Towards a scale-consistent lightning NOx source parameterisation in the MECO(n) model system

COSMO/CLM/ART User Seminar 2014

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JG|U

Motivation

- NOx is an important precursor for tropospheric ozone
- different sources
  - anthropogenic sources
    - traffic
    - airtraffic
    - industrial
    - ...
  - soil
  - lightning
- processes are important on **global and regional** scale
  - → nesting approach

NLDN data are collected by *Vaisala, Inc.* and archived by the *NASA Marshall Space Flight Center*. *Yunyao Li* and *Kenneth E. Pickering* are acknowledged for the processing necessary to estimate total flash rates.

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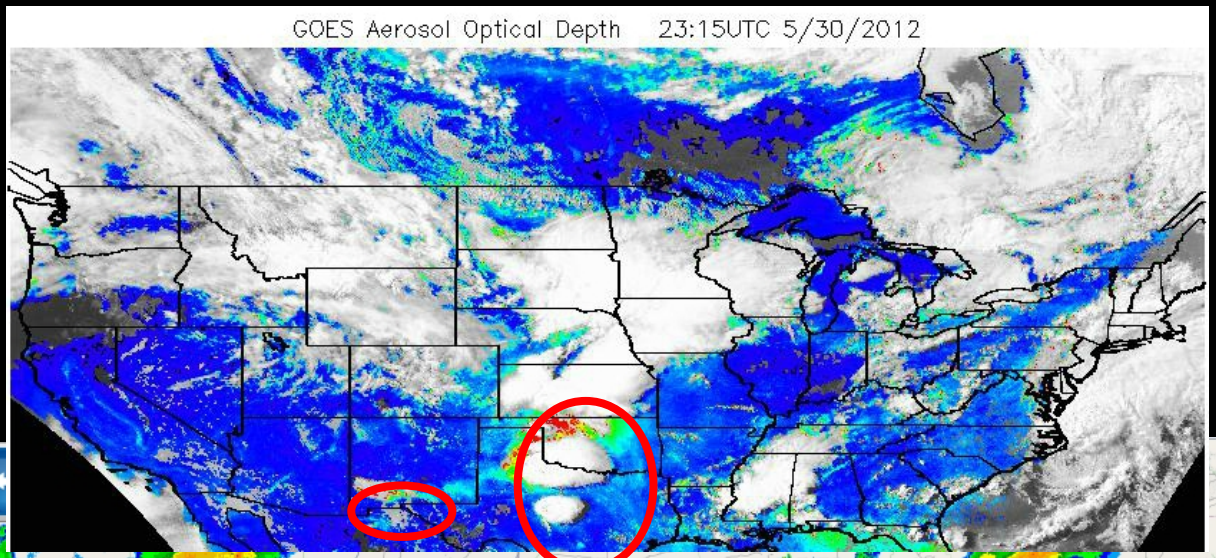
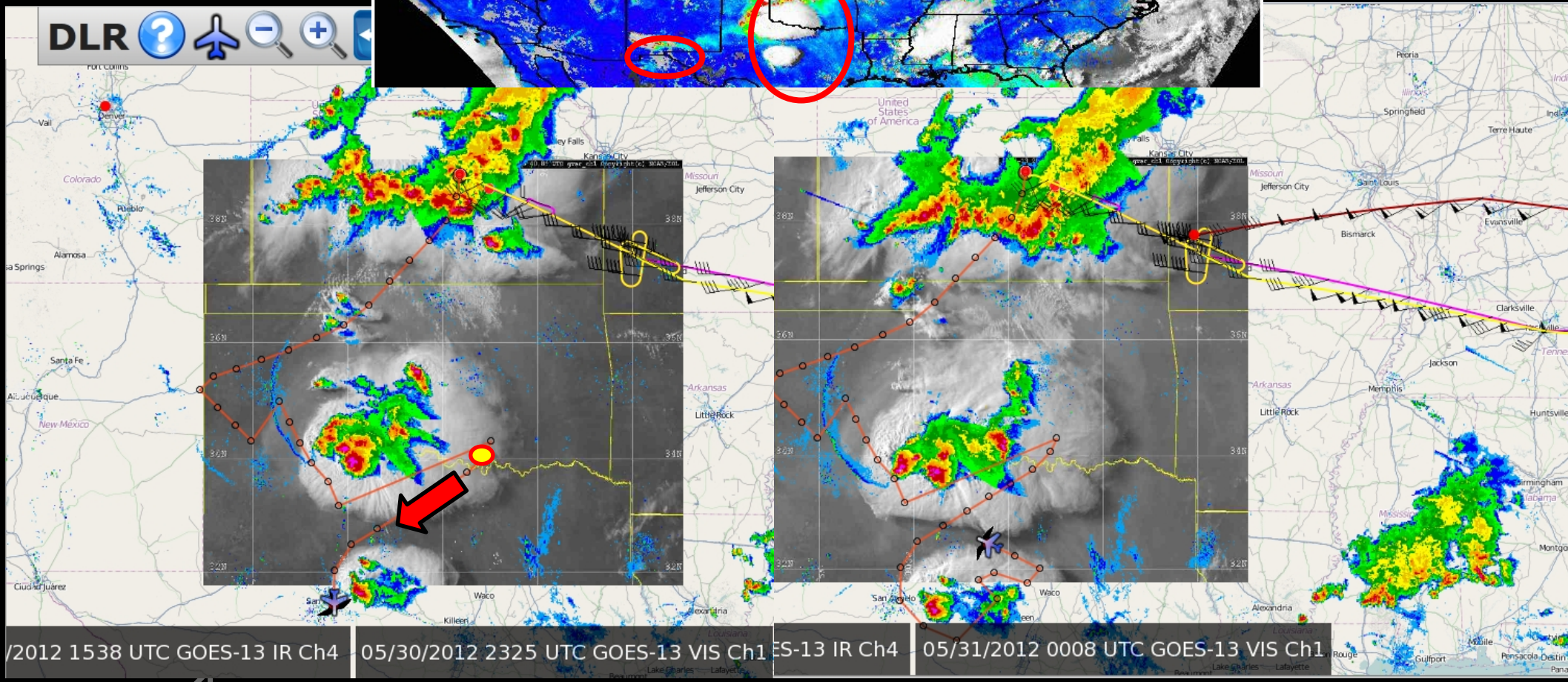
Falcon flight on 30 May 2012: Supercell (border TX/OK)

Whitewater-
Baldy Fire (NM)





