SnT 2019
CTBT: SCIENCE AND TECHNOLOGY CONFERENCE

Uncertainties in Numerical Weather Forecasting Models and infrasound simulations as observed by the ARISE project

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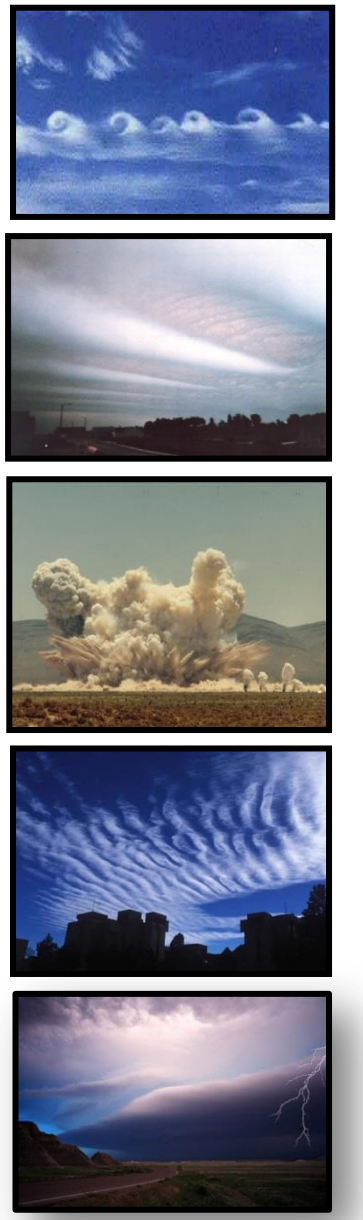
Outline

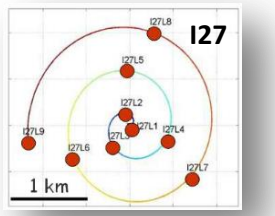
- Variability of the middle atmosphere is at the origin of uncertainties in infrasound monitoring
- ARISE project: multi-instrument observations, including infrasound IMS system and complementary instruments
- Improving the representation of disturbances in weather and climate models as well as in infrasound routine simulations



International infrasound Monitoring System (IMS) for the verification of the CTBT

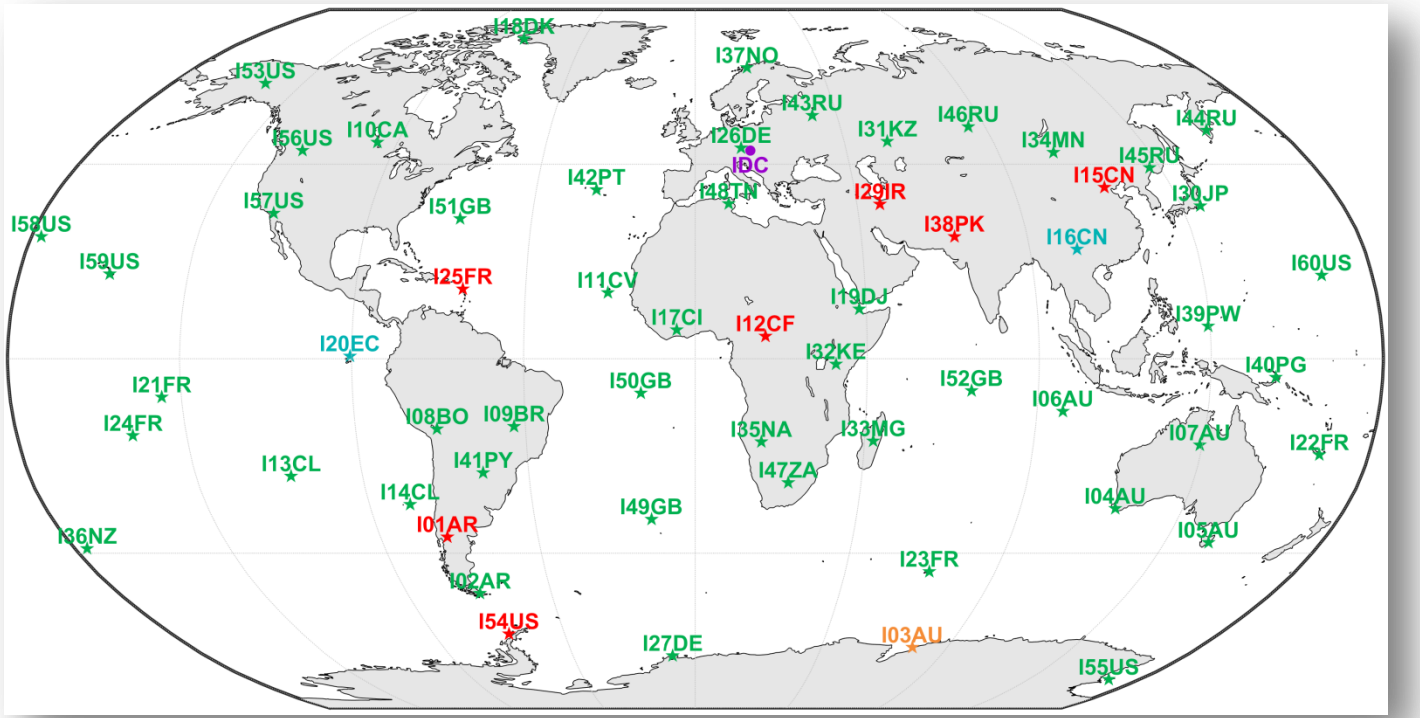
Broadband Microbarometers
(CEA –MB2005 and MB3)

Noise reduction systems



Station configuration

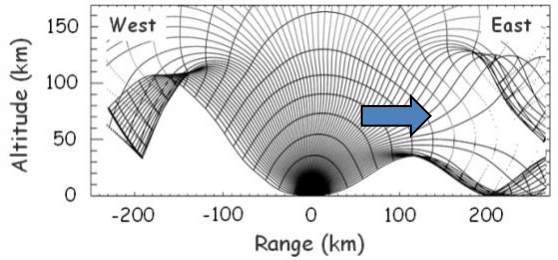
Station mini-arrays
⇒ Very sensitive acoustic antennas



