HWRF time-stepping in real-data and semi-idealized simulations

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HFIP Telecon
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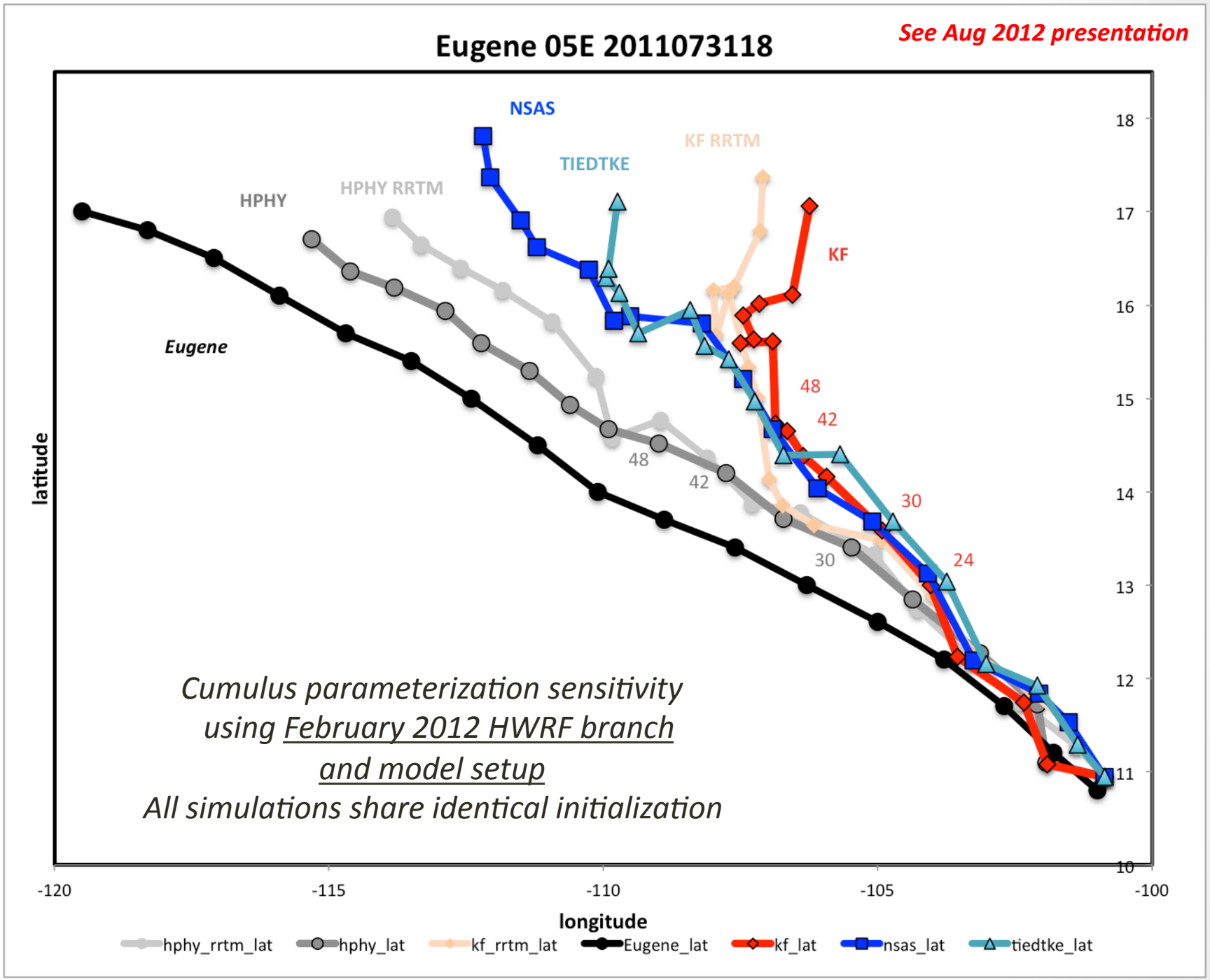
Outline

- Real-data simulations
  - Eugene (2011) and Rina (2011)
  - Different cumulus parameterizations (CPs)
  - "HPHY" = SAS CP, some differences from current ops
  - HWRF v34 (February 2012 version) [validating w/ V34A]
- Semi-idealized experiments
  - HWRF v34A (operational version), v34 (February) and v33 (2011)
  - WRF-ARW v32
  - "HPHY" = physics suite currently used in ops, including SAS CP

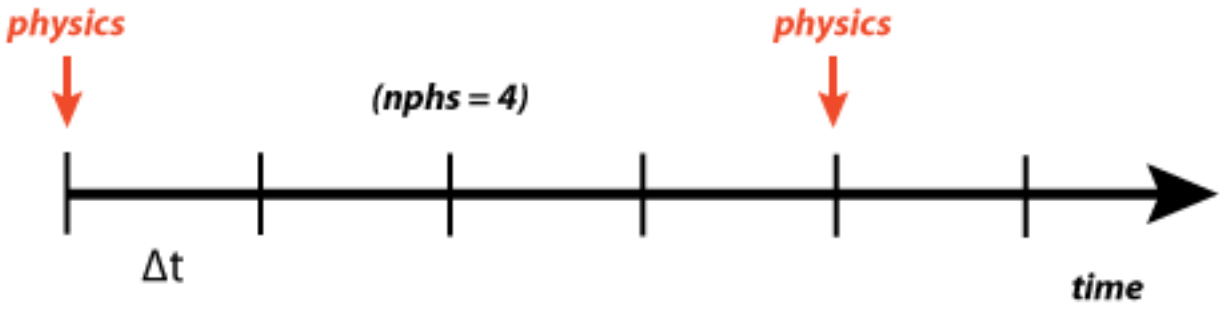
HWRF v34 (Feb) – sensitivity to time stepping

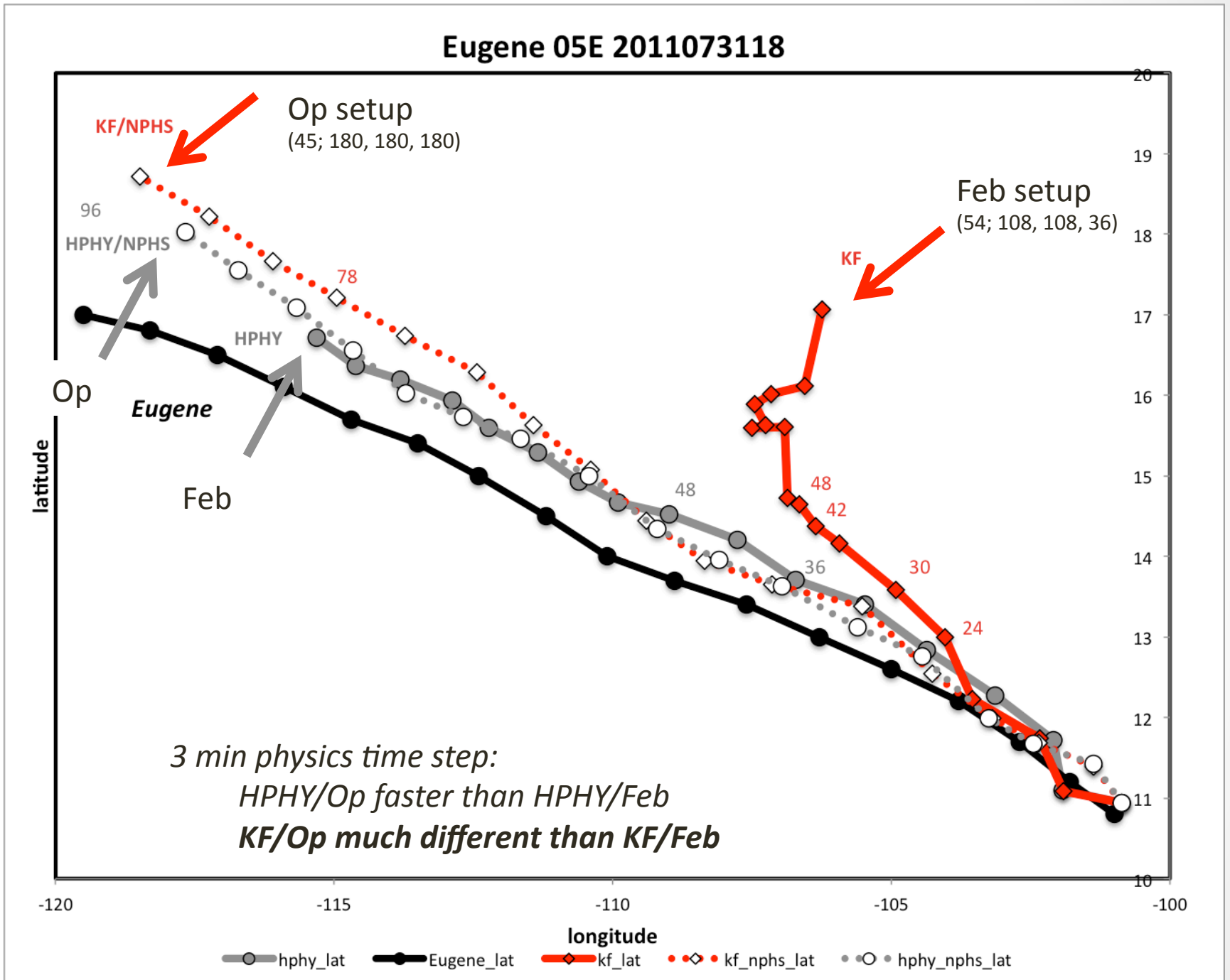
Eugene (2011) example

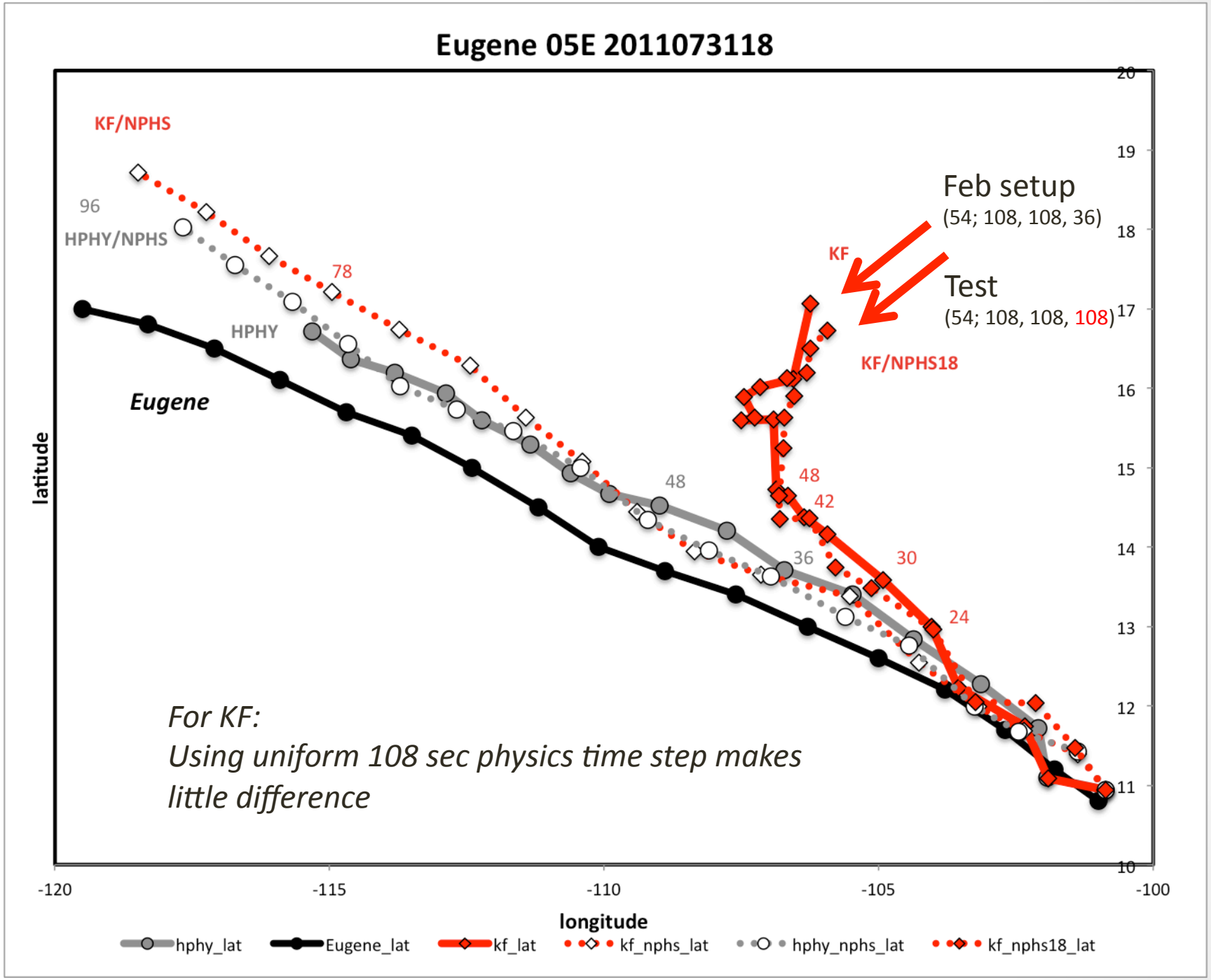

Eugene 05E 2011073118
See Aug 2012 presentation
NSAS
KF RRTM
TIEDTKE
HPHY
HPHY RRTM
KF
Eugene
48
42
30
24
48
42
30
Cumulus parameterization sensitivity
using February 2012 HWRF branch
and model setup
All simulations share identical initialization
latitude
longitude
18
17
16
15
14
13
12
11
10
-120
-115
-110
-105
-100
hphy_rrtm_lat
hphy_lat
kf_rrtm_lat
Eugene_lat
kf_lat
nsas_lat
tiedtke_lat

February vs. operational setups

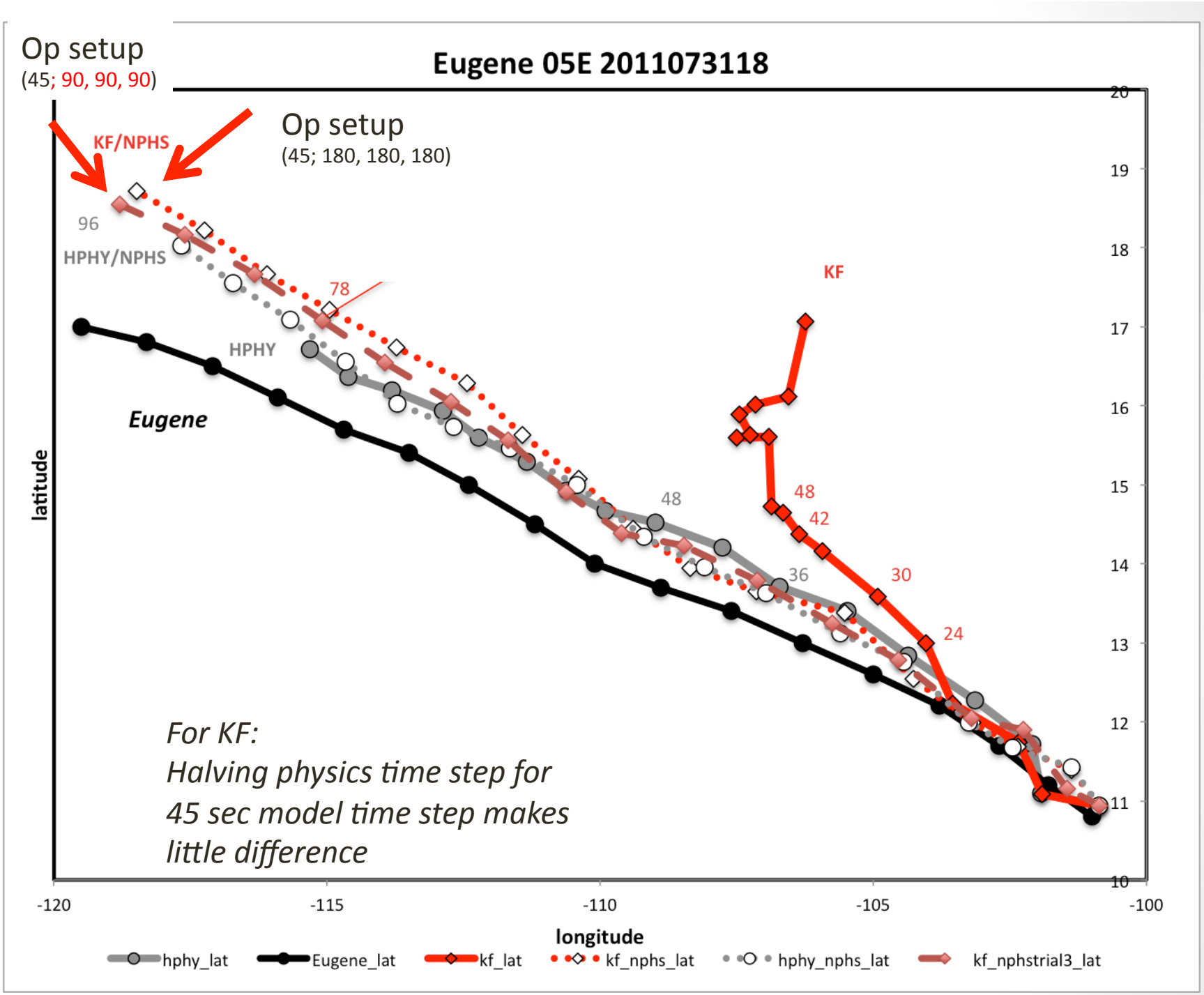
Version	February setup ("Feb")	Operational setup ("Op")
time_step	54 sec	45 sec
nphs	2, 6, 6 (108, 108, 36 sec)	4, 12, 36 (180, 180, 180 sec)

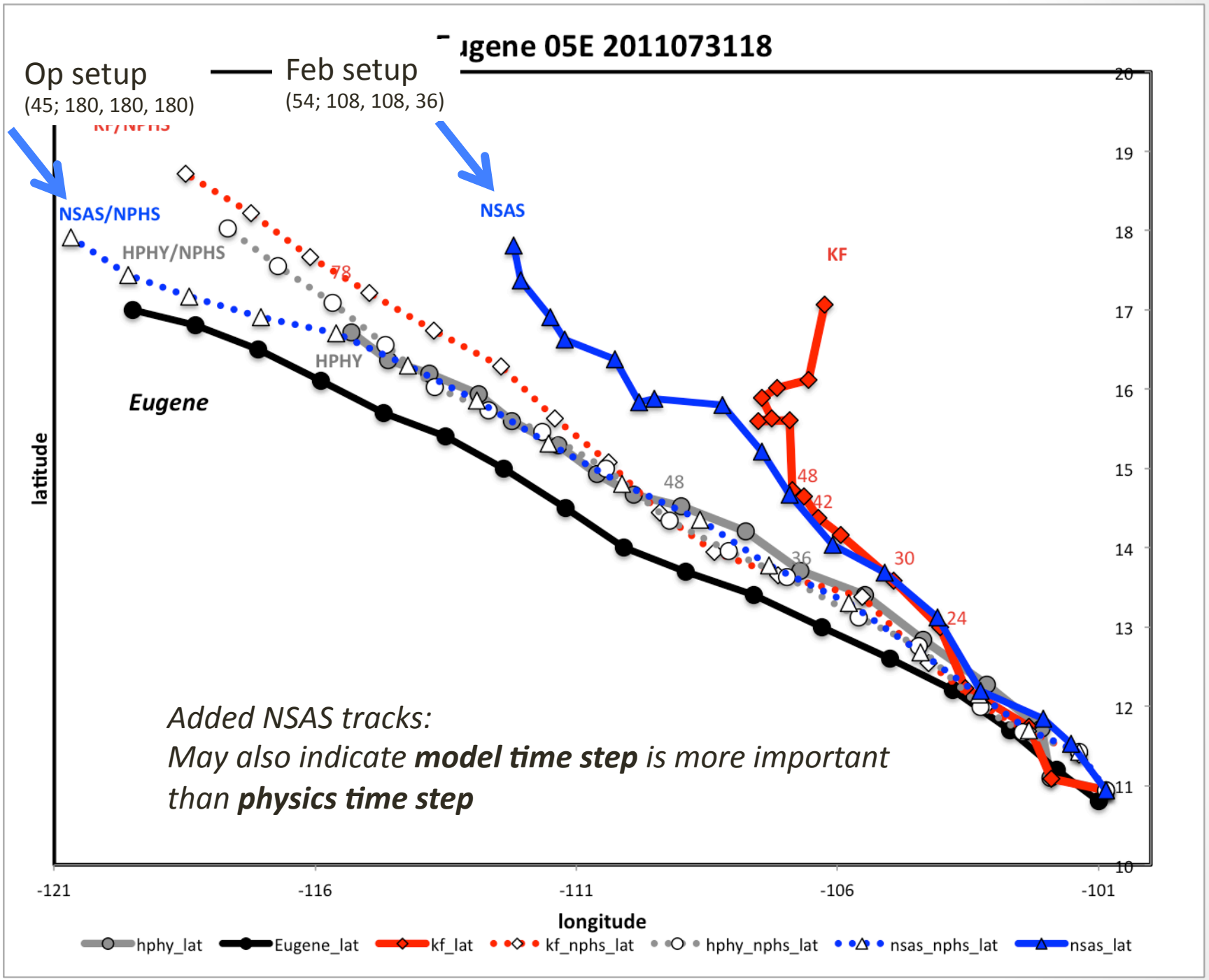



Eugene 05E 2011073118
Op setup
(45; 180, 180, 180)
KF/NPHS
96
HPHY/NPHS
78
HPHY
Op
Eugene
Feb
Feb setup
(54; 108, 108, 36)
KF
48
42
30
24
48
36
3 min physics time step:
HPHY/Op faster than HPHY/Feb
KF/Op much different than KF/Feb
latitude
longitude
-120
-115
-110
-105
-100
10
11
12
13
14
15
16
17
18
19
20
hphy_lat
Eugene_lat
kf_lat
kf_nphs_lat
hphy_nphs_lat


Eugene 05E 2011073118
KF/NPHS
96
HPHY/NPHS
78
HPHY
Eugene
48
36
30
24
KF
48
42
KF/NPHS18
Feb setup
(54; 108, 108, 36)
Test
(54; 108, 108, 108)
For KF:
Using uniform 108 sec physics time step makes little difference
latitude
longitude
-120
-115
-110
-105
-100
20
19
18
17
16
15
14
13
12
11
10
hphy_lat
Eugene_lat
kf_lat
kf_nphs_lat
hphy_nphs_lat
kf_nphs18_lat

Op setup
(45; 90, 90, 90)

