The Marssim Model

- The skeleton is a pretty generic landform evolution model:
  - Weathering
  - Non-linear diffusive creep
  - Bedrock channels erosion by any of several rate laws
  - Sediment transport (single grain size) and deposition – fans, pediments, deltas
    - Uses possibly unique routing procedure for computational efficiency

More details

- Rectangular cells
- Conceived generally as ~X-year time stepping
- Possibility of periodic x-y boundaries
- Model unique features directed primarily towards planetary applications
  - Flow routing through depressions with evaporation
  - Impact cratering
  - Erosion by groundwater seepage/weathering
  - Lava flows
  - Airfall deposition
  - Erosion-deposition by sublimation/precipitation
  - Erosion under fluctuating ocean/lake levels (applied to coastal landform evolution)

More features

- Simple parameterization of vegetation influence on landform evolution as a spatially-temporally varying critical shear stress
  – Coastal plain evolution
  – Badlands and gullying
- Dynamic allocation of arrays dependent upon domain size and simulated processes
- F90 with global variables in modules

Flow Routing Model

- The model balances runoff from precipitation with evaporation from standing water
- Runoff could be direct overland flow or precipitation-fed groundwater discharge
- Flow is routed downstream to collect in depressions, and some or all of the flow is evaporated in the resulting lakes
- The model works on an annual balance of precipitation, runoff, and evaporation
- The next slide shows the flow balance

The Model of Steady-State Annual Runoff Balance (No Groundwater):

Outflow volume from basin

Total basin area

Fraction of precipitation contributing to runoff

Yearly evaporation depth

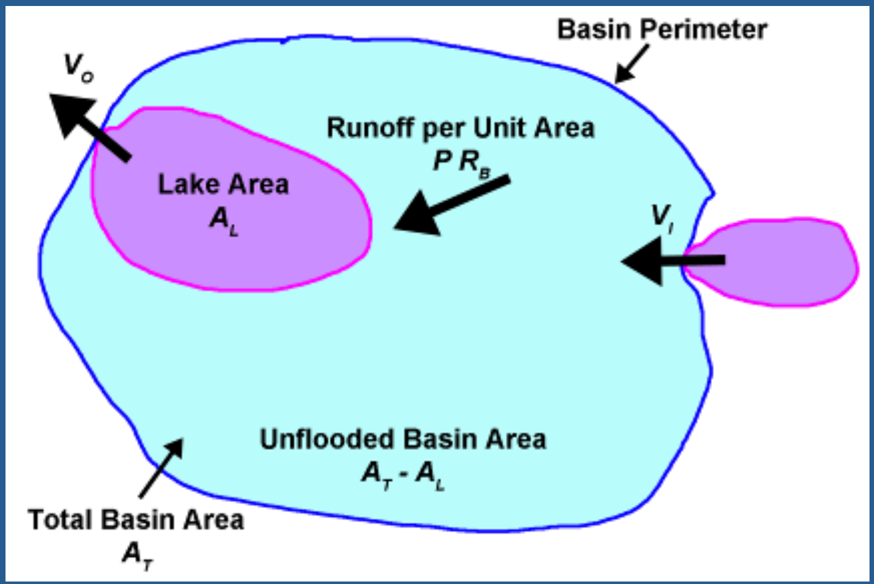
$$V_O = V_I + (A_T - A_L) P R_B + A_L P - E A_L$$