❑ The IMS infrasound network (51 certified stations, 60 when completed) provides relevant global observations of most atmospheric disturbances

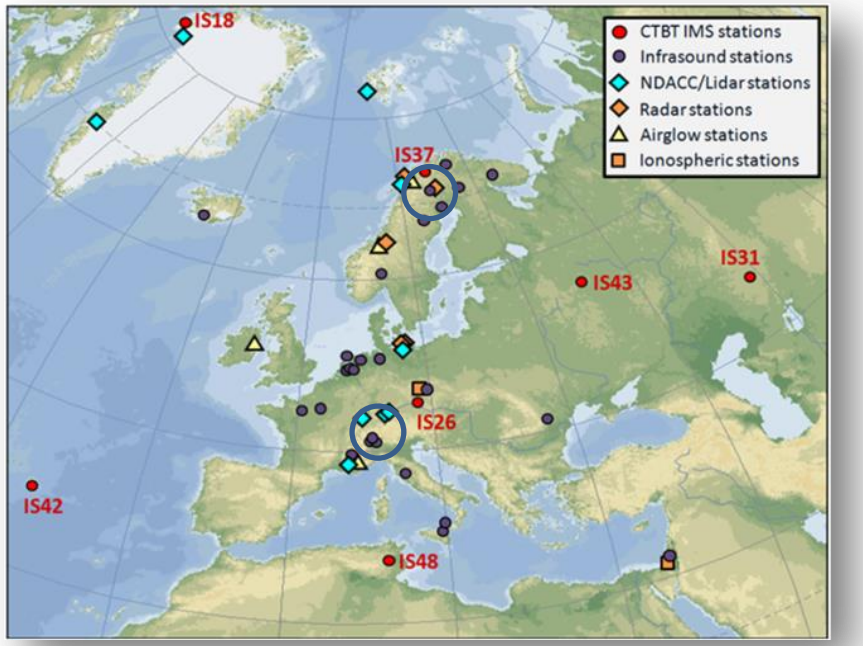
Marty, 2019

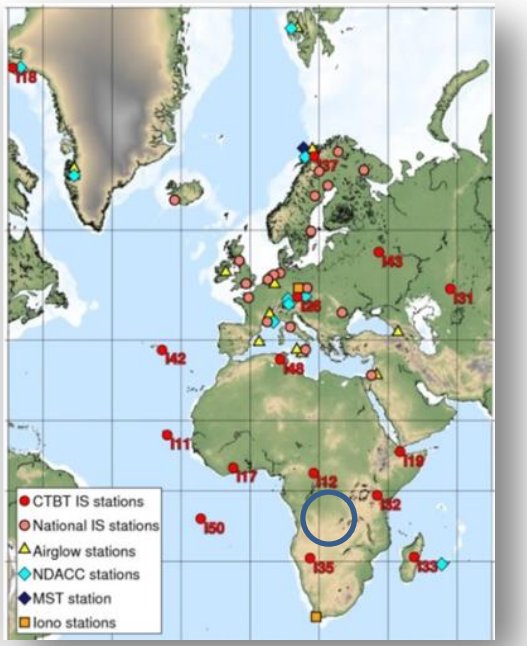
❑ Opportunity to calibrate the network using well identified sources and promote civil and scientific applications



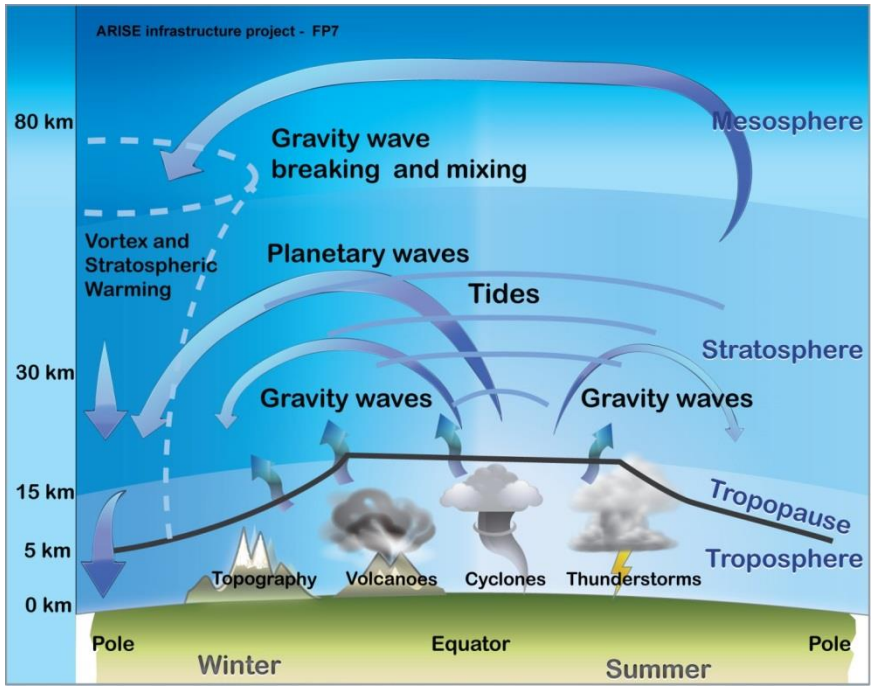
❑ Infrasound propagates in the stratospheric wave guide of the atmosphere. Long range propagation is controlled by the stratospheric winds

ARISE H2020 project
(Atmospheric dynamics Research InfraStructure in Europe)





