Inverse modelling of European CH_4 and N_2O emissions using different inverse models and improved observations

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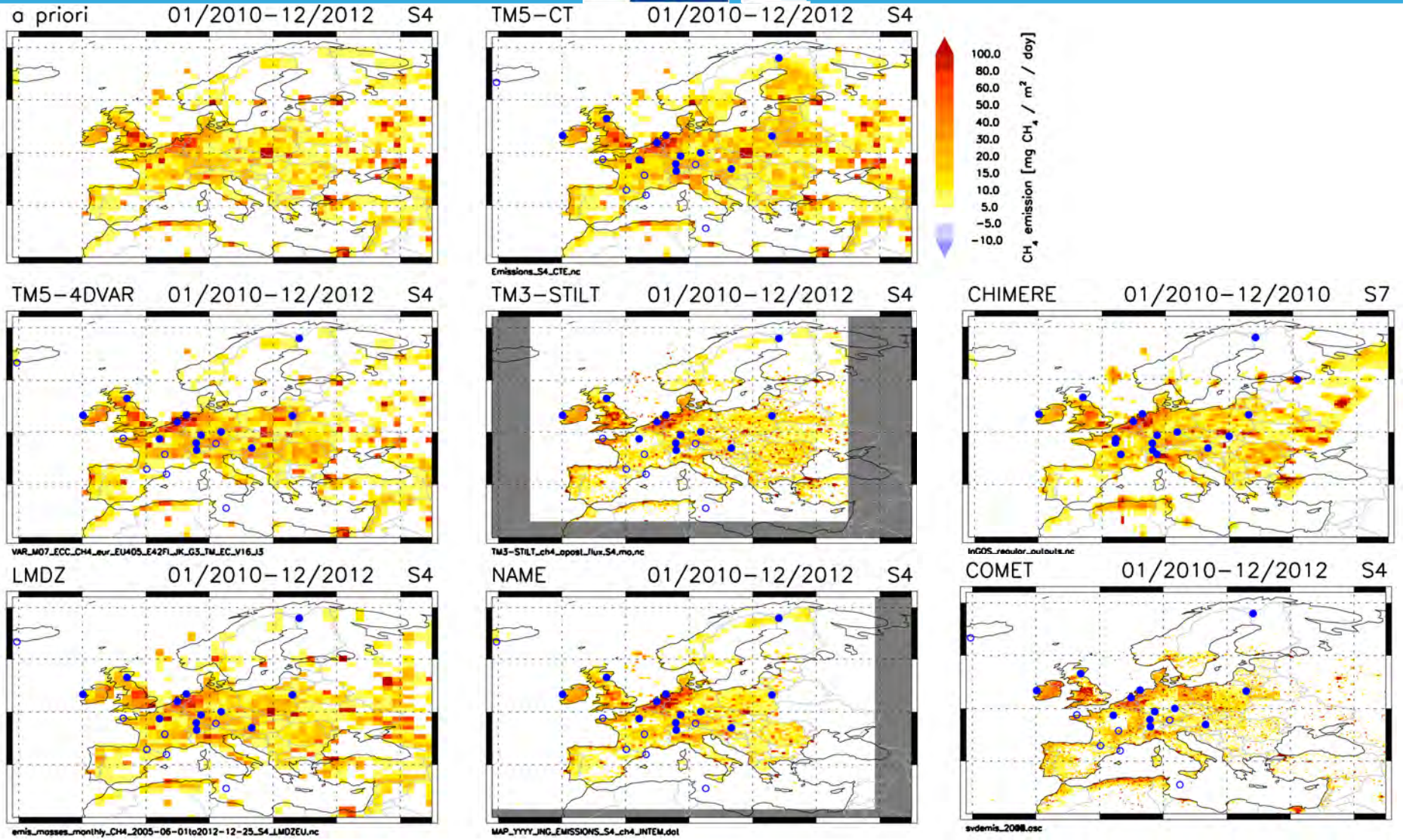
inverse models

	horizontal resolution lon x lat	CH4				N2O			
		S4	S5	S6	S7	S1	S2	S3	S4
TM5-4DVAR	1°x1°	■	■	■	■	■	■	■	■
TM5-CT	1°x1°	■	■	■	■				
LMDZ	~1.2°x0.8°	■	■	■	■				
TM3-STILT	0.25°x0.25°	■	■	■	■	■	■	■	■
NAME	0.56°x0.37°	■	■	■	■	■	■	■	■
CHIMERE	0.5°x0.5°				■				
COMET	0.17°x0.17°	■							

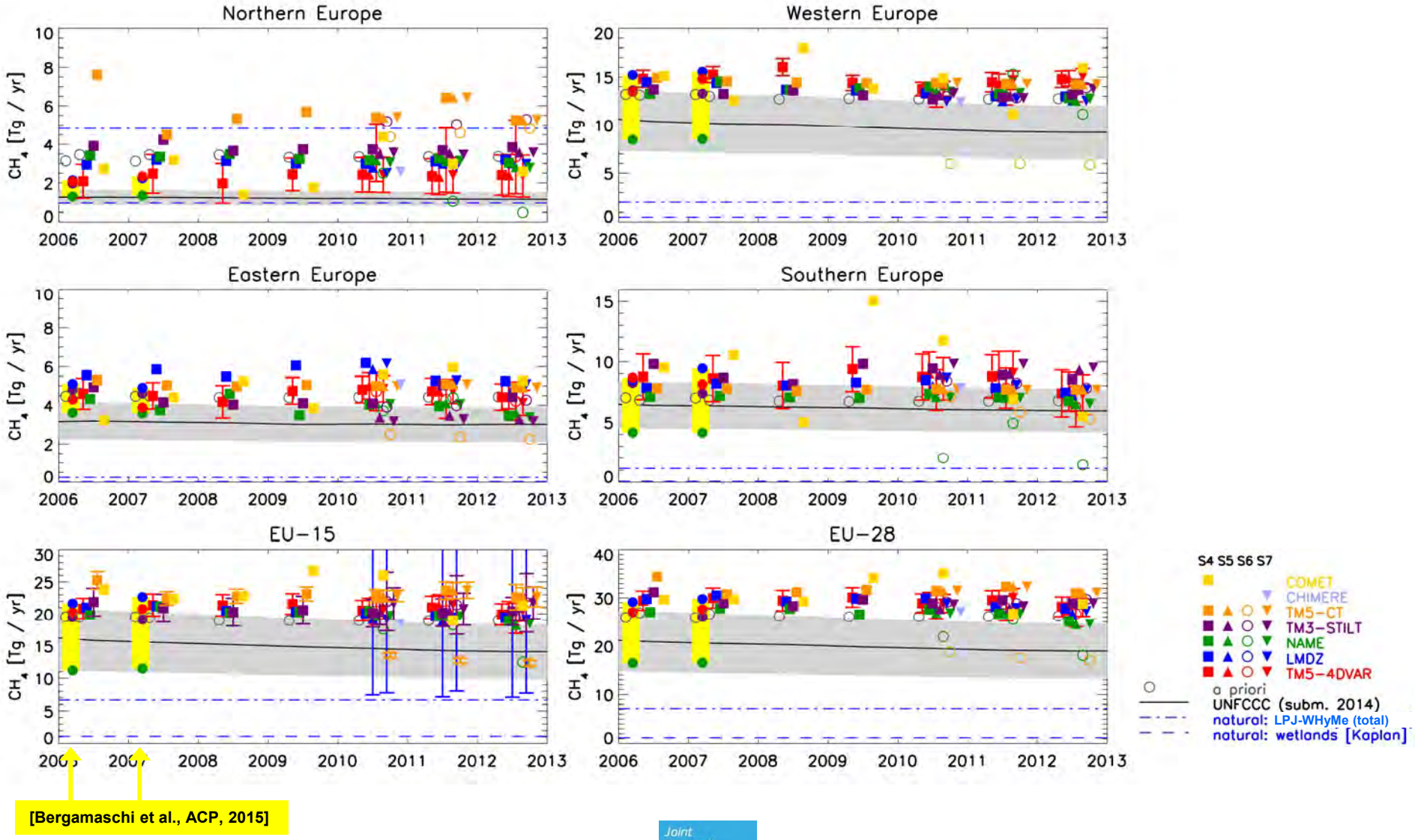
CH_4 / N20 inversions

CH4 inversion	N2O inversion	a priori emissions	period	InGOS station	NOAA+LSCE flask
S4-CH4	S1-N2O	EDGARv4.2FT-InGOS	2006-2012	base	●
S5-CH4	S2-N2O	EDGARv4.2FT-InGOS	2010-2012	extended	●
S6-CH4	S3-N2O	no a priori	2010-2012	extended	●
S7-CH4	S4-N2O	EDGARv4.2FT-InGOS	2010-2012	extended	-

