Comparison between global models and measurements of trace gases during TROCCINOX

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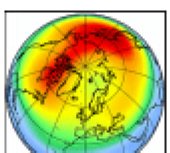
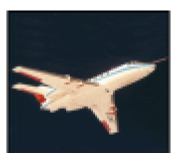
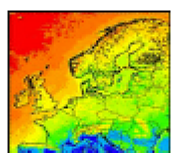
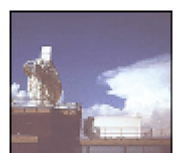
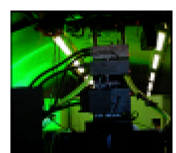

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Outline

The Importance of Lightning induced NOx (LNOX) based on recent model result (APCD)

Global models & Falcon measurements during TROCCINOX

Comparison model - measurements during TROCCINOX:

- along flight routes (NO, NO_y, CO, and O_3)

- vertical profiles (NO, NO_y, CO, and O_3)

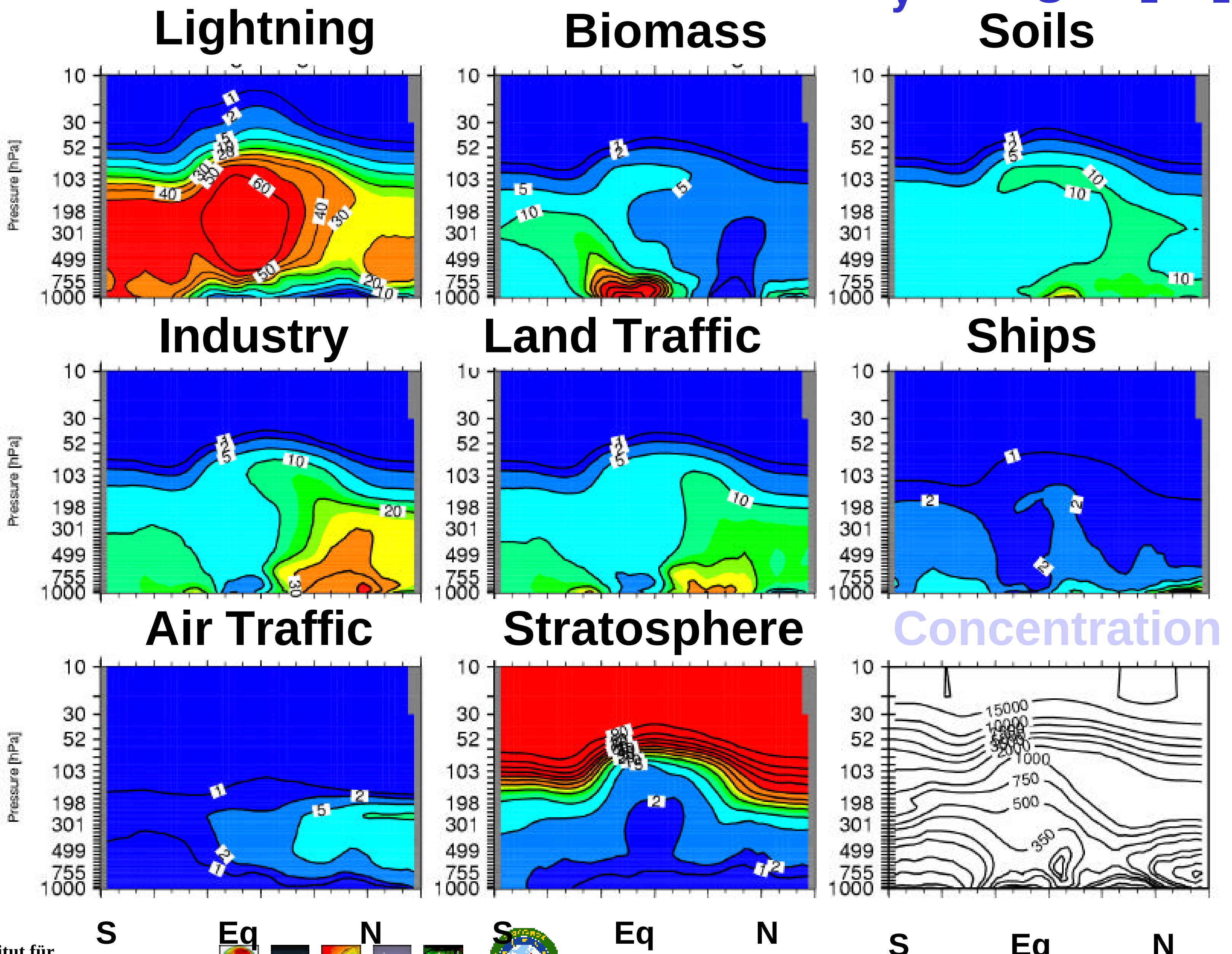
Conclusions & future plans

Global NOx Sources

(Lee et al., 1997)

Source	**Source Rate, Tg(N)/a**
Aviation	0.6 (0.5 - 0.9)
Lightning	5 (2 - 20)
Industry and Traffic at Earth Surface	22 (13 - 31)
Biomass burning	7.9 (3 - 15)
Soil microbes	7 (4 - 12)
N_2O + O -> 2 NO in stratosphere	0.64 (0.4 - 1)

Contribution of NO sources to NO_y budget [%]



(Grewe et al., ACP, 2004)

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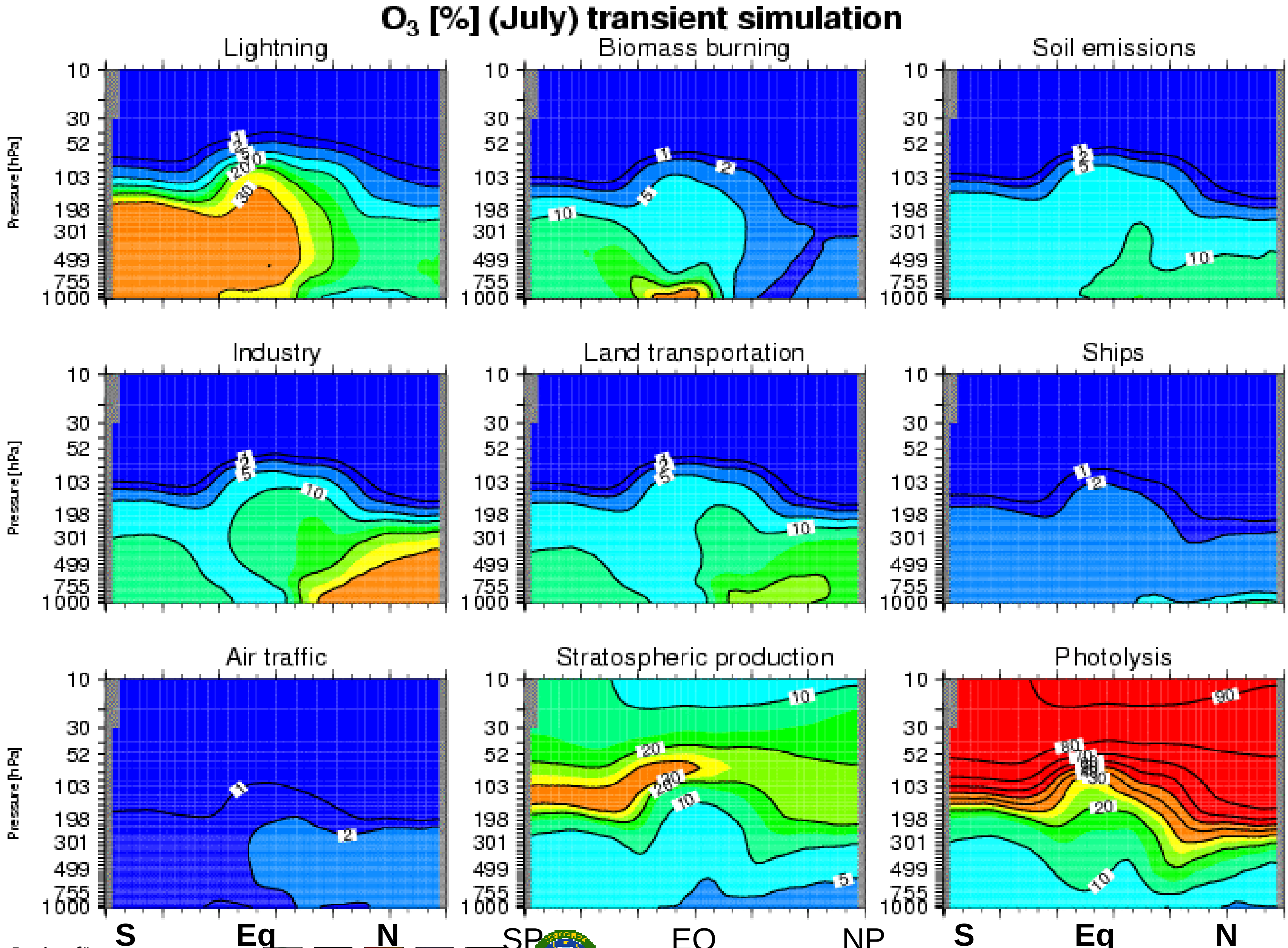
NO_y-contributions to O_3 (ECHAM4/CHEM)



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(Grewe et al., ACP, 2004)