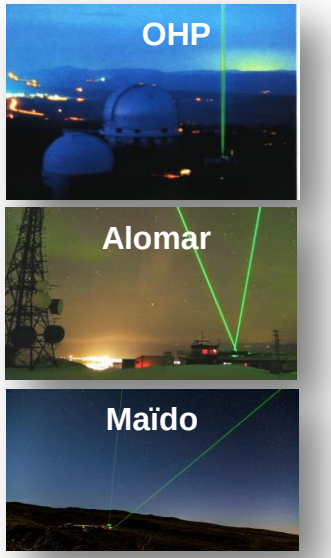
ARISE station network

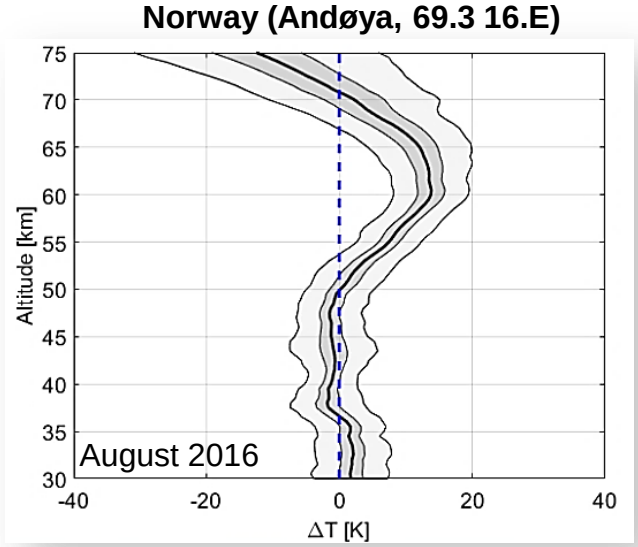


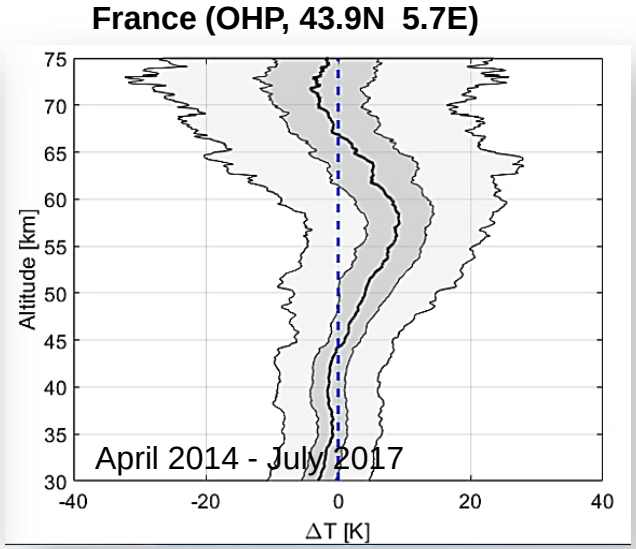
Dynamics of the Middle Atmosphere

The ARISE project aims at establishing a unique atmospheric research and data platform in Europe.
It combines complementary observations with theoretical and modelling studies to better understand and describe the dynamics of the middle and upper atmosphere

Model uncertainties related to atmospheric variability



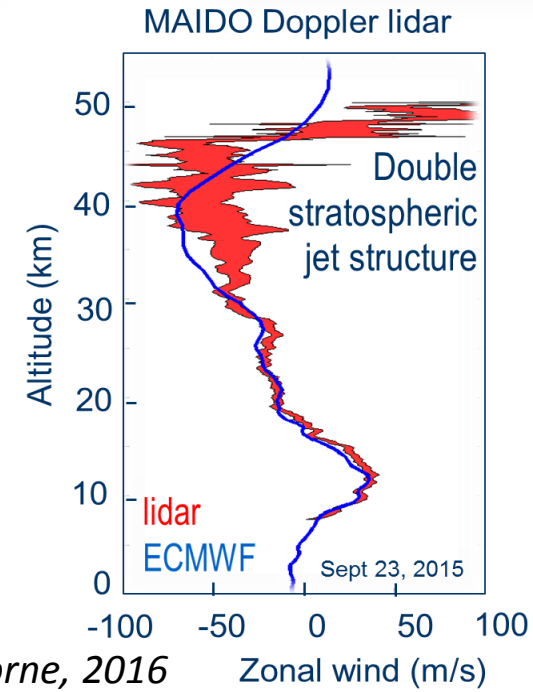




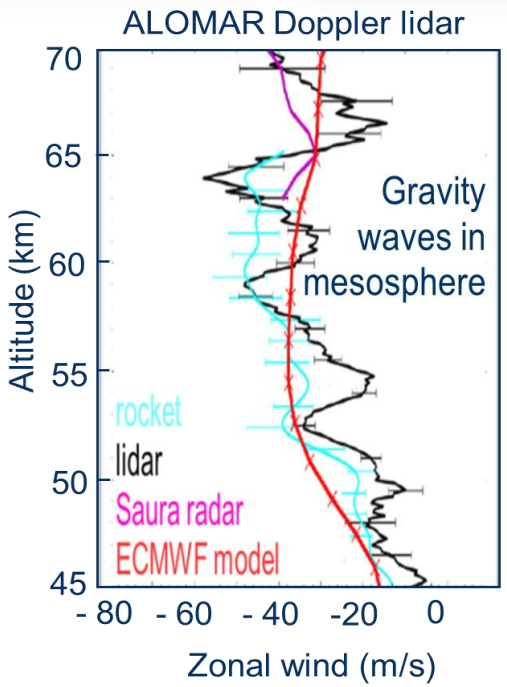
Differences between lidar observations and ECMWF temperature profiles exceeds 10K in the upper stratosphere and mesosphere.

