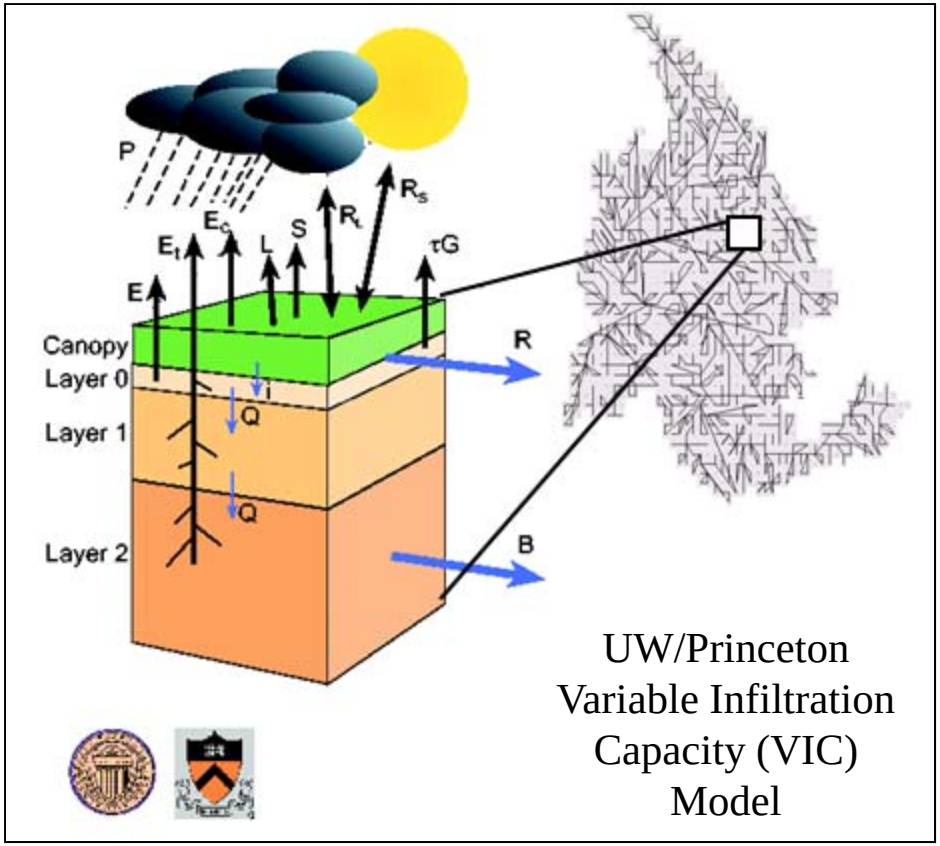
LONG-TERM FORECASTING OF WATER DEMAND AND SUPPLY USING VIC AND CROPSYST

CRPAG Meeting, Sep. 9, 2009

The Hydrology Model: VIC

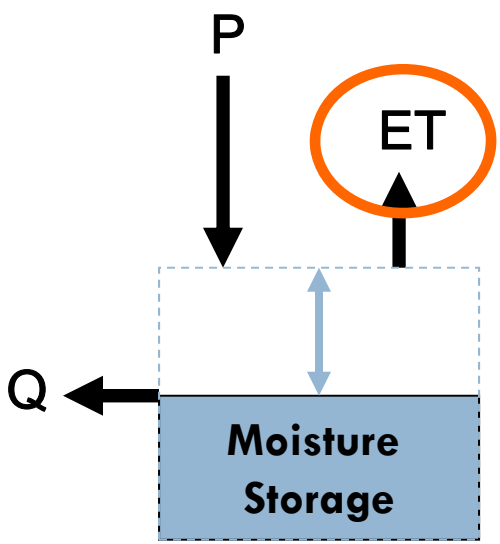
The Hydrology Model (VIC)



- Regional to Global Scales: 1/16° to 2 ° resolution
- 1 to 24 hourly time step
- Spatially distributed
- Closes the water and energy budgets
- Includes: snow, lakes, frozen soil

