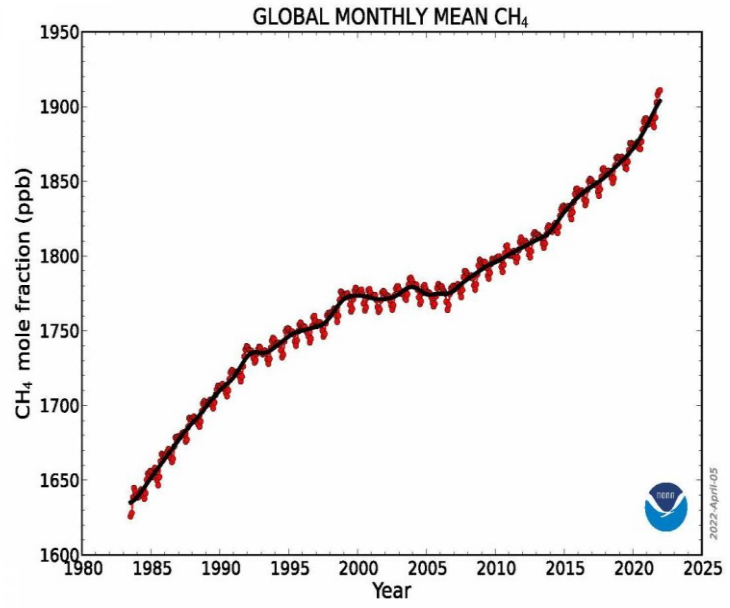
TCOM-CH4: Daily global gap-free CH4 profile data based using TOMCAT CTM, Occultation Measurements

Sandip Dhomse

- Methane is the second most important GHG → nonlinear trends
- Long life-time in the stratosphere →~150 yrs
- All the models have biases → parametrisations
- Satellite measurements are sporadic and cover shorter period
- Machine learning model can be used to correct the biases → construct new data
- Previous version - https://zenodo.org/record/6512139
- Usage: e.g. evaluate strat. chemistry/dynamics, total column retrieval



Methane enters in the Stratosphere via TTL

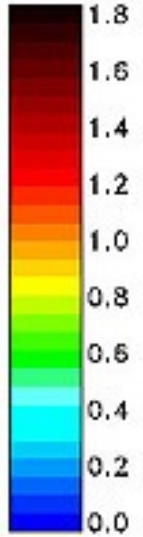
- Major source of strt. H2O

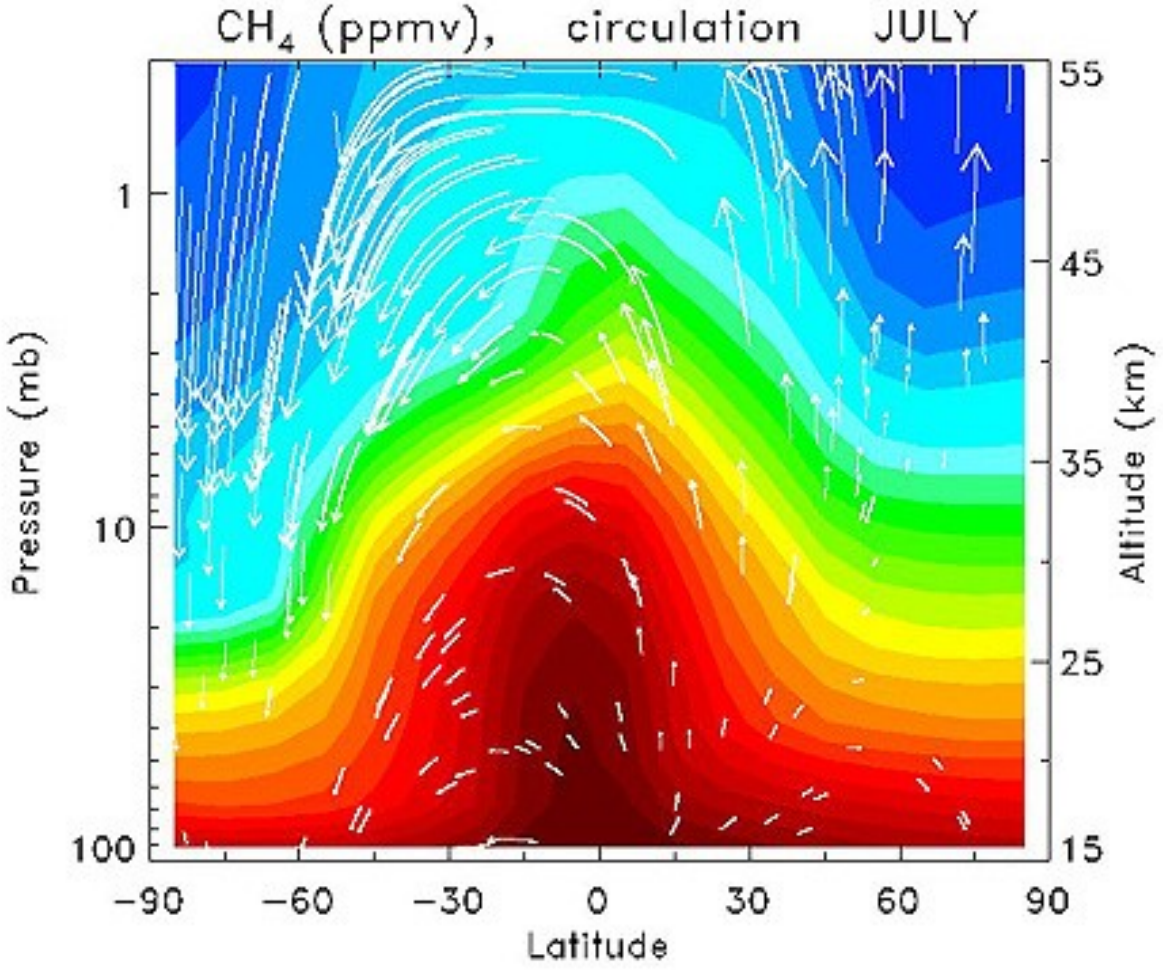
Loss:

CH4+ OH →CH3 +H2O

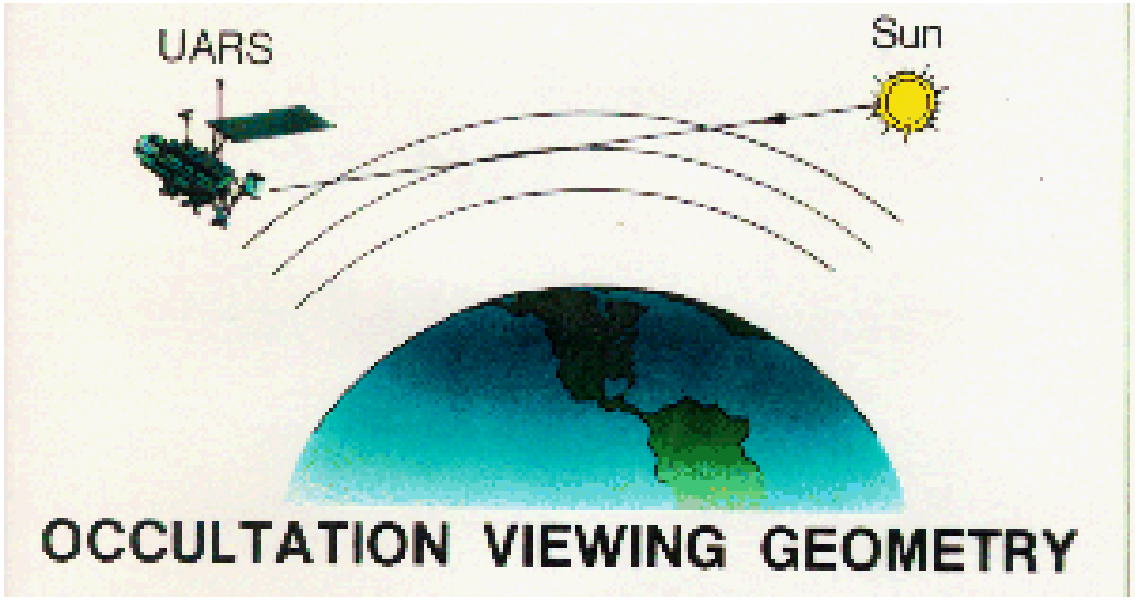
- Reservoir of Cl

CH4+ Cl →CH3 + HCl





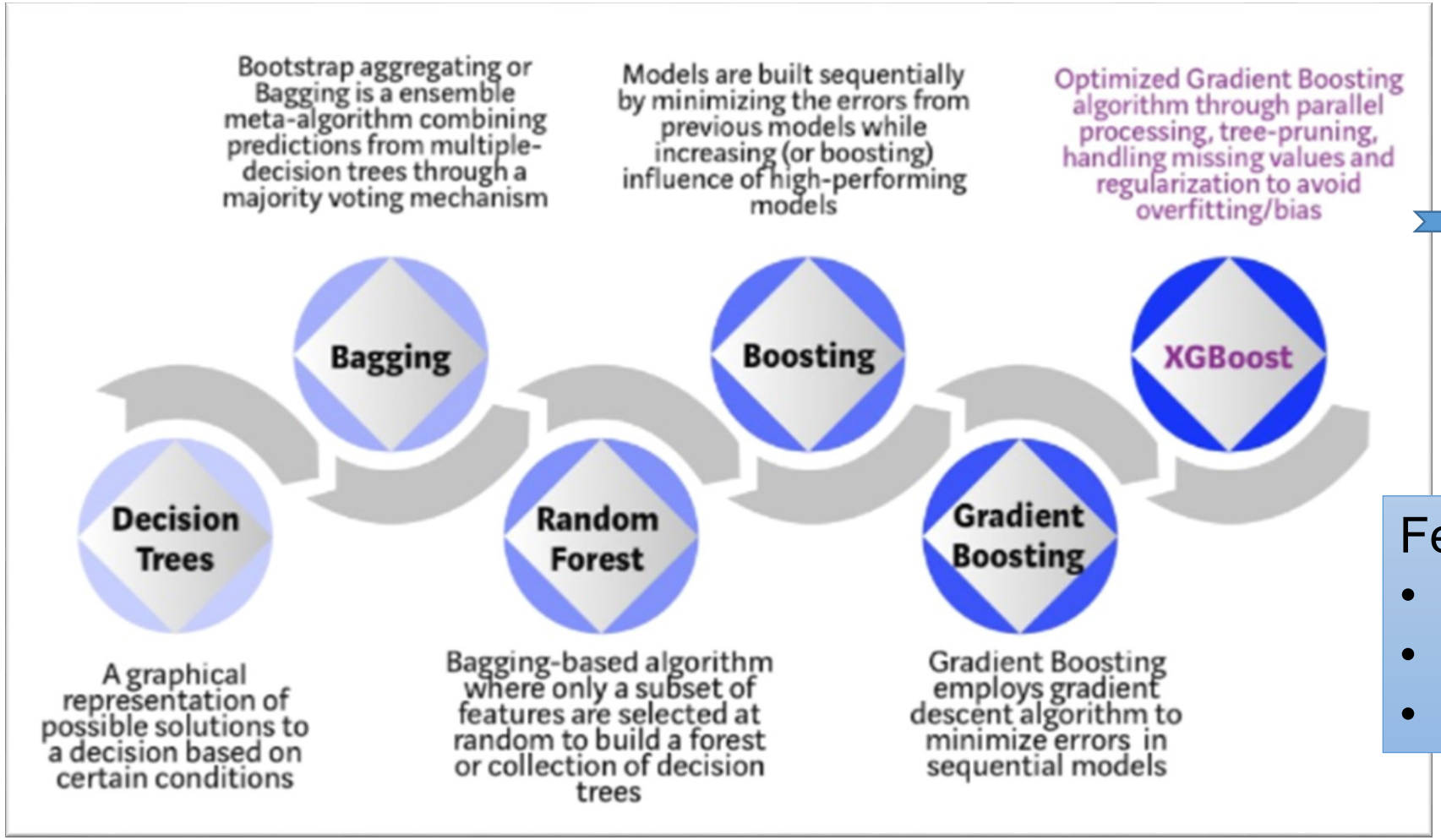
Satellite instruments : HALOE & ACE



- HALOE – UARS satellite - 1991-2005
- ACE-FTS : SCISAT satellite (2004- present)

