PATMOS-x v6.0: Improvements to AVHRR Cloud Climate Record and Analysis of the Updated Data

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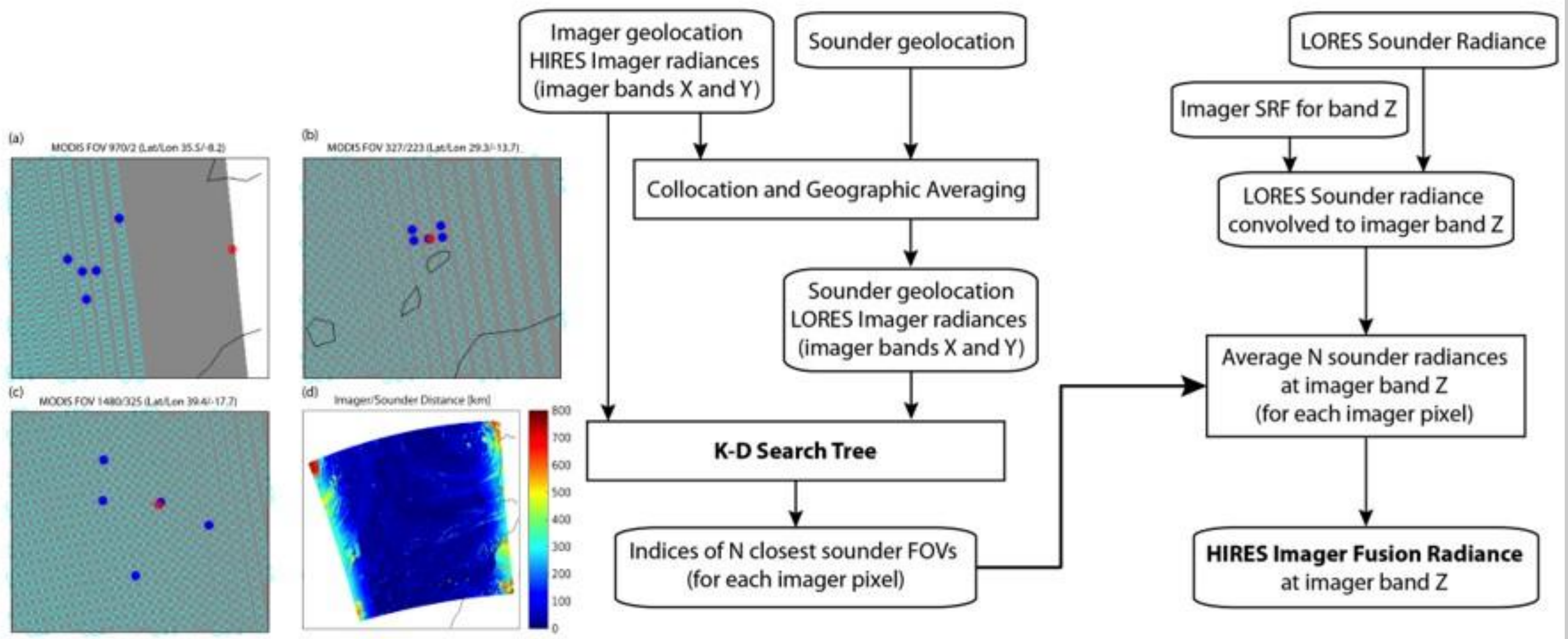
Background