Solving the water and energy balance

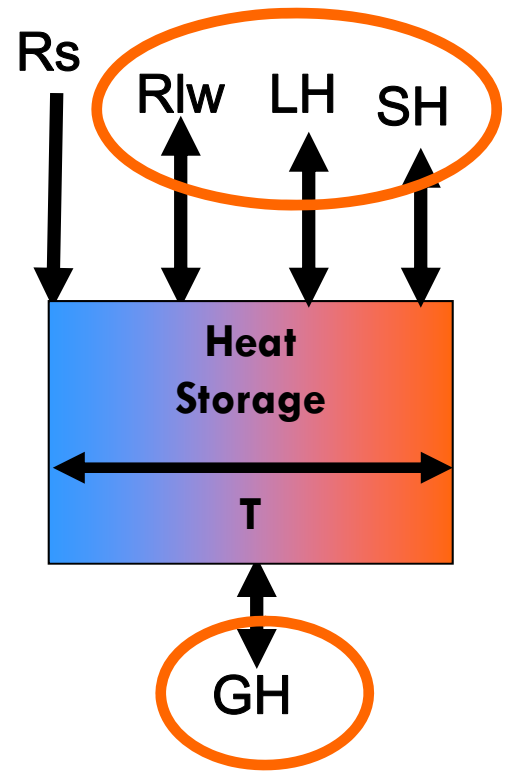
Water Balance



Variables that are a function of temperature

ET = f(LH)

Energy Balance

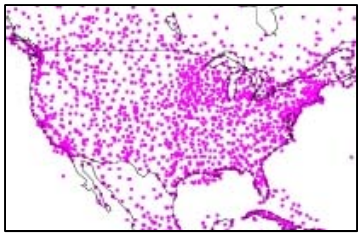


Slide courtesy of Andy Wood

Spatially-Distributed Input Data

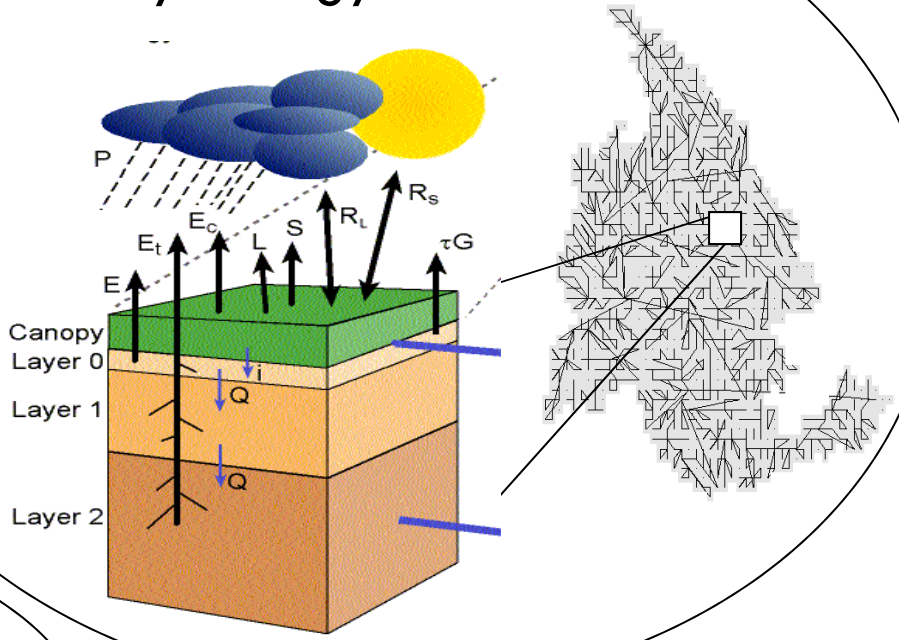
- Meteorology
  - Precipitation, temperature, wind speed, humidity, incoming shortwave
- Vegetation/Land Cover
  - Monthly leaf area index, albedo, roughness, etc…
- Soil Characteristics
  - Hydraulic conductivity, bulk density, surface roughness, infiltration parameters, etc…
- Topography

Historical Climate information (from observed data)

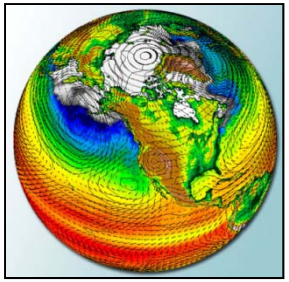


Meteorological Data

VIC Hydrology Model



Future Climate information (from GCMs)



