CERFACS

GSSPOS and BSSPOS options for the global conservation in OASIS3-MCT

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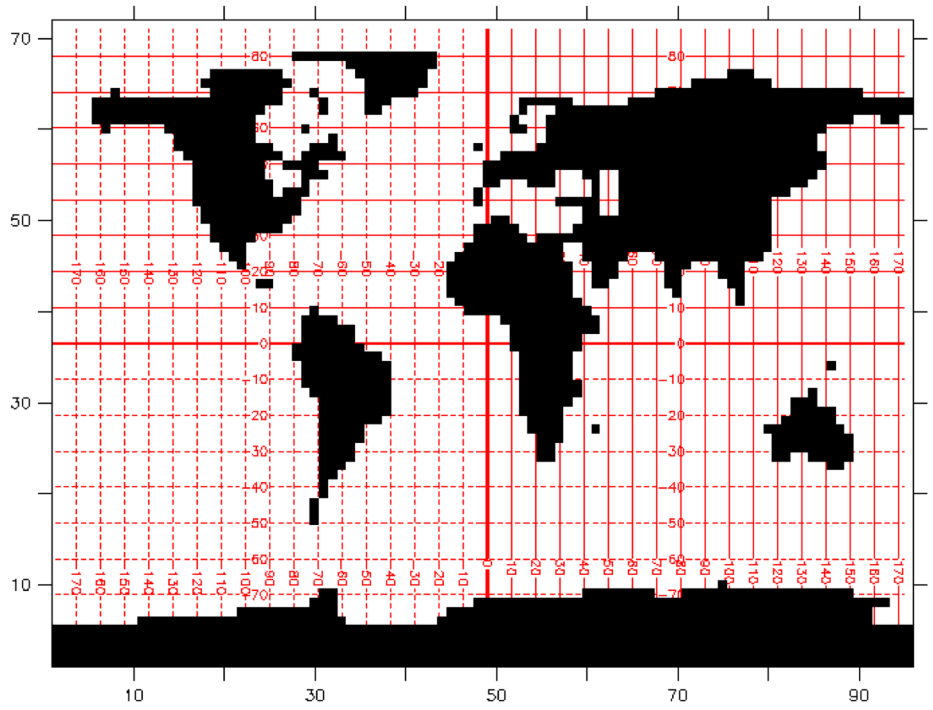
OASIS3-MCT CONSERV tests

- Use OASIS3-MCT_4.0 plus, October, 2019.
- Demonstrate Oasis3-MCT CONSERV capabilities and shortcomings with some challenging problems
- Interpolate between two grids,
  - torc (182x149 tripole grid)
  - lmdz (96x72 lon/lat grid)
  - both directions
  - field is on the ocean non-masked grid points
  - ocean-land masks do NOT match on source and target grids (~10% different in active area)
  - no partial gridcell fractions used
- Use bilinear weights for interpolation
  - Can introduce aliasing in some high gradient cases
  - Conservative interpolation is generally better than bilinear+CONSERV if conservation is important

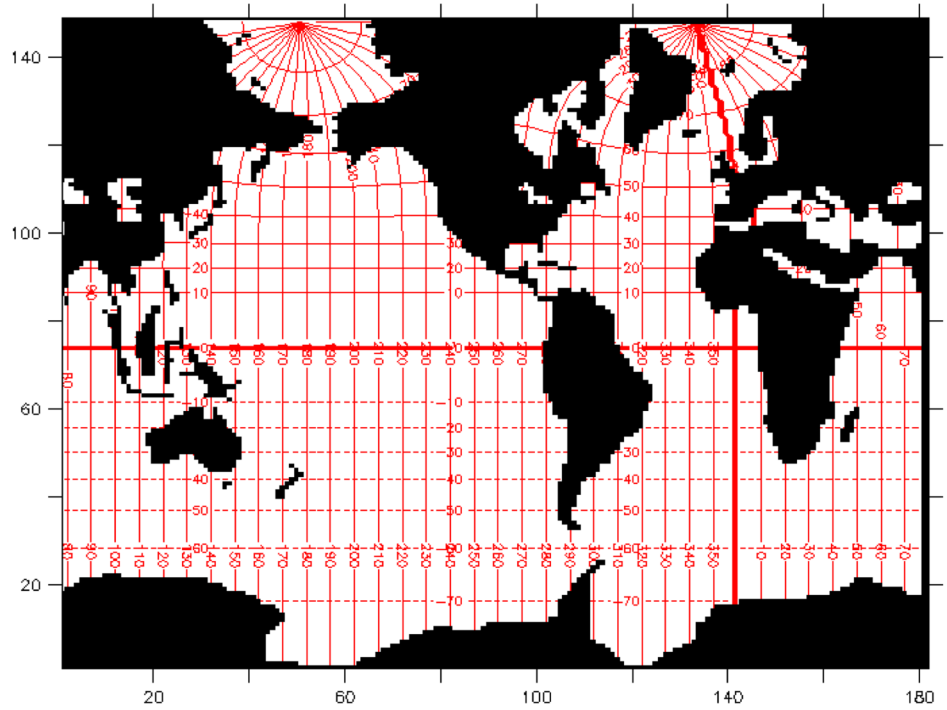
Conclusions and Recommendations

- The success of the CONSERV operation in conjunction with mapping depends on
  - the relative mean value of the field, if it is not well posed (ie. close to zero) CONSERV options can introduce problems
  - the gradients in the source field
  - the sizes of the masked areas in the two grids
  - the relative resolution of the two grids
  - the quality of the mapping weights
- There is no single option that works for all types of fields and interpolation. The user must be aware of the computational issues and choose appropriate methods
- Use of conservative mapping weights will conserve locally and can be a better option than bilinear mapping plus CONSERV.
- Consistent masks and fractions between two grids (which is not the case in this study) tends to minimize global corrections for conservation.
- In general, only fluxes should be conserved.

Two grids



lmdz (96x72), lon/lat
area is 393 million km^2



torc (182x149), tripole
area is 358 million km^2

CONSERV calculation

- Six options, GLOBAL, GLBPOS, GSSPOS, BASBAL, BASPOS, BSSPOS
- General sum calculation computes sum(field*area*mask) over the domain.
- Compares the global sum on the source field and the global sum on mapped destination field. Then a global scalar additive or multiplicative correction is applied to the destination field to conserve.
- The G* CONSERV operations conserve the global sum as defined above.
- The B* CONSERV operations take into account the fact that the two grids may not have the same active areas. With the B* operations the destination field is further corrected by the sum(area*mask) on the source and destination grids such that the field is more likely to be preserved. In this case, the total global sum will not be preserved.
- The GSSPOS and BSSPOS CONSERV operations operate the same as GLBPOS and BASPOS, but the positive and negative values of the source and destination field are treated independently. This should improve the field preserving properties for fields that are not well posed. This requires many extra global sum computations compared to the other options, so is generally more expensive. For cases that are same-signed across the entire domain, results from the GSSPOS and BSSPOS CONSERV operations are identical to the GLBPOS and BASPOS results.

Six CONSERV options

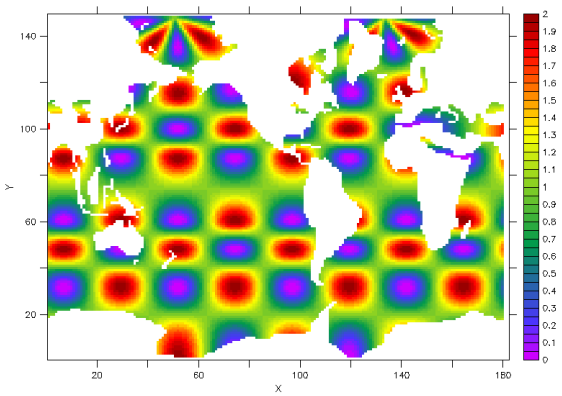
Name	Conservation Properties	Correction Type	Application
GLOBAL	global sum	additive	global scalar
GLBPOS	global sum	multiplicative	global scalar
GSSPOS	global sum	multiplicative	positive/negative scalar computed
BASBAL	area corrected global sum	additive	global scalar
BASPOS	area corrected global sum	multiplicative	global scalar
BSSPOS	area corrected global sum	multiplicative	positive/negative scalar computed

Eight Test Fields

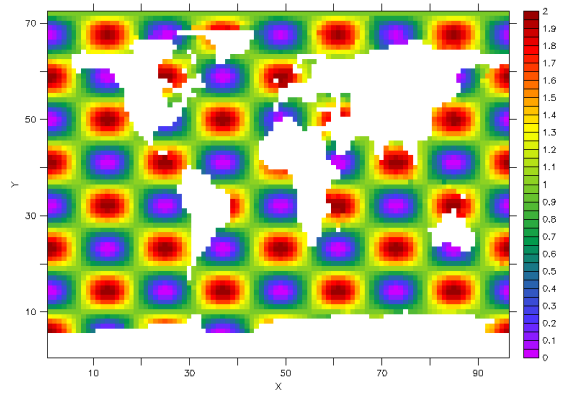
1. moderate frequency sin/cos field with min/max values of [0,2], well behaved
2. low frequency sin/cos field with min/max values of [-1,1], mean value near zero.
3. higher frequency sin/cos field with min/max values of [-1,1], mean value near zero.
4. broad latitude dependent constant values of -1 and 1. mean value near zero.
5. high frequency gridcell scale constant values of -1 and 1. mean value near zero.
6. high gradient blocked pattern with min/max values of [-3.2, 3.2]. mean value near zero.
7. constant field of value zero.
8. constant field of non-zero value.

Fine -> Coarse Mapping

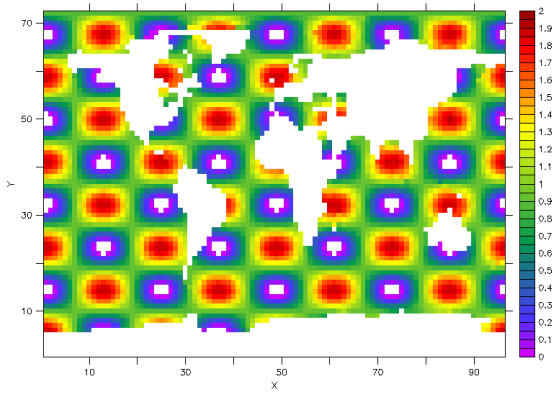
- torc (182 x 149) -> lmdz (96 x 72)
- Plots show the original field (upper left), the interpolated field (left center), and then the interpolated field modified by 6 CONSERV options. All eight plots on a given page have identical color bars. The CONSERV method and scaling constant are shown below the plot. For GLOBAL and BASBAL, the scaling constant will be an additive value (of sign + or -). For the other CONSERV options, the scaling constant will be one multiplicative value (GLBPOS, BASPOS), or two multiplicative values, one for the positive part of the field and another one for the negative part (GSSPOS, BSSPOS) .



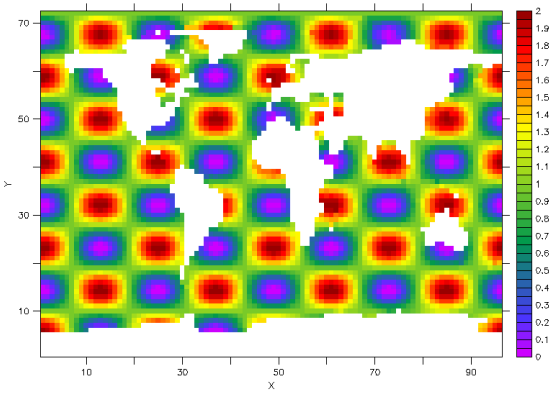
Interpolate



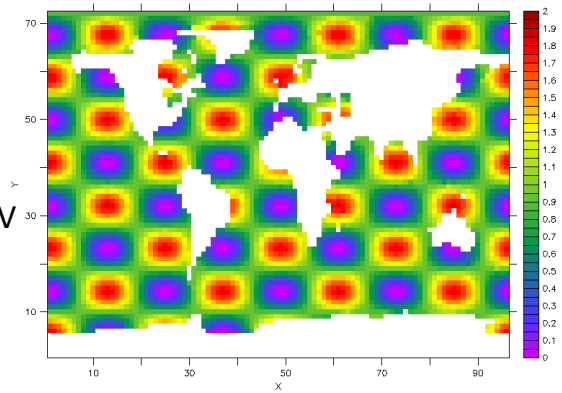
CONSERV



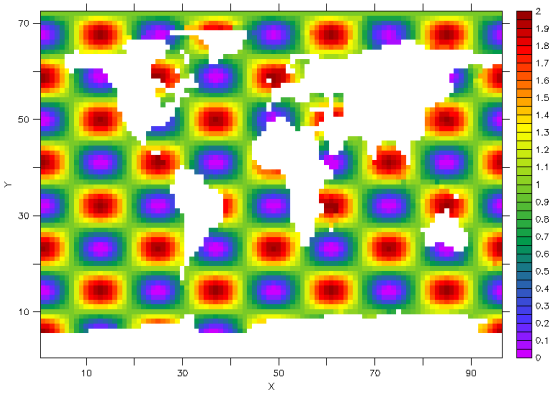
GLOBAL -0.0957



BASBAL -0.00568

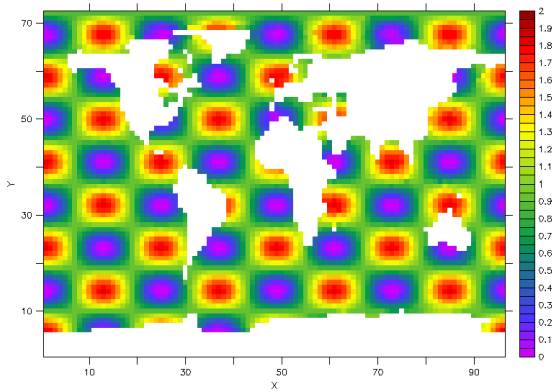


GLBPOS *0.905

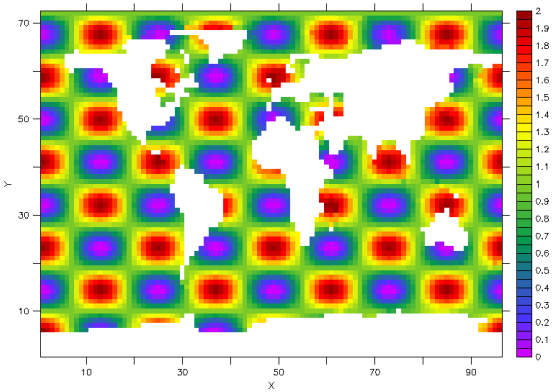


BASPOS *0.994

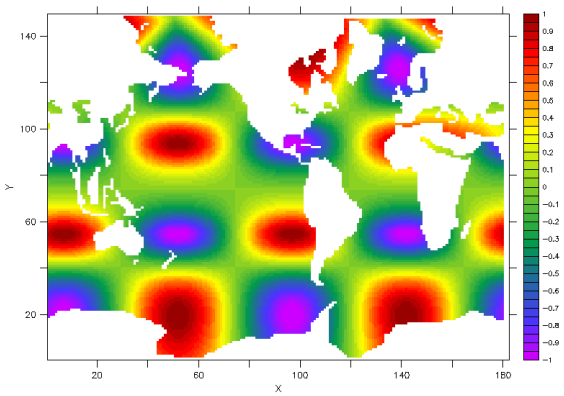
field 1, positive definite, well-posed
Since the field is all the same sign,
the GSSPOS==GLBPOS and
BSSPOS==BASPOS



