EXAMINATION ON THE EFFICACY OF NOAH-MULTIPARAMETERIZATION (NOAH-MP) AS A NEW LAND MODEL IN EARTH SYSTEMS MODELING

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WHAT IS AN EARTH SYSTEMS MODEL?

A background on the tools and techniques used by Earth Scientists

TOOLS USED BY EARTH SCIENTISTS

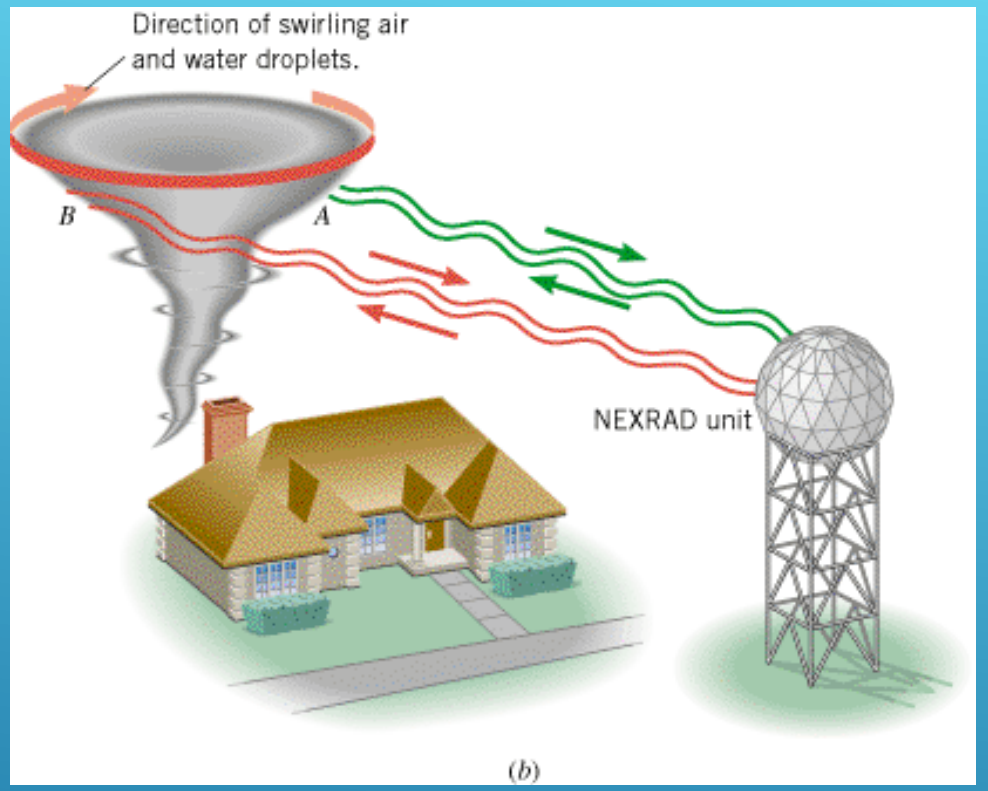
- Direct Measurements
- Indirect Information (e.g., remote sensing)
- Models (Two basic types):
  - Physical Models
  - Mathematical Models
    - A computer program used to project Earth's future climate, of which the modeling results have been used in previous IPCC (intergovernmental program of climate change) assessment reports