Inflow from other basins

Lake area

Precipitation depth

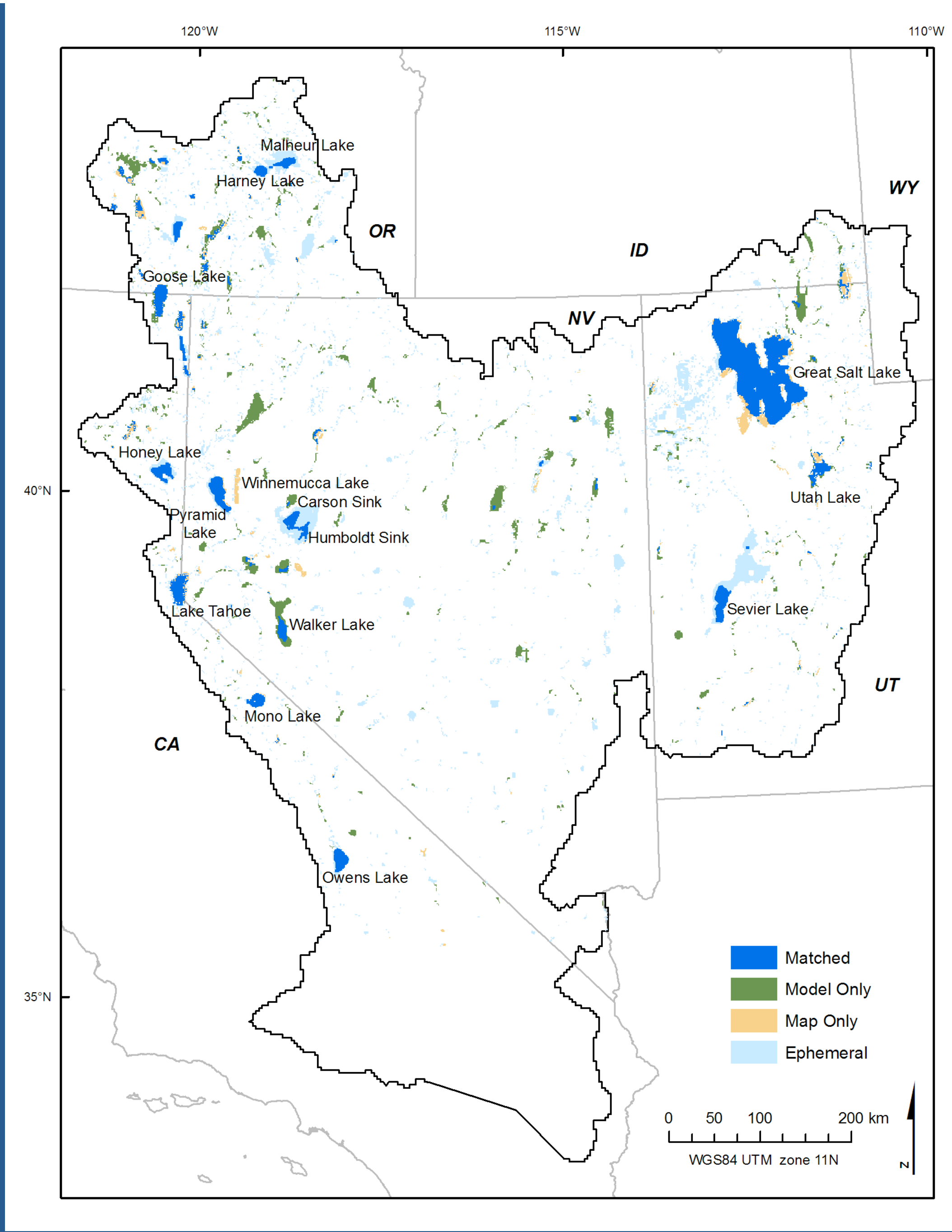
- Assume no en-route evaporation
- $V_O > 0$ if maximum lake area $(A_{LM}) < A_L$