Occultation instruments – 30 measurements per day

Extreme-Gradient Boosting (XGBoost) – Supervised ML



Training: 1992-2018

Evaluation: 2019-2021

Features:

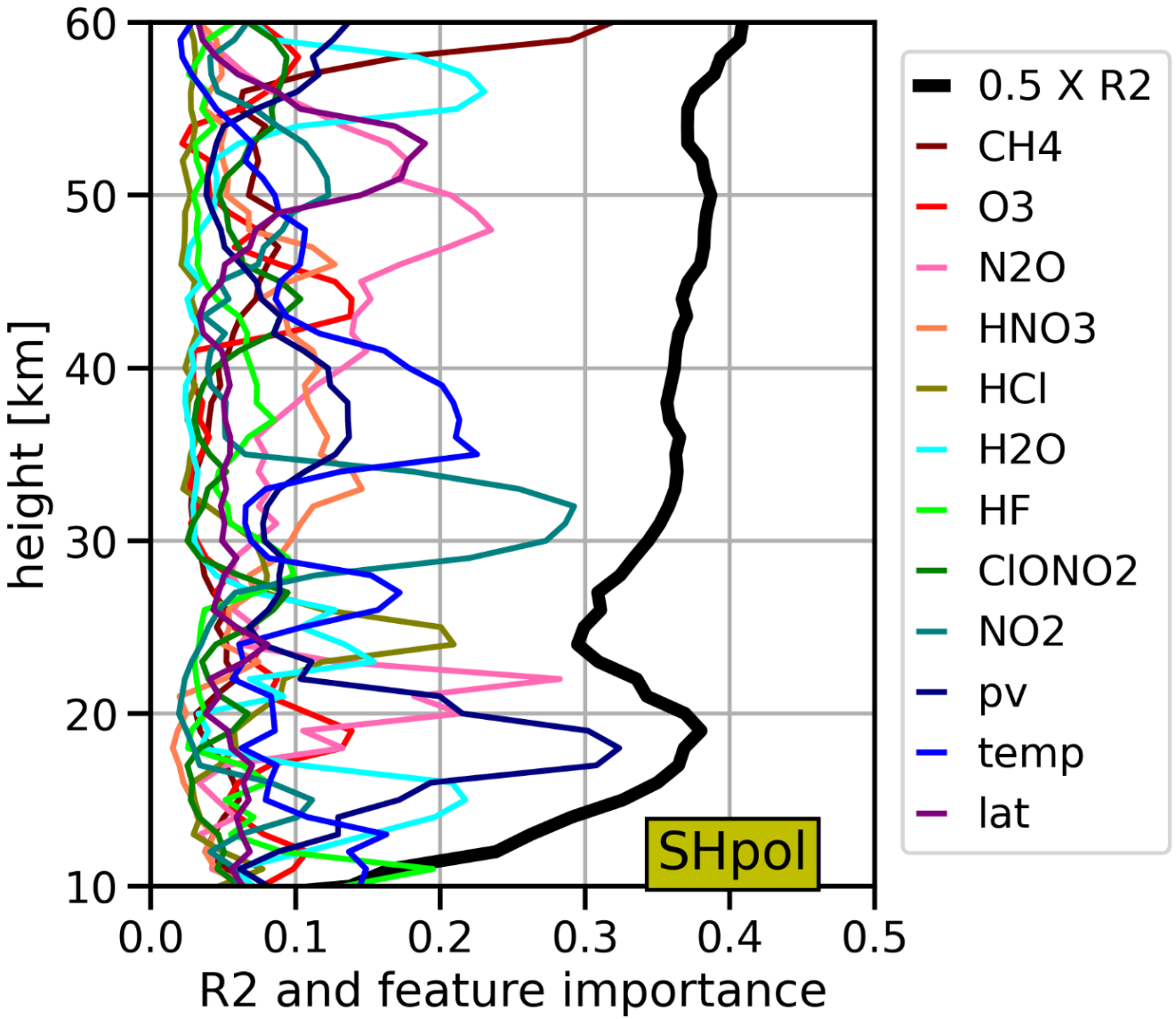
- CH4, O3, N2O, HCl, HNO3,
- temp.., potential vorticity
- Latitude, time, ..

