

# Biological ice nucleating particles at tropospheric cloud height

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# Themen des Vortrags

- Warum sind Eiskeime wichtig?
- Was sind biologische Eiskeime?
- Relevanz der Höhenforschung
- Netzwerke der Messstationen

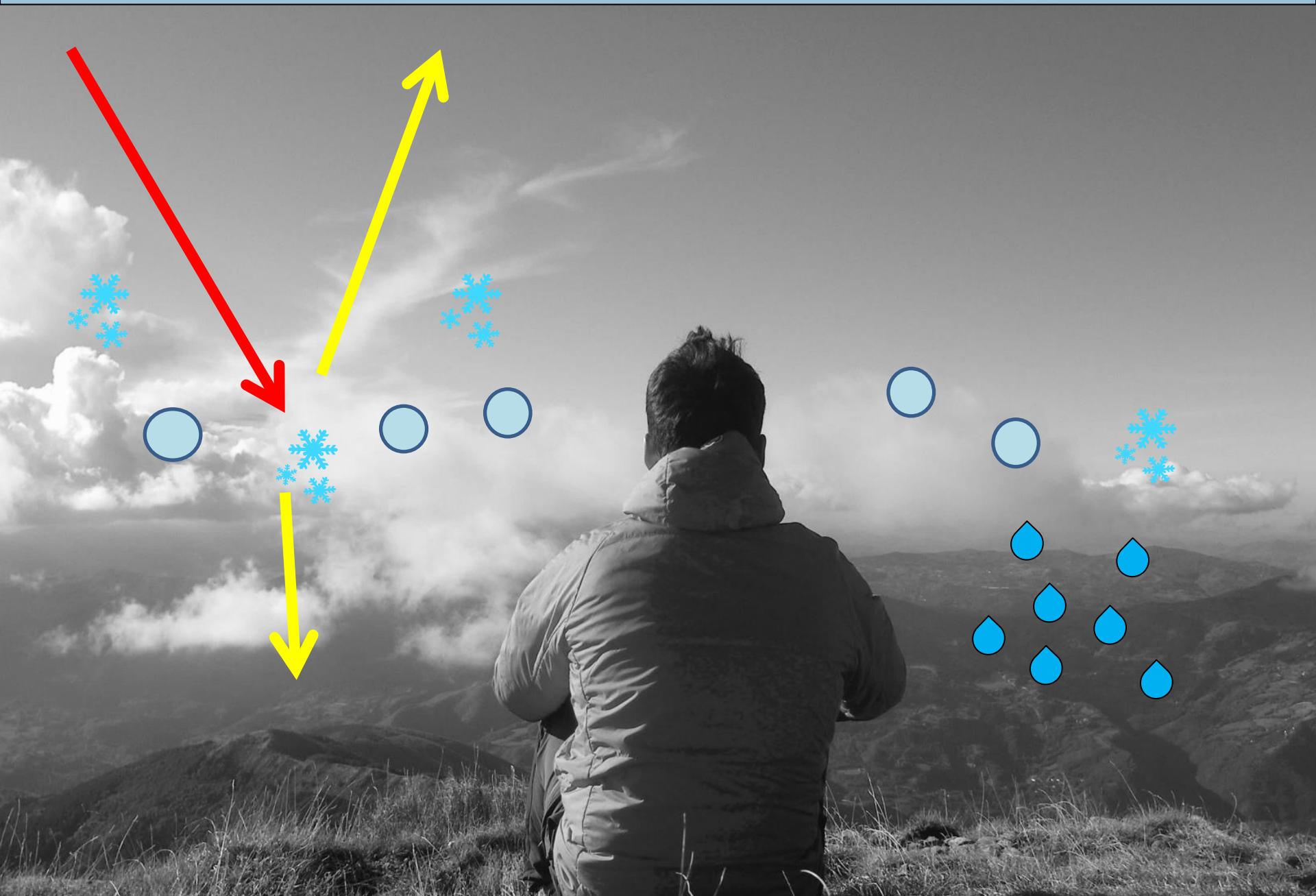
# Wolken und eiskeimaktive Partikel



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# Wolken und eiskeimaktive Partikel (INPs)



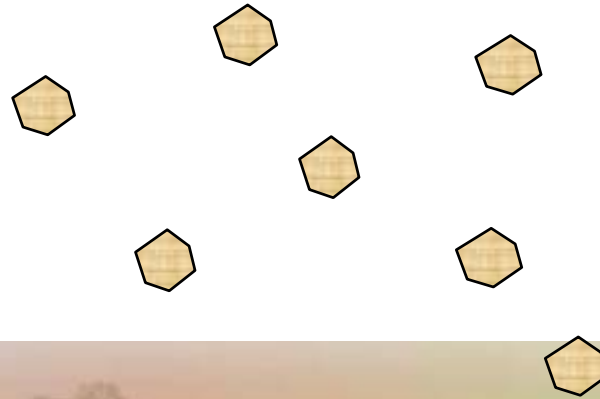
# Wolken und eiskeimaktive Partikel (INPs)



$t > -36\text{ °C}$



INPs



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INPs

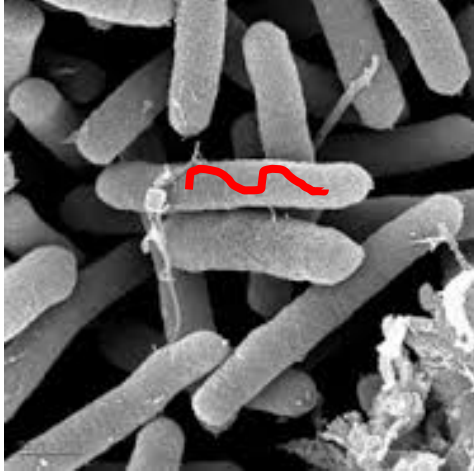


The atmospheric concentrations of IN are very uncertain because of the aforementioned uncertainties in freezing mechanisms and the difficulty of measuring IN in the upper troposphere. (IPCC, 2013-2014)



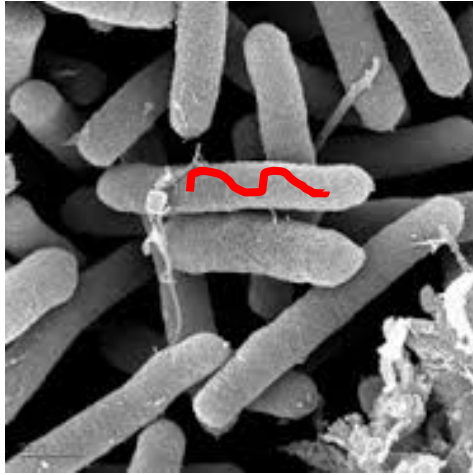


Besonders relevant für biologische INPs, aktiv bei  $> -15\text{ °C}$

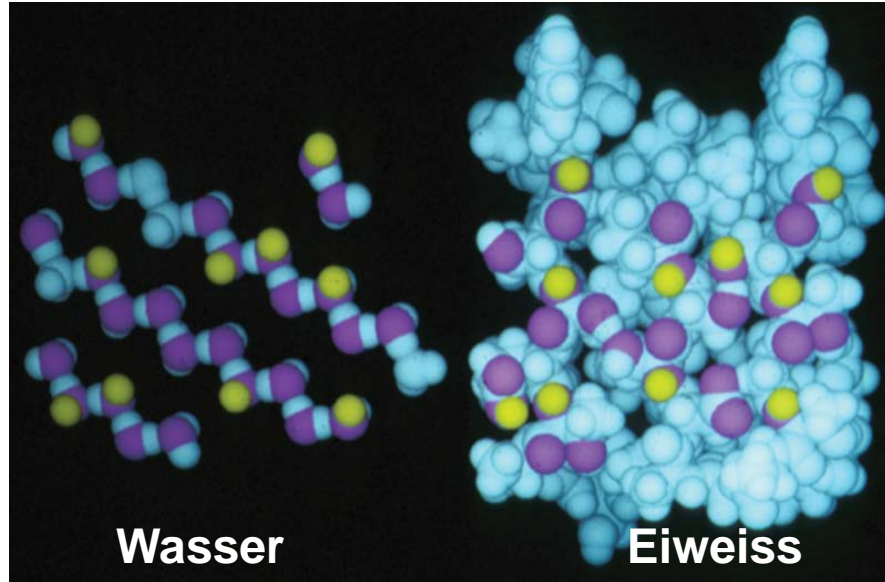


*P. syringae*

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*P. syringae*

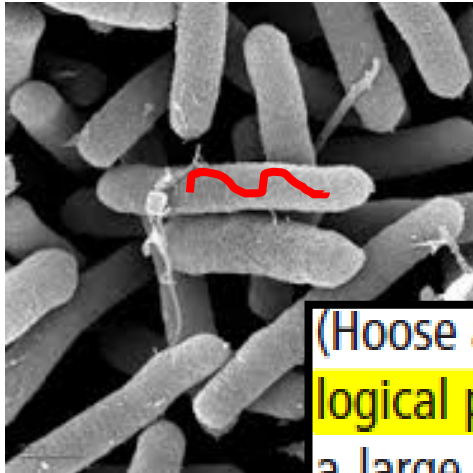


Wasser

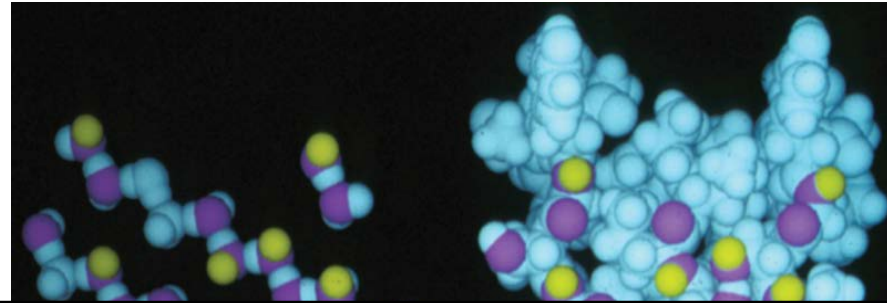
Eiweiss

(from Christner, 2012)

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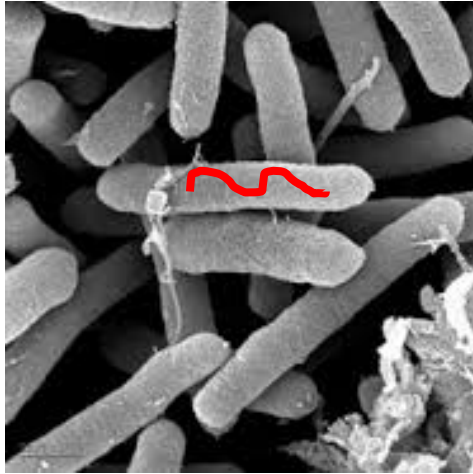
*P. syringae*



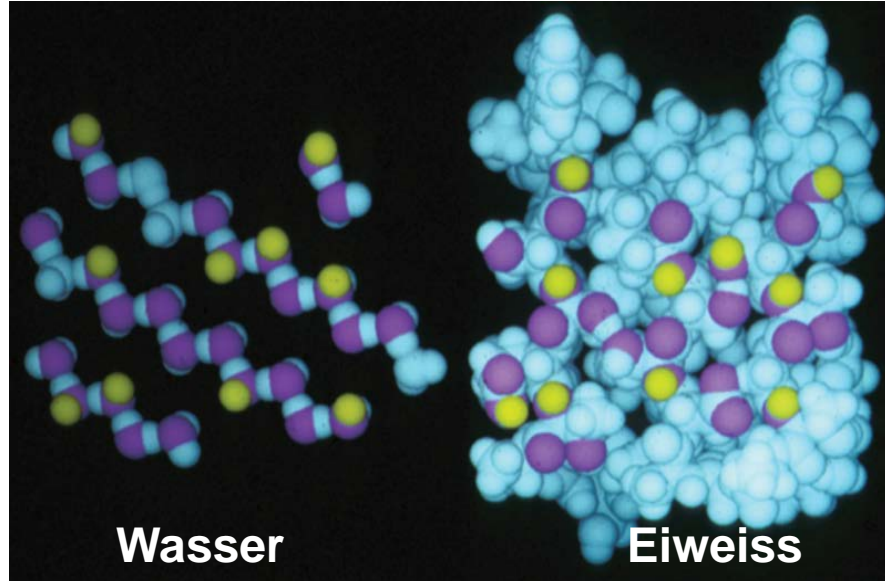
(from Christner, 2012)

(Hoose and Möhler, 2012; Murray et al., 2012). The importance of biological particles acting as IN is unclear. A new study finds evidence of a large fraction of submicron particles in the middle-to-upper troposphere to be composed of biological particles (DeLeon-Rodriguez et al., 2013); however global modelling studies suggest that their concentrations are not sufficient to play an important role for ice formation (Hoose et al., 2010a; Sesartic et al., 2012). Because BC has anthropo-

# Besonders relevant für biologische INPs, aktiv bei > -15 °C



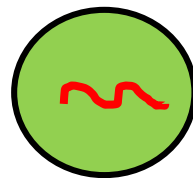
*P. syringae*



(from Christner, 2012)



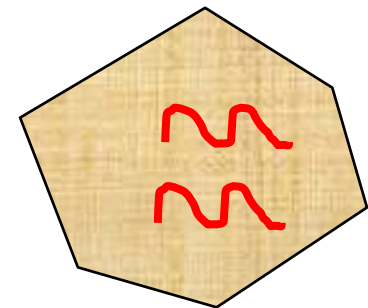
Bakterien



Pilze, Pollen...



