AeroCom phase 2 plan:

Model intercomparison of (BC) vertical direct forcing profiles

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+ AeroCom modellers

Outline

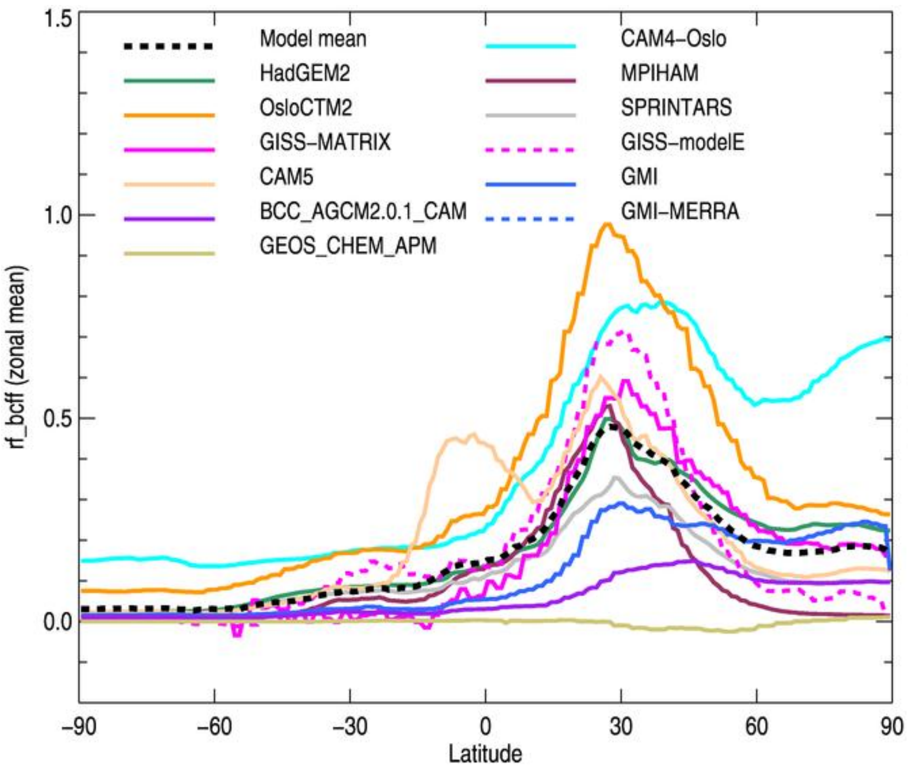
- Vertical aerosol profiles – some motivation
- A tool: NDRF profiles from a single model
  - The OsloCTM2/disort setup
  - Extracting NDRF profiles
  - Core results
- Model intercomparisons
  - SO_4 and BC from OsloCTM2 and CAM4-Oslo
  - Request for additional submissions from other participating models

NDRF = Normalized direct radiative forcing [W/g]

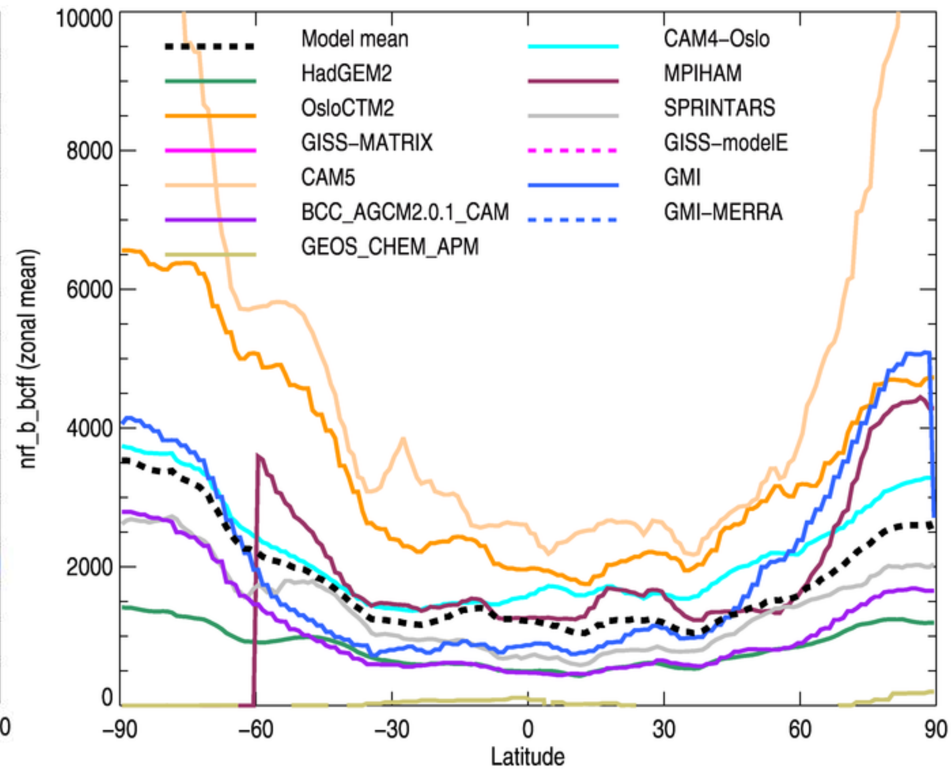
= how much radiative forcing we get from a certain amount of aerosol

AeroCom phase 2:
BCFF intercomparison status

Radiative forcing [W/m2]



Normalized radiative forcing [W/g]



We would like to understand these differences as well as possible…

Motivation:

The NDRF varies with altitude relative to clouds (…and more…)

"Absorbing aerosols above a cloud layer have a substantially larger RF than if the aerosols are situated below the clouds, therefore the vertical profile of aerosols, and in particular the profile for BC is important."

