New Modular system for Modeling and Inverting EM data, written by Gary Egbert

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Modular system

Forward Solver:

-Considered as core of the inversion.

-Solves Maxwell eq. for E-field

-Contains the eq. System (**Ax**=**b**) solver (QMR) with incomplete LU-decomposition as pre-conditioner.

-Should be as general as possible to deal with arbitrary sources and BC. i.e. **J** computation requires solving FWD with many sources.

-In MT 3D FWD, the BC are from REBOCC code with some modifications to fit in the system.

-Written from scratch (Egbert)

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Discretization

jects in S_p and S_s. Key point: 3D E-field on cell edges.

Forward Modeling

Maxwell's equations together with the Ohm's law and the time dependence of EM-field can be written in form of PDE:

$$\nabla \times \nabla \times \vec{E} = -i\omega\mu_0\sigma\vec{E}$$

$$\nabla \times \rho\nabla \times \vec{B} = -i\omega\mu_0\vec{B}$$

-**Solve the first EQ for E as primary field and B as secondary one**

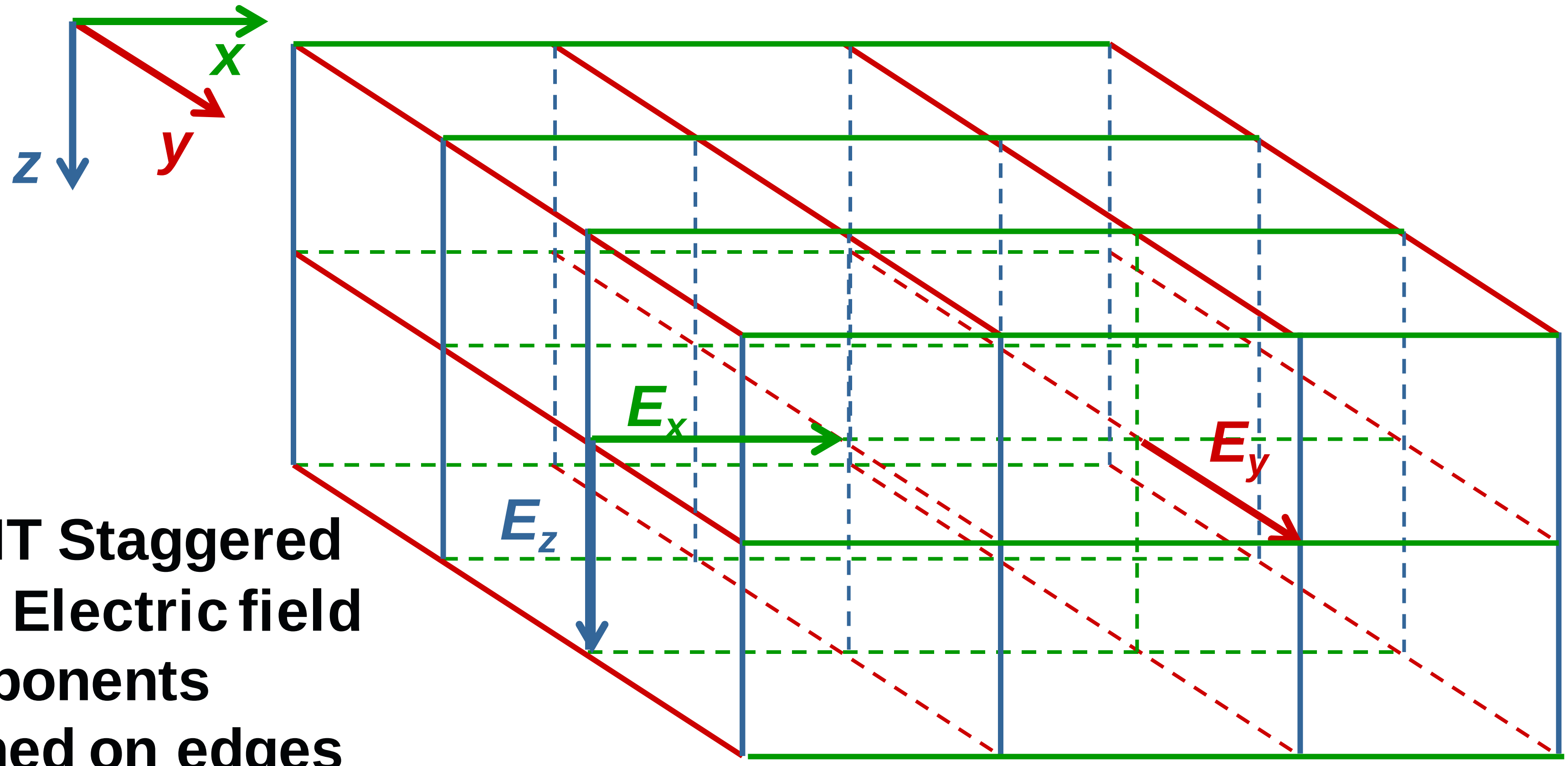
-**Solve the second EQ for B as primary field and E as secondary one**