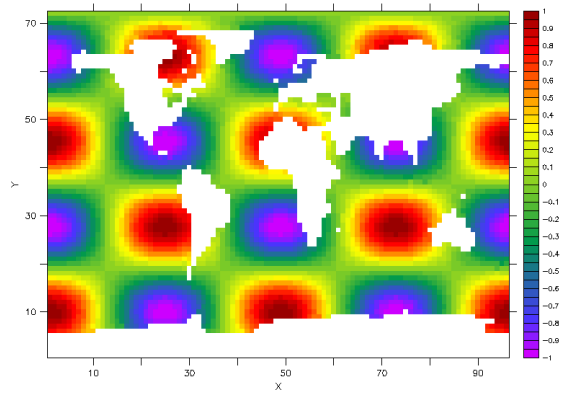
GSSPOS *0.905, -



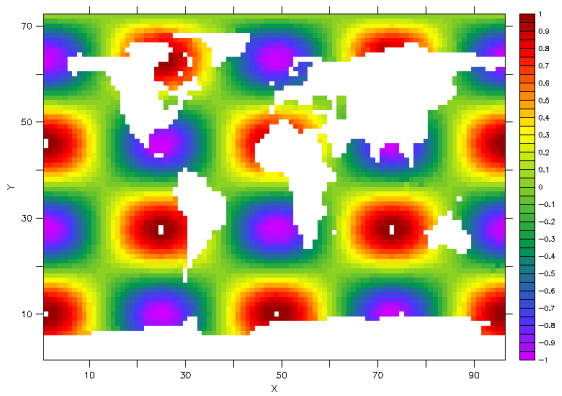
BSSPOS *0.994, -



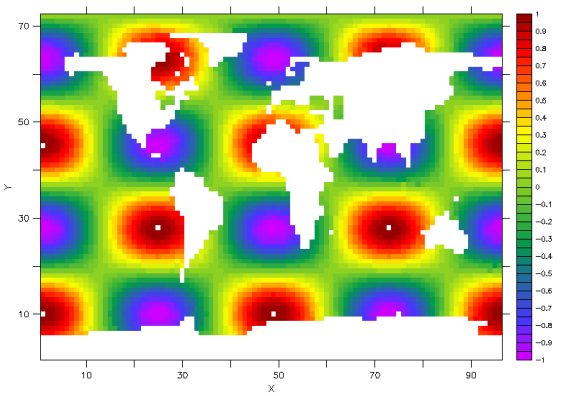
Interpolate



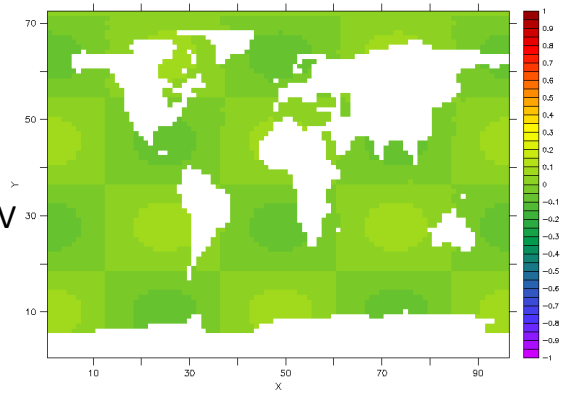
CONSERV



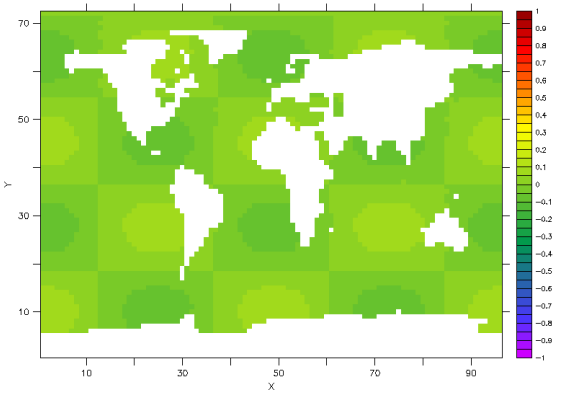
GLOBAL +0.00812



BASBAL +0.00805

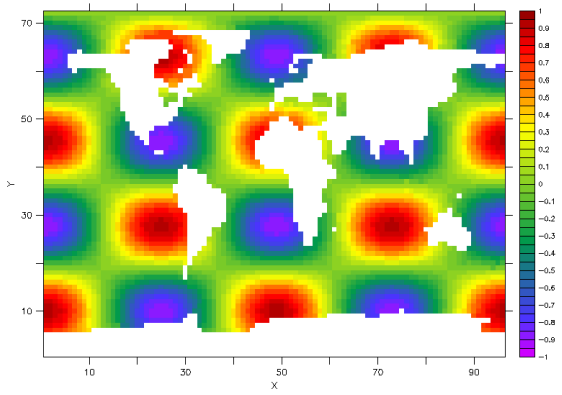


GLBPOS *0.0775

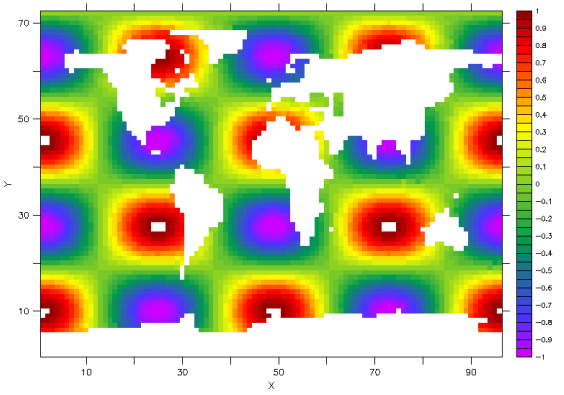


BASPOS *0.0852

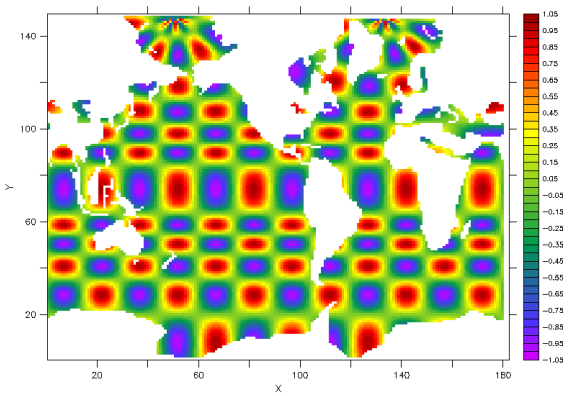
field 2, mean value near zero
Slow gradients
GLBPOS, BASPOS very poor, factors less than 0.1
GSSPOS, BSSPOS large improvement



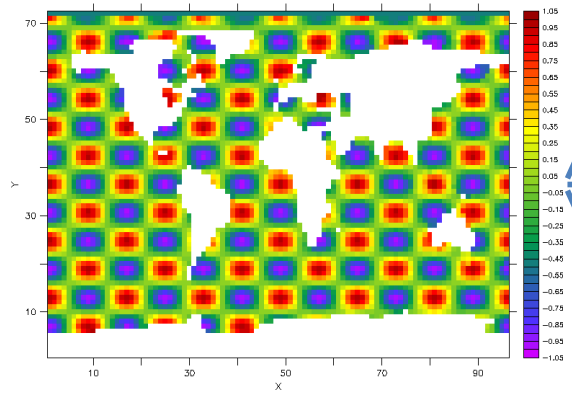
GSSPOS *0.931, *0.894



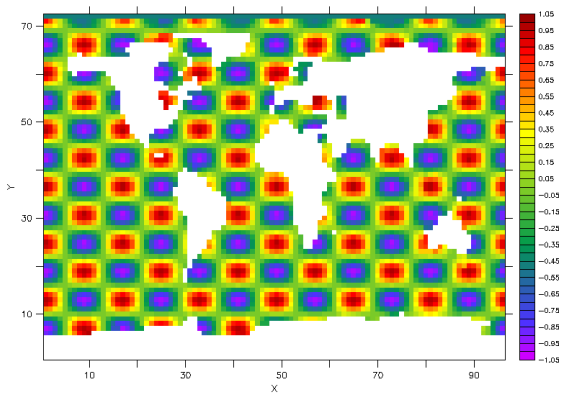
BSSPOS *1.020, *0.995



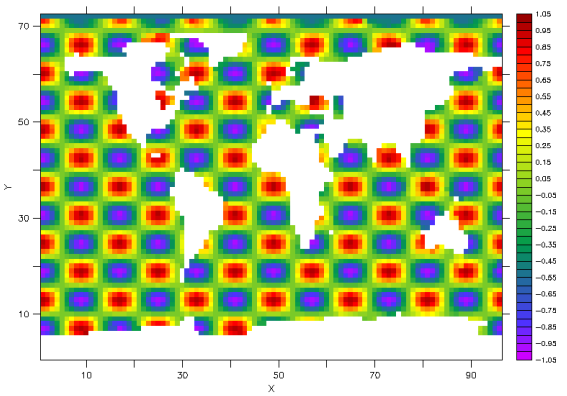
Interpolate



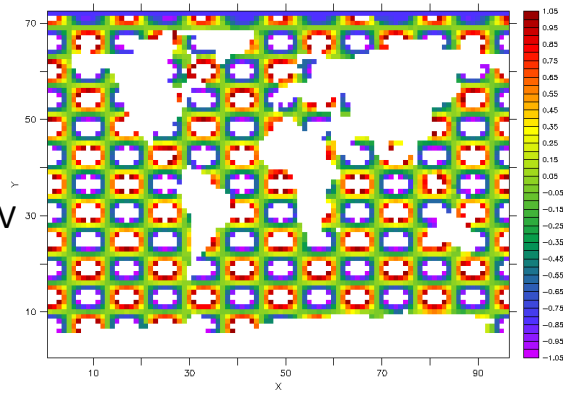
CONSERV



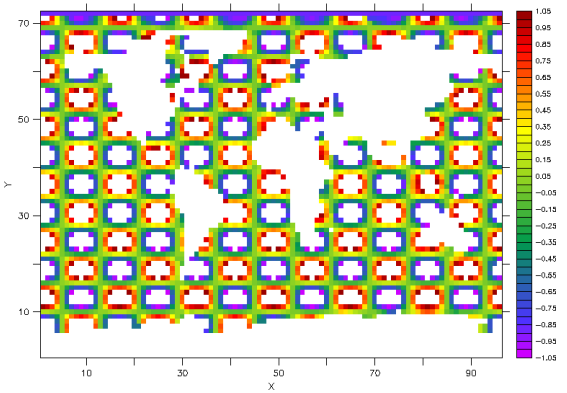
GLOBAL -0.00159



BASBAL -0.00200

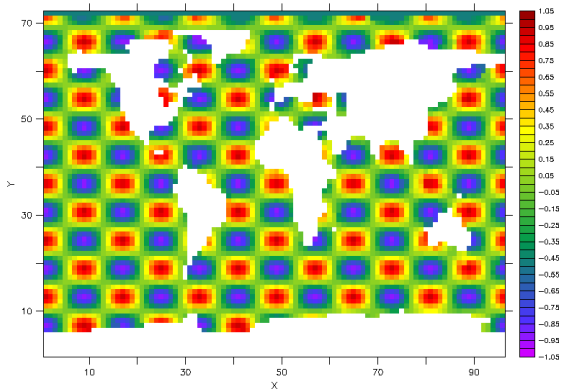


GLBPOS *1.631

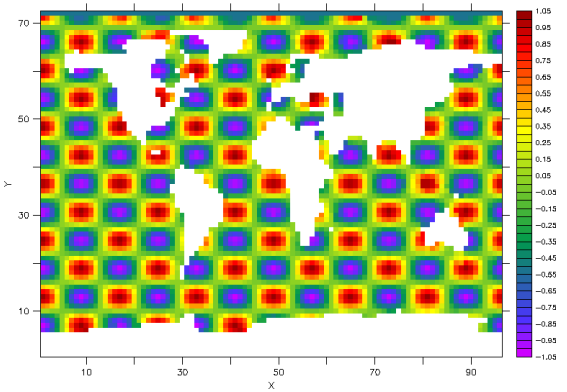


BASPOS *1.792

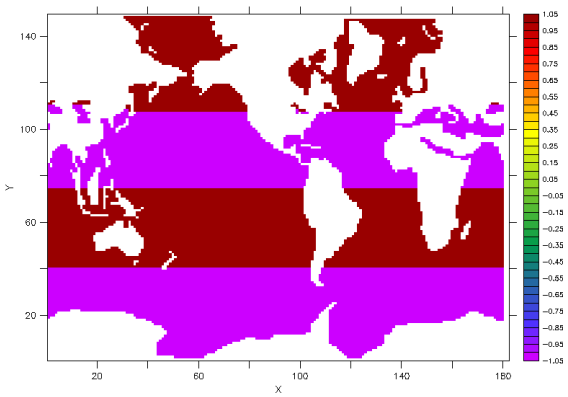
field 3, mean value approaching zero
GLBPOS, BASPOS poor
GSSPOS, BSSPOS improvement



