Set 1: Vertical mixing parameters

The Channel domain was initialized with Alliance CTD data from May 28 - June 1. It was run with forcing comprised of ALADIN winds and FNMOC heat & E-P in the period June 7-20. Alliance CTD data was assimilated on June 9 (ramped up June 8 1800z, 2100z and June 9 0000z with weights 0.33, 0.66 and 0.99 respectively) and then every quarter day from June 12 1200z through June 17 0600z (ramped T-0.125, T-0.0625 and T with weights of 0.33, 0.66 and 0.99 respectively).

21 profiles were extracted from each model run to compare with 21 temperature profiles (selected by Emmanuel Coelho) in the period 0800z June 15 – 0400z June 16. The profiles extracted in the model are at the nearest horizontal grid point and 3/8 of a day before the nearest assimilation cycle (i.e. before the first ramping of the first assimilation cycle that "feels" the data). Two comparisons are presented. First, the extracted profiles and the CTD data are interpolated to a common vertical grid (0-160m at every m). An average difference as a function of depth is plotted. The second comparison is to plot all data and model profiles in a single graph. For this common plot, the model resolution is represented by including open circle glyphs at each point.

The first set of parameter test was an attempt to improve the model/data fit by tuning the vertical mixing parameters. The parameters examined were:

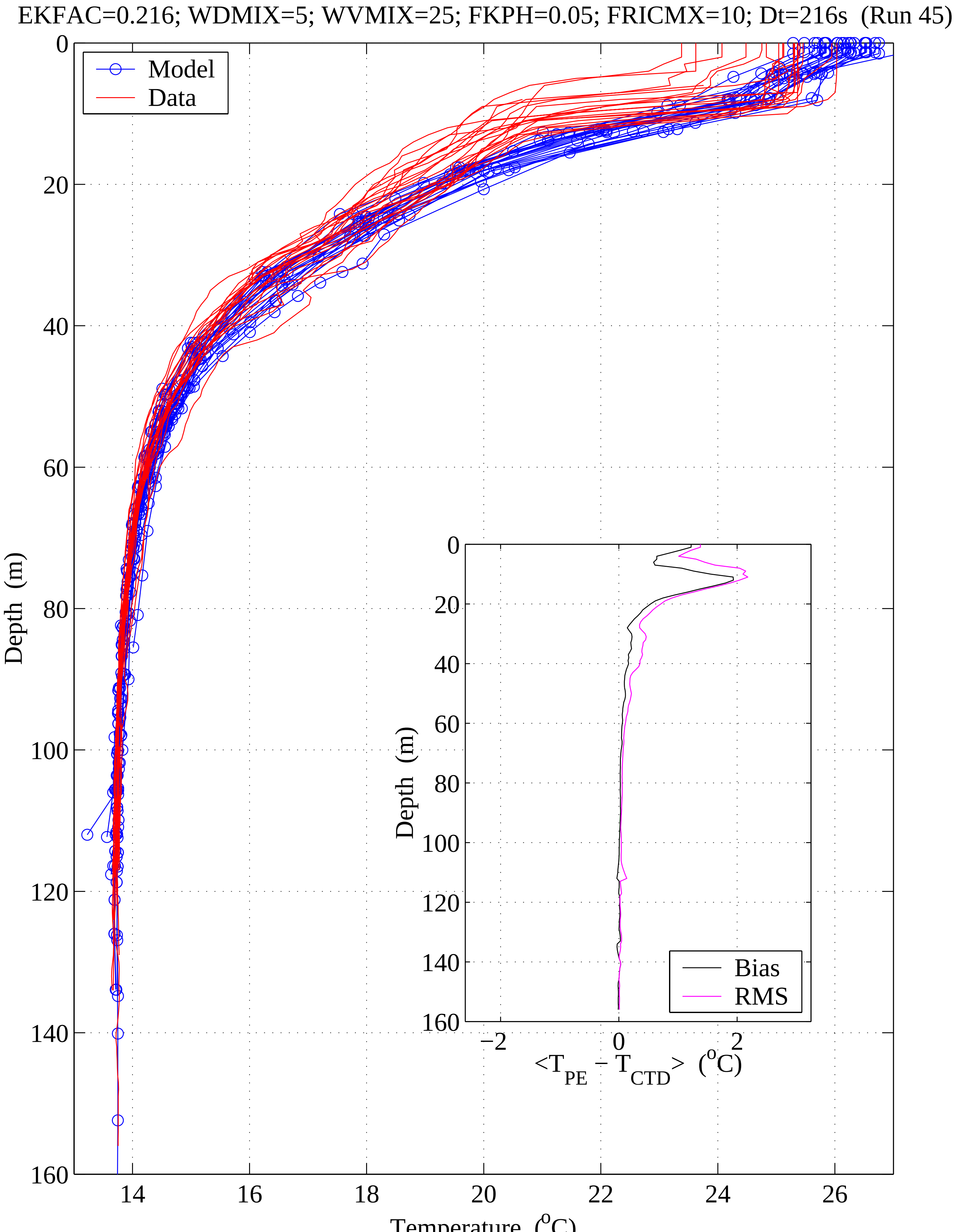
Run #	**EKFAC**	**WDMIX** cm^2/s	**WVMIX** cm^2/s	**FKPH** cm^2/s	**FRICMX** cm^2/s	**dt** s
45	0.216	5	25	0.05	10	216
46	0.162	50	50	0.05	10	216
47	0.108	100	100	0.05	10	216
48	0.216	5	25	0.01	10	216
49	0.162	50	50	0.01	10	216
50	0.162	50	50	0.01	7.5	216
51	0.162	50	50	0.01	10	108

EKFAC	Constant of proportionality between local depth of mixing layer and magnitude of wind forcing.
WDMIX	Vertical mixing coefficient for tracers in upper mixing layer
WVMIX	Vertical mixing coefficient for velocity in upper mixing layer
FKPH	Minimal value for vertical mixing coefficient in entire water column.
FRICMX	Maximal increase in vertical mixing coefficient under Pacanowski–Philander formula.
dt	PE model time step.

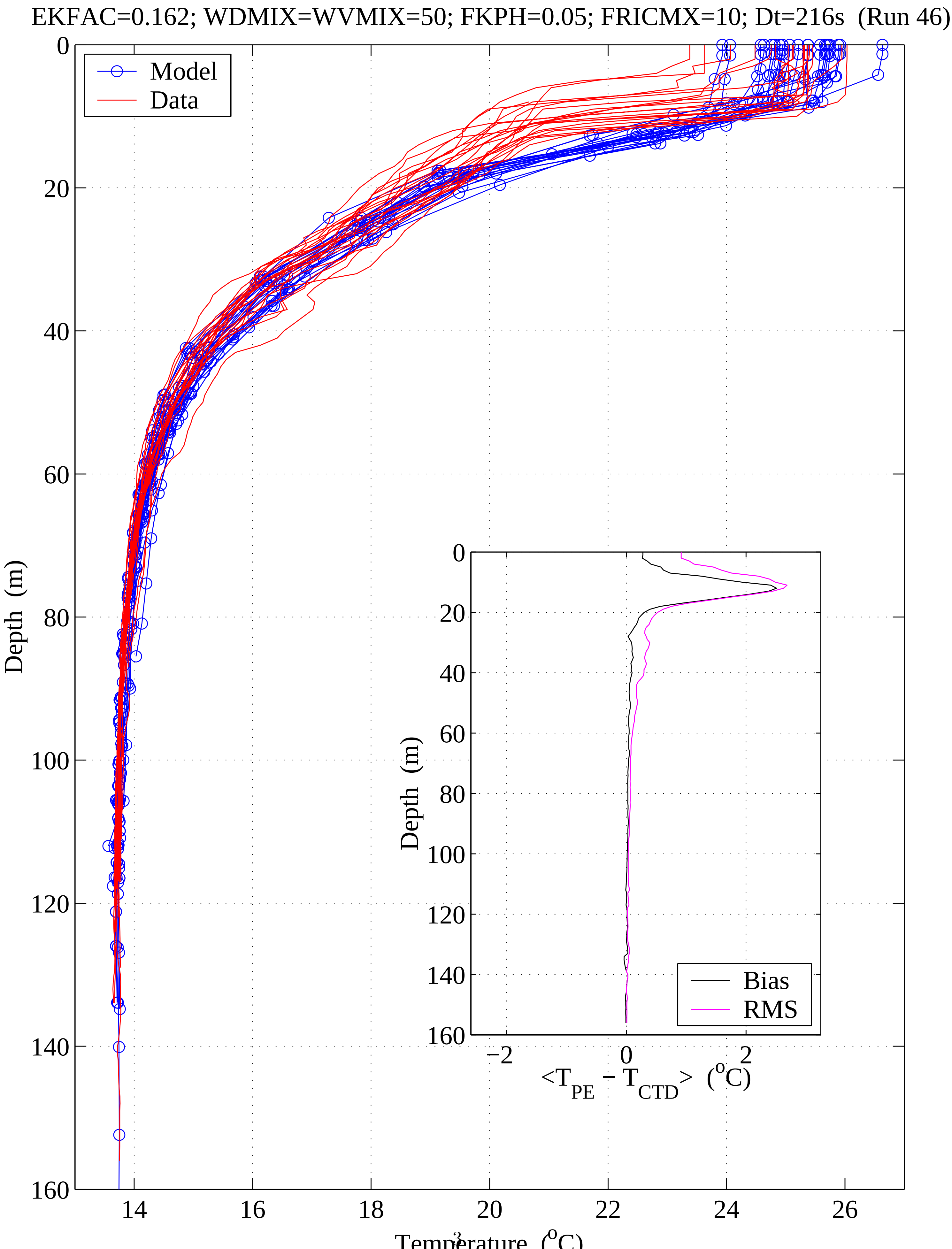
From the above set, run 47 is not presented because it fails before any profiles could be extracted and run 51 is not presented as it is so similar to run 49.

The overall results were that the changes for shallower, more strongly mixed surface layer improved the qualitative shape and the quantitative match at the surface at the expense of the quantitative match in the upper thermocline. One additional observation is the relatively small number of grid points in the upper thermocline

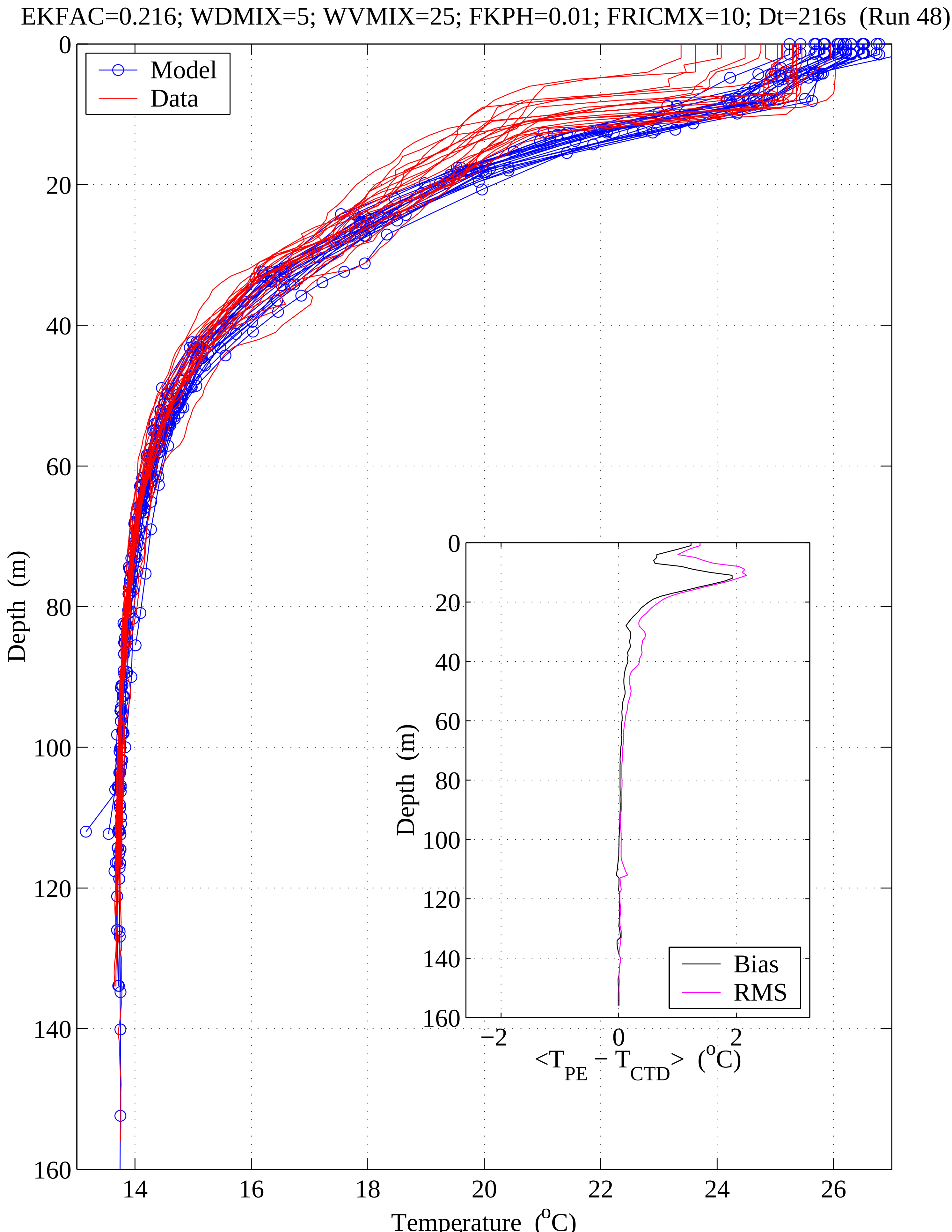
Run 45: First reasonably stable simulation.



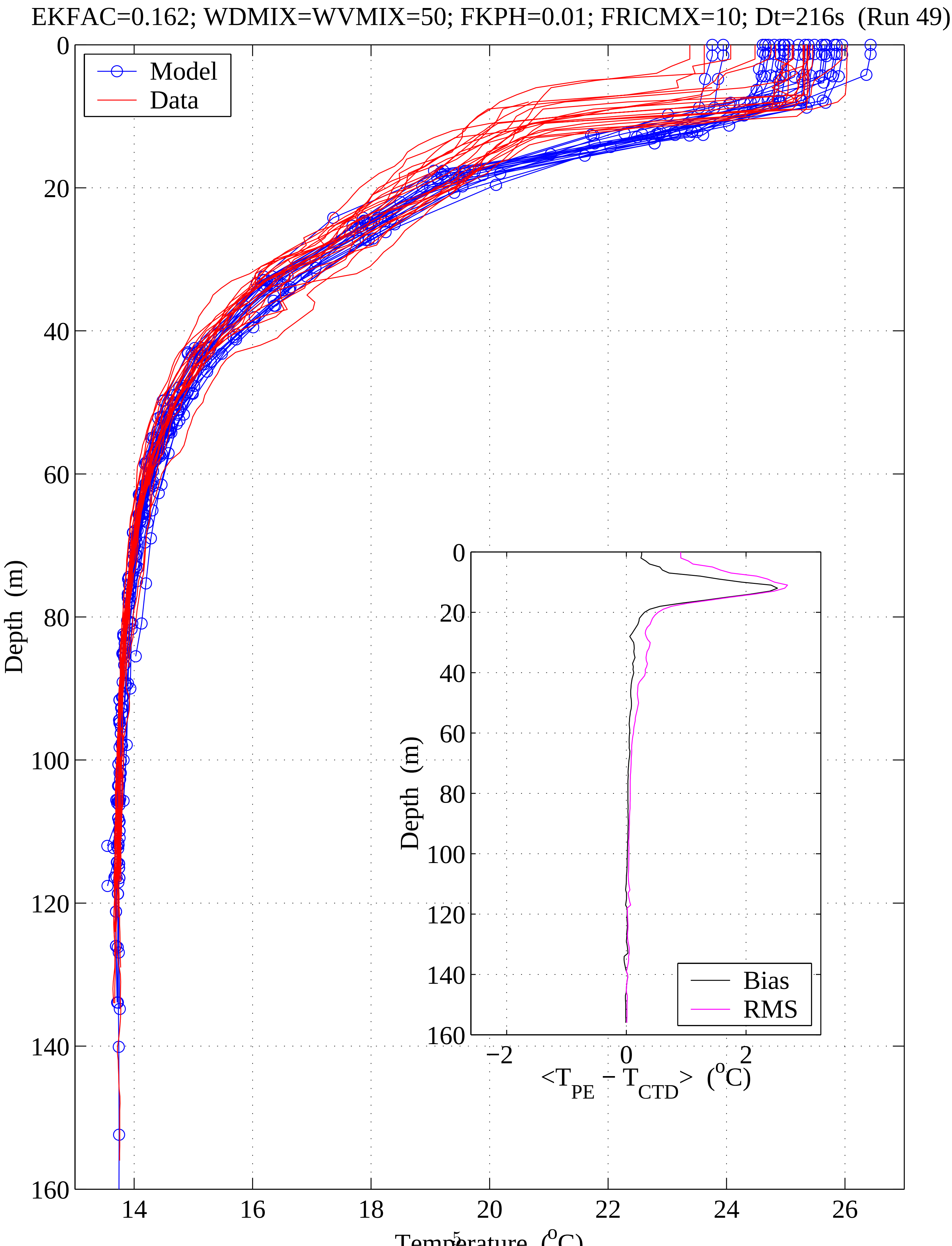
Run 46: run 45 w/ shallower mixed layer and stronger wind mixing.