Vertical distribution of LNOx source matters

atios of the annual zonal means of the

a) PICK5,

b) ANVIL5, and

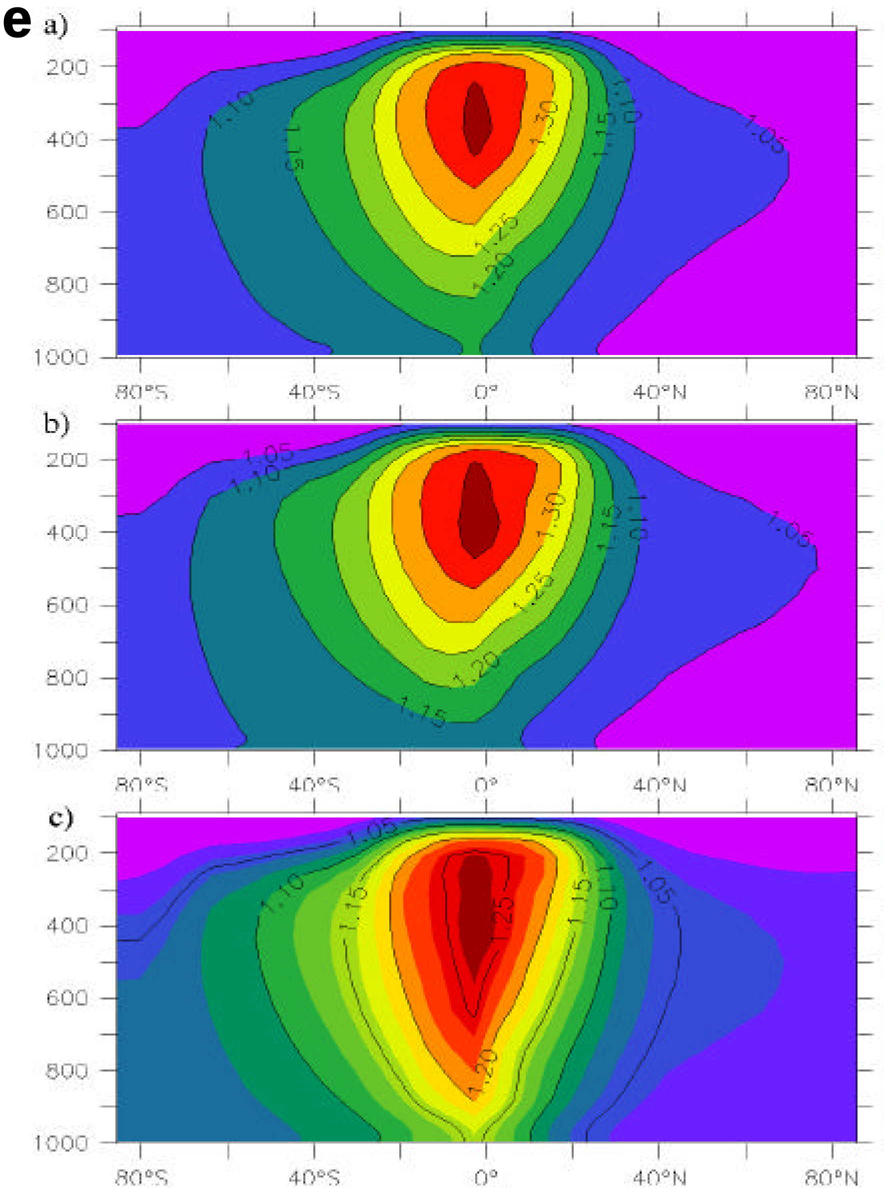
) EVEN5 runs to

oLtNOx run for O_3

-increase in the upper tropical
oposphere in the range of 30-45%
ue to lightning-produced No_x.

d

alues depend on vertical
stribution of LNOx source



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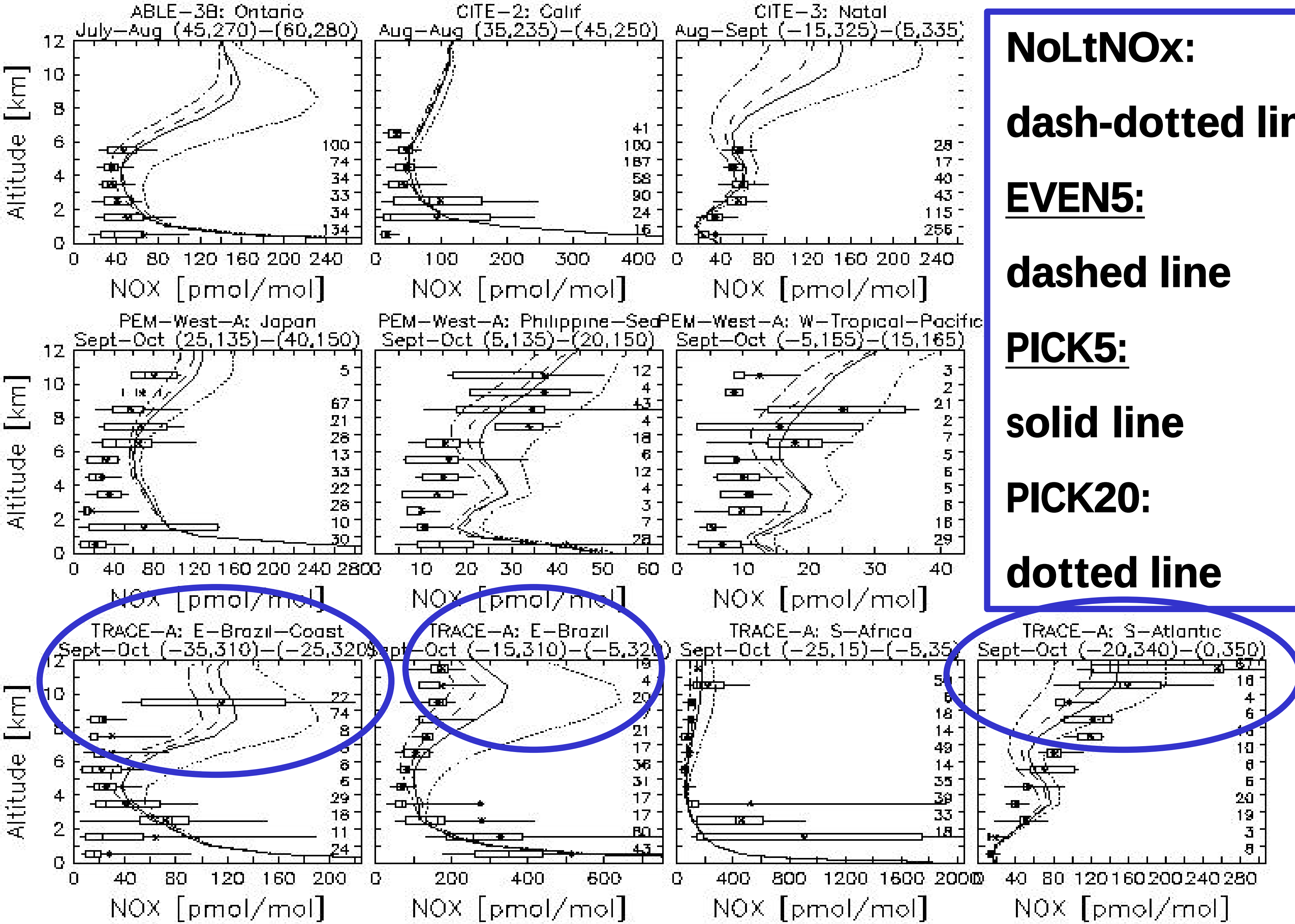
(Labrador et al., ACPD, 2004)

Measured NO_x profiles compared to model



NoLtNOx: dash-dotted line

EVEN5: dashed line

PICK5: solid line

PICK20: dotted line

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NoLtNOx & PICK20 give to low/high values

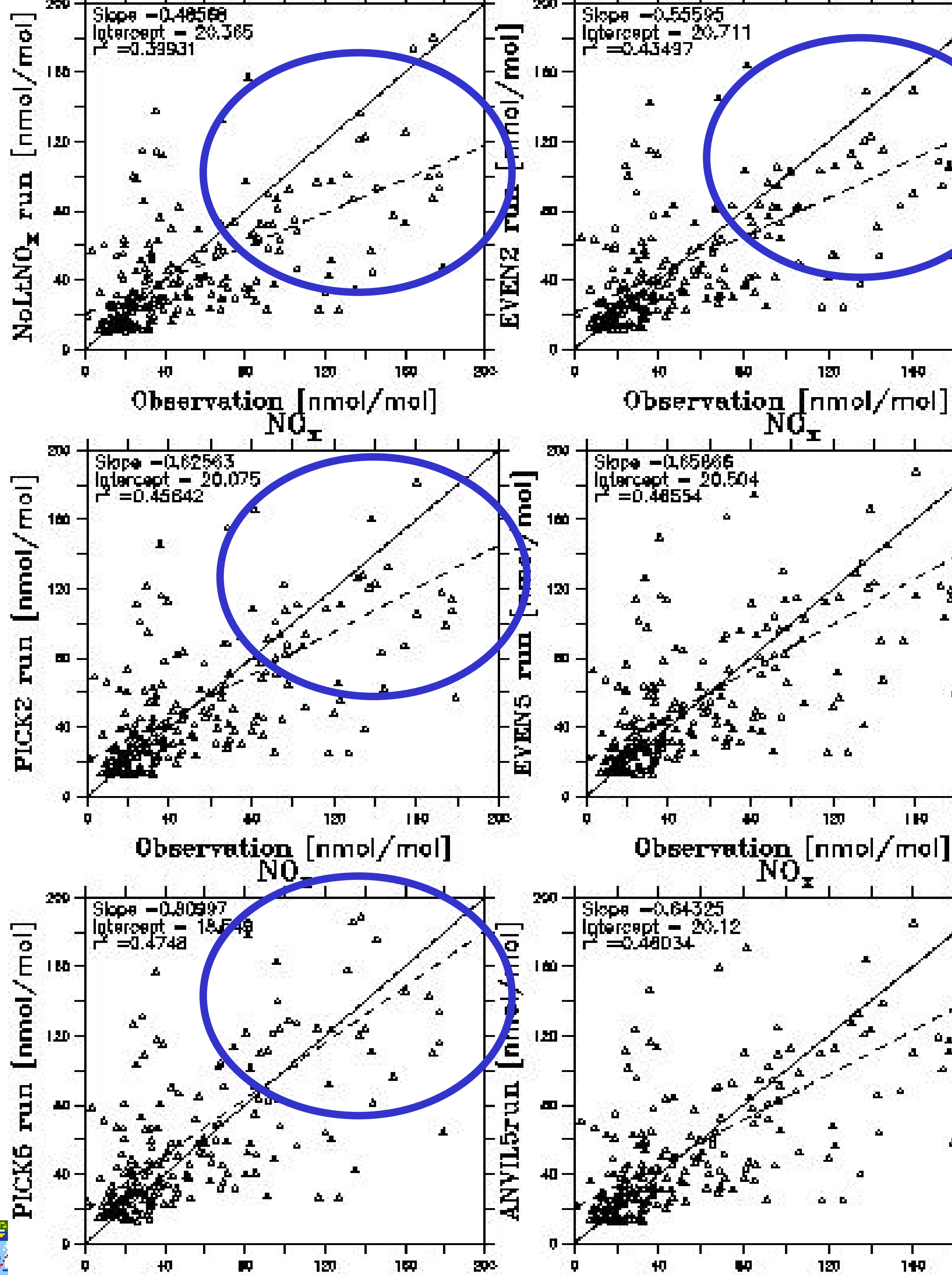
Correlation

neasurements-model

oLtNOx, EVEN2 & PICK2 give
o low values

ICK5 gives best estimate for
TgN yr^{-1}

abrador et al., ACPD, 2004)