European CH_4 emissions 2010-2012

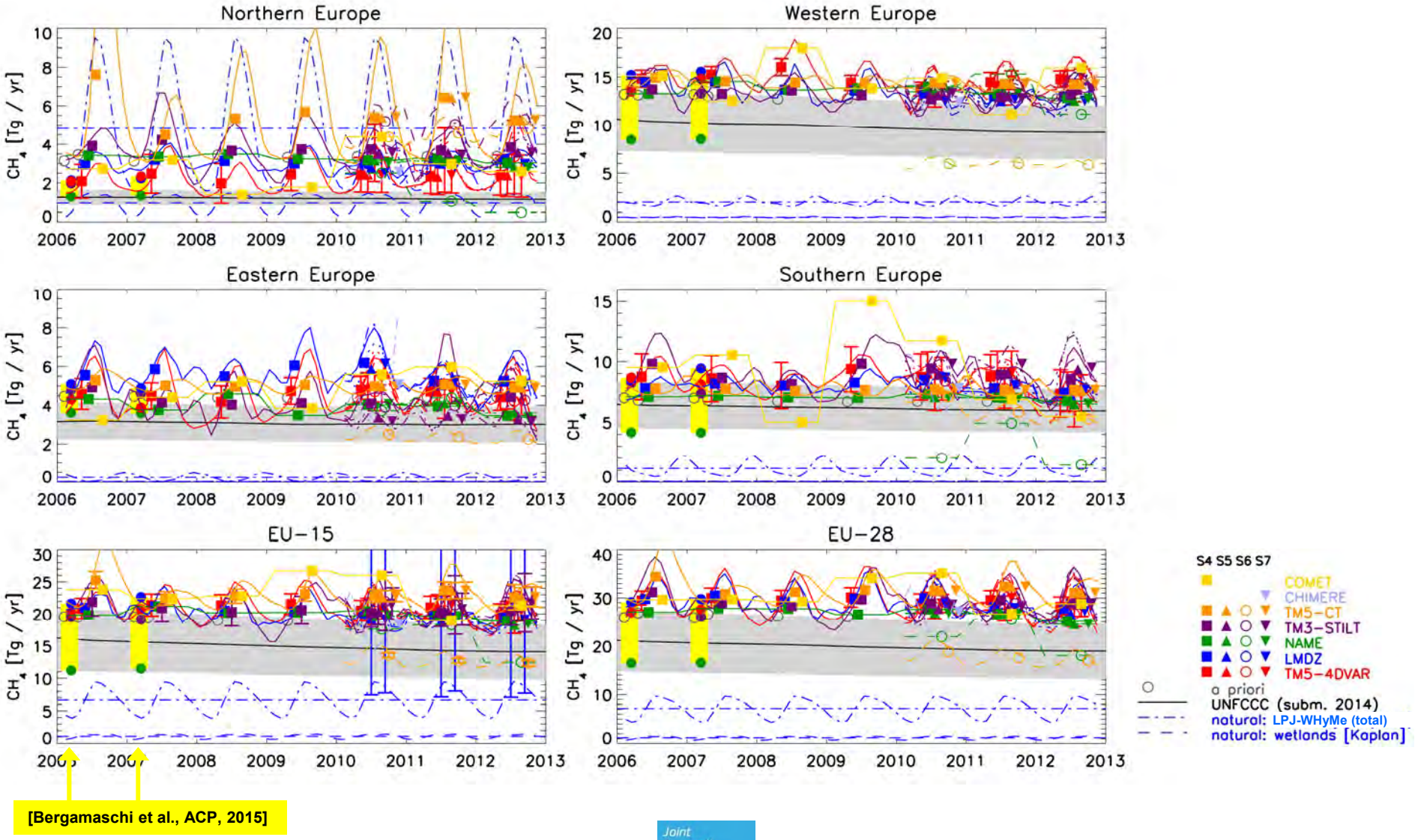


European CH_4 emissions - country totals EU



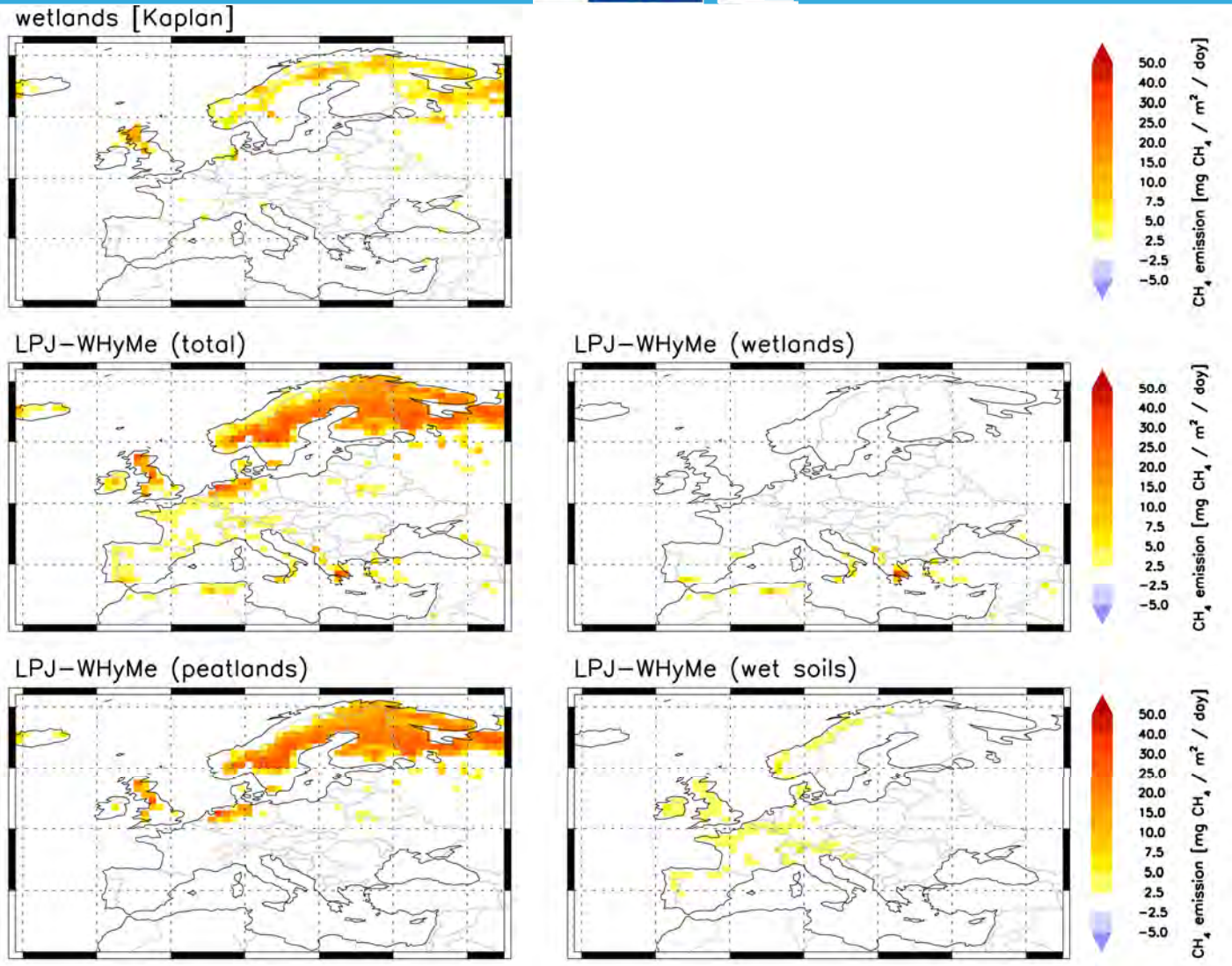
[Bergamaschi et al., ACP, 2015]

