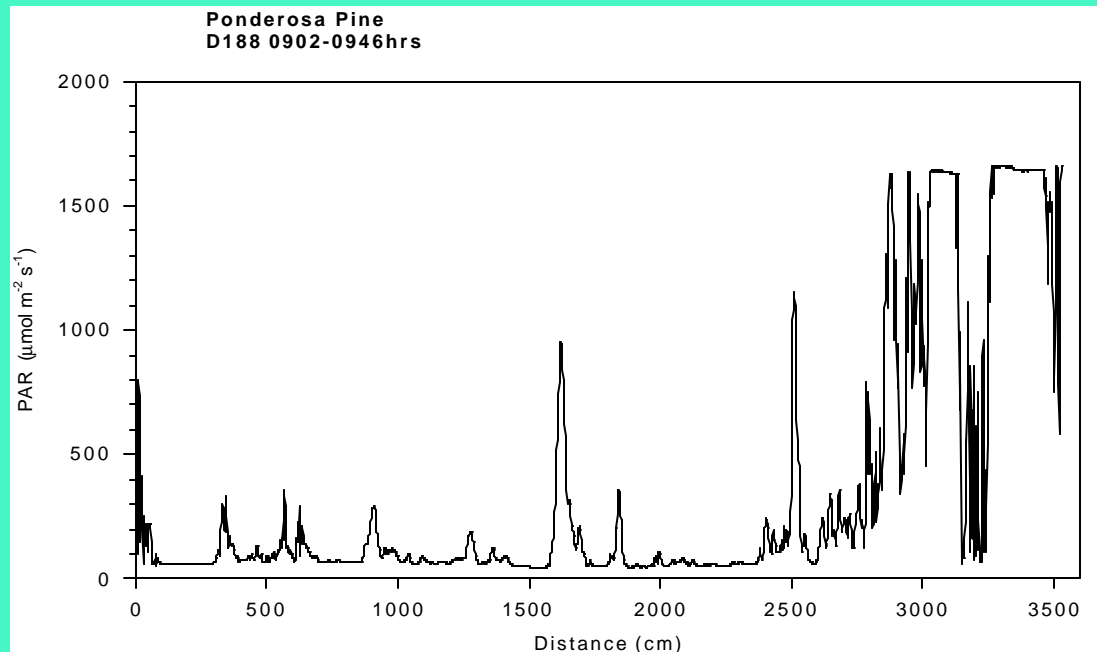


# Sunlight in Forests

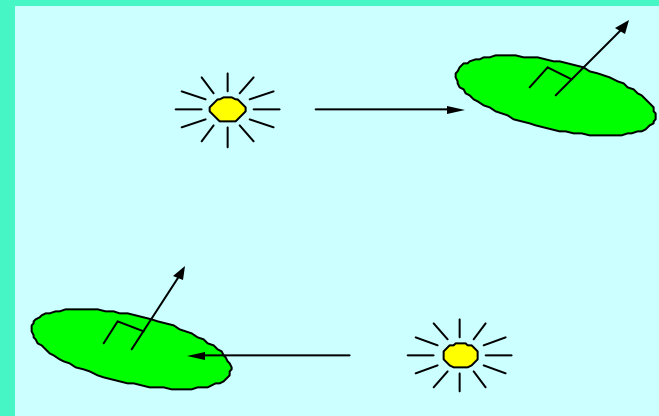
## Radiation and Forests