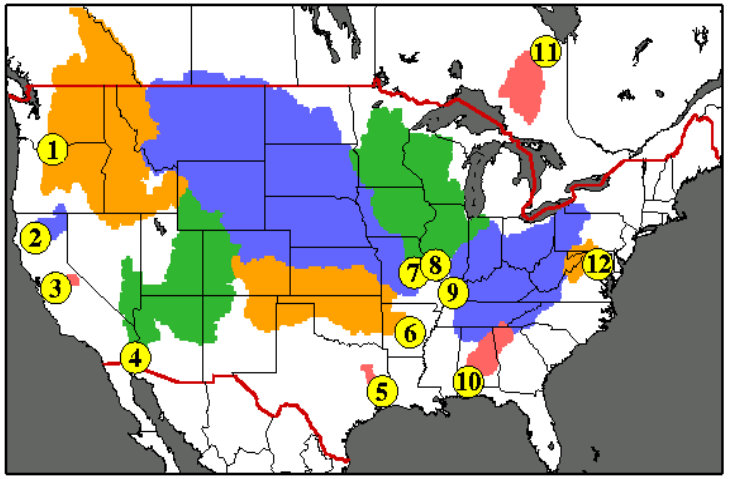
6 Sample Hydrographs (Maurer et al. 2002)

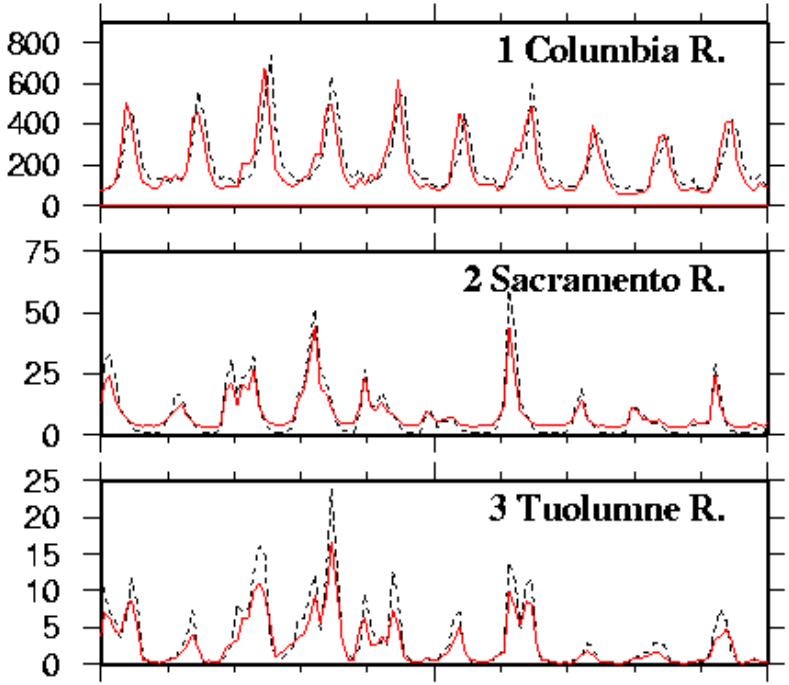
Good agreement of

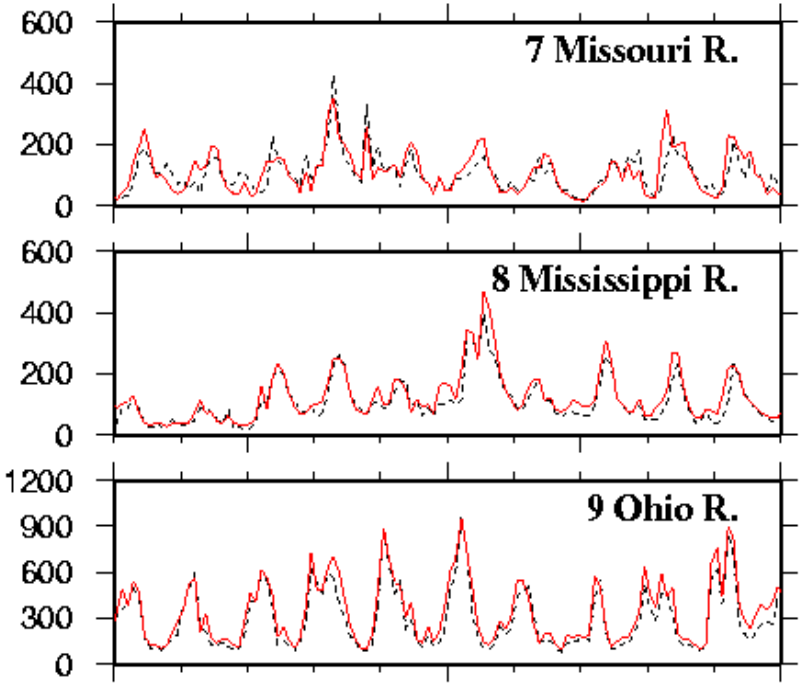
- **Seasonal cycle**
- **Low Flows**
- **Peak Flows**

Model

Obs.

