OLAM-SOIL Workshop

2017 AGU Fall Meeting, December 9

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Simone Fatichi
Dani Or

- Motivation for the project and OLAM-SOIL workshop – ISMC and GEWEX links
- introduction to OLAM and OLAM-SOIL (and brief history of RAMS and OLAM)
- Focus on new developments in OLAM-SOIL
- Vegetation and soil biogeochemistry
- Soil structure effects

OLAM Prehistory:

- Regional Atmospheric Modeling System (RAMS)

- Colorado State University (1987-2000)

- Designed for high resolution simulations of mesoscale and microscale systems (clouds, thunderstorms, hurricanes, flow over mountains, continental-scale weather)

- Limited-area model domain – requires lateral boundary conditions

- Can use nested grids for higher resolution in selected areas

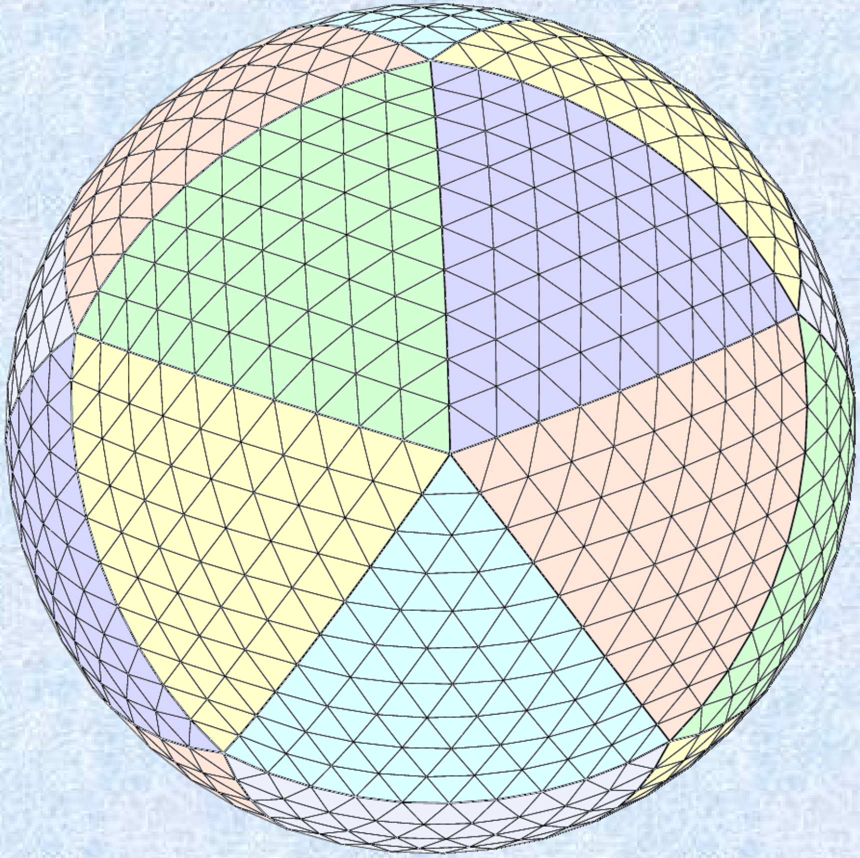
- Solves equations for wind velocity, pressure, density, temperature, water vapor, liquid and ice condensate, trace gases and aerosols

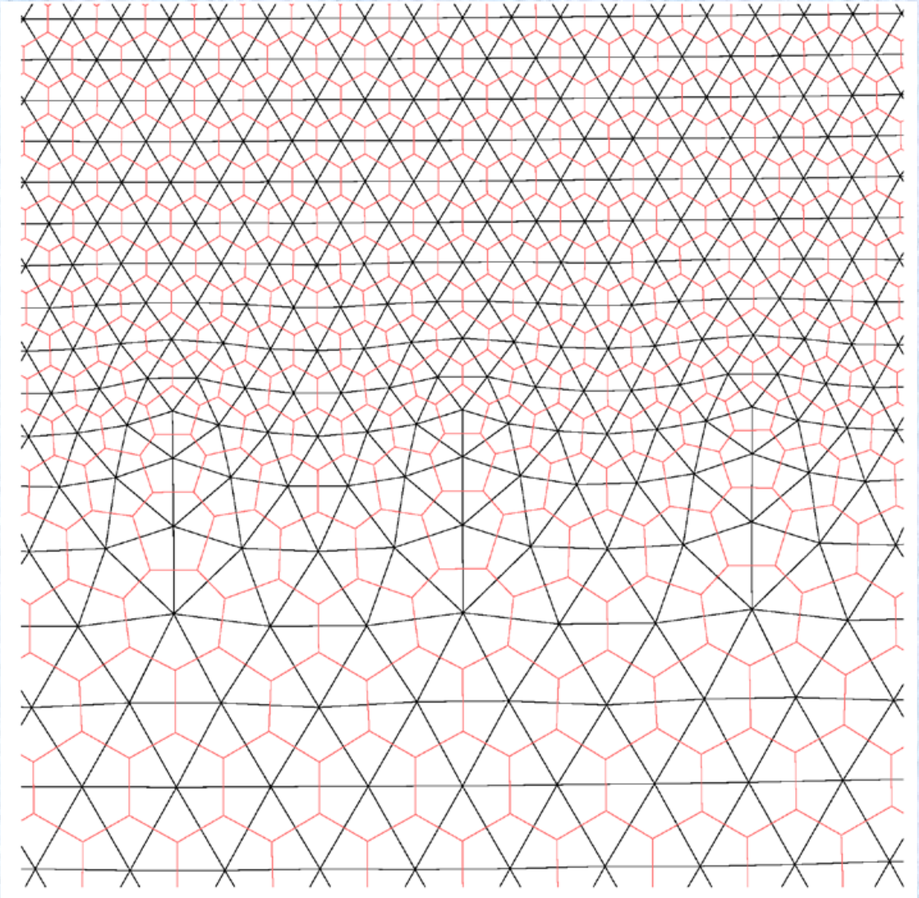
- Principally an atmospheric model, but necessarily includes interaction with land and ocean areas (*OLAM-SOIL → more detailed land interactions*)

Ocean-Land-Atmosphere Model (OLAM)

Duke University 2000-2009; University of Miami 2009-present

Developers: Robert Walko, Martin Otte, David Medvigy
Project Leader: Roni Avissar



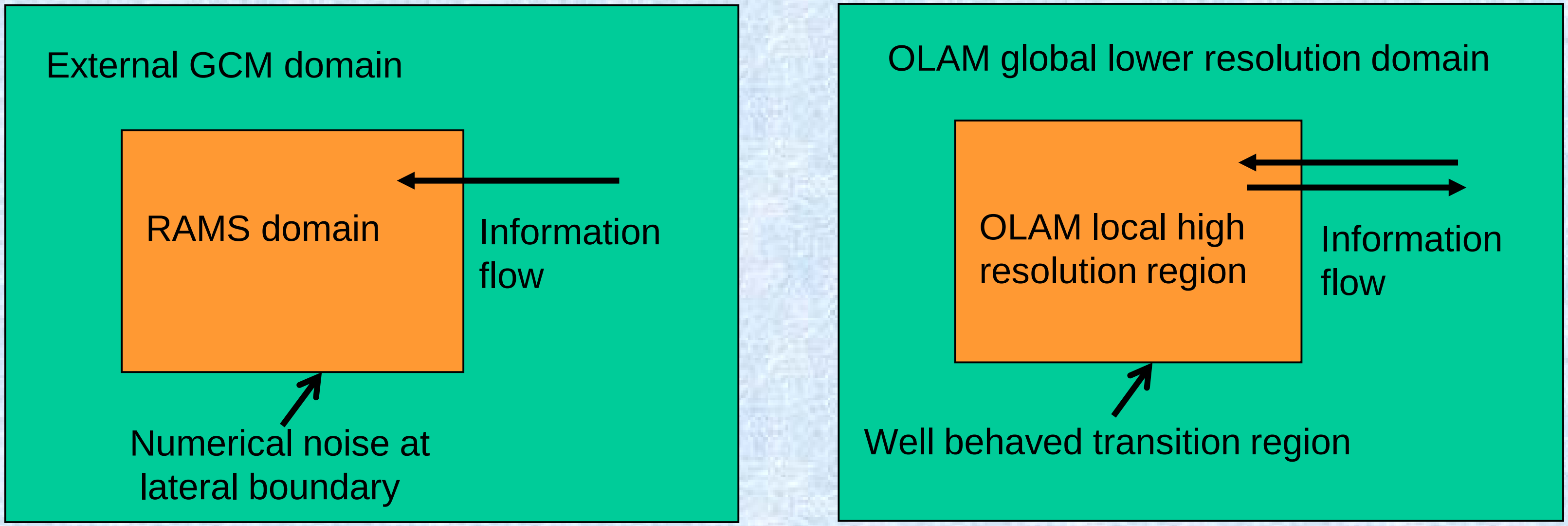


Motivation for OLAM originated in our work with the Regional Atmospheric Modeling System (RAMS)