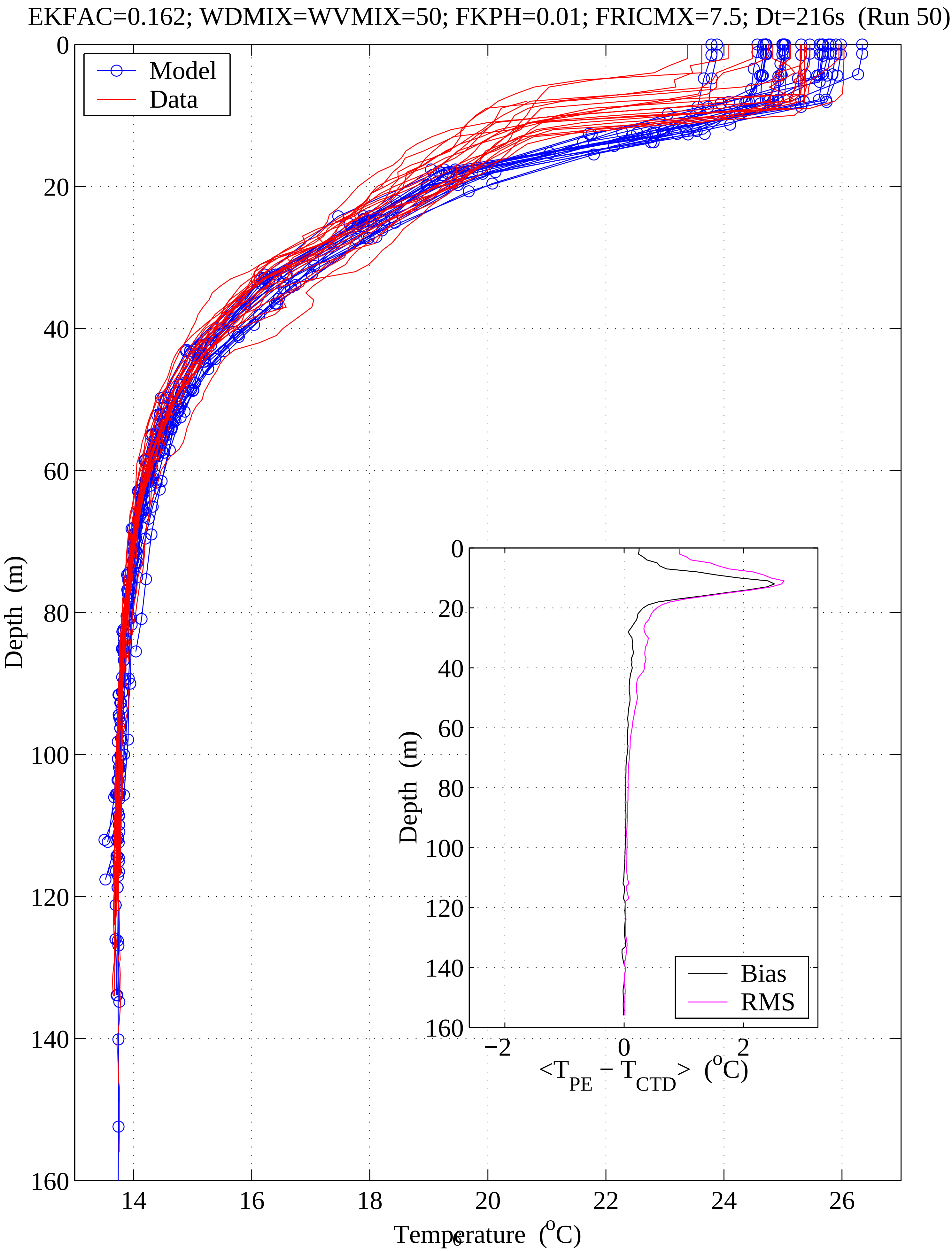
Run 48: run 45 w/ weaker background tracer mixing.



Run 49: run 46 w/ weaker background tracer mixing.



Run 50: run 49 w/ weaker maximal Pacanowski–Philander mixing.



Revising the vertical grid

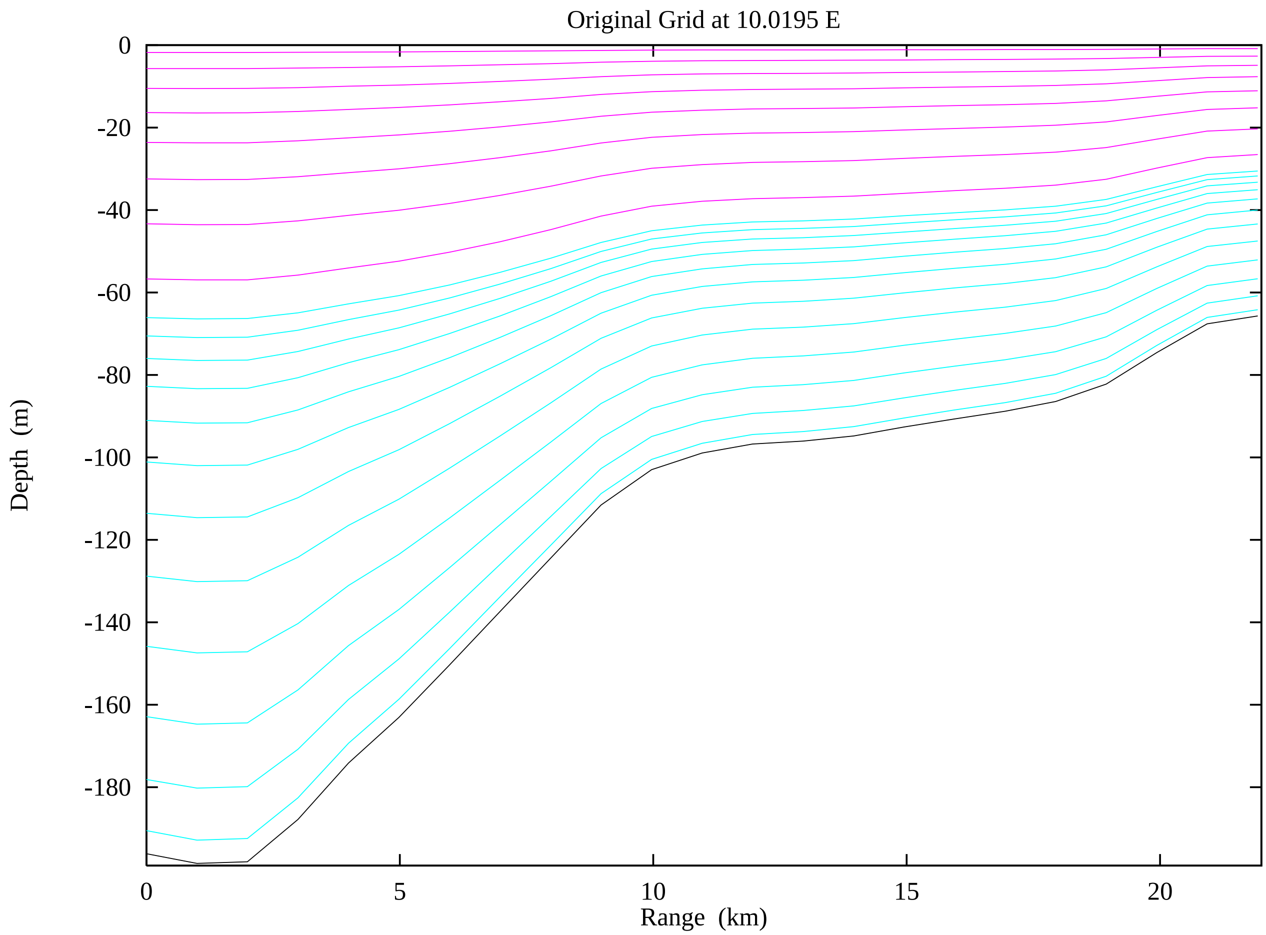
A quick test of the vertical grid is obtained by revising the distribution of vertical levels in the grid. 2 additional vertical grids were tried in the PE model. Both were double sigma grids with 20 levels. The changes were to the relative spacing of sigma levels, the shape of the coordinate interface between the 2 sigma systems and the partition of levels between the 2 systems.

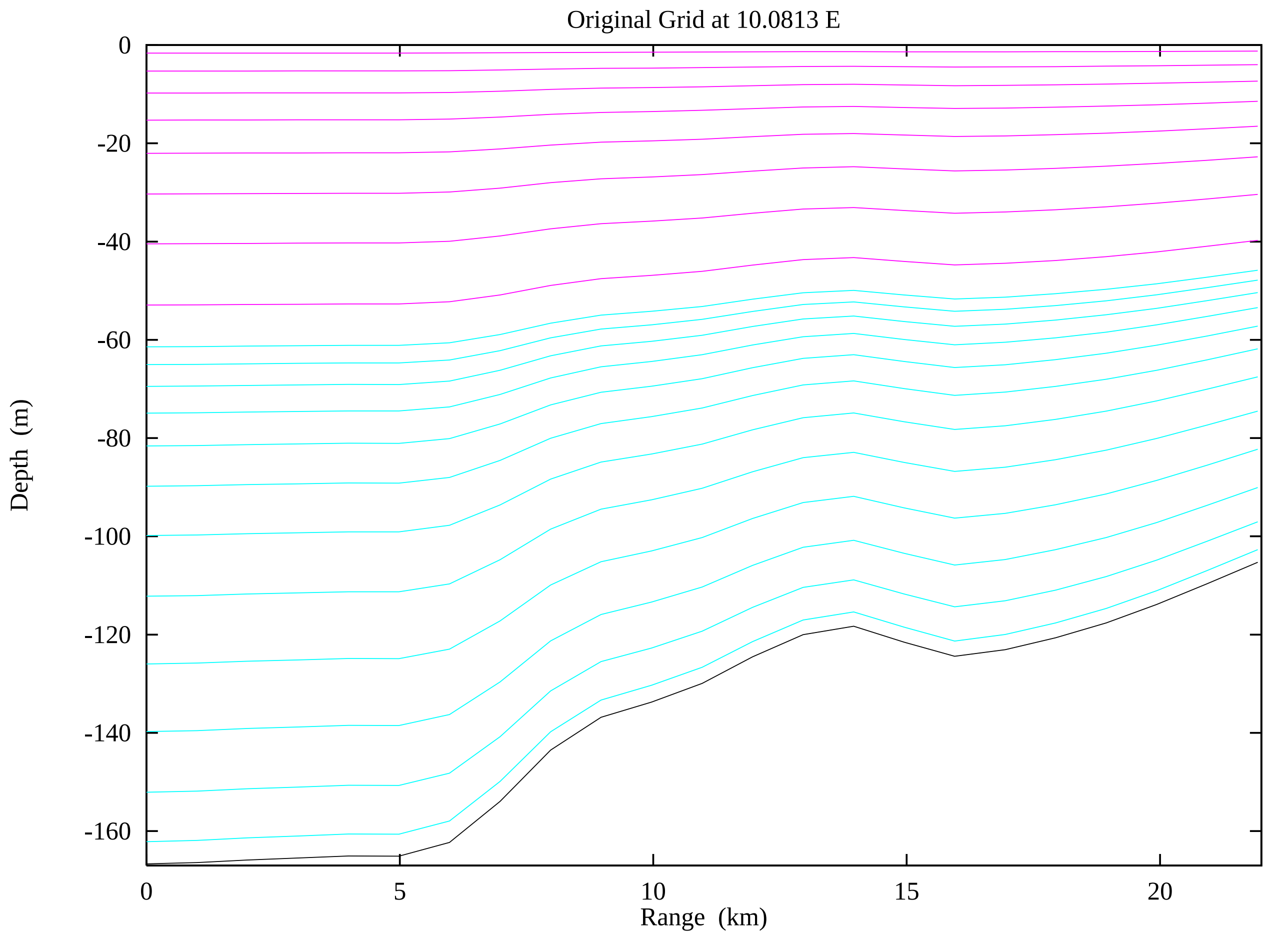
Grid	Optimum	ZSLOPE	KC
Original	No	0.5	8
Revised 1	Yes	0.08	8
Revised 4	Yes	0.25	15

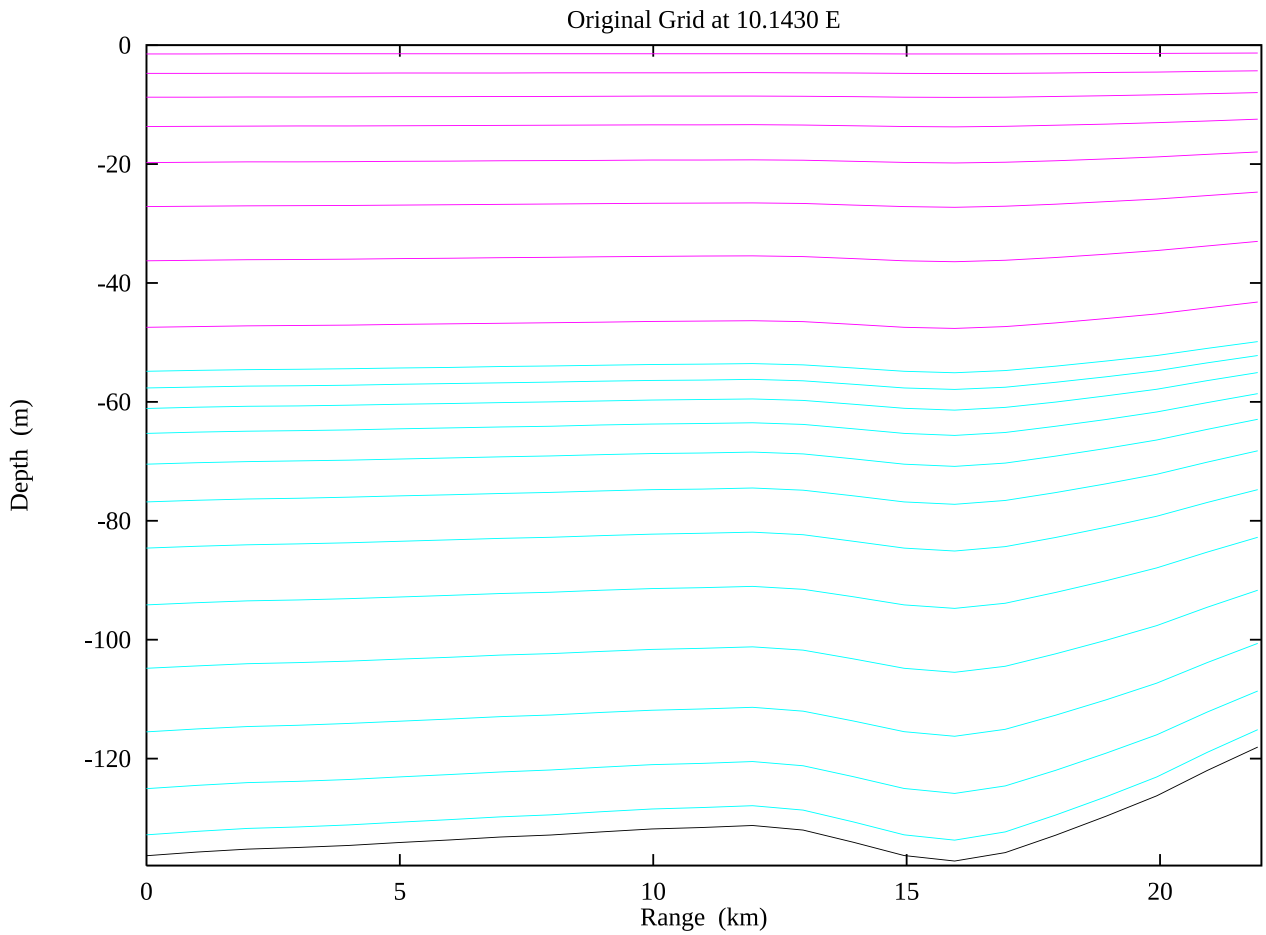
Optimum	Indicates whether the $\delta\sigma$ thicknesses were chosen to reduce the hydrostatic consistency factor.
ZSLOPE	Maximal fraction of bottom slope "transmitted" by the coordinate interface. $\|\|\nabla f\|\| \leq ZSLOPE\|\|\nabla h\|\|$ where f is the coordinate interface and h is the bottom topography.
KC	Number of model level in the upper sigma system.