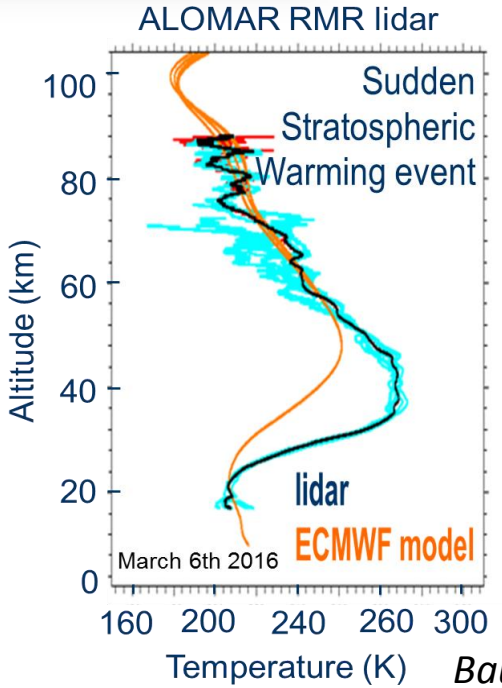
Le Pichon et al, 2018

As infrasound propagates in the stratosphere, these disturbances needs to be determined and included in the infrasound simulations



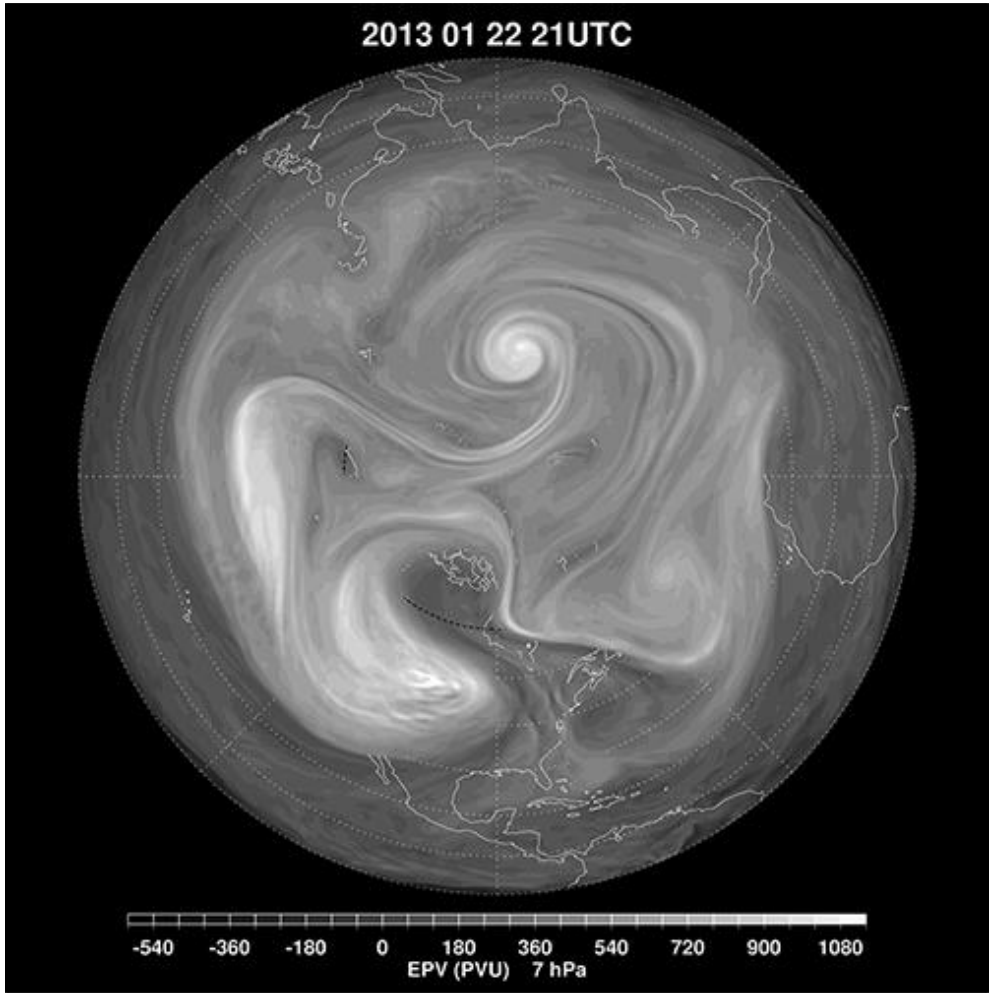
Hauchecorne, 2016





Baumgarten, 2014, 2016

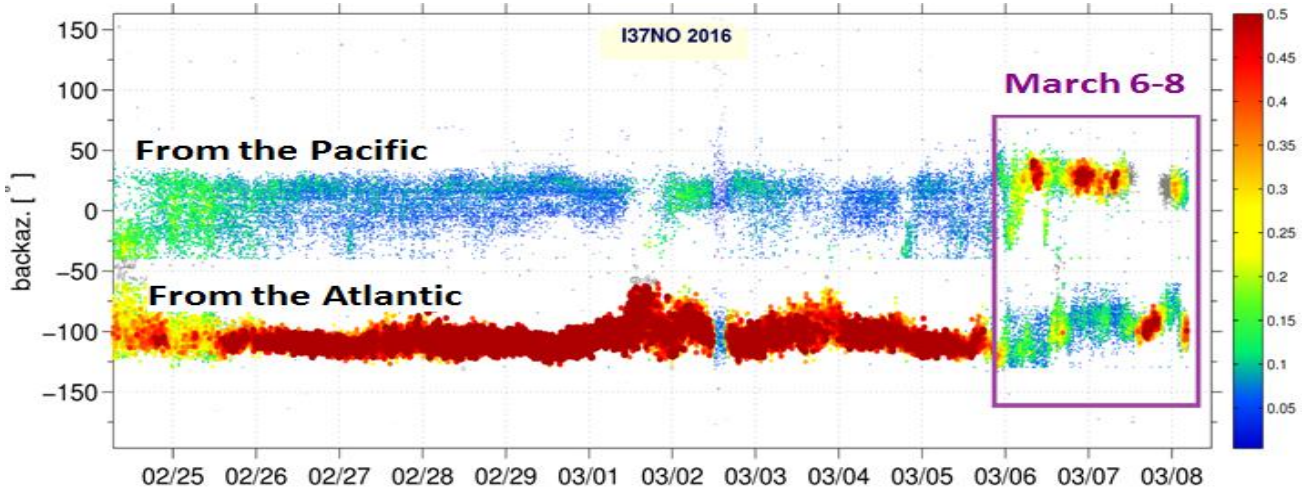
Sudden Stratospheric Warming events in infrasound data