Myhre et al (ACP,2009)

Table 2. Summary of Weighted-Column Model BC NDRFs for the Combinations of Vertical Profile and Cloud Inputs Explored in This Study[a]

BC Profile	Clouds	Grid-Box Average	Wtd-Column NDRF (W/g)	Diff From Base case
		Base Case		
Observation	ISCCP	-	1140	-
		Covariance Tests		
CAM	CAM	-	1210	n/a
CAM	CAM	x	1245	n/a
		Model Diversity		
MPI_HAM	ISCCP	-	1010	−11%
UMI	ISCCP	-	1130	−1%
SPRINTARS	ISCCP	-	1170	3%
CAM	ISCCP	-	1340	18%
LSCE	ISCCP	-	1440	26%
		Extreme Profiles		
Below all clouds	ISCCP	-	525	−54%
Above all clouds	ISCCP	-	2250	97%
Near surface	ISCCP	-	630	−45%
Highly lofted	ISCCP	-	1490	31%
		Simple Profile With Covariance		
ConstMix	CAM	x	1105	n/a
LLCAM	CAM	x	1060	n/a

[a]These NDRF values were determined for unmixed aerosol, so relative values are more important than absolute values.

Zarzycki et al (GRL,2010)

Motivation:

Aerosol density vertical profile is poorly constrained

Table 1. Anthropogenic burden, AOD at 550 nm, radiative forcing (RF) due to the direct aerosol effect, and normalized RF (both with respect to anthropogenic burden and AOD).

Aerosol component	Burden (mg m^{-2})	AOD (550 nm)	AOD Ant fraction (%)	**RF (W m^{-2})**	Normalized RF (W g^{-1})	Normalized RF (W m^{-2})
Sulphate	1.94	0.024	50	**−0.44**	−227	−19
BC (FF+BF)	0.19	0.0018 (0.0024)	91	**0.26 (0.33)**	1326 (1693)	143 (139)
OC (FF+BF)	0.33	0.0034	87	**−0.09**	−273	−27
OC SOA*	0.31	0.0035	38	**−0.09**	−286	−26
Biomass burning	0.74^{+}	0.011	59	**0.07**	95	7
Nitrate	0.11	0.0012	98	**−0.023**	−208	−19
Total	3.63	0.044 (0.045)	41$^{\&}$ (41$^{\&}$)	**−0.35 (−0.28)**	−96 (−77)	−8 (−6)

*Part of it is from biomass burning; $^{+}$87% is OC; $^{\&}$The anthropogenic fraction for the total aerosol refer to fine mode aerosols; Numbers in parentheses for BC are for the enhanced absorption associated with internal mixing.

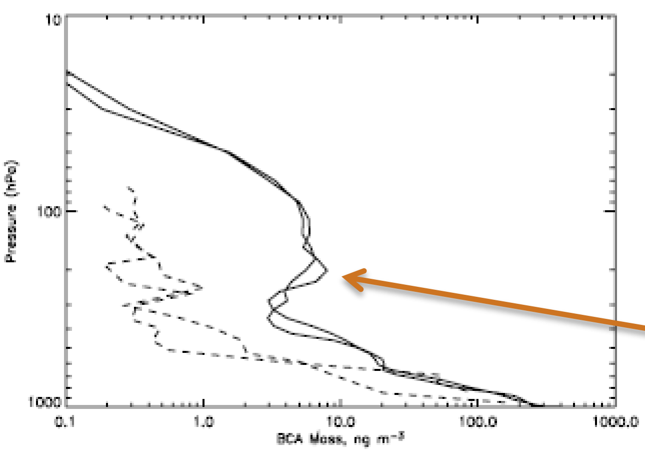
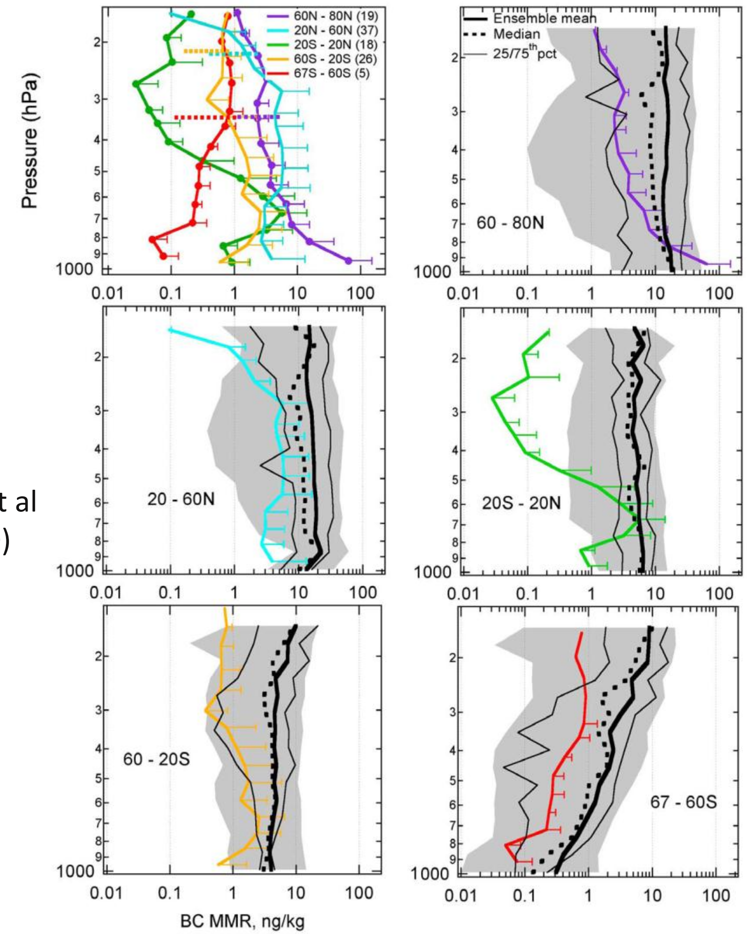


Fig. 14. Vertical profile of BC from observations (dotted line) and the aerosol model (solid line) for two different days in November 2004.