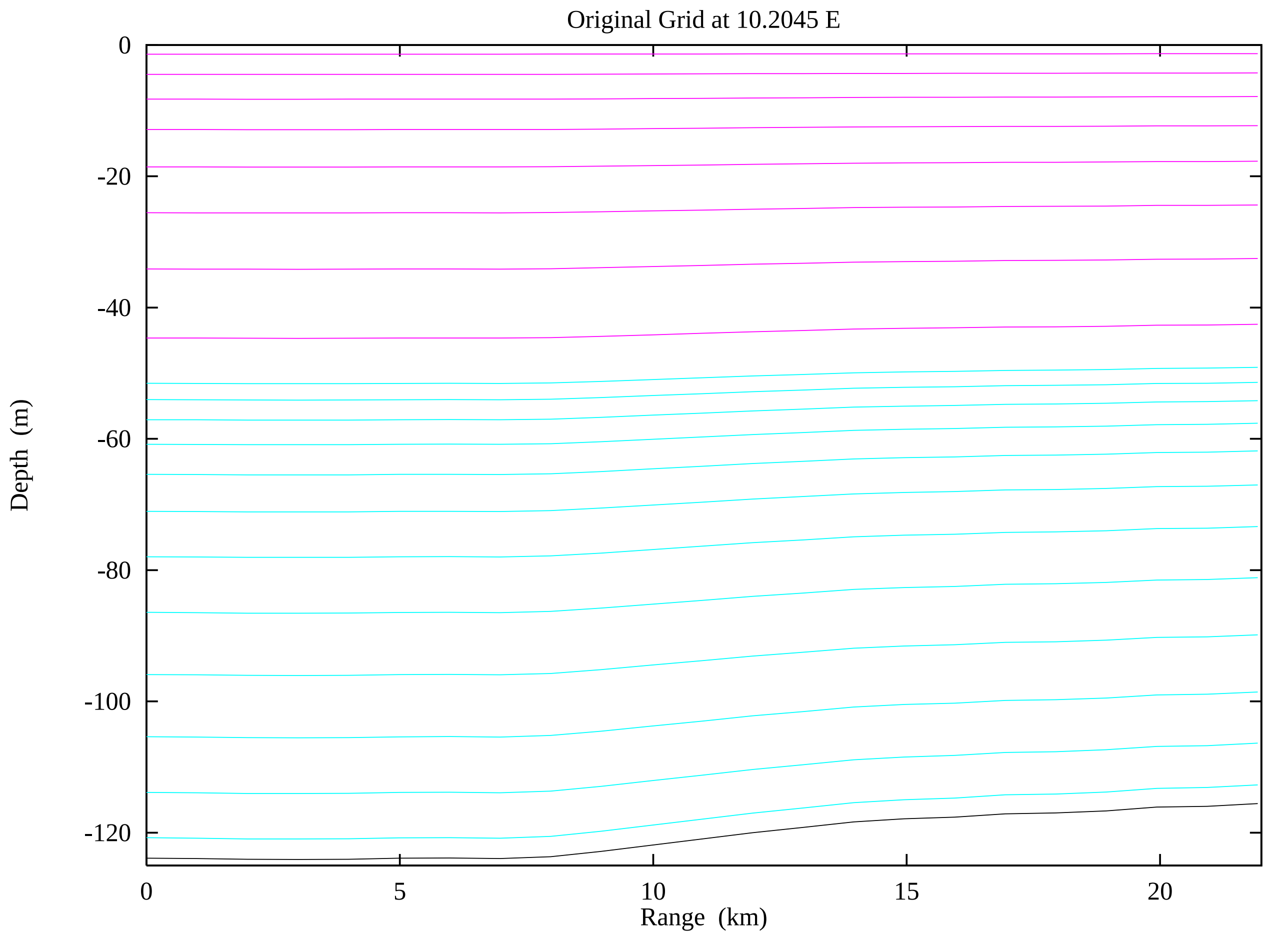
For each grid, north to south transects (43.1105 N – 42.9133 N) showing the distribution of vertical levels are plotted along each of the 5 "legs" of the fine grid survey used for validation.

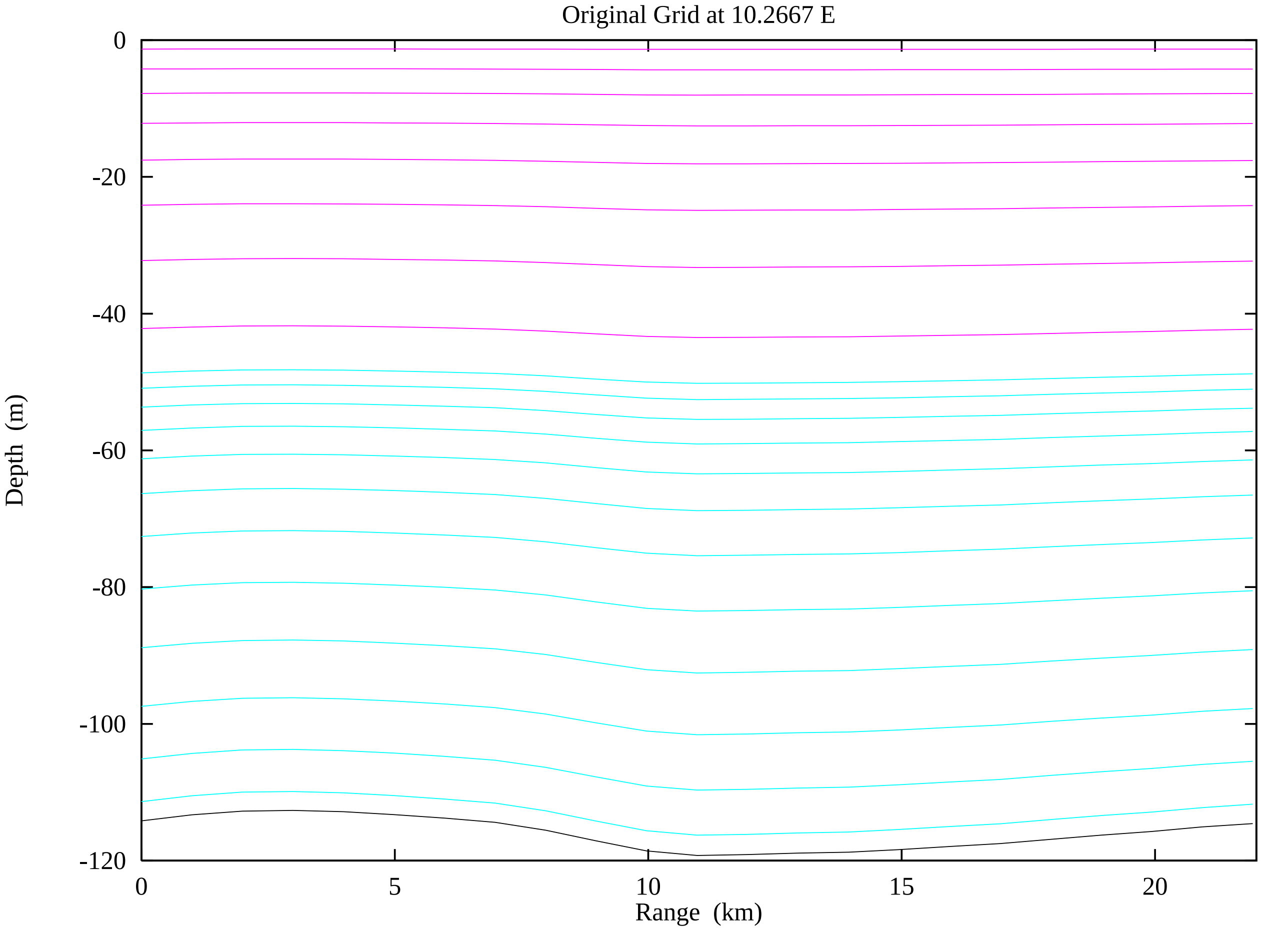
Before running with the grids an interpolation test was made in which the test data was interpolated onto the grids. The interpolated data was then compared to the original data in the same manner as the modeled data. Both revised grids reduce the interpolation error.


Original Grid at 10.0195 E
Depth (m)
0
-20
-40
-60
-80
-100
-120
-140
-160
-180
Range (km)
0
5
10
15
20


Original Grid at 10.0813 E
Depth (m)
0
-20
-40
-60
-80
-100
-120
-140
-160
Range (km)
0
5
10
15
20

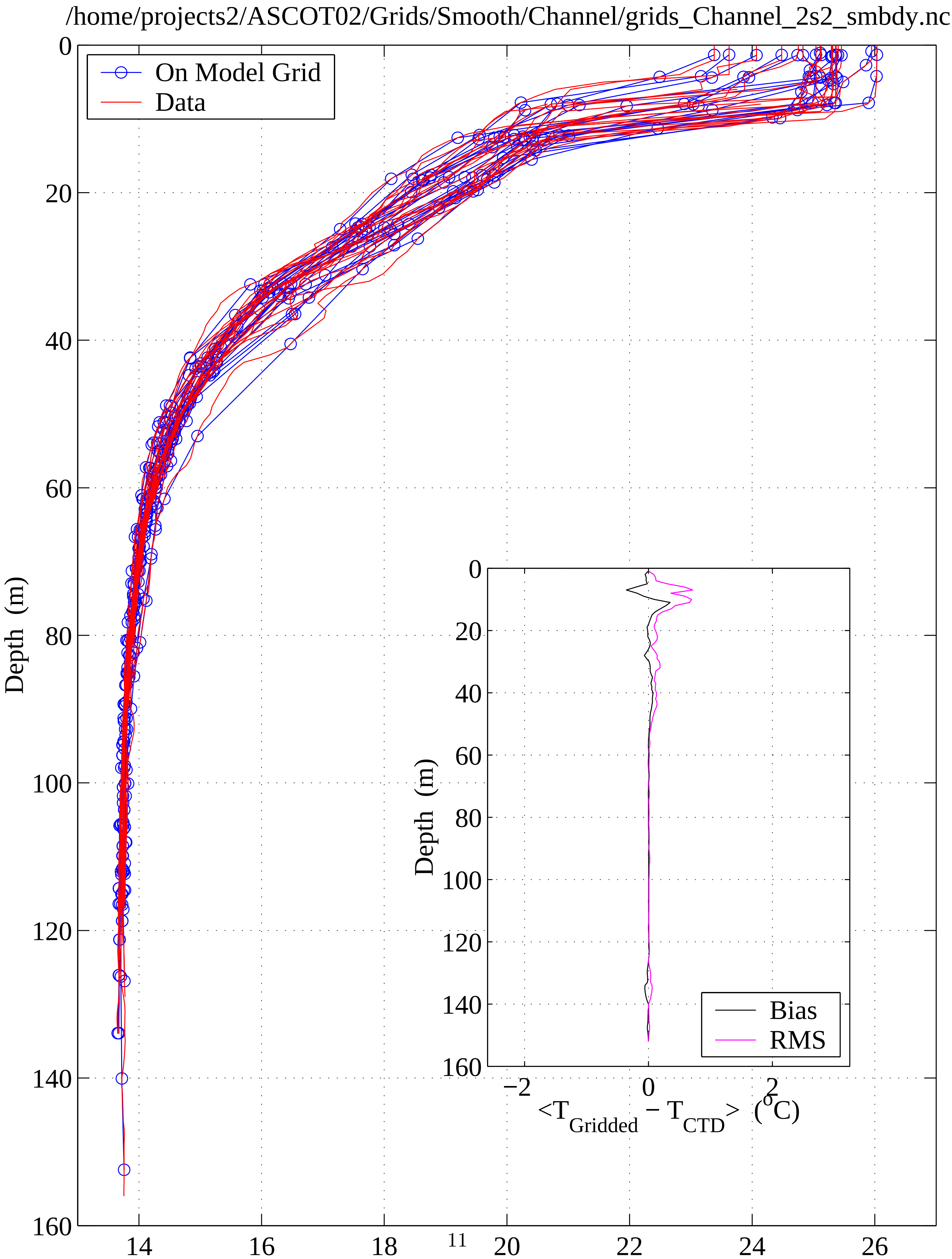

Original Grid at 10.1430 E
0
-20
-40
-60
-80
-100
-120
Depth (m)
0
5
10
15
20
Range (km)