DIRECT MEASUREMENTS AND INDIRECT INFORMATION

Direct Measurements

Data/samples collected in the field

Indirect Measurements



Data is collected for interpretation of something else

PHYSICAL AND MATHEMATICAL MODELS

Physical Models

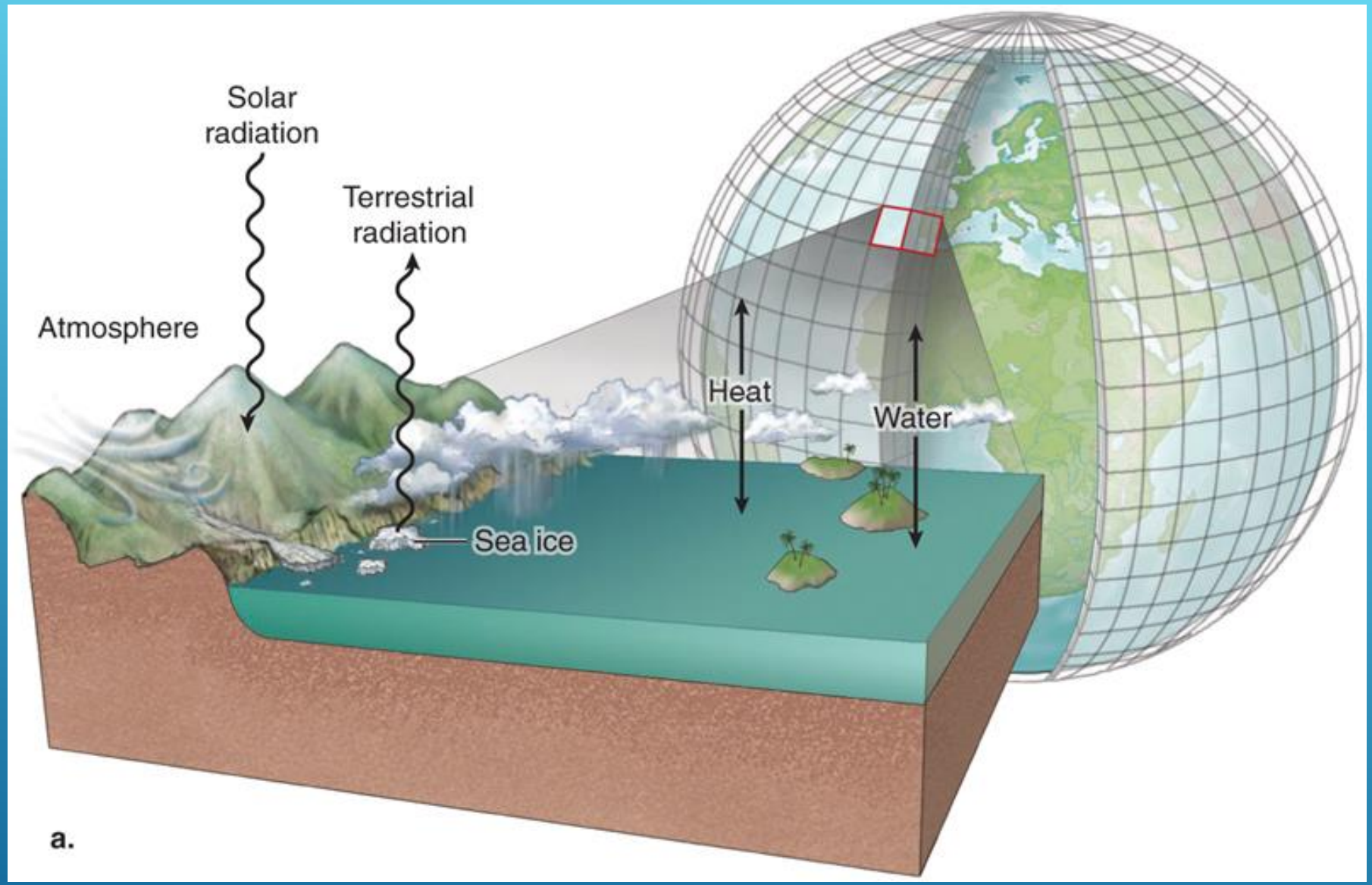
Biosphere 2

Mathematical Models

Hydrological Model

EARTH SYSTEMS MODELS

- Earth system models divide the Earth's Atmosphere, Ocean ,Land, and Sea Ice into many Grid-Boxes
- Earth System Models include numerical descriptions of
  - Energy Cycles
  - Carbon Cycles
  - Water Cycles
- The global water cycle includes evaporation from ocean, transport of water vapor to land through clouds, precipitation over land, evapotranspiration back to the atmosphere, and runoff back to the ocean
- The global water cycle is driven by the energy cycle
- Noah-Multiparameterization (Noah-MP) is a computer model dealing with energy, water, and carbon cycles over land.