Something similar to multivariate regression model (minimise residuals but using multiple decision trees

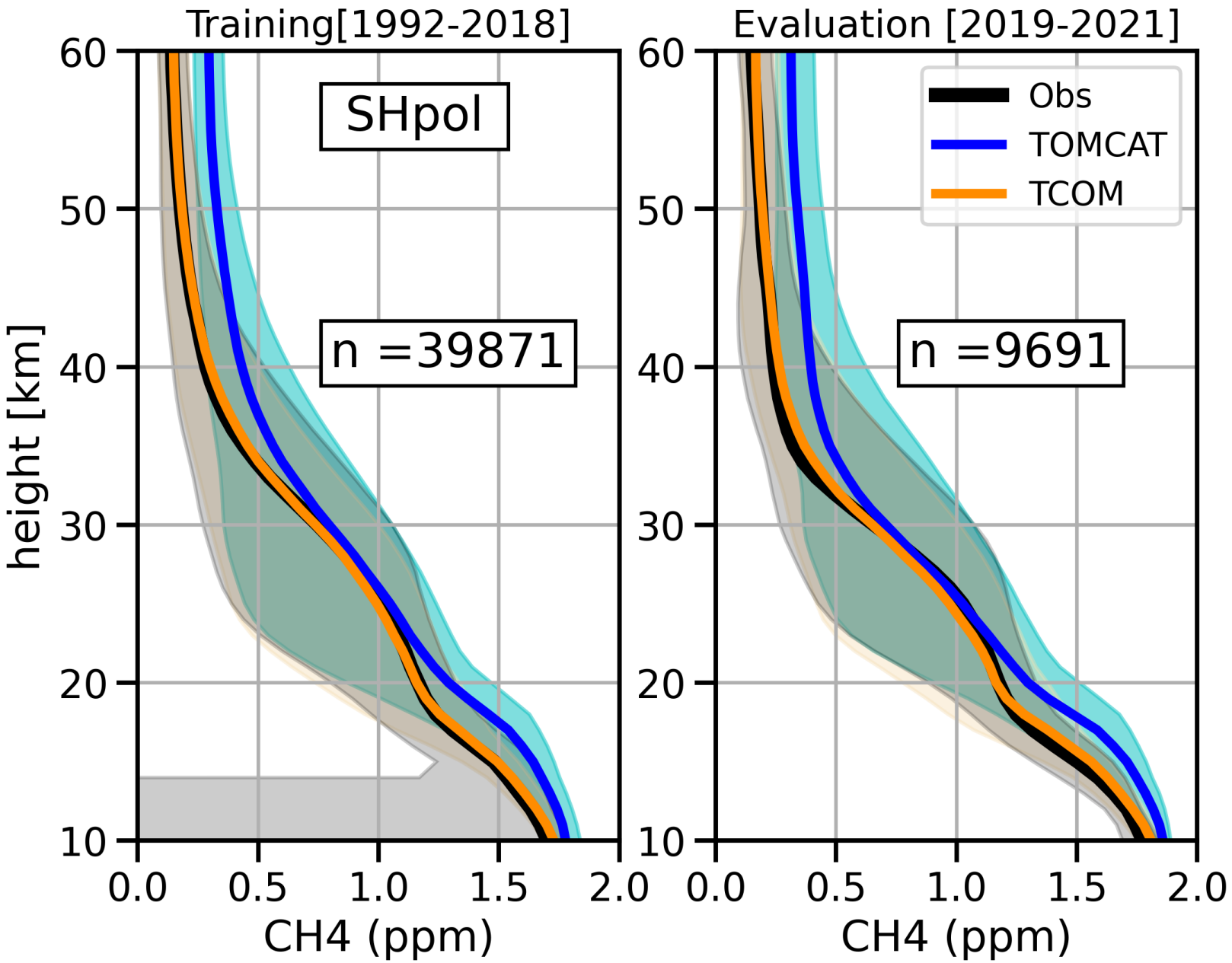
dCH4 = temp + potential vorticity + latitude + time + ozone+ methane + N2O + HCl+…..

dCH4 = observation minus TOMCAT
There are 14 features (mostly from TOMCAT CTM)

R2 & feature Importance's



R2 is scaled down (0.5)
(use only 30% testing data)