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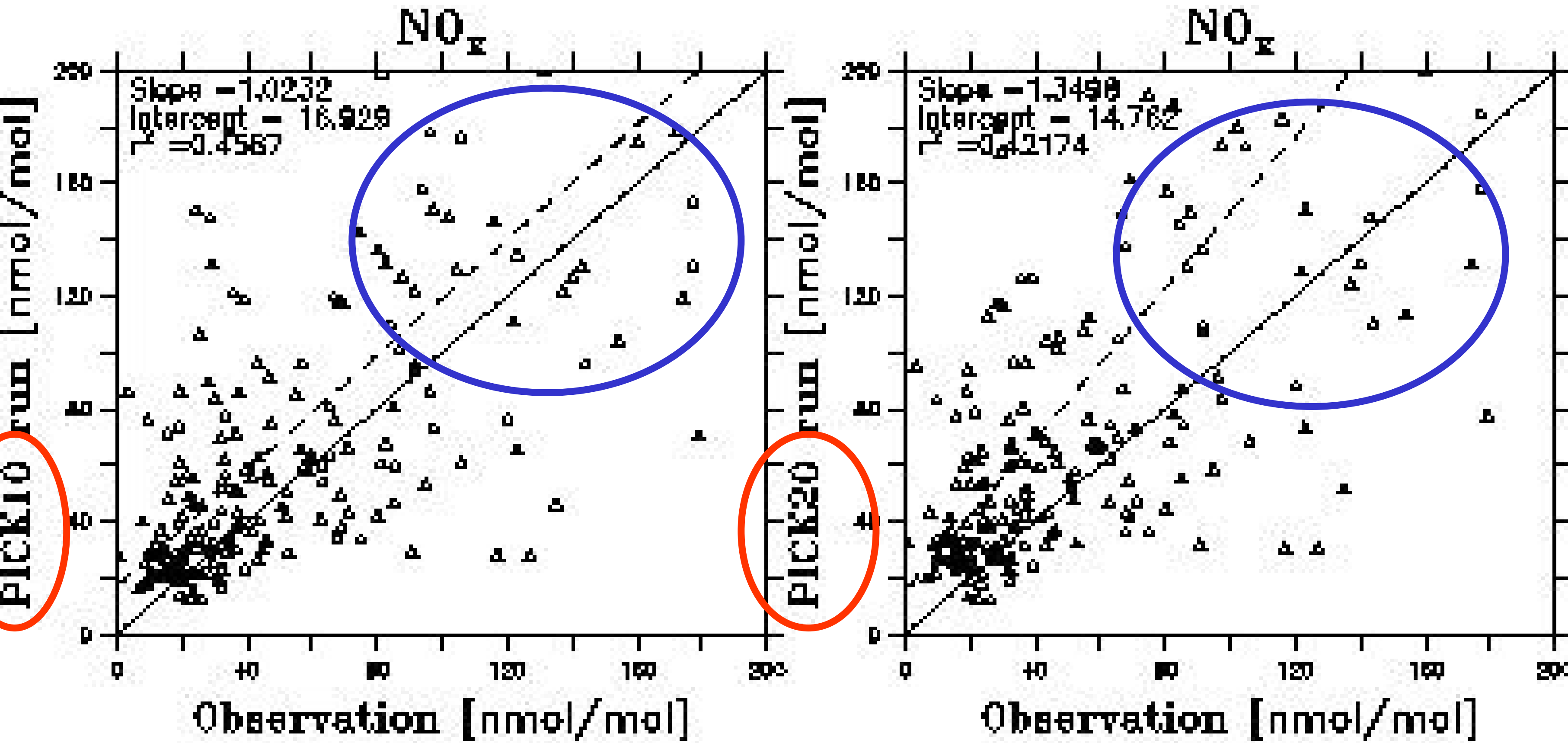
Correlation measurements-model



PICK 10 shows a higher correlation than PICK20

Lightning parameterisation

Grewe et al., 2001
$CTH=0.85 \times MF \times CT^{½}$

Price and Rind, 1992
$FF=3.44 \times 10^{-5} \times CTH^{4.9}$

pdraft“ massflux =MF
Cloud Thickness =CT

Cloud Top
Height =CTH

Flash Frequency
over land =FF

Grewe et al., 2001
$FF=1.54 \times 10^{-5} \times (MF \times CT^{½})^{4.9}$

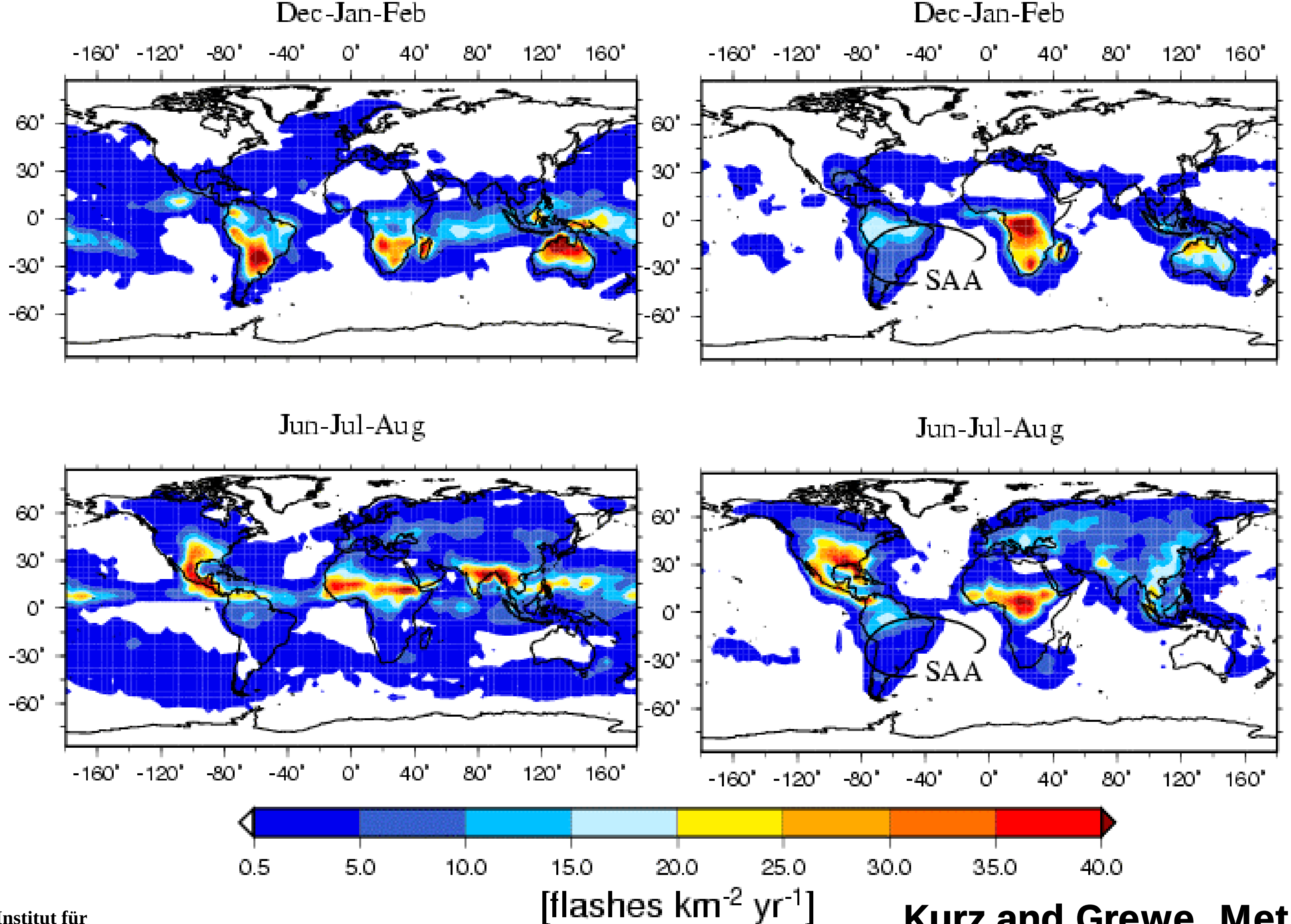
ß

rect relation between Massflux (=„updraft“) and Flash Frequ

Same model over land and over oceans!

Modelled Lightning vs Observations

E39/C model | OTD Satellite data



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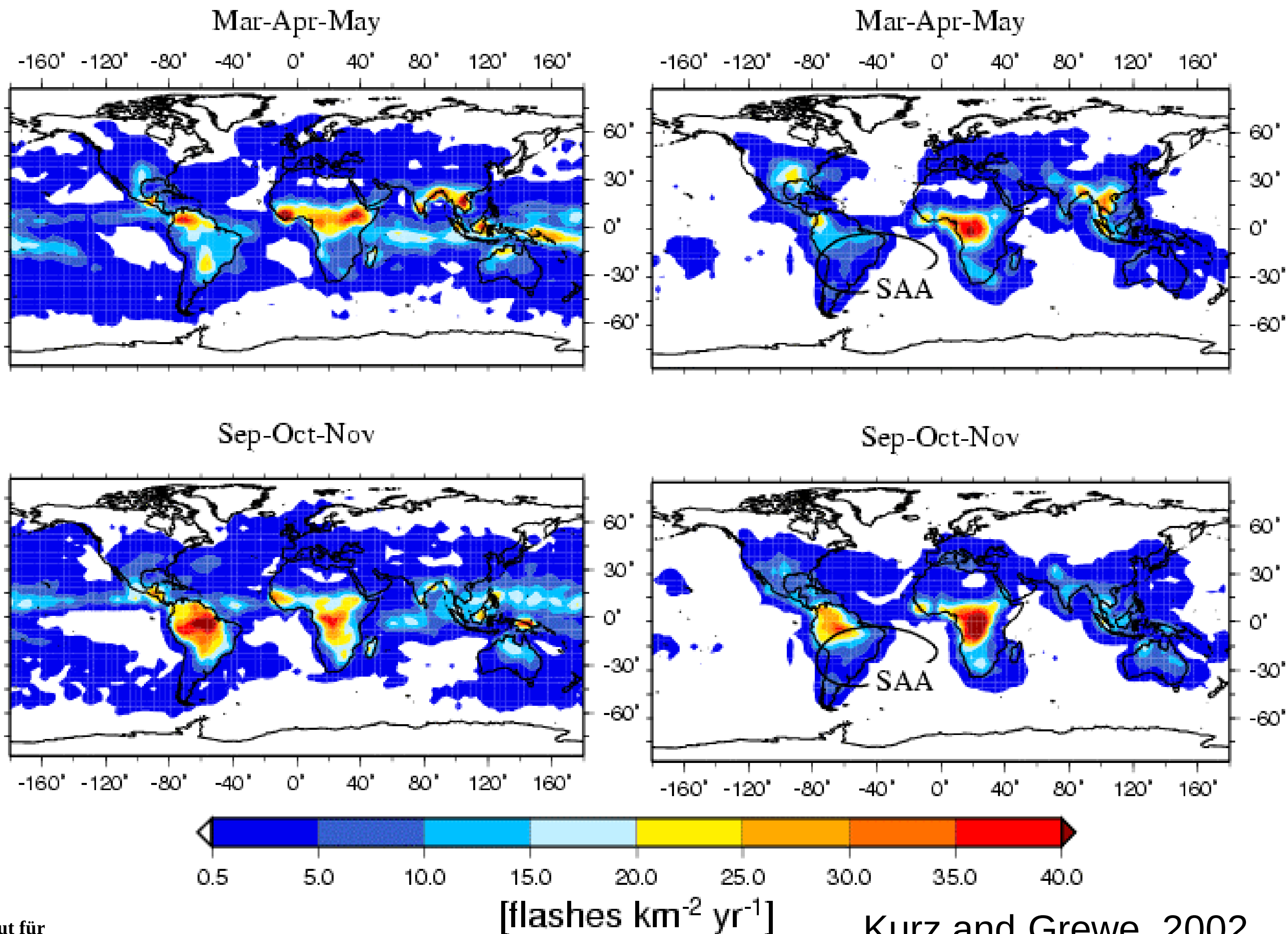
Kurz and Grewe, Met. Z., 2

