The Garden Sprinkler Effect

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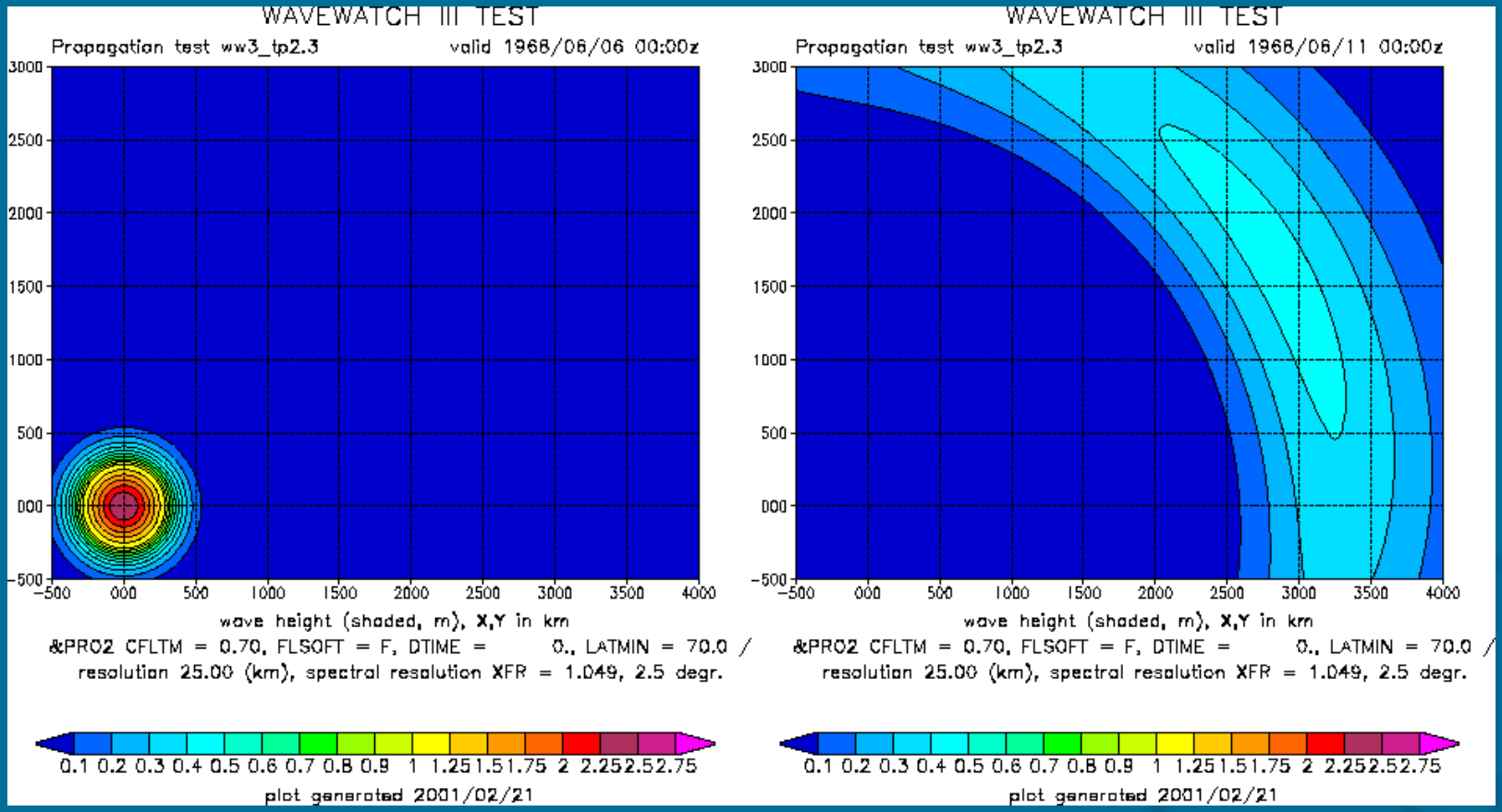
Covered in this lecture:

- What's the Garden Sprinkler Effect (GSE)?
- Present solutions.
- Hurricane Florence example.
- Multi-grid hurricane example.
- Notes and future.

Definition:

- Incompatibility in various discrete resolutions in model.
  - Spectral resolution in direction is so coarse, that spatial propagation of discrete directions results in discrete disintegration of swell field that should be continuous, Booij and Holthuijsen (1987, *JCP*).