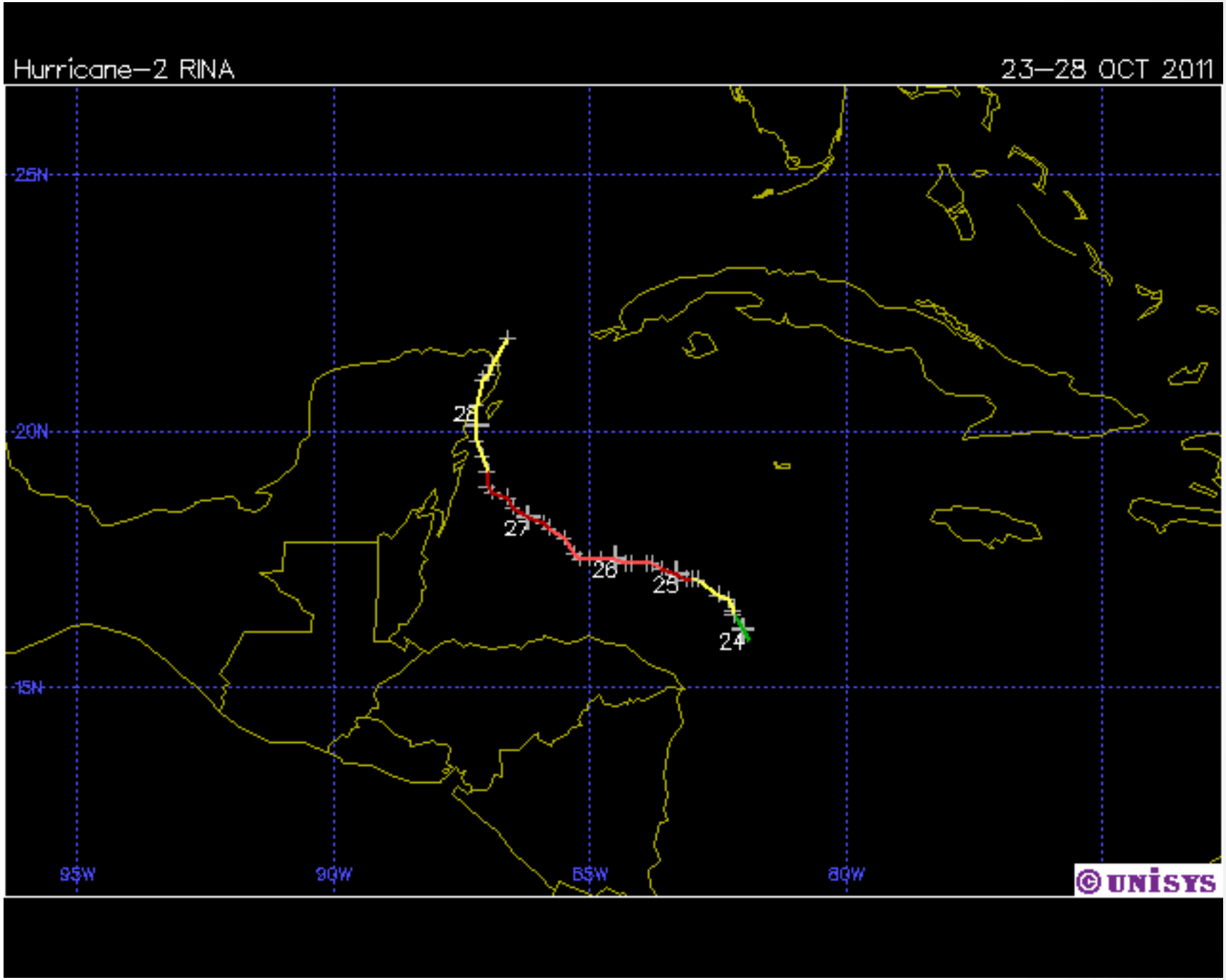


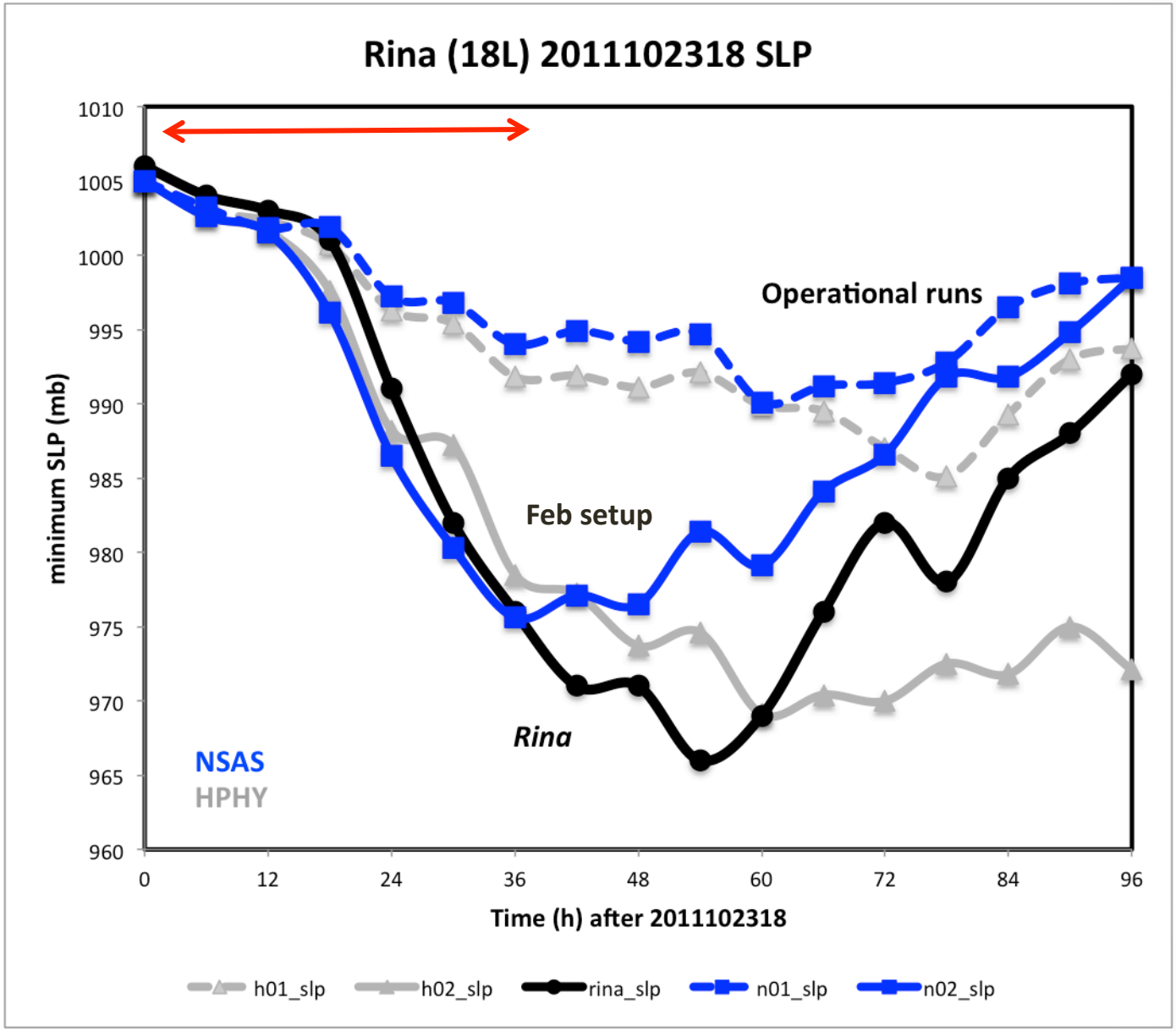

Op setup
(45; 180, 180, 180)
Feb setup
(54; 108, 108, 36)
ugene 05E 2011073118
NSAS/NPHS
HPHY/NPHS
HPHY
NSAS
KF
Eugene
78
48
42
36
30
24
Added NSAS tracks:
May also indicate model time step is more important than physics time step
latitude
longitude
-121
-116
-111
-106
-101
20
19
18
17
16
15
14
13
12
11
10
hphy_lat
Eugene_lat
kf_lat
kf_nphs_lat
hphy_nphs_lat
nsas_nphs_lat
nsas_lat

HWRF v34 (Feb) – sensitivity to time stepping

Rina (2011) example

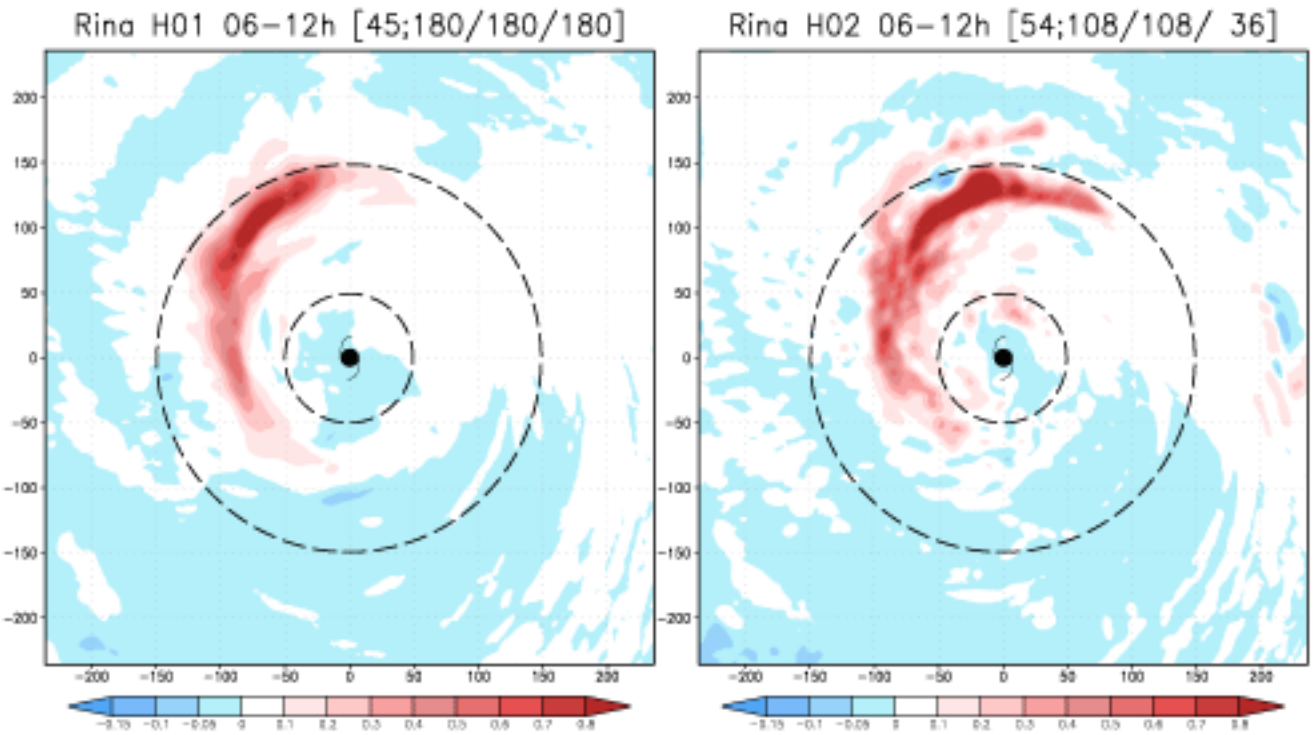
HPHY & NSAS


Hurricane-2 RINA
23-28 OCT 2011
25N
20N
15N
95W
90W
85W
80W
28
27
26
25
24
©UNISYS



February setup superior for this case

06-12h

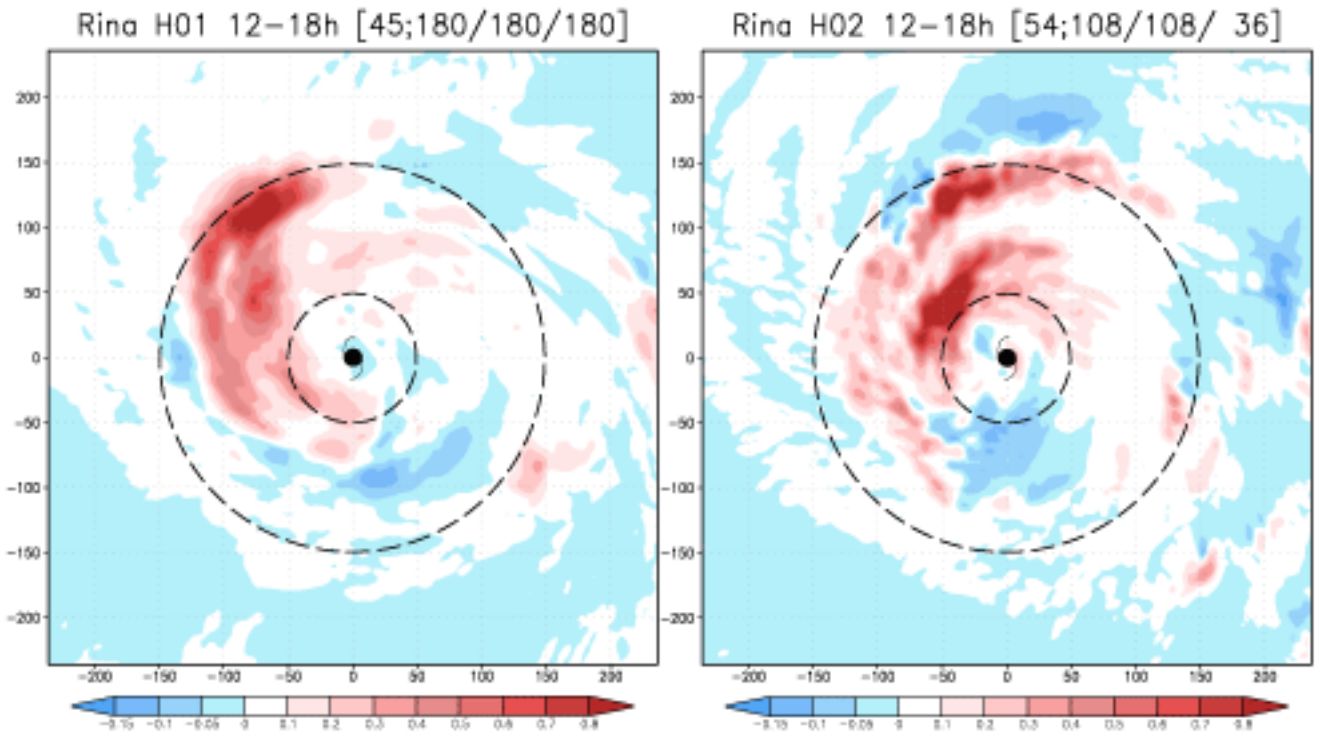


HPHY Op setup
[45; 180, 180, 180]

HPHY February setup
[54; 108, 108, 36]