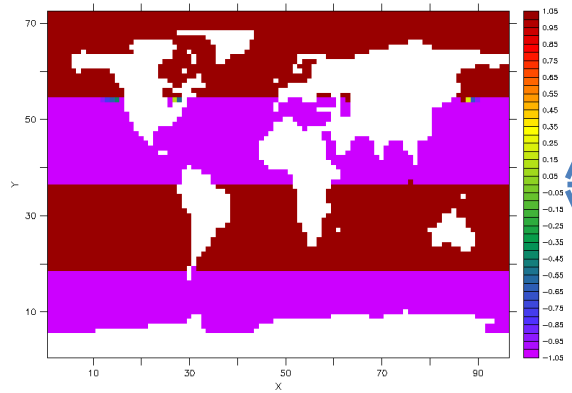
GSSPOS *0.929, *0.938

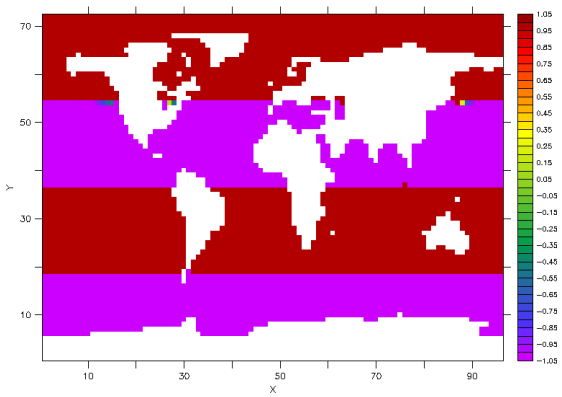


BSSPOS *1.033, *1.020

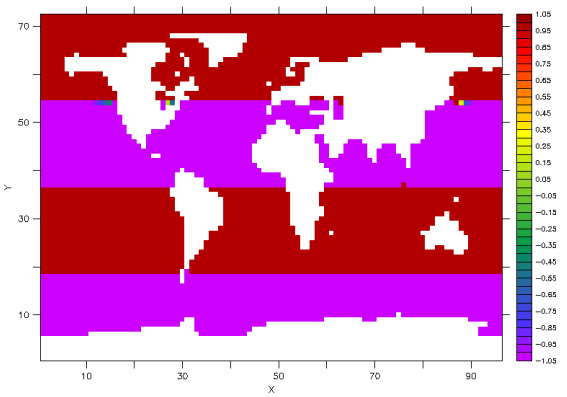


Interpolate



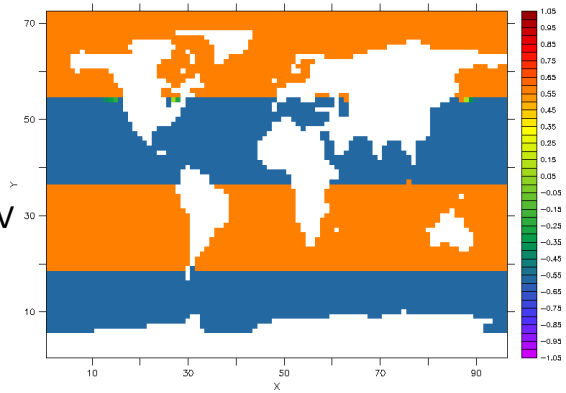


GLOBAL -0.00355

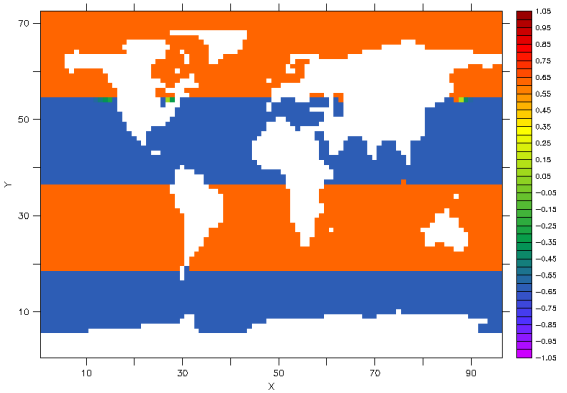


BASBAL -0.00311

CONSERV

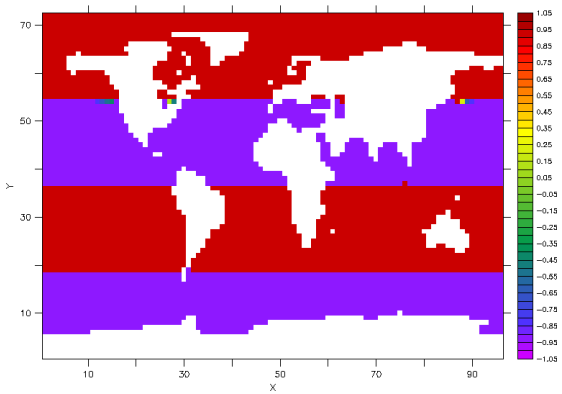


GLBPOS *0.558

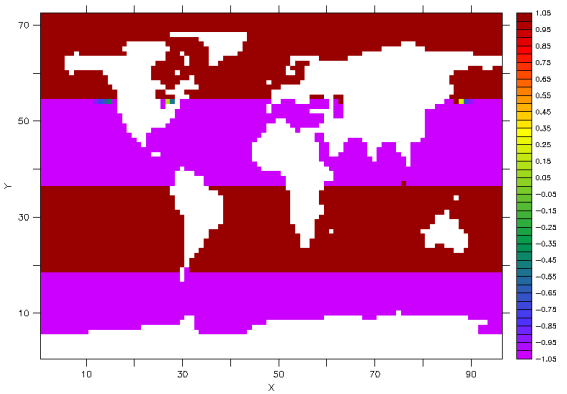


BASPOS *0.613

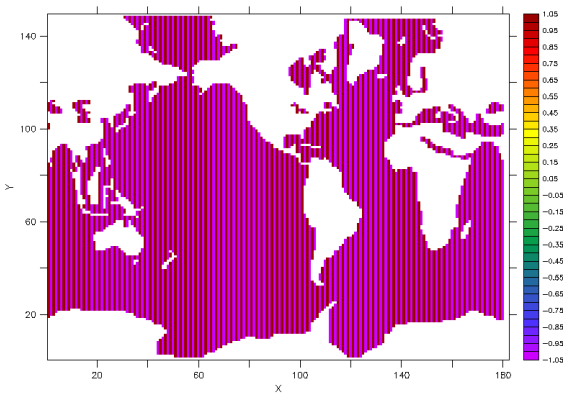
field 4, mean value approaching zero
GLBPOS, BASPOS poor
GSSPOS, BSSPOS large improvement
Some averaging introduced in high gradient locations during interpolation



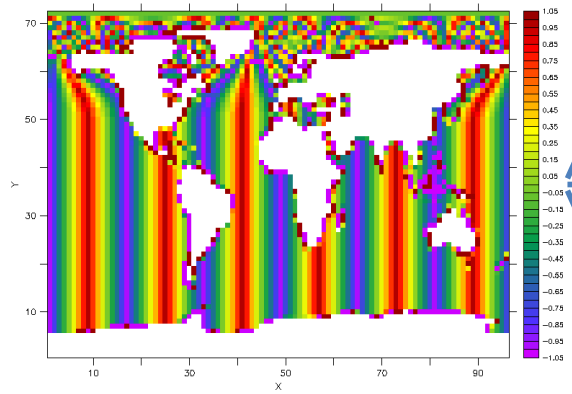
GSSPOS *0.908, *0.913

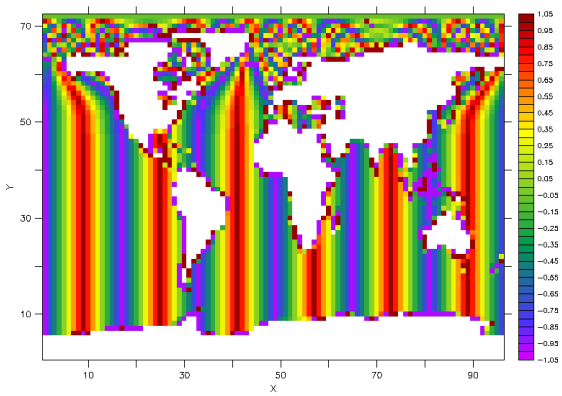


BSSPOS *1.00069, *1.00092

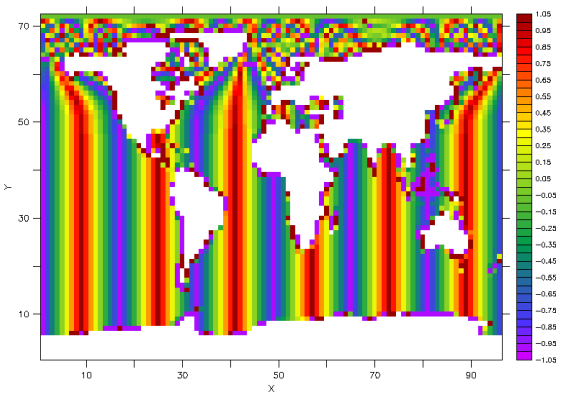


Interpolate



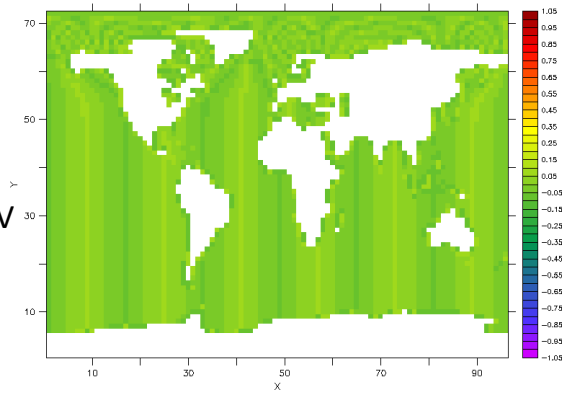


GLOBAL +0.00258

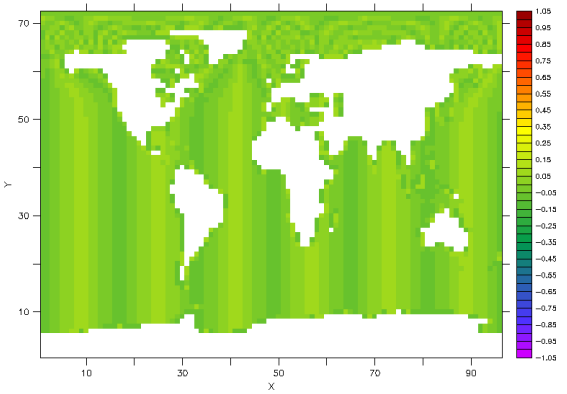


BASBAL +0.00257

CONSERV

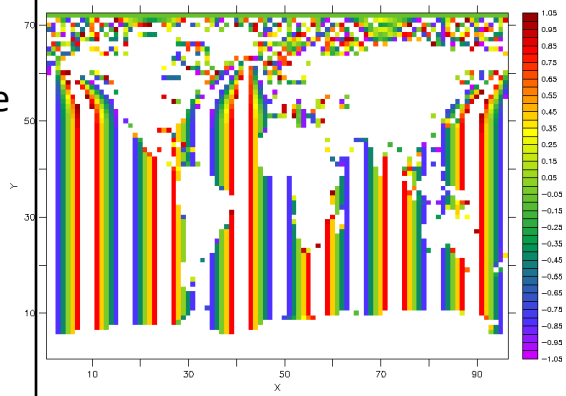


GLBPOS *0.0636

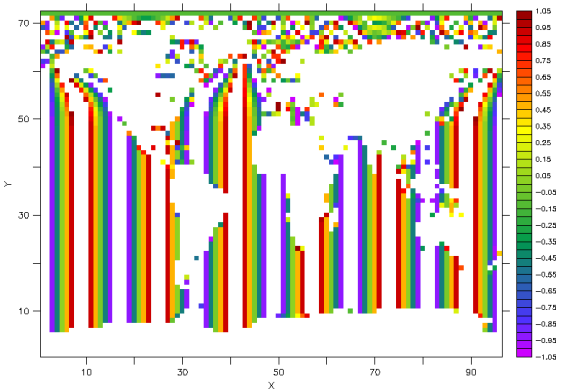


BASPOS *0.0699

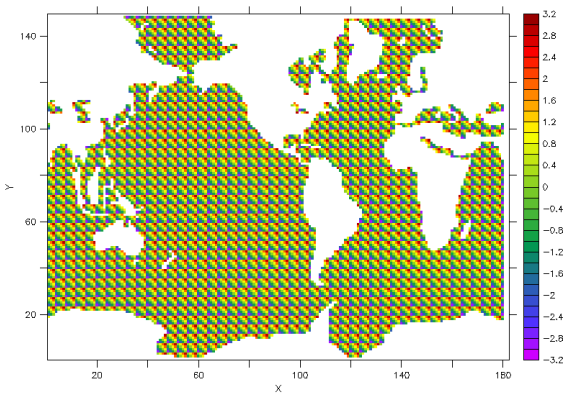
field 5, mean value near zero
Gridcell scale variability
Significant aliasing during interpolation, interpolation field not reflecting source
GLBPOS, BASPOS very poor, factors less than 0.1
GSSPOS, BSSPOS improvement but still not great
Tough case!