AN EARTH SYSTEM MODEL

THE NOAH-MULTIPARAMETERIZATION MODEL

WHAT IS MULTIPARAMETERIZATION?

- Noah-MP is the inclusion of many different so-called “schemes”.
- These schemes are empirical equations based on physical experiments
- The schemes include, but are not limited to:
  - Soil hydrology schemes
  - Runoff schemes
  - Vegetation dynamics
    - plant photosynthesis
    - respiration
    - related nitrogen cycle

WHICH PARAMETERS WERE USED?

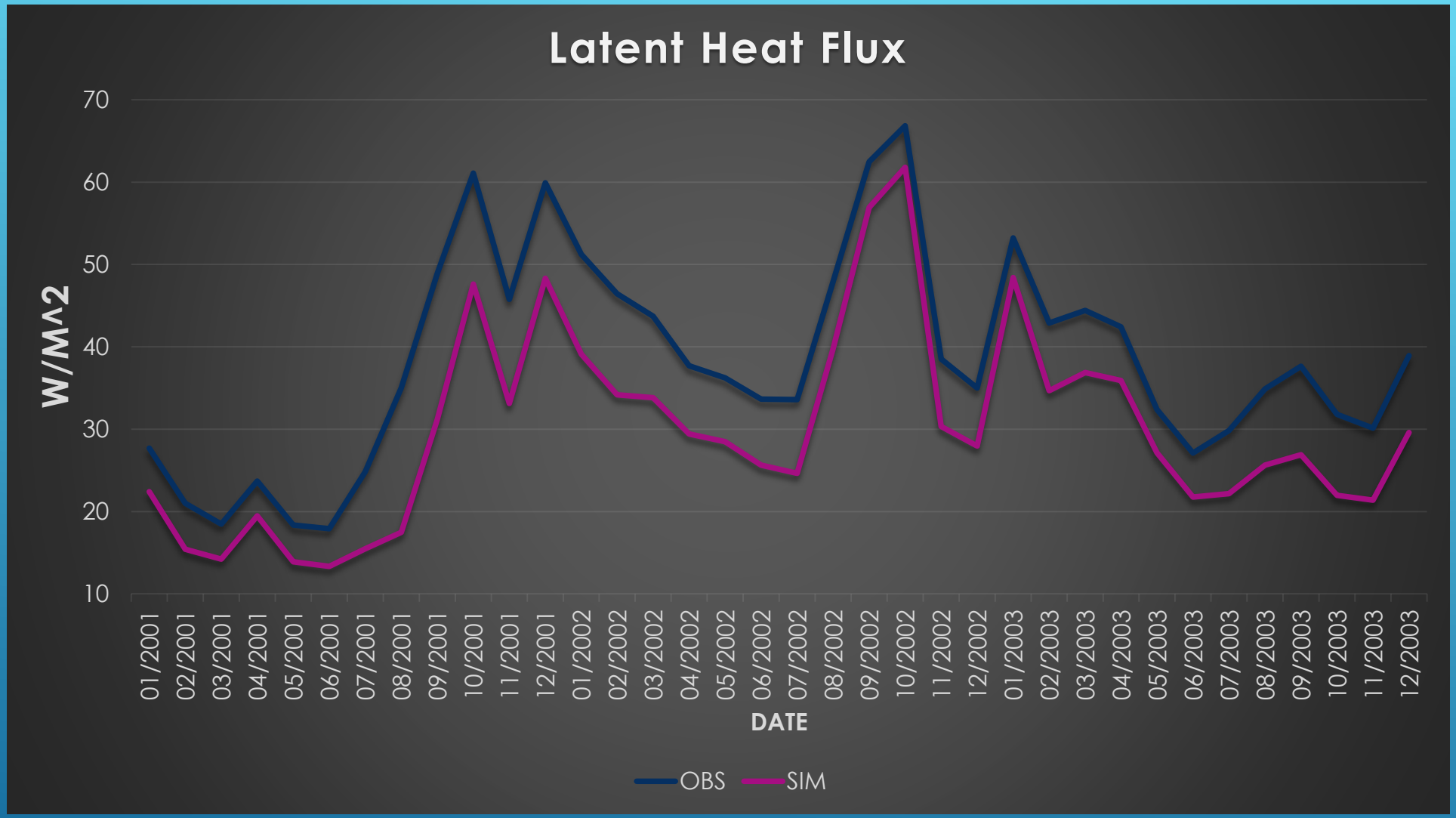
- The parameters included in Noah-MP are:
  - Vegetation Type → stomatal conductance, etc.
  - Soil Type → hydraulic parameters
- Each parameter has a range of values for the different types that is included in the model as "look-up" tables.
- The model used these parameters to predict the following variables:
  - Surface temp of leaves, soil, and snow
  - Soil & snow water storages
  - Surface water fluxes: evaporation & transpiration
  - And energy fluxes: latent and sensible heat fluxes

