Developments in the retrieval of NO_2 from OMI and TROPOMI observations

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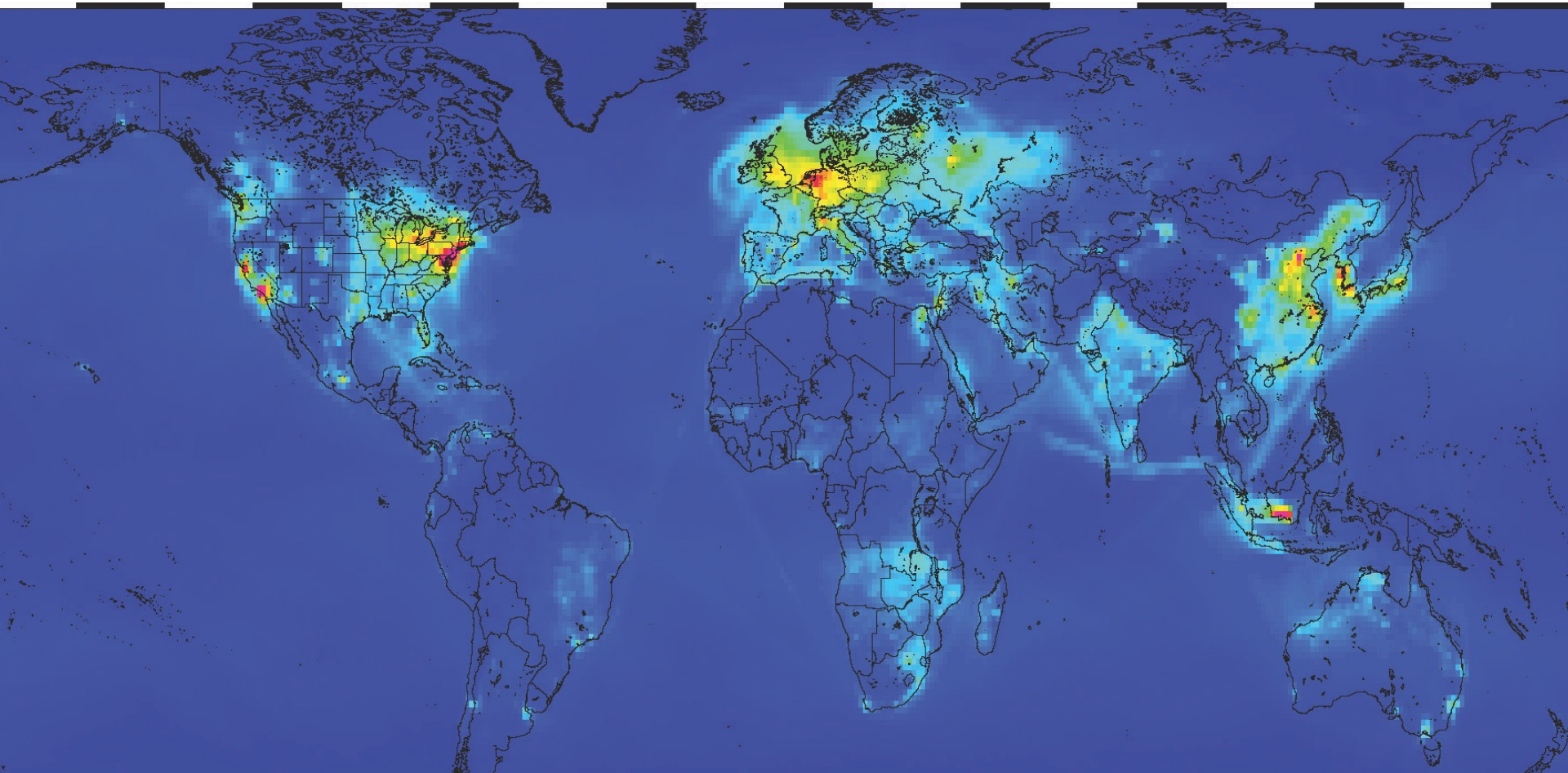
OMI

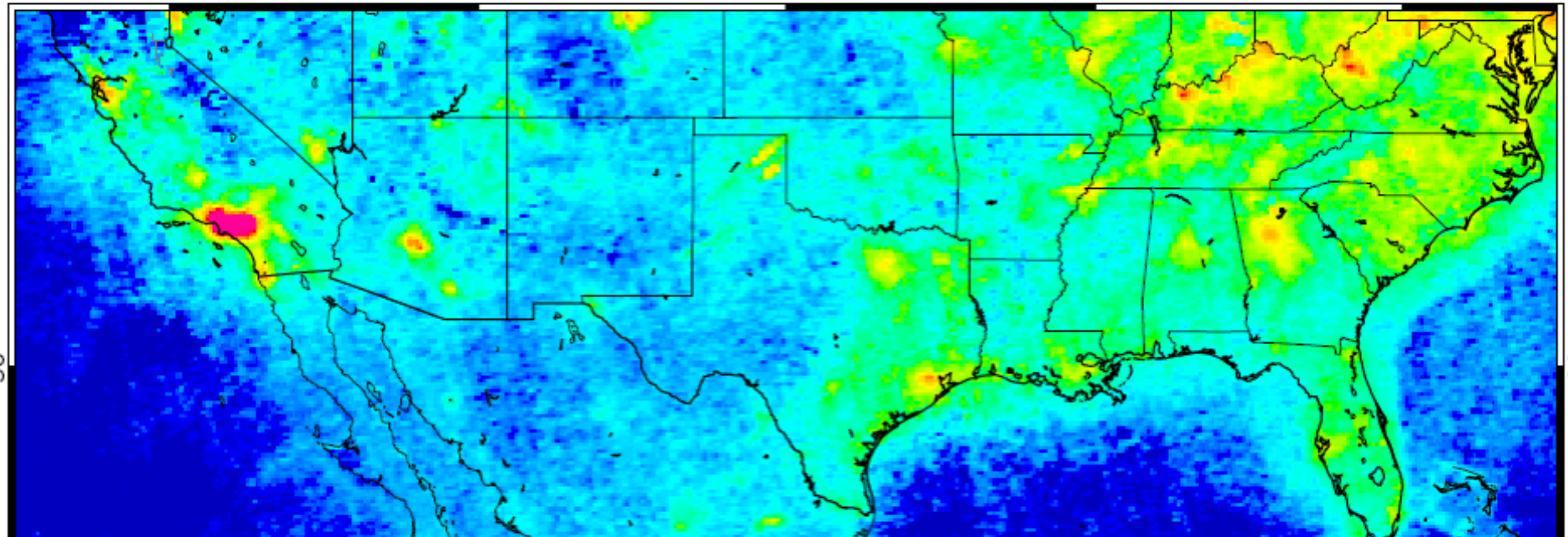
TROPOMI



OMI success-factors

OMI NO_2 provides a different perspective than GOME-2, SCIAMACHY

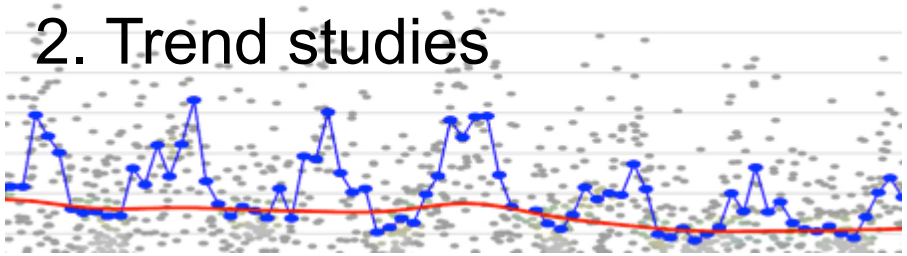
- Smaller pixels: **More spatial detail, less cloud interf.**
- Afternoon overpass time: **Sensitive to natural sources + chem.**
- Global coverage: **Massive data availability**
- Endurance: **Operational for 10 years!**
- Relative stability: **Good for trend analysis, data ass, etc.**