Example of SSW event (NASA)

Sudden Stratospheric Warming events(SSW) are characterized by

- polar vortex breaking,
- inversion of the zonal stratospheric wind and of the infrasound propagation direction



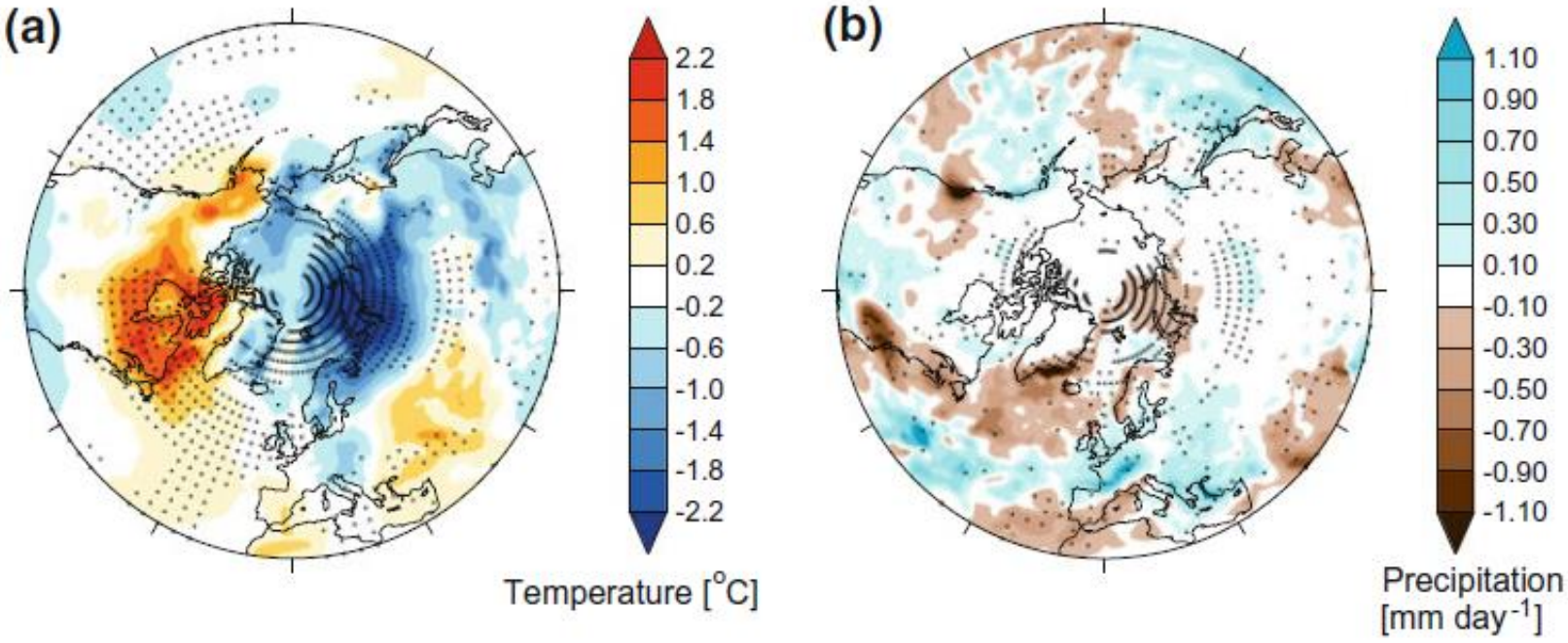
Processed NORSAR infrasound data during the 2016 SSW event.

Näsholm et al., 2017

SSW are now well identified by lidars. Their effects on infrasound propagation can be determined and included in simulations

Effect of Sudden Stratospheric Warming events on Numerical Weather Predictions

Surface temperature and precipitation anomalies over 15-30 days forecasts for 15 SSW

