Report on HFIP Modeling and Physics Strategy Team Discussion

High Priority Areas for Model/ Infrastructure Improvements

- **Model infrastructure**
  - **Current Issues**
  - WRF infrastructure does not scale well beyond certain configurations, posing significant computational challenges
  - Multiple moveable nests in a multi-scale environment is hard to design and implement
  - Model I/O is the major bottleneck
  - **Solutions**
  - Adopt NMMB/NEMS framework for HWRF
  - Configure and test multiple moveable nests within the NMMB/NEMS framework using advanced computationally efficient procedures
  - Accelerate transition of HWRF components to NMMB/NEMS for future operational needs
  - Further increase of model resolution to ~1-2 km near the storm region
  - Efficient coupling between various components within NEMS including post-processing and product generation

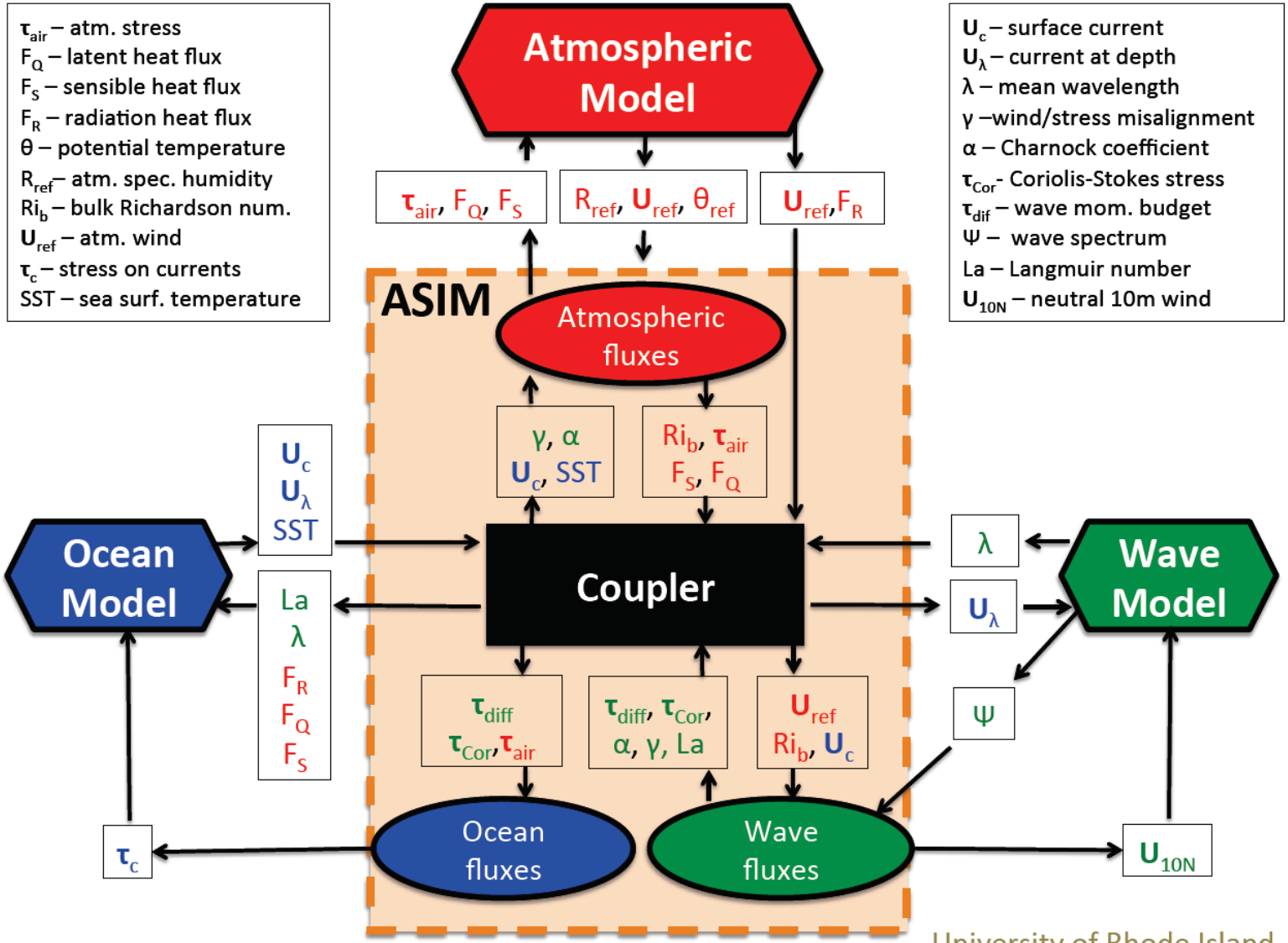
High Priority Areas for Physics Improvements