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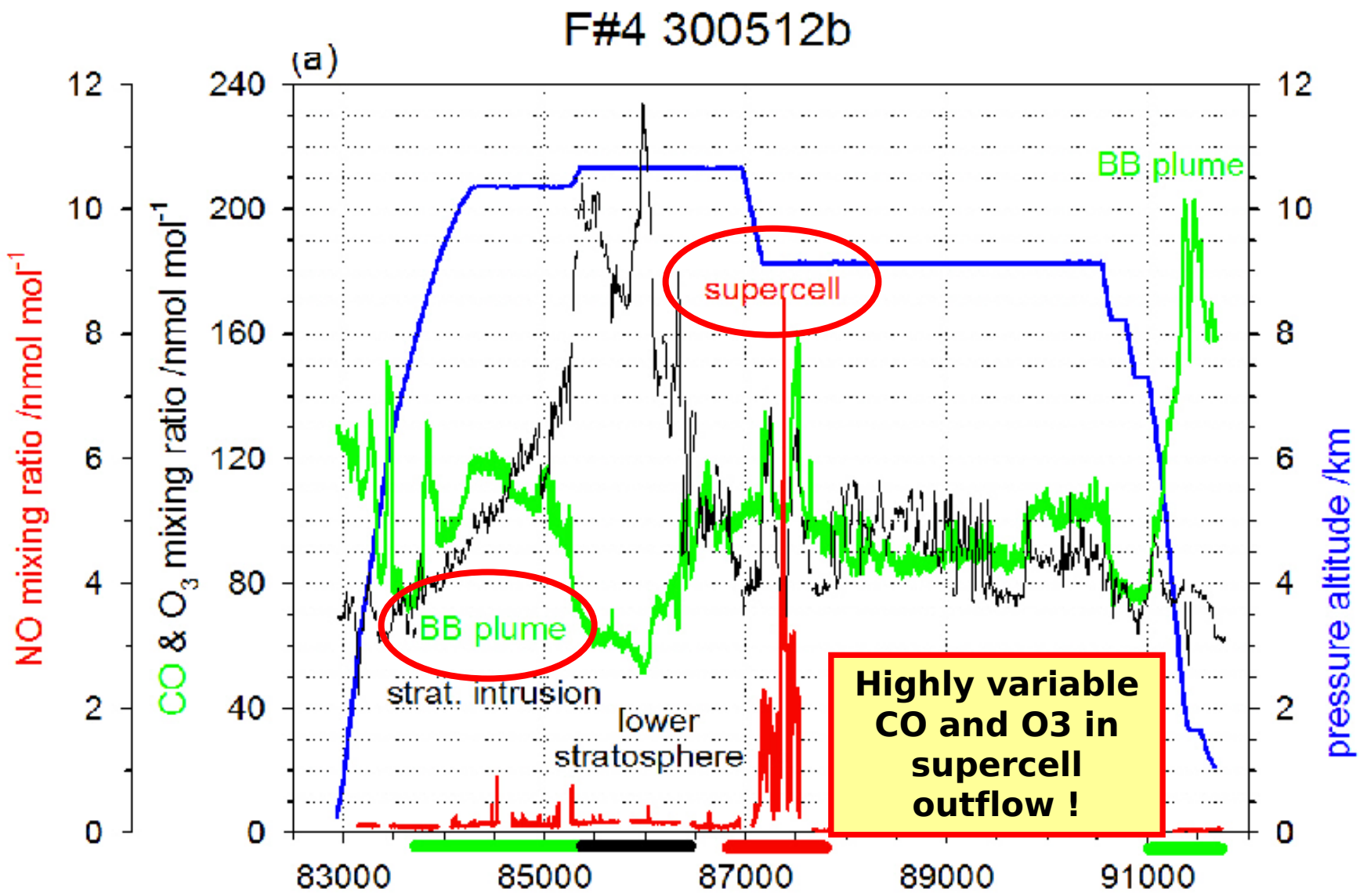
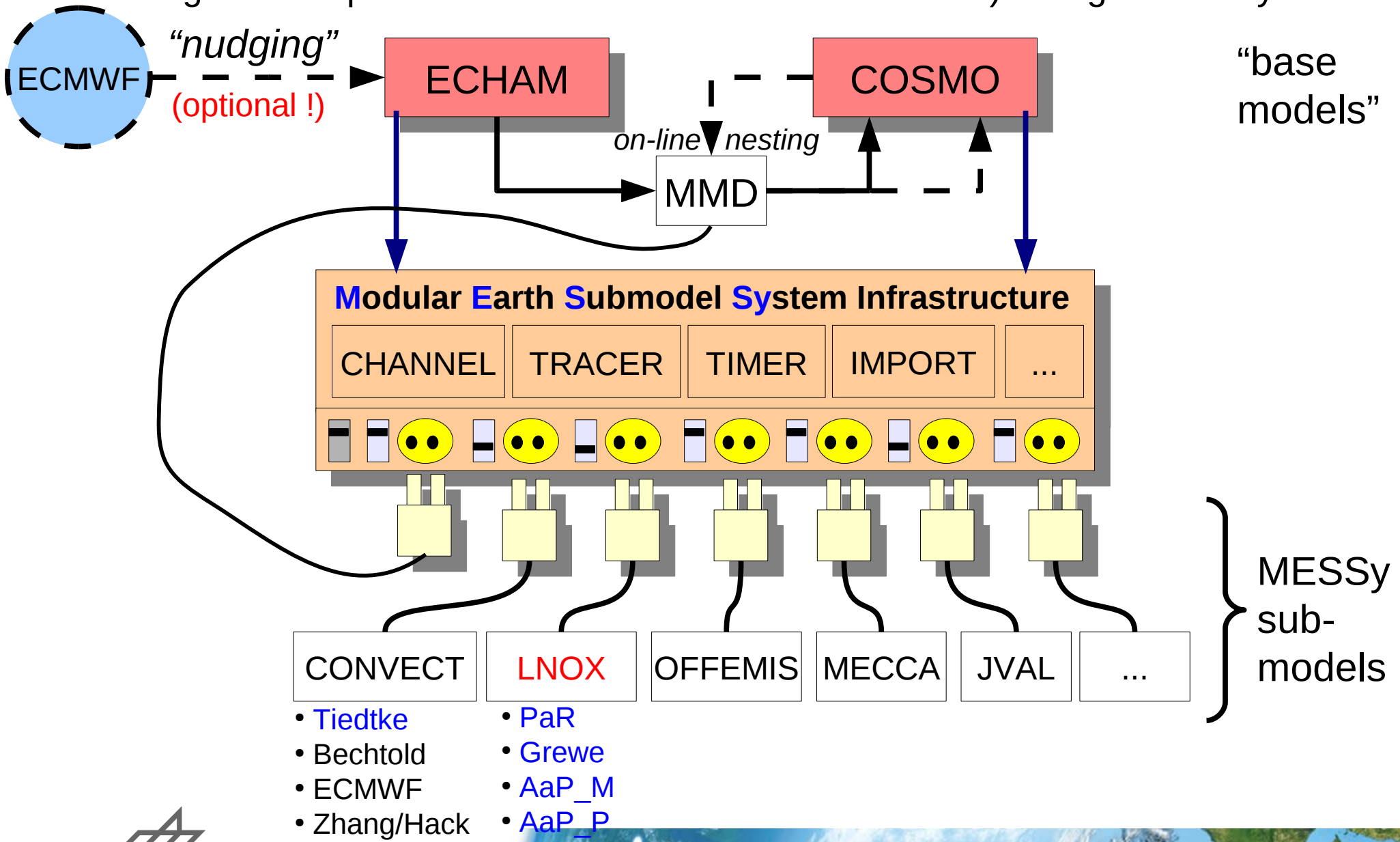

F#4 300512b
(a)
NO mixing ratio /nmol mol-1
CO & O3 mixing ratio /nmol mol-1
pressure altitude /km
BB plume
supercell
BB plume
strat. intrusion
lower stratosphere
Highly variable CO and O3 in supercell outflow !
elapsed UTC time since midnight /s

MECO(n): MESSy-fied ECHAM and COSMO models nested n times

The key is the modular approach (and the strict separation of process / diagnostic implementations from model infrastructure) → high flexibility



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Lightning (NOx) parameterisations

scheme	flash frequency is based on ...	references
PaR_T	cloud top height	*Price and Rind (1992, 1993); Price et al., (1997a,b)*
AaP_M	updraft strength at a specific altitude	*Allen and Pickering (2002)*
AaP_P	amount of convective precipitation	*Allen and Pickering (2002)*
Grewe	updraft velocity	*Grewe et al. (2001)*

- NOx production: ~ 15.6 kg(N)/CG-flash, 1.56kg(N)/IC-flash
- ~ 46 flashes/s globally
- global inter-comparison within EMAC: *Tost et al., ACP, 2007*
- extensive review: *Schumann & Huntrieser, ACP, 2007*