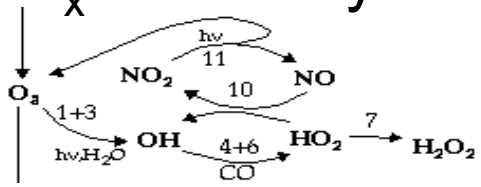
Success of OMI NO_2 - many applications

1. NO_x emission estimates

2. Trend studies

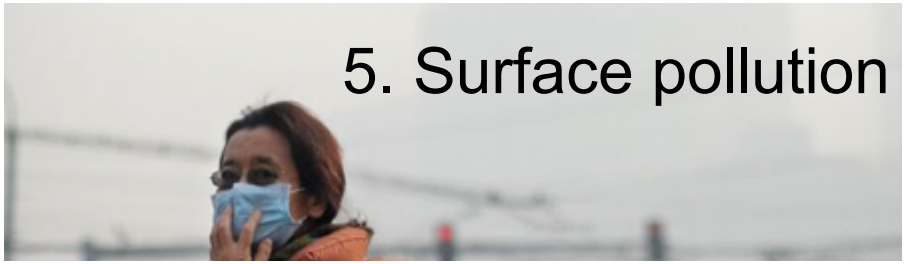


3. NO_x chemistry

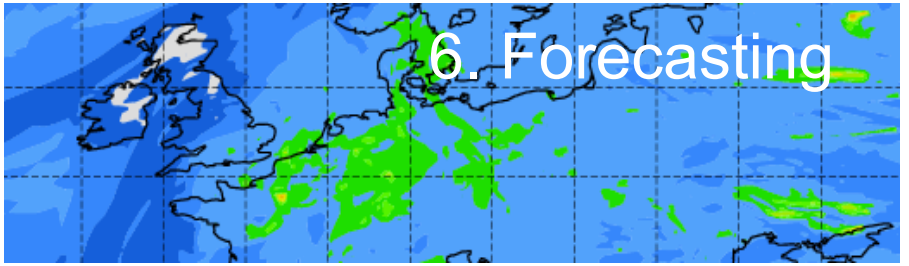


4. Chemical regimes

5. Surface pollution



6. Forecasting



7. Deposition

8. Outreach


Scientist proposes shared delta satellite to monitor air quality

Cheung Chi-fai

Hong Kong and Guangdong could launch a satellite of their own to monitor air quality and make pollu-

fine particles proposed by the government set the 24-hour average at about 75mcg of particles per cubic metre of air.

Currently, there is no standard for

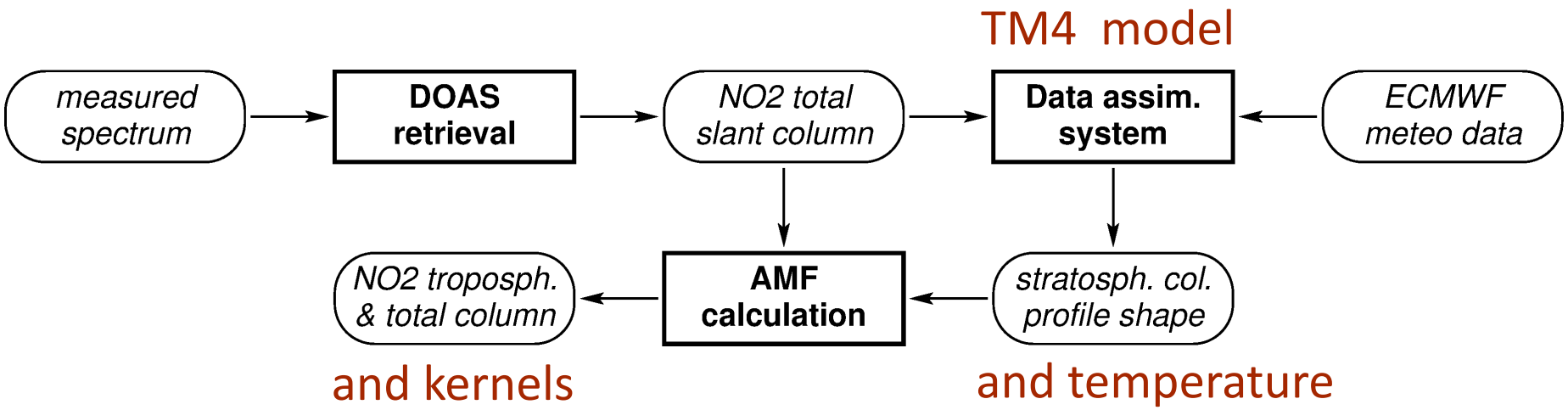
Lingering smog C3

own satellite sending back images every half an hour."

She said use of satellite images in re-

The KNMI DOMINO NO2 product

DOMINO: combined retrieval-assimilation system



Developments: KNMI OMI/TROPOMI NO2 product

Developments NO2 retrieval algorithm

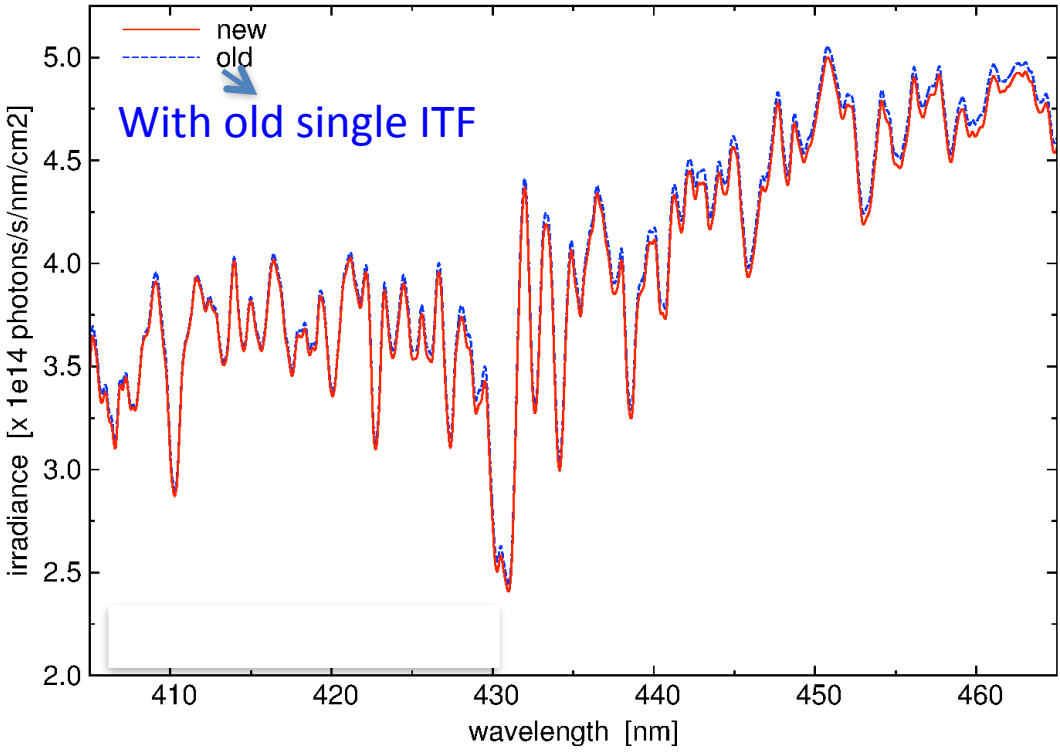
- **DOAS spectral fitting**
- **Air-mass factor improvements:**
  - **Use of TM5 model**
  - **O2-O2 cloud retrieval**
  - **Error modelling update**