Fusion Algorithm

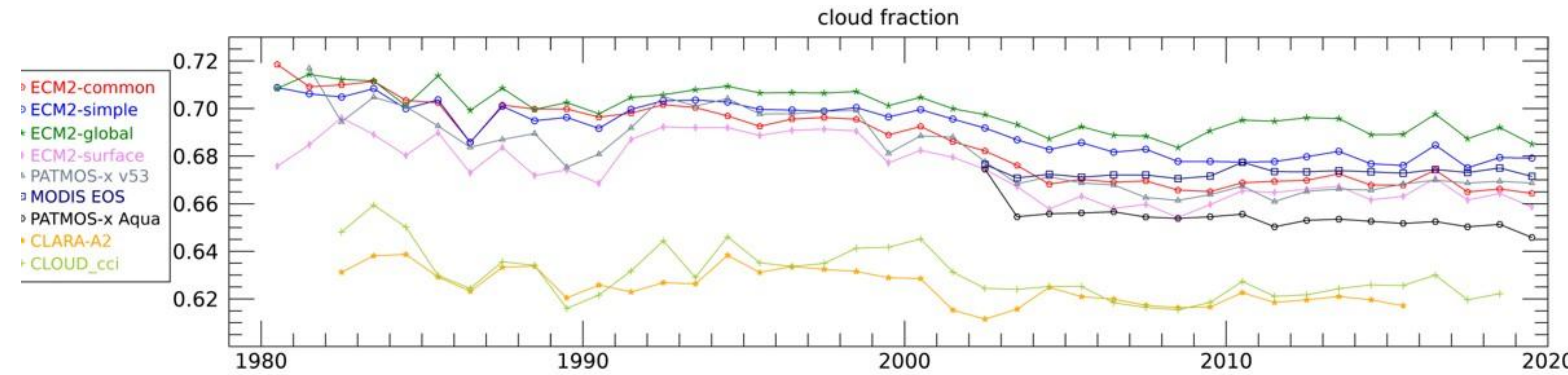


- Combine HIRS and AVHRR to produce HIRS channels at AVHRR resolution
- New naive Bayesian cloud mask allows for 2D and 3D classifiers (features containing up to 3 variables)
- Uses: 11 µm, 13.3 µm (HIRS), 3.75 µm, 7.3 µm (HIRS), 0.65 µm, 0.86 µm
- HIRS 7.3-11µm BT diff improves detection of high cloud and polar cloud inversions at night over land
- HIRS 3.75 µm used when AVHRR channel 3a is operational
- 13.3 µm used for better vertical placement of cirrus

Conclusions

- ECM2 with fusion channels dramatically improves cloud detection over the poles
- Implementing a classifier on universal channel set improves consistency between satellites

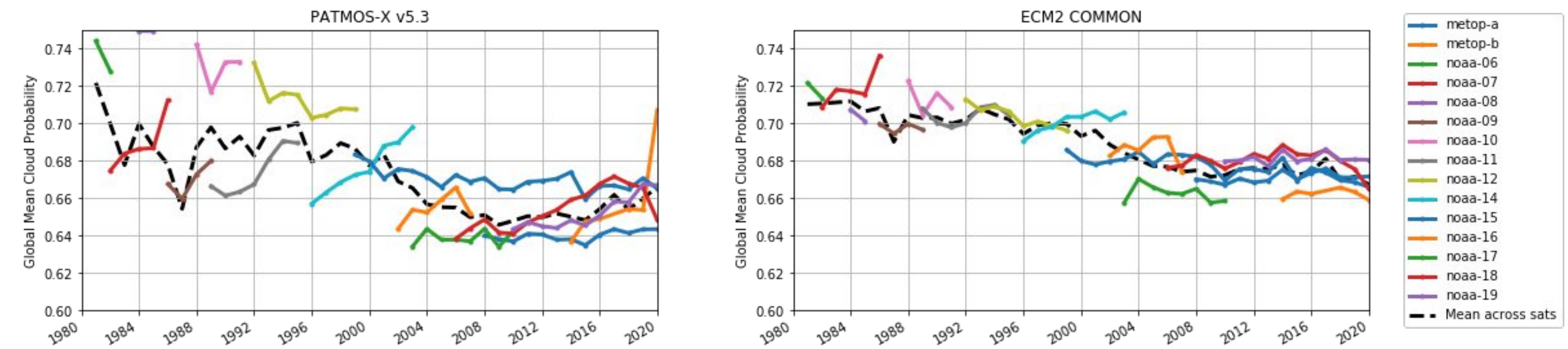
Cloud Detection



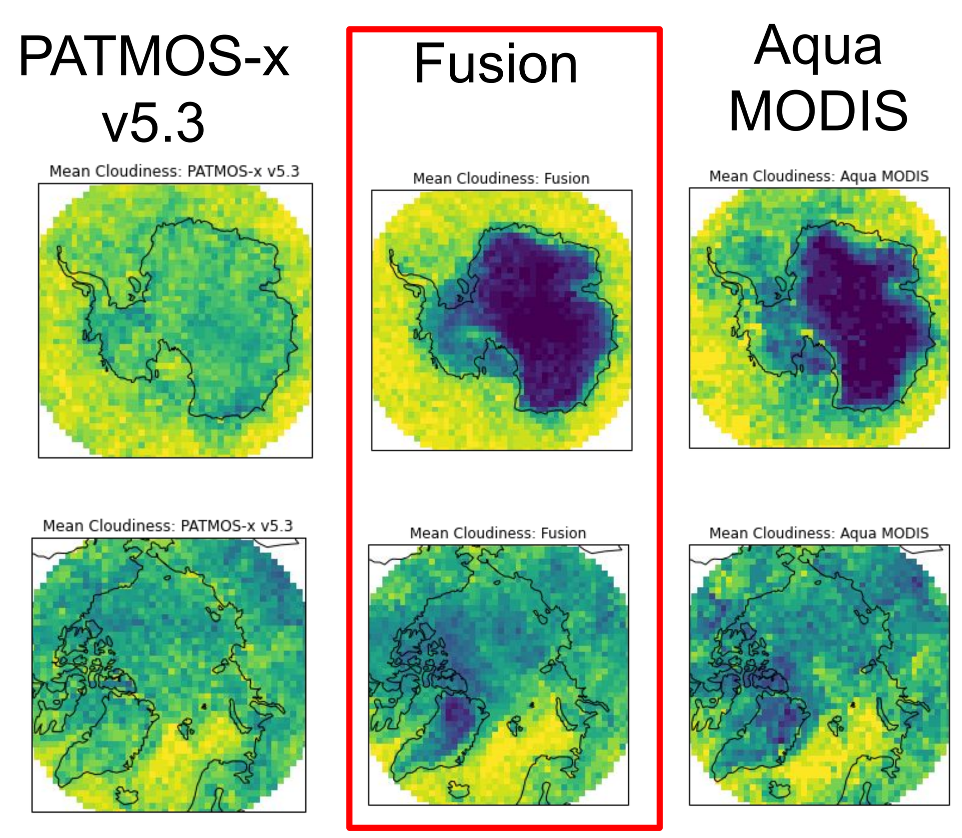
- Various Classifiers sets were tried. No significant advantage was found for the classifiers using non-universal channels
- Global cloudiness is higher than CLARA-A2
- Cause of downward trend is unknown, but likely represents a smoothed step-change at NOAA-15 (see figure below)

As expected, inter-satellite consistency is greatly improved using the ECM2 classifier with channels common to all satellites compared to PATMOS-x v5.3

Method Notes:
- Mean is mean over Earth's surface (proper mean)
- Missing data for individual daily means is imputed from satellite total mean
- V5.3 and ECM2 are masked such that missing data is identical before imputation