Modelled Lightning vs Observations

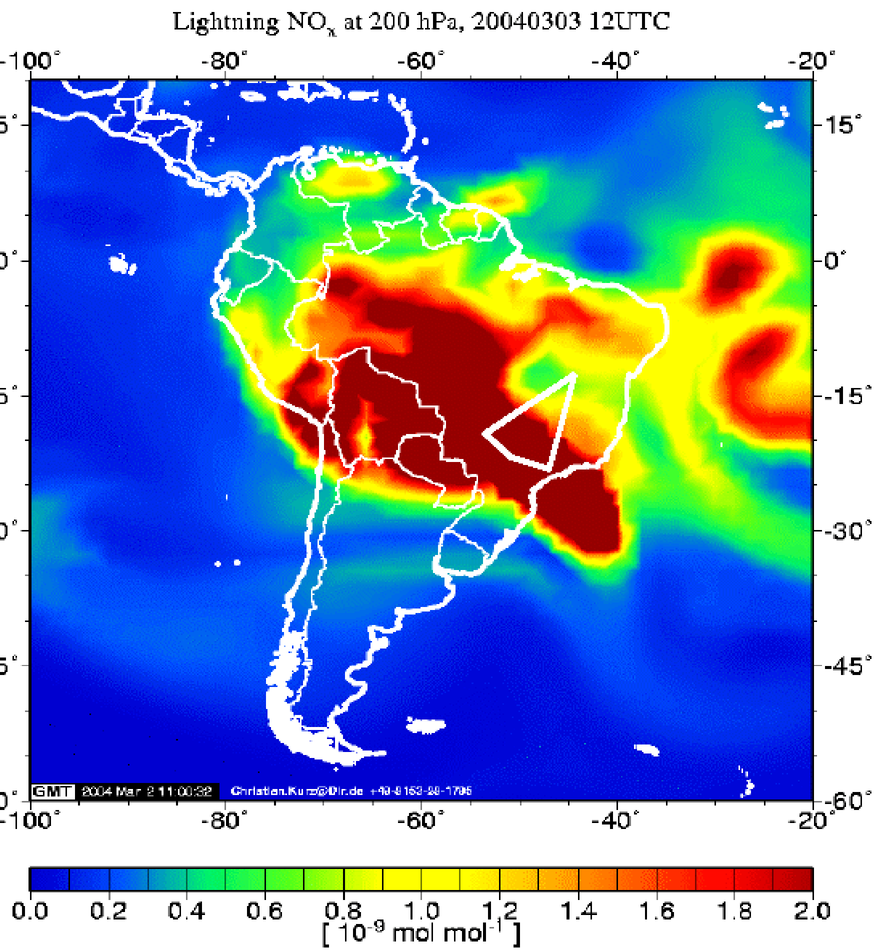
E39/C model

OTD Satellite data



Kurz and Grewe, 2002

Global models for
ROCCINOX



ECHAM5-MESSy (NUDGE/CHEM)

Kurz / Grewe / Jöckel / Sander, DLR-Oberpfaffenhofen, MPI-Mainz
T63 ~1.9° x 1.9°, 19 vertical levels, min.
Tiedke convection
CTH or UPD, 5 Tg(N) yr^{-1}

MATCH-MPIC

Labrador / Lawrence, MPI-Mainz
T42 ~2.8° x 2.8° , 42 vertical levels, min.
Zhang convection
CTH, 2 Tg(N) yr^{-1}

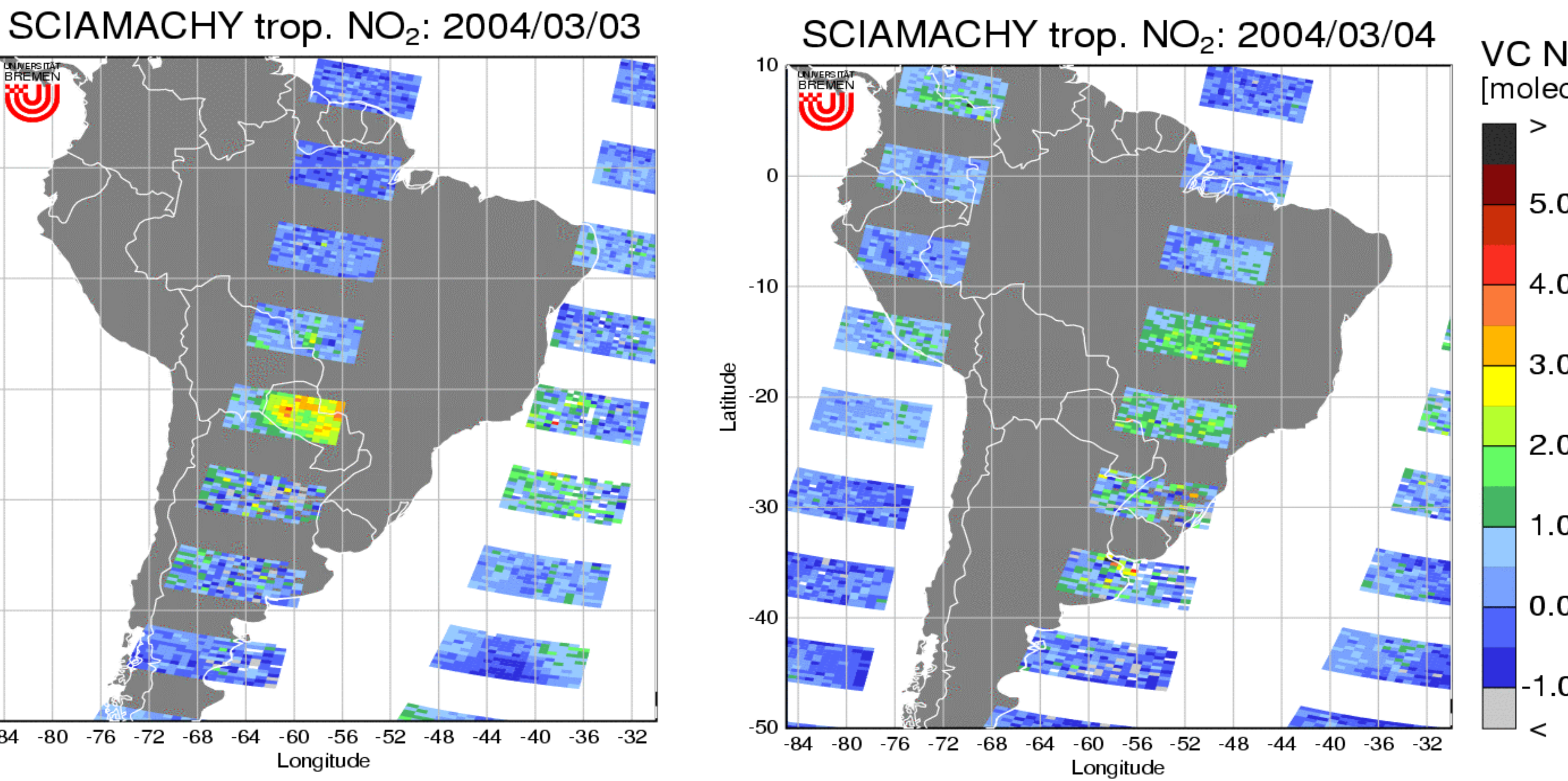
MOZART-2

Schultz, MPI-Hamburg
T63 ~1.9° x 1.9°, 47 vertical layers , min.
Zhang convection
CTH, 4 Tg(N) yr^{-1}

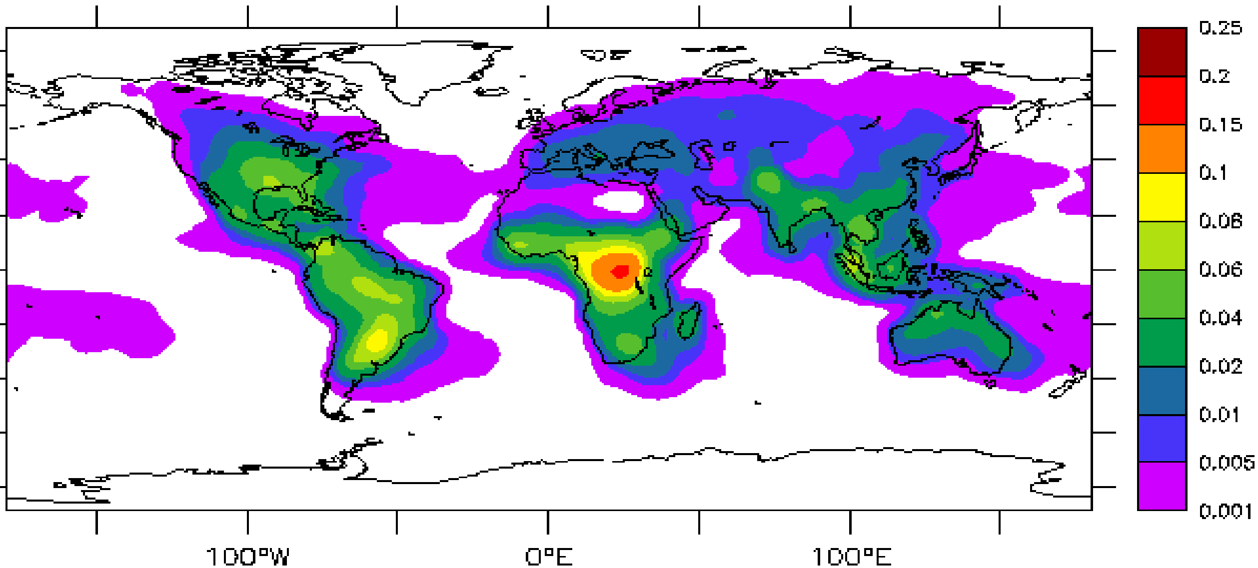
TM4

Meijer / Velthoven, KNMI
2° x 3°, 32 vertical layers, 30 min.
Tiedke convection
convective precipitation, 6.5 Tg(N) y

