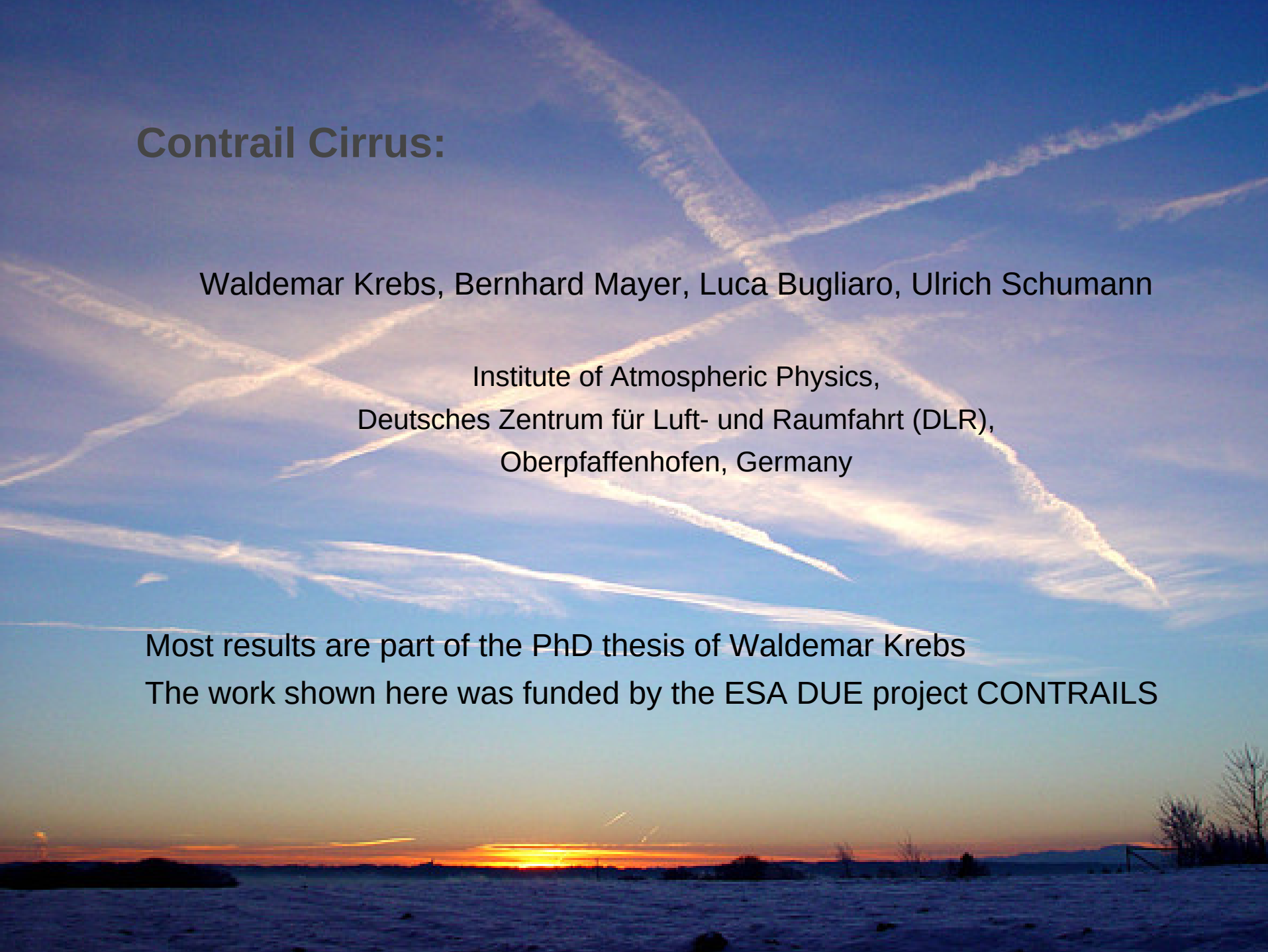
Contrail Cirrus Coverage and Radiative Forcing derived from MSG-SEVIRI Data

H. Mannstein

3rd MSG RAO Workshop, Helsinki, 2006 - 06 - 15



Contrail Cirrus:

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Most results are part of the PhD thesis of Waldemar Krebs

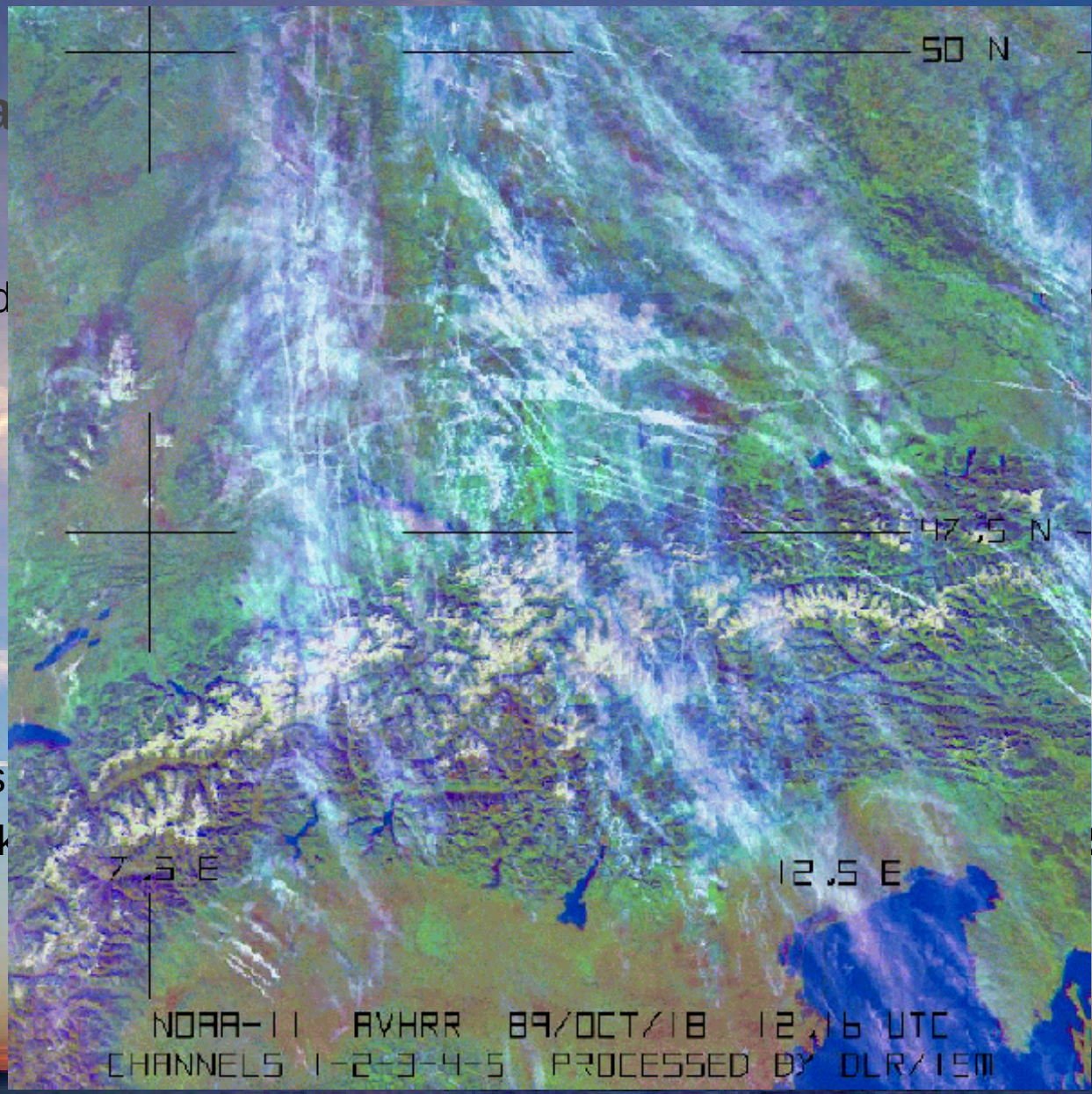
The work shown here was funded by the ESA DUE project CONTRAILS

