6. WRF - ESMF Integration:
Strategies and Discussion

WRF Executive Oversight Board

Meeting 3

13 April 2005

ESMF - WRF Integration:

Why ESMF? **Integration will enhance WRF's ability to pursue its Phase 2 & 3 strategies.**

Phase 2 Strategy: **…Sustain flow of new science and technology into WRF…**

Phase 3 Strategy: **…Extend collaboration to other modeling areas of interest...**

ESMF is an emerging technology

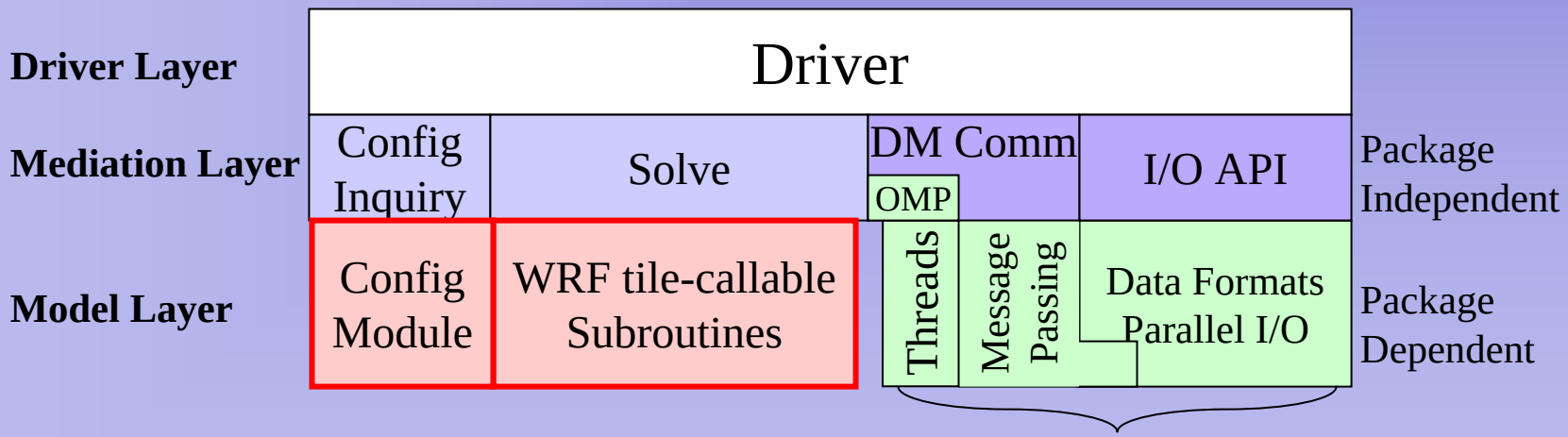
- **Primary goals of WRF-ESMF integration**:
  - **Sustain: Maximize** computational performance, versatility, interoperability and system supportability.
  - **Extend: Minimize** effort to couple WRF with other component models.
- **Where headed? - End state** for ESMF-WRF integration is still **uncertain.**
- **Strategy forward? - Define** and pursue **initial direction.** Pace of transition will **accelerate** as clarity of end state emerges.
- **When?** - Probably **4-5 years**

* **Critical requirement:** Integrated WRF-ESMF end-state **must retain** a single version-control system to preserve the interoperability and user-support system necessary to sustain WRF as a **common modeling infrastructure** shared by research and operations.

What is the current WRF Architecture?

1. **Approach:** ***Tightly-knit three-level hierarchy*** for optimum performance**:**
2. **Objective:** ***Insulate the scientist*** from parallelism and other architecture-specific details.
3. **Known Handicap:** Developers who need to work within WRF infrastructure must deal with ***many levels of complex code***.

