use of cloud properties in flux computations

exploring the impact of data-diversity and to model simulations

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MPI-Met

cloud properties → rad.fluxes

	available	sufficient?	issues
cloud properties			
as function of altitude (layers) …			
cloud-cover	top cover	no	overlap, f(ot)
optical depth	total est.	no	uncertain
particle size	top size	no	top size, habit
cloud phase	ice/water	??	partitioning

- **ancillary data matter**
  - surface albedo
  - surface temperature
  - aerosol properties

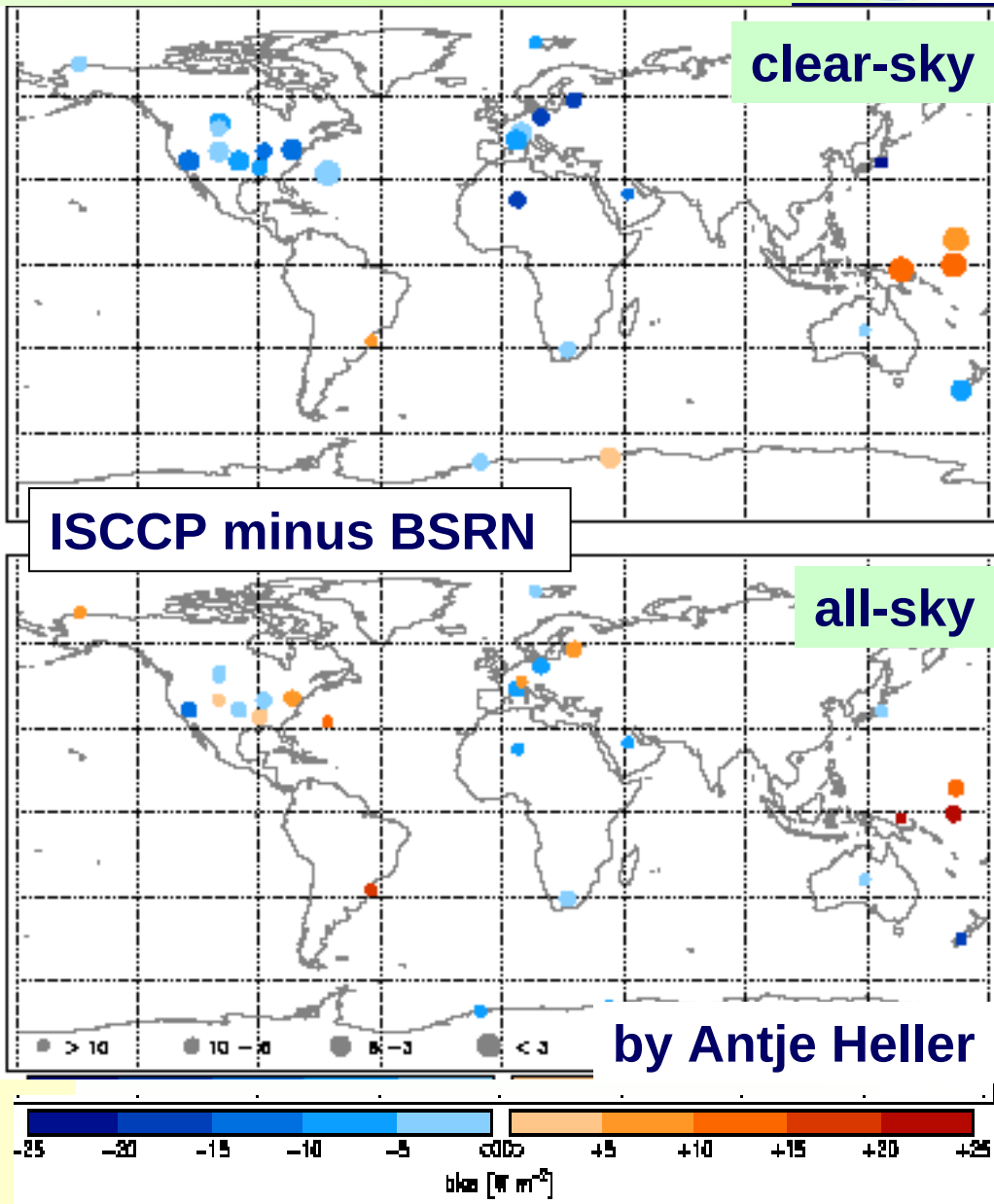
using ISCCP flux products as example

aerosol in ISCCP

- compare to BSRN
  - solar dn-flux at surf.
    - larger differences at clear-sky than at all-sky conditions:

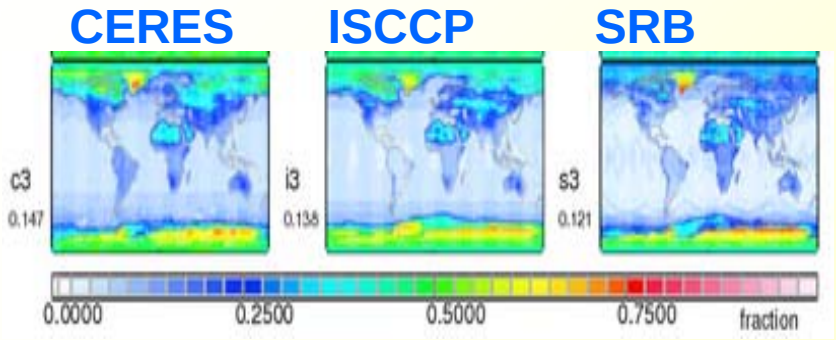
- too much aerosol at mid-latitudes

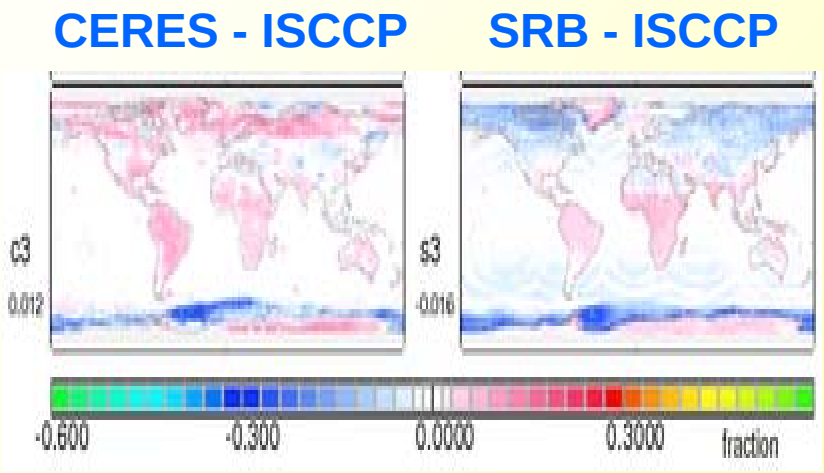
- aerosol impact too small in tropics
  - cloud properties are biased high to cover aerosol err.



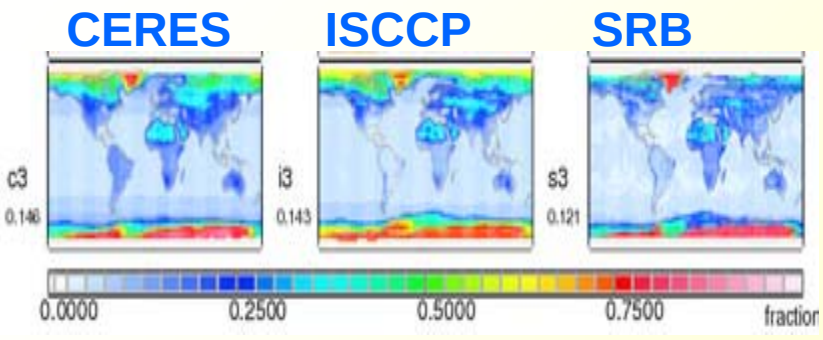
surface albedo (in fraction)

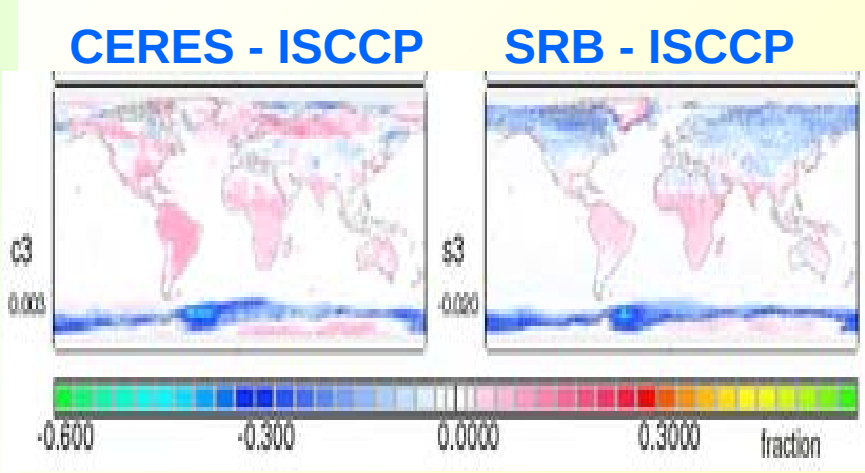
○ clear sky





○ all-sky





large differences for different data-sets
some differences get smaller under all-sky

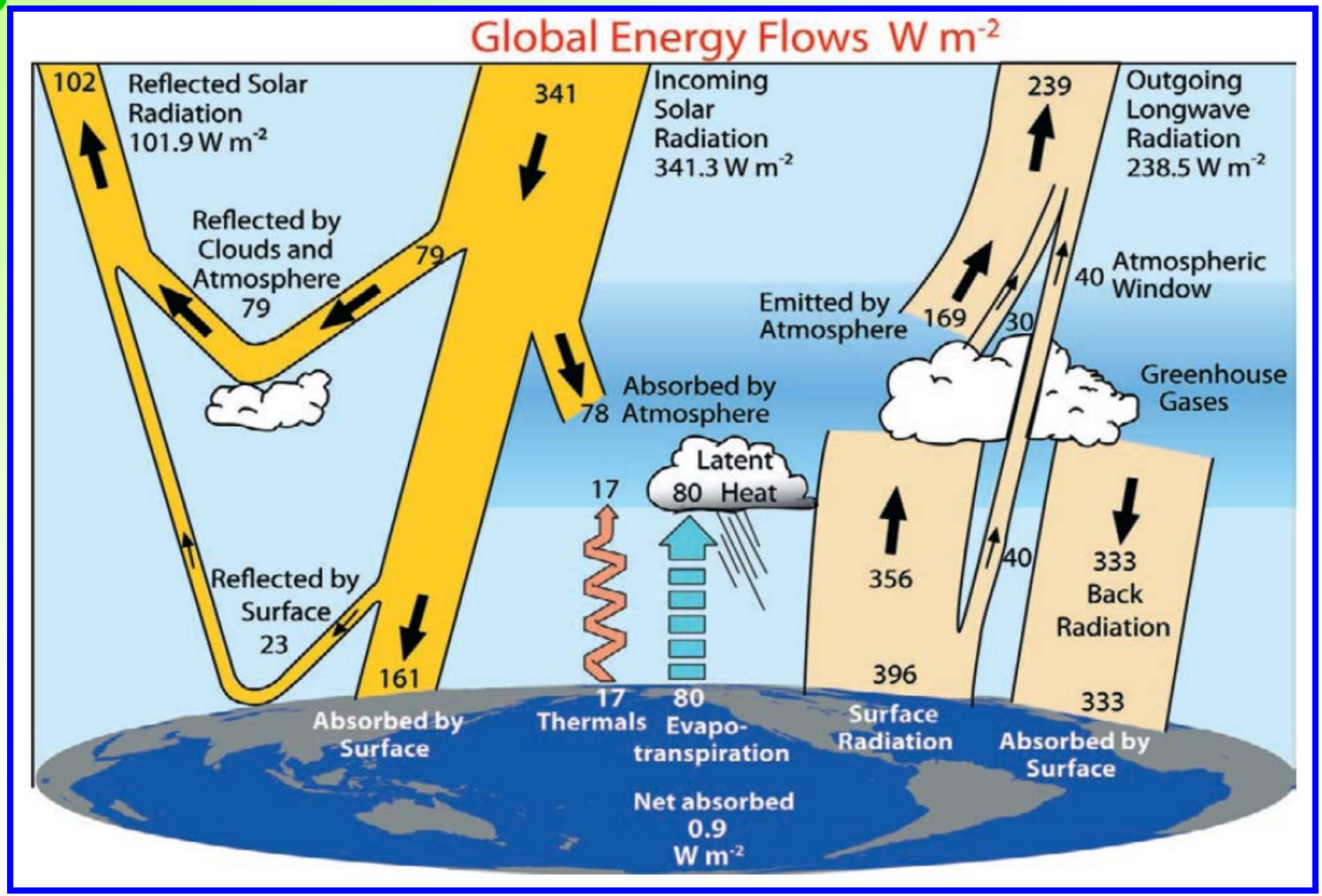
see also Raschke poster

simplify

- take out the impact of ancillary data by substraction

- look at the cloud effect (CE) or how clouds change the distribution of clear-sky fluxes
  - "all-sky fluxes" *minus* "clear-sky fluxes"
    - solar up fluxes at ToA (planetary albedo)
    - IR up fluxes at ToA (OLR Outgoing Longw. Radiation)
    - solar dn fluxes at the surface
    - IR fluxes at the surface

radiative fluxes – global annual



(Trenberth et al., BAMS, 2009)

concept

- what does global modeling suggest ?
  - use the IPCC modeling
- can cloud-products from satellite sensors constrain modeling efforts?
  - ISCCP, CERES, SRB ….
- only overall effect of clouds no details
  - but … changes of individual cloud parameters allow to translate data uncertainties