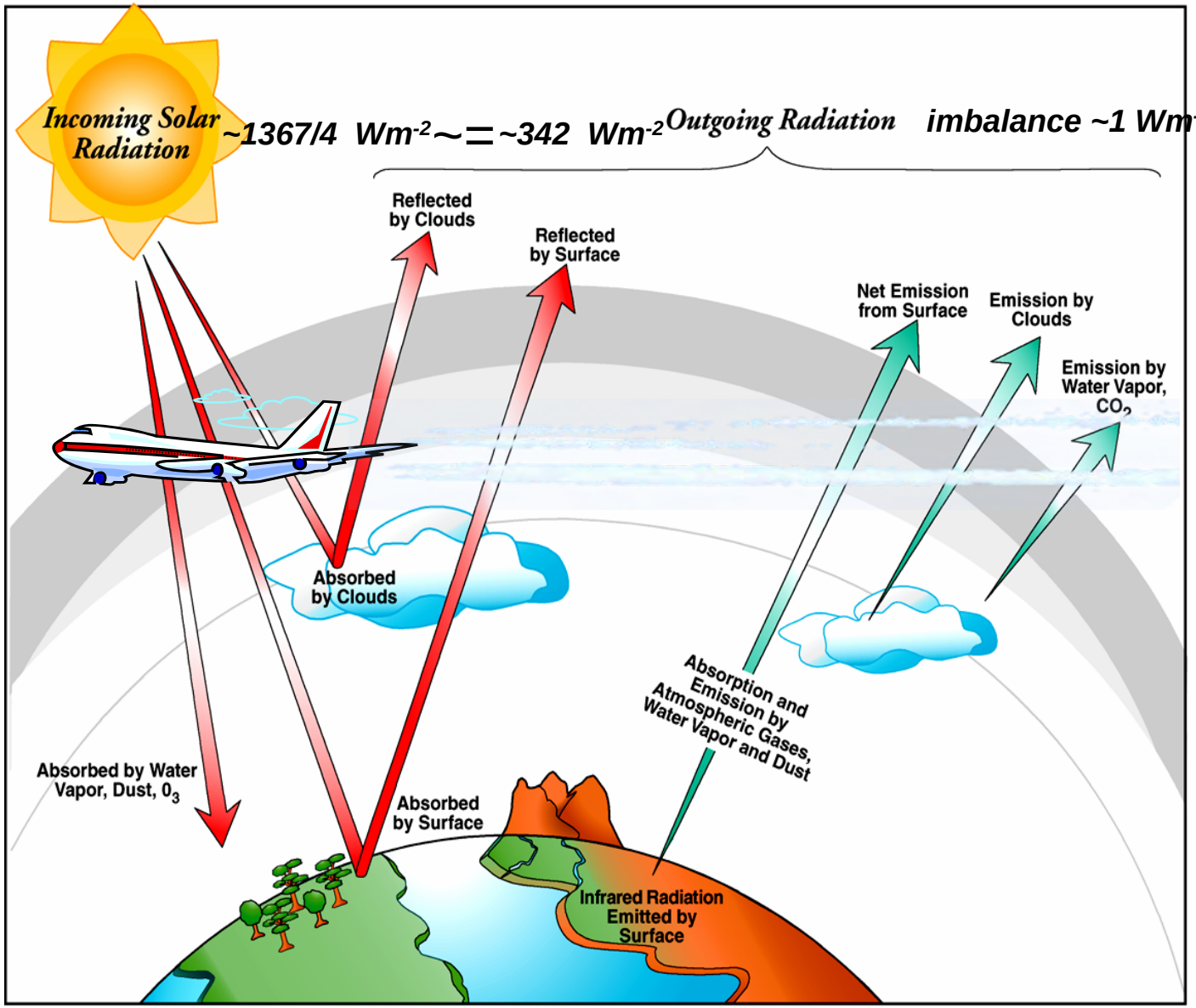
Contra

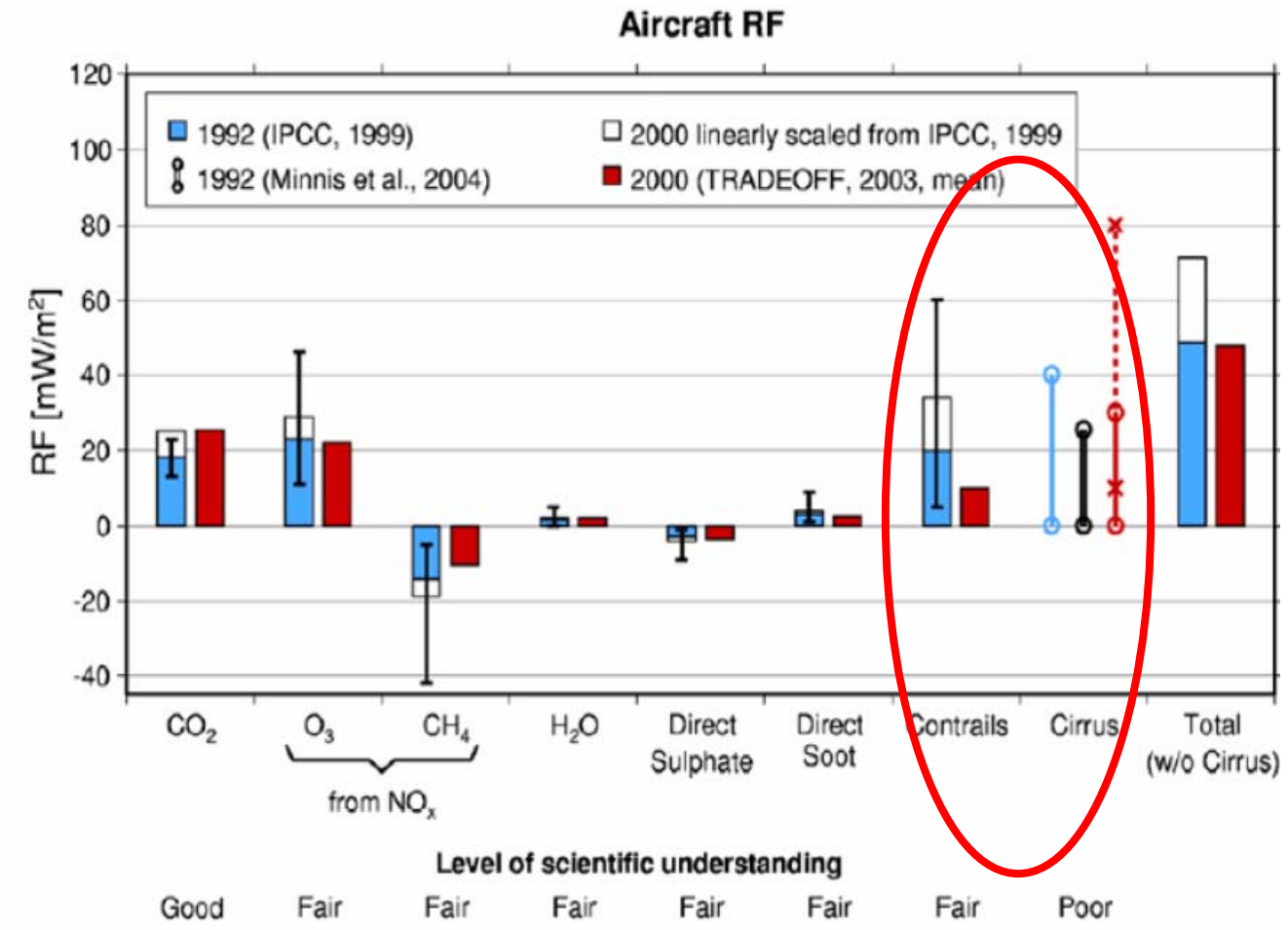
Wald mann

Most res

The work RAILS

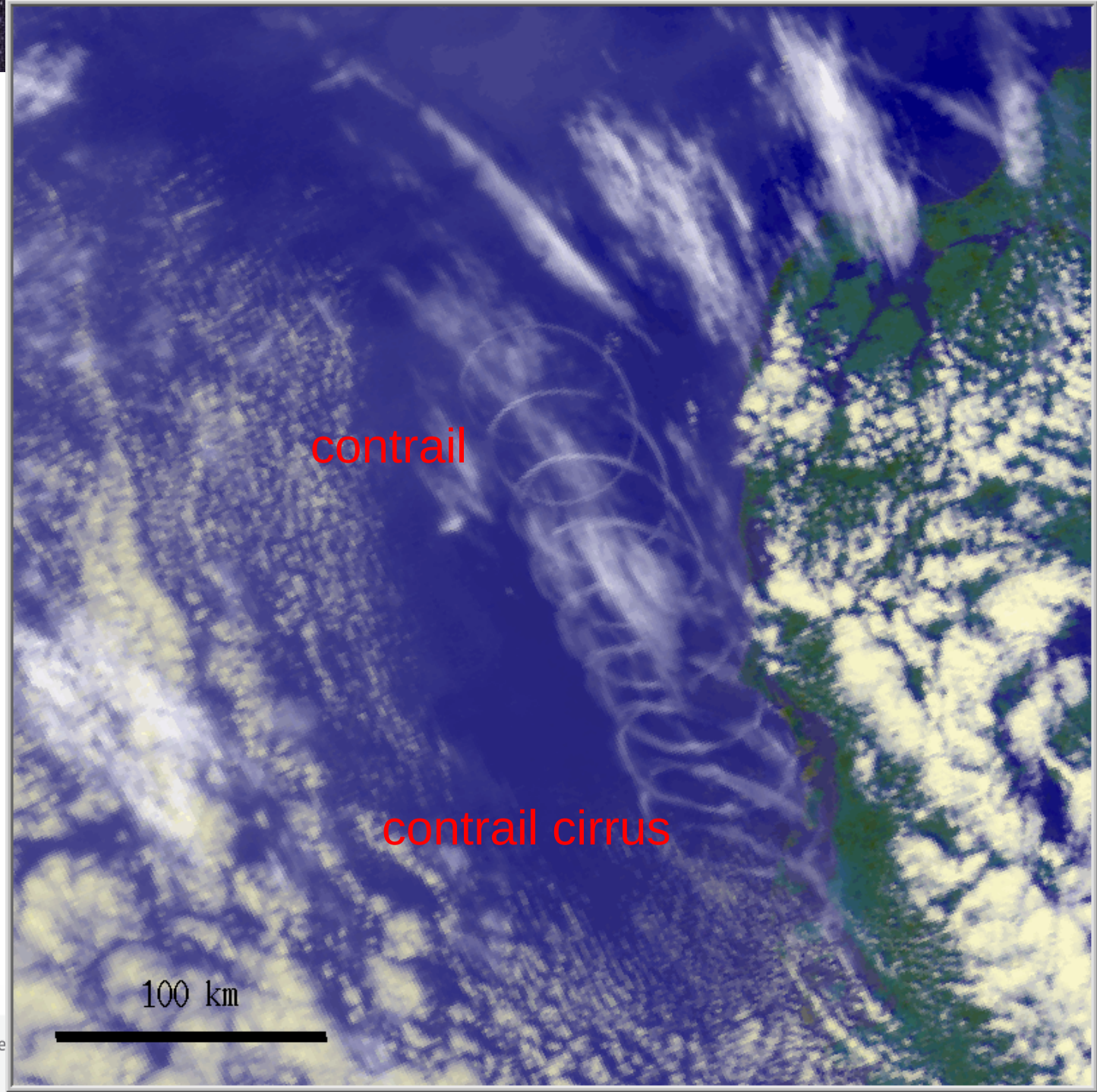



Incoming Solar Radiation
~1367/4 Wm-2 ~= ~342 Wm-2
Outgoing Radiation
imbalance ~1 Wm-2
Reflected by Clouds
Reflected by Surface
Net Emission from Surface
Emission by Clouds
Emission by Water Vapor, CO2
Absorbed by Clouds
Absorption and Emission by Atmospheric Gases, Water Vapor and Dust
Absorbed by Water Vapor, Dust, O3
Absorbed by Surface
Infrared Radiation Emitted by Surface



Sausen, Robert; Isaksen, Ivar; Grewe, Volker; Hauglustaine, Didier; Lee, David S.; Myhre, Gunnar; Köhler, Marcus O.; Pitari, Giovanni; Schumann, Ulrich; Stordal, Frode; Zerefos, Christos: **Aviation radiative forcing in 2000: An update on IPCC (1999)** Meteorol. Z. No 14, 4, August 2005, pp. 555-561

- NOAA 14 AVHRR
- May 22 1998 12:36
- ‘Corkscrew’ contrail
- ~1600km long,
- ~2.6 h old at the end