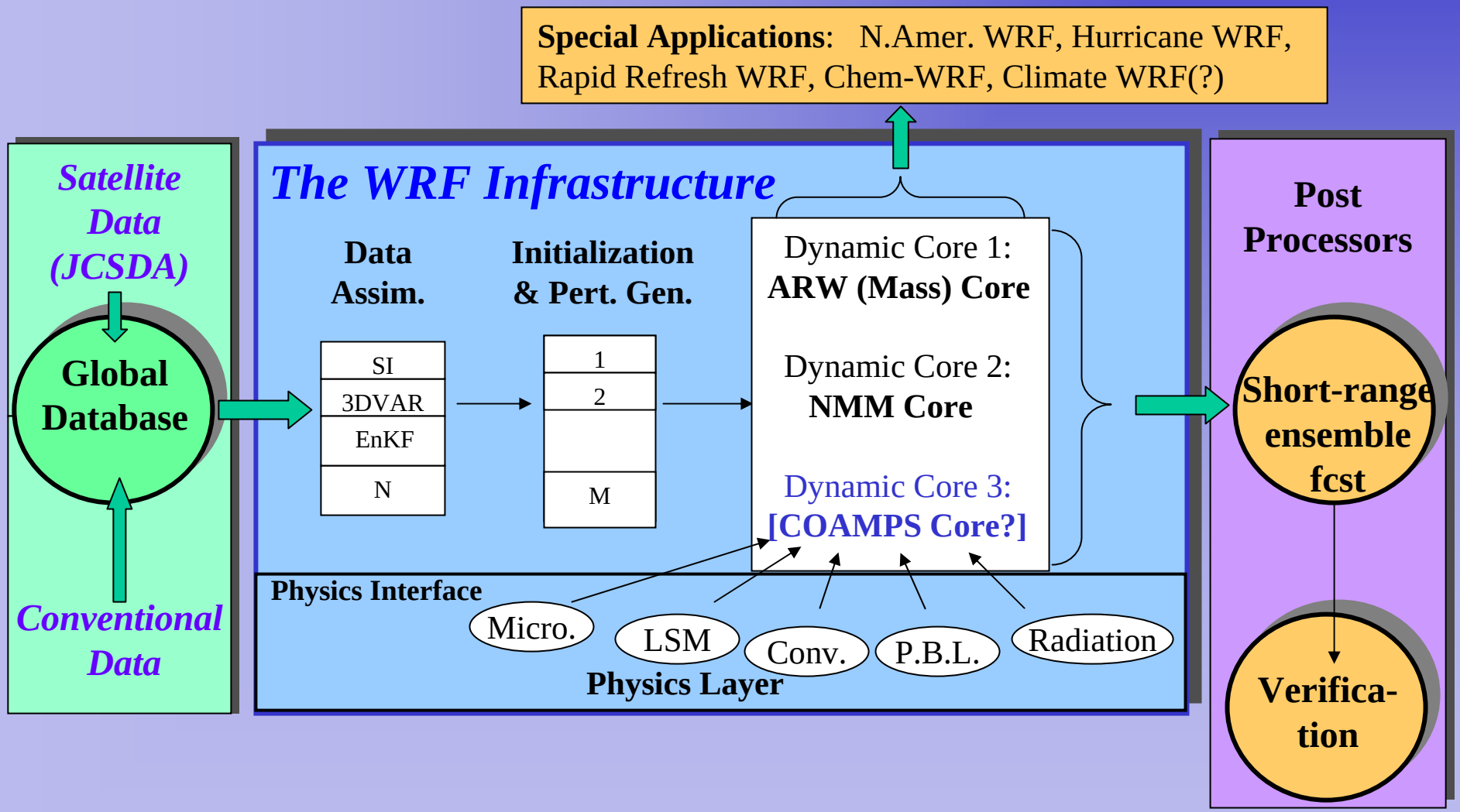
The WRF 3-Layer Architecture



Courtesy John Michalakes, NCAR;