Myhre et al (ACP,2009)

How important is this region?

Schwarz et al (GRL,2010)



The current study:

Quantify the vertical and cloud sensitivity of NDRF in 4D (3D + seasonal)

Tools and inputs:

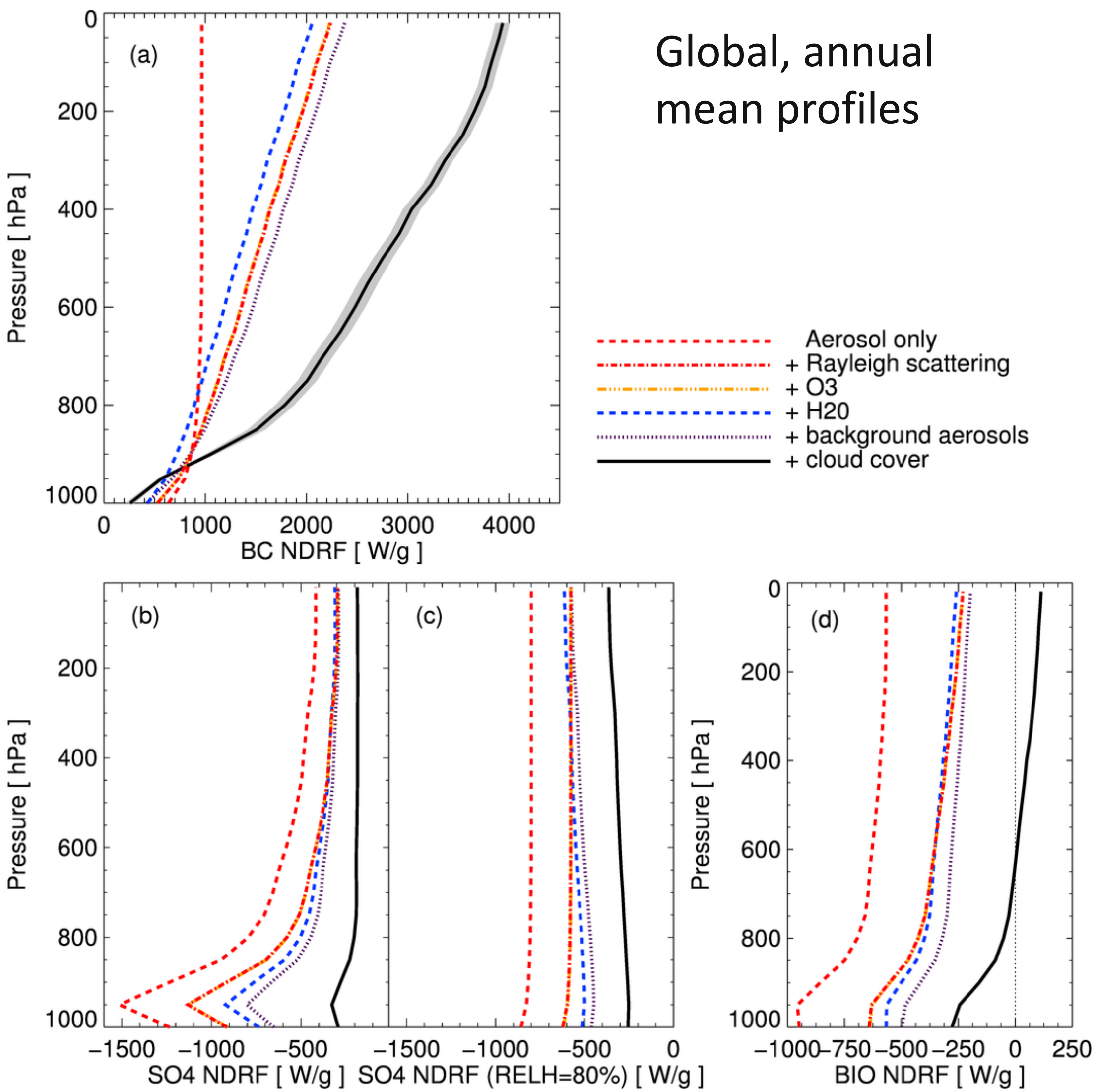
- Software: Disort radiative transport code, run in T42L23 resolution (reduced from L60 due to computational limitations), 3h time steps
- Background: OsloCTM2 output, T42L60 layers (BC, OC, SO4, Nitrates, sea salt, dust, O3, …)
- Clouds: From the Integrated Forecast System at ECMWF, using 3D cloud fraction and ice/liquid water content fields

Method:

- Pick one aerosol type: **BCFF**, **SO4**, **BC/OC from biomass burning**
- Intruduce a known level of aerosol at a known atm. pressure, run the calculation, extract NDRF
- Do this for 23 levels, from 1050hPa to 20hPa

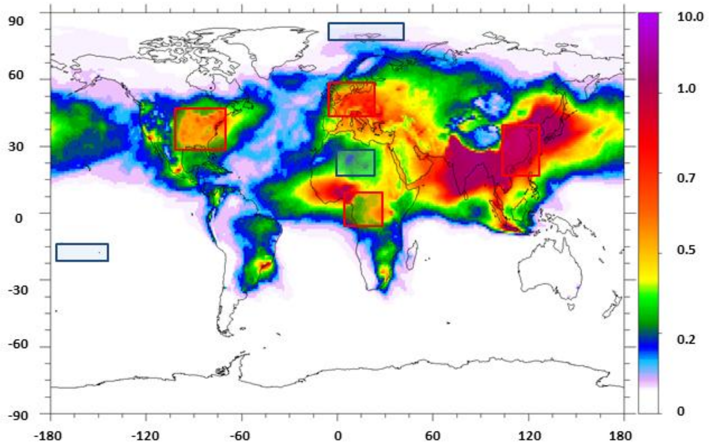
Core result (submitted to GRL, under review):

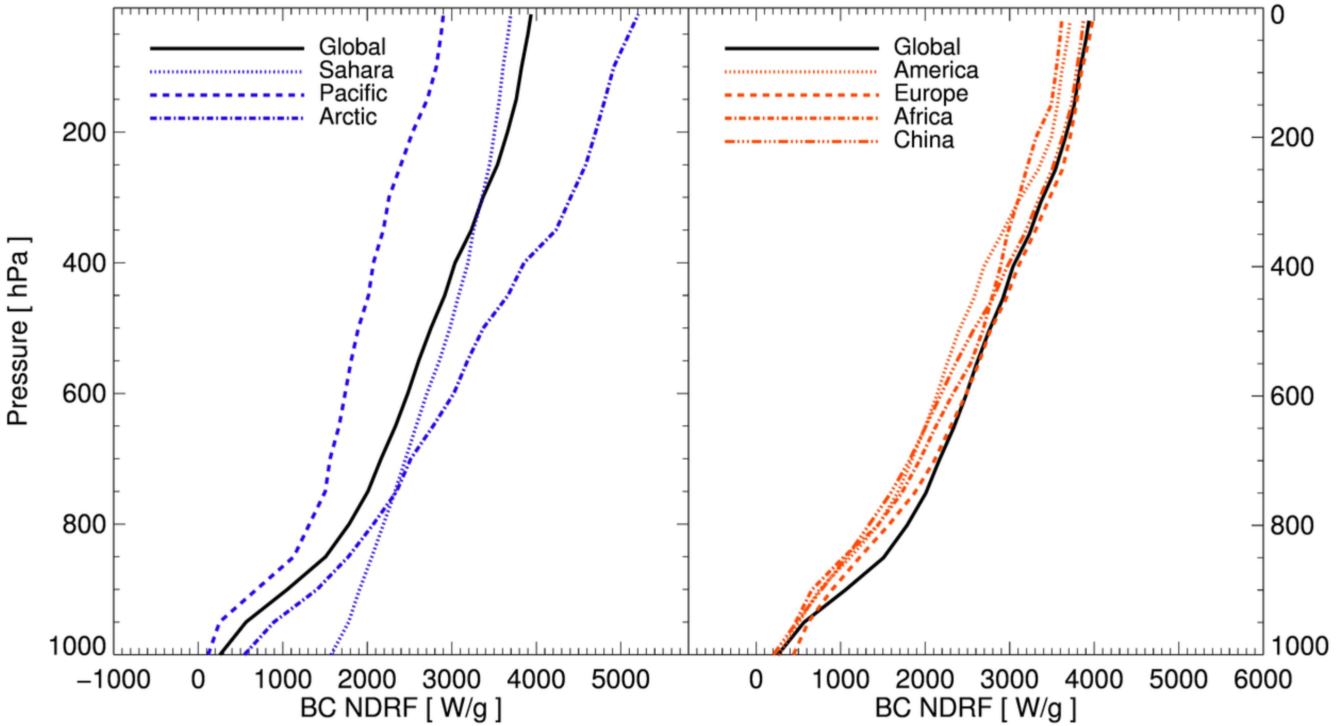
Vertical NDRF profiles, with «physics breakdown»



- **BC**
  - ...means BCFF
  - High sensitivity
  - Only about half from clouds
  - Low seasonal and met year diversity (grey band)
- **SO4**
  - Lower but nonvanishing sensitivity
  - Two exp:
    - Model rel.hum.
    - Constant rel.hum.
- **BIO**
  - 50/50 OC/BC mix
  - Noticeable sensitivity
  - Changes sign when clouds are added

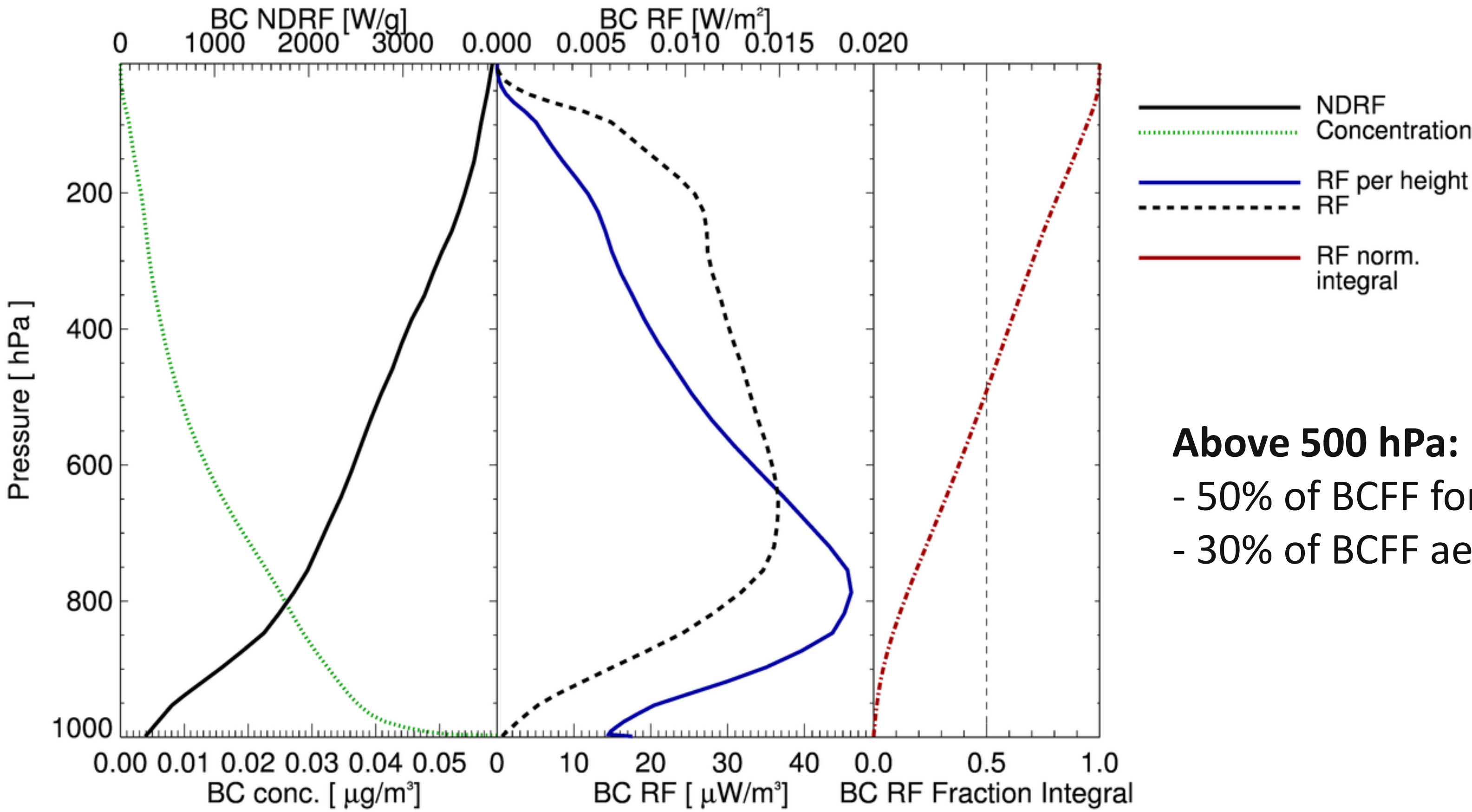
Core result:
Regional differences





- Only BCFF shown
- Selected industrial and illustrative regions
- Industrial: Low variability, but global, annual mean mostly stronger than industrial av.
- Illustrative: Large variability
- Need to use 3D fields, not global average profiles

Core result:
OsloCTM2 vertical RF breakdown



Above 500 hPa:

- 50% of BCFF forcing
- 30% of BCFF aerosol

BCFF profile from Skeie et al., Atmos. Chem. Phys. Discuss., 11, 22545-22617, 2011

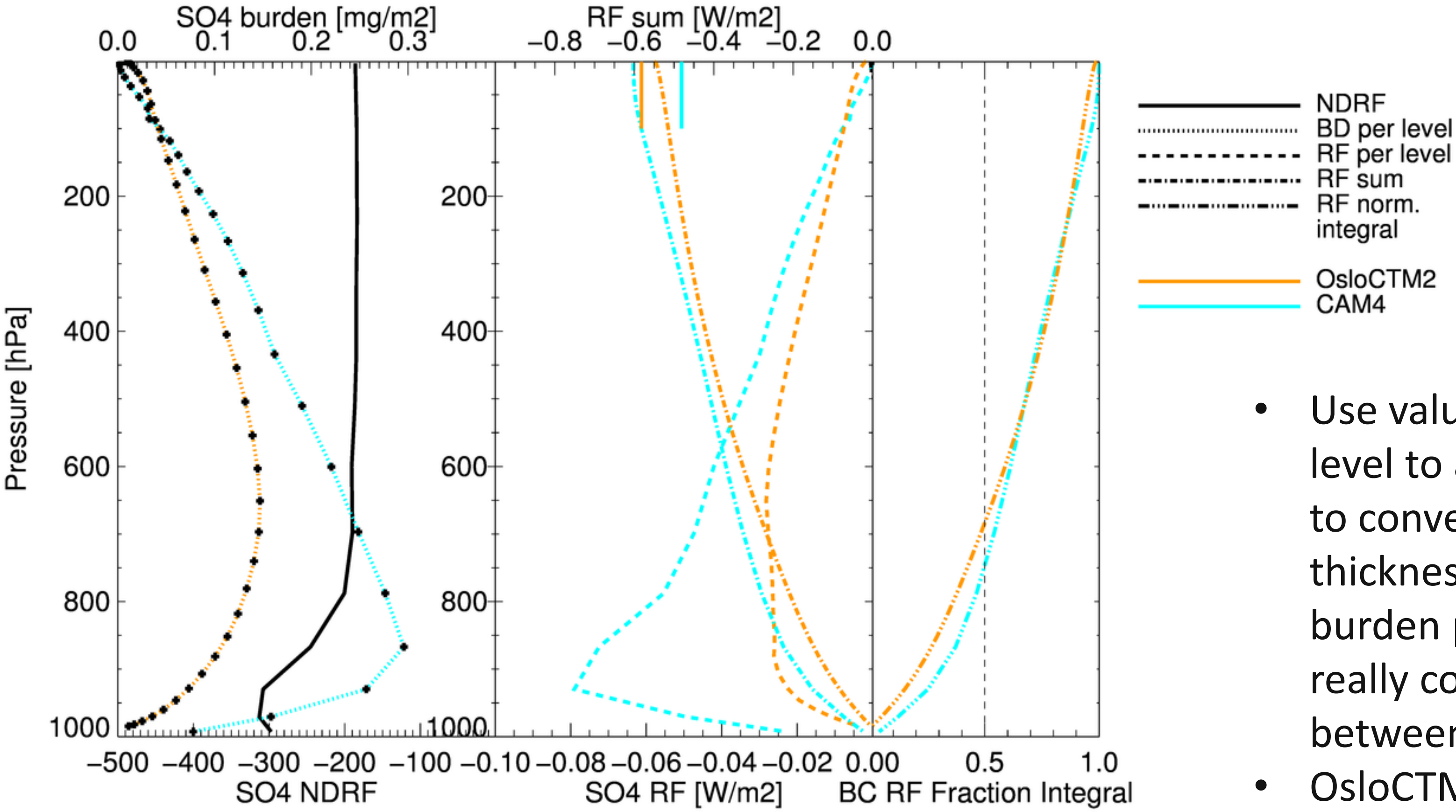
Aerocom phase 2 plan:

Vertical RF profile comparison

- Gather mmr fields from as many models as possible
- Calculate aerosol burden per model level
- Calculate aerosol RF using NDRF profile from the present study
- Compare to the models' own RF values

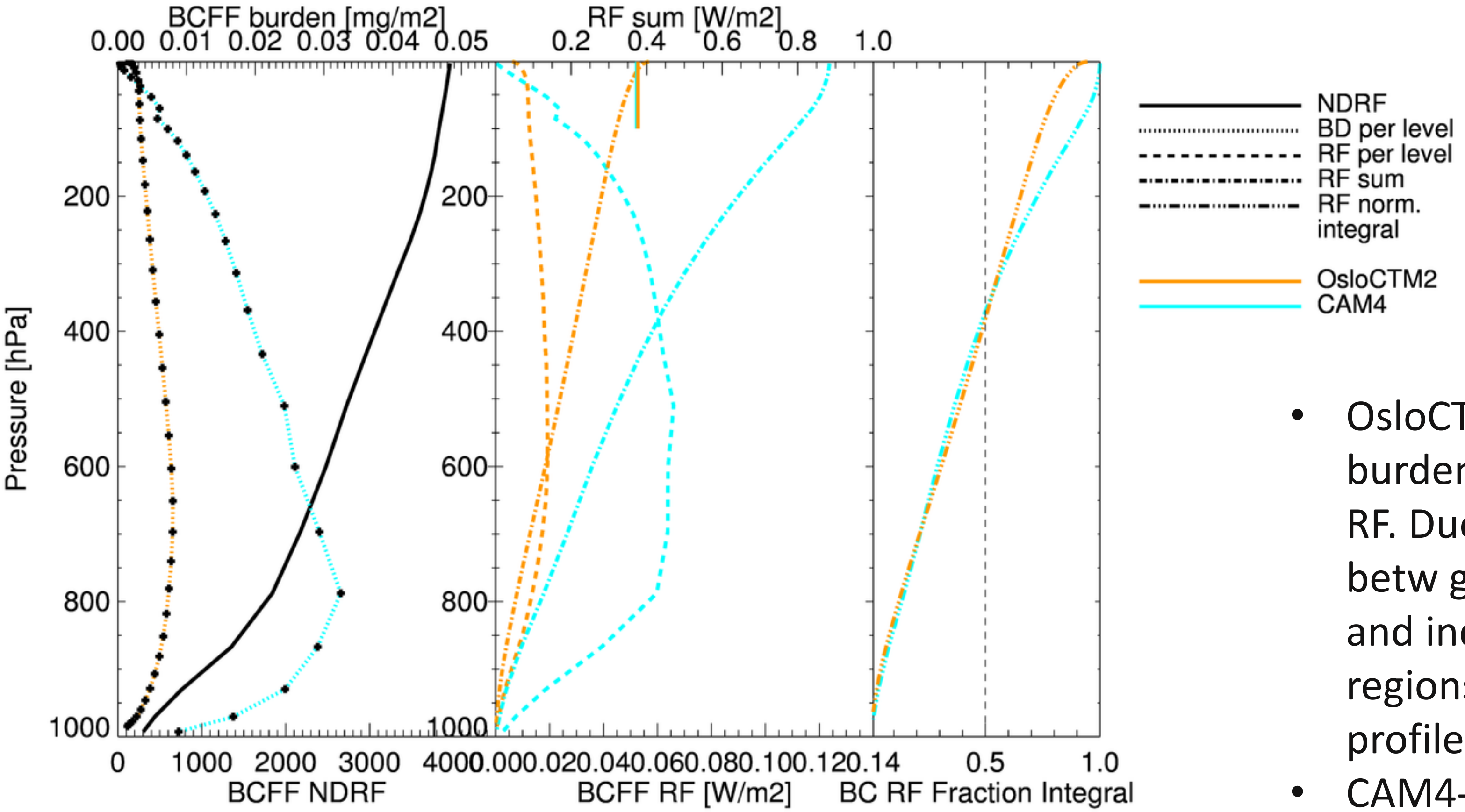
- Will now show **work-in-progress** examples for SO4 and BCFF for two models (OsloCTM2, CAM4-Oslo)

- Request for input from models:
  - ***mmrbcff***, ***mmrso4, mmrbb*** (3D) for CTRL and PRE (or, if easier, anthropogenic burden in 3D)
  - ***airmass*** (3D)
  - ***temp***erature (3D), ***ps*** (surface pressure, 2D)



- Use values per level to avoid having to convert to level thicknesses, i.e. burden profiles not really comparable between models
- OsloCTM2: BD increases, RF decreases. Will improve with 3D profiles
- CAM4-Oslo: Stronger change in RF.

	From submitted fields		Present analysis	
	Burden	RF	Burden	RF
OsloCTM2	2.61	-0.58	2.65	-0.55
CAM4	2.78	-0.48	2.80	-0.60



- OsloCTM2: Same burden, stronger RF. Due to difference betw global mean and industrial regions. -> use 3D profiles.
- CAM4-Oslo field used is all BC, not BCFF – hence large difference.
- Request to all models:
  BCFF mmr 3D fields.

	From submitted fields		Present analysis	
	Burden	RF	Burden	RF
OsloCTM2	0.17	0.38	0.17	0.43
CAM4	0.21	0.37	0.35	0.88

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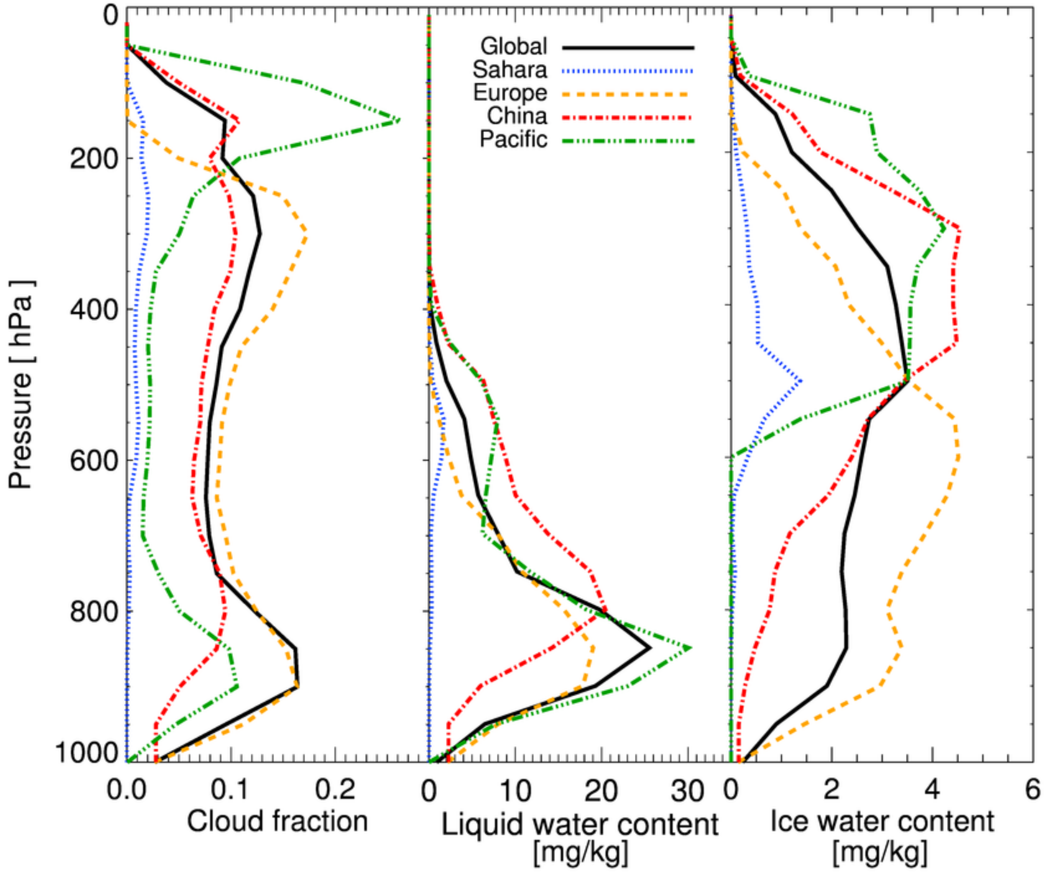
Backups

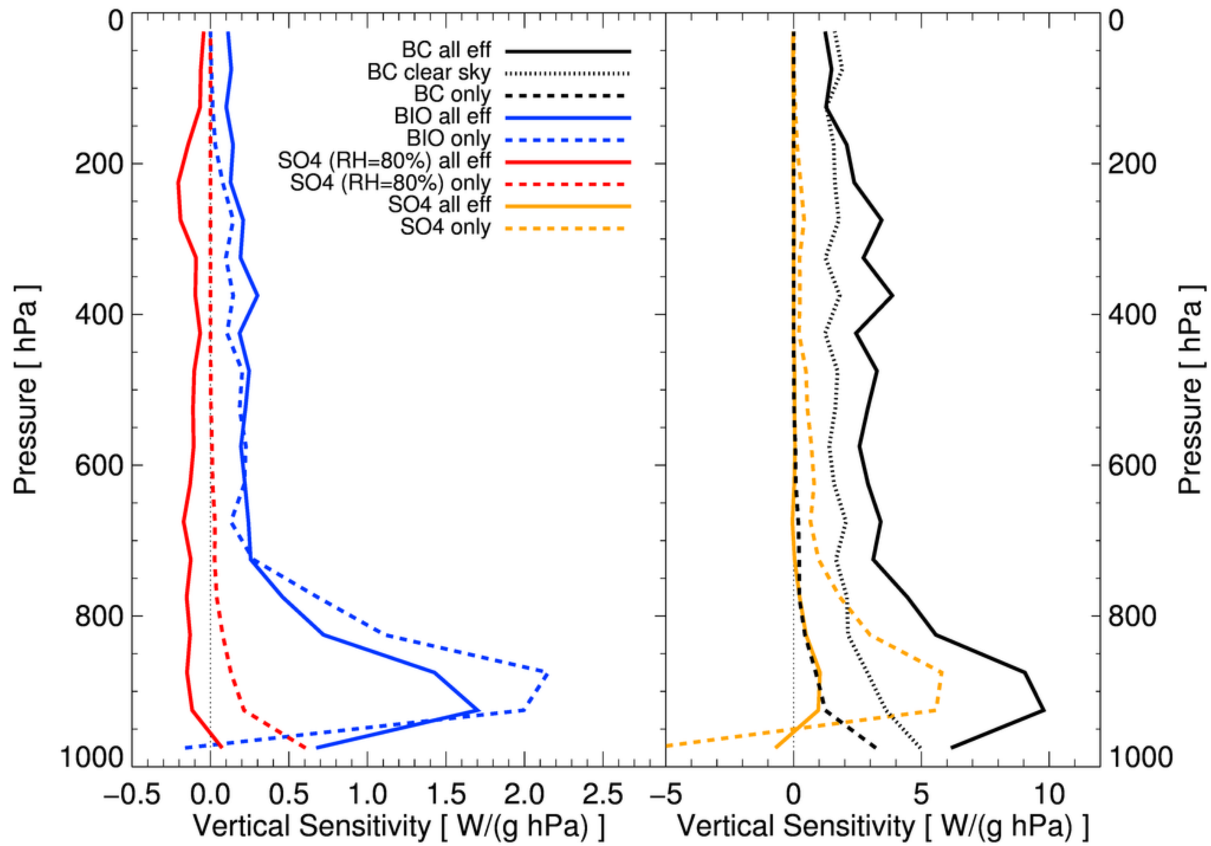
Cloud vertical profiles
Global, annual mean

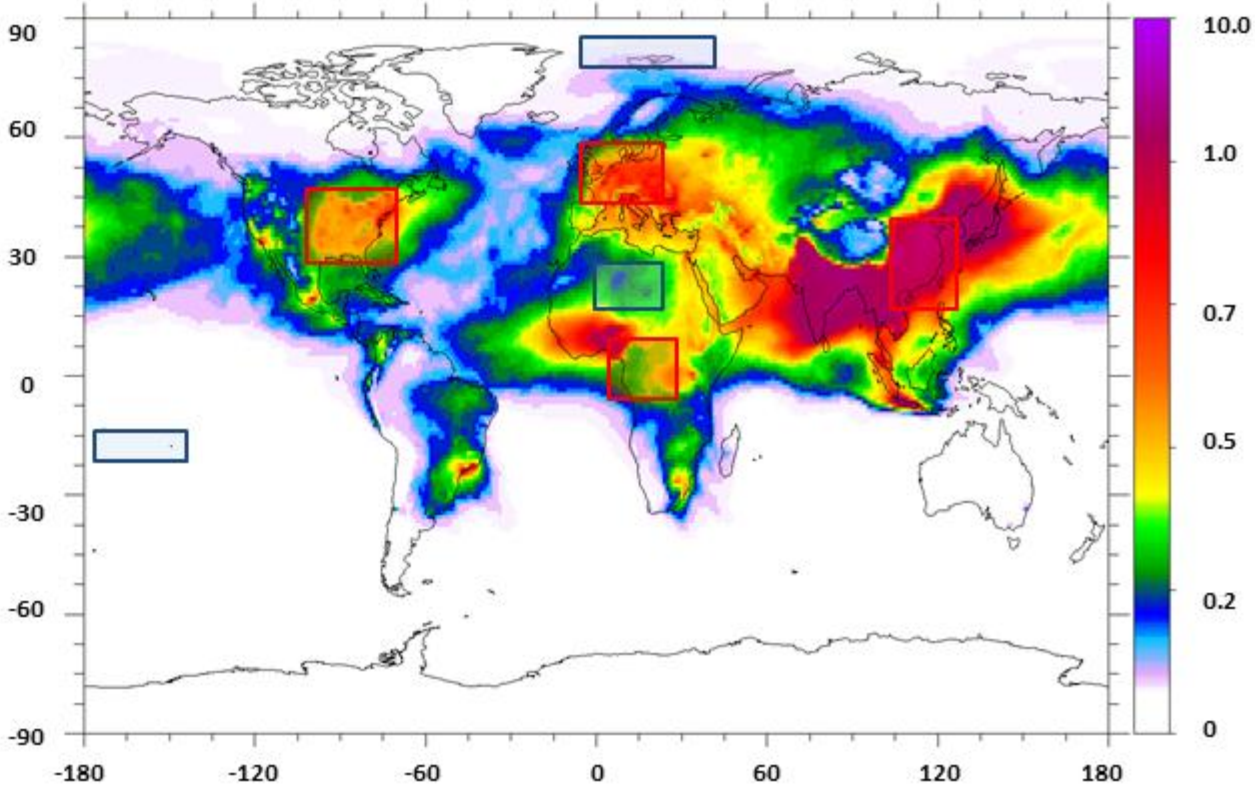


Vertical sensitivity

Global, annual mean

$$s_V = -\frac{dNDRF}{dP} \; [W/(g\ hPa)]$$





90
60
30
0
-30
-60
-90
-180
-120
-60
0
60
120
180
10.0
1.0
0.7
0.5
0.2
0