Operational Hurricane Wave Modeling at NCEP

Beyond 2005

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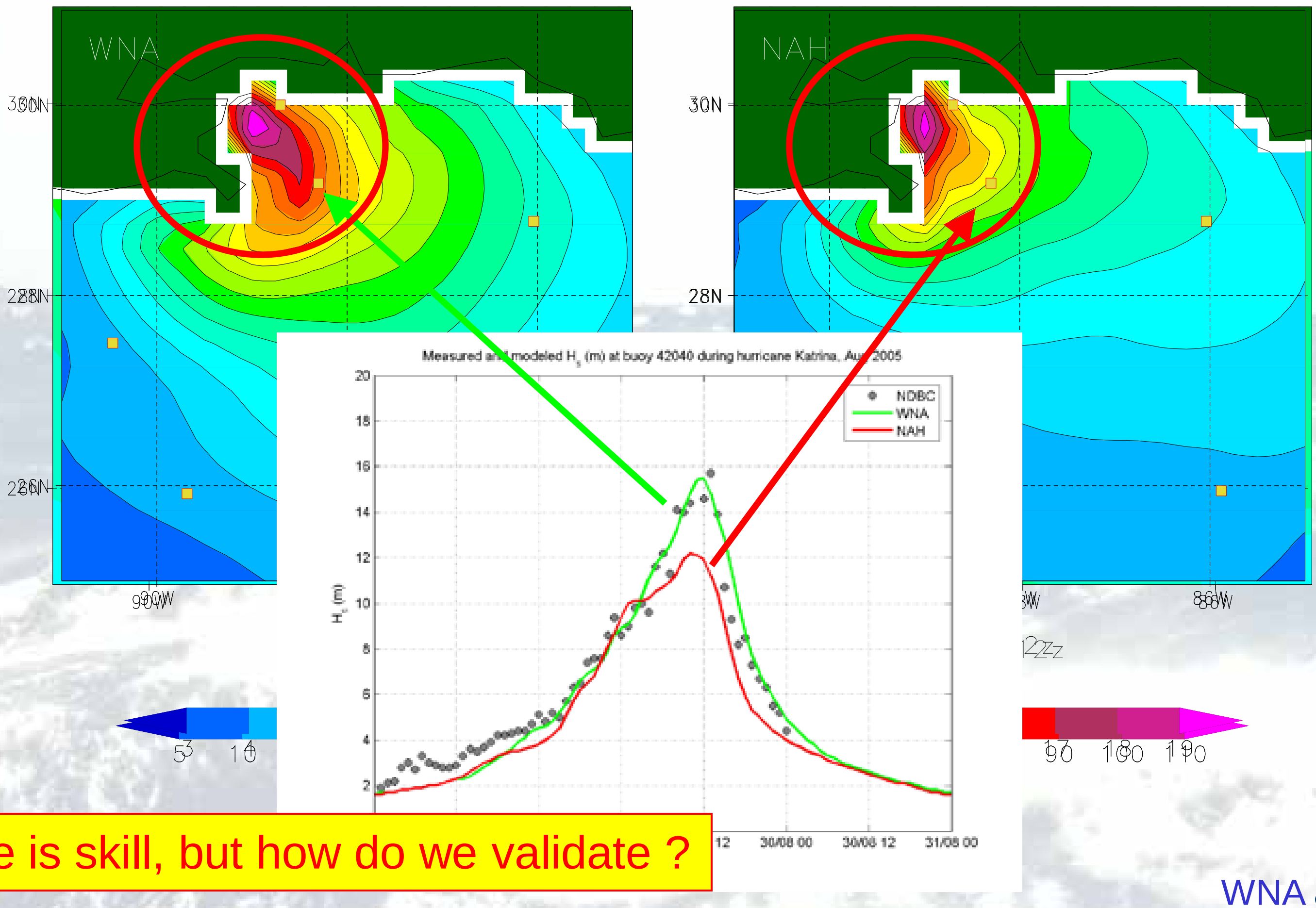
Operational models

- Operational hurricane forecasting with blended winds since 2001.
- No major updates in 2005 (other than GFDL).
- Now fully documented in two papers in *Weather and Forecasting*.
  - Chao et al., 2005, An operational system for predicting hurricane-generated wind waves in the North Atlantic Ocean. *W&F,* **20**, 652-671.
  - Tolman et al., 2005: Operational forecasing of wind generated waves by hurricane Isabel at NCEP. *Weather and Forecasting*, **20**, 544-557.
- Good results in 2005, some issues with early storms due to error in assumed height of winds.