See backup slide for details

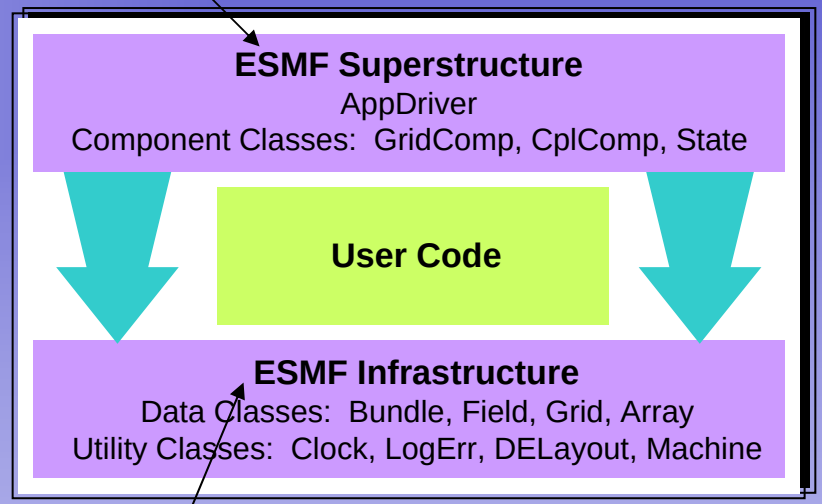
Value: WRF Currently Provides Users an End-to-End NWP Modeling System



What is the ESMF Architecture?

1. **ESMF provides tools to use models in coupled systems** with…
   - standard interfaces
   - standard drivers
2. **ESMF provides a range of optional data structures and utilities…**
   - to organize codes,
   - to improve performance and portability,
   - for common services such as data communications, regridding, time management and message logging.
3. **Unknowns:**
   - **Will developers need to work inside ESMF codes?**
   - **How complex are ESMF codes?**
   - **Who would be ESMF-WRF "code Czar?"**

Many functions equivalent to WRF's driver layer reside here.



Many functions equivalents to WRF's mediation layer and external packages reside here.

Courtesy Cecelia DeLuca, NCAR ESMF Dev. Team

Possible ESMF-WRF Integration Approach: Adapting WRF to ESMF

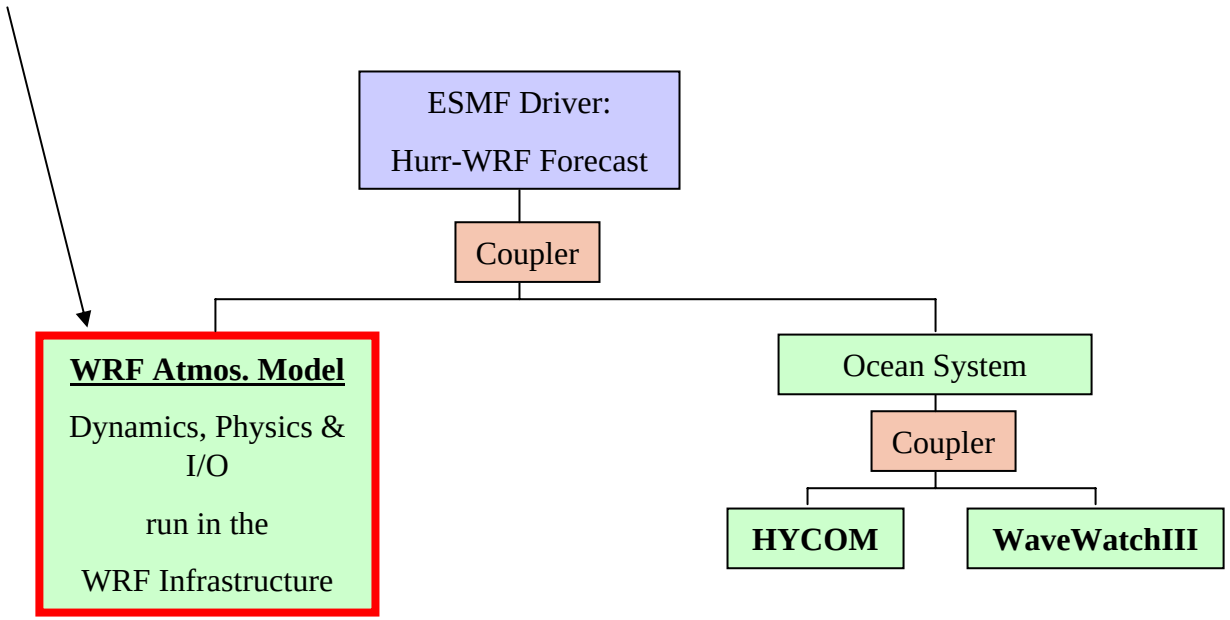
- **Make WRF configurable as a component within ESMF**
  - **Establish same standard interfaces as other ESMF components**
  - **Support inter-model coupling through ESMF**
- **WRF moving towards ESMF Climate and Forecast metadata conventions**
- **ESMF core team is incorporating WRF I/O API into ESMF**
- **WRF software infrastructure used by ESMF intra-component design**
  - **Meta-programming features of the WRF Registry**
  - **Infrastructure for model parallelism**
  - **I/O API**
- **WRF applications not involving model coupling will not require ESMF**
- **Integration of both WRF and CCSM into ESMF may facilitate the nesting of WRF within CCSM**