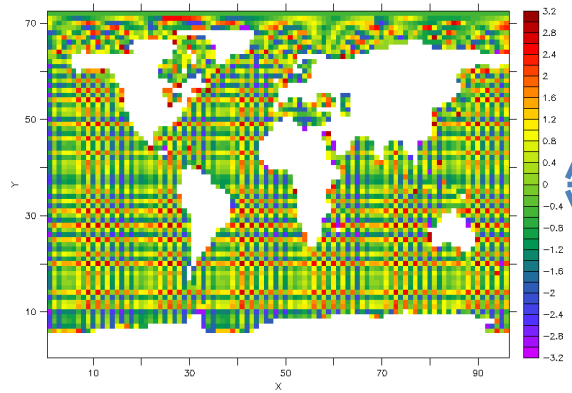
GSSPOS *1.684, *1.668



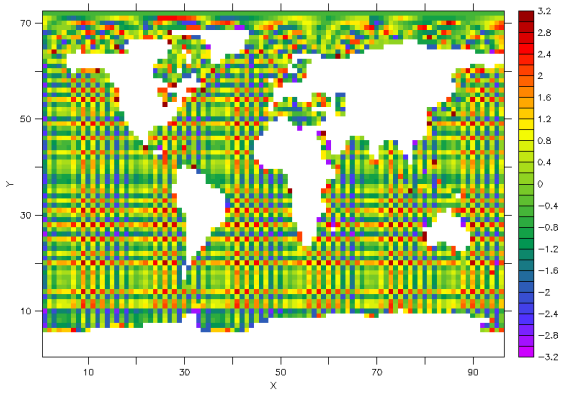
BSSPOS *1.875, *1.810



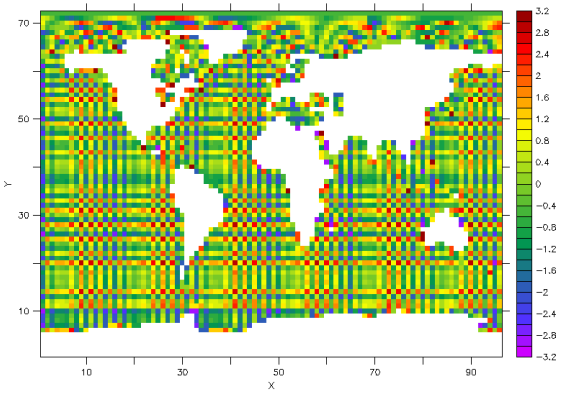
Interpolate



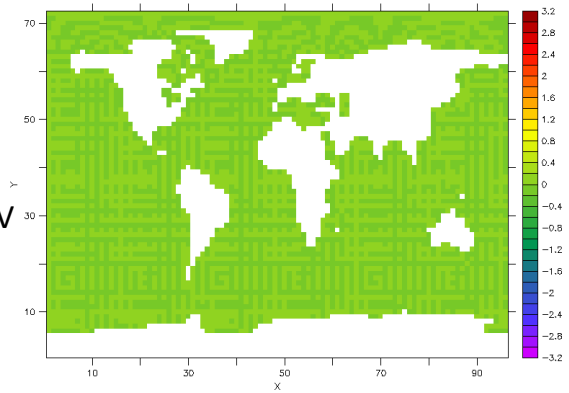
CONSERV



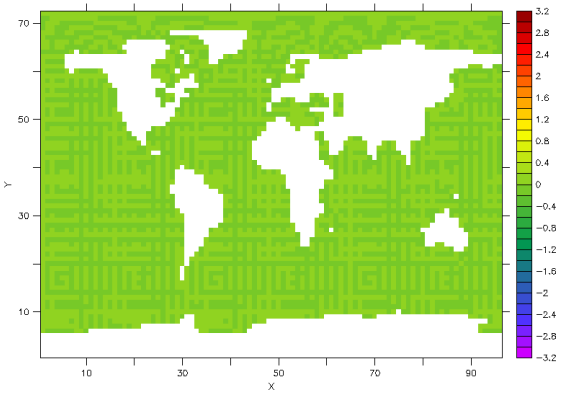
GLOBAL +0.0135



BASBAL +0.0135

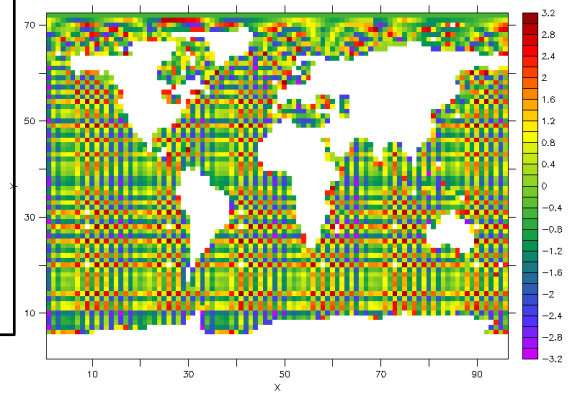


GLBPOS *-0.0172

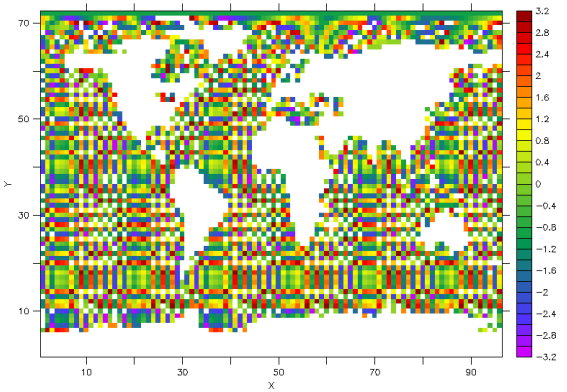


BASPOS *-0.0190

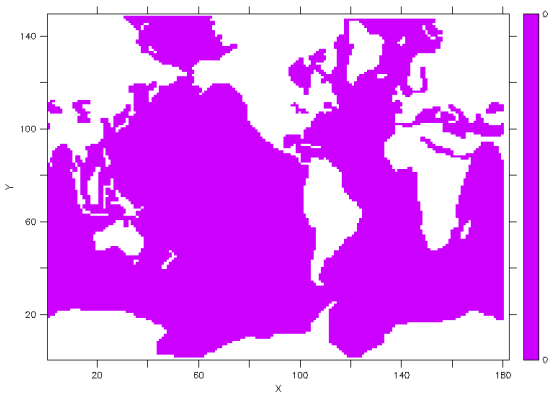
field 6, mean value near zero
Strong gradients
Significant aliasing during interpolation
GLBPOS, BASPOS very poor, factors
less than 0.02, sign change not good!
GSSPOS, BSSPOS large improvement



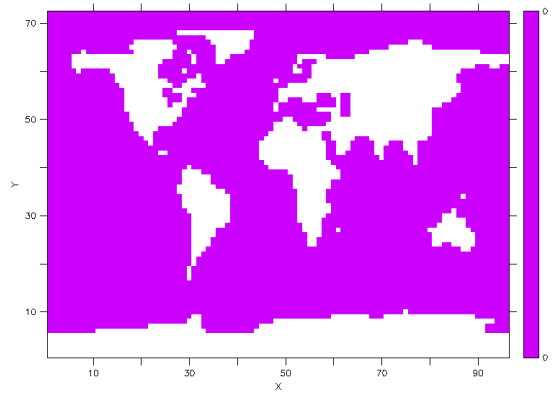
GSSPOS *1.151, *1.120



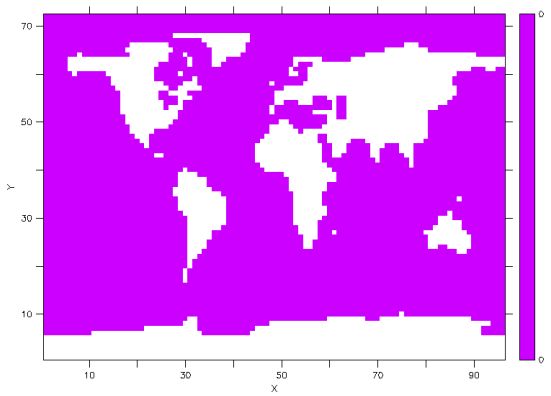
BSSPOS *1.629, *1.643



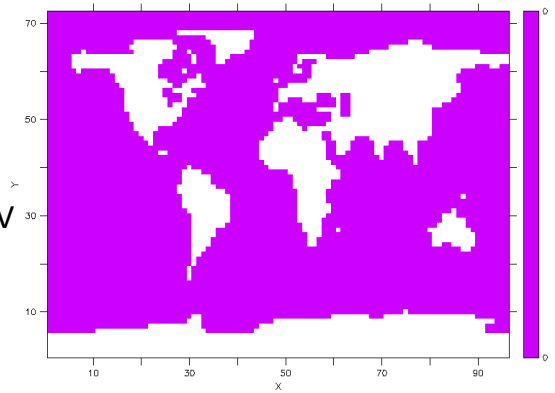
Interpolate



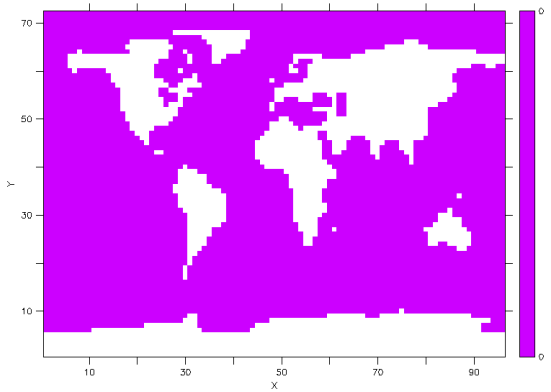
CONSERV



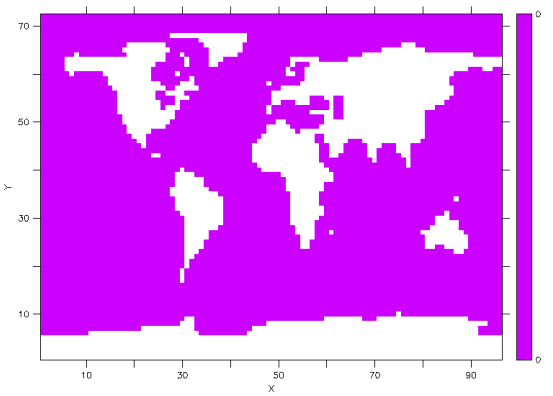
GLOBAL +0.0



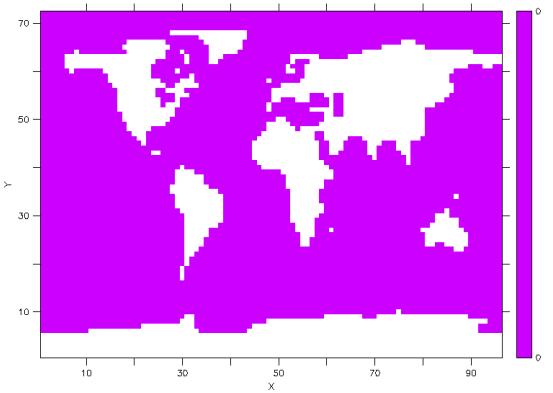
GLBPOS *1.0



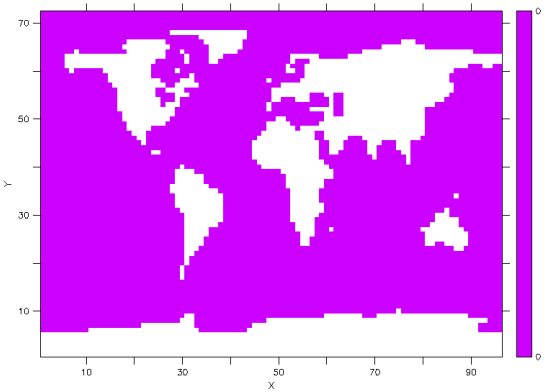
GSSPOS *1.0, -



BASBAL +0.0

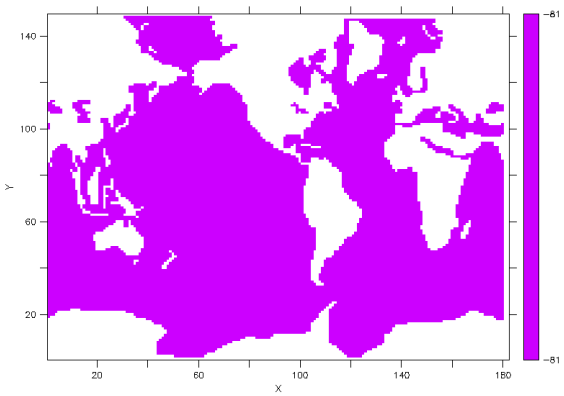


BASPOS *1.0

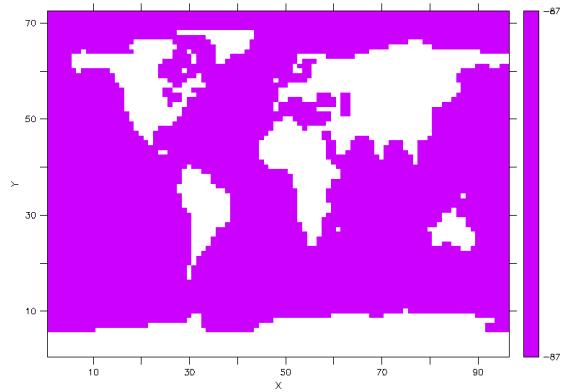


BSSPOS *1.0, -

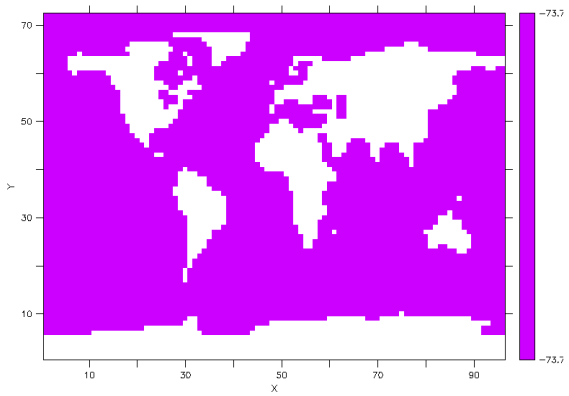
field 7, zero value
Zero value field is preserved in all cases



