• Not finished answering questions!
• Introductions
  – Applications amazingly diverse!
    • Physical systems: astro, chem
    • Engineering: cfd, phones, power, imaging
    • Environmental systems: marine, ecology
    • Biological systems
    • Economic systems: business
    • Social/Political/Historical: archeology ...
  – Compute classes
    – pc’s: small amount of comp
    – clusters: moderate, many jobs
    – supercomputers: model reduction critical
Application Examples

- Turbulence
- Modeling biological system – small to large scale protein
- Environmental fluid mechanics, porous media flow
- Problem solving environment
- Imaged based analysis
- Near real time critical events assessment
- Spatial optimization model
- Global change
- Anomalous behaviors
- Multiple hypotheses
- Automated shop floor to high level decision

- Chemical reaction modeling
- Inverting chemical networks to big chemical networks
- Computational electromagnetics
- Distributed software integration
- Remote instrumentation
- Sense making
- Non time-contiguous data
- Model, data, and simulation integration
- Agent based model of household vis-à-vis landscape
- Revenue modeling
- Supply chain and logistics
Classes of applications

• Many diverse disciplines, but:
  – Model predicts future, data stream coming in, adjust model, repeat quite common
• Self organization of:
  – Application component
  – Measurement system
• Tiered
• Plurality of models
• “Get human out of loop”, “Human needs to check”, “human part of loop”…expert systems important
• More work on this…
Data

• All groups very worried about data!
  – how to distill all info to something on which decisions can be made
  – data streams, changing with time!
  – viz (human in loop), algorithms (computer in loop)
  – state estimator: how to do this?
    • reduction, noise, multiple states, etc
    • what is interface between data and computation?
  – error tracking, confidence in fitting to models of real data, need to be more rigorous
What do apps groups struggle with? What is needed?

• Data!
  – standards not clear, not clear if we should focus discussion on this
  – streams, size of data: but is it really too big?
  – Metadata not discussed, but important

• Algorithms
  – how to find all modes in multimode system? need to find correct state
  – cannot solve scale of problem: need model reductions

• Surely some common tools will develop, but not clear what they will be

• Policies and support at centers for DDDAS
• Dynamic validation!! Both data and models
  – Strongly and weakly constrained systems
  – General framework for validation needed
    • Specifics may all be different depending on app
    • Framework for making decisions
    • There is a lot of development already…need to understand how well it could apply
    • How to assimilate data

• These are all forms of inverse problems
  – How does dddas make this different?

• Metamodels, model management
Next steps

- Answer questions more clearly
- Try to give feedback to other groups
- Are there questions the other groups want to pose to apps?
- We would like to have a workshop on tools and techniques for DDDAS apps
What Opportunities & Challenges in enabling DDDAS?

• Creating vs using dddas
  – Adaptive dddas

• Challenges: what does not work well
  – Current tools…
    • need a tool to refine coarseness
  – Data too simple for the models, or data too complex for the models, observability/identifiability…ties to measurement groups
  – Do our models allow us to identify key features
  – Model discovery: how to get the right model from a plurality to be active? Impedance (mis)match between data and model
    • There are more useful models than current: how to identify
    • How to construct appropriate models that don’t exist
  – Application software, steering interfaces, guidance, toolkits for writing new codes, forces scientists to think about these issues as codes are designed
  – Identifying users, providing interfaces for them
New Apps

- Traffic routing and environment
- Still design experiments by hand for small amounts of data...scale up, can computer suggest experiment: e.g., bio
- Operation of wholesale power markets
- Education & training
  - Computer models what student knows, challenge student, refine model
- Anywhere that new data streams are created...opportunity: every possible discipline
- Sentient world sims:
- Solid earth systems: e.g., earthscope
What are Current Research & Technologies in our projects?

• Grids and related technologies
  – Middleware…dddas special requirements, often discipline specific
• Adaptive computation, changing algorithm based on data
• “service oriented architectures”
  – Services, agents, etc: use of this
• Model autocalibration…tuning to real data
• Toolkits for dddas apps are being used
• Debuggers, profilers, etc all need to work in this environment
• New Research issues: tightly constrained systems, estimating parameters, search applications and combining identifiability
Example apps to benefit from DDDAS?
Challenges: multilevel, multimodal models, composition of complex apps, model coupling

- On demand scaling
- ROM’s: tuning them for different scales
- Algorithms that adapt according to data:
  - Gauge conditions…analogies to others
- Middleware to support these issues
- Model equivalence as scales and models change
Challenges: data management, interfaces to data/experiment

• Synergies between different data sources, model data, experiments...the metadata issue
• Some systems are not controllable, some are...different issues
  – Controllable: optimal design of experiment
• Challenges in location and time of data and model output
• Data so large, can’t be stored...how to discard, and how to reconstruct discarded data? This point was missed this AM
Challenges: computation, memory, I/O requirements

- Yes, including knowing how they develop and change during a dddas process
  - Predicting what will be needed soon
  - Understanding bandwidth between systems based on model coupling
  - Model adaption based on resource availability
  - Access to on-demand computing needs to be provided

- Heterogeneity of grids
  - Driving middleware apps

- QoS issues
Needed Modeling Technology
Advancements, Systems Support?

- Toolkits for creating new apps
- Event driven support at system and scheduling software level
- Semantic composition of dddas apps
- Workflow, etc
- Theory issues to be addressed to deal with all this
  - Recent events show this: tsunami, hurricanes, WTC
Dynamic Data Management
General points

• Interdisciplinary needs, international, interagency cooperation
  – Discuss central and generic nature of dddas; table would be first step…just collecting info
  – Applications require cooperation of other parts of nsf and other agencies: make this point. E.g., can’t do medical w/o dddas
  – Cooperation within nsf divisions: engineering, mps, etc
  – Some agencies (e.g. Navy) require formal correctness tools, strong operational support
  – Requirements/spec steps important

• Strong executive summary
• High level points and recommendations needed
• Workshops…
Dynamic Application Selection
Dynamic Configuration Management
DDDAS - Why now?
DDDAS - Broader Impact