aily NO2 SCIAMACHY images



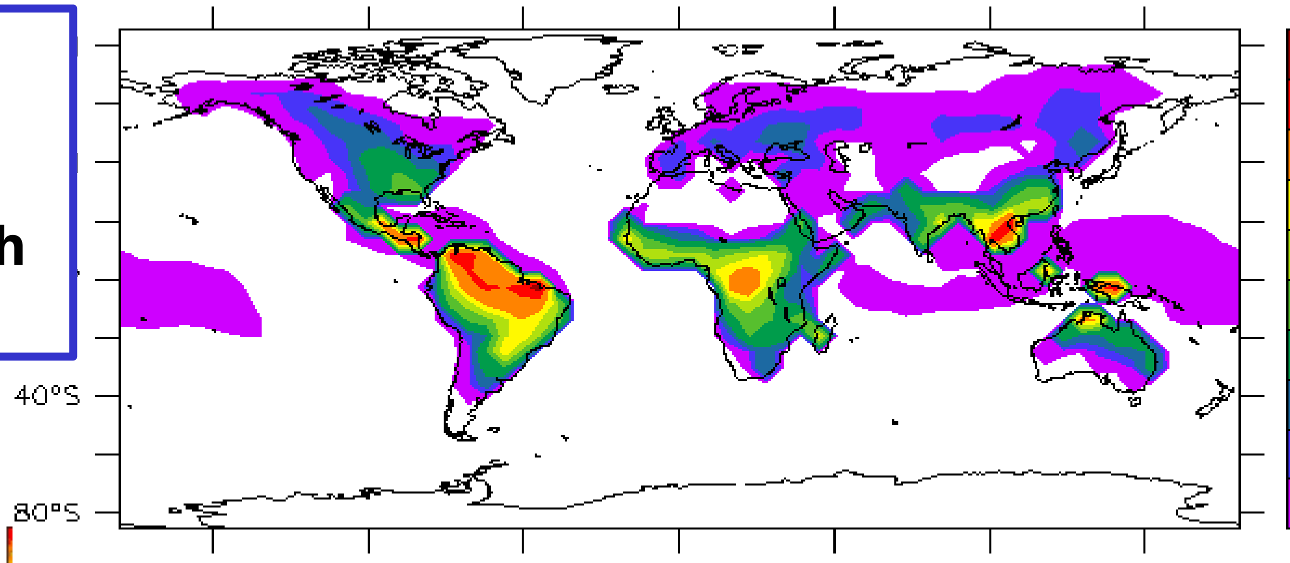
bal flash activity: LIS/OTD versus MATCH-MPIC



LIS/OTD composite
1995-2003
[flashes/km²/day]

(Labrador et al., ACPD, 200

IATCH catches the ash maximum over frica, however, verestimates the flash requency over Brazil



MATCH-MPIC
1997

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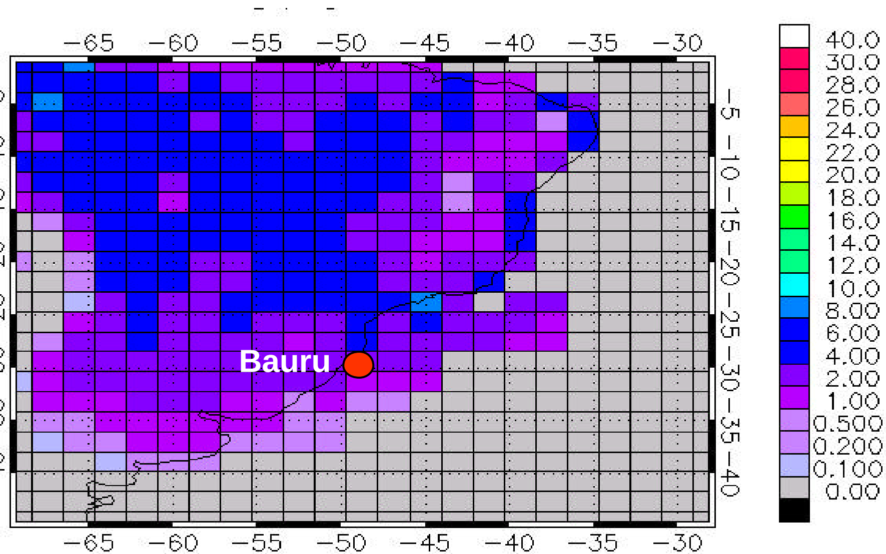
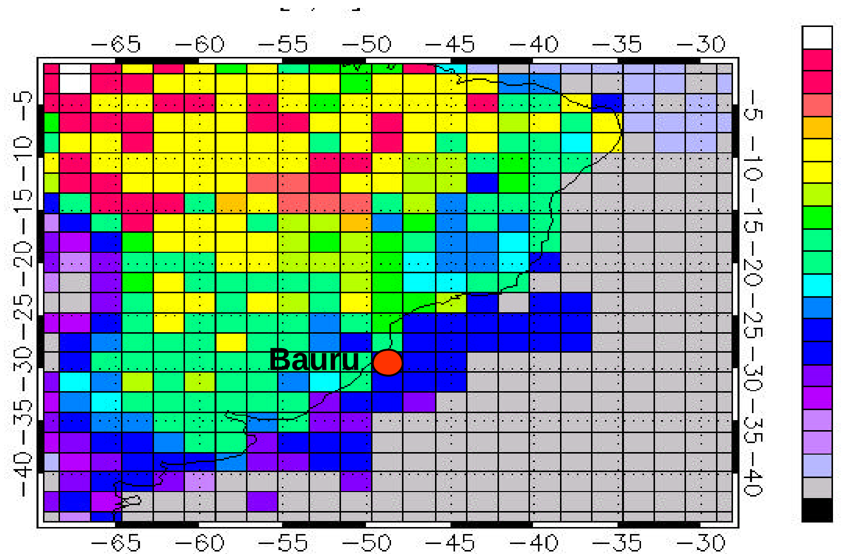
MOZART-Model results for February 2003(!)
Flash frequency



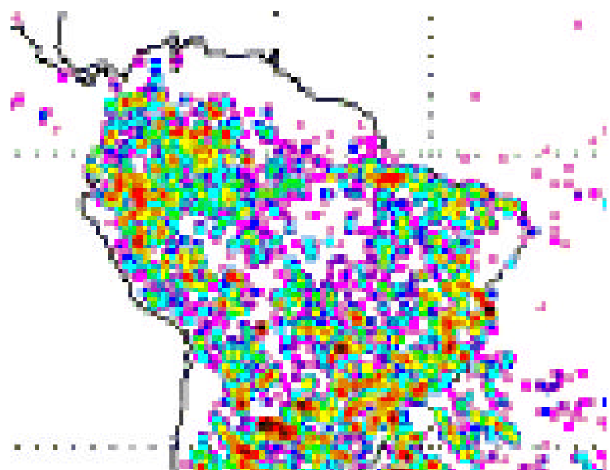


shes/minute (based on Price&Rind, 1993)

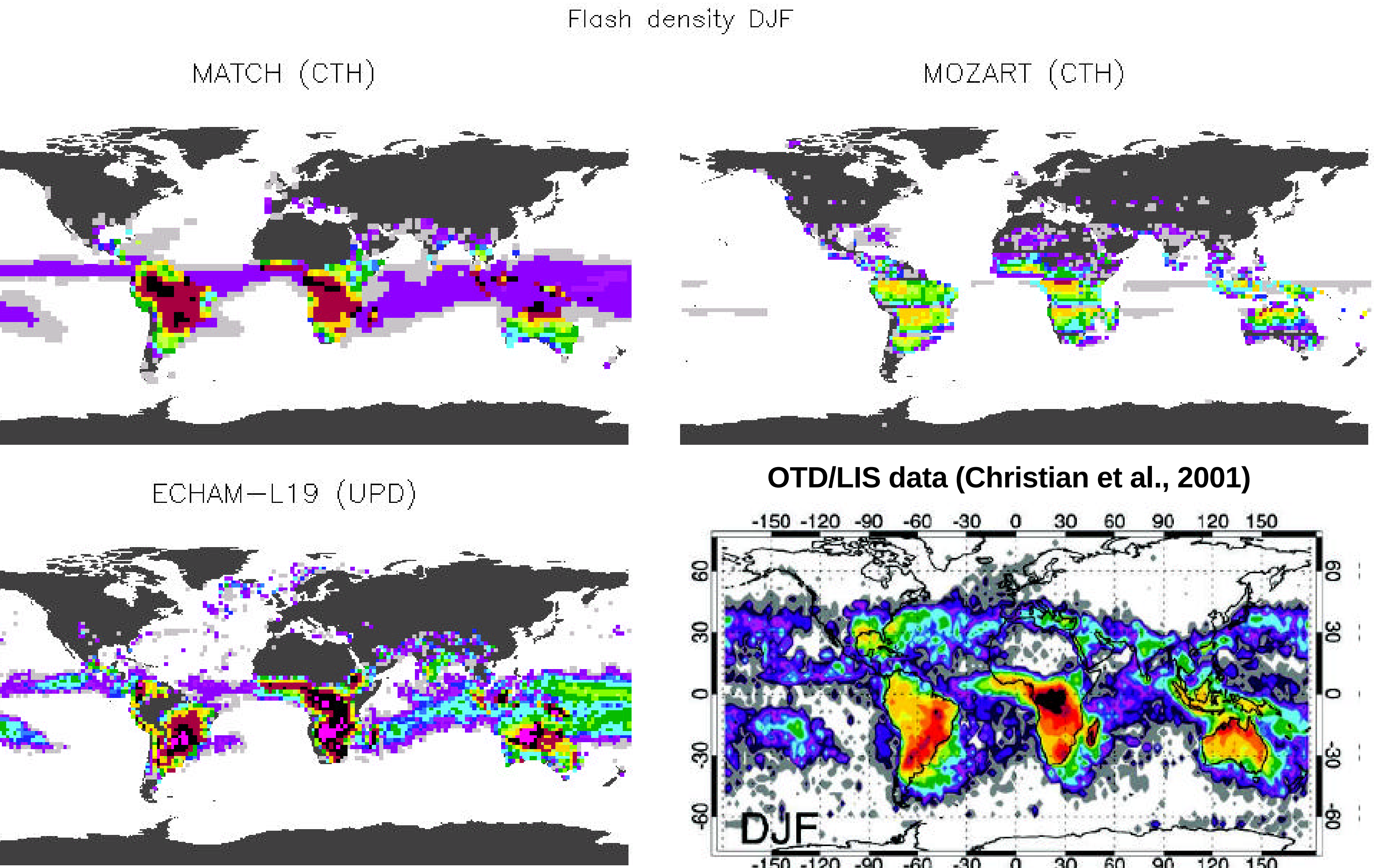
M. Schultz, MPI-Hamburg

MOZART (MATCH and TM) show an increase in flash frequency towards the Amazon region opposite to LIS, why?