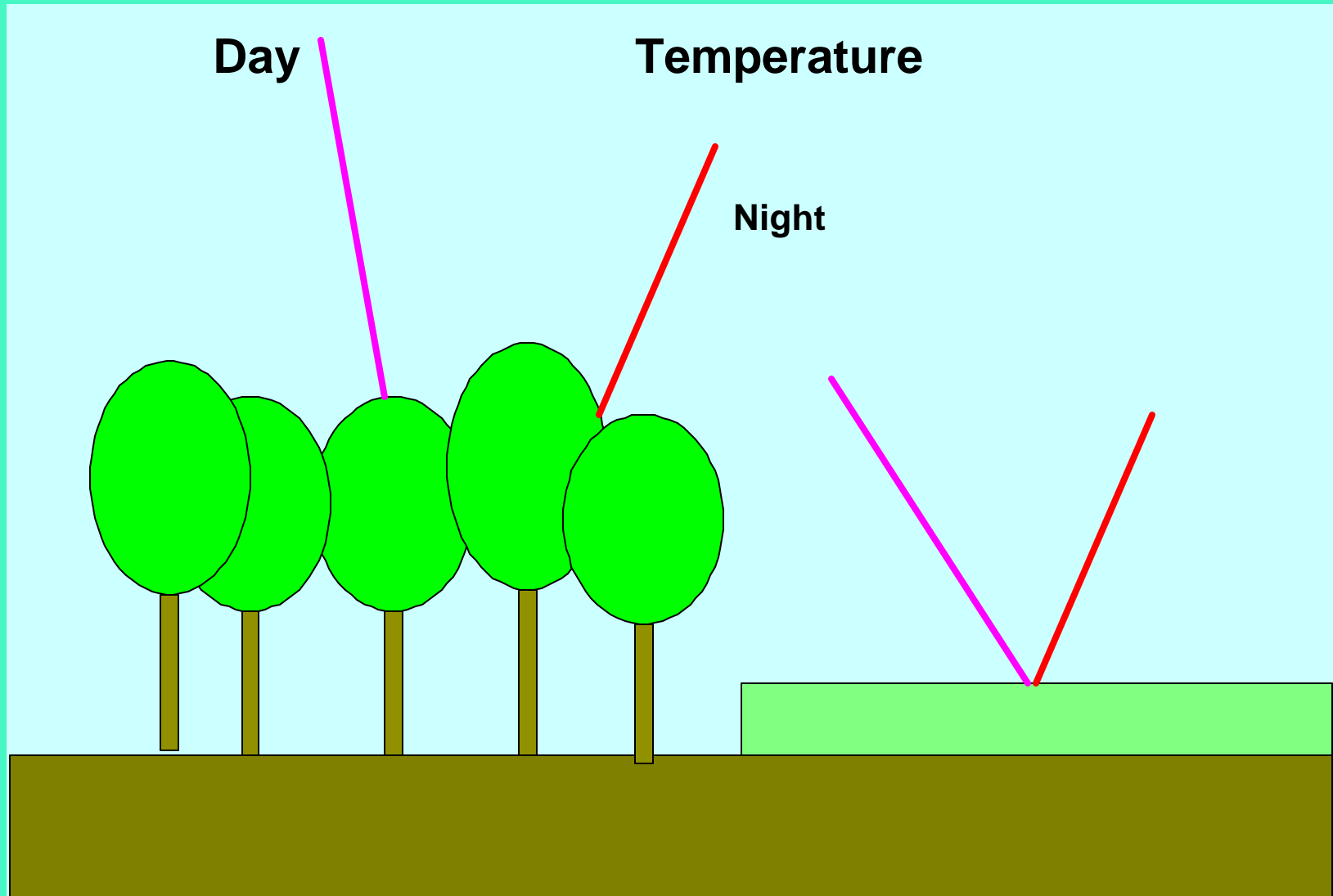
# Horizontal Variations



- Sunlit and Shaded Leaves



# Temperature and Plants



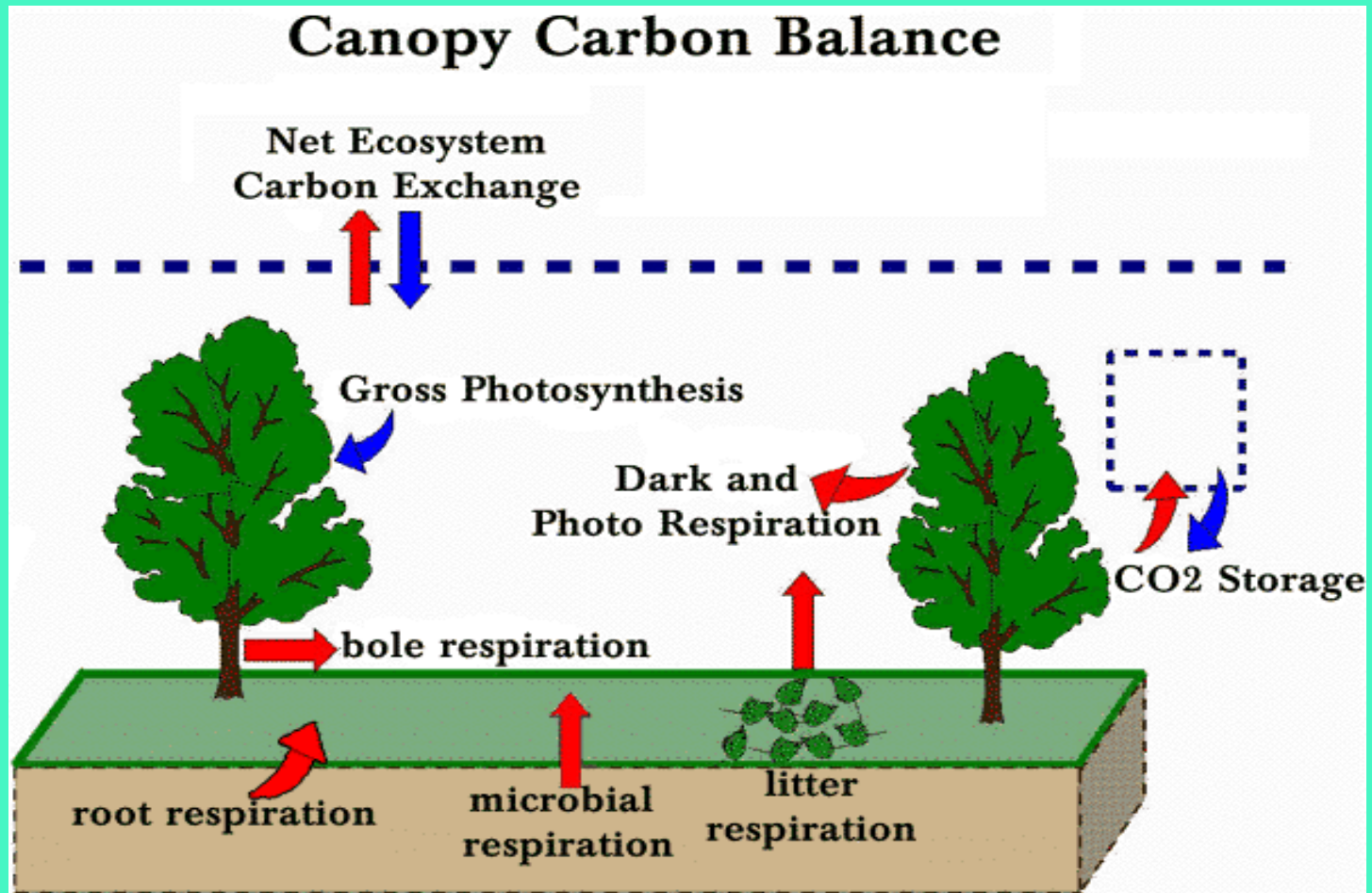