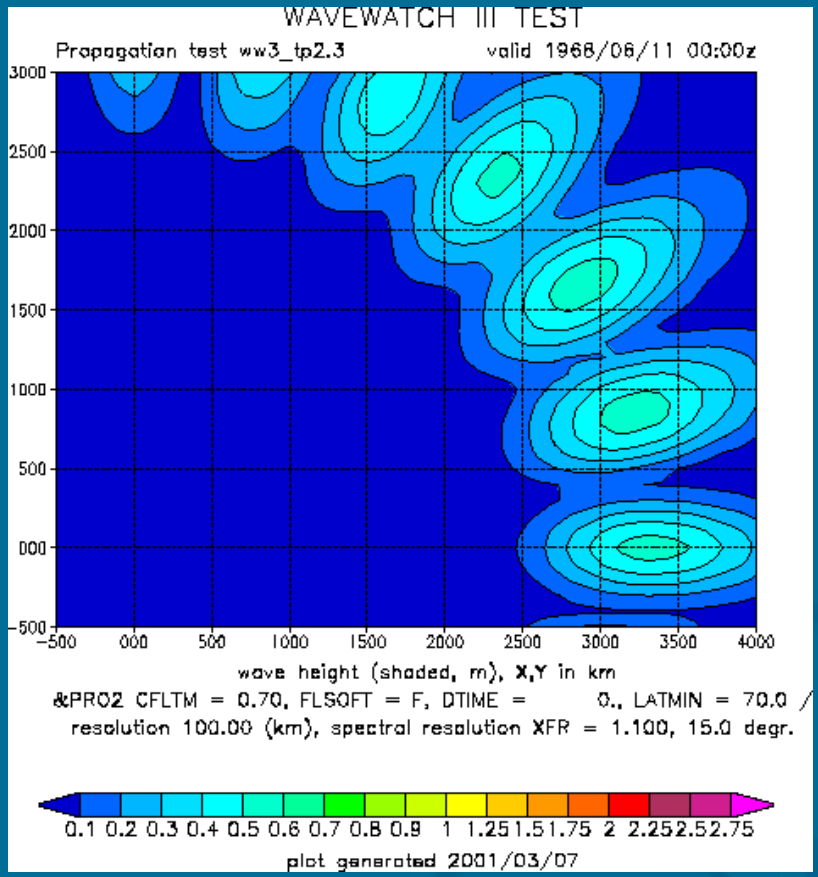
Swell propagation from lower left corner over 5 days (ww3_tp2.3)



Exact solution: continuous dispersion of swell energy over a large area.
(no dissipation !)

Swell propagation from lower left corner over 5 days (ww3_tp2.3)

- Third order accurate Ultimate-Quickest scheme (Leonard) of WAVEWATCH III.
- Obvious garden sprinkler effect, spectral discretization results in disintegration of swell field.
- Better scheme gives worse results. Essentially useless in this form.



Solutions

Traditional:

- Old method (Booij and Holthuijsen, 1987).
  - Add diffusion term to represent sub-grid dispersion.
  - Good but excessively expensive for small scale models (NAH). Requires filtering at high latitudes.

Newer:

- Replace diffusion with straightforward averaging.
  - Almost same as original.
  - Much cheaper than old method.

