Feasibility of Using IASI Satellite NH_3 for Air Quality Monitoring

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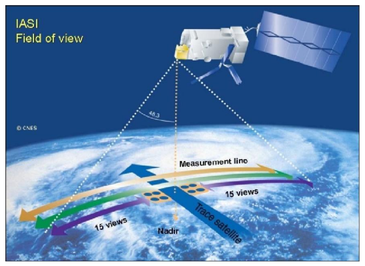
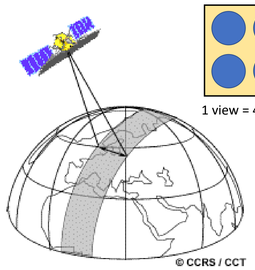
Introduction

Ammonia (NH_3) is an atmospheric trace gas, and contributes to the formation of secondary aerosols and nitrogen deposition. Current NH_3 emission inventories have great uncertainties due to the lack of measurements and significant spatiotemporal variabilities of emissions. Recent advancement of remote sensing techniques has offered great opportunities for improving these inventories and our understanding of NH_3, but satellite NH_3 measurements have not been fully validated.



Credit: CNES

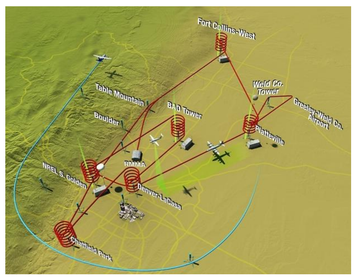


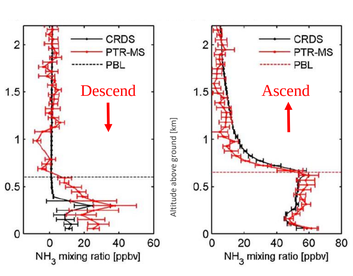
Instrument	Satellite	Equator overpass time (LST)	Pixel size at nadir
IASI	MetOp-A	9:30, 21:30	12 km × 12 km
	MetOp-B	9:00, 21:00	12 km × 12 km
CrIS	JPSS	1:30, 13:30	14 km × 14 km
TES	SNPP	1:30, 13:30	5.3 km × 8.5 km
AIRS	Aqua	1:30, 13:30	13.5km × 13.5 km

Overview of NH_3-neasuring satellites

In-situ measurements

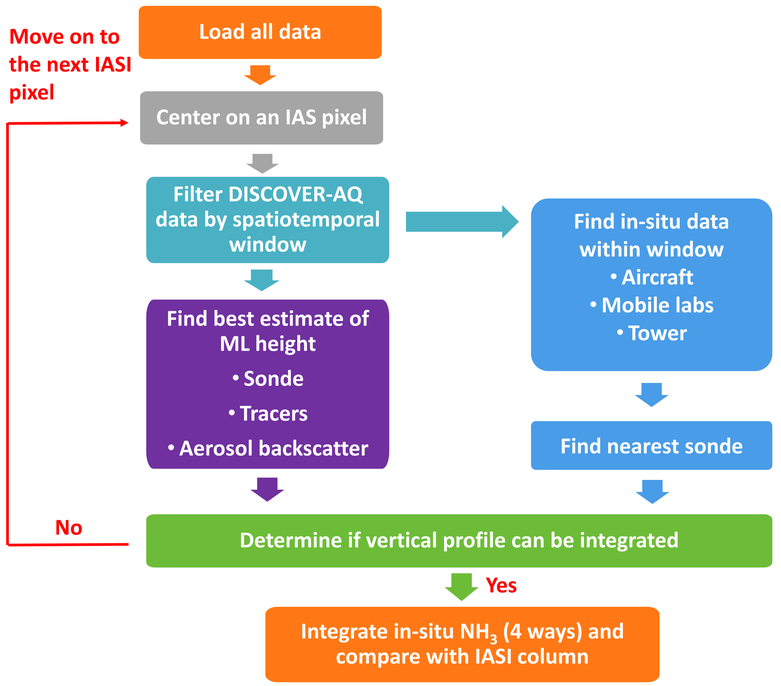
In order to validate satellite total columns, vertical profiles of NH_3 concentration are needed. During the 2014 DISCOVER-AQ* Colorado campaign, a suite of instrument was deployed to measure NH_3, including 2 aircraft, 1 tall tower, 4 mobile labs and 1 mobile FTIR. We propose to construct NH_3 vertical profiles by integrating these measurements. However, sampling artifacts of the instrument might affect the results.



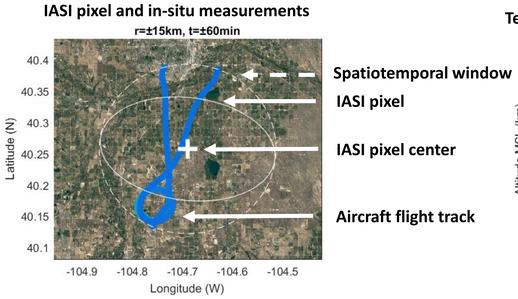


* DISCOVER-AQ: Deriving Information on Surface conditions from Column and Vertically Resolved Observations Relevant to Air Quality

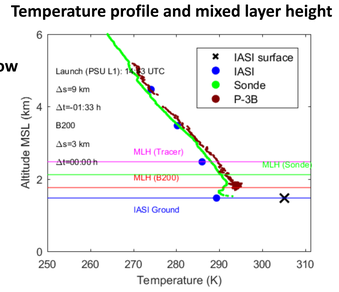
Validation algorithm



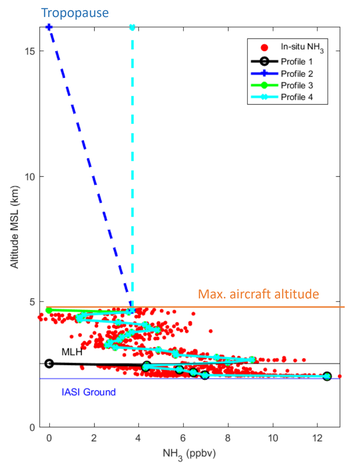
IASI pixel and in-situ measurements



Temperature profile and mixed layer height



Vertical profiles

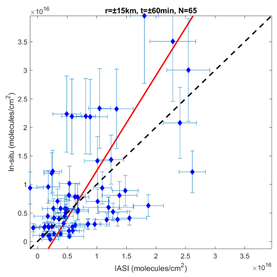


4 reasonable ways to integrate in-situ NH_3:

- Negligible NH_3 above mixed layer **(Profile 1)**
- Linearly extrapolate NH_3 concentration to zero from max aircraft altitude to tropopause **(Profile 2)**
- Negligible NH_3 concentration above max aircraft altitude **(Profile 3)**
- Constant NH_3 concentration above max aircraft altitude **(Profile 4)**

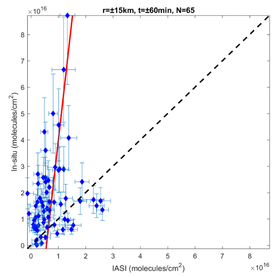
Intercomparison

In-situ vs. IASI orthogonal fit using the four assumptions (±15 km & ±60 min window)



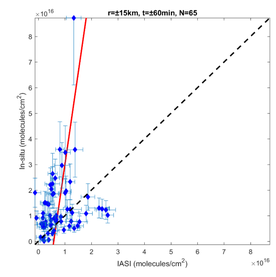
1. Integration up to mixed layer

m = 1.67
b = -4.27e15
r: 0.57



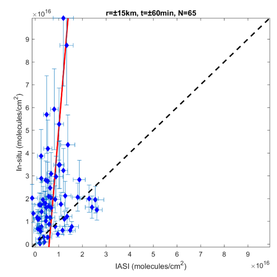
2. Linearly interpolate from max. aircraft altitude to tropopause

m = 9.16
b = -5.22e16
r: 0.22



3. Integration up to max. aircraft altitude

m = 7.13
b = -4.15e16
r: 0.21



4. Constant NH_3 above max. aircraft altitude

m = 12.46
b = -7.45e16
r: 0.21

IASI-in-situ agreement using orthogonal fit for the mixed layer assumption (all spatiotemporal windows)

Slope	0 km (within pixel)	15 km	45 km
20 min	1.5	2.2	3.4
60 min	0.6	1.7	1.1
180 min	1.4	0.6	0.6

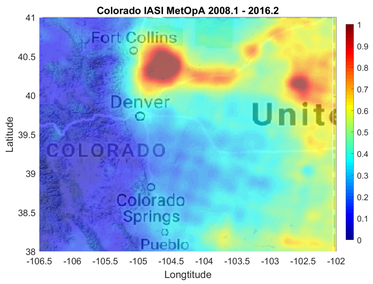
Intercept	0 km (within pixel)	15 km	45 km
20 min	-4.1e15	-8.2e15	-1.7e16
60 min	1.8e15	-4.3e15	-7.9e14
180 min	-4.6e15	1.3e15	1.6e15

Correlation coefficient	0 km (within pixel)	15 km	45 km
20 min	0.67	0.53	0.15
60 min	0.43	0.57	0.27
180 min	0.66	0.62	0.31

Number of matches	0 km (within pixel)	15 km	45 km
20 min	13	24	151
60 min	27	65	252
180 min	48	97	266

Summary

- Best agreement between IASI and in-situ NH_3 up to mixed layer
- IASI underestimates; critical need for unbiased in-situ data
- Future work:
  - ❑ Evaluating agreement between IASI, CrIS and in-situ data
  - ❑ Oversampling – NH_3 emission map



Credit: Kang Sun (Harvard) for the oversampling algorithm

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Acknowledgement

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