RAMS, begun in 1986, is a limited-area model similar to WRF and MM5

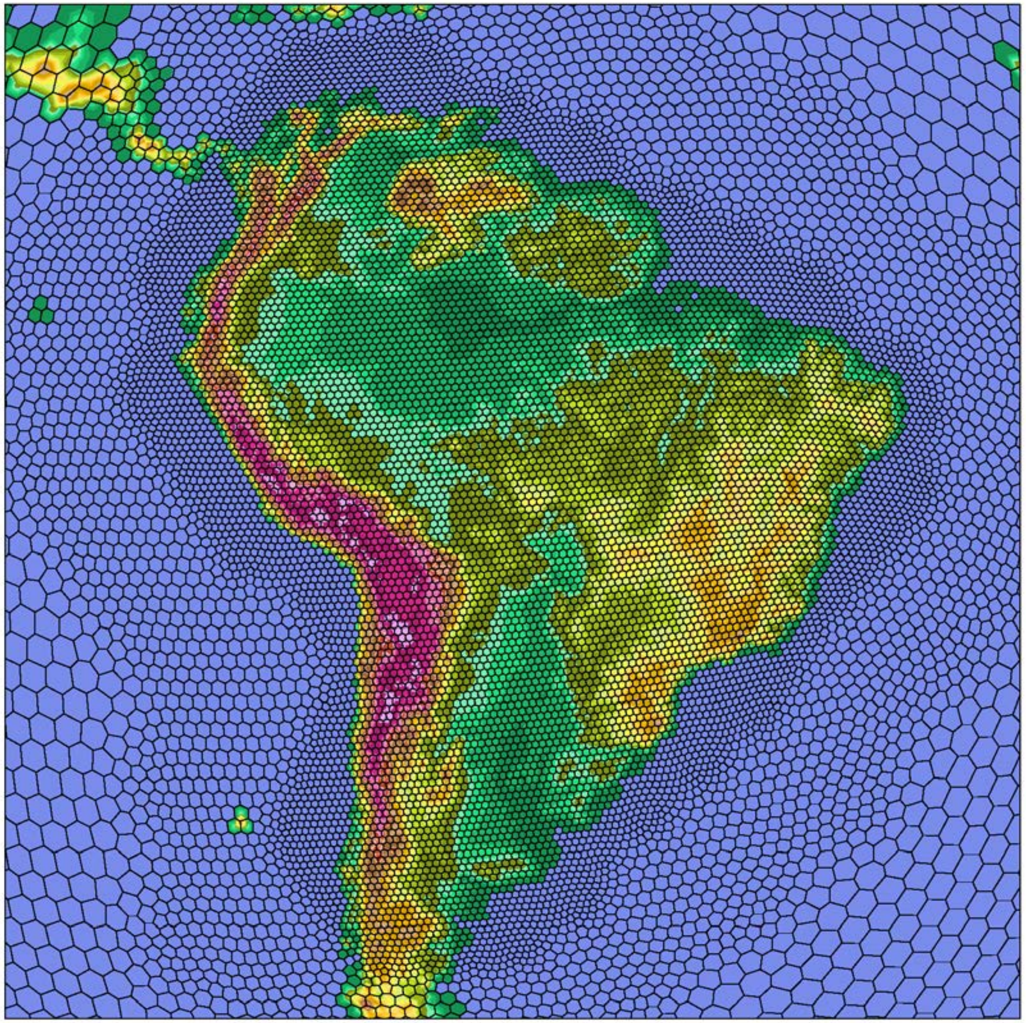
Features include 2-way interactive grid nesting, microphysics and other physics parameterizations designed for mesoscale & microscale simulations

But, there are significant disadvantages to limited-area models

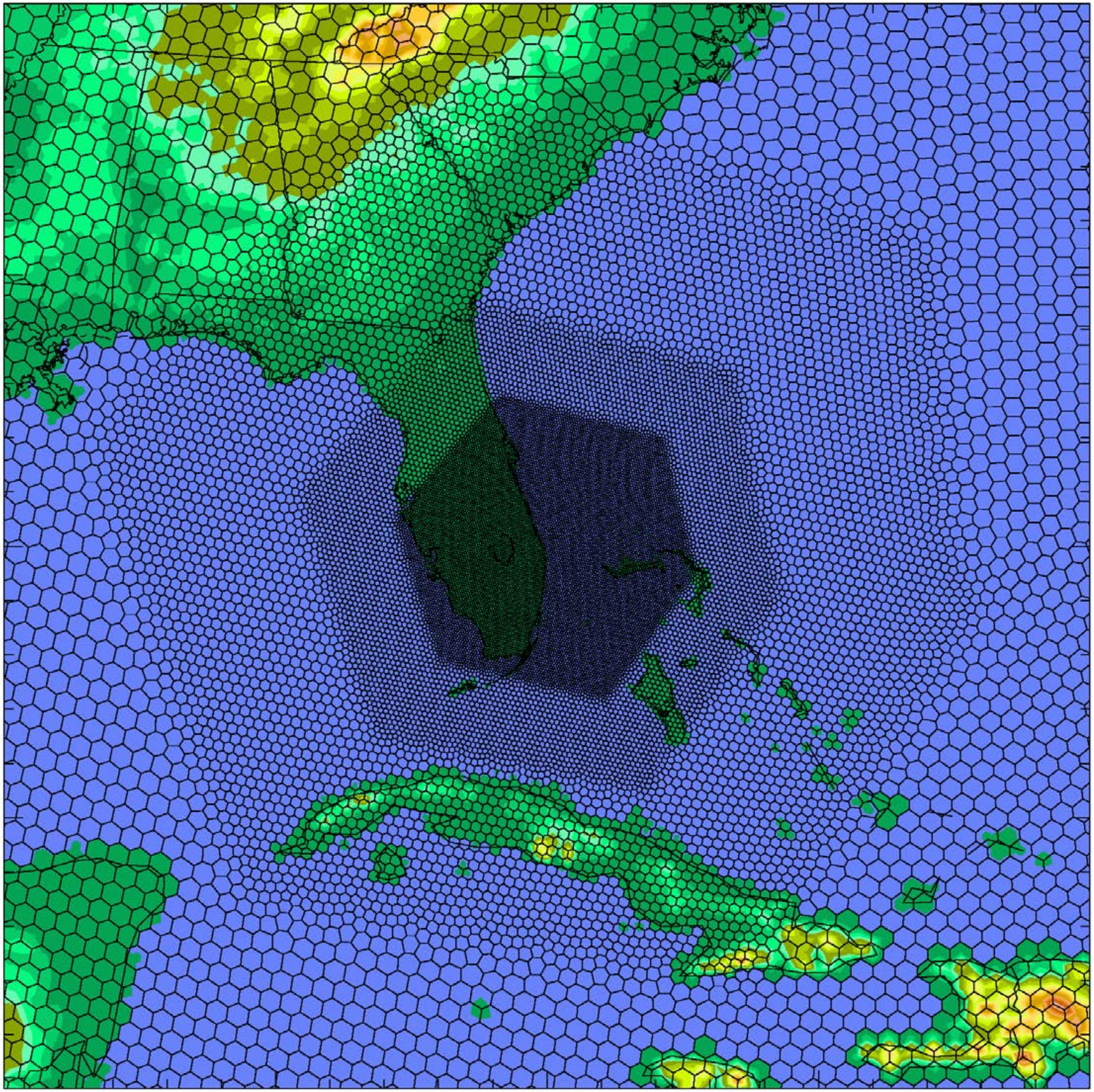


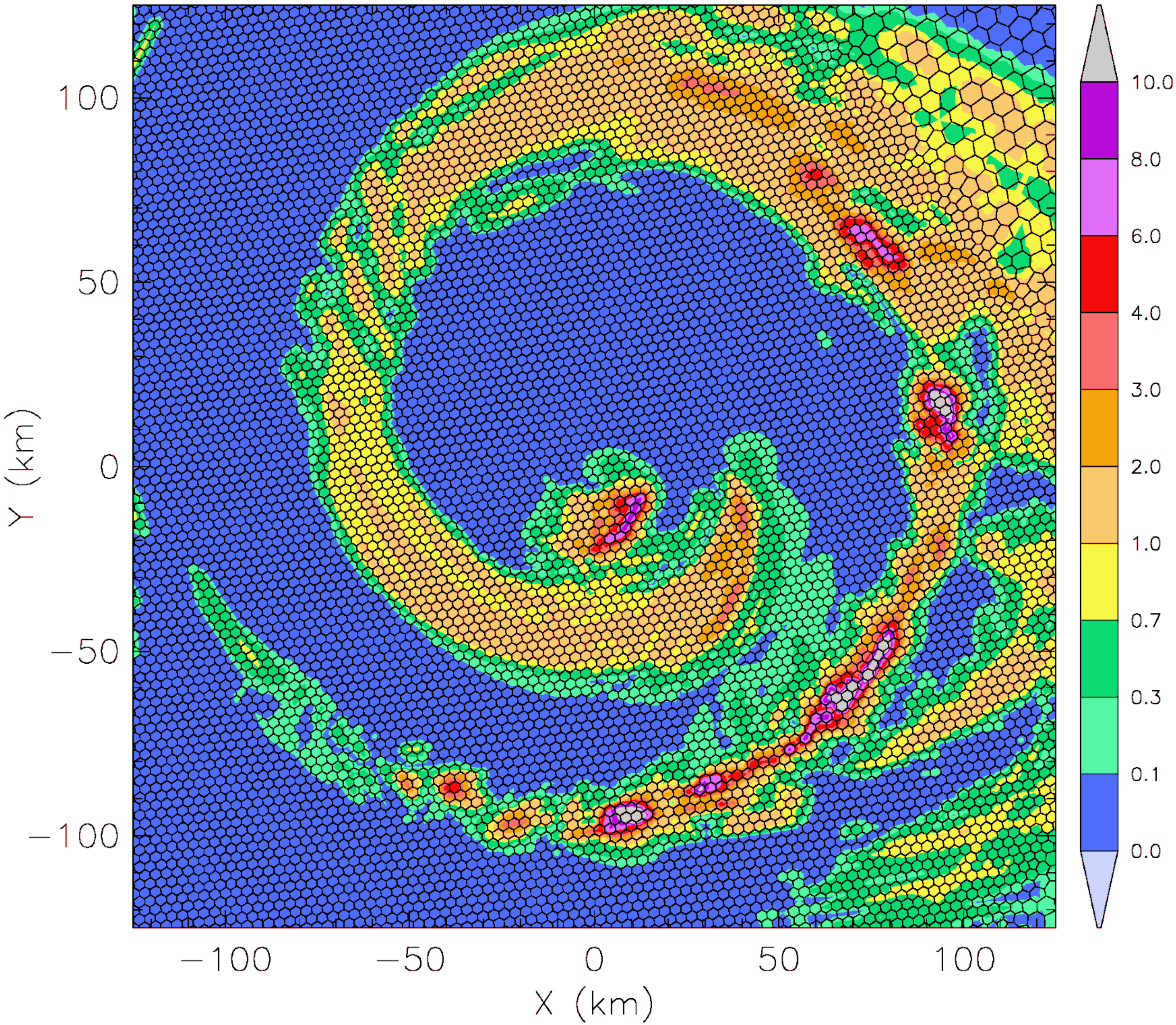
So, OLAM was originally planned as a global version of RAMS.