Improve solar reference spectrum

Update of high-resolution solar spectrum:

- better representation of OMI ITF (now λ-dependent)
- better Ring-spectrum and I_0-corrected reference spectra

New solar spectrum improves effective λ-calibration



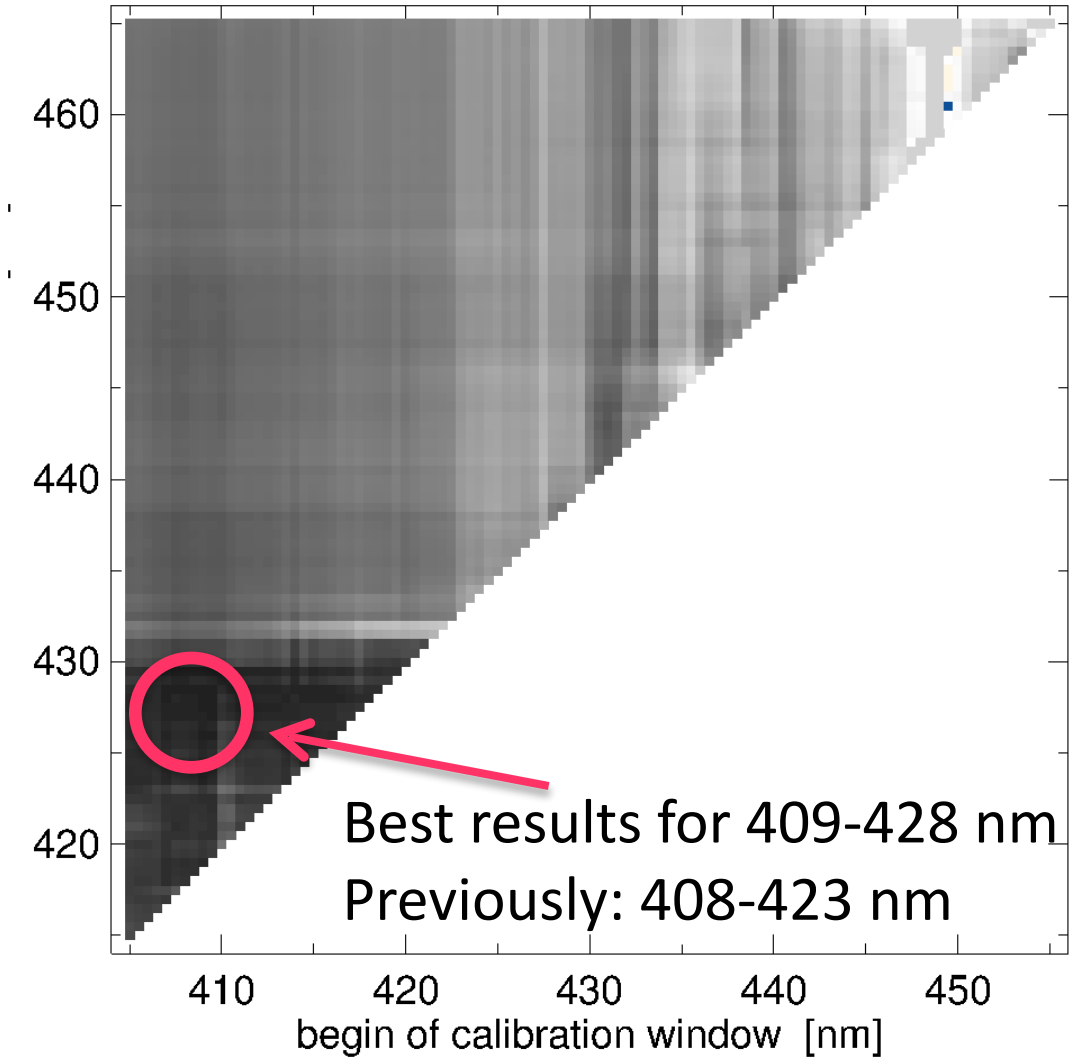
RMS of fit: -17%

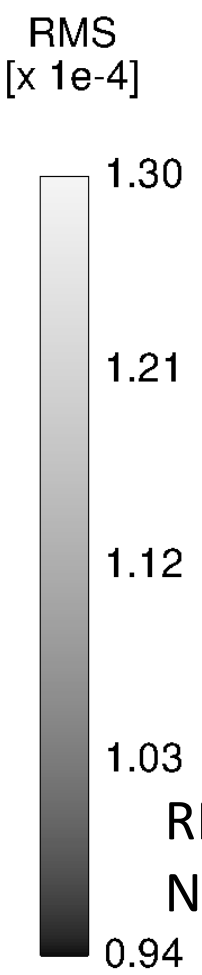
NO_2 slant columns: -6%

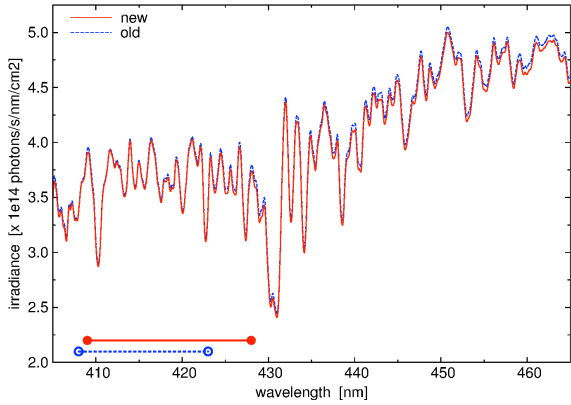
Other reference spectra otherwise identical to OMNO2A