Slide provided courtesy of NCAR/MMM

Possible ESMF-WRF Integration Approach: Maximize use of existing WRF Infrastructure

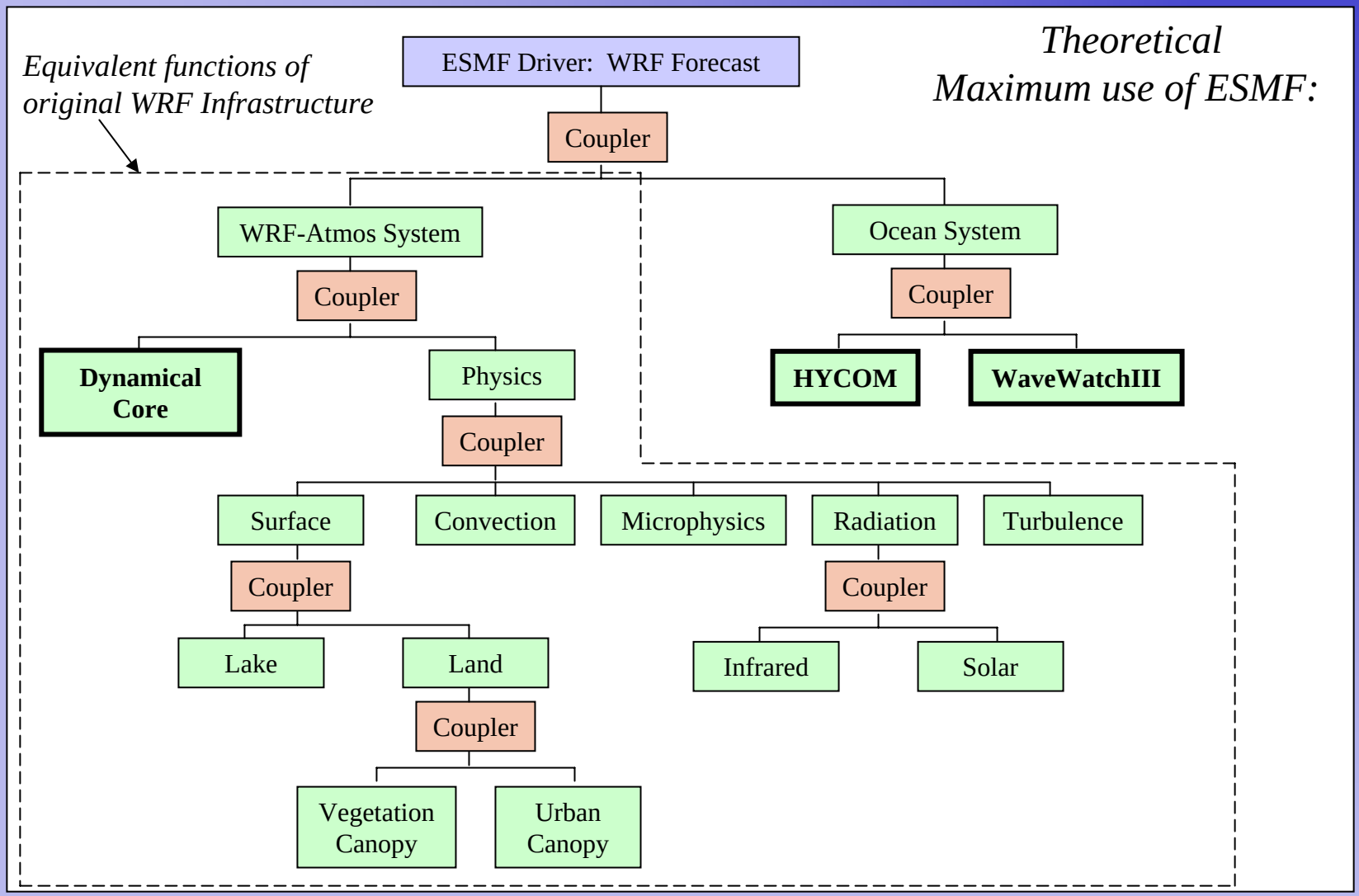
NCAR/MMM is adapting WRF Infrastructure to conform to ESMF standards so WRF can tell ESMF what it is and what it does.