Katrina

Waves, reflections, shallow water and resolution issues

Winds, land, eye, different radius



There is skill, but how do we validate ?

WNA and NAH

The near future

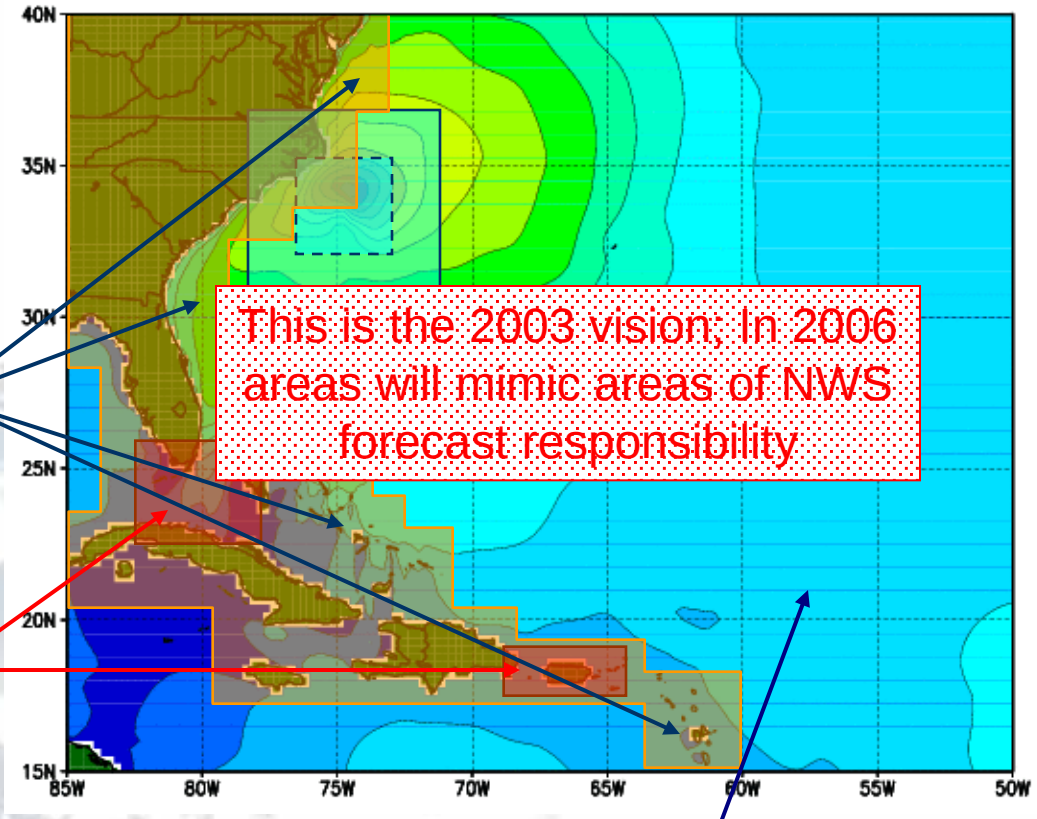
- Physics upgrades:
  - Coupled modeling wind-wave-ocean (see previous four presentations). Tentatively, GFDL in 2006, HWRF in 2007.
  - Stresses (2006).
  - Shallow water physics (2007).
- The multi-scale version of WAVEWATCH III:
  - Two-way nesting, and nests following hurricanes as in the atmosphere.
  - Integrated in HWRF.