Vertical velocity sfc-5.4 km

12-18h



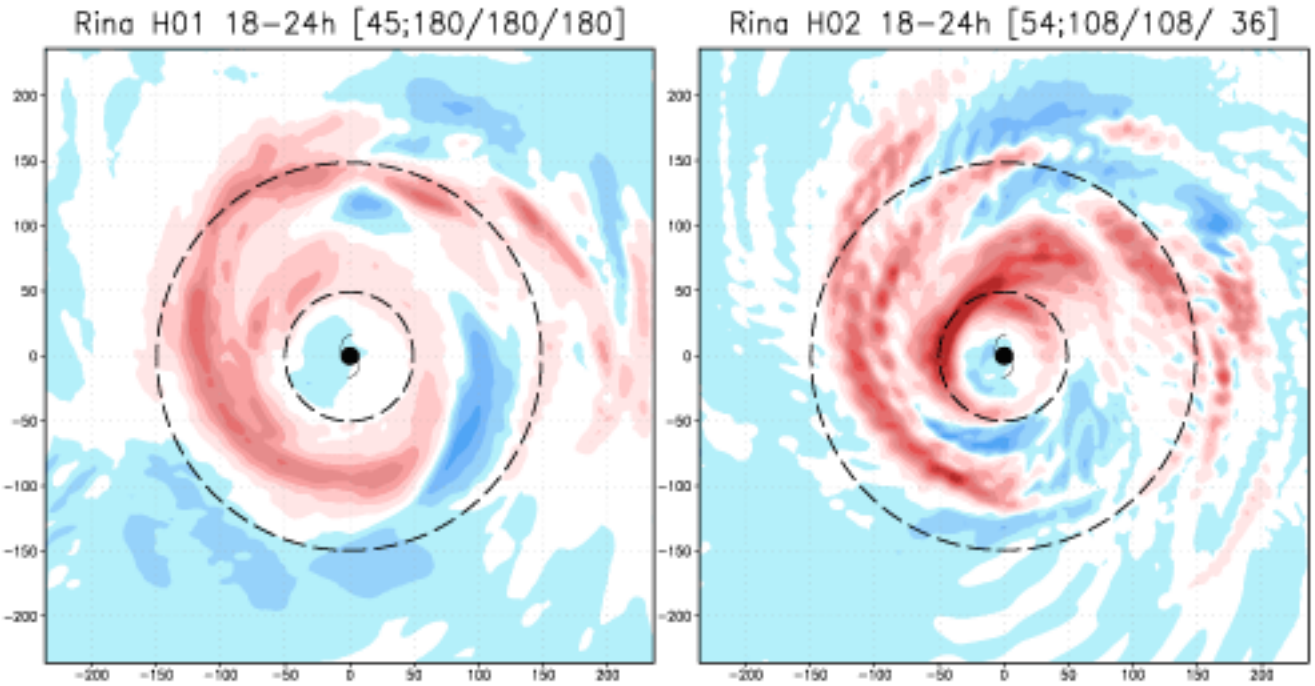
HPHY Op setup
[45; 180, 180, 180]

HPHY February setup
[54; 108, 108, 36]

Vertical velocity sfc-5.4 km

18-24h

996 mb
57 kt



988 mb
60 kt

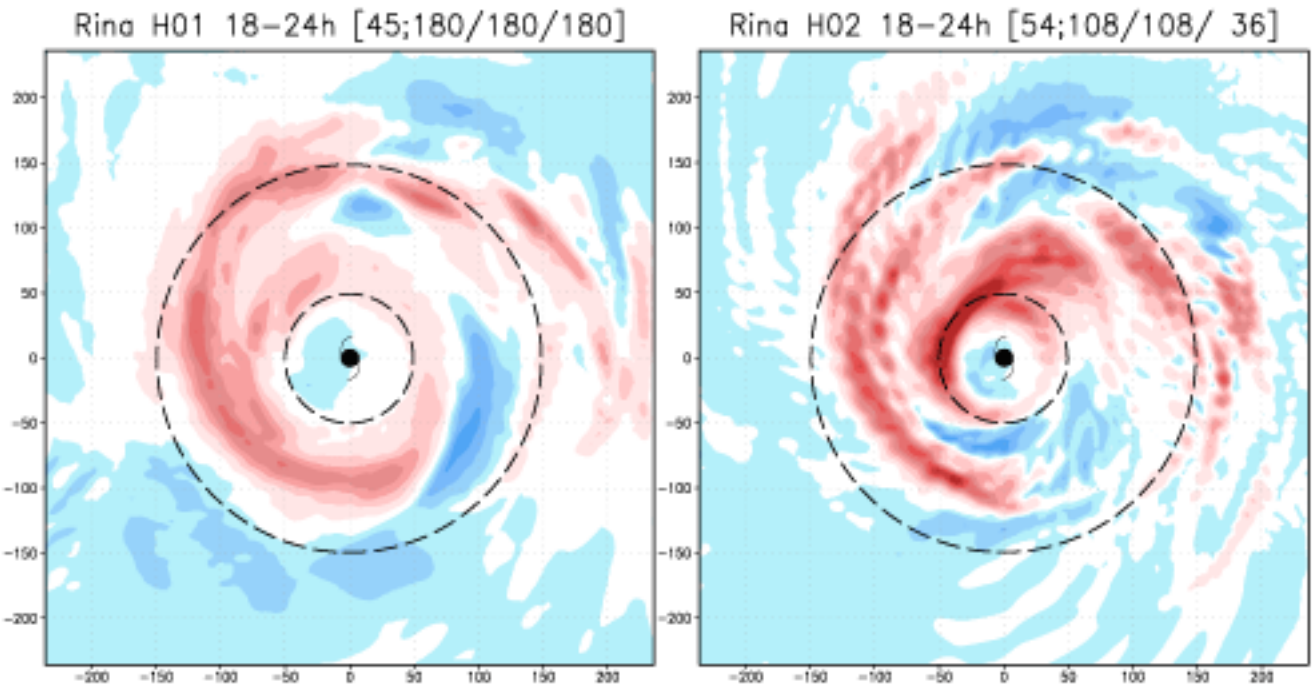
HPHY Op setup
[45; 180, 180, 180]

HPHY February setup
[54; 108, 108, 36]