Application:
NCEP Hurricane WRF
Target implementation: FY07



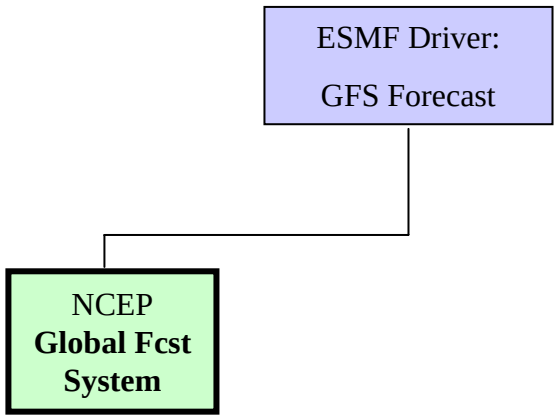
Green: User's model components; Tan: User-written ESMF coupler; Violet: User-written ESMF Driver

Possible ESMF-WRF Integration Approach: Maximize use of ESMF



Test and Evaluation of ESMF-WRF Integration:

***NCEP is now testing the interface functions of ESMF to run GFS forecasts within ESMF. Target: June '05**

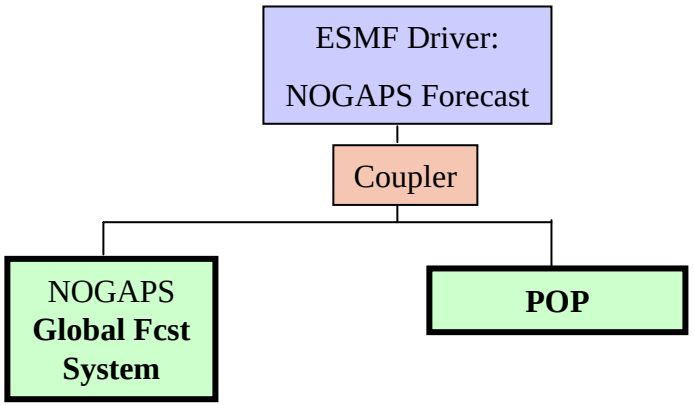


Questions to be answered:

- Computational penalty?
- Resource commitment?
- Impact on scalability?

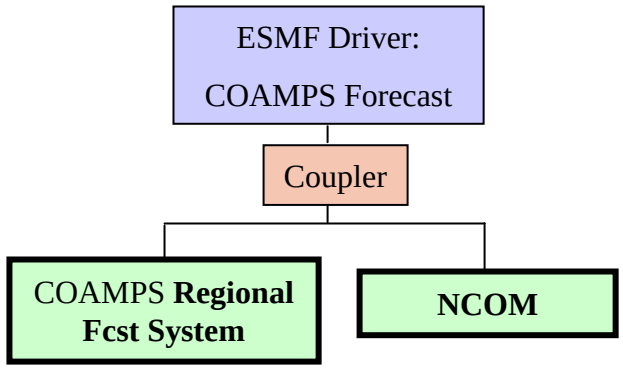
Test and Evaluation of ESMF-WRF Integration:

