Parallel Reduced Order Models for Earth Systems (pROME)

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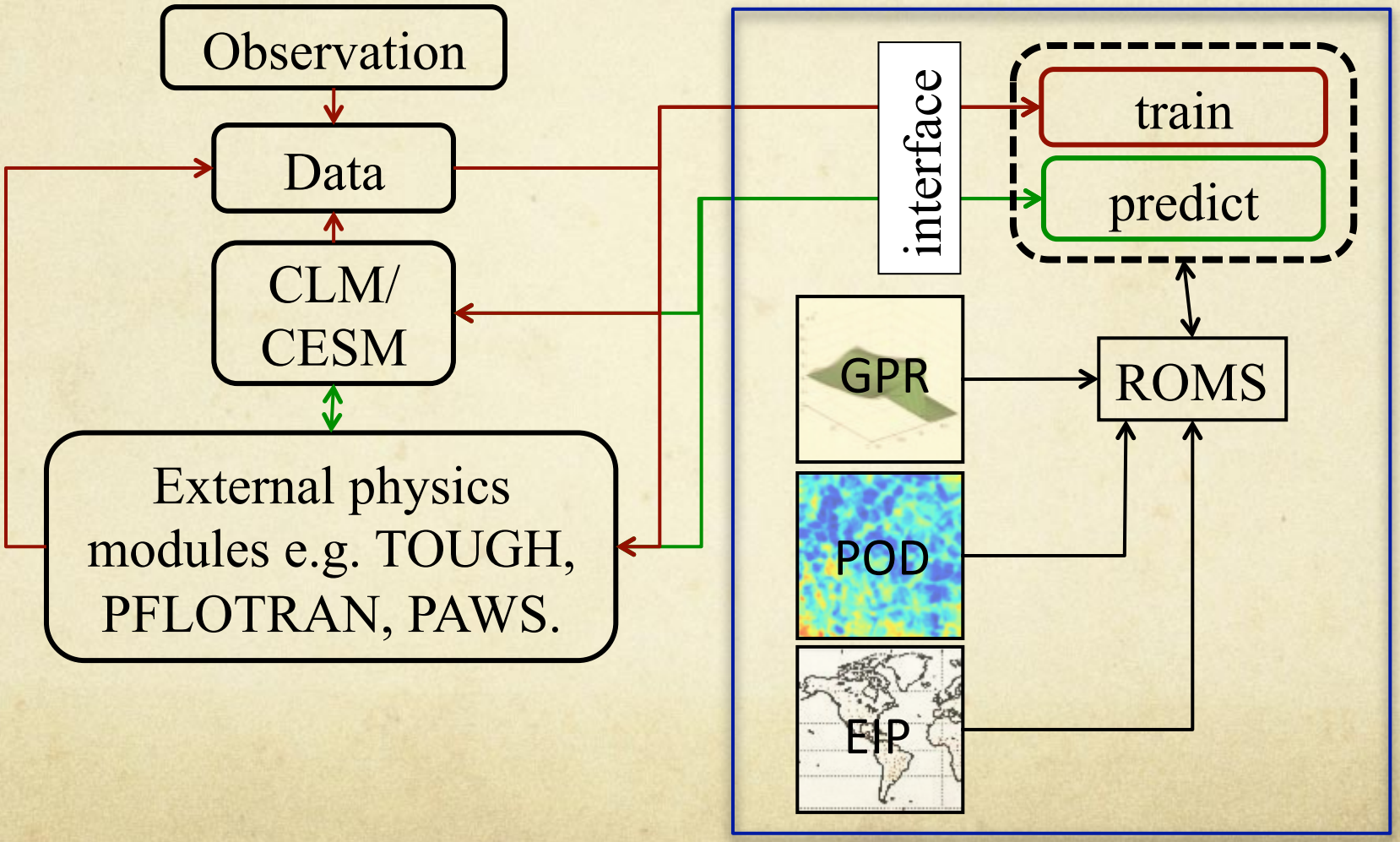
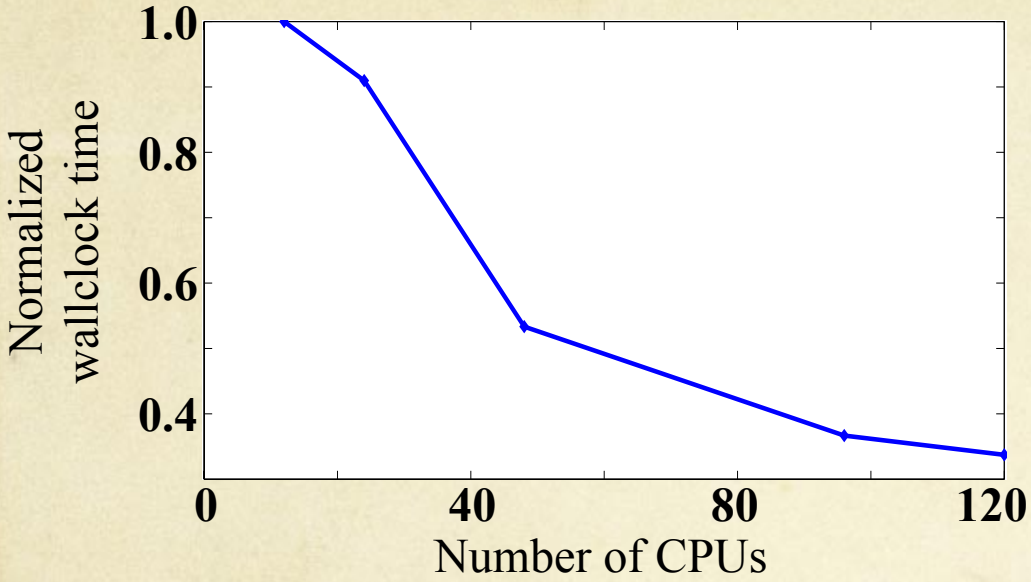