# Landscape-Atmosphere Interactions



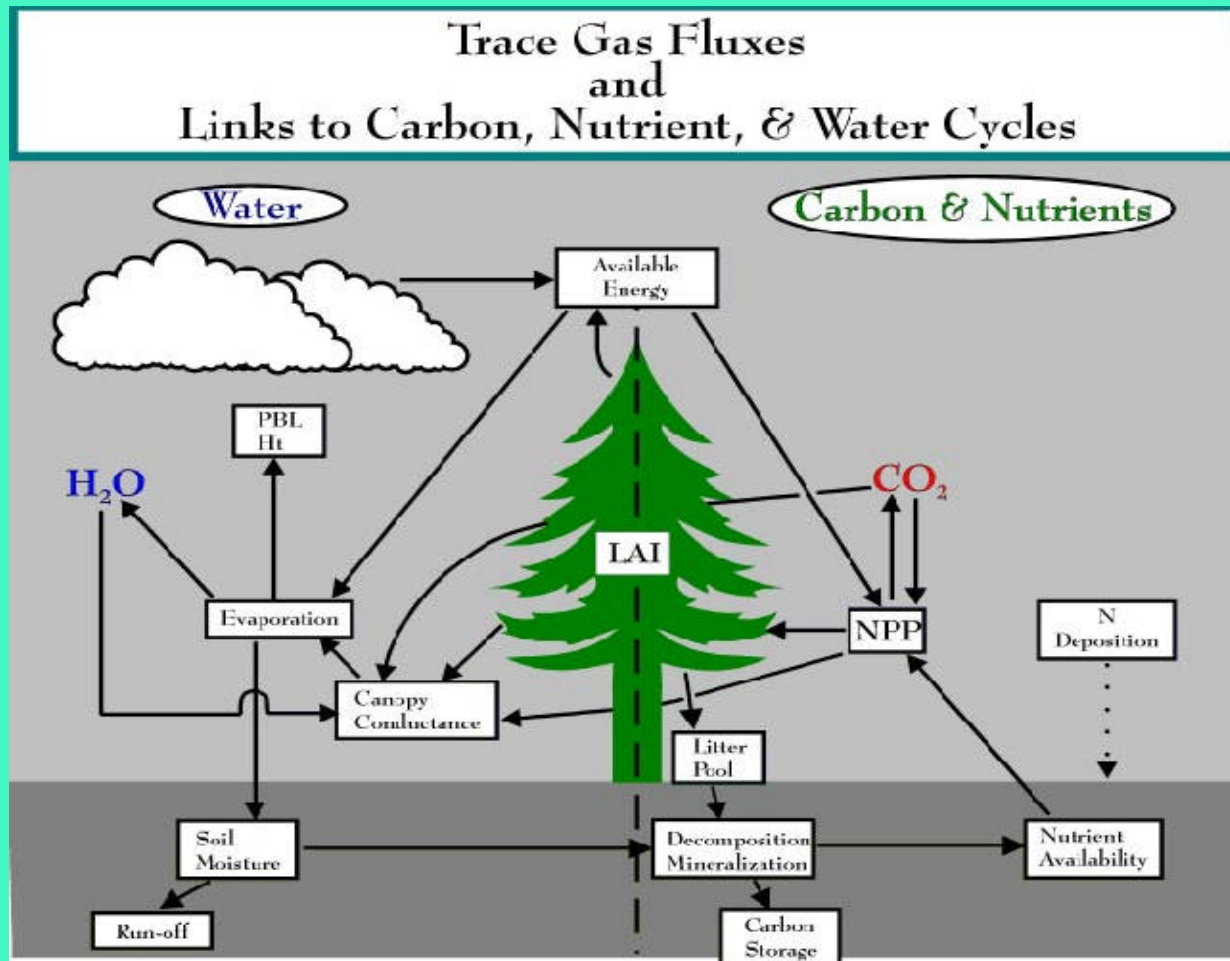
- **How biosphere-atmosphere exchange of trace gases and energy impact local, regional and global climate?**
- **Energy partitioning**
- **PBL growth**
- **Generation of convective clouds**