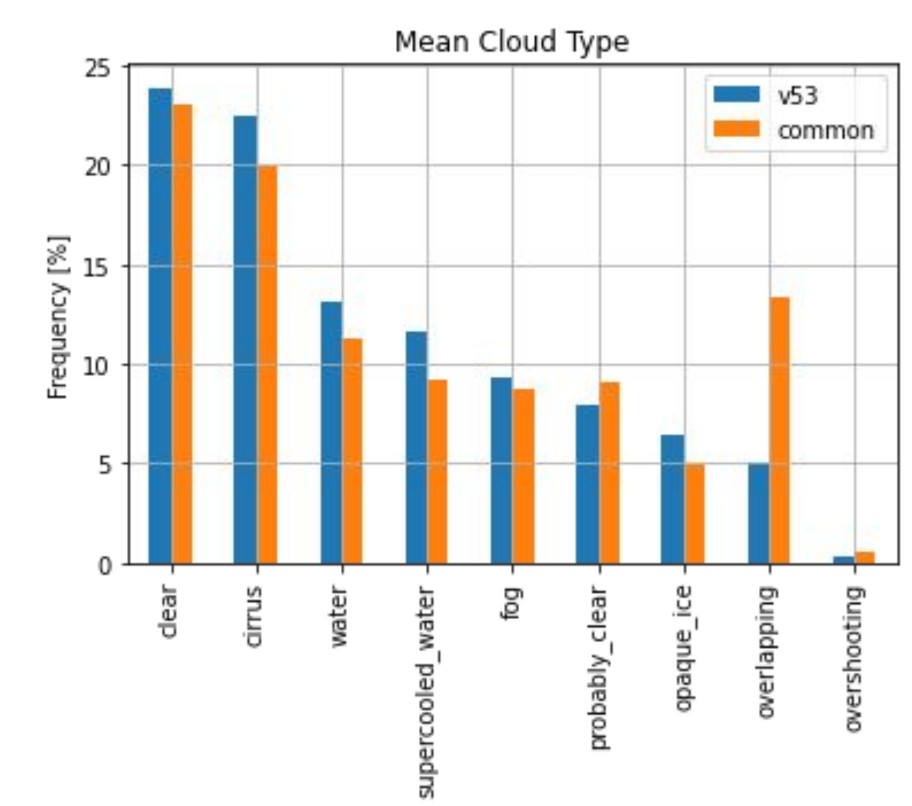


Poles



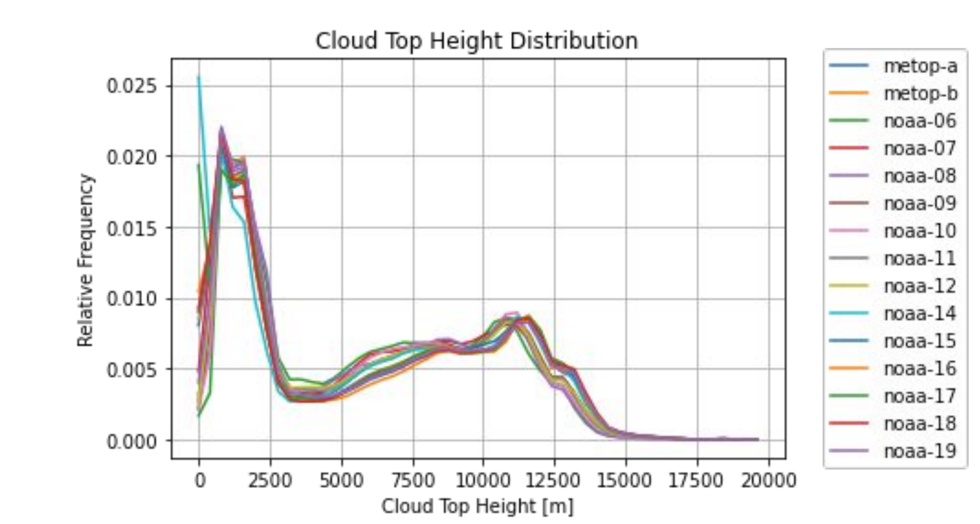
- The new fusion dataset is much closer to the Aqua MODIS "truth" than the PATMOS-x v5.3 over Antarctica and Greenland