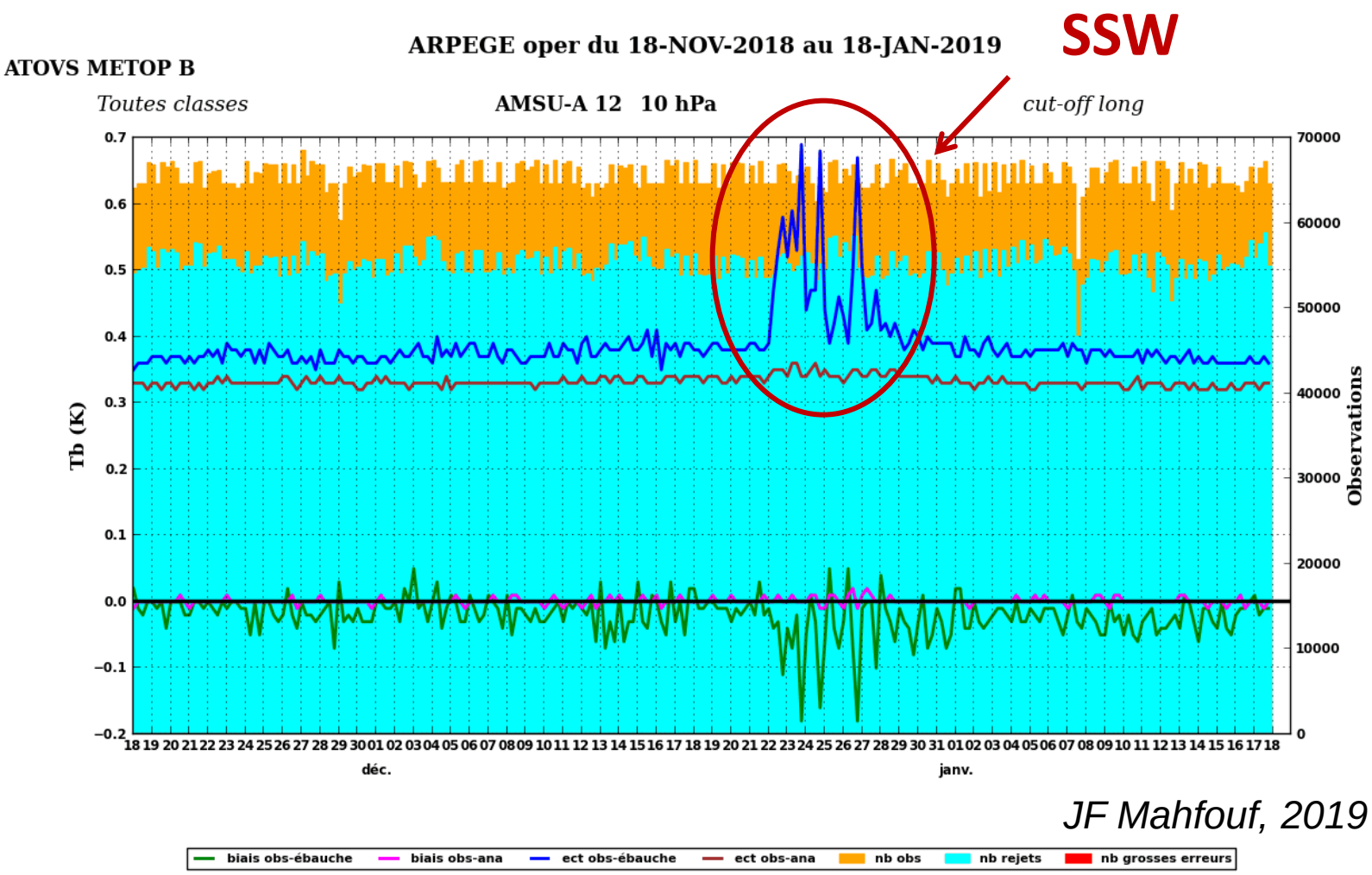


Major SSW events can be followed by cold weather that can affect Europe for several weeks

Average anomalies of (a) surface temperature, (b) precipitation, 15 - 60 days after the onset of 15 SSWs in a 50-year unconstrained climate run of the HadGEM2 Unified Model.

Lee et al., 2019

Sudden Stratospheric Warming (SSW) events are poorly represented in Numerical Weather Prediction models

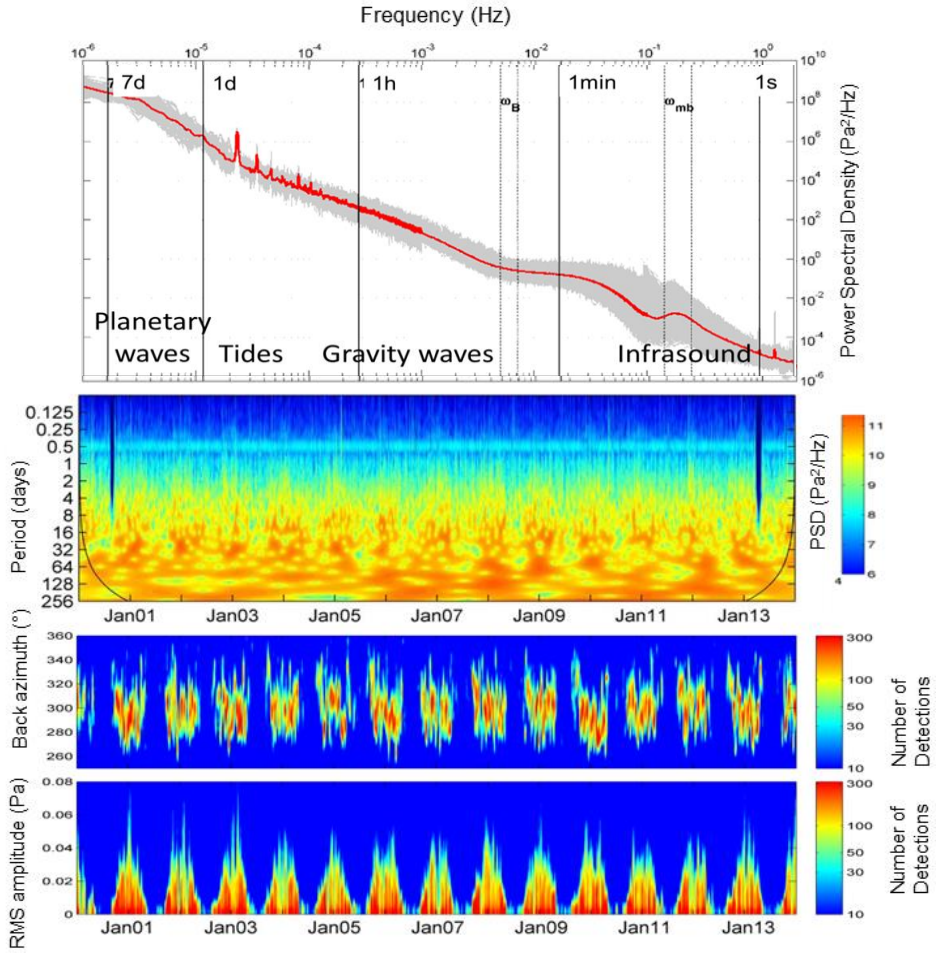


JF Mahfouf, 2019

- During Sudden Stratospheric warming, large anomalies appear in the prediction model. The number of available routine observations of winds in the stratosphere and above is very small for assimilations in models.
- Other requested data concern low latitudes, high altitudes (above the stratosphere) and other small scale disturbances