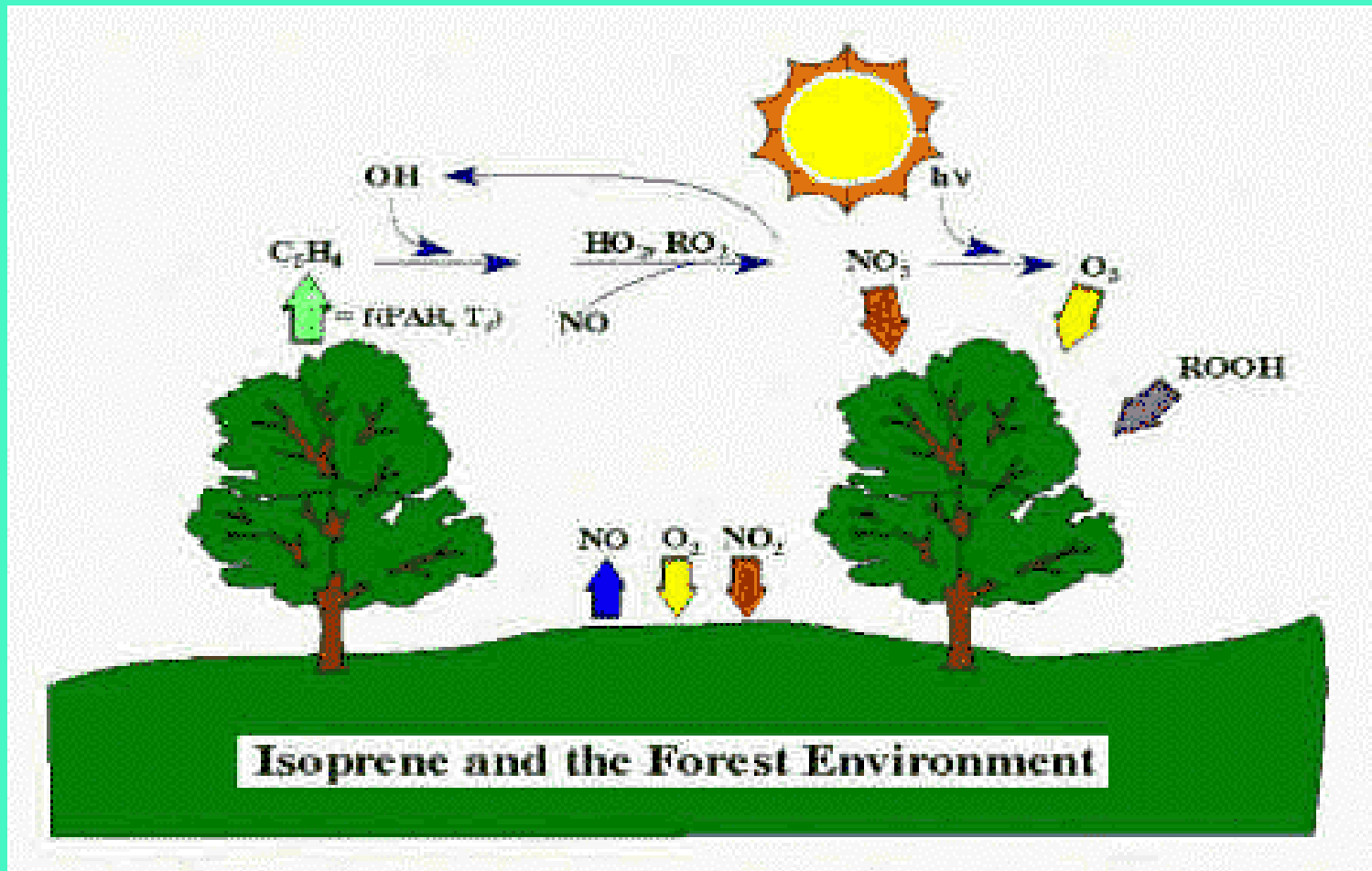
# Carbon Cycling



# Trace Gas Biogeochemistry



# Atmospheric Chemistry



## Modes of Research

- Field Measurements at Canopy scale
- Process-level Studies on Plants and Soil
- Mathematical Integration Models



# Field Research

- Oak-Grass Savanna
- Grassland
- Global Network
- Past Studies
  - Deciduous Forest
  - Conifer Forests
  - Crops
- Future
  - Vineyards + hills



# Methodology

Eddy Covariance Method is use to measure Fluxes of CO<sub>2</sub>, water vapor and energy exchange