The multi-scale model

Deep ocean model resolution dictated by GFS model

Higher coastal model resolution dictated by model economy

Highest model resolution in areas of special interest



Hurricane nests moving with storm(s) like GFDL and WRF

The multi-scale model

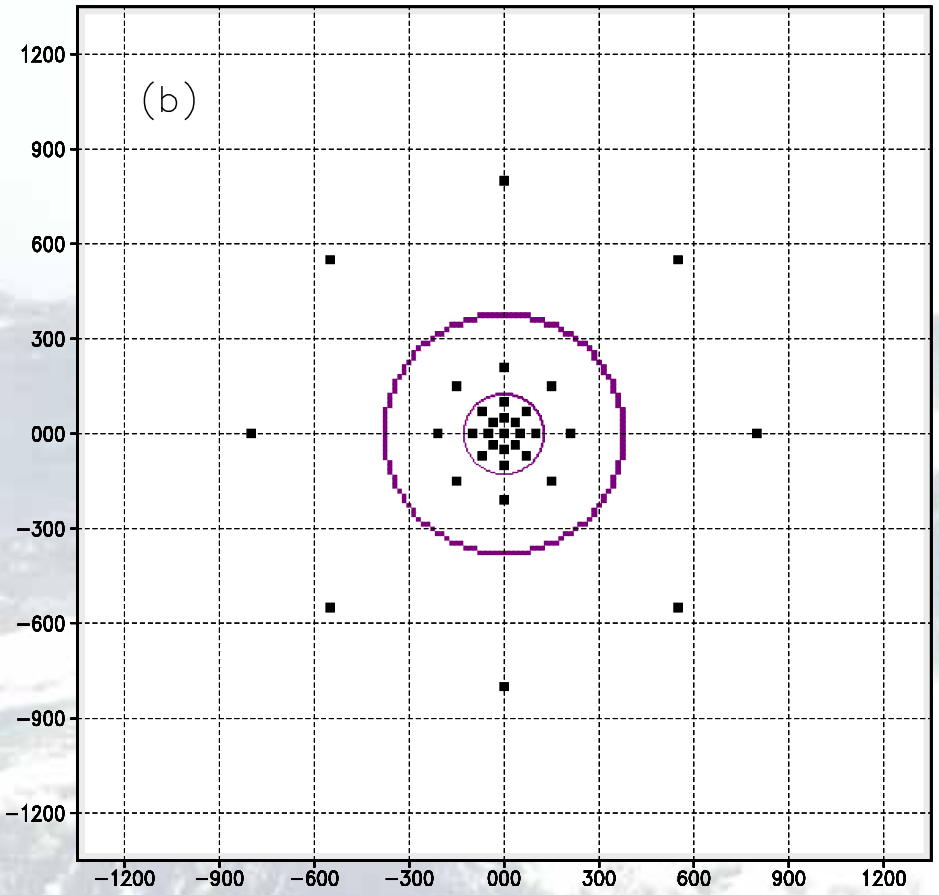
- Run a mosaic of grids with full two-way data flow between all grids.
- Massive software development effort.
  - † Running multiple grids in single program.
  - † Grid time stepping management.
  - † Develop nesting techniques.
    - ¢ Telescoping nests
    - ¢ Overlapping grids.
    - ¢ Relocatable grids.
- Continuously moving grid option for deep ocean hurricanes is already available.

Tolman and Alves, *Ocean Modelling*, **9**, 305-223, 2005

The multi-scale model

- Define rank number of grids, based on resolution.
- Allow for groups of grids with same rank.
- Data transfer from low to high resolution grids by boundary.
- Data transfer from high resolution to low resolution by area averaging.
- Given grid rank, grid time steps and grid points at which boundary data is to be provided, the time management algorithm and data flows between grids are fully automated.