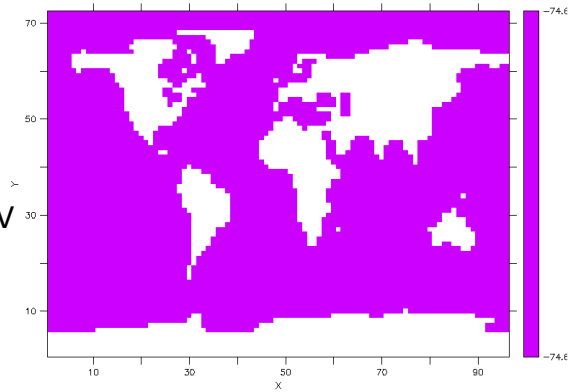
Interpolate



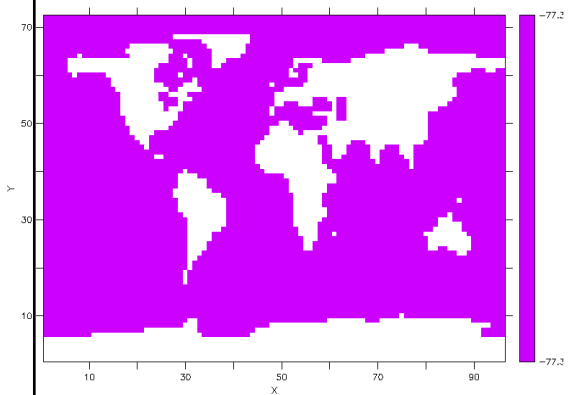
CONSERV



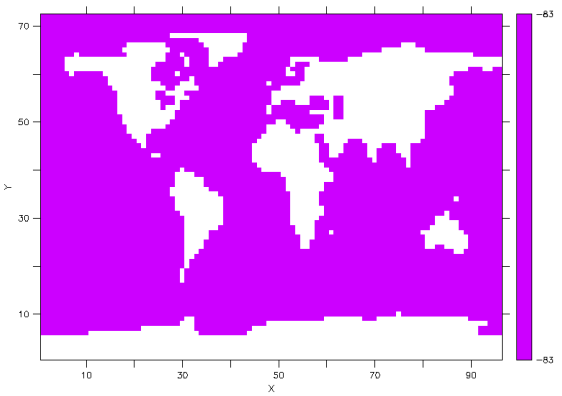
GLOBAL +7.298



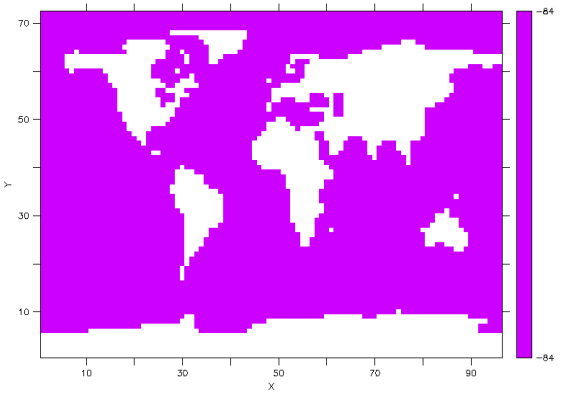
GLBPOS *0.910



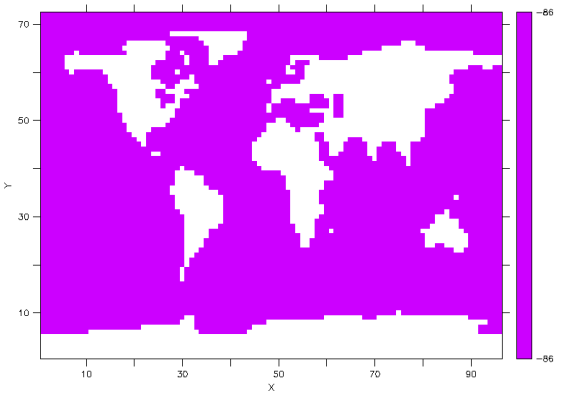
GSSPOS *.910, -



BASBAL +0.00



BASPOS *1.00

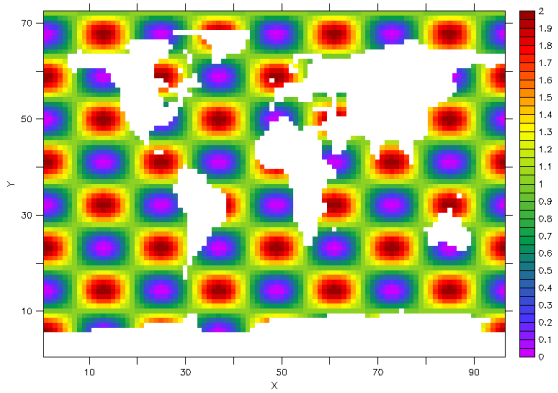


BSSPOS *1.00, -

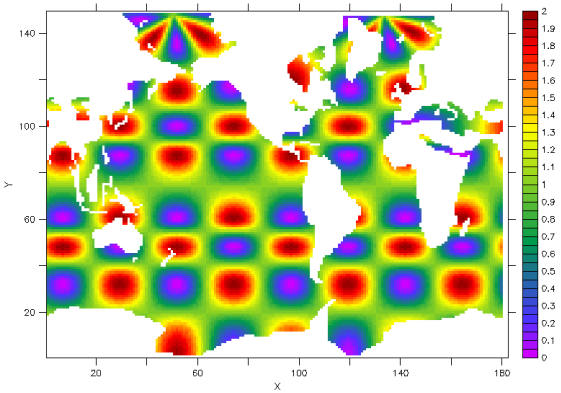
field 8, constant value field (~80)
Interpolation preserves values
All results are constants
GLBPOS and GSSPOS 0.910 reflects active area difference in two grids
B* CONSERV preserves values and all B* cases produce identical values
G* CONSERV preserves global sum and all G* cases produce identical values

Coarse -> Fine Mapping

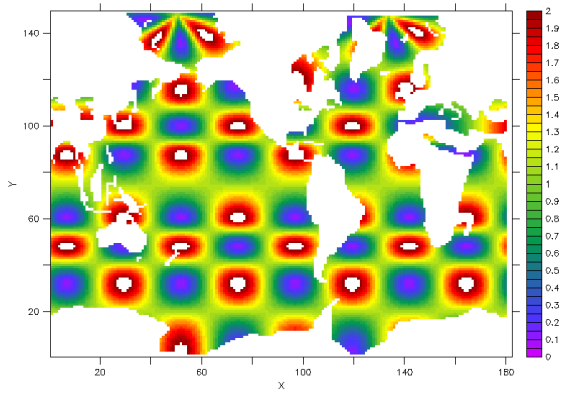
- lmdz (96 x 72) -> torc (182 x 149)
- Again, plots show the original field (upper left), the interpolated field (left center), and then the interpolated field modified by 6 CONSERV options. All eight plots on a given page have identical color bars. The CONSERV method and scaling constant are shown below the plot. For GLOBAL and BASBAL, the scaling constant will be an additive value (of sign + or -). For the other CONSERV options, the scaling constant will be one multiplicative value (GLBPOS, BASPOS), or two multiplicative values, one for the positive part of the field and another one for the negative part (GSSPOS, BSSPOS) .



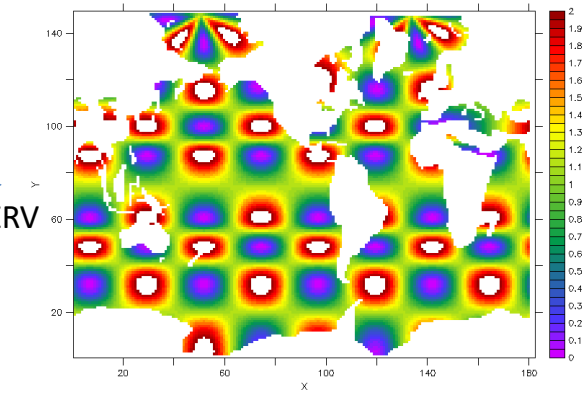
Interpolate



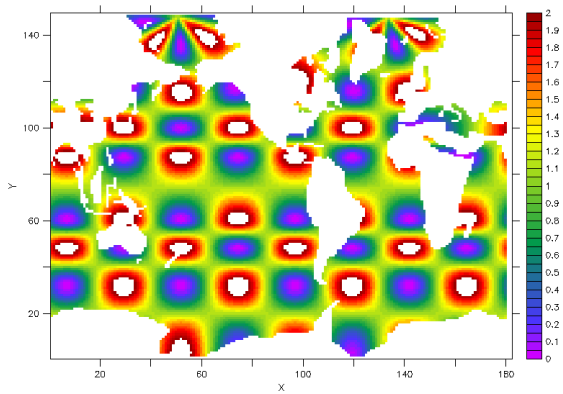
CONSERV



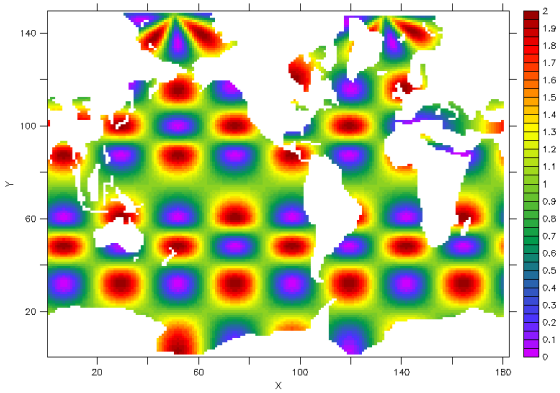
GLOBAL +0.104



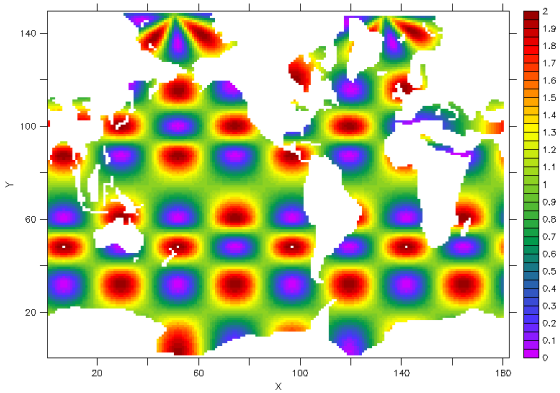
GLBPOS *1.105



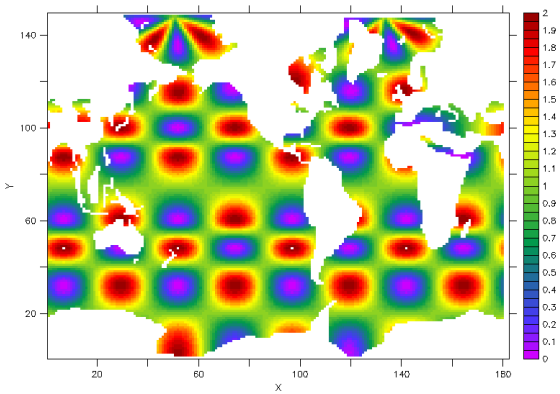
GSSPOS *1.105, -



BASBAL +0.00522

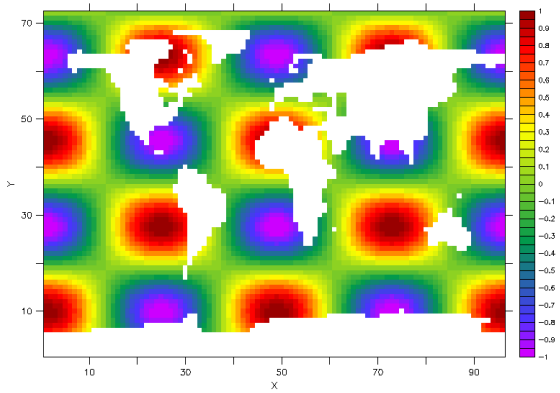


BASPOS *1.005

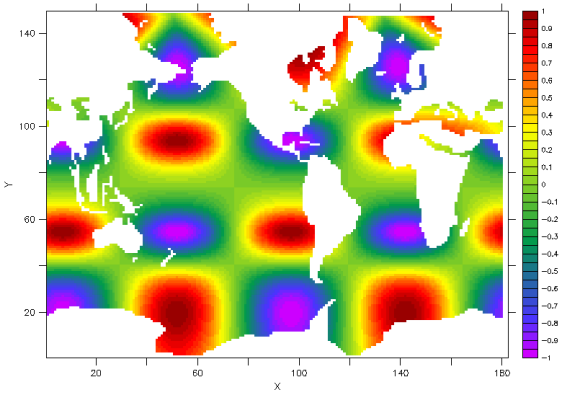


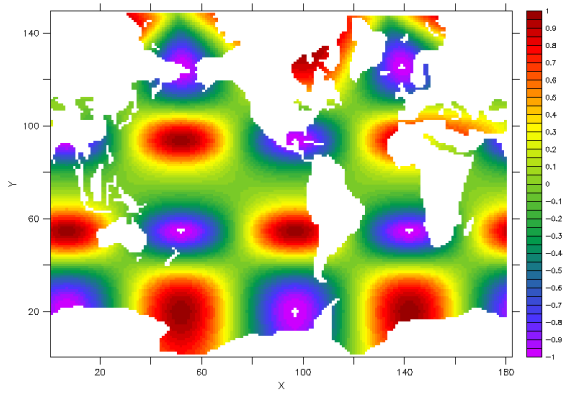
BSSPOS *1.005, -

field 1, positive definite, well-posed
Since the field is all the same sign,
the GSSPOS==GLBPOS and
BSSPOS==BASPOS