Model Discritization

The solution of PDE can be approximated by using the finite differences on a staggered grid:

Specific Example:

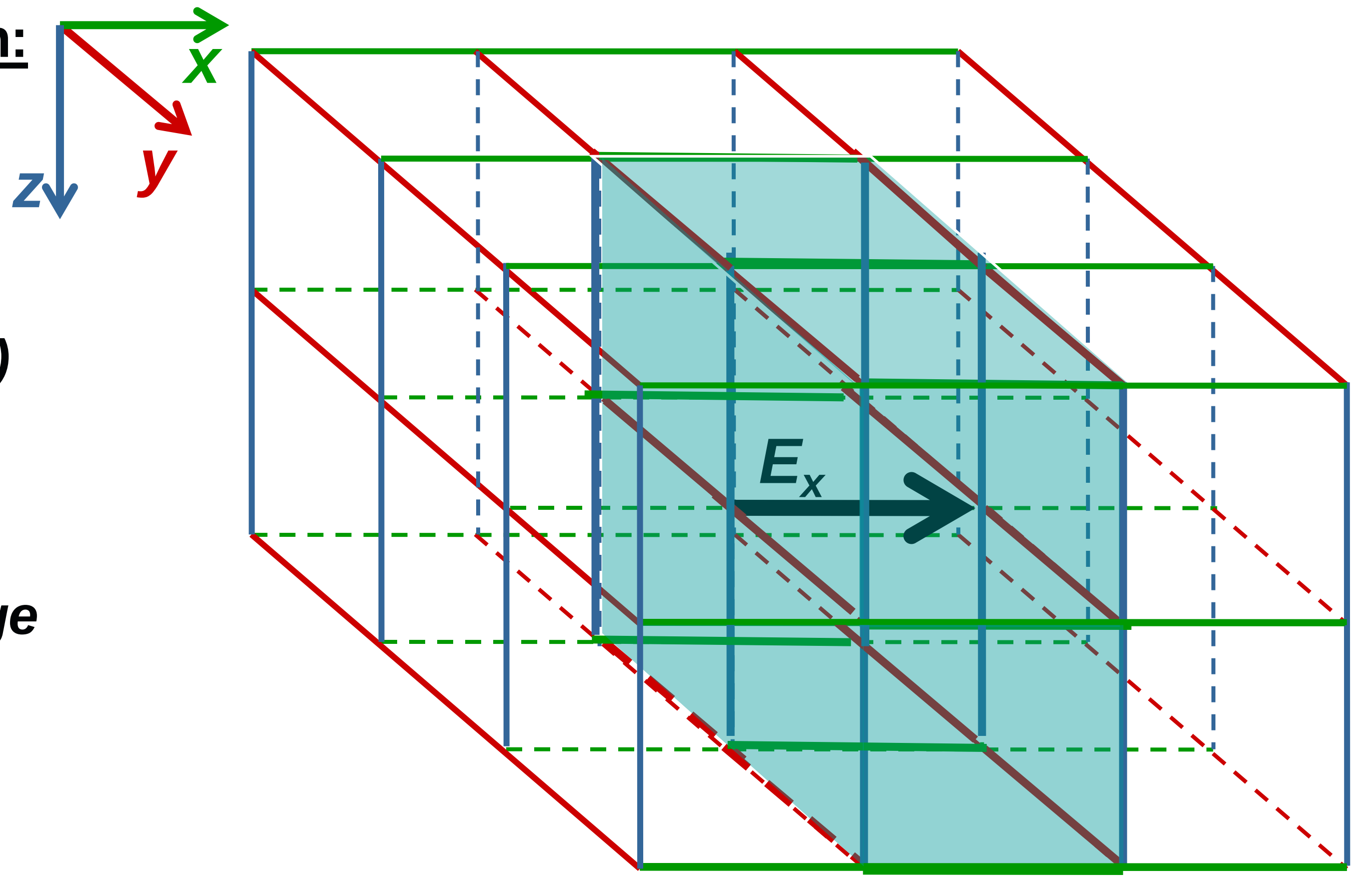
$$\nabla \times \nabla \times \vec{E} + i\omega\mu\sigma\vec{E} = 0$$



3D MT Staggered grid: Electric field components defined on edges

Model parameterization

<u>Conductivity parameterization:</u> ***Each cube is an independent parameter (conductivity or log conductivity)***



Primary model parameter mapping: average from cubes onto edges, where electric field components are defined

Linear conductivity

$$\boldsymbol{\sigma}(\mathbf{m}) = \mathbf{W}\mathbf{m}$$

Log conductivity

$$\boldsymbol{\sigma}(\mathbf{m}) = \mathbf{W}\exp(\mathbf{m})$$

W = operator that averages from cubes to edges

Generic form of the FWD Solver

Applying the FD equations and writing the result in matrix vector form we get:

$$\mathbf{S_m e = b}$$

-Differential Operator
-Coupling coefficient matrix

Source location (CS, DC)
BC (MT)