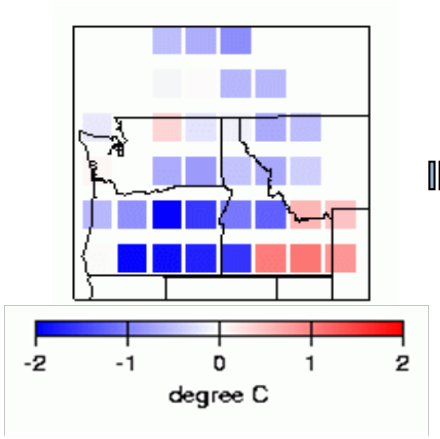




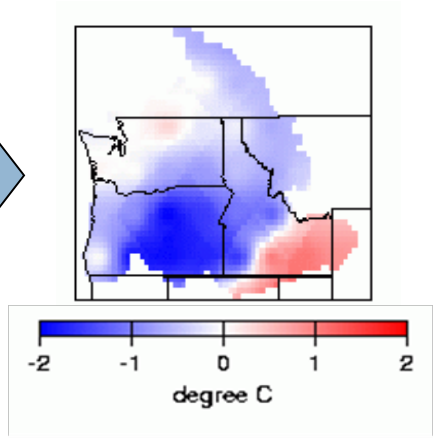


The Global Climate Data: downscaling approach

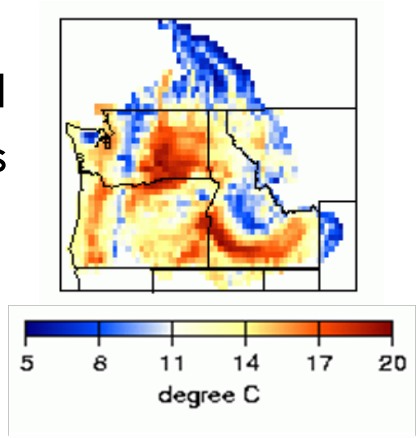
monthly PCM anomaly (T42)