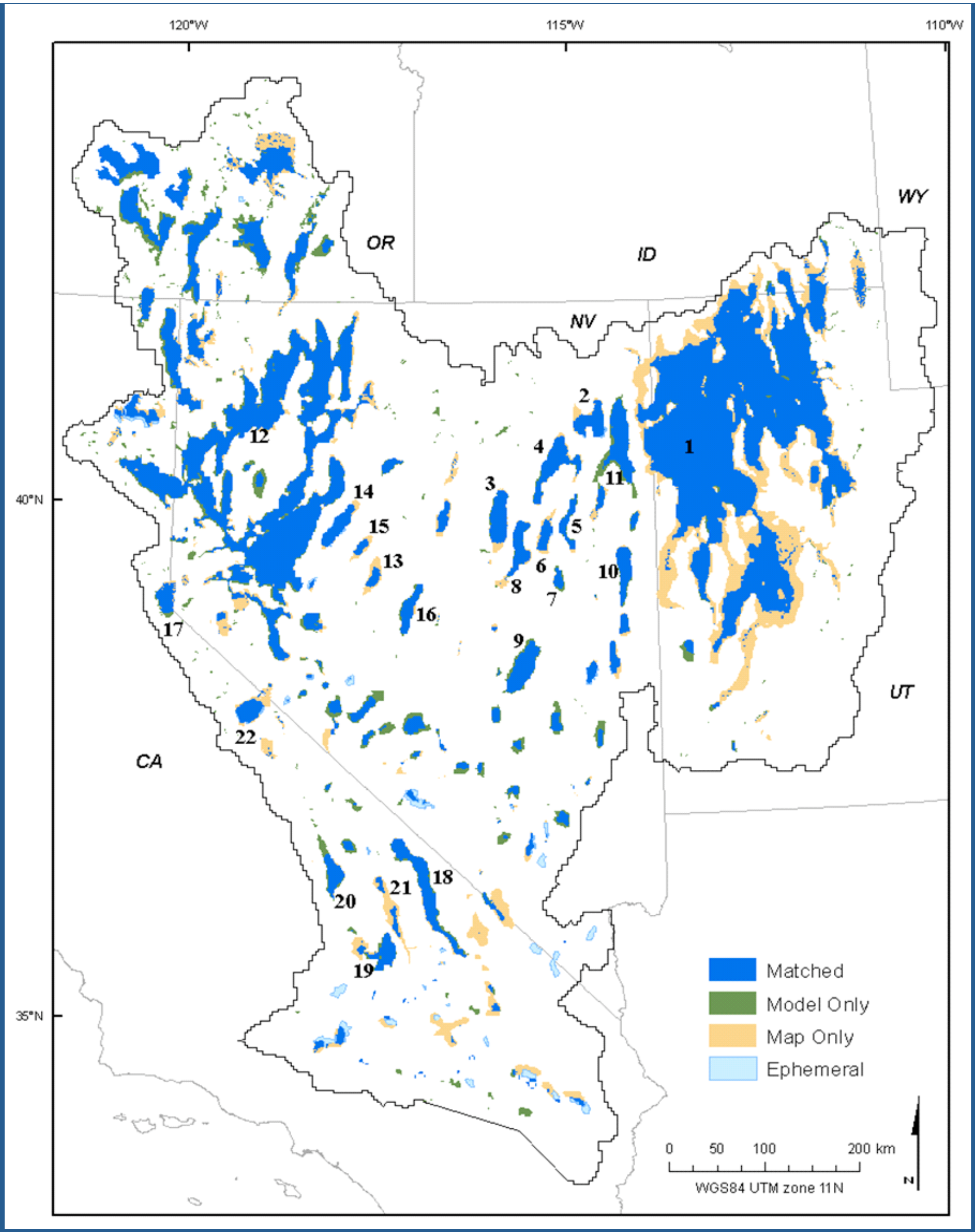
Model Structure

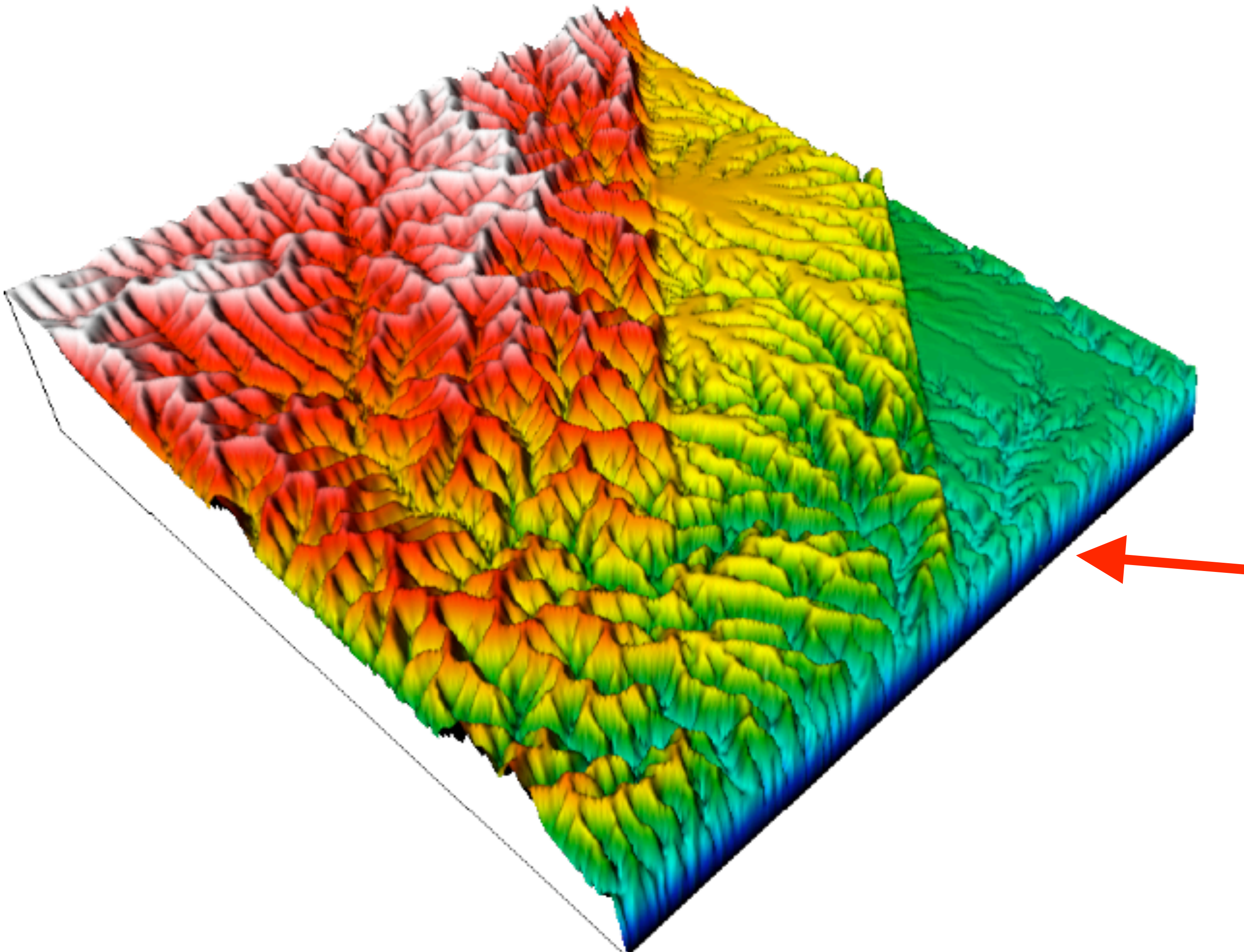
- Lake area in balance with inputs is calculated
- If the calculated lake area is larger than the maximum lake area before overflow, A_{LM}, overflow occurs
- An iterative approach is necessary because of linkage of basins and mutual flooding
- The model was tested by application to the Great Basin region of the southwestern U.S. using data on precipitation, runoff, and lake evaporation and regression relationships.

Simulated lakes under modern conditions



Simulated late Pleistocene lakes for areally uniform -5.5°C mean annual temperature change and +0.09 m of areally uniform annual rainfall increase