******NRL has tested coupling of NOGAPS with an ocean model using ESMF.*
Completed: 4QFY04



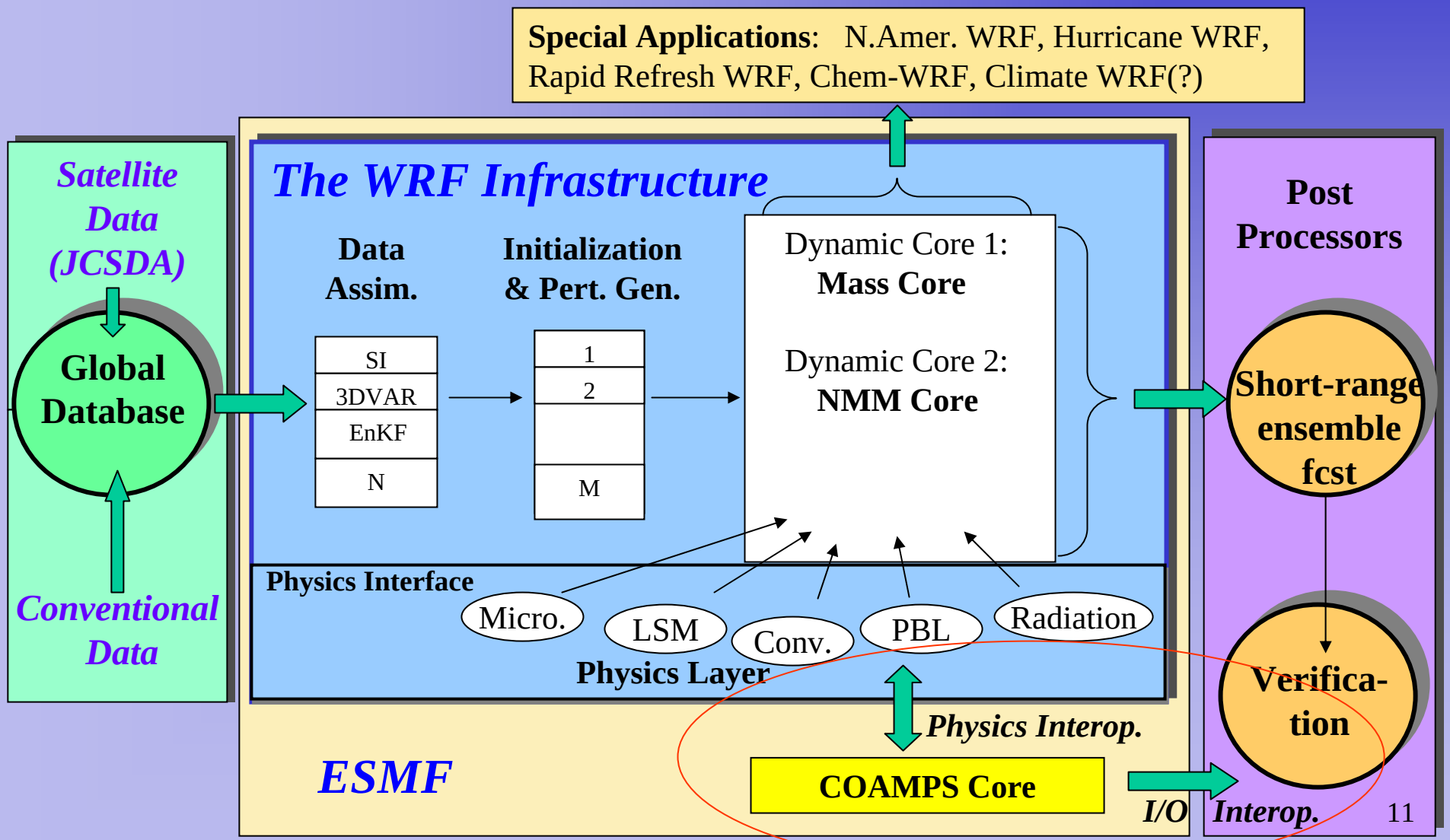
Results of conversion:
-Computational penalty: ~2%
-Resource commitment: ~1/4 FTE
-No effect on scaling

******NRL is putting the COAMPS® atmospheric model, ocean model (NCOM), and flux coupler into ESMF.*
Target date: 4QFY05



Metrics of conversion:
-Computational penalty: <5%
-Resource commitment: ~1/4 FTE
-No effect on scaling
-Code changes: <10%

Concept: ESMF-WRF could be adapted to provide WRF interoperability with COAMPS



How to Proceed with ESMF and WRF?

Many Unanswered Questions:

What's "under the hood" of ESMF?