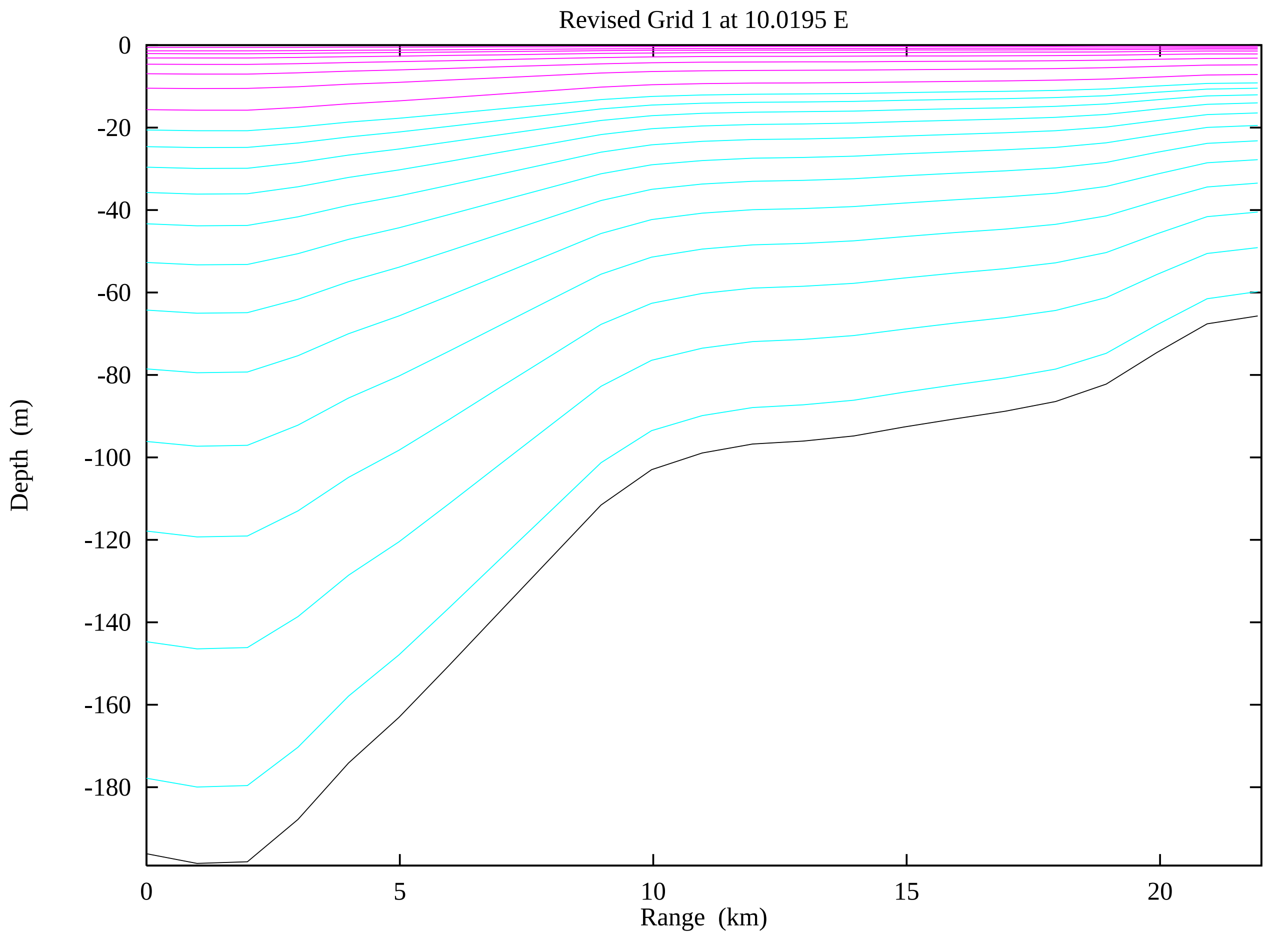

Original Grid at 10.2045 E
0
-20
-40
-60
-80
-100
-120
Depth (m)
0
5
10
15
20
Range (km)

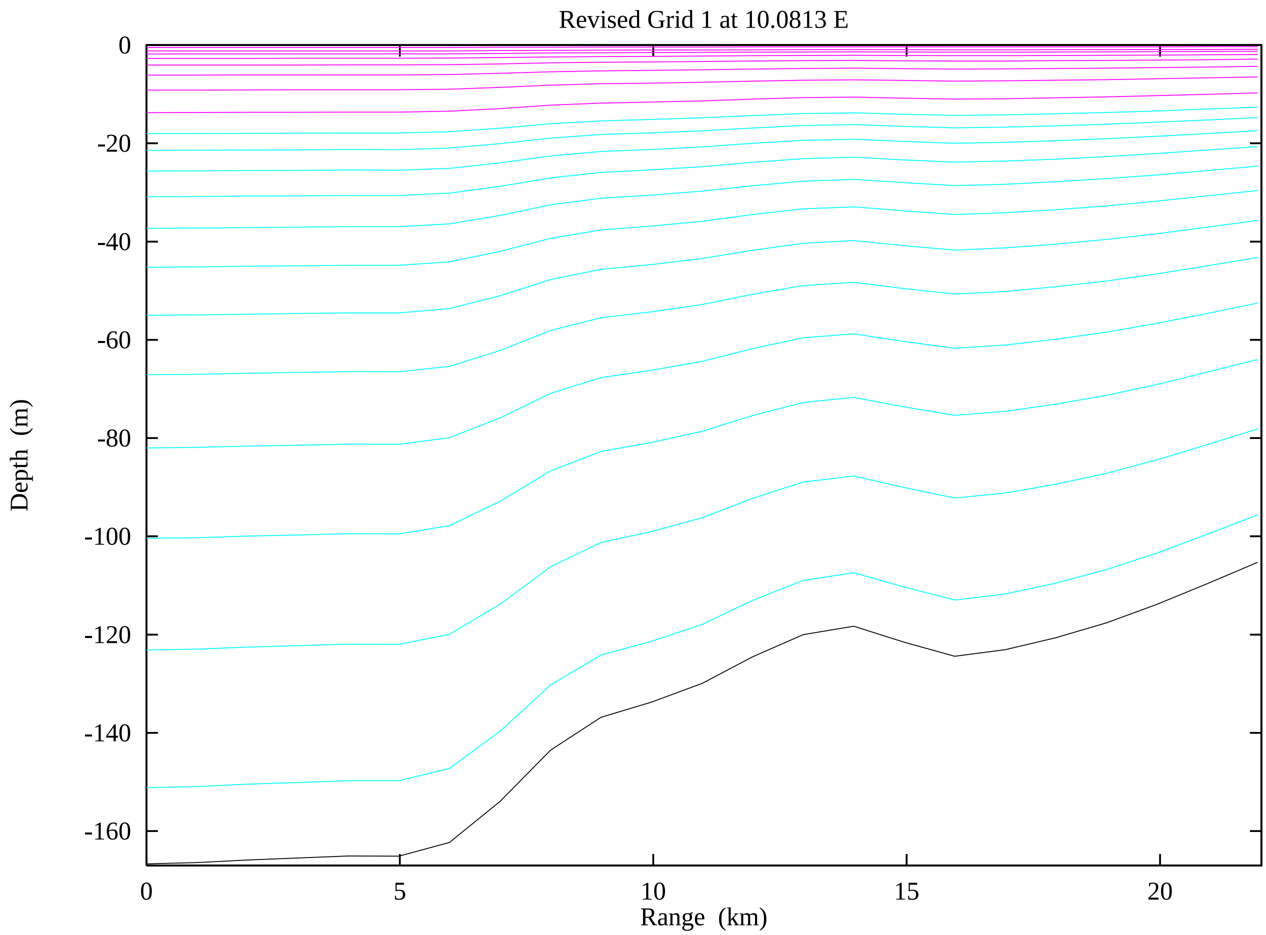


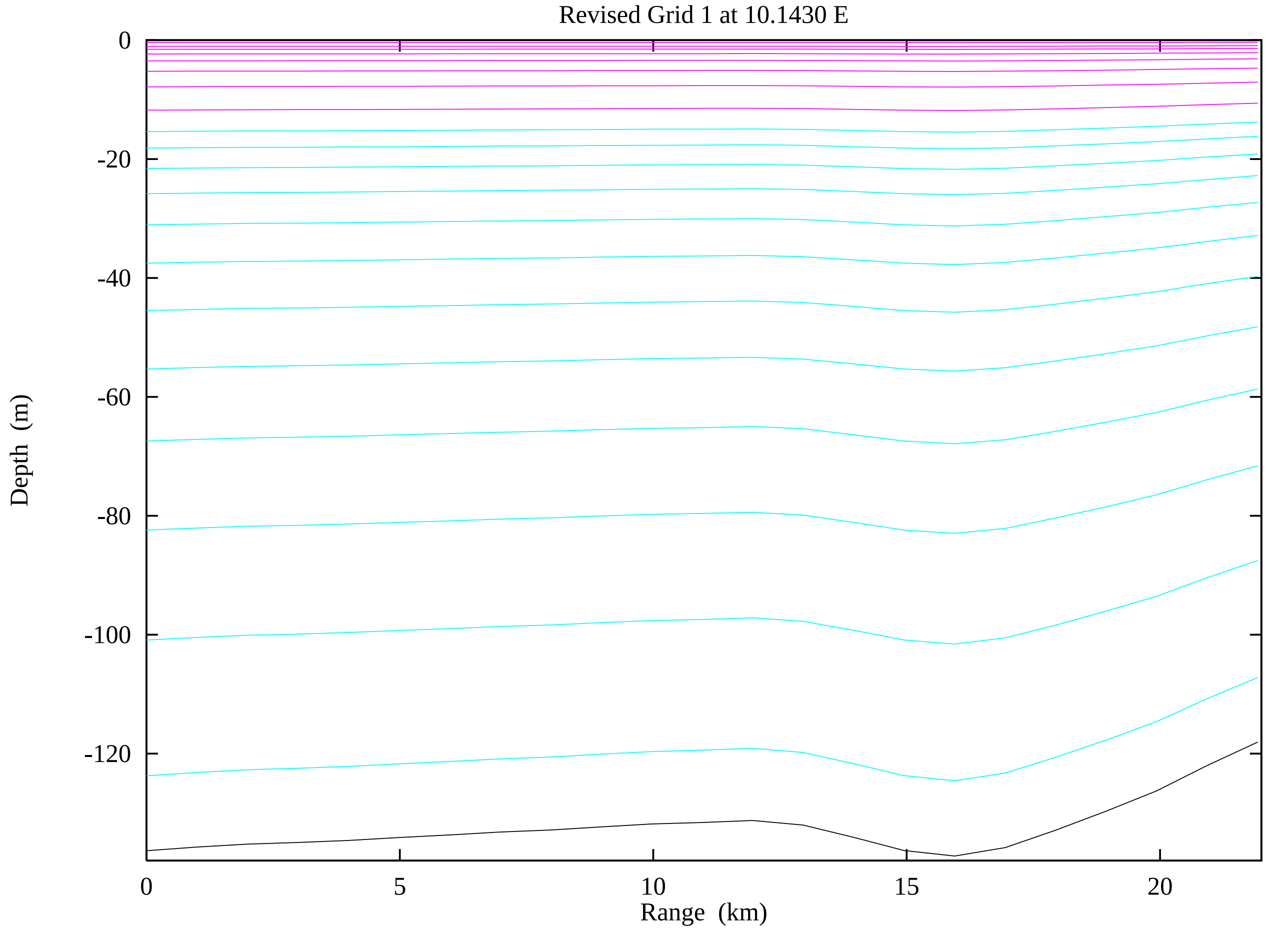
Original Grid at 10.2667 E
0
-20
-40
-60
-80
-100
-120
Depth (m)
0
5
10
15
20
Range (km)

Original vertical grid.

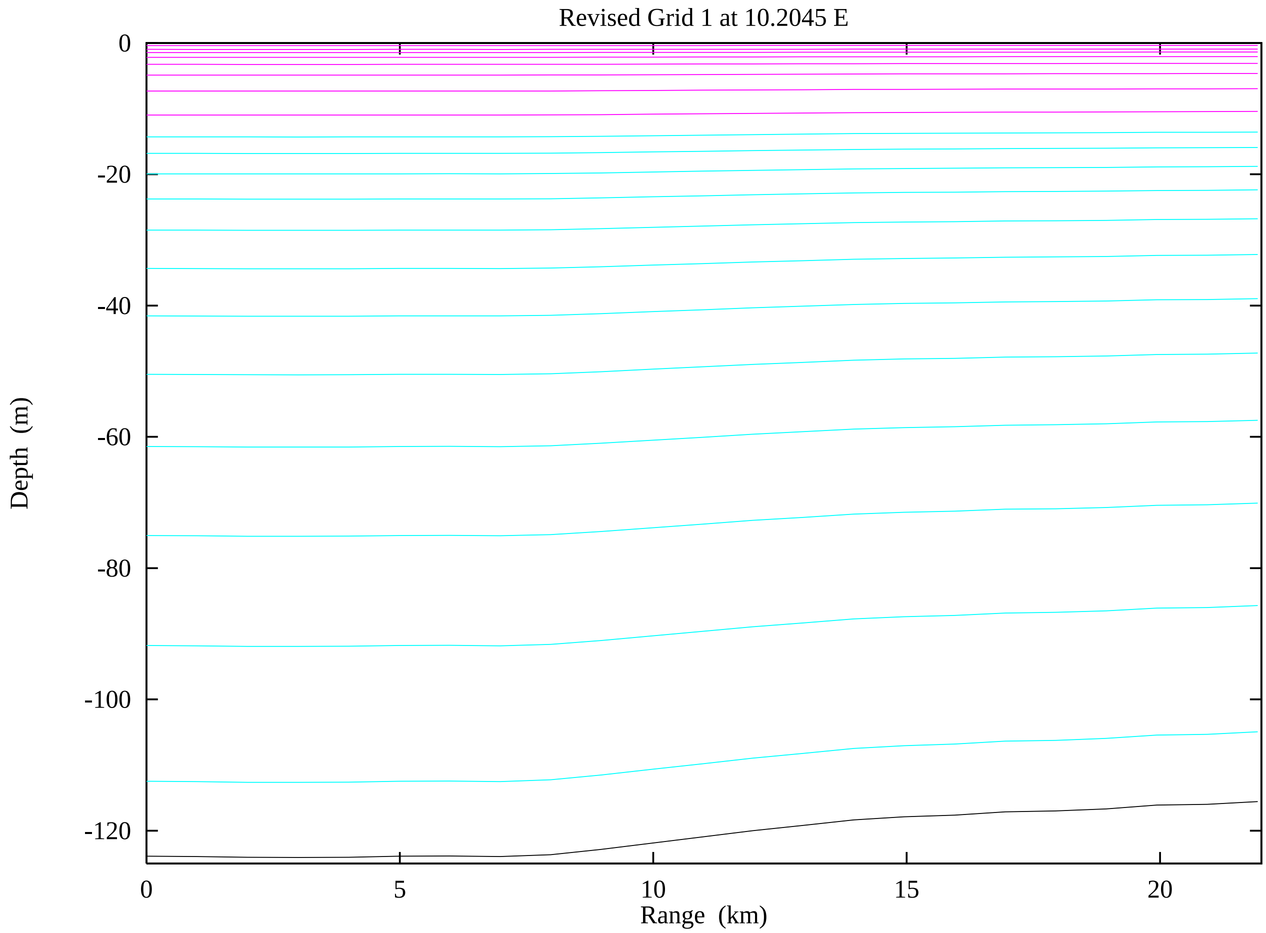



Revised Grid 1 at 10.0195 E
Depth (m)
0
-20
-40
-60
-80
-100
-120
-140
-160
-180
0
5
10
15
20
Range (km)