Improve λ-calibration window to map *I* to I_0

Identify λ-calibration window that minimizes RMS/NO_2 fit error







RMS of fit: -32%

NO_2 slant columns: -13%

Improve other reference spectra

NO_2: still Vandaele et al. [1998] but with new ITF

O_3: Bogumil et al. [2000] instead of obscure WMO-1975

H_2O: HITRAN-2012 intead of HITRAN-2004

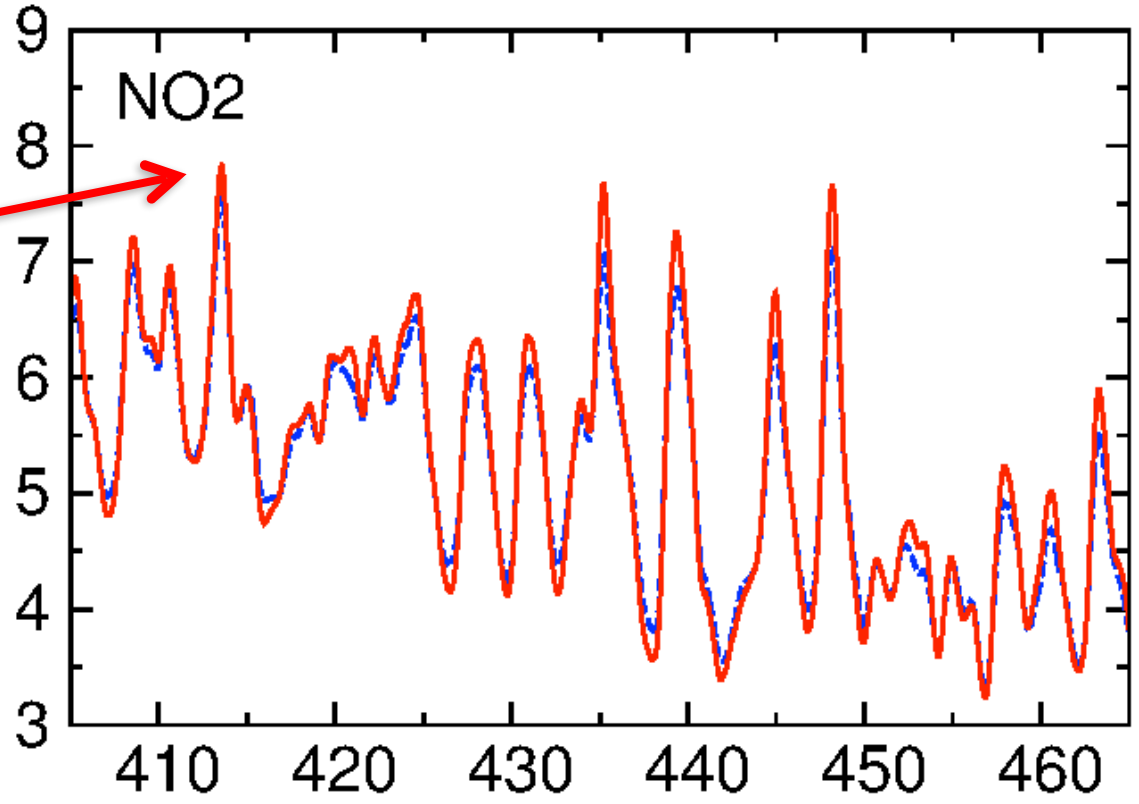
O_2-O_2: Now included!

LQW: Now included!

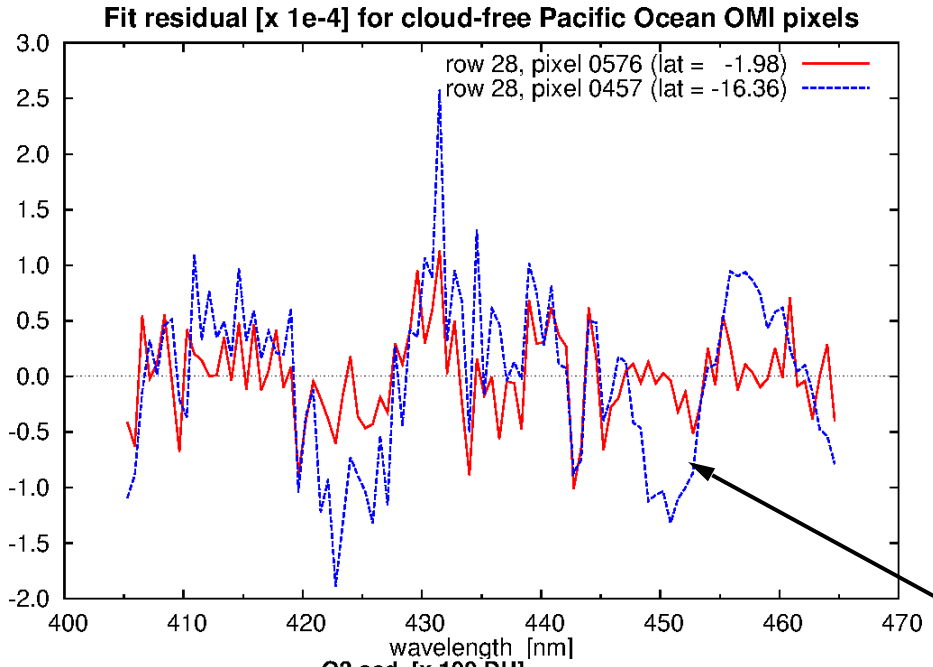
Stronger amplitude in new NO_2 cross section!