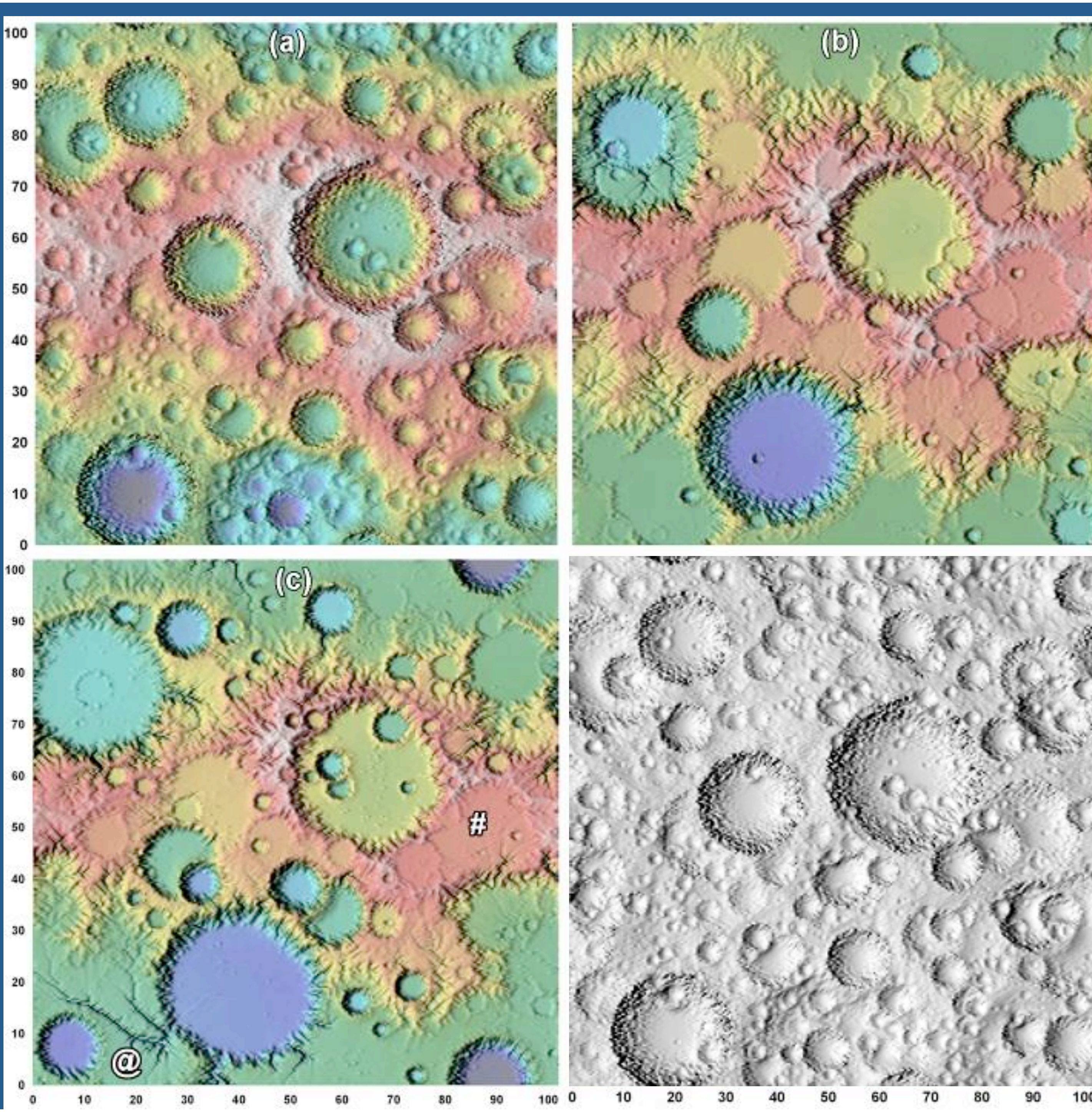




OTOMAC RIVER
ESTUARY

of initially flat
race under simulated
and gradual uplift
development of
wave-cut terraces at certain
highstands.