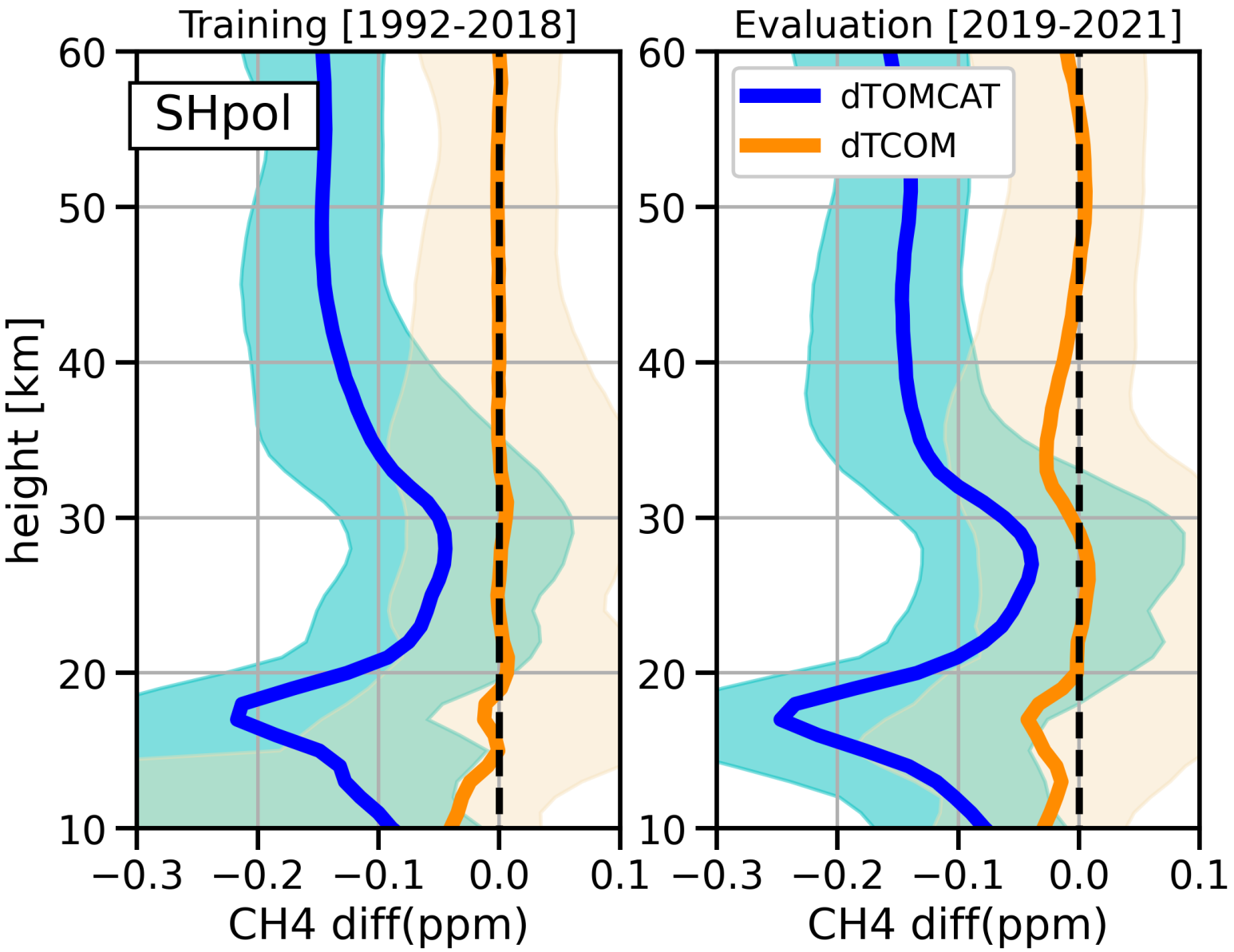


Evaluation: Absolute values

Shaded – 10 & 90 percentiles

Note that recent increase is much faster

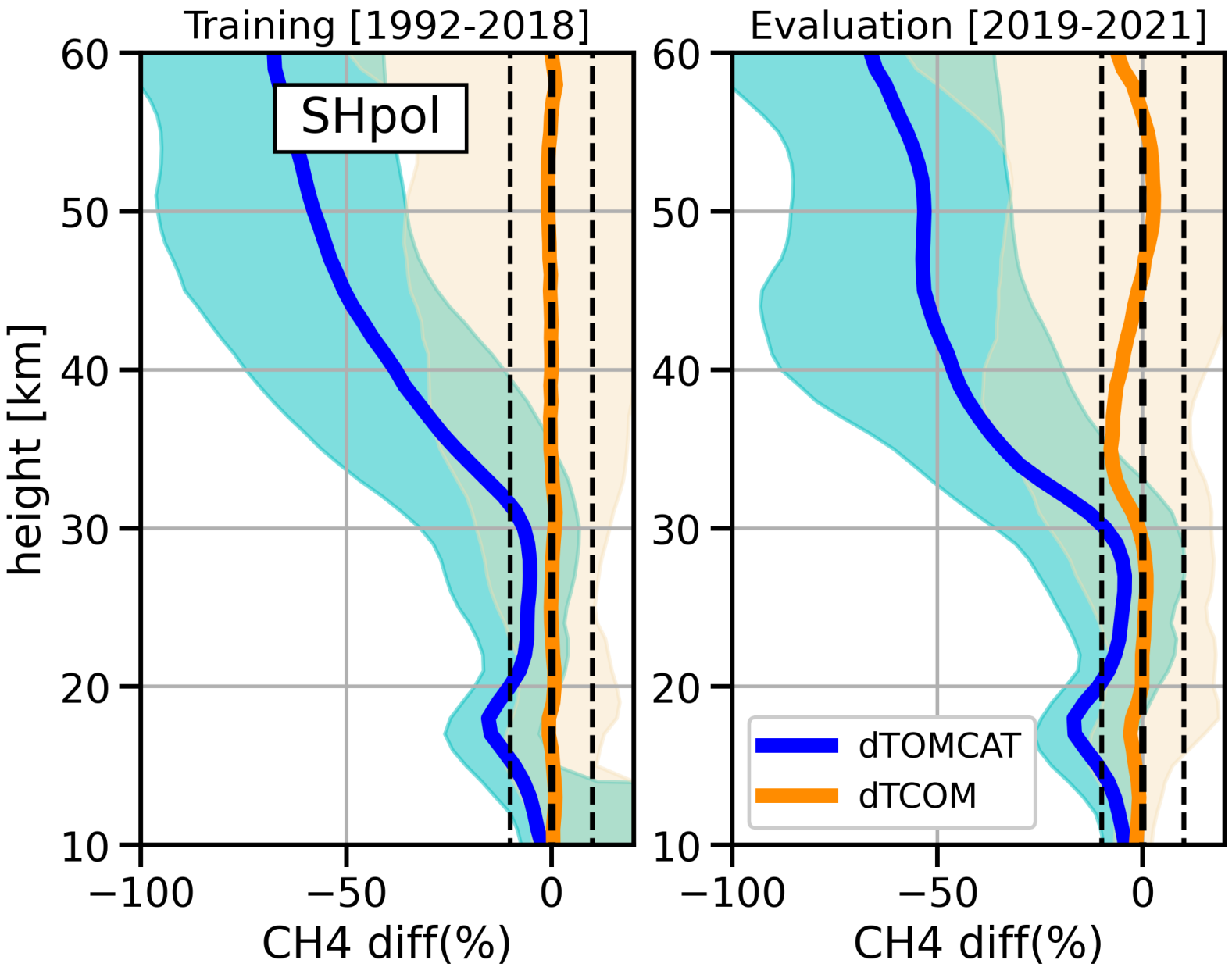