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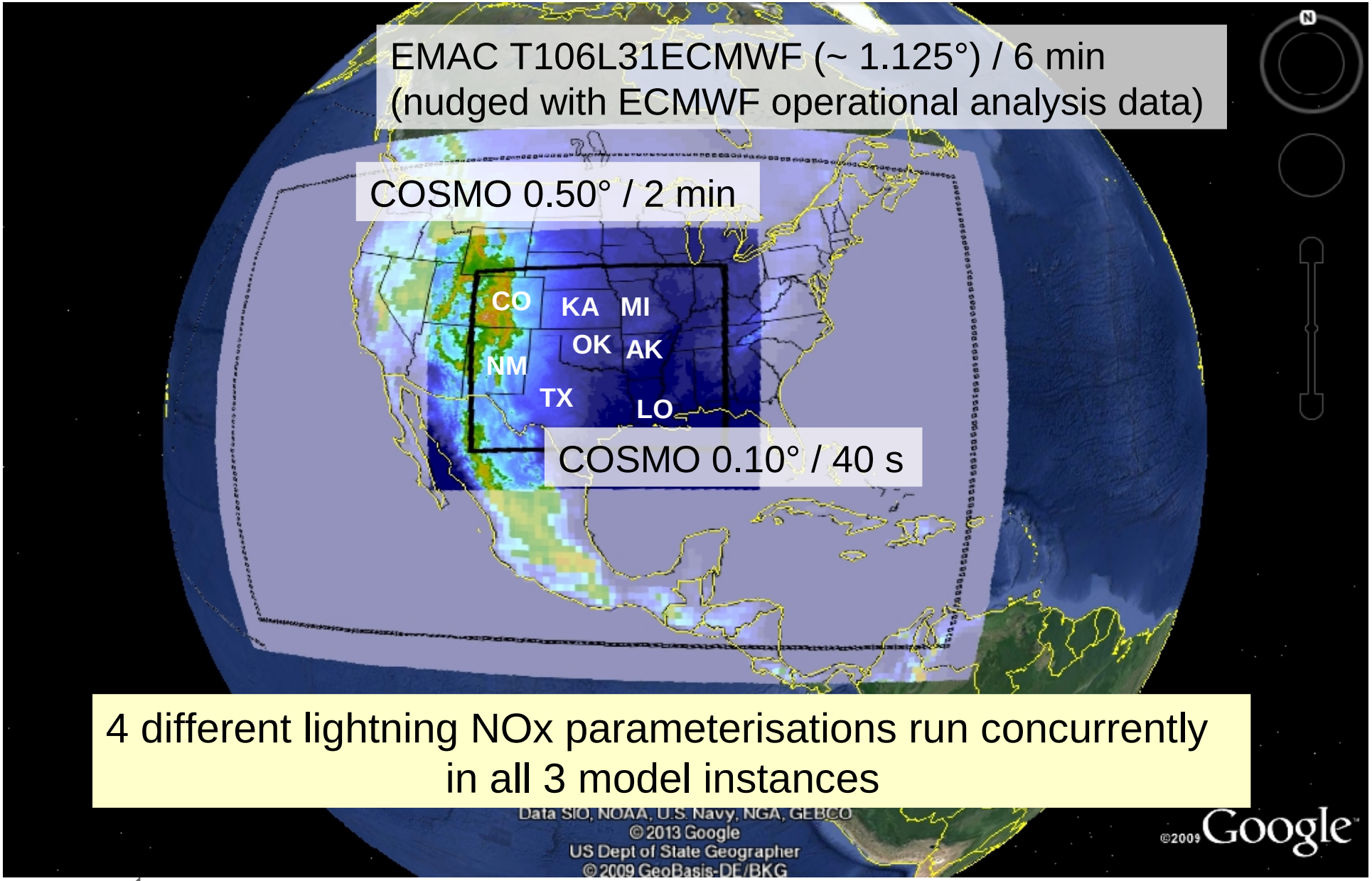
MECO(2) Setup for DC3 Campaign

01-May-2012 – 30-June-2012



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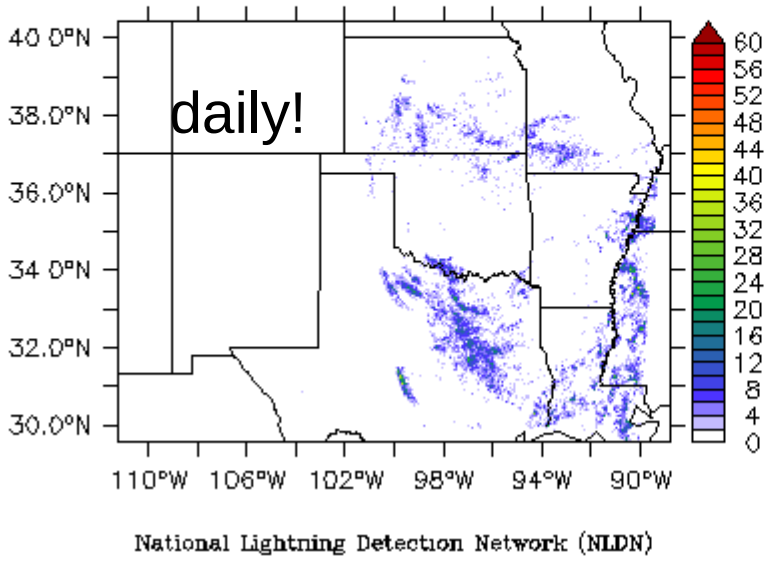
First results …

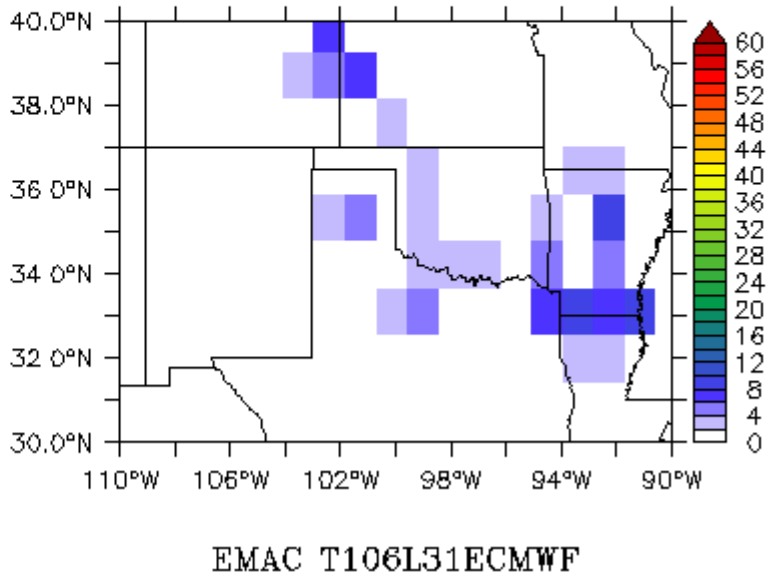
… a case study for the DC3 DLR-Falcon flight on 30/31 May 2012

flash density [10^{-12} / s / m^2] – PaR_T

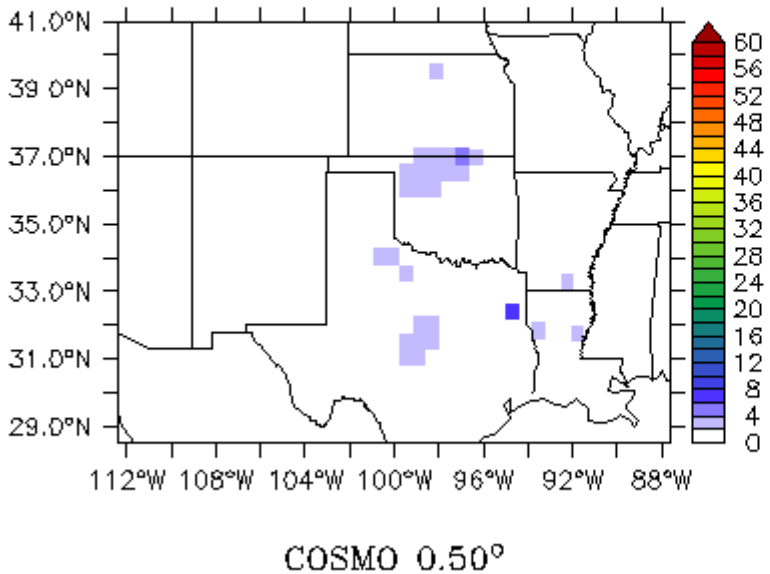
average 30-May-2012 22:00 – 31-May-2012 02:00