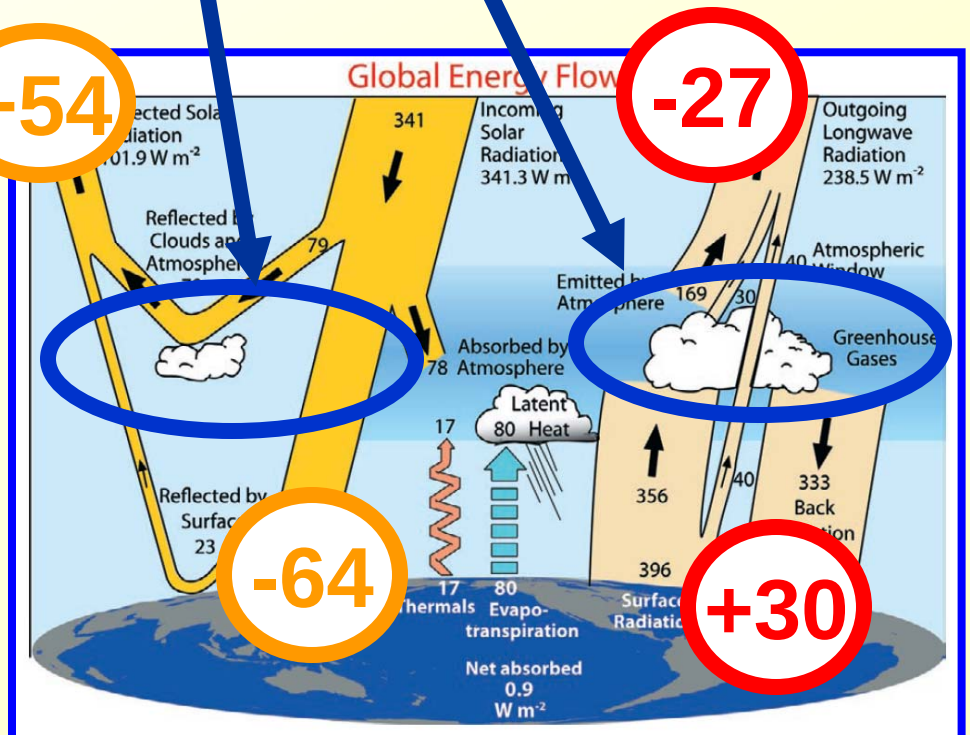
focus

- the modulating role of clouds
  - on infrared (IR) radiative fluxes
  - on solar radiative fluxes

examine at ToA →

examine at surface →

IPCC 4AR
20-model
median

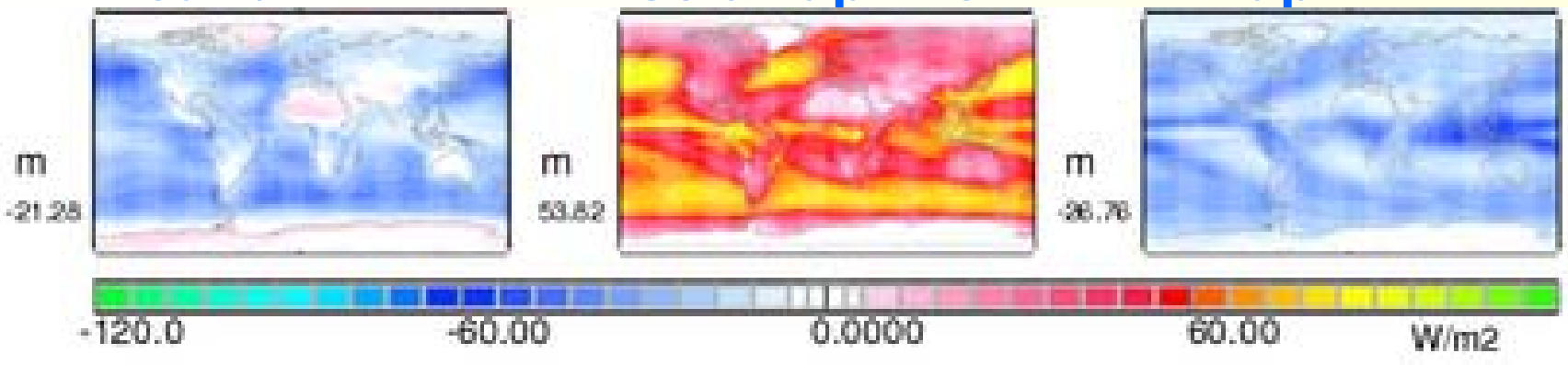


cloud effects – annual global maps

IPCC-4AR model median

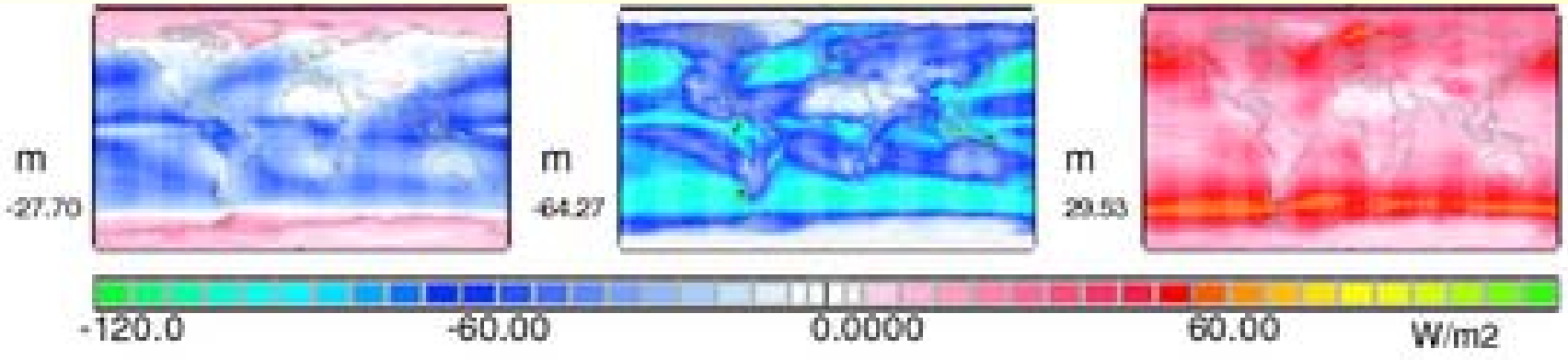
at top of the atmosphere

net flux - 21 | solar-up +54 | IR-up - 27



at the surface

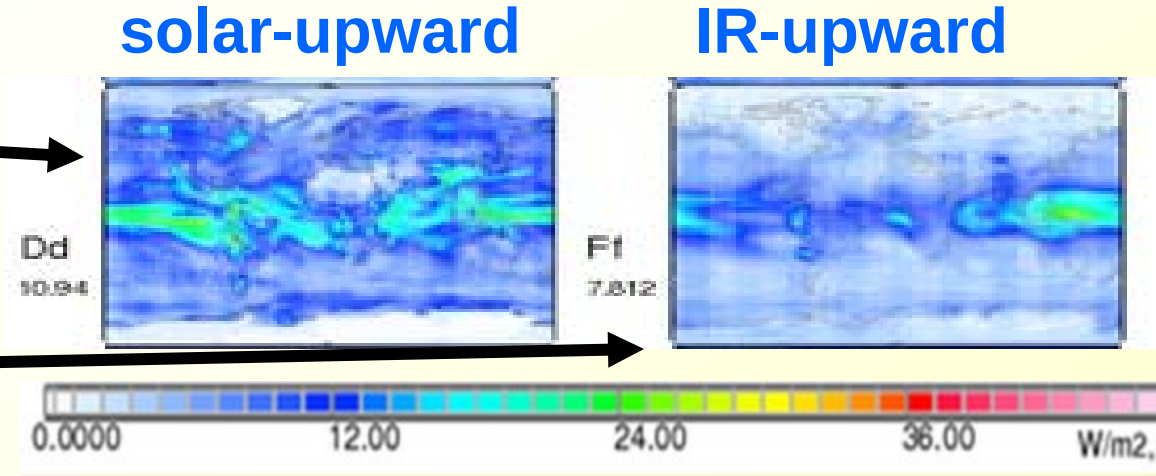
net flux - 28 | solar-dn - 64 | IR-dn + 30



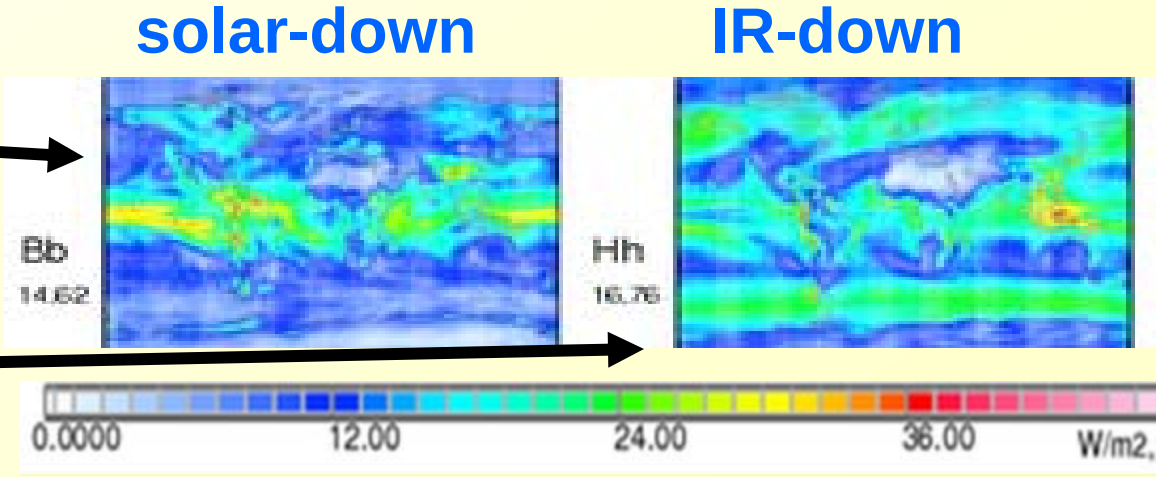
CE uncertainty in modeling

IPCC-4AR model std.dev

- at top of atmosphere
  - +54 +/- 11 W/m²
  - -27 +/- 8 W/m²



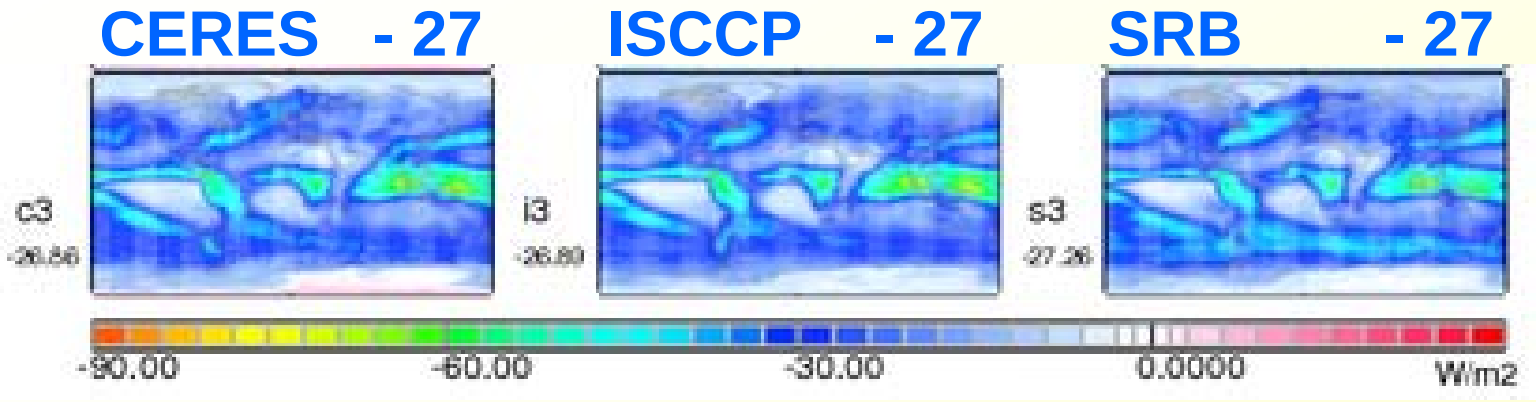
- at the surface
  - - 64 +/- 15 W/m²
  - +30 +/- 17 W/m²