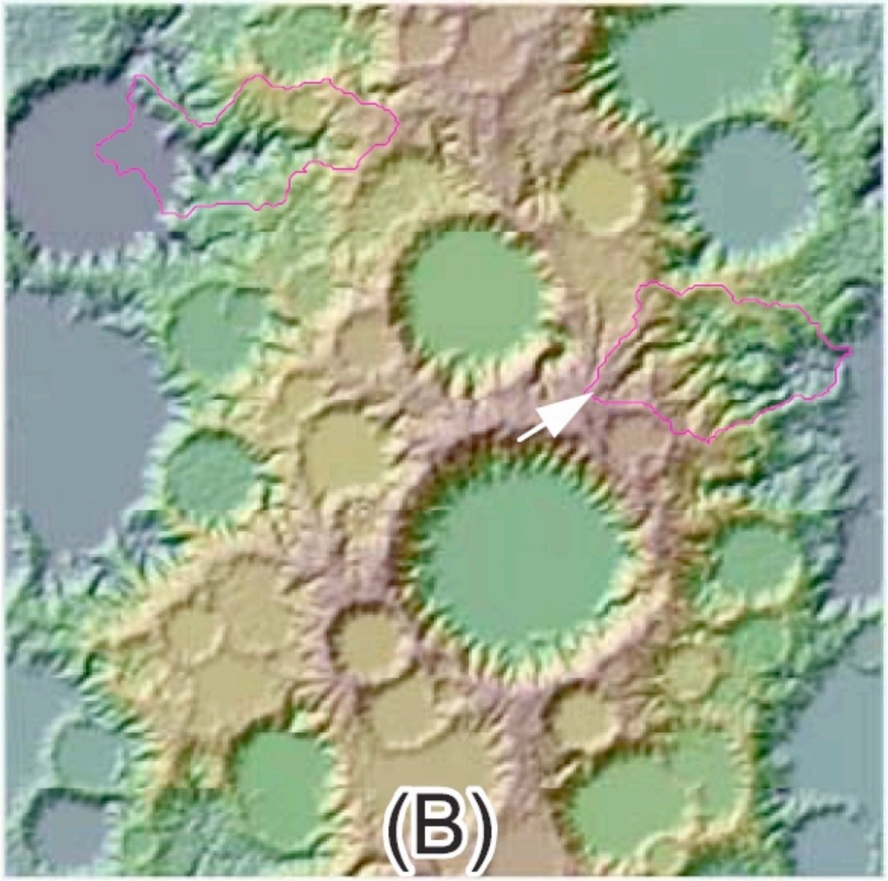
• Effects of vegetation as critical shear stress protecting soft c-p sediments