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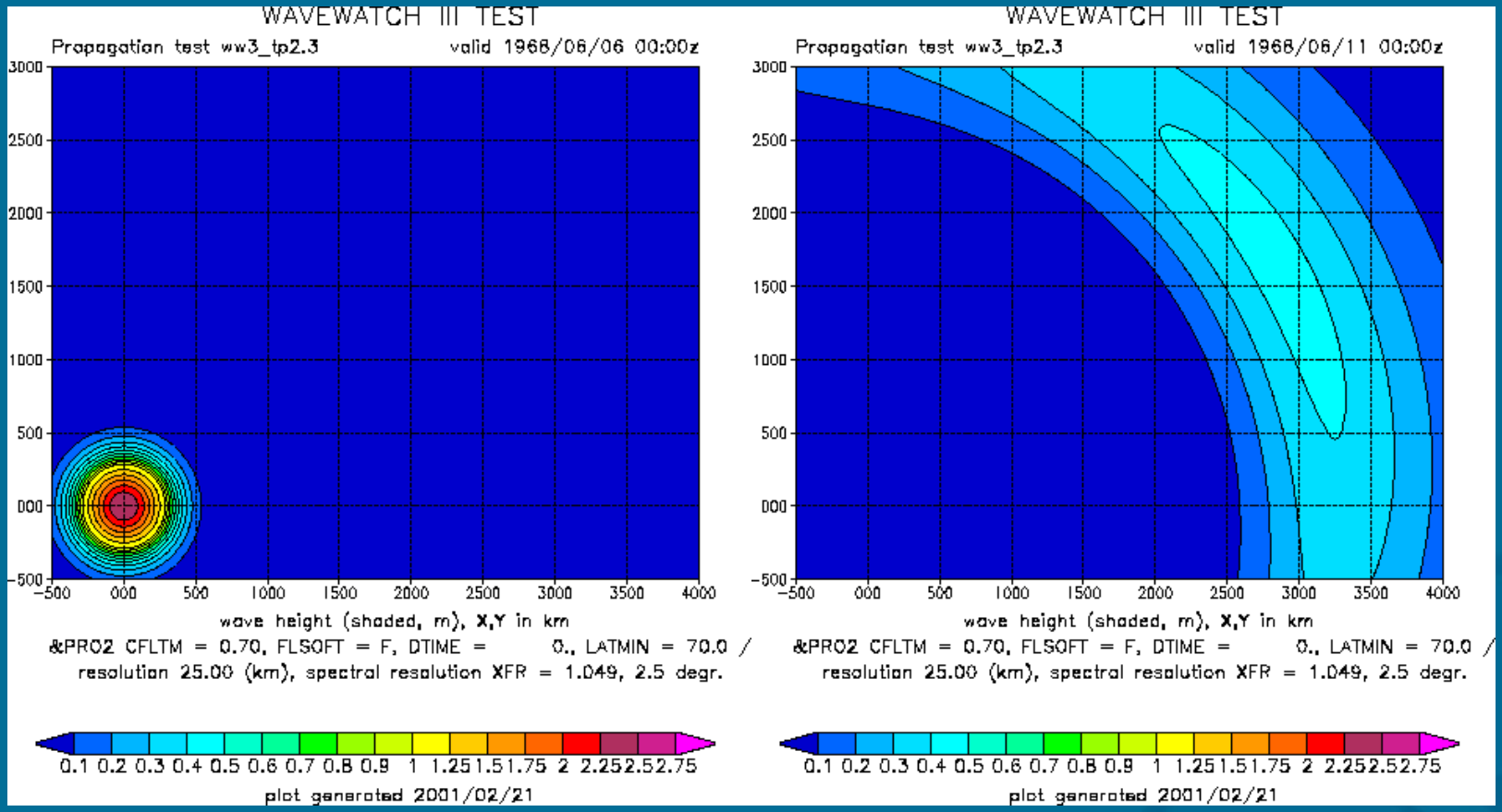