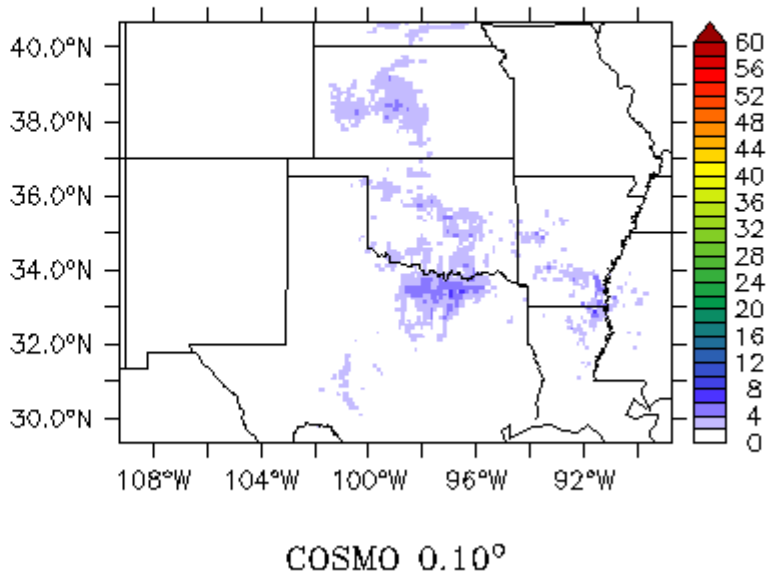
National Lightning Detection Network (NLDN)



EMAC T106L31ECMWF



COSMO 0.50°

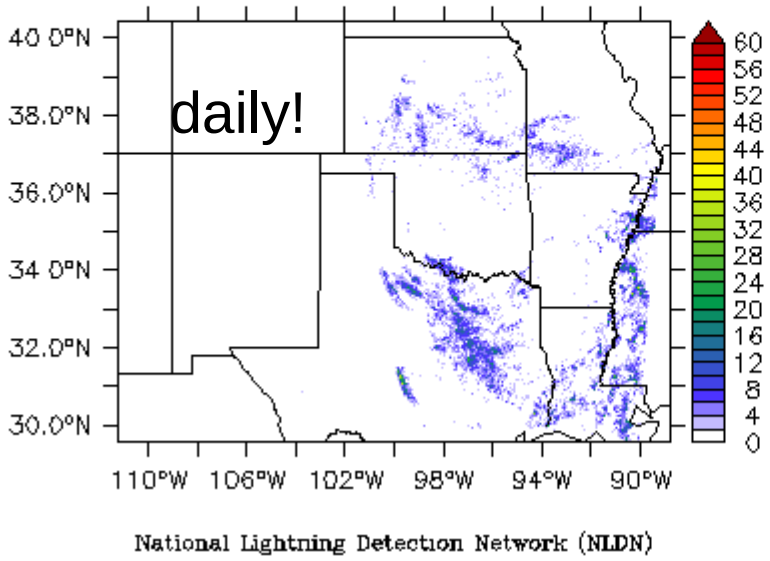


COSMO 0.10°

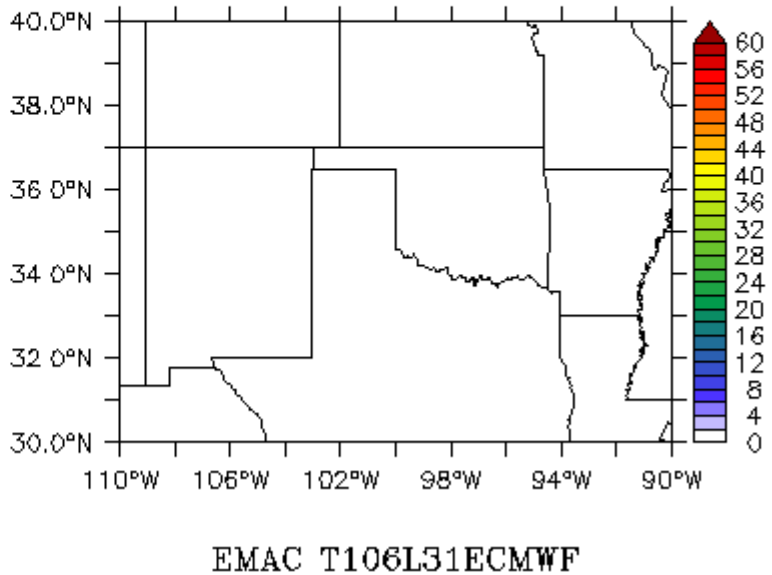
DLR

flash density [10^{-12} / s / m^2] – AaP_P

average 30-May-2012 22:00 – 31-May-2012 02:00



National Lightning Detection Network (NLDN)



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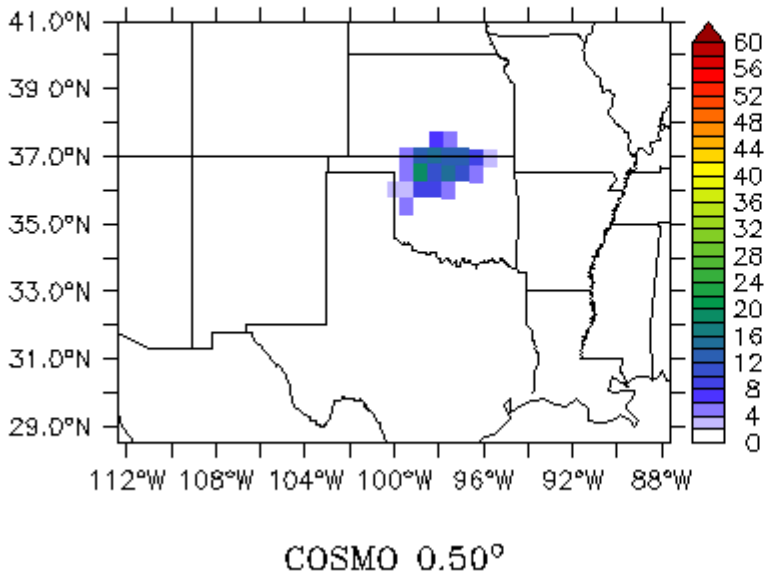
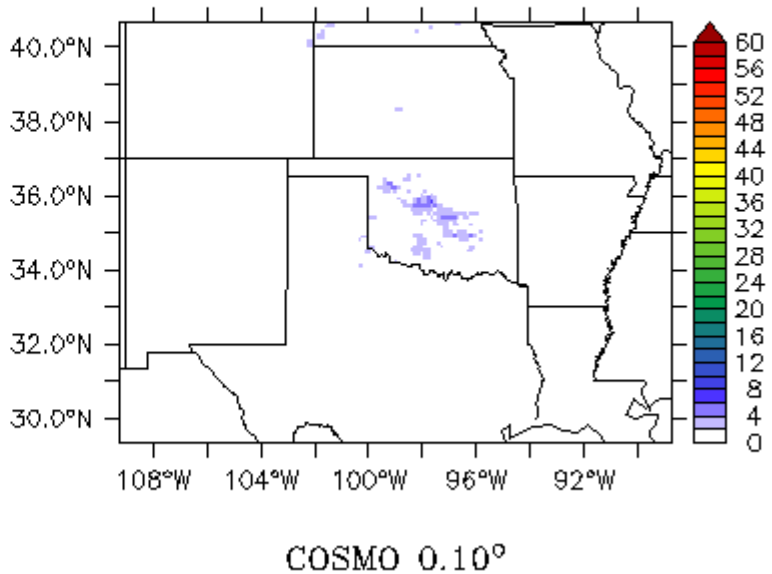