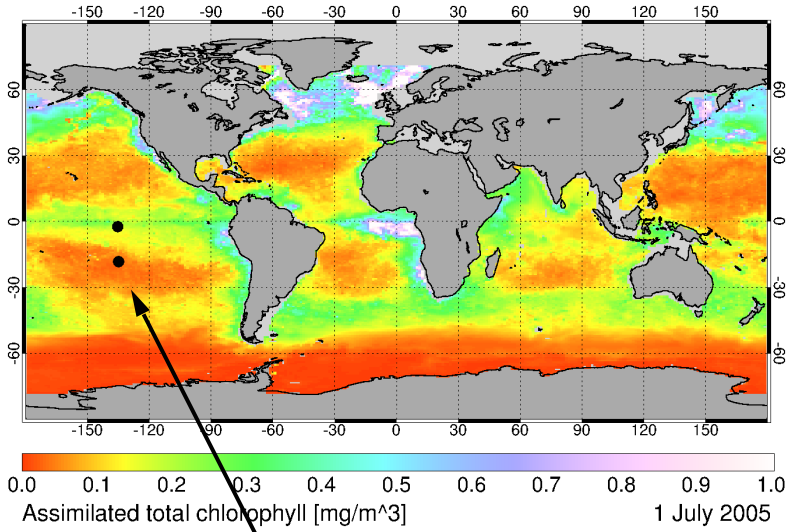
RMS of fit: -30%

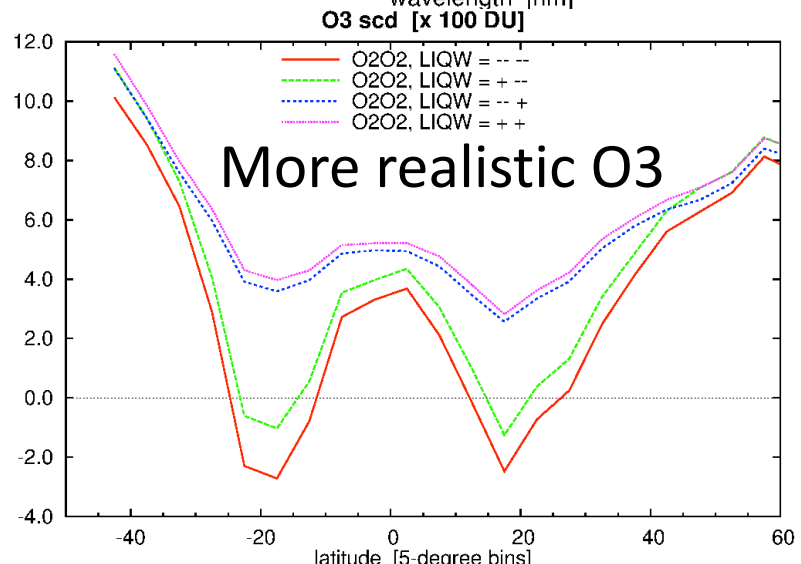
NO_2 slant columns: -11%



Including liquid water





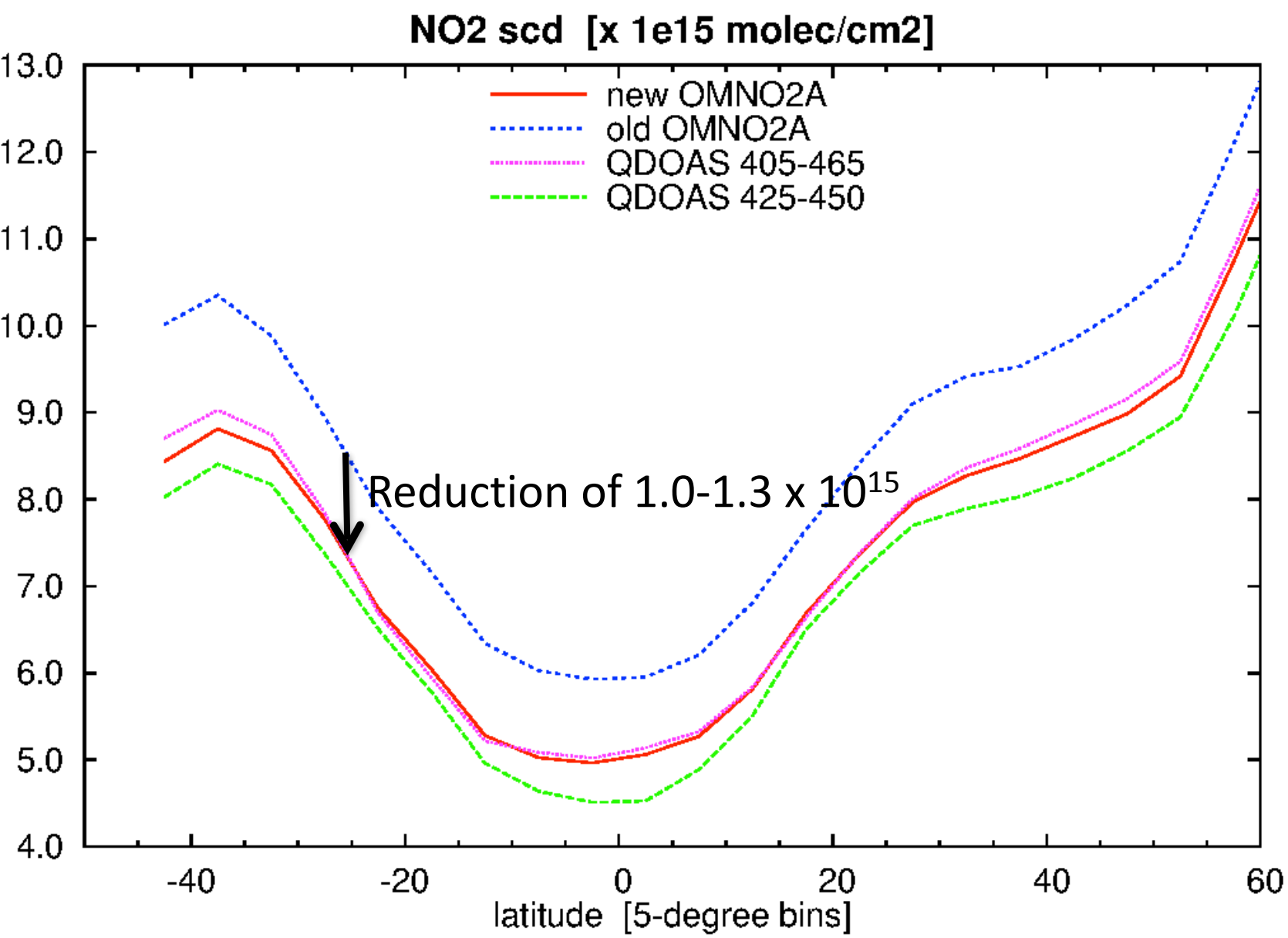


Strong feature for clear water pixel !

Fit results for cloudy pixels are not affected much when including liquid water absorption.

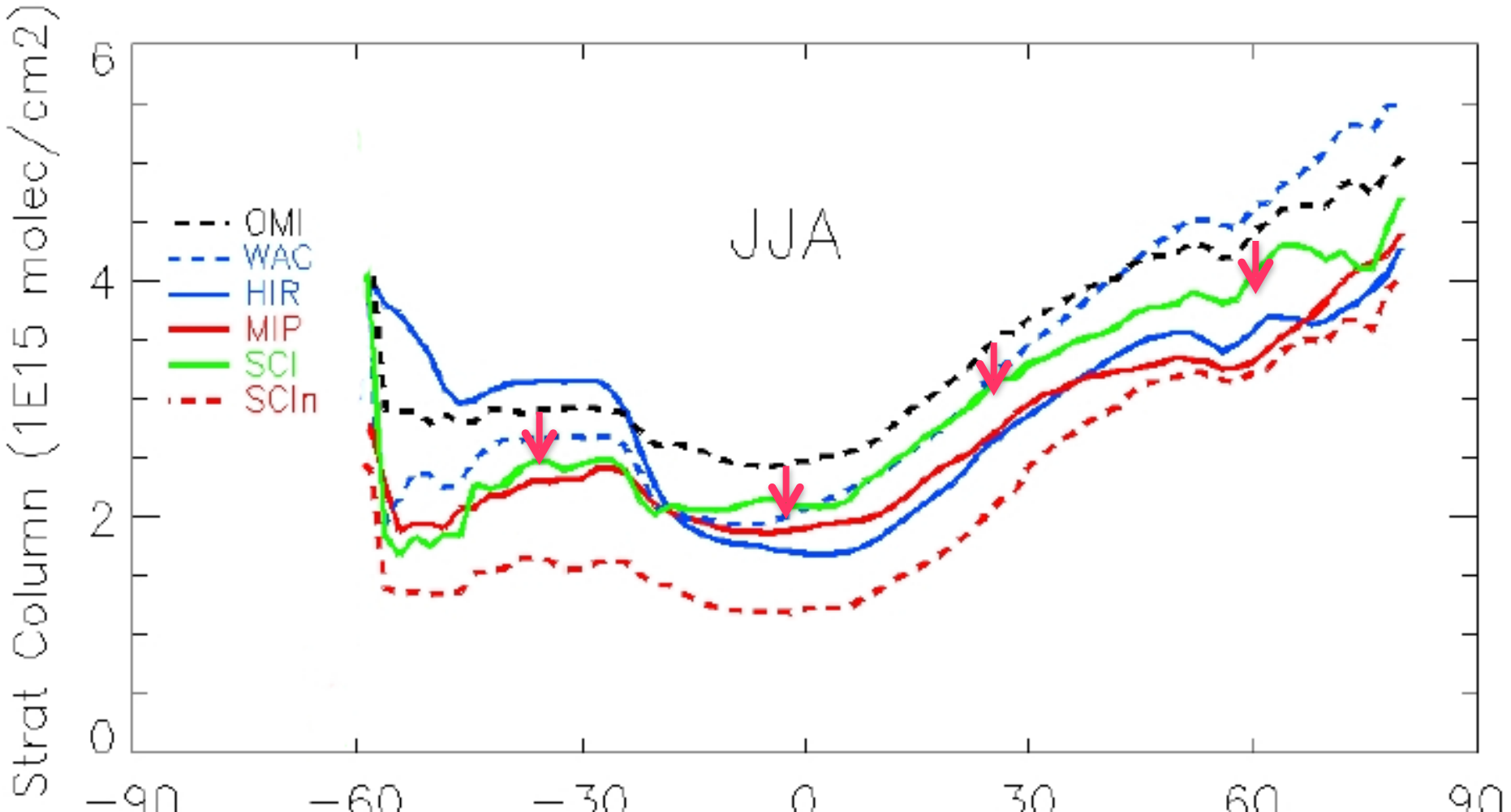
Including liquid water absorption in the NO_2 fit is a good idea.