Roles of PETSc in pROME

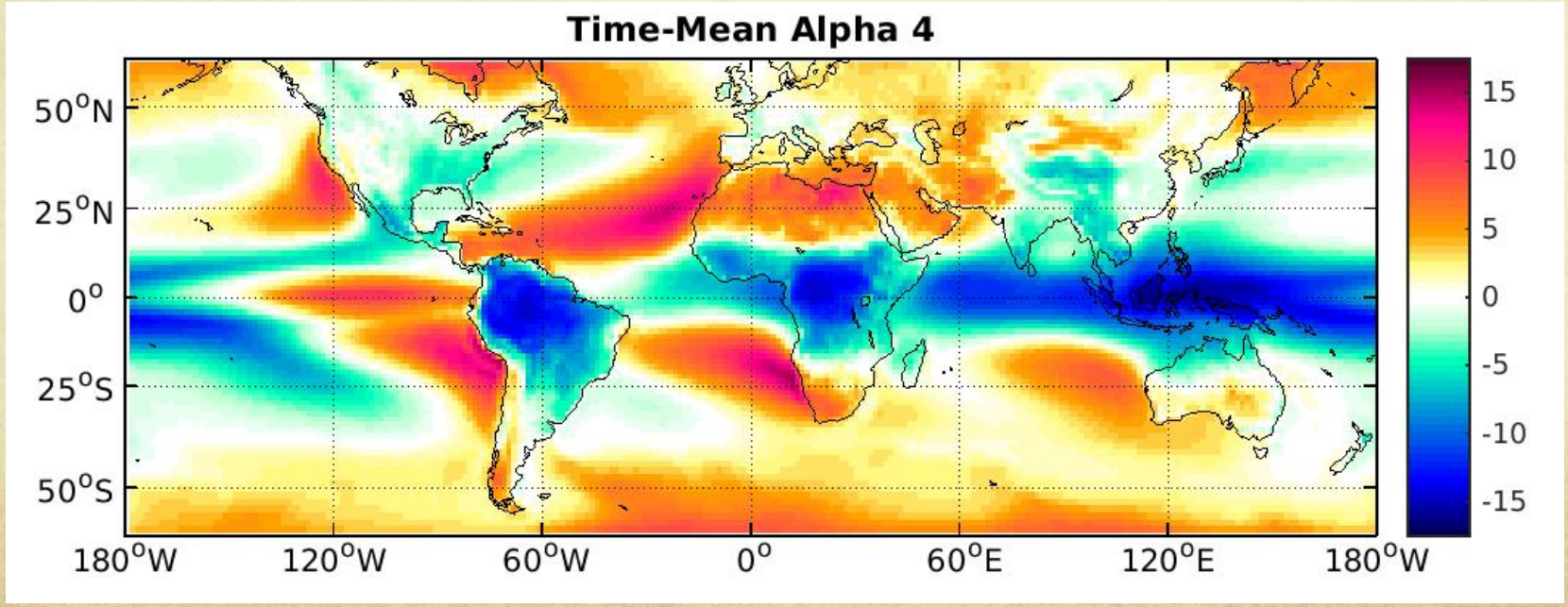
- Manipulation of large high-dimensional dataset
  - Utilizes the distributed infrastructure of PETSc.
  - Exploits convenient parallel IO.
- Linear solvers and eigensolvers
  - PCA utilizes convenient interface to eigensolvers
  - Utilizes KSP to execute many serial linear solves in parallel.
- Model optimization