Evaluation: Absolute differences



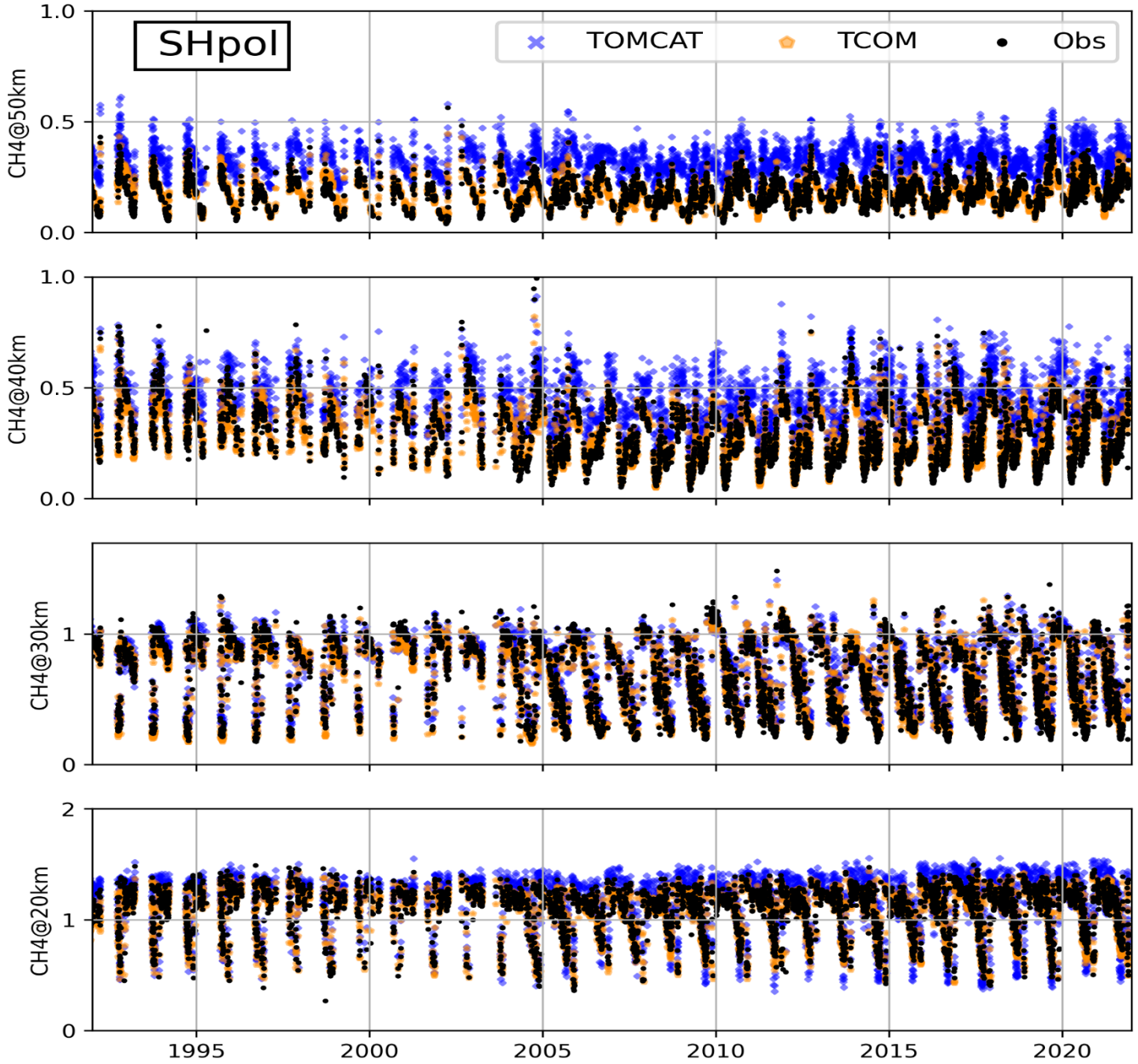
Shaded – 10 & 90 percentiles

Note that recently there is sharp increase in methane

Evaluation: percentage diff.