European CH_4 emissions - country totals EU

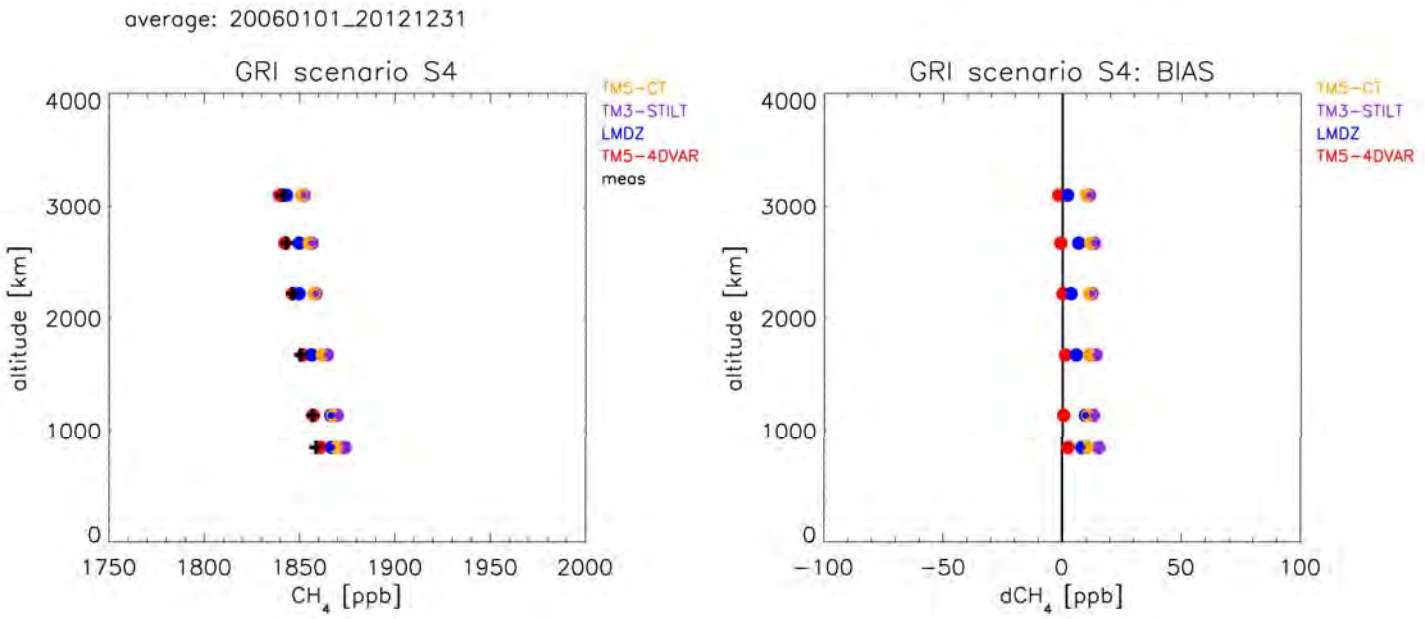


[Bergamaschi et al., ACP, 2015]

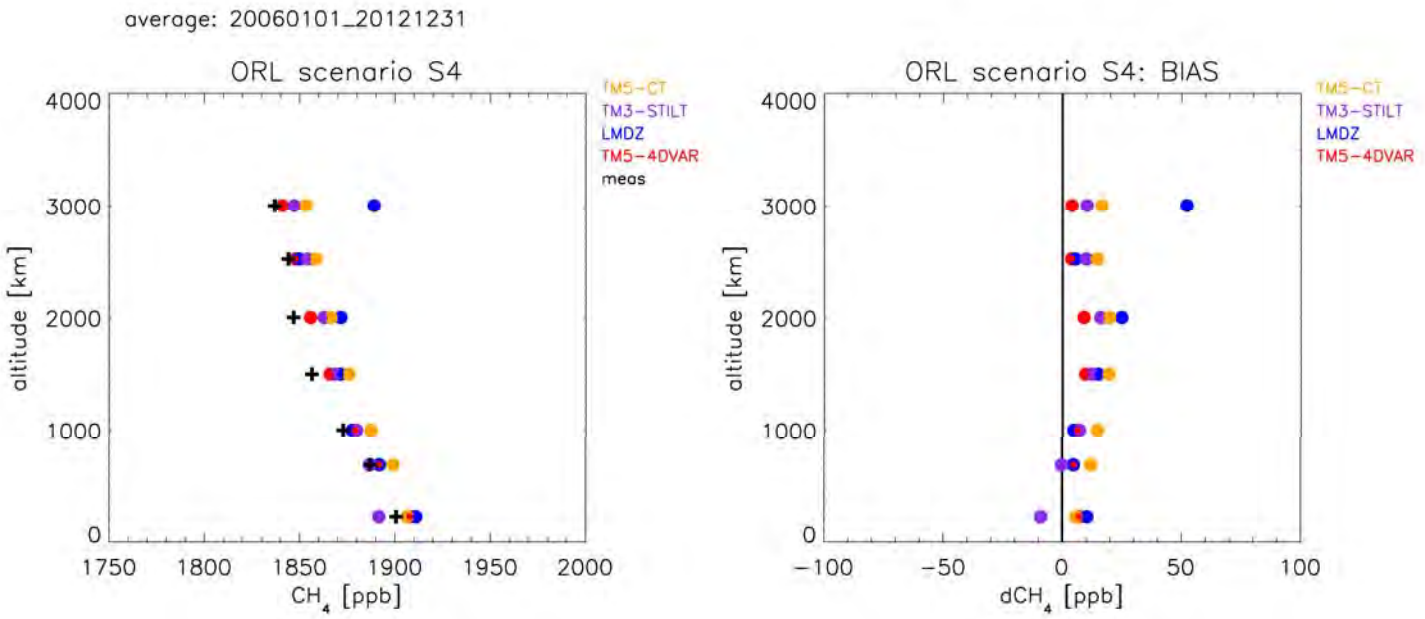
Natural CH_4 emissions



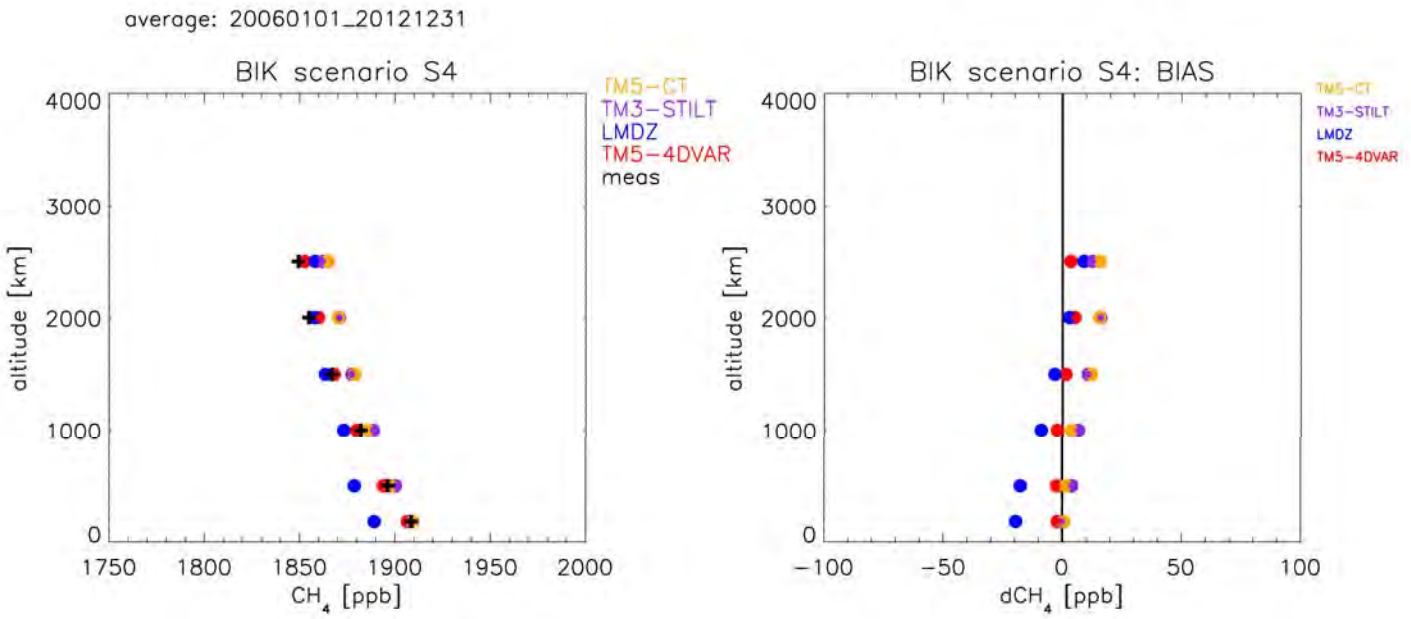
CH_4 inversions: validation LSCE aircraft - GRI