COSMO 0.50°

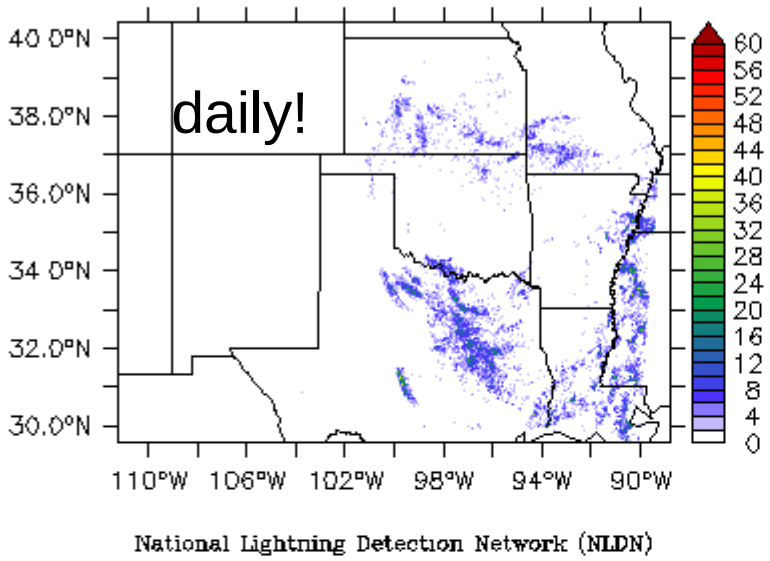


COSMO 0.10°

DLR

flash density [10^{-12} / s / m^2] – AaP_M

average 30-May-2012 22:00 – 31-May-2012 02:00



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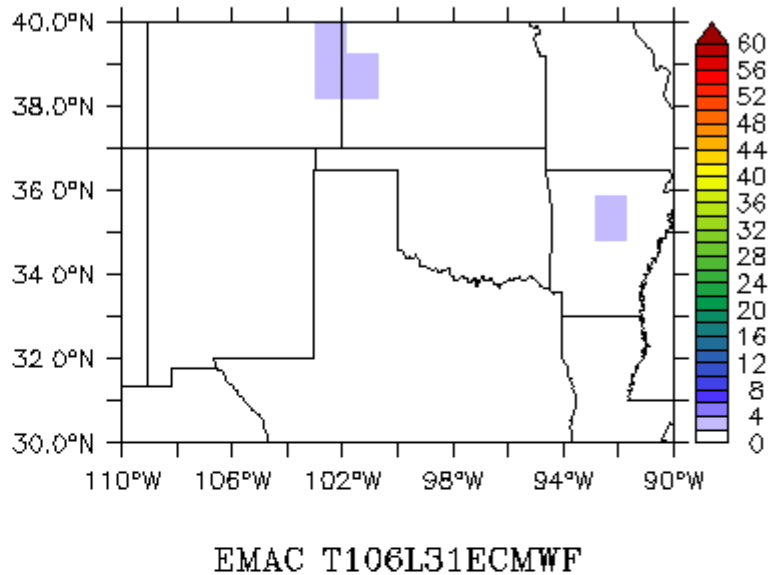

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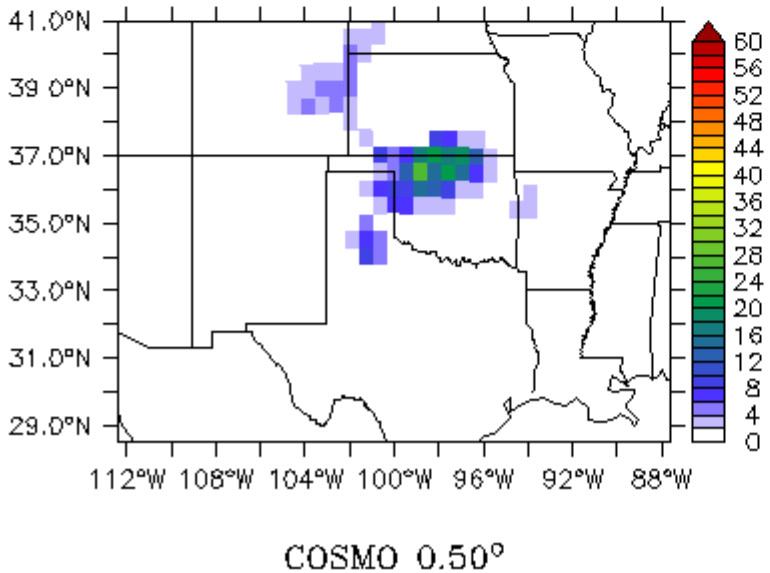
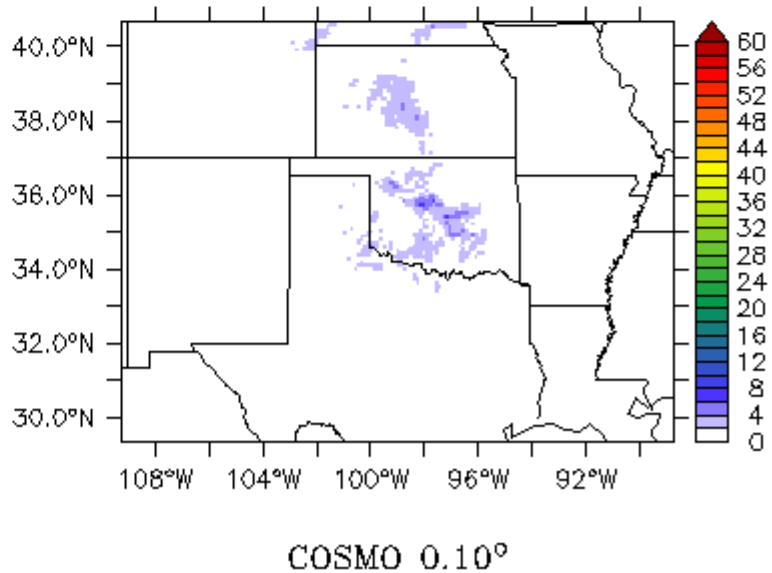


COSMO 0.50°

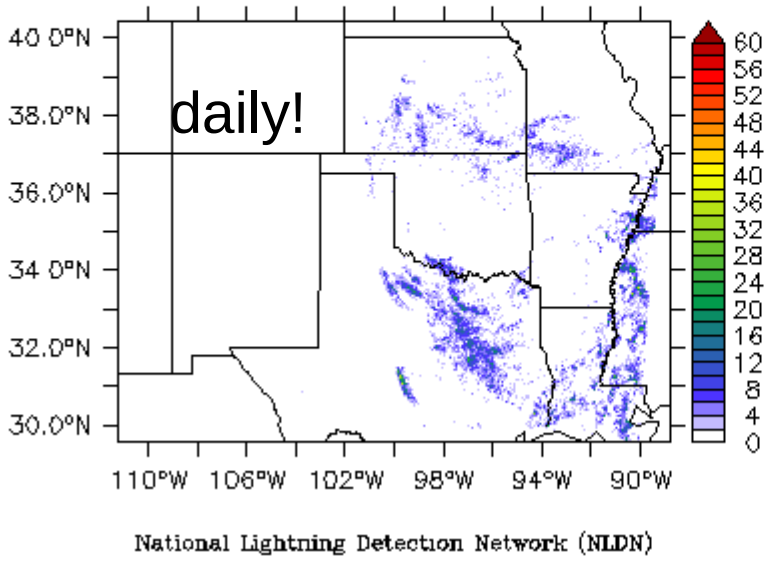


COSMO 0.10°

DLR

flash density [10^{-12} / s / m^2] – Grewe

average 30-May-2012 22:00 – 31-May-2012 02:00



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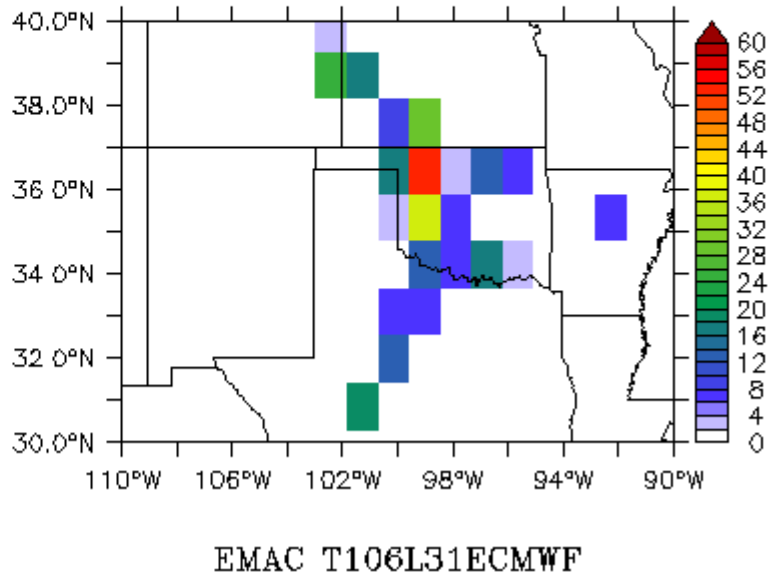