Aerosols???



ash density comparison: model runs for DJF 2003



comparison to MOZART, MATCH and TM,
e ECHAM results show a flash distribution more similar to LIS

Falcon measurements during TROCCINOX

TROCCINOX field experiment 2004:

Selected TROCCINOX flights

F2: 14 February (sub-tropical, radar box)

F4: 17 February (s-t, long-range)

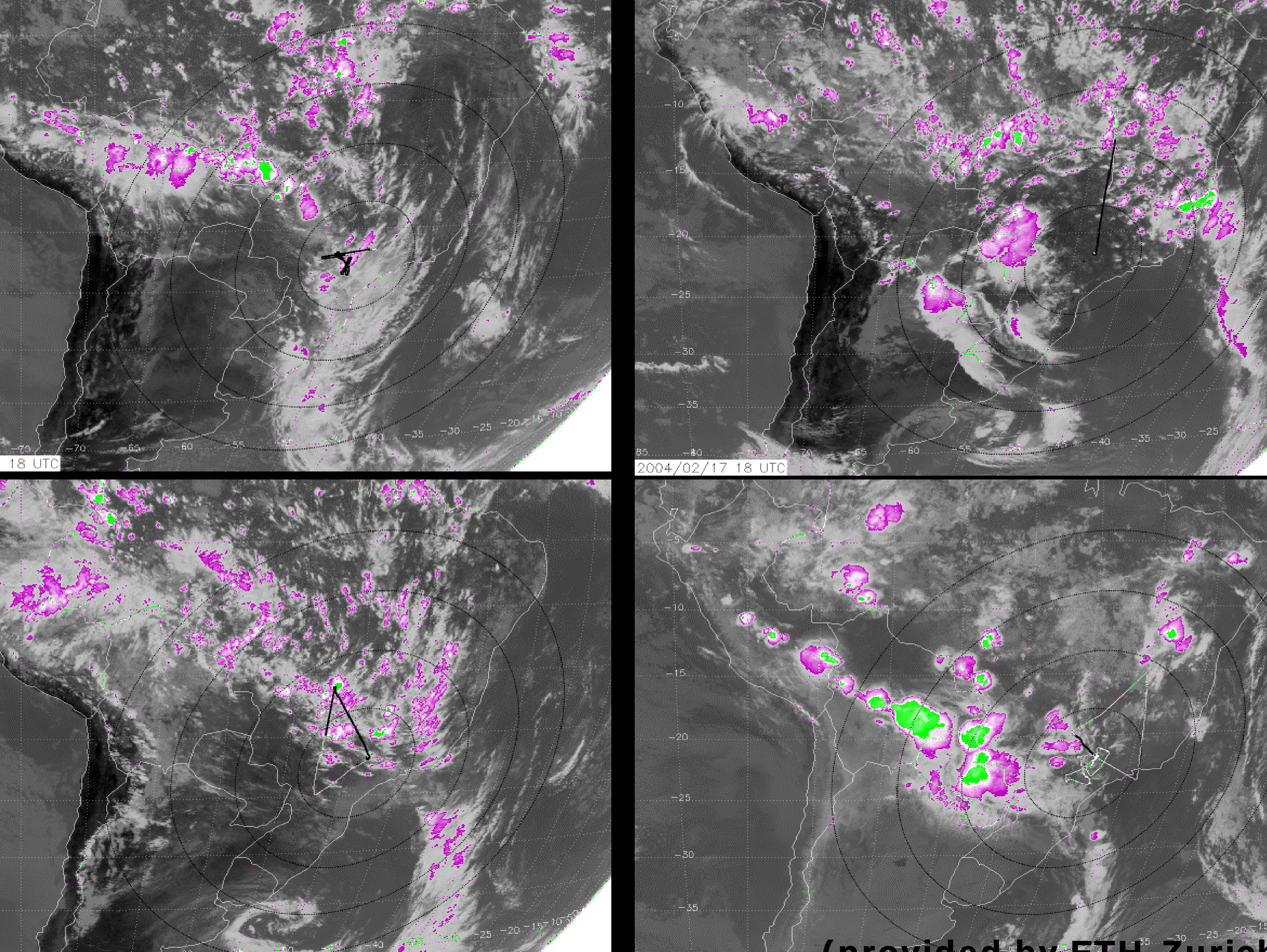
F6: 20 February (s-t, l-r)

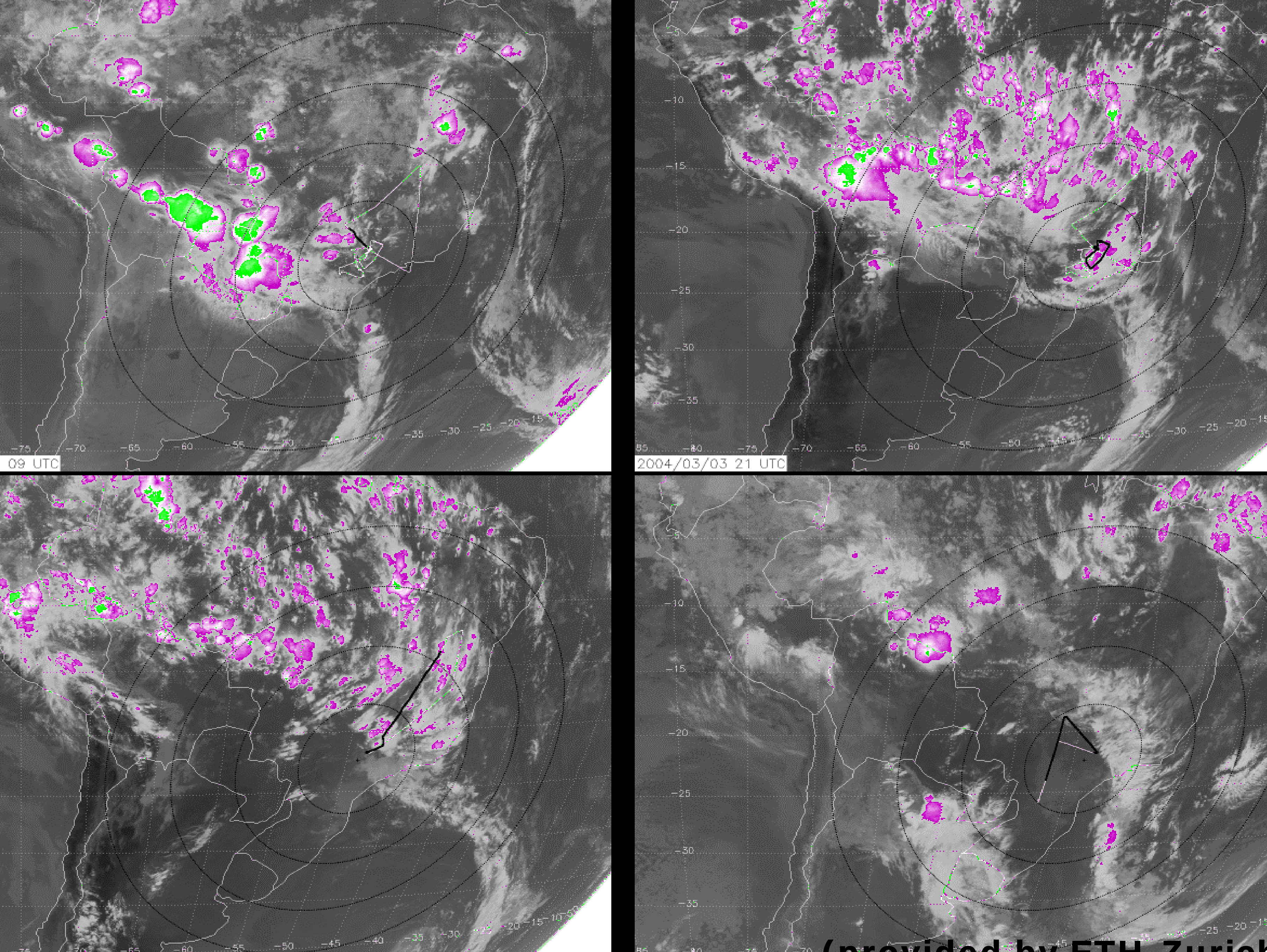
F9: 03a March (tropical, l-r)

F10: 03b March (tropical, radar box)

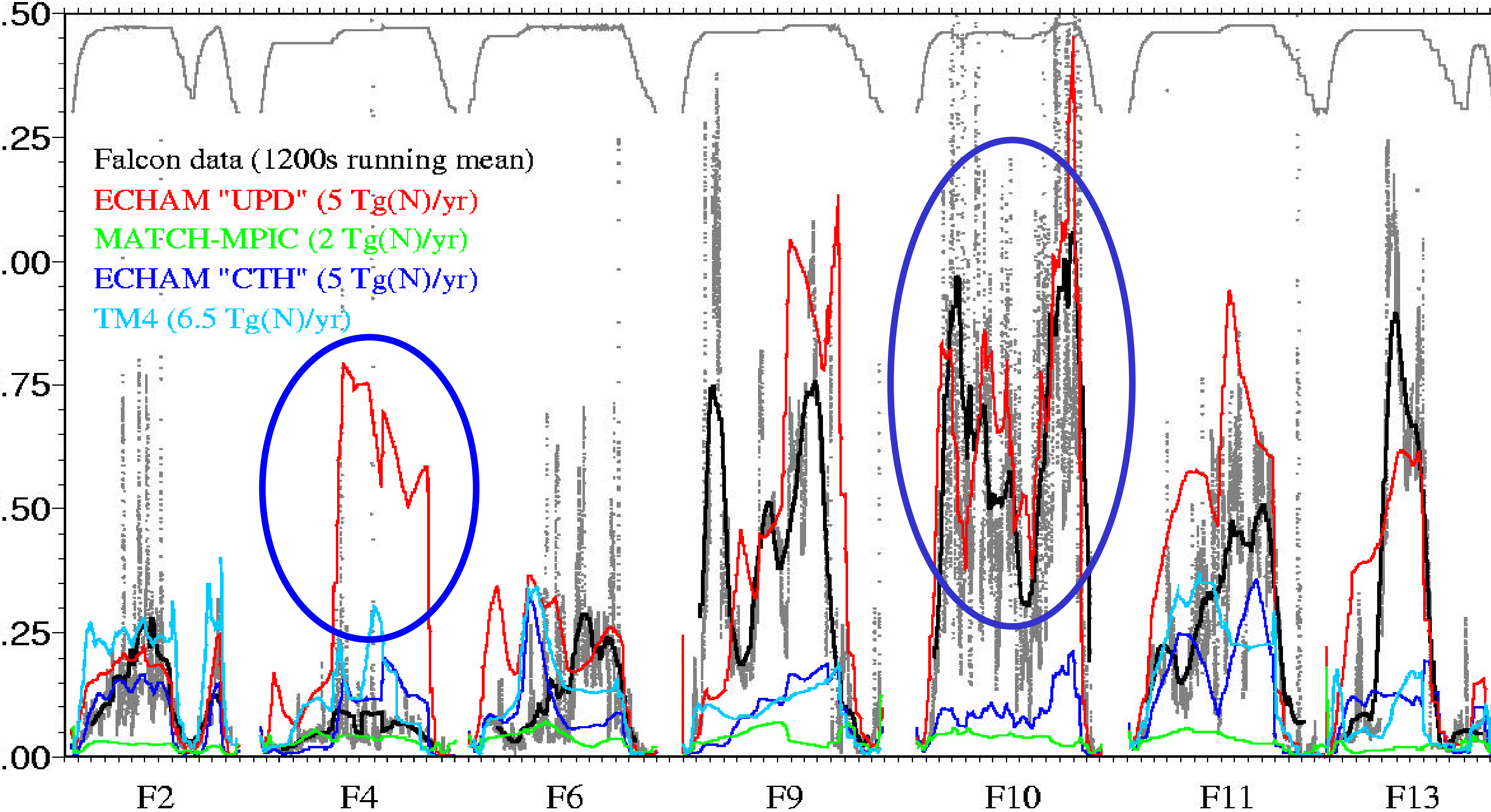
F11: 4 March (tropical, l-r)