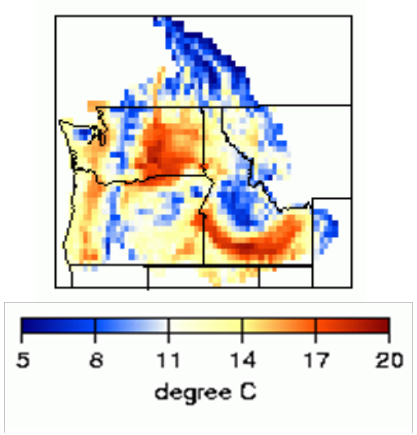
interpolated to VIC scale



observed mean fields



VIC-scale monthly simulation



Slide courtesy of Alan Hamlet

IPCC Emission Scenarios

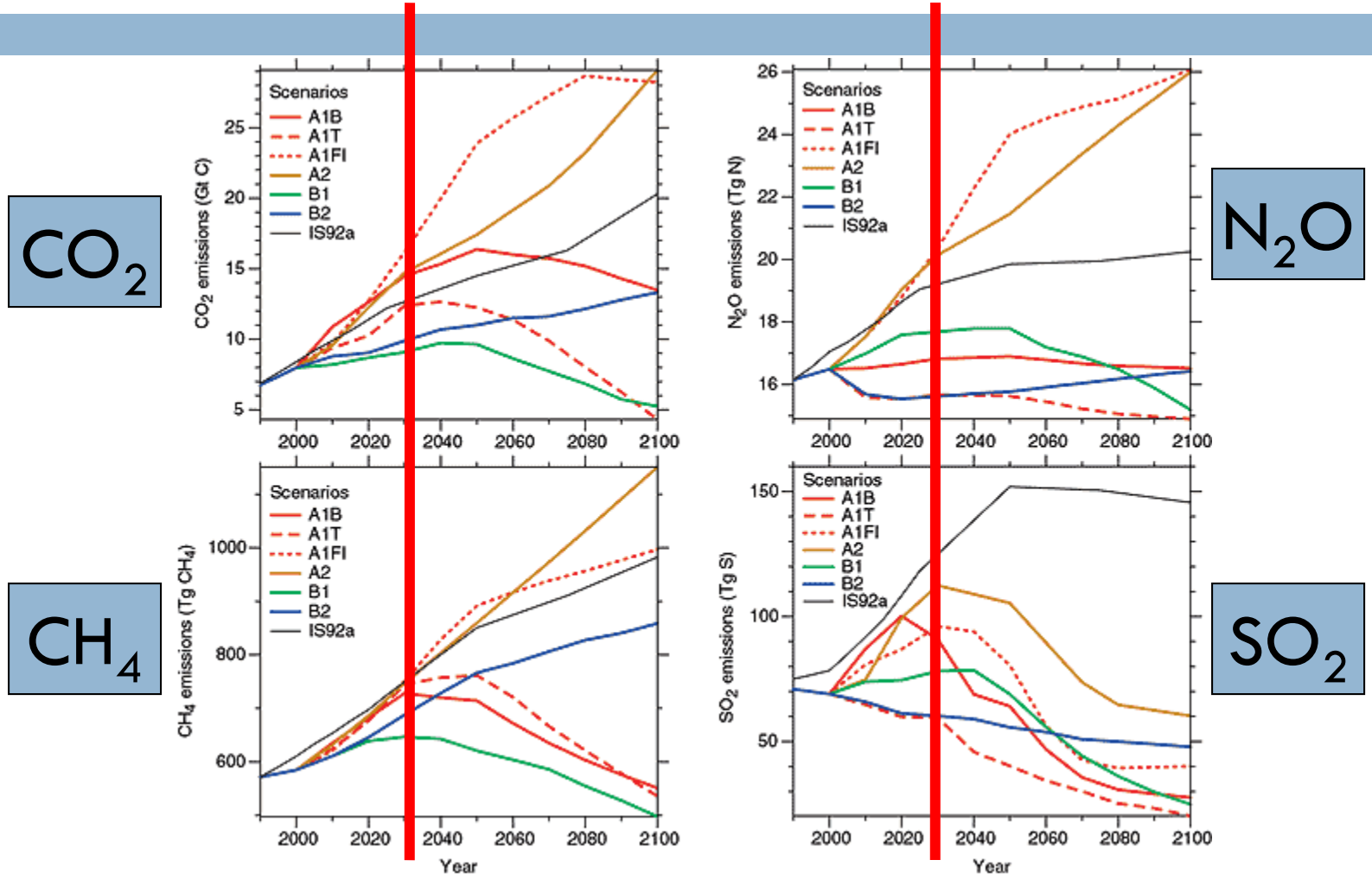
A1 Family of scenarios describe a future world with

- Very rapid economic growth
- Global population that peaks in mid-century and declines thereafter
- Rapid introduction of new and more efficient technologies.
- A1B is a balance of fossil and non-fossil energy sources

B1 Family of scenarios describe a future world with

- Convergent world with the same global population, that peaks in mid-century and declines thereafter, as in the A1
- BUT with rapid change in economic structures toward a service and information economy, with reductions in material intensity and the introduction of clean and resource-efficient technologies