Vertical velocity sfc-5.4 km

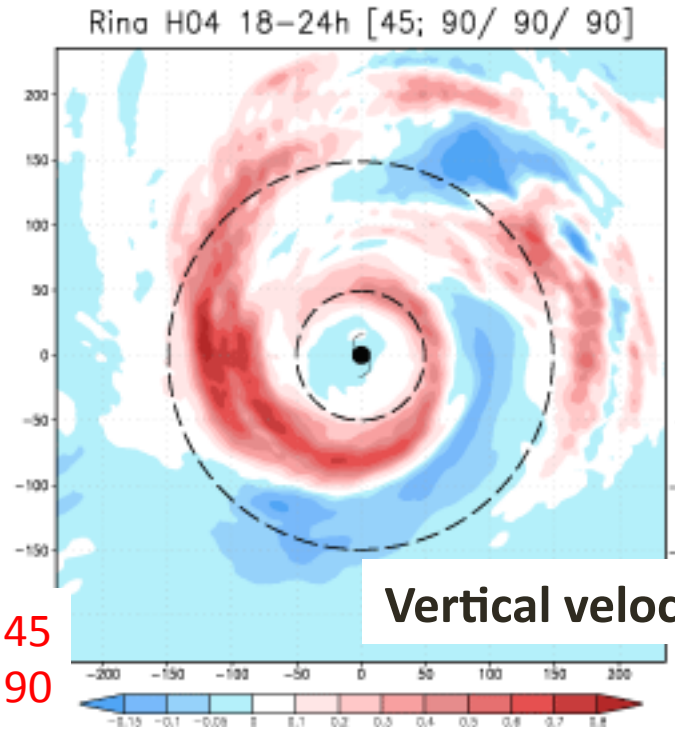
18-24h

996 mb
57 kt

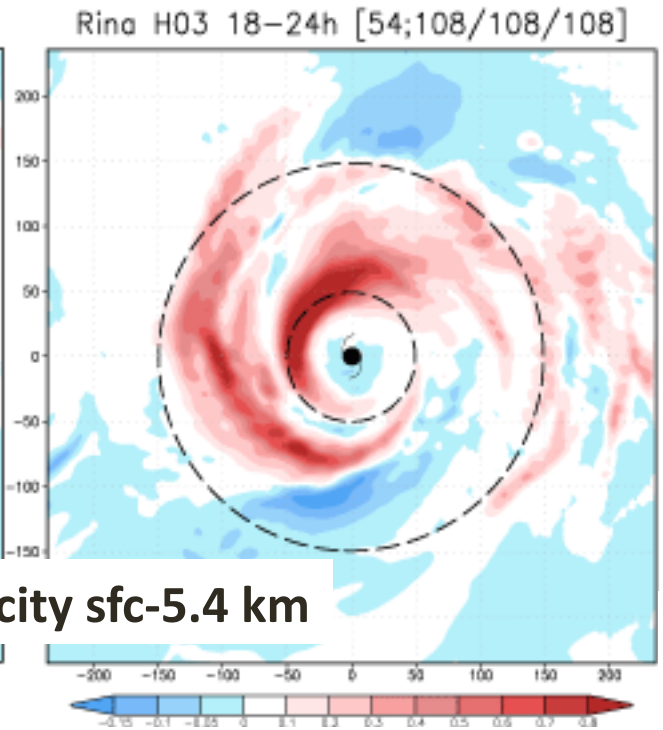


988 mb
60 kt

993 mb
58 kt



989 mb
63 kt



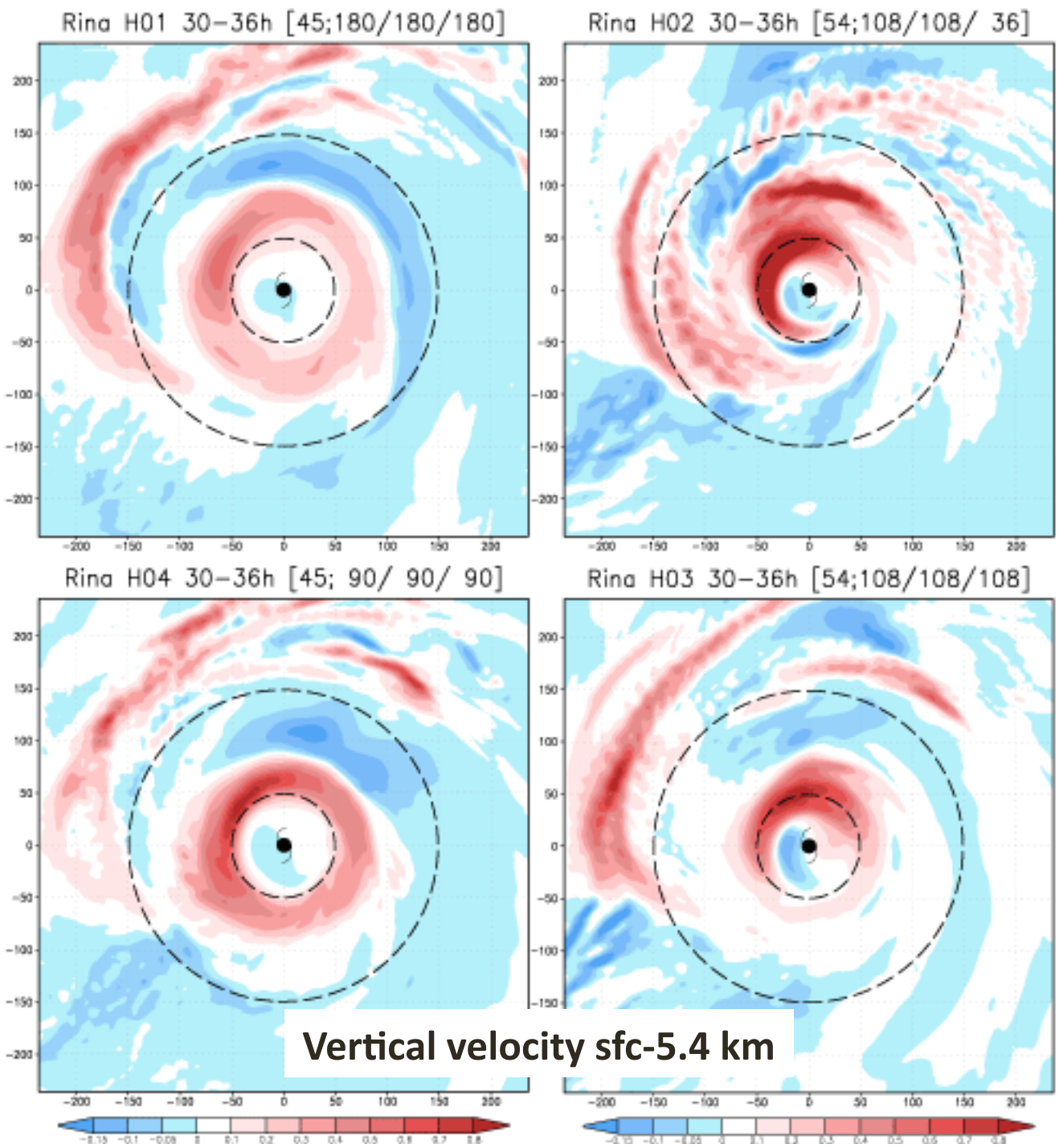
Vertical velocity sfc-5.4 km

model dt = 45
phys dt = 90

model dt = 54
phys dt = 108

30-36h

992 mb
60 kt

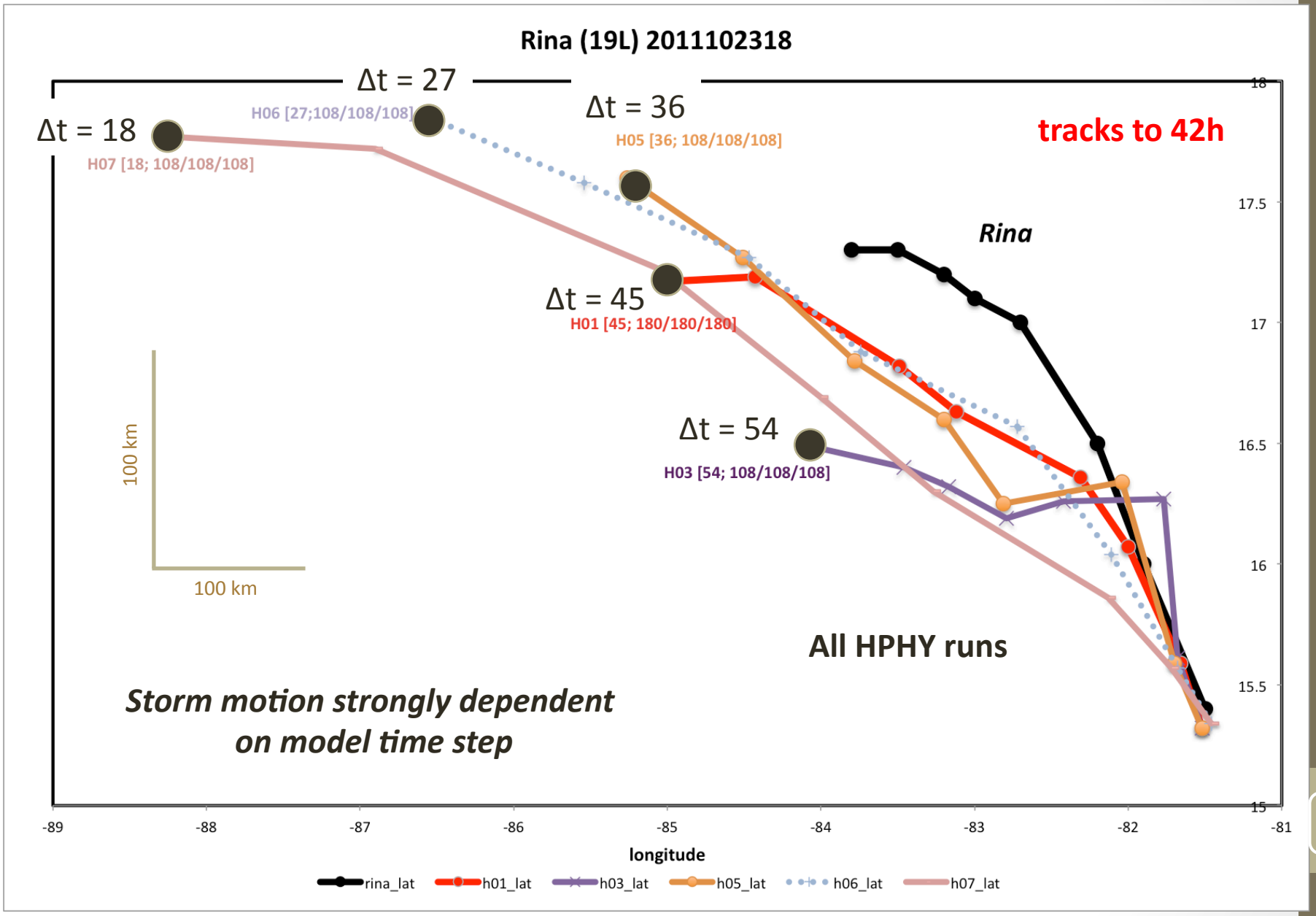


979 mb
72 kt

986 mb
72 kt

984 mb
68 kt

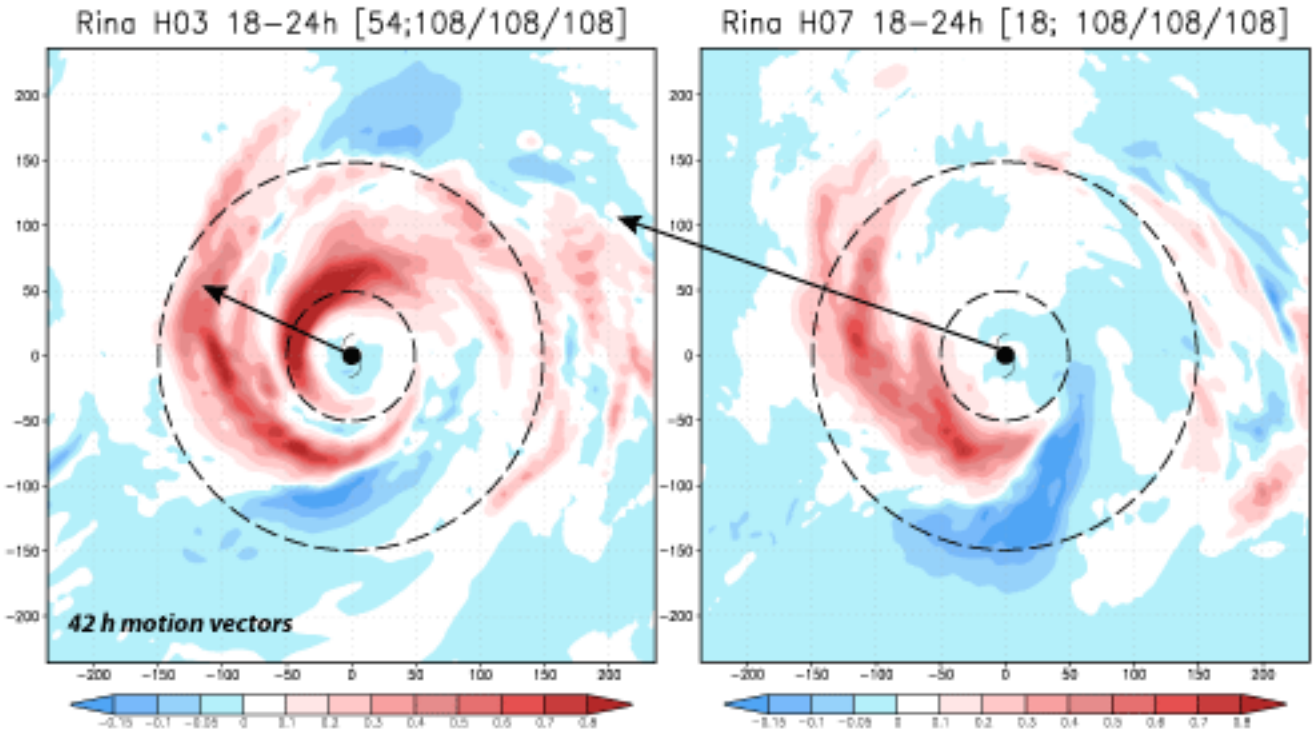
Vertical velocity sfc-5.4 km



Simulations made with version V34A are quite similar…

Δt= 54 sec

Δt= 18 sec



Same physics time steps, different model time steps

Semi-idealized “bubble” experiments

WRF-ARW v.3.2, HWRF v.3.3, HWRF v.3.4A

“no correct answer”

Implementation: common features

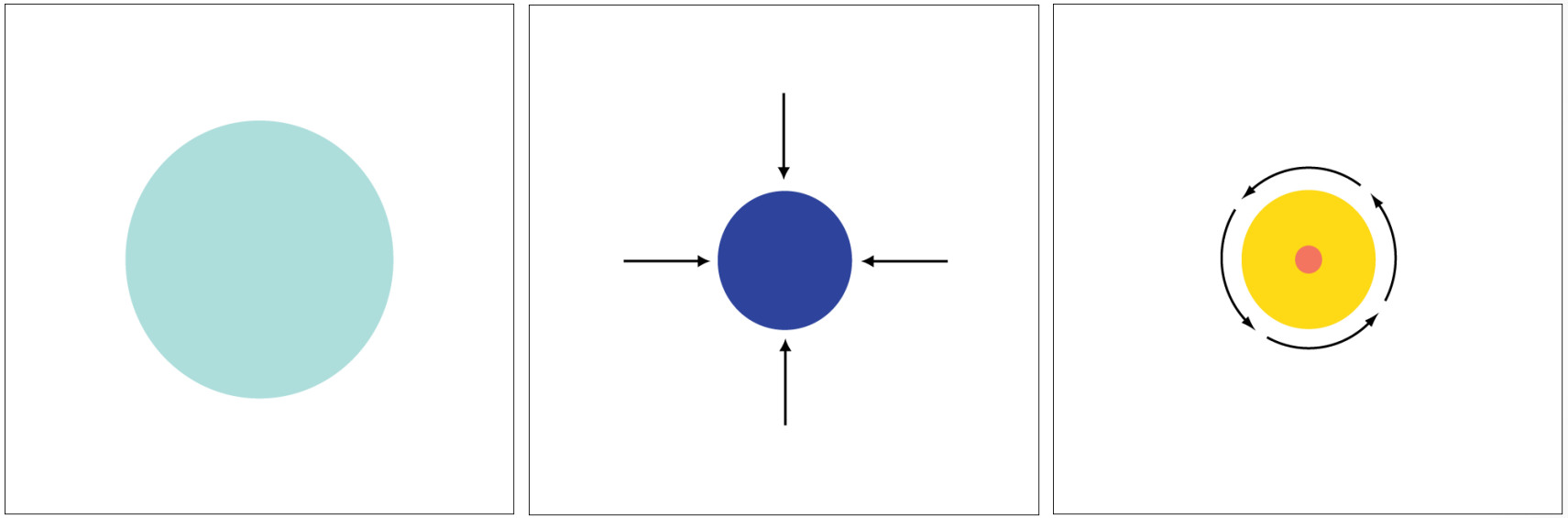
- Horizontally homogeneous environment based on Jordan (1958), and Dunion and Marron (2008)
- Fixed SST at 29.5˚C
- Calm initial state
- Synoptic-scale buoyancy perturbation added to environment
- 24 h “spin-up” period in which a cumulus parameterization (CP) is active in all domains (“bubble initialization”)

Implementation: differences

- WRF-ARW
  - 9 km fixed domain with 3 km moving nest
  - 4500 x 4500 km outer grid; 1500 x 1500 km nest
- CP *off* after spin-up period
- Ferrier scheme not identical to HWRF version