ROM	PETSc functionalities used
Proper orthogonal decomposition/Empirical interpolation procedure	Sparse: SLEPc (SVD and EPS) Dense: Elemental (DistMatrix, HermitianEig) Linear solve: many serial KSP+PC(LU)
Gaussian process regression	Hyperparameter optimization: TAO Linear solve with Cholesky factorization: • serial mode-PC(PCCHOLESKY)/PC+MUMPS • parallel mode-PC+MUMPs

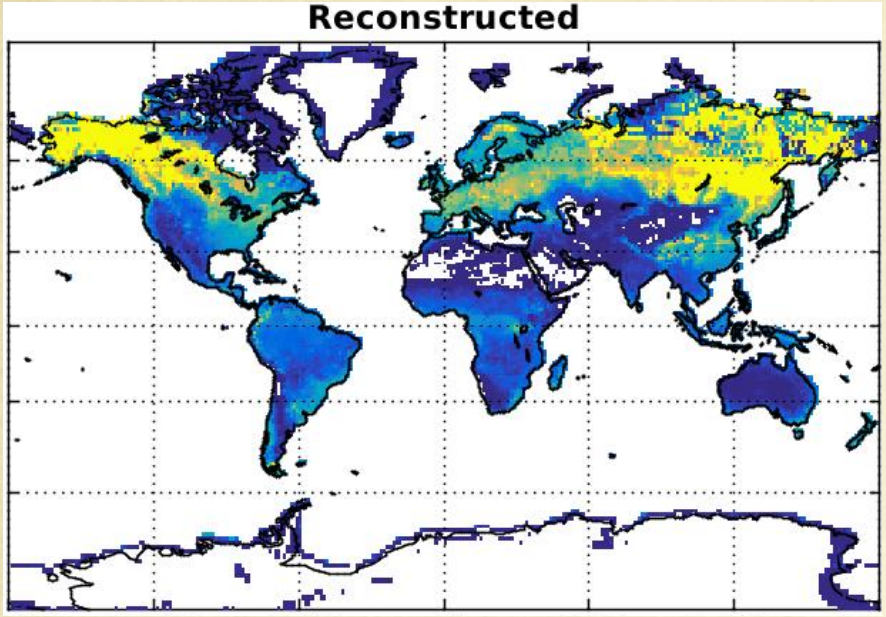
Strong scaling behavior

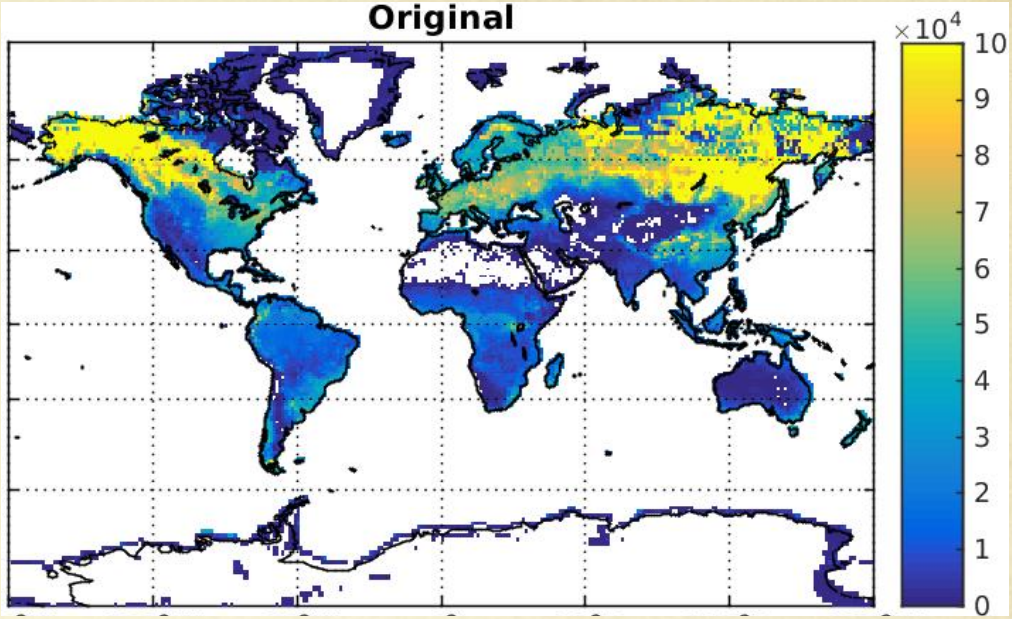