CH_4 inversions: validation LSCE aircraft - ORL

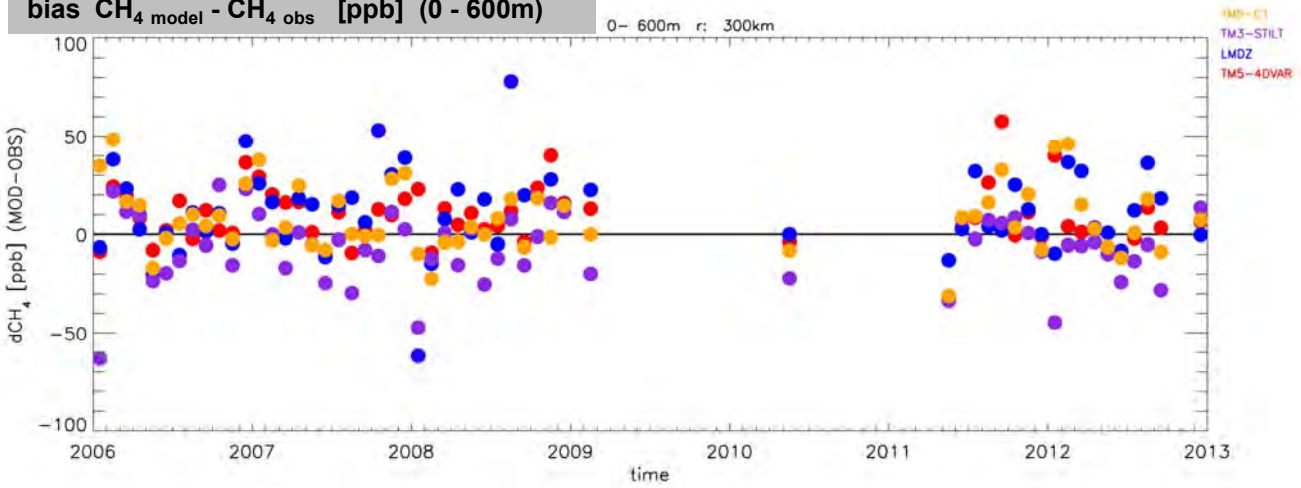


CH_4 inversions: validation LSCE aircraft - BIK

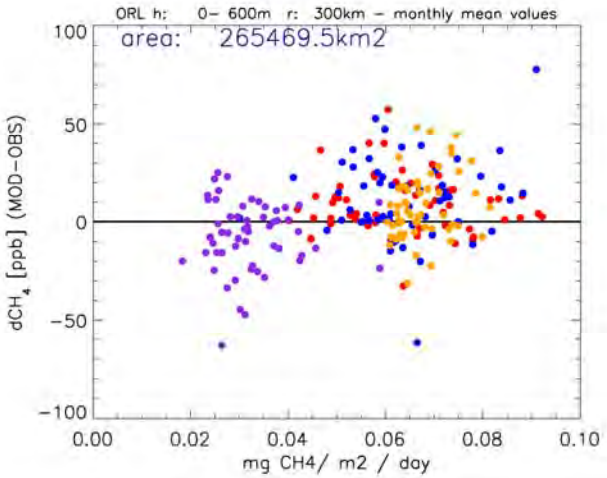


regional CH_4 emissions vs. bias aircraft data: ORL

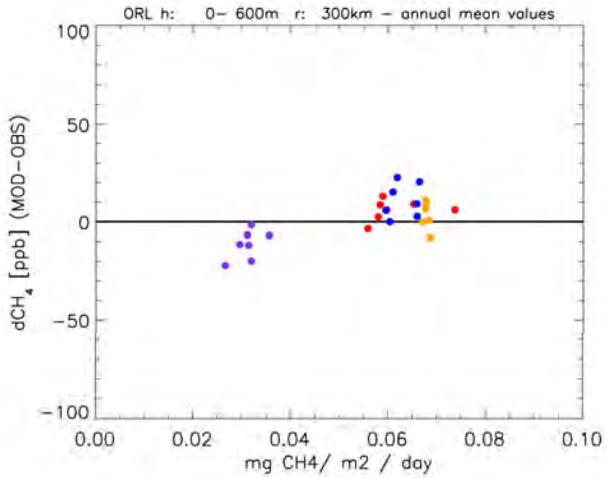
bias $CH_{4\ model}$ - $CH_{4\ obs}$ [ppb] (0 - 600m)



monthly mean bias $CH_{4\ model}$ - $CH_{4\ obs}$



annual mean bias $CH_{4\ model}$ - $CH_{4\ obs}$

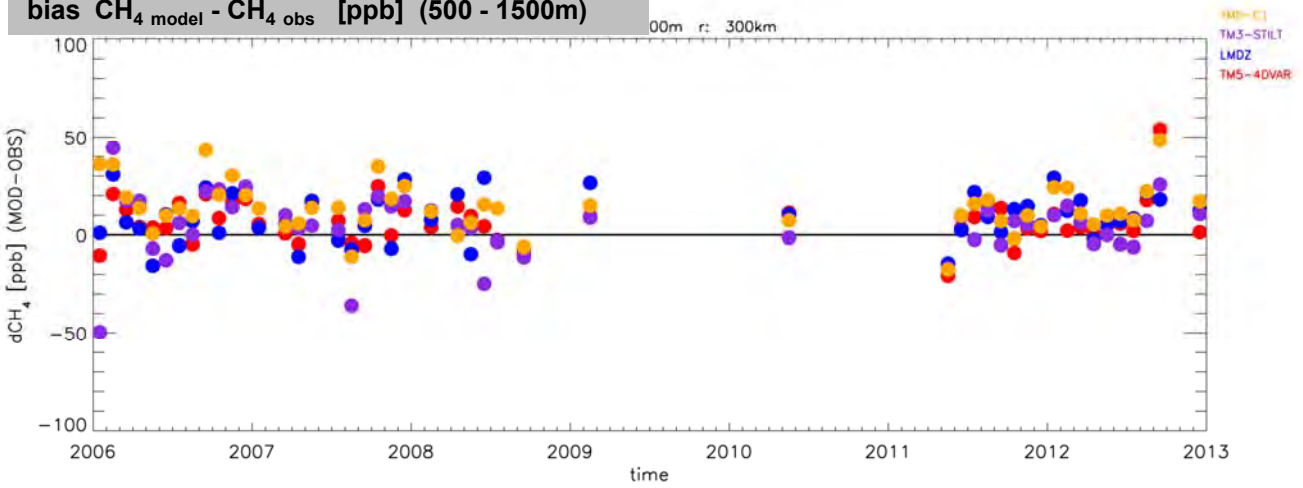


monthly average model emissions around site r=300km

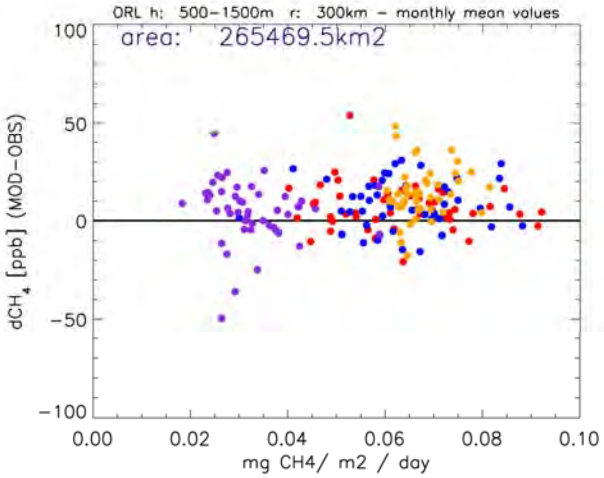
annual average model emissions around site r=300km

regional CH_4 emissions vs. bias aircraft data: ORL

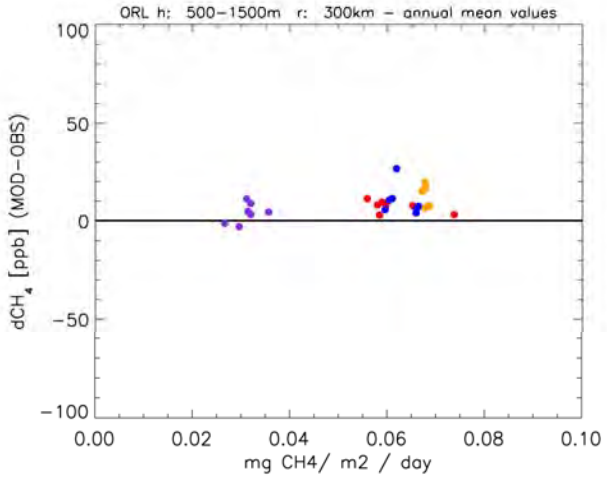
bias $CH_{4\ model}$ - $CH_{4\ obs}$ [ppb] (500 - 1500m)



