Extremely fast retrieval of volcanic SO_2 layer heights from UV satellite data using inverse learning machines

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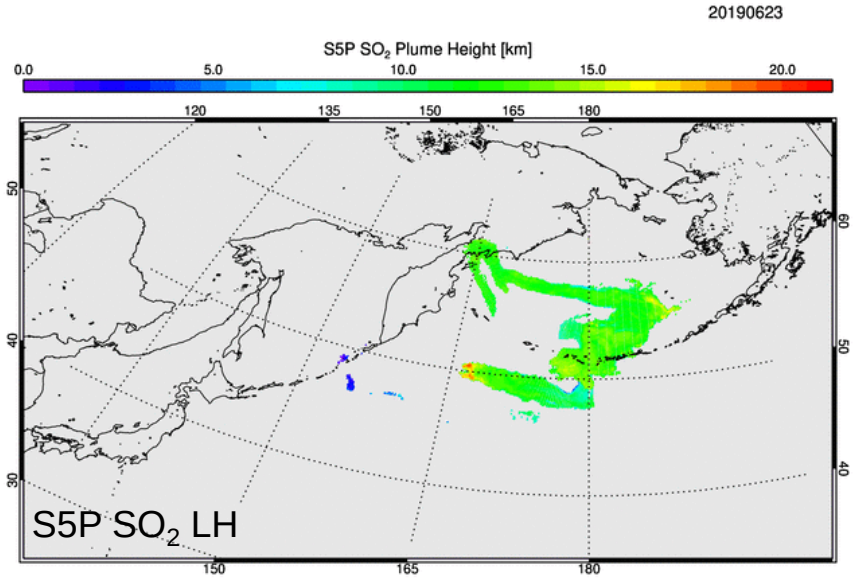
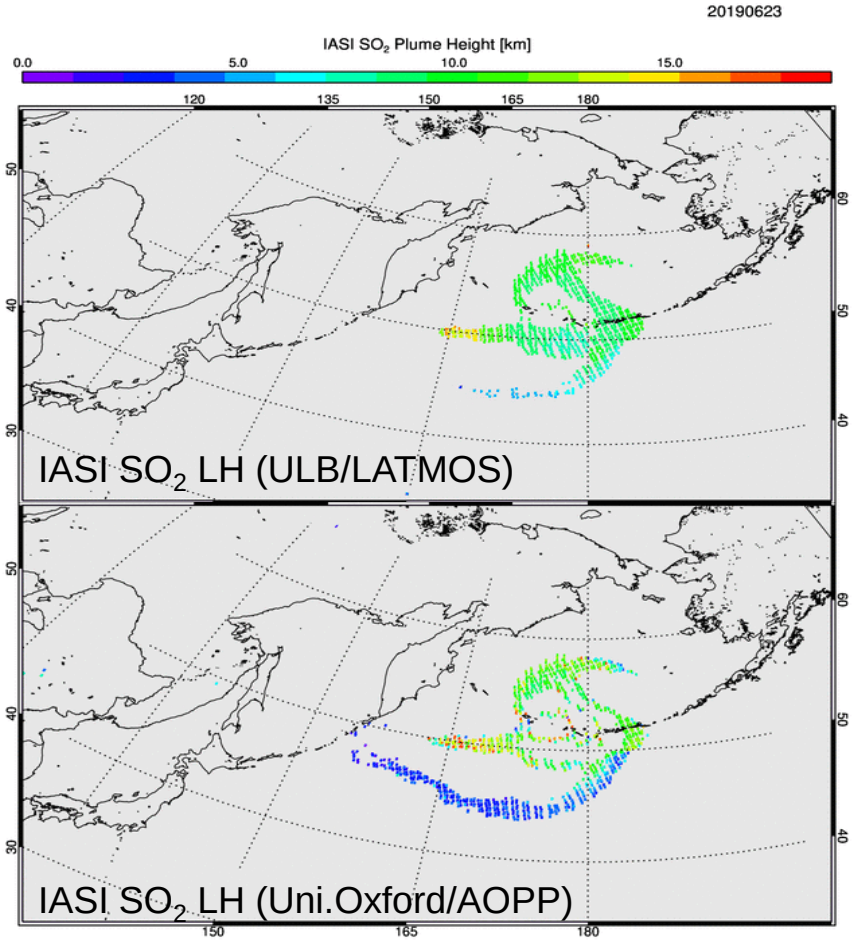
Overview and Motivation

- SO_2 is a clear indicator of volcanic activity
- Regular **ground-based monitoring** limited to few volcanoes
- **Satellites** allow for **global daily** measurements of SO_2
- SO_2 is (relatively) easy to detect but information about SO_2 LH **unknown**
- So far: only time-consuming direct-fitting techniques
  - Not applicable in NRT environment
- Novel FP-ILM (Full Physics Inverse Learning Machine) approach:
  - Combination of PCA and NN approach
  - Extremely fast yet accurate
    - Slow offline training phase
    - Fast operational phase:
      Processing speed: 2ms / TROPOMI Pixel,
      Accuracy: <2km for SO_2 > 20 DU

Raikoke eruption Jun-Jul 2019 (Hedelt et al. 2019)





FP_ILM: Low SO_2 LH close to source (~4km) and high SO_2 LH (~12-15km) in extended plume

Very good agreement with IASI SO_2 LH products and CALIPSO (not shown)

Summary

- Novel method for precise and extremely fast retrieval of SO_2 LH based on UV satellite data
  - Combined Principal Components Analysis (PCA) & Neural Network approach (NN)
- Extremely fast yet accurate retrieval of SO_2 LH:
  - SO_2 LH information for an entire S5P orbit retrieved in a matter of few minutes
  - Applicable in NRT retrieval
- Development in framework of **ESA S5P+I: SO2 LH project**: https://atmos.eoc.dlr.de/so2-lh/
- Hourly S5P SO_2 LH results for volcanic eruptions @Twitter: @DLRSO2
- Application to recent volcanic eruptions shows very good results

Algorithm details can be found in

- Efremenko D.S., Loyola D., Hedelt P. and Spurr R. // International Journal of Remote Sensing. 2017. V. 38:sup1, P. 1-27. https://doi.org/10.1080/01431161.2017.1348644
- Hedelt P., Efremenko D., Loyola D., Spurr R., Clarisse L. // Atmospheric measurement techniques. 2019. V. 12. P. 5503. https://doi.org/10.5194/amt-12-5503-2019