OLAM began with all of RAMS' physics parameterizations in place.

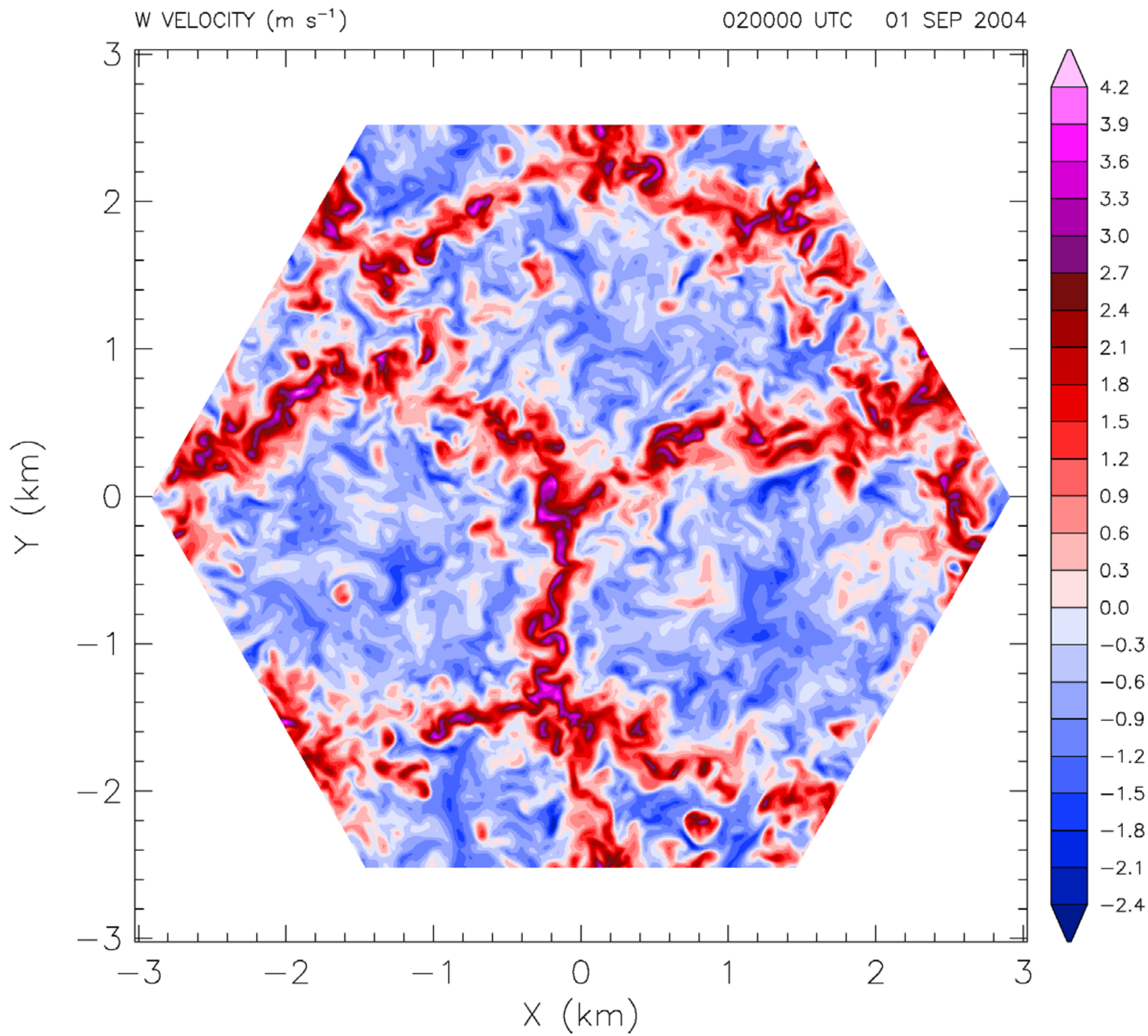


OLAM:
Hexagonal grid cells

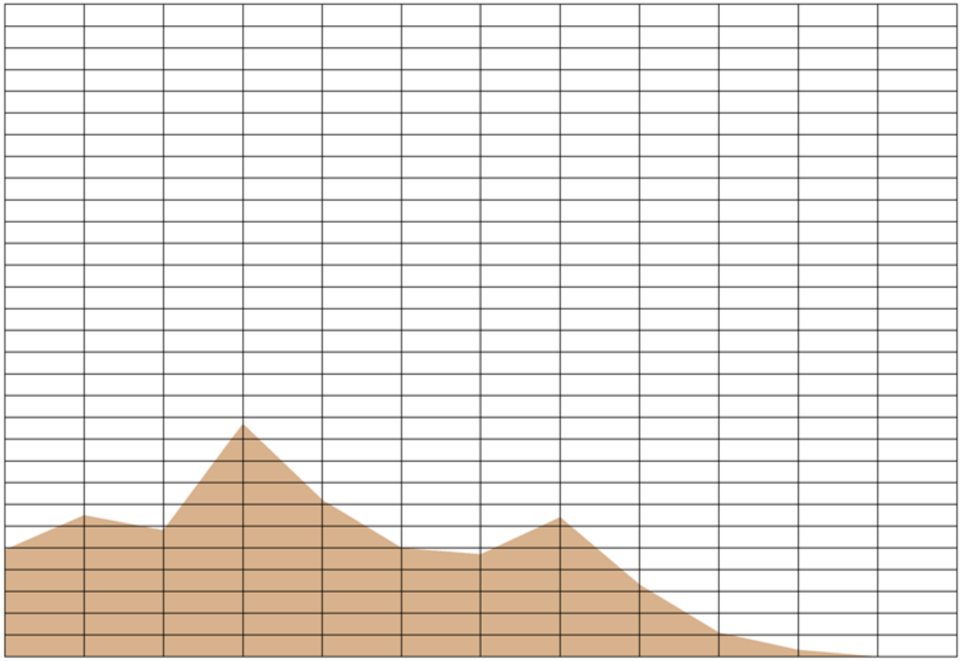




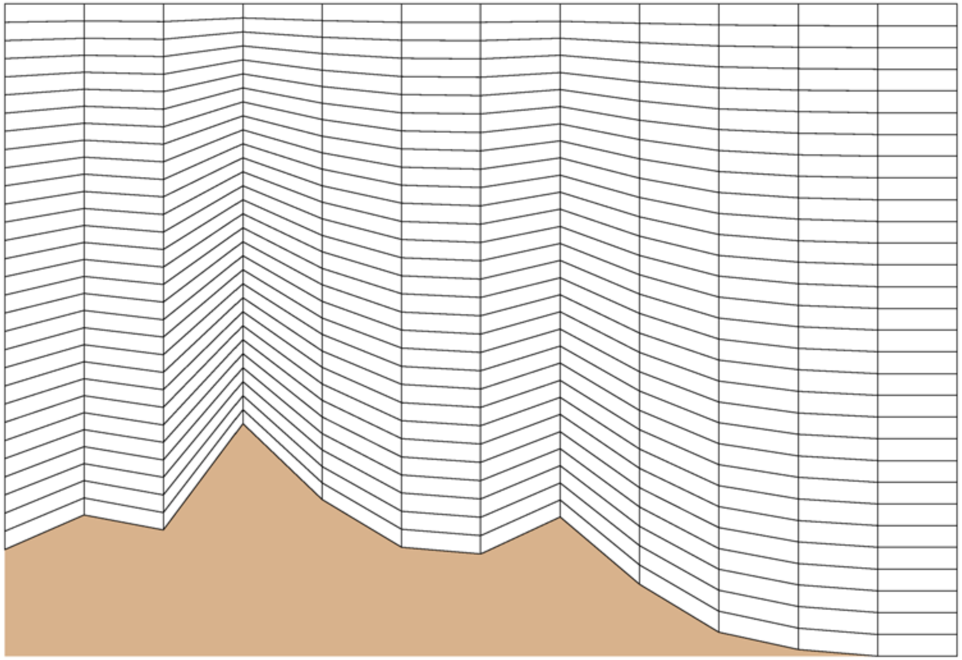
100
50
0
−50
−100
Y (km)
−100
−50
0
50
100
X (km)
10.0
8.0
6.0
4.0
3.0
2.0
1.0
0.7
0.3
0.1
0.0


W VELOCITY (m s^{-1})
020000 UTC 01 SEP 2004
Y (km)
X (km)
3
2
1
0
−1
−2
−3
4.2
3.9
3.6
3.3
3.0
2.7
2.4
2.1
1.8
1.5
1.2
0.9
0.6
0.3
0.0
−0.3
−0.6
−0.9
−1.2
−1.5
−1.8
−2.1
−2.4