1. **What is performance penalty of ESMF?**
2. **What is initial resource commitment to become "ESMF conformable"?**
3. **Can developers remain insulated from ESMF internal codes?**
4. **Can a WRF-ESMF system retain/improve essential WRF characteristics?**
   - **version control**
   - **functional versatility**
   - **interoperability**
   - **supportability, maintenance**
   - **portability, scalability**
5. **Can research community accomplish its WRF goals via WRF-ESMF?**
6. **When will missing ESMF components be available?**
7. **How long for WRF partners to reach common end-state? How defined?**
8. **What is best path for WRF community?**
   - ***Near term:*** **Retain "mostly WRF" integrated architecture?**
   - ***Long term:*** **Adopt "mostly ESMF" integrated architecture?**

Sense of the COPC Directors to WExOB

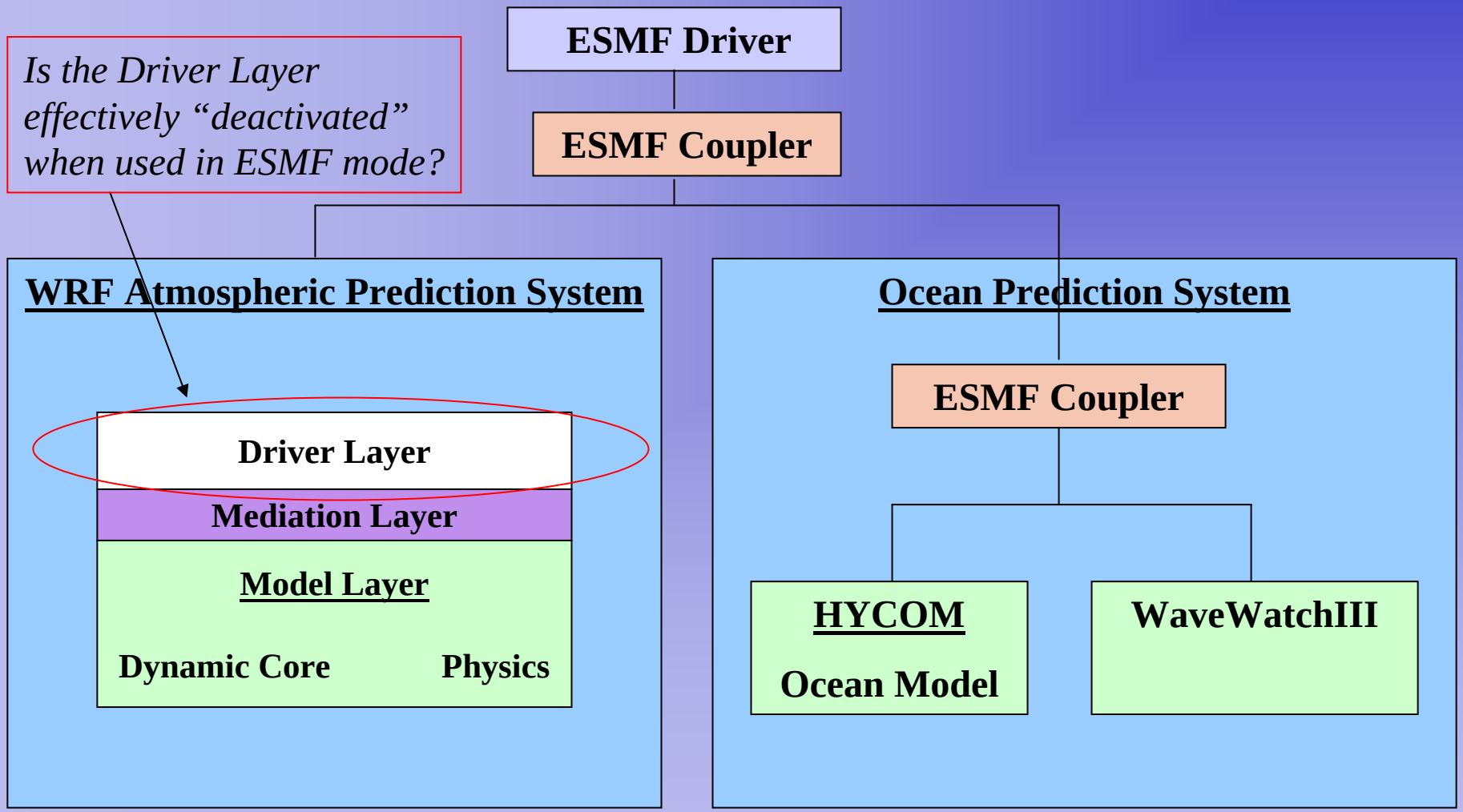
Memo 1. High-priority goal: OPCs expect to develop, test and implement a unified operational **WRF multi-model ensemble** for short-range applications within 5 years (by 2010).