Boden und organisch-minerale Verbindungen



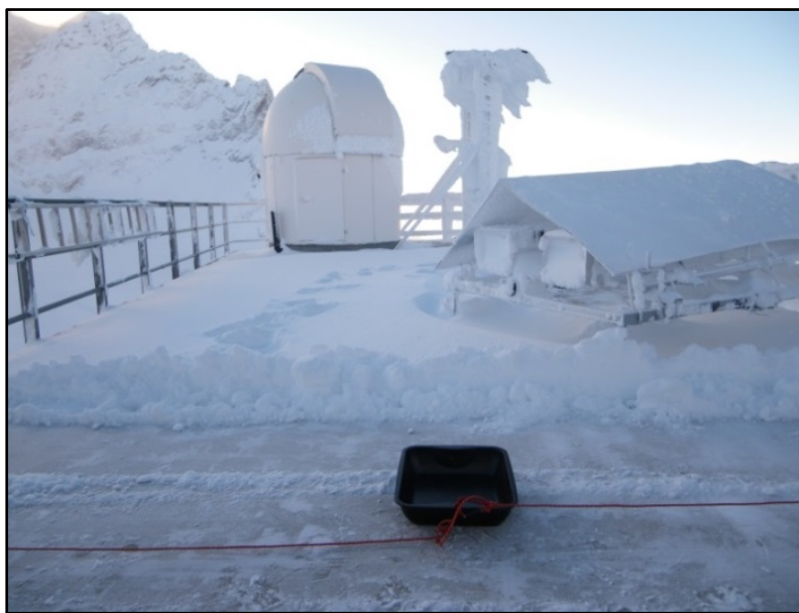
# Was wissen wir durch das Jungfraujoch?



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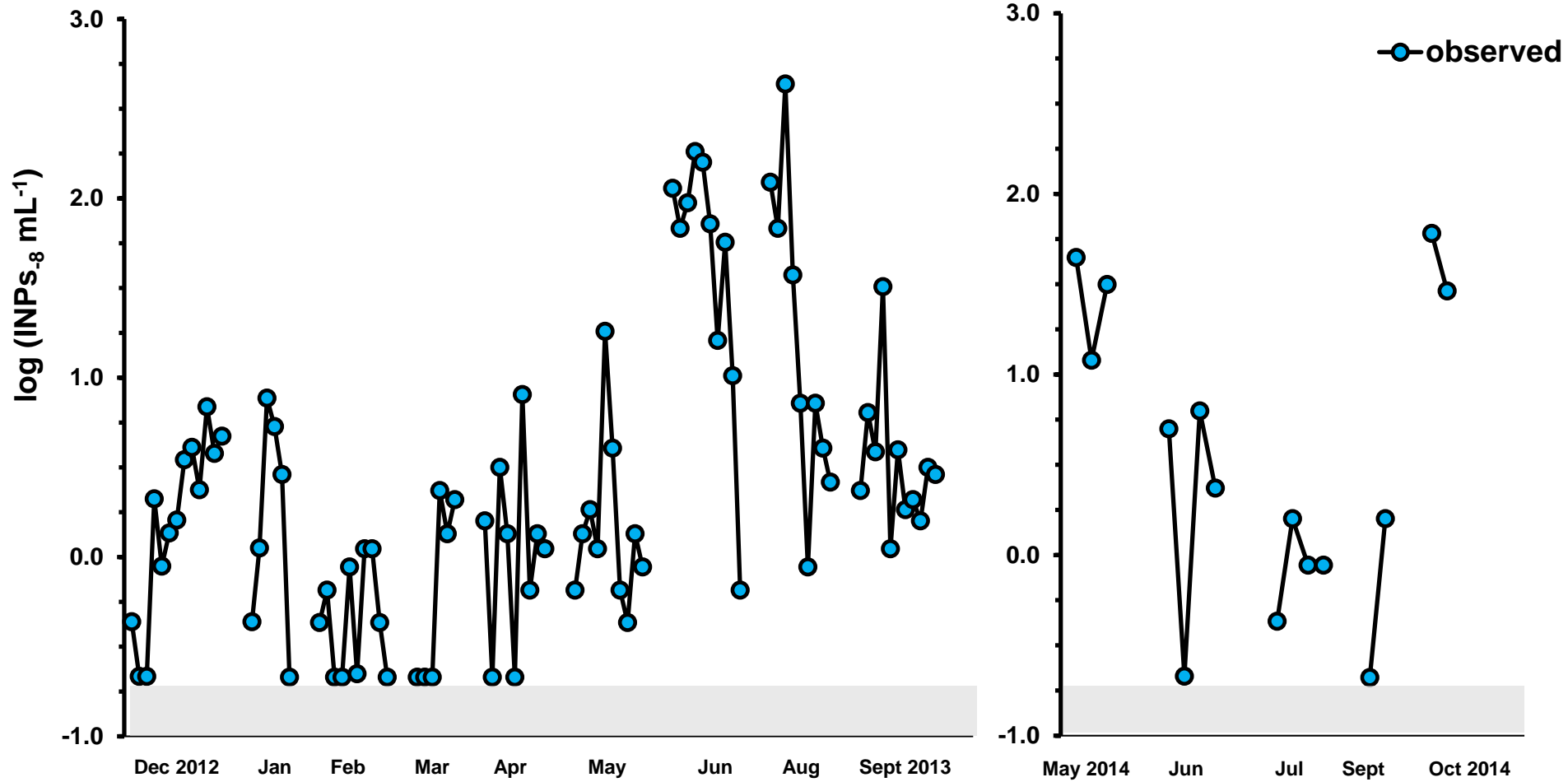


# Was wissen wir durch das Jungfraujoch?



**LINDA**

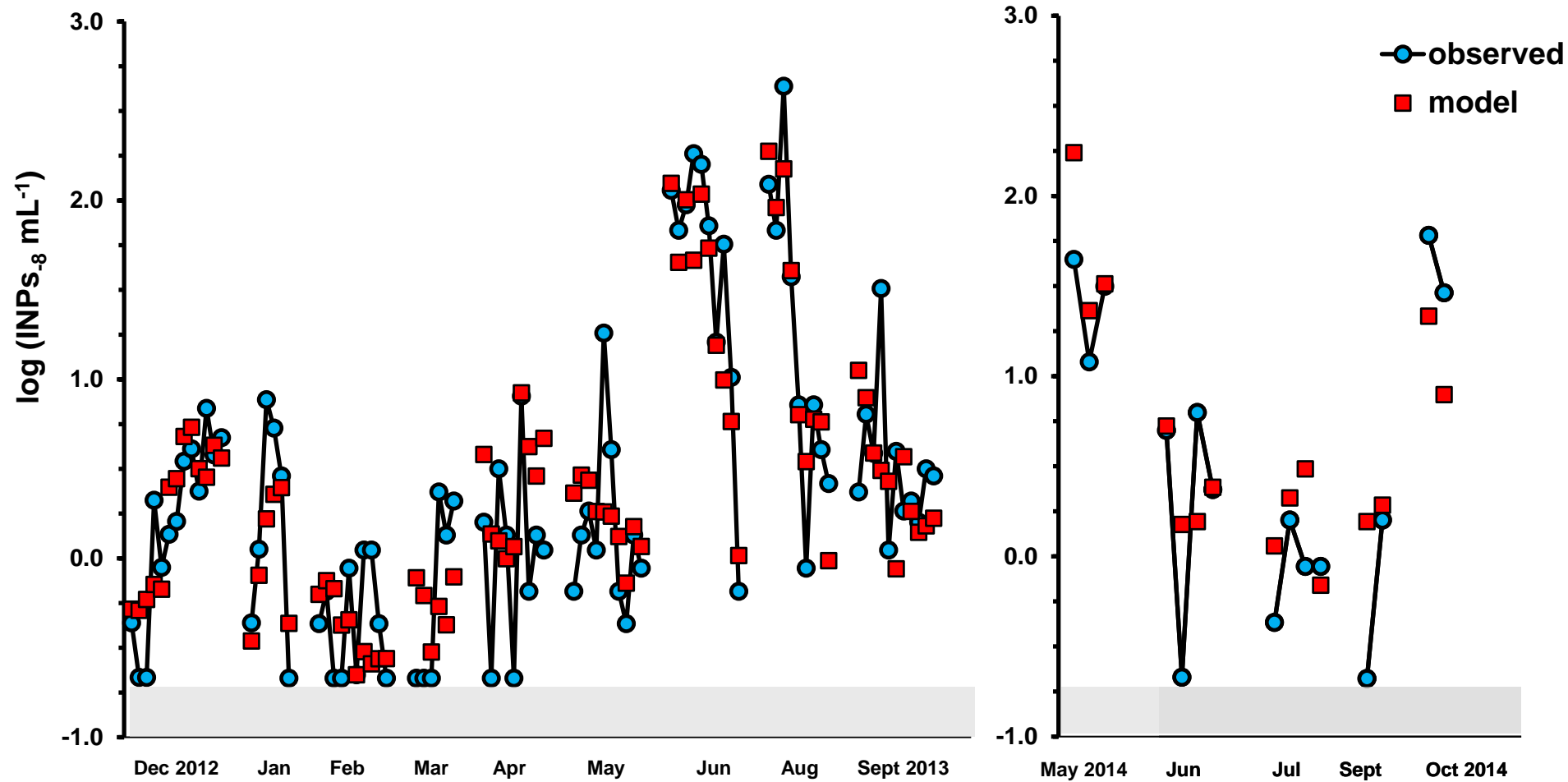
# INPs<sub>8</sub> im Niederschlag auf dem Jungfraujoch