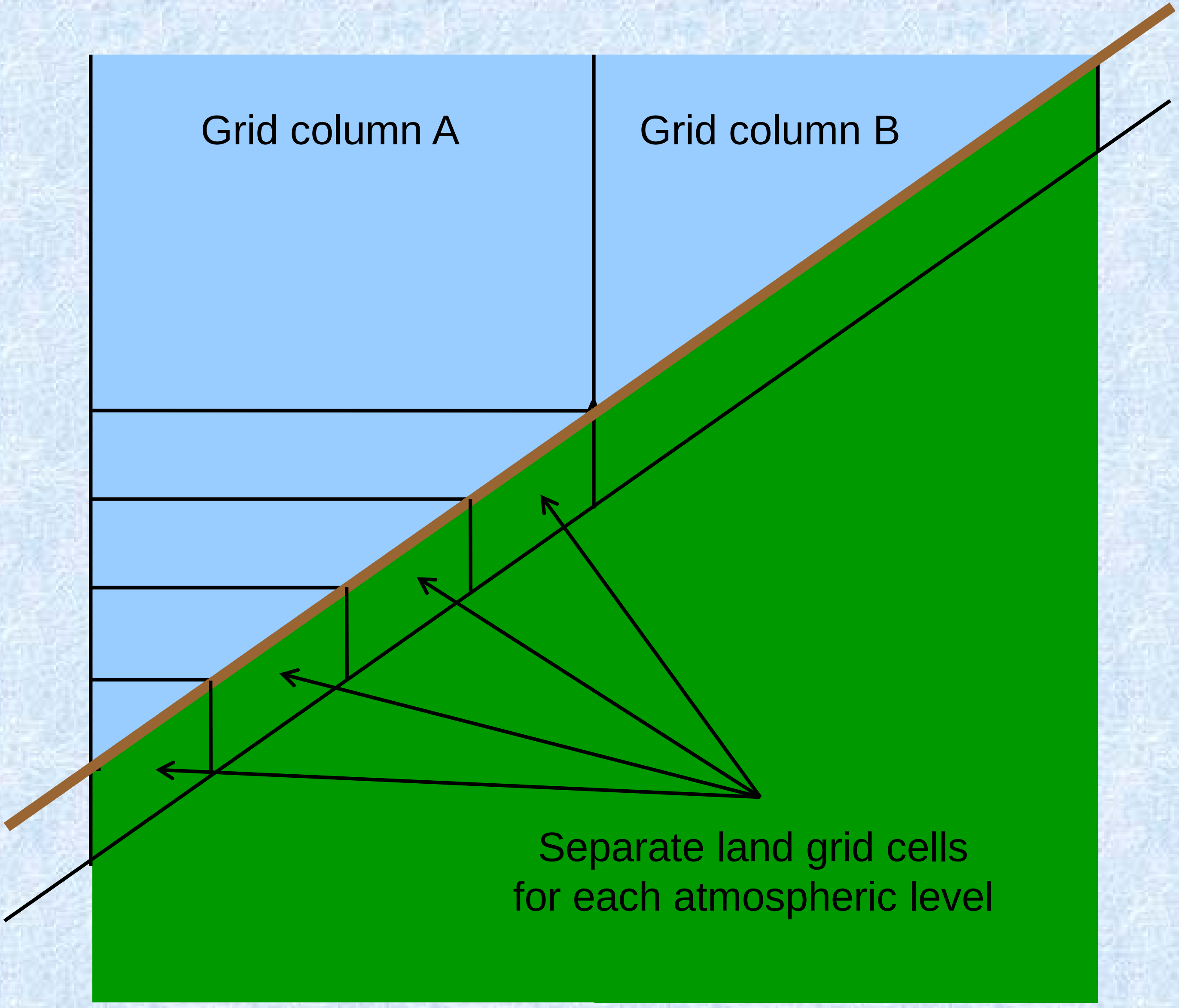
OLAM atmosphere grid uses horizontal levels that intersect topography, resulting in "cut cells"

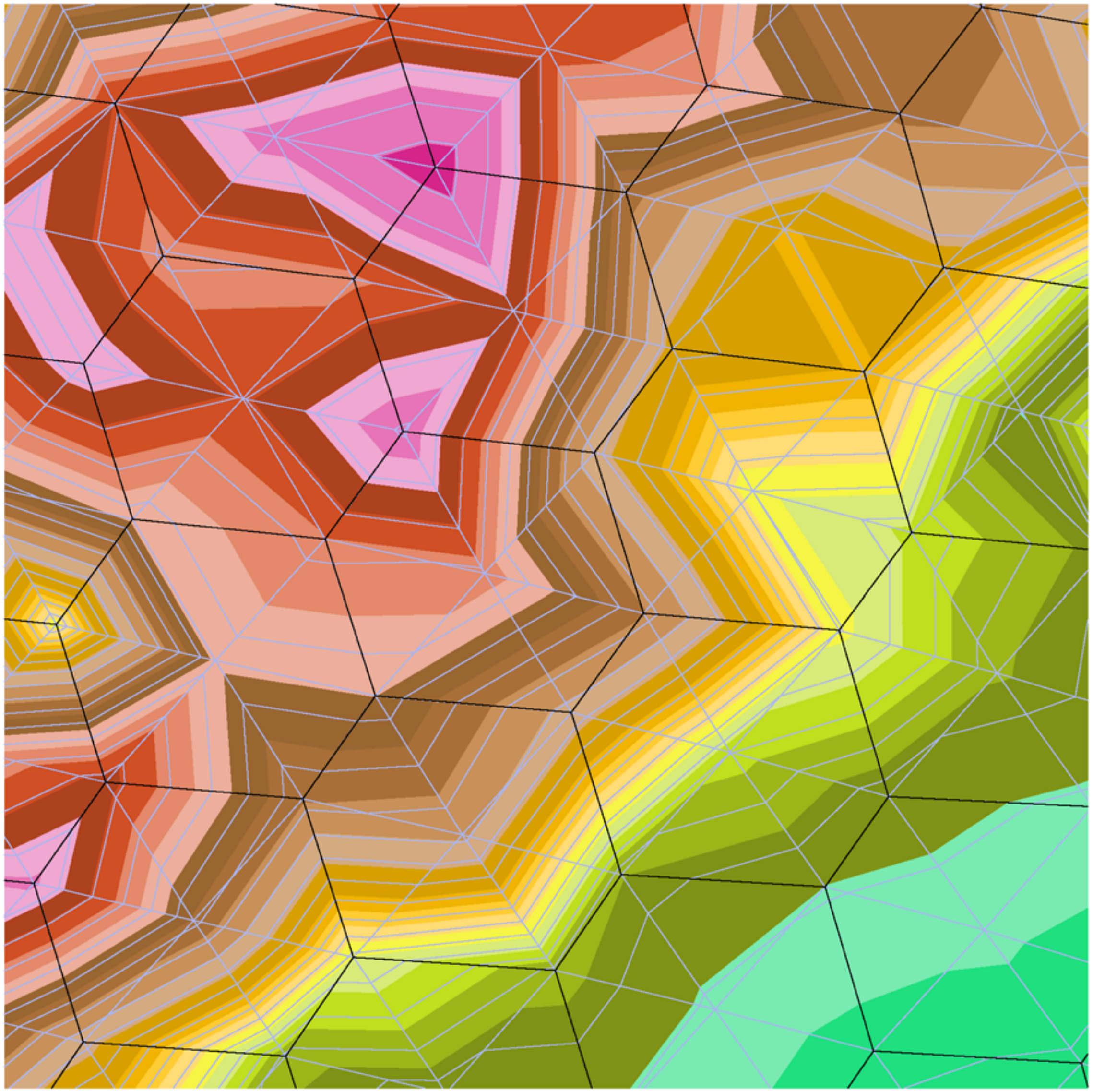


Terrain-following coordinates are almost universally used in atmospheric models.

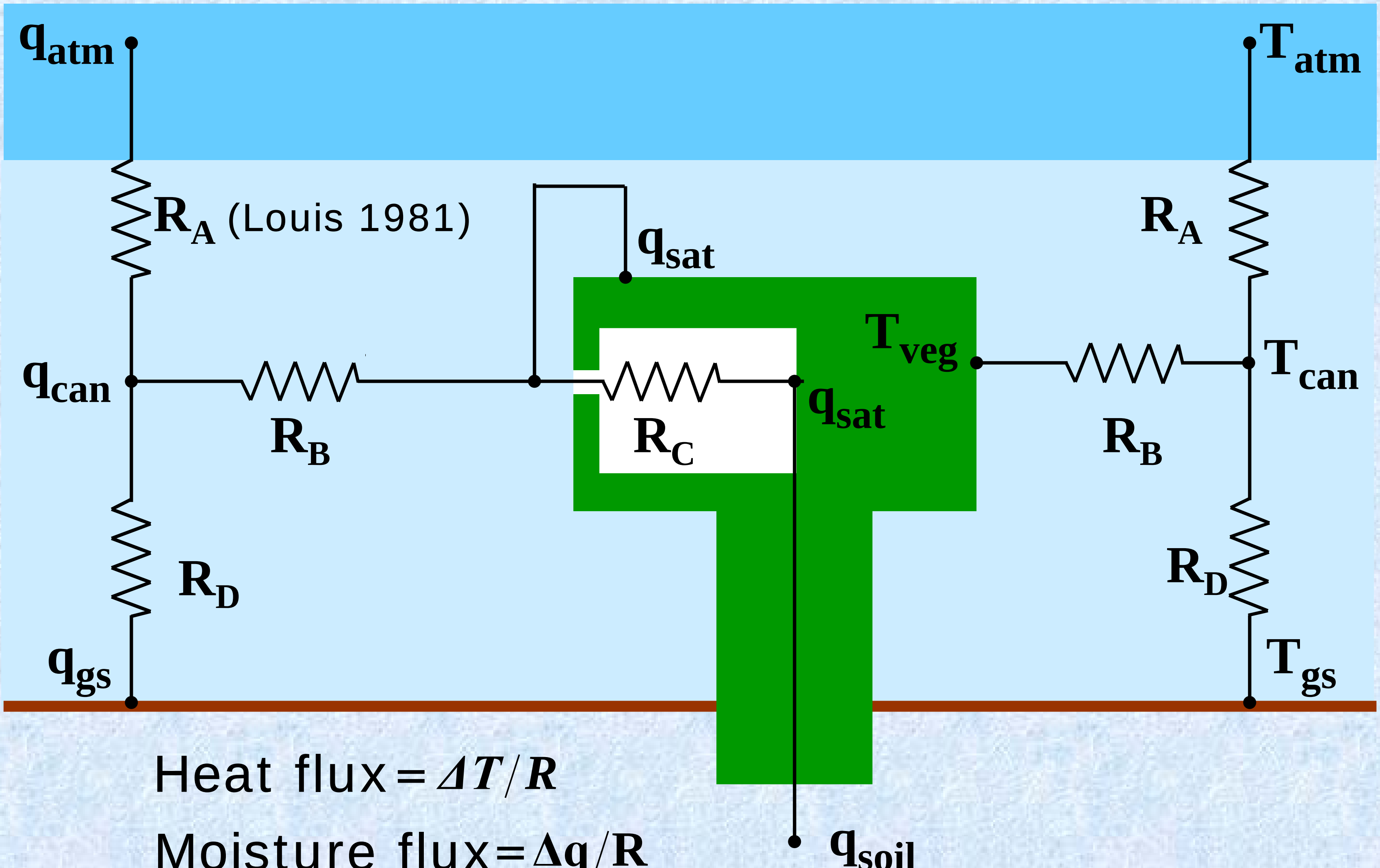


Before OLAM-SOIL, surface grid was same as atmosphere grid, except that finer divisions were used on topographic slopes