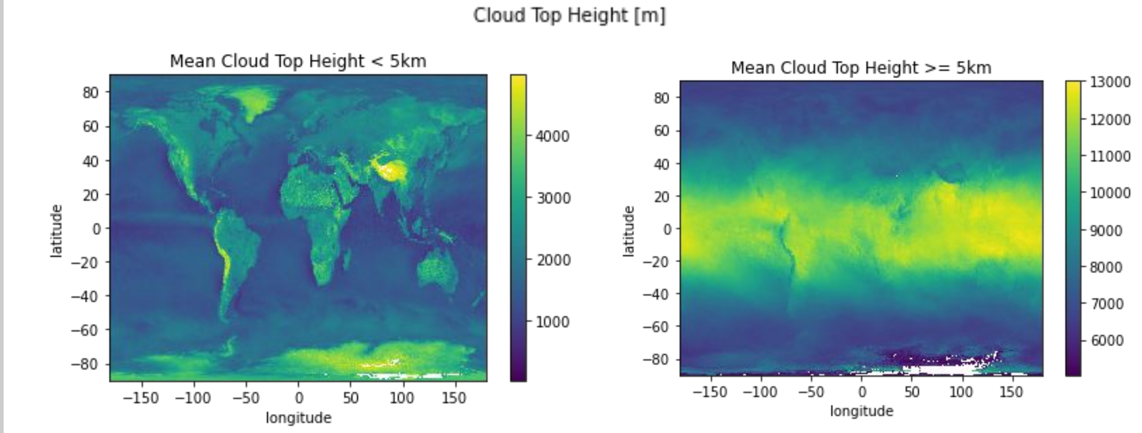
Cloud Type



- More water and supercooled water clouds
- More overlapping identified by the 11µm-13.3µm beta ratio test

Cloud Height





- Cloud height is bimodal
- Mean height of the lower mode reflects topography
- Mean height of the high mode correlates with tropopause height

Abstract

Since 1978, an Advanced Very-High-Resolution Radiometer (AVHRR) has flown onboard 17 polar-orbiting satellites. Together, they are the longest global record from a homogeneous set of satellite sensors. The Pathfinder Atmosphere's Extended (PATMOS-x) dataset is a long-term cloud record derived from the AVHRR radiances, and suitable for climate analysis. It has demonstrated intersensor stability and has been rigorously compared with other cloud datasets.

However, the AVHRR alone has only limited spectral information, so cloud detection during nighttime or over ice is challenging. Therefore, performance degrades over regions with extreme diurnal patterns or low temperatures such as the poles, despite our interest.

The next production version of PATMOS-x will include numerous algorithmic changes as well as the use of High-resolution Infrared Radiation Sounder (HIRS) spectral channels to improve detection accuracy in previously difficult conditions. The low-resolution HIRS soundings are upsampled to match the AVHRR pixels through an edge-preserving process called “fusion”. The higher-resolution AVHRR imagery guides the upsampling and the resulting combination is spectrally consistent with the AVHRR and has a high spatial resolution.

For cloud detection, the difference between the AVHRR and HIRS 11μm and HIRS 6.7μm brightness temperatures has been added as a feature in the naive Bayesian cloud detector. The effect on cloud precision is seen especially in the Antarctic where false-positive cloud detections have decreased dramatically.

Other cloud properties can be improved with the new spectral channels. For example, the new cloud phase algorithm uses the HIRS 6.7μm to determine cloud phase and the AVHRR and HIRS 11μm-13.3μm beta ratio identifies overlapping clouds. Also, the 11μm, 12μm, and HIRS 13.3μm are used in the new cloud height algorithm.

We report on the development of this new version of the PATMOS-x cloud climate dataset, and the methods used to calibrate and homogenize the participating sensors. Finally, observed trends in the improved dataset will be examined and related to the old dataset. In particular, attention will be given to whether high-latitude analysis of climatic trends is finally possible on the new dataset.