Emission Scenarios

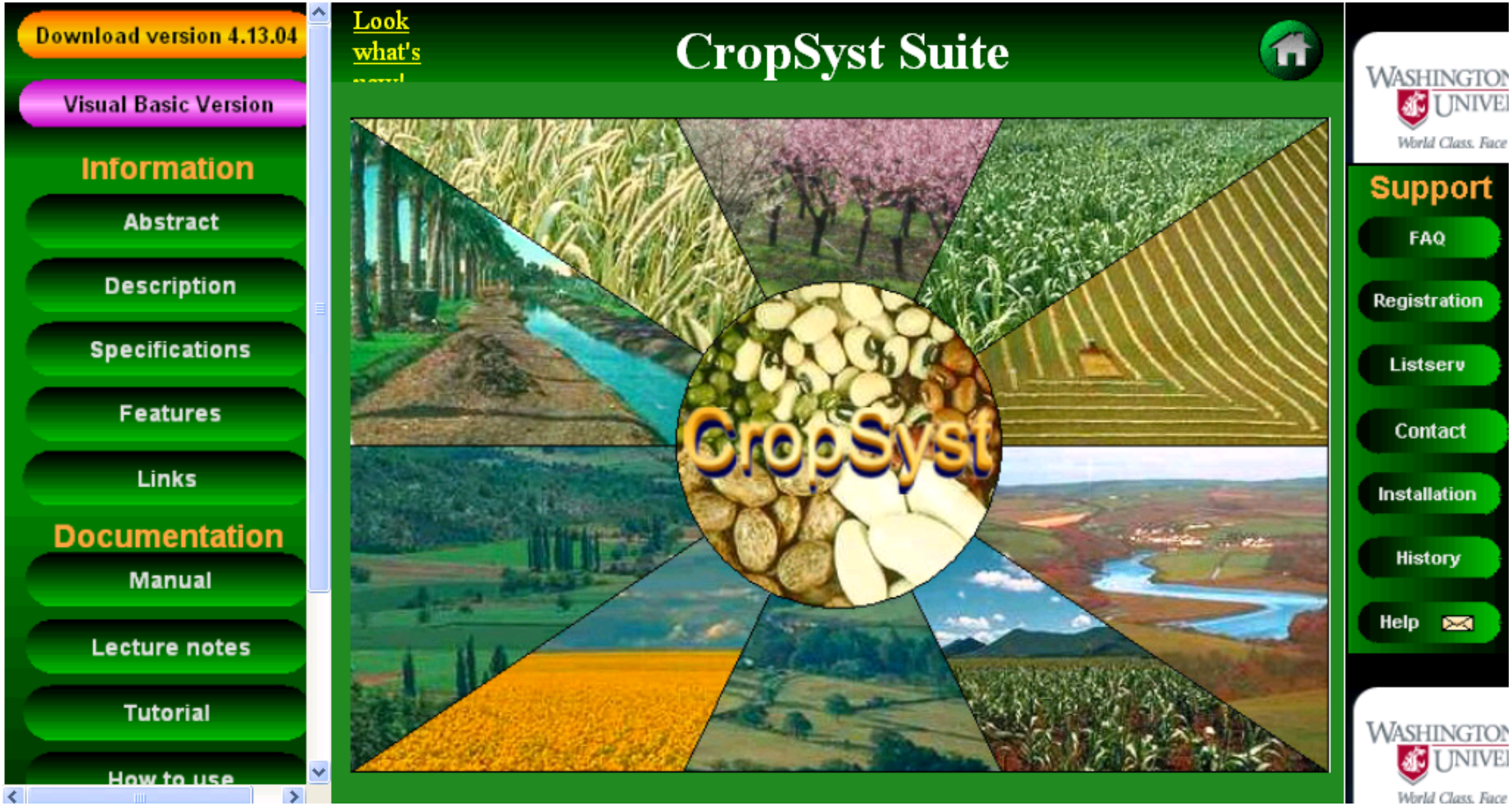


Anthropogenic emissions of CO2, CH4, N2O and sulphur dioxide for the six illustrative SRES scenarios, A1B, A2, B1 and B2, A1FI and A1T. For comparison theIS92a scenario is also shown.

[Based on IPCC Special Report on Emissions Scenarios.]