Summary of the spectral fitting improvements



Discrepancy between DOMINO v2 and limb sensors

A reduction of 0.4-0.5 x 10^{15} molec.cm^{-2} would largely resolve the discrepancies with limb sensors (Belmonte Rivas et al., 2014)



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A new model for (TROP)OMI NO_2 retrievals

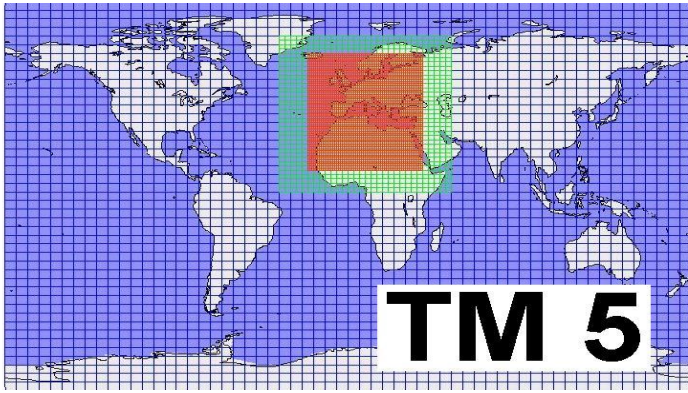
DOMINO v1 and v2: based on TM4 at 3° × 2°
DOMINO v3: based on TM5 at 1° × 1°

Motivation:

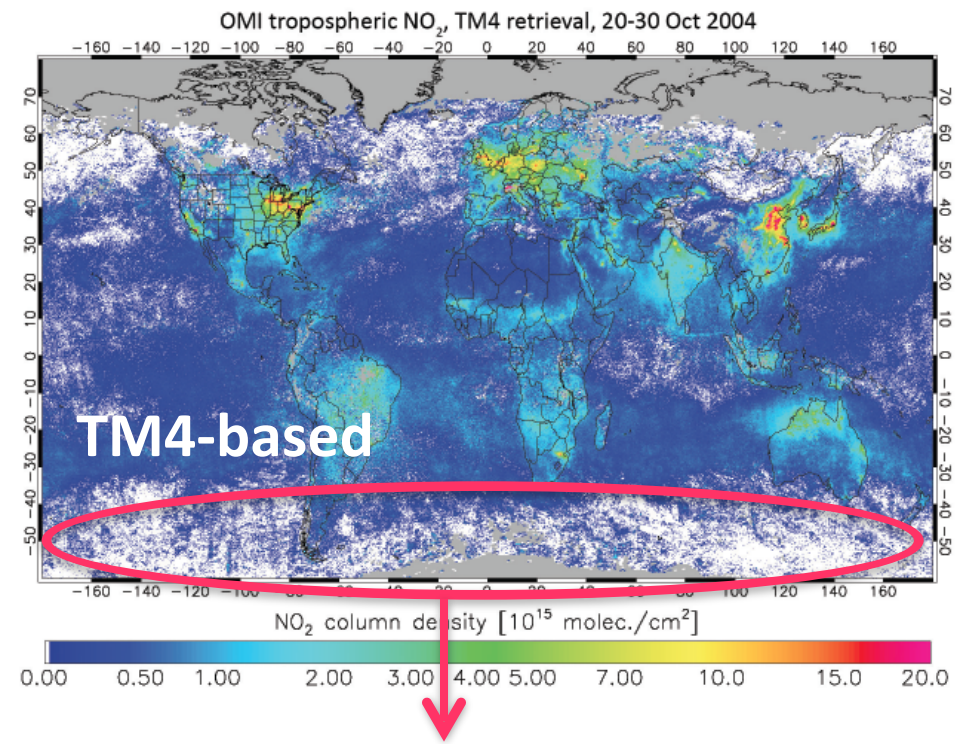
- TM5 is benchmarked (Huijnen et al., 2010)
- Parallel code: allows 1° × 1°
- Extended chemistry (CB05 scheme)
- Employs up-to-date emission inventories