■ Grosse Variabilität über die Zeit



# INPs<sub>8</sub> im Niederschlag auf dem Jungfrauojoch



■ Grosse Variabilität über die Zeit

■ **Gute Nachricht: 75% vorhersagbar durch einfach messbare Parameter**

# INPs<sub>8</sub> im Niederschlag auf dem Jungfraujoch

- Statistische Modellierung basiert auf Umweltparameter

**“Source”- INPs Nachfüllen**

**“Sink”- INPs Verlust vor der Ankunft auf JFJ**

# INPs<sub>8</sub> im Niederschlag auf dem Jungfraujoch

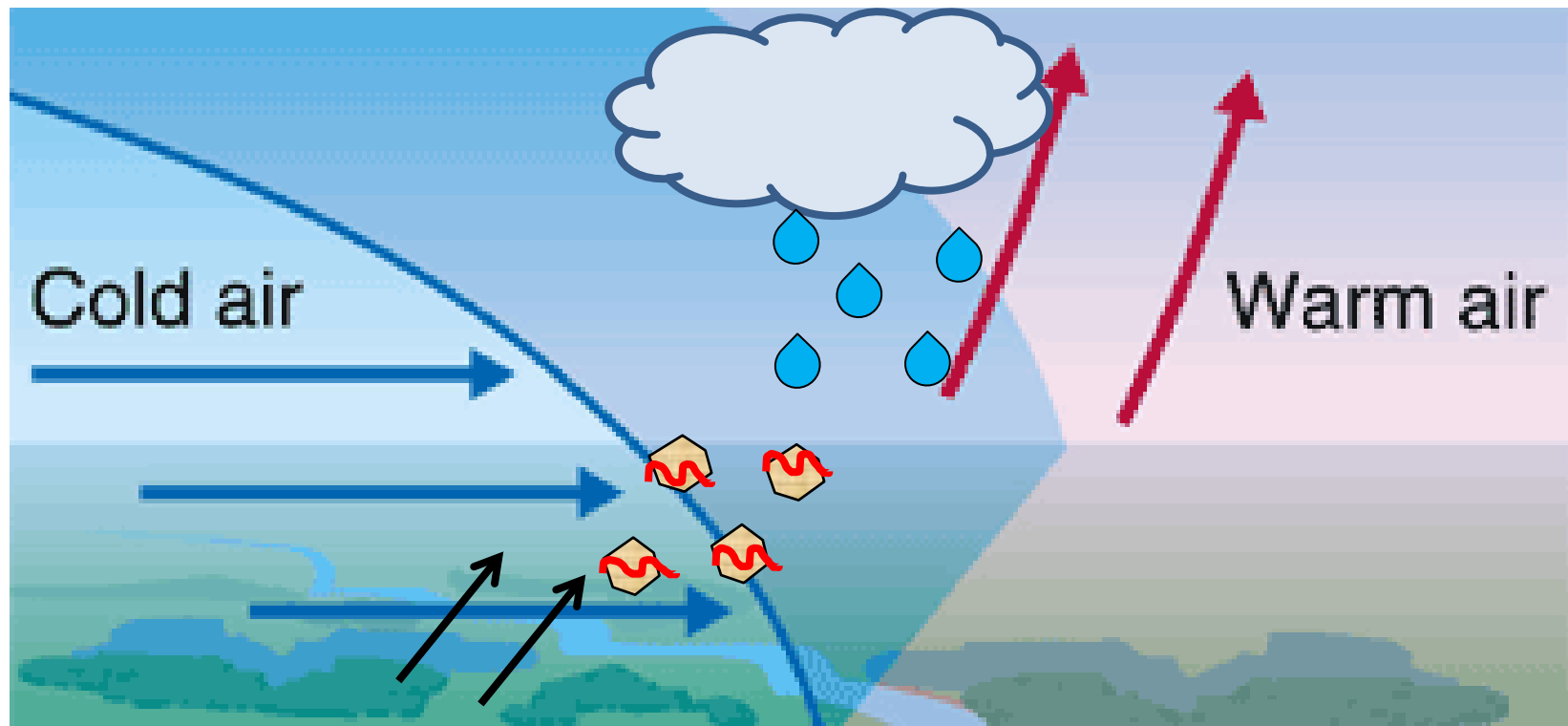
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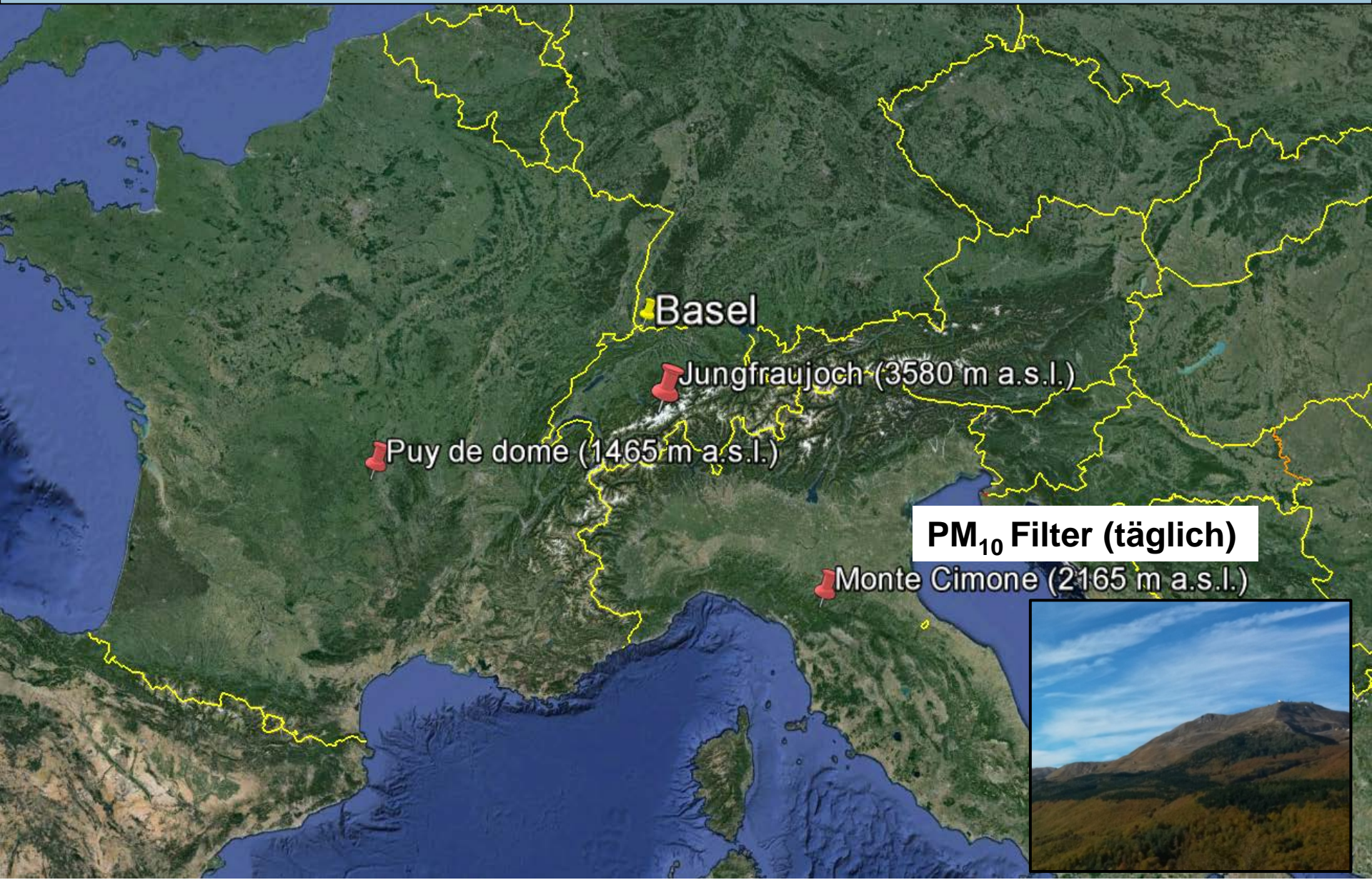
“Source”- INPs Nachfüllen

“Sink”- INPs Verlust vor der Ankunft auf JFJ

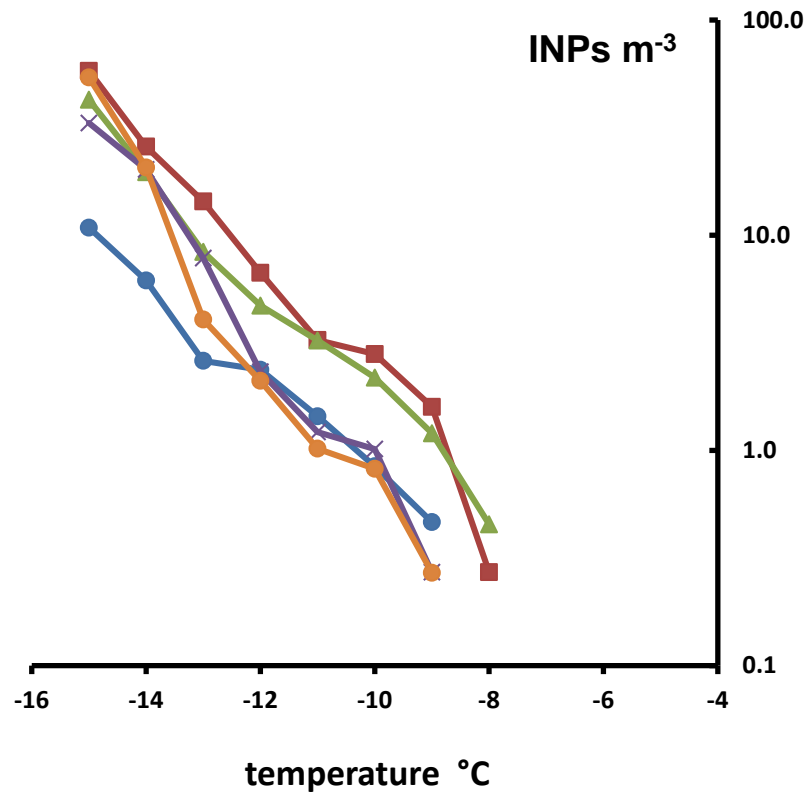
- Viele INPs: mit **hoher Windgeschwindigkeit** und **erstem Niederschlag**

→ Frontüberquerung



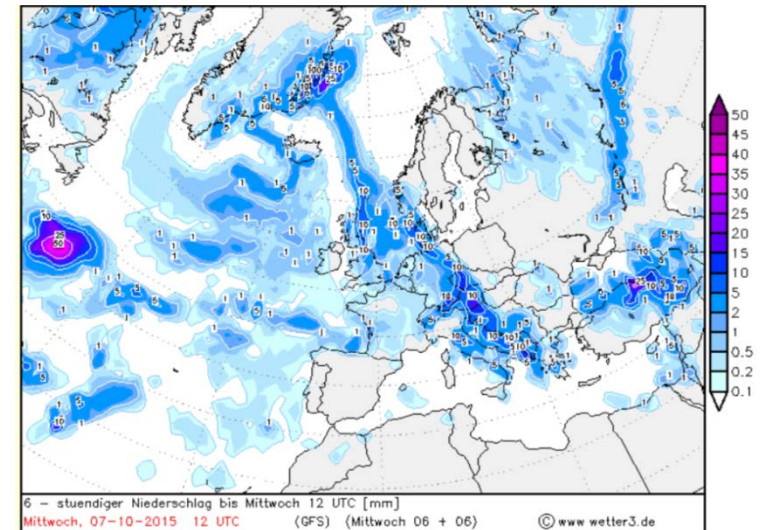
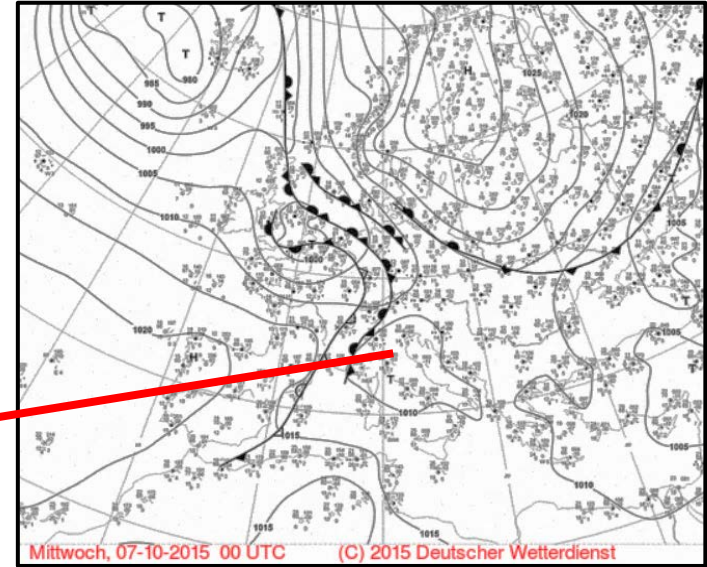
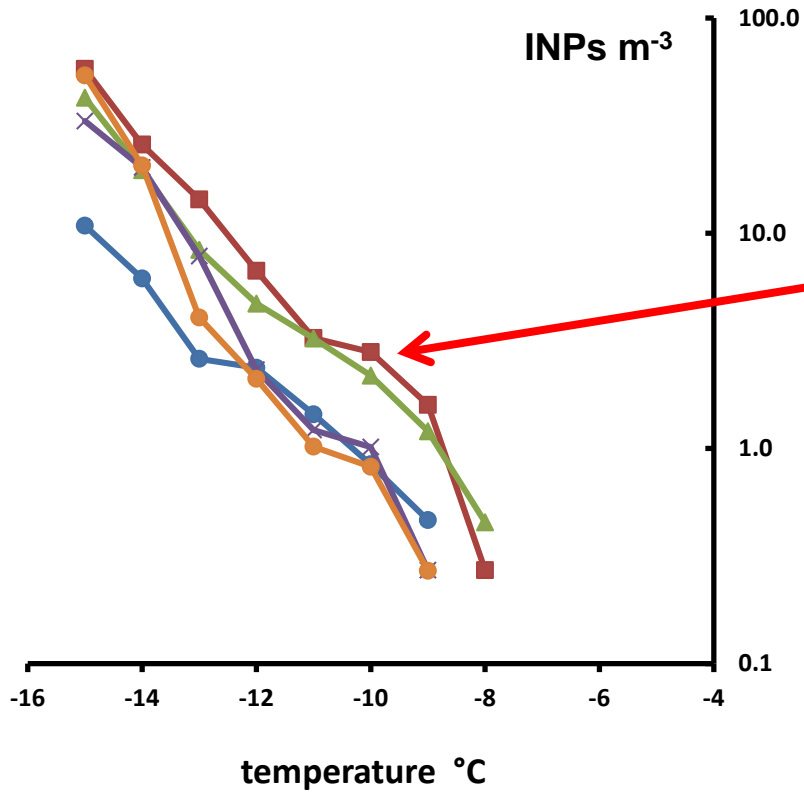


# Luftgetragene INPs auf dem Cimone

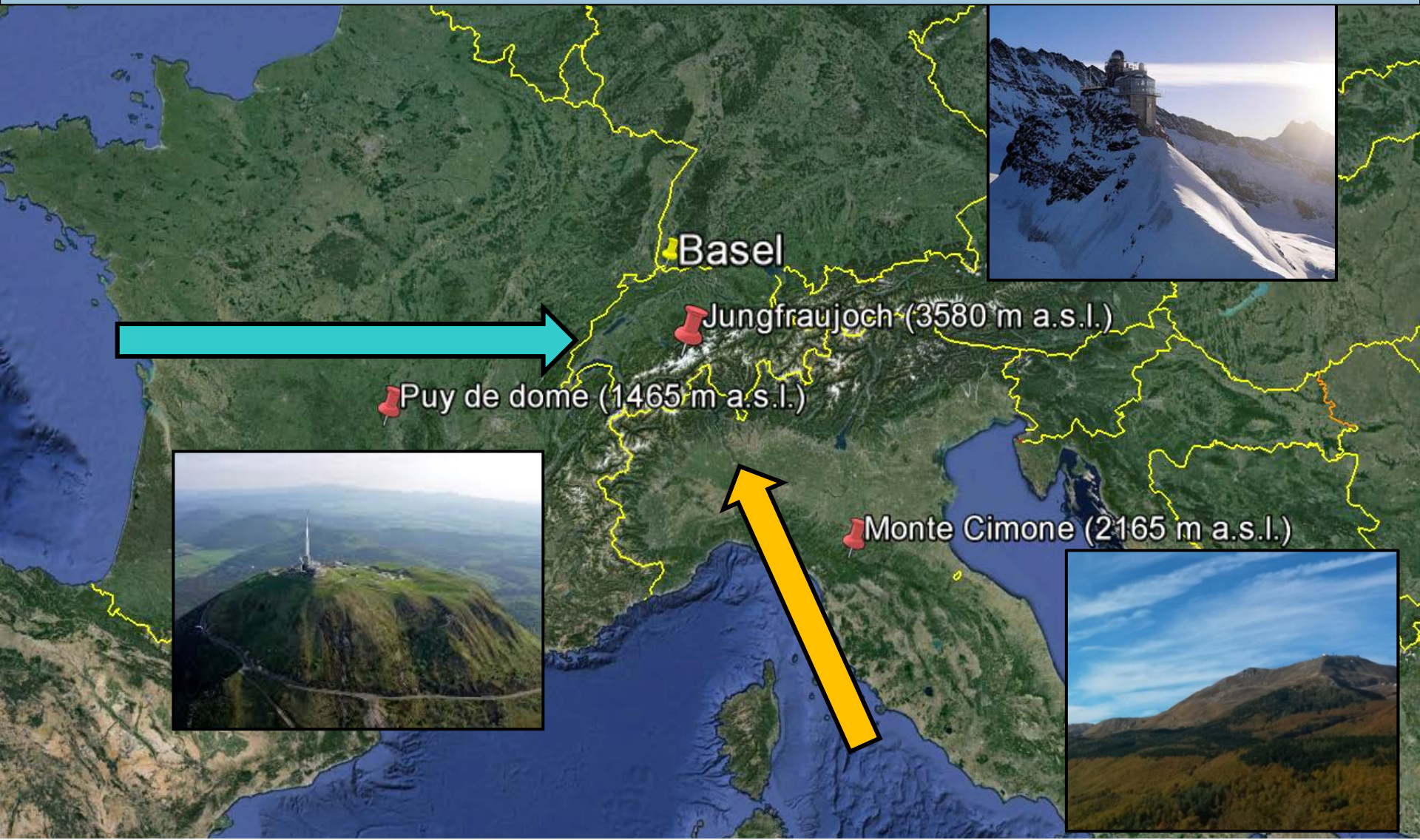


# Luftgetragene INPs auf dem Cimone

06/07.10: Frontüberquerung



Dauerndes Netzwerk von Messstationen  
→ räumliche Variabilität der INPs  
→ Feedbacks mit Klimawandel und Landnutzung



# Schlussfolgerungen


- Warum sind (biologische) Eiskeime wichtig?
- Relevanz der Höhenforschung
- Netzwerke der Messstationen



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- Warum sind (biologische) Eiskeime wichtig?
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- Netzwerke der Messstationen
  
- Weitere Forschung
  - auf dem Jungfraujoch (high altitude)
  - in Norwegen (high latitude)

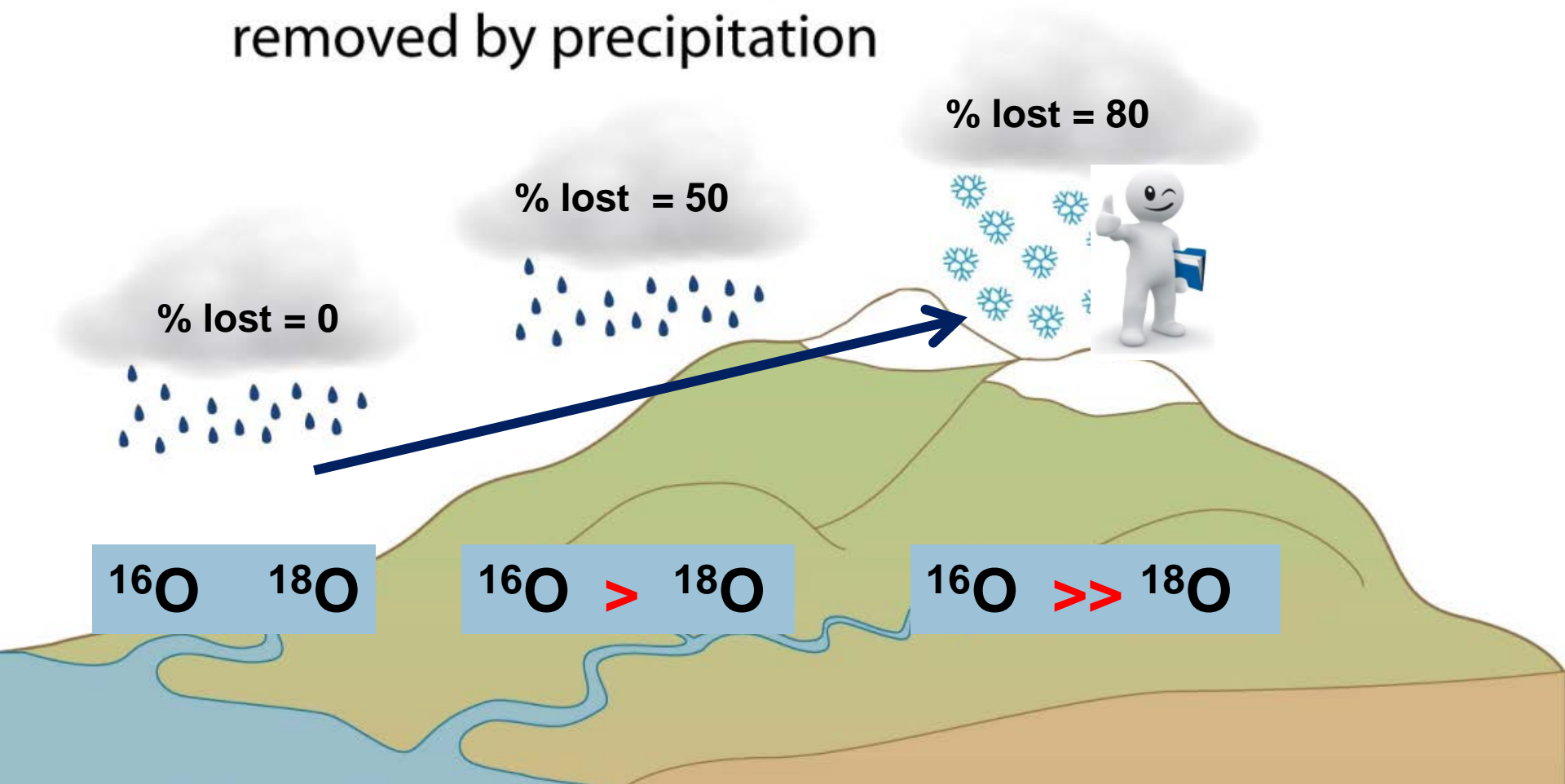
# Dankeschön an:



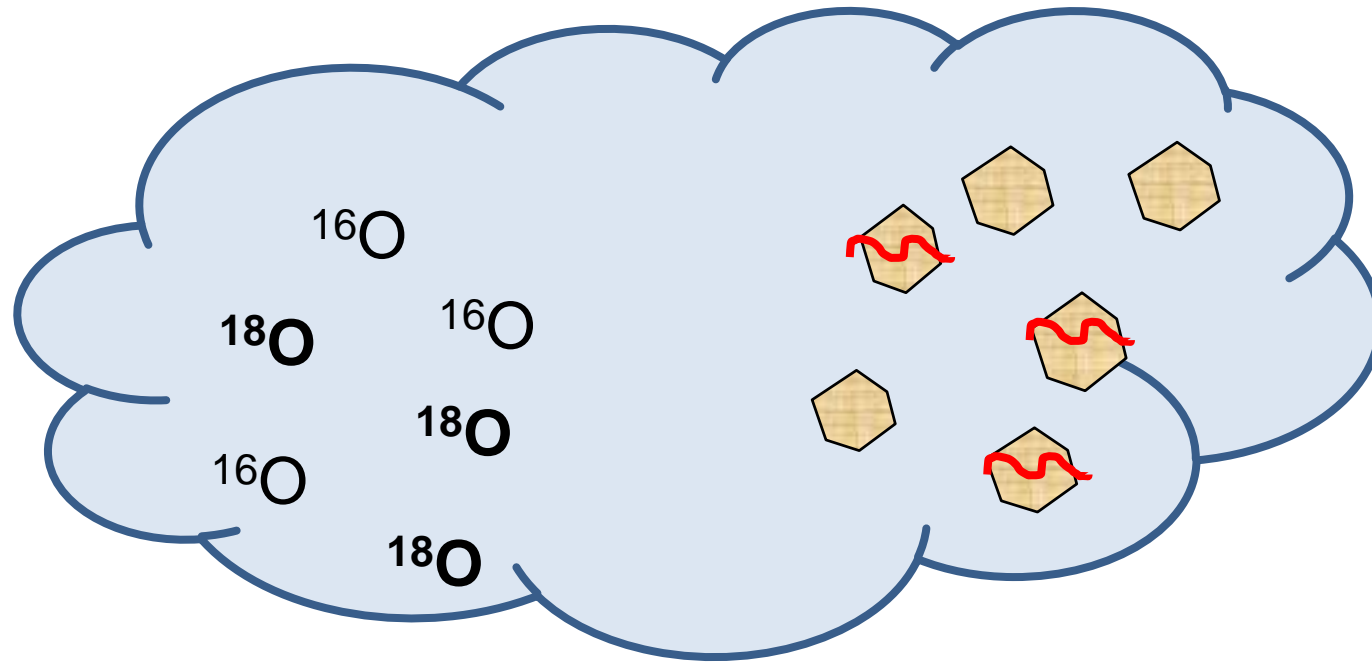
**Schweizerische Kommission für Polar- und Höhenforschung**  
**Schweizerische Kommission für hochalpine Forschungsstation Jungfrauoch**  
**Schweizerische Stiftung für Alpine Forschung**  
**Prof. Alewells Gruppe, Dr. Cindy Morriss Gruppe**  
**Wissenschaftler, Studenten und Hausmeister (Otz und Fischer) auf dem JFJ**

# $^{18}\text{O}/^{16}\text{O}$ informs on the fraction of water lost from a precipitating air mass

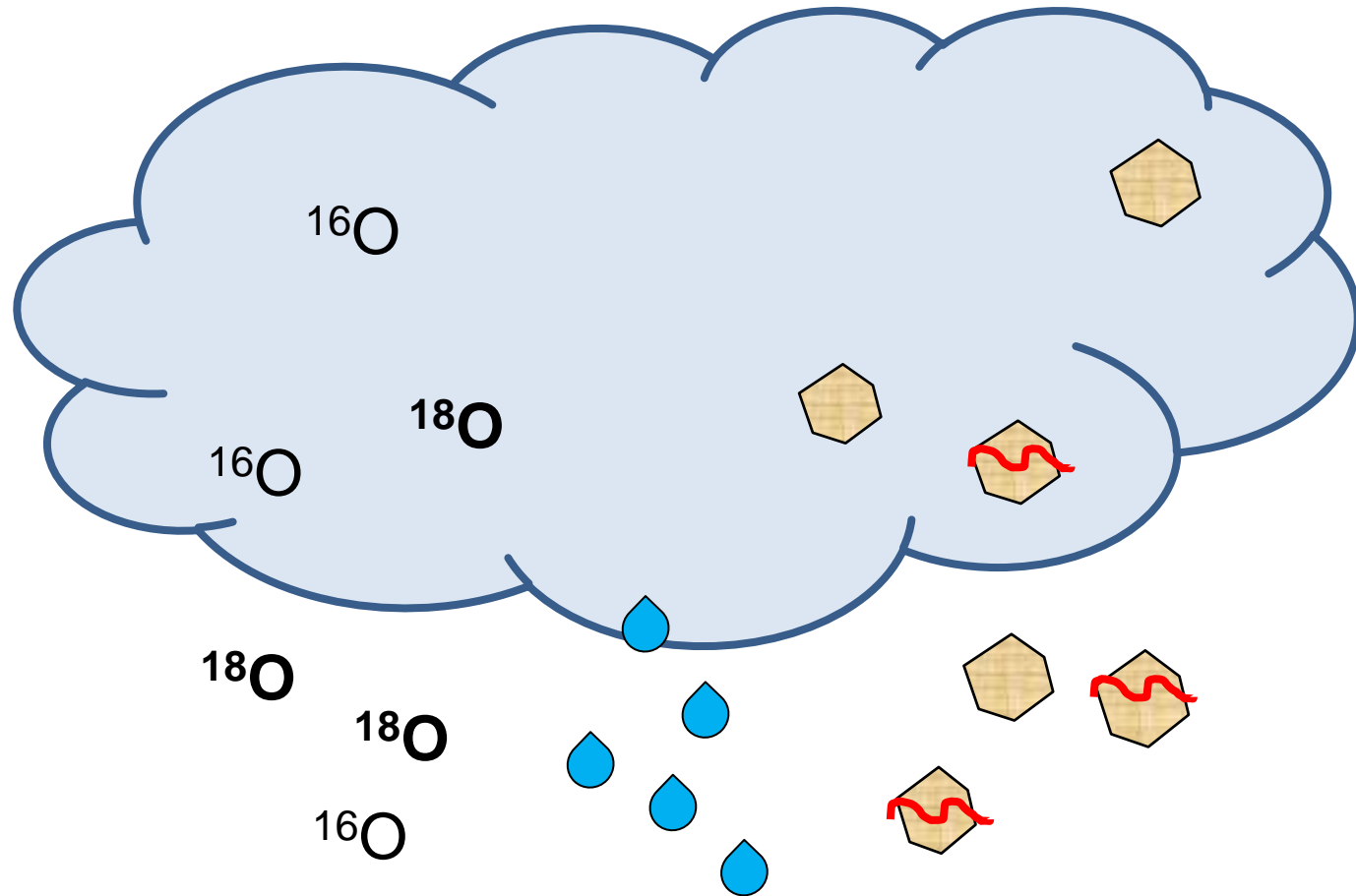
$^{18}\text{O}$  is preferentially removed by precipitation



# INPs are efficiently removed by precipitation



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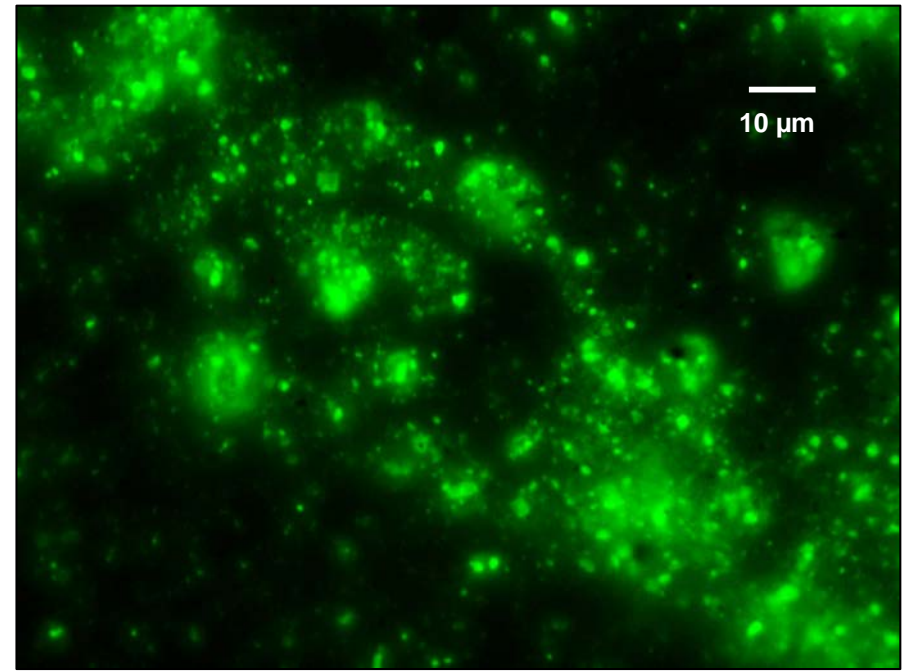


- At early stages of precipitation
- Preferentially compared to particles of similar size ( $N_{>0.5}$ )

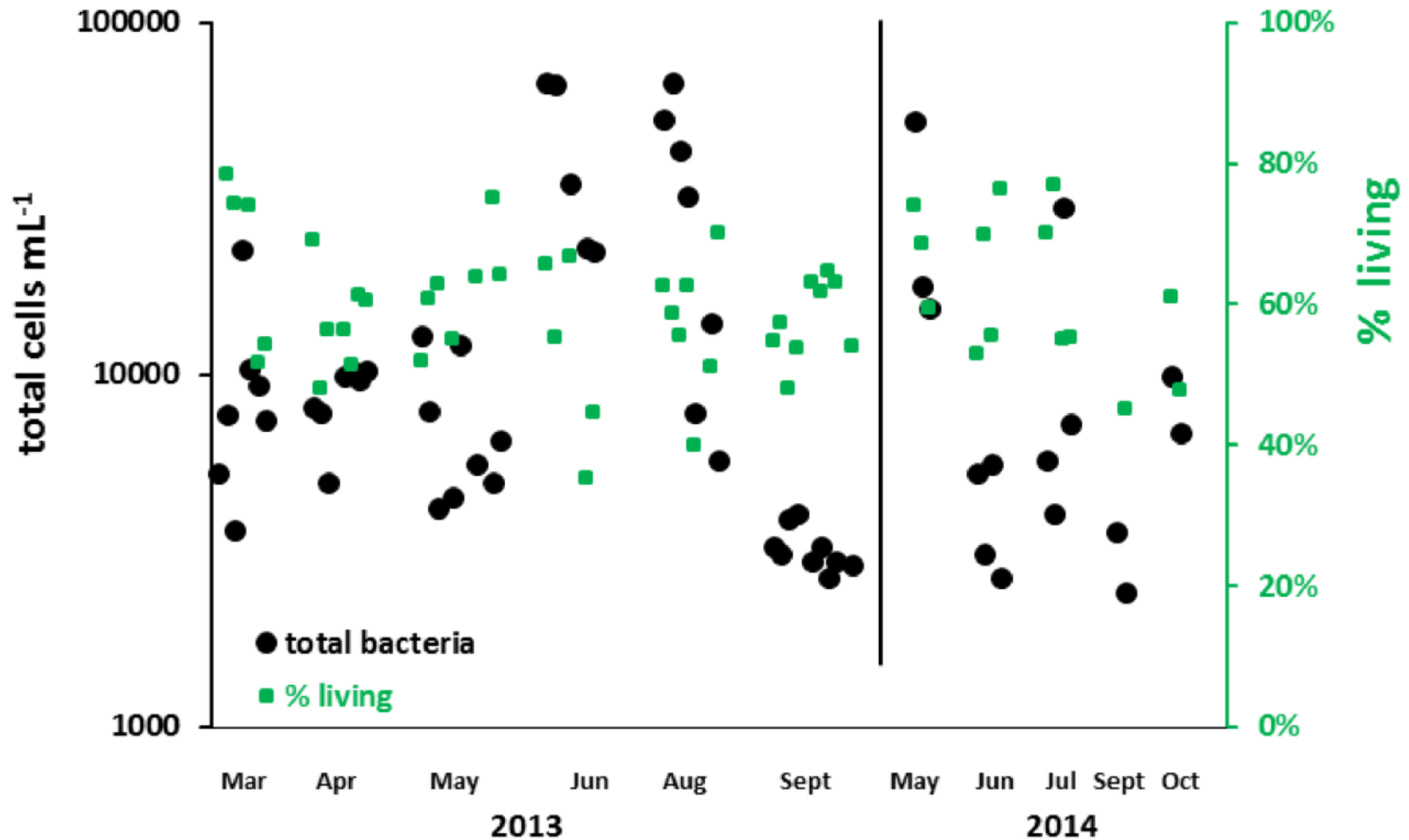
# Bacteria in precipitation at Jungfrauoch



- Atmosphere is a hostile environment
  - Survival? Ecosystem? Dispersal possibilities? Nucleating precipitation?
- ex. Spread of crop diseases



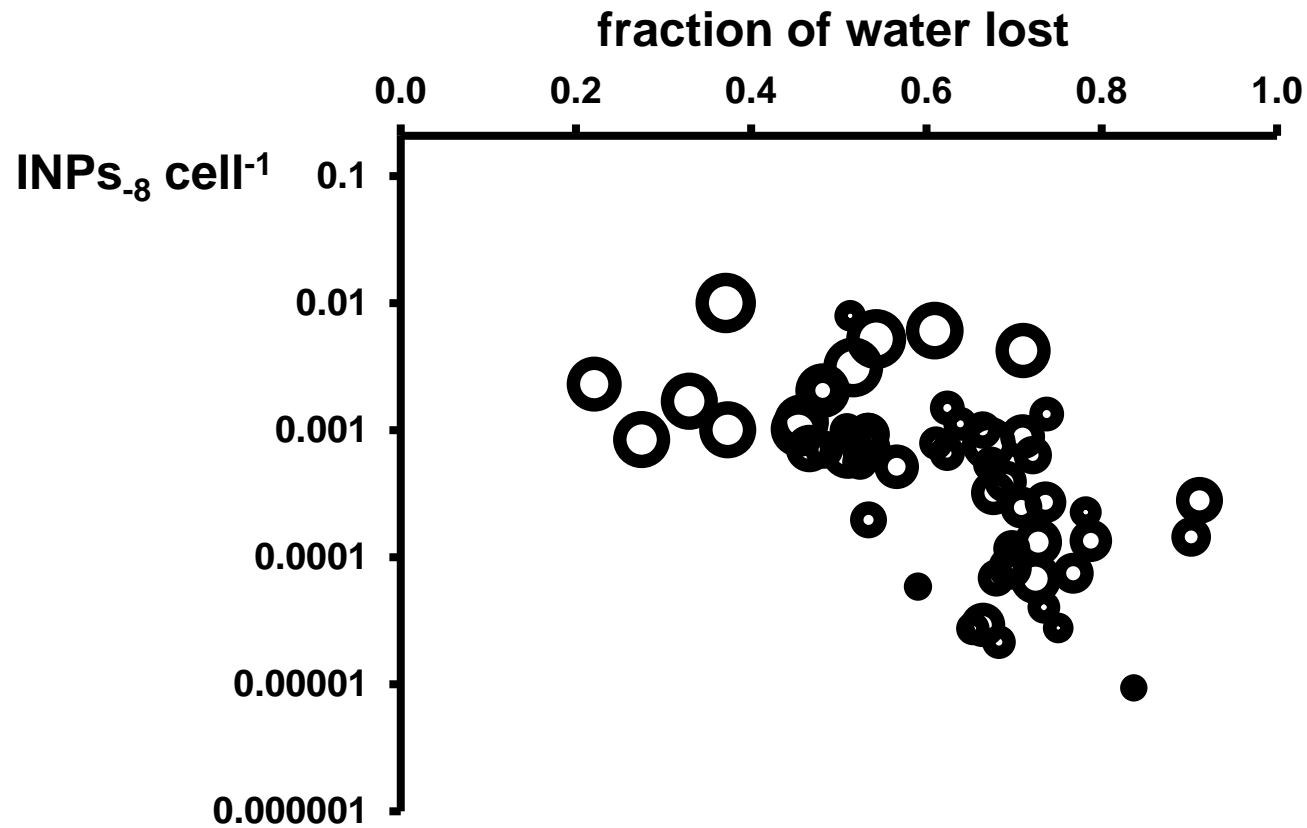
# Bacteria in precipitation at Jungfraujoch



- $2.4 \cdot 10^6$  to  $6.8 \cdot 10^7$  cells L<sup>-1</sup>, 60% living
- Injections with high wind speed  $> 50 \text{ km h}^{-1}$  (yes “source”)
- Not much sensitive to the fraction of water lost (weak wet “sink”)

**INPs<sub>8</sub>: source and sink → larger variations → shorter time/distance**

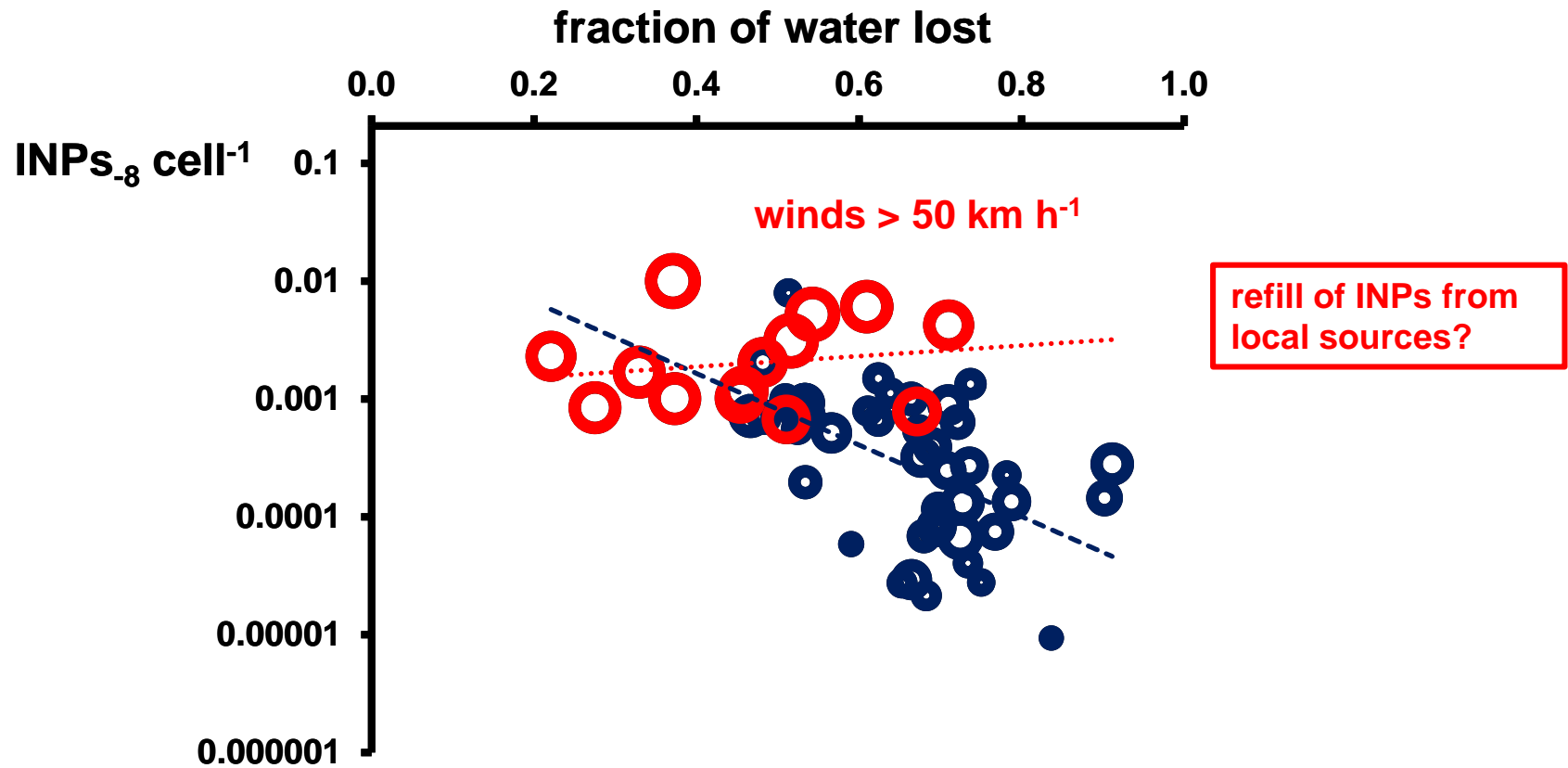
**Bacteria: source → smaller variations → longer time/distance**



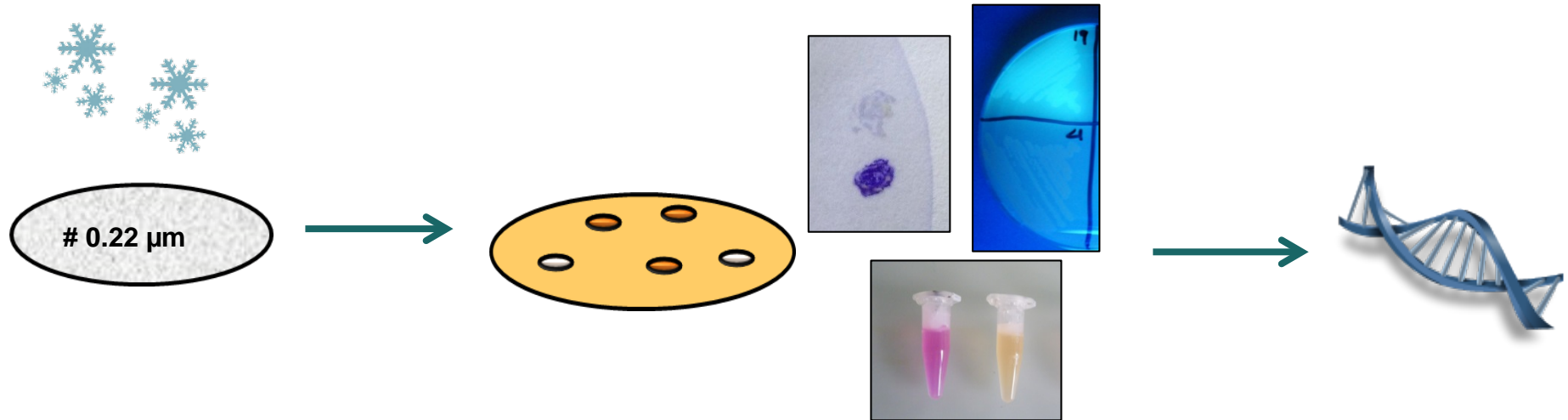


**INPs<sub>8</sub>: source and sink → larger variations → shorter time/distance**

**Bacteria: source → smaller variations → longer time/distance**



# *P. syringae* in precipitation at Jungfrauoch



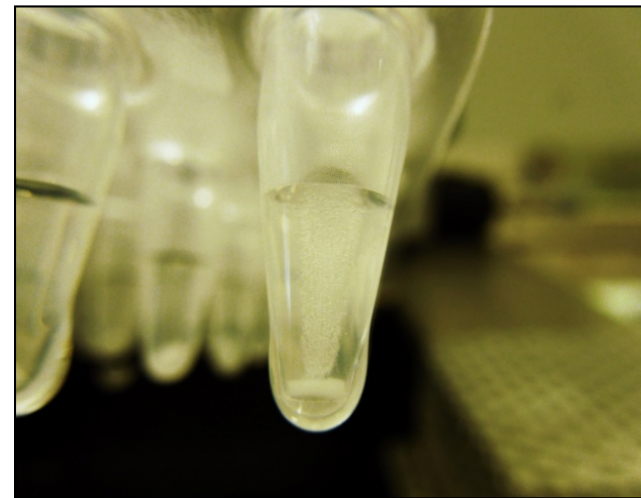
*P. syringae* successfully isolated also at 3580 m a.s.l. (3/13)

- 16/24 IN active and 21/24 potentially pathogenic strains
- associated with large numbers of INPs<sub>8</sub>

**2 - 45 CFU L<sup>-1</sup>** VS 10<sup>6</sup>-10<sup>7</sup> bacterial cells L<sup>-1</sup> AND 10<sup>4</sup>-10<sup>5</sup> INPs<sub>8</sub> L<sup>-1</sup>

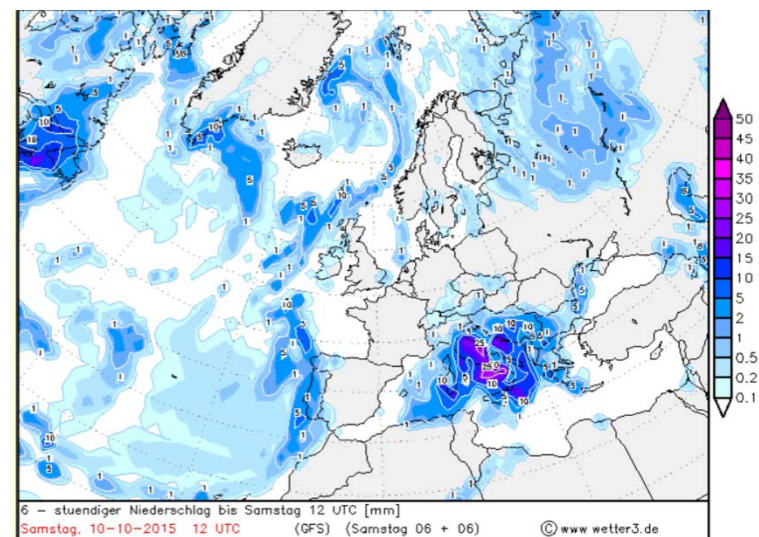
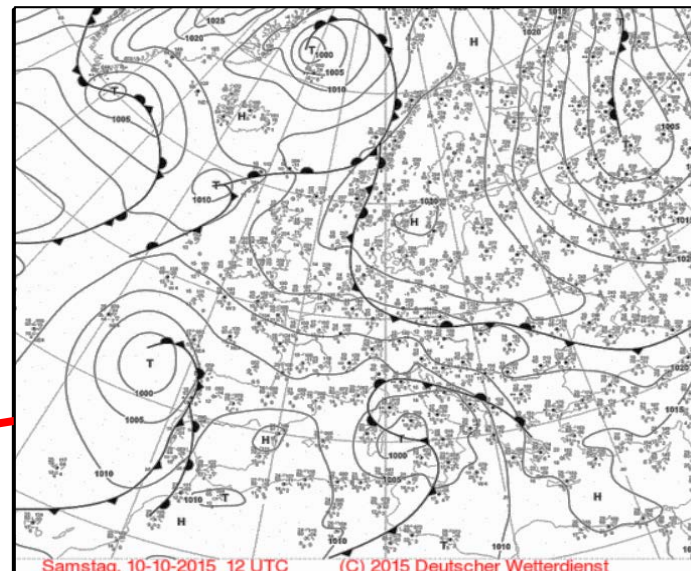
- efficiently removed by precipitation (>> concentrations at < altitudes)
- effect of atmospheric exposure on culture
- **more passenger than driver of precipitation at JFJ**

# PM<sub>10</sub> Methode

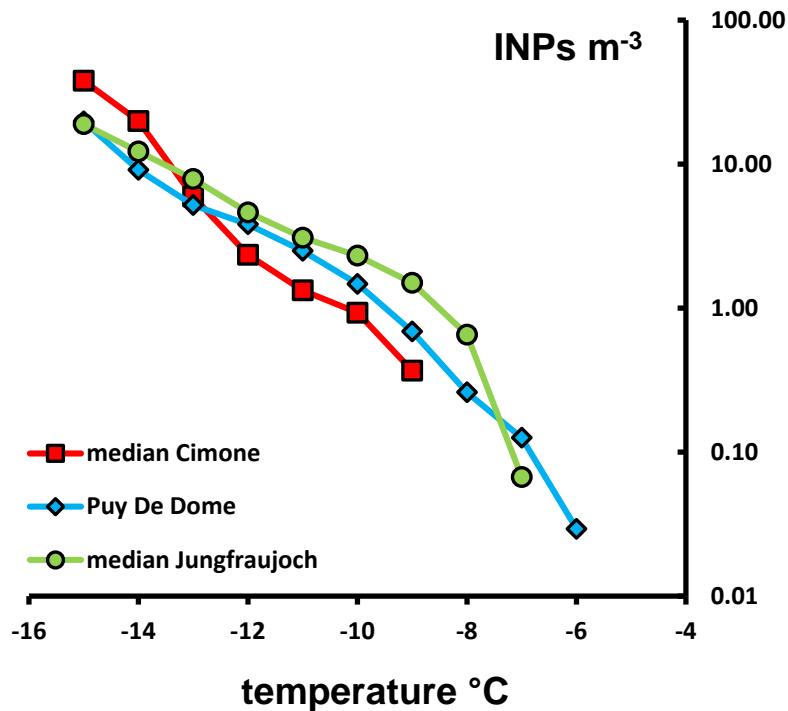


# Airborne INPs auf dem Cimone

10.10: front passage, precipitation!

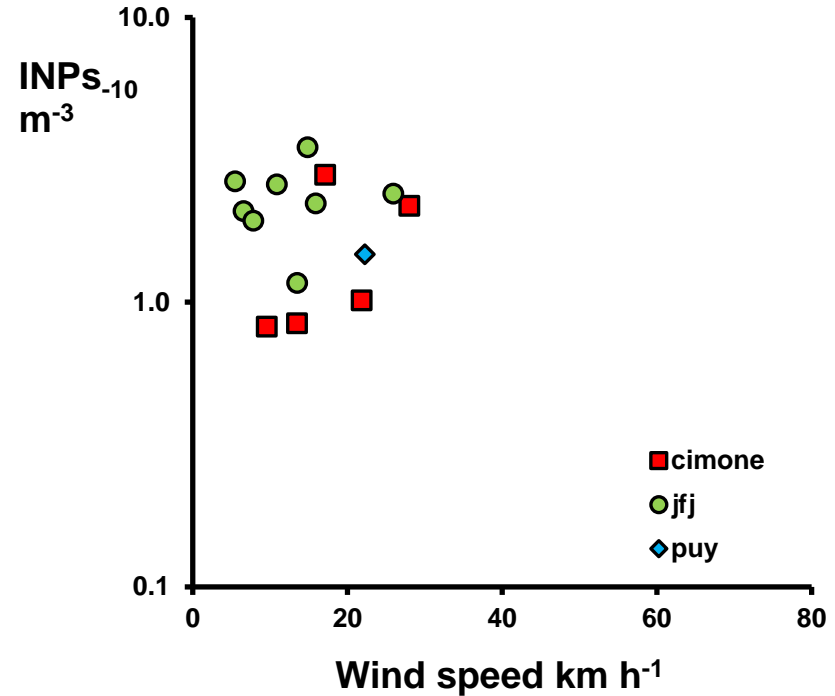
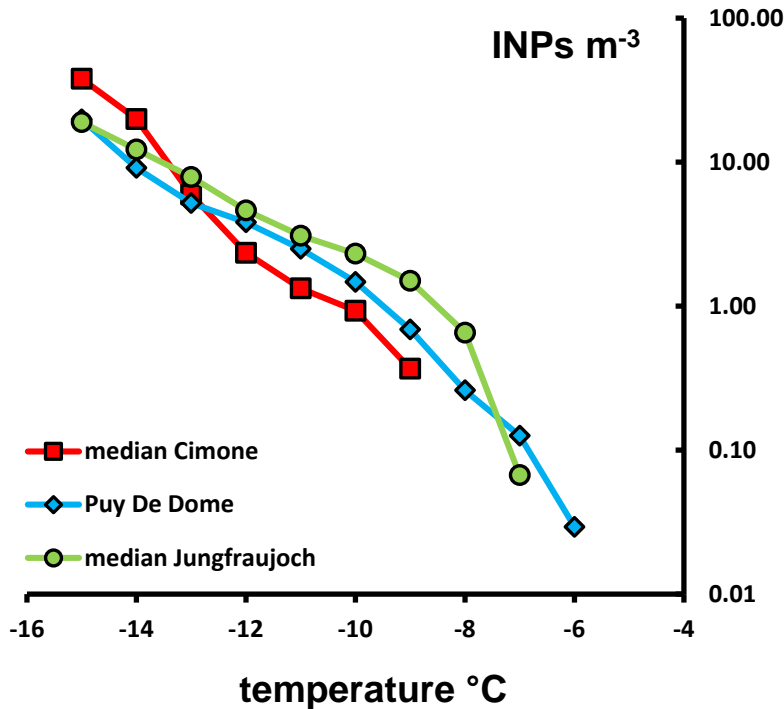


# Luftgetragene INPs an den 3 Messstationen



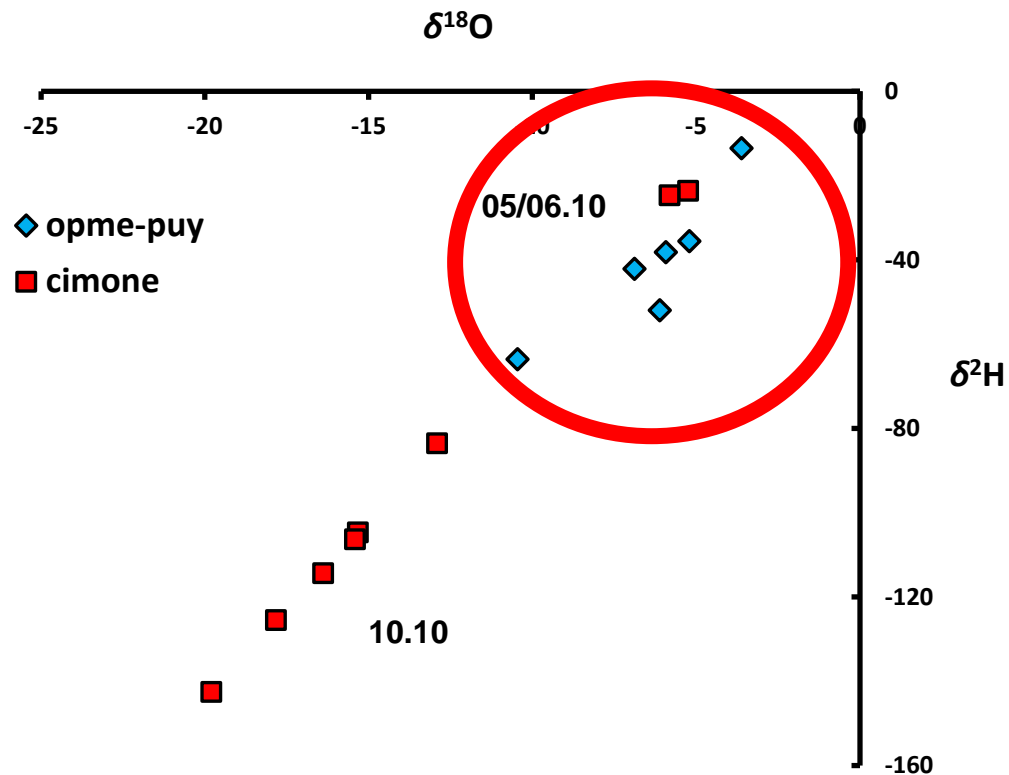
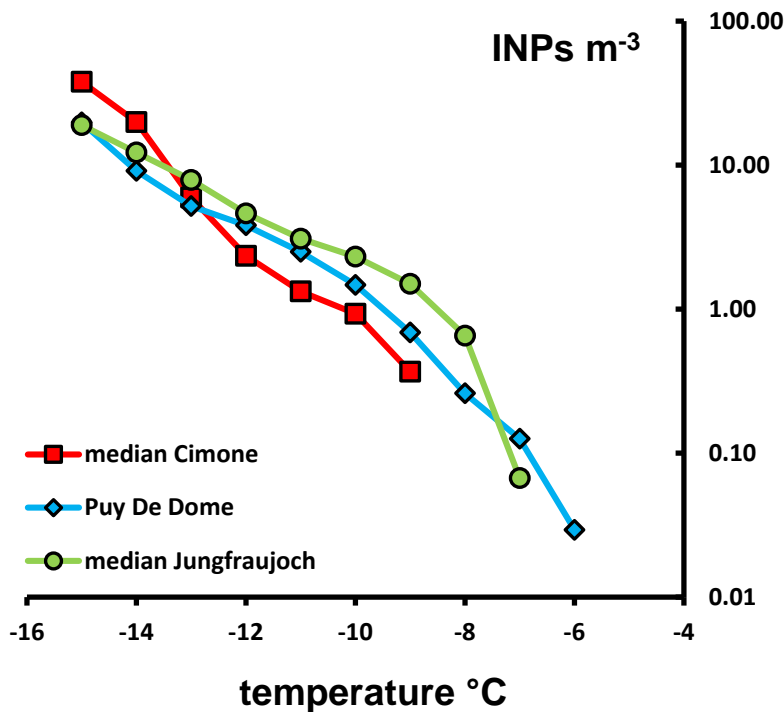
- **Wenig Variabilität...**
- Durchschnittliche Werte von vielen Stunden

# Luftgetragene INPs an den 3 Messstationen



- **Wenig Variabilität...**
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- Ähnliche atmosphärische Bedingungen → Wind und Isotope

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## PM<sub>10</sub> filters

## Precipitation



- Off site analysis
- Archives
- Common method
- Simple analysis

- Connection with isotopes
- Better temporal resolution
- Simple analysis

- Automatic sampling (+/-)
- Better if inside clouds



- Averaging several hours
- Continuous PM<sub>10</sub> measurements
- Different samplers and procedures
- Droplets?