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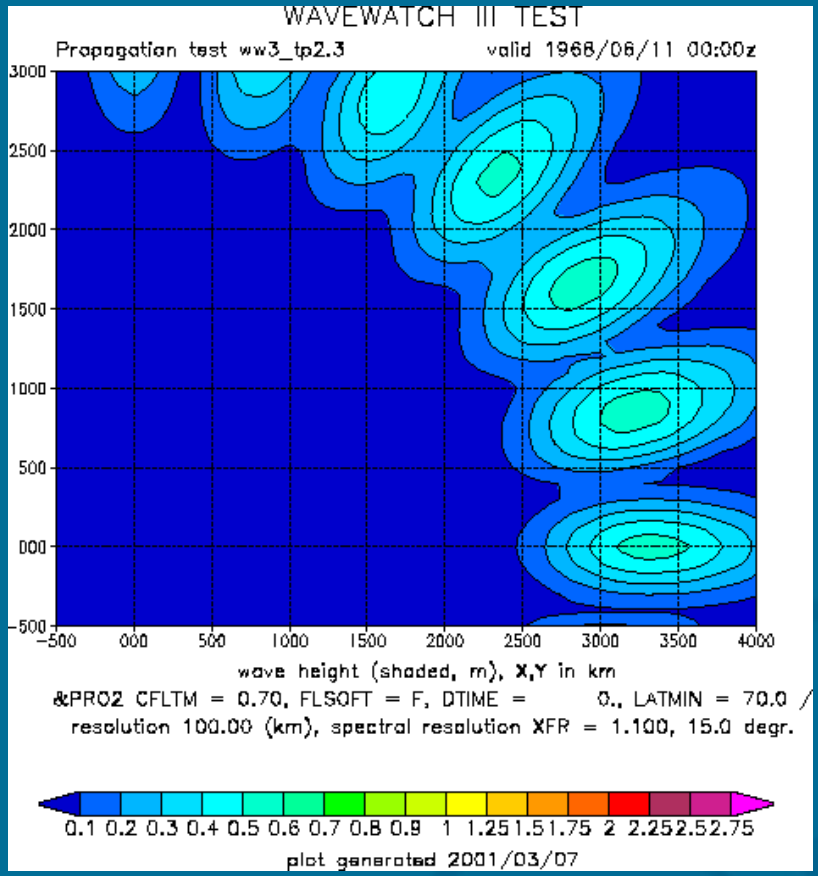
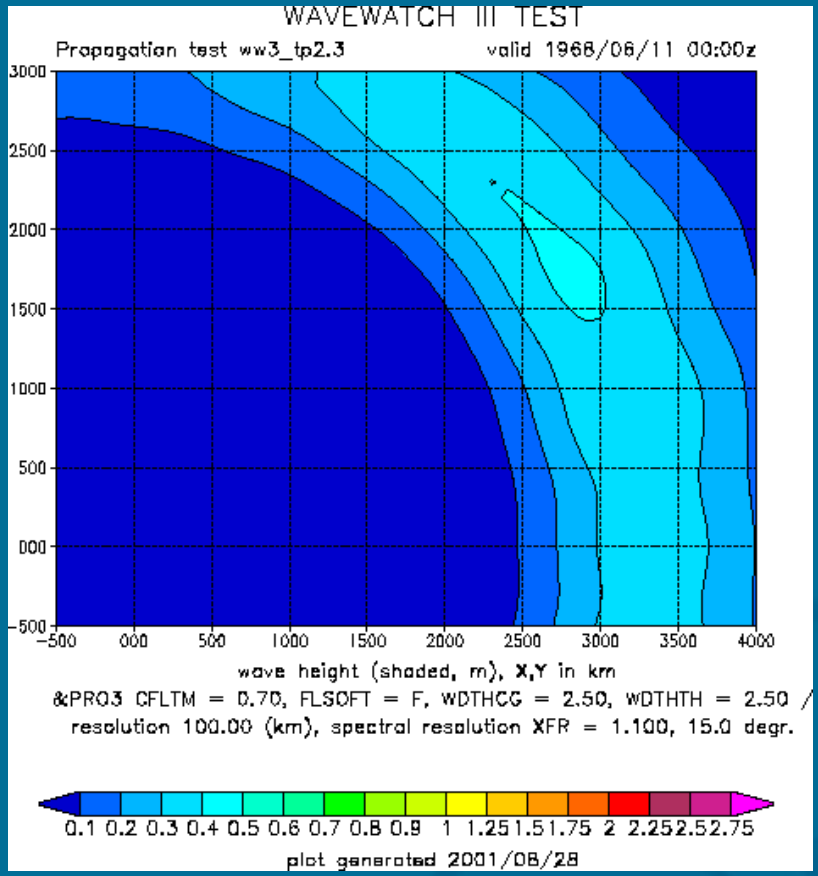


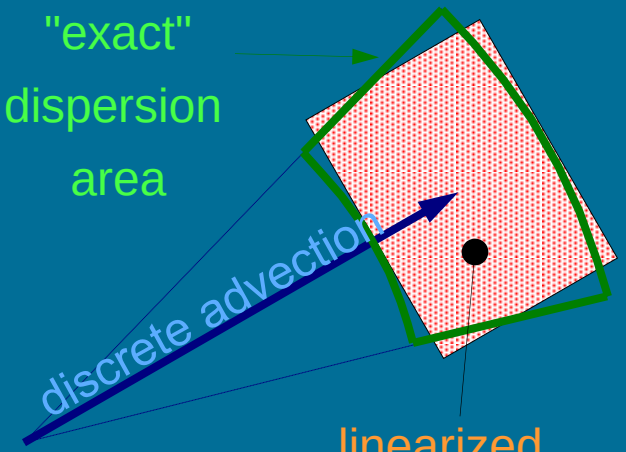
Swell propagation from lower left corner over 5 days (ww3_tp2.3)

