RESEARCH DEPARTMENT MEMORANDUM

To:	RD Scientific Staff and Consultants
Copy:	DR, DF, HPS, HES, Alain Joly, John Hodkinson, François Bouyssel, Claude Fischer, Ryad El Khatib, Karim Yessad
From:	Deborah Salmond, Gabor Radnoti, Tomas Wilhelmsson et al.
Date:	August 23, 2016 — File: RD16-146
Subject:	**IFS Memorandum Cycle CY43R1**

CY43R1 was created in March-August 2016

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Merged branch names:

V0: nat_CY42R3_for_43R1_v0, dag_CY42R3_for_43R1_v0 - ESUITE

dag_CY42R1_esuite

nat_CY42R3_OOPS

V1: nat_CY42R3_for_43R1_v1, dag_CY42R3_for_43R1_v1 - BR

dav_CY42R1_EDA_post_process_opt

dav_CY42R1_ERA5_SST_PERT

da7_CY42R1_Jan20_aeol

dipl_CY42R1_no_loadbalance_ccma

dipl_CY42R1_non_repro_seqno

nesl_CY42R1_archiving_upd_with_esuite ! scripts only

nesl_CY42R1_conservSPPT

nar_CY42R1_enkf_for_43r1

net_CY42R1_dev2

nawd_CY42R1_trans_plus_bytes_io

pae_CY42R1_climplot_filt_lxc

pah_CY42R2_clouddiag_sunshine_lightning

nas_CY42R1_NA_FOR_CY43R1

nat_CY42R1_capes_and_satsim

V2: nat_CY42R3_for_43R1_v2, dag_CY42R3_for_43R1_v2 - PASSIVE - notBR

dipl_CY42R1_bitrepro_blacklist

stc_CY42R1_IASI_ATLAS_LAND

stg_CY42R1_allsky_43r1_v2

da7_CY42R3_aeolus_cp_v2_for_43r1

V3: nat_CY42R3_for_43R1_v3, dag_CY42R3_for_43R1_v3 - SATELLITE+ASSIMILATION

ste_CY42R1_lxc_e_diagnosed_R_for_CrIS

str_SB42R2_NEW_V7_SlantPath

stjl_CY42R1_aer_indpdt

dajg_CY42R1_model_error_stratosphere_only

mpi_CY42R1_airep_varbc1

dabi_CY42R3_for43r1

dap_CY42R1_t2m_vertical_struct_Lswitch

mpi_CY41R2_esuite_highres_wigos_fix

V4: nat_CY42R3_for_43R1_v4, dag_CY42R3_for_43R1_v4 - PHYSICS

pas_CY42R1_physf43r1_ABCDrads1

pad_CY42R1_lambdaskin

V5: nat_CY42R3_for_43R1_v5 - BR

das_SB42R3_CLEAN

stkl_CY42R1_add_met11_clean

nes1_CY42R1_esuite_noLSTOPH_iSPPT_conservSPPT_v2

nal_CY42R3_fieldman_1_3

das_CY42R3_NEW (i.e.CY41T1_op1 aka C43)

dae_CY42R1_EDADEVELOP

nar_CY42R1_enkf_for_43r1 -p enkf (again)

das_CY43_OOPS

need_CY43_surface

V6: nat_CY42R3_for_43R1_v6, dag_CY42R3_for_43R1_v6 - OCEAN+WAVE

wab_CY42R1_for_CY43R1_nemo_wam

V7: nat_CY42R3_for_43R1_v7, dag_CY42R3_for_43R1_v7

datk_CY42R1_for_43r1

pah_CY42R1_nexrad_snow_v1

naj_CY42R1_for_CY43R1_8_bug_fix

sthl_CY41R2_esuite_highres_mwhs2 -f defrun.F90

pa3_CY42R1_nam_gwd

nat_CY42R3_remove_budg

nawd_CY42R1_atlas_ders_esuite

wab_CY41R2_fix_grfield

pah_CY42R2_lightning_param_retuning_alpha

V8: nat_CY42R3_for_43R1_v8, dag_CY42R3_for_43R1_v8

nat_CY43_add_ecfftw_project

pafv_CY43_crm

naj_CY42R1_for_CY43R1_8_bug_fix -f tm5_calrates.F90

wab_CY42R1_for_CY43R1_nemo_wam -f z0wave.F

dipl_SB43_for_final_43r1

waa_CY41R2_esuite_highres_grfield_fix -f grfield.F90

nesk_CY41R2_sst_ice_analysis_script_flags

mo3_CY42R1_obstat

dab_CY41R2_memdiagfix

wab_CY42R1_for_CY43R1_nemo_wam -f wgribout.F

nat_CY42R1_ioserver_fix

nat_CY41R2_taskob_fix

V9b: nat_CY42R3_for_43R1_v9b, dag_CY42R3_for_43R1_v9

da7_CY42R1_Apr25_aeol

datk_CY43R1_macc_tweaks

dae_CY42R1_EDADEVELOP_WVFILT

dipl_CY42R1_fix_atms_update

ne1_CY43R1_nemo_esuite

nes1_SB43_for_v9b_SPPTENfix

dab_CY43_nat_CY43_for_43R1_v9b_fdb5

net_CY42R1_newphysics_dev3 -f read_cmip5ghg.F90

mo3_CY42R1_obstat

pah_CY43R1_bufr_screen_nexrad_fix

ne1_CY43R1_ncomp

mo3_CY42R1_obstat

V0: nat_CY43R1_for_43R2_v0, dag_CY42R3_for_43R1_v9

das_CY43_OOPS_V2

day_CY43_spectral_geom

das_SB43_for_fixes

V1: nat_CY43R1_for_43R2_v1, dag_CY42R3_for_43R1_v9

stg_CY43R1_CY43R1_for_43R2_v1

V2: nat_CY43R1_for_43R2_v2, dag_CY42R3_for_43R1_v9 - FINAL

nat_CY43R1_fixes

das_CY43R1_for_43R2_v2

stg_CY43R1_hop_driver

stg_CY43R1_fix_sha256

stg_CY43R1_hsatang_clean

stj_CY43R1_CAMS_test1

wab_CY43R1_new_parameters

stj_CY43R1_CAMS_test3

dism_CY43R1_fc_error

nat_CY43R1_esuite_vp_and_strf

daom_CY43R1_FSPGLH_bug

pah_CY43R1_online_adjoint_test_fix

ATMOSPHERE

- New aerosol climatology based on MACC/CAMS system.
- Updated ozone climatology.
- Scaling of convective mass fluxes for high resolution and change to mass flux limiter.
- Correction to updraught momentum and environment for shallow convection.
- Modification to VDF (turbulent mixing) cloud scheme to remove spurious ice cloud.
- Assimilation of NEXRAD snowfall.
- More up-to-date total solar irradiance value and minor radiation bug fixes.
- Change resolution dependence of non-orographic gravity wave flux from TC-grid (spectral) to TCo-grid (dx).
- More fixes for single precision runs (radiation, surface scheme, stochastic physics,...) (passive).
- 4 new cloud/freezing diagnostics and GRIB parameters for aviation (diagnostic).
- Improved sunshine duration computation and added direct-beam solar radiation as extra output (diagnostic).
- Clean inclusion of super-parametrization (new project crm containing the external code and scripts) (passive).

Physics+Stochastic physics branch - pas_CY42R1_physf43r1_ABCDrad

Pre-merge of the following branches: paab_CY42R1_aertest_CNT paab_CY42R1_bias_corrected_o3 pae_CY42R1_conv pae_CY42R1_nogwd_octah pafv_CY42R1_single_precision parr_CY42R1_radiation_fixes pa1_CY42R1_Layer1_frozenSoil pas_CY42R1_vdfliq pas_CY42R1_newsnowevap pas_CY42R1_cloud_for43r1_passive need_CY42R1_snowML_tech pad_CY42R1_pp_t2m_nolakes nel_CY42R1_sppV2 parr_CY42R1_fix_average_sza

Look at `https://software.ecmwf.int/wiki/display/PAS/Proposed+physics+changes+for+43r1`

Peter Bechtold and Philippe Lopez - pae_CY42R1_conv - ACTIVE

Convection fixes for high resolution, low clouds and momentum

- absolute mass flux limiter including
- scaling (reduction) of fluxes for dx¡ 8 km
- TL/AD version for rescaled mass fluxes
- fix to updraught momentum perturbation (avoiding discontinuity)

- fix to shallow convection parcel, leading to more detrainment and more low level clouds
- code cleaning

Impact: improves general scores for wind/Z for resolutions higher than TCo1279, largely neutral (with slight improvement tropical winds) otherwise increased low-level cloudines and liquid water content in subtropical anticyclones (mainly improvement) but degraded shortwave radiation in these regions

Files created(IFS):

`namelist/nammethox.nam.h`

Files modified(IFS):

`module/yoecumf.F90 yoecumf2.F90 yomphyder.F90`

`namelist/namcumf.nam.h namcumfs.nam.h`

`phys_ec/callpar.F90 cloudsc.F90 cuascn.F90 cubasen.F90 cucalln.F90 cudtdqn.F90 cuflxn.F90 cuinin.F90 cumastrn.F90 cumastrn2.F90 cumastrn2ad.F90 cumastrn2tl.F90 noconvection.F90 phys_arrays_ini.F90 sucumf.F90 sucumf2.F90 sumethox.F90`

Marta Janiskova and Peter Bechtold - pae_CY42R1_nogwd_octah - ACTIVE

Scaling of non-orographic gravity wave momentum fluxes

Scaling has been changed from the spectral truncation scaling to a more general dx (m) scaling for the octahedral grid. The TL/AD version has been upgraded in accordance.

Impact: neutral, by construction of the chosen scaling fit

Files modified(IFS):

`phys_ec/callpar.F90 callparad.F90 callpartl.F90 gwdrag_wms.F90 gwdrag_wmss.F90 gwdrag_wmssad.F90 gwdrag_wmsstl.F90 gwdragwms_layer.F90 gwdragwms_s_layer.F90 sugwwms.F90`

Alessio Bozzo, Johannes Flemming - paab_CY42R1_bias_corrected_o3_BIN - ACTIVE

New Ozone climatology from CAMSiRA reanalysis

Ozone monthly mean climatology from the newest MACC/CAMS reanalysis CAMS iRA. Better agreement with independent climatology. Cooling effect above 10 hPa with positive impact on temperature bias.

Reads the new climatology from the external binary file MOZOCLIM

Testing: climate run: ggne analysis experiment (combined branch): ggam,ggf5 forecast experiment: gfrb (control:gdil)

Files modified(IFS):

`phys_radi/su_mozoclim.F90`

New binary file: ifsdata/MOZOCLIM (currently in cca:/home/rd/paab/TESTDATA_IFS)

Alessio Bozzo - paab_CY42R1_aertest_CNT - PASSIVE

New aerosol climatology

Aerosol climatology based on MACC/CAMS C-IFS. Monthly mean climatology with updated vertical scale-height for each specie, monthly varying for dust. Same type of constant background as used in the Tegen climatology, but raised to 0.05 from the previous 0.03. This branch introduces only technical changes and the new climatology is not yet active.

Testing: forecasts: g0hl (control gh0m) analysis: g0hn, g0hi

Files modified(IFS):

`module/yoerad.F90`

`namelist/naerad.nam.h`

`phys_ec/su_aerv.F90 suecaec.F90`

`phys_radi/radact.F90 radintg.F90 suecrad.F90 surdi15.F90`

Filip Váňa and Robin Hogan - pafv_CY42R1_single_precision - PASSIVE

Single precision modifications

Further modifications ensuring safe single precision execution of forecast and ensemble jobs with results nearly identical to double precision reference up to resolution TL399.

The main changes to be mentioned are:

- Modified way of computing short way radiation (quasi-identical to the original code but no longer need for security limits).
- Integral operator for VFE scheme is always evaluated in double precision.
- More safety to perturbation generator for stochastic physics.
- PBL height computation reverted to double precision.
- More safety in surface scheme and wave model.
- Generalization of IO server with respect to SP/DP usage.

Testing:

Extensive testing in CY41R2 for ENS jobs (TL399/L91) gdea - CY41R2 reference gcmr - double precision with new modifications. gddq - single precision with new modifications. gdgd - as gcmr with activated mass fixer. gdgf - as gddq with activated mass fixer.

Climate runs (TL399/L137): gc7k - reference gcif - double precision with new modifications.

CY42R1 tests (for double precision only) CTRL: gdsz (dag reference for summer DA jobs), EXP: gge5 CTRL: ggdo (dag reference for winter DA jobs), EXP: ggot

Files created(ALGOR):

`external/linalg/minv_8.F90`

Files modified(ALGOR):

`module/random_numbers_mix.F90 spectral_arp_mod.F90`

Files modified(IFS):

`io_serv/io_serv_hdr_grok_size.F90 io_serv_log.F90 io_serv_sync.F90`
`module/iocptdesc_mod.F90 stoph_mix.F90`
`phys_ec/ec_phys_drv.F90 vdfexcu.F90 vdfhghtn.F90`
`phys_radi/radheatn.F90 radintg.F90 srtm_reftra.F90 srtm_vrtqdr.F90`
`setup/surand2.F90 suvertfe1.F90 suvertfe3.F90`

Files modified(SURF):

`module/flakeene_mod.F90 sppcfl_mod.F90 srfsn_lwimp_mod.F90 susflake_mod.F90`

Files modified(WAM):

`Wam_oper/transf2.F`

Richard Forbes and Maike Ahlgrimm - pas_CY42R1_cloud_for43r1_passive - BR

Additional options for cloud inhomogeneity and rain fallspeed

More realistic representation of cloud condensate inhomogeneity based on ARM data (Ahlgrimm and Forbes, 2016). More realistic mass-weighted rain fall speed.

Passive because needs more thorough evaluation before turning on (will be activated at later cycle).

Testing:

TCo639 summer an expt:ggnk (cntl: gdsz) Cycle to check bit identical.

Files modified(IFS):

`module/yoecldp.F90`
`phys_ec/cloud_layer.F90 cloudsc.F90 sucldp.F90`

Richard Forbes - pas_CY42R1_newsnowevap - ACTIVE

Improved formulation of snow sublimation in cloud scheme

Better representation of snowfall sublimation (from stratiform cloud, including convective anvils) based on integration over a specified particle size distribution.

Testing:

TL255 climate expt: ggnu (cntl: gfyw)

TCo639 winter fc expt:ggmo (cntl: ggmu)

TCo639 summer an expt:ggnh (cntl: gdsz)

TCo639 winter an expt:ggnr (cntl: ggdo)

Files modified(IFS):

`phys_ec/cloudsc.F90`

Richard Forbes - pas_CY42R1_vdfliq - ACTIVE

Remove ice from the VDF diagnostic cloud scheme

Reduces spurious ice ”fog” at high latitudes, improving agreement with low cloud cover from CALIPSO and SYNOP data. Also removes spurious diagnosed cloud cover with no condensate near the tropopause.

Neutral impact on large-scale scores, except a slight cooling in the upper tropical troposphere leads to a small increase in mean Z error at 100hPa.

Testing:

TL255 climate expt: gfv8 (cntl: gfyw)

TCo639 winter fc expt:ggmt (cntl: ggmu)

TCo639 summer an expt:gggq (cntl: gdsz)

TCo639 winter an expt:ggkj (cntl: ggdo)

Files modified(IFS):

`phys_ec/vdfmain.F90`

Robin Hogan - parr_CY42R1_radiation_fixes - ACTIVE

Radiation fixes

In approximate order of the magnitude of their effect, this contribution changes the following:

1. The default total solar irradiance has been reduced from the default of 1366 W m^{-2} to closer to 1361 W m^{-2} to agree with the most recent measurements, and the CMIP5 recommended solar cycle is now included into the future. This is achived by setting NHINCSOL=3 in suecrad.F90, which is also the default in ERA5. It can still be overridden by setting NHINCSOL back to 0 in the NAERAD namelist.
2. The integral of incoming solar irradiance over the RRTM-G shortwave bands is 1368.22 W m^{-2}. It has previously been incorrectly assumed to be 1366. In order to change it to the user-requested value, fluxes from the shortwave scheme were divided by 1366 rather than 1368.22, before multiplying by the user-requested value (in srtm_srtm_224gp_mcica.F90). This means that the solar irradiance was around 2.22 W m^{-2} higher than the user requested. Unfortunately, the TOA Solar Irradiance diagnostic is calculated separately so did not pick up the value the model actually used. The new branch divides by the correct number.
3. The cloud generator was seeded poorly from longitude and latitude in a way that resulted in diagonal stripes in the instantaneous fluxes. Changes to mcica_cld_generator.F90 mean that now the seed is unique for almost every 1-km square on the globe.
4. The branch correctly selects the RRTM-G coefficients, not the RRTM coefficients for shortwave band 21 (yoesrta21.F90). Very small change to heating rates.
5. The branch corrects the argument order in the subroutine declaration in rrtm_setcoef_140gp.F90 to match how it is called in rrtm_setcoef_140gp.F90 and rrtm_setcoef_140gp_mcica.F90. This bug effectively meant that molecular oxygen was set to zero in the longwave scheme, but the impact on heating rates is tiny because of the very small role of molecular oxygen in the longwave.

6. (Diagnostic only) Photosynthetically active radiation (PAR) and clear-sky PAR ought to be the surface shortwave downwelling flux in the interval 0.4 to 0.7 microns, but were estimated from the wrong bands (going too far into the near-infrared and stopping in the mid-visible), and the total was too low by around 30%. Now the fraction of the relevant shortwave bands to use have been computed by using line-by-line results from the first case of the Continual Intercomparison of Radiation Codes (CIRC). The effect is that PAR is reduced in clear-skies by around 30%. The new value is around 0.45–0.5 of the total surface shortwave downwelling flux, which is in agreement with the observed range (e.g. Jakovides et al., 2003, Theor. Appl. Climatology).

Testing

1. Very short forecasts have been run to compare the change to instantaneous fluxes in the first radiation timestep (experiment with radiation fixes: ggdn; control: ggdl). These have confirmed the effect of items 1, 2, 3 and 6 above.
2. A 4-member 1-year atmosphere-only climate experiment (ggeo) has been compared to the control (gfyw), and while the net top-of-atmosphere shortwave flux is reduced by 1.0 W m^{-2} and the net surface shortwave flux by 0.6 W m^{-1}, there is no significant change to global-mean skin temperature (increase by 0.007 ± 0.04 K) or 2-m temperature (increase by 0.006 ± 0.04 K), where the error bars were computed assuming each of the four years to be independent samples. There was likewise no significant change to atmospheric temperature.
3. Linus Magnusson has done longer coupled experiment (ggt8, versus control ggkp) and the ocean response allows more of an atmospheric response: there is a slight but widespread cooling of the troposphere (T500 reduced globally by 0.032 K), which is a slight improvement due to the existing tropospheric warm bias.
4. A 15-day analysis has been performed (ggf3) and the impact is neutral.

Files created(IFS): None.

Files modified(IFS):

```
ifs/module/yoesrta21.F90
ifs/phys_radi/mcica_cld_generator.F90
ifs/phys_radi/rrtm_setcoef_140gp.F90
ifs/phys_radi/srtm_srtm_224gp_mcica.F90
ifs/phys_radi/suecrad.F90
```

Martin Leutbecher, Sarah-Jane Lock, Pirkka Ollinaho - nel_CY42R1_sppV2 - BR

Preparation for introducing the SPP scheme

This contribution prepares for the introduction of the Stochastically Perturbed Parameterization scheme (SPP). The scheme represents model uncertainty through stochastic variations of parameters and variables inside the ECMWF physics. It is activated with switch LSPP in namelist NAMSPP. The default setting is LSPP=false.

Testing:

Results are bit-identical with LSPP=false. This has been validated through two cycles of an TCo639 an experiment using the combined physics branch without nel_CY42R1_sppV2 (CTRL: ggzz) and with nel_CY42R1_sppV2 (EXPT: gh1s).

Files created(IFS):
`module/spp_mod.F90`
`namelist/namspp.nam.h`
`phys_ec/evolve_spp.F90 ini_spp.F90`
`setup/get_spp_conf.F90`

Files modified(IFS):
`control/stepo.F90`
`dia/gridpoint_norm.F90`
`module/yomphyder.F90`
`phys_ec/callpar.F90 cloud_layer.F90 cloudsc.F90 convection_layer.F90 cuascn.F90 cubasen.F90 cucalln.F90 cududv.F90 cuentr.F90 cumastrn.F90 ec_phys_drv.F90 turbulence_layer.F90 vdfexcu.F90 vdfmain.F90 vdfouter.F90`
`phys_radi/radact.F90 raddrv.F90 radflux_layer.F90 radheatn.F90 radintg.F90 radlswr.F90`
`setup/su0yomb.F90`

Simon Lang - nesl_CY42R1_archiving_upd_with_esuite - BR

Techical fixes / modifications:

- option to do parallel archiving of ENS fields
- moved wave archiving out of surface archiving (-¿ wave.sms) also for type fc and an (forecast)
- small fixes to lxc not in the esuite branch

Files modified(SCRIPTS):
`def/eps_nemo.def def/fc.def def/inc_fam.py sms/cleanmc.sms sms/cleanvarfc.sms sms/hl.sms sms/ml.sms sms/oml.sms sms/pl.sms sms/pt.sms sms/pv.sms sms/sfc.sms sms/wave.sms sms_oc/cleanocean.sms gen/modeleps_nemo`

Peter Bechtold and Richard Forbes - pae_CY42R1_climplot_filt_lxc - BR

Climplot

Description: upgrade of the climplot package -enable running on lxc -enable model runs for different years -enable mode comparisons with MODIA data and speed up of comparison with reanalysis by having all verification data on $PERM -improved water vapor comparisons -enable computation of zonal mean fluxes and plotting of EP-fluxes -enable additional wavenumber frequency spectra for temperature and wind

Files created(SCRIPTS):
`metview/eddy_corr_epvec.ncl eddy_corr_epvec_scale.ncl spec_filt_nmima`

Files modified(SCRIPTS):
`metview/climate_obs.met climplot_batch eddy_corr.met monmeans_clim.met monmeans_clim_batch plot_eddy_corr.met save_mean_diurnal_flux.met wavediag/ecmwf_collectscript_runonwkdir_new.sh`

wavediag/ecmwf_wk99_analysis_new.py zondia_def_contour zondia_seas_icon_batch.met

sms/check_periods.sms climplot.sms climplot_save.sms compute_pp_cost.sms mmeans_-ml.sms

This is a description of each one of the three contributions contained in our PRE-MERGED branch (for future cycle 43r1):

Pre-merged branch - pah_CY42R2_clouddiag_sunshine_lightning - BR

Some new radiative and cloud diagnostics, as well as the new lightning parameterization.

Testing:

This pre-merged branch does not have any impact on forecasts or analyses. This has been thoroughly checked. The adjoint test is correct and bit identical to the one run with standard 42r2. The post-processing and archiving of all new GRIB fields on MARS has also been successfully tested.

Note however that results from an analysis experiment using the standard ”ifssupport” bundle and another using a custom-built ”ifssupport” will not be bit identical due to some slight differences between libraries (see Gabor for more details about this technical issue).

Peter Bechtold - pae_CY42R2_clouddiag

Changes

Added 4 new GRIB parameters (260109 228046 228047 228048), cleaning of diagnostics. The new GRIB parameters for aviation and freezing diagnostics for Météo-France are: ceiling, convective cloud top height and zero and on-degree wet bulb temperatures. Regrouped all additional cloud diagnostics in routine diag_clouds. Merged with Thomas Wilhelmson bug corrections for bitmap coding (bug introduced in CY42) and cleaning of some surface field coding.

New GRIB parameters: 260109 (CEIL), 228046 (HCCT), 228047 (HBWT0), 228048 (HBWT1).

Files modified(IFS):

adiab/cpedia.F90 postphy.F90

dia/sucddh.F90 sunddh.F90

fullpos/hpos.F90

io_serv/io_serv_suiosctmpl.F90 io_serv_writefld_ec.F90

module/iogride_mod.F90 parfpos.F90 surface_fields_mix.F90 yoecumf.F90 yom_grib_codes.F90 yomafn.F90 yomio_serv.F90 yomphyder.F90 yomppc.F90

namelist/namafn.nam.h

phys_ec/callpar.F90 cloud_layer.F90 diag_clouds.F90 local_arrays_fin.F90 local_arrays_ini.F90 phys_arrays_fin.F90 phys_arrays_ini.F90 postphy_layer.F90 sucumf.F90

setup/su_surf_flds.F90 suafn1.F90 suafn2.F90 suafn3.F90 supp.F90

Files modified(SCRIPTS):

gen/model modeleps modeleps_nemo

Alessio Bozzo - paab_CY42R2_sunshine

Sunshine duration and direct beam solar radiation

Improved computation of the surface direct solar radiation on a plane perpendicular to the Sun's direction (direct beam). This is used in the computation of the sunshine duration. Does not impact the forecast model, diagnostic only. Added the direct beam as diagnostic output under GRIB code 128047

Files modified(IFS):

```
adiab/cpedia.F90 postphy.F90
dia/sucddh.F90 sunddh.F90
fullpos/hpos.F90
module/parfpos.F90 surface_fields_mix.F90 yom_grib_codes.F90 yomafn.F90
yomphyder.F90 yomppc.F90
namelist/namafn.nam.h
phys_ec/callpar.F90 local_arrays_fin.F90 local_arrays_ini.F90
phys_arrays_fin.F90 phys_arrays_ini.F90 postphy_layer.F90
phys_radi/noradiation.F90 radflux_layer.F90 radheatn.F90 radiation_layer.F90
radina.F90 radintg.F90 srtm_spcvrt_mcica.F90
setup/su_surf_flds.F90 suafn1.F90 suafn2.F90 suafn3.F90 supp.F90 suvareps.F90
```

Philippe Lopez - pah_CY42R2_lightning_param_v9

New lightning parameterization

New lightning parameterization (CULIGHT) to calculate lightning flash densities from the following outputs of the convection scheme: CAPE, contents in hydrometeors and convective cloud base height (see Tech Memo 772). The tangent-linear and adjoint versions of CULIGHT have also been coded. Four new GRIB field codes have been added (228050, 228051, 228052, 228053). The computations of NOx emissions by lightning have been moved to a new separate routine (CULINOX). The main switch to activate the lightning scheme is LELIGHT (namelist NAEPHY, default=FALSE). The new namelist parameter NLIMODE allows to choose between the new parameterization (NLIMODE=6, the new default) and a set of older lightning parameterizations (NLIMODE=1,2,3,4,5,7,8, see CULIGHT for details).

New GRIB parameters: 228050 (LITOTI), 228051 (LITOTA), 228052 (LICGI), 228053 (LICGA). New GRIB parameters require grib_api/1.15.0 (or later).

The CAPE (without water loading) computed in CUBASEN and used in CULIGHT was modified.

Files created(IFS):

```
phys_ec/culightad.F90 culighttl.F90 culinox.F90
```

Files created(SCRIPTS):

```
sms/ifs_support.sms
```

Files modified(IFS):

```
adiab/cpedia.F90 postphy.F90
dia/wrmlpp.F90
fullpos/hpos.F90
module/iogride_mod.F90 parfpos.F90 surface_fields_mix.F90 yoephy.F90
```

yom_grib_codes.F90 yomafn.F90 yomphyder.F90 yomppc.F90

namelist/naephy.nam.h

phys_ec/callpar.F90 callparad.F90 callpartl.F90 cubasen.F90 cubasen2.F90 cubasen2ad.F90 cubasen2tl.F90 cucalln2ad.F90 cucalln2tl.F90 culight.F90 cumastrn2.F90 cumastrn2ad.F90 cumastrn2tl.F90 cupdra.F90 cupdraad.F90 cupdratl.F90 lightning_layer.F90 phys_ad.F90 phys_arrays_fin.F90 phys_arrays_ini.F90 phys_tl.F90 postphy_layer.F90

setup/su0phy.F90 su0yomb.F90 su_surf_flds.F90 suafn1.F90 suafn2.F90 suafn3.F90 supp.F90

Files modified(SCRIPTS):

def/an.def enkf.def fsobs.def gen.def inc_libs.py

gen/model

Tim Stockdale - net_CY42R1_dev2 - BR

Improved control of relaxation to external spectral fields, improved specification of INILANDEXPVER, and minor script fixes for type longrange

The IFS has an option to relax the model fields towards values read in from external files. This update allows better control of which fields are read in, and allows the relaxation to be applied only to wavenumbers below a namelist-specified threshold. The ability to restrict the relaxation to restricted geographical domains is retained.

The getini scripts have an option to specify ”INILANDEXPVER” to obtain land surface initial conditions from a separate source. However, use of this can cause errors in soil moisture initial conditions if there is a mis-match between the climate files used by INILANDEXPVER and that used by the source of the upper air data (e.g. ERA Interim). The scripts now have the option to specify INILANDCLIMVERSION separately from INICLIMVERSION, to ensure consist treatment of INILANDEXPVER. The ability to set INILAND-CLIMVERSION should be added to prepIFS.

Several minor fixes are applied to scripts used in type ”longrange”, including the ability to request output suitable for runs creating land surface initial conditions (set INILAND_OUT=true).

Testing:

The modifications and fixes have been tested in relevant ”longrange” experiments. A bit-reproducibility test with and without the branch has been tested in type ”fc”: gh2f (control, using dab_CY42R1_lxc) and gh3c (using net_CY42R1_dev2).

Files modified(IFS):

module/yomrlx.F90

namelist/namrlx.nam.h

setup/surlx.F90

transform/relaxgp.F90

Files modified(SCRIPTS):

gen/getini getrelax

nemo/nemoarc nprepseaice

oce/archive_sfc model_nemoIFS ninoatmos ninosst_atmgrid

sms_oc/cpmodel_nemo.sms sc_tools.sms

Gianpaolo Balsamo and Irina Sandu - pad_CY42R1_lambdaskin - ACTIVE

Reduce night-time summer biases for 2m temperature forecasts as a follow-up investigation from daily reports

Files modified(SURF):
`module/susveg_mod.F90`

Irina Sandu - pa3_CY42R1_nam_gwd - BR

New parameters for Gravity Wave Drag

Files modified(IFS):
`namelist/namgwd.nam.h`
`phys_ec/sugwd.F90`

LAND SURFACE

- Adjustment to the evapotranspiration computation by shutting it down when the first soil layer is frozen.
- Modify land surface coupling coefficients to reduce diurnal cycle T2m errors.
- Post-processing of 2m temperature on land-only tiles (passive).
- Technical infrastructure to support multi-layer snow fields in the surface (passive).
- Flexible multi-layer soil discretisation (passive).

Souhail Boussetta and Gianpaolo Balsamo - pa1_CY42R1_Layer1_frozenSoil - BR

Evapotranspiration revision in frozen soils (Active)

The evapotranspiration is shut-down in presence of superficially frozen-soil (based on first soil layer temperature). This modification has large beneficial impact on near surface temperature and humidity forecasts in Spring and over a large area of Eurasia (around 60N).

Testing:

The testing was extensively done for AN/FC/FL-long simulations and it includes

AN CTRL: ggdo (TCo639), EXPT: gggs (TCo639) CTRL: gdsz (TCo639), EXPT: gggt (TCo639)

FC-long CTRL: gebl (TL255-1-year), EXPT: ggys (TL255-1-year) CTRL: gfyw (TL255-4-year), EXPT: gg59 (TL255-4-year)

FC-HRES CTRL: gg6l (TL1279-JJA), EXPT: gg6k (TL1279-JJA) CTRL: gg7h (TL1279-SON), EXPT: gg7i (TL1279-SON) CTRL: gg7l (TL1279-DJF), EXPT: gg7k (TL1279-DJF) CTRL: gg7r (TL1279-MAM), EXPT: gg7t (TL1279-MAM)

Files modified(SURF):

`surf/module/vsurf_mod.F90 surf/module/vsurfs_mod.F90 surf/module/vsurfsad_mod.F90 surf/module/vsurfstl_mod.F90`

Gianpaolo Balsamo - pad_CY42R1_pp_t2m_nolakes - ACTIVE

Revised 2m forecast post-processing for coast-lines and wet surfaces (Active, Localized)

Enhance representativeness of 2m-temperature/humidity forecasts post-processing on land-only tiles (based on low-vegetation/bare-soil tiles, to be closer to SYNOPs conditions. This avoids using tiles such as lakes/coastal-water or vegetation intercepted-water in the computation of 2m temperature/humidity forecasts, and it is particularly active in coastal regions to reduce temperature/moisture diurnal cycle biases.

Testing:

The testing showed bit-identical atmospheric upper-air fields and is active only on the screen-level post-processing, therefore was limited to HRES FC-only to verify benefit on SYNOP coastal locations. Experiments includes

FC: CTRL: gg5w (TL1279-JJA), EXPT: ggcq (TL1279-JJA) CTRL: ggms (TL1279-DJF), EXPT: gg03 (TL1279-DJF)

Files modified(SURF):

`surf/module/surfexcdriver_ctl_mod.F90`

Emanuel Dutra - need_CY42R1_snowML_tech - BR

Technical changes to accommodate multi-layer snow fields

Create 2D arrays for snow mass, snow temperature, snow density. New prognostic, also 2D, for snow liquid water. Full infrastructure in "surf" and surface model only, including new snow scheme driver routine. In the IFS, only "patched" the calls to the surface routines (surfbc / susurf / surftstp) by creating temporary 2D arrays. New logical "LESNML" controls the activation of the new snow scheme driver, set to .FALSE. by default. Number of snow layer controled by "NCSNEC": currently only NCSNEC=1 works.

Testing:

Forecast only T255 ggau (control) & ggav (experiment) are bit-identical. Analysis gglb is bit identical to gduf (Gabor winter control) in the first 2 cycles.

Files created(SURF):

`module/srfsn_asn_mod.F90 srfsn_driver_mod.F90 srfsn_vgrid_mod.F90 srfsn_webal_mod.F90`

Files modified(IFS):

`module/yoephy.F90 phys_ec/callparad.F90 callpartl.F90 suphec.F90 surfbc_layer.F90 surftstp_layer.F90 phys_radi/radpar.F90 setup/su0phy.F90`

Files modified(SURF):

`external/surfbc.F90 surftstp.F90 susurf.F90 interface/surfbc.h surftstp.h susurf.h module/srfsn_rsn_mod.F90 surfbc_ctl_mod.F90 surftstp_ctl_mod.F90 sussoil_mod.F90 susurf_ctl_mod.F90 yos_soil.F90 offline/driver/callpar1s.F90 driver/cpg1s.F90 driver/netcdf_utils.F90 driver/parkind1.F90 driver/ptrgp1s.F90`

```
driver/rdfvar.F90 driver/rdsupr.F90 driver/su0phy1s.F90 driver/sucdfres.F90
driver/sucdh1s.F90 driver/sudcdf.F90 driver/sudim1s.F90 driver/sufcdf.F90
driver/sugc1s.F90 driver/sugp1s.F90 driver/supcdf.F90 driver/suphec.F90
driver/upddiag.F90 driver/vdfdifh1s.F90 driver/vdfmain1s.F90 driver/wrtclim.F90
driver/wrtdcdf.F90 driver/wrtp1s.F90 driver/wrtpcdf.F90 driver/wrtres.F90
driver/yoephy.F90 driver/yomcdh1s.F90 driver/yomdphy.F90 driver/yomgp1s0.F90
driver/yomgp1s1.F90 driver/yomgp1sa.F90 namelist/namdim1s.h namelist/namphy1s.h
util/abor1.F90 util/mpl_mod_ctl.F90
```

WAVE and OCEAN

- Activation of the LIM2 sea ice model component of NEMO (ICEMOD=2)
- Limitation on the ocean wave spectral steepness for high winds and minor adjustment to the wind input gustiness parametrisation calculation.
- New perturbation strategy for surface fluxes and observations error
- Improvements in ocean observation quality control
- Online calculation of ensemble and temporal statistics
- Extended archive of daily fields and ensemble statistics
- Improved online verification of ocean-only experiments
- Online comparison with SMOS sea-ice thickness.
- Streamline of surface forcing options
- Streamline of ocean observation version options
- Introduction of stability checks for ocean bias correction.

Jean Bidlot, Kristian Mogensen, Sarah Keeley , Magdalena Alonso Balmaseda, Hao Zuo, Steffen Tietsche - wab_CY42R1_for_CY43R1_nemo_wam

NEMO, WAM, SST and Sea Ice

For NEMO, there are many modifications connected to the use of ORCA025 configuration. The sea ice model (LIM2) within NEMO is active. This is a single category dynamic-thermodynamic sea ice model. The sea ice concentration and thickness is given to the IFS every coupling timestep.

Initial import of NEMO version 3.6 has been carried out. This is for future developments only and is not active in CY43R1.

Implementation of the ORAS5 reanalysis:

- New surface forcing perturbation for ocean
- Ocean Observation perturbation

- Modified (bug fixed) ocean observation quality control
- Online calculation of ensemble and temporal statistics
- Extended archive of daily fields and ensemble statistics
- Improved online verification of ocean-only experiments
- Online comparison with SMOS sea-ice thickness.
- Streamline of surface forcing options
- Streamline of ocean observation version options
- Introduction of stability checks for bias correction.

The wave model has two changes with meteorological effect: A minor adjustment to the gustiness parametrisation calculation and a limitation on the wave spectral steepness for high winds.

Technical changes are Update to unstructured grid software. Update to wave data assimilation software as implemented in ERA5 (not activated). Bug fix to Meteo-France physics package. Performance code enhancement as implemented in CY41R2 e-suite. Output of H10 (significant wave height of all waves with period above 10s) as implemented in CY41R2 e-suite. Code clean-up.

The treatment in the IFS of SST when sea ice is present in uncoupled mode was modified to ensure that the input values as obtained from analysis were not modified at step 0.

Testing:

Some brief information on testing e.g.

analysis experiments: CTRL: ggdo (Tco639), EXPT: ggsj (Tco639) (winter case)

CTRL: ggyr (TL639), EXPT: ggy7 (TL639) (summer case)

Files created(IFS):

`dia/ppfidhec.F90`

`nemo/getnemo1way.F90`

Files created(NEMO):

`Check in branch`

Files created(SCRIPTS):

`build/arch/Makefile.in.cca_cdt arch/Makefile.in.cca_gcc arch/Makefile.in.cca_intel arch/Makefile.in.ccb_cdt arch/Makefile.in.ccb_gcc arch/Makefile.in.ccb_intel arch/Makefile.in.lxc_gnu`

`functions.pifs/LOAD_MODULE REMOVE_MODULE_CONFLICTS`

`nemo/nemo_rd_model nemo_rdwam_model ngetmars_blkcldcov_fcst ngetmars_blkfc_fcst ngetmars_blkqtml_fcst ngetmars_blkuv10m_fcst ngetmars_wam_fcst ngetsmosice ngetsstbufr retrieve_omona`

`sms/libxios.sms`

`sms_an/wav_fc_to_an.sms`

`sms_nemo/nemoreshape.sms nemoreshapereg.sms ngetmars_fcst.sms ngetmarswam_fcst.sms prepicenemoclm.sms`

`wav/biascorrection_era5.swh blackwave_era5 wave_fc_to_an`

Files created(WAM):

Alt/uraurt.F

Buoy/altcol.F bsdcol.F stats.F statsc.F statsdir.F statse.F statsi.F statsp.F

Wam_oper/se10mean.F wam_time_routines.F90 z0wave.F

Wam_others/combine_odb_txt.F convert_grbspec.F convert_irishgrb.F convert_to_1dspec.F f4spec.F

module/output_struct.F90 wav_netcdf_fct.F90

Files modified(IFS):

climate/updclie.F90 updnemoocean.F90

control/cnt4.F90 reresf.F90 stepo.F90

dia/posddh.F90 ppsydh.F90

fullpos/scan2m_vpos.F90

io_serv/io_serv_suiosctmpl.F90

module/yoewcou.F90 yommcc.F90

namelist/nammcc.nam.h

nemo/getnemo.F90

oops/allobs_mod.F90

parallel/dresddh.F90

phys_ec/suphec.F90 suwcou.F90 wvcouple.F90 wvxf2gb.F90

setup/su0phy.F90 su0yoma.F90 sufdb.F90 sumcc.F90 sumcclag.F90

utility/gstats_label_ifs.F90

Files modified(IFSAUX):

linux/linux_bind.c

module/fdbsubs_mod.F90

Files modified(NEMO):

Check in branch

Files modified(SCRIPTS):

Check in branch

Files modified(SSA):

sub/sst_analysis.F90

Files modified(TRANS):

module/trgtol_mod.F90 trltog_mod.F90

Files modified(WAM):

Alt/expoint.F

Buoy/Makefile.wam.ibm bsdcol_off_line.F mc_ecmwf_scatter_plot.F mc_ecmwf_stats.F mc_scatter_plot.F mc_scatter_plot_2.F mc_stats.F qcbuoy.F qccbm.F

Wam_oper/Makefile.wam.ibm abort1.F airsea.F altas.F90 buildstress.F cal_second_order_spec.F check.F chesig.F cireduce.F ciwaf.F class_wgrib.F clean_outbs.F closend.F confile.F create_wam_bathymetry.F current2wam.F decode_integrated_parameter.F decode_point_spectra.F ersfile.F fdur.F findb.F fld2wam.F fldinter.F fndprt.F fustar.F fwsea.F getcurr.F getspec.F getstress.F getwnd.F grdata.F grfield.F90 grib2wgrid.F grstname.F gsfile_new.F headbc.F ifstowam.F implsch.F incdate.F init_fieldg.F initialint.F initmdl.F iniwcst.F intspec.F intwaminput.F inwgrib.F jafu.F makegrid.F mbounc.F mbounf.F mboxb.F mcout.F meansqs.F mergesarcor.F mfredir.F mgrid.F micep.F mintf.F mpabort.F

mpbcastintfld.F mpbcastscfld.F mpclose_unit.F mpexchng.F mpfldtoifs.F
mpgatherersfile.F mpgathergrdfld.F mpgatherspp.F mpuserin.F mstart.F mswell.F90
mtabs.F newwind.F notim.F oifield.F out_onegrdpt.F out_onegrdpt_sp.F outbc.F
outbs.F outers.F outgrid.F outint.F outnam.F outpp.F outspp.F outwnorm.F
outwspec.F outxt.F packi.F packr.F peak.F peak_freq.F preproc.F preset.F
prewind.F propag_wam.F propdot.F prspp.F prspps.F readbou.F readcur.F readfl.F
readsat.F readsta.F readstress.F readwgrib.F readwind.F resize_gap_array.F
rfl4wam.F90 rotspec.F runwam.F saras.F savrest.F savspec.F savstress.F sbottom.F
sdiss_ardh_vec.F90 sdissip.F secondhh.F setmarstype.F setwmask.F sinput.F
sinput_ard.F90 skewness.F spectra.F spr.F stress.F stresso.F strspec.F tauhf.F
timin.F topoar.F transpart.F uiprep.F unblkrord.F update.F updatewd.F
updnemostress.F upwspec.F userin.F vmin_d.F vplus_d.F wam2odb.F90
wam_user_clock.F wamadszidl.F wamassi.F wamininemoio.F wamnorm.F wamodel.F
wavemdl.F wdfluxes.F wgribencode.F wgribenout.F wnfluxes.F write_currents.F
write_mpdecomp.F writefl.F writestress.F writsta.F wsigstar.F wsmfen.F
wstream_strg.F

module/parkind_wave.F90 unwam.F90 wav_netcdf.F90 yowcard.F yowcout.F yowfred.F yowintp.F yowmean.F yowpcons.F yowstat.F yowtabl.F yowunpool.F yowwind.F

Files deleted(NEMO):

Check in branch

Files deleted(WAM):

Alt/altcol.F

Wam_oper/analyse.F blsp_usage.F bsdcol.F combine_odb_txt.F convert_grbspec.F convert_irishgrb.F convert_to_1dspec.F crewfn.F exchng.F f4spec.F fillbl.F findb_ice.F getinptb.F getrest.F incint.F ispoff.F locint.F make_blsp2grs.mk makeblo.F makeblos.F makegridb.F makegrids.F mpdistribintfld.F mpgatheroifld.F msort.F mt_allot.F peakfr.F prealloc_file.F setmat.F splitbl.F stats.F statsc.F statsdir.F statse.F statsi.F statsp.F write_grid_description.F

Jean Bidlot - wab_CY43R1_new_parameters - BR

New set of wave model output parameters

The following output parameters have been added to the wave model post processing:

- Wave Energy Flux magnitude
- Wave Energy Flux mean direction
- Significant wave height of all waves with period between 10 and 12 seconds
- Significant wave height of all waves with period between 12 and 14 seconds
- Significant wave height of all waves with period between 14 and 17 seconds
- Significant wave height of all waves with period between 17 and 21 seconds
- Significant wave height of all waves with period between 25 and 30 seconds

DYNAMICS

- 3D limiter for GFL (tracer) variables with consistent tangent-linear and adjoint code (passive under switch, details here).
- Vertical scaling for Bermejo-Conde mass fixer weight to improve CO2, CH4 transport in stratosphere (passive, only affecting CAMS forecast using this fixer).
- Support of an alternative FFT option to FFTW based on Bluestein's algorithm (passive under switch).
- Spectral transform library improvements for post-processing (bit-reproducible)

George Mozdzynski, Michail Diamantakis, Sylvie Malardel - nas_CY42R1_NA_FOR_CY43R1 - PASSIVE

Pre-merge of the contributions from the Numerical Aspects team. This branch is currently passive, but, Michail is waiting for longer validations before deciding to activate or not some of his changes. The NA branch is a merge of 5 individual branches A+B+C+D+E detailled below. Note that Michail's contributions had been merge with dab_CY42R1_lxc, so nas_CY42R1_NA_FOR_CY43R1 also contains dab_CY42R1_lxc modifications.

Testing:

The bit reproducibility has been checked in AN mode with 2 assimilation cycles. The reference ggw0 (rdna2/nas/ecflow) is a copy of ggdo from Gabor. The experiment with the NA branch nas_CY42R1_NA_FOR_CY43R1 is ggxn.

George Mozdzynski and Nils Wedi - mpm_CY42R1_bluestein2 - BR

Support of an alternative FFT option to FFTW.

This branch implements an alternative FFT option to FFTW, using the Bluestein algorithm as described in a paper titled "Bluestein's FFT for Arbitrary N on the Hypercube", Paul N. Swarztrauber et al., Parallel Computing, 17 (1991), pp. 607-617. The purpose of this option is to perform FFTs for latitude lengths which are not supported by FFT992 and where there is NO FFTW library available. It should be noted that FFTW should always be used where performance is required, as it implements in addition to Bluestein other more performant algorithms (e.g. Rader) based on its analysis during plan creation of the specific user FFT requirements. To accomodate this alternative FFT option we have removed LFFT992 from NAMTRANS and added checks in FFT initialisation to determine whether a latitude length is supported by FFT992 i.e. having just prime factors 2, 3 and 5. Of course if LFFTW=true is specified then FFTW will be used for all latitude lengths. So with this approach we maintain bit reproducibility with control experiments whether FFT992 or FFTW are used.

Files created(ALGOR): `external/fourier/fft992_cc.F90 fourier/set99b.F module/bluestein_-mod.F90`

Files modified(IFS): `fullpos/cpfpfilter.F90 sufptrans.F90 module/yomtrans.F90 namelist/namtrans.na obs_preproc/suobscor_resol.F90 phys_radi/suecrad.F90 setup/suecphypo.F90 sutrans.F90 var/sujbwavtrans.F90`

Files modified(IFSAUX): `support/gstats_print.F90`

Files modified(PREPDATA): `programs/gptosp.F90 sptogp.F90 unbal_eda.F90 vod2uv.F90`

Files modified(SCRIPTS): `build/Makefile Makefile.root.ifsaux gen/ifsmin ifstraj mknam_-fp model modeleps_nemo modelsv sekf_sm sms/p4setup.sms`

Files modified(TRANS): `external/setup_trans.F90 trans_end.F90 interface/setup_trans.h module/dealloc_resol_mod.F90 ftdir_mod.F90 ftdirad_mod.F90 ftinv_mod.F90 ftinvad_-mod.F90 set_resol_mod.F90 sufft_mod.F90 tpm_fft.F90`

George Mozdzynski - mpm_CY42R1_rad_halo_calc - BR

Optimisations to reduce the size of halos required for interpolations between model to radiation and radiation to model grids. Tests confirming the correctness of these halos have been run up to 16,384 tasks using LSLDEBUG=T and temporary setting of LLDEBUG=T in suecrad.F90.

Files modified(IFS): `phys_radi/suecrad.F90`

Sylvie Malardel - nas_CY42R1_EZDIAG - BR

Modification in fullpos to be able to output GFL EZDIAG variables

The idea is that the EZDIAG (already existing GFL structure) can be use "on demand" by a user if they need a 3D GP diagnostics in the GP dynamics or in the physics. The user has to "hack" the namelist for that. There will be soon a quick documentation on how to do that at `https://software.ecmwf.int/wiki/display/NA/EZDIAG` .

Files modified(IFS): `module/parfpos.F90 module/yomafn.F90 pp_obs/pos.F90 pp_obs/pos_-prepgfl.F90 setup/suafn1.F90 setup/suafn2.F90 setup/suafn3.F90`

Michail Diamantakis - namd_CY42R1_mfix_scale - BR

Introduce pressure scaling in Bermejo-Conde mass fixer weight.

Testing of the above fixer in CO2, CH4 atmospheric composition forecasts showed that the algorithm was introducing a large correction in the stratosphere. This issue is addressed in this branch introducing a simple scaling of the correction weight.

The branch is merged with dab_CY42R1_lxc to be testable.

List of routines/files changed: *Files modified(IFS):* `control/jmgfixer.F90 qmfixer.F90 qmfixer2.F90 setup/sudefo_gflattr.F90`

Michail Diamantakis - namd_CY42R1_intlimit - BR

An improved 3D limiter for GFL (tracer) variables with consistent tangent-linear and adjoint code

In operational configurations, a limiter is used to prevent cubic interpolation at semi-Lagrangian advection generating new min/max values and negatives. This limiter is quite active and diffusive which for horizontal wind components turns to be beneficial as it reduces excessive kinetic energy. For tracers, the diffusiveness of this limiter may result in increased biases. For such variables the standard 3D Bermejo-Staniforth limiter can be alternatively applied which is available in IFS. However, in the new high resolution system, use of this 3D limiter degrades slightly the accuracy of the 4DVAR tangent-linear model as it results in increased "roughness" of the trajectory. The new 3D limiter introduced in this branch addresses this problem:

- the limiter is a hybrid cubic-linear 3D interpolation scheme i.e. if the 3D cubic interpolant overshoots/undershoots then the 3D linear interpolation result is used which is by nature monotone

- the limiter is less active than the operational one but when is triggered has greater damping than the standard 3D limiter which could be beneficial for 4DVAR. Tests show that it improves the accuracy of the tangent-linear model compared with the standard Bermejo-Staniforth 3D limiter

- a consistent tangent-linear and adjoint code is provided which could be beneficial for the convergence of the 4DVAR system.

This limiter when activated on humidity, cloud fraction and ozone results in a very small increase of the CPU time: for a Tco1279 fc experiment DR_HOOK analysis showed an extra 0.11

The branch is merged with dab_CY42R1_lxc to be testable. Modifications are restricted in ifs project and any other changes are due to lxc branch.

Files created(IFS):
`adiab/laitre_gfl_ad.F90 laitre_gfl_tl.F90`
`interpol/laitriqm3d.F90 laitriqm3dad.F90 laitriqm3dtl.F90`

Files modified(IFS):
`adiab/laitre_gfl.F90 larcinbad.F90 larcinbtl.F90`
`module/yom_ygfl.F90`
`setup/sucslint.F90 sudefo_gflattr.F90 sugfl3.F90`

Sylvie Malardel - nas_CY42R1_ACAD - BR

Cleaning of option for initialisation (under suini)

- N3DINI=0 : read "real case" upper air initial files
- N3DINI=1 : artificial data for bench mark
- N3DINI=2 : idealized test cases which could be run purely from analytic setup computed in suspecg2 and sugridug2 (case which work with NSUPERSEDE=0, i.e. no need to read a file)

A documentation for the idealized test cases available in the IFS is under development at `https://software.ecmwf.int/`

Files modified(IFS): `adiab/cppsolan.F90 adiab/gprh.F90 control/gp_model.F90 fullpos/endpos.F90 module/yomct0.F90 module/yomdyncore.F90 namelist/namdyncore.nam.h phys_ec/noturbulence.F90 phys_ec/sugwd.F90 phys_ec/updtier.F90 phys_radi/radheatn.F90 phys_radi/radozc.F90 phys_radi/suecrad.F90 phys_radi/surdi.F90 pp_obs/apache.F90 setup/gp_sstaqua.F90 setup/modgri setup/su0phy.F90 setup/sucst.F90 setup/sudcmip12_gu.F90 setup/sudcmip12_spec.F90 setup/sudefo vv1.F90 setup/sudyncore.F90 setup/sugeometry.F90 setup/sugridf.F90 setup/sugridu.F90 setup/sugridug2.F90 setup/sumisc_spec.F90 setup/suphy.F90 setup/suspec.F90 setup/suspecg2.F90` setup/susta.F90 setup/sustadlr.F90 setup/suvv1.F90 utility/tsl.F90 utility/updtim.F90

Willem Deconinck, Mats Hamrud, Nils Wedi - nawd_CY42R1_trans_plus_bytes_io - BR

Trans library improvements

Following contributions aid in the retirement of libemos and are bit-reproducible.

- Spectral transforms to latlon grids and staggered latlon grids
- Reading and writing Legendre coefficients to file or memory buffer in case of NPROC==1
- Introduction of bytes_io module in ifsaux to be replacement for pbio (excluding pbbuffr and pbgrib)

Testing:

Some brief information on testing e.g.

Analysis experiment, 2 cycles: CTRL: ggdo (TCO639), EXPT: ggyq (TCO639)

Forecast experiment, 240 hours CTRL: ggys (TL511), EXPT: ggyt (TL511)

All results are bit-reproducible.

Files created(ALGOR):

`module/seefmm_mix.F90 wts500_mod.F90`

Files created(IFSAUX): `bytes_io_mod.F90 sharedmem_mod.F90 transmem_mod.F90`
`programs/test_bytes_io.F90`

`support/bytes_io.c sharedmem.c`

Files created(TRANS):

`external/vordiv_to_uv.F90`

`interface/vordiv_to_uv.h`

`module/cdmap_mod.F90 pre_suleg_mod.F90 read_legpol_mod.F90 tpm_ctl.F90`
`vd2uv_ctl_mod.F90 vd2uv_mod.F90 write_legpol_mod.F90`

`programs/gpscalar_cos.F90 gpwind_cos.F90`

Files modified(ALGOR):

`module/butterfly_alg_mod.F90 interpol_decomp_mod.F90 random_numbers_mix.F90`

Files modified(IFSAUX):

`linux/linux_bind.c`

`module/distio_mix.F90`

Files modified(SCRIPTS):

`build/Makefile.root.ifsaux Makefile.root.trans`

Files modified(TRANS):

`external/dir_trans.F90 inv_trans.F90 setup_trans.F90 trans_end.F90 trans_inq.F90`

`interface/dir_trans.h inv_trans.h setup_trans.h` module/dealloc_resol_mod.F90 fsc_mod.F90 ftinv_ctl_mod.F90 ledir_mod.F90 leinv_mod.F90 ltdir_mod.F90 ltinv_mod.F90 set_resol_mod.F90 setup_geom_mod.F90 suleg_mod.F90 sump_-trans_mod.F90 sustaonl_mod.F90 tpm_fields.F90 tpm_flt.F90 tpm_trans.F90

Files deleted(TRANS):

module/prle1_mod.F90 prle1ad_mod.F90

programs/aatestprog.F90

MODEL UNCERTAINTY

- Global fix for tendency perturbations in SPPT to improve conservation of humidity (active).
- General tidying of stochastic physics code (passive).
- Option for independent random patterns for different processes or groups of processes in SPPT (passive).
- Stochastically Perturbed Parametrisation scheme (SPP, passive).

Simon Lang and Antje Weisheimer - nesl_CY42R1_conservSPPT - BR

Modification to stochastic physics

Files modified(IFS):

module/yomphyder.F90 module/yomspsdt.F90 namelist/namspsdt.nam.h phys_ec/callpar.F90 phys_ec/ec_phys_drv.F90 phys_ec/sppten.F90 phys_ec/spptgfix.F90 phys_ec/stochpert_-layer.F90 setup/suspsdt.F90

Files modified(SCRIPTS):

gen/modeleps_nemo gen/ifstraj gen/model oce/model_nemoIFS

Simon Lang, Sarah-Jane Lock, Antje Weisheimer, Jost von Hardenberg - nes1_CY42R1_esuite_-noLSTOPH_iSPPT_conservSPPT_v2

This contribution merges several changes to the SPPT scheme:

1 — SPPTGFIX

Modification to SPPT: perturbed tendencies are constrained with the unperturbed tendencies (RD Memo in preparation). Switch to activate / deactivate : LSPPTGFIX This element is an active contribution. Results from nesl_CY42R1_conservSPPT are bit reproducible for an analysis experiment and also for EDA and ENS when LSPPTGFIX=.FALSE.

2 — General tidying of SPPT routines and option to enable independent patterns in SPPT, "iSPPT"

Extensive tidying of the SPPT routines, which introduces small changes to all routines that USE YOMSPSDT. Introduces the option for multiple independent perturbation patterns in SPPT: up to 6 independent patterns to perturb outputs from 6 physics parametrisations. The additional patterns are enabled via MPSDT(1:6) in the namelist NAMSPSDT. The default is MPSDT(1:6)=1, i.e. a single pattern, consistent with the current scheme.

This element is a passive contribution. Results with nes1_CY42R1_iSPPT_v2 show bit-identical ENS results when compared to an experiment without iSPPT.

3 — Removes LSTOPH option

Removal of the redundant stochastic physics scheme enabled by LSTOPH. This element is a passive contribution. Results with nes1_CY42R1_DELETE_LSTOPH show bit-identical ENS results when compared to an experiment without the changes.

Testing:

Testing SPPTGFIX: ENS experiments gg8v (CTRL) and gg8x EDA experiments gh17 (CTRL) and gh1j

Testing iSPPT and LSTOPH changes: ENS experiments ghdk (CTRL) and ghdj

Files modified(SCRIPTS):

```
eps/ifsnam.eps_fc.h
gen/ifstraj model modeleps modeleps_nemo
oce/model_nemoIFS model_oceatm
sms/modeleps_nemo.sms modeleps.sms
sms_oc/cpmodel_nemo.sms
```

Files created(IFS):

```
phys_ec/spptgfix.F90
```

Files deleted(IFS):

```
stochadiaten.F90
```

Files modified(IFS):

```
adiab/cpg_drv.F90 cpg.F90
control/cnt4.F90 gp_model.F90 reresf.F90 stepo_oops.F90 stepo.F90
module/stoph_mix.F90 yomphyder.F90 yomrandom_streams.F90 yomspsdt.F90
namelist/namspsdt.nam.h namstoph.nam.h
phys_dmn/apl_arome.F90 mf_phys.F90
phys_ec/callpar.F90 ec_phys_drv.F90 local_state_ini.F90 sppten.F90
stochpert_layer.F90
setup/su0yomb.F90 surand1.F90 surand2.F90 suspsdt.F90
utility/dealmod.F90 wrresf.F90
```

Files modified(SCMEC):

```
dummy/stoph_mix.F90
source/cpg1c.F90
```

ASSIMILATION

- Reintroducing model error forcing in the stratosphere levels 1-44 using a new model error covariance matrix (active).
- Increase in the resolution of EDA variance (SES) calculation to TL399 (active).
- New spectral noise filter for EDA variances (SES) based on TCo639 EDA's (active).

- New climatological covariance matrices based on TCo639 EDA's (active).
- Introduction of OSTIA based SST perturbation in the EDA, from ERA-5 (active).
- Introduction of a vertical structure function in the screen level analysis (active).
- OOPS developments.

Massimo Bonavita, Shoji Hirahara, Simon Lang - dav_CY42R1_ERA5_SST_PERT - ACTIVE - BR with 42r1

ERA5 and EPS SST perturbations: This branch implements: a) new climatological Sea Surface Temperature perturbations developed for ERA5 in the operational EDA; b) SST perturbations derived from the coupled EPS forecast; c) Blended SST perturbations from a) and b) By default option a) is active. Experimentation has shown significantly positive impact in tropospheric scores and improved reliability of the EDA

Testing: CTRL winter: gex9 EXPT winter: gevi CTRL summer: gg9f EXPT summer: ggei

Files created(PREPDATA):
`module/gen_pert_sub.F90`
`programs/gen_pert.F90`

Files modified(IFS):
`module/yomdyn.F90`
`namelist/namdyn.nam.h`
`setup/sudyn.F90 suhdf_ec.F90`

Files modified(SATRAD):
`programs/calc_radiance_fields.F90`

Files modified(SCRIPTS):
`build/arch/Makefile.in.cray_XC30_cce`
`gen/fetchmars mkabs_prepdata sstana`

Files modified(SSA):
`module/yomarrays.F90 yomsst.F90`
`namelist/namssa.nam.h`
`sub/ice_analysis.F90 inisst.F90 reg_to_gg.F90 ssa.F90 sst_analysis.F90`
`util/alloc_mem.F90 field2array.F90 setcomssa.F90`

Massimo Bonavita - dav_CY42R1_EDA_post_process_opt - BR with 42r1

Optimization of EDA post-processing and correction of grib_header bug for control vector error fields

Files modified(PREPDATA):
`programs/Ensemble_Stats.F90 sptogp.F90 unbal_eda.F90`

Files modified(SATRAD): `calc_radiance_fields.F90`

Files modified(SCRIPTS):

def/inc_common.py inc_stream.py
gen/ens_stats_gather ens_stats_mem mkabs_satrad

Testing: TCo639 EDA gfsw

Mats Hamrud and Massimo Bonavita - nar_CY42R1_enkf_for_43r1 - BR

EnKF developments

More EnKF stuff.

Testing:

CTRL: ggzk (TL511), EXPT: ggzm (TL511)

emphFiles modified(ENKF):

module/analysis_mod.F03 comp_kernel_mod.F03 control_mod.F03 covar_local_mod.F03 enkf_-utils.F03 obs_base_mod.F03 obs_constants.F03 obs_distr_mod.F03 state_geometry.F03 state_mod.F03 state_utils.F03 xb_state_mod.F03

Files modified(SCRIPTS):

def/inc_fam.py
gen/enkf_anal ens_precomp fetchmars getxb ifstraj ifsvar obstat postenkf vardata wave_assimtrajs

Jacky Goddard and Mike Fisher - dajg_CY42R1_model_error_stratosphere_only

Reintroducing Model Error Forcing in the Stratosphere Only

Reintroducing model error forcing in the stratosphere levels 1-44 using a new model error covariance matrix (Q). The Q matrix is calculated from the EPS using a sample of ensembles run with identical initial conditions but different realisations of model error.

Testing:

CTRL: gdi0 (Tco1279), EXPT: gef3 (Tco1279)

Files modified(IFS):

transform/spec2grid.F90 spec2gridad.F90

Files modified(SCRIPTS):

gen/mklinks model

Patricia de Rosnay - dap_CY42R1_t2m_vertical_struct_Lswitch

Vertical correlation function for SYNOP screen level analysis

Introduction of a vertical correlation function for the two-meter temperature and relative humidity analyses. It accounts for the vertical distance between the observations and the model grid point, reducing the weight of the stations which are less representative of the model grid point elevation and increasing the weight of the stations closer to the model orography. Following the approach used at CMC, the vertical correlation is expressed as a Gaussian function consistent with that used for snow depth analysis. The branch also accounts for a few technical changes, such as a cleaned fetchobs for the use of IMS snow cover to account for the recent reprocessing that we archived on ECFS in a single place. It is also adapted to cope with cases where few SYNOP observations available before QC without any observation remaining after QC.

Testing:

Tests were conducted as follow using a preliminary branch (dap_CY42R1_t2m_vertical_struct) CTRL: gdsz (Tco639 from dag), EXPT: gg8e (Tco639), period 20150601-20150801 The scores after two months are at: file:///scratch/rd/dap/gg8e_gdsz/index.html

We found a bug in the 42R1 rdx files (in /home/rd/rdx/data/42r1/odb_archive) which did not allow to put the station orography feedback in the ODB in any of the 42R1 experiments. Although it is a a completely passive bug, it was crucial to fix it to enable RD experiments evaluation and monitoring. So, it was fixed and both the control (which also needs to be rerun) and the experiments were set-up as follow:

CTRL: gh9h (Tco639 dag_CY42R1_esuite), EXPT: gh9i (Tco639 dap_CY42R1_t2m_vertical_struct_Lswitch) 20140601-20140930 CTRL: gh9q (Tco639 dag_CY42R1_esuite), EXPT: gh9r (Tco639 dap_CY42R1_t2m_-vertical_struct_Lswitch) 20150601-20150801

For the EXPTs gh9i and gh9r the vertical correlation feedback was used (L_VERT_CORR=.true.) as specified by default in the script ssaana in /vol/ifs/sms Further evaluation results will be provided and a Research memo will be written.

An other test was conducted to ensure that using the L_VERT_CORR=.false. at the script level enables to produce Bit Identical results with the control using the branch dag_CY42R1_esuite: EXPT gh9p (Tco639 dap_-CY42R1_t2m_vertical_struct_Lswitch) 2014060100-2014060112 Results confirm it is BI to the control gh9h for two analysis cycles (also confirming that the other changes , which are technical such as fetchobs cleaning, are passive as expected).

Files modified(SCRIPTS):

```
gen/fetchobs ssaana
```

Files modified(SSA):

```
module/yomssa.F90
namelist/namssa.nam.h
plot/print_summary.F90
sub/inisnw.F90 init2m.F90 oiinc.F90 snow_analysis.F90 t2m_analysis.F90
util/setcomssa.F90
```

Philippe Lopez - branch pah_CY42R1_nexrad_snow_v1

NEXRAD snowfall assimilation

The proposed change consists of the activation of the assimilation of snowfall observations from the NCEP Stage IV (NEXRAD ground-based radars) precipitation composites over the eastern U.S.A.. Since Nov 2011, only rainfall situations have been assimilated in operations. The number of NEXRAD observations assimilated in 4D-Var should therefore substantially increase in winter over the U.S.A., while it will obviously remain unchanged during the warm season. Note that observation error for snowfall is set to half of that for rainfall.

Testing:

This branch has been tested in two TL639 L137 4D-Var winter runs:

15 Dec 2013 –¿ 15 March 2014: ctrl = ggaq ; exper = ggap 15 Dec 2014 –¿ 15 March 2015: ctrl = ges6 ; exper = gery

The overall impact on global scores is relatively small (within 1

Files modified(IFS):
`gbrad/gbrad_put.F90 gbrad_put_tl.F90 gbrad_screen.F90`
`module/yomgbrad.F90`

Massimo Bonavita and Elías Hólm, Mohamed Dahoui - dae_CY42R1_EDADEVELOP

Memory and computational savings in EDA error calculations

This cycle will see an increase in the resolution the EDA variances are calculated at, from TCo159 to TL399. The TCo159 error are effectively just T159 errors due to the way they are calculated. This made it necessary to improve the memory use and computational efficiency of the EDA error calculations.

The message passing was changed in /ifs/obs_preproc/inifger.F90 and /ifs/parallel/commfce2.F90 to accommodate larger error files. Both /prepdata/programs/Ensemble_Stats.F90 and unbal_eda.F90 were partially recoded to reduce memory requirements. The gridtype of the errors has also been changed to that of the first inner loop GTYPEINC_0 (i. e. linear rather than cubic octahedral in current configuration) to save on computation and memory without any loss of accuracy, and this change affects the scripts /scripts/gen/ens_errors, ens_errors_rad, ens_fetch_fields, ens_stats_gather and ens_stats_mem.

A new variable LENS_CAL_PASSIVE is introduced for the EDA to enable monitoring calculation of spread-error for the EDA variances without applying the calibration. This is activated by LENS_CAL=true and LENS_CAL_PASSIVE=true. This configuration will not calculate monitoring for radiances, which requires further optimization of odb file handling. The scripts affected are /scripts/def/inc_stream.py, /scripts/gen/ens_cal_rad, ens_errors and ens_errors_rad.

For 6-hour EDA cycling the way previous wavelet files are fetched needed a minor adjustment in /scripts/gen/fetchmars and varconsts.

In /scripts/gen/obstat an update was needed for the tratment of gbrad for the EDA.

Testing:

This branch has been tested for correctness in a few cycles of EDA (ggq1).

Files modified(IFS): `obs_preproc/inifger.F90 parallel/commfce2.F90`

Files modified(PREPDATA): `programs/Ensemble_Stats.F90 unbal_eda.F90 wm.F90`

Files modified(SCRIPTS): `def/inc_stream.py gen/ens_cal_rad ens_errors ens_errors_rad ens_fetch_fields ens_stats_gather ens_stats_mem fetchmars obstat varconsts`

Elías Hólm and Massimo Bonavita - dae_CY42R1_EDADEVELOP_WVFILT

Wavelet signal-to-noise filtering of control variable variances

The EDA control variable variances (type=ses) are now signal-to-noise filtered with a wavelet filter. This introduces geographic variability (the previous spectral filter was globally constant) and reduces over/undershooting close to strong gradients in the field which was present in the previous spectral filter. For non-control variables (only used for first-guess check) there is no filtering. The signal-to-noise filtering takes place in the EDA variance post-processing in ens_errors. It calls the new programs Wavelet_Decomp.F90, which does a wavelet decomposition of the input variances and Wavelet_Filter.F90, which makes the convolution of the wavelet signal-to-noise filter and the wavelet variances. The original Wavelet_Filter.F90 which included all of the above steps in one routine was found inefficient, but is retained as Wavelet_Filter_IBM.F90 for future development.

Files modified(PREPDATA):
`programs/Wavelet_Filter.F90`

Files modified(SCRIPTS):
`gen/ens_errors mkabs_prepdata`

Files added(PREPDATA):
`programs/Wavelet_Decomp.F90 Wavelet_Filter_IBM.F90`

OOPS

Deborah Salmond, Yannick Trémolet, Alan Geer, Mike Fisher and Olivier Marsden - das_-CY43_OOPS_V2 - BR

Developments and fixes for 3D-Var in OOPS

This entered as branch stg_CY43R1_CY43R1_for_43R2_v1 and was composed of several sub-branches which followed an integration, debugging and development stream by the OOPS team to enable running of 3D-Var from OOPS.

Yannick Trémolet - day_CY43_spectral_geom

Modified constructor of SPECTRAL_FIELDS derived type to take a GEOMETRY argument

Olivier Marsden - daom_CY43_SUPERGOM

Files modified(IFS):
`1283 files - see 343024`

Mike Fisher - dai_CY43_fix_jb_file_skip

Files modified(IFS):
var/sujbwavelet.F90

Mike Fisher - dai_SB43_jb_trajectory

Pass the Jb trajectory as a FIELDS type

Files modified(IFS):
control/cva2.F90 stepo.F90 stepo_oops.F90 stepotl.F90 module/fields_mod.F90 mtraj_mod.F90 oops/error_covariance_3d_mod.F90 fields_io_mod.F90 setup/sufpinif.F90 transform/transinvh.F90

Alan Geer - stg_CY43_supergom

Continued refactoring of observations including supergom - BR

Interpolation from model space to observation space is now fully encapsulated inside the "supergom" object that is created at the top level and passed by argument only to the routines that need it. Many global module dependencies have been removed, especially dependencies on the forecast model. This supports OOPS 3D-Var (and beyond) by allowing flexible use of the GOM interpolation and the observation operator (and their TL and adjoint) as fully encapsulated objects. This has also required cleaning of the first-trajectory screening (e.g. screen, decis and blacklist) so that it uses the same framework as the observation operator: obsop_-sets, supergom and gom_plus. The copy-and-paste duplicated "ecset_thsafe" formerly used in this area has been removed. Also included are: further cleaning of the gom_plus processing; integration with the slant path developments; allow the offline hop_driver test harness to run in TL and adjoint mode; changes to allow Meteo-France code (CANARI, CADAVR) to continue working; new thread internals functions like screen_timeslot and taskob_thread to workaround a Cray multithreading bug that generates severe memory overwrites when Fortran objects are used inside OMP loops with large OMP PRIVATE lists.

Files created(IFS):
module/supergom_class.F90 yomhop_results.F90

obs_preproc/screen_final.F90 screen_timeslot.F90

var/taskob_thread.F90 taskobad_thread.F90 taskobtl_thread.F90

Files modified(IFS):
adiab/gprcpad.F90 gprcptl.F90

canari/cadavr.F90 calver.F90 canari.F90 cancer.F90

control/adjotest.F90 cfcsens2obs.F90 cnt1.F90 cnt2.F90 cnt3.F90 cnt3ad.F90 cnt3tl.F90 cnt4.F90 cnt4ad.F90 cnt4tl.F90 cva1.F90 cva2.F90 forecast_error.F90 scan2m.F90 scan2mad.F90 scan2mtl.F90 sim4d.F90 stepo.F90 stepo_oops.F90 stepoad.F90 stepotl.F90

dfi/dfi3.F90

interpol/slcset.F90

module/gom_mod.F90 gom_plus.F90 obsop_sets.F90 yomct0.F90 yomlocs.F90

obs_preproc/black.F90 blackhat.F90 decis.F90 fgwnd.F90 first.F90 flgtst.F90 gefger.F90 mkglobstab_model.F90 pertobs.F90 pertobs_interchan_corr.F90 pertobs_uncorr.F90 pre_prsta.F90 prech.F90 redsl.F90 repra.F90 screen.F90 sualobs.F90 sugoms.F90 suobsb.F90 verco.F90

oops/allobs_oper_mod.F90 fields_interp_mod.F90 obstraj_mod.F90

op_obs/bgobs.F90 cobs.F90 cobsad.F90 cobsall.F90 cobsallad.F90 cobsalltl.F90 hop.F90 hradp_ml.F90 hradp_ml_ad.F90 hradp_ml_tl.F90 hretr_rad.F90 obsop_conv.F90 obsv.F90 obsvad.F90 obsvtl.F90

phys_dmn/suparar.F90 suphy0.F90

pp_obs/ppnew.F90 ppobsac.F90

programs/hop_driver.F90

setup/suct0.F90

utility/deallo.F90 prtjo.F90

var/adtest.F90 congrad.F90 ecset.F90 taskob.F90 taskobad.F90 taskobtl.F90 vec2gp.F90

Files modified(ODB):

cma2odb/getdb.F90

Files deleted(IFS):

module/yomobset_thsafe.F90

obs_preproc/mkglobstab.F90 mkglobstab_obs.F90 sufger.F90

var/ecset_thsafe.F90

Alan Geer - stg_CY43R1_hop_driver - BR

Allow hop_driver external test harness to work at 43r1

Deal with issues arising from the complicated three-way merge between the OOPS observation operator developments, slant-path radiative transfer and vertical geometry object.

Testing:

CTRL: gk2l (TCo399), EXPT: gkd0 (TCo399) *Files modified(IFS):*
module/supergom_class.F90 programs/hop_driver.F90

Alan Geer - stg_CY43R1_fix_sha256 - BR

Problems in SHA256 driver used by GOM checksum

On small numbers of processors, the GOM storage area becomes larger than size covered by a 4-byte integer. In this situation the SHA256 driver would go into an infinite loop.

Testing:

CTRL: gk2l (TCo399), EXPT: gkcn (TCo399) *Files modified(IFSAUX):*
utilities/sha256_hash.c

Alan Geer and Deborah Salmond - stg_CY43R1_hsatang_clean - BR

Cleaning satellite zenith angle code to help address out-of-bounds errors

Bounds testing revealed issues in the new radiance observation operator code when filling the VarBC special predictor object in the adjoint. This problem was fixed, but it required an improved structure for the satellite zenith angle code, down as far as "hsatang".

Testing:

CTRL: gk2l (TCo399), EXPT: gkb4 (TCo399) *Files modified(IFS):*

```
mwave/mwave_emis.F90 mwave_obsop.F90 mwave_tl.F90 mwave_ad.F90
op_obs/obsop_rad.F90 departure_jo.F90 bgobs.F90 hop.F90 hsatang.F90
hretr_rad.F90 hradp_ml_tl.F90 hradp_ml.F90
```

Tomas Wilhelmsson - nat_CY42R3_OOPS - BR

Refactoring of YGFL for OOPS

OBSERVATIONS

- Updated observation error covariance matrices (with inter-channel error correlations) for IASI and CrIS.
- Updated ozone anchor channels for IASI and CrIS.
- New channel selection for CrIS (going from 77 to 117 channels).
- New aerosol detection scheme (independent from cloud detection) for IR sounders (IASI, AIRS and CrIS).
- Slant-path radiative transfer for all clear-sky sounder radiances.
- Enhanced all-sky capabilities: zenith angles by channel, clear-sky assimilation through all-sky route, more sophisticated observation error model, more consistent diagnostics in ODB (passive).
- Monitoring of radiances from SAPHIR, F-15 SSMI, F-16 & 19 SSMIS, Windsat (passive).
- Improved treatment of zenith angle for GMI humidity channels (passive).
- Capability to treat Meteosat-11 AMVs and ASRs (passive).
- Option to use a global infrared land surface emissivity atlas for IASI (passive).
- Optimisations: added new options which reduce computational cost of observation processing in IFS by another factor of two (related to load balancing of CCMA ODB and seqno assignment).
- Technical change to help with bit-reproducibility testing of new observations.

Reima Eresmaa, Niels Bormann - ste_CY42R1_lxc_e_diagnosed_R_for_CrIS - ACTIVE

Update on IASI and CrIS observation errors

Observation error covariance matrices are updated for the assimilation of IASI and CrIS radiances. The new matrices are based on diagnosed error statistics and they alter the weights given to these radiances significantly. The updated error specification contains explicit treatment for correlated observation errors. Additionally, anchor channels used in the assimilation of ozone-sensitive radiances are changed for both IASI and CrIS, and the number of actively-used CrIS channels is increased from 78 to 118 by a blacklist change.

Testing:

CTRL: gduf (TL639), EXPT: ggnd (TL639)

Files modified(SCRIPTS):

`gen/ifstraj mklinks`

Marco Matricardi and Cristina Lupu - stc_CY42R1_IASI_ATLAS_LAND - PASSIVE

RTTOV-11 Infrared land surface emissivity atlas

Calculations of infrared radiances over land are reliant on a single emissivity value, assumed to be a constant of 0.98 for all wavelengths. The RTTOV-11 infrared emissivity atlas provide monthly climatological land surface emissivity values. The IR atlas may be initialised and called for any IR instrument. The data file for the atlas are available as NetCDF files and were provided by the NWP-SAF. In this branch, the atlas is only called for IASI over land surfaces and it is not activated (i.e., IASI observations are not currently assimilated over land).

Testing: CTRL: gh4b (T639/137L, CY42R1) EXP: gh4c (T639/137L, CY42R1)

Files created(SATRAD):

```
module/mod_iratlas.F90 rttov_hdf_chanprof_io.F90 rttov_hdf_coefs.F90
rttov_hdf_emissivity_io.F90 rttov_hdf_mod.F90 rttov_hdf_opt_param_io.F90
rttov_hdf_options_config_io.F90 rttov_hdf_options_interp_io.F90
rttov_hdf_options_io.F90 rttov_hdf_options_pc_io.F90
rttov_hdf_options_rt_all_io.F90 rttov_hdf_options_rt_ir_io.F90
rttov_hdf_options_rt_mw_io.F90 rttov_hdf_pccomp_io.F90 rttov_hdf_profile_io.F90
rttov_hdf_profiles.F90 rttov_hdf_radiance2_io.F90 rttov_hdf_radiance_io.F90
rttov_hdf_reflectance_io.F90 rttov_hdf_rttov_coef_io.F90
rttov_hdf_rttov_coef_pcc1_io.F90 rttov_hdf_rttov_coef_pcc2_io.F90
rttov_hdf_rttov_coef_pcc_io.F90 rttov_hdf_rttov_fast_coef_io.F90
rttov_hdf_rttov_nlte_coef_io.F90 rttov_hdf_s2m_io.F90 rttov_hdf_sskin_io.F90
rttov_hdf_transmission_io.F90
```

`rttov/hdf/rttov_hdf_load.F90`

Files modified(IFSAUX):

`module/rttov_const.F90`

Files modified(ODB):

`lib/Dummies_netcdf.c`

Files modified(SATRAD):

```
module/mod_rttov_emis_atlas.F90
mwave/mwave_emis_rttov.F90
```

`rttov/emis_atlas/rttov_atlas_setup.F90 emis_atlas/rttov_deallocate_atlas.F90 emis_-atlas/rttov_get_emis.F90 ifs/rttov_ec.F90 ifs/rttov_ec_ad.F90 ifs/rttov_ec_tl.F90 ifs/rttvi.F90`

Files modified(SCRIPTS):

`build/Makefile.root.satrad arch/Makefile.in.cray_XC30_cce`
`gen/mklinks varconsts`
`sms/libs.sms`

Niels Bormann - str_SB42R2_NEW_V7_SlantPath - ACTIVE

Slant path radiative transfer

The developments enable radiative transfer calculations to be based on a slanted path through the atmosphere, taking the viewing geometry from the satellite better into account. This will be active in the next cycle for all clear-sky and overcast sounder radiances (not yet all-sky).

The developments use the 2d-GOM infrastructure initially developed for GPSRO and limb-radiances and consist of the following:

- Addition of a stand-alone routine CALC_GEOM_HEIGHT (and TL and AD) to calculate the geometric height (based on relevant parts from the GPSRO observation operator). This is called from the GOM_-PLUS_FILL routine.
- Modifications to make the viewing information (azimuth and zenith angle) available in the required routines and structures (MKGLOBSTAB_OBS and ECSET-structure, respectively), and to activate the extraction of the 2d-GOMS, ie, a series of profiles which describe the plane that contains the slant-path (in MKGLOBSTAB_OBS using the routine LIMB_PLANE).
- Modifications to make latitude and longitude available in the GOM and GOM-plus structures.
- Addition of a new private routine MAKE_SLANT_PATH (and TL and AD) in the GOM_PLUS module. This takes the 2d-GOM-plus structure, and outputs a 1d-GOM-plus structure containing the profile information interpolated along the slanted path. The output is subsequently used in RTTOV as usual. MAKE_SLANT_PATH is called from the public GOM_PLUS_CREATE routine in the GOM_PLUS module. GOM_PLUS_CREATE is a new routine to handle such modifications to the GOM-plus structure if required. The routine previously called GOM_PLUS_CREATE has been renamed GOMS_PLUS_GET and made into a private routine in the GOM_PLUS module.

Changes are also introduced to B2O_CONVERT_ATOVS and HSATANG, to address differences in the specification of azimuth and zenith angles, respectively.

The slant path radiative transfer calculations are activated by setting NOBSPROFS(7) in the namelist NAMNPROF to a value larger than 1. The number describes the number of profiles used in the 2d-GOM, and the proposed configuration is 6 for ifstraj and 3 for ifsmin.

Testing:

Scientific and part-technical testing of pre-merged branch: Control: gfcb and gfcl (T639) Experiments: gfde and gfdd (T639)

Technical testing of submitted branch: Control: gh4p (T639) Experiment: gh4q (T639)

Files created(IFS):

`pp_obs/calc_geom_height.F90 calc_geom_height_ad.F90 calc_geom_height_tl.F90`

Files created(ODB):

```
ddl.CCMA/ecset_sat.sql
ddl.ECMA/ecset_sat.sql
ddl/ecset_sat.sql
```

Files modified(IFS):

```
module/gom_mod.F90 gom_plus.F90 obsop_sets.F90 yomsats.F90
obs_preproc/limb_plane.F90 mkglobstab.F90 mkglobstab_obs.F90 sugoms.F90
oops/allobs_oper_mod.F90
op_obs/bgobs.F90 hsatang.F90 slint.F90 slintad.F90
var/ecset.F90 taskob.F90 taskobad.F90 taskobtl.F90
```

Files modified(ODB):

```
bufr2odb/b2o_convert_atovs.F90
cma2odb/ctxinitdb.F90 getdb.F90
ddl/mkglobstab_gpsro.sql
```

Files modified(SCRIPTS):

`gen/ifsmin ifstraj`

Alan Geer, Katrin Lonitz and Philippe Chambon - stg_CY42R1_allsky_43r1_v2

All-sky microwave upgrades - passive

This upgrade adds new scientific features to the all-sky system and puts a number of sensors into passive monitoring for the first time. This gives us the possibility to assimilate SAPHIR, Windsat, SSMIS F16, SSMIS F19 and sounding channels on GMI; however, all these new or reinstated sensors are monitored passively (i.e. fail(experimental)) and any decision to assimilate them will be taken separately.

The new scientific possibilities are:

- Ability to simulate zenith angles which vary by channel, which is important for correctly modelling Windsat and the GMI sounding channels
- Option to do clear-sky assimilation of certain channels on an otherwise all-sky sensor
- Option to specify the ”alpha” parameter in the symmetric observation error model, by satellite and by channel - this can be used to tune the amount of total error that is assumed to be ”observation error”
- The report_tbcloud field has been improved so that the all-sky instruments have a standard diagnostic measure of the presence of radiatively active hydrometeors. This field can be used by obstat to select a ”clear-sky” sample for monitoring purposes.

To support these options, the ”mwave_error” files have all been standardised and restructured.

In detail, the sensor changes are:

- SAPHIR has been added for passive monitoring. This is a humidity-sounding sensor with tropical coverage. In the tropics it has an impact equivalent to assimilating several MHS instruments; consequently it is a priority to prepare for possible operational activation.
- SSM/I F15 has been restored to passive monitoring. This old sensor was lost for a few cycles until it was possible to derive the azimuth angle, which is now a required input for RTTOV but was not historically provided with microwave imager data. This is mainly in support of ERA-5 but it also means we can add this sole surviving SSM/I back into the satellite monitoring service, for the benefit of the scientific community.
- SSMIS F16 has been restored to passive monitoring. This instrument is still a potential backup in case of loss of F17, our main all-sky sensor.
- SSMIS F19 has been added to passive monitoring. This is the most recently launched SSMIS, though it has data quality issues.
- GMI humidity sounding channels can now be monitored more accurately due to the improved treatment of zenith angle. This adds the possibility of operational activation of these channels in the future.
- Windsat can be passively monitored for the first time, again due to the improved zenith angle treatment. This sensor is a backup for AMSR2 and GMI. Note that the polarimetric channels will not be monitored.

Testing:

To include the latest available microwave satellites, testing has been run from a period starting 10th October 2015. Testing is not bit reproducible, but it shows there are no scientific changes to the analyses or forecasts.

CTRL: ggg0(TCo639), EXPT: ggpf (TCo639)

Files created(SCRIPTS):

`sms/fc_sens_save_saphir.sms`

`sms_an/archive_saphir.sms b2o_saphir.sms convert_saphir.sms obstat_archive_saphir.sms obstat_saphir.sms pre1crad_saphir.sms`

Files modified(IFS):

`common/yomdb_defs.h yomdb_vars.h`

`module/varbc_allsky.F90 varbc_setup.F90 yommwave.F90`

`mwave/mwave_emis.F90 mwave_get.F90 mwave_get_ad.F90 mwave_get_tl.F90 mwave_obsop.F90 mwave_obsop_ad.F90 mwave_obsop_test.F90 mwave_obsop_tl.F90 mwave_obsop_traj.F90 mwave_read_sat_error.F90 mwave_screen.F90 mwave_setup.F90`

`var/getsatid.F90`

Files modified(ODB):

`bufr2odb/b2o_convert.F90 b2o_convert_atovs.F90 b2o_convert_gmi.F90 b2o_convert_ssmi.F90 b2o_convert_windsat.F90 get_varindex.F90`

`cma2odb/initmdb.F90`

`ddl/radiance.h satbody_allsky.sql`

`module/varindex_module.F90`

`tools/Merge_gmi_swaths.F90`

Files modified(SATRAD):

`interface/obs_az_ang_cal_conic.h`

mwave/mwave_emis_rttov.F90 mwave_obsop_rttov.F90 mwave_obsop_rttov_ad.F90
mwave_obsop_rttov_adtest.F90 mwave_obsop_rttov_tl.F90

programs/bufr_screen_ssmi_1d.F90 obs_az_ang_cal_conic.F90

Files modified(SCRIPTS):

def/inc_obs.py

gen/bufr2odb fetchobs pre1crad_screen premwimg varconsts

Julie Letertre-Danczak - stjl_CY42R1_aer_indpdt - ACTIVE

Aerosol detection for infrared instrument independant of the cloud screening

The code change increase the number of data rejected because of aerosol. The result is not bit-reproducible.

Testing:

The code was tested on 1 month (gfx2, CTRL: gfwx). New tests are running on summer (gh08, CTRL: gh0a) and winter (gh09, CTRL: gh0b). All tests are running on resolution T511

Files created(IFS):

module/yomaerdet.F90

namelist/namaerdet.nam.h

obs_preproc/aerosol_detect_setup.F90

Files modified(IFS):

module/yomclddet.F90

namelist/namclddet.nam.h

obs_preproc/cloud_detect_setup.F90 defrun.F90

op_obs/aerosol_detect.F90 cloud_detect.F90 hretr.F90

Files modified(SCRIPTS):

gen/mklinks varconsts

Lars Isaksen and Hans Hersbach - mpi_CY42R1_airep_varbc1 - ACTIVE

Introducing temperature bias correction of AIREP (codetype 141) aircraft observations)

Until now we have not applied temperature bias correction for the old-style AIREP (Codetype=141) aircraft observations. The varBC code has been fixed. All AIREP are bias corrected together, as we have no flight identifier for this old-style data. It has been found better to do this bulk bias correction, rather than not doing a bias correction at all. This correction will be activated in CY43R1. It will led to improved fit to aircraft data and a consistent bias correction between various aircraft types. It will mainly affect the analysis in the North Atlantic at flight level on the routes between Europe and USA.

Testing:

Some brief information on testing e.g.

CTRL: ggdo (TCo639), EXPT: ggnz (TCo639)

Files modified(IFS):

```
module/varbc_airep.F90 varbc_pred.F90
```

Files modified(ODB):

```
ddl/getairepid.sql
```

Bruce Ingleby - dabi_CY42R1_for43r1a

Minor change: use Sonntag formula for background humidity

1. Add Sonntag function (FOELSON) to fcttre.func.h called indirectly by ppobsa (radiosondes and aircraft) and ppobsas (surface). This means that the background RH is consistent with the obs* (and the Jo statistics for H are slightly improved), it doesn't affect the q statistics. Radiosonde/aircraft RH are not assimilated so this doesn't affect the ifsmin statistics (but could affect the assimilation indirectly via the bias correction). Surface RH2 is assimilated, but the impact will be quite small (the biggest difference between the Sonntag and Buck equations is below -40C). * Note. At 42r1 there was a COPE change to use the Sonntag function in conversions of in situ humidity observations - this change makes the background RH as used in the JO statistics and ODB consistent. Discussed with Elias Holm and others.

Testing:

Some brief information on testing

CTRL: gglq (TL639), EXPT: ggdo (TL639)

There was also limited testing of change 2 in 2014.

Files modified(IFS):

```
adiab/gprh.F90 function/fcttre.func.h module/yomobs.F90 namelist/namobs.nam.h
obs_preproc/prech.F90 op_obs/hop.F90 pp_obs/ppobsa.F90 pp_obs/ppobsas.F90
pp_obs/pprh.F90 pp_obs/pprh2m.F90
```

Michael Rennie - da7_CY42R1_Jan20_aeol and da7_CY42R1_Apr25_aeol - BR

Aeolus L2B/C processing and L2/Met PF scripting changes

An update of the aeolus project code i.e. Aeolus L2B/C processing software, to a pre-version 2.30 release. A number of modifications to ecflow suite definitions regarding the Aeolus processing chain.

Testing:

A bit-reproducibility test was passed with Aeolus switched "off". 2 cycles 2014/12/01 (00 and 12): Control: da7/gh3f, T511, LWDA, CY42R1 using dab_CY42R1_lxc scripts Experiment: da7/gh3z, T511, LWDA, CY42R1 using da7_CY42R1_Jan20_aeol scripts

Have also successfully tested Aeolus switched "on" i.e. the L2B/C processing and Aeolus assimilation works (using a L1B test dataset provided by ESA) in various experiments.

Note the following comparison is to dab_CY42R1_lxc from 16/11/2015 (apparently dab_CY42R1_lxc has changed since that date, which confuses things a little).

Files created(SCRIPTS):

```
gen/L1B_GT2odb2 fetch_GRND_TRACK l2b_bufr_to_odb transfer_auxmet
sms_an/L2B_BUFR_to_ODB.ecf fetch_GRND_TRACK.ecf transfer_auxmet.ecf
```

Files modified(SCRIPTS):

```
build/Makefile.root.aeolus
def/aeolus.py inc_libs.py inc_obs.py
gen/L1B_gtt2odb2 aeolus_archive aeolus_auxmet_odb aeolus_l2b_parallel
aeolus_l2b_prepare aeolus_l2b_tidy aeolus_l2c aeolus_l2c_getodb
fetch_L2BP_inputs fetchobs fetchorbpre get_external_l2b_odb gtt gtt2simulobs
mkabs_aeolus odb2odb1 varconsts
sms_an/l1b_pred_orb2odb.sms
```

comparison to aeolus project of CY42R1: q2 find_files -m -p aeolus

Files created(AEOLUS):

```
AMD_file_handling/Convert_E2S_xml_profile_to_AMD.F90
BUFR_file_handling/L2B_bufr2odb.F90 Makefile.aeolus.odb_test l1b_bufrutil.F90
l2b_bufr_and_odb.F90
BUFR_tables/B0000000000098026002.TXT D0000000000098026002.TXT
OpticalProperties/whocallswho_opt_prop.txt
Scripts/parse_test_make_system_results.py
ThinLayer/Processor_Configuration_IPF2B_L1B_L2B.xml
auxiliary/dummyauxiliarymodule.F90
groundtrack/convert_gt_hdr.py
templates/JobOrder.template_l2b_processor_and_l2b_ee2bufr_and_repgen.xml
```

Files modified(AEOLUS):

```
See branch
```

Files deleted(AEOLUS):

```
See branch
```

Katie Lean and Julie Letertre-Danczak - stkl_CY42R1_add_met11_clean - BR

Addition of Meteosat-11 AMV and CSR processing

The code change allows processing of Meteosat-11 AMVs and CSRs when the data are available (either passively or actively when appropriate blacklist changes are in place) and is a bit reproducible change when no data are present. The satellite is currently in in-orbit storage, as backup for Meteosat-10, so this is currently a passive change in preparation of future use of the data.

Testing: Branch with code changes: stkl_CY42R1_add_met11_clean Control branch: stkl_CY42R1_control_-for_met11_code_addition

Control: ghi1 (no Met-11 data available). New blacklist file: ec:/stjl/blacklists/black_ds2016020400_42r1_-Met11_out ensures Met-11 will not be used if data are received unexpectedly. This blacklist will be submitted for operational use.

Experiments: ghj7 (no Met-11 data available, test blacklist puts Met -11 AMV and CSR in passive mode if present): bit reproducible with ghi1 ghj8 (Met-11 test data present, blacklist puts Met-11 in passive mode): no met-11 data processed as no code is in place to retrieve pre-operational data

Further testing was conducted with code present in fetchobs to allow retrieval of Met-11 data for testing. Note: final code version does not include changes to fetchobs as data are pre-operational and should not be used: ghi3 (no Met-11 data available, blacklist puts Met-11 in passive mode): bit reproducible with ghi1

ghfb (Met-11 data present, blacklist puts Met-11 in passive mode): data available for monitoring ghh9 (Met-11 data present, blacklist puts Met-11 in active mode): data successfully assimilated

Files modified(IFS): `var/getsatid.F90` *Files modified(ODB):* `bufr2odb/b2o_convert_asr.F90` `satobfreq.F90` `cma2odb/map_reportype.F90` *Files modified(SCRIPTS):* `gen/mklinks pregeos`

Tomas Kral, Bruce Ingleby, and Marijana Crepulja - datk_CY42R1_for_43r1 - ACTIVE - fix in TEMP obs errors

Support for new BUFR buoy format

It was only in July 2015 that the new BUFR templates for drifting and moored buoys were officially approved and a few months later we started receiving reports. E-SURFMAR/CLS intend to stop sending alphanumeric FM18 reports in March. This timescale is shorter than we would like, but given the importance of surface pressure reports from drifting buoys to NWP we cannot afford to loose the data temporarily. Both on the GTS and in the ECMWF system there has been some confusion/mixing-up of drifting and moored buoys, the new templates make the distinction clearer.

This branch also contains fix for mobile TEMP observations where prescribed obs. errors for T, u, and v were not being correctly assigned.

Other minor technical changes:

- Remove obsolete libcope.ecf build script from 'make' family (now superseded by ifs_support.ecf) - Loading radiosonde bias database in the screening is not necesserry when LCOPE=true. This is now switched off via a namelist. - Consolidate the setup of ODB environment variables [ODB-211]

Testing:

bit-reproducibility test (for mobile TEMPs): CTRL: gh5d, EXPT: gh5s

Further tests of duplicate checks and Ps bias correction, for new BUFR buoy data, were done independently by Bruce and Marijana.

Files created(ODB):

```
bufr2odb/b2o_convert_acars.F90 b2o_convert_airep.F90 b2o_convert_amdar_wigos.F90
b2o_convert_buoy_drifting.F90 b2o_convert_buoy_moored.F90 b2o_convert_tamdar.F90
tools/Odbcompress.F90 odbversion.c
```

Files created(SCRIPTS):

```
build/arch/Makefile.in.cca_cdt arch/Makefile.in.cca_gcc
arch/Makefile.in.cca_intel arch/Makefile.in.ccb_cdt arch/Makefile.in.ccb_gcc
arch/Makefile.in.ccb_intel arch/Makefile.in.lxc_gnu
functions.pifs/LOAD_MODULE REMOVE_MODULE_CONFLICTS
sms/ifs_support.sms
```

Files modified(IFS):

```
module/yomcoctp.F90
obs_preproc/redgl_no_sq.F90
```

`setup/cmoctmap.F90 cmoctmap_inv.F90`

Files modified(ODB):

`bufr2odb/b2o_access.F90 b2o_amend.F90 b2o_convert.F90 b2o_convert_asr.F90 b2o_convert_atms.F90 b2o_convert_cris.F90 b2o_convert_gch2.F90 b2o_convert_gch3.F90 b2o_convert_gch4.F90 b2o_convert_gch5.F90 b2o_conve rt_gmi.F90 b2o_convert_ims.F90 b2o_convert_iscat.F90 b2o_convert_metar.F90 b2o_convert_oscat.F90 b2o_convert_pilot.F90 b2o_convert_qscat.F90 b2o_convert_radio_lat_long.F90 b2o_convert_rain_gauges.F90 b2o_conve rt_rain_rates.F90 b2o_convert_reo3.F90 b2o_convert_satob.F90 b2o_convert_scat.F90 b2o_convert_snow.F90 b2o_convert_synop_land.F90 b2o_convert_synop_ship.F90 b2o_convert_temp.F90 b2o_convert_temp_hires.F90 b2o_ convert_windprofiler.F90 b2o_decode.F90 b2o_handle.F90 get_varindex.F90`

`cma2odb/obsproc_init.F90`

`module/b2o_internal.F90 odbmap_reportype.F90`

`scripts/odb_compress`

`tools/Ps_bias_correction.F90`

Files modified(SCRIPTS):

`See branch`

Files deleted(ODB):

`bufr2odb/b2o_convert_aircraft.F90`

`tools/Odb_compress.F90 odb_version.c`

Files deleted(SCRIPTS):

`gen/mkabs_cope odbclean odbcomp odbf90 odbgunzip odbgzip odbmerge odbprune`

`sms/copetools.sms`

Lars Isaksen - mpi_CY41R2_esuite_highres_wigos_fix - ACTIVE

Fix for increase in AMDAR aircraft temperature biases Corrected error in the implementation of WIGOS AMDAR (done in Nov 2014) in the IFS. Data from new WIGOS AMDAR aircraft identifiers are not bias corrected, only the WIGOS AMDAR aircraft that were available as AMDAR in November 2014 are bias corrected. The error was therefore not spotted in the testing pre Nov 2014. Recently we have received a large amount of new WIGOS AMDAR aircraft data, so now 25AMDAR (or 12can see the effect on attached plots.

Files modified(ODB):

`ddl/getairepid.sql`

TECHNICAL

Tomas Wilhelmsson - nat_CY42R1_capes_and_satsim - BR

Satim

Enable production of global simulated satellite images for geostationary sensors with cloudy brightness temperatures (clbt, 260510) and/or clear brightness temperatures (csbt, 260511). Instrument is selected with new variables MFPSAT in NAMFPC using format SSSCCC where SSS is Satellite Id, and CCC is channel number.

Also enables post processing of cape shear (capes, 228044), 10 meter wind speed (10si, 207) and 100 meter wind speed (100si, 228249).

Tomas Wilhelmsson - nat_CY43R1_esuite_vp_and_strf

Enable post processing of stream function (strf) and velocity potential (vp).

Files modified(IFS):
`module/yom_grib_codes.F90 setup/suafn1.F90`

ESUITE

Gabor Radnoti - dag_CY42R1_esuite - ACTIVE

Catch-up of Esuite

Based on dag_CY41R2_esuite_highres as is used in operations

OPTIMISATION

Peter Lean - dipl_CY42R1_no_loadbalance_ccma - BR

Add option to turn off load balancing of CCMA in first trajectory

Observations in ODB are partitioned into separate pools of data, spread across MPI tasks. Load balancing ensures that each pool has approximately the same number of observations of each type, in each 4D-Var timeslot. Load balancing is currently performed during bufr2odb during the creation of the ECMA. However, at the end of the first trajectory, the data are load balanced a second time during the creation of the CCMA.

Code profiling has revealed that the load balancing procedure performed in IFS is one of the most costly things that happens in the observation processing chain. Currently, the cost of the load balancing process is more than the time savings it provides.

This branch adds an option to turn off the load balancing of the CCMA using the environment variable switch: export ODB_LOADBALANCE_CCMA=0

The default setting in this branch leaves the load balancing turned on.

Once activated, this change, together with others submitted in 43r1, halve the overall computational cost of observations in the first trajectory.

Testing:

CTRL: ggit (TCo639), EXPT: ggiu (TCo639)

Files created(ODB):
`ddl.CCMA/getactive_gnssro_body.sql getactive_hdr2allsky_body.sql getactive_hdr2auxiliary_body.sql getactive_hdr2gbrad_body.sql`

getactive_hdr2gnssro_body.sql getactive_hdr2radar_body.sql getactive_hdr2raingg_body.sql getactive_hdr2scatt_body.sql

ddl.ECMA/getactive_allsky.sql getactive_allsky_body.sql getactive_auxiliary.sql getactive_body.sql getactive_cloud_sink.sql getactive_collocated_imager_information.sql getactive_conv.sql getactive_conv_body.sql getactive_errstat.sql getactive_gbrad.sql getactive_gbrad_body.sql getactive_gnssro.sql getactive_gnssro_body.sql getactive_hdr.sql getactive_hdr2allsky_body.sql getactive_hdr2auxiliary_body.sql getactive_hdr2body.sql getactive_hdr2conv_body.sql getactive_hdr2gbrad_body.sql getactive_hdr2gnssro_body.sql getactive_hdr2radar_body.sql getactive_hdr2radiance_body.sql getactive_hdr2raingg_body.sql getactive_hdr2scatt_body.sql getactive_index.sql getactive_limb.sql getactive_modsurf.sql getactive_radar.sql getactive_radar_body.sql getactive_radar_station.sql getactive_radiance.sql getactive_radiance_body.sql getactive_raingg.sql getactive_raingg_body.sql getactive_resat.sql getactive_resat_averaging_kernel.sql getactive_sat.sql getactive_satob.sql getactive_scatt.sql getactive_scatt_body.sql getactive_smos.sql getactive_ssmi.sql getactive_ssmi_body.sql getactive_update_1.sql getactive_update_2.sql getactive_update_3.sql

ddl/getactive_allsky.sql getactive_allsky_body.sql getactive_auxiliary.sql getactive_-body.sql getactive_cloud_sink.sql getactive_collocated_imager_information.sql getactive_-conv.sql getactive_conv_body.sql getactive_errstat.sql getactive_gbrad.sql getactive_-gbrad_body.sql getactive_gnssro.sql getactive_gnssro_body.sql getactive_hdr.sql getactive_-hdr2allsky_body.sql getactive_hdr2auxiliary_body.sql getactive_hdr2body.sql getactive_-hdr2conv_body.sql getactive_hdr2gbrad_body.sql getactive_hdr2gnssro_body.sql getactive_-hdr2radar_body.sql getactive_hdr2radiance_body.sql getactive_hdr2raingg_body.sql getactive_-hdr2resat_averaging_kernel.sql getactive_hdr2scatt_body.sql getactive_index.sql getactive_-limb.sql getactive_modsurf.sql getactive_radar.sql getactive_radar_body.sql getactive_-radar_station.sql getactive_radiance.sql getactive_radiance_body.sql getactive_raingg.sql getactive_raingg_body.sql getactive_resat.sql getactive_resat_averaging_kernel.sql getactive_sat.sql getactive_satob.sql getactive_scatt.sql getactive_scatt_body.sql getactive_smos.sql getactive_ssmi.sql getactive_ssmi_body.sql getactive_update.sql getactive_update_1.sql getactive_update_2.sql getactive_update_3.sql

Files modified(ODB):

cma2odb/ctxinitdb.F90 getdb.F90 shuffle_odb.F90 shuffledb.F90 xchangedatadb.F90

interface/shuffledb.h xchangedatadb.h

Files modified(SCRIPTS):

gen/ifstraj

Peter Lean - dipl_CY42R1_non_repro_seqno - BR

Add new, faster ODB sequence number assignment method

In ODB, each observation report is assigned a unique identifying sequence number (seqno@hdr) during the first trajectory. Code profiling revealed that the default method of doing this was relatively expensive and so a simpler, faster method of assigning these numbers has been added which doesn't involve as much MPI communication between tasks.

The current assignment method is designed to give reproducible results regardless of the number of MPI tasks that the experiment is running on. The new option is much faster, but does not provide reproducible results when changing the number of tasks.

This branch leaves the default seqno assignment method unchanged. The new method can be activated by setting: export ODB_REPRODUCIBLE_SEQNO=-1

Testing:

CTRL: ggit (TCo639), EXPT: ggiv (TCo639)

Files created(ODB):
`ddl.CCMA/non_reprod_seqno.sql`
`ddl.ECMA/non_reprod_seqno.sql`
`ddl/non_reprod_seqno.sql`

Files modified(ODB):
`cma2odb/ctxinitdb.F90 reprod_seqno.F90`

Peter Lean - dipl_CY42R1_bitrepro_blacklist - not BR - PASSIVE

Technical change to help with bit-reproducibility testing of new observations

When new observations are added to the system, technical tests are often performed where the new data are blacklisted ("fail constant") to check that their code changes don't have any impacts when the new observations are excluded. However, in certain configurations this process did not provide bit-identical results, as the order of the observations in the CCMA was changed by the presence of the new observations in the ECMA. This situation only occurs when data from a new source is being added to an existing ECMA.¡obsgroup¿, and results in the pooling of the existing observations being changed during the load balancing step.

This branch sorts the observations during the creation of the CCMA so that the order is always identical in these situations.

Testing:

CTRL: ggit (TCo639), EXPT: ggiw (TCo639)

The results are not bit-reproducible, however as the change only involved re-ordering the observations in the CCMA, no meteorological impact is expected.

26 days of experimentation have completed (so far). IVER first guess departure statistics show broadly neutral impacts at t+12h.

See IVER results on brynhild: file:///var/run/media/dipl/hugetmp/iver/plots/ORDERBY_SEQNO_IN_SHUFFLE/index.html

The experiment is too short to show statistically significant forecast impacts, but none are expected from this relatively minor change.

Timing impacts: Very slight increase in first trajectory runtime (approx 2s) Average Total 4D-Var: ggiw: 4420.8s ggit: 4420.6s

Files modified(ODB): `ddl/obsort_allsky.sql obsort_allsky_body.sql obsort_auxiliary.sql obsort_body.sql obsort_cloud_sink.sql obsort_collocated_imager_information.sql obsort_conv.sql obsort_conv_body.sql obsort_errstat.sql obsort_gbrad.sql obsort_gbrad_body.sql` obsort_gnssro.sql obsort_gnssro_body.sql obsort_hdr.sql obsort_hdr2allsky_body.sql obsort_hdr2auxiliary_body.sql obsort_hdr2body.sql obsort_hdr2conv_body.sql obsort_-hdr2gbrad_body.sql obsort_hdr2gnssro_body.sql obsort_hdr2radar_body.sql obsort_hdr2radiance_-body.sql obsort_hdr2raingg_body.sql obsort_hdr2resat_averaging_kernel.sql obsort_-hdr2scatt_body.sql obsort_index.sql obsort_limb.sql obsort_modsurf.sql obsort_radar.sql obsort_radar_body.sql obsort_radar_station.sql obsort_radiance.sql obsort_radiance_-body.sql obsort_raingg.sql obsort_raingg_body.sql obsort_resat.sql obsort_resat_-averaging_kernel.sql obsort_sat.sql obsort_satob.sql obsort_scatt.sql obsort_scatt_-body.sql obsort_smos.sql obsort_ssmi.sql obsort_ssmi_body.sql obsort_update.sql obsort_-update_1.sql obsort_update_2.sql obsort_update_3.sql obsortca_auxiliary.sql obsortca_-body.sql obsortca_errstat.sql obsortca_hdr.sql obsortca_hdr2auxiliary_body.sql obsortca_-hdr2body.sql obsortca_index.sql obsortca_update_1.sql obsortca_update_2.sql obsortca_-update_3.sql

Kristian Mogensen and Marcin Chrust - ne1_CY43R1_nemo_esuite

MPI optimizations and I/O optimizations for NEMO

The halo exchange in NEMO version 3.4 has been optimized based on work done for NEMOVAR. Optimizations for netCDF output to avoid redefining the metadata.

Files modified(nemo):
`See the branch.`

CAMS

Anna Agusti-Panareda, Angela Benedetti, Antje Innes, Francesca Di Giuseppe, Johannes Flemming, Mark Parrington, Richard Engelen, Samuel Remy, Sebastien Massart, Victor Bayona - cxvb_CY42R1_CAMS_for_CY43R1_8

Update for MACC

- New features for GHG model and data assimilation changes
- New SOA source scheme
- MOPITT profile assimilation
- Bug fixes and small correction of parameters in chemistry
- Pressure weight correction in BC Mass Fixer

Testing:

Look at `https://software.ecmwf.int/wiki/display/CA/CY43R1` for testing experiments information.

Testing for NWP: ggps: dag_CY42R1_esuite (control); ggpt: cxvb_CY42R1_CAMS_for_CY43R1_1 (bit-identical); ggpw: cxvb_CY42R1_CAMS_for_CY43R1_2 (bit-identical); ggpx: cxvb_CY42R1_CAMS_for_CY43R1_3 (bit-identical); ggvk: cxvb_CY42R1_CAMS_for_CY43R1_4 (bit-identical); ggxc: cxvb_CY42R1_CAMS_for_CY43R1_5 (bit-identical); gh1q: cxvb_CY42R1_CAMS_for_CY43R1_7 (bit-identical); gh5u: cxvb_CY42R1_CAMS_for_CY43R1_8 (bit-identical);

Testing for Chemistry: cxvb_CY42R1_CAMS_for_CY43R1_8 gh4o (Sebastien: LinCO forecast); gh4u (Sebastien: GHG DM analysis) gh87 (Anna: GHG linCO forecast); gh8y (analysis, copy of ggqi) gh8u (AERO+GHG+LCHEM forecast)

Files created(IFS):

`chem/chem_linco.F90 gpincoch.F90 linco_chem_ini.F90 updcoch.F90`

`op_obs/mopitt_profile_ak_ad.F90 mopitt_profile_ak_op.F90 mopitt_profile_ak_tl.F90`

Files created(ODB):

`ddl.ECMA/obsort_hdr2resat_averaging_kernel.sql`

Files created(SCRIPTS):

`gen/add_cams_black add_cams_climerr add_cams_jb_eda add_perturb_bfas get_linco_coefficients get_linco_initcond`

Files modified(IFS):

`chem/chem_init.F90 chem_main.F90 chem_massdia.F90 chem_noxadv.F90 chem_tm5.F90 tm5_calrates.F90 tm5_do_ebi.F90 tm5_photorates_tropo.F90`

`control/qmfixer.F90`

`fullpos/hpos.F90`

`module/gom_plus.F90 parfpos.F90 surface_fields_mix.F90 tm5_chem_module.F90 yoeaeratm.F90 yom_grib_codes.F90 yom_ygfl.F90 yomafn.F90 yomchem.F90 yomppc.F90`

`namelist/naeaer.nam.h namafn.nam.h namchem.nam.h namgfl.nam.h`

`op_obs/bgobs.F90 ghg_ak_ad.F90 ghg_ak_op.F90 ghg_ak_tl.F90 grg_ak_ad.F90 grg_ak_op.F90 grg_ak_tl.F90 hjo.F90 hop.F90 hopad.F90 hoptl.F90 reo3bcor.F90 rtl_oberror.F90`

`phys_ec/aer_bdgtmss.F90 aer_phy1.F90 aer_phy2.F90 aer_phy3.F90 aer_phy3_layer.F90 aer_src.F90 aerini_layer.F90 callpar.F90 chem_initflux.F90 chem_main_layer.F90 chemini_layer.F90 fireinj.F90 gems_init.F90 local_arrays_ini.F90 phys_arrays_ini.F90 sppten.F90 stochpert_layer.F90 su_aerw.F90`

`phys_radi/radact.F90 radcfg.F90 radheatn.F90 radintg.F90 surdi15.F90 uvradi_layer.F90`

`raingg/raingg_put.F90`

`setup/su_surf_flds.F90 suafn1.F90 suafn2.F90 suafn3.F90 sucpicgfl.F90 sugfl1.F90 sugfl3.F90 supp.F90`

`utility/updrlxref.F90`

`var/rdfpinc.F90 sujb.F90 sujbwavelet.F90`

Files modified(ODB):

`bufr2odb/b2o_convert_gch5.F90`

`cma2odb/getdb.F90 map_reportype.F90`

`ddl/get_soe_resat.sql`

Files modified(PREPDATA):

mc_tools/decode_track.F90 find_target_area.F90

programs/interpo.F90

Files modified(SCRIPTS):

def/fc.def inc_fam.py inc_stream.py

gen/add_nrt_fire_chem anml ansfc chem_setup comp_gpp_rec_bfas eda_err_save ens_cal ens_errors ens_fetch_fields ens_stats_gather ens_stats_mem fetch_jb_fields_mem fetcherr fetchmars fetchobs gems_ifsnam.pl gems_setup get_bfas_factors get_fire_emis get_gems_surface get_nrt_fire_chem getenkf getgrb getgrbe getinigems getmars getrelax mkabs_black mkabs_fieldman mkabs_odbtools mkidta mklinks mknam_fp model obstat prep_flux prep_initcond prereo3 resize_netcdf.py tctrackbb vardata

nemo/nemo.h

sms/getfcdata.sms ml.sms prep_chem.sms sfc.sms targets.sms

sms_an/black.sms eda_err_save.sms ens_cal.sms ens_errors.sms ens_fetch_fields.sms ens_stats_gather.sms ens_stats_mem.sms fetch_jb_fields_mem.sms fetcherr.sms fetchmars.sms

wav/wave_getrst

Files deleted(SCRIPTS):

gen/get_fire_emis_ctm

Tomas Kral - datk_CY43R1_macc_tweaks

[COPE-42] Loading of MACC/CAMS ozone observations to ODB

For operations and non-MACC/CAMS experiments, bufr2odb loads ozone observations (subtype=206) to varno=206 only. For MACC/CAMS experiments, bufr2odb loads ozone data (subtype=206) to varno=185 and has the option (via a flag) to also load to varno=206. This option is necessary at the moment as further testing is needed to see if the MACC/CAMS experiments work without having data present in varno=206. The desire is that operationally CAMS would only load to varno=185.

This will erradicate the fictitious subtype=205, allow deprecation of the undesirable separate ozone reportypes for MACC/CAMS and result in a cleaner archive of analysis input data.

This branch also bundles two other bug-fixes:

[ODB-231] GNU 5.x internal compiler error in odb/module/odbprint.F90

[COPE-50] Failure in pre1crad_cris task when running t42 experiments

Files modified(ODB):

bufr2odb/b2o_convert.F90 b2o_convert_radio_lat_long.F90 b2o_convert_reo3.F90 b2o_options.F90 cma2odb/ctxinitdb.F90 reprod_seqno.F90 subuoctp.F90 update_obsdb.F90 ddl/update_body_3.sql module/b2o_common.F90 b2o_internal.F90 odbprint.F90 tools/Bufr2odb.F90

Files modified(SATRAD):

programs/bufr_screen_cris.F90

Sebastien Massart and Alan Geer - dism_CY43R1_fc_error - PASSIVE

Randomisation and Analysis sensitivity to observation

Modifications ensuring the possible use of the randomisation and the analysis sensitivity to observation in IFS.

Testing:

CTRL: gkb9 (TCo399), EXPT: gkd2 (TCo399)

Files modified(IFS):

```
control/forecast_error.F90 module/supergom_class.F90 op_obs/bgobs.F90
var/bgvecs.F90 var/xformev.F90
```

BUG-FIXES

Peter Lean - dipl_CY42R1_fix_atms_update - BR

Fix uninitialised arrays in 3x3 avergaing in ATMS data

Technical fix for unsafe code in 3x3 spatial averaging of ATMS data during b2o_atms. Previously, the use of uninitialized data in some of the arrays could occasionally lead to a floating point exception. This fix correctly initialises all the arrays. The change is bit-reproducible.

Testing:

CTRL: giyb, EXPT: giya

Output from 'q2 find_files -m' which gives a list of files you changed

Files modified(ODB):

```
cma2odb/shuffle_odb.F90
```

Files modified(SCRIPTS):

```
gen/odbshuffle
```

Philippe Lopez - pah_CY43R1_online_adjoint_test_fix

4D-Var adjoint test correction: setting of adjoint contributions from precipitation observations to zero when testing the adjoint of the forecast model alone (to be consistent with all other observation types).

Files modified(IFS):

```
control/gp_model_ad.F90
```

Philippe Lopez - pah_CY43R1_bufr_screen_nexrad_fix

Pre-processing correction to avoid occasional loss of NEXRAD data due to the reshuffling of input BUFR files during acquisition.

Files modified(SATRAD):
`programs/bufr_screen_nexrad.F90`

Deborah Salmond - das_CY43R1_for_43R2_v2

Fixes for offline ADJOINT and TL tests:

Files modified(IFS):
`control/gp_model_ad.F90 tesadj.F90 testli.F90 testlievol.F90 setup/su0yomb.F90`

Fixes for FSOBS

Files modified(IFS):
`control/cnt3.F90 cva2.F90 forecast_error.F90 module/yomspjb.F90 setup/su0yomb.F90 utility/dealspa.F90 sbsfgs.F90 swap73.F90 var/cosjr.F90 estsig.F90 rd801.F90 suallr.F90`

Fix for offline TL test from Filip Váňa

Files modified(IFS):
`module/control_vectors_comm_mod.F90`

Alan Geer - stg_CY43R1_for_43R2_v2

Fixes for CAMS

Files modified(IFS):
`module/gom_plus.F90 op_obs/obsop_composition.F90 pp_obs/ppnew.F90`

Richard Engelin - stj_CY43R1_CAMS_test1

Fixes for CAMS

Files modified(IFS):
`module/gom_plus.F90 op_obs/obsop_composition.F90 radtr_ml.F90 radtr_ml_ad.F90 radtr_ml_tl.F90 phys_radi/uvradi.F90 pp_obs/ppnew.F90`

Files modified(SCRIPTS):
`def/inc_fam.py gen/add_cams_jb_eda fetchobs get_bfas_factors get_bfas_nee_climate_data.ksh get_gems_surface getgrb mkabs_black`