LEAF-3 Canopy Fluxes

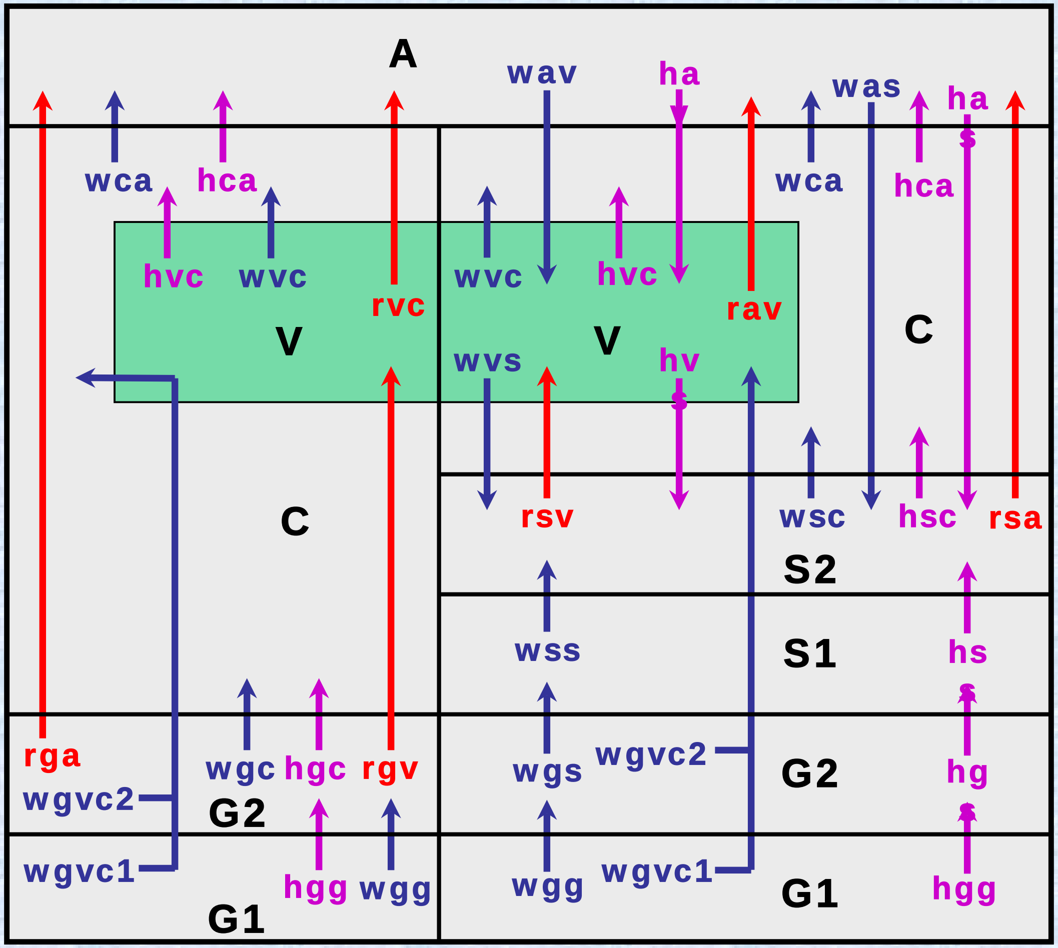


Heat flux $= \Delta T / R$

Moisture flux $= \Delta q / R$

LEAF-3

fluxes



longwave radiation

sensible heat

water

OLAM-SOIL Project – Required Soil Model Capabilities (Year 1)

1. Coupling to atmospheric (Earth-System) model
2. 3-D groundwater modeling
3. Horizontal resolution can be (much) higher than atmosphere model
4. Possible local mesh refinement
5. Utilize SoilGrids datasets (in uppermost 2 m) and other available datasets at deeper levels for groundwater modeling
6. Implement one or more sets of Pedotransfer Functions to obtain hydraulic properties from these datasets
7. Implement soil structure effect on hydraulic conductivity

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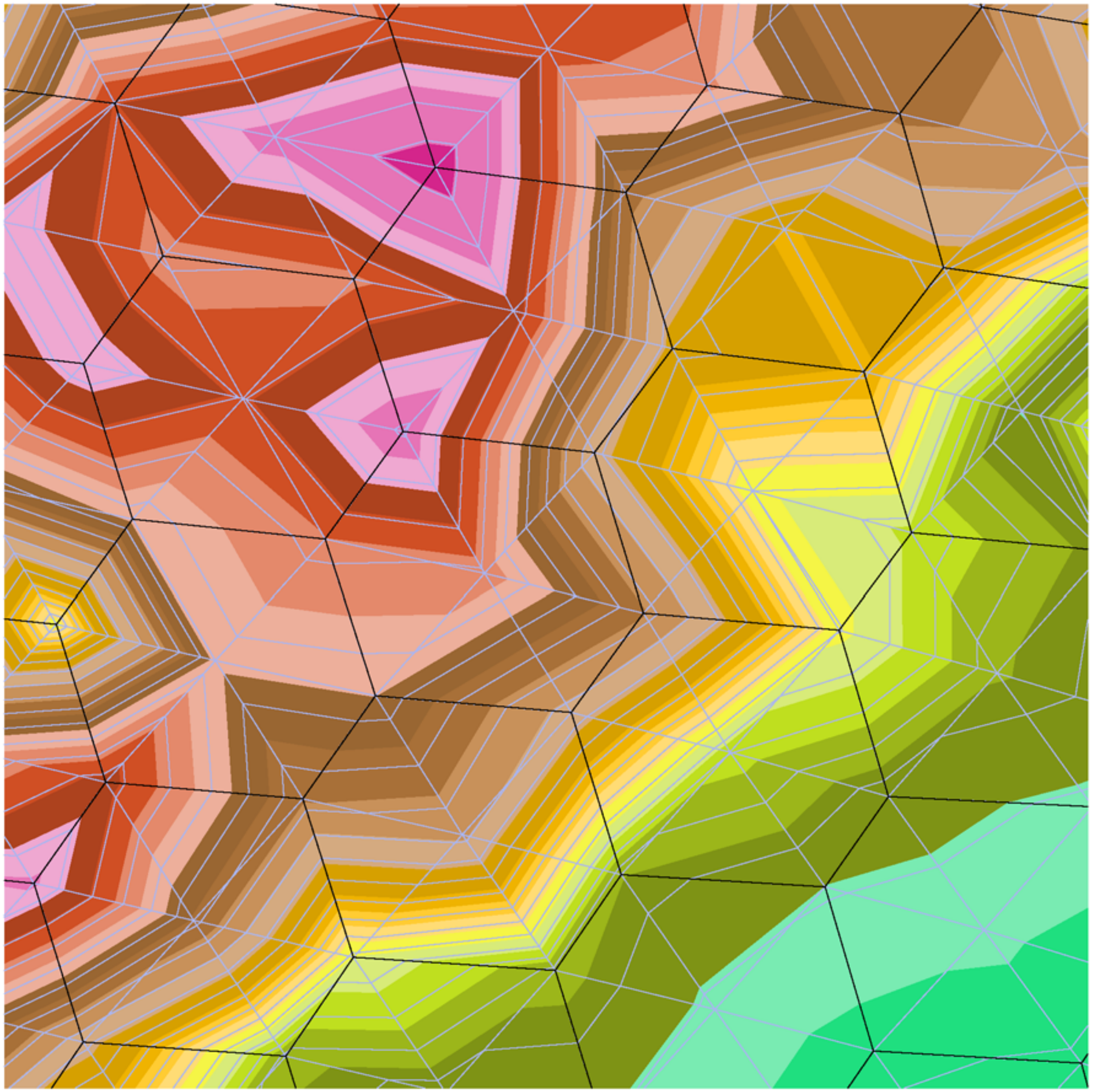