F13: 7 March (s-t, l-r)


18 UTC
2004/02/17 18 UTC


09 UTC
2004/03/03 21 UTC
(provided by ETH

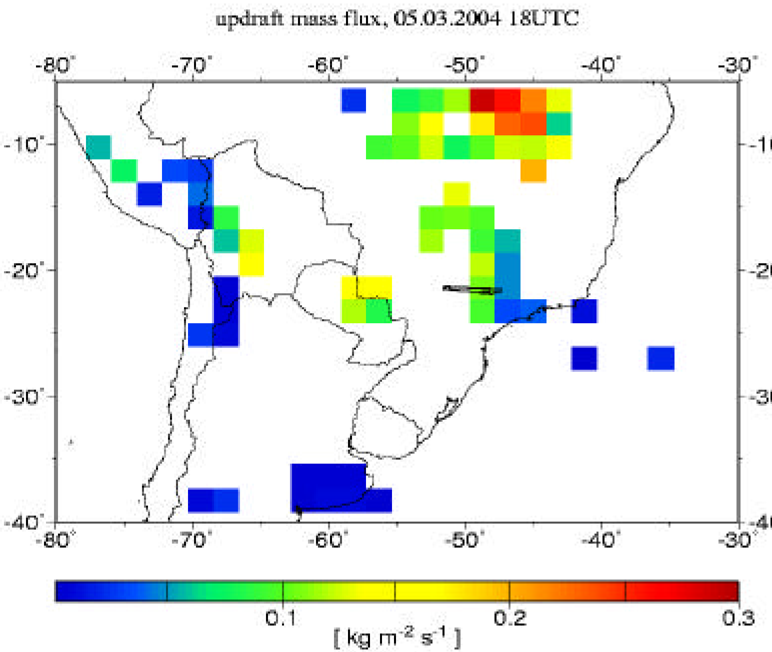
Comparison model - measurements for NO



od agreement between ECHAM “UPD” and measurements

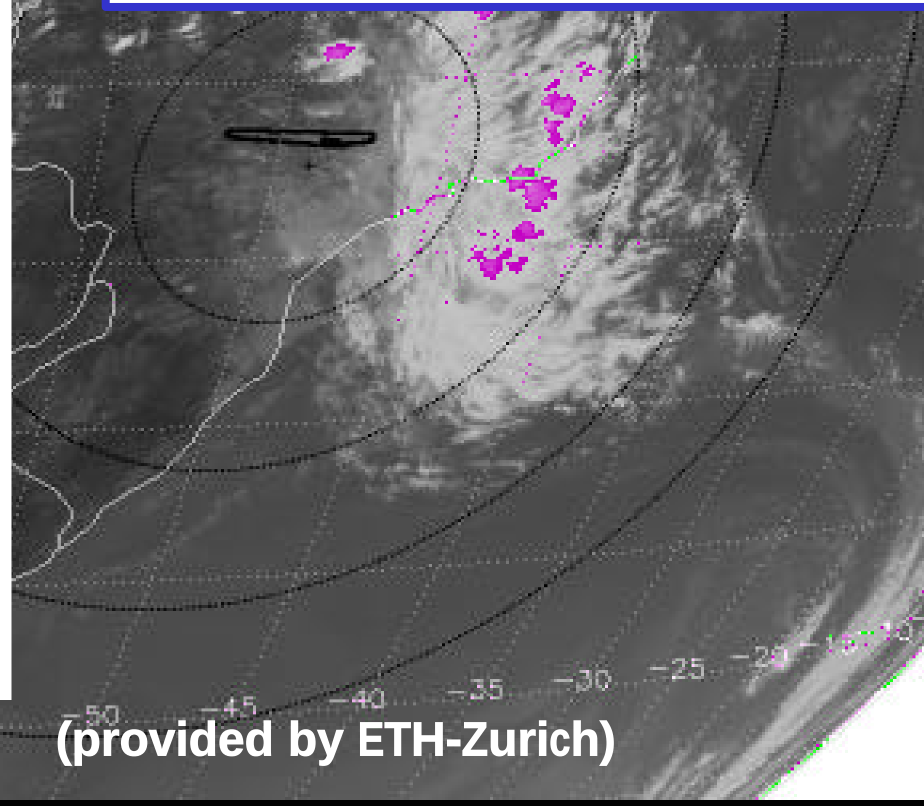
ECHAM updraft mass flux

05.03.2004, 18 UTC



Explanation for occasionally larg disagreement between ECHAM "UPD" and measurements (last blue ellipse):

Time delay of convection in ECHAM model (ECMWF analysis shifted by one grid box) in comparison to reality (GOES).

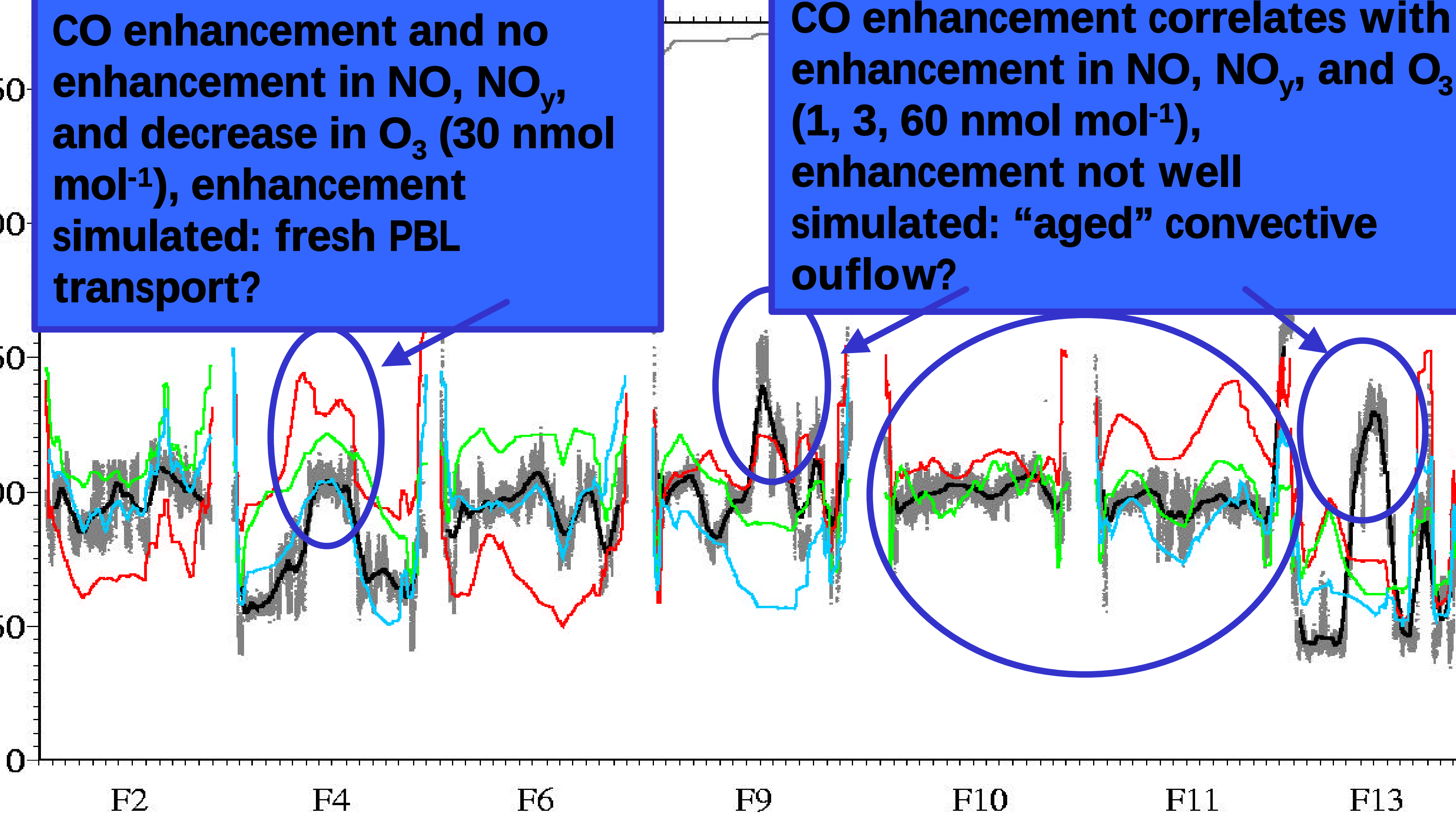


(provided by ETH-Zurich)