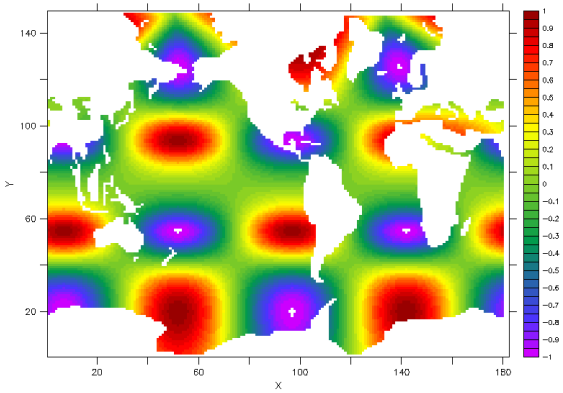


Interpolate



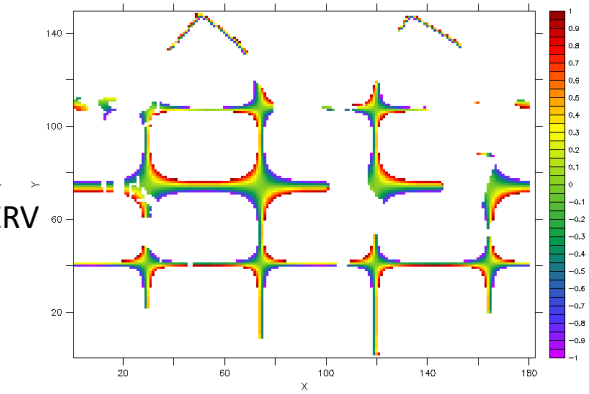


GLOBAL -0.00868

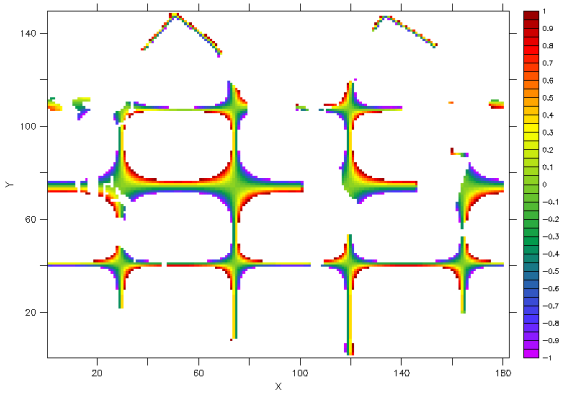


BASBAL -0.00522

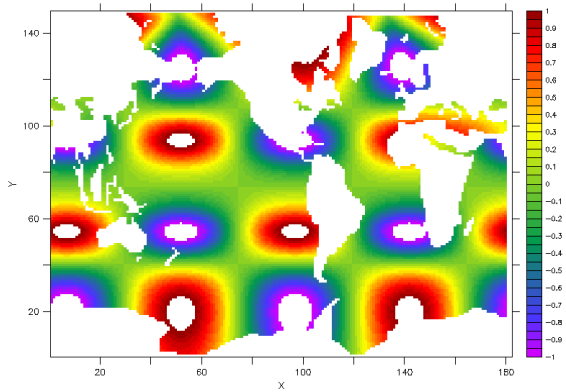
CONSERV



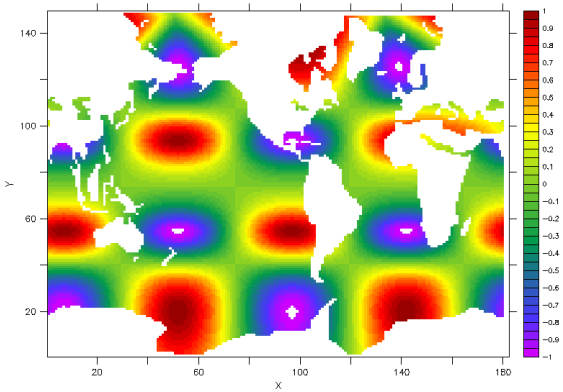
GLBPOS *12.58



BASPOS *11.45

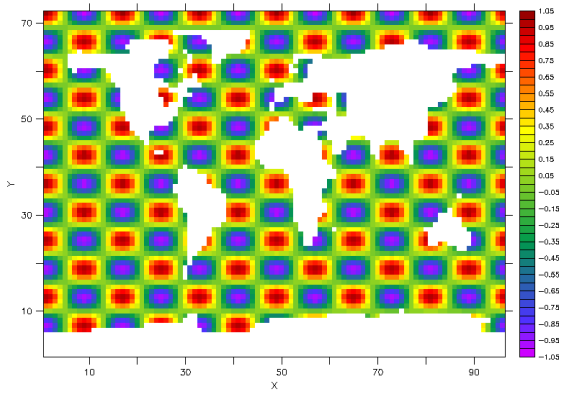


GSSPOS *1.081, *1.124

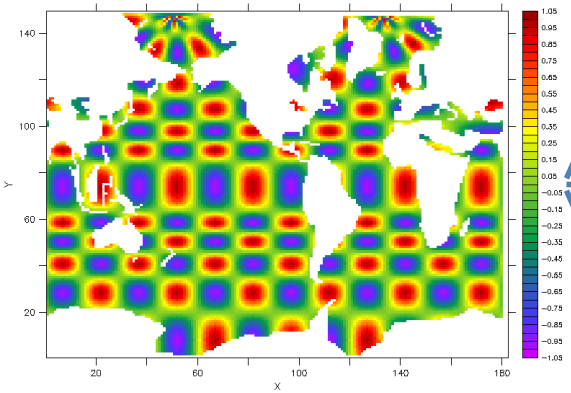


BSSPOS *0.992, *1.013

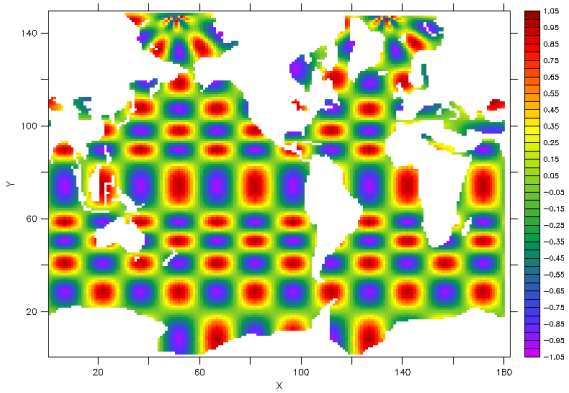
field 2, mean value near zero
Slow gradients
GLBPOS, BASPOS very poor, factors greater than 10!
GSSPOS, BSSPOS large improvement but GLOBAL and BASBAL better at preserving field locally



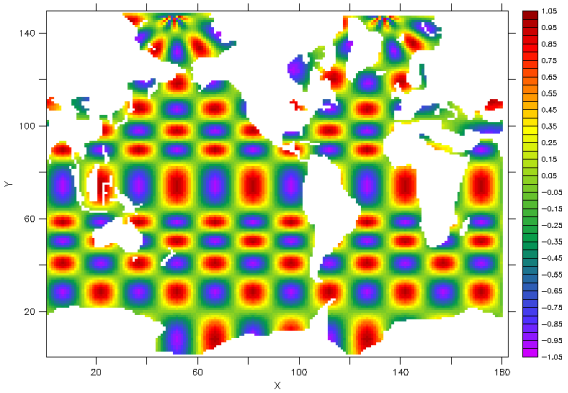
Interpolate



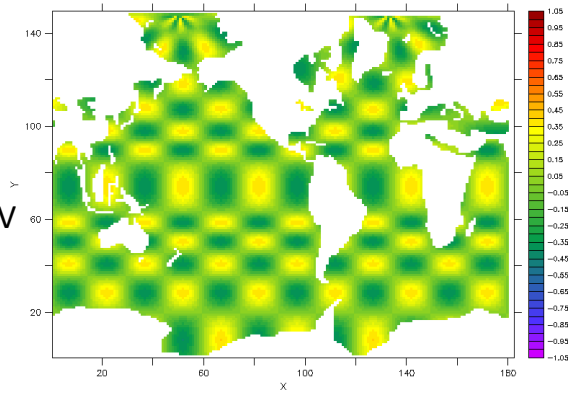
CONSERV



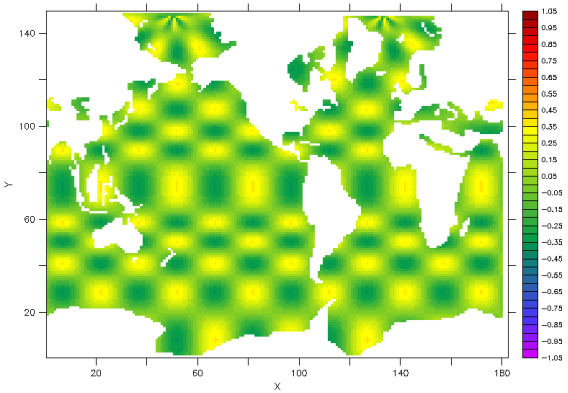
GLOBAL +0.00258



BASBAL +0.00274

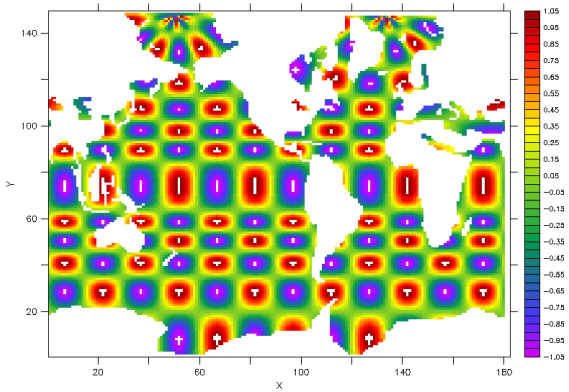


GLBPOS *0.405

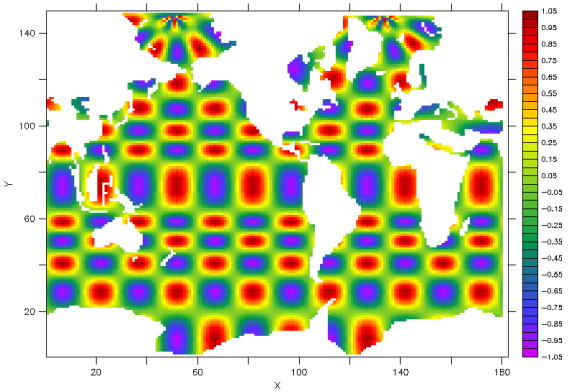


BASPOS *0.368

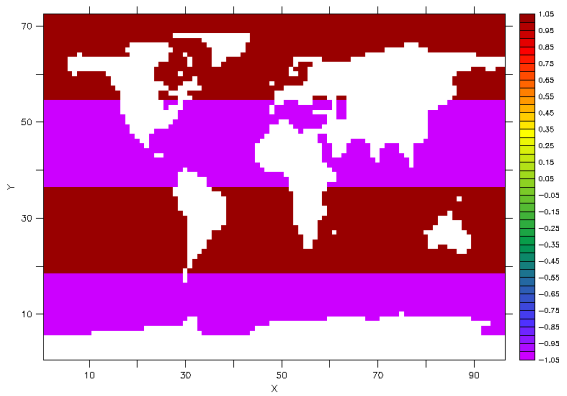
field 3, mean value approaching zero
GLBPOS, BASPOS poor, factors
less than 0.5
GSSPOS, BSSPOS improvement