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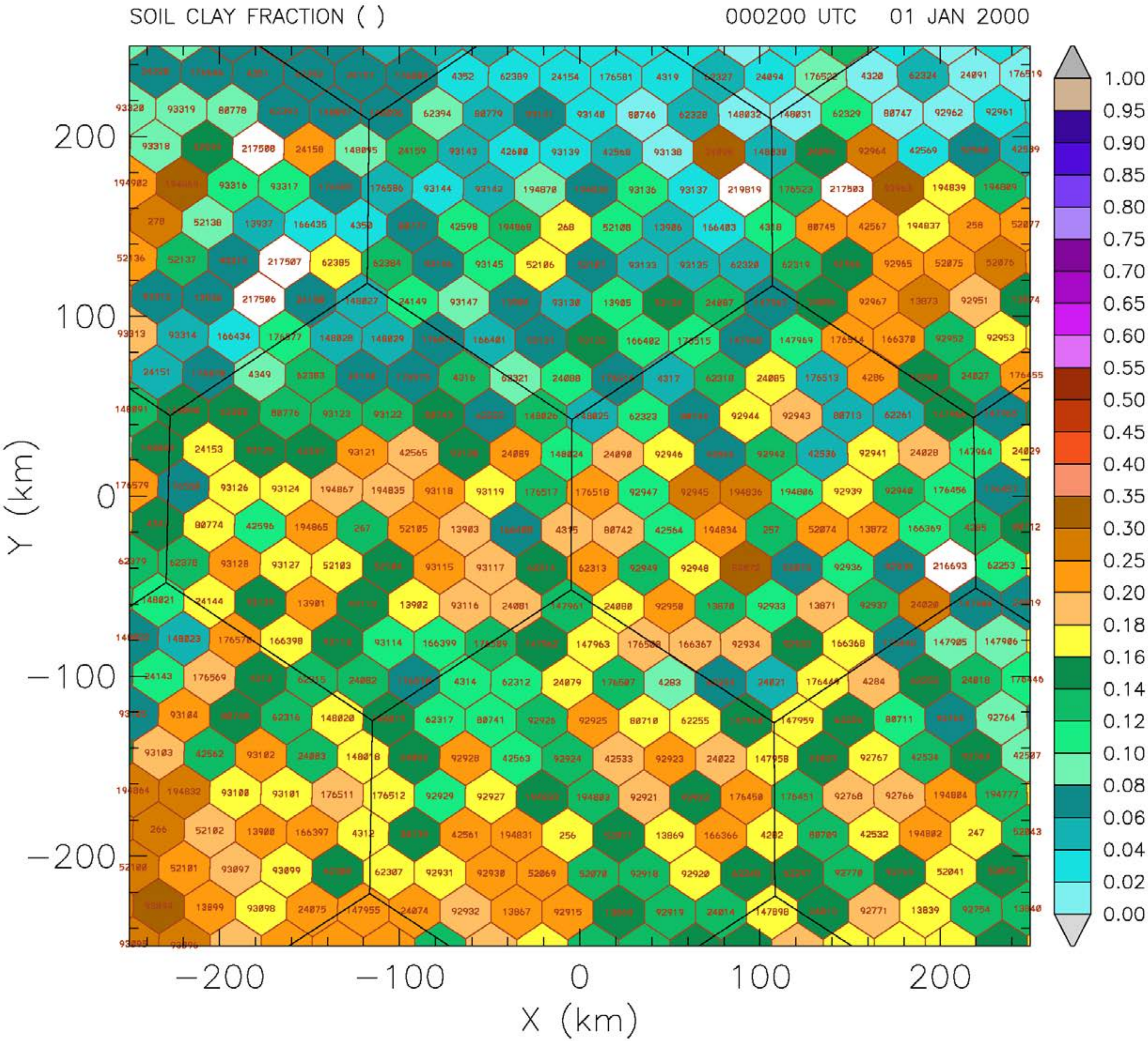
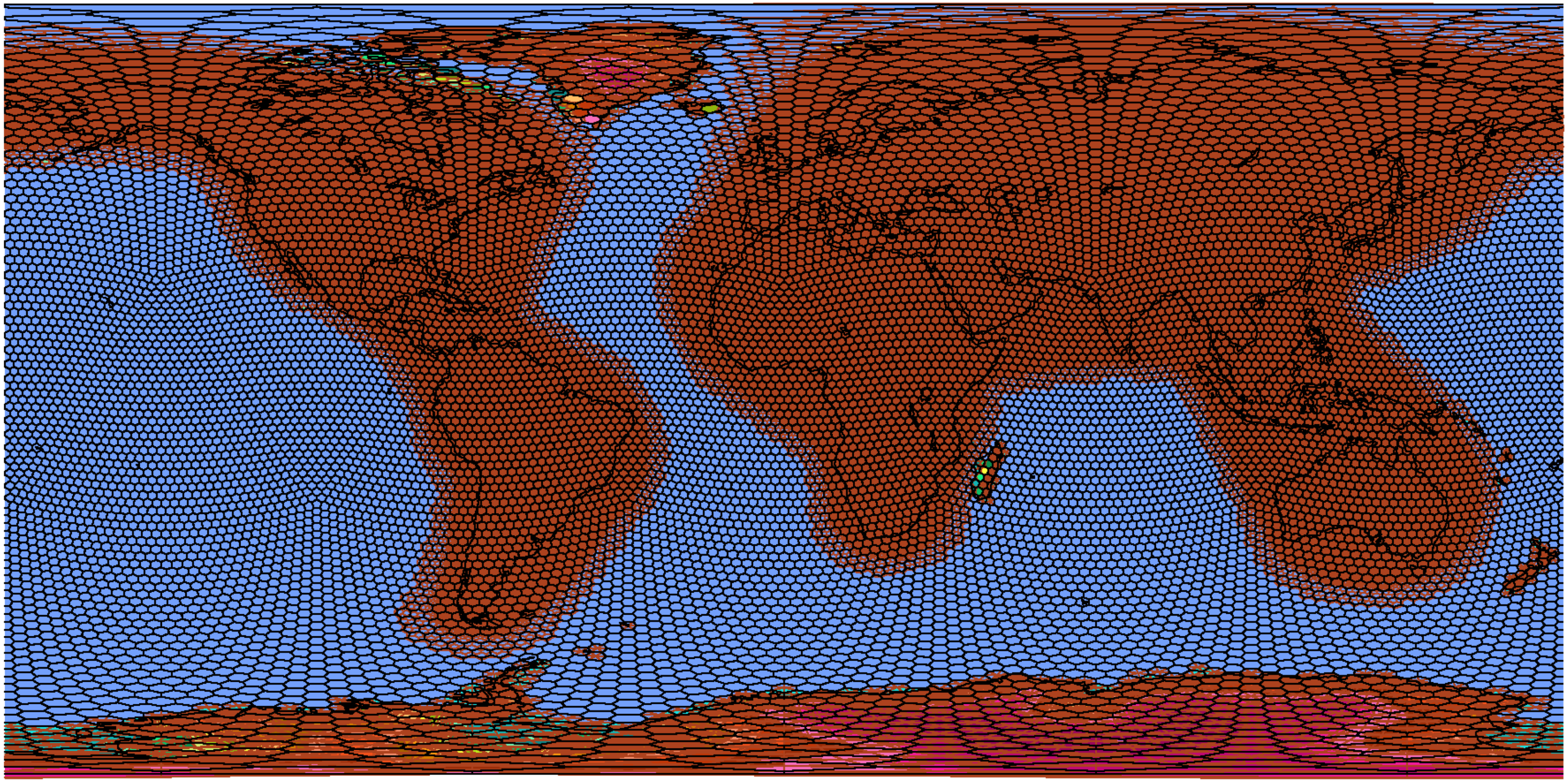
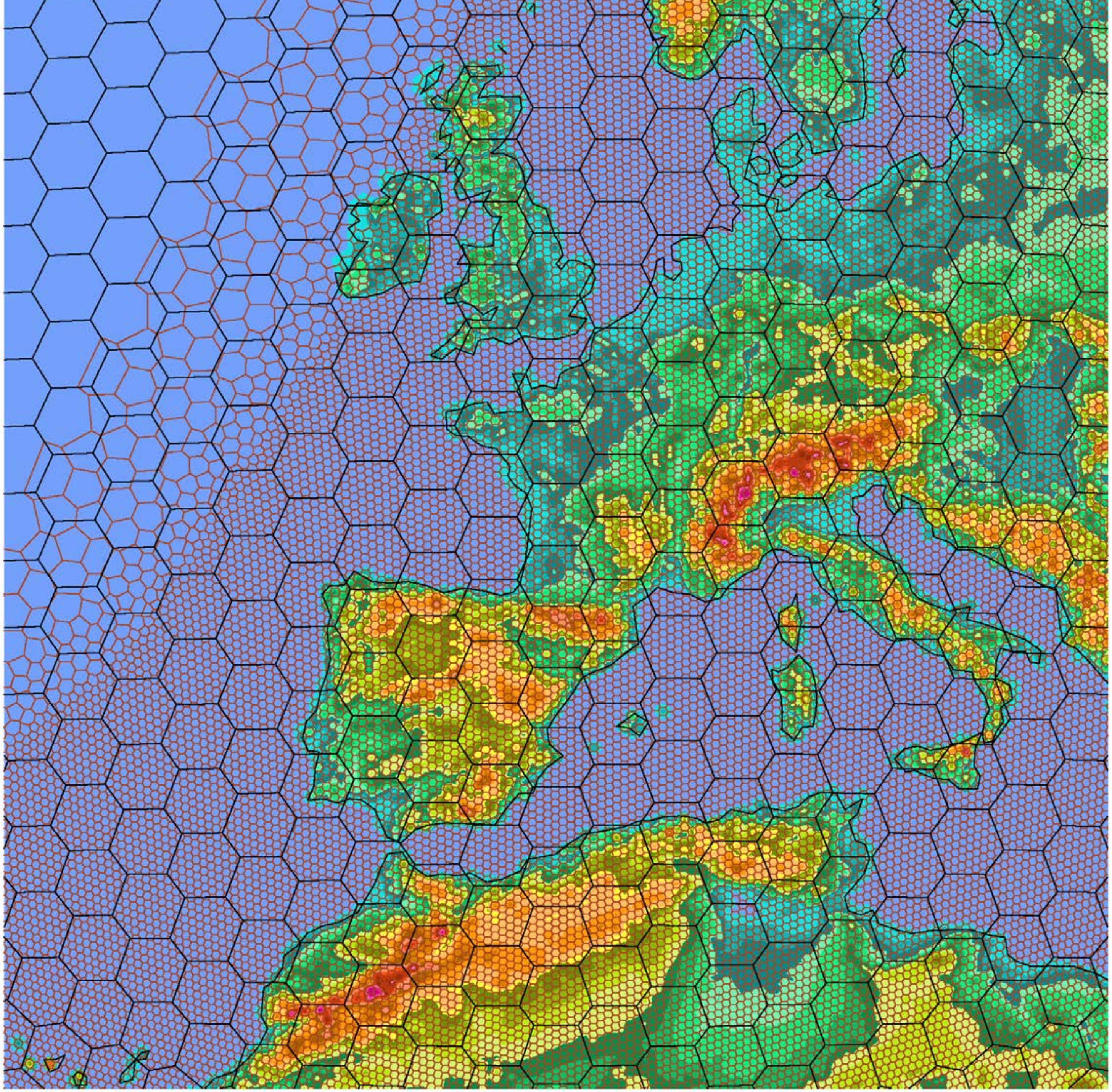


SOIL CLAY FRACTION ( )
000200 UTC 01 JAN 2000
Y (km)
200
100
0
−100
−200
X (km)
−200
−100
0
100
200
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00

