ACCF (version 1.0) User Manual

Algorithm Climate Change Functions submodel

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This manual is a part of the electronic supplement of our article "Predicting the climate impact of aviation for en-route emissions: The algorithmic climate change function sub model ACCF 1.0 of EMAC 2.53.0"

ACCF is a new MESSy submodel to calculate the average temperature response of aviation CO_2 emissions and non-CO_2 effects of NO_x (from ozone formation and methane depletion), H_2O and contrails effects through the call process of subroutines in Figure S1. The following information lists major elements of ACCF version 1.0 to be implemented in the ECHAM_5.3.02/MESSy version 2.53 model.

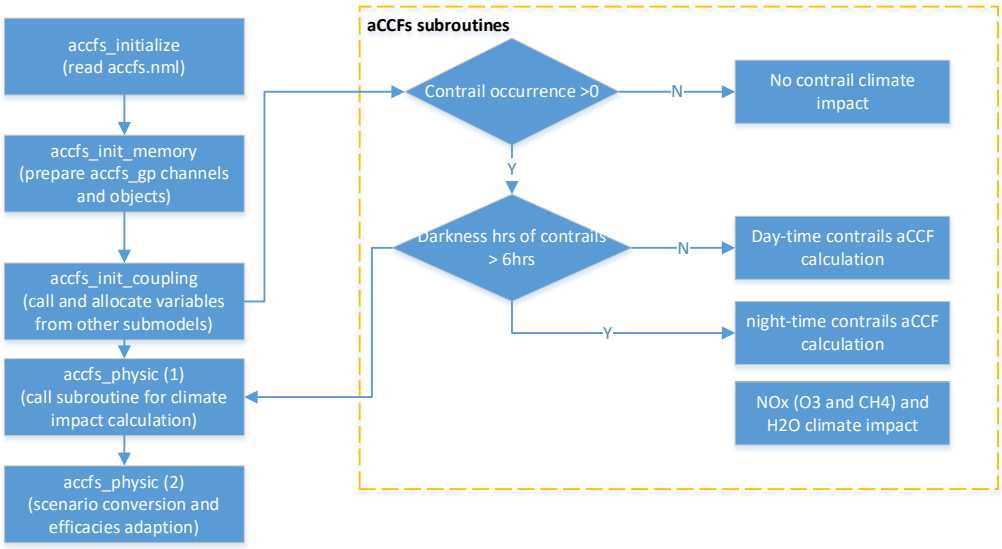

Figure S1: Calling sequence of process subroutines in ACCF submodel

S1. Namelist

The first step before running the submodel is to define several inputs in the accfs.nml file. The template for this file can be seen in Figure S2.

```
!-*- f90 -*-

&CTRL
!------------------------------------------------------
! for scaling
!------------------------------------------------------
l_scen_cov = .FALSE.  ! default true pulse-->BAU
l_eff_scal = .FALSE.  ! default true apply efficacies for different effects

!scenario coversion pulse emisison-->BAU
scen_co2 = 9.4
scen_o3  = 14.5
scen_ch4 = 10.8
scen_h2o = 14.5
scen_contrails = 13.6

!efficacies
lamda_co2 = 1.0,
lamda_o3 = 1.37,
lamda_ch4 = 1.18,
lamda_h2o = 1.0,
lamda_contrails = 0.42,

!------------------------------------------------------------------------
! for coupling
!------------------------------------------------------------------------
l_cpl_rad      = .TRUE.,
l_cpl_tropop   = .TRUE.,
l_cpl_orbit    = .TRUE.,
```

```
l_cpl_contrail = .TRUE.
/
&CPL
!--------------------------------------
!coupling with accfs
!--------------------------------------
c_LR_rad             = 'rad01','flxt',
c_pv_tropop          = 'tropop','PV',
c_cossza_orbit       = 'orbit','cossza',
c_dec_orbit          = 'orbit','dec',
c_potcov_contrail = 'contrail_gp','potcov'
/
```

Figure S2: ACCF submodel namelist example

S1.1 Process switches

- l_scen_cov: switch to determine whether the pulse emission scenario is converted into an increasing scenario of BAU (Business As Usual).
- l_eff_scal: switch to determine whether the efficacies of climate impact of O_3, CH_4, H_2O, and contrails are applied.
- l_cpl_rad: switch to determine whether the coupling with RAD submodel is activated
- l_cpl_tropop: switch to determine whether the coupling with TROPOP submodel is activated
- l_cpl_orbit: switch to determine whether the coupling with ORBIT submodel is activated
- l_cpl_contrail: switch to determine whether the coupling with CONTRAIL submodel is activated

S1.2 Physics parameters

- scen_o3: the scenario conversion factor for O_3
- scen_ch4: the scenario conversion factor for CH_4
- scen_h2o: the scenario conversion factor for H_2O
- lamda_co2: efficacy of CO_2 climate impact
- lamda_o3: efficacy of O_3 climate impact
- lamda_ch4: efficacy of CH_4 climate impact
- lamda_h2o: efficacy of H_2O climate impact
- lamda_contrails: efficacy of contrails climate impact

S1.3 Channel and object names to access input data

- c_LR_rad: longwave radiative flux
- c_pv_tropop: potential vorticity
- c_cossza_orbit: solar zenith angel
- c_dec_orbit: solar declination angel
- c_potcov_contrail: contrail potential coverage

S2 Coupling with other MESSy submodels

For its computations, ACCF requires some variables from the other MESSy submodels:

- Outgoing Longwave Radiation (OLR) from RAD (Dietmüller et al., 2016)
- Potential vorticity (PV) from TROPOP (Jöckel et al., 2006)

- Potential contrail coverage (potcov) from CONTRAIL (Supplement of Grewe et al., 2014a; Yin et al., 2018)
- Solar declination angel (dec_ang) from ORBIT (Dietmüller et al., 2016)

S3 Starting a simulation

To prepare an ACCF run, activate the submodel (set USE_ACCF = .TRUE. in switch.nml), set all input parameters in accf.nml and other namelists.

S4 Output

Running EMAC/ACCF generates standard MESSy output file to store the output parameters. A list of output variables in the ACCF channel can be seen in Table S1.

Table S1: List of variables in accf_gp channel

Variable	Description	Unit	Dimension
atr20_co_2	ATR20 by aviation en-routing CO_2 emissions	K/kg(fuel)	LON, LAT, LEV
atr20_o_3	ATR20 ozone by aviation en-routing NO_x emissions	K/kg(NO_2)	LON, LAT, LEV
atr20_ch_4	ATR20 methane by aviation en-routing NO_x emissions	K/kg(NO_2)	LON, LAT, LEV
atr20_h_2o	ATR20 by aviation en-routing H_2O emissions	K/kg(fuel)	LON, LAT, LEV
atr20_contrail	ATR20 by aviation contrails (day or night)	K/km(contrail)	LON, LAT, LEV

References

Dietmüller, S., Jöckel, P., Tost, H., Kunze, M., Gellhorn, C., Brinkop, S., Frömming, C., Ponater, M., Steil, B., Lauer, A. and Hendricks, J. (2016). "A new radiation infrastructure for the Modular Earth Submodel System (MESSy, based on version 2.51)." Geoscientific Model Development, 9(6): 2209-2222. DOI: 10.5194/gmd-9-2209-2016.

Grewe, V., Frömming, C., Matthes, S., Brinkop, S., Ponater, M., Dietmüller, S., Jöckel, P., Garny, H., Tsati, E. and Dahlmann, K. (2014a). "Aircraft routing with minimal climate impact: the REACT4C climate cost function modelling approach (V1. 0)." Geoscientific Model Development, 7(1): 175-201.

Jöckel, P., Tost, H., Pozzer, A., Brühl, C., Buchholz, J., Ganzeveld, L., Hoor, P., Kerkweg, A., Lawrence, M. G., Sander, R., Steil, B., Stiller, G., Tanarhte, M., Taraborrelli, D., van Aardenne, J. and Lelieveld, J. (2006). "The atmospheric chemistry general circulation model ECHAM5/MESSy1: consistent simulation of ozone from the surface to the mesosphere." Atmospheric Chemistry and Physics, 6(12): 5067-5104. DOI: 10.5194/acp-6-5067-2006.

Yin, F., Grewe, V., Frömming, C. and Yamashita, H. (2018). "Impact on flight trajectory characteristics when avoiding the formation of persistent contrails for transatlantic flights." Transportation Research Part D: Transport and Environment, 65: 466-484. DOI: https://doi.org/10.1016/j.trd.2018.09.017.