- **Physics**
  - **Current Issues**
  - Lack of Scale/Feature Aware Physics for multi-scale interactions
  - Lack of comprehensive evaluation of model physics
  - Parameterization of convection for varying resolutions
  - Resilience to shear, inadequate representation of vortex-shear interactions
  - Impact of up-scale feedback and multi-scale processes
  - Mechanisms for RI/RW
  - Role of Waves and Sea Spray
  - Primitive land surface and radiation schemes
  - Bulk microphysics vs. higher moment schemes (or advection of multiple species)
  - **Solutions**
  - Systematic and extensive evaluation of model physics using all available observations
  - Optimum combination of LSM/PBL/Radiation/Microphysics/Convection schemes
  - Implement scale/feature/aerosol aware physics components including radiation
  - Stochastic physics and ensembles for improved RI/RW predictions
  - 3-way air-sea-wave coupling for better representation of physical processes at the air-sea interface
  - Coupling to advanced NOAH LSM

Proposed Air-Sea Interface Module for accurate representation of air-sea-wave coupling

τ_{air} – atm. stress
F_Q – latent heat flux
F_S – sensible heat flux
F_R – radiation heat flux
θ – potential temperature
R_{ref} – atm. spec. humidity
Ri_b – bulk Richardson num.
U_{ref} – atm. wind
τ_c – stress on currents
SST – sea surf. temperature

U_c – surface current
U_λ – current at depth
λ – mean wavelength
γ –wind/stress misalignment
α – Charnock coefficient
τ_{Cor}- Coriolis-Stokes stress
τ_{dif} – wave mom. budget
Ψ – wave spectrum
La – Langmuir number
U_{10N} – neutral 10m wind



University of Rhode Island

HFIP MODELING / PHYSICS NOTES

MILESTONES – 5 YRS

- HOW TO IMPROVE OPERATIONAL NWP

FUTURE – MULTISCALE MODELING (5 YR, HIGHER RES)

ISSUES – GLOBAL v. BASIN APPROACH – 1 - 3/5 days Regional &

SEPARATE GFS & HWRF GOALS

THERE IS VALUE IN NWP FOR INTENSITY 5 days

NHC – 24-48 HR CRITICAL (INTENSITY)

RI – UNIQUE PHYSICS? / 5 DAYS

STORM SURGE COUPLING ⇒ BETTER STRUCTURE.

Structure predictions / INNER CORE D.A.

INITIALIZATION IMPACTS 0-24 hr

- NO 2DARY CIRCULATION
- INIT. RESOL (HOR / VERT)