Surface grid refinement over major land areas





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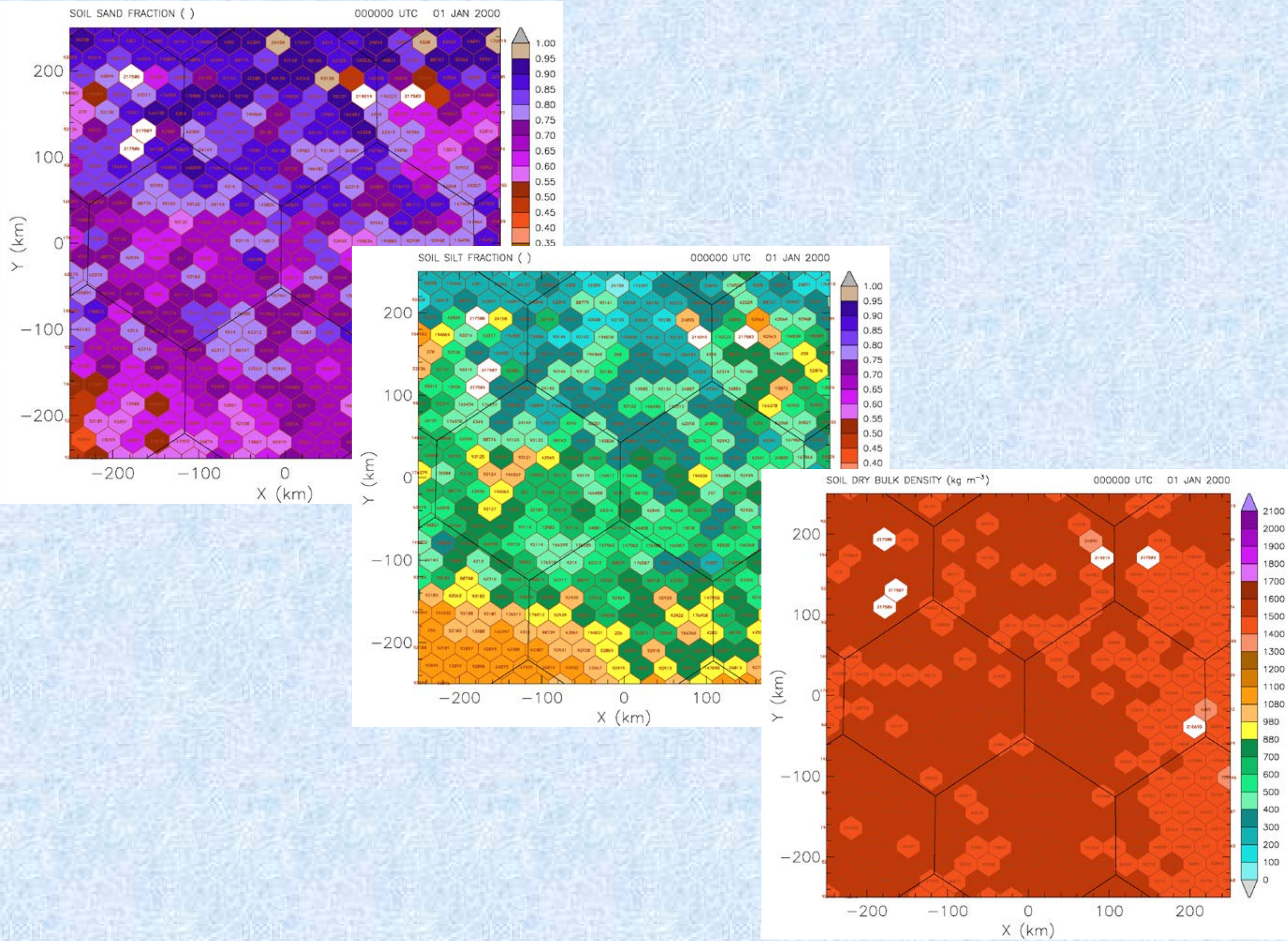
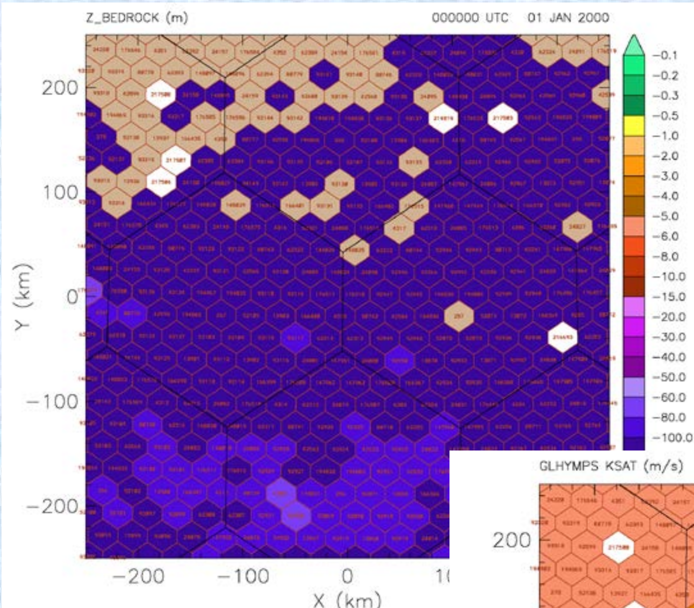
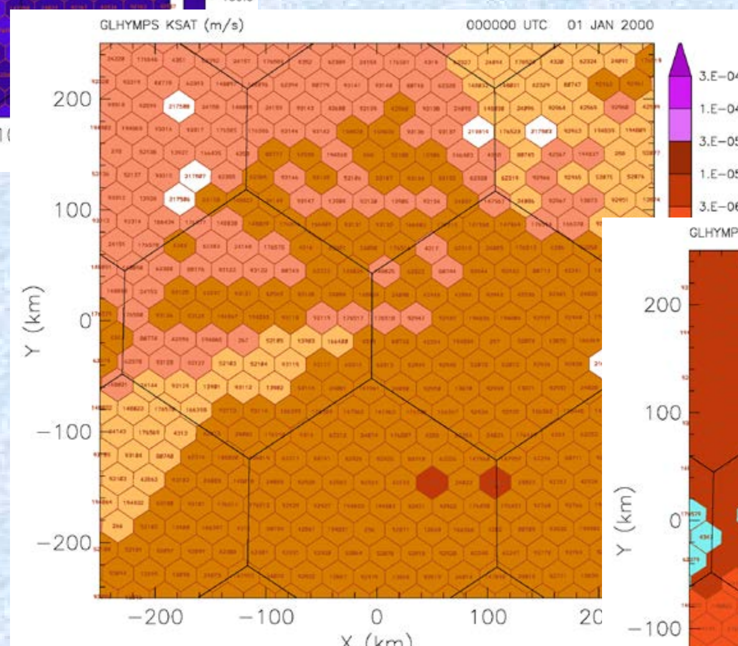
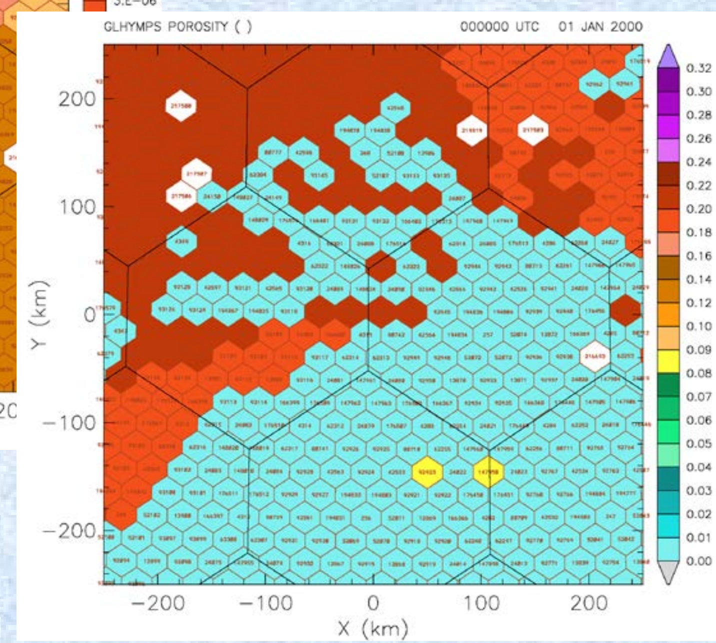
SoilGrids Parameterization and Gridding



Groundwater Parameterization (GLHYMPS) and Gridding







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Pedotransfer Functions in OLAM-SOIL

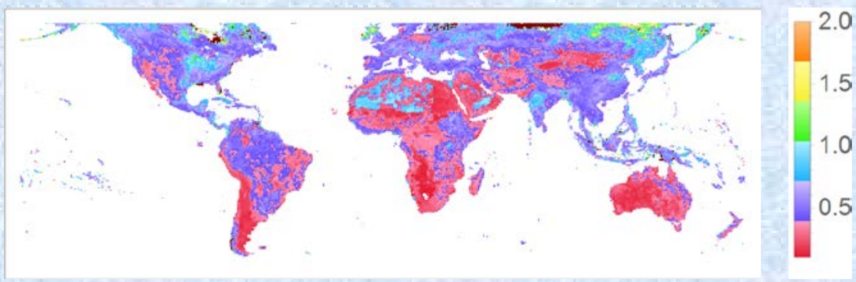
Weynants, Vereecken, and Javaux (2009)

de Boer (2016) (HiHydroSoil, based on SoilGrids)

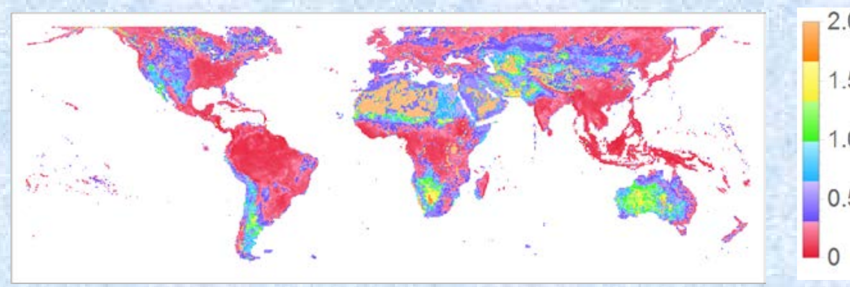
USDA van Genuchten parameters (from LEAF4)