monthly mean bias $CH_{4\ model}$ - $CH_{4\ obs}$



annual mean bias $CH_{4\ model}$ - $CH_{4\ obs}$

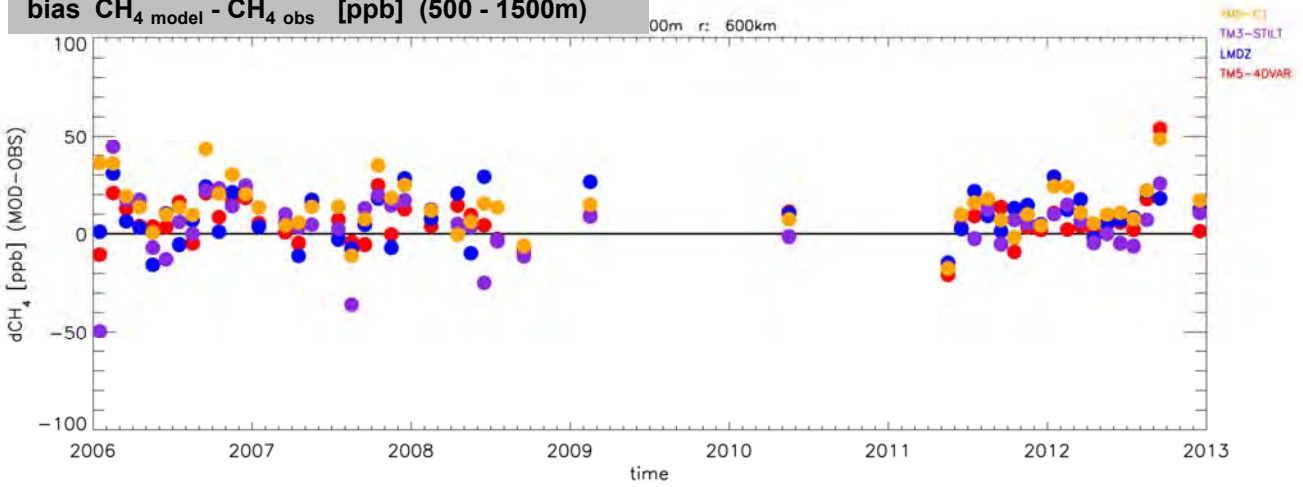


monthly average model emissions around site r=300km

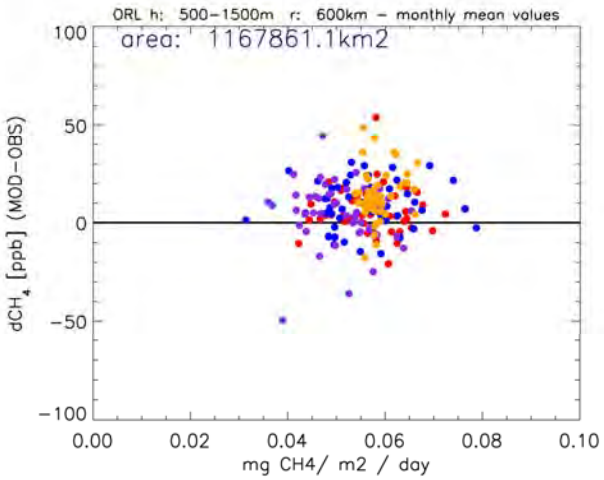
annual average model emissions around site r=300km

regional CH_4 emissions vs. bias aircraft data: ORL

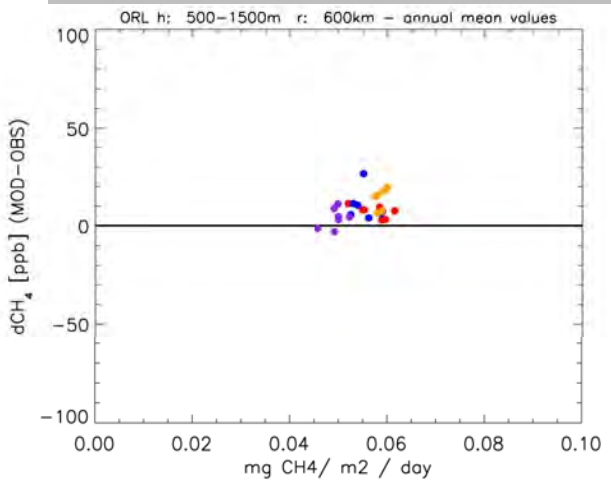
bias $CH_{4\ model}$ - $CH_{4\ obs}$ [ppb] (500 - 1500m)



monthly mean bias $CH_{4\ model}$ - $CH_{4\ obs}$



annual mean bias $CH_{4\ model}$ - $CH_{4\ obs}$

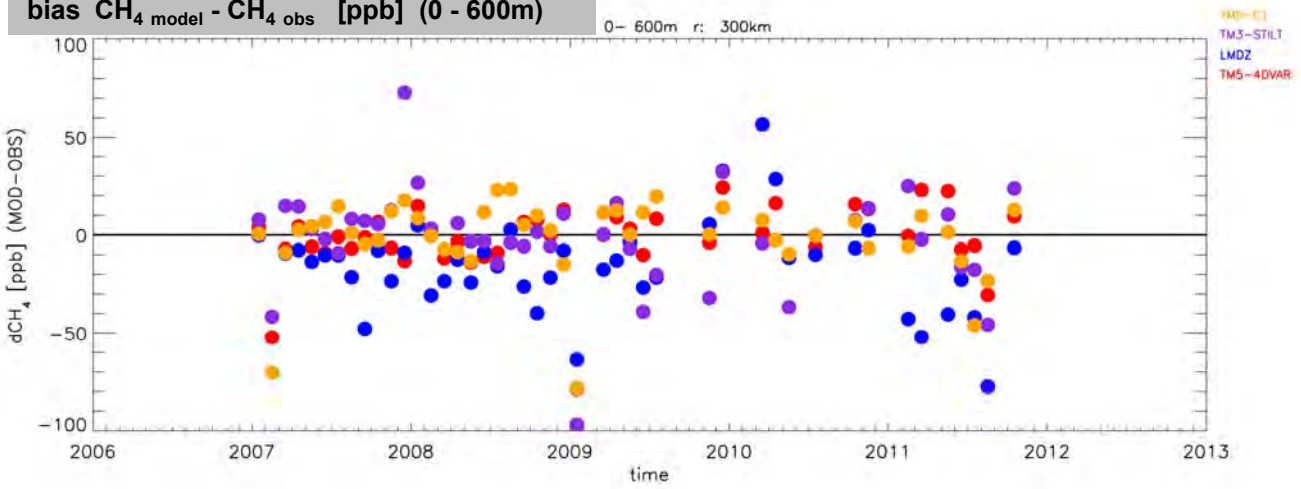


monthly average model emissions around site r=600km

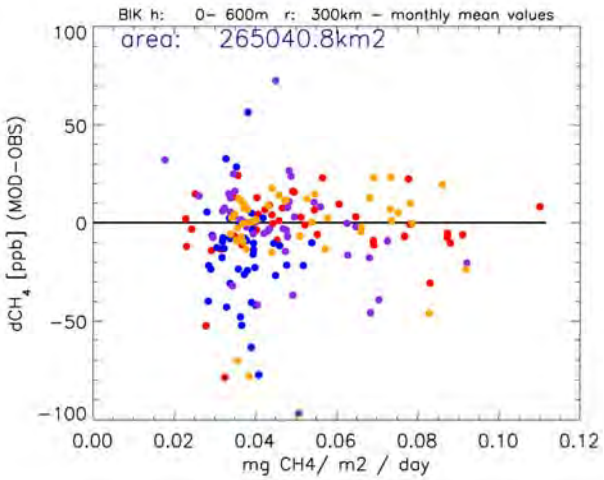
annual average model emissions around site r=600km

regional CH_4 emissions vs. bias aircraft data: BIK

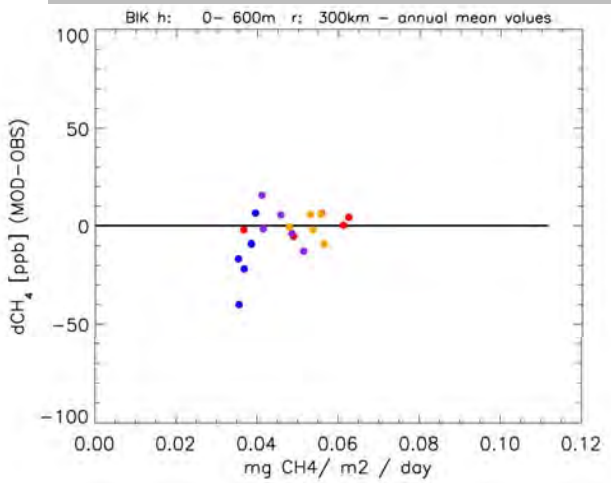
bias $CH_{4\ model}$ - $CH_{4\ obs}$ [ppb] (0 - 600m)



monthly mean bias $CH_{4\ model}$ - $CH_{4\ obs}$



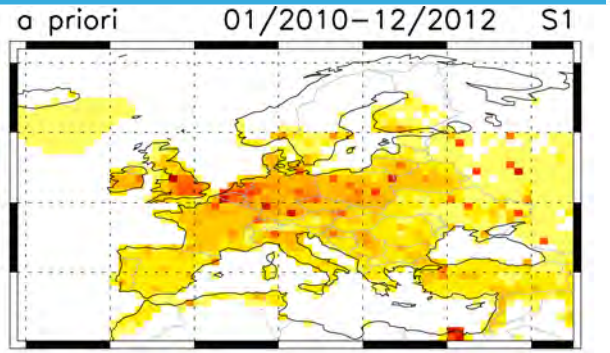
annual mean bias $CH_{4\ model}$ - $CH_{4\ obs}$