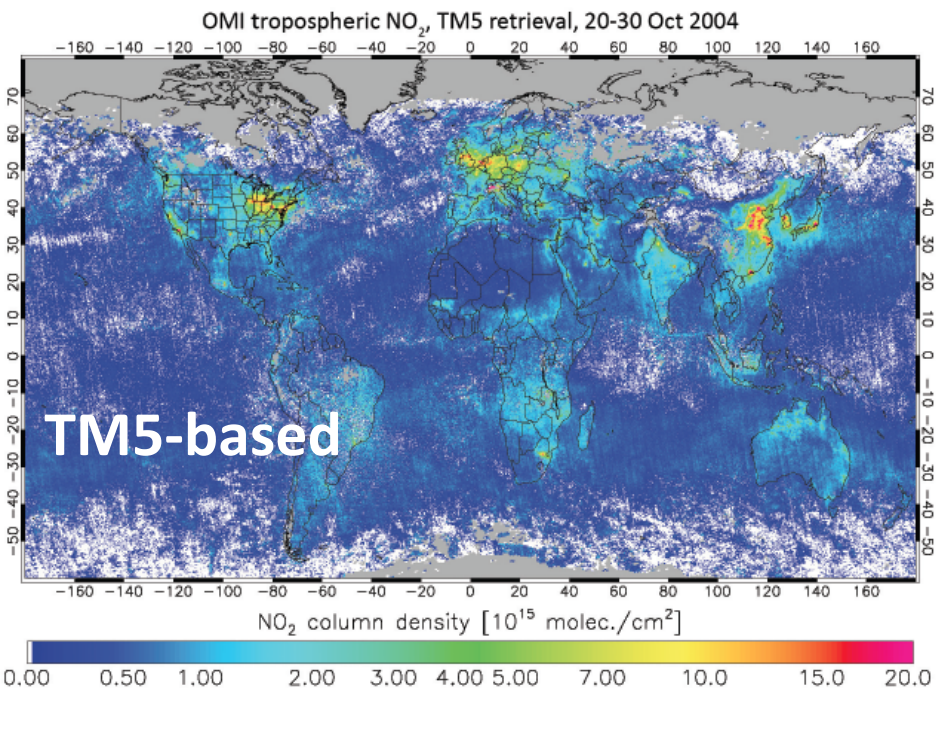
Bram Maasakkers, M.Sc

Note: TM5 2005 model data available for TROPOMI teams



Impact on the stratosphere



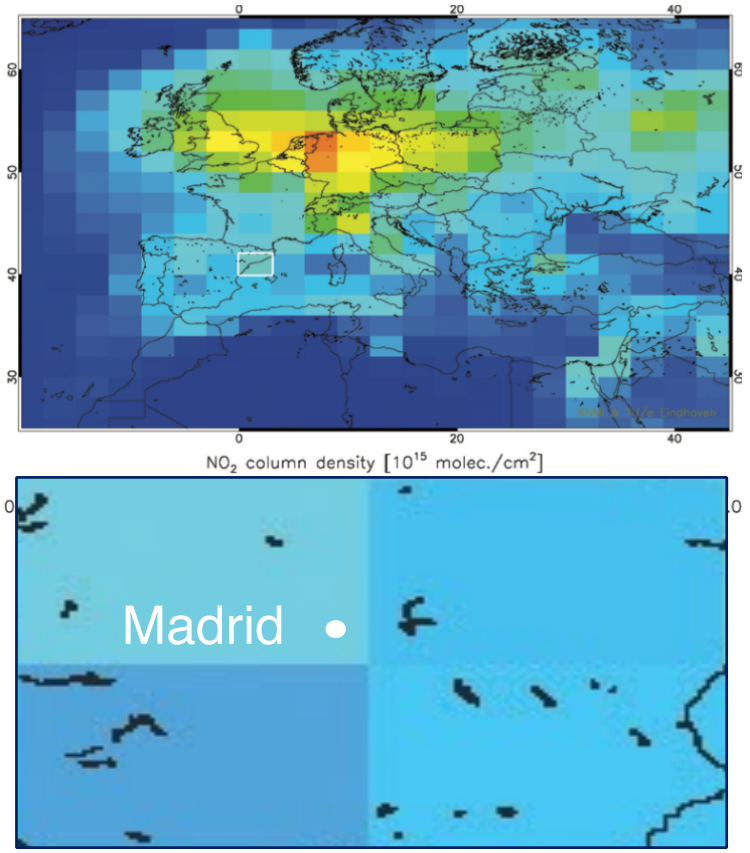


White areas: negatives

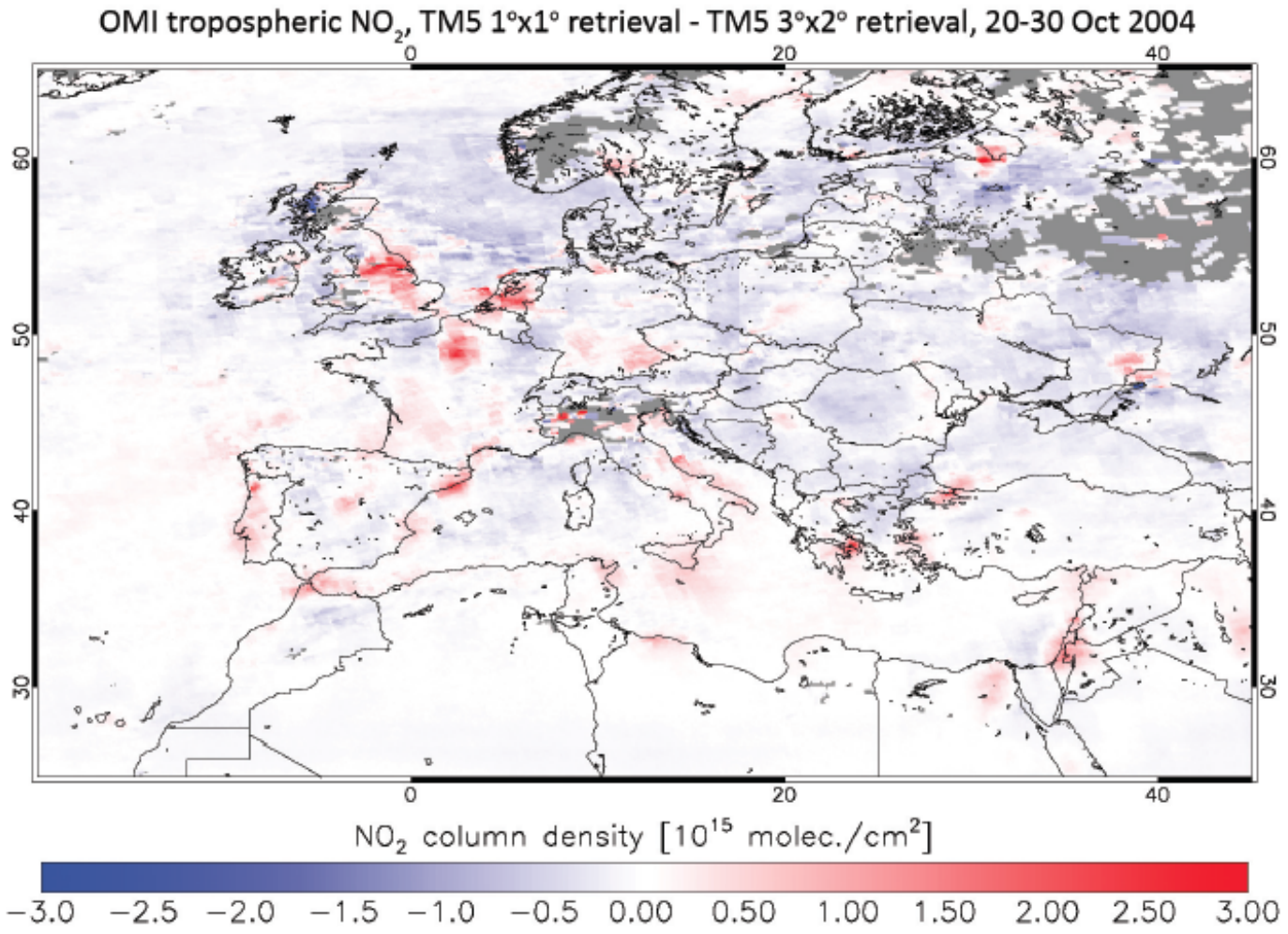
With new TM5: 27% fewer negatives

Increasing resolution to 1° × 1°

Better resolved a priori profile shapes lead to a better understanding of pollution gradients observed from space



DOMINO with TM5 at 1° × 1° vs. at 3° × 2°



Increase of the urban-to-rural contrast !

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Systematic error in O_2-O_2 cloud pressures

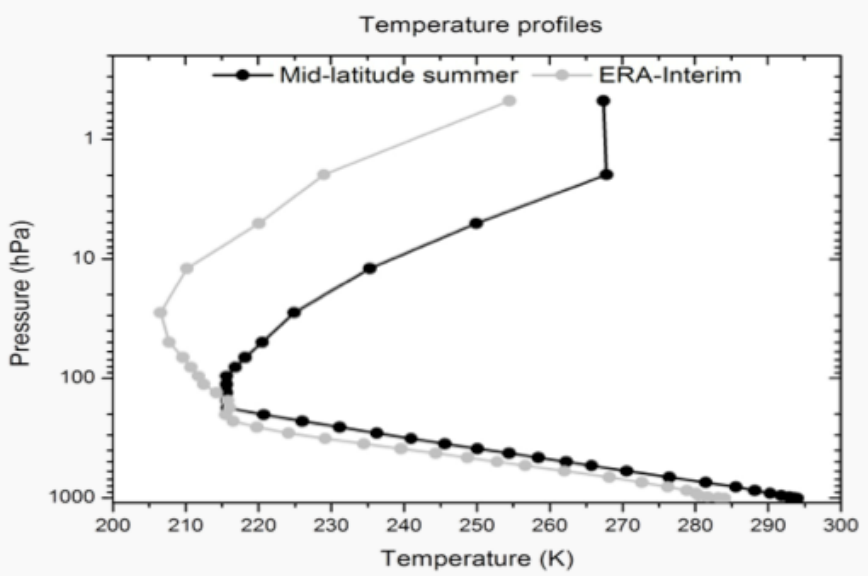
- Retrieved O_2-O_2 slant column depends on atmospheric temperature profile

$$I(\lambda) = I_0(\lambda) \exp\left(- \int_{z_c}^{z_{TOA}} m(z,\lambda)\, n_{O_2}^2(z)\, \sigma_{O_2-O_2}(\lambda)\, dz \right)$$

