# Reduced-space ODA

**Rough Plan.**

- make space for the data using a module.
- read it. What format is convenient?
- How is ares handled? All one vector? by basin?
- add linear algebra.
- diagnostics.

**MOM1 source.**
Source is located on `crunch` in `/c1/tippett/mom-1/src_rsp/`.
**Getting eof data into the program.**
EOFs, work arrays and diagonostics are in the module `/c1/tippett/mom-1/src_rsp/reduced_data.f90`.

```
module reduced_data
  integer,parameter :: ii=114,jj=152,leof=ii*jj*22,neof=138
  dimension proj1(neof),proj2(neof),proj3(neof)
  real, public, dimension(:,:,:,:), allocatable :: rsp
  real, public, dimension(neof,neof) :: pf
  real, public, dimension(neof) :: rwork
  integer, public  :: iomf,miomf
  real, public, dimension(ii,22,jj) :: bias1,bias2,var1,var2
end module reduced_data
```

EOFs are read in `ocean.F`

```
        allocate(rsp(imt,kass,jmt,neof),stat=istat)
        open(57,file='/c1/tippett/yan/eof_full_orth_all.bin',
     $        form='unformatted',access='direct',recl=imt*jmt*kass*8)
        do ieof=1,neof
           read(57,rec=ieof) rsp(:,:,:,ieof)
        enddo
        close(57)
        pf = 0.
        do ieof = 1,neof
           pf(ieof,ieof) = 1.0
        enddo
```

MOM3 eofs need to be normalized by the number of grid points in eof grid.

**Only reduced space.**

To use only the EOF covariance add the following to `assim.F` after `ares` is calculated in `comobs` and skip congugate gradiant iteration.

It computes

$$\delta T = P^a Z^T H^T R^{-1}(T^o - HT^f)$$

where

$$P^a = \left(Z^T H^T R^{-1} HZ + \left(P^f\right)^{-1}\right)^{-1}.$$

$P^a$ is not really calculated.

```
      xcr = -1.0
! proj1 = rsp'*ares
      call dgemv
     $     ('T',kass*jmt*imt,neof,1.,rsp,kass*jmt*imt,ares,1,0.,proj1,1)
!     proj2 = pf*proj1
      call dgemv('N',neof,neof,1.,   pf,neof,proj1,1,0.,proj2,1)
! ares = xcr*rsp*proj2
      call dgemv
     $ ('N',kass*jmt*imt,neof,xcr,rsp,kass*jmt*imt,proj2,1,0.,ares,1)
      goto 400
```

**Reduced-space and Gaussian**

Need to make changes in `lsmth` to compute

$$S^f v = (I - ZZ^T)G(I - ZZ^T)v + ZP^f Z^T v$$

rather than just $Gv$ where $G$ is the Gaussian, columns of $Z$ are the eofs, $v$ is `ares`.

Insert the following at the begining of `lsmth` to calculate $(I - ZZ^T)v)$

```
! reduced space calculation
!     rsp - reduced space basis
!     proj1 = rsp'*ares
      call dgemv('T',leof,neof,1.,rsp,leof,ares,1,0.,proj1,1)
!     proj2 = pf*proj1
      call dgemv('N',neof,neof,1.,pf,neof,proj1,1,0.,proj2,1)
!     ares    = ares - rsp*proj1
      call dgemv('N',leof,neof,-1.,rsp,leof,proj1,1,1.,ares,1)
```

After applying $G$ to $(I - ZZ^T)v)$, that is after the usual Gaussian part, compute

$$Z(-Z^T G(I - ZZ^T)v + P^f Zv + G(I - ZZ^T)v)$$

with the following:

```
!     proj2 = - rsp'*s2 + proj2
      call dgemv('T',leof,neof,-1.,rsp,kass*jmt*imt,s2,1,1.,proj2,1)
!     s2    = s2 + rsp*proj1
      call dgemv('N',leof,neof,1.,rsp,kass*jmt*imt,proj2,1,1.,s2,1)
```