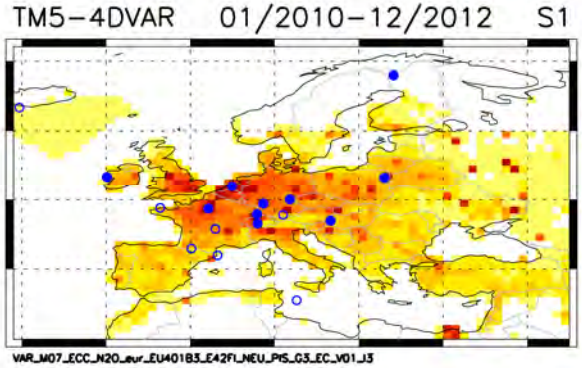


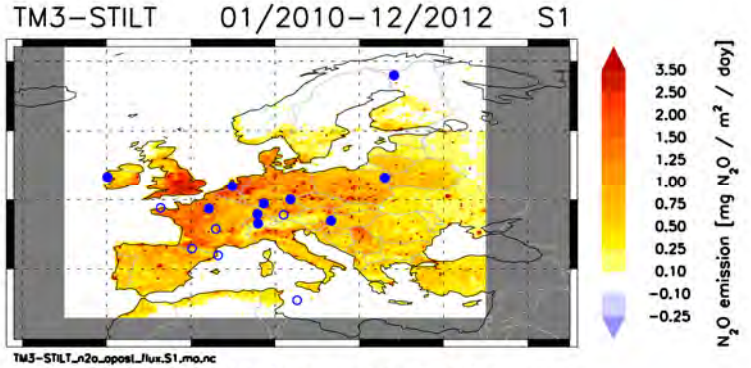
monthly average model emissions around site r=300km

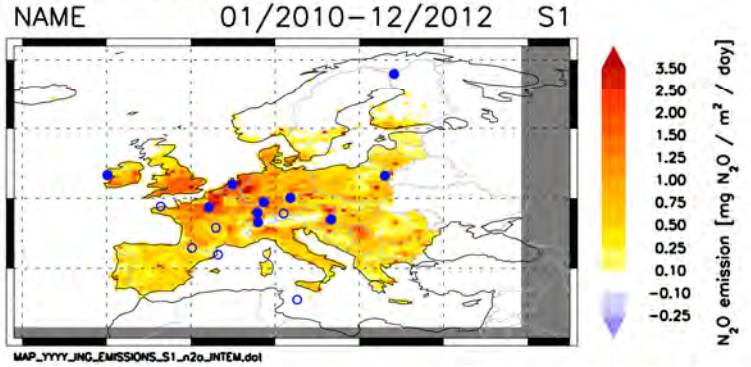
annual average model emissions around site r=300km