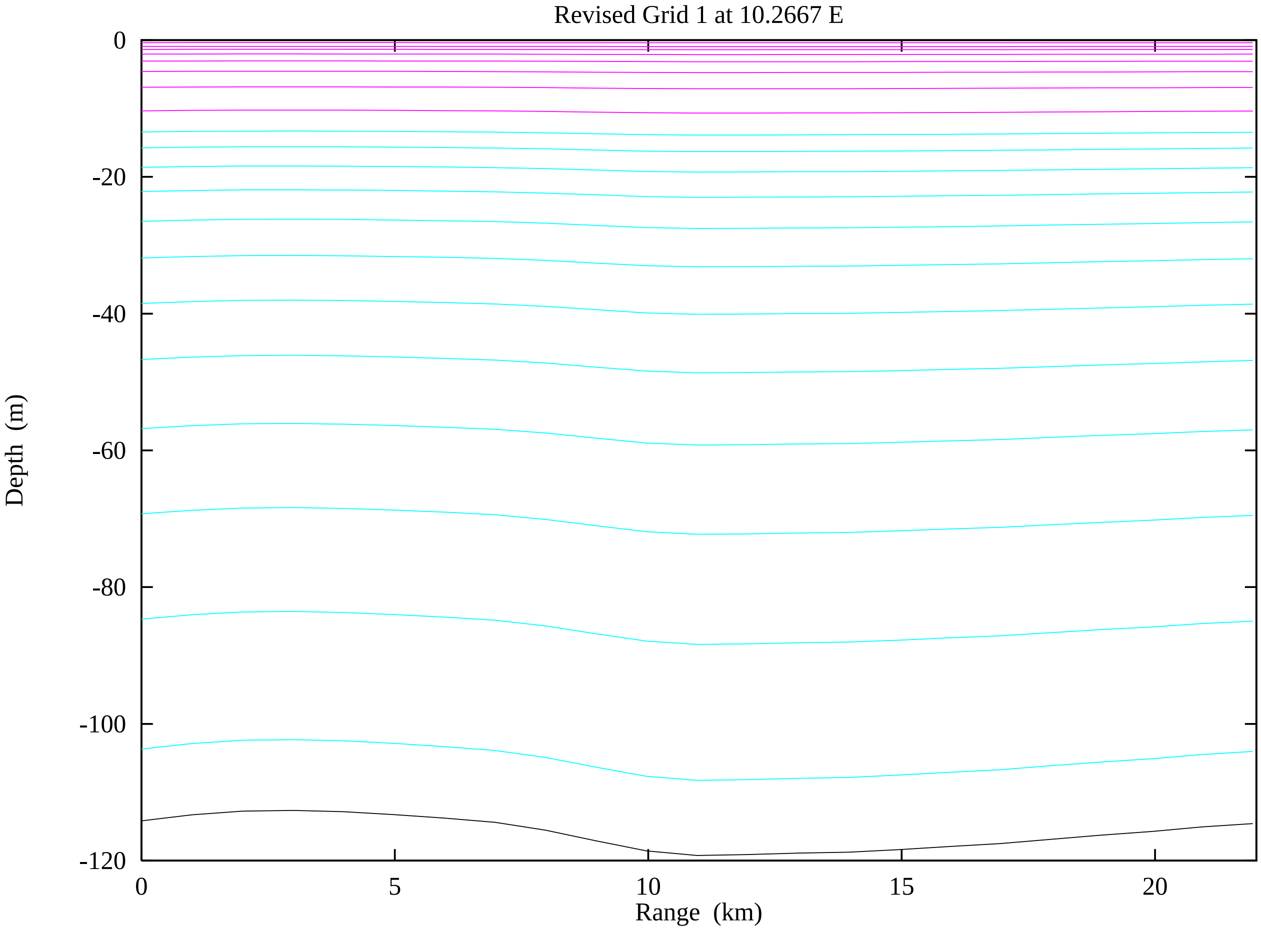

Revised Grid 1 at 10.0813 E
Depth (m)
0
-20
-40
-60
-80
-100
-120
-140
-160
0
5
10
15
20
Range (km)



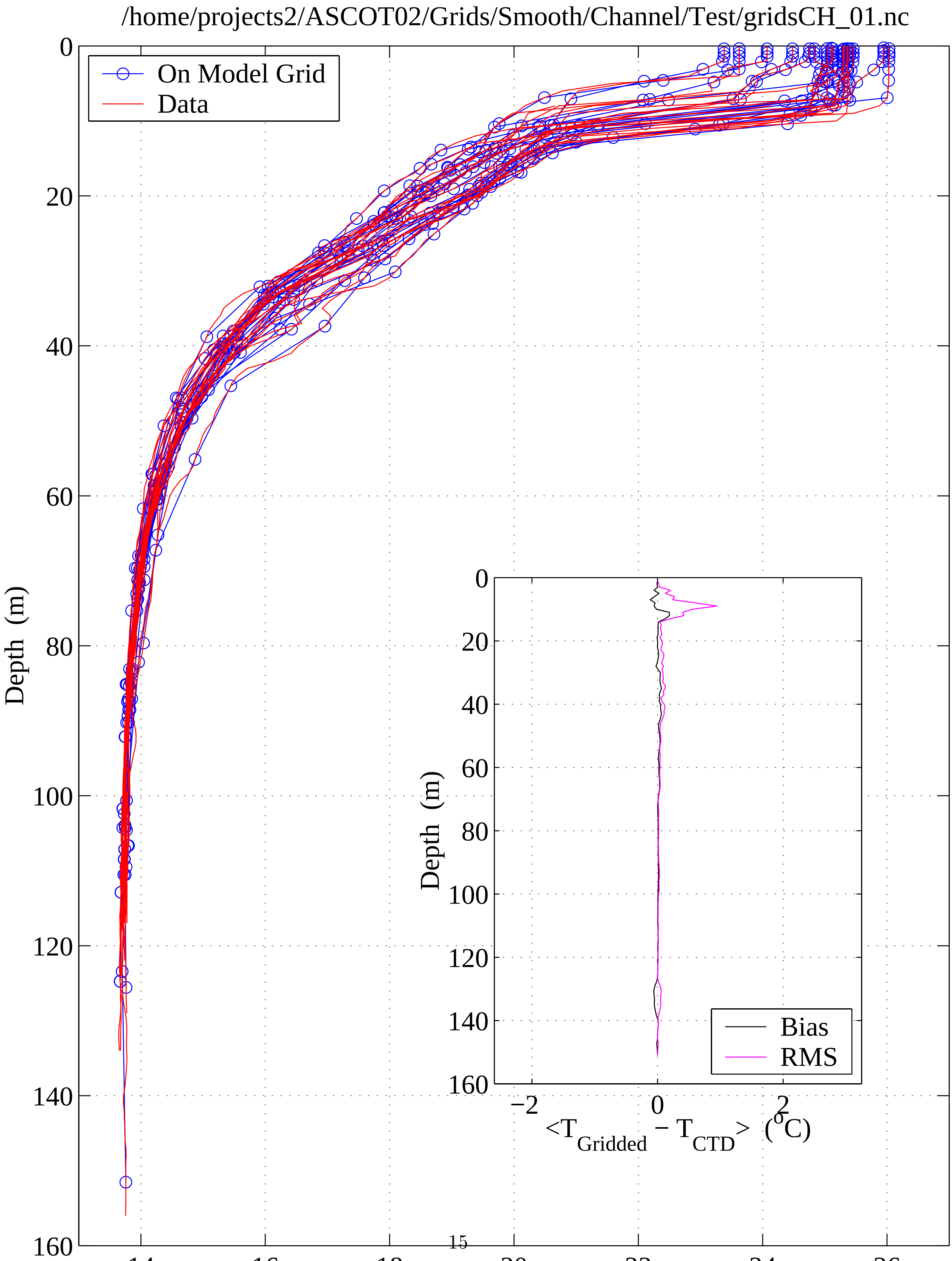
Revised Grid 1 at 10.1430 E
Depth (m)
0
-20
-40
-60
-80
-100
-120
Range (km)
0
5
10
15
20

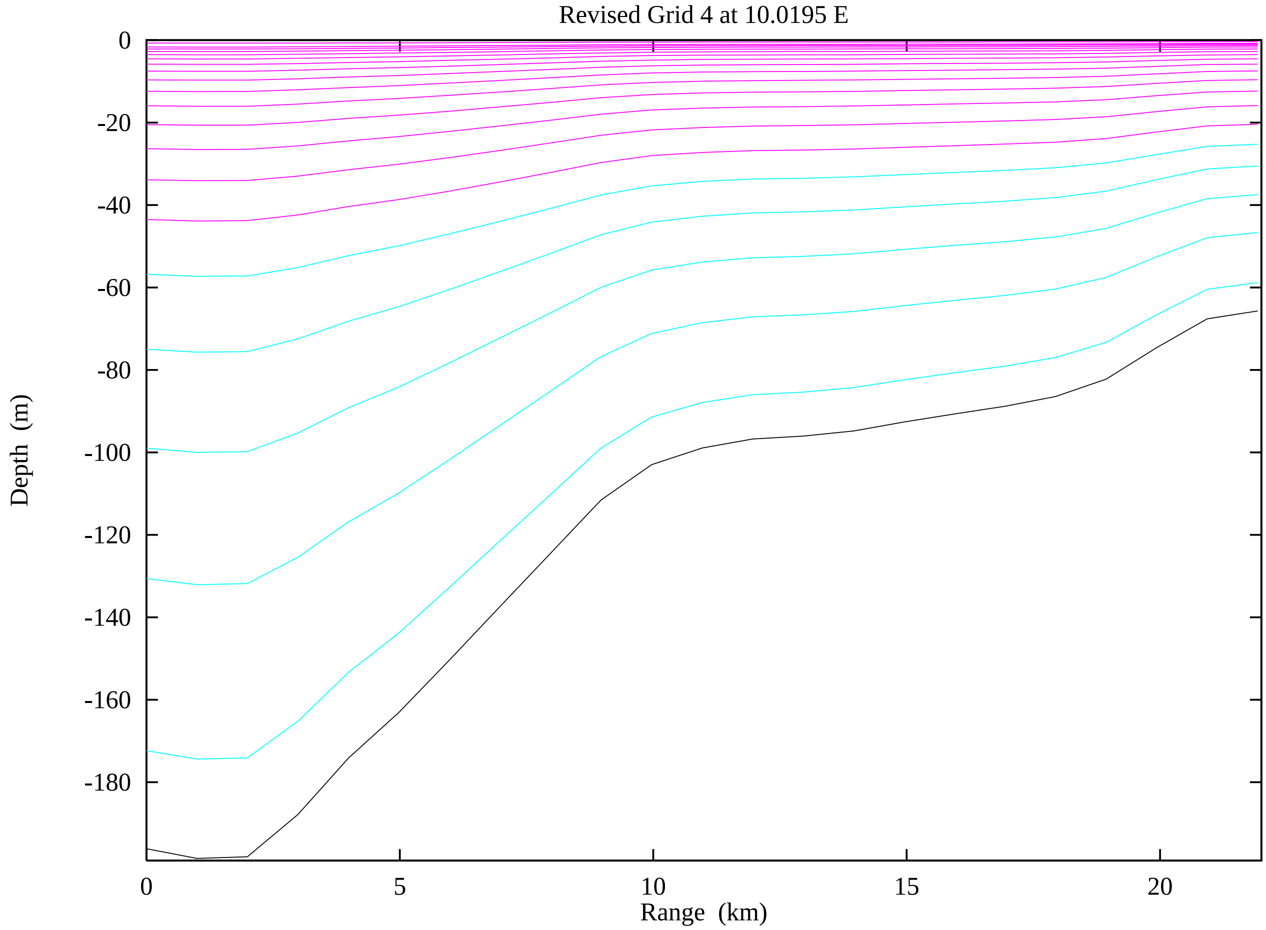


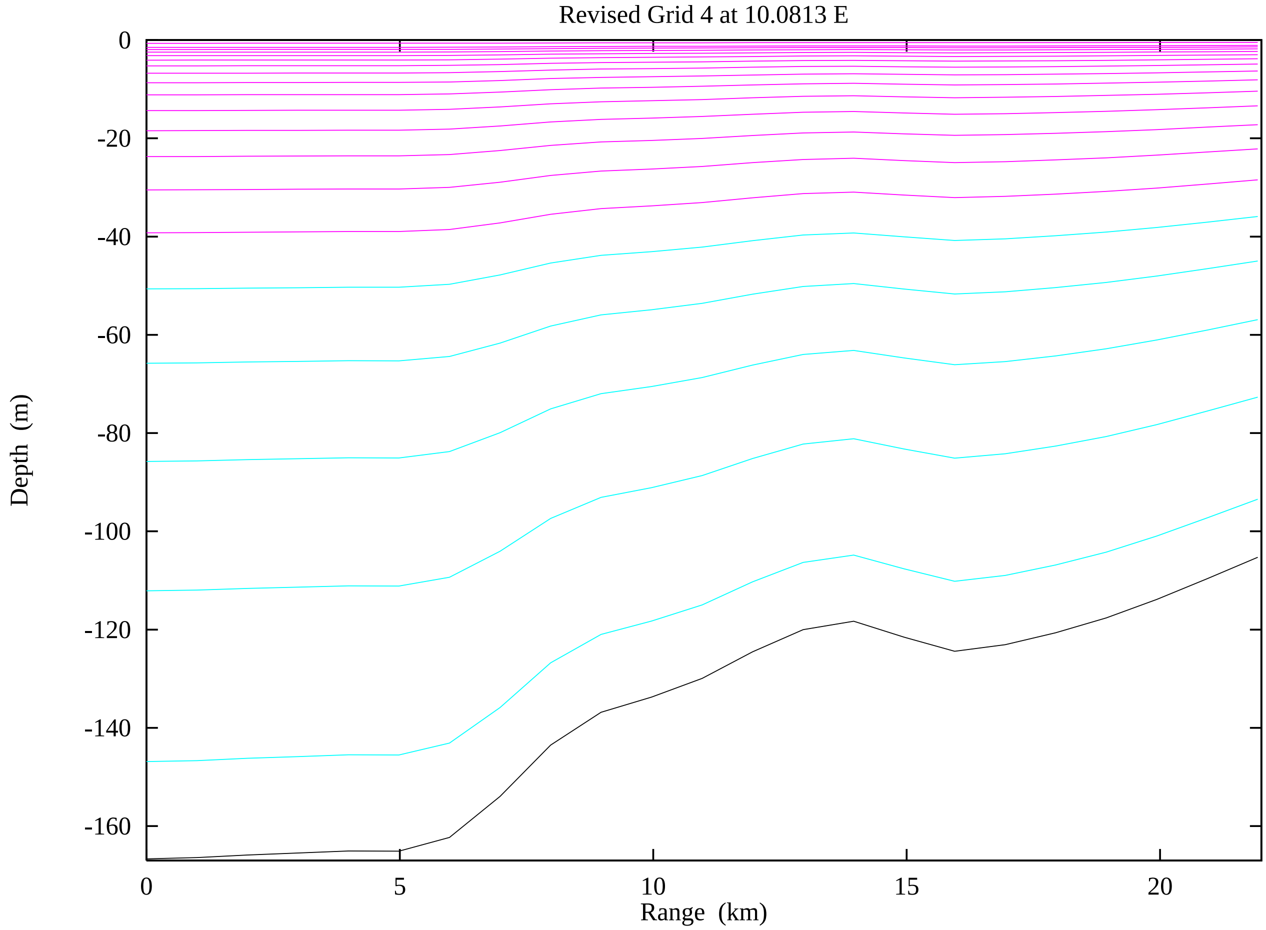
Revised Grid 1 at 10.2045 E
Depth (m)
0
-20
-40
-60
-80
-100
-120
Range (km)
0
5
10
15
20

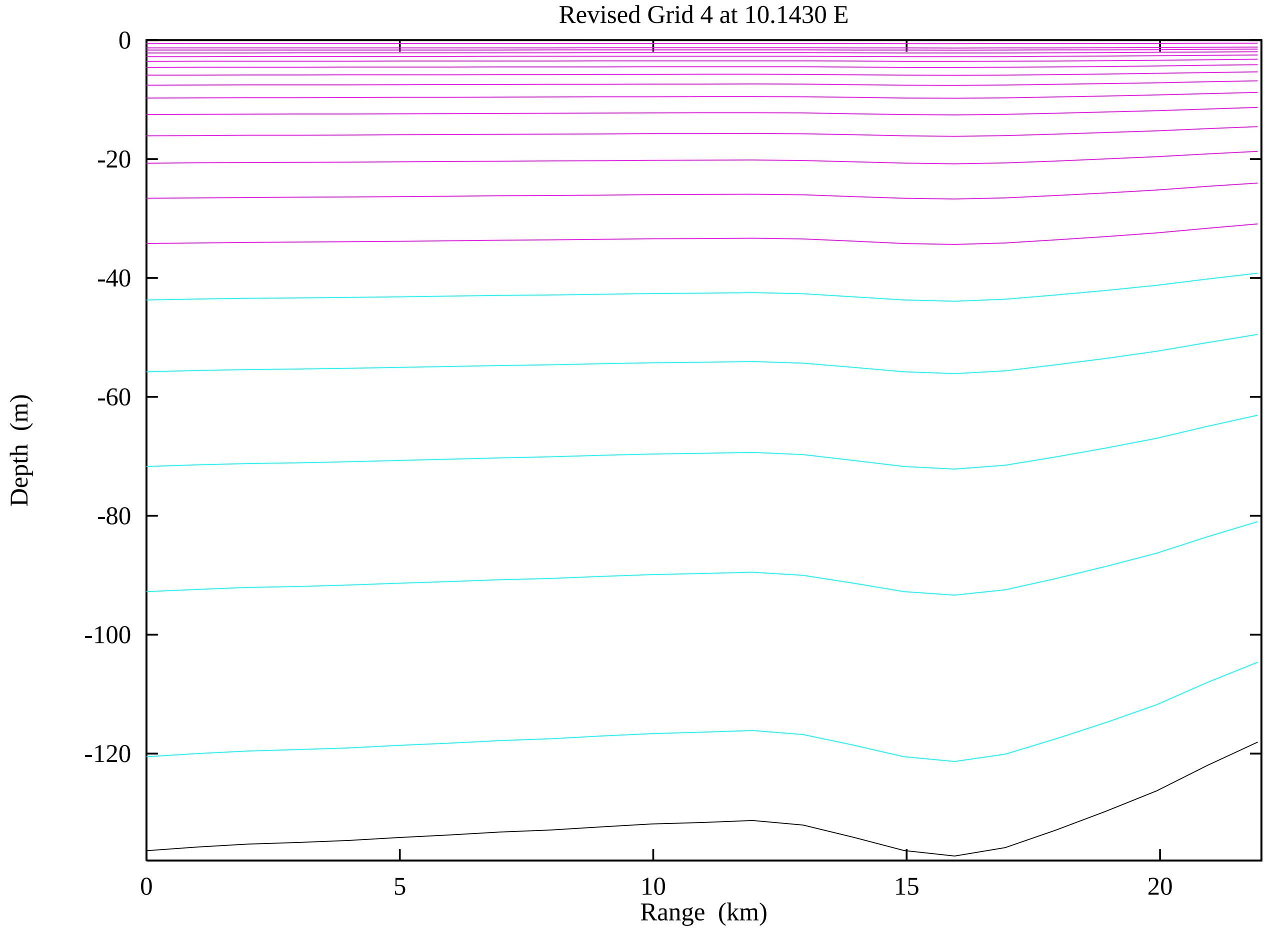

Revised Grid 1 at 10.2667 E
0
-20
-40
-60
-80
-100
-120
Depth (m)
0
5
10
15
20
Range (km)

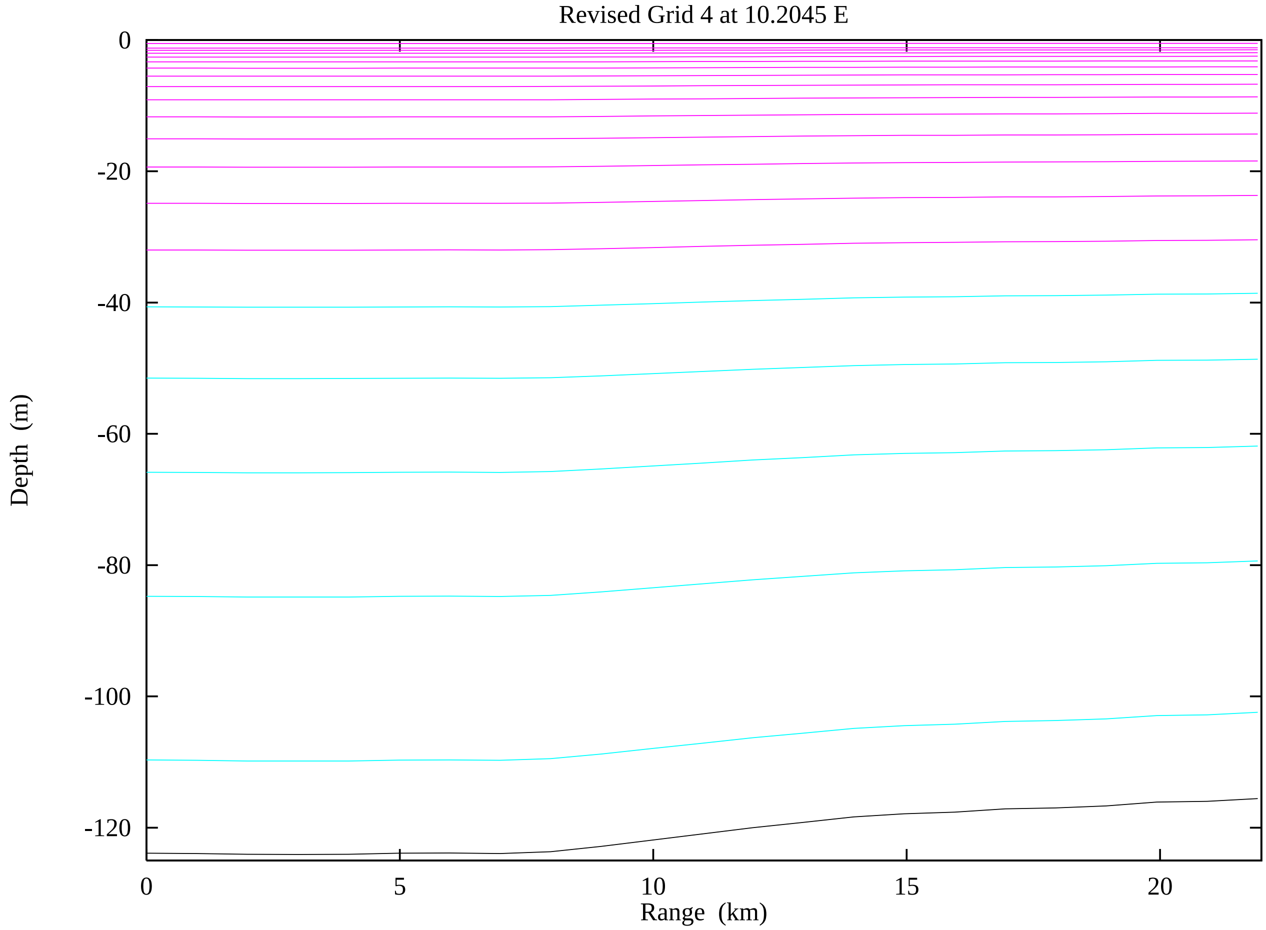
Revised vertical grid 1.

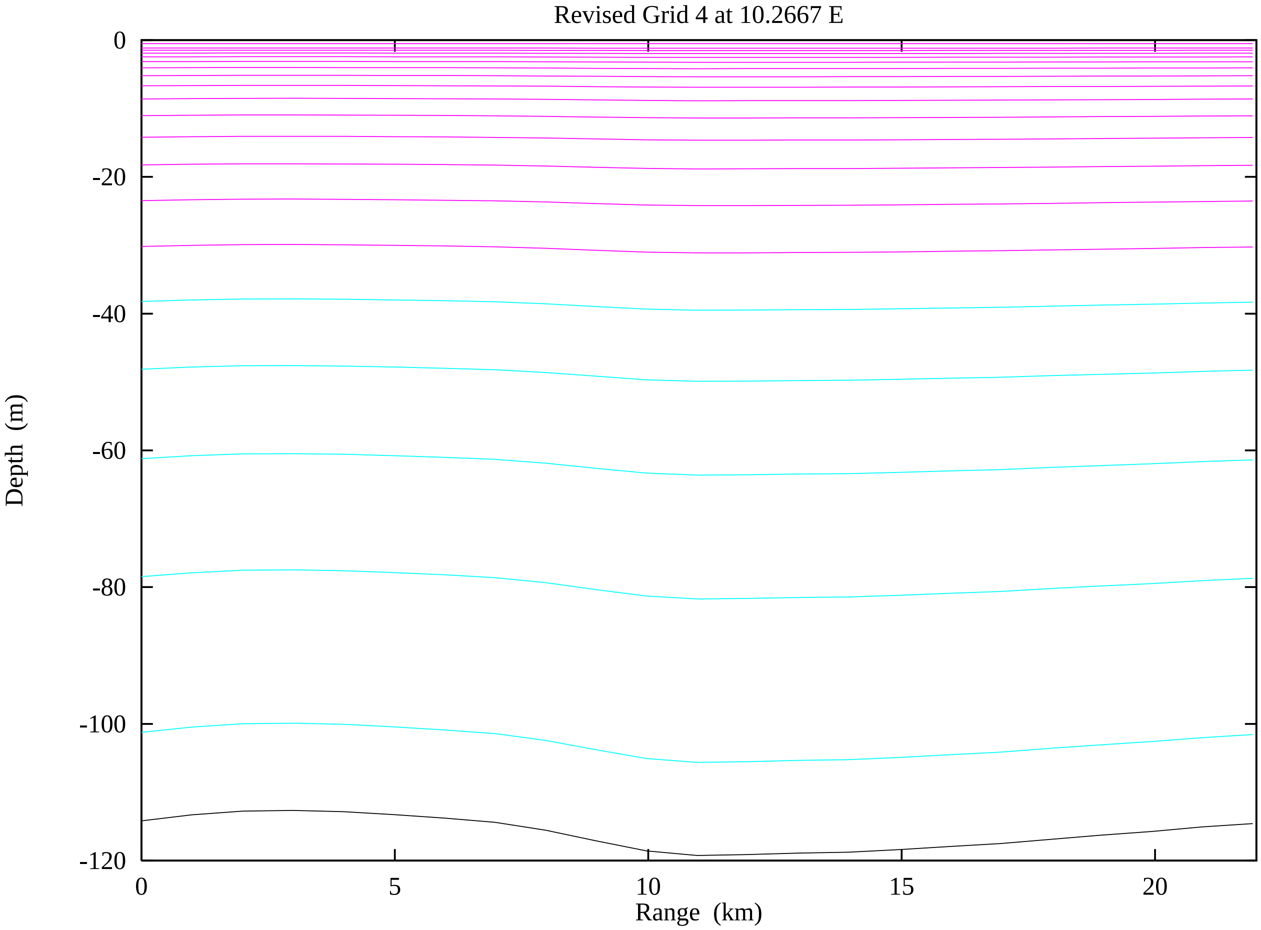



Revised Grid 4 at 10.0195 E
Depth (m)
Range (km)
0
-20
-40
-60
-80
-100
-120
-140
-160
-180
0
5
10
15
20


Revised Grid 4 at 10.0813 E
Depth (m)
Range (km)
0
-20
-40
-60
-80
-100
-120
-140
-160
0
5
10
15
20

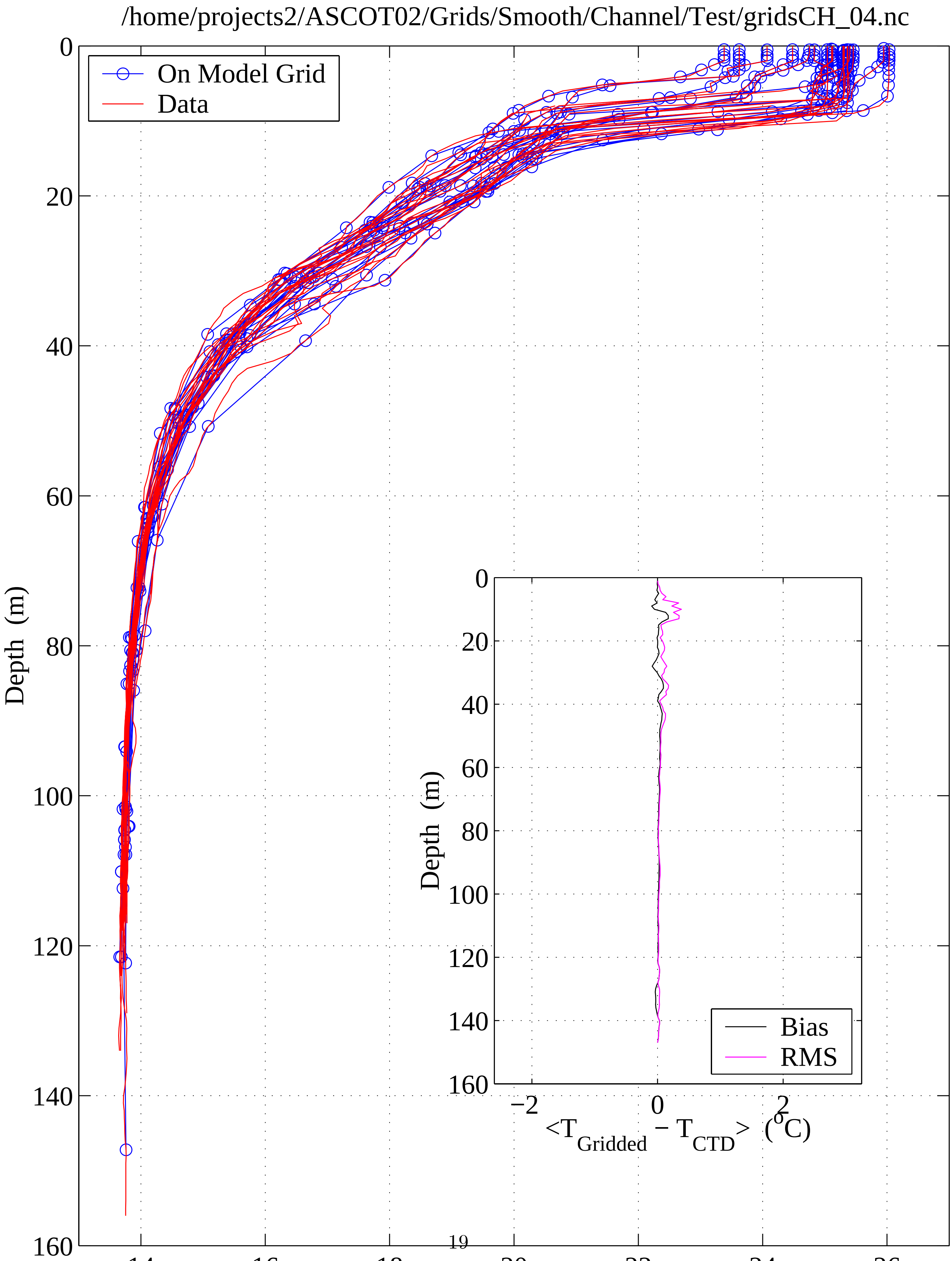

Revised Grid 4 at 10.1430 E
Depth (m)
0
-20
-40
-60
-80
-100
-120
Range (km)
0
5
10
15
20


Revised Grid 4 at 10.2045 E
Depth (m)
0
-20
-40
-60
-80
-100
-120
Range (km)
0
5
10
15
20



Revised Grid 4 at 10.2667 E
0
-20
-40
-60
-80
-100
-120
Depth (m)
0
5
10
15
20
Range (km)

Revised vertical grid 4.



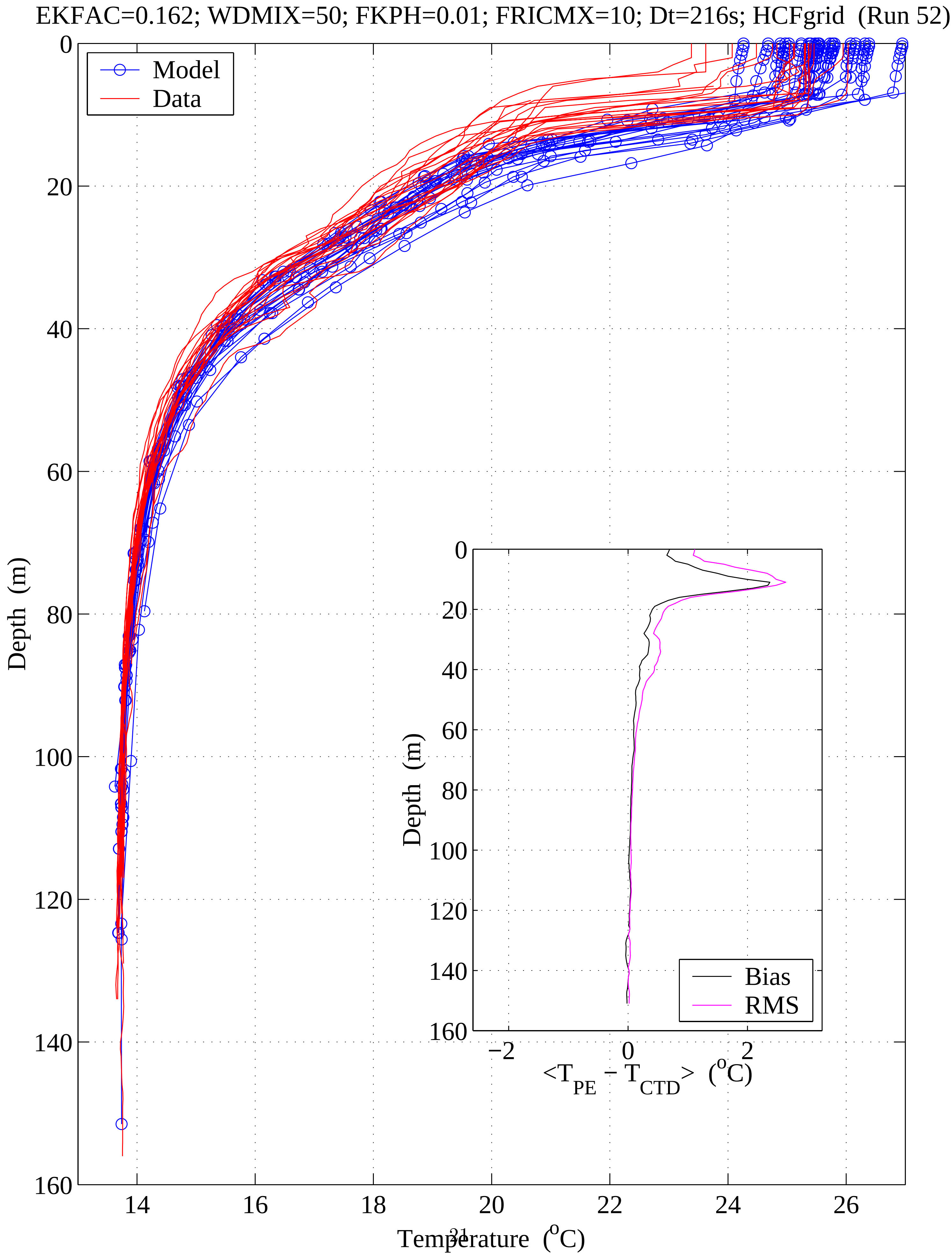
Set 2: Repeating a subset of set 1 on revised grid 1

PE run parameters

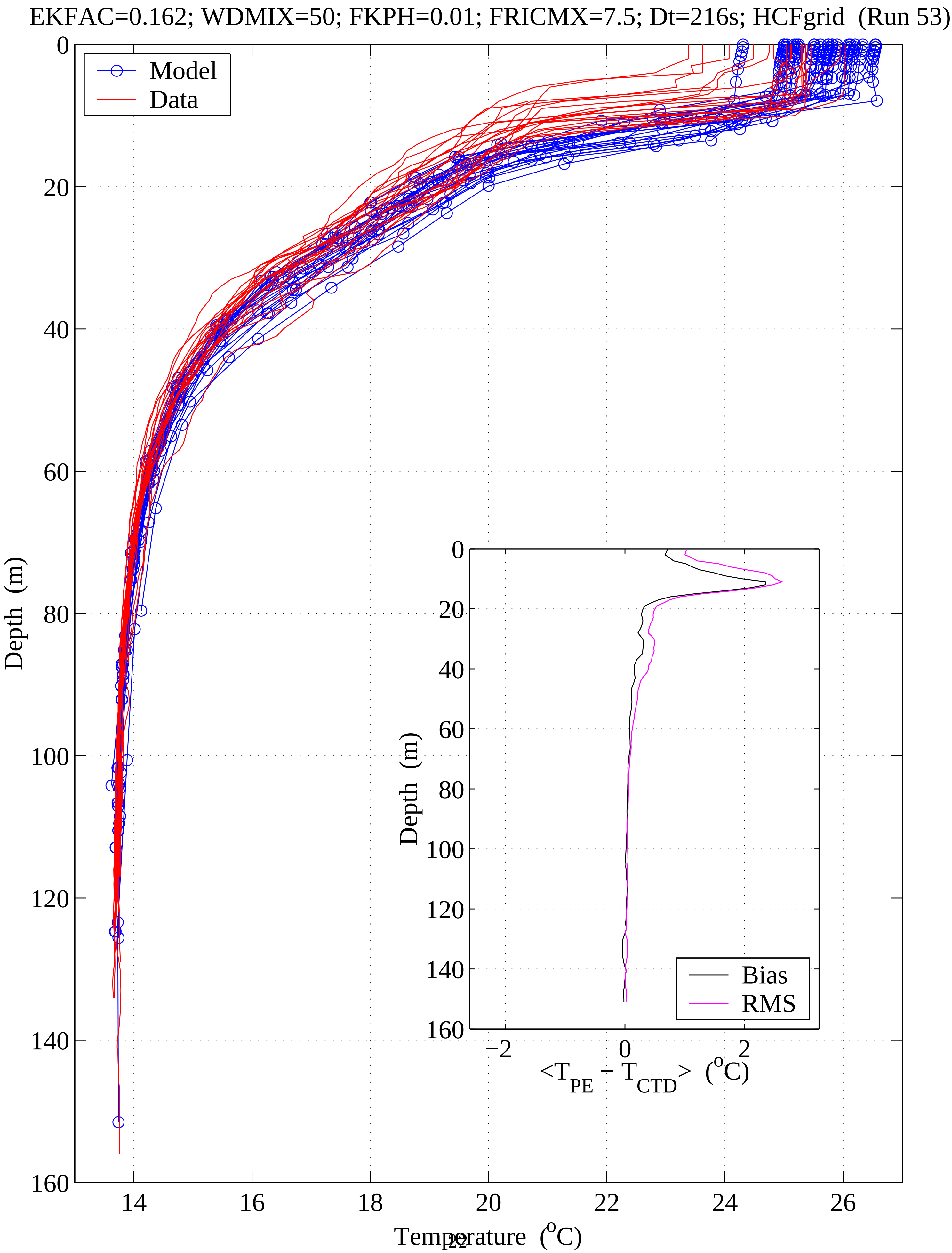
Run #	**EKFAC**	**WDMIX** cm^2/s	**WVMIX** cm^2/s	**FKPH** cm^2/s	**FRICMX** cm^2/s	**dt** s
52	0.162	50	50	0.01	10	216
53	0.162	50	50	0.01	7.5	216
54	0.216	5	25	0.05	10	216

The overall result is that improved surface resolution leads to an excess of heat in the near surface. A secondary observation is that the entire upper sigma system (first 8 levels) is largely in the upper mixed layer.

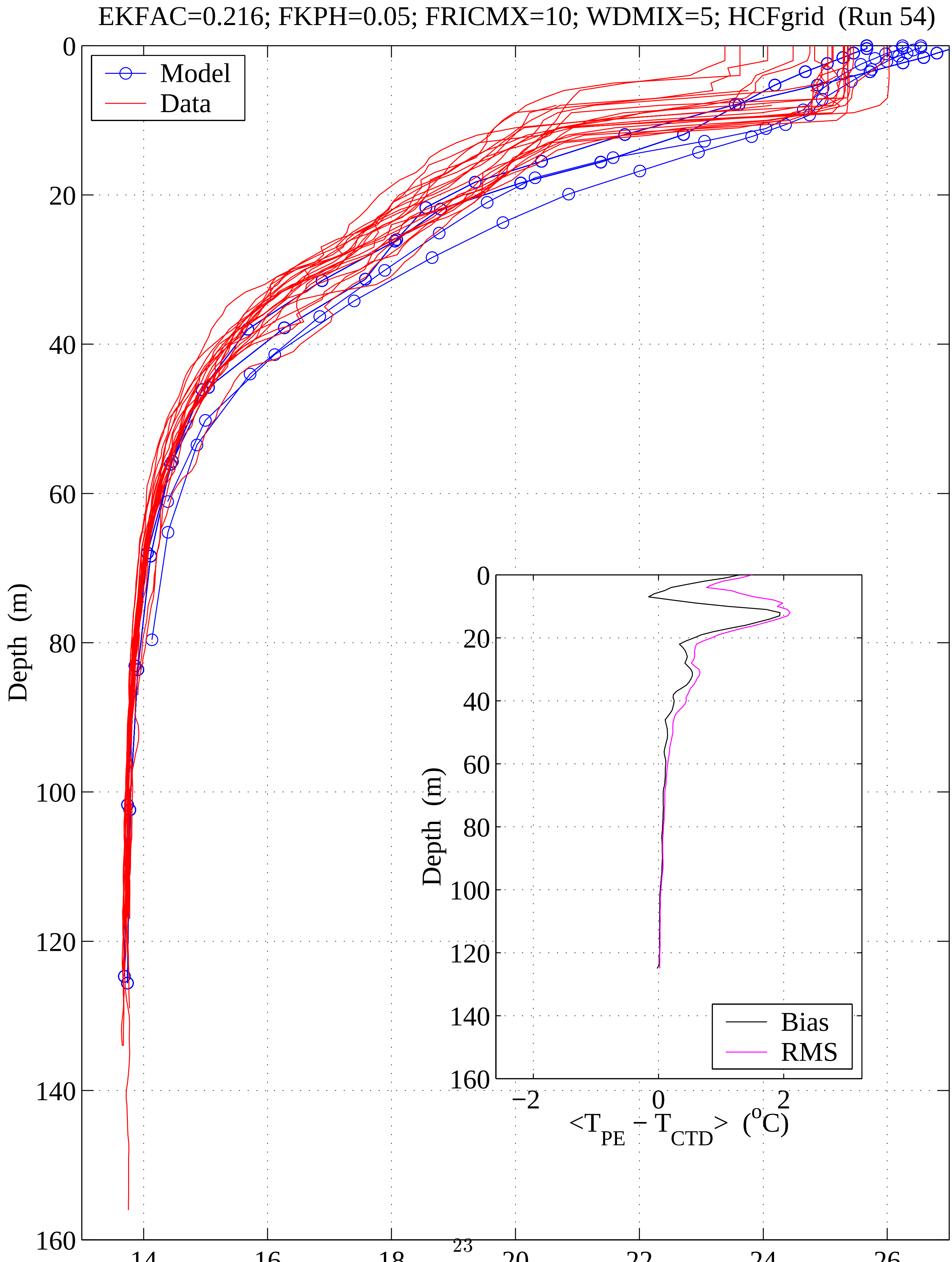
Run 52: run 49 on revised grid 1.



Run 53: run 52 w/ weaker maximal Pacanowski–Philander mixing.



Run 54: run 45 on revised grid 1.



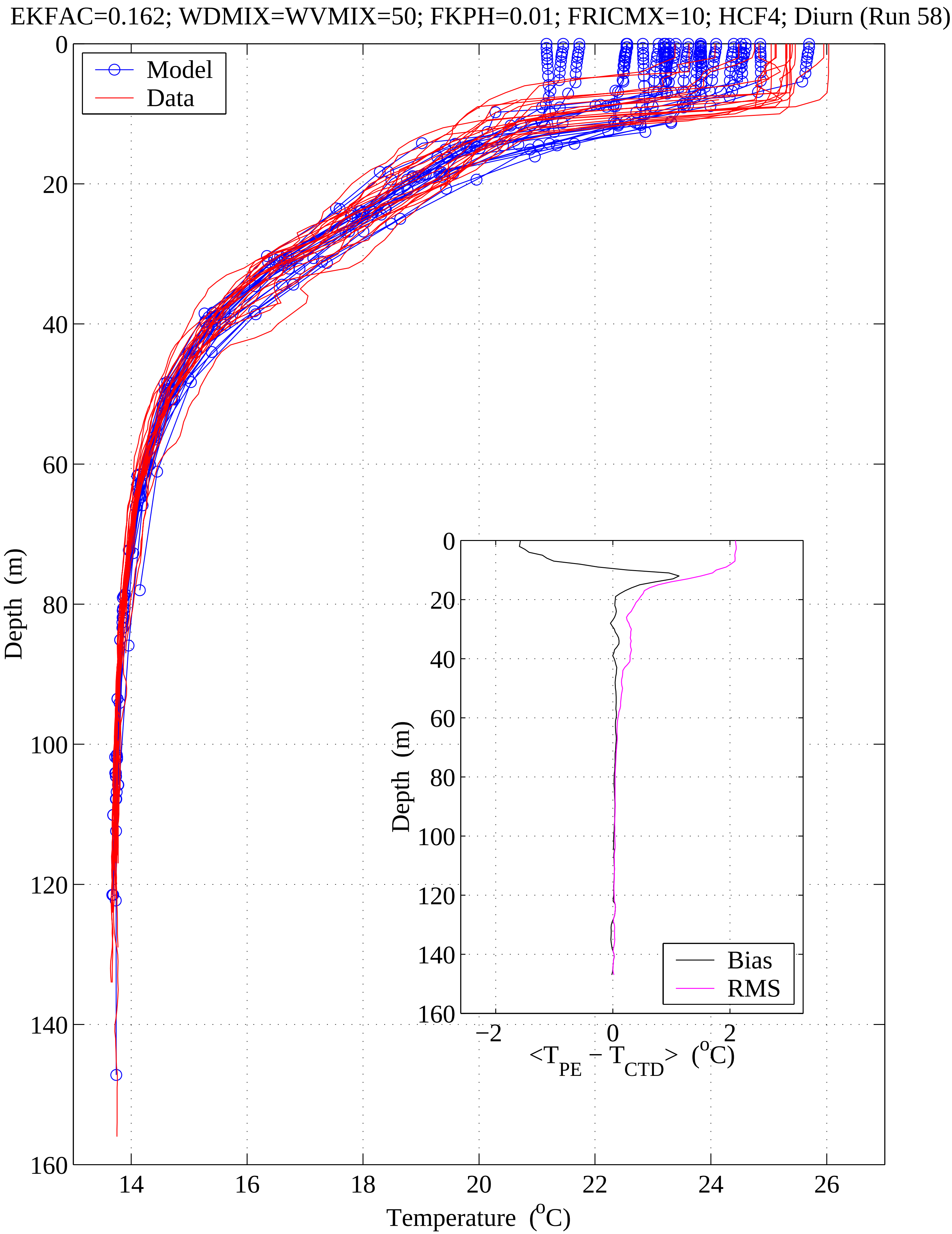
Set 3: Repeating set 2 on revised grid 4, with diurnal forcing