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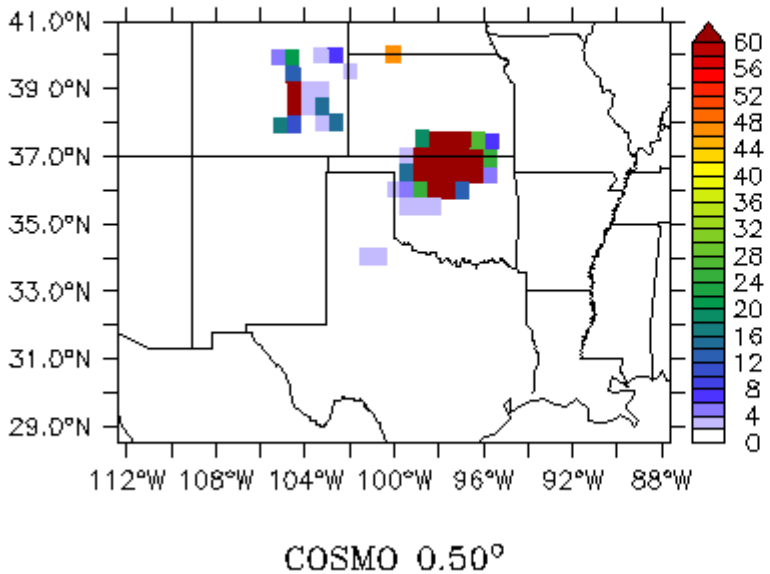
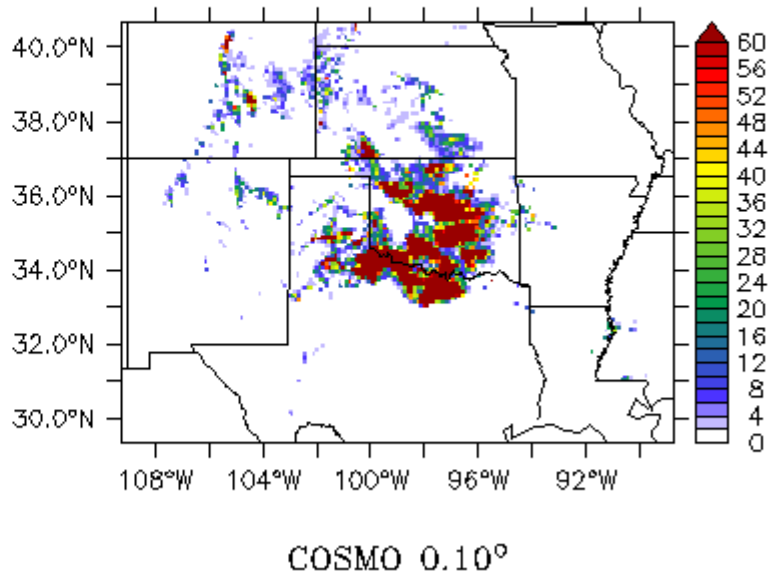


COSMO 0.50°



COSMO 0.10°

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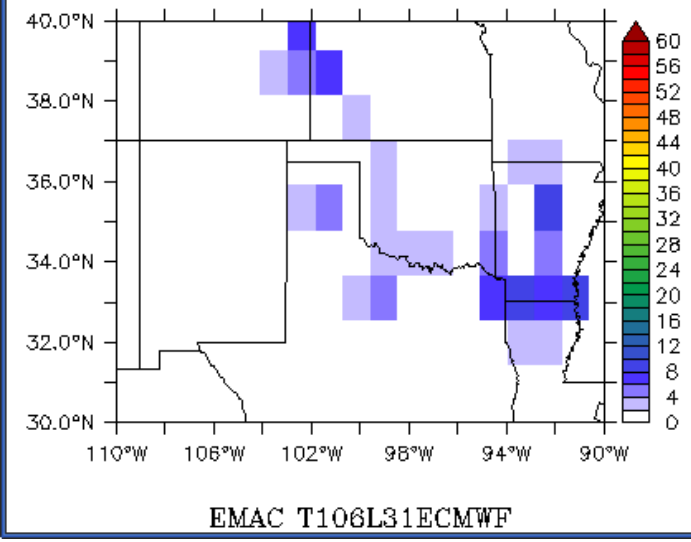
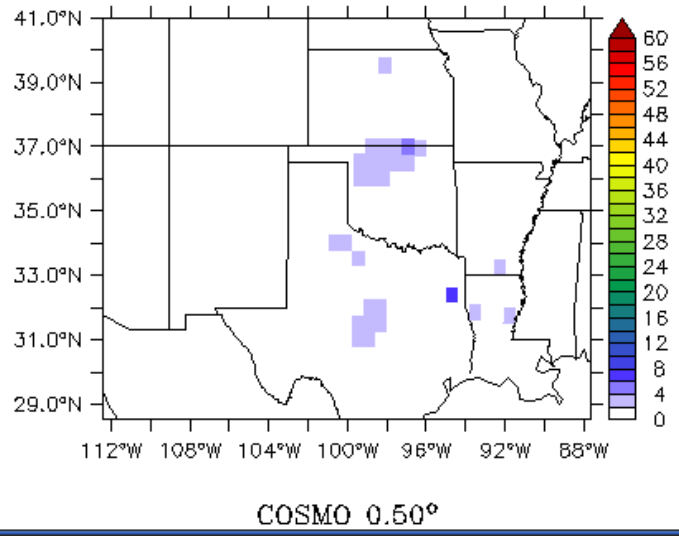
Consistency with convection ...?

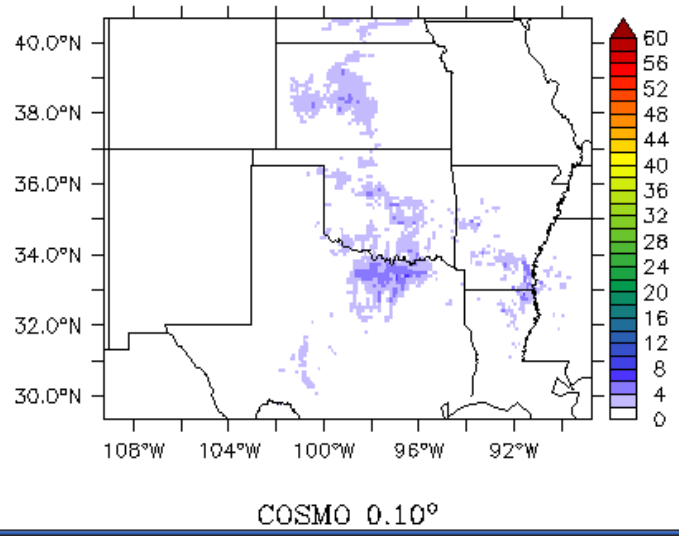
flash density [10^{-12} / s / m^2] – PaR_T