Comparison model - measurements for CO

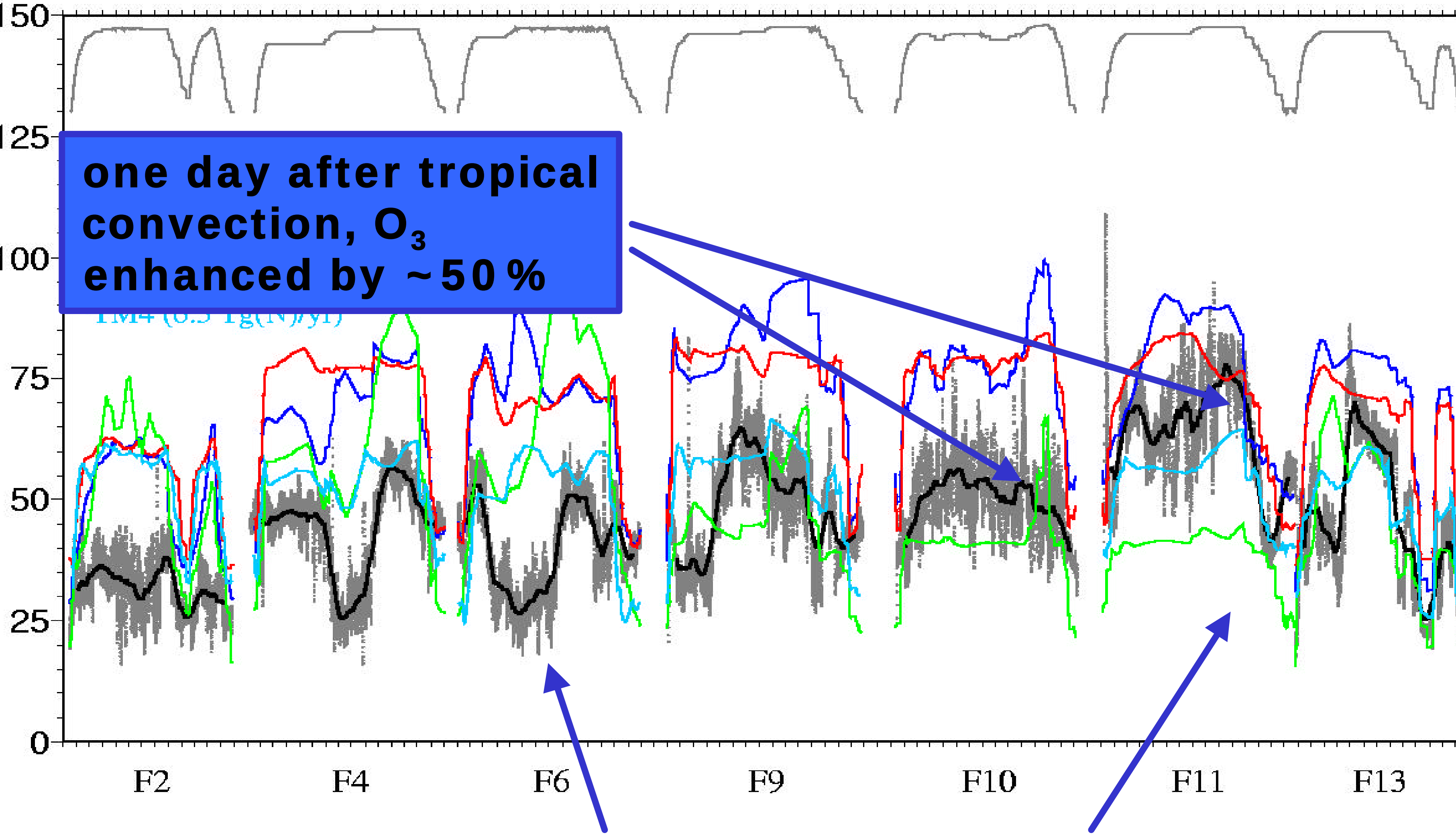
CO enhancement and no enhancement in NO, NO_y, and decrease in O_3 (30 nmol mol^{-1}), enhancement simulated: fresh PBL transport?

CO enhancement correlates with enhancement in NO, NO_y, and O_3 (1, 3, 60 nmol mol^{-1}), enhancement not well simulated: “aged” convective ouflow?



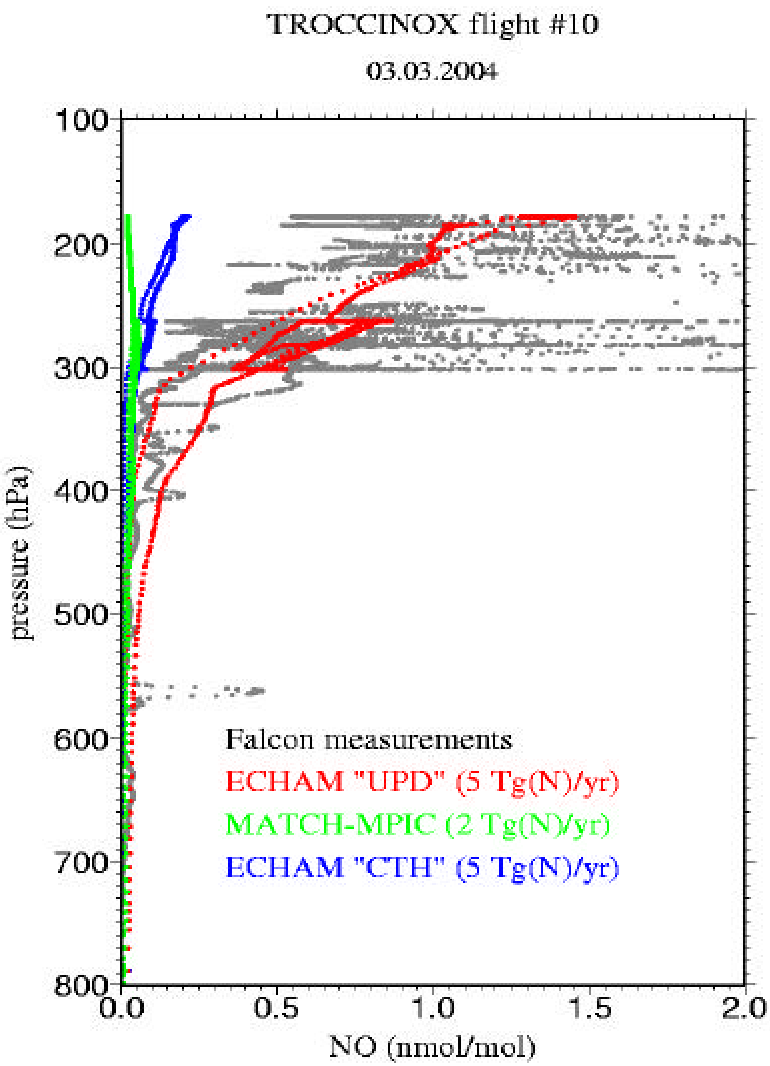
M agrees very well with measurements (exceptions F9 and F13)
ATCH slightly overestimates CO (good agreement for F10 and F11)

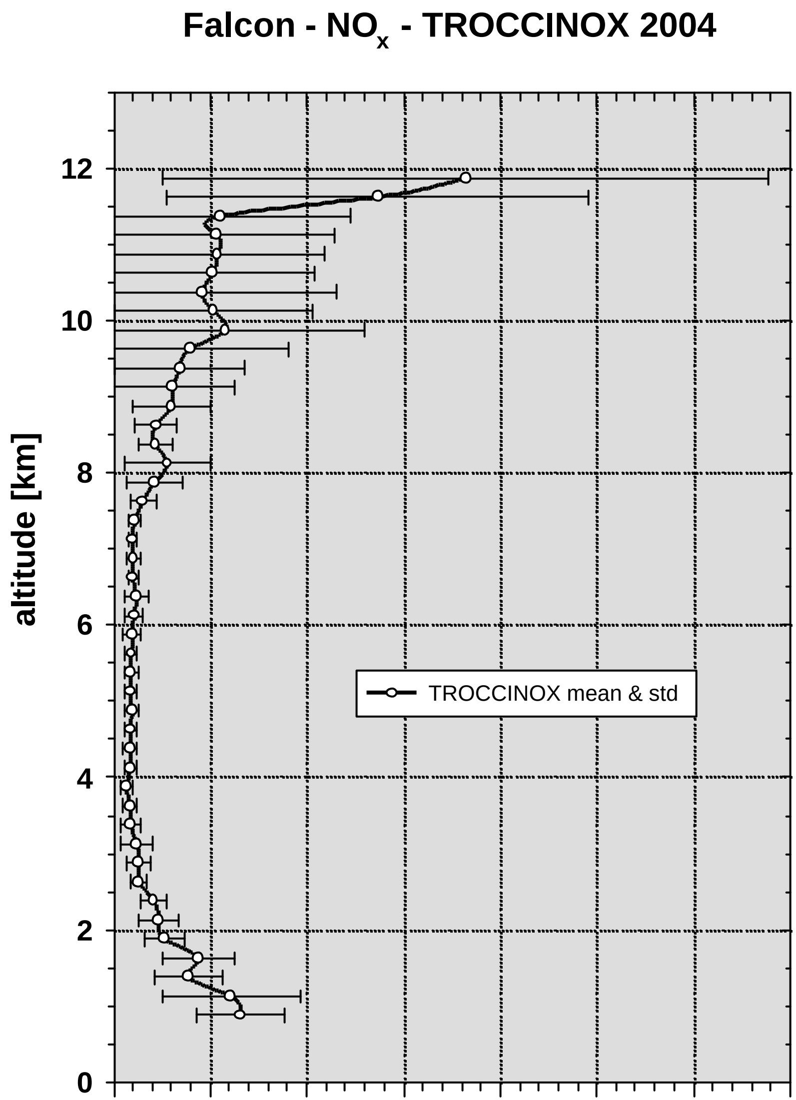
Comparison model - measurements for O_3



MATCH > & < measurements (tropopause), variability seen
TM slightly too high
ECHAM far too high

Comparison model - measurements for NO





od agreement between ECHAM "UPD" and measurements

Conclusions

(~first impressions from TROCCINOX)

convective mass flux (Grewe)
better than cloud-top-height (Price&Rind) parameterisat

NO: ECHAM (5 TgN yr^{-1}) better than MATCH (2 TgN yr^{-1})
(MATCH 5 TgN yr^{-1} better than MATCH 2 TgN yr^{-1}
as indicated in ACPD)

CO: TM and MATCH (32 and 42 vertical levels)
better than ECHAM (19 vertical layers)

O_3: enhanced in "aged" air masses by ~50%
(importance of lightning-NO_x over Brazil and transport
from Africa?)

Future plans: Sensitivity studies

determine correlations for model versus measurements

best lightning-NOx parameterisation:

- cloud top height (Price& Rind)
- convective mass flux (Grewe)
- convective precipitation (Meijer)

best vertical distribution:

- density-weighted, Pickering profile, cloud top layers

best estimate for lightning-produced NOx:

- values between 2-10 Tg(N) yr^{-1}

comparison of the horizontal flash distribution between models and LIS/OTD climatology and SCIA-NO2