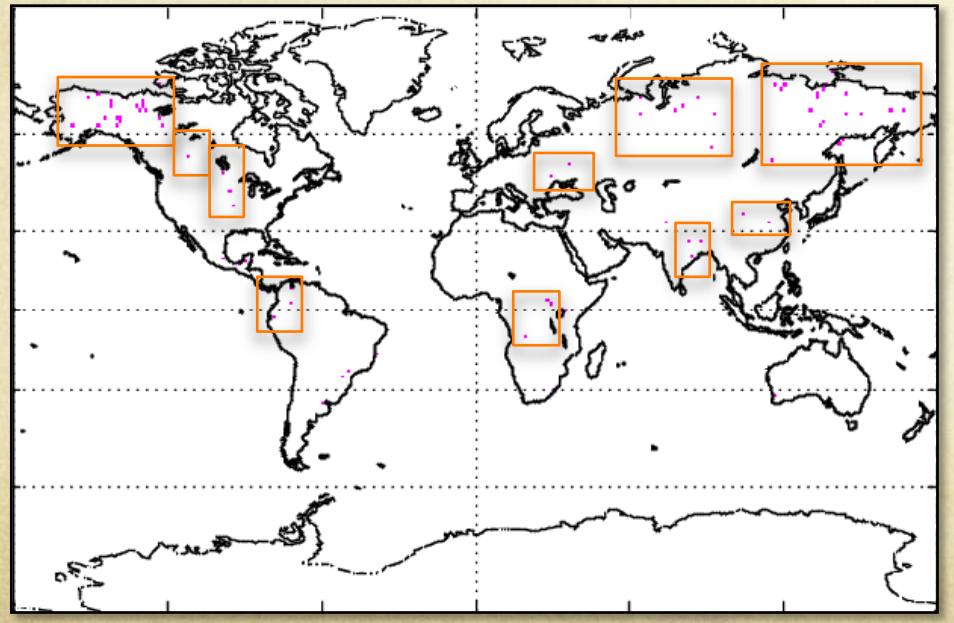
- Application of POD to a century-long satellite spectroscopic dataset
- Good strong scaling behavior



Examples: Prediction of soil carbon content







- Uses POD+EIP
- Annual Mean soil carbon (g m^{-2}).
- 80 grid blocks (0.4% of total grid blocks)
- Largest relative error: 0.8%.

Examples: Prediction of riverbasin-scale variables

- Uses proper orthogonal mapping method: reproduces fine-resolution solution using coarse-resolution solution.