“data”

CE - IR up-flux at ToA "OLR"

- 27
model
IPCC4
median



clouds reduce the OLR (up to -80 W/m2)

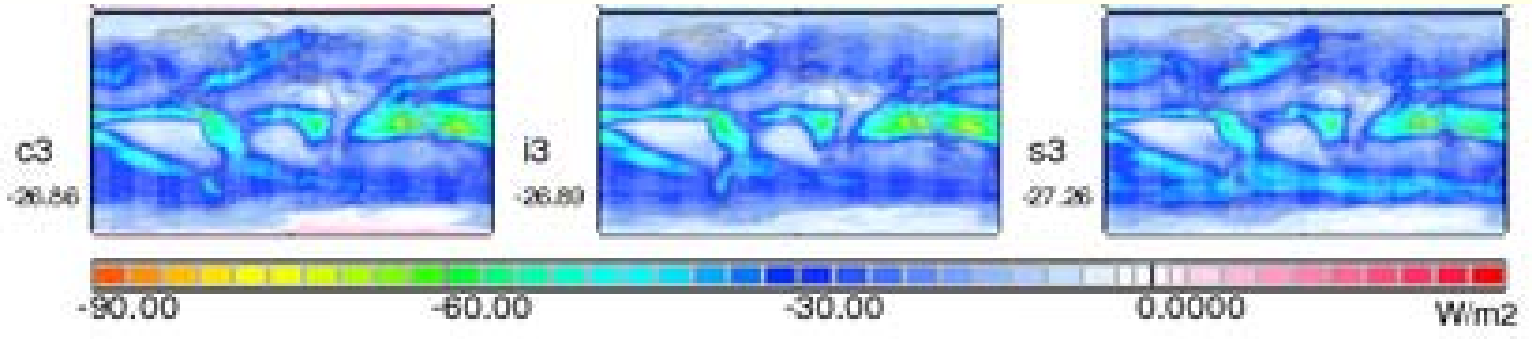
- global annual values agree well
- there are slight pattern strength difference though

… better noticeable by difference fields

CE - IR up-flux at ToA "OLR"

- 27 model IPCC4 median

CERES - 27 **ISCCP - 27** **SRB - 27**

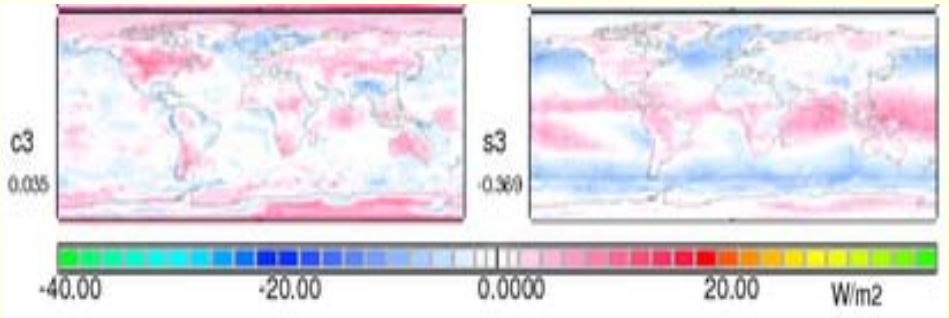


differences

stronger reductions than ref.

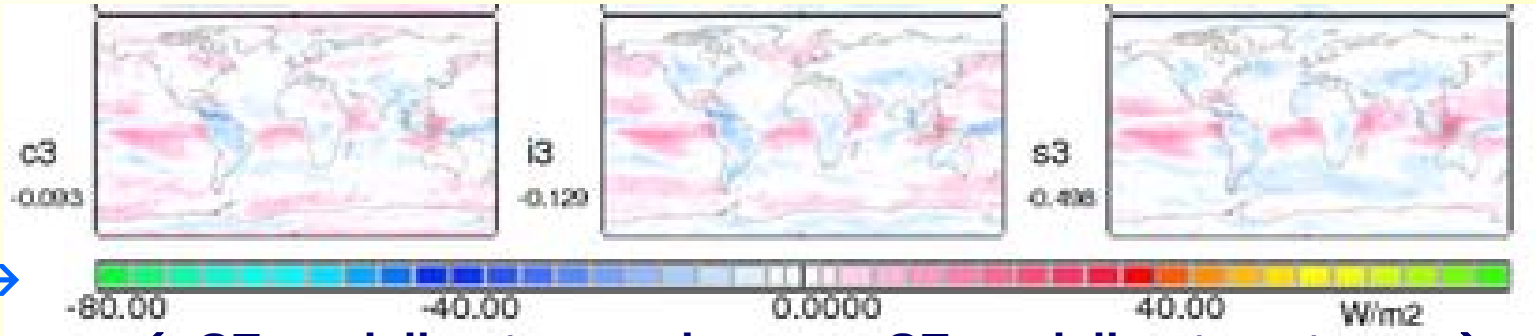
weaker reduction than ref.

CERES *minus* ISCCP



SRB *minus* ISCCP

CERES-model **ISCCP-model** **SRB-model**

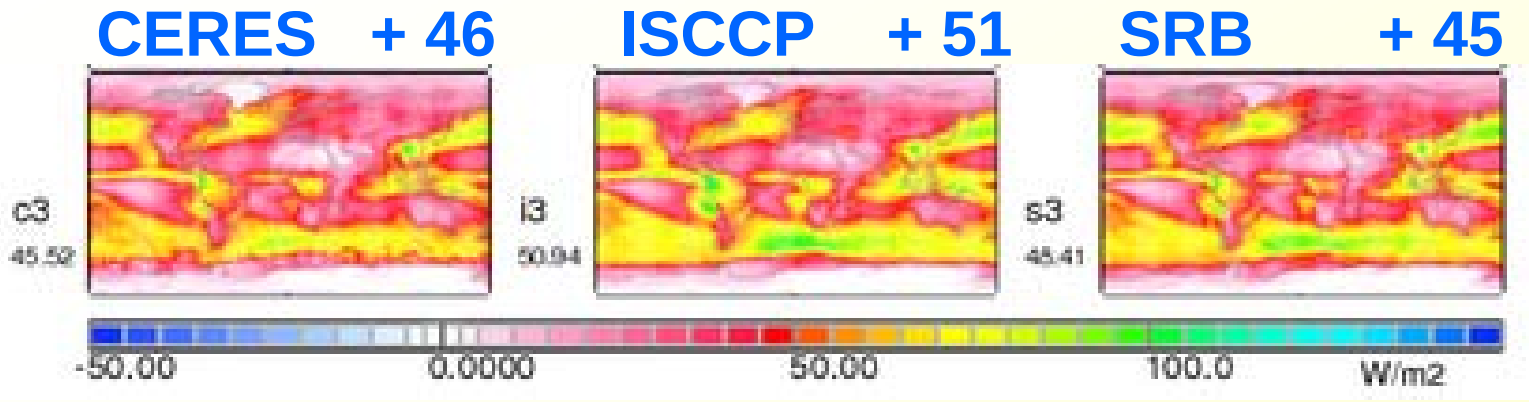


- 80 to 80 →

← CE modeling too weak **CE modeling too strong →**

CE - solar up-flux at ToA

+ 54
model
IPCC4
median



clouds increase the planetary albedo
(up to +110 W/m2)

for the planetary albedo

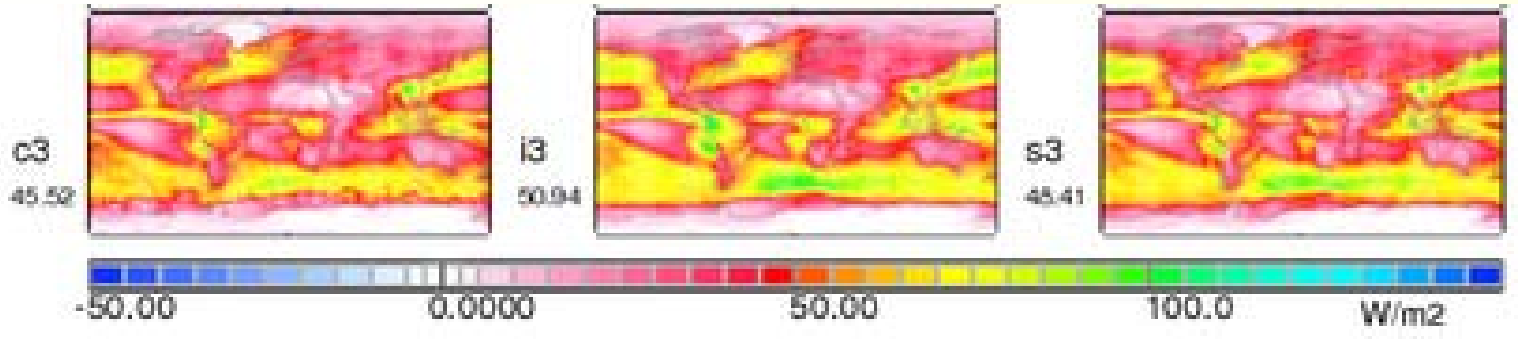
- already global averages do not agree !
- neither do patterns agree

… better noticeable by difference fields

CE - solar up-flux at ToA

+ 54
model
IPCC4
median

CERES + 46 **ISCCP + 51** **SRB + 45**

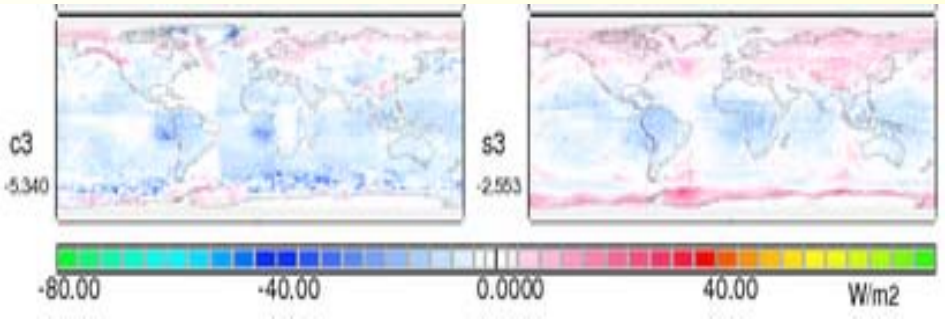


differences

weaker increases than refer.