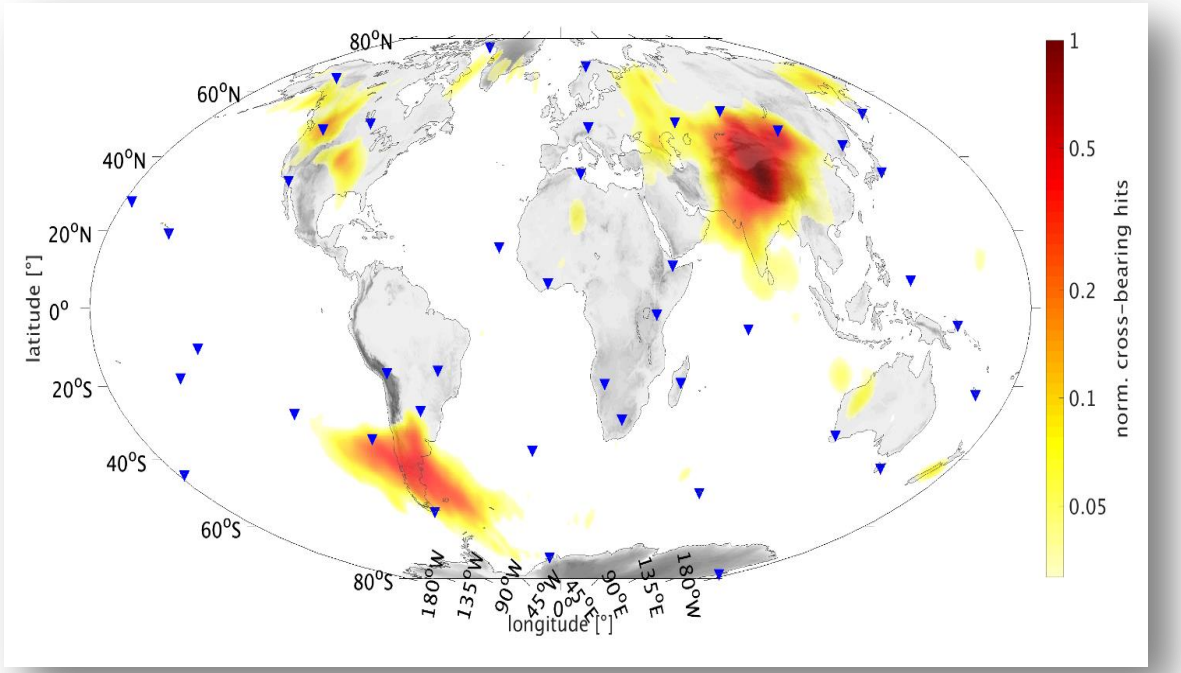
ARISE data are relevant for the description of these disturbances which are not yet integrated in the models

Potential of the IMS for gravity wave observations



Infrasound broadband observations in the IS26 station

Hupe, Pilger, 2017

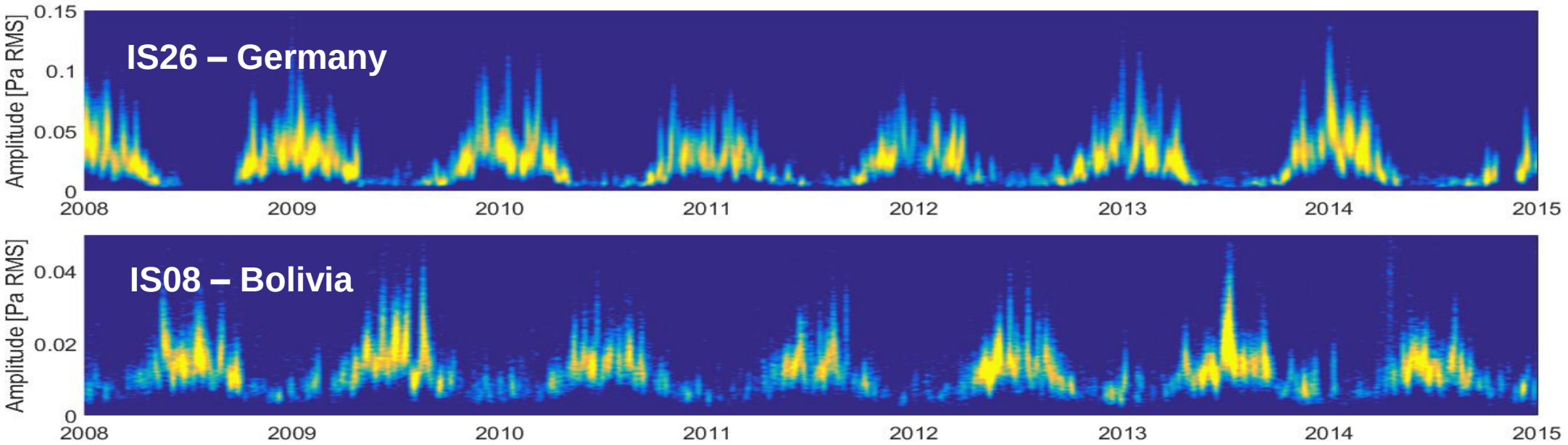


- Example of mountain waves observed by the infrasound technology, using a cross bearing approach.
- Mountain gravity waves are at the origin of uncertainties in ECMWF models

Hupe, PhD 2019

Potential of the IMS for planetary waves observations at larger scales

Example of planetary wave observed by IMS stations



Infrasound sources: Ocean swell providing microbarom signals

Fluctuations of microbarom amplitudes, observed by the IMS network represent planetary wave activity which impacts infrasound propagation. Planetary waves are expected to be larger in winter. Such observations at global scale are relevant for weather and climate models