Example 1



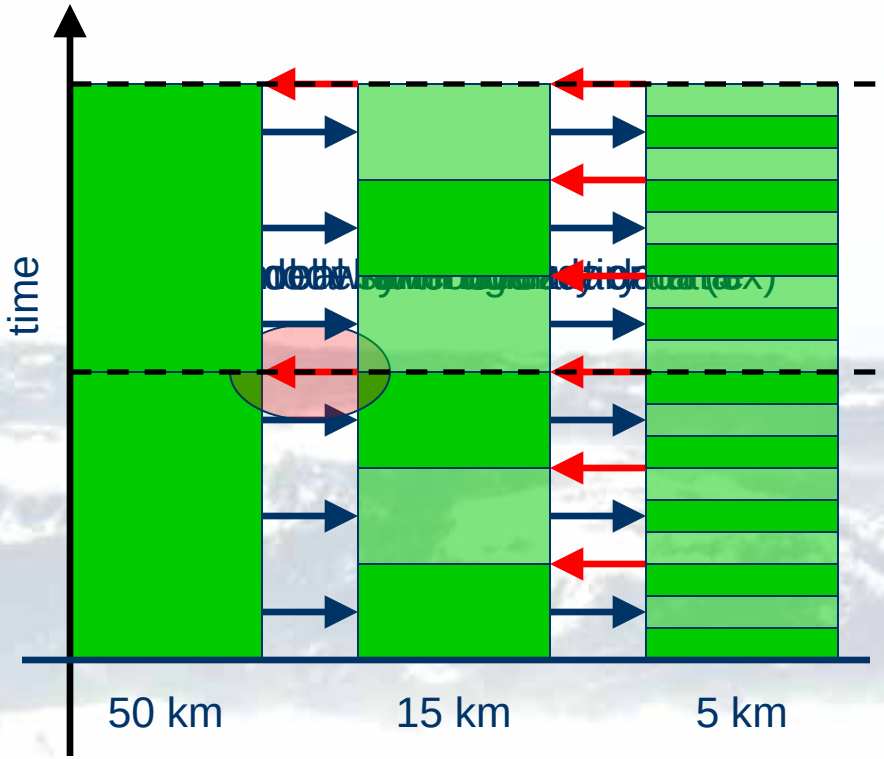
Hurricane described with Rankin vortex with maximum wind of 45 m/s at radius of 50km. Stationary hurricane or continuously moving grids.

Telescoping grids with 50, 15 and 5 km resolution.

Alternative circular domains.

Example 2

- Factor 3 in time steps between grids.
- Full communication between grids
- Fully automated data flow / time stepping.



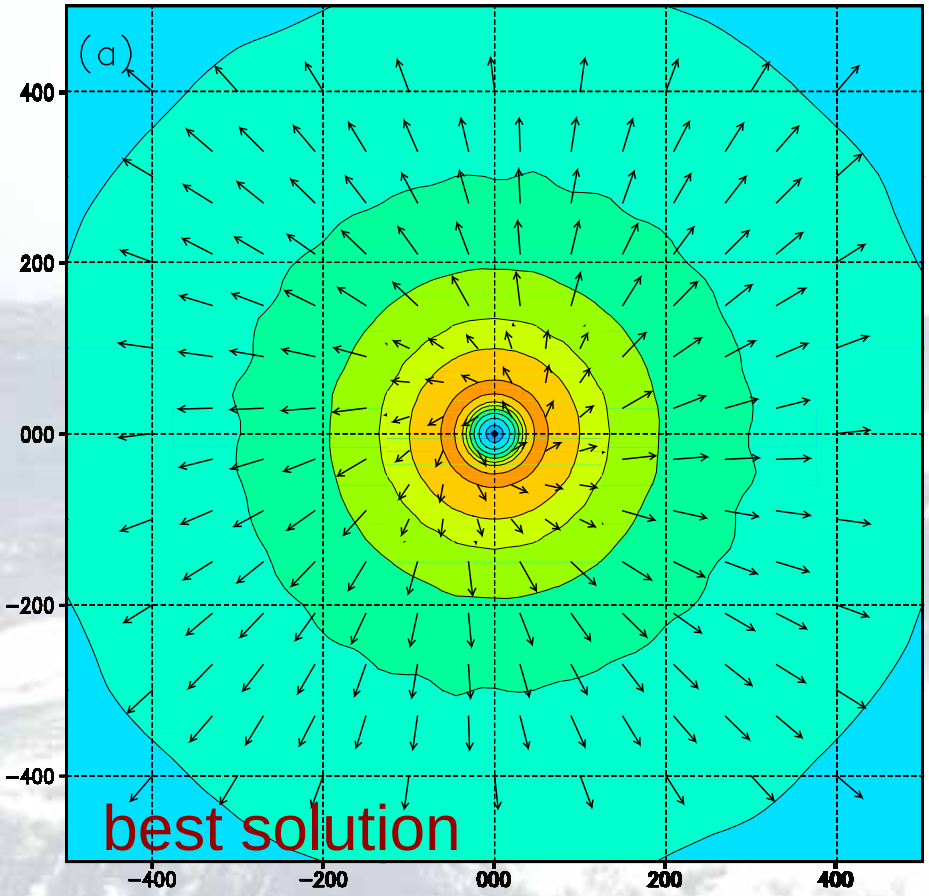
run model

bound. data

global sync.