ARW v. NMM LIBARIES / COMMUNITIES

UNDERDIAGNOSED MODEL DATA

NEMS ⇒ SYNCH PARALLEL INTEGRATION

5 STORM NCO ALLOCATION

* RUN UPGRADED GFS CASE

- TC VITALS FORC
- HIGHER INNER COR

PHYSICS: EN

- WHAT PHYSICS
- RAD/CLOUDS
- BL mixing (tur
- Air-sea inter

* 'Scale aware' phy

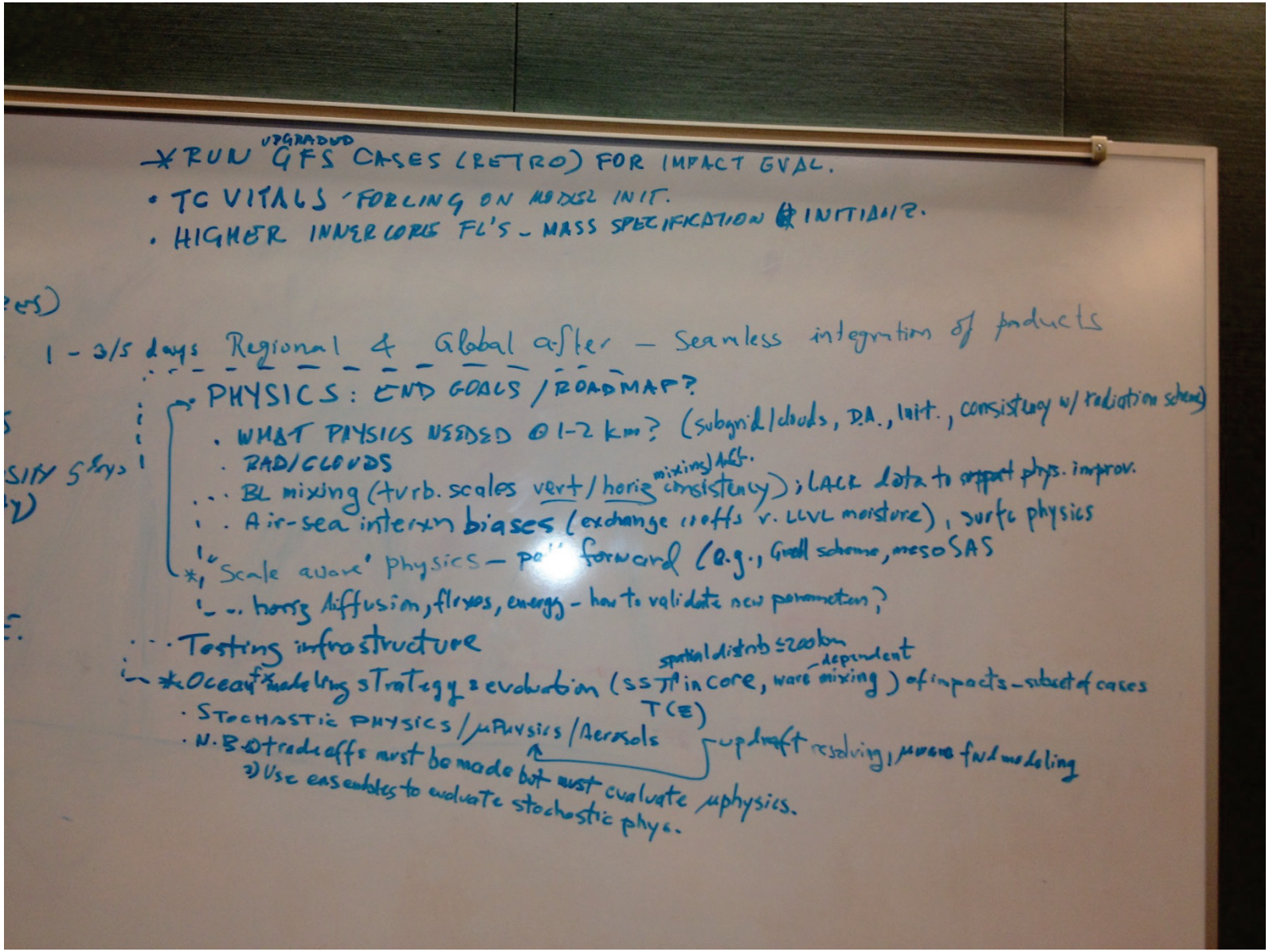
horiz diffusion

Testing infrastruc

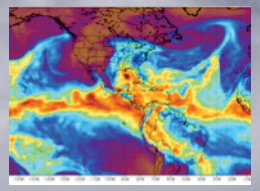
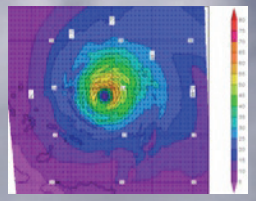
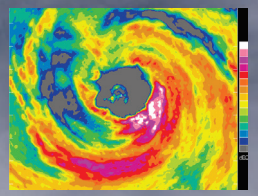
* Ocean coupling strat

- STOCHASTIC PHYS
- N.B. trade-offs amst

2) Use ensembles to


*RUN UPGRADED GFS CASES (RETRO) FOR IMPACT EVAL.
• TC VITALS - FORCING ON MODEL INIT.
• HIGHER INNER CORE FL'S - MASS SPECIFICATION & INITIALIZ.
1 - 3/5 days Regional & Global after - Seamless integration of products
PHYSICS: END GOALS / ROADMAP?
. WHAT PHYSICS NEEDED @ 1-2 km? (subgrid/clouds, DA., Init., consistency w/ radiation schem)
. RAD/CLOUDS
. . . BL mixing (turb. scales vert/horiz mixing) consistency); LACK data to support phys. improv.
. . Air-sea interxn biases (exchange coeffs v. LLVL moisture), surf. physics
*, 'Scale aware' physics - pa'' forward (e.g., Grell scheme, meso SAS
'_ .. horiz diffusion, fluxes, energy - how to validate new parameters?
. . . Testing infrastructure
*Ocean modeling strategy & evaluation (SST in core, wave mixing) spatial distrib scales dependent
T(E)
• STOCHASTIC PHYSICS / μPhysics / Aerosols
• N.B. tradeoffs must be made but must evaluate μphysics.
updraft resolving, μwave fwd modeling
2) Use ensembles to evaluate stochastic phys.