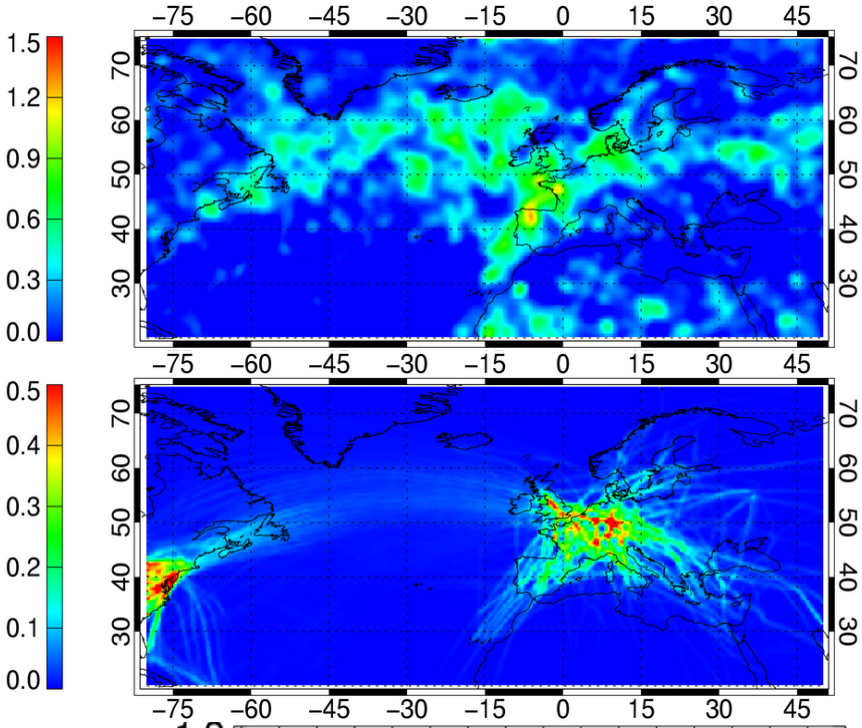


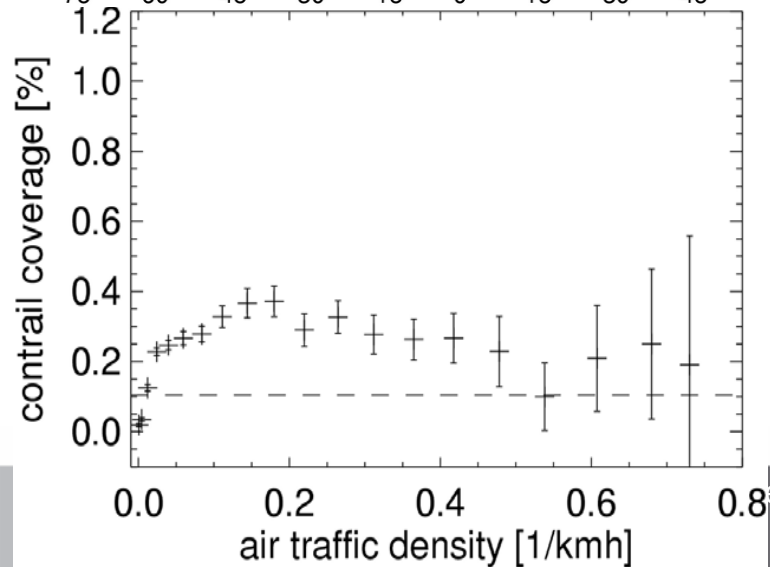
contrail coverage (%) from AATSR data 2004
mean: 0.11 ± 0.04%

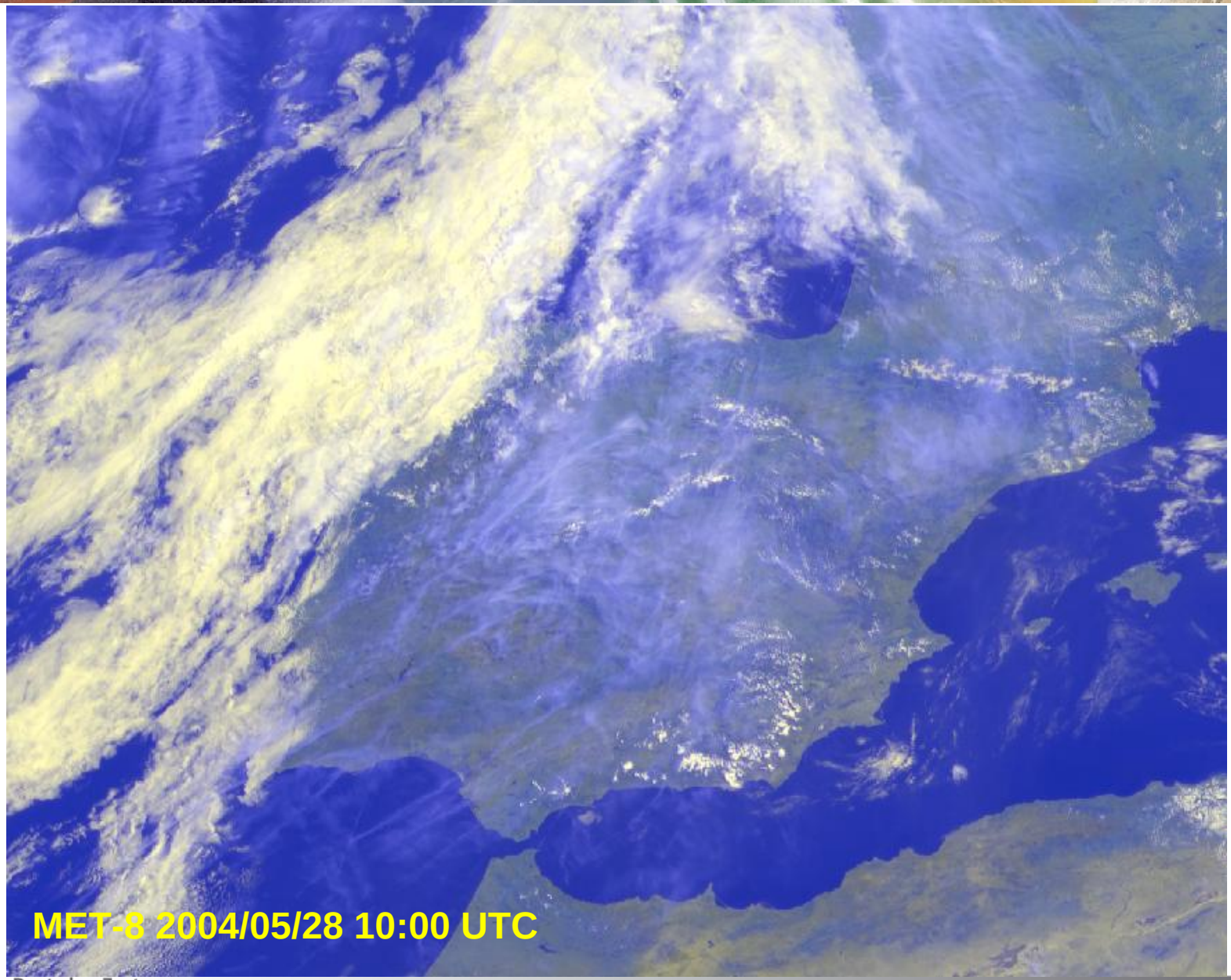
air traffic density [km/(km^{2}h)] within 1 hour before ENVISAT overpass

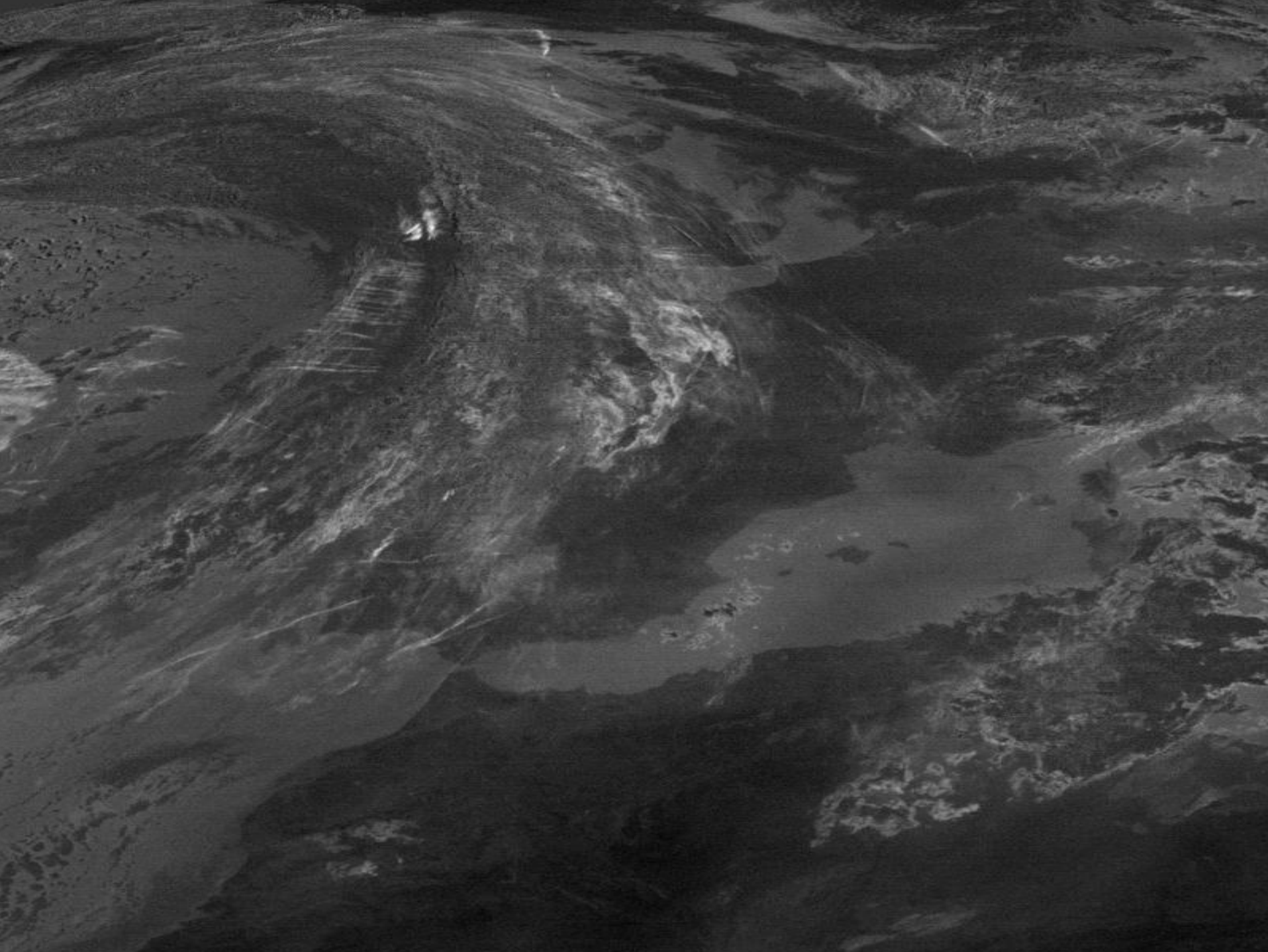
40% of global air traffic
11% of global area
global estimate:

0.03% contrails

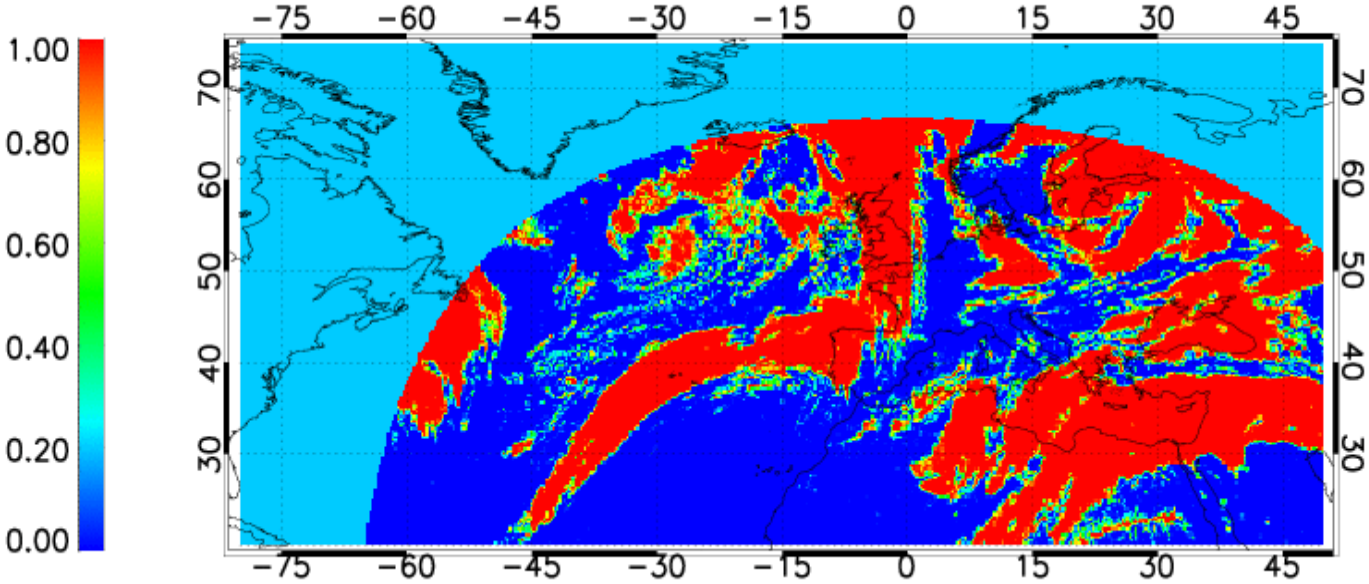





MET-8 2004/05/28 10:00 UTC



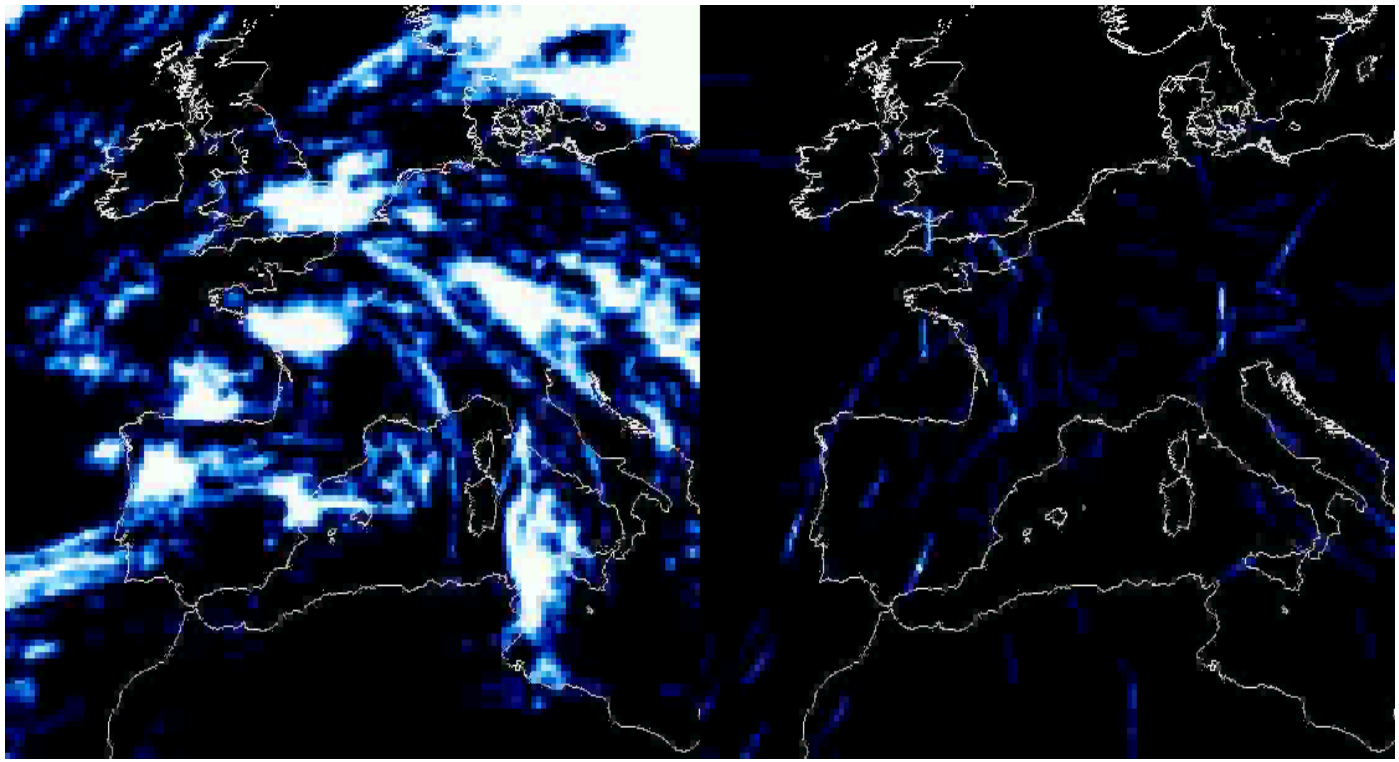
Cirrus coverage 0.25° x 0.25° 2004/03/03 00:00