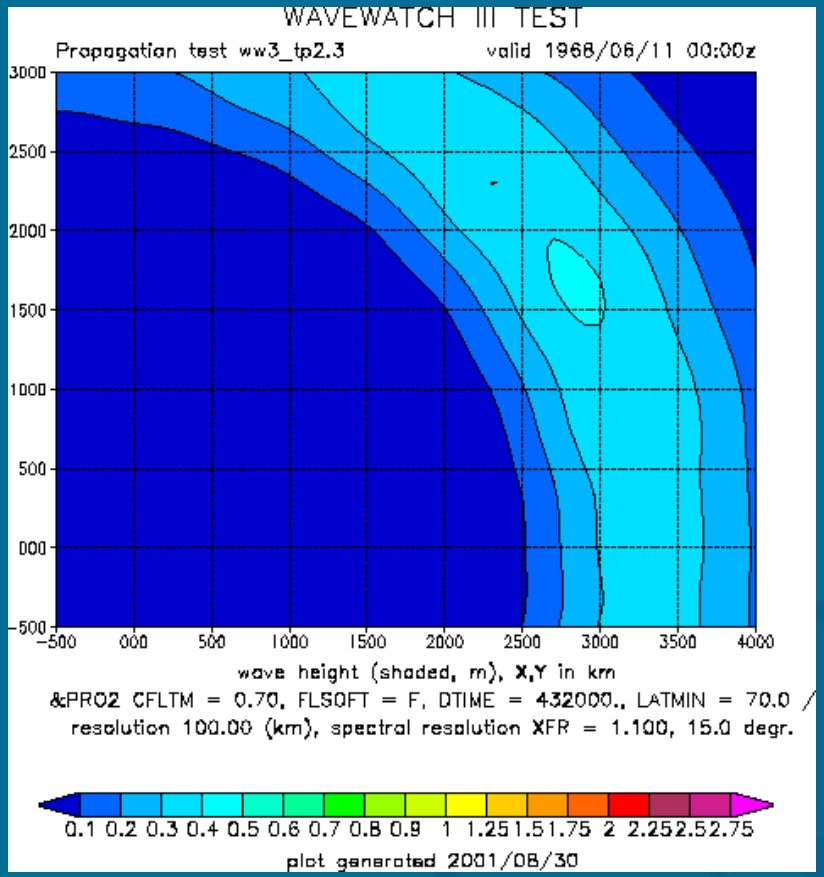
- UQ scheme with Booij and Holthuijsen (1987) diffusive dispersion correction.
- Major improvement over plain UQ scheme, tunable.
- Due to explicit schemes, stability becomes a major issue at small grid steps (order 25 km).



Swell propagation from lower left corner over 5 days (ww3_tp2.3)

- UQ scheme with simple pre- or post- averaging of fields.
- Virtually identical results as previous, tunable, cheap.

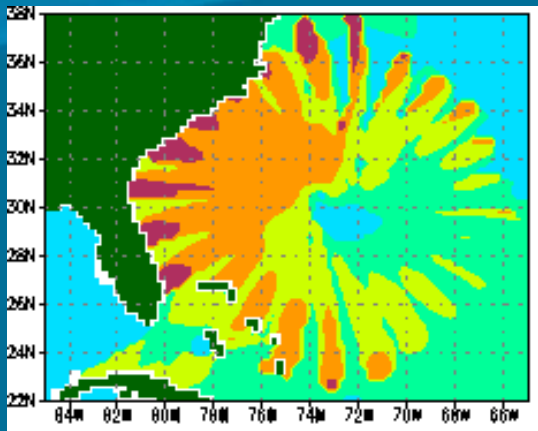




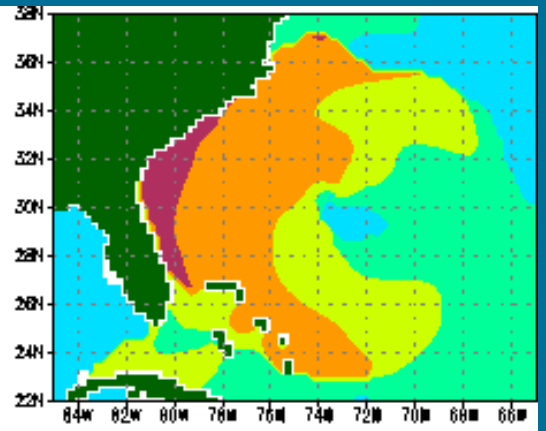
Tolman, 2002: *Ocean Mod.*, **4**, 269-289.