EMAC T106L31ECMWF

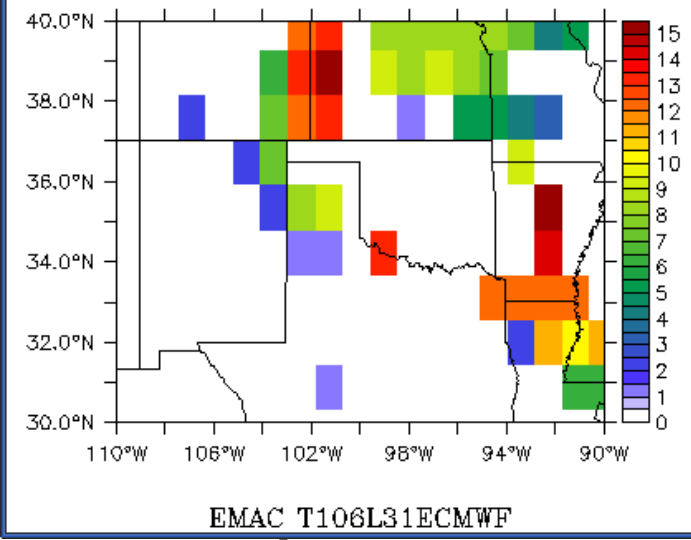


COSMO 0.50°

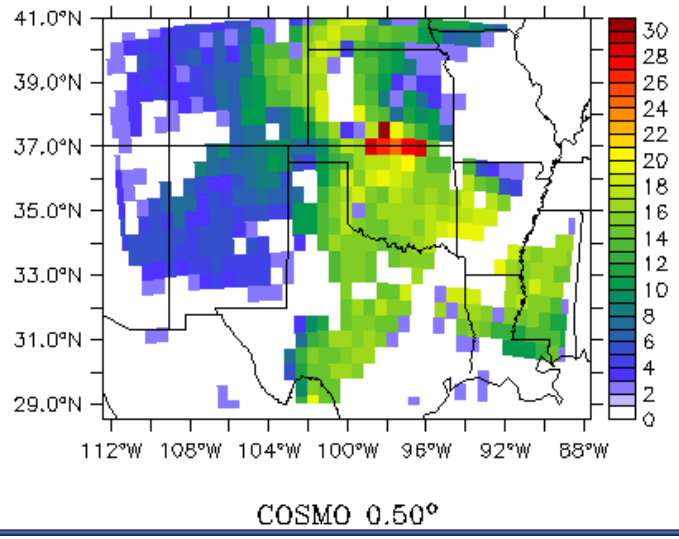


COSMO 0.10°

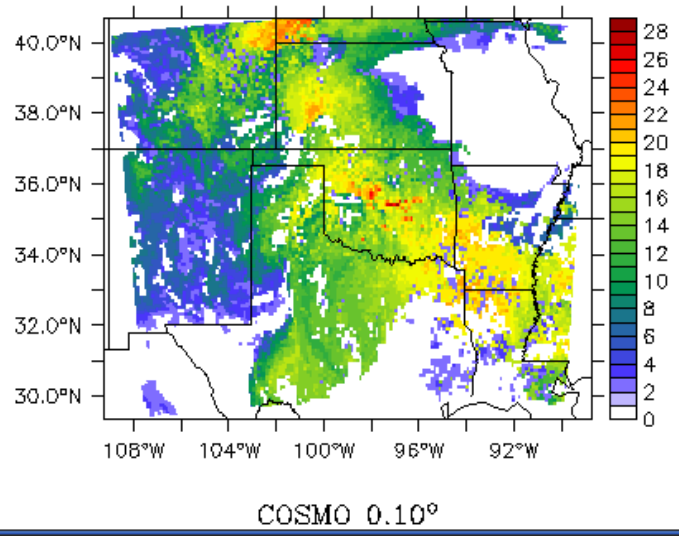
max. (t) convective cloud "thickness" [Δ level index]



EMAC T106L31ECMWF



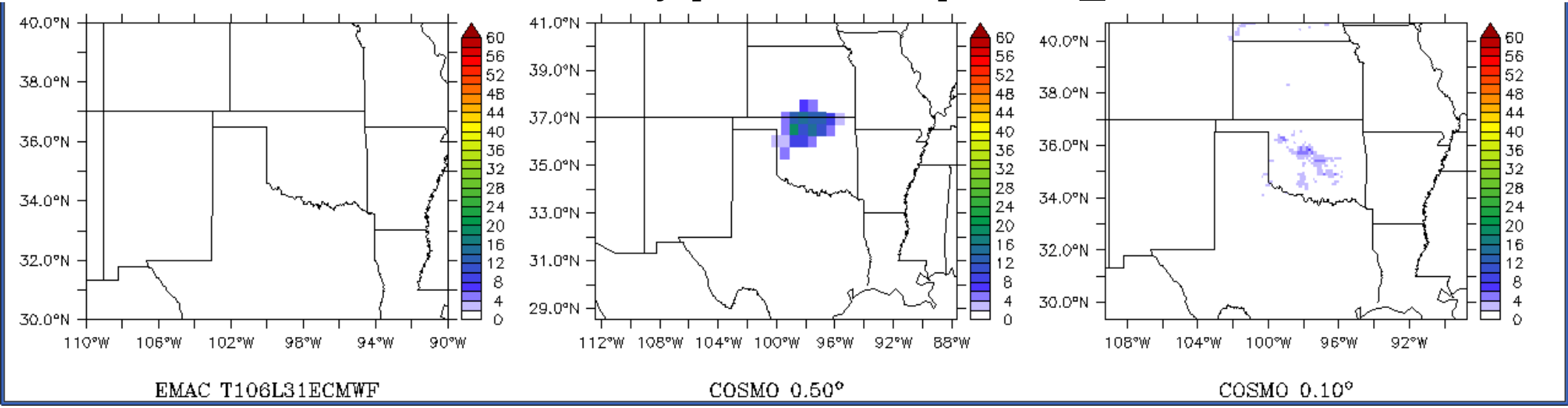
COSMO 0.50°



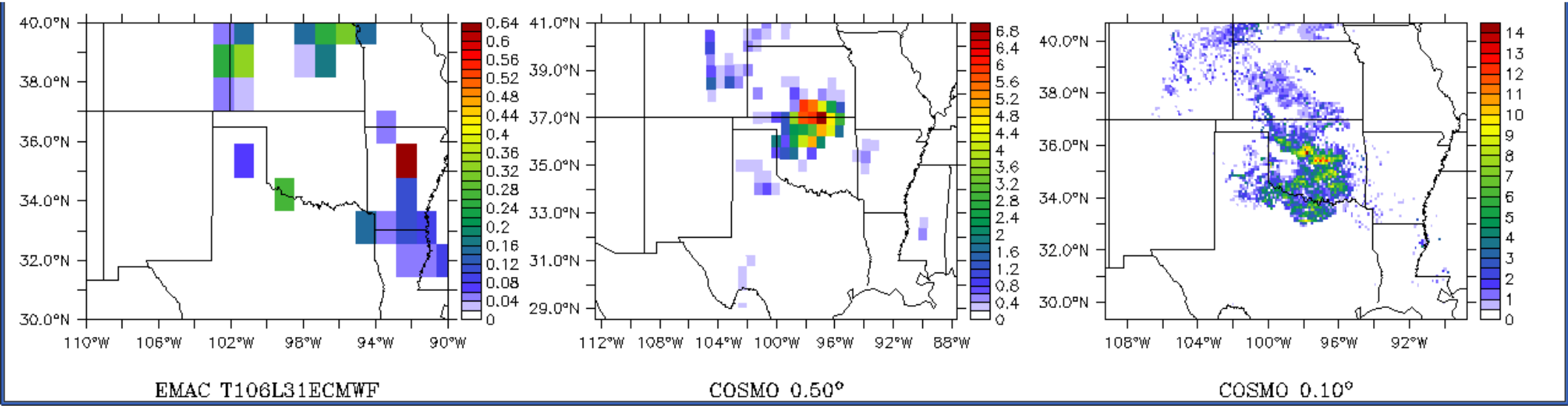
COSMO 0.10°

DLR

flash density [10^{-12} / s / m^2] – AaP_P

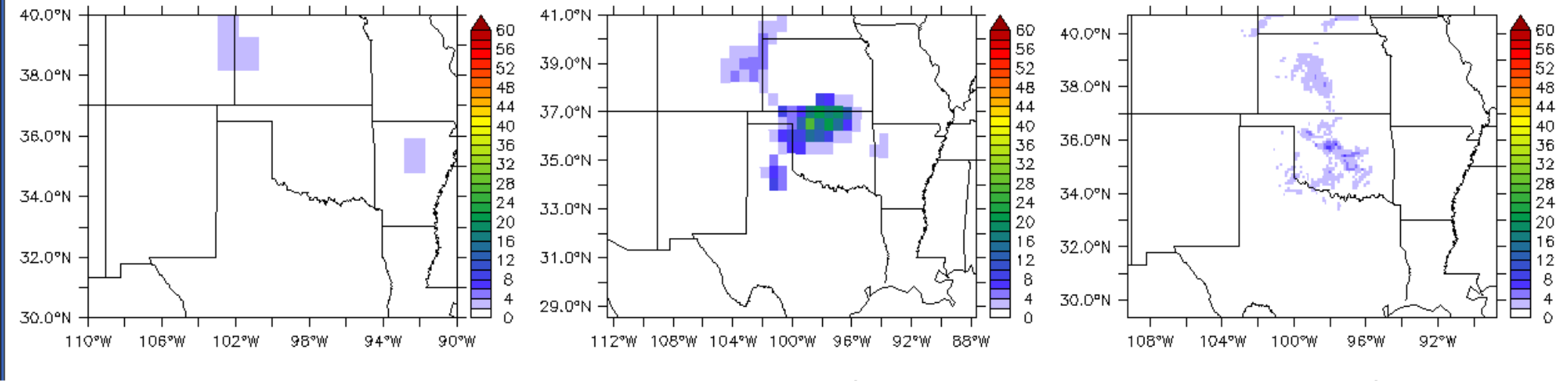


max. (t) surface (convective) precipitation [g / s / m^2]