The Crop Growth Model: CropSyst

CropSyst

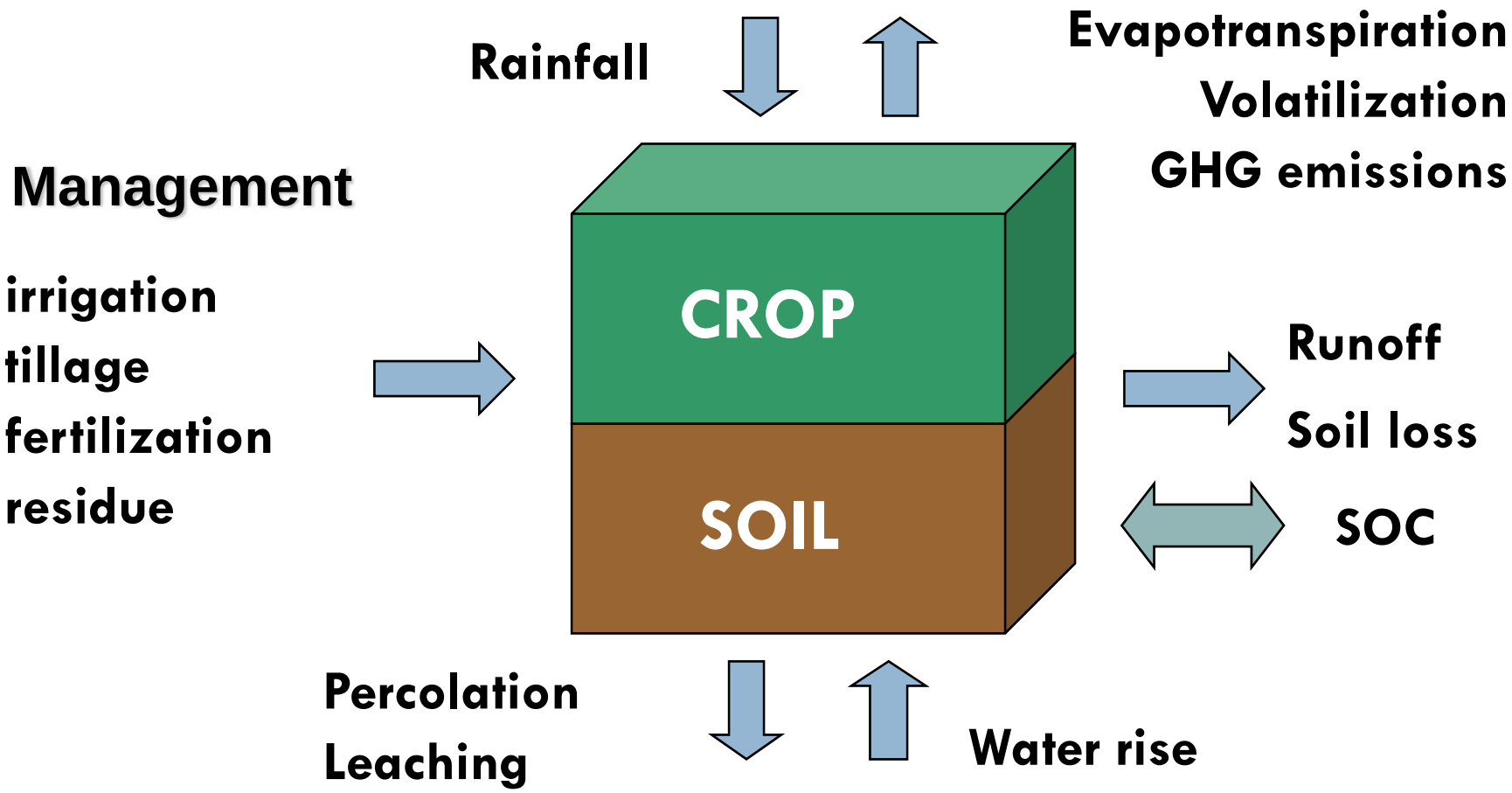


- http://www.bsyse.wsu.edu/cropsyst

CropSyst Description

- Developed by Claudio Stockle at WSU
- Multiyear, multicrop, daily time-step crop simulation model
- Technically sound, packaged in a user-friendly interface
- Available for Windows, Unix, Linux
- Accessible via Internet:
  - manuals, programs, documentation
  - listserver
  - related programs

Input and Output Fluxes of CropSyst



CropSyst includes the simulation of:

- Crop development and growth (unstressed or stressed)
- Simulation of growth under increased atmospheric CO_2 concentration
- Water and nitrogen balance
- Salinity
- Residue fate
- Soil erosion by water
- Carbon sequestration
- Greenhouse gas emissions (CO_2 and N_2O)

Crop processes in CropSyst

- development
- growth
- ligth interception
- net photosynthesis
- biomass partitioning
- Canopy expansion
- root deepening
- senescence
- water uptake
- nitrogen uptake
- water stress
- nitrogen stress
- temperature stress

Soil Processes in CropSyst

- water infiltration
- water redistribution
- runoff
- evaporation
- percolation
- solutes transport
- salinization
- nitrogen fixation
- residues fate
- O.M. mineralization
- nitrogen transformations
- soil erosion
- ammonia volatilization
- N_2O emission