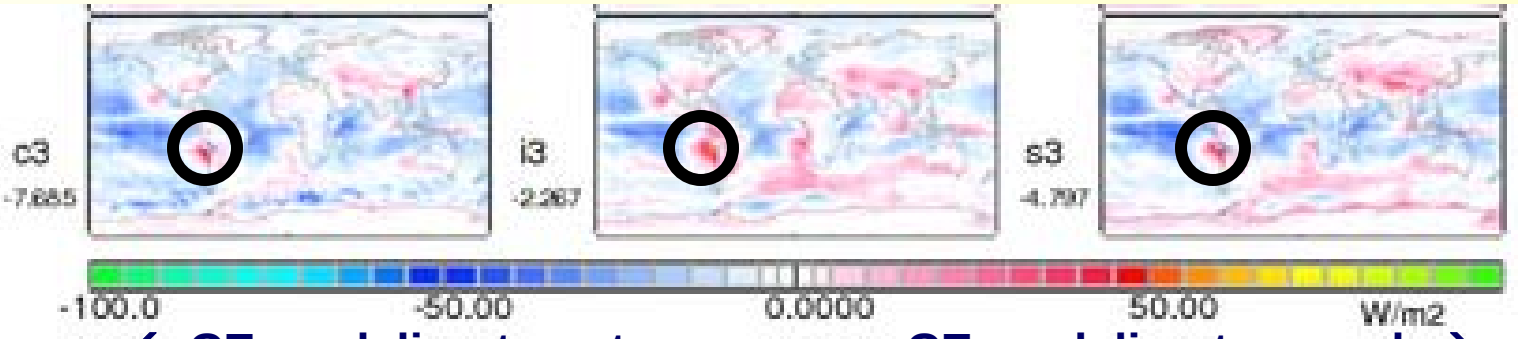
stronger increases than refer.

CERES *minus* ISCCP



SRB *minus* ISCCP

CERES-model **ISCCP-model** **SRB-model**

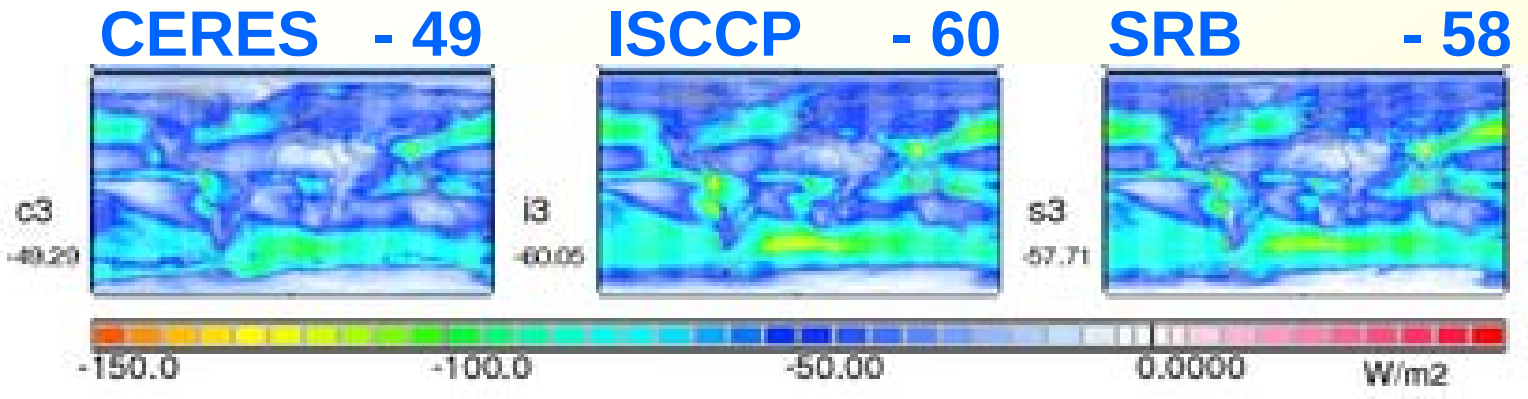


← CE modeling too strong **CE modeling too weak →**

CE – down fluxes at surface

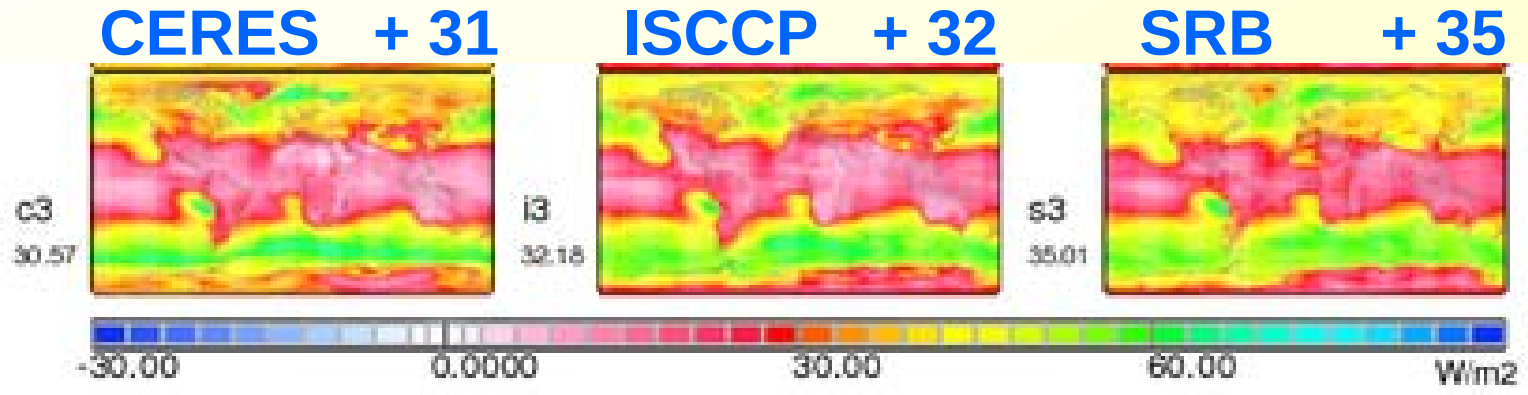
- 64
model
IPCC4
median

solar



- 30
model
IPCC4
median

IR



at the surface, the cloud-effect differences among data-sets are much larger …

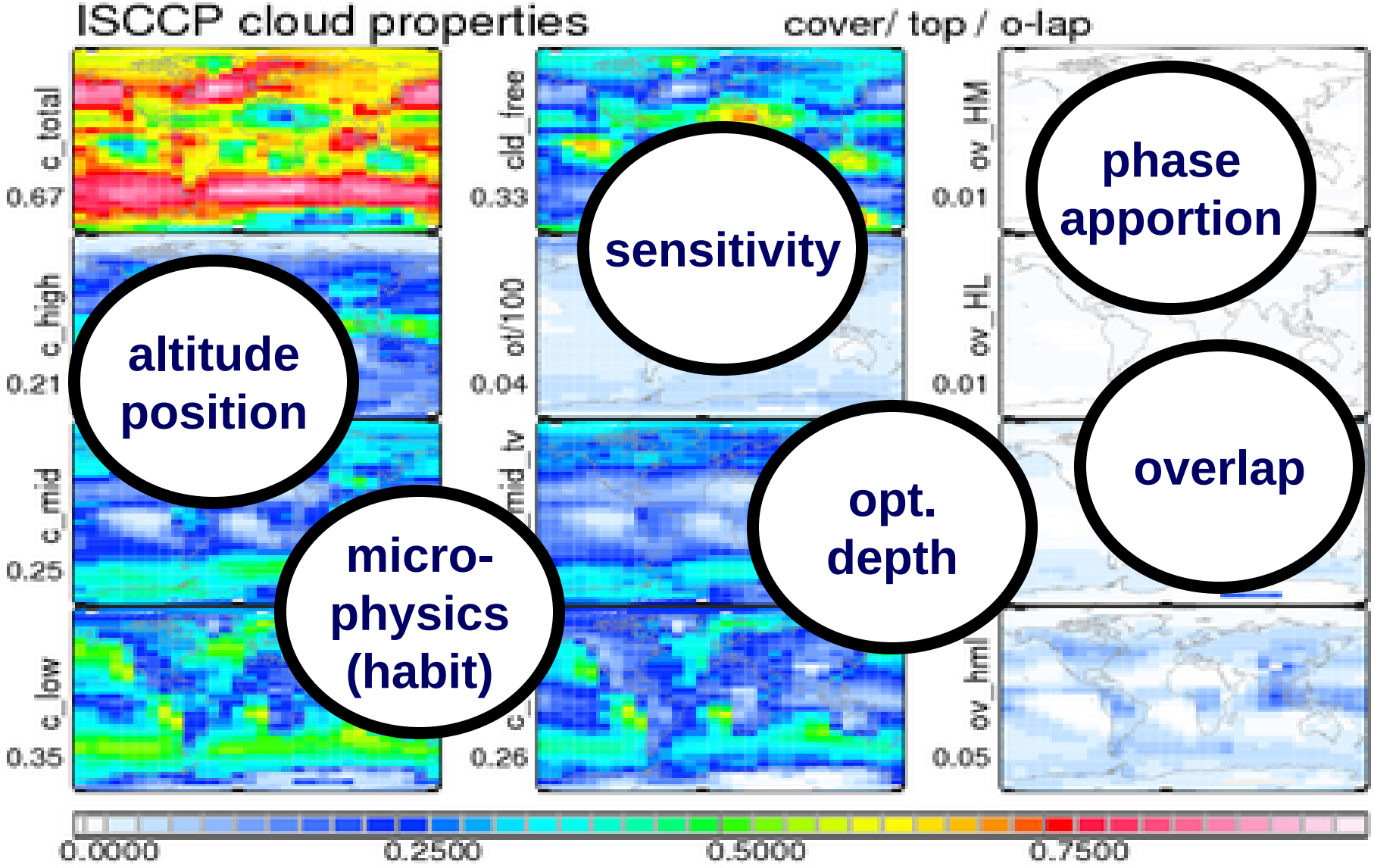
… because of needed assumptions to cloud-properties

overall impression

- **CE 'reference' notables on cloud treatment**
  - **CERES: weaker solar CE (less cloud opt.depth ?)**
  - **SRB: weaker solar up/dn CE ratio (larger sizes ?)**
  - **SRB: larger IR dn over land (lower cloud base ?)**

- **satellite data reference**
  - **flux pattern agreement among satellite data is better than to modeling (deviations can be locally large)**
  - **diversity is larger at surface (assumptions needed)**
  - **diversity is larger for solar region**

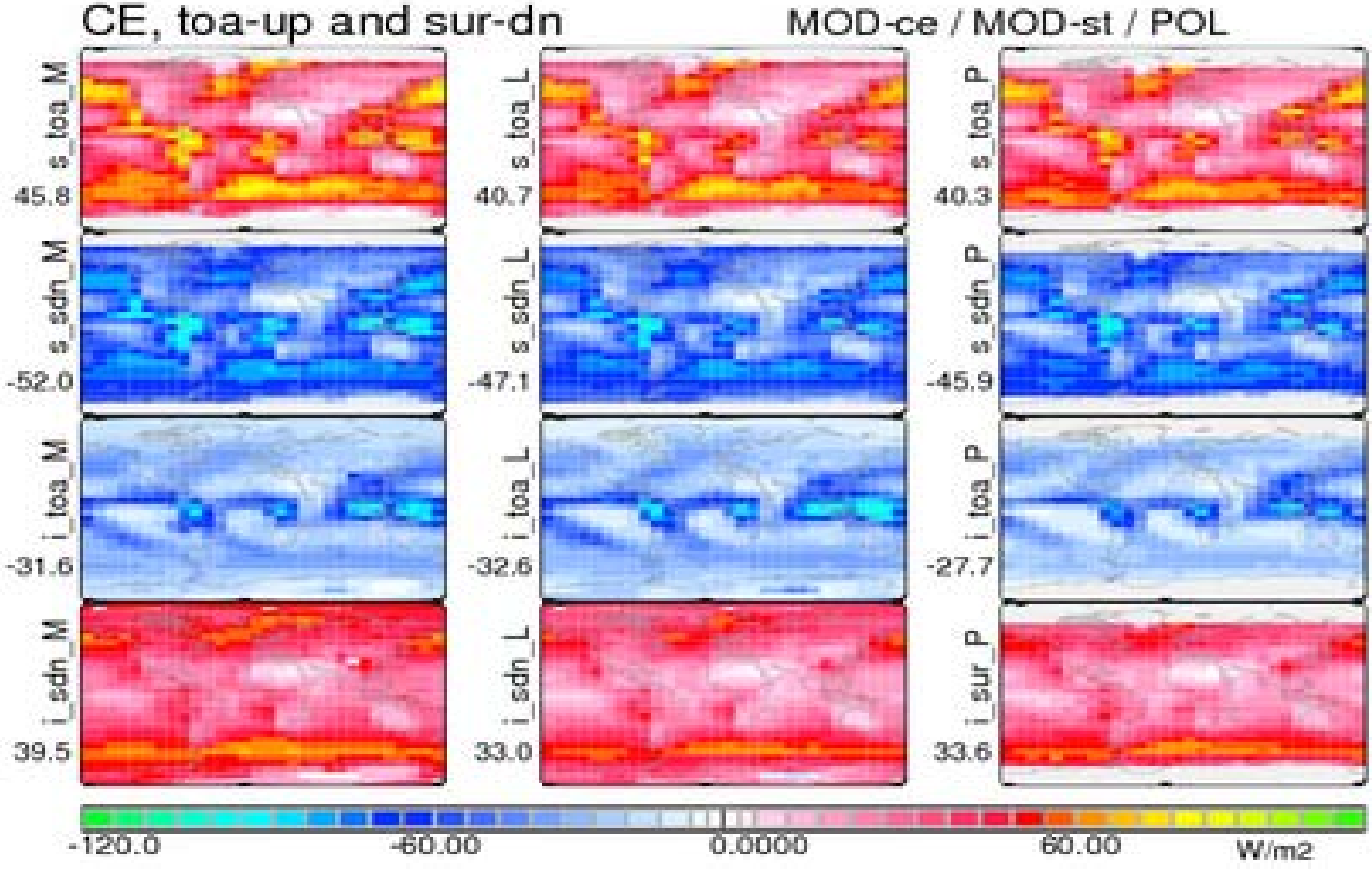
cloud properties matter



next

- forcing with different cloud data-sets
  - use geoprop data to investigate impact of different sensor sensitivities
  - compare the impact of different cloud-data sets
  - examine uncertainties of uncertainties to individual properties of a data-set
  - compare with trusted references at ToA
- need
  - unbiased, properly averaged properties
  - associated uncertainty to each property

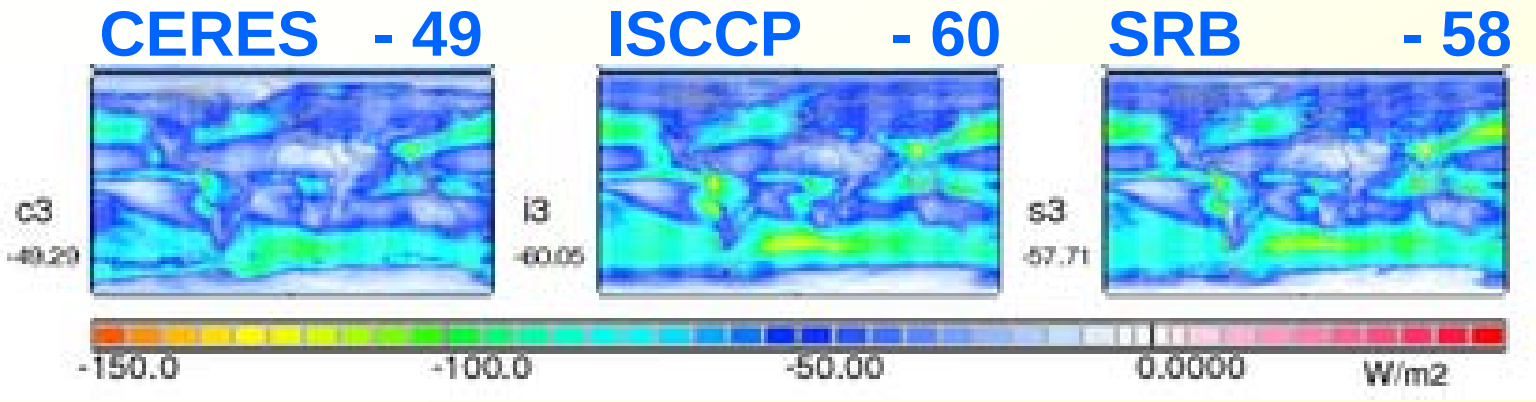
CE MODIS-CE, MODIS-ST, POLDER



- **extras**

CE - solar dn-flux at surface

- 64
model
IPCC4
median

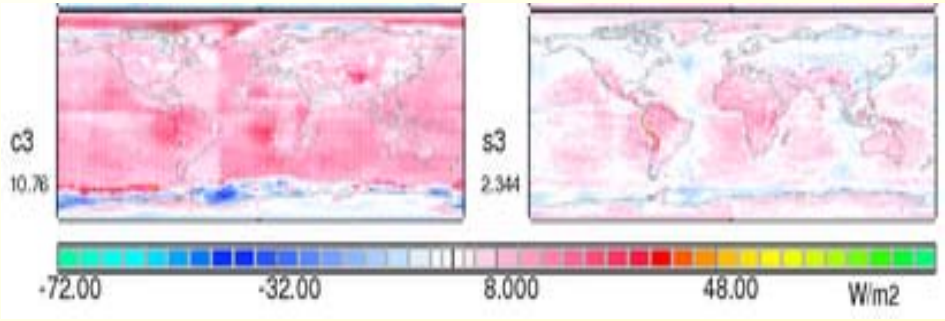


differences

stronger reductions than refer.

weaker reduction than refer.

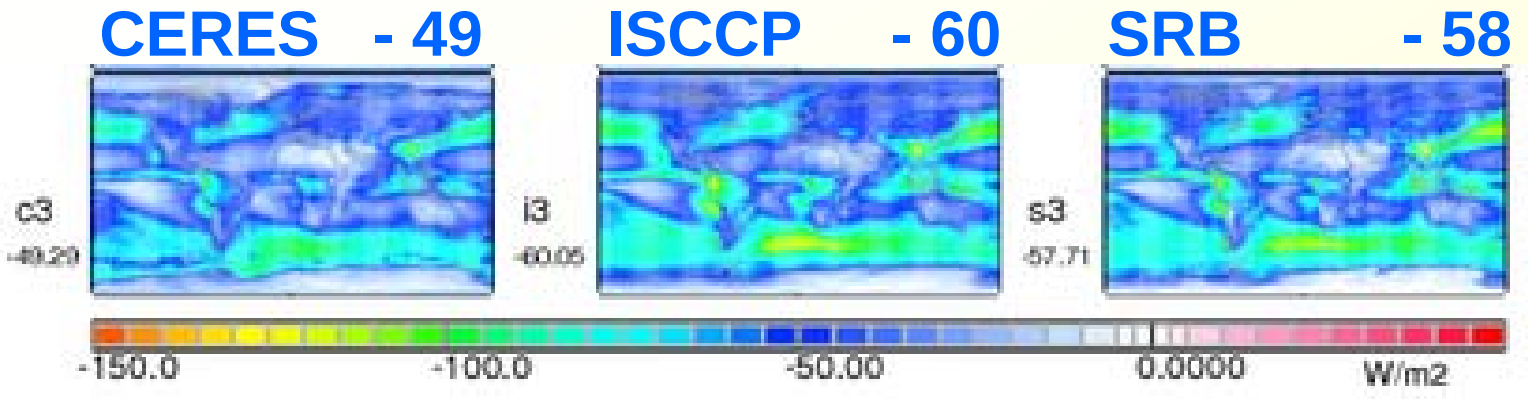
CERES *minus* ISCCP



SRB *minus* ISCCP

CE - solar dn-flux at surface

- 64 model IPCC4 median



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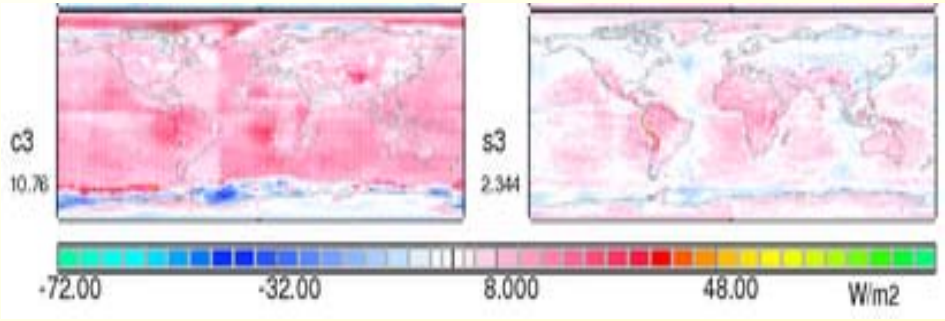

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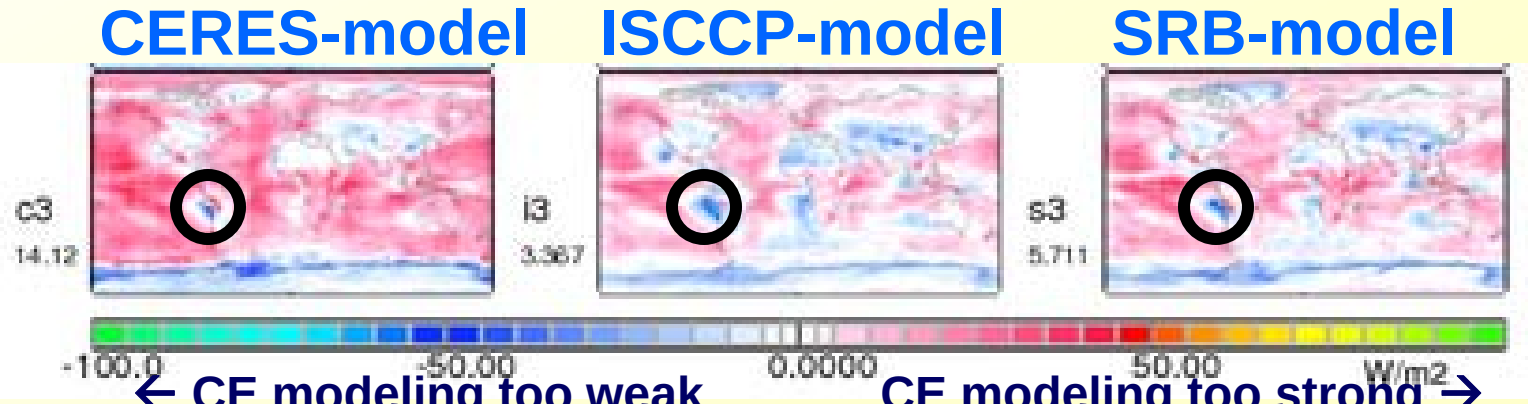
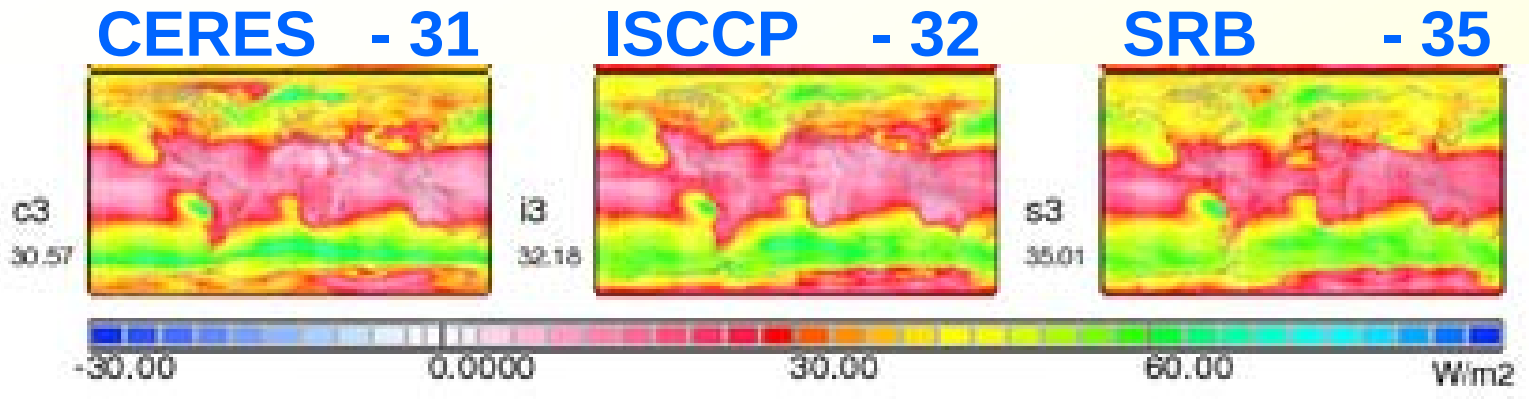


← CE modeling too weak

CE modeling too strong →

CE - IR dn-flux at surface

- 30
model
IPCC4
median



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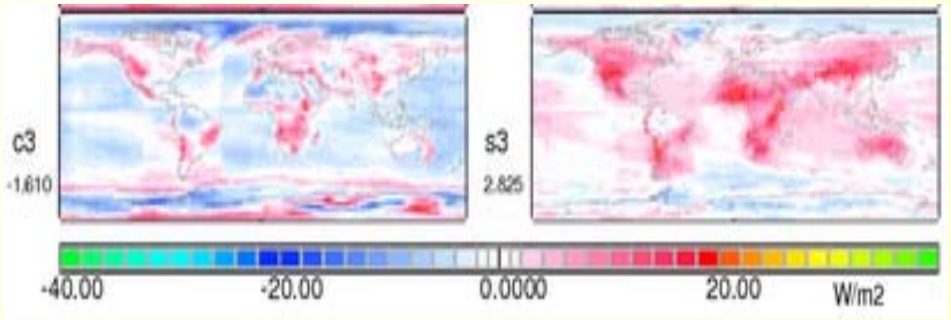
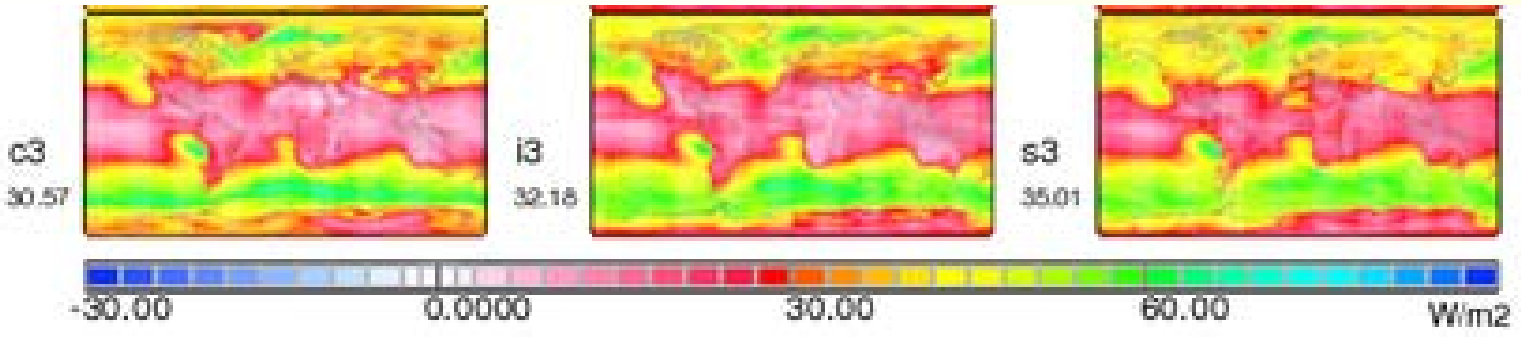


SRB *minus* ISCCP

CE - IR dn-flux at surface

+ 30 model IPCC4 median

CERES + 31 **ISCCP + 32** **SRB + 35**



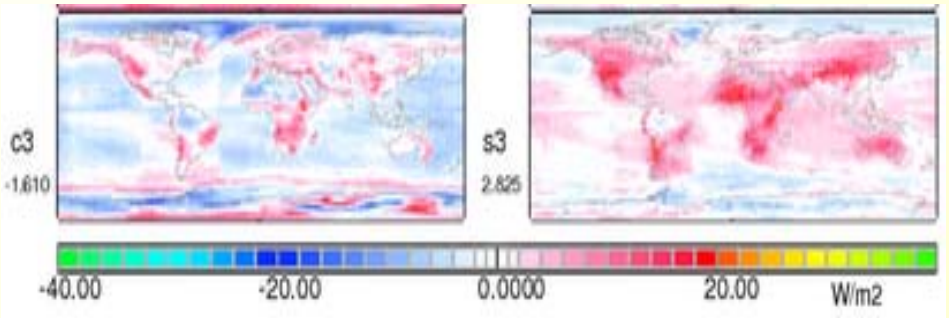
differences

weaker increases than refer.

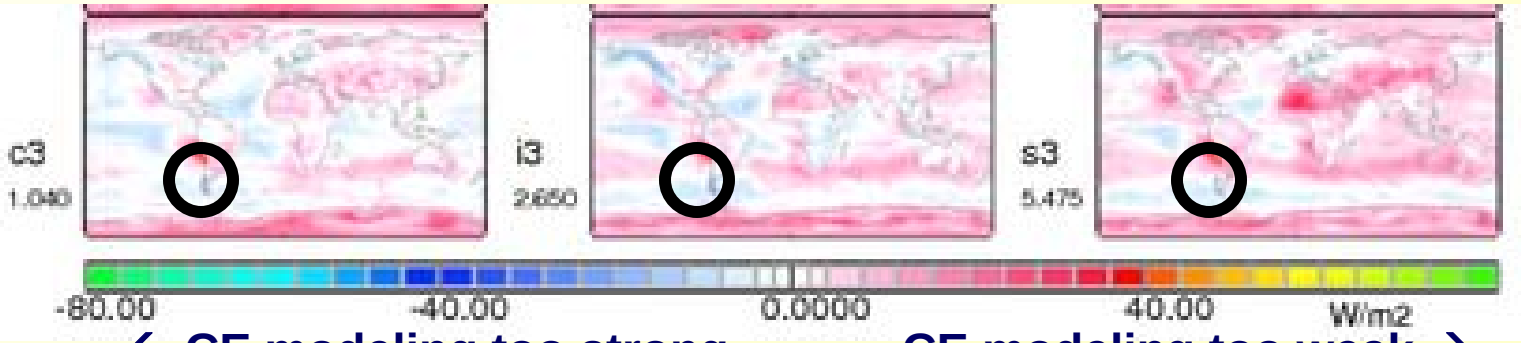
stronger increases than refer.

CERES *minus* ISCCP

SRB *minus* ISCCP



CERES-model **ISCCP-model** **SRB-model**



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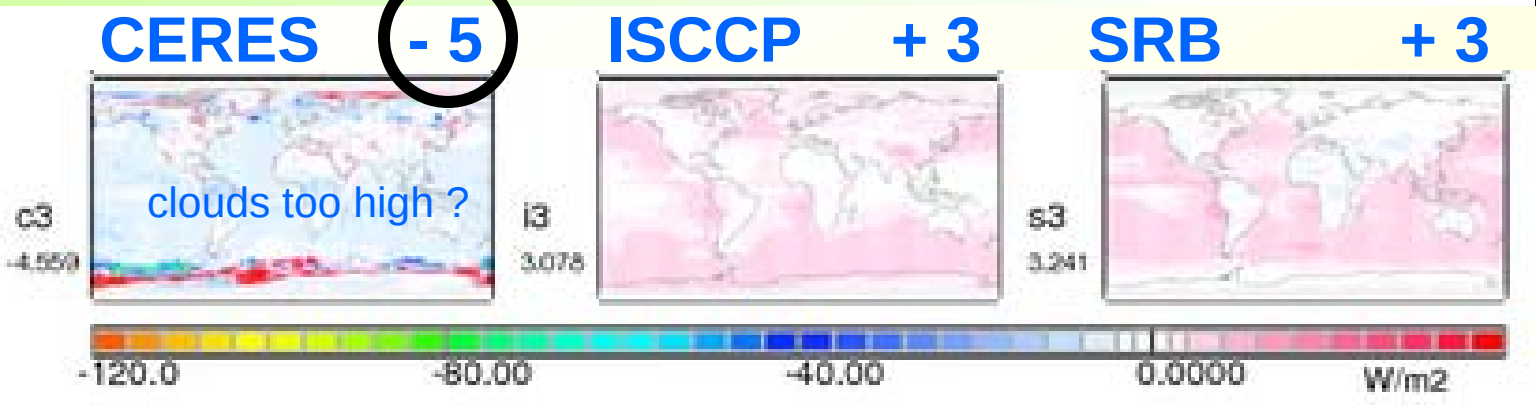
tasks ahead

how to achieve ‘better’ and ‘more consistent’ satellite data references ?

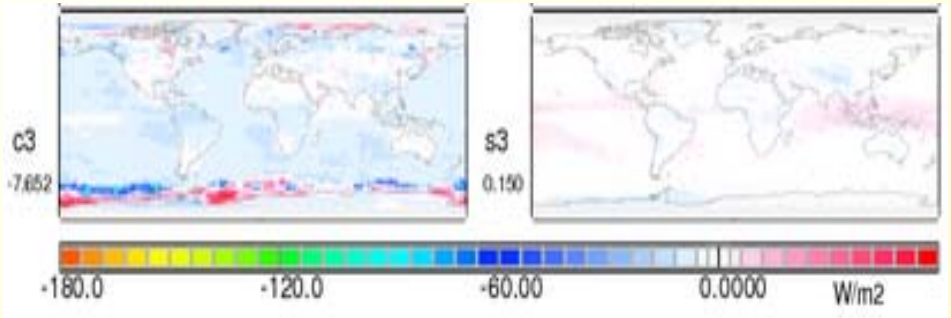
- **better understanding of sampling biases**
  - **ground-based network data, closure-studies**
  - **smart use of modeling capabilities**
- **better validation of assumptions**
  - **apply active remote sensing / in-situ**
  - **check consistency in ancillary data**
- **|: fix bugs, improve approach, reprocess :|**

CE on solar divergence

+ 6 model IPCC4 median



CERES *minus* ISCCP



SRB *minus* ISCCP

CERES clouds in contrast to ISCCP, SRB and modeling

reduce atmospheric solar absorption …

… are possibly placed the clouds too high ?

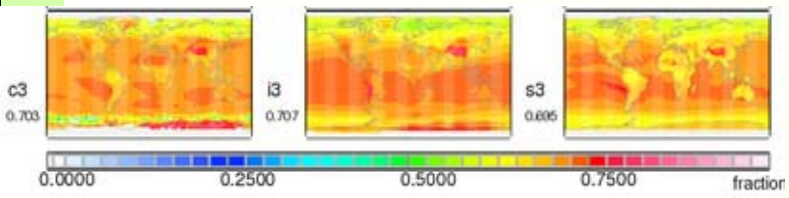
… CLOUDSAT to the rescue?

ancillary data

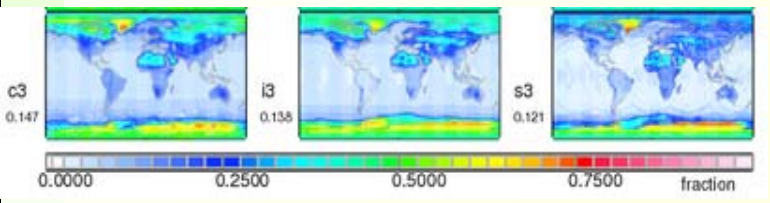
more info on a poster

CERES ISCCP SRB

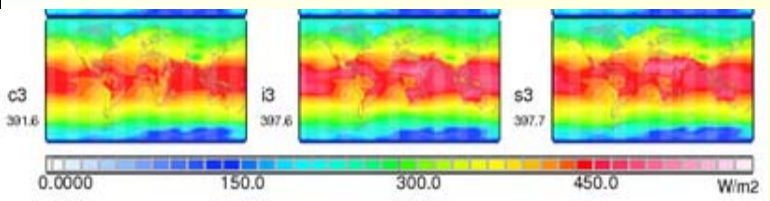
- clr solar trans.



- surf.sol albedo

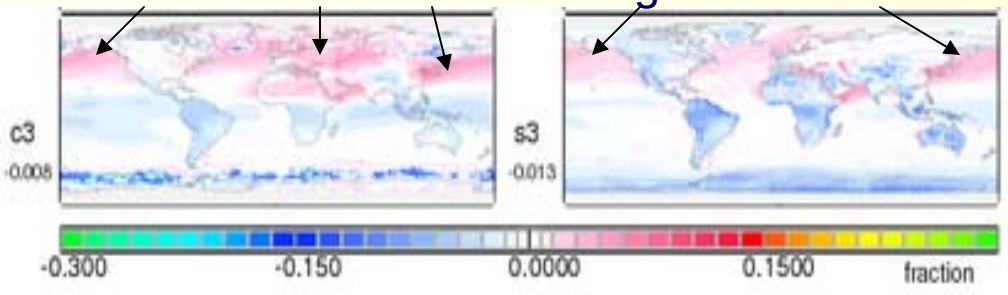


- surf. emission

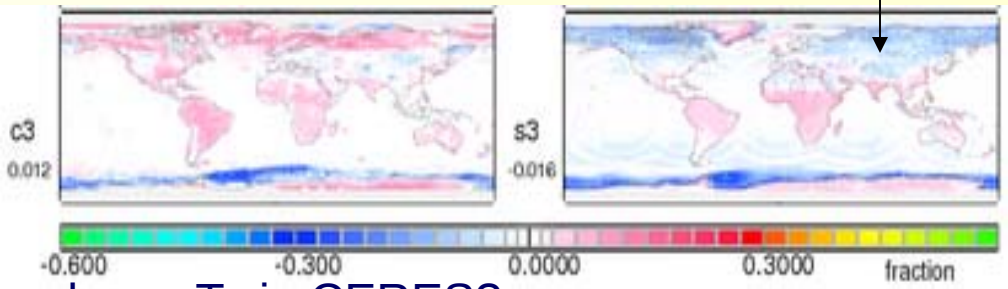


CERES -ISCCP SRB -ISCCP

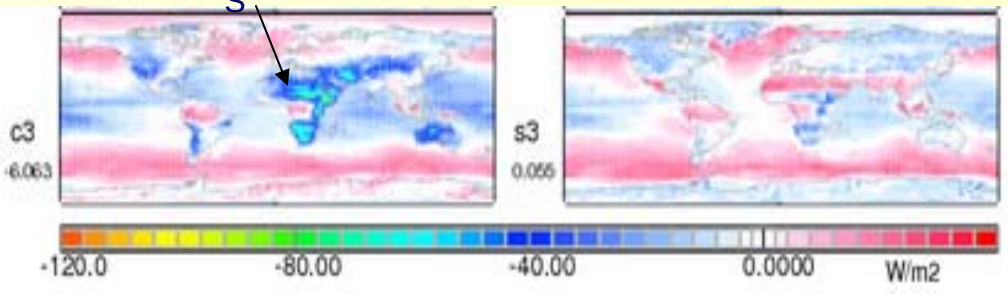
too much aerosol at NH high lat in ISCCP?



less snow in SRB?



lower T_S in CERES?

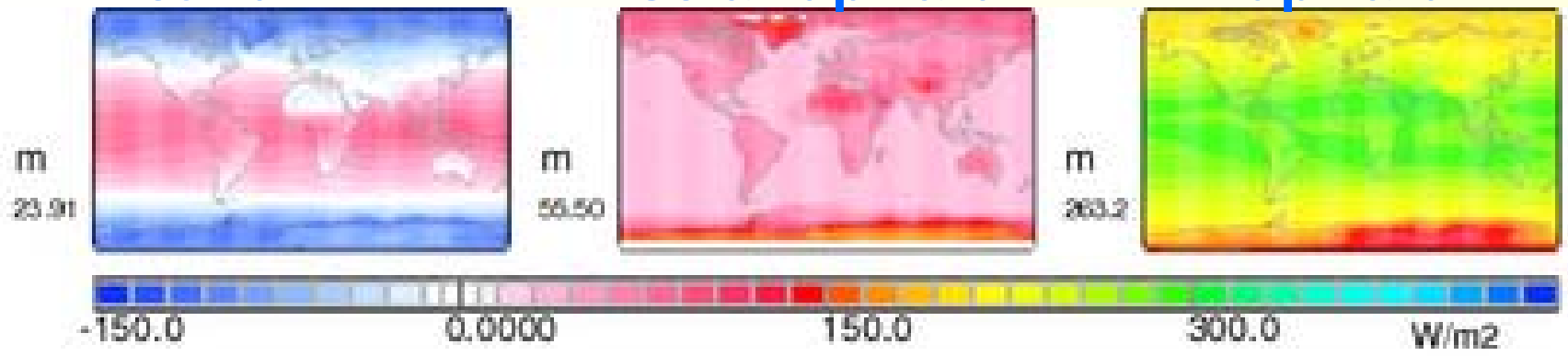


clear sky fluxes – no clouds

IPCC-4AR model median

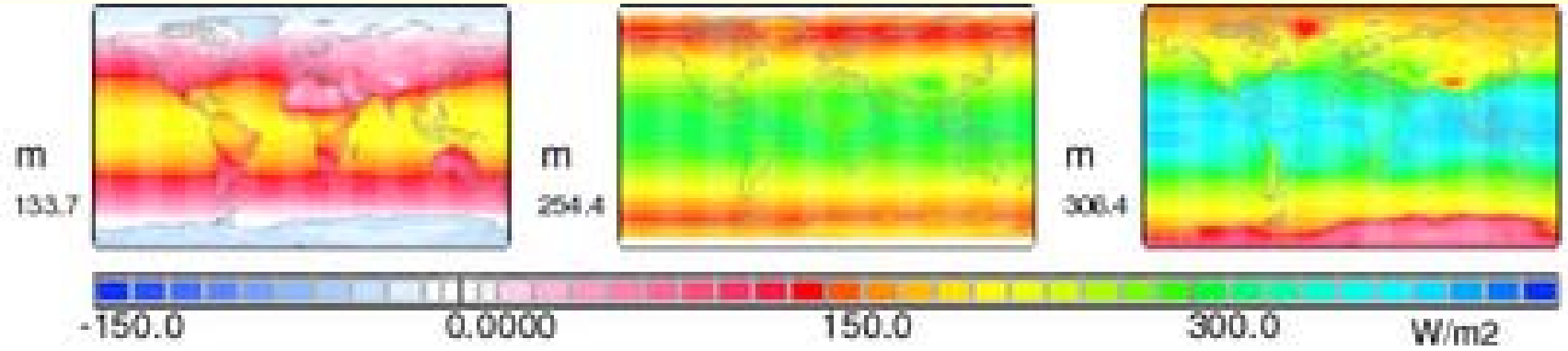
at top of the atmosphere

net flux | solar-upward | IR-upward



at the surface

net flux | solar-down | IR-down

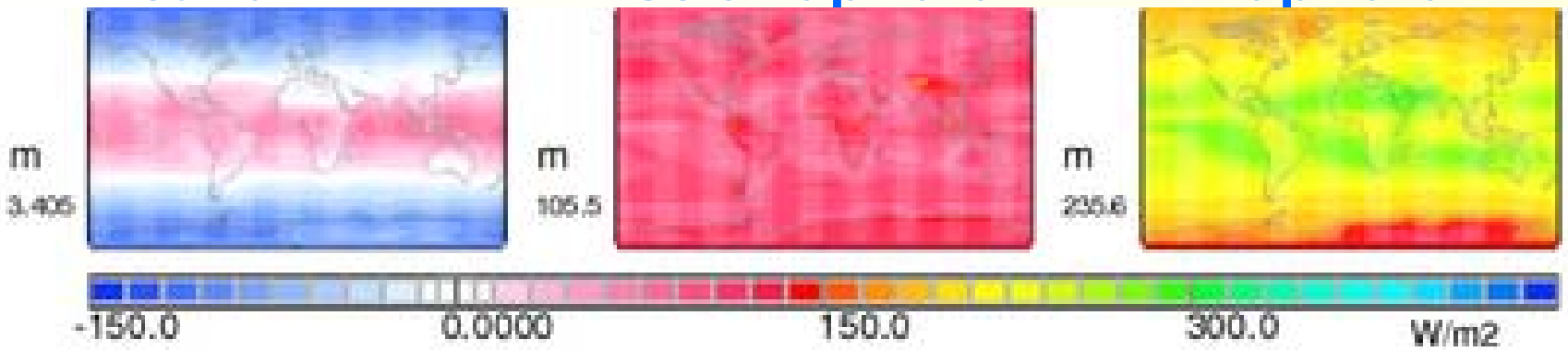


all sky fluxes – with clouds

IPCC-4AR model median

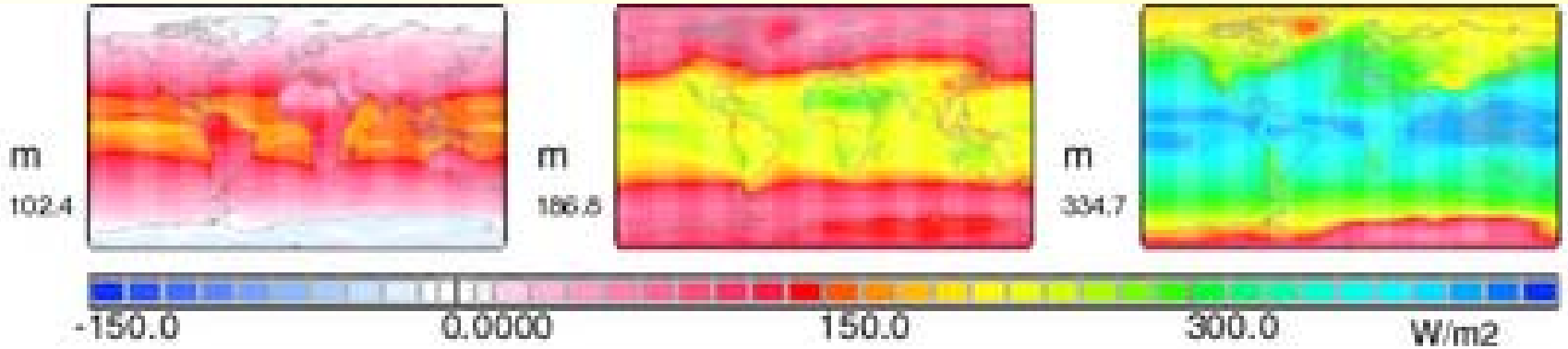
at top of the atmosphere

net flux | solar-upward | IR-upward



at the surface

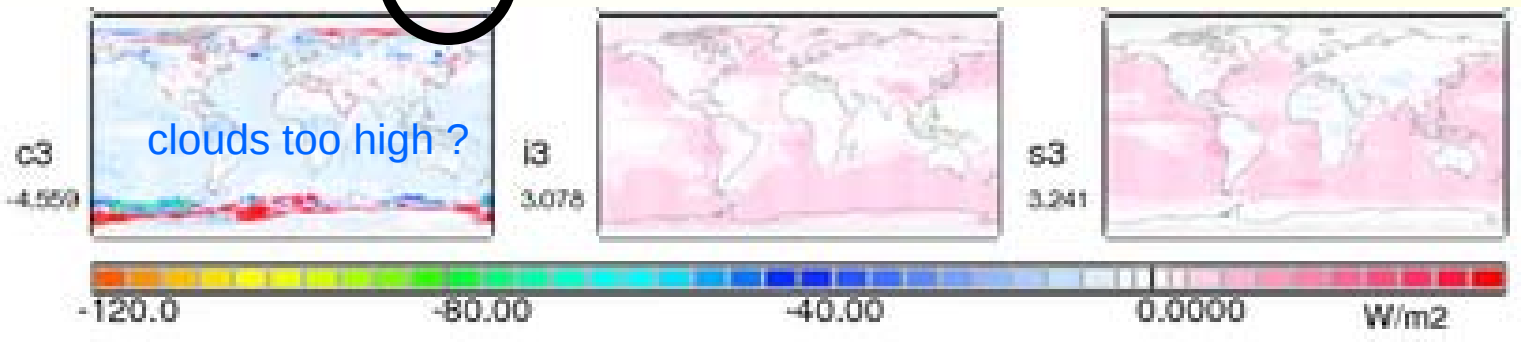
net flux | solar-down | IR-down



CE on solar divergence

+ 6 model IPCC4 median

CERES **- 5** **ISCCP** **+ 3** **SRB** **+ 3**

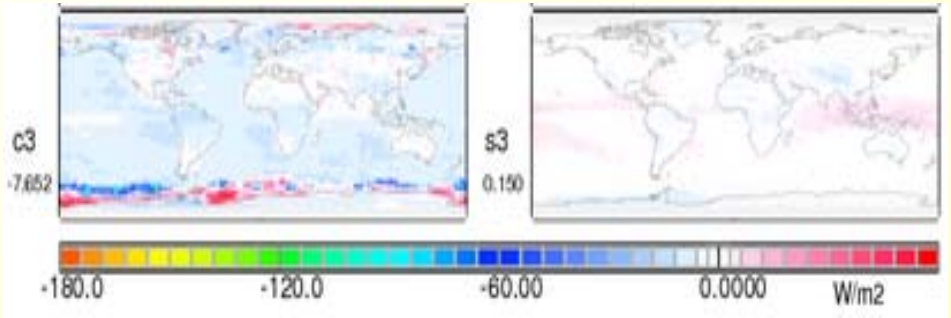


differences

weaker impact than refer.

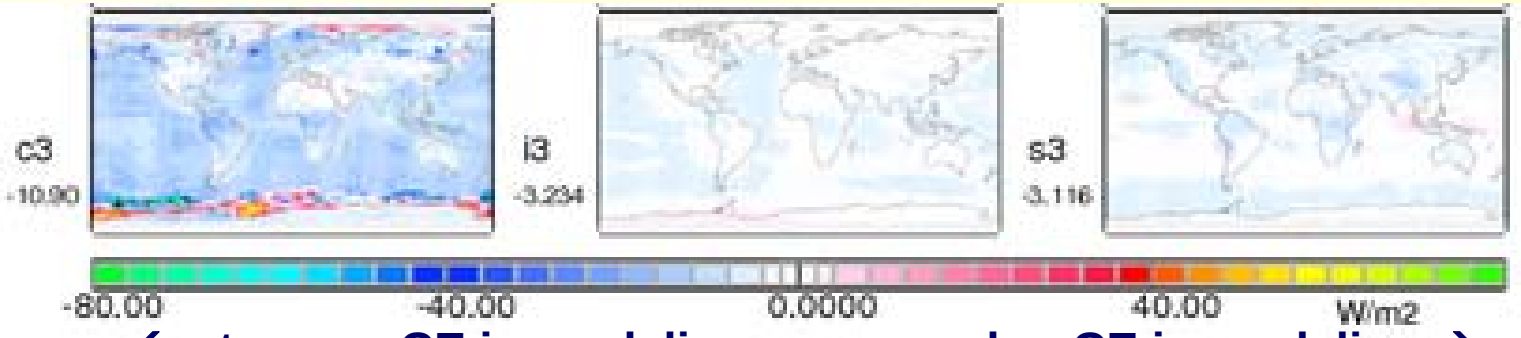
stronger impact than refer.

CERES *minus* ISCCP



SRB *minus* ISCCP

CERES-model **ISCCP-model** **SRB-model**

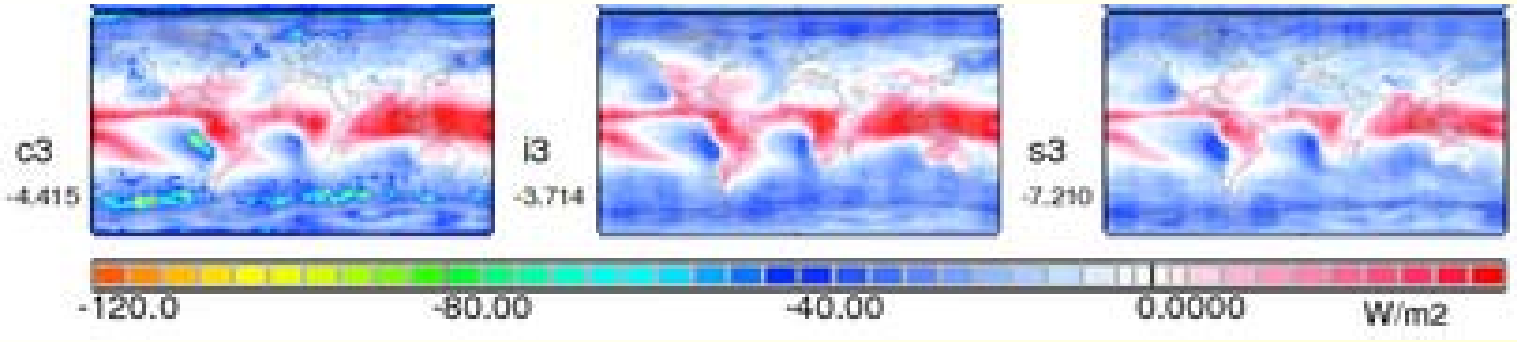


← stronger CE in modeling **weaker CE in modeling →**

CE on IR divergence

- 3 model IPCC4 median

CERES - 4 **ISCCP - 4** **SRB - 7**

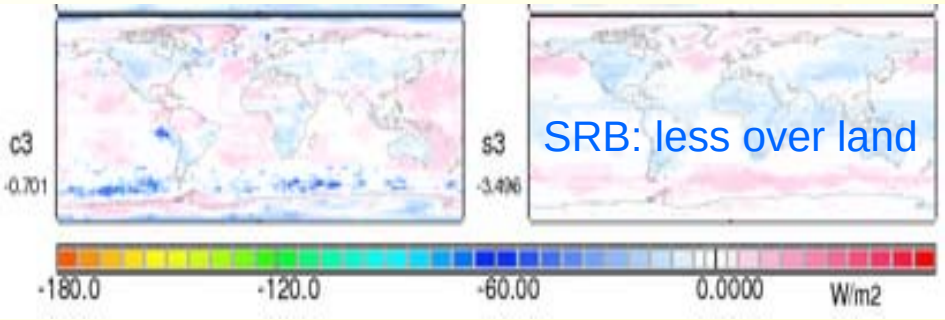


differences

stronger reductions than refer.

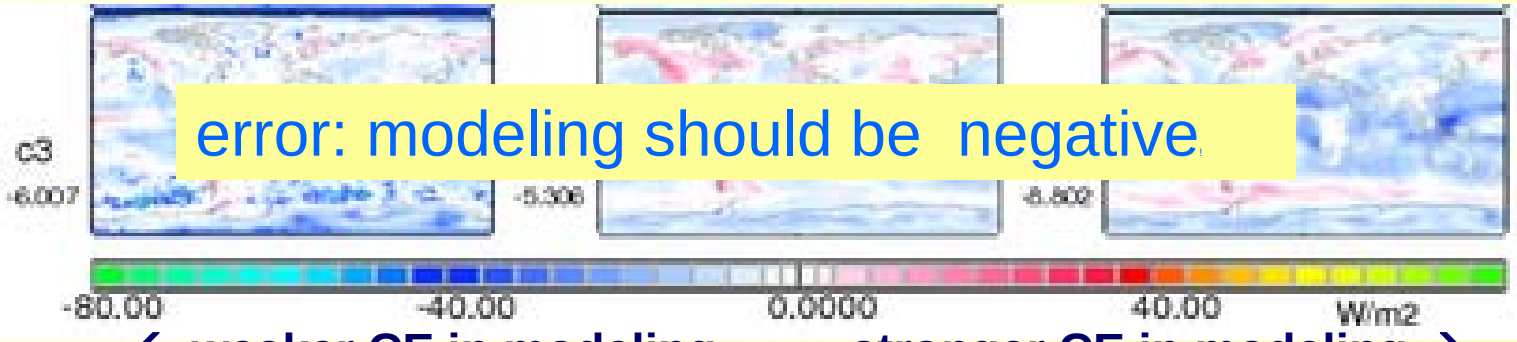
weaker reduction than refer.

CERES *minus* ISCCP



SRB *minus* ISCCP

CERES-model **ISCCP-model** **SRB-model**

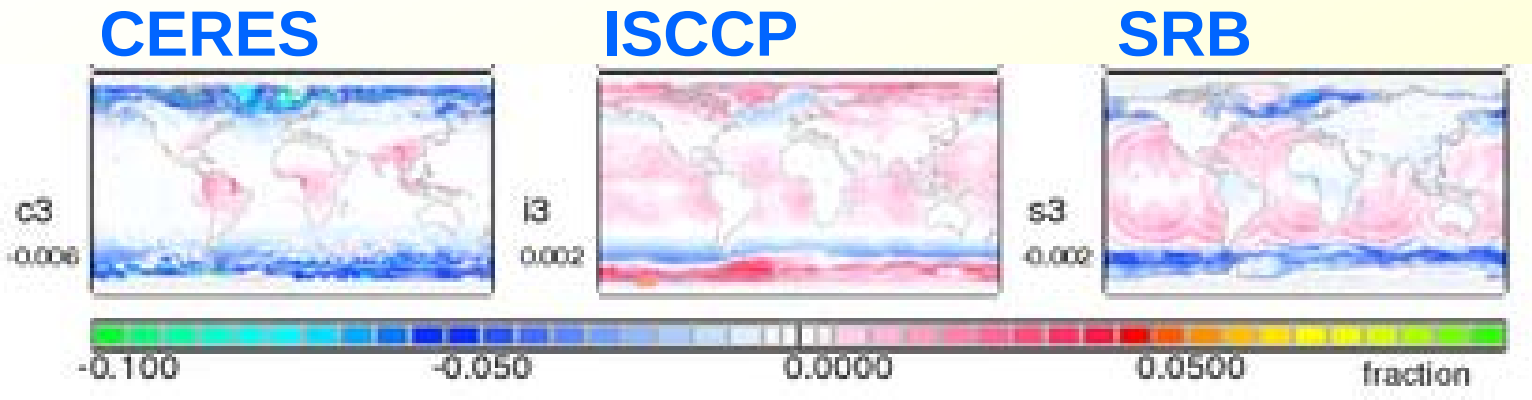


← **weaker CE in modeling** **stronger CE in modeling** →

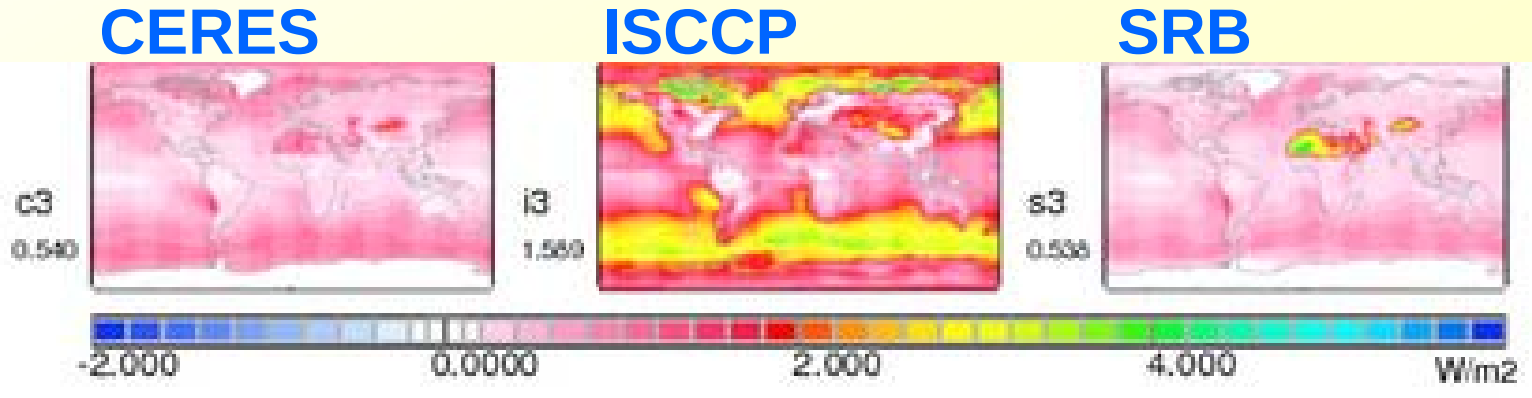
CE – for ancillary data

… they do exist

- surface albedo



- surface emission



undesirable pre-conditioning

- ISCCP has less solar transmission over NH high lat. oceans (too much aerosol ?)
- SRB lacks solar surface albedo over high latitude continents (not enough snow?)
- CERES emissions are lower over tropical Africa and S. Asia (different surface T ?)
- … and ancillary data are even differently modified by clouds in satellite data-sets

aerosol properties