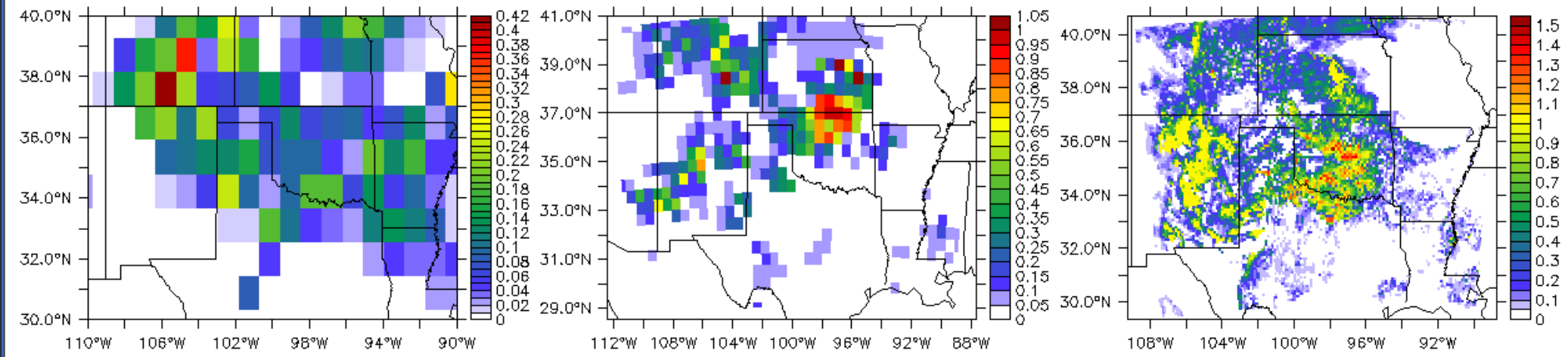


DLR

flash density [10^{-12} / s / m^2] – AaP_M



max. (t,z) convective upward mass-flux [kg / s / m^2]



EMAC T106L31ECMWF | COSMO 0.50° | COSMO 0.10°

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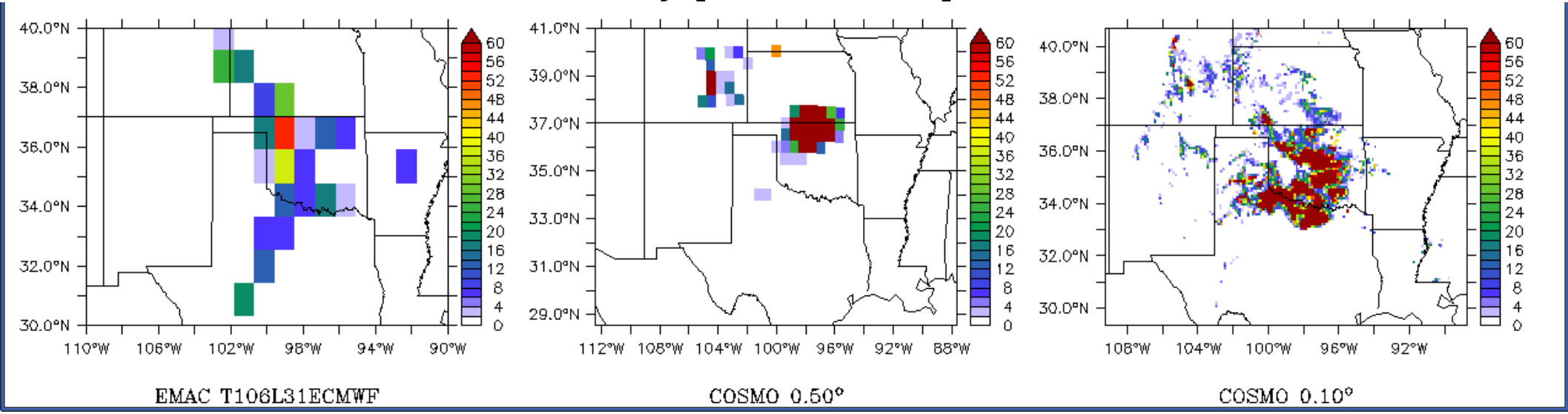
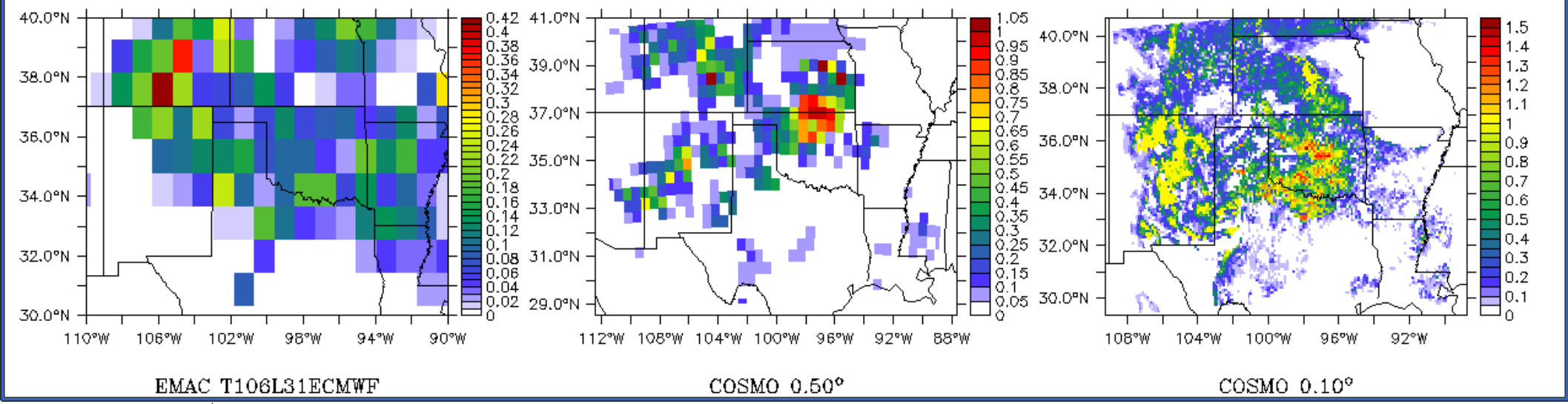
flash density [10^{-12} / s / m^2] – Grewe



max. (t,z) convective upward mass-flux [kg / s / m^2]



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Some conclusions

- lightning (NOx) parameterisations rely on convective parameterisation
  - updraft mass flux, precipitation flux, updraft velocity depend on grid-box area
  - cloud top height does (probably) not so much depend on grid-box area
- none of the schemes can be rated “best”, representation of convection is the limiting factor
- nested instances (COSMO 0.50° and 0.10°) behave differently, at least in the presented case-study, finer resolution is not necessarily better

Outlook

- statistical analysis of data (time series analysis)
- select “good” cases (with “good” representation of convection) and evaluate simulated lightning activity
- alternative convection schemes
- simulate NOx emission & interactive chemistry

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