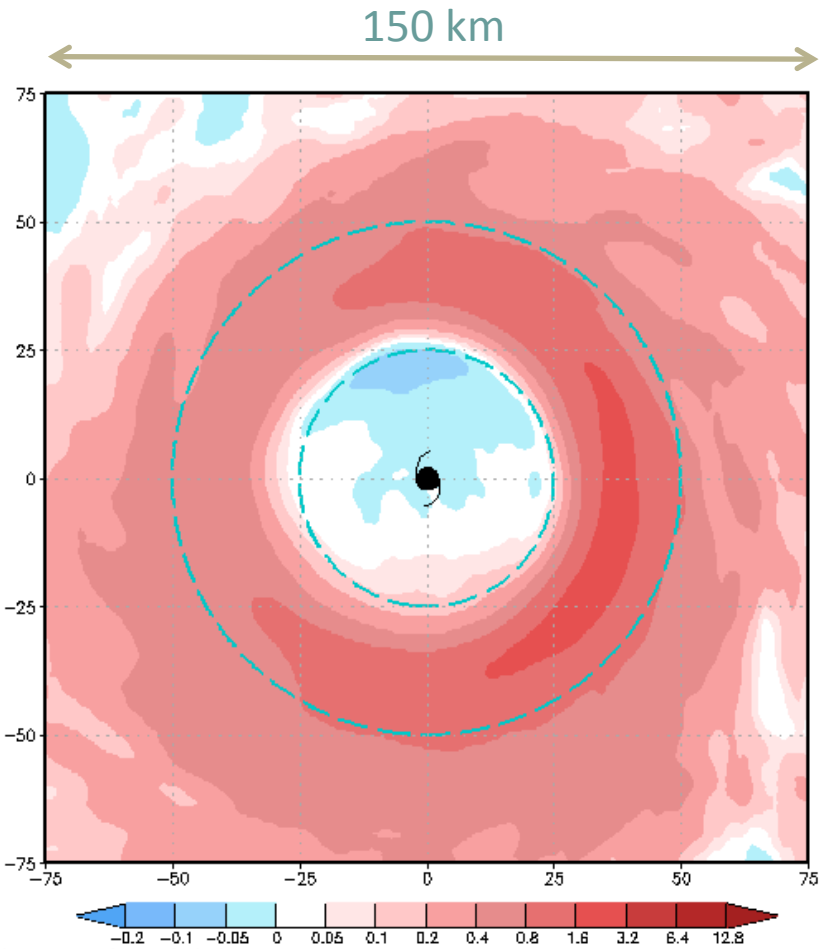
- HWRF v.3.3
  - 27 km fixed with 9 km moving nest
  - 75˚ x 75˚ outer; 6˚ x 6˚ inner
- HWRF v.3.4A
  - Additional 3 km moving nest added In standard runs
  - D2 is 10˚ x 10˚, D3 is 5˚ x 5˚
- CP *on* in D1 and D2 after spin-up period for standard runs
- Modifications made to **geogrid** code only
- NO Δt = 54 sec runs… unstable