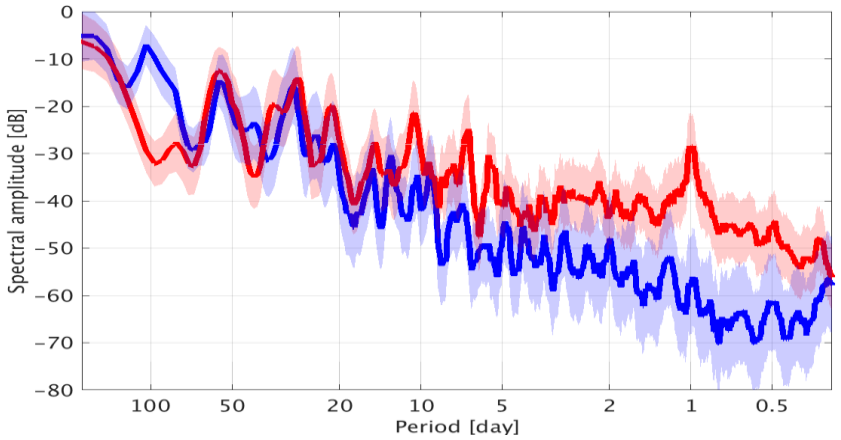
Le Pichon et al., 2010

Comparison between planetary wave observations and ECMWF model

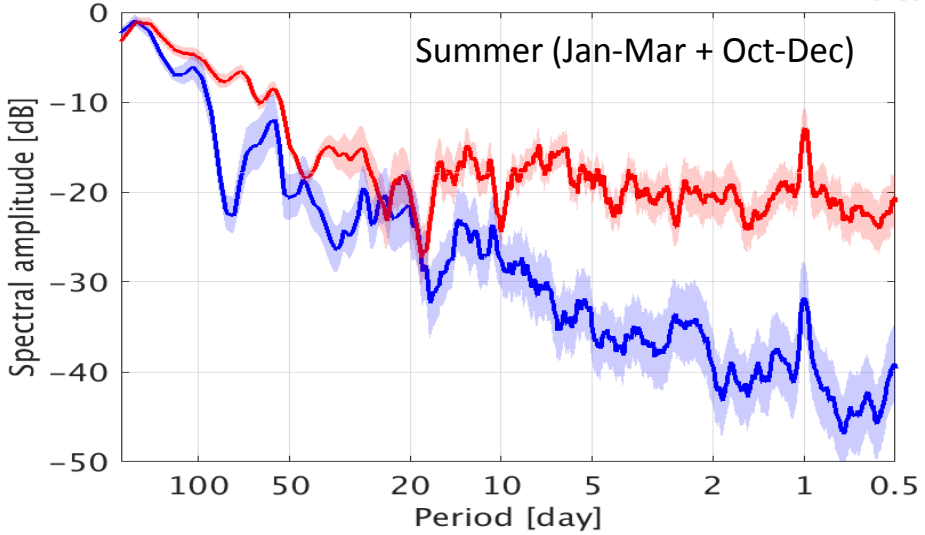
Comparison of Power Spectral Density of observations and models

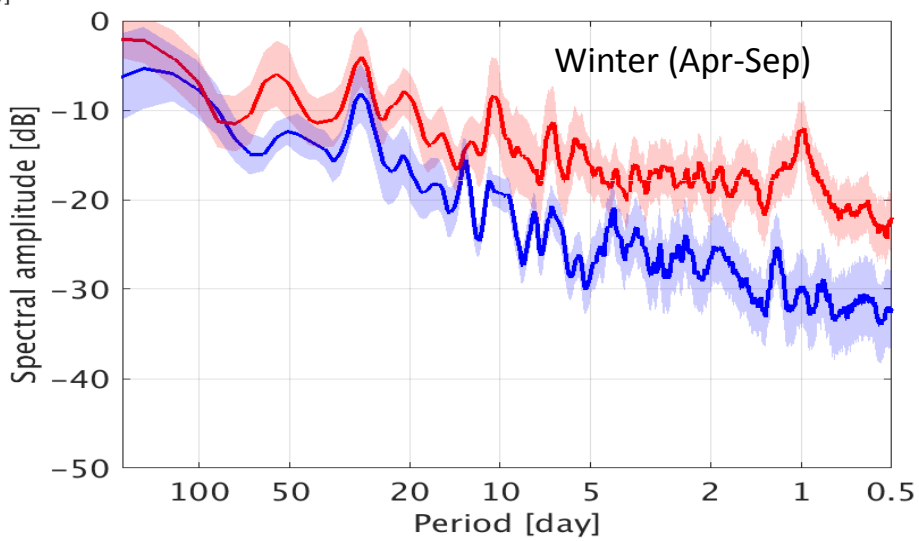
CORAL lidar (DLR) and ECMWF renalyses

Argentina, Rio Grande station



Such disturbances at scales of several days could contribute to changes in wind and temperature and impact global atmospheric circulation





The Coral lidar in Argentina during one year showed that planetary wave activity is larger than predicted by ECMWF at periods smaller than several days, especially in summer, when smaller activity is expected

Conclusion and perspectives

- The atmosphere is a highly variable environment. Small scale disturbances such as stratospheric warming and gravity waves affect the infrasound propagation and need to be integrated in routine monitoring tools.
- The IMS infrasound network provides unique global observations about these disturbances both by direct observations in the lower frequency range of the sensors and by inversions using well determined infrasound sources.
- The ARISE perspective are the following:
  - Improving observations by using synergy between infrasound and lidar observations for ECMWF model assessment (and improvement) and in routine infrasound simulations
  - Developing Near Real Time processing needed for societal applications such as remote volcano monitoring and assimilations in models
  - Extending the coverage in space and altitude (from ground to near Earth Space)

ARISE (http://arise-project.eu) was funded by the European Union within FP7 (grant 284387) and H2020 programs (grant 653980).