Strategic Implementation Plan (SIP) for a Community-based Unified Forecast System (UFS)

Data Assimilation Plans

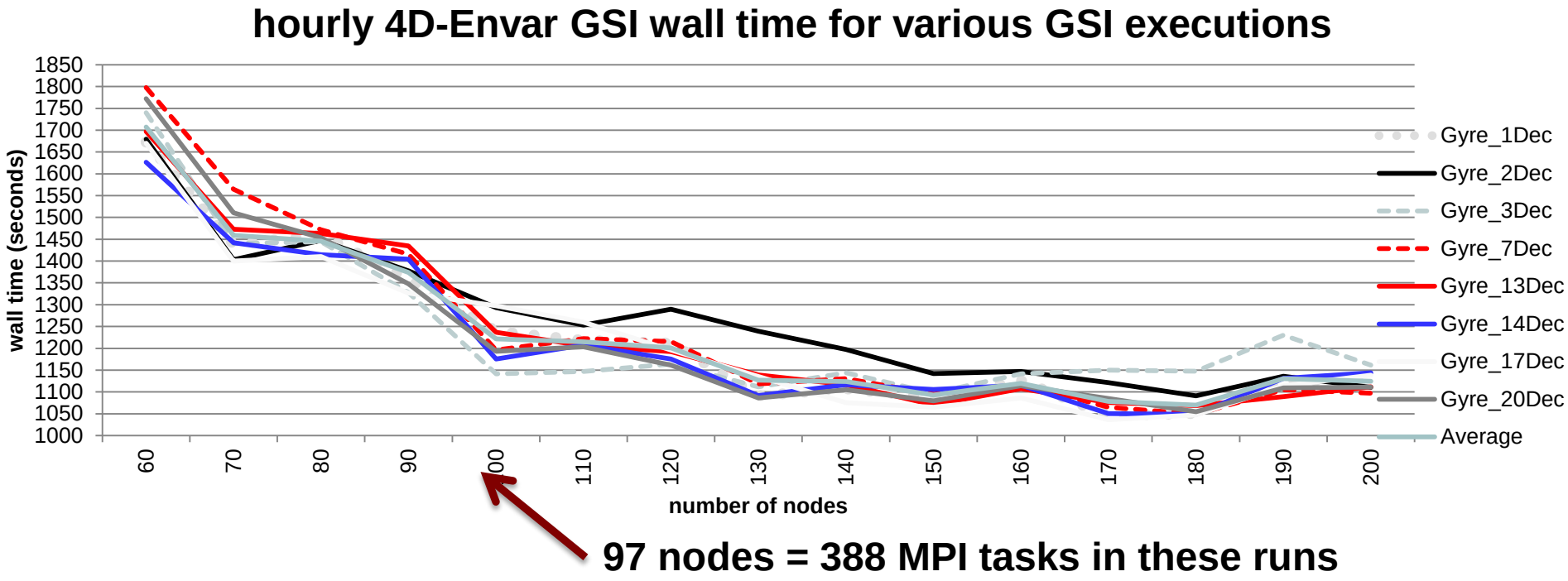
August 2, 2018; College Park, MD

(1) Status of Current Data Assimilation

- Ensembles and hybrids are now state-of-the science, operational for global NWP at most centers
  - Also critical for regional systems, sometimes leveraging global ensemble information
  - Direct connection to ensemble prediction systems
  - Variants also applicable to non-atmospheric component applications

- NCEP has largely pursued adjoint-free developments
  - For 4D, implementation of ***hybrid 4DEnVar*** for GDAS/GFS
  - This is the starting point for FV3-GFS/FV3-GDAS

Technical Challenge Example: Scalability



We already have a need for re-engineering of parts of the GSI. This was something underway prior to formation of JEDI project.

(2) “The Plan”

- JEDI Transition
  - ***Requirements Document***
    - Focus on current capabilities such as Hybrid 4DEnVar, etc.
  - ***Transition Plan***
    - Identification of incremental components to replace GSI functionality. JEDI/UFO through I/O (netcdf diag files) as first prototype/example.
  - ***Co-development of Infrastructure***
  - ***Consolidation of “marine DA” through JEDI-based DA***

- Science Evolution
  - Inter-comparison of Hybrid 4DEnVar and Hybrid 4DVar for FV3-GFS/GDAS (skill, computational cost, future considerations): ***evidence-based decision***
  - Grand challenges, Coupled, CAM, and much more….