PE run parameters

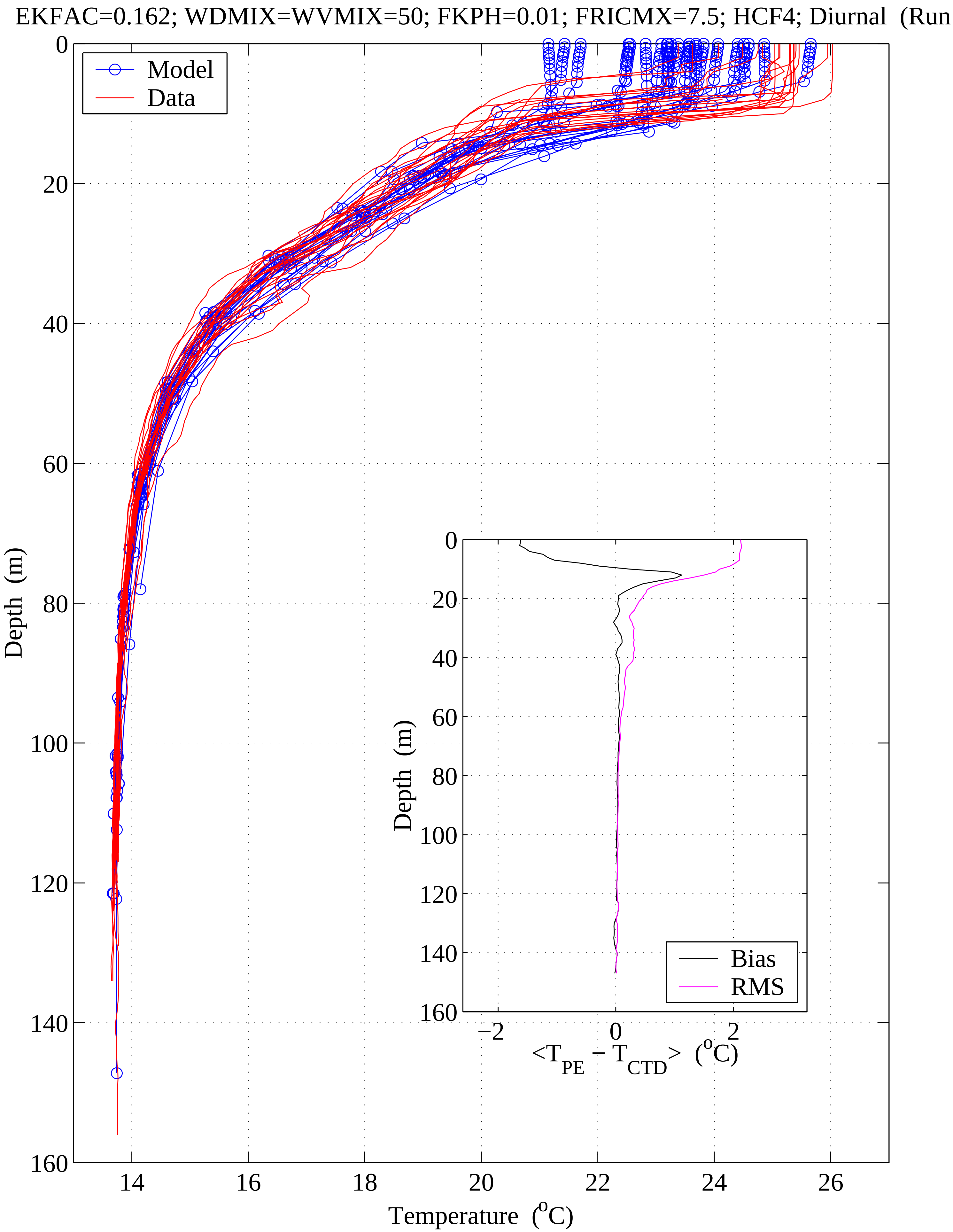
Run #	**EKFAC**	**WDMIX** cm^2/s	**WVMIX** cm^2/s	**FKPH** cm^2/s	**FRICMX** cm^2/s	**dt** s
58	0.162	50	50	0.01	10	216
59	0.162	50	50	0.01	7.5	216
60	0.216	5	25	0.05	10	216
61	0.095	50	50	0.01	7.5	216

The original thought was perhaps the timing of the daily heating/cooling mattered for matching the near surface temperature. The biggest effect turned out to be that the daily averaged forcings in the previous runs were too large. Putting the correct forcings now leads to a surface temperature deficit.

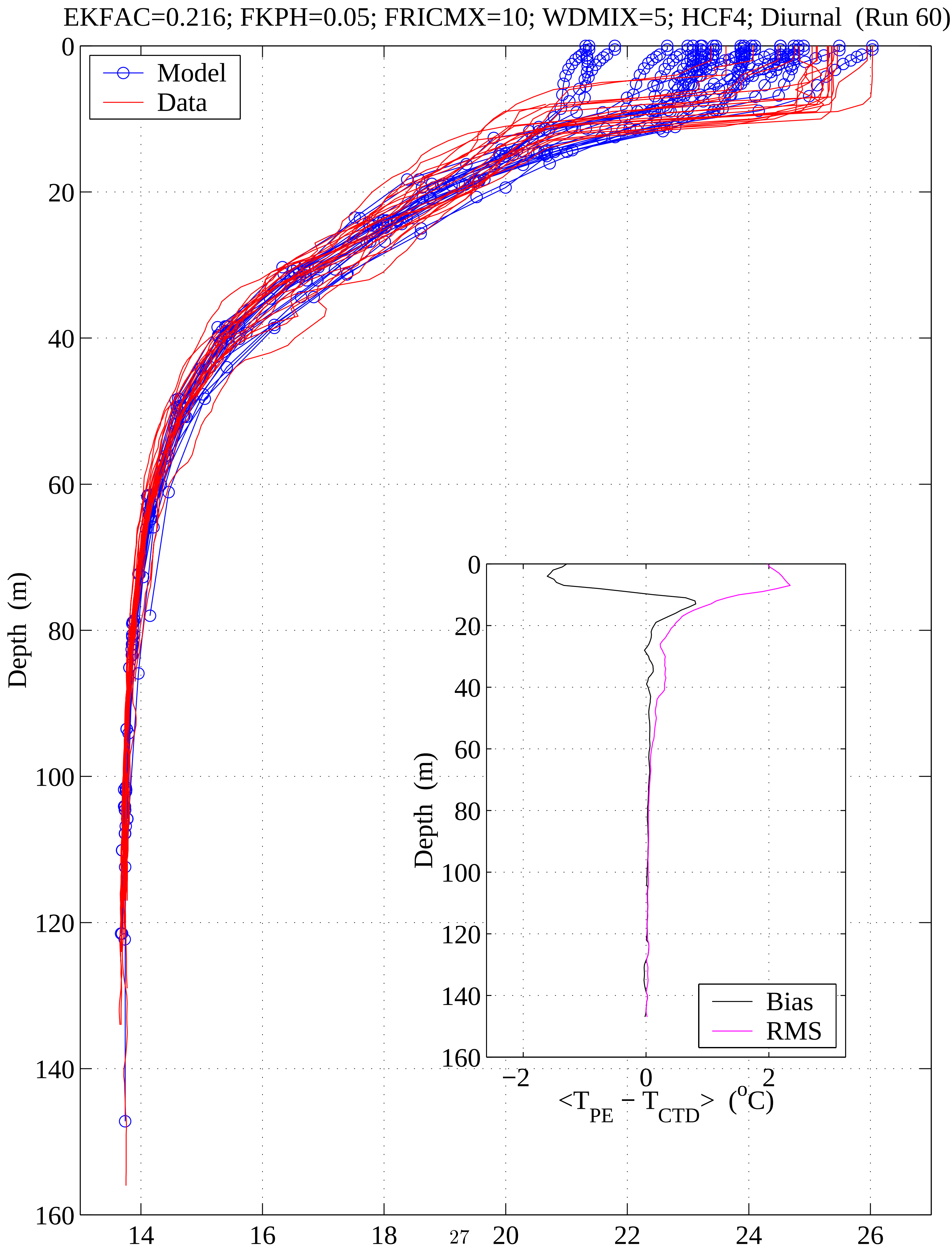
Run 58: run 52 w/ diurnal heating, on revised grid 4.



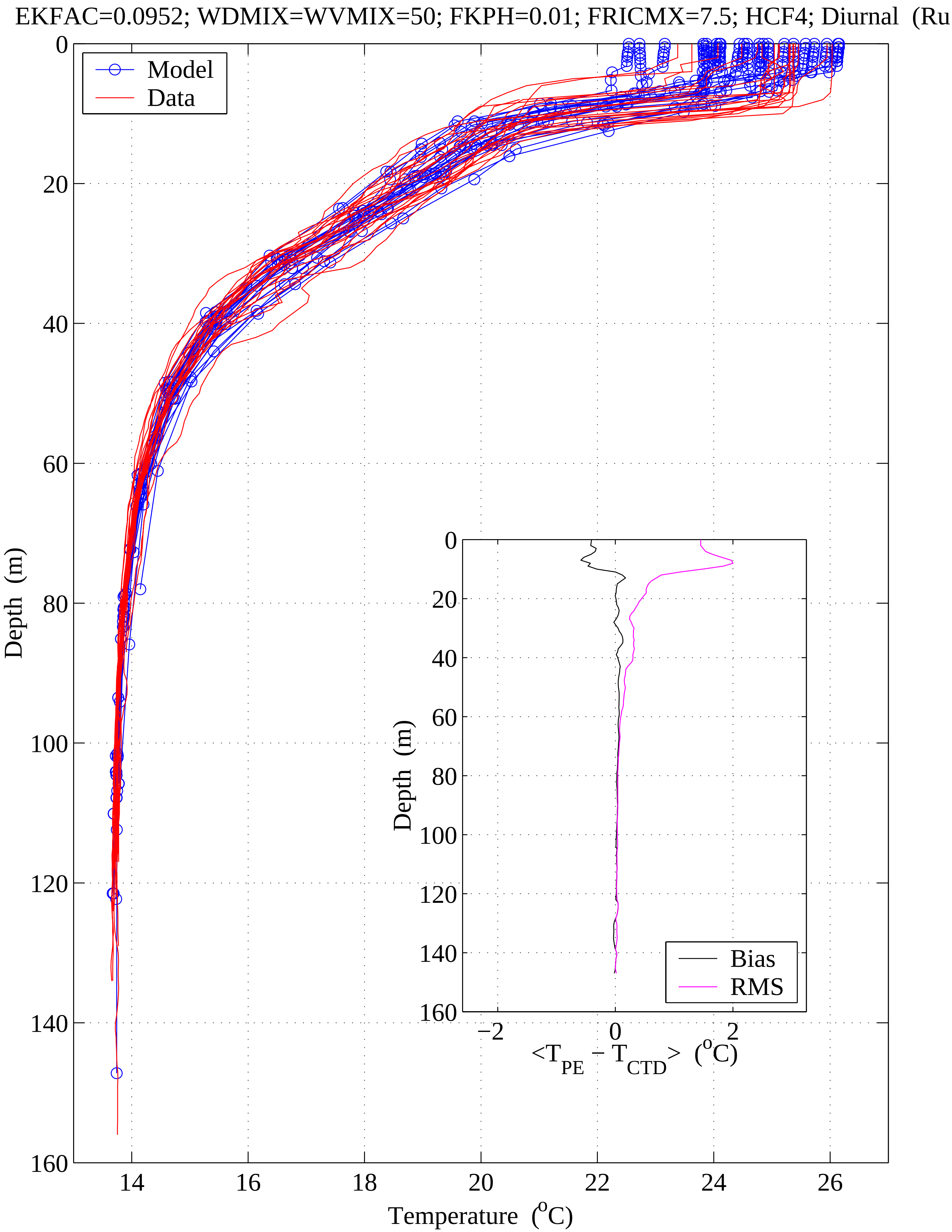
Run 59: run 53 w/ diurnal heating, on revised grid 4.



Run 60: run 54 w/ diurnal heating, on revised grid 4.



Run 61: 59 w/ smaller Ekmann constant.

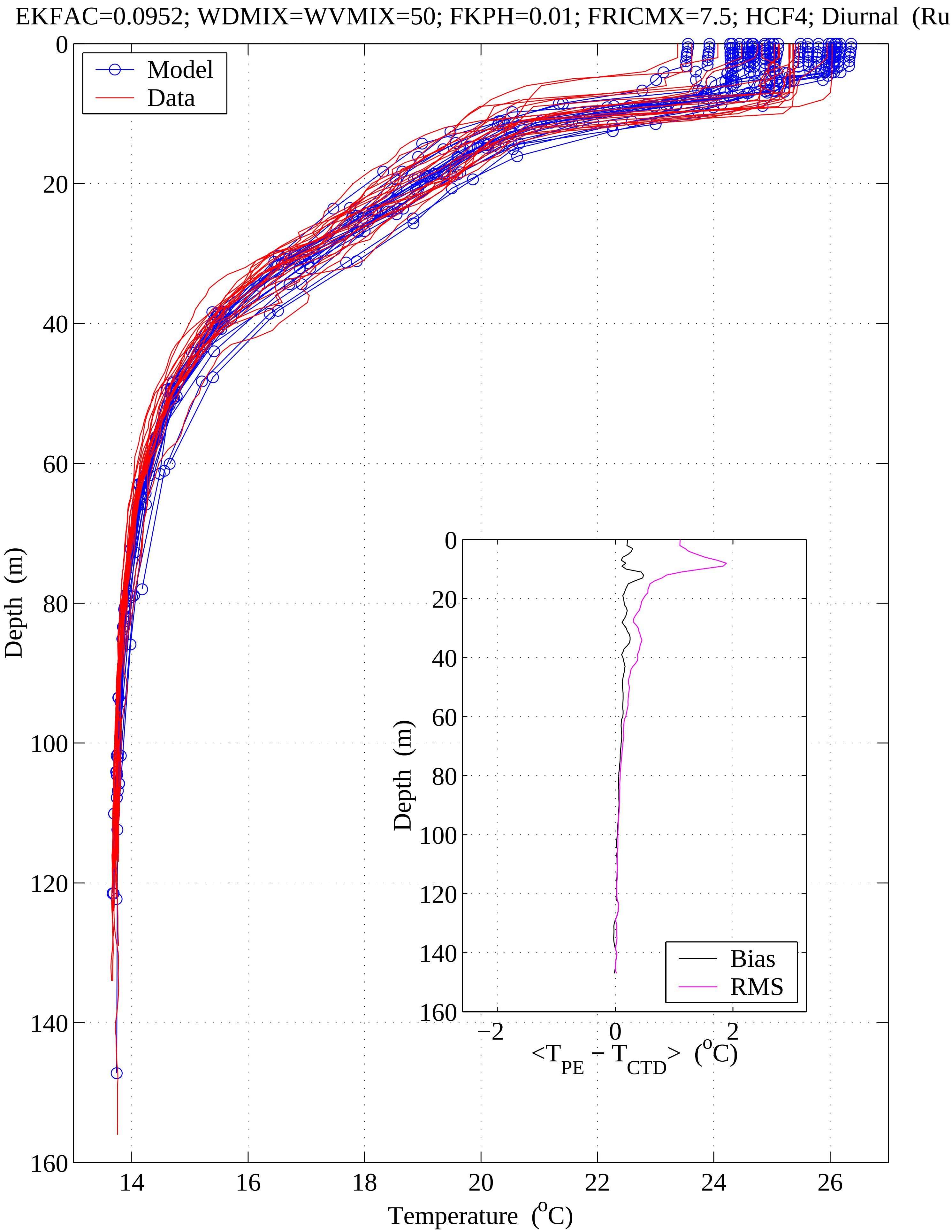


Set 4: Initial conditions at sampling time

To correct for the temperature deficit in the previous set, more time is allowed for heating. For this series, the model is forced with ALADIN winds and FNMOC heat & E-P in the period May 28 - June 20. With the simulation started back earlier, additional assimilation is done. Alliance CTD data was assimilated on every have day from 1200z May 28 – 0000z June 1 (ramped T-0.25, T-0.125 and T with weights of 0.33, 0.66 and 0.99 respectively). Similar rampings are performed for 1200z June 4, 0000z June 5, 1200z June 6, 0000z June 7 and 0000z June 9. Then data is assimilated every quarter day from June 12 1200z through June 17 0600z (ramped T-0.125, T-0.0625 and T with weights of 0.33, 0.66 and 0.99 respectively).

Run 63 shows the profiles extracted from the described simulation. Run 64 shows the profiles extracted at the nearest model time steps in a run in which all assimilation stops at 1800z June 14. The tendency is for a the surface layer to be too thin and warm.

Run 63: 61 w/ ICs at sampling time.



Run 65: run 63 with all assimilation stopped before sampling.