Crop Categories

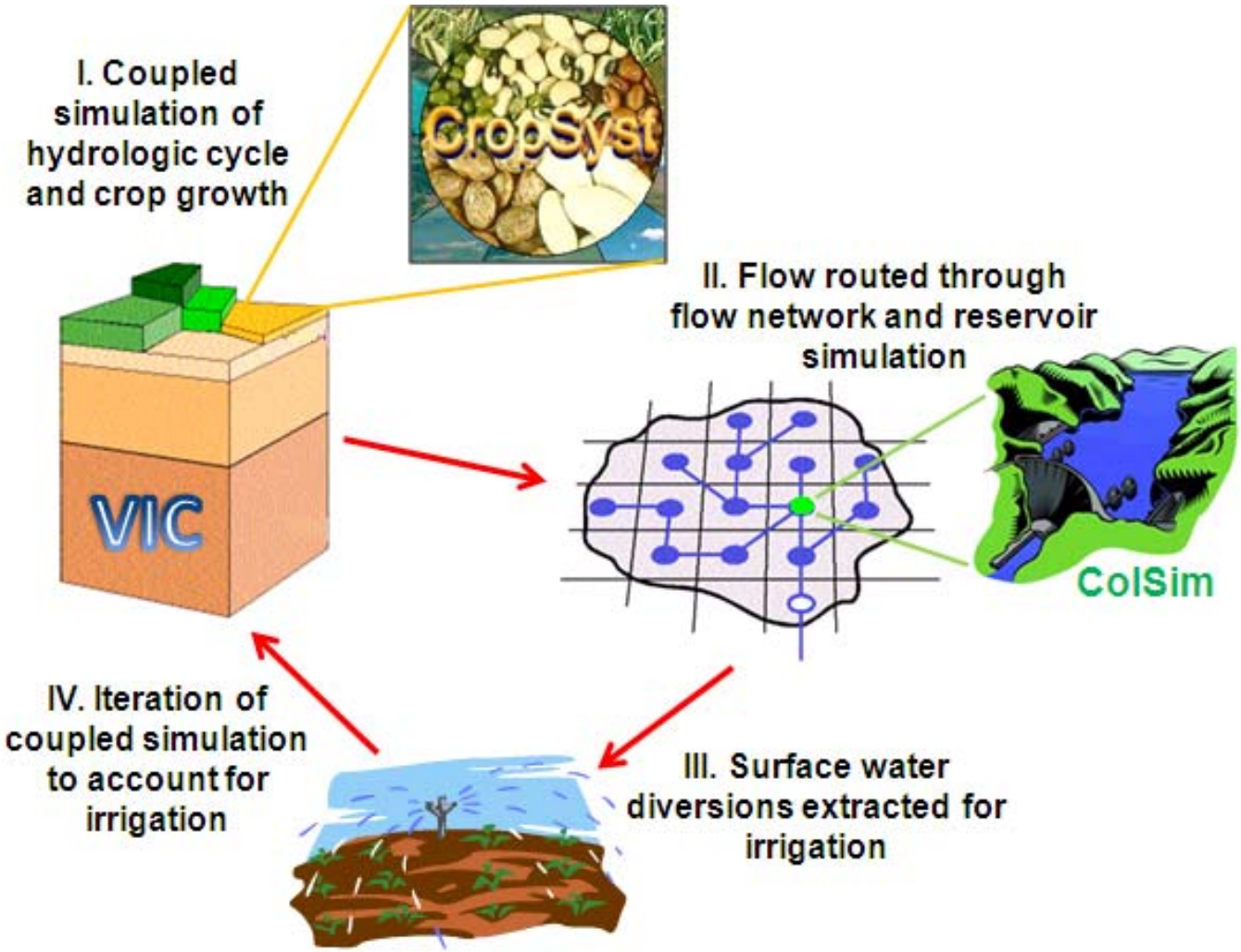
- Alfalfa
- Apples
- Cherries
- Other fruit trees (apricots, peaches, pears, prunes)
- Corn (sweet corn, silage corn, grain or seed corn)
- Dry peas, dry beans, and lentils
- Grass hay (uses significantly less water than alfalfa)
- Juice grapes (irrigated differently than wine grapes)
- Onions and other vegetables
- Pasture grass
- Potatoes
- Spring Wheat
- Winter Wheat
- Other cereals (barley, oats, rye)
- Wine grapes

Biofuel Crops

- Canola
- Sorghum
- Switchgrass

Integration

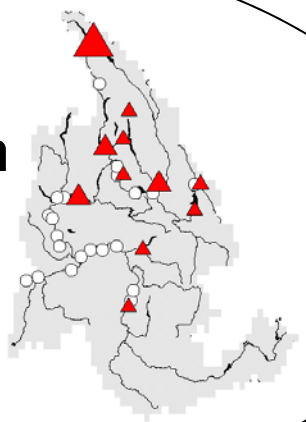
Model Integration



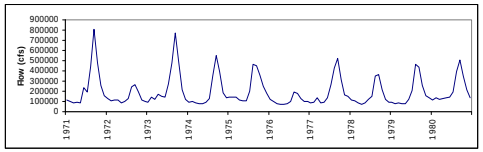
The Reservoir Model (ColSim)

Reservoir Operating Policies

Physical System
of Dams
and Reservoirs



VIC Streamflow Time Series



Reservoir Storage
Regulated Streamflow
Flood Control
Energy Production
Irrigation Consumption
Streamflow Augmentation

Slide courtesy of Alan Hamlet

Model Scenarios

- Climate Change
  - A1B and B1
- Quantity of Additional Water Resources
  - 100,000 – 1,000,000 acre-feet
- Spatial Distribution of Available Water Resources
  - Columbia River and dedicated tributary reserves only
  - Columbia River and tributary sources
- Value of Water
  - Free - $200/acre-ft/year
- Trade Scenarios Options
  - Low, mid, high
- Economic Growth
  - Low, mid high

Questions??