~Tdp

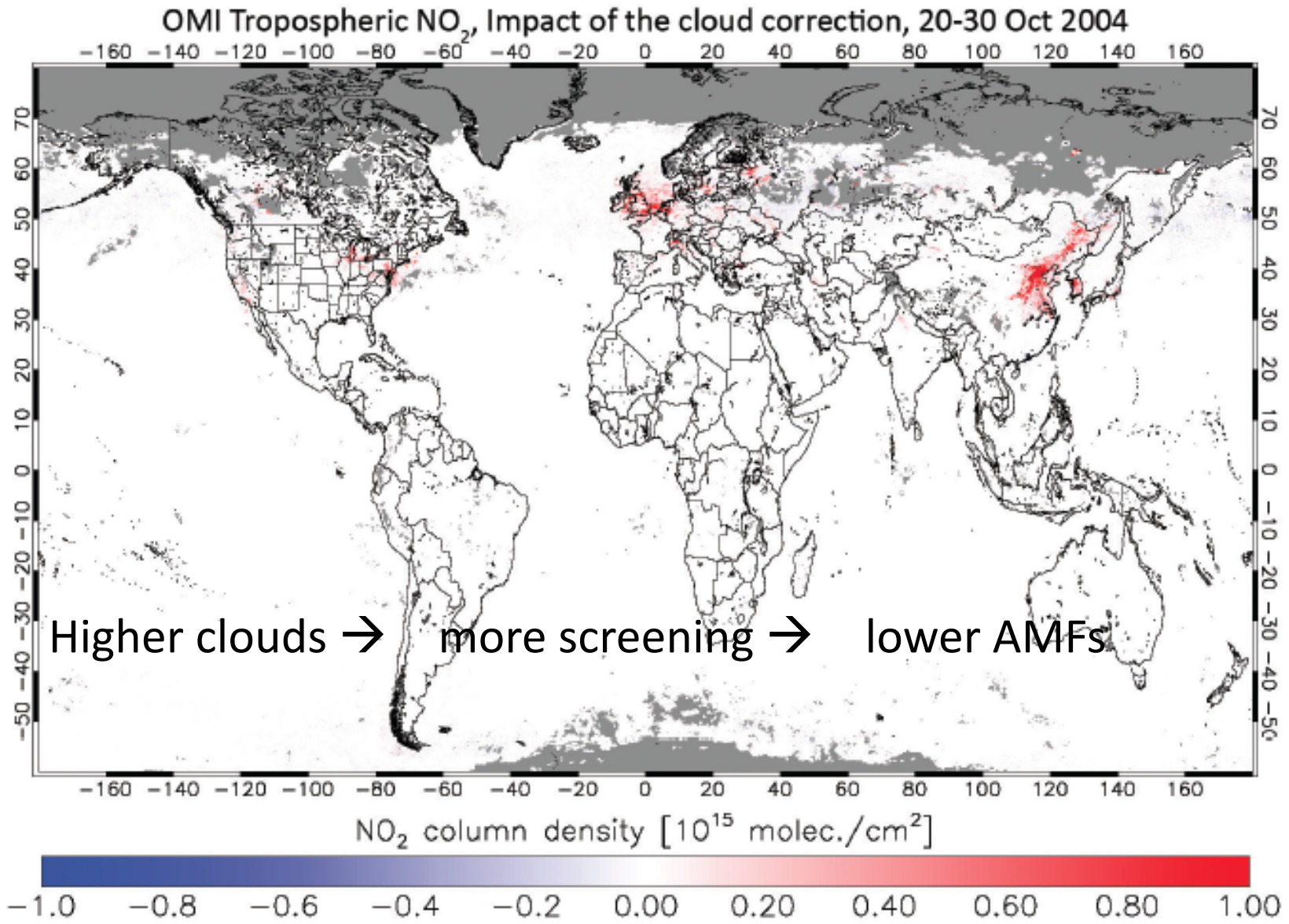
$n^2 \sim 1/T^2$

- LUT for O_2-O_2 based on fixed AFGL mid-latitude summer *T*-profile
- O_2-O_2 slant columns require T-correction since 'true' T profile may differ strongly from mls-profile



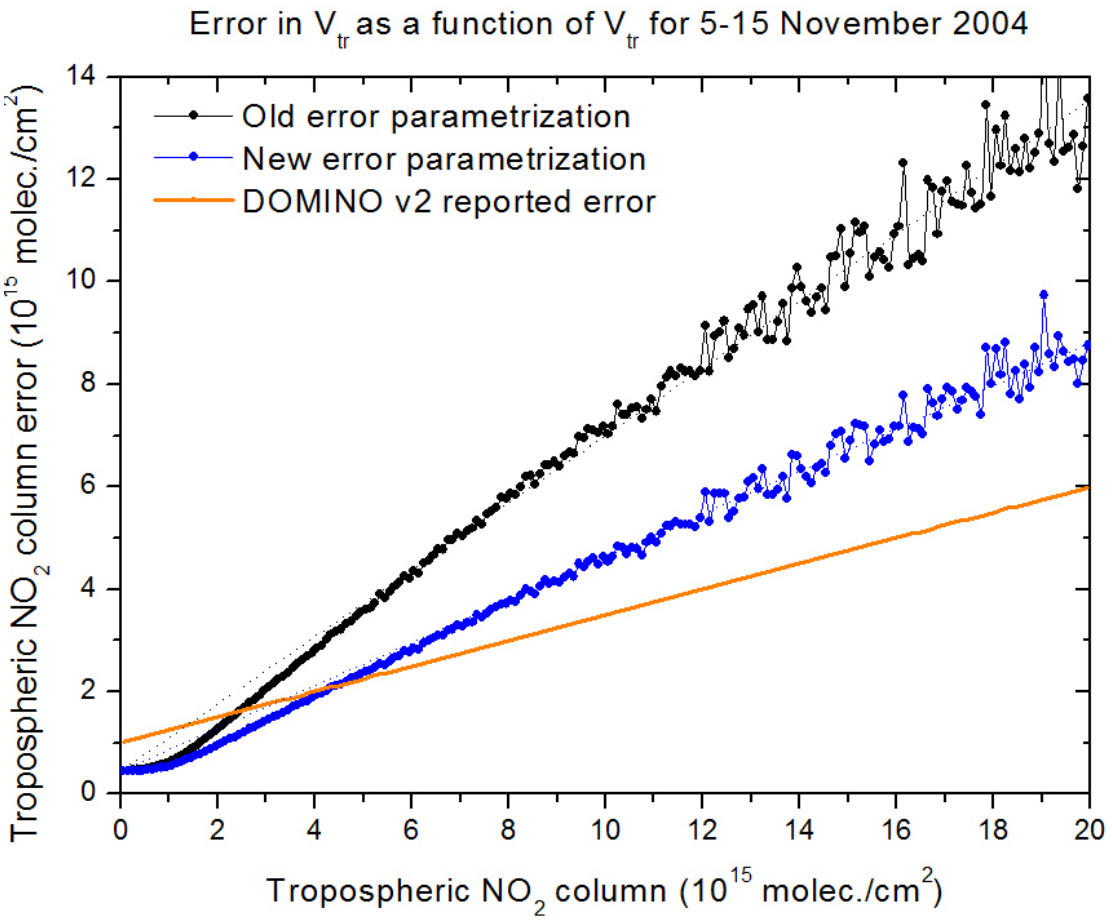
Acknowledgment: Johan de Haan

Impact on NO_2 retrievals of O2-O2 improvement



Refined error modelling

Update of error modelling inputs:
cloud fraction error, albedo error, profile error,
stratosphere error, slant column error



Ongoing work

- Preparing for DOMINO-v3 re-processing of OMI
- Preparing the TROPOMI NO2 algorithms
  - Near-Real Time
  - Assimilation-Retrieval
- Preparing for QA4ECV reprocessing of NO2 for multiple sensors

Conclusions: DOMINO-2 ➜ DOMINO-3

- Improved NO_2 slant columns are smaller by 1.0-1.3 10^{15} molec.cm^{-2} with 30% lower fitting residuals
- Coupled DOMINO to TM5-mp (2015 version)
- Improved resolution for a priori profile leads to increases over hotspots (+20%) and stronger contrast urban-rural
- Temperature-correction for cloud pressures relevant over polluted areas

(TROP)OMI NO_2 team from 2014 onwards: