AEROCOM Indirect effect

Protocol for pilot experiments

Johannes Quaas, 17 December 2007

Project description

See AeroCom Indirect effect working group wiki: http://wiki.esipfed.org/index.php/Indirect_forcing

Contact

Please do not hesitate to contact me for any remarks or questions

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Data submission deadline

Submission of results by 30 April 2008

Simulation setup

Simulation start 1 October 1999
Forcing by AMIP2 sea surface temperature and sea-ice extent
Greenhouse gas concentrations for year 2000
Aerosol direct, semi-direct, and indirect effects taken into account.

simulation PD (present-day): year 2000 AEROCOM aerosol emissions
simulation PI (pre-industrial): pre-industrial AEROCOM aerosol emissions (year 2000 GHG concentration)

option (a) (recommended if possible)
nudged to ECMWF re-analysis wind and temperature fields (1 year simulations for each, PD and PI)

option (b)
free run (5 years simulations for each, PD and PI)

Diagnostics

Data is to be collected at the AEROCOM server.
Data in NetCDF format
All data are 3-dimensional (lon x lat x time)
(optional ISCCP-simulator output 5-dimensional (lon x lat x time x COD x PTOP). For the ISCCP simulator please refer to http://gcss-dime.giss.nasa.gov/simulator.html.)

In addition to the diagnostics below, it is **highly recommended to store the AEROCOM standard and forcing diagnostics**, so that the simulations can be analysed for the direct forcing as well, and future more in-depth analyses are possible.

(1) For evaluation with satellite data

1 year (year 2000) of daily data from the PD run, taken at the overpass time of the Aqua Train satellite constellation (about 13.30 p.m. local time) (or, alternatively, at an arbitrary instant, 13.30 UTC).

	name	long_name	units	description
1	od550	atmosphere_optical_thickness_due_to_aerosol	-	Aerosol optical depth (@ 550 nm)
2	cdr	liquid_cloud-top_droplet_effective_radius	m	Droplet effective radius at top of liquid water clouds
3	cdnc	liquid_cloud_droplet_number_concentration	m^{-3}	Droplet number concentration in top layer of liquid water clouds
4	tcc	cloud_area_fraction	-	Fractional cover by all clouds
5	lcc	liquid_cloud_area_fraction	-	Fractional cover by liquid water clouds
6	lwp	atmosphere_cloud_ice_content	kg m^{-2}	In-cloud liquid water path for liquid water clouds
7	albs	planetary_albedo	-	TOA broadband SW planetary albedo, all-sky
8	rst	toa_net_downward_shortwave_flux	W m^{-2}	Net TOA downward SW flux, all-sky
9	rstcs	toa_net_downward_shortwave_flux_assuming_clear_sky	W m^{-2}	Net TOA downward SW flux, clear-sky
10	rlt	toa_net_downward_longwave_flux	W m^{-2}	Net TOA downward LW flux, all-sky
11	rltcs	toa_net_downward_longwave_flux_assuming_clear_sky	W m^{-2}	Net TOA downward LW flux, clear-sky
12	ttop	air_temperature_at_cloud_top	K	Temperature at top of clouds
13	lts	lower_tropospheric_stability	K	Difference in potential temperature between 700 hPa and 1000 hPa
14	iwp	atmosphere_cloud_ice_content	kg m^{-2}	In-cloud ice water path for ice clouds
15	icr	cloud-top_ice_crystal_effective_radius	m	Effective radius of crystals at top of ice clouds
16	icc	ice_cloud_area_fraction	-	Fractional cover by ice clouds
17	cod	atmosphere_optical_thickness_due_to_clouds	-	In-cloud optical depth
18	ccn	cloud_condensation_nuclei	m^{-3}	Cloud condensation nuclei number concentration for liquid water clouds where activation corresponding to CDR and CDNC occurs (cloud base or top-layer of liquid water clouds)
19	isccp	isccp_cloud_area_fraction	-	Joint histogram of the fractional cover by clouds for 49 bins of cloud optical thickness and cloud top pressure
20	hfls	surface_upward_latent_heat_flux	W m^{-2}	Surface latent heat flux
21	hfss	surface_upward_sensible_heat_flux	W m^{-2}	Surface sensible heat flux
22	rls	surface_net_downward_longwave_flux_in_air	W m^{-2}	Net surface LW downward flux
23	rss	surface_net_downward_shortwave_flux	W m^{-2}	Net surface SW downward flux
24	rsds	surface_downwelling_shortwave_flux_in_air	W m^{-2}	Surface SW downward flux (in order to estimate the model's 'true' surface albedo)

(2) For forcing estimates

as (1), but monthly-mean fields for both PD and PI simulations
if option (a): for year 2000
if option (b): for five years (one average seasonal cycle)

“Satellite simulator”

(1) Sampling of cloud-top quantities

The idea is to use the cloud overlap assumption (maximum, random, or maximum-random) to estimate which part of the cloud in a layer can be seen from above.

Note: For the CCN, whether to sample it in the same way as CDNC, or use a similar apporach (going from bottom up) to samle it at cloud base depends on your parameterization of the activation.

let i=1,2,...,nx be the index for the horizontal grid-points
let k=1,2,...,nz be the index for the vertial levels, with 1 being the uppermost level, and nz the surface level

<u>naming convention for the 3D input fields:</u>
iovl is the flag to select the overlap hypothesis
cod3d(nx,nz) cloud optical thickness
f3d(nx,nz) cloud fraction
t3d(nx,nz) temperature
phase3d(nx,nz) cloud thermodynamic phase (0: entire cloud consists of ice, 1: entire cloud consists of liquid water, between 0 and 1: mixed-phase)
cdr3d(nx,nz) cloud droplet effective radius
icr3d(nx,nz) ice crystal effective radius
cdnc3d(nx,nz) cloud droplet number concentration

```
thres_cld = 0.001
thres_cod = 0.3
tcc(:) = 0
icc(:) = 0
lcc(:) = 0
ttop(:) = 0
cdr(:) = 0
icr(:) = 0
cdnc(:) = 0


DO i=1,nx
   DO k=2,nz ! assumption: uppermost layer is cloud-free (k=1)
      IF ( cod3d(i,k) > thres_cod and f3d(i,k) > thres_cld ) THEN ! visible, not-too-small cloud
           ! flag_max is needed since the vertical integration for maximum overlap is different from the
two others: for maximum, tcc is the actual cloud cover in the level, for the two others, the actual
cloud cover is 1 - tcc
         ! ftmp is total cloud cover seen from above down to the current level
         ! tcc is ftmp from the level just above
         ! ftmp    tcc is thus the additional cloud fraction seen from above in this level

         IF ( iovl = maximum ) THEN
            flag_max = -1.
            ftmp(i) = MAX( tcc(i), f3d(i,k))  ! maximum overlap
         ELSEIF ( iovl = random ) THEN
            flag_max = 1.
            ftmp(i) = tcc(i) * ( 1    f3d(i,k) ) ! random overlap
         ELSEIF ( iovl = maximum-random ) THEN
            flag_max = 1.
            ftmp(i) = tcc(i) * ( 1 - MAX( f3d(i,k), f3d(i,k-1) ) ) / &
               ( 1 - MIN( f3d(i,k), 1 - thres_cld ) )  ! maximum-random overlap
         ENDIF
```

```
         ttop(i) = ttop(i) + t3d(i,k) * ( tcc(i) - ftmp(i) )*flag_max

         ! ice clouds
         icr(i) = icr(i) + icr3d(i,k) * ( 1    phase3d(i,k) ) * ( tcc(i) - ftmp(i) )*flag_max
         icc(i) = icc(i) + ( 1    phase3d(i,k) ) * ( tcc(i) - ftmp(i) )*flag_max

         ! liquid water clouds
         cdr(i) = cdr(i) + cdr3d(i,j) * phase3d(i,k) * ( tcc(i)    ftmp(i) )*flag_max
         cdnc(i) = cdnc(i) + cdnc3d(i,j) * phase3d(i,k) * ( tcc(i)    ftmp(i) )*flag_max
         lcc(i) = lcc(i) + phase3d(i,k) * ( tcc(i) - ftmp(i) )*flag_max

         tcc(i) = ftmp(i)
      ENDIF ! is there a visible, not-too-small cloud?
   ENDDO ! loop over k

   IF ( iovl = random OR iovl = maximum-random ) THEN
      tcc(i) = 1. - tcc(i)
   ENDIF
ENDDO ! loop over I
```

(2) Sampling of the satellite-overpass-time

To sample the overpass time of the satellite (13.30 h local time), the idea is to create a mask (satmask) indicating whether or not at the grid-box the local time is 13.30 h ± ½ model-timestep.
Then, all output fields are weighted with this mask (field * satmask), and in the output, the diurnal mean is taken. The physical fields at 13.30 h local time are obtained in post-processing by dividing each field by the mask (field / satmask).
So, the diurnal mean of satmask must be stored as well!

naming convention for the input variables:
utctime current time of the day in UTC in seconds
time_step_len length of model time-step
lon(nx) longitude in degrees from 0 to 360°

```
sat_mask(:) = 0
overpasstime = 48600 ! 13.30 p.m. local time

DO i=1,nx
   localtime(i) = utctime + 240 * lon ! for each degree of longitude east, 4 min earlier local time
   IF ( localtime(i) > 86400 ) THEN ! this is still the previous day
      localtime(i) = localtime(i) - 86400
   ENDIF

   ! Select 10.30 a.m. ± dt/2
   IF ( ABS( localtime(i) - overpasstime ) <= time_step_len/2 )
      sat_mask(i) = 1
   ENDIF

   ! Weight the output fields with this mask
   aod(i) = aodd(i) * sat_mask(i)
   cdr(i) = cdr(i) * sat_mask(i)
   cdnc(i) = cdnc(i) * sat_mask(i)
   tcc(i) = tcc(i) * sat_mask(i)
   lcc(i) = lcc(i) * sat_mask(i)
   lwp(i) = lwp(i) * sat_mask(i)
   albs(i) = albs(i) * sat_mask(i)
   ssw(i) = ssw(i) * sat_mask(i)
   sswclr(i) = sswclr(i) * sat_mask(i)
   slw(i) = slw(i) * sat_mask(i)
   slwclr(i) = slwclr(i) * sat_mask(i)
   ttop(i) = ttop(i) * sat_mask(i)
   lts(i) = lts(i) * sat_mask(i)
   iwp(i) = iwp(i) * sat_mask(i)
   icr(i) = icr(i) * sat_mask(i)
   icc(i) = icc(i) * sat_mask(i)
   cod(i) = cod(i) * sat_mask(i)
   ccn(i) = ccn(i) * sat_mask(i)
ENDDO
```

In the diurnal-mean output files, the actual in-cloud fields are derived by
cdr' = cdr / lcc
cdnc' = cdnc / lcc
lwp' = lwp / lcc

ttop' = ttop / tcc

iwp' = iwp / icc
icr' = icr / icc

For all other fields, the actual values are derived by
aod' = aod / sat_mask
etc.

Potential participants as of December 2007

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Yves Balkanski, LSCE (LMDZ-INCA)
Ulrike Lohmann, ETH (ECHAM5 with convection microphysics)
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