European N_2O emissions 2010-2012 S1

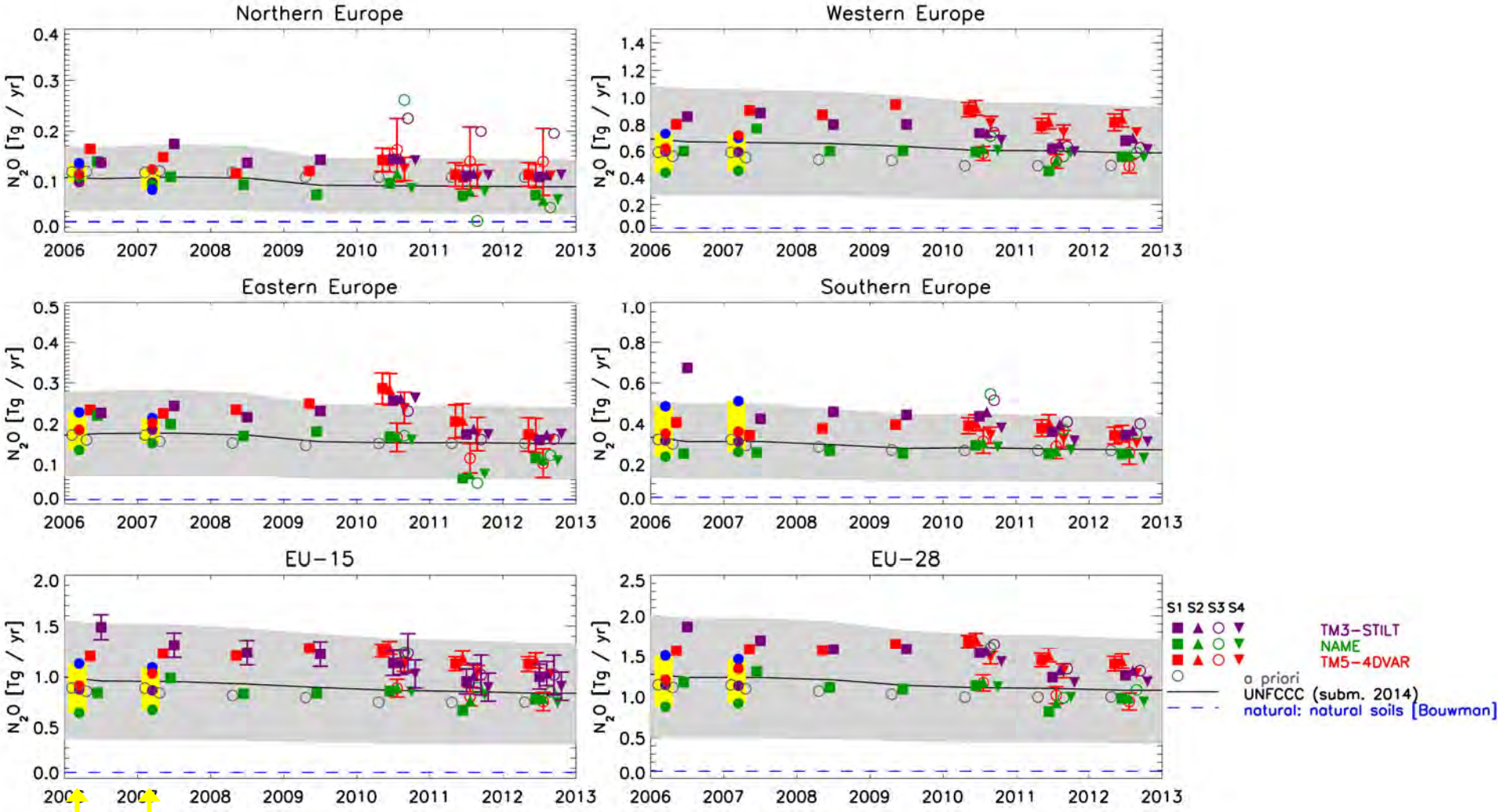






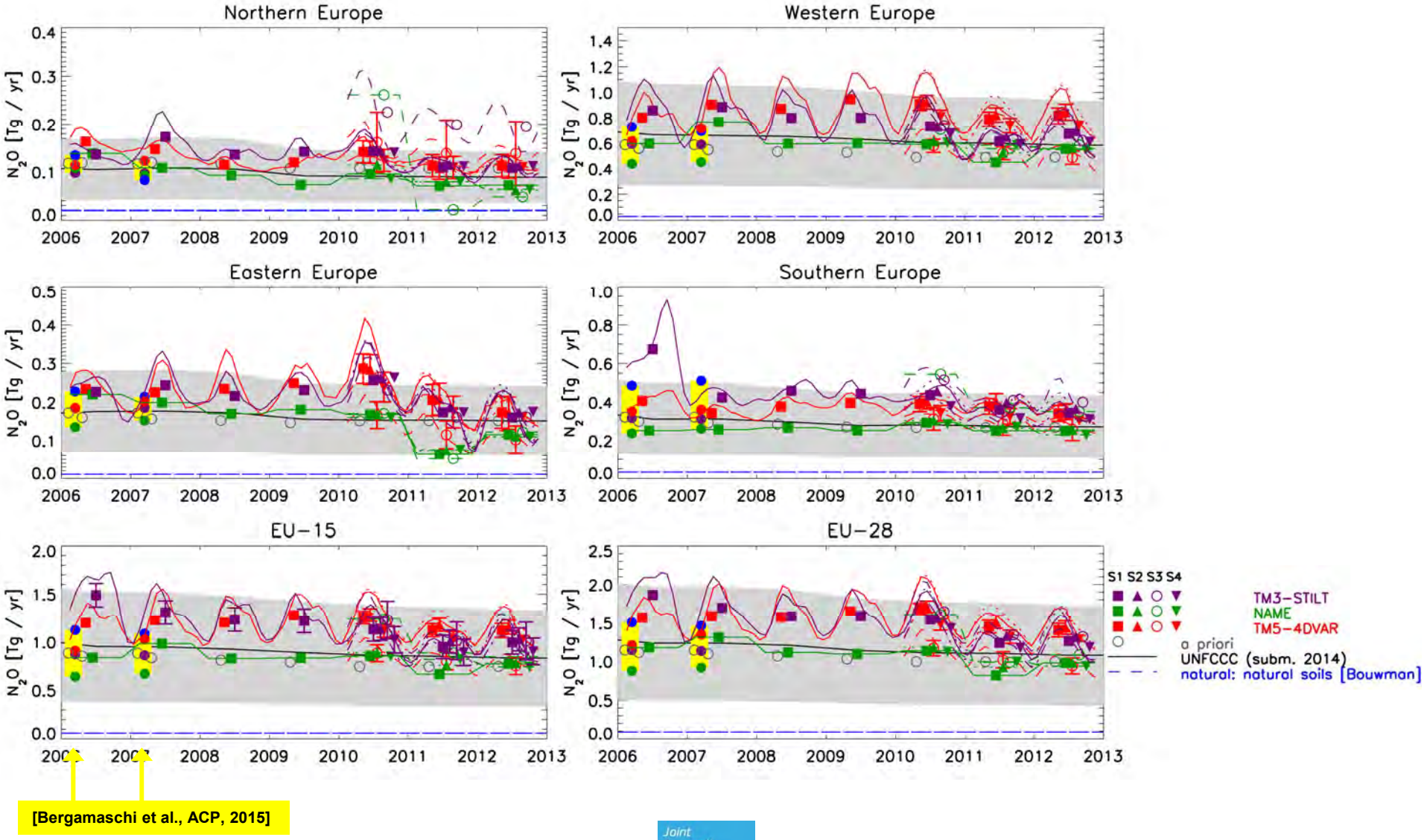


European N_2O emissions - country totals EU



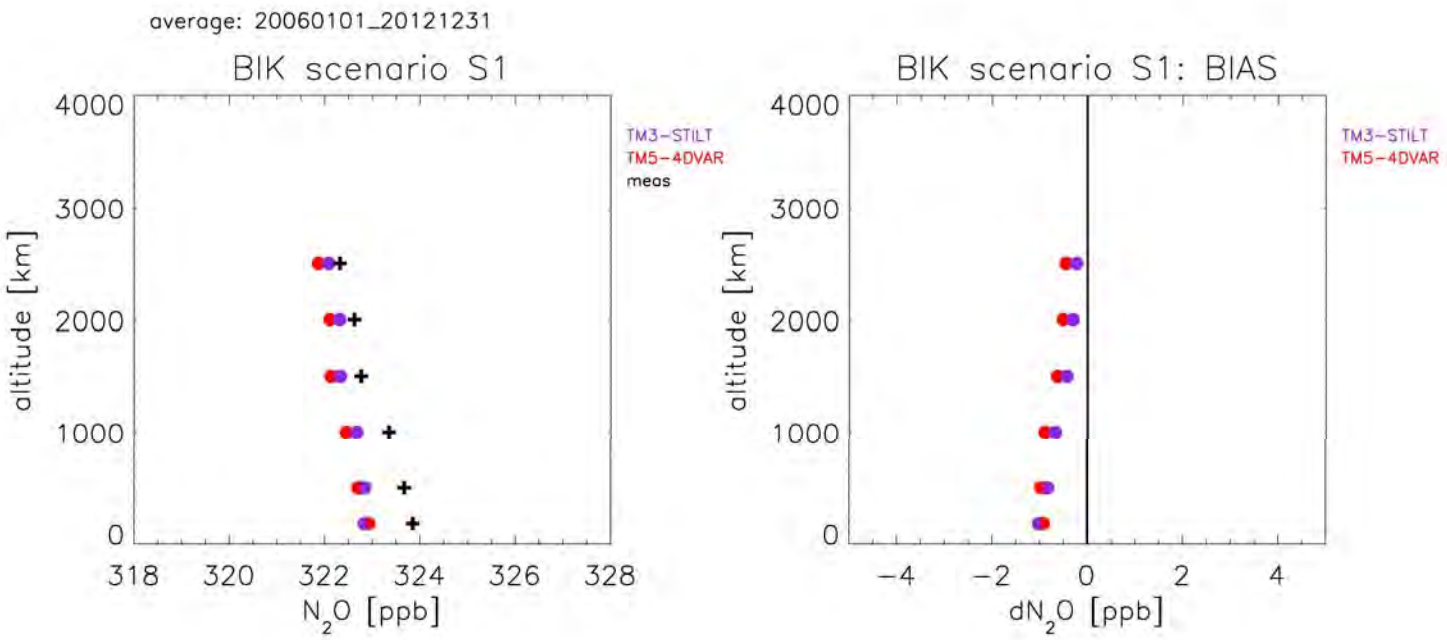
[Bergamaschi et al., ACP, 2015]

European N_2O emissions - country totals EU



[Bergamaschi et al., ACP, 2015]

N_2O inversions: validation LSCE aircraft - BIK



conclusions

CH_4

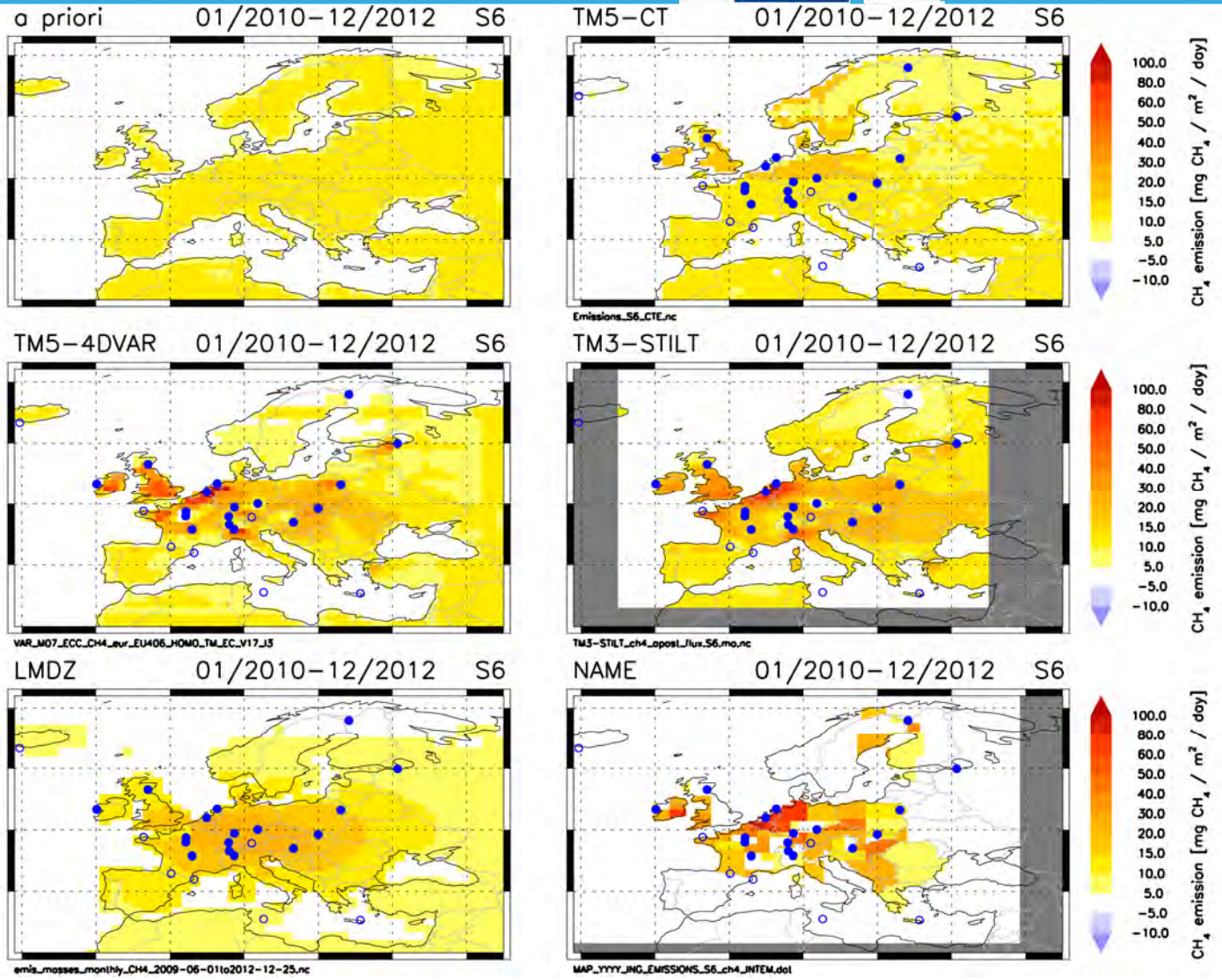
- **total CH_4 emissions from inverse models > anthropogenic CH_4 emissions UNFCCC**
  - **UNFCCC CH_4 emissions underestimated ?**
    - EDGARv4.2 > UNFCCC (with largest differences from fossil fuels (natural gas / oil / coal))
  - **significant contribution of natural CH_4 sources ?**
    - LPJ WHyMe : peatlands / wet soils / wetlands ~ 1/3 of anthropenic CH_4 (EU-28)
    - inverse models derive significant seasonal cycle with summer maximum
  - **model biases ?**
    - validation against aircraft data
    - some models tend to overestimate observations in 1.5 - 3 km range
      (bias in background or in European emissions ?)
    - significant correlation between model emissions around aircraft site (300km) and
      bias model-obs at low altitudes (< 600 m),
      but only poor / no correlation for 0.5-1.5 km altitude range