HOW WAS NOAH-MP'S VIABILITY TESTED?

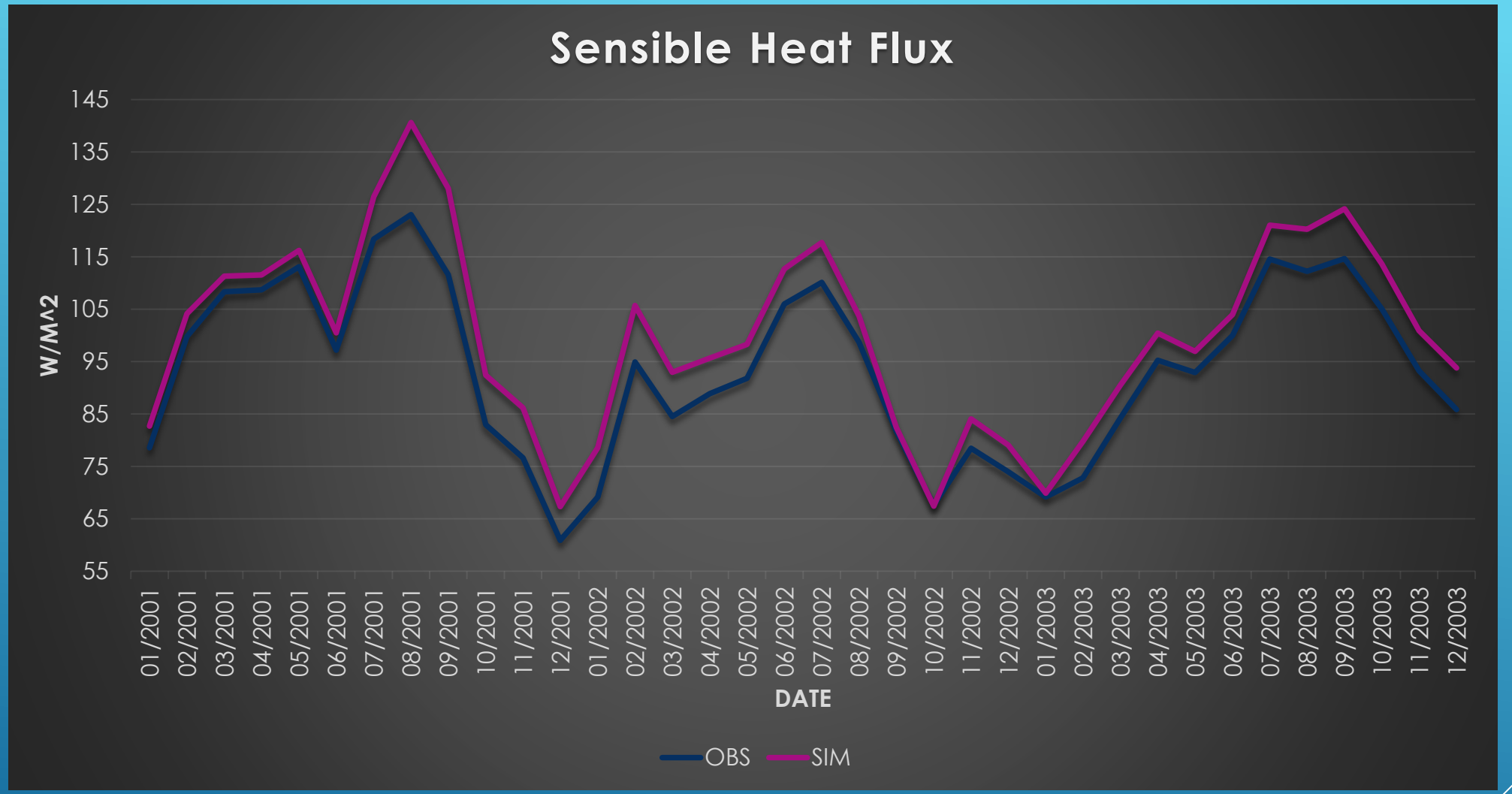
- In order to test the viability of Noah-MP, simulated data was compared to observed data.
- Data collected at different sites was run through the program to produce simulated data for that site. The parameters varied from site to site.
- For example, the Amazon Rainforest's profile of parameters is different from the profile of a grassland, especially in terms of vegetation and soil types.
- Data needed to run the program consisted of
  - Wind speed (m/s)
  - Wind direction (degrees)
  - Temp (K)
  - Humidity (%)
  - Pressure (hPa)
  - Radiation—longwave/shortwave (W/m^2)
  - Precipitation (kg/m^2s^1)
- Spin

RESULTS AND DISCUSSION

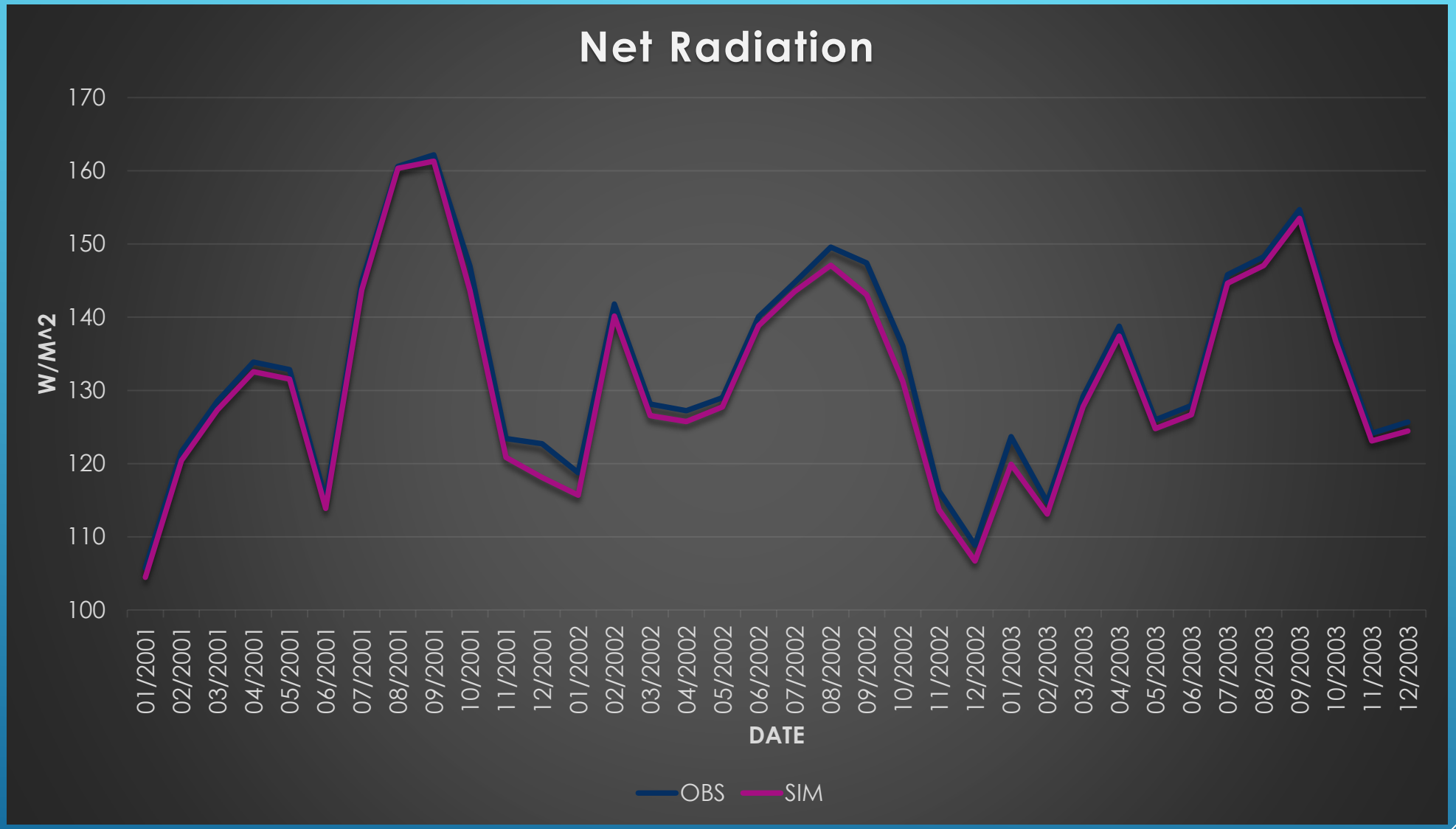
How well did Noah-MP hold up?



LATENT HEAT FLUX IS THE PART OF NET RADIATION THAT IS BEING PARTITIONED FOR EVAPOTRANSPIRATION, WHICH IS THE TOTAL WATER TRANSFERRED FROM LAND TO THE ATMOSPHERE



SENSIBLE HEAT FLUX IS THE PART OF NET RADIATION ENERGY THAT IS BEING PARTITIONED TO HEAT, WHICH IS USED TO HEAT UP THE LOWER ATMOSPHERE.



THIS IS TOTAL ABSORBED ENERGY BY THE LAND SURFACE – THE ULTIMATE ENERGY SOURCE FROM THE SUN AND THE NEAR INFRARED RADIATION FROM THE ATMOSPHERE

- Latent heat flux is consistently underestimated by the model
- Meanwhile, sensible heat flux is overestimated by the model
  - The underestimation of QFX and overestimation FSH balance each other out.
- However, total net radiation is steadily in line with the observed data
  - This is because total net radiation is the sum of QFX and FSH.
- Other variables are represented much in the same way as these three

THESE RESULTS HELP US TO RE-EXAMINE THE MODEL SCHEMES (PHYSICS THAT SHOULD BE UNIVERSAL)

CONCLUSIONS

WHAT DOES IT ALL MEAN?

- The model is well on its way to becoming a viable tool in Earth Scientists' toolbox.
- This model has been coupled with the National Center for Environmental Prediction (NCEP) for weather prediction and short-term climate predictions.
- Since some variables are either overestimated or underestimated, the error(s) causing this may be consistent and therefore relatively easy to fix.
  - Change tree root depth (make it more dynamic)
- This data only represents a small portion of the work to be done
  - More regions/biomes tested
  - Integration with other ESMs (oceanographic/atmospheric models)
- Test same regions/biomes with different data
  - Resistance to drought, etc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DISCLAIMER

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- [2] Zong-Liang Yang, Guo-Yue Niu, Kenneth E. Mitchell, Fei Chen, Michael B. Ek, et al.. The community Noah land surface model with multiparameterization options (Noah-MP): 2. Evaluation over global river basins. Journal of Geophysical Research, American Geophysical Union (AGU), 2011, 116, pp.12110. <10.1029/2010JD015140>. <hal-00708063>
- Some pictures taken from a presentation Dr. Niu gave at Biosphere 2