(3) Scientific Plan for Data Assimilation: "Algorithm Development"

- Given results from UKMO, ***draft test plan for our own inter-comparison between Hybrid 4DEnVar and Hybrid 4DVar (with FV3 TL/AD)***
  - Continue to invest in improvements to 4DEnVar as it is operational system (time evolving full rank B, time evolving localization)
  - Forward thinking, HPC considerations
  - Consider implication of choices on coupled data assimilation
    - Is TL/AD available for coupled model, etc.

- Further exploitation of information from ensembles
  - Scale dependent hybrids (weights, localization), shifting/lagging, multi-resolution

- ***Choice of algorithms may be application dependent!*** This has implications for coupled assimilation.

(3) Scientific Plan for Data Assimilation: "Observations"

- New observations including those from non-traditional sources
  - Private, crowd-sourced, cell-phone, etc.

- Exploitation of current observing system
  - All-sky radiances
  - Better extraction of information content beyond selection/thinning

- Use of data analytics research
  - Improved, automated way for QC/data selection
  - Bias correction

(3) Scientific Plan for Data Assimilation: Coupled Data Assimilation

- Start with ensemble-based (or hybrid) “weakly coupled” assimilation system
  - Leverage state-of-science for each component
  - Explore coupled covariances through coupled ensemble forecasts
- Investment in coupled observation operators
  - Some observations have value for more than one component, think fluxes/interfaces for example
- Additional research into coupling strategies
  - Weakly, quasi-strongly coupled, strongly coupled
- Algorithm testing. Standard 4DVar difficult without TL/AD of fully coupled model (ensemble-TLM, quasi-strongly coupled assimilation, etc.).
- How to deal with differing temporal / spatial scales of components. Alternate cycling strategy
  - Various overlapping windows with differing lengths?
- Recommendations from 2016 Coupled DA workshop sponsored by WMO WWRP DAOS :
  - https://www.wmo.int/pages/prog/arep/wwrp/new/documents/Final_WWRP_2017_3_27_July.pdf

(3) Scientific Plan for Data Assimilation: "Longer Term"

- Currently in process of drafting research & strategic plan for improving operational data assimilation capabilities in the 5-10 year timeframe. Beyond some of the aforementioned:
  - ***Careful consideration to HPC aspects***
  - Leveraging data analytics (machine learning, etc.)
  - Alternate cycling strategies including overlapping windows
  - "In-core" data assimilation
  - Non-Gaussian, nonlinear errors
  - Bridging very short timescale (WoF) to S2S and beyond

(4) Risks and management strategies

- **Schedule:** If JEDI milestones are not aligned with implementation schedules, either implementation or leveraging of JEDI will be delayed
  - Mitigation**:** Integration of operational schedule into agreed upon "transition plan". Reduction in scope (features, etc.) as needed to accommodate.

- **Transition:** If well-defined, specific, incremental improvements cannot be identified, operational innovation will be delayed
  - Mitigation: Build agreed upon requirements document and "transition plan". Leverage more pieces of things like GSI where possible.

- **Operational viability:** If JEDI/OOPS cannot meet operational requirements, NOAA cannot efficiently leverage JEDI developments
  - Mitigation**:** Transition plan. Investments in co-development to keep things on track for operational viability.

(4) Risks and management strategies

- **Spin-up**: If new system has too steep of a learning curve, operational improvements may be delayed
  - Mitigation: Regular training & communication
- **Funding/Resources**: If additional resources are not provided to EMC to transition to JEDI, implementation will be delayed.
  - Mitigation: Reallocation of internal resources. External supplemental resources.
- **Physical Location**: If JEDI core team remains remote from EMC customer/partner, implementation may be delayed due to communications issues
  - Mitigation: Regular conference calls. Liaison positions at each location.
- **Authority/Accountability**: If JEDI is not focused on specific operational outcomes as described by customers and partners, development efforts may fracture.
  - Mitigation: Leveraging common resources such as hurricane supplemental. Co-development strategy. Greater involvement from working staff from ESRL, EMC, GMAO, etc.. Co-author 5-10+ year strategic research plan for DA.