EM solution,
e.g. E in 2D TE, and 3D in MT
or ϕ in DC

The Structure of the **S** Matrix

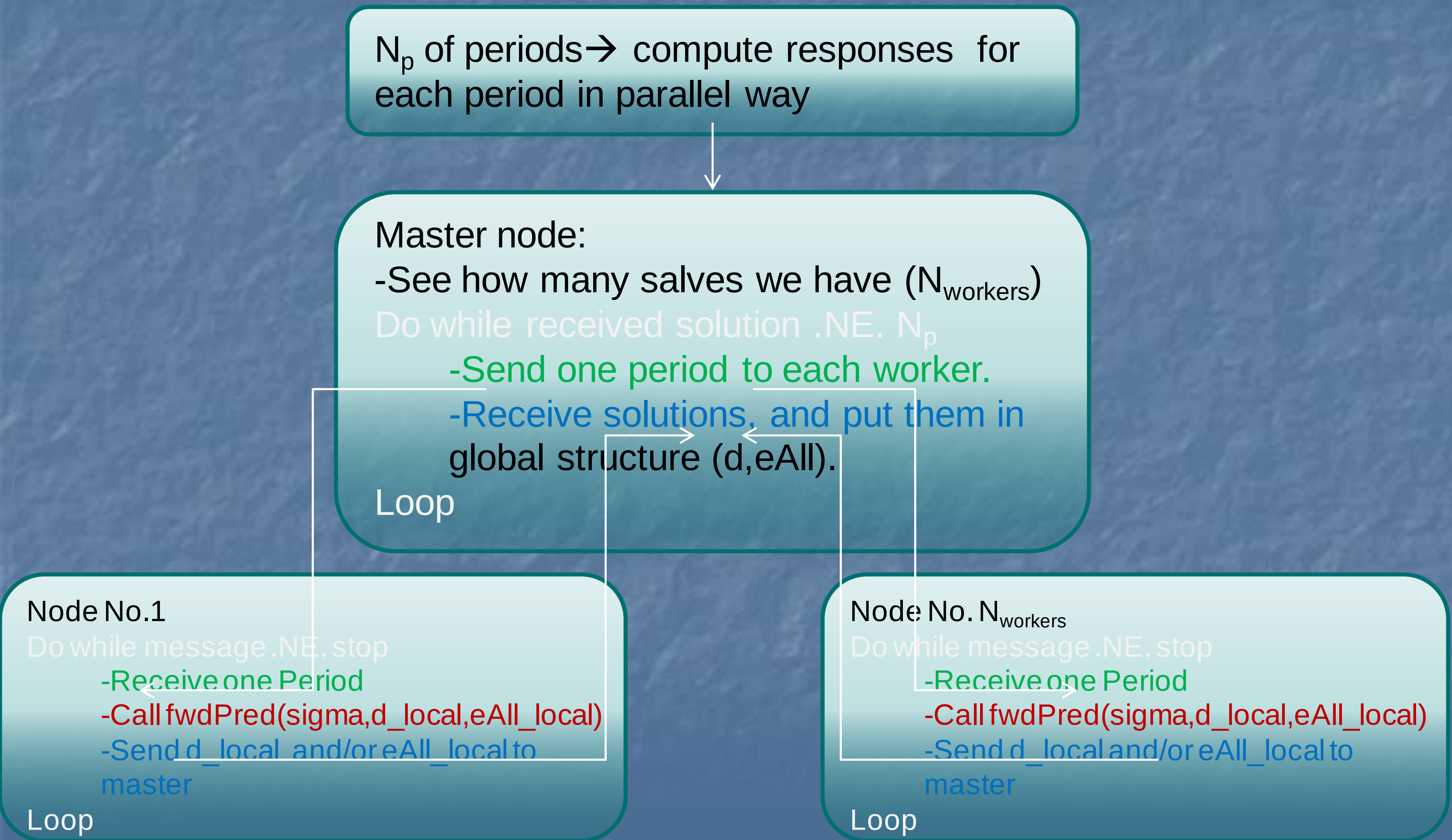
- In general: **S** matrix has the form:

$$\mathbf{S_m} = \mathbf{A}^{\mathbf{0}} + \mathbf{A}^{\mathbf{1}}\mathrm{diag}[\boldsymbol{\pi}(\mathbf{m})]\mathbf{A}^{\mathbf{2}}$$

Parallelization

- Few comments:
  - Keep the modular system as general as possible.
  - Deal with Fortran derived data types in MPI.
  - At the moment, parallelize over periods (transmitters).
  - Right now, parallel version of forward modeling problem in general form is ready.

Parallelization: Basic concept



Thank You very much for Your Intention