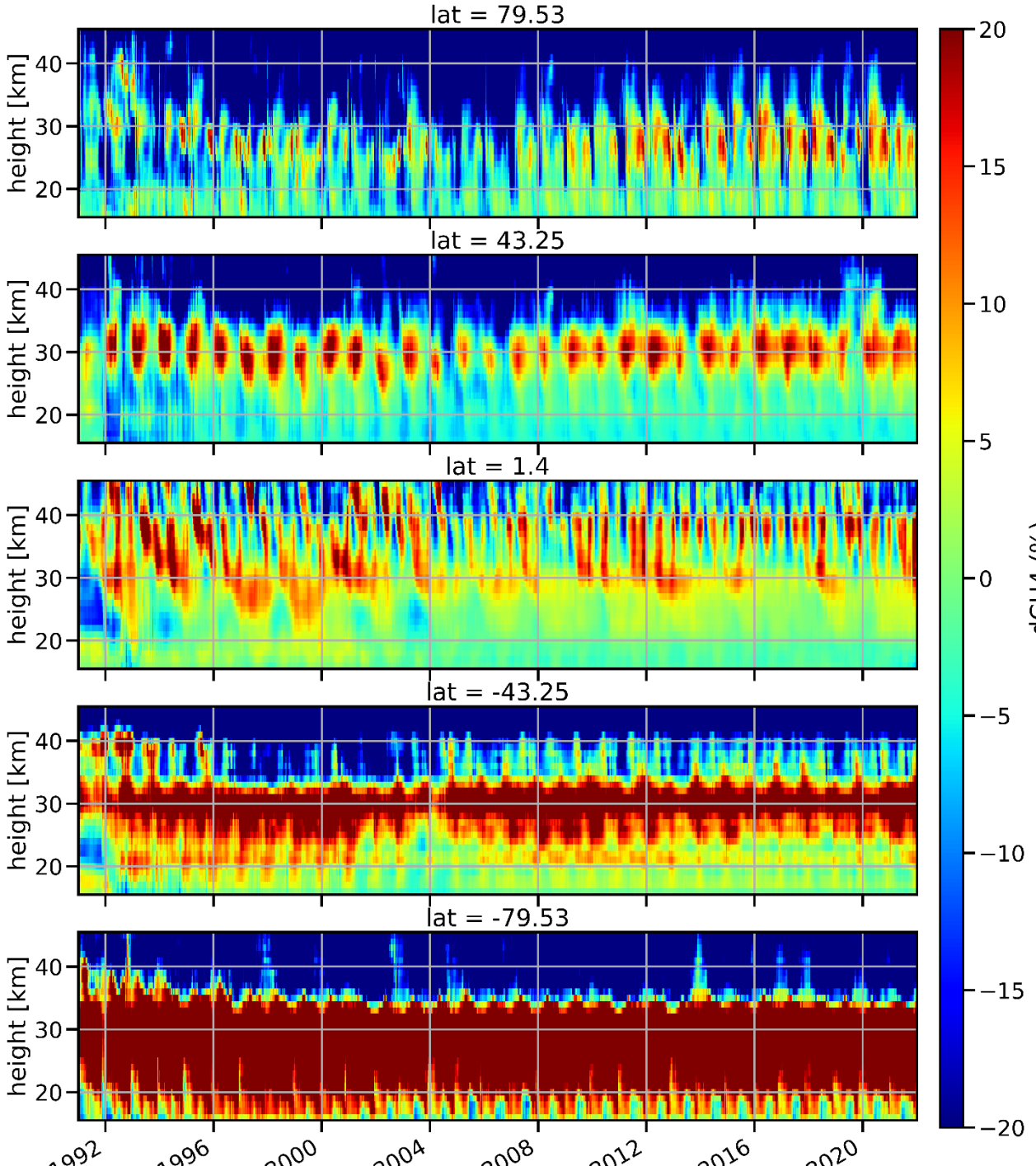
Shaded – 10 & 90 percentiles



Comparison: SH polar lats

Only 10% points are plotted

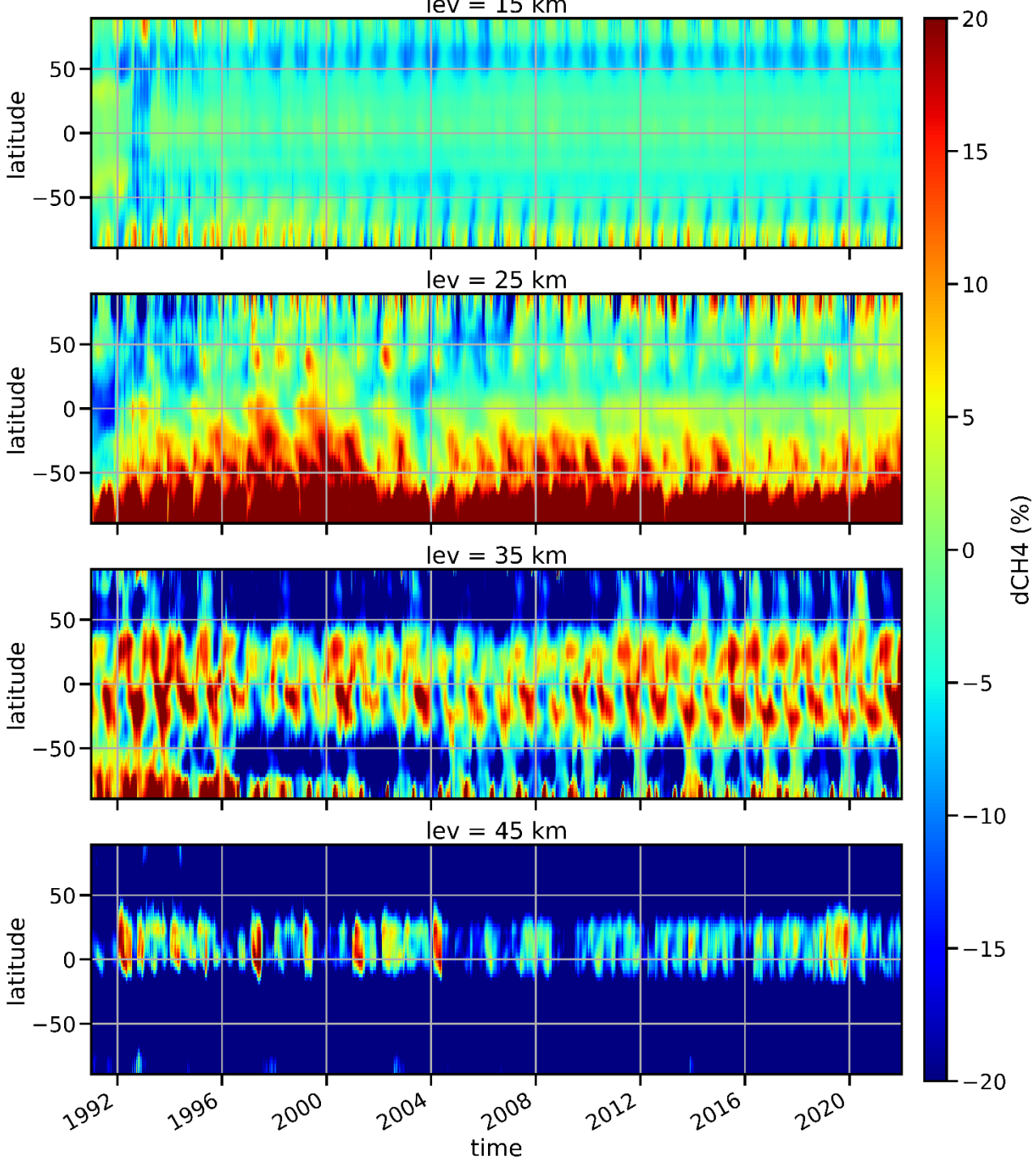
- Black dots : Obs
- Blue : TOMCAT
- Orange : TCOM



