

RESEARCH DEPARTMENT  
MEMORANDUM

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To: RD Scientific Staff and Consultants

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John Hague

From: Deborah Salmond et al.

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**Subject: IFS Memorandum Cycle CY36R2**

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Cycle 36r2 was created in November/December 2009. This is mainly a technical cycle including capability to run Ensemble Data Assimilation, the use of GRIB\_API to decode and encode gribdata and several optimisations to improve the scalability of 4D-Var. There have been many changes to the scripts including a new rebuild step for the ifsMASTER executable.

*Modified libraries:* algor ifs ifsaux obstat odb prepdata satrad scripts trans wam

*Contributors:*

Gianpaolo Balsamo, Jean Bidlot, Rossana Dragani, Milan Dragosavac, John Hague, Mats Hamrud, Jan Haseler, Hans Hersbach, Lars Isaksen, Martin Leutbecher, Jean-Jacques Morcrette, George Mozdzyński, Carole Peubey, Deborah Salmond, Tomas Wilhelmsson

## Scientific changes

### Lars Isaksen and Jan Haseler

#### Ensemble Data Assimilation

##### Capability to run Ensemble Data Assimilation

###### *Files modified(SCRIPTS):*

def/an.def gen/anml, anpl, ansfc, anwave, biassave, copyodb, emiskf, fdbksave, fetchmars, fetchobs, forceinv2clim, gather\_endaodb, get\_exe, getgrb, getgrbe, getini, getmars, ifsgmon, ifsmin, ifstraj, ifstsave, ifsvar, lowres\_fp, mkabs\_an, mkabs\_black, mkabs\_fc, mkabs\_prepdata, mkidta, mklinks, model, modeleps, modelsv, obstat, obstat\_init, preCleanFDB, preobs, rebuild\_ifs, run\_fp, sample\_svs, sekf\_sms, soilana, ssaana, sstana, var\_include, varconsts, vardata oce/stageini sms/getfcdata.sms, getini.sms, ifs.sms, inidata.sms, intHtoL.sms, model.sms, modeleps.sms, sv.sms, wavini.sms sms\_an/4dvar.sms, bufr2odb.sms, cleanodb.sms, copyodb.sms, create\_ccma.sms, create\_s2o\_aeolus\_md.sms, dobstat.sms, gather\_endaodb.sms, ifssv.sms, ifssvtraj.sms, ifstsave.sms, lowres.sms, makecma.sms, makeodb.sms, matchup.sms, mergeodb.sms, odb2bufr.sms, odb\_compress.sms, rebuild\_ifs.sms, revmatchup.sms, sekf.sms, simulobs2odb.sms, vardata.sms sms\_era/get\_obtime.sms sms\_oc/ocwavini.sms, sv1.sms, svnh.sms wav/prep\_wave, wave\_find\_stream, wave\_getalt, wave\_getgrb, wave\_getrst, wave\_getsar, wave\_getwind, wave\_run, wave\_setup, wave\_setup\_3v, wave\_setup\_4v, wave\_setup\_an

###### *Files modified(WAM):*

Wam\_oper/flld2fdb.F setwgribhd.F userin.F

### Rossana Dragani

#### Implementation of NOAA-19 SBUV/2 and fix to MLS bias correction

This implementation enables the passive monitoring of NOAA-19 SBUV/2 partial column ozone. In addition, a fix to MLS bias correction was applied.

###### *Files modified(IFS):*

module/varbc\_to3.F90

###### *Files modified(OBSTAT):*

satmon/sat\_add\_geo.F90

###### *Files modified(SATRAD):*

programs/reo3\_prescreen.F90

###### *Files modified(SCRIPTS):*

gen/fetchobs prereo3 smon\_def

#### Implementation of NOAA-19 SBUV/2 PCO

###### *Files modified(OBSTAT):*

satmon/sat\_add\_geo.F90

*Files modified(SATRAD):*

programs/reo3\_prescreen.F90

*Files modified(SCRIPTS):*

gen/fetchobs prereo3 smon\_def

## **Jean-Jacques Morcrette**

### **Fix for bug in McRad ShortWave radiation**

For details of the impact see:

<http://intra.ecmwf.int/publications/library/do/references/show?id=783>

*Files modified(IFS):*

phys\_ec/radlswr.F90

## *Passive and technical changes*

### **Gianpaolo Balsamo**

#### **Fix for interpo**

*Files modified(PREPDATA):*

programs/interpo.F90

### **Jean Bidlot**

#### **Small changes to Wave model**

For runs with 36 frequencies we need to adapt the value of the minimum Charnock coefficient. The efficiency of the small utility create\_wam\_bathymetry needed to be improved. Note that these 2 changes were originally intended for CY36R1 (as mentioned in the CY36R1 FLUB), but they did not make it at the end.

*Files modified(WAM):*

Wam\_oper/preproc.F create\_wam\_bathymetry.F

#### **Fix for stand-alone version of wam**

*Files modified(WAM):*

Alt/altcol.F

### **Milan Dragosavac**

#### **Fix bufr2odb software not to round decimal part of seconds to nearest integer**

*Files modified(ODB):*

bufr2odb/bufr2odb\_205.F90 bufr2odb\_airs.F90 bufr2odb\_amsre.F90  
bufr2odb\_amsre\_1d.F90  
bufr2odb\_ascat.F90 bufr2odb\_atovs.F90 bufr2odb\_gch1.F90 bufr2odb\_gch2.F90  
bufr2odb\_gch3.F90 bufr2odb\_gch4.F90 bufr2odb\_grad.F90 bufr2odb\_iasi.F90  
bufr2odb\_meris.F90 bufr2odb\_modisaer.F90 bufr2odb\_msg.F90 bufr2odb\_qscat.F90  
bufr2odb\_radio.F90 bufr2odb\_scatter.F90 bufr2odb\_ssmi.F90 bufr2odb\_ssmis.F90  
bufr2odb\_tmi.F90 bufr2odb\_tmi\_1d.F90

### **John Hague**

#### **Fixes to enable to rerun of final Trajectory in 4D-Var**

*Files modified(IFSAUX):*

utilities/rtoi.F

*Files modified(SCRIPTS):*

gen/ifstraj

#### **Optimisation of 4D-Var scripts**

When running the operational T1279 4dvar on 48 nodes (192 tasks, 16 threads/task), the difference between the Elapsed time and the Wallclock time (reported within IFS) was as much as 500 sec (out of about 2000 sec).

This is as much as 25% of the total 4dvar time - during which only one processor out of 48 nodes is being used!

A few modifications to the scripts have reduced the time taken by the scripts themselves by approximately 170 (which is about 8% of the total 4D-Var time).

- Using "tar" asynchronously instead of "cp" to save and restore the CCMA directory.
- Only linking files in 4dvar during the first trajectory
- Linking files (ln -sf) asynchronously.
- Removing links for "1dvar" and "scldcoef" files.
- Removing "ls -l".
- Creating "Here documents" asynchronously.

*Files modified(SCRIPTS):*

```
gen/ifsmin ifsvar varconsts  
sms_an/4dvar.sms
```

### **Optimisation**

*Files modified(SCRIPTS):*

```
phys_ec/sltend.F90
```

## **Mats Hamrud**

### **GRIB\_API in IFS**

IFS has been converted to use grib\_api instead of gribex to decode and encode gribdata. The conversion is not quite complete, e.g. some climate files are still read using gribex but all output used operationally is encoded with grib\_api. It has been verified that this version supports the use of GRIB2 for model level data, a prerequisite for starting experimentation with more than 127 model levels.

There are still remnants of the old, GRIB1 specific, constructs in the code. They will be cleaned up in a subsequent cycle, at present they are still needed for communication with the wave model.

As part of this work the IOSTREAM package has been made partially independent of the IFS, it can now be used in other applications.

*Files created(IFS):*

```
dia/grib_code_message.F90 preset_grib_template.F90  
module/grib_handles.F90 yom_grib_codes.F90  
setup/su_grib_api.F90
```

*Files created(IFS AUX):*

```
module/grib_api_interface.F90
```

*Files modified(ALGOR):*

module/spectral\_fields\_data.F90 spectral\_fields\_mod.F90

*Files modified(IFS):*

climate/updclie\_co2.F90  
control/cprep1.F90  
dia/pregrbenc.F90 wrmlpplg.F90 wrmoderr.F90  
fullpos/specfitg.F90 sufpc.F90 sufpg1.F90 sumpfpos.F90 wrmlfp.F90 wrmlfp1.F90  
module/gridpoint\_fields\_mix.F90 iostream\_mix.F90 traj\_main\_mod.F90  
traj\_surface\_mod.F90 trajectory\_mod.F90 yomgrb.F90 yomtraj.F90  
obs\_preproc/gefger.F90  
parallel/read\_spec\_grib.F90 write\_spec\_grib.F90  
setup/modgrin.F90 su0yomb.F90 su\_surf\_flds.F90 suafln1.F90 suarg.F90 sugem.F90  
sugfl.F90 sump.F90 supp.F90 suvert.F90  
sinvect/rdtllcz.F90 sulcz.F90 wrtllcz.F90  
utility/reset\_accfie\_vareps.F90 write\_grid\_traj.F90  
var/estsig.F90 jqvcor.F90 suinfce.F90 subj.F90 sumoderr.F90 vec2gp.F90  
writesd.F90

*Files modified(PREPDATA):*

programs/spint.F90

*Files modified(SCRIPTS):*

build/Makefile.root.ifs Makefile.root.ifsaux Makefile.root.prepdata  
gen/mkabs\_an mkabs\_fc mkabs\_prepdata p4\_mklib run\_parallel

*Files modified(TRANS):*

external/trans\_inq.F90  
interface/trans\_inq.h

### **Optimisation of control-vector dot-product**

The computation of the dot-product of control-vectors has been optimized and simplified. A new (more efficient) routine to compute the dot-product of a control vector with an array of control-vectors has been introduced.

*Files modified(ALGOR):*

module/control\_vectors\_base\_mix.F90 control\_vectors\_data\_mix.F90  
control\_vectors\_para\_mod.F90

*Files modified(IFS):*

var/congrad.F90 precondition.F90 sualctv.F90 xforme.F90

### **Improvements for 4D-Var scalability**

- The distribution of spectral fields when reading spectral data has been parallelized
- the distribution of vertical correlation matrices for wavelet Jb has been optimized with the use of OpenMP
- the MPL\_ALLREDUCE function has been changed to use a binary tree construct. The reason for not using MPI\_ALLREDUCE directly for summation is to avoid getting different results depending on the number of OpenMP threads used.

*Files modified(IFS):*

module/iostream\_mix.F90  
utility/gstats\_label\_ifs.F90

var/sujbwavallo.F90

*Files modified(IFSAUX):*

module/mpi\_allreduce\_mod.F90

*Files modified(TRANS):*

dist\_spec\_control\_mod.F90

## Jan Haseler

### Rebuilding the IFS executables in a data assimilation experiment

With the ensemble data assimilation system, it is possible that at any one time, different ensemble members will be running different dates. Because blacklists are date-dependent, ifsMASTER needs to be rebuilt every time that there is a blacklist change. There is now a new task, rebuild.ifs, at the start of the 'an' family. This task compares the blacklists at the current and previous cycles and if there has been a change, it rebuilds IFS and stores the executable as \$BINS/ifsMASTER.\$Basetime. (This used to be done in task vardata and the ifsMASTER did not have a date-tag in its name.) Task rebuild.ifs has an SMS variable, FORCE\_REBUILD, which is false by default. If you have modified your Perforce branch and recompiled the code in the 'make' family, you should set FORCE\_REBUILD=true and rerun rebuild.ifs to rebuild ifsMASTER with your new code. Do not rerun task make/bins/ifs unless you are going back to the 'make' family before the first cycle, because that will have the wrong date-tag. Before each execution of ifsMASTER, the new script get\_exe finds the version of \$BINS/ifsMASTER.\$yyyymmddhh with the most recent date-tag at or before \$Basetime.

*Files created(SCRIPTS):*

gen/copyodb gather\_endaodb get\_exe rebuild\_ifs  
metview/avgtime.f90 plot\_amp\_phase\_clim.met save\_mean\_diurnal\_flux.met  
sms\_an/copyodb.sms gather\_endaodb.sms ifstraj\_999.sms rebuild\_ifs.sms  
sms\_oc/cleantc.sms

*Files modified(SCRIPTS):*

build/Makefile.root.ifs Makefile.root.ifsaux Makefile.root.prepdata  
def/an.def eps\_varfc.def fsobs.def gen.def  
gen/anml anpl ansfc anwave archive\_obs biassave bufr2odb emiskf fdbksave  
fetchmars fetchobs forceinv2clim getgrb getgrbe getini getmars getpersSST  
grib\_def.h ifsgmon ifsmm ifstraj ifstsave ifsvar lowres\_fp ma\_init mkabs\_an  
mkabs\_black mkabs\_fc mkabs\_mctools mkabs\_prepdata mkidta mkidta\_eps mklinks  
model modeleps modelsv obstat obstat\_init p4\_mklib preCleanFDB preobs prereo3  
prescat run\_fp run\_parallel sample\_svs satmon\_getdat sekf\_sm smon\_def soilana  
ssaana sstana var\_include varconsts vardata  
metview/climate\_obs.met climplot\_batch monmeans\_clim.met monmeans\_clim\_batch  
zondia\_seas\_icon\_batch.met  
oce/extrafields\_veps\_create stageini stagemars storm  
sens/J1.sms  
sms/climplot.sms getfcdata.sms getini.sms getiniLeg.sms hl.sms ifs.sms  
inidata.sms intHtoL.sms logfiles.sms mkdir\_edaeps.sms ml.sms mmeans\_ml.sms  
mmeans\_pl.sms mmeans\_sfc.sms model.sms modeleps.sms pertinic.sms pl.sms pt.sms  
pv.sms sfc.sms sv.sms verify.sms wamverify.sms wavini.sms  
sms\_an/4dvar.sms bufr2odb.sms cleanodb.sms create\_ccma.sms  
create\_s2o\_aeolus\_md.sms dobstat.sms ifssv.sms ifssvtraj.sms ifstsave.sms  
lowres.sms makecma.sms makeodb.sms matchup.sms mergeodb.sms odb2bufr.sms

odb\_compress.sms revmatchup.sms sekf.sms simulobs2odb.sms vardata.sms  
sms\_era/get\_obtime.sms  
sms\_oc/mofc\_tools.sms ocvavini.sms sv1.sms svnh.sms  
wav/prep\_wave wave\_find\_stream wave\_getalt wave\_getgrb wave\_getrst wave\_getsar wave\_  
getwind wave\_run wave\_setup wave\_setup\_3v wave\_setup\_4v wave\_setup\_an

*Files deleted(SCRIPTS):*

metview/avgtime.f

## **Other Scripts Modifications**

### **EPS**

*Files modified(SCRIPTS):*

def/eps\_varfc gen/modelsv, sample\_svs sens/J1.sms sms/getiniLeg,.sms,  
mkdir\_edaeps.sms, pertinic.sms sms\_oc/cleantc.sms

### **GRIB\_API**

*Files modified(SCRIPTS):*

build/Makefile.root.ifs, Makefile.root.ifsaux, Makefile.root.prepdata  
def/eps\_varfc.def gen/mkabs\_an, mkabs\_fc, mkabs\_mctools, mkabs\_prepdata,  
p4\_mklib, run\_parallel sms/pertinic.sms

### **MARS syntax**

*Files modified(SCRIPTS):*

oce/stagemars sms/hl.sms, ml.sms, pl.sms, pt.sms, pv.sms, sfc.sms

### **Forecast sensitivity to observations**

*Files modified(SCRIPTS):*

def/fsobs.def

### **Oceansat**

*Files modified(SCRIPTS):*

def/an.def gen/archive\_obs, fetchobs, prescat

### **Ozone**

*Files modified(SCRIPTS):*

gen/fetchobs, prereo3, smon\_def

### **Monitor-only mode**

*Files modified(SCRIPTS):*

def/an.def gen/vardata

### **Monthly forecasting system**

*Files modified(SCRIPTS):*

def/eps\_varfc.def oce/storm sms\_oc/mofc\_tools.sms

### **Model error initial data for 6hr 4D-Var**

*Files modified(SCRIPTS):*

gen/getini



## **Post-process u100 and v100**

### *Files modified(SCRIPTS):*

gen/grib\_def.h, model, modeleps

## **From MetApps**

### *Files modified(SCRIPTS):*

gen/getini, getpersSST, ma\_init, mkidta\_eps, modeleps  
oce/extracfields\_veps\_create wav/wave\_getrst

## **Optimisations**

### *Files modified(SCRIPTS):*

def/an.def gen/bufr2odb, ifsmin, ifstraj, ifsvar, run\_parallel, varconst  
sms\_an/4dvar.sms, ifstraj\_999.sms

## **Clean up compilation**

### *Files modified(SCRIPTS):*

def/gen.def

## **Verify close to real time**

### *Files modified(SCRIPTS):*

sms/verify.sms, wamverify.sms

## **Satellite monitoring**

### *Files modified(SCRIPTS):*

gen/satmon\_getdat

## **Climplot**

### *Files modified(SCRIPTS):*

metview/avgtime.f, avgtime.f90, climate\_obs.met, climplot\_batch,  
monmeans\_clim.met, monmeans\_clim.batch, plot\_amp\_phase\_clim.met,  
save\_mean\_diurnal\_flux.met, zondia\_seas\_icon\_batch.met, sms/climplot.sms,  
mmeans\_ml.sms, mmeans\_pl.sms

## **Hans Hersbach**

### **Prepare for the OceanSAT-2 scatterometer**

#### *Files created(IFS):*

obs\_preproc/iscatin.F90

#### *Files created(ODB):*

bufr2odb/bufr2odb\_iscat.F90 odb2bufr\_dep\_135.F90 odb2bufr\_fos\_135.F90 odb2bufr\_qc\_  
135.F90

#### *Files modified(IFS):*

module/parersca.F90 yomcoctp.F90 yomcosjo.F90 yommkodb.F90 yomnmev.F90  
yomsc.F90 yomthlim.F90  
namelist/namjo.h nammkodb.h namsc.h  
obs\_preproc/decis.F90 defrun.F90 pertobs\_uncorr.F90 repsel.F90 scaqc.F90

scat\_ob.F90 scatsin.F90 sufglim.F90  
op\_obs/hjo.F90  
setup/cmoctmap.F90 su\_events.F90 sucmoctp.F90

*Files modified(ODB):*

cma2odb/buf2cmat\_new.F90 buoctmap.F90 subuoctp.F90  
module/yomboctp.F90  
tools/Bufr2odb.F90

*Files modified(SCAT):*

programs/qscat25to50km.F  
qretrieve/write\_50kmbufr.F

*Files modified(SCRIPTS):*

def/an.def fsobs.def gen.def  
gen/archive\_obs fetchobs prescat

## **Martin Leutbecher**

### **Use of grib\_api in singular vector related code in prepdata**

The code in prepdata that deals with the creation of the initial perturbations from the singular vectors has been revised. The encoding and decoding of fields in GRIB is now based on grib\_api routines. The code has been tested with GRIB\_API\_VERSION=1.8.1 and GRIB edition 1.

In addition, obsolete code has been removed. The number of tasks and threads for task getpersSST has been reduced to  $8 \times 8$ .

*Files created(PREPDATA):*

mc\_tools/add\_pert.F90

*Files modified(PREPDATA):*

mc\_tools/aev\_norm.F90 sv\_gram\_schmidt.F90 sv\_lin\_combi.F90 sv\_poc.F90  
svgp2sp.F90 svsp2gp.F90 te\_norm.F90  
module/svvgg.F90 svtools.F90

*Files modified(SCRIPTS):*

def/eps\_varfc.def  
gen/mkabs\_mctools mkabs\_prepdata sample\_svs  
sms/pertinic.sms

*Files deleted(PREPDATA):*

mc\_tools/comp\_add\_p2c.F90 comp\_combslb.F90 pert\_grib2rpert.F90

## **George Mozdzyński**

### **Updates to the gstats package**

- compute imbalance as a percentage of total wall

- ignore counters 1007 and 1013 when finding unexpected delays
- corrections to some wam counters (missing labels)
- separate trgtol comms use by gpnorm

*Files modified(IFS):*

utility/gstats\_label\_ifs.F90

*Files modified(IFSAUX):*

support/gstats.F90 gstats\_print.F90

*Files modified(TRANS):*

external/gpnorm\_trans.F90 module/tpm\_trans.F90 trgtol\_mod.F90

*Files modified(WAM):*

Wam\_oper/wamassi.F wamodel.F

**Fix for LSLONDEM=false**

*Files modified(IFS):*

parallel/slcomm.F90 slcomm2.F90

**Optimisation to SL communications for 4D-Var minimisations**

This branch is an enhancement to the on-demand SL communication scheme by recognising that SL communications in CALL\_SL\_TL and CALL\_SL\_AD are identical at a given time-step over all minimisations iterations in an ifsmin job step. By identical I refer to the MPI tasks and grid columns communicated in these routines and not the specific data values.

Given this property, in the first minimisation iteration (i.e. NSIM4D=0) we store the on-demand masks at each time-step and also which processors in the SL halo are actually communicated with. This information can then be used for SL communications in subsequent minimisation iterations to obtain all the required fields in a single communication (with the minimum halo) rather than two-stage communication before (stage 1: full halo for U,V,W and stage 2: minimum halo for the rest of the fields).

The improvement in the performance of ifsmin's has been measured at about 3 percent for a T799L91 4D-Var experiment using 128, 256 and 512 tasks (all with 8 threads).

This branch gives identical results to CY36R1 controls for all cases tested. It has also been tested with LRE-PRO4DVAR=T, giving identical results at 128 tasks and 256 tasks (both with 8 threads).

*Files modified(IFS):*

adiab/call\_sl.F90 call\_sl\_ad.F90 call\_sl\_tl.F90 module/yommask.F90 yommp.F90  
parallel/slcomm.F90 slcomm2.F90 slcomm2a.F90 setup/susc2b.F90 utility/deallo.F90

**Improve flexibility in the partitioning of spectral space**

Up till now, NPRTRW could not exceed NSMAX+1, without IFS aborting with the error message 'NPRTRW TOO LARGE FOR SPECTRAL RESOLUTION'.

With this branch the above restriction on partitioning spectral space is removed. This allows any combination of NPRTRW and NPRTRV, where NPROC = NPRTRW x NPRTRV.

This change in particular now permits the partitioning of spectral space in 4D-Var minimisations to be determined by the more significant (in terms of performance) minimisation step resolution rather than (up till now) the lowest wavelet scale resolution (see NSPECRESMIN).

This branch produces identical results to 36R1 controls for an IFS model and 4D-Var ifstraj steps. However, for ifsmin steps, when this branch results in different values for spectral space partitioning (NPRTRW, NPRTRV), then last bit differences will be seen in JO='s as compared with a 36R1 control and in particular when LREPRO4DVAR=F (the default). Of course, if the 36R1 control uses the same values for spectral space partitioning, then JO='s are identical.

For LREPRO4DVAR=T, 4D-Var continues to produce identical results when wave space partitioning is changed, or the number of tasks is changed.

*Files modified(IFS):*

setup/sump.F90 var/sujb.F90

*Files modified(SCRIPTS):*

scripts/gen/ifsmin

*Files modified(TRANS):*

module/sump\_trans\_preleg\_mod.F90

**Improvement to message passing in 4D-Var Rain Assimilation**

*Files modified(IFS):*

module/yommwave.F90

mwave/mwave\_get\_ad.F90 mwave\_get\_tl.F90 mwave\_gp2obs.F90 mwave\_igp2obs.F90

mwave\_iobs2gp.F90 mwave\_nearest.F90 mwave\_obs2gp.F90 mwave\_put\_tl.F90

utility/deallo.F90

**Fix for bug in sujbwavelet message passing**

Fix for an error in the message passing in sujbwavelet.F90 that resulted in ICUTOFFS missing the last word on non-master tasks that was subsequently used in an allocate. The problem occurs on the last JSCALE (=IN-SCALES ) iteration.

This bug appears not to affect results - for a T1279 4D-Var expt with the fix, and JO='s are identical to the control (having the bug).

*Files modified(IFS):*

var/sujbwavelet.F90

**Speed-up of bufr2odb jobs**

Improvement to bufr2odb script by removal of fscheduler.

Some examples. Using a 12-hour incremental 4D-Var expt, full obs, (resolution is irrelevant here), average of 4 runs, times in seconds

b20_conv	control	optimised	saving
npools=256	352	223	129
npools=512	606	391	215
b2o_satob	control	optimised	saving
npools=256	187	100	87
npools=512	233	136	97

*Files modified(SCRIPTS):*

gen/bufr2odb

## **Carol Peubey and Deborah Salmond**

### **Increase ISEC2 dimensions to run satsim at higher resolution**

*Files modified(SATRAD):*

programs/gensatsim.F90

## **Deborah Salmond**

### **Optimisation of LWVDR**

Introduce index instead of IF tests - gives 1% reduction in total runtime for 4D-Var minimisations.

*Files modified(IFS):*

phys\_radi/lwvdr.F90 lwvdrad.F90 lwvdrtl.F90

## **Deborah Salmond and Mats Hamrud**

### **Insert missing deallocates for allocated local arrays**

The Fortran90 standard does not automatically deallocate arrays when they go out of scope. We obtained a significant memory saving in ifsmin steps by inserting deallocates for allocated local arrays where they were missing.

*Files modified(IFS):*

adiab/spcimpfsolvead.F90 control/spcmad.F90 phys\_ec/callpar.F90  
utility/write\_grid\_grib.F90 var/jgvcor.F90 bgevecs.F90 mwave/mwave\_put.F90  
op\_obs/hretr.F90 hoptl.F90 hopad.F90 parallel/gatherspa.F90

## **Tomas Wilhelmsson**

### **Cleaning - add INTENT**

*Files modified(IFS):*

phys\_ec/callpar.F90 ec\_phys\_ad.F90 ec\_phys\_tl.F90 stochadiaten.F90 vdfmainsad.F90

### **Improvement of parallelism for control vector I/O**

*Files created(IFS):*

var/getmini2.F90 savmini2.F90

*Files modified(IFS):*

module/control\_vectors\_comm\_mod.F90  
utility/gstats\_label\_ifs.F90

var/getmini.F90 preppcm.F90 savmini.F90 xforme.F90

### **Improve scalability of the implicit Coriolis solver**

The semi-implicit spectral calculations had limited scalability in the implicit Coriolis configuration (LIMPF=T) since it required all total wave numbers  $n$  to be present within a zonal wave number  $m$ . This branch removes this limitation by rearranging the computations in `spsci` and introducing an extra pair of `trstom`/`trmstos` transposes around the call to the penta-diagonal solver `simplico`.

Only the hydrostatic and non-stretched configuration is affected by this branch. It is not bit-reproducible due to a changed summation-order via the temporary array (PSPAUX).

The non-hydrostatic non-stretched configuration (LNHDYN=T) has been verified to still work.

The stretched configuration (LSIDG=T) should be unaffected, but this has not been tested. That configuration could potentially also be improved in a similar manner.

#### *Files created(IFS):*

adiab/spcimpfinit.F90 spcimpfinitad.F90 spcimpfpost.F90 spcimpfpostad.F90 spcimpfsolve.F90  
spcimpfsolvead.F90

#### *Files modified(IFS):*

adiab/sigamad.F90 spchor.F90 spsci.F90 spsciad.F90 spnhsi.F90 spnhsi\_geogw.F90  
tricsi.F90  
control/scan2m.F90 spcm.F90 spcmad.F90  
module/yomdyn.F90  
parallel/trmtos.F90 trstom.F90  
setup/sudyn.F90  
utility/gstats\_label\_ifs.F90

### **Move RTTOV9 allocations to higher level in IFS**

This branch moves the calls to `rttov_alloc_temp` up to the `radtr*` level using new `rttov_ec_alloc*` interface routines and a `rttov_ec_temp` module.

Furthermore, the `p_cloud` and `p_cfrac` arrays in `rttov_ec` are now automatic instead of allocatable. Additionally, the indices of `pradcldev` and `tau` in `rttov_ec` have been reordered for simplicity.

#### *Files created(SATRAD):*

module/rttov\_ec\_temp.F90  
rttov/rttov\_ec\_alloc.F90 rttov\_ec\_alloc\_ad.F90 rttov\_ec\_alloc\_k.F90  
rttov\_ec\_alloc\_tl.F90

#### *Files modified(IFS):*

op\_obs/co2cldairs.F90 radtr.F90 radtr\_ml.F90 radtr\_ml\_ad.F90 radtr\_ml\_tl.F90  
radtrad.F90 radtrk.F90 radtrtl.F90  
phys\_dmn/mts\_phys.F90

#### *Files modified(SATRAD):*

interface/rttov\_alloc\_temp.h rttov\_check\_temp.h rttov\_ec.h  
programs/gensatim.F90  
rttov/rttov\_ad.F90 rttov\_alloc\_temp.F90 rttov\_check\_temp.F90 rttov\_direct.F90  
rttov\_ec.F90 rttov\_ec\_ad.F90 rttov\_ec\_k.F90 rttov\_ec\_tl.F90 rttov\_k.F90  
rttov\_opdep.F90 rttov\_opdep\_9.F90 rttov\_opdep\_9\_ad.F90 rttov\_opdep\_9\_k.F90  
rttov\_opdep\_9\_tl.F90 rttov\_opdep\_ad.F90 rttov\_opdep\_k.F90 rttov\_opdep\_tl.F90

rttov\_tl.F90 rttov\_transmit.F90 rttov\_transmit\_9\_solar\_ad.F90  
rttov\_transmit\_9\_solar\_k.F90 rttov\_transmit\_ad.F90 rttov\_transmit\_k.F90  
rttov\_transmit\_tl.F90

### **Check for contiguous buffers in MPL routines**

*Files modified(IFS AUX):*

module/mpl\_allgatherv\_mod.F90 mpl\_allreduce\_mod.F90 mpl\_alltoallv\_mod.F90  
mpl\_gatherv\_mod.F90 mpl\_recv\_mod.F90 mpl\_send\_mod.F90

### **Modifications to allow use of more vertical levels**

*Files modified(IFS):*

module/parrrtm.F90 parsrtm.F90  
phys\_ec/vdfvint.F90  
setup/sudim1.F90