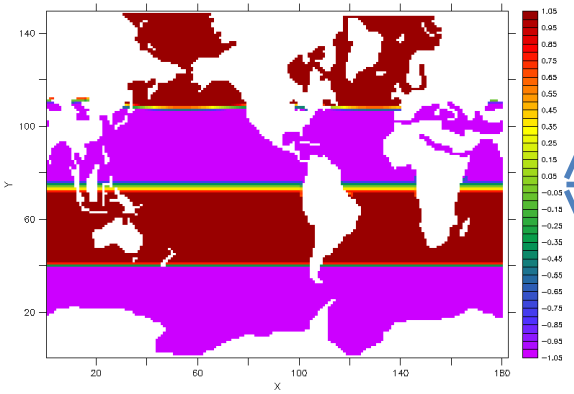
GSSPOS *1.127, *1.111

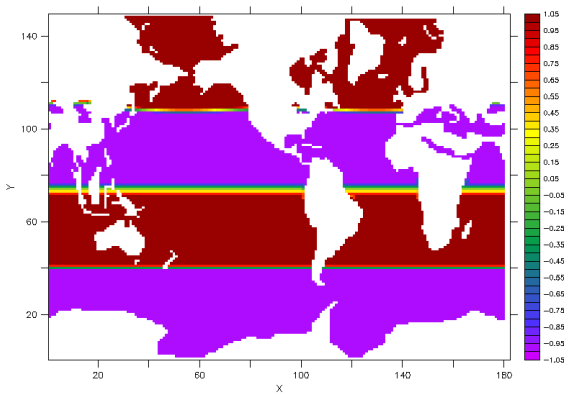


BSSPOS *1.019, *1.017

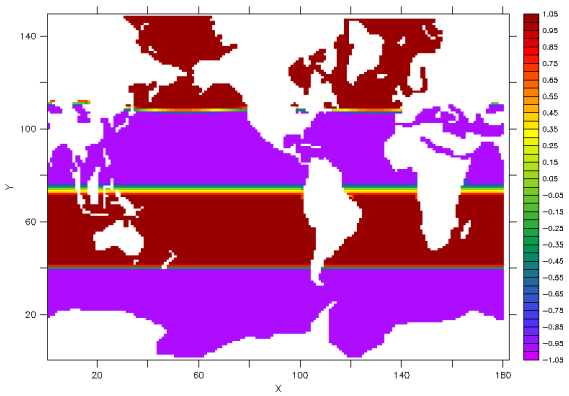


Interpolate



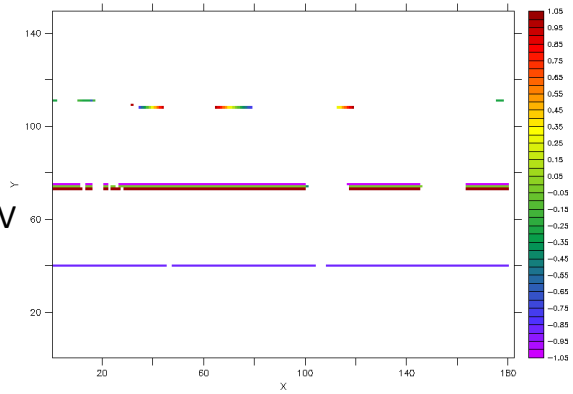


GLOBAL +0.00410

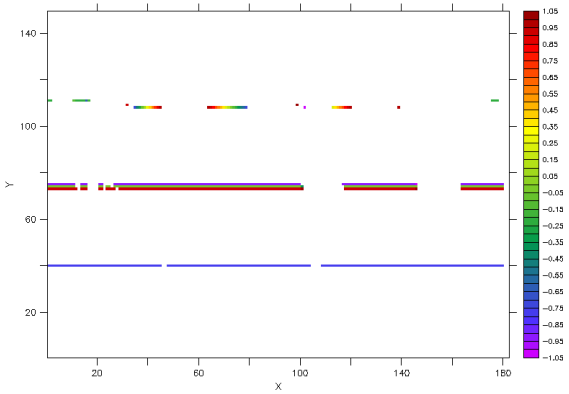


BASBAL +0.00351

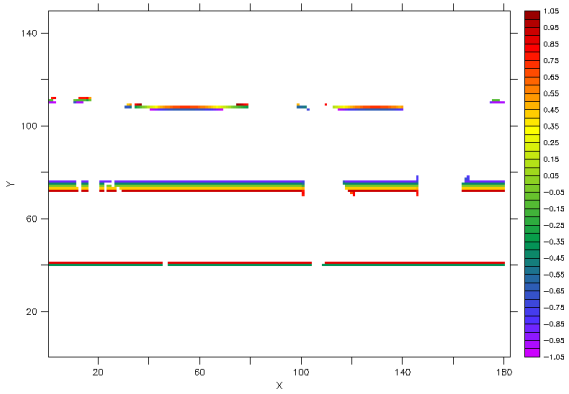
CONSERV



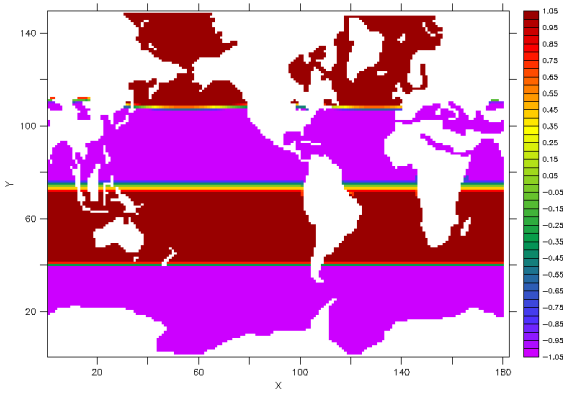
GLBPOS *2.612



BASPOS *2.376

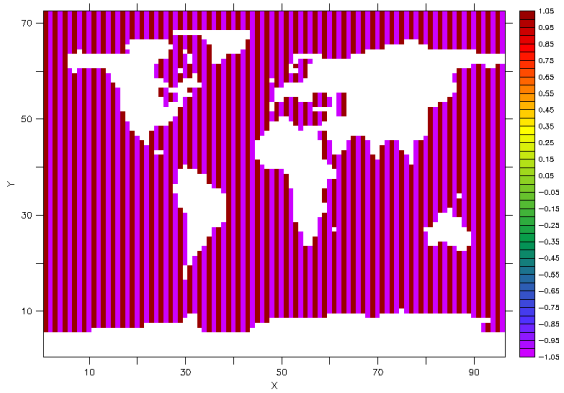


GSSPOS *1.135, *1.127

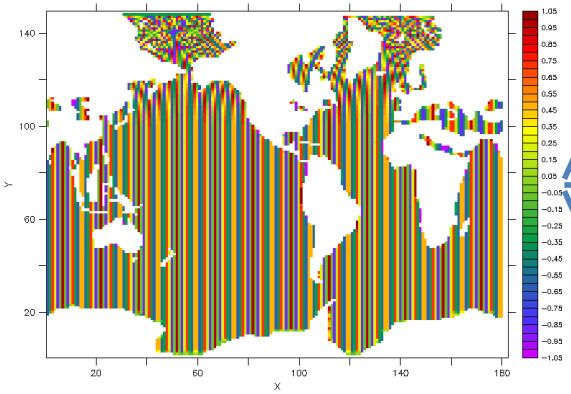


BSSPOS *1.019, *1.039

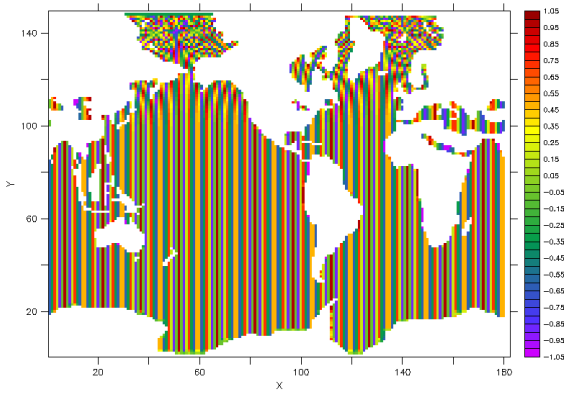
field 4, mean value approaching zero
GLBPOS, BASPOS poor, factors greater than 2
GSSPOS, BSSPOS large improvement
GSSPOS looks worse than it is due to color bar
Some averaging introduced in high gradient locations during interpolation



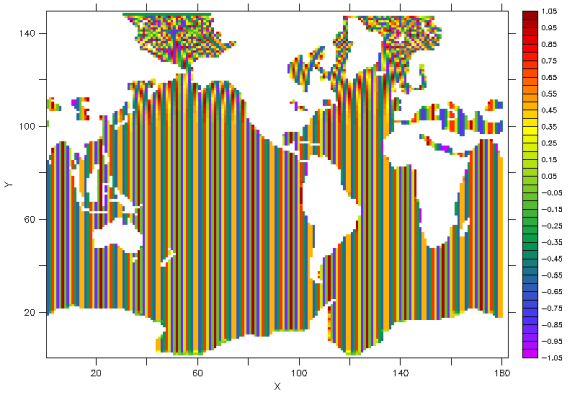
Interpolate



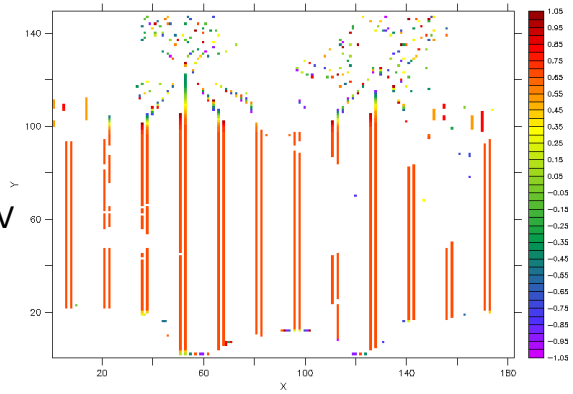
CONSERV



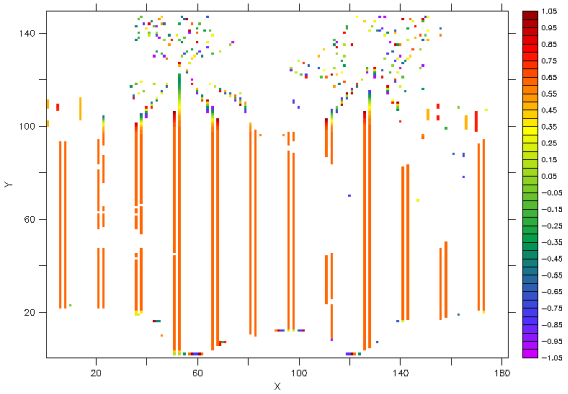
GLOBAL -0.00471



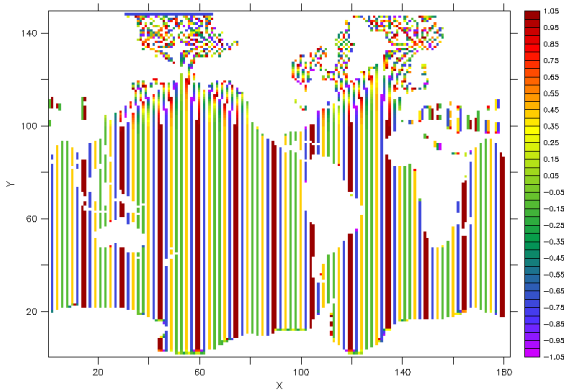
BASBAL -0.00432



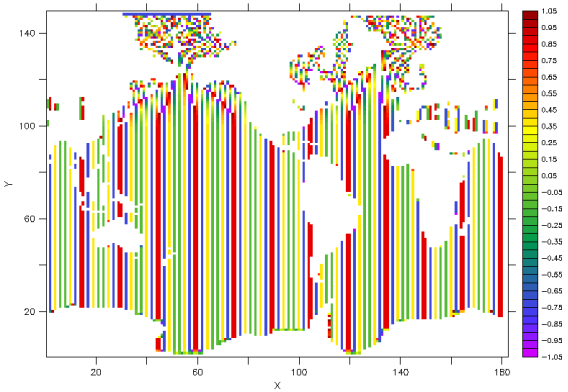
GLBPOS *-10.14



BASPOS *-9.228

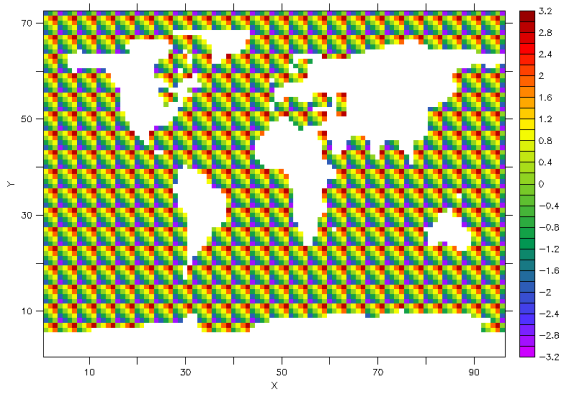


GSSPOS *2.174, *2.195

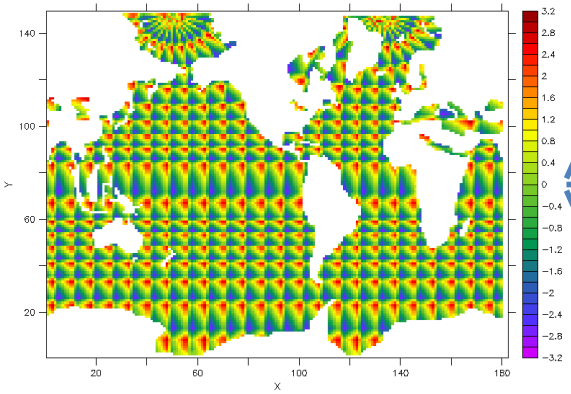


BSSPOS *1.862, *2.113

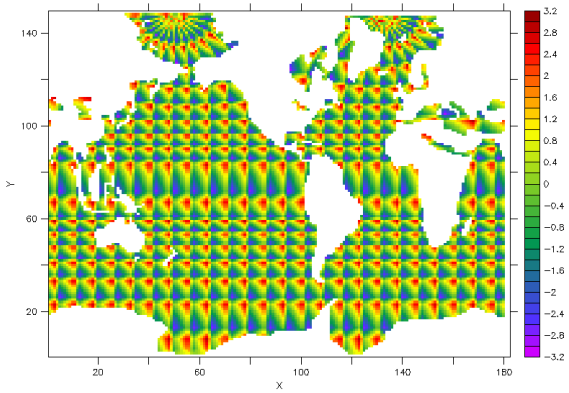
field 5, mean value near zero
Gridcell scale variability
Interpolation somewhat problematic
GLBPOS, BASPOS very poor, factors about 10 with sign change!
GSSPOS, BSSPOS improvement but still not great
Tough case!