Differences between TCOM & TOMCAT profiles for various lat bins (%)

- Tropics – QBO & vertical velocities
- Mid-lats : isentropic transport + BD circulation
- Polar lats : mixing near polar vortex

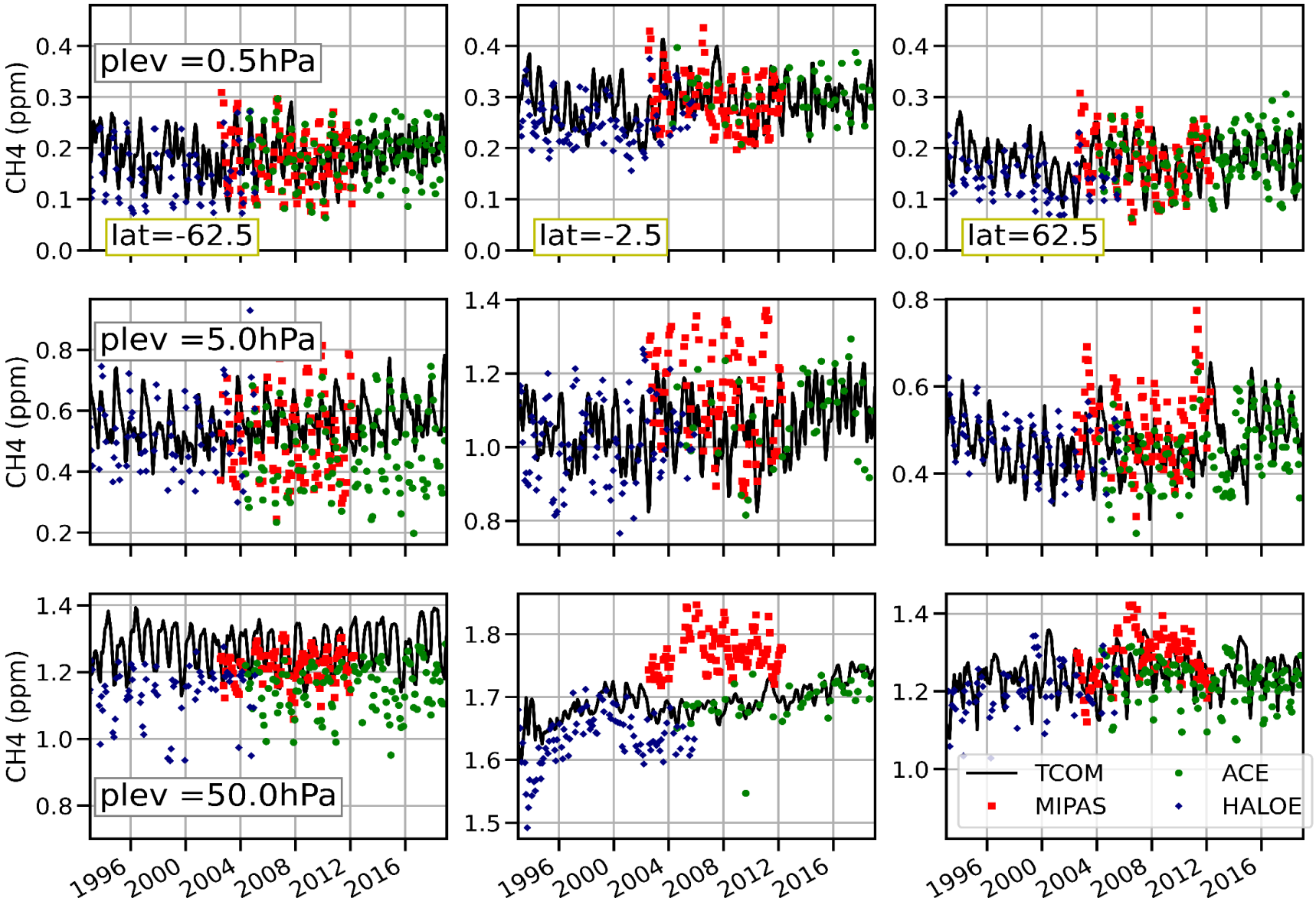
ACE has fewer profiles at low-latitudes



Differences between TCOM & TOMCAT profiles for various levels (%)

Can be used to identify inhomogeneities in ERA5 are non-uniform

Comparison with SPARC Data Initiative (Hegglin et al., 2021)



SPARC data files:

- 26 plev, 36 lat bins
- Separate for separate instruments
- No correction/adjustment
- Monthly means are calculated only if there are >5 profile at 5 deg. Latitude bins

Summary &Outlook

- Successfully constructed daily global gap-free CH4 profile data sets using CTM output & Obs. → biases <10%
- Ideal to study changes in the stratosphere (e.g. inhomogenities in reanalysis data) , model evaluation, satellite retrievals algorithms,…
- XGBoost regression performs better than other machine learning based regressions
- Data on height and pressure level would be released soon
- Next is N2O, O3, HCl, HNO3…
- *For daily 3D data contact: s.s.dhomse@leeds.ac.uk*