averaging

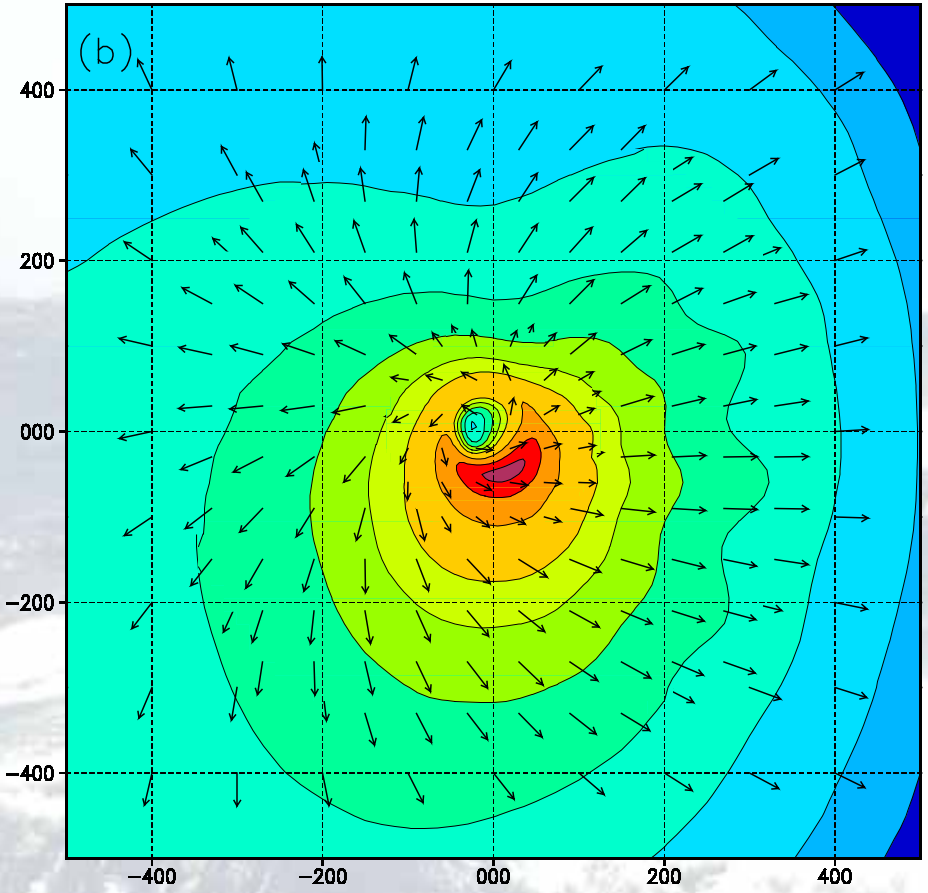
Example 3



Stationary hurricane with default settings in WAVEWATCH III.

- 50km grid
- 15km grid
- 5km grid
- composite of grids
- large 5km grid
- multi-scale model

Example 4



Hurricane moving to the right at 5m/s with circular domains and the Tolman and Alves (2005) moving grid approach.

composite of grids

multi-scale model

Tolman, H. L. and J. H. G. M. Alves, 2005: *Ocean Modelling*, **9**, 305-323.

Example 5

- Multi-scale approach gives consistent results between grids.
- Avoids some of the GSE due to natural scale enlargement in hurricane modeling.
- Adds of the order of 15% to run time compared to sum of constituent grids, with good scaling behavior for large number of processors.
- Up to orders of magnitude faster than large grid with high resolution, *and* more physical results.
- Minor inconsistencies at boundaries possible, particularly at the corners.

Finally …

If you have any questions or requests, contact us at the wave group address

NCEP.EMC.waves@NOAA.gov

E-mails to this address are distributed to our entire wave model group, and will be answered quickly. To get me personally use

Hendrik.Tolman@NOAA.gov

But I travel a lot ….