HiHydroSoil, based on SoilGrids

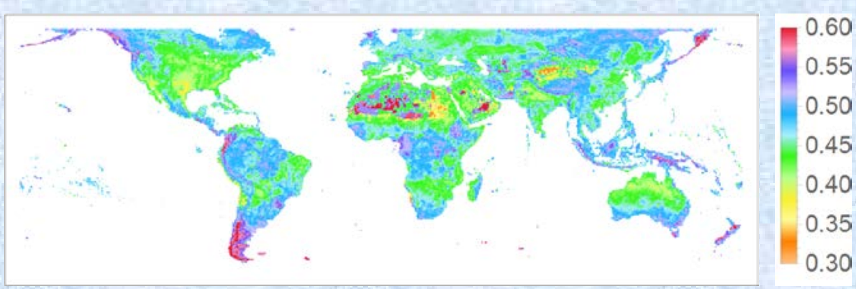
Characteristic pressure 1/α [m]



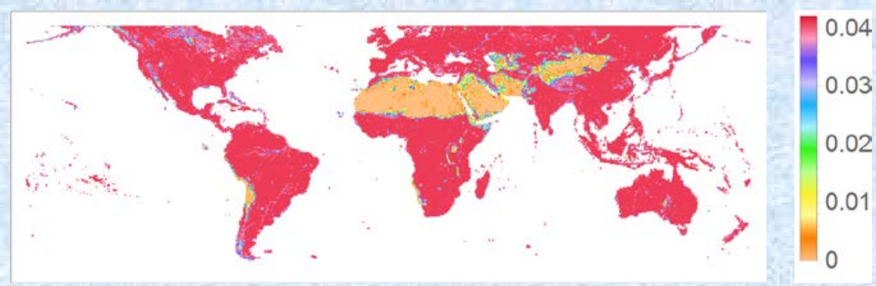
Saturated hydraulic conductivity [m/day]



Saturated water content [m^3/m^3]



Residual water content [m^3/m^3]



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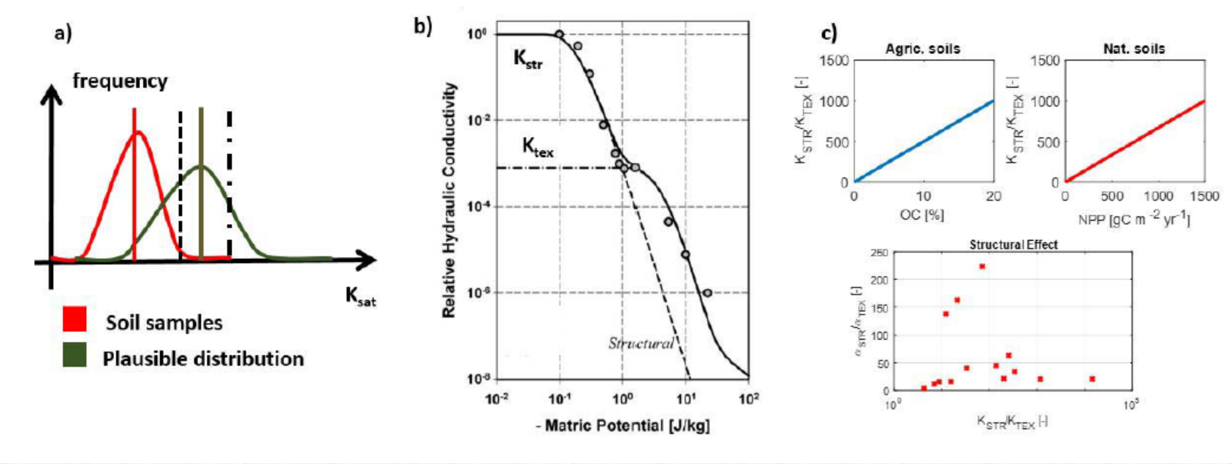
The influence of soil structure on global climate…



- A simple addition of soil structure information by adjusting Ks for structured soils (correlated with vegetation cover) – changes the energy balance of surfaces globally!

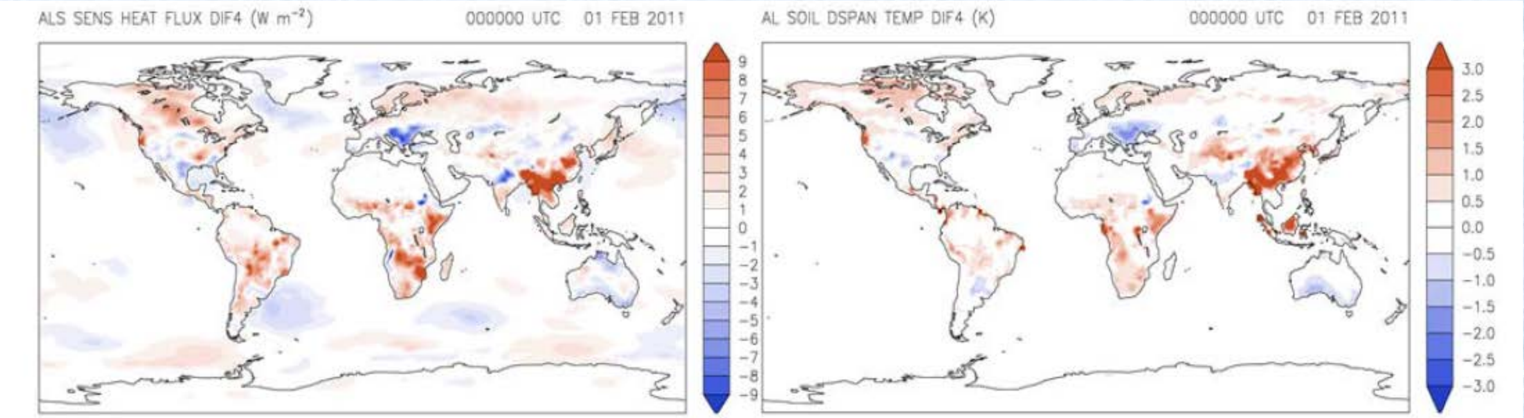


Fig. 6. *Global changes in sensible heat flux (left, W/m²) and diurnal surface temperature range (right, K) when soil structure effects on loamy soils are considered (results are averages over 10 years).*

Soil Structure Effect – increased hydraulic conductivity

Expressed as multiplicative factor on hydraulic conductivity

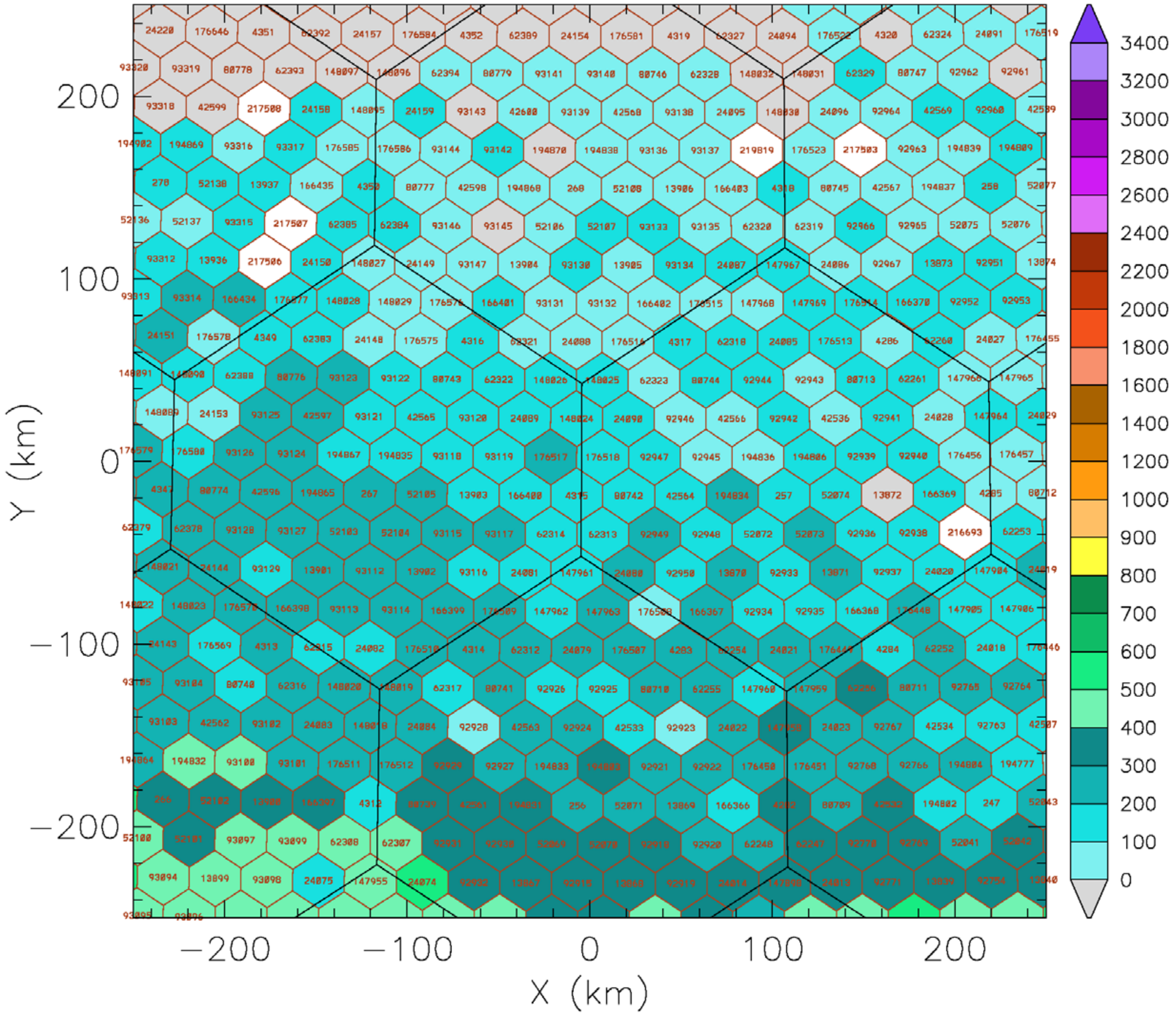
Can have a value up to 1000

Only applicable when soil is near saturation (matric head > -10 cm)

Important in root zone where vegetation is active: decreases linearly from surface to zero value at bottom of root zone

Proportional to annual mean GPP (a proxy for vegetation activity)

GROSS PRIMARY PRODUCTION OF CARBON ()   000000 UTC   01 JAN 2000



Two comparative climate simulations are in progress, one with the soil structure effect and the other without. Show some early results…