Hurricane Florence

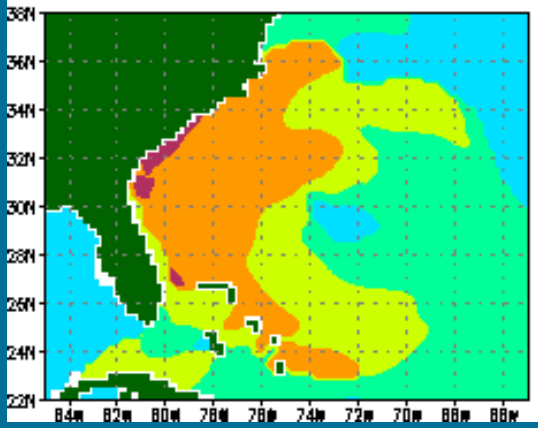
UQ plain
1.00



UQ + dif.
1.75

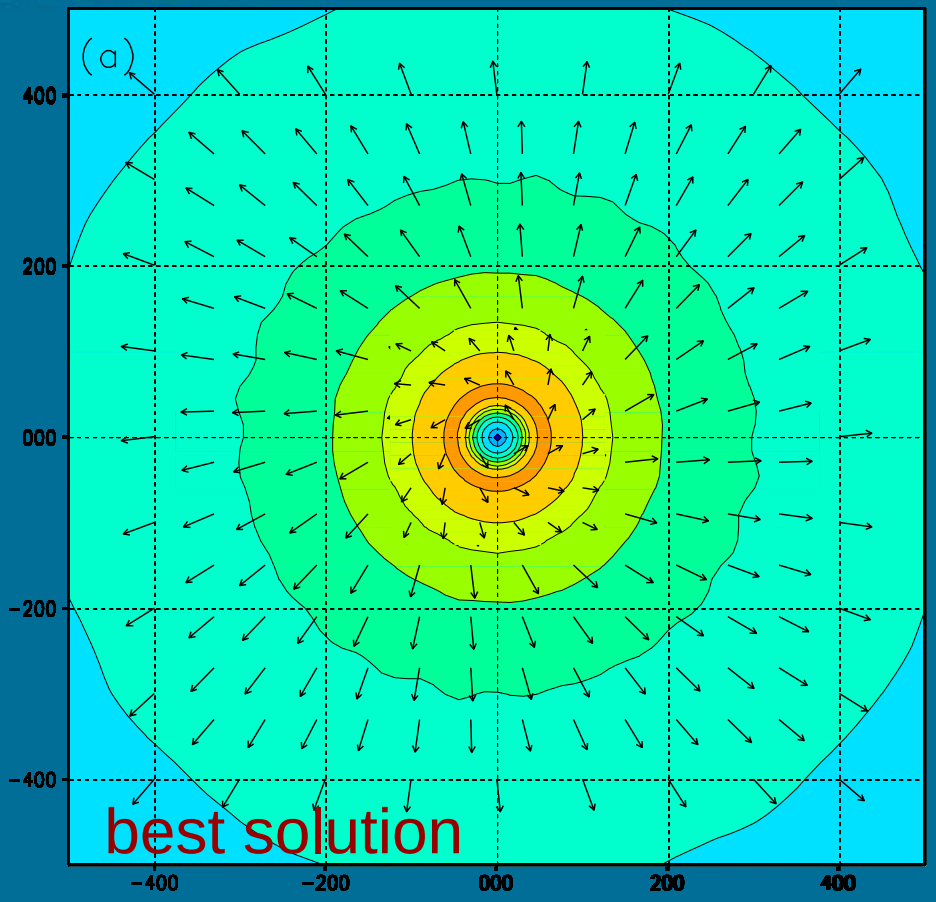


UQ + avg.
1.09



Peak periods from 7 to 10s from hurricane Florence at 00z Sept. 13 2000 from NCEP's NAH model. Relative computational costs in red.

Multi-grid hurricane



Stationary hurricane with default settings in WAVEWATCH III.

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

There is some GSE mitigation, but no solution.

- As the resolution of models goes up, the GSE shows up again.
  - Example of multi-grid model and automatic scale adjustments that helps.
  - Not easily applied generally.
- Alternative method to solve uses divergent dispersion consistent with mean energy per spectral grid box.
  - Experimental in Tolman (2002).
  - Needs to be set up using local spectral data only to become feasible.
  - Is this a solution or a mitigation?

The end

End of lecture