N_2O

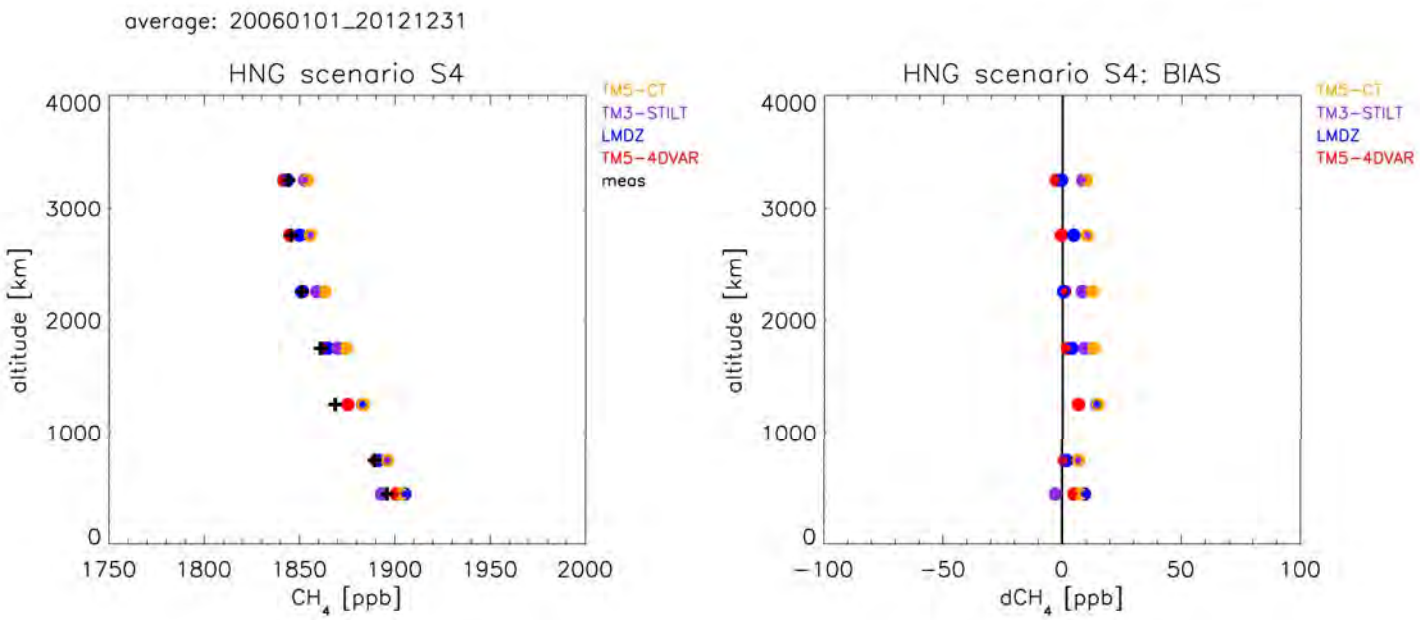
- **total N_2O emissions from NAME close to UNFCCC,**
  TM5 and STILT higher, but within large uncertainties of bottom-up inventories

supplementary material

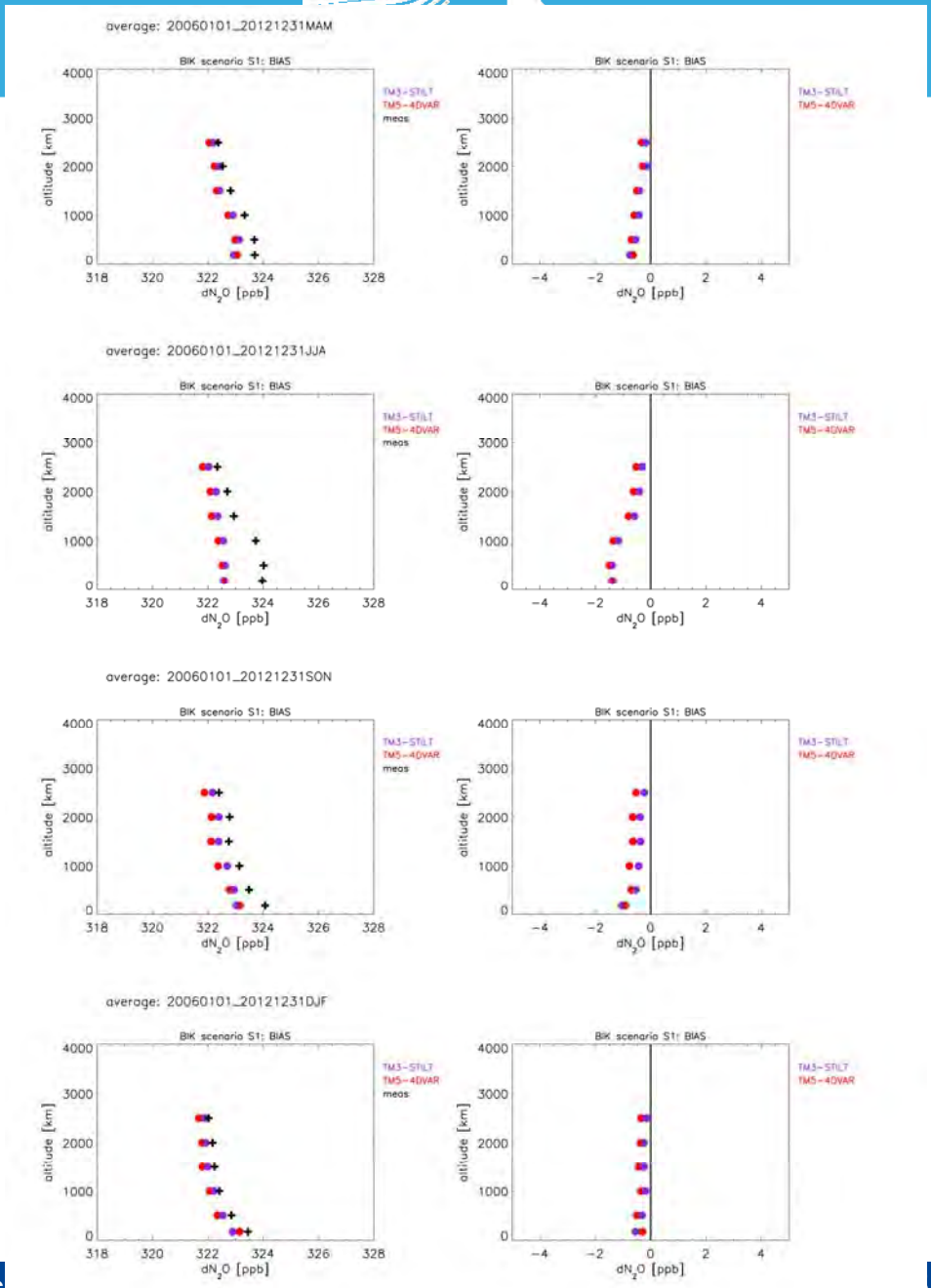
European CH_4 emissions 2010-2012 S6



CH_4 inversions: validation LSCE aircraft - HNG



N_2O inversions: validation LSCE aircraft - BIK



N_2O inversions: validation LSCE aircraft - BIK