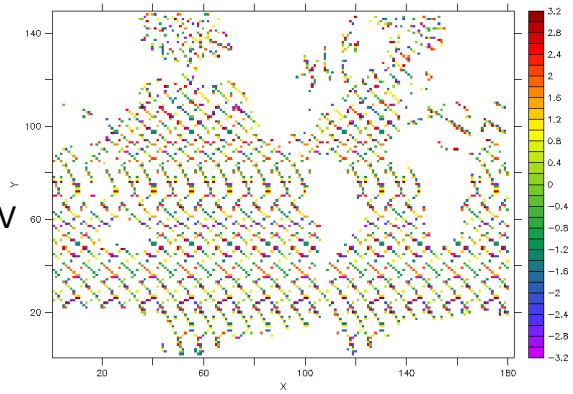
Interpolate



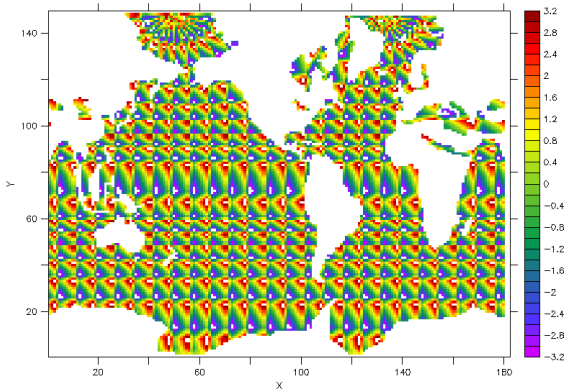
CONSERV



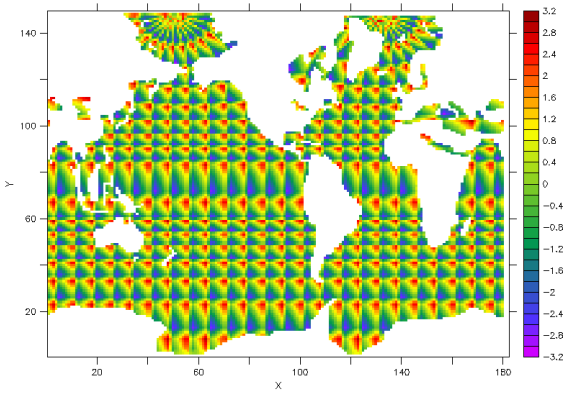
GLOBAL +0.0114



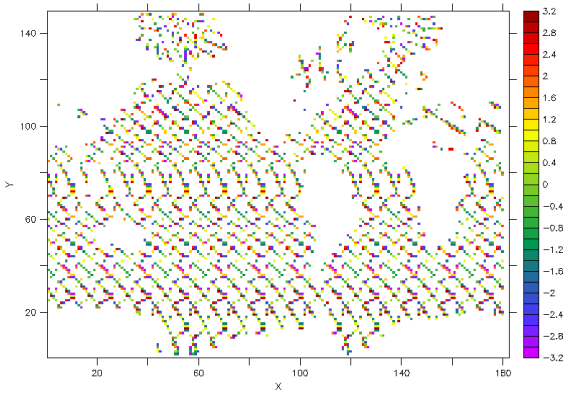
GLBPOS *-9.929



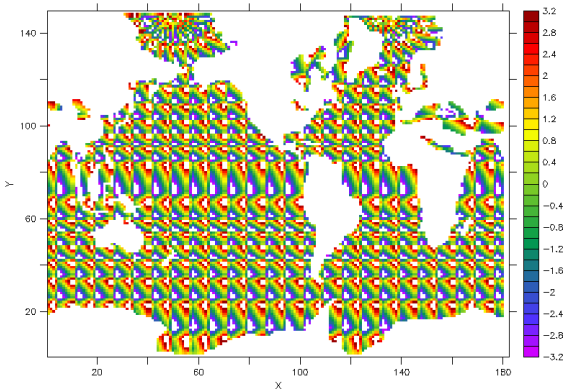
GSSPOS *1.397, *1.373



BASBAL +0.01049

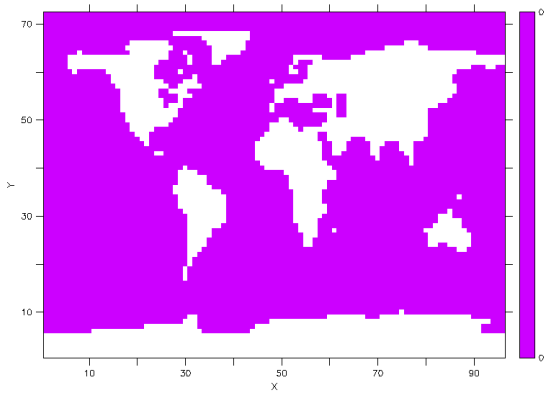


BASPOS *-9.034

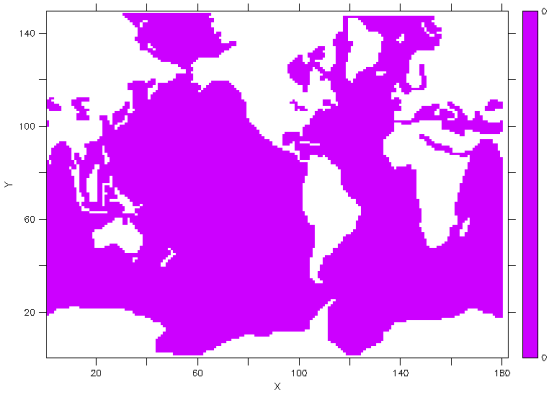


BSSPOS *1.681, *1.672

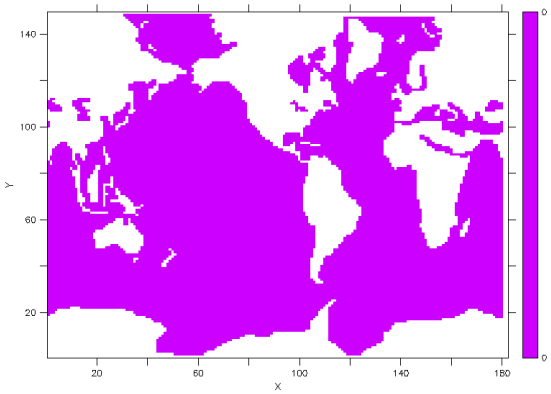
field 6, mean value near zero
Strong gradients
GLBPOS, BASPOS very poor, factors about 10, sign change not good!
GSSPOS, BSSPOS large improvement but GLOBAL or BASBAL introduce smaller changes relative to the interpolated field



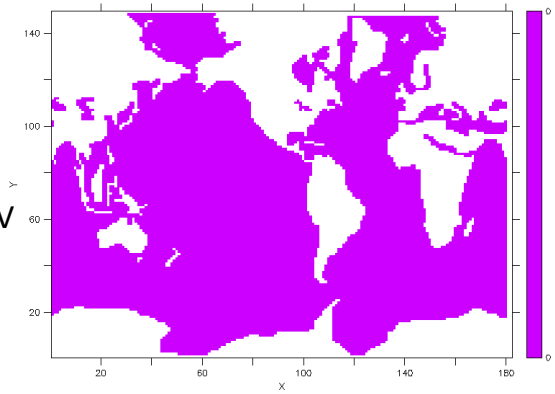
Interpolate



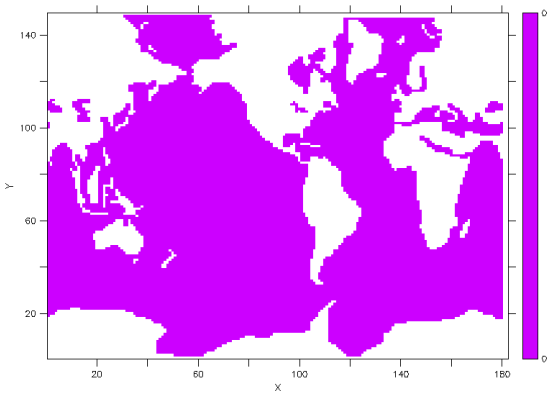
CONSERV



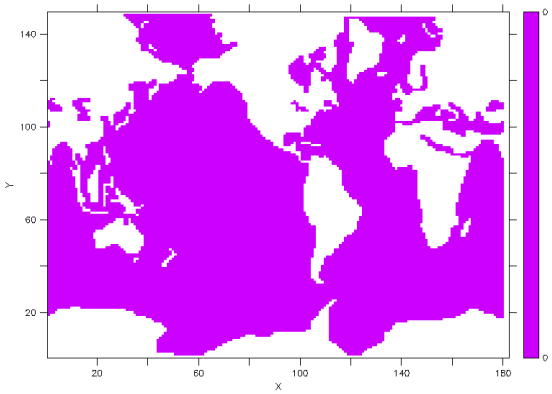
GLOBAL +0.0



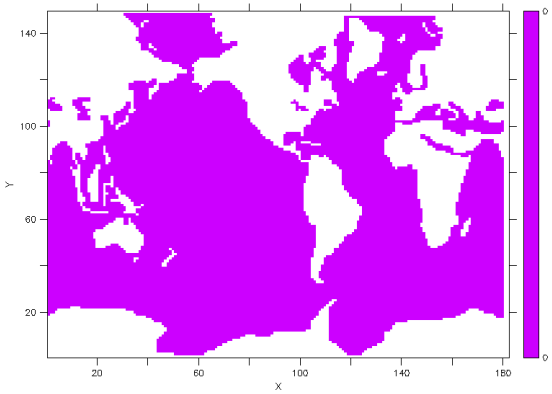
GLBPOS *1.0



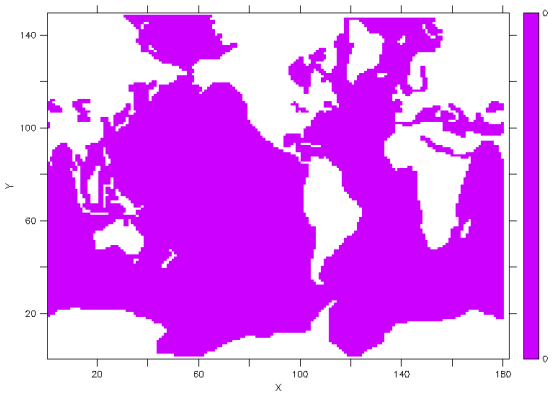
GSSPOS *1.0, -



BASBAL +0.0

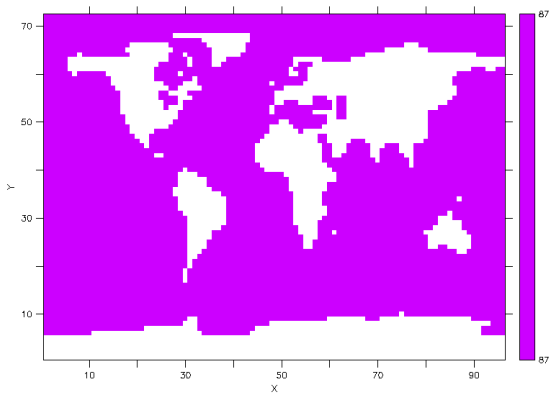


BASPOS *1.0

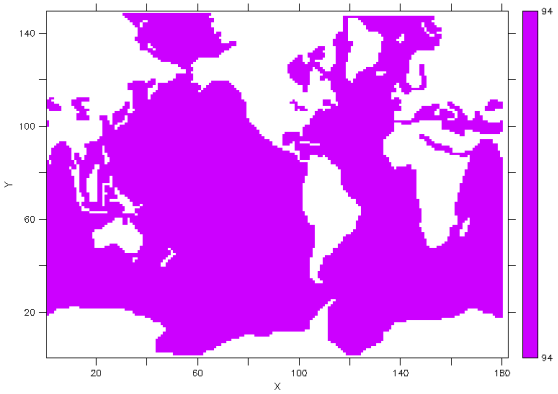


BSSPOS *1.0, -

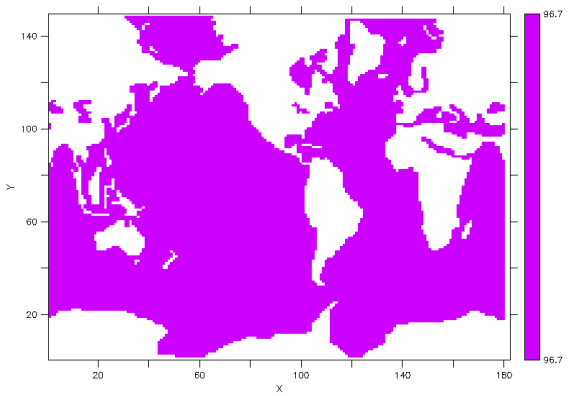
field 7, zero value
Zero value field is preserved in all cases



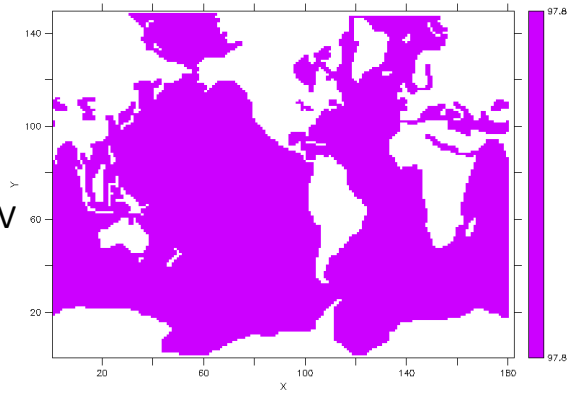
Interpolate



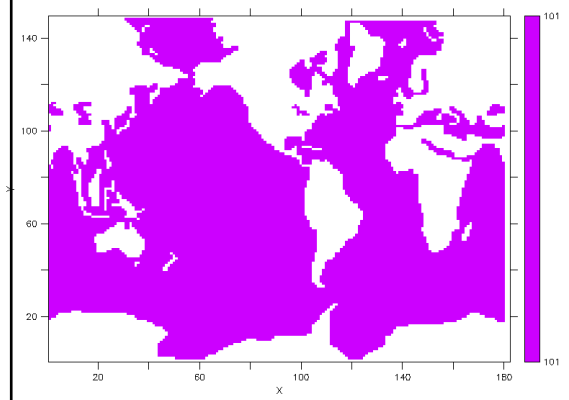
CONSERV



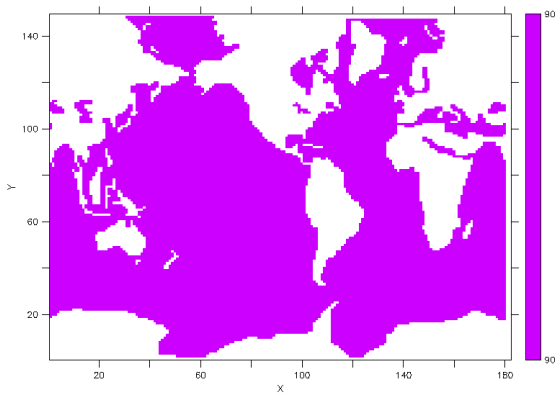
GLOBAL +8.713



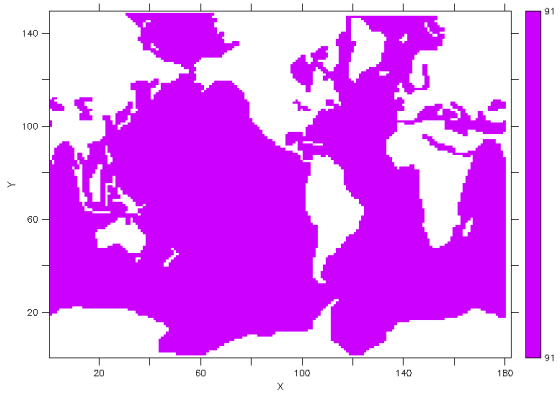
GLBPOS *1.099



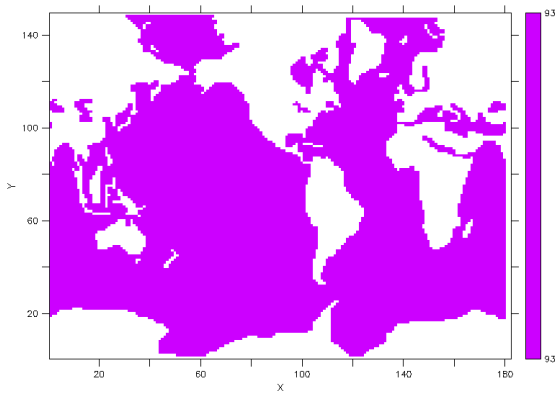
GSSPOS *1.099, -



BASBAL +0.0



BASPOS *1.0



BSSPOS *1.0, -

field 8, constant value field (~80)
Interpolation preserves values
All results are constants
GLBPOS and GSSPOS 1.099 reflects
active area difference in two grids
B* CONSERV preserves values and all
B* cases produce identical values
G* CONSERV preserves global sum and
all G* cases produce identical values