“Bubble” initialization

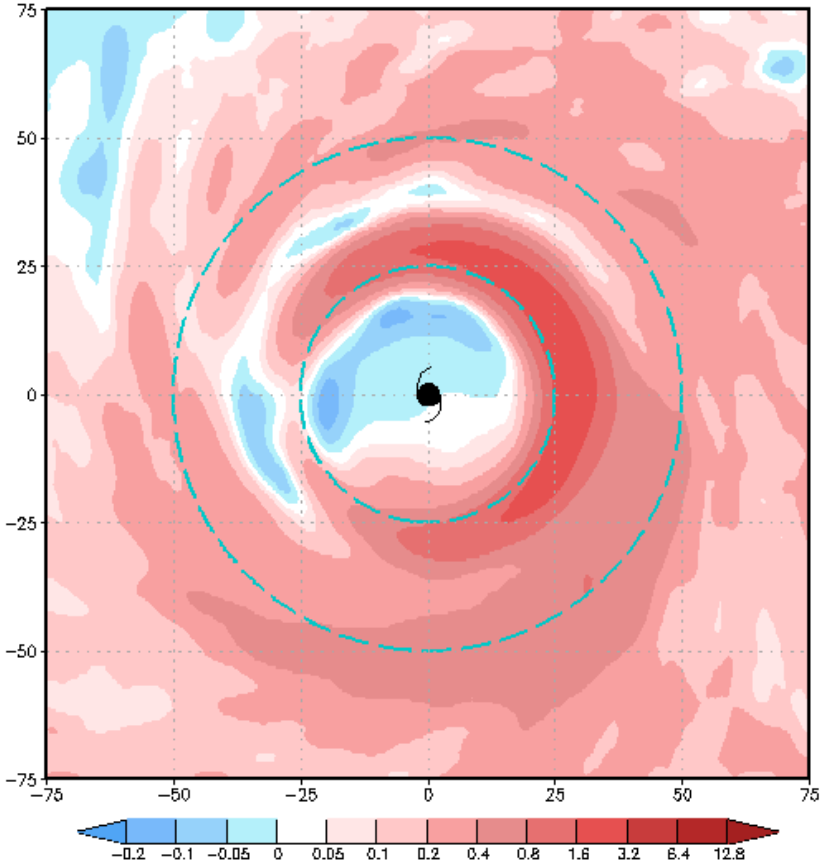


Small portion of domain shown

Vertically averaged W



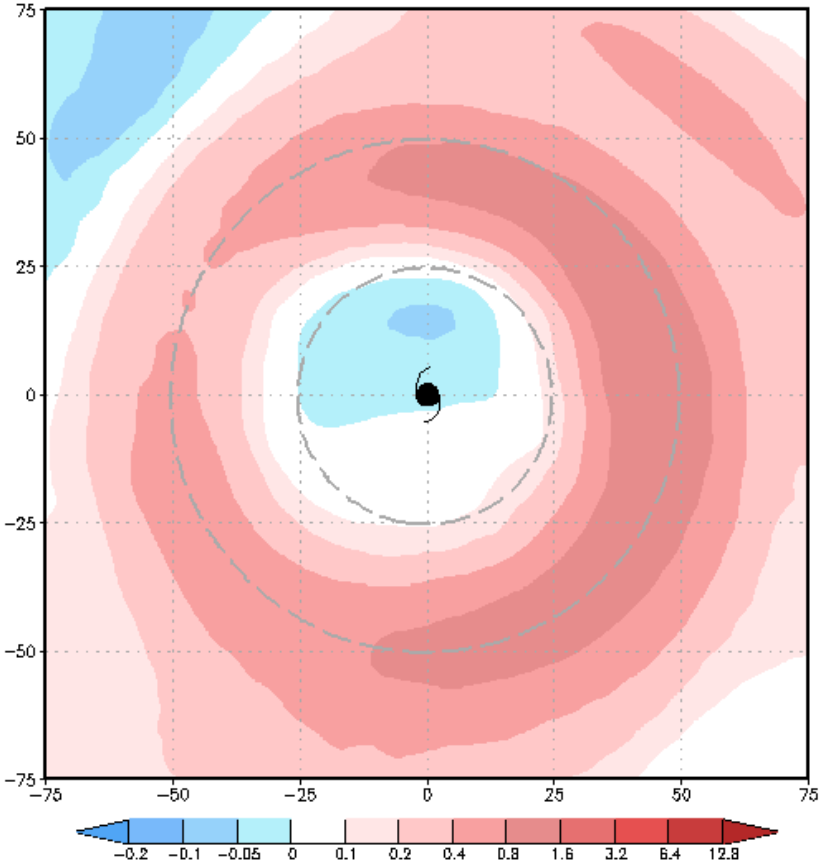
WRF-ARW
S2 with RRTM



WRF-ARW
F with GFDL

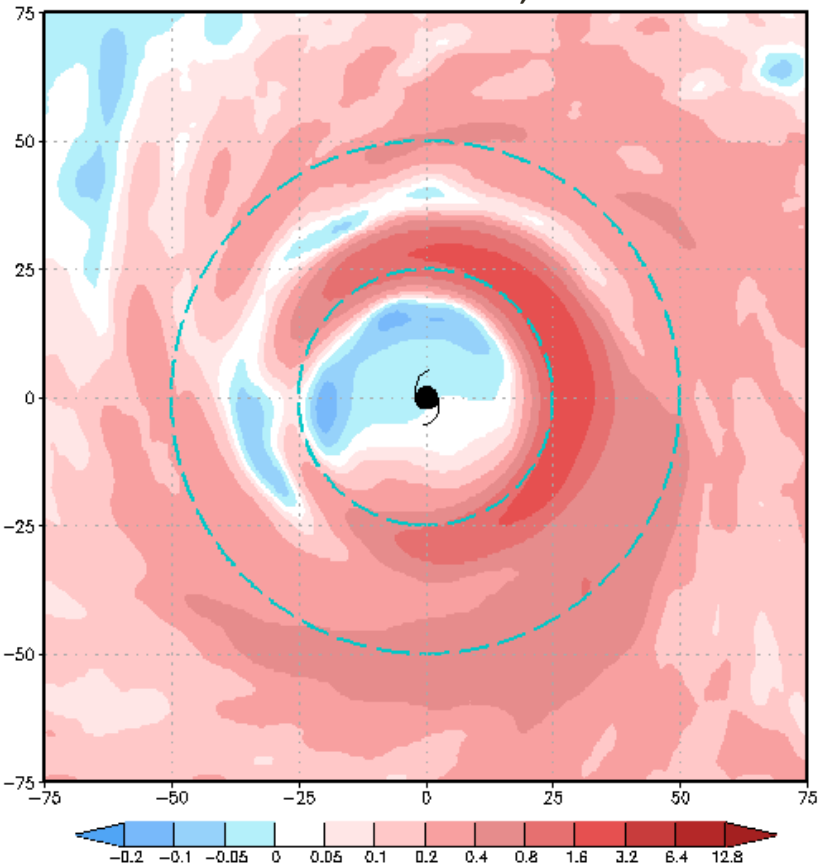
Vertically averaged W

2 domains – 27 and 9 km, CP on



HWRF v33

2 domains – 9 and 3 km, CP off

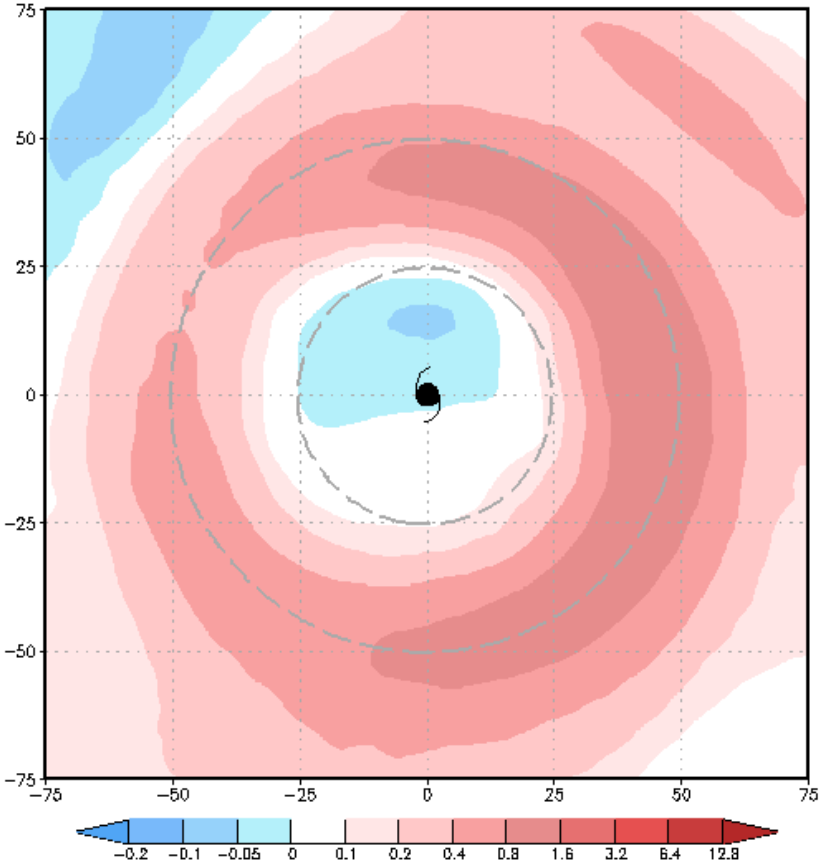


WRF-ARW

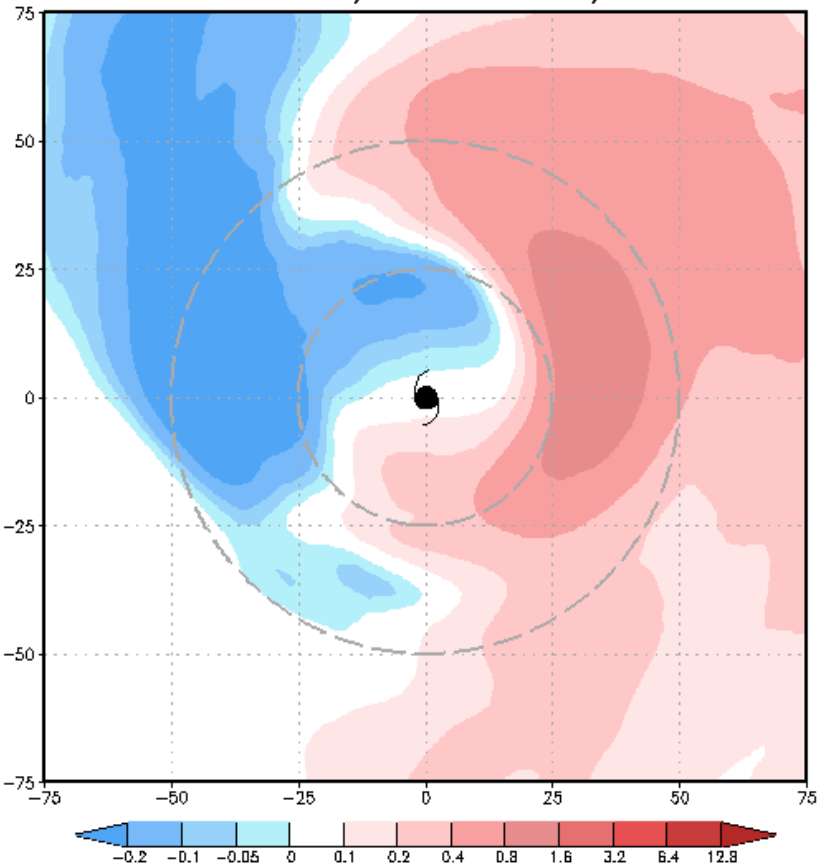
F with GFDL

Vertically averaged W

2 domains – 27 and 9 km, CP on



3 domains – 27, 9 and 3 km, CP off in D3



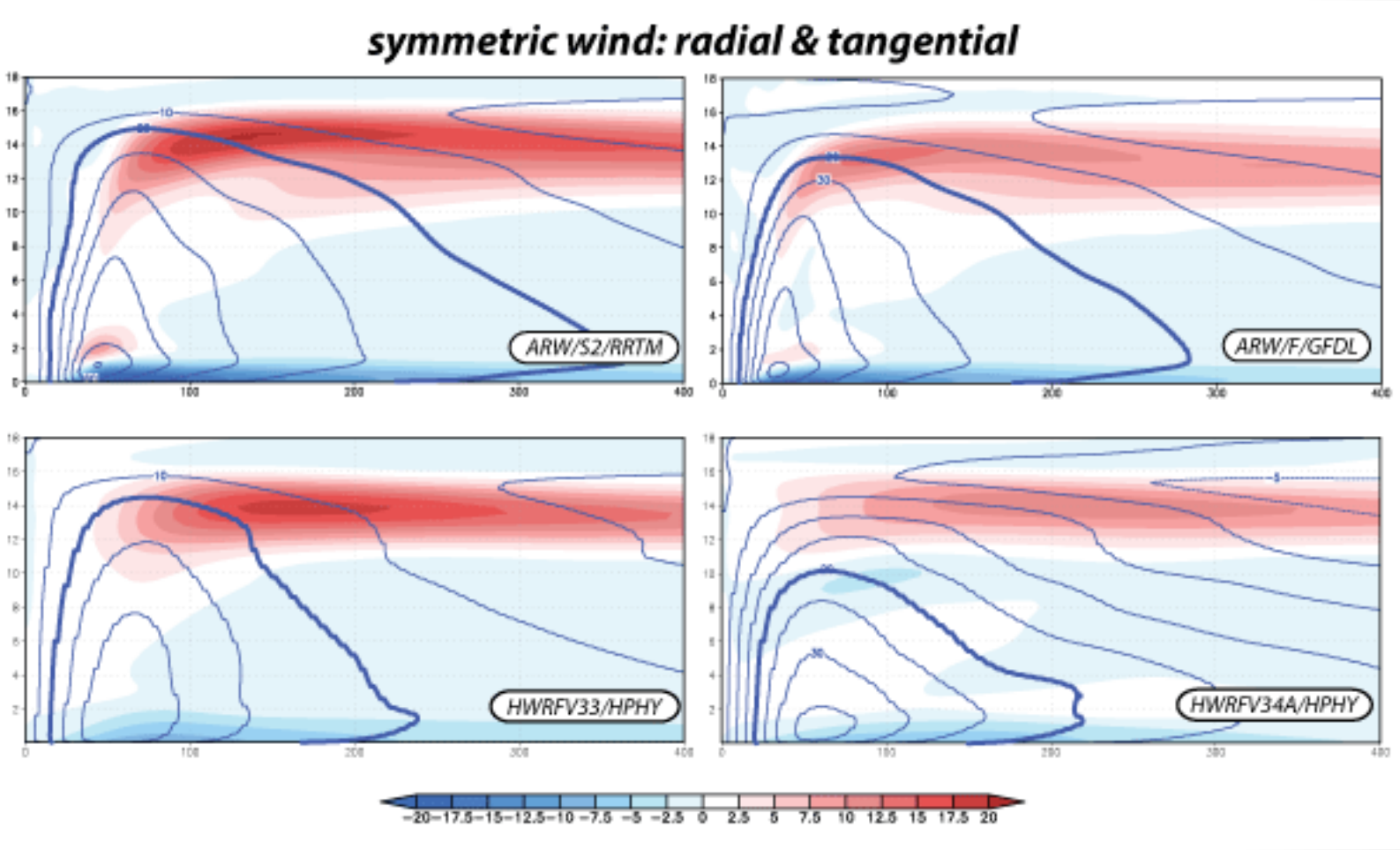
HWRF v33

Different ≠ wrong

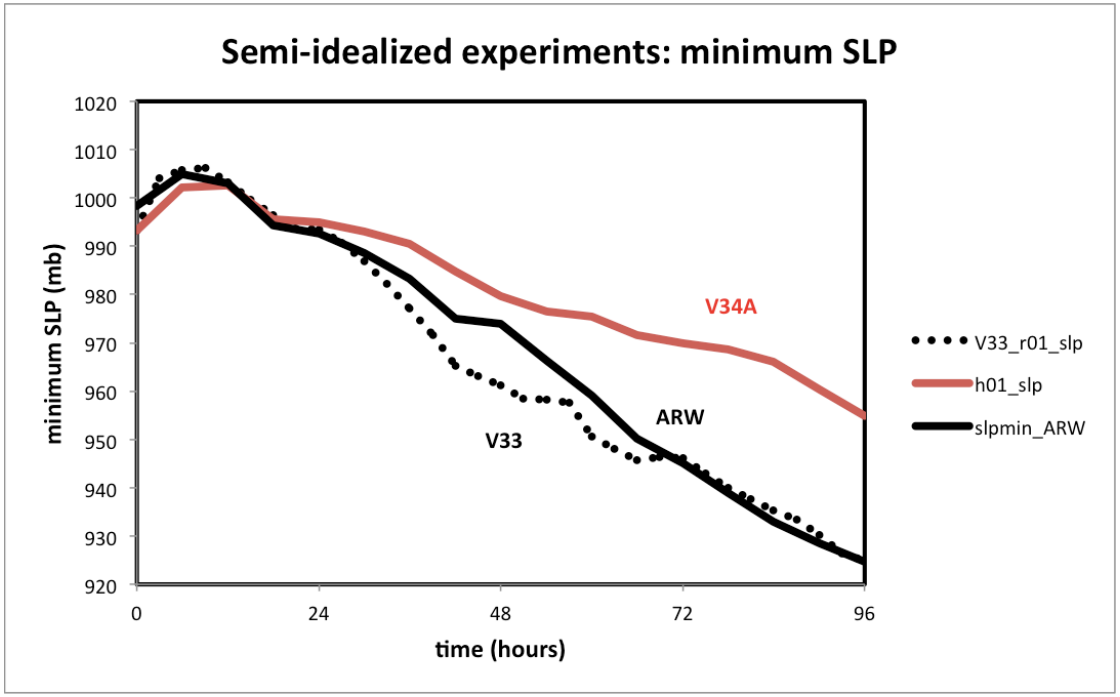
HWRF v34A

Azimuthally averaged winds

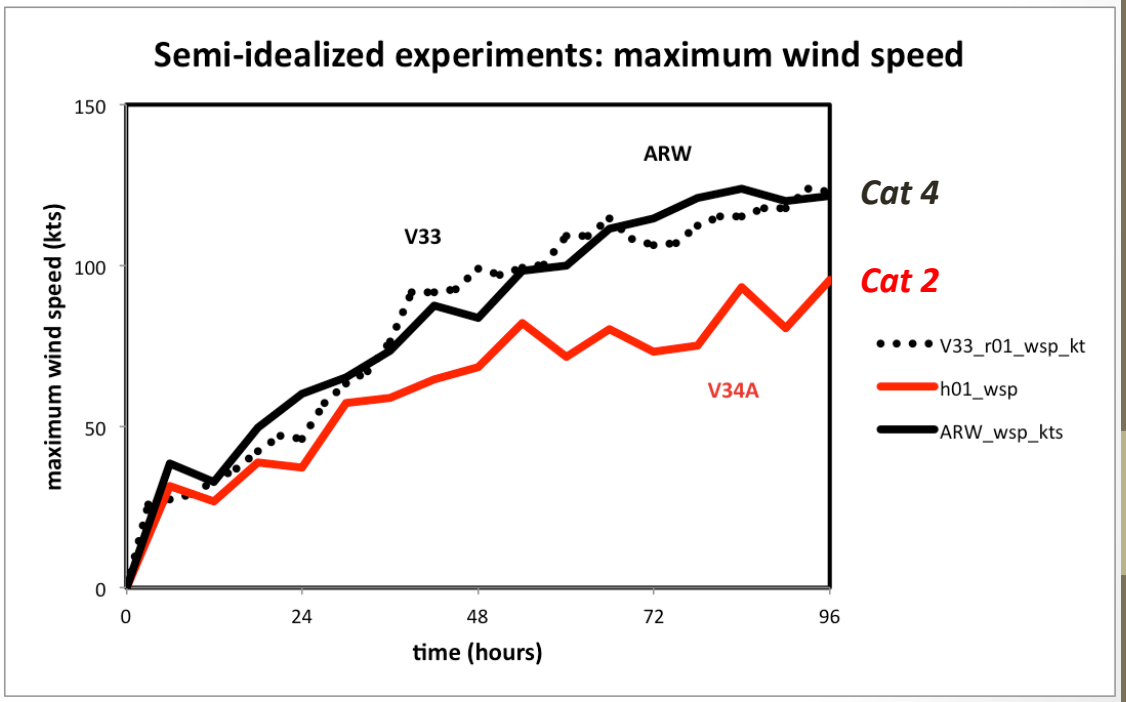
radial (shaded) and tangential (contoured)



All simulations started with same initial environment;
Keep *asymmetric structure differences* in mind…