- Operator on site
- Necessity of fast analysis

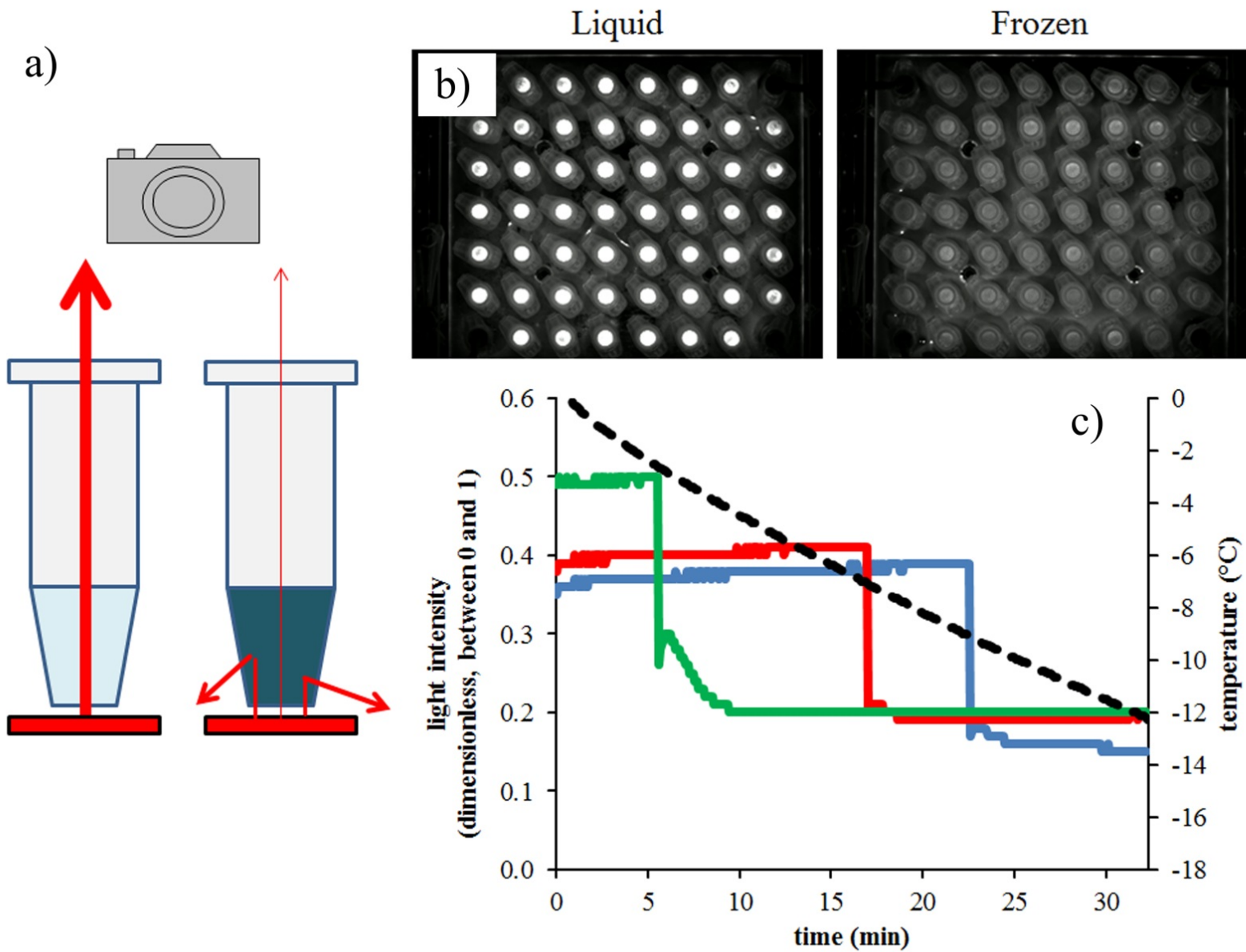


# *P. syringae* in precipitation at Jungfraujoch

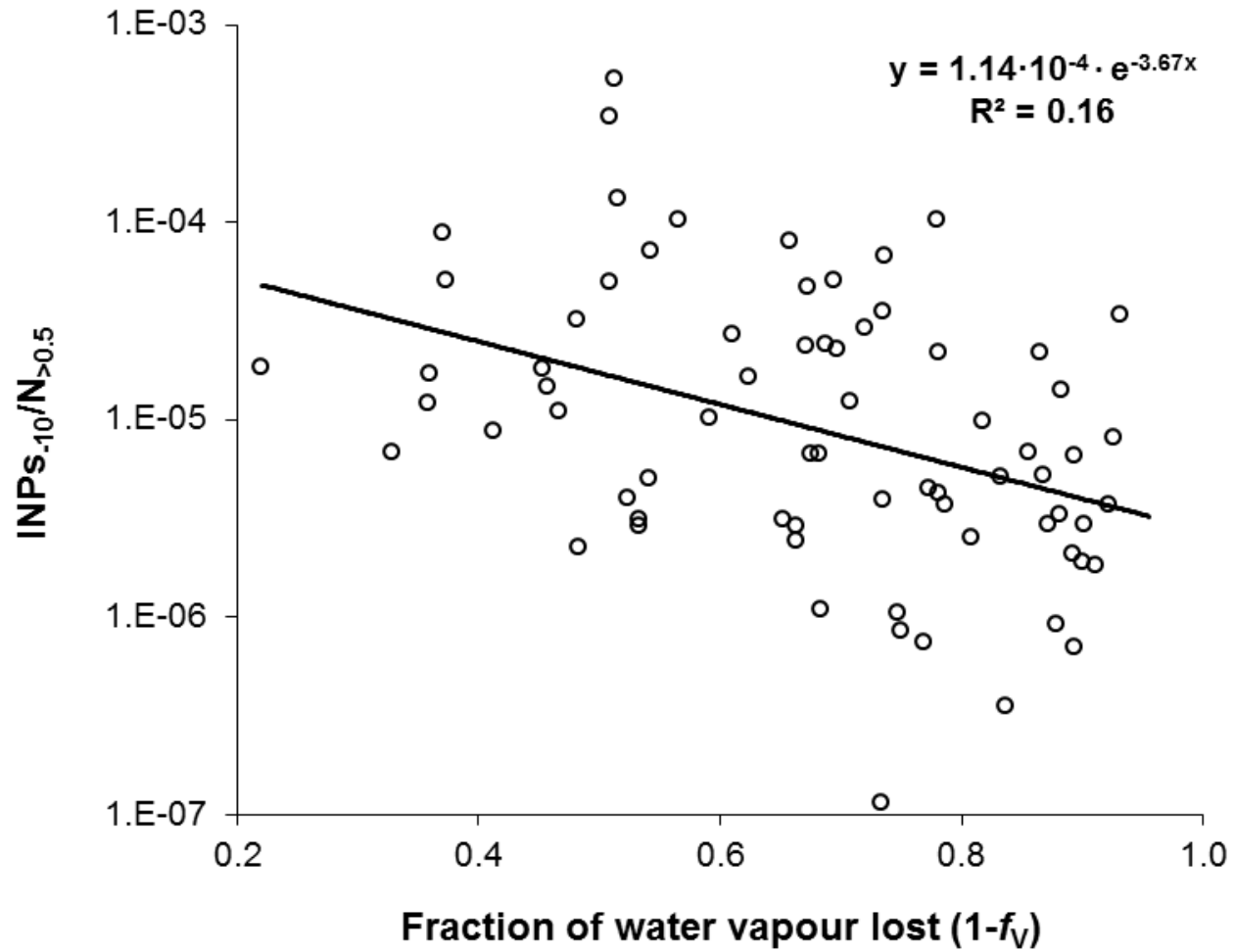
- 16/24 strains were IN active and 21/24 potentially pathogens
- Almost all known phylogroups: few rich sources or several sources?

Strain	Date	Phylogroup <sup>1</sup>	INA <sup>2</sup>	HR <sup>3</sup>
JFJ-0007	22 May 2014	2	-4.2	+
JFJ-0008	22–23 May 2014	3	–	–
JFJ-0011	22–23 May 2014	5	-3.7	+
JFJ-0039	21–22 Oct 2014	1	–	+
JFJ-0045	21–22 Oct 2014	1	–	+
JFJ-0048	21–22 Oct 2014	1	–	+
JFJ-0061	21–22 Oct 2014	1	–	+
JFJ-0043	21–22 Oct 2014	2	-2.6	+
JFJ-0047	21–22 Oct 2014	2	–	–
JFJ-0050	21–22 Oct 2014	2	-3.6	+
JFJ-0052	21–22 Oct 2014	2	-2.7	+
JFJ-0054	21–22 Oct 2014	2	-2.2	+
JFJ-0055	21–22 Oct 2014	2	-2.2	+
JFJ-0058	21–22 Oct 2014	4	–	+
JFJ-0056	21–22 Oct 2014	7	-2.9	+
JFJ-0059	21–22 Oct 2014	7	-4.9	+
JFJ-0040	21–22 Oct 2014	10	-4.2	+
JFJ-0044	21–22 Oct 2014	10	-2.1	+
JFJ-0049	21–22 Oct 2014	10	-2.8	+
JFJ-0051	21–22 Oct 2014	10	-2.9	+
JFJ-0053	21–22 Oct 2014	10	-4.0	+
JFJ-0060	21–22 Oct 2014	10	-2.8	+
JFJ-0046	21–22 Oct 2014	13	–	–
JFJ-0057	21–22 Oct 2014	13	–	+

# LINDA



# INPs preferentially lost



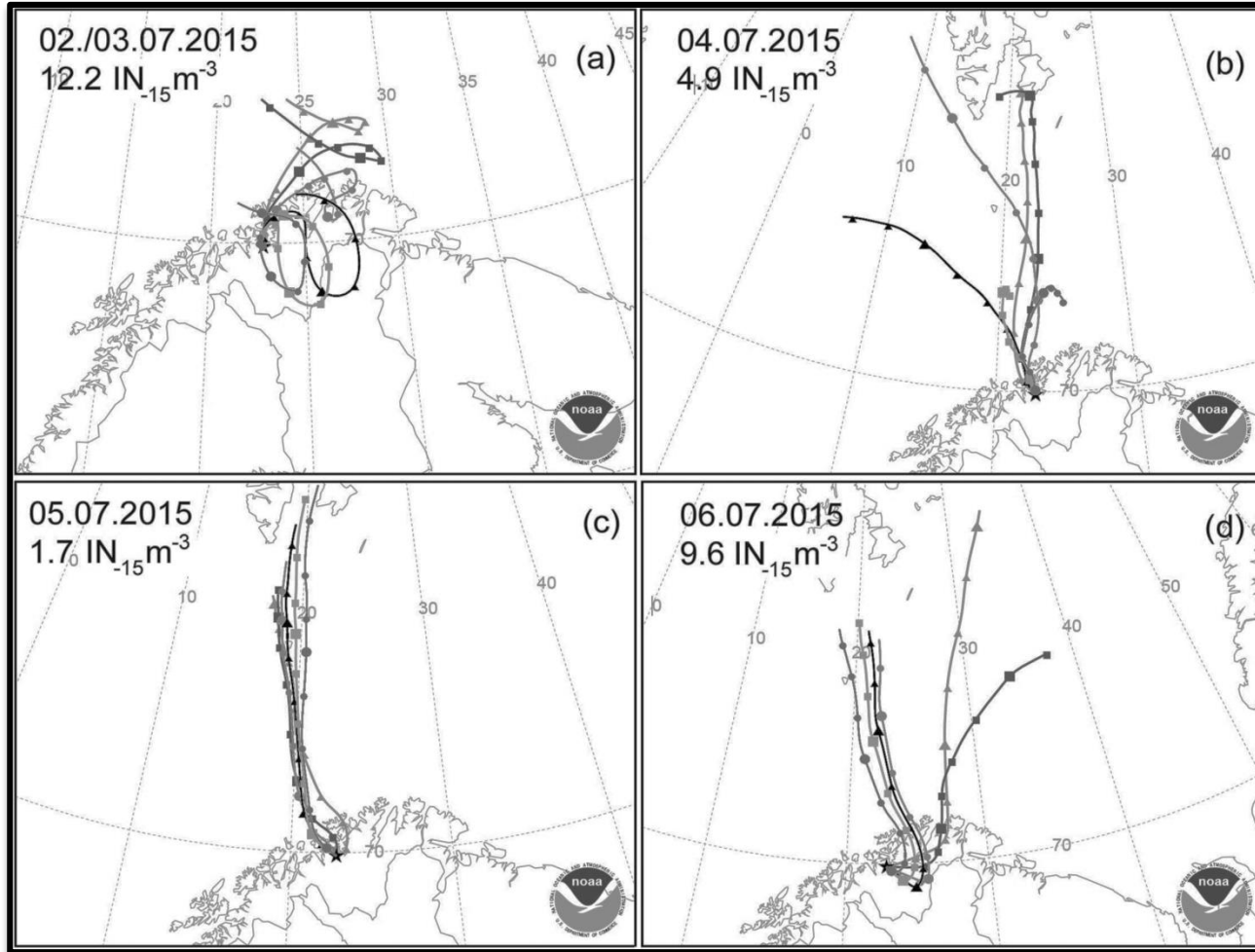
# Observations in the Arctic



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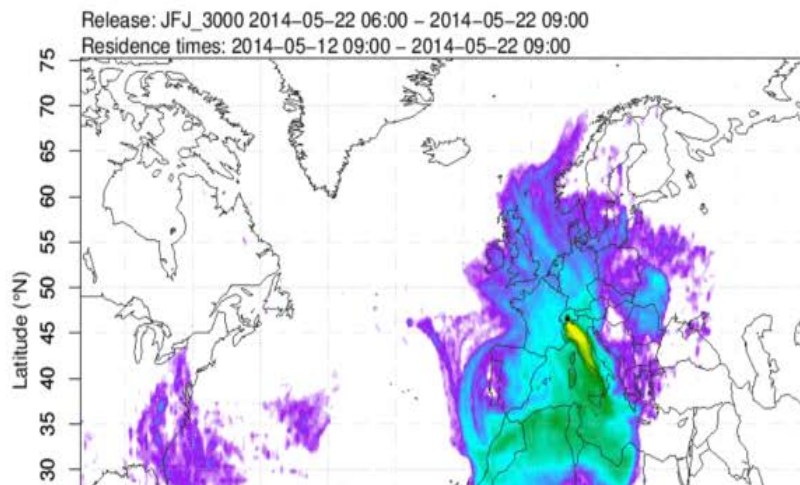


# Observations in the Arctic



- Enrichment of INPs in air masses passing over land
- Leaf litter as candidate: huge reservoir → effectively airborne?
- INPs-limited environment → greening and effects of INPs on clouds

# A Sahara dust event



# B Event from Northern Europe