MSG CIRRUS

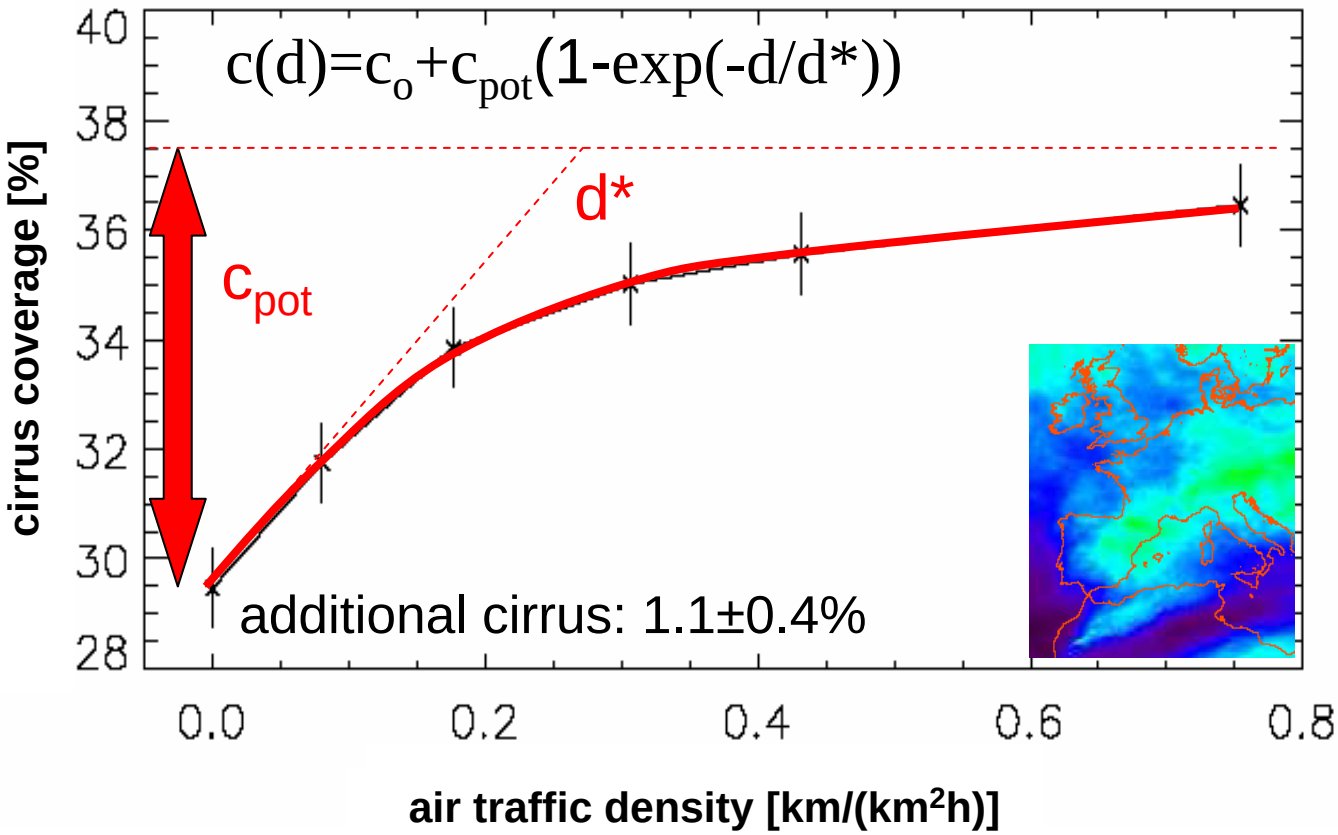
AIR TRAFFIC DENSITY

flight levels: 200 hfeet - 450 hfeet



equidistant cyllindrical co-ordinates, 15W - 20E, 30N - 60N, 0.25° x 0.25°

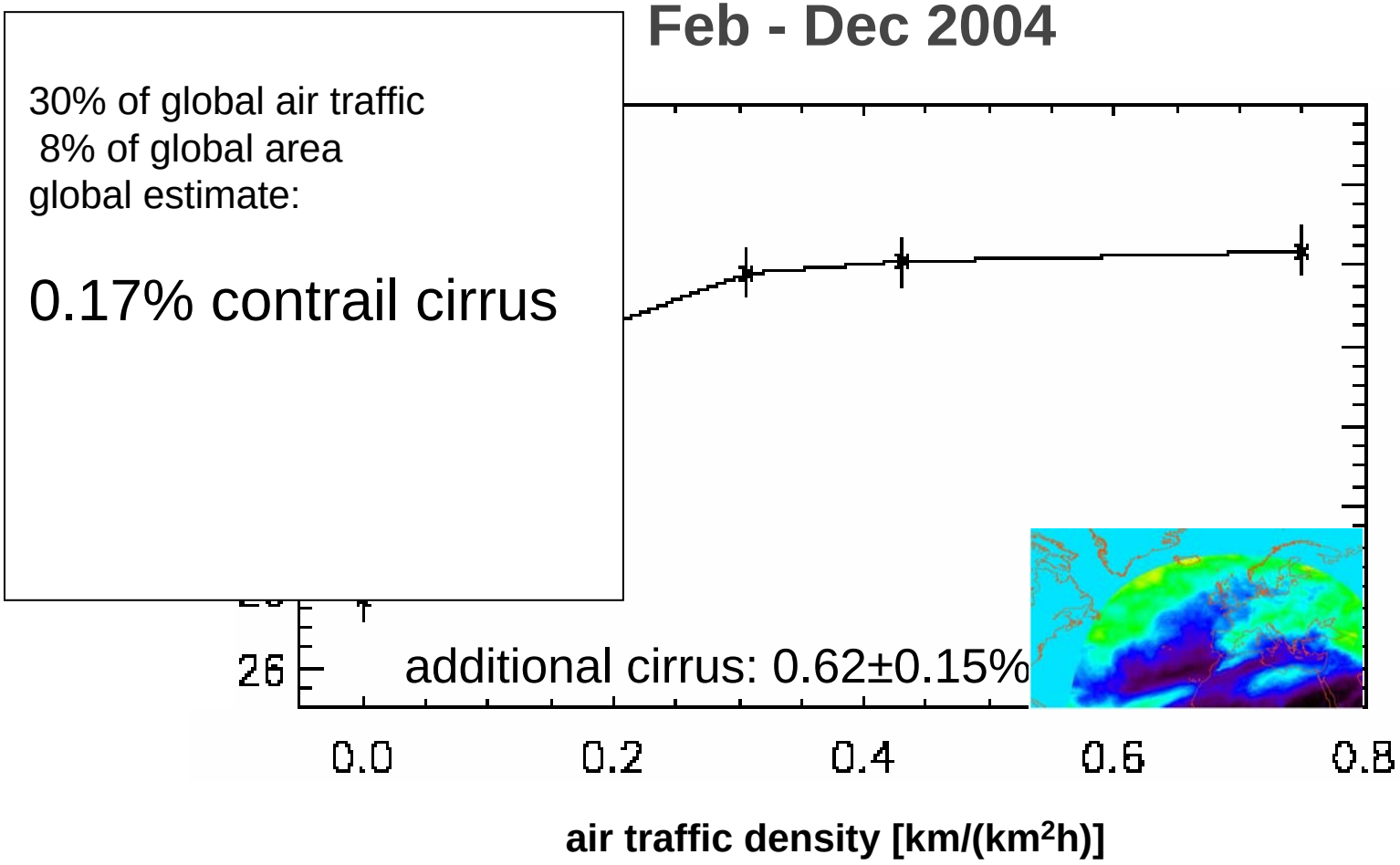
cirrus coverage vs. air traffic density
Feb - Dec 2004



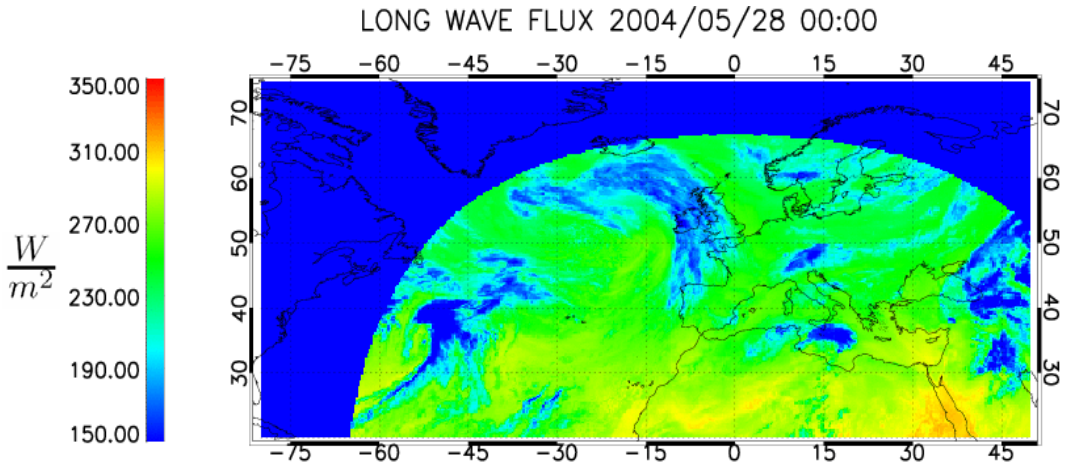
cirrus coverage vs. air traffic density
Feb - Dec 2004

30% of global air traffic
8% of global area
global estimate:

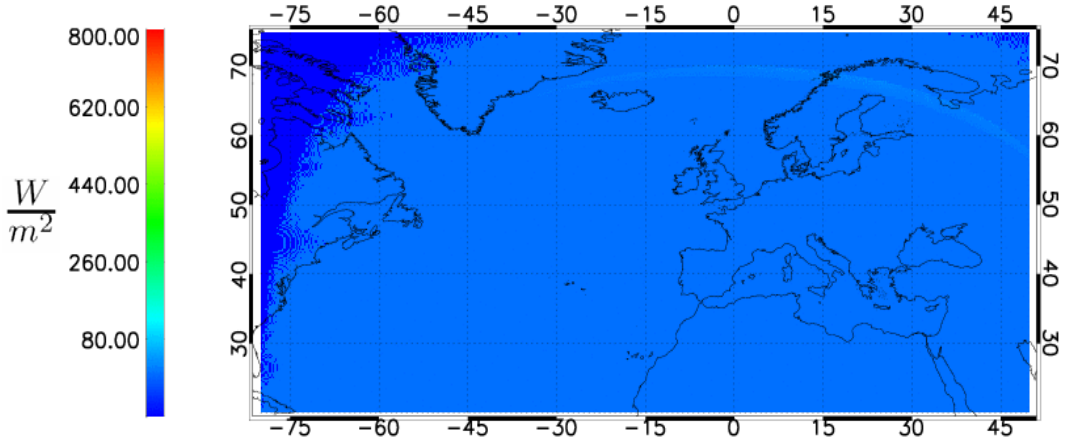
0.17% contrail cirrus



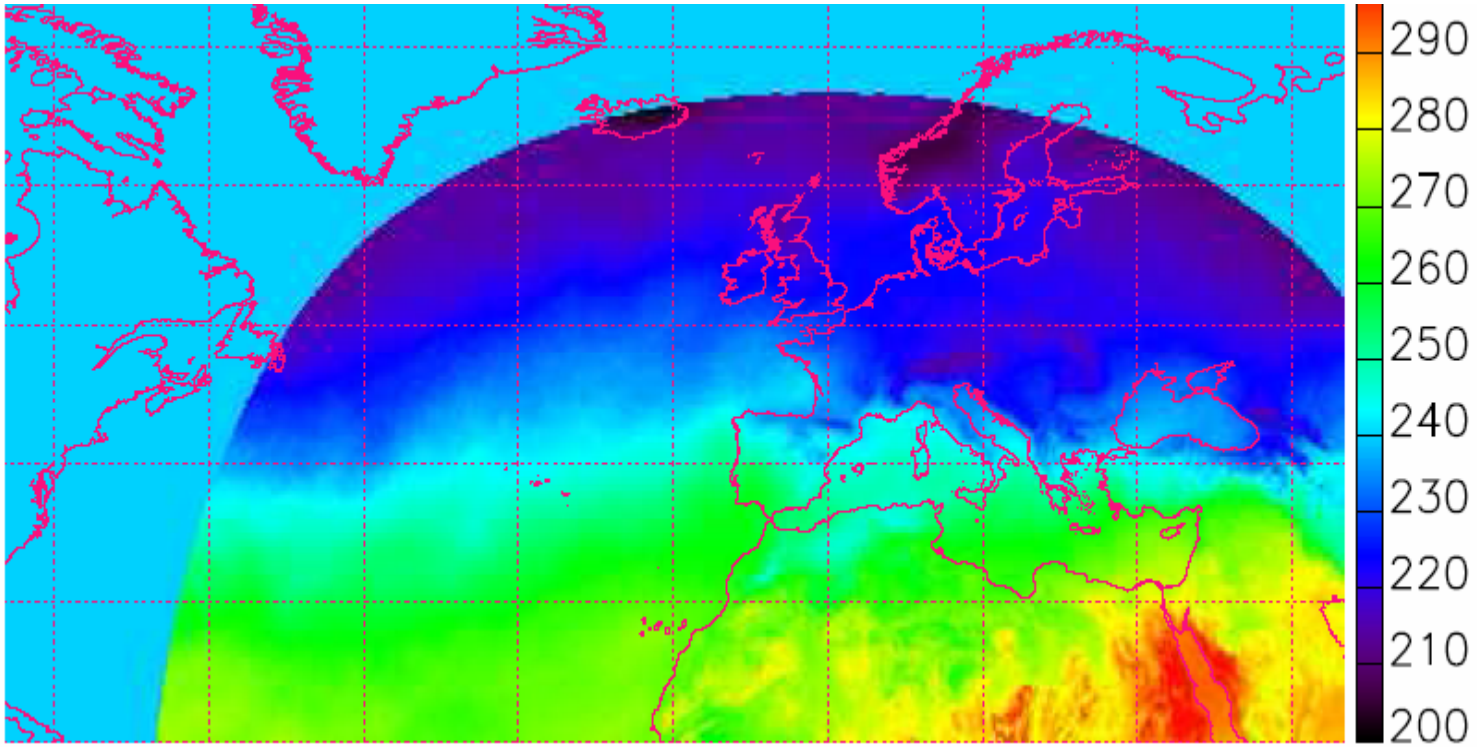
MSG/SEVIRI **terrestrial**
outgoing flux density
Top of atmosphere



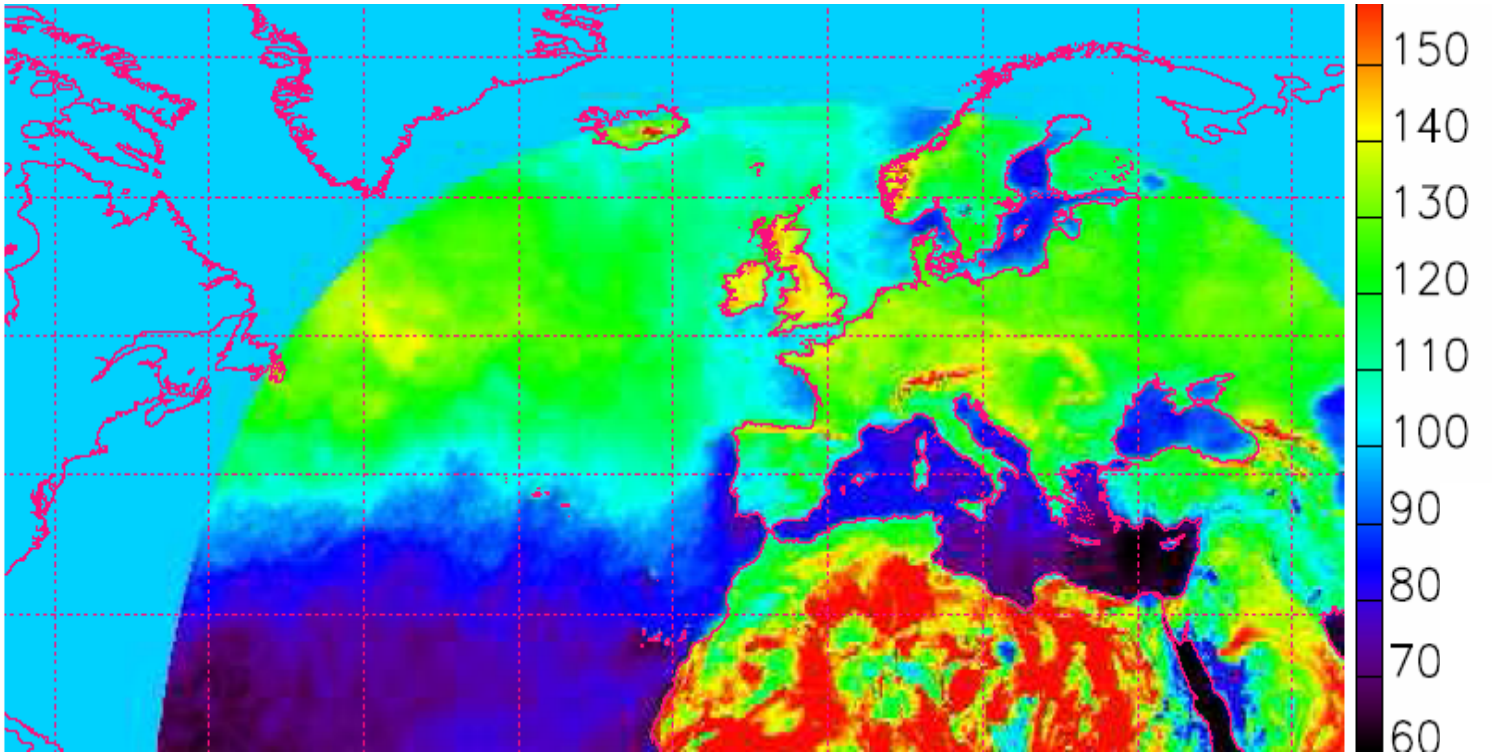
MSG/SEVIRI **reflected**
outgoing flux density
Top of atmosphere



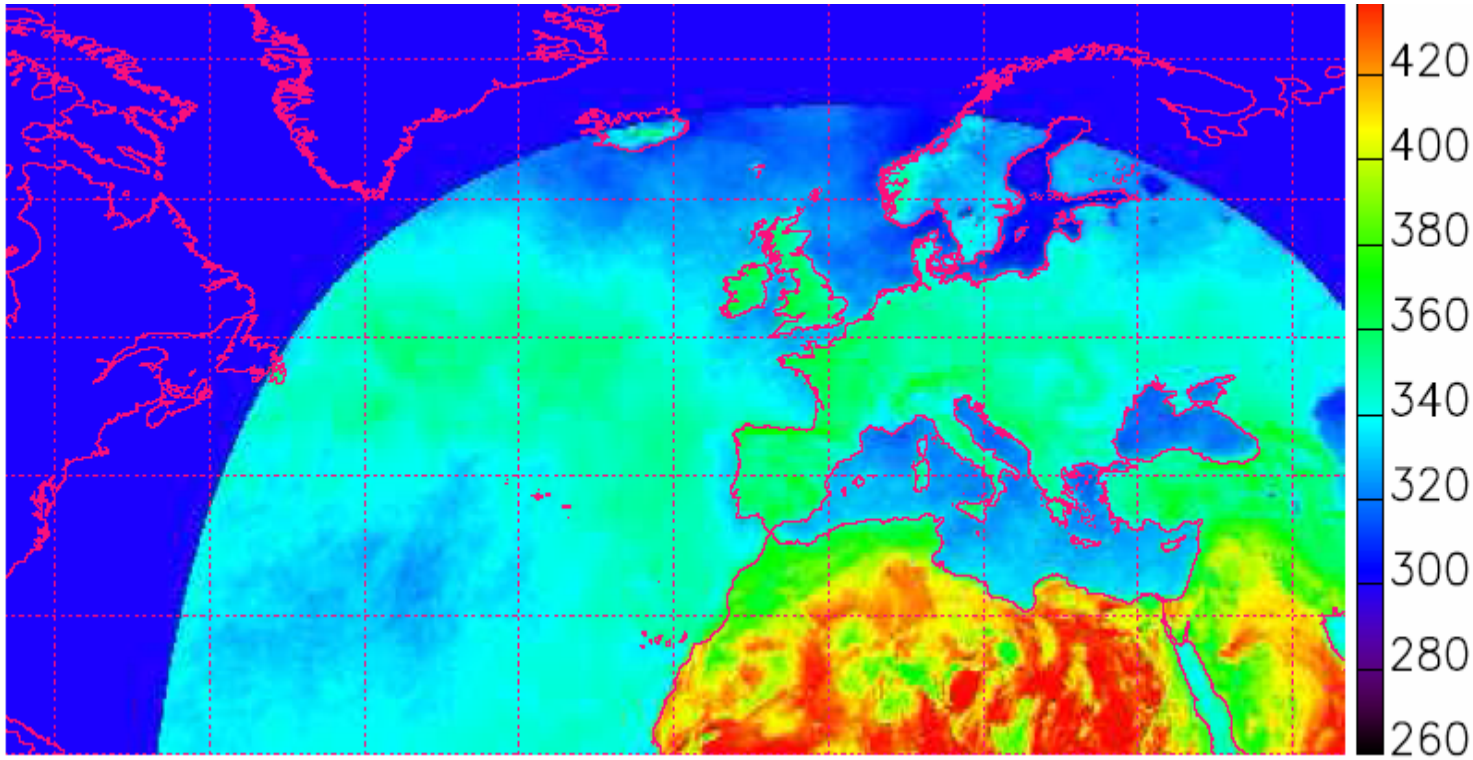
MSG/SEVIRI **terrestrial** outgoing flux density [W/m2]
Top of atmosphere



MSG/SEVIRI **reflected** outgoing flux density [W/m2]
Top of atmosphere



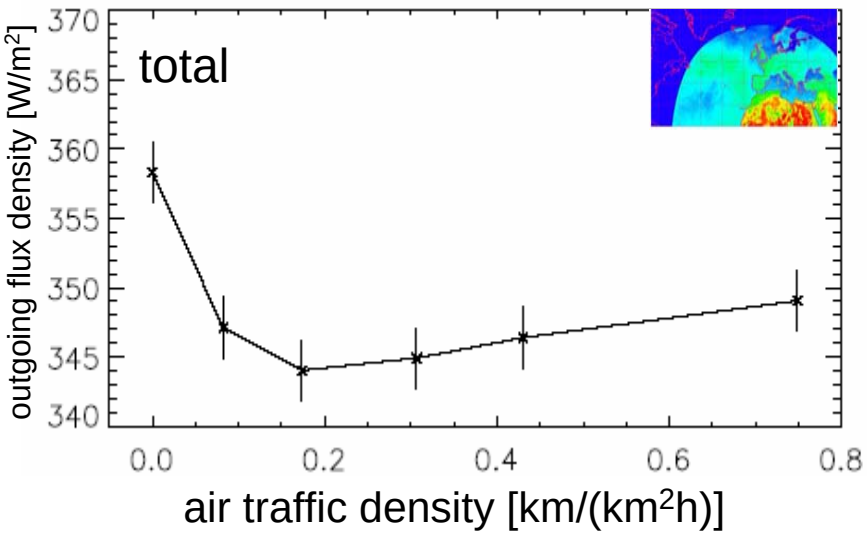
MSG/SEVIRI **total** outgoing flux density [W/m2]
Top of atmosphere



Outgoing flux density Feb-Dec 2004 vs. air traffic density

difference w/o air traffic

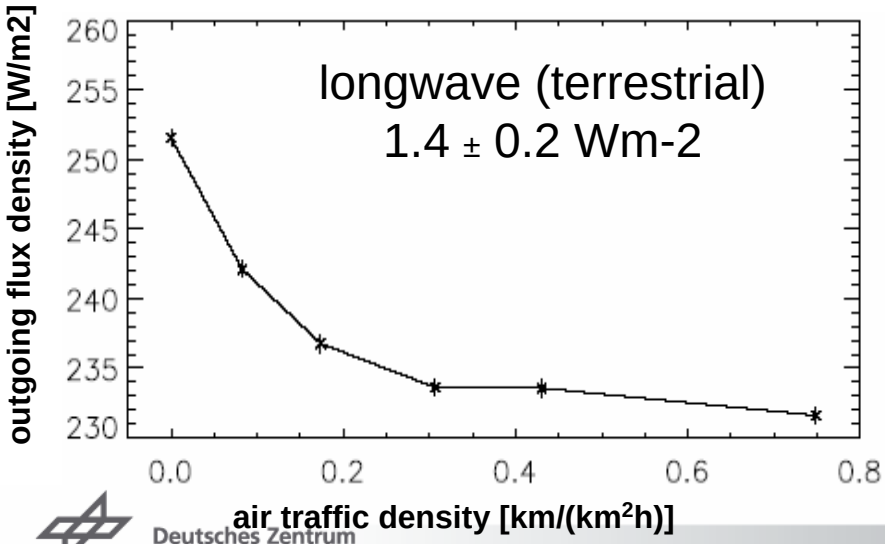
1.1 ± 0.8 Wm^{-2}

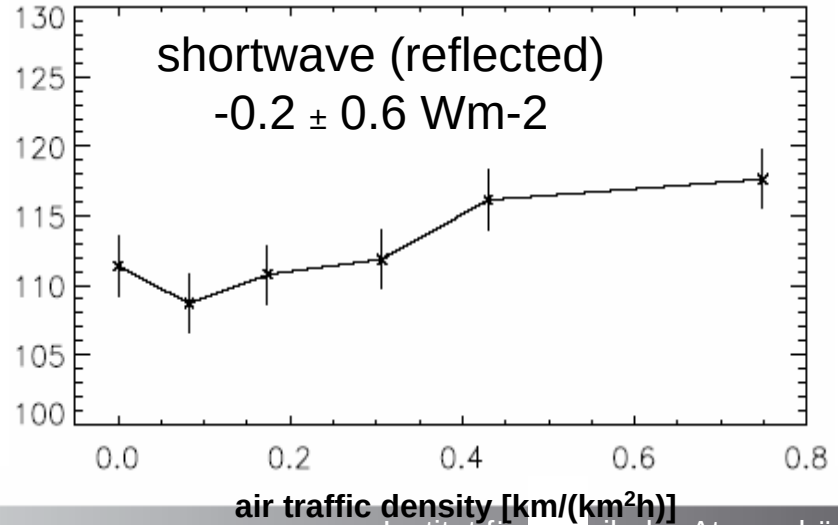


30% of global air traffic
8% of global area
global estimate:

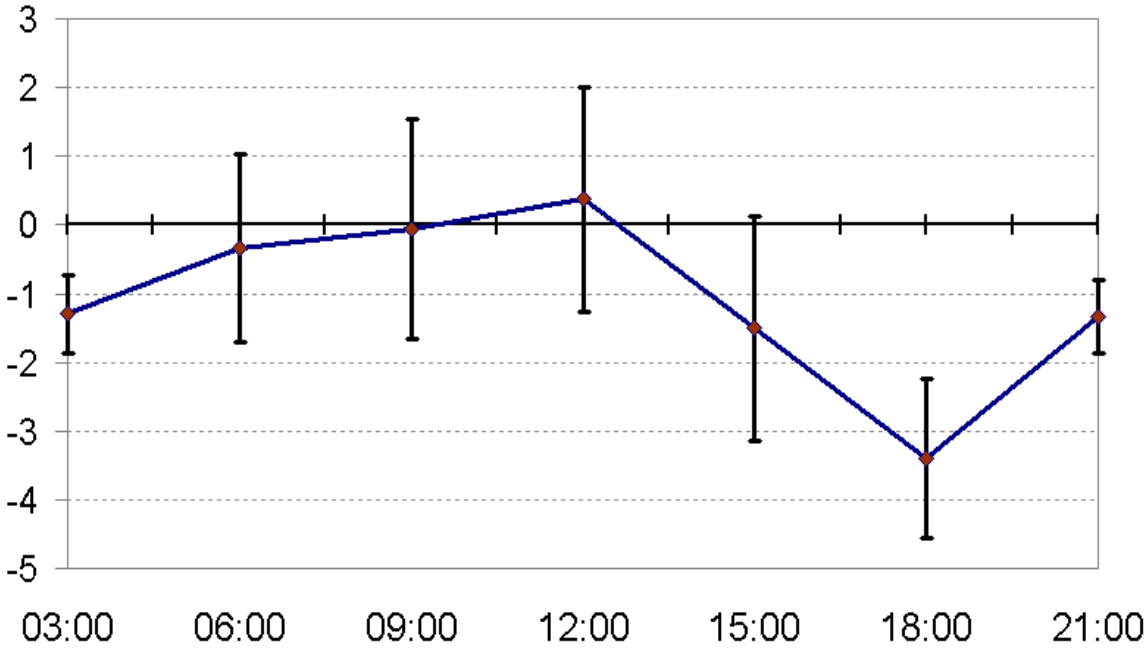
0.3 ± 0.3 Wm^{-2}

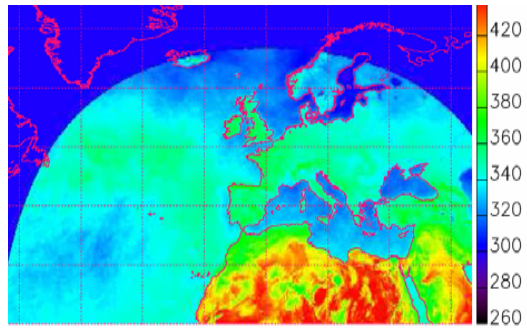
0.4 ± 0.1 Wm-2 (LW)
-0.1 ± 0.3 Wm-2(SW)

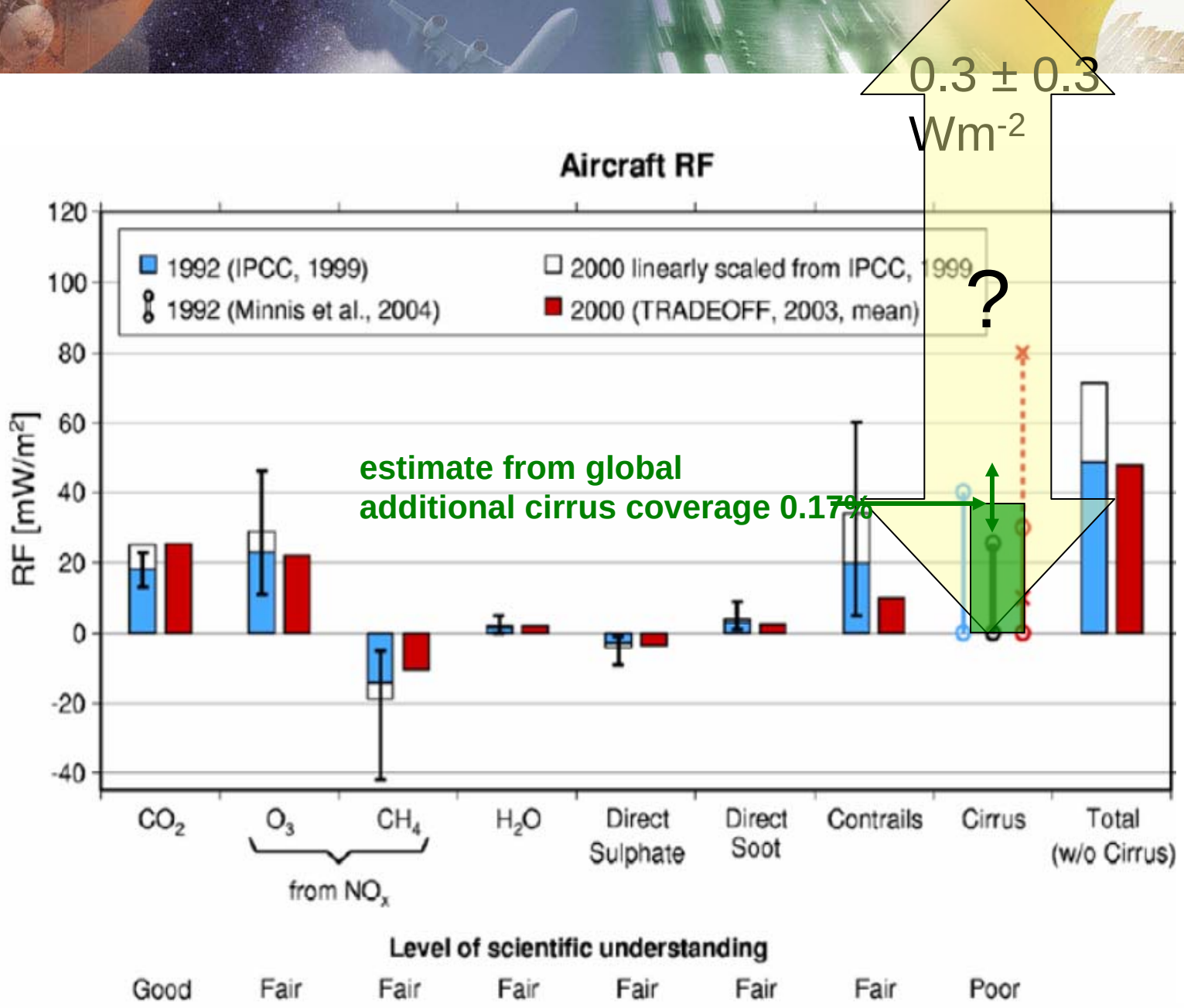




Diurnal variation: difference outgoing radiation [W/m²]






0.3 ± 0.3
Wm-2
Aircraft RF
1992 (IPCC, 1999)
2000 linearly scaled from IPCC, 1999
1992 (Minnis et al., 2004)
2000 (TRADEOFF, 2003, mean)
?
estimate from global
additional cirrus coverage 0.17%
RF [mW/m2]
120
100
80
60
40
20
0
-20
-40
CO2
O3
CH4
from NOx
H2O
Direct Sulphate
Direct Soot
Contrails
Cirrus
Total (w/o Cirrus)
Level of scientific understanding
Good
Fair
Fair
Fair
Fair
Fair
Fair
Poor

mWm^{-2}

400

300

200

100

0

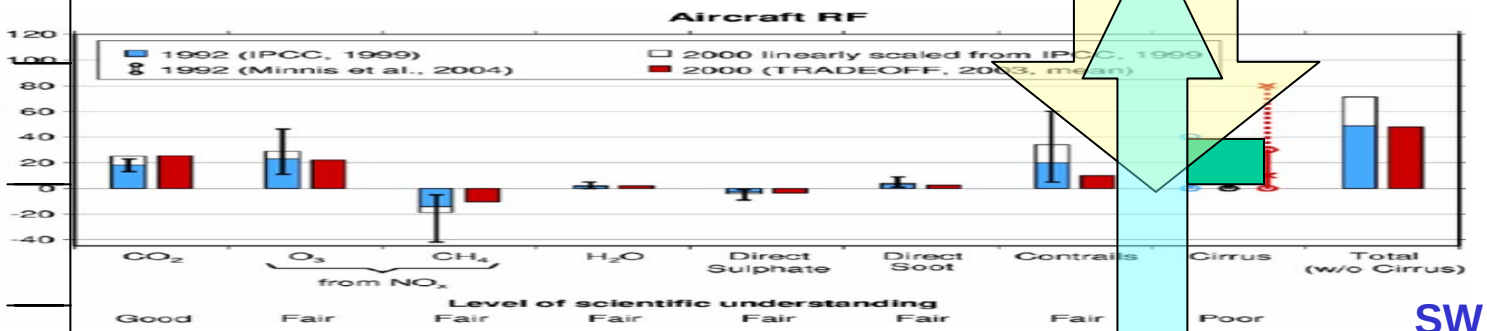
-100

-200

-300

-400

total difference
w/o air traffic
0.3 ± 0.3 Wm^{-2}



bias due to correlation of air traffic and latitude

large error bars: not enough data

LW
0.4 ± 0.1 Wm^{-2}
warming

SW
-0.1 ± 0.3 Wm^{-2}
cooling

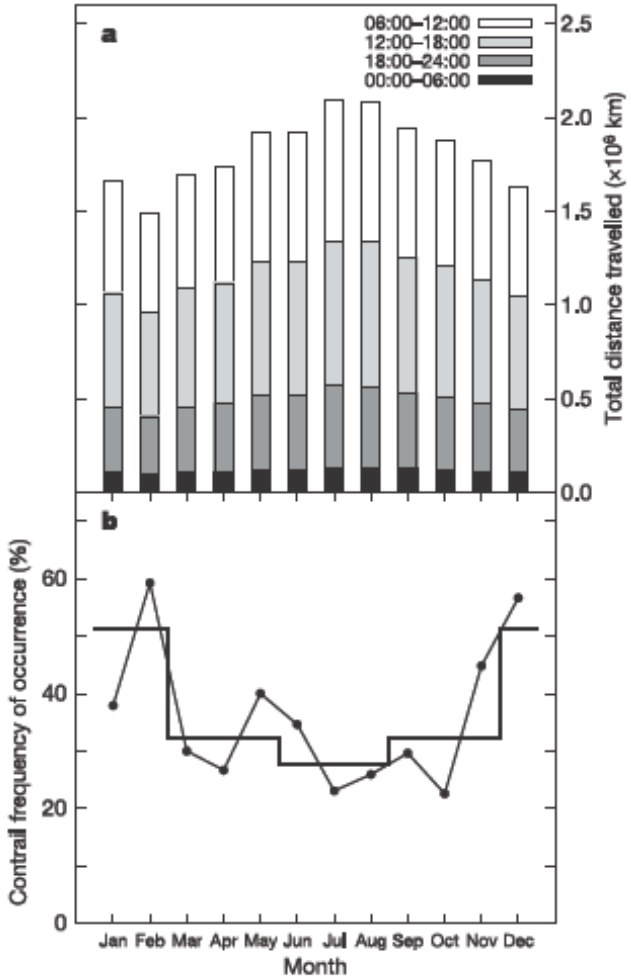


Figure 1 | Air traffic and contrail occurrence over Herstmonceux. **a**, Annual cycle of total column air traffic over Herstmonceux. Contributions of the four individual six-hour time periods are indicated by differently shaded

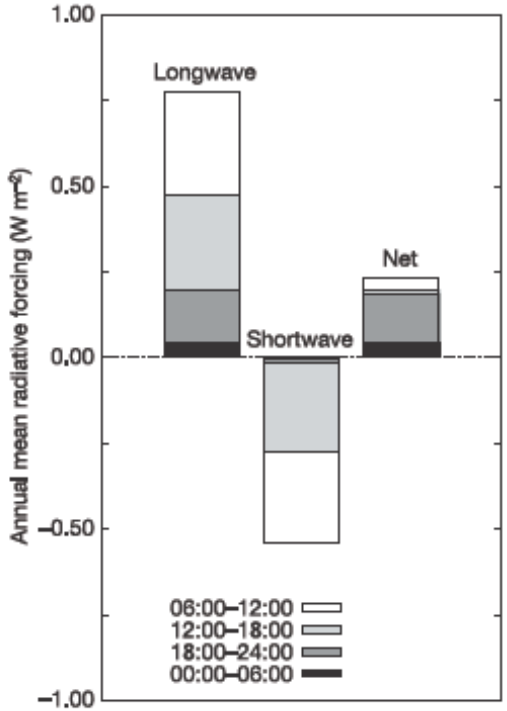


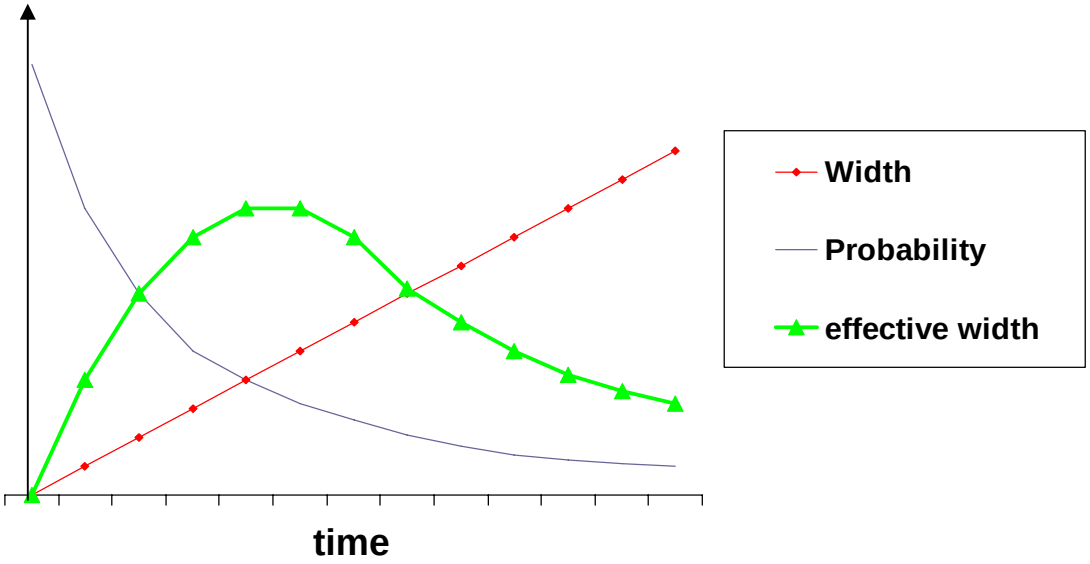
Figure 2 | Annual mean longwave, shortwave, and net radiative forcing due to persistent contrails over Herstmonceux. The contributions of flights occurring during different time periods to the diurnal mean values are indicated by differently shaded bars.

06:00 GMT, even though these night flights are responsible for only 25% of the air traffic.

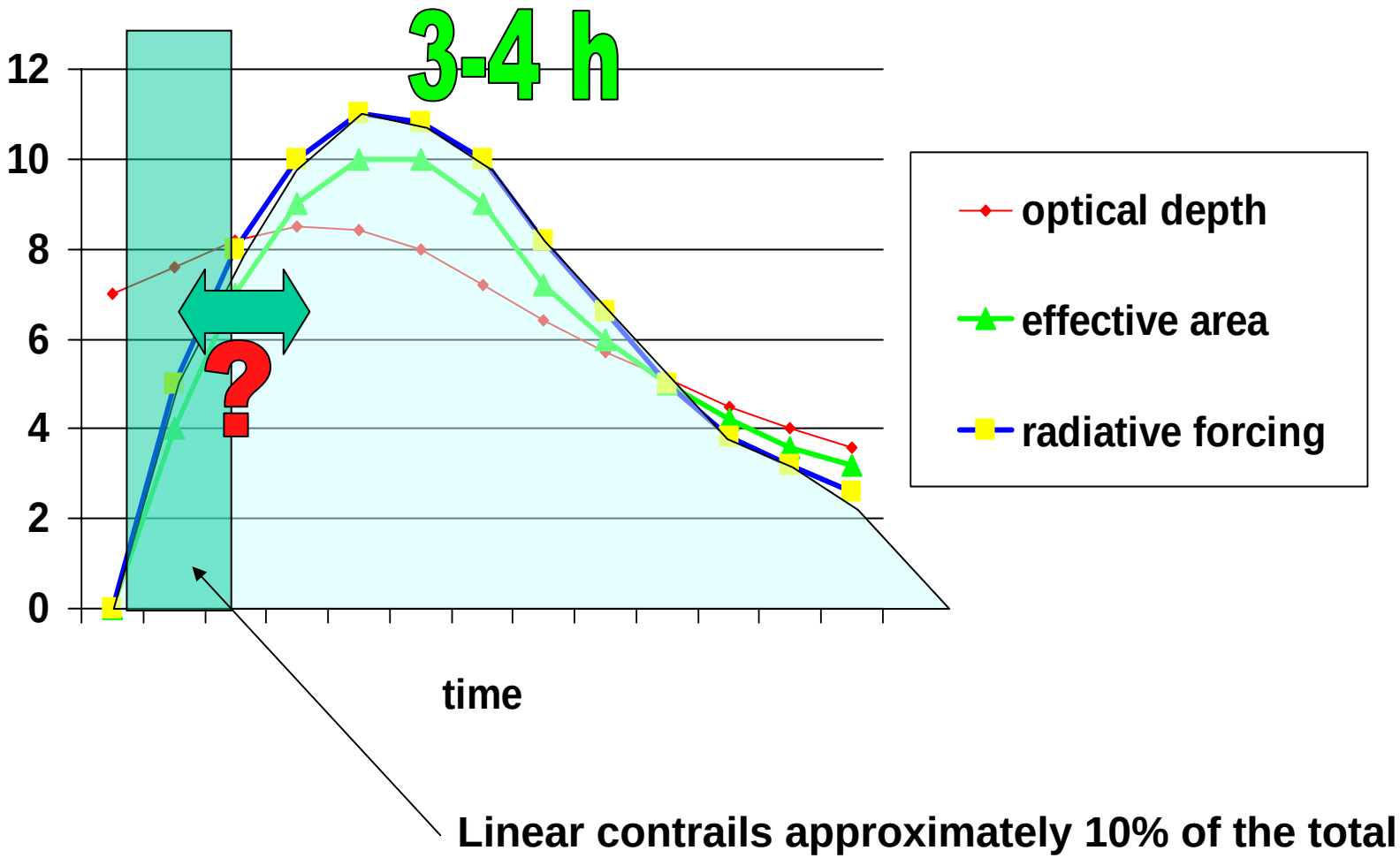
The annual cycle of forcings (Fig. 3) reveals the complex interaction and competition of different effects: Time-averaged shortwave forcings are affected by daylength and solar zenith angle. With all

The missing dimension: Time

Width:	linear	$b(t) = s \cdot (t - t_0)$
Probability of existence:	exponential decay	$p(t) = p(0) \exp[-(t-t_0)/t_e]$
Effective width:		$y_e(t) = b(t) \cdot p(t)$



Do we estimate the cirrus coverage produced by air-traffic?



MetOp RAO 3030, Life Cycle of Aircraft Contrails by Synergetic Use of MetOp and MSG Observations

1. **Detect linear contrails in MetOp/AVHRR images**
2. **Map results onto MSG/SEVIRI images**
3. **Study the time evolution in the MSG image to determine life-time, width, and radiative impact of contrail cirrus**
4. **Consider the time component in the correlation between air-traffic and cirrus cloud cover**

→ These numbers are urgently required to quantify the impact of contrail cirrus on the climate system.


Thanks