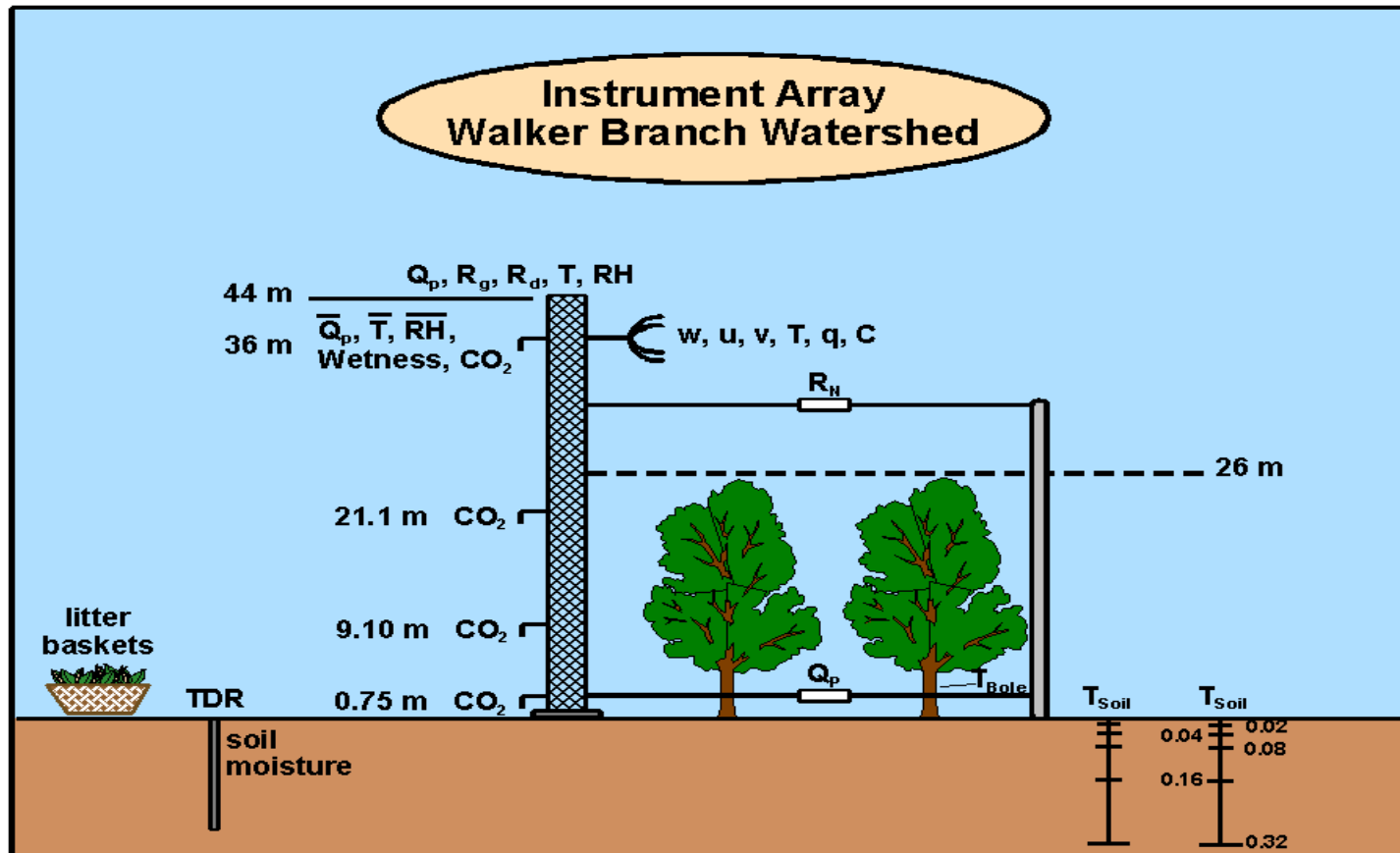
$$F_c = \overline{w'c'}$$



## Meteorological + Flux Variables

- Photosynthetic Active Radiation, **PAR**
- Air temperature, **T(air)**
- Precipitation, **PPT**
- Relative humidity, **RH**
- **Wind** speed & direction
- Vapor Pressure Deficit, **VPD**
- Soil temperature, **T(soil)**
- Carbon dioxide concentration, **CO<sub>2</sub>**
- Net Ecosystem Exchange from eddy correlation, CO<sub>2</sub> flux (**NEE**)
- Sensible heat from eddy correlation, **H**
- Latent heat from eddy correlation, **LE**
- Net radiation, **R(net)**
- Soil heat flux, **G(soil heat)**

# Experimental Set-up





# Tower in Oak Forest



# Tower in Oak/Grass Savanna



# Meteorological Instruments



## Plant and Soil Variables

- **Plants**

- Height
- Leaf Area Index (f(time))
- Photosynthetic Capacity
- Species/Functional Type
- Leaf N,  $^{13}\text{C}$
- Age, site history
- Clumping index
- Basal Area/Stand Density

- **Soil**

- Physical Properties (bulk density, porosity, thermal and hydraulic conductivity)
- Chemical Properties (N, C, pH)