Memo 2. A. OPC Directors have strong interest in pursuing a **unified modeling approach** that embraces global-regional mesoscale modeling with WRF as a prime candidate vehicle.

B. Our collective interest would be best served by **one modeling infrastructure** which cuts across all models (atmosphere, oceans, land, cryosphere.

Backup Slides

Possible ESMF-WRF Modeling System

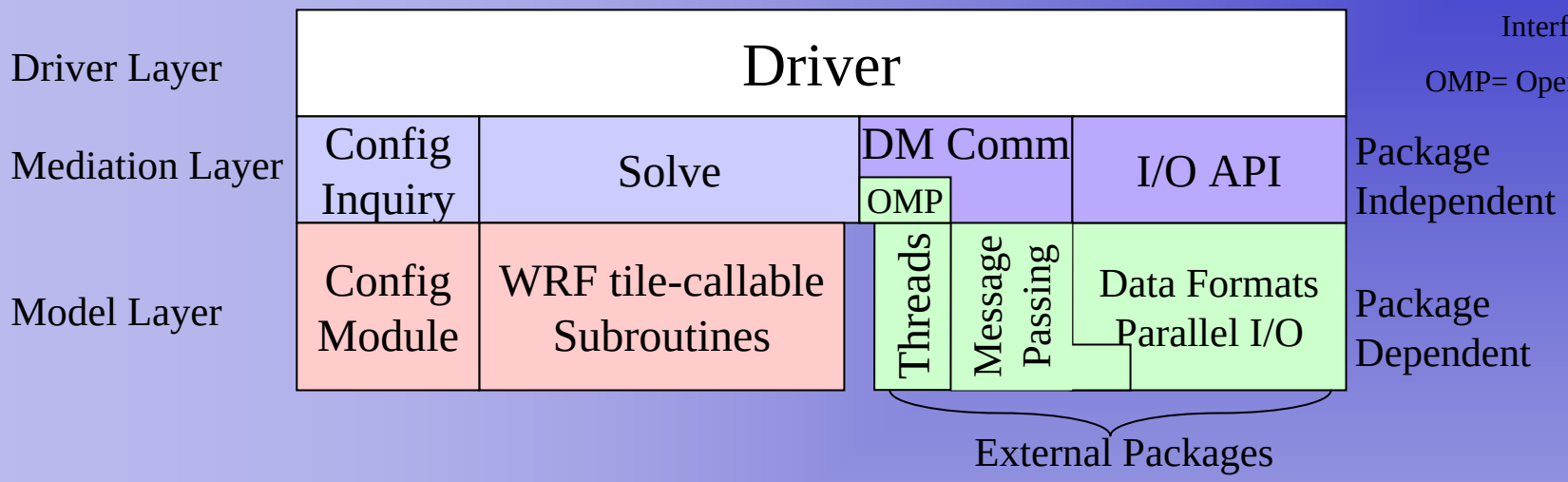


The WRF Software Engineering Infrastructure (NCAR):

DM=Distributed Mem.

API= Application Program Interface

OMP= Open MP



1. **Objective:** Insulate the scientist from parallelism and other architecture-specific details.
2. **Three-Level Hierarchy:**
   - **Driver Layer:** Responsible for top-level control of initialization, time-stepping, I/O, domain set-up, nesting, domain decomposition, computer processor topologies and other aspects of parallelism
   - **Mediation Layer**: "Glue" between driver and model layers; tiling, communication, time step control; makes driver layer transparent to model layer.
   - **Model Layer**: Subroutines that perform actual model computations; meteorological codes, physics
   - **Package Dependents**: Open MP, parallel I/O libraries, message passing libraries, node thread packages