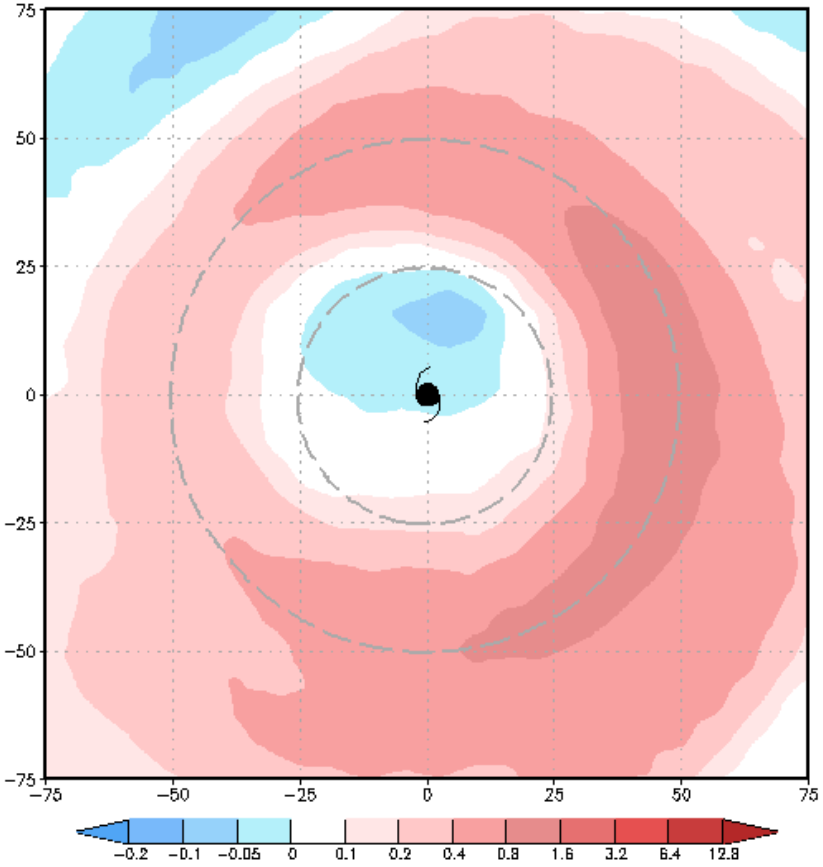


Different ≠ wrong

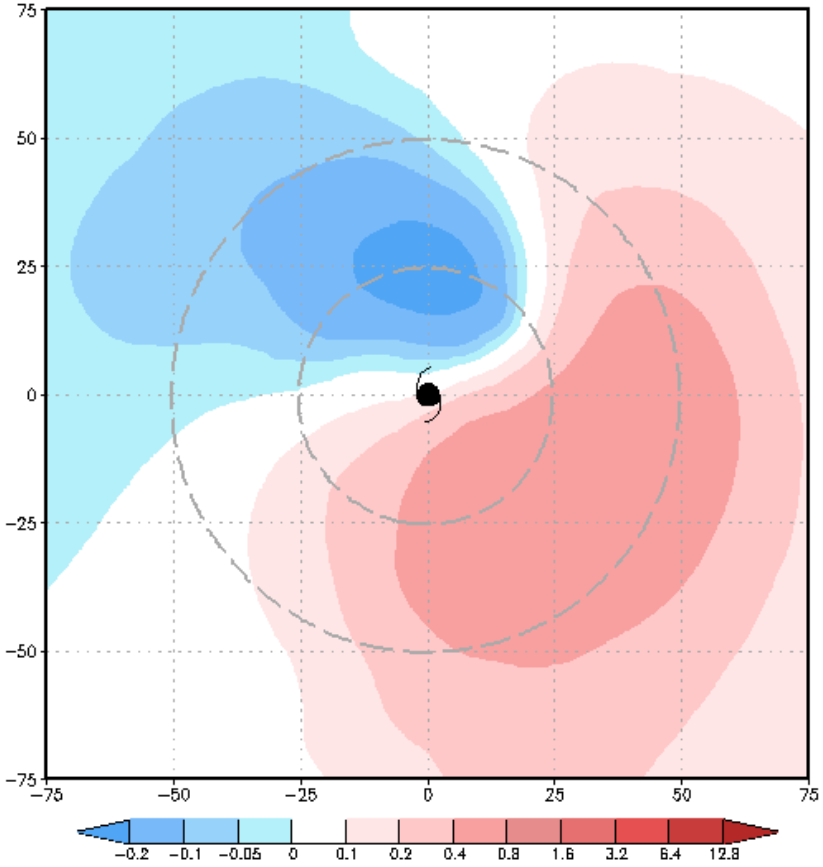


2 domain tests: V33 vs. V34A

2 domains – 27 and 9 km – V33



2 domains – 27 and 9 – V34A



HWRF v33

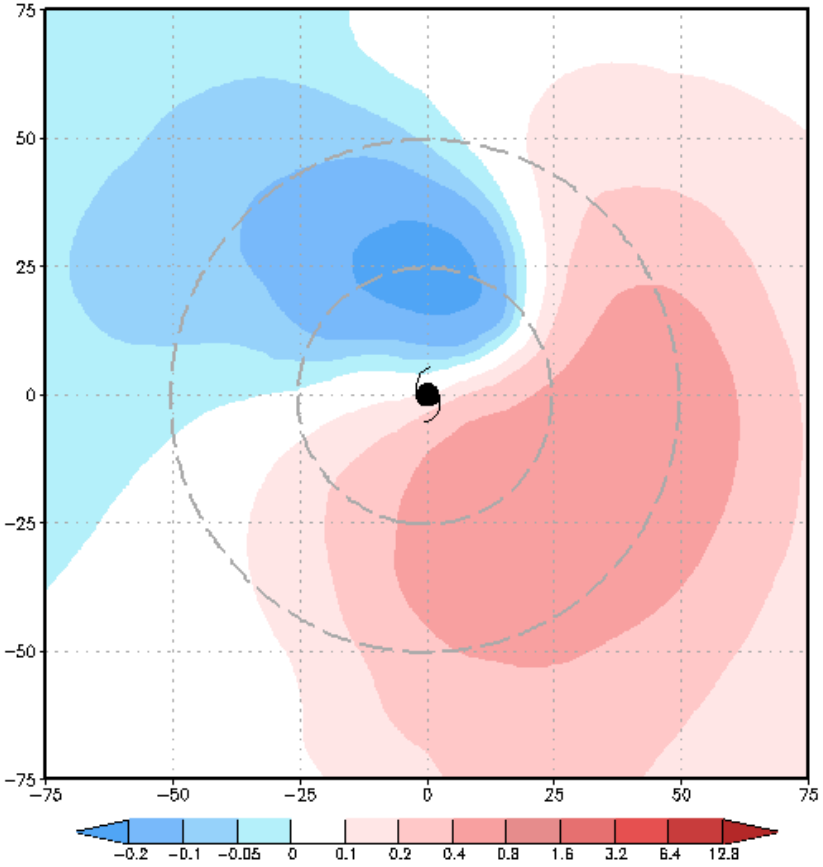
HWRF v34A

Exploring intensity and structure differences…

- Assessed impact model and physics time steps
  - appears **minor** w/ HPHY … but does not exercise SAS CP in coarse domains
- Assessed `nest_influence` in `module_dm.F`
  - `nest_influence` = 1.0 for ARW, 0.5 for HWRF
  - little impact
- Reverted v33-v34A code changes (including bugfixes) in `module_mp_HWRF.F`
  - minor impact
- Reverted SAS CP (used in HPHY) code and namelist changes
  - `sas_pgcon`, `sas_mass_flux`, shallow convection
  - small impact
- Reverted PBL changes (critical Richardson number)
  - minor impact
- Reverted mods to `module_sf_gfdl.F` (Ch profile)
  - minor impact
- Reverted `coac` (horizontal diffusion weighting factor)
  - Impact on min SLP, less on max wind, very little on structure

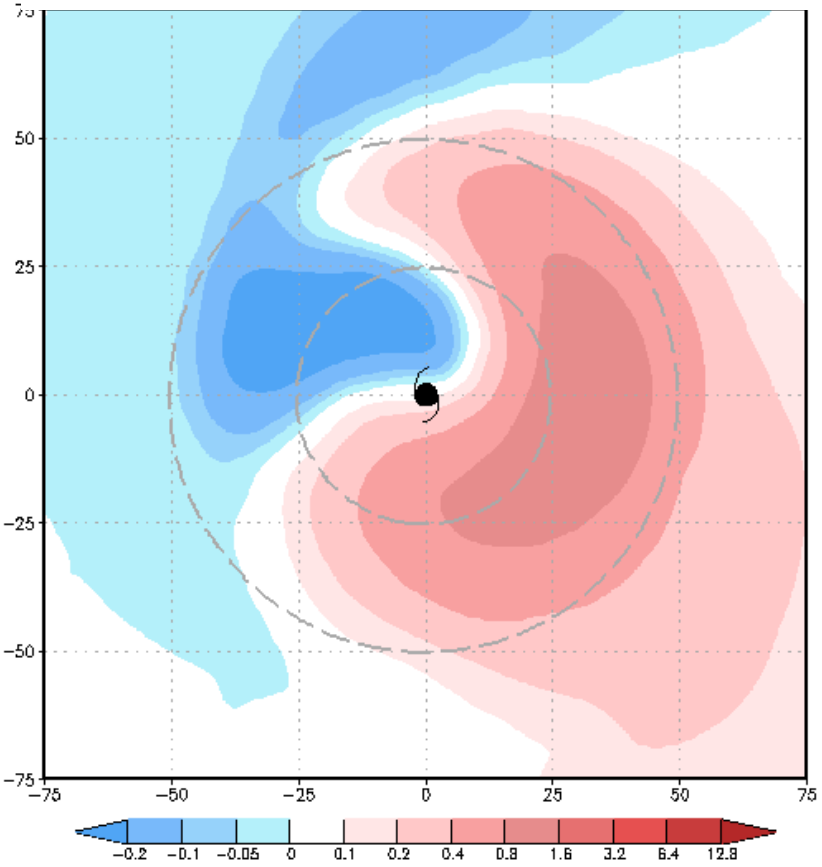
Vertically averaged W

2 domains – 27 and 9 km



HWRF v34A

2 domains – 27 and 9 km (*coac reverted*)



HWRF v34A

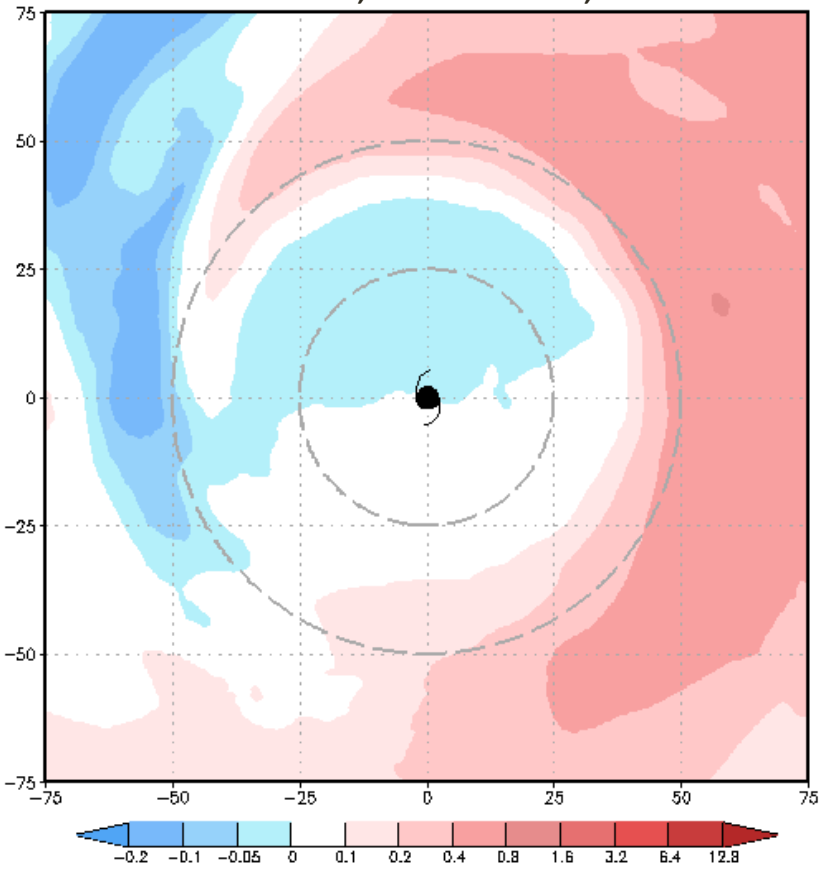
Future plans

- Finish intercomparison of ARW – V33 – V34A for semi-idealized
- Continue adding and analyzing real-data simulations with V34A
- Initialize a vortex into semi-idealized simulations

[end]

Vertically averaged W

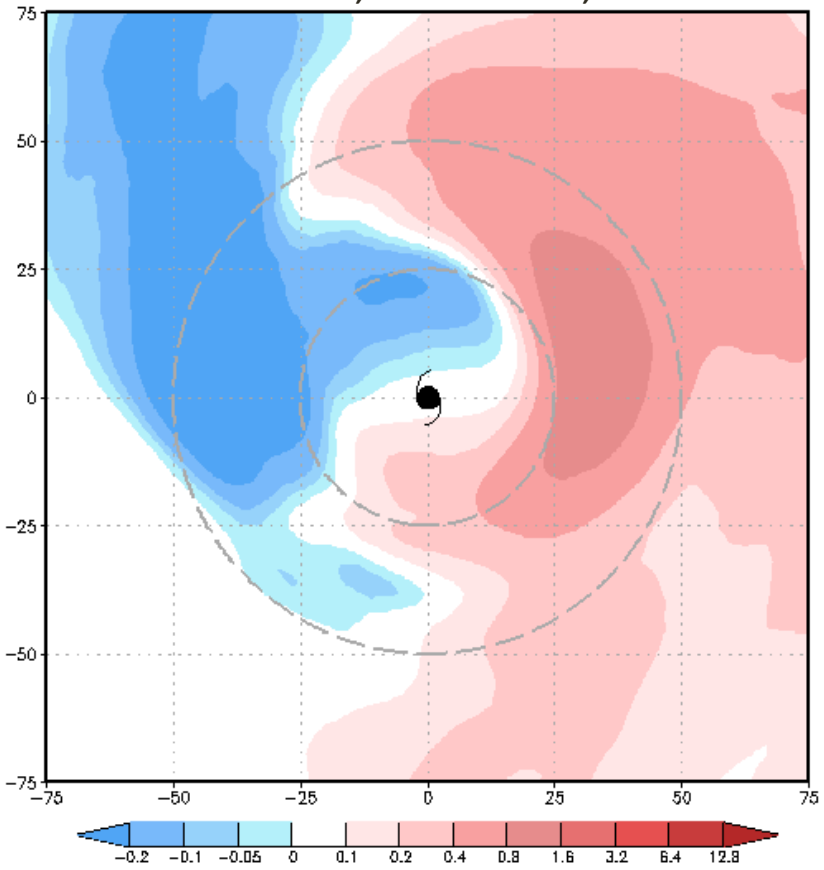
3 domains – 27, 9 and 3km, **CP off in all**



HWRF v34A

Most similar to WRF-ARW strategy

3 domains – 27, 9 and 3km, **CP off in D3**



HWRF v34A