# Understanding Component Processes: Soil Respiration



# Measurements in a Forest Understory

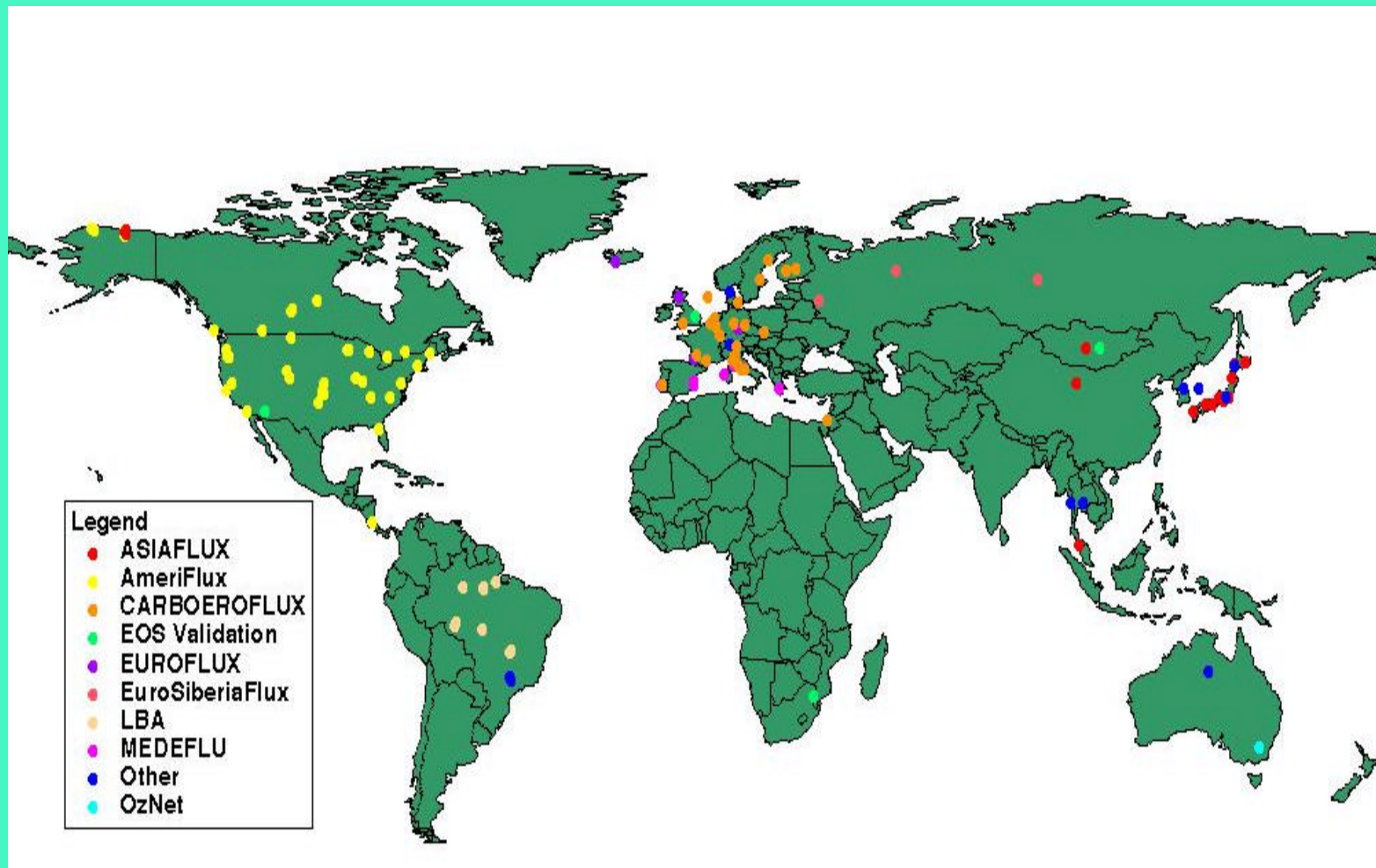


# FLUXNET Project



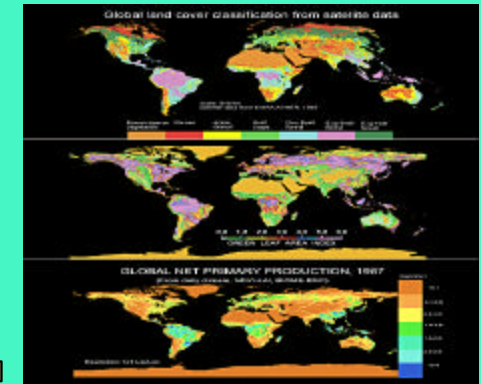
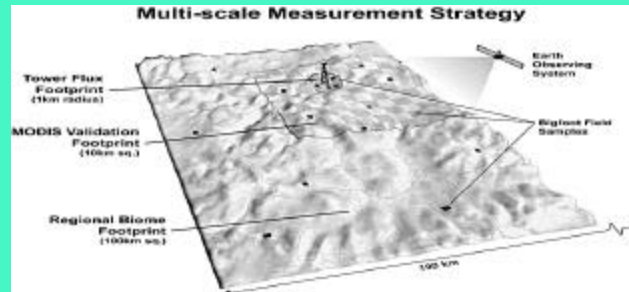
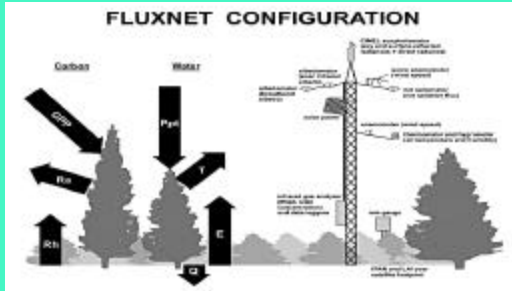
- **Synthesize and Interpret carbon and energy fluxes, across biomes and climate zones**

# FLUXNET-2001





# Linkage between FLUXNET and EOS

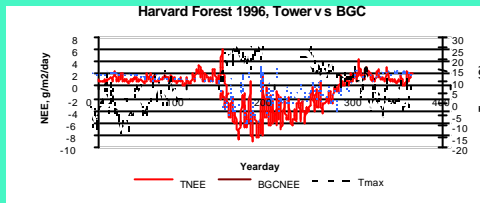


- Data from Flux Towers**
- Micro-meteorological data** (hourly/daily)
    - Incident PAR
    - Air Temperatures
    - Vapor Pressure
    - Rainfall
    - Wind
  - Land surface properties** (seasonal/annual)
    - Land cover
    - Leaf area index
    - Soil carbon
    - Soil nitrogen
    - Biomass (stem)
  - Fluxes:** CO<sub>2</sub>, water and heat

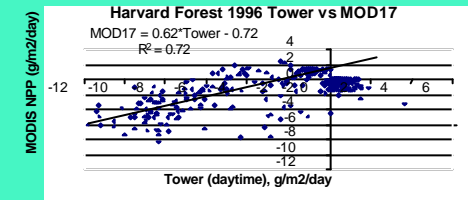
**VALIDATION**

Ecosystem models are used to relate Flux tower measurements to MODIS derived products

**EOS/MODIS PRODUCTS**



**MODELING CARBON FLUXES IN NEAR-REAL TIME**



**TESTING MODIS NPP WITH FLUX TOWER MEASUREMENTS**

Nemani/2/28/00

# FLUXNET Synthesis 2000 Workshop



# Plant-Atmosphere Interactions



- What are the impacts of leaf area, timing of growing season and latitude on carbon and water vapor budgets of plant stands?

# Quo Vadis?



- Non-ideal landscapes
- Long term studies
- Partial Canopies
- Vegetation Exposed to Soil Moisture Deficits
- Multi-scale + Multi-Process Integration

# Forests As Two Layered Systems



# Ponderosa Pine Study



# Oregon Field Crew



## Flux Footprints

- Where does material come from and where is it going?





## UCB Biomet Lab

- Lianhong Gu: Associate Specialist
- Liukang Xu: Postdoctoral Fellow
- Nancy Kiang: PhD Candidate
- Ted Hehn: Developmental Technician
- Francesca Ponti: Visiting Student

# Photo and Art Credits

- Stephen McMillen
- Ben Hernandez
- Kimberly Hill
- Vincent van Gogh
- Berthe Morisot