Optimizing observations and observing strategies to better evaluate and improve model physical processes

Motivation

Overarching Objective…

Improve forecast performance through a systematic evaluation process, whereby model biases are documented, understood, and ultimately eliminated by implementing accurate, observation-based physical parameterizations.

Model Evaluation and Improvement Methodology…

- **Compare operational model output with similar, observationally-based corollaries over appropriate spatial & time scales (e.g. air-sea interaction, boundary layer, etc.).**

- **Emphasize analyses highlighting wave number 0/1 (i.e. mean/asymmetry) structure.**

- **Based on these inter-comparisons, begin work in specific areas where model improvement may be possible (e.g. parameterization modification, etc.).**

- **Identify processes/areas that are poorly evaluated due to inadequate sampling.**

- **Target "observational gaps" by strategically utilizing existing and emerging observing technologies to better evaluate and improve model physical fields.**

- **In parallel, conduct targeted OSE/OSSEs to determine the optimal mix of new and existing observations most likely to improved future forecasts of intensity change.**

- **As model improvements are made, conduct process-oriented simulations to improve physical understanding and better quantify model sensitivity and variability.**

- **Model physics evaluation….**
  - For this effort, de-emphasize…
    - Model vs. Best Track
    - Forecast A vs. Forecast B
    - Model X vs. Model Y
  - Instead ask..How well are we simulating reality (physical fields/processes)?
  - How often do we get the right answer (forecast) for the wrong reason?
  - Where are the model biases, what physical processes are causing them?
  - Where are the (model sensitive) data gaps and how can we best fill them?
- **In a world of limited resources we need to….**
  - Identify the low hanging fruit (and grab it!)
  - Maintain realistic goals:
    - Target evaluation and improvements linked to wave number 0 (mean) and wave number 1 (asymmetric) structure and phenomenon…

Modeling Strategy

- Shifting of paradigm: storm-centric to domain-centric with multiple moving nests in one big domain (even global domain) which allows multi-scale interactions and storm-storm interactions
- Need to define the roles of global and regional models. Regional models would more focus on short rage forecast (0-5days) with special emphasis on RI for 0-72hr period, while global model's focus will be longer time such as over 5days
- NHC needs more accurate intensity forecast in 1-3days prediction time scale. Regional modeling team needs to work on improving the storm intensity in these time periods
- Global model still provides valuable intensity guidance via intensity trend although the intensity prediction itself is not as good as regional model

Physics Strategy

- Need more clear road map for physics development in HFIP team
- How to make full use of observational data to evaluate the performance physics schemes, which would lead to improve the physics schemes
- Focus on developing the physics suites which can predict RI/RW more accurately.
- Needs to consider scale awareness and feature awareness physics
- Do we need to consider the horizontal turbulent mixing in PBL while the grid spacing is getting finer?
- Recommend a tiger team for evaluating the role of a ocean model
  - How complex the ocean model should be (1-D vs. simple feature based models vs. comprehensive 3D ocean models) for intensity forecasts?
  - How and where to evaluate the influence of ocean models?
- Microphysics scheme evaluation would be difficult due to lack of observations
- Adopt Stochastic physics components especially for high-resolution regional model ensembles

Global directions for HFIP

- HIWPP-funded testing of multi-model global ensemble with FIM and GFS (HIWPP= High-Impact Weather Prediction Project)
  - Support past and upcoming participation of FIM in HFIP Stream 1.5 testing/evaluation
- 7-day TC forecast requirement –
  - This can be met only with global model forecasts.
  - Requires TC genesis and dissipation verification (Fiorino, Marchok)
- Suggested prerequisites for global evaluation in HFIP for new models
  - Nearly equal TC track forecast skill with operational GFS for 3-5+ day forecasts
  - Nearly equal 500 hPa height anomaly correlation with operational GFS for 5-7-day forecasts
- If these conditions are met, HFIP can consider future evaluation of new global models in 2015-2016.
- HIWPP selection of a preferred non-hydrostatic global model for future OAR development for data assimilation and physics would be a likely focus for HFIP global modeling for the 2017-2019 period.

Scale-aware physics

- 2014 testing at global and regional scales
  - Global – FIM definitely, GFS possible
  - Regional – HWRF
- Primary candidates
  - Grell-Freitas convection scheme (deep/shallow)
  - New Han-Pan convection scheme (GFS/Meso-SAS)
  - Future Climate Prediction Team (CPT) development of scale-aware physics (~2016)

Discussion points

Does there need to be a separate NCEP global model (e.g., global HWRF) devoted to TC prediction?

HFIP opportunity to coordinate / leverage off of HIWPP (High Impact Weather Prediction Project) activities