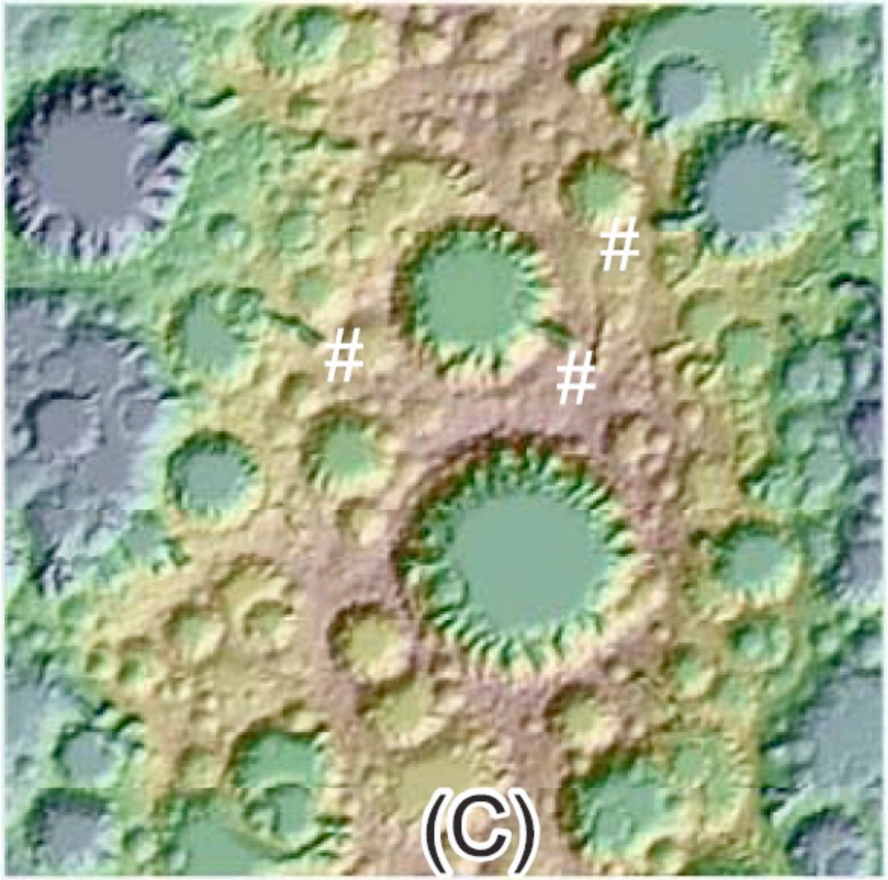


Simulated fluvial erosion with modest concomitant cratering rate and high initial relief

Fluvial networks are dynamic due to cratering, but they are fairly obvious in the landscape

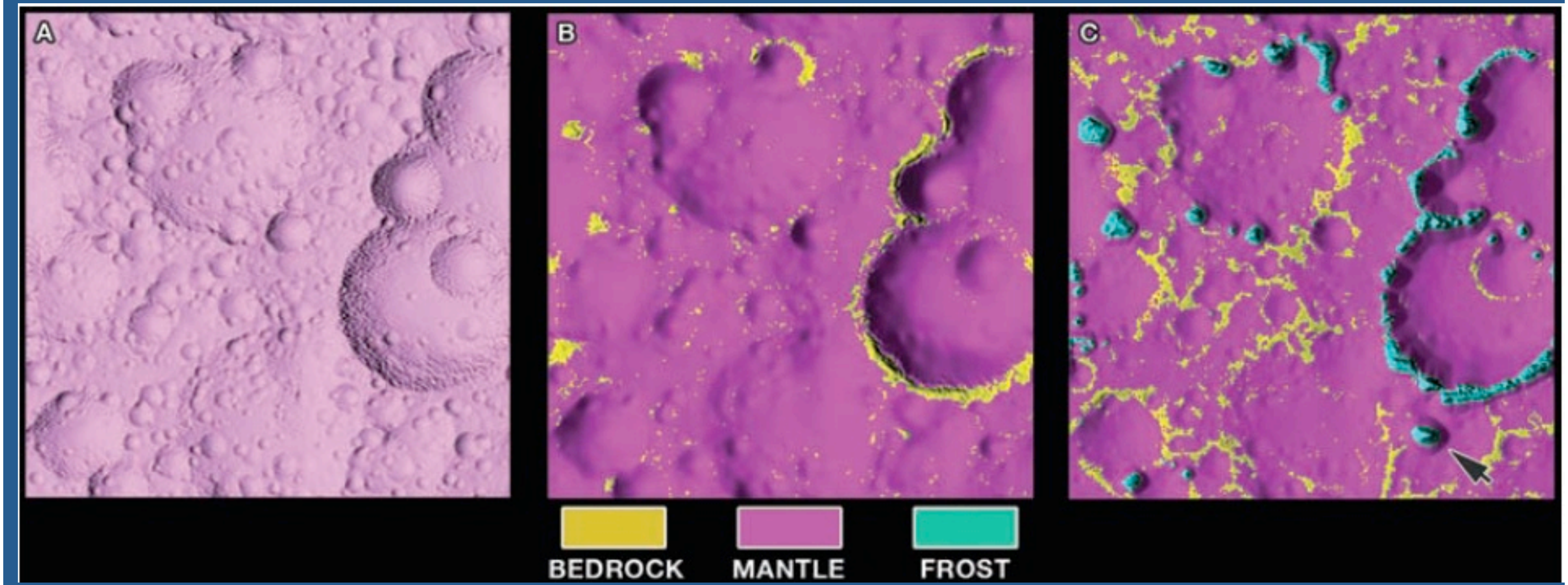
For more on this simulation modeling see Howard, 2007, in *Geomorphology*





Fluvial erosion

Seepage Erosion



- Dusty ice “bedrock” is sublimated by reflected IR radiation
- Icy mantle accumulates in low areas, protecting bedrock
- If no ice redeposition , upper crater walls retreat (central panel)
- If ice is redeposited on high points, crater rims exaggerated (last panel)